Annexure-I

Industrial Automation

LOVELY PROFESSIONAL UNIVERSITY

Center For Professional Enhancement

PLC Based

A training report

Submitted in partial fulfillment of the requirements for the award of degree of

Bachelor of Technology

(Electronics And Communication Engineering)

Submitted to

LOVELY PROFESSIONAL UNIVERSITY

PHAGWARA, PUNJAB

Submitted by

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Course: Industrial Automation

Declaration by Student

I hereby declare that this report entitled **"PLC-Based Phase Sequence Indication And Controlling Sysytem "** is the result of my own work carried out during the course of my study at [Lovely Professional University]. I have acknowledged all the sources used in this report and have not engaged in any form of plagiarism. This report has not been submitted for the award of any other degree or diploma.

[N.Vishnu]
[16-07-24]

Training Certificate from Organization/Company

This is to certify that [N.Vishnu], a student of [Lovely Professional University], has successfully completed the training on PLC-based systems. The training included theoretical and practical knowledge of designing, programming, and implementing PLC-based control systems, with a special focus on Sequence And Controlling systems.

- Certification provided by the Lovely professional University confirming the completion of the project.

CENTRE FOR PROFESSIONAL ENHANCEMENT

Certificate No. 341410

NAAC GRADE A++

Certificate of Merit

This is to certify that Mr./Ms. **Nimbagallu Vishnu** S/o,D/o,W/o **Mr. N Somasekhar** student of **School of Electronics and Electrical Engineering** Registration No. **12305434** pursuing **B.Tech. (Electronics and Communication Engineering) [Lateral Entry]** participated in skill development course named **Industrial Automation** organized by **Centre for Professional Enhancement** Lovely Professional University w.e.f **05-06-2024** to **17-07-2024** and obtained **A** Grade.

Date of Issue : 03-08-2024
Place of Issue: Phagwara (India)

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A comprehensive list of all figures and charts included in the report.

- **Figure/Chart No.**

List of Abbreviations

- A list of abbreviations used throughout the report with their full forms.

- **Abbreviation Full Form**

PLC: Programmable Logic Controller
HMI: Human-Machine Interface
SCADA: Supervisory Control and Data Acquisition
IO: Input/Output
CPU: Central Processing Unit
RTO: Real-Time Operating System
NPN: Negative-Positive-Negative (type of sensor)
PNP: Positive-Negative-Positive (type of sensor)
DC: Direct Current
AC: Alternating Current
I/O: Input/Output

Chapter-1 INTRODUCTION OF THE PROJECT UNDERTAKEN

Industrial Automation

1. Definition and Importance Industrial automation encompasses the use of advanced control systems such as computers, robots, and information technologies to handle processes and machinery in manufacturing and other industries. By automating tasks, industries can achieve higher productivity, greater precision, and enhanced safety. The importance of industrial automation lies in its ability to:

- **Increase Efficiency:** Automation systems operate continuously without breaks, which maximizes production rates and reduces idle time.
- **Improve Quality:** Consistent automation processes ensure uniform product quality, minimizing variations and defects.
- **Enhance Safety:** Automated systems reduce the need for human intervention in hazardous environments, thereby decreasing the risk of workplace accidents.
- **Reduce Costs:** Automation reduces labor costs and operational expenses by streamlining processes and minimizing human errors.

2. Historical Development and Advancements

- **Early Automation:** The concept of automation began with early mechanical devices, such as waterwheels and windmills, which were used to automate simple tasks like grinding grain.
- **18th Century:** During the Industrial Revolution, the development of mechanized looms and steam engines marked significant advancements in automation, laying the groundwork for modern manufacturing.
- **Early 20th Century:** The introduction of electrical control systems and relay-based controls allowed for more complex automation processes. The advent of the first programmable controllers further advanced automation capabilities.
- **Mid-20th Century:** The invention of the Programmable Logic Controller (PLC) revolutionized industrial automation by providing a flexible and programmable alternative to traditional relay-based systems.
- **Late 20th Century to Present:** The integration of digital technology, computer networks, and the Internet of Things (IoT) has enhanced automation with real-time monitoring, remote control, and data analytics capabilities.

3. Applications and Benefits in Various Industries

- **Manufacturing:** Automation is extensively used in assembly lines, where robots perform tasks such as welding, painting, and assembling components. This results in increased production speeds, improved precision, and reduced operational costs.
- **Food and Beverage:** In this sector, automation ensures consistent product quality, adherence to hygiene standards, and efficient processing of ingredients, packaging, and labeling.
- **Pharmaceuticals:** Automation in pharmaceuticals includes automated systems for drug formulation, quality control, and packaging, ensuring accuracy and compliance with regulatory standards.
- **Automotive:** The automotive industry leverages automation for tasks such as parts manufacturing, assembly, and quality testing, leading to higher production rates and enhanced vehicle safety features.

- **Energy:** Automation systems optimize the operation of power plants, manage the distribution of electricity, and integrate renewable energy sources, enhancing efficiency and reliability.

4. Overview of the PLC's Role in Industrial Automation Programmable Logic Controllers (PLCs) play a pivotal role in industrial automation by controlling and monitoring various processes. Key aspects of PLCs include:

- **Real-Time Control:** PLCs execute control commands in real-time, allowing for precise regulation of machinery and processes based on input signals from sensors.
- **Flexibility and Reprogramming:** PLCs can be reprogrammed to accommodate different tasks and processes, making them highly adaptable to changing production needs.
- **Integration Capabilities:** PLCs integrate seamlessly with other automation systems such as Human-Machine Interfaces (HMIs) and Supervisory Control and Data Acquisition (SCADA) systems, providing a comprehensive automation solution.
- **Durability and Reliability:** Designed to operate in challenging industrial environments, PLCs are built to withstand temperature fluctuations, electrical noise, and mechanical stress, ensuring long-term reliability and performance.

5. Future Trends in Industrial Automation

- **Artificial Intelligence (AI):** The incorporation of AI in automation systems is enhancing predictive maintenance, process optimization, and decision-making capabilities.
- **Industrial IoT (IIoT):** IIoT technologies are enabling advanced data collection, real-time analytics, and improved connectivity between devices and systems.
- **Advanced Robotics:** Developments in robotics are leading to more sophisticated and versatile robots capable of performing complex tasks with greater precision and flexibility.
- **Cybersecurity:** As automation systems become more connected, robust cybersecurity measures are essential to protect against cyber threats and ensure data integrity.

This chapter provides a comprehensive overview of industrial automation, its historical evolution, applications, and the crucial role of PLCs in modern automation systems.

PLC Block Diagram

1. Detailed Explanation of the PLC Block Diagram The Programmable Logic Controller (PLC) block diagram is a visual representation of the internal structure of a PLC. It illustrates the main components of the PLC system and their interactions. The block diagram typically includes the following key elements:

- **Power Supply:** Provides the necessary electrical power for the PLC operation.
- **Central Processing Unit (CPU):** The brain of the PLC, responsible for executing control programs and processing inputs and outputs.
- **Input/Output (I/O) Modules:** Interfaces for connecting the PLC to external devices such as sensors, switches, and actuators.
- **Communication Interfaces:** Facilitate communication between the PLC and other systems or devices, such as computers or other PLCs.

- **Programming Interface:** Allows for programming and configuration of the PLC, often through software.

2. Description of Each Block/Component and Its Function

- **Power Supply:** Supplies the PLC with the necessary voltage and current. It converts the input AC voltage to the DC voltage required by the PLC components.
  - *Function:* Ensures stable operation by providing consistent power to all PLC components.
- **Central Processing Unit (CPU):** Executes the control programs stored in its memory, processes inputs from the I/O modules, and sends control commands to the output modules.
  - *Function:* Performs logical operations, calculations, and decision-making based on the program logic.
- **Input Modules:** Receive signals from input devices (such as sensors and switches) and convert them into signals that the CPU can process.
  - *Function:* Provides the PLC with information about the state of external devices.
- **Output Modules:** Send control signals to output devices (such as motors, valves, and lights) based on the instructions from the CPU.
  - *Function:* Activates or deactivates external devices according to the PLC's control logic.
- **Communication Interfaces:** Include various ports and protocols for data exchange with other systems, such as Ethernet, serial ports, or fieldbus connections.
  - *Function:* Allows the PLC to communicate with other PLCs, computers, or control systems for data sharing and coordination.
- **Programming Interface:** Provides a means for users to program and configure the PLC, typically through a computer and specialized software.
  - *Function:* Enables the creation, modification, and upload of control programs to the PLC.

3. How These Components Interact with Each Other

- **Data Flow:** The PLC's operation begins with the input modules receiving data from external devices. This data is then sent to the CPU, which processes it based on the stored program logic.
- **Processing:** The CPU executes the program instructions, performs necessary calculations, and determines the appropriate responses.
- **Control Output:** Based on the CPU's decisions, the output modules are activated to control external devices or processes.
- **Communication:** The PLC can exchange data with other systems through communication interfaces, allowing for integrated and coordinated control across multiple devices.

4. Examples and Illustrations

Example 1: Manufacturing Conveyor System

- **Inputs:** Sensors detect the presence of items on the conveyor belt.
- **Outputs:** Motors control the movement of the conveyor belt.
- **Operation:** The PLC receives signals from the sensors (input modules), processes the information to determine the belt's operation, and sends commands to the motors (output modules) to move the conveyor as required.

Example 2: Temperature Control System

- **Inputs:** Temperature sensors provide data on the current temperature.
- **Outputs:** Control signals are sent to heating or cooling units to maintain the desired temperature.
- **Operation:** The PLC reads temperature data from sensors, compares it with the setpoint, and adjusts the heating or cooling units accordingly to achieve the desired temperature.

Illustrations:

- **Figure 1:** Basic PLC Block Diagram – Shows the standard components such as power supply, CPU, I/O modules, and communication interfaces.
- **Figure 2:** Detailed PLC Component Interaction – Illustrates the data flow from input modules through the CPU to output modules and communication interfaces.
- **Figure 3:** Example Application Diagrams – Diagrams of specific applications like conveyor systems and temperature control systems, highlighting how the PLC components interact in each scenario.

This chapter provides an in-depth look at the PLC block diagram, detailing the functions of each component and their interactions within the system. The examples and illustrations help to clarify how PLCs are used in real-world applications to control and automate various processes.

 Figure 1: Basic PLC Block Diagram – Shows the standard components such as power supply, CPU, I/O modules, and communication interfaces.

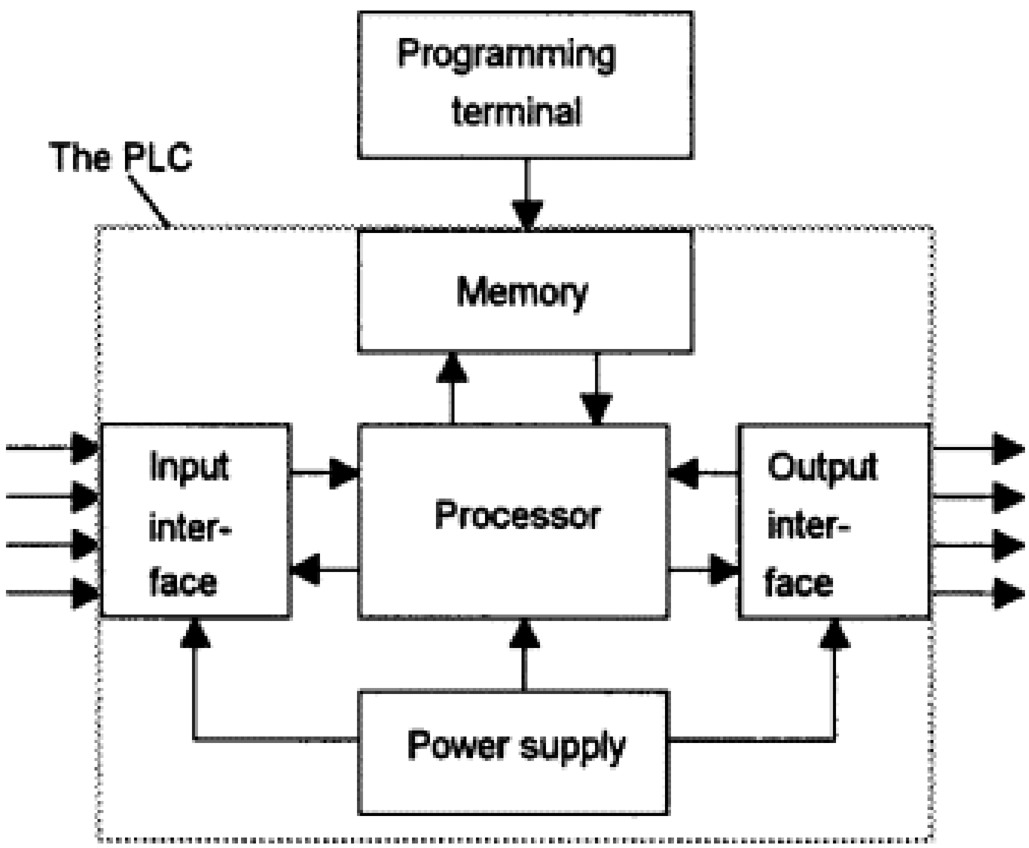
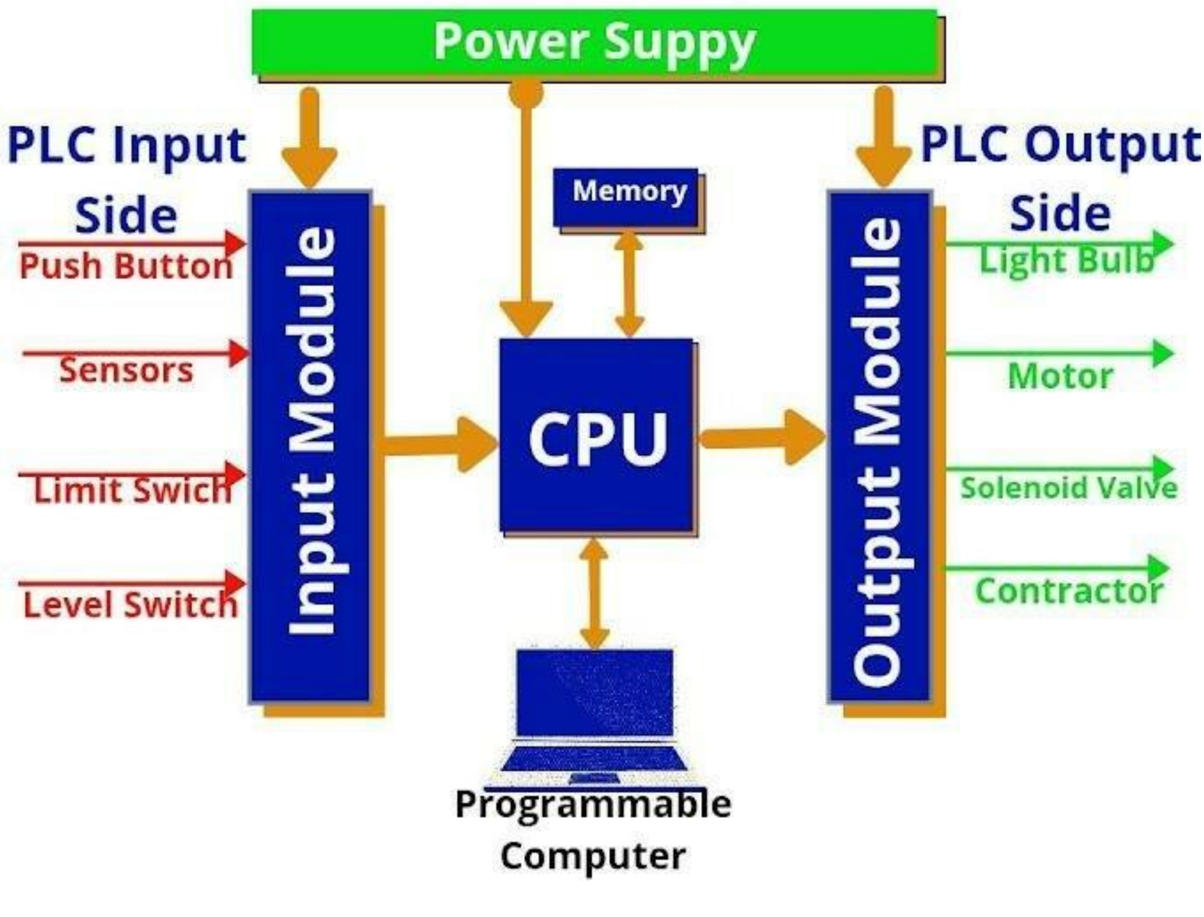


 Figure 2: Detailed PLC Component Interaction – Illustrates the data flow from input modules through the CPU to output modules and communication interfaces.



Chapter-3 TIMERS OF PLC

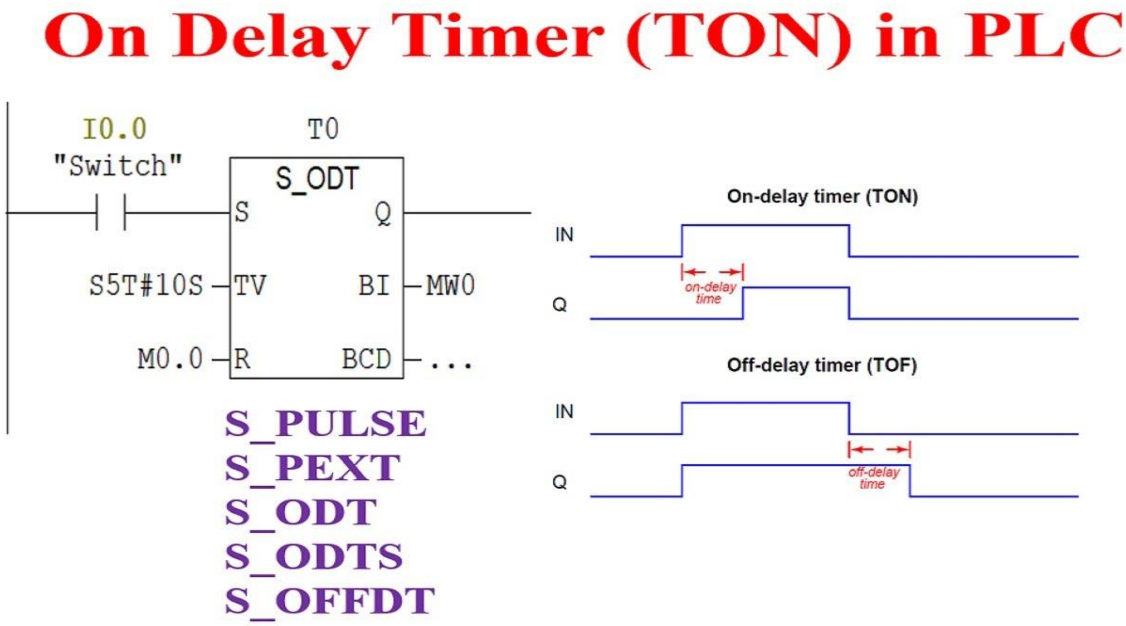
Introduction to PLC Timers

1. Introduction to PLC Timers PLC timers are integral components in programmable logic controllers that allow for the execution of time-dependent control processes. Timers function similarly to mechanical or electronic timers but are implemented in software within the PLC. They are used to create delays, measure the passage of time, and coordinate sequences of operations in an industrial control system.

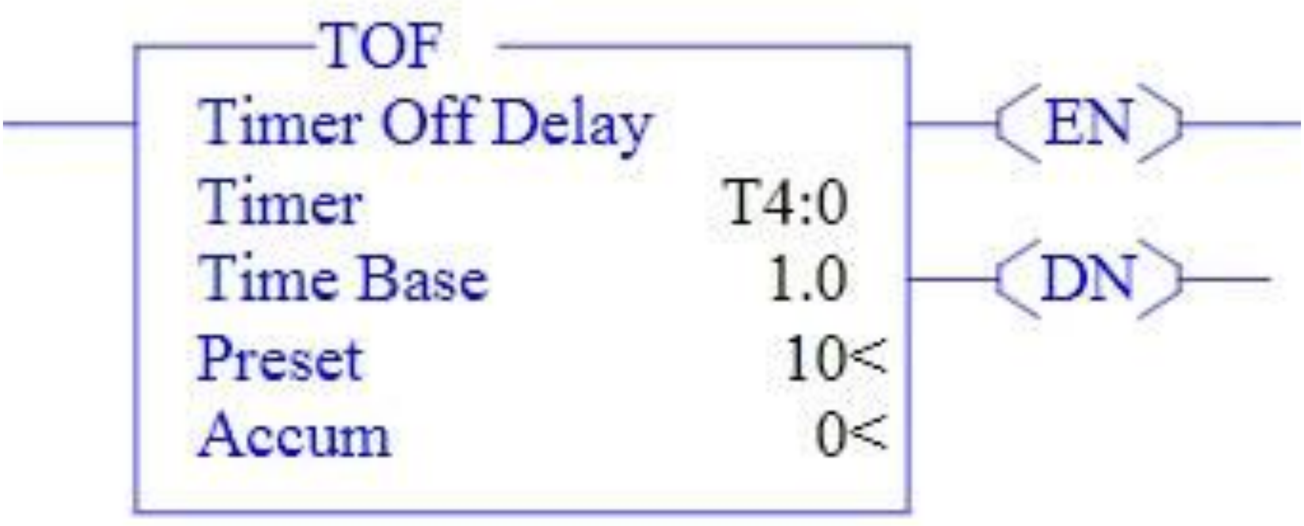
Timers in a PLC enable automation systems to perform tasks such as delaying the start of a motor, timing the interval between events, or controlling the duration of a signal. They are essential for achieving precise timing control in various applications, including manufacturing processes, machine control, and building automation.

2. Types of Timers PLC timers can be categorized into several types, each with distinct characteristics and uses. The primary types of timers include on-delay timers, off-delay timers, and retentive timers.

- **On-Delay Timer (TON):**
  - *Function:* The on-delay timer starts counting when it receives an activation signal. After the specified time delay, the timer's output becomes active.
  - *Usage:* Commonly used to delay the start of an operation. For example, in a conveyor system, an on-delay timer can delay the start of the conveyor belt after a sensor detects an item.

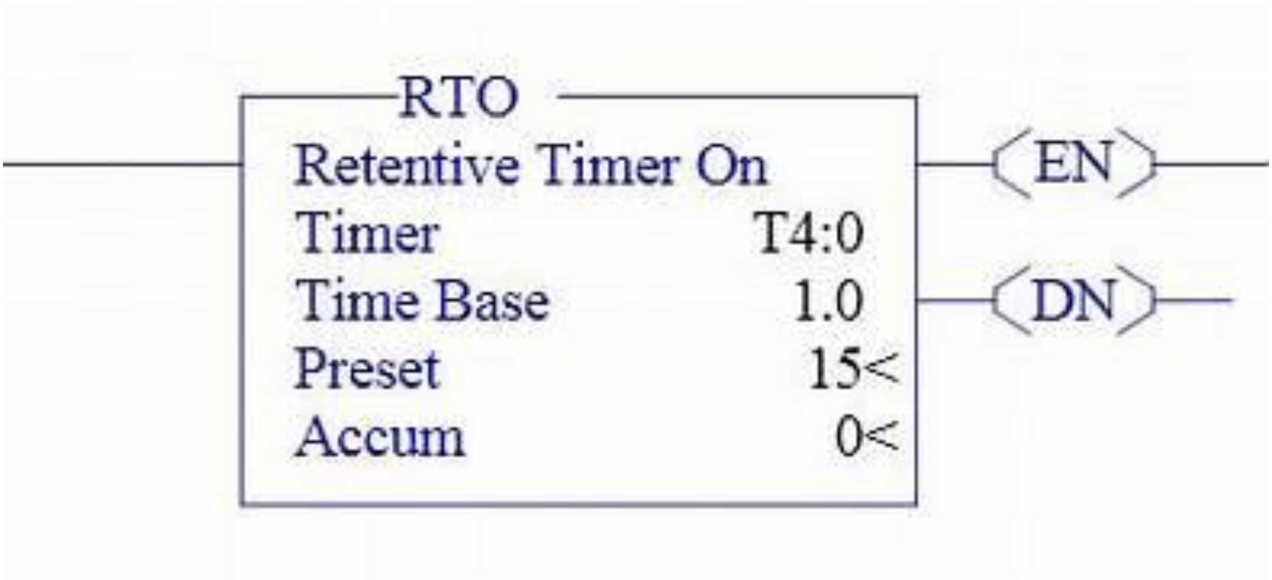


- **Off-Delay Timer (TOF):**
    - *Function:* The off-delay timer activates its output immediately upon receiving an activation signal. When the signal is removed, the timer begins counting down the specified delay time. After the time elapses, the output is deactivated.
    - *Usage:* Used to keep an operation running for a specific period after an event occurs. For instance, a fan might continue to run for a set time after a machine is turned off to cool it down.



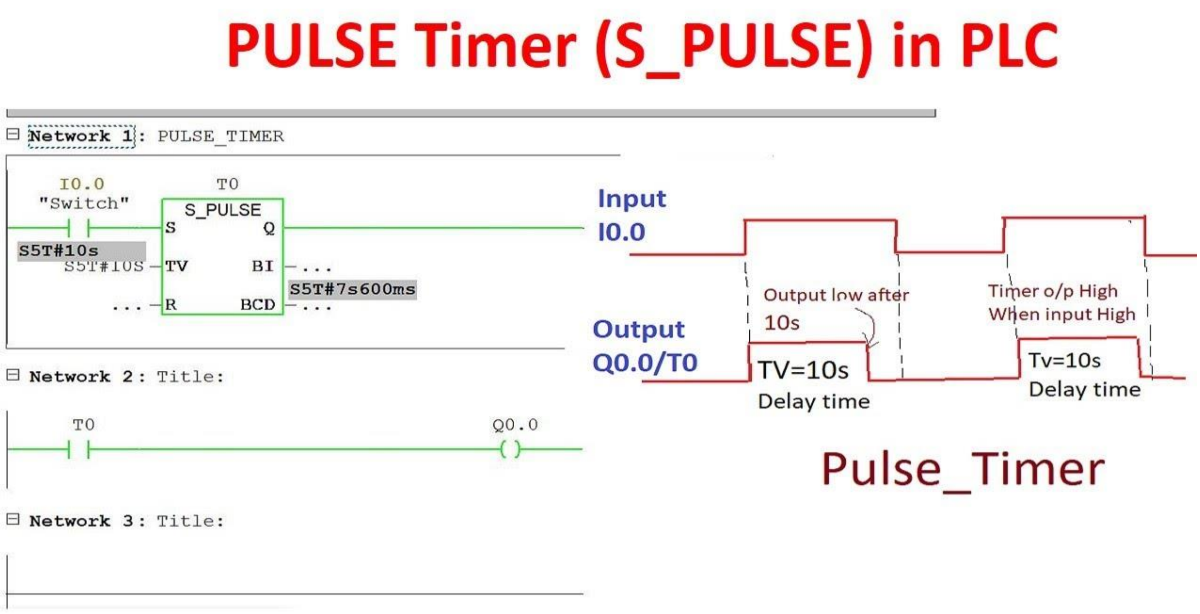
Retentive Timer (RTO):

- *Function:* The retentive timer accumulates time when it receives an activation signal and pauses when the signal is removed. It retains the accumulated time and resumes counting when the signal is reactivated.
- *Usage:* Suitable for applications where the timing process needs to resume from where it left off. For example, in a machine cycle, if the process is interrupted, the retentive timer ensures that the cycle continues from the last point upon resumption.



Pulse Timer (TP):

- *Function:* The pulse timer generates a single output pulse of a specified duration when it receives an activation signal.
- *Usage:* Ideal for generating brief control signals. For instance, a pulse timer can be used to trigger a short burst of compressed air to clean a sensor.



3. How Timers are Used in PLC Programming Timers are programmed into the PLC logic using ladder diagrams or other programming languages such as Structured Text or Function Block Diagram. The process involves configuring the timer's parameters, such as the time delay and setting conditions for activation and deactivation.

- **Ladder Logic Implementation:** In ladder logic, timers are represented by specific blocks or instructions. The timer's input is typically connected to a control relay or a condition that triggers the timing function. When the condition is met, the timer begins its countdown or count-up based on its type.
- **Configuring Timer Parameters:** Each timer requires setting parameters such as the preset time (the time duration for the timer) and the time base (the unit of time, such as seconds or milliseconds). These parameters define the behavior of the timer.
- **Integration with Other Instructions:** Timers are often used in conjunction with other PLC instructions such as counters, comparators, and logical operations. For example, a timer might work alongside a counter to ensure that a process runs for a certain number of cycles before triggering the next operation.

4. Practical Examples and Applications

Example 1: Conveyor Belt System with On-Delay Timer

- **Objective:** Delay the start of a conveyor belt by 5 seconds after an item is detected.
- **Implementation:** An on-delay timer (TON) is programmed with a 5-second delay. When a sensor detects an item, the timer starts counting. After 5 seconds, the timer's output activates, starting the conveyor belt.
- **Ladder Logic:**

  ```
  scss
  |----[Sensor Input]----[TON Timer 5s]----(Conveyor Output)----|
  ```

Example 2: Ventilation System with Off-Delay Timer

- **Objective:** Keep a ventilation fan running for 10 minutes after a machine is turned off to ensure proper cooling.
- **Implementation:** An off-delay timer (TOF) is programmed with a 10-minute delay. When the machine is turned off, the timer begins counting down. The fan continues to run until the timer reaches zero, then it turns off.
- **Ladder Logic:**

  ```
  |----[Machine OFF Input]----[TOF Timer 10min]----(Fan Output)----|
  ```

Example 3: Production Line with Retentive Timer

- **Objective:** Track the total running time of a production line, even if it stops and starts intermittently.
- **Implementation:** A retentive timer (RTO) is used to accumulate the running time. The timer starts counting when the production line is running and pauses when it stops. It resumes counting from the accumulated time when the line restarts.
- **Ladder Logic:**

|----[Production Line Running]----[RTO Timer]----(Display Running Time)----|

Example 4: Packaging Machine with Pulse Timer

- **Objective:** Generate a brief pulse to operate a solenoid valve for 0.5 seconds to eject a package.
- **Implementation:** A pulse timer (TP) is configured with a 0.5-second duration. When a sensor detects a package, the pulse timer generates a 0.5-second pulse to activate the solenoid valve.
- **Ladder Logic:**

|----[Package Detected]----[TP Timer 0.5s]----(Solenoid Valve Output)----|

Summary

PLC timers are versatile and essential components in industrial automation, providing precise timing control for various processes. By understanding the types of timers and their applications, engineers can design efficient and reliable control systems that enhance productivity and safety in industrial environments. Practical examples illustrate the implementation of timers in real-world scenarios, highlighting their importance in achieving automated control solutions.

Chapter-4 COUNTERS

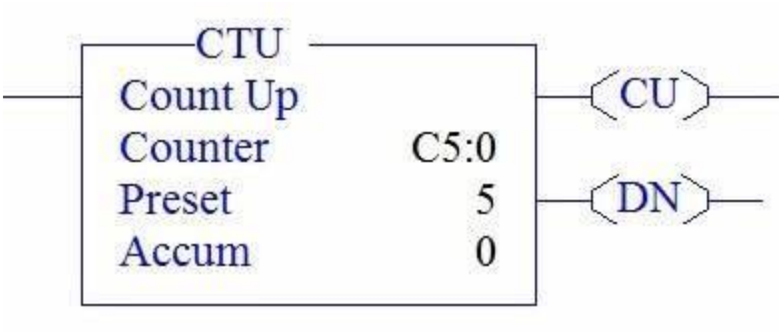
Introduction to PLC Counters

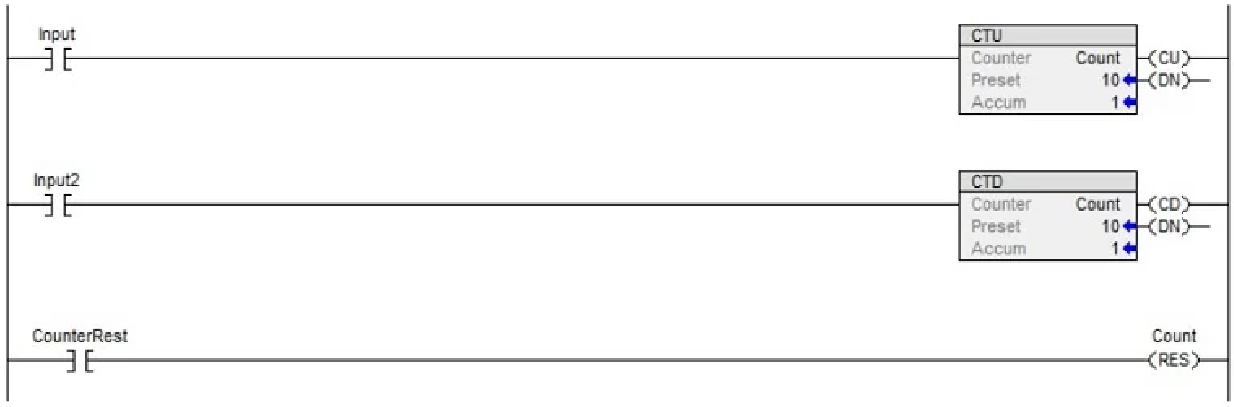
1. Introduction to PLC Counters PLC counters are specialized instructions used to count occurrences of input signals. They are similar to mechanical or digital counters but are implemented in the PLC's software. Counters keep track of events or objects, incrementing or decrementing a count based on input signals. They are essential for applications requiring precise tracking of quantities, cycles, or events.

Counters are widely used in industrial automation for tasks such as counting products on a conveyor belt, monitoring machine cycles, and controlling batch processes. By providing accurate count data, counters enable automated systems to make informed decisions and maintain control over processes.

2. Types of Counters There are several types of counters commonly used in PLC programming, each with specific characteristics and applications:

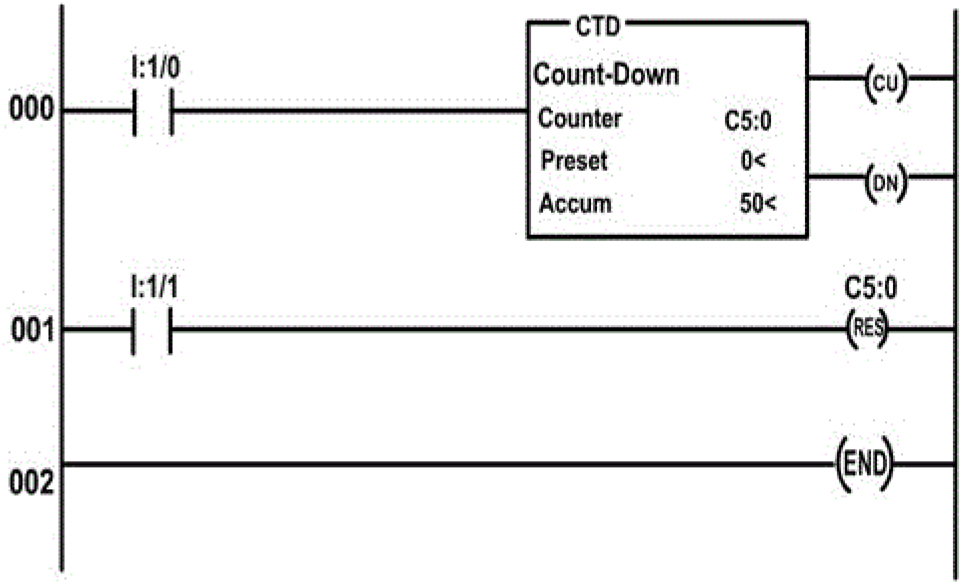
- **Up Counter (CTU):**
  - *Function:* Increments the count each time it receives an input signal. When the count reaches a predefined value (preset value), the counter's output is activated.
  - *Usage:* Used for counting events or objects in an increasing order. For example, counting the number of items passing through a sensor on a conveyor belt.





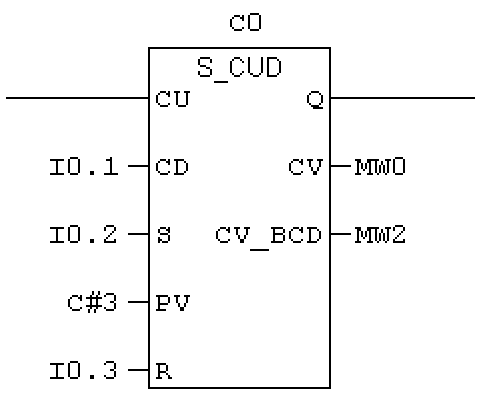
Down Counter (CTD):

- *Function:* Decrements the count each time it receives an input signal. When the count reaches zero, the counter's output is activated.
- *Usage:* Used for counting events or objects in a decreasing order. For example, tracking the remaining number of products to be processed in a batch.



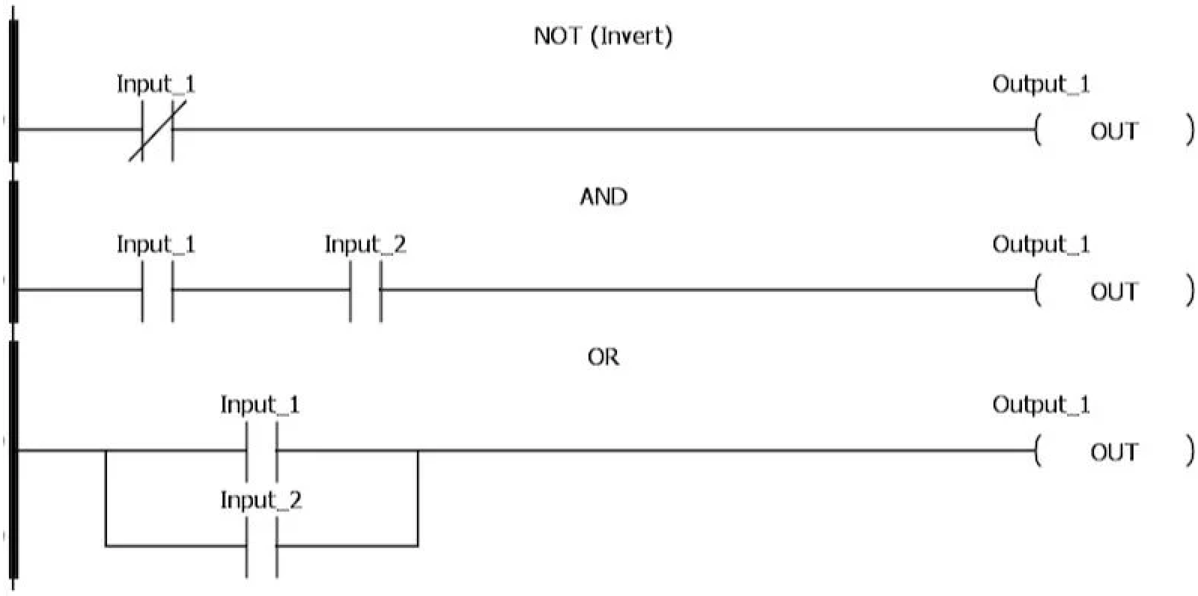
Up/Down Counter (CTUD):

- *Function:* Can increment or decrement the count based on different input signals. One input signal increases the count, while another decreases it. The counter's output is activated when the count reaches the preset value or zero.
- *Usage:* Suitable for applications where bidirectional counting is required. For example, tracking inventory levels where items are both added and removed.



3. How Counters are Used in PLC Programming Counters are programmed into the PLC logic using ladder diagrams or other programming languages. The process involves configuring the counter's parameters, such as the preset value and setting conditions for incrementing or decrementing the count.

Ladder Logic Implementation: In ladder logic, counters are represented by specific blocks or instructions. The counter's input is typically connected to a control relay or condition that triggers the counting function. The preset value is set according to the desired count limit.



- **Configuring Counter Parameters:** Each counter requires setting parameters such as the preset value (the target count) and the current count value. These parameters define the behavior of the counter and the conditions under which the counter's output is activated.
- **Integration with Other Instructions:** Counters are often used in conjunction with other PLC instructions such as timers, comparators, and logical operations. For example, a counter might work alongside a timer to control the duration of a counting process or with a comparator to trigger an action when a specific count is reached.

4. Practical Examples and Applications

Example 1: Conveyor Belt Product Counting with Up Counter

- **Objective:** Count the number of products passing through a sensor on a conveyor belt.
- **Implementation:** An up counter (CTU) is programmed with a preset value representing the desired count. Each time a product passes the sensor, the counter increments. When the count reaches the preset value, the counter's output activates, signaling that the desired number of products has been reached.
- **Ladder Logic:**

  ```scss
  |----[Sensor Input]----[CTU Counter]----(Count Reached Output)----|
  ```

Example 2: Batch Process Control with Down Counter

- **Objective:** Track the remaining number of products to be processed in a batch.
- **Implementation:** A down counter (CTD) is programmed with a preset value representing the total number of products in the batch. Each time a product is processed, the counter decrements. When the count reaches zero, the counter's output activates, indicating that the batch is complete.

- **Ladder Logic:**

```
scss
|----[Product Processed Input]----[CTD Counter]----(Batch Complete Output)----|
```

Example 3: Inventory Management with Up/Down Counter

- **Objective:** Track the inventory levels where items are both added and removed.
- **Implementation:** An up/down counter (CTUD) is used to increment the count when items are added to the inventory and decrement the count when items are removed. The counter's output activates when the count reaches the preset value or zero, indicating the need for inventory replenishment or depletion.
- **Ladder Logic:**

```
mathematica
|----[Item Added Input]----[CTUD Up]----(Inventory Level Output)----|
|----[Item Removed Input]----[CTUD Down]----(Inventory Level Output)----|
```

Example 4: Machine Cycle Counting with Up Counter

- **Objective:** Monitor the number of cycles a machine has completed.
- **Implementation:** An up counter (CTU) is programmed to count the number of cycles. Each time the machine completes a cycle, the counter increments. When the count reaches the preset value, the counter's output activates, triggering maintenance or other actions.
- **Ladder Logic:**

```
scss
|----[Cycle Complete Input]----[CTU Counter]----(Maintenance Trigger Output)----|
```

Summary

PLC counters are versatile and essential components in industrial automation, providing precise counting control for various processes. By understanding the types of counters and their applications, engineers can design efficient and reliable control systems that enhance productivity and accuracy in industrial environments. Practical examples illustrate the implementation of counters in real-world scenarios, highlighting their importance in achieving automated control solutions.

This chapter has provided an in-depth exploration of PLC counters, detailing their types, functions, programming techniques, and practical applications. Counters are crucial for tasks requiring accurate tracking of events, objects, or cycles, making them indispensable in modern industrial automation systems.

Chapter-5 Sensor

Introduction to Sensors in Automation

Sensors are essential components in industrial automation systems, providing the necessary data for controlling and monitoring processes accurately. They detect various physical parameters, such as position, temperature, pressure, and light, converting these changes into electrical signals that can be interpreted by a PLC (Programmable Logic Controller). The integration of sensors with PLCs enables real-time data acquisition and responsive control, making automation systems efficient and reliable.

Types of Sensors Used with PLCs

1. Proximity Sensors

- **Function:** Detect the presence or absence of objects without physical contact.
- **Types:**
  - **Inductive:** Detect metallic objects.
  - **Capacitive:** Detect both metallic and non-metallic objects.
  - **Magnetic:** Use magnetic fields to detect objects.
- **Usage:** Commonly used for object detection, counting, and positioning in manufacturing and packaging processes.

2. Photoelectric Sensors

- **Function:** Detect objects, changes in surface conditions, and other light-based variations.
- **Types:**
  - **Through-beam:** Separate transmitter and receiver.
  - **Retro-reflective:** Transmitter and receiver in one unit, using a reflector.
  - **Diffuse-reflective:** Transmitter and receiver in one unit, detecting reflected light from the target.
- **Usage:** Suitable for detecting the presence or absence of parts, counting items, and detecting color or contrast differences.

3. Ultrasonic Sensors

- **Function:** Use sound waves to detect the distance to an object.
- **Usage:** Ideal for level detection, distance measurement, and presence detection in applications such as liquid level monitoring and material handling.

4. Temperature Sensors

- **Function:** Measure temperature and convert it into an electrical signal.
- **Types:**
  - **Thermocouples**
  - **RTDs (Resistance Temperature Detectors)**
  - **Thermistors**

- **Usage:** Used for monitoring and controlling temperature in processes such as HVAC systems, ovens, and refrigeration units.

5. Pressure Sensors

- **Function:** Measure pressure and convert it into an electrical signal.
- **Types:**
  - **Strain gauge**
  - **Piezoelectric**
  - **Capacitive pressure sensors**
- **Usage:** Employed in applications like hydraulic and pneumatic systems, process control, and leak detection.

6. Level Sensors

- **Function:** Measure the level of liquids or solids within a container.
- **Types:**
  - **Float switches**
  - **Ultrasonic level sensors**
  - **Capacitive level sensors**
- **Usage:** Used in applications such as tank level monitoring, material handling, and process control.

7. Flow Sensors

- **Function:** Measure the flow rate of liquids or gases.
- **Types:**
  - **Turbine flow meters**
  - **Ultrasonic flow meters**
  - **Differential pressure flow sensors**
- **Usage:** Used in fluid delivery systems, HVAC systems, and process industries.

How Sensors Interact with PLCs

Sensors are connected to PLCs through input modules. The sensors send electrical signals (analog or digital) to the PLC input modules, which process and convert these signals into data that the PLC can use. The PLC then interprets this data to make decisions and execute control actions based on the programmed logic.

- **Digital Sensors:** Send discrete signals (on/off) to the PLC, represented as 0 or 1, corresponding to the presence or absence of an object or condition. They are connected to digital input modules on the PLC.
- **Analog Sensors:** Send continuous signals representing a range of values, such as temperature or pressure levels. These signals are converted into a standardized format (e.g., 4-20 mA or 0-10 V) and connected to analog input modules on the PLC.
- **Signal Conditioning:** In some cases, signals from sensors require conditioning (e.g., amplification, filtering) before they can be accurately read by the PLC, ensuring that the sensor data is accurate and reliable.

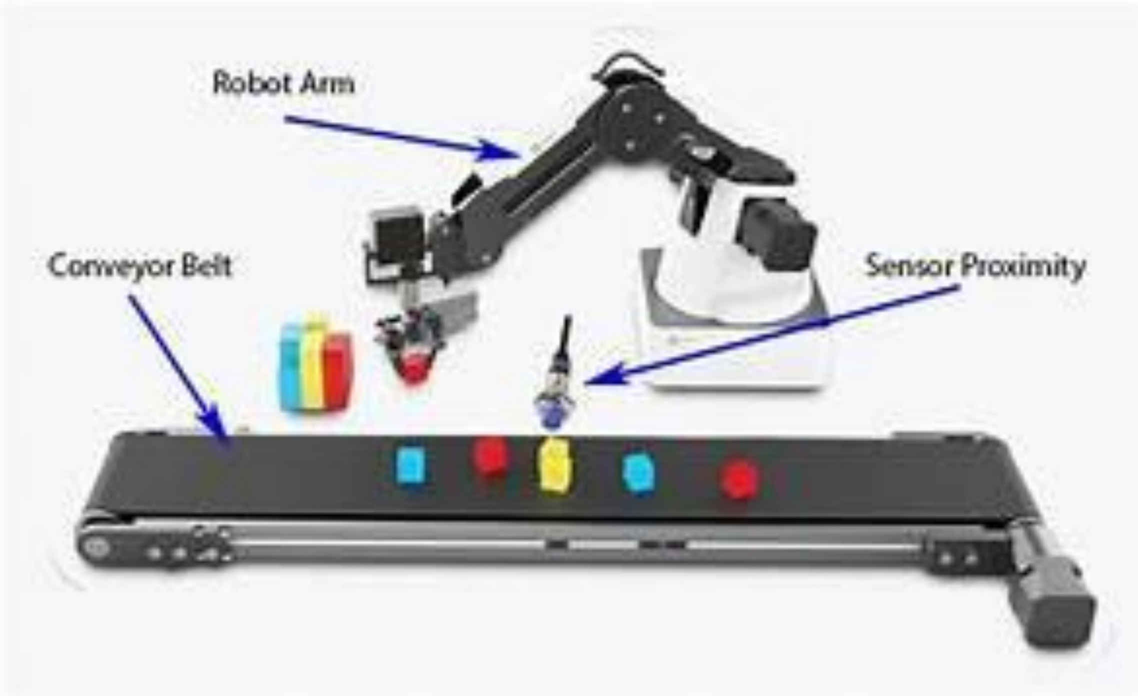
- **Programming and Logic:** The PLC is programmed with logic specifying how to respond to sensor inputs, including conditions for turning devices on or off, triggering alarms, or adjusting process parameters based on sensor data.

Practicle Example And Application

Example 1: Conveyor Belt with Proximity Sensors

- **Objective:** Detect the presence of objects on a conveyor belt and count them.
- **Implementation:** Inductive proximity sensors are placed along the conveyor belt to detect the presence of metallic objects. Each time an object passes a sensor, the sensor sends a signal to the PLC, which increments a counter.
- **Ladder Logic:**

  mathematica
  Copy code
  |----[Proximity Sensor Input]----[Counter Up]----(Count Display Output)----|



Example 2: Liquid Level Monitoring with Ultrasonic Sensors

- **Objective:** Monitor the level of liquid in a tank and control a pump to maintain the desired level.
- **Implementation:** An ultrasonic level sensor measures the liquid level in the tank. The sensor sends a continuous signal to the PLC, which compares the level to setpoints. If the level is too low, the PLC activates the pump; if the level is too high, the PLC deactivates the pump.
- **Ladder Logic:**

  scss
  Copy code
  |----[Ultrasonic Sensor Input]----[Level < Low Setpoint]----(Pump On)----|

|----[Ultrasonic Sensor Input]----[Level > High Setpoint]----(Pump Off)----|

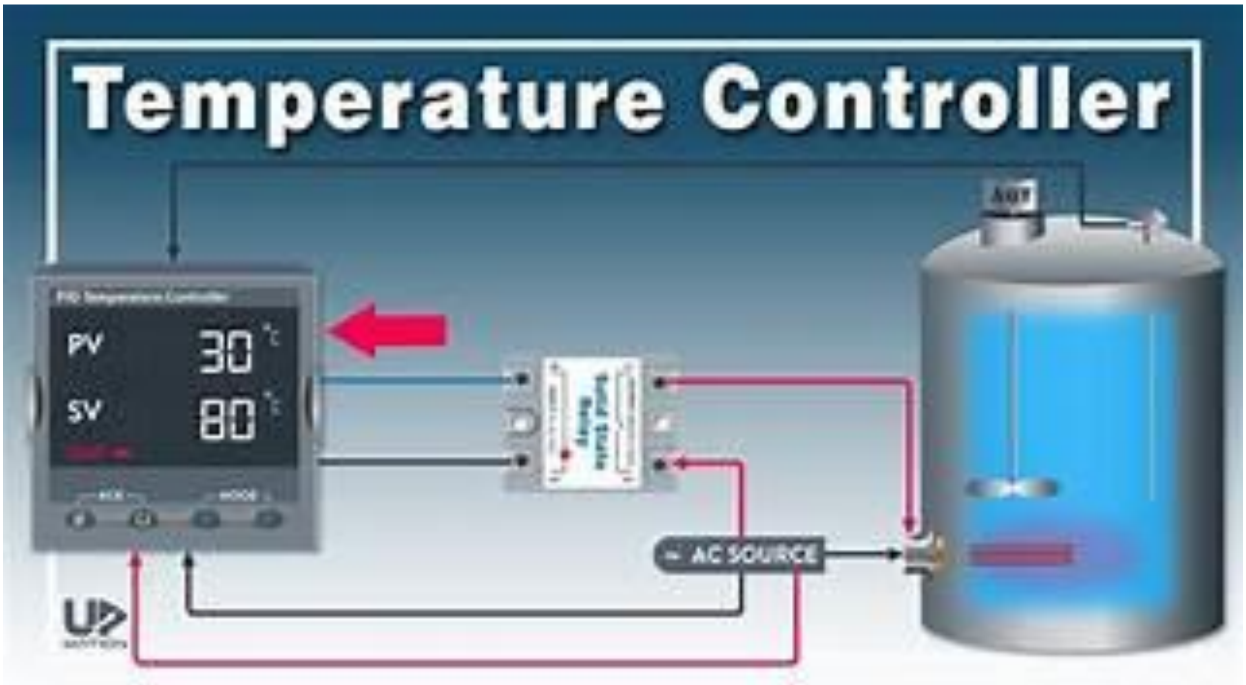
Example 3: Temperature Control in an Oven with Temperature Sensors

- **Objective:** Maintain a specific temperature range in an industrial oven.
- **Implementation:** RTD temperature sensors measure the oven's temperature. The sensors send analog signals to the PLC, which processes the data and adjusts the heating elements to maintain the desired temperature range.
- **Ladder Logic:**

scss

|----[Temperature Sensor Input]----[Temp < Low Setpoint]----(Heater On)----|

|----[Temperature Sensor Input]----[Temp > High Setpoint]----(Heater Off)----|



Example 4: Packaging Line Quality Control with Photoelectric Sensors

- **Objective:** Ensure that each package is correctly filled and sealed.
- **Implementation:** Photoelectric sensors detect the presence and position of packages, checking for correct fill levels and proper sealing. If a defect is detected, the PLC triggers a rejection mechanism to remove the faulty package from the line.
- **Ladder Logic:**

  scss
  ```
  |----[Fill Level Sensor Input]----[Correct Fill Level]----(Allow Package)----|
  |----[Seal Sensor Input]----[Correct Seal]----(Allow Package)----|
  |----[Incorrect Fill or Seal]----(Reject Package)----|
  ```

Summary

Sensors are crucial for the effective operation of automation systems, providing essential data that PLCs use to monitor and control processes. Understanding the various types of sensors and their applications allows engineers to design robust and efficient automation systems. Practical examples illustrate the integration of sensors with PLCs, demonstrating their role in achieving precise and reliable control in industrial environments.

By enabling real-time detection and response to physical changes, sensors ensure high productivity and quality in industrial processes. Whether used for simple tasks like counting products on a conveyor or complex applications such as maintaining precise temperature control, sensors play a vital role in modern automation systems.

Chapter-6

PLC Based Phase Sequence Indication and Controlling System.

Using Logic X Software
1. Introduction to the Phase sequence indication and controlling system

Project

The PLC Based Phase Sequence Indication and Controlling System is an advanced solution designed to ensure the correct phase sequence in three-phase electrical systems. In industrial applications, maintaining the proper sequence of phases is crucial for the optimal operation of equipment like motors and transformers. This system utilizes a Programmable Logic Controller (PLC) to automatically monitor and indicate the phase sequence, providing real-time feedback and control. The PLC can detect any phase reversal or imbalance, which can lead to equipment damage or operational failure. Upon detecting an incorrect phase sequence, the system can initiate corrective actions, such as shutting down the equipment or triggering alarms. This automation not only enhances safety but also reduces downtime and maintenance costs. The system is highly adaptable and can be integrated into various industrial settings, making it a vital component for electrical engineers. With its robust design and precise control capabilities, the PLC Based Phase Sequence Indication and Controlling System is an essential tool for modern industrial automation.

2. Step-by-Step Process of Designing and Programming the Elevator Using PLC

Step 1: Selection of PLC Hardware

- **Choose a PLC that meets the system's input/output requirements, processing speed, and memory capacity.**
- **Ensure the PLC has enough analog and digital inputs to monitor all phases.**

Step 2: Designing the Circuit:

- **Create a schematic of the electrical circuit, including the connections between the power source, PLC, and sensors.**
- **Design the placement of phase sequence sensors to detect the order of the phases accurately.**

Step 3 Phase Sequence Detection Logic:

- **Implement logic to determine the correct phase sequence (e.g., A-B-C).**
- **Program the PLC to detect any deviation from this sequence, such as A-C-B or B-A-C.**

Step 4: Simulation and Testing:

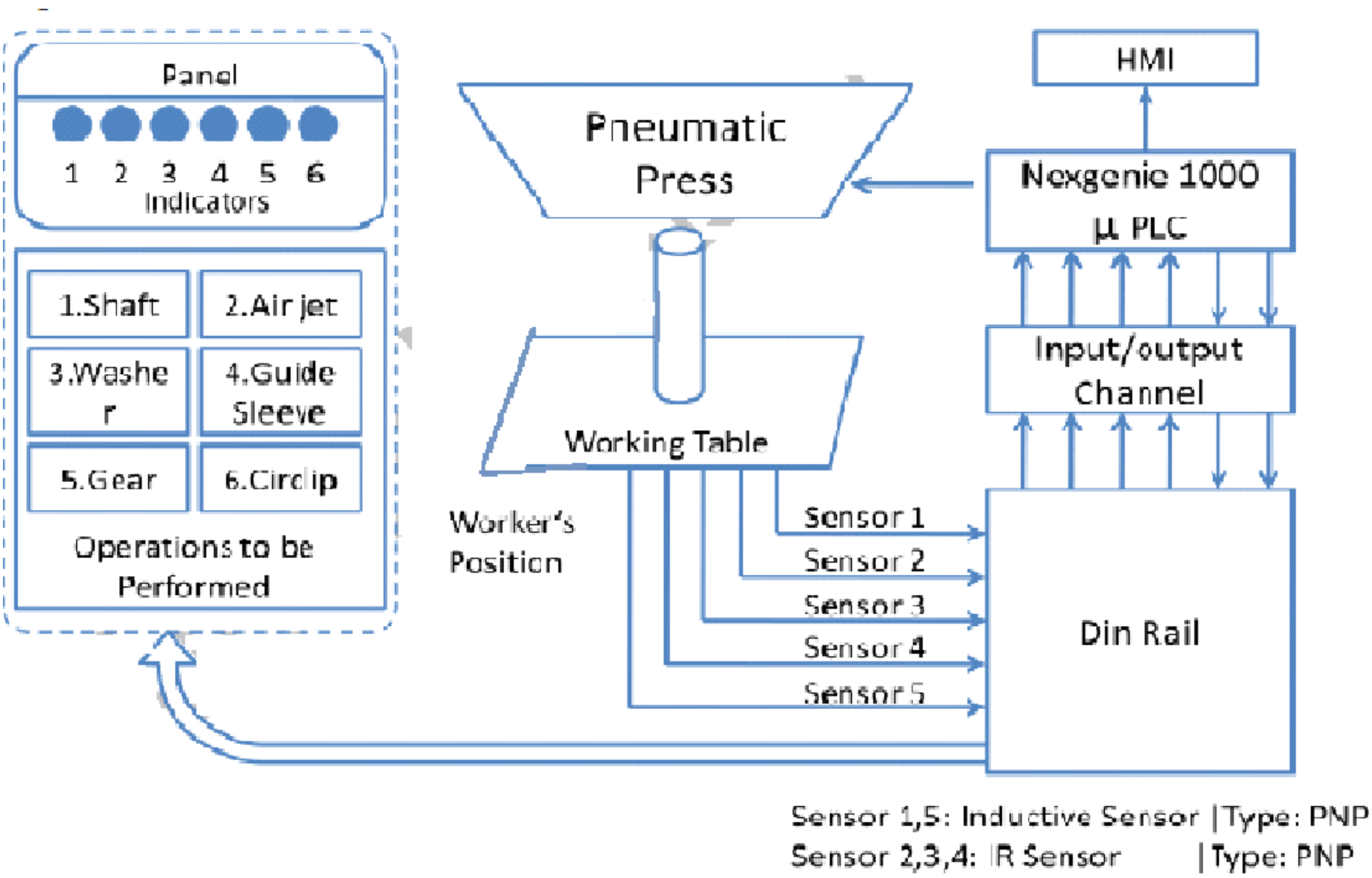
- Simulate the PLC program in a controlled environment to test the logic and control functions.
- Verify that the system correctly identifies phase sequences and responds as expected.

• About Sequence detection and monitoring system

All sequence detection and monitoring system automated using PLC (programmable logic controller). PLC atomizes the plant which not only monitor but controls sequence of operation on each stage. It controls sensors, pressing operation by using pneumatic valve .

• Input Module The input module includes the IR sensors, inductive sensor. The sensors whose output is given as an input to the PLC. The sensors kept near the input side, where the part of assembly (gear, shaft) to be inserted the conveyor, are called detection sensors .Thus, these are the inputs given to the input module.

• Signal Conditioning The output of the sensors cannot be given directly to the PLC as the input voltage to the PLC should be 24V. Hence they are given through signal conditioning circuits which condition the input signals and in turn give it as an input to the PLC.



• PLC

PLC’s are well-adapted to a range of automation tasks .All monitoring operations are done using the PLC. The entire sequence detection and monitoring process is semi automated by feeding the necessary conditions into the PLC using ladder logic. Ladder logic is one of the methods of programming a PLC. Thus, depending on the logic developed the various operations take place and the filling and capping of bottles are done. PLC consists of an I/O unit, central processing unit, and a memory unit. All logic and control operations, data transfer and data manipulation operations are done by the central processing unit. The results and statuses are stored in the memory of the PLC.

• Pneumatic Valve

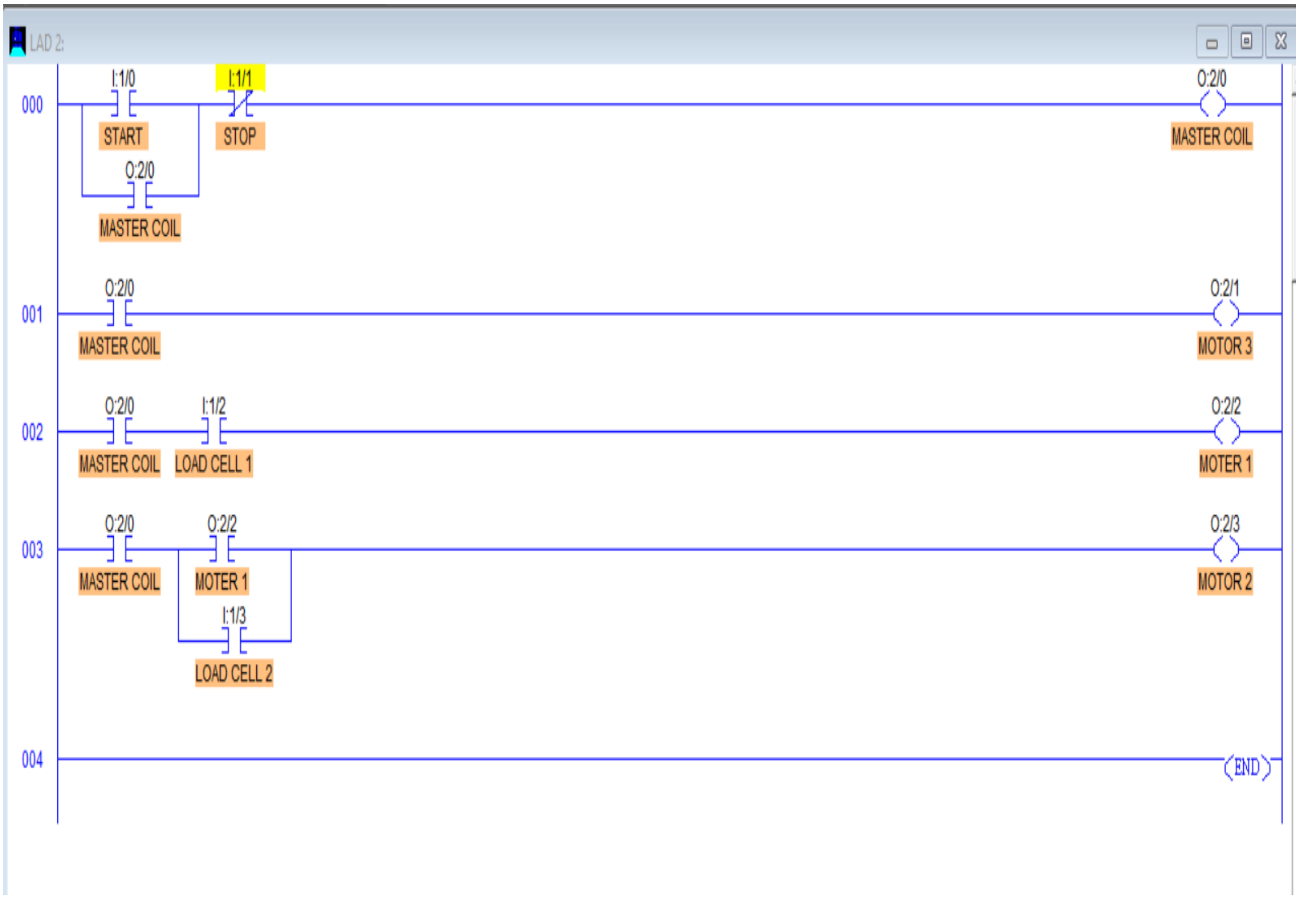
The Pneumatic Valve operated when it get signal from PLC to press the circlip. It mainly used to pressing operation

• Output Module

The indicator is used as output devices in the sequence detection and monitoring process .Different assembly parts like gear shaft are inserted sequentially depending on input process. This completes the sequence detection and monitoring process as we want

The worker has to insert various elements such as washers, bearings, various gears, guide sleeves, etc as per the predefined sequence. The sequence of operation to be performed is as per the list given above. The system even can recognize the position of the gear when all process is done successfully then signal send to press to insert circlip. The heart of the system is PLC, which controls the operation of the system. Various sensors such as IR proximity sensors, inductive proximity sensors are connected to sense the parameters then to the PLC. In this system we are going to use Mitsubishi‘s Nexgenie 1000 µ PLC having along with associated circuitry i.e. (power supply, connecting wires, indicators etc).

LADDER DIAGRAM:



About The Project

A PLC (Programmable Logic Controller)-based Phase Sequence Indication and Controlling System is an advanced approach to monitoring and controlling the phase sequence in three-phase power systems. Unlike traditional systems that rely on relays and indicator lights, this system uses a PLC for more precise control, automation, and flexibility.

Purpose and Importance

The primary purpose of a PLC-based phase sequence system is to:

Automate the Detection Process: Automatically monitor and detect the phase sequence.

Provide Real-Time Feedback: Offer real-time indications and alerts through the PLC's interface.

Implement Advanced Control Logic: Use the PLC to implement more complex control actions, such as automatic correction of phase sequence or integration with other automated systems.

Components of the PLC-Based System

A PLC-based phase sequence system typically includes:

PLC Unit: The brain of the system, programmed to monitor the phase sequence, process inputs, and control outputs.

Phase Sequence Detector: A sensor or module connected to the PLC that detects the phase order.

HMI (Human-Machine Interface): Provides a user-friendly interface for monitoring the system status and controlling actions.

Output Devices: Such as alarms, indicator lights, or actuators that respond to the PLC's commands.

Communication Interfaces: To connect the PLC with other systems or remote monitoring units.

How It Works

Phase Sequence Detection

Phase Sequence Detector: The detector monitors the incoming three-phase supply and sends data about the phase sequence to the PLC.

PLC Input Processing: The PLC receives the phase sequence information as input signals. The logic programmed into the PLC then determines whether the sequence is correct or incorrect.

How It Works

The Phase Sequence Indication and Controlling System operates through a series of steps designed to monitor, indicate, and control the phase sequence of a three-phase power supply. Here's a detailed breakdown of its working:

Phase Sequence Detection

Phase Sequence Relay: The core component is the phase sequence relay, which is designed to detect the order of the phases (L1, L2, L3). It monitors the electrical supply and identifies whether the phase sequence is correct (clockwise) or incorrect (counterclockwise).

Phase Voltage Monitoring:The relay continuously checks the voltages of each phase. It compares these voltages to determine the sequence and identify any abnormalities, such as phase reversal or phase loss.

Indication

Visual Indicators: The system typically includes indicator lights or digital displays that show the status of the phase sequence. For instance:

Green Light: Indicates the correct phase sequence.

Red Light: Indicates an incorrect phase sequence.

Alarm Systems: In advanced systems, an audible alarm may be triggered if an incorrect sequence is detected, alerting operators to take corrective action.

Controlling Mechanism

Automatic Control: Upon detecting an incorrect phase sequence, the system can automatically take corrective action. This may include:

Shutting Down Equipment: To prevent damage, the system may turn off motors, transformers, or other connected equipment.

Switching Phases: In some systems, relays may automatically swap the phases to correct the sequence.

Manual Override: Operators may also have the option to manually intervene and correct the phase sequence using control switches or buttons.

Feedback Loop

Continuous Monitoring: The system continues to monitor the phase sequence even after corrective actions are taken. This ensures ongoing protection and operational safety.

System Reset: Once the phase sequence is corrected, the system resets, allowing the equipment to resume normal operation.

• Input Module

The input module includes the IR sensors, inductive sensor. The sensors whose output is given as an input to the PLC. The sensors kept near the input side, where the part of assembly (gear, shaft) to be inserted the conveyor, are called detection sensors .Thus, these are the inputs given to the input module.

• Signal Conditioning

The output of the sensors cannot be given directly to the PLC as the input voltage to the PLC should be 24V. Hence they are given through signal conditioning circuits which condition the input signals and in turn give it as an input to the PLC

• Output Module

The indicator is used as output devices in the sequence detection and monitoring process . Different assembly parts like gear shaft are inserted sequentially depending on input process. This completes the sequence detection and monitoring process as we want. Sample Ladder Logic Snippets:

PLC Program

Here is PLC program to Control the Sequence of Conveyors and Interlocking Them, along with program explanation and run time test cases.

List of Inputs and Outputs

I:1/0 = Start (Input)

I:1/1 = Stop (Input)

I:1/2 = Load cell (Input)

I:1/3 = Load cell (Input)

O:2/0 = Latching Coil (Output)

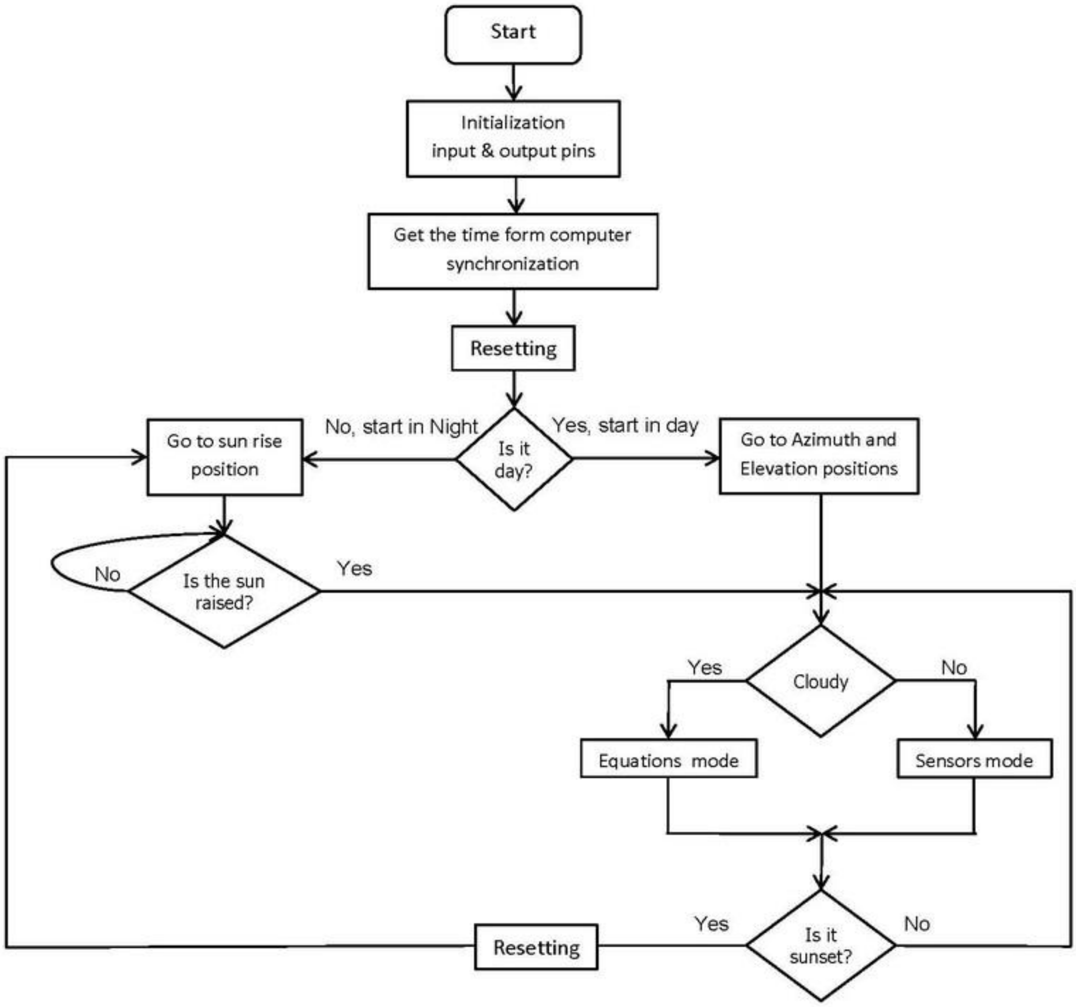
O:2/1 = Motor 3 (feeder) (Output)

O:2/2 = Motor 1 (Output)

O:2/3 = Motor 2 (Output)

Program Description

- RUNG000 is for Master Start/Stop the process.
- RUNG001 is to operate feeder with output address O:2/0 which is operated when Start PB is pressed.
- RUNG002 is to operate Motor 1 of Conveyor 1 which is operated when Load cell 1 detects the presence of material. As long as material is on the conveyor, Motor 1 remains energized.
- RUNG003 is to operate Motor 2 of Conveyor 2 O:2/3 which is operated whenever Motor 1 is ON AND/OR as long as material is presence on the conveyor 2 which is detected by Load cell 2 (I:1/3).



TESTING AND TROUBLESHOOTING:

A PLC-based phase sequence indication and controlling system involves several key steps. Begin by verifying that all wiring and power connections are correct, including inputs for phase detection (X0, X1, X2) and outputs (Y0, Y1, Y2). Ensure the reset button (X3) functions properly.

Start by applying the correct phase sequence (A → B → C). If the sequence is correct, Y0 should activate, Y1 should remain off, and the contactor (Y2) should engage. Next, test an incorrect sequence, like B → A → C, where Y1 should turn on, indicating a fault, while Y0 and Y2 remain off. Test for missing phases, such as leaving Phase B unconnected. In this case, Y1 should activate, and Y0 and Y2 should stay off.

Test the reset function by introducing a fault and pressing the reset button. Y1 should turn off, and the system should reset. If Y0 doesn't activate or Y1 is always on, check wiring and phase sequence order, ensuring the ladder logic is functioning correctly. Address any issues by inspecting the program and connections to ensure proper operation.

Summary

A PLC-based phase sequence indication and controlling system is designed to ensure the correct order of three-phase electrical supply, which is crucial for the proper operation of industrial equipment. The system uses a Programmable Logic Controller (PLC) as the central unit to monitor and control the phase sequence. A phase sequence detector continuously checks the order of the three phases (R, Y, B) and sends this data to the PLC. The PLC then processes this information to verify if the phase sequence is correct. If the sequence is correct, the PLC allows the power to flow to the equipment through relays or contactors. In the event of a phase reversal or fault, the PLC immediately activates the relays to disconnect the load, preventing potential damage. This setup enhances operational safety by ensuring that machinery operates under the correct phase conditions, reducing the risk of damage and improving overall reliability in industrial settings. An optional Human-Machine Interface (HMI) can be added to provide users with real-time status updates and system alerts, making it easier to monitor and manage the phase sequence.

Final Chapter - CONCLUSION AND FUTURE PERSPECTIVE

Summary

The PLC-based phase sequence indication and controlling system is a sophisticated solution designed to manage and safeguard the operation of three-phase electrical systems in industrial environments. At its core, the system integrates a Programmable Logic Controller (PLC), which acts as the central processing unit, to monitor the sequence of electrical phases and ensure they are in the correct order. The system incorporates a phase sequence detector that continuously assesses the order of the three phases—typically denoted as R (Red), Y (Yellow), and B (Blue)—and feeds this information to the PLC.

The PLC processes the phase sequence data and determines whether the order of the phases is correct. If the phase sequence is correct, the PLC allows the power to flow to connected machinery by activating relays or contactors. This ensures that equipment operates under optimal conditions and reduces the risk of malfunction or damage. In cases where the PLC detects a phase reversal or other sequence faults, it immediately engages the relays to disconnect the load, thereby preventing potential damage to the equipment and ensuring safety.

Key Takeaways and Lessons Learned

1. **Understanding of Industrial Automation:** The project reinforced the importance and applications of industrial automation across various industries, showcasing how PLCs are integral to modern automation systems.
2. **PLC Fundamentals:** Detailed exploration of PLC components, block diagrams, and their interactions provided a solid understanding of how PLCs function and their role in controlling industrial processes.
3. **Timers and Counters:** Practical examples of timers and counters illustrated how these essential elements are used in PLC programming to manage time-based and count-based operations.
4. **Sensors in Automation:** Learning about different types of sensors and their integration with PLCs emphasized the importance of accurate data acquisition and control in automated systems.
5. In the future, the phase sequence indication and controlling system will continue to play a crucial role in enhancing the reliability and safety of industrial electrical systems. As industries increasingly adopt automation and advanced technologies, the need for precise control and monitoring of electrical supply will grow.

Potential Improvements and Future Developments in PLC and Automation

1. **Enhanced Connectivity:** Future PLC systems are likely to incorporate advanced connectivity options, such as IoT (Internet of Things) integration, allowing for seamless communication between devices and centralized control systems.
2. **Improved User Interfaces:** Development of more intuitive and user-friendly interfaces for PLC programming and monitoring can reduce complexity and enhance productivity.
3. **Advanced Algorithms:** Implementing more sophisticated algorithms, such as machine learning and artificial intelligence, can enable PLCs to adapt to changing conditions and optimize performance autonomously.
4. **Energy Efficiency:** Future developments may focus on optimizing PLC systems for energy efficiency, reducing operational costs, and minimizing environmental impact.
5. **Safety and Security:** Enhancing safety features and cybersecurity measures will be crucial to protect automated systems from failures and cyber threats.

Impact of Automation on Future Industries

1. **Increased Productivity:** Automation will continue to drive productivity gains in manufacturing and other industries by streamlining processes and reducing human error.
2. **Job Transformation:** While some jobs may be displaced by automation, new roles will emerge that require advanced technical skills to manage and maintain automated systems.
3. **Quality Improvement:** Automation ensures consistent quality and precision in production processes, leading to higher standards and reduced defects.
4. **Cost Reduction:** Automated systems can lower operational costs by reducing labor requirements and increasing efficiency, making businesses more competitive.

5. **Innovation and Growth:** The integration of advanced automation technologies will spur innovation, enabling companies to develop new products and services and expand into new markets.

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