Investing in rural people

Industrial Automation

45 Hours Training Program - TEVT Sector

Teaching - Learning Material

Project Implementation Unit

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1. Introduction

Across all manufacturing sectors, industrial automation with Programmable Logic Controllers (PLCs) is essential for increasing efficiency, productivity, and dependability. Technically minded people who want to obtain practical experience with PLC-based industrial control systems—ideally with an electrical or electronic background—are the target audience for this rigorous training. Through scenario-based tasks, simulation exercises, and hands-on experience, this training program focuses on core competencies that are in line with the demands of contemporary industries. It equips participants for automation and control roles in the real world.

2. Training Objectives

1. Comprehend the fundamental principles of Programmable Logic Controllers (PLCs), including their architecture, components, and role in industrial automation across manufacturing, processing, and utility sectors.
2. Develop practical skills in ladder logic programming, I/O interfacing, HMI integration, and troubleshooting through hands-on tasks, real-world simulations, and small-scale industrial project implementation.
3. Design safe and effective automation solutions by applying technical knowledge alongside soft skills such as workplace safety, industrial ethics, job search strategies, and entrepreneurial fundamentals relevant to the automation industry.

3. Training Learning Outcomes (TLOs)

TLO 1: Understand the purpose and applications of various switches, pushbuttons, fuses and circuit breakers, relays, contactors, timers, counters, sensors, transducers, etc.

TLO 2: Understand PLC, its parts, and the various kinds of PLC-based devices and their uses. basics of ladder logic diagrams and convert logic implementation into PLC code.

4. Assessment Structure

Component	Marks	Passing Criteria
Theory (MCQs + Short Questions)	30	50% (15 marks)
Practical (Capstone + Presentation)	70	60% (42 marks)
Total	100	To be eligible for the Certificate of Competency in Industrial Automation, trainees must maintain at least 75% attendance and successfully pass both the theory and practical components of the assessment.

5. Training Module and Delivery Plan:

Total Training Hours	45 Hours
Training Methodology	**Theory**: 9 Hours (20%) **Practical**: 36 Hours (80%)
Medium of Instruction & Assessment	English & Urdu

6. Who Should Enroll?

- DAE (Electrical/Electronic),
- BTech, or Technical Diploma Holders
- Technicians looking to upskill into automation role

1. Trainer Qualification Level

Criteria	Details
Mandatory Education	DAE (Diploma of Associate Engineer) in Electrical / Electronics / Mechatronics.
Mandatory Certification	Proficiency in PLC programming (Siemens S7-1200 preferred) Hands-on experience with ladder logic & automation systems
Mandatory Experience	Minimum 3 years of industrial automation or control panel experience Practical training experience (workshop/lab)

2. Job Opportunities

Graduates can pursue roles such as:

1. PLC/SCADA Technician
2. Maintenance Electrician – Automation
3. Automation Assistant Engineer
4. Control Panel Technician
5. Freelance PLC Programmer
6. Manufacturing (textile, food, cement)
7. Pharmaceuticals
8. Packaging Utilities and Power Sector

3. Recommended Books

1. Industrial Automation: Hands-On by Frank Lamb (1st Edition, 2013)
2. Handbook of Industrial Automation, edited by Richard L. Shell (1st Edition, 2000)
3. PLC and HMI Development with Siemens TIA Portal by Nathan Clark (1st Edition, 2019)

Module 1: Introduction To Digital Logic Design

Module Objective

Understand the digital logic implementation

Basics

1.1 Introduction

Digital electronics and logic design provide the foundation for all modern computing systems, enabling devices to process and store information in binary form. Digital electronics and logic design are the foundation of modern computing systems, controlling everything from smartphones to advanced computers. Digital electronics focuses on circuits that process binary data (0s and 1s). Digital signal is use to storing, processing and communicating information in term of digital form. In digital signal we used discrete steps to represent values and these values are change in discrete time intervals. We also measure the amplitude and time in discrete steps. The digital signal is used in audio, images and speech (signal processing) etc. and also in computing communication and data storage, among others. Now a day almost all electronic systems are partially or totally digital based. All real word signals are analog but machines only understand the digital signal. The ability to produce larger and complex system economically makes them excellent for processing and storing information (data).

1.2 Binary Number System Review of Arithmetic Operations with Binary

A binary number system is one of the four types of number system. In computer applications, where binary numbers are represented by only two symbols or digits, i.e. 0 (zero) and 1(one).

The binary numbers here are expressed in the base-2 numeral system. For example, (101)2 is a binary number. Each digit in this system is said to be a bit. Learn about the number system here.

Binary Number System: According to digital electronics and mathematics, a binary number is defined as a number that is expressed in the binary system or base 2 numeral system. It describes numeric values by two separate symbols; 1 (one) and 0 (zero). The base-2 system is the positional notation with 2 as a radix. The binary system is applied internally by almost all latest computers and computer-based devices because of its direct implementation in electronic circuits using logic gates. Every digit is referred to as a **bit**.

1.3 Logic Gates (Symbol, Truth Table, etc.) Boolean Algebra Basics

Logic gates are the fundamental building blocks in digital electronics.

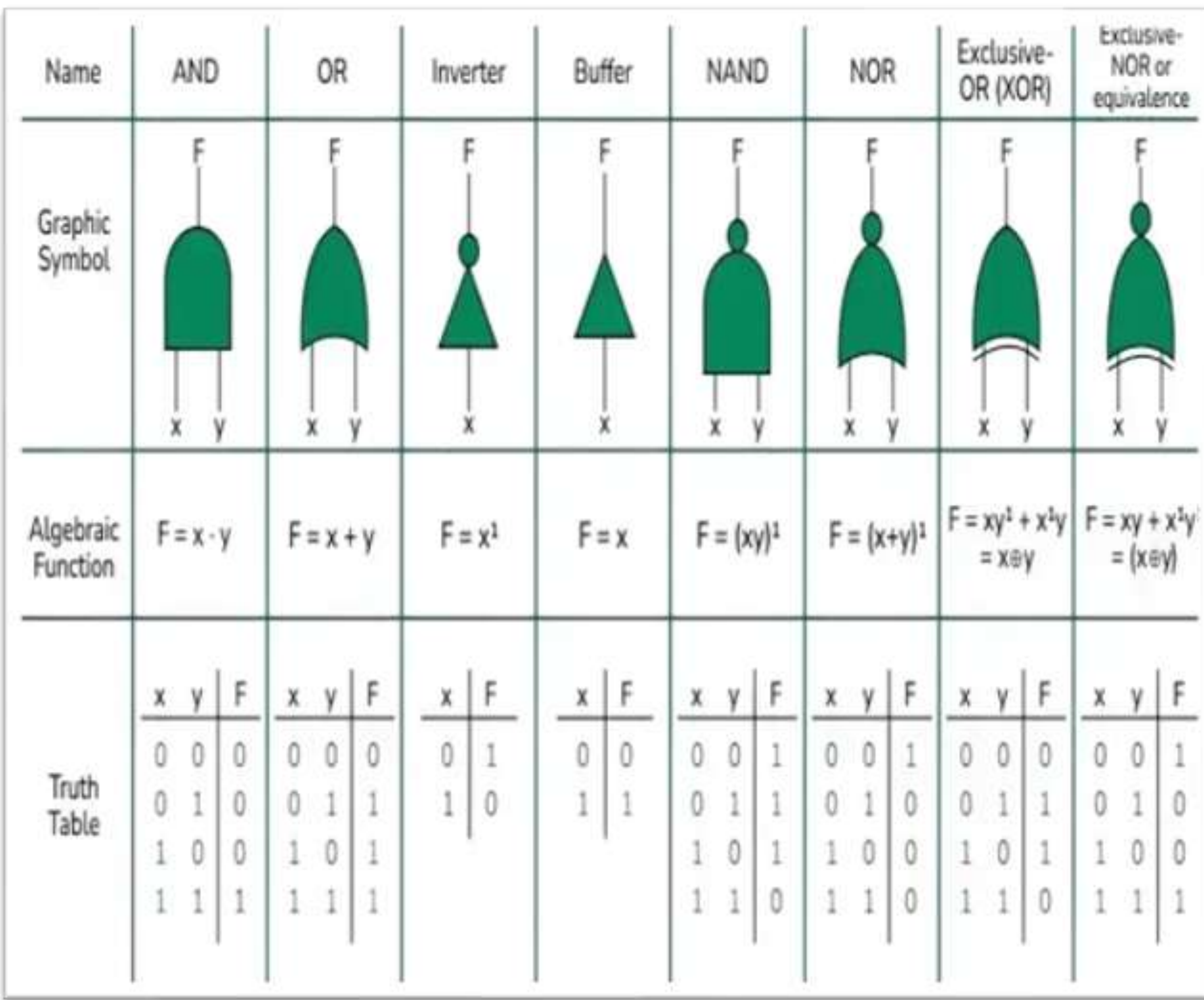
Used to perform logical operations based on the inputs provided to it and gives a logical output that can be either high (1) or low (0).

The operation of logic gates is based on Boolean algebra, or mathematics.

There are basically seven main types of logic gates that are used to perform various logical operations in digital systems.

By combining different logic gates, complex operations are performed, and circuits like flip-flops, counters, and processors are designed. In this article, we will see various types of logic gates in detail.

Logic gates find their uses in our day-to-day lives, such as in the architecture of our telephones, laptops, tablets and memory devices.



Name	AND	OR	Inverter	Buffer	NAND	NOR	Exclusive-OR (XOR)	Exclusive-NOR or equivalence
Graphic Symbol	F, x, y	F, x, y	F, x	F, x	F, x, y	F, x, y	F, x, y	F, x, y
Algebraic Function	$F = x \cdot y$	$F = x + y$	$F = x^1$	$F = x$	$F = (xy)^1$	$F = (x+y)^1$	$F = xy^1 + x^1y = x \oplus y$	$F = xy + x^1y^1 = (x \oplus y)^1$
Truth Table	x y | F 0 0 | 0 0 1 | 0 1 0 | 0 1 1 | 1	x y | F 0 0 | 0 0 1 | 1 1 0 | 1 1 1 | 1	x | F 0 | 1 1 | 0	x | F 0 | 0 1 | 1	x y | F 0 0 | 1 0 1 | 1 1 0 | 1 1 1 | 0	x y | F 0 0 | 1 0 1 | 0 1 0 | 0 1 1 | 0	x y | F 0 0 | 0 0 1 | 1 1 0 | 1 1 1 | 0	x y | F 0 0 | 1 0 1 | 0 1 0 | 0 1 1 | 1

1.4 Understanding Fuses and Circuit Breakers and Their Importance.

Fuses:

A fuse is an electrical safety device that contains a metal filament or strip that melts and breaks a circuit to protect against excessive current, such as from a short circuit or overload. Fuses are primarily categorized by the type of current they are used in (AC or DC) and by their speed of

response (fast-acting, slow-acting, or ultra-rapid). Common types include cartridge fuses, high rupturing capacity (HRC) fuses, and automotive blade fuse.

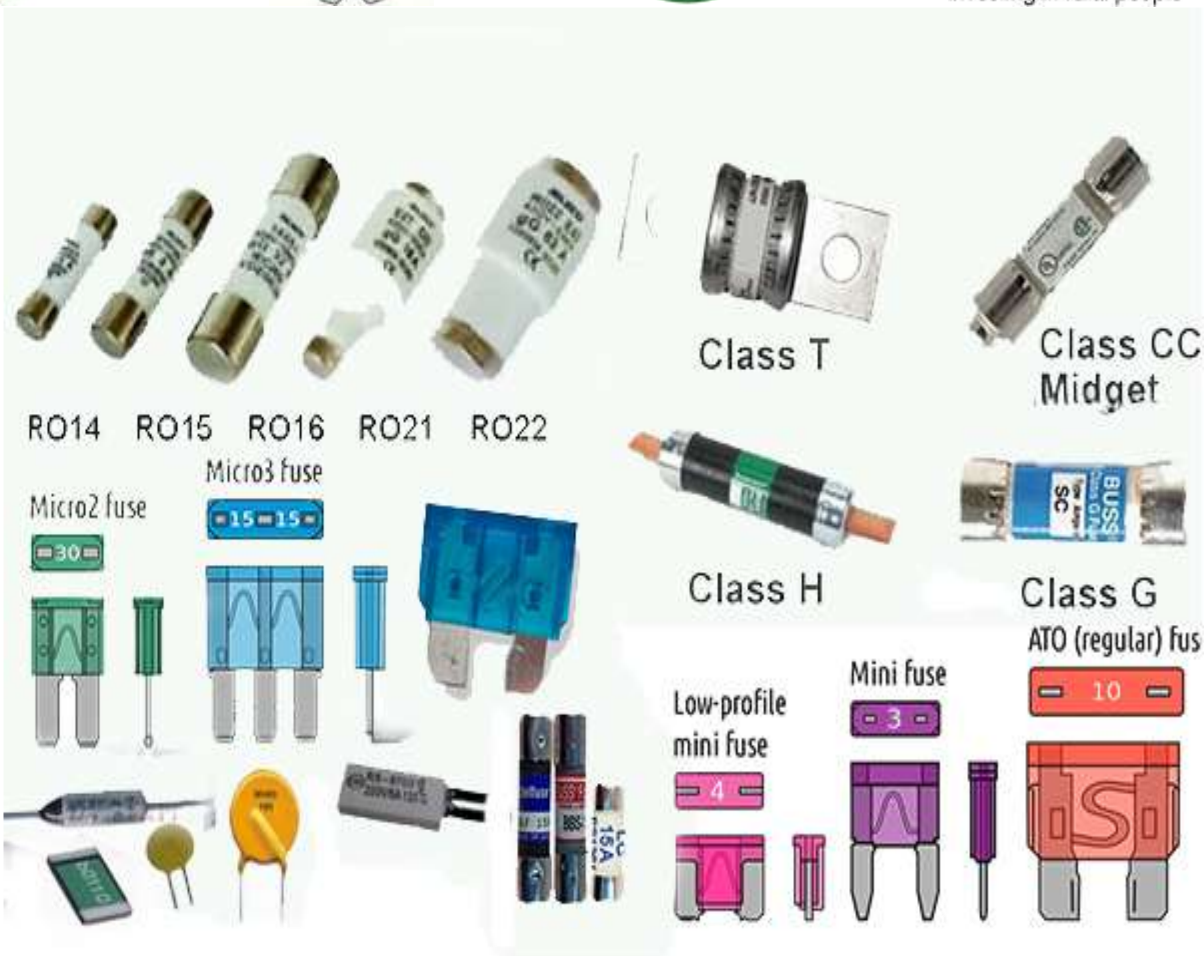
Types of fuses

Fuses can be categorized in several ways:

AC Fuses: Used for alternating current circuits, often for higher voltages.

DC Fuses: Used for direct current circuits.

Circuit Breakers and Their Importance.



1.5 Exploring Different Types of Switches and their Uses

Switch

An electric switch is a device that controls the flow of electricity by either opening or closing an electrical circuit to turn a device on or off. It acts as a simple on/off controller for electrical devices by physically connecting or disconnecting the conductive path, which allows or stops the flow of current.

How it works

Open state:

When a switch is open, it creates a break in the circuit, stopping the flow of electricity and keeping the connected device off.

Closed state:

When a switch is closed, it completes the circuit, allowing electricity to flow and turn the device on.

Contacts:

At its core, a switch uses electrical contacts. When the switch is operated, these contacts are either pushed together to make a connection or pulled apart to break it.

Types:

Switches come in many varieties, from simple toggle switches used in homes to more complex electronic and mechanical switches used in industry and other applications.

1.6 Function and Applications of Push Buttons in Electrical Systems.

Push buttons act as momentary switches that complete or break an electrical circuit when pressed, and they are used to control and operate electrical systems. Their primary function is to turn

devices on/off, select functions, activate signals, or serve as safety/emergency stops. They are found in numerous applications, from home appliances and computers to heavy industrial machinery and medical equipment.

Function of push buttons

Control and operation: They are used to start, stop, or control the operation of electrical devices.

Power on/off: One of their main uses is to control the flow of power to a device.

Function selection: They allow users to select different modes or functions in a system, such as changing settings on a microwave or a computer.

Signal activation: They are used to trigger specific actions or send signals within a system.

Reset or clear: Many push buttons are designed to reset a system or device to a default state.

Safety and emergency stops: They are crucial for safety, allowing for the quick activation of emergency shut-off procedures on heavy machinery.

User interface: They provide a simple, intuitive, and tactile way for a user to interact with a device or system.

1.7 Relay: Construction, Operation/Working Principle, Types, and Applications.

Relay

A relay is an electrically operated switch that uses a small control current to switch a separate, higher-power circuit on or off. Construction typically involves an electromagnet, a movable armature, and contacts. When the coil is energized, it creates a magnetic field that pulls the

armature, which moves the contacts to complete the secondary circuit; a spring returns the armature and breaks the circuit when the coil is de-energized. Relays are used in applications like motor protection, industrial automation, and for isolating control systems from high-power loads.

Construction

Coil: A wire coil wound around an iron core that becomes an electromagnet when current flows through it.

Armature: A small, movable metal component pivoted to move when attracted by the electromagnet.

Contacts: Conductors that are physically connected to the armature. They open or close the secondary circuit.

Spring: A spring that holds the armature in its resting position and pulls it back to open the contacts when the coil is de-energized.

Housing and Terminals: The physical casing and the connection points for the control (coil) and load (contacts) circuits.

Operation/Working Principle

Energizing: A small control current flows through the coil, creating a magnetic field.

1. **Activation:** The magnetic field attracts the armature, pulling it toward the electromagnet.
2. **Switching:** The movement of the armature causes the contacts to move.

Normally Open (NO): The contacts, which are initially open, are closed to complete the load circuit.

Normally Closed (NC): The contacts, which are initially closed, are opened to break the load circuit.

De-energizing: When the control current is cut off, the magnetic field collapses, and the spring pulls the armature back to its original position, breaking the connection in the load circuit.

Contractor

A contactor is one of the main electrical circuit parts, which can stand on its own power control device or a part of a starter. They are used to connect and break power supply lines running through power lines or repeatedly establish and interrupt electrical power circuits. These are used in light loads, complex machine control. They are used with motors, transformers, heaters. It can be considered as an intersection point between the control circuit and power circuit because it is controlled by the control circuit, it also controls the circuit between power and loads. This article focuses on the importance of contactor in and electric field.

Construction of a Contactor

The contactor consists of two iron cores, where one is fixed and the other one is the movable coil and it is an insulated copper coil. Where the copper coil is located on the fixed core. There are six main contacts for power connection, where three are fixed cores and the other three are movable cores. These contacts are made from pure copper, and the contact points are made from special alloy to withstand high starting current and temperature. A spring which is located between coil and the movable core, auxiliary contacts it could be normally open or closed. The main contacts cut on and off the light current loads such as contactors coil, relays, timers, and many other control circuit parts are linked to contact mechanism.

It consists of three main parts they are

Coil

It provides a force which is required to close the contact. The coil is also named as an electromagnet. An enclosure is used to safeguard the coil and contactor.

Enclosure

It acts like an insulator and protector, which protects the circuit form any electrical contact, dust, oil, etc. They are made up of different materials like Nylon 6, Bakelite, Thermosetting plastic, etc.

Contacts

The main function of this is that it carries the current to various parts of the circuit. There are classified into contact springs, axillary contacts, and power contacts. Where each of the contacts has its own functions, which is explained in principle of operation of the contactor.

Types of Contactors

These are classified based on three factors they are

1. The load being used
2. The current capacity and
3. The power rating.

1.9 Introduction to Indicators and Their Significance.

Indicators are observable and measurable factors used to provide evidence of change, progress, or performance in a system. They are essential for monitoring and evaluation, allowing for comparisons over time or across different groups and helping to assess whether goals are being met. The significance of indicators lies in their ability to simplify complex information, track

progress, ensure accountability, and guide decision-making. They can be either quantitative (numerical data) or qualitative (descriptive data).

Significance of indicators

Monitoring and evaluation: They are central to monitoring and evaluation systems, helping to assess progress, determine success, and provide evidence of change.

Accountability: Indicators allow for open scrutiny by holding individuals, teams, and organizations accountable to stakeholders, such as the government or the public.

Performance assessment: They are used to monitor how a system is performing against an agreed-upon standard, helping to identify areas for improvement.

Decision-making: By simplifying complex information, indicators provide evidence to inform decisions and actions, guiding the direction for addressing problems.

Comparison: They provide standardized measures that allow for comparisons over time, across geographic areas, or between different programs.

Module 2: Introduction to Industrial automation.

Module Objective

Learn a knowledge about industrial automation and application and implementation

Basic

Introduction

Industrial Automation is the use of control systems, including machines, actuators, sensors, processors, and networks to perform tasks, with the goal of automating production.

The history of industrial automation started with simple conveyor belts pulling parts through an assembly line. Machines performed basic tasks and work that reduced manual labor. Today, industrial automation is a wide range of machines, actuators, sensors, processors, and networks that work to connect an industrial environment. From PLCs, AI, Machine Learning, and IIoT devices, modern industrial automation is focusing on the best way to leverage technology. The following will introduce industrial automation, its types, and its benefits that are leading global industries, expanding markets, and evolving competition.

Types of Industrial Automation Systems

Ranging from a conveyor belt to advanced AI and Machine Learning systems, it is important to understand the types of industrial automation to pinpoint where each technology will find the greatest benefit. Not every solution or trend will fit your application or goals.

Fixed Automation

Fixed automation often has a set task, continuous workflow, large volume production, and a high barrier of entry. Also called hard automation, this type of industrial automation rarely sees changes.

The expense and time associated with a new product or changes in production are high. For lower volume or shorter product life cycles, programmable industrial automation will yield greater benefits.

Programmable Automation

Often associated with batch production, programmable automation works well for making several dozens to thousands of units. The lower production volume results in more changeovers which are considered when determining batch sizes and lead times. However, many companies are concerned with improving uptimes and increasing production. These goals are leading to more flexible automation.

The Benefits of Industrial Automation

There are several advantages of industrial automation with manufacturers, OEMs, and industrial operations can leverage to increase operational efficiency.

Monitoring provides data to make sure new automated solutions meet goals. If production data exists in silos, it will be difficult to find how to integrate automation solutions. Data from all assets will yield the greatest benefits. To keep data from becoming a liability, find IIoT and monitoring devices that offer built in security. Encryption, gateway protection, and Cloud services are some of the features that act like security guards to keep your assets protected. With security in mind, consider which of the following benefits might provide the greatest value to your application.

Improve Worker Safety

To start, industrial automation can help free workers from dull, dangerous, and dirty tasks. Industrial automation can reduce injuries associated with repetitive motion and lifting objects to create a safer work environment. This initial benefit can make a worker day-to-day better while freeing them for more complex tasks.

Increase Productivity

Downtime, performance problems, and bottlenecks all slow down production. Using monitoring and automated devices communicating across a single platform these problems can be found and mitigated before production slows. Downtime and performance problems can be reduced or eliminated through data that offers predictive maintenance. Real-time information is able to find root causes of problems, regulate inventory, and monitor production speeds so adjustments can happen before bottlenecks occur.

Higher Quality

Connected automation devices offer greater repeatability, higher fidelity, data collection from almost anywhere in a production line, and send notifications to anyone with access. Catching changes in quality early can improve production, reduce waste, cut down on rework, and increase profit. Additionally, automation devices able to verify and validate quality can improve transparency and ensure parts produced meet a customer's requirements before leaving the factory floor.

Better Decision Making

As more devices are connected and controlled with industrial automation tools, managers will be able to generate more accurate models to find new revenue streams and provide better estimates to build stronger relationships with stakeholders. Industrial automation technology can increase the ability to monitor and control multiple locations remotely for a holistic solution that can streamline supply chain management, track assets in the field, and provide data to make more informed decisions.

2.1 **Definition, History, Types, PLC Configuration: Overview of how PLCs are set up, Sizes, & Brands of PLCs.**

A **Programmable Logic Controller (PLC)** is a rugged, specialized digital computer used to automate industrial electromechanical processes such as controlling machinery on assembly lines, in manufacturing plants, and in power systems. PLCs monitor inputs from sensors and switches, process the information based on a pre-programmed logic, and then control outputs like motors, valves, and lights.

History

Before PLCs, industrial automation relied on hard-wired relay logic systems, which were complex, difficult to maintain, and required extensive rewiring to make changes.

1968: General Motors developed a specification for a "Standard Machine Controller" to replace unreliable relay systems.

1969: Dick Morley, working for Modicon (MODular Digital CONtroller), invented the first operational PLC, the Modicon 084.

1970s-1980s: PLCs became faster, more powerful, and programming methods evolved. The advent of personal computers in the 1980s allowed for easier programming and documentation using PC-based software.

1993: The International Electrotechnical Commission (IEC) released the IEC 61131-3 standard, which brought consistency to PLC programming languages across different manufacturers.

Types of PLCs

PLCs are classified based on their hardware design and size/I/O capacity.

By Hardware Structure

Compact (Fixed) PLC: All components (CPU, power supply, I/O) are integrated into a single, fixed enclosure.

Advantages: Cost-effective for small applications and simpler to install.

Limitations: Limited expansion and difficult to repair or modify, as I/O points are fixed by the manufacturer.

Modular PLC: Composed of separate, interchangeable modules that fit into a chassis or rack.

Advantages: Highly flexible, scalable (can add or remove I/O, communication modules, etc., as needed), and easier to maintain and troubleshoot by swapping individual modules.

Limitations: Higher initial cost and larger size than compact PLCs.

By Size (Typically within the Modular Category)

Nano PLC: Very small with less than 15 I/O points, typically used in embedded systems or very small, simple machines.

Micro PLC: Handles small to medium applications with 15 to 128 I/O points.

Medium PLC: Common in most industries, handling hundreds of I/O points for mid-sized production lines and offering more communication options.

Large PLC: Used for complex control functions in large plants or SCADA systems, with thousands of I/O points, high memory capacity, and advanced processing capabilities.

Brands of PLCs

Several major brands manufacture PLCs, each with its own product lines and software ecosystems:

Rockwell Automation (Allen-Bradley): A market leader, especially popular in North America.

Siemens: Widely used globally, known for its SIMATIC family of products.

Mitsubishi Electric: Prominent in agricultural automation and other sectors, especially in Asia.

Omron: Offers a wide range of reliable automation solutions.

Schneider Electric (Modicon): A historical pioneer in the PLC market.

Hitachi, Bosch, General Electric (GE): Other significant manufacturers in the industrial automation space.

2.2: Definition and scope of industrial automation

The scope of industrial automation is to use technology to control and monitor industrial processes, which leads to increased productivity, quality, and safety. It involves applying a wide range of technologies like PLCs, SCADA systems, and robotics to replace manual labor, resulting in greater efficiency and lower costs. The scope extends across all industries to optimize manufacturing, material handling, and quality control, with its applications continuously expanding due to advancements in software, robotics, and digital integration.

2.3: Types of automation systems (fixed, programmable, flexible).

2.3.1 Fixed Automation

This system is designed for a single, specific task and is not easily changed. It is engineered for consistency and is ideal for high-volume production of identical products.

Example: An assembly line for producing one model of a car body or bottling beverages.

2.3.2 Programmable Automation

This type can be reconfigured to switch between different products or tasks. It involves programming new sequences of instructions for different batches, making it suitable for moderate production volumes with product variations.

Example: A production line that switches between making different versions of the same part.

2.3.3 Flexible Automation

This is an agile system that can handle a wide range of tasks with minimal downtime. It is often exemplified by robotic arms that can be reprogrammed for various jobs and allows for the automation equipment to be repurposed in the future.

Example: A robot arm that can perform different assembly tasks, welding, or painting.

2.4: Basic components of an automation system.

An automation system fundamentally consists of three basic elements: a power source, a program of instructions, and a control system. These core elements work together to enable a process to operate without continuous human assistance.

Core Components
Power Source:

Provides the necessary energy to drive the automated process and power the control components. Electricity is the most common power source due to its wide availability and versatility in conversion to other forms of energy (mechanical, thermal, etc.).

Program of Instructions:

A set of commands and decision-making logic that defines the sequence of steps and specific details of the work cycle. This program dictates what the system should do and how the components must function to achieve the desired results.

Control System:

Executes the program of instructions. It causes the process to accomplish its defined function, using control devices like controllers (e.g., PLCs) to manage the operation. Control systems can be open-loop (without feedback) or closed-loop (using feedback).

2.5: Introduction to PLC – architecture and working.

By Architecture there are mainly 6 major parts of a PLC that are

1. Processor

2. Memory (RAM/ ROM)

3. Input device

4. Output device

5. Power supply

6. Programming device

Description of each part of a PLC

CPU: CPU is the brain of a PLC, responsible for executing the control program stored in memory. It performs tasks such as data processing, decision-making and communication with other devices.

Memory (RAM/ROM): PLCs have main type of memory one is ram and another is rom. RAM is used for storing data and variables temporarily during the execution of the program. ROM is used to store the operating system of a PLC and the user program. The program typically consists of two ladder logic, function block diagrams or other programming languages.

Input Device : This is responsible for interacting with the machine and the instructor which can be external sensors, switches etc. This part helps to take input and send the CPU to response accordingly.

Output Device: Output device is responsible for interacting with the end point external device like motor, valve or indicator. It converts control signal from the PLC that these devices can interpret.

Power Supply: PLC requires a stable power supply to run its program and match the voltage levels that needed for a PLC component.

Programming Device: As PLC is mainly a programmable device, so we need a device where we can write code and execute it, just like a monitor and keyboard.

2.6: Advantages of PLC over relay logic.

Programmable Logic Controllers (PLCs) offer numerous significant advantages over traditional hardwired relay logic systems, primarily in flexibility, cost-effectiveness over time, and advanced functionality.

Flexibility and Reprogram ability The most significant advantage is the ability to change the control logic in software (via a computer or programming device) without physical rewiring. In contrast, a relay system requires time-consuming and labor-intensive physical rewiring to alter its function.

Reduced Space and Wiring A single, compact PLC unit can replace a large control panel filled with numerous individual relays, timers, and counters, saving significant physical space and reducing the complexity and quantity of wiring required for installation.

Enhanced Diagnostics and Troubleshooting PLCs have built-in diagnostic and monitoring tools that allow technicians to quickly identify faults via software, reducing downtime. Troubleshooting a relay system often involves manually tracing complex wiring to find the issue.

Reliability and Durability PLCs use solid-state electronics, which have no mechanical parts to wear out, unlike the physical contacts of electromechanical relays. This results in higher reliability and reduced maintenance needs.

Advanced Functionality PLCs can easily perform complex tasks beyond simple switching, such as mathematical operations, timing, counting, data logging, and processing analog signals. These functions are difficult or impossible to implement with only relays.

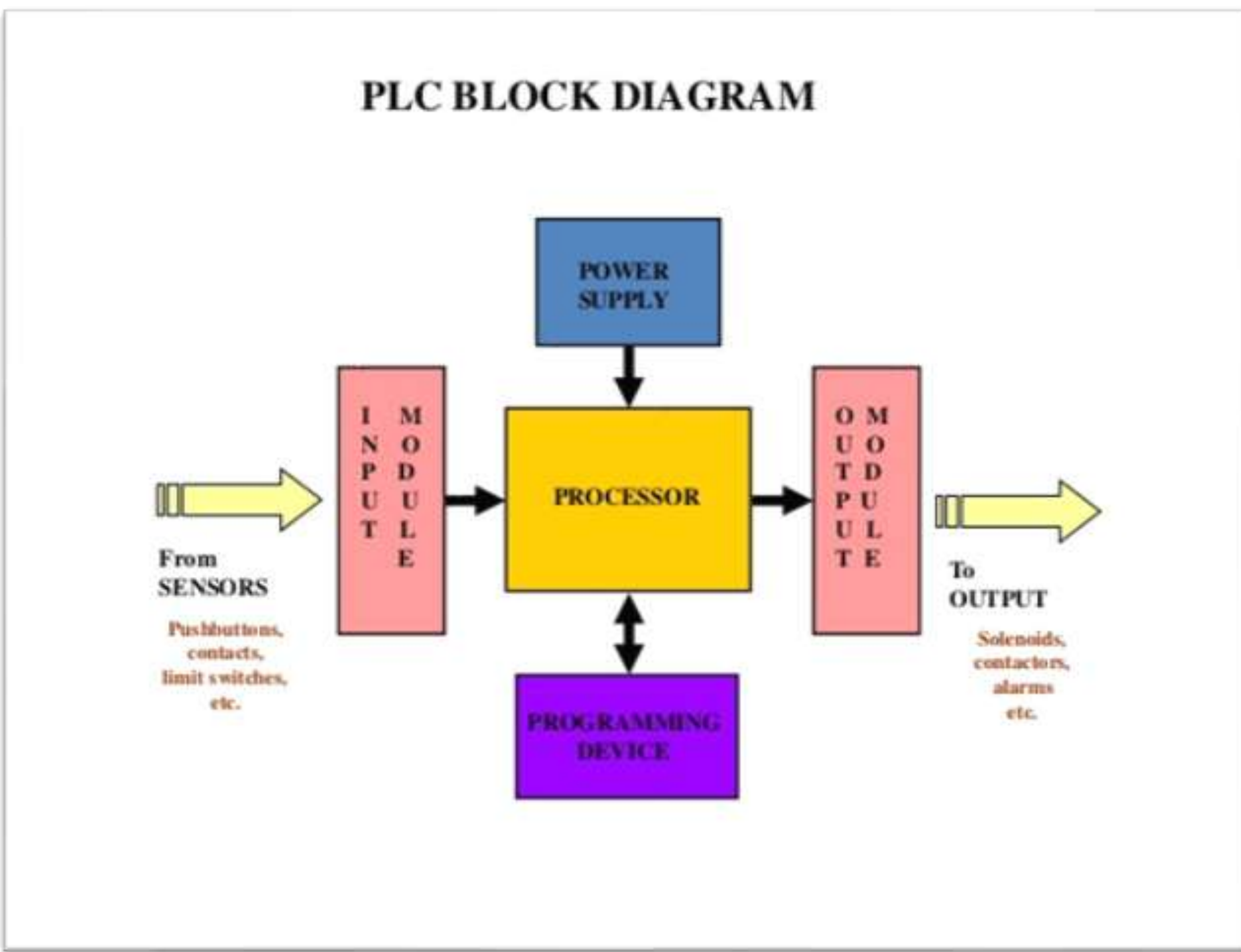
Speed of Operation PLCs process information electronically at high speeds (milliseconds), leading to faster response times than the mechanical action of relays.

Integration and Communication PLCs can easily integrate with other industrial systems like Human-Machine Interfaces (HMIs), SCADA (Supervisory Control and Data Acquisition) systems, and computer networks, allowing for centralized control and remote monitoring.

Cost-Effectiveness While the initial cost of a PLC might be higher, the long-term savings in reduced installation time, less wiring, easier maintenance, and simple modifications typically make them more cost-effective for most industrial applications.

Scalability Systems can be easily expanded by adding I/O (Input/Output) modules or linking to other PLCs, whereas expanding a relay system would require significant hardware additions and rewiring.

2.8: Block Diagram of PLC: Overview of the Internal structure



2.9: Analog & Digital I/O Modules: Understanding input and output modules for analog and digital signals.

Analog and Digital I/O (Input/Output) modules are fundamental components in industrial automation systems like PLCs (Programmable Logic Controllers) and DCSs (Distributed Control Systems). They serve as the interface between the central controller and real-world physical devices, such as sensors, actuators, motors, and switches.

1. Digital I/O Modules

Digital I/O modules handle signals that exist in only two discrete states: ON (True, 1) or OFF (False, 0). These are binary signals.

Key characteristics:

Signals: Represented by the presence or absence of voltage (e.g., 24V DC ON, 0V DC OFF).

Purpose: To detect simple states (is a switch open or closed?) or to trigger simple actions (turn a light on or off).

Types of Digital I/O:

Digital Input (DI) Modules: Read the status of input devices into the controller.

Examples: Push buttons, limit switches, proximity sensors, safety interlocks.

Digital Output (DO) Modules: Send control signals from the controller to output devices.

Examples: Indicator lights, motor starters, solenoids, relays.

2. Analog I/O Modules

Analog I/O modules handle continuous, variable signals that can fall anywhere within a specified range. These signals represent physical quantities that are not simply "on" or "off."

Key characteristics:

Signals: Usually, a standard range of voltage or current (e.g., 0-10V, 4-20mA).

Purpose: To measure physical parameters precisely (temperature, pressure, speed) or to control devices with variable outputs (adjusting a motor's speed, opening a valve partially).

Types of Analog I/O:

Analog Input (AI) Modules: Measure continuous signals from field instruments and convert them into a digital value the controller can process.

Examples: Thermocouples, RTDs (Resistance Temperature Detectors), pressure transmitters, flow meters.

Analog Output (AO) Modules: Convert a digital value from the controller into a variable analog signal to drive field devices.

Examples: Variable Frequency Drives (VFDs) for motor speed control, modulating control valves, chart recorders.

Module 3: Ladder Logic Programming

Module Objective

Understand the Ladder logic programming and implementation

3.1: Industrial automation overview

Industrial automation uses control systems and information technologies to minimize human intervention in industrial processes, with tasks performed or assisted by machines like computers and robots. This increases efficiency, accuracy, and safety while reducing production costs. Key types include fixed, programmable, and flexible automation, with integrated automation representing a modern, networked approach.

Key components

Control systems: These are the brains of the operation, ranging from low-level Programmable Logic Controllers (PLCs) to higher-level supervisor PCs for process visualization.

Sensors and actuators: Sensors collect data from the process, while actuators perform actions on the machinery based on instructions from the controllers.

Communication systems: Wired or wireless networks connect all the different components, allowing for data exchange and coordinated actions.

Human-Machine Interface (HMI): This provides operators with a way to monitor and interact with the automated system.

3.3: Ladder Logics Basics.

Ladder logic is a fast and simple way of creating logic expressions for a PLC in order to automate repetitive machine tasks and sequences. It is used in a multitude of industrial automation applications. Some industrial automation application examples where PLC ladder logic is used include…

3.4: Architecture, Input/Output modules, Scan cycle.

PLC Architecture

CPU (Central Processing Unit): The brain of the PLC, the CPU executes the user's program and controls the entire system.

Power Supply: Converts AC power to the DC voltage required by the CPU and I/O modules.

I/O Modules: These modules act as the interface between the field devices and the CPU.

Input Modules: Read signals from input devices like switches and sensors and convert them into data the CPU can understand.

Output Modules: Receive commands from the CPU and send signals to control output devices such as motors, lights, and valves.

Programming Device: A device like a PC used to create, load, and edit the control program.

3.5 Symbols (NO/NC, Coils, Timers, Logic gates.

The ladder logic symbols that are used in PLC programming have been derived from traditional relay logic control circuits. If you have a basic knowledge of electric circuits then getting started in ladder logic programming should be a breeze. If not, don't worry, ladder logic is a graphical

programming language and getting to know the basic ladder logic symbols and concepts is quite easy. In ladder logic the normally open contact (NO) and normally closed contact (NC) symbols are mainly used to define PLC digital inputs and internal logic instructions. They have been translated into ladder logic from switches and relay contacts used in electric circuits.

A coil in ladder logic is the symbol which mainly defines PLC digital outputs. However, a coil can also be used with internal memory in order to trigger internal logic instructions. The coil symbol has been translated into ladder logic from relay coils used in electric circuits.

The NO and NC contacts are some of the fundamental symbols used in PLC programming. Let's take a more detailed look at them and other symbols used in PLC programming by investigating their operation and how they are commonly used in a ladder diagram.

3.5.1 Normally Open Contact (NO) Symbol

Operation:

If the condition is TRUE then the contact is CLOSED and output logic flow is enabled. If the condition is FALSE then the contact is OPEN and output logic flow is blocked.

3.5.2 Normally Closed Contact (NC) Symbol

Operation:

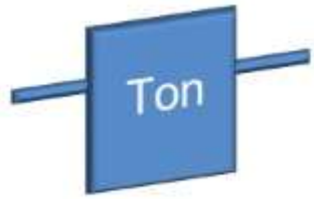
If the condition is TRUE then the contact is OPEN and output logic flow is blocked. If the condition is FALSE then the contact is CLOSED and output logic flow is enabled. The NC contact symbol operation is opposite to the NO contact symbol.

3.5.3 Output Coil Symbol

Operation:

If the input condition is TRUE then the output is ON. If the input condition is FALSE then the output is OFF.

3.5.4 Timer Delay On Symbol



Operation:

If the input condition is TRUE then the timer begins. When the preset time set point has been reached the output turns ON. If the input condition goes FALSE, at any stage, the timer stops and the output turns OFF as well.

3.6 PLC Programming Software

PLC programming software is used to write programs for a Programmable Logic Controller (PLC) to automate tasks by controlling a machine's inputs and outputs. Popular examples include Siemens' TIA Portal (Step 7), Rockwell Automation's Studio 5000, Schneider Electric's Contribute Control Expert, and CODESYS, which is an open-source platform compatible with many hardware manufacturers. Some software, like Connected Components Workbench (CCW) and Machine Expert Basic, have free or partially free versions for learning, while others require a paid license.

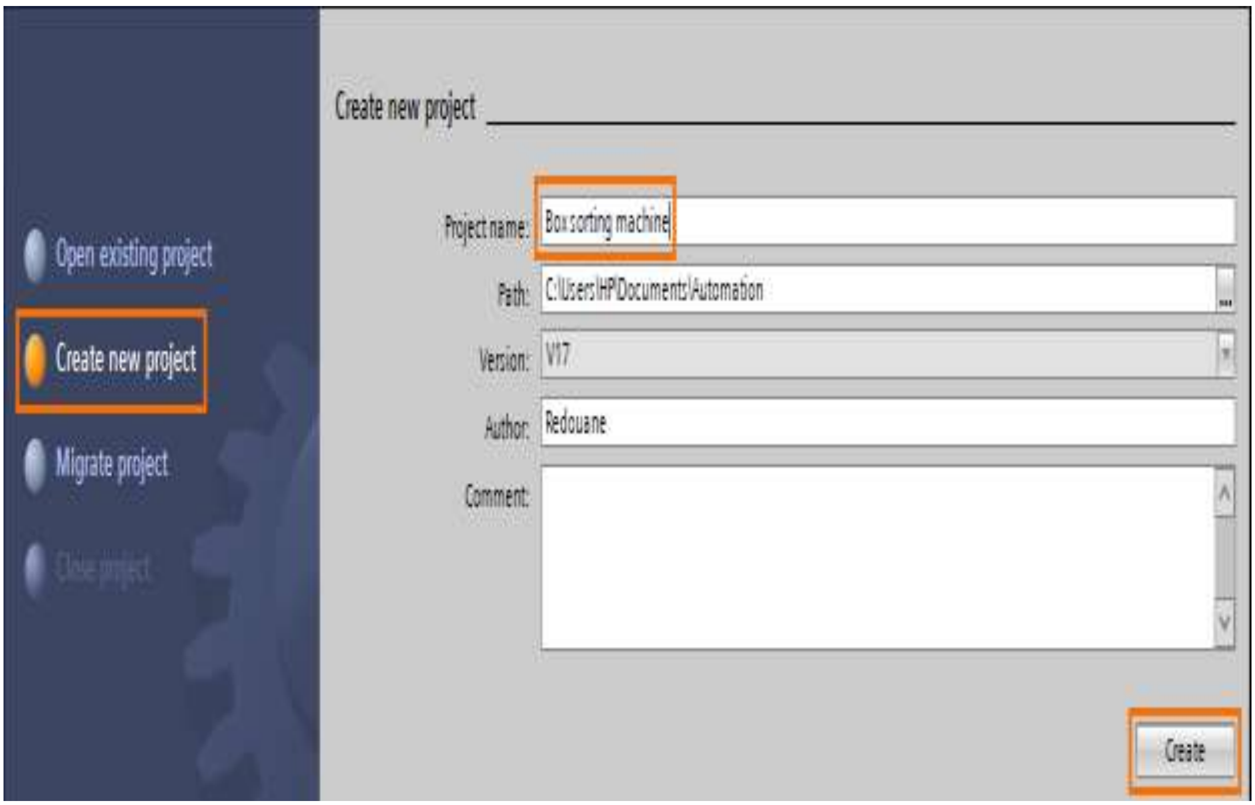
3.7 Introduction to TIA Portal/RS Logix.

Siemens offers one of the most intuitive and user-friendly development environments. This makes it a great starting point for those who want to start practicing PLC programming. In this tutorial, we will explore the basic instructions available in the Siemens environment (defined by the IEC 61131-3 standard) by programming a simple box sorting machine in LADDER in TIA Portal. The purpose is to show how these instructions can be used in a real application.

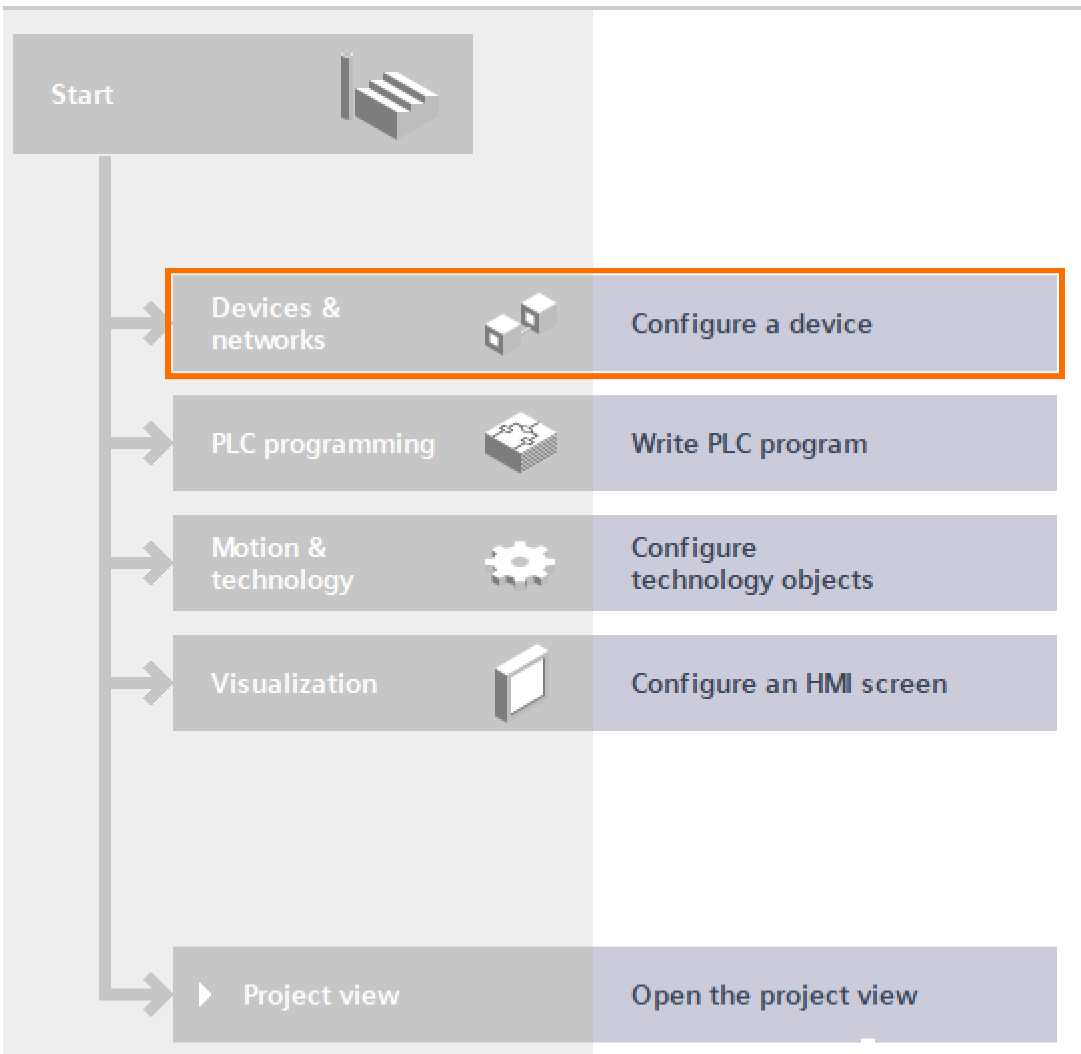
Creating a new project in TIA Portal

Now that we have defined all the machine’s specifications, we can start writing our PLC program.

Start by launching TIA Portal. Then, on the first screen, click on "Create a new project", give it a name ("Box sorting machine" in this instance), and click on "Create".



Then, on the next view click on "Configure a device".



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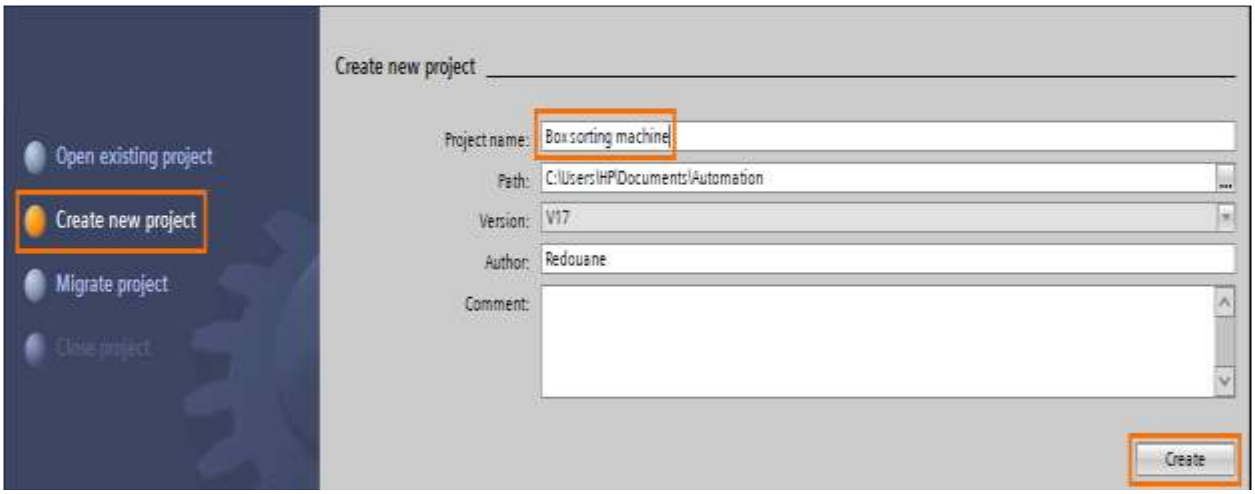
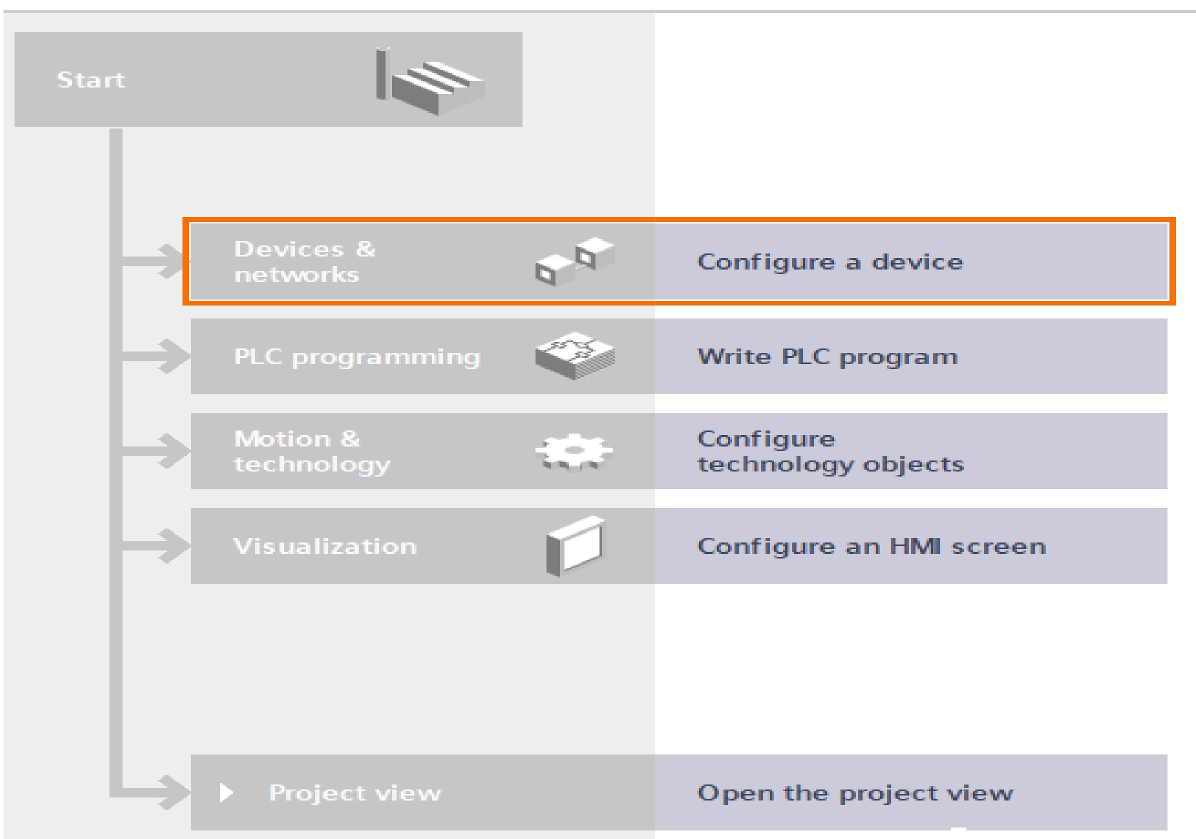
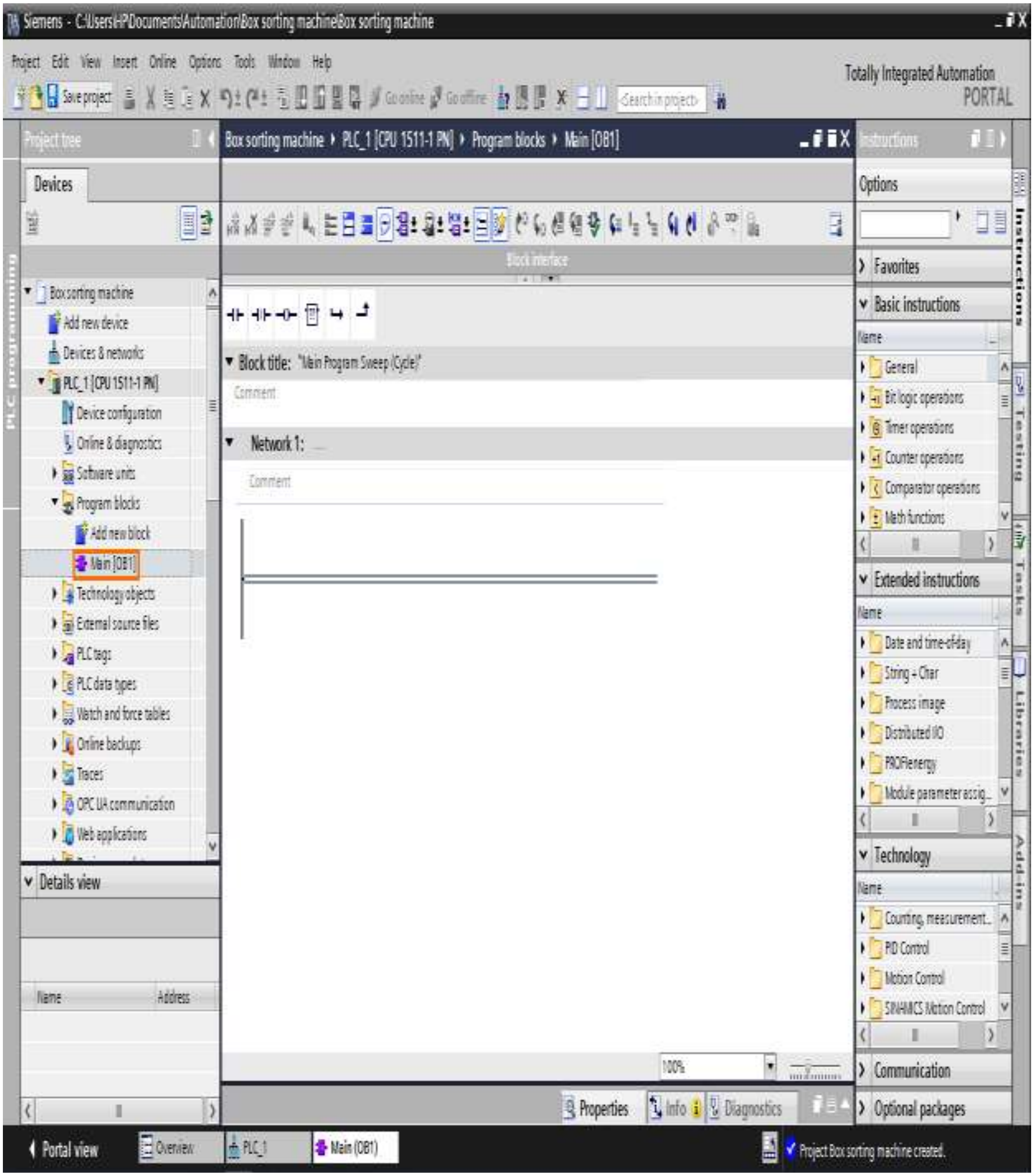


Then, on the next view click on “Configure a device”.



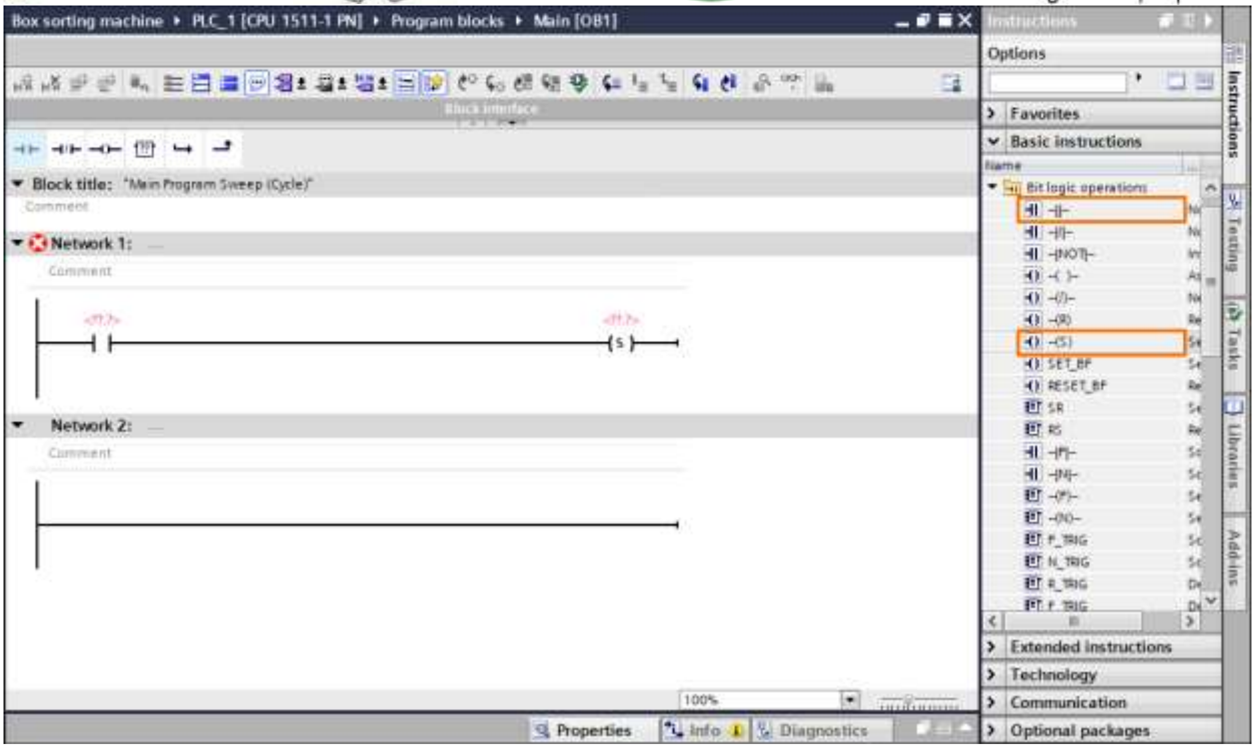
Let the software initiate the project until the project’s interface appears.

Open the “Program blocks” folder on the Project tree then double click on “Main [OB1]”

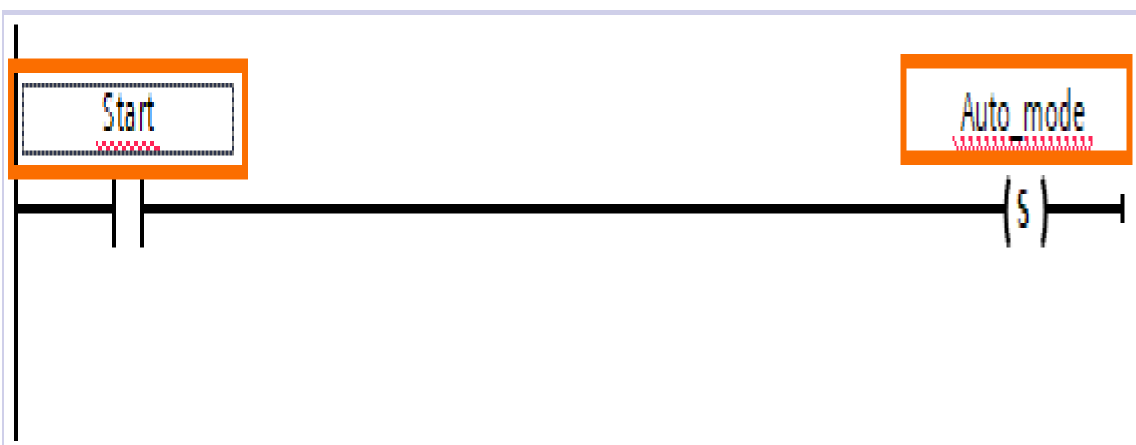


Programming bit logic operations in TIA Portal

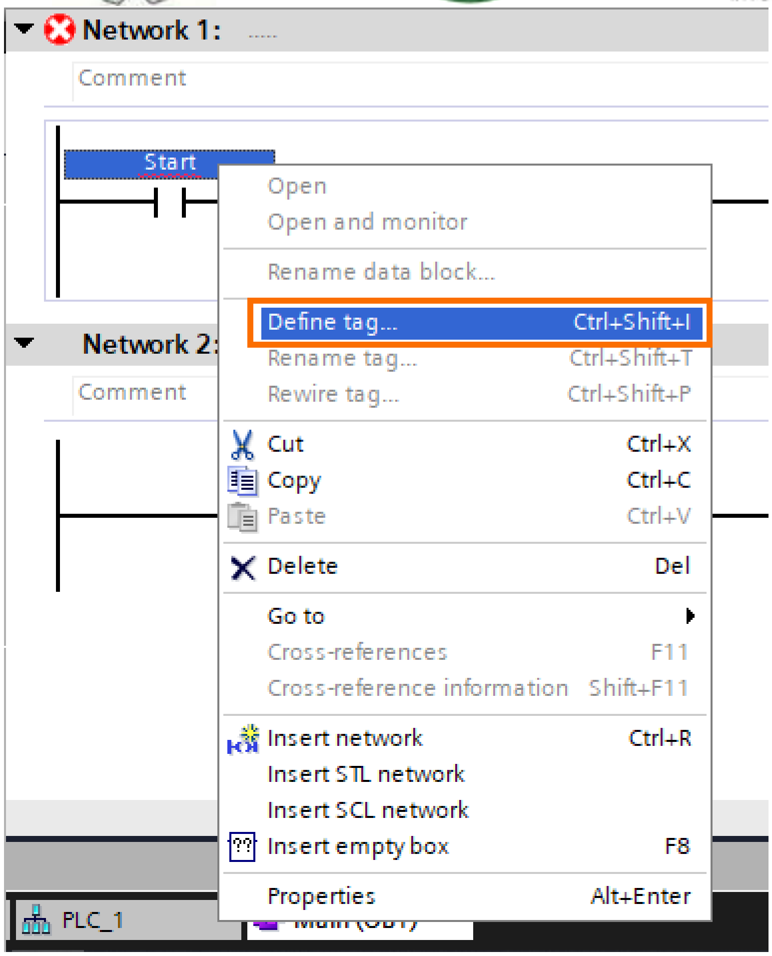
Open the "Bit Logic Operations" folder then drag and drop a normally open contact and a Set instruction on the line of Network 1.



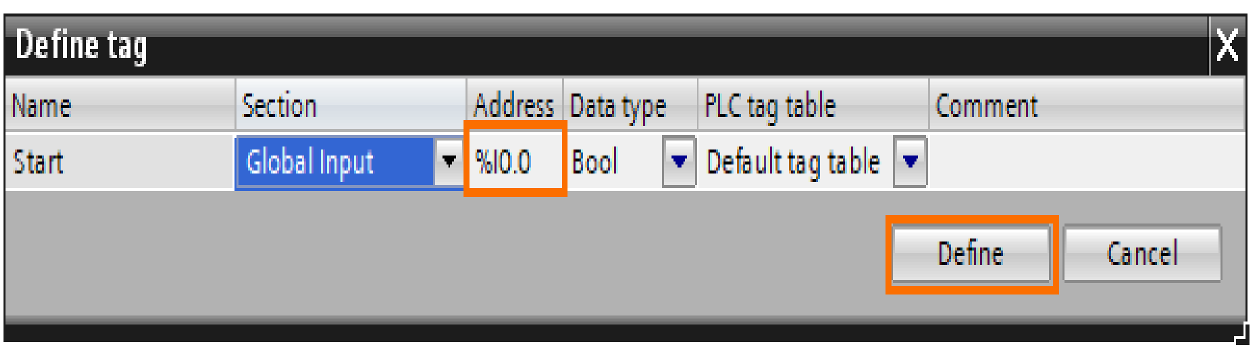
Now we have to associate a bit address to each instruction. First thing is to give it a tag. Click on the red question marks above the instructions and write the name as shown in the next figure.



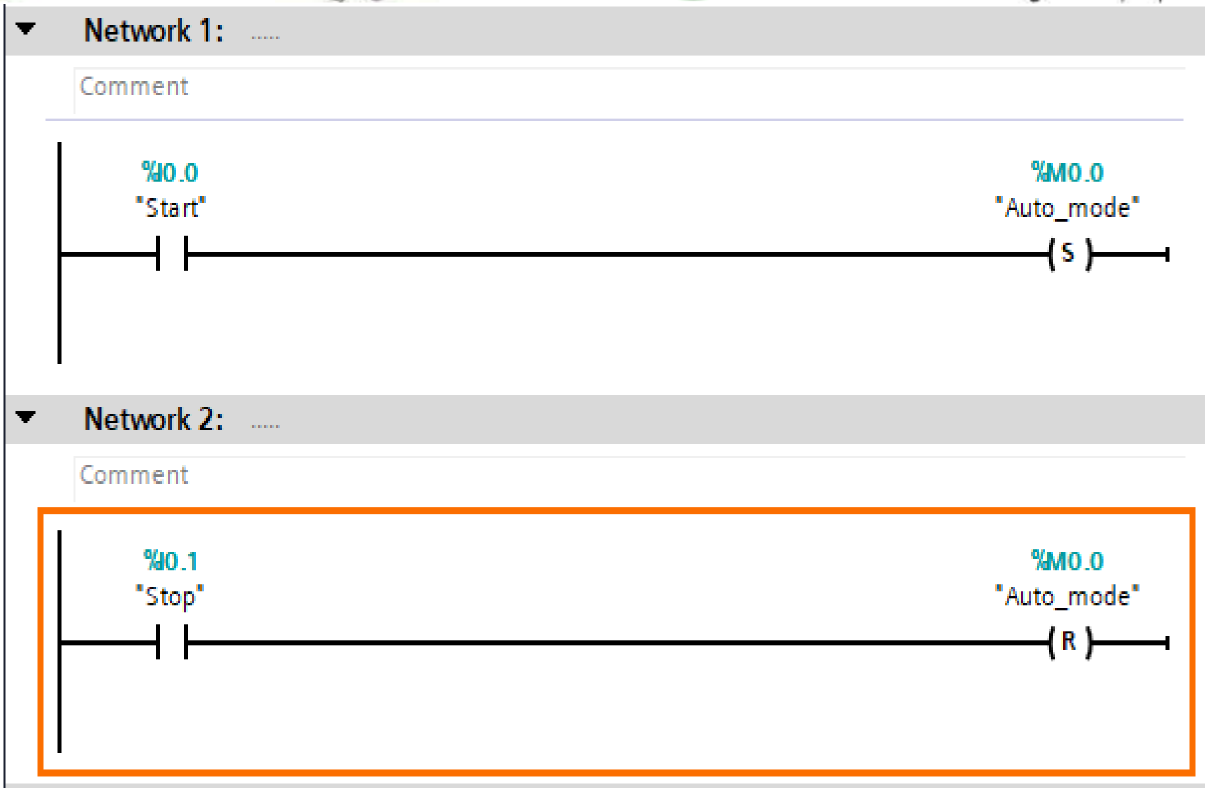
As you can see, there's a red line under our tags. This is normal because we didn't define these tags yet. It can be done by right-clicking on the tag then clicking on "Define tag".



A small window will open asking you to define the data section, data type, and memory address of the tag. Define it as a Global input BOOL. Once done, the first physical address available will be automatically attributed to this tag. In our case, it is “%I0.0”. Once done, click on “Define”.

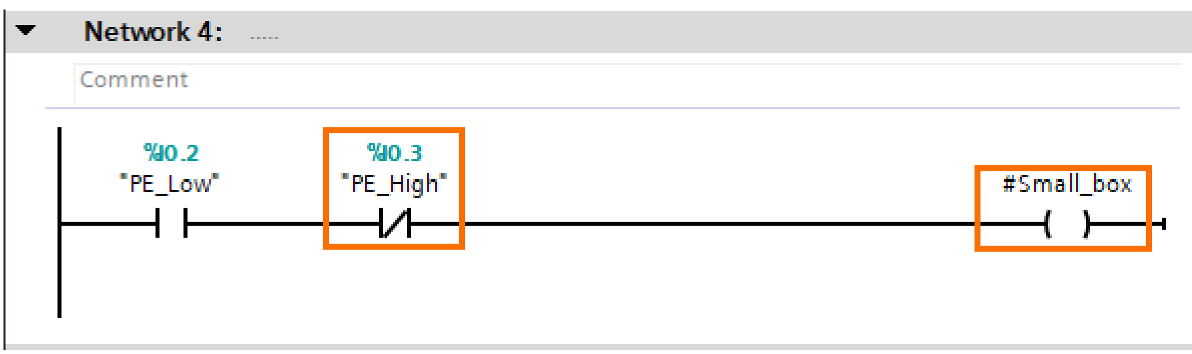


define the “Stop” tag for the NO contact as a Global input BOOL (its address will be automatically set to “I 0.1”) and assign “Auto mode” to the Reset instruction.

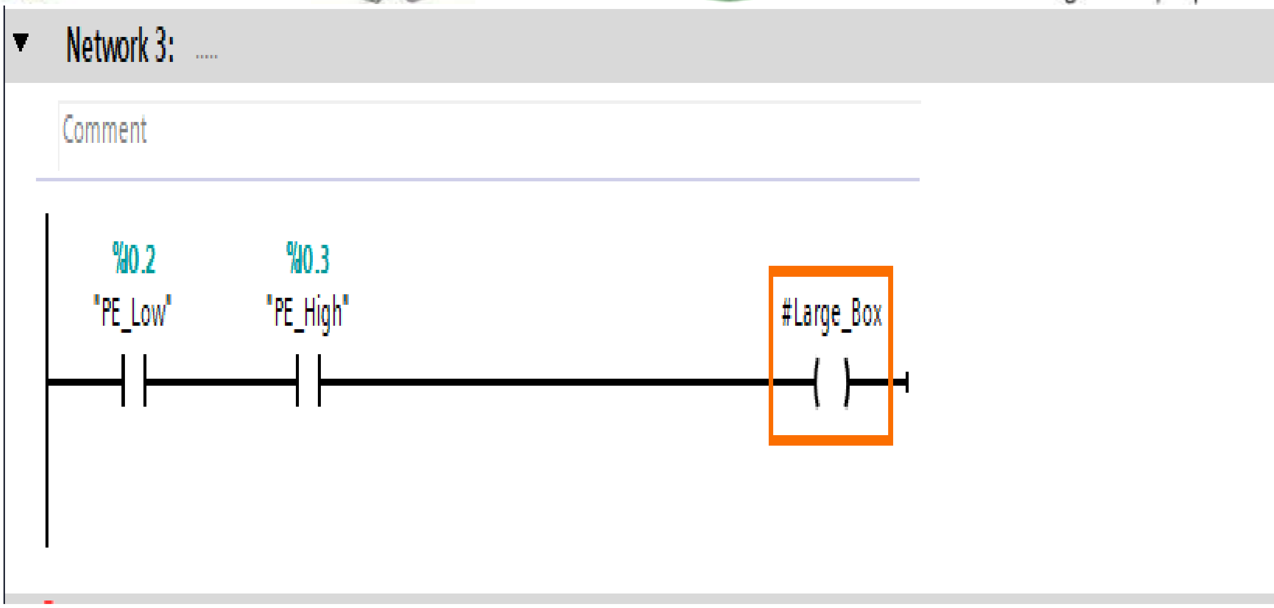


3.8 Digital I/O Programming, Input/Output Wiring.

Use the "Small_box" tag name for the assignment instruction.



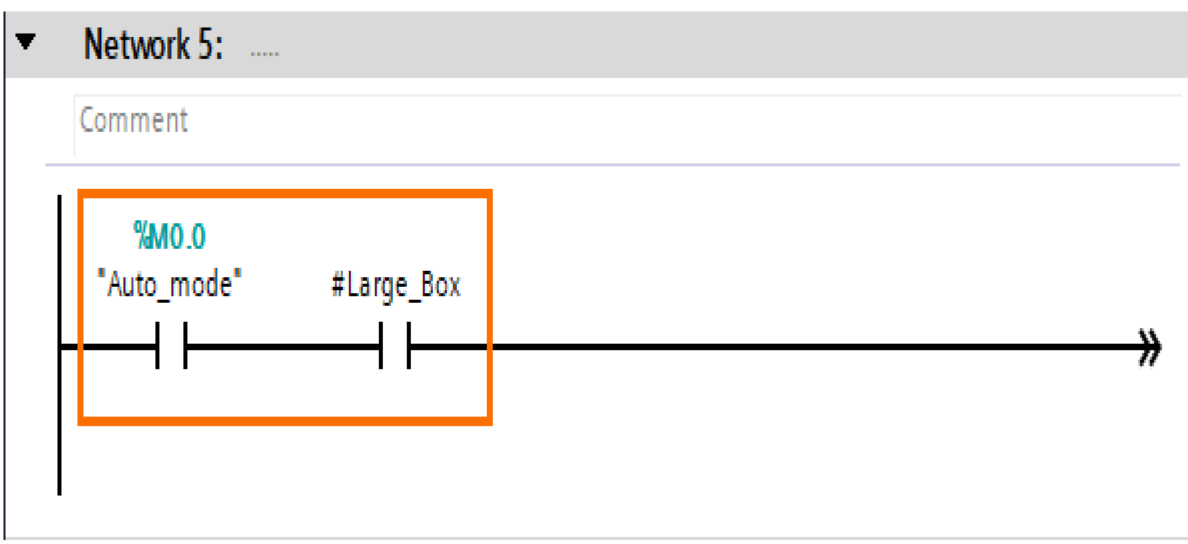
Drag and drop the instruction, name it "Large box" and define it as a Local temp BOOL.



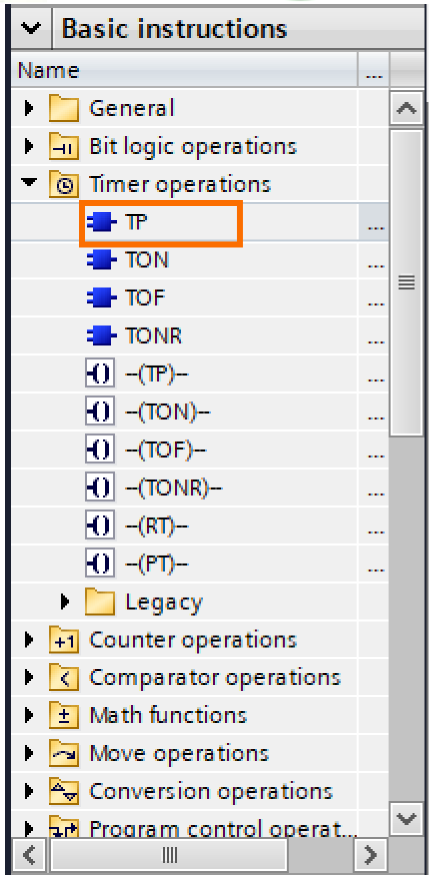
3.9 Timers and Counters.

First, we will define the conveyor's A behavior (large boxes). add two normally open contacts to Network 4.

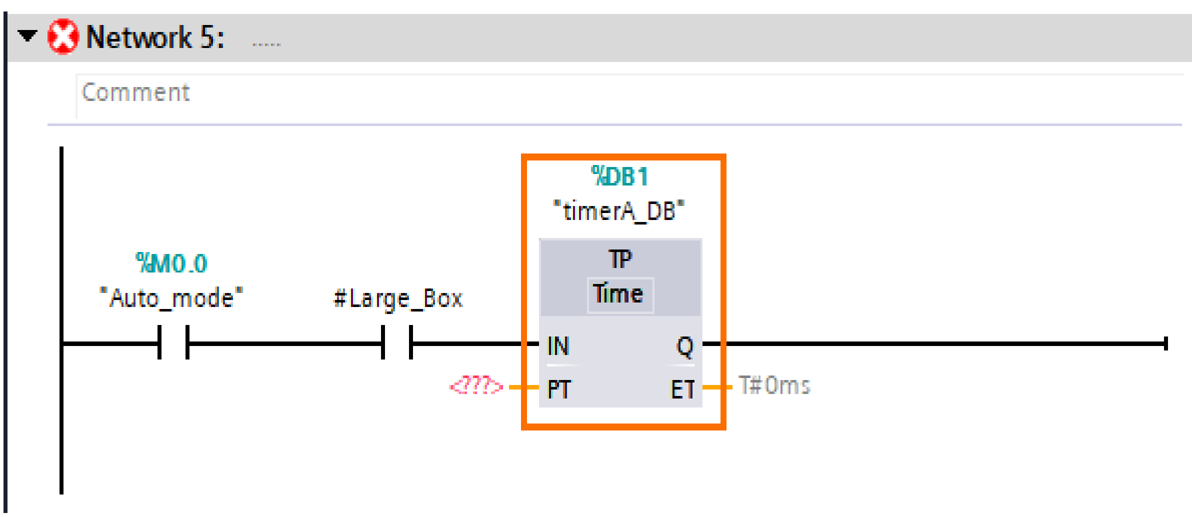
And define them as "Auto mode" and "Large box".



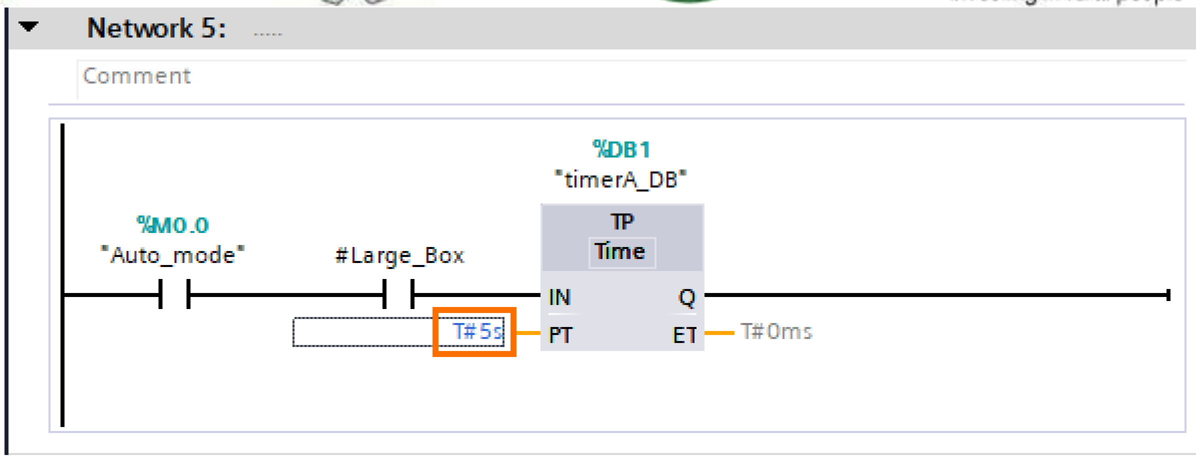
From the "Timer operations" folder, drag and drop a TP instruction.



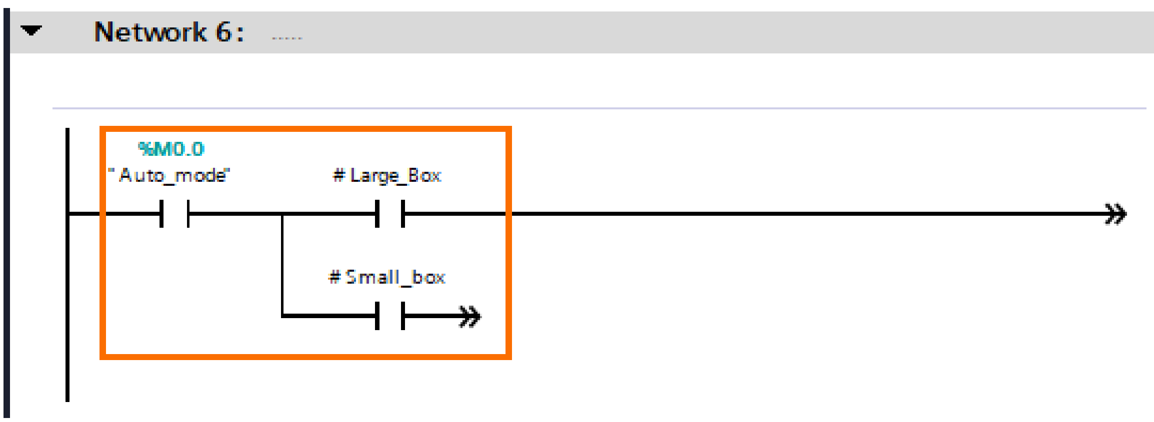
NB: This window will open each time you'll create a timer or a counter. Let the DB's number be set automatically.



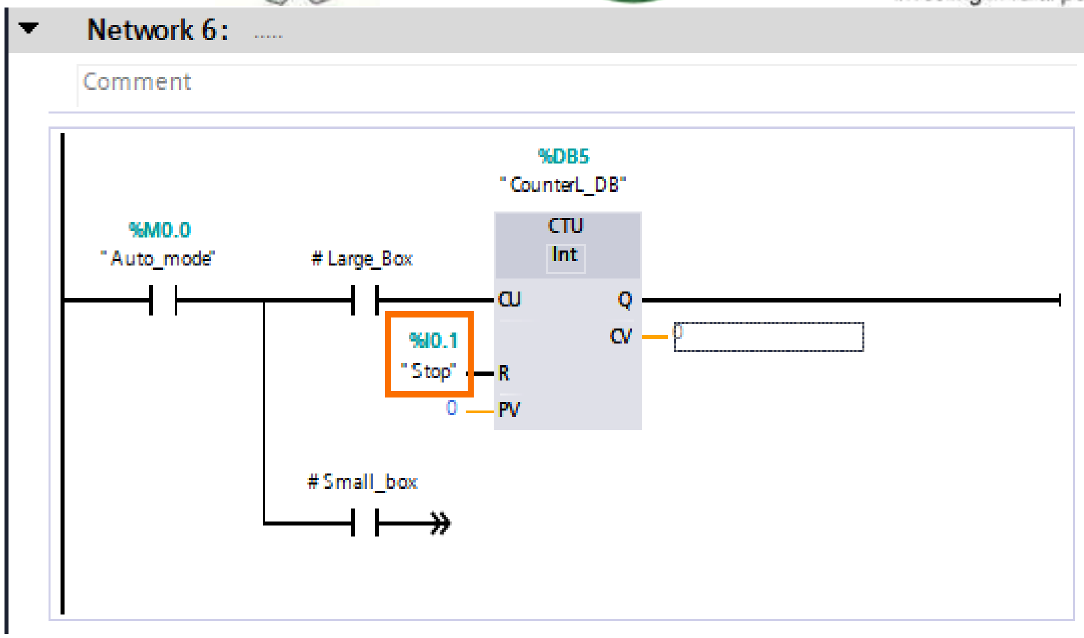
The PT input requires a TIME data type. To define a TIME data, you have to write "T#" then specify a time duration with its unit. For this case, we want the timer to run for 5 seconds. So we have to write "T#5s".



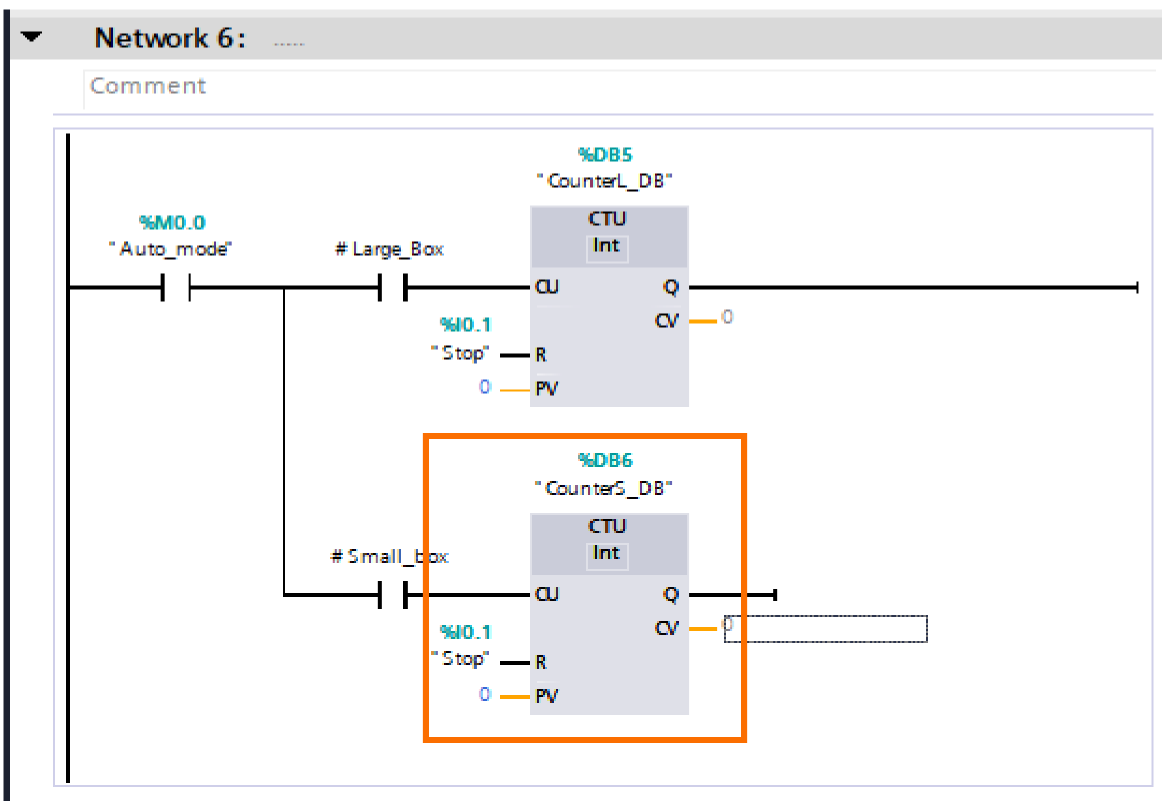
Now with the machine's behavior achieved, let's add counters to measure the number of large and small boxes. First, add an "Auto_mode" NO contact followed by two branches: one leading to a "Large_box" NO contact and the other to a "Small_box" NO contact in Network 6 as shown in the next figure.



Let the PV input at 0 (as a constant) and assign the "Stop" bit to the R input.



Go ahead and repeat the same step for the counter after the "Small_box" contact.



Investing in rural people

Module 4: Industrial Communication and Field Devices.

Module Objective

Understand the communication protocol and field devices link with plc.

4.1 Field Devices (Sensors/Actuators).

PLC field devices are the sensors, actuators, and instruments that connect to a Programmable Logic Controller (PLC) to monitor and control an industrial process. They are the link between the physical world and the PLC's control logic, including input devices like sensors and switches, and output devices like motors, valves, and lights. These devices can be digital, receiving on/off signals, or analog, converting physical quantities into continuous signals like voltage or current.

4.2: Proximity Sensors.

A **proximity sensor** is a non-contact sensor that detects the presence or absence of nearby objects. It does so without any physical contact, relying on a field or a beam of radiation and monitoring for changes in that field or return signal.

Principles of Operation

Different types of proximity sensors operate on various physical principles:

Inductive Inductive sensors use an electromagnetic field to detect metal objects. When a metallic target enters the sensing field, it causes a change in the field characteristics (e.g., creating eddy currents, as described in search results) that the sensor electronics convert into a signal.

Capacitive These sensors generate an electrostatic field and detect changes in capacitance when any material (metal, liquid, plastic, wood, a human body, etc.) enters the field. They are versatile in the range of materials they can detect.

Optical (Photoelectric) Optical sensors operate by emitting a beam of light (often infrared) and detecting if the light is reflected back from an object or if the beam is broken. They can detect a wide variety of materials and have a longer sensing range than many other types.

Ultrasonic These sensors emit sound waves at ultrasonic frequencies and measure the time it takes for the echo to return from a target, thereby calculating distance or presence.

Magnetic Magnetic sensors typically use a magnetic field and a magnet (either as part of the sensor or the target) to detect presence, position, or angular displacement.

4.3 Industrial Networks

Industrial networks are communication systems that connect devices, sensors, and control systems in industrial settings to enable real-time monitoring, control, and automation. These networks are designed for reliability, performance in harsh conditions, and the high-volume data transfer required for tasks like controlling manufacturing lines and critical infrastructure. Examples of industrial networks include Profibus, Modbus, and Ethernet/IP, which use specific protocols to ensure seamless data exchange.

Fieldbus networks: These networks, such as Profibus and Foundation Fieldbus, are designed for real-time distributed control and data exchange between field devices and control systems.

Serial networks: These use protocols like RS-232, RS-422, and RS-485 for data transfer between controllers and remote devices.

Ethernet-based networks: Standards like Profinet and Ethernet/IP use Ethernet technology for high-speed communication between industrial devices and controllers. Sensor networks: These specifically connect numerous sensors to interfaces and transmit their status information. Modbus: A widely used protocol that can run on various physical layers, often used in a master/slave configuration.

4.4 VFD & Motor Control

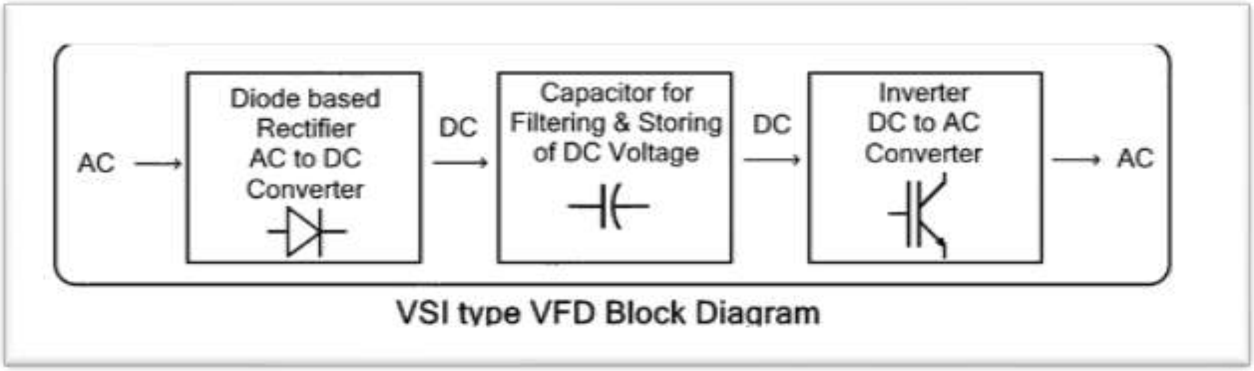
There are different types of large electrical motors used in industries that have very high power consumption. To increase the efficiency of AC electrical motors and also provide speed control, these motors are equipped with VFD (variable frequency drive). In addition to speed control, they also provide phase-protection, over-voltage protection and overcurrent protection.

Types of VFDs

There are three types of VFD classified based on the method of power conversion.

VSI type VFDs

The VSI or Voltage Source Inverter type VFD is the most common type. it provides a smooth voltage waveform that depends on the output frequency. It has a very simple design including a simple diode rectifier with a capacitor for filtering and storing DC energy. The DC voltage is then converted into AC using an inverter. They offer very good operating speed and control multiple motors.



4.5 Pneumatics & PLCs

Pneumatics & PLCs appears to be a module or learning unit focused on the integration of **pneumatic systems** (which use compressed air to power mechanical systems) and **Programmable Logic Controllers (PLCs)** (industrial computers used for automation). The objective is to teach students how to design and program automated systems where the physical actions are performed by pneumatic components and the logic/sequence control is managed by a PLC.

By creating an automated, centralized platform accessible via the internet, users can control and monitor all machines in the industry from one place. This work particularly focusses on the conveyor belt application in industry and the implementation of Industry 4.0 in Industries. To achieve this, Cyber-Physical Systems (CPS), Internet of Things (IoT) and Internet of Services technologies are used. These technologies enable efficient operation and monitoring of conveyor systems, ultimately leading to increased productivity, reduced downtime and increased safety. The proposed system provides real-time data for decision-making and optimization, ultimately paving the way for the future of Industry 4.0 in the conveyor belt industry. IoT and Industrial automations the technology that can be utilized to reduce human interventions and manual overhead in the system to monitor as well as to indicate any errors in the system. Artificial Intelligence could also be used to control and monitor the industry. IoT is not a technology basically it is an ecosystem with Industry Specific Implication. In many Industries monitoring of belt conveyor application is manual with an operator, particularly for sorting application based on color, shape and size of the object. Industry 4.0 lean towards the use of sensor and internet of things to achieve these functions with no errors.

This work is an effort made to realize the use of IoT and Industry 4.0 for sorting and counting application in an industrial environment like conveyor belt applications.

Module 5: SCADA and Advanced Automation.

Module Objective

Understand the Ladder logic programming and implementation

5.1 SCADA Architecture.

A **SCADA (Supervisory Control and Data Acquisition)** architecture is a layered system of hardware and software components that enables real-time monitoring and control of industrial processes across wide geographic areas. It typically consists of field devices, control stations, a supervisory system, and enterprise-level integrations.

Key Architectural Layers and Components

The SCADA architecture is typically structured in a hierarchical model, with data flowing from the physical world up to the business systems.

Level 0: Field Layer (Physical Devices) This is the lowest level, consisting of physical devices such as **sensors** and **actuators** that directly interact with the industrial process (e.g., measuring temperature, opening a valve).

Level 1: Control Layer (Local Control Stations) This layer contains **Remote Terminal Units (RTUs)** and **Programmable Logic Controllers (PLCs)**. These microcomputers collect data from the field devices, execute local control logic, and send the data to the supervisory layer.

Level 2: Supervisory Layer (Master Station/Host Computer) The core of the SCADA system, often a network of servers known as the **Master Terminal Unit (MTU)** or host computer. It processes and stores data, and provides a **Human-Machine Interface (HMI)** for operators to

monitor the system and issue commands. This layer also includes a central database (Historian) for long-term data storage and analysis.

Level 3: Operational Layer (MES) This layer integrates operations for scheduling, workflow management, and production control using Manufacturing Execution Systems (MES).

Level 4: Enterprise Layer (ERP) At the top, this layer connects the SCADA data to business-level analytics and planning systems like Enterprise Resource Planning (ERP) to support high-level decision-making.

5.2 Alarm Management.

Alarm management in SCADA (Supervisory Control and Data Acquisition) systems is the process of effectively handling and responding to alerts generated by industrial processes and equipment to ensure safety, efficiency, and reliability. The goal is to provide operators with timely, relevant, and actionable information, avoiding "alarm fatigue" caused by excessive, non-critical notifications.

Core Concepts and Challenges

Definition of an Alarm: An alarm is an audible or visible indication of an abnormal condition, malfunction, or process deviation that requires an operator's response. It should not be a routine event or normal process condition.

Alarm Fatigue: A common and serious problem where operators are overwhelmed by too many alarms, leading to stress, errors, and the potential to miss critical safety alerts.

Nuisance Alarms: These include alarms that chatter (go on and off repeatedly), are permanently active, or are meaningless in the current process state. Removing these is a crucial step in effective management.

Standards and Guidelines: The industry relies on standards like the ISA 18.2 (ANSI/ISA-18.2-2009, also international standard IEC 62682) and EEMUA 191 to define best practices and key performance indicators (KPIs) for alarm system design and management.

Key SCADA Features for Effective Alarm Management

Modern SCADA software includes features designed to help manage alarms efficiently:

Prioritization and Filtering: Alarms are categorized by severity (high, medium, low) allowing operators to focus on critical issues.

Alarm Shelving and Suppression: Operators can temporarily hide or suppress alarms during maintenance or specific process states to reduce noise; with the understanding they will require attention later.

Data Logging and Analytics: Alarms and events are logged for historical analysis, helping identify "bad actors" (frequently tripping alarms) and perform root cause analysis.

Remote Notification and Escalation: Automated systems can notify on-call

personnel via mobile devices (push, SMS, email, voice) and escalate the alarm if unacknowledged within a defined timeframe.

Integration: Seamless integration with other systems (e.g., PLCs, safety systems) and adherence to standards like OPC UA to ensure data flow and a unified view of operations.

5.3 Data logging and Reporting.

Data logging and Reporting" appears to be a specific identifier, likely from a course module, user manual, or technical specification document. Without additional context, it is impossible to provide specific details. However, the general principles of data logging and reporting typically involve the following components

5.4 Batch processing.

Batch processing" likely refers to a specific section within an academic paper or course material dealing with **batch processing**, specifically in contexts like **batch distillation** or **LU factorization**.

5.5 Connecting level sensors

Connecting level sensors to a PLC involves wiring the sensor to the PLC's power and input terminals, with the specific connections depending on the sensor type (e.g., analog vs. discrete) and the sensor's output (PNP vs. NPN). The PLC then receives the signal, processes it based on programmed logic, and uses the information to control other devices.

5.6 Understanding the process of connecting level sensors to PLC systems.

Connecting level sensors to a PLC involves wiring the sensor to the PLC's power and input terminals, with the specific connections depending on the sensor type (e.g., analog vs. discrete) and the sensor's output (PNP vs. NPN). The PLC then receives the signal, processes it based on programmed logic, and uses the information to control other devices.

Power supply: Connect the sensor's power wires (often brown and blue) to a 24V DC power supply, with the brown wire going to the positive terminal and the blue wire to the negative or DC common terminal.

Signal wire: Connect the sensor's signal wire (often black) to the PLC's input terminal.

For a PNP sensor (sourcing), which outputs a positive signal, connect the signal wire to the PLC's digital input terminal. The 0V terminal of the power supply is connected to the PLC's common terminal.

For a NPN sensor (sinking), which outputs a negative signal, the wiring is slightly different. The PLC's input terminal can be configured to sync with a negative signal by connecting its sync source (SS) terminal to the 24V positive terminal.

Analog sensors: For sensors with a 4-20mA output, connect the power and signal wires to the analog input module as specified by the PLC manual. Terminal 3 is a common connection point for 4-20mA signals, while terminal 2 is for 0-10V signals.

Discrete sensors: Connect the signal wire from discrete sensors (e.g., float switches, tuning fork sensors) to individual digital input terminals on the PLC.

Module 6: Fault Finding and Troubleshooting Assessment.

Module Objective

Understand the Ladder logic programming and implementation

A **Fault Finding and Troubleshooting Assessment** evaluates an individual's ability to systematically identify, analyze, and resolve issues in various systems (electrical, mechanical, software, etc.). These assessments are commonly used in technical fields to measure critical thinking, logical reasoning, and practical problem-solving skills.

Common Formats

Assessments may use various formats depending on the job role and industry:

Multiple-Choice Questions (MCQs): Covering theoretical knowledge and basic troubleshooting principles.

Scenario-Based Problems: Presenting real-world descriptions of faulty systems where candidates must choose the appropriate diagnostic steps.

Diagram/Schematic Analysis: Analyzing circuit layouts, flowcharts, or system schematics to pinpoint the fault location.

Practical/Hands-On Simulations: Using physical equipment or computer-based virtual labs to perform actual diagnostics and repairs.

The Systematic Troubleshooting Process

Expert troubleshooters typically follow a logical sequence to minimize steps and rule out trial and error:

1. **Identify the Problem/Gather Information**: Collect detailed symptoms from the operator or system logs. Understand how the system is supposed to work normally.
2. **Analyze the Information/Define the Problem Area**: Apply logic to the observations to determine the probable cause and eliminate sections of the system that are working correctly.
3. **Identify Possible Causes**: List all potential faults that could cause the observed symptoms.
4. **Determine the Most Probable Cause/Test Hypotheses**: Prioritize the list of possible causes and systematically test them using appropriate tools (e.g., multimeter, wire tracer) to confirm or rule out the fault.
5. **Rectify the Fault**: Safely repair or replace the defective component(s).
6. **Verify Full System Functionality**: Thoroughly test the system after the repair to ensure the original fault is resolved and no new issues exist.
7. **Document Findings**: Record the symptoms, actions taken, outcome, and lessons learned for future reference.

6.1: Common wiring faults in automation systems.

Common wiring faults in automation systems include loose connections, improper grounding/shielding, incorrect wiring installation, and aging insulation, which lead to issues like intermittent faults, communication errors, overheating, and short circuits.

Key wiring faults found in industrial automation include:

Loose Connections/Poor Contact: A prevalent issue where connections at terminals or connectors become loose over time due to vibration or improper installation. This causes intermittent operation, signal drops, overheating, arcing, and potential fire hazards.

Improper Grounding and Shielding: Inadequate or incorrect grounding leads to electrical noise, interference (EMI/RFI), sensor inaccuracies (ghost readings), and ground loops, which can severely affect the reliability and communication of sensitive control equipment like PLCs and VFDs.

Short Circuits: These occur when current takes an unintended path due to insulation failure, damaged wires, or incorrect wiring, causing excessive current flow that can trip breakers, damage components, and pose fire risks.

Open Circuits: Caused by a broken conductor, disconnected terminal, or a burned-out component like a fuse or light bulb. This results in a complete loss of power or signal to a part of the circuit, and the affected component will not operate.

Overloaded Circuits: Running too many devices with high current draw on a single circuit can exceed its capacity, leading to frequent breaker trips, overheating, and premature wire degradation.

Faulty/Outdated Wiring: Aged or poorly installed wiring may not handle modern energy demands or environmental conditions (moisture, heat, vibration), leading to insulation breakdown and various faults.

Incorrect Wiring/Poor Labeling: Human error during installation can lead to wires being connected to the wrong terminals or poorly labeled, making troubleshooting difficult and causing unexpected system behavior or complete failure.

Power Quality Issues: While not strictly a wiring fault, issues like power surges, voltage fluctuations, and harmonics can be exacerbated by or indicate underlying wiring weaknesses, damaging sensitive electronic components.

6.2 Fault codes in PLC and devices.

Fault codes in PLCs and devices are diagnostic messages that indicate a system or hardware issue, helping engineers pinpoint and resolve problems. They can range from simple issues like a bad connection or a safety device being triggered to more complex problems like a hardware failure or communication loss. Troubleshooting involves cross-referencing the specific fault code with the device's manual to identify the cause and determine the necessary fix, which might be a simple reset or a more in-depth repair. **How fault codes work**

Communication: When a fault occurs, the PLC or device generates a specific code (often in hexadecimal or decimal format).

Diagnostic: This code is then displayed on a human-machine interface (HMI), sent to a monitoring system, or recorded in a log file.

Interpretation: The code is cross-referenced with the device's documentation to understand the exact nature of the problem.

Examples of fault codes

C061 : In PLCnext Engineer, this code indicates a safety-related issue, requiring verification of connected contactors and the reset control device.

E201 : In a Scribd document, this means a safety device tripped during operation, requiring immediate attention.

101 : In Automation Direct CLICK PLCs, this code signifies that an I/O module has failed.

0x040 : In Allen Bradley systems (OPC Support), this indicates a hardware fault prevented a remote PLC from completing a function.

6.3 Troubleshooting Methodology.

the CompTIA troubleshooting methodology, a widely recognized industry standard, is a systematic, six-step process for resolving IT issues efficiently.

The Six-Step Troubleshooting Methodology

1. **Identify the Problem**: Gather information by questioning the user, identifying symptoms (e.g., unusual noises, error messages), determining if any changes were made recently, and, if possible, duplicating the problem. Safeguard any critical data before proceeding with changes.

2. **Establish a Theory of Probable Cause**: Based on the gathered information, question the obvious and create a primary theory for the problem's cause. The "divide and conquer" technique can be useful for complex systems by systematically testing components.

3. **Test the Theory to Determine the Cause**: Implement simple changes (e.g., updating drivers, swapping cables) to test your theory. If the theory is confirmed, the cause is found. If not, establish a new theory and go back to step 2.

4. **Establish a Plan of Action to Resolve the Problem and Identify Potential Effects**: Once the cause is confirmed, create a detailed plan to implement the solution, considering its potential effects on the system and other systems.

5. **Implement the Solution or Escalate as Necessary**: Carefully execute the action plan. If you are unable to implement the solution yourself (e.g., due to lack of authorization or expertise), escalate the issue to the appropriate department or senior technician.

6. **Verify Full System Functionality and, if Applicable, Implement Preventive Measures**: After implementing the fix, ensure the system works as expected through comprehensive testing (e.g.,

checking network connectivity, running applications, restarting the system). Implement measures to prevent the problem from recurring if possible, and obtain necessary permissions for these measures.

7. **Document Findings, Actions, Outcomes, and Lessons Learned**: Record the entire process, including the initial problem, steps taken (both successful and unsuccessful), the final solution, and any preventative measures. This documentation builds a valuable knowledge base for future reference.

Input/output (I/O) signal issues can range from display problems like "no input signal" or "out of range" to connectivity problems in digital or analog systems. To troubleshoot, start with simple steps like checking cables and restarting devices, then move to more specific checks like verifying the correct input on the display, ensuring the correct resolution and refresh rate, or checking device-specific settings for audio and signal paths.

Common troubleshooting steps for display issues

Check cables and connections:

Ensure the display cable is securely plugged into both the computer and the monitor.

Try a different cable to rule out a faulty one.

Plug the monitor into a different port on the computer. On a PC, make sure the cable is plugged into the graphics card, not the motherboard, if you have a dedicated graphics card.

Restart devices:

Restart both the computer and the monitor.

Adjust resolution and refresh rate:

If you get an "out of range" error, the resolution is likely too high for the monitor.

Restart the computer, possibly in Safe Mode, to change the resolution and refresh rate to a compatible setting, such as

Verify input source:

Make sure the monitor's input source (e.g., HDMI1, HDMI2, DisplayPort) matches the port the computer is plugged into.

Update drivers/firmware:

Ensure your graphics card drivers and the monitor's firmware are up to date.

Test the hardware:

If possible, connect the monitor to a different computer to see if the problem persists. If it does, the issue is with the monitor.

If the monitor works with another computer, the problem could be with your original computer's components, like the graphics card or RAM.

6.4 Software logic errors.

Software logic errors are bugs in a program's code where the program runs without crashing but produces incorrect or unintended results due to flawed algorithms or incorrect assumptions. These errors are often subtle because the computer doesn't report them as syntax errors, making them challenging to find and fix by having developers carefully examine the code, use debugging tools, and perform testing.

6.5 Documentation and Logging.

Documentation is the process of creating and maintaining records to explain how something works, while logging is the process of automatically recording events and activities in a system. Both are crucial for knowledge sharing, process control, and troubleshooting, but documentation is typically human-generated and conceptual, whereas logging is system-generated and factual. For example, a software application's documentation explains its features to users, and its logs record every time a user performs an action.

6.6 Entrepreneurship

Entrepreneurship is the process of designing, launching, and running a new business venture, which typically involves **innovation, risk-taking**, and the goal of creating value for a target audience. It is a driving force for economic development, job creation, and social change.

Key Characteristics of Entrepreneurship

Successful entrepreneurship involves a blend of specific mindsets and actions:

Innovation: Introducing new ideas, products, services, or methods of production to the market.

Risk-taking: The willingness to put financial security, time, and effort on the line for an uncertain outcome. Successful entrepreneurs take *calculated* risks, not reckless ones.

Vision and Leadership: Having a clear, long-term picture of what the business can become and the ability to inspire and guide others toward that goal.

Adaptability and Flexibility: The capacity to respond quickly to market changes, learn from setbacks, and pivot strategies when necessary.

Persistence and Resilience: The drive to keep going despite challenges, rejections, and failures.

Opportunity Recognition: Identifying market gaps or emerging trends that others might miss.

6.6.1 Types of Entrepreneurships

Entrepreneurship is not a single, uniform activity; it can take several forms:

Small Business Entrepreneurship: Involves creating a business primarily to support a local market and provide income for the owner and their family (e.g., local grocery stores, hairdressers, consultants). These ventures typically rely on personal savings or small business loans for funding.

Scalable Startup Entrepreneurship: Focuses on innovative ideas with the potential for rapid, large-scale growth, often seeking venture capital investment with the goal of disrupting industries (e.g., tech companies in Silicon Valley).

Large Company Entrepreneurship (Intrapreneurship): Occurs within established corporations, where employees are encouraged to be innovative and develop new products or services to help the company stay competitive and adapt to market changes.

6.6.2 Business idea generation

Business idea generation is the process of brainstorming, identifying, and refining new business concepts, often by combining your passions and skills with market research. Effective techniques include traditional brainstorming, using the SCAMPER method, and analyzing industry trends to find problems and gaps in the market. Validating your idea through market research and potential customer feedback is a crucial final step before creating a business plan.

This video explains the process of generating business ideas, from identifying your passions to understanding market needs:

Key steps for idea generation

Self-reflection:

Explore your personal interests, passions, and skills to find a foundation for your business.

Market research:

Stay updated on current industry trends, consumer preferences, and technological advancements to identify potential gaps in the market.

Problem-solving:

Look for pain points or problems that people experience in their daily lives and consider how you can provide a solution.

Brainstorming:

Generate a wide variety of ideas without immediate judgment. Techniques include:

Mind mapping: Visually organizing thoughts and ideas.

SCAMPER: A structured approach to idea generation that involves substituting, combining, adapting, modifying, putting to another use, eliminating, or reversing elements of an existing idea.

Storyboarding: Using visual illustrations to map out an idea.

Validation:

Test your concept before committing significant resources by conducting surveys, interviewing potential customers, or creating a minimal viable product (MVP).

Refinement:

Based on feedback and research, refine your concept and develop a comprehensive business plan that outlines resources, budget, and timelines.

6.7 Business Planning and strategy

Business planning and strategy involve defining a business's long-term direction and setting short-to-mid-term goals and action plans to achieve it. **Strategic planning** focuses on the big picture, including vision, mission, and long-term goals, while **business planning** translates these strategies into actionable steps for operations, products, markets, and financials. Both are crucial for growth, as strategic planning provides direction and business planning details the tactical execution.

6.8 Financing Business

Business financing is the process of acquiring funds to start, operate, and grow a company through sources like **debt financing** (loans), **equity financing** (selling ownership stakes), **retained earnings**, and **alternative sources** (like crowdfunding or grants). Choosing the right mix of financing depends on a business's specific needs, goals, and financial situation.

Common types of business financing

Debt Financing: Borrowing money that must be repaid over time, usually with interest.

Examples: Term loans from a bank, lines of credit.

How it works: You borrow a lump sum and pay it back in monthly installments. Study.com explains this with the example of financing a car.

Equity Financing: Selling a portion of your company to investors in exchange for capital.

Examples: Angel investors and venture capital firms.

How it works: You trade ownership for funding, so investors become part-owners of the business.

Retained Earnings: Using the profits a business has already earned to fund its activities.

How it works: This is an internal source of funding, so there are no outside obligations to repay.

Alternative Financing: Less traditional methods of raising capital.

Examples: Crowdfunding, government grants, or small business loans from institutions.

How it works: Crowdfunding can be done through online platforms that connect businesses with many small individual investors.

6.9 Environment

The **environment** is the complex of all external living (biotic) and non-living (abiotic) conditions and elements that surround an organism or a community, ultimately influencing their survival, development, and behavior

he Natural Environment

This refers to the natural world and encompasses all naturally occurring living and non-living things.

Components: It consists of the atmosphere (air), hydrosphere (water), lithosphere (land/soil/rocks), and biosphere (all living organisms).

Interactions: The natural environment involves the complex relationships and interactions of climate, weather, living species, and natural resources.

Ecology: Ecology is the scientific study of these relationships between organisms and their surroundings.

6.9.1 The Built Environment

This includes environments that are created or significantly modified by humans, such as urban settings, buildings, roads, and agricultural areas. These environments still rely on the fundamental principles of balance between living and non-living factors but present challenges like pollution and habitat destruction

KP-RETP Component 2: Classroom SECAP Evaluation Checklist

Purpose:

To ensure that classroom-based skills and entrepreneurship trainings under KP-RETP are conducted in an environmentally safe, socially inclusive, and climate-resilient manner, in line with the Social, Environmental, and Climate Assessment Procedures (SECAP).

Evaluator:________________________

Training Centre / Location:________________________

Trainer:________________________

Date: ________________________

Category	Evaluation Points	Status		Remarks /Recommendation
		Yes	NO	
Social Safeguards	Is the training inclusive (equal access for women, youth, and vulnerable groups)?			
	Does the classroom environment ensure safety and dignity for all participants (no harassment, discrimination, or child Labor)?			

	Are Gender considerations integrated into examples, discussions, and materials?			
	Is the Grievance Redress Mechanism (GRM) process, along with the relevant contact number, clearly displayed in the classroom			
	Are the Facilities and activities being accessible and inclusive for specially-abled (persons with disabilities)			

Environmental Safeguards	Is the classroom clean, ventilated, and free from pollution or hazardous materials?			
	Is there proper waste management (bins, no littering)			
	Are materials used in practical sessions environmentally safe (non-toxic paints, safe disposal of wastes)?			
	Are lights, fans, and equipment turned off when not in use			

	(energy conservation)?			
Climate Resilience	Are trainees oriented on how their skills link with climate-friendly practices (e.g., renewable energy, efficient production, recycling)?			
	Are trainers integrating climate-smart examples in teaching content?			
	Are basic health and safety measures available (first aid kit, safe exits, fire safety)?			

	Is the trainer using protective gear or demonstrating safe tool use (where relevant)?			
Institutional Aspects	Is SECAP awareness shared with trainees (via short briefing, posters, or examples)?			
	Are trainees encouraged to report unsafe, unfair, or environmentally harmful practices?			
Overall Compliance	Overall SECAP compliance observed	☐ High ☐ Medium ☐ Low		

Overall remarks/ recommendations			
Name	**Designation**	**Signature**	**Date**