Introduction to Automation Systems

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Schneider Electric

Agenda

MC 80 – Small PAC & RTU

M340 – Mid PAC & RTU

M580 – High End PAC & RTU

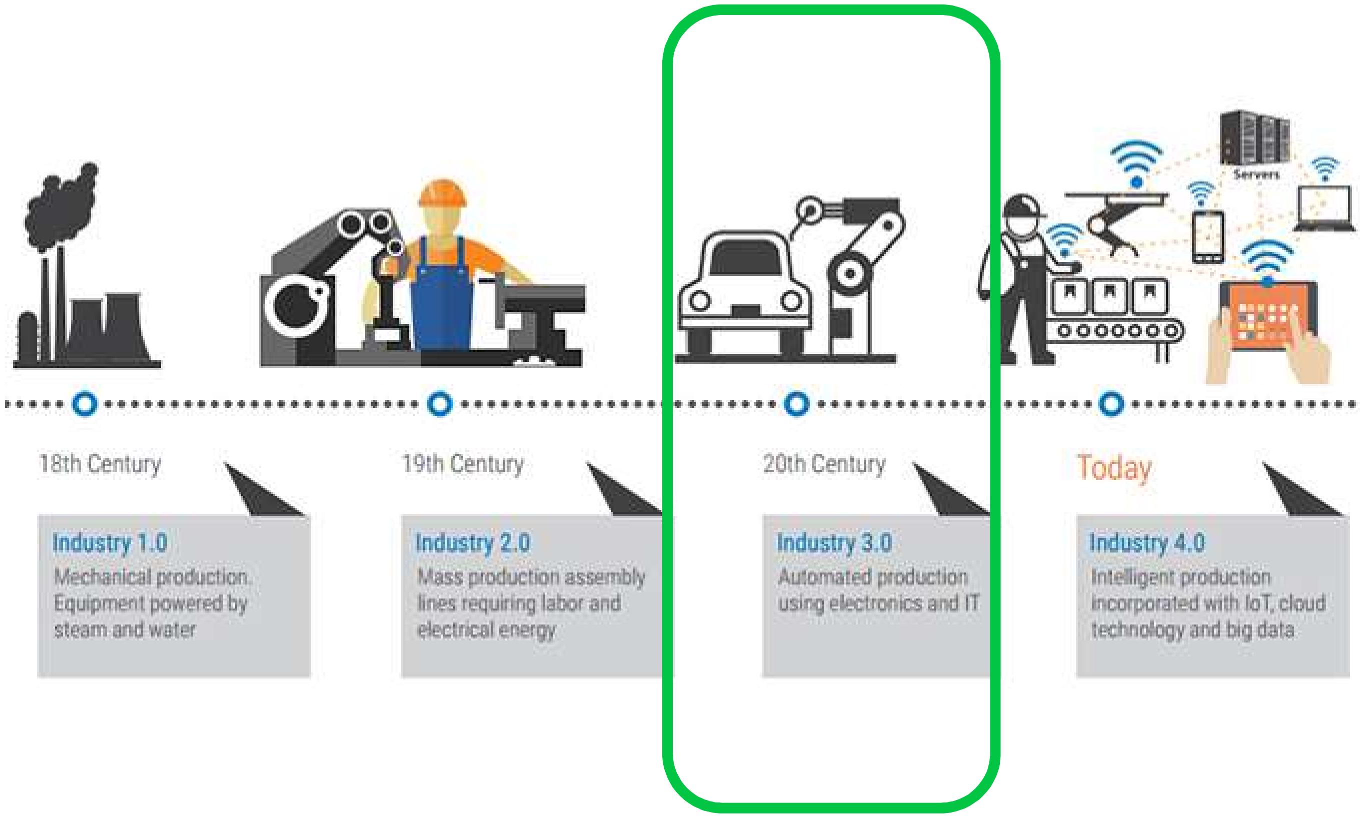
M580 HSBY – High End PAC & RTU

M580 Safety SIL 3 PAC

Modicon Switches & Firewall

1	Control System Fundamentals
2	Automation Control System
3	Industrial Processes
4	Overview of PLC
5	Overview of RTU
6	PAC offering for all EU Applications
7	Discussion

The 4 Industrial Revolutions



What is Automation?

"The technique of making an apparatus, a process or a system operate automatically"

"The technology by which a process or procedure is performed without human assistance"

"Making Products under the control of computers and programmable controllers"

"The Creation and application of technology to monitor and control the production and delivery of products and services"

Introduction to Automation Systems

An Automation System consists of sophisticated hardware and software components that automatically manage and monitor processes within an industrial plant with minimal or no human intervention.

Automation systems are industry influenced, different systems are developed to provide solutions to meet industry requirements

Key Takeaways in this session

- Identify different types of control loops
- Define automatic control systems
- Identify common components of industrial process control system

Control System Fundamentals

A plant requires control systems to operate and maintain industrial production processes. Processes within the plant convert input data to output data. Using the control components and output data, you can achieve accurate measurement and precise execution of these processes.

This topic provides answers to the following questions:

- What is a control system?
- What is the difference between an open-loop and a closed-loop system?
- What is feedforward control?

Introduction to Control Systems

A control system operates either manually or automatically to manage dynamic processes by adjusting or maintaining physical variables, such as temperature, speed, or flow rate.

The following figure represents the flow of activities in a control system.

Input → Process → Output

To ensure smooth flow and better optimization, a control engineer relies on a control system to allow proper input, execute the process, and obtain an output.

Control systems can be categorized into two types of operation:

- **Manual Control Systems** – Processes which are controlled by a person, such as a farmer operating a cultivator to remove weed from soil.
- **Automatic Control Systems** – Processes do not require a person to operate the system; a machine runs the system independently. An air-conditioning unit which has its output temperature setting controlled by a thermostat is an example of an automatic control system.

Objective of Control Systems

Modicon PAC controllers support the customers to achieve the following aims

Real time operations management

Robust Safety and environment management

Better quality control and customer service

Performance control and management

Accelerate processes

Improve productivity and accuracy

Boost sustainability, Save time and money

- Operating principles

Operative Part

Command Part

Sensors

Reports

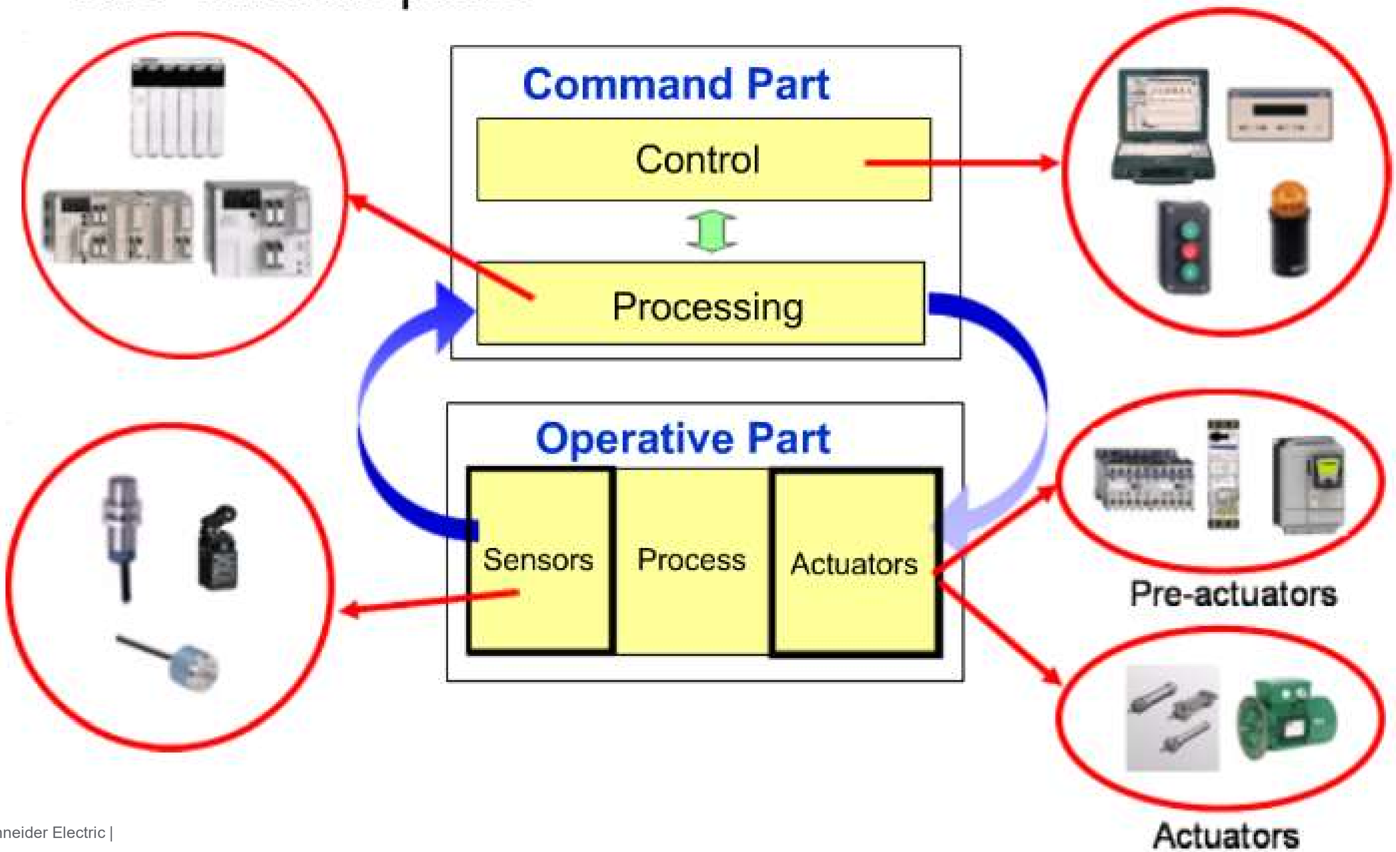
Commands

Actuators

acts on
physical values
solid, liquid or gaseous products
machines or processes

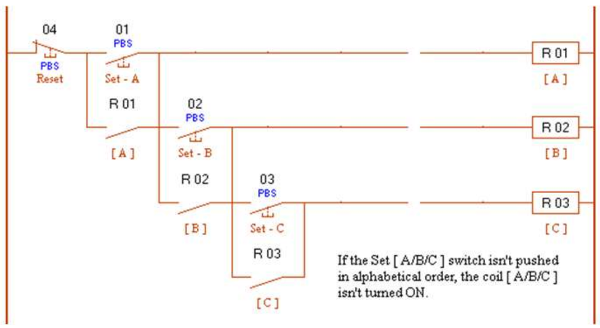
one or more processors
controlled by
man-machine interfaces

- The various parts

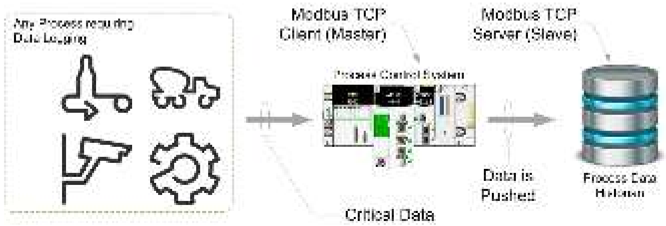


Applications of PLC

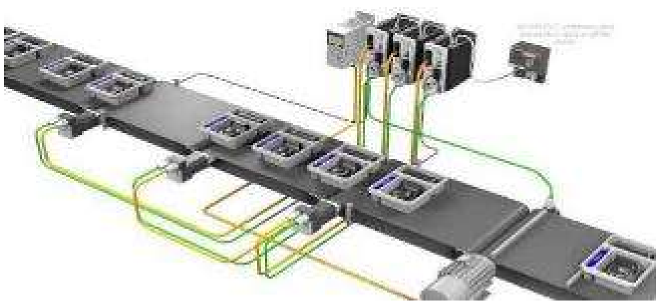
Typical day to day use cases



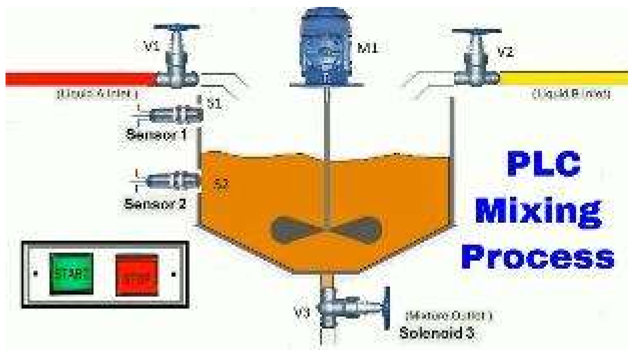
Interlocking & Changeover



Data Logging



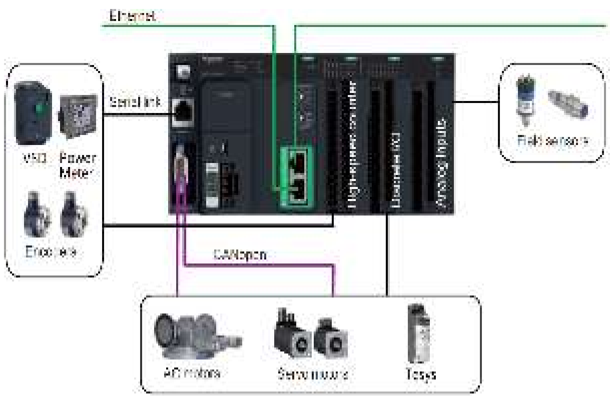
Sequencing & Line Control



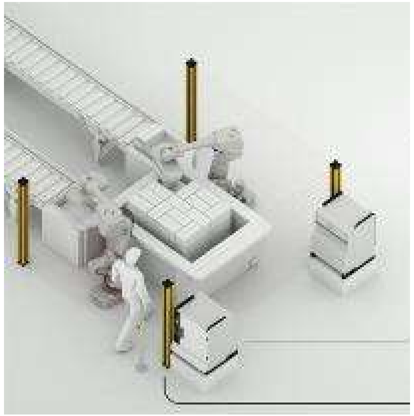
Process Control

Applications of PLC

Contd.



Control of Drives & IMCC
& Communication Gateway



Safety & Protection

Open-Loop Control

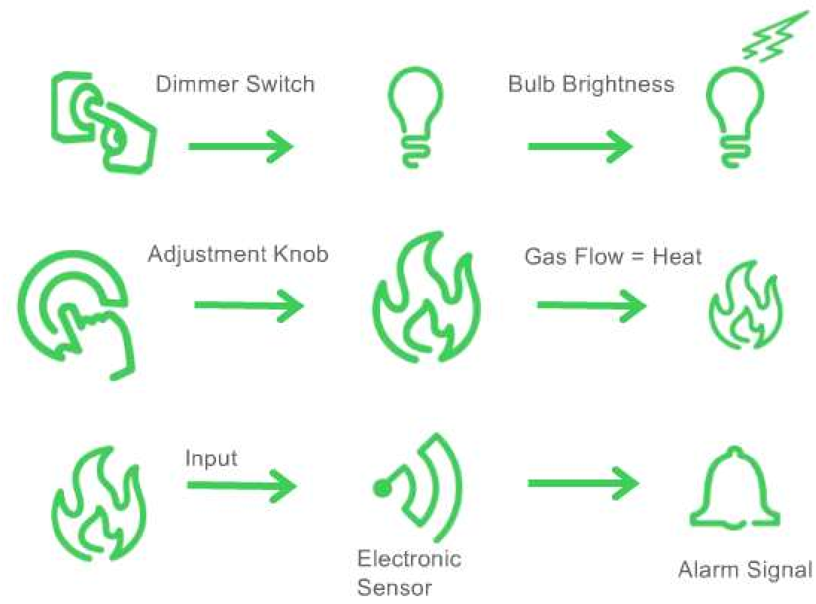
Control systems can be further classified into two common classes depending on how information is used to decide an action.

An open loop control system is a system that does not feed information from the process to the controller to decide the control action.

A sprinkler system controlled by a timer is a good example of an open loop system. If the timer is set to open the water valve at 9:00 pm every day, it does so regardless of the intensity or availability of water.

Here are common examples of the use of open-loop control to control a process:

- An automatic light dimmer controlling a light bulb.
- An adjustment knob to decrease the heat on the hob.
- A fire alarm, the electronic sensor sense the fire, the alarm rings.



Closed-Loop Control

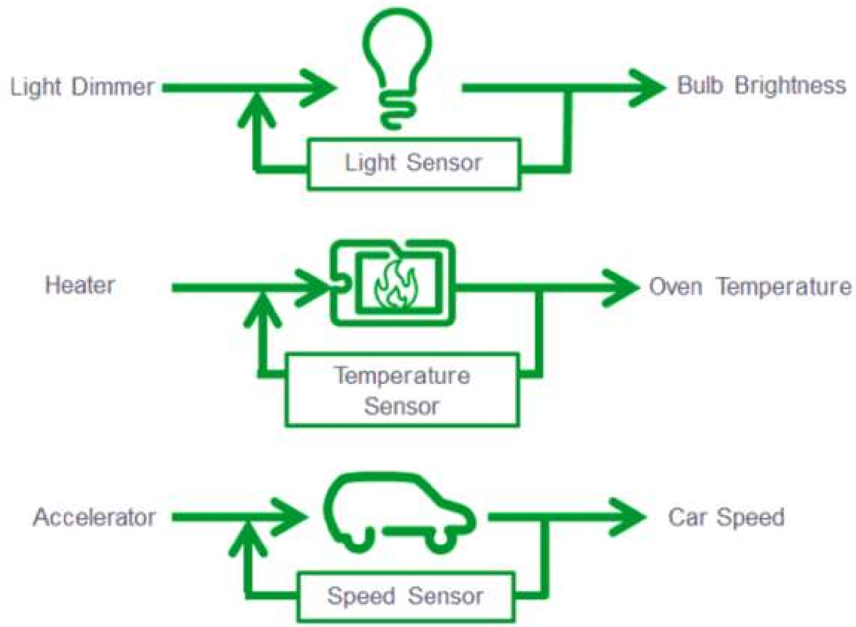
A control system whose controller is using a measure of the processed output as feedback to decide the control action is a closed-loop or feedback control system.

The controller uses the set point to compare with the measured process output to compute the control action.

A common household item which uses closed loop control is the refrigerator. The controller uses a thermostat to compare the actual temperature inside the refrigerator to the required temperature. If the temperature is too high than what was set, the controller starts the cooling process. When the temperature becomes too low, the controller shuts the cooling process.

Here are other common examples of the use of closed-loop control:

- The electrical current feeding a bulb
- A temperature controller of an oven
- A cruise controller of a car



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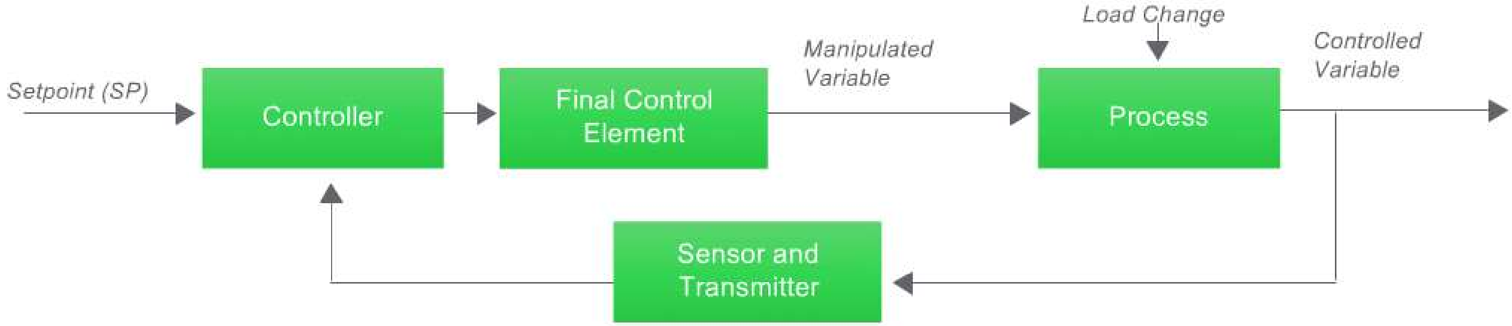
Fundamentals of Closed-Loop Control

A control system closed-loop helps you measure, evaluate, and actuate a control system. The following illustration depicts the flow of process in a control system with feedback.



Theoretically, a closed loop consists of four basic components:

- Controller
- Final control element
- Process
- Sensor and transmitter

You must define the setpoint (SP), manipulated variable, and controlled variable for a feedback loop.

Feedforward Control System

Control systems are complex systems whose characteristics are not limited to just the two basic classifications discussed so far. Control systems can use predictive control as a form of early warning to the control system. An experienced control engineer, who fully understands the process, identifies trends or any information that can predict a fault or a certain state. The engineer feedforwards the information to the control system to take the appropriate control action ahead of time.

The images below show examples for feedforward control. *Click each image for more information.*

Feedforward Control System

Control systems are complex systems whose characteristics are not limited to just the two basic classifications discussed so far. Control systems could use predictive control as a form of early warning to the control system. If the control engineer understands the process well and can identify trends or any information which would predict a fault or a certain state, he feedforwards the information to the control system to take the appropriate cor

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You can observe the feedforward control mechanism in a water balloon toss contest. When a person tosses a water balloon towards his team member standing a few meters away, the latter receives the balloon without giving too much pressure to the balloon. He controls his body to receive the balloon gently so that the balloon will not burst. Knowledge of what was heading helped him succeed.

Feedforward Control System

Control systems are complex systems whose characteristics are not limited to just the two basic classifications discussed so far. Control systems could use predictive control as a form of early warning to the control system. If the control engineer understands the process well and can identify trends or any information which would predict a fault or a certain state, he feedforwards the information to the control system to take the appropriate control action ahead of time.

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A more complex example is the control of power generation plants in industry. During summer, there is high consumption of electricity because of high usage of air conditioners. To meet electricity demand cycles during summer, power plants feedforward this information to the plant controller to get the plant ready for the upcoming demands and thereby increase the power generation output.

Automatic Control System Fundamentals

Automatic control systems are becoming imperative in all fields of engineering. The control systems applications cover a very wide range of designs, from delicate electronic equipment to massive industrial equipment, such as steel manufacturing.

This topic answers the following questions:

- What is an automatic control system?
- What is the analogy between automatic control system and human body?

Automatic Control Systems

Some of the earliest automatic control systems, such as water clocks, ages back to 270 BC. Automatic control systems evolved in complexity during the Industrial revolution, hence entering the digital age.

Advantages of automatic control system include but are not limited to:

- Increased quality with minimal human intervention and errors
- Achieve high levels of consistency and accuracy
- Monitor operation and performance
- Increased productivity with reduced cost

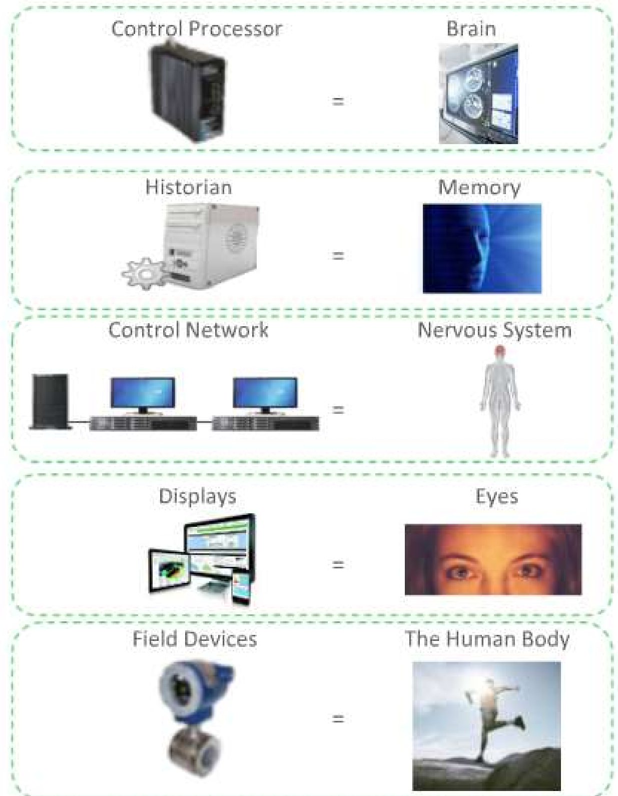
Engineers use feedback systems to ensure that the system is stable, robust, immunized against disturbances and that the systems output tracks the command signal.

Controllers or compensators receive feedback from actuators, sensors, motors, and other devices with set parameters. Predictive feedback can be fedforward to the automatic control system, when required.

Control System Analogy

The functionality of a control system resembles a human body, where in:

- The control processor acts as the brain of the system.
- The historian is the memory and the control network represents the human nervous system.
- The display units function as the eyes of the control system.
- The field devices (instruments) work similar to the other human body parts.



Industrial Processes

The automatic control systems help control and manage complex industrial processes.

This topic answers the following questions:

- What is an industrial process?
- What are the types of industrial production processes?
- What is the evolution of industrial process control systems?
- What are the components of industrial process control system?

Industrial Processes Overview

Industrial processes are procedures involving chemical or mechanical steps to aid in the manufacture of one or more items. Such processes are performed on a large scale using automatic control systems.

Some of the popular industrial processes are:

- Forging
- Pyroprocessing
- Refining
- Machining
- Distilling
- Mining
- Casting
- Stamping
- Smelting

Industrial Production Processes

There are three types of industrial production processes. Control systems can operate one or more types of production processes.

Click each production process for more information.

Continuous Production Process

Discrete Production Process

Batch Production Process

Industrial Production Processes

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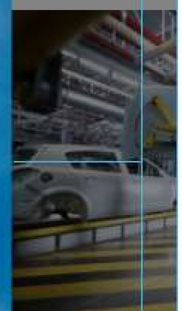

A continuous production process is a nonstop procedure wherein raw materials are continuously fed into the plant. These materials pass through different stages in the production process and the final outcome continuously flows out of the plant.

In large, continuous production processes are followed by petrochemical plants, oil refiners, power stations, and pulp and paper plants.

Continues Production Process

Discrete Production Process

Batch Production Process

Industrial Production Processes

There are three types of industrial production processes. Control systems can operate one or more types of production processes.

Click each production process for more information.

In a discrete production process, an individual product is built in stages; for example, cars, computers, and mobile phones. In contrary to the continuous production process, a discrete process is a discontinuous process. A process starts, performs a function, and then stops. In the next stage, the output moves on the conveyor belt. After this cycle of events, another discrete process runs until the final product is produced at the end.

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Industrial Production Processes

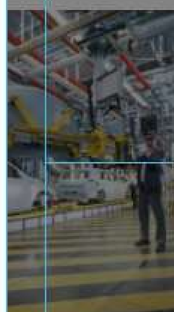
There are three types of industrial production processes. Control systems can operate one or more types of production processes.

Click each production process for more information.

Batch production process is a combination of continuous and discrete processes, wherein products are produced in batches.

For example, a bakery uses a reservoir to prepare dough, which is sufficient to bake a batch of 1,000 cookies. After the reservoir empties, the baker uses a continuous process to prepare the dough, which is used for the next batch of cookies; the process is sequential.

Examples of industries that use the batch process are pharmaceuticals, beverage, and newspaper production plants.



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Logic Control Basics

After discussing open-loop and closed-loop control systems, which are the basic control solutions facilitating continuous control.

Discrete control systems, where the values to be controlled are described as on-off, are controlled through conditional or sequential logical functions.

For example, a control unit of a cable car transferring people or goods from one peak to another can be divided into two categories:

Logical (Sequential):

1. When push button one is activated, the cable car moves towards peak one.
2. When proximity sensor one at peak one detects the cable car, the car doors opens.
3. When close doors push button is pushed, the car door closes.

Continuous:

1. If the set point and position changes to a new state, the car moves towards that state at a speed predefined per controller tuning.
2. When the cable car approaches the preset state, the car reduces the speed and opens the doors upon arrival.
3. The controller continuously compare the setpoint with the current state and take the control action accordingly.

We will learn more about the logic control in the PLC topic.

Industrial Process Control Systems

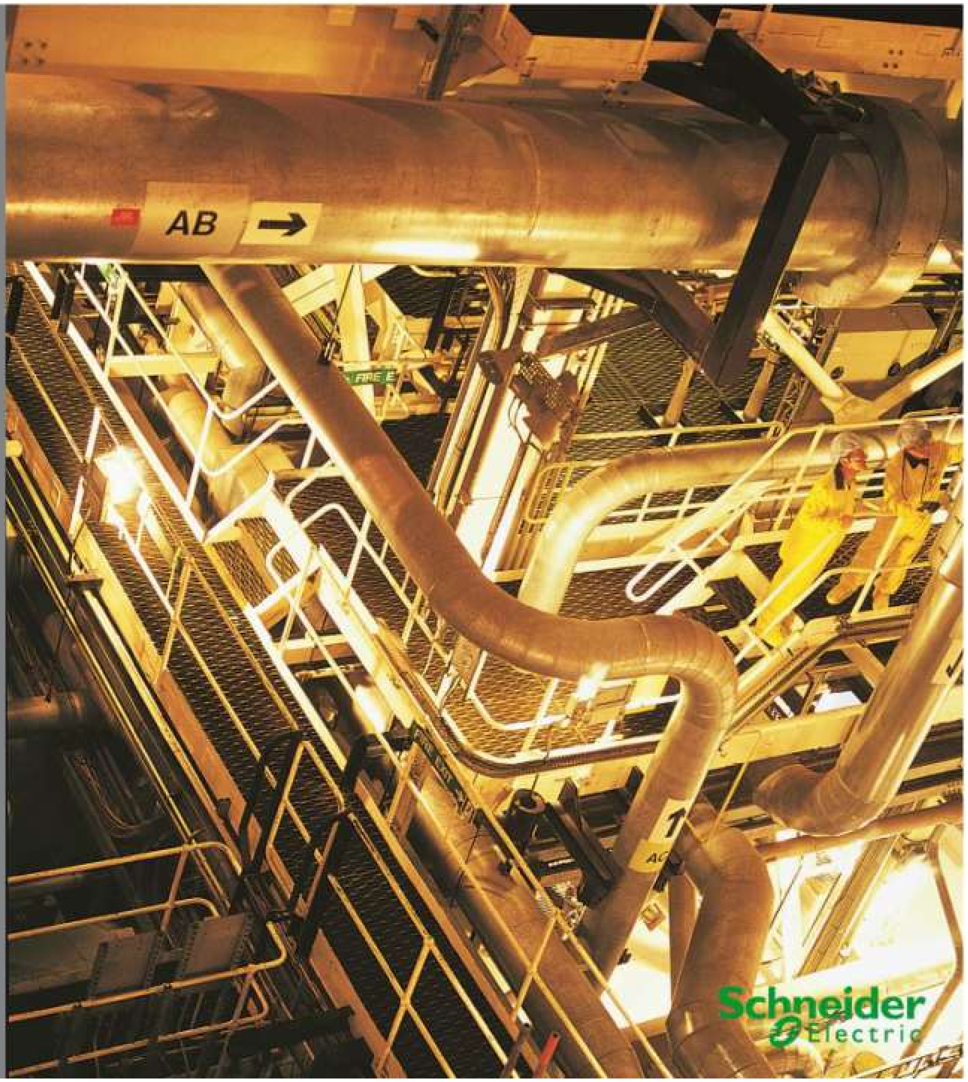
Industrial process control systems manage and monitor the control loop of an industrial process.

Common industrial process control systems include:

- Programmable Logic Controller (PLC) system
- Distributed Control System (DCS)
- Supervisory Control and Data Acquisition (SCADA) system

Using industrial process control systems, you can:

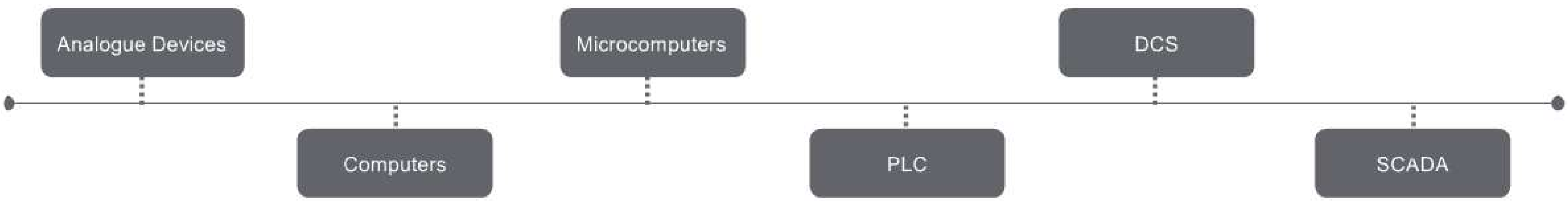
- Automate all industrial processes and activities.
- Minimize or eliminate human intervention.
- Execute a pre-defined action based on the result of a process.
- Perform real-time operation management.
- Ensure better performance and productivity.



Evolution of Control Systems

The industrial process control systems have undergone years of research and development to adaptively provide better functionality and integrate high level technologies.

Digital computers and software technologies are advancing; systems initially designed for different, but complementary industrial automation requirements are converging. The differentiating lines between various classes of industrial automation systems will eventually disappear as more universal automation platforms emerge. The timeline below explains how and why each system was developed. *Click each system for more information.*



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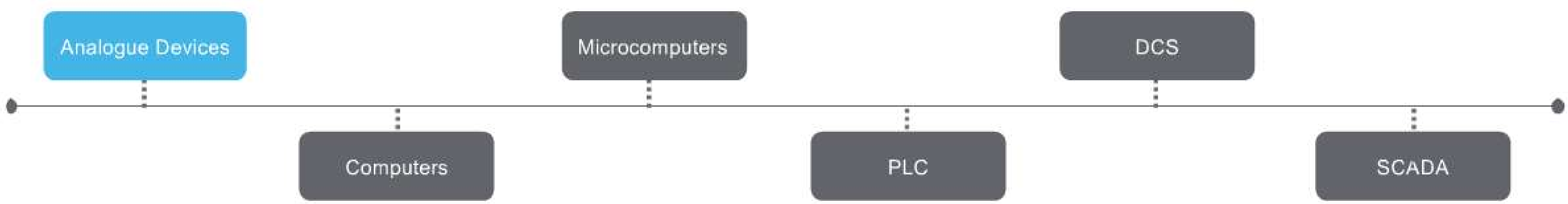
Evolution of Control Systems

Before the 1950's, only mechanical and electrical manipulation succeeded in operating process controls. Control systems were basically a group of analogue devices or relays connected with wires.



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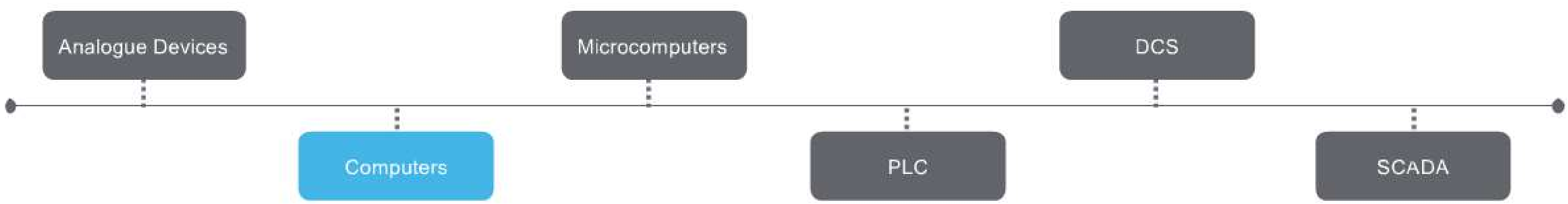
Evolution of Control Systems

In the 1960's, computers were introduced in process control systems as assistive tools and not as the main process controllers. The process was run by analogue devices, and computers assisted in supervision and limited process control functionalities.



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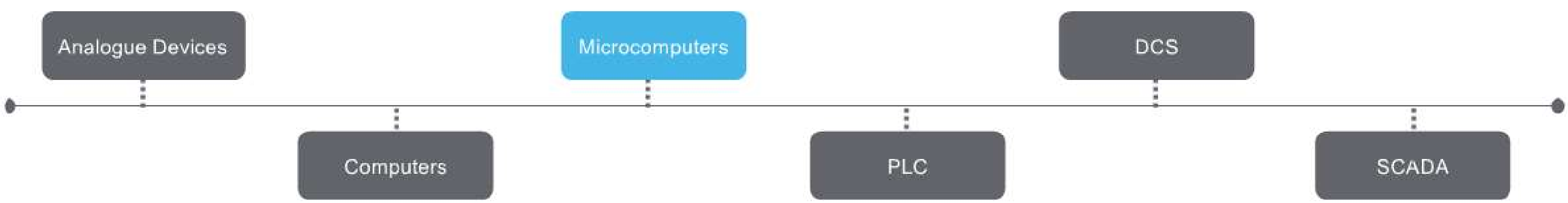
Evolution of Control Systems

In the 1970's , microcomputers and microprocessors evolved. They leveraged for cheaper, smaller, and faster computer process controlled systems.



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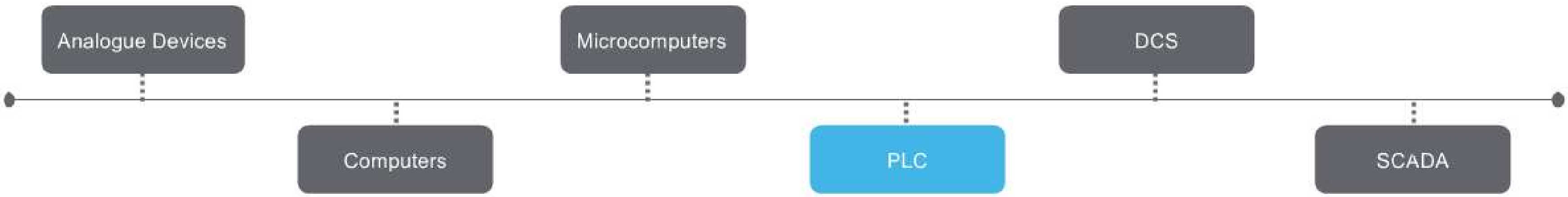
Evolution of Control Systems

PLC systems were developed to replace the earliest types of control systems, the Relay control systems. Relay control systems consumed a lot of space and required extensive wiring. The process changes were time-consuming. Troubleshooting was a tedious job because of extensive wiring and vast reference documents, which complicated tracing wires connecting the Relays.

In 1969, the first PLC was introduced, the Modicon 084. Ladder logic was used to configure the controller and is still used in Modern PLCs. PLCs were designed to have the program downloaded to the memory through an engineering station, the processor runs through the logic control sequence using the logic solver, while controlling field equipment through a field interface device.



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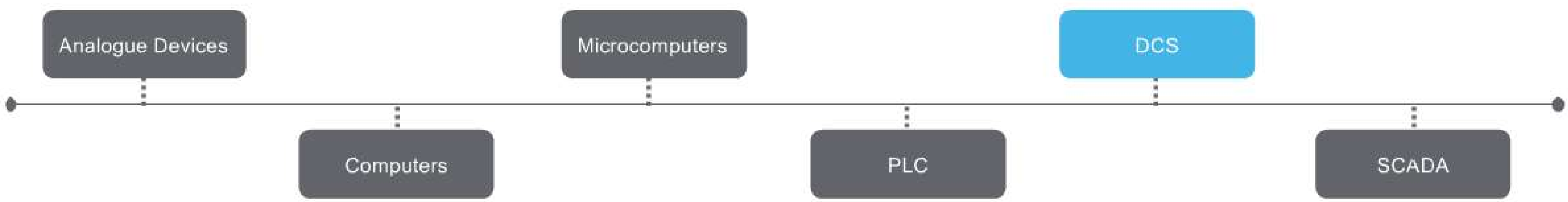
Evolution of Control Systems

By the 1980s, industries were transferring from analogue control systems to computer systems. The concept of a central computer system interfacing with a network of computers controlling processes was introduced. Demand for a geographically and functionally distributable system grew and DCS was born.



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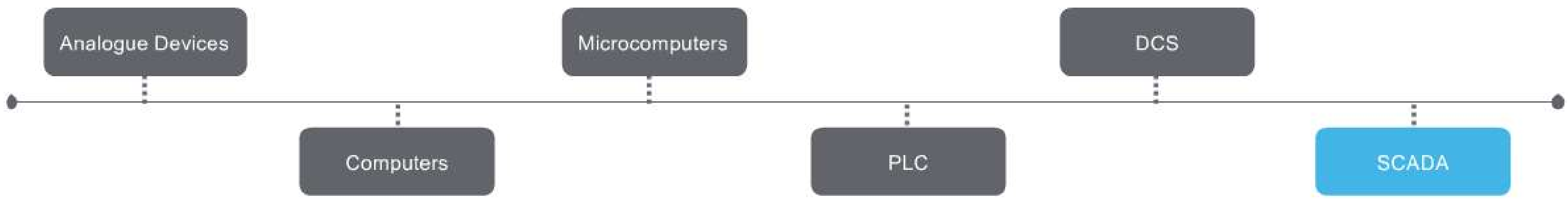
Evolution of Control Systems

SCADA systems provide automation solutions for long distance, such as long pipelines. These pipelines require supervision and controls similar to industrial plants controlled by DCS and PLC systems. SCADA systems extend automation beyond the plant over long distances. This course discusses SCADA for telemetry solutions, that is automation over distance using Remote Terminal units (RTU) supervised by a Master Terminal Unit (MTU).

Note: The term SCADA is ambiguous because some personal computers with software similar to DCS functionality, such as operator interfacing and process control, are also called SCADA.



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Industrial Process Control System Components

A typical process control system consists of the following three components.

Click each component for more information.

Control Field

Controller

Control Room

Overview of PLC

PLC control systems are used in a wide range of industries because they are easily programmed, maintained and can withstand tough environments.

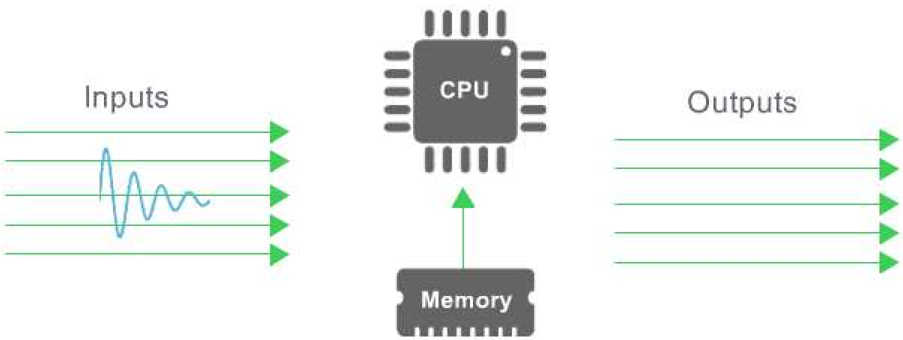
This topic answers the following questions:

- What is the PLC hardware?
- What are the PLC programming languages?
- What are the advantages of PLC?

Programmable Logic Controller Overview

A programmable logic controller (PLC) is a modular solid state computer with custom programming. PLCs are used in industrial control systems for machinery in a wide range of industries, including many of those involved in critical infrastructure. PLCs replaced many antiquated systems, such as relays, drum sequencers and cam timers. PLCs are not as functionally rich as DCS.

PLC is essential in processes that require high reliability control, such as robotic devices or assembly lines. PLC processes a program from the memory, reads the signals from the input devices, and then takes a decision that affects the output devices per program logic.



PLC Hardware

The following are PLC hardware components:

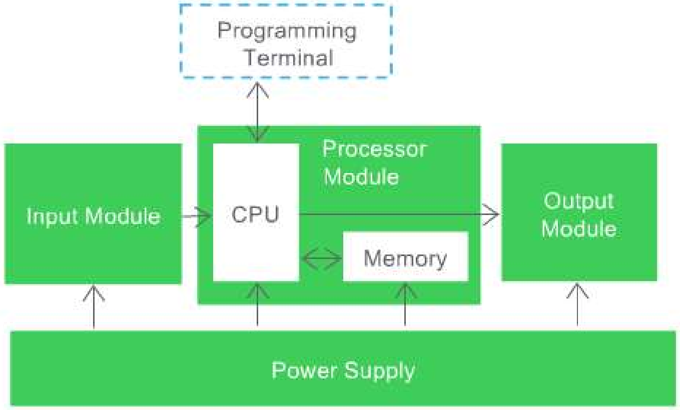
- Processor module
- Power supply
- I/O modules

In the displayed figure, the arrows between blocks indicate the information and power flowing directions.

The processor module consists of the central processing unit (CPU) and memory. In addition to a microprocessor, the CPU contains an interface to a programming device. It also contains interfaces to remote I/O and other communication networks. The power supply is usually a separate module.

The I/O modules are separate from the processor. The types of I/O modules include discrete (on/off), analog (continuous variable), and special modules like motion control or high-speed counters. The field devices are connected to the I/O modules.

The programming terminal in the diagram is not a part of the PLC, but it is essential to have a terminal for programming or monitoring a PLC.



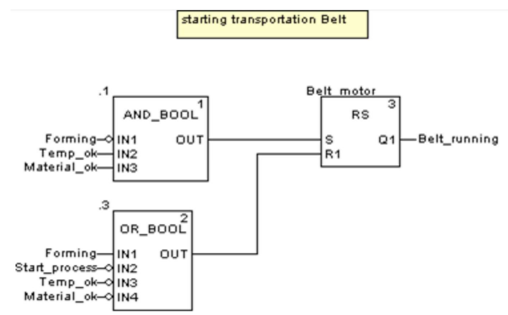
PLC Hardware Block Diagram

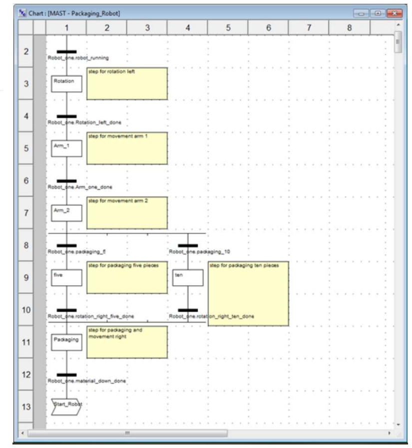
PLC Programming Languages

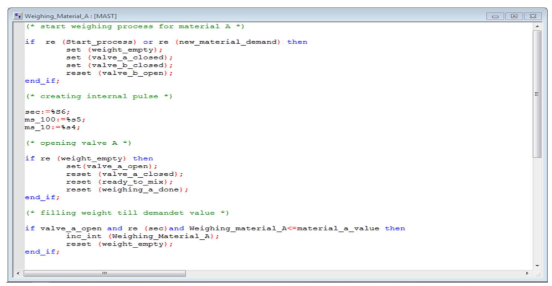
A programmer writes PLC programs in a special application on a personal computer, and then downloads through a direct-connection cable or over a network to the PLC. He stores the program in the PLC either in battery-backed-up RAM or some other nonvolatile flash memory. Generally, you can program a single PLC to replace thousands of relays .
You can program a PLC using the following standards-based programming languages:

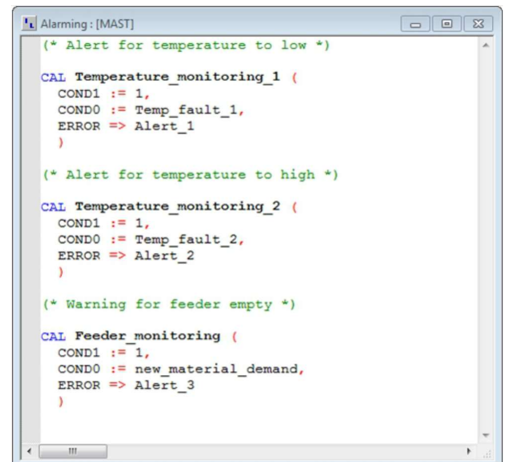
- Ladder diagram (LD)
- Sequential Function Chart (SFC)
- Function block diagram (FBD)
- Structured text (ST)
- Instruction list (IL)

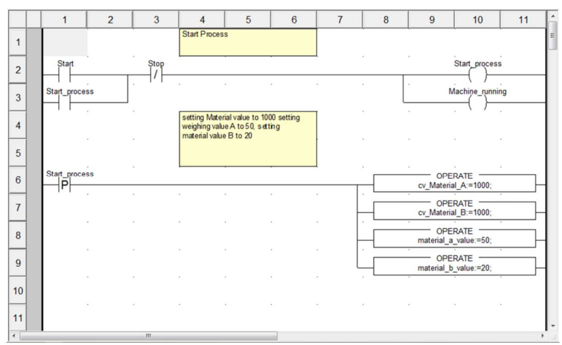
These languages emphasize logical organization of operations.
The fundamental concepts of PLC programming are common to all manufacturers, differences in I/O addressing, memory organization, and instruction sets mean that PLC programs are not interchangeable between different makers. Even within the same product line of a single manufacturer, different models may not be directly compatible.











Life Is On

PLC Advantages

The advantages of PLC include:

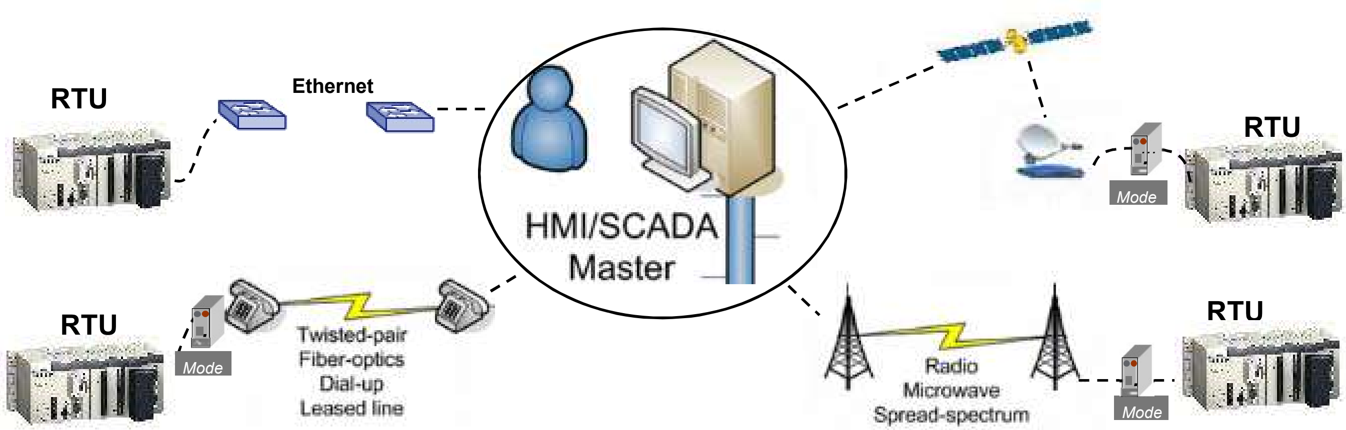
- Increased system flexibility
- Low cost
- Fast system response
- Easy troubleshooting
- Controlled remotely
- Space efficient

these advantages imply the following:

- You can run many machines on one single PLC.
- You can simply retype the logic to make any change in circuit design or sequence. Correcting errors in PLC is extremely short and cost effective.
- You can test and evaluate a PLC program in a lab.

What is an RTU?

An **RTU**, **(Remote Terminal Unit)** is an electronic device which operates as a stand-alone data acquisition and control unit. It also interfaces remote stations with Telemetry/SCADA systems or other Distributed Control Systems (DCS).



RTU Key Features

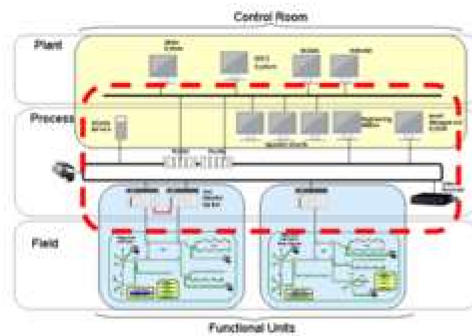
The key features of an RTU are:

- Monitor Analog and Digital field values.
- Transmit data to the Central Monitoring Station.
- Support standard RTU protocols.
  - DNP3
  - IEC 60870-5 -101 & 104
  - Modbus
- Communications with other RTUs.
- Generally for wide geographically dispersed Telemetry applications.
- Harsh Environment support. (-20deg to +70deg C)
- Act as a Relay Station (Store and Forward).
- Non permanent communication connections.

RTU vs. PLC

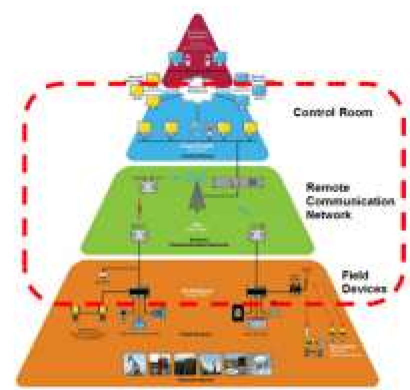
Plant solutions use **PLCs** to automate process control through connection with field devices.

- Important characteristics for PLCs in the plant environment include determinism of control algorithms, I/O performance and interconnectivity with field bus technologies.



Remote solutions use **RTUs** to collect data from field devices.

- RTUs provide sophisticated communications to overcome the unreliable, non-permanent and low bandwidth nature of many remote communication solutions.
- RTUs do this whilst preserving information integrity. RTUs often integrate data from a wide variety of local devices.



Plant vs. Remote Challenges

SCADA Communication links:

- **Plant**: high bandwidth, network engineered for high reliability, typically < 100 local devices.
- **Remote**: low bandwidth, low reliability, long distances to field sites, typically 20 ~ 2000 remote devices.

Communication Methodology:

- Polling of **PLCs**: current data.
- **RTUs**: event driven, polling, optional unsolicited reporting.

Communication Protocols:

- **PLCs**: OPC, Modbus/TCP, EtherNet/IP protocols.
- **RTUs**: DNP3, IEC 60870-5, Modbus, proprietary.

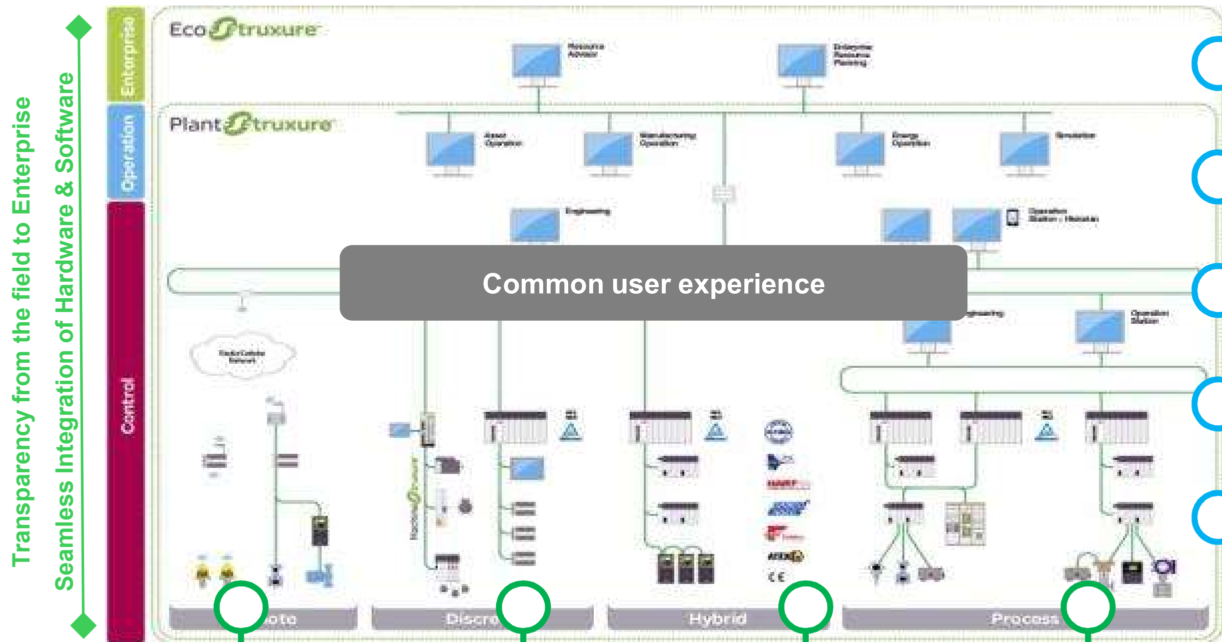
Field Devices:

- **PLCs**: Large I/O counts, Fieldbus connectivity.
- **RTUs**: small to medium I/O, integrated/lower price expectation, discrete device communication (more ports).

Plant Automation offer

Our Offer for Plant Automation:

Providing users with greater Information transparency, efficiency, redundancy, and flexibility to make operations more efficient



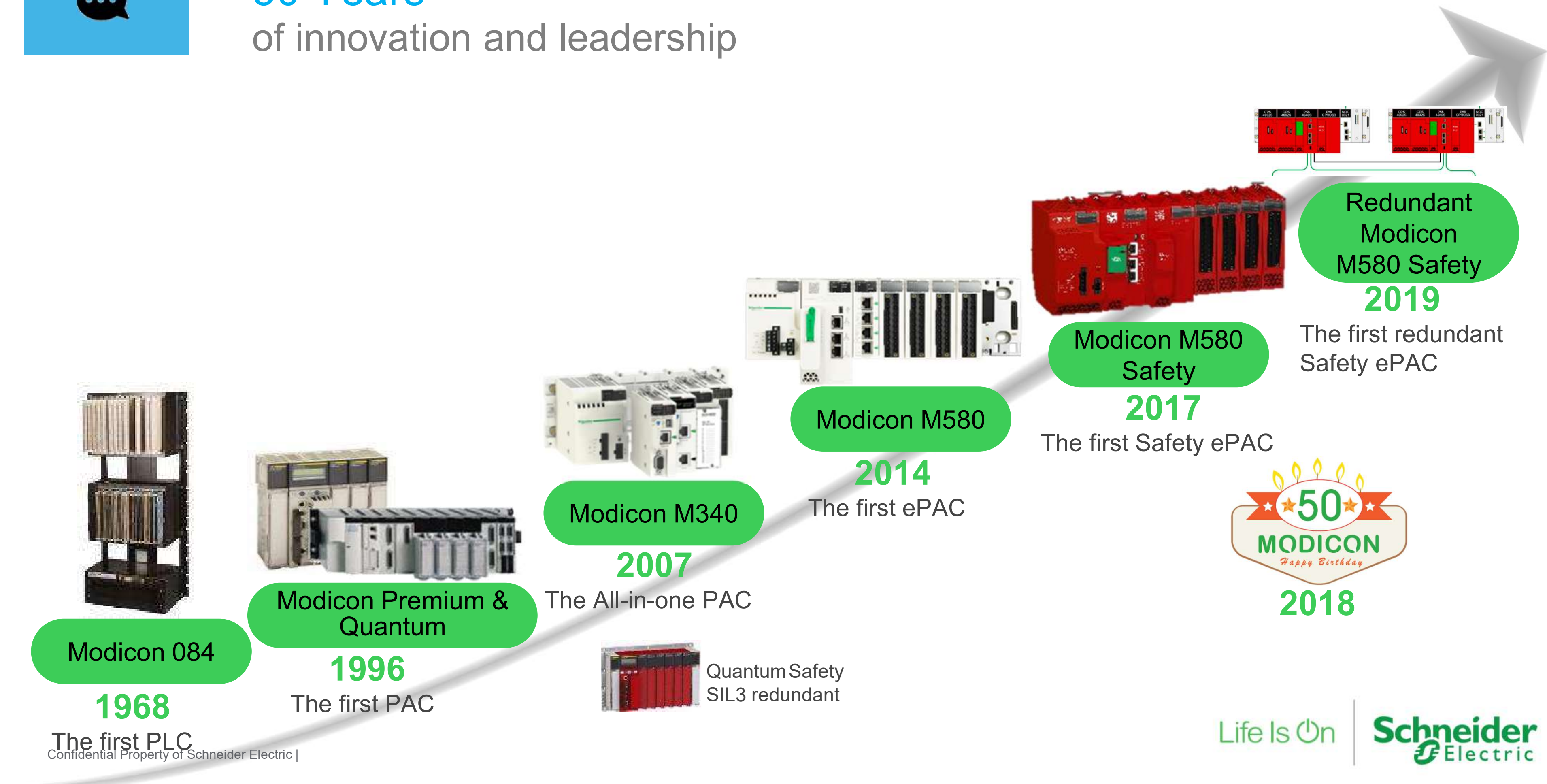
- IT/OT Convergence
- Industry specific Solutions
- Ethernet architecture
- Proven in use brands
- Life time services

Remote	Discrete/Hybrid	Process	Safety
M340 RTU	M340 M580	EcoStruxure Plant DCS	M580S

Best in class offers across 4 key automation profiles

50 Years
of innovation and leadership

team



Life Is On | Schneider Electric

One scalable Modicon PAC Offer with tangible benefits

-25% Time to Market

x5 Productivity

Safe ↘ Likelihood of cyber-attacks

Save Process Energy Consumption

+++ Improve Revenues

Control Expert Software

Modicon M340

Modicon M580

Modicon MC 80

Modicon Firewall & Switch

Modicon STB I/O System

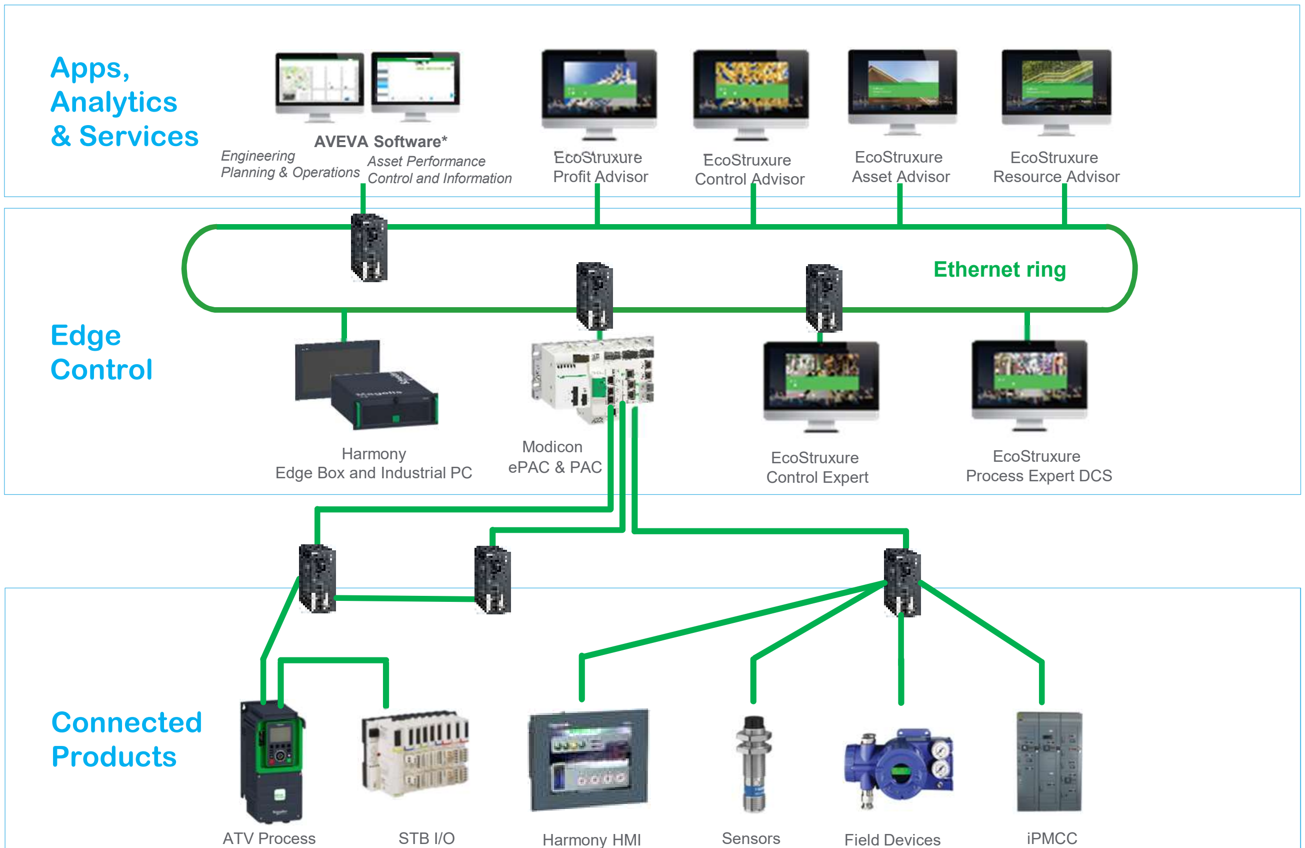
Modicon X80 I/O System

- Achieve **earlier return on automation investment** for greenfield and modernization projects
- **Operate efficiently** and **protect your plant** with increased availability and strong cybersecurity
- Unleash quickly **the potential of digitization** in your automation to better grow your business

… to serve Automation needs in a wide range of Industries

Water & Waste Water	Food & Beverage	Mining, Metals & Minerals	Oil & Gas	Infrastructures	Energy Generation
Pumping station control, Desalination plants, Waste water treatment…	Dairy Foods, Liquid Foods, Agro Business (Silos, Sugar..)	Extraction, Grinding, conveyors, Cement, blast furnace, steel production	Transportation pipeline management Gas Processing	Airports luggage systems, metros / tunnel signaling control..	Gas / steam turbine control, solar field management, nuclear auxiliaries

Application in Digital Plant Field



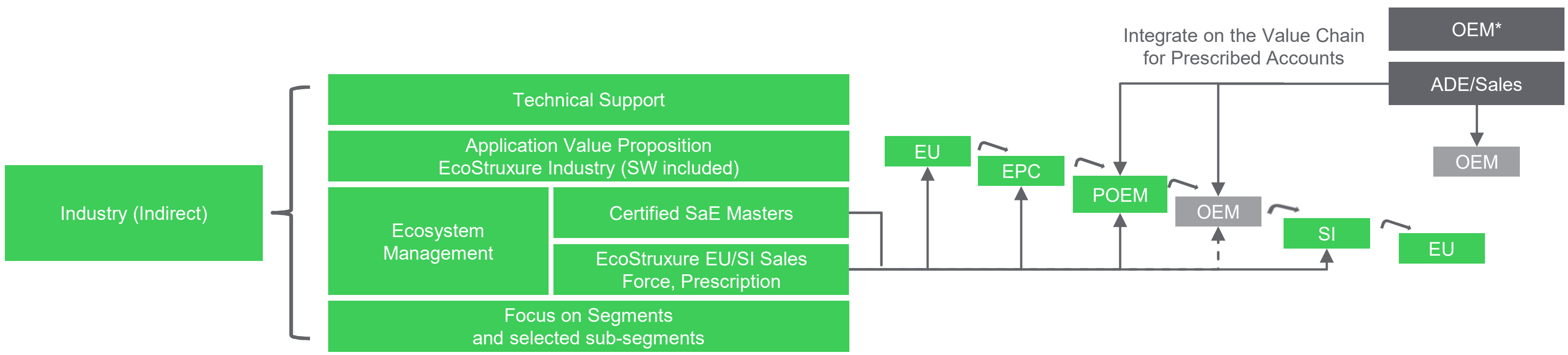
Answer customer challenges and market trends

With IIoT-ready solutions, industrial operations are future-ready

- ENHANCED SAFETY
- DATA-DRIVEN OPTIMIZATION
- GREATER CYBERSECURITY
- MAXIMIZED PRODUCTIVITY

Managing the full Value Chain

3.2 End User SI GTM



OEM* No changes on the current model for non-prescribed OEM

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Questions to be asked for Automation

Are you using Automation in your current plant? What is your plant process? Continuous , Discrete , Batch + UTILITIES (WAGES)

If yes, who is the current supplier of automation?

What are the parts of the plant that are under automation?

Are the utilities integrated in it?

Are you happy with the service?

Is Automation fulfilling your expectations for plant performance? Or Do you still rely on the Operator for manual controls and automation only for monitoring

What are your future expectations

Would you like to have utilities, plant and electrical integrated into one system? Or are you looking to expand the scope or have any more capacity augmentation ?

Reduce the reliance on the operator?

Help you with planned maintenance / increasing the operational efficiency?

If no, are you looking to automate your plant?

2. What part of the process / section are you looking to automation? Main process or utility?

3. How do you think automation will benefit you / expectations for going forward into automating a plant

4. What is the expectation on the service part?

Modicon is Back!