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Unit 1

Syllabus →

Duration (hour)		9
S-1	SLO-1	*Programmable logic controllers*
	SLO-2	*PLC vs Computer*
S-2	SLO-1	*Parts of a PLC*
	SLO-2	*Architecture*
S-3	SLO-1	*PLC size and Application.*
	SLO-2	*Fixed and Modular I/O*
S-4	SLO-1	*Discrete Input Modules*
	SLO-2	*Discrete Output Modules*
S-5	SLO-1	*Analog Input Modules*
	SLO-2	*Analog Output Modules*
S-6	SLO-1	*Special I/O Modules*
	SLO-2	*High Speed Counter Module*
S-7	SLO-1	*Power Supplies*
	SLO-2	*Isolators*
S-8	SLO-1	*Input/output Devices: Switches*
	SLO-2	*sensors*
S-9	SLO-1	*Relays*
	SLO-2	*Solenoid valve*

CT1 (17th Feb 24) →

5 mcq

2*

4 marks

*1**

12 marks

Contents

Session	Topic	Reference
1	PLC vs Computer	Frank D. Petruzella, Programmable Logic Controller
2	Parts of a PLC	
3	Architecture, PLC size and Application.	
4	Fixed and Modular I/O	
5	Discrete Input Modules, Discrete Output Modules	
6	Analog Input Modules, Analog Output Modules	
7	Special I/O Modules, High Speed Counter Module	
8	Power Supplies, isolators, sensors	
9	Input/output Devices: Switches, Relays, Solenoid valve	

Question Bank

Industrial Automation

Unit I

1. Sourcing input/output circuit supply current to_________ field device.
   A. Sinking
   B. Digital
   C. Sourcing
   D. Analog

Ans: Sinking

2. Sensor is a device that converts
   A. Electrical signal into physical quantity
   B. Physical quantity into mechanical signal only
   C. Mechanical signal into electrical
   D. Physical quantity into measurable signal

Ans: Physical quantity into measurable signal

3. The father of PLC is
   A. Bill gates
   B. Charles Babbage
   C. DickMorley
   D. Massachusetts

Ans: DickMorley

4. Which of the following is not a part of PLC?
   A. CPU
   B. Memory
   C. Power unit
   D. Relay

Ans:Relay

5. The first company to build PLC was
   A. General motors
   B. Modicon
   C. Allen Bradley
   D. Siemens

Ans:Midicon

6. Relay is a (an) _______ switch
   A. Toggle
   B. Selector
   C. Electromagnetic

D. Electric

Ans: Electromagnetic

7. The ______ is moved towards relay magnet when relay is ON
   A. Armature
   B. Coil
   C. NC contact
   D. NO contact

   Ans :Armature

8. Which of the following cannot be an input to a PLC?
   A. Manual switch
   B. Relay
   C. Sensor
   D. Thermocouple

   Ans: relay

9. Which of the following can be a input of PLC
   A. Sensor
   B. Solenoid
   C. Buzzer
   D. Motor

   Ans: Sensor

10. Choose the function an input module of a PLC
    A. Sense when the signal is received
    B. Isolate the PLC from fluctuation
    C. Sense the input and isolate the PLC from fluctuation
    D. Send the signal to output device

    Ans: Sense the input and isolate the PLC from fluctuation

11. Solenoids, lamps, motors are connected to
    A. Analog output
    B. Digital output
    C. Analog input
    D. Digital input

    Ans: Digital output

12. PLC are designed to operate in the _________ environment

D. Industrial - Answer

13. _________ separates the higher AC input voltage from logic circuits in PLC

A.Diode

B.Optical Isolator - Answer

C.Switch

D.Transistor

14. A high-density discrete I/O module have up to ___________ points

A.16

B.32

C.64 - Answer

D.128

15. A PLC which does not require to communicate with other PLCs

A.Stand-alone - Answer

B.Multi task

C.Control management

D.Distributed

16. In discrete output module, _______ is not used as a switching element

A. SCR - Answer

B. Relay

C. Transistor

D. Triac

17. Which of the following is not a standard signal range

A. 0-20mA

B. 4-20mA

C. 10-20mA - Answer

D. 0-10V

18. Which of the following is not relevant to fixed I/O PLC

A. No removable units

B. lower cost

C. divided by compartments

D. lack of flexibility

19. The function of input module in a PLC is

A. Send the signal to output device

B. Sense when the signal is received - Answer

C. Process the input signal

D. Actuate the output signal

20. _______________ are designed to operate only when a predetermined limit is reached

A. Toggle switches

B. Push buttons

C. Limit switches - Answer

D. Relays

21. Which of the following device can be a input of PLC

A. Sensor - Answer

B. Solenoid

C. Buzzer

D. Motor

22. The PLC are designed for ______ inputs and ______ output arrangements.

A. Single, Single
B. Single, Multiple
C. Multiple, Single
D. Multiple, Multiple –Ans.

23. The PLC program that executes as part of a repetitive process referred to as a ________.

A. Loop
B. Scan-Ans
C. Closed path
D. Path

Personal Notes →

Introduction

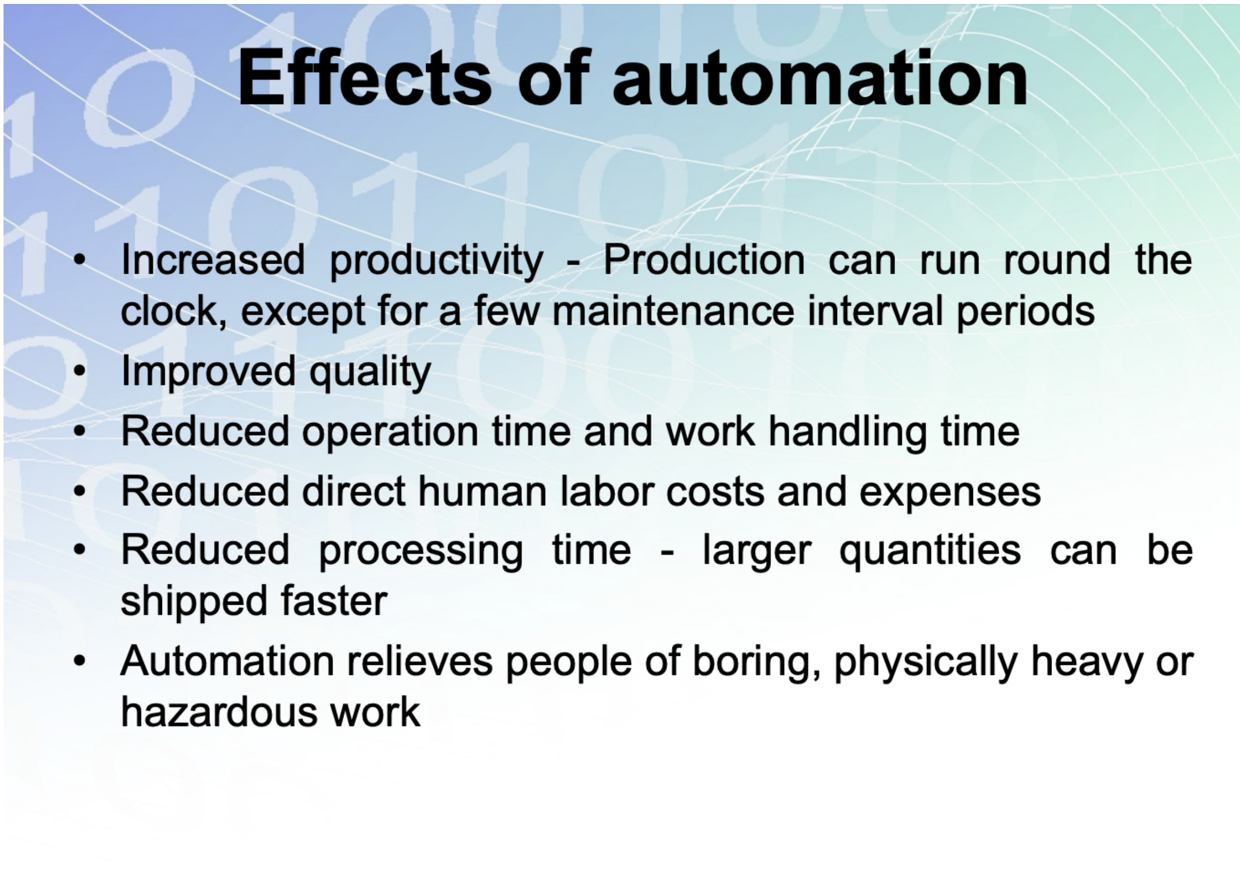
Automation is a set of technologies that results in operation of machines and systems without significant human intervention and achieves performance superior to manual operation.

‘Automation’ is derived from Greek words

Auto - self

Matos - moving.

Automation therefore is the mechanism for systems that “move by itself”



Programmable Logic Controller (PLC) →

A Programmable Logic Controller (PLC) is a specialized digital computer used in industrial automation and control systems. It is designed to operate in harsh industrial environments and is used to automate processes, machinery, and various other applications in manufacturing plants, assembly lines, and other industrial settings.

Here's how a PLC typically works and what it does:

1. **Input/Output (I/O) Handling**: PLCs interface with sensors, switches, actuators, and other devices in the industrial environment. These devices provide inputs to the PLC (such as temperature readings, pressure values, switch statuses, etc.) and receive outputs from the PLC (such as control signals to start/stop motors, open/close valves, etc.).

2. **Processing Logic**: PLCs contain a microprocessor that executes a stored program to control the process based on the input signals it receives. The program, typically written in ladder logic, function block diagrams, or other specialized languages, defines the behavior of the system. The logic implemented in the program determines when and how to activate outputs based on the current states of the inputs and the defined control algorithms.
3. **Real-Time Operation**: PLCs operate in real-time, meaning they respond to input signals and execute control actions within a predetermined time frame. This real-time capability is crucial for ensuring timely and accurate control of industrial processes.
4. **Reliability and Robustness**: PLCs are designed to be reliable and robust, capable of operating in harsh industrial environments with temperature variations, electrical noise, vibration, and other challenging conditions. They often have features like redundancy and fault tolerance to ensure continuous operation.
5. **Communication**: PLCs may communicate with other PLCs, human-machine interfaces (HMIs), supervisory control and data acquisition (SCADA) systems, and higher-level control systems using various communication protocols such as Modbus, Profibus, Ethernet/IP, etc. This enables integration with broader control systems and allows for remote monitoring and control.
6. **Programming and Configuration**: PLCs are typically programmed using specialized software provided by the manufacturer. Programmers use graphical or textual programming languages to create the control logic, configure I/O modules, set up communication parameters, and perform other necessary tasks to tailor the PLC to the specific application requirements.

Overall, PLCs play a crucial role in industrial automation by providing a flexible and reliable means of controlling and monitoring complex processes, improving efficiency, productivity, and safety in industrial operations.

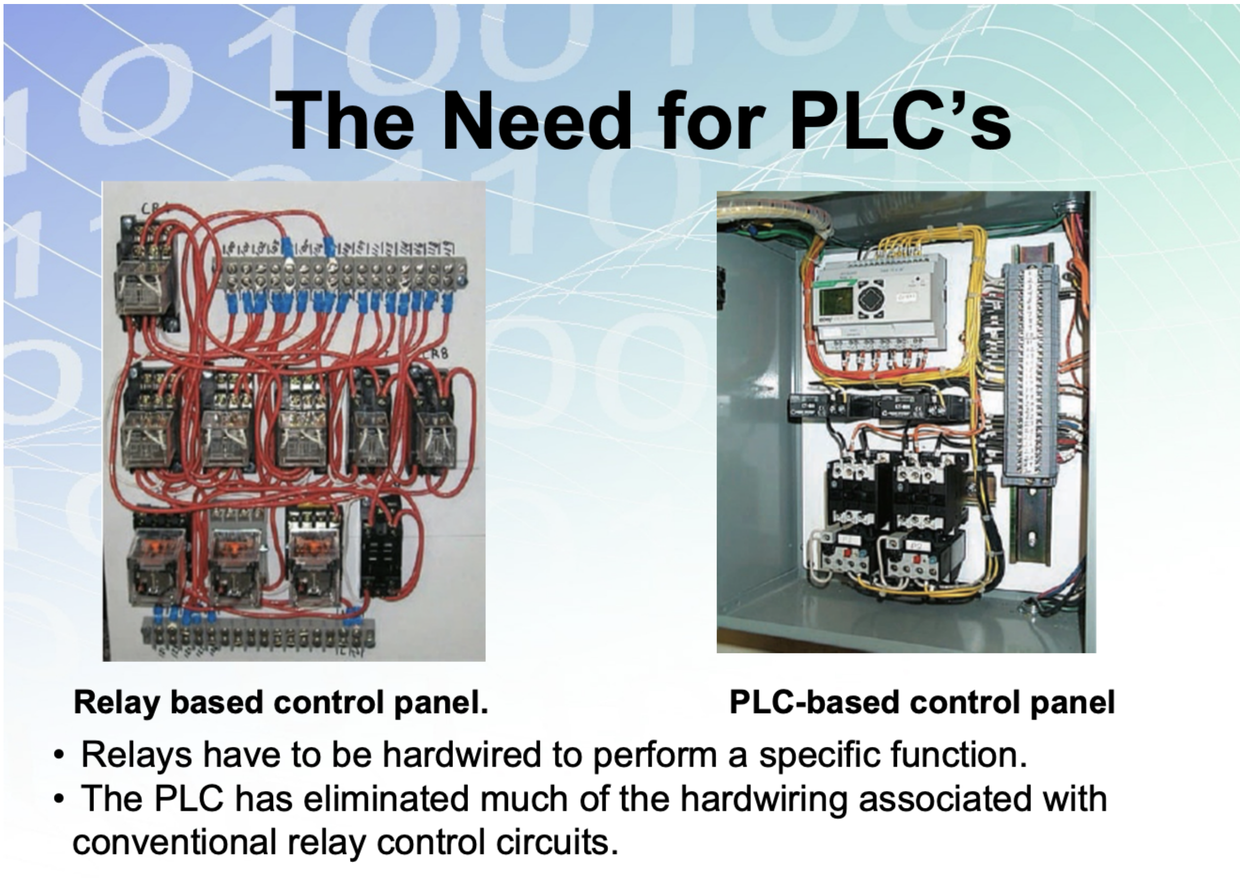
Programmable Logic Controller (PLC)

PLC is an assembly of solid state digital logic elements designed to make logical decisions and provide outputs to control the process.

History of PLC’s

- First PLC was introduced in the late 1960s.
- The automobile sector was the first industry to deploy PLCs into its operations.
- Father of the PLC -Dick Morley
- The first company to build PLC – Modicon

PLC vs relay →



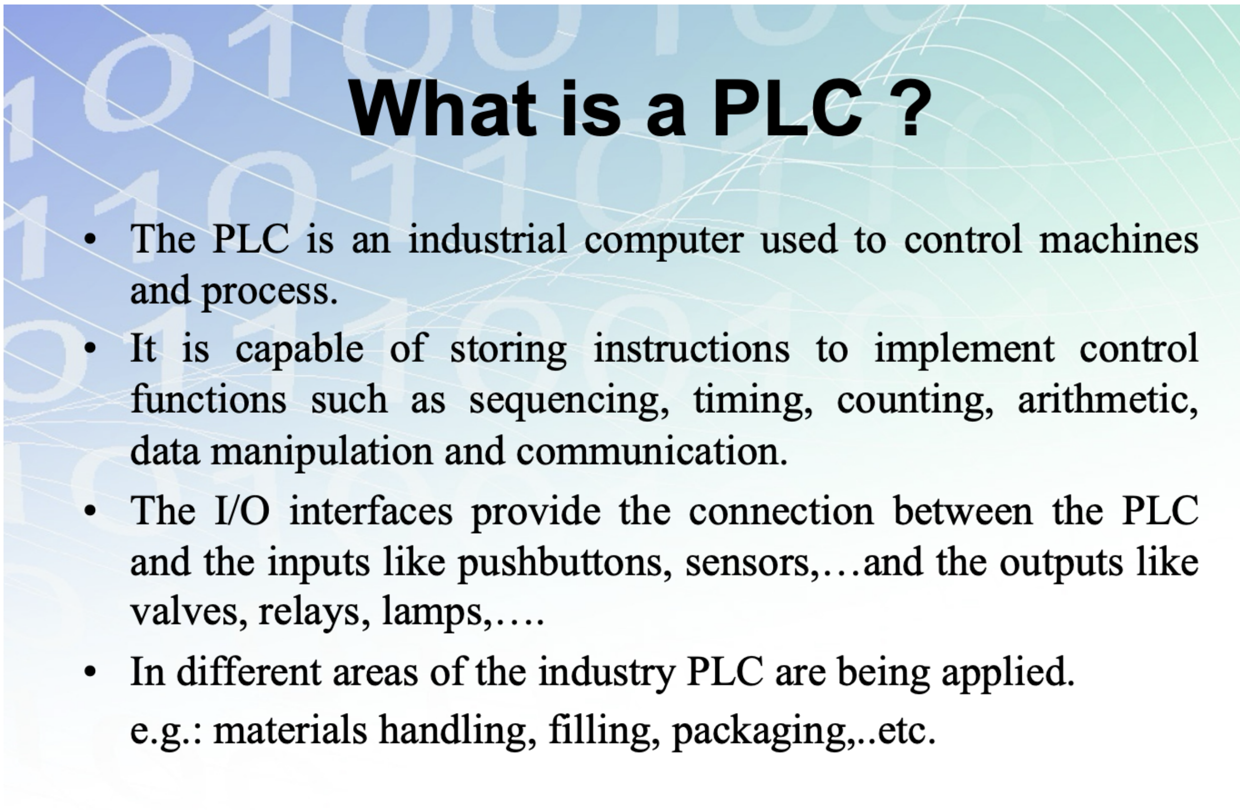
Relays and PLCs (Programmable Logic Controllers) are both used for control and automation purposes, but they differ significantly in their capabilities, flexibility, and complexity. Here's a comparison between the two:

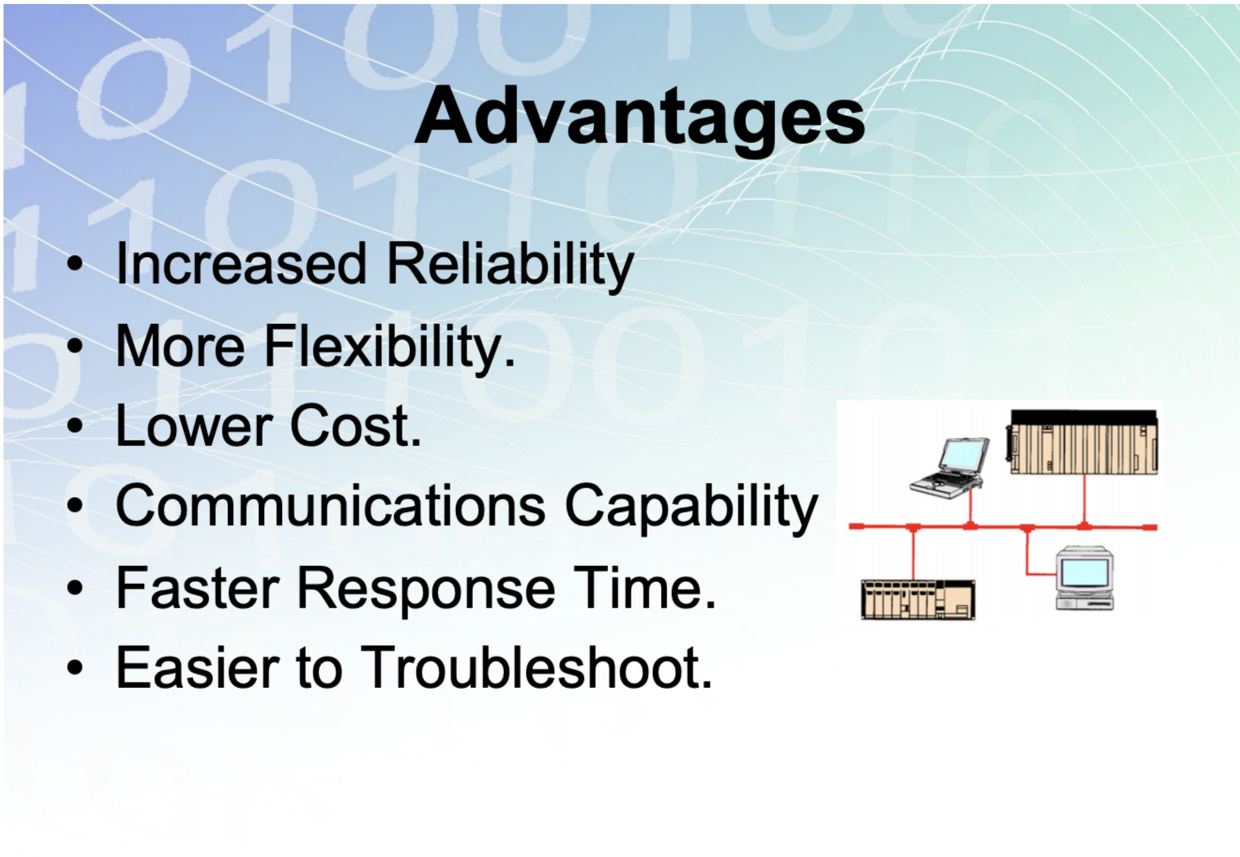
1. **Functionality**:
    - Relays: Relays are electromechanical switches that open or close circuits based on the presence or absence of an electrical signal. They provide basic control functions such as turning devices on or off.
    - PLCs: PLCs are programmable devices capable of executing complex control algorithms. They can perform a wide range of functions beyond simple on/off control, including logic operations, timing, counting, and mathematical calculations. PLCs offer greater flexibility and sophistication in controlling industrial processes.
2. **Programming**:

- Relays: Relays do not require programming. They are typically wired directly to the control circuit, and their behavior is determined by the electrical connections.
- PLCs: PLCs require programming to define the control logic. Programmers use specialized software to create the control program, which is then downloaded to the PLC. PLC programming allows for the implementation of complex control strategies and customization for specific applications.

3. **Flexibility**:
    - Relays: Relays offer limited flexibility and scalability. Adding new control functions or modifying existing ones often requires rewiring and physical changes to the control panel.
    - PLCs: PLCs are highly flexible and scalable. Control logic can be easily modified or expanded by reprogramming the PLC, without the need for physical changes to the wiring. This flexibility allows for rapid adaptation to changing process requirements and easy integration with other automation systems.
4. **Integration**:
    - Relays: Relays are standalone devices and do not offer built-in communication capabilities. Integrating relays into a larger control system may require additional hardware and wiring.
    - PLCs: PLCs are designed for integration into complex control systems. They typically support various communication protocols, allowing them to communicate with other PLCs, HMIs, SCADA systems, and higher-level control systems. PLCs facilitate seamless integration and data exchange within the broader automation infrastructure.
5. **Cost**:
    - Relays: Relays are generally less expensive than PLCs, especially for simpler control applications.
    - PLCs: PLCs are more expensive upfront due to their advanced capabilities and flexibility. However, they can offer cost savings in the long run by reducing wiring complexity, enabling easier maintenance and troubleshooting, and improving overall system efficiency.

In summary, while relays are suitable for basic control tasks, PLCs offer greater flexibility, scalability, and functionality, making them the preferred choice for most industrial automation applications. PLCs provide the ability to implement complex control strategies, integrate with other systems, and adapt to evolving process requirements efficiently.





PLC vs Computers →

PLCs (Programmable Logic Controllers) and computers serve distinct purposes in the realm of automation and control systems, each with its own advantages and applications. Here's a comparison between PLCs and computers:

1. **Purpose**:
    - PLCs: PLCs are specialized devices primarily designed for industrial automation and control applications. They are optimized for real-time control, reliability, and robustness in harsh industrial environments. PLCs excel at controlling machinery, processes, and equipment in manufacturing plants, assembly lines, and other industrial settings.
    - Computers: Computers are general-purpose devices used for a wide range of tasks, including data processing, communication, entertainment, and more. While computers can also be used for control and automation,

they are typically not as well-suited for real-time control applications or environments with high levels of electrical noise and vibration.

2. **Architecture**:
    - PLCs: PLCs typically have a ruggedized hardware architecture optimized for industrial environments. They often feature digital and analog input/output (I/O) modules, a microprocessor, memory for program storage, and communication interfaces. PLCs are designed for deterministic operation, meaning they execute control tasks predictably and reliably within specified time constraints.
    - Computers: Computers have a more generalized architecture consisting of a central processing unit (CPU), memory, storage, input/output interfaces, and other peripherals. While modern computers can perform real-time tasks with the right software and hardware configurations, they are not inherently designed for deterministic operation like PLCs. Operating systems and background tasks running on computers can introduce unpredictability and latency, which may not be suitable for time-critical control applications.
3. **Programming**:
    - PLCs: PLCs are programmed using specialized software tools that allow engineers to create control logic using programming languages such as ladder logic, function block diagrams, or structured text. PLC programming is tailored to the needs of industrial automation and emphasizes ease of use, reliability, and real-time performance.
    - Computers: Computers are programmed using general-purpose programming languages such as C, Python, Java, etc. While computers offer greater flexibility and programming capabilities compared to PLCs, developing control software for real-time applications requires careful consideration of timing constraints and system responsiveness.
4. **Reliability and Robustness**:
    - PLCs: PLCs are designed to operate reliably in harsh industrial environments with temperature variations, electrical noise, vibration, and other challenging conditions. They often incorporate features such as

redundancy, fault tolerance, and ruggedized enclosures to ensure continuous operation.

- Computers: While modern computers are generally reliable, they may not be as well-suited for operation in industrial environments without additional protection and hardening measures. Computers are more susceptible to hardware and software failures, and they typically require regular maintenance and updates to ensure reliability.

In summary, PLCs and computers serve different roles in control and automation systems, with PLCs offering specialized functionality optimized for industrial applications requiring real-time control, reliability, and robustness. While computers offer greater flexibility and computational power, they may not be as well-suited for industrial control tasks without additional hardware and software modifications.

PLCs versus Computers

- The PLC is designed to operate in the industrial environment with wide ranges of ambient temperature and humidity.
- PLC is programmed in ladder logic or other easily learned languages.
- Computers are complex computing machines capable of executing several programs or tasks simultaneously
- PLC control systems have been designed to be easily installed and maintained.

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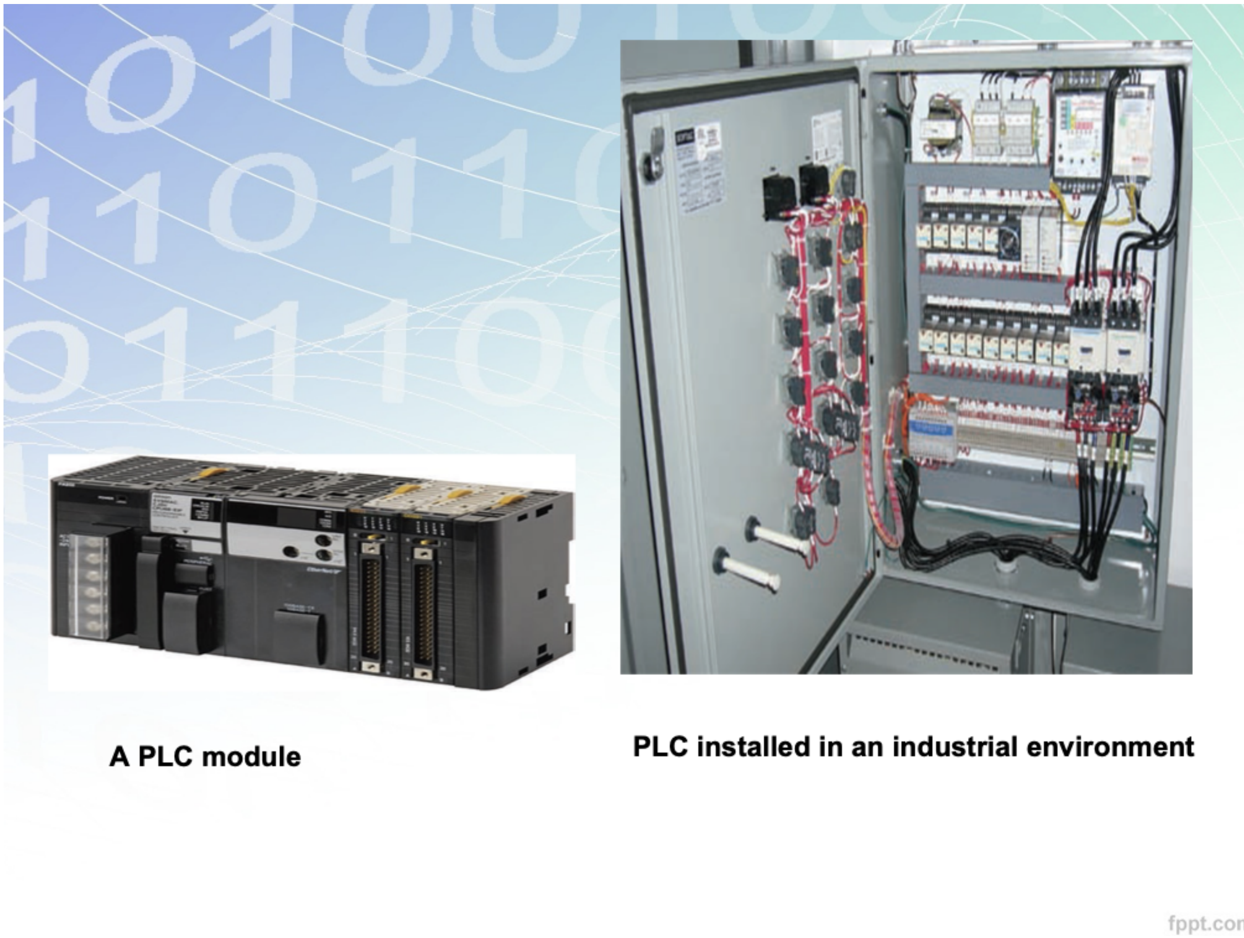
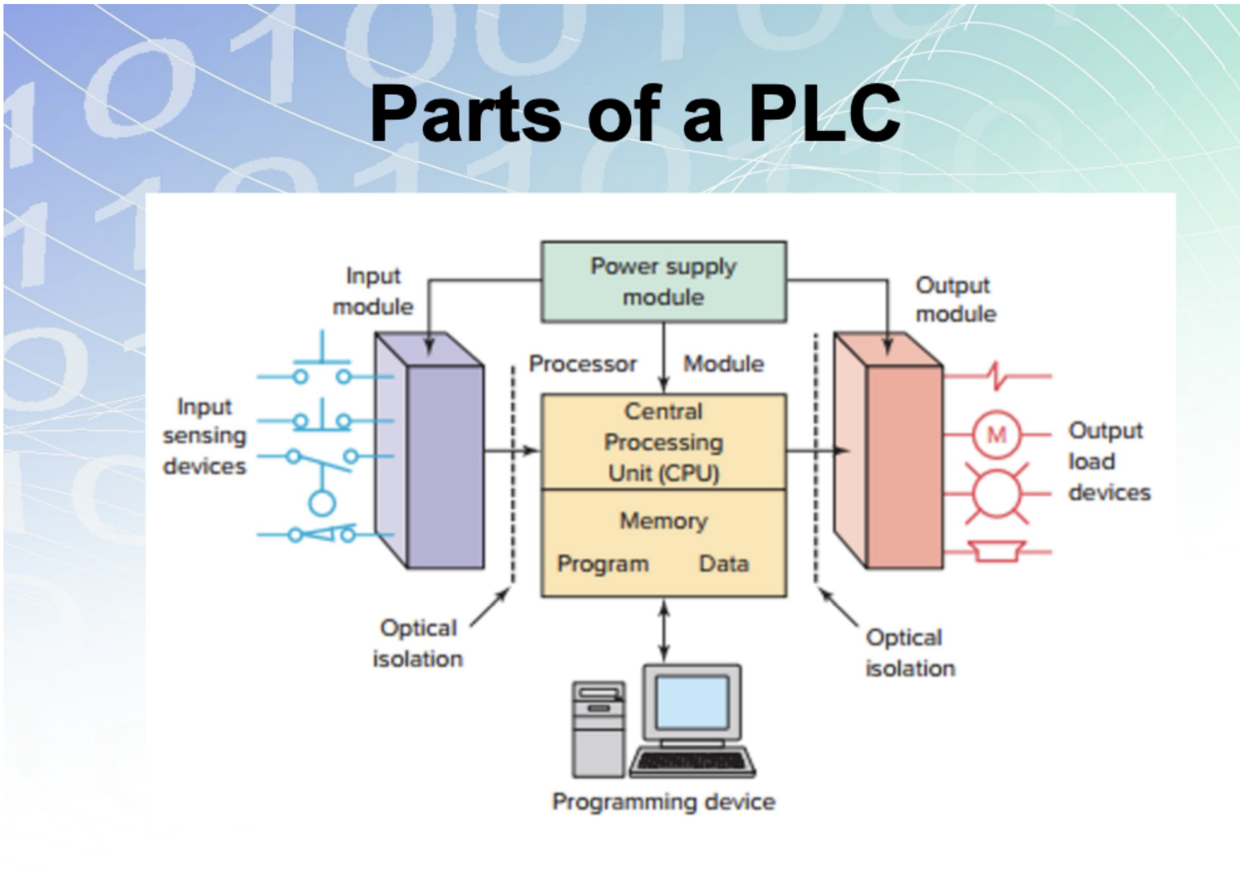
PLC	PC
Industrial environment	Office / Home environment
Wide ranges ambient temperature	Controlled low temperatures
Varied humidity	Controlled humidity
Varied dust/dirt	Controlled dust / dirt



Parts of a PLC →



A Programmable Logic Controller (PLC) typically consists of several key components, each serving a specific function in the control and automation process. Here are the main parts of a PLC:

1. **Central Processing Unit (CPU)**:
    - The CPU is the brain of the PLC, responsible for executing the control program and coordinating the operation of other components. It performs tasks such as reading input signals, executing control logic, and generating output signals. The CPU may also include memory for storing the control program and data.
2. **Input Modules**:
    - Input modules interface with sensors, switches, and other devices to receive input signals from the controlled process. These signals can include digital signals (on/off, high/low) or analog signals (voltage, current,

temperature). Input modules convert these signals into digital data that the CPU can process.

3. **Output Modules**:
    - Output modules interface with actuators, valves, motors, and other devices to send control signals to the controlled process. Output modules convert digital data generated by the CPU into signals that can actuate or control external devices.
4. **Power Supply**:
    - The power supply provides electrical power to the PLC system, supplying voltage levels required for the operation of the CPU, input modules, output modules, and other components. PLC power supplies typically accept a range of input voltages and provide regulated output voltages to ensure stable operation of the system.
5. **Memory**:
    - PLCs include various types of memory for storing the control program, data, and configuration settings. This memory may include:
        - Program memory: Stores the user-programmed control logic.
        - Data memory: Stores variables, timers, counters, and other data used by the control program.
        - Retentive memory: Retains data even when power is removed, allowing the PLC to retain critical information such as device statuses and accumulated counts after a power cycle.
        - EEPROM (Electrically Erasable Programmable Read-Only Memory) or Flash memory: Stores configuration settings and firmware.
6. **Communication Interfaces**:
    - PLCs may include communication interfaces for connecting to other PLCs, Human-Machine Interfaces (HMIs), Supervisory Control and Data Acquisition (SCADA) systems, and higher-level control systems. These interfaces support various communication protocols such as Ethernet/IP, Modbus, Profibus, etc., enabling data exchange and integration with external systems.

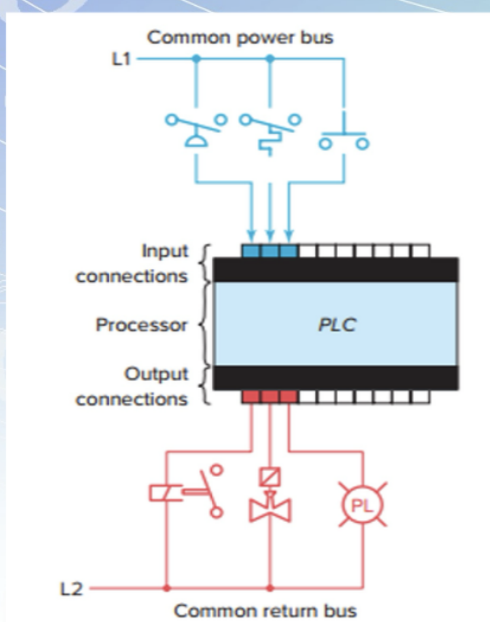
7. **Programming Port**:
    - The programming port allows users to connect a programming device (such as a personal computer) to the PLC for programming, monitoring, and debugging purposes. This port may use serial communication (RS-232, RS-485) or USB connections, depending on the PLC model.

These components work together to form a complete PLC system capable of controlling and monitoring industrial processes, machinery, and equipment. Depending on the specific application requirements, additional modules and accessories (such as analog I/O modules, special function modules, expansion racks, etc.) may be added to extend the functionality of the PLC system.

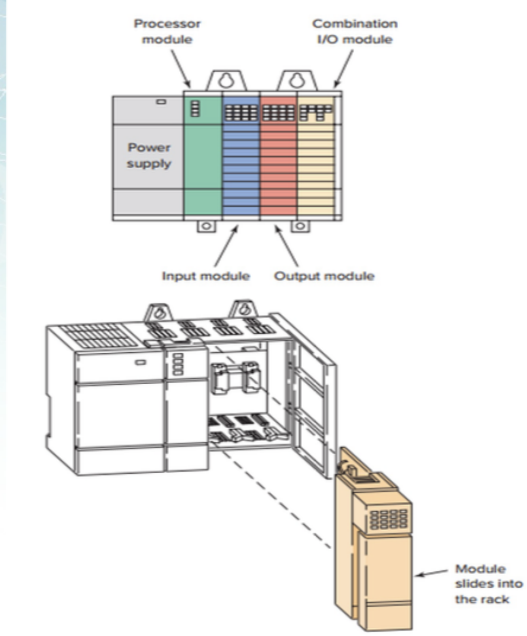
Input / Output Module

- ***Fixed I/O-*** typical of small PLCs that come in one package with no separate, removable units. The main advantage of this type of packaging is lower cost. One disadvantage of fixed I/O is its lack of flexibility.

- ***Modular I/O -*** divided by compartments into which separate modules can be plugged. The main advantage of this type of packaging is flexibility.



Fixed I/O configuration.



Modular I/O configuration.

Fixed I/O (Input/Output) and Modular I/O are two different approaches to designing the I/O system of a Programmable Logic Controller (PLC). Each approach has its advantages and is chosen based on the specific requirements of the control application. Here's a comparison between fixed and modular I/O:

1. **Fixed I/O**:
    - In fixed I/O systems, the input and output circuits are built into the PLC unit itself, and the number and types of I/O points are fixed and cannot be expanded or modified.
    - Fixed I/O systems are typically used in smaller, simpler control applications where the number of I/O points required is known and unlikely to change over time.
    - Advantages:
        - Simplified installation: Since the I/O circuits are integrated into the PLC unit, there is no need for additional wiring or connections between the PLC and external I/O modules.
        - Cost-effective: Fixed I/O systems are often more cost-effective for smaller-scale applications with relatively few I/O points.
    - Disadvantages:
        - Limited scalability: The number and types of I/O points are fixed, so the system cannot be easily expanded to accommodate additional I/O requirements.
        - Limited flexibility: Changes to the I/O configuration may require replacing the entire PLC unit, which can be cumbersome and costly.
2. **Modular I/O**:
    - In modular I/O systems, the PLC unit is separate from the I/O modules, which are installed in racks or enclosures adjacent to the PLC. These I/O modules can be added, removed, or rearranged as needed to accommodate changing I/O requirements.

- Modular I/O systems are commonly used in larger, more complex control applications where the number and types of I/O points may vary or expand over time.
- Advantages:
  - Scalability: Modular I/O systems allow for easy expansion of the I/O capacity by adding additional I/O modules as needed.
  - Flexibility: The I/O configuration can be easily customized and modified to meet changing application requirements without replacing the entire PLC unit.
  - Maintenance flexibility: Individual I/O modules can be replaced or upgraded without affecting the rest of the system, simplifying maintenance and troubleshooting.
- Disadvantages:
  - Additional wiring: Modular I/O systems may require more wiring to connect the I/O modules to the PLC unit, compared to fixed I/O systems.
  - Increased cost: The modular nature of the system and the need for additional components (racks, modules) may result in higher upfront costs compared to fixed I/O systems.

In summary, fixed I/O systems offer simplicity and cost-effectiveness for smaller-scale applications with fixed I/O requirements, while modular I/O systems provide scalability and flexibility to accommodate changing I/O needs in larger and more complex control applications. The choice between fixed and modular I/O depends on factors such as the size of the control system, the flexibility required, and budget constraints.

- The ***I/O system*** forms the interface by which field devices are connected to the controller.
- **Input devices** such as pushbuttons, limit switches, and sensors are hardwired to the input terminals.
- **Output devices** such as small motors, motor starters, solenoid valves, and indicator lights are hardwired to the output terminals.
- To electrically **isolate the internal components** from the input and output terminals, PLCs commonly employ an **optical isolator**, which uses light to couple the circuits together.

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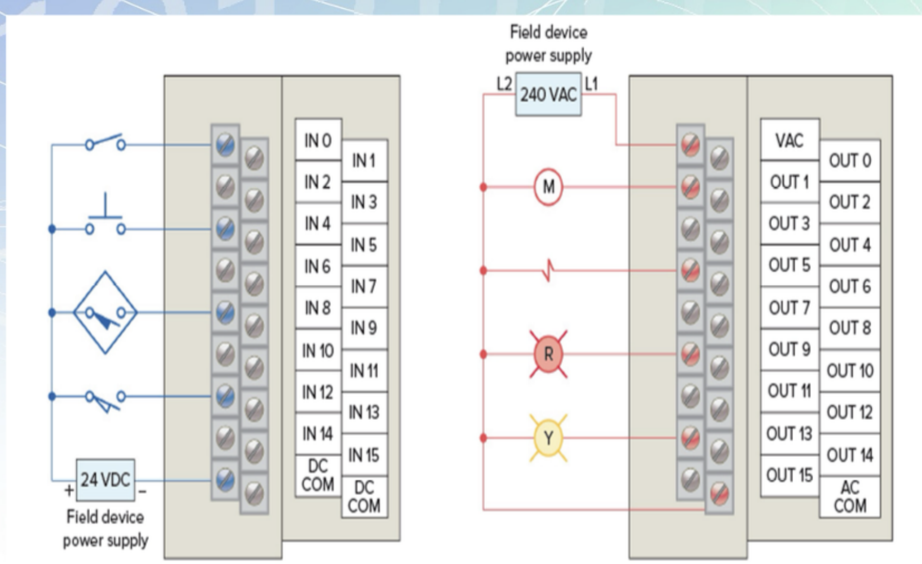
Typical PLC input/output



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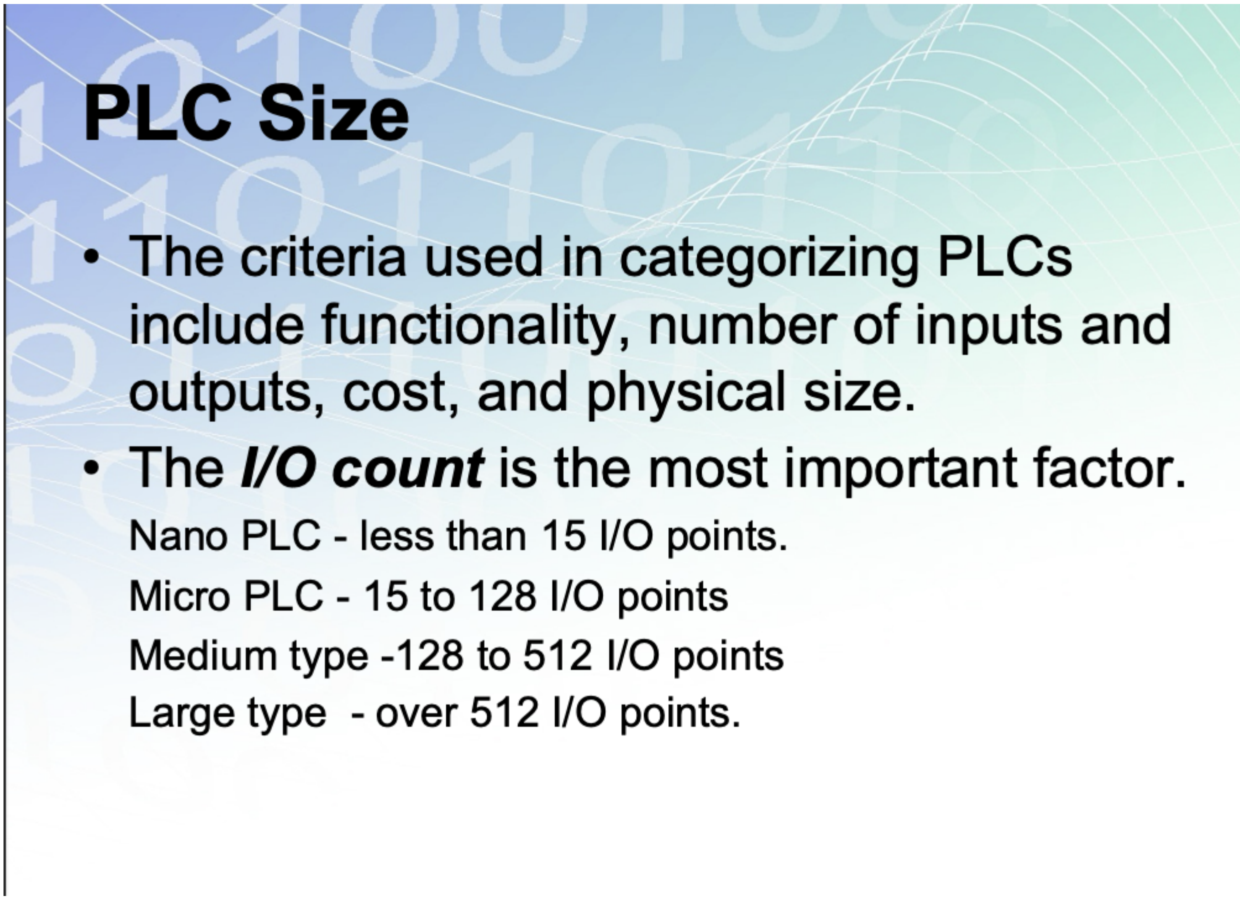
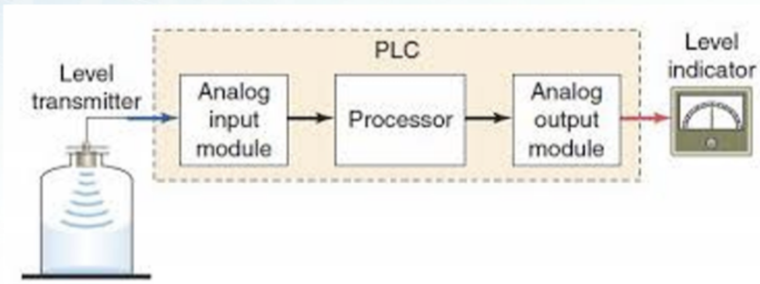
- The **power supply unit** supplies DC power to other modules that plug into the rack.
- The ***processor (CPU)*** is the “brain” of the PLC.
- A typical processor usually consists of a **microprocessor** for implementing the logic and controlling the communications among the modules. The processor requires memory for storing user program instructions, numerical values, and I/O devices status.
- A ***programming device*** is used to enter the desired program into the memory of the processor. The program can be entered using relay ladder logic, which is one of the most popular programming languages.


PLC Size
• The criteria used in categorizing PLCs include functionality, number of inputs and outputs, cost, and physical size.
• The I/O count is the most important factor.
Nano PLC - less than 15 I/O points.
Micro PLC - 15 to 128 I/O points
Medium type -128 to 512 I/O points
Large type - over 512 I/O points.

PLC Types →

PLC Application

- **Types** – Single ended, multitask, and control management
- A ***single-ended*** or stand-alone PLC application involves one PLC controlling one process.



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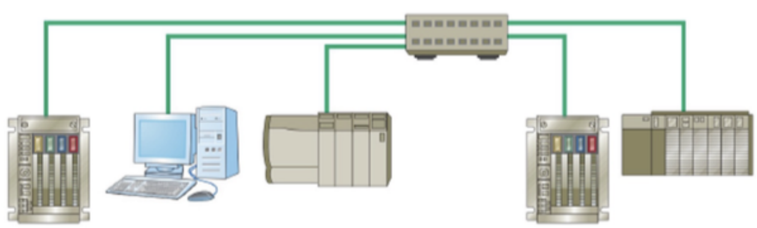
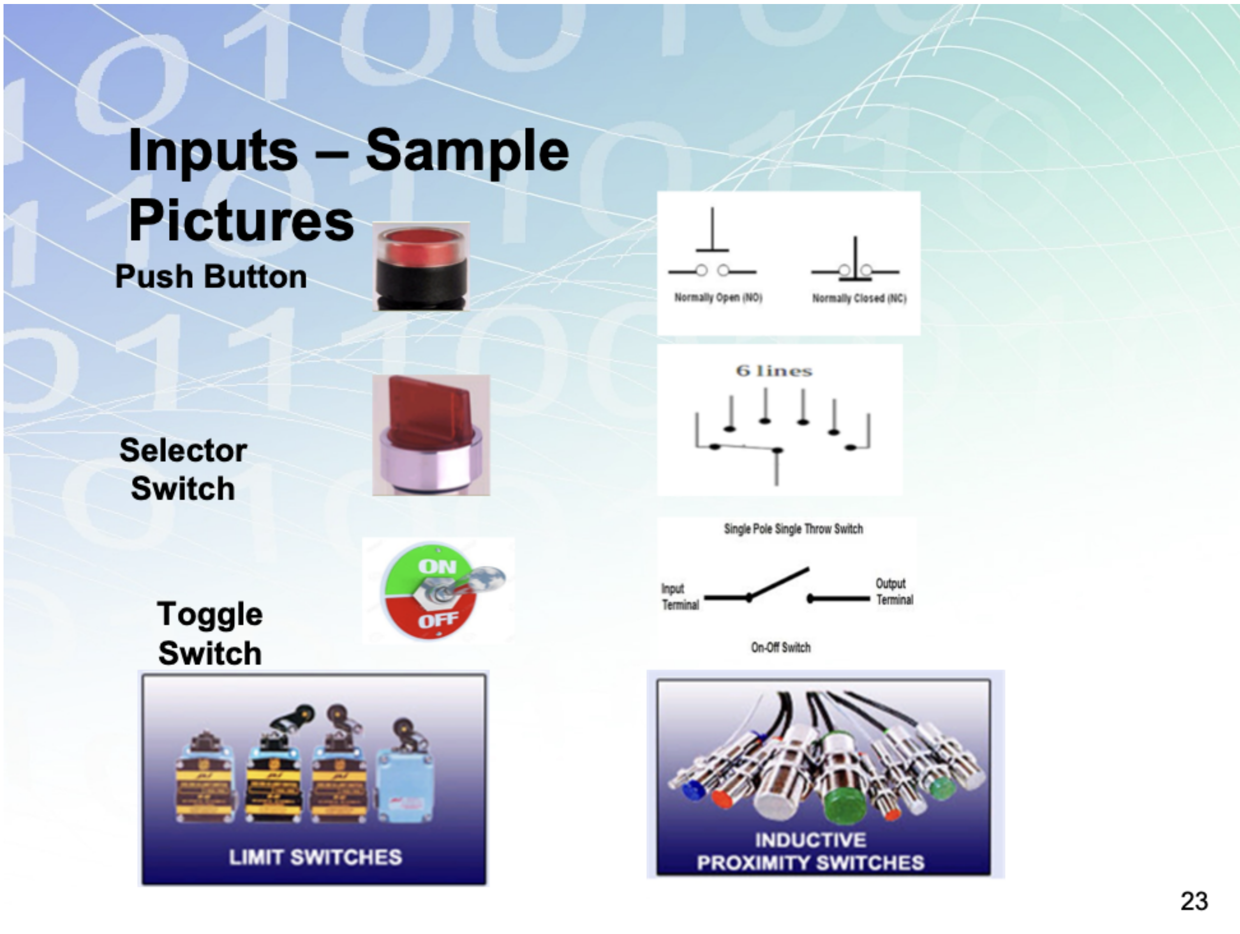
- A **multitask PLC** application involves one PLC controlling several processes(Ex. Level, Flow etc.)

- A ***control management PLC*** application involves one PLC controlling several other PLC's
- Requires large PLC processor
- Control management PLC supervises several PLCs
- Downloads programs to other PLCs
- Specifies what operation needs done



PLC Inputs and Outputs →



In a Programmable Logic Controller (PLC) system, inputs and outputs (I/O) play a crucial role in interfacing the PLC with the external world, allowing it to monitor and control industrial processes and equipment. Here's an explanation of common types of PLC inputs and outputs:

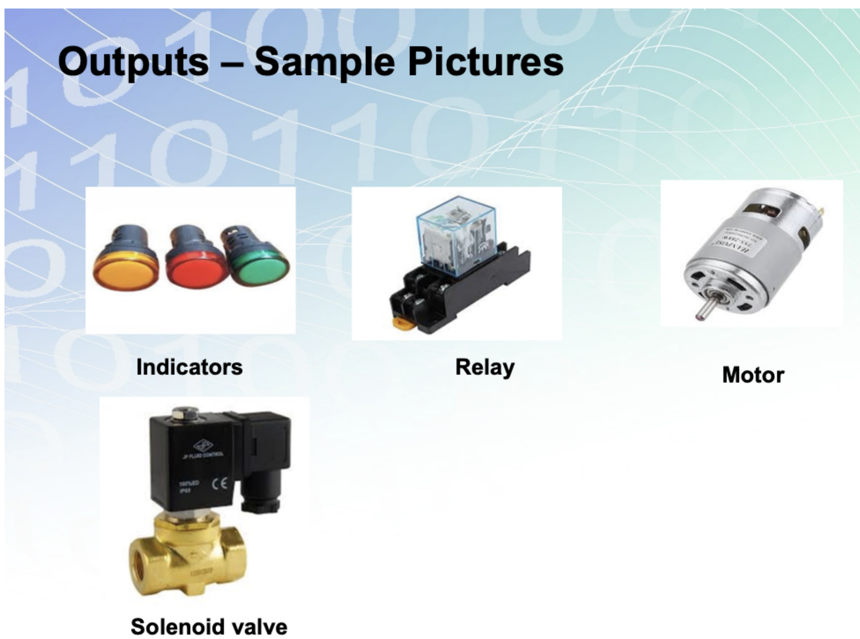
PLC Inputs:

1. **Push Button**:
   - Push buttons are momentary switches that provide a signal to the PLC when pressed. They are commonly used to initiate or stop specific functions or operations in the controlled system. For example, a start button might be used to initiate a machine cycle, while a stop button would halt the operation.
2. **Selector Switch**:

- Selector switches are manually operated switches with multiple positions, allowing the operator to select from different options or modes. Each position corresponds to a specific input signal sent to the PLC. Selector switches are often used for mode selection, parameter adjustment, or control mode switching in industrial applications.

3. **Toggle Switch**:
    - Toggle switches are mechanical switches with two positions (on/off). They maintain their state once set until toggled again. In PLC systems, toggle switches are used to provide binary input signals representing two states (e.g., open/closed, enabled/disabled).

Outputs →



PLC Outputs:

1. **Indicators**:
    - Indicators, such as LEDs or lamps, are used to provide visual feedback on the status of the controlled system. They are typically connected to PLC output points and illuminate to indicate various conditions, such as power on/off, system ready, fault conditions, or specific process states.
2. **Relays**:

- Relays are electromechanical switches controlled by the PLC output signals. They are used to control power circuits or other devices that require high-current switching. Relays provide isolation between the PLC's low-voltage control signals and the higher voltage/current circuits of the controlled equipment, ensuring safety and protecting the PLC from damage.

3. **Motor**:

    - Motors are commonly controlled by PLCs to drive machinery, conveyors, pumps, fans, and other mechanical equipment. PLC output signals are used to energize motor contactors or motor drives, starting, stopping, and controlling the speed and direction of the motor as required by the application.

4. **Solenoid Valve**:

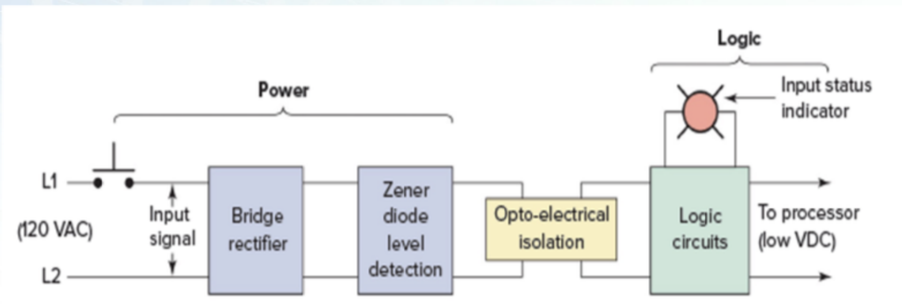
    - Solenoid valves are used to control the flow of fluids or gases in industrial processes. They are actuated by electrical signals sent from the PLC outputs. Solenoid valves can be used for tasks such as opening/closing pipelines, regulating fluid flow rates, or directing flow to specific paths in a process.

In summary, PLC inputs and outputs facilitate the interaction between the PLC and the controlled equipment or processes. Inputs provide information to the PLC about the state of external devices or sensors, while outputs enable the PLC to control actuators, indicators, and other devices to perform desired operations and achieve the desired control outcomes.

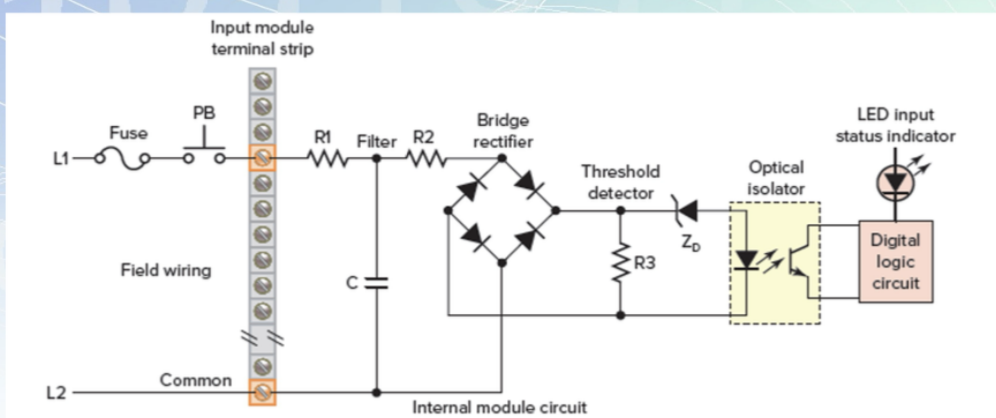
Discrete Input Module →

Discrete Input Module

- This type of interface connects field input devices of the ON/OFF nature such as selector switches, pushbuttons, and limit switches.



Discrete Input Module



Electrical optical isolator:
A device that couples input to output using a semiconductor light source and detector in the same package

- When the pushbutton is closed, 120 VAC is applied to the bridge rectifier input.
- This results in a low-level DC output voltage that is applied across the LED of the optical isolator.
- The zener diode (ZD) voltage rating sets the minimum threshold level of voltage that can be detected.
- When light from the LED strikes the phototransistor, it switches into conduction and the status of the pushbutton is communicated in logic to the processor.

Discrete input modules perform four tasks in the PLC control system.

- Sense when a signal is received from a field device.
- Convert the input signal to the correct voltage level for the particular PLC.
- Isolate the PLC from fluctuations in the input signal’s voltage or current.
- Send a signal to the processor indicating which sensor originated the signal.

Discrete input modules are a type of input module used in Programmable Logic Controllers (PLCs) to interface with discrete or digital input devices. These input modules are designed to process signals that represent binary states, typically "on" or "off," "high" or "low," or "open" or "closed." Here's an overview of discrete input modules in PLCs:

1. **Functionality**:
    - Discrete input modules are responsible for converting signals from external devices, such as push buttons, limit switches, proximity sensors, and other digital sensors, into binary data that the PLC can process.
    - These modules monitor the state of the connected input devices and provide corresponding input data to the PLC's CPU.
2. **Types of Inputs Supported**:
    - Discrete input modules support various types of input signals, including:
        - Normally open (NO) or normally closed (NC) contacts from switches or sensors.
        - PNP (sourcing) or NPN (sinking) digital signals from sensors or actuators.
        - Pulse signals from encoders or proximity sensors for counting or speed measurement applications.
        - High-speed inputs for capturing rapid changes in input signals, such as in motion control or high-speed counting applications.
3. **Module Configuration**:
    - Discrete input modules typically come in various configurations to accommodate different numbers of input channels and voltage/current levels.
    - They may support different input voltage ranges (e.g., 24VDC, 120VAC) and have configurable input characteristics (e.g., input filter settings, debounce times) to adapt to the requirements of the connected devices.
4. **Connection to PLC**:

- Discrete input modules are installed in the PLC's rack or enclosure, typically in designated slots or positions.
- They connect to the PLC's backplane or internal bus system to communicate with the CPU and other modules.
- The wiring from external devices is terminated at the input terminals of the discrete input module.

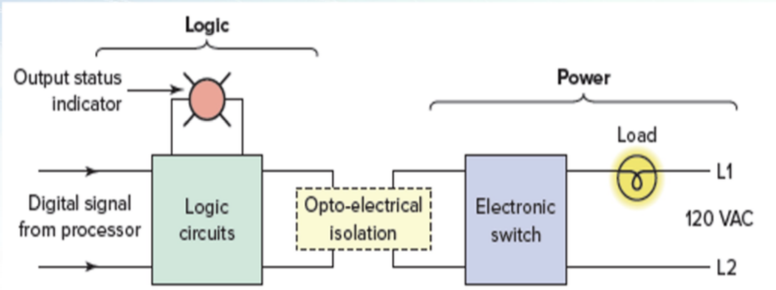
5. **Status Indication**:
    - Discrete input modules often feature status indicators or LEDs for each input channel to provide visual feedback on the status of the connected devices.
    - These indicators may show whether an input is active or inactive, helping with troubleshooting and diagnostics.
6. **Compatibility and Integration**:
    - Discrete input modules are designed to work seamlessly with the PLC's programming environment and software tools.
    - They are typically configured and programmed using the PLC's programming software, allowing users to define the behavior of the input channels within their control logic.

In summary, discrete input modules play a vital role in PLC systems by interfacing with digital input devices and providing the necessary input data for controlling and monitoring industrial processes and equipment. They offer flexibility, reliability, and ease of integration, making them essential components in various automation applications.

Discrete Output Module →

Discrete Output Module

This type of interface connects field output devices and turns the output load device on and off.



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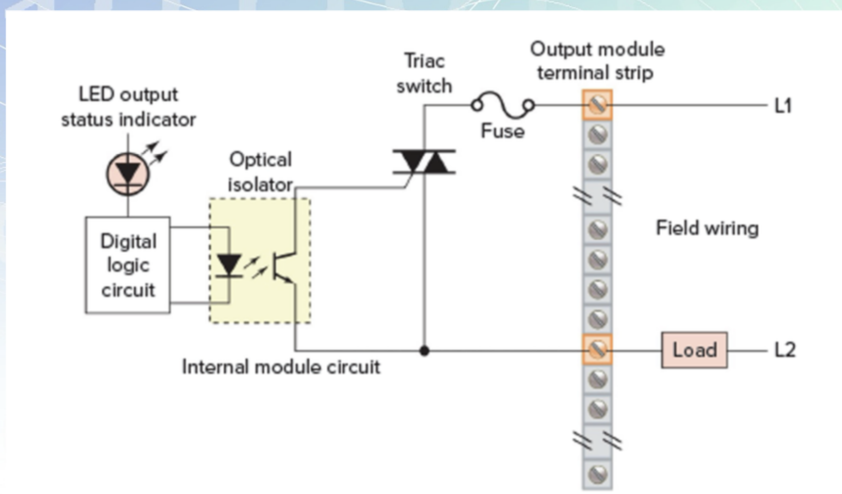
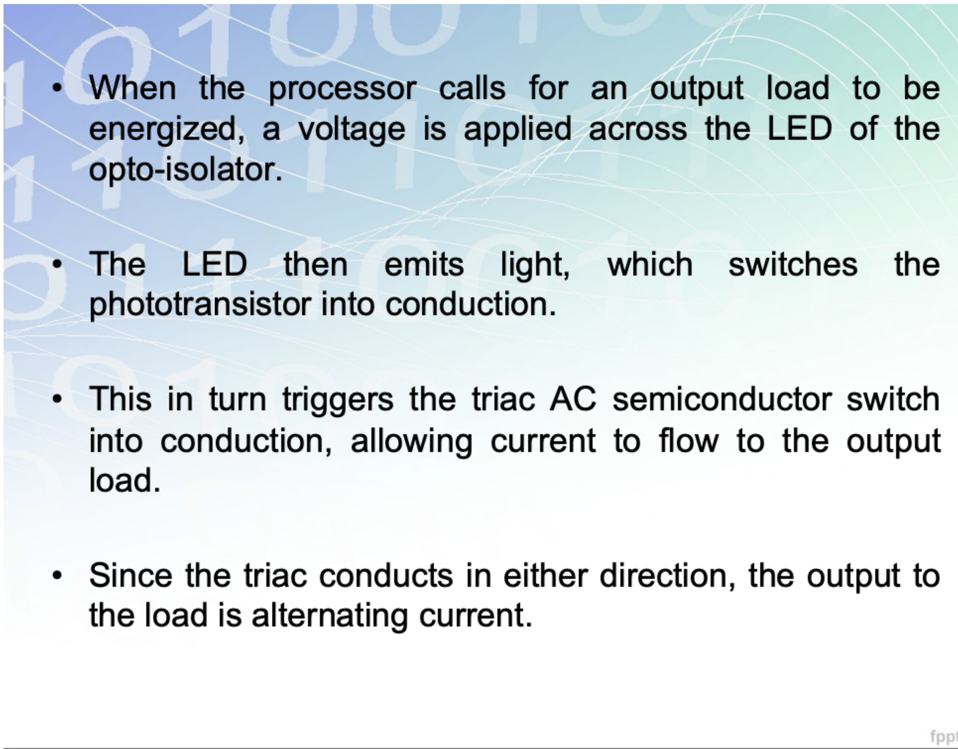
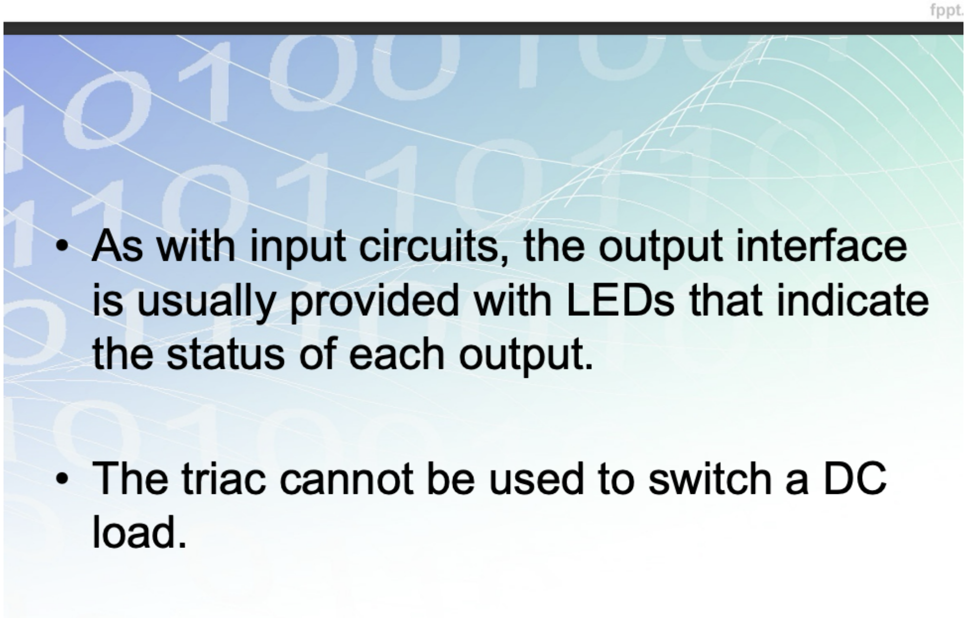
Discrete Output Module







Discrete output modules are components used in Programmable Logic Controllers (PLCs) to interface with discrete or digital output devices. These modules are responsible for controlling binary output devices such as relays, solenoid valves, indicator lamps, motor starters, and other devices that operate in an on/off or open/close fashion. Here's an overview of discrete output modules in PLCs:

1. **Functionality**:

- Discrete output modules convert digital output signals generated by the PLC's CPU into electrical signals suitable for driving external devices. They control the state (on/off) or action (open/close) of the connected output devices based on the PLC program's logic.
- These modules provide the necessary power and isolation to safely control external devices while protecting the PLC from damage.

2. **Types of Outputs Supported**:
    - Discrete output modules support various types of output signals, including:
        - Relay outputs: Typically used for controlling higher power loads or devices that require electrical isolation, such as motors, contactors, and large solenoid valves.
        - Transistor or solid-state outputs: Used for driving lower power devices, such as indicator lamps, small solenoids, and LEDs.
        - Triac outputs: Used for switching AC loads, such as lamps or heaters.
3. **Module Configuration**:
    - Discrete output modules come in various configurations to accommodate different numbers of output channels and types of output signals.
    - They may support different output voltage or current levels, such as 24VDC, 120VAC, or 230VAC, depending on the requirements of the connected devices.
    - Some modules may offer additional features, such as built-in surge protection, short-circuit protection, or diagnostics capabilities.
4. **Connection to PLC**:
    - Discrete output modules are installed in the PLC's rack or enclosure, typically in designated slots or positions.
    - They connect to the PLC's backplane or internal bus system to communicate with the CPU and other modules.
    - The wiring to external devices is terminated at the output terminals of the discrete output module.

5. **Status Indication**:
    - Discrete output modules often feature status indicators or LEDs for each output channel to provide visual feedback on the status of the connected devices.
    - These indicators may show whether an output is energized or de-energized, helping with troubleshooting and diagnostics.
6. **Compatibility and Integration**:
    - Discrete output modules are designed to work seamlessly with the PLC's programming environment and software tools.
    - They are typically configured and programmed using the PLC's programming software, allowing users to define the behavior of the output channels within their control logic.

In summary, discrete output modules are essential components in PLC systems, enabling the control and operation of external devices in industrial automation applications. They offer reliability, flexibility, and ease of integration, making them critical for controlling processes and equipment in various industries.

Analog I/O Modules →

Analog I/O (Input/Output) modules are components used in Programmable Logic Controllers (PLCs) to interface with analog input and output devices. Unlike discrete I/O modules, which handle binary signals (on/off), analog I/O modules process continuous signals with varying voltage or current levels, representing physical quantities such as temperature, pressure, flow rate, or position. Here's an overview of analog I/O modules in PLCs:

Analog Input Modules:

1. **Functionality**:
    - Analog input modules convert analog signals from external sensors, transducers, or other devices into digital data that the PLC's CPU can process.
    - They typically sample the analog input signals at regular intervals, digitize the signal using an analog-to-digital converter (ADC), and provide the

digital data to the PLC for further processing.

- Analog input modules are used to measure physical parameters such as temperature, pressure, level, flow rate, voltage, current, or position.

2. **Types of Inputs Supported**:
   - Analog input modules support various types of analog input signals, including:
     - Voltage inputs: Accept input signals within a specified voltage range (e.g., 0-10V, -10V to +10V).
     - Current inputs: Accept input signals within a specified current range (e.g., 4-20 mA).
     - Resistance inputs: Used for measuring resistance-based sensors, such as potentiometers or RTDs (Resistance Temperature Detectors).
3. **Module Configuration**:
   - Analog input modules come in different configurations to accommodate different numbers of input channels and types of analog signals.
   - They may offer configurable input ranges, filtering options, and signal conditioning features to adapt to various sensor types and measurement requirements.
4. **Connection to PLC**:
   - Analog input modules are installed in the PLC's rack or enclosure, typically in designated slots or positions.
   - They connect to the PLC's backplane or internal bus system to communicate with the CPU and other modules.
   - The wiring from external sensors is terminated at the input terminals of the analog input module.
5. **Resolution and Accuracy**:
   - Analog input modules have specifications for resolution (the smallest detectable change in input signal) and accuracy (the deviation of the measured value from the true value). Higher-resolution and higher-

accuracy modules are available for applications requiring precise measurements.

Analog Output Modules:

1. **Functionality**:
    - Analog output modules generate analog output signals based on digital data received from the PLC's CPU.
    - They typically use digital-to-analog converters (DACs) to convert digital data into analog signals with varying voltage or current levels.
    - Analog output modules are used to control analog devices such as variable speed drives, control valves, actuators, or proportional control devices.
2. **Types of Outputs Supported**:
    - Analog output modules support various types of analog output signals, including:
        - Voltage outputs: Provide analog signals within a specified voltage range (e.g., 0-10V).
        - Current outputs: Provide analog signals within a specified current range (e.g., 4-20 mA).
3. **Module Configuration**:
    - Analog output modules come in different configurations to accommodate different numbers of output channels and types of analog signals.
    - They may offer configurable output ranges, output impedance, and current-limiting features to match the requirements of connected devices.
4. **Connection to PLC**:
    - Analog output modules are installed in the PLC's rack or enclosure, typically in designated slots or positions.
    - They connect to the PLC's backplane or internal bus system to communicate with the CPU and other modules.

- The wiring to external devices is terminated at the output terminals of the analog output module.

5. **Resolution and Accuracy**:
    - Analog output modules have specifications for resolution (the smallest increment in output signal) and accuracy (the deviation of the output signal from the desired value). Higher-resolution and higher-accuracy modules are available for applications requiring precise control.

In summary, analog I/O modules are essential components in PLC systems, allowing the PLC to interface with analog sensors, actuators, and control devices to measure and control continuous physical quantities in industrial automation applications. They offer flexibility, accuracy, and scalability, making them suitable for a wide range of measurement and control tasks in various industries.

Analog I/O Modules

- **Analog devices** represent physical quantities that can have an infinite number of values. Typical analog inputs and outputs vary from 0 to 20 mA, 4 to 20 mA, or 0 to 10V.
- Analog sensors measure a varying physical quantity over a specific range and generate a corresponding voltage or current signal.
- Common physical quantities measured by a PLC analog module include temperature, speed, level, flow, weight, pressure, and position.

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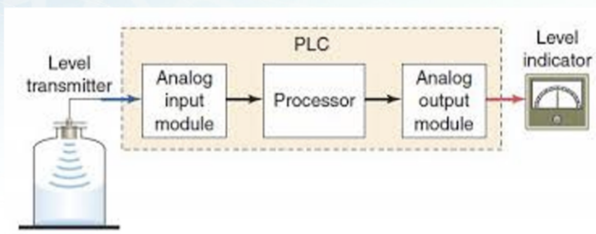
Example

- PLC analog input and output modules are used in measuring and displaying the level of fluid in a tank.



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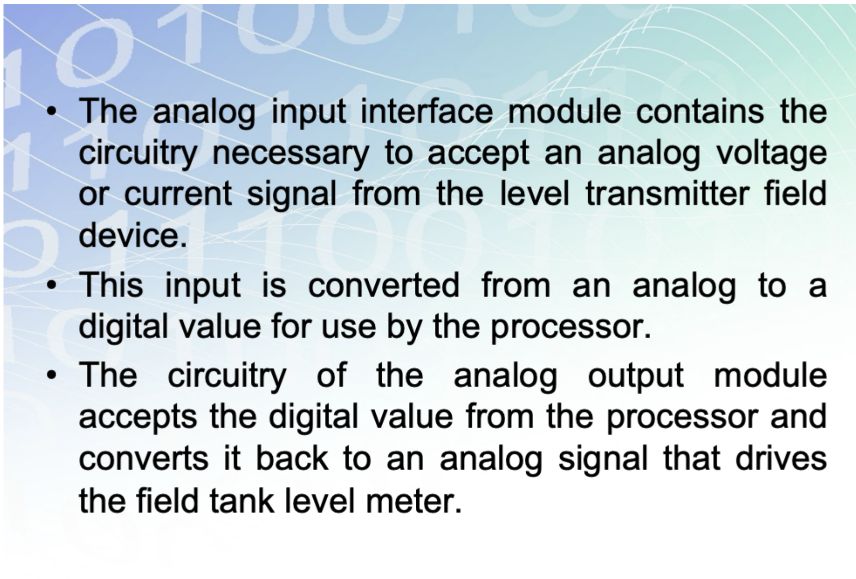
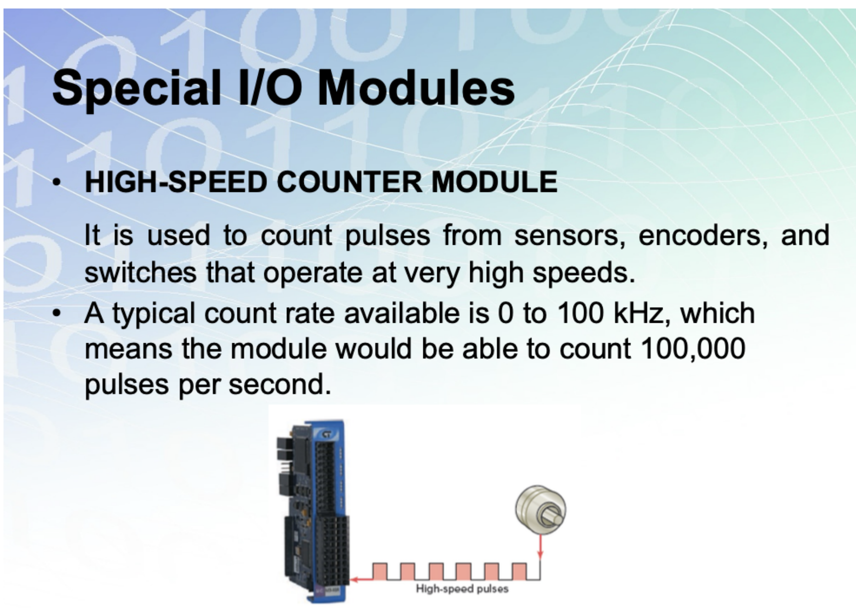


Special I/O Modules →



Special I/O modules in PLCs provide additional functionality beyond standard digital or analog I/O modules. These modules are designed to meet specific requirements or address unique challenges in industrial automation applications. Here are some examples of special I/O modules commonly used in PLC systems:

1. **High-Speed Counter/Encoder Input Modules**:

- High-speed counter or encoder input modules are designed to handle fast pulse signals generated by encoders, tachometers, or other high-speed counting devices.
- These modules often feature dedicated hardware for counting and tracking rapidly changing input signals, providing accurate position or speed feedback for motion control applications.

2. **Temperature Input Modules**:
   - Temperature input modules are specialized modules designed to interface with temperature sensors, such as thermocouples or resistance temperature detectors (RTDs).
   - They include built-in signal conditioning circuits to accurately measure temperature and compensate for temperature drift, providing precise temperature readings for process control and monitoring applications.
3. **Weight/Load Cell Input Modules**:
   - Weight or load cell input modules are used to interface with load cells or weighing scales to measure weight or force.
   - These modules provide signal conditioning and amplification for load cell signals, ensuring accurate and reliable weight measurements for applications such as batching, filling, or material handling.
4. **Analog Output Modules with PID Control**:
   - Some analog output modules include built-in PID (Proportional-Integral-Derivative) control algorithms for closed-loop control applications.
   - These modules allow the PLC to regulate process variables such as temperature, pressure, flow rate, or level by automatically adjusting analog output signals based on feedback from sensors or other sources.
5. **Safety Input/Output Modules**:
   - Safety input/output modules are designed to meet safety standards and requirements for critical safety applications.
   - They may include features such as redundant channels, self-monitoring, fault detection, and diagnostics to ensure safe operation and compliance

with safety regulations.

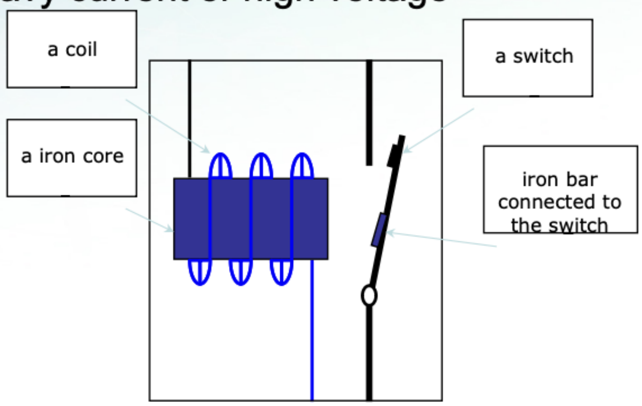
6. **Positioning Modules**:
    - Positioning modules are specialized modules used for precise positioning and motion control applications, such as robotics, CNC machines, or linear actuators.
    - They offer advanced motion control capabilities, including trajectory planning, speed profiling, and coordinated motion control of multiple axes.
7. **Communication Modules**:
    - Communication modules provide additional communication interfaces for connecting the PLC to external devices, networks, or protocols.
    - They may support various communication standards such as Ethernet/IP, Profibus, Modbus, DeviceNet, CANopen, etc., enabling integration with other automation systems and devices.
8. **Remote I/O Modules**:
    - Remote I/O modules allow the PLC to interface with remote I/O devices located at a distance from the main PLC unit.
    - These modules use communication networks such as Ethernet, Profibus, or DeviceNet to transmit I/O data between the remote modules and the PLC, providing flexibility in system layout and installation.

These special I/O modules extend the capabilities of PLC systems, enabling them to address specific application requirements, meet industry standards, and achieve precise control and monitoring in a wide range of industrial automation applications.

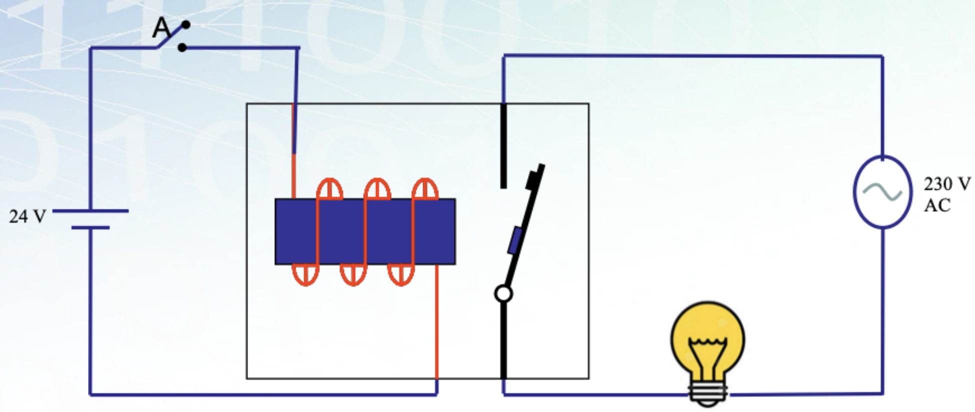
Electromagnetic Control Relays →

Electromagnetic Control Relays

- An electrical relay is a magnetic switch. It uses electromagnetism to switch contacts.
- A relay will usually have only one coil but may have any number of different contacts.
- Used to handle heavy current or high voltage

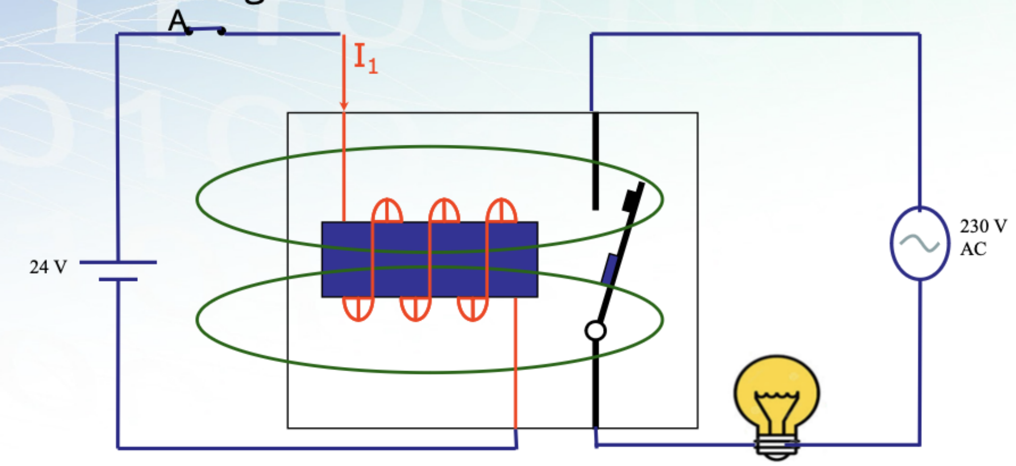


How does a Relay work ?



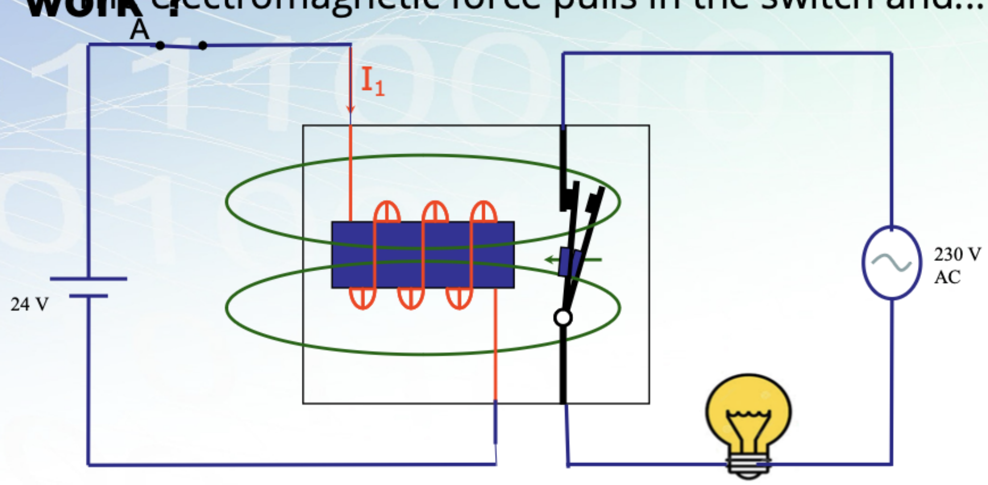
How does a Relay work ?

When a current goes through the coil a magnetic field is produced in the coil and the iron core in the coil becomes magnetic.



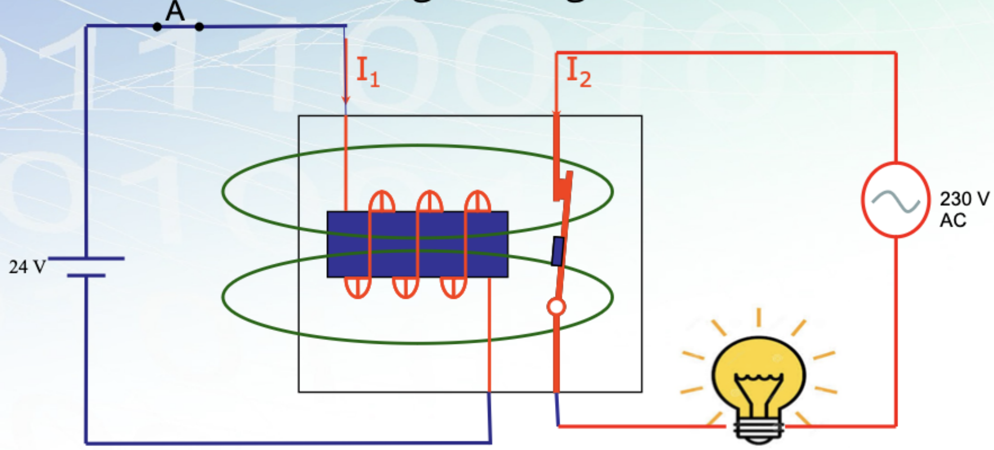
How does a Relay work ?

The electromagnetic force pulls in the switch and...

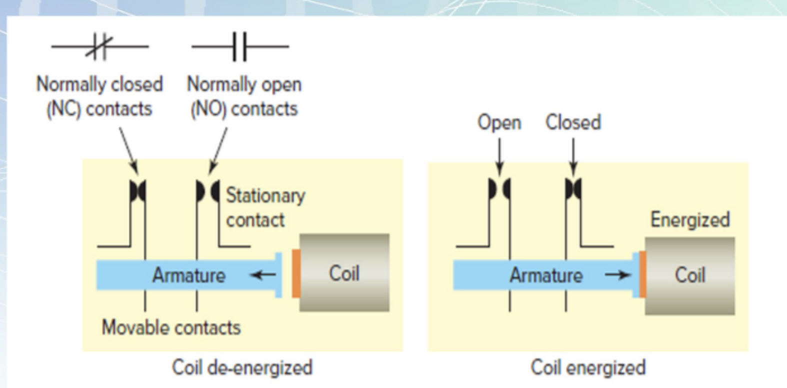


How does a Relay work ?

...a current can go through the switch.



Relay normally open and normally closed contacts.



Electromagnetic control relays are commonly used in conjunction with Programmable Logic Controllers (PLCs) to perform various control and switching functions in industrial automation systems. While PLCs offer digital and analog input/output capabilities, they often interface with external devices, equipment, and processes through relays for control purposes. Here's how electromagnetic control relays are utilized in PLC-based systems:

1. **Input Interface**:
   - PLCs receive input signals from sensors, switches, or other devices to monitor the state of the controlled process. These input signals can be digital (on/off) or analog (voltage or current signals). Electromagnetic control relays are used to interface digital input signals with the PLC. For example, a limit switch detecting the position of a conveyor belt might be connected to a relay input, which in turn is connected to a PLC input module.
2. **Output Control**:
   - PLCs send output signals to actuators, motors, valves, or other devices to control their operation. Electromagnetic control relays are used as output devices to switch power to these actuators or devices based on the control logic programmed in the PLC. For instance, a PLC might energize a relay to close a circuit and start a motor when certain conditions are met, such as reaching a setpoint temperature or detecting a specific event.
3. **Interfacing with High-Power Loads**:
   - PLCs have limited output current capacity and may not be directly capable of driving high-power loads such as motors or heaters. Electromagnetic control relays act as intermediary devices that can handle higher currents or voltages than the PLC's output circuits. The PLC controls the relays, which, in turn, switch power to the high-power loads. This ensures that the PLC's internal components are not subjected to excessive currents or voltages.
4. **Safety Functions**:
   - Electromagnetic control relays are often used in safety-critical applications to implement safety interlocks or emergency stop functions. For example,

a safety relay may be used to monitor emergency stop buttons or safety switches and ensure that power is immediately cut off to hazardous equipment in case of an emergency.

5. **Logic and Sequencing Control**:
    - Relays can be used in combination with PLCs to implement logic functions, timing sequences, or interlocking operations. Multiple relays can be interconnected to perform complex control tasks based on the programmed logic in the PLC. For instance, relays may be used to implement ladder logic functions such as AND, OR, and NOT operations.
6. **Isolation and Protection**:
    - Electromagnetic control relays provide electrical isolation between the PLC's low-voltage control circuits and the higher-voltage or higher-current devices they control. This isolation helps protect the PLC from damage due to electrical transients, noise, or faults in the external circuits.

Overall, electromagnetic control relays play a crucial role in PLC-based control systems, providing a reliable means of interfacing with external devices, implementing control logic, and ensuring safe and efficient operation of industrial processes and equipment.

Switches →

In Programmable Logic Controllers (PLCs), various types of switches are used as input devices to detect the state of external equipment, machines, or processes. These switches provide digital signals to the PLC, indicating whether a particular condition is met or not. Here are some common types of switches used in PLC applications:

1. **Push Button Switches**:
    - Push button switches are momentary-contact switches that are manually actuated by pressing a button. They provide an input signal to the PLC only while the button is pressed. Push button switches are often used for operator control, start/stop functions, or manual input.
2. **Selector Switches**:

- Selector switches are rotary or lever-operated switches with multiple positions. They allow the operator to select from multiple options or modes, with each position corresponding to a specific input signal. Selector switches are commonly used for mode selection, parameter adjustment, or control mode switching.

3. **Toggle Switches**:
   - Toggle switches are manually operated switches with a lever or toggle that can be flipped between two stable positions (on/off). They maintain their state until toggled again. Toggle switches provide binary input signals to the PLC, representing two states (e.g., enabled/disabled, open/closed).
4. **Limit Switches**:
   - Limit switches are mechanical switches activated by the motion of an object or machine part. They provide a signal to the PLC when the object reaches a specific position or limit. Limit switches are used for position sensing, end-of-travel detection, or safety interlocking in industrial applications.
5. **Proximity Sensors**:
   - Proximity sensors detect the presence or absence of objects without physical contact. They use various sensing principles such as inductive, capacitive, or optical sensing to detect objects within their detection range. Proximity sensors provide digital input signals to the PLC, indicating the presence or absence of the detected object.
6. **Photoelectric Sensors**:
   - Photoelectric sensors use light beams to detect the presence or absence of objects. They emit a light beam and detect changes in light intensity caused by the presence or absence of objects in the sensor's field of view. Photoelectric sensors provide digital input signals to the PLC, indicating object detection.
7. **Pressure Switches**:
   - Pressure switches are activated by changes in fluid pressure. They provide a signal to the PLC when the pressure reaches a certain threshold.

Pressure switches are used for pressure monitoring, safety interlocking, or controlling pneumatic or hydraulic systems in industrial applications.

8. **Temperature Switches**:
    - Temperature switches, also known as thermal switches or thermostats, are activated by changes in temperature. They provide a signal to the PLC when the temperature exceeds a certain setpoint. Temperature switches are used for temperature monitoring, over-temperature protection, or temperature-based control in heating or cooling systems.

These are some common types of switches used in PLC applications to provide input signals for controlling and monitoring industrial processes and equipment. The selection of a particular type of switch depends on factors such as the application requirements, environmental conditions, and desired functionality.

Switches

- ***Manually operated switches -*** are controlled by hand. These include toggle switches, pushbutton switches, knife switches, and selector switches.
- ***Mechanically operated switches -*** are controlled automatically by factors such as pressure, position, or temperature.

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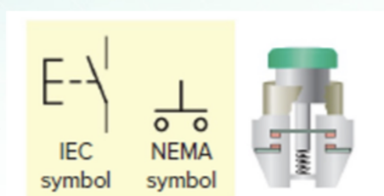
Manually operated switches

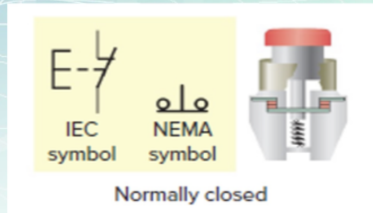
- ***Pushbutton switches*** - It operates by opening or closing contacts when pressed.

- ***Normally open (NO)*** *pushbutton, which makes a* circuit when it is pressed and returns to its open position when the button is released.

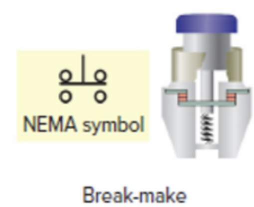


Normally open

Normally closed (NC) *pushbutton, which opens the* circuit when it is pressed and returns to the closed position when the button is released.

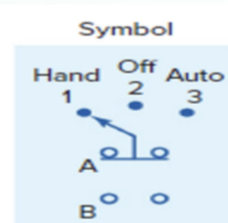


Break-before-make *pushbutton in which the top* section contacts are NC and the bottom section contacts are NO. When the button is pressed, the top contacts open before the bottom contacts are closed.



- ***Selector switch***

  Switch positions are established by turning the operator knob right or left. Selector switches may have two or more selector positions



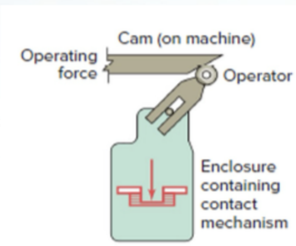
Toggle Switch

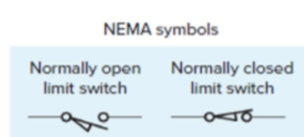
- **Toggle switches** are actuated by a lever angled in one of two or more positions. The common light switch used in household wiring is an example of a toggle switch.

Mechanically Operated Switches

- **Limit switch**

  Limit switches are designed to operate only when a predetermined limit is reached, and they are usually actuated by contact with an object such as a cam.
- They are often used in the control circuits of machine processes to govern the starting, stopping, or reversal of motors.

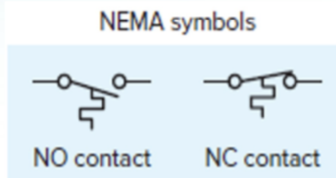




- ***Temperature switch, or thermostat***

  These switches open or close when a designated temperature is reached.

  Industrial applications for these devices include maintaining the desired temperature range of air, gases, liquids, or solids.



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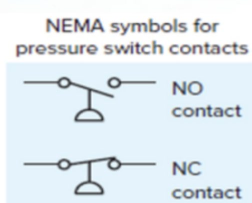
- **Pressure switches**

  used to control the pressure of liquids and gases.

  They are all basically designed to actuate (open or close) their contacts when a specified pressure is reached.

  Pressure switches can be pneumatically (air) or hydraulically (liquid) operated switches.

  Generally, bellows or a diaphragm presses up against a small microswitch and causes it to open or close.



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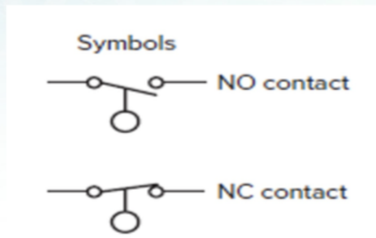
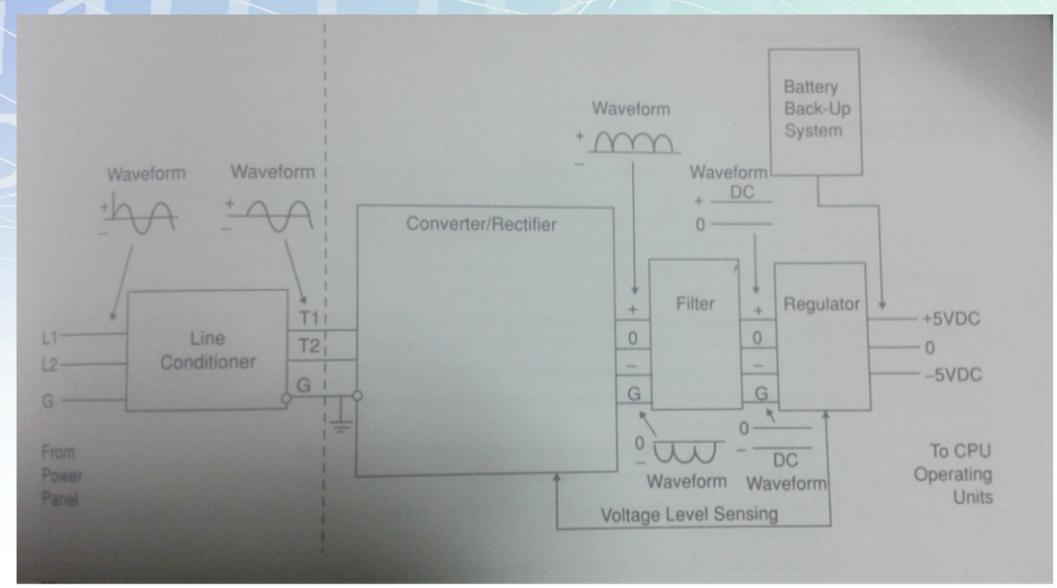
- ***Level switches***

used to sense liquid levels in vessels and provide automatic control for motors that transfer liquids from sumps or into tanks.



Power Supply



Types of Sensors →

In Programmable Logic Controllers (PLCs), various types of sensors are used to detect and measure physical quantities such as temperature, pressure, position, proximity, light, flow, and more. These sensors provide input signals to the PLC, enabling it to monitor and control industrial processes and equipment. Here are some common types of sensors used in PLC applications:

1. **Proximity Sensors**:
    - Proximity sensors detect the presence or absence of objects without physical contact. They can use different sensing principles such as inductive, capacitive, or optical sensing. Inductive proximity sensors detect metal objects, while capacitive proximity sensors detect non-metallic objects. Optical proximity sensors use light beams to detect objects within their sensing range.
2. **Photoelectric Sensors**:
    - Photoelectric sensors use light beams to detect the presence, absence, or changes in position of objects. They emit a light beam and detect changes in light intensity caused by the presence or absence of objects in their field of view. Photoelectric sensors can be diffuse, retroreflective, or through-beam, depending on the application requirements.
3. **Temperature Sensors**:
    - Temperature sensors measure temperature variations in their surroundings. Different types of temperature sensors include thermocouples, resistance temperature detectors (RTDs), and thermistors. Thermocouples generate a voltage proportional to the temperature difference, RTDs change resistance with temperature, and thermistors change resistance with temperature in a non-linear manner.
4. **Pressure Sensors**:
    - Pressure sensors measure the pressure of gases or liquids in their surroundings. They can be categorized as absolute, gauge, or differential pressure sensors depending on the reference pressure used. Pressure sensors are used in various applications such as monitoring pneumatic or

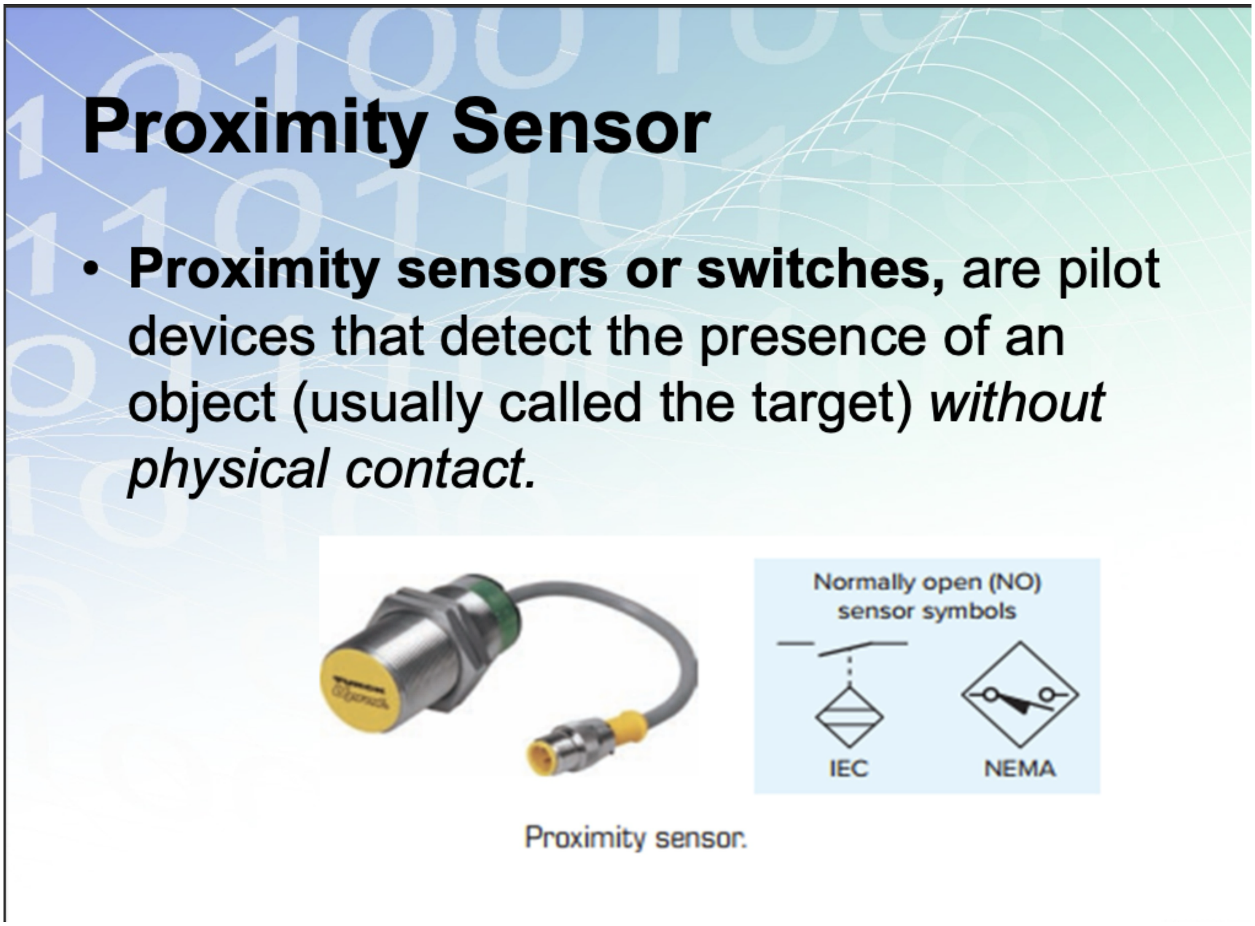
hydraulic systems, gas pressure measurement, and industrial process control.

5. **Flow Sensors**:
   - Flow sensors measure the flow rate of liquids or gases in a pipeline or system. They can be mechanical, such as paddlewheel or turbine flow sensors, or non-contact, such as ultrasonic or magnetic flow sensors. Flow sensors are used in applications such as monitoring fluid flow in pipelines, controlling flow rates in industrial processes, and metering fluid consumption.
6. **Level Sensors**:
   - Level sensors measure the level of liquids or solids in tanks, vessels, or containers. They can use different sensing principles such as float switches, ultrasonic sensors, capacitive sensors, or radar sensors. Level sensors are used in applications such as liquid level monitoring, inventory management, and pump control.
7. **Position Sensors**:
   - Position sensors detect the position or movement of objects or machine parts. They can be linear or rotary and use various sensing principles such as potentiometers, encoders, Hall effect sensors, or magnetostrictive sensors. Position sensors are used in applications such as machine positioning, robotic systems, and motion control.
8. **Force Sensors**:
   - Force sensors measure the force or load applied to an object. They can be categorized as load cells, strain gauges, or piezoelectric sensors. Force sensors are used in applications such as weighing scales, force measurement, material testing, and robotics.

These are some common types of sensors used in PLC applications to provide input signals for monitoring and controlling industrial processes and equipment. The selection of a particular type of sensor depends on factors such as the application requirements, environmental conditions, and the physical quantity to be measured.

Types

- Proximity Sensor
- Magnetic Reed Switch
- Light Sensors
- Ultrasonic Sensors
- Strain/Weight Sensors
- Temperature Sensors
- Flow Measurement
- Velocity and Position Sensors



inductive-type proximity sensor →

An inductive-type proximity sensor is a non-contact sensor that detects the presence or absence of metallic objects within its sensing range without physical contact. These sensors operate based on the principle of electromagnetic induction. Here's how an inductive-type proximity sensor works:

1. **Sensing Principle**:
   - Inductive proximity sensors generate an electromagnetic field around their sensing surface when energized by an electrical power supply. This electromagnetic field extends from the sensor's active face into the surrounding area.
2. **Detection of Metallic Objects**:
   - When a metallic object enters the sensing range of the inductive proximity sensor, it disturbs the electromagnetic field. This disturbance alters the

impedance of the sensor's coil, causing a change in the sensor's output signal.

3. **Output Signal**:

   - Inductive proximity sensors typically provide a digital output signal, which changes state (e.g., from OFF to ON or vice versa) when a metallic object is detected within the sensor's sensing range.

Inductive-type *proximity sensor*

- Used to detect both ferrous metals (containing iron) and nonferrous metals (such as copper, aluminum, and brass).
- Inductive proximity sensors operate under the electrical principle of inductance, where a fluctuating current induces an electromotive force (emf) in a target object.

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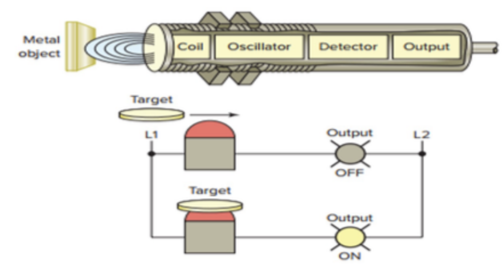
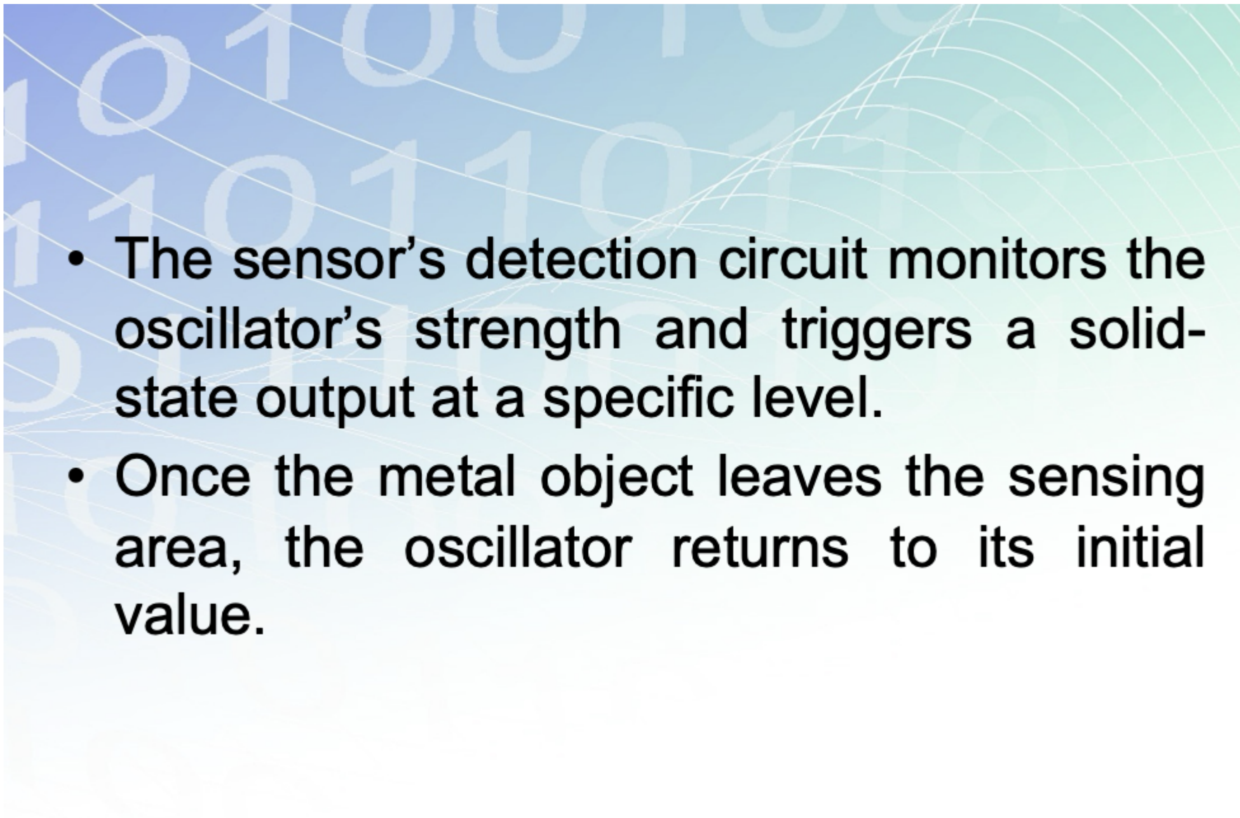
• The oscillator circuit generates a high-frequency electromagnetic field that radiates from the end of the sensor.
• When a metal object enters the field, eddy currents are induced in the surface of the object.
• The eddy currents on the object absorb some of the radiated energy from the sensor, resulting in a loss of energy and change of strength of the oscillator.



Inductive proximity sensor.



Capacitive proximity sensors →

Capacitive proximity sensors are non-contact sensors that detect the presence or absence of objects based on changes in capacitance. These sensors operate by generating an electrostatic field and detecting changes in the capacitance caused by the presence or absence of objects within their sensing range. Here's how capacitive proximity sensors work:

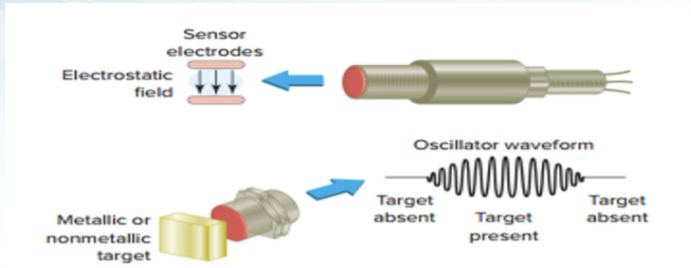
1. **Sensing Principle**:
    - Capacitive proximity sensors consist of two closely spaced electrodes, typically a sensing electrode and a ground/reference electrode. When voltage is applied to the sensing electrode, it generates an electrostatic field in the surrounding area.
    - The presence of an object within the sensor's sensing range alters the electrostatic field, resulting in a change in capacitance between the sensing electrode and the object.
2. **Detection of Objects**:

- When an object enters the sensor's sensing range, it disturbs the electrostatic field around the sensing electrode. This disturbance changes the capacitance between the sensing electrode and the object.
- The change in capacitance is detected by the sensor's electronics, which triggers a corresponding change in the sensor's output signal.

3. **Output Signal**:
    - Capacitive proximity sensors typically provide a digital output signal, which changes state (e.g., from OFF to ON or vice versa) when an object is detected within the sensor's sensing range.

Capacitive proximity sensors

- Senses both conductive and nonconductive materials such as paper, glass, liquids, and cloth.



Capacitive proximity sensor.

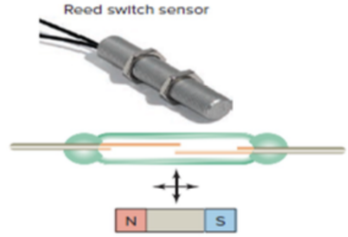
Operation

- A capacitive sensor contains a high-frequency oscillator along with a sensing surface formed by two metal electrodes.
- When the target nears the sensing surface, it enters the electrostatic field of the electrodes and changes the capacitance of the oscillator.
- As a result, the oscillator circuit begins oscillating and changes the output state of the sensor when it reaches a certain amplitude.
- As the target moves away from the sensor, the oscillator's amplitude decreases, switching the sensor back to its original state.

A magnetic reed switch, also known simply as a reed switch, is a type of electrical switch operated by a magnetic field. It consists of two ferromagnetic, flexible metal reeds sealed in a glass tube filled with inert gas. When a magnetic field is applied to the reed switch, the reeds are magnetized and attracted to each other, closing the electrical circuit.

Magnetic Reed Switch

- A magnetic reed switch is composed of two flat contact tabs that are hermetically sealed (airtight) in a glass tube filled with protective gas.

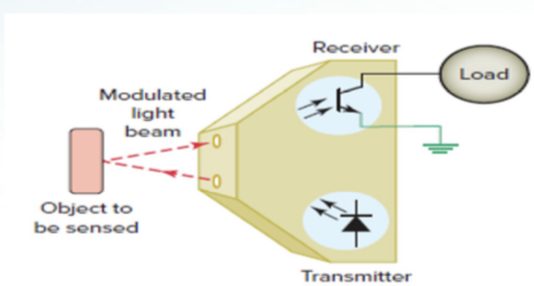


Magnetic reed switch.
Source: Courtesy of Reed Switch Developments Corp., used with permission.

Light Sensors

- A ***photoelectric sensor* –** It is an optical control device that operates by detecting a visible or invisible beam of light and responding to a change in the received light intensity.

- The transmitter contains a light source, usually an LED along with an oscillator.
- The oscillator modulates or turns the LED on and off at a high rate of speed.
- The transmitter sends this modulated light beam to the receiver.
- The receiver decodes the light beam and switches
- the output device, which interfaces with the load.



Ultrasonic Sensors

- An ***ultrasonic sensor operates by sending high-frequency*** sound waves toward the target and measuring the time it takes for the pulses to bounce back.
- The time taken for this echo to return to the sensor is directly proportional to the distance or height of the object because sound has a constant velocity.

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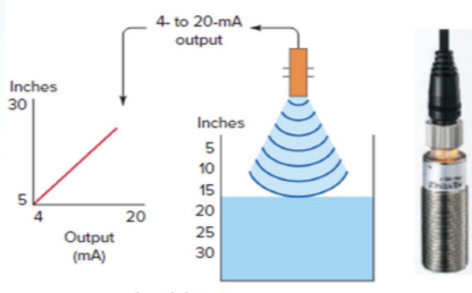
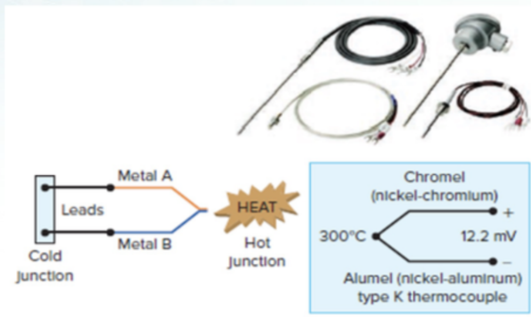
- A practical application in which the returning echo signal is electronically converted to a 4 to 20 mA output.
- The 4- to 20-mA mA represents the sensor's measurement span.
- The sensor will proportionately generate a 4-mA signal when the tank is empty and a 20-mA signal when the tank is full.



Temperature Sensors

- The **thermocouple** is the most widely used temperature sensor.
- Thermocouples operate on the principle that when two dissimilar metals are joined, a predictable DC voltage will be generated that relates to the difference in temperature between the hot junction and the cold junction



Thermocouple temperature sensor.
Source: Photo courtesy Omron Industrial Automation, **www.ia.omron.com**.

- **Resistance temperature detectors (RTDs)** are wire wound temperature-sensing devices that operate on the principle of the positive temperature coefficient (PTC) of metals.
- That means the electrical resistance of metals is directly proportional to temperature.
- Platinum is the material most often used in RTDs because of its superiority regarding temperature limit, linearity, and stability.