Introduction to Programmable Controllers

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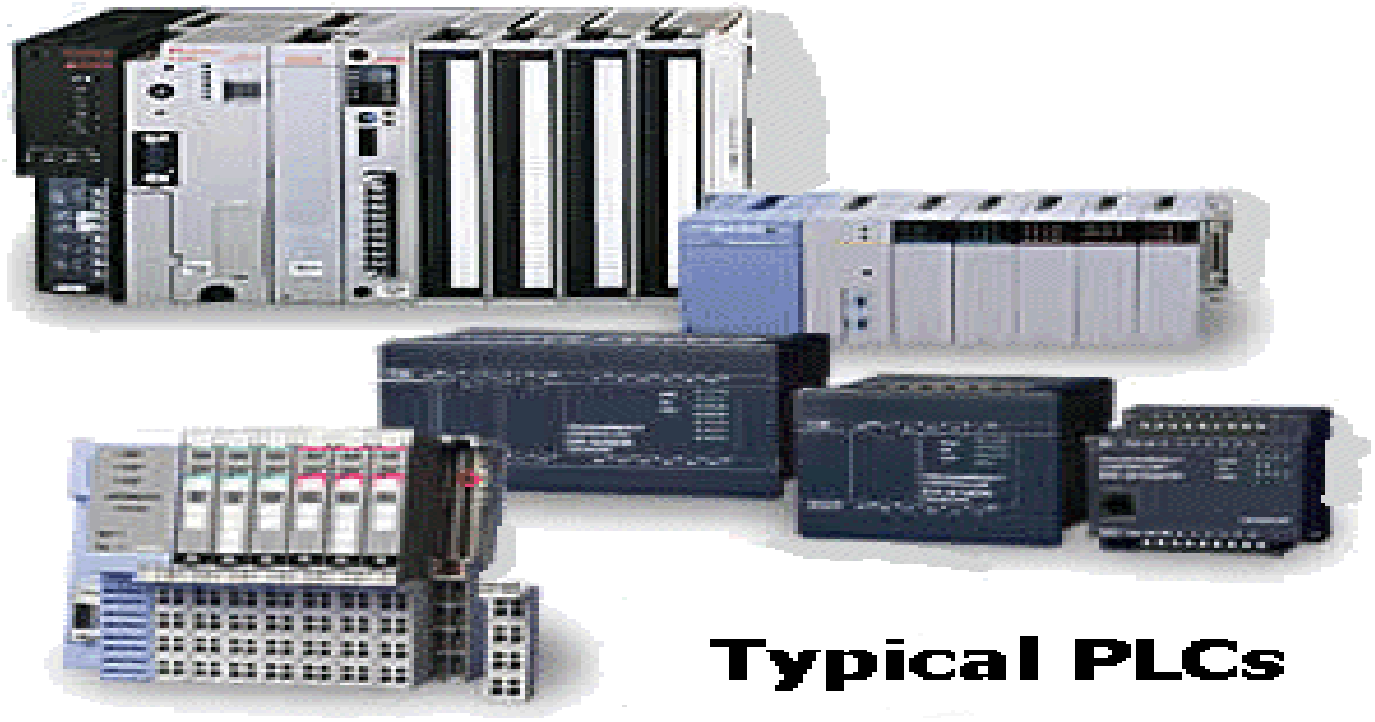


Typical PLCs

Definition

- **Programmable logic controllers**, also called *programmable controllers* or *PLCs*, are **solid-state** members of the computer family, using integrated circuits instead of electromechanical devices to implement control functions.

- They are capable of storing instructions, such as sequencing, timing, counting, arithmetic, data manipulation, and communication, to control industrial machines and processes.

Definition

- PLCs are industrial computers with specially designed architecture in both their central units (the PLC itself) and their interfacing circuitry to field devices (input/output connections to the real world).

Definition

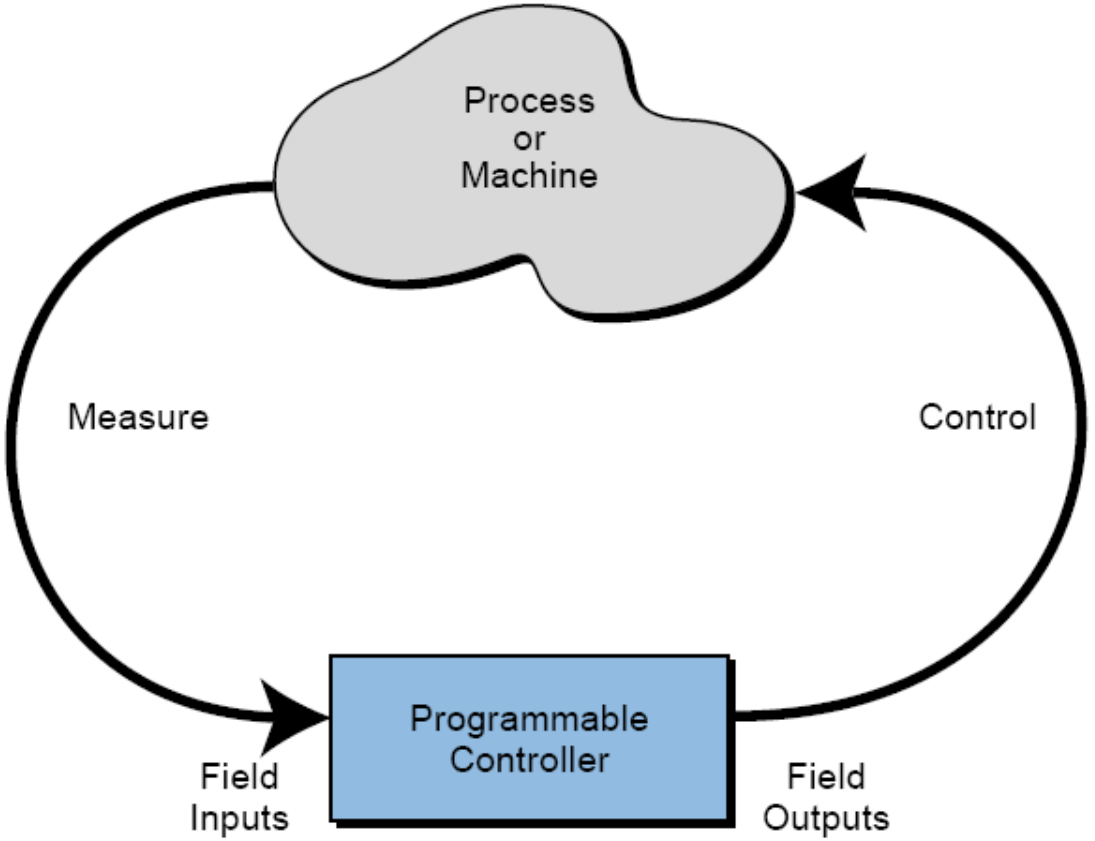
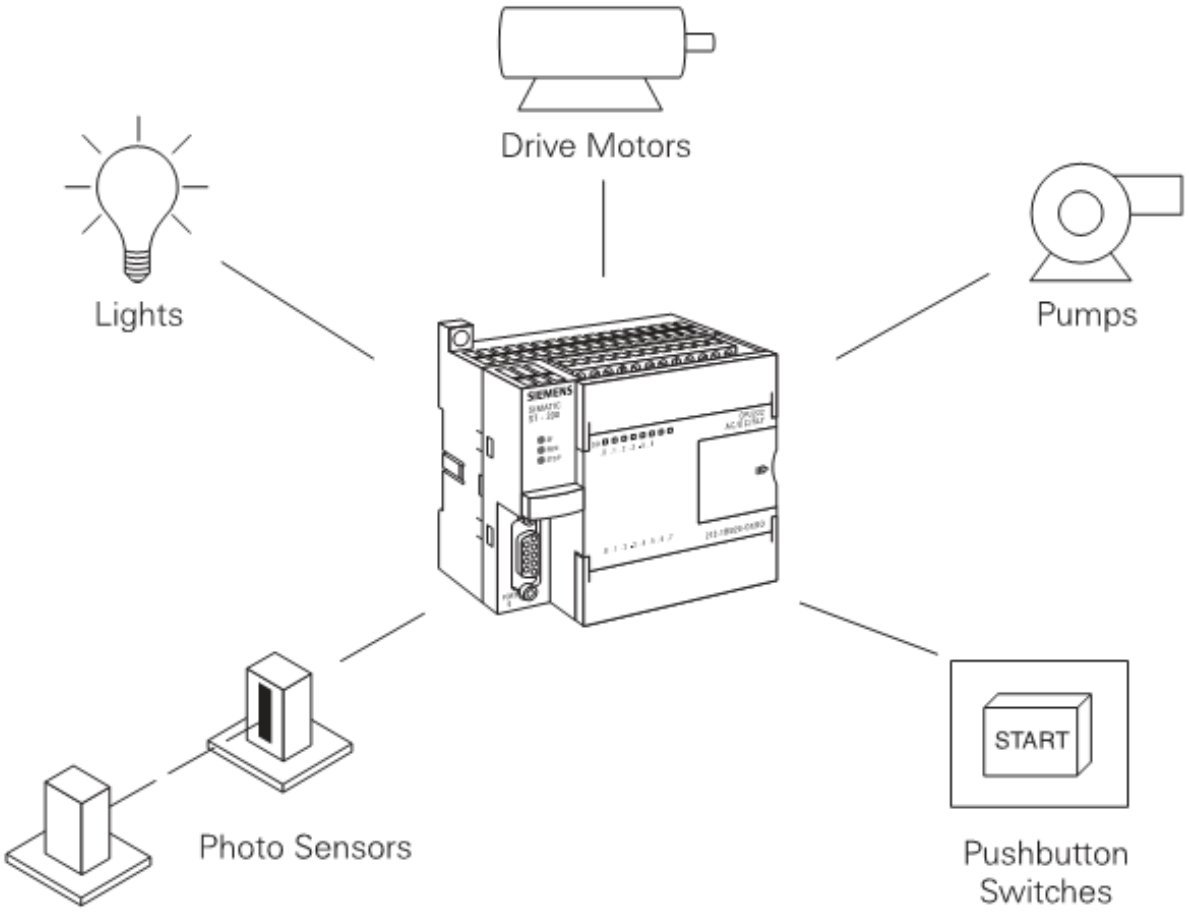


Figure 1-1. PLC conceptual application diagram.

Definition


Drive Motors
Lights
Pumps
SIEMENS
START
Photo Sensors
Pushbutton
Switches

Historical Background

- General Motors specified the design criteria for the first programmable controller in 1968.
- Their primary goal was to eliminate the high costs associated with inflexible, relay controlled systems.
- Initial Specification included the following:
  - The new control system had to be price competitive with relay systems.
  - The system had to be capable of sustaining an industrial environment.
  - The input and output interfaces had to be easily replaceable.
  - The control system needed to pass data collection to a central system.
  - The system had to be reusable.
  - The method used to program the controller had to be simple

Historical Background

- The first PLCs offered relay functionality, thus replacing the original hardwired **relay logic**, which used electrically operated devices to mechanically switch electrical circuits.
- They met the requirements of:
  - Modularity.
  - Expandability.
  - Programmability.
  - Ease of use in an industrial environment.
  - Ease of installation.
  - Used less space.
  - Were reusable.
- The controller programming, although a little tedious, had a recognizable plant standard: the ladder diagram format.

Historical Background

- By 1971, PLCs were being used to provide relay replacement as the first steps toward control automation in other industries, such as food and beverage, metals, manufacturing, and pulp and paper.

- Many technological advances in the programmable controller industry continue today. Changes include both **hardware** (physical components) and **software** (control program) upgrades.

Historical Background: PLC hardware enhancements

- Faster scan times.
- Small, low-cost PLCs with more power.
- High-density input/output (I/O) systems.
- Intelligent, microprocessor-based I/O interfaces such as PID, network, and host computer.
- Mechanical design improvements have included: rugged input/output enclosures and input/output systems that have made the terminal an integral unit.
- Special interfaces have allowed certain devices to be connected directly to the controller, such as thermocouples and strain gauges.
- Peripheral equipment has improved operator interface techniques

Historical Background

Figure 1-4. Allen-Bradley's programmable controller family concept with several PLCs.

Historical Background: PLC software enhancements

- Object-oriented programming tools have been incorporated.
- Powerful instructions have been provided.
- High-level languages, such as BASIC and C, have been implemented.
- Advanced functional block instructions have been implemented for ladder diagram instruction.
- Diagnostics and fault detection have been expanded.
- Floating-point math has made it possible to perform complex calculations.
- Data handling and manipulation instructions have been improved and simplified.

Historical Background

- PLCs are being incorporated into computer-integrated manufacturing (CIM) systems, robots, and CAD/CAM systems.
- Advances in PLC technology include features such as better operator interfaces, graphic user interfaces (GUIs), and more human-oriented man/machine interfaces (such as voice modules).
- Advances include development of interfaces that allow communication with equipment, hardware, and software that supports artificial intelligence, such as fuzzy logic I/O systems.
- New PLC instructions are developed out of the need to add intelligence to a controller.
- The future will almost certainly continue to cast programmable controllers as an important player in the factory.

Principles of Operation

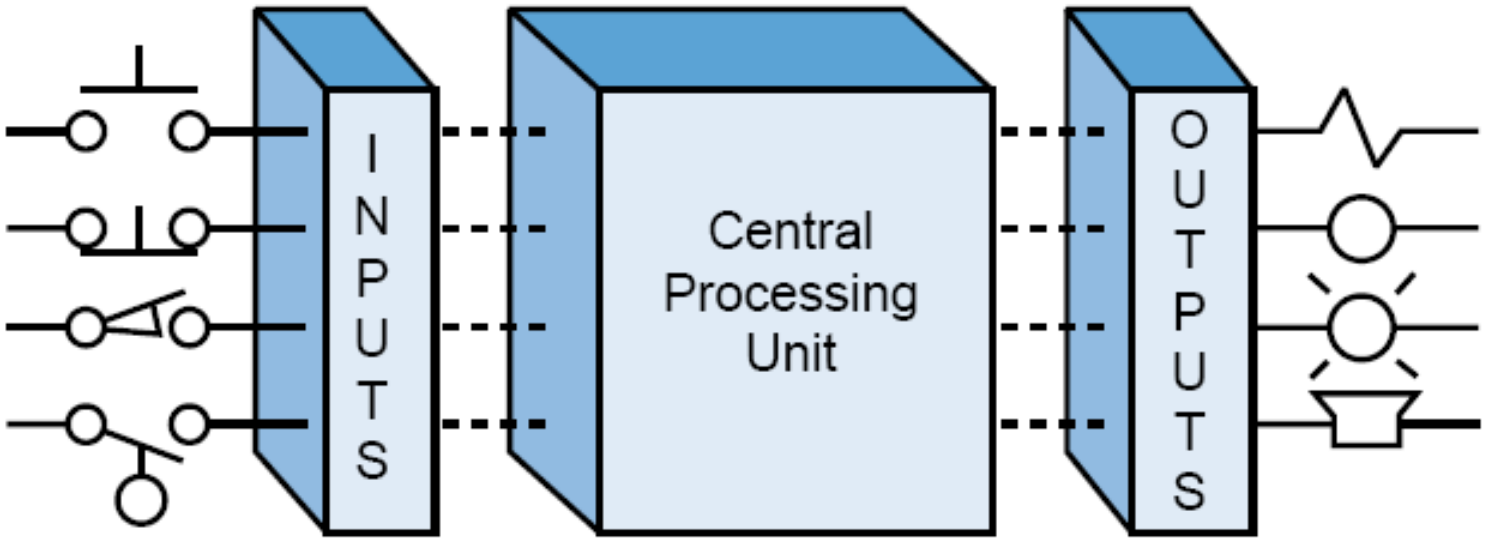


Figure 1-5. Programmable controller block diagram.

Principles of Operation

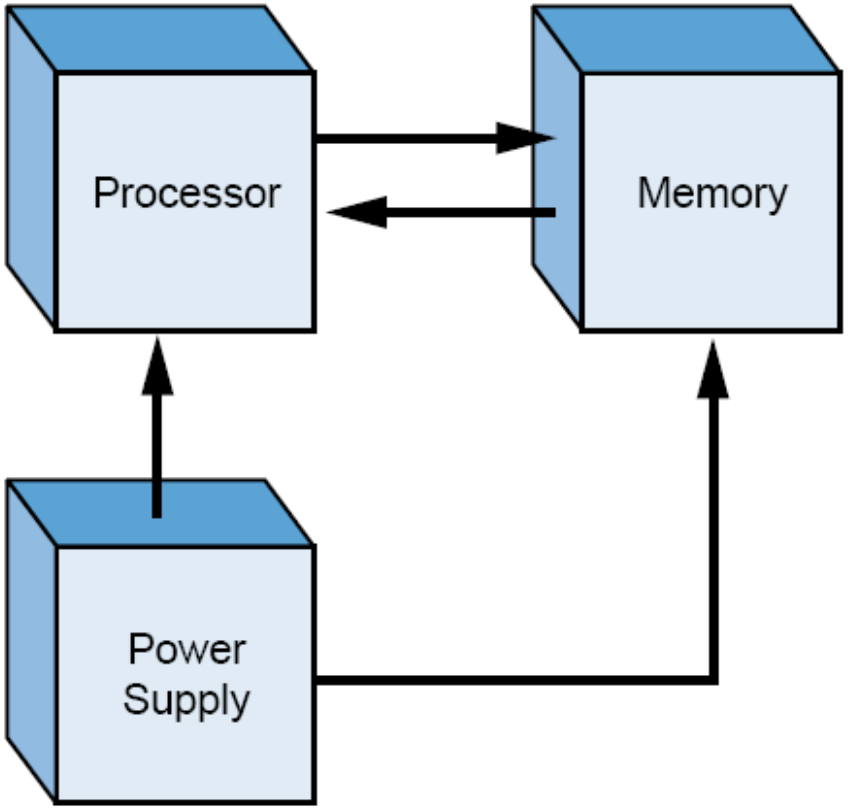


Figure 1-6. Block diagram of major CPU components.

Principles of Operations

- The input/output system forms the **interface** by which field devices are connected to the controller.
- The main purpose of the interface is to condition the various signals received from or sent to external field devices.
- Incoming signals from sensors (e.g., push buttons, limit switches, analog sensors, selector switches, and thumbwheel switches) are wired to terminals on the input interfaces.
- Devices that will be controlled, like motor starters, solenoid valves, pilot lights, and position valves, are connected to the terminals of the output interfaces.
- The system **power supply** provides all the voltages required for the proper operation of the various central processing unit sections.

Principles of Operation

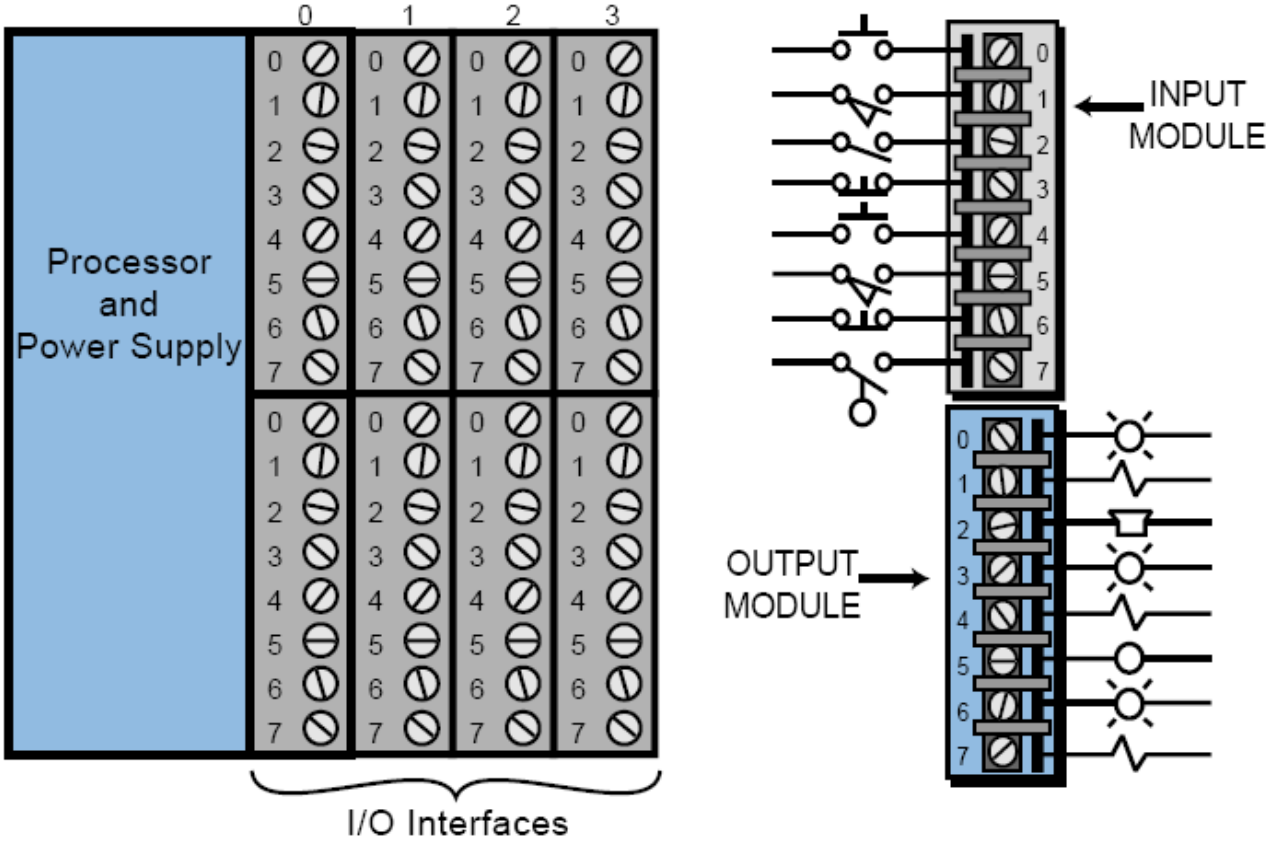


Figure 1-8. Input/output interface.

Principles of Operation: Scan Cycle

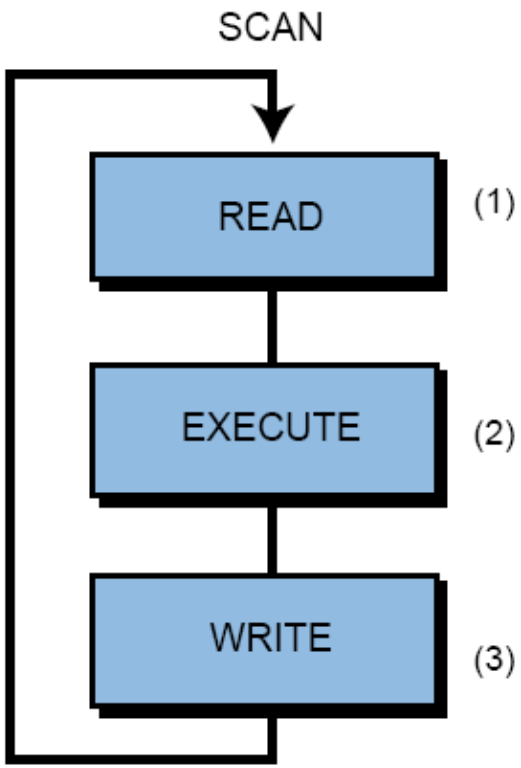


Figure 1-7. Illustration of a scan.

PLCs versus other controllers

- Is there a need for flexibility in control logic changes?
- Is there a need for high reliability?
- Are space requirements important?
- Are increased capability and output required?
- Are there data collection requirements?
- Will there be frequent control logic changes?
- Will there be a need for rapid modification?
- Must similar control logic be used on different machines?
- Is there a need for future growth?
- What are the overall costs?

PLC Applications

- Automotive.
- Chemical and Petrochemical.
- Glass Processing.
- Manufacturing and Machining.
- Materials Handling.
- Metals.
- Power.
- Pulp and Paper.
- Rubber and Plastic.

PLC Applications: Automotive

- **Internal Combustion Engine Monitoring.**
- **Carburetor Production Testing.**
- **Monitoring Automotive Production Machines.**
- **Power Steering Valve Assembly and Testing.**

PLC Applications: Chemical and Petrochemical

- **Dyes.**
- **Chemical Batching.**
- **Fan Control.**
- **Gas Transmission and Distribution.**
- **Pipeline Pump Station Control.**
- **Oil Fields.**

PLC Applications: Manufacturing / Machining

- **Production Machines.**
- **Transfer Line Machines.**
- **Wire Machine.**
- **Tool Changing.**
- **Paint Spraying.**

PLC Applications: Power

- **Plant Power System.**
- **Energy Management.**
- **Coal Fluidization Processing.**
- **Compressor Efficiency Control.**

Ladder Diagrams and PLC

- The **ladder diagram** represents electrical sequences of operations.
- These diagrams represent the interconnection of field devices in such a way that the activation, or turning ON, of one device will turn ON another device according to a predetermined sequence of events

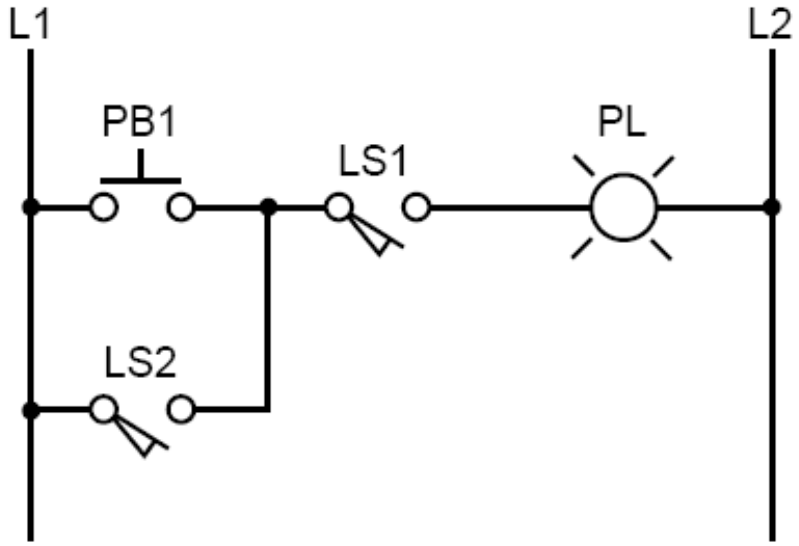


Figure 1-15. Simple electrical ladder diagram.

Ladder Diagrams and PLC

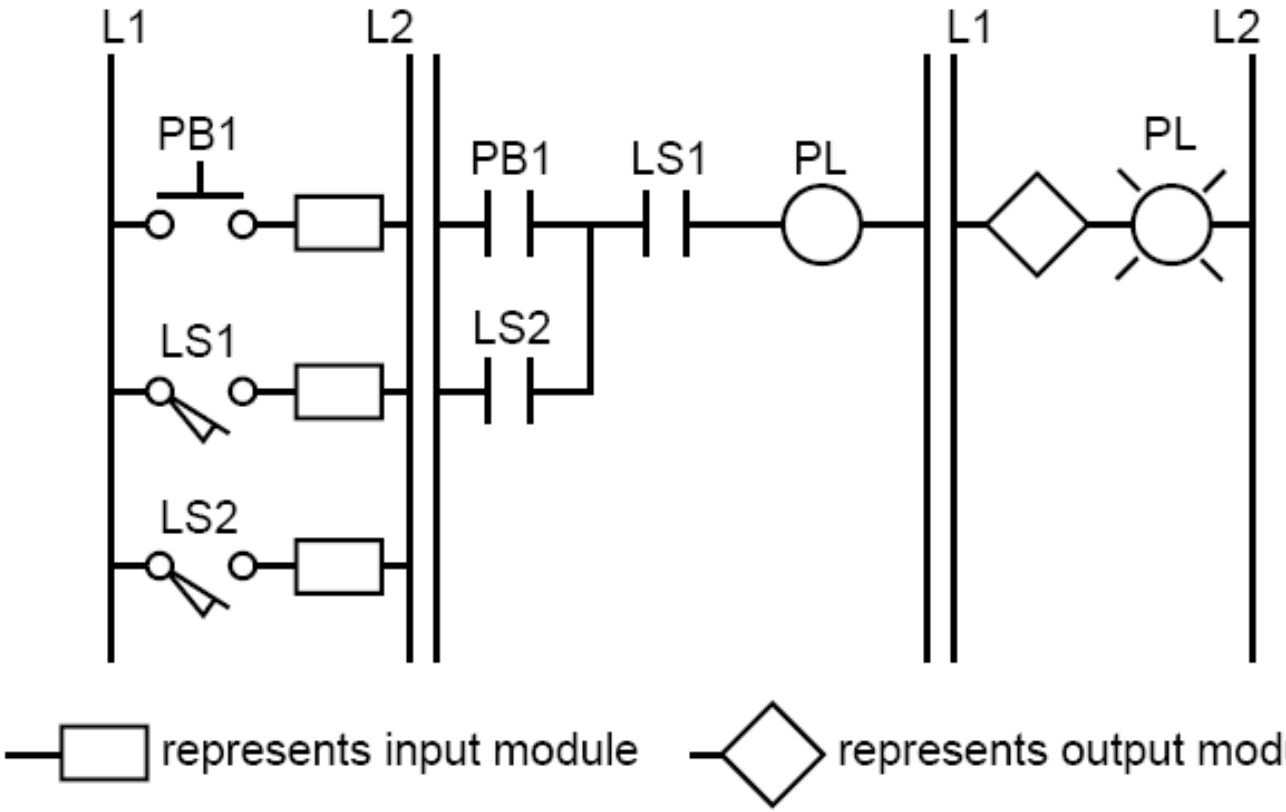


Figure 1-16. PLC implementation of Figure 1-15.

Ladder Diagrams and PLC

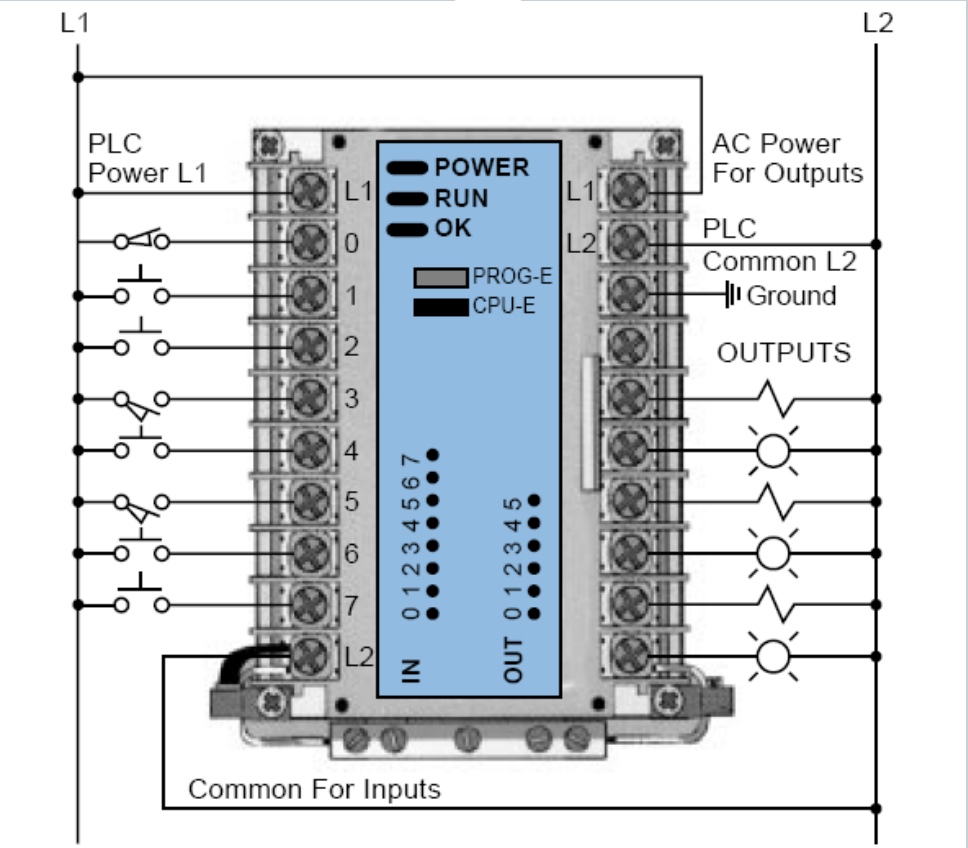
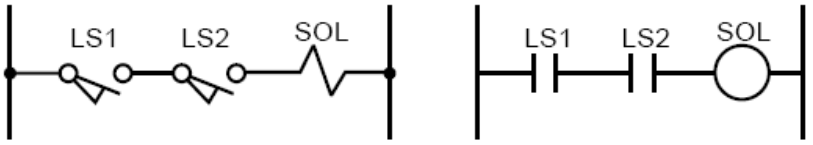
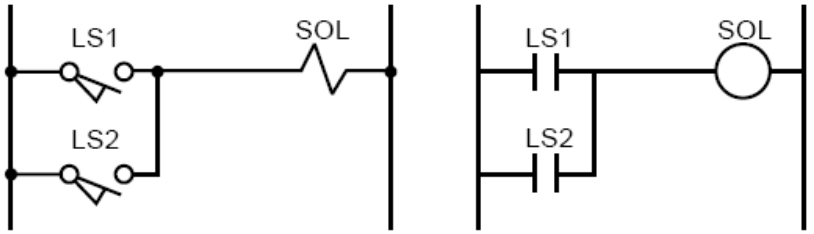


Figure 1-18. Programmable controller I/O connection diagram showing no physical connections between the inputs and outputs.

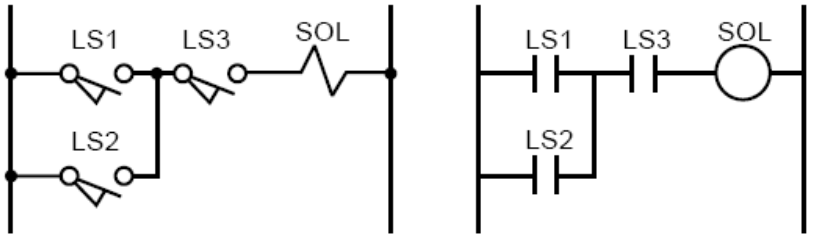
Ladder Diagrams and PLC



(a) Series



(b) Parallel



(c) Adding one LS in series

Figure 1-19. Example of hardwiring changes as opposed to softwiring changes.

PLC Advantages

Inherent Features	Benefits
Solid-state components	• High reliability
Programmable memory	• Simplifies changes • Flexible control
Small size	• Minimal space requirements
Microprocessor-based	• Communication capability • Higher level of performance • Higher quality products • Multifunctional capability
Software timers/counters	• Eliminate hardware • Easily changed presets
Software control relays	• Reduce hardware/wiring cost • Reduce space requirements
Modular architecture	• Installation flexibility • Easily installed • Reduces hardware cost • Expandability
Variety of I/O interfaces	• Controls a variety of devices • Eliminates customized control
Remote I/O stations	• Eliminate long wire/conduit runs
Diagnostic indicators	• Reduce troubleshooting time • Signal proper operation
Modular I/O interface	• Neat appearance of control panel • Easily maintained • Easily wired
Quick I/O disconnects	• Service without disturbing wiring
System variables stored in memory data	• Useful management/maintenance • Can be output in report form

Table 1-3. Typical programmable controller features and benefits.

Ease of Installation

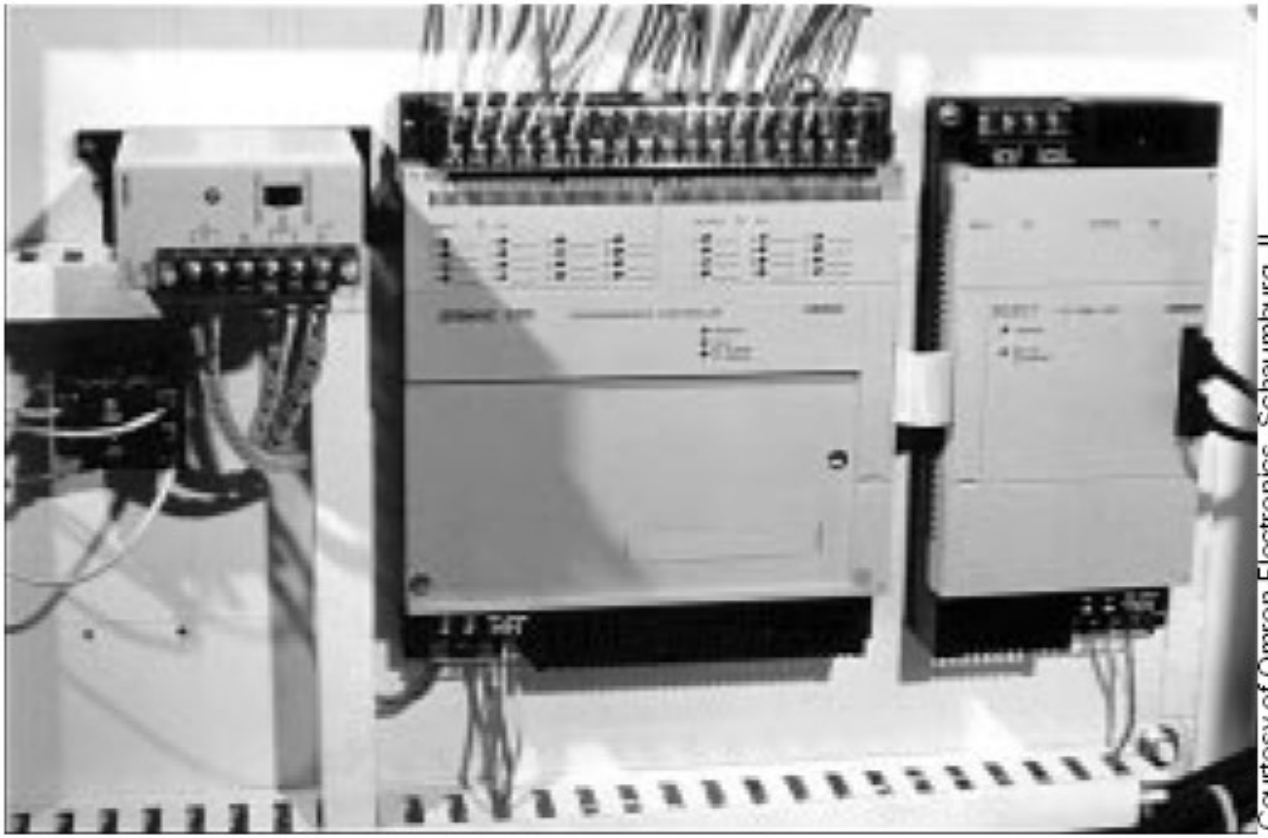


Figure 1-20. Space-efficient design of a PLC.

Remote I/O

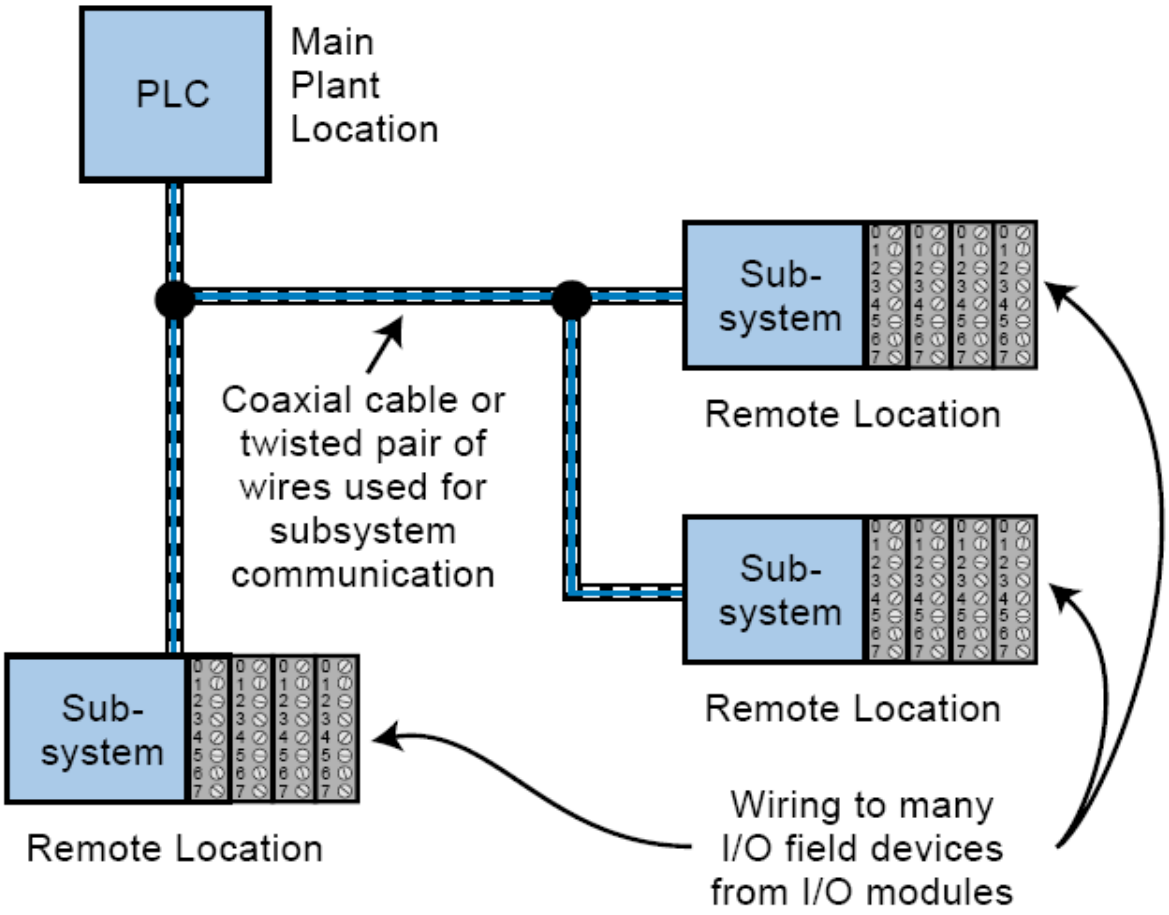
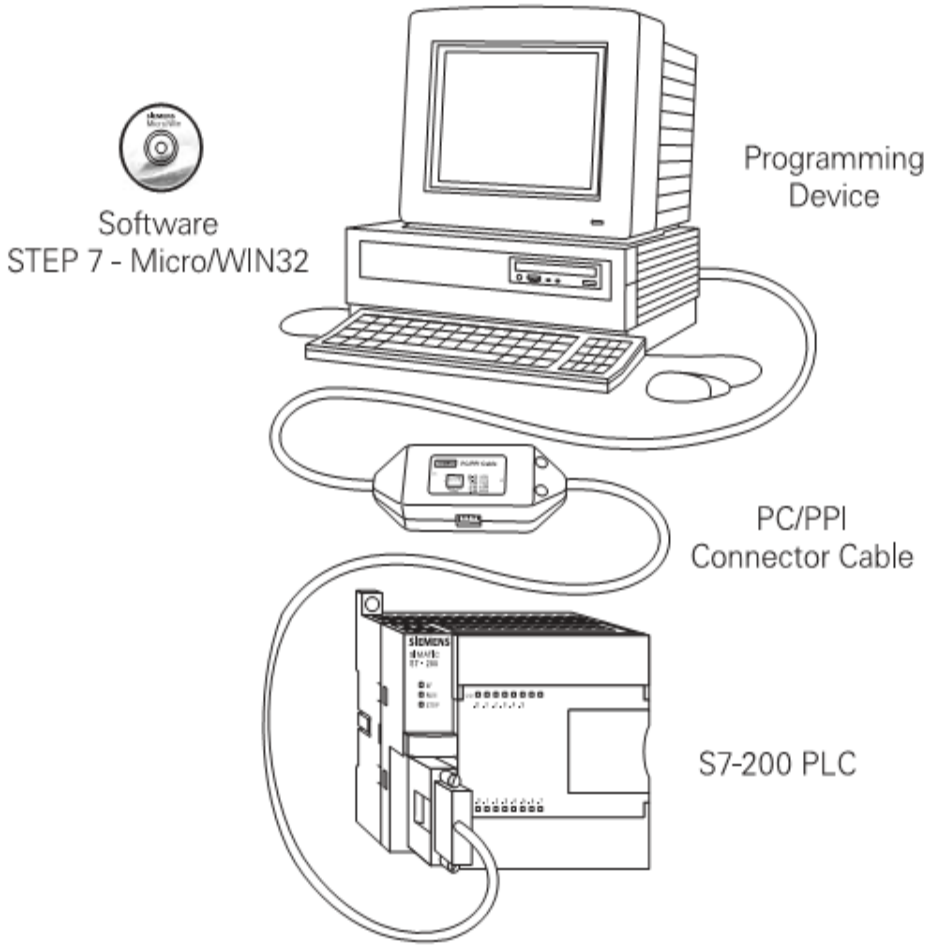


Figure 1-21. Remote I/O station installation.

PC is used as Programming Device



REFERENCE: PROGRAMMABLE CONTROLLERS: THEORY AND IMPLEMENTATION BY BRYAN AND BRYAN