Introduction to PLCs

Course Number: EE-02-500

PDH: 3

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Module 1: Programmable Logic Controllers

Learning Objectives

By the end of this section, you will be able to:

- **Identify** the fundamental components and internal architecture of a Programmable Logic Controller (PLC).
- **Evaluate** the advantages of using microprocessor-based systems over traditional hard-wired control logic.
- **Select** appropriate input/output interfaces and signal types (discrete, digital, or analogue) for specific industrial control tasks.

Executive Summary: A Programmable Logic Controller (PLC) is a specialized microprocessor-based system designed for industrial environments. Unlike traditional hard-wired logic, which requires physical rewiring to alter control sequences, a PLC's functionality is defined by software. This provides a flexible, rugged, and cost-effective solution for managing complex industrial processes through programmable logic, sequencing, timing, and arithmetic functions.

Controllers

Industrial control systems are designed to manage sequences of events, maintain constant variables, or follow prescribed operational changes.

Control Task Examples

- **Automatic Drilling Machine:** Initiates the drill when a workpiece is sensed, controls drilling depth, retracts the bit, and resets for the next cycle.
- **Packing Systems:** Utilizes photoelectric sensors to count items on a conveyor belt and triggers deflectors to direct them into packaging.

Traditional vs. Microprocessor Control

- **Hard-Wired Logic:** Historically, control rules were determined by physical wiring, relays, and switches. Changing the process required labor-intensive physical reconfiguration of the electrical circuits.
- **Microprocessor-Based Systems:** By using a microprocessor, the same hardware can react differently to inputs (switches/sensors) based on a software program. For example, modern washing machines use this logic to manage motors, water valves, and heaters based on sensor feedback (temperature, water level).

The Programmable Logic Controller (PLC)

A PLC is optimized for the industrial floor. Unlike standard computers optimized for calculation and display, PLCs are:

1. **Rugged:** Designed to operate amidst high vibration, temperature fluctuations, humidity, and electrical noise.
2. **Integrated:** Built with internal I/O interfacing ready for direct connection to sensors and actuators.
3. **Accessible:** Programmed using intuitive languages (like Ladder Logic) designed for engineers rather than specialized computer programmers.

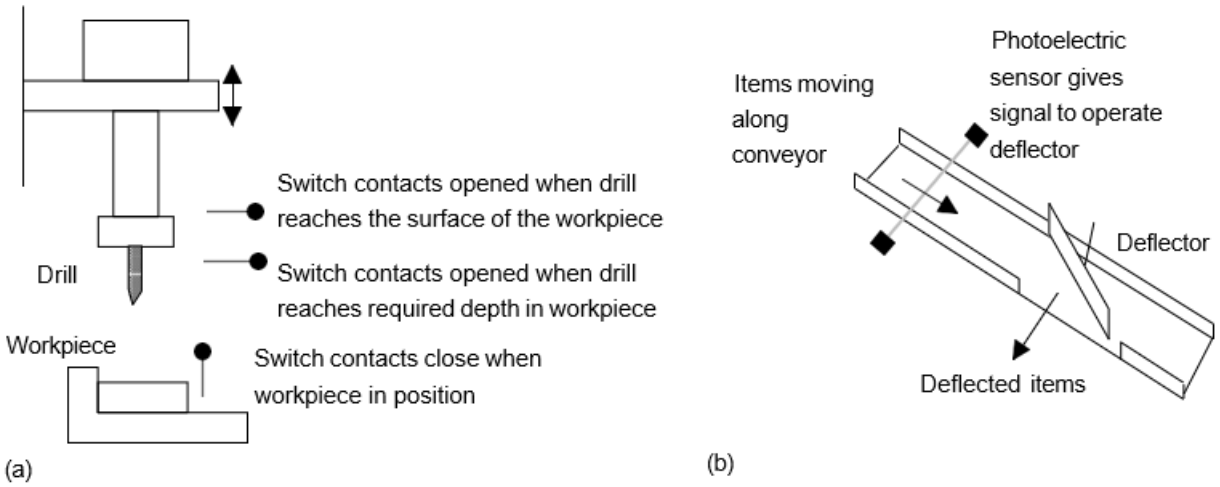

Figure 1.1 An example of a control task and some input sensors: (a) an automatic drilling machine, (b) a packing system

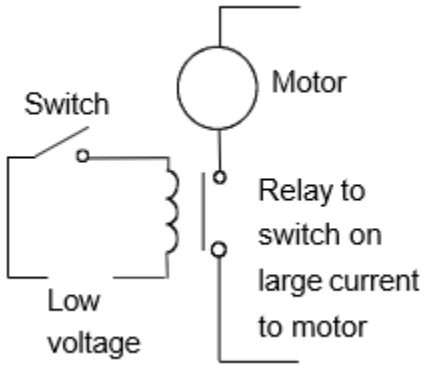

Figure 1.2 A control circuit

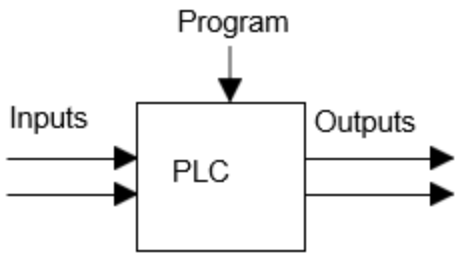

Figure 1.3 A programmable logic controller

Hardware Architecture

A standard PLC system consists of several functional components arranged to facilitate real-time control.

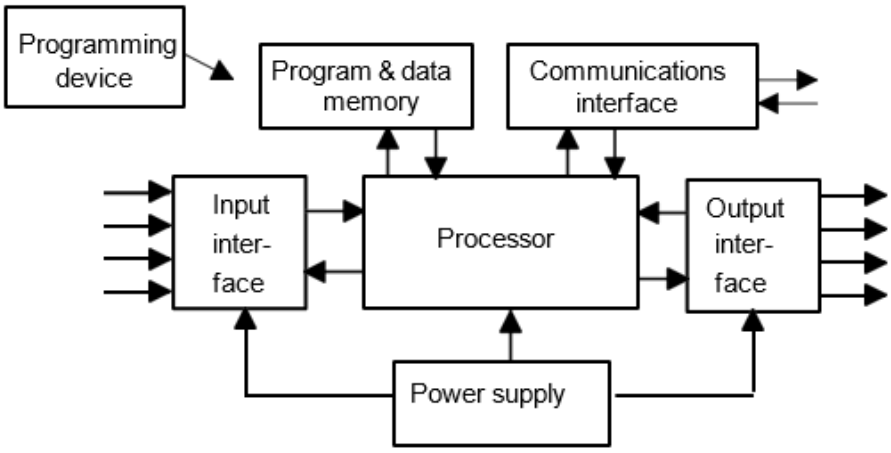

Figure 1.4 The PLC system

Core Components

- **Central Processing Unit (CPU):** The "brain" that interprets input signals and executes control actions based on the stored program.
- **Power Supply:** Converts mains A.C. voltage to the low-voltage D.C. (typically 5V) required by the processor and I/O modules.
- **Programming Device:** A PC or handheld unit used to develop and transfer the program to the PLC memory.
- **Memory Unit:** Stores the operating system (ROM) and the user-defined control program and data (RAM).
- **Communications Interface:** Facilitates data transmission across networks for device verification and synchronization between multiple PLCs.

Signal Classification

Industrial signals are categorized into three primary types:

- **Discrete:** Binary "On/Off" signals (e.g., a standard limit switch).
- **Digital:** A sequence of On/Off pulses.
- **Analogue:** Continuous signals proportional to a variable (e.g., a 4-20mA temperature sensor signal).

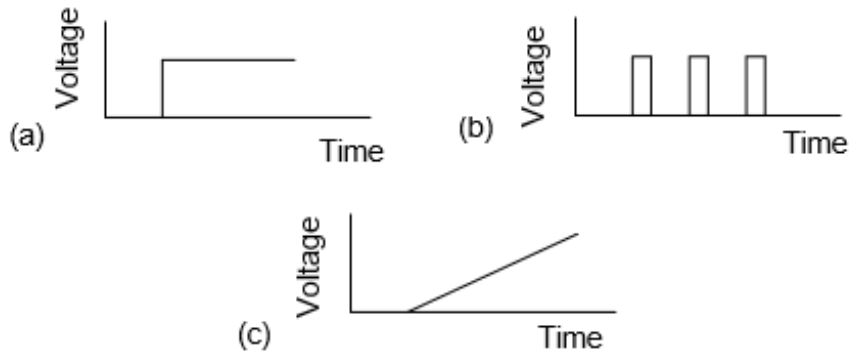

Figure 1.5 Signals: (a) discrete, (b) digital, (c) analogue

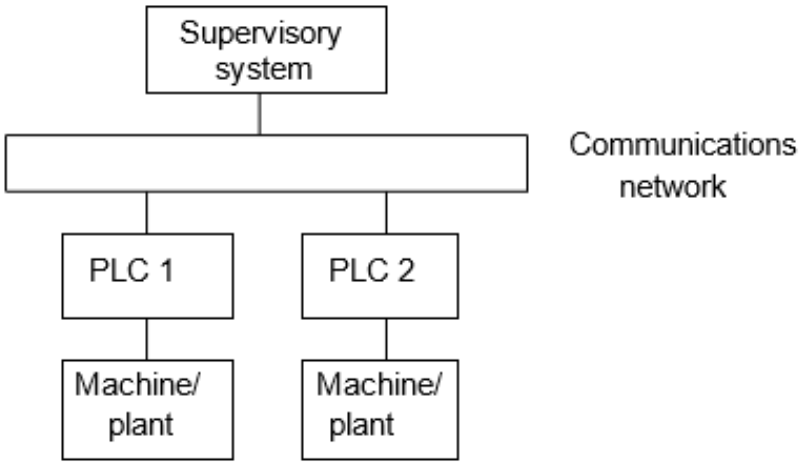

Figure 1.6 Basic communications model

Internal Architecture

The CPU manages operations using a clock frequency (typically **1 to 8 MHz**) which dictates the processing speed and synchronization.

Internal Bus System

Digital signals move along internal paths called **Buses**:

- **Data Bus:** Transmits actual data between elements. An "8-bit" PLC handles 8-bit numbers.
- **Address Bus:** Carries the location code of where data is stored. A 16-bit address bus can access **65,536** unique locations (2^16).
- **Control Bus:** Transmits timing and synchronization signals.
- **System Bus:** Manages communication between I/O ports and the I/O unit.

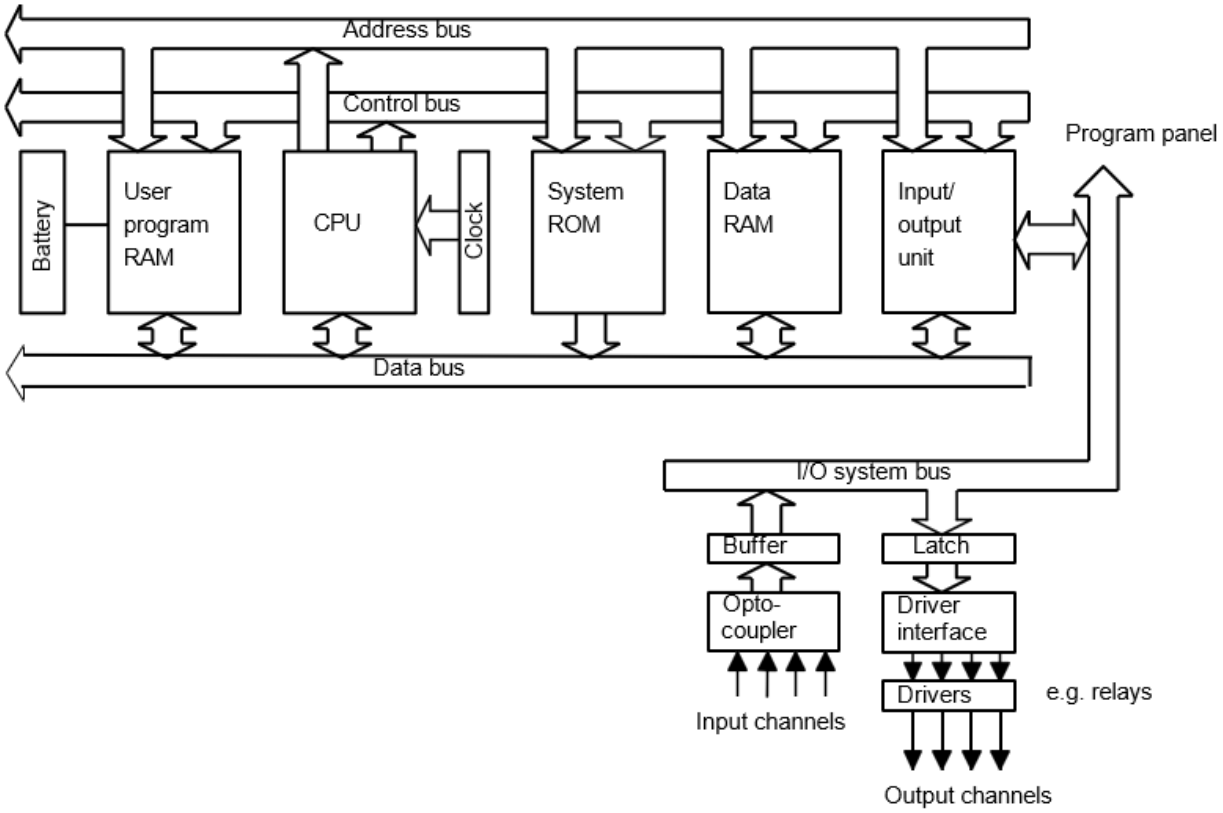

Figure 1.7 Architecture of a PLC

Memory Types

- **System ROM:** Permanent storage for the operating system.
- **User RAM:** Stores the user's program and status data (inputs, outputs, timers, counters).
- **EPROM:** Used for permanent storage of a finalized program via a "bolt-on" module.

💡 **Design Tip:** While RAM allows for easy program changes, it is volatile. Always ensure the PLC's internal battery is functional to maintain the RAM contents during power outages.

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