Control System & PLC

PLC Fundamentals

Content

- Review of Last Lecture.

- Benefits of PLC.

- Types of PLC.

- Block Diagram of PLC.

- CPU operation.

- Input & Output module.

Learning Objectives

▸ Able to define use of PLC.

▸ Able to analyze function of each part.

▸ Various input and output devices.

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Programmable Logic Controller

- A programmable logic controller (PLC) is an industrial grade computer that is capable of being programmed to perform control functions.

- Basically a digital computer designed for use in machine control.

Benefits of PLC

▸ **Increased Reliability:**

-Program has been written and tested, it can be easily downloaded to other PLCs

▸ **More Flexibility:**

-Easier to create and change a program in a PLC than to wire and rewire a circuit.

▸ **Lower Cost:**

-PLCs were originally designed to replace relay control

logic, and the cost savings have been so significant.

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Benefits of PLC

▶ **Communications Capability:**

-PLC can communicate with other controllers or computer equipment to perform such functions as supervisory control, data gathering, monitoring devices etc.
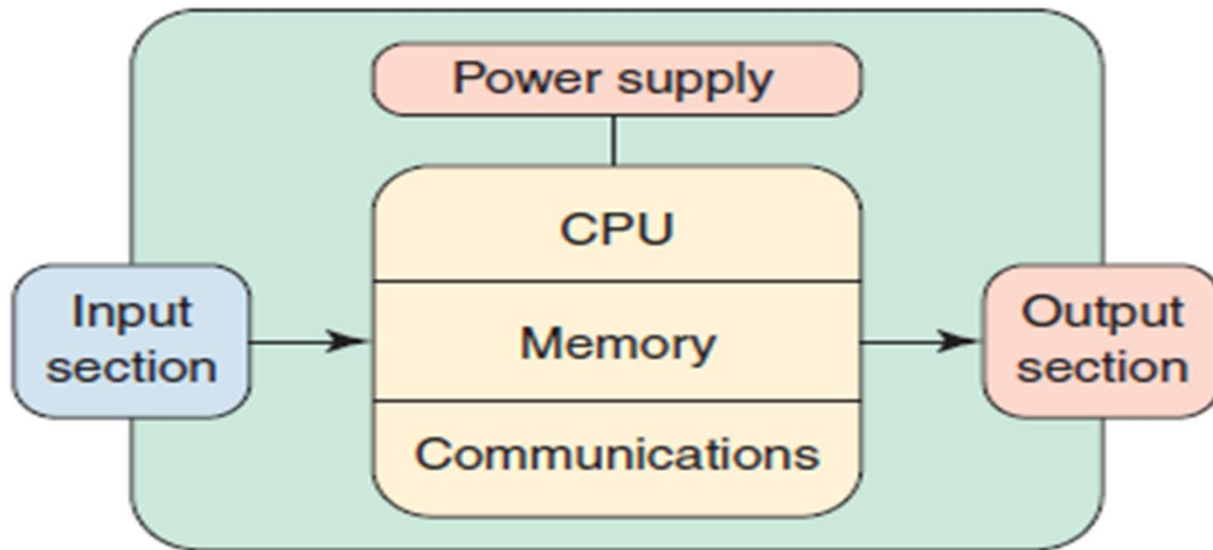
▶ **Faster Response Time:**

-PLCs are designed for high speed and real-time applications.

▶ **Easier to Troubleshoot:**

- PLCs have resident diagnostics and override functions that allow users to easily trace and correct software and hardware problems.
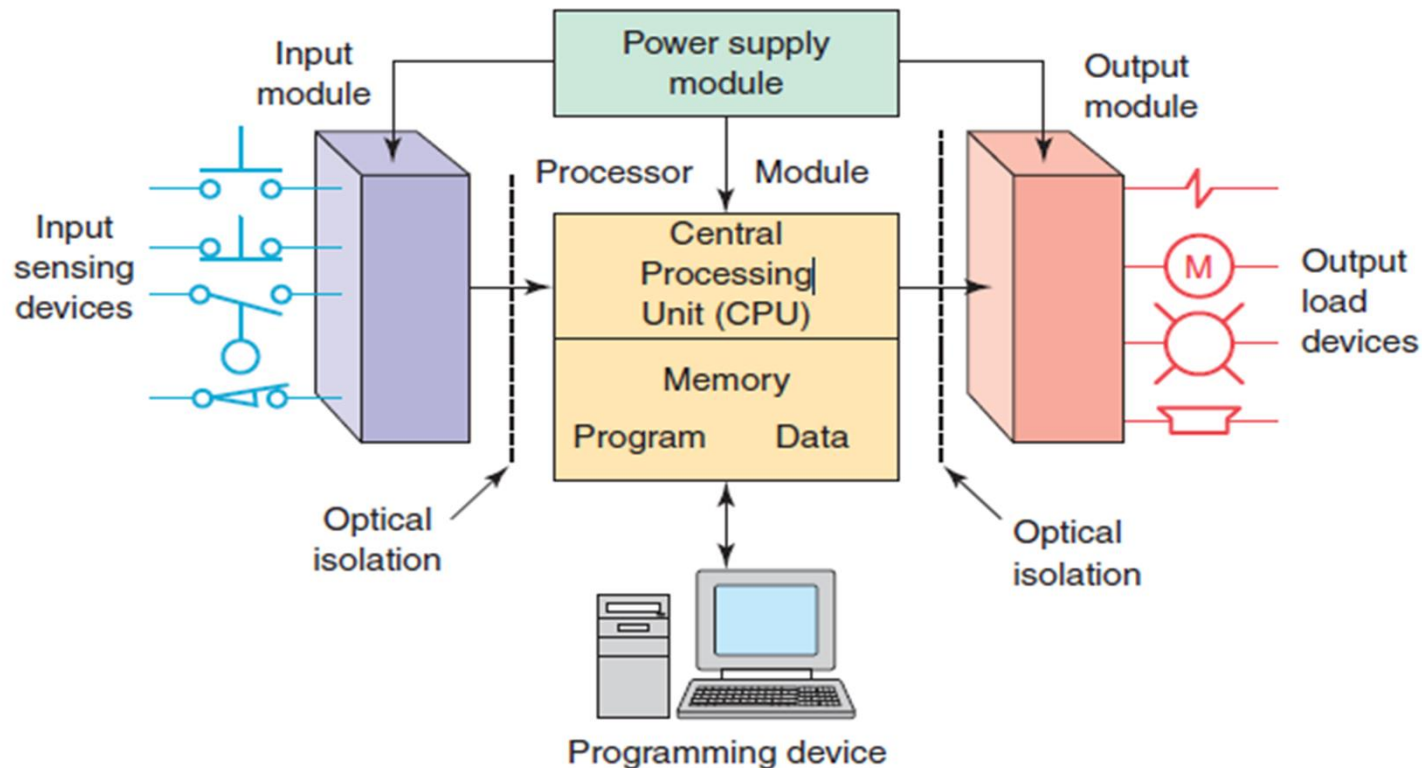
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Fixed PLC

▸ Small PLCs that come in one package with no separate, removable units. The processor and I/O are packaged together, and the I/O terminals will have a fixed number of connections built in for inputs and outputs.
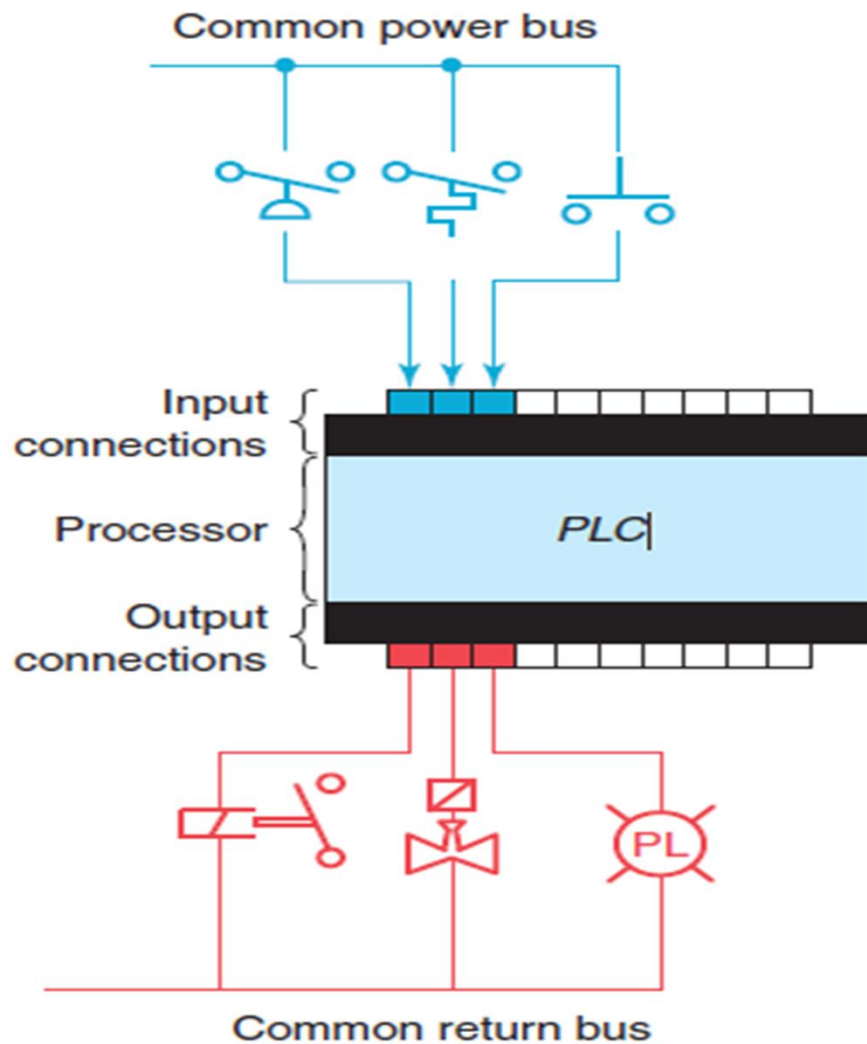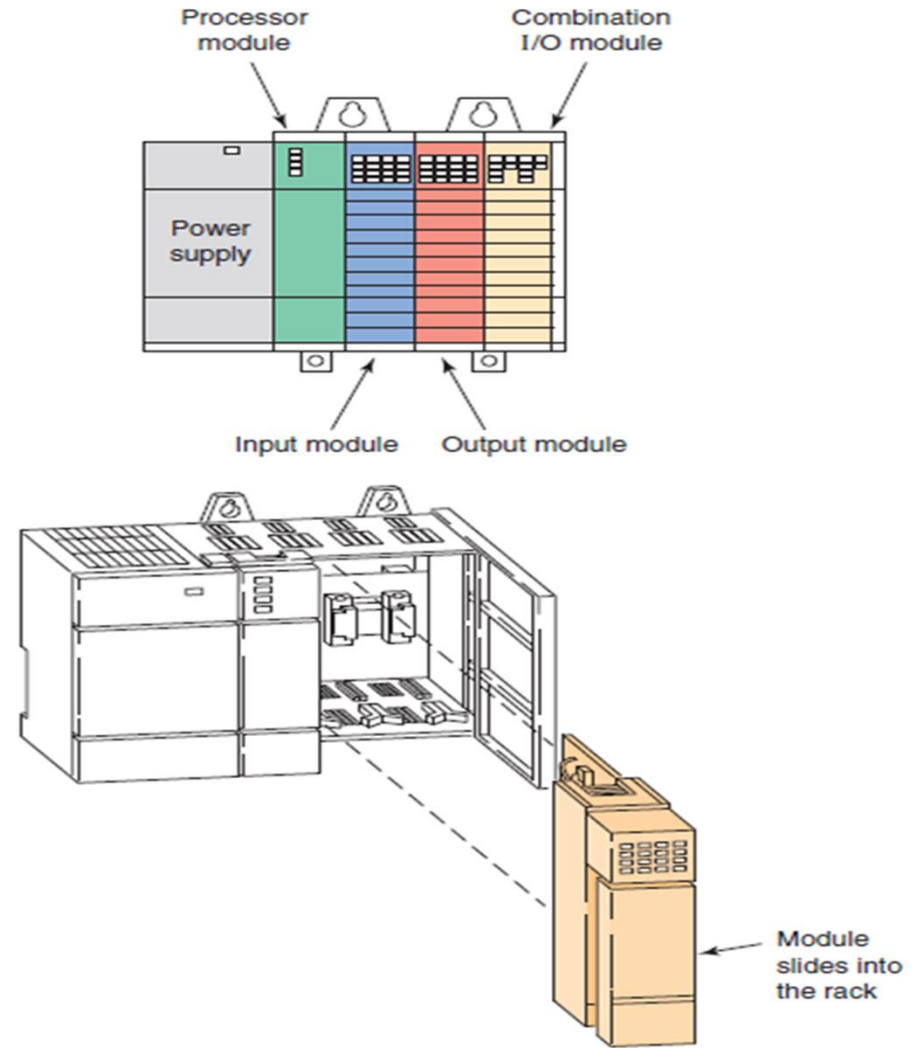
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Modular PLC

▶ Modular I/O is divided by compartments into which separate modules can be plugged. This feature greatly increases your options and the unit's flexibility.

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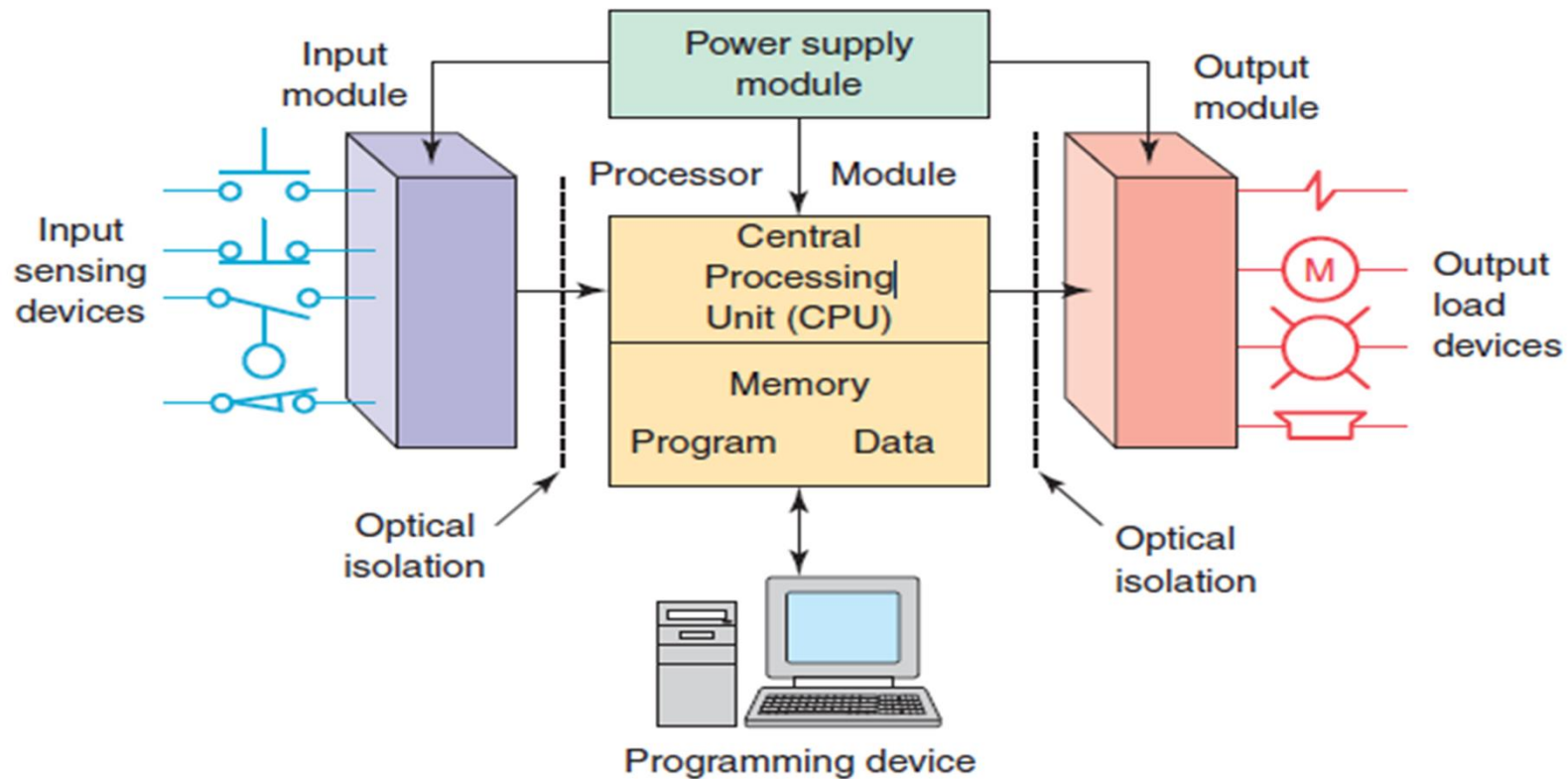# Fixed & Modular I/O

Fixed I/O Configuration

Modular I/O Configuration

Block Diagram of PLC

- A typical PLC is classified into central processing unit (CPU), the input/output (I/O) section, the power supply, and the programming device.

Block Diagram of PLC

▸ The power supply supplies DC power to other modules that plug into the rack .

▸ Processor (CPU) is the "brain" of the PLC. Consists of a microprocessor for implementing the logic and controlling the communications among the modules. The processor requires memory for storing the results of the logical operations performed by the microprocessor.

▸ I/O system forms the interface by which field devices are connected to the controller. Purpose of this interface is to condition the various signals received from or sent to external field devices.

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Block Diagram of PLC

▸ PLCs commonly employ an optical isolator, which uses light to couple the circuits together.

▸ 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 language.

▸ Personal computer (PC) is the most commonly used programming device. Most brands of PLCs have software available so that a PC can be used as the programming device.
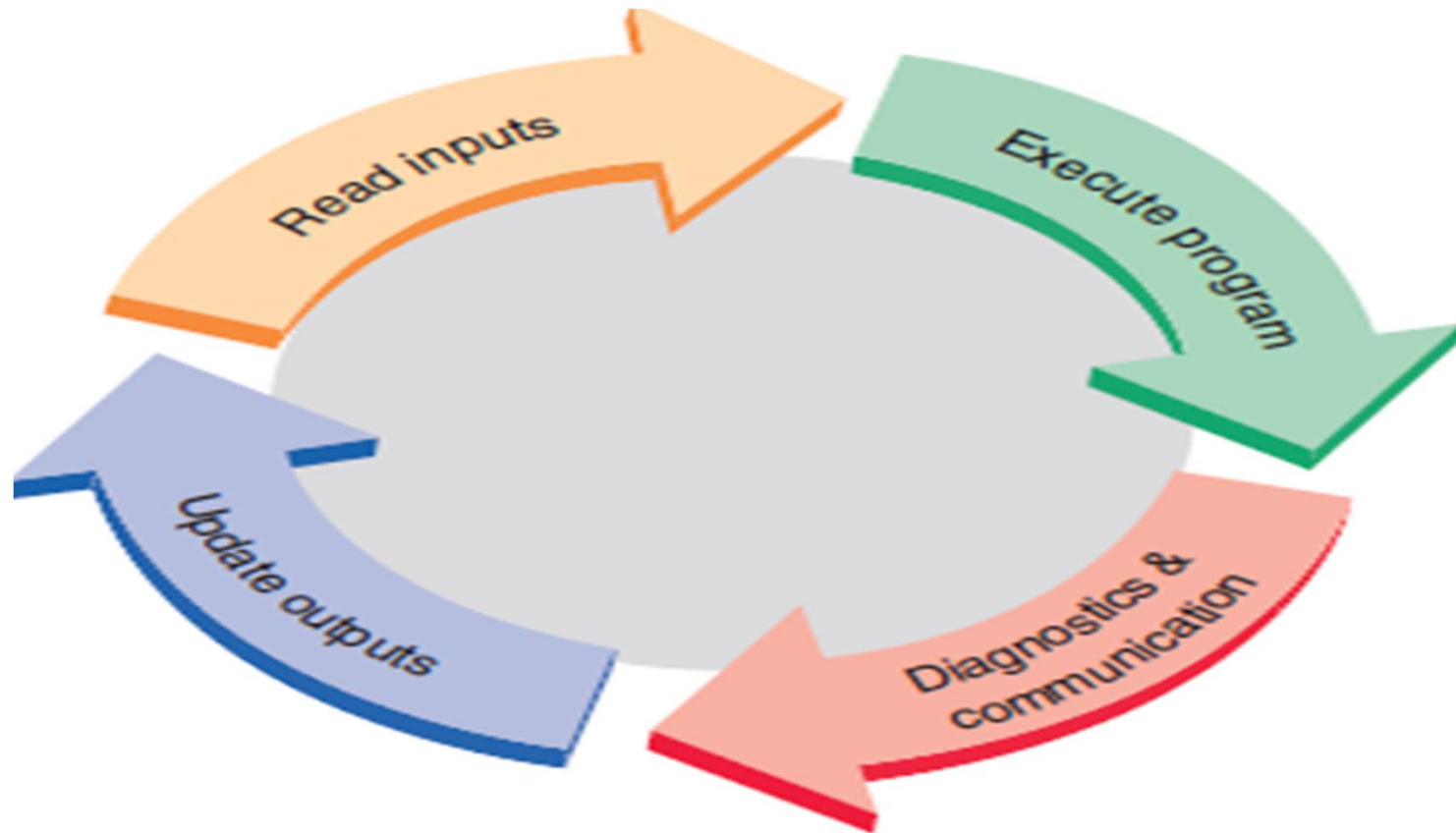
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Block Diagram of PLC

▸ Personal computer communicates with the PLC processor via a serial or parallel data communications link, or Ethernet.

▸ Program is a user-developed series of instructions that directs the PLC to execute actions.

▸ Relay ladder logic (RLL) is the standard programming language used with PLCs.

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Scan Cycle of PLC

▸ PLC program is executed as part of repetitive process referred as "Scan Cycle"

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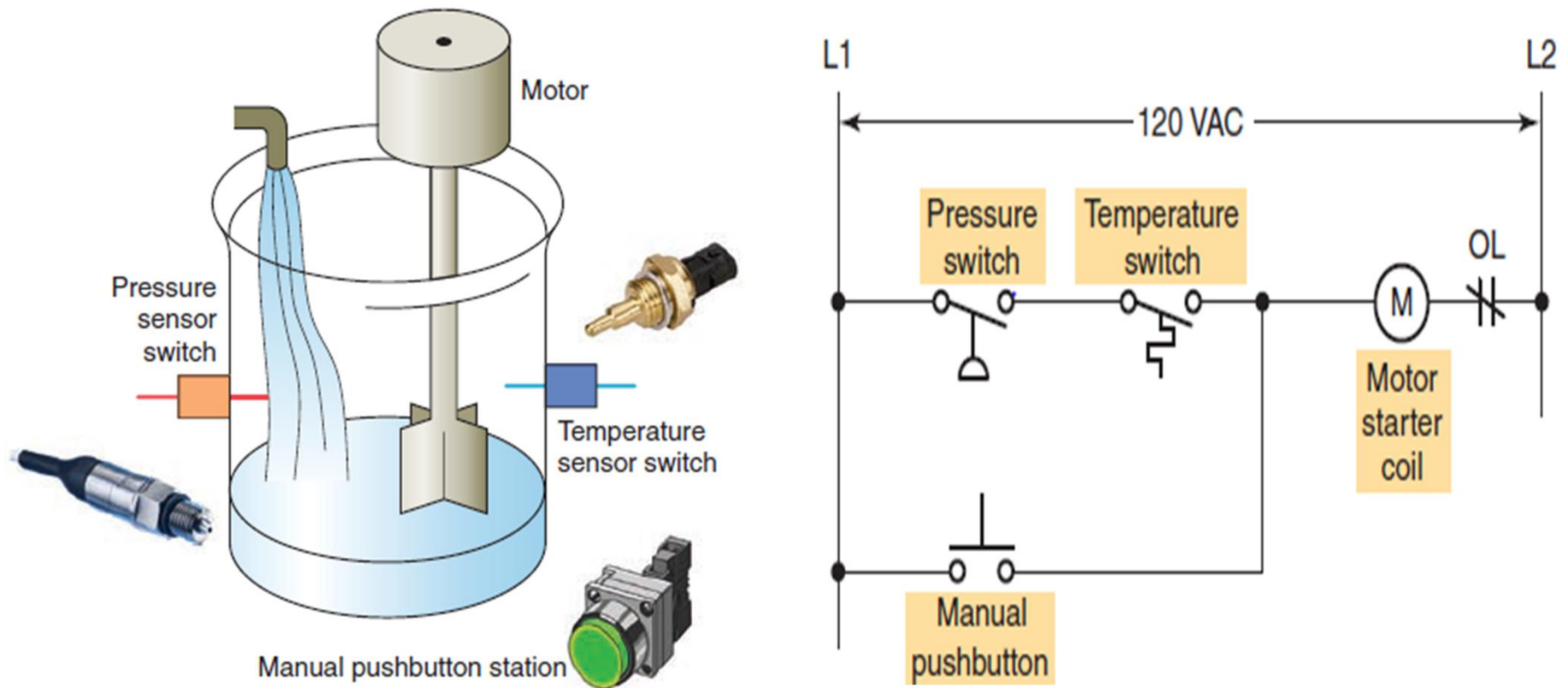# Scan Cycle of PLC

▸ Start with CPU reading status of inputs.

▸ Then, the application program is executed.

▸ Once the program execution is completed, the CPU performs internal diagnostic and communication tasks.

▸ Next, the status of all outputs is updated.

▸ Process is repeated continuously as long as the PLC is in the run mode.

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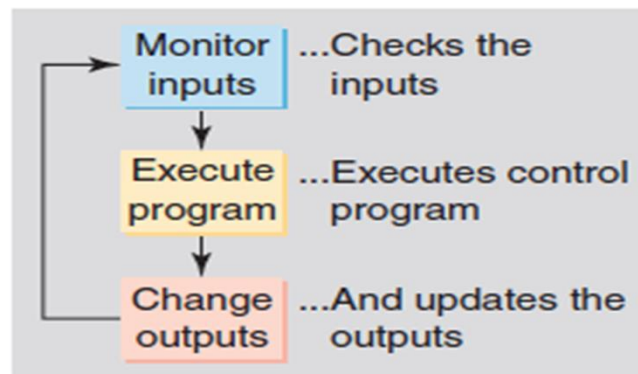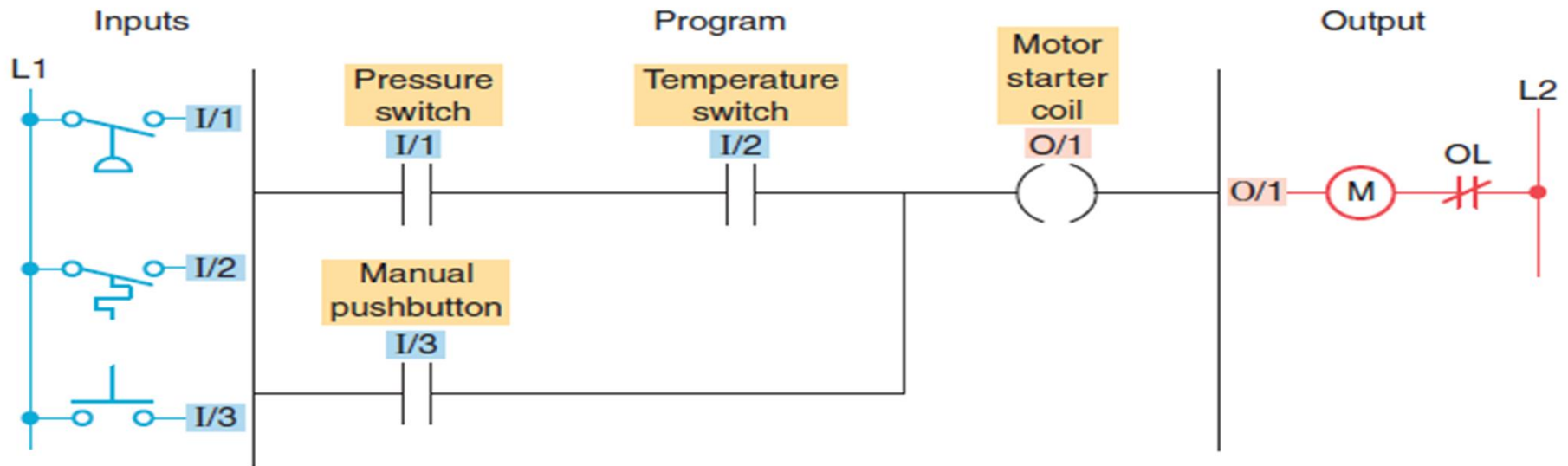# Principle of operation of PLC

- Mixer motor is to be used to automatically stir the liquid in a vat when the temperature and pressure reach preset values.

Principle of operation of PLC

- Motor starter coil (M) is energized when both the pressure and temperature switches are closed or when the manual pushbutton is pressed.

- In PLC, devices would be hardwired to an appropriate input and output module according to the manufacturer's addressing location scheme.

- PLC ladder logic program would be constructed and entered into the memory of the CPU.

- To program the controller, instructions are entered one by one into the processor memory from the programming device

Principle of operation of PLC

▸ Individual symbols represent instructions, whereas the numbers represent the instruction location addresses

Principle of operation of PLC

▸ For the program to operate, the controller is placed in the RUN mode, or operating cycle. During each operating cycle, the controller examines the status of input devices, executes the user program, and changes outputs accordingly.

▸ Coil O/1 is energized when contacts I/1 and I/2 are closed or when contact I/3 is closed.

▸ Output memory location is updated during the scan but the actual output is not updated until the end of the program scan during the I/O scan.

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Memory Organization

▸ Memory is the element that stores information, programs, and data in a PLC.

▸ The user memory of a PLC includes space for the user program as well as addressable memory locations for storage of data.

▸ **Read Only Memory (ROM)**
▸ **Random Access Memory (RAM)**
▸ **Erasable Programmable Read-Only Memory(EPROM)**
▸ **Electrically erasable programmable read-only memory (EEPROM)**
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Memory Organization

‣ Memory organization is arrangement of available memory into different sections.

‣ Memory space can be divided into two broad categories: *program files and data files*.

▸ Program files stores the user ladder logic program.

▪ **System functions (file 0)** :-Processor type, I/O configuration, processor file name, and password.

▪ **Reserved (file 1)** :-Reserved by the processor and is not accessible to the user.

▪ **Main ladder program (file 2)**

▪ **Subroutine ladder program (files 3–255)** :-Files are user-created and are activated according to subroutine instructions

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Memory Organization

▸ Data files store the information needed to carry out the user program.

- **Output (file 0)** :Stores the state of the output terminals for the controller
- **Input (file 1)** :stores the status of the input terminals for the controller.
- **Status (file 2):** stores controller operation information Program files stores the user ladder logic program.
- **Bit (file 3)** :used for internal relay logic storage
- **Timer (file 4)** :stores the timer accumulated and preset values and status bits.
- **Counter (file 5)** :stores the counter accumulated and preset values and status bits.
- **Control (file 6), Integer (file 7), Reserved (file 8), Network communications (file 9), User-defined (files 10–255)**

CPU Operation

▶ CPU section executes the program and makes the decisions needed by the PLC to operate and communicate with other modules.

▶ CPU executes the operating system, manages memory, monitors inputs, evaluates user logic (ladder program), and turns on the appropriate outputs.

▶ A key-switch may be provided that allows you to select one of the following three modes of operation: RUN, PROG, and REM.

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CPU Operation

▶ **RUN Position:-**

- Executes the ladder program and energizes output devices
- Prevents from performing online program editing in this position
- Prevents from using a programmer/operator interface device to change the processor mode

▶ **PROG Position:-**

- Prevents the processor from scanning or executing the ladder program, and the controller outputs are de-energized
- Allows you to perform program entry and editing
- Prevents from using a programmer/operator interface device to change the processor mode.

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CPU Operation

- **REM Position:-**
- Places the processor in the Remote mode: either the REMote Run, REMote Program, or REMote Test mode
- Allows you to change the processor mode from a programmer/operator interface device
- Allows you to perform online program editing.

Input Module & Devices

▸ Serve as a link between field devices and PLC's CPU.

▸ Main function is to take field device input signal, convert it to a signal level that CPU can work with, electrically isolate it, and send signal, by the way of backplane board to CPU.

▸ Pressure switch, temperature switch, and pushbutton are used as input devices.

▸ **Input Devices:**

1. Mechanical Switches.

2. Proximity Switches

3. Photoelectric Sensors and Switches

4. Encoders

5. Temperature Sensors

6. Position/Displacement Sensors
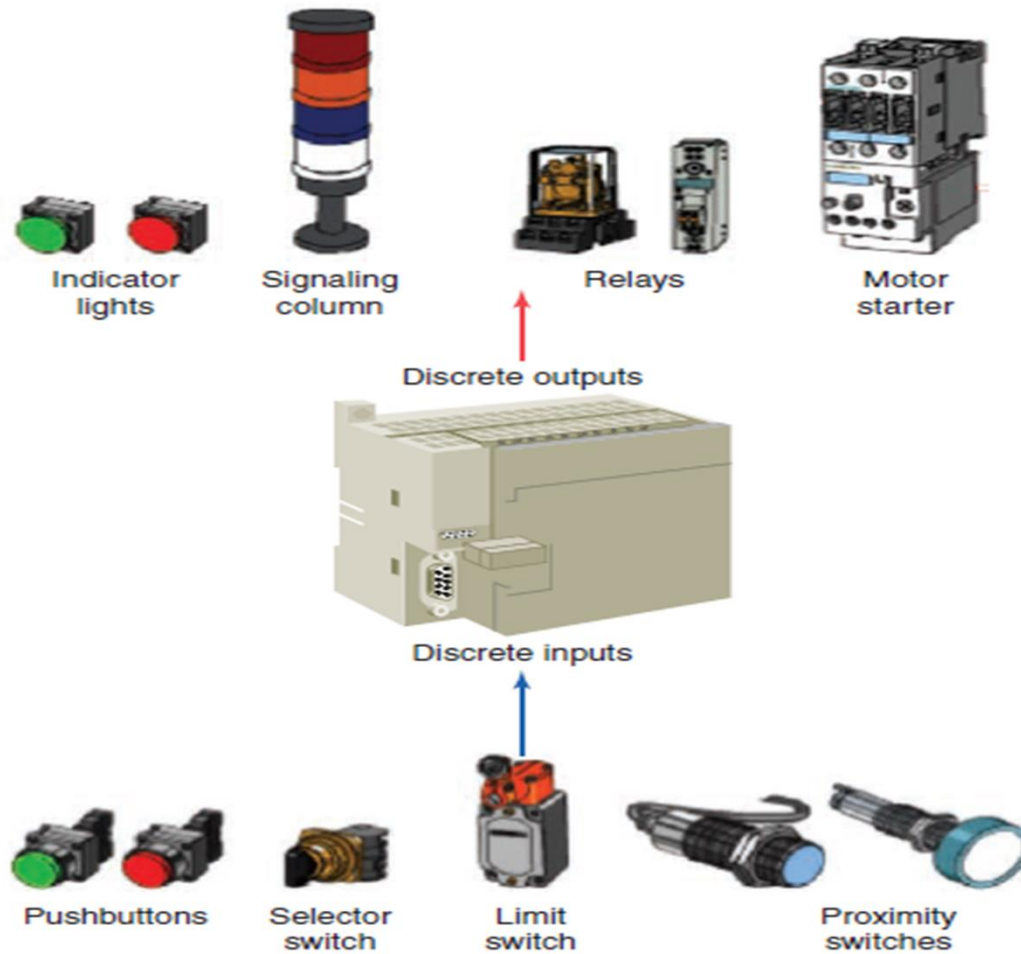
Output Module & Devices

▸ Serve as a link between PLC's microprocessor and hardware field devices.

▸ Output signal once received from the CPU, must be stored before being sent to each output module's output screw terminals.

▸ Storage area for output signals is called the output status file.

▸ **Output Devices:**

1. Relay

2. Directional Control Valves

3. Motors

4. Stepper Motors

▸

Field Devices

Indicator lights — Signaling column — Relays — Motor starter

Discrete outputs

Discrete inputs

Pushbuttons — Selector switch — Limit switch — Proximity switches

Summary

▸ Benefits of PLC.

▸ Types of PLC.

▸ Block Diagram of PLC.

▸ CPU operation.

▸ Input & Output module.

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