➢Chapter 1

➢Programmable Logic Controller (Overview)

❑ Chapter Objectives

✓*After completing this chapter, you will be able to:*

- Define what a programmable logic controller (PLC) is and list its advantages over relay systems
- Identify the main parts of a PLC and describe their functions
- Outline the basic sequence of operation for a PLC
- Identify the general classifications of PLCs

❑Programmable Logic Controllers

➢ Programmable logic controllers (Figure 1-1) are now the most widely used industrial process control technology.

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

➢The programmable controller has eliminated much of the hardwiring associated with conventional relay control circuits.

(a)

(b)

❑Programmable Logic Controllers

➢ In the 1960s, electromechanical relays, timers, counters, and sequencers were the standard.

➢Many control panels contained hundreds of these devices and a mile or more of wire.

➢ Reliability was low and maintenance costs were high.

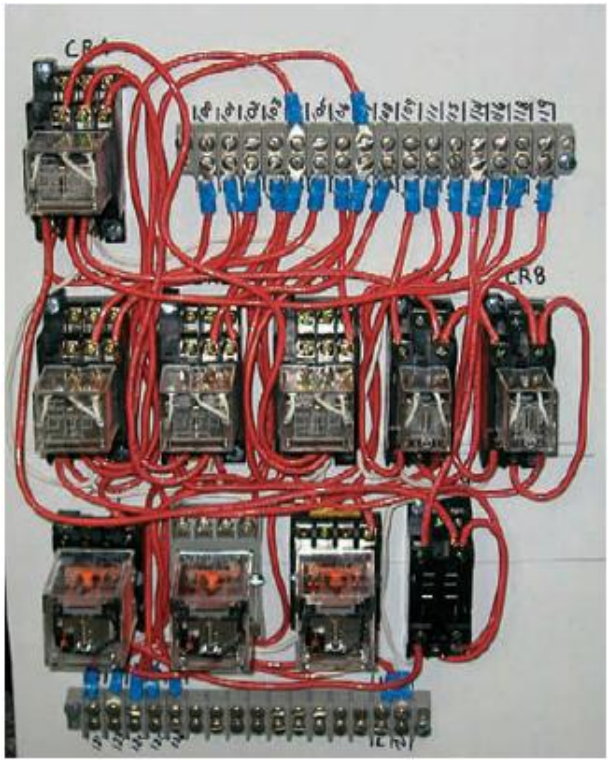
➢Cost was high to modify or upgrade control panels.

➢ In 1968 the General Motors Hydramatic division specified a device that would become what we know today as the programmable logic controller.

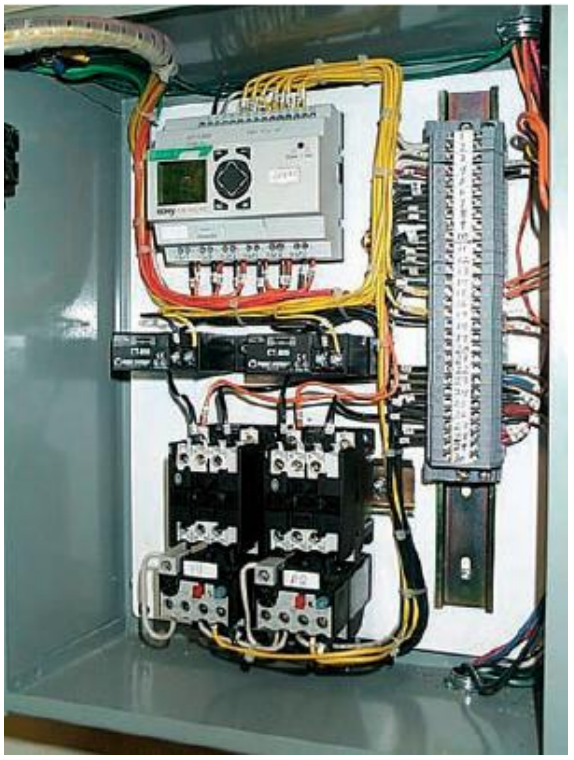
❑Programmable Logic Controllers

Programmable controllers offer several advantages over a conventional relay type of control

1. Easily changeable



Relay based control panel



PLC based control panel

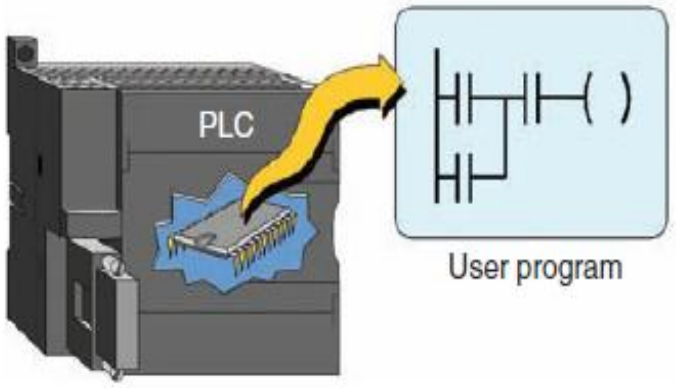
❑ Chapter Objectives

✓ Programmable Logic Controllers

Programmable controllers offer several advantages over a conventional relay type of control

2. Increased Reliability

- *Once a program has been* written and tested, it can be easily downloaded to other PLCs.
- Since all the logic is contained in the PLC's memory, there is no chance of making a logic wiring error (Figure 1-3).
- The program takes the place of much of the external wiring that would normally be required for control of a process.



- Hardwiring, though still required to connect field devices, is less intensive. PLCs also offer the reliability associated with solid-state components.

✓ Programmable Logic Controllers

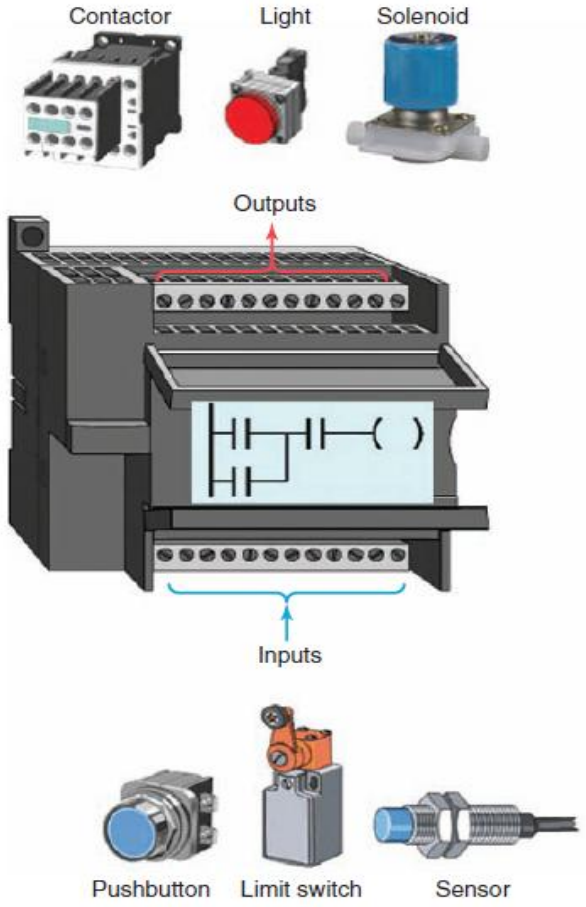
Programmable controllers offer several advantages over a conventional relay type of control

3. More Flexibility.

➢ *It is easier to create and change a program* in a PLC than to wire and rewire a circuit.

➢ With a PLC the relationships between the inputs and outputs are determined by the user program instead of the manner in which they are interconnected .

➢ Original equipment manufacturers can provide system updates by simply sending out a new program. End users can modify the program in the field, or if desired, security can be provided by hardware features such as key locks and by software passwords.



✓ Programmable Logic Controllers

Programmable controllers offer several advantages over a conventional relay type of control

4. Lower Cost

- *PLCs were originally designed to replace* relay control logic, and the cost savings have been so significant that relay control is becoming obsolete except for power applications.

- Generally, if an application has more than about a half-dozen control relays, it will probably be less expensive to install a PLC.

✓ Programmable Logic Controllers

Programmable controllers offer several advantages over a conventional relay type of control

5. Communications Capability

➢ *A PLC can communicate* with other controllers or computer equipment to perform such functions as supervisory control, data gathering, monitoring devices and process parameters, and download and upload of programs.

✓ Programmable Logic Controllers

Programmable controllers offer several advantages over a conventional relay type of control

6. Faster Response Time.

➢ *PLCs are designed for highspeed* and real-time Applications .

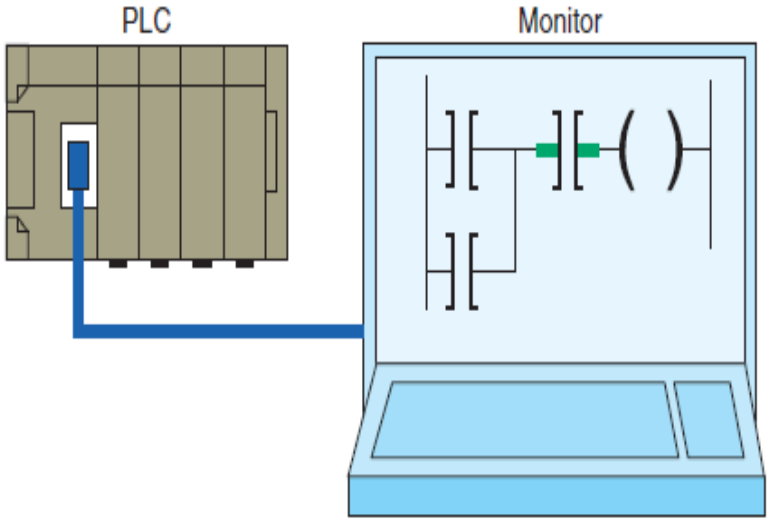
➢ The programmable controller operates in real time, which means that an event taking place in the field will result in the execution of an operation or output.

➢ Machines that process thousands of items per second and objects that spend only a fraction of a second in front of a sensor require the PLC's quick-response capability.

✓ Programmable Logic Controllers

Programmable controllers offer several advantages over a conventional relay type of control

7. Easier to Troubleshoot.



➢ *PLCs have resident diagnostics* and override functions that allow users to easily trace and correct software and hardware problems.

➢ To find and fix problems, users can display the control program on a monitor and watch it in real time as it executes

❑ Parts of a PLC

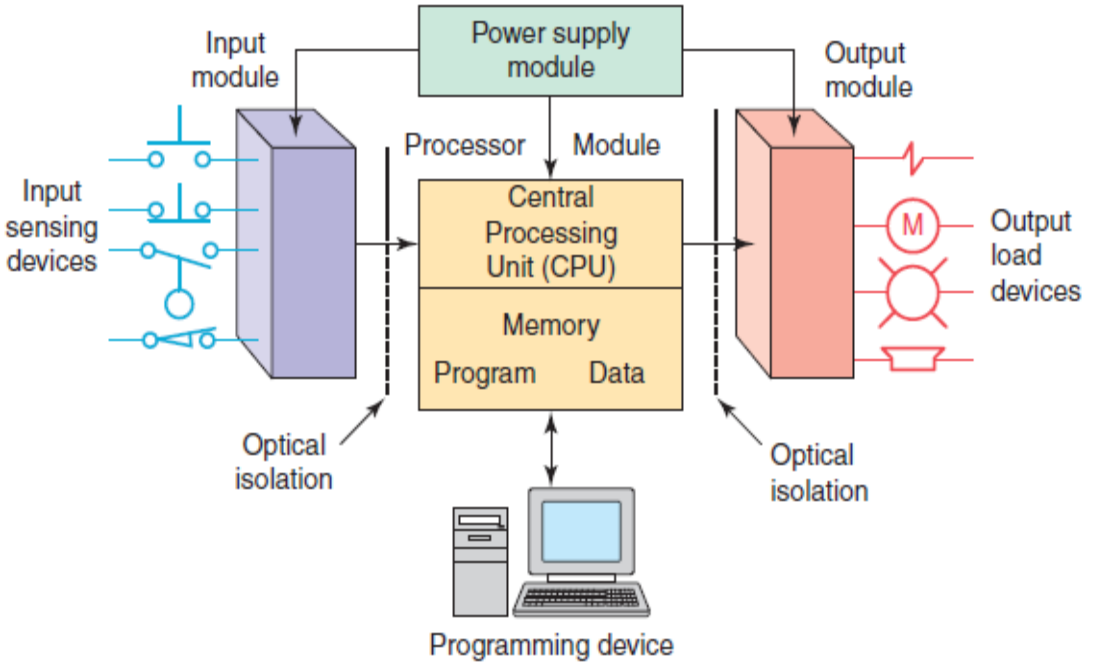
✓ typical PLC can be divided into parts

➢ the *central processing unit (CPU)*

➢ the *input/output (I/O) section*

➢ the *power supply*

➢ The *programming device*



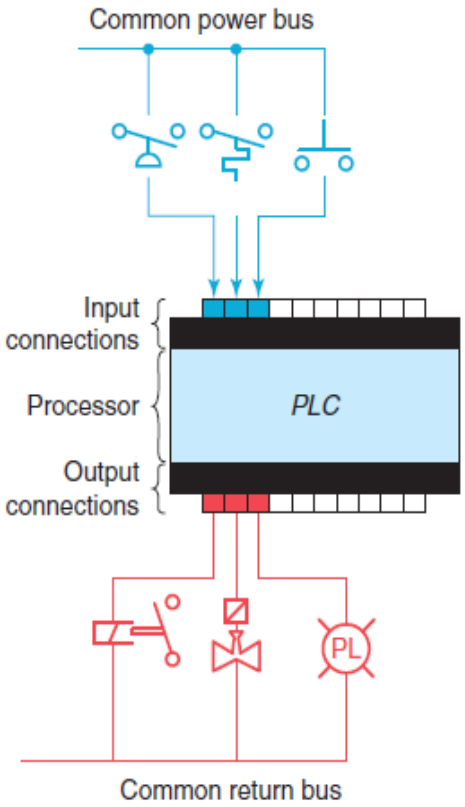
❑ Parts of a PLC

✓ There are two ways in which I/Os (Inputs/Outputs) are incorporated into the PLC

- *Fixed I/O*
- *Modular I/O*

❑ Parts of a PLC

✓ *Fixed I/O*



➢ *Fixed I/O* is typical of 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

➢ The main advantage of this type of packaging is lower cost.

➢ The number of available I/O points varies and usually can be expanded by buying additional units of fixed I/O

➢ One disadvantage of fixed I/O is its lack of flexibility; you are limited in what you can get in the quantities and types dictated by the packaging

➢ Also, for some models, if any part in the unit fails, the whole unit has to be replaced

❑ Parts of a PLC

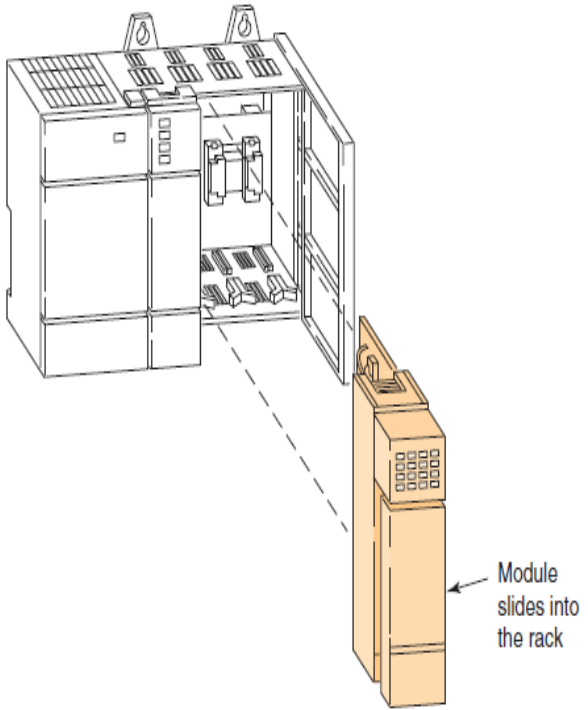
✓ *Modular I/O*

➢ *Modular I/O is divided by compartments* into which separate modules can be plugged.

➢ The basic modular controller consists of a rack, power supply, processor module (CPU), input/output (I/O) modules), and an operator interface for programming and monitoring

➢The modules plug into a rack.

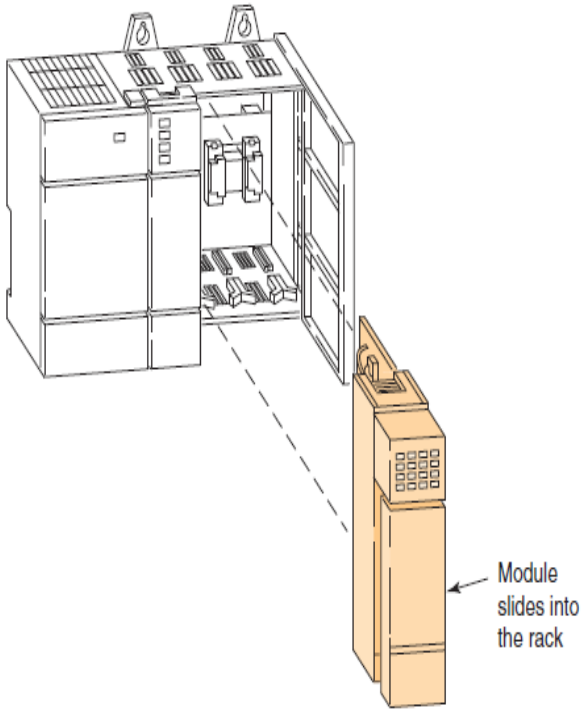
➢When a module is slid into The rack, it makes an electrical contacts



❑ Parts of a PLC

✓ There are two ways in which I/Os (Inputs/Outputs) are incorporated into the PLC

- The *power supply supplies DC power to other modules* that plug into the rack
- For large PLC systems, this power supply does not normally supply power to the field devices.
- With larger systems, power to field devices is provided by external alternating current (AC) or direct current (DC) supplies.
- For some small micro PLC systems, the power supply may be used to power field devices.



❑ Parts of a PLC

✓ The *processor (CPU)*

➢ The *processor (CPU) is the "brain" of the PLC*

➢ Typical processor usually 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 and storing the program.
➢ The CPU controls all PLC activity and is designed so that the user can enter the desired program in relay ladder logic.

❑ Parts of a PLC

✓ The *processor (CPU)*

- The PLC program is executed as part of a repetitive process referred to as a scan.
- A typical PLC scan starts with the CPU reading the 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.
- This process is repeated continuously as long as the PLC is in the run mode.

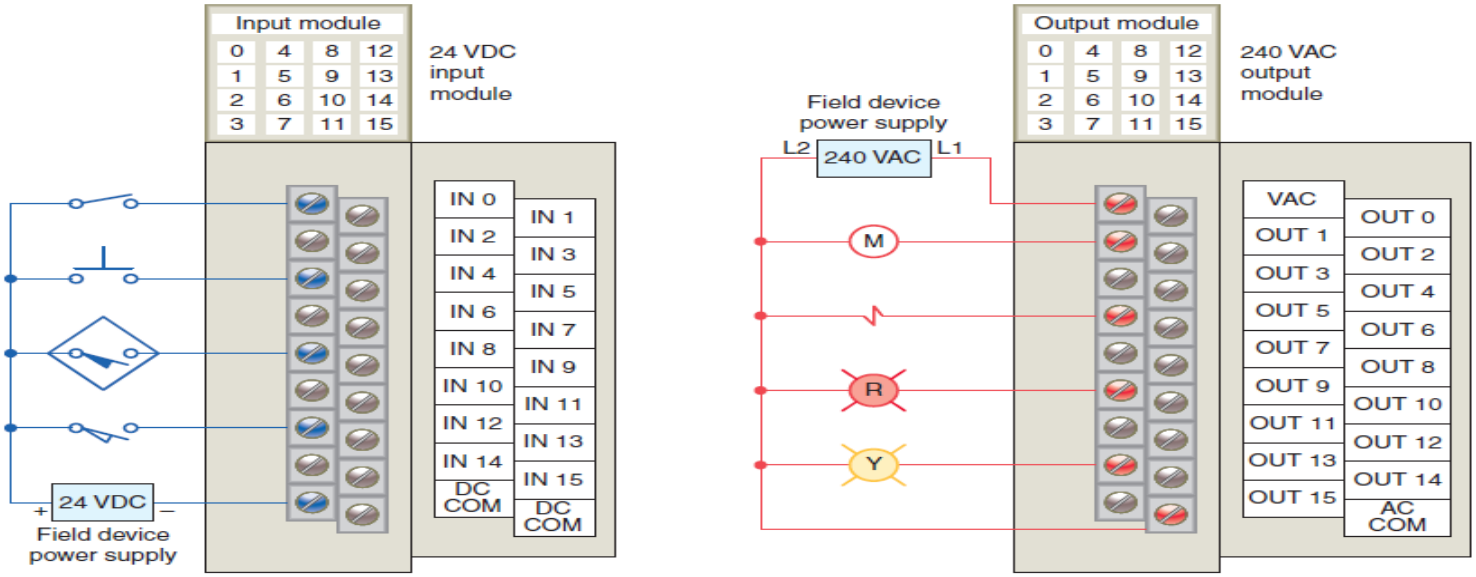
❑ Parts of a PLC

➢ the *I/O system forms the interface by which field devices* are connected to the controller.

➢ The purpose of this interface is to condition the various signals received from or sent to external field devices

➢ 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.



❑ Parts of a PLC

✓ How can PLC be programmed?

➢Hand-held Terminal (HHT)

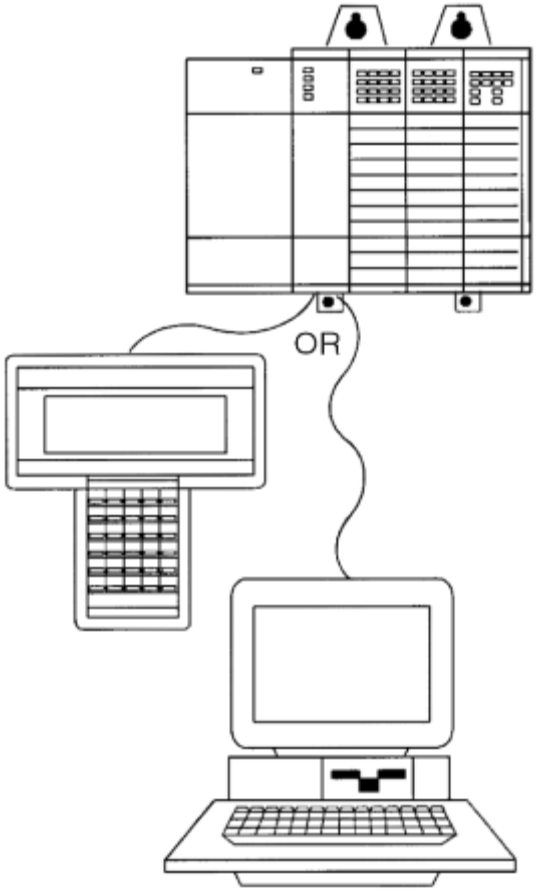
➢ PC s

✓PLC programming

➢ A *program is a user-developed series of instructions* that directs the PLC to execute actions.

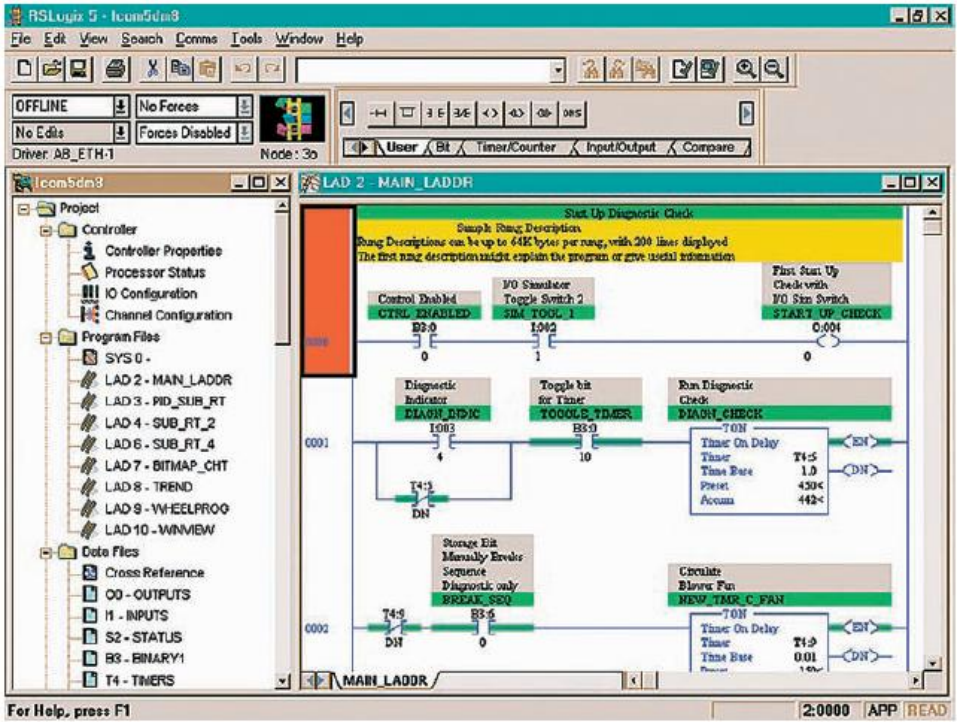
➢A *programming language provides rules for combining the instructions* so that they produce the desired actions.

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



❑ Parts of a PLC

- Its origin is based on electromechanical relay control.
- The relay ladder logic program graphically represents rungs of contacts, coils, and special instruction blocks.
- RLL was originally designed for easy use and understanding for its users and has been modified to keep up with the increasing demands of industry's control needs.



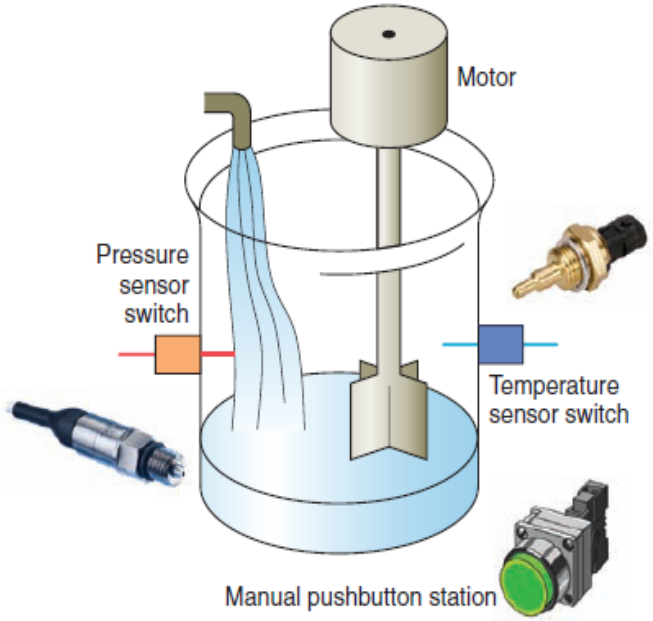
❑ Principles of Operation

➢ To get an idea of how a PLC operates, consider the simple process control problem illustrated in Figure

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

➢In addition, direct manual operation of the motor is provided by means of a separate pushbutton station

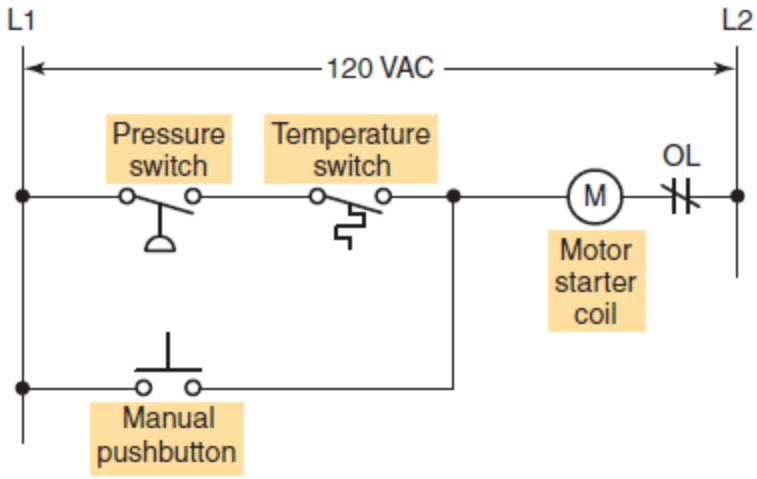
➢ The process is monitored with temperature and pressure sensor switches that close their respective contacts when conditions reach their preset values.



❑ Principles of Operation

➢ This control problem can be solved using the relay method for motor control shown in the relay ladder diagram of Figure .

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



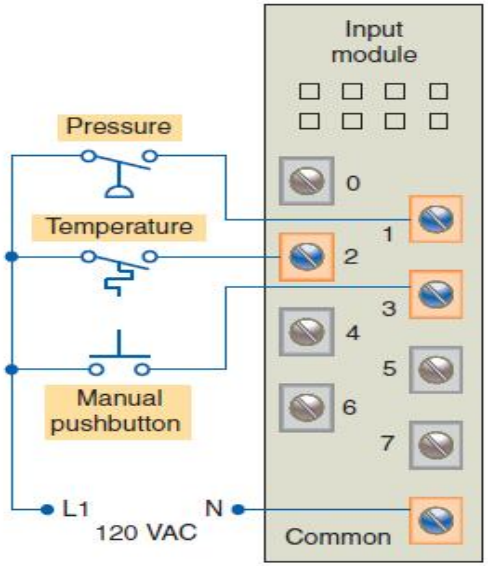
❑ Principles of Operation

➢ Now let's look at how a programmable logic controller might be used for this application.

➢The same input field devices (pressure switch, temperature switch, and pushbutton) are used.

➢These devices would be hardwired to an appropriate input module according to the manufacturer's addressing location scheme.

➢Typical wiring connections for a 120 VAC modular configured input module is shown in Figure

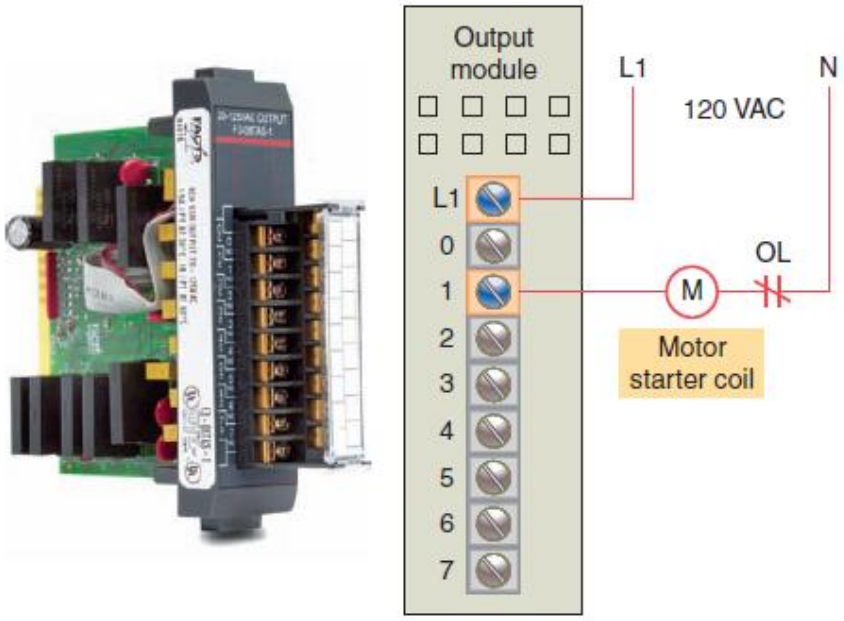


❑ Principles of Operation

➢ The same output field device (motor starter coil) would also be used.

➢This device would be hardwired to an appropriate output module according to the manufacturer's addressing location scheme.

➢Typical wiring connections for a 120 VAC modular configured output module is shown in Figure.



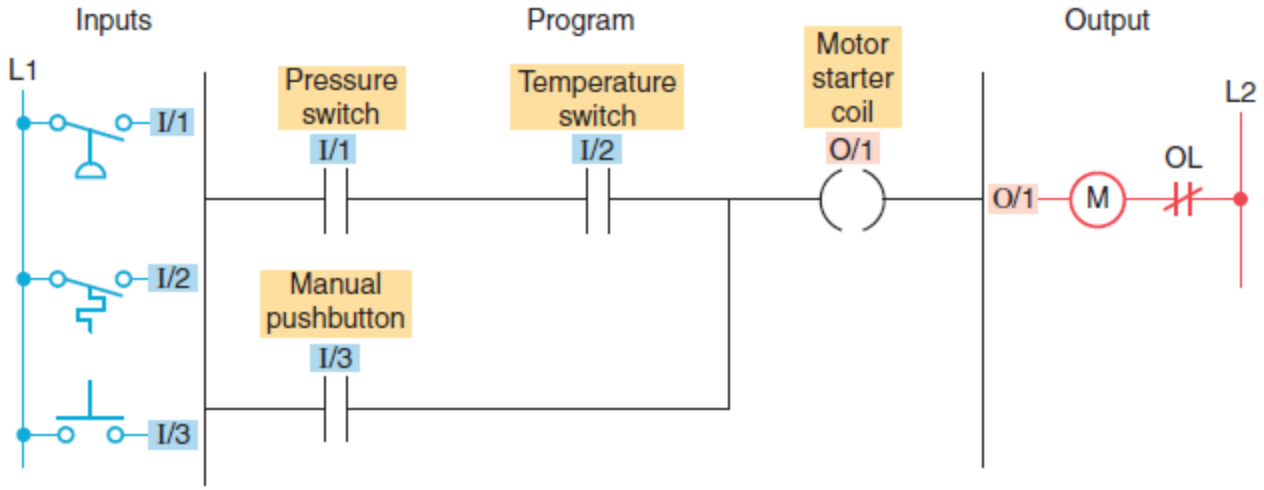
❑ Principles of Operation

➢ Next, the PLC ladder logic program would be constructed and entered into the memory of the CPU.

➢A typical ladder logic program for this process is shown in Figure .

➢The format used is similar to the layout of the hardwired relay ladder circuit.

➢The individual symbols represent instructions, whereas the numbers represent the instruction location addresses.



❑ Principles of Operation

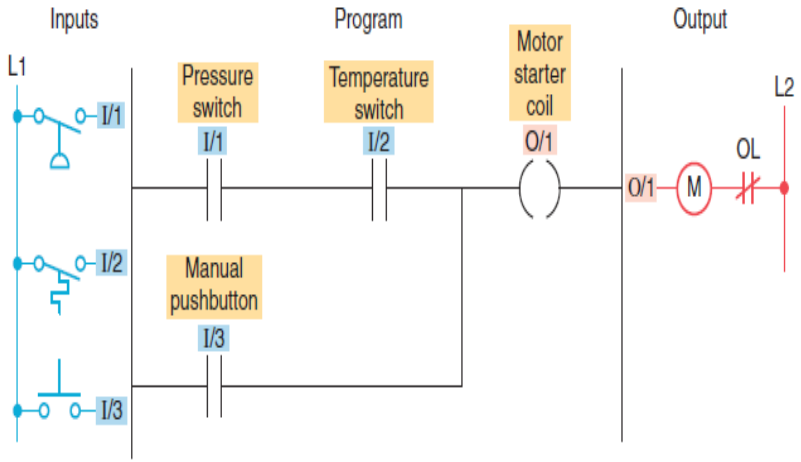
➢ To program the controller, you enter these instructions one by one into the processor memory from the programming device.

➢Each input and output device is given an address, which lets the PLC know where it is physically connected.

➢Note that the I/O address format will differ, depending on the PLC model and manufacturer.

➢Instructions are stored in the user program portion of the processor memory.

➢ During the program scan the controller monitors the inputs, executes the control program, and changes the output accordingly.



❑ Principles of Operation

➢ For the program to operate, the controller is placed in the RUN mode, or operating cycle.

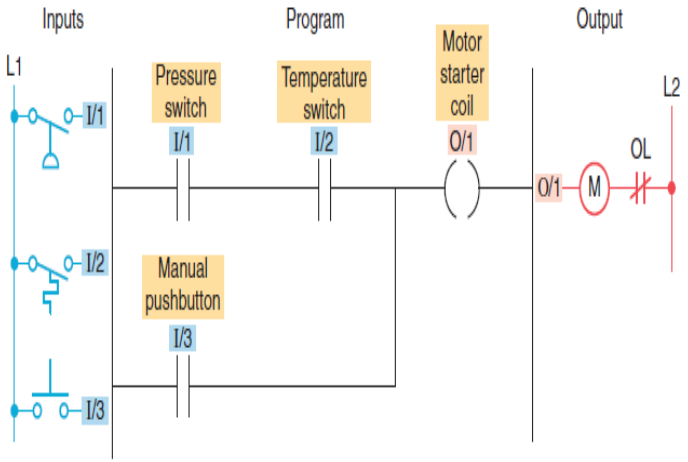
➢During each operating cycle, the controller examines the status of input devices, executes the user program, and changes outputs accordingly.

➢Each symbol ⊣⊢ can be thought of as a set of normally open contacts.

➢The symbol ( ) is considered to represent a coil that, when energized, will close a set of contacts.

➢In the ladder logic program of Figure ,the coil O/1 is energized when contacts I/1 and I/2 are closed or when contact I/3 is closed.

➢Either of these conditions provides a continuous logic path



❑ Principles of Operation

➢ A programmable logic controller operates in real time in that an event taking place in the field will result in an operation or output taking place.

➢The RUN operation for the process control scheme can be described by the following sequence of events:

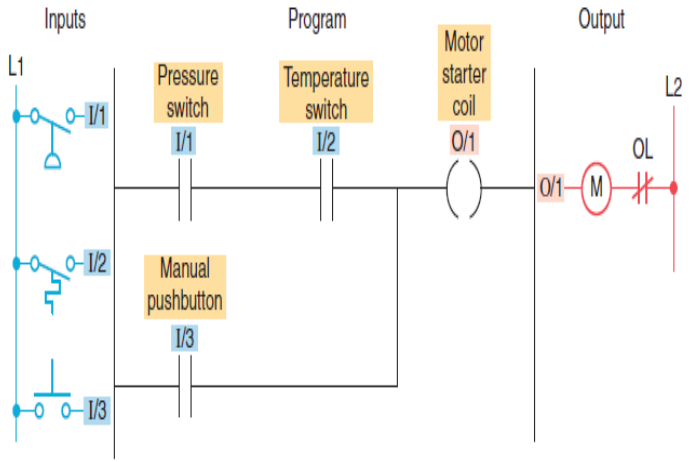
• First, the pressure switch, temperature switch, and pushbutton inputs are examined and their status is recorded in the controller's memory.

• A closed contact is recorded in memory as logic 1 and an open contact as logic 0.

• Next the ladder diagram is evaluated, with each internal contact given an OPEN or CLOSED status according to its recorded 1 or 0 state.

• When the states of the input contacts provide Logic continuity from left to right across the rung, the output coil memory location is given a logic 1 Value and the output module interface contacts will close.

•



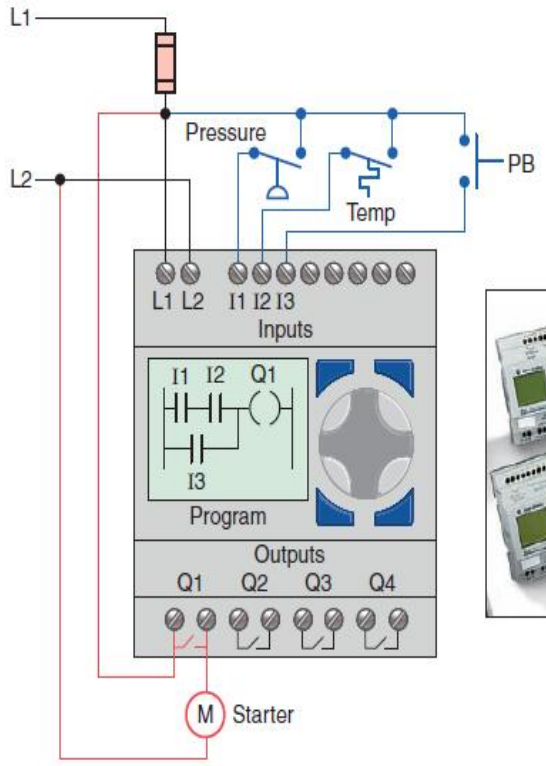
❑ Principles of Operation

• When there is no logic continuity of the program rung, the output coil memory location is set to logic 0 and the output module interface contacts will be open.

• The completion of one cycle of this sequence by the controller is called a *scan. The scan time, the time* required for one full cycle, provides a measure of the speed of response of the PLC.

• Generally, the 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.

▪Figure shows the typical wiring required to implement the process control scheme using a fixed PLC.



❑ Principles of Operation

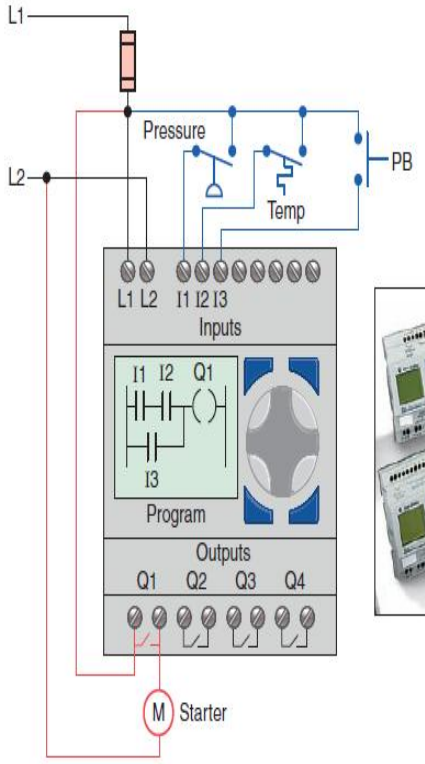
➢ In this example the Allen-Bradley Pico controller equipped with 8 inputs and 4 outputs is used to control and monitor the process. Installation can be summarized as follows:

• Fused power lines, of the specified voltage type and level, are connected to the controller's L1 and L2 terminals.

• The pressure switch, temperature switch, and pushbutton field input devices are hardwired Between L1 and controller input terminals I1, I2, and I3, respectively.

• The motor starter coil connects directly to L2 and inseries with Q1 relay output contacts to L1.

• The ladder logic program is entered using the front keypad and LCD display.



❑PLC Size and Application

➢ 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.

➢ In general, the nano is the smallest size with less than 15 I/O points, This is followed by micro types (15 to 128 I/O points), medium types (128 to 512 I/O points), and large types (over 512 I/O points).

➢Matching the PLC with the application is a key factor in the selection process. In general it is not advisable to buy a PLC system that is larger than current needs dictate.

➢However, future conditions should be anticipated to ensure that the system is the proper size to fill the current and possibly future requirements of an application.

❑PLC Size and Application

➢ There are three major types of PLC application: singleended, multitask, and control management.

➢A *singleended* or stand-alone PLC application involves one PLC controlling one process Figure.

➢This would be a stand-alone unit and would not be used for communicating with other computers or PLCs.

➢The size and sophistication of the process being controlled are obvious factors in determining which PLC to select.

➢The applications could dictate a large processor, but usually this category requires a small PLC.

❑PLC Size and Application

➢ A *multitask PLC application involves one PLC controlling* several processes.

➢Adequate I/O capacity is a significant factor in this type of installation.

➢In addition, if the PLC would be a subsystem of a larger process and would have to communicate with a central PLC or computer, provisions for a data communications network are also required.

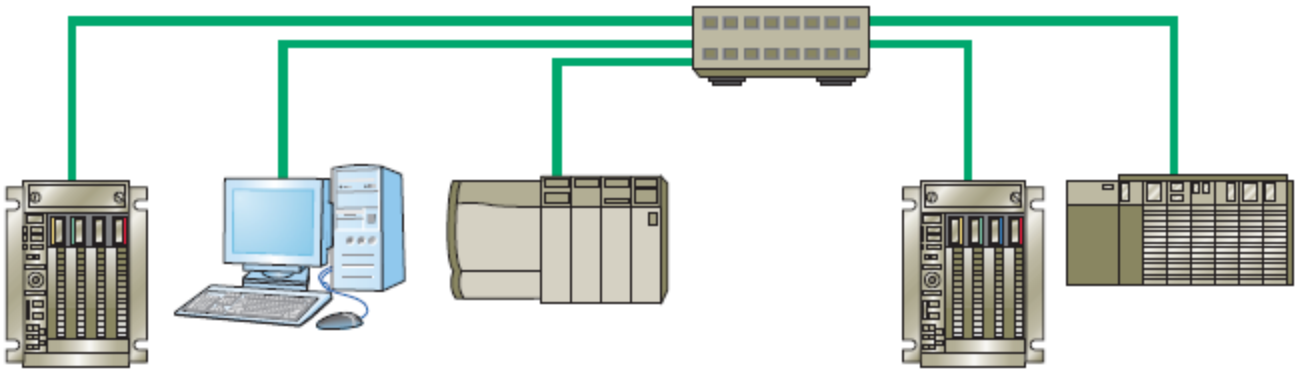
❑PLC Size and Application

➢ A *control management PLC application involves one* PLC controlling several others (Figure).

➢This kind of application requires a large PLC processor designed to communicate with other PLCs and possibly with a computer.

➢The control management PLC supervises several PLCs by downloading programs that tell the other PLCs what has to be done.

➢It must be capable of connection to all the PLCs so that by proper addressing it can communicate with any one it wishes to.



❑PLC Size and Application

- *Memory is the part of a PLC that stores data, instructions,* and the control program.
- Memory size is usually expressed in K values: 1 K word, 6 Kword, 12 Kword, and so on .
- word can be 8,16,32,64 bits
- The amount of memory required depends on the application.
- Factors affecting the memory size needed for a particular PLC installation include:

• Number of I/O points used
• Size of control program
• Data-collecting requirements
• Supervisory functions required
• Future expansion