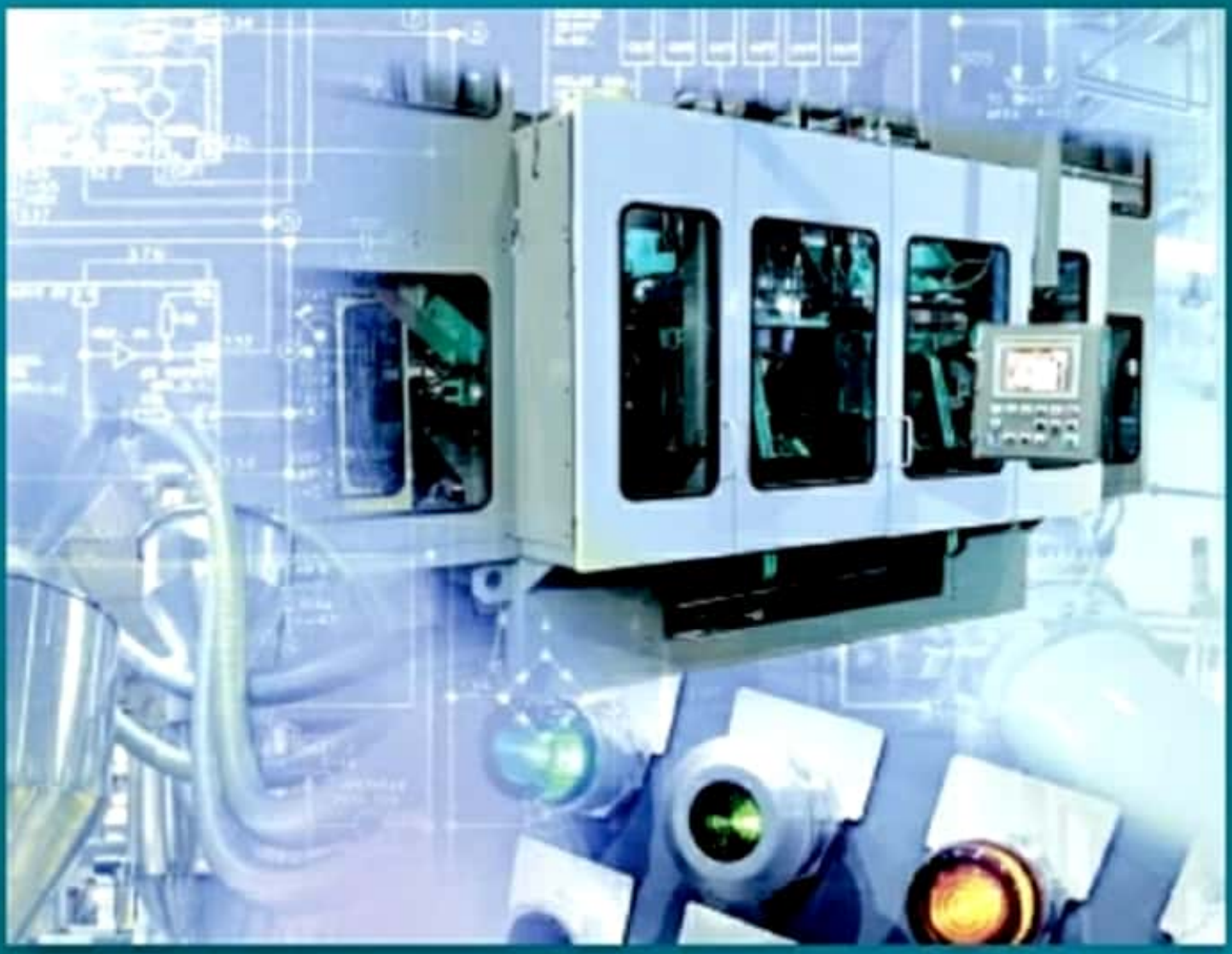
Programmable Logic Controllers



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Institute of Textile Technology

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The Need for PLCs

- Hardwired panels were very time consuming to wire, debug and change.
- GM identified the following requirements for computer controllers to replace hardwired panels.
  - Solid-state not mechanical
  - Easy to modify input and output devices
  - Easily programmed and maintained by plant electricians
  - Be able to function in an industrial environment

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The First Programmable Logic Controllers (PLCs)

- Introduced in the late 1960's
- Developed to offer the same functionality as the existing relay logic systems
- Programmable, reusable and reliable
  - Could withstand a harsh industrial environment
  - They had no hard drive, they had battery backup
  - Could start in seconds
  - Used Ladder Logic for programming

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Programmable Logic Controller

- A programmable logic controller (PLC) is a specialized computer used to control machines and process.
- It uses a programmable memory to store instructions and specific functions that include On/Off control, timing, counting, sequencing, arithmetic, and data handling

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Advantages of PLC Control Systems

- Flexible
- Faster response time
- Less and simpler wiring
- Solid-state - no moving parts
- Modular design - easy to repair and expand
- Handles much more complicated systems
- Sophisticated instruction sets available
- Allows for diagnostics “easy to troubleshoot”
- Less expensive

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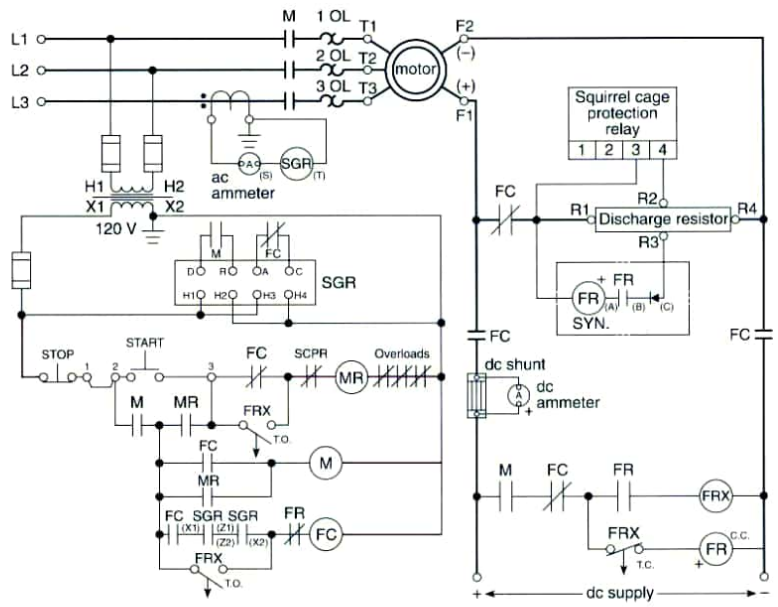
Advantages of a PLC Control System

Eliminates much of the hard wiring that was associated with conventional relay control circuits.



The program takes the place of much of the external wiring that would be required for control of a process.

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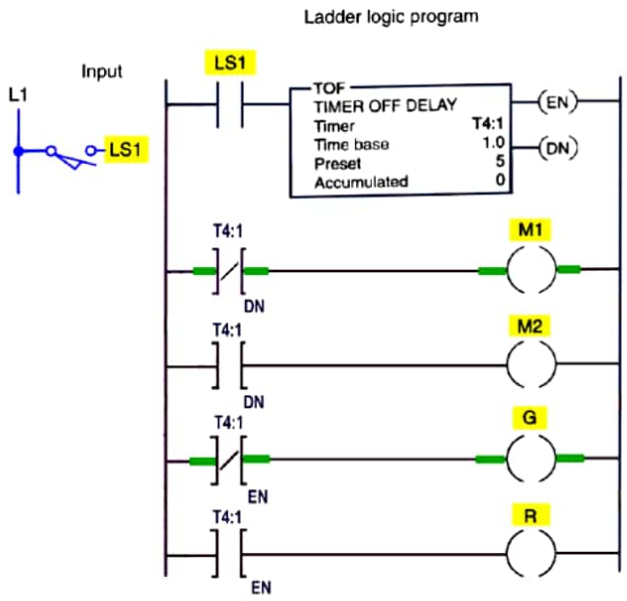
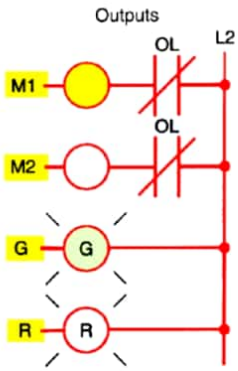
Advantages of a PLC Control System

Increased Reliability:
Once a program has been written and tested it can be 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.

Conversely .....

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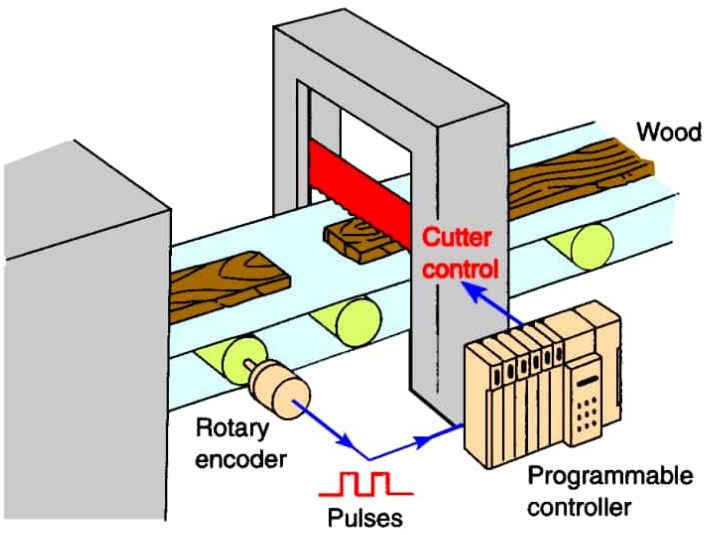
Advantages of a PLC Control System

More Flexibility:
Original equipment manufacturers (OEMs) can provide system updates for a process by simply sending out a new program.



It is easier to create and change a program in a PLC than to wire and rewire a circuit. End-users can modify the program in the field.

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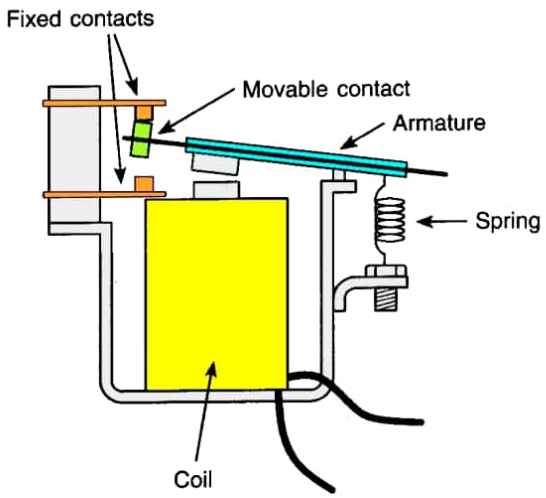
Advantages of a PLC Control System

Lower Costs:
Originally PLCs were designed to replace relay control logic. The cost savings using PLCs have been so significant that relay control is becoming obsolete, except for power applications.



Generally, if an application requires more than about 6 control relays, it will usually be less expensive to install a PLC.

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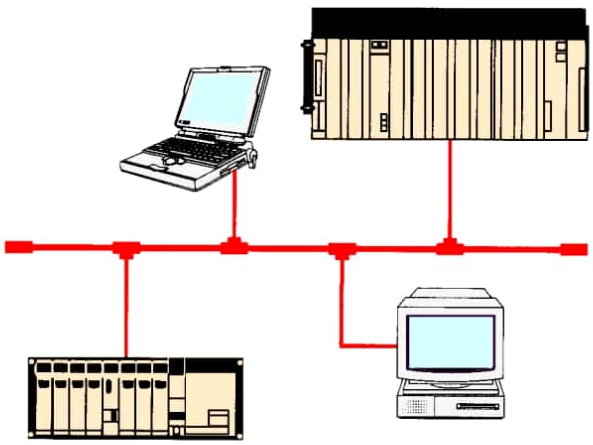
Advantages of a PLC Control System

Communications Capability:
A PLC can communicate with other controllers or computer equipment.



They can be networked to perform such functions as: supervisory control, data gathering, monitoring devices and process parameters, and downloading and uploading of programs.

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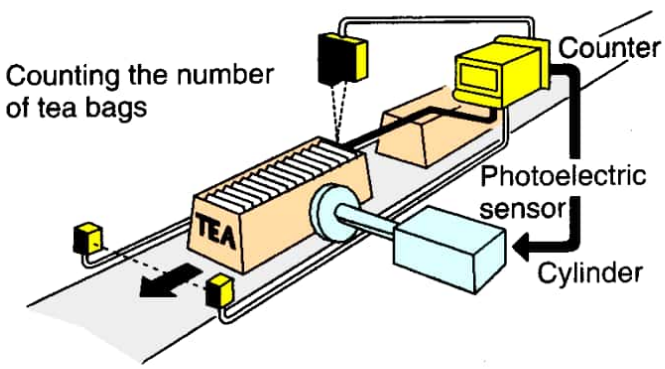
Advantages of a PLC Control System

Faster Response Time:
PLCs operate in real-time which means that an event taking place in the field will result in an operation or output taking place.



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.

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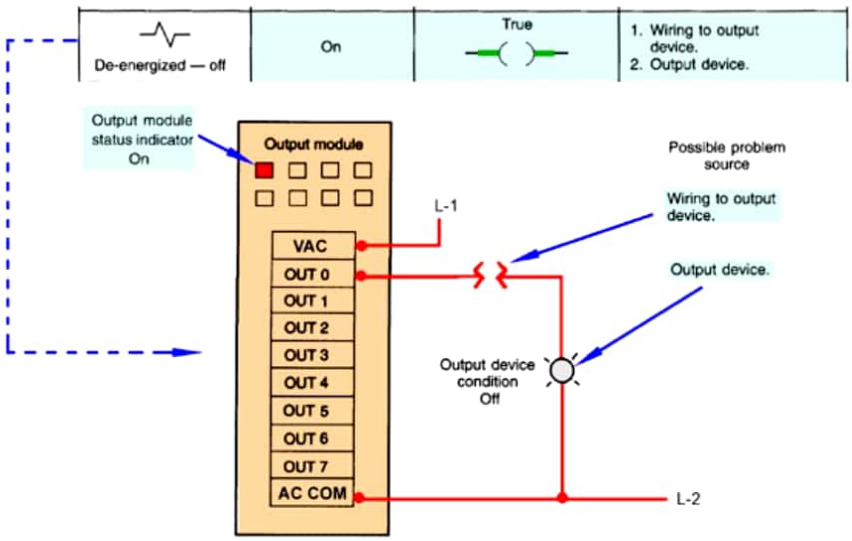
Advantages of a PLC Control System

Easier To Troubleshoot:
PLCs have resident diagnostic and override functions allowing users to easily trace and correct software and hardware problems.



The control program can be watched in real-time as it executes to find and fix problems

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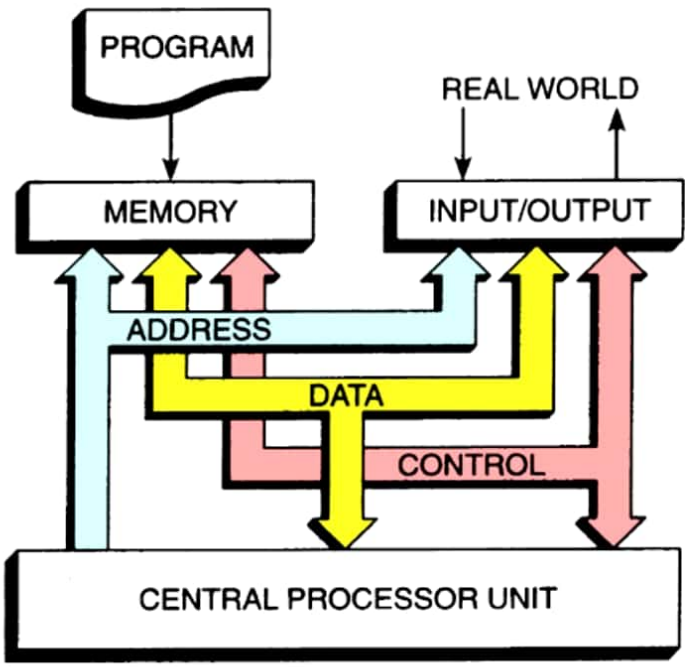
PLC Architecture



The structure of a PLC is based on the same principles as those employed in computer architecture.

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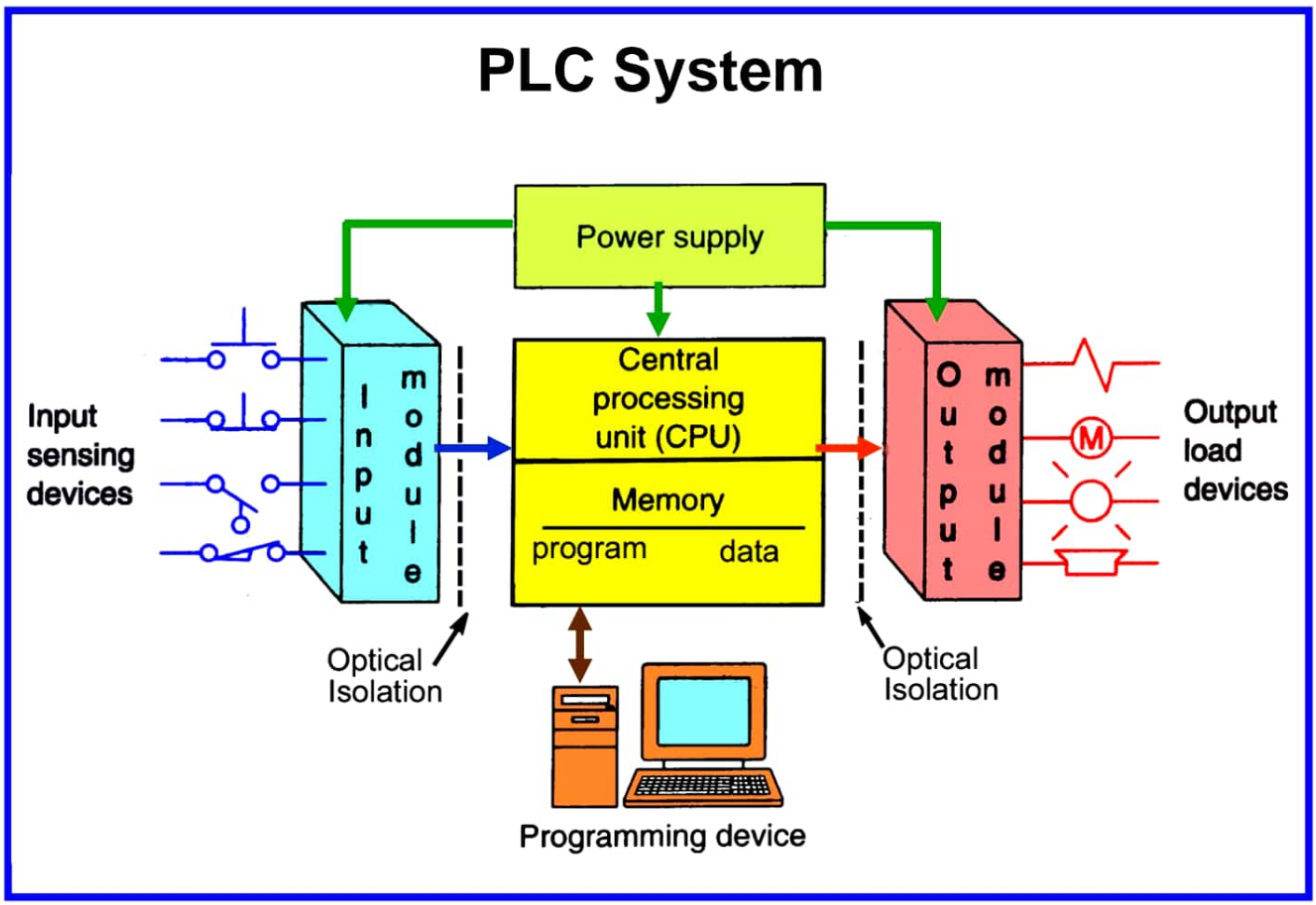

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PLC Architecture

- An *open architecture* design allows the system to be connected easily to devices and programs made by other manufacturers.

- A *closed architecture* or *proprietary* system, is one whose design makes it more difficult to connect devices and programs made by other manufacturers.

NOTE: When working with PLC systems that are proprietary in nature you must be sure that any generic hardware or software you use is compatible with your particular PLC.

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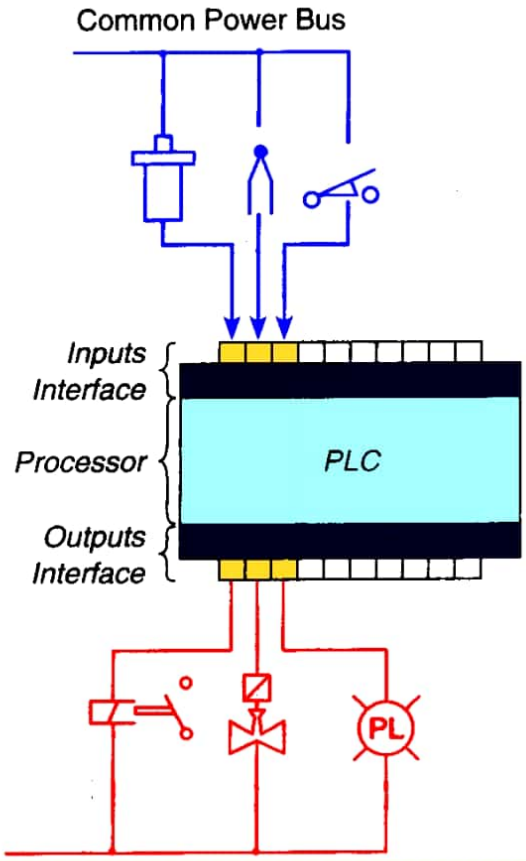
I/O Configurations

Fixed I/O

- Is typical of small PLCs
- Comes in one package, with no separate removable units.
- The processor and I/O are packaged together.
- Lower in cost – but lacks flexibility.



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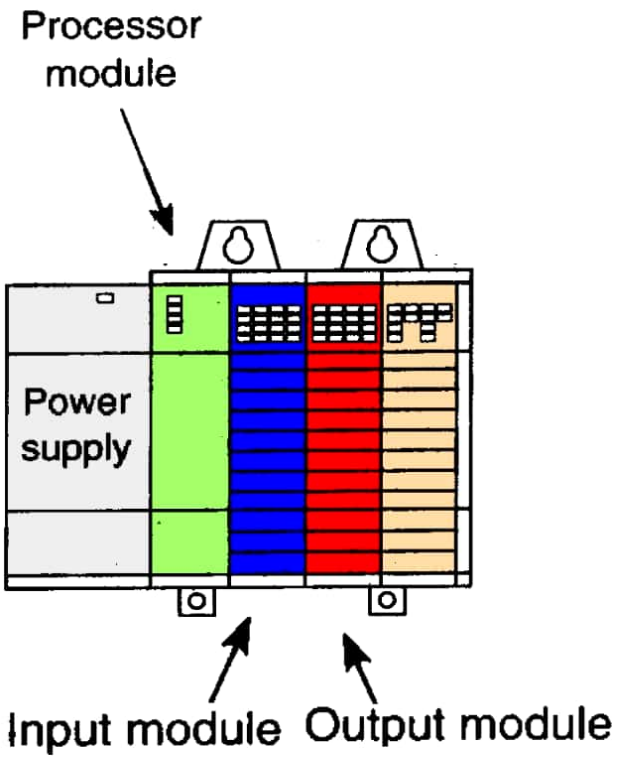
I/O Configurations

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. You can choose from all the modules available and mix them in any way you desire.



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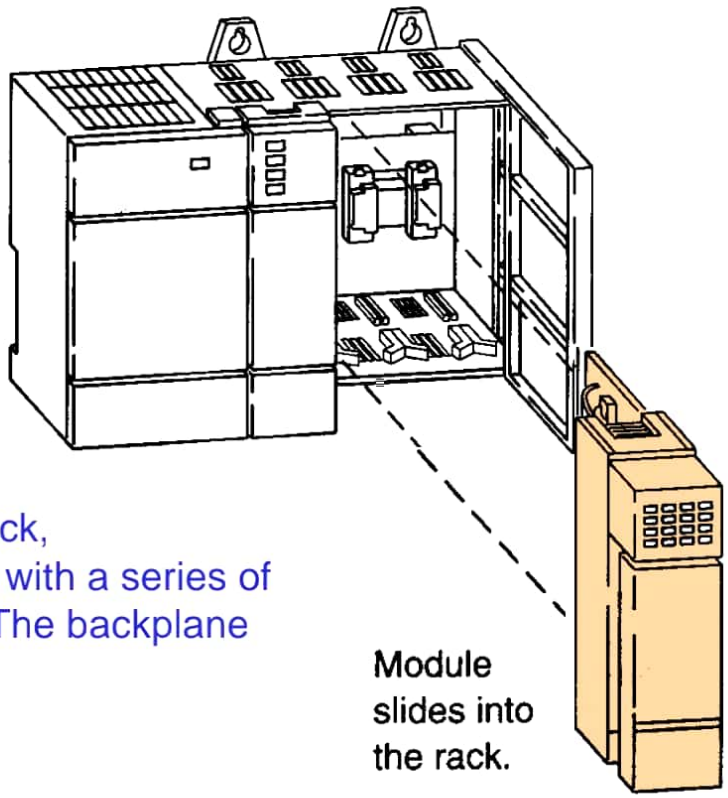
I/O Configurations

Modular I/O



When a module slides into the rack, it makes an electrical connection with a series of contacts - called the *backplane*. The backplane is located at the rear of the rack.

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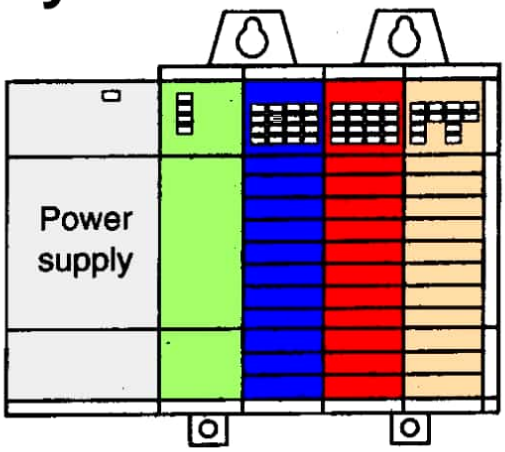
Power Supply



- Supplies DC power to other modules that plug into the rack.
- In large PLC systems, this power supply does not normally supply power to the field devices.
- In small and micro PLC systems, the power supply is also used to power field devices.

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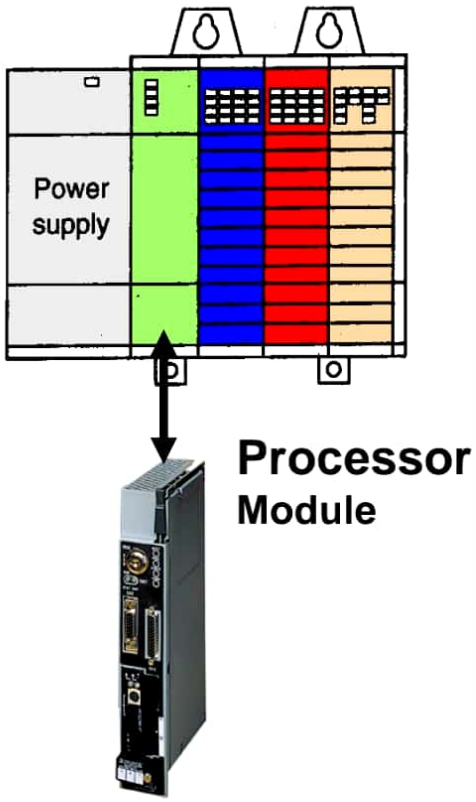
Processor (CPU)

- Is the “brain” of the PLC.
- Consists of a microprocessor for implementing the logic, and controlling the communications among the modules.
- Designed so the desired circuit can be entered in relay ladder logic form.
- The processor accepts input data from various sensing devices, executes the stored user program, and sends appropriate output commands to control devices.



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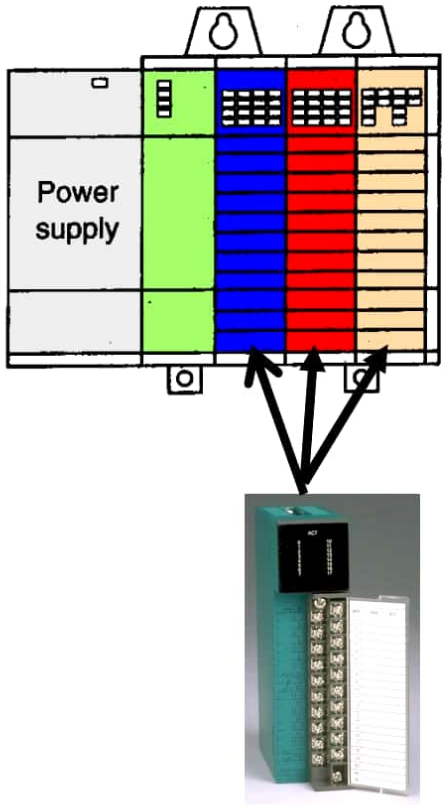
I/O Section

Consists of:

- Input modules
- Output modules.



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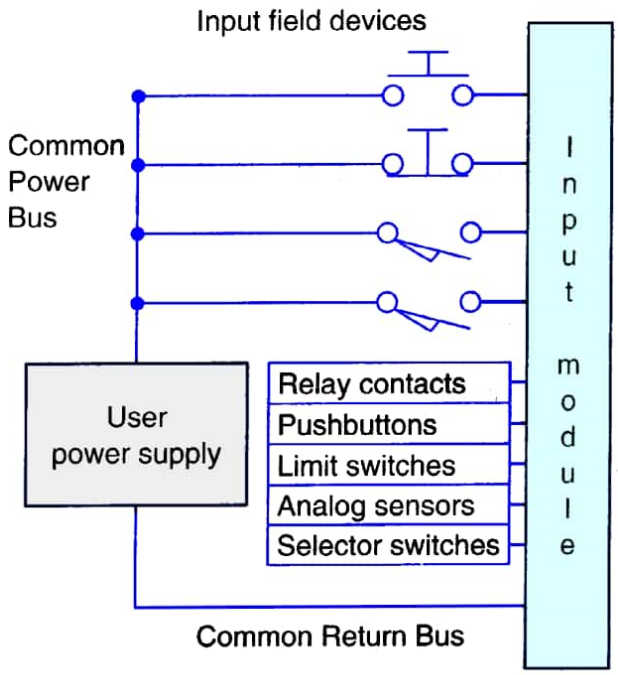
I/O Section

Input Module

- Forms the interface by which input field devices are connected to the controller.
- The terms “field” and “real world”are used to distinguish actual external devices that exist and must be physically wired into the system.



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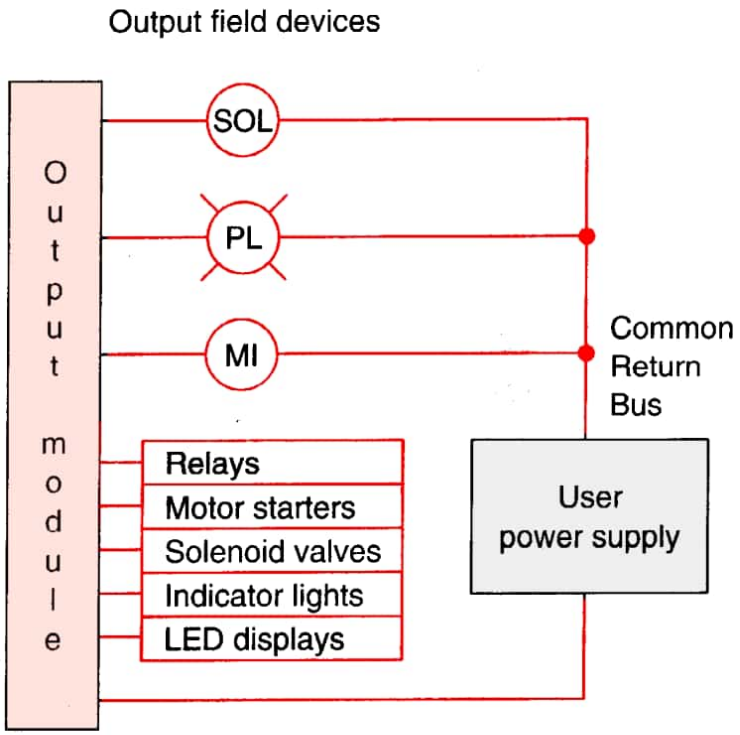
I/O Section

Output Module

- Forms the interface by which output field devices are connected to the controller.
- PLCs employ an optical isolator which uses light to electrically isolate the internal components from the input and output terminals.



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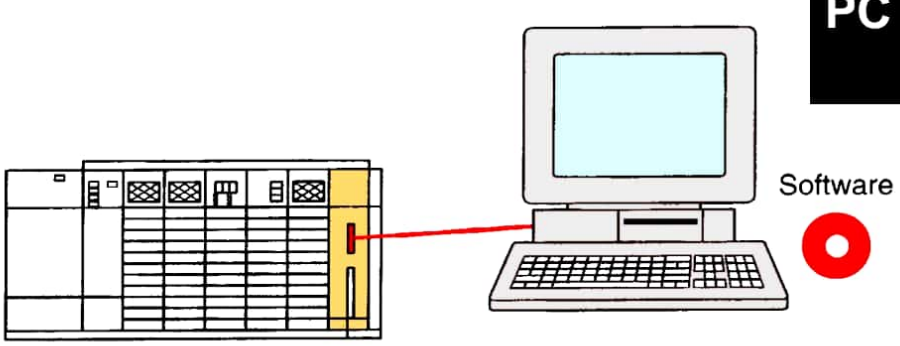
Programming Device

PC with appropriate software



- A personal computer (PC) is the most commonly used programming device
- The software allows users to create, edit, document, store and troubleshoot programs
- The personal computer communicates with the PLC processor via a serial or parallel data communications link

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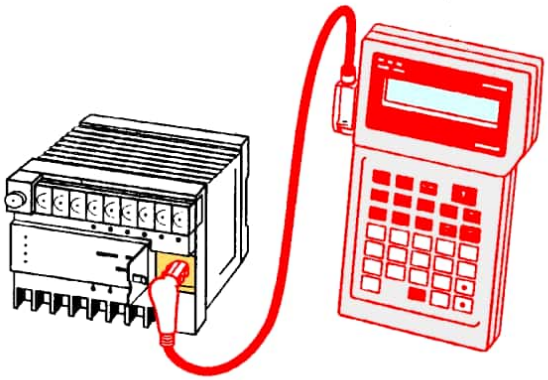
Programming Device

Hand-held unit with display



- Hand-held programming devices are sometimes used to program small PLCs
- They are compact, inexpensive, and easy to use, but are not able to display as much logic on screen as a computer monitor

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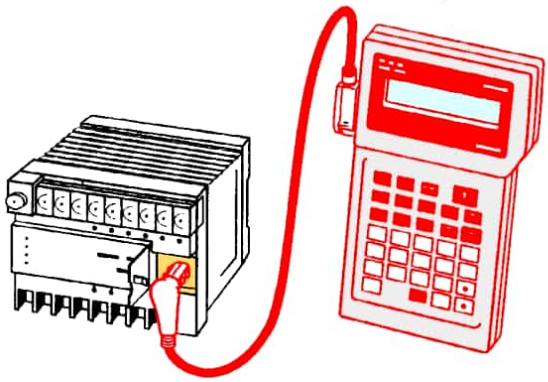
Programming Device

Hand-held unit with display



- Hand-held units are often used on the factory floor for troubleshooting, modifying programs, and transferring programs to multiple machines.

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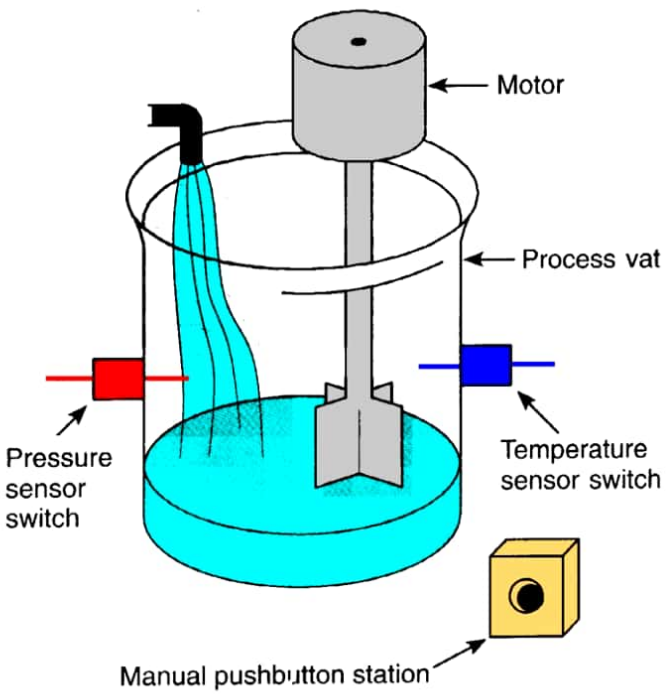
PLC Mixer Process Control Problem

Mixer motor to automatically stir the liquid in the vat when the temperature and pressure reach preset values

Alternate manual pushbutton control of the motor to be provided



The temperature and pressure sensor switches close their respective contacts when conditions reach their preset values

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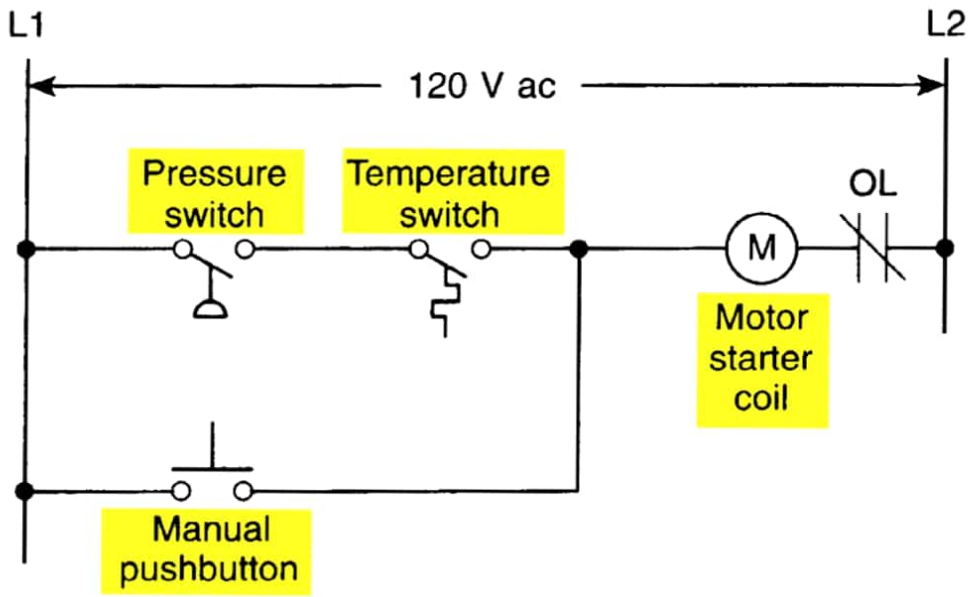
Process Control Relay Ladder Diagram



Motor starter coil is energized when both the pressure and temperature switches are closed or when the manual pushbutton is pressed

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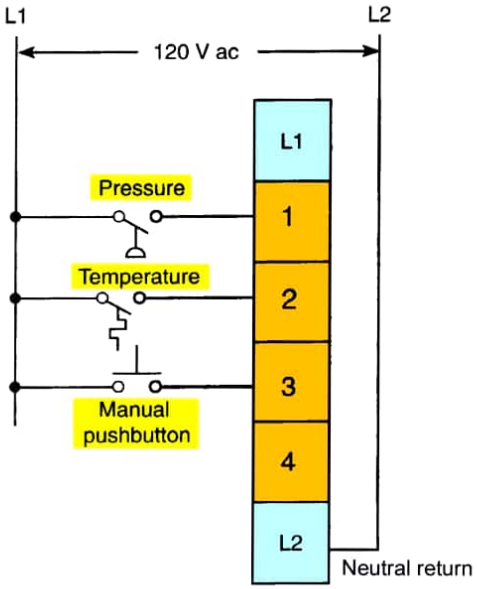
PLC Input Module Connections

- The same input field devices are used
- These devices are wired to the input module according to the manufacturer's labeling scheme



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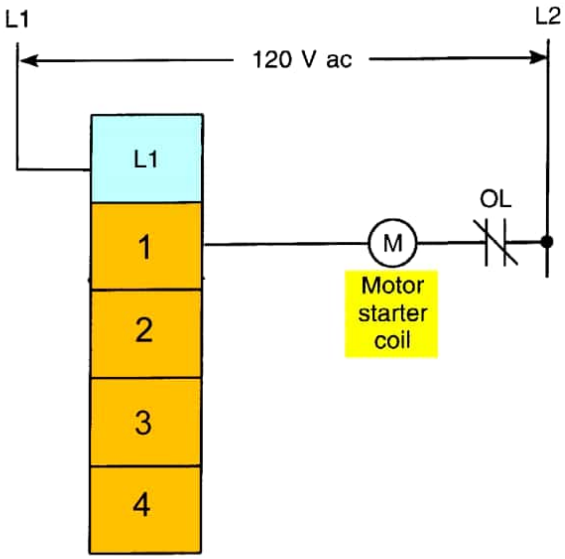
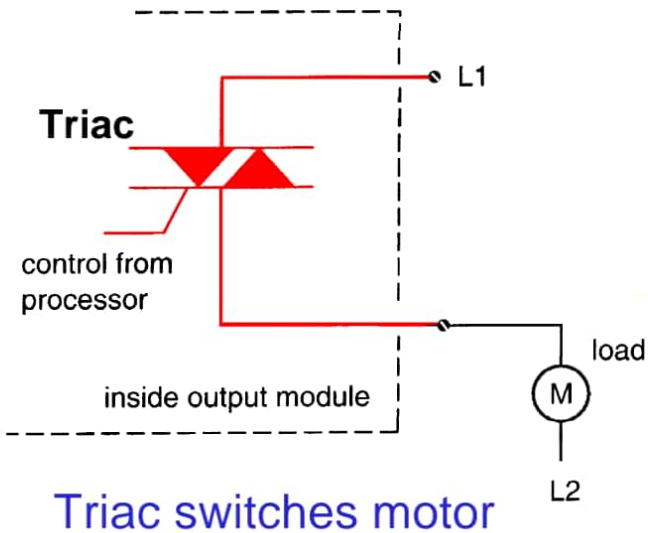
PLC Output Module Connections

Same output field device is used and wired to the output module





Triac switches motor ON and OFF in accordance with the control signal from the processor

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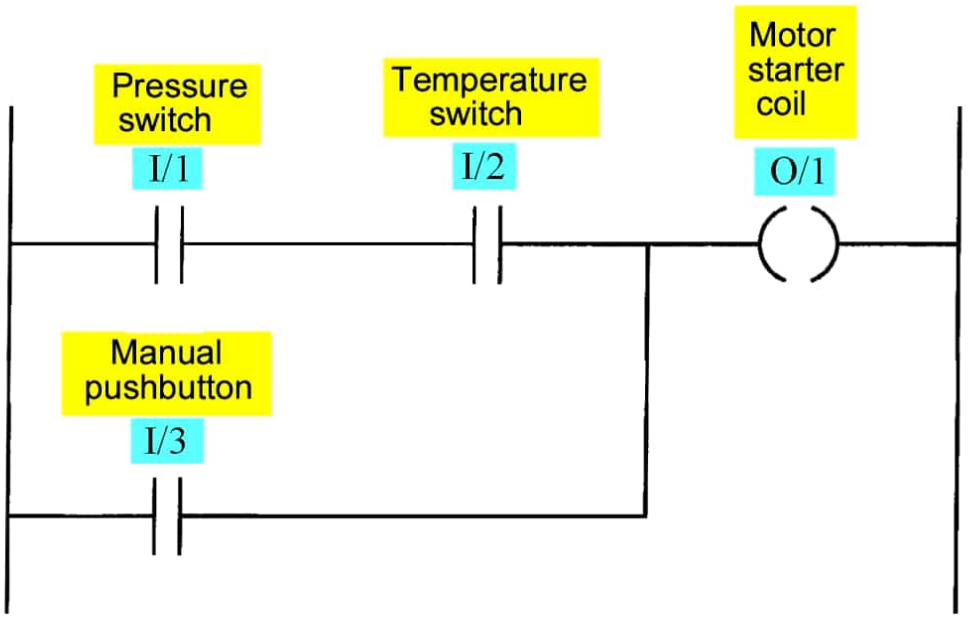
PLC Ladder Logic Program



- The format used is similar to that of the hard-wired relay circuit

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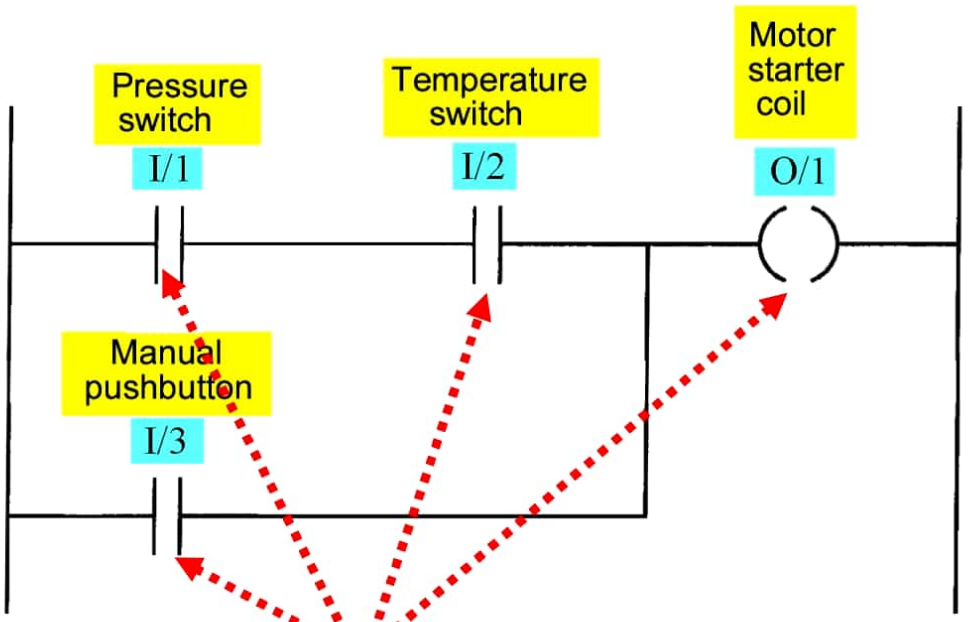
PLC Ladder Logic Program



The *symbols* represent *instructions*

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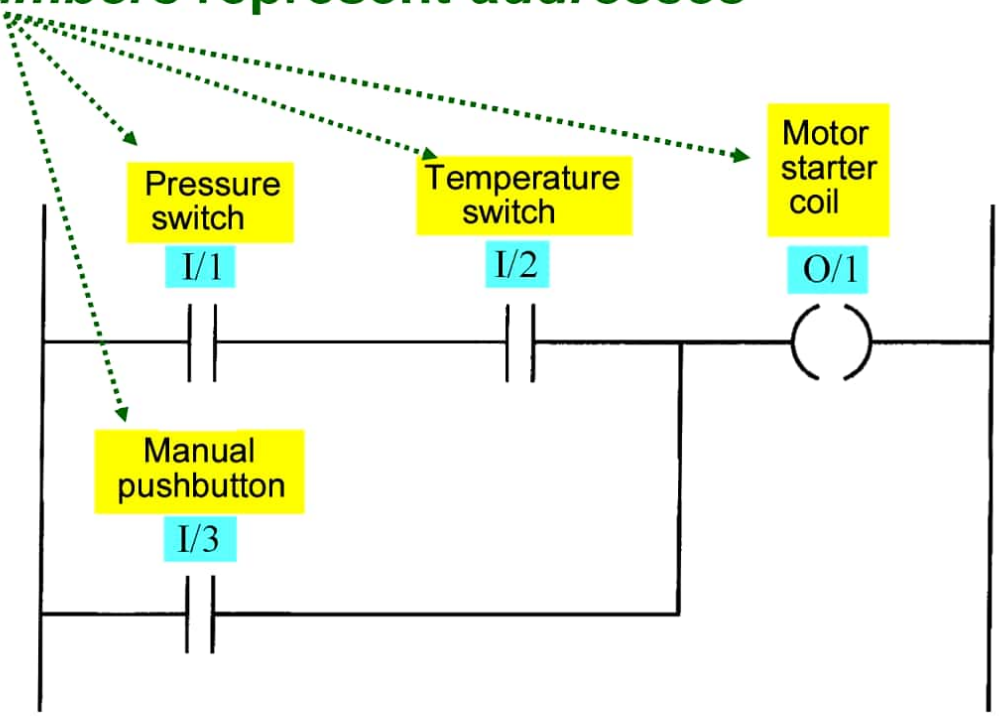
PLC Ladder Logic Program

The *numbers* represent *addresses*



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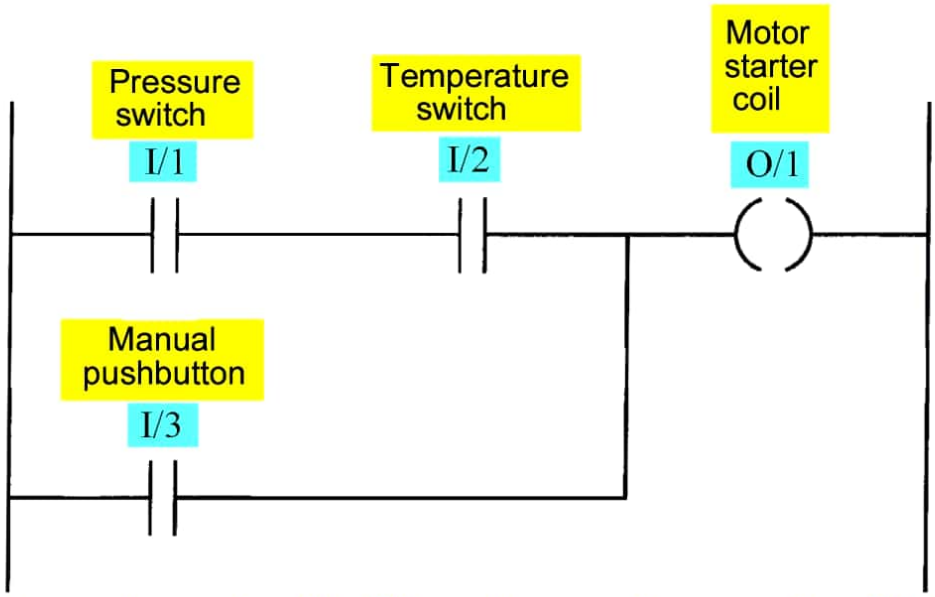
PLC Ladder Logic Program



- I/O address format will differ, depending on the PLC manufacturer. You give each input and output device an address. This lets the PLC know where they are physically connected

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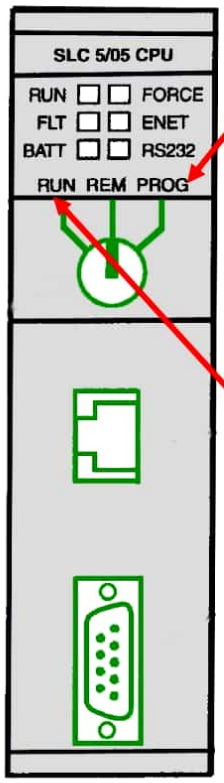
Entering And Running The PLC Program



To enter the program into the PLC, place the processor in the PROGRAM mode and enter the instructions one-by-one using the programming device

To operate the program, the controller is placed in the RUN mode, or operating cycle

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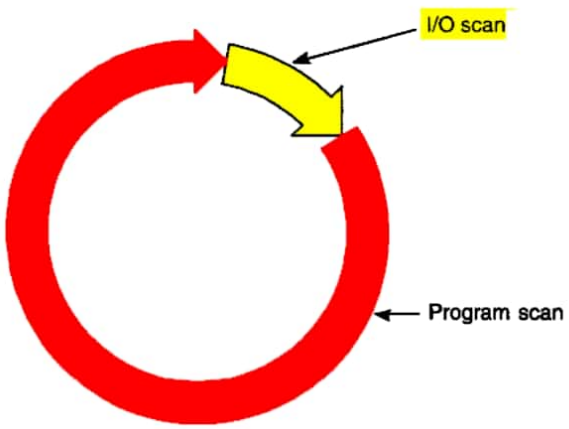
PLC Operating Cycle

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



The completion of one cycle of this sequence 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

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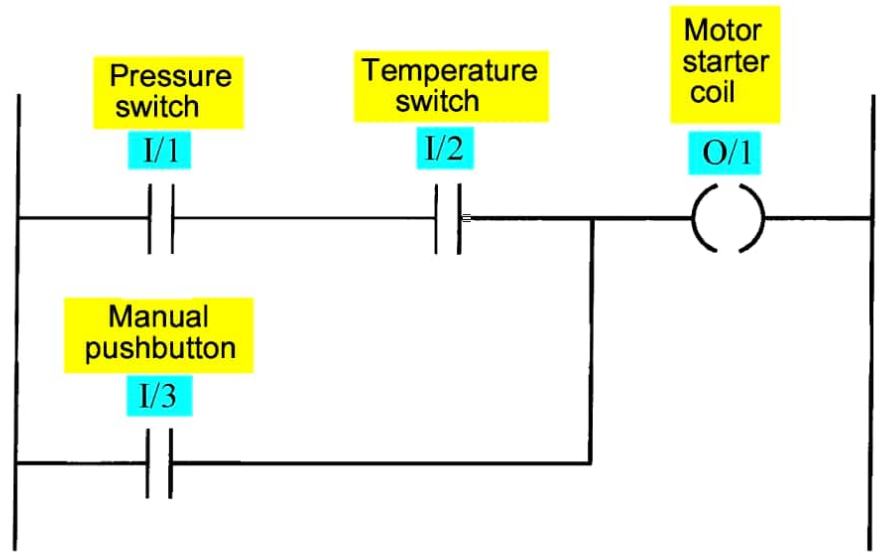
PLC Operating Cycle



Each ⊣⊢ can be though of as a set of normally open contacts

The ( ) can be considered to represent a coil that, when energized, will close a set of contacts.

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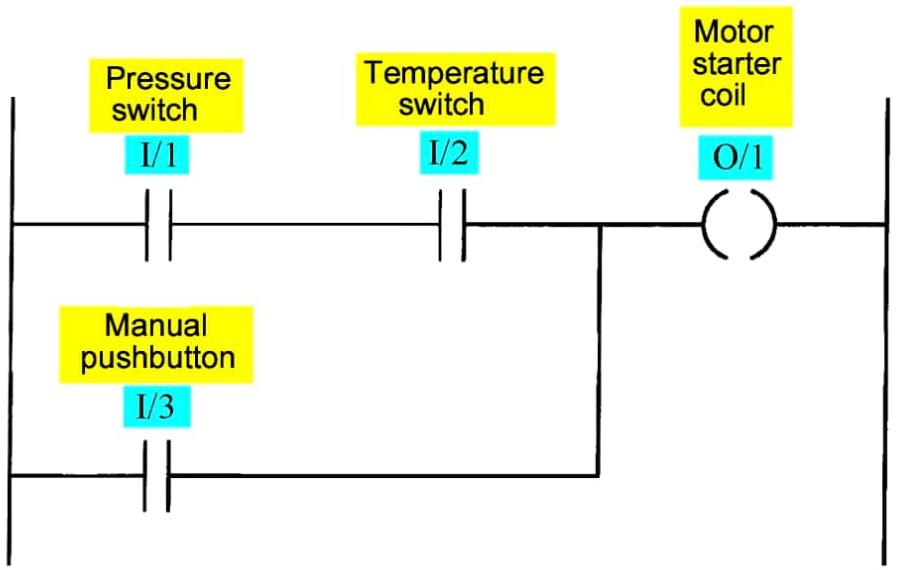
PLC Operating Cycle



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 path from left to right across the rung that includes the coil.

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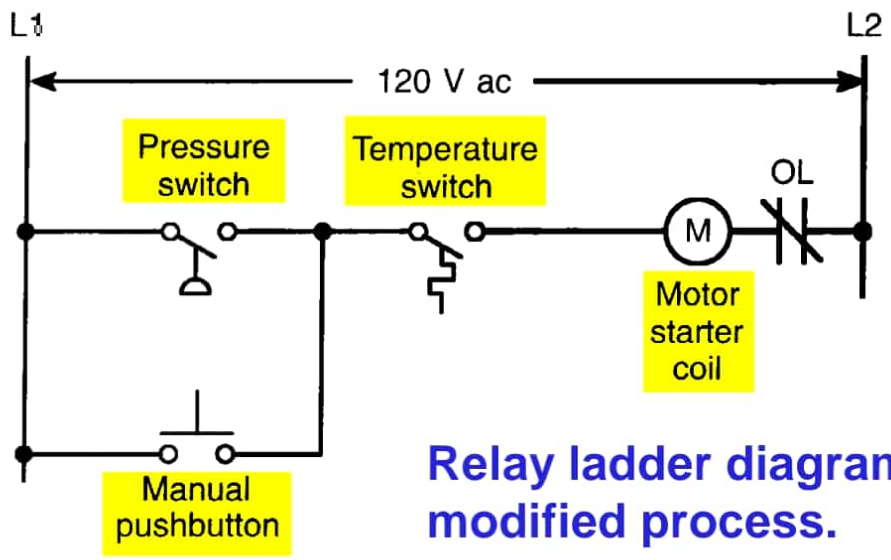
Modifying A PLC Program



Relay ladder diagram for modified process.

The change requires that the manual pushbutton control should be permitted to operate at any pressure but not unless the specified temperature setting has been reached.

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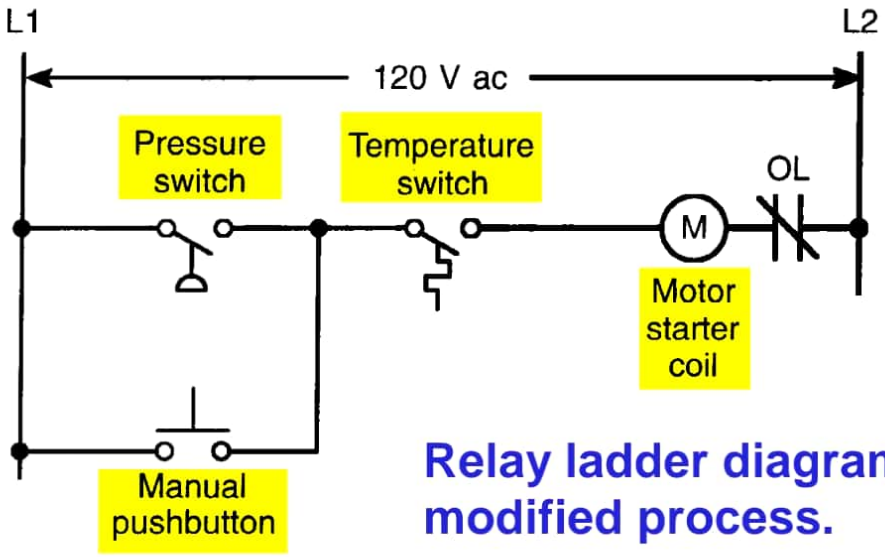
Modifying A PLC Program



Relay ladder diagram for modified process.

If a relay system were used, it would require some rewiring of the system, as shown, to achieve the desired change.

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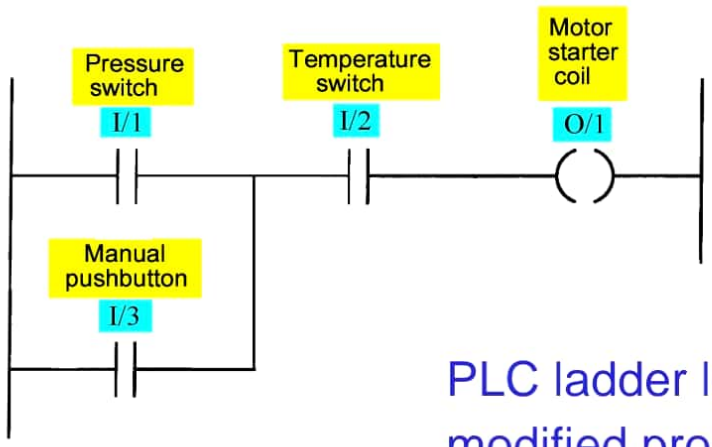
Modifying A PLC Program



PLC ladder logic diagram for modified process.

If a PLC is used, no rewiring is necessary!

The inputs and outputs are still the same.

All that is required is to change the PLC program

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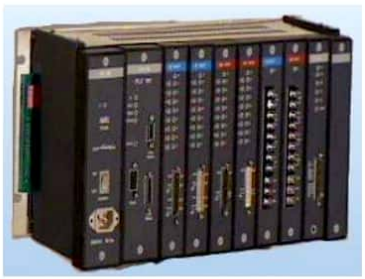
PLCs Versus Personal Computers



Same basic architecture

PLC

- Operates in the industrial environment
- Is programmed in relay ladder logic
- Has no keyboard, CD drive, monitor, or disk drive
- Has communications ports, and terminals for input and output devices

PC

- Capable of executing several programs simultaneously, in any order
- Some manufacturers have software and interface cards available so that a PC can do the work of a PLC

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PC Based Control Systems

Advantages

- Lower initial cost
- Less proprietary hardware and software required
- Straightforward data exchange with other systems
- Speedy information processing
- Easy customization

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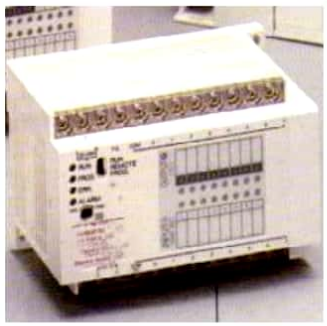
PLC Size Classification

Criteria
- Number of inputs and outputs (I/O count)
- Cost
- Physical size

Nano PLC
- Smallest sized PLC
- Handles up to 16 I/O points



Micro PLC
- Handles up to 32 I/O points

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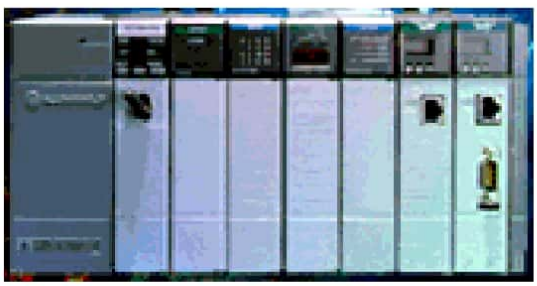
PLC Size Classification



Allen-Bradley SLC-500 Family
- Handles up to 960 I/O points

Allen-Bradley PLC-5 Family
- Handles several thousand I/O points

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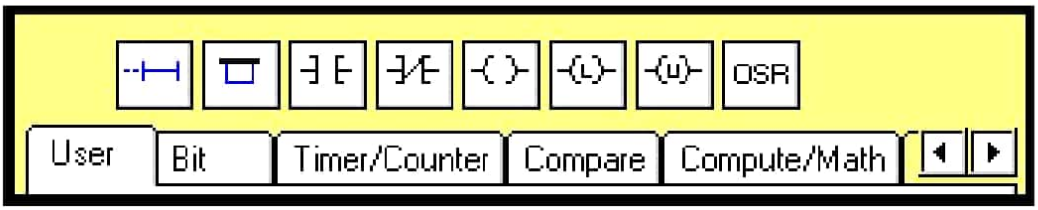
PLC Instruction Set

The instruction set for a particular PLC type lists the different types of instructions supported.



An instruction is a command that will cause a PLC to perform a certain predetermined operation.

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Typical PLC Instructions

XIC (Examine ON)	Examine a bit for an ON condition
XIO (Examine OFF)	Examine a bit for an OFF condition
OTE (Output Energize)	Turn ON a bit (non retentive)
OTL (Output Latch)	Latch a bit (retentive)
OTU (Output Unlatch)	Unlatch a bit (retentive)
TOF (Timer Off-Delay)	Turn an output ON or OFF after its rung has been OFF a preset time interval
TON (Timer On-Delay)	Turn an output ON or OFF after its rung has been ON for a preset time interval
CTD (Count Down)	Use a software counter to count down from a specified value
CTU (Count Up)	Use a software counter to count up to a specified value

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