Programmable Logic Controller

Dr. Md. Zahurul Haq, *Ph.D., CEA, FBSME, FIEB*

Professor
Department of Mechanical Engineering
Bangladesh University of Engineering & Technology (BUET)
Dhaka-1000, Bangladesh

zahurul@me.buet.ac.bd
http://zahurul.buet.ac.bd/

Programmable Logic Controller (PLC) & VFD Workshop for Industrial Automation

Overview

1. PLC Features
2. PLC Basic Components & Operations
3. PLC Programming
4. Examples of Basic of PLC Operations
5. PLC Troubleshooting

PLC Features

A programmable logic controller (PLC) is an industrial grade computer that is capable of being programmed to perform control functions. PLC has eliminated much of the hard-wiring associated with conventional relay control circuits.

- Rugged design,
- Industry standard I/O interfaces,
- Industry standard programming languages,
- Robust timing, counting and switching operations,
- Field programmable,
- Reduces hard wiring and wiring cost,
- Monitoring, error checking and diagnostics capability,
- Competitive in both cost and space requirements.

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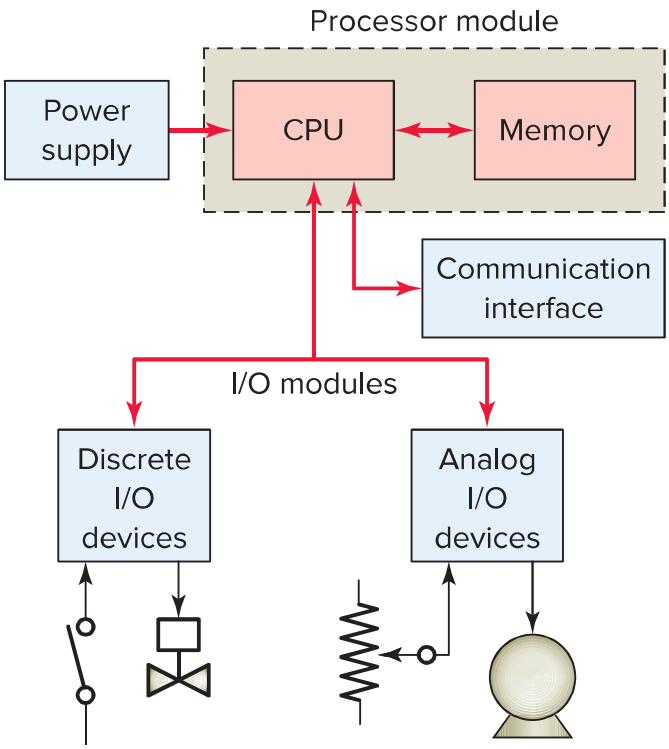
1. Power supply
2. PLC (programmable logic controller)
3. Digital input cards
4. Digital output cards
5. Analog input cards
6. Transient surge protectors
7. Circuit breakers
8. Relay switches
9. Operator interface terminal
10. NEMA 12 enclosure

Typical PLC control panel enclosure.



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PLC key components

Considerations in Choosing PLC

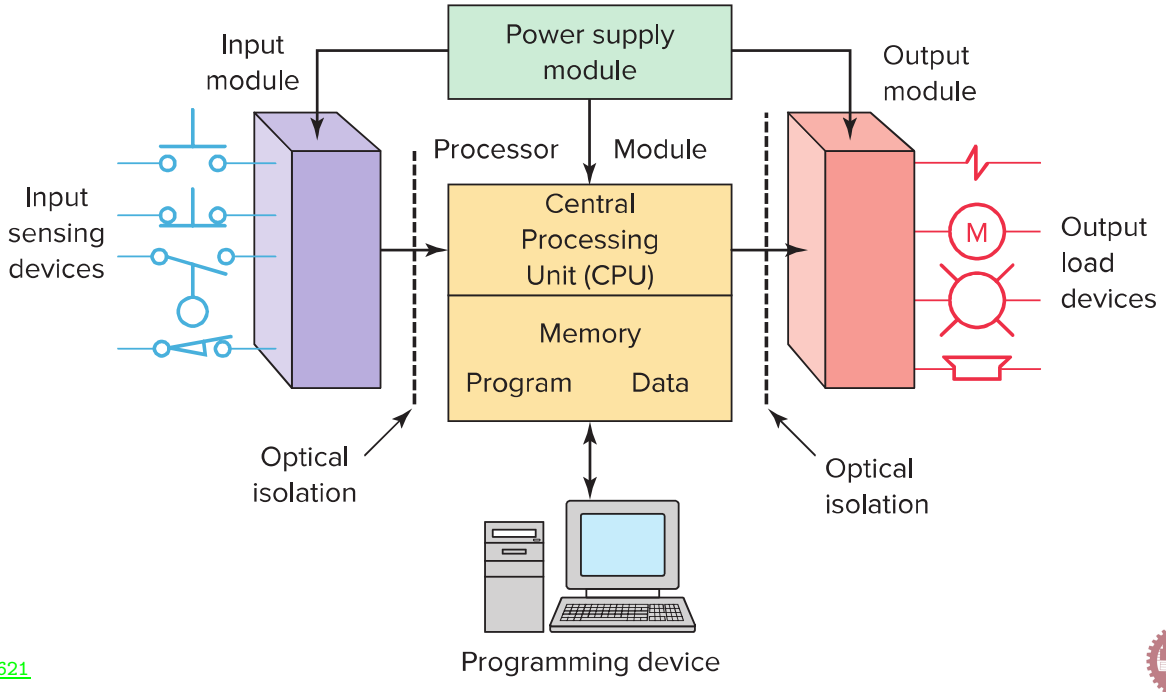
- Number and Types of input & output points required
- Size and type of memory required
- Speed and power required of CPU and instruction set
- Manufacturer's support and backup

Basic Components

PLC is a microcomputer tailored specifically for certain control tasks.

- Hardware: consists of the actual device technology.
- Firmware: is the software part, known as *executive software*, that is permanently installed and supplied by the the PLC manufacturer. Executive software determines
  - what functions are available to the user's program,
  - how the program is solved,
  - how the I/O is serviced,
  - what the PLC does during power up and down and fault conditions.
- Software: is the user program. User programs are usually stored in the RAM.

Key Components of a PLC



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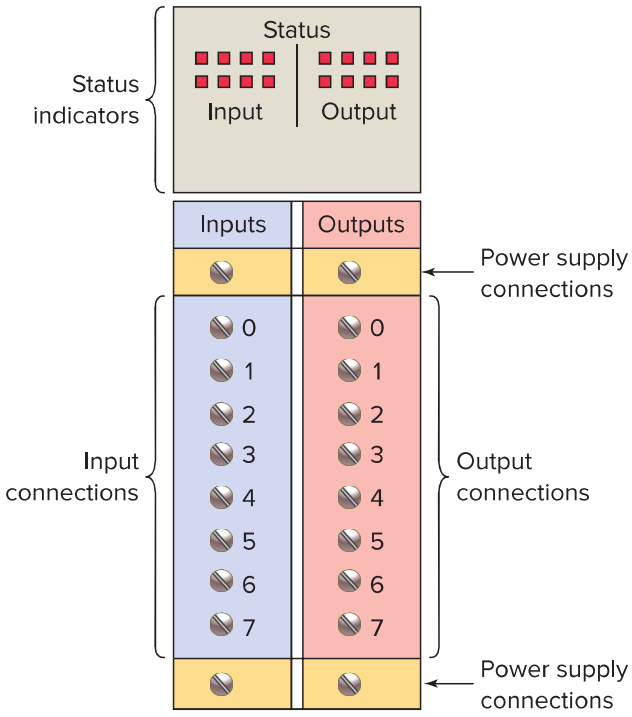

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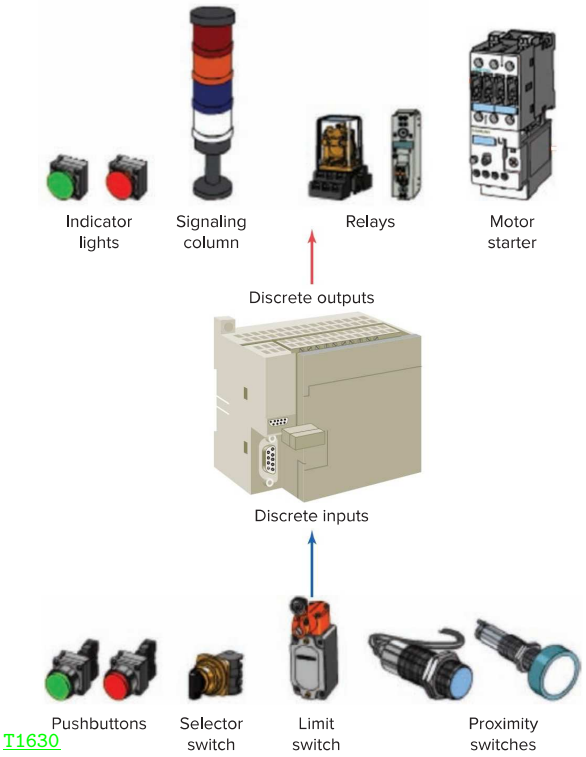
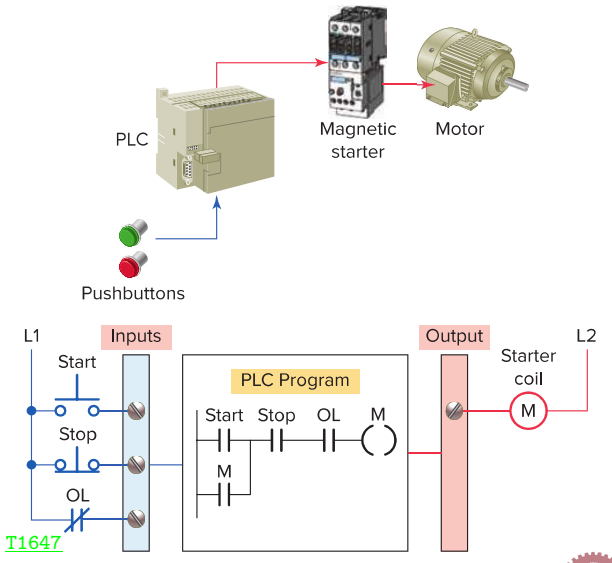
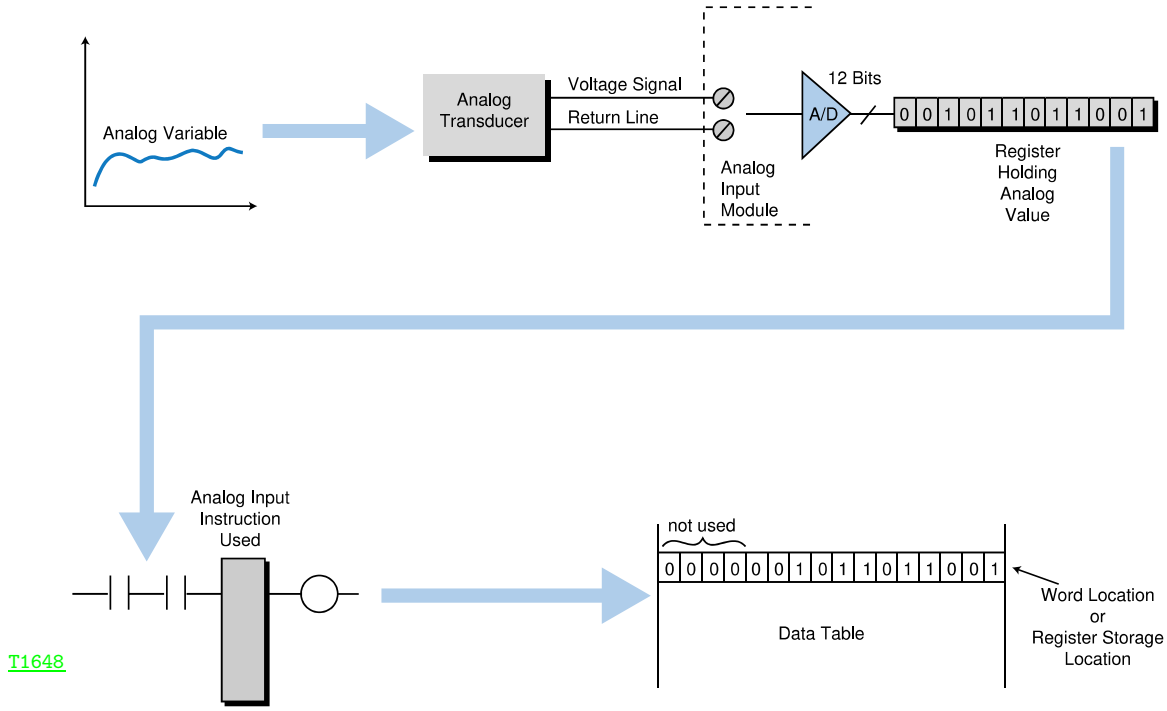
Typical combination I/O module.



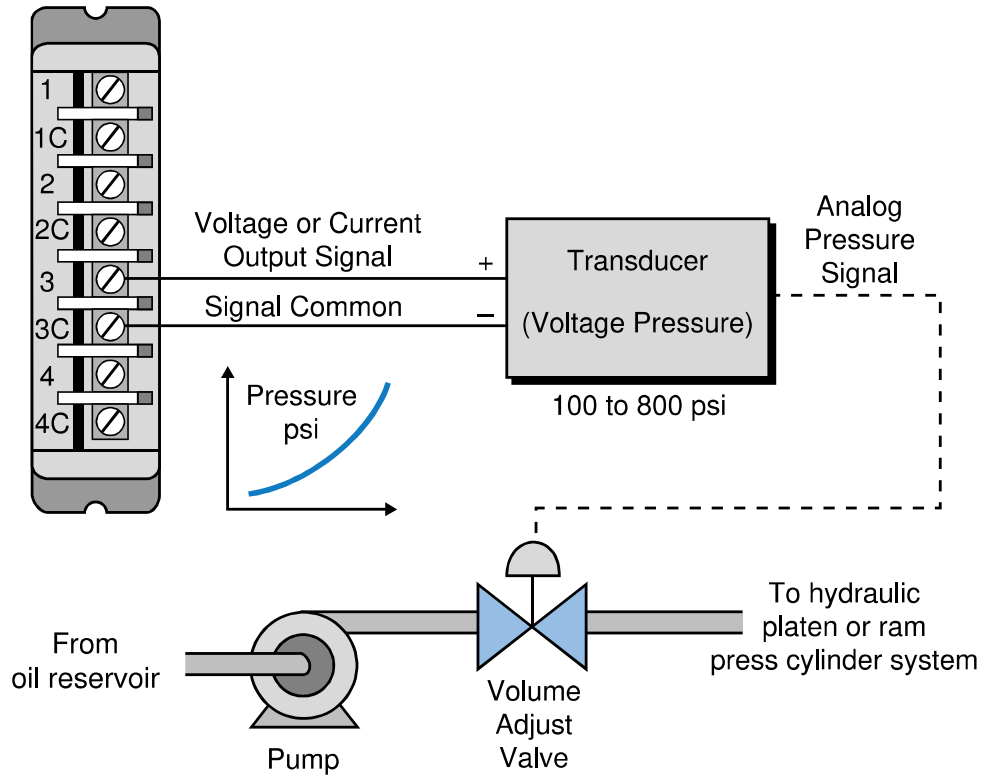
Discrete input and output devices.



PLC control of a motor.



Process for inputting analog data to a word location.



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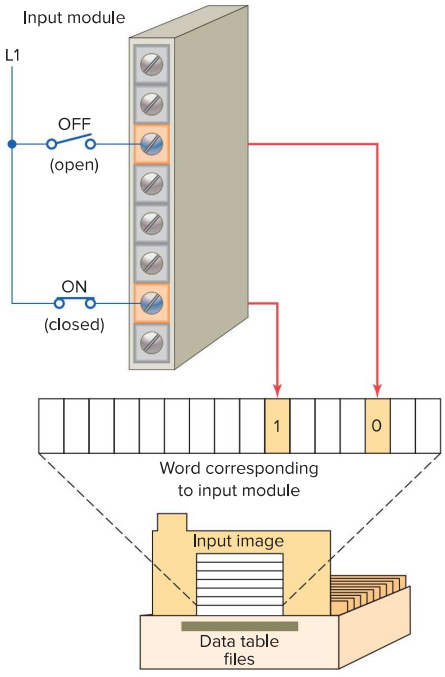
Volume adjustment.



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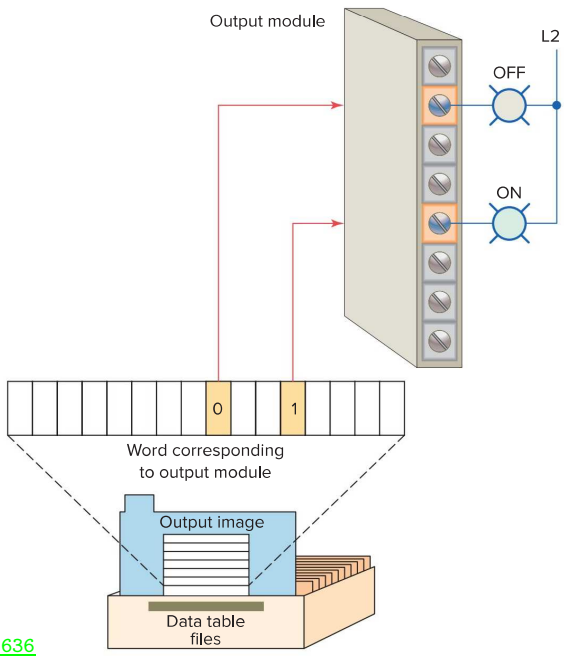
Connection of an open and closed switch to the input image table file through the input module



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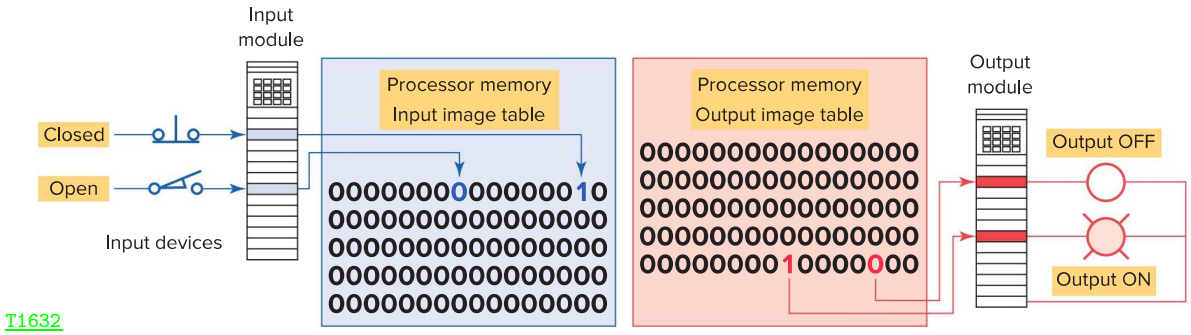
Connections of pilot lights to the output image table file through the output module



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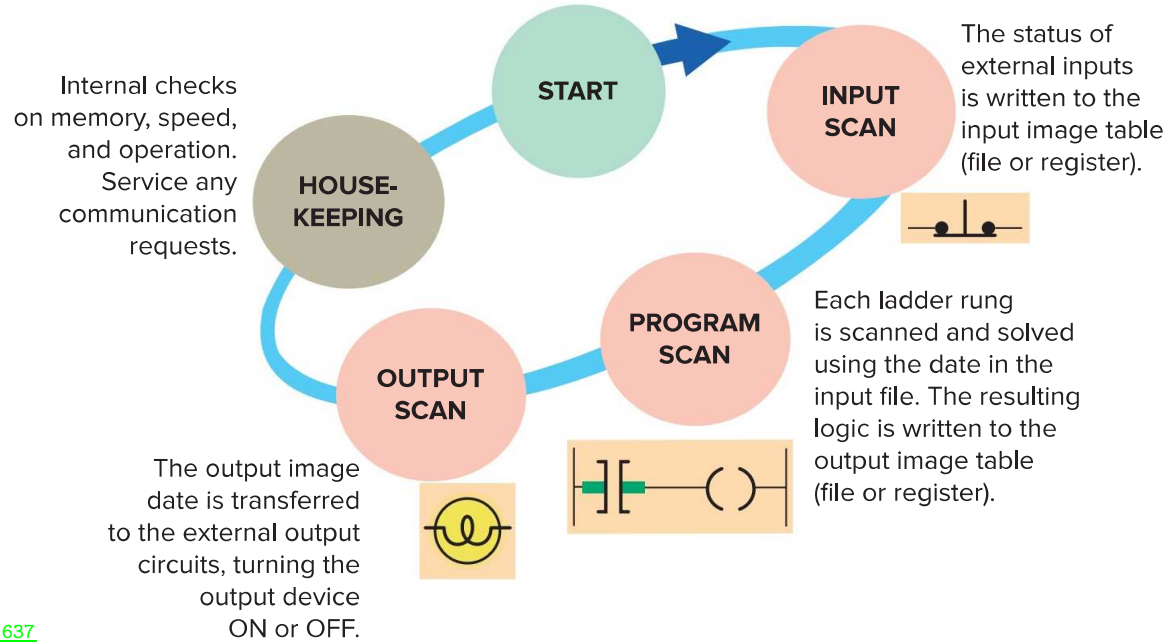
Input and output tables.



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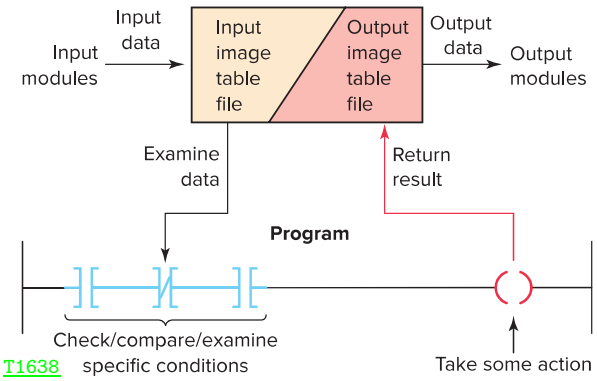
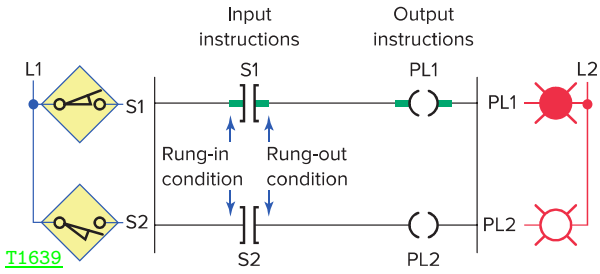
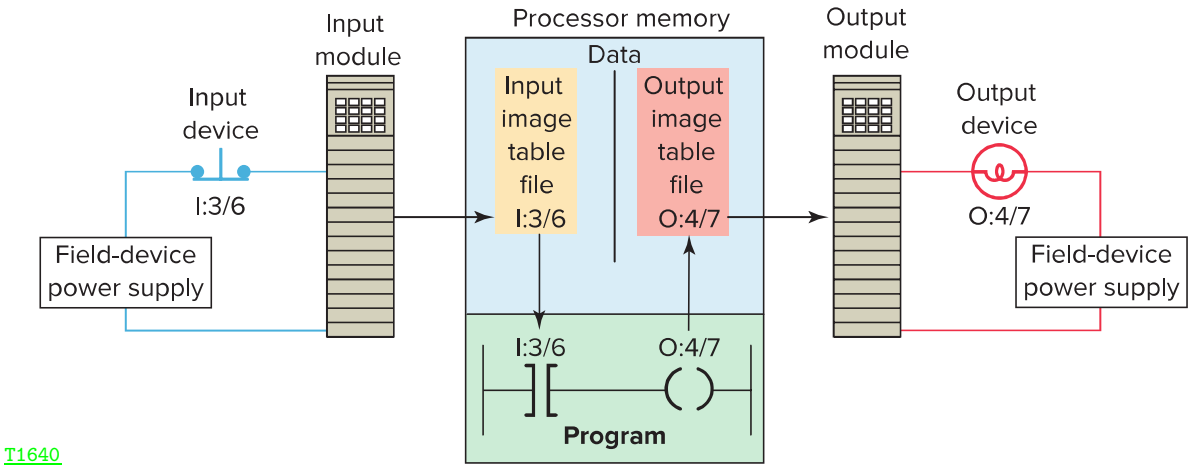
PLC program scan cycle.



Data flow during the scan process.

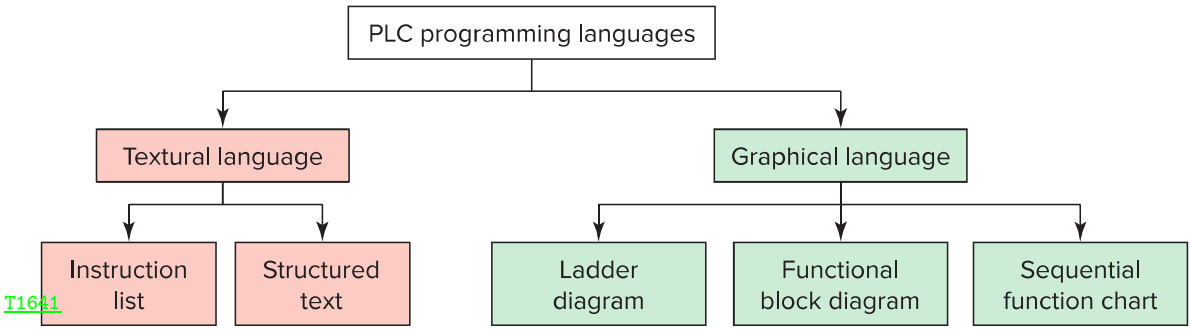


Evaluating ladder logic rung conditions.



Scan process applied to a single rung program.

PLC Programming



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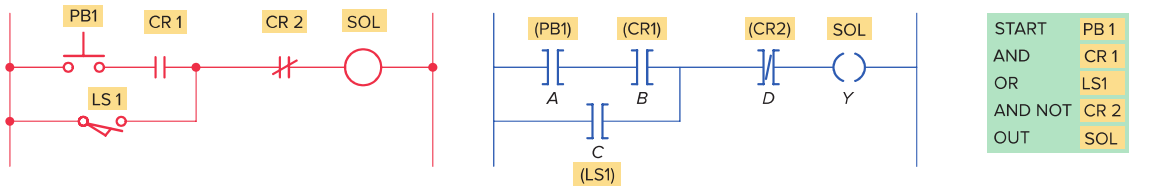
Standard IEC 61131 languages associated with PLC programming.



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(*a*) Hardwired relay control circuit

(*b*) Equivalent ladder diagram (LD) program

(*c*) Equivalent instruction list (IL) program

Comparison of ladder diagram and instruction list programming.

Typical PLC instruction

Instruction	Operation
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 (nonretentive)
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 for 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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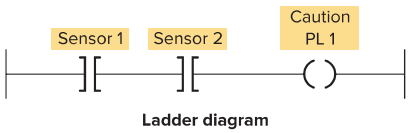
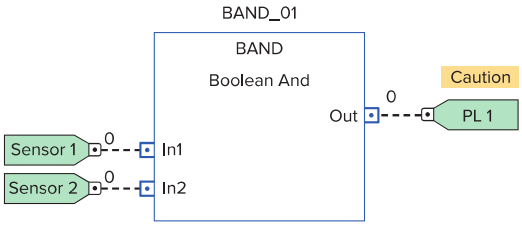
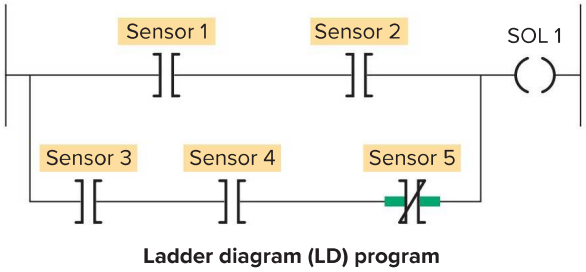


Ladder diagram



T1643 Function block diagram

PLC ladder and equivalent function block diagram.



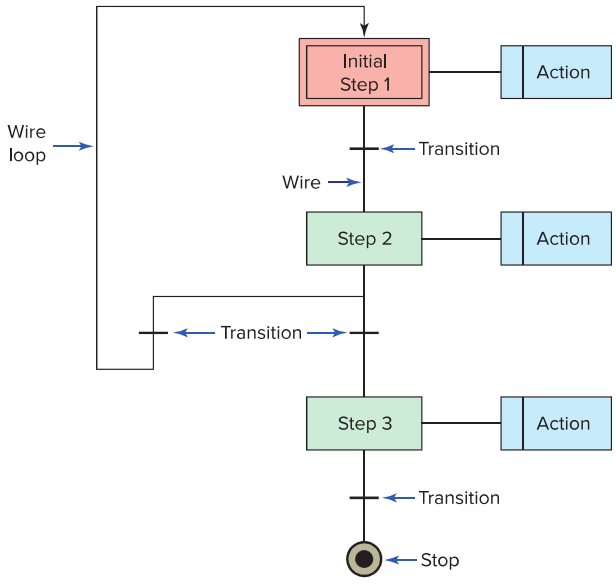
Ladder diagram (LD) program

```
IF Sensor_1 AND Sensor_2 THEN
        SOL_1 := 1;
ELSEIF Sensor_3 AND Sensor_4 AND NOT Sensor_5 THEN
        SOL_1 := 1;
END_IF;
```

T1644 Structured text (ST) program

PLC ladder and equivalent structured text program.

Sequential function chart programming language is similar to process flowchart. SFC programming is designed to program more advanced processes. Program can be split into steps with multiple operations happening in parallel branches.



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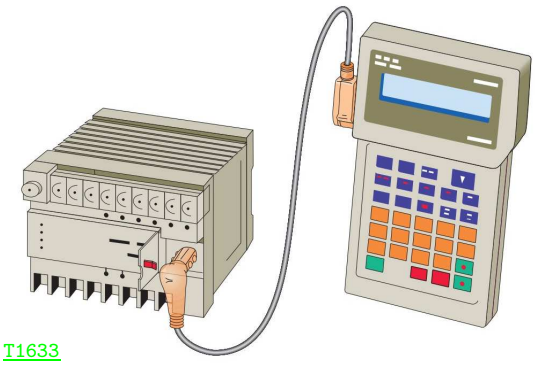
Major elements of a sequential function chart program.

Programming Devices

Programming a PLC involves 3 categories:

1. Handheld Programmers - are small inexpensive devices. These typically have membrane keys for entering data and LCD displays to show one line of a ladder program.
2. Dedicated Terminals - are designed for one particular brand of PLC. These provides troubleshooting operation while the PLC is running.
3. Micro-Computers / PCs - are widely used to program and simulate the program. Tested programs are downloaded to the PLC using serial communications.



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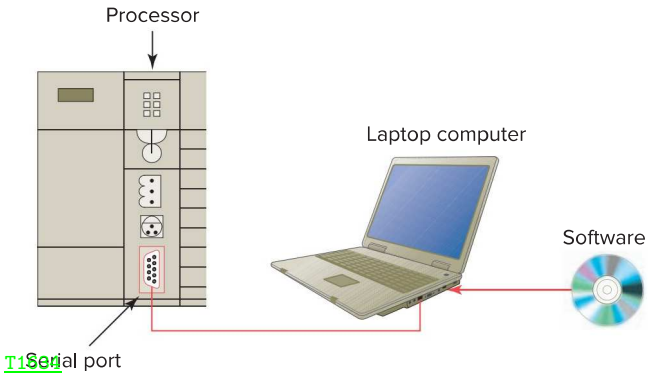
Hand-held programming terminal.



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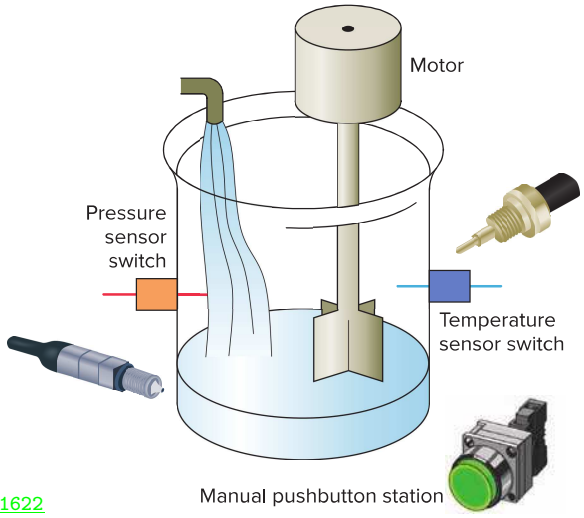
Computer used as the programming device.

Example: A Mixing Process

A mixer motor is to be used to stir the liquid in a vat when temperature and pressure reach pre-set values. Direct manual operation of the motor is provided by means of a separate push-button.



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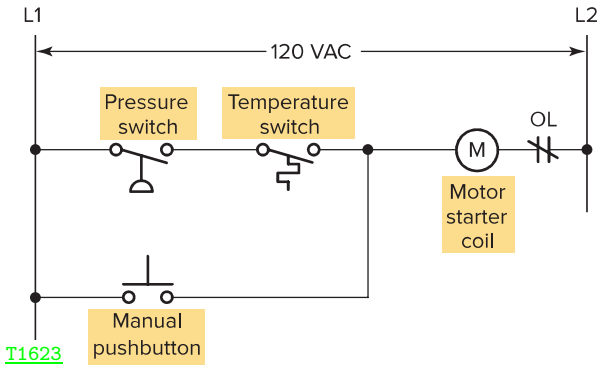

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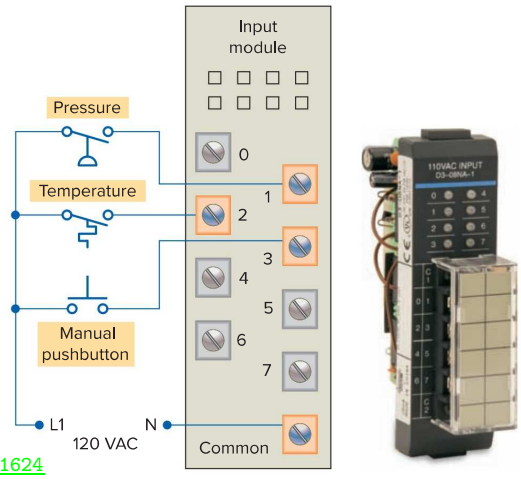

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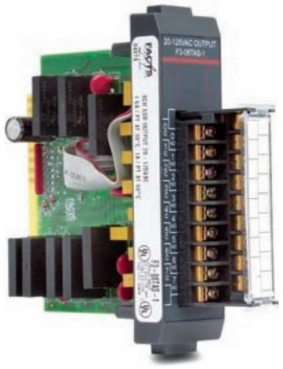
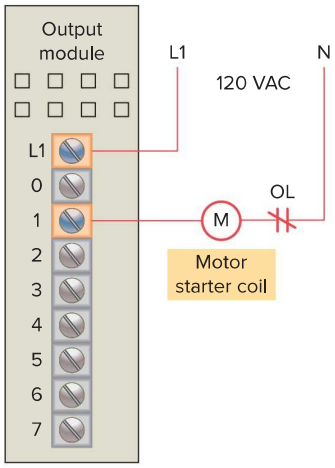
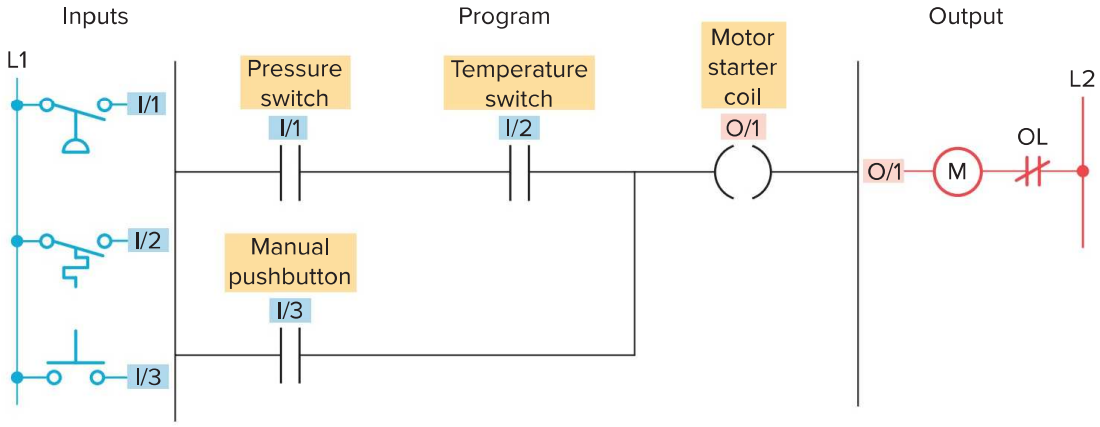


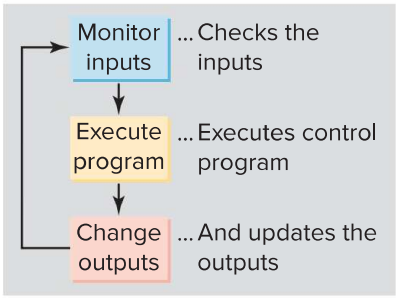


T1625

Configured input module

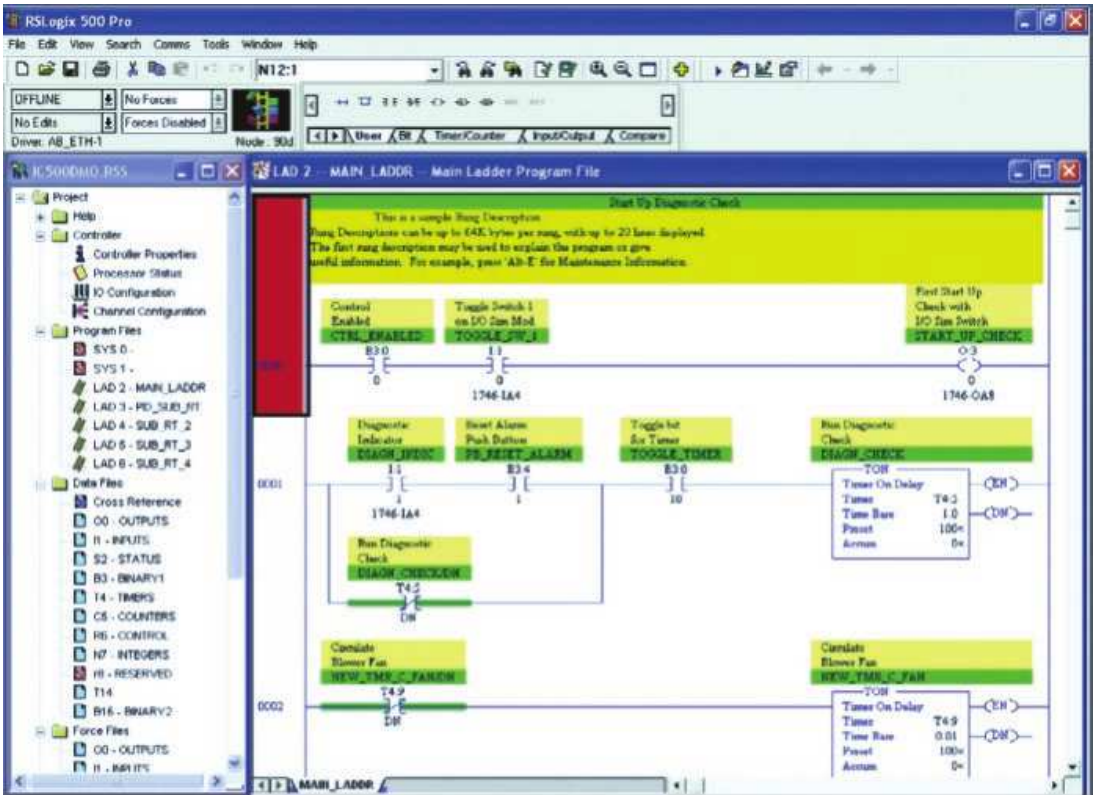
Configured output module





T1626

Process control PLC ladder logic program with typical addressing scheme



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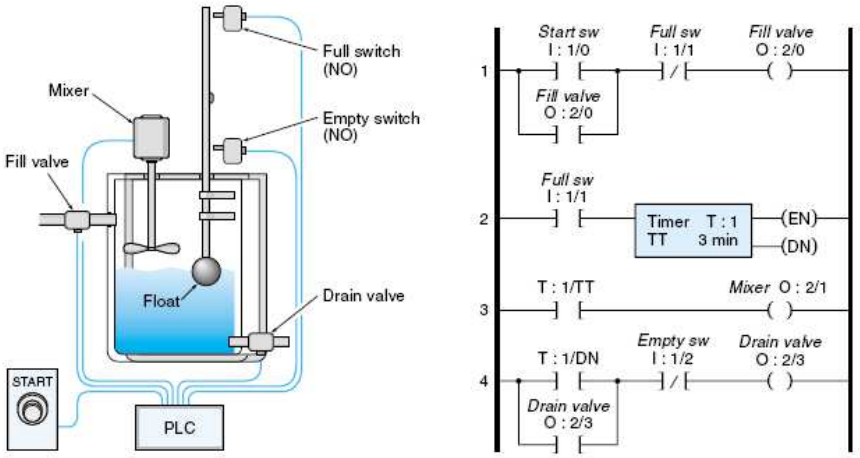
Typical PC software used to create a ladder logic program

Example: Batch Process using Timer

A batch process – filling a container with a liquid, mixing the liquid, and draining the container – is automated with a PLC. Steps:

1. a valve opens and lets the liquid into the container until it is full.
2. liquid in the container is mixed for 3 minutes.
3. a drain valve opens and drains the tank.



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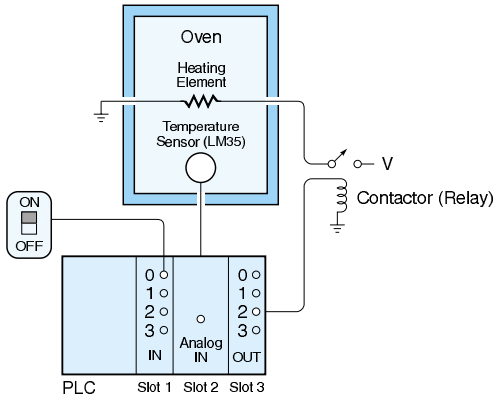
Example: 2-point Controller in Oven at 100°C



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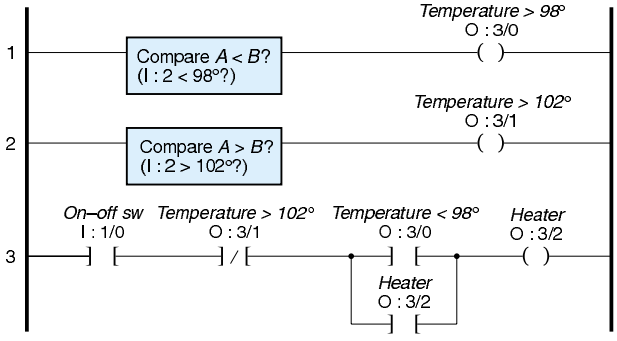

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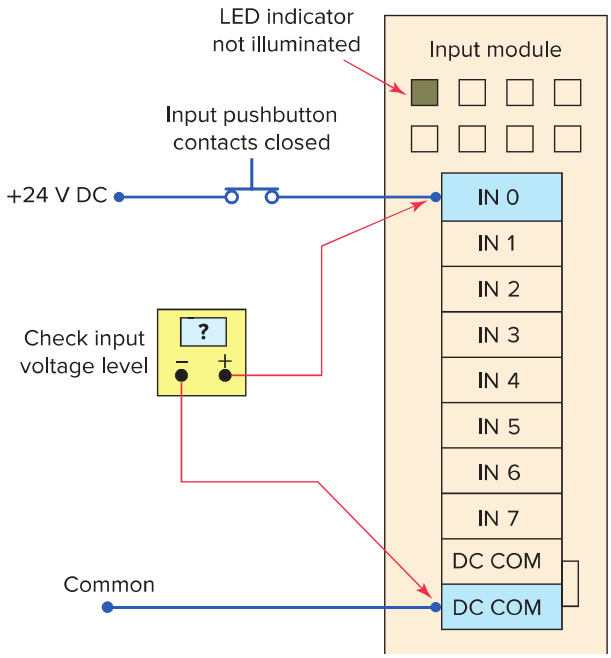
Input Trouble-shooting



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Checking for input malfunctions.

Input device troubleshooting guide

Input device condition	Input module status indicator	Monitor display status indicator		Possible fault(s)
				
 Closed — ON 24 V DC input	ON	True 	False 	None - correct indications
 Open — OFF 0 V DC input	OFF	False 	True 	None - correct indications
 Closed — ON 24 V DC input	ON	False 	True 	Sensor condition, input voltage, status indicator are correct. Ladder instructions have incorrect indications. Input module or processor fault.
 Closed — ON 0 V DC input	OFF	False 	True 	Status indicator and instructions agree but not with the sensor condition. Open field device or wiring.
 Open — OFF 0 V DC input	OFF	True 	False 	Sensor condition, input voltage, status indicator are correct. Ladder instructions have incorrect indications. Input module or processor fault.
 Open — OFF 24 V DC input	ON	True 	False 	Input voltage, status indicator, and ladder instructions agree but not with sensor condition. Short circuit in the field device or wiring.

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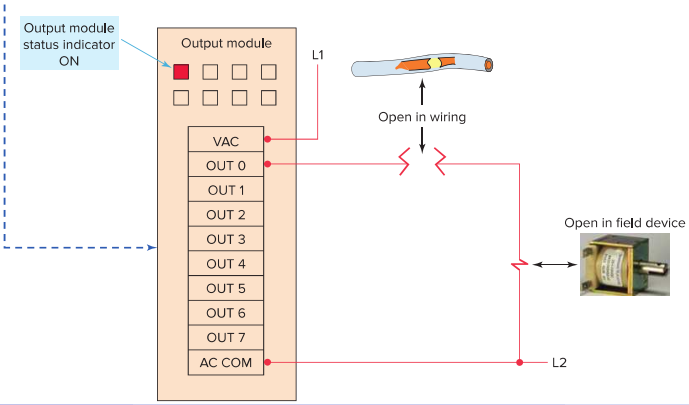
Output Trouble-shooting

Output device troubleshooting guide			
Output device condition	Output module status indicator	Monitor display status indicator	Fault(s)
Energized — ON	ON	True	None - correct indication
De-energized — OFF	OFF	False	None - correct indication
De-energized — OFF	ON	True	Output instruction and status indicator agree but the field device does not. Open field device or wiring. Module circuit or fuse.
De-energized — OFF	OFF	True	Field device status and status indicator agree but the output condition does not. Module circuit or fuse.



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Thanks a Lot!