Programmable Logic Controllers(PLC)

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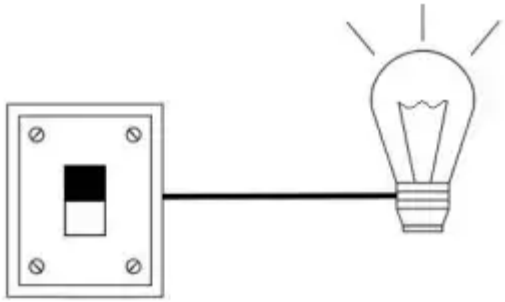
Definition

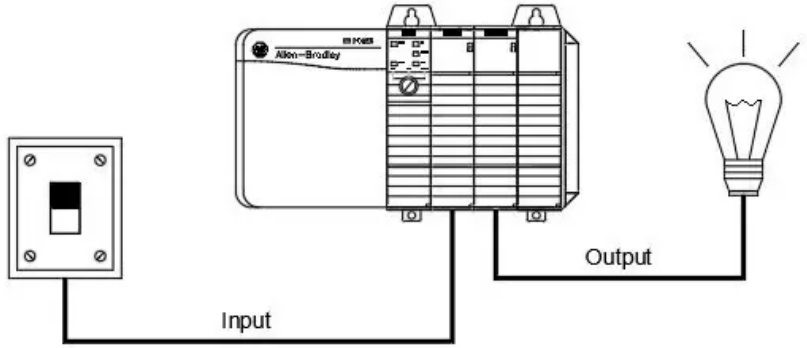
- PLC stands for “Programmable Logic Controller”.
- A PLC is a computer specially designed to operate reliably under harsh industrial environments – such as extreme temperatures and wet, dry, and/or dusty conditions.
- PLCs are used to automate industrial processes such as a manufacturing plant’s assembly line, an ore processing plant, or a wastewater treatment plant.
- PLCs are industrial computers, with various inputs and outputs, used to control and monitor industrial equipment based on custom programming.

PLC Basics

Alight connected to a switch. In general, the light operates under two conditions – ON and OFF. Now you are given a task that when you turn ON the switch, the light should glow only after 30 seconds. With this hard-wired setup – we're stuck. The only way to achieve this is to completely rewire our circuit to add a timing relay. That's a lot of hassle for a minor change.

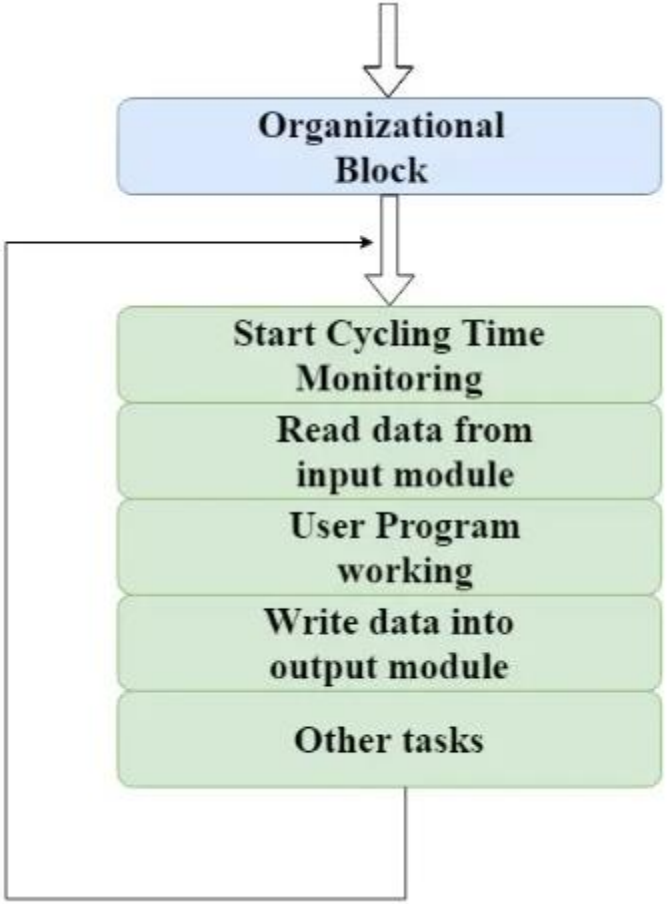


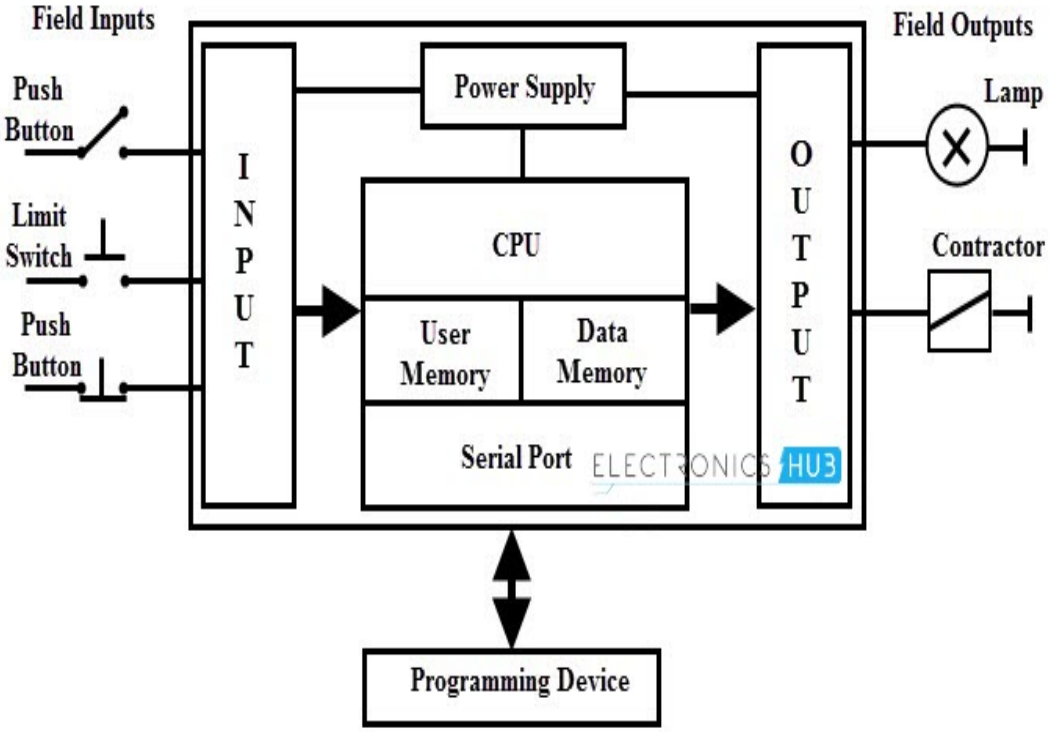
Light Switch



Light operated by a PLC

PLC Works


Organizational Block
Start Cycling Time Monitoring
Read data from input module
User Program working
Write data into output module
Other tasks


Field Inputs
Push Button
Limit Switch
Push Button
INPUT
Power Supply
CPU
User Memory
Data Memory
Serial Port
OUTPUT
Field Outputs
Lamp
Contractor
Programming Device

PLC Structure

Connected to a power supply and consists of:

- A central processing unit (CPU),
- A mounting rack,
- Read-only memory (ROM)
- Random access memory(RAM),
- Input/output (I/O) modules,
- A power supply, and
- A programming device

- **CPU, Processor or Controller**: The operations within the PLC is controlled and processed by a main Central Processing Unit (CPU). It contains arithmetic and logic unit to perform data manipulation and logical operations. The CPU reads the status of the Input Devices and executes the control program in order to control the load.
- **Memory Unit**: It stores the instructions needed to run the program, the data to be processed from input sensors and the data to be sent for output devices. It consists of ROM as a permanent storage for operating system and other data used by the CPU. RAM is used for storing the user program, status of various input and output devices and history data of various devices.
- **Power Supply Unit**: Power Supply Unit provides the necessary power to the PLC. It converts the mains AC voltage to the low DC voltage as per the requirements needed to power the processor and the other circuits in input, output and communication modules. Most PLC systems work at 230V AC or 24V DC.

Input / Output Modules: Input and Output Modules form the physical connections to the field modules to the main controller. I/O modules i.e. sensors and actuators allow the PLC system to interface with the outside world. PLCs typically consists of many number of channels for input and output devices with integrated isolation and signal conditioning circuits so that each sensor and actuator can be connected directly to the PLC without any external circuitry.

I/O Modules can be either fixed i.e. controller and I/O are packed together or modular i.e. I/O can be easily fitted into removable racks. The most commonly used I/O devices include

- Digital input modules
- Digital output modules
- Analog input modules
- Analog output modules
- Special purpose modules

Program and Programming Device: The heart of the PLC is the CPU and we need to program the CPU as per the requirement. Usually, the programming part of the PLC is implemented using a dedicated language and is generally a Graphical Method. The Program for PLC can be designed by the operating engineers without vast knowledge in computers or programming.

The program must be loaded into the memory of the PLC using external programmers and the controller monitors the input and output devices according to this program.

Advantages of PLC

- PLCs are built ruggedly and are used in industries where they must withstand rigorous temperatures, humidity, vibrations and other extreme operating conditions.
- PLCs eliminate the complex hard wiring associated with traditional relay based control systems.
- PLCs are fast and the response time is very less.
- Programmable Logic Controllers or PLCs can have a modular design and plug and play modules.
- The program for PLC can be easily modified and update its functionality that to rewire the relay circuits.
- Also the troubleshooting process for hardware and software modules in easy.

Applications of PLC

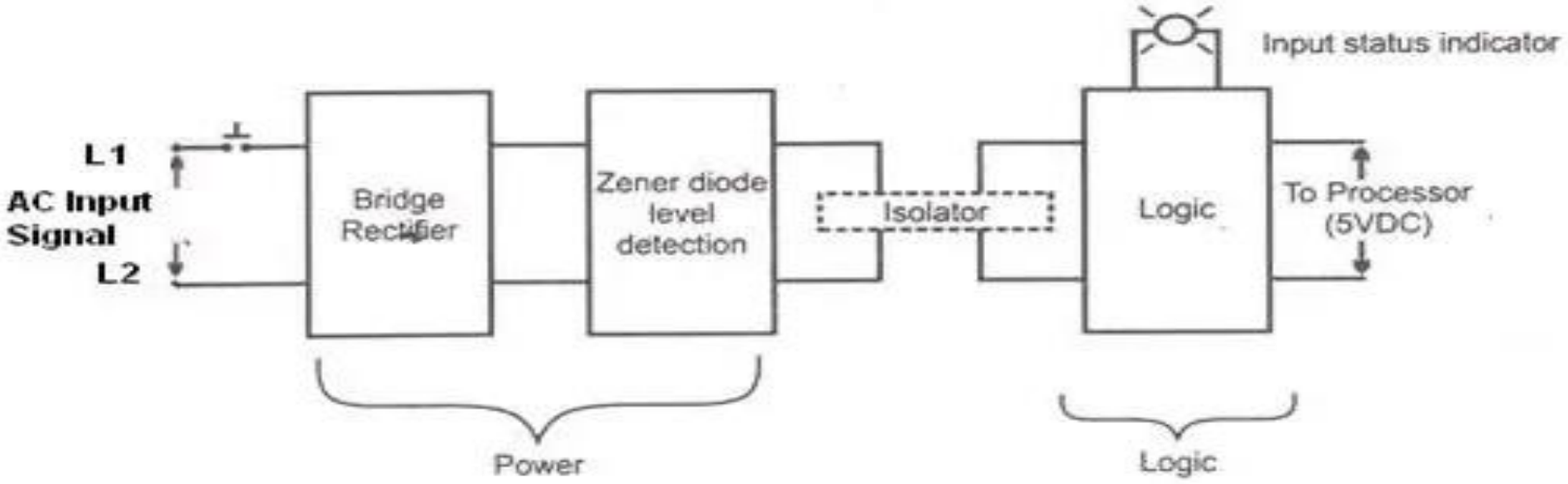
- Programmable Logic Controllers or PLCs are optimized for industrial environment in order to control processes.
- PLCs are used in almost all industries like automotive, chemical, food, metal, power, etc. for different tasks like batch processing, material conveyors, packaging, operating cranes, waste management etc.
- Process Automation Plants (e.g. mining, oil &gas)
- Glass Industry
- Paper Industry
- Cement Manufacturing
- In boilers – Thermal Power Plants

Input / Output Processing

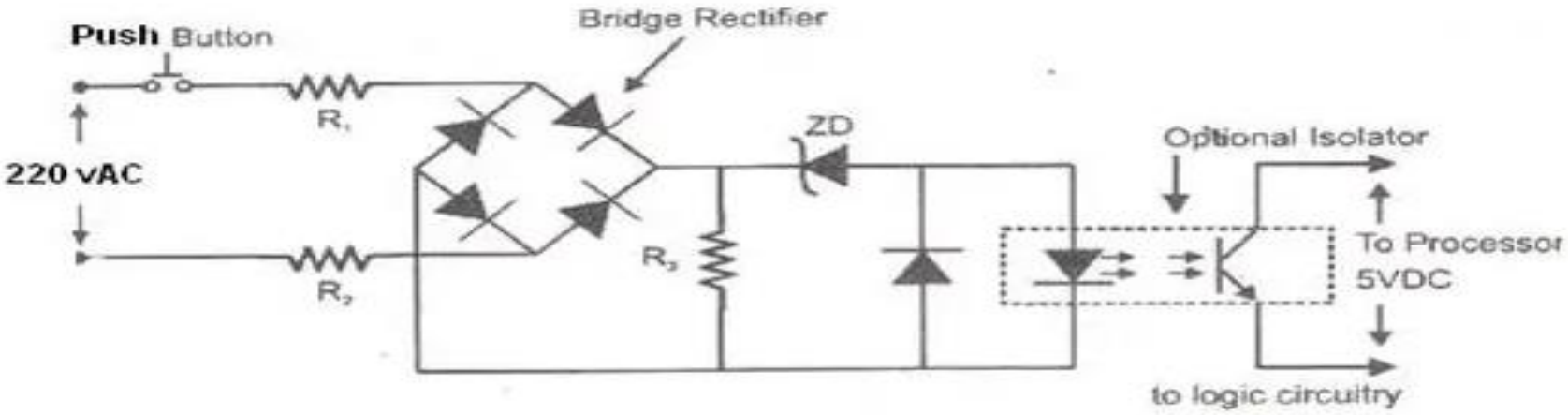
- How to sense physical parameters like temperature, pressure, flow, etc.?

Using PLC

- Because, PLC has an exclusive module for interfacing inputs and output, which is called an input & output module.
- Input devices can be either start and stop pushbuttons, switches, etc. and output devices can be electric heater, valves, relays, etc.
- I/O module helps to interface input and output devices with a microprocessor.
- The input module of PLC is explained as:



PLC Input Module



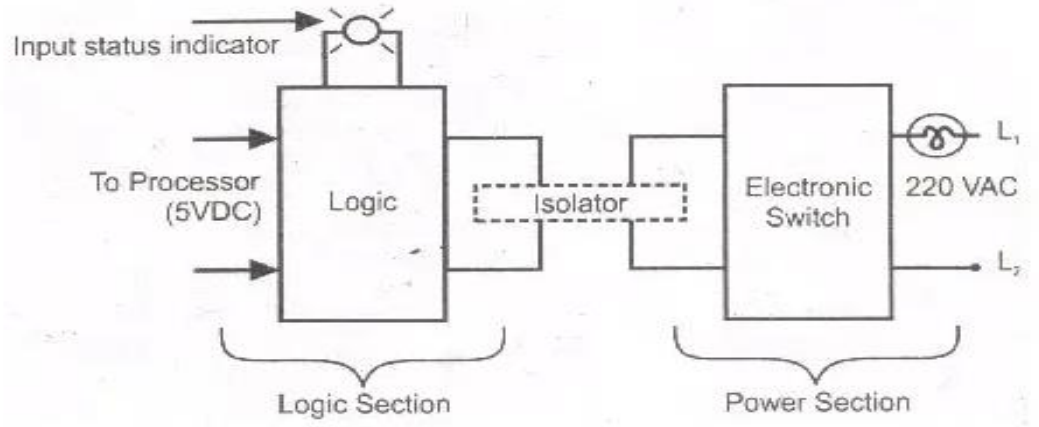
Circuit Diagram of PLC Input Module

The input module of PLC has four **main functions.**

- The input module interface receives the signal from process devices at 220V AC
- Converts the input signal to 5 V DC that can be used by PLC
- Isolator block is used to isolate/prevent PLC from undergoing fluctuation
- After which the signal is sent to the output end i.e the PLC

1. There are two main sections in the input module namely the power section and the logical section.
2. Both sections are electrically isolated from each other. Initially push button is closed.
3. So, 220 V AC supply is given to the bridge circuit through the resistors R1 and R2.
4. A bridge rectifier (such as a diode bridge rectifier) is used to convert the AC signal into DC and Zener diode is used to provide a low voltage supply to LED.
5. When the light from the LED falls on the phototransistor, it works in the conduction region.
6. Finally, a 5V DC supply is given to the processor.

- The output module of PLC works similarly to the input module but in the reverse process. It interfaces the output load and processor. So here the first section would be the logic session and the power section comes next. The working of the output module is shown in the figure below:
- So, here when the program logic high signal is generated from the processor, the LED will turn ON and allow the light to fall on a phototransistor.
- When the transistor goes to the conduction region, it generates a pulse to the gate of the Triac.
- The isolator block is used to isolate the logic section and control section.



PLC Output Module

INPUTS

- Switches and Pushbuttons
- Sensing Devices
  - Limit Switches
  - Photoelectric Sensors
  - Proximity Sensors

- Condition Sensors
- Encoders
  - Pressure Switches
  - Level Switches
  - Temperature Switches
  - Vacuum Switches
  - Float Switches

OUTPUTS

- Valves
- Motor Starters
- Solenoids
- Actuators

- Horns and Alarms
- Stack lights
- Control Relays
- Counter/Totalizer
- Pumps
- Printers
- Fans

PLC Programming

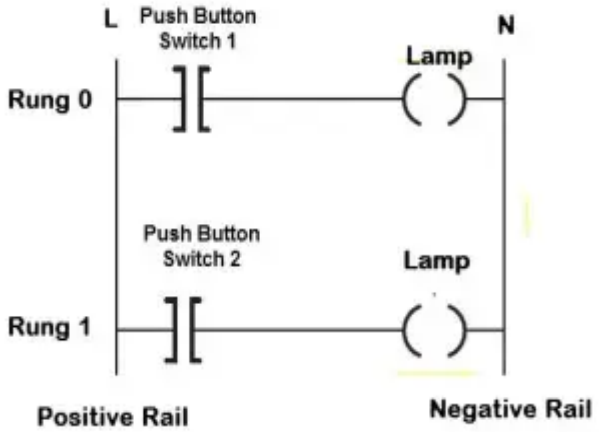
A PLC program consists of a set of instructions either in textual or graphical form, which represents the logic that governs the process the PLC is controlling. There are two main classifications of PLC programming languages, which are further divided into many sub-classified types.

- **Textual Language**
  - Instruction list
  - Structured text
- **Graphical Form**
  - Ladder Diagrams (LD) (i.e. Ladder Logic)
  - Function Block Diagram (FBD)
  - Sequential Function Chart (SFC)

Although all of these PLC programming languages can be used to program a PLC, graphical languages (like ladder logic) are typically preferred to textual languages (like structured text programming).

Ladder Logic

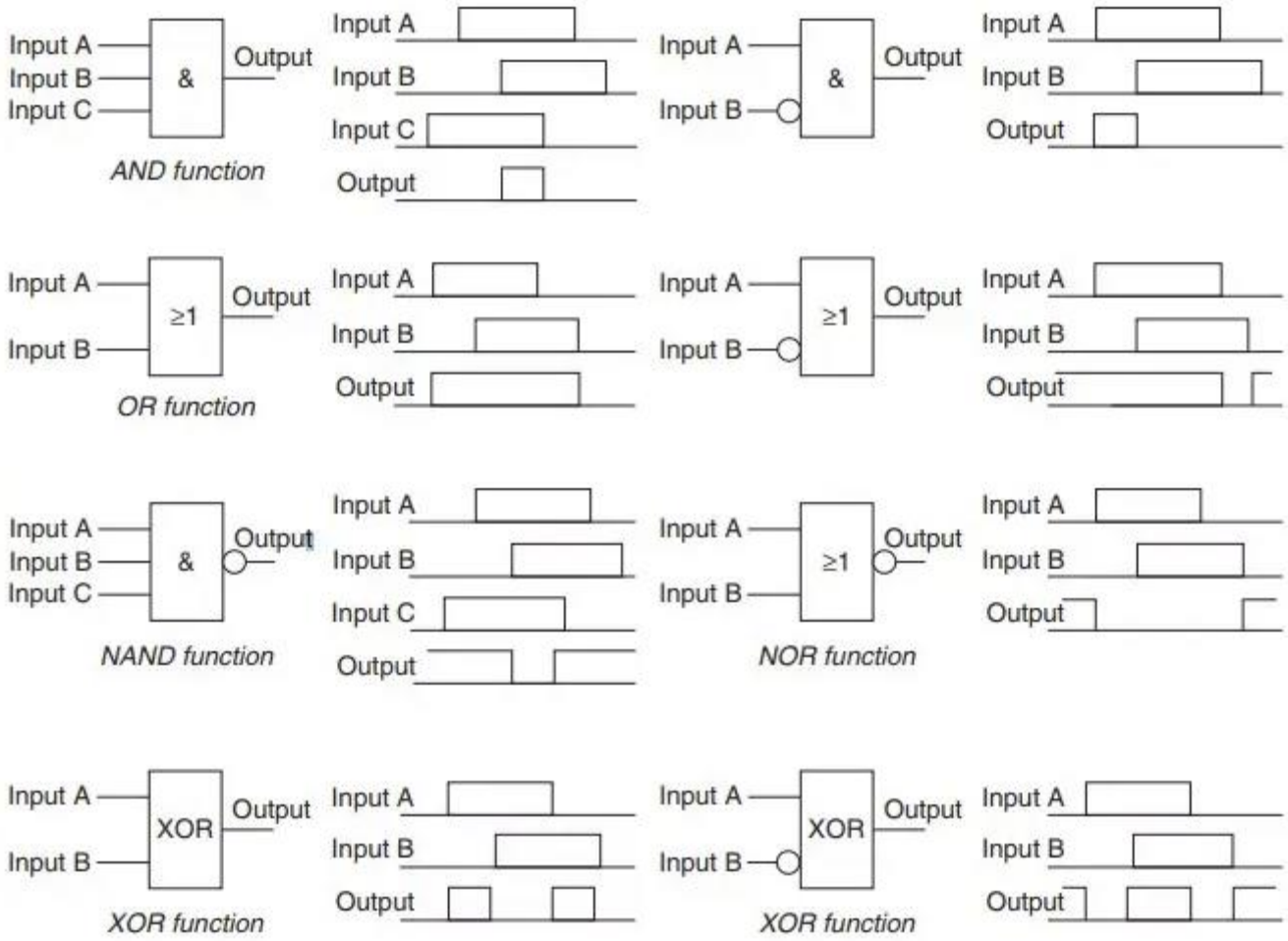
- Ladder logic is the simplest form of PLC programming. It is also known as “relay logic”. The relay contacts used in relay-controlled systems are represented using ladder logic.
- In the above-mentioned example, two pushbuttons are used to control the same lamp load. When any one of the switches is closed, the lamp will glow.
- The two horizontal lines are called rungs and the two vertical lines are called rails. Every rung forms the electrical connectivity between the Positive rail (P) and the Negative rail (N). This allows the current to flow between input and output devices.



PLC Ladder Logic

Functional Block Diagrams

- Functional Block Diagram (FBD) is a simple and graphical method to program multiple functions in PLC.
- A function block is a program instruction unit that, when executed, yields one or more output values.
- It is represented as a rectangular block with inputs entering on the left and output lines leaving on the right.
- It gives a relation between the state of input and output.



Functional Block Programming

Structured Text Programming

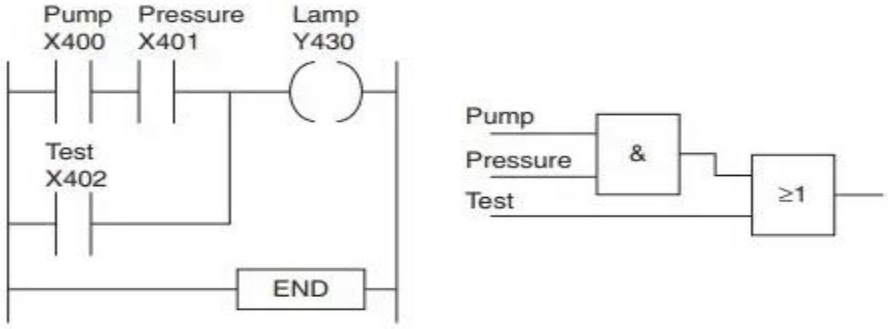
- Structured text is a textual programming language that utilizes statements to determine what to execute. It follows more conventional programming protocols but it is not case sensitive. A series of statements (logic) is constituted of expressing assignments and relationships using several operators. The structure's text operators are listed below in the image.

Order	Operation
1.	( )
2.	function (…)
3.	**
4.	- (negate)
5.	NOT
6.	*, /, MOD
7.	+, - (subtract)
8.	<, <=, >, >=
9.	=, <>
10	&, AND
11.	XOR
12.	OR

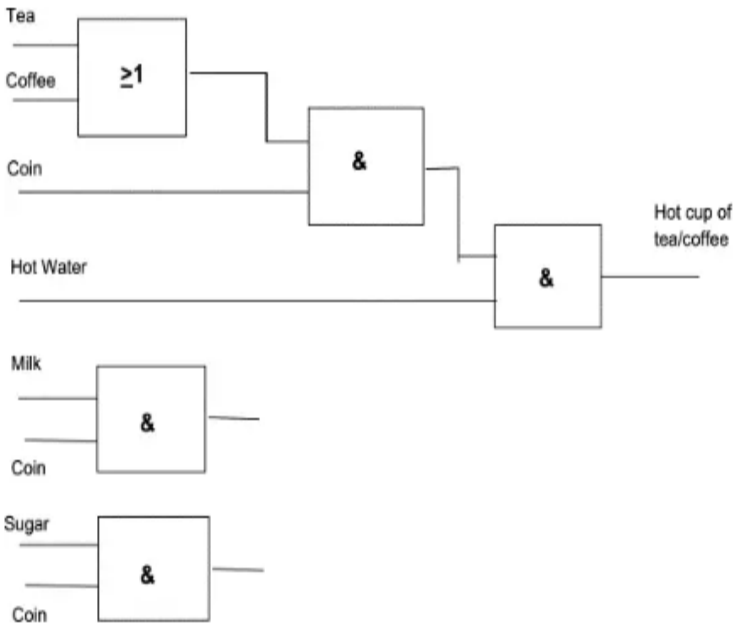
Structured Text Programming

PLC Programming Example

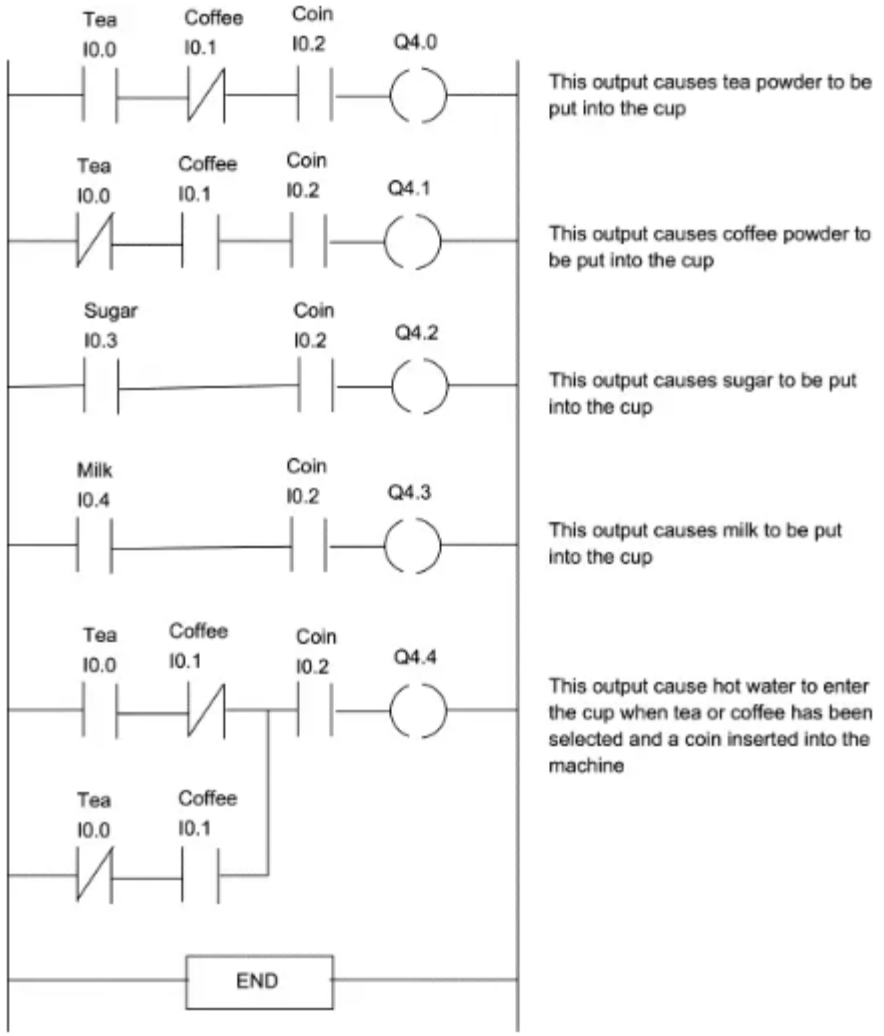
- A signal lamp is required to be switched on if a pump is running and the pressure is satisfactory, or if the lamp test switch is closed. In this application, if there should be an output from the lamp inputs from both the pump and pressure sensors are required. Hence, AND logic gates are used.
- OR logic is used for the test input condition, it is required to give an output of lamp on regardless of whether there is a signal from the AND system. By using END or RET instruction in the ladder diagram, we can tell PLC has reached the end of the program. The function block diagram and the ladder diagram are shown



PLC Program to Test Lamp Glowing



FBD for Drinking Machine



Ladder Logic for Drinking Machine Application

PLC Operations

- There are four basic steps in the operation of all PLCs; Input Scan, Program Scan, Output Scan, and Housekeeping.
- These steps continually take place in a repeating loop.

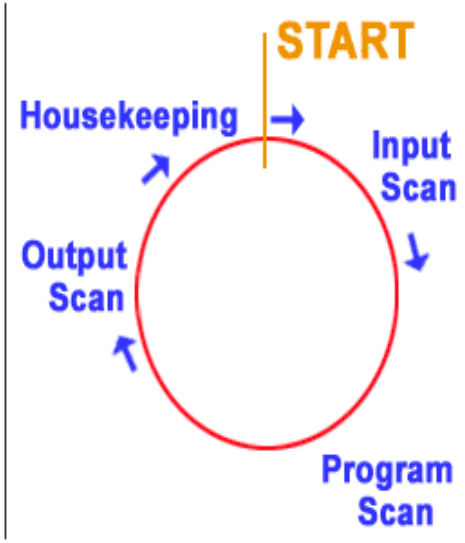
Four Steps In The PLC Operations

1.) Input Scan
- Detects the state of all input devices that are connected to the PLC

2.) Program Scan
- Executes the user created program logic

3.) Output Scan
- Energizes or de-energize all output devices that are connected to the PLC.

4.) Housekeeping
- This step includes communications with programming terminals, internal diagnostics, etc...



These steps are continually processed in a loop.

PLC V/S Microcontroller

- A PLC can handle a large number of processes and cycles so it is best used for industrial applications. Microcontrollers cannot cater to a large number of IOs with complex wiring and communication requirements so best suitable for small-scale applications.
- Signal processing is much more flexible in PLC as compared to a microcontroller. This means, analog to digital conversion, high-speed counter inputs, and outputs are more easily configured in a PLC than in a microcontroller.
- Microcontrollers are cheaper in price than PLC, due to the limited amount of features it provides.
- The main advantage of PLC is its ruggedness and stability. With a very high temperature and environmental stubbornness, it is the best suitable product for critical, risky, and harsh environments.
- PLC can be much better prone to electromagnetic noise and such other types, than a microcontroller.
- Programming is very easier in PLC than in a microcontroller.
- Microcontrollers use complex software like C and C++ for programming, which is much easier in a PLC as it has languages that easily co-relate to an electrical drawing understanding.
- Microcontrollers require knowledge of embedded systems, VLSI, and software to design it, whereas PLC programmers require knowledge of industrial automation, instrumentation, and networking to design it.

Difference Between PC and PLC

- PC is required to run a PLC, a PC does not need a PLC to function. This is because a PLC is run using a microcontroller while a PC runs a microprocessor.
- A PLC uses a scan-based method to execute code while PCs use an event-based method to execute code.
- PLC inputs are signals rather than the data fed into from PC drives.
- Often data from a PLC is collected by a PC and used to trigger work orders, reports, and notifications.
- A PLC's operating system is designed to carry out control tasks and so, unlike with PCs, they do not generally use antivirus or registry cleaning utilities.
- PLCs are programmed using proprietary vendor languages or ladder logic. PCs are programmed using high-level languages like Java or C++.
- PLCs are not immune to cyber security attacks and malware but reported instances are fewer than PCs. The reason for this is that PLCs have limited functionality compared to PCs.
- Small PLC systems are usually cheaper to implement than a similar use case for a PC but large PLC systems required for complex logic operations can be expensive. Being more suited to harsh environmental conditions, PLCs can be cheaper to physically maintain.

Thank You