Programmable Logic Controllers

Fundamentals of PLCs, mnemonics and timers, relays and counters, master and jump control

What is a PLC?

- PLC stands for “Programmable Logic Controller”.
- A PLC is a computer specially designed to operate reliably under harsh industrial environments – such as extreme temperatures, 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 share many features of the personal computer.
- They both have a power supply, a CPU, inputs and outputs (I/O), memory, and operating software.
- The biggest differences are that a PLC can perform discrete and continuous functions that a PC cannot do.
- A PLC is much better suited to rough industrial environments.

PLC

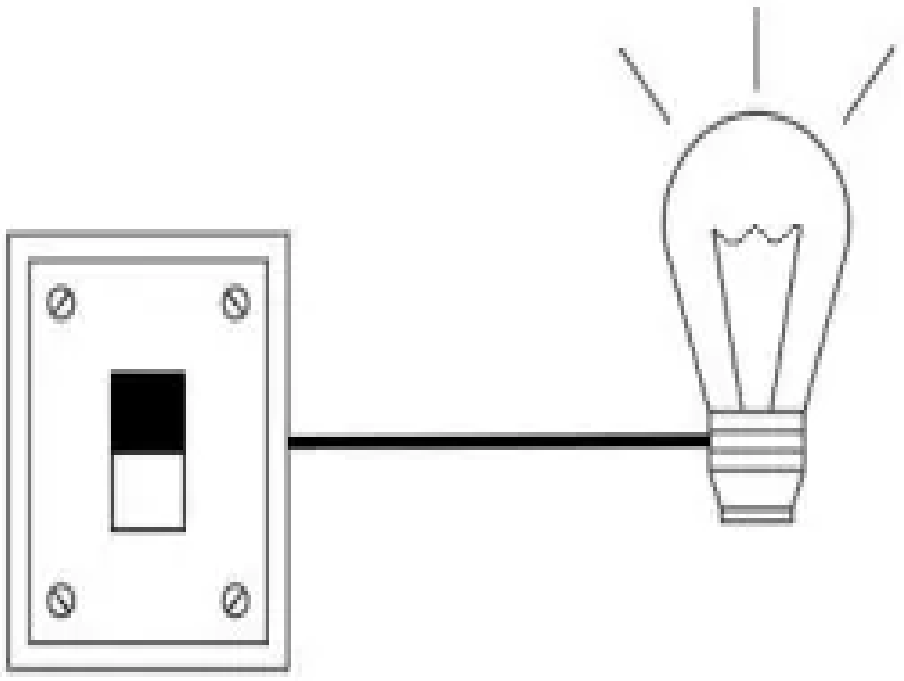
- PLCs play a crucial role in the field of automation, using forming part of a larger SCADA (supervisory control and data acquisition) system.
- SCADA is a category of software applications for controlling industrial processes, which is the gathering of data in real time from remote locations in order to control equipment and conditions.
- A PLC can be programmed according to the operational requirement of the process.
- In the manufacturing industry, there will be a need for reprogramming due to the change in the nature of production.
- To overcome this difficulty, PLC-based control systems were introduced.

History of PLC

- PLCs were invented by Dick Morley in 1964.
- Since then PLC has revolutionized the industrial and manufacturing sectors.
- There is a wide range of PLC functions like timing, counting, calculating, comparing, and processing various analog signals.
- The main advantage of PLC over a "hard-wired" control system is that you can go back and change a PLC after you've programmed it, at little cost.
- In a hard-wired control system, you're essentially having to rip out wires and start from scratch (which is more expensive and takes longer).
- Let's look at an example to better understand this advantage.

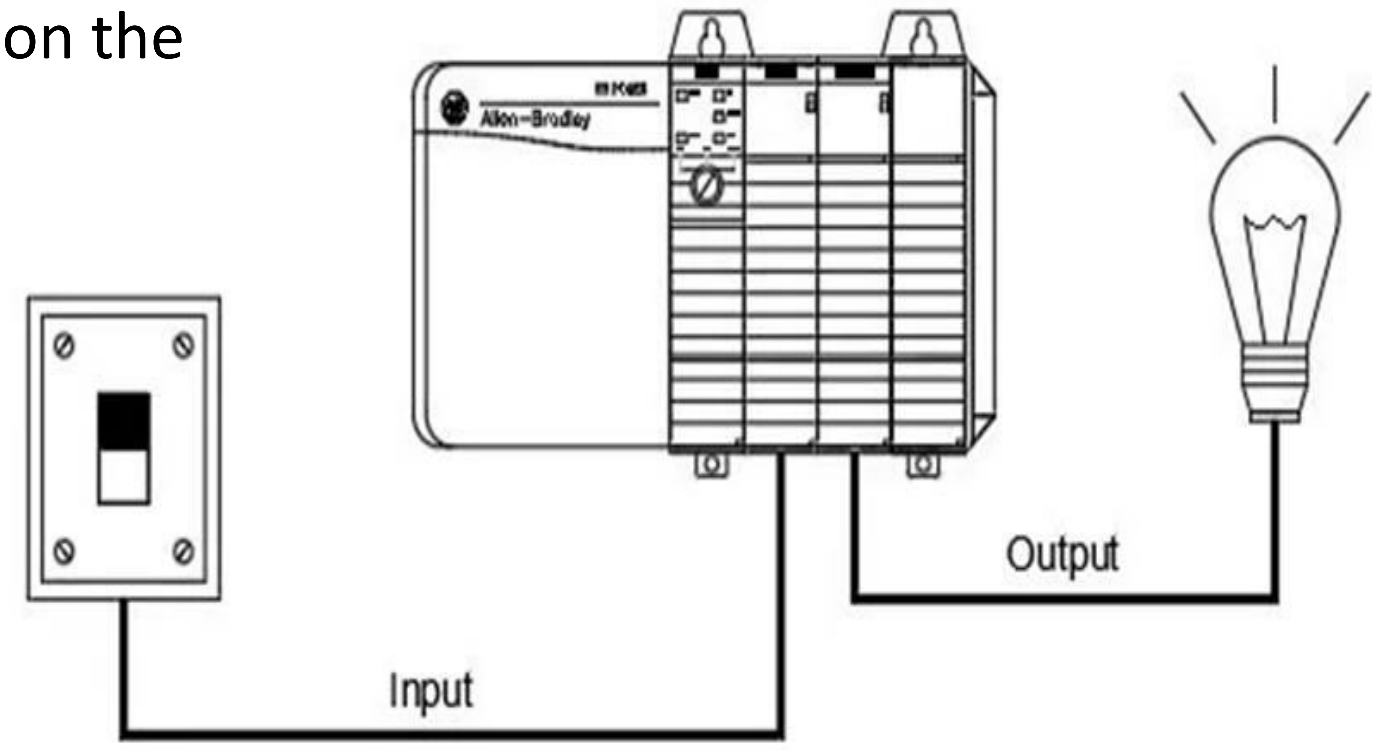
Example

- Imagine you have a light connected to a switch.
- 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.
- This is where a programmable logic controller comes into the picture, which doesn't require any additional wiring and hardware to make sure of a change.



Light Switch

- Rather it requires a simple change in code, programming the PLC to only turn on the light 30 seconds after the switch is turned ON.
- So, by using a PLC, it is easy to incorporate multiple inputs and outputs.
- This is just a simple example – a PLC has the ability to control much larger and more complex processes.
- A PLC can be customized depending on the application and needs of the user.



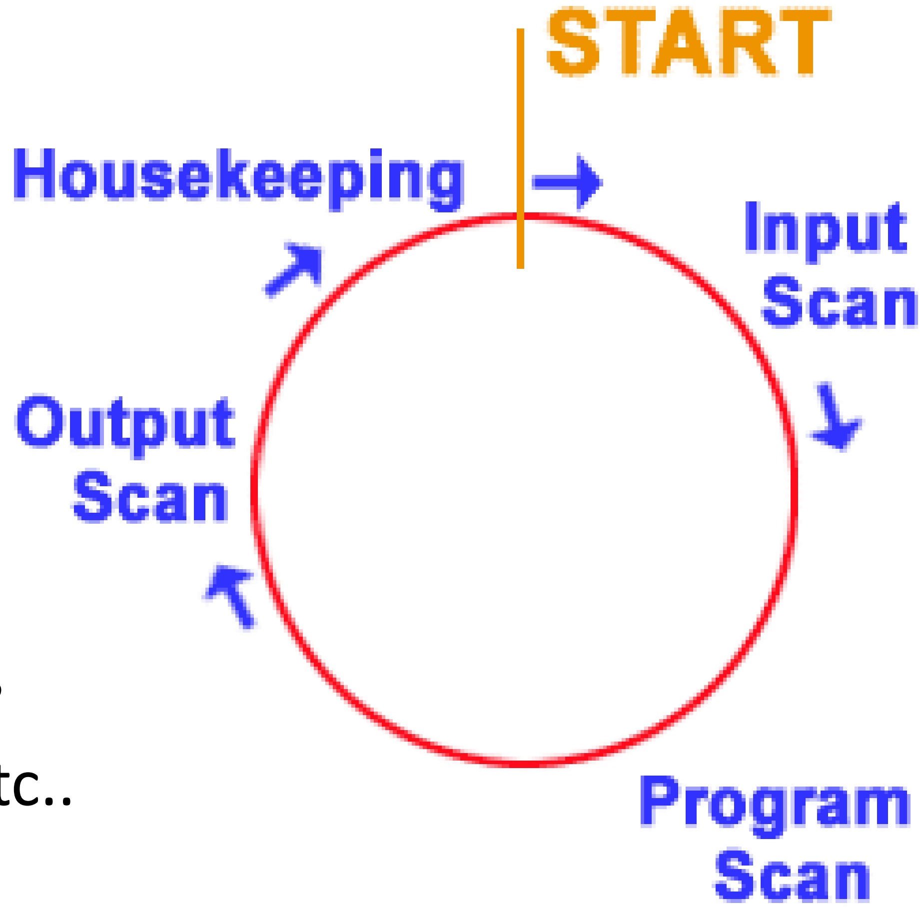
Light operated by a PLC

How does a PLC operate?

There are four basic steps in the operation of all PLCs.

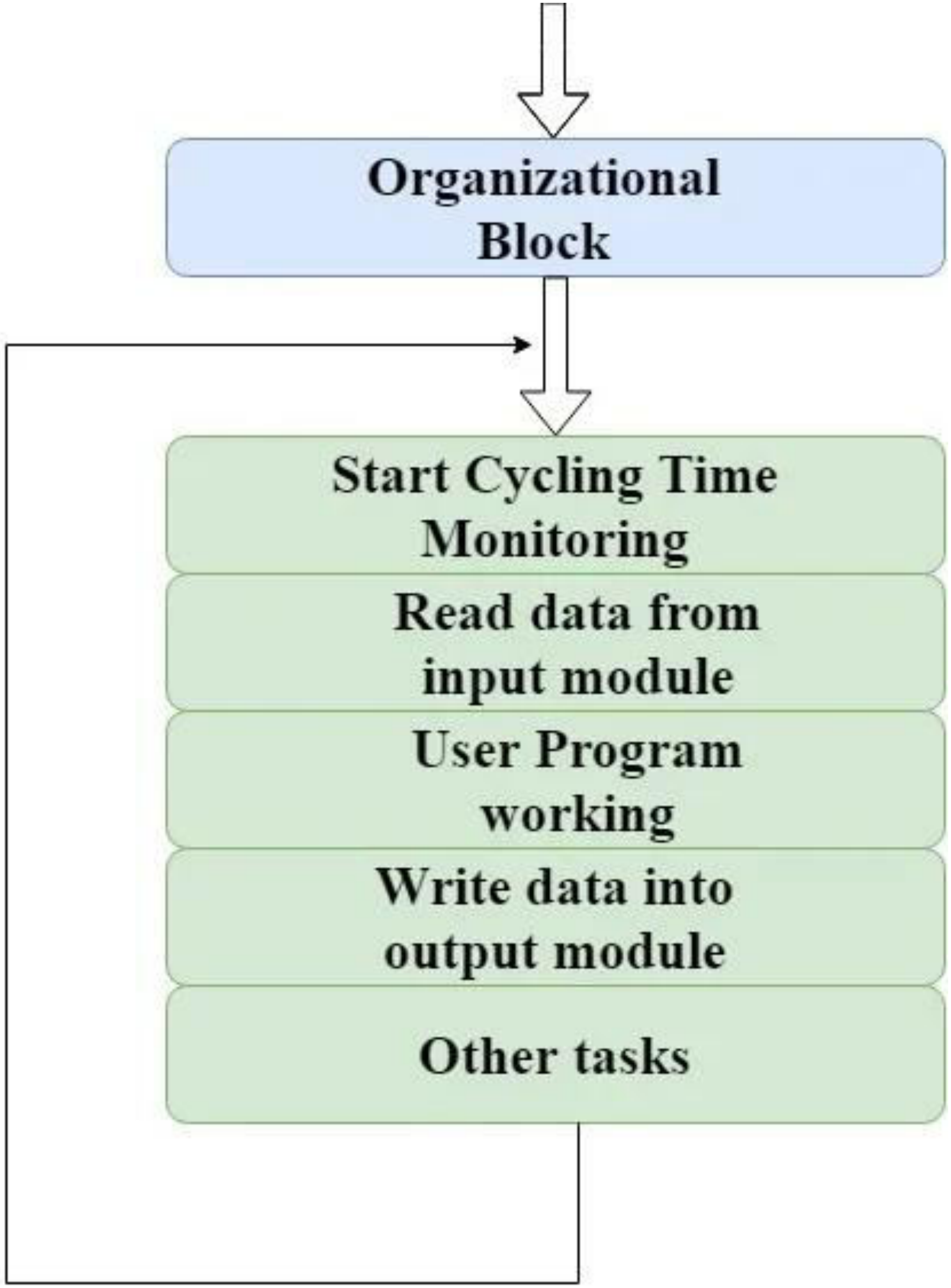
These steps continually take place in a repeating loop:

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..



How Does a PLC work?

The working of a programmable logic controller can be easily understood as a cyclic scanning method known as the scan cycle.



Working Block Diagram of a PLC

A PLC Scan Process includes the following steps

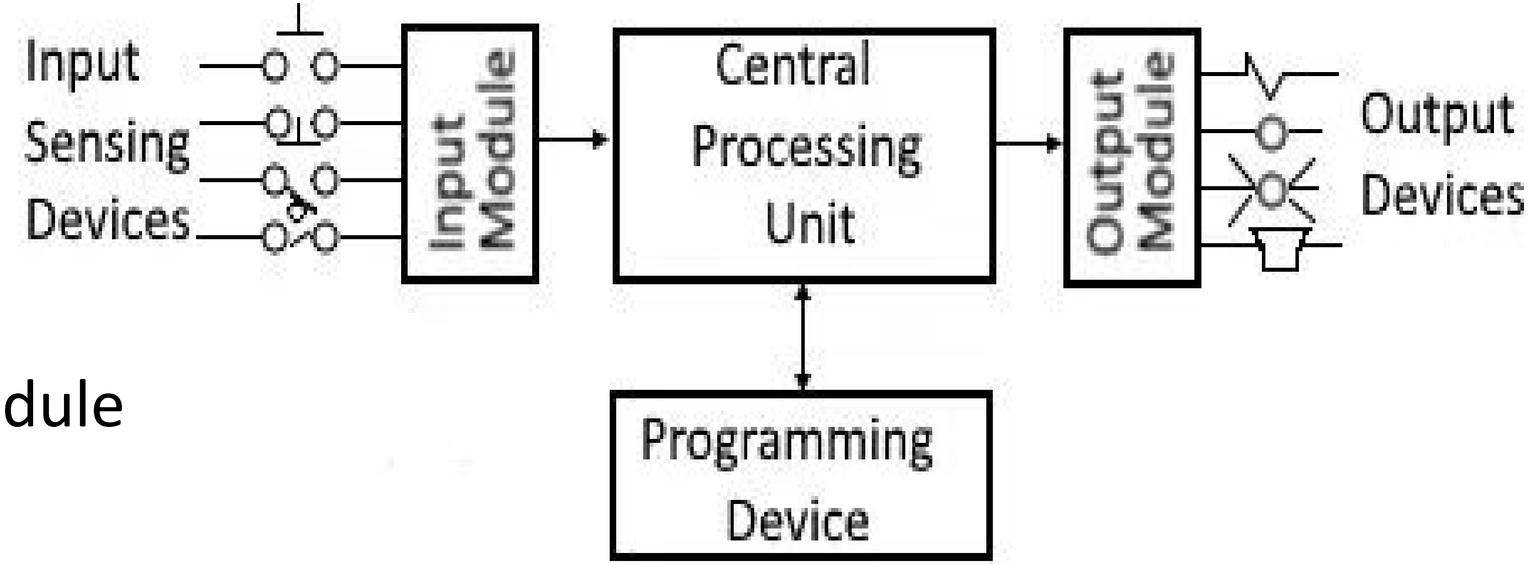
- The operating system starts cycling and monitoring of time.
- The CPU starts reading the data from the input module and checks the status of all the inputs.
- The CPU starts executing the user or application program written by any PLC-programming language.
- Next, the CPU performs all the internal diagnosis and communication tasks.
- According to the program results, it writes the data into the output module so that all outputs are updated.
- This process continues as long as the PLC is in run mode.

Physical Structure of PLC

- The structure of a PLC is almost similar to a computer's architecture.
- PLCs continuously monitors the input values from various input sensing devices (e.g. weight scale, accelerometer, hardwired signals, etc.) and produces corresponding output depending on the nature of production and industry.

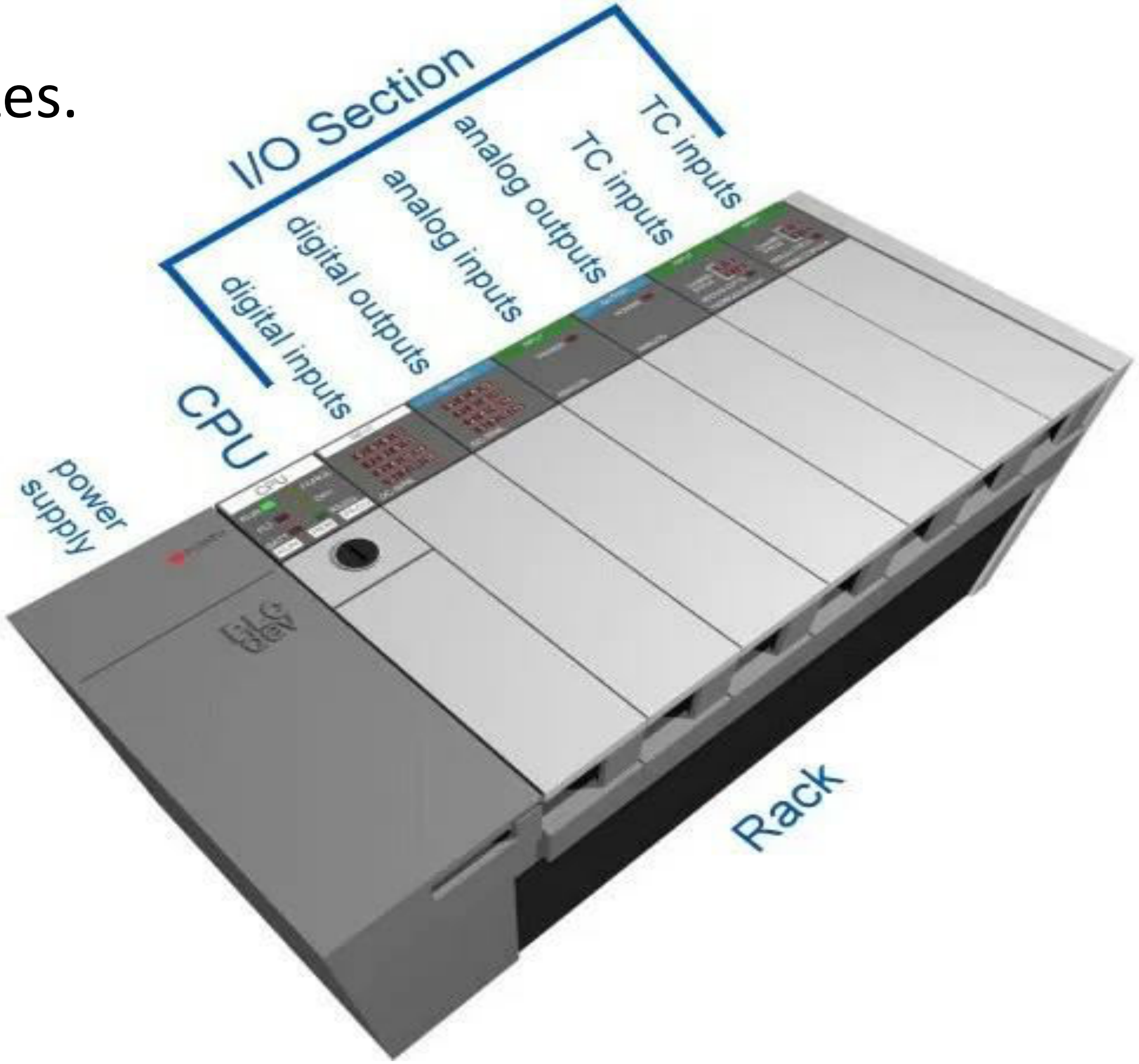
A typical block diagram of PLC consists of five parts namely:

- Rack or chassis
- Power Supply Module
- CPU
- I/O Module
- Communication Interface Module



Rack or Chassis

- In all PLC systems, the PLC rack or chassis forms the most important module and acts as a backbone to the system.
- PLCs are available in different shapes and sizes.
- When more complex control systems are involved, it requires larger PLC racks.
- All I/O modules will be residing inside this rack/chassis.



Power Supply Module

- This module is used to provide the required power to the whole PLC system.
- It converts the available AC power to DC which is required by CPU and I/O module.
- PLC generally works on a 24V DC supply.
- Few PLC uses an isolated power supply.

Communication Interface Module

- To transfer information between CPU and communication networks, intelligent I/O modules are used.
- These communication modules help to connect with other PLCs and computers which are placed at a remote location.

CPU Module and Memory

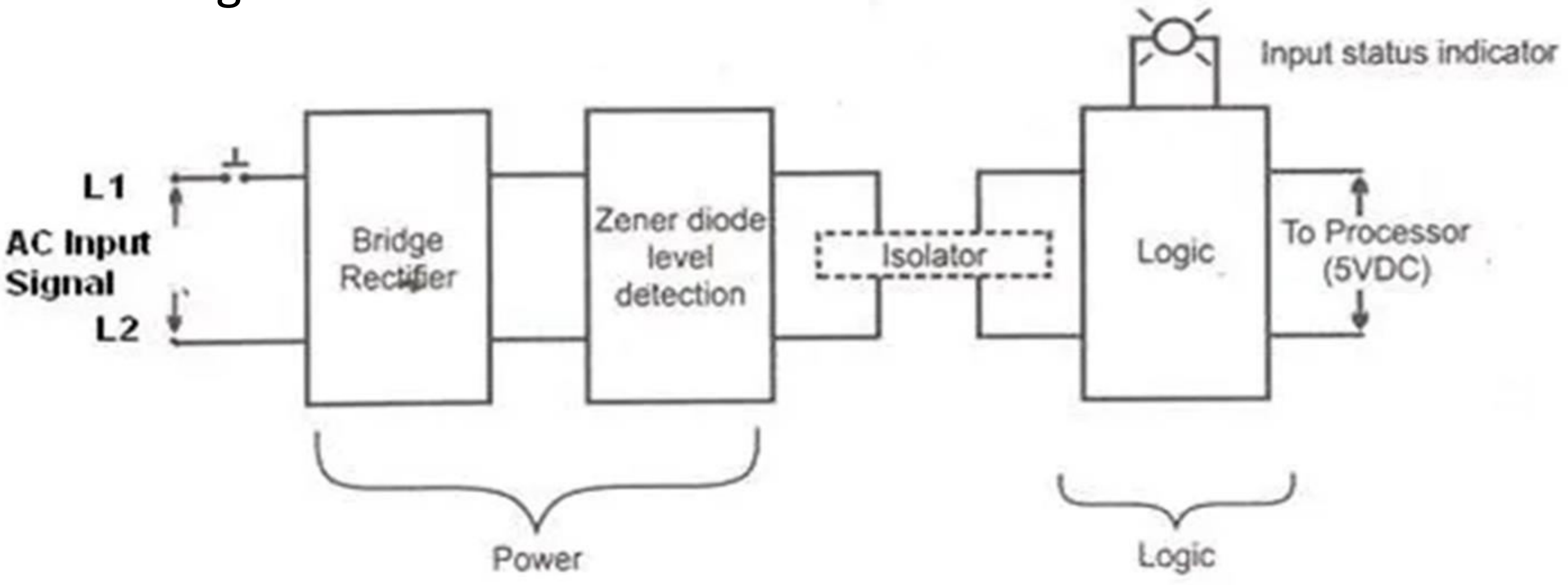
- CPU module has a central processor, DC power source ROM & RAM.
- CPU reads the input data from sensors, processes it, and finally sends the command to controlling devices.
- CPU also contains other electrical parts to connect cables used by other units.

Input and Output Module

- PLC has an exclusive module for interfacing inputs and output.
- Input devices can be either start and stop pushbuttons, switches, etc and output devices can be an electric heater, valves, relays, etc.

PLC Input Module

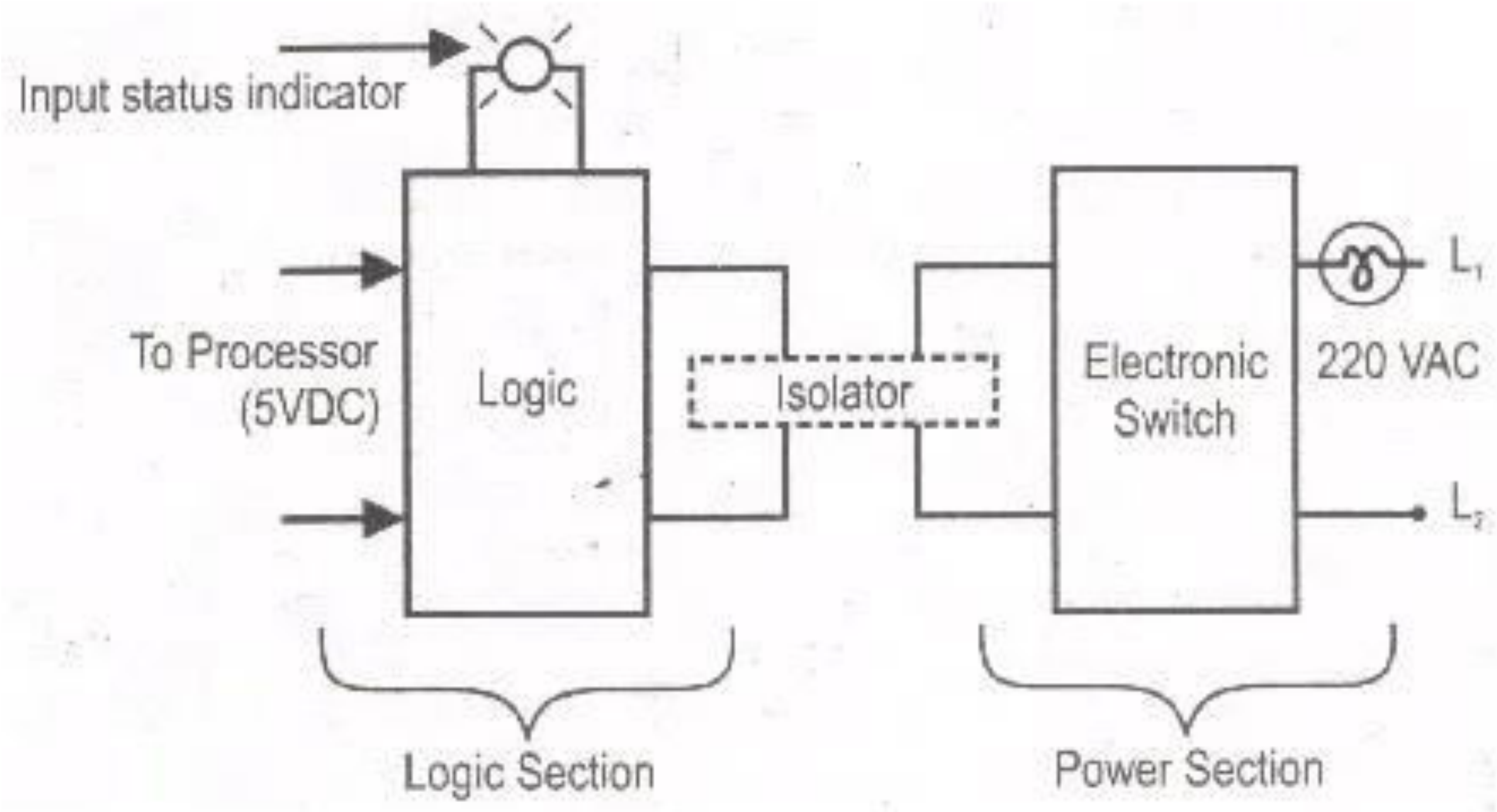
- The input module of PLC has power section and logic section.
- Input module interface receives the signal from process devices at 220 V AC and converts the input signal to 5 V DC that can be used by PLC.
- Isolator block is used to isolate/prevent PLC from undergoing fluctuation.
- After that the signal is sent to the PLC.



The output module

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

PLC Output Module



Types of PLCs

Compact PLC

- Within a single case, there would be many modules.
- It has a fixed number of I/O modules and external I/O cards.
- So, it does not have the capability to expand the modules.

Modular PLC

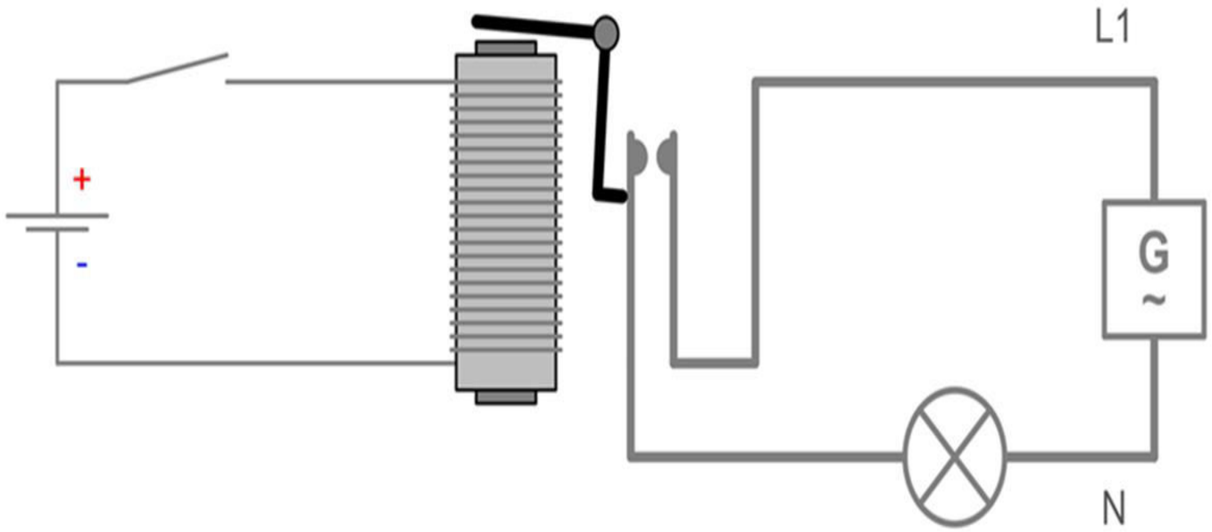
- This type of PLC permits multiple expansion through "modules", referred to as Modular PLC.
- I/O components can be increased.
- It is easier to use because each component is independent of each other.

Type of PLC according to Output

- There are three types: **Relay type PLC, Transistor output PLC, Triac output PLC.**
- However, the type of load must be considered first before you choose the type of output that the PLC should have.

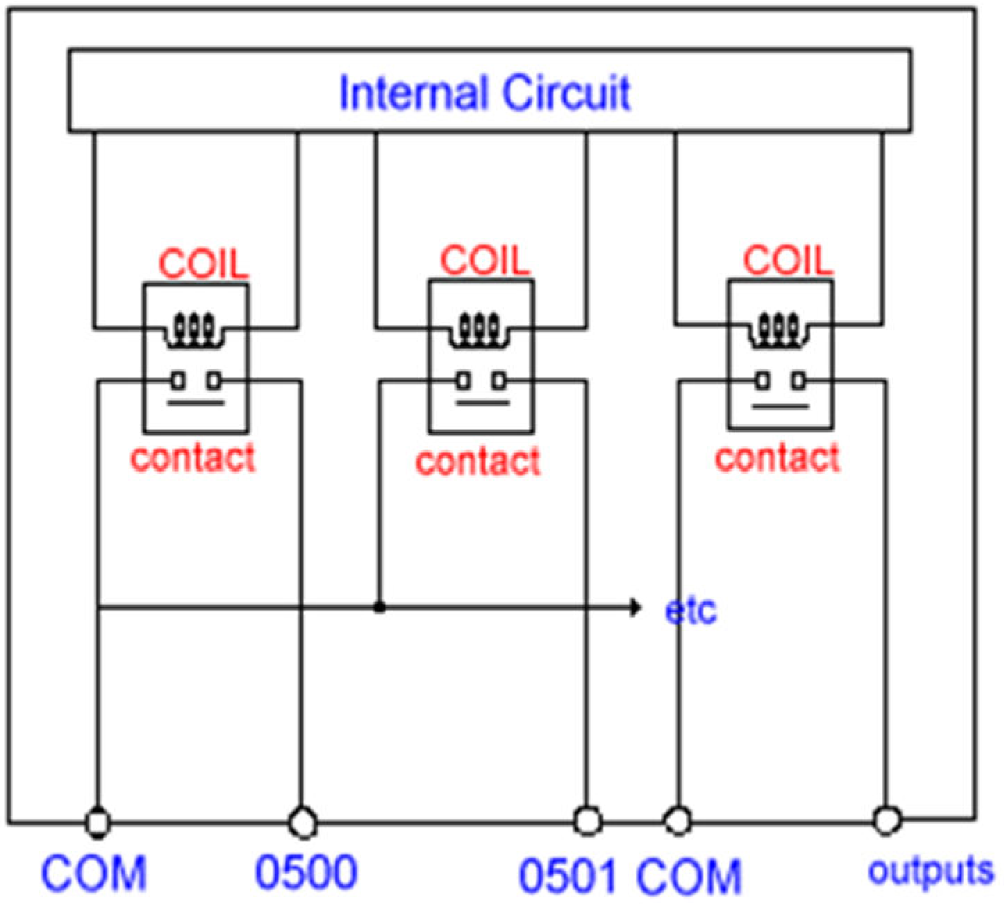
Relay

- A relay is an electrically operated switch.
- Relays are used where it is necessary to control a circuit by an independent low-power signal, or where several circuits must be controlled by one signal.
- Relay outputs are suitable for both AC and DC output devices.



Relay type PLC

- It's basically a Relay as an output, and the PLC controls the switching of the relay by running current through its coils.
- The coil creates a magnetic field which attracts the metallic contacts of the relay.
- Relay type output is more suitable in infrequent switching operations e.g. activating a continuous-running device (a motor.)

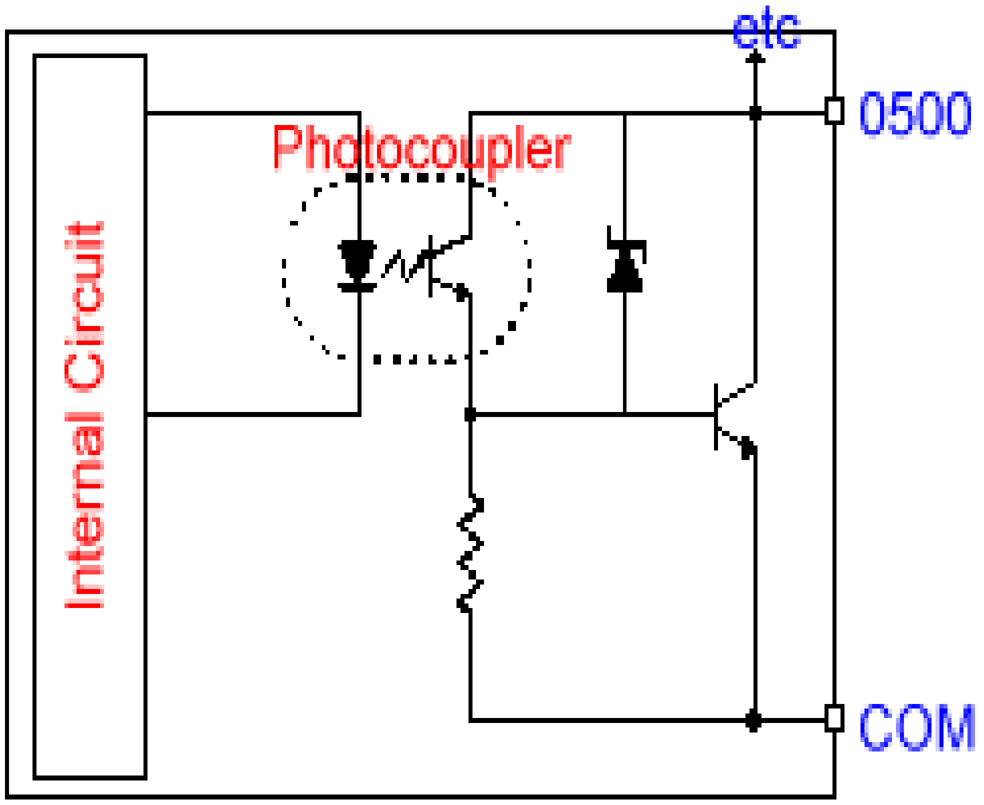


Transistor output PLC

- Transistors are used for switching operations and are used inside microprocessors.
- Faster switching is achieved using this type of output.
- Only DC outputs may be handled by it.

Triac Output PLC

- The triac is also a solid-state device that is an equivalent of two “mirrored” BJT .
- Here current can now flow in two directions.
- So, this type of output can control AC devices.



Types of PLC according to Size

larger PLCs

- Larger PLCs usually have above 512 I/O points.
- These are usually designed to handle a higher number of devices

Mini PLC

- Mini PLCs usually have 128 to 512 I/O points.
- For small control system, Mini PLCs are ideal to use instead of larger PLCs.

Micro PLC

- Micro PLCs are the ones that have 15 to 128 I/O points.
- They are used in very small automation or control systems like amusement rides.

Pico/Nano PLC

- Pico PLCs have less than 15 I/O points.
- Usually, they are seen in PLC trainer systems.

PLC Applications

- PLCs are found everywhere in industry like Process Automation Plants (e.g. mining, oil &gas), Glass & Paper Industry, Cement Manufacturing, in Thermal Power Plants.
- Proper PLC system design can provide many years of service for a machine or process and greatly improve efficiency and profitability for the owner.
- PLCs can perform math functions, making calculations based on external signals and/or HMI (human-machine interface) input.
- A good example of PLC use is with VFDs (variable frequency drives).
- PLCs can now be networked to many VFDs via Ethernet/IP or other fieldbus type communications protocols.
- By using the communications protocol, a great deal of wiring can be eliminated.

Good design practices for PLC systems

- Before we apply a PLC to a machine or process, let's look at some design and maintenance practices that are critical to a successful implementation.

1. Safety
2. Good grounding practices
3. Environmental concerns (heat / cold / surges)
4. Design strategy
5. Electrical schematic and PLC logic documentation
6. Programming considerations
7. Human Machine Interfacing usage
8. Maintenance factors (keep free of dust, dirt, and other debris)