Paper presented on

# Initial Face of Automation
# “Programmable Logic Controller”

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# Programmable Logic Controller


## ABSTRACT:

This paper presented on Programmable Logic Controller (PLC) is to give insights on hardware of PLC.
Control engineering has evolved over time. In the past humans were the main methods for controlling a system. More recently electricity has been used for control and early electrical control was based on relays. These relays allow power to be switched on and off without a mechanical switch. It is common to use relays to make simple logical control decisions. The development of low cost computer has brought the most recent revolution, the Programmable Logic Controller (PLC). The advent of the
PLC began in the 1970s, and has become the most common choice for manufacturing controls.
PLCs have been gaining popularity on the factory floor and will probably remain predominant for some time to come.


Programmable logic controllers were first created to serve the automobile industry, and the first programmable logic controller project was developed in 1968 for General Motors to replace hard-wired relay systems with an electronic controller.

The advantages they offer are:

• Cost effective for controlling complex systems.
• Flexible and can be reapplied to control other systems quickly and easily.
• Computational abilities allow more sophisticated control.
• Trouble shooting aids make programming easier and reduce downtime.
• Reliable components make these likely to operate for years before failure.

Earlier automation systems had to use thousands of individual relays and cam timers, but all of the relays and timers within a factory system can often be replaced with a single programmable logic controller. Today, programmable logic controllers deliver a wide range of functionality, including basic relay control, motion control, process control, and complex networking, as well as being used in Distributed Control Systems.

There are several different types of interfaces that are used when people need to interact with the programmable logic controller to configure it or work with it. This may take the form of simple lights or switches or text displays, or for more complex systems, a computer of Web interface on a computer running a Supervisory Control and Data Acquisition (SCADA) system.

Automation of many different processes, such as controlling machines or factory assembly lines, is done through the use of small computers called a programmable logic controller (PLC). This is actually a control device that consists of a programmable microprocessor, and is programmed using a specialized computer language.

Typically, the program is written in a development environment on a personal computer (PC), and then is downloaded onto the programmable logic controller directly through a cable connection. The program is stored in the programmable logic controller in non-volatile memory.

## • What is Automation?

Automation is the act of implementation of the control system, to control industrial machinery and processes, reducing the need for human intervention. Control & Automation generally go hand in hand.

The advantages offered by Automation are:-

1) Increase in productivity
2) Reduction in running cost.
3) Precision in control.
4) Early Fault Notification.
5) Safety in operation for both man & Machine.

Use of PLC is most effective method to provide automation.

## • What is PLC?

A PLC (i.e. Programmable Logic Controller) is a device that was invented to replace the necessary sequential relay circuits for machine control. In the late 1960's PLC's were first introduced.

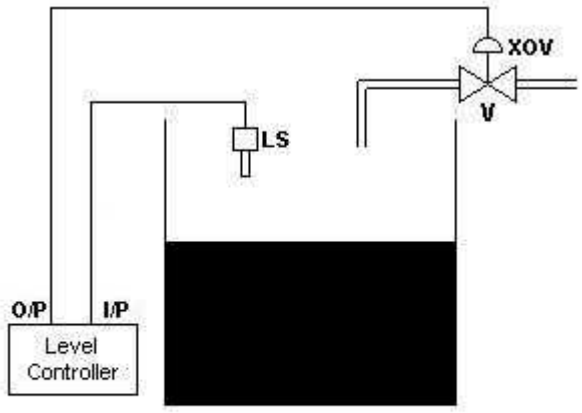
The primary reason for designing such a device was eliminating the large cost involved in replacing the complicated relay based machine control systems.

Bedford Associates (Bedford, MA) proposed - Modular Digital Controller (MODICON). The MODICON 084 brought the world's first PLC into commercial production

PLC is computerized industrial controller that performs discrete or sequential logic in a factory environment. A PLC is currently defined as digital electronic device that uses programmable memory to store instructions & to implement specific functions such as timing, counting, logical, arithmetic operations, to control machine & processes.

## • Automation with PLC

Following is the example of small control system required to control the level of the tank. A level sensor (LS) continuously measures the level of liquid in a tank & sends the signal to the level controller. A controller then sends the signal to control ON/OFF action of valve. This system works on definite logic. When liquid level goes below the predetermined level then valve turns ON, & when liquid level goes above the predetermined level then valve turns OFF.




Level Control Application

In this process PLC is the Controller, which decides controlling action. PLC receives number of inputs from different devices located at different parts of the plants. PLC then decides controlling action on the basis of status of inputs & logic written in its memory. According to

the controlling action the output device operates. As it uses programming logic to control the process, called as Programmable Logic Controller. As PLC takes decisions without interference of man, it is used for automation.

- **Why to use PLC's?**

∗**Cost:** - PLC can scan Digital & Analog Inputs through relevant Scan time. It can execute the Logic with respect to the Scanned Inputs, take necessary decision and send it to Digital / Analog Outputs. It can also perform PID control Functions. The cost of all this is much less than a conventional DATA Logger.

∗**Versatility:** - The ability to combine discrete (Digital) & Analog logic is a powerful tool for the Control Engineers. Control of critical start-up parameters, such as temperature and pressure, can be precisely pre-programmed for each start-up step.

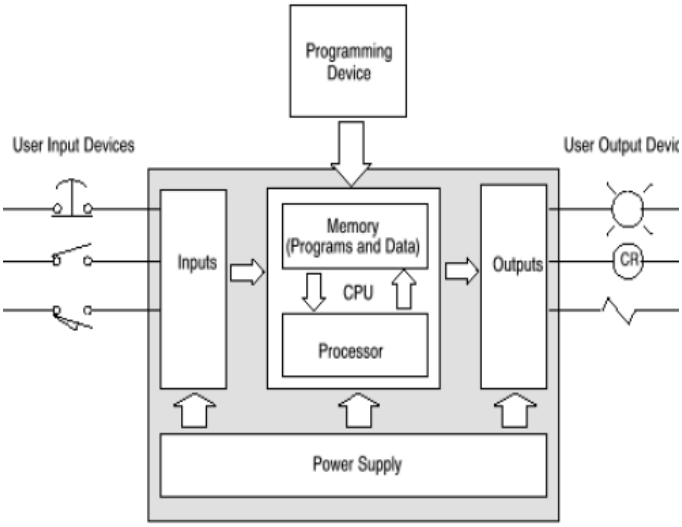
∗**Flexibility:** - As a process goes ONLINE and refined, the control equipment could be easily reconfigured to accommodate such modifications.

∗Bottling Plant Control, Traffic Light Control, Process Control of Temp., Pressure, Level, Flow etc., Car Parking Control etc. are all within the Capabilities of PLC's.

∗As one common device (PLC) performs multiple functions in a Plant with fewer spare parts.

∗ The Digital nature and self-Diagnostic capabilities are strong additional justification for the PLC.

- **Components of PLC**




## ∗ I/O Devices connected to the PLC

**Input Devices:-**

Analog I/P Devices -
•4 to 20 mA / 0 to 5V DC
•12 Bit or better ADC
•32 Bit Storage (For SCADA)
•Thermocouples T/C / RTD's
•Flow Transmitters
•Temperature Transmitters
•Level Transmitters
•Pressure Transmitters
•Strain Gauge

Digital I/P Devices
•Digital Input Field Devices
•Pushbuttons,
•Thumbwheel Switches
•Limit Switches
•Selector Switches
•Proximity Sensors
•Photoelectric Sensors

**Output Devices:-**

Analog Outputs –
•4 to 20mA / 0 to 5V DC –
Can drive signals to variable speed drives etc.,
•Control Temperature, Pressure, Level, Flow, pH, Conductivity etc.

•Discrete Outputs - Relays, Solenoids, Contactors, Motors starters, Annunciator Windows, Pilot Lights etc.

•Register Outputs - Displays, Panel Meters etc.

## ∗ I/O Modules:-

Status of input devices, which is in analog form, is applied to the input module. This section of PLC converts analog status into digital form & transfers to the CPU via bus. After processing the data CPU generates O/P status , which comes in a O/P module, where it gets converted into analog form & then transfer to the O/P devices.

## ∗ CPU:-

CPU is a control element. It is basically divided into processor area & memory area.

**Processor:-** It process the data by executing the instructions stored in memory & generates related o/p data.
**Memory:-** It is library where the programs are stored. Memory is generally divided into two parts data memory & program memory.

**Memory Organization**

The CPU consists of the memory, where programs & data are stored & the processor processes the data & executes the program. In most of the PLC the memory is divided into specific areas. The most common areas are Program area & Data area. In some PLCs these areas are of fixed size. While in some PLCs like Allen Bradley, the size of these areas are not fixed, but depend on the program requirements.

**Program Area: -**
This is where the user enters all his programs, which will be scanned continuously when the PLC is in run mode. The program decides how the outputs of the PLC will behave. Generally most of the PLCs use ladder logic for programming. All these PLCs have built –in software which convert the logic into a code , which is then used by the processor of the CPU to generate an output.

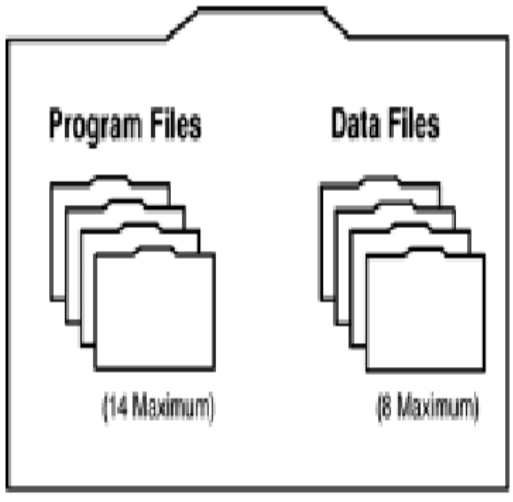
**Data Area:**
The data area in a typical PLC is divided into a number of tables also known as data Tables or Data Files. A typical PLC will have different data files for different data types, the most common being Input data, output data, bit data (also referred to as internal relays or internal contacts), timers, counters, and integer data.
Data files contain the status information associated with external I/O and all other instructions that you use in your main

and subroutine ladder program files. In addition, these files store information concerning processor operation. You can also use the files to store "recipes" and look-up tables if needed.

## ∗ Programming Device: -

Programmer performs ladder logic into Programming Device. Processor files are created in the offline mode using programming device. These files are then downloaded to the processors for on line operations.

Most of the operations perform with the programming device involve the processor file & the two components created with it, program files & data files. The programming device stores processor files on hard disk (or floppy disk). Monitoring and editing of processor files is done in the workspace of the computer. After you select a file from disk and edit it, you then save the file hard to disk, replacing the original disk version with the edited version. The hard disk is the recommended location for a processor file.




Processor File

## ∗Power supply: -

Power supply is necessary to covert power line voltage to those required by each soiled state components.

## • Operating Cycle of PLC

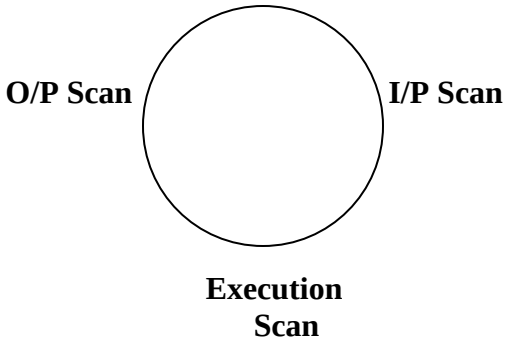
A PLC works by continually scanning a program. PLC scan Cycle consisting of 3 steps.

**1) Input Scan time**
Time required to check input status( ON-OFF) & store in data memory.

**2) Execution Scan time**
Time required by PLC to actually execution of ladder logic. The program is executed sequentially, starting from first rung & proceeding to the last rung.

**3) Output scan time:-**
Time required by PLC to update the output status.

Thus, ***One Scan Time= I/P scan time + Execution scan time + O/P scan time.***




∗Unit of Scan time is Millisecond

∗Typical value of one time Scan is 1 millisecond to 50 millisecond.

*Scan time is defined by the particular manufacturer hence each different PLC has its own fixed Scan time.

*Scan time depends upon the number of input & output channel involved & the length of the ladder diagram.

## • WDT - Watch-Dog-Timer

• In order to insure system predictability a WDT is used to insure that the processor completes each scan in a timely manner.

• WDT is a hardware timer incorporated into the CPU's circuitry that monitors the cyclical process / scan of the CPU.

• WDT is a safeguard that verifies the processor does not become stuck while scanning the user program or for some other reason, become unable to complete the current scan**.**

• The WDT is reset at the end os each Scan Cycle by the CPU when the scan time is less than WDT's preset time.

• In case of one or more sub-routines, Program scan time can exceed WDT time value. In some cases increasing the WDT's preset value can solve the problem.

• Some PLC's have WDT with fixed time intervals, while others are adjustable within specific limits.

• A typical default time of 100 / 200 mS is standard for many PLC's with either fixed or variable WDT Timing Cycles.

## • PLC Programming Languages

* Ladder Diagram Programming
* Function Block Diagram
* Sequential Function Chart
* Statement / Instruction List
* Structured Text

## • PLC Programming Steps

[1] Edit / Write a Ladder Programme

[2] Simulate Programme using Simulator

[3] Change the Programme if necessary

[4] Download the Programme PC to PLC

[5] Execute the Programme in PLC

[6] Change Inputs to see effects on Outputs

[7] Modify the Programme for different field conditions & repeat steps 4,5,6.

## • PLC Applications

* Car parking
* Traffic light control
* Soft drink dispenser
* Washing machine
* Reaction vessel
* Process control
* Tank level control
* Doorbell digital lock
* Microwave oven
* Bottling plant
* Sequential control motors
* Switching of lights
* Mixing of 2 chemicals

## • While Choosing PLC for an Application, following points should be taken into consideration

• Maintenance
• Spare Parts
• Operation
• Modifications
• Losses (Production, Equipment, Personnel)
• Information Technology
• Space & Weight
• Flexibility
• Expandability
• Operability
• Cost of Control & Instrumentation

## • Safety Considerations

∗ The most important safety feature, which is often neglected, is PLC system design. This feature must be included whenever a hardwired device is used in order to ensure operator protection against the unwanted application of power.

∗ Emergency STOP function should be completely hardwired.

∗ Software functions should not be relied upon to shut-off the process or the machine.

## • Temperature Considerations

• Installing any solid state device requires paying attention to –
Ambient Temperature
Radiant Heat Bombardment
And the Heat generated by the Device itself.

• PLC's are typically designed for operation over a broad range of Temperatures, usually from 0 to 60 Deg.C
• For Cooling, blowing filtered air through the enclosure can resolve minor difficulties.

## • Enclosures

• Enclosure of PLC protects PLC's from moisture, Oil, Dust Particles and unwanted tampering.
• Most Manufacturers recommend NEMA 12 Enclosure for the Standard Industrial Environment.
• PLC's are designed to be located close to the machine or the process under control. This keeps the wiring runs short and aids in the trouble-shooting procedure.
• It is not advisable to place a PLC near a Vibrating Machine, Electrical NOISE Interference or Excessive Heat Environment conditions.

## • Soft wired & Hardwired components of PLC

• Soft-wired Components –
Timers
Counters
Logic Circuits
Latches
•Hard-wired Components -
24 V DC Lamps
Relays
Contactors
Solenoid Valves

## • Types of PLC

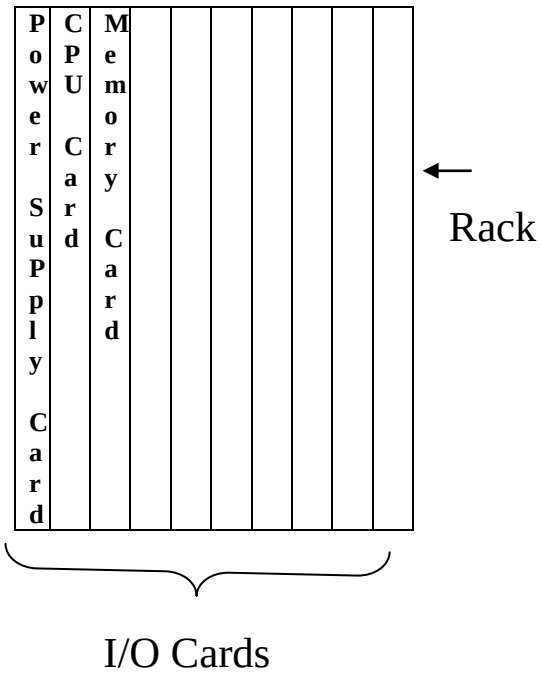
**1) Packed or composite PLC**

∗ Different parts of PLC like power supply, memory, processor etc are available in one package or in one box .

* I/O capacity is fixed
* No redundancy
* If any one part fails complete PLC has to be replace.
*Maintenance cost is high.

**2) Modular PLC**

* For each part of PLC separate card is available.
* I/O capacity is not fixed .
* Redundancy is possible .
* If any one card fails there is no need to replace complete PLC. Particular card can be changed.
* Maintenance cost is less.




**Brands of PLC's**

Allen Bradley
Siemens
Mitsubishi
Tata Honeywell

ABB
ALSTOM
FESTO
Fuji Electric

Reliance
B & R
Toshiba
Cutler Hammer

Anshuman
Schneider
Koyo
Sigmatek

Messung
Omron
Fanuc
Modicon

- **PLC – Reference Books**

• Introduction to Programmable Logic Controllers By – Gary Dunning

• Programmable Logic Controllers & Industrial Automation an Introduction By- Madhuchhanda Mitra

• Process Control Instrumentation Technology- By- Curtis Johnson

• Web site_ PLC Wikipedia