© November 2015 | IJIRT | Volume 2 Issue 6 | ISSN: 2349-6002

PROGRAMMABLE LOGIC CONTROLLERS

Vaibhav Awasthi
Department of Electrical and Electronics Engineering
Dronacharya College of Engineering, Gurgaon

Abstract- **Abstract Programmable Logic Controllers (PLCs) were invented to replace relay control systems. This papers tells a little about the history of PLC development. It also talks about the components that make up PLCs. Ladder Logic is discussed briefly as a common way to program PLCs. The need, and current effort, to standardize PLCs is mentioned. Soft PLCs are brought up, along with their advantages and disadvantages as compared to regular PLCs. Practical applications of PLCs are also looked at in order to give the reader and idea of the importance of PLCs in everyday life.**

I. USES

Less wiring. Wiring between devices and relay contacts are done in the PLC program.
Easier and faster to make changes.
Trouble shooting aids make programming easier and reduce downtime.
Reliable components make these likely to operate for years before failure.

II. PLC ORIGIN

Developed to replace relays in the late 1960s
- Costs dropped and became popular by 1980s
- Now used in many industrial designs

III. HISTORICAL BACKGROUND

The **Hydromantic Division** of the **General Motors Corporation** specified the design criteria for the first programmable controller in **1968**
Their primary goal
To eliminate the high costs associated with inflexible, relay-controlled systems.

IV. PROGRAMMABLE LOGIC CONTROLLERS

First developed to replace relays and relay control systems in 1960. Relays, while very useful in some applications, also have some problems. The main problem is the fact that they are mechanical. This means that they wear down and have to be replaced every so often. Also, relays take up quite a bit of space. These, along with other considerations, led to the development of PLCs. More improvements to PLCs occurred in the 70's. In 1973 the ability to communicate between PLCs was added. This also made it possible to have the controlling circuit quite a ways away from the machine it was controlling. However, at this time the lack of standardization in PLCs created other problems. This was improved in the 1980's. The size of PLCs was also reduced then, thus using space even more efficiently. The 90's increased the collection of ways in which a PLC could be programmed (block diagrams, instruction list, C, etc.). They also saw PLCs being replaced by PC's in some cases. However, PLCs are still very much in use in all sorts of industries, and it's likely that they will remain there for quite some time.

(DEFINITION ACCORDING TO NEMA STANDARD ICS3-1978)

A digitally operating electronic apparatus which uses a programming memory for the internal storage of instructions for implementing specific functions such as logic, sequencing, timing, counting and arithmetic to control through digital or analog modules, various types of machines or process.

V. LEADING BRANDS OF PLC

AMERICAN
1. Allen Bradley
2. Gould Modicon
3. Texas Instruments
4. General Electric
5. Westinghouse
6. Cutter Hammer
7. Square D

EUROPEAN
1. Siemens
2. Klockner & Mouller
3. Festo
4. Telemechanique

JAPANESE
1. Toshiba
2. Omron
3. Fanuc
4. Mitsubishi

VI. AREAS OF APPLICATION

- Manufacturing / Machining
- Food / Beverage
- Metals
- Power
- Mining
- Petrochemical / Chemical

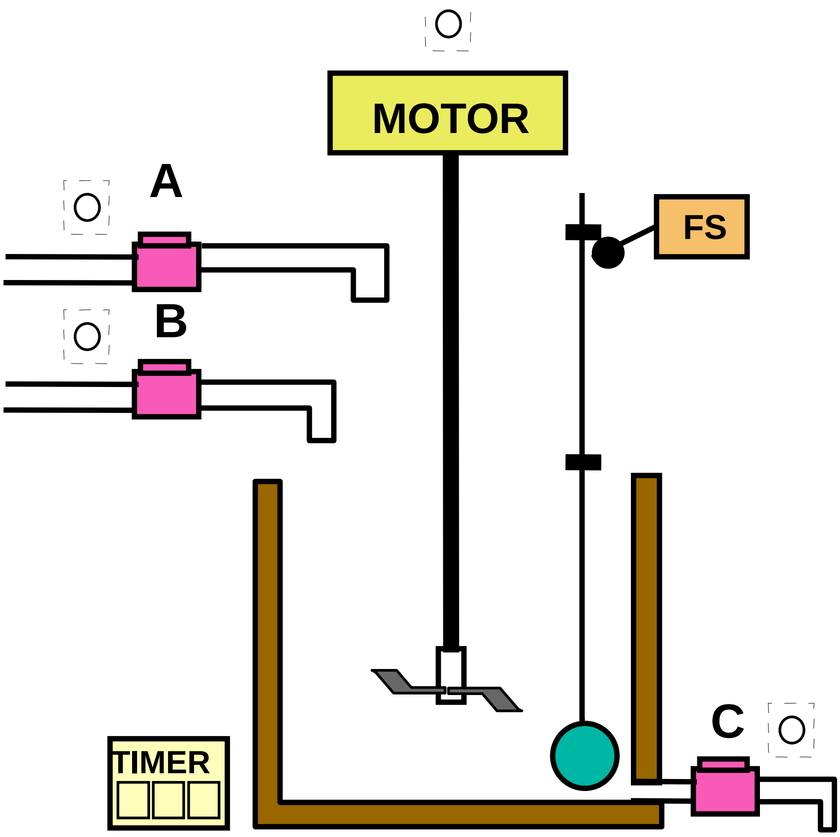
VII. PROGRAMMING:

Ladder Logic is often used to program PLCs. Symbols like the ones below are used. Figure 2: Ladder Logic Symbols The Load is like a normally open contact, and the Load Bar a normally closed contact. The Out represents a relay coil, or a normally open output. The Out Bar is not always available, but it is like a normally closed relay coil. These four symbols are used to represent almost everything in PLC logic. Things can, in fact, get rather complex with multiple inputs and outputs and "seals" (where an active output sort of acts like an input). There are also other symbols that are used for this sort of PLC coding. Programmable Logic Controllers also include counters and timers, and so there are ways to represent both in Ladder Logic.

VIII. PLC SIZE

1. SMALL - it covers units with up to 128 I/O's and
2. MEDIUM - have up to 2048 me /O's and memories up to 32 Kbytes.
3. LARGE - the most sophisticated units of the PLC family. They have up to 8192 me /O's and memories up to 750 Kbytes.
- can control individual production processes or entire plant

IX. TANK USED TO MIX TWO LIQUIDS



TANK USED TO MIX TWO LIQUIDS

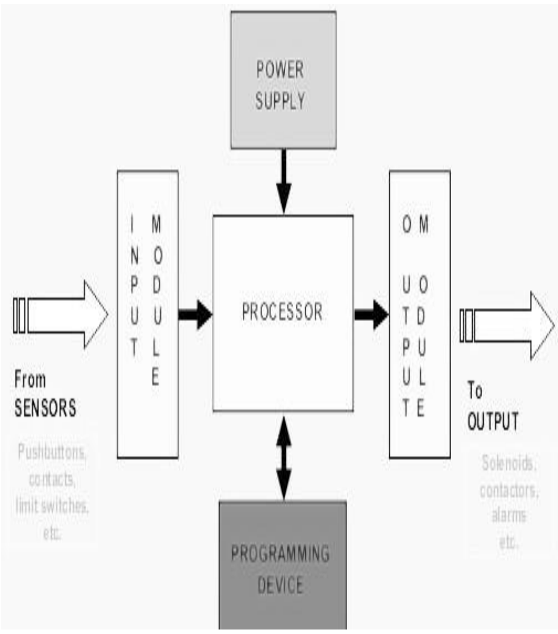
A tank is used to mix two liquids. The control circuit operates as follows:

1. When the start button is pressed, solenoids A and B energize. This permits the two liquids to begin filling the tank.

2. When the tank is filled, the float switch trips. This de-energizes solenoids A and B and starts the motor used to mix the liquids together.

3. The motor is permitted to run for one minute. After one minute has elapsed, the motor turns off and solenoid C energizes to drain the tank.

X. MAJOR COMPONENTS OF A COMMON PLC



POWER SUPPLY

Provides the voltage needed to run the primary PLC components

I/O MODULES

Provides signal conversion and isolation between the internal logic- level signals inside the PLC and the field's high level signal.

PROCESSOR

Provides intelligence to command and govern the activities of the entire PLC systems.

PROGRAMMING DEVICE

used to enter the desired program that will determine the sequence of operation and control of process equipment or driven machine.

PROGRAMMING DEVICE

Also known as:

- Industrial Terminal (Allen Bradley)
- Program Development Terminal (General Electric)
- Programming Panel (Gould Modicon)
- Programmer (Square D)
- Program Loader (Iadec-Izumi)
- Programming Console (Keyence / Omron)

Types:

- Hand held unit with LED / LCD display
- Desktop type with a CRT display
- Compatible computer terminal

I/O Module

- The I/O interface section of a PLC connects it to external field devices.
- The main purpose of the I/O interface is to condition the various signals received from or sent to the external input and output devices.
- Input modules converts signals from discrete or analog input devices to logic levels acceptable to PLC's processor.
- Output modules converts signal from the processor to levels capable of driving the connected discrete or analog output devices.

XI. DIFFERENT TYPES OF I/O CIRCUITS

1. Pilot Duty Outputs

Outputs of this type typically are used to drive high-current electromagnetic loads such as solenoids, relays, valves, and motor starters.

These loads are highly inductive and exhibit a large inrush current.

Pilot duty outputs should be capable of withstanding an inrush current of 10 times the rated load for a short period of time without failure.

2. General - Purpose Outputs

These are usually low- voltage and low-current and are used to drive indicating lights and other non-inductive loads. Noise suppression may or may not be included on this types of modules.

3. Discrete Inputs

Circuits of this type are used to sense the status of limit switches, push buttons, and other discrete sensors. Noise suppression is of great importance in preventing false indication of inputs turning on or off because of noise.

4. Analog I/O

Circuits of this type sense or drive analog signals.

Analog inputs come from devices, such as thermocouples, strain gages, or pressure sensors, that provide a signal voltage or current that is derived from the process variable.

Standard Analog Input signals: 4-20mA; 0-10V

Analog outputs can be used to drive devices such as voltmeters, X-Y recorders, servomotor drives, and valves through the use of transducers.

Standard Analog Output signals: 4-20mA; 0-5V; 0-10V

5. Special - Purpose I/O

Circuits of this type are used to interface PLCs to very specific types of circuits such as servomotors, stepping motors PID (proportional plus integral plus derivative) loops, high-speed pulse counting, resolver and decoder inputs, multiplexed displays, and keyboards.

This module allows for limited access to timer and counter presets and other PLC variables without requiring a program loader.

XII. MEMORY DESIGNS

VOLATILE.

A volatile memory is one that loses its stored information when power is removed.

Even momentary losses of power will erase any information stored or programmed on a volatile memory chip.

Common Type of Volatile Memory

RAM. Random **A**ccess **M**emory(Read/Write)

Read/write indicates that the information stored in the memory can be retrieved or read, while write indicates that the user can program or write information into the memory.

The words **random access** refer to the ability of any location (address) in the memory to be accessed or used. Ram memory is used for both the user memory (ladder diagrams) and storage memory in many PLC's.

RAM memory must have battery backup to retain or protect the stored program.

Several Types of RAM Memory:

1.MOS

2.HMOS

3.CMOS

The CMOS-RAM (**C**omplimentary **M**etal **O**xide **S**emiconductor) is probably one of the most popular. CMOS-RAM is popular because it has a very low current drain when not being accessed (15microamps.), and the information stored in memory can be retained by as little as 2Vdc.

NON-VOLATILE

Has the ability to retain stored information when power is removed, accidentally or intentionally. These memories do not require battery back-up.

Common Type of Non-Volatile Memory

ROM, Read **O**nly **M**emory

Read only indicates that the information stored in memory can be read only and cannot be changed. Information in ROM is placed there by the manufacturer for the internal use and operation of the PLC.

Other Types of Non-Volatile Memory

PROM, Programmable **R**ead **O**nly **M**emory

Allows initial and/or additional information to be written into the chip.

PROM may be written into only once after being received from the PLC manufacturer; programming is accomplish by pulses of current.

The current melts the fusible links in the device, preventing it from being reprogrammed. This type of memory is used to prevent unauthorized program changes.

EPROM, Erasable **P**rogrammable **R**ead **O**nly **M**emory

Ideally suited when program storage is to be semi-permanent or additional security is needed to prevent unauthorized program changes.

The EPROM chip has a quartz window over a silicon material that contains the electronic integrated circuits. This window normally is covered by an opaque material, but when the opaque material is removed and the circuitry exposed to ultra violet light, the memory content can be erased.

The EPROM chip is also referred to as **UVPROM.**

EEPROM, **E**lectrically **E**rasable **P**rogrammable **R**ead **O**nly **M**emory

Also referred to as E^2PROM, is a chip that can be programmed using a standard programming device and can be erased by the proper signal being applied to the erase pin.

EEPROM is used primarily as a non-volatile backup for the normal RAM memory. If the program in RAM is lost or erased, a copy of the program stored on an EEPROM chip can be down loaded into the RAM.

PLC Operation

Basic Function of a Typical PLC

Read all field input devices via the input interfaces, execute the user program stored in application memory, then, based on whatever control scheme has been programmed by the user, turn the field output devices on or off, or perform whatever control is necessary for the process application.

This process of sequentially reading the inputs, executing the program in memory, and updating the outputs is known as scanning.

While the PLC is running, the scanning process includes the following four phases, which are repeated continuously as individual cycles of operation:

PHASE 1 – Input Status scan

A PLC scan cycle begins with the CPU reading the status of its inputs.

PHASE 2– Logic Solve/Program Execution

The application program is executed using the status of the inputs

PHASE 3– Logic Solve/Program Execution

Once the program is executed, the CPU performs diagnostics and communication tasks

PHASE 4 - Output Status Scan

An output status scan is then performed, whereby the stored output values are sent to actuators and other field output devices. The cycle ends by updating the outputs.

As soon as Phase 4 are completed, the entire cycle begins again with Phase 1 input scan.

The time it takes to implement a scan cycle is called SCAN TIME. The scan time composed of the program scan time, which is the time required for solving the control program, and the I/O update time, or time required to read inputs and update outputs. The program scan time generally depends on the amount of memory taken by the control program and type of instructions used in the program. The time to make a single scan can vary from 1 ms to 100 ms.

XIII. PLC COMMUNICATIONS

Common Uses of PLC Communications Ports

- Changing resident PLC programs - uploading/downloading from a supervisory controller (Laptop or desktop computer).
- Forcing I/O points and memory elements from a remote terminal.
- Linking a PLC into a control hierarchy containing several sizes of PLC and computer.
- Monitoring data and alarms, etc. via printers or Operator Interface Units (OIUs).

Serial Communications

PLC communications facilities normally provides serial transmission of information.

Common Standards

RS 232

- Used in short-distance computer communications, with the majority of computer hardware and peripherals.
- Has a maximum effective distance of approx. 30 m at 9600 baud.

Local Area Network (LAN)

- Local Area Network provides a physical link between all devices plus providing overall data exchange management or protocol, ensuring that each device can “talk” to other machines and understand data received from them.
- LANs provide the common, high-speed data communications bus which interconnects any or all devices within the local area.
- LANs are commonly used in business applications to allow several users to share costly software packages and peripheral equipment such as printers and hard disk storage.

RS 422 / RS 485

Used for longer-distance links, often between several PCs in a distributed system. RS 485 can have a maximum distance of about 1000 meters.

XIV. SPECIFICATIONS

OUTPUT-PORT POWER RATINGS

Each output port should be capable of supplying sufficient voltage and current to drive the output peripheral connected to it.

SCAN TIME

This is the speed at which the controller executes the relay-ladder logic program. This variable is usually specified as the scan time per 1000 logic nodes and typically ranges from 1 to 200 milliseconds.

MEMORY CAPACITY

The amount of memory required for a particular application is related to the length of the program and the complexity of the control system. Simple applications having just a few relays do not require significant amount of memory. Program length tend to expand after the system have been used for a while. It is advantageous to a acquire a controller that has more memory than is presently needed.

XV. TROUBLESHOOTING

1. Look at the process
2. PLC status lights

HALT - something has stopped the CPU
RUN - the PLC thinks it is OK (and probably is)
ERROR - a physical problem has occurred with the PLC

3. Indicator lights on I/O cards and sensors
4. Consult the manuals, or use software if available.
5. Use programming terminal / laptop.

XVI. EXAMPLES OF PLC PROGRAMMING SOFTWARE:

1. Allen-Bradley – Rockwell Software RSLogix500
2. Modicon - Modsoft
3. Omron - Syswin
4. GE-Fanuc Series 6 – LogicMaster6
5. Square D- PowerLogic
6. Texas Instruments – Simatic
6. Telemecanique – Modicon TSX Micro

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