

Programmable Logic Controller and Its Applications

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ABSTARCT: Since the industrial revolution took place in 18th century, various improvements have been done in the sector of industry. The sole principle behind it was to reduce the human efforts by means of automation. A Programmable Logic Controller(PLC) has created a huge impact in the field of automation because of its exceptional capabilities. It has transformed the industry into a new era and hence study of PLC need to be done in order to thrive in this competitive 21st century. This paper studies and analyses structure of a PLC, its components, programming, functioning and further discusses on how it is being used in present world.

KEYWORDS: PLC, Automation, Ladder logic, Input Output, Memory, Relays, Switches

I. INTRODUCTION

A programmable logic controller, commonly known as PLC is a specialized computer mainly used for automation in various industries. It is used in place of automation of a car manufacturing company where robotic arms are used, places where motors needs to be driven on reception of a command signal, in electrical power system for the operation of circuit breaker, etc. PLCs are programmable hence a single unit can be used for different kind of operations based on where it is used making it a versatile device. The major advantage of a PLC over the conventional controllers its robust nature. It has high fidelity in most dynamic environments. PLC is reluctant to noise from the peripherals and hence is a reliable device for automation where accuracy and correctness is prominent. Another major advantage of a PLC is its ability to handle multiple input and output ports which processes analog as well as digital signals.



Figure 1. SIEMENS S7-300 PLC

II. NEED FOR PLC

Earlier in all types of industries, relays were used for automation purpose. Relays are electromagnetic device which contains a coil and a mechanical action switches the relay between ON and OFF state. Various relays needed to be incorporated in a given system in

order to control its various parameters such as current or voltage for driving a motor. Thus in order to control a complete system multiple relays had to be used. It ultimately required lot of space and power because of bulky size of a relay due to its components. Also coordination between relays was a major issue because of their electromechanical operation. Thus development in the field of automation led to the invention of programmable logic controller. A PLC occupies very less space as compared to the conventional relay controller with high number of input and output ports included in one device. PLC is widely used in different kinds of industries because of its simplicity, user friendly operation, versatility, efficiency and compactness.

III. BUILDING BLOCKS OF PLC

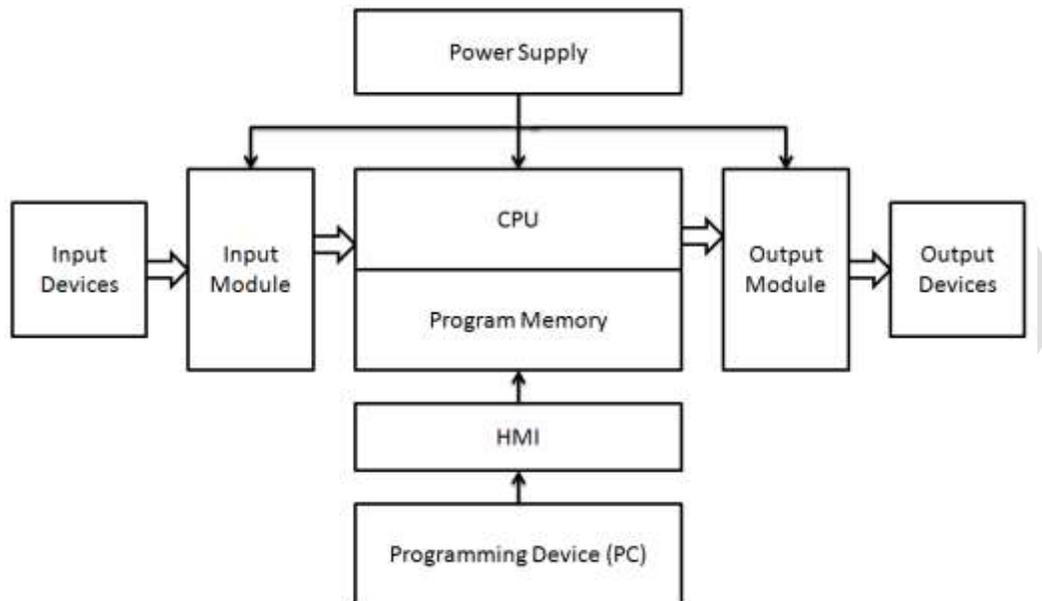


Figure 2. Block diagram of PLC

The major blocks constituting a programmable logic controller are 1)Power supply, 2)CPU, 3)Input Output system, 4) Memory, 5) Communication module

- A.** Power supply: The power supply module powers the controller including all its components with a standard 24V DC supply. It is generally placed at one end in the PLC rack. It converts the input power from 240V AC/ 120V AC to the rated 24V DC. It supplies an output current of 2A, 5A and 10A to the PLC modules.
- B.** CPU: It is the brain of the PLC controlling all the activities inside the controller. It resides typically adjacent to the power supply in the rack. The CPU is mainly composed of micro controllers and integrated circuits and is responsible for coordination between different units such as memory access, signal modules, I/O modules, etc. CPU has the following operating modes:
- Programming mode- In this mode a user program compiled on a PC is downloaded to the PLC for its execution.
 - Run mode- In Run mode the PLC executes the downloaded program. It takes in the input values and produces the desired output as instructed in the program. In this mode PLC may also use the communication interfaces such as RS232, Profibus, SCADA or CC-Link.
 - Stop mode- In this mode, the PLC stops executing the program. Hence no output is produced in this mode. Necessary input checks can be carried out for analysing or debugging.
 - Reset mode- It resets the CPU and bring it back to its original position from where it started. If reset is done without deleting any data from the memory registers, such reset is called warm reset; and if reset is done erasing all the data from memory registers then such type of reset is called the cold reset.
- C.** Input Output System: The I/O modules in a PLC can be of two types namely, Analog modules or Digital modules. Depending on the application corresponding digital or analog input cards are placed in the PLC rack. The input cards basically does the function of collecting the data from external devices such as sensors, push buttons or communication devices, makes it compatible with PLC CPU by doing signal conditioning and sends it to the CPU for further execution. These input devices are connected to the PLC input module by the means of screw terminals on the card.
- The output module performs the function of sending the control signal from CPU to corresponding output device for actual action. The hardware is similar to the input module. It can be digital module if has to send signals to devices accepting discrete signals such

as push buttons, micro switches, selector switches, etc. or it can be an analog module if the output devices are motors drives, alarm system, lamp, etc.

D. Memory: The memory block present in the PLC is majorly divided into three sections viz.

- Load memory
 - Work memory
 - System memory
- Load memory: It is used to store the user program. It can be ROM, ROM or EEPROM memory. In many PLCs the load memory can be extended by the means of memory card (RAM or EEPROM).
- Work memory: The work memory (Integrated RAM) is used to store the parts of the user program required for program processing.
- System memory:
- a) PII and PIQ- Peripheral Image Input and Peripheral Image Output are the memory areas used to store and transfer data between input devices, PLC and output devices. These areas are checked in a cyclic manner during the execution of a program. The status signals from various input devices are stored in the PII region during program scan. At the end of program scan, the output signals stored in the PIQ region are transferred to the corresponding peripheral devices.
 - b) Timer/Counter area- This memory contains the 16-bit timers or counters. These timers/counters can be used by the programmer for various purposes. The number of timers and counters depends on the CPU.
 - c) Bit memory- This memory is used to store the intermediate results of a program execution. It is abbreviated by M. Size of this area depends upon the CPU.
 - d) Retentive memory- In PLC taking backup of certain memory is essential. This memory area is a non-volatile RAM which backs up the timer/counter, bit memory and data blocks without a backup battery.
 - e) Local stack- It is similar to bit memory in order to store the intermediate results, however it is not a global memory, that means it stores the data specific to a given block only.
 - f) Diagnostic area- It is used to store the diagnostic data such as ISTACK, BSTACK or Diagnostic buffer.

E. Communication module: A communication module in a PLC is used to establish a connection between PLC to PC or PLC to other PLC etc. With the advent of SCADA systems, ethernet module is widely used for communication. It uses TCP/IP protocol for communication over a network of other devices(PCs, PLCs). It is given an RJ-45 connector to establish connections with the help of a CAT-5 Ethernet cable.

IV. PLC PROGRAMMING

As seen before, the major advantage of PLC over the conventional devices is its ability to implement desired automation based on a user program. This program can be compiled by user on a PC and can be uploaded to the PLC. The manufacturer of PLC develops their own software to program the PLC, e.g, SIMATIC S7 by SIEMENS. The program can be written in following logics:

- Ladder Logic(LAD)- An ON-OFF switch and a relay coil are the basic components of these method. These symbols emulates the real life components used in an actual control system and thus LAD logic can be understood by person having little or no specific knowledge of programming. The switches used can be normally open type or normally closed type depending on their use. The entire program can be written using these symbols in separate lines. The complete program structure looks like a ladder hence the name.
- Statement Logic(STL)- In this method, logical statements are written as a program. Various keywords are used to represent various parameters in the program. Programmer need to have prior knowledge of these keywords in order to compile an accurate program to produce desired automation results.
- Functional Block Diagram(FBD)- This is a graphical programming language for a PLC. The block represents a function and is provided with input and output ports which can be connected to other blocks or input/output. The direction of signal through the blocks is fixed, i.e., from left to right.

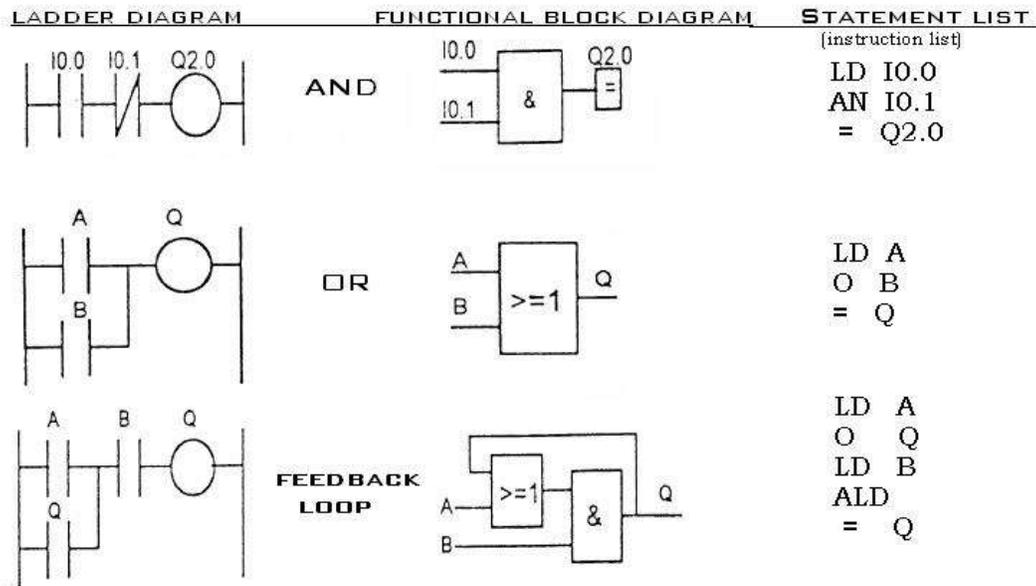


Figure 2. Comparison between PLC program logics

V. APPLICATIONS OF PLC

Because of the versatility of PLC, it is used in various places for automation. In industries various processes needs to be controlled at every instant of time such as valve control, pressure control, robotic action, etc. It becomes tedious and infeasible for humans to control all such activities on their own. Thus relays were used to perform those activities. However, a relay can be used only for a specific and limited operation which makes their use bulky and uneconomic. On the contrary PLC having the ability to perform number of tasks by simply modifying the program has become a prominent device for automation of such activities. There are various places where a PLC can be used. Some of those are listed as below:

- Robotic arm in car manufacturing
- Air compressors
- Airport runway lighting control
- Traffic signal control
- Smoke alarm control
- Process valve control
- Textile equipments
- Vacuum pump system

Apart from these applications, PLC is widely used in automation of electrical power system. At electrical substations automatic reclosing, circuit breaker tripping, capacitor switching, etc. can be controlled with PLCs.

VI. ADVANTAGES

1. Multiple devices such as timers, memory shells, etc. are embedded in one system which makes PLC very convenient and versatile to use
2. PLCs are robust in nature and can be operated effectively in adverse external conditions such as temperature, humidity, motion, etc.
3. PLCs are easily programmable and its programming language is easily understood
4. The interfacing between input and output is already done inside a PLC
5. Interfacing with HMI makes the monitoring of inputs and outputs of a PLC easy and convenient
6. Complex operations can be performed easily

VII. DISADVANTAGES

1. A lot of hard wiring is required for connection of input and output devices
2. Since PLC is a semiconductor device, it can't be operated over a level of temperature where it can't sustain it
3. Debugging with PLCs may become tedious as finding the fault is not very easy
4. Initial cost of PLC is high

VIII. CONCLUSION

A programmable logic controller has a huge potential in the field of automation because of its simplicity and effectiveness. In this century it is developing at a rapid rate in order to synchronize with the ever growing technology. PLC have become a must have in

industries dealing with automation. Along with that it has a lot of scope in functions at domestic level. Though it has certain disadvantage, these are certainly going to be solved in the near future because of increasing dominance of PLC. The use of ladder logic in PLC programming has made its much more easy to understand and requires very less training. In order to develop the automation field further, understanding of PLC is essential.

REFERENCE:

- [1] Edward HRYNKIEWICZ, Mirosław CHMIEL, "About Programmable Logic Controller- step by step"- <http://pe.org.pl/articles/2012/9a/66.pdf>
- [2] PLC History- http://www.machine-information-systems.com/PLC_History.html
- [3] How PLCs Work- http://www.machine-information-systems.com/How_PLCs_Work.html
- [4] PLC Manual, Basic guide to PLC- <http://www.plcmanual.com/plc-programming>
- [5] PLC Applications- <http://www.entertron.com/application.htm>
- [6] Siemens, SIMATIC S7-300 Module data Manual, February 2013.
- [7] Siemens, SIMATIC Programming with STEP 7 Manual, March 2006.
- [8] W. Bolton- "Programmable Logic Controllers, Sixth Edition"
- [9] ANTONIO SORIN TASU- "PROGRAMMABLE LOGIC CONTROLLER"- http://www.idc-online.com/technical_references/pdfs/electronic_engineering/0305_0310.pdf
- [10] L. A. Bryan, E. A. Bryan, "Programmable Controllers, Theory and Implementation, Second Edition"
- [11] Frank Petruzella, "Programmable Logic Controllers, Third Edition"
- [12] Industrial Manufacturing- Siemens, <https://www.industry.usa.siemens.com/services/us/en/industry-services/training/self-study-courses/quick-step-courses/Documents/plcs.pdf>