

THE ROLE OF PLC IN AUTOMATION, INDUSTRY, AND EDUCATION PURPOSE: A REVIEW

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Abstract: A programmable logic controller (PLC) plays a significant role in every era, whether it is in the field of automation, industry, or educational purposes. As the demand for automation grows exponentially, control systems need to be easy to program, flexible, reliable, and cost-effective. This article provides an overview of PLC implementation in automation, industry, and education. This article reviews an investigation into the role of PLC in automation, industrial, and educational goals. PLC has its limitations, but research shows that it has more benefits than limitations. After the survey, it will be seen that the PLC can be used in any application, whether it is simple or complex control systems. The analysis conducted and focuses on the concept, operation, advantages, and practical applications of PLC, as well as comparison with other control systems.

Keywords: Automation, Education purpose, Industry, Ladder programming, PLC

I. INTRODUCTION

PLC is a unique type of microprocessor-based controller. It comprises a programmable memory to accumulate instructions and execute tasks like timing, logic, arithmetic, counting, and sequencing the same as illustrated in Figure 1 [1].

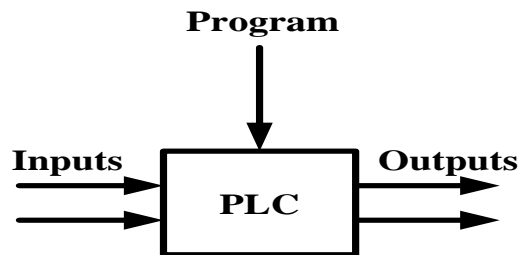


Fig 1: PLC Structure

PLCs are designed and used by engineers to process and control machines with narrow information of computer programming. The same PLC unit can be used to control different systems after each scan. The programmable logic controller can be regarded as a special computer for industrial use. It is not influenced by vibration, noise, heat, and moisture. It can be simply automatic by easy encoding language, which mainly involves logic and switch operations.

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The PLC contains hardware and software systems for standard input/output or multiple input/output systems. PLC is also used in analog or digital control systems [2]. PLC is the control center of various automation systems and processes. They contain multiple inputs and outputs that use transistors and other circuits to simulate switches and relays to control devices. It can be programmed by software connected through standard computer interfaces, registered languages, and network options. The development of low-cost computers revolutionized the PLC. PLC began to appear in the 1970s and has become the most popular choice for manufacturing control. Programmable logic controllers are becoming more and more popular in factories and are likely to maintain a dominant position for some time in the future [3]. The National Electrical Manufacturers Association (NEMA) defines a PLC as: "A digitally operated electronic device that uses programmable memory to store instructions inside to perform specific functions, such as control logic, sequencing, synchronization, and counting. And calculations, through digital or analog I/O modules, different types of machines or processes [4, 5].

A. Fundamental Parts of PLC

The fundamental parts of a PLC are as follows in Figure 2.

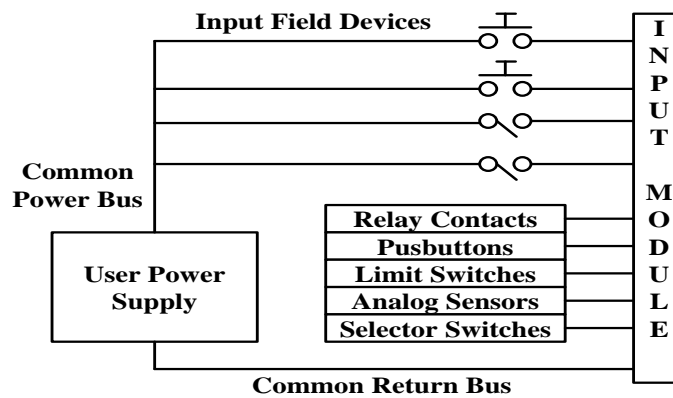


Fig 2: Block diagram of a PLC

I/O Modules: The real-time controller input gives the state of the variable invalid indication. This variant can be registered, analog, or discrete. Particularly, analog i/p may be thermocouple, RTD, voltage, current, and heat of transmitters. After it is converted into digital data, it is sent to the central processing unit (CPU) via the input/output bus. The input unit is responsible for altering electrical signals from the i/p apparatus into electrical signals that PLC can accept [6].

CPUS: The function and capability requirements of the PLC depend on the application, which is why the CPU of this controller can be implemented as a general-purpose microcontroller [7-9] or sometimes as a dedicated processor for two processors [10, 11] the reason. A separate module for bit type and word operations [12] or use programmable logic circuits to perform logical operations on physical devices [13].

Power Supply: Mainly, PLC controllers operate under 24 VDC / 220 VAC. Some of them include the power supply as a separate unit, while the small and medium-sized series include the power supply unit [14].

B. PLC History: At the request of American automakers, PLC development began in 1968 and was installed in the industry for the first time in 1969. They can be used to transmit and receive variable voltages in the 1970s and enter the analog world through communication functions. In the 1980s, attempts were made to standardize communication with the Manufacturing Automation Protocol (MAP), thereby reducing the size of the PL and making it programmable through symbolic programming on a personal computer. In the 1990s, the introduction of new protocols and the modernization of the physical layer of some of the more common protocols that survived the 1980s gradually declined. An attempt has been made to integrate the latest "IEC 1131-3" standard into a PLC programming language under a single international standard. Now, we can use programmable controllers in functional block diagrams, command menus, C, and structured text at the same time [15, 16]. *Currently, more than a dozen manufacturers are producing*

programmable logic controllers, as shown in Table 1. Among these companies produce numerous models, which differ in cost, size, and complication to reach exact application requirements.

Table 1 PLC maker companies in the worldwide

Manufacturer	Reference
Rockwell/ Allen Bradley	[3]
Toshiba	
Mitsubishi	
Koyo	
GE Fanuc	
Keyence	
Omron	
Rockwell (Allen-Bradley)	
Fuji	
Idec	
Schneider (Modicon)	
ABB	
Panasonic	
Beckhoff	
Bosch Rexroth	
Siemens	

The paper is distributed into 8 sections. In Section 1, the PLC has been discussed and Section 1 is further subdivided into subsections to explain more about the basic component of PLC and the history of PLC. In section 2, PLC has been described as a system. In addition to this, the detailed literature on the usage of PLC has been discussed. The programming of PLC has been explained in Section 3. In section 4, the comparison-based analysis of PLC with other controllers has been discussed. Apart from this, the salient features of PLC have been explained in Section 5. And, the advantages of PLC are presented in Section 6. Finally, the overall manuscript is concluded in section 7, and future work has been presented in section 8.

II. PLC AS A SYSTEM CONTROLLER

The PLC-based control system is a microprocessor-based controller. In this memory, a special programmable memory is used to store various instructions and functions [17-19]. Currently, programmable logic controllers are widely used in industry. PLC is a functional computer used in motors that are controlled and operated by completion methods. This is a programmable retention function and direct accumulation and termination, including opening and closing [20, 21]. In this case, a dedicated programmable memory is used to store various instructions and functions. Currently, PLCs have been widely used in industry [22]. PLC is a functional computer used to operate and control machines completely [23]. This is a programmable retention function and direct accumulation and termination, including opening and closing, as shown in Figure 3.

A. PLC in Automation

The meaning of automation is a self-perpetuating taken from Greek. Automation assists in enlarging output by updating and improving efficiency of work [15, 24]. The main goal of automation is to integrate the manufacturing process, improve the safety level of operators and increase productivity, improve quality and efficiency, reduce labor costs and human error work. To automate the process, the basic needs are power, correct i/p and o/p control. The current automation has carried out a series of conversions of relay and connector logic [25, 26]. PLC is a devoted workstation with a modular I/O system, which can be simply linked to the actual hardware used to process and control. An easy automation system based on PLC has three essential parts, as shown in figure 4.

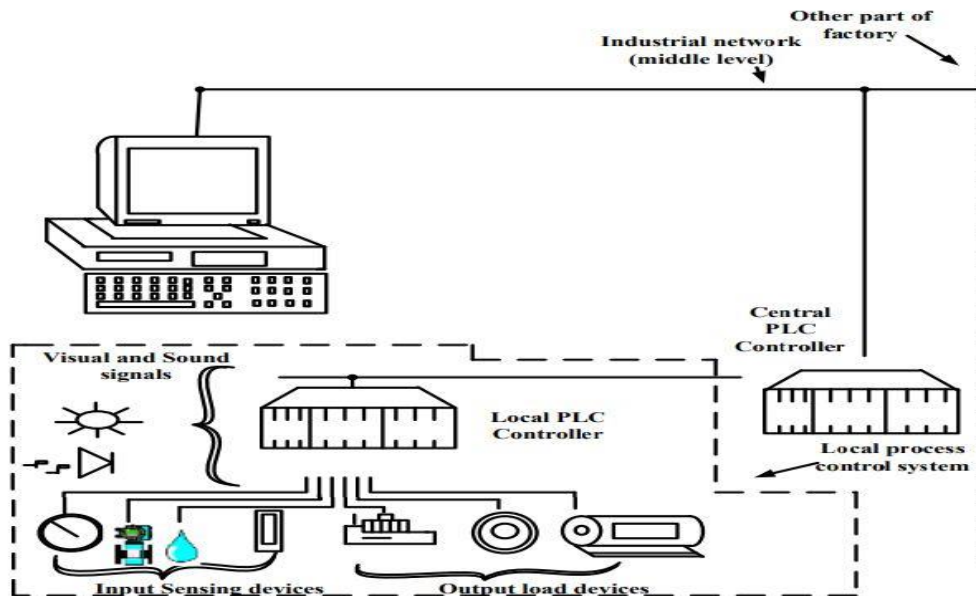


Fig 3: Layout of PLC [22]

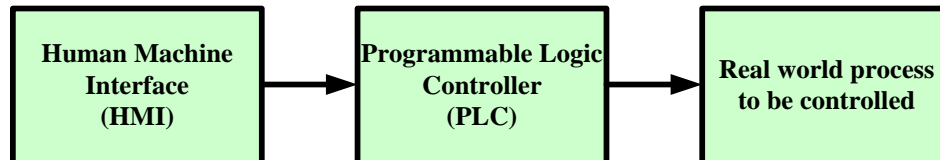


Fig 4: Automation based Essential parts of PLC

The PLC-based computerized system permits the worker to interfere with the logic stored in the PLC through the human machine interface (HMI) to control the actual operation in real time. The operator can see the information needed to make control decisions on the HMI screen, and then issue commands to the PLC logic through the HMI, which in turn processes the process variables to produce the desired results [27].

B. PLC in Industry

Nowadays, time is very important to the industry and people. For example, we all need the quality of products used in daily life. Automobile manufacturing, solar tracking, wind energy, HVAC control, all these processes require automation and control systems. The control system automatically controls all processes that we don't have to manage manually. After globalization, the industry has undergone tremendous changes, and various devices are used to control the process, for example Industry 4.0 issued by the German government. In India, all operations are controlled by a programmable logic controller (PLC). In 1969, the first PLC was used in the automotive industry [28]. At present, industrial control, especially PLC is an important technical basis for industrial process automation. Yet in the era of industry 4.0 and the Industrial Internet, it can be supposed that these controllers will still be in great demand in future production. However, the controller necessity meets a series of further needs brought about by the new manufacturing circumstances [29]. While, applying the principles of Industry, a high standard manufacturing system is based on a cyber-physical production system (CPPS) [30, 31]. Therefore, the ability of programming based manufacturing systems will play a significant task. In the circumstance of Industry, rapid constructive validation and changes in the technological process of industrialized exact goods will occur frequently and have turned into routine tasks. As a result, the rapid and simple change of factory design, and apparatus and the reshaping of its performance are the fundamentals for automated industrialized systems in Industry 4.0 [32, 33].

C. Purpose of PLC in Education

PLCs are usually included in automation and control courses for undergraduates, and many educational institutions lack resources to help students become skilled API programmers. The high teacher-student ratio, limited laboratory access and limited equipment availability make it difficult for students to obtain personal attention and sufficient practical opportunities [34]. In most university engineering education programs, "control system" refers to closed-loop control. Programmable logic controllers are often considered "technical" and usually have a rare and better appearance. With current technology, this is a bit short-sighted. The control system can be divided into three functional groups:

- Supervisory systems, such as supervisory control and data acquisition (SCADA) systems, provide operators with process status information.
- The sequencing system is used when certain processes must follow a predetermined sequence of discrete events.
- Closed-loop systems, as widely taught in engineering courses, are usually implemented so that certain operations have a set of required performance characteristics [35].

PLCs are widely used in agricultural production and processing. Application examples include food processing [36, 37], environmental monitoring of buildings [38], grain drying [39], animal production [40] and aquaculture production. This requires teaching machines and APIs in university classrooms [41].

III. PLC PROGRAMMING

PLC is widely used in automatic control. They lead the assembly line, robots and the entire chemical plant. The network system can be well combined with PLC which realizes different purposes [3]. The IEC 61131-3 standard describes a specific quantity of programming languages for PLC [5, 42, 43]. These languages vary from high intensity graphic languages with strong structural capabilities to little intensity close to design of circuit. The main general method to program a PLC to arrange the required control circuit as a logic diagram (LD) and then input the LD to the programming mortal [44]. The programming station can convert the ladder diagram into digital code, then send the program to the PLC, and then store it in the memory. In addition to the ladder diagram in figure 5, there are other PLC programming methods [45].

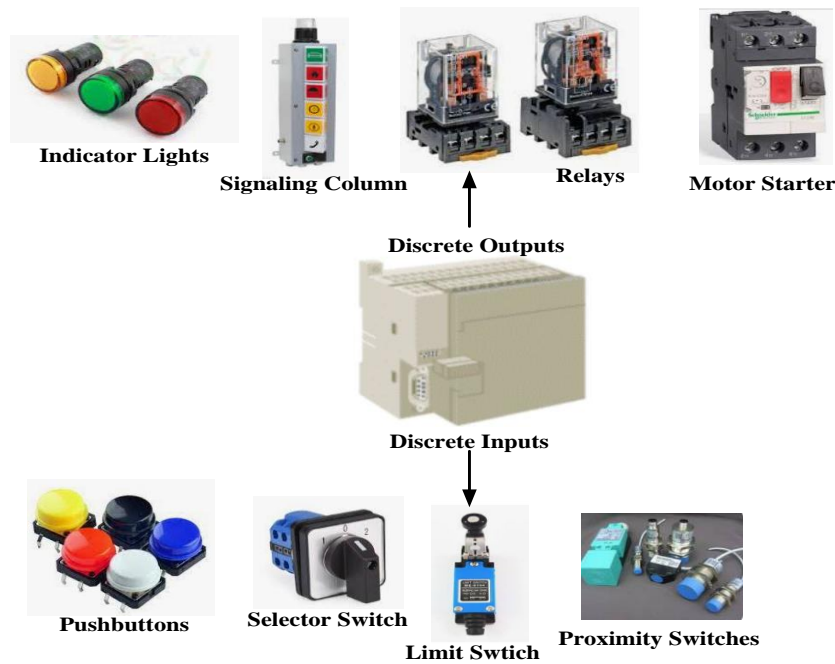


Fig 5: Distinct I/P and O/P devices [46]

Below, figure 6 illustrate the LD programming by CX-One Programmer Software that emerged by Omron.

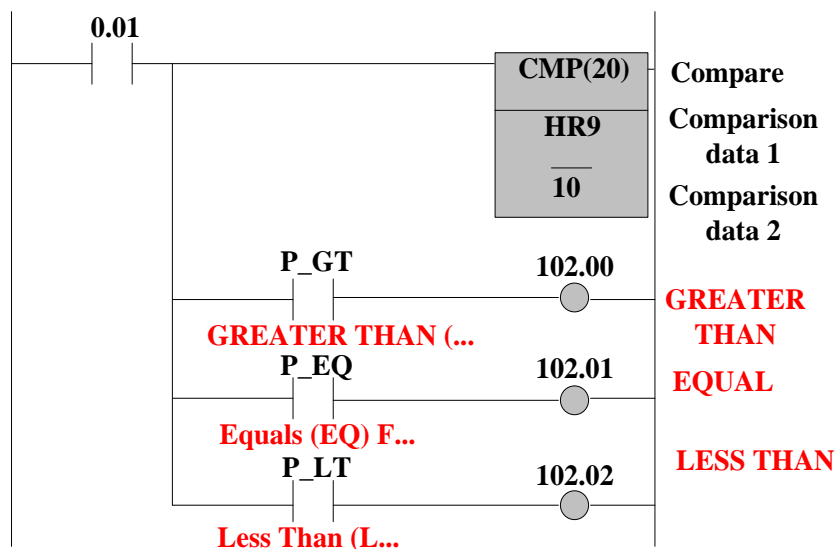


Fig 6: Compare Instruction Ladder diagram

IV. DIFFERENTIATION OF PLCs WITH REST OF CONTROLLER

PLC is mainly used in industrial processes, in which the cost of developing and maintaining automation systems exceeds the entire expenditure of automation, and it may be essential to modify the system, such as motion control and positioning, during its service life. In addition, they can also meet the requirements of the system for very personal applications. However, the PLC does not have the functions required for the operation of very complex algorithms in the chemical industry. For high-volume or simple static automation tasks, various technologies including microcontrollers, paging systems, microcomputers, and continuous electronic control systems, digital logic control

systems, and solid state motors, are the first choice. Relays can build complex control systems by connecting a set of logic apparatuses. On the other side, a complex relay system has hundreds of switch contacts, which brings a tedious task to the design engineer, especially when the board control function needs to be changed, which will eventually cause the system to be completely reconnected. It does not give the compensation adjustability provided by modern PLC. Relays also acquire additional area and need ordinary maintenance. Additionally, the high charge, small speed and unreliability caused the relay system to be replaced by modern alternatives. Relays are still ideal for reconstructing small control signals into higher current/voltage control. This shows that they are completely used as output devices for other control systems [16, 47].

Table 2 Comparison of PLCs with other Control Systems [4]

Specifications	PLCs	Solid State Control	Relay	Minicomputer	Microprocessor	Digital Logic
Hardware charge	Number of controls dependent	Equal	Low	Huge	Low	Normal
Flexibility	Yes	Low	Low	Yes	Yes	
Compensation	Good	Needy	Needy	Needy	Needy	Needy
Programming charge	Low	High in Wiring	High in Wiring	High	High	Low
Re-usable	Yes	No	No	Yes	Yes	
Computer well-suited	Yes	No	No	Yes	Yes	Yes
Essential area	Small	Large	Greatest	Ok	Small	Quite compact
Speed of performance	Fast	Quicker Electromechanical relays	Slow	Quite Rapid	Quite Rapid	Quite Rapid
Arithmetic Ability	Yes	No	No	Yes	Yes	Yes

V. MAIN ASPECT OF PLC

Over the years, various functions of PLC have been developed to comprise sequential control of relays, distributed, process, and motion control networks. The PLC takes as a main control component and adopts special input/output units to form a control system device with a small quantity of measurement and nonessential circuits, and realizes the control of the entire system during programming.

A. High Consistency

To build PLC work steadily and professionally under strong interference circumstances, the most important feature of PLC is its high reliability and high anti-interference quality. Program control instead of relay control can reduce errors caused by the failure of the original outboard electrical contacts. Industrial rank apparatus finished by advanced processing expertise can withstand interference, and the self-analysis program of the monitoring circuit can protect the memory, which can greatly get better performance of the PLC.

B. Excellent Elasticity

PLC has a variety of programming languages, including ladder diagram, SFC, STL, ST, etc. If the operator can be proficient in any programming language, then he can run the PLC well. According to engineering carry out, the purpose and ability can be extended by increasing the number of units, so that the PLC has excellent flexibility.

C. Superiority of Strong and Simple in use

In offline or online mode, it is extremely simple to alter, modify and revise the PLC program through the computer. By displaying the fault location information and self-diagnosis function, it is easy to know the location of the fault,

all of which make it easy to repair and maintain the PLC. Due to the standardization, and serialization of the PLC, the configuration of the PLC is very simple [48, 49].

VI. ADVANTAGES OF PLC

Some of the advantages of a PLC are discussed below,

- Less running time.
- High flexibility
- There are no moving parts, which improves reliability
- Low energy consumption
- Modular structure, easy to maintain.
- Simple troubleshooting and diagnosis.
- Ability to handle complex logic operations.
- Good facilities for recording and data collection
- Convenient interface with practical computers [50].

VII. CONCLUSION

PLCs were first envisioned in the 1960s and are now widely used for automation, industry, and educational purposes. Generally speaking, the survey results indicate that PLCs may be fully adjusted for several research projects, regardless of how simple or intricate the structure is further PLC development in the current market, with a focus on hardware and software application. It can investigate how other citizens are addressing their requirements by using PLCs as their primary controllers in their roles. The role and purpose of PLC in automation for industrial control development has a history of tough novelty in industry and education. In this article, the thoughts of PLCs and their purposes are reviewed. Applications of PLC are normally extremely adapted so the charge of an enclosed PLC is little compared to the charge of an exact traditional assembled controller design. Improvement of little modular arrangement in evaluation with the former constitution has enlarged the elasticity of;

- PLC configurations
- work out,
- Examine time,
- Processing of Data
- System communication,
- Display of Graphics, and
- Other purposes.

PLC programming tools are continuously increasingly, used further generally in the functions of mathematical control skills, and control of motor.

VIII. FUTURE WORK

The analyzers will tend to use PLC as major controller for several meadows of investigation yet there are further controllers out there in the globe. We can deduce, that PLC can be put in every network, regardless it is an easy/complex control network.

Appendix:

Nomenclature			
CPU	Computer Processing Unit	NEMA	National Electrical Manufacturers Association
HMI	Human Machine Interface	PLC	Programmable logic controller
I/O	Input-output	SCADA	Supervisory Control and Data Acquisition

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