

# *PLC Controller in Electric Control System*

Ying Yao\*

*School of Electrical and Information Engineering, Liaoning Institute of Science and Technology,  
Benxi, Liaoning, 117004, China*

*9145188@qq.com*

*\*Corresponding author*

**Keywords:** Electrical System, Control System, PLC Controller, Program Development

**Abstract:** Programmable logic controller (PLC) is an electronic system for digital operation, designed for applications in industrial environments. It uses a programmable memory, used to store in its internal execution of logical operations, sequential control, timing, counting and arithmetic operations and other instructions, and through digital, analog input and output, control of various types of machinery or production processes. This paper mainly studies the PLC controller in the electric control system. Firstly, the selection of PLC controller is carried out in this paper. CPU414 series PLC with Ethernet interface is selected based on various factors such as price, cost and operation speed. The main control system of PLC is developed and the system is debugged. in the debugging process, the problems are constantly modified until the function is realized.

## **1. Introduction**

Since the industrial age, the strength of manufacturing industry has become the core index to measure a country's economic strength and comprehensive national strength. From the middle of the 18th century, European and American countries began to embark on the road of industrial power and became the first developed countries in the world through advanced manufacturing technology [1]. In the last century, with the development of computer technology, the manufacturing industry also entered a computer technology as the basis of information integration into the trend of the information age, in this era background, programmable logic controller PLC came out. Time comes to the 21st century today, China is moving towards a strong revival of the road, PLC and other applications in industrial manufacturing production links in the computer technology can be said to have contributed. The industrial production control and management in China are realized through PLC technology and computer control [2]. PLC has the characteristics of high reliability, easy programming and convenient installation. As a controller specially designed for application in industrial environment, it is often used as the main controller in most industrial control systems to complete various complex industrial automatic control tasks [3]. Introduce PLC technology into the electrical control system, improve the reliability and stability of the system; It also uses PLC control system of machine body combination machine and its automatic line, to meet the requirements of efficient, safe and reliable operation design, quickly improve the reliability of homemade equipment and processing accuracy stability; The development of hardware and software not only fully reflects good versatility and flexibility, but also can achieve a high degree of automation of the production

line, the failure rate is significantly reduced, and the application efficiency of the automatic line of the body is improved [4].

Since the beginning of the 21st century, the application of traditional PLC in various fields has been very mature, such as the charging control of electric vehicles, the control of industrial robots and the control of automatic waterworks system, PLC can be used to complete the control work [5]. But because the control system is becoming more and more complex, the requirement of PLC is also becoming more and more high, multi-core PLC came into being. At the same time, small soft PLC and embedded PLC enter the market and have been applied in many fields, among which there are products that use FPGA and ARM chip to realize the function of soft PLC [6]. As foreign enterprises such as Siemens and Mitsubishi have been standing in the PLC market for a long time, the research on PLC in China started late [7]. From a certain point of view, the PLC controller and the following implementation equipment are monopolized by foreign enterprises.

The use of PLC to transform the electrical system, the realization of programming input, human-computer interaction, automatic processing control mode, not only can give full play to the original equipment function, but also to the traditional equipment manufacturing industry how to achieve technical innovation, walk sustainable development has important significance.

## 2. Design of Electrical Control System Based on PLC

### 2.1 PLC Selection

The Programmable Logical Controller is a special industrial control device with similar structure and components as a general computer [8]. The core hardware is mainly central processing unit, memory and programmer, equipped with power module, and implements control function with input, output and other peripheral devices. Its structure is shown in Figure 1.

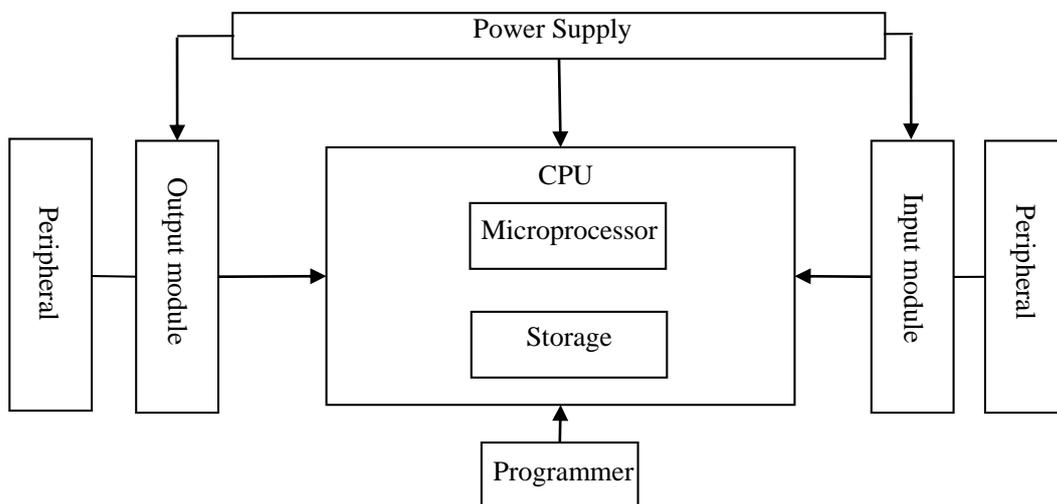


Figure 1: PLC structure diagram

#### (1) Central Processing Unit (CPU)

The CPU is the brain of the PLC, and the microprocessor is the most important component of the brain. PLC logic operation, work scheduling and information transfer, processing and other important work are completed by the microprocessor. The operating logic of PLC is realized through the program programmed by the translation engineer [9].

#### (2) Memory

Memory is divided into three categories: system memory, user memory, and working memory. Its main functions are shown in Table 1.

Table 1: Memory classification

Classification	Data type	Read / write operation
System memory	System program of PLC	Read-only
User memory	User programs and data	Reading and writing
Working memory	Work data	Reading and writing

(3) Input and output module

The input and output modules can be divided into two categories according to the types of input signals: switch module; Analog quantity module. The switch input module is used to receive external signals, such as button, switch, limit switch, brake switch, proximity switch, etc.

The switch output module is to convert the signal processed by PLC into the signal that can be recognized by external equipment. Which one to use depends on the actual project. The analog input module is to change the process value (4-20mA) signal into the digital signal that the main controller can process. The signal of the process sensor has voltage type and current type. Current-type sensors have 2-wire and 4-wire systems [10]. The PLC converts the processed process signal into analog signal by the analog output module and sends it to the actuator, such as the height indicator.

(4) Power module

The power supply of PLC internal circuit uses switch type regulated power supply, which has the advantages of wide input voltage range, small size, light weight and strong anti-interference.

(5) The programmer

Different PLC manufacturers have corresponding to different programmers. When the computer installed with PLC programming software is connected with the field PLC, the PLC hardware configuration, download, upload user program, online debugging, field simulation and other operations can be performed. PLC work mode belongs to the cyclic scanning mode, in order to execute the action of the program. The time taken for each cycle is called a scan cycle, as shown in Figure 2.

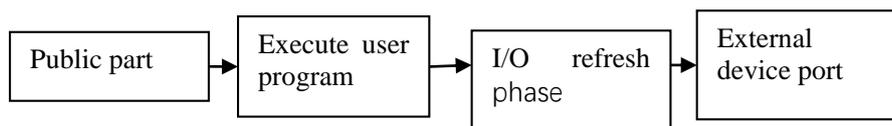


Figure 2: PLC working mode

Different brands of PLC have different performance, specifications are mainly divided into large, medium, small, micro PLC. The selection is based on the following factors: memory capacity, number of INPUT/output points, scanning speed, type and number of internal devices, and network communication capability.

The main controller PLC as the core component of the control system, it must be able to quickly process a variety of data, has a strong communication ability, flexible scalability ability. For the reliability and security requirements are relatively high, combined with the above factors, price cost and calculation speed and other factors to choose the Ethernet interface CPU414 series PLC.

## 2.2 PLC Program Development

In the development process, TwinCAT software needs to be installed on the programming

development PC and connected to the embedded PC through Ethernet for development and debugging. TwinCAT2 software development environment mainly consists of two parts: configuration software and PLC language programming, which are realized by System Manager and PLC Control respectively.

The System Manager tool designs the configuration software, including the controller System configuration and I/O port configuration. To control physical hardware through PLC programs, variables in PLC-Configuration are mapped to hardware channels in I/O Configuration, including universal I/O signals, transfers over fieldbus, and TwinSAFE related quantities. After the correlation mapping is completed, the PLC of the main control system of the simulation platform can be realized to interact with computer models such as paddle controller, converter controller and generator.

PLC Control tool is the main Control system of PLC program development, debugging and testing tools. PLC using this tool can simplify the development process, the application of this software development environment can be more simple and fast, the processing of industrial standard programming language is also more free.

In this paper, the programming language used in the control process of the main control system based on PLC mainly includes: instruction table, function block diagram, sequence function table diagram and structured text.

After the system is powered on and started, the PLC system starts to change the initial state, mainly including the system self-test, reading all kinds of necessary signals, and initializing global variables and control parameters. After that, it will enter the shutdown state. When we manually press the Start button, the master controller will Start the frequency conversion controller after receiving the command. After reaching the predetermined value, the system enters the startup state.

The main control system enters two shutdown states: normal shutdown state and emergency shutdown state. The normal shutdown state includes manual shutdown button, remote shutdown command and shutdown command issued by unit controller. Emergency stop state includes manually triggered emergency stop button, safety chain system alarm, unit failure, failure caused by external environment, etc. When it is in the shutdown state, the control cabinet at the bottom of the tower of the main control system turns the maintenance switch (key knob) to trigger the maintenance state, and the variable paddle speed is set to the variable paddle speed in the maintenance mode.

### **3. Human-computer Interaction Interface Design**

Human-computer interaction refers to the operation of the device, device or control system to obtain the control information of the operator, so that the device, device or control system to make corresponding actions. Human-computer interaction interface is a specific application of human-computer interaction. Early human-computer interaction just come through a simple signal indicator to reflect the operation of machinery, equipment or system information, through the development of science and technology, the human-computer interaction technology is relatively mature, through the interface can display all kinds of operation information of the whole system, as well as various operating control instructions, greatly simplifies the daily operation and maintenance workload. It is widely used in all walks of life, especially in industrial control.

PLC realizes the human-computer interaction (HMI) with the touch screen, which makes the PLC more convenient and flexible in the industrial application. The dynamic screen can also be made on the touch screen to show the automation process better. The design of dynamic screen can be realized by LEVI Studio configuration software. LEVI Studio is a machine oriented automation concept HMI software, using a modular idea, can flexibly add a variety of functions according to

user needs.

Human-computer interaction mainly consists of three screens: main interface, electrical control interface and alarm history query interface. The upper part of the main interface screen is the main menu bar, including the title, interface switch button, time, system logout and other contents; The larger area on the left is the working area, which uses the form of animation to visually express the state of electrical control operation.

#### 4. System Operation Debugging

I/O terminal test, can determine whether the connection is well connected, connected to the corresponding FO port, in this system, there are keys, indicators, sensors, voice, etc., these correspond to the corresponding VO port, all need to be tested. We can temporarily replace the field input signal by manual way to manually check and verify the PLC input terminals one by one. If the output power supply is good, the indicator of the PLC input terminal lights on, indicating that it is normal. Otherwise, the wiring or I/O point should be checked. For example, when the corresponding sensor device is operated by manual force, the indicator light at the corresponding I/O port will be on, and there will be a fault alarm at the slave station and the master station. Only in this way can it be considered successful. The test of I/O terminals is the basis for other debugging. As long as there is no problem with I/O terminals, other problems can be considered from the programming and hardware itself.

System debugging needs to build all the hardware, after the detection is correct, power on, then write the PLC program, watch the effect, through manual control of the sensor, observe the control reaction, if there is abnormal need to consider the problem of program and wiring. In the process of debugging the system, most of the cases are problems with the control program. There is no fixed routine in the debugging process. Some people rely on their experience.

- 1). The signal indicator light of PLC interface is detected separately;
- 2). Check the hardware and modify the program;
- 3). Stability and reliability test of function realization;
- 4). The debugging is finished;

For this system, after debugging and modification, the final results are: the master station communication is normal, the master station indicator light is normal, the master station button control is normal, the master station touch screen display and control is normal.

#### 5. Conclusions

This paper discusses the research background and significance of electrical control system, learning from the advantages of domestic and foreign electrical control technology, put forward a design of electrical control system based on PLC. The electrical control and running condition monitoring of the factory are realized, which has higher engineering practical value and higher practical guiding significance. Although this paper has done some research on the design of electrical control system, due to time, experience and other factors, it still finds some problems that need to be further improved and perfected: Electrical control system can be designed more intelligent, such as in the design of human-computer interaction interface added fault diagnosis system, when the system failure system can be quickly detected, and give the cause of the failure and the corresponding solution; The communication module with the mobile phone can be added to realize the function of the mobile phone to send short messages to query fault information and display fault alarm.

## References

- [1] Suharti P H, Kristiana H M, Amalia R N. Design of flow control system based on PLC armfield pressure control module in chemical engineering laboratory [J]. *IOP Conference Series: Materials Science and Engineering*, 2021, 1073(1):012053 (6pp).
- [2] Konkani A, Bera R, Paul S. [Lecture Notes in Electrical Engineering] *Advances in Systems, Control and Automation Volume 442 || Spectral Analysis and Comparison of Single-Carrier PLC Modules in Narrowband Power Line Communication System* [J]. 2018, 10.1007/978-981-10-4762-6(Chapter 19):199-212.
- [3] Boobalan S, Gobinath S, Dharmalingam A, et al. An Integrated IoT LabVIEW Based Fuzzy-PLC Controller for Automation of Boiler [J]. *IOP Conference Series: Materials Science and Engineering*, 2020, 937(1):012049 (11pp).
- [4] Shpenst V A. Telecommunication systems of mines and underground structures based on PLC [J]. *IOP Conference Series: Earth and Environmental Science*, 2019, 378(1):012071 (6pp).
- [5] Dwinugroho T B, Hapsari Y T, Kurniawanti. Greenhouse automation: smart watering system for plants in greenhouse using programmable logic control (PLC) [J]. *Journal of Physics: Conference Series*, 2021, 1823(1):012014 (9pp).
- [6] Chakraborty K, Choudhury M G, Das S, et al. Development of PLC-SCADA based control strategy for water storage in a tank for a semi-automated plant [J]. *Journal of Instrumentation*, 2020, 15(04):T04007.
- [7] Garrido J, Santos D, J Sáez, et al. Information model to support PLCOpen Motion Control programming from Mechanical Design [J]. *Procedia Manufacturing*, 2020, 51:258-265.
- [8] Moraes M, Grover M A, Souza M, et al. Optimal Control of Crystal Size and Shape in Batch Crystallization Using a Bivariate Population Balance Modeling [J]. *IFAC-PapersOnLine*, 2021, 54(3):653-660.
- [9] Rajkumar K, Thejaswini K, Yuvashri P. Automation of Sustainable Industrial Machine using PLC [J]. *Journal of Physics: Conference Series*, 2021, 1979(1):012049.
- [10] Sartika E M, Sarjono T R, Christian K. Modular Production System Control Using Supervisory Control Theory Method [J]. *Journal of Physics: Conference Series*, 2021, 1858(1):012095.