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The Design and Research of Electric Automation Control System Based on PLC

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Abstract: *In recent years, programmable logic controller (PLC), a new technology for electrical control, has developed rapidly and has been widely used in various production processes and automatic control of production machinery. It has the characteristics of convenient operation, simple and easy to understand, and high reliability, has become one of the most popular, most important, and most applied industrial control devices. It brings new vitality to power automation control technology, improves the efficiency of power work, and becomes one of the important pillars in the field of modern industrial automation control systems. This article aims to study the design of PLC-based electrical automation control system. Based on the analysis of the classification of PLC, the basic structure of PLC and the working principle of PLC, the PLC power automation control system is designed, and the system is simulated and tested. The test results show that the operation effect of the traditional electrical control system can not meet all the automatic working conditions, and the overall performance is poor, while the system in this paper performs well, indicating that the design of this paper is effective.*

Keywords: *PLC, Electrical Automation, Control System, PID Algorithm*

1. Introduction

The electrical automation control system has played an important role in promoting the development of industrialization. The electrical automation system promotes the development of industrialization by virtue of its high reliability and safety factor, and has achieved obvious results [1-2]. The use of PLC technology in electrical automation control can make up for the shortcomings of traditional technology and promote the continuous advancement of electrical control in the direction of intelligence [3-4].

PLC is a technology that can be controlled by programming logic; it is also an electronic system for electrical automation applications. It is mainly composed of three technologies: computer digitization, control system, and field bus [5-6]. PLC has good adaptability and practicability in electrical automation, and good control effect [7-8].

Based on the analysis of the classification of PLC, the basic structure of PLC and the working principle of PLC, this paper design a PLC power automation control system, and conduct a simulation test on the system. The test results show that the operation effect of the traditional electrical control system is not consistent, can not meet all the automated working conditions, the overall performance is poor, and the system in this paper performs well, indicating that the design of this paper is effective.

2. Design of Electrical Automation Control System Based on PLC

2.1. Classification of PLC

There are many types of PLC, and there is no strict national unified standard yet. The required functions, control size, internal capacity, appearance and shape are all very different from PLC. They are generally classified according to their control scale, structural shape, and their required realization functions [9-10].

(1) Divided according to the size and scale of the controller, the control scale of a PLC generally refers to the capacity of an input with simulation values, the number of distribution circuits, and other types of control switches. One of the main methods is to calculate it based on the number of points of each switch; the path of the analog quantity can also be directly converted into the form and converted

into the points of each switch. Usually, the distance of this route is equivalent to 8-16 o'clock [11-12].

(2) According to the structure of the hardware, PLC can be divided into unit type and overall type according to its structure. Unit type plc is also called modularity: unit type plc is composed of racks and various units. The structural design of this unit has strong flexibility in software and hardware, each unit can be easily assembled, assembled, expanded and routinely maintained as a building block, that is, we can follow the actual situation, choose different units to form PLC control systems with different control scales and different functions. The PLC is made into several units according to the main functional components, such as cpu unit, basic i/0 unit, power supply unit, remote control i/0 module, analog measurement module, various functional units and various specific functional modules. General large and medium-sized PLCs use a unit-shaped structure.

Integral PLC is also called box type: PLC looks like a rectangular box from the outside. It has the characteristics of small system size, compact structure and low cost. It integrates cpu, power supply, i/0 and other parts into a cabinet. Ordinary minicomputers or microcomputer PLCs use this kind of structure.

In addition to the above two structures of PLC, some manufacturers have also developed PLC products with stacked structure in recent years. Its main feature is to absorb the advantages of unit type and integral type PLC. Various units and CPUs form independent units, which are directly connected to each other through plug connectors or cables, and each unit can be stacked layer by layer. Installing the rack can not only reduce the volume, but also achieve flexible configuration, which is suitable for the needs of electromechanical integration.

Classified according to the production process manufacturers, there are many process manufacturers specializing in the production of plc in the world. Generally, we can be divided into three process schools of the United States, Japan and Europe. The companies and PLC series models that are more influential in the Chinese market and occupy a larger share mainly include: omron, the current mainstream products cpm2*series, cs1-s series, cj1-s series, etc.; Siemens in Germany, the mainstream models include s7-200, s7-300 and s7-400, etc., with more than 6000 control points and more than 300 analog channels; Mitsubishi, the mainstream models include the FX series of minicomputers. There are also many manufacturers that produce PLCs. According to incomplete statistics, there are thousands of manufacturers producing PLC products in the world.

2.2. The Basic Structure of PLC

(1) Unit (module) PLC structure

In the unit (module) PLC structure, the various parts of the PLC are composed of highly integrated modules. These modules are connected with the PLC rack to form a PLC control system, which can also be called a modular structure. The characteristic of the unit type PLC is that the CPU is an independent unit, and the power supply, input, output and other units are also independent units. To form a PLC system, connect the power supply unit, CPU unit, input unit, output unit, A/D unit, communication unit, D/A unit and other special function units to each other through a bus cable to form a suitable user’s needs the multifunctional control system. The block diagram of the unit PLC is shown in Figure 1.

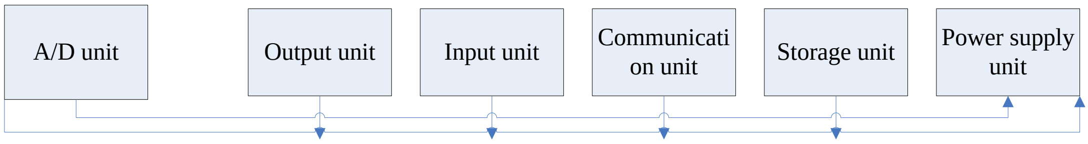

Figure 1: The basic structure block diagram of the unit type PLC

Nowadays, most of the large and medium-sized PLCs adopt the unit structure. The PLC system of the unit structure has flexible configuration, users can choose different CPUs and various functional units according to different control requirements. Whether it is installation, selection and debugging, or maintenance and expansion, the unit type PLC system is very convenient. The PLC system of the unit type structure not only connects the main frame with various units, but also provides expansion racks to connect more units. However, cables must be used to connect the main frame and the expansion racks, and the expansion racks are also connected to each other need to use a cable to connect.

(2) Integral structure

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The overall PLC hardware system is mainly composed of a central processing unit, storage, power supply circuit, input/output circuit, communication interface, and i/o interface. At present, the overall structure of PLC is also undergoing changes. After the CPU, communication unit, power supply unit, and a certain number of input and output units are integrated into one chassis, expansion ports are still left. In use, if the points or functions of the input and output units are insufficient, the units can be expanded as needed.

2.3. PLC Working Principle

The programmable controller adopts the cyclic scanning method for the user program. The control request is processed and judged according to the running state of the input signal, and the corresponding control output is generated. This cycle scanning process can be roughly divided into data input and processing, user program execution and processing, output and processing. The time taken to scan each other in a periodic scan is called a scan cycle. The time for PLC to scan the user program is higher than the response speed of the actual relay, generally only tens of milliseconds, which can meet the needs of most industrial control.

For data input/output processing, it is called i/0 refresh, which includes sampled input and sent processing results.

(1) Data input and processing stage

The plc reads all input signals from the on/off of an input signal by scanning in the two input time phases of reading and writing. After the two stages of reading and writing and input are completed, the PLC will enter the actual execution process of the user compiler program.

(2) User program execution stage

All user programs are installed and placed in the internal memory of the user program. When running the application, the cpu will execute and execute each command separately up, down, left, and right. When the last command is finally executed, it is completely over. In the operation and processing stage of a single application operating system, the designer chooses the cpu from a single output data mapping register and input component mapping register to different relays, and follows the logic given by each user program. Perform corresponding logic operations on it, and re-input the result of the operation into the mirror register of the component.

(3) Data output and processing stage

The output mapping register refers to the data area corresponding to the PLC storage processing result, collectively referred to as the output mapping area. When the PLC is executed, the editing results of the user program are saved in the previous output image register. When the program is completed, the next output refresh step will directly record the operating state of the previous output image register on the output of the previous latch circuit. Internally, the output mode of the last lock circuit is amplified and isolated by the last output drive circuit so that the external load can move, the input or read mode after refresh should be kept until the next refresh. For control systems with slower changes in speed, the output signal must be sent out in time, because the time interval between two updates and the idle time of the input signal in it are usually only tens of milliseconds.

3. Experiment

3.1. PLC Electrical Automation Control System Design

(1) Hardware design

When designing the system, first confirm the operation and control indicators of the transformer, such as current transmission and operation status, voltage level, etc. Then define the corresponding control indicator sensor in the physical layer. The sensors are because they have received the corresponding data information, through which we can accurately judge the current operating status of the transformer.

(2) Input circuit design

The PLC software itself and the hardware equipment are a kind of electrical equipment, so they must be designed in terms of output and power. The number of PLC circuits is relatively large and complex. For safety reasons, AC power must be selected. However, due to the relatively large scale of these systems and the relatively large threads, voltage is required when using high-frequency AC motors. Protection device to prevent over voltage or other abnormal phenomena. DC power supply is mainly suitable for some small PLC software and hardware systems. Due to its small scale, simple power distribution lines and short threads, it is also difficult to design and control. It is relatively small, so AC power should not be considered. In addition, in terms of interference and safety capacity requirements, we can consider using a 1:1 isolation transformer and power supply to effectively isolate the external interference in the integrated circuit. In research, its application and operation have been fully confirmed, and it can be applied directly in accordance with these specifications. As for the capacity of the safety device, it must be determined according to the actual situation, and the specific capacity of the device should generally not exceed 80% of the entire device.

(3) Output circuit design

The purpose of the output circuit is to automatically control the system, and it is an important part of ensuring the stable operation and operation of the system, because the output circuit itself is a monitor and the output of electrical signals, the main reason is that the sensor material gets all of this. The data is collected and processed, and then sent to the signal processor. The signal processor converts the radio signal into data and sends it to the automatic control terminal. In one aspect of the system design, the PLC automatic control system and the sensor image register are connected to the data register of the chip assembly. At present, we can already program the data in a more automated control system to send these data directly to the sensor or input signal. In addition, because of the detection and monitoring of various electrical operating conditions, we must always maintain real-time dynamics, that is, we must also update and plan each data input and method. Mainly refers to the update of the input method and the selection of the balance value in some equipment that is particularly suitable for electronic signal processing.

3.2. Data Preparation

The main purpose of this article is to allow everyone to use simulation and simulation experiments to analyze their results. Then, before we finally start to practice this kind of simulation and simulation experiment, we need to find a way to get the results of the experiment well. The amount of data preparation is relatively large. First of all, according to the specific conditions of the building automation projects involved in each company, the actual data of various indicators are obtained through field research; for specific electrical units, take the traditional electrical control system as an example, specifically from some related systems of working conditions and documents parameter. Secondly, we can design the collected information and data according to the actual situation of the investigated system, and obtain the simulation effect. According to the case of this article, the parameters of the traditional electronic control system are used in the traditional electronic control unit, a system is simulated and calculated based on the traditional electronic control unit, and then all the system parameters required in this article are input.

3.3. PID Control Algorithm

PID control algorithm has been widely used in the control of modern machinery and industry in my country. If the improved PID control algorithm is calculated into it, the control loop with PID structure accounts for about 90% of each control system. Due to the increasing complexity of the controlled objects and the increasing requirements for control accuracy, many experts have made various improvements to the PID control algorithm.

PID control belongs to linear control, and the control deviation error(t) is obtained according to the given value rin(t) and the actual output value yout(t).

$$error(t) = rin(t) - yout(t) \tag{1}$$

The control law of PID is

$$u(t) = k_p\left(error(t) + \frac{1}{T_I}\int_0^t error(t)dt + \frac{T_D derror(t)}{dt}\right) \tag{2}$$

Written in the form of a transfer function

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$$G(s)=\frac{U(s)}{E(s)}=k_p\left(1+\frac{1}{T_I s}+T_D s\right) \tag{3}$$

Where, k_p : proportional coefficient

T_I : Integration time constant

T_D : Differential time constant

The function of each link of the PID controller, proportional link k_p reduces the deviation. Integral link T_I eliminates static errors, and differential link T_D improves response speed.

4. Discussion

Based on simulation and simulation scenarios, the traditional electrical control system and the system designed in this paper are used at the same time. During operation, it is only necessary to change the automatic operating conditions of the electronic control system from time to time, record the operating status and operating status data of each control system. After changing all these states and conditions, all recorded data has been sorted. The results are shown in Table 1.

Table 1: Comparison curve diagram of traditional electric control system and electric automation control system

	Traditional electrical control system	Electrical automation control system
0	100%	100%
0.5	86%	90%
1	65%	94%
1.5	62.5%	90%
2	63%	93%
2.5	57%	88.5%
3	69%	92%
3.5	38%	89%
4	55%	94%
4.5	22%	88%
5	37%	91%

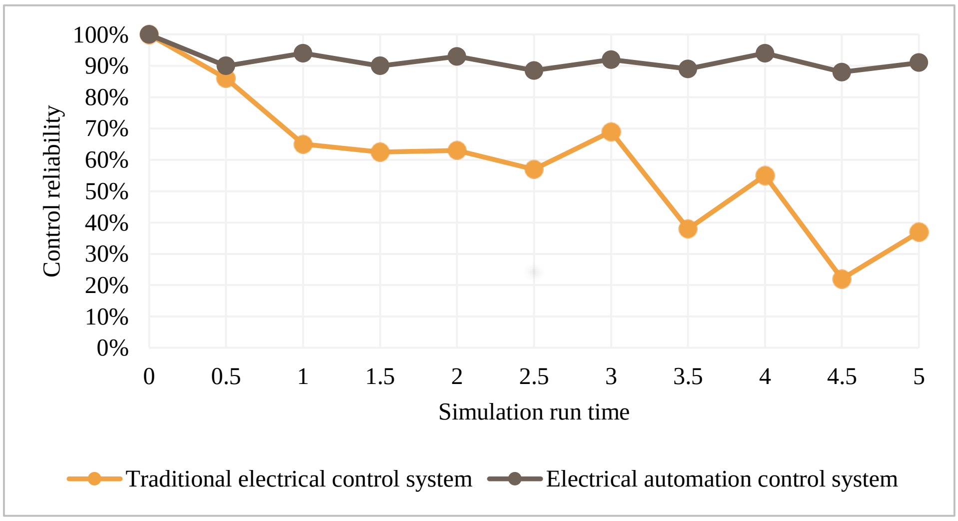

Figure 2: Comparison curve diagram of traditional electric control system and electric automation control system

It can be seen from Figure 2 that the curve of the electrical automation control system designed in this paper has a slight increase, while the overall curve has always been maintained at a higher level.

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Different from the traditional electric control system, it starts to show a downward trend at the beginning of operation. Although there is a peak in the middle, it does not touch the high level interval. Therefore, the operation effect of the traditional electric control system cannot meet all the automatic working conditions. The overall performance is poor, and the system in this paper performs well, indicating that the design of this paper is effective.

5. Conclusions

In the practice of optimization and upgrading of electrical automation control system functions, with the help of PLC technology, various functions of the electrical automation control system can be continuously improved, and the overall maintenance and management of the electrical automation control system can be enhanced. With the significant improvement of work quality and work performance, the development and design of electrical automation control systems will continue to improve. The wide application of PLC technology in the electrical automation control system can effectively reduce the cost and energy consumption of the system, effectively solve all the problems that may occur in the electrical automation control system, and make the electrical automation control system better meet the needs of development, and continuously optimize and Innovation.

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