Artificial Intelligence Technology in Electric Automation Monitoring System of Power Plant

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Abstract. With the development of large-capacity and high-parameter units, the degree of electrical automation in power plants is becoming more and more important. Due to the relatively backward technology of traditional electrical monitoring, it is more human monitoring, and the level of automation is low. Nowadays, communication network technology has been rapidly developed, and machinery and equipment have become more intelligent. These have laid a good technical foundation for the reform and innovation of electrical automation monitoring systems in power plants. This article first studies the development status of the electrical automation monitoring system, and then uses the fieldbus and Ethernet technology to carry out the configuration mode and construction of the electrical automation system. Then, this article designs the basic functions, advanced application functions and software parts of the system. Finally, this paper tests the running time and update function of the system dynamic module. The test result shows that the running time of the dynamic module meets the requirements of the system, and the update function is relatively fast.

Key words: Power Plant, Electric Automation, Configuration Mode, Fieldbus

1. Introduction

Our country is a big energy and economic country, among which the electric power industry has made a great contribution. In recent years, our country has promulgated a series of policies to support the development and research of the power industry. With the continuous progress of society, the previous electrical monitoring systems of power plants have gradually exposed their shortcomings [1-2]. For example, in the field of automated monitoring, traditional monitoring systems do not perform satisfactorily. Due to the continuous maturity of communication technology, the way of controlling industrial network systems through components in the past has changed to controlling industrial network systems through information networks, from manual to automatic [3-4]. The electrical monitoring system of power plants has always been reformed and innovated, from one person controlling one machine to one person controlling multiple machines, then to automatic machine operation, and finally to the current fieldbus control system. The electrical automation establishment system that applies the fieldbus is called ECMS for short, which is the main mode of the electrical monitoring system of power plants today [5-6].

Many scholars have conducted in-depth studies on the design of electrical automation monitoring
systems for power plants. For example, Chinese scholar Luo Zhiyun pointed out that artificial intelligence is a hot technology developed in recent years. The application of artificial intelligence in engineering electrical automation systems can improve the level of electrical automation [7]. Qin Xianfeng believes that modern electronic automation researchers must actively change their own technical concepts, fully realize the importance of the rational use of artificial intelligence technology, and effectively combine electronic automation control systems with advanced intelligent technologies [8]. Zhang Zhongwen analyzed the relationship between artificial intelligence technology and electrical automation control technology, and discussed the specific application of current artificial intelligence technology in it, so as to promote the continuous improvement of electrical automation control system [9]. The electrical automation monitoring system is very important to the development of our country. Although many scholars have achieved rich research results, there are relatively few researches on the electrical automation monitoring system based on artificial intelligence technology. Therefore, the research in this article has certain academic value and great practical significance.

With the continuous development and application of communication technology in our country, communication network technology has become more and more mature, which has laid a good foundation for the development of industrial automation control field [10-11]. As a communication system that has developed rapidly in recent years, fieldbus is excellent in compatibility, safety, and system efficiency, and it is becoming more and more popular [12]. There are many types of fieldbuses, among which CAN is the one with the highest frequency and has a good development prospect. Since the emergence of Ethernet, it has received a lot of attention from people. Because the remote interaction capability of Ethernet is very powerful, and it has very fast transmission efficiency, almost all enterprises have applied Ethernet. The transmission speed of the field bus is relatively slow, but in combination with Ethernet, the problem of slow speed can be well overcome. Interconnecting fieldbus and Ethernet has become the primary choice for enterprises to control their systems.

2. Configuration Mode and Construction of Electric Automation System in Power Plant

2.1. Configuration Mode
From the development of electrical monitoring systems in power plants in recent years, it can be found that there are three main types of electrical monitoring systems, which are centralized, remote and fieldbus-based. The design of the centralized monitoring method is not difficult, the system maintenance is more convenient, but the safety performance is low. The centralized monitoring method is to implement all functions by one processor, which will inevitably make the processor produce a lot of work, which seriously affects the operating efficiency of the system. The control area of the remote monitoring mode is reduced, economical is saved, and the configuration is more flexible. Because the transmission speed of fieldbus is relatively slow, and the monitoring field of power plants is also relatively large, this method is generally applied to small departments of power plants. With the continuous application of information technology and fieldbus in the field of electrical monitoring, more and more application experience has been obtained, combined with the continuous improvement of the intelligent level of machinery and equipment, the application time of the network control system is just right. The field bus monitoring method not only has all the advantages of the previous two methods, but can also reduce the use of components, and smart devices can be placed anytime and anywhere, which greatly reduces the workload and saves operating costs. In the fieldbus monitoring method, all equipment and functions are scattered, and they are connected through the network, the network configuration is flexible, and the stability of the system is very high. After the above detailed analysis, it is not difficult for us to know that the fieldbus monitoring method will become the preferred mode of power plants in the future.

2.2. Construction of the Whole Plant Electrical Monitoring System
The electrical automation monitoring system adopts Windows NT as the operating system platform, which has the following characteristics: (1) The closeness with the hardware platform is not strong, the
code can be used directly between different platforms, and the user can freely choose the hardware platform. Users can easily feel the convenience brought by technology, and users are also very safe and reliable in terms of investment. (2) The memory structure of the system has the characteristics of virtualization, and the management method is very orderly. All work is done separately, and the security is very strong. (3) The network function of the system is very powerful, and the information transmission efficiency of the system is very high, which allows users to use various communication methods. All the subsystems of the system are connected through the field bus, this article uses the CAN bus as the bus network. Some system components have limited interfaces, and a converter needs to be configured to ensure the normal function of the subsystem. In order to prevent network failures, the system is connected to dual networks, and the network can be directly switched at will. In this way, when the system encounters a network interruption, another network can be activated to maintain the normal operation of the system. The formulas used in the build process are:

\[ R = \frac{I(u, v)}{\sqrt{H(u, v)}} \]  

Among them, u represents the main system and v represents the subsystem.

2.3. Establishment of Workstation

The operator workstation is mainly used to set and change the operating data of the machinery and equipment. It is equipped with 2 machines, namely the main machine and the auxiliary machine. When the main machine fails, the auxiliary machine is converted to the main machine to work. The operating workstation is mainly used to monitor and process the operating status of the system, such as the recording of work content, the conversion of machinery and equipment, and the management of operating status. The system generally has two operating workstations, one for work and one for standby. The operating workstation greatly improves the control level of the electrical monitoring system, which is of great significance. The telecontrol workstation is mainly used for remote access between the various subsystems, for data input and output between the subsystems, and realizes the overall management of the system. The maintenance workstation is mainly used for maintenance and modification of machinery and equipment, and can also be used for simulation training of maintenance work for staff, and performance training for maintenance work flow. The communication station is used to share information, and use communication technology to realize the interconnection between local area networks, which lays the foundation for the mobile use of machinery and equipment and the real-time access between systems. The formulas used in the creation of the workstation are:

\[ Y = \sum_i |y_i - \sum_j W_{ij}y_j|^2 \]  

Among them, i represents the host and j represents the slave.

3. Electric Automation Monitoring and Management System of Power Plant

3.1. Basic Skills

The electrical automation monitoring system includes 3 kinds of databases, namely real-time database, historical database, and user database. The real-time database is mainly used to update the data in the database, and is updated in real time with the operation of the system to monitor the operation of the machine at any time. The historical database is similar to the historical record function in the browser. It mainly records the past data of the system for a certain period of time and saves and processes relatively important data. The user database mainly serves the user, the data content that the user has browsed will be recorded by the user database. When the user searches for the data next time, he can clearly see the information he has browsed the most times. In terms of database maintenance, the database needs to be protected during the maintenance process, and the data can be browsed and used at any time. The screen display function requires that a series of states of the device can be simulated, such as current and voltage. Operation monitoring and alarm functions are used to deal with the
abnormal conditions of the system. When the voltage, current, value of the system are abnormal, the alarm is handled, and different levels of alarms are carried out according to different degrees. The online calculation function is used to calculate the operating values of the equipment, analyze the efficiency according to the calculation results, and change the operating mode of the equipment in time. The diagnosis and recovery function is used to self-check the system's failures. After finding the specific cause of the failure, the system can perform self-recovery.

3.2. Advanced Application Functions

Management and protection of electrical equipment and automatic device accounts, files, maintenance records, etc. The main system of the monitoring and management system can directly manage the machine equipment of each subsystem, such as the operating parameters of the machine. Voltage reactive power control controls the voltage quality of the system through a voltage regulator. Under normal circumstances, the electrical monitoring system will regard the circuit of the subsystem as the main control object, and the circuit of the main system will be affected by the circuit of each subsystem. However, the direct coordinated control of the subsystem is not very convenient. In order to reduce the influence of the subsystem circuit on the main system circuit, it is necessary to set the subsystem circuit reasonably. This control method is voltage reactive power control. Automatic power generation control is to control the power of the system according to certain requirements. The principle of control is to achieve the purpose of saving economy under the normal operation of the system. Through the operation of different subsystems, reasonable power control of all subsystems is carried out, and the number of equipment of each subsystem, the combination of machinery and equipment, and the voltage distribution of equipment are determined to improve the overall operating efficiency of the system. The automatic power generation control adopts a computer network to control the entire system. Most of the automatic power generation control designs are very simple and the effect is not very good. However, the electrical automation monitoring system can better realize the function of control technology and economy.

3.3. Software Design

Due to the rapid development of self-media technology and computer graphics technology, more and more people are attracted by visualization technology, and scientific researchers have made more in-depth research on visualization technology. The application of visual programming is inseparable from a suitable development environment. Visual C++ is currently the most frequently used integrated environment. Programming in the Visual C++ integrated environment is very convenient, with various types of editing tools, suitable for various types of users, and deeply loved by people. Visual C++ has the following characteristics: (1) Compared with the traditional integrated environment, the editor is more powerful and suitable for more templates. (2) The editor can automatically edit some commonly used codes, not only for viewing documents, but also for creating projects. (3) There are many ways to access the database efficiently. Under normal circumstances, the amount of data that the monitoring system needs to process is huge, and the data needs to be classified, deleted, and saved. There are many ways to save data. You can create a file and save it yourself, save it with the help of software, or save it through a database. It is difficult to share data with self-made files. Although it is more convenient to use software, it has certain security risks. Therefore, it is a relatively good way to save data through a database. This article chooses the Microsoft Access database management system, this system does not need to be programmed, only a simple operation, you can save the data well.

4. System Test

4.1. System Dynamic Module Runtime Test

It can be seen from Table 1 and Figure 1 that when the number of system nodes reaches 1600 points, the response time is 74.3ms, which is lower than the 200ms required by the system and meets the requirements. At the same time, according to the experimental results, the execution time of the
dynamic calculation part is not strictly linear with the increase of the number of nodes. After analysis, it is believed that this is because the real-time database is still in the testing stage and the basic real-time performance of the database is unstable. When there are too many nodes, the interaction time with the dynamic unit increases.

Table 1. Running time of the dynamic module

| Number of nodes | Running time (ms) |
|-----------------|------------------|
| 200             | 9.0              |
| 400             | 9.7              |
| 600             | 10.0             |
| 800             | 14.0             |
| 1000            | 23.5             |
| 1200            | 37.4             |
| 1400            | 54.2             |
| 1600            | 74.3             |

Figure 1. Running time of dynamic module

4.2. System Update Function Test

Table 2. System update function test

| Number of times | Percentage |
|-----------------|------------|
| Update in time  | 77.1%      |
| Slower update   | 17.1%      |
| No update       | 5.7%       |

Figure 2. System update function test

According to Table 2 and Figure 2, we can know that the system's update function was tested 25
times, and the test results showed that: 27 updates were timely, accounting for 77.1%. Six updates are slower, accounting for 17.1%. No update 2 times, accounting for 5.7%. After in-depth analysis of the results that were not updated, it was found that the main system line was caused by the subsystem interference. After the line is adjusted, it can be updated normally. Therefore, there is no problem with the update function of the system.

5. Conclusions
With the continuous development of science and technology and the continuous progress of society, the monitoring system of power plants also needs to be reformed and innovated. The traditional power plant monitoring system is of low level and requires manual operation, which seriously affects the economic benefits of the power plant. In recent years, communication technology has been rapidly developed, network security performance has also been continuously improved, and the level of intelligence of machinery and equipment has also become higher and higher. Based on science and technology, this paper proposes a fieldbus-based system construction based on the traditional power plant monitoring system, and develops an electrical automation monitoring system. Different from the previous design ideas, this article adopts a multi-task real-time operating system, forming an open framework model, making the system more secure and reliable.

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