Optimization Research of Power Supply and Distribution Monitoring System Based on PLC

Xiangjun Qian

1 PetroChina West Pipeline Company, Urumqi, 830013

Abstract: With the continuous development of comprehensive and multi-functional power distribution system, the reliability of power distribution system has higher and higher requirements. Therefore, it is particularly important to strengthen the real-time monitoring of power supply and distribution system. We choose PLC controller as the control core, and build the building automation power supply and distribution platform by matching with frequency converter, sensor and other equipment. We mainly take the district distribution room as the basic research object, design and optimize the monitoring system with automatic detection function. In this paper, S7-300 PLC is used as the core controller. Through the control program design and WinCC monitoring interface, the field monitoring is realized, and the realization of graphics monitoring system is discussed.

1. Introduction
Electricity is not only the premise of realizing the material skills of contemporary human civilization, but also the important power and resources of contemporary industrial management. Through the power supply and distribution skills, we can study the power supply and distribution situation. It plays a vital role in ensuring the smooth operation of enterprise’s production and residents' lives, and in implementing the overall modernization of the national economy. At present, with the rapid development of modern technology, the masses have a more rigorous inspection of power quality and power supply reliability. The control and guarantee system of high-voltage and ultra-high-voltage substations should conform to such a new situation. Therefore, to improve the power grid structure, enhance the power supply strength, stability and integration of automatic control level, will adapt to the increasing needs of the reality of the power industry as the top priority. PLC technology is a key technology in modern industrial automation. The greatest advantage of PLC technology lies in its control performance. Its core is single chip computer. With the continuous development of power system, more attention has been paid to PLC technology. This technology has been used in industrial process automation control as a new type of computer device. According to the analysis of the past technology, some mechanical contact relays cannot meet the requirements of relay protection control at present, so the relevant personnel have carried out continuous research on this issue. At present, PLC technology is used more and more widely in power supply and distribution system, and it also has certain technical support. It is widely welcomed and has broad prospects for development. Traditional control technology cannot play an effective role, the use of PLC technology can continuously improve the reliability and safety of power supply and distribution monitoring system, and has the role of saving resources and improving work efficiency.
2. Concept and functions of power supply and distribution monitoring system
The basic meaning of power supply and distribution monitoring system is to add modern information technology into the traditional power supply and distribution links. In other words, it is to use modern information technology, communication technology and Internet technology to form a modern power supply and distribution monitoring system to assist the work of substation staff, reduce their workload and improve the normal operation of power supply and distribution system. Operational monitoring. In the power supply and distribution monitoring system, strong anti-interference ability of mechanical equipment and intelligent power instrumentation as well as the software configuration for the management of the power supply and distribution monitoring system are also adopted, which basically realizes the monitoring and management of the power supply and distribution monitoring system. The power supply and distribution monitoring system monitor the electrical parameters of the substation in real time. It records every fault and accident in substation indiscriminately. In the face of unexpected accidents, the monitoring system can alarm and warn in time. Distribution monitoring system can be applied to many fields such as medium and low voltage substations, engineering, residential areas, buildings and so on. According to the situation of distribution room in residential area, we should make clear the capacity and quantity of distribution transformers in the current distribution room, and how much power loss will be produced by transformers under normal operation. If there is a change in load, we need to choose the best way, pay attention to ensuring the removal of automatic control transformers and input links, save resources as much as possible, and pay attention to prolongation. In order to save resources, the on-load voltage regulator and capacitor of intelligent control transformer should be switched on and off in the process of monitoring, combining with the basic parameters such as voltage and power, so as to ensure that the minimum power can meet the basic needs of power consumption, once special situations arise in the process of monitoring. If there is a big change in the parameters, the alarm will be given, and the managers can go to the maintenance according to the alarm.

3. Optimization principles of power supply and distribution monitoring system based on PLC
In the optimization process of power supply and distribution monitoring system based on PLC, many factors need to be taken into account, especially in the application process of power supply and distribution monitoring system. In the process of optimization design, we need to consider not only the environment of distribution room, but also the basic problems such as voltage and power. Therefore, we need to meet the control requirements of the system and set up in the actual design, avoid accidents and maintain integrity, in order to ensure more stability in the use of the system. The use of PLC technology not only improves the efficiency of work, but also improves the current situation of power supply and distribution. It scientifically uses the advantages of technology to complete the monitoring of power supply and distribution, and pays attention to the timely analysis and treatment of some abnormal conditions, including parameters, so as to reduce safety risks. Although new technologies are used, this does not mean that resources can be wasted at will. Safety and reliability are the basic requirements of power supply and distribution system. However, due to the complexity of the power supply and distribution network topology, the access of various power systems or equipment will affect the power quality of the power supply and distribution network. The improper operation of some power systems or equipment may lead to a wide range of blackouts. Therefore, in the process of software design, the results of design are required to be simple and practical. This not only meets the needs of the monitoring system to the greatest extent, but also saves a certain amount of cost and avoids the economic losses caused by failure and other situations. No design can be accomplished overnight, so in the process of PLC software design, attention should also be paid to the needs of production development, especially the design link needs to leave some room. We can further improve in the future research process, improve the frequency of software use, expand the scope of use.

4. Hardware optimization of power supply and distribution monitoring system based on PLC
The hardware design of power supply and distribution monitoring system based on PLC mainly needs five parts: S7-300 PLC, which is the core controller of the system. S7-300 PLC is mainly responsible
for the program control of county equipment. It collects the temperature and humidity data of all the machines in the substation, and then transmits them to CPU314C-2DP. Then it needs to call the conversion module FC105, which can convert the module FC105. Enough to convert the output signal of the transmitter into the actual temperature of the temperature analogue, and finally transmit the system's detection data and signals to WinCC, a visual configuration software, for visual display on the PC. S7-300 PLC is a small and medium-sized PLC product owned by Siemens. The power module, CPU module and signal module of this PLC are independent, so its installation mode is flexible and changeable, and the installation mode can be changed in time when a fault occurs in the operation process, which has the characteristics of simplicity and rapidity. The protective starting element is used to open the power supply of the protective trip outlet relay and to start the protective fault processing program. The starting elements of each protection are independent of each other and basically the same. The startup element includes differential current mutation startup element and differential current overshoot startup element. Any startup element operates to protect startup. WinCC, a visual configuration software, is mainly able to facilitate substation staff to understand and master the normal working state of the power supply and distribution system. Its main functions are to realize user rights management, add users and change user passwords, and to display data information such as current, voltage and power completely on the screen. Compared with monitoring slave station, the difference of control slave station is that SM321 and SM322 are configured to monitor the operation of power supply and distribution switchgear on-line by switching input and output. The system is composed of S7-300 PLC distributed I/O and upper computer, and its hardware diagram is shown in Figure 1.

![Hardware diagram of power supply and distribution monitoring system](image)

Figure 1. Hardware diagram of power supply and distribution monitoring system

5. Software optimization of power supply and distribution monitoring system based on PLC

5.1 PLC software optimization

In all Siemens PLC software, S7-300 PLC as a relatively small system, including CPU module, signal module and other independent modules, and in the process of use, these modules can be fixed on the standard track of S7-300 using U-shaped lines. The process of installing the monitoring system in the district distribution room is mainly that the line has a basic understanding of the requirements of the monitoring system in the district distribution room, detects the surrounding environment and humidity, pays attention to the power quality parameters, and then inputs signals according to the requirements of the distribution room, chooses appropriate power supply and communication cables and other hardware equipment. The input and output signals need to be allocated scientifically, and the wiring of hardware circuit should be completed. In order to analyze the basic requirements of the monitoring system of distribution room, and to write the corresponding control program, simulation debugging can be carried out first, and on-line debugging can be carried out after successful debugging. The PC monitoring software developed is connected with the main and standby double PLC system by using the OPC protocol standard. OPC implementation includes two parts: S7-300 PLC monitoring data reading and PC control data writing. When both redundant master and standby PLCs are normal, master S7-300
writes monitoring data into OPC server in real time. OPC client writes data back to the power supply and distribution parameters monitored by users according to the requirements of PC monitoring software and OPC server writing data. Detailed understanding of the district distribution room monitoring system requirements and indicators, analysis of temperature and humidity detection, power quality parameters, distribution equipment action and other monitoring requirements of the input signal and output signal points. According to the actual design requirements, we choose suitable power supply CPU input/output module, communication cable and other hardware. Reasonably assign the address of input/output signal, and complete the wiring of hardware circuit. First of all, we establish the initial interface of the software, set up the main interface of the building automation power supply and distribution system, and set up the definition of variables. By associating animation and graphics with data, the data can be expressed in an intuitive way, and finally the linkage between software, lower computer and field equipment can be completed. The flow chart is shown in Figure 2.

5.2 Graphic monitoring system optimization

The editing of graphics monitoring system can be done by graphics editor. After using the process screen edited by graphics editor, various objects can be set up in the screen. By using the function of dynamic attribute configuration, these objects can be dynamic in the system operation. The image object represents each circuit breaker. The image object connects the display attribute with the process variable indicating the closing or segmenting of the circuit breaker. When the system detects the change of the process variable, it dynamically displays or hides the graphic object. Through this step, the dynamic display of the opening and closing of the corresponding circuit breaker can be realized. Connecting the color attributes of graphic objects with the corresponding process variables representing the voltage and current values can realize a little deduction function of the system. The power data is realized by connecting the I/O domain with the corresponding process variables. Power supply and distribution monitoring system mainly includes user management function, distribution system operation parameters monitoring function, temperature and humidity detection and several major functions in distribution room. Distribution system operation parameters monitoring function is mainly used to monitor the output parameters of the distribution system, such as phase voltage, phase current, line voltage, line current, output power, etc. Alarm warning will be given if the value is too high or too low. Alarm warning will be released only after staff find problems and solve them. User management function can mainly realize administrator login, password modification and adding new users. User management function is one of the means to facilitate management, and it is the function of unified and convenient management of all user information. Temperature and humidity detection and anti-theft alarm function in the distribution room detects the temperature and humidity of various power equipment points in the distribution room through sensors, sends the tested models to the PLC for processing, and transmits them to the upper computer for display. When the detected temperature and humidity value cannot guarantee the normal operation of the equipment, the alarm prompt is issued.
5.3 Human-machine interface design optimization.
In order to better realize data acquisition, configuration monitoring software can be used. This software mainly uses the monitoring layer of automatic control system and software platform. It can not only
realize automatic monitoring, but also be applied in many fields, such as power system, petrochemical industry, etc. to achieve data acquisition and monitoring, which can better meet the needs of industry development. At present, WinCC, Kingview and MCGS are commonly used configuration software. In the process of using, data acquisition and monitoring can be carried out simultaneously. As an important software of Siemens, it not only effectively improves the function of the system, but also provides a more important communication channel, which is more convenient for the communication of S7-300 PLC. In the distribution room in the district, the whole monitoring system is required to include user management, system operation parameters monitoring, temperature and humidity detection and alarm functions. In the process of user management, users need to add, modify passwords and other functions. The monitoring of operation parameters of distribution system is to monitor the voltage, power and other parameters of the whole distribution system in real time so as to avoid abnormal situations and ensure that problems can be solved in time. Especially when managers hear the alarm, they should check it immediately to prevent the situation from getting worse. The detection of humidity and temperature is mainly based on the role of sensors. In the process of detection, signals can be processed and displayed in the process of transmission to the host computer. Humidity and temperature should be kept at a normal level. If there are external conditions, even when the equipment is used, there will be alarm prompts. In addition, there are anti-theft and other basic functions to avoid the influence of uncontrollable factors on the distribution room. WinCC provides functional modules for graphic display, information, archiving and reporting in industry. OPC client, as the interface of data transmission in this system, plays the role of connection and essentially provides an effective channel for variable transmission. In the process of variable upload, the client is used as the "variable register", we display all the defined variables, complete the setting of OPC server and upload the selected variables. The variable transmission channel is shown in Figure 3.

![Figure 3. PLC variable transmission channel](image)

6. Conclusions
With the rapid development of industrial automation, the demand for power system is becoming higher and higher. Therefore, intelligent system equipment and automation design concept have been widely used in power system. This design uses S7-300 PLC for reliable control, which meets the demand of intelligent power supply and distribution system in the future. The system is powerful and easy to control. The application of the visual monitoring interface of the system in the monitoring system of the modern new district distribution house is becoming more and more popular.

References
[1] Żymełka, Piotr, Nabaglo, Daniel, Janda T, et al. Online Monitoring System of Air Distribution in Pulverized Coal-Fired Boiler Based on Numerical Modeling[J]. Archives of Thermodynamics, 2017, 38(4):109-125.
[2] Liu W, Niu S, Huiting X U. Optimal planning of battery energy storage considering reliability benefit and operation strategy in active distribution system[J]. Journal of Modern Power Systems & Clean Energy, 2017, 5(2):177-186.
[3] Lee U J, Kim H R. Development of AN On-site, Rapid, Environmental Radiation-distribution Monitoring System for Decision Making during a Radiation Emergency[J]. Health Physics, 2018, 115(4):422-431.
[4] Liu K, Wang K, Xiaopeng Q I. Reliability evaluation and distribution terminal optimal configuration of power distribution system based on bathtub curve of component failure rate[J]. Dianli Xitong Baohu Yu Kongzhi/power System Protection & Control, 2017, 45(13):49-56.
[5] Shu W, Zhao Y D, Luo F, et al. Stochastic Collaborative Planning of Electric Vehicle Charging Stations and Power Distribution System[J]. IEEE Transactions on Industrial Informatics, 2018, 14(1):321-331.

[6] Reddy M J B, Meyur R, Pal D, et al. An on-line geographical information system–based condition monitoring system for 11-kv distribution line insulator[J]. IEEE Electrical Insulation Magazine, 2017, 33(3):26-32.

[7] Zhang L, Hongdou Y E, Chen X. Transmission and Distribution Pricing Method Based on Peak-load Pricing[J]. Automation of Electric Power Systems, 2017, 41(14):92-98.

[8] Agüero J R. Guest Editorial Special Section on Protection and Real-Time Monitoring of Transmission and Distribution Systems with High Penetration of Distributed Generation and Microgrids[J]. IEEE Transactions on Power Delivery, 2017, 32(1):333-334.

[9] Yu X, Zhang Q, Yang X, et al. Influence of non-uniform hydrophobicity distribution on pollution flashover characteristics of composite insulators[J]. Iet Science Measurement & Technology, 2018, 12(8):1009-1014.

[10] Xie Z S, Zheng Y, Wang A N, et al. Experimental investigation on safety and reliability of ball-eye under bending load in electrical systems[J]. IET Generation Transmission & Distribution, 2018, 12(15):3692-3698.

[11] Liu S, Li J, Wu J, et al. Ultra-high voltage/extra-high voltage transmission-line protection based on longitudinal tapped impedance[J]. Iet Generation Transmission & Distribution, 2017, 11(17):4158-4166.

[12] Zhen W, Bian Q, Xin H, et al. A Distributionally Robust Co-Ordinated Reserve Scheduling Model Considering CVaR-Based Wind Power Reserve Requirements[J]. IEEE Transactions on Sustainable Energy, 2017, 7(2):625-636.