Research on the Architecture of Integrated Platform of Intelligent Substation Auxiliary Monitoring System

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Abstract. For the problems existing in the current substation auxiliary monitoring system, such as various types of equipment, inconsistent standards and poor interaction, the structure design scheme of integrated platform of intelligent substation auxiliary monitoring system is proposed. The structure, function and algorithm of the system are introduced in detail. Firewall isolation technology and security partition technology are adopted to ensure the security of the system, and give consideration to the real-time data transmission. Through the use of software bus technology, multi data fusion technology and interface standardization technology, the availability and reliability of data are effectively improved and the reliability of the system is improved. Combined with the integrated monitoring platform, the characteristics of intelligent linkage technology of main and auxiliary equipment are put forward. The intelligent linkage and unified management between auxiliary equipment is realized, which effectively improves the intelligent operation and maintenance level of substation auxiliary system.

Keywords: Intelligent substation; Auxiliary monitoring system; Integrated platform; Interface standardization; Intelligent linkage.

1. Introduction

The auxiliary monitoring system mainly realizes the functions of condition monitoring and operation management of important equipment in the substation. Therefore, with the promotion of the development strategy of ‘strong smart grid’, it is becoming more and more important in ensuring the safe, reliable and economic operation of the whole power grid. In the newly constructed smart substation, the power sector mainly adopts the ‘five Tele-operation’ technology of ‘Tele-Signaling, Tele-Measuring, Tele-Controlling, Tele-Adjusting and Tele-Viewing’ [1], and combines online monitoring system, lighting control system, fire and fire alarm monitoring system, security system, environmental monitoring system, video monitoring system, SF6 monitoring system, inspection robot and other subsystems to interact. The function of auxiliary system is more and more powerful, and the structure is more and more complex. In order to adapt to the development of substation informatization and intelligence, the substation auxiliary monitoring system is designed according to the functional characteristics of each subsystem and the actual engineering requirements.

Due to the wide variety of equipment in the auxiliary monitoring system, the following problems exist in practical application: (1). Substation equipment, subsystems from different manufacturers, there is no unified data interface. (2). During installation, equipment wiring and conversion devices cannot be managed centrally, resulting in high operation and maintenance costs in the later stage. (3). The information between equipment and subsystems is closed and communication cannot be carried out.
Generally, the alarm signal cannot alarm accurately or on time, and the equipment cannot give full play to its due value. (4). The subsystem generates a large amount of historical data during operation, and processing these needs to consume a lot of time cost and labor cost. (5). When a police situation occurs, regardless of size, usually need to be handled by the personnel of the control center, not only increases the burden of staff, but also can not ensure that emergency events are timely processed. (6). The operation of each equipment and subsystem is often issued by the control center. In order to realize a series of actions, it is often used to send instructions to relevant equipment separately, which is cumbersome and can not be linked.

To solve the above problems, an integrated platform of auxiliary monitoring system based on the third generation intelligent substation is studied to monitor the operation status of important main equipment and the internal and external operation environment of the substation. The linkage between the monitoring equipment and the relevant operating mechanism is required, that is, when the relevant alarm occurs, the relevant equipment can act quickly and accurately to reduce the burden of the staff and ensure the safety of the substation, which depends on running. In the first part of this paper, the monitoring host technology of auxiliary system is studied. According to the power security requirements of the national energy administration, the equipment deployment shall be divided into security zones. The coupling between host program and sub module is reduced by software bus technology, and the system operation efficiency and reliability are improved by multi-source data fusion technology; in the second part, the software architecture of the integrated platform is studied, and the interface between related devices is standardized; the third part studies the integrated monitoring platform, which uses edge computing algorithm for task balancing, and uses diversified display technology to monitor the real-time state of each subsystem, so as to realize the intelligent linkage control between devices.

2. Research on the Host and Subsystems of the Integrated Platform of the Intelligent Substation Auxiliary Monitoring System

As shown in Figure 1., the integrated platform structure of intelligent substation auxiliary monitoring system mainly includes auxiliary equipment monitoring system host, video processing unit, inspection robot server, secure access module, intelligent interface device and other equipment. The local module is expandable, including online monitoring, lighting control, safety precaution, inspection robot, video surveillance and other subsystems. The auxiliary equipment monitoring system host realizes the operation data monitoring, intelligent linkage control, authority configuration management, data storage management and other functions of auxiliary equipment. The video processing unit realizes the functions of industrial camera data acquisition, motion control, video forwarding service and so on.
The inspection robot server realizes the functions of data forwarding and signaling distribution of inspection robot equipment. The intelligent interface device mainly realizes the data acquisition and operation monitoring of each subsystem, and provides information support for the comprehensive monitoring of the substation.

According to the national energy security requirements, different security zones are set up, and the equipment deployment structure is shown in Figure 2. Main equipment monitoring system host is deployed in security zone I, and auxiliary equipment monitoring host is deployed in security zone II according to DL/T 860 specification. Online monitoring, fire protection, security, environmental monitoring system in zone II upload equipment information through the intelligent interface device, and receive main equipment monitoring system linkage information in zone I through the firewall, or using security isolation device to send linkage information to zone IV. The video surveillance host is deployed in the zone IV, and the video surveillance information of the industrial camera in the zone IV. The video linkage between the main and auxiliary equipment is realized by the forward isolation device. The inspection robot host is deployed in zone IV, and the security access module is used to access the substation inspection robot server. Zone II and zone IV achieve information exchange through scheduling data network and integrated data network respectively.

Multi source data fusion technology is used to realize the processing and display of the fecundity data, using the ‘intermediary model’, the key elements include data source, query and feedback, data package, the intermediary. (1). Data source: resulting from the previous level of data after cleaning, with high credibility and accurate. (2). Query and feedback: the query and feedback were performed twice, which were divided into query and feedback between the packet and the data source, and query and feedback between the intermediary and the packet. (3). Data packaging: when a system queries data, it is split and packaged for the required data. Accompanying information such as required labels, addresses, error corrections in data frames enables data from different devices to be integrated into a single package. This transforms one-to-many associations between objects into one-to-one associations, improves the flexibility of the system, and makes the system easy to maintain and expand. (4). Intermediary: The intermediary maintains a virtual data pattern. It queries the wrapped data label and address, combines the data patterns of each data source, reduces the coupling between objects, and makes objects easy to be independently reused at the next level.

3. Integrated Platform Architecture and Interface Standardization Design of Intelligent Substation Auxiliary Monitoring System
The integrated platform architecture of intelligent substation auxiliary monitoring system is shown in Figure 3., which is composed of expression layer, business application layer, public service layer, data processing layer, communication processing layer, operating system layer and hardware layer.

Figure 2. Deployment structure and its secure partition.
(1). The hardware layer includes the main hardware devices such as server host and workstation involved in the operation and monitoring of the system software.

(2). The operating system layer includes the operating system of the server, workstation and other main equipment involved in the software deployment of the auxiliary equipment monitoring system.

(3). The communication processing layer is responsible for protocol analysis and real-time data storage of the received data. The protocol parsing module can parse the data uploaded by different communication protocols for subsequent modules to process; it also supports configuration and analysis of access parameters of DL/T 860 communication.

(4). The data processing layer should include real-time database, maintaining database and historical database: the real-time database is used to store the data with high real-time requirements, and the data resides in the memory for real-time calculation and analysis processing. It can generate data sources with different communication protocols, form a unified real-time data interface, and realize the centralized management, sharing and storage of real-time data. The maintaining database is used to store the configuration data and some business data to ensure the normal operation of the system. The historical database is used to store the historical data of the system for later data analysis.

(5). The public service layer integrates transaction management, configuration management, daily management, authority management, linkage management, time management, database interface, report engine, front-end service, message bus and other related modules to support and complete various business application layer functions.

(6). The business application layer mainly includes online monitoring, environmental monitoring, security precaution, fire control and other applications, and is responsible for the application of the basic management functions of the system.

(7). The expression layer is in charge of the human-computer interaction of the system, supporting the monitoring, operation, system management and other user side applications. It supports the access to the workstation.

**Figure 3.** Software architecture of integrated platform system of intelligent substation auxiliary monitoring system.

**Figure 4.** Display diagram of integrated platform of intelligent substation auxiliary monitoring system.
4. Research on Integrated Platform and Intelligent Linkage Technology of Intelligent Substation Auxiliary Monitoring System

4.1. Research on Integrated Platform

Integrated platform displays data, control, alarm, management and panoramic information on the corresponding panel module in an all-round way through the access of auxiliary system monitoring host. Platform software functions include business applications and advanced applications, as shown in Figure 4. Among them, the business application functions include the whole station overview, video surveillance, lighting control, security, fire protection, environmental monitoring, SF6 monitoring, online monitoring, and lock control modules. Advanced application functions include three-dimensional model, intelligent linkage and video analysis module. The whole station overview realizes the statistical content of three-dimensional map, equipment status, alarm and behavior analysis in substation control system jurisdiction. The home page also has the display function of all real-time warning information windows in substation monitoring system jurisdiction. The video monitoring module realizes the functions of substation video browsing, preset position viewing, and substation historical video access. The lighting control module realizes the real-time status of substation lighting equipment, lighting on/off control and other functions. The security module realizes the functions of real-time status, intrusion warning information and access control management of substation security equipment. The fire module realizes the information collection, access and display function of substation fire equipment. The environmental monitoring module monitors the real-time state of environmental temperature, humidity and harmful gas concentration in substation, and controls the start and stop of air conditioning equipment. SF6 monitoring realizes the real-time monitoring function of SF6 gas concentration and oxygen concentration in substation GIS room. The online monitoring module can monitor the operation data information of the primary key equipment of the substation through the online monitoring equipment, and provide data for the primary equipment fault judgment. The three-dimensional model display module realizes the three-dimensional display function of the data signal in the substation through the overall modeling of the substation, integrates video and robot images, and completes the panoramic display function of the substation scene from the three-dimensional perspective. The intelligent linkage module can trigger the main equipment signal to check the auxiliary equipment online, and realize the integration and cooperation between the auxiliary equipment.

4.2. Linkage Technology

The linkage between auxiliary equipment is a comprehensive technology. The intelligent linkage proposed in this paper has four characteristics: (1). The linkage scheme under IETF intelligent management strategy is adopted, and the linkage action can be developed according to the requirements of main and auxiliary equipment; (2). The intelligent linkage between main and auxiliary equipment is realized by automatic control command after being determined by the system; (3). It has visual logic configuration technology, convenient and intelligent configuration of the required linkage strategy scheme. (4). With intelligent linkage exception handling mechanism, it can filter invalid and illegal linkage requests, and the linkage is more reliable. Intelligent linkage includes the linkage between auxiliary equipment and the linkage between main and auxiliary equipment. The intelligent linkage management strategy meets the following requirements: (1). It has the function of remote preset signal linkage of main equipment. (2). It supports the function of expanding signal linkage of main equipment. (3). It supports the function of alarm linkage of main equipment monitoring system. According to the functions of relevant subsystems, the linkage between auxiliary equipment can be divided into: intrusion alarm linkage of security system, fire alarm linkage of fire protection system, alarm linkage of environmental monitoring out of limit, SF6 monitoring concentration out of limit linkage, inspection robot alarm linkage, online monitoring system linkage, video monitoring linkage, access control management linkage and auxiliary lighting linkage.
5. Conclusion
This paper studies the architecture and interface standardization, auxiliary system monitoring host, auxiliary equipment remote control and intelligent linkage and other technologies in the substation auxiliary equipment monitoring system. A set of integrated platform structure design for the intelligent substation auxiliary monitoring system featuring simple structure, strong scalability and network security is proposed. A unified protocol and interface standard for auxiliary equipment monitoring system are established, and data fusion technology is used to improve the reliability of data. Through the research on the integrated platform and intelligent linkage technology of intelligent substation auxiliary monitoring system, the status monitoring, operation control and intelligent linkage among substation auxiliary subsystems are realized, and the intelligent operation and maintenance level of substation auxiliary system is effectively improved.

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