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Research on Secondary System of Smart Substation

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Abstract. This article has completely analyzed and introduced the intelligent substation secondary system. Firstly, the structure of the "three-tier and two-network" of the secondary system of the smart substation is introduced, and the concepts of "three-tier" and "two-network" are described in detail. Secondly, according to the three classifications of "station control layer", "space layer" and "process layer", the configuration and related requirements of the secondary equipment of the smart substation under different voltage levels are introduced in detail. Finally, the network structure of the secondary system of the smart substation is introduced, and the IEC 61850 system and the smart substation network structure are described in detail.

1. Introduction

Substation electrical equipment is divided into primary equipment and secondary equipment. Primary equipment constitutes the main body of the power system and is directly responsible for the production, transportation and distribution of electrical energy [1]. The primary system consists of the primary equipment and its interconnected electrical circuits. Secondary equipment is equipment that controls, regulates, protects, and monitors primary equipment. The system of secondary equipment and its interconnected electrical circuits is called a secondary system. The secondary system is an important guarantee for the safe production, economic operation and reliable power supply of the power system. The contents of the secondary system include: transformer secondary circuits, control systems, signal systems, measurement systems, synchronization systems, protection systems, and DC systems. The emergence of smart substations has made the primary and secondary equipment more closely linked to each other to some degree, and is no longer as clearly differentiated as traditional substations [2].

The relay protection equipment belongs to the secondary equipment and is an important guarantee for ensuring the safety of the primary equipment operation. Relay protection system is an important part of the secondary system, its main role is to obtain a variety of signal and measurement parameters of the primary equipment, remote control operation of the primary equipment, automatically cut off the isolation fault or monitor and the on-duty operator issues an alarm signal. Relay protection devices do not completely prevent the occurrence of faults, but they can control the impact of the fault to a minimum [3].

2. The structure of secondary system of smart substation

The secondary system of the smart substation adopts the “three-tier, two-network” structure. The "three layers" refers to the station control layer, the bay layer, and the process layer. The "two networks" refers to the station control layer network and the process layer network.

The station control layer is composed of a host and operator station, a telecontrol communication device, a network communication record analysis system and other various secondary functional stations, and provides a man-machine contact interface for the operating personnel in the substation. The station control layer realizes the monitoring, control, alarming, and information exchange of the entire station, including the bay level equipment and the process level equipment, and collects and manages the related electrical quantity parameters, protection signals, and operation information. It is the monitoring and control center of the entire smart substation. , And is responsible for communication with the remote control center, upload all the information required by the control center.

The spacer layer is generally composed of secondary devices such as a system measurement and control device, an energy metering device, a relay protection device, and a centralized processing device. The spacer device can collect data of one interval and can affect the operation of the primary device of the interval, and realize the transmission of data signals and control signals with the remote ports. The separation layer composed of several secondary subsystems has a certain degree of independence, and even in the case of losing connection with the network of the station control layer, the normal operation of the on-site monitoring function of the bay level equipment can still be guaranteed [4].

The process level includes primary devices such as main transformers, switches, switches, current transformers and voltage transformers, as well as smart units and smart terminals associated with these devices. Compared with conventional substations, the most obvious change in the structure of smart substations is the emergence of the process layer. The process layer connects the primary device and the secondary device through intelligent components, intelligent terminals and merging units. Its main role is to assist and support primary devices, electronic transformers, merging units, intelligent terminals, on-line monitoring devices and related Auxiliary equipment acts on functions related to primary equipment, such as collecting and sending real-time operating data, monitoring and managing equipment operating status, and receiving and executing remote control commands.

There are "two networks" between the "three levels." The station control layer network is a manufacturing message specification network between the station control layer and the bay layer; the process layer network is a network between the bay layer and the process layer including the sampled value network and the object-oriented substation general event network.

The MMS specification regulates the communication behavior of intelligent sensors, intelligent electronic devices, and intelligent control devices that have communication capabilities in the industrial field, and enables interoperability between devices from different manufacturers. The substation is mainly used to protect the communication between the secondary equipment such as the measurement and control device and the communication management machine (master control unit).

Sampled value (SV) messages and GOOSE messages for general purpose objects are two types of messages defined in IEC 61850, which are used to transmit sample values and trip commands, respectively. In the communication of the substation process network, sampling measurement values and trip commands are the two most important types of data. SV refers to the related model objects and services that exchange sampled values in sampled data sets based on publish/subscribe mechanisms, and the mapping between these model objects and services to ISO/IEC 8802-3 frames. Currently, the sampling value transmission protocols specified in IEC61850 are IEC61850-9-I and IEC61850-9-2. GOOSE (Generic Object Oriented Substation Event) refers to a substation event-oriented generic object service that supports the exchange of public data organized by a data set and is mainly used to implement a locking function for protection functions among a plurality of protection-enabled IEDs [5]. And trip. Smart substation secondary system structure diagram shown in Figure 1.

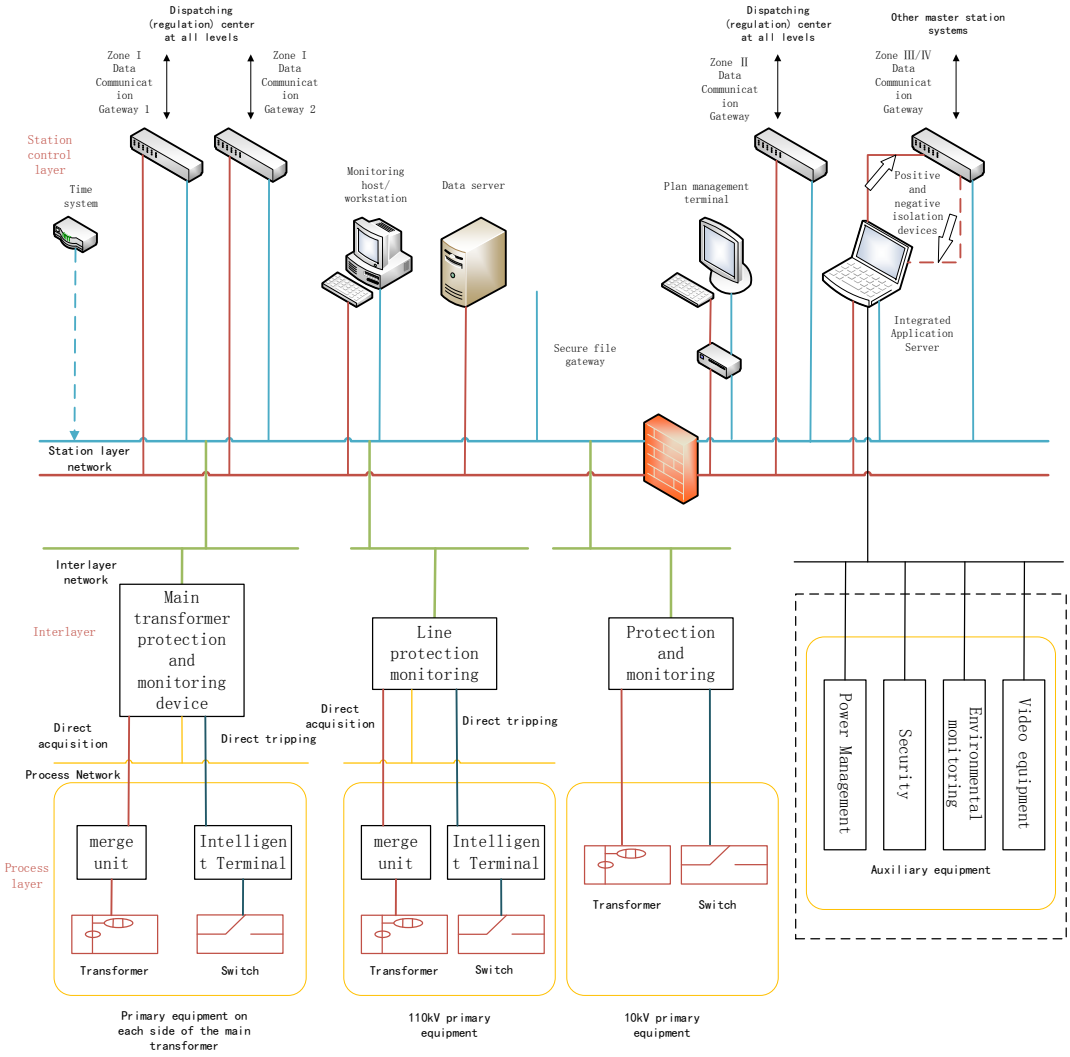

Figure 1. Smart substation secondary system structure diagram.

3. Smart Substation Secondary System Equipment Configuration

According to Figure 1, it can be seen that the secondary system equipment of the smart substation is divided into three layers of station control layer, bay layer and process layer in terms of logic function. Each layer of equipment has related configuration requirements. Different voltage levels, the requirements of the secondary system equipment configuration are not the same. In 2009, the State Grid Corporation of China issued the relevant provisions of the "110 (66) kV~220kV Smart Substation Design Specification", and made clear requirements for the equipment configuration of each voltage class.

3.1. Station control equipment

The station control layer equipment includes host and operator workstations, telecontrol communication devices, network communication record analysis systems and other various secondary functional devices.

The host and operator workstations provide an intuitive and convenient human-machine interface for on-site operators. This man-machine interface is supported by the entire substation automation system. Its system configuration should meet the needs of the automation system within the station and good operational performance requirements. It should be able to adapt to the planned capacity of

the smart substation and be able to manage related information such as protection information and fault information. Features. In addition, the host-operator workstation should also meet the requirements for communication with the control center, and upload various information collected and processed at the site according to the requirements of the control center. The 220kV smart substation of the host and operator workstation should be configured in double sets and can be configured as a single set in the 110kV smart substation.

3.2. Spacer equipment

Spacer equipment includes measurement and control devices, protection devices, energy metering devices, centralized processing devices, and other smart interface devices. The 220kV smart substation and the 110kV smart substation are basically the same in the configuration requirements of the bay equipment. Therefore, this article will not be separately described here.

3.3. Process layer equipment

Process level equipment generally includes equipment such as transformers, merging units and smart units. The difference between the 220kV smart substation and the 110kV smart substation is not different from that of the process layer equipment. The only difference is that the process layer equipment of the 220kV smart substation is generally double-set configuration, while 110kV is a single set.

The main principle of transformer configuration is to take into account both economical and technological advancement. Compared with traditional transformers, electronic transformers have the advantages of small volume, strong anti-saturation ability, and good linearity, which can avoid the inherent inductivity of traditional transformers such as ferromagnetic resonance, explosion of insulating oil, leakage of sulfur hexafluoride, and high voltage risk caused by CT disconnection. At high voltage levels, it has obvious economic advantages compared with traditional transformers. In addition, compared to conventional transformers, electronic transformers have greater advantages in terms of insulation performance, volume, weight, and saturation resistance, and the higher the voltage level, the more obvious the advantages of electronic transformers. Table 1 lists the advantages and disadvantages of the electronic transformer and conventional transformer in terms of insulation, volume and weight, CT dynamic range, PT resonance, CT secondary output, and output format.

Table 1. Comparison between conventional and electronic transformers.

Compare items	Conventional transformer	electronic transformers
Insulation	Complex	Simple
Volume and weight	Large and heavy	Small and light
CT dynamic range	Small range, magnetic saturation	Wide range, no magnetic saturation
PT resonance	Easy to generate ferromagnetic resonance	No resonance
CT secondary output	Can not open circuit	Can open circuit
Output form	Analog output	Digital output, high precision

4. Intelligent substation secondary system network structure

4.1. IEC61850 standard

In order to realize the three major functions of monitoring, remote operation and relay protection required by the substation automation system, the IEC 61850 divides the substation communication system from the logical level and the physical concept level into three levels: the substation layer, the bay layer and the process layer, and The definition of the communication interface between the various layers is given. This is the concept of information layering in the IEC 61850 standard.

The characteristics of the IEC61850 standard are shown in Figure 2:

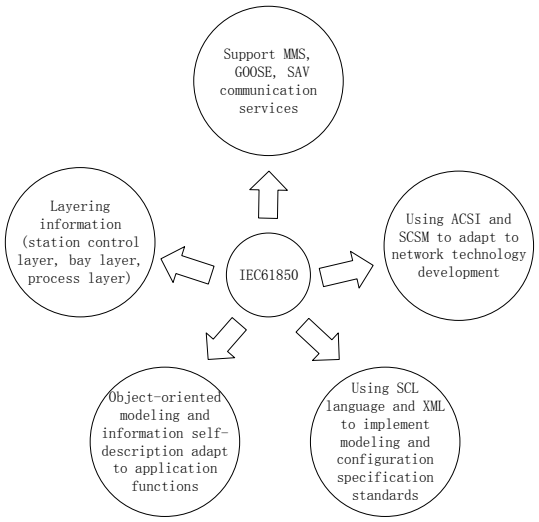

Figure 2. IEC61850 standard features.

4.2. Smart Substation Network Structure

Smart devices should be further interconnected and interoperable, supporting the adoption of system-level operational control strategies. The network architecture adopted by the intelligent substation automation system should be reasonable and Ethernet and ring networks can be adopted. The network of the whole station should adopt the high-speed Ethernet to make up, can divide into station control layer network, interval layer network and process layer network. The station-level network, bay-level network, and process-level network should be relatively independent and reduce their mutual influence.

5. Conclusion

The secondary system of the smart substation utilizes optical fiber and network to form a high-speed network communication mode, which makes the connection between the various systems within the station more compact and the data exchange more secure and reliable. The information of the primary device is first collected by the intelligent terminal through a cable or optical fiber network, and then enters the merging unit through the optical fiber network. Various reliable data and electrical quantities are transmitted by the merging unit to the relay protection device. High-quality, accurate signals and electrical quantities are the guarantees for the correct judgment and operation of relay protection equipment. Therefore, a perfect secondary system is the basis for the normal operation of relay protection equipment in smart substations.

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