Research and Implementation of Automatic Configuration Method for Monitoring Information Table of Smart Substation Equipment

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Abstract. Aiming at the problems of low efficiency and difficult configuration of equipment monitoring information in smart substation, an automatic generation method of substation monitoring information table is proposed. By analyzing the configuration file of smart substation, the information of primary and secondary equipment is obtained, and the full model of equipment monitoring information table can be established automatically. According to the classification characteristics of the standard monitoring template, the equipment monitoring information table is automatically generated by association mapping with the monitoring template.

1. Introduction
With the development of unattended substation construction in State Grid Corporation of China, more and more information is required to be collected and sent to the monitoring centres from substations. The state grid dispatching centre has successively issued a series of standards, which regulated the requirements of substation signal access at various voltage levels, and defined the meaning and level of signal alarm. With the increasing of substation equipment monitoring information, the configuration and management of substation monitoring information is becoming more and more difficult [1].

Substation equipment monitoring information mainly includes four categories: telesignal, telemetry, telecontrol and teleregulation. There are a lot of signals within the monitoring information, especially tens of thousands of telesignal monitoring information. In the design stage, the monitoring information is generated by the designer. There are lots of problems such as low design efficiency, low fault tolerance, long design cycle and difficult version management by this method.

Based on the problems, this paper proposes an automatic configuration method of equipment monitoring information table in smart substation. According to the standardized monitoring information, the standard monitoring template is generated. The primary and secondary equipment in SCD model file is analyzed, and the equipment monitoring information table model is automatically established, and the monitoring information table is automatically generated by associating the standard monitoring template and intelligent electronic device instance configuration file.
2. The scheme ideas

According to "QGDW11398-2015 Substation equipment monitoring information specification", the standard monitoring template corresponding to the equipment can be edited and generated, and divided into the following types: GIS, transformer protection, circuit breaker, switch, line protection, bus protection, stability control device, DC system, other equipment, etc.

The SCD model file is analyzed to obtain the information of primary and secondary equipment, and the full model of monitoring information table is established by voltage level, interval and equipment type. In the whole model, the primary and secondary equipments are automatically associated and mapped to the same type of standard monitoring template.

The whole model of the monitoring information table contains the device name. According to the device name, the corresponding ICD file can be automatically identified and the mapping relationship can be established.

3. The Key Technologies and Implementation

3.1. The standard monitoring template

The basis of smart substation monitoring information table configuration is standard monitoring template. This section not only proposes multi template editing of monitoring information, but also adds monitoring template verification and template intelligent merging.

The standard monitoring template generates different template files according to the equipment type, and the name of the template file is named by the equipment type. The standard monitoring template proposed in this section is the basis for automatic generation of substation monitoring information table. According to the specification, the monitoring entry information is extracted and structured to generate the standard monitoring information template. Table 1 is the partial screenshot of the national dispatching standard transmission line equipment monitoring information entry.

| Sequence number | Information name                                      | Alarm class | Station end description       | Remarks   |
|-----------------|------------------------------------------------------|-------------|-------------------------------|-----------|
| 1               | 220kV XX Line Active Power                           | Over-limit  | 220kV XX Line Active Power    | None      |
| 2               | 220kV XX Line Reactive Power                         | Over-limit  | 220kV XX Line Reactive Power  | None      |
| 3               | 220kV XX Line A Phase Current                        | Over-limit  | 220kV XX Line A Phase Current | None      |

The configuration model of standard monitoring template is classified by equipment type, and different templates are generated by configuration respectively, as shown in figure 1. The standard monitoring template is displayed in a tree list.
3.2. Monitoring information table modeling

The main elements needed for configuration of monitoring information table are: voltage level, bay type, equipment name, design drawing information, point number, information classification, dispatching information, etc. In this section, a monitoring information table model is proposed, which is represented by a tree structure.

The voltage levels in the monitoring information model include 750kV, 500kV, 220kV, 110KV, 66kV, 35kV, 10kV. The bay types are divided into main transformer, HVS of main transformer, MVS of main transformer, LVS of main transformer, line bay, bus coupler bay, bus section bay, bus bar bay, capacitor bay, reactor bay, substation transformer bay, arc suppression coil, small current grounding, station power, DC system, common bay, etc. The type of primary and secondary equipment with voltage level and bay information provides a method for automatic association of point table model with standard monitoring template, as well as the possibility of automatic matching of monitoring information with ICD file [2~3]. Figure 2 shows the whole model of monitoring information table. The whole model includes the main properties and configuration methods of monitoring information table configuration.
3.3. Monitoring information associated with ICD file

The smart substation monitoring information table model contains design drawing information, which can be automatically obtained from the configured SCD file. The design drawing information can be obtained automatically by associating the specific channel in the configuration file. The monitoring template contains the station side information description, which identifies the station side information to be associated with the current monitoring information, that is, the channel information in the ICD file. Finding the station side information association mapping is the basis for generating the monitoring information table. If the station side information in the monitoring template cannot be found the corresponding signal association in the current application project configuration file, the signal can be considered not applicable to the current project, and the signal should be deleted from the generated final monitoring information table. Station information description is the basis of automatic association of monitoring information with ICD files.

Obtain the names of primary and secondary equipment of monitoring information, automatically search the corresponding ICD file, and according to IEC61850 standard, the relevant information of ICD is arranged according to the hierarchical relationship of access point, logical device, logical node, data set, data object, etc. It is shown as a tree diagram, as shown in Figure 3. After the ICD file is associated, the channel description in the ICD data set is searched and compared with the station information description in the monitoring information. If it is consistent, the channel identification will be recorded in the corresponding information of the current monitoring information design drawing, and the matching is completed.

The matching of monitoring information and ICD supports manual mode, so as to handle special cases. In figure 3, the corresponding information of ICD is shown in tree form to facilitate manual association. The automatic and manual matching mode of monitoring information and ICD file ensures the integrity of matching.

3.4. Automatic associated monitoring template for primary and secondary equipment

The generation of standard monitoring template and the establishment of substation monitoring information table model provide a method for smart substation monitoring information table configuration generation. The voltage level, bay, equipment and other substation instance information contained in the model are indispensable information in the monitoring information table. The equipment in the point table model can establish association with the monitoring template according to the equipment type, and automatically obtain the telecontrol, telesignal, teleregulation, telemetry and other information in the standard monitoring template [4–5].

Analyze the SCD configuration model file to obtain the primary and secondary equipment information in SCD configuration model file, including voltage level, bay name, device name, etc [6–7]. Since the standard monitoring template files corresponding to primary and secondary equipment are generated by equipment type classification, the corresponding standard monitoring template files of corresponding types can be automatically associated with primary and secondary equipment according to equipment type and device name. The primary and secondary devices and monitoring templates can also support manual association.

4. The system design

The overall configuration architecture of smart substation equipment monitoring information table is shown in figure 3, which mainly includes monitoring information table design unit and monitoring information table management unit module.

750kV Xiazhou substation monitoring information table configuration using this research and development system. The system operation flow chart is shown in figure 4, the specific configuration process is described in detail below.
4.1. The design unit of monitoring information point table

The design unit of monitoring information point table mainly realizes the configuration generation of monitoring information table. The functions include: standard monitoring template generation module, point table model and monitoring template automatic mapping module, monitoring information table modeling module, SCD model file configuration module, monitoring information and ICD automatic mapping module, monitoring information table verification module.

4.1.1. Point table model and monitoring template automatic mapping module. The automatic mapping module of point table model and monitoring template provides automatic and manual association of monitoring information table model with monitoring template. The monitoring information table model is displayed in the form of tree and table, and the monitoring information content is edited.

4.1.2. Monitoring information table modeling module. Monitoring information table modeling module is mainly to establish monitoring information table model, according to SCD model file, obtain voltage level, bay, equipment and monitoring information, etc. It can automatically generate monitoring information point table model.

4.1.3. SCD model file configuration module. SCD model file configuration module is mainly based on IEC61850 object-oriented modeling idea to establish the whole model SCD configuration file, mainly including primary equipment modeling, secondary equipment modeling, primary and secondary equipment association modeling, etc.

4.1.4. Monitoring information and ICD automatic mapping module. The automatic mapping module of monitoring information and ICD mainly realizes the automatic matching of instantiated monitoring information with ICD files. At the same time, it can support manual dragging. The content of ICD file is displayed in tree form, which is convenient for matching with monitoring information.

4.1.5. Check module of monitoring information table. The verification module of monitoring information table mainly checks the integrity, repeatability and correctness of the generated monitoring information table entry information, and displays the verification results in the form of table.

4.2. The management unit of monitoring information table

The management unit of monitoring information table mainly includes point table management module and version management module.

4.2.1. The management module of point table. The management module of point table is mainly used to manage the information of monitoring information table. In this interface, the verification status can be confirmed manually, and the information such as the verifier and check time can be filled in automatically, and the check information can be counted in the status column of the interface.
4.2.2. The version management module. The version management module is mainly used to manage the version of the monitoring information table. It supports import, deletion and other operations. At the same time, the monitoring information of different versions can be compared in this interface.

5. Field application
The system has participated in the design and use of equipment monitoring information table in 750kV Xiazhou Substation and other substations. Through field feedback, it greatly improves the configuration efficiency of monitoring information table, shortens the design cycle of substation equipment monitoring information and the debugging period of equipment monitoring information.

![System operation process chart](image)

Figure 4. System operation process chart

750kV Xiazhou substation monitoring information table configuration using this research and development system, the specific configuration process is described in detail below.

According to the design method of monitoring template in this paper, the standard monitoring information template can be generated by adding monitoring information items and editing the attribute information of monitoring information elements according to the specification. Enter the monitoring information table design interface, select the SCD model file corresponding to the smart substation, analyze the corresponding information in the file, and automatically generate the monitoring information table model. The system will automatically find the corresponding ICD and establish association according to the currently selected equipment. Drag the ICD content displayed in the tree to the point table model to realize the association by manual if any mistake is found after automatically association. At this point, the configuration of the monitoring information table is completed.

Click the self check button to automatically check the current monitoring information table, as shown in figure 5. The interface for display and check results of monitoring point table is shown.

![Monitoring information table generation and verification display](image)

Figure 5. Monitoring information table generation and verification display
6. Conclusion

In this paper, through the analysis and research on the current situation of smart substation monitoring information table configuration, a method of automatic configuration of monitoring information table is proposed, and based on this, the smart substation equipment monitoring information table configuration system is developed. The standard monitoring template library of this system makes it possible to reuse the standard monitoring template. The automatic matching generation and verification of monitoring information table solves the problems of long time-consuming, complex configuration and error prone of traditional manual configuration of monitoring information table. Point table management and version management solve the problem of point table management of substation monitoring information in the past. The smart substation monitoring information table automatic generation system developed in this paper can be widely used in substation design, commissioning, acceptance and other fields, improve the efficiency of substation equipment monitoring information design, and ensure the reliability of substation monitoring information debugging and acceptance. At the same time, it provides the possibility of automatic transmission test of monitoring information and has a high application prospect.

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