The Data Sharing Platform System of Electrical Main Wiring Based on the Results of 3D Digital GIM

Na Qin *, Zheng Tang, Yuqiang Wang
Taiyuan Power Supply Company of State Grid Shanxi Electric Power Company

*Corresponding author e-mail: qinna@sgcc.com.cn

Abstract. The main wiring design is the key to the design of the substation system. It is the process of establishing the logic model of the entire substation. Through the digital design of the main wiring, the whole process of digitization from equipment information to the logic model of the substation and even the layout model of the substation is realized. At the same time, it is a real digital handover Provide the basis. Aiming at the problems of automatic generation and verification, release and query, update and management of the main wiring diagram of the power grid, based on the relevant software of the PMS system, a design method of the integrated drawing management system combining C/S and B/S is presented. Realize the complete synchronization update of the electrical main wiring drawing of the dispatch centre. After the automatic generation and verification system of the main wiring diagram of the power grid was put into operation in the Guangdong Power Grid, it effectively improved the drawing speed, accuracy and standardization of the drawing.

Key words: 3D digitization, GIM, electrical main wiring data, data sharing platform.

1. Introduction
In January 2019, the State Grid Corporation of China proposed the goal of building a "three types and two networks" at the two sessions. The construction of the ubiquitous power Internet of Things is an important content and key link to promote the construction of the "three types and two networks". The State Grid Corporation of China has clearly proposed to carry out digital three-dimensional design of power transmission and transformation projects, as the leading stage of the whole life cycle of power transmission and transformation projects, to accumulate basic digital data for power transmission and transformation projects, and to achieve "a source of data and a map of the power grid". The ubiquitous power Internet of Things construction goal of "one line of business" is of great significance.

At present, the main electrical wiring design method in the design stage and the electrical main wiring drawing method of the PMS platform are all integrated, which directly leads to the repeated drawing of the electrical main wiring on the 3D design platform and the PMS platform, resulting in a waste of time and resources [1]. If the main wiring data conversion interface can be directly established between the 3D design platform and the PMS platform, the sharing of the main wiring data between the 3D design platform and the PMS platform can be formed, and the main wiring drawing work of the PMS platform will be omitted, and labour will be saved.
The thesis closely follows the requirements of the State Grid Corporation of 3D digital design, in line with the original intention of maintaining data uniformity and saving labour costs, making full use of the digital design GIM results, and improving the GIM standard format to realize the conversion of the main wiring results at the design stage into the GIM format. Transfer the results to the subsequent operation and maintenance stage [2]. Through the analysis of the GIM format, they are directly converted into the main operation and maintenance wiring diagram, and the correct transmission of data information is ensured to realize "the main wiring data is one source" and better serve the follow-up Operation and maintenance.

2. Overall system design

2.1. Overall structure
The digital design results of the main wiring that need to interact between the substation three-dimensional design platform and the PMS system include engineering information, system interval information, equipment classification and attribute information, and main wiring diagram information. The main wiring diagram information needs to include the name, type, location of the equipment legend, and the end coordinates of the wires and bus bars. The position of the equipment legend and the end points of the wires and bus bars need to form a connection relationship for drawing the main wiring diagram.

The GIM specification format covers and expands the content that the two systems need to interact. The GIM specification format file is selected as the structured carrier of the digital main wiring design results. The project entry cbm and the first three levels of cbm format files in the project model list are fully described [3]. Engineering and system interval information. The 4th and 5th level cbm format files describe the engineering characteristics of the main equipment and sub-equipment respectively. The dev format file describes the equipment classification and attribute information of the three-dimensional physical model. The sch format file describes the main wiring design of the logical model. The file reference structure is shown in Figure 1 below:

![Figure 1. File reference structure](image)
The physical model of the three-dimensional design and the logic model of the main wiring design are correlated and searched through the equipment KKS code, so that the engineering characteristics and equipment attributes of the equipment legend can be determined; the physical ID number is also derived through the engineering attributes of the equipment, and the engineering attributes of the equipment include period, Information such as phase, equipment KKS code, physical ID number, etc.; the longitude and latitude coordinates of the station building wall are output through the attributes of the project entry cbm file of the extended engineering model list.

3D design platform related software vendors developed and exported a unified interaction specification format GIM file interface containing the main wiring design results; PMS system related software vendors developed the GIM file import interface according to the unified interaction specification, and parsed the imported GIM file to form what the PMS system needs the main wiring diagram is shown in Figure 2.

![Figure 2. The main wiring diagram formation process](image)

The system adopts a hierarchical and modular design concept, provides dozens of functional modules, and provides effective information processing methods for the grid company's drawing generation and drawing management business. The system deployment is shown in Figure 3.

![Figure 3. System deployment](image)
2.2. Functional design
The main wiring diagram of the primary equipment refers to the voltage level adopted by the power station and the substation, and the incoming and outgoing line status of each voltage. It must reflect the voltage level of the factory station and the incoming and outgoing line status of each voltage. Therefore, related graphics elements are added to conventional drawing software to provide standard component graphics objects and improve drawing efficiency [4]. In addition, the numbers of various graphic elements and lines in the main wiring diagram of the equipment must meet industry standards and naming rules, and can be automatically generated and filled in with the drawing process. The generated drawings need to be strictly reviewed before they can be archived, and submitted to the corresponding library in a certain format for later review and use. The system includes the following main functional modules.

2.2.1. Graphic element editing. Embedded programs that can draw busbars, switches, incoming and outgoing wires, transformers, circuit breakers, isolating switches, etc., can be embedded in AutoCAD, and the required graphic elements can be expanded by themselves.

2.2.2. Graphics are drawn quickly. The drawn graphic elements are saved in the graphic element library and automatically added to the AutoCAD graphic objects. When drawing the main wiring diagram, you can directly drag the "component" graphic to the corresponding position.

2.2.3. Drawing template. Express the main wiring type, outgoing branch, transformer branch, numbering and other rules of the plant station as a program-implementable rule. Following the rules can roughly determine the basic structure of the plant station’s wiring diagram, and the positioning of the remaining components can be based on this. According to the strong regularity of the outgoing branch and transformer branch [5]. Sort out various rules, according to the essential characteristics that the structure of the primary main wiring diagram is mainly determined by the number of busbars and circuit breakers, the main drawing template is given, and the number of the subsequent manual editing part is automatically matched.

2.2.4. Workflow control. Realize the integration and process management of electrical drawings from entry, drawing to review, approval, and filing.

2.2.5. Report and release. The archived drawings are uploaded to the server, managed and released in a unified way through the Web, and form a synchronization interface for equipment management.

2.2.6. Drawing query. It provides global drawing search and query services via Web, and has functions such as format conversion, local saving and printing.

3. Implementation of electrical main line data sharing platform system
Based on the results of the above investigation and analysis of the output and input differences and requirements of the two systems, the graphical symbols, data, and connection relationships of the main wiring diagrams of the two systems are unified, and the GIM specifications are selected and expanded, and a unified interaction specification is finally formulated. PMS system related software vendors develop and complete the GIM file import interface according to the unified interaction specification, and analyse the imported GIM file to form the main wiring diagram required by the PMS system for display and subsequent use. Relying on the project to complete the test, and constantly adjust and optimize the import and export interfaces of the systems of both parties based on the test results. After the project is completed, a research report will be formed [6]. The paper selects the "University Park" project as the pilot project, perfects the design modelling according to the GIM specification, and exports the GIM results of the main wiring of the 3D design system of the real project. The main wiring design example diagram of the 3D design platform is shown in Figure 4 below:
4. System reliability verification

According to the general equipment operating statistics provided in Table 1, the reliability data of the equipment unit without considering the existence of the equipment overhaul status (Table 2) and considering the existence of the equipment overhaul status (Table 3) are respectively calculated. If only considering the two states of the component in normal operation and failure, the probability of the equipment in normal operation and failure state can be calculated respectively. The calculation formula is:

\[ P_0 = \frac{\lambda}{\lambda + \mu} \]

\[ P_1 = \frac{\mu}{\lambda + \mu} \]

In the formula, \( P_0 \) represents the probability of a normal working state; \( P_1 \) represents the probability of a fault state. If the influence of the overhaul status is included, the calculation formula for the probability of the equipment being in normal operation, failure or overhaul status is:

\[ P_0 = \frac{\mu_1 \mu_2}{\mu_1 \mu_2 + \lambda_1 \mu_2 + \lambda_2 \mu_1} \]

\[ P_1 = \frac{\lambda_1 \mu_2}{\mu_1 \mu_2 + \lambda_1 \mu_2 + \lambda_2 \mu_1} \]

\[ P_2 = \frac{\lambda_2 \mu_1}{\mu_1 \mu_2 + \lambda_1 \mu_2 + \lambda_2 \mu_1} \]

In the formula, \( P_2 \) represents the probability of overhaul status.
Table 1. Equipment reliability data

| Equipment                     | GIS bus | Overhead lines | 500 kV circuit breaker | Transformer | Generator |
|-------------------------------|---------|----------------|------------------------|-------------|-----------|
| Failure rate/time·year⁻¹      | 0.015   | 0.25           | 0.04                   | 0.021       | 1.5       |
| Repair time/h                 | 20      | 16             | 160                    | 300         | 73        |
| Repair rate/time·year⁻¹       | 438     | 547.5          | 54.75                  | 29.2        | 120       |
| Inspection rate/time·year⁻¹   | 0.2     | 0.5            | 0.2                    | 0.2         | 1         |
| Inspection time/h             | 12      | 24             | 400                    | 160         | 280       |
| Inspection and repair rate    | 730     | 365            | 21.9                   | 54.75       | 31.2857   |

Table 2. Probability of normal operation and failure of system equipment of the state component model

| Equipment                     | Probability of normal work | Probability of failure |
|-------------------------------|----------------------------|------------------------|
| GIS bus                       | 0.999966                   | 3.42454x10⁻5           |
| Overhead lines                | 0.999544                   | 4.56413x10⁻4           |
| 500 kV circuit breaker        | 0.999270                   | 7.30060x10⁻4           |
| Transformer                   | 0.999281                   | 7.18661x10⁻4           |
| Generator                     | 0.987654                   | 0.012346               |

Table 3. Probability of normal operation, failure probability, and overhaul probability of system equipment in the state component model

| Equipment                     | Probability of normal work | Probability of failure | Probability of overhaul |
|-------------------------------|----------------------------|------------------------|-------------------------|
| GIS bus                       | 0.999692                   | 3.42360x10⁻5           | 2.73888x10⁻4            |
| Overhead lines                | 0.998177                   | 4.55789x10⁻4           | 0.001367                |
| 500 kV circuit breaker        | 0.990233                   | 7.23458x10⁻4           | 0.009043                |
| Transformer                   | 0.995647                   | 7.16047x10⁻4           | 0.003673                |
| Generator                     | 0.957429                   | 0.011968               | 0.030603                |

5. Conclusion
According to the requirements of the design and PMS for the system diagram, this project realizes the connection between the design and the PMS system diagram, and ensures the consistency of the system diagram graphics and data. Through the sample engineering test, the GIM standard has been extended. According to the GIM specification, the digital design of 3D and main wiring is carried out, and then the GIM design results of the unified interaction specification between the 3D design platform and the PMS system are derived. The PMS system analyses the design results and draws the main wiring for subsequent use.

References
[1] Ketzler, B., Naserentin, V., Latino, F., Zangelidis, C., Thuander, L., & Logg, A. Digital Twins for Cities: A State of the Art Review. Built Environment, 46(4) (2020) 547-573.
[2] Lee, J. I., Kang, D., Kong, S. H., Gim, H., Shin, I. S., Kim, J., & Kang, M. S. Dynamic Interplay between Transport and Reaction Kinetics of Luminophores on the Operation of AC-Driven Electrochemiluminescence Devices. ACS applied materials & interfaces, 10(48) (2018) 41562-41569.
[3] Mao, B., Ban, Y., & Laumont, B. Dynamic Online 3D Visualization Framework for Real-Time Energy Simulation Based on 3D Tiles. ISPRS International Journal of Geo-Information, 9(3) (2020) 166-185.
[4] Zhao, L., Matsuo, I. B. M., Zhou, Y., & Lee, W. J. Design of an industrial IoT-based monitoring
system for power substations. IEEE Transactions on Industry Applications, 55(6) (2019) 5666-5674.

[5] Chu, S., Vanka, S., Wang, Y., Gim, J., Wang, Y., Ra, Y. H., & Mi, Z. Solar water oxidation by an InGaN nanowire photoanode with a bandgap of 1.7 eV. ACS Energy Letters, 3(2) (2018) 307-314.

[6] Li, Q., Rui, X., Chen, D., Feng, Y., Xiao, N., Gan, L., & Huang, S. A high-capacity ammonium vanadate cathode for zinc-ion battery. Nano-Micro Letters, 12(1) (2020) 1-12.