IOP Publishing

Journal of Physics: Conference Series
IPEC 2021
1952 (2021) 032082
doi:10.1088/1742-6596/1952/3/032082

Design and Research of Automatic Test Control System for Electric Energy Metering Equipment

Yuanfeng Zhou*, Haili Ding, Tingting Hu and Pengyuan Liu
Marketing Service Center of State Grid Ningxia Electric Power Co., Ltd, China
*Corresponding author: yuanfengzhou@nx.sgcc.com.cn

Abstract. Design an automatic test control system for electric energy metering equipment to realize automatic detection of smart electric energy meters and collection terminals. Use data processing technology, data storage technology, data transmission network technology, and automated instrument analysis technology to realize information management and quality control. The test detection system realizes information collection, processing, storage, transmission, analysis and summarization of various detection businesses, and provides quick and efficient query services, forming the multi-level business processing capabilities of the metrology and testing center, and establishing an efficient, true, and accurate modern detection system.

Keywords: Electric energy measurement, Automatic detection, Intelligent electric energy meter.

1. Introduction
As an important infrastructure to protect people’s livelihood, electric energy meters, collection terminals, and other electric energy measurement equipment are the basis for the settlement of electricity and energy consumption, related to the vital interests of thousands of households, and the foundation of national economic development. Their quality is directly related to the fairness and justice of energy trade settlement. It is related to the fundamental interests of the people. The stable and reliable operation of the smart electric energy meter requires a comprehensive inspection of the electric energy meter, including the accuracy, stability, insulation, safety, and electrical compatibility of the electric energy meter.

At present, the testing methods of electric energy metering equipment have higher requirements for testing personnel, and the layout of testing environment needs to be carried out in strict accordance with the requirements of national standards. There are fewer testing personnel who can master and understand each testing standard. Manual-based energy meters and collection terminals the test detection method cannot realize the intelligent optimization control of the detection process.

Change the traditional manual, cumbersome, and low-efficiency energy metering equipment verification and detection methods, complete the research and development of the key technologies and key equipment of the intelligent detection system for the full performance test of the smart energy meter and the collection terminal, and realize the fully automatic of the smart energy meter and the collection terminal Detection. Establish a standardized and unified testing mode, integrating advanced technologies such as automatic transmission, automatic verification, and information technology.
Research and develop the intelligent detection system for the full performance test of electric energy metering equipment, and use intelligent and information methods to effectively improve the quality and efficiency of metering work. Through the popularization and application of automatic verification system technology, the differences in verification quality caused by human and regional factors are eliminated, and the rapid verification of electric energy metering equipment is realized.

2. Architecture design of automated test control system

The automatic test management and control system of electric energy metering equipment adopts a service-oriented architecture component model, divides the different functions of the application into services, and connects these services through well-defined interfaces and contracts. The interface is defined in a neutral way. The feature of a neutral interface definition is called loose coupling between services. It is independent of the hardware platform, operating system, and programming language that implements the service. This makes the various Services can interact in a unified and universal way.

The automation test control system architecture is divided into comprehensive application layer, business processing layer, data exchange layer, pre-collection layer, communication layer and terminal equipment layer. The structure of the automated test control system is shown in Figure 1.

![Figure 1. Structure diagram of automated test control system.](image-url)

The comprehensive application layer uses data from different automation subsystems to complete functions such as detection result processing, detection report management, and sample defect analysis. The business processing layer completes the processing functions of business subsystems such as detection process control, signal control, and equipment control. The data exchange layer is mainly used to store archive data, collected inspection data, store comprehensive application data, and exchange data with system interfaces such as management automation. The pre-collection layer can communicate with various access terminals in various communication methods, analyze the data according to the
established communication protocol, and perform preliminary processing on the data. The communication layer completes the communication function between the system and the terminal, and is mainly composed of communication access equipment and communication networks. The terminal equipment layer is mainly composed of electromagnetic compatibility equipment, PLC transmission units, robots, monitoring equipment, and environmental monitoring equipment.

The system construction includes main and standby database servers, application servers, interface servers, switches and workstations. The physical architecture of the automated test control system is shown in Figure 2.

![Physical architecture diagram of automated test control system](image)

**Figure 2.** Physical architecture diagram of automated test control system.

The control system and the control system are coordinated and controlled by the detection systems of each station body. By controlling the assembly line, robots, various detection stations and system networks, serial ports, etc., system applications can be realized through protocol messages, files, databases, and application service access methods.

### 3. Data management design of automated test control system

The data architecture design of the automatic test control system for electric energy metering equipment is a subject-oriented, integrated, relatively stable data collection that reflects historical changes to support management decision-making. The system mainly includes data source layer, data warehouse layer, and data display layer. The data in the data warehouse is stored in the same topic according to its purpose, and the system data structure is shown in Figure 3.
Data source means that the system supports the direct collection of automated testing that meets the technical requirements in a certain stage, and for the existing automated equipment that does not meet the current technical requirements. The data warehouse layer extracts the data from the source data into the database of the system through operations such as data transformation and extraction, and further processes the metadata to perform multi-dimensional modeling. The data in the data display layer displays the data in the form of reports, multi-dimensional analysis, and graphics. The detection system collects environmental state data, test parameter data, test process data, and test sample test data, and summarizes them to the control software system. The control software is time stamped in chronological order and stored in the database. The automatic test management and control system of electric energy metering equipment adopts a comprehensive data platform, unified management and control, and a unified design database.

4. User interface design of automated test control system

The automatic test management and control system for electric energy metering equipment is designed with a detection configuration management module, including functions such as detection items, detection points, test schemes, grouping schemes, and preset content configuration. The test detection point configuration and test program configuration interfaces are shown in Figure 4 and Figure 5 respectively.
The functional design of the designated grouping scheme can set single-phase meters, three-phase meters, concentrators, and terminals to set a batch of different number of meter groups. There are several meters that need to be tested for setting test items. The preset content configuration function is designed to configure all event detection parameters.

The design function of the detection scheduling module includes starting test equipment detection and detection data query. The starting detection function can assign the detection by specifying the scheduling mode and the random mode, and the test items of the detection can be checked. At the same time, it supports release tray, run, pause, release tray, task configuration, parameter configuration, start
detection, stop detection and continue detection. The design of the test result query function includes querying whether the test result of the tested sample of each test unit is qualified, as shown in Figure 6.

![Figure 6. Test result query interface.](image)

The operation monitoring module mainly includes detection status monitoring, environmental monitoring, and abnormal alarm monitoring. The detection status monitoring mainly includes the detection platform, test items and test status, as shown in Figure 7.

![Figure 7. Detection status monitoring interface.](image)

The environmental monitoring function is designed to monitor the real-time temperature and humidity in the testing laboratory and display it with image data. The design of abnormal monitoring function is to display various alarm information that appears in the detection process of the pipeline and detection equipment. The environmental monitoring interface and the abnormal system operation monitoring interface are shown in Figure 8 and Figure 9, respectively.
Average temperature

Inquire 2020.08.09

Temperature Humidity

Current temperature: 24.21°C
Current humidity: 53.22%

Figure 8. Environmental monitoring interface.

![Thermometer and Hygrometer](Image)

Figure 9. System operation abnormal monitoring.

5. Conclusion
The automatic test control system for electric energy metering equipment is an attempt to automatically test the full performance of metering equipment in the electric power industry, and is a major advancement in the realization of unmanned and fully automatic testing of metering equipment. Through the establishment of a compact performance test automatic detection system, centralized management of the detection equipment. It has realized the in-depth application of the Internet of Things technology in the quality inspection business, reversed the traditional information system's model of human-driven data and business process operation, and promoted the operation of data and business processes driven by smart devices, reducing manual workload and improving quality Check business efficiency. Ensure the safe and reliable operation of the automated verification system, realize all-round management and control of the measurement business and comprehensive sharing of measurement information.

References
[1] Xiao Tao, Zheng Fan. Application research on quality monitoring method of automatic measurement assembly line verification system [J]. Electrical Measurement and Instrumentation. 2013, 50 (569), 72-76.
[2] Long Guishan, Liu Lei, Liu Ying, Liu Jian'an, Jiang Qi, Hu Jian, Liu Jinhai, Zhao Haiyan. Research on the fully automated verification and intelligent storage integrated system of electric energy meters [J]. Guizhou Electric Power Technology. 2013, 15 (7), 31-35.

[3] Advanced metering infrastructure design and test bed experiment using intelligent agents: focusing on the PLC network base technology for Smart Grid system [Z]. Advanced metering infrastructures. 2016.

[4] Desianina and operating through compromise: Architectural analysis of CKMS for the advanced metering infrastructure [Z]. Advanced metering infrastructures. 2013.

[5] Wang Libin, Wang Hongying, Zhang Chao. Research on the best maintenance frequency of automatic verification assembly line equipment for electric energy meters [J]. Electrical Measurement and Instrumentation, 2017, 54(8): 89-92.

[6] Dong Lijun. Design and technical research of automatic verification assembly line verification system for electric energy metering device [D]. Beijing: North China Electric Power University, 2017.

[7] Zhang Yan. Research and application of intelligent verification assembly line system for electric energy meters [J]. Electrical Measurement and Instrumentation, 2009, 46 (12): 74-77.