Design and Development of Intelligent Control System for Full Performance Test

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Abstract. Design and develop the intelligent management and control system for the full performance test of the smart electric energy meter to realize the intelligent detection of the full performance test of the electric energy meter. The test intelligent control system is compatible with the automatic connection and disconnection technology of a variety of metering equipment, and realizes the automatic connection and disconnection and automatic testing of the equipment. Complete the automatic capture of abnormal phenomena and automatic judgment of unqualified items, complete the design and validity verification of the electromagnetic compatibility test automatic detection implementation plan. During manual test operation, various circuits and test points can be switched manually to realize automatic testing of various tests. The test intelligent management and control system realizes the system flexible scheduling control strategy, and completes the intelligent scheduling of the status of the equipment to be inspected and the idle status of each test unit.

Keywords: Smart energy meter, full performance test, automatic test.

1. Introduction

Smart energy meters are important metering equipment for the settlement of electricity trade between power generation companies and power supply companies, and between power supply companies and power customers. The stability and reliability of the running state of the metering equipment is directly related to the harmony and stability of the interests of users and society. The measurement accuracy and operational reliability of electric energy meters are the focus of attention of power grid companies. State Grid Corporation has also formulated a series of energy meter quality management measures. Covers the whole process of planning, procurement, pre-supply, post-arrival, construction and operation, high-quality service, and all links of the whole life cycle, including plan rationality evaluation, supplier evaluation, quality supervision before delivery, and quality supervision after delivery, Construction and operation quality supervision and control, etc. According to the quality control requirements of smart energy meters, the quality inspection of metering equipment is divided into full performance inspection before arrival, sampling inspection after arrival, and full inspection and acceptance inspection after arrival. Among them, the most comprehensive performance test items include accuracy requirement test and electrical requirement Test, insulation, electromagnetic compatibility test, cost control safety test, climate impact test, mechanical test, etc.
There are many full-performance test items for smart energy meters and collection terminals, and the test equipment is complex and diverse, and each test equipment is completely independent. After many tests are completed, functional testing is required for error testing. The detection operation is relatively random, and the detection standardization cannot be controlled. The design and research and development of the intelligent inspection system for the quality of metering equipment is conducive to improving the level of automated inspection, intelligent data management, and the standard, efficiency and accuracy of intelligent inspection.

2. Overall design of intelligent control system for full performance test

The intelligent management and control system for full performance test completes the construction of the smart detection system for the full performance test of the watt-hour meter and the collection terminal by designing the full performance test project and detection process of the electric energy meter and the collection terminal. The intelligent management and control system for full performance test is composed of hardware and systems such as robot unit, conveying unit, independent test equipment, power supply facilities, abnormal monitoring and environmental monitoring. The system adopts automatic control technology to realize the circulation and transportation of test samples, and uses the connection and disconnection tooling to realize quick connection and disconnection. Under the intelligent management and control software scheduling, the full performance test items of the smart electric energy meter and the collection terminal are automatically detected. The system is mainly composed of assembly line units, robot units, independent test equipment, special fixtures, power supply facilities, abnormal monitoring and environmental monitoring. The intelligent management and control system for full performance test is shown in Figure 1.

![Figure 1. Overall architecture diagram of intelligent control system for full performance test.](image-url)
for general trays. The power supply facility mainly completes the power supply of all equipment in the smart laboratory. The full performance intelligent detection system can monitor abnormal phenomena during the sample test. The full performance test has strict requirements on the temperature and humidity of the test environment. In order to ensure the accuracy of the test, three temperature and humidity sensors are placed equidistantly in the system laboratory to monitor whether the temperature and humidity of each test module meet the requirements.

3. Hardware design of intelligent control system for full performance test

The fixed jig is used to clamp and fix the sample, which is convenient for the robot to take, and is convenient for positioning during the revolving transportation, converts the wiring of different samples to a uniform arrangement, and is also convenient for automatic connection and disconnection of samples. The fixed fixture includes three parts: general wiring adapter, transfer wiring adapter, and special fixture for general tray.

The universal wiring adapter is used to connect the test equipment and the transfer wiring adapter. The universal wiring adapter is fixedly placed on the test table and is always connected to the test equipment. In order to be compatible with single-phase meters, direct-connected three-phase meters, transformer-connected three-phase meters, concentrators, and special transformer terminals, five metering devices, the connection end of the universal wiring adapter and the transfer wiring adapter is the largest according to the technical specifications. It is required to design strong current terminals and weak current terminals. The wiring adapter is equipped with 10 strong current terminal interfaces and 26 weak current terminal interfaces. The strong current terminals and the weak current terminals can be detached and separated.

The strong current terminal and the weak current terminal of the universal wiring adapter adopt an integrated terminal design. The connection mode of the heavy current part and the transfer wiring adapter is that the universal wiring adapter is a jack, and the transfer wiring adapter is a pin. The connection mode of the weak current part and the transfer wiring adapter is that the universal wiring adapter is a pin, and the transfer wiring adapter is a jack. The schematic diagram of the connection device of the universal wiring adapter and the schematic diagram of the connection surface with the transfer wiring adapter are shown in Figure 2 and Figure 3 respectively.

![Connect the auxiliary circuit of the test equipment](image)

**Figure 2.** Schematic diagram of universal wiring adapter connecting equipment.
Connect the adapter voltage and current circuit

**Figure 3.** Connection surface view of universal wiring adapter to transfer wiring adapter.

The transfer wiring adapter is used to connect the universal wiring adapter and the sample to be inspected. One end connected with the universal wiring adapter is provided with 10 strong current terminal interfaces and 26 weak current terminal interfaces for one-to-one connection with the universal wiring adapter. The schematic diagram of the transfer wiring adapter is shown in Figure 4. The special positioning jig needs to be compatible with the external dimensions of the metering equipment, so that it can circulate on the assembly line together with the equipment. The fixture is divided into three layers, single-phase surface placement layer, three-phase surface placement layer, concentrator and special transformer placement layer, as shown in Figure 5.

**Figure 4.** Schematic diagram of transfer cable adapter.

**Figure 5.** Schematic diagram of special positioning fixture.

To carry out the 0.5mT power frequency magnetic field strength test and the 0.5mT power frequency magnetic field no-load test, manual wiring is required, which takes a long time, and the detection efficiency is low; it is close to the magnetic field coil, which causes greater harm to
personnel. A power frequency magnetic field test detection system suitable for automatic assembly lines for full performance testing of various measuring instruments is proposed. It automatically places samples, automatically connects, automatically energizes samples, automatically applies magnetic fields, automatically adjusts coil angles, automatically disconnects, and automatically determines conclusions, greatly improve detection efficiency, save labor and cost. The schematic diagram of the power frequency magnetic field strength 0.5mT equipment is shown in Figure 6.

In the external constant magnetic field test, the watt-hour meter is supplied with reference voltage and reference current, and a 50mm×50mm×50mm magnet with a surface magnetic field strength of 300mT is placed on the cylinder. The cylinder rotates the magnet to make the front, side, and the bottom surface close to the position of the power module of the tested sample, and each plane test lasts for 20 minutes. Look for the sensitivity, check the running status of the electric energy meter, whether there is a crash, no pulse, and error change out of tolerance. The constant magnetic field test device is designed as a single-meter structure, compatible with single-phase meters, three-phase meters connected via transformer, and three-phase direct-connect meters. The constant magnetic field test device diagram is shown in Figure 7.

![Figure 6. Schematic diagram of power frequency magnetic field strength 0.5mT equipment.](image1)

![Figure 7. Schematic diagram of constant magnetic field test device.](image2)

The multi-functional verification test unit can test five products: single-phase smart electric energy meter, three-phase intelligent electric energy meter connected via transformer, three-phase direct connection intelligent electric energy meter, type I concentrator, and type III special transformer terminal. The table body adopts a two-layer partition arrangement: a total of six electric energy meters in an electric energy meter type area, three upper and lower, from left to right, there are single-phase electric energy meter positions, and three-phase direct-access electric energy meter positions. Three-
phase meter position, concentrator and terminal meter position connected by transformer. The schematic diagram of the multifunctional verification test unit is shown in Figure 8.

The spring hammer and the terminal pressure test bench body can verify single-phase smart meters, three-phase smart meters with mutual inductor access, and three-phase smart meters with direct access. For the spring hammer test, the table body is equipped with a 0.2J spring hammer, and the spring hammer is controlled by controlling the movement of the motor to apply the spring hammer to each point on the surface of the tested sample. At the same time, the device is equipped with a spring hammer reset mechanism to ensure that the spring hammer is after the test. It can be reset and is in working condition. At the same time, a high-definition camera is installed above the unit, which can identify subtle changes on the surface of the electric energy meter and determine whether it is qualified after the test. The structure diagram of the spring hammer and the terminal pressure unit is shown in Figure 9.

![Figure 8. Schematic diagram of multifunctional verification test unit.](image1)

![Figure 9. Structure diagram of spring hammer and terminal pressure unit.](image2)

4. Hardware design of immunity test system unit

The fast transient pulse group immunity test is divided into voltage and current loop test and 485 communication loop tests. The wiring methods of the two are different. Measurement errors are required during the test. WE0191 outputs standard voltage and current signals, which are connected to the electric energy meter through EFT500T. During the test, the EFT500T is controlled by computer software to send out a fast transient disturbance signal, and the signal is coupled to the connection line with the measured electric energy meter. Connect the WE0191 pulse receiving port and the pulse output port of the tested electric energy meter with a dedicated pulse line, and then the error of the electric energy meter can be measured during the test. The layout of the fast transient pulse group immunity test is shown in Figure 10.

The surge (impact) immunity test unit includes an electronic voltage source, UCS500M, and a relay switch box. All equipment is controlled by computer software and automatically crimped by robots. The voltage source output ports are respectively connected to the corresponding input ports of
UCS500M, and the output ports of UCS500M are connected to the corresponding ports of the electric energy meter under test. During the test, the UCS500M sends out a surge signal to the connection line of the electric energy meter under test. Before the test, the voltage source is adjusted to the rated voltage of the tested electric energy meter, the tested electric energy meter is connected to the rated voltage, and the current is open. The layout of the surge (impact) immunity test is shown in Figure 11.

![Figure 10. Layout of the fast transient pulse group immunity test.](image1)

![Figure 11. Surge (impact) immunity test layout.](image2)

The attenuated shock wave immunity test unit is aimed at instruments connected via a transformer. The test layout should include ground plane, test equipment, test generator, induction coil, terminal network, anti-reverse filter, etc. The test equipment includes a test generator and an electric energy meter detection device. The auxiliary circuit mainly includes the transfer wiring adapter and so on. All equipment is controlled by computer software and automatically crimped by robots. The layout diagram of the attenuated shock wave immunity is shown in Figure 12.

Voltage sags and short-term interruptions are caused by the failure of power grids and power facilities (mainly short circuits) or sudden large changes in load. In some cases, there will be two or more consecutive sags or interruptions. Voltage changes are caused by continuous changes in the load connected to the grid. The EUT shall perform three voltage sag or interruption tests in sequence according to each selected test level and duration combination. The minimum interval of 10s (the interval between two tests) shall be tested in each typical working mode. The layout diagram of immunity test for voltage dips, short interruptions and voltage changes is shown in Figure 13.
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Figure 12. Layout of attenuated shock wave immunity.

Figure 13. Layout of immunity test for voltage dips, short interruptions and voltage changes.

5. Conclusions
Carry out the construction of the intelligent detection system for the full performance test of the smart electric energy meter, and realize the automatic detection of the full performance test of the electric energy meter and the collection terminal. The climate impact test, some mechanical tests and the electromagnetic compatibility test carried out in the anechoic chamber cannot be integrated into the full-performance intelligent detection system, but the test data can be automatically uploaded to the intelligent detection system management and control platform.

Through the analysis of the test items, most of the functional and performance tests can be done directly using the test bench. Electromagnetic compatibility and other parts of the test need to connect the current independent equipment to the test system. Each test requires a separate design of sample
placement, fixing and Wiring method, wiring and control method of test equipment. The design and development of the intelligent detection system for the full performance test of the intelligent electric energy meter lays the foundation for the intelligent control technology of the intelligent electric energy meter experiment.

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