Development and Research of Intelligent Testing Information System for Full Performance Test of Metrology Equipment

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Abstract. Aiming at the measurement laboratory with many types of testing equipment, many test items, low automation of instruments and equipment, inconsistent data interface standards, ineffective coordination of testing services, low level of laboratory testing resources and data sharing, and difficulty in achieving effective data and resources connection, etc. Problem, design and develop an intelligent detection system for full performance test of measurement equipment. The research and development of the full-performance test intelligent detection system replaces manual operation with standardized automatic operation, which improves the consistency, standardization and reliability of the full-performance test of the measurement equipment, and realizes the reproducibility and traceability of the test. The automatic collection of full performance test data has been realized, laying a solid foundation for the construction of the national industrial basic database.

Keywords: Metering equipment, full performance test, intelligent detection.

1. Introduction
At present, the manual-based full-performance test and detection methods of electric energy meters and collection terminals cannot achieve intelligent optimization control of the detection process, which is not conducive to the intelligent data collection and management of power test data. Carrying out the design and development of the intelligent detection system for the full performance test of the smart electric energy meter is conducive to improving the automatic detection level of the full performance test project, and is conducive to improving the intelligent data management of the full performance test project.

The developed measurement production scheduling platform adopts information technology such as data visualization and data fusion, provides a wealth of interfaces, integrates intelligent and flexible scheduling of various automated verification systems to ensure efficient and stable, unified and coordinated operation, and realizes efficient, stable and orderly automatic detection of measurement equipment Unfold. Combining production information and management information, realize the comprehensive deployment of internal and external resources in multiple production links such as planning, purchasing, acceptance, warehousing, verification, and distribution. Solve the conflicts of various resources, build a fault diagnosis model based on various data of the automatic detection
system. Ensure the safe and reliable operation of the automated verification system, and finally realize the comprehensive management and control of the measurement business and the comprehensive sharing and interaction of measurement information.

2. **Overall design of intelligent detection system for metering equipment**

The intelligent detection system of metering equipment realizes the automatic detection of the full performance test of the electric energy meter and the collection terminal. The intelligent detection system for metering equipment is compatible with the automatic connection and disconnection technology of five types of metering equipment: single-phase electric energy meter, three-phase direct-connected electric energy meter, three-phase connected meter through mutual inductor, centralized meter reading terminal, and special change collection terminal. The intelligent detection system automatically captures abnormal phenomena during the test, and automatically determines whether the test is qualified, and intelligently determines the system test results during the test process such as sample crashes, destructive discharge, error out of tolerance, and damage to the casing or liquid crystal.

The intelligent detection system for metering equipment completes the accuracy, insulation withstand voltage, and accuracy retest tests in accordance with the requirements of the full performance test sequence, maximizes the use of each test unit and metering equipment, avoids the idleness of the test unit or metering equipment, and shortens the overall inspection cycle. According to the system's flexible scheduling control strategy, intelligent scheduling is completed according to the status of the equipment to be inspected and the idle status of each test unit. The top view of the layout of the intelligent detection system for metering equipment is shown in Figure 1.

![Top view of the layout of the intelligent detection system for metering equipment.](image)

The intelligent detection process of the full performance test is mainly composed of the steps of loading, information entry, work order generation, full performance testing, blanking, data uploading, and data analysis. Among them, the full performance test consists of assembly line unit, robot unit and test unit.

Manually place the tested samples on the universal tray fixture according to different types, and then start the feeding procedure. The general tray fixture is transferred to the image recognition unit to scan, analyze and summarize the nameplate information under the equipment, record the manufacturer, quantity, specification, model and other information of each batch of samples to be inspected, and compare it with the winning batch information in the system Associated. It can also perform appearance inspection by powering up the device, performing full-display operation of the liquid crystal, detecting whether there is a missing segment of the liquid crystal, etc.
The intelligent control system automatically generates a detection plan based on the input information and enters the detection process. According to the testing procedures and methods of smart electric energy meters and the measurement center, with the help of automated means such as assembly line devices and robotic devices, the full performance testing of electric energy meters is carried out. Including accuracy requirement test, electrical requirement test, insulation, electromagnetic compatibility test, mechanical performance test, cost control safety test, communication protocol consistency check, function check, etc.

The tested sample is tested according to the distribution method of the control system. After receiving the cutting instruction, the tested sample is transferred to the figure-eight line body, and the stop mechanism transfers the tested sample to the unloading area. Manually remove the equipment, place the pallets in the pallet storage cabinet, and perform unified scheduling with the loading pallet storage cabinet.

After the test, each subsystem uploads the test results to the control system in real time, and the control system summarizes the data based on the input information. The management and control system performs data analysis based on the uploaded data and forms a test report.

3. Design of control software for intelligent detection system of metering equipment

The intelligent control system includes control system service, assembly line control system, robot control system, control system of each test bench, etc., through the optimal scheduling algorithm, to achieve rapid detection of tested samples and output of test results. The assembly line control system, the robot control system, and the control system of each test bench interact data through the interface and work closely with the management system to complete the scheduling work.

The dispatching control system and the testing control system of each test bed are shown in Figure 2 and Figure 3 respectively.

![Figure 2](dispatching-control-system.png)

*Figure 2. Dispatching control system control logic diagram.*

![Figure 3](test-bench-body-detection-system.png)

*Figure 3. Control function diagram of each test bench body detection system.*

The scheduling control system is responsible for generating inspection tasks and real-time scheduling. Responsible for actively notifying the robot subsystem to perform loading and unloading operations, and passively receiving the execution results of the robot subsystem. Responsible for proactively notifying the assembly line system to perform unloading, tray raising, and tray lowering.
operations, and passively receive the execution results of the assembly line subsystem. Responsible for proactively notifying each test station subsystem to power off, power on, and start the detection operation, and passively receive the execution results of the test station subsystem test completion, detection abnormal stop, etc., and monitor the operation of each subsystem.

The control system of each test bench body inspection system receives the inspection start instruction, the inspection is over, and the dispatcher is notified to complete the start-up subsequent processes. The abnormal detection stops, the dispatcher is notified that a certain equipment to be checked is abnormal, and the subsequent processing is started. Each station body detection subsystem decides whether to inform the dispatch system about the follow-up according to the abnormal situation classification, and can decide the follow-up processing method according to the abnormal type. The platform subsystem decides whether to allow power off according to the configuration to allow the robot to load and unload equipment. The test results of each test item are managed independently and automatically entered into the database.

The pipeline subsystem control and robot subsystem control systems are shown in Figure 4 and Figure 5 respectively.

![Figure 4. Control function diagram of pipeline subsystem.](image1)

![Figure 5. Robot subsystem control function diagram.](image2)

The assembly line subsystem adopts 8 type + loop assembly line to realize loading, unloading and automatic transfer of samples to be inspected. It is mainly composed of loading unit, image recognition unit, recognition and positioning device, unloading area and supporting line body. The assembly line subsystem controls the speed of the assembly line, decides whether to allow the equipment in the loading area to be sent according to the current tray situation on the assembly line, and controls the positioning device between the feeding line body and the loop line body to activate the feeding permission.

According to the scheduling instructions, the assembly line control system identifies and locates the designated sample to be inspected, and controls the tray to rise at the designated position on the assembly line. After the test is completed, it controls the tray to drop, and continues to flow or unload.

The robot subsystem operates the robot to move and position, and operate the robot to grab according to the scheduling instructions. Fix and release the device under test, and release the device at the designated location. Place the equipment on the assembly line and raise the tray. Report the command execution result of the dispatch control system, grab the transfer terminal from the specified position, install it to the inspection station, and unload the transfer terminal, and send it back to the specified location.

4. Inspection system AC voltage test unit inspection
Insulation withstand voltage test includes impulse voltage test and AC voltage test. There are many types of measuring equipment to be inspected, and there are many test lines. AC voltage test switching
device and pulse voltage test switching device are required to verify the test line and switching device settings at the adapter end of the transfer line. Whether the test lines are the same. The AC voltage test has been taken as an example for the test unit inspection design.

According to different types of measuring equipment to be inspected, select the corresponding transfer wiring adapter to cooperate with the universal wiring adapter, and set the test circuit through the AC voltage switching device. Use a digital multimeter to test the continuity and disconnection of the terminal on the side of the connection between the adapter and the measurement equipment to be tested, and verify whether it is consistent with the set test circuit. The verification test is classified according to the measurement equipment to be inspected, and each type of measurement equipment to be inspected is verified separately according to the test line. The connecting surface between the transfer wiring adapter and the electric energy meter is shown in Figure 6.

Figure 6. Connection diagram of transfer wiring adapter and electric energy meter.

(a) Connection surface between the adapter and the electric energy meter in the single-phase electric energy meter
(b) Three-phase direct access type electric energy meter connecting surface between the adapter and electric energy meter
(c) The connection surface between the adapter and the electric energy meter in the three-phase electric energy meter connected through the transformer
(d) Concentrator transfer terminal and concentrator connection surface
(e) The connection surface between the adapter and the terminal in the special transformer collection terminal meter

Single-phase watt-hour meter, three-phase direct-connected watt-hour meter, three-phase connected watt-hour meter via transformer, and concentrator AC voltage test circuit switching logic correctness verification is shown in Table 1 and Table 2.

Table 1. AC voltage test circuit switching logic correctness verification table of electric energy meter.

| Type                                                                 | Test line                                                                 | Verify terminal                                                                 | On-off state |
|----------------------------------------------------------------------|---------------------------------------------------------------------------|--------------------------------------------------------------------------------|--------------|
| Verification of switching logic of AC voltage test circuit for single-phase electric energy meter | Between all current lines and voltage lines and auxiliary lines with a reference voltage exceeding 40 V and ground | Between 1, 2, 3, 4, 5, 6 terminals                                              | ●            |
|                                                                      |                                                                             | Between 7, 8, 9, 10, 11, 12 terminals and ground                               | ●            |
|                                                                      |                                                                             | Between 1 and 7 terminals                                                     | ▲            |
| Verification of the correctness of the switching logic of the AC voltage test circuit of the three-phase direct-access electric energy meter | Between all current lines and voltage lines and auxiliary lines with a reference voltage exceeding 40 V and ground | Between 1, 3, 4, 6, 7, 9, 10, 13, 14, 15, 16, 17                           | ●            |
|                                                                      |                                                                             | Between 19, 20, 21, 22, 23, 24, 25, 26, 27, 28 terminal and ground            | ●            |
|                                                                      |                                                                             | Between 1 and 19 terminals                                                   | ▲            |
| Verification of the correctness of the switching logic of the AC voltage test circuit of the three-phase transformer-connected electric energy meter | Between all current lines and voltage lines and auxiliary lines with a reference voltage exceeding 40 V and ground | Between 1, 3, 4, 6, 7, 9, 10, 13, 14, 15, 16, 17   | ●            |
|                                                                      |                                                                             | Between 19, 20, 21, 22, 23, 24, 25, 26, 27, 28 terminal and ground            | ●            |
|                                                                      |                                                                             | Between 1 and 19 terminals                                                   | ▲            |
|                                                                      | Between all disconnected current lines and voltage lines                   | Between 1, 3, 4, 6, 7, and 9 terminals                                         | ●            |
|                                                                      |                                                                             | Between 2, 5, 8, 10 terminals                                                | ●            |
|                                                                      |                                                                             | Between 1 and 2 terminals                                                   | ▲            |
| Remarks                                                              | ●: Conduction, ▲: Open circuit.                                            |                                                                                |              |
Table 2. Concentrator AC voltage test circuit switching logic correctness verification table.

| Test line                              | Verify terminal                                      | On-off state |
|----------------------------------------|------------------------------------------------------|--------------|
| Between current line, voltage line and ground | Between 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 terminals       | ●            |
|                                        | Between 1 terminal and ground                        | ▲            |
| Between current line and voltage line   | Between 1, 3, 4, 6, 7, and 9 terminals               | ●            |
|                                        | Between 2, 5, 8, 10 terminals                        | ●            |
|                                        | Between 1 and 2 terminals                            | ●            |
|                                        | Between 1 and 3 terminals                            | ●            |
|                                        | Between 4 and 6 terminals                            | ●            |
|                                        | Between 7 and 9 terminals                            | ●            |
|                                        | Between 1 and 4, 7 terminals                         | ▲            |
| Between disconnected current lines     | Between 13, 14, 15, 16, 21, 22 terminals             | ●            |
|                                        | Between 13 and ground                                | ▲            |
| Between status input line and ground   | Between 23, 24, 25, 26 terminals                     | ●            |
|                                        | Between 23 and ground                                | ▲            |
| Between pulse output line and ground   | Between 27, 28, 29, 30 terminals                     | ●            |
|                                        | Between 27 and the ground                            | ▲            |
| Between 485 communication line and ground | Between 27, 28, 29, 30 terminals                     | ●            |
|                                        | Between 27 and the ground                            | ▲            |
| Remarks                                | ●: Conduction, ▲: Open circuit,                      |              |

The verification method of switching logic for AC voltage test circuit of special transformer acquisition terminal is similar.

Pulse voltage test circuit switching logic verification is also based on different types of measurement equipment to be tested, select the corresponding transfer wiring adapter to cooperate with the universal wiring adapter, set the test circuit through the pulse voltage switching device, and use a digital multimeter to test the connection adapter and the universal wiring adapter. The on-off conditions of the terminals on the connection side of the measuring equipment to be tested are verified whether they are consistent with the set test circuit. The method is similar to the verification of the switching logic of the AC voltage test circuit.

5. Conclusion
This design is an attempt to automate the testing of the full performance of metering equipment in the 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 and centralized management of the detection equipment, the in-depth application of the Internet of Things technology in the quality inspection business has been realized. It has reversed the traditional information system's model of human-driven data and business process operation, and upgraded it to a smart device-driven data and business process operation, reducing manual workload and improving quality inspection business efficiency. Significant improvements have been made in data standardization, process intelligence, and refined management. By means of intelligence, automation, and information, the inspection business is standardized, controlled, and traceable, and the business management of the quality inspection room of the metrology center is improved Efficiency, and makes the establishment of a national industrial basic database feasible. Really build the metrology center into a high-level industrial product quality control and technology evaluation laboratory, product quality supervision and inspection center.

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