Research on Intelligent Metrological Verification Technology Based on Internet of Things

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Abstract. Intelligent metrological verification is of great significance to improve the accuracy of equipment. Especially in the current situation of rapid increase in residential electricity consumption, electric energy meters have received widespread attention from the society as an important device that affects electricity trade settlement. In this research, this article will be based on the technological environment of the Internet of Things. After the analysis of the intelligent metrological verification system, the key technical means will be highlighted, including automatic sealing technology, automatic connection and disconnection technology, and cycle simulation system design. This article provides support for the verification system construction of the metrological center.

1. Introduction
At present, with the further development of China’s electric power industry, it has become an unstoppable development trend for electric power companies to realize the intensive management of electric energy measurement. In this context, how to improve the accuracy of metrological testing data has become a key concern of the academic community. As a representative technology in the modern information age, the Internet of Things can improve work efficiency and ensure the accuracy of verification results in intelligent measurement verification. It has a far-reaching impact and is worthy of attention.

2. Research on intelligent metrological verification of the Internet of Things

2.1. Basic design ideas
In accordance with the requirements of intelligent metrological verification, the ultimate goal of this design is to build an uninterrupted assembly line operation system without human intervention. The design not only can effectively control various risks in the process, but also control construction costs. It is possible to implement the national technical standards for metrological verification, and complete many testing links such as power-on inspection, identification, connection and disconnection, and tribute withstand voltage test, so as to ensure the realization of the verification goal. Therefore, in order to achieve this goal, with the support of the Internet of Things, technologies such as laser sensing and RFID should be combined through software and hardware design methods. Finally, a complete metrological verification structure is formed. The detailed information is shown in figure 1.
2.2. The principle of design
In this study, the industry 4.0 IoT verification system is adopted. Compared with other systems, this system has significant advantages in intelligence and automation. It integrates modern technology such as computer network and photoelectric information. Among them, with the support of optoelectronic information technology, the system can detect the status of the equipment to be measured, and complete a series of functions such as positioning control and information collection. Through information technology, the binding and interconnection between the verification equipment and the production data can be realized. In addition, relevant personnel can further improve the content of the system according to the requirements of use, such as adding barcode information to realize anti-counterfeiting, or verifying the execution effect of the system through PLC servo technology.

2.3. Functional module design of the verification unit

2.3.1 Design of loading unit. The feeding unit is the initial function of the intelligent measurement verification, by taking out the equipment to be inspected from the turnover box and putting it into the electric energy meter conveying unit. The entire unit uses a constant speed motion mode. Its detection cycle meets the requirements of intelligent verification, and can be automatically adjusted after a deviation in the delivery cycle of the equipment to be inspected is found. In terms of function settings, the operating speed of the equipment can be automatically adjusted within the range of 0-120%. The positioning priority is controlled within ±2.0mm, and the success rate is higher than 99.0%.

2.3.2 Identification. This unit checks the barcode information and RFID tags of the equipment to be inspected by scanning the equipment. After the identity information is bound, the RFID module of the tooling board can be used to quickly read the information to be verified, helping the system to extract the identity information in a short time.

2.3.3 Connection and disconnection unit design. After the electric energy meter is positioned, the connection and disconnection unit can connect the terminals of the electric energy meter with communication ports and multi-function pulses. The terminal has the advantages of uniformity, reliability and stability, and can be effectively separated from the button box of the electric energy meter after the wire is disconnected. It can take protective action against the abnormal operation and avoid damage to the electric energy meter and other equipment. The connection success rate of each meter position of the connection and disconnection unit should be higher than 99%. It can meet the requirements of Q/GDW
1356, Q/GDW 1355 and other standards. The current terminal can be tested continuously for 10 minutes during the inspection, and the temperature rise detection range is within 35°C. The operating pressure of the voltage terminal is less than or equal to 60N, and the operating pressure of the auxiliary terminal of the electric energy meter is less than or equal to 10N, which ensures the adaptability of the system [1].

3. Key technical analysis

3.1. Automatic disconnection technology

In the intelligent verification of electric energy meters, it is necessary to realize the docking of several electronic terminals under a large current of 100A. There will be no problems such as displacement and heating during the detection process. This is the basis for effective verification.

3.1.1 The self-calibrated wiring support design. During the design period, the standard extension current terminal has an eccentric semi-circular arc surface structure. Effective contact is made with the electric energy meter column, wiring hole, etc., so the problem of insufficient contact area under the traditional mode can be changed. At the same time, because the resistance is inversely proportional to the area of the conductive material. Therefore, choosing the multi-surface design mode can ensure effective matching with the power meter terminals. According to the above mentioned standard, the reliability connection test is performed under laboratory conditions, and the test is performed by an infrared imager by applying a current of 100A. The detailed test results are shown in table 1.

| Test time | Common table temperature (°C) | Common table temperature (°C) |
|-----------|-------------------------------|-------------------------------|
| 0min      | 20                            | 20                            |
| 3min      | 49                            | 32                            |
| 6min      | 74                            | 41                            |
| 9min      | 79                            | 52                            |

It can be found from the data that after 100A of current is applied to the verification device, the temperature change of the multisurface watchholder is less, so the equipment safety can be better guaranteed.

3.1.2 Air cylinder. Air cylinder is an important power structure for automatic disconnection. It must have the advantages of fast response speed, stable and reliable action, etc. The double electronically controlled solenoid valve used in this design can make the disconnection action more reliable with the support of the Internet of Things. However, how to define the size of the cylinder thrust has become a key factor. In order to be able to determine the value, formula (1) can be used for verification.

\[ F = \eta p S \]  
Formula (1)

In formula (1), \( F \) is the thrust value of the cylinder. \( \eta \) is the load rate under static load and negative pressure. \( p \) is the pressure. \( S \) is the area under pressure.

3.1.3 Self-protection device. Intelligent metrological verification based on the Internet of Things needs to work in a continuous high-current environment. Therefore, security issues have always been the focus. In order to avoid damage to the equipment caused by temperature rise, a temperature control device needs to be added. The device can continuously detect and sample the temperature changes after connection. When an abnormal temperature is found during the verification process, an alarm can be issued in time and isolation can be performed to ensure the safety of the entire system.

In the design, the current terminal of the gauge holder recognizes the temperature of the gauge holder through the DS18B20 temperature sensor, monitors other abnormal data by paralleling the single-chip microcomputer, sets the temperature safety threshold on the upper computer software.
When the temperature is higher than the threshold, it can be cut off directly, ensuring the safety of the system.

3.2. Automatic sealing technology

When the test result of the electric energy meter shows that it is qualified, the system needs to automatically seal it. In the traditional mode, the electric energy meter and the meter body adopt the method of screw fastening, and the watch case and the screw are provided with through holes to facilitate the lead sealing line to pass through. Although this method is feasible, it has problems such as complicated operation methods. It is difficult to realize automatic processing. Therefore, it is necessary to design a new automatic sealing technology suitable for the automation mode of the Internet of Things.

3.2.1. Embedded design scheme. The embedded design scheme structure introduced in this paper is shown in figure 2.

![Figure 2. Embedded structure diagram](image)

In the structure described in figure 2, the designed shape has a diameter of 8mm, a height of 7mm, and a thickness of 1mm. The length of the undercut button is 1.5mm, and the angle of the undercut angle is 45°. The screw thread adopts a one-way feed method, so it has a non-reverse effect. The cap is composed of a circular cap and a plurality of arc-shaped plates arranged at the edge position. An undercut angle is set under the arc-shaped plate, which can be directly embedded in the screw hole by vertical pressing. The curved plate can be squeezed directly after being resisted by the watch case and produce an elastic bending effect, so the passing process is smoother. The arc-shaped plates are evenly distributed around, so that they can be directly pressed into the screw holes [2].

According to the relevant standards of the Electric Energy Metering Sealing Technical Specification (DL/T 1496-2016), the sealing materials used are all environmentally friendly materials that comply with the RoHS standard. The material has good toughness and good performance stability. No deformation was found during the continuous 6-hour 90°C temperature test, which ensures that the seal can remain stable under complex field conditions and is feasible.

3.2.2. The design scheme of the two-dimensional code of riding seam. On the basis of the above-mentioned sealing scheme, with laser technology, data such as the date and serial number of the verification can be recorded on the seal and the sewing position of the electric energy meter. After the seal is unsealed, the anti-counterfeiting mark is destroyed and not be restored. With the help of laser and pressing equipment, the sealing speed can reach up to 3 pieces/s, which has a higher sealing efficiency compared with the traditional mode.

3.3. Beat simulation design

The intelligent metrological verification system based on the Internet of Things involves multiple fields, and each verification function module is connected to each other. The unreasonable
configuration of the number of devices in any one link will directly affect the final operating effect of the system, which is worthy of attention.

3.3.1 Beat measurement formula. Taking into account the complexity of the metrological verification, the entire operation unit needs to be equipped with many functional modules such as accuracy inspection, card verification, power-on inspection, multi-function experiment, and blanking. According to the content of the national metrology regulations, identification, card insertion verification, power-on inspection and multi-function testing can be completed, and each project has a detailed schedule. The time consumption of sealing, labeling and blanking are all affected by the operating efficiency of automated equipment [3]. In order to meet the requirements of flow operation, it is necessary to maximize the efficiency as much as possible on the basis of ensuring the functions of the entire module, and do a good job in the docking with the verification unit, and cooperate with the online data transmission method to transfer the blanking data, and finally realize precise feeding. Therefore, in response to this requirement, calculations can be made in accordance with the verification link and the time-consuming work of each module. According to the requirements of the empirical formula, the checking calculation can be carried out according to the content of formula (2) and formula (3).

\[
\frac{m_1 n_1}{t_1} = \frac{m_2 n_2}{t_2} = \cdots = \frac{m_x n_x}{t_x} \quad \text{Formula (2)}
\]

\[
\frac{n_{tr}}{t_{tr}} = k \frac{n_{bu}}{t_{bu}} \quad \text{Formula (3)}
\]

In formula (2) and formula (3), \(m_1 \cdots m_x\) Represents the number of power meters per batch, \(n_1 \cdots n_x\) is the number of configurations for each module. \(t_1 \cdots t_x\) is the time consumption generated for each batch test. \(t_{tr}\) is time consumption for storage lines. \(t_{bu}\) is the time-consuming verification. \(k\) is the consumption of the basic verification unit.

3.3.2 Develop a simulation test of beats. In the intelligent metrological verification, in order to realize the effective operation between each verification unit and realize the optimization of the equipment action, the simulation operation of the intelligent verification tempo can be developed. Through simulation technology, the operating data of each system can be checked and the technical requirements of each key process node can be identified. It is possible to simulate any failure event according to the technical parameters of the functional module, and find the most effective emergency treatment plan based on all discovered process bottlenecks. The function can identify operational risks, optimize the on-site debugging mode through on-site debugging and simulation methods, finally eliminate the debugging time, and deal with various possible risk events in advance.

3.4. Clock standard network set control

3.4.1 Design method of clock multiple-route frequency division. According to the error verification of traditional electric energy meters, the high-precision clock in each verification device is used as a standard metering clock, and the tested clock is compared and calculated. It is necessary to add a clock crystal oscillator to pass the large-scale centralized application of the verification device. This method will lead to an increase in equipment investment and a significant increase in maintenance workload. In response to this problem, this article uses a single crystal oscillator signal in the standard clock source multi-channel frequency division setting. The method of multi-channel frequency division output is completed through the network channel. The standard clock signal is transmitted to each individual verification device to ensure that the clock signal can complete effective transmission and synchronize the update time.
3.4.2 Clock network centralized control system. The network centralized control of the clock generally includes many functional modules such as frequency dividing circuit, shaping circuit, optical isolation circuit and clock error processing. The specific structure of this module is shown in figure 3.

![Network set control structure diagram of the clock standard](image)

Figure 3. Network set control structure diagram of the clock standard

In the content introduced in figure 3, the precision clock reference can be converted into a square wave signal with the same frequency through a shaping circuit after sending out a sine wave high frequency clock signal. Through the frequency divider circuit, the high-frequency signal is converted into a signal with a lower frequency. After frequency division, the signal can be converted into multiple clock signals with the same frequency under the action of the drive circuit, and the signal can be uploaded to the clock error system to ensure that the time error can be recorded at any time and recognized by the system [4].

3.4.3 Shaping circuit. A sine wave output signal with a parameter of 10MHz is used in the standard clock signal setting. The square wave drive method verifies the constant error method in the device. With the support of the system, the square wave signal can be directly counted. Therefore, in order to achieve this effect, it is necessary to reshape the clock signal. The sine wave can be transformed into a rectangular wave or square wave with the same frequency through a voltage comparator. It needs to select MAX903 during signal conversion. This comparison circuit has the advantage of low power consumption, and the conversion time reaches 10ns.

3.4.4 Drive circuit. The clock signal after the frequency division of the drive circuit can realize long-distance data transmission. In the technical implementation, the 74HC14 trigger inverter structure is adopted. A gate drive mode is set on each channel. This method can complete the drive and shaping of the input signal, and set a signal source input mode port can output 10 signals through the same frequency. At the same time, by setting a photoelectric isolation receiving board on the verification device to receive the clock signal, this design method can avoid the problem of transient pulse interference and strengthen the stability of the system.

4. Conclusion

In the intelligent metrological verification technology of the Internet of Things, the functions of the system can be significantly enhanced through diversified functional modules such as the beat simulation system. The system introduced in this article has stronger system operation capability, satisfactory stability of the system, better identification of the function of the electric energy meter. The aim is to improve the verification efficiency of the equipment, and finally lay the foundation for improving the function of the electric energy meter, which is worthy of promotion.
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