Design and Research of Constant Magnetic Field Verification Device for Electric Energy Meter

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Abstract. Design the electric energy meter constant magnetic field verification device system, carry out the constant magnetic field verification, and realize the electric energy meter constant magnetic field automatic verification. To ensure the accuracy and traceability of the magnetic field, a magnetic field sensor is installed at the bottom of the tray, and the test magnetic field is read in real time through the magnetic field sensor. The device is fixedly connected with an infrared sensor to detect the rotation angle of the magnetic steel. The operation of the three-axis motor of the magnetic field detection device changes the position of the magnetic steel around the bottom and top of the electric energy meter to complete the verification of the entire electric meter. The electric energy meter constant magnetic field verification device has high accuracy, strong safety, and can complete the automatic detection function.

Keywords: Electric energy meter, magnetic field verification, sensor.

1. Introduction
In recent years, it has been discovered that many illegal users have used strong magnets to interfere with electric energy to express the purpose of stealing electricity. When the magnet is close to the current transformer inside the meter, the power measurement value of the meter changes. The external constant magnetic field has a great influence on the metering performance of the electric energy meter, mainly affecting the internal power module, current transformer, and sampling unit of the electric meter, resulting in inaccurate measurement. In order to ensure the safe and reliable operation of the smart electric energy meter and accurate measurement, the electric energy meter needs to be subjected to an external constant magnetic field influence test.

The traditional test device is inconvenient to operate, has low accuracy, and does not have an external constant magnetic field generator that meets the requirements of the standard. The existing device cannot meet the requirements of the national standard GB/T17215.321-2008 to apply an external constant magnetic field to all accessible surfaces of the meter under test. The test process did not realize automatic operation, and it was impossible to avoid injury to the operator. The position, size and direction of the external magnetic field cannot be adjusted, and the influence of different magnetic fields on the measurement of the electric energy meter cannot be tested. Design a device for constant magnetic field verification of electric energy meters that can meet national standards to solve the corresponding problems.
2. **Overall design of magnetic field verification device**

The electric energy meter constant magnetic field verification device includes a verification device casing. The housing of the verification device is a rectangular box with an opening on the upper side, and the inside of the housing of the verification device is divided into three layers: upper, middle and lower structures. The upper electric cylinder assembly, rotating magnetic steel mechanism and electric energy meter are installed in the upper structure. The lower electric cylinder assembly and a three-phase portable source are installed in the middle structure. The motor driver and electrical backplane are installed in the lower structure. The overall structure of the electric energy meter constant magnetic field verification device is shown in the figure.

![Figure 1. The overall structure of the constant magnetic field verification device.](image)

At the junction of the upper structure and the middle structure, a flat plate is fixed as a table top. A countersunk groove is opened at the lower center of the table as an electric energy meter seat. The upper linear slide rail is fixedly connected to the table on the right side of the electric energy meter seat. The upper electric cylinder fixing bottom plate is fixedly connected to the table on the left side of the meter base. A sliding block is slidably connected to the upper linear sliding rail, a long connecting plate is vertically connected to the sliding block, an upper linear sliding table is fixedly connected to the fixed bottom plate of the electric cylinder, and a Gauss meter bracket is fixedly connected to the table.

In order to meet the requirements of the State Grid's latest standards for single-phase smart meters, three-phase mutual-induction smart meters, and three-phase straight-through smart meters, constant magnetic field test detection requirements, namely single-phase 200mT, three-phase 300mT. The electric energy meter constant magnetic field verification device uses 500mT permanent magnets, which are designed as two three-axis structures. By installing a position sensor, the distance between the magnet and the meter under test can be changed to achieve the requirements of different magnetic fields for single three-phase meters.

The three-axis mechanism above the constant magnetic field verification device is used for the front and three side magnetic fields of the electric energy meter. A 500mT permanent magnet is installed on the Y axis. Through the position sensor, the three-axis X, Y, Z structure can be up and down, left and right, front and rear Move in all directions to realize the test on the front and side of the electric energy meter.

At the same time, a three-axis mechanism is designed below for the test requirements of the bottom surface of the electric energy meter, and a 500mT permanent magnet is also installed on the lower
three-axis structure. When the device is tested on other sides, the three-axis mechanism will drive the magnet away from the electric energy meter. Prevent the bottom magnet from affecting the electric energy meter.

3. Component design of magnetic field verification device

In order to ensure that when the electric energy meter is doing the test, the test of all the electric meters can be realized by one connection, a universal adapter device is designed, which is composed of a bottom bracket, a universal terminal, and a transfer terminal tray. The base is designed to be hollowed out on the bottom of the electric energy meter to meet the requirements of electromagnetic compatibility. It is installed with a wedge structure to prevent the permanent magnet from failing to meet the test requirements due to the existence of the bottom support.

The transfer terminal is used to connect the universal terminal and the sample to be inspected. The one end connected to the universal terminal is equipped with a maximum of 10 strong current terminal interfaces and 26 weak current terminal interfaces. The maximum working current of the strong current terminal of this device is 30A, and the maximum working voltage of this device is 6000VAC, so as the connection terminals are connected one by one, and the end connected to the sample to be tested needs to be designed separately according to the shape and size of each sample. The connection mode of the transfer terminal of the heavy current part is that the universal terminal is a jack, and the transfer terminal is a pin. The connection mode of the transfer terminal of the weak current part is that the universal terminal is a pin, and the transfer terminal is a jack. In this way, the size of general and transfer terminals is reduced. The universal adapter device is shown in Figure 2.

![Figure 2. General adapter device diagram.](image1)

![Figure 3. Bottom tray device diagram.](image2)
In order to ensure the test accuracy of single-phase and three-phase meters, this device is designed with matching trays. Two types of trays are designed, one is a single-phase tray for single-phase meters, and the other is a three-phase tray for three-phase meters. The bottom tray device is shown in Figure 3.

In order to ensure the accuracy and traceability of the magnetic field, a magnetic field sensor is installed at the bottom of the tray. The magnetic field intensity of the magnetic field sensor is 0-1000mT. During the test, the equipment uses the magnetic field sensor to read the test magnetic field in real time to ensure that the single-phase meter 200mT. The phase table is 300mT.

The tray is designed as a hollow structure, which not only ensures that the magnetic field sensor is close to the surface of the meter, and the accuracy of sensor sensing, but also to prevent the permanent magnet from failing to meet the test requirements due to the existence of the tray.

The rotating magnetic steel mechanism of the constant magnetic field verification device of the electric energy meter includes a magnetic steel fixed rod which is fixedly connected to the sliding block of the linear sliding table of the shaft. The bottom of the magnetic steel fixed rod is fixedly connected to the rotating cylinder support, and the first rotating cylinder is fixedly connected to the rotating cylinder support. The output shaft of the first rotating cylinder is arranged downward, the shaft end of the motor is fixedly connected with a magnetic steel support through a coupling, and one side of the magnetic steel support is fixedly connected with a second rotating cylinder whose output shaft extends into the magnetic steel support. The output shaft end of the second rotating cylinder is fixedly connected to the magnetic steel casing, which is made of transparent acrylic material. The magnetic steel casing is provided with magnetic steel, and the magnetic pole direction of the magnetic steel can be changed at will. The rotating magnetic steel mechanism diagram of the constant magnetic field verification device is shown in Figure 4.

![Figure 4. Rotating magnet mechanism diagram of constant magnetic field verification device.](image)

The two sides of the rotating cylinder support are fixedly connected with infrared sensors, and the upper side of the magnetic steel support is fixedly connected with a fixed plate, so as to detect the rotation angle of the magnetic steel and prevent damage to the components caused by excessive rotation.

The lower electric cylinder assembly of the middle-level structure of the electric energy meter constant magnetic field verification device is shown in Figure 5.
Figure 5. Diagram of the lower electric cylinder assembly of the constant magnetic field verification device.

The lower electric cylinder assembly includes a lower linear slide rail and a lower Y-axis linear slide fixedly connected to the inner bracket of the verification device housing. The sliding block of the lower Y-axis linear sliding table is fixedly connected to one end of the base of the lower X-axis linear sliding table. The other end of the base of the lower X-axis linear slide is fixedly connected to the slider on the lower linear slide, and the sliding block of the lower X-axis linear slide is fixedly connected with the lower Z-axis linear slide set upward. The sliding block of the lower Z-axis linear sliding table is fixedly connected with a lower magnetic steel fixing rod. The top of the lower magnetic steel fixing rod is fixedly connected with a magnetic steel fixing seat, and a magnetic steel is arranged in the magnetic steel fixing seat. The detection system can change the position of the magnetic steel at the bottom of the electric energy meter to meet national standards.

In the lower structure of the electric energy meter constant magnetic field verification device, the motor driver is connected to the electric cylinder components of the upper and middle layers, and is connected to the external computer. The computer is used to control the position of the upper and lower magnetic steel. Provide electricity.

4. Magnetic field verification device detection process and function

According to the type of electric energy meter to be tested, select the appropriate relay terminal and tray, and place the electric meter on the tray with tight crimping. After starting the test, the three-axis structure drives the magnetic field to move. After reaching the position, the magnetic field sensor detects that the magnetic field requirements for the test are met. Start the electric energy meter verification device and start testing.

The constant magnetic field verification device of the electric energy meter is designed with two mechanical structures, which are divided into upper and lower parts to facilitate the movement of the magnetic steel. The constant magnetic field is obtained by permanent manganese strong magnet, which acts on the 5 accessible surfaces of the instrument installed in normal use. The volume of the magnetic steel used for the test is 50*50*50mm, and the field strength is about 580mt. During the test, the three-axis manipulator controls the distance between the magnetic steel and the meter surface to ensure that the field strength of the meter surface meets the test requirements. A magnetic field intensity detection sensor is designed at the bottom of the tray, which can trace the source of a constant magnetic field.

The magnetic field verification device is divided into two parts, one is the test bench body, and the other is the power source cabinet. When designing safety, the mechanism is covered with an acrylic cover on the top. The detection unit has an obvious running light display, and the power supply of the
The detection unit is automatically cut off after the test. The device is equipped with multiple switches and serial port servers for communication between the device and the PLC master control and upper computer. The number of power meter test stations is 1, which can be compatible with single-phase smart meters, three-phase inductive smart meters, and three-phase through-type smart meters by replacing the relay terminals.

5. Conclusions
Design a constant magnetic field verification device for electric energy meters. By controlling the operation of the three-axis motors of the upper and middle layers, the positions of the magnets around the bottom and the top of the electric energy meter are changed, so that the entire meter verification work conforms to the national standard GB/T17215.321-2008 Provisions. The magnetic field verification device can meet the automatic detection requirements of the State Grid's latest standard single-phase intelligent electric energy meter, three-phase mutual induction intelligent electric energy meter, and three-phase straight-through intelligent electric energy meter constant magnetic field test. The constant magnetic field verification device of the electric energy meter has a high degree of automation, which can realize the automatic verification of the constant magnetic field of various types of electric energy meters, which greatly improves the verification efficiency.

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