Computer Intelligent Analysis Model of Abnormal Smart Meter under Electric Energy Meter Measurement Principle

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Abstract. Aiming at several problems in the measurement process of electric energy meters under spot market conditions, an improvement strategy is proposed based on an in-depth analysis of the abnormal causes of smart meters. Firstly, perform statistical analysis on the failure of the disassembled electric energy meter to determine the three main failure modes; then analyse the abnormal causes of the three main failures.

Keywords: spot market, smart meter, abnormal analysis, improvement strategy.

1. Introduction
In 2002, China opened the curtain of power system reform, and power market-oriented trials represented by the separation of power plants and grids, bidding on the Internet, and direct power purchase by large users were successively launched across the country [1], [2]. In 2015, since the release of "Several Opinions of the Central Committee of the Communist Party of China and the State Council on Further Deepening the Reform of the Electricity System" (Zhongfa [2015] No. 9)[3],[4], 30 provincial-level power trading centers and 2 national-level trading centers have been established across the country (Beijing and Guangzhou), the purpose is to let the market play a decisive role in the allocation of power resources, and guide market entities to effectively produce, consume and invest [5]. In 2017, the National Development and Reform Commission and National Energy Administration of Japan issued the "Notice on the Pilot Work for the Construction of Electricity Spot Markets", selecting eight regions in the South (starting from Guangdong), Mengxi, Zhejiang, Shanxi, Shandong, Fujian, Sichuan, and Gansu. As the first batch of pilot power spot market reforms. In October 2018, the South (starting with Guangdong) power spot market-related documents were released, which opened the trial operation of the power spot market [6].

In order to adapt to the ever-changing market-oriented demand for electricity trading, higher requirements are also put forward for smart energy meters [7]. After the existing on-site electric energy meters have been running for a period of time, some electric energy meters will have clock out of tolerance, which will affect the accuracy of their billing for users who implement tariff rates.
2. Electric energy meter measurement principle
The metering principle of a single-phase electric energy meter is shown in Figure 1, which mainly includes a metering module, an MCU module, an LCD display module, a communication module, and an E2 storage module.

![Electric energy meter diagram](image)

**Figure 1.** The measurement principal diagram of a single-phase electric energy meter

3. Abnormal analysis of electric energy meter
With the popularization of traditional smart electric energy meters, many problems have been exposed during on-site operation, which can generally be attributed to storage problems, display problems, communication problems, and metering problems. Through the analysis of the failure of the State Grid Shandong Company in recent years, it can be seen that there are three main types of failures: clock failure, storage failure, and metering failure. Clock failures are mainly manifested in clock out-of-tolerance; storage failures are mainly manifested as sudden changes in power, such as sudden changes in storage power to zero, constant power accumulation, and sudden changes in frozen power to abnormal values; The metering failure mainly manifests the metering error, such as a sudden increase or decrease in daily power consumption.

3.1. Clock anomaly analysis
After the on-site electric energy meter has been running for a period of time, some electric energy meters will have clock out-of-tolerance. The main reason is that the clock battery in the electric energy meter is under-voltage. In the event of a power outage, the electric energy meter clock chip will not work properly. Causes the occurrence of abnormal clock failure. The general life cycle of an ordinary battery in an electric energy meter is shown in Figure 2. It can be seen from the figure that when the battery in the meter works for a period of time, its battery voltage drops sharply. Once it drops below the operating...
threshold of the clock chip, the clock chip will not be able to Normal work, resulting in out of tolerance of the energy meter clock.

Figure 2. The general life cycle of an ordinary battery in an electric energy meter

3.2. Storage anomaly analysis

Figure 3. I^2C bus protocol sequence diagram
When the on-site electric energy meter is subjected to external interference, there will be a sudden change in power. The main reason is that the E2 memory chip of the electric energy meter is faulty. When the electric energy meter is affected by external interference factors, such as the sudden power failure of the electric energy meter, the electric energy meter will store abnormally. In addition, when the electric energy measurement data is suddenly disturbed during the transmission process, it will also cause the transmission of the transmission data to jump, resulting in an abnormality in the stored power. The data transmission from the electric energy meter MCU to the E2 memory chip adopts the I2C bus mode, as shown in Figure 3. When the transmission process is disturbed suddenly, making the transmission bit change from 0 to 1 or from 1 to 0, it will cause a sudden change in the stored power.

3.3. Out-of-tolerance analysis of measurement errors

The principle of active power measurement of electric energy meter is shown in Figure 4. It mainly includes voltage sampling circuit, current sampling circuit, phase correction, gain correction and other parts. Voltage sampling circuit and current sampling circuit are generally composed of resistors and capacitors (as shown in Figure 5). When a resistor or capacitor is damaged or its amplitude occurs, Changes will lead to measurement error out-of-tolerance. At the same time, when the phase correction factor or gain correction factor jumps due to a sudden change, it will also cause the final active power value to change, which will eventually lead to a serious measurement error and cause electricity. Sudden change, thus causing greater economic losses to users or grid companies.

![Figure 4. Schematic diagram of active power metering](image-url)
In addition, the unstable load of power grid will also affect the measurement accuracy.

3.3.1. Influence of load fluctuation on metering. To ensure the metering accuracy of smart meter, multi-cycle averaging method is generally used to calculate voltage, current, power, etc. This method takes too long to calculate the instantaneous sliding window, cause delay of pulse output and bigger running error, and influence the real-time settlement of pluralistic electricity under spot trading settlement.

3.3.2. Influence of impulsive current on metering. When the current suddenly changes, if range measure or gain cannot switch timely, which will influence the metering accuracy of smart meter. At the same time, high current impulse will lead to smart meter transformer saturated. So that smart meter must have wide dynamic range metering function.

3.3.3. Influence of waveform distortion on metering. Large harmonic distortion rate of wind turbine and other new energy will introduce the total electric energy of inversion harmonic, and lead to less calculation of total active energy and source failure of smart meter because of increasing voltage harmonic distortion rate.

3.3.4. Influence of harmonic introduction on power factor. The power factor is calculated as follows:

\[ P_f = \frac{P}{S} \]  

(1)
Where: Pf- power factor, P- active power, S- reactive power.

\[ S = V \cdot I \]  

Where: V-voltage, I-current.

Generally, harmonic source load on site will inject harmonics into power network, active power P will decrease because reverse harmonic energy was offset into full wave energy, and full wave electric energy decreases.

Harmonic current resulted in the increases of current effective value, as a result, the apparent power increases.

The above two cases will cause the power factor to become smaller, and the specific reduction degree is directly related to the level of harmonic distortion rate.

### 3.3.5. Influence of harmonic introduction on active power

The power frequency sinusoidal source supply power to harmonic source load will increase with the change of current harmonic frequency, and active power loss will occur. Therefore, harmonic active energy doesn't have a positive effect but is consumed in the form of transformer loss and line loss.

### 4. Concluding remarks

Through the failure analysis of the failure to remove the electric energy meter, the three main failure modes of the intelligent electric energy are found, and the causes of the three failure modes are analysed in detail. The manufacturer has certain guiding significance.

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