

Analysis on the Reasons for Smart Meter Failure and Solutions

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Abstract: Smart meter as a national legal measurement appliance and professional instrument is the basic modern equipment for smart grid technology management. It is very important for electric power company to reduce the wrong calculations of electric power meter and cut down the numbers of the failure for smart meter. This paper will start from analysis for common failures and analyze reasons that cause different failures inside the power meter and corresponding solutions to solve the problems.

1. Introduction

Besides the basic function to measure the electric energy, smart meter also has the functions of positive and negative measurement, time-sharing measurement, remote reading, remote monitoring and control, safe protection of using the electricity information, event recording, active reporting and so on. It can help users to choose the methods to use the electricity reasonably and save electricity. As the development of electronic forms, integration, intelligence and networking for power meter, it is very vital for the whole power system to let its normal function to work. However, because of the natural environment, the installation, the operation and the maintenance of smart meter. They causes various failures for smart meter. This paper takes the smart meter as a research object to analyze its common failures during its operation. In order to make sure the normal operation for smart meter, it is used to make different effective methods to reduce the number of failures and keep a safe and stable smart power grid according to different breakdowns.

2. Common faults of smart meter

The failure rate of smart meter refers to the number of failures of smart meter within a fixed time. The more faults of smart meter occur, the higher the failure rate of smart meter is. The common faults of smart meter are battery fault, clock fault, display fault, burning fault, communication fault and so on. The details are shown in Table 1.

Table 1 Common faults of smart meter

| No. | Fault type | Fault phenomenon | Fault cause |
|-----|------------------------|---|---|
| 1 | Battery fault | Alert prompt“ERR04” | Meter failure, battery under-voltage Poor contact of battery connector |
| 2 | Clock fault | Alert prompt“ERR08” | Chip failure, battery under-voltage Poor communication signal |
| 3 | Display fault | Display screen scrambling, Flicker phenomenon | High temperature and high humidity |
| 4 | Burning fault | Connection head burn, Meter burn | Improper installation of smart meter overload, poor wiring contact |
| 5 | Communication fault | Meter reading failure, Communication partition | Wrong parameter setting, component virtual welding |

3. Analysis of the reasons for smart meter failure

3.1 Impacts of human factors

During the installation of smart meter, because the operation process is not standard and the installation process is unreasonable, the current and voltage for smart meter welding, the wire disconnected, the voltage divider resistance fracture, PCB circuit components welding, all these are the critical reasons for smart meter to break down. Besides, because of the lack of maintenance during the operation, especially not handling the potential serious problems for smart meter in time, the aging problems for line of smart meter during operation, the loosening sealing problems and too much duct inside the smart meter, if all these problems are not solved in time, they will expand the potential hazards so that they will cause smart meter to break down.

3.2 Impacts of natural factors

In order to judge the impact of the environment on the accuracy of smart meter, we chose ten DSZY22 models of three-phase smart meters whose accuracy level are 0.02 and put them under a relative humidity of 80% to do the circulation. After connected to the transformer and under the positive active power for error value is 1, the evaluation results are shown in Table 2.

Table 2 Results for three- phase power meter under damp-heating alternating test

| No. | Basic Error% | | | | | | | |
|-----|--------------|--------|--------|--------|--------|--------|--------|---------|
| | -10°C | 0°C | 10°C | 20°C | 30°C | 40°C | -10°C | 40°C |
| 1 | -0.020 | -0.016 | -0.000 | -0.000 | +0.001 | -0.028 | -0.016 | +25.116 |
| 2 | -0.017 | -0.013 | -0.006 | -0.001 | +0.002 | +0.032 | -0.018 | +24.756 |
| 3 | -0.031 | -0.024 | +0.002 | -0.001 | -0.001 | +0.026 | -0.022 | +24.081 |
| 4 | -0.023 | -0.017 | -0.005 | -0.002 | -0.000 | +0.025 | -0.025 | +25.783 |
| 5 | -0.026 | -0.022 | +0.004 | +0.001 | +0.003 | +0.028 | -0.019 | +24.725 |
| 6 | -0.018 | -0.018 | -0.008 | +0.003 | -0.000 | -0.031 | -0.017 | +25.099 |
| 7 | -0.017 | -0.017 | +0.011 | -0.002 | +0.002 | +0.031 | -0.018 | +25.761 |
| 8 | -0.021 | -0.021 | -0.009 | +0.001 | +0.004 | +0.022 | -0.033 | +24.649 |
| 9 | -0.040 | -0.015 | -0.007 | -0.002 | -0.000 | +0.043 | +0.019 | +25.322 |
| 10 | -0.028 | -0.023 | +0.008 | -0.004 | -0.001 | -0.041 | +0.028 | +24.437 |

The basic error measurement is measured by the standard method for smart meter, which is the presetting method of high-frequency pulse number. Its principle as shown.

Applying the same voltage, current and power factor to the standard smart meter and checked smart meter at the same time and under the constant and stable condition, during the same time period, the output for the number of high-frequency pulses of the standard power meter is m and m is as the actual number of high-frequency pulses. Meantime, the output for the number of low-frequency pulses of the checked power meter is N and N is converted into the calculated pulses number m_0 . The relative error γ of the measured meter is obtained.

$$m_0 = \frac{C_H \cdot N}{C_L}$$

$$\gamma = \frac{m_0 - m}{m} \times 100\%$$

In this formula

m —— actual number of pulses

m_0 ——Calculated (preset) number of pulses

C_H, C_L —— high-frequency pulses of the standard power meter

Therefore, it has a great influence under the high-humidity environment when the temperature changes. During the test, under the high humidity and low temperature environment, the inside

component of power meter is frost which will reduce the accuracy of power meter. Under the high humidity and high temperature environment, it will cause the flowing water into the inside of the power meter and impacts the power meter's normal operation.

From the point of natural factors, if the operation and installation of smart meter are carried out strictly with the standard environmental conditions, it will cause the smart meter in a relatively humid environment and lots of water will cause the short circuit inside the circuit board of smart meter to cause the damage of smart meter. When there is high temperature and the inside of smart meter does not spread the heat in time, it will cause the brightness of display not normal and the color is unusual. Meanwhile, under the bad environment and condition, especially under the frequent thunder and lightning, the smart meter and its circuit will have a second shock by thunders and the instant too much voltage will cause the damage of smart meter.

3.3 Impacts of the inside component of the smart meter

Inside the smart meter it is the lithium batteries to supply electricity, so the quality of the lithium battery affects directly whether the smart meter can operate normally. For the normal lithium batteries, the both ends voltage are $3.66\text{V} \pm 0.02\text{V}$ by using the multimeter. When some things happen to the batteries, the voltage value will change to cause the measurement is not accurate. The voltage value of lithium batteries will change as the storage time goes by. More storage, less power for lithium batteries. When the power is not enough to keep the smart meter to work normally, situations will appear such as the data will lost and measurement is not accurate.

Smart meter are made up of built-in current transformer, voltage divider circuit, integrated metering chip, microcontroller unit, ESAM (embedded security control module), clock/battery, LCD, button, prepaid module, communication module and RS485/ far-infrared man-machine interface module. Its working principle is shown in Figure 1.

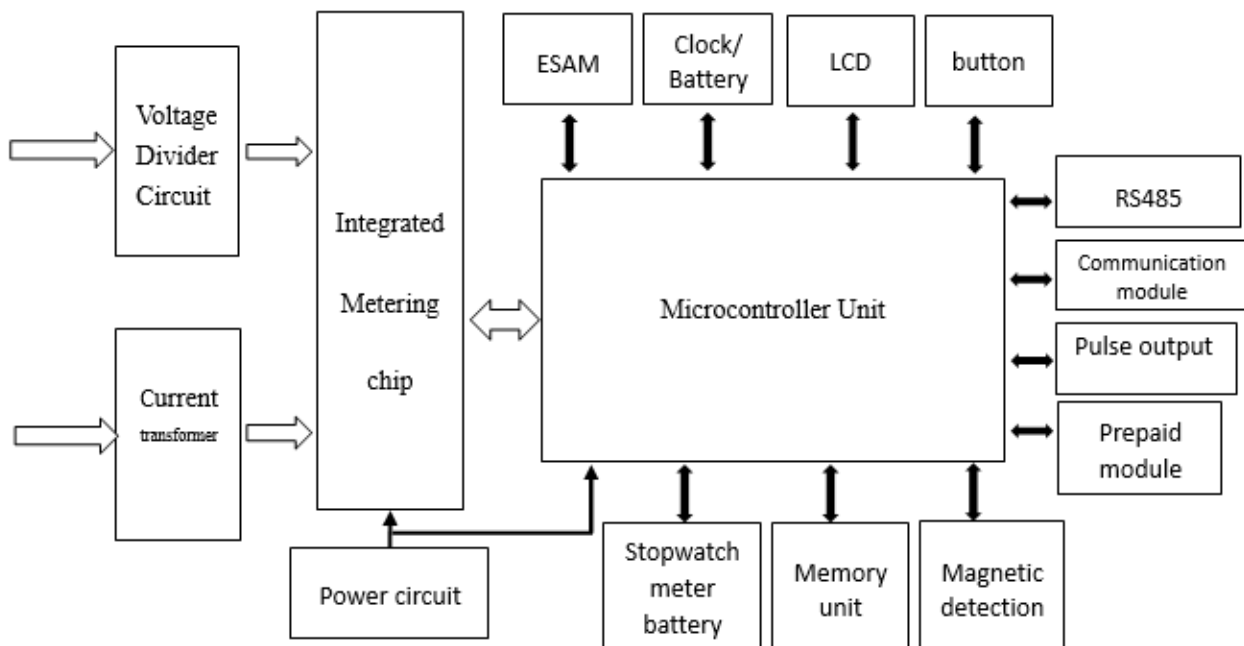


Fig.1 Smart meter working principle

The integrated metering chip can convert the analog signals from voltage divider circuit and power transformer into digital signals and carry out number integral calculation for it so that it can accurately get active power and reactive power. The micro-controller will deal with the data according to corresponding rates and meets. Because the hardware has poor anti-interference, the design of the PCB circuit board should separate the strong and weak current to eliminate the electromagnetic interference from the digital signal circuit. When the circuit board cannot meet these design standards, smart meter will not restrain the interference sources. This will cause the

measurement is not accurate. Meantime, when the chip capacitor for divider resistance, manganese-copper shunt, sample circuit and external voltage reference loop filtering are welding, this will cause the sample values into the measurement chip not correct and indicate the abnormal numbers for voltage, current and power display.

4. Measurements to handle the failure of smart meter

According to the above analysis, common breakdown for smart meter can be the abnormal display, inaccurate measurement and inter transformer burnout and so on. Based on the analysis of the reasons that cause the failure of smart meter, there are mainly three aspects, human factors, environmental factors and inter component factors. Therefore, in order to reduce the number of the occurrence of the failures for smart meter, we need to prevent and control from the below aspects.

4.1 Enhancing the routine inspection work for smart meter

The routine inspection work for smart meter includes meter inspection, looking at the power factor, whether the frequency is normal, three-phase voltage, whether the current is balanced, whether there is an indicator for voltage loss, current loss and so on. Next, it is also necessary to inspect whether there is any loosening place, strike fires, even burnout mark, also the end of the connection of smart meter, the second connection for transformer.

4.2 Strengthen the potential dangerous work for smart meter

We need to take effective methods to control and prevent easily observable failures for smart meter. As for potential dangerous work for smart meter, we need to use multimeter, phase meter, field calibrator and such equipment to measure. Through measuring the power factor of power meter, the phase of secondary circuit for current, and whether the voltage condition is normal. Therefore, we need to enhance the inspection failure work for smart meter periodically to make sure the accuracy of the measured numbers for smart meter.

4.3 Improving the reliable experiment for checking the hardware for smart meter

There are many external factors that can affect the reliability for power meter's hardware, but temperature, humidity and voltage are main factors. During the process of making power meter, it is necessary to do a comprehensive test and verification. Enhancing the high-temperature and high-humidity test, broadening the range for temperature and humidity, increasing the changing grades in order to make the surface of the components can have condensation and frost in low temperature and evaporate in high temperature so that it can increase the corrosion strength. Meanwhile, according to the principle of thermal expansion and contraction to strength the bad joints and packaging breakdown.

4.4 Enhancing the management of smart meter

First of all, people who work to measure need to improve their skills. The main responsibility for power measurement people is to manage the volume of electricity and devices to measure power and to do a great job in checking the power measurement devices, including the economic index to verify fees and evaluate power systems, supervise and verify the electric power devices at the metering points. They are responsible for storage, remove, scrap the power meter, transformers and measurement equipment. They need to install, rotate, check, verify, quality inspect, manage asset and technical management, periodically checking and maintain measurement devices.

Next, they need to manage every line for normal operating grid of smart meter and periodically collect monitoring data. Through the analysis of collected date, they need to observe the data changes in certain area and find rules from it. The old equipment are replaced in time in case of potential hazards.

Finally, the failure types of smart meter are analyzed accurately and in time from failure evaluation. They'd better solve the problems from the root to make sure the measurement is accurate and reliable and make sure the collected--power-data systems work orderly. For example,

during the process of analyzing the failure, there is a breakdown for meter memory chip or the chip is damaged seriously and cannot work normally, people can infer the abnormal point situations based on daily freezing data and load date to track historic electricity.

5. Conclusions

In the process of operation, the failure of smart meter will affect the power data collection which is related to the safety, stability and reliability of power consumption. When we evaluate different types of breakdowns of smart meter, the number of failures, the causes of failures, the rates of failures, the statistical analysis results are collected and counted in time. The key factors that affect the quality of smart meter are analyzed and the hidden trouble eliminated in time. As an important part of the whole process to monitor and manage the quality, effectively prevent and control quality risks, effective measure should be taken accordingly. With the development of innovation for smart meter and the change of details, the difficulty of fault analysis is gradually increased. For example, the infrared reading data need to be authenticated and ESAM module exception caused by the remote command execution. Enhancing the routine inspection work for smart meter and potential hazards failure measurement, enhancing the high-temperature and high-humidity experiment. Reducing the failure rate of smart meter and improve the safety and stability of the power grid.

References

- [1] Yuan Ruiming, Theory and technology of electric energy metering for smart grid, China electric power press, 2018.
- [2] Gao Weizhi, Intelligent watt-hour meter detection, Hei Longjiang science and technology information, 2012
- [3] Zhang Xiaoyan, Common faults and treatment measures in the operation of smart meter, Science and technology innovation and application, 2017
- [4] Huang Quanyong, Discussion on failure rate of smart meter, Management of Chinese Electric Power Enterprises, 2010
- [5] Xiao Yong, Zhou Shangli, Zhang Xinjian, Energy metering automation technology, China electric power press, 2011
- [6] Chen Jiabin, Electric energy metering device and management technology, China water conservancy and hydropower press, 2010