

Research on Verification Platform of Electric Energy Metering Equipment Operated in Typical Environment

You Gong, Hui Ying Liu, Xin Yin, Xing Gong Li, Yan He Liang , Jiang Xue Man and Ru Xin Wen

(State Grid Heilongjiang Electric Power Co., Ltd. Electric Power Research Institute)

Abstract. under typical environmental conditions, various faults may occur in key components of metering equipment, which directly affect the accurate and reliable operation of metering equipment and impair the vital interests on the supply side and the demand side. Through the recurrence of the fault phenomenon , which is easy to occur under this condition, the causes of the failure are analyzed, and the preventive measures and the optimal design scheme for the metering equipment are put forward. The experiment not only verifies that the scheme greatly reduces the error of experimental data, but also can obtain the change rule of the operating characteristics of the parameters, and at the same time, verifies the feasibility and validity of the experiment.

1. Introduction

As the basis of trade settlement of each interconnected network, metering equipment lays an important foundation for promoting the construction of global energy Internet^[1]. At present, metering devices often occur under severe weather conditions in some areas, and are obviously affected by climatic factors. The reliability of measuring equipment not only affects the security, stability and economic operation of smart grid, but also relates to the reliability and safety of household electricity consumption^[2].

In the high and cold environment, the key components of the measuring equipment may appear various faults, such as the sampling resistance temperature drift, the capacity decline of the capacitor, the increase of the clock error, the liquid crystal display ghosting and the decline of the capacity of the battery^[3]. In order to protect the fairness and impartiality of trade settlement in interconnected power grids under different climate conditions, we have set up an international leading natural cold outdoor testing facility. The test field , exposing the defects of measuring equipment, analyses the causes of the failure, accumulates the operating data of the typical environment, leads the international standard system(repair),and implement the strategy of strong country in quality and manufacturing^[4].

2. Construction of platform structure

We put 48 single-phase meters, 24 three-phase watches and 10 concentrators into the stepping refrigerator, and carried out the low temperature test. The whole system adopts the separation mode of the testing equipment and the hanging meter rack. The test area of walk-in fridge is placed in single-phase meter, three-phase meter and concentrator by means of hanging meter rack. The indoor laboratory realizes the verification test function of intelligent electric energy meter and concentrator by configuring power source and error processor. The measurement equipment mainly inspects the measurement error, the carrier communication, the charge control trip (a certain meter tripping does not affect the normal verification of other meters), the meter reading time, the liquid crystal display and other functions. All test tasks are configured by the system software and sent out to verify the functions



of metering equipment in low temperature environment. As shown in figure 1.

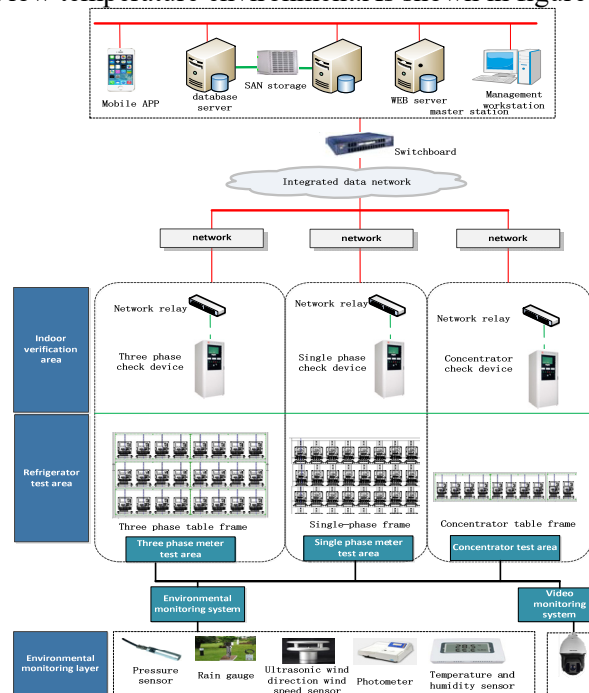


figure 1. Platform overall structure

The working status of metering equipment detection devices and walk-in refrigerators can be monitored through the WEB server to support the remote connection of mobile phones to view the working status of field devices. It also can check at any time to ensure the safe operation of the equipment and can start the alarm function in time after problems occur^[5].

3. Design of system hardware

3.1 Design of signal source

Working principle of signal source: the signal source adopts advanced digital synthetic signal technology of digital frequency modulation, amplitude modulation and phase modulation, which is composed of a powerful programmable digital logic array (CPLD) chip, micro-controllers MCU, D / A chip and so on. The fundamental or superimposed harmonic of sinusoidal waves is digitally dispersed by MCU and stored in RAM. The frequency reference generator inputs the sinusoidal digital value stored in the RAM to the D / A converter through the calculator. The digital synthetic sinusoidal signals with certain phase relationship between each other are obtained respectively. After active low-pass filtering, the voltage and current signals with distortion less than 0.2% are input to the power amplifier. The amplitude of the signal source is adjusted by a 16-bit D / A converter, which makes the adjusting fineness less than 0.01%.

3.2 Design of power source

As shown in figure 2, the power amplifier adopts advanced pulse width modulation technology, which has the characteristics of high conversion efficiency, large output capacity, high output reliability, strong load capacity and stable output. Perfect abnormal protection, main circuit over-current protection, device overheating protection, output short circuit overload protection and output open circuit protection are designed to make the power amplifier work stably and reliably for a long time. The principle of power amplifier is that the standard sinusoidal signals of voltage and current generated by the signal source are transmitted to the voltage amplifier and the current amplifier through their respective feedback compensation adjustment circuits for power amplifier. Output voltage, current signal sampled by current, voltage feedback sampling transformer, feedback back to the feedback

compensation adjustment circuit of the previous level of the feedback power amplifier^[6]. If the alarm signal is generated by the device, it can be fed back to the signal source quickly, and the signal output can be stopped through the signal source.

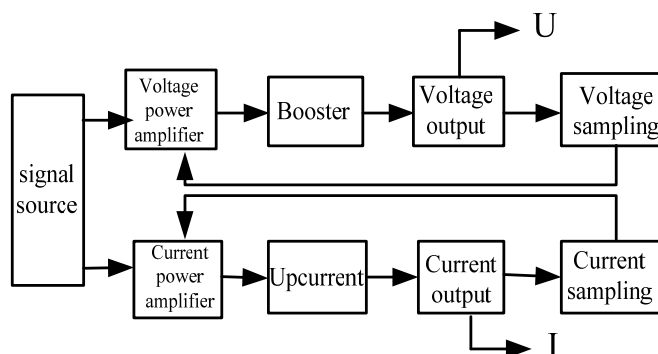


Figure 2. Power amplifier

4. Experimental test

4.1 Measurement error test

The detection device is shown in Figure 3. The temperature of the experimental environment is set to 20 °C, 10 °C, 0 °C, -10 °C, -20 °C, -30 °C, -40 °C, -50°C. Error test starts after each temperature is stabilized for 2 hours. The selection of single-phase watt-hour meter frequency, three-phase watt-hour meter frequency, voltage, load, phase is shown in Table 1. The test voltage in the table of three-phase watt-hour meter is phase voltage. It is required to arrange the load voltage, frequency, phase and load in the array and combination mode, that is, the verification point includes voltage, frequency, phase and load combinations of various working conditions.



Figure 3. Detection equipment diagram

Table 1. selection of working conditions

Voltage (V)	176	187	198	209	220	231	242	253	264
frequency (Hz)	49	50	51	—	—	—	—	—	—
phase	0°	30°	60°	120°	150°	180°	—	—	—
load (A)	0.25	0.5	1	2	4	5	5.5	6	10
	20	30	40	50	60	65	—	—	—

4.2 Communication and function test

The temperature of the experimental environment is set to 20°C and -50°C. The communication and function tests were carried out on the test samples under the specified test environment. For single-phase and three-phase watt-hour meters, the communication test software is used to test the communication of watt-hour meters, and the function tests are carried out by means of the verification device of watt-hour meters. Make the Watt-hour meter read the fixed data module, record the time and save the summary in time of communication.

For the concentrator, uplink communication test and downlink communication test should be carried out respectively. 1) Uplink communication is carried out by using GPRS communication mode, and the on-line test and master station call test are carried out on the concentrator by using the analog master station. Record communication time and the concentrator on-line time. 2) The downlink communication adopts the carrier communication mode, carries on the meter reading test, records the reading success rate and the reading time.

4.3 Display test

The temperature of the experimental environment is set to 20°C, -20°C, -50°C. The test sample LCD screen is photographed in the specified test environment, and the display fault is recorded if the LCD screen appears at this time. On average, three photographs were taken at each temperature.

4.4 Power off test

The temperature of the experimental environment is set to 20°C, -20°C and -50°C. The test samples shall be powered on, powered off and re-electrified during power - off test. Each operation interval is 30s. Each test should be turned on, cut off, and re-electrified for more than 2 times. The electric parameters of watt-hour meter shall be measured and compared before and after the test, and the concentrator shall be tested for communication. After the test is completed, observe whether each device of the test sample is normal.

4.5 Experimental detection analysis

Experimental error data as shown in Table 2, including Test value of positive active error of three phase meter and Test value of active positive error of single phase meter. We can see that the experimental error is small and achieves the predetermined effect, which verifies the feasibility and effectiveness of the experiment.

Table 2. Experimental error data

asset number	Test value of positive active error of three phase meter												
	1.0				0.5L				0.8C				
	I _{max}	I _b	0.5I _b	0.1I _b	I _{max}	I _b	0.5I _b	0.1I _b	I _{max}	I _b	0.5I _b	0.2I _b	0.1I _b
1	0.03	0.01	0.02	0.03	0.02	0.02	0.02	0.04	-0.01	-0.01	0.02	-0.02	0
2	0.02	0.01	0.02	0.03	0.02	0.02	0.04	0.02	-0.02	-0.01	0.01	-0.02	-0.02
3	0.03	0.01	0.02	0.04	0.02	0.03	0.02	0.01	-0.01	-0.03	0.02	-0.03	-0.03
4	0.03	0.01	0.01	0.03	0.02	0.03	0.02	0.03	-0.02	-0.02	0.01	-0.03	-0.03
5	0.03	0.01	0.02	0.03	0.02	0.03	0.03	0.03	-0.02	-0.02	0.03	-0.05	-0.04
6	0.02	0	0.01	0.02	0.02	0.03	0.02	0.03	-0.02	-0.02	0.01	-0.04	-0.03
7	0.02	0.02	0.02	0.04	0.03	0.02	0.02	0.01	-0.02	-0.01	0.02	-0.01	-0.01
8	0.03	0.01	0.02	0.04	0.03	0.03	0.02	0.01	-0.01	-0.02	0.02	-0.03	-0.02
9	0.02	0	0.01	0.03	0.02	0.03	0.03	0.01	-0.02	-0.02	0.01	-0.04	-0.03
10	0.02	0.01	0.01	0.03	0.02	0.02	0.03	0.03	-0.02	-0.02	0.01	-0.02	-0.04

5. Performance impact analysis of metering equipment

Since the influence of temperature, voltage, load, phase and time on the watt-hour meter is investigated, the above factors are applied to the sample table at the same time, in which the temperature is the local natural environment of Harbin, voltage, load, phase and other electrical parameters are supplied by a controllable power source. When analyzing the influence quantity, change the influencing factors to be analyzed, and fix other variables. Sample meter error curve shown in Figure 4.

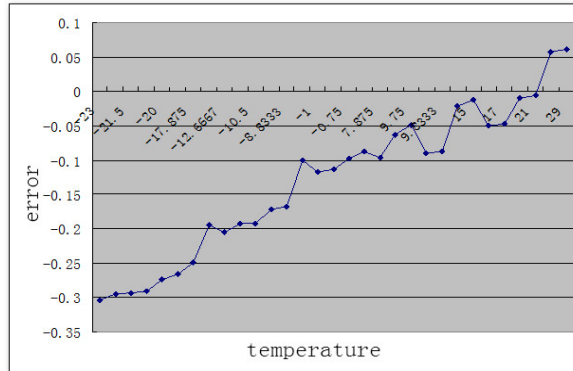


Figure 4(a). the error of sample table of the same manufacturer varies with temperature

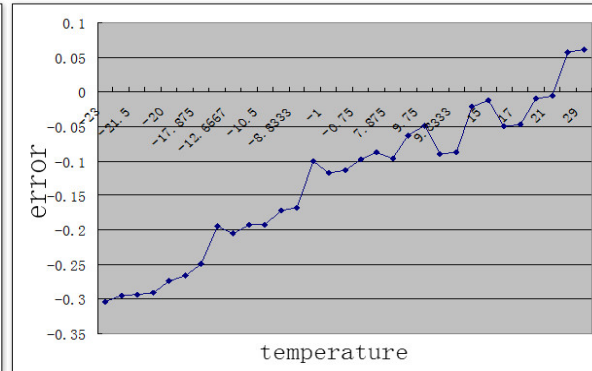


Figure 4(b). variation of sample error with power factor

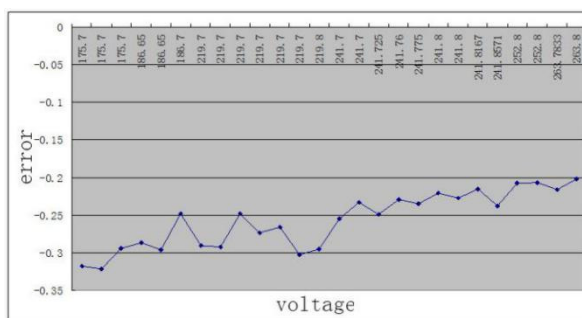


Figure 4(c). variation of sample error with voltage

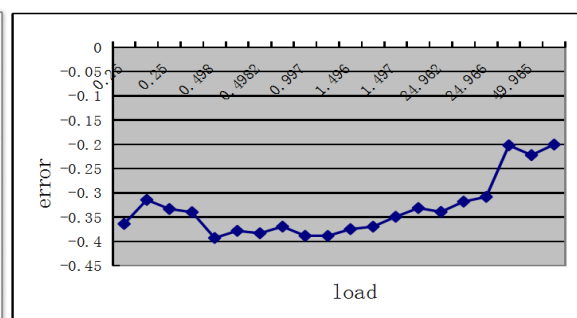


Figure 4(d). Sample table error varies with load

Figure 4. Sample meter error curve

The sample error shows certain regularity as shown in figure 4(a). When analyzing the influence of temperature, the temperature error of the operating condition with 220 V voltage and 1A current are extracted.

In the diagram, the horizontal coordinate is the measurement error of the sample table when the temperature is increased from -25 °C to 25 °C. It can be seen that the measurement error of the sample table is small at about 20 °C and the absolute value is about 0.1. When the temperature is lower than -10 °C, the error increases gradually. It shows that the temperature has an obvious effect on the metering accuracy of metering equipment, and the lower the temperature, the greater the measurement error.

The sample error variation curve is shown in figure 4(b). In order to study the effect of phase on the metering performance of single phase watt-hour meter, the collected errors are screened. The fixed voltage parameter is 220 V, the current parameter is 1 A, the temperature is about -20 °C, and the power factor varies from 0.5 to 1.

The measurement error curve of sample with voltage is shown in figure 4(c). In order to comprehensive analyze the effect of phase, the relationship between measurement error and phase of samples with different voltage, different temperature and different load condition is analyzed. The conclusion is that the effect of phase on measurement error is not obvious.

In order to study the effect of voltage on the measurement performance of the sample, the fixed load is 1A and the temperature is about -20 °C. The test data are extracted to analyze the effect of voltage.

Since the influence of power factor is not obvious, the power factor in the next analysis is all set to 1.

In the diagram, the horizontal coordinates change from small to large, and the longitudinal coordinates are sample measurement errors. The trend of error curve shows that the error decreases with the increase of voltage. But the margin of error does not exceed 0.2.

The sample error varies with the load as shown in figure 4(d). When the sample voltage is 220 V, the power factor is 1, and the temperature is -20 °C.

It can be seen from the diagram that the measurement error of the sample tends to decrease with the increase of the load. And the error fluctuation is not big, the maximum range is 0.25.

6. Conclusion

Under the typical environment such as high and cold conditions, various faults may occur in key components of metering equipment, which directly affect the accurate and reliable operation of metering equipment. By setting up a test ground for natural outdoor metering equipment in high and cold condition, exposing the defects of metering equipment and improving manufacturing technology, the quality of metering equipment is changed from conformity to usability and reliability, and the operation data of typical environment are accumulated. The causes of failure are analyzed, and the preventive measures and optimal design scheme are put forward for metering equipment. The experiment not only verifies that the scheme greatly reduces the error of the experimental data, but also can obtain the change rule of the operating characteristics of the parameters, and at the same time, verifies the feasibility and validity of the experiment.

Acknowledgment

This paper is supported by Research on Performance Verification Platform Technology of Electric Energy Metering Equipment Based on Typical Environmental conditions (Grant No. 5442JL160013).

References

- [1] Wang Yumo, Zhang Meng, Jiang Honglang, Yang Guanghui. Current status, development direction and application of new technologies in electric energy metering equipment [J]. Instrument Technology, 2010(02):55-57.
- [2] Ye Meng. Research on the overall plan for the construction of an integrated management platform for electric energy metering equipment [D]. North China Electric Power University, 2013.
- [3] Liao Yunjing. Research on fault analysis and treatment measures for on-site electric energy metering devices [J]. Communications World, 2015(22):139-140.
- [4] Su Xianle. Research on Electric Energy Metering Management Based on Typical Design of Southern China Grid Electric Energy Measurement [D]. South China University of Technology, 2014.
- [5] Dang Sanlei, Zhang Jie, Zhou San. Design and implementation of intelligent interface for energy measurement equipment communication interface design and implementation [J]. Electrical and Energy Efficiency Management Technology, 2015(12):16-21.
- [6] Lu Jianhao. Research on Condition Monitoring Technology of Electric Energy Metering Device [D]. Guangdong University of Technology, 2017.