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Research on Test Method of Communication Interface Converter Based on Simulated Field Conditions

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Abstract. This paper used the wind pressure, sealed water circulation system, wireless attenuator and interface state analog circuit to establishes simulated field operation condition of "Multi-meter unification". A test method of communication interface converters and concentrator for "Multi-meter unification" is proposed based on the experimental environment, which including function test, interface performance test and compatibility test, and to ensure the stable operation of the field communication interface converter and concentrator.

1. Introduction

With the continuous development of smart cities and smart communities, the application and construction of "Multi-meter unification" information acquisition are becoming more and more mature. At present, the main scheme of realizing "Multi-meter unification" information acquisition relies on the existing electric energy data acquisition system of the state grid company, and install the communication interface converter in the lower layer of the concentrator to collect data of water meters, gas meters and heat meters[1-2]. And the concentrator needs to be upgraded to achieve the purpose of sharing data resources of different industries. In the piloted areas, although the pilot units have proposed various technical requirements for "Multi-meter unification" acquisition equipment, the concentrators and communication interface converters of different manufacturers have defects in compatibility, function and performance[3]. Only through site commissioning can solve various problems. It's not only the installation efficiency is low, but also the quality of the collection cannot be guaranteed. However, there is no effective detection method for such problems. In this paper, A communication interface converter and concentrator detection method of simulating the "multi-meter unification" field condition is proposed, and a detection platform is built.

2. simulation condition test platform of " multi-meter unification "

2.1. Test platform hardware structure

The test platform includes host computer, infrared probe, display screen, water storage tank, pump, heating device, drain bucket, blower, analog load and short circuit device, and micro power wireless attenuator; The platform is designed with multiple communication interface converter positions, water meter positions, heat meter positions, gas meter positions, electricity meter positions and one concentrator position, wherein the water meter and the heat meter connected with the communication interface converter pass the M-Bus line; The gas meter connected with the communication interface converter pass the micro-power wireless; The communication interface converter connected with

concentrator through the RS485 line, and the electricity meter is also connected to the concentrator through the RS485 line. In order to test the real-time data and the valve switch control ability of the communication interface converter and the concentrator, the water meter, the gas meter and the heat meter are all in operation when testing.

2.2. Operating condition simulation of water meter and gas meter

The working principle of the water meter is that the water flows through the water meter to drive the impeller in the water meter box to rotate. The rotation speed is proportional to the flow velocity of water. The impeller shaft drives a set of linkage gears and then transmits them to the recording device. The indicator needle indicates the accumulation value of flow on the scale plate. The working principle of the gas meter is to use the pressure difference in the flow process of the gas in the body as the power, and the relative position of the valve seat and the valve cover to control the distribution of the gas flow direction, and finally the counter shows the displacement of the gas meter.

In order to simulate the operating conditions of water meters and gas meters, this paper uses air blower to generate wind pressure to drive air flow. When the fast flowing gas passes through the water meter, it drives the impeller in the water meter box to rotate, so that the water meter is in working state; and the gas meter itself has gas flowing through it. Therefore, it is also in working state. Figure1 is the structure diagram of water meter and gas meter operating conditions simulation. The airflow generated by the blower is returned to the blower through the water meter and the gas meter.
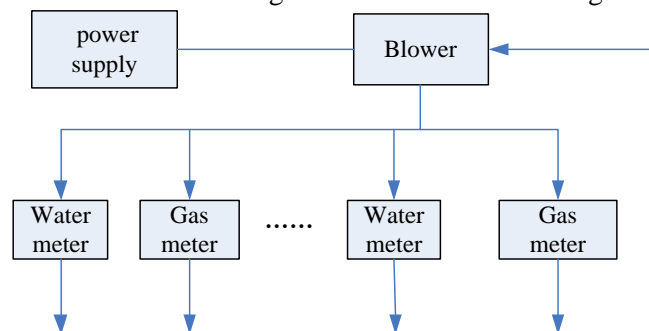

Figure 1. Structure diagram of water meter and gas meter operating conditions simulation.

2.3. Operating condition simulation of heat meter

The heat meter is mainly composed of inlet water temperature sensor, return water temperature sensor, integrator and flow meter. It is installed on the inlet and outlet pipes of the user's heating equipment. When the hot water flows from the inlet pipe into the heating device to supply heat to the user at a higher temperature, the low-temperature hot water flows out from the return pipe. The heat meter calculates the calorific value provided by the heating equipment according to the temperature difference between the hot water inlet and outlet, the water flow, and the heating time.

In order to simulate the temperature difference between the inlet and outlet of the heat meter, this paper designed a sealed water circulation system to simulate the water flow of the heat meter, the inlet water temperature sensor of the heat meter to connect the heating device, and the return water temperature sensor to the water circulation system to form the temperature difference between the inlet and outlet of the heat meter. Simulate the normal operation state of the heat meter, the structure diagram of heat meter operating conditions simulation is shown in Figure 2.
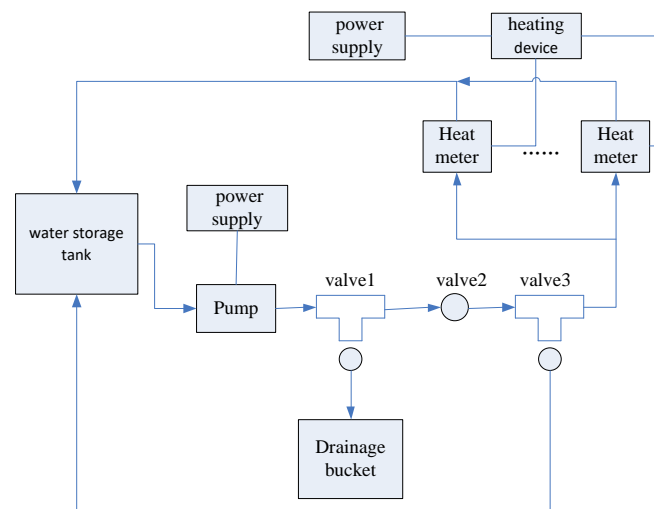
Figure 2. Structure diagram of heat meter operating conditions simulation.

The water storage tank is the water source of the whole water circulation system. When the simulated heat meter is in normal working state, the valve 1 and the valve 3 are closed, the valve 2 is opened, and the water pump extracts the water in the water storage tank, and through the heat meter flows back to the water storage tank to form a water circulation system, then the heat meter has water flow rate; When the switching power supply is turned off, the valve 3 is opened, the water in the tube will flow back to the storage tank, and there is no water in the heat meter, which is convenient for replacing the heat meter; When the switching power supply is turned on, the valve 2 is closed, and the valve 1 is opened, the water in the water storage tank can be drained to the drain tank to facilitate the replacement of the water in the water storage tank.

2.4. M-BUS interface state analog circuit

In the "Multi-meter unification" acquisition system, the M-BUS interface of the communication interface converter is the master node, the M-BUS interface of the water meter, gas meter and heat meter are the slave nodes. The communication interface converter needs to supply power to the water meter, gas meter and heat meter. Therefore, the interface performance of the M-BUS not only affects the communication between the meters, but also affects the working state of the water meter, gas meter and heat meter which connected to the communication interface converter. The phenomenon of wrong wiring, burning meter, or insufficient carrying capacity often occurs when installation and debugging in the field. In order to restore the possible situation which occurs in the field, the M-BUS interface state analog circuit proposed in this paper, which can simulate the normal, short circuit, crusting, crossover and loading states of M-BUS. Figure 3 is a circuit diagram of the M-BUS interface state analog circuit.

When S is opened, interfaces 3-4 and 13-14 are closed, and the other interfaces are open, the M-BUS+ interface of the meter is connected to the MBUS+ interface of the communication interface converter, and the M-BUS- interface of the meter is connected to the M-BUS- interface of the converter. Namely, the test circuit is in a normal state. When S is opened, interfaces 7-8, 9-10 are closed and the other interfaces are opened, the M-BUS+ interface of the meter is connected to the M-BUS- interface of the communication interface converter. Namely, the test circuit is short-circuited. When S is opened, interfaces 5-6, 11-12 are closed and the other interfaces are opened, the M-BUS+ interface of the meter is connected to the MBUS+ interface of the communication interface converter via the resistor R, and the M-BUS- interface of the meter is connected to the M-BUS- interface of the converter. Namely, the test circuit is in a crusting state; When S is opened, the interfaces 1-2, 15-16 are closed and the other interfaces are opened, the M-BUS+ interface of the meter is connected to the M-BUS- interface of the converter, and the M-BUS- interface of the meter is connected to the M-BUS+ interface of the communication interface converter. Namely, the test circuit is in a crossed state.

When S is closed, interfaces 3-4, 13-14 are closed and the other interfaces are opened, the M-BUS interface of the communication interface converter is connected to the load meter to form a loading circuit. Test the load capacity of the M-BUS by adjusting the magnitude of the current absorbed by the load meter.
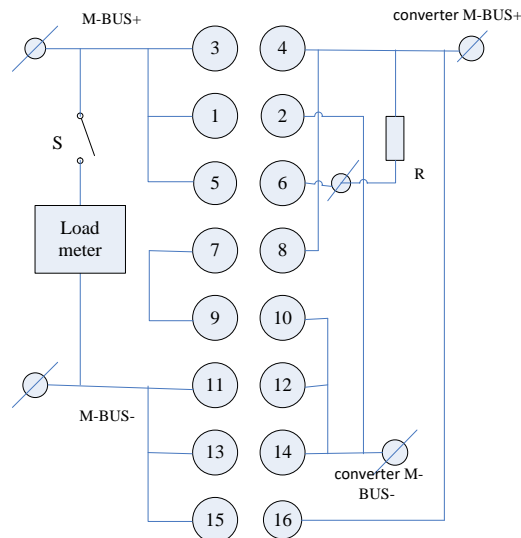

Figure 3. circuit diagram of the M-BUS interface state analog circuit.

Table 1. Interface status corresponding to Circuit status.

"S" state	Interface status	Circuit state
open	3-4、13-14are close, the others are open	normal
	7-8、9-10 are close, the others are open	short circuit
	5-6、11-12 are close, the others are open	crusting
	1-2、15-16 are close, the others are open	crossover
close	3-4、13-14 are close, the others are open	Load

3. Test method
The test of "Multi-meter unification" acquisition equipment includes test concentrator and communication interface converter which used for reading water meters, gas meters, and heat meters. The concentrator test technology is relatively mature, and the test scheme is relatively perfect. The concentrator used for "Multi-meter unification" acquisition only adds some functions on the basis of ordinary concentrator. These functions include file setting, real-time data acquisition, historical data acquisition, valve control and other functions of water, gas and heat meters. So the concentrator test is relatively simple, it can be tested on the simulation working condition test platform of "multi-meter unification". The test methods of electromagnetic compatibility, insulation performance and environmental impact of the communication interface converter are consistent with the ordinary acquisition terminal, and will not be repeated here. This paper mainly studies the test methods such as its function, micro power wireless performance and M-BUS interface performance[4-5].

3.1. Functional test
According to the actual application, this paper studies the test method of "Multi-meter unification" acquisition equipment, and builds a test platform in the laboratory to simulate the working conditions. Standard water meter, standard thermometer, standard gas meter and standard electric energy meter are used as accompanying inspection instruments.

When concentrator is tested, the standard communication interface converter, electric energy meter, water meter, gas meter and heat meter are used as accompanying instruments, and five communication interface converters of different manufacturers are connected to the tested concentrator. The main station through the GPRS sets the parameters of the water, gas and heat meters, reads the historical data and real-time data of water, gas and heat meter, and checks the values of the water, gas and heat meters, and verifies the concentrator function of "Multi-meter unification" data acquisition and communication protocol consistency[6].

When the communication interface converter is tested, the standard concentrator, electric energy meter, water meter, gas meter, and heat meter are used as the accompanying instruments. The main station through GPRS sets the parameters of water, gas and heat meter, reads the historical data and real-time data of water, gas and heat meters, and checks the values of the water, gas and heat meters, and verifies the communication interface converter function of "Multi-meter unification" data acquisition and communication protocol consistency.

The test schematic diagram of the concentrator and communication interface converter is shown in Figure 4. The number of water meters, gas meters and heat meters are not less than 30.
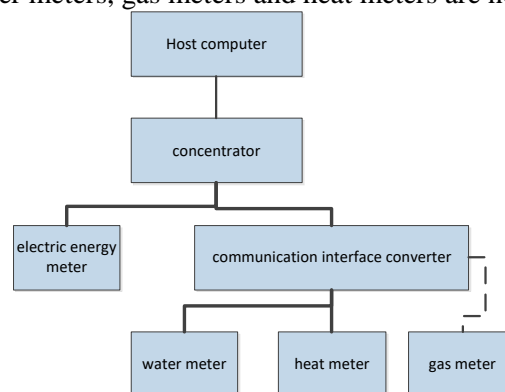

Figure 4. The test schematic diagram of the concentrator and communication interface converter.

3.2. Micro power wireless performance test

Due to the limited laboratory space, in order to simulate the phenomenon of wireless attenuation caused by the installation distance between the meter and the communication interface converter, the wireless attenuator is connected to the tested equipment. According to the path loss model: Los(dB)=32.4+20lgf(MHz)+20lgd(km) calculate the simulated distance.

Where Los is the transmission loss, d is the transmission distance, and f is the frequency. At the same environmental factors with the specified radio frequency, as the communication distance increases, the transmission loss increases.

$$\Delta \text{Los(dB)} = \text{Los2} - \text{Los1} = 20(\lg f d_2 - \lg f d_1) = 20 \lg \frac{d_2}{d_1}$$

Where d_2 is the transmission distance that you want to simulate and d_1 is the actual transmission distance. According to the above formula, when the attenuation is increased by 3dB, the communication distance is about 1.4 times the actual distance. When the attenuation is increased by 5dB, the communication distance is about 1.78 times the actual distance. When the attenuation is increased by 6dB, the communication distance is about twice the actual distance.

3.3. M-BUS communication interface performance test

3.3.1. M-BUS interface output voltage and input current test method

When the main M-Bus interface of the communication interface converter is not loaded, the water meter, gas meter and heat meter is not connected to the communication interface converter. The output voltage measured by the standard meter shall comply with the requirements of Table 2. When the

slave M-Bus interface of the communication interface converter is working, that is communicating with the downstream meter (Using the host computer to issue the command to read the water, gas and heat meter data), the input current measured by the standard meter shall comply with the requirements of Table 3 [7].

Table 2. M-BUS node signal transmission specification requirements (voltage source).

Logical value	Identification	Ranges
1	V_{mark}	$22V \leq V_{mark} \leq 42V$
0	V_{space}	$12V \leq V_{space} \leq V_{mark} - 10V$

Table 3. M-BUS node signal receiving specification requirements (current source).

Logical value	Identification	Ranges
1	I_{mark}	$0mA \leq I_{mark} \leq 1.5mA$
0	I_{space}	$I_{mark} + 11mA \leq I_{space} \leq I_{mark} + 20mA$

3.3.2. Load capacity test
Each main M-Bus interface of the communication interface converter is connected to the electronic load. By adjusting the size of the electronic load and ensuring that the output current of the interface is maintained at 256 mA. The output voltage is measured by standard meter and the voltage should meet the requirements of Table 2.
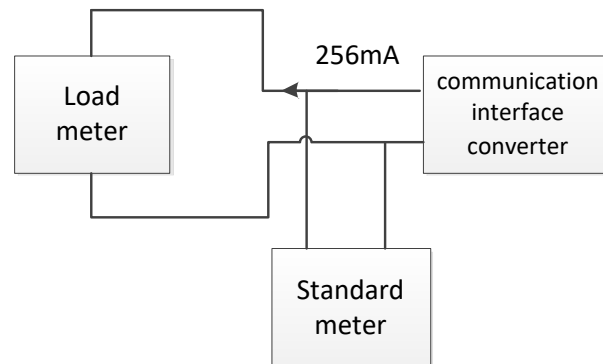

Figure 5. Load capacity test circuit.

3.3.3. Port automatic identification test
When the first main M-Bus interface of the communication interface converter is connected to the accompanying meters, the converter should be able to read the meter data correctly；When the accompanying meters connected to the second main M-BUS interface of the converter, and without changing the port setting parameters, the converter should be able to correctly identify the port where the meter is located and read the meter data correctly after reading the meters data five times continuously.

3.3.4. Communication protocol adaptive test
The communication interface converter has 6 different protocols built in, and one standard meter for each protocol is prepared. Two meters are randomly selected and connected to the M-Bus interface, and the converter should be able to reply to the correct data within 30 minutes.

3.3.5. M-Bus interface overload protection test
The main M-Bus output interface of the communication interface converter is shorted under normal communication state. At this time, the converter should have an overload status light indication.

Except the main M-Bus interface, the converter should can work normally; After 4 hours disconnect the short contact point and the converter status indicator should be able to recover, and the shorted main M-Bus interface should not be damaged, the converter should work normally.

4. Ending

This paper builds a "Multi-meter unification" test platform of simulating on-site working conditions. This platform based on the working principle of water meter, gas meter and heat meter, uses sealed water circulation system, heating device and blower to simulate water meters, gas meters and heat meters operating status in the real environment. According to the relationship between transmission distance and transmission loss, the distance analog between the communication interface converter and the wireless meter is adjusted by adjusting the attenuator; The designed analog load and short circuit device can test the electrical performance of the communication interface converter. The proposed test method effectively guarantees the stable and reliable operation of the "Multi-meter unification" acquisition device on-site.

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