Gateway Electric Energy Meter Measurement System Based on Independent Load Control

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Abstract. .In order to meet the efficiency and timeliness measurement requirements for electric energy meters with different specifications in gateway energy meter testing laboratory, a new testing system based on multithreading technique is proposed here. Through identifying the different wiring modes of electric meters, integrating with newly designed CT based on zero-flux compensation principle and applying creative multi-channel load control for different tap positions, the system can provide differentiated testing loads for different meters at the same time. Meanwhile, electric energy pulses required by different electric energy meters can be worked out by one standard meter. Consequently, completely independent measurement for different meters will be achieved with improved timeliness substantially. Through simulation tests for different electric energy meters, and comparison for calculated testing time, the initial design purposes are tested and verified.

1 Introduction

With the reform of bidding on the power grid, gateway energy meters are widely utilized in power plants, consumers and distribution units[1]. Gateway energy meters which belonged to the I type of electric energy meter need to be replaced every two or three years. The electric energy meters on I type of metering nodes should be tested once every three months[2-3].After years of installation, its amount has become large with increasing quantity of newly erected, replaced and periodic checked, which causes remarkably high efficiency verification demand.

Since there are many specifications of gateway electric energy meters with small quantity of each batch, the meters will be classified before using conventional measurement devices[4], and then only the same type meters may be tested in one batch. The efficiency of measurement is very low, which cost big time and manpower[5-6]. In order to improve the efficiency and meet the increasingly testing demand of the gateway electric meters, the intelligent testing method study for gateway electric energy meters based on multithreading technique is proposed in this article.

2 System General Design

Conventional three-phase electric energy meter verification device mainly consists of PC electric test software platform, multi-serial port server, high power program control power source, three-phase multifunction standard electric meter, precision timing source, GPS controller, 1:1 high accuracy CT, error calculation, display unit, and manual operation controller, etc. Three-phase electric meters that are provided with identical wiring method, voltage and current may be tested together, but for meters with different wiring method, voltage and current will be tested in batches.

The working principle for verification: firstly the tested meters parameters will be recorded by the software platform and the judgment threshold for corresponding measurement result will be set, and then the measurement process is started. Data will be transmitted through the bus communication of the ethernet and the multi-serial port server. Power source rising and output setting points of voltage and current will be controlled by RS485 multi-serial port. After received voltage and current signals by the standard meter and the tested meters, both standard electric energy pulse and the tested electric energy pulse from each meter will be sent to the meter's error calculation unit to work out the electric energy meter error. The error calculation results will be sent to the measurement software platform through multi-serial port server to confirm whether the tested results are qualified by comparing with the given threshold discrimination parameters, thus the whole verification process for the electric energy errors on the setting point is completed.

In the conventional three-phase verification device, its equal potential CT is designed by 1:1, that is, the current circuit is connected in series. If one of the electric energy meters is fault, the current circuit will become an open circuit, and the tested current of each meter must have the same character. In case of unique wiring method of the three-phase multifunction standard meter, the output electric energy pulse is also unique,

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which the error calculation and display unit are not provided with
mutual conversion function between electric energy pulses of 3P4W and 3P3W, only one wiring method may be calculated at one time. Therefore, it is obviously that the centralized synchronous measurement for gateway electric energy meter with different specifications will not be achieved by the conventional three-phase verification device.

In order to solve the application limitation of the conventional three-phase verification device, a new solution is proposed in this article, which is based on multithreading technique.

Following new units are designed again for the system comparing with the conventional three-phase verification device.

2.1 Current balance unit

In order to achieve the current balance in condition of PF=1.0 by wiring methods of 3P4W and 3P3W, the following formula is established.

$$\vec{I}_a + \vec{I}_b + \vec{I}_c = 0 \qquad (1)$$

The active power of 3P4W will be identical with the 3P3W. For the convenience of calculation, suppose U_a=U_b=Uc=U, with three-phase voltage angle of 120°. Substitute $\theta = 60°$ and U_{ab}=U_{cb}= U" into power calculation formulas as following.

$$\Sigma P_{3P4W} = U_a I_a + U_b I_b + U_c I_c = 3UI \qquad (2)$$

$$\Sigma P_{3P3W} = U_{ab} I_a \sqrt{3}/2 + U_{cb} I_c \sqrt{3}/2 = \sqrt{3}UI \times \sqrt{3}/2 \times 2 = 3UI \qquad (3)$$

In order to meet condition of formula (1), the improved scheme will adopt following current synthesis technique, which the synthesis principle is showed in figure 1.

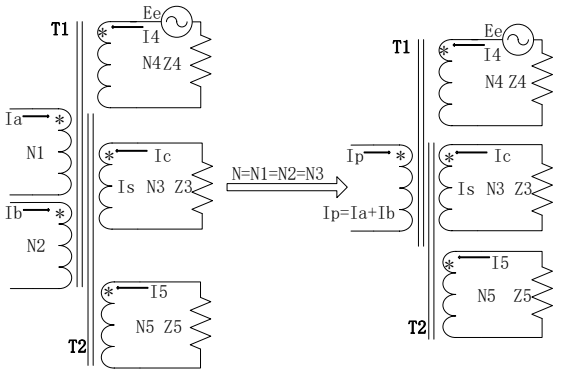

Figure 1. Diagram of current merge

In figure 2, the balance unit consists of T1 magnetic core, T2 magnetic core, and windings of N1, N2, N3, N4 and N5. In stable condition, the T1 magnetic core is close to zero-flux, and the N5 winding is the measuring winding with high inputting impedance, which the magnetic potential loss is nearly zero. The measurement signals at both ends of N5 winding response the flux error of primary and secondary windings, which is the excitation potential. The T2 magnetic core will be used as a current transformer to transmit power. The N4 winding will be used as compensation winding to supply excitation motive force. If the error is in allowable range, the N5 measuring winding will process the signal by high gain amplification, and the N4 compensating current will be supplied, which the N4 winding will almost completely undertake the excitation for TC magnetic core, so the current of primary and secondary windings can be converted with high accuracy.

2.2 Multi-channel control module

Since different gateway electric meters are provided with different current, and measured current uniqueness of the standard electric energy meter at the same time, in process of synchronous verification, the power source output current will be converted properly in different tap positions. At the same time, the primary power source output current is measured by the standard meter, so the conversion accuracy of multi-channel CT will be guaranteed in order to ensure the error transmission accuracy of the whole verification system and meet the requirements of corresponding indexes. Multi-channel control technique is achieved by multi-channel CT, which the system functional block diagram sees in Figure 2.

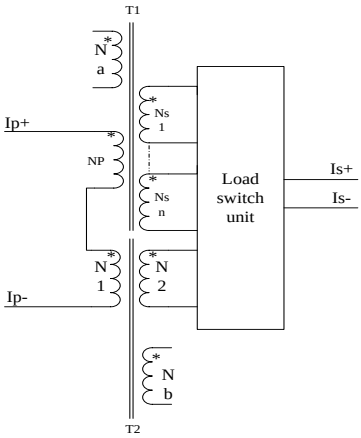

Figure 2. The functional diagram of multi-channel control

This system consists of magnetic cores of T_1 and T_2, N_p, N_{s1}, N_{sn}, N_1, N_2, N_a, N_b and load switching unit, in which the T_1 is the power transmission magnetism, T_2 is the zero-flux verification magnetic core, N_b is the zero-flux verification winding and N_a is the compensation winding. In case of different load demands at different tap positions, host computer system will control the load switching unit to the corresponding load winding of N_{sn} to output, which the switching error will be detected by T_2 magnetic core through zero-flux verification, and amplified by the electronic circuit for compensation.

2.3 Automatic verification unit of wiring method

Variety of the gateway meter pulse constant is limited caused by the meter's specification characteristic. When the verification device is used for electric energy test, the actual pulse constant of the detected gateway meter will be calculated through the error calculation unit, and then the pulse constant of gateway meters with known specification is matched by using fuzzy search theory, finally, the electric energy error is worked out.

Accordance to the difference of 3P3W and 3P4W, the system will conduct the verification for the wiring unit. The functional block diagram of automatically verification unit for wiring methods sees in figure 3.

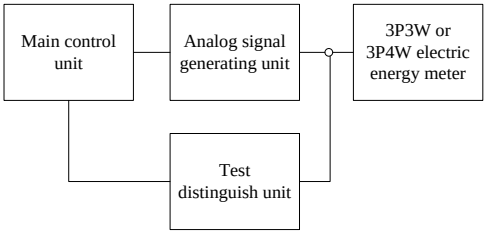

Figure 3. Diagram of Auto wiring verification

This functional block diagram consists of main control unit, analog signal generator unit, 3P3W or 3P4W electric energy meter, verification unit, etc. Firstly, the main control unit will issue a signal generation order to inform the analog generator unit to input voltage signals separately to U_a and U_n, U_b and U_n, U_c and U_n. The current signals change from U_a, U_b and U_c signal wirings will be monitored by the verification unit, which the results can be used to detect the wiring faults of 3P3W gateway meters, 3P4W gateway meters or other meters. In case of one 3P3W gateway meter, according to its internal structure, since the U_n terminal is empty, and the signal wirings of U_a, U_b and U_c are open-circuit with the U_n, so the current cannot be detected by the verification unit when the voltage is input; In case of one 3P4W gateway meter, since impedance exists between U_n and the signal wirings of U_a, U_b and U_c, so the current change can be detected by the verification unit, and the automatic wiring verification is achieved.

3 Data management system

The data management system adopts the multithreading task management mode. Comparing with the multithreading task, the single thread has only one thread in its application system, no matter whether the tasks have relevance or not, any of which will be conducted one by one in order, which means that Message 2 will not be conducted until Message1 is completely and correctly conducted.

The data management system adopts the multithreading task management that can conduct many tasks at the same time. For example, when the main thread is waiting for the response from the Message1 of Web Service, other database tasks, such as Message2 and Message3 can be conducted at the same time. During the multi-task conducting, the main thread or the user interface is always in active condition, which can conduct startup and shutdown tasks independently, and receive notification messages and response other operation from the user. Message4 will notice the conducting condition and result of the main thread task during the conducting. Figure 4 is the multithreading function diagram.

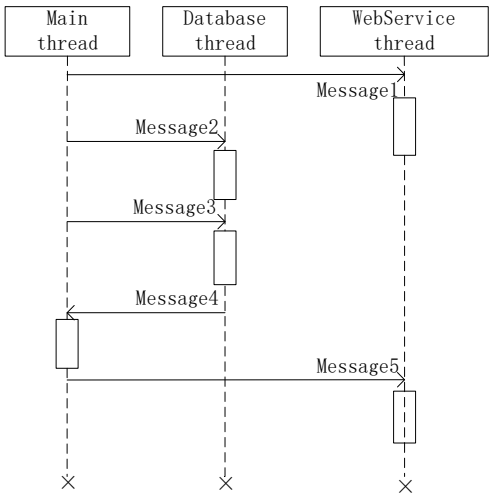

Figure 4. MTT flow chart

ActionQueue and TaskManager are encapsulated in the system. ActionQueue is the encapsulation to conduct a series of action threads, which is the basic unit to control multithread. When the main thread is started, each subtask thread will be established and operated independently without sequence and waiting, which the efficiency is very high. The operation condition of the sub-threads will be sent to the main thread for process, which will be regulated and controlled by the main thread. The main task of the main thread is to receive various input messages (such as sub-thread messages, user interface messages, etc.) and control other tasks. When one sub-thread operation is completed, the message may be directly sent to the main thread to finish the progress, and the system may distribute its redundant process capacity to the new thread to restart.

4 System Measurement Instance

In order to verify whether the system design function meet the practical application, the tests for four electric energy meters with different specifications have been conducted separately on the multithreading device and conventional device, with separate recording of typical test point (100V/1A) error and testing time. The gateway electric energy meter adopts the red phase electric energy meter from Australia EDMI, which the electric energy error measurement accuracy is 0.2, and both active and reactive electric energy pulses are 5000imp/kWh. Since the existed electric energy meter device can only separately conduct verification for electric energy meters with different specifications, so the test time is the whole process of single electric energy meter measurement.

The multithreading verification system will be established by the simulation system, and each tap

position load will be accurately controlled by the electric energy standard device, meanwhile, current and voltage in different ranges will be output, and the electric energy measurement error and testing time will be worked out in the system.

Based on the experimental data, the conventional device consumed 20 hours to detect 4 electric energy meters, but the multithreading device only consumed 5.5 hours that is the longest time of one meter required. Since 4 electric energy meters can be detected at the same time, so the assembly and disassembly on the same device and wiring connection time is saved.

Comparing the measurement results of the electric energy measurement errors for 4 electric energy meters by two devices, the errors are all qualified. But the multithreading device improved verification efficiency of 72.5% on time consumption, which the result proved the superiority of the multithreading technique, meeting the expected design requirement, and achieved the overall design target.

5 Conclusion

Firstly, The article analyzed the necessity of the gateway electric energy meter verification system based on the multithreading technique, and the special requirement for gateway electric energy meters with different specifications conducting synchronous verification, and compared the differential features of conventional verification device and multithreading device. Through focusing on description of the implementation plans of current balance unit, multi-channel load control unit and wiring connection recognition unit, the methods of output control for different load achieved through multi-channel zero-flux CT and wiring connection recognition for voltage circuit signal measurement have been set forth in the article. Meanwhile, the unified coordination management for the verification system that is conducted by the multithreading verification software, which the purpose is to achieve the function of detecting gateway electric energy meters with different specifications. Finally, through the simulation test, verification is done for the multithreading system's design function, which proved that the system improved the verification efficiency obviously for gateway electric energy meters.

The new system designed by the article solves a series of practical problems. It serves for the vast number users on testing of gateway electric energy meters, and saves users from repetitive tasks.

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