Research on Intelligent Substation Energy Metering System

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Keywords: intelligent substation; IEC61850; design scheme; metering system

Abstract. With the rapid development of substation automation and network communication technology, IEC61850 standards promulgated and implemented, the traditional substation has been a gradual transition to the smart substation. In the collection intelligent substation energy measurement technology realized the conversion of analog quantization to all-digital by the fiber optic transmission lines, through the point to point or Ethernet way to transport to digital power meter digital, provide accurate and reliable data origin for the smart substation energy metering system, compose the smart substation energy metering system. This paper presents several design scheme of intelligent substation energy metering system. By analysis of the characteristics of the three programs, the advice on suitability of each program is given.

Introduction

Energy metering system is an important part of intelligent substation which has changed dramatically on analog acquisition mode compared to conventional substation power meter, its meter sampling sensors generally use high power output of the current transformer and voltage transformer device, while the smart substation analog sampling is all-digital before transmission by fiber optic lines and the primary side of the sensor use a low-power output electronic transformer, which has the advantages of a wide frequency response, no saturation phenomenon, good anti-electromagnetic interference performance , high accuracy, no open or shorted secondary danger facilitate the development of digital technology, computer technology, provides accurate and reliable data sources for the smart substation energy metering system, electromagnetic compatibility of the system can be greatly improved; at the same time assimilate intelligent substation power acquisition and management into the IEC61850 standard system which laid the foundation for the smart substation highly integrated[1, 2].

Meter system under the influence of intelligence

A variety of intelligent devices, especially the application of electronic voltage transformers, current transformers promote digital smart meters based on the current , voltage inputs metering plug-ins and network way of collecting / processing electrical energy information electrical energy has become a core device intelligent remote terminal substation energy measurement[3].

(1) The advantage of intelligence

The voltage, current, active, reactive and power measurement information’s of intelligent substation are all provided by electronic transformers. Electronic transformer is a digital signal transmission, completely free from the load, as long as choosing the right calculation accuracy; pure computing numeric values will not cause additional error on the measurement meter. The interfaces on the physical and link layer of intelligent substation electronic transformer and smart meter use a high-speed fiber-optic Ethernet which the IEC61850 [4, 5] recommend, reducing various losses of traditional secondary circuit, the error of the measurement system depends only on the electronic

transformer, thereby significantly reducing systematic errors.

(2) Intelligence problems and solutions

However, the application of the electronic transformer also brings some new problems to the metering system, precision measurement, metering system for high sampling rates and requirements for metering device verification, etc. included. However, with the reform of the management system and the development of technology, these problems will gradually be resolved.

1) Measurement accuracy requirements and solutions

According to the electrical energy metering code requirements, the measurement precision of metering point electronic current transformers must reach 0.2s level. Because of poor change accuracy of Rogowski coil type current transformer in a small value, measurement professional staff worried Rogowski coil type current transformer can not meet the accuracy requirements of electric energy metering device.

However, in the actual project, nearly all of Rogowski coil type current transformers are based on LPCT (low power core coils) and Rogowski coil. Wherein LPCT is used in measuring and metering, and Rogowski coil is used for protection. LPCT is a development of the traditional electromagnetic current transformer; it differs from traditional current transformer with the fixed secondary small load. According to the principle of electromagnetic current transformer, the source of error lies almost in the power transmission, the smaller the transmission power is, the smaller the error. In addition, LPCT can improve the transient characteristics of transformers largely in a high saturation current to improve the basic characteristic to expand the measuring range. Although LPCT can not eliminate the problem of magnetic saturation completely, it has linearity in 5% to 120% rated current. The current accuracy is up to 0.1 / 0.2s level, and it is suitable for measuring devices, electric energy metering devices and remote actuating means.

Therefore, the intelligent substation metering point mark should be used the CT of Rogowski coil with LPCT or purely optical which is identified by national metrology department. The measurement accuracy must meet the 0.2s level.

2) The requirement and solution of the high sampling rate

The smart meters need to get the sample data from the combined unit. The sampling frequency is 192 points / cycle, and the protection and monitoring control require 48 points / cycle. In intelligent substation, all secondary devices are sampling to obtain data from the combined unit, which poses a problem that the same data needs different sampling frequency.

3) The verification and solution of the metering devices

The signal which is transmitted by the secondary circuit of the electronic transducer in intelligent substation is digital signal, rather than the traditional one. Therefore, the traditional instruments cannot detect the error directly. Further, due to the electronic transformer and the measurement standard of the smart meter cannot be traceable, and there is lack of the regulation of verification or inspection, the electronic transformers of metering point cannot be verified traceability in reasonable and lawful.

a) Error detection

The working mode of smart meters led to the traditional meter calibration station cannot detect the smart meter error. Therefore, it is necessary to re-design a calibration device. The device should have a fiber-optic Ethernet interface with electric energy calculations. Link layer can be based on the IEC61850-9 or FT3 standard format, to receive, compare and save the pulse signal which is output by the meter calibration. The calibration device complies with the above design is shown in Figure 1.

The device includes a digital signal source, a digital standard meter and pulse sampling equipment. It also contains a standard electrical energy calculation module to calculate the fiducially value of electric energy by the configured current and voltage data source.

Calibration device output standard digital current and voltage signals that complies with IEC61850-9, transmitted through the optical fiber Ethernet to the smart meter, the smart meter is subjected to electric meter energy calculation, the output calibration pulse to the calibration device. After calibration device collection to check the pulse, calculated standard compares with its own

electrical energy, and then meter errors are corrected.

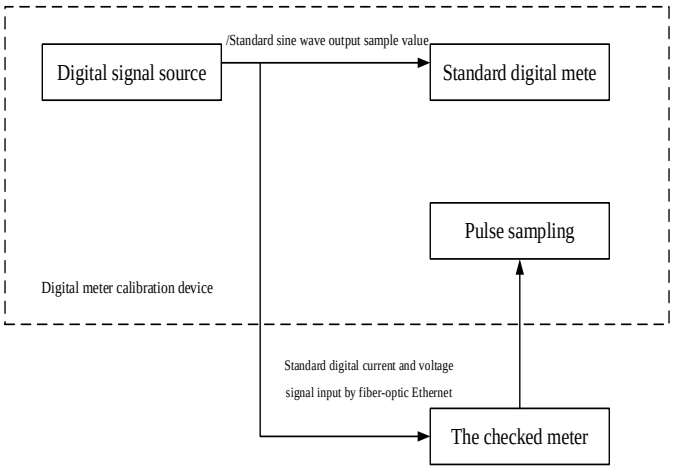

Fig.1 The principle of smart meter calibration device

b) Traceability issues

Smart meter's data input are Ethernet frame type, the physical medium is optical fiber or twisted pair transmission system, and there is no electrical connection between the traditional meter and transformer. The calculated value of electric energy smart meter no error in theory, but by the word length, the system clock and other factors, the error must be exist, but greater precision and stability smart meter, temperature drift more smaller. Therefore, smart meters still to go through traceability, and the new verification method should be used.

Design of smart substation metering system's solution

(1) Metering point's set

According to the <electric energy metering system design technical specification> principle and smart substation qualifying circumstances set metering points. For the supply of electricity set property boundaries or contractual agreements stipulated in trade settlement points, and the grid across the region, as well as inter-provincial power grid enterprises and power lines between the power source side is set to mark the measurement point, smart meters according to 1+ 1principle configuration, accuracy class 0.2S. For the assessment of the main transformer station and low voltage side of the accounting high voltage reactive compensation devices metering point, the smart meter in accordance with the principle of 1 + 0 configuration, the precision is 0.5S level.

The metering transformer configuration and choose accuracy requirements should comply with DL/T448. The precision metering of substation electric energy gateway point's electronic current transformers should meet 0.2S level precision and electronic voltage transformer should meet the level of 0.2.

(2) Metering system's function requirements

Smart substation metering system should be able to calculate the exact amount of electrical energy, calculations complete, reliable, timely, confidential information to meet the electrical energy requirements of uniqueness and credibility. Also should have different time periods, the amount of electrical energy required automatic collection, processing, transmission, storage and other functions, and can be reliable access to the network. According to the importance of addressing certain components are redundant configuration. Metering transformer configuration and choose accuracy requirements shall comply with DL/T448. Metering IED should have reliable digital or analog inputs, the signal receiving unit output for merging. The combined unit should have parameters set hardware protection; it should be able to meet the accuracy requirements of the measurement requirements.

All parties should develop verification and traceability rules approved as soon as possible for different metering IED features.

(3) Design of metering system scheme

Compared with the traditional configuration of the substation primary equipment, electronic voltage, current transformer device does not have a plurality of secondary windings according to the professional division, the configuration of the electronic transformer secondary winding is generally no more than three. Therefore, electronic transformer output information is public information protection, measuring, metering and other equipment. According smart substation equipment in order to obtain electrical energy information, energy metering device should have digital communication capabilities. Implementation available in the following three scenarios:

1) Scheme I

In intelligent substation each installation unit independently configurable smart meters, the meter to IEC61850-9-2 SV network layer protocol through a process combining unit receives the output signal, and which resolves the voltage and current samples, sampling frequency and other information, via high performance DSP calculates the network parameters and consumption data. When used as a crossing metering point, smart meters respectively access procedure layer SV dual network; when used as an assessing point, smart meters access procedure layer SV single network following the principles of load sharing.

2) Option II

This program is similar with the program one, just the electricity data on the smart meter through the Ethernet port station level access MMS network, set up an independent electric energy on remote terminal of the station control layer Ethernet, which means IEC61850-8-1 protocol MMS station level network to obtain information for each interval of smart meters, and IEC60870-5-102 Statute of the scheduled data Netcom to dispatch end electric energy metering system master transfers. When used as a crossing point metering, smart meters are access station level MMS dual network; when the metering point for assessing accounting, smart meters to the principle of sharing the access load station level MMS single network.

3) Option III

Set an electric energy metering device in the station control layer MMS online, the device is different with the traditional electrical energy remote terminals, along with computing and information transfer function of electric energy data. Electrical energy metering device upload and calculate the samples information from each interval integration of devices via level MMS according to IEC61850-9-2 protocol, Obtaining needed electrical energy information and transfer to electric energy metering system master via scheduled data Netcom according to the IEC60870-5-102Statute The program system configuration described in Figure 2.

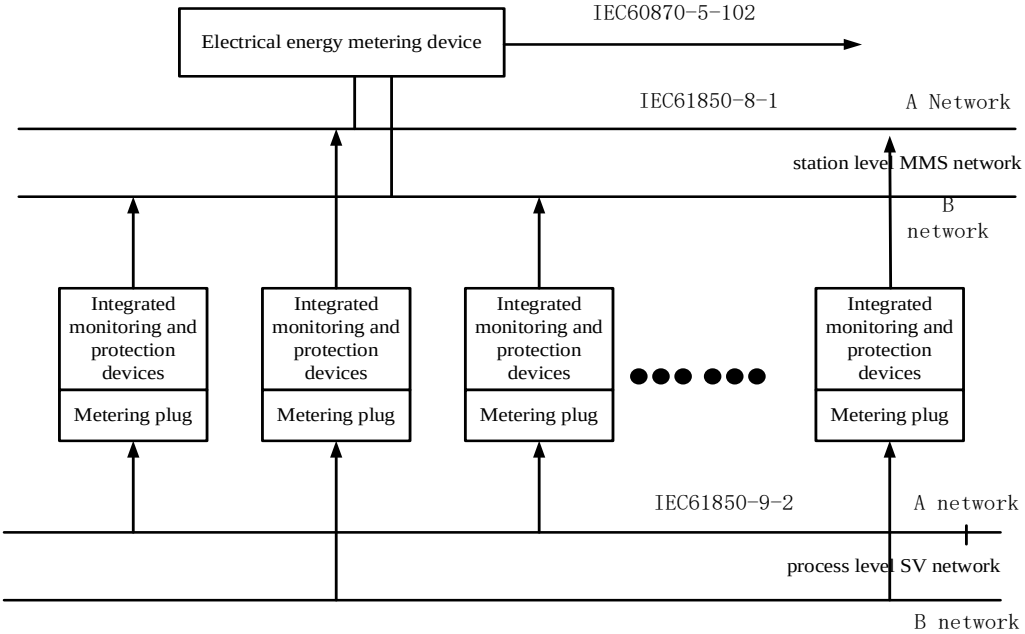

Fig.2 Option III system configuration diagram

4) Scenario Comparison

Scheme one adopts a Electrical energy information transfer mode which is a traditional passive, when the master system need electricity metering information, issued a command to charge information, then the information acquisition will transmit electricity to the master station side. The biggest advantage of this program will not have any impact on information flow station control layer of the network, and greatly reduce the number of stations and network interface control layer switch.

Summary

The data collection method that data is transmitted through optical fiber with full digital quantitative data reduces the electromagnetic interference effectively in the process of transmission and improves the overall measurement accuracy. This method can provide accurate and reliable data sources for power metering system in the digital substation. However, it is necessary to further strengthen the digital electric energy metering technology, use the digital technology effectively, and ensure that the metering device in the digital substation are accurate and stable operation because the electric energy metering system in technology and operations management is not yet mature in the intelligent substation.

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