Discussion the Traceability of Quantity Value of Digital Watt-hour Meter

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Abstract

To resolve the traceability of quantity value and calibration of digital watt-hour meter, in this paper introduced working principium of digital electric power metering system briefly, and analyzed the main origin of error from the theory of digital watt-hour meter and its calibration device. This paper also proposed new verification method of digital watt-hour meter calibration device and project of digital watt-hour meter traceability of quantity value. The method is used in digital signal generator calibration. The traceability project is traceability to the national primary standard which is corresponding to the device using in the method. The project in this paper, which is figure out verification and traceability of quantity value from main origin of error, provides a reasonable approach to traceability of digital watt-hour meter and a useful reference to decriminalization of digital metrology. Meantime, the scheme provides strong technical support for construction of digital transformer substation and “Smart Strong Grid”.

1. Preface

Digital transformer substation became important department of “smart strong grid” and development orientation of electric power system, because of its high-performance, high security and high economic behavior. It also have been subjected to extensive concern.

Main sign of digital transformer substation is adoption digital electricity measurement system (such as optical transformer or electronic transformer, digital watt-hour meter) to collect current & voltage etc. electrical variables. With continuously increasing of digital transformer substation, digital electric energy metering system which is composing by digital watt-hour meter, digital transformer etc. will gradually applied to larger scale. Decriminalization of digital metrology became an important subject of digital transformer substation study, because of none uniform verification method and legitimate, effectively traceability of quantity value scheme. [1]

As shown in the figure 1, digital transformer transforms primary current & voltage into secondary current & voltage, and sending secondary current & voltage to merging unite after sampled at 10kHz by A/D converter. After synchronization, merging unite send the sampled signal of current & voltage to digital watt-hour meter in the form of data frames by fiber Ethernet. Digital watt-hour meter write all kinds of data, which generated after parsed the data frames by integration, real-time operation etc., to FRAM and dynamic display by LCD interface, at the same time sending those data to background and received commands from background by RS-485 serial port. [2]

As known from the working principium of digital electric energy metering system, the main difference is type of signal input between digital and common watt-hour meter. The input of common three-phase four-wire watt-hour meter is three-phase analog current & voltage signal, and there’s an electrical connection with transformer’s secondary output. But the input of digital watt-hour meter is data frames type of Ethernet, and there’s none electrical connection between digital watt-hour meter and transformer, because of the medium of physical layer is fiber or twisted - pair cable transmit system[3]. In the whole electric energy metering system, digital watt-hour meter just as a calculator with function of integration, multiplication etc..

According to ‘metrology law of the people's republic of China ’[4], electric energy metering device using in trading and settlement must be compulsory verification. Between digital and common watt-hour meter take fundamental change of working princinpium, thus digital watt-hour meter can only adopt uncommon verification method. But until now, there’s no digital watt-hour meter verification regulation and no legitimate, effectively or recognized traceability of quantity value scheme in national metrological verification system. This situation has become the serious obstacle in popularization of digital watt-hour meter. According to approach of traceability, this is required in ‘Requirements for Measurement Traceability of CNAS’[5], this paper advanced traceability scheme of digital watt-hour meter using in digital transformer substation.

3. Traceability Of Quantity Value Of Digital Watt-Hour Meter

At present, the most important thing is could not verified calibration device of digital watt-hour meter in study of digital watt-hour meter traceability, and this caused verification of digital watt-hour meter does not conform the requirement of legal metrology. The author of this article considered resolving the verification and traceability of digital watt-hour meter calibration device is key problem of digital watt-hour meter traceability of quantity value. Thus resolving verification and traceability of digital watt-hour meter calibration device, furthermore, traceability of digital watt-hour meter could be realized.
A. Principium of digital watt-hour meter calibration device[6]

Because digital watt-hour meter calibration device adopt standard digital interface which coincidence IEC 61850-9-1, so that common standard calibration device with 5A (1A)/100V analog interface could not apply to calibration of digital watt-hour meter. In device of digital watt-hour meter besides error compare module is preserved, such as digital synthesize D/A convert module, power amplification module etc. in common watt-hour meter calibration device are not needed. But those modules, which have been taken out, are the origin of error in common watt-hour meter calibration device.

Working principium of digital watt-hour meter calibration device at present is shown in figure 2. Digital watt-hour meter calibration device simulate digital output of digital transformer, which is according to requirement of IEC 61850-9-1. Digital watt-hour meter calibration device transmit digital current & voltage signal to digital watt-hour meter and received proportional impulse which is the output of digital watt-hour meter after calculation. Digital watt-hour meter calibration device calculate error of digital watt-hour meter by compared the impulse came from digital watt-hour meter with theory electric power.

As known from working principium of digital watt-hour meter verification, the main function of digital watt-hour meter calibration device in digital watt-hour meter verification system is generate data signal. Calibration device of digital watt-hour meter is equal to data source, more accurate to say is equal to digital signal generator. Verification of digital watt-hour meter by its calibration device is essentially to verify rate of error code in transmission and software design of digital watt-hour meter. This shows the error origin of digital watt-hour meter calibration device is its stability and veracity of output signal.

But there’s no national primary standard with interface corresponding to IEC 6182-9-1 in China. This case makes traceability of digital watt-hour meter calibration device very difficult.
B. Data output of digital watt-hour meter calibration device

Current & voltage signal of digital watt-hour meter calibration device output is theoretical values of current & voltage, which is setting based on load and voltage grade in setting place of digital watt-hour meter. Rated values of current & voltage output are shown in table 1.

For example, setting current value is 1000A in digital watt-hour meter calibration device, while output data is 03E8. The wave in data frame transmission is shown as figure 3.

![Figure 3. Wave of digital watt-hour meter calibration device output](image)

C. Traceability scheme of digital watt-hour meter calibration device

In conclusion, digital watt-hour meter calibration device act as digital signal generator in digital watt-hour meter verification system. Therefore, indirect realization of traceability of quantity value of digital watt-hour meter by verification and traceability of digital watt-hour meter calibration device, which is using verification method of digital signal generator. Concrete traceability scheme is shown as following figures.

![Figure 4. Data working Frequency & data Output capacity](image)

![Figure 5. Data output amplitude](image)

![Figure 6. Data signal width & data setting time](image)
Realized verification of digital watt-hour meter calibration device by adopted the method shown from figure 4 to figure 8. The device using in the verification, include ‘transit load’, ‘cymometer’, ‘digital oscillograph’, ‘DV voltage source’ and ‘impulse signal generator’, can traceability to national primary standard, such as ‘DC resistance standard’, ‘standard frequency verification device’, ‘volts d.c. standard verification device’ and etc.. Through this method realized traceability of digital watt-hour meter calibration device, and then realize traceability of digital watt-hour meter. Sketch map of digital watt-hour meter traceability system is shown in figure 9.

4. Conclusion
Through digital watt-hour meter calibration device verification and traceability, and adopt traceability system as shown in figure 9 to achieve digital watt-hour meter and traceability. This method solved traceability of digital watt-hour meter from theory. It also provides an effective way of decriminalization of digital metrology and strong technical support for construction of digital transformer substation and “smart strong grid”. Also carried out traceability from principle of the idea, provides a useful reference to other digital power metering device verification / calibration and traceability. This scheme is only for further discussion by large professional and researchers of electric energy metering.

References


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