

Analysis of Present State of the Digital Power Meter Field Calibration Technology

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ABSTRACT

This paper introduced the concept of digital meter, analyzed the error sources, and summarized its development status and the existing calibration method.

The paper study the calibration system based on IEC61850-9 and provided an accurate and safe application method for digital electric energy meter.

As one of the most important measurement equipment of the intelligent substation, digital electric energy meter fundamentally resolved the technical bottleneck of traditional substation. During the operation process, measurement accuracy and reliability are related to the safe and stable operation of power system. Based on the literatures related to the digital electric energy meter,

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I. INTRODUCTION

As compared with the traditional electric power meter, operating principle and interface mode of digital electric power meter were modified fundamentally. nowadays, the majority have inherited the thoughts of traditional tool size, calibration parameters, calibration approach, provision of technical signs and so on, which has demanded new requirements for the calibration of the digital power meter[1]. As an electric power transmission and consumption metering device, electric power meter has gone thru a couple of hundred years of records. Its improvement has skilled induction kind (mechanical), pulse kind (electromechanical) electric power meter and digital power meter and many others. In 1880, the world's first electric power meter changed into born. through non-stop development, in nineteenth century the inductive power meter production concept become proposed and had for the reason that been extensively used for its benefits of simple manufacturing, desirable reliability and occasional value and so on.[2]With the updated requirements of the power control modernization, pulse electric power meter got here to the marketplace with the accuracy of 2.0, 1.0 and maximum 0.5. In 1976, digital power meter prototype seemed in Japan. Following the improvement of electronic devices, in particular the electric power metering chip, the overall performance of digital power meter become stepped forward substantially, and regularly changed the everyday induction meter. nowadays, with the improvements of intelligent substation[3] digitized requirements, its corresponding era, and

the non-stop development of the digital and network dimension mode, virtual multifunctional electric meter based on IEC61850 has been broadly used and end up the development trend of the smart grid. due to the fact there is no single standard of digital electric power meter calibration, 347 digital substations all over the u . s . a . that use digital electric power meter are running without entire check or the measuring accuracy can not be assured. This paper provided a selection of ideas for realizing high precision within the modern verification era.

II. OVERVIEW OF DIGITAL ELECTRIC ENERGY METER

Digital electric power meter makes use of digital interface, optical fiber interface, information interface and so on. and the excessive-velocity optical fiber Ethernet are used inside the physical layer and hyperlink layer. the electric current and voltage indicators are digitized by means of digital substation fore-end electromagnetic or electronic transformer, and the digital signal is transmitted to the merging unit (equal to the analog signal processing and A/D converter) by using the optical fiber. The merging unit outputs normative digital signal frame that is based on the IEC61850 standard. digital energy meter can parent out electric power parameter by means of receiving this digital signal frame. The digital electric power meter is a pure digital signal processing device or an IT equipment. It requires that the gadget is dependable, the algorithm is scientific and the calculation mistakes is minimized.

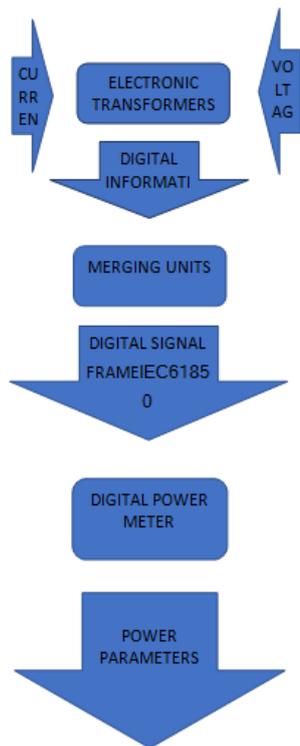


Fig1. digital substation electrical power measurement precept diagram

The digital substation electric power metering device is comprised with an digital type voltage, current transformer, combining unit (which plays a role of protocol conversion and time synchronization), digital electric powered strength meter and general station sampling synchronous clock as well as the connecting cable. as compared with the conventional electric power meter,[3] digital substation metering tool's current and voltage digital signal should guarantee the synchronization to ensure the correct measurement. So it's far necessary to design a brand new calibration tool to update the traditional electric power meter calibration tool. The device ought to have the following basic capabilities: first of all, it need to be equipped with an optical fiber Ethernet interface; secondly, the link layer desires to have the ability to conform to exclusive standards; and thirdly, it have to have the function of calculating the power. most impotent element is to have the feature of preserving historical statistics for comply with-up, and the detection system must additionally be capable of acquire the meter pulse signal to do a little errors analysis. thinking about the measurement shape principle, digital electric power meter can be divided into categories[5]: digital electric power meter based on single chip microcomputer (MCU) and digital signal processor (DSP). DSP chip is 32 bit register with a very high clock rate and very rich signal processing optimized practise set with its

operational velocity on "practise degree". the opposite class is based totally at the special electric power metering chip, which has a robust anti-interference functionality and exact measurement accuracy. but the improvement value is excessive and its flexibility is low due to the fact it's far too depending on the multi capabilities of the electric energy metering chip. The hardware body of digital electric power meter is greater stable and the information processing is the key to recognize the wide software of the digital electric power meter. In other phrases, the way to reform the electric power meter and recognize the high precision size is based on how to overcome the issue of electric power parameter measurement set of rules. relating to the troubles that took place at some stage in the software of digital electric power meter, studies suggests that the subsequent points have to be considered for excessive-precision: the size accuracy of the digital electric power meter in the multi unit information packets, the measurement accuracy in unique sampling ratio, the measurement accuracy at 0.01% Packet-loss Ratio, and the digital electric power meter must maintain the same degree of accuracy when trade the voltage and current specifications.

III. ANALYSIS OF ELECTRIC ENERGY METER ERROR FORMATION

3.1 Error formation of traditional electric energy meter

The error of the traditional measurement system is mainly from aspects such as Holzer component, shunt circuit, voltage divider circuit, TV and TA.[5] The error characteristics curve of A/D preamplifier and A/D converter under different temperature, different load or power factors are nonlinear. For example, Figure 2 is the error characteristic curve of the inductive electric energy meter under voltage change, in which $\mu = U/U_e$. The relative error μ represents the voltage influence, The induction watt-hour meter is composed of the electromagnetic element, the rotating element and the brake component. In reality, the turntable is affected by the driving torque and braking torque that is proportional to the load power. It is also affected by the inhibition torque, parasitic torque, friction torque and torque compensation. The influence of the turntable displacement, will directly affect the basic error of the electric energy meter.

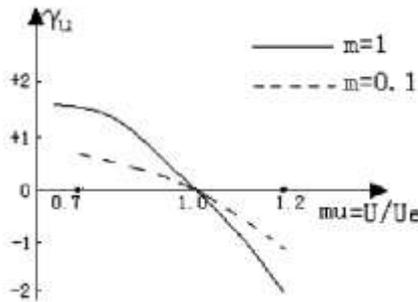


Figure 2. characteristic curve diagram for Voltage error of induction type electric power meter

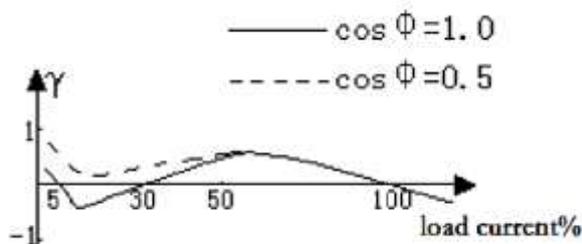


Figure 3 characteristic curve diagram for Load of induction type electric power meter

In the same way, the error characteristic curve of the induction watt-hour meter is nonlinear when load changes. In Figure 3, the electric energy meter working characteristic is unstable when the load current is less than 5%, The influences are from the friction torque, self-induced dynamic torque, the current magnet nonlinear error and nonlinear error changes when the load current is from 5 to 100 percent.[6] Due to its different principle of electronic energy meter, the load characteristic curve is a straight line as shown in Figure 4.

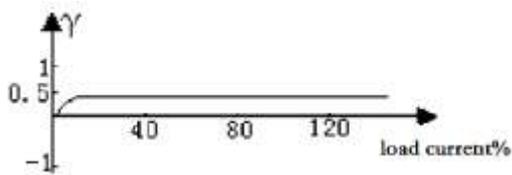


Fig4. characteristic curve diagram for Load of Electric power meter

3.2 Error formation of the digital electric energy meter

inside the digital electric power meter, there may be no start, running concept and overload restrict. the measured power values is not affected by Small current or no current case. distinct from the traditional analog electronic power meter, there's no impacting issue inclusive of signal transformation, A/D conversion, sampling, and synchronization that because of the equipment itself. adjustments in voltage, frequency fluctuations, three-phase

imbalance, noise, and different external signal impact additionally do now not have an impact on the digital electric power meter. In concept, the digital electric power meter can be considered as no error a mathematical operation. The actual errors cause can be considered by three factors. the first is the abnormal phenomena because of the loss of frames and packet throughout the method of sending the packet, which will have an effect on the meter's work feature and reliability. it'll no longer change the internal application (algorithm) so that the measured values overall performance is not impacted. The second is the error due to the distinction between the real electric power accumulation and the electrical power pulse output and. errors ultimately, are because of the truncation errors or floating-point operation [8]. which is the pc device inherent errors. but in the digital substation, the sampling facts errors resulting from the restrict of the IEC61850 protocol is more suitable to be taken into consideration as the error of digital transformers[9]. In fact, inside the field of electronic transformer, it is one a part of the error. As for the tremble throughout the process of analog signal harmonic, noise and digital signal transmission, it's far the error issue of mutual inductance and the combination unit. Even being disposed by means of the electric power meter, it nonetheless belongs to the class of the set of rules errors.

IV. RESEARCH STATUS AND METHODS OF ELECTRIC ENERGY METER

research on electric power meter checking out technology have begun very early, and many of applicable technical solutions for the measurement tool state detection were proposed. however, there's no international requirements to comply with. within the digital electric power meter field, lacks authoritative research results are still. domestic calibration technology is incredibly susceptible. It changed into not till the mid-Nineteen Eighties, China started to develop subject calibration instrument. market speedy growth calls for substantially inspired the enthusiasm of domestic field calibration devices and tools studies. In a short span of much less than two decades calibration equipment has experienced 3 levels of improvement. the primary level is mechanical pointer type devices and tool, the second level is digital device and tools, and the third level is intelligent device and tools. With the continuous development of the digital technique, many studies institutions, universities, and producers have launched the exploration and studies on the measurement device system of digital electric power. For extraordinary standards and applications, a number of distinct digital electric power meter calibration techniques are proposed:

digital power supply and standard digital electric power meter technique, standard digital power source method, and analog power supply and analog standard electric power meter technique.

4.1 Digital power source and standard digital electric power meter method

standards of digital power supply and popular digital electric power meter technique are proven in figure 5. The digital power supply and network system have to be solid and dependable. The accuracy grades of standard digital electric power meter must be two steps better than the established digital electric power meter. It also requires that the standard digital electric power meter ought to bypass the power value.

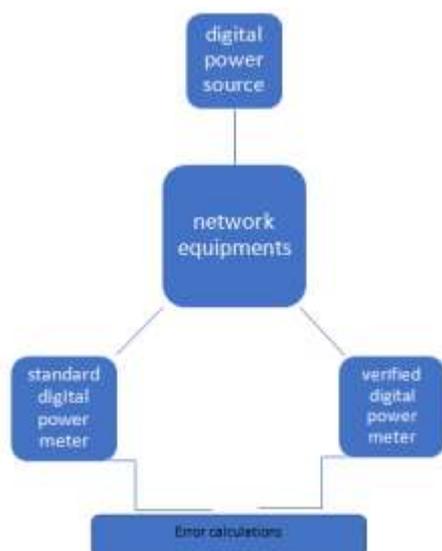


figure 5. principle block diagram of digital power source and preferred digital power meter technique

some of scientific institutions and universities, which include Chinese Academy of Metrology[7], have proposed calibration techniques based totally at the concepts above. A scheme of test tool have been designed by nation Grid Hubei electric power research Institute's could simulate and take a look at the meter accuracy while network packet is peculiar which provides a brand new design concept for the laboratory check of the digital electric power meter. Zhejiang electric power take a look at research Institute advanced a digital electric power meter detection tool based totally at the digital power source and standard digital electric power meter technique. In its precise design, the digital channels may be configured, number one and secondary pulse constants are non-compulsory, the IEC61850 associated parameters may be configured; makes use of each of 220V and 110V AC auxiliary power supply, and with single mode, multi-mode and so

on[5]. This device can clear up the trouble of standard digital energy source output with most effective one manner, and also solve the hassle of a network interface that cannot be connected to both single and multimode optical converters.

4.2 Standard digital power source method

Jiangsu electric energy studies Institute, Nanjing Automation Co. Ltd, China Institute of Metrology and many institutions put forward the so-referred to as popular digital power source technique. extraordinary from the China Institute of Metrology which attain the usual electric power value via the manner of receiving line with IEC61850-9-1/2 communication protocol requirements packet and then unpacking, the Nanjing Automation Co. Ltd obtains the standard electric power value thru direct calculation.

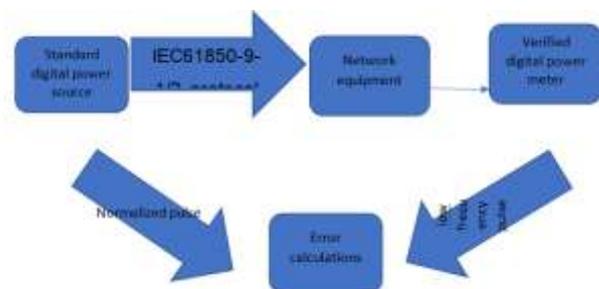


figure 6. principle block diagram of popular digital power technique

4.3 Analog power source and analog standard electric power meter method

Guangdong electric energy scientific studies Institute and different institutions have proposed a technique primarily based at the analog power source. The precept is to apply three-phase power supply output analog voltage and current signal directly to the standard analog meter, and after sampling and communicate protocol conversion, analog voltage and current signal are supplied to the confirmed digital electric power meter and standard digital electric power meter. the error of the digital electric energy meter may be acquired by way of evaluating the electrical power value of standard digital electric power meter and the confirmed electricpower meter.

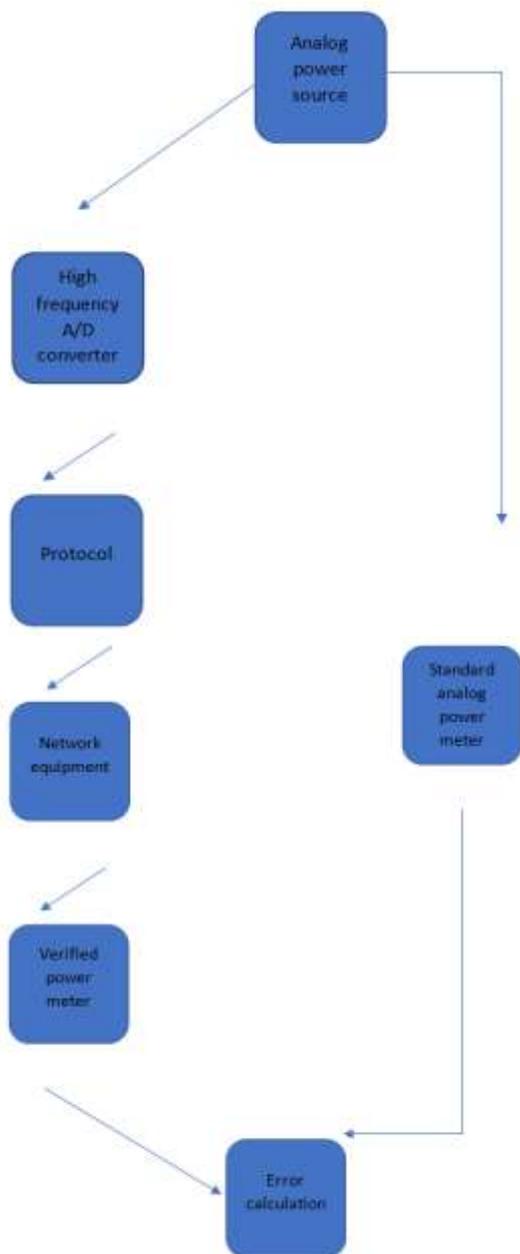


Figure 7. precept block diagram of analog power supply and standard analog power meter technique

the first two strategies are using the digital frequency direct synthesis technology to generate a sine wave signal. This procedure can set up the yield sine wave adequacy, stage, recurrence and channel amount.

standard computerized vitality source approach moreover can test the error that since of the error rate and the calculation of the advanced electric power meter. in any case the calculated current and voltage values created by way of the regular computerized power supply aren't quickly traceable to the same ancient analog values.. The third technique have higher flexibility since it

generates digital signal through excessive precision A/D conversion device acquisition of analog power source voltage current signal and then packaged.

4.4 Other related research results

In studies on the field surroundings for check technology to simulate the merging unit, Wasion institution digital electric power meter checking tool first proposed the merging unit measurement technology, which could simulate the maximum three units in on-site inspection environment, help maximum of fifty channel sampling information and GMRP networking, and realise multi-fiber access port digital electric power meter calibration[8]. On the electric power meter error characteristic and the digital electric energy dimension traceability technique[6], the Sichuan electric power research Institute and the Tsinghua college have been operating collectively to assemble a kind of "input kind digital standard power meter" that can output two forms of digital parameters. Zhejiang Han Pu electric power technology Co. Ltd has designed a digital power meter calibration tool based totally on embedded platform .The device can realise the function of analog voltage and current collection, digital power output, and all forms of electric power calculation, display, storage, and many others. it may furthermore give the characteristic of MMS communication to total the calibration of the electric power meter. Sichuan electric power science considers Institute progressed a advanced power meter with DSP since the center to assist the IEC61850 protocol[9]. It ended up an electric power meter with integration of the meter and its power source realized the test of positive reverse and active reactive energy. based on their format, specialists and understudies are able of keep creating and optimize the energy meter look at function.

V. RESEARCH OF DIGITAL POWER METER CALIBRATION SYSTEM BASED ON IEC61850 PROTOCOL

In current years, based totally on the digital transformer's suitable linear relationship with the measurement value, the huge measurement variety, and the magnetic saturation isn't a problem, output sampling statistics packets may be carried out with standard format. whilst the conventional energy meter can't get hold of the digital signal, the digital electric meter is coming into play. in this paper, a transportable digital electric power meter calibrator is tested and validated within the laboratory and on-the-spot. it could efficaciously solve the trouble of discipline calibration of digital electric power meter with excessive accuracy and performance. The

calibrator consists of hardware and software platform. the main feature of the hardware platform is that thru the manner of actual-time receiving, to convert the standard channel merging unit's digital output and the electrical power meter pulse output

into the corresponding electric signal, and transmitted them to the software program platform for evaluation and calculation via the signal processing unit body. The software platform for digital energy meter is proven in figure 8.

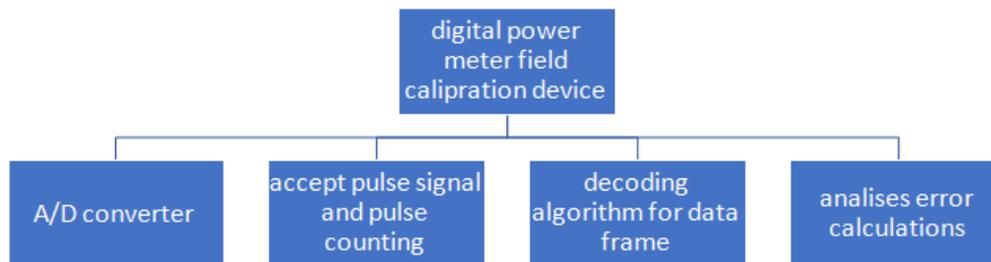


figure 8. digital electric power meter area calibration software program platform

Its most important capabilities are summarized right here. First, is the information body decoding of the merging unit's digital output, which could gain it's voltage and current signal after which carry out the standard channel energy calculation. The information frame of the merging unit output is normally inside the 61850-9-2 IEC frame layout. The software program platform needs to receive the information of the merging unit in actual time so that it is able to perform the body decoding correctly; second, is to obtain the pulse of the demonstrated meter and analyze the corresponding electric power. eventually, the software platform will evaluate the standard channel and the electrical power meter calibration facts to get the error value and the outcomes could be displayed in actual time which can be stored as wished. There are two key factors of this research. First, the data acquisition and transmission system of the field digital electric power meter is split into the standard channel merging unit data acquisition and the established electric power meter pulse output acquisition. because it's far compatible with the current mainstream synchronous mode and may attain higher synchronization accuracy[12], the synchronization error among the same old and the check channel can be controlled inside 0.01%. second[10], primarily based on high precision and multifunction clock synchronization method studies, it may realize clock synchronization by means of taking advantage of the substation clock, and preserve excessive precision synchronization by the usage of its excessive frequency crystal oscillator clock. it's far of excellent significance to the promotion of the digital electric energy meter generation improvement and the energy grid's intelligent level. via the studies of this undertaking, we will broaden a transportable calibration tool

which can perform real-time verification of digital electric energy meter, now not handiest assure the device's accuracy and reliability however additionally improve the accuracy of the current channel and the voltage channel to the 0.05 levels. This work has an important theoretical and practical importance in regulating the financial advantage evaluation index of electrical energy industry and promoting the standardization and intelligence of the whole network.

VI. CONCLUDING REMARKS

The brand new era of smart substation is within the direction of large-scale and practical applications. meanwhile, making sure the accuracy of the virtual electric power meter has notable financial and social blessings to the substation production. look at the existing studies consequences is important to the technological know-how and improvement in this area. . This paper provided a selection of design thoughts for experts and students through the evaluation on the digital strength meter error form factor. The work summarized and analyzed the improvement status of present strategies and introduced digital electric energy meter calibration system based totally at the IEC61850-9 protocol.

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