Verification Scheme and System Design of Charging Pile Electric Energy Measurement

Verification Scheme and System Design of Charging Pile Electric Energy Measurement

Xiaohui Li, Lei Li, Xiaochen Liu, Guang Yang and Qi Zhou

Electric Power Research Institute of State Grid Tianjin Electric Power Company, Tianjin 300384, China

Abstract. Design a charging pile electric energy verification device to improve the electric energy measurement accuracy of the charging pile. The device is mainly used for detecting whether the charging pile can be correctly configured, including a tariff period, a billing unit power, a billing rate, and the like, and detecting the communication reliability of the charging station. The test charges the pile output data by the broadband current comparator. Through RS485 communication mode, the instrumentation communication with the charging pile is always used to improve the accuracy of detection and measurement. The design and development of the DC charging pile verification device promoted the construction of the charging infrastructure and solved the charging problem of the electric vehicle.

1. Introduction

As new energy vehicles enter thousands of households, the relative lack of charging facilities is even more pronounced. According to the data released by the National Energy Administration, as of the end of last year, China has built 780 replacement power stations and 31,000 AC and DC charging piles.

Domestic charging piles generally provide two charging modes: normal charging and fast charging. The regular charging is an AC charging mode, which is generally used for charging the underground garage at night. Charge for about 5 hours. Since the AC charging pile only provides power input, and the power of the general vehicle charging machine is not large, fast charging cannot be achieved.

Fast charging is generally DC charging. The DC charging pile is a power supply device that is fixedly installed outside the electric vehicle and connected to the AC power grid, and can provide DC power for the non-vehicle electric vehicle power battery. The input voltage of the DC charging pile is sampled by three-phase four-wire AC380V±15%, the frequency is 50Hz, and the output is adjustable DC. Charge the power battery of the electric car directly. Design a portable detection instrument that meets the needs of the market, and overcome the key technologies and difficulties of the DC charging column.

2. Research on Key Technology of DC Charging Pile Verification Device

1. Study of Broadband Current Comparator

By analyzing the basic principles of the magnetic modulator and the current comparator in detail, based on the three-fold line drawing method, the sensitivity expression of the DC current comparator is derived by Fourier series expansion. A line structure of a magnetic modulation AC/DC current comparator is designed, and a dedicated excitation signal source, power amplifier and peak difference demodulation circuit are designed.

By analyzing the inherent noise of the magnetic modulator and the peripheral noise caused by the auxiliary circuit, together with the magnetic error and capacitive error of the current comparator, measures to reduce the noise and error of the magnetic modulation current comparator are proposed.

Through the establishment of a virtual instrument automatic test system, the performance of the developed current comparator was investigated. The measurement results show that the linear error of the developed AC/DC current comparator is 1×10-4, the uncertainty is better than 2×10-5, and the AC measurement bandwidth is not lower than 100 kHz.

The performance and indicators fully meet the measurement needs of AC and DC charging piles during fast charging. It laid the foundation for the measurement test of AC and DC charging piles.

2. On-site inspection solution research

In order to accurately measure the energy metering of AC-DC charging piles, the test equipment must be designed with an AC-DC charging connector for electric vehicles that meets national standards. It is seamlessly connected to the charging pile interface. The test instrument contains 2 interfaces. The charging post and the test instrument input interface are docked, and the electric vehicle or test load is docked with the output interface. The charging post output data is tested by a broadband current comparator.

Design 485 circuit, through RS485 communication mode, time and time and AC and DC charging pile instrumentation communication, detection and measurement accuracy.

The socket standard must meet the IP65 protection level, meet the requirements of the Ministry of Industry and Information Technology, national standards, and IEC62196 /61850-2010 to meet all the electric vehicle interfaces on the market.

Since the output current of the DC charging pile is relatively large, the maximum is 400A. The use of a clasped full contact silver plated terminal minimizes the momentary arcing caused by contact. The locking bayonet lock prevents the connection from being secure and reliable.

3. Energy Measurement Harmonic Processing Solution Research

The most feasible method of harmonic measurement is based on the FFT detection algorithm. Because the FFT has high real-time performance, the spectral value distribution of N frequency points can be obtained by calculation.

In order to achieve the above algorithm, it is best to use DSP processor in CPU selection. DSP has powerful digital signal processing function, especially for FFT special optimization, such as providing bit reverse order addressing (FFT algorithm butterfly), independent hardware multiplication And a special FFT package.

3. Functional Analysis of DC Charging Pile Verification Device

1. Basic function

Measuring function: detecting the accuracy of DC voltage and DC current of DC charging pile

Metering function: detecting the measurement accuracy of DC power and DC power of DC charging pile;

Charging function: Check whether the DC charging pile can be correctly configured, including the rate period, billing unit power, billing rate and other parameters;

Communication: detecting the communication reliability of the main station communication (optical fiber, GPRS or CSMA), RS485, far infrared communication of the DC charging pile;

Clock error: verify whether the display of the DC charging pile clock is accurate;

Insulation resistance test: Verify the insulation strength of the DC charging post charging port to the outer casing to ensure the safety of use.

2. Scalable features

Accounting management: Whether the charging management module of the charging pile can correctly read the electricity quantity data of the electric energy meter, accumulate and write back the consumption amount of the user IC card according to the electricity consumption of the electric energy meter and the set unit price;

Read and write card: The charging pile detecting device can detect whether the charging pile can correctly read and write the IC card;

Data storage: detecting whether the transaction data is correct, continuous, complete, and stored in non-volatile memory;

Threshold parameters: Check whether the charging pile has correct alarm and protection functions under various voltage and current thresholds;

Power failure writing card function: When the power failure occurs during charging of the charging pile, whether the charging pile can still maintain (24 hours) read and write functions to the user IC card;

Timing function: Detecting the automatic timing function of the charging pile, verifying the timing error of the charging management module and the internal energy meter.

4. DC charging pile verification device technical indicators

1. DC voltage measurement

Quantity limit: 100mV, 1V, 10V, 100V, 1000V (automatic range switching); adjustment range: (0~120) %RG (RG is the limit, the same below); adjustment fineness: 0.01% RG, 0.1% RG, 1% RG, 10% RG optional; measurement resolution: 0.01% RG; measurement accuracy: 0.05% RD (RD is reading, the same below) ($0.1V \leq U \leq 1000V$).

2. DC current measurement

Quantity limit: 0.1A, 1 A, 10 A, 100 A, 200 A, 500 A (range automatic switching); adjustment range: (0~120) % RG; adjustment fineness: 0.01% RG, 0.1% RG, 1 %RG, 10% RG optional; measurement resolution: 0.01% RG; measurement accuracy: 0.05% RD ($100mA \leq I \leq 600A$).

3. Voltage and current ripple measurement

Measurement bandwidth: ≤ 1 kHz; accuracy: ± 5% RD.

4. Power measurement

Power measurement accuracy: 0.05% RG ($60V \leq U \leq 1000V$, $100mA \leq I \leq 500A$)

5. Energy measurement

Active energy: 0.05% RG ($60V \leq U \leq 1000V$, $100mA \leq I \leq 500A$)

6. Input energy pulse

The setting range of the check circle is 1~999999999; the highest receiving pulse frequency is 160 kHz.

7. Output energy pulse

The maximum receiving pulse frequency is 160 kHz; the energy pulse type: supports active and passive pulses; load capacity: greater than 20mA.

8. Other indicators

Working temperature: -25°C ~ 60°C; relative humidity: ≤ 95%; Dimensions: 800mm * 1000mm * 2500mm; working power: single-phase / three-phase AC220V ± 20%; machine weight: <200KG.

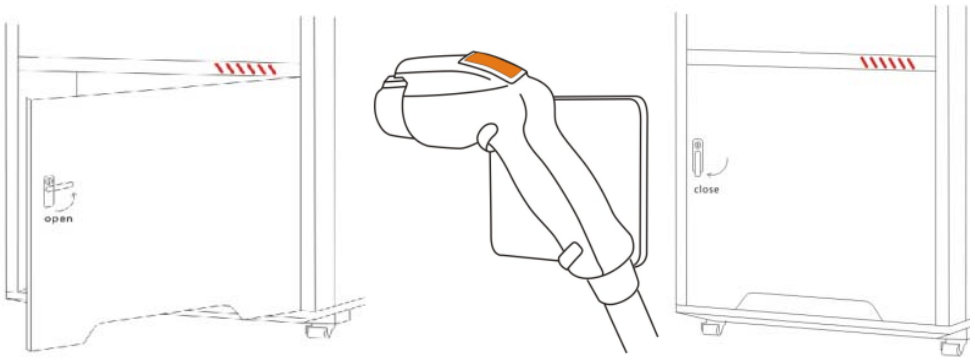
5. Design of DC charging pile verification device

Design a DC charging pile verification device with an accuracy class of 0.05, which is used for full-function verification before charging pile installation. The appearance of the DC charging pile verification device is shown in Figure 1.

Figure 1. DC charging pile verification device design drawing.

Complete the wiring work of the DC charging pile verification device. Remove the double-headed charging gun, open the lower cabinet door of the verification device, and insert the charging gun into the charging gun socket in the lower cabinet. Lift the charging gun cable of the verification device from

the groove directly under the cabinet, hang it on the hook on the side of the cabinet, and then close the lower cabinet door. The entire workflow is shown in Figure 2.

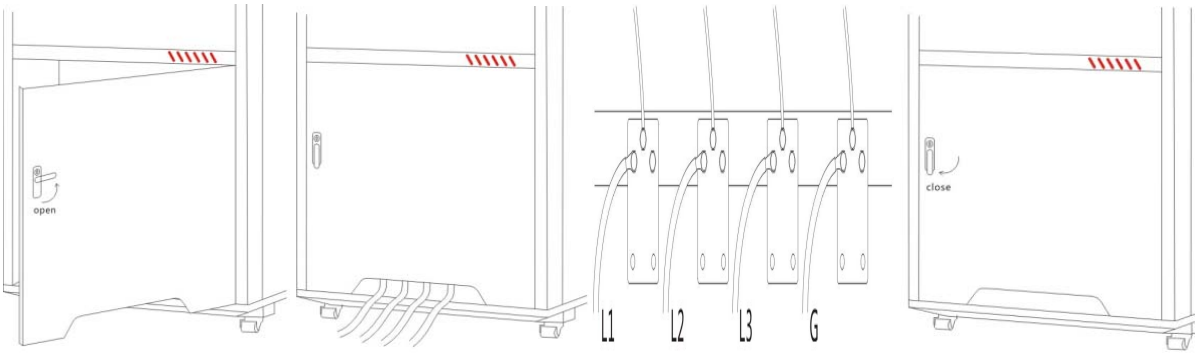


(a) (b) (c)

Figure 2. Calibration device wiring diagram.

Before the verification begins, the user should have the charging pile to be inspected and have a charging card that matches the charged charging pile. At the same time, ensure that there is sufficient balance in the charging card to complete the verification, and install the verification software on the computer. The software comes with the system.

Connect the verification device to the charging post. Open the lower cabinet door, take out the power supply cable of the verification device, connect it to the power supply port of the charging post, and close the lower cabinet door. In addition, in order to ensure the measurement accuracy and safety of high-precision instruments, the instrument must be reliably grounded. The grounding terminal of the DC charging pile verification device is on the interface panel at the lower rear of the cabinet. The workflow is shown in Figure 3.



(a) (b) (c) (d)

Figure 3. Calibration device and charging station wiring diagram.

At present, there is no uniform standard for the power supply port of the charging pile. Most manufacturers do not have a power supply interface. Only the copper wire column for power supply is left under the charging pile. The user can press the power supply cable of the verification device on the copper column. The access mode of the power supply interface during the inspection and delivery is negotiated with the charging pile manufacturer. Various communication parameters of the verification device and a verification scheme of the charging pile are set in the detection system.

After the charger is started normally, please operate the charger as prompted. First insert the charging card into the card slot. When the charging pile prompts to “Please insert the charging plug”, the charging socket door of the charging post automatically pops open. At this time, insert the charging gun of the

verification device into the charging socket of the charging pile, and close the socket door according to the subsequent prompt. Charging pile prompt: When "Start charging, please take the card", please take out the charging card spit out at the card slot, and the charging post will enter the charging state. The workflow is shown in Figure 4.

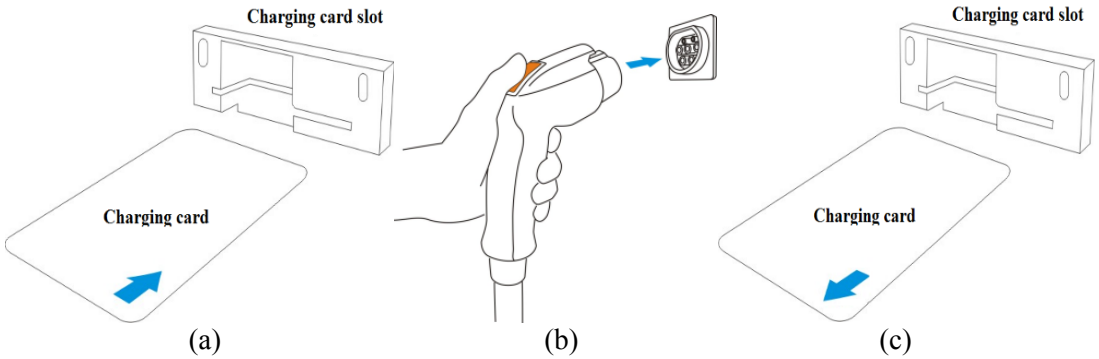


Figure 4. Charging pile charging work flow chart.

The inspection work is completed in the operating system, including communication test, measurement verification, billing verification and other detection items. First, the system automatically completes the communication test, and then the system enters the measurement verification. After the measurement verification is finished, if the charge verification is to be performed, the card needs to be inserted again before the determination. The workflow is shown in Figure 5.

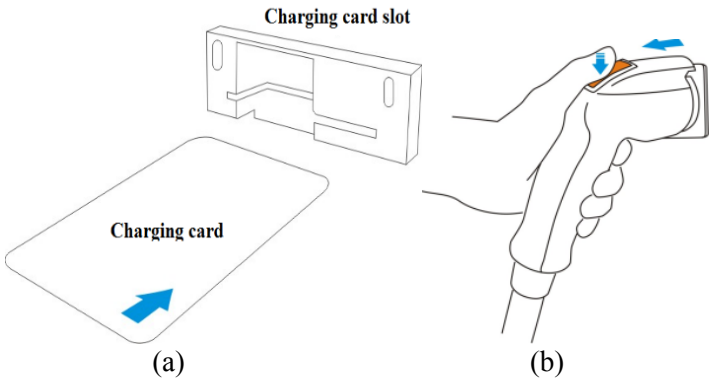


Figure 5. Charging pile fee settlement work flow chart.

The charging card is again inserted into the charging pile to settle the charge, the charging pile ends the charging state, the charging socket door is opened, the charging gun is pulled out as shown in the figure, and the hook of the side door of the verification device is put back, and the charging pile socket door is closed.

Determine on the detection system user interface and start the billing verification work. When the verification process ends, the verification results are displayed and the data is saved.

Follow the prompts of the charging post to request the card, then click the power button to turn off the charging post.

The physical diagram of the DC charging pile verification device is shown in Figure 6.

Figure 6. DC charging pile verification device physical map.

The DC charging pile verification device needs to pay attention to related matters when it is used.

1. Please pay attention to the strength when plugging in the charging gun to prevent damage to the charging gun or charging socket.
2. It is recommended to use the verification device with its own wiring. If you need to wire it yourself, please use the same wire and length. The connection between the verification device and the charging port of the charging post should not be too long, so as not to affect the verification result.
3. As the current national standards have not been determined, the charging interface and power supply interface may be changed. If there is any change, it will be replaced according to national standards.
4. There are no parts that need to be adjusted by the user. Do not disassemble the equipment to avoid damage to the instrument.
5. Do not tear open the "Maintenance Mark" to avoid liability for damage to the instrument caused by improper use.
6. Packaging aluminum boxes, wooden boxes and pearl cotton for transportation, please keep them in a safe place for later use.

6. Conclusion

With the promotion and popularization of AC-DC charging piles, how to verify the output accuracy of AC-DC charging piles is not only related to the development of charging piles, but also to the immediate interests of users.

This system is designed with a charging pile verification device. The accuracy grade of the series is 0.05 grade and 0.1 grade. It can be used for the verification of the charging pile before installation, after installation and the inspection in use. The detection device is mainly composed of a high-precision standard electric energy meter, a high-stability AC power source, a high-power program-controlled AC electronic load, a main control unit and other functional modules. The device uses the latest design technology and patented technology, and its performance is stable and reliable, which can be used in industrial testing.

References

[1] Hanuschak M, Finley J A, Quigley M. Emergency telecommunication device: US, US 6765991B1 [P]. 2004.
[2] Jiang L, Xiao W, Zhen M, et al. Design and implementation of maximum power point tracking inverter based on IR2101 [J]. Electronic Design Engineering, 2010.
[3] Murat Yilmaz, Philip T.Krein.Review of Battery Charger Topologies,Charging Power Levels, andInfrastructure for Plug-In Electric and Hybrid Vehicles [J]. IEEE TRANSACTIONS ON POWERELECTRONICS, 2012, 28 (5), pp. 2151 - 2169.
[4] Soon T K, Mekhilef S, Safari A. Simple and low cost incremental conductance maximum power point tracking using buck-boost converter [J]. Journal of Renewable & Sustainable Energy, 2013. 5 (2), pp. 1777 - 1790.
[5] Imaoka J, Kimura S, Martinez W, et al. A Novel Integrated Magnetic Core Structure Suitable for

Transformer-Linked Interleaved Boost Chopper Circuit [J]. Ieej Journal Ia, 2014, 3 (5), pp. 395 - 404.

[6] S. Douzi, M. Tlig, J. Ben Hadj Slama. Experimental investigation on the evolution of a conducted-EMI buck converter after thermal aging tests of the MOSFET [J]. Microelectronics Reliability, 2015, 55, pp. 9 - 10.