Wide frequency band UHV bundle conductor corona current measurement system based on GPS synchronous clock

Liu Yunpeng[1*], Zhu Lei[1], You Shaohua[1], Lv Fangcheng[1]
1. Hebei Provincial key laboratory of Power Transmission Equipment Security Defense, North China Electric Power University, Baoding, China
*Email: gylyp@263.net

Abstract: In order to analyze wide frequency band corona current characteristics of the UHV bundle conductor, a corona current measurement system is developed. The synchronous collect of the voltage and current signal is realized by the GPS technology. The corona current signal is transmitted to the lower computer through the wireless network. And the current signal collected in this way is safe and reliable. The result of the error analysis and the practical application of the system shows that this system can be used to measure the wide frequency band corona current of the UHV bundle conductors.

1 INTRODUCTION

When the surface electric field strength exceeds the breakdown field strength, the ionization occurs in the vicinity of the conductor. The charged particles moves away and then back toward the conductor in the AC voltage, and the current forming in the movement of the particles is the so called corona current. Accompanied with the ionization of the air, noise, light and radio interference will also take place, and the energy consumed by those kinds of effects is called corona loss. Corona current is a very important parameter that reflects the corona effect and corona onset characteristics, the accurate measure of all the frequency components of the corona current is of great importance. The effect caused by corona discharge, will effluence the economic operation of the transmission lines, corona loss etc. This is not only a decisive factor of choosing the cross-section of the conductor but also influence the investment and annual operation cost of the transmission lines which is extremely prominent for the UHV transmission line[1].

Nowadays, the traditional way is to gain the current from the cage wall, and the high efficient oscilloscope is used to measure the corona current signal. But corona discharge occurs when the AC voltage is applied to the conductor, large quantities of charged particles, especially the electrons, are limited to the surrounding of the conductor. Collection of the signal from the conductor can better reflect the wide frequency band component of the current [2-10]. Based on wireless network technology, virtual instrumental technology, and application of the high sampling rate data acquisition card, the measurement system in this paper can realize the accurate measure of the corona current.

2 SYSTEM DESIGN

2.1 Hardware design

System sketch is shown in Fig.1: in the corona current sampling section, the high-power precise no-inductance resistor is applied as the current sensor, which can assure that the resistor itself could not been destroyed by the transient voltage and current. The resistor is connected in series with the bundle conductors in the corona cage. What is more, because the resistor is almost of no inductance, when the current passes through the conductor, the voltage produced at the two ends of the resistor has the same phase as the current, which can assure that there is no distortion of the wave form and reflect the wide frequency band information of the corona current. The current signal is collected by the data acquisition card PXI-9820 installed in the upper computer 4. the whole upper computer is placed in the Faraday cage which is made-to-order.

In the voltage sampling section, the high precise capacitor voltage divider 12 is used to extract the voltage signal, and the data acquisition card is used to collect the voltage signal. The synchronous collect of the voltage and current is realized through the use of GPS synchronous clock. The trigger time can be set to 1second, 1 minute or 1 hour [11-12]. The trigger time is set to 1 minute in this test, which means the trigger signal will be sent out each whole minute, after receiving the TTL trigger signal , the upper computer and lower computer collect the signal synchronously.

The current signal is transmitted via the wireless network composed of 300M/s wireless network card 7, 10 and the wireless router, which can separate the high voltage side and the low voltage side, so there is no electric connection between them. As there is no insulation problem, when the experiment stuff operate on the lower computer, the advantage includes continence of operation and no safety problem [13].

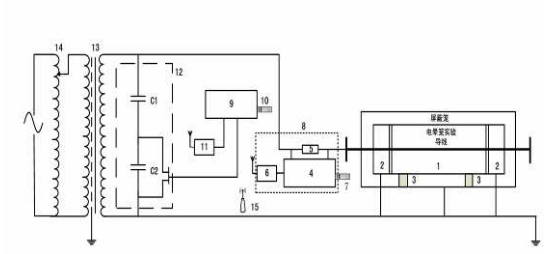

Fig.1 Sketch of the system structure

1-corona cage measurement section；2-shielding section；3-insulation support；4-upper computer；5-resistor sampling unit；6-upper GPS clock；7-upper wireless net card；8-Faraday cage；9-the lower computer；10-lower computer net card；11-ower GPS clock；12-TRF-800model standard capacitor divider；13- test transformer；14-voltage regulator

2.2 Software design

Based on the thought that 'software is equipment', the programming software LabVIEW is used [14]. First, the parameter of the data acquisition card is set. The synchronous collect of the voltage and current signal is realized by the GPS synchronous clock. The corona current collected in the upper computer is transmitted to the lower computer through the wireless network. The voltage and current signal is saved in the lower computer. The program flowchart is shown in Fig.2, and Fig.3 shows the software interface.

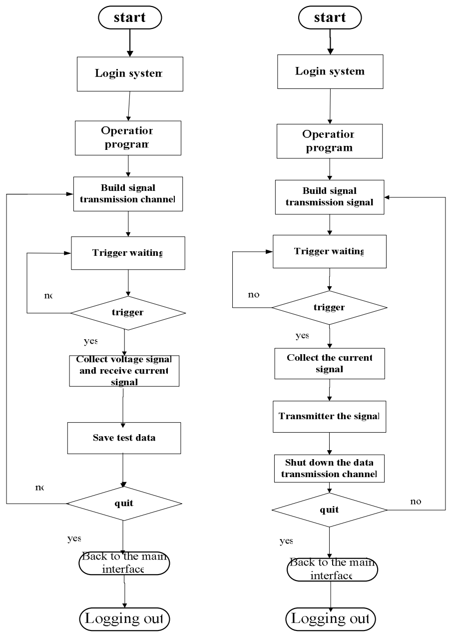

Fig.2 Program flowchart of the system

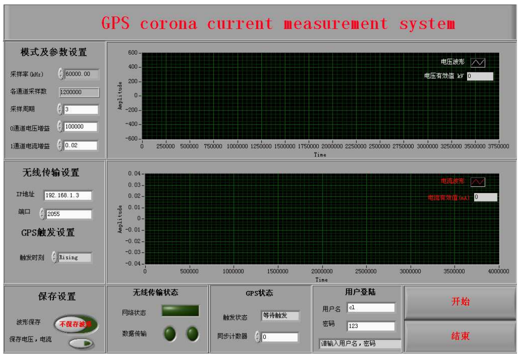

Fig.3 Software interface

3 ERROR TEST

The source of the corona current measurement system mainly comes from GPS synchronous pulse, wireless net work transform error and the inductive character of the no-inductive resistor.

3.1 Synchronous test of the voltage and current sampling

In order to assure the synchronization collection of the voltage and current signal, error caused by the GPS clock, wireless network and the no-inductance resistor. The test method is: first, the signal generator is used to generate a voltage signal of 1V and 50Hz. The GPS clock triggers the upper and lower computer to collect the signal. After the signal is transmitted from the upper computer to the lower computer, the two signals are compared in the lower computer and synchronous error contains the phase error and the ratio error.

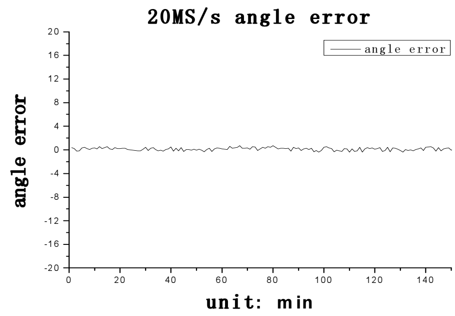

Fig.4 Measurement result of the angle error

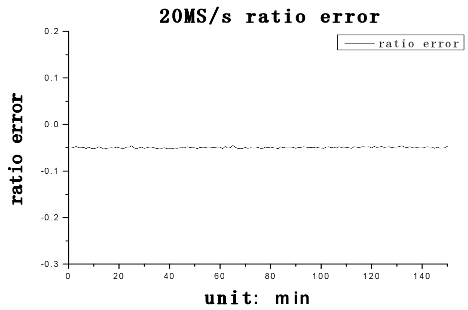

Fig.5 Measurement result of the ratio error

The average value of the phase error is 0.14’, the largest phase error is 0.729’. The average value of the ratio error is -0.04%, and the largest ratio error is -0.0552%. From the error data above, the system in this paper satisfy the requirement of 0.2 level and could be used to measure the corona current.

3.2 Amplitude-frequency and phase-frequency characteristic of the resistor

The no-inductance resistor refers to low inductance, while the inductance could never be 0. So in the high frequency condition, the resistor will show a certain inductive character. The frequency band is so wide that it is necessary to test the amplitude-frequency and phase-frequency characteristic of the resistor.

Nowadays, there is no related criterion of how to choose the no-inductive resistor in the high frequency condition. The main solution is choosing the proper sampling resistor according to the concrete test. The Amplitude-frequency and phase-frequency characteristic is test with the sweep signal generator. With the increase of the frequency, the amplitude of the impedance value and the phase error caused by the inductive character are shown in Fig.6 and Fig.7. The test result illustrate that when the resistor is applied with signal of 10MS/s, the amplitude error is within 0.1%, and the phase error is less than 2^0, which can meet the requirement of the test well.

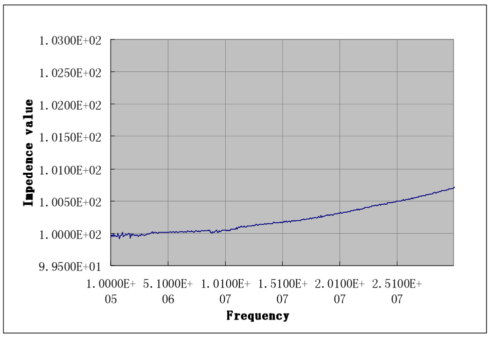

Fig.6 Amplitude-frequency characteristic of the no-inductance resistor

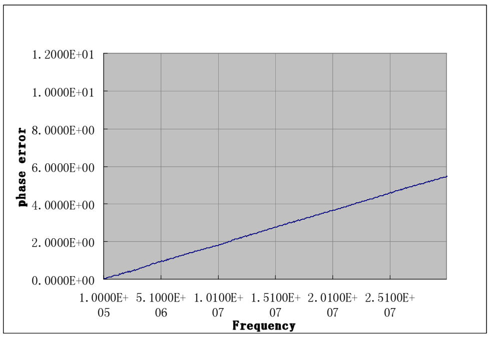

Fig.7 Phase-frequency characteristic of the no-inductance resistor

4 CORONA TEST

4.1 Test layout

Fig.8 is the upper computer sampling unit, which includes the GPS synchronous clock, precise no-inductance resistor, wireless net card and data acquisition card.

The general arrangement of the test is shown in Fig.9. The upper computer is encapsulated in the metal box and place in the grading ring of the UHV corona cage together with the battery, which could make the upper be in a equal potential environment and prevent the corona discharge on the upper computer.

The lower computer is placed in the control room, and the function of the upper computer besides collecting the voltage signal is to control the corona current measure with the wireless net work.

Fig.8 GPS upper equipment

Fig.9 General layout of the test

4.2 Test result

This system mentioned in this paper has been applied to the UHV corona cage of the State Grid Power Research Institute of China. The corona current of 8 bundle LGJ630-45 conductor is measured. Fig.10 shows the voltage and current waveform in the rain condition when the bundle conductor is applied with 599.5kV of voltage. The sampling rate is 20MS/s, and from the figure the high frequency pulse of the corona current could be obviously observed.

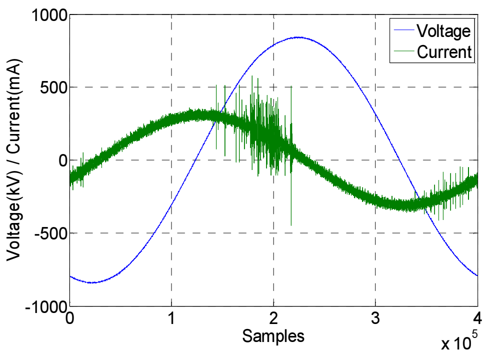

Fig.10 Measurement result of the corona current

5 CONCLUSION

1) Based on wireless network system, virtual instrumental technology, and application of high sampling rate data acquisition card PXI-9820, a kind of GPS synchronous wide frequency band UHV bundle conductor corona current measurement system is designed.

2) The source of the corona current measurement system mainly comes from GPS synchronous pulse, wireless net work transform error and the inductive character of the no-inductive resistor.

The average value of the phase error is 0.14', the largest phase error is 0.729'. The average value of the ratio error is -0.04%, and the largest ratio error is -0.0552%. From the error data above, the system in this paper satisfy the requirement of level 0.2 and could be used to measure the corona current. when the resistor is applied with signal of 10MS/s, the amplitude error is within 0.1%, and the phase error is less than 2^0, which can meet the requirement of the test well.

3) This measurement system is used to measure the corona current of the UHV bundle conductor LGJ630-45 in State Grid Power Research Institute, and the wide frequency band corona current is gained.

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