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Comparative study of two different measuring methods for corona current pulses

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ABSTRACT

Based on a designed coaxial cylindrical corona discharge platform, this paper compares two methods for the measurement of corona current pulse, namely from cage side and conductor side both at low potential. It is found that the corona pulse can be obtained from both methods and the waveform of the current pulse is highly dependent on the sampling resistor. Then two simplified models are proposed to interpret the experimental results and the relationship between the two measurement methods. It shows that the key point in accurately measuring the corona current pulse is the selection of suitable sampling resistor.

1. Introduction

Since the detection of corona current pulses in 1934, corona discharge has been the subject of various studies including the field of electrophotography, semiconductor manufacture and high voltage transmission lines, and so on. For the high voltage transmission lines, the corona current pulses will cause undesired radio interference which could pose serious interference to nearby communication system [1,2]. Thereby, accurate measurement of corona current pulse is of great importance for study of the radio interference effects from high voltage transmission lines, and also for the mechanism of corona discharge, since the main information about corona discharge is derived from corona current pulse [3].

The typical corona pulse sustains for dozens to hundreds of nanoseconds depending on the polarity of applied voltage and the electrode geometry [4,5]. For the purpose of precise measurement of the corona current pulses, many scholars have contributed their efforts [3,6,7]. However, most of their work is about the point to plane electrode and few of them involve the measurement from corona cage geometry.

Generally, the prior choice for the measurement of corona current pulse is from low potential terminal considering the convenience in operation. As to the corona cage, there exist two methods of measuring the corona current pulse from low potential terminal [8]. One is to feed the inside conductor with high voltage and measure the corona current pulse from the grounded corona cage [9], which could be called cage side method. The other is to energize the corona cage with high voltage and measure the corona current pulse from grounded conductor [2], which could be named conductor side method. In the second method, the imposed high voltage energizes the inside conductor surface with opposite high electric field strength which initiates the corona discharge on the conductor. In different scholars' research, they may adopt either of the two methods. Hence, it is necessary to find out the detailed differences between them. Unfortunately, to authors' best knowledge, no comprehensive comparison has ever been reported.

Aiming at the aforementioned problem, a cylindrical cage platform was designed to measure the corona current pulse respectively from the cage side and the conductor side. The obtained waveforms of the corona current pulses under different sampling resistors were systematically compared for both methods. Besides, two simplified mathematical models were proposed to interpret the experimental results.

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2. Experimental setup

Since the corona cage will be applied with high voltage when measure corona current pulse from the test conductor, thus, the surface of the corona cage must be as smooth and round as possible to keep it from corona. In this experiment, a cylindrical corona cage is chosen which is constructed of 36 smooth stainless pipes with two rings on both sides as shown in Fig. 1(a). The diameter of the stainless pipe is 12 mm. The length and radius of the corona cage are 180 cm and 40 cm, respectively, and the axis of the corona cage is 150 cm above the ground. The test conductor is set at the axis of the corona cage with an artificial 2 mm diameter spherical metallic ball mounted in the middle to act as the corona discharge point. For cage side method as shown in Fig. 1(b), positive DC source is applied to the test conductor and corona current pulse is measured at bottom of the vertical conductor which grounds the corona cage through a sampling resistor. While for conductor side method, negative DC source is applied to the corona cage and the inside conductor is grounded with two sampling resistors on both sides, then the corona current pulse is obtained likewise from the low potential terminal as shown in Fig. 1(c). A resistive trap of 10 MΩ is used to block the interference from the DC source for both methods, and the DC voltage sources are regulated and can provide voltages from 0 kV to 120 kV in magnitude with ripple less than 0.1%. The frequency response range of the current probe is from 1.5 kHz to 200 MHz which is enough to cover the bandwidth of the corona pulses. An acquisition card, with sampling rate of 200 Msamples/s is connected to personal computer to record the corona current pulses.

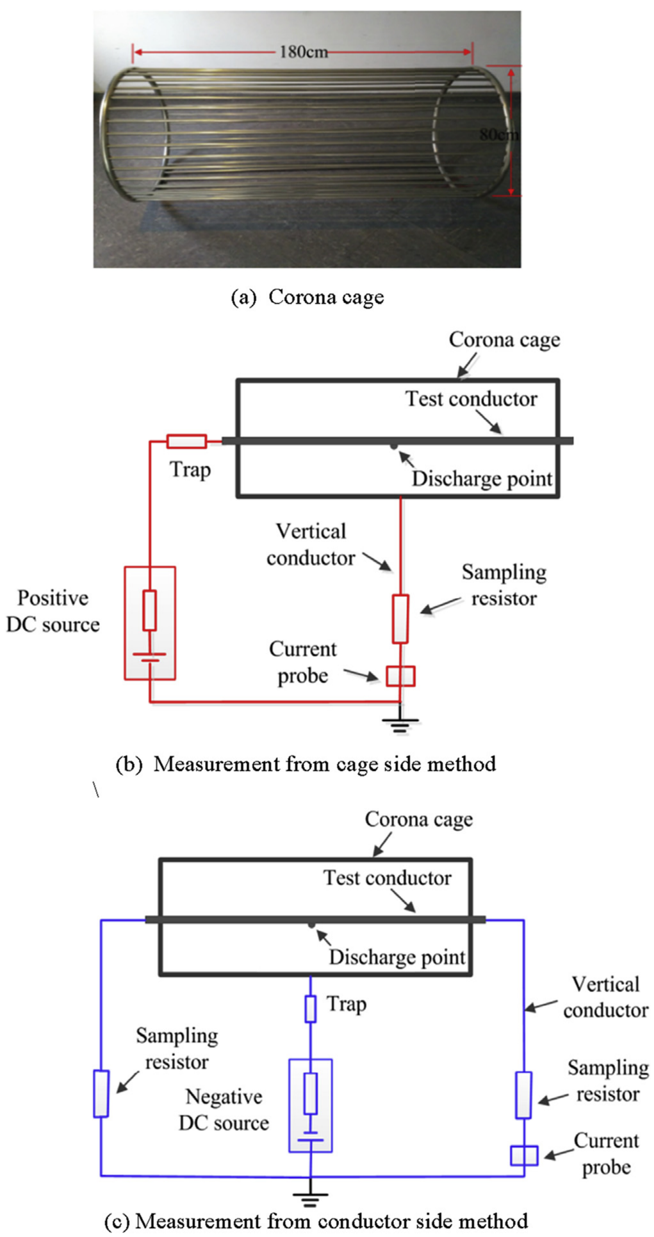

Fig. 1. Schematic diagram of the platform.

3. Experimental results

The positive corona current pulse is known to be the main source of radio interference produced by high voltage transmission lines [10]. Hence, in this paper, the comparison between the two methods is based on measurement of positive corona current pulses. Since the mode of corona discharge is quite sensitive to electric field intensity [4], the voltages of same magnitude were imposed in both methods. Thereby, the corona discharges were controlled at the same mode with almost evenly distributed corona current pulses as shown in Fig. 2 where the maximum surface electric field strength of the discharge point is calculated to be 71 kV/cm. The amplitude and the time interval are stable and they are about 52 mA and 4 ms, respectively.

In the measurement of corona current pulse, the use of sampling resistor is often inevitable whether to obtain the voltage across the resistor as replacement of the current signal or for the purpose of impedance matching. Thereby, the sampling resistor in this experiment is also changed to have an insight on its influence on the corona current pulse waveform and the experimental results are illustrated in Fig. 3.

It is observed that the typical double exponential waveform corona current pulse can be obtained from both methods when the sampling resistor is big enough. However, when the resistor becomes smaller, such as 22Ω, fierce oscillation occurs and the period of oscillation for the cage side method is larger than that of conductor side method as shown in Fig. 3(a) and (b). The curves from the conductor side method are almost overlapping to each other on the rising and falling edge except for the oscillation, while for the cage side method, the corona current pulses exhibit a smoother rising edge and more slow falling tail with increase of sampling resistance. The average amplitude of the corona current pulses for the cage side method is about two times of that measured from the conductor side as shown in Fig. 3(c). For both

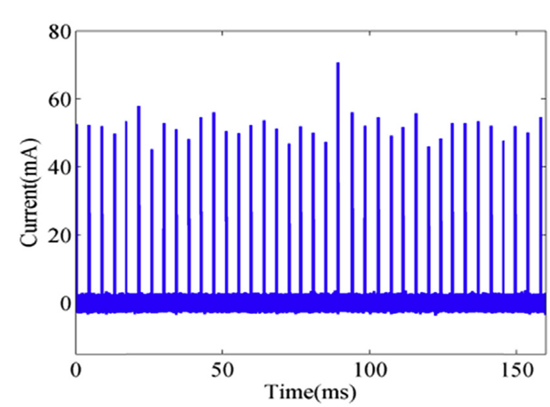

Fig. 2. Stable corona current pulses.