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Experimental Evaluation of Potential Distribution in a Grounding Grid Subjected to Impulse Current

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Abstract- A methodology to evaluate the response of a grounding grid system subjected to electrical current impulses is proposed in this work. The methodology is based on analysing the signal of voltage propagated in the vicinity of the injection rod. An impulse generator (80 kJ/100 kV) was used to generate waveform 8/20 µs, this is a signal that represent lightning surge. The signals were acquired using by a digital oscilloscope. From the results obtained, one observes that the amplitude of propagated voltage is attenuated in the direction of propagation.

I. Introduction

Grounding grid is one of the key elements to ensure the safety of people and equipment in the electrical systems. Its function is basically to provide a physical connection of an electrical system to the earth [1].
Several studies have shown that the response of a grounding grid subjected to electrical current impulses is significantly different from the behavior at industrial frequency. They also believe that the diversity of conditions under which experiments are conducted, as well as, the different approaches of the parameters used, makes the comparison of results to be a difficult task [2, 3, 4, 5].
The electrical characteristics of the soil, the dimensions of the electrode and the geometry of distribution of electrodes has a great influence on the performance of grounding submitted to electrical current impulses [6, 7]. Besides the factors presented, [3] adds the characteristics of the current signal applied to the soil.
To evaluate the response of the electrode to the current impulse [4] proposes three parameters: Grounding potential rise (GPR); Voltage along the electrode; Potential distribution along the ground in the vicinity of the electrode in which current is applied.
This paper shows some results on the response of grounding grids subjected to electrical current impulses, in which it was assessed the potential distribution in the vicinity of the injection electrode.

II. Materials and Methods

This section presents materials and methods used to obtain the voltage and current signals resulting from the application of electrical impulse current in a grounding grid.

A. Experimental setup

Experiments were performed using an 80 kJ/100 kV generator of electrical current impulses with 8 stages. Depending on the number of stages interconnected, the generator can reach a maximum charging voltage of 100 kV. Were generated signals 8/20 µs which represents the waveform of lightning. The setup of the experiment is shown in Figure 1. The elements V, Rp, D, SG C, R and L represent the schematic diagram of the current impulse generator. The signals were acquired with a 4-channel digital oscilloscope with an acquisition rate of 2 GHz. Also we used three probes high-voltage, with a maximum of 40 kV and attenuation of1,000 times and also coaxial cables with an impedance of 50 Ω.
To perform the measurements of voltage applied to the soil it was used the classical methods of the voltage divider. The applied voltage was obtained from the samples of voltage measured in voltage divider consisting of impedances Z_A and Z_B. To measure current applied to the soil it was used classical methods of shunt resistor. The electric current injected into the soil was obtained from the voltage across resistor R_{SHUNT} (5.488 mΩ).

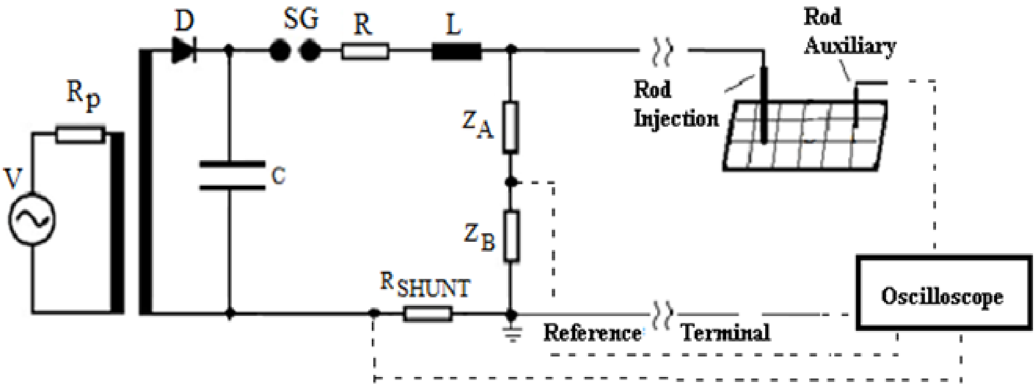

Figure 1. Setup of the experiment to obtain data of voltage and current.

They were used two steel rods, made in copper coated with 13 ± 2 mm in diameter. One being a 1.20 m length, which was buried at a depth of 1.0 m in the ground and it was used as a current injection rod. The second was used as an auxiliary rod, measuring 0.49 m, it was 0.40 m buried in the soil, 4.0 m far from injection rod and was used to acquire the voltage signal propagated in soil. It is shown in Figure 2 a sectional view of the two rods buried in the soil.

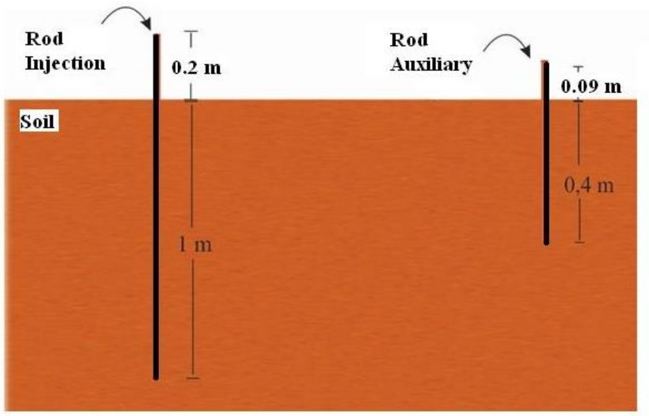

Figure 2. Sectional view of the rods into the ground.

III. Results

It is presented in this section the results obtained from the application of current impulses in the ground with a voltage of 11 kV charging in the capacitor of the impulse generator.

The current impulse generator has been configured to produce an 8/20 µs signal. It is displayed in the Figure 3 the signal obtained.

When the current impulse is applied to the soil, the electrical characteristics of the soil cause changes in the circuit. Therefore the decay of the signal voltage and current applied to the soil is different in relation to the signal 8/20 µs generated.

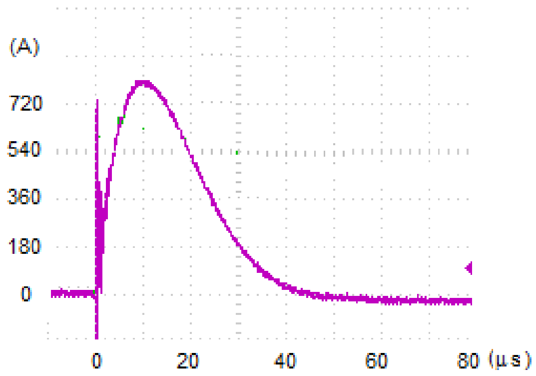

Figure 3. Signal 8/20 µs generated.

The waveforms of the voltage and current signals applied to the soil are shown in Figure 4.
The voltage waveform on the current injection rod was obtained by means of the voltage divider. The current signal was obtained by the ratio *v(t)*/ R_{SHUNT}, wherein $R_{SHUNT} = 5.488\ \Omega$ and *v(t)* is the voltage on this resistor.

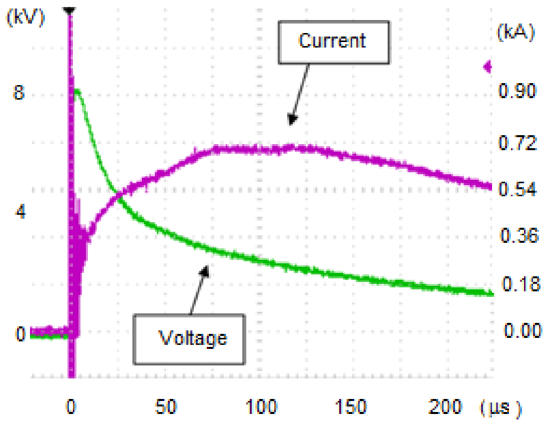

Figure 4. Waveforms of the signals voltage and current applied to the soil.

The waveform of the voltage signal propagated in the soil, distant 4 m far from the electrode of current injection, is shown in Figure 5

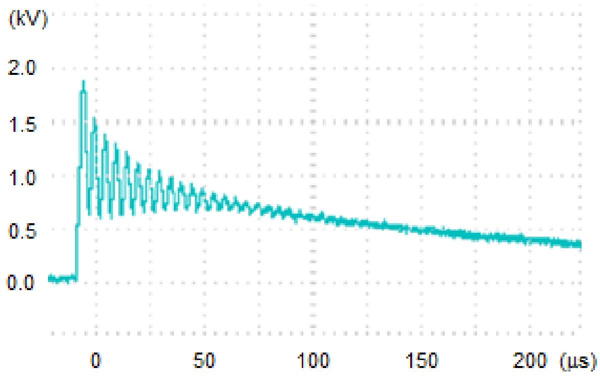

Figure 5. Waveform voltage signal propagated measured 4 m far from the rod of injection.

They were made 5 measurements with charging voltage of 11 kV. It is shown in Table 1 peak values of data obtained.

Table 1. Peak values of voltage propagated in the soil and voltage and current applied to the soil.

	Peak Value		
Measurements	**Applied Current (A)**	**Applied Voltage (kV)**	**Propagated Voltage (kV)**
M1	728.8	8.0	1.9
M2	720.0	7.8	1.7
M3	690.0	7.8	2.1
M4	732.6	8.0	1.9
M5	729.9	7.9	1.8
Mean Value	**720.26**	**7.9**	**1.88**

The verified behavior of voltages and current waveforms are in agreement with the results achieved by [1, 8, 9].
One can observe that the voltage propagated, resulting from application of a electric current impulse in the soil has suffered attenuation along the propagation direction. The waveform of the voltage propagated presents an attenuation of 76.2% of the peak value at 4 m from the point of injection.
For all measurements, the voltage signal has presented oscillation, as shown in Figure 5. This result might be attributed to variations presented in the signal of applied current, however, confirmation of this result should be assessed in future work.
The ionization of the soil was not an object of the present study, however, results presented in [6] suggests that the slow decay of the current (Figure 4) may mean that no ionization occurred in the soil tests.

IV. Conclusion

In this paper was presented and analysed a methodology for measuring and evaluating grounding systems subjected to high electric current impulses. The methodology was adequate for the research being carried out in order to improve the performance of grounding systems. From results it was concluded that potential distribution in the vicinity of the injection electrode is attenuated along the propagation direction.

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