Investigation of Currents Injected by a Surge Generator into the Lightning Protective System of a Small Residential Structure

Grzegorz Maslowski

Department of Electrical and Computer Engineering, Rzeszow University of Technology
W. Pola 2, Rzeszow, Poland, e-mail: maslowski@prz.edu.pl

Abstract

The paper presents preliminary results of the lightning protective system (LPS) tests of a small residential structure conducted in 2007 at the Rzeszow University of Technology area in Poland using the mobile surge current generator. The primary objective was to examine the current waveshapes in all parts of the circuit and the division of the injected surge current between the grounding system of the LPS and remote ground. In case of the first tested configuration (LPS I) with the dc grounding resistance of the entire system 4.09 Ω, the value of the peak current entering the electrical circuit neutral was about 56% of the injected surge current peak, while in case of the second configuration (LPS II) with the dc grounding resistance of the entire system 2.88 Ω it was about 20%. The current waveshapes in the ground rods differed from the injected current waveshapes and the current waveshapes in other parts of the test system for both configurations.

1. Introduction

The structural lightning protective system tests using triggered lightning and two residential structures were conducted in 1997, 2004, and 2005 at the International Center for Lightning Research and Testing (ICLRT) at Camp Blanding, Florida [1-3]. The experimental results presented in [1-2] show that the current waveshapes are not the same in all parts of the circuit, and the division of the injected lightning current between the grounding system of the LPS and remote ground depends significantly on the LPS configuration. All obtained results were for sandy soil of relatively low conductivity. According to recommendations given in [1] it is need to conduct similar experiments for other types of soil. A new test for high conductivity clay soil using the mobile surge current generator and two different configurations of LPS were conducted in 2007 at the Rzeszow University of Technology area in Poland (Fig. 1).

2. Experimental Setup

The entire test system, schematically shown in Fig. 2 has been installed on the flat terrain close to the grounding system of lamps. Three insulated conductors were used to form the return path of the surge generator in order to decrease external inductance of the circuit and for uniform distribution of current flowing in ground. The horizontal and down conductors of the lightning protection systems were mounted on the wooden poles. Configurations of the LPS I and the LPS II together with their electrical diagrams are shown in Fig. 3 and Fig. 4, respectively.

The simple LPS I consisted of two LPS ground rods and two down conductors which were separated by about 6 m and connected by a horizontal conductor at height 2.8 m. There was also installed an additional power supply system ground rod which was connected by a buried horizontal conductor 3.1 m long to the nearest LPS

Fig. 1. Surge current generator GUP-80/10 (left panel) and the LPS II (right panel) mounted on the wooden poles.

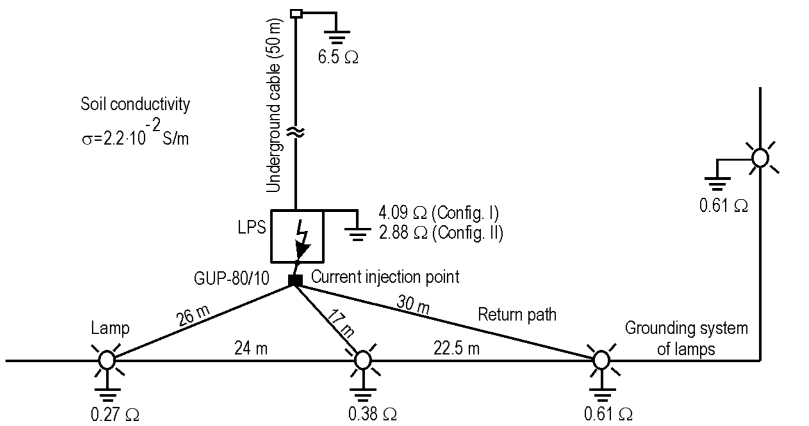
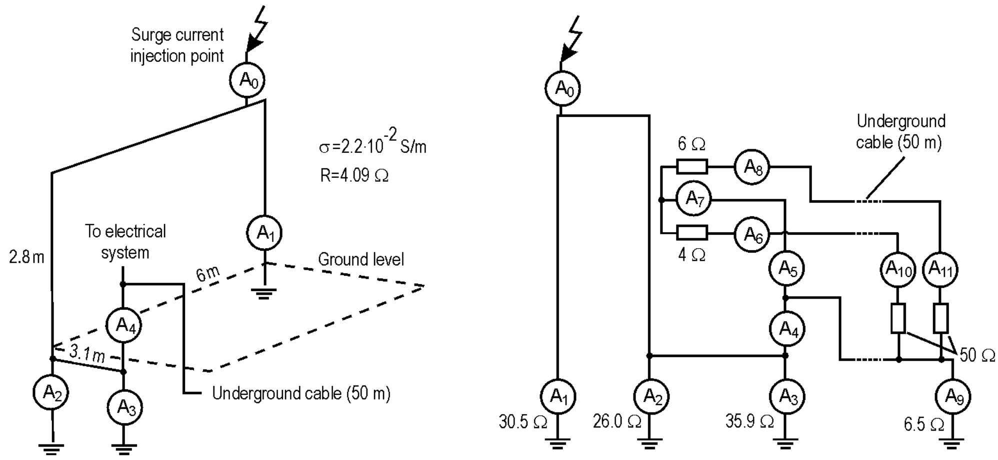
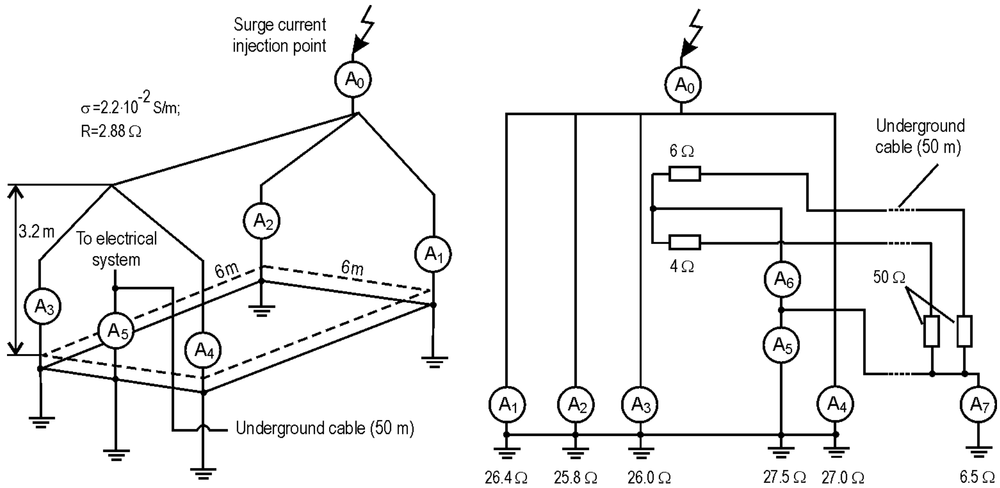


Fig. 2. Diagram of the entire test system which consists of the LPS, the house electrical circuit connected to remote ground via 750-V underground cable, and return path to the surge generator.



(a) (b)

Fig. 3. The first test system (LPS I). (a) diagram with configuration of the LPS I conductors; (b) electrical diagram of the LPS I together with the power feeder grounded 50 m away.



(a) (b)

Fig. 4. The second test system (LPS II). (a) diagram with configuration of the LPS II conductors; (b) electrical diagram of the LPS II together with the power feeder grounded 50 m away.

ground rod. The house electrical circuit was modeled similar as during triggered-lightning testing of the LPS of a residential building at Camp Blanding, Florida [2], that is, resistors 4 and 6 ohms simulated an interior electrical load. Two phase conductors and the grounded neutral were connected to remote ground by a 750-V underground cable 50 m long. On the other end of the cable the phase conductors were terminated in 50-ohm resistors and cable's neutral was grounded using four ground rods interconnected by the loop conductor in order to obtain a low dc resistance of remote ground system.

The more complex LPS II consisted of four LPS ground rods and four down conductors which were connected by a horizontal conductor at height 3.2 m. Similarly as for the LPS I there was installed a power supply system ground rod. These five ground rods were interconnected by a buried loop conductor of a total length of about 24 m. The house electrical circuit was modeled as for the LPS I and connected to remote ground using the same underground power feeder.

3. Results and Discussion

The injected surge current and currents in different parts of the LPS I are shown in Fig. 5. Current measured at point A_4 had practically the same waveshape as the current A_9 which were going to the ground system installed 50 m away. Thus, no insulation breakdown occurred along the 750-V underground cable. The injected current together with the total current going to the ground system of the LPS I represented by the sum of three ground rods currents A_1, A_2, and A_3 are shown in Fig. 5(c). The current A_{123} included less lower-frequency components than the injected current. Therefore, risetime of the current A_{123} was shorter than risetime of the injected current. Also, its half peak width (HPW) was smaller than the HPW of the current A_0. On the other hand, the current entering the neutral of the 750-V cable which was measured at point A_4 included less higher-frequency components than the injected current (see Fig. 5a). It means that higher-frequency current components tend to flow to ground locally, while lower-frequency components travel to remote ground, 50 m away. According to Table I the value of the peak current entering at point A_4 the electrical circuit neutral was about 56% of the injected current peak.

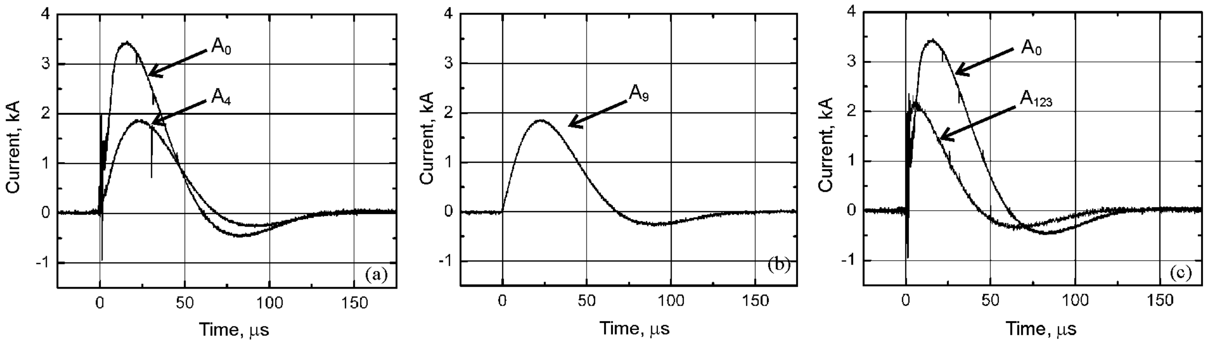


Fig. 5. Current waveshapes in different parts of the LPS I. (a) injected current at point A_0 and current at point A_4; (b) current at point A_9 going to the ground system on the other end of the underground cable (practically the same as A_4); (c) injected current at point A_0 and sum of three ground rods currents A_1, A_2, and A_3.

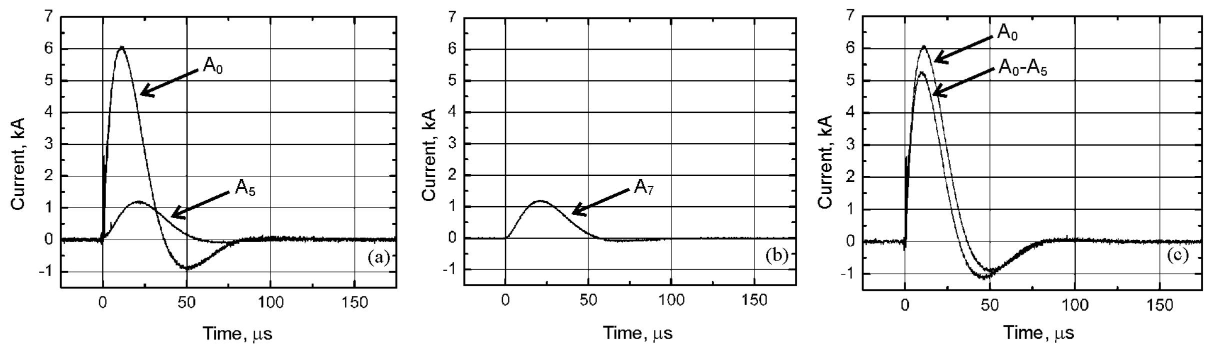


Fig. 6. Current waveshapes in different parts of the LPS II. (a) injected current at point A_0 and current at point A_5; (b) current at point A_7 flowing into the ground system (practically the same as A_5) on the other end of the underground cable; (c) injected current at point A_0 and difference of currents at points A_0 and A_5 (total current going to the ground system of the LPS II).

Table I
Peak value of current going to the electrical circuit and remote ground vs. injected peak current for tests conducted in Summer 2007 at the Rzeszow University of Technology area in Poland.

Tests of Lightning Protection Systems	Injected Surge Current, I_{in}, kA	Current at Points A_4 (LPS I) and A_5 (LPS II) I_{out}, kA	$\frac{I_{out}}{I_{in}}100\%$
LPS I – June, 2007	3.4	1.9	**56**
LPS II – September, 2007	6.0	1.2	**20**

The injected surge current and currents in different parts of the LPS II are shown in Fig. 6. The same as for the LPS I current measured at point A_5 had practically the same waveshape as the current A_7 which were going to the ground system installed 50 m away (Fig. 6a and Fig. 6b). The injected current together with the total current going to the ground system of the LPS II represented by the difference of currents at points A_0 and A_5 are shown in Fig. 6(c). Similarly, the current A_0-A_5 included less lower-frequency components than the injected current but their current waveshapes differed not so significantly as for the LPS I. Note that the dc grounding resistance of the entire LPS II was about 30% less than the dc grounding resistance of the entire LPS I. In case of the LPS II, more significant difference seems to be between the current A_0 and the current A_5 (Fig. 6a). It is worth to note that the IEC current distributions assume that the current waveshapes in all parts of the circuit are the same [4]. According to Table I the value of the peak current entering at point A_5 the electrical circuit neutral was about 20% of the injected current peak.

4. Conclusion

The paper have presented preliminary results of the lightning protective system (LPS) tests of a small residential structure conducted in 2007 at the Rzeszow University of Technology area in Poland using the mobile surge current generator. The primary objective was to examine the current waveshapes in all parts of the circuit and the division of the injected surge current between the grounding system of the LPS and remote ground. In case of the first tested configuration (LPS I) with dc grounding resistance of the entire system 4.09 Ω, the value of the peak current entering the electrical circuit neutral was about 56% of the injected surge current peak, while in case of the second configuration (LPS II) with dc grounding resistance of the entire system 2.88 Ω it was about 20%. The current waveshapes in the ground rods differed from the injected current waveshapes and the current waveshapes in other parts of the test system for both configurations. Comparison of results obtained during the tests in Rzeszow and at Camp Blanding is planned in the near future.

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6. References

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