TRANSIENT STEP AND TOUCH VOLTAGES DISTRIBUTIONS DURING LIGHTNING STROKE TO STRUCTURE PROTECTION SYSTEM

A.W. Sowa, J. Wiater
Electrical Department, Technical University of Białystok
ul. Wiejska 45d, Białystok, Poland
E-mail: andrzejsowa@ochrona.net.pl, jaroslawwiater@vela.pb.bialystok.pl

Abstract: The purpose of this paper is to provide knowledge about the step and touch voltage distributions around building with lightning protective system LPS during direct lightning stroke in it. These distributions were computed based on field theory approach.

I. INTRODUCTION

Lightning stroke to LPS can cause damage to electric and electronic equipment and can be dangerous for the people inside and outside this building. Transient step and touch voltages can arise on the ground surface due to surge current injected into the soil by the earth electrode.
Still, not much information concerning the life hazard caused by transient electric stress on human being is provide. Taking this fact into account, paper presents the results of numerical simulations of touch and step voltages distributions around the building in the case of direct lightning stroke to LPS. The mathematical model includes the wires of LPS, earthing network as well as simplified model of human body [1].

II. MODEL OF LPS

The calculations were made for the simple external LPS, which protect the building with the following dimensions 38m x 12,5m and height 28m. The basic parts of the LPS were horizontal conductors, ten down conductors and ring earth electrode 1m from the structure completely embedded into the soil at 0,5m depth (Fig. 1.). Where large numbers of people frequently assemble in the areas near the structures further potential control should be provided by additional ring earth electrodes. These electrodes were installed 4m, 7m and 10m from the structure at depths 1,5m, 2,5m and 3,5m adequately (Fig.1-ring 1, 2 and 3). General geometric configuration of LPS and earthing system is shown in Fig.2.

III. NUMERICAL SIMULATIONS

A direct lightning stroke is simulated by an ideal current source presented by the following equation:

$$i(t) = \frac{I}{\eta}\left(e^{-\alpha t} - e^{-\beta t}\right)$$

where:

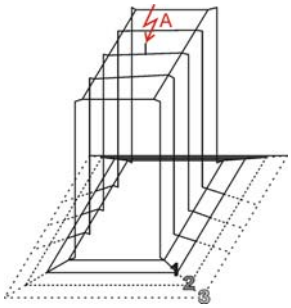

Fig.1. Different grounding system configurations.

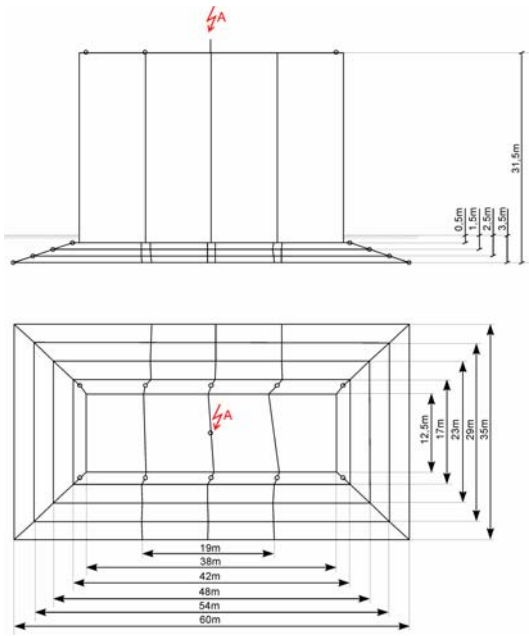

Fig. 2. Geometrical configuration of LPS

t - time, α= 2049,38 s^{-}, β=563 768,3 s^{-1}, I=100kA, η=0,976.

According to the IEC 61312-1 [3], such a waveform is characterized by the peak value 100kA, front time 10μs and time to half value 350μs and simulated the surge current of the first lightning stroke in the channel. In investigations this surge current was injected to the different points of LPS.
Numerical simulations were performed by MultiFields [2] software package, which is a part of CDEGS package. The computation methodology assumes frequency decomposition of the time domain current

surge, frequency domain computations for a single harmonic unit current and superposition of the frequency domain computations modulated by the amplitude of the lightning current.

The investigated structure is represented as an appropriate network of conductors partitioned in short segments. The lengths of the segments were chosen so that the current can be assumed to vary linearly along them for all the analyzed frequencies. Thus, the segments can be represented as electric dipoles and all the electromagnetic quantities at any observation point can be expressed as a sum of contributions from all the dipoles.

The calculation allows an evaluation of magnitude of crest value of step and touch voltages and the graphical distribution of it during lightning strike. Some examples were presented in Fig. 3 and 4.

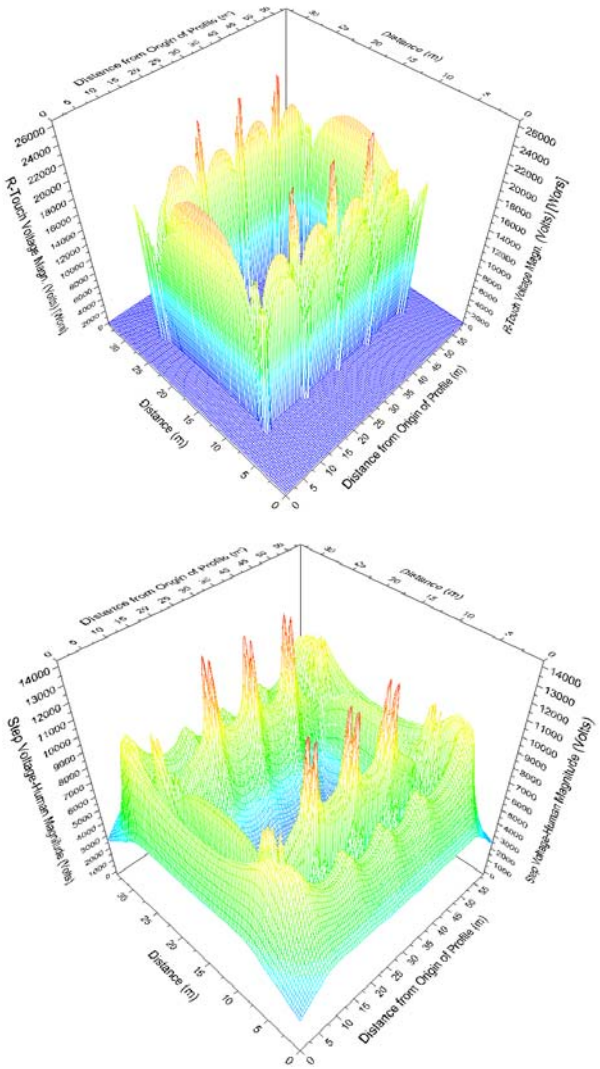

Fig.3. Touch (a) and step voltage (b) distribution near the high-rise – for one ring earth electrode

III. CONCLUSION

This is relevant information for selecting the grounding system for this kind of objects. Step voltage

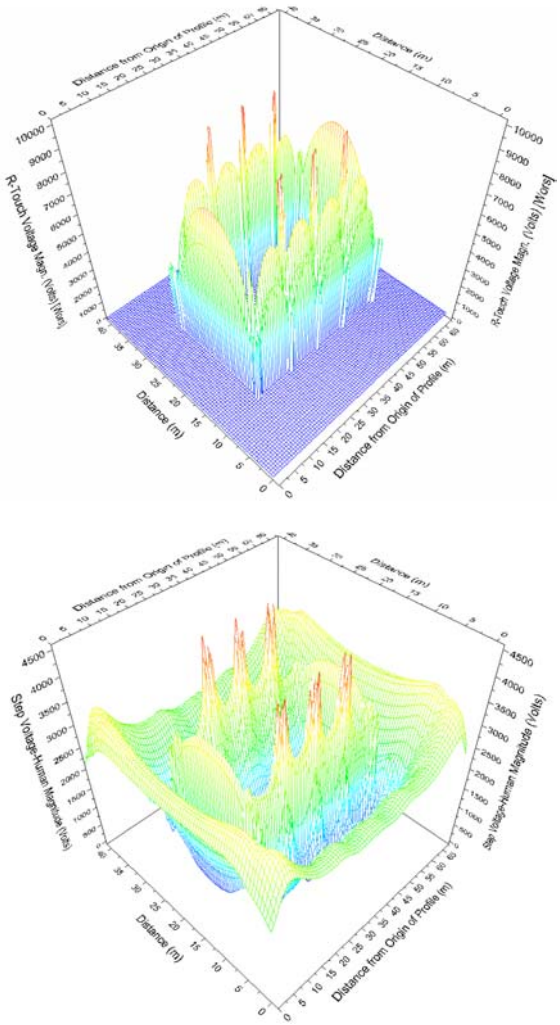

Fig. 4. Touch and step voltage distribution near the high-rise – for the four ring earth electrodes

near the high-rise front wall reaches 14kV for the first configuration. For the second one reaches 10kV. Touch voltage is also very high. It reaches 26kV for first one configuration and 4,5kV for the second one. This situation can be very dangerous. Presented method can be implemented to any other grounding systems.

REFERENCES

[1] G. Ala, M.L. Di Silvestre "A Simulation Model for Electromagnetic Transients in Lightning Protection Systems", *IEEE Transactions on Electromagnetic Compatibility, vol. 44, no. 4, November 2002.*

[2] *"GDEGS Current Distribution, Electromagnetic Interference, Grounding and Soil Structure Analysis"* Safe Engineering Services & Technologies Ltd., Montreal Canada.

[3] IEC 61312-1:1995 International Standard, Protection against lightning electromagnetic