# LIGHTNING DANGEROUS DURING A DIRECT STROKE TO LPS OF TYPICAL BUILDING

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

## 1. 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 there isn't much information concerning the life hazard caused by transient electric stress on human being is providing. 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].

## 2. NUMERICAL SIMULATIONS

The calculations were made for the simple external LPS, which protect the building with the following dimensions 40m x 15m 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 and 2.).

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

$$i(t) = \frac{I}{\eta}\left(e^{-\alpha t} - e^{-\beta t}\right) \qquad (1)$$

where: *t - time,* $\alpha$*= 2049,38* $s^{-1}$*,* $\beta$*=563 768,3* $s^{-1}$*, I=100kA,* $\eta$*=0,976.*

According to the standard IEC 61312-1 [3], such a waveform is characterized by the peak value 100 kA, front time 10 μs and time to half value 350 μs 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.

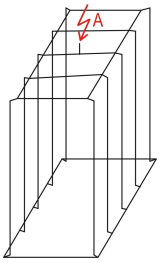


**Fig.1.** LPS of building with one ring earth electrode

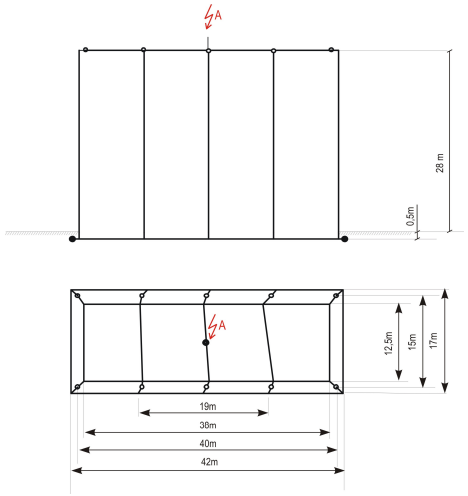


**Fig. 2.** Geometrical configuration of LPS

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 calculation allows an evaluation of the crest values of step and touch voltages and the graphical distribution of it during lightning stroke to LPS. Some examples for the LPS with one ring electrode were presented in Fig. 3.

*a)*

*b)*

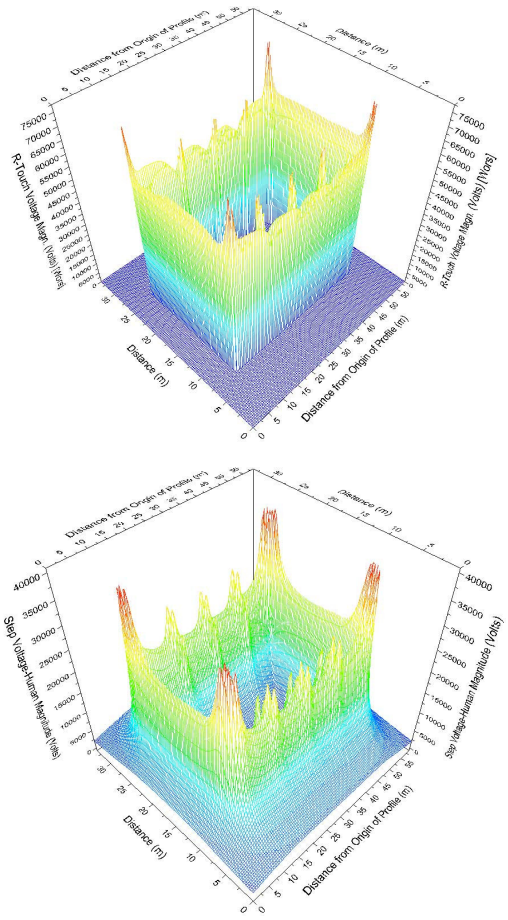


**Fig.3.** Touch (a) and step voltage (b) distribution near the high-rise – for one ring earth electrode

Where large numbers of people frequently assemble in the areas nearby the structures further additional ring earth electrodes should provide potential control.

These electrodes were installed 4m, 7m and 10m from the structure at depths 1,5m, 2,5m and 3,5m adequately.

General geometric configuration of LPS and earthing system is shown in Fig. 4.

The values distributions of step and touch voltages around the building with additional ring earth electrodes during lightning stroke to LPS are presented in Fig. 5 and 6.

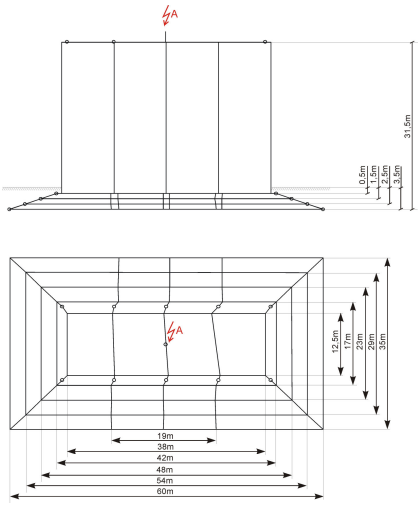


**Fig. 4.** Geometrical configuration of LPS

The maximal values of touch and step voltages for different grounding system of building are presented in Tab. 1.

Table 1. The maximal values of touch and step voltages

| Grounding system | Max. touch voltage | Max. step voltage |
|---|---|---|
| 1 ring | 76982 | 39665 |
| 2 rings | 26461 | 13982 |
| 3 rings | 14918 | 6932 |
| 4 rings | 9827 | 4555 |

## 3. CONCLUSION

Calculation showed, that that the values of step and touch voltages is strongly dependant on the grounding systems of LPS. Using additional rings it is possible several times reduced (8 - 9 times in most complex grounding system for 4 rings) these voltages.

Modelling of objects creates possibility for selection of the grounding system for different kind of objects.


### *Acknowledgment*

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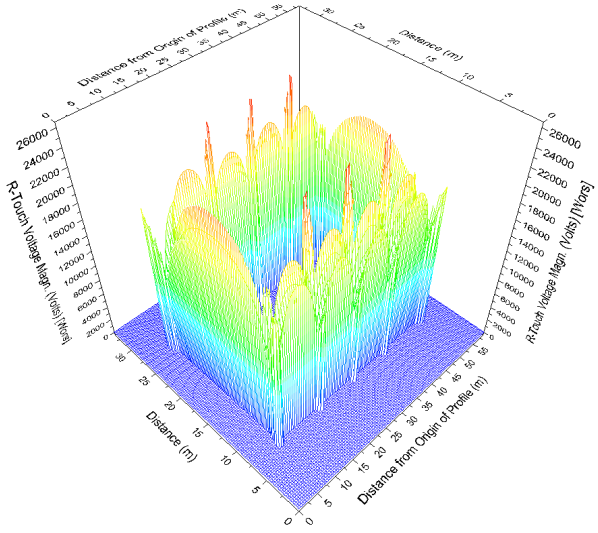
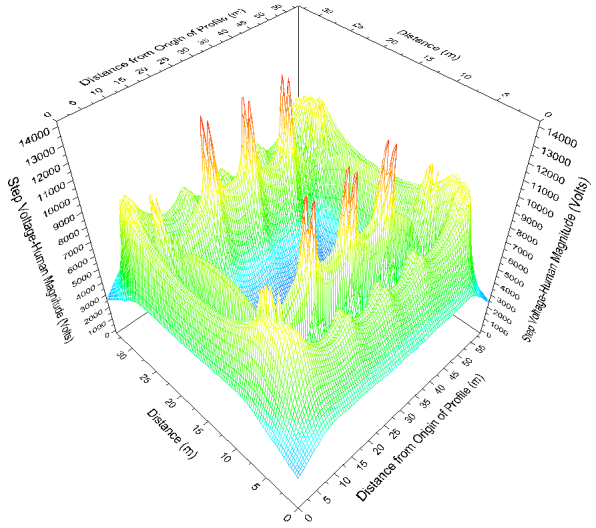
## 4. REFERENCES

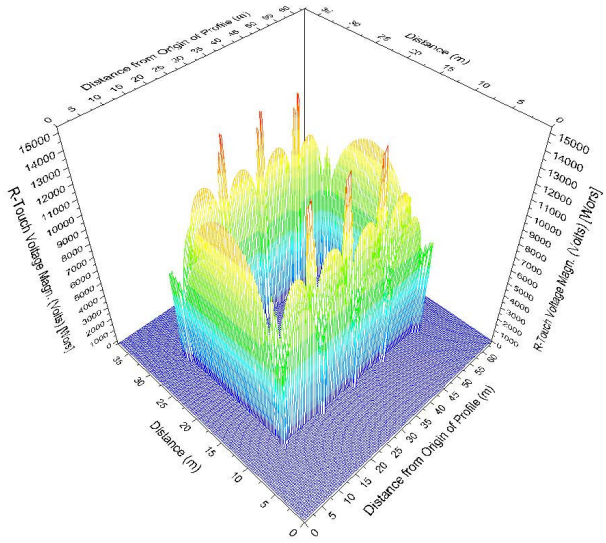

1. G. Ala, M.L. Di Silvestre “A Simulation Model for Electromagnetic Transients in Lightning Protection Systems”, IEEE Transactions on Electromagnetic Compatibility, vol. 44, no. 4, November 2002.
2. “GDEGS Current Distribution, Electromagnetic Interference, Grounding and Soil Structure Analysis” Safe Engineering Services & Technologies Ltd., Montreal Canada.
3. IEC 61312-1:1995 International Standard, Protection against lightning electromagnetic LPS with 2 ring earth electrodes



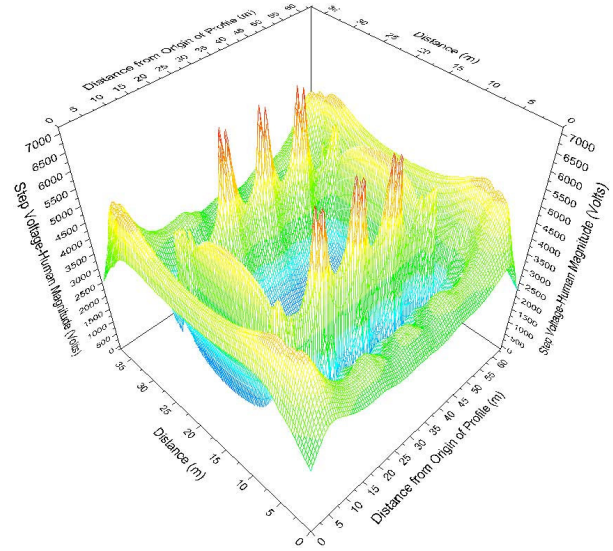

LPS with 3 ring earth electrodes




LPS with 3 ring earth electrodes




LPS with 4 ring earth electrodes




LPS with 4 ring earth electrodes

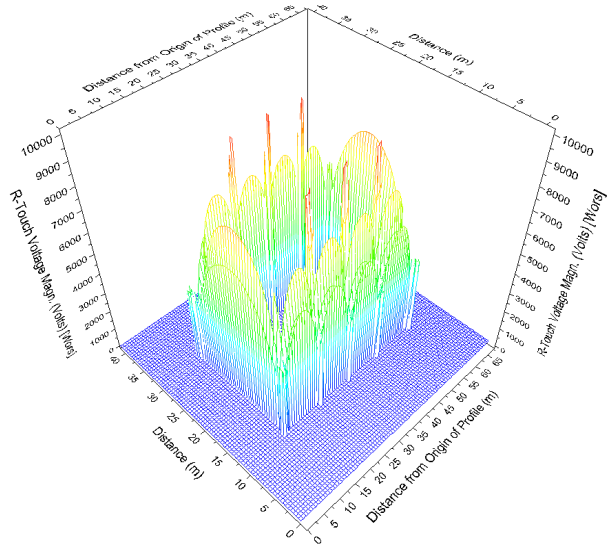



**Fig. 5.** Touch voltage distributions near building
LPS with 2 ring earth electrodes

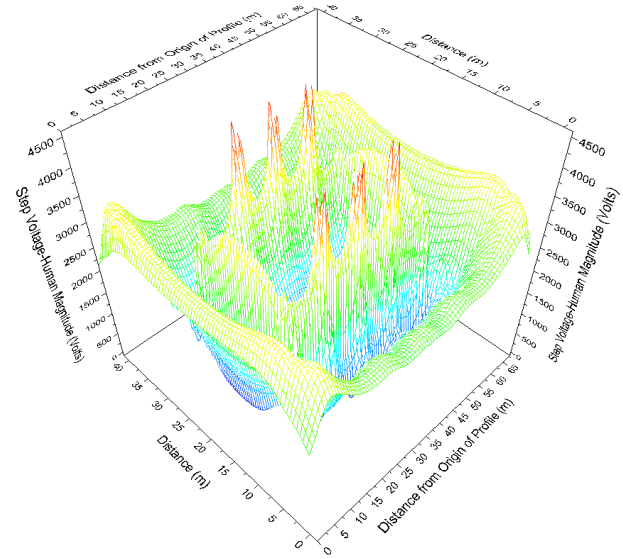



**Fig. 6.** Step voltage distributions near building