Effect of Corona on Lightning-Induced Voltages

Tran Huu Thang
Tsuruoka National College of Technology
Department of Electrical and Electronic Engineering
Yamagata 997-8511, Japan
thangth@tsuruoka-nct.ac.jp

Yoshihiro Baba Naoto Nagaoka Akihiro Ametani
Doshisha University
Department of Electrical Engineering
Kyoto 610-0321, Japan
ybaba/nnagaoka/aametani@mail.doshisha.ac.jp

Naoki Itamoto
Hokuriku Electric Power Company
Institute of Research and Development
Toyama 930-8686, Japan
n.itamoto@rikuden.co.jp

Vladimir A. Rakov
University of Florida
Department of Electrical and Computer Engineering
Gainesville, FL 32611, USA
rakov@ece.ufl.edu

***Abstract*— A simplified model of corona discharge for the finite-difference time-domain (FDTD) computations has been applied to analysis of lightning-induced voltages at different points along a single overhead wire in the presence of corona space charge around the wire. The magnitudes of FDTD-computed lightning-induced voltages in the presence of corona discharge are slightly larger than those computed without considering corona.**

Lightning; corona discharge; finite-difference time-domain method; lightning induced voltage

I. INTRODUCTION

In this paper, we apply a simplified (engineering) model [1, 2] of corona discharge developed for FDTD computations to analyzing lightning-induced voltages on a single wire above ground, which simulates the configurations employed in *Nucci et al.* [3] and *Dragan et al.* [4]. In the corona model, the progression of corona streamers from the wire is represented as the radial expansion of cylindrical weakly-conducting (40 μS/m) region (sheath) around the wire.

II. MODELING

Figs. 1 (a) and (b) show the plan (*xy*-plane) and side (*yz*-plane) views of a 5-mm radius, 1-km long overhead horizontal perfectly conducting wire located 7.5 m above ground. Lightning channel is represented by a 600-m long, vertical phased ideal current source array. Two cases are considered in which lightning is assumed to terminate on ground at points A (midpoint of the wire) and B (close to one of the line terminations). For FDTD computations, this conductor system is accommodated in a working volume of 400 m × 1200 m × 750 m. Cell sides along *x*, *y* and *z* axes are 2.2 cm in the vicinity of the conductors, and increase gradually to 10 and 200 cm beyond that region. Corona discharge is assumed to occur only on the horizontal wire.

III. ANALYSIS AND RESULTS

Figs. 2 (a) and (b) illustrate induced voltages at different points along the overhead wire with and without considering corona on the wire, computed using the FDTD method for a negative lightning return stroke. Fig. 2 (a) is for stroke location A (35-kA current), and Fig. 2 (b) is for stroke location B (55-kA current). It follows from Fig. 2 that the induced voltage magnitudes are larger and the risetimes are longer in the presence of corona discharge on the horizontal wire. This trend agrees with that reported in [3] and [4], although the increase predicted by our full-wave model (up to 5%) is less significant than in their studies based on the circuit-theory approach (up to a factor of 2).

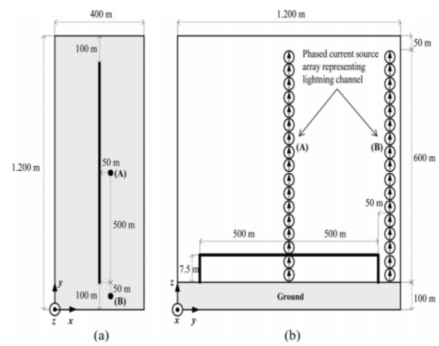

Figure 1. Plan and side views of a 5-mm radius, 1-km long overhead horizontal wire located 7.5-m above the ground.

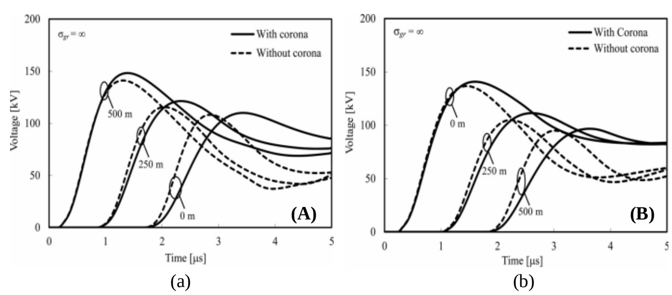

Figure 2. FDTD-computed waveforms of induced voltages at different points along the wire. The computations were performed for perfectly conducting ground with (a) stroke location A (y = 500 m) and (b) stroke location B (near y = 0 m).

REFERENCES

[1] T. H. Thang, Y. Baba, N. Nagaoka, A. Ametani, J. Takami, S. Okabe, and V. A. Rakov, "A simplified model of corona discharge on overhead wire for FDTD computations," IEEE Trans. Electromagnetic Compatibility, vol. 54, no. 3, pp. 585-593, 2012.

[2] T. H. Thang, Y. Baba, N. Nagaoka, A. Ametani, J. Takami, S. Okabe, and V. A. Rakov, "FDTD simulation of lightning surges on overhead wires in the presence of corona discharge," IEEE Trans. Electromagnetic Compatibility, vol. 54, no. 6, pp. 1234-1243, 2012.

[3] C.A. Nucci, S. Guerrieri, M. T. Correia de Barros, and F. Rachidi, "Influence of corona on the voltages induced by nearby lightning on overhead distribution lines", IEEE Trans. Power Delivery, vol. 15, no. 4, pp.1265-1273, 2000.

[4] G. Dragan, G. Florea, C. A. Nucci, and M. Paolone, "On the influence of corona on lightning-induced overvoltages", Paper presented at 30th International Conference on Lightning Protection, Cagliali, Italy, 2010.