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Editorial

Lightning Modeling and Its Effects on Electric Infrastructures

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1. Introduction

Infrastructure security and people's safety are the first objectives when it comes to dealing with high voltages or high currents issues. In this framework, lightning studies play a crucial role because of the dangerous consequences of this kind of phenomenon. It is well known that the normal operation of transmission and distribution systems is greatly affected by lightning, which is one of the major causes of power interruptions: lightning causes flashovers in overhead transmission and distribution lines, resulting in overvoltages on line conductors that are due either to direct strikes or to nearby, indirect strikes.

The contributions to this Special Issue mainly focused on modeling lightning activity, investigating physical causes, and discussing and testing mathematical models for the electromagnetic fields associated with lighting phenomena. In this framework, two main topics have been presented by the authors: (1) the interaction of lightning phenomena with electrical infrastructures such as wind turbines [1] and overhead lines [2–4]; and (2) the computation of lightning electromagnetic fields in the case of particular configuration, as the one presented in [5], considering a negatively charged artificial thunderstorm, in [6], considering a complex terrain with arbitrary topography, and in [7], where the ground is simplified and considered a Perfect Electric Conductor.

2. Interaction of Lightning Phenomena with Electrical Infrastructures

Wind turbines are one of most commonly damaged electrical infrastructures. The probability of being damaged increases with their height, and despite the existing lightning protection systems available for wind turbine blades, there are still many cases reported wherein damage is caused by lightning strikes. In this framework, wind turbine blades represent the most critical element of the structure, and the work proposed in [1] shows an innovative approach based on a hybrid down conductor system, which shows excellent results compared to the traditional one.

On the other hand, when we deal with lightning effects on electrical systems, researchers usually refer to overhead transmission and distribution lines. The literature has developed different numerical codes for evaluating such effects [8,9], but some open questions and unsolved doubts can still be found, especially when we deal with indirect lightning strikes. Within this category, the evaluation of the corona effect on overhead lines and a correct description of soil characteristics represent a crucial issue.

First of all, the corona effect on overhead lines requires a complex description of the relationship between the total charge and the applied voltage due to the presence of minor loops, as proposed and discussed in [4]. Secondly, in order to evaluate how the corona effect changes the number of flashovers in a distribution system, a detailed lightning performance analysis is required, as proposed by the authors of [2].

Secondly, consideration of a detailed representation of the soil and of the grounding system is extremely important as it could enhance the induced voltage. In order to solve this issue, in principle, a Full-Maxwell simulation is required, leading to high computational costs. The authors of [3] addressed this problem by introducing an equivalent circuit which takes into account all the details of the grounding grid and computing the enhancement of lightning-induced voltage compared to the traditional case [10].

3. Electromagnetic Fields Computation and Measurement

The analysis of electromagnetic fields in different configurations in terms of lightning strike and surrounding areas is crucial in order to have a comprehensive view of the phenomena.

In this framework, the analysis of upward streamer is usually neglected in the literature since it does not represent the main part of the flash. However, dealing with it is crucial in order for a monitoring system to be protected. The authors of [5] focused their efforts on replicating a physical simulation representing an upward streamer discharge and testing the spectrum of possible electromagnetic field effects on monitoring systems.

On the other hand, consideration of the principal part of lightning flashes, i.e., the return stroke, is crucial to evaluating the effect on electrical infrastructures. The research has recently divided its efforts in two main categories: (1) reducing the computational effort and (2) considering more detailed geometries for the surrounding area.

In order to reduce the computational effort, the authors of [7] provided a new method which requires a summation of analytical formulae and a simple integral operation, achieving results comparable to the one proposed in [11] and assuming a Perfect Electric Conductor ground.

The complexity of the surrounding area is taken into account by [6] thanks to an innovative open accelerator (OpenACC)-aided graphics processing unit based on the FDTD method and applied to 3D systems, which also helps in the reduction in the computational effort with respect to traditional methods based on CPU-based models.

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