28th International Conference on Lightning Protection

Topic III: Lightning Electromagnetic Impulse (LEMP) and Lightning-Induced Effects Moderator's Report

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I. Introduction

14 papers, coming from several countries, namely Brazil, Italy, Japan, Norway, Poland, Switzerland and Tanzania, which confirm the interest on this subject, cover this session. The papers of this section are grouped in three main categories, the first relevant to LEMP, the second mainly relevant to computational methods and the third to the analysis of the induced effects and protection of electric and electronic systems.

II. LEMP

In paper III-1 "*The Influence of Attachment Point on Lightning Induced Voltage*", Silveira, Visacro and Soares find a significant decrease of induced voltage magnitude with the increase of attachment point height. The finding is obtained by numerical simulations carried out by using a model, developed by the authors' research group, which determines the current distribution along channel, taking into account corona sheath and core losses, and calculates the electromagnetic coupling between return-stroke channel and line conductors.

III. Computational Method

Several different numerical approaches are proposed to be used for the simulation of lightning induced effects in complex systems.

In paper III-2 "*Simulation of Induced Voltages on an Aerial Wire due to a Current through a Buried Bare Wire Using the FDTD Method*", Tatematsu, Noda and Motoyama use the FDTD (Finite Difference Time Domain) method with a non-uniform grid, which numerically solves Maxwell's equations using the difference method, to simulate the voltages induced in a low-voltage control circuit by a lightning current flowing through a buried bare wire such as part of a grounding mesh below the ground surface in a substation. The simulation results are compared with those measured using a test system of a buried wire and a control circuit for validation purpose.

The FDTD approach based on a non-uniform grid is also successfully applied for the analysis of lightning-induced voltages on overhead multi-phase wires above lossy ground, as illustrated in paper III-8 "*FDTD Simulation of Lightning-Induced Voltages on an Overhead Wire Above Lossy Ground*", by Okazawa, Oka, Shimazoe, Baba, Nagaoka and Ametani.

In paper III-3 "*Accuracy and Applications of Time-Domain Numerical Electromagnetic Code to Lightning Surge Analysis*", Pokharel and Ishii apply the thin-wire in time-domain (TWTD) approach to the analysis of lightning surge characteristics of a double circuit transmission tower, and, combined with a switch model, for the analysis of both the lightning surge characteristics of a transmission tower equipped with a surge arrester and the lightning-induced voltages on an overhead line. Some results are also compared with those computed by a Numerical Electromagnetic Code in frequency domain based on the method of moments (NEC-2). The TWTD approach results to be more advantageous than NEC-2 in incorporating nonlinear elements in the system, though it is difficult to analyze a system including finitely conducting ground.

In paper III-4 "*Comparison of different approaches for the evaluation of lightning-induced overvoltages in light-rail DC traction power systems*", by Delfino, Procopio, Rossi, Nucci, Rachidi, Borghetti and Paolone, an ad-hoc full-wave formulation is used to calculate the

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electromagnetic coupling between LEMP and a typical light-rail DC traction overhead power line. The results are also compared with those obtained by a classical field-excited transmission line method and by a general purpose NEC code based on the Method of Moment.

In paper III-9 "*Effectiveness of FFT-IFFT transformation during calculation of the electrical pulse under ground surface*", Bajorek, Gamracki, and Maslowski address a more specific problem. As the LEMP waves transmitted into the ground computed by various codes show the influence of the surge input waveform, they propose a form of system input signal that, used during frequency domain calculation, gives very stable time responses even for low number of data samples and short time-windows.

IV. Induced Effects on Electrical and Electronic Systems

Low voltage (LV) distribution networks are rarely affected by direct lightning, but can be affected both by the overvoltages originated in the feeding medium voltage (MV) lines transferred through the MV/LV transformer and by the induction effects of LEMP. Paper III-5 "*Overvoltages on LV networks associated with direct strokes on the primary line"*, by Obase, Piantini, and Kanashiro and paper III-12 "*Lightning Induced Voltages on LV Distribution Lines*", by Piantini and Neto address both issues. By means of a detailed simulation analysis the papers analyzes the overvoltages, both in terms of magnitude and waveform, and the influence of various parameters, such as the stroke current front time, the grounding resistance and the distance between line and lightning strike point, taking into account the effect of the loads connected to the low-voltage network. Such an analysis is useful for a more effective installation of surge protective devices (SPD).

The same topic is also dealt with in paper III-6 "*Lightning-induced Overvoltages in Rural Isolated Neutral Low-voltage Systems*", where Høidalen summarizes five seasons of measurements of transient overvoltages in a 230 V isolated neutral rural overhead line system in Norway. The shape of the recorded signals (mostly impulses) indicates that lightning is the primary source of the overvoltages. The measurements are compared to data from the national lightning detection system and calculation of lightning induced voltages. However, the Author has found that the correlation between measured overvoltages and individual detected lightning strokes is rather poor.

In paper III-13, "*Estimation of Sparkover Rate of Medium-Voltage Line Due to Lightning-Induced Voltage*", by Hongo, Michishita, and Ishii, the sparkover rate of a medium voltage line associated with indirect hits is investigated based on numerical calculations and statistical analysis by taking account of the correlation between the peak and the rise time of the negative return-stroke current waveform.

Paper III-11, "*A Computational Tool to Study the Induced Voltages on a Rural Line Due to Nearby Lightning*", by Nunes de Souza, Oltremari, Zago and Silva, presents some ATP simulation results obtained by applying the so-called Rusck's Model to represent the coupling between LEMP and overhead power lines.

Paper III-10, "*Factors Influencing Lightning Induced Over-voltage Conducts on Overhead Power Lines: Experience from Tanzania Power Lines Setup*", by Clemence, Manyahi, Damas and Mvungi, deals with the induced voltages on the medium and low voltage lines when direct lightning strike terminate on the topmost conductor.

Paper III-7, "*Analysis of Lightning-induced Surge at Protection Control Device in Substation*", by Tamura and Shibuya, deals with the grounding potential rises when a lightning current flows into the grounding grid in substation. In the case a control cable sheath is connected to the grounding grid, the potential rise induces an abnormal voltage at the protection control device through the control cable. The paper proposes a two-step simulation procedure to evaluate the induced abnormal voltage at the protection control device with the use of the FDTD method and EMTP.

In paper III-14, "*Evaluation of lightning surge current characteristics induced on the aerial subscriber's cable at telecommunications center end in NTT*", Kuramoto, Chikai, Suzuki, and Tada present the measurements of induced lightning surge currents on a metallic aerial cable in subscriber cable at telecommunications center, showing that the induced current was largest in the cable sheath and that it flowed out into the subscriber lines through the surge protector. Installing surge protectors in the splicing closure on each subscriber's cable is presented as an effective countermeasure against the current flowing into the telecommunications equipment.