28th International Conference on Lightning Protection

Topic VI: Lightning Protection of Power Systems

VI-A: Lightning Performance of Distribution Lines

Moderator's Report

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I. Introduction

A total of 15 papers have been accepted for presentation at Session VI-A, which is devoted to the Lightning Performance of Distribution Lines. The authors represent 7 countries (Canada, Greece, Indonesia, Italy, Japan, Switzerland and Ukraine).

The papers deal predominantly with lightning surge characteristics (VI-1, VI-7, VI-23, VI-27, VI-28, VI-29) and lightning performance of distribution lines (VI-2, VI-3, VI-5, VI-22, VI-24, VI-25, VI-26). Two of them address transformer and reinforced concrete pole modelling (VI-4, VI-6). It is interesting to note that most of the papers involve either laboratory or field experiments.

II. Overview of the Papers Selected for Session VI-A

The session is divided into one oral and one poster session, to which 7 and 8 papers have been assigned, respectively.

A. Papers selected for Oral Presentation:

VI-1 "*Fundamental surge propagation characteristics of overhead distribution line*", S. Matsuura, T. Noda, A. Asakawa, S. Yokoyama (*Japan*)

The paper reports the results of an experimental investigation upon the basic characteristics of the surges associated with direct strokes to overhead distribution lines. A reduced scale model was used and tests were conducted by the authors on lines either with or without shield wires, considering 'stroke' currents with different front times and various values for the pole grounding resistance. The paper describes the experimental setup, provides a nice discussion about the variation of the pole surge impedance and of the pole top and insulator voltages for different test configurations, and compares the results obtained for lines with and without shield wires.

VI-2 " *Analysis of lightning phenomena observed in distribution lines*", T. Hirai, S. Okabe, T. Miyazaki, K. Aiba (*Japan*)

The paper describes the results of an analysis of the lightning performance of distribution lines carried out by the authors by using still cameras and voltage and current monitoring sensors. The study was carried out over a period of five years, in which 204 lightning strokes occurred in the observation area, 45 of which struck the lines directly. As the observed frequency of line faults due to direct lightning strokes was only 52 %, discussion is provided based on correlations between the time of lightning occurrences and the corresponding recorded surge waveforms. A deeper analysis of the obtained results requires a description of the line configurations in the monitored area.

VI-3 "*Insulation coordination of MV cables against lightning-induced overvoltages generated by LEMP-coupled overhead lines*", A. Borghetti, M. Marzinotto, C. Mazzetti, C. A. Nucci, M. Paolone (*Italy*)

An original method is proposed for the evaluation of the stresses of cable insulations due to lightning induced overvoltages for the case of MV distribution networks composed of overhead lines and buried cables. The estimation refers to the conditional probability of cable

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breakdown in absence of line flashovers. The procedure is well described and is based upon the use of the LIOV code for the calculation of the lightning induced voltages on the overhead line, being the lightning events generated by the application of the Monte Carlo method. The paper describes the experimental tests carried out to infer the breakdown behaviour of extruded cable insulation and the method used to attribute a breakdown probability to each simulated overvoltage on the basis of the test results. The risk of cable failure is assessed for different cable lengths and soil resistivities. The analysis of the obtained results is adequate and future developments on the proposed procedure are indicated.

VI-4 "*Improvements to a pole-mounted distribution transformer model for electromagnetic transient studies and validation by field tests*", H. Honda, T. Noda, A. Asakawa, T. Shindo, S. Yokoyama (*Japan*)

The paper presents a distribution transformer model for electromagnetic transient calculations. The proposed model represents an improvement with respect to a previous circuit developed by the authors, as it takes into account the skin effect of the secondary winding. The values of the model parameters are indicated in the paper. Both laboratory and field tests were conducted and comparisons between measured and calculated voltages transferred from the primary to the secondary transformer side are presented. The model is shown to provide accurate results for all the presented cases and the results demonstrate its usefulness for the computation of transferred voltages in realistic situations.

VI-5 "*Estimation of lightning-caused stresses in a MV distribution line using a three-wire approach*", V. Shostak, W. Janischewskyj, F. Rachidi, A. M. Hussein, J. S. Chang, D. Pavanello, E. Petrache (*Ukraine, Canada, Switzerland*)

An approach is presented for the assessment of the characteristics of lightning surges caused by direct strikes to a top wire of a three-wire MV distribution line that arrive at the end or at the intermediate points of the line. The attenuation of the surges due to finite ground conductivity and corona effects is taken into account. The results are expressed in terms of curves that allow the estimation, at a specific point of the line, of the minimum period of occurrence of a surge with magnitude and front steepness greater than specified values. In comparison with a single-wire line, a three-wire one is much more stressed for periods of observation shorter than about 1000 years. The authors are invited to clarify some modelling options such as the voltage attenuation due to the finite ground conductivity and the statistical distribution of the lightning current front steepness.

VI-6 "*Verification of a composite model of a reinforced concrete pole and a grounding electrode*", T. Miyazaki, S. Okabe, K. Mori, K. Aiba, T. Hirai, J. Yoshinaga, S. Sekioka (*Japan*)

The authors present a composite model for the representation of a reinforced concrete pole and grounding system (down conductor and grounding electrode) for lightning transients calculations. The model is based on test results and takes into account the soil ionization and the mutual coupling between the pole and the grounding system, as well as the sparkover voltage between the pole and the down conductor. Comparisons are drawn between measured and calculated voltage and current waveforms, under different test conditions, and the proposed method reproduces well the experimental results.

VI-7 "*Experimental study on customer indoor overvoltage due to lightning strike on the joint pole of power line and telecommunication line*", M. Ikuta, A. Asakawa, S. Yokoyama, M. Soeda (*Japan*)

The paper reports an experimental study about the division of the stroke current among different paths in the case of a lightning strike to a pole on which the power distribution and the telecommunication lines are jointly mounted. By means of an impulse generator, currents of about 13 kA were injected on the test circuit and voltages and currents were measured at different points. Different test configurations were considered concerning the power drop and the telecommunication drop wires, as well as for the installation conditions regarding the surge protective device and the bonding wire on a customer´s premises.

B. Papers selected for Poster Presentation:

VI-22 "*Effect of overhead ground wire positioning under MV lines against surge arrester failures*", H. Sugimoto, H. Sugimoto, Y. Asaoka (*Japan*)

In order to reduce the number of surge arrester failures associated with direct lightning strokes to MV distribution lines, the authors suggest the installation of overhead ground wires under the phase conductors. The effectiveness of the proposal is analysed from computer simulations run with the EMTP program for the case of lightning strokes both to the top of a pole and to an outer phase conductor. Comparisons are made of the probability of arrester failures considering different heights of the ground wire. The authors are encouraged to include in their poster a discussion about the influence, on the obtained results, of the values of the grounding resistance and stroke current front time, which were kept constant in the simulations.

VI-23 "*Statistical data of lightning surges in real distribution lines*", T. Miyazaki, S. Okabe, K. Aiba, T. Hirai (*Japan*)

The paper reports the results of an investigation of the lightning surge magnitudes expected on distribution lines and of the amount of stroke current diverted into reinforced concrete poles in case of direct strikes. By analysing lightning data obtained from still cameras and measuring sensors over a period of five years, the authors present statistical data of voltage and current surges caused by both direct and indirect strokes. Cumulative frequency distribution curves of the peak values of insulator voltages

and of the peak values of currents through ZnO surge arresters are presented. Statistical data of the division of the surge current due to sparkover between the down conductor and concrete pole reinforcements is also discussed.

VI-24 "*Lightning performance on distribution lines: after improvement field observation*", R. Zoro, R. Mefiardhi, S. Hidayat, R. Mardiana (*Indonesia*)

The paper compares the lightning performances of two 20 kV overhead distribution lines prior to and after the installation of overhead ground wires and surge arresters in about 17 % of their lengths. The lines are located in areas characterised by high ground flash densities and a reduction of over 40 % was observed in the number of outages. From calculations the authors conclude that indirect strokes are the main cause of the outages, their associated flashover rate being more than ten times greater than that due to direct strokes. The system used for lightning observations is also described. The authors are encouraged to present in their poster the basis of the method used for the calculations.

VI-25 "*Case study on lightning protection effects of power distribution lines with overhead ground wires*", R. Chiba, A. Asakawa, S. Yokoyama (*Japan*)

The paper addresses the issue of the effect of the messenger wires on the reduction of the number of line outages due to direct strokes to distribution lines. From computer simulations, the lightning performances of a line with different protection arrangements are compared. The results show that the combination of overhead ground wires and messenger wires may lead to a significant decrease of the line flashover rate. A description of the method used for calculation of the line performance is required.

VI-26 "*Post mounted distribution transformer failures due to lightning correlating to the grounding resistance*", D. P. Agoris, E. C. Pyrgioti, S. Dragoumis (*Greece*)

The paper discusses the correlation between grounding resistance values and lightning-caused distribution transformer failures in the Greek island of Lefkas.
Grounding resistance measurements were done at all the 241 pole mounted transformers and for the analysis the island was divided into five parts. The study was carried out over a period of ten years and the authors found a high correlation between those two variables, showing clearly that the areas associated with large transformer failure rates are those with great values of grounding resistance.

VI-27 "*Lightning surge propagation across electric power and communication system in residence*", Y. Nagai, K. Kitamura, H. Fukuzono (*Japan*)

The paper reports an experimental study of the propagation of lightning surges to a house in the case of nearby strokes either to a close concrete pole or to the ground. The test set up comprised an impulse current generator, a model house, a power line, a distribution transformer and a telecommunication line, and currents were measured at various points of the circuit. Different test configurations were considered in the experiments, including the presence of surge protective devices in the installation.

VI-28 "*Experimental study of the relation between the earth system at the pole installed transformer and lightning overvoltages on distribution lines*", A. Asakawa, R. Chiba, S. Yokoyama (*Japan*)

The authors present the results of a comparative study of the influences of two earth methods of distribution transformers on the lightning overvoltages on the primary and secondary sides. The investigation was carried out experimentally considering either common or separate earths for the transformer and surge arresters. Analysis of the measured voltages and currents shows clearly an advantage of the common earth over the separate earth system.

VI-29 "*The testing for verification of lightning protection system on iDC*", A. Higano, E. Sudou, D. Imaoka, T. Kurama, K. Seki, T. Hashimoto (*Japan*)

The paper reports experiments conducted to test the effectiveness of low-voltage lightning protection systems under various conditions. The behaviour of the transient voltages appearing at the end of a low-voltage circuit was investigated for different types of surge protection device, cable lengths and distances between conductors. The authors are invited to present in their poster the SPD V-I characteristic and the waveform of the impulse current injected into the test circuit.