

Sessions 6a, 6b, 6c, 6p

Lightning Protection of Power Systems

Moderator's report

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INTRODUCTION

Three oral presentation sessions and one poster session are devoted to the Lightning Protection of Power Systems. A total of 24 papers were selected for presentation at these sessions.

The authors represent 16 countries with a significant number of contributions from Brazil, followed by Japan.

The papers have been organized per subject, as shown in Table I. Under the title Lightning Protection are the papers addressing more specifically protection methods and devices.

Table I also shows how papers will be presented: Oral Presentation or Poster Presentation. Distribution of papers accepted for Oral presentation among sessions 6a, 6b and 6c is shown in Table II.

Table I – Papers per Subject

	Lightning Performance	Lightning Protection	Miscellaneous
ORAL	6_22 6_136 6_65 6_182 6_70 6_201 6_250	6_1 6_101 6_160 6_188	6_131
POSTER	6_38 6_52 6_40 6_145 6_209	6_124 6_176 6_185 6_214	6_72 6_88 6_237

Table II – Papers per Oral Session

	Session 6a	Session 6b	Session 6c
ORAL	6_1 6_101 6_160 6_188	6_22 6_70 6_136 6_182	6_201 6_250 6_65 6_131

LIGHTNING PROTECTION

The papers included in this subject address lightning interception, as well as overvoltage protection. Four papers have been selected for **Oral Presentation**:

6-1 Lightning Protection of Overhead 35 kV Lines by Antenna-module long Flashover Arresters
G. V. Pdporkin, N. G. Lozinova, A. D. Sivaev

The authors suggest a new type of arrester for lightning interception, to be used on the protection of medium voltage overhead lines. The aim of the paper is the description of experimental tests performed to determine the effectiveness of the suggested long flashover arrester using antenna modules. The paper contains results which are expected to motivate technical discussions, and therefore is selected for oral presentation. Concerning the described experimental tests, it is not clear why the authors have used 250/2500 μ s and 500/2500 μ s pulses for testing the effectiveness of the arresters against simulated lightning discharges.

6-101 Effect of Multiple Lightning Impulse Currents on Zinc Oxide Arrester Blocks
Bok-Hee Lee, Sung-Man Kang, Ju-Hong Eom

The paper describes the effect of multiple lightning pulses on the performance and failure of Zinc Oxide arresters by means of experimental tests. These tests are well described in the paper, as well as the assessment of the different causes for arrester failure.

6-160 Lightning Current Evaluation for Arrester Application in Buildings with Medium Voltage Supply
R. Brocke, M. Kompacher, S. Pack, P. Zahlmann

The paper reports simulation results referring to the direct-lightning response of power systems networks installed in buildings with internal medium voltage supply. The main assumptions adopted by the authors for the modelization of the various system components are clearly described and accompanied by relevant references. The simulation analysis performed by the authors for the assessment of the considered power network is properly described and the

results suitably discussed. A complete discussion of the obtained results requires a more comprehensive discussion regarding the energy stresses of the different surge arresters installed in the considered network.

6-188 Line Surge Arrester Application Pilot Project
M. Puharic, M. Lovric, J. Radovanovic, Z. Cosic, S. Sadovic

The paper describes a pilot project of line surge arresters installation on a 123 kV overhead line. Computer simulation is used for predicting and comparing the lightning performance of the line, considering different protection arrangements. Installation of gaped as well as gapless surge arresters is considered. The authors are invited to highlight their conclusions on the comparison of results obtained for the two different technologies.

In addition, on the subject of Lightning Protection, four papers have been selected for **Poster Presentation**:

6-124 Evaluation of Fuses for Protection of Lightning Current Arresters Close to Transformers of High Rated Power

Michael Benzin, Jan Meppelink, Jürgen Trinkwald

The paper reports experimental and simulation tests for the assessment of the design of fuses installed with class I arresters for lightning protection of distribution networks. There is a lack of information regarding the description and explanation of the high frequency modeling of some power system components.

6-176 Optimization of the High Voltage Substation Direct Stroke Protection System

Y. A. Wahab, Z. Z. Abidin, S. Sadovic

A three dimensional electro-geometric model is used for the design of lightning interception rods at substations. The adequacy of some simulation options, such as the use of the corona related design current, are not clear in the paper. Also not clear is the advantage of using a Monte Carlo simulation in their software.

6-185 Development of 220 kV Tubular Lightning Protection Devices

Yasunari Morooka, Fumihiro Kinoshita, Horitaka Soi, Kiyonori Watanabe

The Paper reports experimental tests aimed at the development of tubular protection devices for the lightning protection of distribution power networks. In order to provide a complete understanding of the behavior of this new non-linear protection device, the authors are encouraged to include in their poster a more comprehensive discussion of the V-I characteristic for different pulse conditions.

6-214 High Performance Triggered Lightning Current Arresters

M. Wetter, J. Schimanski, K. Scheibe

The paper describes the development of triggered lightning arresters, including few tests for their characterization. The synthesized and schematic description of the basic operation principles should be enriched by discussion, in particular of the experimental results.

LIGHTNING PERFORMANCE

In general, papers included in this subject address models and methods for the computation of lightning transients in power systems, aiming at predicting lightning performance of power systems. In particular, they address transmission lines, distribution lines, and equipment in substations. Seven papers have been selected for **Oral Presentation**:

6-22 A Methodology to the Calculation of Lightning Performance of Conventional and Non-Conventional Transmission Lines

João Clavio Salari Filho and Carlos Portela

The authors developed a sophisticated method for evaluating lightning performance. They point out that the presented methodology takes into account the most relevant aspects related to lightning effects on transmission lines, with some approximations, reasonably accurate for most applications. The authors are invited to enlighten these approximations, and discuss the error margin resulting from such approximations, as well as identifying the aspects and conditions that they consider as requiring a more detailed representation.

6-65 Non-Conventional Measures for Improvement of Lightning Performance of Transmission Lines

S. Visacro, A. Soares Jr, Renato Oliveira, Marcelo Filipe, Adelino Silva, Maria Helena M. Vale

The authors report the actual improvement on the lightning performance of a 230 kV obtained after taking non-conventional measures, which were decided based on exhaustive evaluation of different alternative practices. For this evaluation, the so-called Hybrid Electromagnetic Model is used. The non-conventional practices act on the values of parameters affecting transmission line lightning performance, going beyond reducing the tower footing resistance. In the actual line, installation of additional wires below the phase conductors is considered to reduce by 30% the overvoltages across insulator strings. A summarized comparison of the evaluated benefits of each alternative measure is welcome.

6-70 A Methodology Based on Severity Indexes to Determine Critical Spots along Transmission Lines Concerning Lightning Performance

S. Visacro, Roseline N. Dias, Cláudia R. Mesquita, Maria Helena M. Vale

The work reported in the paper is devoted to identifying critical spots along transmission lines, as regards lightning

performance. The developed methodology combines Lightning Location System indications with the relevant transmission line parameters. Combination of these data is used to evaluate a Severity Index associated with each transmission line tower. Discussion of the accuracy allowed by LLS on discriminating micro regions lightning incidence is welcome.

6-136 Lightning Surge Response of Actual 500 kV Transmission Tower with Ground Wires

Yasuhide Kinoshita, Katsumasa Nonaka, Hideki Motoyama

The paper reports experimental work carried out for measuring tower surge response of an actual 500 kV transmission tower with shield wires. According to the authors it shows the effect of the configuration of the lead wire used for measurement. Interpretation of the experimental results suggests that the tower surge impedance is affected by lightning path. The meaning and practical consequences of this conclusion may be interesting for oral discussion.

6-182 Response of Pole-Type Transformers to Lightning Overvoltages on Distribution Line

Koji Michishita, Yasuji Hongo

The paper addresses the response of transformers to impulse voltage. The equivalent circuits developed by the authors for different rated voltage transformers allow interpretation of their different responses to impulse voltage waveform. The validity of the developed circuits is demonstrated by comparison with experimental results. The authors are invited to discuss the differences between their model and other well accepted models published in the international literature.

6-201 Lightning Performance of Overhead Distribution Lines Considering Effect of Nearby Trees

S. Yokoyama, A. Tan, Y. Morooka, Y. Hashimoto, M. Sakae, K. Ikesue, K. Sawabe

According to the authors, experimental results presented in the paper show that the existence of nearby trees does not always imply a better lightning performance of power overhead lines. Experimental research on lightning stroke attachment to power lines considering nearby trees is presented, as well as a calculation program for predicting lightning performance of distribution lines, which takes into account the studied effect. The authors are invited to provide additional details on their experimental conditions, during the presentation of the paper.

6-250 Estimation of Lightning-caused Stresses in a MV Distribution Line

V. Shostak, W. Janischewskyj, F. Rachidi, A. M. Hussein, J. L. Bermudez, J. S. Chang S. Sokolovsky

The paper presents an approach for the estimation of overvoltages in MV overhead lines (without shield wires), due to both direct and nearby lightning. The developed

method is used to obtain statistical distributions of voltage surge amplitude and steepness at the line terminating substation. The authors are commended for the overview of relevant work by other authors, expressed by the list of references used in their work.

In addition, on the subject of Lightning Performance, five papers have been selected for **Poster Presentation**:

6-38 Lightning Protection Problems for 110 and 220 kV Overhead Lines in Areas with Permafrost Low-conductivity Soils and Methods for solving them

A. S. Gayvoronsky, Y. R. Gunger, A. V. Klepikov, E. N. Prokofyeva

Research on evaluating lightning performance of twin-circuit 110 and 220 kV lines is presented, as well as discussion on different measures for improving the actual situation. The influence of critical transmission line design parameters is discussed.

6-40 Lightning transients in control circuit wiring in HV substations

Andrzej W. Sowa, Jaroslaw Wiater

The paper reports and discusses the simulation results concerning lightning induced voltages in the measuring and control circuits of an HV substation. Computation is made by means of commercial software; only few details concerning modeling options are provided. In particular, it is not clear how the injection in the system of a high impulsive current is treated as a source of electromagnetic field and if it is considered in the calculation of the source terms. The geometry of the simulated system needs some more detailed description.

6-52 Effects of lightning strokes to transmission lines on distribution cable systems

B. Vahidi, M. Heidari

The paper addresses the response to direct lightning of HV/MV power system networks, in order to evaluate transferred overvoltages. Transformer and other power system components are modeled in the EMTP. A complete discussion on the modeling options is required.

6-145 Observation of Lightning Overvoltage at a Japanese EHV Station

H. Omura, T. Sonoda, K. Kakahana, S. Sekioka

The paper describes lightning overvoltage results observed at an EHV switching station showing, in particular that impinging overvoltages originated by backflashover are not always the most severe. In particular, they conclude that induced overvoltages are of the same order of magnitude. This observation should be supported with at least some theoretical considerations.

6-209 Lightning-Induced Overvoltages on MV Distribution Lines: Spacer-Cable Versus Conventional Line Configuration

A. R. De Conti, F. H. Silveira, S. Visacro, J. V. P. Duarte, J. C. S. Ventura

The paper presents a comparative study between conventional line versus super-cable line configuration aimed at estimating the lightning induced voltages in the two considered line geometries including the presence of periodically grounded conductors. The paper represents an additional welcome contribution. Notwithstanding, some modeling options need clarification. An additional discussion on the effect of the grounding wires seems adequate.

MISCELLANEOUS

The papers included in this subject address withstand voltages as regards lightning and damages caused by lightning stresses. The paper on Lightning withstand voltages has been selected for **Oral Presentation**:

6-131 Breakdown characteristics of air spark-gaps stressed by short tail lightning impulses: test results and comparison of different to sparkover models

A. Ancajima, A. Carrus, E. Cinieri, C. Mazzetti

The paper reports comprehensive research on determining the critical flashover voltage of air spark-gaps. The experimental tests results are used in order to ascertain the most suitable parameters for modeling the disruptive effect, so that the V-t characteristics can be predicted. The obtained results are satisfactory.

The three papers on damages caused by lightning stresses were selected for **Poster Presentation**:

6-72 Damages in Equipment of a Hydroelectric Power Plant Substation Due to Lightning – Case Study

A. Soares Jr, S. Visacro, R. Z. Oliveira, M. A. Felipe, A. P. Silva

An analysis of substation equipment damage is presented and analyzed. A conclusion on the types of events that may have caused the reported damages is derived. Different mitigation solutions are proposed based on computer simulation of grounding grid behavior.

6-88 Evaluation of the Effect of the Lightning Discharges in the Overhead-Line Conductors used in Electric Rural Distribution

Ana Angélica da Silva Oliveira, Carmen Polycarpo Medeiros

The paper reports an experimental study aimed at assessing the damages caused by direct lightning stroke currents on overhead line conductors. A clear distinction between standards and available experimental results is required.

6-237 Examples of Errors causing Lightning Damages in Electrical Installations

K. Aniserowicz, M. Zielenkiewicz

Several examples of lightning caused damages are reported, and guidance is provided on avoiding incorrect project and procedures that may be responsible for the observed damages.