

ABSTRACTs of SESSION 9

Paper n°10

Lightning protection for track circuits in railway applications

Abstract: A new device for lightning protection of track circuits in electrical traction and railway applications has been developed. In the paper, first the special system parameters for this specific application, used in traction systems will be described. In the second part a brief overview of the complete project is given. Following computer simulations will be described, in which the lightning current distribution in a traction system was determined. In the next clause the laboratory testing of the voltage limiting device, especially its lightning current behavior is explained. Next the practical application of the lightning resistant fuse link both in a field test and following in stand applications is described. Finally the design of this lightning resistant fuse link is explained.

Keywords: Lightning protection, railway application, track circuit, computer simulation, laboratory testing, field experience

Paper n°13

Protection of antennas of mobile phone relay stations against direct strokes

Abstract: The antennas of mobile phone relay stations are exposed to direct lightning stroke on top of high tower or building. The air termination system usually consists of lightning rods placed behind each antenna. This study aims to analyze the influence of different sizes and positions of these rods. The calculation method is based on the collection (attractive) space of the antennas and it finally results in the expected frequency of shielding failure (stroke per year).

Keywords: Antenna, lightning interception, risk.

Paper n°14

A Study of transferred surge from a low voltage side of a transformer when a lightning strikes a wind turbine generator system

Abstract: The lightning surge phenomena of a wind turbine generator system has been verified by EMTP simulations and experiments in this paper, when the lightning surge transfers from the primary (the low voltage side) to the secondary (the high voltage side) of a transformer. The transformer used in the experiments is a single-phase three-wire and 10kVA. The transfer surge deeply depends on the several floating capacitances, the electromagnetic coupling in a transformer and the load condition connected to the secondary.

Keywords: Wind turbine generator system, Lightning protection, EMTP, Transfer surge

Paper n°29

A varying surge impedance transmission line model evaluate lightning current contamination at tall structures

Abstract: A new model based on the lightning channel representation by means of the transmission line concept is presented. In this model, the lightning channel is represented by surge impedances varying with height, with the purpose of evaluating the current profile throughout the lightning channel and the instrumented tower. The model is applied in the

study of current waveform contamination when a metallic structure is hit by lightning. This study implies the electrical modeling of instrumented towers and the associated grounding systems. Systematic time domain simulations were achieved, by means of the EMTP/ATP program.

Keywords: Return stroke model, current contamination, instrumented towers.

Paper n°35

The observation of the direct lightning stroke in the wind turbine generator system

Abstract: The development of wind turbine generator system in our country is expected as a clean energy, and its popularization rapidly increases. In Japan, there are many cases installed in the Sea of Japan coast with the much wind capacity on the wind turbine generator system. However, since the Sea of Japan coast is known as a region with much winter lightning, the wind turbine generator system is receiving the damage the winter lightning. In such situation, it is important to observe the lightning current which strikes for the wind turbine generator system, in order to carry out lightning protection of these one. Therefore, authors installed the current sensor (Rogowski coil) for wind turbine generator constructed in Hokkaido and Kagoshima, and the waveform observation of lightning stroke current which strikes for the system was carried out in the winter of 2002, and summer of 2003. By this observation, we obtained a few lightning current waveform which struck to the wind turbine generators. This paper shows this outline and observed result.

Keywords: Wind turbine generator system, Lightning stroke current, Observation

Paper n°37

Calculation of electric fields in a wind mill due to a lightning discharge using finite elements method

Abstract: Nowadays, wind power is one of the major renewable energy resources. In particular the use of this energy in Spain has grown in the last decade. But wind turbines are usually placed on high grounds, where there is good wind but there is too a lightning risk. For this reason lightning is considered a threat that must be taken into account in wind turbine design and specially in blades design. For this purpose one of the most important parameter that must be known is the electric field. In this paper it has been calculated using finite element technique. The results show the wind turbine zones which are sensitive of being stroke, depending the blades position and the distance from the tip discharge to the structure

Keywords: lightning protection, wind mills, finite elements.

Paper n°51

Application of charge simulation method for wind turbine lightning protection

Abstract: Wind sites are areas of possible lightning strike struck windmill are exposed to great danger. This danger is two: Destruction of important mechanical parts, e.g. rotor blade. Interference with or damage of electrical equipment of the system.

In this paper a wind plant is simulated for charge simulation method (CSM) computation. In this simulation; blades, tower of turbine, nacelle, protection tower, cloud, downward and upward leaders simulated with different kind of charges. Potential distribution on the surface of blades, electric field on the blades and distribution of electric field over windmill in the presence of protection tower are computed.

Keywords: Charge simulation method, Wind turbine, Lightning

Paper n°55

Measurements of lightning transients entering a Swedish railway facility

Abstract: Transient measurements in the railway facilities have not received much attention earlier. In this paper we describe the measurements of lightning transients entering a railway facility during the summer of 2003. The measurements of the transients were made in a technical house that supplies an uninterrupted supply for the telecommunication systems and the signal systems. Examples of transient waveforms are presented and discussed.

Keywords: Lightning, transients, transmission lines.

Paper n°69*Lightning protection of air traffic control RADAR systems*

Abstract: This paper aims to analyse the lightning protection system (LPS) design of an isolated RADAR system, which is installed on the Hellenic island of Letkada. The area where the RADAR operates is characterised by the high ground flash density (≈ 50 thunderstorm days per year, ~ 5.3 flashes per square km) and the extremely high soil resistivity value (i.e. pure rock with a resistivity of more than $2000\Omega\text{m}$). The paper includes performance results of the LPS system since the date that was installed (1998) in comparison with previous techniques that were unsuccessfully used for lightning protection. The LPS design includes external and internal LPS (ie. air terminations, earthing and surge protection). It also includes solutions to some difficult overcoming problems that were faced during the application of the lightning protection design.

Keywords: RADAR, external LPS, surge protection devices - SPDs, earthing system impedance

Paper n°79*Investigations of lightning electromagnetic pulse effect in GSM base station*

Abstract: The object of this paper is lightning threat of telecommunication equipment in a GSM base station. A direct lightning strike to a communication tower is considered. The paper presents selected results of on-site measurements using surge generators and numerical simulations for a freestanding base station. In the numerical simulations a current energization of both surge-type (as in the field tests) and lightning-type were used. The combination of these methods allows for a verification of object computation models and then a numerical evaluation of lightning threat using current parameters close to real.

Keywords: lightning, Lightning Electro-Magnetic Pulse, simulation of lightning, GSM base station

Paper n°110*Lightning protection for a complex isolated renewable and diesel power network - Micro grid*

Abstract: In this paper a specific Lightning Protection System (LPS) design for an isolated complex renewable and diesel power network - micro grid will be described. This isolated power network was established in 1992 on the Holy Mount - Agion Oros - for the Simonopetra monastery in northern Hellas. It is composed of a 33kW Hydro generator, a 45kW Solar system, and 60kVA Diesel generator.

Due to the wide space area of the installation a specific external LPS needed to be designed. Additionally due to the sensitive electronics of the control and protection systems of the network, surge protection (Surge Protection Devices - SPDs), equipotential bonding and shielding were also of major importance. The high altitude in addition to the high ground flash density made this system vulnerable to lightning flashes. Ten years now the isolated power

network it is protected against lightning. The paper apart from the LPS design, which was used it also aims to evaluate the performance of the LPS that is now in use over this ten years period.

Keywords: Lightning protection system, surge protection devices - (SPDs), Micro-Grid, photovoltaic system, hydro generator, diesel generator

Paper n°122

Effect of a direct stroke into reinforced concrete

Abstract: Earliest streamer devices (ESD) for lightning protection are used in many areas. It was reported that damages on the corners of buildings have been found in frequent cases. If the protection area of an ESD device is not sufficient to protect the corners of the building at the roof, due to the high field strength in case of a downward leader an upward leader will start from this point and cause the final jump and a lightning current will flow directly through the reinforced concrete. In some cases a large mass of concrete was found after such an event in front of the building. Such event is a great danger for persons in front of the building. The above mentioned effect was the motivation to investigate such case in the laboratory.

Keywords: First stroke, damage of concrete, protection area

Paper n°133

Overvoltage protection concept for DC railway systems

Abstract: Protection concepts for DC railway systems are introduced, considering the different insulation of the rails and the earthing concepts. The requirements and ratings for MO-surge arresters are based on the relevant EN standards and national guidelines. A newly developed hybrid voltage limiter, which combines overvoltage protection and the protection against dangerous touch voltages, is introduced.

Keywords: DC railway systems, overvoltage protection, hybrid voltage limiter.

Paper n°135

Lightning analysis on wind farm --- Sensitivity analysis on earthing ---

Abstract: In this paper, we case study surge analysis using a wind farm model with 10 windmills connected to a power system. The aim of the present analysis is to clarify the tendency of influence of earth and the combination of other insulation environment. The result of the sensitivity analysis shows that the surge propagates to the next windmill and outside of the wind farm sometimes become large depend on the conditions of earthing. The result suggests possibilities of serious accidents to electric and electronics devices of non-thunderstruck windmill due to surge propagation, as well as directly thunderstruck one.

Keywords: wind power generation, wind farm, lightning, surge, earthing(grounding).

Paper n°142

Application of aircraft lightning protection to radar stations

Abstract: Near an antenna (radar or radio frequencies), set-up of a standard metallic lightning protection system may create troubles due to its metallic frame which may disturb the field emitted or received by the antenna. To solve this problem a new lightning protection system has been developed which is "transparent" to electromagnetic waves. This new lightning protection system has been tested thoroughly with high voltage impulse and the high energy lightning strike used by the aircraft industry. Testing performed are described. Area

protected by this system is the same than the one given by a metallic lightning rod and all the standard rules have to be fulfilled.

Keywords: Radar, lightning protection, lightning rod

Paper n°157

Lightning damages of wind turbine blades in winter in Japan -Lightning observation on the Nikaho-Kogen wind farm-

Abstract: The lightning damage of wind turbine blades is a serious problem. The international standard (IEC) of the lightning protection level for windmills was published. However, the destruction mechanism of blades due to winter lightning is not clear. The authors started to observe the lightning discharges to the windmills on the Nikaho-Kogen wind farm in Japan. The observational results will contribute to understand the mechanism of blade destruction and to discuss the proper lightning protection method of windmills for winter lightning discharges.

Keywords: Winter lightning, Wind turbine blade, Windmill, Upward lightning, Japan

Paper n°173

Experimental study of effective lightning protection measures for railway level crossing system in Japan

Abstract : In Japan, the railway signalling system has made remarkable progress in recent years with their components becoming increasingly compact and multi-functional due to the adoption of microcomputers and other electronic devices in wide ranges. On the other hand, burning of circuits, system-down and other lightning damages on the railway signalling system frequently occur because electronic devices are easily broken by lightning surges. It is required to build up effective and economical countermeasures for preventing lightning damages on the railway signalling system since suspension and delays of trains due to lightnings may cause social confusion. Therefore, we measured the wayside ground potential distribution when a rail potential rise was caused by injecting a lightning surge current into a rail. Moreover, we injected a lightning surge current into the rail or wayside ground to raise their potential, in order to measure the lightning overvoltages on a level crossing so that we can obtain basic data for insulation design. There are no precedents that have carried out these experiments in the field until now. In addition, we implemented experiments on countermeasures for suppressing the lightning overvoltages on the level crossing in the test site. We could obtain the following results.

(1) The potential rises of the induced rail and wayside ground are generated in parallel with the potential rise of the induction rail. The potential difference between the inducting rail and the wayside ground that is 3m vertically distant from its rail is approximately 80% of the potential rise of the inducting rail.

(2) Flashovers may occur at the terminals in the equipment of a level crossing in case 1) a 2kA lightning surge current is directly injected into the rail, or 2) a 10kA lightning surge current is injected into the wayside ground that is 2m vertically distant from the rail. Therefore, lightning protection measures are required for the level crossing.

(3) It is an effective countermeasure to earth lightning protective devices attached to electronic train detectors for a level crossing in order to suppress the lightning overvoltages on the level crossing.

Keywords : lightning surge, lightning overvoltages, lightning protection measure, railway signaling system, level crossing

Paper n°200*Manner of Lightning Attachment to Non-conductive Wind Turbine Blades*

Abstract: Lightning protection measures for wind turbines are becoming increasingly important as their use is increasing rapidly along with its capacity and height, exposing it to a higher risk of lightning strokes. In order to understand the manner of lightning attachment to wind turbine blades, study on nature of lightning damage to wind turbine blades is reported with blade samples made of different materials. Experimental studies revealed that non-conducting blade reduce the 50% sparkover voltage compared with an air gap for some kind of impulse voltages. Surface discharge effect on actual long blades can adversely affect the lightning performance of wind turbine.

Keywords: Wind power generation, wind turbines, lightning protection

Paper n°207*Lightning protection of intrinsically safe areas*

Abstract: The methods of protection of hazardous zones of direct lightning strokes are covered by internationally recognized standards.

Intense electromagnetic fields associated to nearby lightning activity may develop very high voltages, followed by electrical arcs inside explosion proof hardware.

On the other side, zenner barriers or galvanic isolators may breakdown under the high energy levels developed during lightning storms, with the associated danger of fire or explosion inside the pretended intrinsically safe zone.

In this paper the authors show that with appropriated lay out and with the help of the Ground Window (GW) concept, energy entering IS zone may be reduced to safe levels.

Keywords: Hazardous zones, intrinsically safe barriers, galvanic isolators.

Paper n°219*Lightning strike to helicopters during winter thunderstorms over North Sea*

Abstract: South Wind over the Shetland Islands produces a wave flux which, in winter time, triggers convective clouds over the Atlantic Ocean. Those clouds get electrified and produce isolated lightning flashes. In an attempt to describe the atmospheric electrical configuration produced by this meteorological situation, we run Méso-NH, a meso-scale non hydrostatic model, which delivers a 3D description of the convective cell. A microphysical and dynamical 1.5D model is then applied to simulate the vertical electrification within the cell. From the electrification study, the attachment model of ONERA is used to compute the zones on helicopters from which the lightning discharge can develop.

Keywords: Lightning strike, helicopters, attachment, North Sea.

Paper n°222*System electromagnetic compatibility for the lightning protection of EDF hydro-electric power plants in Corsica*

Abstract: This document describes the unclassified part of the Lightning protection studies for a power plant.

The studies were conducted with a new EMC (Electromagnetic Compatibility) System concept: "Zero Method". This concept uses an accessible and easy process to control the industrial electromagnetic interference from various electromagnetic effects. In particular, the protection against the lightning current intrusion is treated.

The adopted solutions improve personnel and facility safety and provide light costs and effective works.

Keywords: Lightning protection, EMC system, Zero Method.

Paper n°224

Lightning protection of wind turbines and its test with a high performance lightning current generator

Abstract: Owing to their exposed position, wind turbine installations (WTIs) are particularly at risk from lightning strikes. The damage a lightning strike can cause to a WTI, especially modern installations designed for offshore operation, can result in considerable costs in terms of downtime, replacement devices and assembly. For this reason, WTI manufacturers are increasingly developing lightning protection concepts that will ensure the installation will continue to operate without hindrance both during and after a lightning strike. The measures this requires can partly be put to the test by replicating the atmospheric discharge in a lightning voltage laboratory.

Keywords: Lightning protection, Wind turbines, Lightning Current Generator, Long duration current

Paper n°226

Tracking tests of Glass Fibre Reinforced Polymers (GFRP) as part of improved lightning protection of wind turbine wings.

Abstract: The paper describes test procedures and evaluation of the tracking resistance of several GRP specimens. Twenty one series of five specimens each have been tested according to IEC publication 587.

Classification referring to the standard, as well as general comments on surface characteristics, fibre orientation, different types of resin etc. is performed. Finally some suggestions for material improvements are treated and held together with the manufacturing relations of wind turbine blades.

Keywords: Tracking resistance, composite materials, wind turbine blades

Paper n°233

Global engineering methodology and designer studies examples

Abstract: The number of disasters (fire, blaze, explosions, pollution, death) caused by lightning and /or EMC increases as well as their seriousness. Moreover their consequences become more and more serious because of new legislative and environmental requirements, associated criminal responsibilities and detections systems susceptibilities (fire, alarm, intrusion, camera, theft...) spread by new international pre-cautious neurosis.

This paper deals with the incidents caused by natural disturbances, especially lightning. Following by survey supported by statistics, costs, the analysis of the causes, and informations collected in France and abroad.

Paper n°238

A new algorithm for antenna theory modelling of a lightning return stroke

Abstract: A new algorithm for modelling of a lightning return stroke using the antenna theory is presented. The lightning channel is modelled as a vertical monopole above a perfectly conducting ground. Inductive loading is applied to obtain the required return stroke current

speed. The adjustment of the distributed R-L loading and the channel radius is based on the analysis of the group delay in the frequency domain. The model is compared to one of the previously published antenna models [4].

Keywords: Antenna theory, lightning channel, modelling, distributed inductance, group delay