

Development of Lightning Risk Management Schemes

Background and Objective

We have carried out studies of lightning protection design for transmission lines, substations and distribution systems and established lightning protection schemes for these apparatuses. However, introduction of ICT (Information and Communication Technology) in power systems such as smart meters and capacity of renewable energy sources such as wind power and solar power will increase in the future. Therefore, lightning protection methods for these facilities are required

in addition to those for conventional power apparatuses.

In this project, we will develop a lightning risk assessment procedure for various power apparatuses and establish lightning protection guidelines for facilities using ICT considering their electro-magnetic immunity. We will then utilize these lightning protection guidelines for the rational lightning protection design of power systems.

Main results

1 Investigating characteristics of lightning strikes to extremely high structures

We installed a wide-band lightning current observation system on Tokyo Skytree, the height of which is 634 m, to clarify lightning current characteristics and characteristics of lightning strikes to extremely high structures such as UHV transmission lines. Observation using this system commenced in 2012*1. It was considered that upward lightning mainly occurred on such high

structures, but two years of observing the Tokyo Skytree revealed that it is subjected to downward lightning as well as upward lightning (Fig. 1). This phenomenon is due to the difference in weather conditions when the tower is struck by lightning. The cumulative distribution of crest values for lightning striking the tower is similar to those previously reported (H13012).

2 Acceleration of 'VSTL REV' and its application to lightning surge analysis of a reinforced-concrete building

We have developed a surge simulation code, VSTL REV, which is based on the numerical electromagnetic computation method in order to predict surge phenomena of three-dimensional structures such as buildings and grounding structures such as grounding grids. In 2013, using the parallel and GPU (Graphics Processing Unit) computing techniques, we made it possible to execute the VSTL REV on GPU-based parallel computers to accelerate the VSTL REV calculation. We confirmed that the improved VSTL REV enables a surge simulation more than forty-times faster in

comparison to a conventional CPU-based simulation. As an example of a surge simulation using the accelerated VSTL REV, we calculated electromagnetic fields inside a real-scale reinforced-concrete building in case of direct and indirect strikes. These calculated results reveals that the concrete and structures of the building such as walls influence the electromagnetic fields inside the building significantly and it is possible to reduce these electromagnetic fields by installing a grid-like shielding inside the building (Fig. 2)(H13009).

3 Evaluation of immunity characteristics for IP equipment installed in power stations

To establish immunity test methods suitable for IP (Internet Protocol) equipment installed in power stations, each bit packet was observed during LAN packet transmissions. The electric fast transient / burst (EFT/B) noise was applied to the power port and the signal (Ethernet) port of switching hubs to observe their effect on data transmission quality by measuring packet losses. It was observed that the interference

to the LAN packet transmission has different aspects for the power port application and the signal port application (Fig. 3). That is, for the power port application, the packet losses occurred in synchronization with each pulse of the burst, while for the signal port application, synchronization was not observed and losses increased as the applied voltage of the noise elevated.

*1 Collaborative research by CRIEPI, University of Tokyo and Tobu Tower Skytree Co. Ltd.

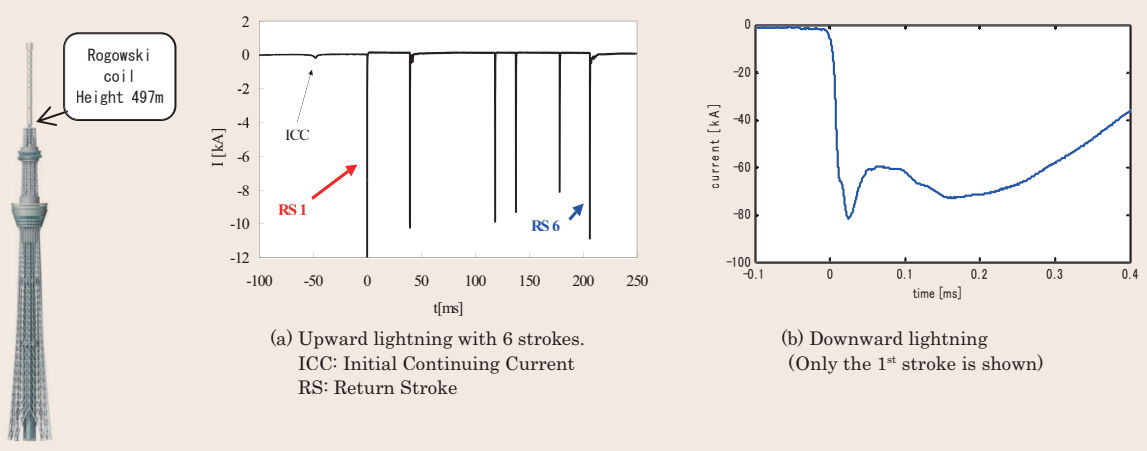


Fig. 1: Examples of current waveforms of upward and downward lightning

In the case of lightning in summer, a lightning flash often contains several strokes. The rise time of a current waveform is in the order of micro-seconds as shown in Fig. 1 (b).

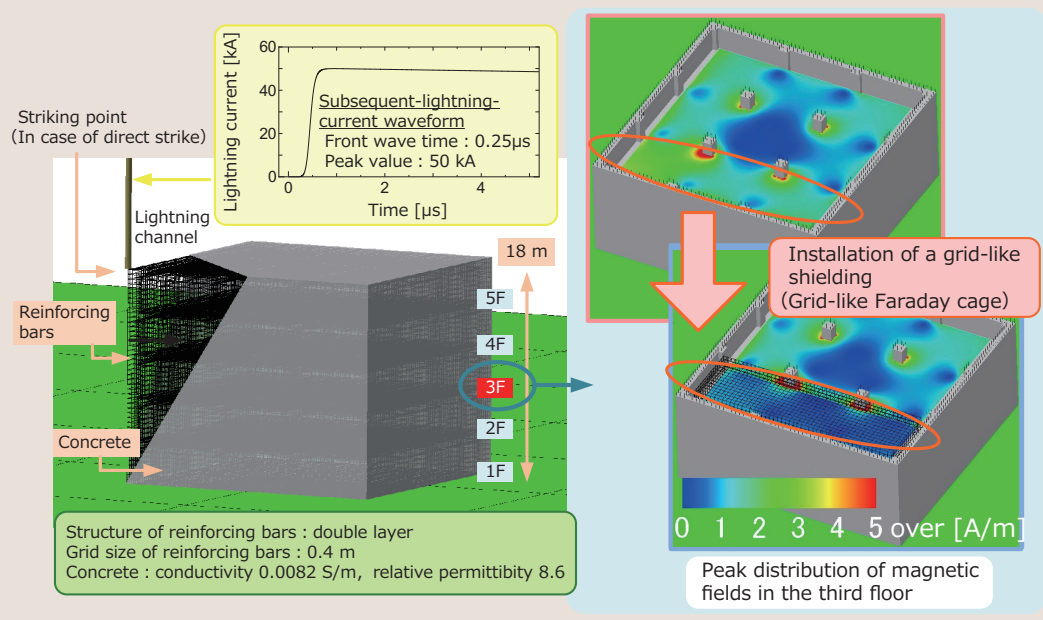


Fig. 2: Analysis of electromagnetic fields inside a reinforced-concrete building struck by lightning

Modeling a building of which the roof is struck by lightning, we calculated electromagnetic fields inside the building and confirmed the effectiveness of a grid-like shielding installed in the building against the electromagnetic fields.

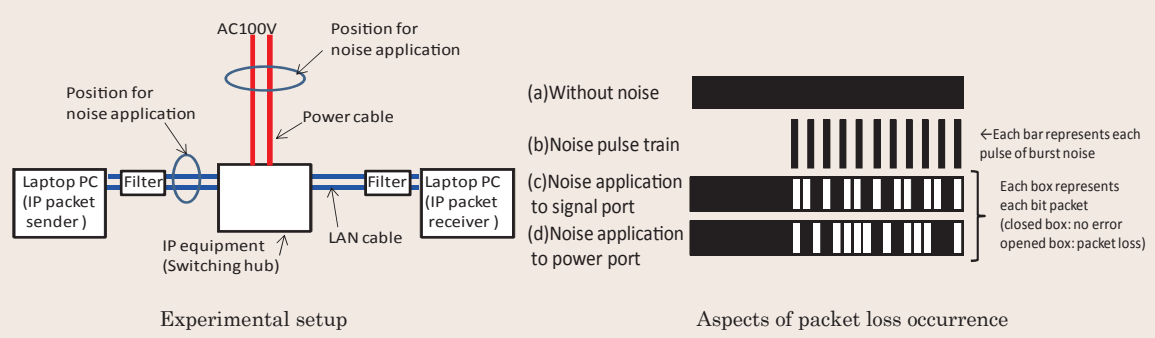


Fig. 3: Aspects of packet loss occurrence for burst noise application to power port and signal port of IP equipment

For the power port application, the packet losses occurred in synchronization with each pulse of the burst, while for the signal port application, synchronization was not observed and the losses increased as the applied voltage of noise elevated.