

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 the electro-magnetic immunity. We will then utilize these lightning protection guidelines for the rational lightning protection design of power systems.

Main results

1 Development of a lightning risk assessment program for distribution lines considering regional characteristics

We have added the following two functions to the previously developed lightning outage prediction program in order to assess the lightning risk of power distribution lines;

- 1) Evaluation of the difference between lightning current characteristics in summer and those in winter.
- 2) Evaluation of the ratio of burn-out outages of arresters.

The new program reproduces actual field experiences such that the number of flashovers of

insulators is larger in summer and the number of burn-out outages of arresters is larger in winter. It enables us to predict outage features of distribution lines accurately.

We have also developed a lightning risk assessment program which quantitatively evaluates outage ratio of distribution lines taking the regional difference of protection measures into consideration based on the data of regional densities of distribution lines and lightning (Fig. 1). (H12010)

2 Investigation of characteristics of lightning strikes to extremely high structures

We have developed a unique lightning current measuring system that consists of two Rogowski coils for high frequencies and low frequencies to clarify the relationship between characteristics of lightning strikes to high structures and damage by lightning.

We have confirmed from impulse current tests of these coils that it is possible to observe lightning current waveforms for a wide frequency

range. We have installed the coils on TOKYO SKYTREE at a height of 497m and started current observation from March, 2012. We have obtained current waveforms of 9 flashes in the fiscal year of 2012 (Fig. 2). We will use these data for the analysis of transient electro-magnetic fields inside the structures and overvoltages on the low-voltage circuits such as communication and control circuits.

3 Observation of radiation fields by lightning strikes

We have installed antennas at Maebashi, Abiko and Yokosuka to observe radiated electromagnetic fields generated by lightning strikes in an attempt to improve the accuracy of lightning location systems. The observation system enables the synchronized observation of lightning currents at TOKYO SKYTREE

and radiated fields. We will use the obtained data to evaluate the accuracy of locations and currents estimated by lightning location systems, investigation of the estimation errors and development of a novel lightning location algorithm.

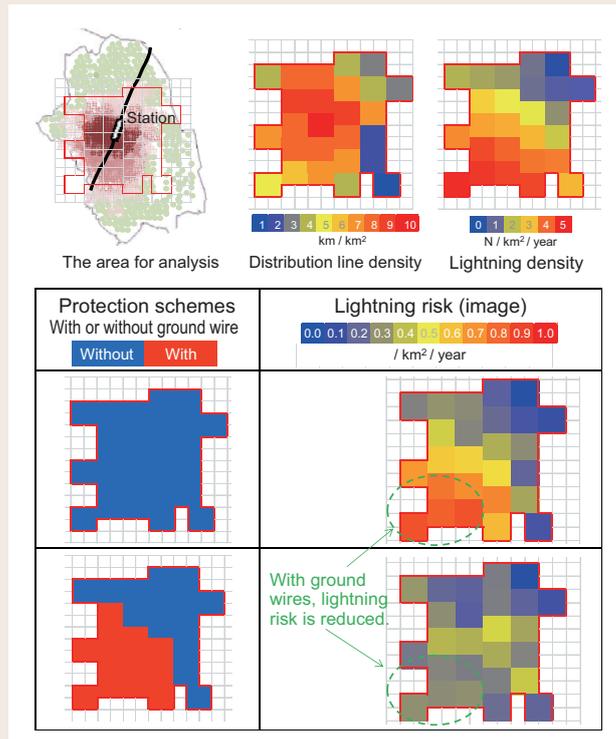


Fig. 1: Difference of lightning risks of high-voltage distribution lines with different lightning protection schemes

Lightning risk is evaluated considering regional distribution line density, lightning density and lightning protection schemes. In the case of a non-uniform lightning protection scheme, high risk areas are reduced (bottom right) compared with that of a uniform lightning protection scheme (top right).

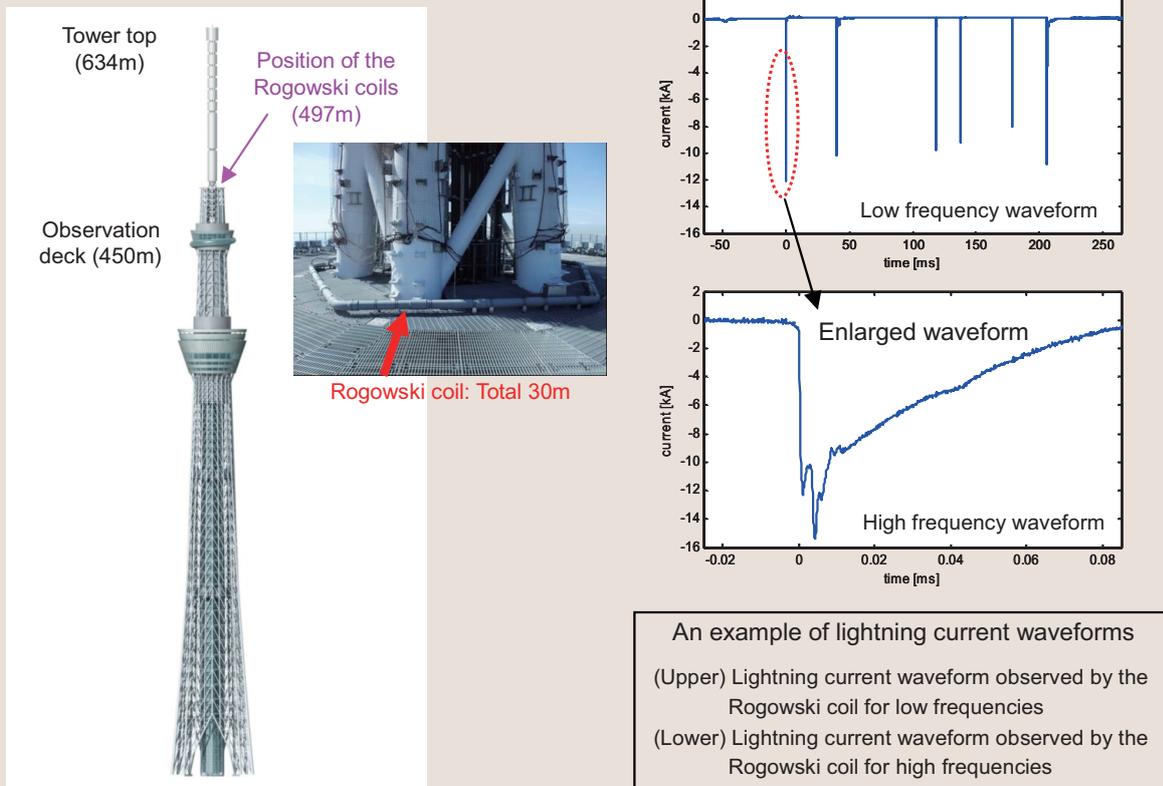


Fig. 2: Lightning current observation system installed on the TOKYO SKYTREE and an example of observed lightning current waveforms

Two Rogowski coils for high frequencies and low frequencies are installed on the TOKYO SKYTREE at a height of 497m. Measured signals are transmitted to a recording system in the observation room of the tower via optical fibers. An example of observed waveforms is shown on the right side. This is a negative lightning consisting of 6 strokes. The steep wavefront is also precisely observed.