

# 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, in the future, ICT (Information and Communication Technology) will be increasingly applied to power systems such as smart meters and the capacity of renewable energy sources such as wind power and solar power will increase. 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 Investigation of relationship between lightning strikes to extremely high structures and meteorological conditions

We have observed lightning strikes on Tokyo Skytree, the height of which is 634 m, to clarify lightning striking characteristics on extremely high structures such as UHV transmission lines\*1. Approximately 40 events were successfully observed from 2012 to 2014. From this data, we have found that downward lightning to the tower and upward

lightning from the tower generally occurs when the height of  $-10^{\circ}\text{C}$  is higher than 5,500 m and lower than 5,500 m, respectively (Fig. 1). In addition to this, we have obtained statistical distributions of peak values of lightning currents and transferred charges of lightning flashes for both types of lightning (Fig. 2) (H14015).

#### 2 Establishment of an immunity test method for IP equipment installed in power stations

Consideration of immunity against electromagnetic interference has become one of the important issues in installing ICT devices in power stations and substations. In this study, a model estimating packet loss rate in the IP transmission against burst noises was established based on experiments. The model

estimates packet loss rate by considering duration and cycle of a burst noise\*2, and elapsed time of IP packet transmission. Using the loss estimation model, a simple and effective immunity test scheme for IP devices to be installed in power stations and substations was proposed (Fig. 3) (H14012).

#### 3 Enhancement of lightning database based on the recent data of lightning location systems

Collaborating with electric power companies in Japan, we have constructed an enhanced lightning database tracking up to the year 2013 based on the data of lightning location systems. From the database, we have clarified the annual variation of

lightning occurrence, relationship between lightning occurrence and meteorological conditions, and correlations between the number of outages of transmission lines and that of lightning occurrence.

#### 4 Potential for relaxation of the regulations on grounding of communication lines of power systems

Aiming at relaxation of the regulations on grounding of communication lines of power systems, we have investigated the possibility from three viewpoints; namely, lightning, mixture contact of AC circuits and electromagnetic induction, with full-scale

experiments and computer simulations. As a result, we have found that the regulations on grounding resistance value and interval of grounding points can be relaxed.

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

\*2 A train of repetitive impulsive noises characterized by number, duration and period of repetition of pulses.

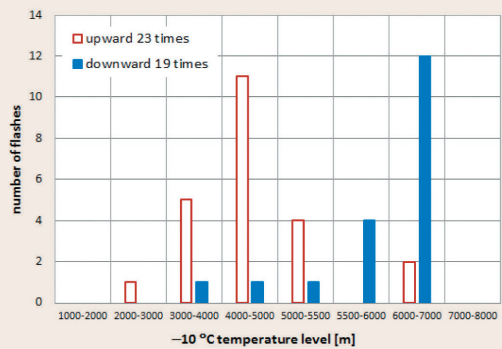


Fig. 1: Occurrence of upward and downward lightning flashes and height of -10°C level upward lightning and downward lightning

It has been considered that lightning strikes on structures with heights of over 500 m is mostly upward (more than 90%). However, in the case of Tokyo Skytree, downward lightning flashes are often observed. Hence we have investigated the meteorological conditions when lightning to the tower occurs and have discovered that most of upward lightning flashes occur when the height of -10°C level is lower than 5,500 m.

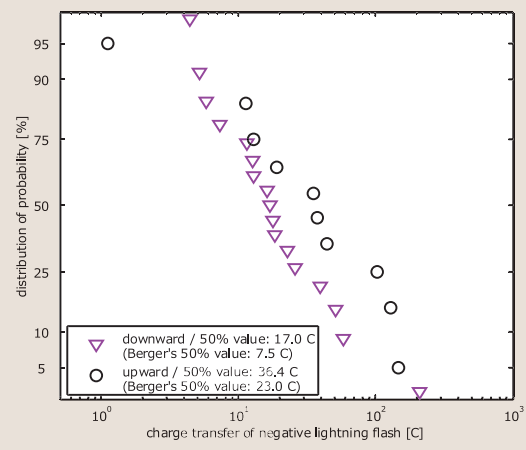


Fig. 2: Cumulative distributions of transferred charges of upward and downward lightning flashes

In regards to the lightning parameters such as peak current and transferred charge, the data observed in Switzerland by Berger is popular around the world. Present data observed at Tokyo Skytree is almost the same as that for the cumulative distribution of lightning currents, but the median value of transferred charges are 1.5 to 2.3 times larger than the values previously reported and the difference by regions is shown.

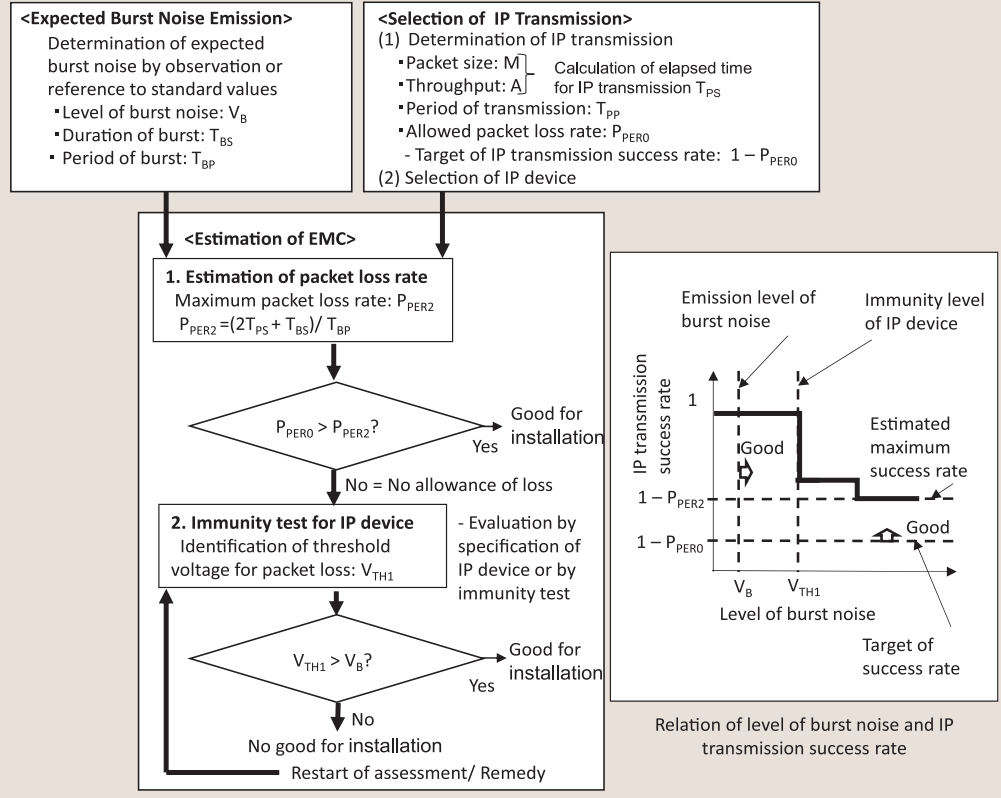


Fig. 3: Immunity test scheme for IP devices to be installed in power stations and substations

The IP transmission success rate rapidly changes at a level of applied burst noise, and converges to a value determined by cycle and duration of the burst noise and cycle of packet transmission. In the immunity test, the estimated maximum IP transmission success rate will be compared with its target value. If it is not satisfied, another investigation will be conducted, i.e. the threshold voltage emerging packet loss for the IP device will be compared with the noise level at the location.