Lightning Protection for an ICT Oriented Society

Background and Objective

Recently, highly sophisticated social systems have been constructed using information and communication technologies (ICTs). These systems, however, are vulnerable against external disturbances such as lightning. Once social infrastructures such as information networks and power supply systems stop, extraordinary confusion may occur in society.

In this project, we will further develop lightning protection methods constructed so far and will establish novel lightning protection technologies to construct robust power supply systems in society with information and communication technologies, taking the concept of lightning risk management into consideration.

Main results

1. Improvement on the lightning risk assessment program

We have installed calculation modules such as a lightning outage calculation module on a basic lightning risk assessment program developed in 2009 and made it possible to assess transmission risk and instantaneous voltage dip risk (Fig. 1). With the newly developed program, we can assess these risks on any conditions by inputting lightning data, topographical data and facility data such as transmission arrangements on the program.

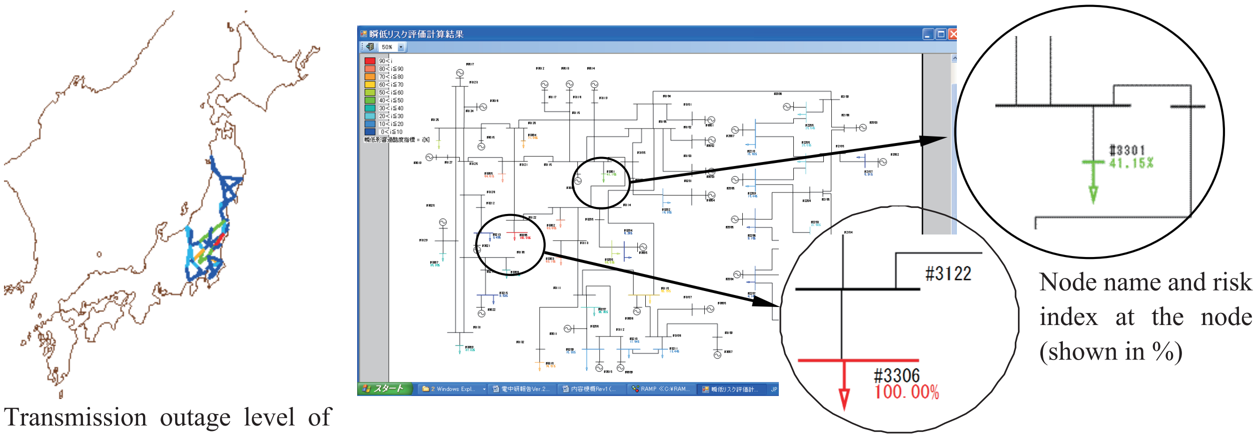
2. Analysis of induced voltages on low voltage control circuits in power stations.

Most faults of control circuits in power stations are caused by lighting surges invading into main circuits and grounding meshes. Nevertheless, effects of configurations of control circuits on induced voltages have not been clarified yet and effective protection methods have not been established. We have already clarified the relationship between circuit configurations and the magnitude of induced voltages when lightning surges invade into grounding meshes.

In 2010, for the cases where lightning surges invade into a main circuit, we have evaluated the effects of facility conditions (i.e. types of control cables and their arrangements, grounding methods of the sheath of a gas-insulated bus) on induced voltages using the production-version voltage transformer (VT) and current transformer (CT) and digital relays. The results have clearly proved that the induced voltages are mainly generated by transition surge from the primary circuit to the secondly circuit at the VT and/or CT (Fig. 2, Fig. 3) [H10011]. With these results, we have clarified the effects of circuit configurations on induced voltages qualitatively.

3. Research of immunity assessment methods of digital equipments and ICT facilities.

We have reviewed domestic and international standard on immunity assessment methods for digital equipments and ICT facilities. From the research, we have found that in the standards of digital relays and digital wireless telecommunication systems, the immunity test items and required immunity levels are determined considering the kinds of noise and noise levels at the sites where the facilities are installed.



(a) Transmission outage level of an assumed transmission line (Blue: low, Red: high)

(b) An example of the risk map of instantaneous voltage dip

Fig. 1 An example of instantaneous voltage dip risk map

In this example, a standard model system used for the system analysis in Japan is set arbitrarily on the map and outage rates of all transmission lines are calculated with actual lightning data and topographical data. Using the results, the magnitude and frequency of instantaneous voltage dip at every node are calculated. Then risk index of instantaneous voltage dip at each node is evaluated and relative values of these indices are shown in the figure using different colors according to the severity.

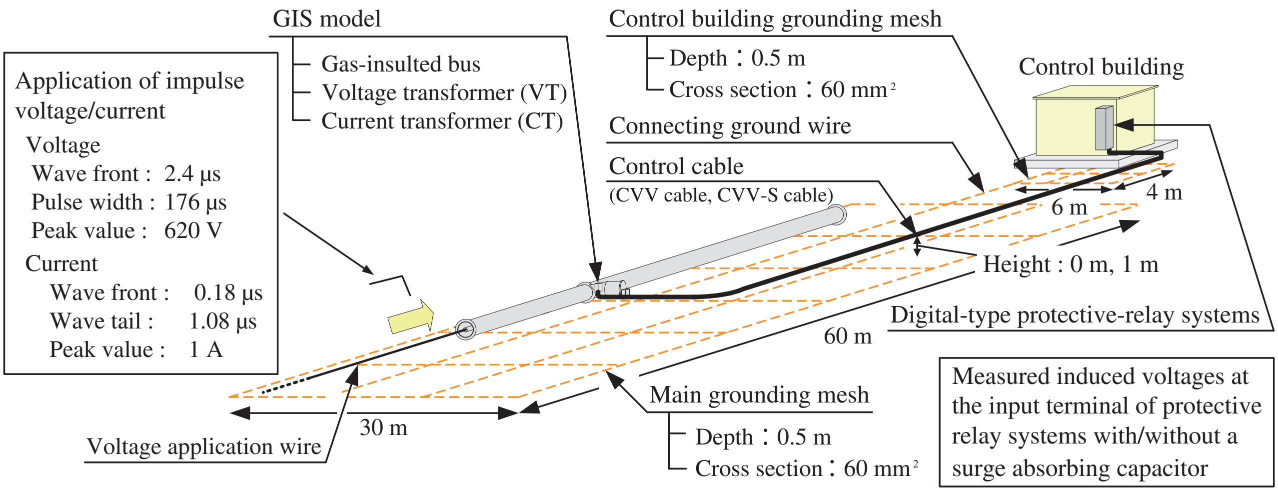
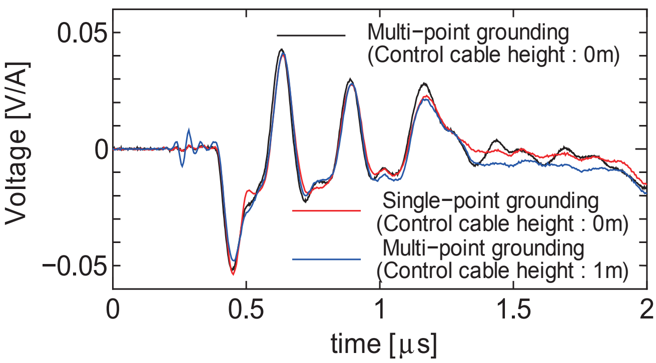


Fig. 2 Experimental arrangement to simulate the main circuit and low-voltage control circuit



This is an example of induced voltage observations. In this case, the signal output of a CT at the GIS side and signal input at the relay are connected with each other by a control cable (CVV cable).
The grounding method of the sheath of a gas-insulated bus (multi-point grounding or single-point grounding) and the height of control cable (0m or 1m from the ground) have little effect on the peak value of induced voltages.

Fig. 3 Effects of grounding methods on the sheath of a gas-insulated bus and height of control cable