Development of Analytical Software to Predict Influence of Voltage Dips by Lightning Faults

Background

With the widespread use of high-tech load equipment which is very sensitive to power quality in recent years, there is growing concern regarding the possible adverse influence of momentary voltage dips lasting for several tens to more than one hundred milli-seconds, mainly caused by lightning faults with transmission lines, on such load equipment.

There are basically two types of measure to these voltage dips: (i) clarification of the situation of voltage drop at each load point due to these dips and (ii) introduction of an equipment to avoid voltage dips. One presumably effective method for the former is the computation of the influence of voltage dips (scale and frequency of the occurrence of voltage drops) at each load point of the power supply system based on the probability of lightning faults with transmission lines.

At present, however, the accuracy of estimation method regarding such computation is low and an analytical technique to predict voltage dips, which is easy to use, has not yet been developed.

Objectives

To develop a highly accurate analytical technique to predict voltage dips caused by various lightning faults with probabilities on the standard parallel 2 circuits in Japan, and then to develop an analytical computation software based on that technique.

Principal Results

1. Development of Highly Accurate Analytical Technique for Voltage Dips

The analytical technique already developed *1 by the CRIEPI was further extended to develop a highly accurate as well as high speed computing technique for voltage dips at load points caused by lightning faults with the respective transmission lines. The main characteristics of this newly developed technique are described below (Fig. 1).

(1) A total of all 12 types of lightning fault pattern, which can emerge with the parallel 2 circuits shown in the top right of Fig. 1, can be computed.

(2) Computation is possible for multiple faults on the transmission route in addition to the conventional node end faults (sending end and receiving end) so that the accuracy of the computation results can be improved.

(3) To efficiency compute multiple voltage dips caused by entire transmission faults at the target load points (ds), a technique capable of producing solutions in higher speed in the order of two digits or so without losing computing accuracy by using the sensitivity coefficient between each fault point and the load point d has been developed.

2. Development of Analytical Software to Predict Voltage Dips

An analytical software based on the new analytical technique described above has been developed. Its main characteristics are listed below (Fig. 2).

(1) The software is configured for computation using existing standard input data for power system analysis owned by each electric company (CRIEPI Transient Stability Simulation Software). Users can compute multiple voltage dips only by adding transmission fault data.

(2) The above-mentioned high speed analysis function allows the speedy analytical solutions even for the largest scale power system model in practical use in Japan.

(3) Accumulative probability variation values of voltage dips in a target period can be computed to allow easy analysis and evaluation of the influence of voltage dips on load points which users are concerned about. In addition, a useful voltage dip severity index for comparison of the influence of voltage dips on multiple load points has been devised and incorporated in the new software.

A study analysis is shown in Fig. 3 where a hazard map used for earthquake prediction, etc. is applied. By using different colours for different ranges of computation results on the system diagramme, it is visually possible to see and analyse different degrees of influence of voltage dips in different areas.

Future Developments

Apart from contributing to the analytical computation of the distribution of influence of voltage dips caused by lightning faults with the power systems of electric companies, efforts will be made to use the new software to quantify the voltage dip reduction effects of various measures, including the installation of lightning arresters.

Main Researcher: Kazuyuki Tanaka,
Senior Research Scientist, Consumer Systems Sector, System Engineering Research Laboratory

Reference

Development of Analytical Software to Predict Voltage Dips by Lightning Faults, CRIEPI Report T03004 (October, 2003)

*1 : Development of Multi-Fault Analysis Software for Large-Scale Power Systems, No. T92034 (1993)

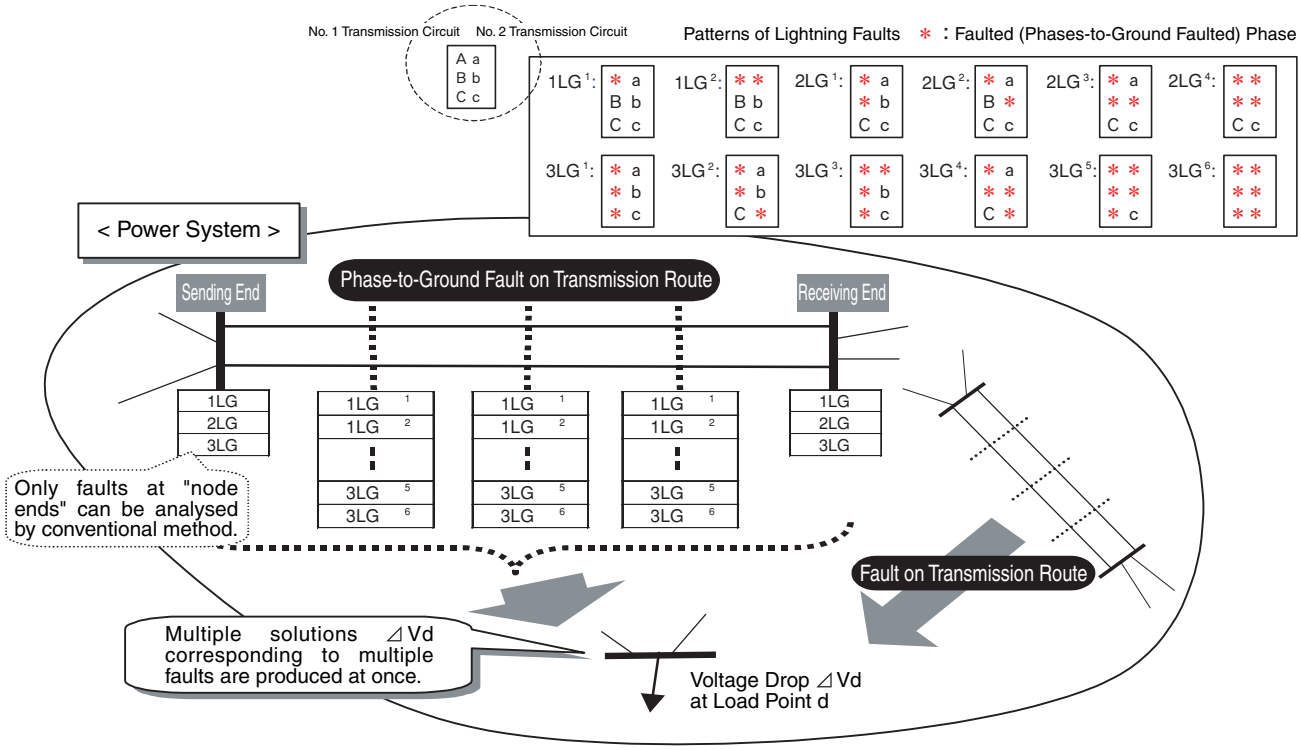

Fig.1 Outline of Developed Analytical Technique for Voltage Dips

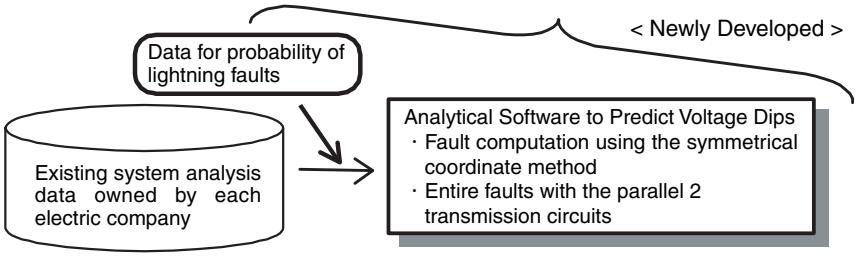

Fig.2 Configuration of Newly Developed Voltage Dip Analysis System

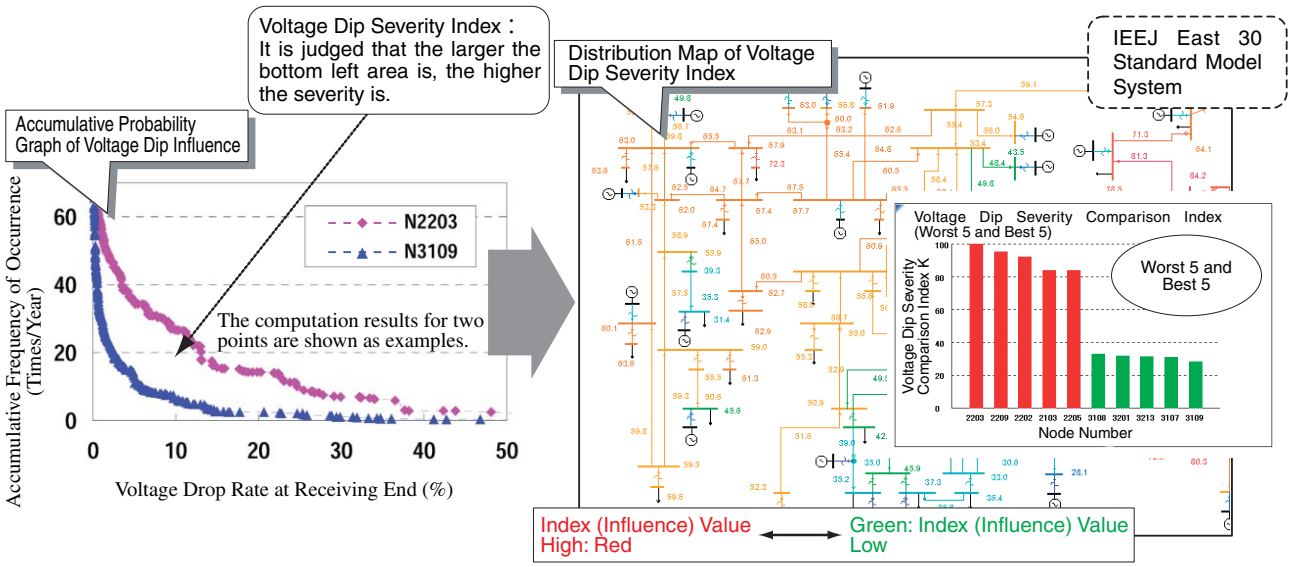

Fig.3 Study Analysis of Distribution of Voltage Dip Severity Index (Hazard Map)