Basic Technology Subjects

Electric Power Engineering Research Laboratory

Brief Overview

The Electric Power Engineering Research Laboratory is engaged in the advancement of fundamental technologies, including electrical insulation, lightning protection, high-voltage and high-current technologies for power transmission and distribution equipment. It is also developing next-generation power equipment and new electric power technologies such as laser, arc plasma and power electronics application.

Achievements by Research Theme

High-voltage and Insulation

We aim to clarify the deterioration mechanism of solid electrical insulation materials used in aged electrical equipment, advance external insulating technology for transmission lines, improve the accuracy of high voltage measurements and evaluate new insulation materials for next-generation power transmission and distribution equipment.

■The residual charge method with pulse voltages was improved as a diagnosis method for water tree degraded XLPE cables and applied to removed 6.6 kV XLPE cables. As a result, signals relating to water tree degradation were successfully measured and AC breakdown voltages of the removed cables could be estimated from the amplitude and duration of the signals. Therefore, this method is applicable to 6.6 kV XLPE cables in the field as a cable diagnosis method*1.

Lightning and Electromagnetic Environment

We aim to establish reasonable measures to deal with lightning damage and develop insulation coordination technology for power systems in an information-communications technology (ICT) society, as well as establish technology for electromagnetic compatibility (EMC) in power systems and consumer equipment.

■In order to locate the position of insulation deterioration points on electric power equipment, a system for locating the source of electromagnetic noise caused by spark discharge generated on insulation deterioration points was developed. The developed system is applicable for multipath environments, and can locate the position of the source with high accuracy (Fig. 1) (H12004).

■The concurrent flashover process of two parallel arcing horns*2 was observed by a highspeed camera for the purpose of clarifying multiphase faults on transmission lines caused by lightning. Based on experimental result, a relational expression was derived to estimate the concurrent flashover rate. Moreover, this result leads to improvement of the lightning outage rates program, "LORP" (H12012).

■A series of numerical calculation codes was developed to investigate compliance testing with existing guidelines limiting human exposure to several types of electromagnetic fields. These codes include: (1) a postured voxel-based human body model which simulates several exposure conditions of workers in a variety of postures, (2) a calculation code for internal electric fields induced by outer electric fields, and (3) a calculation code for SAR (specific absorption rate) caused by radio frequency electromagnetic fields (H12006).

Applied High Energy Physics

We aim to develop simulation methods of pressure rising and propagation characteristics to complement the internal arc testing of electric power equipment, as well as innovative measurement technologies using laser and optical technologies and to work on their application toward the diagnosis of power delivery apparatuses. We also develop plasma melting technology to reduce the volume of radioactive waste for disposal.

■When a fault arc occurs in electric power installations, the internal pressure rises steeply due to gas heating, which may cause severe damage to the installations and their surroundings. Reduction of the internal pressure rise is required to minimize damage. We clarified that it is brought about by the intentional melting and vaporization of copper or iron metal, which can be installed by a fault arc as a partition or similar inside the installation.

■The thermally grown oxide layer, which forms under the topcoat of thermal barrier coating (TBC) of gas turbine blades during operation, is one cause of topcoat delamination. A simple nondestructive inspection method to detect the thermally grown oxide layer was developed. This method is capable of rapid detection, and will enable effective maintenance of turbine blades by combination with precise delamination detection methods (H12011).

■In order to expand the application of plasma melting to the low radioactive solid wastes, the applicability of plasma melting method to the high melting points of wastes such as soil is clarified. We elucidate clarify the appropriate kind types and the additive amounts of flux to melt soil (H12008).

Electric Power Application

We aim to develop analysis methods for electric power quality and technologies for the design and management of reasonable electric power systems connected by power electric equipment by developing cooperating technologies with customer side equipment for improving electric power quality.

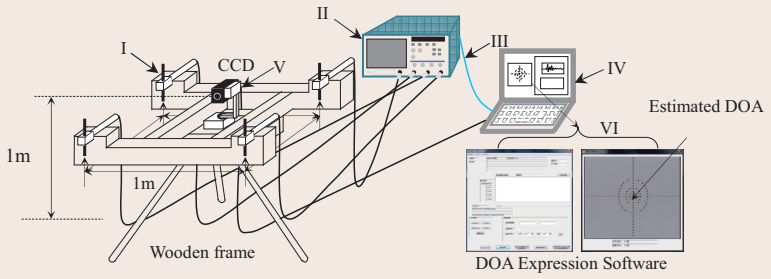
■We increased calculation speed of the Electromagnetic Transient Analysis Program for Power Systems (XTAP), by improving algorithms, and added a calculation menu of frequency response characteristics. Also, we made basic simulation models for switching transient overvoltage caused by switching operation of circuit breakers, which are very important in terms of the insulation design of power transmission lines (H12005).

High Current Technology

To estimate the performance of electric equipment when short-circuit faults occur, we aim to improve short-circuit test techniques and establish measuring techniques for frequency currents.

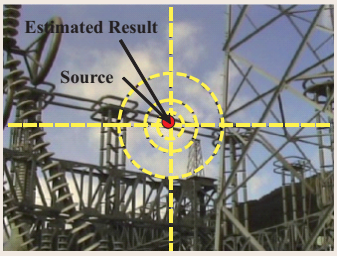
■The melting time of metal wires used for arc ignition in high power arc tests for investigating the short-circuit performance of electric equipment was calculated. The results showed that thin metal wires should be used to melt in a short time when transformers with cutout fuses are tested.

*1 Cooperative research with Chubu Electric Power Co., Inc.
*2 Arcing horns are attached to both ends of insulator strings to suppress the overvoltage across the insulator strings.
*3 DOA: Direction of Arrival.

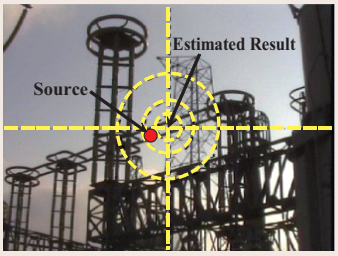


I. Receive waveforms on four dipole antennas (Center frequency: 500MHz)
II. Express the waveforms on oscilloscope (DC~12GHz, sampling rate 50GS/s)
III. Load waveforms on PC through LAN cable
IV. Estimate DOA*3 by using the developed program
V. Aim the camera automatically by the program command to the estimated DOA
VI. Display and record the picture

(a) Configuration of the developed locating system



(b) Example of location result (less interference on electromagnetic propagation path)



(c) Example of location result (much interference on electromagnetic propagation path)

Fig. 1: Configuration of the locating system and location results

(a) shows the configuration of the developed locating system. The system is composed of four dipole antennas, oscilloscope, PC and a CCD camera. The signals received by the antennas are sampled and processed by oscilloscope and PC. The position of the source can be located and displayed by the developed program and the camera. (b) and (c) shows the examples of location results. The red point is the position of the source, and the center of the circular broken line is the located position. It is shown that the position of source can be located with high accuracy whether less or much interference on the electromagnetic propagation.