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 high voltage technology, electrical insulation, lightning protection, electromagnetic environment and high current technology for power transmission and distribution equipment. It is also developing next-generation power equipment and XTAP (eXpandable Transient Analysis Program), simulation and application of arc, application of power electronics and lasers.

Achievements by Research Theme

High-voltage and Insulation

We aim to clarify the deterioration mechanism of solid type 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.

- We applied the residual charge method with pulse voltages to removed cross-linked polyethylene (XLPE) cables of the 60 kV class. The relationship between duration of degradation signal and AC breakdown voltage was clarified and the applicability of the method to 22 to 77 kV XLPE cables was confirmed.
- We applied condition assessment methods using SF_6 decomposition gases to actual gas insulated switchgears (gas section of gas filled bushing, disconnector, and bus-bar), and confirmed the applicability as fault detection method.

Lightning and Electromagnetic Environment

We aim to develop new technologies for lightning protection and insulation coordination that are applicable to the demand and supply system of electricity and energy in an information-communications technology (ICT) society. We also aim to establish the technologies for assessing the electromagnetic compatibility (EMC) and electromagnetic environment in power systems and consumer equipment.

- For the development of a new type of LLS (Lightning Location System) with the aim of establishing the lightning protection design with high accuracy for power systems and creating a method to efficiently detect lightning fault locations, we theoretically investigated and identified the cause of detection errors in the current LLS. As a result, it became clear that optimization of the sensor spacing enables creation of new LLS which is equipped with an acceptable detection error range of several-dozens meters (H14007).
- For the development of lightning protection measures for smart meters, the lightning performance of electronic watt-hour meters having a function equivalent to smart meters was evaluated with the lightning impulse tests. As a result, it became clear that lightning performance varies depending on the internal structure of electronic watt-hour meters. Based on the results obtained from the lightning impulse tests, we proposed a method for calculating the lightning failure rate of electronic watt-hour meters (Fig. 1). We suppose that a guidebook of lightning protection design for smart meters will be created in the near future (H14009).

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 to develop 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.

- Cost reduction of Fault Current Interrupting Arcing Horns (FCIAH) was achieved by reducing the number of interruption cores from the present two to one, through computational fluid dynamics to calculate the pressure distribution in the interruption core and a nozzle design to generate a supersonic flow. Moreover, strength enhancement of FCIAH was realized by appending pressure relief holes to suppress the pressure rise in the interruption core due to the arc heat (Fig. 2) (H14001).
- A portable system for nondestructive detection of the thermally grown oxide layer, which is a cause of topcoat delamination in thermal barrier coating (TBC) for gas turbines, was developed. Using this system, TBC specimens heated in the air were measured and emission, which is thought to result from high concentration of Cr^{3+}, was observed. This result showed the possibility of evaluating regions of the TGO layer with high Cr^{3+} concentration (H14006).

Electric Power Application

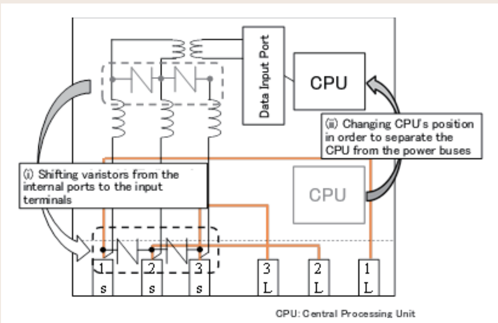
We aim to develop analysis methods for electric power quality and technologies for the design and management of reasonable electric power systems connected via power electric equipment by developing cooperating technologies together with customers for improving electric power quality.

- A frequency-dependent line model for electromagnetic transient (EMT) simulations based on the FDTD (Finite Difference Time Domain) method has been developed. This model does not require modal decomposition and has excellent numerical stability (H14013).
- An electromagnetic transient (EMT) simulation model of STATCOMs for distribution systems has been developed as countermeasure for the problem of voltage rise due to the spread of renewable energy. This model enables a dynamic voltage analysis which considered switching of power electronics equipment (H14014).

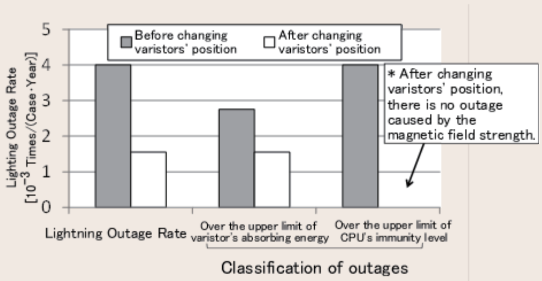
High Current Technology

To estimate the performance of electric equipment upon a short-circuit fault, we aim to improve short-circuit test techniques and establish measuring techniques for power frequency current.

- We investigated the fault conditions for which the rate of rise of recovery voltage on current interruption in power systems in Japan exceeds the values in JEC2300, the standard for high-voltage alternating-current circuit-breakers (CB), and clarified the range which the high power short-circuit test facilities of CRIEPI can verify the current interruption performance of CBs.



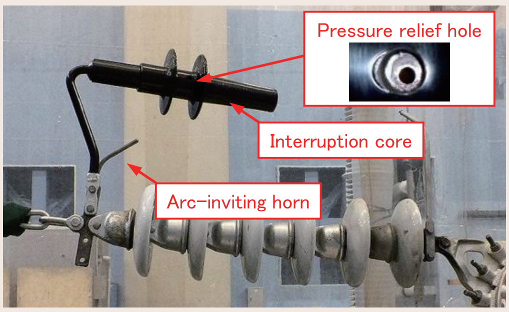
(a) Lightning protection measures using the position change of internal elements



(b) Evaluation of lightning outage rate for electronic watt-hour meters

Fig. 1: Lightning protection measures for electronic watt-hour meters and their evaluation results

We developed a calculation method of the lightning outage rate for these meters. In the calculation method, the lightning outage rate is calculated with the threshold of the lightning fault occurrence of meters obtained from the experiment. With the calculation method, we calculated the lightning outage rate of meters. Based on the results, we evaluated which lightning protection measure is most effective. As a result, the following became clear:
(i) Shifting varistors from the internal ports to the input terminals is effective for reducing the lightning outage rate of meters.
(ii) Changing the CPU's position to separate the CPU from the power buses is also effective for reducing the lightning outage rate of meters.



Breaking current and its iteration	Up to 7 kA three times
Current breaking time	Within an AC cycle
Explosion-proof current (*)	Up to 15 kA

(*) Maximum current which does not cause damage of the interruption core.

Fig. 2: High-strength type Fault Current Interrupting Arcing Horns for 77 kV overhead transmission lines

Strength enhancement of Fault Current Interrupting Arcing Horns was realized by increasing the explosion-proof current from the present 10 kA to 15 kA, through the installation of pressure relief holes to suppress the pressure rise in the interruption core due to the arc heat and an arc-inviting horn to reduce the damage to the interruption core by moving an arc generated by an excessive fault from the inside of the interruption core to the outside.