SUMMARY OF Ph.D. DISSERTATION

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Title

Advanced Modeling of a Distribution Line and Its Experimental Evaluation for Lightning Overvoltage Studies

Abstract

As the information society progresses, a variety of electronic appliances have come into wide use in common houses, factories, and buildings. If a lightning stroke causes faults or incorrect operations of these electronic appliances, a social economic loss is considered to be large. In order to prevent these lightning damages, lightning protection measures of a distribution system which connect the high-voltage distribution line to the consumers must be established based on lightning surge characteristics of the distribution system.

This dissertation presents lightning surge characteristics and modeling methodologies of components of the distribution system, which are an overhead distribution line, a service-drop wire, a watt-hour meter, a current limiter, and an interior-wiring cable. Finally, the distribution system is modeled for accurate lightning overvoltage simulations.

The contents of this dissertation are summarized as follows.

Chapter 1 describes the background, purpose, and contents of this study.

Chapter 2 presents lightning surge characteristics of a distribution line obtained by experiments using a reduced-scale distribution line model and an actual-scale distribution line. The surge impedance of a reinforced concrete pole is measured considering the effects of a ground wire, phase wires, and a lightning channel.

In Chapter 3, the experiments of Chapter 2 are simulated using the FDTD (Finite Difference Time Domain) method which is one of the numerical electromagnetic field computation methods and comparisons are shown to validate the application of the FDTD method. Secondly, the differences between calculated results by the EMTP (Electro-Magnetic Transients Program) and the FDTD lightning overvoltage simulations are clarified.

In Chapter 4, new EMTP models of the distribution pole and wires are proposed from the test results obtained in Chapter 2. The proposed models can reproduce the transient overvoltages at the insulators.

Chapter 5 presents test results of fundamental surge characteristics of service-drop wires and interior-wiring cables. A new modeling methodology of these wires and cables for accurate EMTP simulations is proposed through the obtained test results.

Chapter 6 presents lightning surge characteristics of a mechanical watt-hour meter and a current limiter obtained by field tests. Most of the lightning overvoltages at the consumer side are not affected by the electric characteristics of these appliances.

Chapter 7 proposes a new model of the distribution system based on the studies discussed in Chapter 4 to Chapter 6. The proposed model is evaluated by experiments using an actual-scale distribution line with a service-drop wire and an interior-wiring cable.

Finally, Chapter 8 describes the conclusions of this study.