B6.1

Study on diagnostic method for water treed XLPE cable by loss current measurement

YAGI Y., TANAKA H., MUTO H., KIMURA H., The Furukawa Electric Co. Ltd., Chiba, Japan

Résumé

L'endommagement des cables PR par arborescences d'eau donne naissance à des harmoniques dans les courants de pertes. La 3ème harmonique dans le courant de pertes est intimement liée à l'endommagement par arborescences d'eau. Elle prend naissance comme résultante du caractére non-linéaire de tension-intensité des arborescences d'eau. Il est possible de reproduire expérimentalement la forme de l'onde de courant de pertes à l'aide d'un circuit équivalent qui mime la non-linéarité des arborescences d'eau. On peut aussi reproduire le profil de la 3ème harmonique et le glissement de la phase de superposition. Lorsque des tensions de 50Hz et 100Hz sont appliquées à un isolant qui présente des arborescences d'eau, un signal endommageant de 200Hz prend effet par modulation réciproque. Par des simulations expérimentales, nous avons vérifié l'efficacité d'une méthode plus pratique, basée sur les propriétés non-linéaires des arborescences d'eau et mettant en oeuvre l'effet de modulation réciproque.

Abstract

Degradation of XLPE cables by water trees gives rise to harmonics in the loss current. The third harmonic in loss current is closely correlated with the degradation by water trees. It arises as a result of the nonlinear voltage-current characteristic of water trees. Through an equivalent circuit which takes the non-linearity of water trees, it is possible to reproduce the loss current waveforms obtained in experiments, including appearance of the third harmonic and shift of the superposition phase. When both of 50 Hz voltage and 100 Hz voltage are applied on a insulation with water trees, a degradation signal occurs at 200 Hz by mutual modulation effect. We verified the effectiveness of a more practical method utilizing the mutual modulation effect based on the nonlinear properties of water trees through simulations and experiments.

1. Introduction

Degradation by water trees is one of serious problems for XLPE cables. A number of diagnostic methods for 6 kV-class and lower cables have been developed, but they cannot be applied to 22 kV-class and higher cables. They were sufficient to detect signals from water trees which had bridged the insulation. But in 22 kV-class and higher cables, water trees are harmful even before bridging due to the greater operating stress, and so a more precise diagnostic method is needed. Water tree degradation acts to increase the current flowing in the insulator which is in phase with the applied voltage (the loss current). Observation of the waveform of this loss current yields interesting results. As water tree degradation advances, the loss current waveform becomes distorted by harmonic components. These harmonic components may contain more detail information about the water trees [1],[2].

We conducted a number of experiments to confirm the relation between water tree degradation and harmonic components in the loss current, and studied the mechanism of generation of harmonics by the equivalent circuit of the insulation with water tree. We also examined a more practical method of diagnosis utilizing the mutual modulation effect based on the nonlinear properties of water trees, and verified the effectiveness of the method through simulations and experiments.