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Space charge measurement in dispersive dielectrics

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Résumé

Les développements récents de techniques non-destructrices permettant la mesure des charges d'espace dans les diélectriques solides ont eu un important impact pour la compréhension de la formation des charges et de leur influence sur les performances électriques des matériaux isolants. Les méthodes, électroacoustique et de propagation d'onde de pression, sont deux techniques très largement utilisées par les instituts de recherche et les fabricants de câbles. Cependant ces techniques ne donnent pas une représentation exacte de la formation des charges d'espace dans le cas de matériaux dispersifs.

Dans cette publication, une technique de traitement du signal est proposée pour remonter à la distribution de charge à l'intérieur des échantillons dispersifs en considérant l'atténuation et les facteurs dispersifs des matériaux utilisés. L'éfficacité de cette technique a été démontrée sur des plaques de polyéthylène basse densité (PEBD) et de polyéthylène réticulé (PR).

Abstract

The recent development of techniques to measure space charge non-destructively in solid dielectrics has made a significant impact on the understanding of charge formation and its influence on the electrical performance of insulation materials. The pulsed electroacoustic method and the pressure wave propagation method are two techniques widely used by research institutes and cable manufacturers. However, the techniques do not give a correct measurement of the space charge formation when dispersive materials are considered.

In this paper a signal processing technique is proposed to recover the actual charge distribution within dispersive samples by taking the attenuation and dispersion factors of the material into account. The effectiveness of the technique has been demonstrated with space charge measurements on low-density polyethylene (LDPE) and cross-linked polyethylene (XLPE) plaque samples.

1. Introduction

Polymeric materials are being extensively used for the bulk insulation of underground high voltage power cables. Their electrical properties, such as conduction and breakdown, can be strongly influenced by the presence of trapped charge. Electric stressing of the material can result in charge injection and trapping which may lead to space charge formations that significantly alter the internal electric stress distribution from anticipated or design values. This in turn can lead to further stress enhancement resulting in the premature failure of the insulation.

An important advance in the study of space charge phenomena has been the development of techniques to measure it non-destructively in dielectric materials (electrets [1] or insulators [2]) subjected to an electric stress. These modern techniques make use of ultrasonics to obtain the charge profile in the dielectric sample. They can be divided into two groups in terms of how the acoustic wave is generated. With the pressure wave propagation (PWP) method [3,4], an acoustic wave is induced externally either by a piezoelectric device or by a laser. It travels through the sample displacing any apparent charge, resulting in a variation in the induced charges on the electrodes which produce a short circuit current in an external circuit. The pulsed electroacoustic (PEA) [5-7] method, where the acoustic waves are induced internally by charges stimulated in the sample under an applied voltage pulse, are detected by a piezoelectric transducer that converts them into an electrical signal. Detailed descriptions of the PWP and PEA techniques are published elsewhere. However, a detailed treatise of the results from the two methods for dispersive materials has not been fully achieved.

In the present paper a signal processing technique is proposed to recover the actual charge distribution within dispersive samples by taking the attenuation and dispersion factors of the material into account. The effectiveness of the technique has been demonstrated on measurements for low-density polyethylene (LDPE) and cross-linked polyethylene (XLPE) samples.