A finite-element-based reverse identification of DC conductivity based on leakage current measurements on miniature cables

Adrien **CHARMETANT**, Dimitri **CHARRIER**, Jean-Hugues **DOUMBE**, Arnaud **ALLAIS**; Nexans, Lyon, France,
adrien.charmetant@nexans.com, dimitri.charrier@nexans.com, jean-hugues.doumbe@nexans.com,
arnaud.allais@nexans.com

ABSTRACT

DC leakage current measurements on miniature cables are presented. Two approaches are proposed to deduce the DC electrical conductivity of the tested insulation material from these measurements: one approach based on an assumed electric field value in the insulation, and a coupled LMA-FEM approach which does not require this assumption. It is shown that using a-priori electric field values leads to significant mistakes on the identified DC conductivities, which can lead to underestimated DC conductivities.

KEYWORDS

HVDC, leakage current, electrical conductivity, finite-element simulation

INTRODUCTION

In the context of the land power transmission, the technology of direct current at high voltage (HVDC) offers many technical and commercial advantages over AC technology [1].

The electrical conductivity and its variation with temperature, electric field and by-products content are of key importance to assess the stability and the performance of an HVDC insulation system in rated condition and in test condition according to CIGRE recommendations.

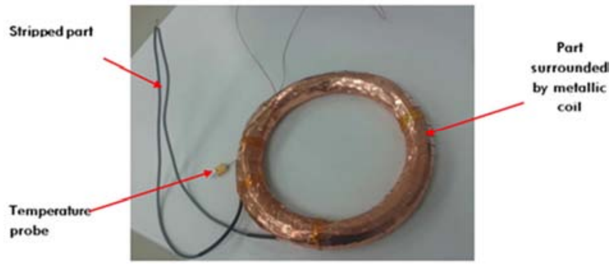

Fig. 1: Miniature cable coil used for leakage current measurements

This paper presents how the measurement of leakage currents through miniature cables insulations has been optimized to avoid biases due to surface currents coming from the termination.

In order to estimate the electrical conductivity from these measurements, two approaches are then proposed. The first approach uses a-priori assumption of the electric field distribution in the miniature cable. The second approach, more complex but also more versatile, does not need this assumption as it uses a coupling between an optimization algorithm and a finite-element model. It is shown how sensitive the results are to the reverse identification used.

LEAKAGE CURRENT MEASUREMENTS ON CABLES

Neither the electrical conductivity of a material nor the electric field distribution in a sample can be directly measured. Therefore, the law describing the electrical conductivity as a function of the electric field and the temperature must be calculated from current, voltage and temperature measurements.

A measurement methodology of leakage currents through the insulation in a miniature cable has been reported [2]. The inner and outer semiconductor radiuses are 1.4 mm and 2.9 mm respectively. In this method a 30-meter long coil of miniature cable is used (see Fig. 1). Using such a large length allows obtaining accurately measureable currents. This coil is surrounded by a copper tape which collects the current flowing through the insulations.

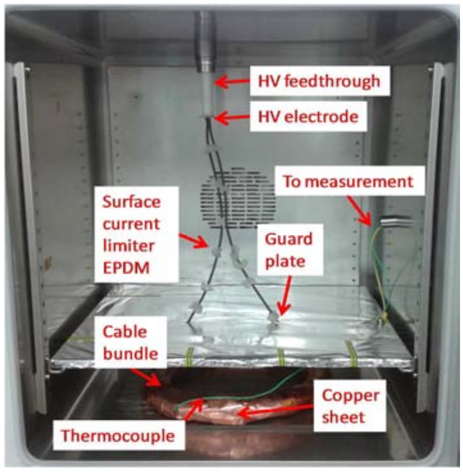

Fig. 2: Picture of the leakage current measurement bench

As shown in Fig. 2, the leakage current measurement consists in applying a high voltage (HV) in the conductor of the cable and to ground its outer semiconductor which is covered by a copper sheet. The sheet is connected to the electrometer used as an ammeter. A LabVIEW interface allows driving these equipments and acquiring data. An oven is used, and a thermocouple probe is placed inside the cable bundle to monitor its temperature.

An equivalent schematic of the electrical part of the bench is showed in Fig. 3. As dynamic en transient phenomenon can take place during measurement, the cable is represented by a capacitance in parallel with a resistance that we want to estimate.