DEVELOPMENT AND OPTIMIZATION OF A PULSED ELECTROACOUSTIC SYSTEM SUITABLE FOR SILICONE RUBBERS WITH CARBON BLACK NANOFILLERS

Rashid **HUSSAIN**, Julian **MOXTER**, Volker **HINRICHSEN;** Technische Universität Darmstadt, High-Voltage Laboratories, (Germany), hussain@hst.tu-darmstadt.de, moxter@hst.tu-darmstadt.de, hinrichsen@hst.tu-darmstadt.de

ABSTRACT

This work presents the complete procedure to develop a PEA setup suitable to investigate silicone rubbers (LSR). Special attention was paid to the optimization of the acoustic coupling and the pulse generator to optimize the investigation of LSR samples. A line transmission pulse generator is used with an impedance-matching circuit. The important steps to develop such a circuit are described in detail. The measured voltage signal is translated into the charge density by proper signal processing. The attenuation and dispersion factors of LSR with and without Carbon Black (CB) nanofillers are determined and used for the final calibration process.

KEYWORDS

PEA, HVDC, LSR, cable joints, space charge, nanofillers, carbon black, attenuation, dispersion.

INTRODUCTION

Nowadays, high voltage direct current (HVDC) power transmission is becoming very important for bulk power transmission over long distances. Especially HVDC cable lines are attractive for crossing wide metropolitan areas or long distances in the open sea [1]. But still there are several challenges for proper functioning of HVDC cable systems. Especially the insulation material used in such systems must be adequately designed for HVDC operation. As the use of extruded cable systems is still increasing since the last decade especially the insulation materials used in such systems, mainly XLPE, is part of actual research [1, 2]. Problem of polymeric materials under HVDC stress is their tendency of space charge accumulation inside the material, which can increase the electric field and, in some cases, lead to an electric breakdown. There are two main mitigation strategies: using very clean materials to avoid the presence of defects (traps), which are the main reason for space charge development, or to insert nanofillers that act as deep traps and can help modifying the space charge behaviour as desired [1,3,4]. The weakest point in a cable system is always the cable joint, where different materials at boundary layers can cause high tangential electric field stress. Regarding the cable insulation, numerous publications exist reporting on the space charge behaviour of XLPE with and without nanofillers [1,3,4]. Just very little has been published on the materials used for cable joints, which is preferably silicone rubber (LSR) because of its outstanding mechanical and electrical properties. Nowadays the most commonly used technique for space charge measurement is the pulsed electroacoustic method (PEA) [5, 6]. Especially for silicone rubbers several requirements on the PEA setup itself and on the signal processing must be considered. The aim of this paper is to present a PEA setup suitable for the investigation of silicone rubbers and an appropriate signal post processing method. In addition, the focus is put on several important components like the pulse voltage generator or the issue of electromagnetic interference caused by the pulse voltage generator. Moreover, the mounting of the PVDF transducer and the associated acoustic detection unit are outlined in detail.

PULSED ELECTROACOUSTIC SYSTEM

In this chapter the most important components and the general operating principle of a PEA system are described.

General Setup

The general measurement setup of the PEA system will be explained using Fig. 1.

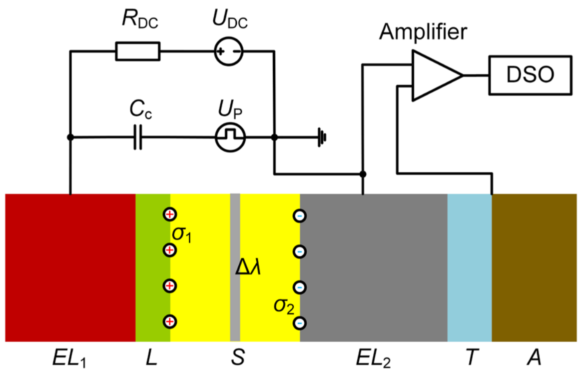

Fig. 1: General setup of a PEA measurement system

In Fig. 1 a schematic of the general test setup is shown including the sample (*S*) placed between two electrodes (EL_1 and EL_2). On the backside of EL_2 a piezoelectric transducer (*T*) is mounted to transform the acoustic waves into a voltage signal. To avoid reflections the system has a conducting acoustic layer (*L*) between EL_1 and the sample and an acoustic absorber (*A*) on the backside of the transducer. The signal of the transducer is amplified and then analyzed with a digital storage oscilloscope (*DSO*). To polarize the sample a DC voltage source is connected to the electrodes EL_1 and EL_2 with a series resistor R_{DC}. Due to the DC voltage charge layers σ_1 and σ_2 are induced at the interfaces between the electrodes and the sample. Depending on the sample properties charge layers $\Delta\lambda$ can build up inside the sample. To generate acoustic waves from all the mentioned charge layers that can be detected by the piezoelectric transducer a pulse voltage generator is connected in parallel to the sample with a coupling capacitor C_c (see Fig. 1). For the pulse voltage C_c behaves like a short-circuit, and U_p is applied to the sample. With regard to the DC voltage, C_c exhibits a very high impedance, and U_p is protected against U_{DC}. The requirements on the other important components like the thickness of the electrodes and the absorber or the dimensioning of the coupling capacitor C_c are explained in detail in the following section [4, 7, 8].