Weak current measurement for the assessment of the insulation degradation of high voltage cables

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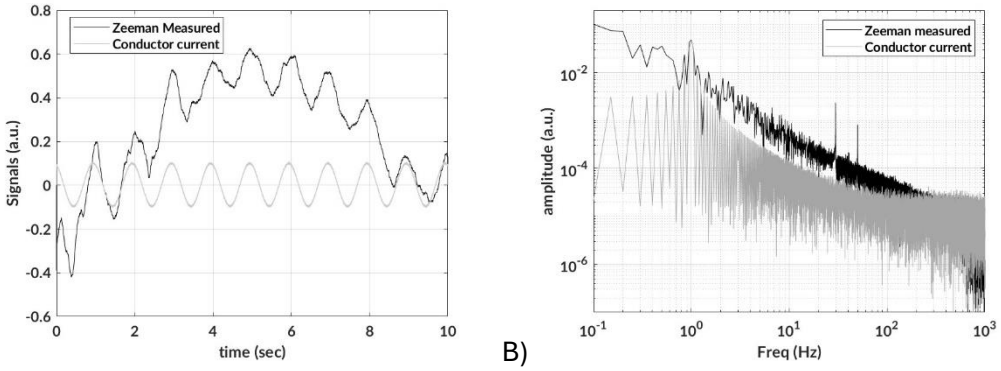
As the High Voltage Direct Current (HVDC) cables constitute the backbone of the newly developed power transmission systems based on renewable energies, it is becoming increasingly important to monitor the integrity of these cables. Here, we propose to monitor the degradation of the cable insulation performance by measuring the current passing through the cable insulation layer, commonly called leakage current [1]. Given the need for a sensitive and galvanically isolated sensor, the current measurement prototype is using a magneto-optical technique, the Zeeman Effect. The prototype is briefly described hereafter. The source, a tunable laser diode, is locked off resonance at a close frequency corresponding to the D2 transition of Rubidium, the alkali used to generate the Zeeman Effect. The laser beam is launched into an optical fiber to transport the light to the probing area. Back into free space, the light is linearly polarized before probing the magnetic field in 2 Rubidium-filled cells. The cells are placed on each side of the conductor that induces the magnetic field to be measured: this configuration helps cancel out the ambient magnetic field (hypothesized to be homogeneous in the probing area). Balanced polarimetry is used to quantify the polarization rotation angle of the output light. The 2 output beams are then launched into optical fibers for remote detection on 2 paired photodiodes. The photodiodes are connected in a head-to-tail configuration to a transimpedance amplifier (TIA) circuit in order to amplify the differential current. Figure 1 shows the filtered temporal signal and its FFT acquired for a 4 mA reference current at 1 Hz. The next step is to improve the signal-to-noise ratio to reach a sensitivity of 1 mA.



A) B)

Figure 1. A) Measured signal and B) its FFT for a reference current peak to peak of 4mA (@1 Hz); TIA gain = 10 MV/A

[1] L. Boyer, P. Daniel, M. Henriksen, X. Festaz, Current measurements on HVDC XLPE model cable during type test Proceedings IEEE 4th International Conference on Dielectrics (ICD), 150-153 (2022).