ETH
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Swiss Federal Institute of Technology Zurich

High Voltage Laboratory
Head: Prof. Dr. Christian Franck

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Semester project for: Aron Philipp
Group project for: Leonard Deuschle
Supervisor: Raphael Färber
Title: Feasibility study on the use of current transformers in high-voltage dielectric spectroscopy

Description:

Mixed-frequency voltages are characterized by kV pulses of high slew rates (>10 kV/µs) and high repetition frequency (>1 kHz) superimposed to a low-frequency (50 Hz) or dc bias of tens of kV. The resulting electric field stress has been shown to lead to accelerated aging and premature failure of various high/medium voltage insulation systems. While enhanced partial discharge activity and enhanced dielectric heating have been identified as increased aging factors under mixed-frequency stress, low-level degradation below partial discharge inception and corresponding failure modes are to a large extent unexplored yet of great practical importance to assure the long-term stability of insulation systems exposed to this kind of stress (e.g. Solid State Transformers).
The complex dielectric permittivity is an interesting aging marker for insulators exposed to mixed frequency stress, as it can potentially be determined while stressing the specimen and, due to the broad-band signal content, it is accessible for a range of frequencies simultaneously (a number of harmonics of the pulse). A major challenge of a multiharmonic dielectric setup operating under high voltage stress is the handling of test object breakdown. The use of a current transformer is promising in this respect as it is galvanically isolated from the high voltage. It is not clear however whether the relatively low polarization currents (≤1mA/harmonic component) through our test objects can be acquired precisely enough to achieve the measurement precision required for resolving values of tanδ down to 10^{-3}.
This semester project seeks to answer this question by direct experimental tests with a low voltage dielectric setup using an off-the shelf current transformer (CT) (Pearson™ 2877). Pulse parameters can be adjusted by use of an arbitrary waveform generator to simulate the actual currents encountered in the high voltage test cell. A lumped Debye circuit model (C_0 || R-C || R_∞) will be used as a variable test object.

Definition of tasks:

- Determination of specimen capacitance as a function of electrode separation by using COMSOL, and determination of proportionality factor (magnitude of permittivity) by direct optical distance measurements.
- Dimensioning a protection/attenuation/pre-filter box between CT output and the filter/voltage amplifier input.
- Dimensioning a small test bench holding the Debye equivalent circuit elements (capacitors/resistors -> should be easily exchangeable) and the current transformer.
- Dimensioning a capacitive voltage divider with pre-resistor to measure the “high voltage” and pre-filter it.
- Assess the protective clamping capability on discharge currents simulating test object breakdown currents.
- Measuring current/voltage waveforms for various excitation voltages and determine the complex dielectric permittivity of the Debye network (the digital signal processing is already implemented). Assessing performance and resolution limits. Using results to improve the units dimensioned above.

Prof. Dr. Christian Franck Supervisor Students

Head High Voltage Laboratory Group

Timetable:

Start of work:

Intermediate presentation:

Final presentation:

Deadline delivery final report: