Localization and recognition of PD defects in power cables with extruded insulation

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ABSTRACT

This paper deals with partial discharge measurements and localization on power cables with extruded insulation. It describes the measuring procedure that can be used to accurately localize PD defects within the cable insulation. An enhanced trigger method for the unfiltered scope, based on the filtered phase resolved partial discharge pattern, as well as different advanced localization methods, such as statistical time domain reflectometry and statistical time-of-flight are proposed. Measurements are performed in the factory on short lengths of power cables with simulated defects and on longer lengths with defects originating from the manufacturing process.

KEYWORDS

power cable, extruded insulation, routine testing, partial discharge measurements, partial discharge defect localization, time domain reflectometry, time-of-flight.

SCOPE OF THE PAPER

The scope of the paper is to highlight the partial discharge (PD) localization procedure used in the factory during routine testing of power cables of different lengths with extruded insulation. PD localization methods based on time domain reflectometry (TDR), time-of-flight (ToF) and statistical approaches (sTDR, sToF) are proposed. The paper highlights a trigger method for the unfiltered scope view based on a selection in the filtered phase resolved PD (PRPD) pattern. Limiting the frequency content of the Scope View to certain frequencies in post processing can further improve the signal quality.

The PD localization methods are evaluated during measurements on 20 kV power cables with different lengths and defects. A knowledge database was started by simulating typical defects and expanded as well as compared with the results of cables failed during the routine test.

KEY FEATURES OF PD MEASUREMENT SYSTEM

A state-of-the-art PD measuring system with advanced hardware and software features is used for tests and PD data evaluation. It ensures the highest sensitivity when it comes to PD detection as well as minimizes the impact of negative super position errors [1]. Settings might be changed from the standard compliant values once PD activity is detected to significantly improve the accuracy of the individual PD localization methods. Figure 1 shows the default view of a PD measurement, where signals can be analyzed in the unfiltered time (*Scope Window)* and frequency domain (*FFT Window*), as well as in the bandpass filtered and quasi peak integrated PRPD pattern (*PRPD Window*). The PRPD pattern represents the single events in the selected measuring frequency range with a double pulse resolution mainly influenced by the selected filter bandwidth. Beside the PRPD pattern, the apparent charge Q_{IEC} is typically used to assess whether the measurement has passed or failed the test.

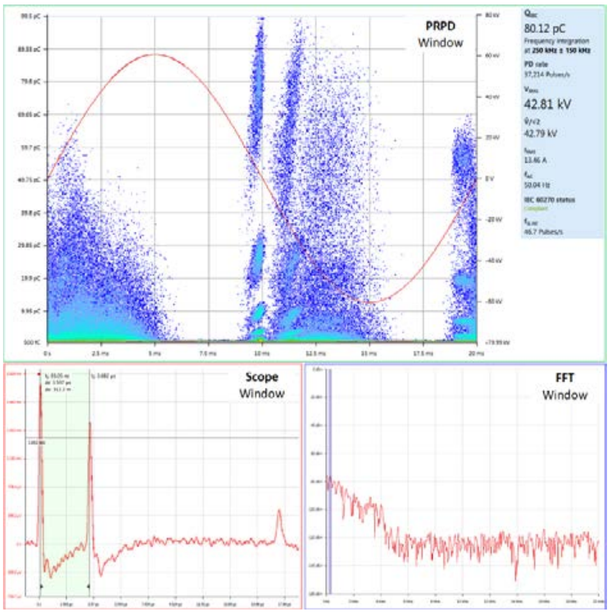

Fig. 1: PD analysis in time and frequency domain as well as the filtered PRPD pattern.

The *Scope Window* of the PD measuring system used represents the unfiltered input signal with a resolution of 2 ns and a refresh rate of 41 ms in case the trigger conditions are fulfilled. The system can be used for localizing PD on power cables based on TDR as well as ToF, where the signals are decoupled at different locations along the test object.

PD events occurring in the insulation of a power cable will lead to induced current pulses on the inner and outer conductor of the cable and will propagate in both directions. At the point of the origin, these signals can contain frequencies up to several tens or even hundreds of megahertz. At the point of measurement, the frequency content of the pulse can however strongly be reduced due to attenuation, dispersion and reflections.

Using ordinary trigger methods, such as edge or peak trigger where a threshold must be set in the time domain, does not allow a correlation between the filtered PRPD and the unfiltered scope signal. Noise signals close to the measurement points can strongly limit the ability to trigger on the event of interest using such trigger methods.