Sensitive and selective partial discharge measurement method for DC and AC cable joints

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ABSTRACT

In this paper a PD measurement method for high voltage cable joints is presented that allows very sensitive and selective PD measurements with a high certainty in discrimination/separation of PD from a joint and external PD or disturbance pulses. The basic principle, the additional assembly steps for application on joints, some examples of results and considerations for usage for in-service joints are presented. Especially for DC PD measurements the usage of the method presented is reasonable due to low PD repetition rates and the lack of proper discrimination methods under DC voltage stress.

KEYWORDS

Partial discharges, DC PD measurement, HVDC cable, HVAC cable, joints, laboratory PD measurement

INTRODUCTION & MOTIVATION

Partial discharge (PD) measurements on cable accessories can be used for an evaluation of the assembly quality and/or the insulation condition by means of identifying defects and weaknesses in the insulation that result in PD occurrence. For a convenient and reliable evaluation one has to be very certain about measured pulses actual are coming from the device under test (DUT). Thus the correct discrimination between relevant PD from the DUT and all other pulses, e.g. external PD and/or disturbances, is absolutely necessary. With AC voltage the visual interpretation of Phase Resolved Partial Discharge (PRPD) pattern diagrams can give information about measured pulses are more likely being PD or disturbances – e.g. from nearby power electronics – as well as about the type of the defect [1]. But often it is quite hard to be sure about an actual PD source location just looking at the pattern, in particular because most of the times there are several pulse sources (internal and external PD, disturbances) live during a measurement which results in superposed pattern hard to analyze. Thus the first and most important step of a sufficient PD measurement is to separate relevant PD from all the other pulses. Besides some common methods/tools as time-of-flight analysis, 3PARD, 3CFRD and several more [2], an usage of clever measurement methods can make a correct and solid interpretation of testing results possible.

Under DC voltage stress the task of reliable PD measurements is much more complicated. Without an adequate ripple component of the DC voltage there is no correlation of the PD appearance to a voltage phase, thus an analysis of PRPD pattern is not applicable. The PD repetition rate under DC voltage can be expected to be much lower than under AC voltage. The fig.1 and fig.2 show two DC PD measurements that illustrate such low repetition rates. Figure 1 shows the PD activity of a pre-initiated tree in DC XLPE that is stressed with a constant DC voltage of -75 kV. 69 PD pulses larger than 2 pC occurred during tree propagation until the breakdown of the sample occurred after around about 9 h.

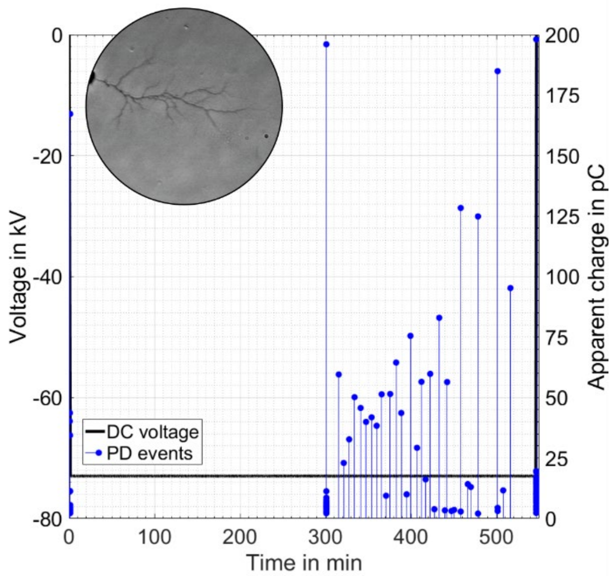

Fig. 1: PD activity of a pre-initiated tree in XLPE under DC voltage stress. With beginning of occuring PD the tree propagates until the samples breakdown.

The fig.2 shows the PD repetition rate of an artificial defect (a cut in the cable insulation) inside a cable joint. As can be seen the PD repetition rate is quite low, lower than 35 PD/min for PD larger than 5 pC. For PD with larger apparent charges the repetition rate is even lower, e.g. less than 10 PD/min occur with charges larger than 50 pC. Both these examples as well as DC PD measurements on 320 kV DC-joint, published in [3], show that in DC PD measurements on polymeric cables there may occur much less PD pulses compared to AC. Thus it can be considered to be even more important to detect and identify each PD pulse correctly, even when several PD sources and/or disturbances are superposing (in particular on-site).

So it is quite important to use PD measuring methods that give reliable information whether the measured pulse is a PD from the DUT or not. For cable joints some approaches have been made in the past which mainly use PD pulse couplings on both sides of the joint using High Frequency Current Transformers (HFCT) and a comparison of the pulses polarities. By comparing the polarity on the left side of a joint with the polarity on the right side it is possible to decide whether the pulse originates inside or outside the joint. Such approaches are kind of directional couplers and can be used in two ways: The HFCT can either be mounted in the earthing leads (copper screen wires) [4] or around the inner conductor, the insulation and the outer semi-conductive layer [5]. The former measures pulses in the screen connections of the cable, the latter measures pulses on the inner conductor. The latter may be less disturbed but obviously for large cable diameter it is not possible to mount a common HFCT around it. There is also an approach using sensors on the outer-semi conductive layer [6]. The most sophisticated method are combinated capacitive and