SENSITIVITY ASSESSMENT FOR PARTIAL DISCHARGE MEASUREMENTS ON SOLID DIELECTRIC TRANSMISSION CABLES

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ABSTRACT

Over the last decade, partial discharge testing has gained acceptance as a valid diagnostic tool for condition assessment of cable insulation. As a result, PD testing has become the corner stone of most asset management programs. However, the results obtained from a partial discharge test depend not only on the conditions under which the test was performed but also on the test equipment it self including the type of sensor used and its location. The issues related to attenuation and dispersion of partial discharge pulses is well known. For testing long lengths of cable, performing a terminal measurement is often not possible. Still, such tests are performed on long lengths of transmission class cable with claims that sensitivities of down to 5pC can be achieved. This paper provides a brief review of partial discharge detection, signal propagation and discusses so called calibration procedures. As well, this paper also presents a framework for a model providing a meaningful sensitivity assessment prior to performing a partial discharge test. Data acquired on different classes of transmission class circuits is presented.

KEYWORDS

Partial Discharges, Pulse Propagation, Calibration, Sensitivity Assessment.

INTRODUCTION

Partial discharges occur in the bulk of high voltage insulation materials where local electrical field conditions are sufficiently high to sustain PD activity. In the case of extruded cables (EPR or XLPE cables) partial discharges typically occur in cavities at the conductor shield, cavities in the insulation due to shrinkage or gas-formation, near defects in the insulation shield, near loosely bound solid particles in the insulation, at protrusions, at splinters or fibers or near contaminants in the insulation shield. In cable joints or terminations, partial discharges typically occur along dielectric interfaces, along stress interfaces, in cavities near the conductor or insulation shield due to, for instance, misalignment during installation or thermal movement as a result of normal operation. Finally, partial discharges may also occur within the cable insulation itself around mechanically degraded spots and or impurities resulting in the formation of electrical trees.

Partial discharges are a high frequency phenomenon. Fundamentally, whenever a partial discharge occurs internal to a cable section or a cable joint, high frequency currents are induced in both the cable core and the cable shield. The magnitude of a measured partial discharge signal depends partly on the magnitude of the partial discharge current itself, i.e. the higher the actual partial discharge current the higher the induced currents, and partly on the radial proximity of the partial discharge location relative to the cable conductor, i.e. the closer to the cable conductor, the higher the induced current on the conductor [2, 3]. The specific relationship between the induced partial discharge current and the actual discharge current it self may be evaluated by the λ- function [2, 3]. The frequency of the induced partial discharge current is similar to the frequency of the actual partial discharge current itself. The frequency of the partial discharge current itself depends on path and velocity of the partial discharge (avalanche) itself. Consequently, the frequency depends primarily on (1) the strength of the electrical field (the higher the strength of the electrical field the higher the velocity of the avalanche itself, the faster the rise time of the PD current and the higher the frequency of the PD current) and (2) the size of the void relative to the direction of the electrical field (the longer the void, the longer the duration of the PD pulse, the longer the rise time of the PD current and the lower the frequency of the PD current).

In addition, as the induced PD currents propagate through the cable towards the cable ends, they are subjected to attenuation and dispersion. In other words, the magnitude and main frequency component of the currents decrease with increasing travel length. The further an induced PD current travels before being detected, the lower the magnitude and the lower the frequency content.

It can thus be intuitively seen that for shorter cable runs induced currents as a result of partial discharge activity may be readily detected via a terminal measurement, i.e. via a capacitive or inductive sensors connected to the conductor or shield at the end of a cable. For longer cable runs, dispersion and attenuation will prevent the measurement of inducted currents related to PD activity occurring from the opposite cable and thus a distributed PD measurement must be performed. A distributed PD measurement refers to the scenario where sensors are connected to joints and splices throughout the length of the cable.

A key step to assess when a terminal PD measurement is sufficient and when a distributed PD measurements is required. To assess this, a meaningful sensitivity assessment must be performed.