Optimized test setup and decoupling strategy for onsite pd measurements

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ABSTRACT

The advantages of pd measurements have led to a frequent implementation into after-installation AC-tests for high voltage cable systems. Both the technology for providing the test voltage and the pd measurement devices and techniques have undergone a constant improvement process. However, a main aspect of improvement is often left unconsidered: Optimizing the existing and field-tested equipment with adequate arrangements at the test site can increase the sensitivity of the measurements greatly. To achieve this, the measurement frequency has to be taken into account as well as high voltage and earth connection components including their dampening characteristics.

KEYWORDS

Partial discharge measurement, frequency, dampening, high voltage cable, after-installation, testing, calibration

INTRODUCTION

Onsite pd measurements differ from measurements at a laboratory in the conditions and influences that cannot be controlled in a technological and/or cost efficient way. Therefore, some adaptions are needed and current practice. Adapting to onsite conditions can be realized with equipment consisting of hardware / software and experience. While it is a matter of course to use the newest proven and tested equipment, the qualification and experience of the personnel is from the tester's point of view much more difficult to build up and harder to prove to the client. The responsible test engineer always has to find a compromise between optimizing the setup and following the time schedule. There is no use to prepare a highly optimized test setup if the measurement would be undisturbed and sensitive anyway – which takes experience to estimate. Also, there are no exact values for pd measurements during a high voltage test that a client could use to evaluate. The test setup not only comprises of physical components but also the configuration of those and the right software settings. This leads to a wide range of potential improvements. The essentials of IPH's gathered experience in this field are given in this paper.

FREQUENCIES

To perform a sensitive pd measurement on high voltage cables onsite, it is necessary to leave the frequency range of IEC 60270 because of various influences from the surrounding, that might overlay pd resulting from the test object. A lot of after-installation tests take place at substations where other cable systems / overhead lines are already online. At power plants or facilities, large equipment near to the test site might be in use. Even railway lines could produce disturbances at frequencies in the range of IEC 60270. Avoiding those external influences is essential to achieve a low ground noise level. Another aspect can be pulses from the voltage source itself, depending on the technology used to generate the test voltage. Still, it is not an option to raise the measuring frequency until every disturbance is eliminated. Every part of a test setup shows innate transmission behaviour for pd pulses. Also, the test object itself has to be taken into account when raising the frequency. Along a cable, any occurring pulse is undergoing a dampening. Setting the frequency too high can lead to an incapability of detecting pulses originating from a distant source along the cable. In addition, the frequency range of any decoupling device has to be met. Common practice is using high frequency current transformers (HFCT) at the screen wires, which provide nearly linear transmission characteristics up to a few MHz. Therefore, a frequency setting slightly above most disturbances should be chosen. Not taken into account is the fact that some disturbances could occur initially during the measurement and might require further adaption of the settings. This would be the case if devices close to the test setup are switched on or transmission lines, bus bars and other parts at a substation are being connected. Especially on short cables (a few hundred meters or below) it can be difficult to find a suitable frequency even when considering all described aspects. Because of the shorter distance a pulse can be reflected more often at the terminations and travel back along the cable before being damped below recognition. This can lead to a fast fourier transformation (FFT) with many local maxima and minima, as shown in figure 1.

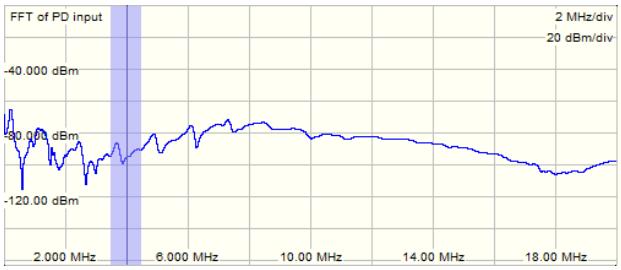

Fig. 1: FFT during pd calibration on short cable

Under certain circumstances, setting the measuring frequency onto such a peak can result in overrating pulses, if original pulse and reflection are superposed. The opposite might also occur, when original pulse and reflection erase each other partly. Optimization regarding the described aspects starts with the test setup, followed by calibration and interpretation during the high voltage test and pd measurement.

To avoid disturbances and localize pd sources, ultra high frequency (UHF) can be used. This is a well suited solution for transformers and gas insulated switchgear. On the other hand, at high voltage cable system these measuring frequencies have a disadvantage: Due to the extreme dampening it is not possible to oversee the whole cable length. With UHF, decoupling pd signals is possible only up to a few meters from the pd source.