PD Characteristics under the Aspect of Different Voltage Wave Shapes and Frequencies

Daniel **GOETZ**, Hein **PUTTER**, Frank **PETZOLD;** Seba Dynatronic, Germany, daniel.goetz@megger.com, hein.putter@megger.com , frank.petzold@megger.com

Marco **STEPHAN**, Sacha **MARKALOUS**; Hagenuk KMT, Germany, marco.stephan@megger.com, sacha.markalous@megger.com

ABSTRACT

The authors want to introduce the different voltage wave shapes which are currently used for offline partial discharge diagnosis and their impact on partial discharge parameters. A literature survey gives a brief overview among several respective recent and past publications. The main scope of this paper is about the influences of the frequency of the test voltage on partial discharge defects. Selected case studies were used to prove the effects.

KEYWORDS

Partial discharge, PD Diagnosis, Damped AC, Very Low Frequency for PD Diagnosis, PDIV, PDEV, condition monitoring.

INTRODUCTION

Partial Discharge (PD) testing has become a well established method for condition monitoring and quality control of medium voltage cable systems. Different voltage wave shapes are internationally accepted and used for localizing partial discharge defects. Each voltage wave shape has individual advantages and drawbacks. This is one of the reasons why in the utility world almost all types could be found, simply because they were selected by application situation. It is a given fact, that comparison between results regarding partial discharge characteristics has been a central research subject in several publications.

VOLTAGE WAVE SHAPES

The following voltage wave shapes are known and successfully applied in terms of partial discharge measurements.

Damped AC (negative and positive charging)

The damped AC (DAC) voltage wave shape is generated by a constant ramp up of the voltage, which could either be of positive or negative energizing voltage. The charging time depends on the load capacitance of the test object and the power of the used voltage sources. Common available systems use a powerful source and are able to charge up a capacitance of 2µF within a couple of seconds. When the required test voltage is reached a thyristor switch (used in most cases) closes and creates a resonant circuit, which is composed of a fixed inductance and a capacitance. The named capacitance is divided in the capacitance of the test object, a cable e.g. and the supporting capacitance. An additional supporting capacitance limits the oscillating frequency of the voltage. The oscillating frequency is maintained in a range between 20 Hz to 400 Hz, even if low test capacities, e.g. a 1m cable or a joint are tested. The losses of the resonance circuit, which are determined by losses of the test object and losses of the test system, lead to the attenuation of the oscillating voltage. The voltage gets damped. The damped AC voltage is non-continuous in its application. After each excitation of DAC, the stress for the test object decays out within a certain time. The decay time depends on the losses in the resonant circuit. It could be named as “shot based” wave form. The fact, that the stress is non-continuous, qualifies the voltage wave shape as a non-destructive diagnostic test voltage.

Currently there is a working group finalizing the IEEE 400.4 “Guide for field testing with damped AC”. DAC systems up to 400kVpeak for testing and diagnosis of both MV and HV are commercially available.

0.1 Hz VLF Cosine rectangular (VLF CR)

The VLF CR is generated by a circuit containing a HVDC power supply **U** (positive and negative), an auxiliary capacitor **C**, a thyristor controlled switch **S**, a choke **L** and a toggle switch with a zero position **W**. Figure 1 shows the block diagram of a VLF CR unit. One of the substantial advantages of the CR technology is its capability to store and recover the energy required to charge the cable via the choke during the polarity reversal of the voltage. It is capable to recover about 80 to 90% of the stored energy of the cable, which is available to charge the cable in the opposite polarity during the next half cycle. This concept allows substantial higher test loads at 0.1Hz at a fairly small input power compared to the sinusoidal VLF concept. Systems with up to 25 µF @60 kV RMS are commercially available.

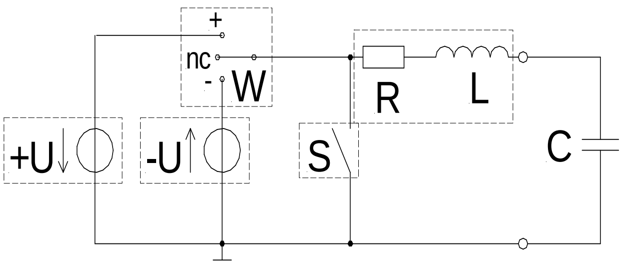

Fig. 1: Block diagram VLF CR.

Figure 2 shows the characteristic shape of the cosine rectangular wave at 0.1Hz ground frequency. The polarity reversal follows a cosine curve and happens within a time interval (milliseconds) that is very similar to frequencies as applied at DAC, between 20 Hz and 400 Hz. The technical configuration of these systems allows generating DAC voltages as well.