Identification of acoustic signals of Internal Electric discharges on glass insulator under variable applied voltage

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Abstract

A Partial Discharge (PD) is an unwanted phenomenon in electrical equipment. Therefore it is of great importance to identify different types of PD and assess their severity. This paper investigates the acoustic emissions associated with Internal Discharge (ID) from different types of sources in the time-domain. An experimental setup was arranged in the high voltage laboratory, a chamber with an electrode configuration attached to it was connected to a high voltage transformer for generating various types of PD. A laboratory experiment was done by making the models of these discharges. The test equipment including antennas as a means of detection and digital processing techniques for signal analysis were used. Wavelet signal processing was used to recover the internal discharge acoustic signal by eliminating the noises of many natures.

Keywords. Acoustic; wavelet; glass insulator; internal discharge

10 Introduction

Outdoor insulation represents an important component of electric power transmission and distribution systems, given that a single insulator failure can result in an excessive outage of the power system. Different insulator designs and materials are employed by power corporations and their behaviours are investigated and tested in laboratories and field tests as well as during service conditions. Specimens (rods and plates) are also tested when researchers focus on investigating certain phenomena of surface activity or material performance without being influenced by the insulator design [1]. The performance of insulators is strongly linked to local conditions, especially to the accumulation of pollutants and the wetting mechanisms present.

The weak parts of the insulation are the cavities, since the gas breakdown strength is lower than that of the solid insulation. On the other hand, the electric field in the cavities is much stronger than in the big insulation parts due to lower gas permittivity [2]. Hence, the PD is limited inside the cavities and does not penetrate through the solid material to reach the electrodes. Initiation of a PD in a cavity needs two major conditions; essentially the cavity electric field should be more than that of the gas, a condition called the inception voltage level. To start an electron avalanche, a free electron must be present in the cavity [3]. The extinction voltage level may depend on the actual voltage at which a discharge starts, since presumably a higher inception voltage yields a higher initial temperature in the streamer channel.

11 Methodology

The test setup consists of two main parts: the circuit loop (AC source, transformer, connections and insulator), and the measurement and acquisition system (earthing resistor, wideband antennas). Figure 1 shows the experimental set-up for generating various types of discharges as well as detecting the consequent acoustic signal due to the PDs. The test cell was connected across a high voltage source.

Figure 31 Experimental setup for generating ID

12 Results and Discussion

Figure 2 shows the captured internal discharge PD signal under applied voltage of 5 kV; no contamination levels are used for this type of discharge since it is dipped in oil. Here two types of sensors were used, the acoustic and the piezo-electric sensor. The real PD signal due to internal discharge is very noisy, and it is difficult to distinguish between partial discharge pulses and noise, even by visual inspection and knowledge of internal discharge patterns. Thus PD due to internal discharge cannot be distinguished due to the heavy noise as shown in Figure 3, where the pattern captured under operating voltage of 15kV.

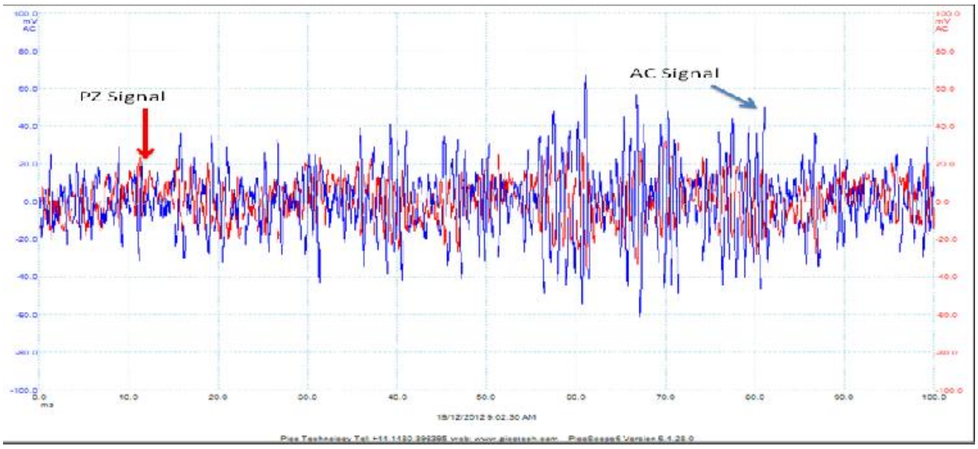

Figure 32 Internal discharges at 5 kV detected by piezo-electric (PZ) and acoustic sensors (AC)

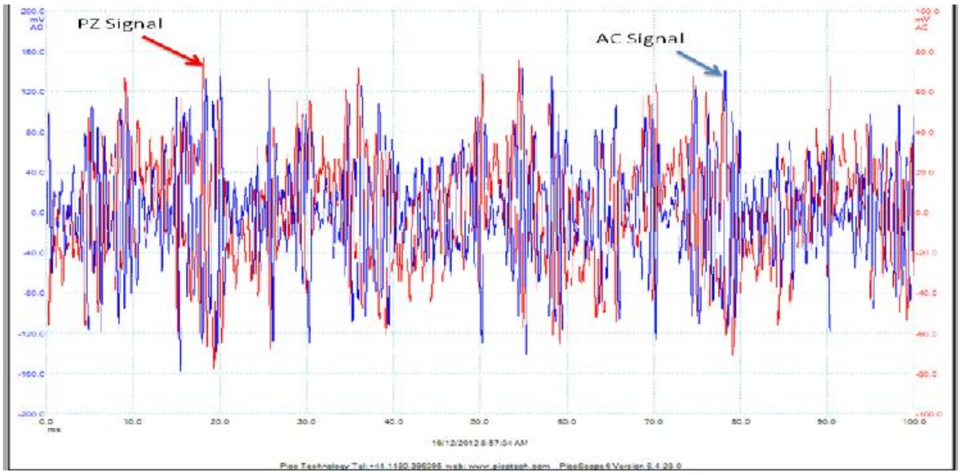

Figure 33 Internal discharges at 15 kV

13 Conclusion

The results show good enough information on frequency content for example the frequency amplitude which is a clear indication of energy loss when discharge occurs and also the frequency location i.e. the time at which it occurred. By knowing this information the insulator condition can be interpreting and could be used for early failure detection. The use of multi-resolution analysis wavelet transform has given good representation of original signal, and very efficient in extracting relevant features from the signal. As it was seen, the environmental conditions also played in an important role on surface discharge phenomena. The locations of the acoustic detector as well as the types of antenna used contribute to the sensitivity of the signal detection. The wavelet analysis indicates clearly the point of occurrence of high frequency contents. The magnitude of high and low frequency contents increases enormously when arcing takes place.

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