Combined electrical and optical diagnostics of surface discharges in high-voltage systems

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Diagnostics of surface discharges in power apparatus during their initial stage is of great importance for the electric power generation and delivery system. The typical rise times of a single discharge event are of sub-nanosecond scale and represent a challenging task for measurements of the current pulse form due to signal distortion through the measuring circuit. In contrast to this, the optical signals do not suffer on the transmission line limitations and can be principally used for diagnostics. This work focusses on the precise measurements of both the electric current of an individual discharge and of its optical signal. It is shown that optical signals carry the same information as conventional electric methods, like e.g. phase resolved partial discharge diagrams.

1. Experimental setup

Two circular glass plates covered on one side with transparent conducting ITO layer were put together in a polyacrylics (PA) housing, as shown in Fig. 1. The gap between glass and PA surfaces is about 0.5 mm. The voltage was supplied by copper rings contacted with the ITO layers. One is connected with the grounded electrode, the other one is connected to the high-voltage power supply.

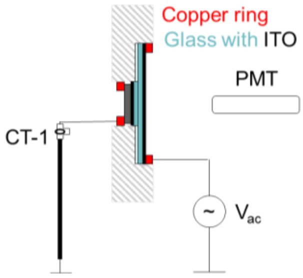

Figure 1: Experimental setup.

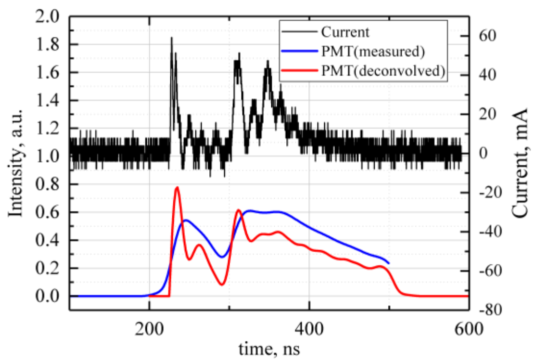

Figure 2: Measured profiles of electric current (black) and optical signal (blue and red curves).

Surface discharges could be observed in such arrangement, when a high voltage was applied (16 kV_{pp}, 50 Hz). The electric current was measured with a current transducer CT-1. Optical signals were recorded with the help of a photomultiplier (PMT).

2. Results

Typical measured profiles of the electric current and optical signal of a single discharge pulse are shown in Fig. 2. Three partially overlapping current pulses of a typical width of 20-50 ns can be identified. The corresponding optical signal exhibits widths of about 100-200 ns. For each current pulse, the apparent charge value was obtained by integration of the measured profile. Similar quantity

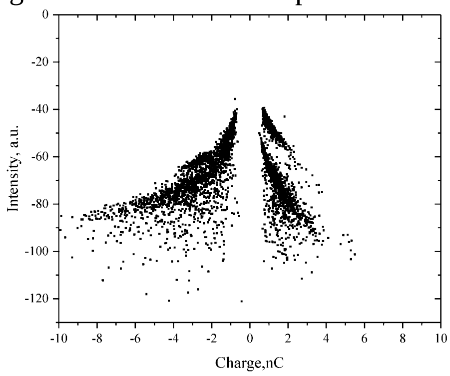

Figure 3: Correlation between charge transferred in single discharge and light intensity in the same discharge.

was calculated for optical signals by integration of the profiles resulting in intensity. The light intensity-charge diagram is shown in Fig.3. Here, the electrical signals and the corresponding optical emissions of 4000 subsequent current pulses were recorded simultaneously. Several structures were observed in this diagram, which are characteristics for this type of discharge. A further improvement in the description of the electric current by an optical signal can be achieved by application of signal deconvolution based on known regularization algorithms (see red curve figure 2).

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