**High Performance UHF Sensors for GIS**

The sensor is designed for measurement of partial discharge (PD) signals with the UHF method. In addition it can be used as voltage detector.

![Image of UHF sensor]

**Main characteristics**

- **Withstand voltages:** between enclosure and HV conductor - depending on the GIS product type
  - 325..750 kV (lightning impulse 1.2/50 µs) and
  - 140..325 kV (short-duration power frequency, 1 min.)
  Other values on request

- **Insulation to cover:** 3 kV eff (AC – 1 min.) with removed 50 Hz suppression circuit

- **Measuring terminal:** N socket, 50 Ω

- **Measuring circuit impedance:** $Z_m = 50 \, \Omega$

- **Standard Solution** Includes 50 Hz suppression circuit

- **Option** Use as voltage detection or for power frequency voltage measurements (adaption needed according the customer specification)

**Function and operation**

The UHF method can be used for measurements with the narrow-band or broad-band method:

- **The narrow-band method** (typical bandwidth only several MHz) is generally used in conjunction with a spectrum analyser. The location of the resonance peaks is first detected with a recording of the entire frequency range. The spectrum analyser is then set to the frequency of a resonance peak produced by the PD signals and then operated in the so-called “zero span mode”. In this mode, the PD signal components at a given frequency can be registered with respect to their intensity and their phase angle or time occurrence. The benefit of this method is that it effectively suppresses external HF noises.

- **The broad-band method** utilises the signal energy from a very broad frequency range (typically 0.1 to 1.5 GHz). The PD signals coupled out from a UHF sensor are recorded by a broad-band peak detector. The disadvantage of this method is that it includes also external HF noises that may be present, thus reducing the signal-to-noise ratio and the overall sensitivity of the method. Modern online-monitoring equipment is therefore equipped with high frequency band stop filters which suppress external noises in special frequency ranges (for example GSM900 mobile phone range).
In three phase GIS each PD detector couples simultaneously to all 3 phases.

The preferred locations for the sensors are the ends of busbar and on outgoing feeders.

**Overvoltage protection**

Switching operations generate overvoltages at high frequencies inside the GIS. These signals are picked up by the sensor. To prevent damage to the input circuits of attached electronic devices, the sensor is delivered with an overvoltage protection circuit. For personnel and equipment safety this circuit operates also as low frequency shortcut to protect the output of induced 50/60 Hz signals. The protection has a frequency-dependent characteristic, and effectively attenuates the low frequencies and overvoltages while having little effect on the UHF signals.

**Inverse antenna factor (effective height)**

The inverse antenna factor is equal to the ratio of the voltage measured at the detector output to the applied field strength for a given frequency. During the measurements, the coupler is terminated with the measurement impedance $Z_M = 50 \, \Omega$. In some publications the inverse antenna factor is also known as effective height $H_e$.

$$\frac{1}{AF} = \frac{V_{50\Omega}}{E}$$

$AF$: antenna factor [1/m]
$V_{50\Omega}$: detector output voltage with 50 $\Omega$ termination [V]
$E$: applied electric field [V/m]

The inverse antenna factor of the UHF sensor is shown in the following diagram.
In TGN(T)121 [1] limit values are stated for 420 kV and 525 kV substations. For the mean effective height a minimum value of 6 mm and for the minimum effective height a value of 2 mm (over 80% of the frequency range) is specified. For lower and higher voltages levels no values are specified.

The following table summarizes the calibration data of the high performance UHF sensors:

<table>
<thead>
<tr>
<th>Frequency range (MHz)</th>
<th>Min. effective height $H_{e_{\text{min}}}$ (mm)</th>
<th>Max. effective height $H_{e_{\text{max}}}$ (mm)</th>
<th>Mean effective height $H_e$ (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>500 - 1500</td>
<td>16.1</td>
<td>30.0</td>
<td>21.9</td>
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</table>

Therefore the sensor exceeds the specifications according [1].

The inverse antenna factor (effective height) offers a way to estimate the sensor sensitivity. Measurements are performed in a calibration cell under laboratory conditions. Because of the confined space inside GIS equipment, the directional response of the detectors and thus their sensitivity depend heavily on nearby conductive parts such as electrodes. The sensitivity therefore varies as a function of the place of installation. The optimal detector installation position can be determined only by measurements using, for example, the correlation method of CIGRE Joint TF Document 1998 (15/33.03.05) [2].

References
