

## Quick Info



The GANZ inventors were the first to use term of “transformer” in 1883 for their patent application, a name created from Latin meaning of ‘change the shape’.

## Next Issue



**Corrosive Sulphurs in Transformer - A Serious problem?**

# TRANSFORMER ON-SITE PARTIAL DISCHARGE MEASUREMENT: ISSUES AND CHALLENGES

Since decades, Partial Discharge (PD) testing has been used to assess the quality of insulation system in high voltage equipment as part of Factory Acceptance Test (FAT), site commissioning as well as diagnostic tool for condition based maintenance of aged assets. According to IEC 60270, PD can be defined as localised electrical discharge that only partially bridges the insulation between conductors or between conductor to ground. It is well established that different character of PD measurements enables identification of weak points in the insulation system.

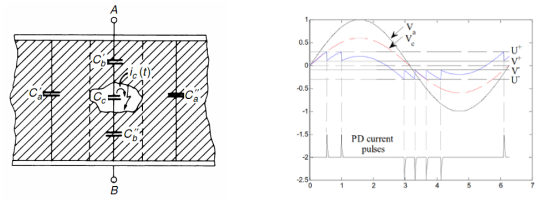
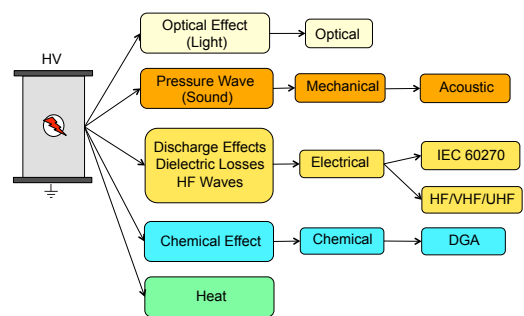


Illustration of PD process

During its service life, power transformers has experienced a different kind of stresses namely of thermal, electrical, mechanical and environmental stress; causing degradation of its insulation system. The ageing of oil, paper and pressboard insulation may create partial discharge activities in transformers. To ensure safe and reliable operation, assessing and verifying the healthiness of the ageing insulation is a must. Therefore, the detection of PD at the early stage is important in determining the condition of insulation system and to avoid further degradation process.

## PARTIAL DISCHARGE MEASUREMENT TECHNIQUES

Partial discharge activity within the transformer generates electromagnetic signals and also accompanied by emission of sound, light, heat, and chemical reactions. The detection of PD signal is technically able to detect these dielectric defects and even identify the presence of a specific defect from the patterns obtained. Utilising the specific coupling methods and sensors can be used to identify, quantize and localise the PD faults.



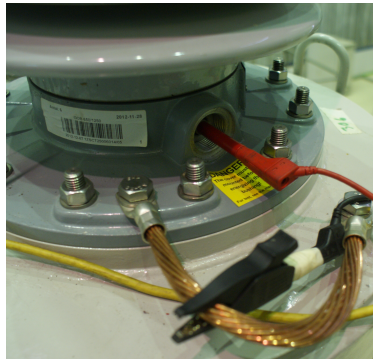
Overview of physical effect of PD and its detection technique

## Conventional PD Measurement Technique (IEC 60270)

Conventional PD monitoring refers to PD measurement method according to the IEC 60270 or IEEE C57.113. All standardized methods are based on the detection of electrical PD signals. Depending on the rated voltage and type of bushings used, the current impulses measured by PD analysis system can be connected either to the capacitive tap of the bushings or to an external coupling capacitor, as is often the case in high-voltage labs and test bays.



PD Coupling method



PD bushing capacitive tap

### Electrical Method IEC 60270

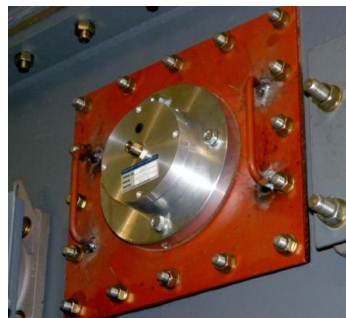
- Test frequency from hundred kHz to few MHz
- Can be used for offline and online method
- Calibration of signal are possible
- Helps to quantify the PD signal intensity

## UHF PD Measurement

UHF PD signals can result from the rapid formation of current pulse in any part of the insulation system, resulting in an electromagnetic transient wave at the short rise and fall times of PD current pulses. This radiated signal extends into the GHz frequency spectrum, which has an advantage of higher sensitivity due to the fact that background noise is usually reduced compared to what is seen at lower frequencies. Using this method, PD is directly measured inside the transformer tank using ultra-high frequency (UHF) sensors (usually in the range of 0.1 to 2 GHz).



UHF probe install in oil drain



UHF probe installed on tank wall

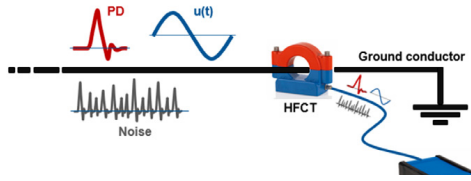
### UHF PD Measurement

- Provides good noise shielding due to metal enclosure.
- Used frequency depends on the device under test
- UHF sensor usable for online measurements
- Magnitude and signal damping depend on PD defect position. If sensor is placed far from the PD source, signal will be highly attenuated.
- Calibration not possible

## HFCT PD Measurement

PD measurement for power transformer can also be performed by inductive coupling using HFCT installed at the earth connection of tank ground. Any current of the PD pulses flowing through it and the output is the induced voltage that is measured over the input impedance of the measuring

instrument. In field environment, this measurement might be difficult to interpret due to high level of noise measured from the ground terminals.



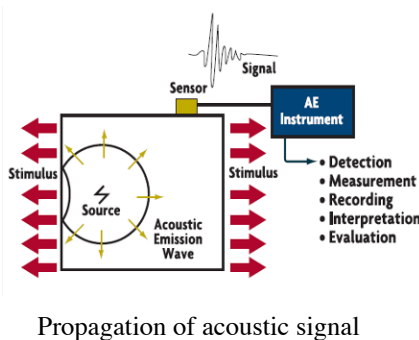
**HFCT PD Measurement**

- Used frequency depends on the device under test
- HFCT usable for online measurements
- Interpretations are difficult due to high noise for field testing
- Calibration not possible

HFCT installed at ground connection

**Acoustic PD Measurement**

Acoustic PD detection is a non-conventional technique based on the fact that electrical discharge initiates wave pressures in the insulation and propagates from the source into the transformer tank wall. Based on the triangulation of propagation signal, the wave pressures will be detected by the multiple acoustic sensors attached outside of the transformer tank. The acoustic PD measurement can also be performed with electrical measurement as a trigger for better localization when PD is detected with the electrical measurement.



Installation of acoustic sensor

**Acoustic PD Measurement**

- Used to locate the possible fault location in power transformer
- Usable for online measurements
- Can be coupled with electrical triggering to allow easier & better fault localization
- Typically performed after indication of problems or prior to transformer internal inspection

**OFF-LINE VS ON-LINE PARTIAL DISCHARGE MEASUREMENT**

PD measurement on power transformer can be performed either through online or offline detection. Both techniques have their own advantages and disadvantages. Offline PD testing allows the variation of applied voltage and frequency, which provide more information for better diagnosis purposes. This is typically done at the factory but for on-site offline PD measurement, it may not practical to arrange such high voltage and high power external source.

Meanwhile, the non-conventional PD detection technique such as installation of bushing tap, UHF sensor and acoustic sensor allows the operator perform PD measurement during normal operating conditions without shutting down the power transformer. Thus, the PD activities can be monitored continuously or periodically depending on the criticality of the transformers.

Off-Line PD Measurement	On-Line PD Measurement
<ul style="list-style-type: none"> <li>▶ Test in accordance to IEC 60270 compliance</li> </ul>	<ul style="list-style-type: none"> <li>▶ Provide early fault detection to prevent transformer failure</li> </ul>
<ul style="list-style-type: none"> <li>▶ Part of transformer Type Test and Routine Test in factory</li> </ul>	<ul style="list-style-type: none"> <li>▶ Continuous assessment of insulation condition under real operating condition</li> </ul>
<ul style="list-style-type: none"> <li>▶ Can be used for troubleshooting and fault localisation</li> </ul>	<ul style="list-style-type: none"> <li>▶ Reduce loss of useful information between routine measurement</li> </ul>
<ul style="list-style-type: none"> <li>▶ Transformer need to be shutdown or de-energised for PD measurement</li> </ul>	<ul style="list-style-type: none"> <li>▶ Allow long term planning of transformer maintenance and outage</li> </ul>
<ul style="list-style-type: none"> <li>▶ Can test at different voltage steps for more information and accurate diagnosis</li> </ul>	

Comparison of off-line and on-line PD measurement

## CONCLUSIONS

With regards to commissioning tests by manufacturers, PD measurement has been proven as an excellent method for quality control of HV insulation for many years. Due to on-going insulation ageing of the HV components in service, on-site PD testing and diagnosis has attracted increased interest. Several non-conventional PD detection methods have been used for some time for PD detection on power transformers. Nevertheless, calibration or sensitivity verification procedures, techniques for noise suppression and methods of fault location are among the challenges that need to be considered for on-site PD measurement.

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