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APPLICATION OF UHF PD DETECTION FOR DEAD TANK BREAKER (DTB)

Sushil Shinde, ABB/ Thomas Linn, Qualitrol

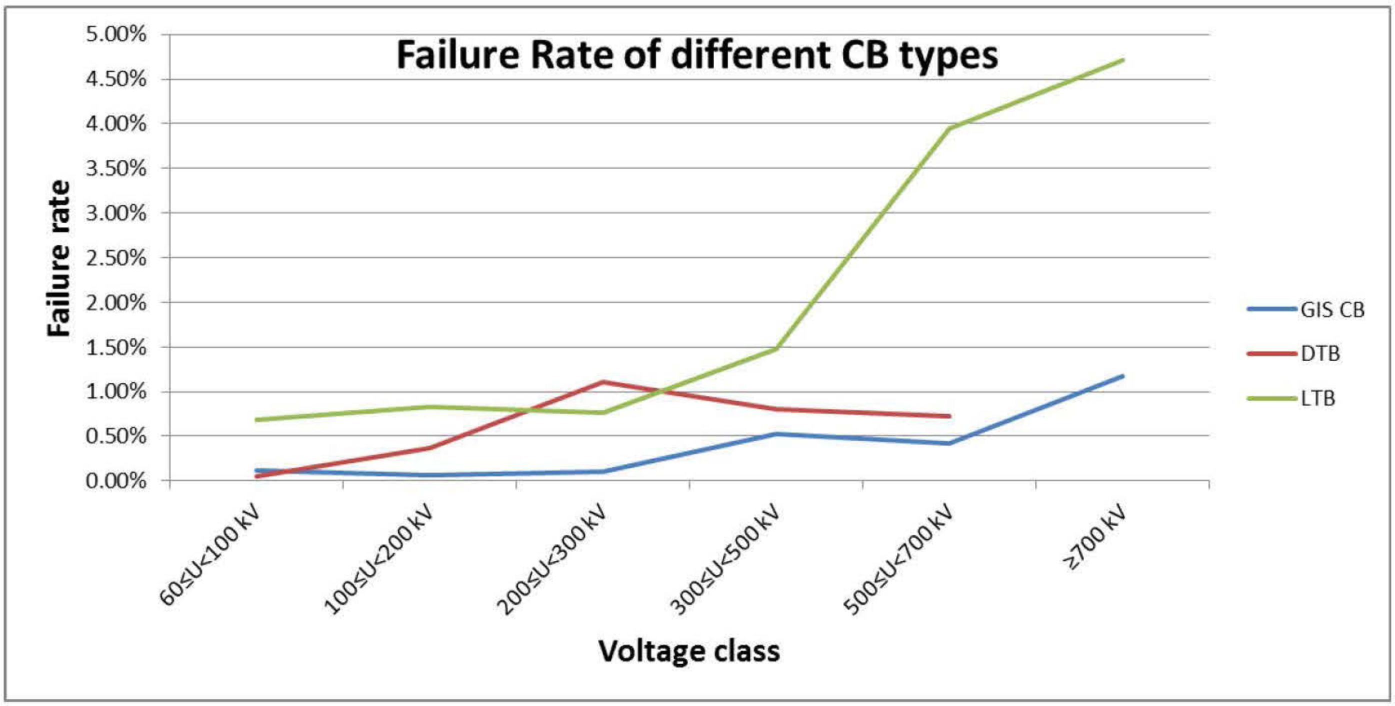
DEAD TANK TYPE CIRCUIT BREAKER

In dead tank type CB, the switching device is located, with suitable insulator supports inside a metallic vessel(s) at ground potential filled with insulating medium. DTB has current transformer build in and tend to use larger control cabinet when compared with Live Tank Breakers.

EXAMPLES

INTRODUCTION

- Ultra High Frequency (UHF) partial discharge measurements are common practice for GIS for high voltage site testing after erection and for partial discharge continuous monitoring for more than 20 years.
- The UHF techniques has proven its efficiency in detecting partial discharge in GIS and transformers
- The failure rate of major failure since then could be reduced for GIS equipment and the quality and reliability could be further improved.
- In the CB failure statistics GIS circuit breaker showing the lowest failure rate compared to Dead Tank Breaker (DTB) and Live Tank Breaker (LTB) – Sources see next slide.
- So far the application of UHF PD methodology always failed due to signals from external disturbances and outside discharges, which can enter easily into the tank and disables a reliable PD measurement.



COMPARISON OF FAILURE STATISTIC FOR DIFFERENT CIRCUIT BREAKER TYPES (ALL FAILURE TYPES (ELECTRICAL, MECHANICAL AND GAS LEAKAGES/ IN AND OUTDOOR APPLICATIONS)

Sources:: FINAL REPORT OF THE SECOND INTERNATIONAL ENQUIRY ON HIGH VOLTAGE CIRCUIT-BREAKER FAILURES AND DEFECTS IN SERVICE, CIGRE WG 13-06, Brochure 83, June 1994 INTERNATIONAL ENQUIRY ON RELIABILITY OF HIGH VOLTAGE EQUIPMENT; Part 5 - Gas Insulated Switchgear (GIS) (2004 – 2007); CIGRE Report 2012

TECHNICAL CHALLENGES

Problem Statement 1

All existing PD measuring solutions have limitations in their applicability for DTB testing

- DTB bushings are not fine graded bushings (SF6 filled bushings with a ground and a head electrode which leads to high field strength on the silicone or porcelain surface (chance of having external discharges in case of silicon surface during HV testing and in service is very high, but not causing operational problems during service only for PD measurement)
- Silicone rubber bushings in general are tending more than porcelain once to have surface discharges already under service conditions which disturbing a sensitive PD measurement
- Conventional PD measurement (IEC 60270 method):
  - Also the external discharges will be measured, which are in most of the cases higher than the internal
  - Not well applicable under onsite conditions (discharges from overhead lines etc.)
  - Not applicable for online monitoring solutions due to the need of coupling capacitor

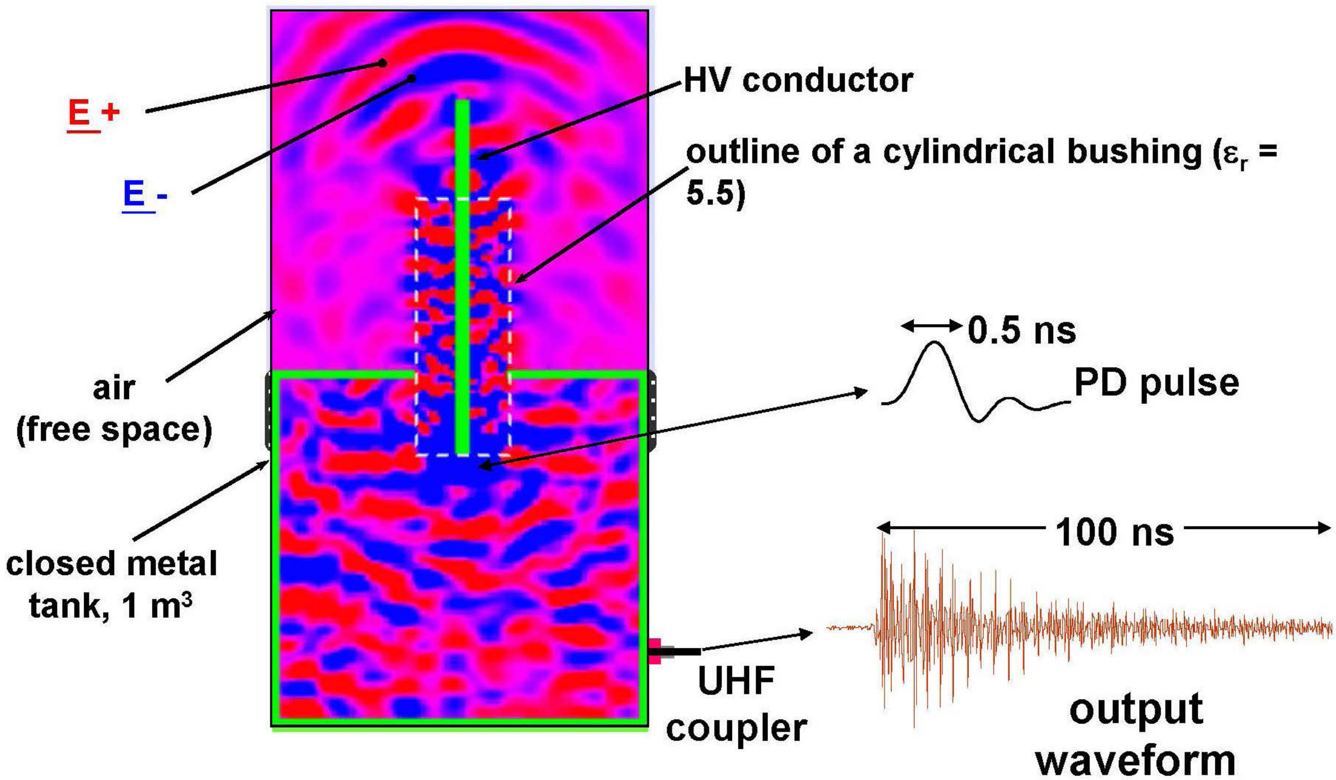
Problem Statement 2

Acoustic PD measurement:

- DTB tank not accessible during HV testing for personal
- Limited in detection of all types of defects
- Very sensitive to external disturbances (leakages in pressured air systems, external works with metallic tools, wind, rain etc.)

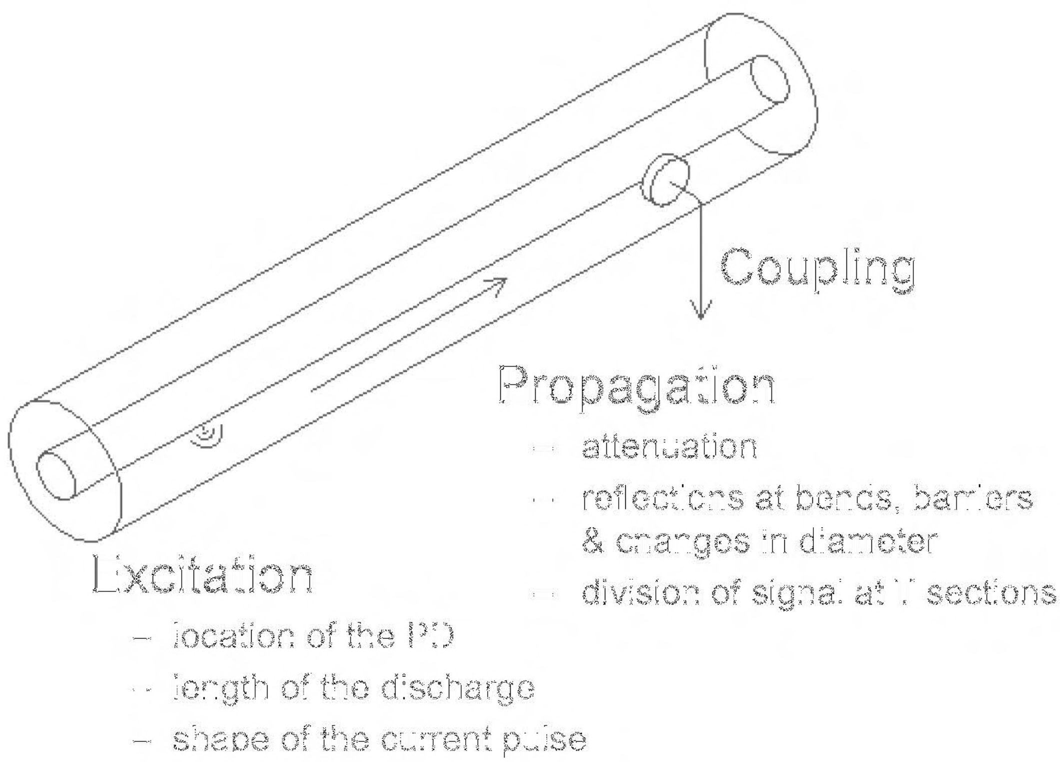
UHF PD measurement:

- Limited access points for existing UHF sensors (in availability and size)
- Bushings with DTB tank will show low pass filter behavior but with a relatively high cutoff frequency – external UHF PD signals (e.g. from bushings/ overhead lines) can mask the internal discharges

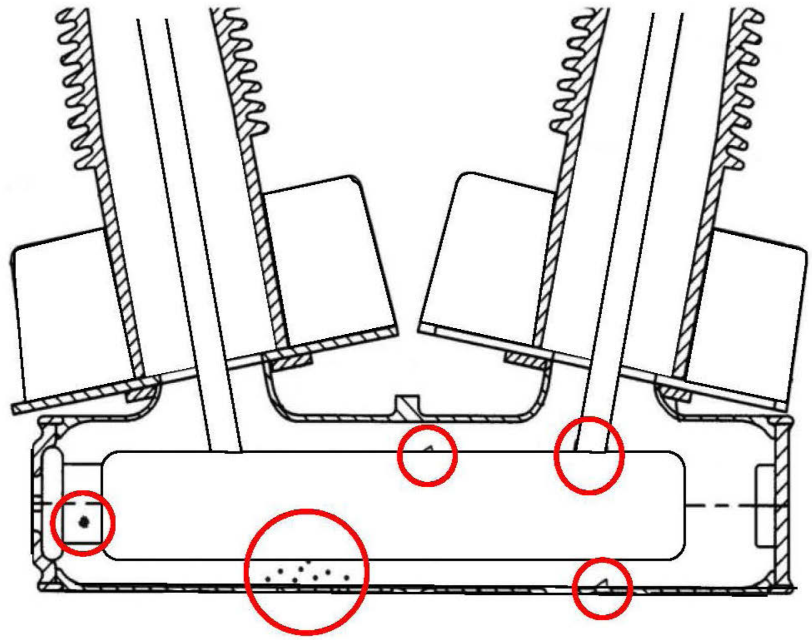

E +
E -
HV conductor
outline of a cylindrical bushing (ε_r = 5.5)
air (free space)
closed metal tank, 1 m^3
0.5 ns
PD pulse
100 ns
UHF coupler
output waveform

PD SIGNAL - STAGES IN TRANSMISSION

TYPICAL FREQUENCY RANGES FOR GIS: 300 MHZ TO 1.2 GHZ



TYPE OF TYPICAL DEFECTS IN HV BREAKERS



1. Protrusions on conductor (fixed particle)
2. Protrusions on enclosure (fixed particle)
3. Free particles on live parts and insulators
4. Bad contact between two conductors
5. Voids and treeing in insulation

SOLUTION APPROACH

Due to the following advantages the UHF method was chosen

HIGH RELIABILITY OF THE UHF METHOD	LIGHT WEIGHT TECHNIQUES	USABLE ALSO FOR MONITORING SOLUTIONS	SENSITIVITY

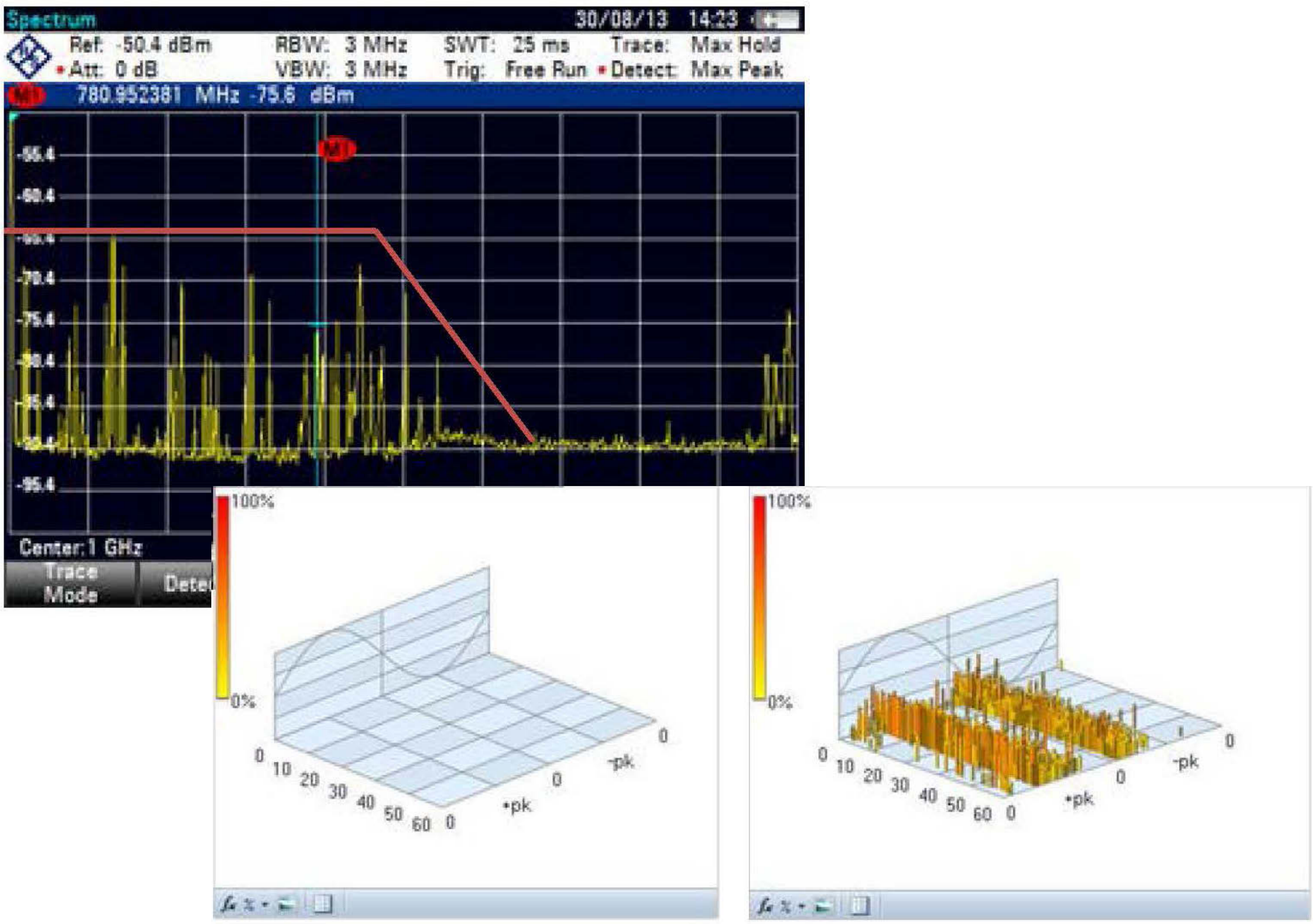
How to overcome the challenges?

1. Limited access points for existing UHF sensors (in availability and size)
   - Designing a UHF sensor, which fits to the gas valve sensors opening (these are existing in each kind of DTB)

2. External UHF PD signals (e.g. from bushings/ overhead lines)
   - Adapting the frequency band in that way, that the measuring band is higher than the cutoff frequency from the bushing- DTB low pass filter to keep these external signals outside.

ADAPTATION OF MEASUREMENT FREQUENCY BAND

Measured frequency response from bushing/ DTB low pass filter
The frontend channels of the UHF PD measuring device had been adapted to that higher frequency band.

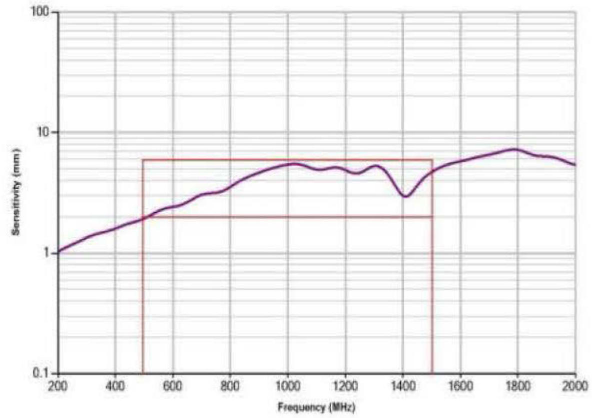


Measurement with external corona with modified channel (left)
and not modified channel (right)

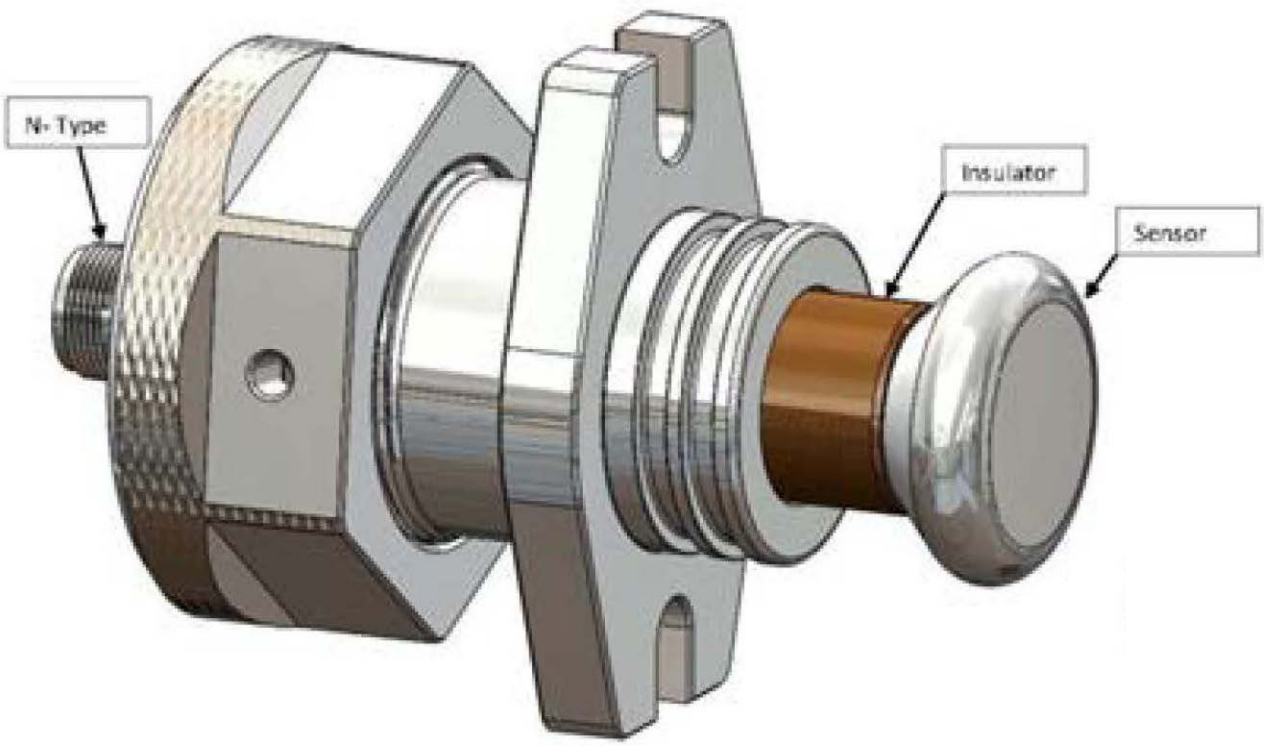
NEW SENSOR DESIGN

- Sensor fits to Gas Valve
- Frequency response is shifted to higher frequencies (the red rectangles is presenting the common response)

Sensor Frequency Response

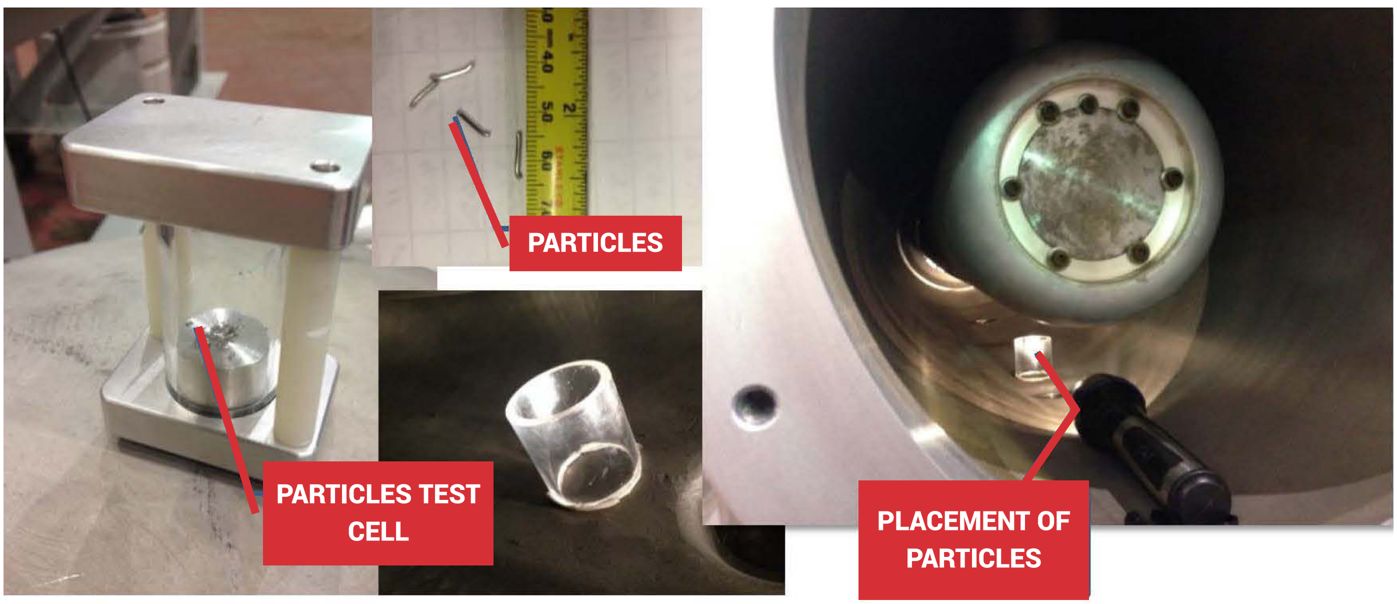


Internal Coupler



DEFECT SIMULATION – PARTICLES

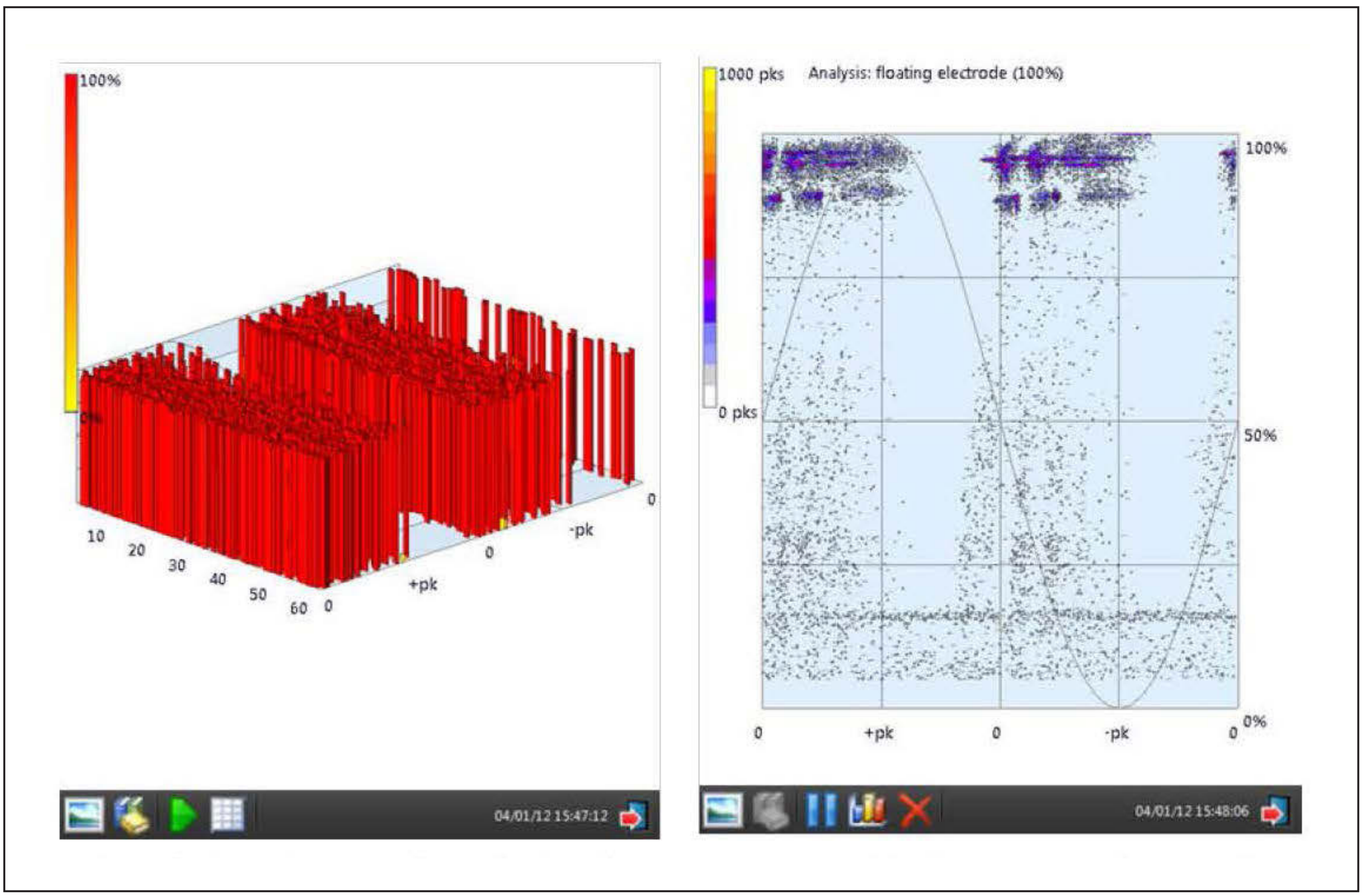
Early detection for particles as the most common cause for breakdowns in DTB's, is the main focus. Different measurements were adapted, to study how particles are behaving in terms of PD activity and PD patterns and repeatability by the use of artificial sources and free particles placed in the DTB tank.



DEFECT SIMULATION – PARTICLES

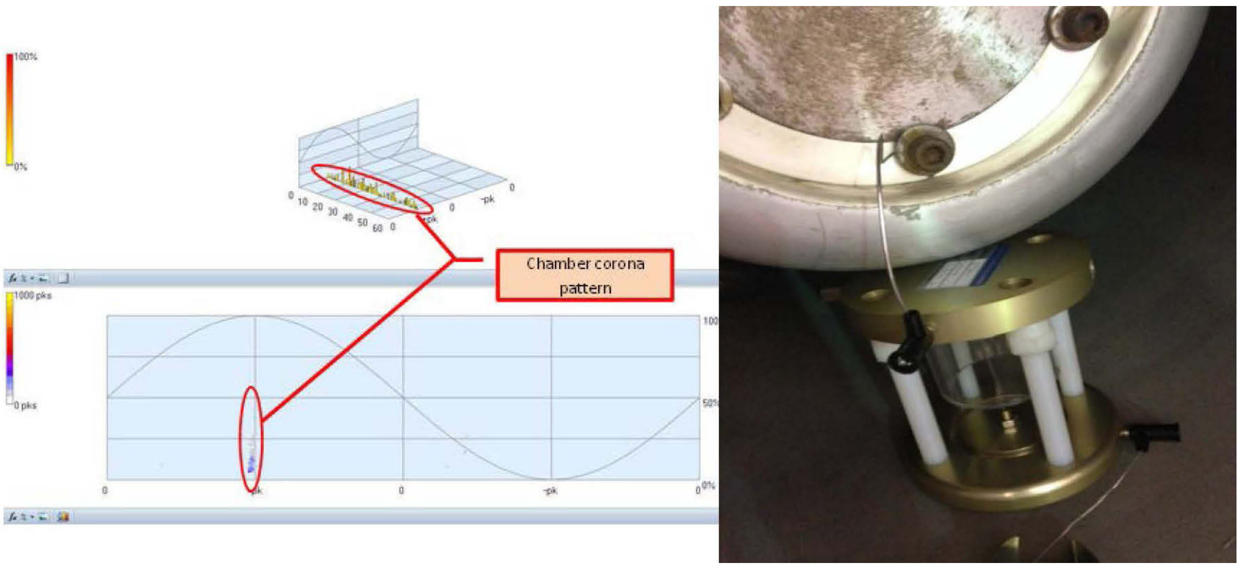
As result of the tests with the particle test cell and free particles inside the DTB housing, ‘non- typical particle patterns’ were showing up. The pattern shows a floating element (not proper connected to ground or HV).

By analysing the results it shows, that the particles, before they start to lift-off, are sliding over the surface. During that movement, the electrical contact between particles and surface of housing is almost not given, which gives a discharge pattern of a typical floating element pattern. In one case the placed particles moved inside the disrupture disc flange and the discharge stopped. It happens also, that the particle in the test cell stood upright in the test cell against the test cell wall and gave an protrusion like pattern. Once the particle lift-off, it flashed over. In all cases the sliding particles could be well detected and their behaviour and the recorded patterns were consistent.



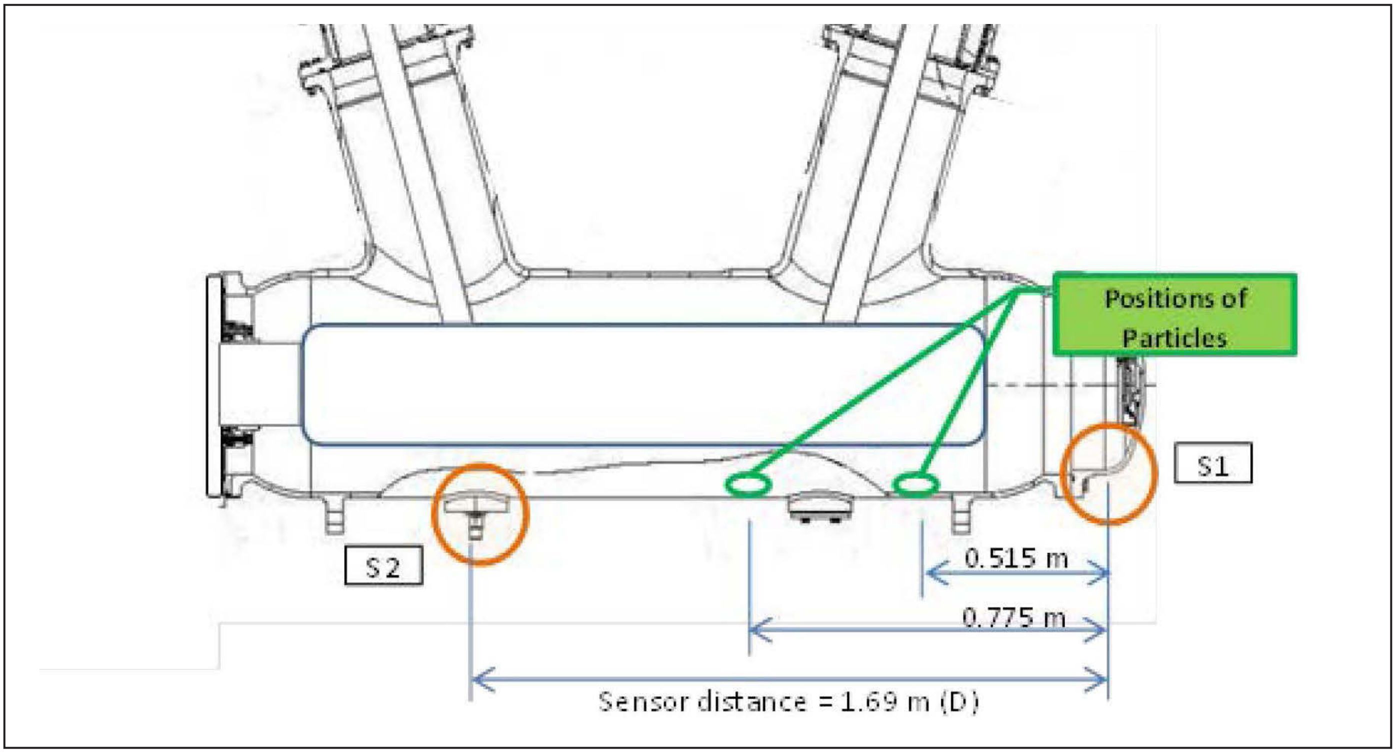
DEFECT SIMULATION – BUSBAR AND CHAMBER CORONA

Furthermore the two defect types busbar and chamber corona were simulated by use of a sharp needle placed in a test cell. The below pattern for example is showing the typically pattern of a chamber corona type discharge. Also these test where showing consistent the same correct results.



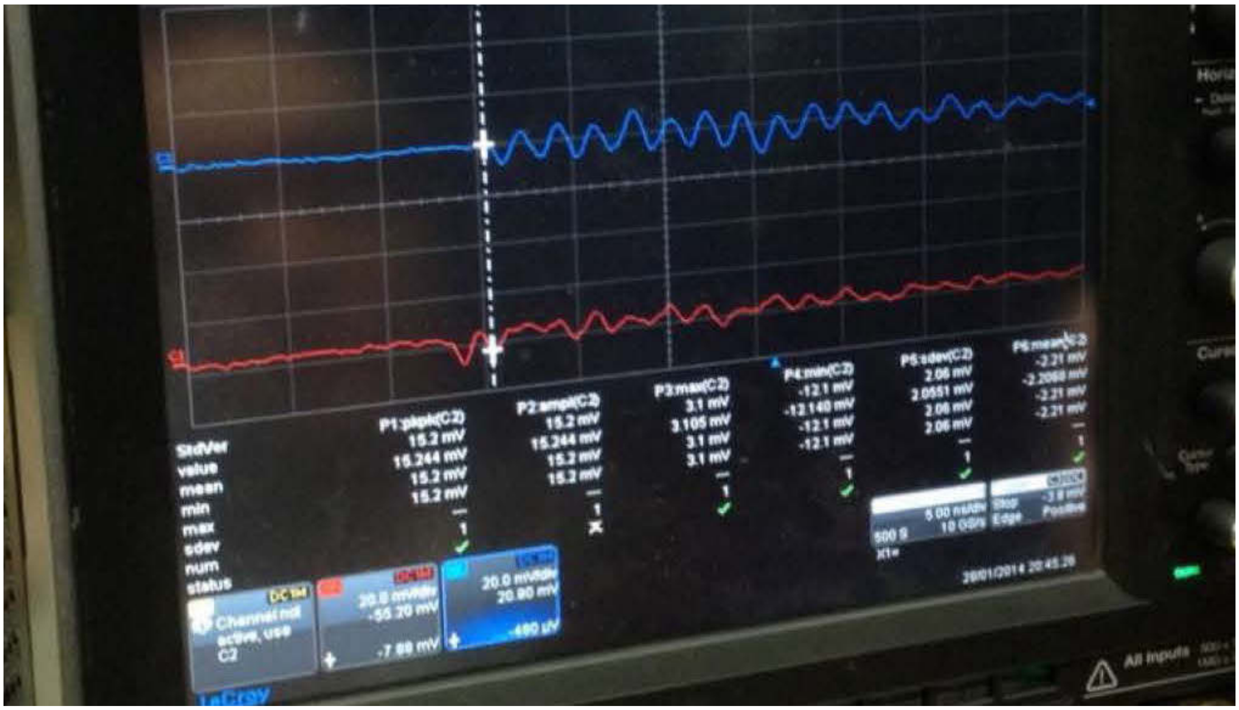
DEFECT LOCALIZATION

Setup for localization test:



EXAMPLE FOR TIME- OF- FLIGHT MEASURING SCREEN ON A OSCILLOSCOPE:

The measured results are confirmed the position of the placed particles.



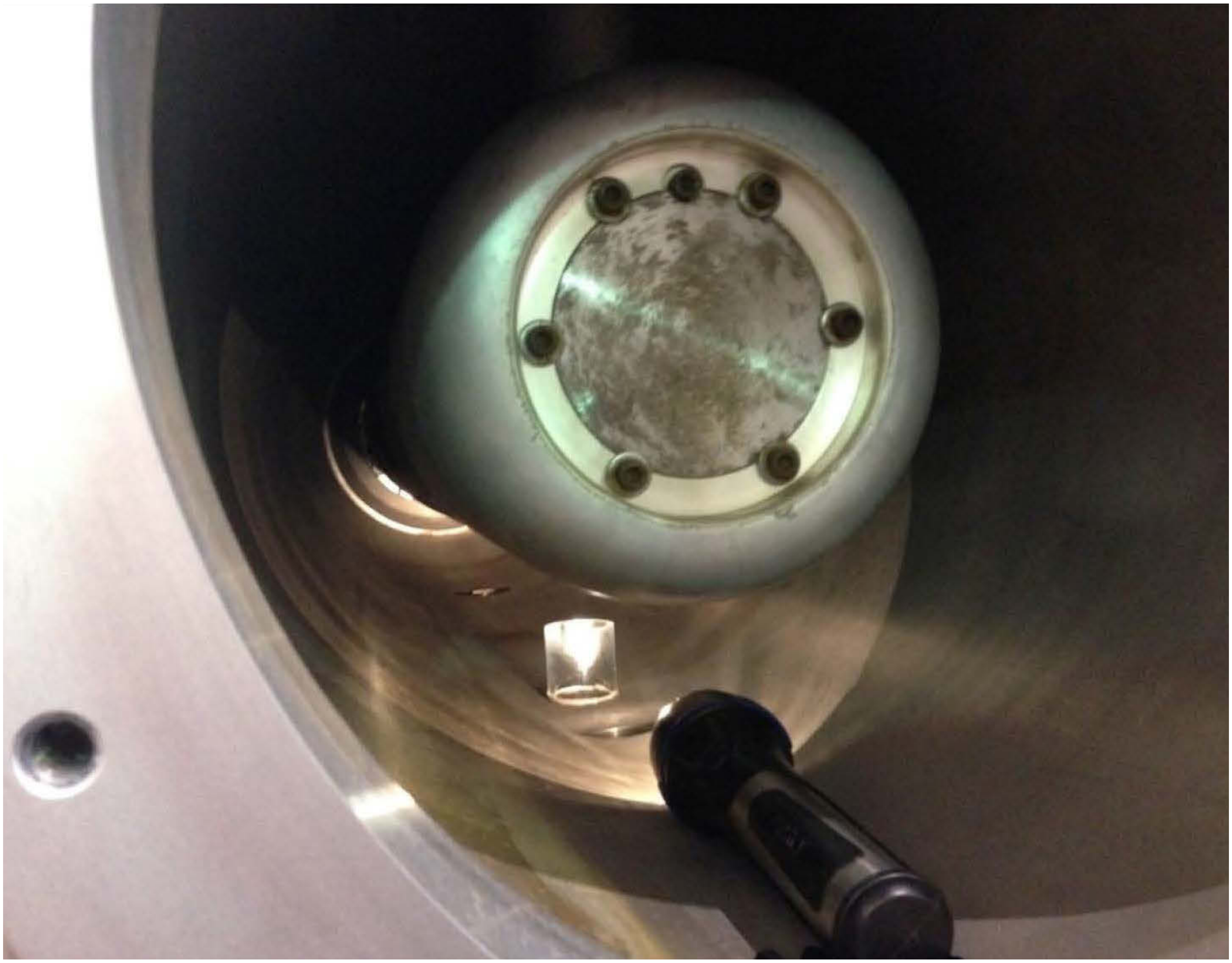
d = (D – 0.3 t) / 2

d – Distance of PD source to sensor [m]

t – Measured time difference between the two signals [ns]

D – Distance between the two sensors [m]

QUALITROL / ABB - PDM ON DTB BREAKERS (245KV / 63KA)



CONCLUSION

1. By shifting the frequency range, the low pass behavior of SF6 filled bushings could be used to attenuate the external disturbances in a way, that a sensitive detection of the internal discharges is possible even in the presence of strong outside discharges.
2. Typical patterns could be verified. In case of free particles it turned out, that instead getting the typical patterns for hopping particles, the particles rather slide across the surface and gave a floating type of pattern in all tests.
3. The localization worked very accurate for the placed particles. Different discharge location could be clearly separated.

The investigated method turned out to be suitable to be supportive for routine and onsite PD detection on DTB.

Due to the ability of that method to be resistive against outside discharges it can be also applied for continuous PD monitoring for DTB installations.

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