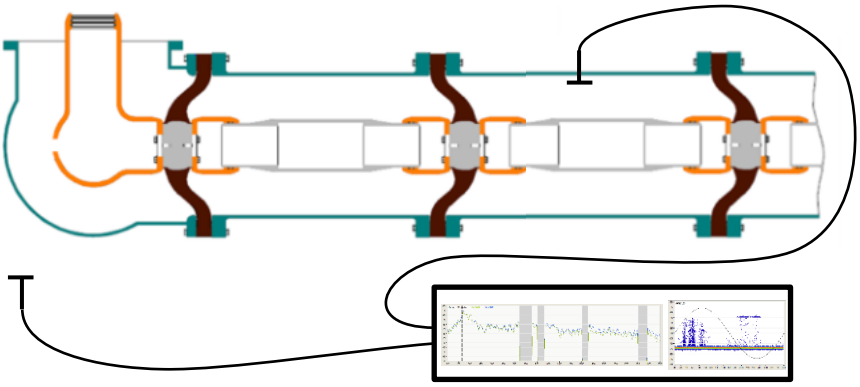
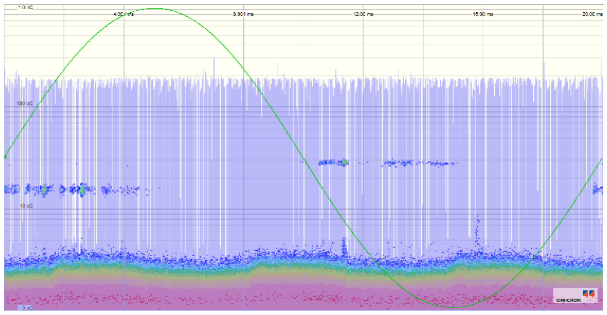
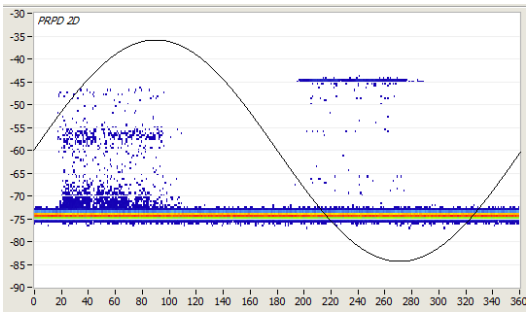
Partial Discharges (PD) due to defects in the insulation are well known in high voltage systems such as power transformers or Gas Insulated Switchgear (GIS); several categories have been identified and have similar shapes in air, SF_6, Oil and some new SF_6 free insulating gases. These Phase Resolved Patterns are easy to measure in a laboratory with low external noise. It is also commonly accepted that a default free GIS system will reach its breakdown voltage without clear partial discharge pattern recorded, especially with large band monitoring systems. This makes the breakdown unpredictable in another way than dielectric strength calculation which always has a percentage of uncertainty; the breakdown voltage being highly statistical.
A recent experiment in laboratory involved a comparison between conventional large band PD measurement and UHF band scanning measurement system. An observation of the premises of the breakdown in a default free gas insulated mock-up was achieved using the band scanning system.



Schematic drawing of the default free mock-up and band scanning PDMS.

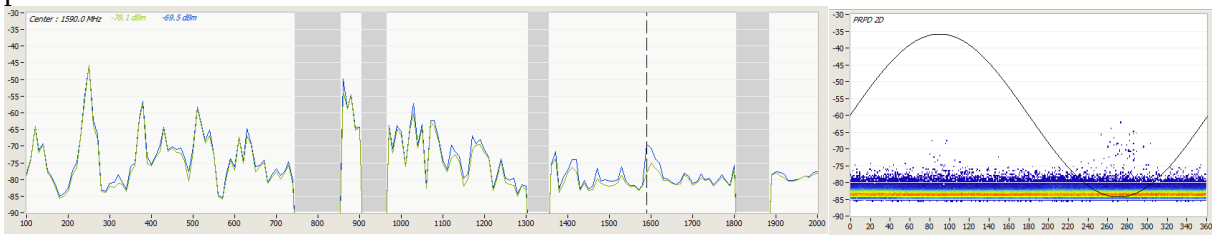
One internal and one external UHF sensor were used to differentiate between internal and external to GIS signals. The band scanning system allows a precise spectrum measurement of the PD activities and displays a specific frequency band, excluding from the pattern all unwanted signals. Band scanning capabilities resides in the possibility to distinguish between several events, even if those events have a lower magnitude than another event.
In a noisy environment, such as site environment, wide band systems cannot focus on one specific fault, all signals are displayed, even external/noise signals which lead to either wrong diagnosis or hides smaller signals which could be the sign of an early-stage fault. In the example below the conventional measuring system is perturbated by a nearby pump while plotting the frequency band around 1610MHz only displays the external floating potential PD signal, allowing a precise diagnosis of the PD without being influenced by the pump noise.





Conventional method Band scanning system @ 230MHz

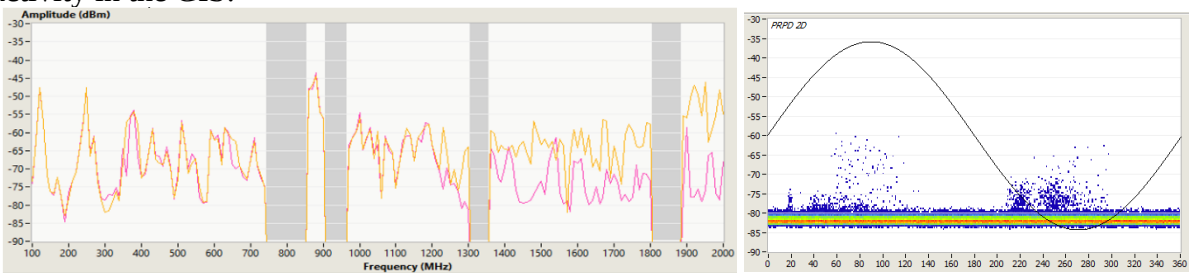
In a defect-free GIS, the PDs announcing a breakdown are very unstable with low magnitude; however, a band scanning system analyzing signals from 100MHz to 2000MHz proved being able to record these signals in a noisy environment. In the spectrum below, in green is the real time calculated average of measurements and in blue the maximums recorded during the period.



Maximums (blue) and Average (green) of the measurements & PRPD @ 1590MHz – 475kV.

PD in ambient air is measured below 1200MHz and especially below 300MHz. On the graph above we have low impact of the external PD above 1200MHz. We can detect a maximum activity above the average at the frequency 1590MHz. This activity is far below the maximum activities on the 100MHz-2000MHz range. It would be hidden by external noise using wide band systems, a band scanning system can plot this specific activity in phase resolved.

In this other example, two spectrums measured at 500 & 520kV show the evolution of the PD activity in the GIS:



500kV & 520kV spectrums and PRPD @ 1690MHz

The frequencies above 1200MHz are activated by the internal PD when approaching the dielectric limits of the mock-up. This activity remains below the external PD activities – seen here below 1000MHz - and can only be displayed clearly using a band scanning system.

This band scanning system is widely used worldwide and has proven its efficiency to detect and diagnose PD activity. Its precision in frequency analysis allows the differentiation between internal and external activity.

Conclusion

Wide bands systems are widely used in FAT to measure all possible PD activities occurring in faraday cage conditions to ensure there is no activity in the tested object. It requires a perfectly clean environment and sometimes imposes to stop nearby activities such as the factory activities: cranes, pumps... In site conditions, the external electromagnetic pollutions bring a new challenge that a band scanning system will efficiently handle to detect and plot the pattern of specific PD activities, then allowing an efficient diagnosis. Moreover, the band scanning system can measure a signal with low repeatability and low amplitude such as the PDs announcing a breakdown in a clean environment. This type of PD was recorded despite external PD on a default-free mock-up around 1600MHz with low intensity just before reaching breakdown