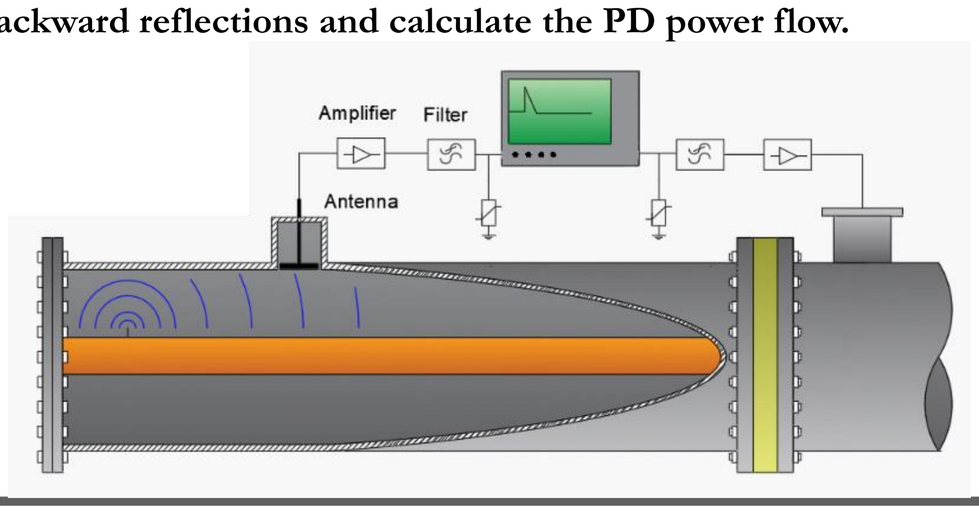
VHF Sensor for calibrated PD measurements in GIS

Motivations and goal

Motivations:
-The increased need for gas-insulated substations (GIS) with remote monitoring.
- The IEC 62270 method is difficult to apply for onsite online substations.
- Unconventional methods do not provide a calibrated measurement.

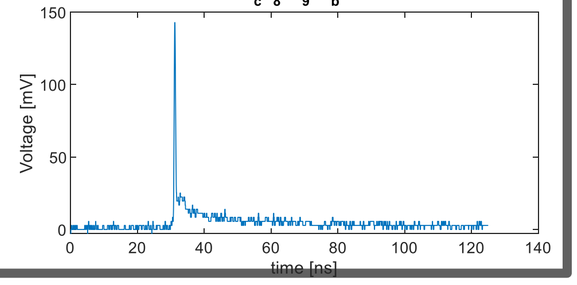
This research focuses on an unconventional method in the very-high frequency range, aiming to measure calibrated online PD in on-site substations. The project resulted in a measuring system with a sensitivity below 5 pC and with an error uncertainty from 10% to 50% depending on the noise level. This research also found that by combining an electric and a magnetic sensor, it is possible to eliminate backward reflections and calculate the PD power flow.



HVDC PD parameters

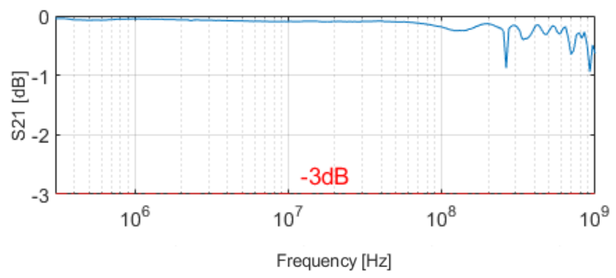
The PD BW does not change after electric ageing for corona discharge, jumping particle, and Floating electrode. A change of BW was observed in SD. The PD BW determines the BW of the measuring system.

	Corona	FE	SD	JP
no ageing	>1000 MHz	>500 MHz	350 MHz	>500 MHz
end of ageing	>1000 MHz	>500 MHz	125 MHz	>500 MHz



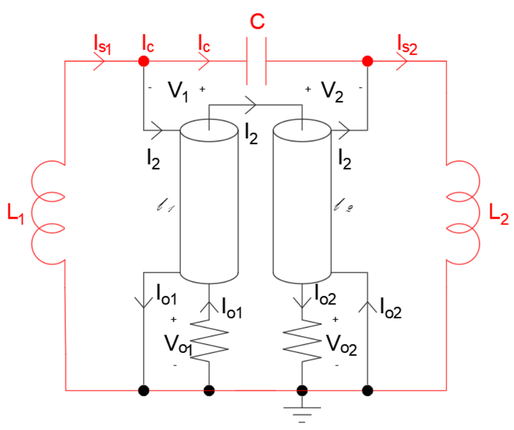
Test Workbench

1GHz bandwidth workbench for PD sensors characterization.



Sensor design

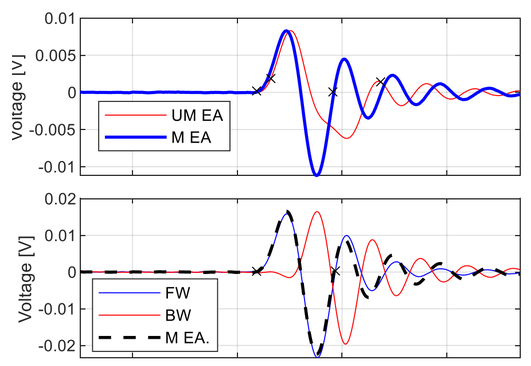
- **Balanced magnetic antenna with a frequency range of up to 300MHz.**
  - **Higher common-mode noise rejection.**



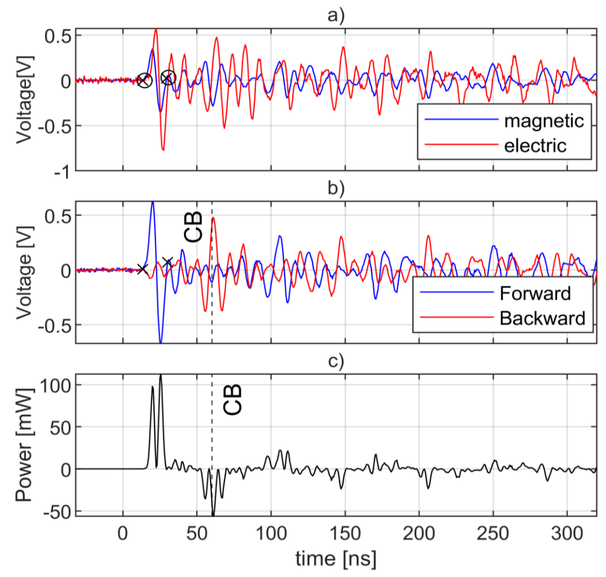
- **Addition of VHF electric antenna for 50 Hz electric field grading.**
  - **Aluminum and carbon black combination.**

Sensor design

- **Addition of VHF electric antenna for PD power flow and reflection suppression for PD charge improvement.**



Top: Overlapped pulse and matched pulse. Bottom: Forward and backward pulse and matched pulse.

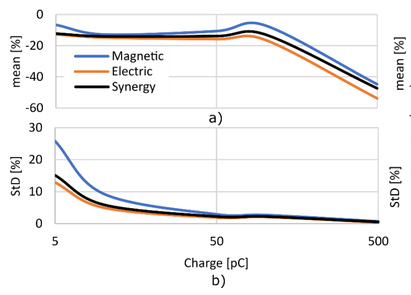


PD measured with: a) HFCT, b) magnetic and electric antenna, c) forward and backward pulses, d) power flow.

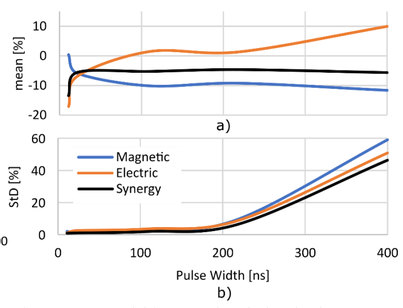
Validation

Charge estimation uncertainty in the LV test bench.

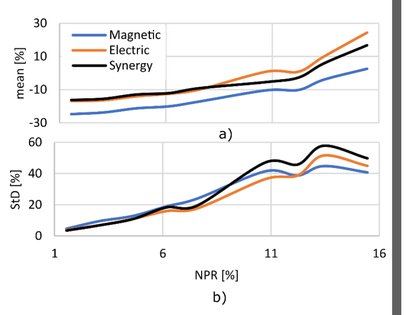
- **Magnitude linearity**
- **Frequency linearity**
- **Noise to signal ratio**



a) Mean and b) standard deviation error with different charge inputs.



a) Mean and b) standard deviation error with different pulse lengths inputs.



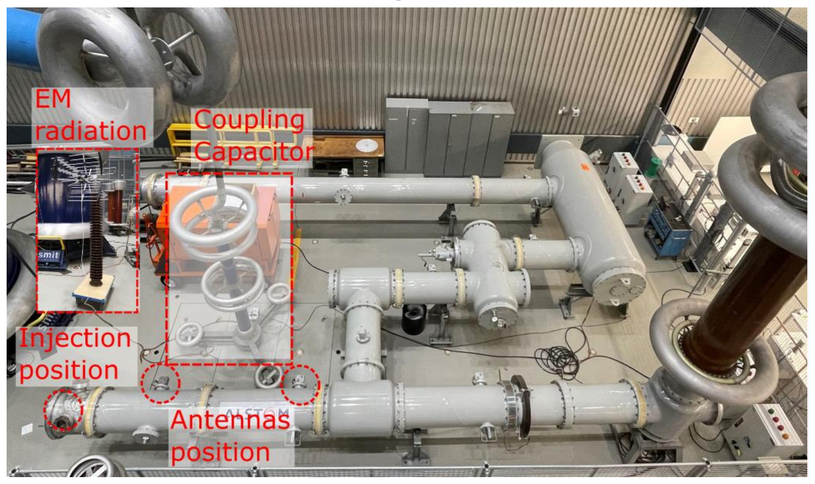
a) Mean and b) standard deviation error with different NSR inputs.

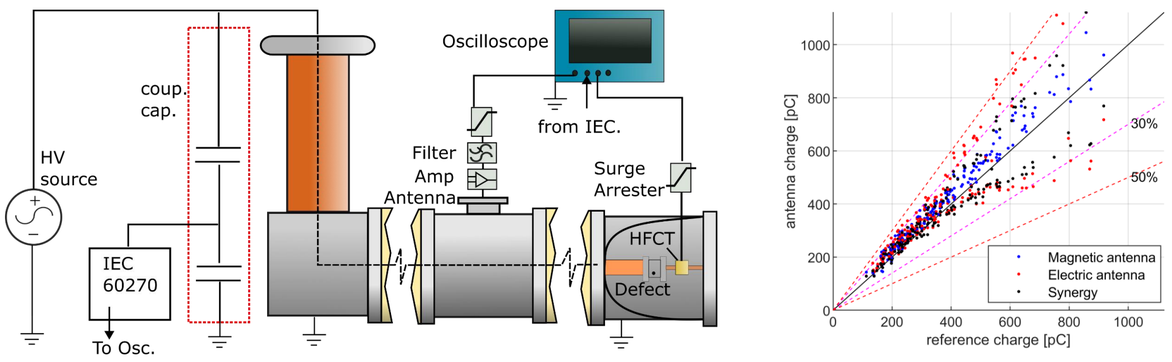
Charge estimation uncertainty in the HV test bench.

Voltage sources:
- **AC**
- **DC + and -**

Defects:
- **Corona**
- **moving particle**
- **surface discharge**
- **floating electrode**

Noises:
- **Random noise**
- **CM pulses**
- **EM radiation**





Conclusions

This novel measuring system is an alternative method for measuring calibrated PD in GIS. Its contactless functionality allows its use for online monitoring. However, the PD charge estimation is very sensitive to the non-impulsive noise, increasing the measurement uncertainty. This method paves the way for trustworthy insulation conditioning remote monitoring.

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