High Sensitivity Partial Discharge Monitoring Using FOS: Experience and Examples

OptiFender

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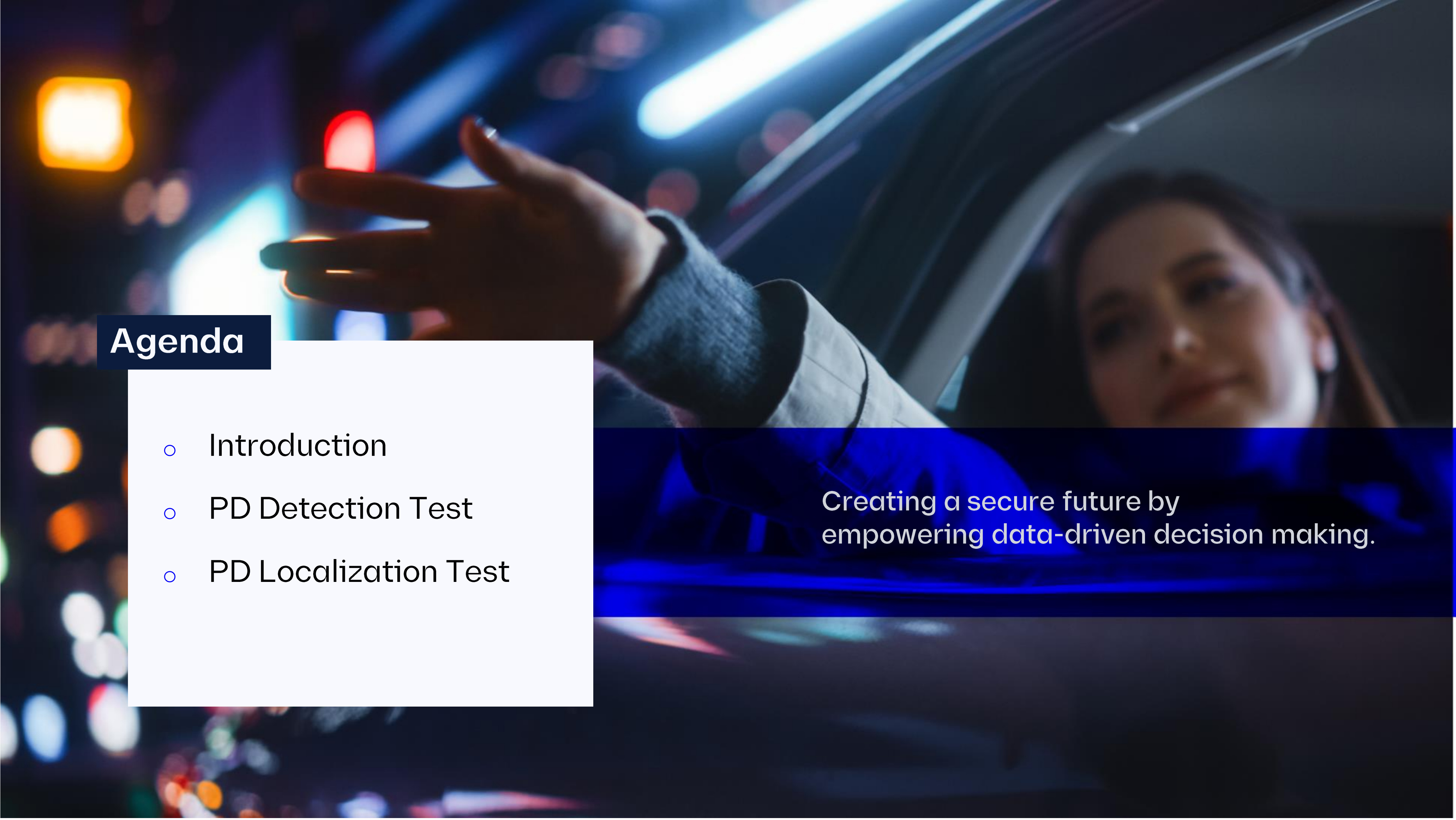
Porto, April 18-20, 2023



Agenda

- Introduction
- PD Detection Test
- PD Localization Test

Creating a secure future by
empowering data-driven decision making.

About Optics11

2022 — **€5 Mio. Investment** FORWARD.one (Advancing your innovations), VALUE CREATION CAPITAL (We build great technology companies)

2020 — **Launch** Structural Health Monitoring & Partial Discharge Monitoring System

2019 — **Acquisition** FAZ Technology

2018 — **Launch** Optic Acoustic Emission System

2016 — **Investment** VALUE CREATION CAPITAL (We build great technology companies)

2014 — **Start** Industrial Sensing

2011 — **Founded** Life Science

Headquarters: Amsterdam, NL

Employees: 50+

Owned: 100% Dutch

Patents: 9

Fiber Optic Advantages

Passive sensor

- No power at sensing location

Optical signal

- Long distances (>15km)
- Remote locations
- Immune to EM interferences
- Immune to HV fields
- Intrinsically safe

Harsh environments

- Extreme temperatures
- Outdoor conditions
- Moistures
- Lightning
- Radiation

Core Solutions

OPTICS11®

Energy	Defense	Industrial
"The world's only commercial fiber optic acoustic emission sensing system for partial discharge monitoring"	"The world's thinnest most sensitive fiber optic hydrophone array"	"The world's most accurate and precise FBG monitoring system"
○ Partial Discharge	○ Anti-Submarine Warfare	○ Process Industry
○ Temperature	○ Threat detection	○ High-Tech Machines
○ Clamping Force	○ Unmanned Vessels	○ Infrastructure
○ Vibrations	○ Subsea asset security	○ Maritime
○ Pressure	○ Harbour perimeter security	○ Medical

Meet OptiFender

World's first passive partial discharge solution

- Fiber optic acoustic emission (AE) sensors
- Non-metallic, galvanically isolated sensors
- Dedicated software package with PRPD patterns
- Optimized for PD monitoring & localization

EMI IMMUNITY

REMOTE LOCATIONS

EASY INSTALLATION

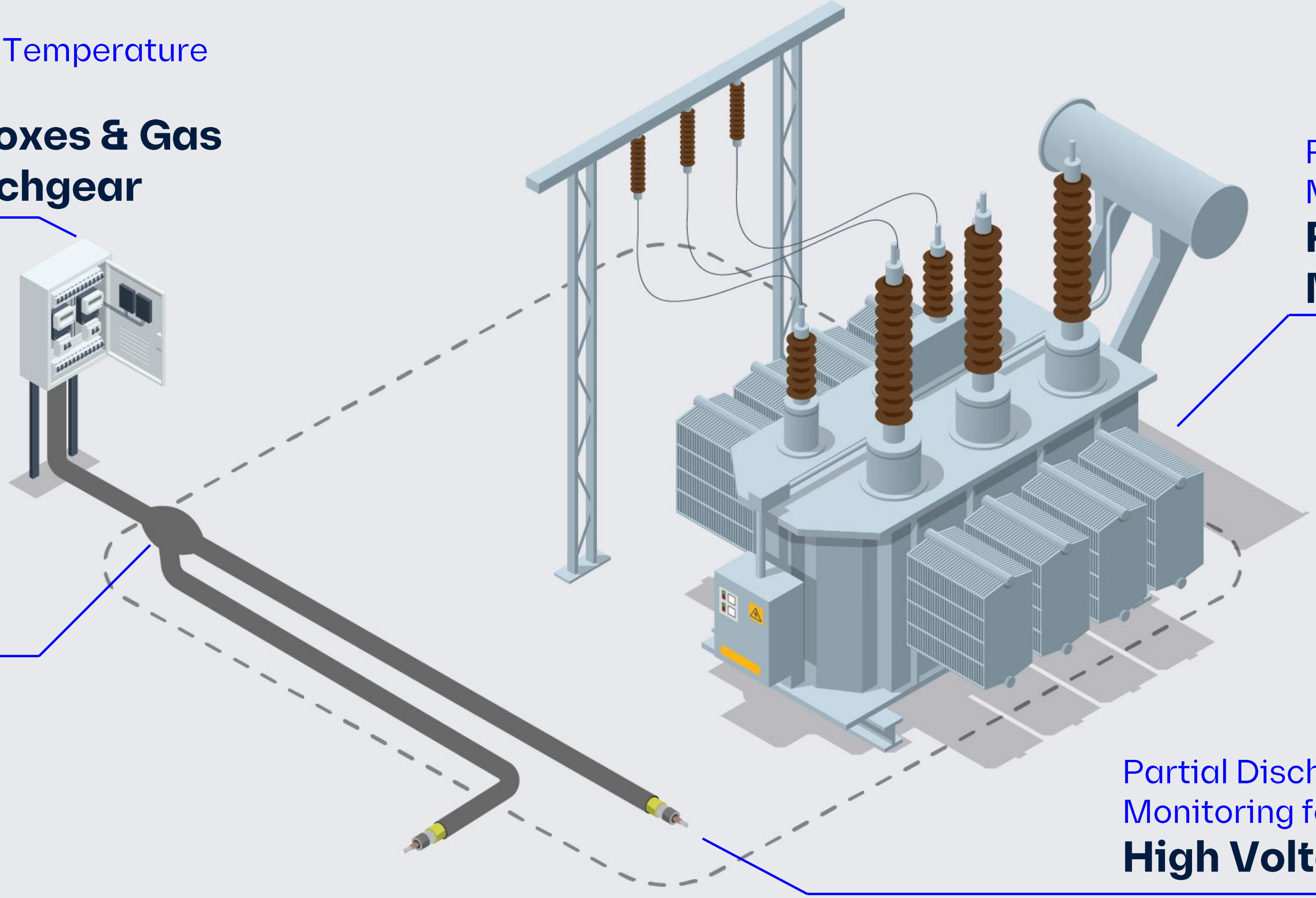
NO POWER REQUIRED

Applications

OptiFender champions groundbreaking, enabling technologies to elevate the electric power sector.

Partial Discharge & Temperature Monitoring for
Termination Boxes & Gas Insulated Switchgear

Partial Discharge Monitoring for
Power Electronics & Motors

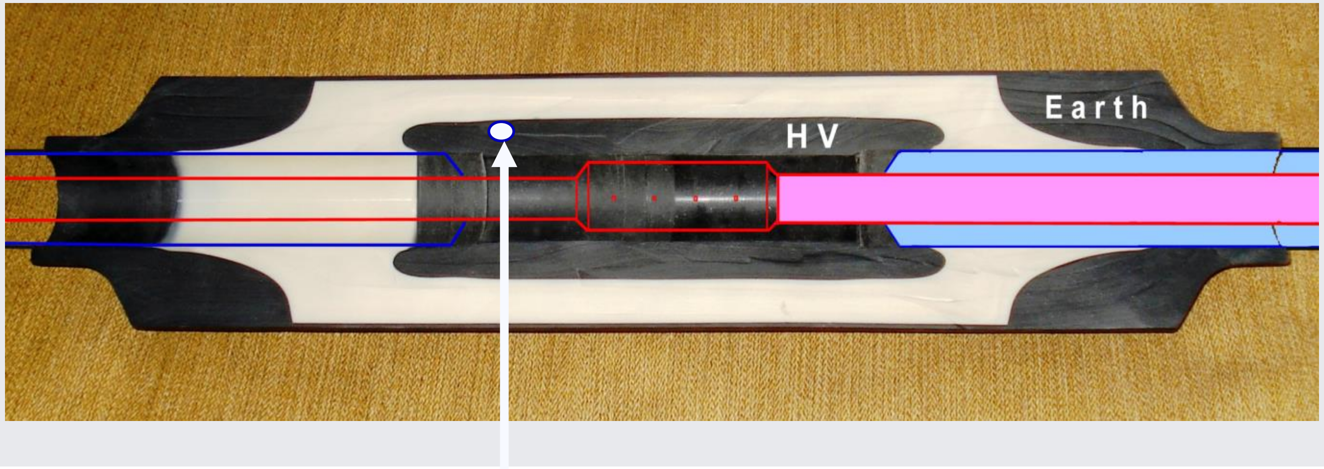


Partial Discharge Monitoring for
Cable Joints

Partial Discharge Monitoring for
High Voltage Cable

Partial Discharge (PD)

- PD in solid insulators is localized electrical discharge between areas of different electric field strengths.
- PD can occur due to the formation or inclusion of (extremely small) voids or foreign materials in the insulation layers of high-voltage assets.
- The discharge can start from fC or pC levels, but if left unattended, it can progress to nC levels and eventually, total failure of the HV asset.
- Early detection of PD can guarantee the safety and operation of the power grid



Examples

Smart HV joint with embedded OptiFender sensors

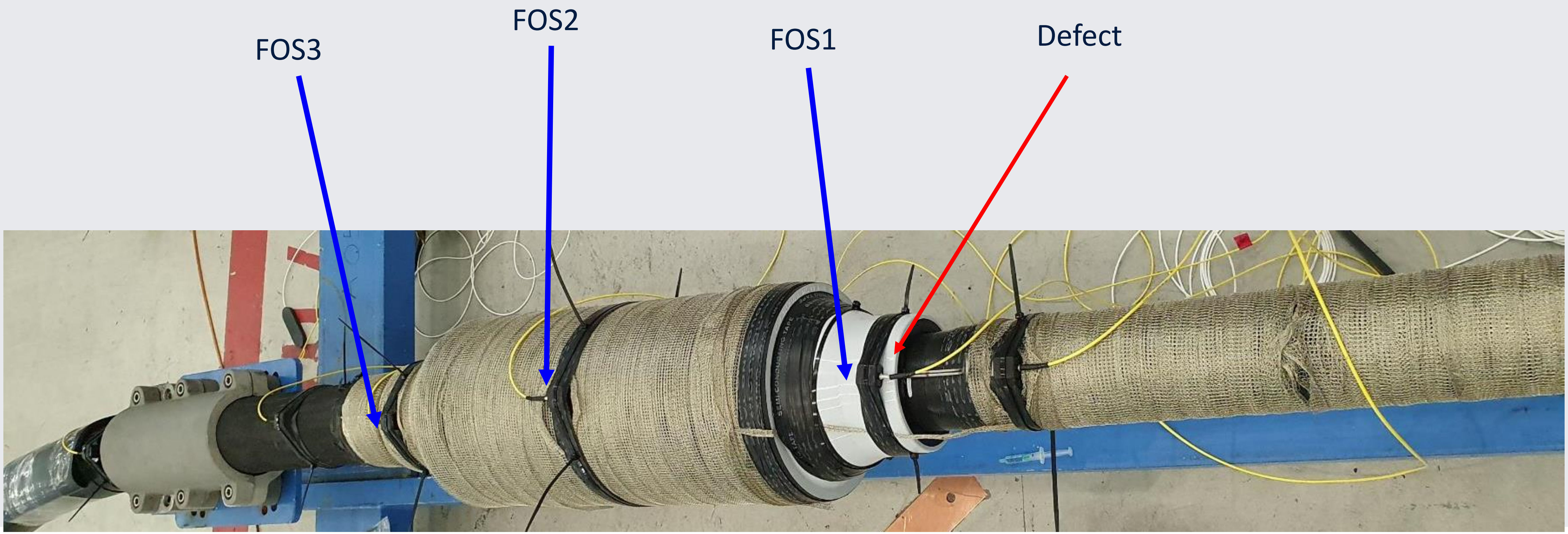
PD detection

Objective

- In cable joints and accessories, a PD level of more than 200pC normally means maintenance action is required.
- The objective of this PoC test was to demonstrate the effectiveness of OptiFender senor embedding in a cable joint for PD monitoring.
- Test was done with the old generation of OptiFender sensors with metal housing.
- The internal PD was created in the cable joint artificially by pushing the needle inside the joint body and disturbing the electric field inside it.

The optimal sensors positions for embedding

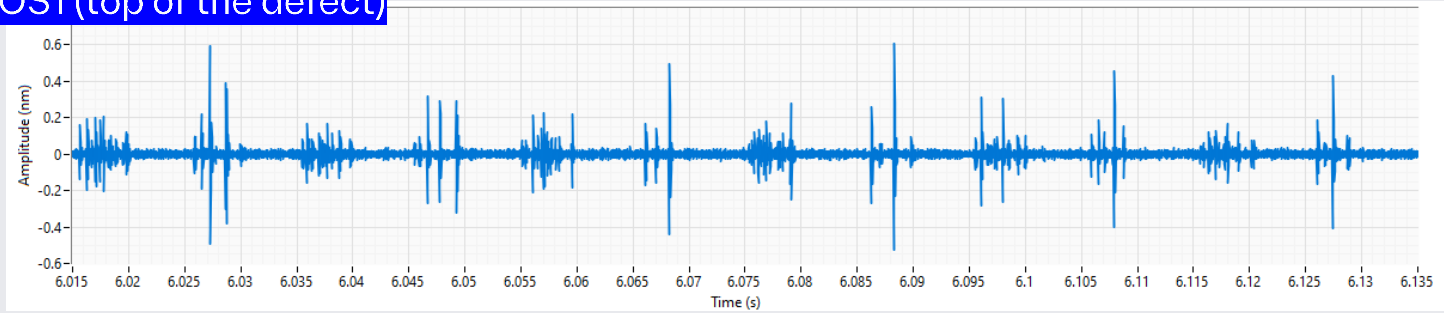
- The best sensor positions are on the joint body.
- Three sensors were installed on top of the defect, on top of the joint body, and far side of the defect.



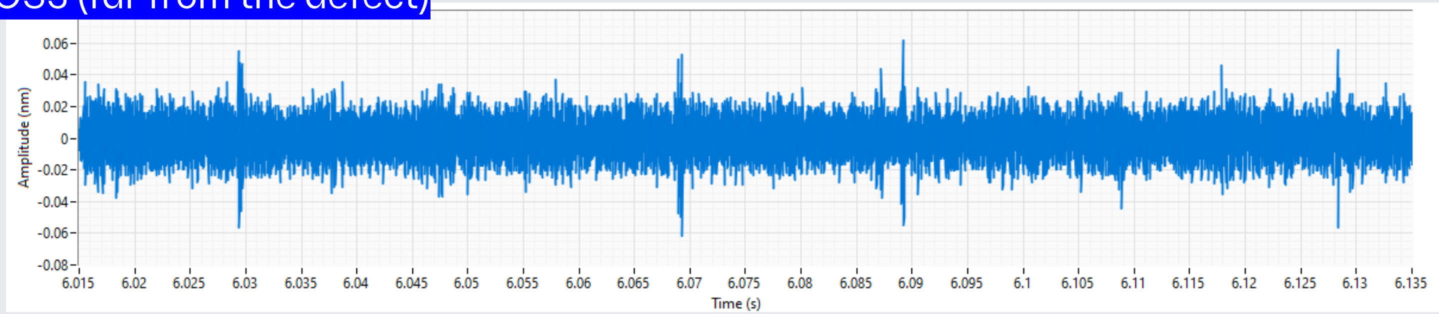
Cable joint after assembling

Test of sensors installed outside of the cable joint

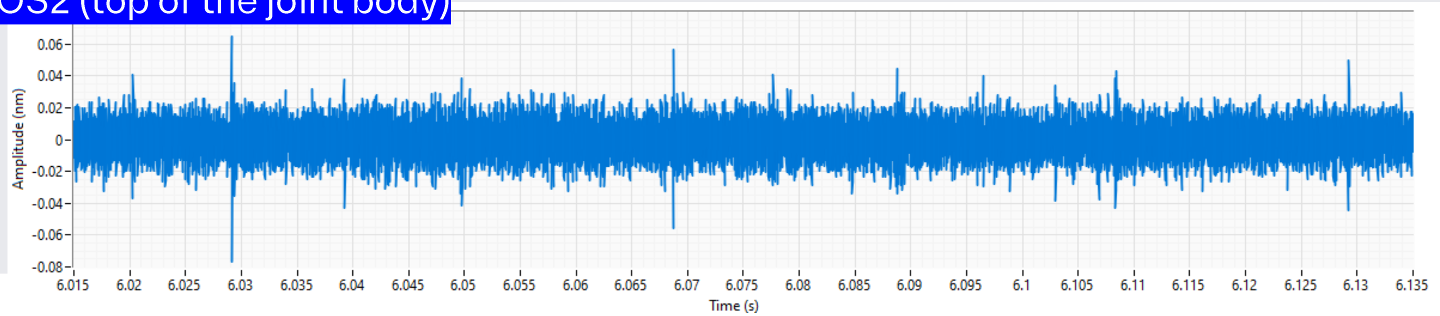
FOS1 (top of the defect)



FOS3 (far from the defect)



FOS2 (top of the joint body)

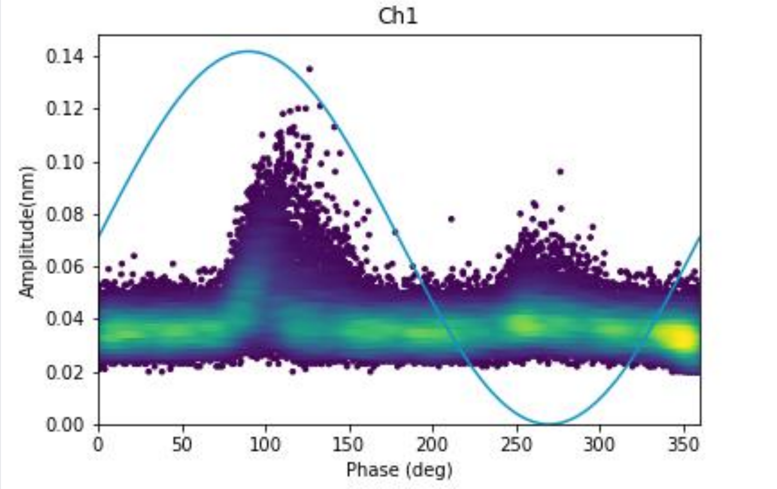


200 pC
46,2 kV

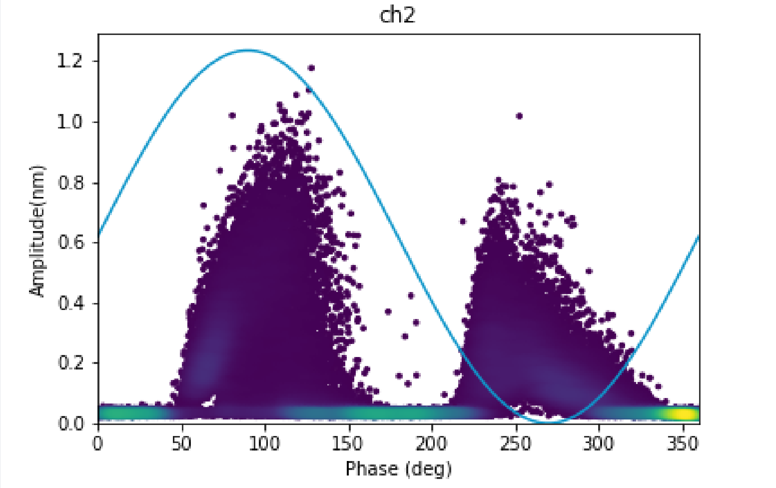
- Embedded sensors survived the embedding process and showed the same performance.
- Sensors installed outside the joint or on crossbanding cable do not show any distinguishable signal.

Examples of PRPD patterns

FOS3 (far from the defect)

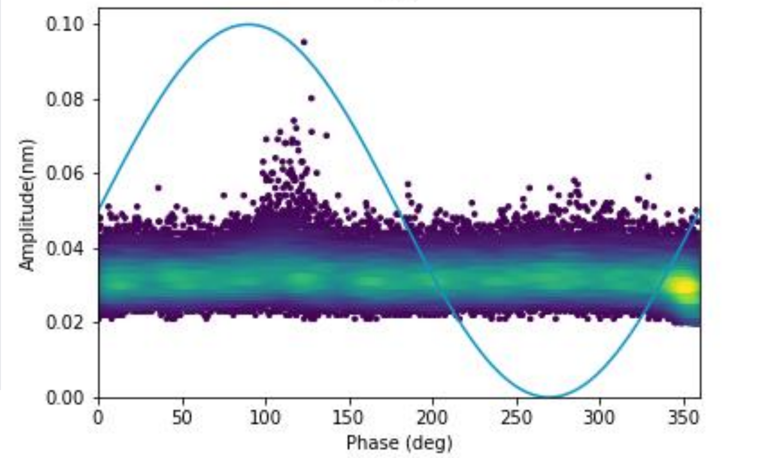


FOS1 (top of the defect)



400 -600 pC
38,5 kV

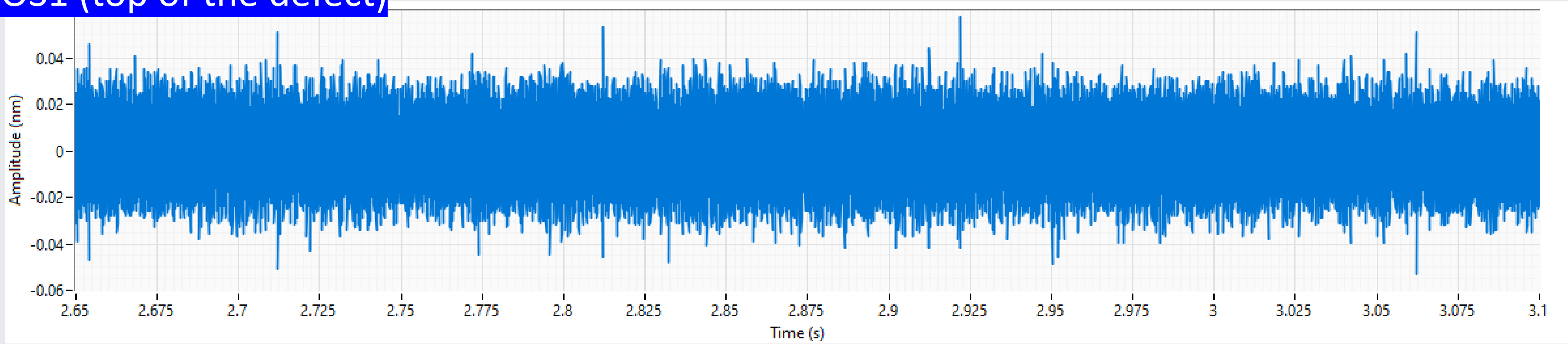
FOS2 (top of the joint body)



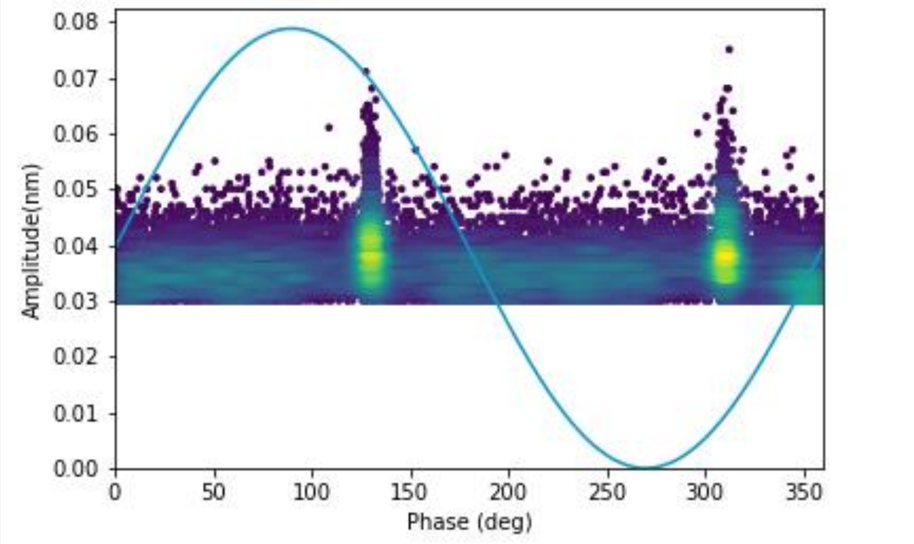
Examples of PRPD patterns

Tests of sensor sensitivity to the PD levels

FOS1 (top of the defect)



10-11 pC
21,9 kV



The sensor on top of the defect can detect even the smallest PD.

Conclusions

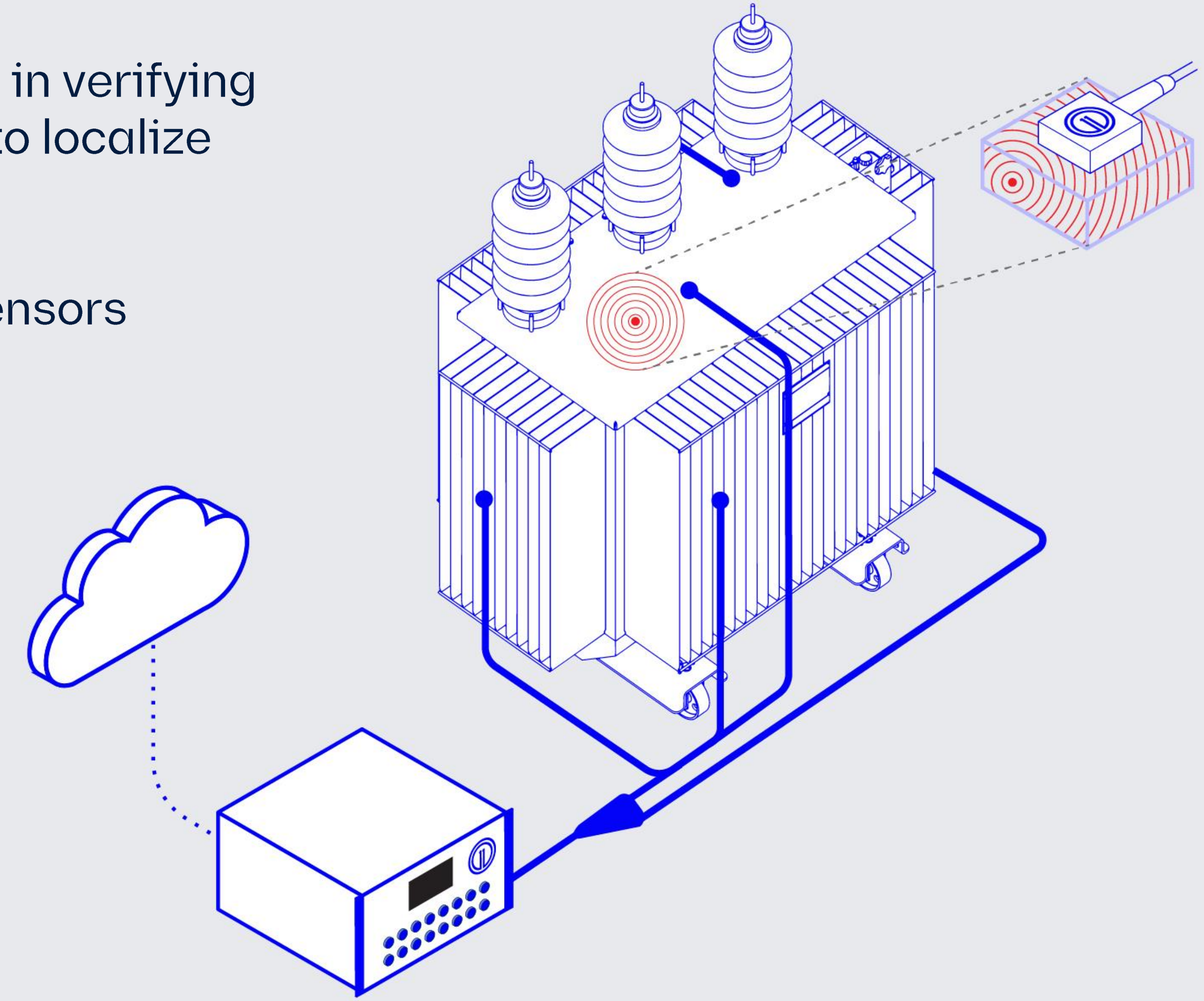
- OptiFender sensors can be embedded inside the cable joint without degradation in performance.
- OptiFender can detect PD down to the noise levels.
- OptiFender detects more robust signals at a higher voltage.
- The sensitivity is limited by the distance and amount of layers between the defect and the sensor.
- PD levels of down to 10 pC could be detected.

Field test with OptiFender in transformer substation

PD localization

Objective

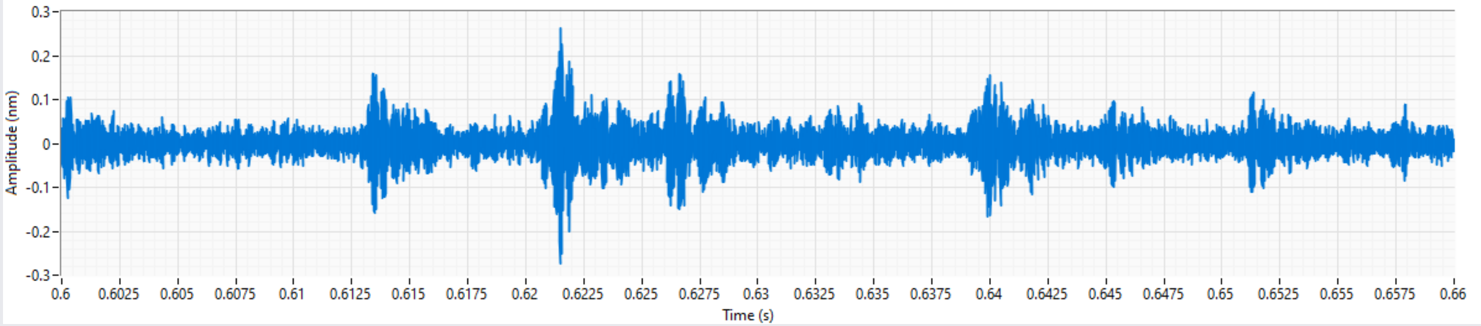
- The test goal was to assist customer service team in verifying that the transformer in the field is free of PD, and to localize the PD source if possible.
- A 16 channel OptiFender system was used, with sensors placed all around the transformer.
- There was high electric background noise, about 400-500 pC. It is a rather special case. Typically noise is about 50 pC outside of the lab conditions.
- OptiFender detected PD as well as some powerful
- events coming inside the transformer.



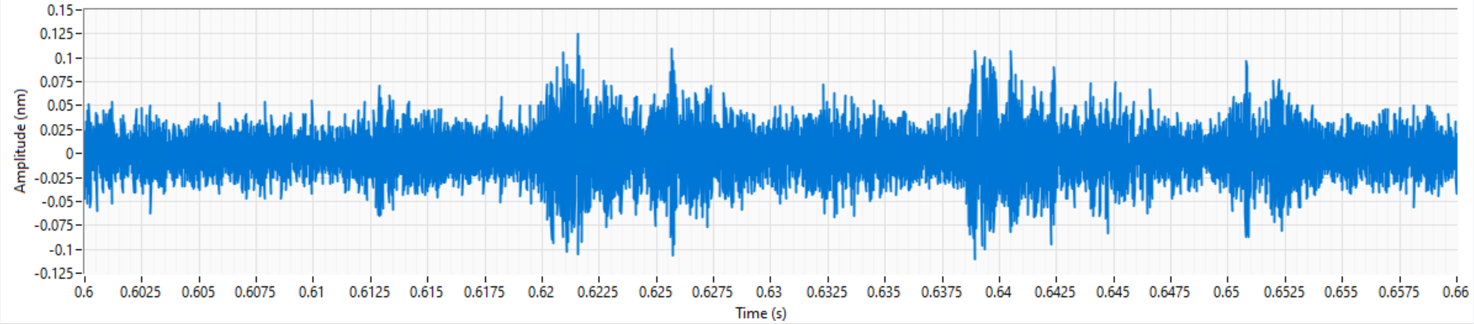
PD activity

Examples of the waveforms

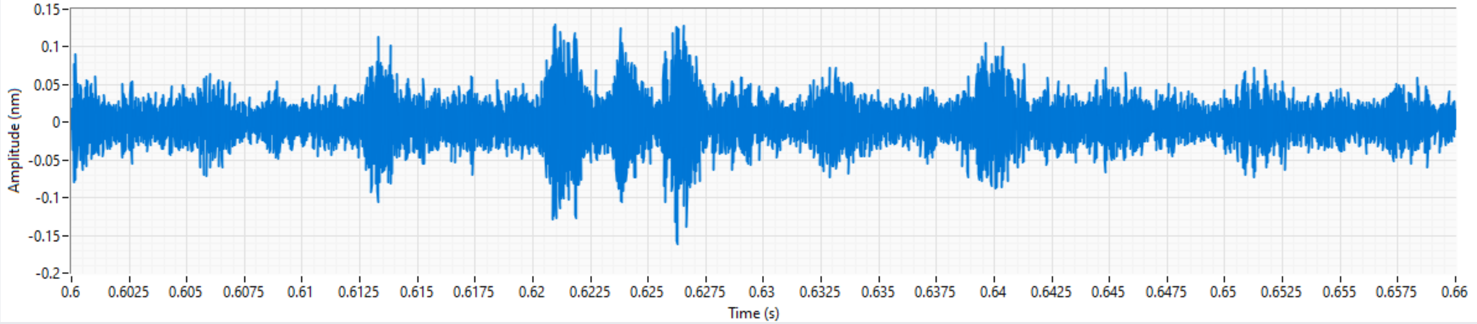
Ch4



Ch7



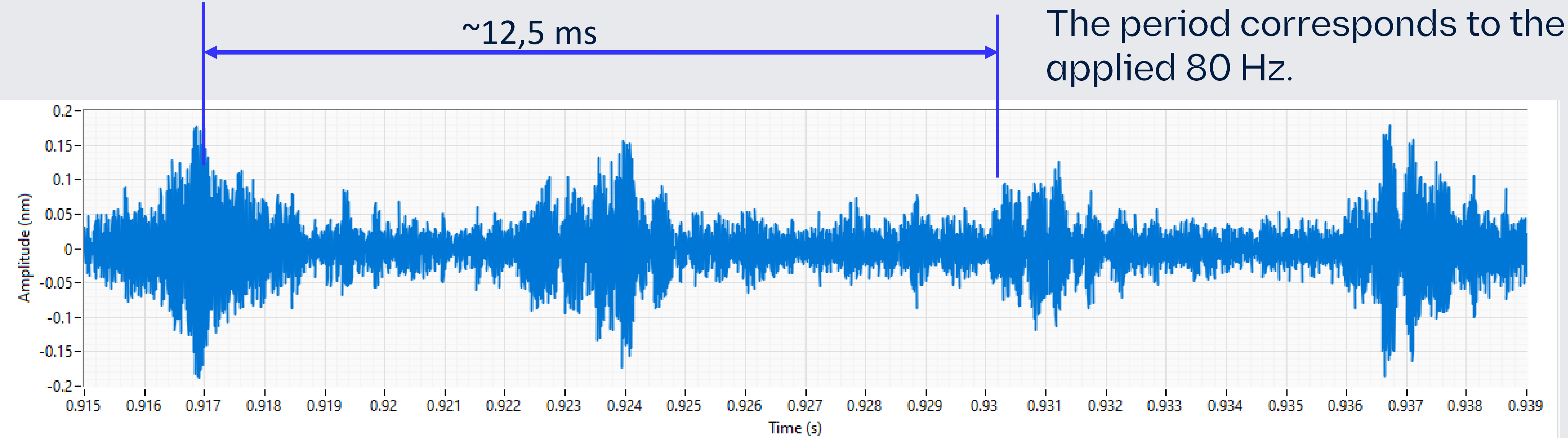
Ch11



Periodicity

120 %

Ch4



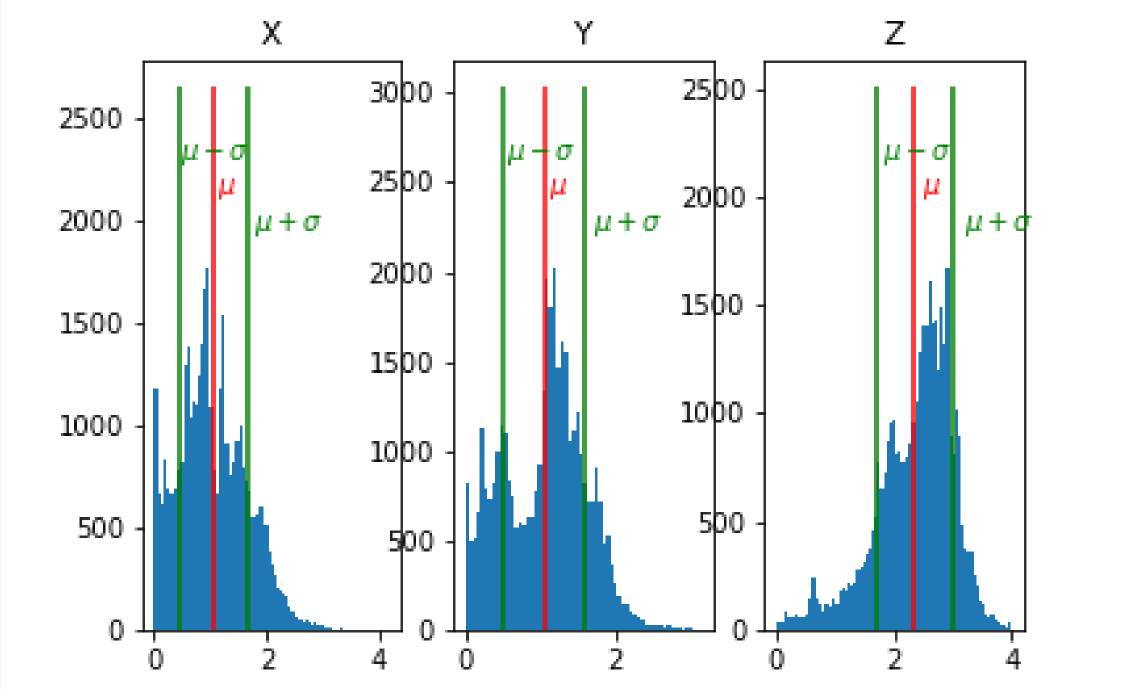
The period corresponds to the applied 80 Hz.

The periodicity and voltage dependence indicates that the observed signal is indeed PD.

Localization

20220826_110600 - 20220826_110801

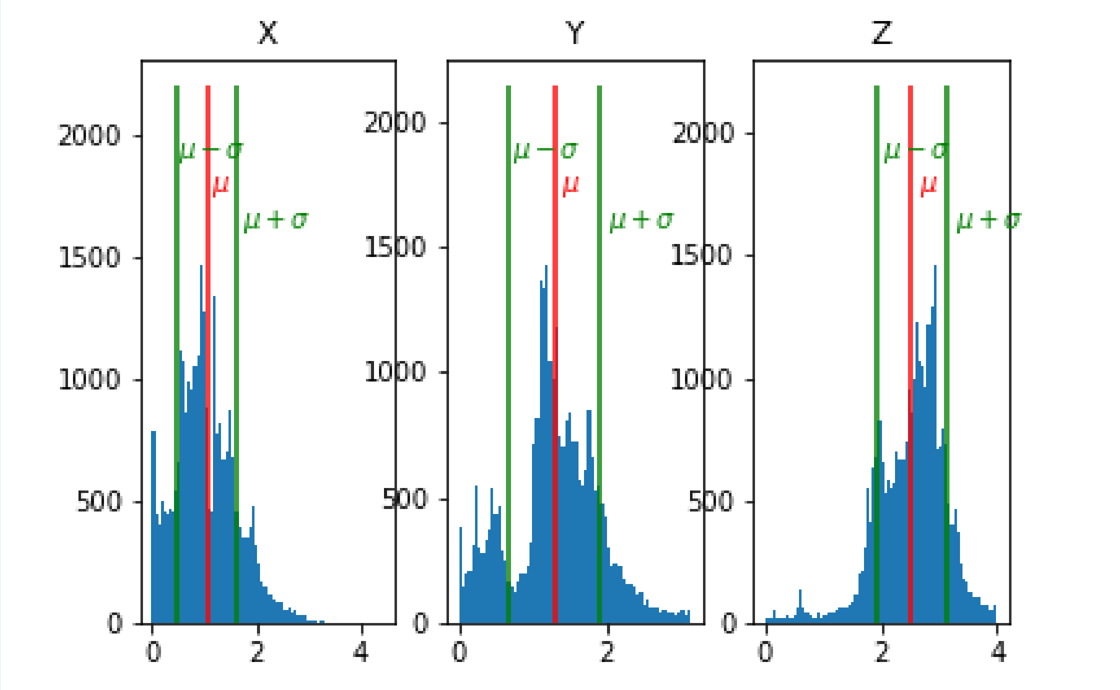
Conf 2



Result
X 1.049 +- 0.611
Y 1.052 +- 0.548
Z 2.354 +- 0.664

20220826_120001 - 20220826_120202

Conf 3



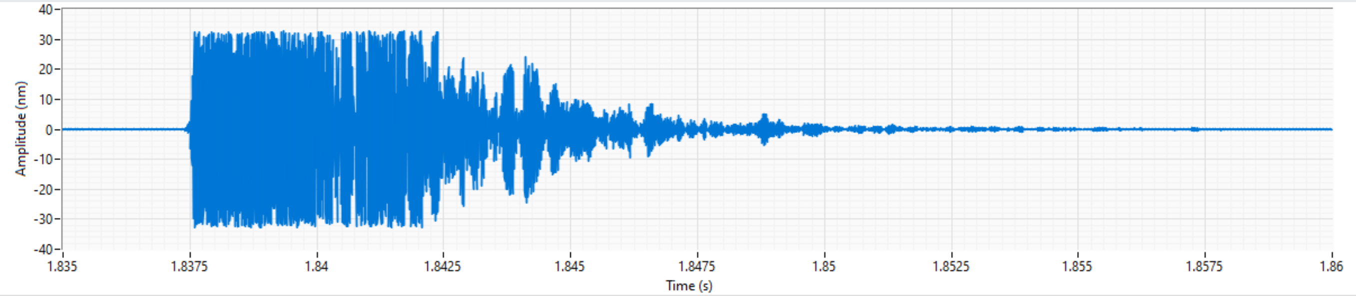
Result
X 1.046 +- 0.592
Y 1.294 +- 0.603
Z 2.524 +- 0.607

Example of powerful signals

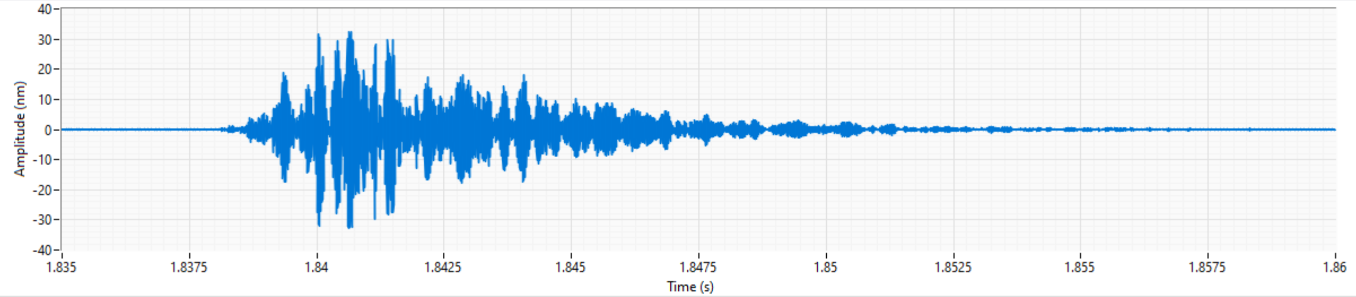
Examples of waveforms

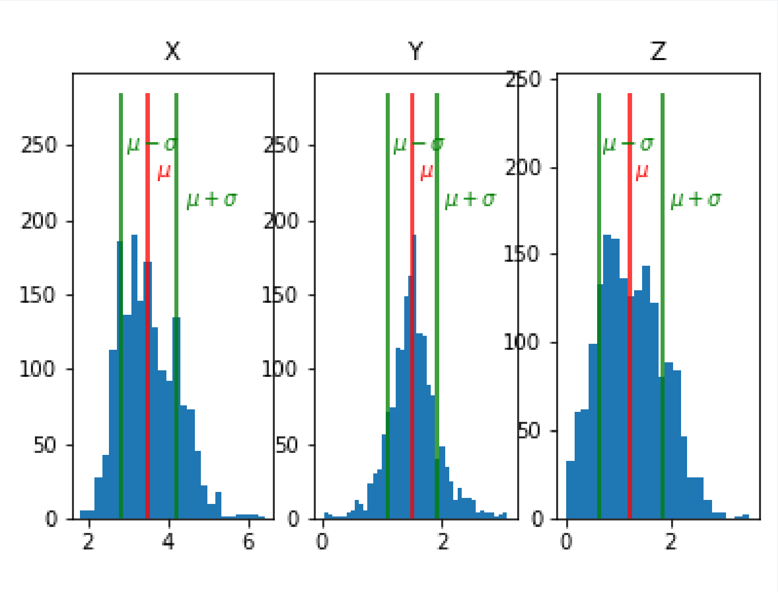
Signal 1- 20220825_132815

Ch1



Ch4





Result
X 3.525 +- 0.711
Y 1.527 +- 0.412
Z 1.238 +- 0.615

Conclusions

- Sensors performed well in a substation environment with severe background noise levels.

- Electrical sensors registered background noise of more than 500 pC. OptiFender sensors were insensitive to this noise.

- Moreover, rare powerful acoustic signals are coming from inside the transformer, which may indicate sparks or some mechanical issues.

- It was possible to localize the source of the PD activities as well as loud events.

Thank You

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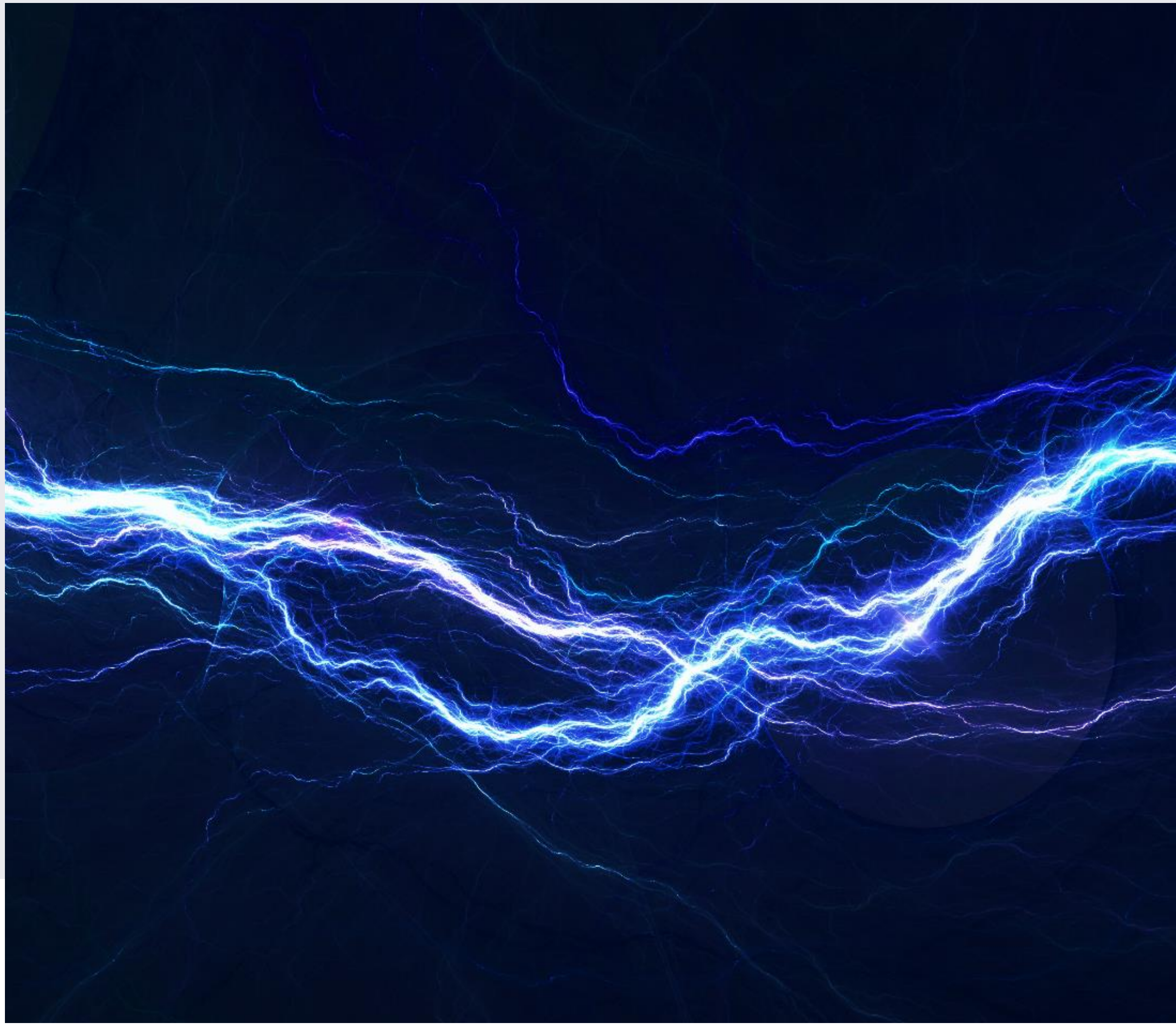

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