Underground cables online diagnostics

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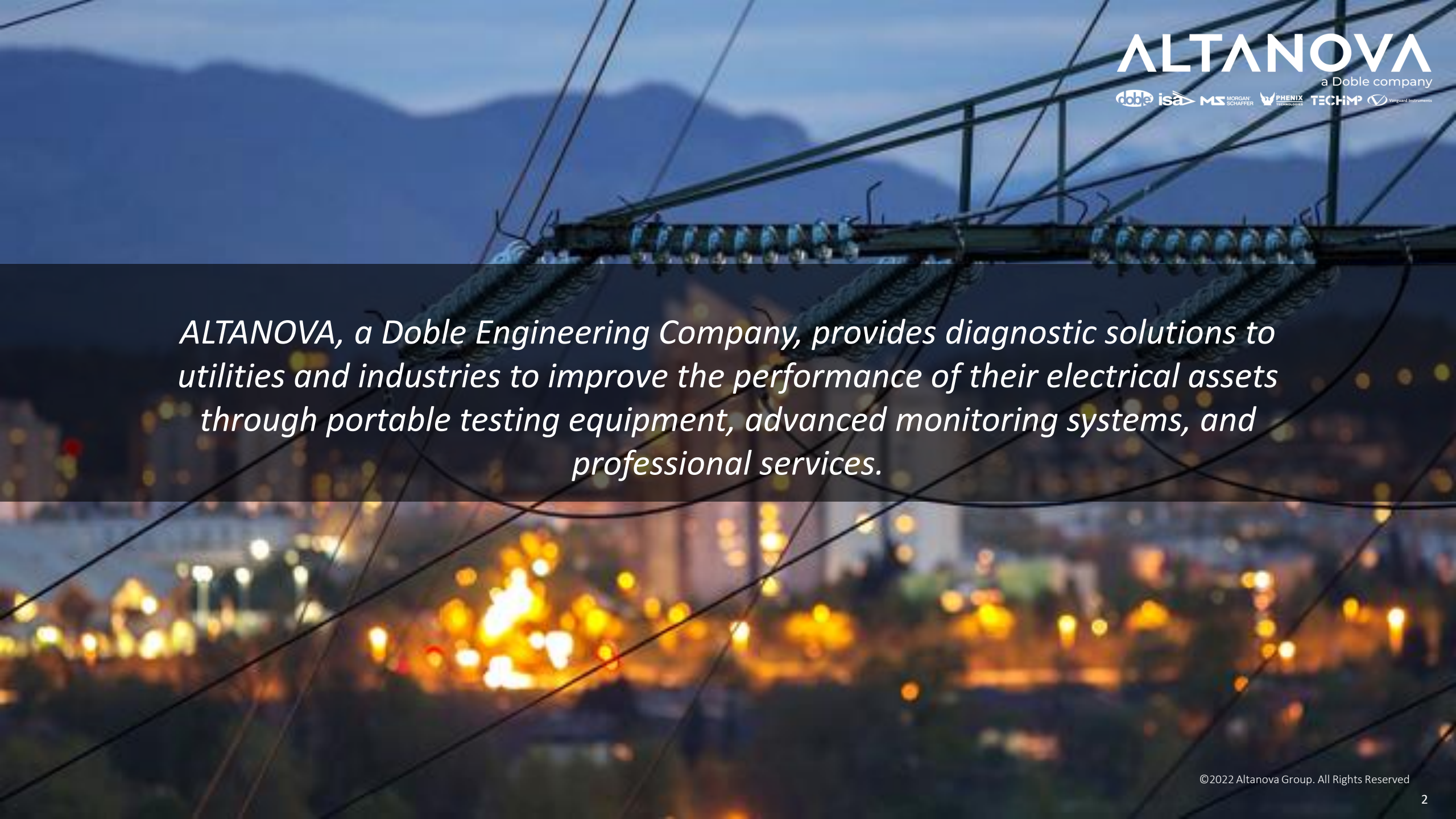


ALTANOVA
a Doble company

ALTANOVA, a Doble Engineering Company, provides diagnostic solutions to utilities and industries to improve the performance of their electrical assets through portable testing equipment, advanced monitoring systems, and professional services.

Altanova History

1938 I.S.A. Istrumentazioni Sistemi Automatici S.r.l. is established in Taino ITALY

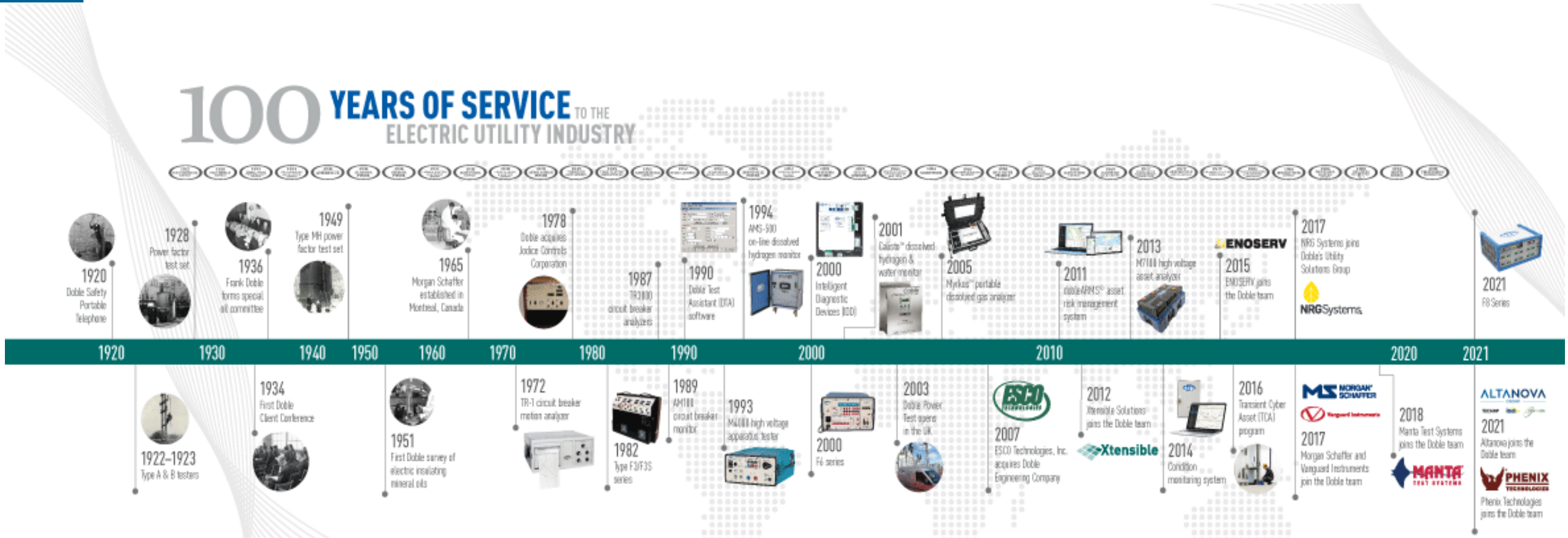
1999 TECHIMP was born as a spin-off from the University of Bologna ITALY.

2017 I.S.A. and TECHIMP merge giving birth to the ALTANOVA GROUP

2019 INTELLISAW joins ALTANOVA GROUP

2021 ALTANOVA GROUP becomes part of ESCO Technology Group and joins the Doble Engineering Company, as part of the Utility Solution Group (USG) division.

Doble History



Altanova Today

ALTANOVA
a Doble company

100
COUNTRIES

12
GLOBAL FACILITY LOCATIONS

150+
EMPLOYEES

150+
SALES PARTNERS

5550+
CUSTOMERS GLOBALLY

Part of ESCO Technologies' Utility Solutions Group

PRODUCT BRANDS

doble® isa MORGAN SCHAFFER® PHENIX TECHNOLOGIES TECHIMP Vanguard Instruments

Our Solutions

Electrical Test Equipment

Essential for day-to-day maintenance tests of electrical assets. Useful in specific phases of the asset lifecycle:

- Procure
- Operate
- Maintain
- Decommission.

Professional Services

Diversified offer according to the electrical asset lifecycle:

- Installation and commissioning
- Diagnostic test
- Data analysis
- Consultancy
- Training.

Monitoring Systems

Shift from a time-based maintenance to a condition-based maintenance.

Focus on predictive maintenance and shift in focus from electric asset value cost to network outage costs.

Strong evolution of digitalization trend in the power industry.

Testing And Monitoring Solutions For:

- Power transformers
- Circuit breakers
- HV gas insulated switchgears
- MV/HV/EHV cables
- MV/LV switchgears
- Batteries
- Current & voltage transformers
- Protective relays
- Meters and transducers
- Rotating machines
- Variable speed drives
- Overhead lines






Overview

- Maintenance strategies and challenges
- Survey methods
- PD investigation on UG
- UG Permanent monitoring systems

Undeground cables

Undeground cables are becoming key assets for transmission and distribution utilities as well as industrial environments.

Yesterday: cables used for special application only

Today: cities where underground cables>95% total lines

Cables advantages:

- Visual impact
- No electric field
- More acceptable by population
- Efficient installation techniques
- Decreasing prices

Underground cables

When in service the cables:

- Out of service for periodic check and maintenance is not desirable for the system operator.
- Circuits often buried, only accessible at terminations, cable route can be unknown.
- HV/EHV cables are equipped with accessible link boxes and may be installed in tunnels or joint bay manholes.

Intro

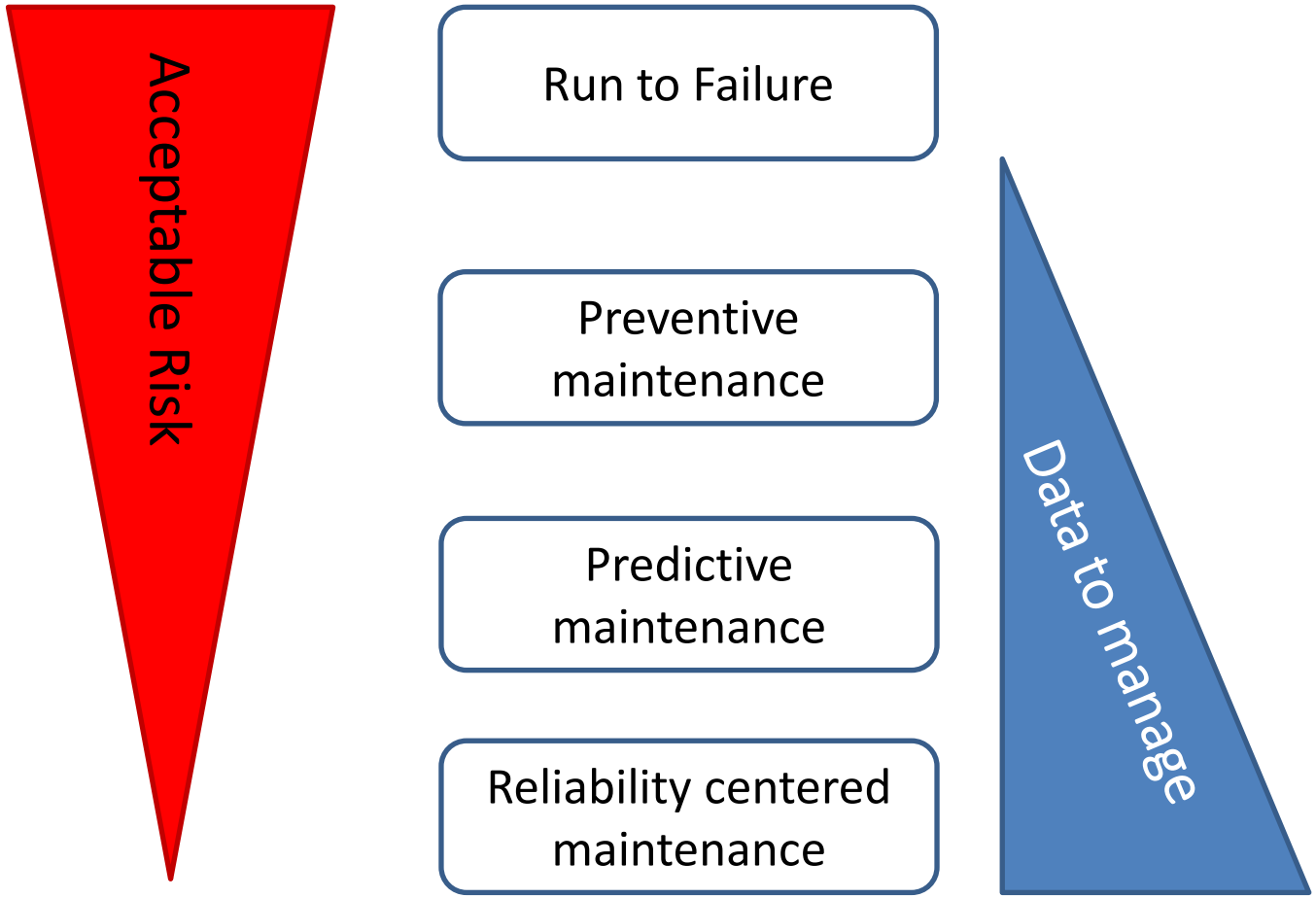
Several test techniques can be applied to UG cables, need to find a balance:

- Effort vs focus of the target.
- Information from the assessment vs maintenance actions.

The strategies need to take into account

- Acceptable risk of asset fault
- Resource allocation
- Information management

Maintenance Strategies



SURVEY

Visual Checks
Thermography
RFI surveys

INVESTIGATION

PD Screening
PD test on specific assets

CONTINUOUS ASSESSMENT

Permanent monitoring MV cables
Permanent monitoring HV cables


Pool #1

Thermography

Widely used at all voltage levels, able to detect the temperature on the test object surface.

A thermal camera can be found in a EMD toolbox for quick surveys in outdoor substations.

Human eye image recognition!

Thermography

Cannot be applied to buried cables but significant results can be achieved when testing accessible portions of the cable.

➔ Terminations

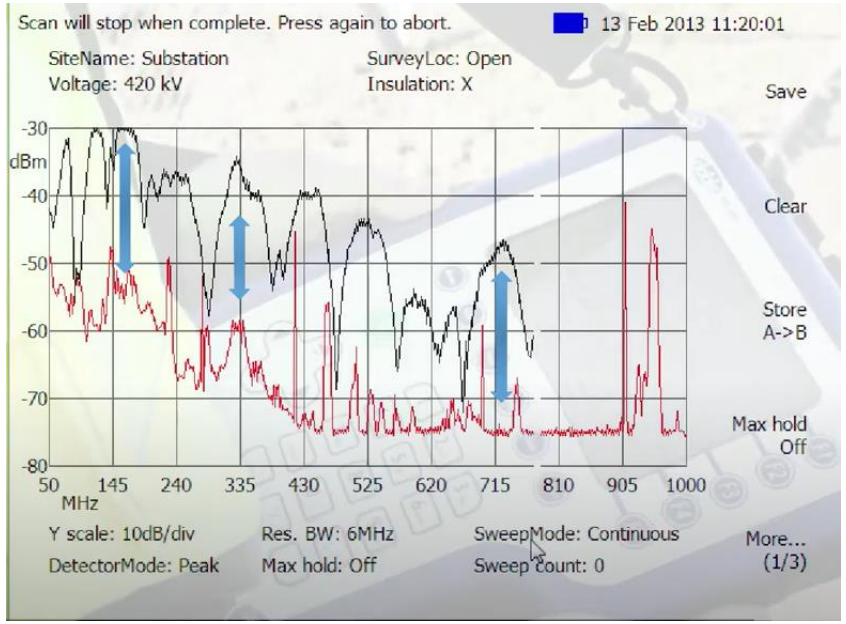
➔ Earthing system & bonding cables

RFI surveys

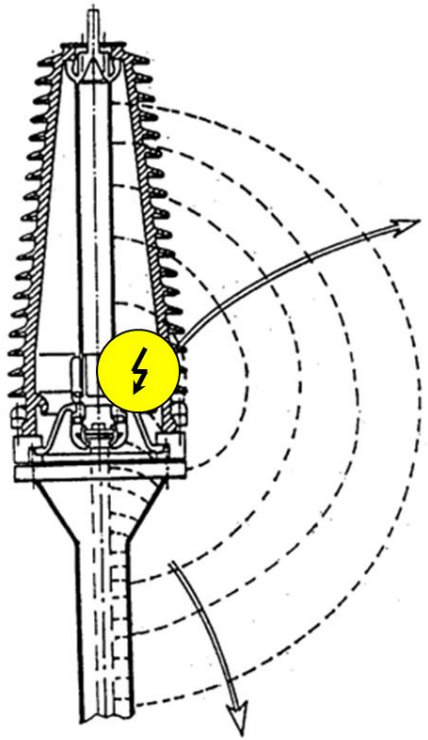
RFI measurement with UHF antenna is used for quick and easy substation survey.

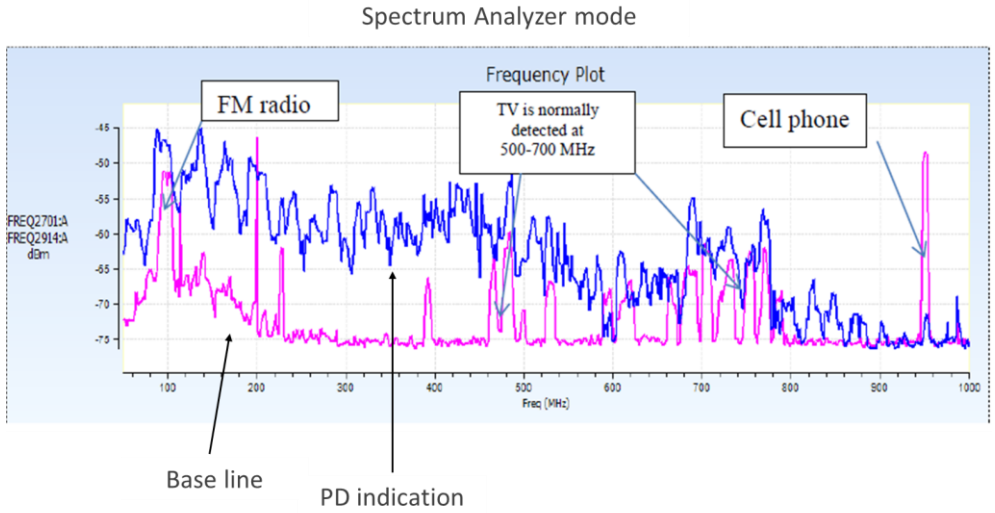
Several issues occurring in the MV/HV assets can be found including PD occurring in cable terminations.

Easy to perform as routine test (ie: every 3 months), the local EMD operator will have its own history data of the substation and new signals will be easily highlighted.



RFI surveys





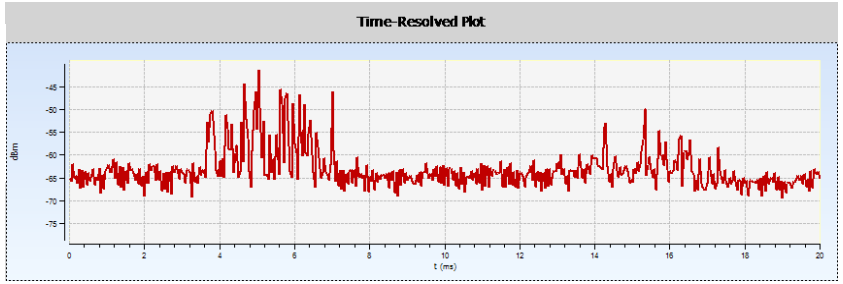
Spectra correlation highlights unwanted signals to be further investigated

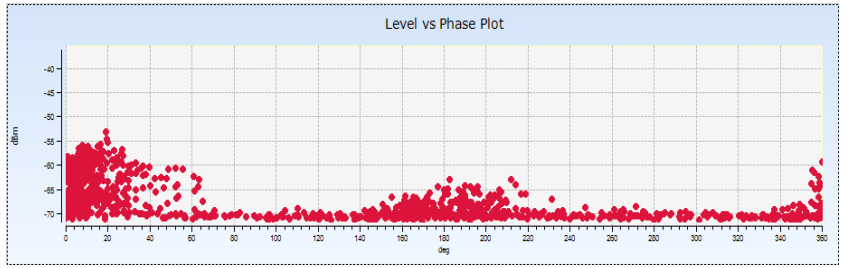
RFI surveys

Time Resolved Mode

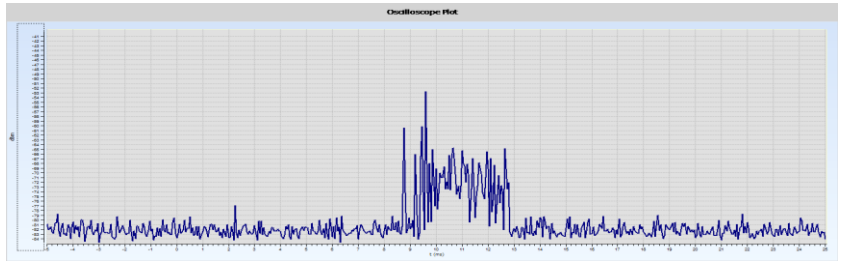
PRPD pattern

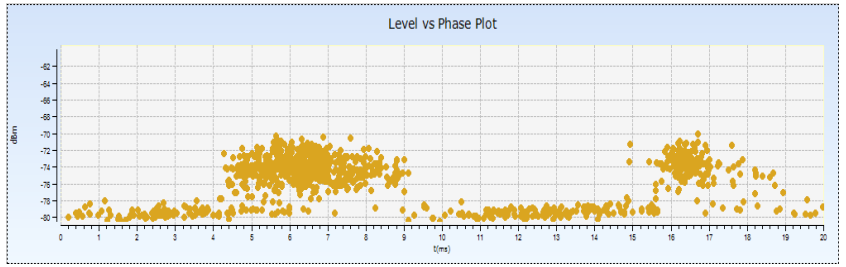
Surface Discharge



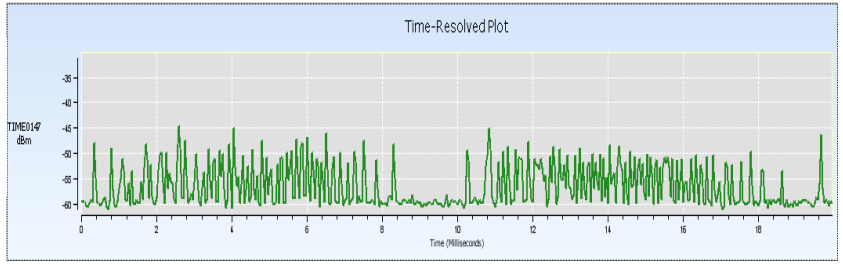


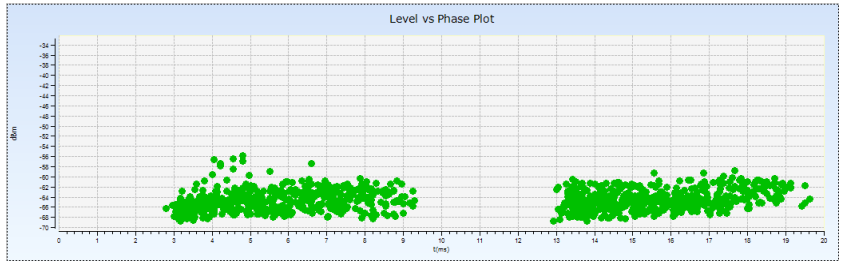
Corona





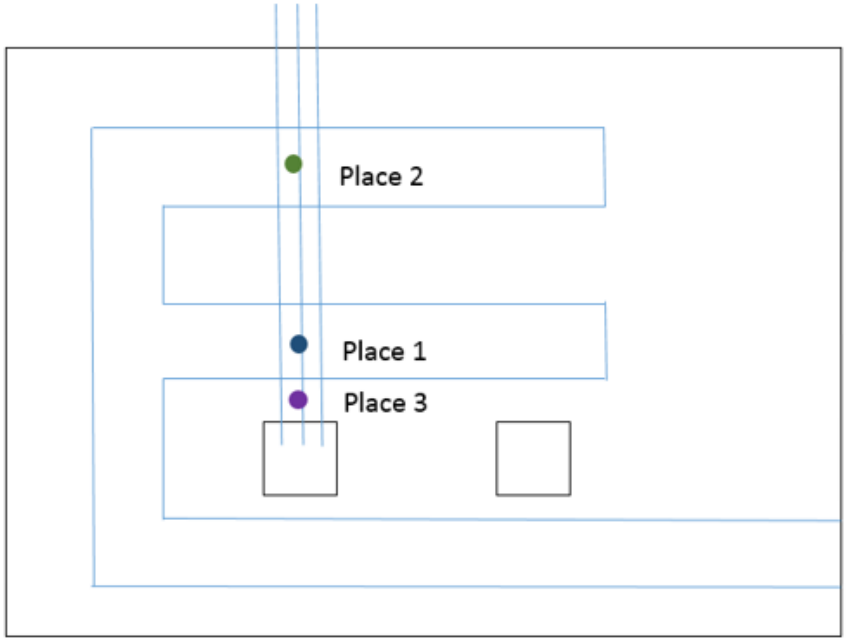
Floating Potential





RFI surveys

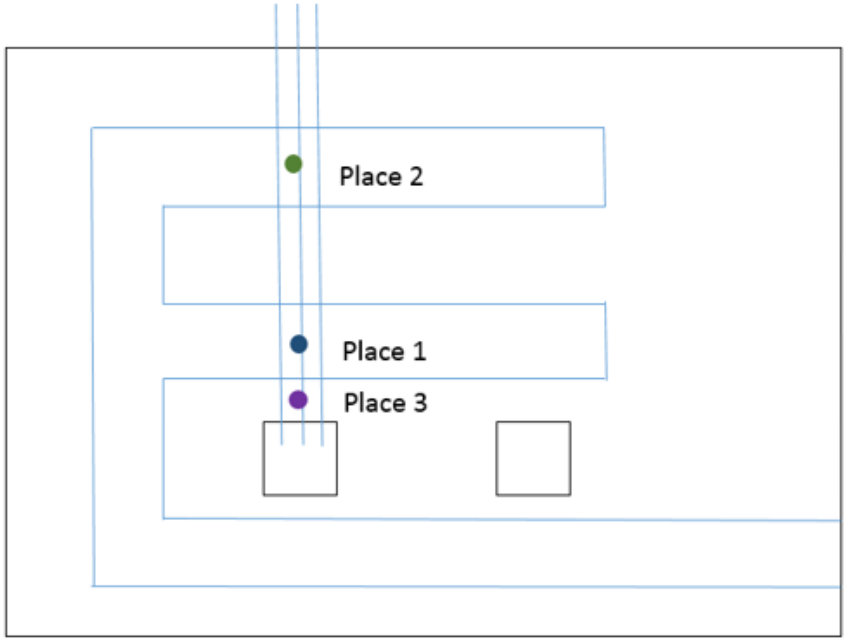
CASE STUDY



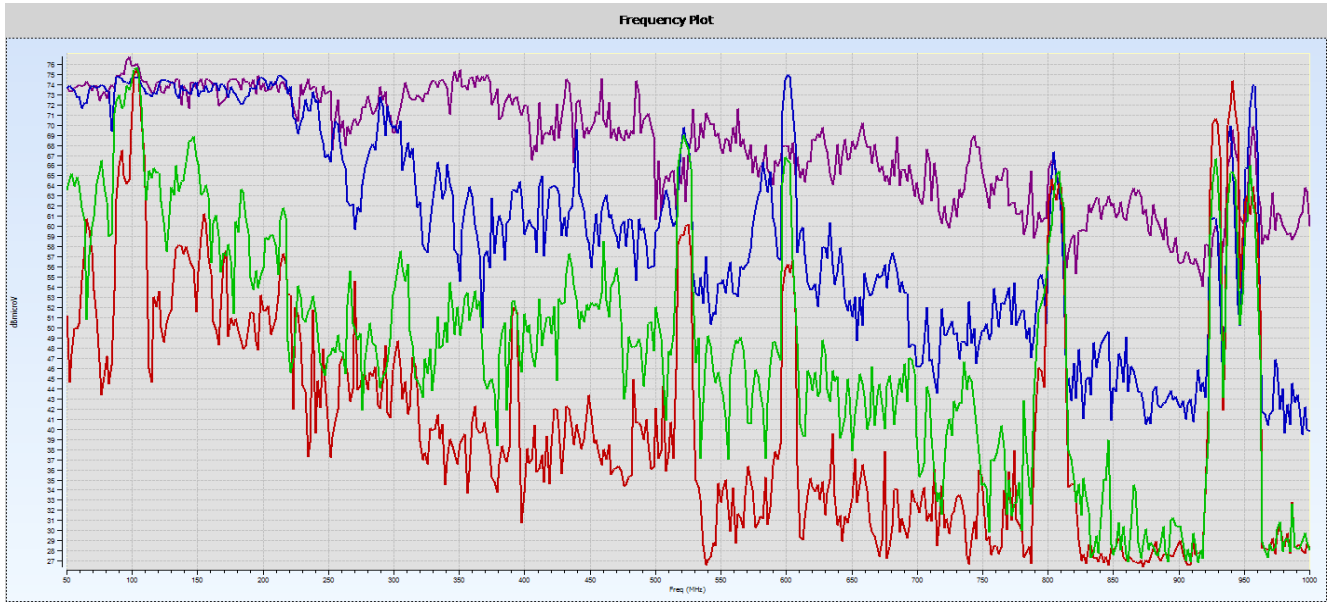
Base line

RFI surveys

CASE STUDY

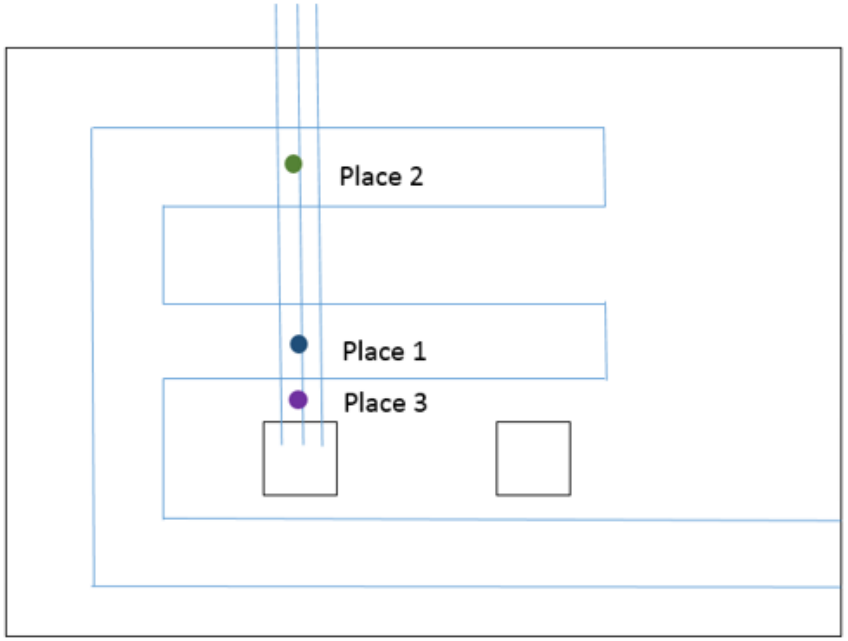


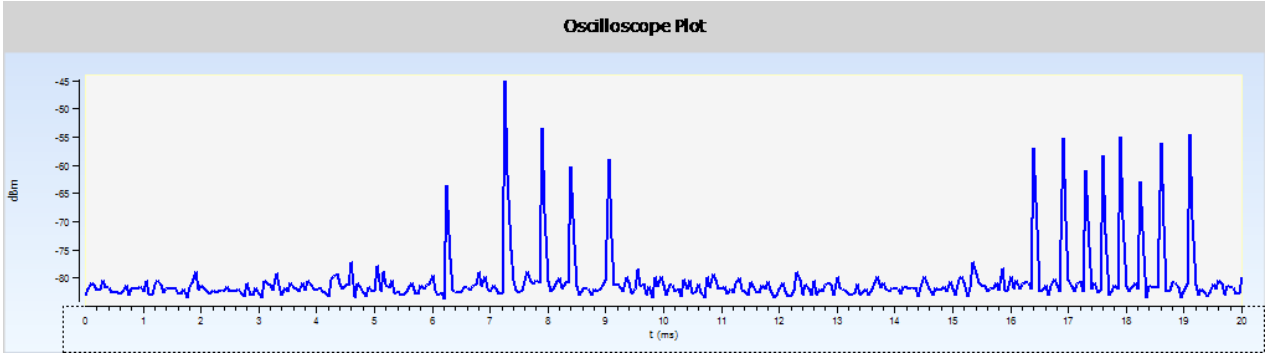
Base line

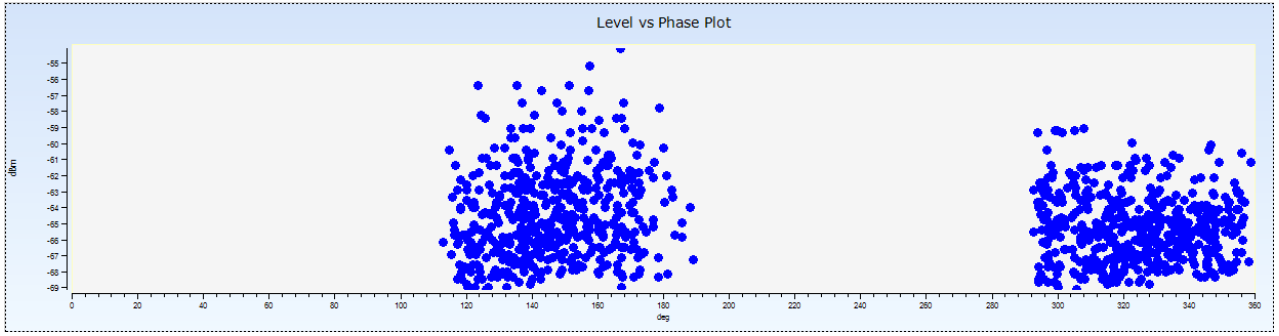


RFI surveys

CASE STUDY








Pool #2

MV cables, PD test

Deeper investigation on undeground cable without outages can include partial discharge test.

PD screening

➔ Fault prevention

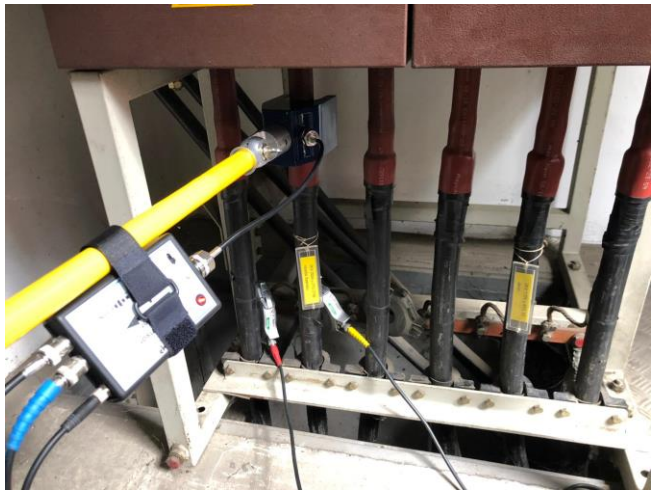
➔ Out of service & maintenance management

PD investigation

➔ PD localization

MV cables, PD test

Depending on the cable circuit layout PD test:



@Terminations

- Prevent faults in the terminations
- Triggers major defects along the cable route

@Link boxes

- Prevent faults in joints and cable route overview

@Cable route

- Tunnels & industrial plants only

MV cables, PD test

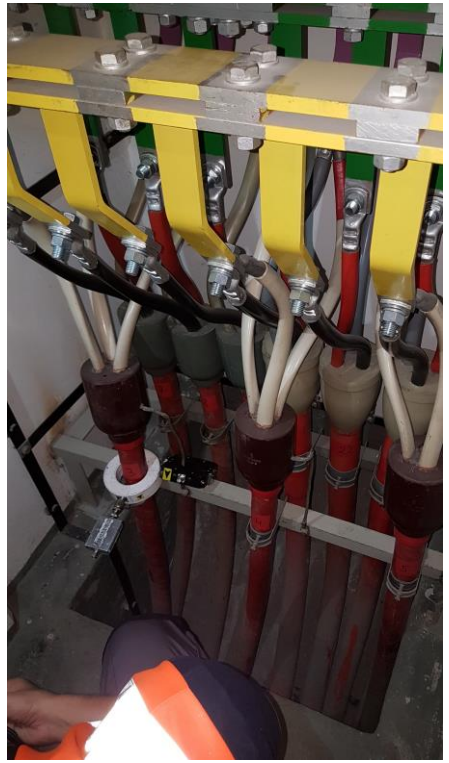
Air insulated terminations.

HFCTs sensors

PRPD pattern analysis

Perfect for screening and

1st order investigation



Effective tool in terminations fault prevention, signal attenuation decreases sensitivity for long routes, noisy environment.

MV cables, PD test

Gas insulated terminations

HFCTs are the preferred sensor, sometimes no ground leads available

➔ HFCT on cables

➔ Flexible magnetic couplers

Good SNR thanks to the GIS enclosure

MV cables, PD test

Joints and cable route

HFCT on cables

Antennas on sectionalized joints

Flexible magnetic couplers

Industrial plants can have accessible cable routes

➔ PD survey

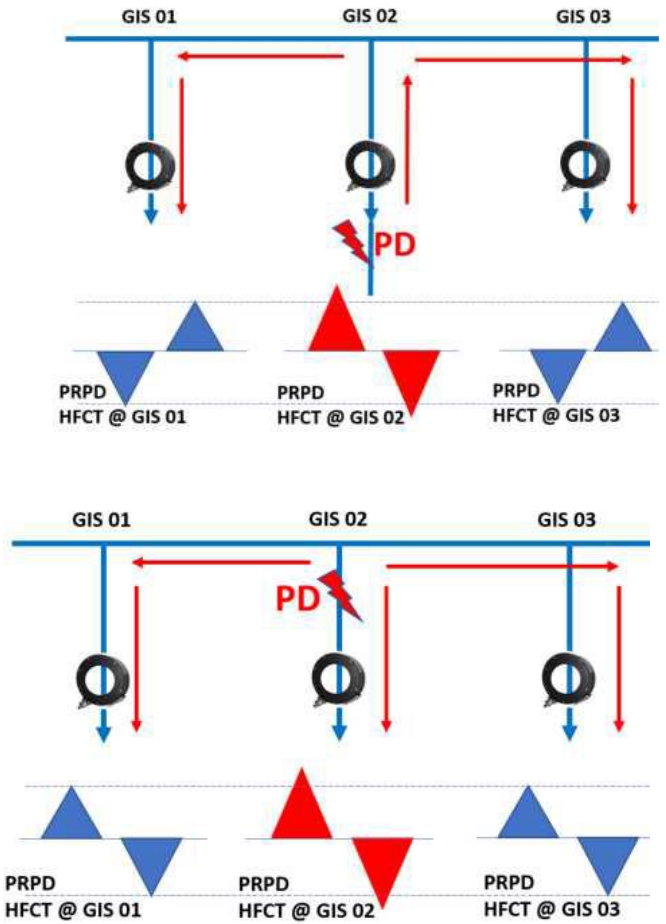
MV cables, PD test

CASE STUDY*

MV GIS panels, PD measurement taken with HFCT on cables as part of routine screening.

In MV networks PD signals can easily spread along the common earth.

The PD pulses are strictly referred to the applied voltage phase angle and the polarity information is used to localize the source



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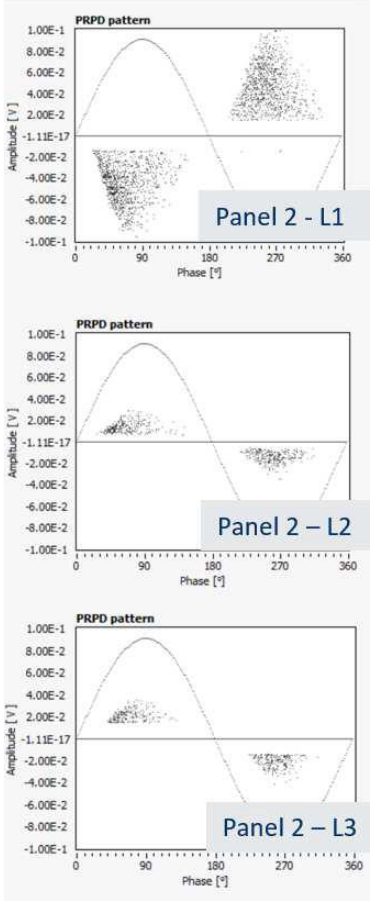
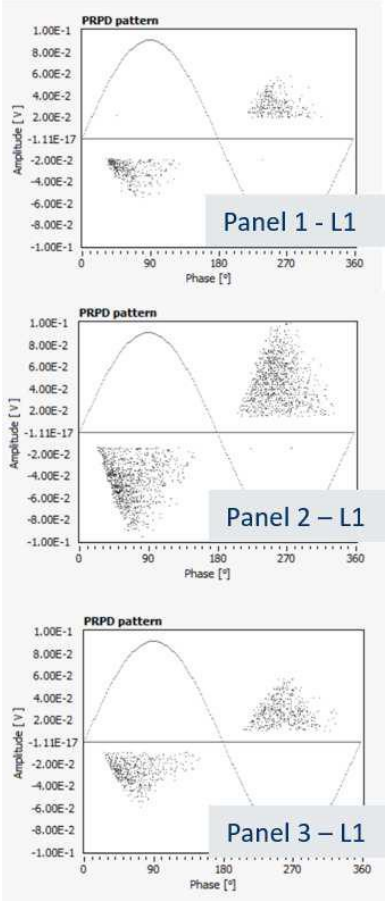
MV cables, PD test

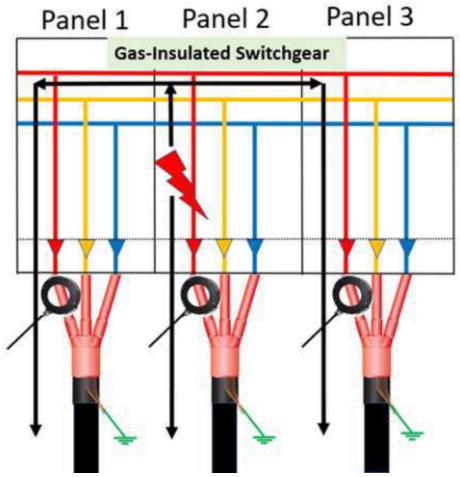
CASE STUDY*



Reversed polarity on nearby phases, higher amplitude on L1



Same polarity on nearby panels for the same phases, higher amplitude on panel 2



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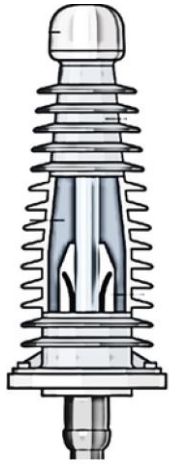
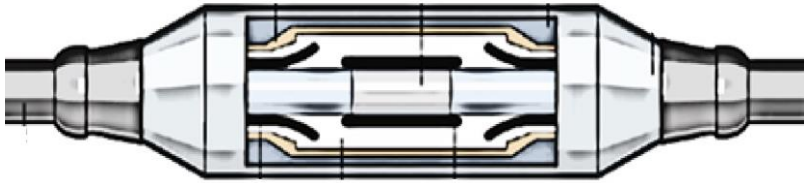
HV cables, PD test

HV cables present standardized layouts that enhance the test method effectiveness.

The most critical components for insulation stress are cable accessories (joints and terminations).

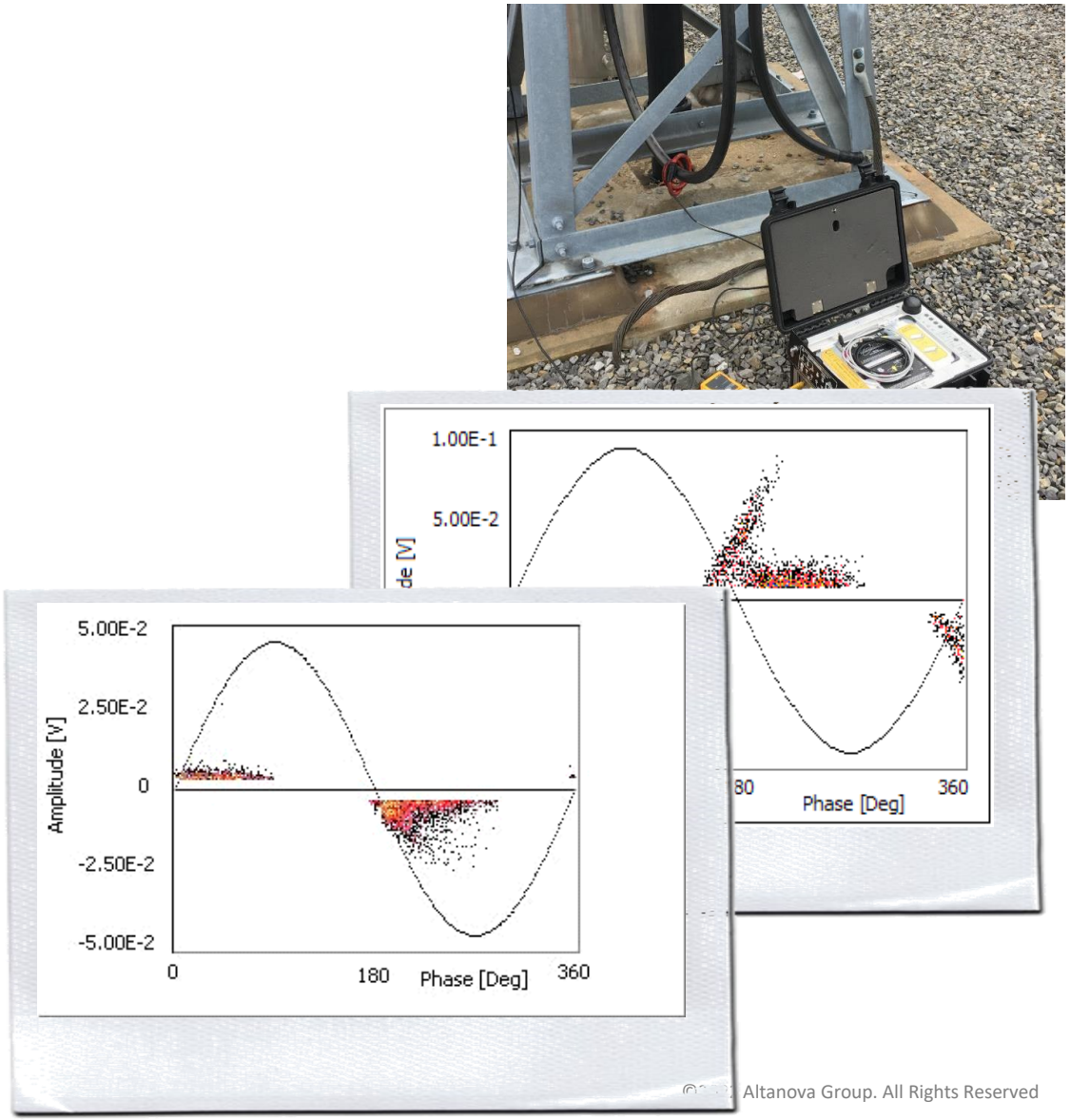




HV cables, PD test

On line spot test PROs and CONs

- Real working conditions
- No out of service, cheap & quick test
- Short frame of the asset routine
- Noisy environment
- Skills & experience required for test and analysis

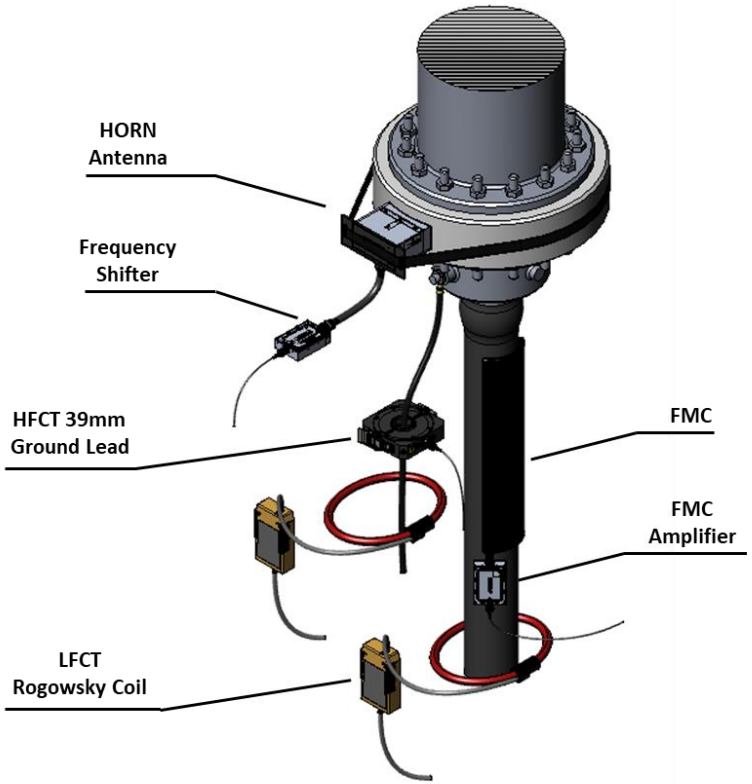


HV cables, PD test

GIS TERMINATIONS

PD tests at GIS termination are carried out by means of

- HFCT on the ground leads
- UHF measurements on insulating spacer
- Coupling with cable (FMC sensor)
- Eventual embedded sensors



Thanks to the GIS layout the background noise is usually very low and external disturbances are limited.

HV cables, PD test

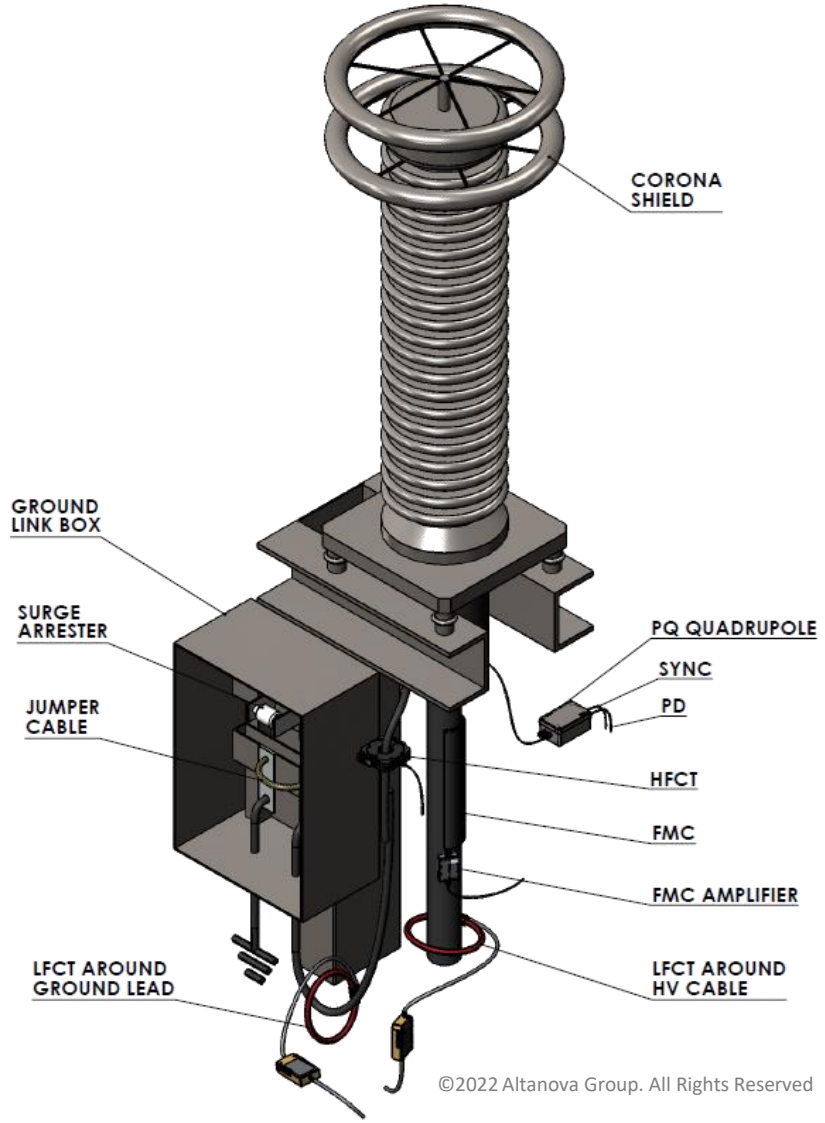
OUTDOOR TERMINATIONS

PD tests at outdoor terminations are carried out by means of

- HFCT on the ground leads
- Coupling with cable (FMC sensor)
- Eventual embedded sensors

Outdoor terminations are often a source of external surface discharges

➔ PD separation PD identification

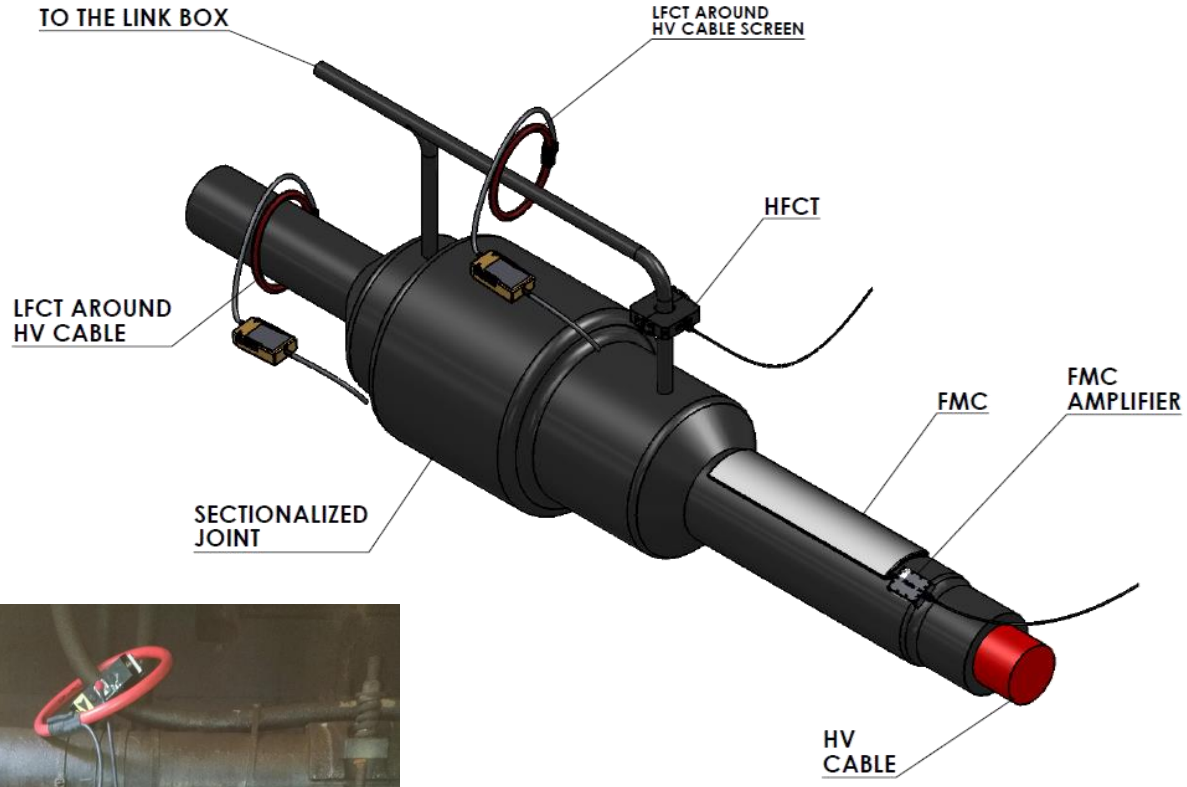


HV cables, PD test

ACCESSIBLE JOINTS

- HFCT around ground leads
- FMC along cable portion
- UHF antenna on joint sectionalized portion

Far from terminations all the substations disturbances are attenuated and the PD survey can be very sensitive.

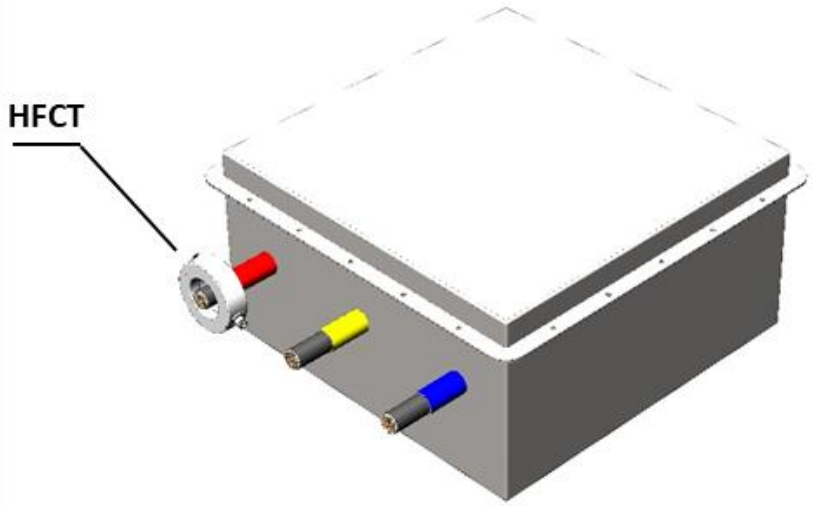


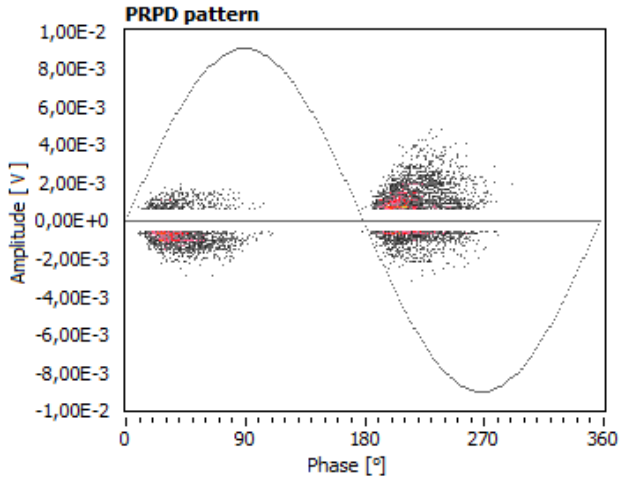
HV cables, PD test

LINK BOXES

In case of inaccessible joint a PD measurement can be performed on the bonding cable entering the link box by the means of HFCTs.

The sensitivity is lower compare to single core but the solution can lead to interesting findings as well.





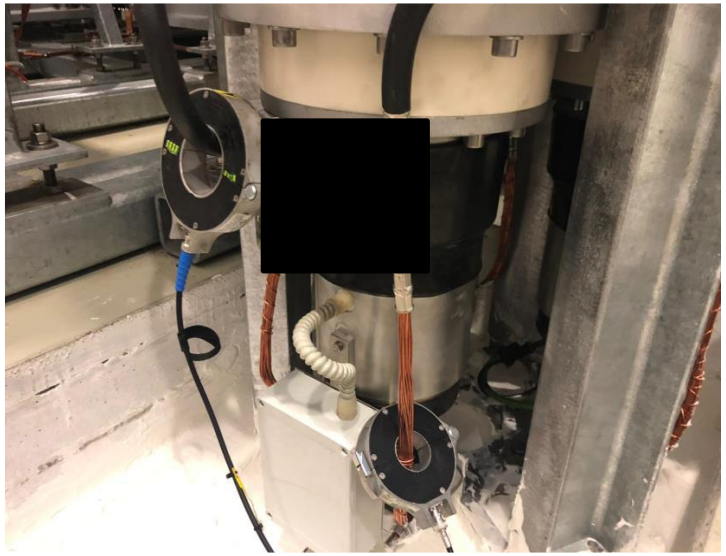
HV cable, PD test

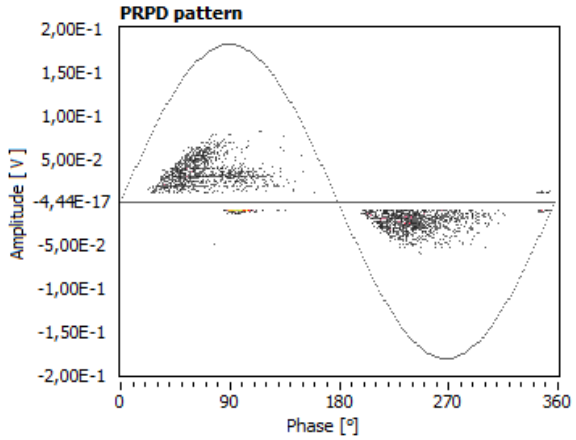
CASE STUDY

220kV GIS termination

PD screening of all cable terminations in a 220kV GIS substation highlighted PD signals from one phase only of a specific circuit.

➔ Inspection and new stress cone replacement.



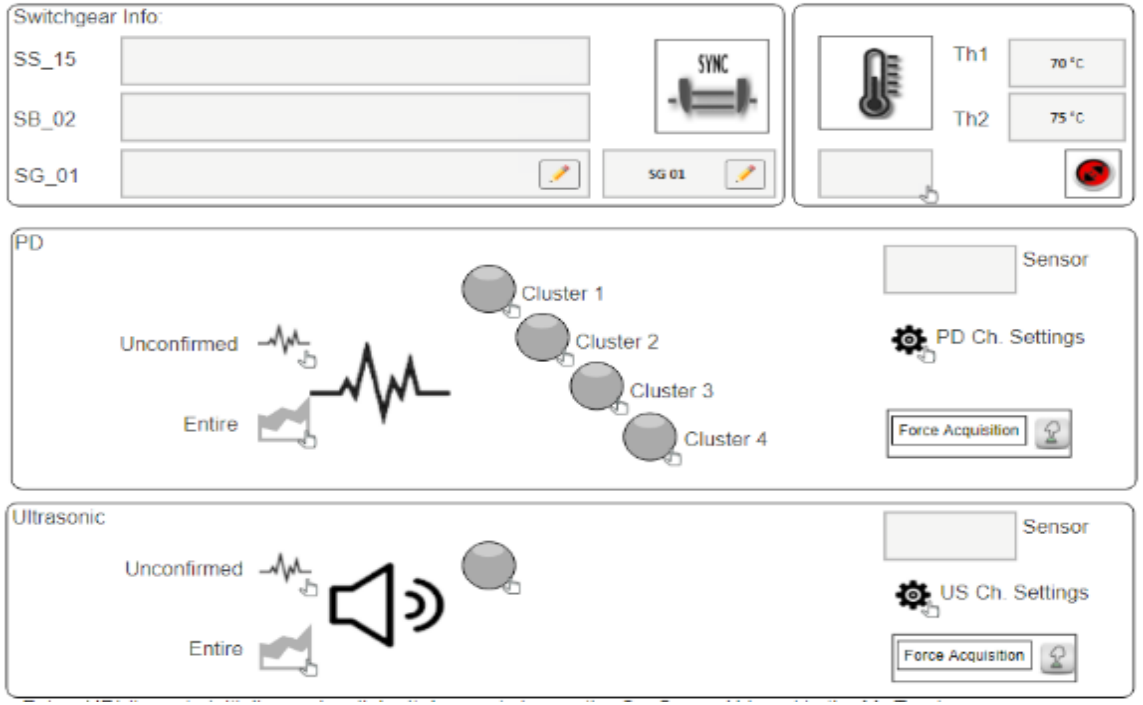



Pool #3

MV cable online monitoring

State of the art MV cables monitoring includes

- Partial Discharge monitoring
- Ultrasonic monitoring
- Temperature monitoring



MV cable online monitoring

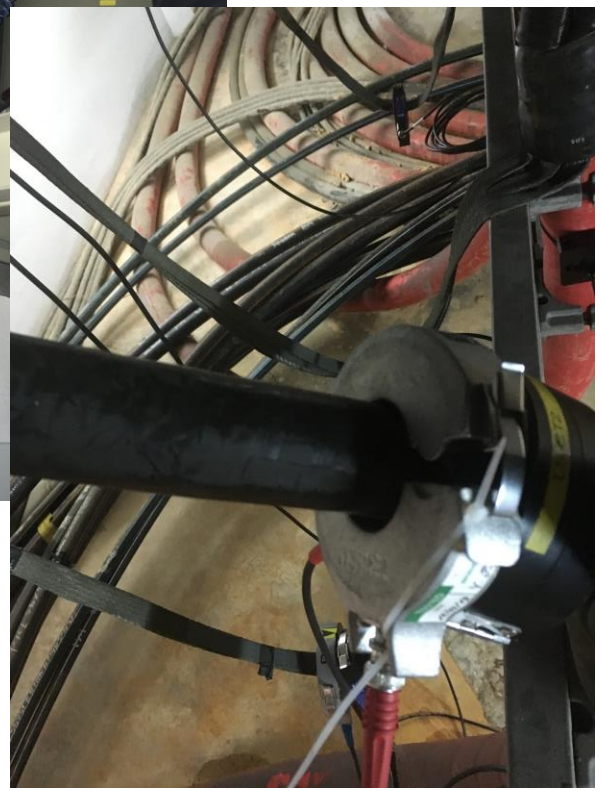
CASE STUDY

Permanent online monitoring system installed on 20kV cables GIS terminations.

No grounding lead available

➔ HFCT on cable monitoring

➔ Acoustic airborne monitoring



MV cable online PDM

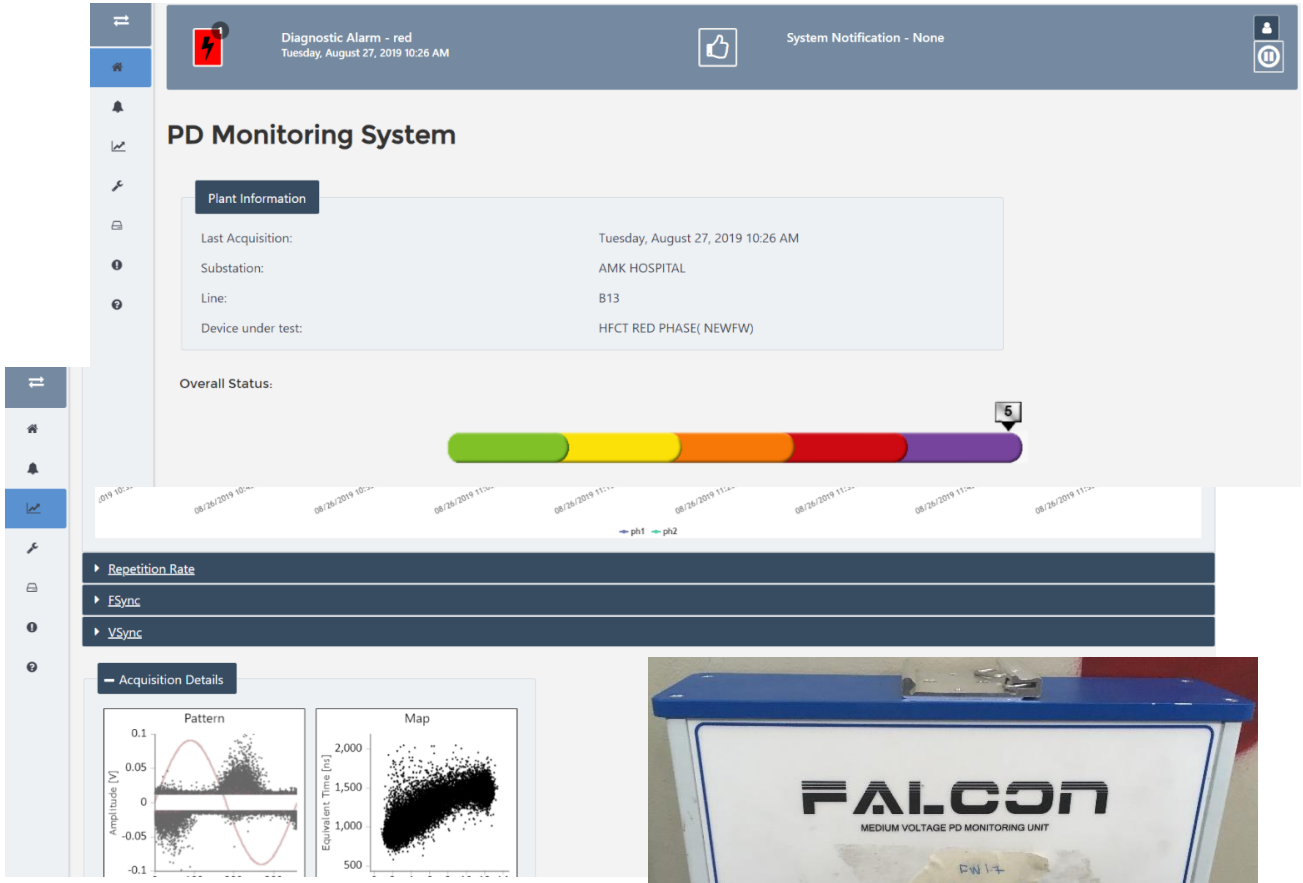
CASE STUDY

HFCT on the MV cable.

PD activity was observed in one of the cables connected to the Switch side.

Asset owner policy is «zero PD»

➔ Out of service, offline test, PD localization, visual inspection and maintenance program.



HV cable online monitoring

Continuous information

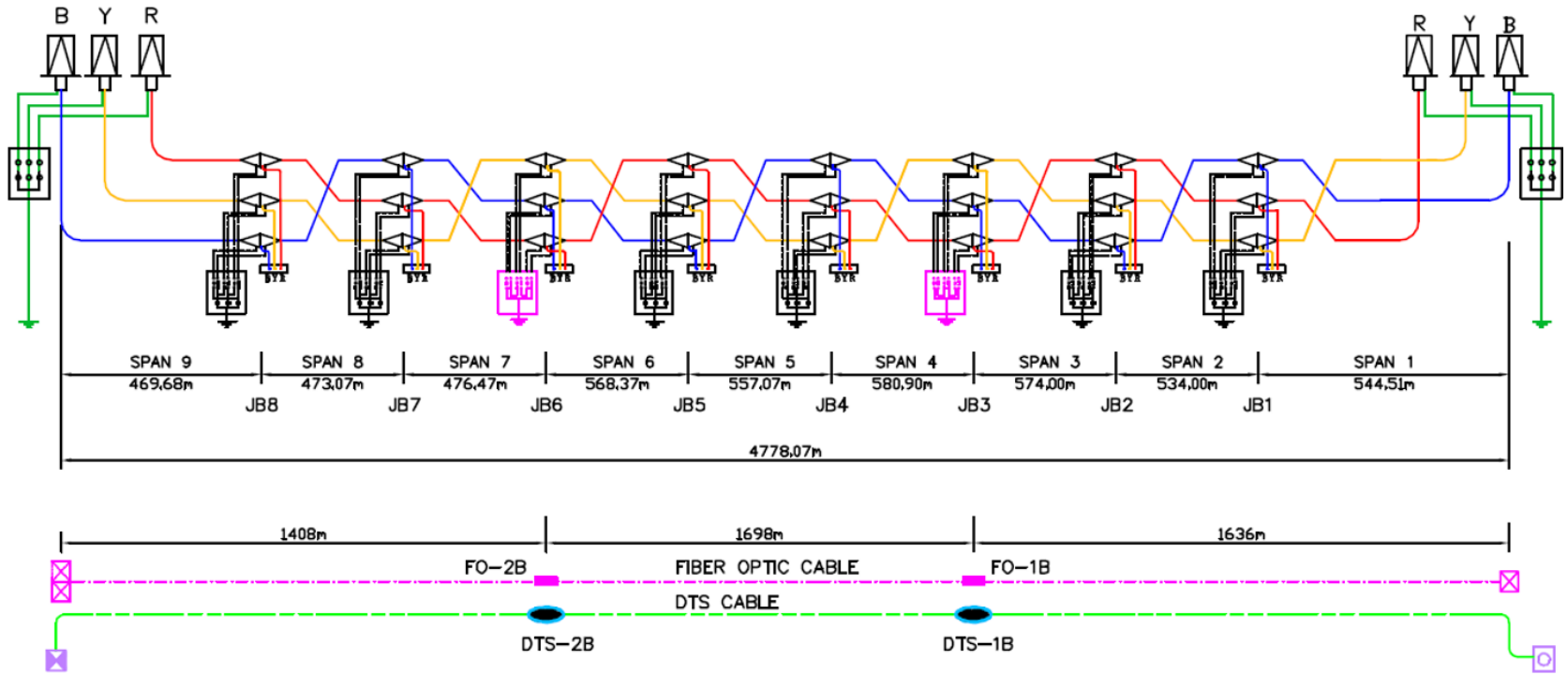
Data trends available

Automatic alarms triggered

Big investement for the asset

Follow up resources

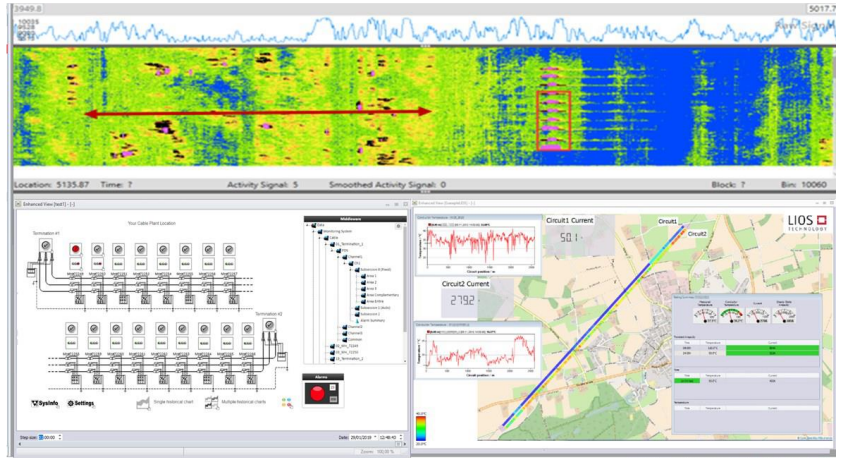
Complex installation

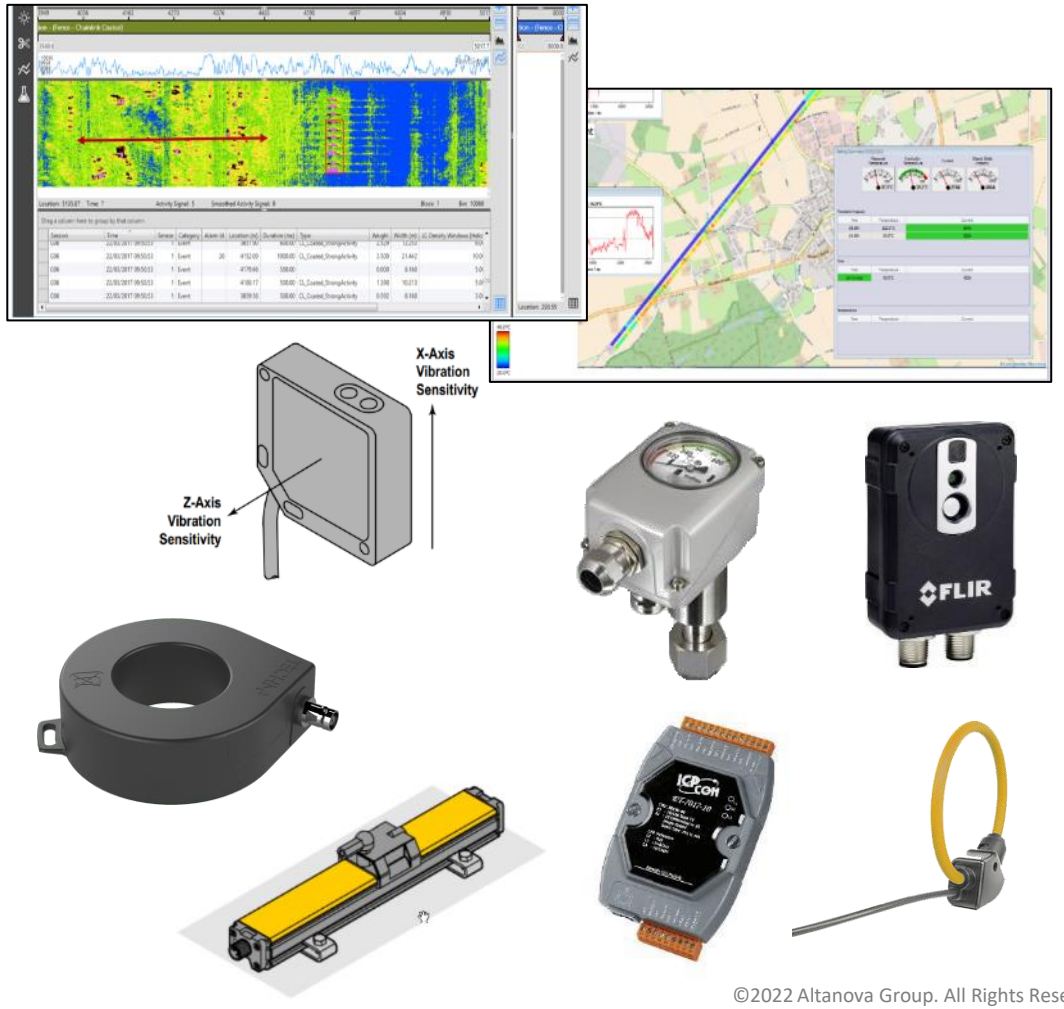


HV cable online monitoring

State of the art of monitoring systems in HV cables includes:

- Partial Discharge
- DTS Distributed Temperature
- DAS Distributed acoustic
- SC Sheath Current
- Oil Pressure/IR cams/SVL





HV cable online monitoring

HARDWARE

PD & SC sensors in each link box and termination

Fiber Optic along the cable route

Reliable power supply and communication

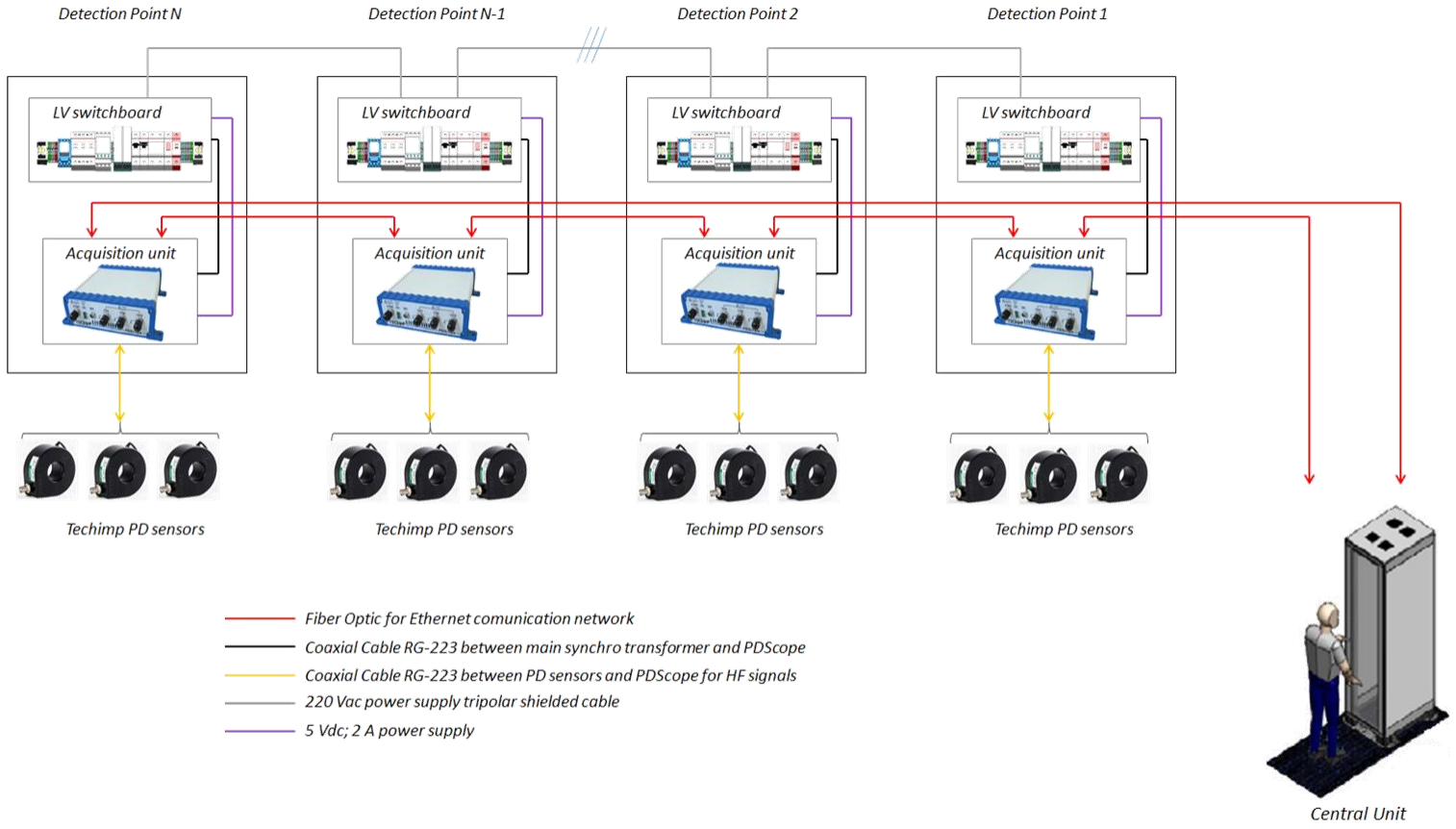
➔Fiber optic network/4G

➔Power supply line/standalone

HV cable PD monitoring

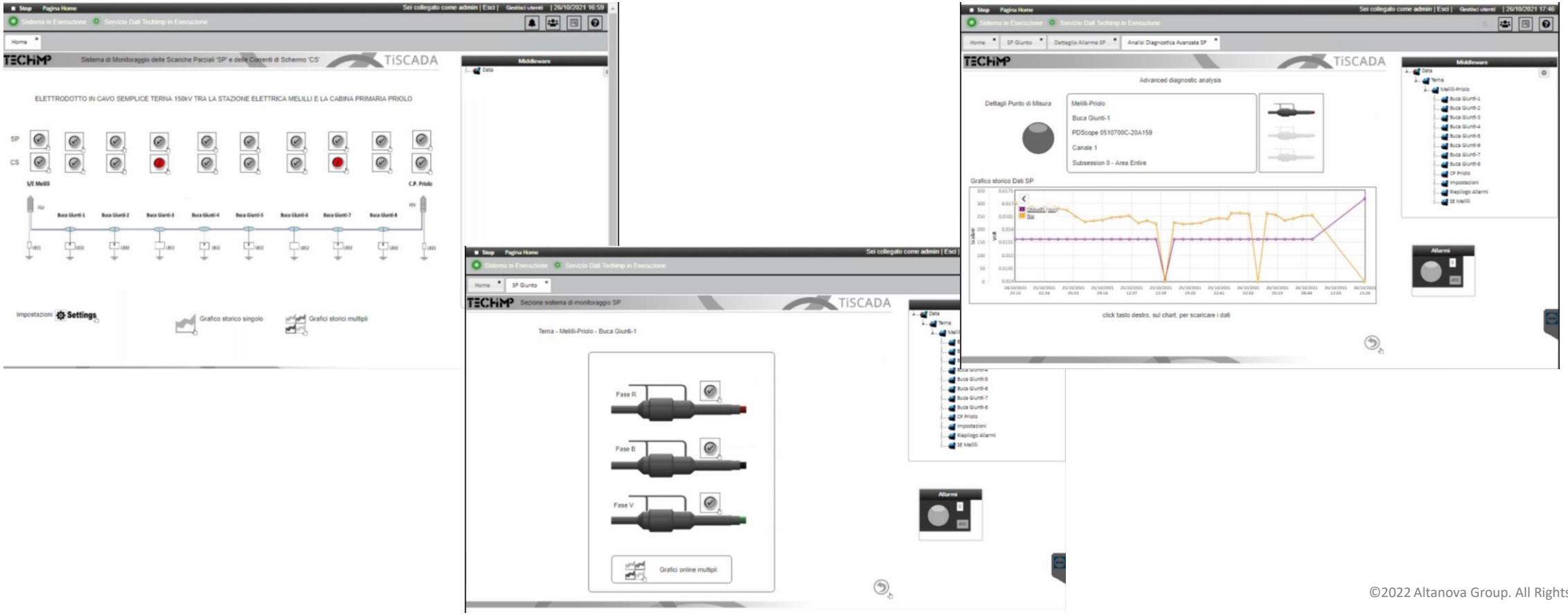
HARDWARE

- PD Sensors
- PD Hubs
- Power and FO network
- Central Server
- Connectivity



HV cable PD monitoring

Permanent partial discharge monitoring is a 24/7 monitoring system focussed on the detection of PD activity occuring in the cable system.

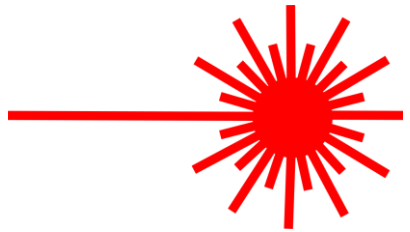


HV cable DTS & DAS monitoring

Distributed Temperature & acoustic system

By installing a dedicated FO along the cable it is possible to combine the fiber with a laser source and an analyzer.

Taking advantage of the physical phenomena occurring in the fiber it is possible to extract information correlated with temperature and acoustic vibrations making the fiber a **linear sensor**.



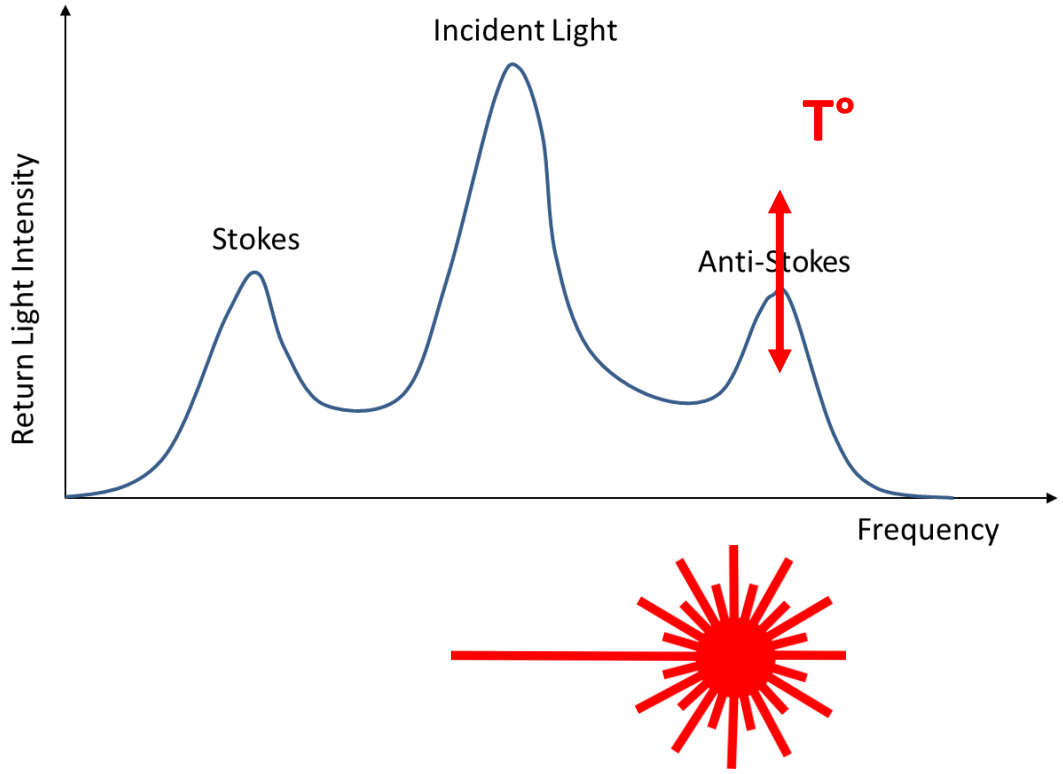
HV cable DTS & DAS monitoring

Distributed Temperature Sensing

Temperature affects the light transmission properties of the media.

The laser light scattered back from the fiber is then characterized by 3 spectra

- **Rayleigh scattering** related to the wavelenght of the laser source
- **Stoke** components shifted in lower frequencies
- **Antistoke** components shifted to higher frequencies, influenced by temperature.

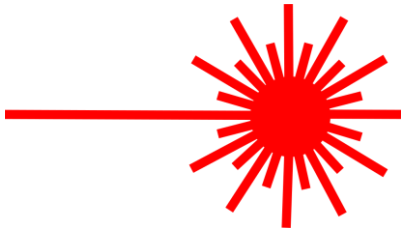


HV cable DTS & DAS monitoring

Distributed Acoustic Sensing

Similar to the DTS the DAS uses the Rayleigh backscattering physical principle to evaluate mechnical events occurring near the FO cable

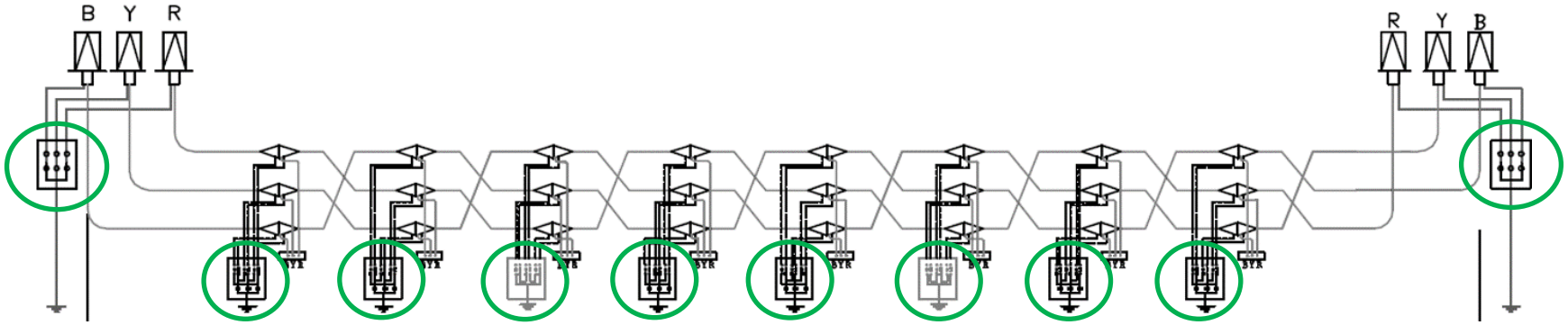
- Cable faults
- Manual/mechanical digging
- Unexpect vibrations due to third party interactions



HV cable SC monitoring

Faults detectable:

- Bonding system installation
- Resistive connections
- Faulty SVLs & flooded link boxes
- Low earthing resistance sheath faults



HV cable SC monitoring

Expected sheath currents are not easy to predict due to the system complexity and variables involved.

The advantage of a permanent monitoring systems that records the values at all the minor sections is to have a historic DB from the time of cable commissioning

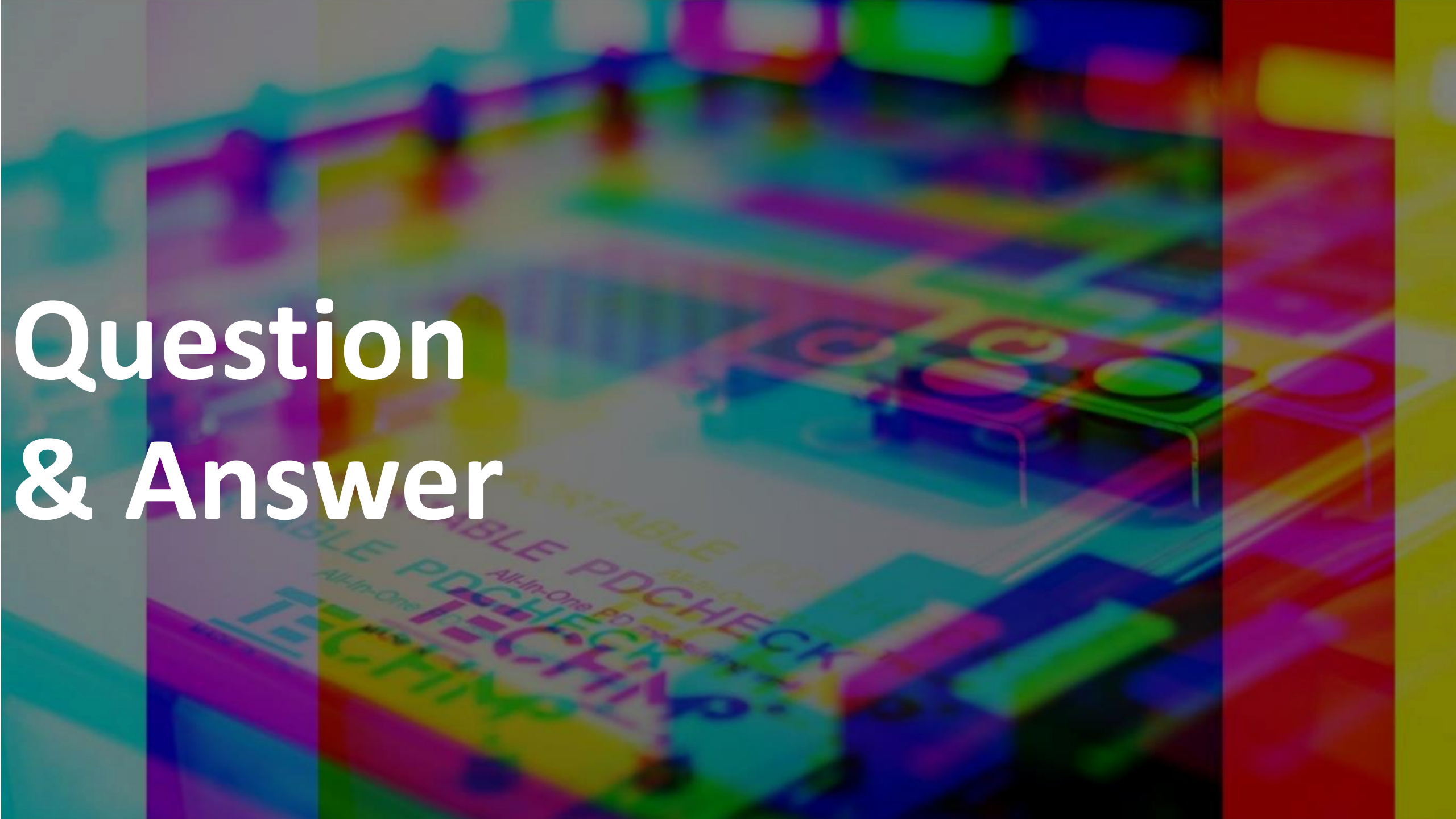
➔ Alarms evaluated on real data

➔ Sheath current correlation with line currents

Summary

Challenges in UG diagnostics

- Evaluate the risk of the systems (experiences, literature, regulations)
- Set up a maintenance strategy
- Explore the possible solution for the specific asset/fleet
- Plan the test campaigns/system installation accordingly
- Introduce the diagnostics on the maintenance plan


Question
& Answer

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Next ALTANOVA **WEBINARS**

08 Feb — Creating and using meaningful Asset Health Indices (AHI) – EMEA

09 Feb — Medición y detección de descargas parciales

15 Feb — Creating and using meaningful Asset Health Indices (AHI) - APAC

16 Feb — Methoden zur Zustandsbewertung von Mittel- und Hochspannungsbetriebsmitteln

22 Feb — Desarrollo y utilización de Índices de Salud (AHI) más significativos en Activos Eléctricos

Thank you for attending our webinar!

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