Advanced PD Testing

Let's explore TF Map Technolgy

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JOIN US FOR

PD ACADEMY 2025

November, 24th-28th
Bologna, Italy

MORE INFO

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doble®

Engineering expertise and advanced diagnostics to ensure that all people globally have *reliable*, *safe & secure* energy in a sustainable world

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BUILT ON OVER A CENTURY OF INNOVATION AND EXPERTISE.
FOR THE NEXT CENTURY.

100 YEARS OF SERVICE TO THE ELECTRIC UTILITY INDUSTRY

doble®

Timeline (above axis):

- **1920** — Doble Safety Portable Telephone
- **1928** — Power factor test set
- **1936** — Frank Doble forms special oil committee
- **1949** — Type MH power factor test set
- **1965** — Morgan Schaffer established in Montreal, Canada
- **1978** — Doble acquires Jodice Controls Corporation
- **1987** — TR3100 circuit breaker analyzers
- **1990** — Doble Test Assistant (DTA) software
- **1994** — AMS-500 on-line dissolved hydrogen monitor
- **2000** — Intelligent Diagnostic Devices (IDD)
- **2001** — Calisto™ dissolved hydrogen & water monitor
- **2005** — Mykos™ portable dissolved gas analyzer
- **2011** — dobleARMS™ asset risk management system
- **2013** — M7100 high voltage asset analyzer
- **ENOSERV**
- **2015** — ENOSERV joins the Doble team — NRG Systems
- **2017** — NRG Systems joins Doble's Utility Solutions Group
- **2021** — F8 Series

Axis years: 1920 · 1930 · 1940 · 1950 · 1960 · 1970 · 1980 · 1990 · 2000 · 2010 · 2020 · 2021

Timeline (below axis):

- **1922–1923** — Type A & B testers
- **1934** — First Doble Client Conference
- **1951** — First Doble survey of electric insulating mineral oils
- **1972** — TR-1 circuit breaker motion analyzer
- **1982** — Type F3/F3S series
- **1989** — AM100 circuit breaker monitor
- **1993** — M4000 high voltage apparatus tester
- **2000** — F6 series
- **2003** — Doble Power Test opens in the UK
- **2007** — ESCO Technologies, Inc. acquires Doble Engineering Company
- **2012** — Xtensible Solutions joins the Doble team — Xtensible
- **2014** — Condition monitoring system
- **2016** — Transient Cyber Asset (TCA) program
- **2017** — Morgan Schaffer and Vanguard Instruments join the Doble team — Morgan Schaffer / Vanguard Instruments
- **2018** — Manta Test Systems joins the Doble team — MANTA Test Systems
- **2021** — Altanova joins the Doble team / Phenix Technologies joins the Doble team — ALTANOVA / PHENIX Technologies

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.

Webinar Summary

What is a PD ?	Basic Diagnostic Technique	PD Acquisition and Post- processing Analysis

- ❑ *Definition*
- ❑ *Fundamental concepts*
- ❑ *PD pulse acquisition parameters*

- ❑ *PRPD pattern*
- ❑ *TF Map*
- ❑ *Streaming window*

- ❑ *PD signal flow*
- ❑ *SID method*
- ❑ *Denoising technique*
- ❑ *PD phenomena trending*
- ❑ *Pratical example*

What is a PD?

Definition

Partial Discharge (PD)

IEC: *"Localized electrical discharge that only partially bridges the insulation between conductors, and which can or can not occur adjacent to a conductor."*
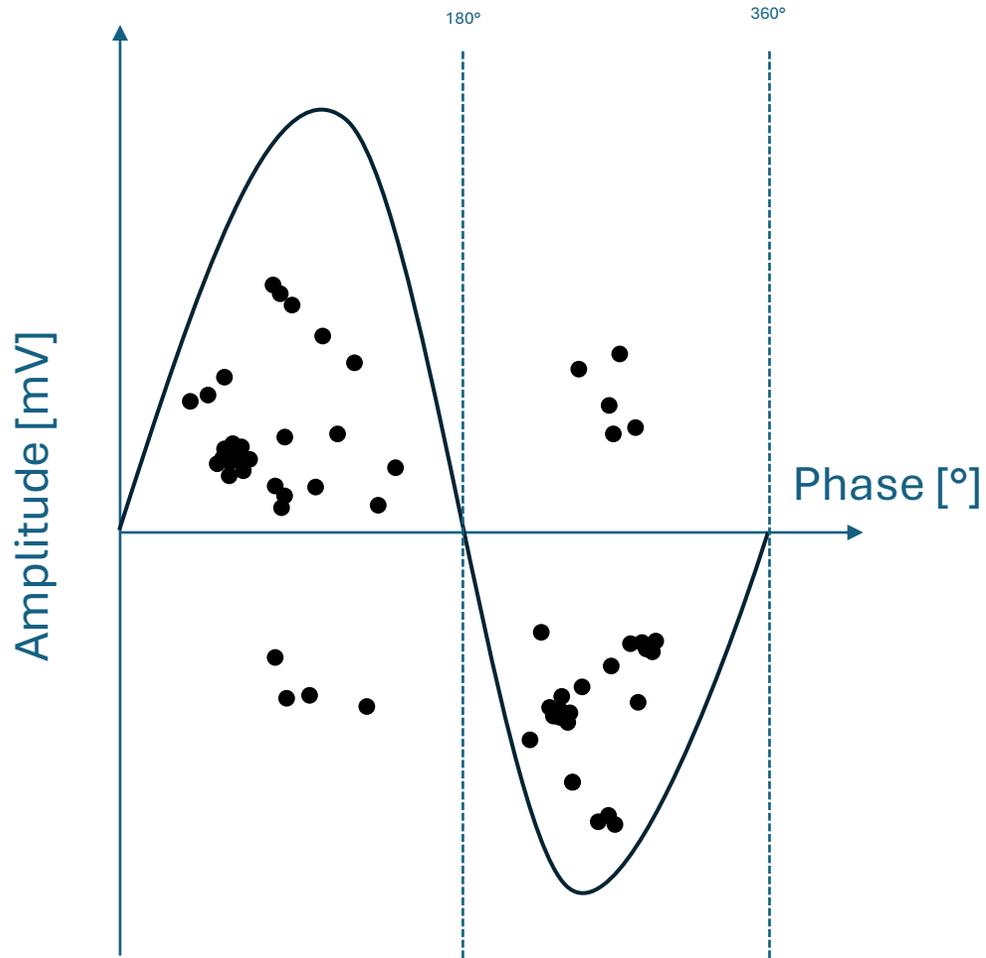
Partial Discharge Pulse

IEEE: *"An high frequency current or voltage pulse that results from a partial discharge. In a shielded power cable the pulse propagates away from the PD source in both directions along the cable."*

Shield (LV Electrode)

Defect

HV Conductor
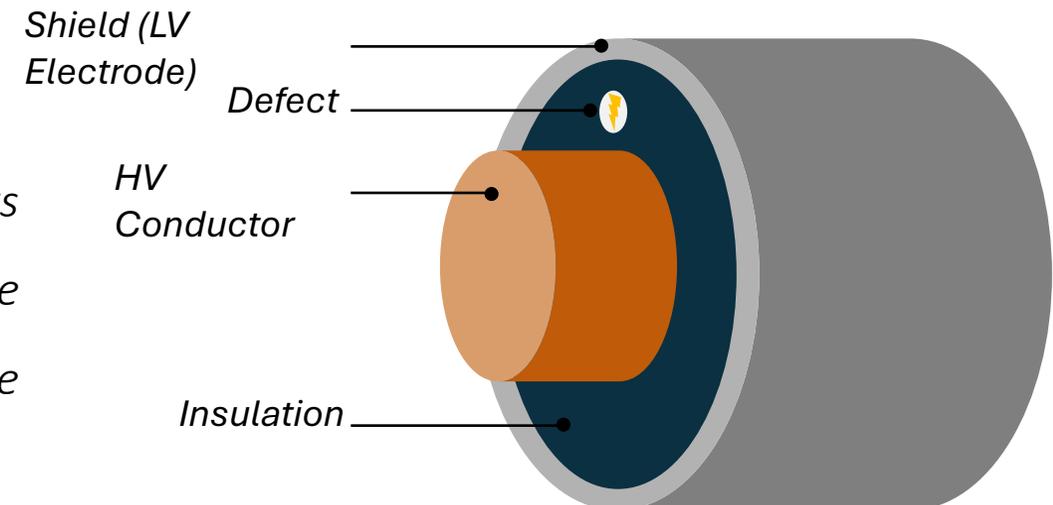
Insulation

Definition
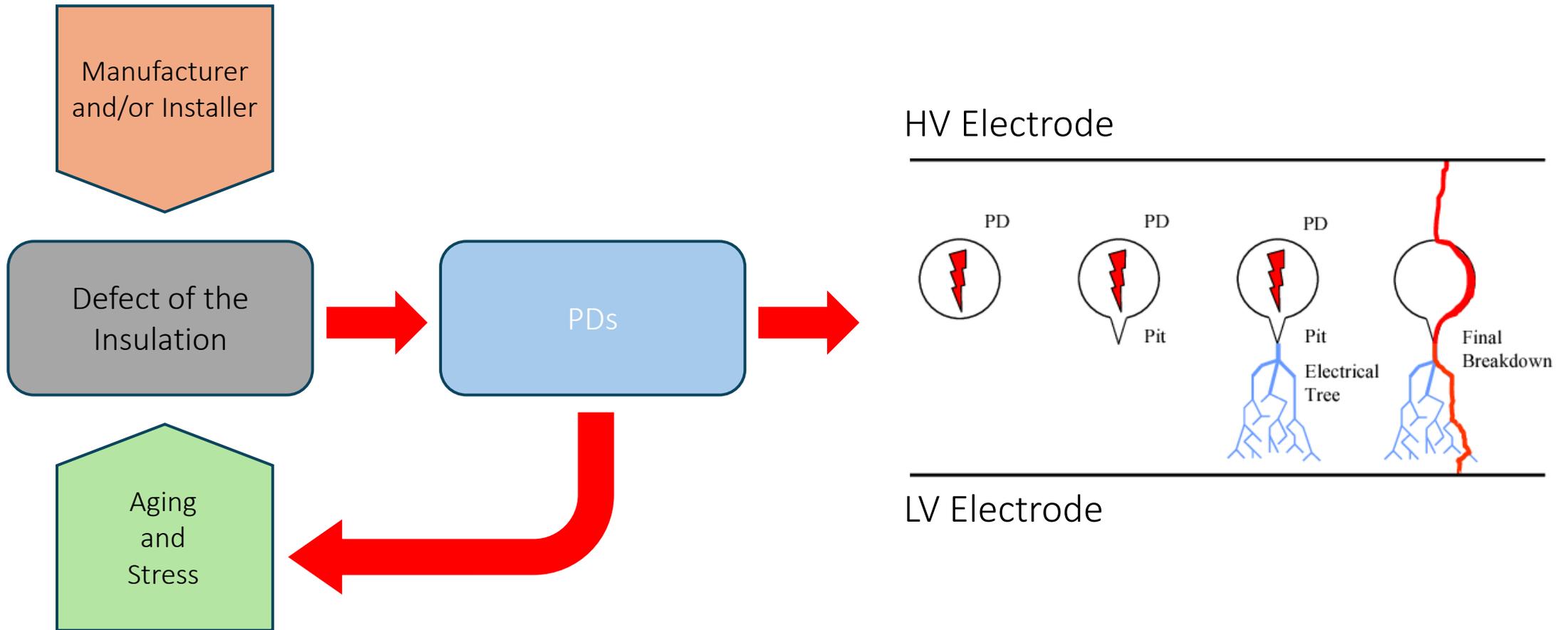
Fundamental Concept
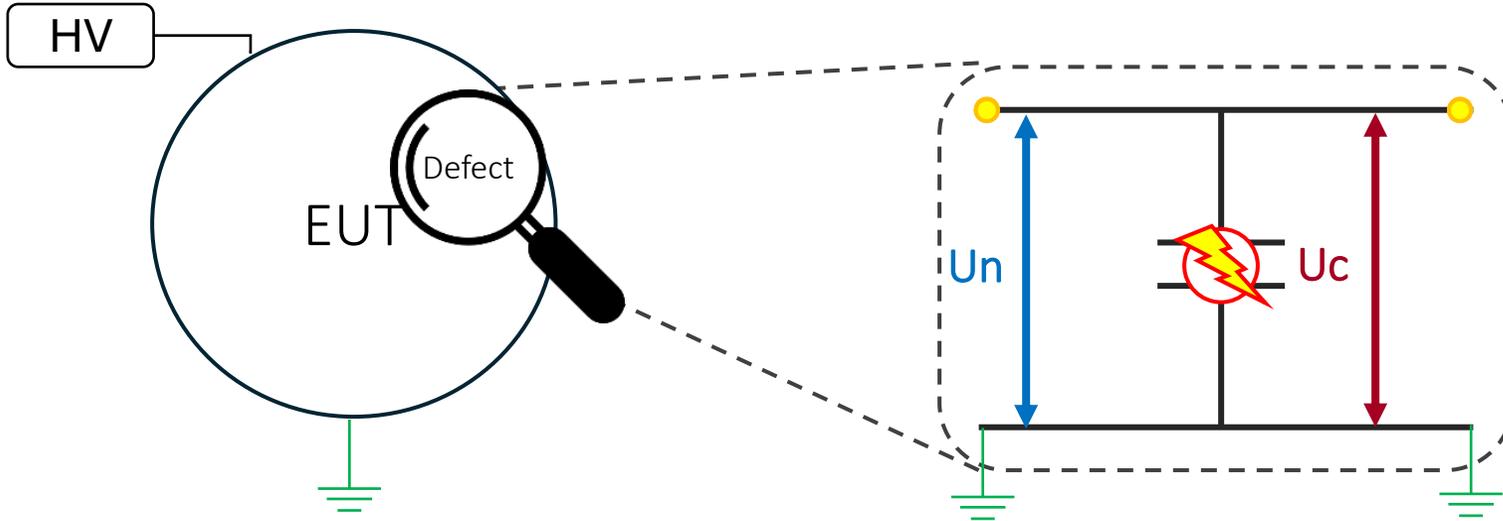
The defect inside the insulation can be modelled as a capacitor, with the dielectric composed of the gas molecule inside the defect itself.

On a fundamental level, a PD can be seen as the breaking of said capacitor's dielectric.

- When a PD occurs, the energy stored in the capacitor is released and its voltage drops (Uc).
- This will create an imbalance between the voltage applied between the two electrodes (Un) and the voltage of the capacitor.
- To re-establish the balance, charges will flow "through" the capacitor to the ground potential, thus recharging it.

The principle behind the measurement of PD is to detect the electro-magnetic field produced by the flow of charges through the use of appropriate sensors and elaborate it to return information on the original phenomenon.

PD Pulse Acquisition Parameters

The PD pulse is detected by the PD sensor and recorded by the PD acquisition unit, normally as a voltage signal.

Full Scale: Maximum amplitude recorded by the acquisition unit;

Trigger level: minimum signal amplitude detected by the acquisition unit;

Timelength: total length of the acquisition windows [μs];

Pre-trigger: timelength recorded before the peak [%];
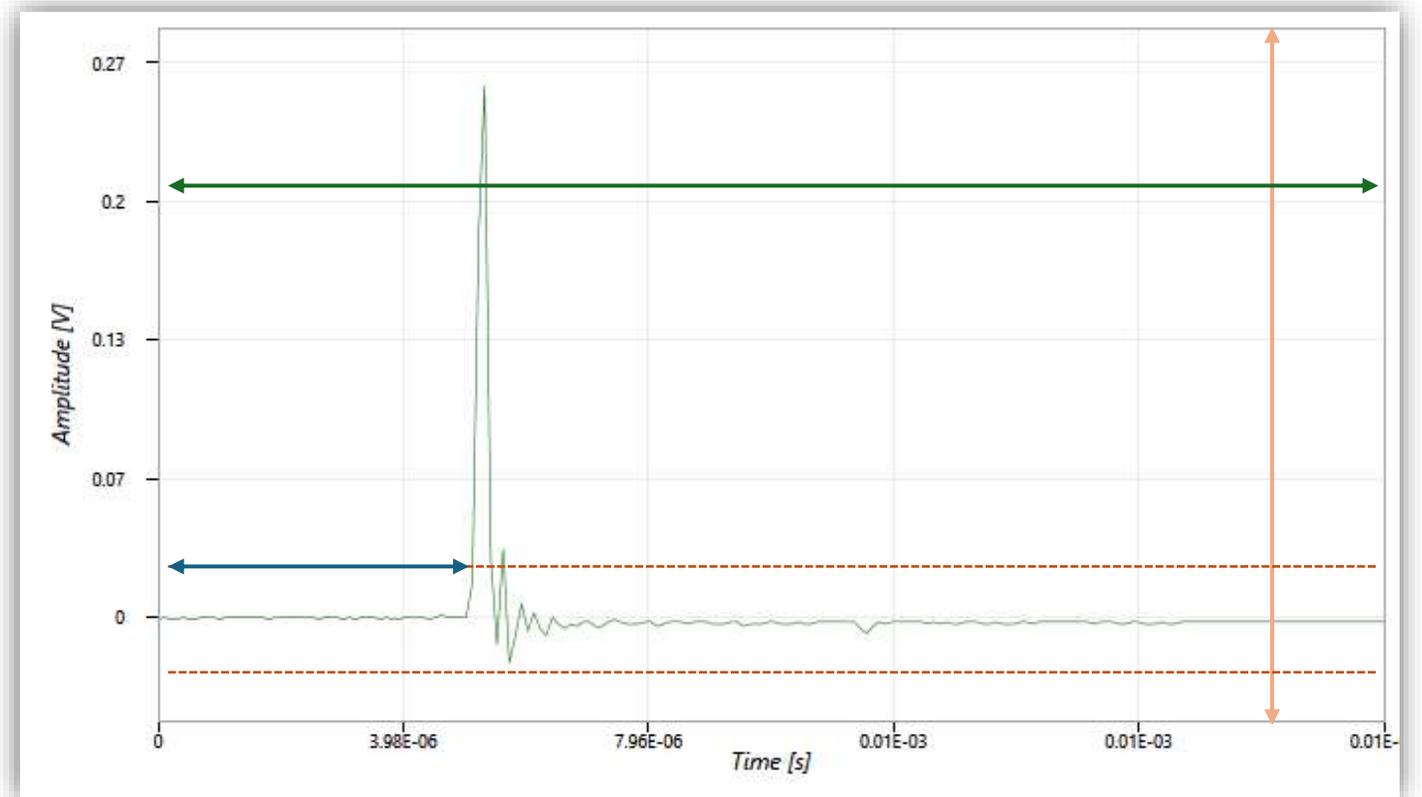
PD Pulse Acquisition Parameters
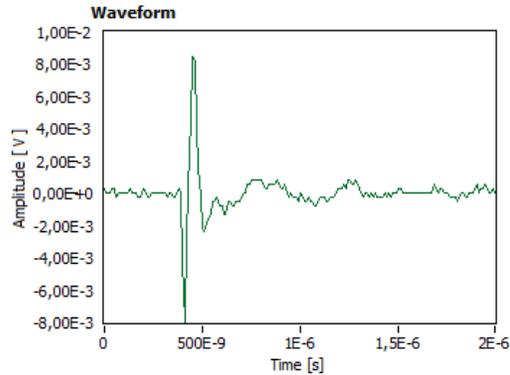
The Algorithm studies the pulse waveform to produce two extremely useful tools for the identification of the type and severity of each phenomenon: the "PRPD Pattern" and the "T-F Map".
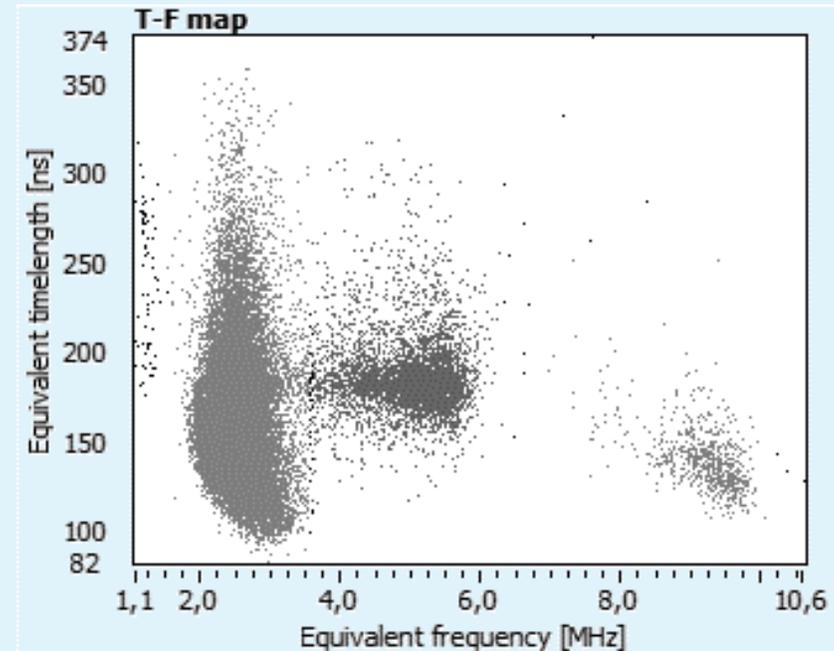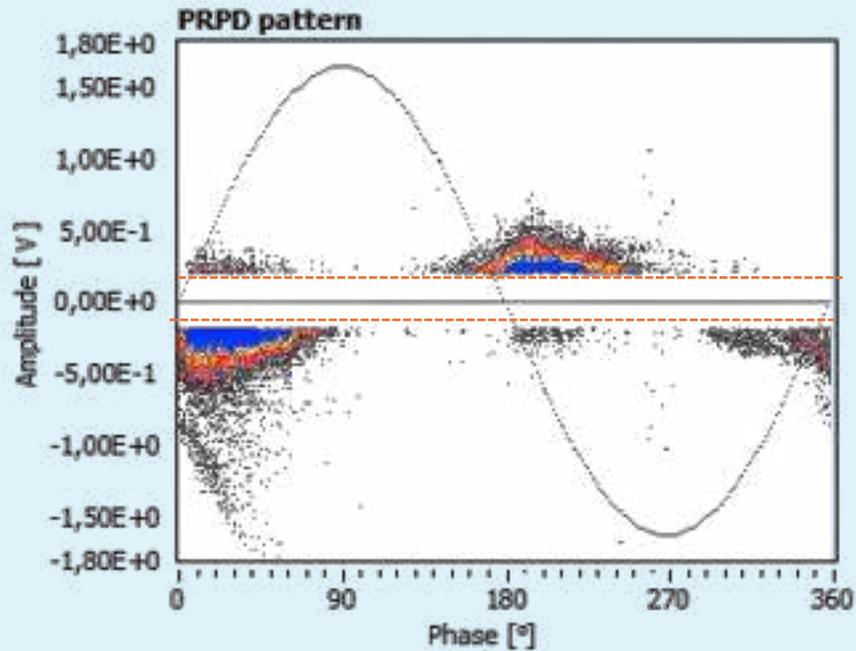
Basic Diagnostic Technique

PRPD Pattern
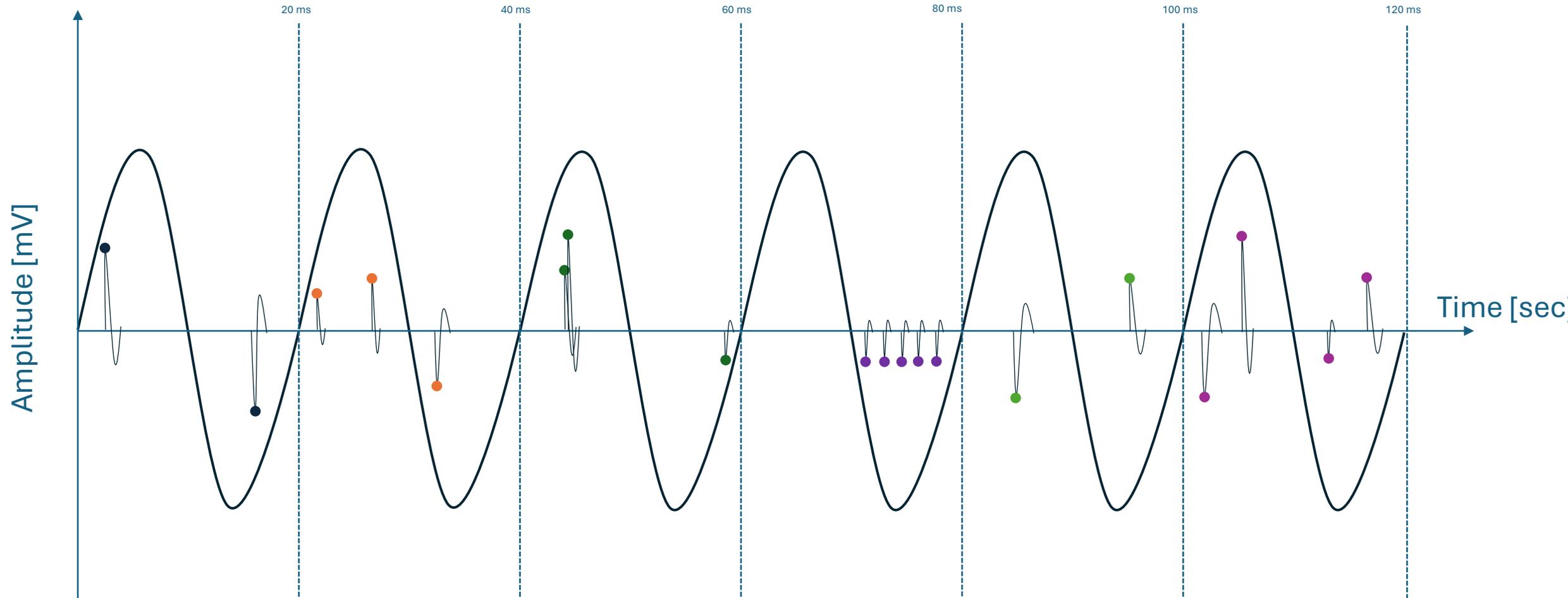
PRPD Pattern
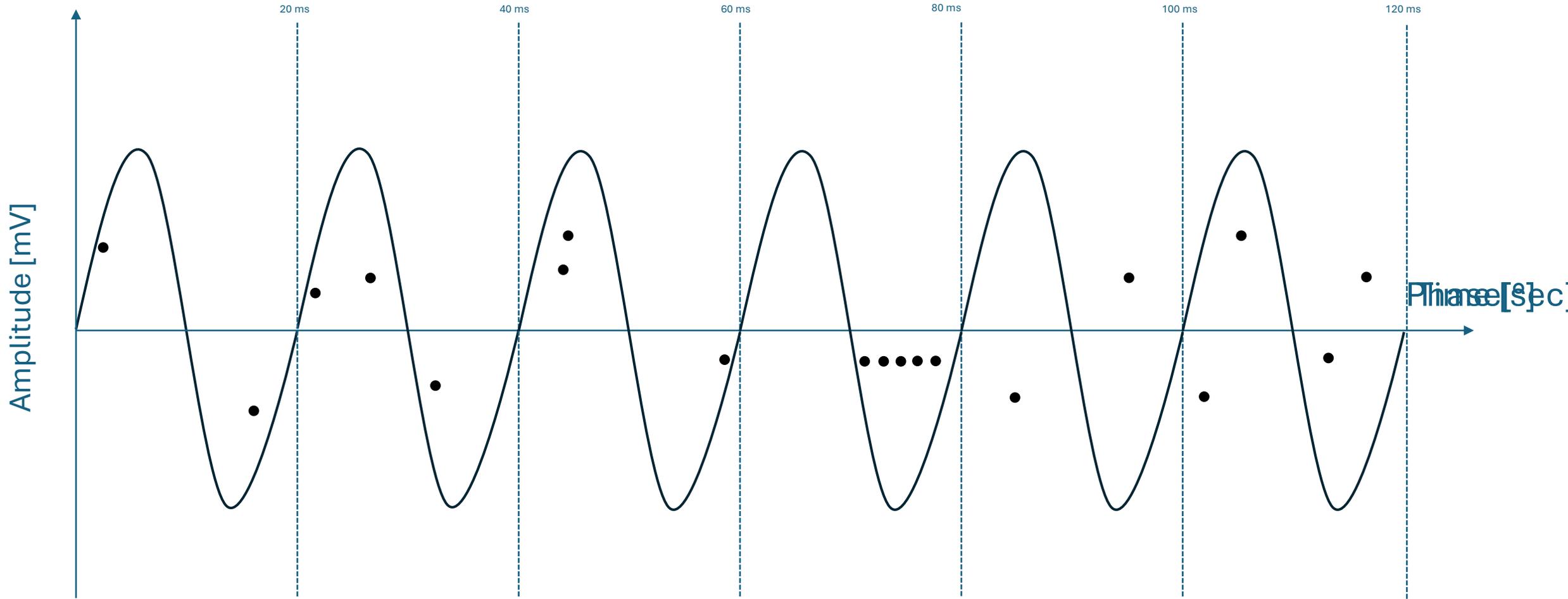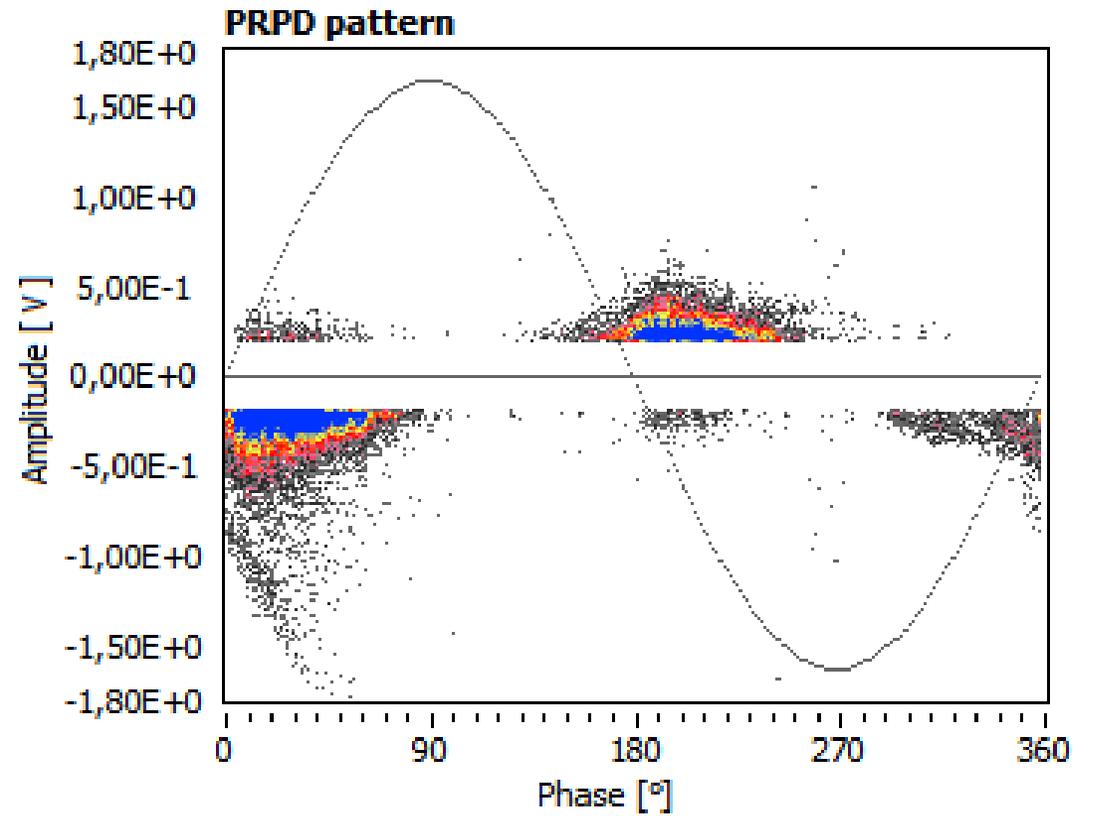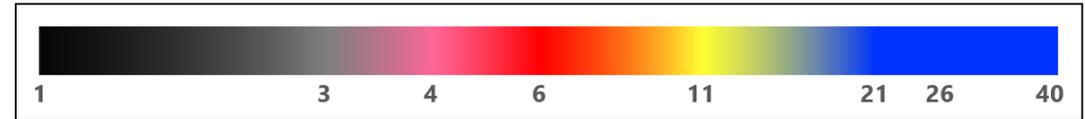
PRPD Pattern

PRPD Pattern

After enough pulses are plotted on the graph, a "Pattern" will appear.

The <u>shape</u> of the pattern and its <u>position</u> on the graph are the main indicators of the type and origin of the Partial Discharge phenomenon.

Internal Discharge   Surface Discharge   Corona Discharge
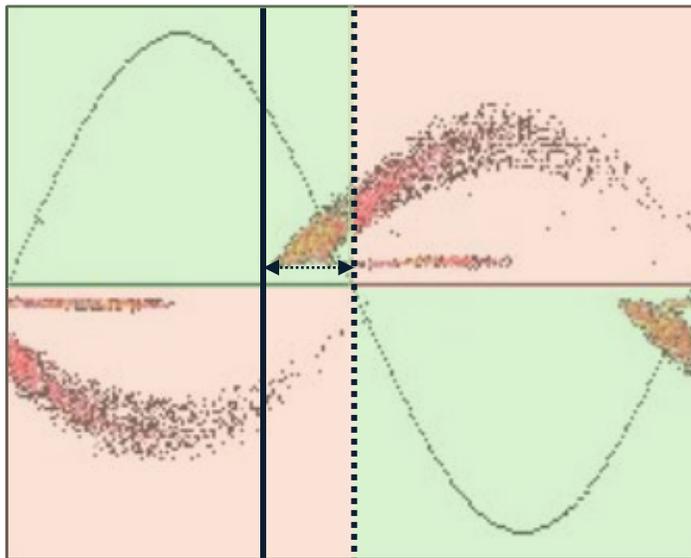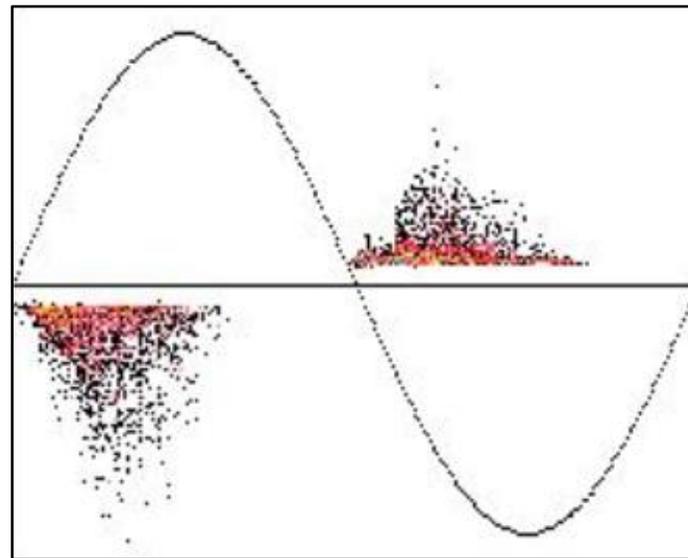
Phase Angle [ϑ]   Phase Angle [ϑ]   Phase Angle [ϑ]
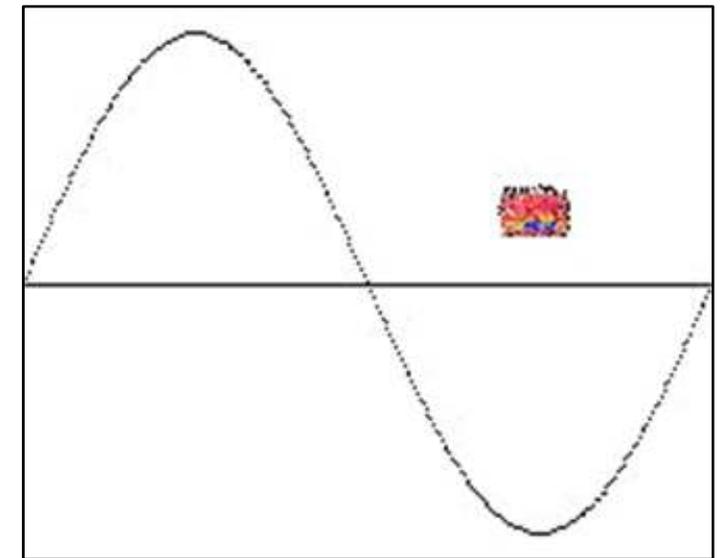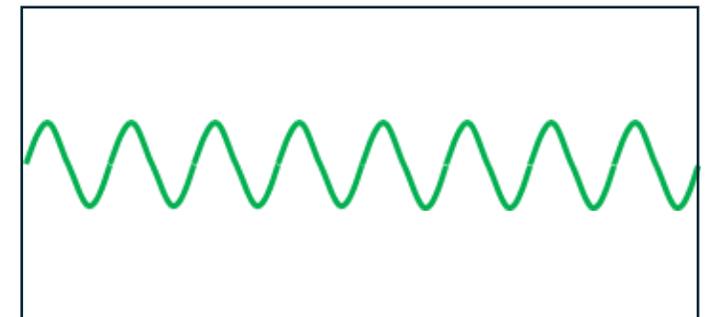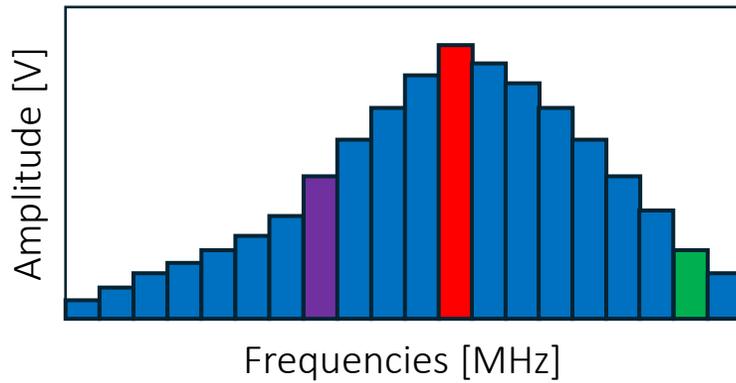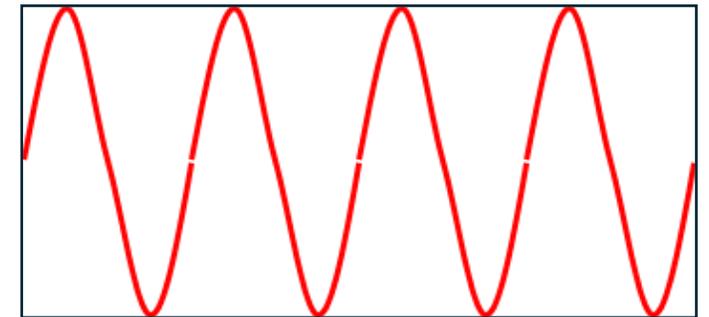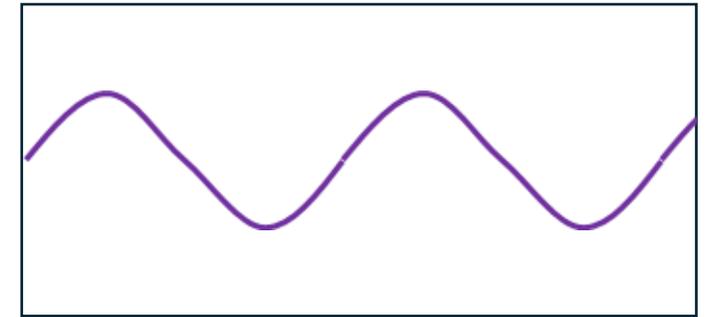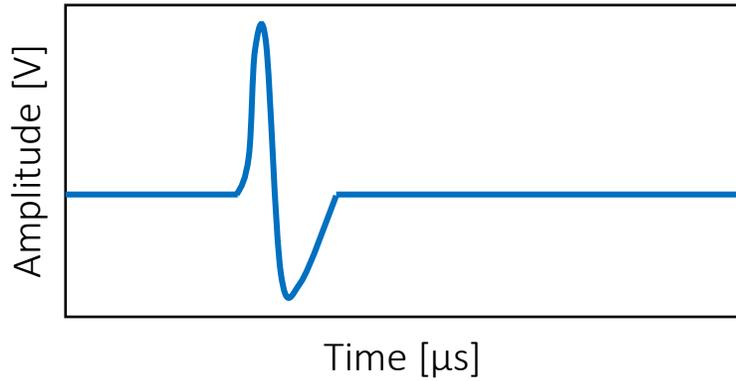
T–F Map

T–F Map

Through the Pulse Waveform and its Spectrum, the Techimp algorithm calculates two numerical values called "**Equivalent Time**" and "**Equivalent Frequency**".

$$F = \sqrt{\int\limits_{0}^{\infty} f^2 \left| \tilde{S}(f) \right|^2 \, \mathrm{d}f}$$
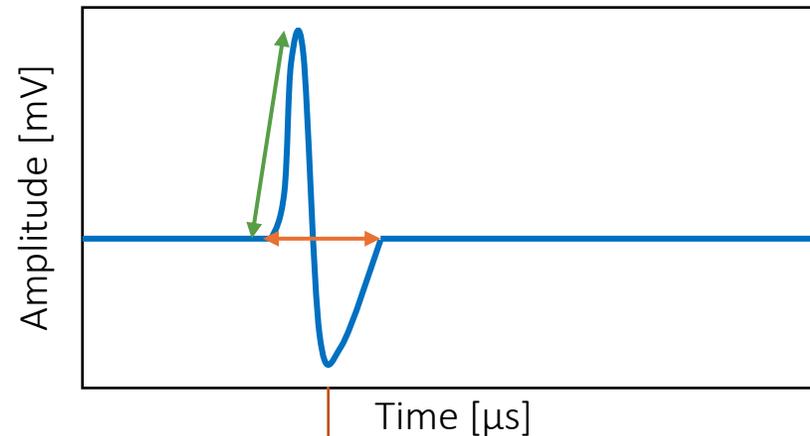
$$T = \sqrt{\int\limits_{0}^{L} (t - t_0)^2 \, \tilde{s}(t)^2 \, \mathrm{d}t}$$

It is possible to think of the Equivalent Frequency as an indication of how "steep" its rising edge is.

It is possible to think of the Equivalent Time as an indication of how "narrow" the waveform is.
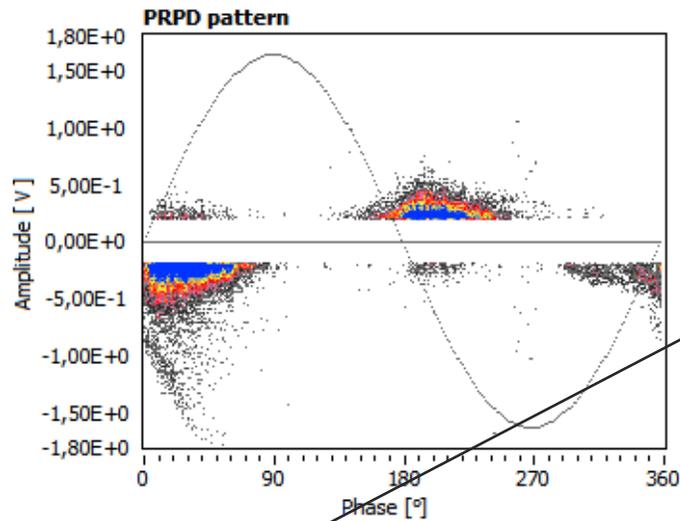
T–F Map
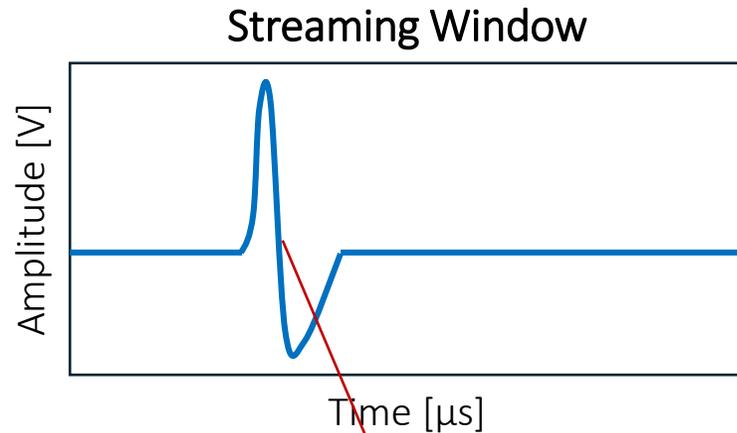
Streaming Window

To sum up: to each PD pulse recorded by the system it is associated a point on the PRPD Pattern and a point on the T-F Map.
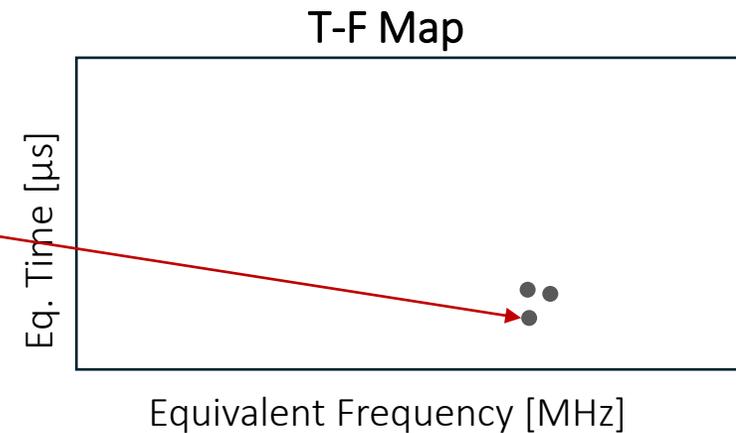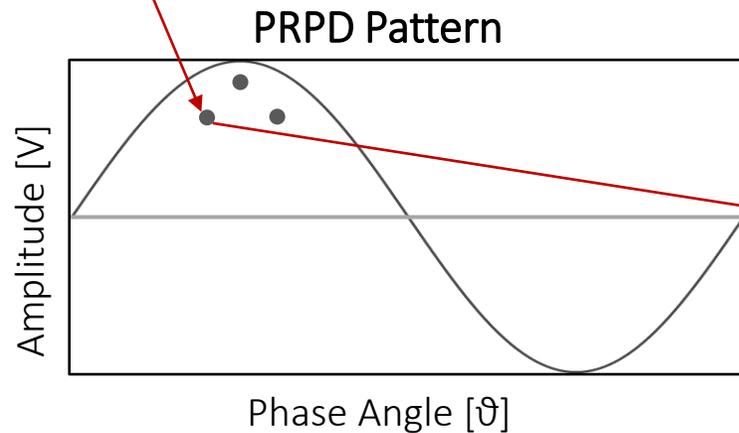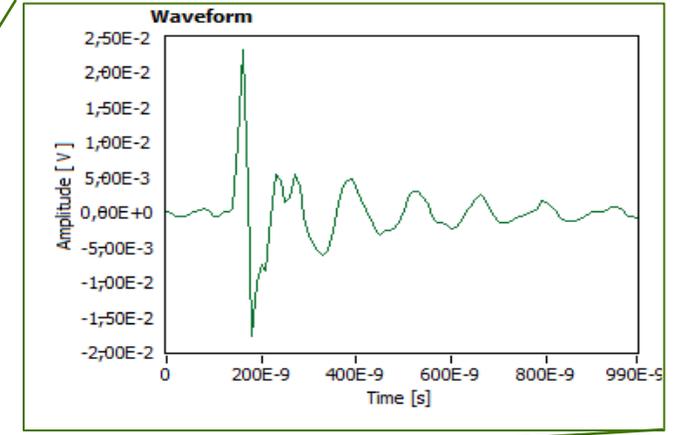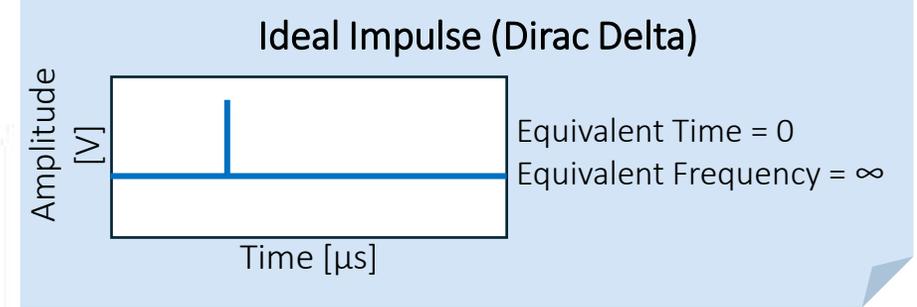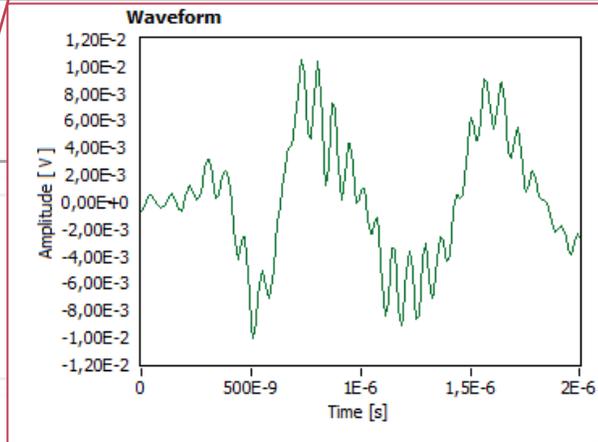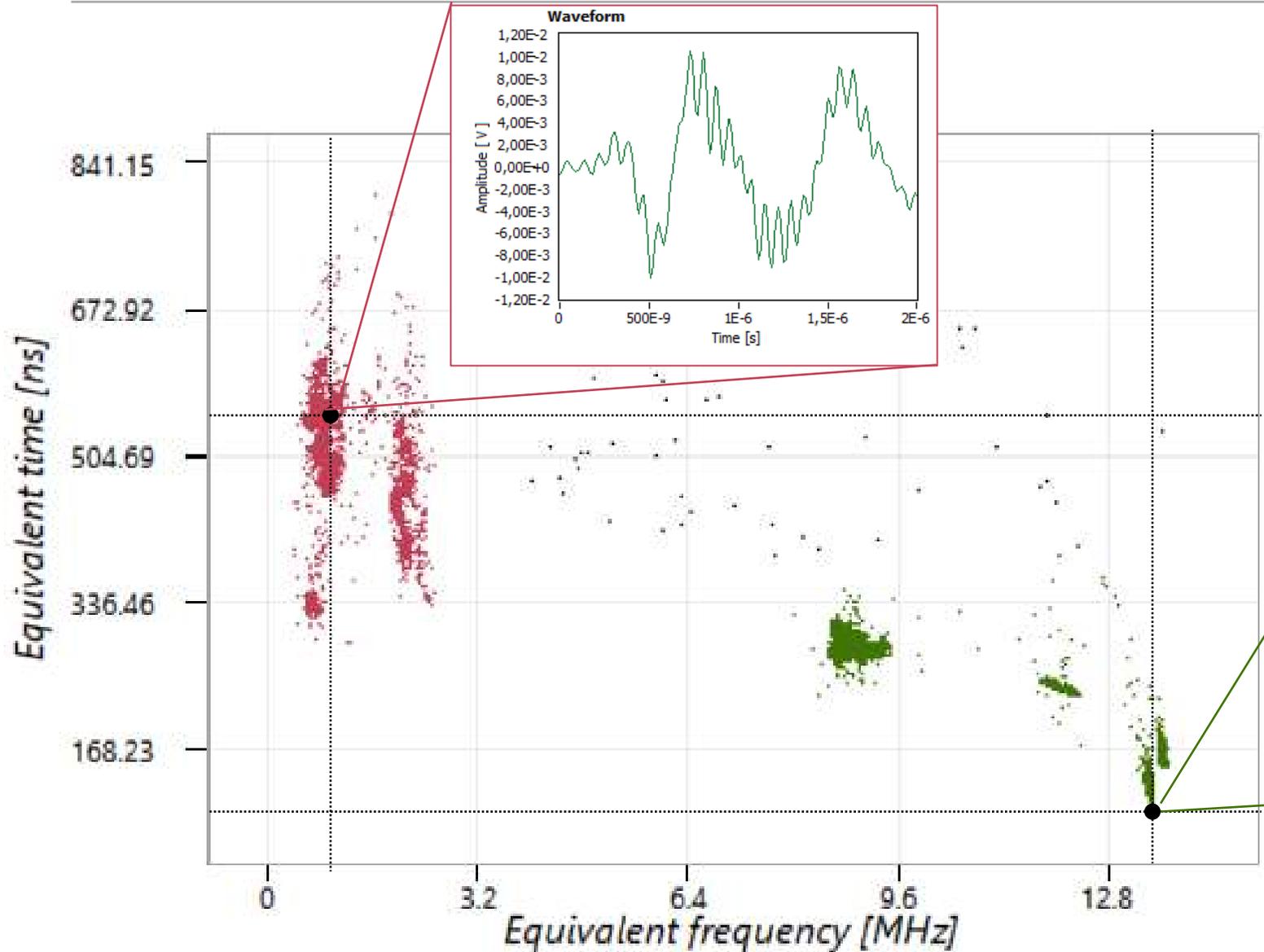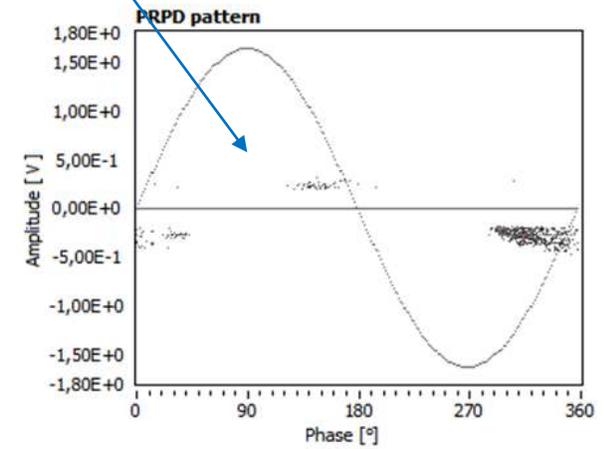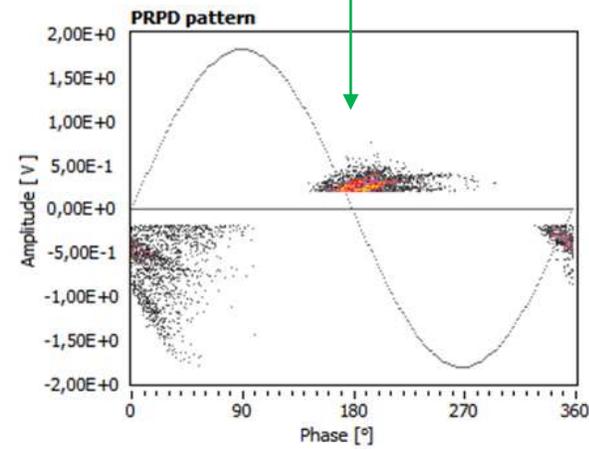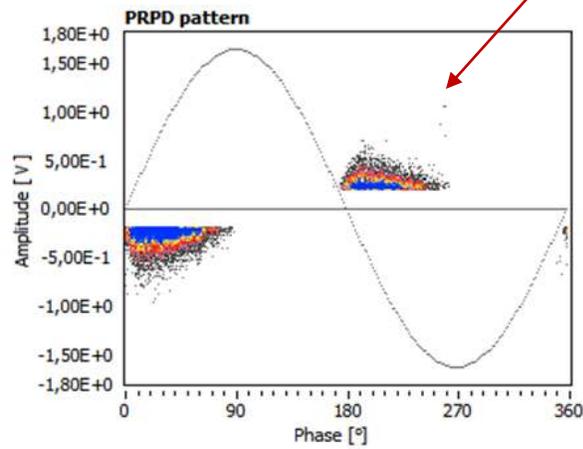
PRPD Pattern

T-F Map

Streaming Window

T–F Map
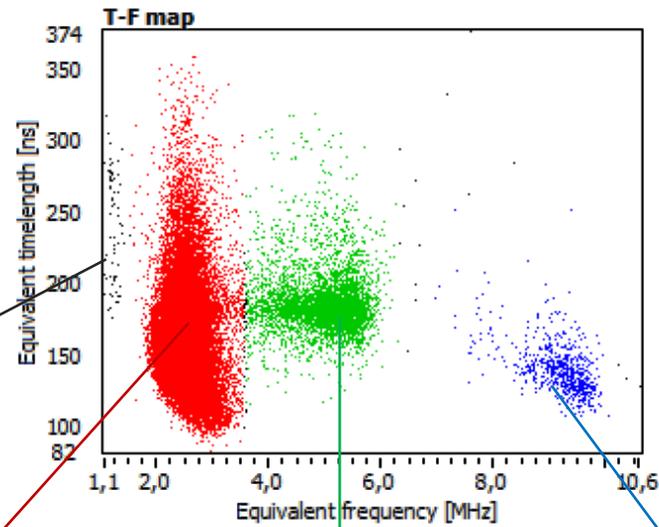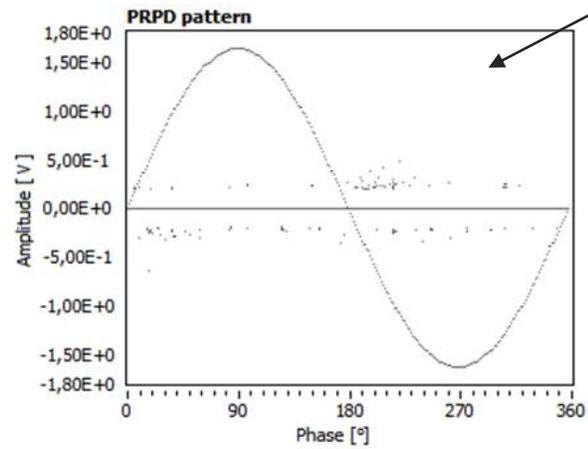
PD Acquisition and
Post-processing analysis

PD signal flow

S I D Method

SEPARATION
- *Noise rejection*
- *Source separation*

IDENTIFICATION
- *Classification of PD or not PD phenomena*
- *Potential defect harmfulness*

DIAGNOSIS
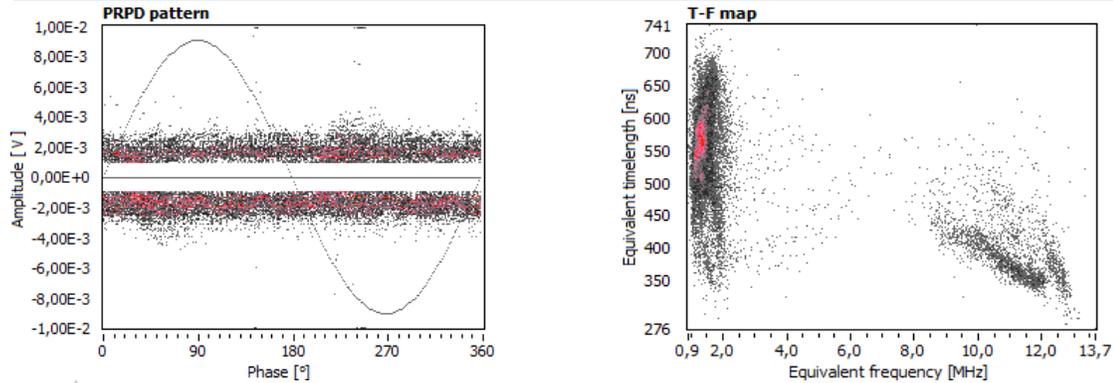- *Risk assessment*
- *Maintenance program*
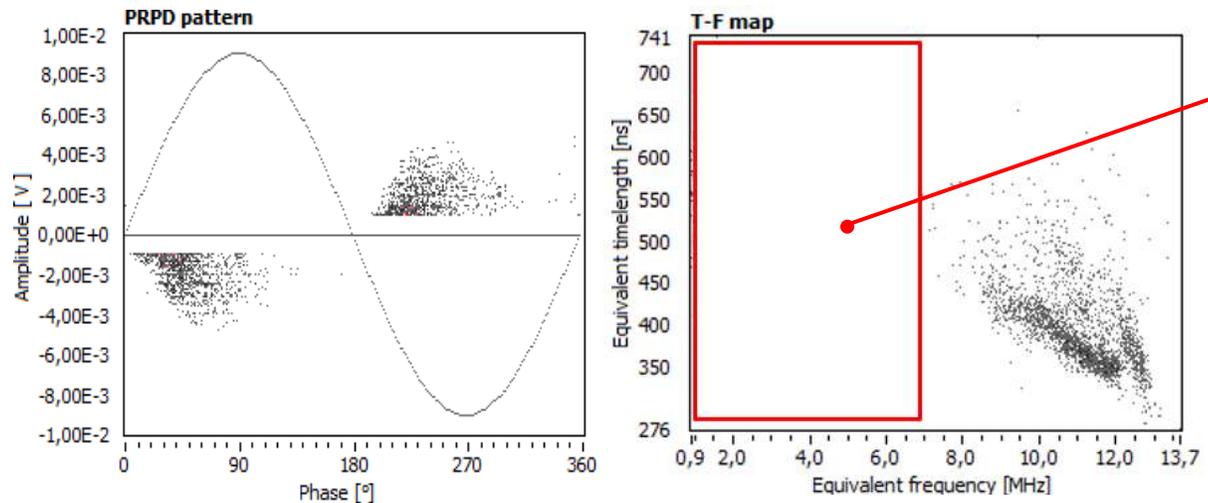- *Life extension*
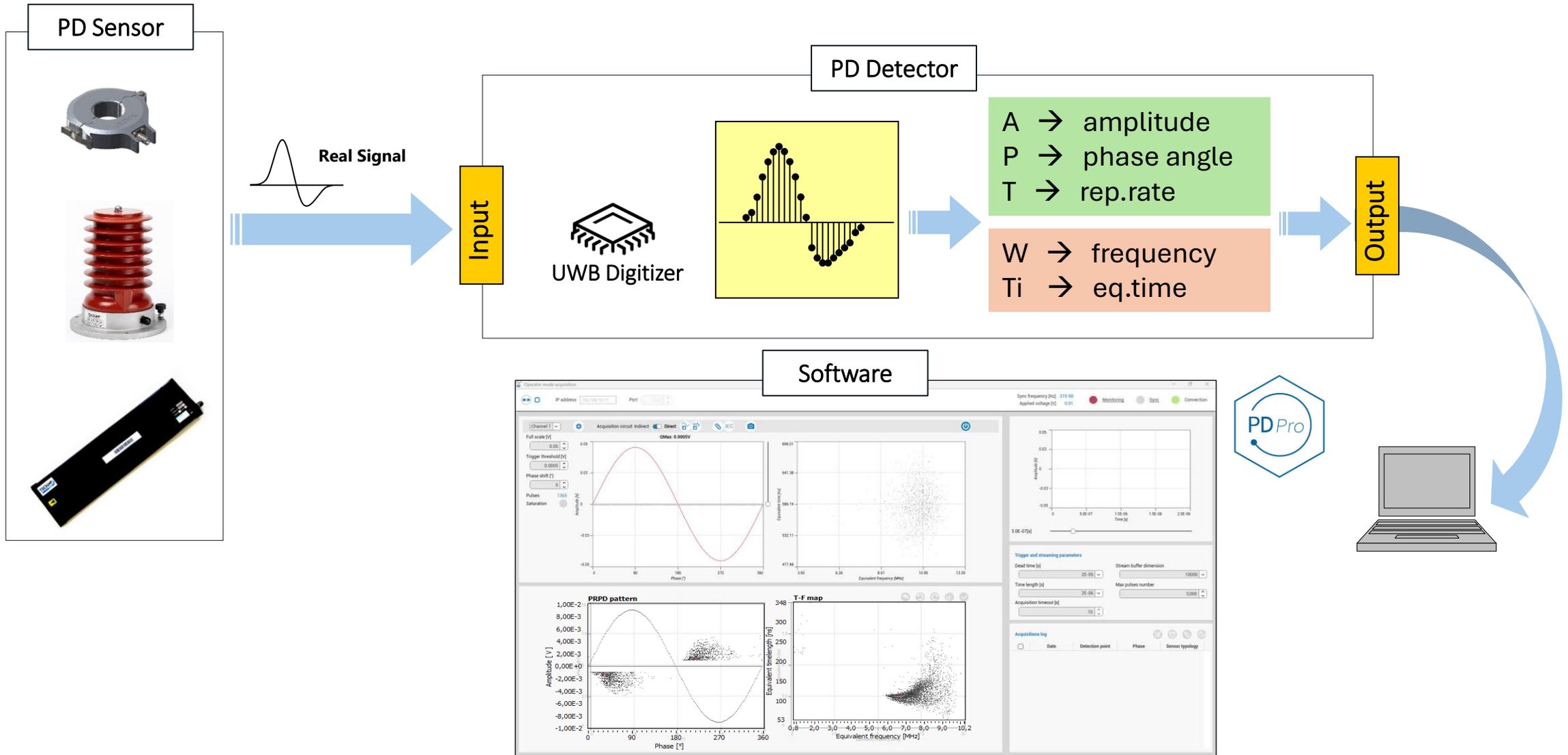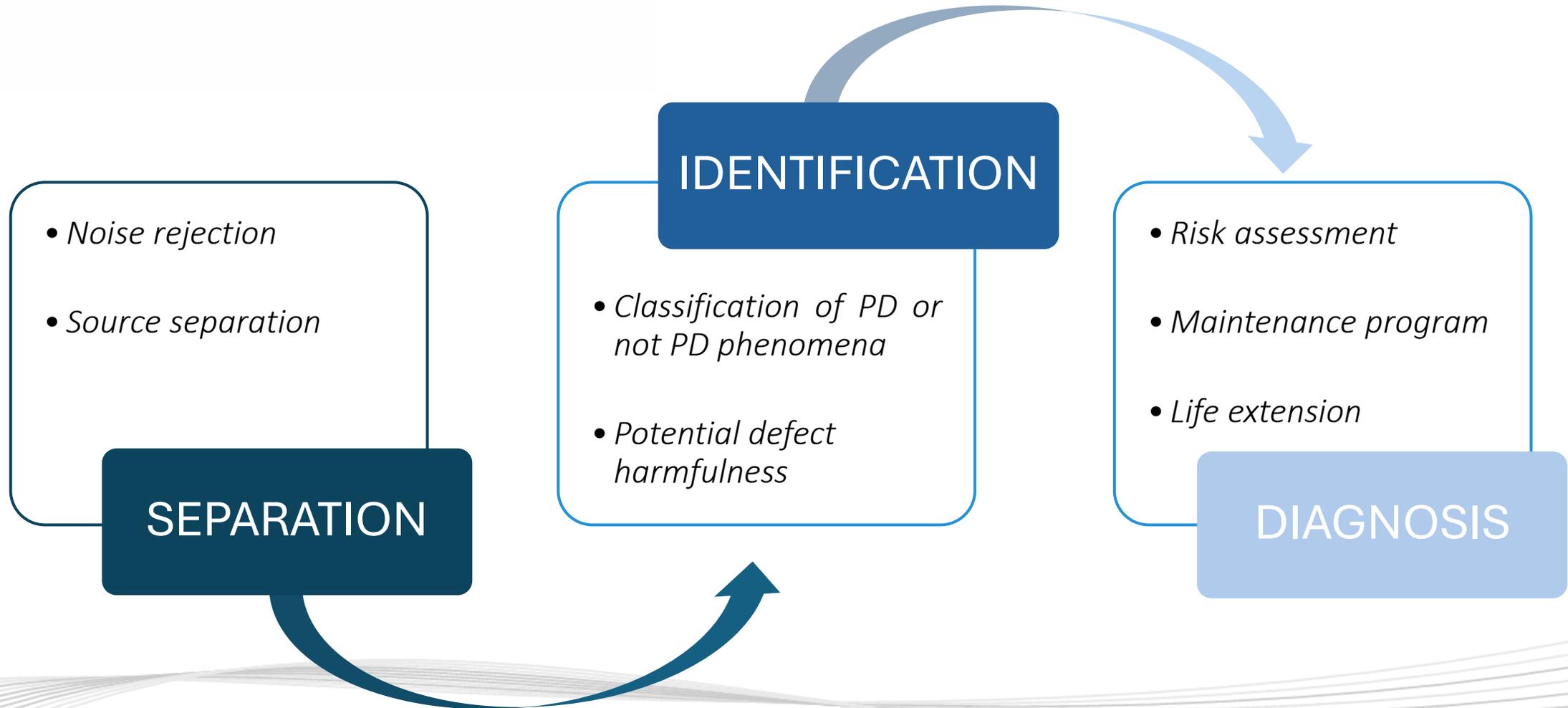
Denoising Technique

BEFORE

When performing PD testing, due to the complex electrical system involved, background/exciter noise and external disturbances may affect the readings of amplitude and repetition rate, leading to a decrease of the S/N.
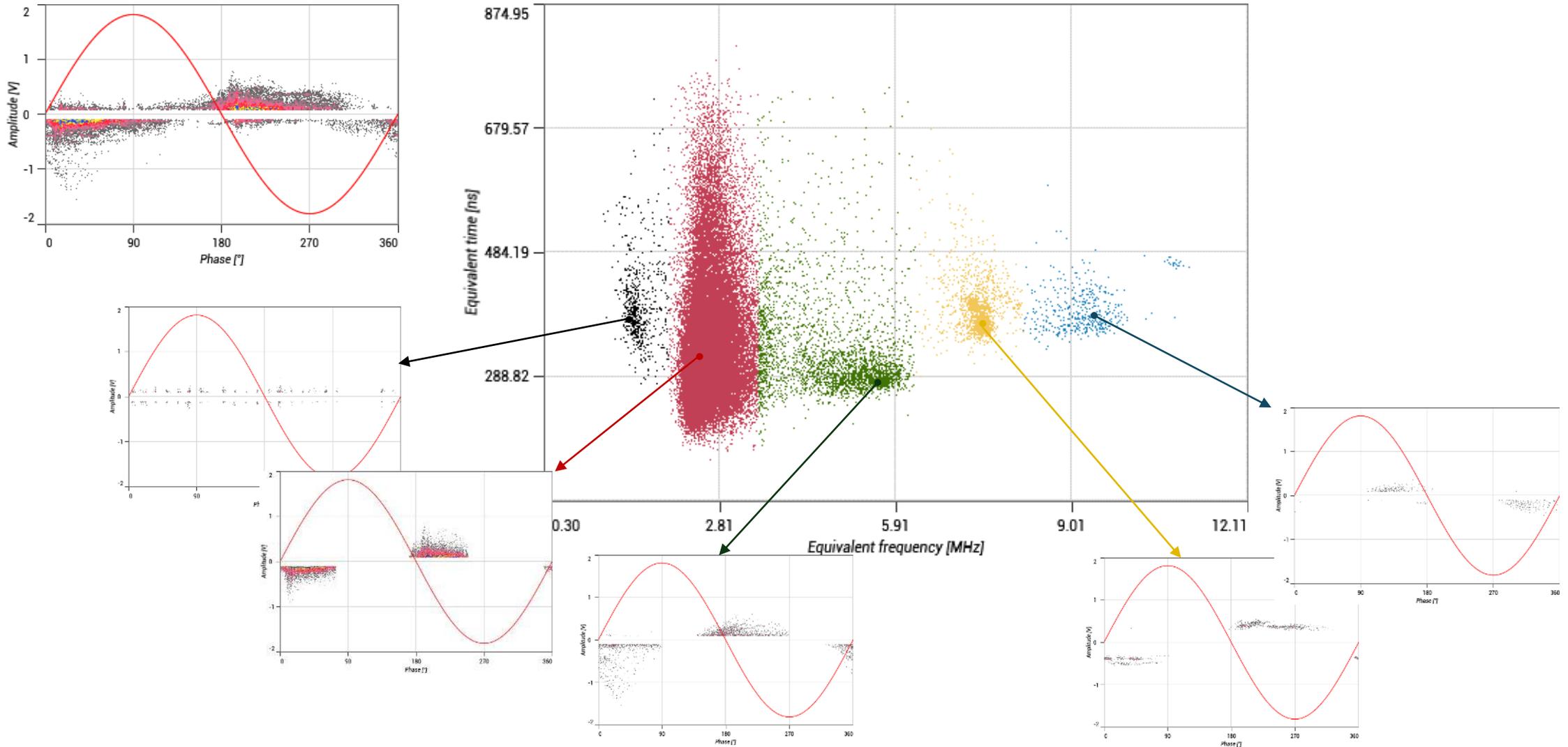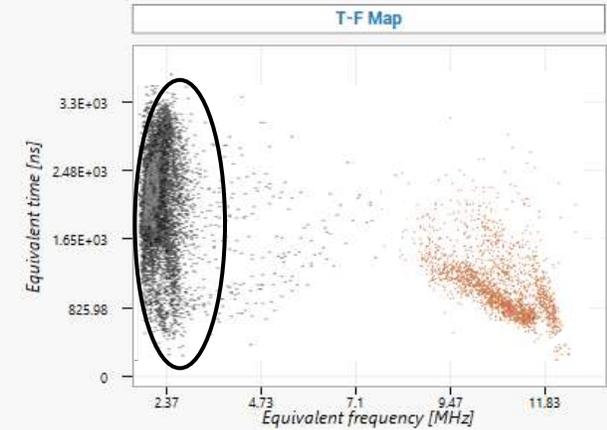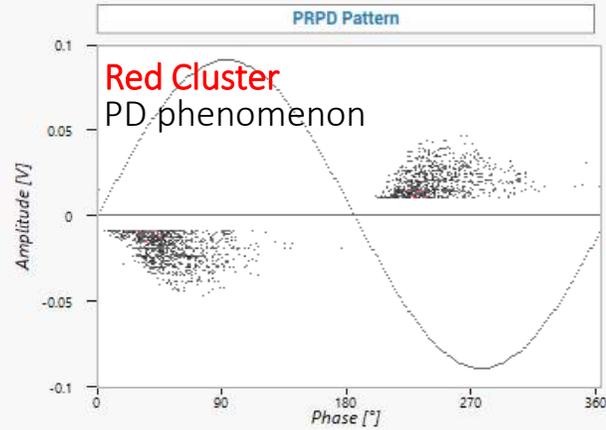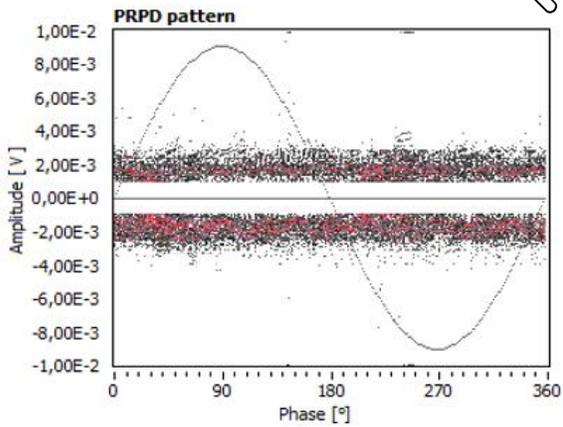
HW & **SW** Filters

AFTER

Software filters

S I D Method

S I D Method

Black Cluster
Background Noise

Red Cluster
PD phenomenon

S I D Method

3 **_Diagnosis_**

PD test are a fundamental tool for more informed **asset management**:

- ☐ Reducing the risk of failure
- ☐ Providing a risk quantification
- ☐ Creating an index for the fleet health

The «Bathtub curve»

Early "Infant Mortality" Failure

Observed Failure Rate

Wear Out Failures

Constant (Random) Failures

Failure Rate

Time

Quality Control → Commissioning Test → Online Spot Test → Offline Spot Test → Permanent Monitoring
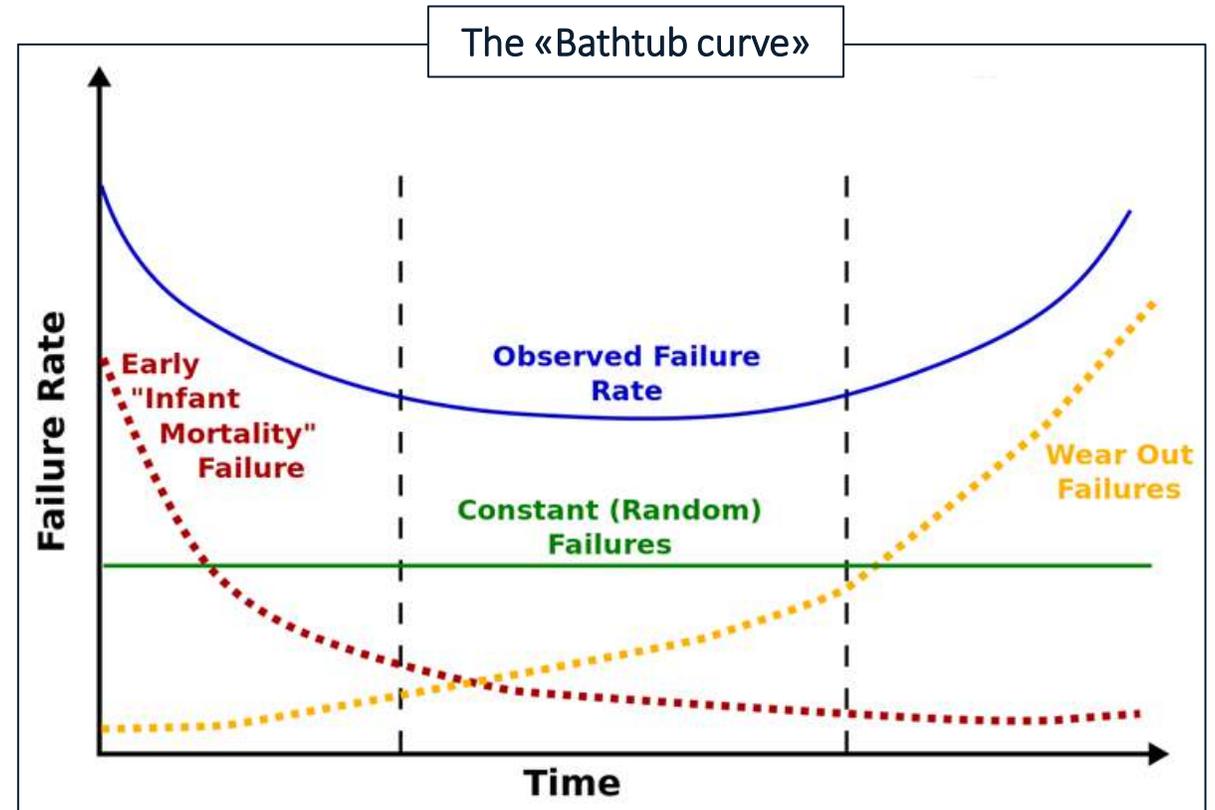
PD phenomena trending
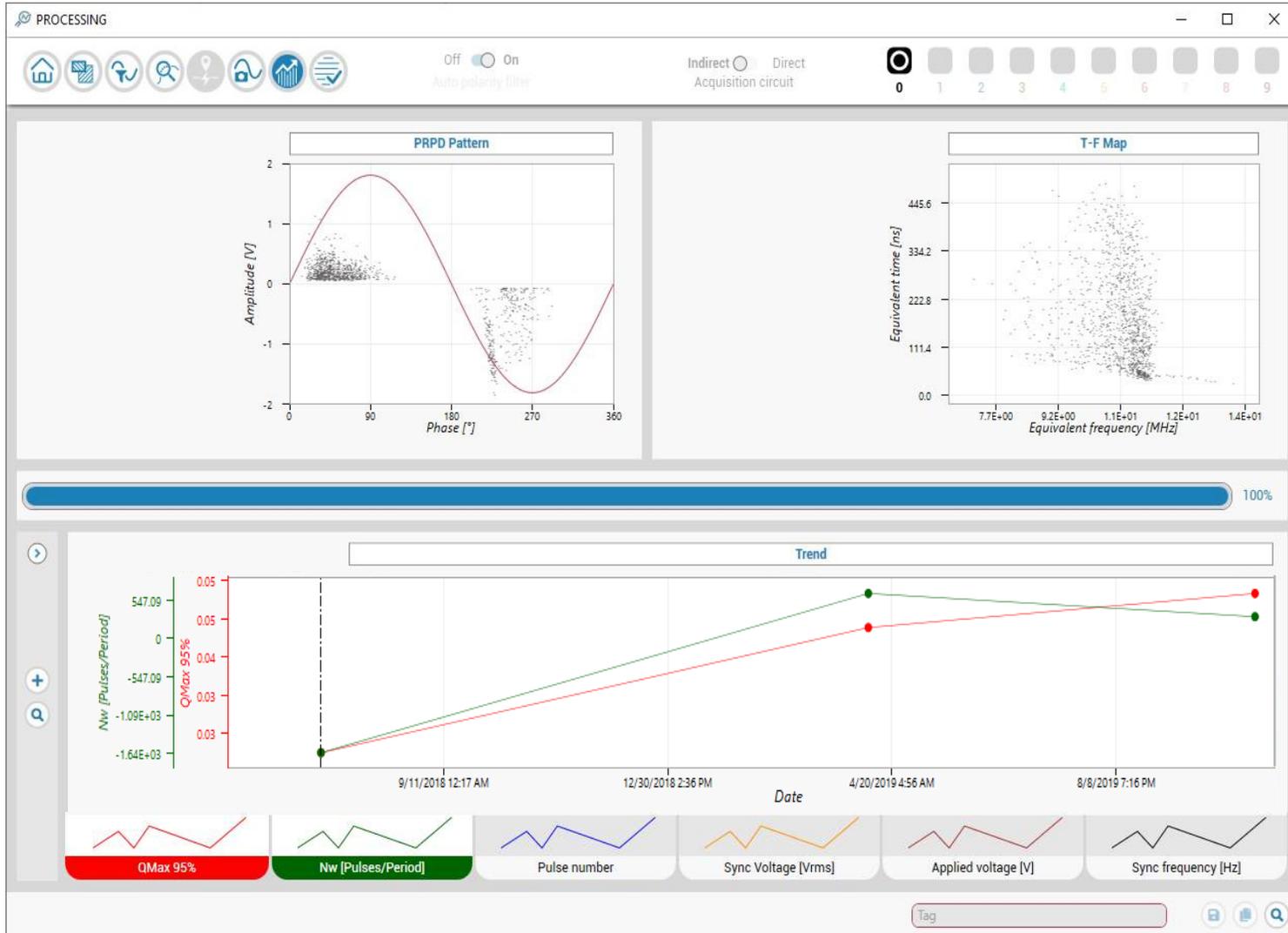
As the identification of a PD phenomenon, the PD evolution over the time plays a key role for a correct diagnosis and can be evaluated in terms of amplitude and repetition rate of the detected phenomenon.
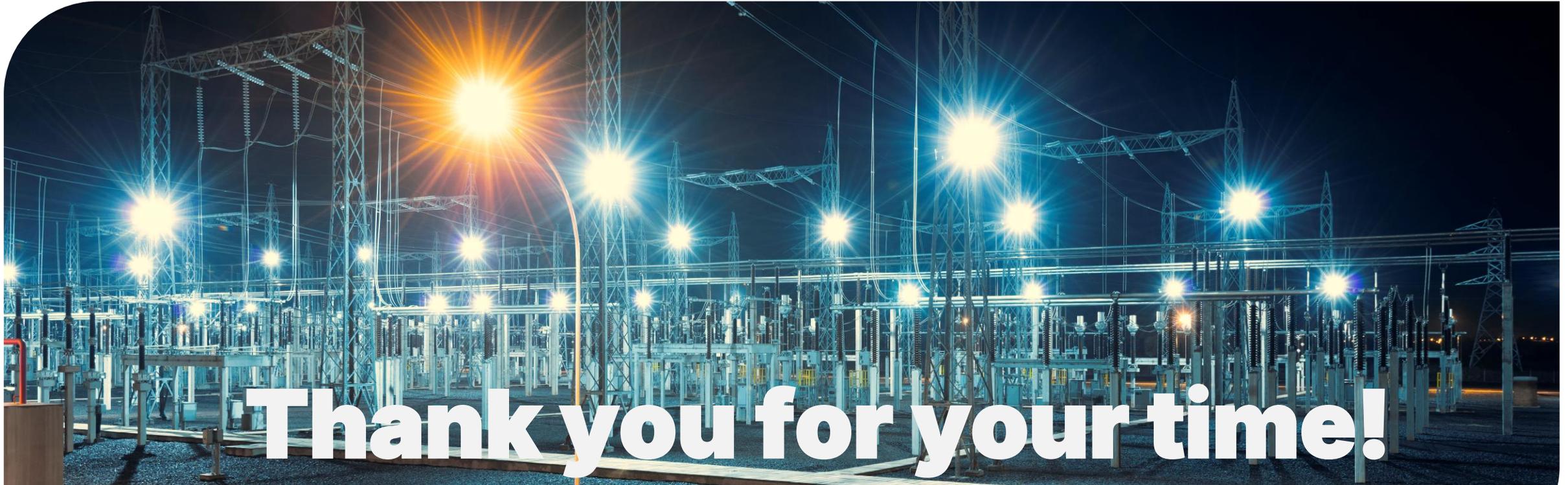
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Thank you for your time!

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