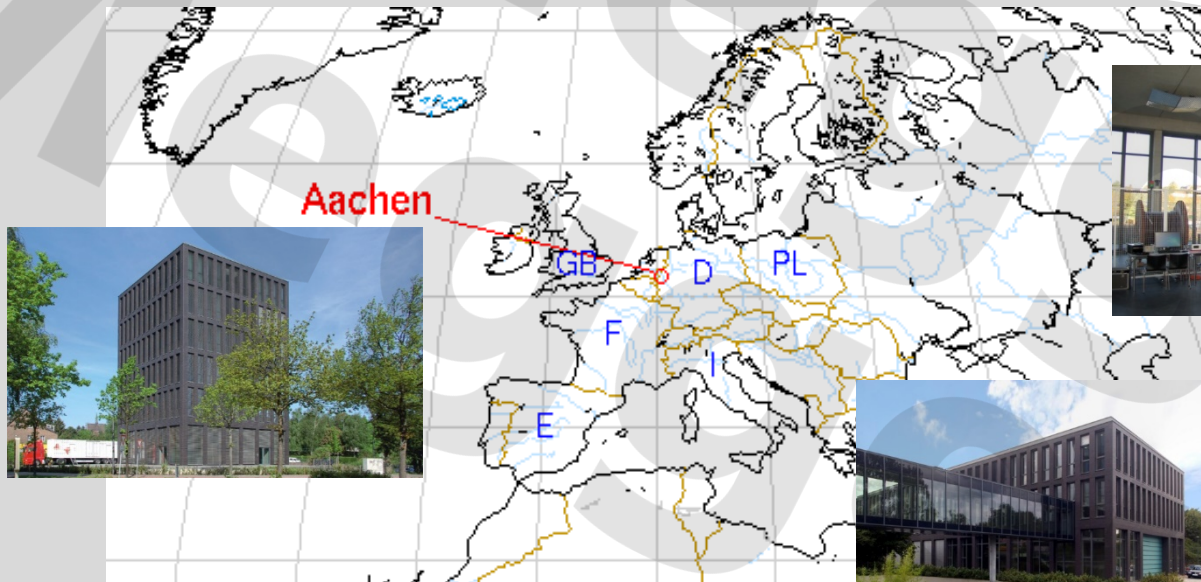


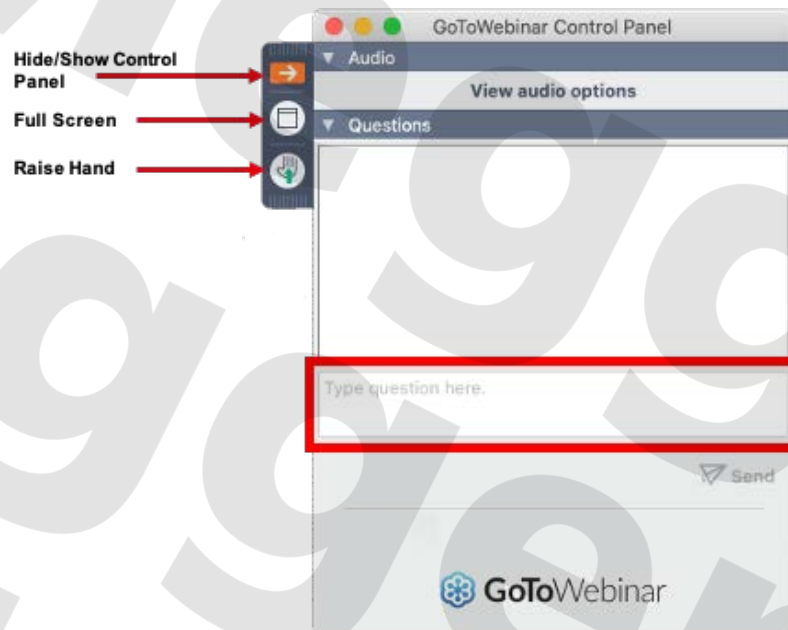
# Transformer Condition Assessment Through On-line Partial Discharge Monitoring

Mihai Huzmezan, Ph.D.  
Power Diagnostix Managing Director



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Vaalser Strasse 250, 52074 Aachen,  
Germany, [www.pdix.com](http://www.pdix.com)

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## Presenter

- Dr. Mihai Huzmezan
  - PDIX Managing Director

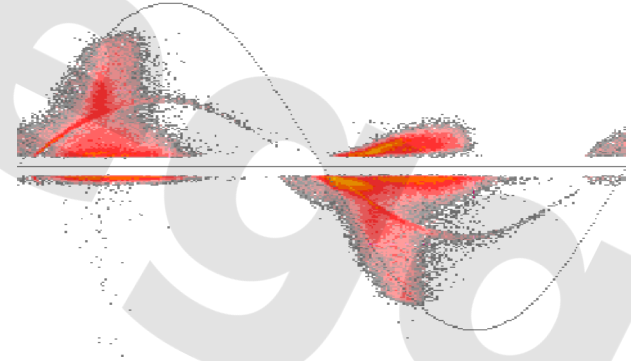
## Panelists

- Markus Soeller
  - PDIX Managing Director
- Charles Nybeck
  - Substation Application Engineer

## Moderator

- Michael Fleischer
  - Digital Marketing Specialist

- **Why PD monitoring?**
- Technical details
- Features and benefits
- References



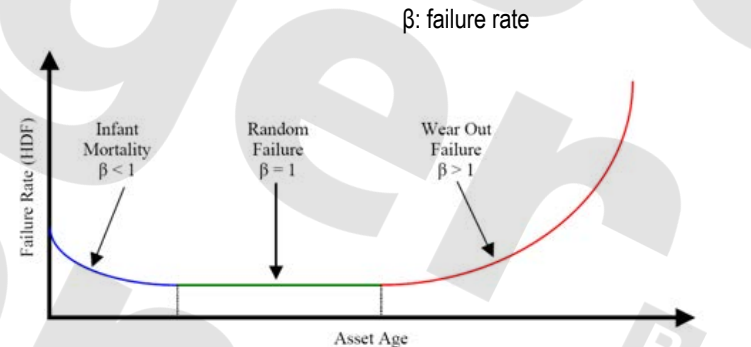
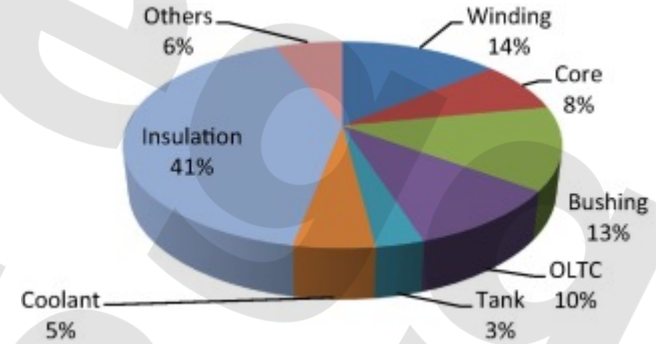
# PD Monitoring of Power Transformers

Transformer Failure is costly and can be disastrous...



## Why PD Monitoring on PTs?

- High percentage of failures related to insulation problems
- Bushing and Winding problems can be detected by PD monitoring
- Early failures due to improper FAT, transportation, onsite commissioning
- Random failures caused by special stress (e.g. high load, lightning or switching impulses or ambient cond.)
- End of life failures due to aging of insulation materials

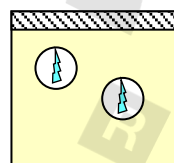
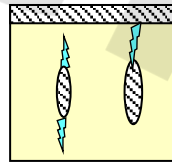
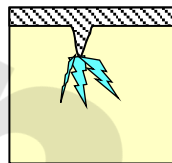
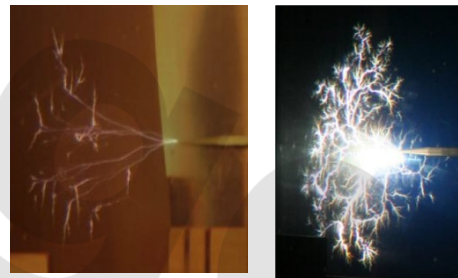


- **General Root Causes of PD in transformers**
  - Inferior quality of insulation materials
  - Fundamental design related problems
  - Incomplete or improper processing
  - Assembling related problems
  - Humidity in oil
- **Impact of Partial Discharges on transformer insulation systems**
  - Severity depends on the nature of the PD and location in the main tank
  - Accelerated degradation of Insulation materials
  - Reduced life expectancy of the grid system
  - Worst case scenario: unexpected breakdown → black outs



- Most common root causes:

- Inadequate vacuum stage prior to impregnation
- Insufficient drying of the active part before oil impregnation
- Remaining (conductive) particles in the oil
- Increased water content in the oil
  - reduced breakdown strength
- Missing electrical connections (e.g. floating static shields)
- Poor contacting of tap leads towards at OLTC
- Drops of casein glue in areas with elevated electrical fields



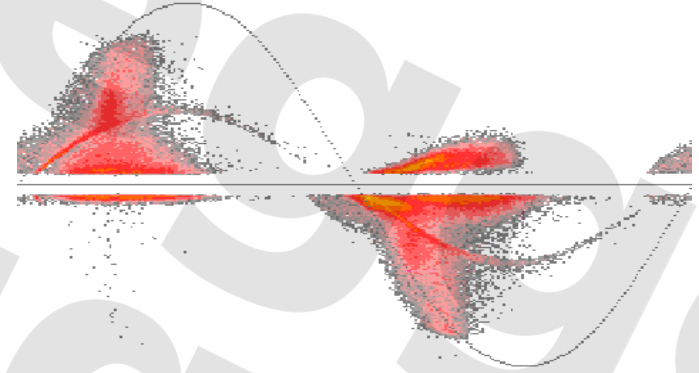
## Why PD Monitoring on PTs?

- Online PD Monitoring to assess insulation health of Power Transformers and Transformer Accessories
- PD Trending and Changing PD Patterns indicate incipient failure
- PD Pattern Analysis assists with failure Investigations (Root Cause Analysis)
- Added value if PD Monitoring is combined with DGA, Voltage, TD, Temperature and Load Monitoring

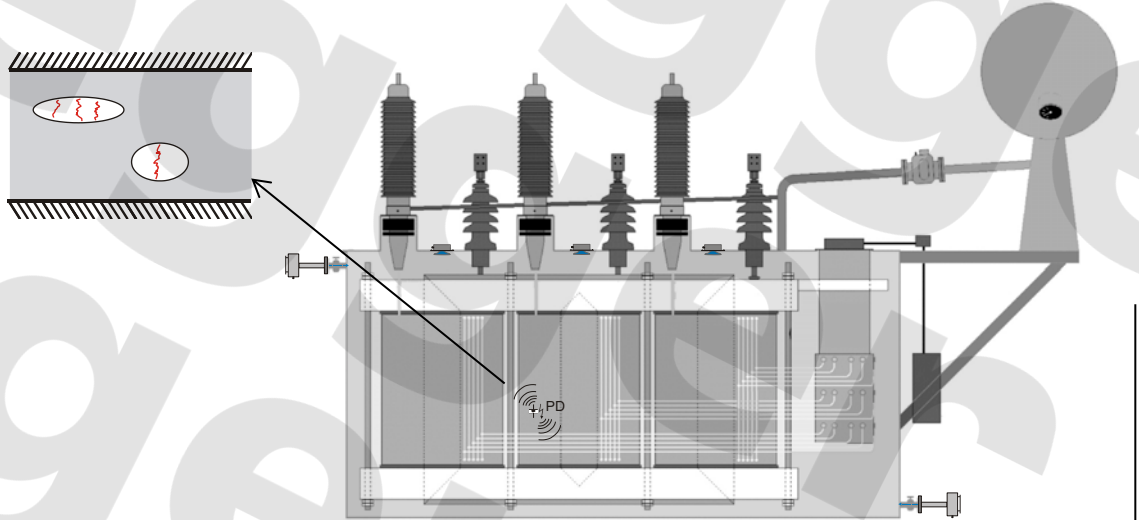


Foto: First PDM installation on a 400kV grid transformer (RWE) 1998

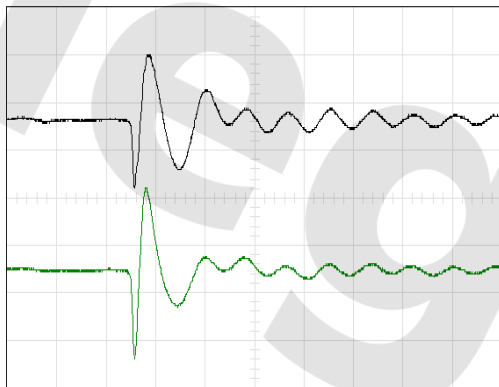
- Why PD monitoring?
- **Technical details**
- Features and benefits
- References



- Partial Discharge is a breakdown of a small area of the overall insulation
- Each PD pulse generates different measurable electrical signals
  - Local displacement current pulse
  - Electromagnetic pulses
  - Acoustic pulse

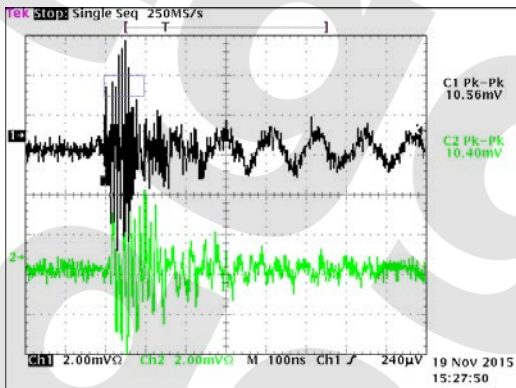


Electric PD Pulse  
taken from the test tap  
of a bushing

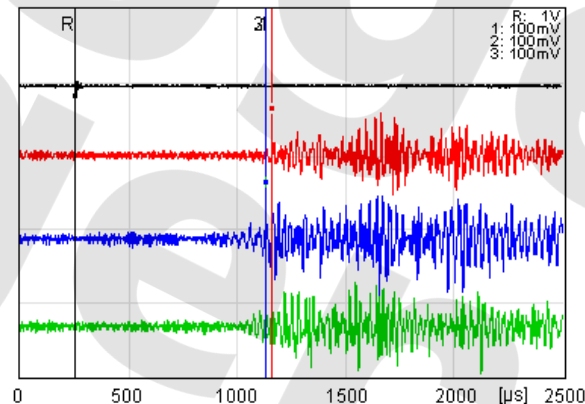


X Scale 10.00  $\mu$ s / DIV  
Y Scale CH1 1.00 V / DIV  
Y Scale CH2 1.00 V / DIV  
Y Position CH1 1.72 DIV  
Y Position CH2 -1.56 DIV

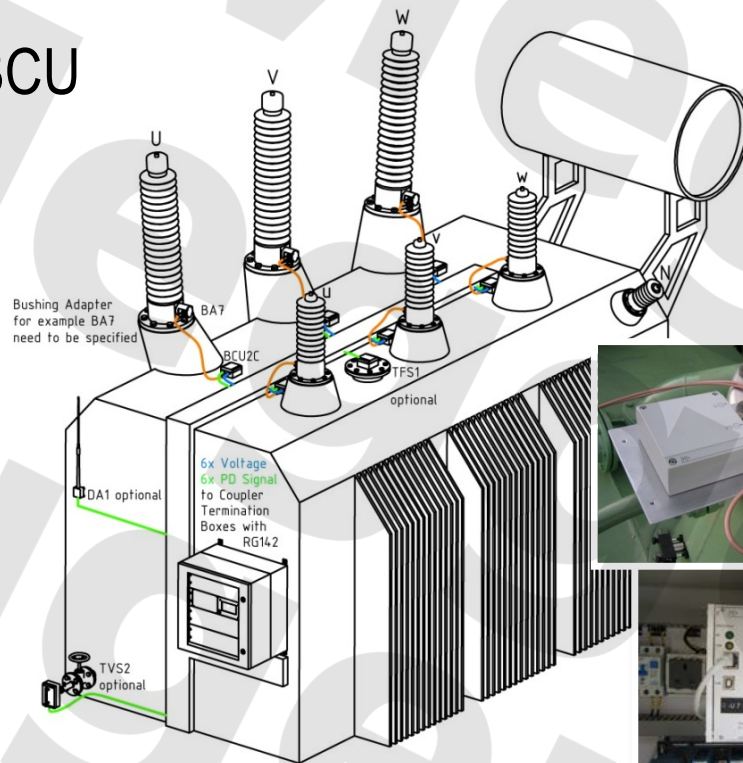
UHF PD Pulse taken  
from UHF antenna via  
oil valve



Acoustic Signal  
measured on the tank  
wall



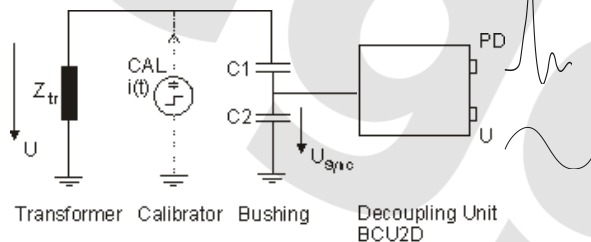
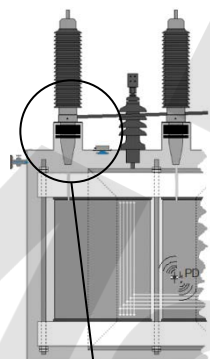
- PD and Sync from BCU to Input Multiplexer
- HF or UHF Sensors
- Noise Gating (DA1)
- Spectrum Scan
- PD Pattern & Trend
- OEM Solutions for Koncar and others...



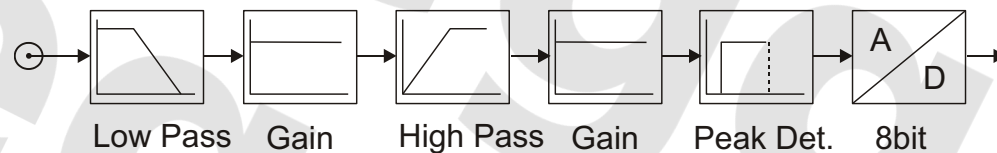
## Overview ICMmonitor



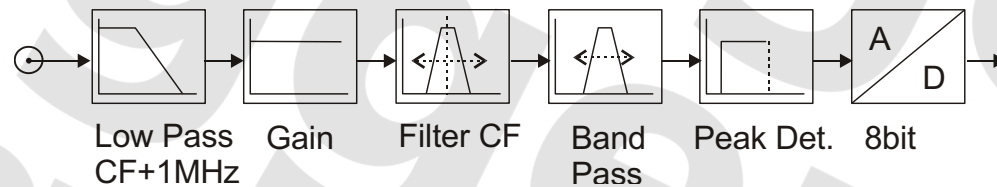
## Signal Processing of PD Signals



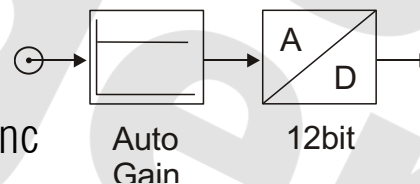
### AMP Mode



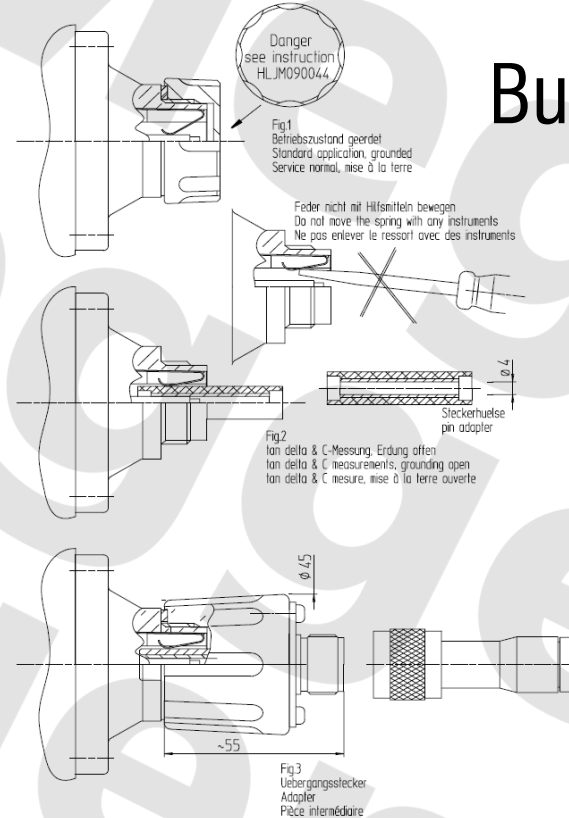
### SPEC Mode



### Sync



- Multiple Types and Designs
- Aluminum Enclosure
- Two 600Vdc Surge Arrestor
- Output Connector: N Type
- Protection Class: IP65
- Temp. Range: -40°...+90°C

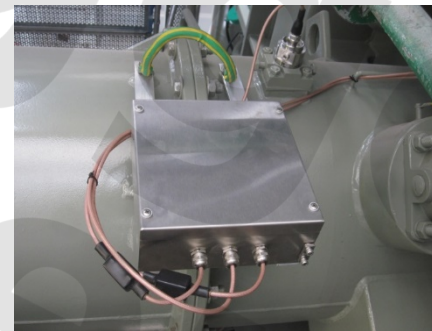


## Bushing Adapter BAXy

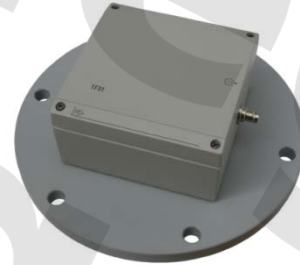


- PD Decoupling Circuit: HFCT or Quadrupole (switchable)
- Voltage Output via Capacitive Divider
- Two Output Connectors of N Type
- Protection Class: IP65
- Temperature Range: -40°C to 75°C
- Stainless Steel housing available on request

## Bushing Coupling Unit BCU2C or BCU2D



- Sensor for Noisy Site Conditions
- Transformer Valve Sensor  
(DN40 - DN50 and DN100 flanges)
- Hatch sensor (various diameters)
- Built-in logarithmic UHF signal converter
- Frequency Range: 300MHz – 1GHz
- TNC Output Connector
- Oil-tight Design



## UHF Sensors TVS2 and TFS1



- Cables suited for extreme site temperatures and heavy weather conditions
- High Quality PTFE Teflon Coaxial Cable RG142, 50Ohm
- Recommended Distance (BCU to ICMmonitor) up to 20m
- CTB2C provides protective ground
- Both Cable Ends grounded and fitted with clamp-on ferrite cores

## Signal Cabling



- Disturbance Antenna DA1 picks up Noise Pulses radiated by Corona for instance
- High Frequency Current Transformers CT1 or CT100 pick up Disturbance Pulses from shields of signal cables or from ground connections
- Instrument interrupts PD Measurement for the duration (in  $\mu\text{s}$ ) of Disturbance Pulses, so called Gating

## Noise Gating Tools



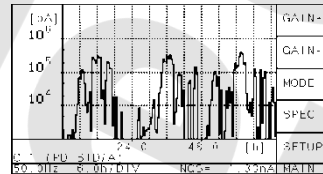
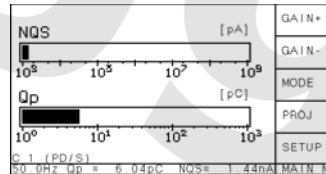
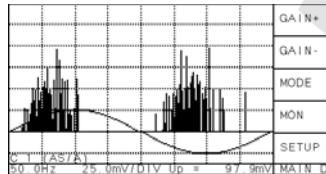
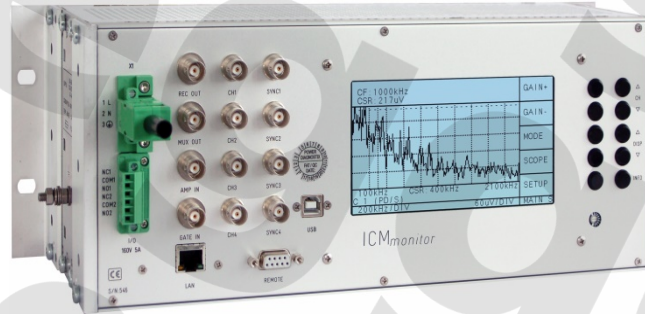
- 4, 8 or 12 Multiplexed PD Input Channels
- Separate Sync and Gate Input
- LAN and USB Interface
- 12-26Vdc Supply, 20VA max
- Customized Design for Hat-Rail Mounting
- Opt. 240x128px LC Display for Onsite Configuration and Inspection
- Commissioning and Monitoring Mode

## Acquisition Unit *ICMmonitor*



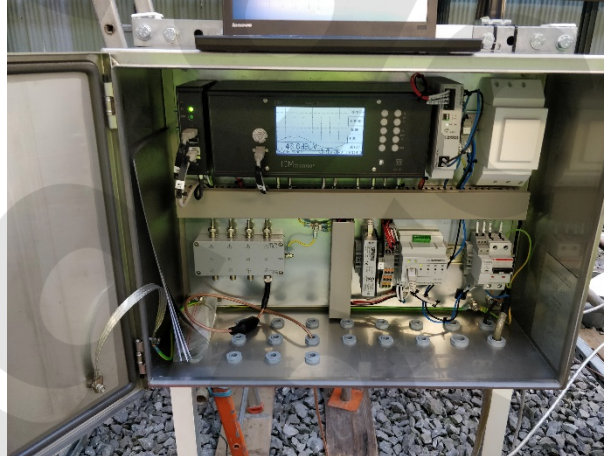
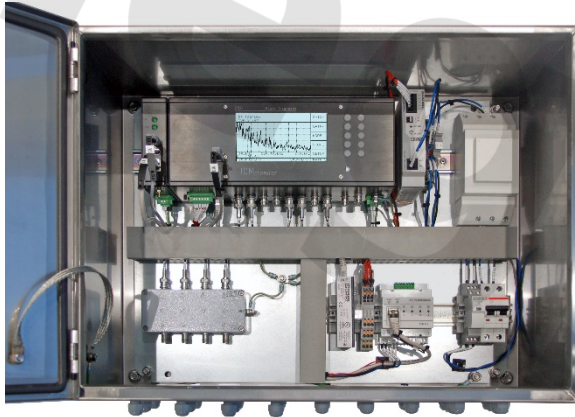
- Frequency Selective Measurement
- Wide Band and Narrow Band Filter
- Spectrum Analysis
- UHF Measurement
- Dry Alarm Contacts
- IEC61850 (HW or SW)

## Acquisition Unit *ICMmonitor*



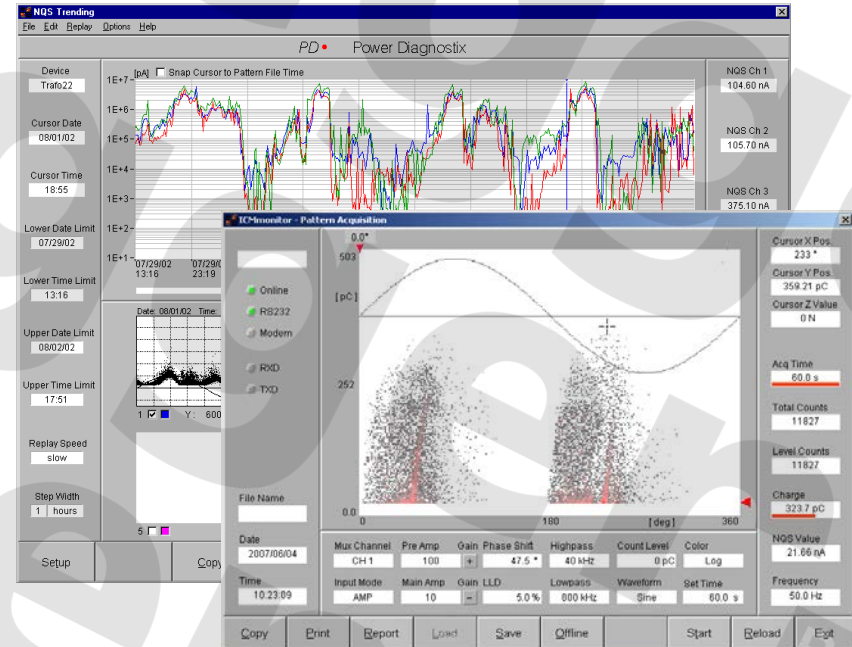
- Stainless steel cabinet
- ICMmonitor, CTB, Network Interface, IOs, Main Switch,...built-in
- Compact design

## PDMAR500



- Remote Access to Multiple Monitoring Instruments
- Long Term Trending, History Structure
- Alarm Handling
- Colored PD Pattern Acquisition
- Automated Data Acquisition
- Connects via USB or LAN

## Windows SW: ICMmonitor



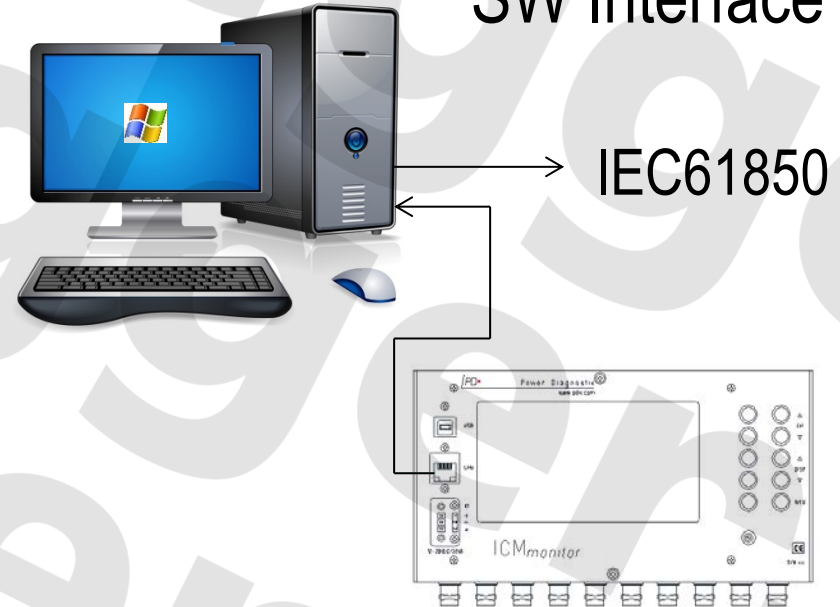
- SERVICEMON.EXE w/o GUI and integrated ActiveX Interface
- Full Description of all Functions
- Provided Data Sets such as:  
Trending Values, PD Pattern,  
Alarm PD Pattern, Spectrum  
Scans, Instrument Settings

## Windows: ActiveX Library



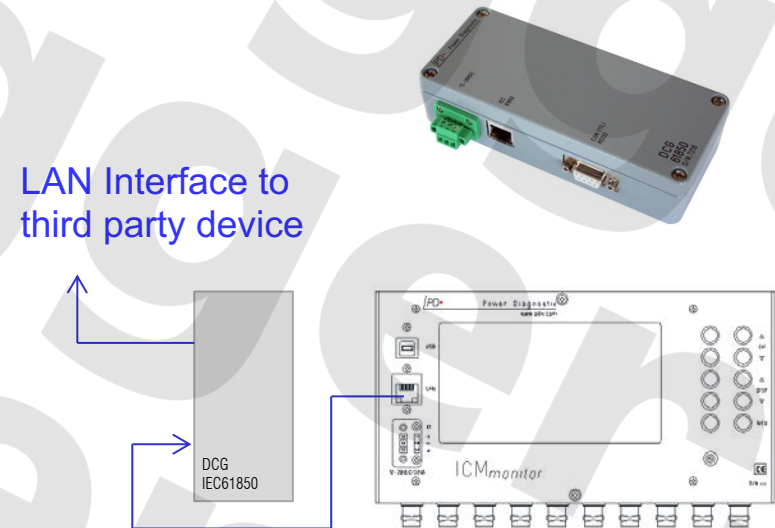
- ICMmonitor SW runs as Service without Graphical User Interface
- Provision of ICDs for Third Party Data Integration
- Full Description of all Data Sets and 61850 relevant documents
- Provided Data Sets such as:  
Current Readings of NQS, Qp,  
Alarm Status

## Windows: IEC61850 SW Interface



- Additional Hardware based Device Communication Gateway
- OS independent
- Provision of ICDs
- Full Description of all Data Sets and 61850 relevant documents
- Provided Data Sets such as:  
Current Readings of NQS, Qp,  
Alarm Status per Channel

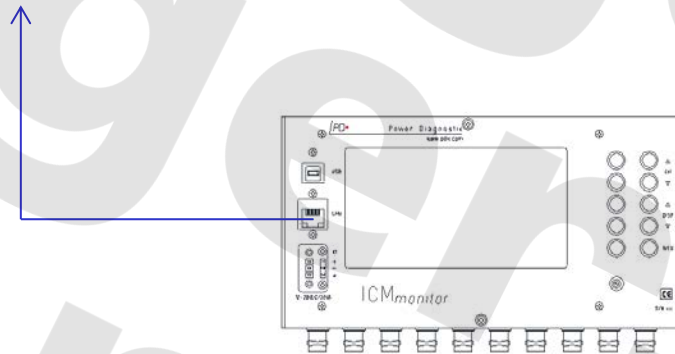
## IEC61850 HW Interface



- OS independent
- Full Description of communication protocol, commands and structures
- Code Examples for Third Party Programming
- Access to all Data Sets provided by the instrument

## Direct LAN, USB or RS232 Communication

LAN Interface to  
third party device



- ICMmonitor SW connects via **pdmon.com** Cloud-Server to the instrument at site
- Direct Access via virtual IP address
- No network cabling
- UMTS provider with local SIM required

## Mobile Communication Interface MCI1



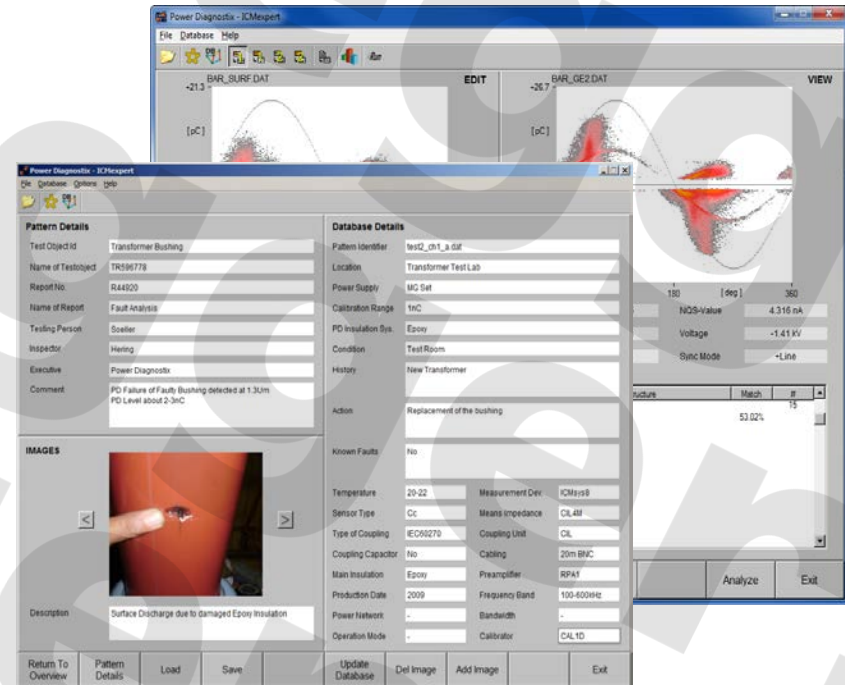
- OS independent
- Direct Access via local IP address
- Full Description of API
- Access to specified Data Sets provided by the instrument

## Mobile Web Server MWS1

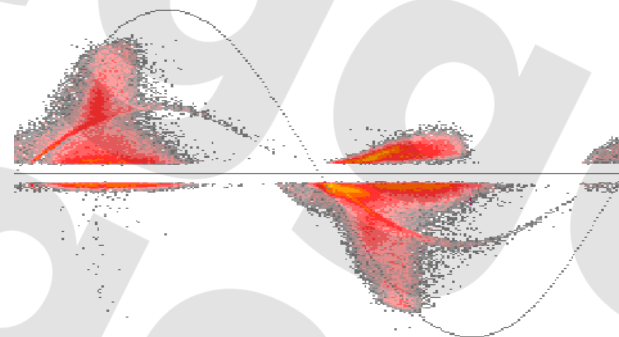


- Database-Supported Handling of all Measurement Files and Supplementary Information
- PD Pattern Comparison
- PD Pattern Classification
- Storage of Photos, Comments, and all Instrument Settings with each Data Set
- Add On Tool for all Products

## Advanced Data Management



- Why PD monitoring?
- Technical details
- **Features and benefits**
- References



| Feature                                        | Benefit                                                                    |
|------------------------------------------------|----------------------------------------------------------------------------|
| HF, UHF and Acoustic Measurement Mode          | All kind of sensors can be used                                            |
| Spectrum Analysis (narrow and wideband filter) | Suitable measurement frequency can be selected at site<br>SNR optimization |
| Gating input                                   | External disturbance pulses can be rejected                                |
| Multiplexer                                    | Less costly                                                                |
| Multiple interfaces                            | Customizable                                                               |
| Auxiliary inputs 4-20mA                        | Easy integration of DGA, oil temperature, voltage,<br>load,...monitoring   |
| Long term data record and data consistency     | Historical data can be analyzed                                            |
| Multiple interfaces                            | Local and remote access                                                    |

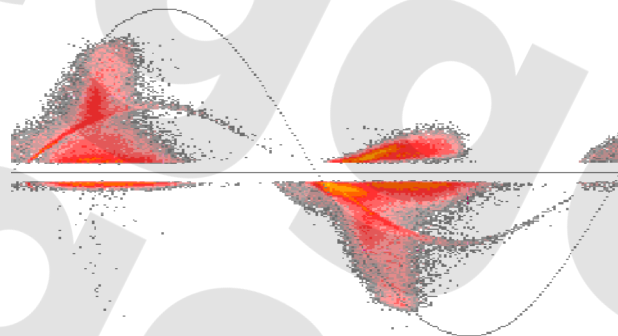
UHF technology insensitive for external noise, but:

- does not identify all defects in transformers
- higher modes above 300MHz attenuated
- does not allow any comparison with FAT results acc. IEC
- no calibration in terms of pC applicable
- UHF sensors costly and more difficult to install

- Questionnaire for PDM on PT
- Spec sheets and manuals
- BCU, BA design specification
- TVS, TFS data sheets



- Why PD monitoring?
- Technical details
- Features and benefits
- **References**



- GE, Mönchengladbach, Germany (**MS3000**),
  - Kahramaa, Qatar (2009-2020)
  - Multiple other installations worldwide
- Koncar, Zagreb, Croatia (**TMS**)
  - Kahramaa, Qatar (2008-2020)
  - Multiple other installations worldwide
- ABB (SE, DE)
- Siemens Weiz (AT)
- BKW (CH), ESBI (Ireland), ...

# Survey and Contact Information

## Contact Information

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Everyday we assist our customers with monitoring, acceptance, commissioning, testing and maintenance for predictive diagnostic or routine purposes.

By working closely with electrical utilities, standards bodies and technical institutions, we contribute to the dependability and advancement of the electrical supply industry.

