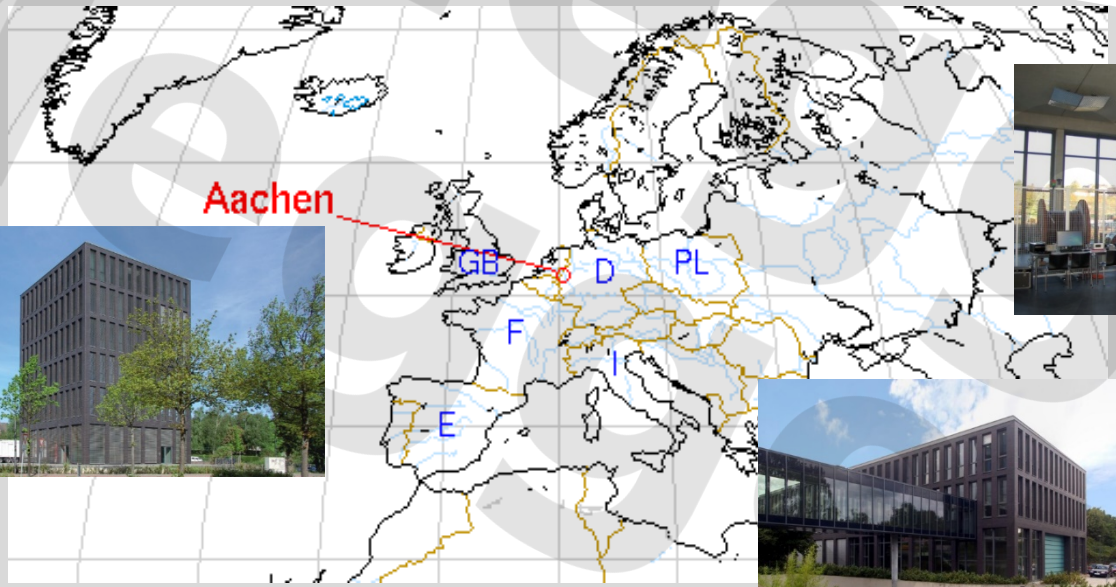
Transformer Condition Assessment Through On-line Partial Discharge Monitoring

Mihai Huzmezan, Ph.D.
Power Diagnostix Managing Director



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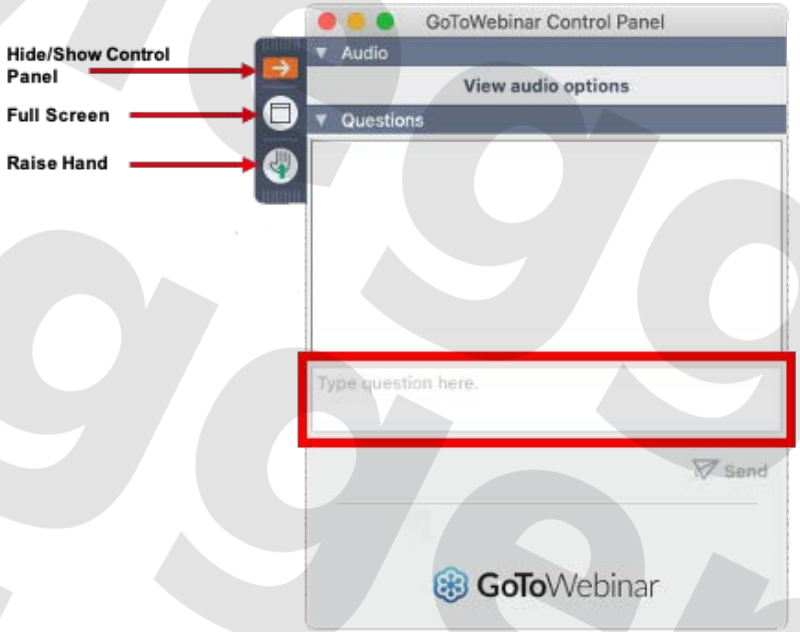
Q&A

- Please send us your questions and comments in writing during the presentation

- The moderator will ensure they are addressed during or after the presentation by the presenter and the panelist



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Today's Presenter, Panelists and Moderator

Presenter

- Dr. Mihai Huzmezan
  - PDIX Managing Director

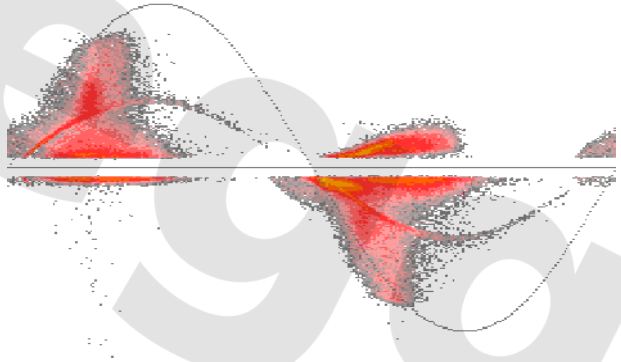
Panelists

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

Moderator

- Michael Fleischer
  - Digital Marketing Specialist

PD Monitoring on Power Transformers



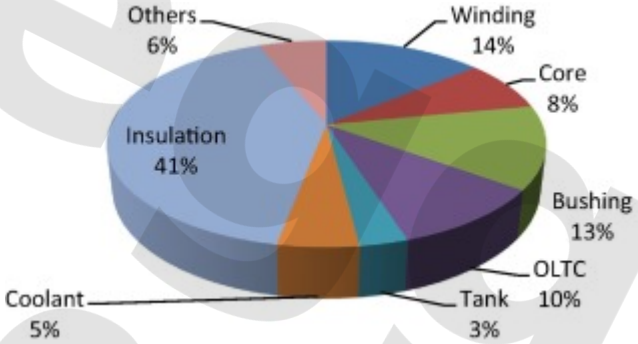
- **Why PD monitoring?**
- Technical details
- Features and benefits
- References

PD Monitoring of Power Transformers

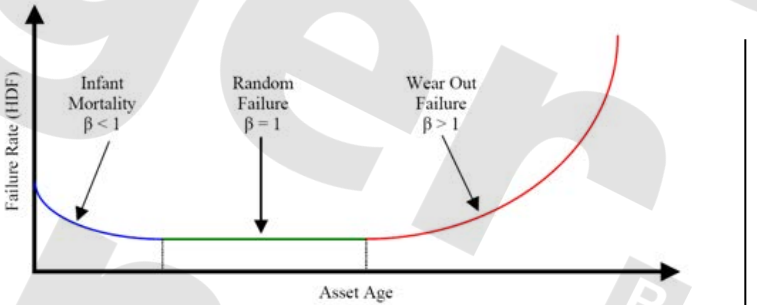
Transformer Failure is costly and can be disastrous...

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

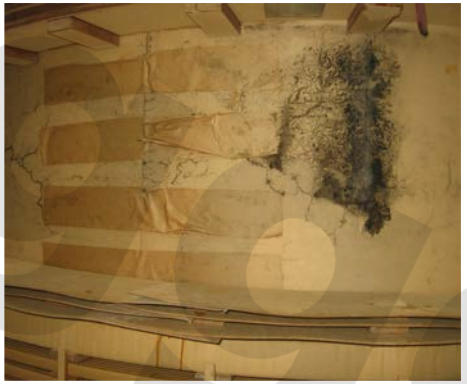


β: failure rate



Why PD Monitoring on PTs?

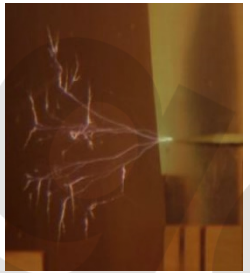
- General Root Causes of PD in transformers
  - Inferior quality of insulation materials
  - Fundamental design related problems
  - Incomplete or improper processing
  - Assembling related problems
  - Humidity in oil

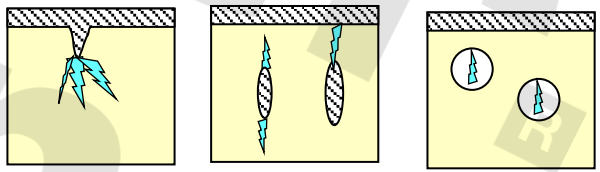


- Impact of Partial Discharges on transformer insulation systems
  - Severity depends on the nature of the PD and location in the main tank
  - Accelerated degradation of Insulation materials
  - Reduced life expectancy of the grid system
  - Worst case scenario: unexpected breakdown → black outs

Why PD Monitoring on PTs?

- 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

PD Monitoring on Power Transformers

- Why PD monitoring?
- **Technical details**
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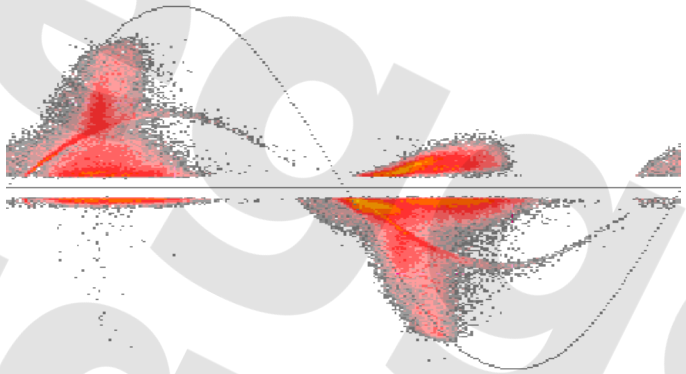
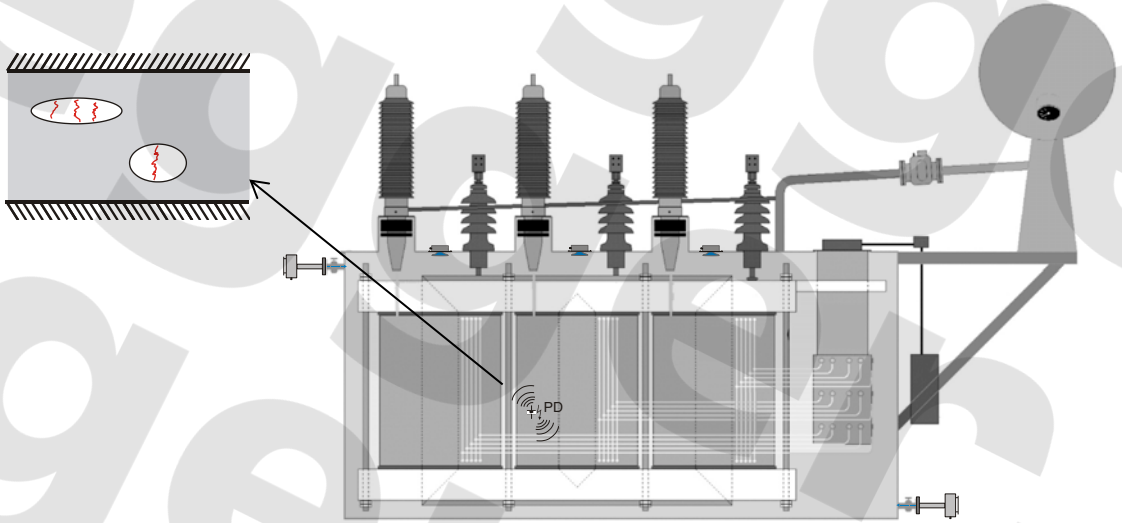
- References



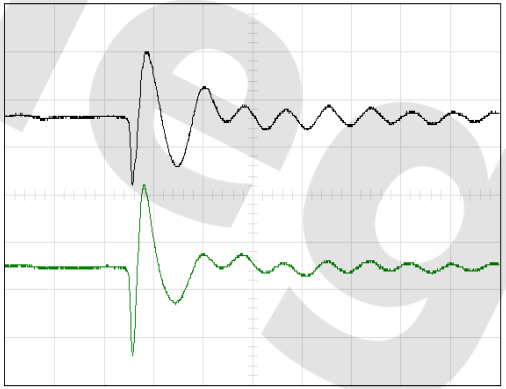
Technical details

- 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



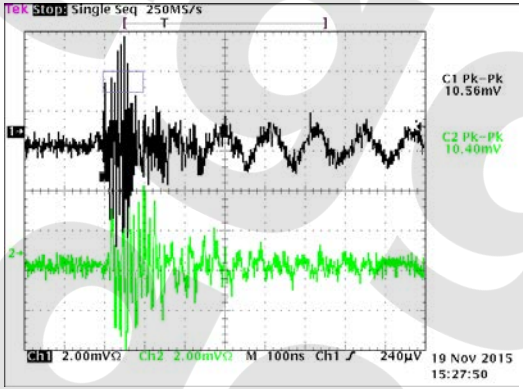
Technical details

Electric PD Pulse taken from the test tap of a bushing

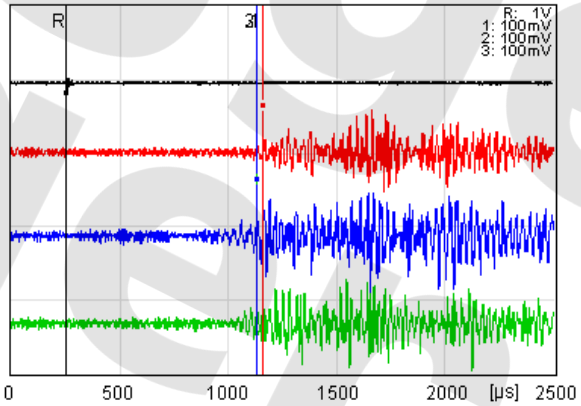


X Scale 10.00 µs / DIV | Y Scale CH1 1.00 V / DIV | Y Scale CH2 1.00 V / DIV
Y Position CH1 1.72 DIV | Y Position CH2 -1.56 DIV

UHF PD Pulse taken from UHF antenna via oil valve



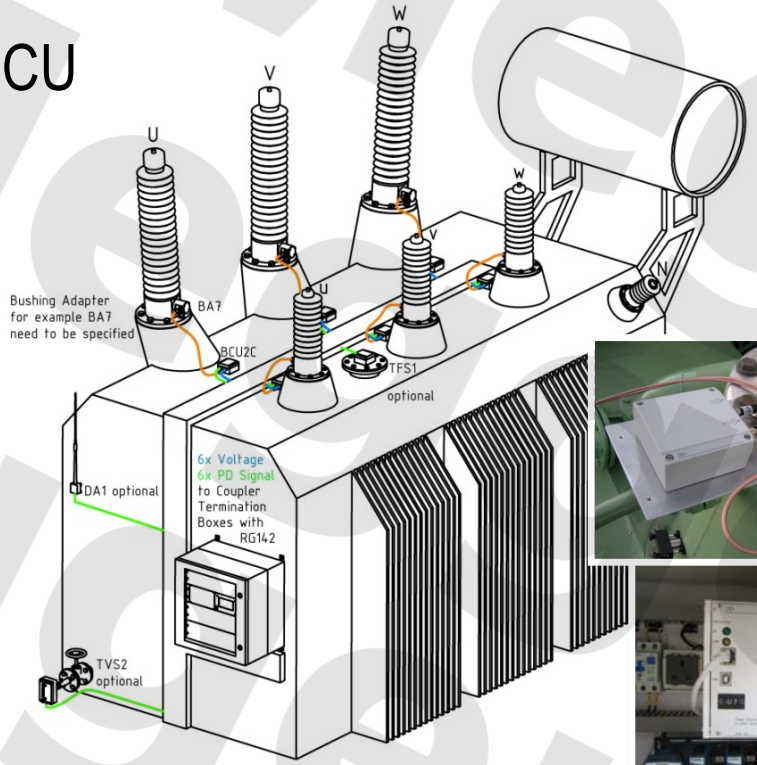
Acoustic Signal measured on the tank wall



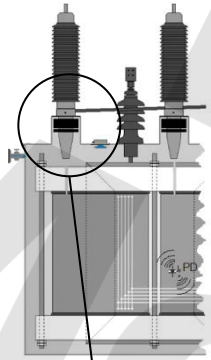
Technical details

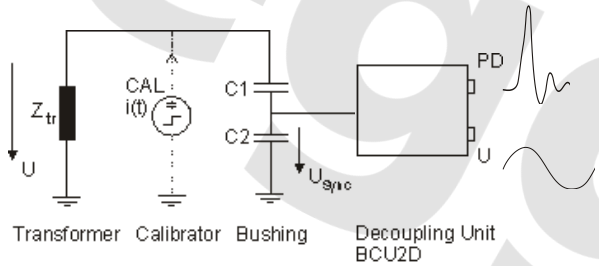
- PD and Sync from BCU to Input Multiplexer
- HF or UHF Sensors
- Noise Gating (DA1)
- Spectrum Scan
- PD Pattern & Trend
- OEM Solutions for Koncar and others...

Overview ICM*monitor*

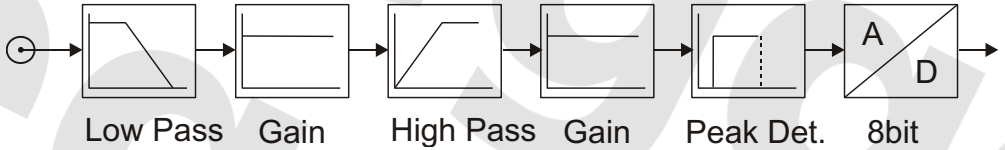


Signal Processing of PD Signals

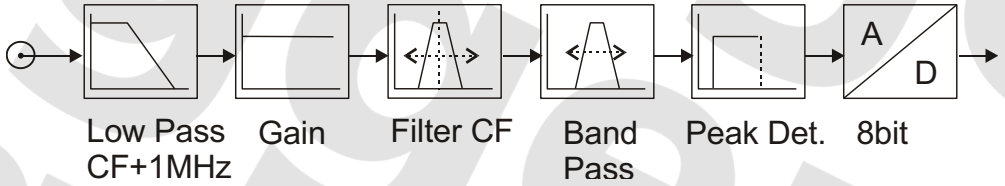




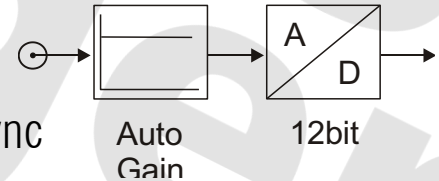
AMP Mode



SPEC Mode

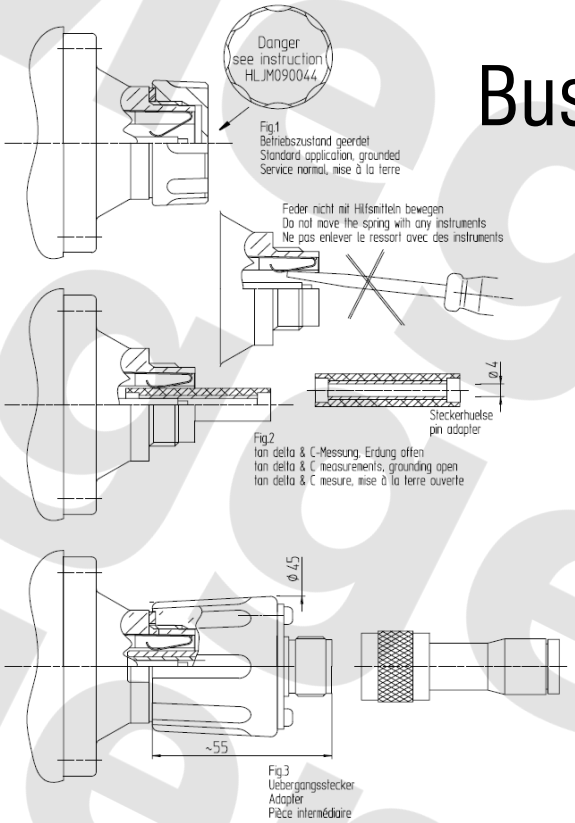


Sync



Bushing Adapter BAxy

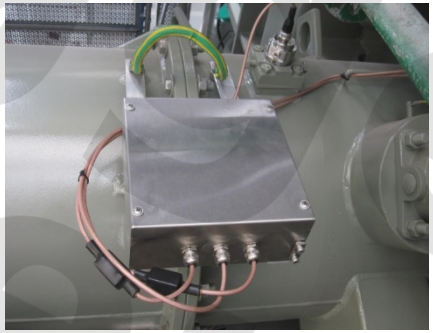
- Multiple Types and Designs
- Aluminum Enclosure
- Two 600Vdc Surge Arrestor
- Output Connector: N Type
- Protection Class: IP65
- Temp. Range: -40°...+90°C



Hardware

Bushing Coupling Unit BCU2C or BCU2D

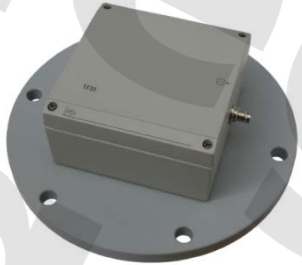
- PD Decoupling Circuit:
  HFCT or Quadrupole (switchable)
- Voltage Output via Capacitive Divider
- Two Output Connectors of N Type
- Protection Class: IP65
- Temperature Range: -40°C to 75°C
- Stainless Steel housing
  available on request



Hardware

UHF Sensors TVS2 and TFS1

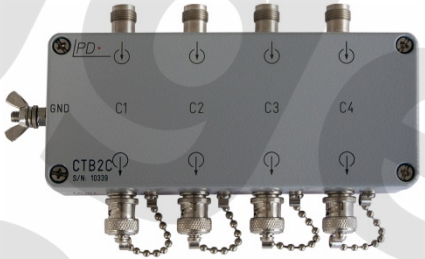
- Sensor for Noisy Site Conditions
- Transformer Valve Sensor (DN40 - DN50 and DN100 flanges
- Hatch sensor (various diameters)
- Built-in logarithmic UHF signal converter
- Frequency Range: 300MHz – 1GHz
- TNC Output Connector
- Oil-tight Design



Hardware

Signal Cabling

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



Hardware

Noise Gating Tools

- 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 µs) of Disturbance Pulses, so called Gating

Hardware

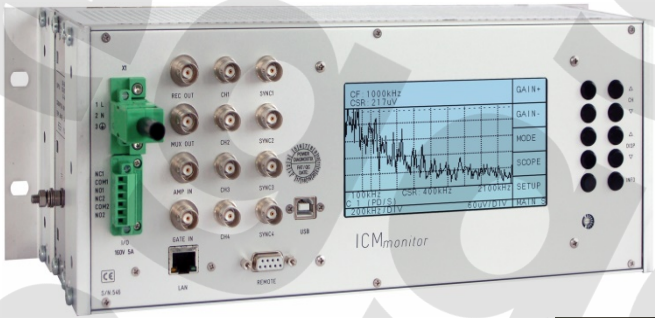
Acquisition Unit ICM*monitor*

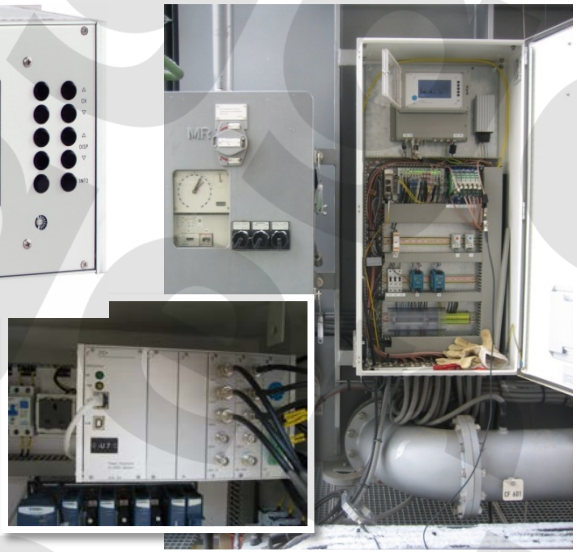
- 4, 8 or 12 Multiplexed PD Input Channels
- Separate Sync and Gate Input
- LAN and USB Interface
- 12-26Vdc Supply, 20VA max
- Customized Design for Hat-Rail Mounting
- Opt. 240x128px LC Display for Onsite Configuration and Inspection
- Commissioning and Monitoring Mode

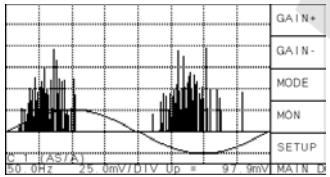
Hardware

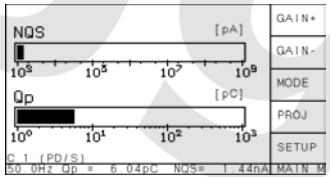
Acquisition Unit ICM*monitor*

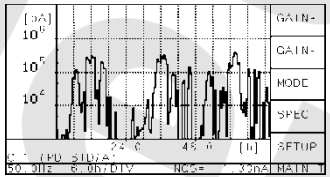
- Frequency Selective Measurement
- Wide Band and Narrow Band Filter
- Spectrum Analysis
- UHF Measurement
- Dry Alarm Contacts
- IEC61850 (HW or SW)







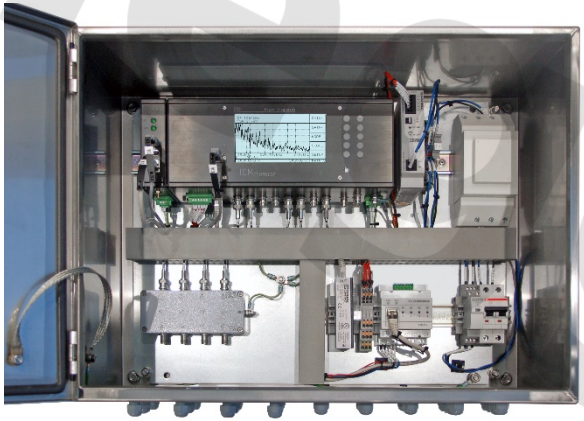


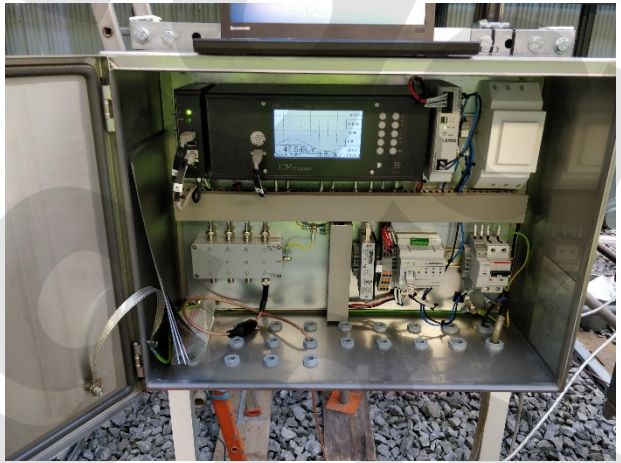


Hardware

PDMAR500

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

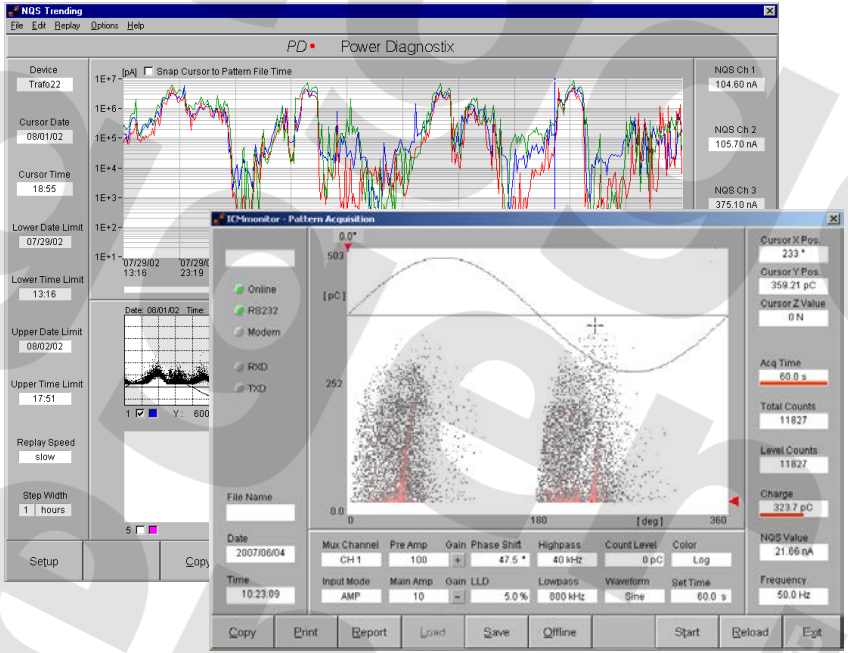




Software & Data Integration

- 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

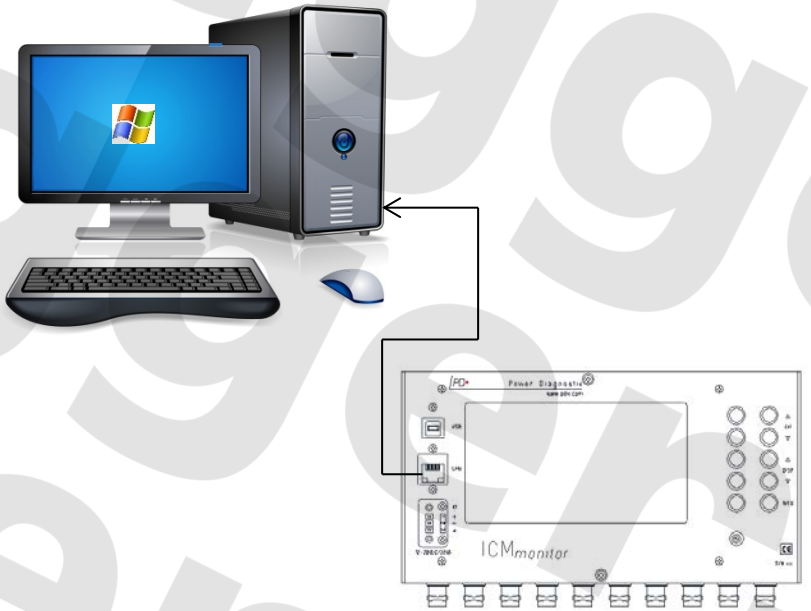
Windows SW: ICM*monitor*



Software & Data Integration

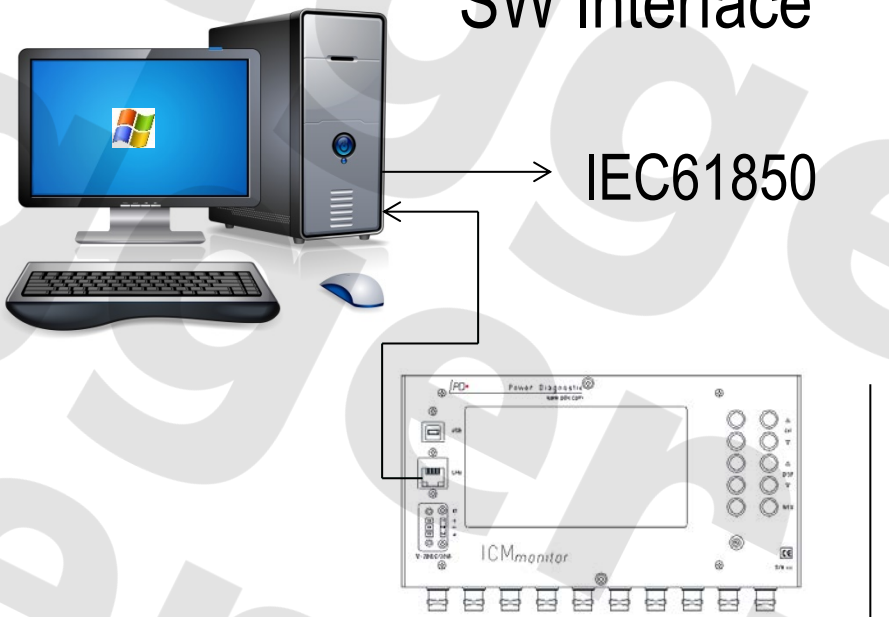
- SERVICEMON.EXE w/o GUI and integrated ActiveX Interface
- Full Description of all Functions
- Provided Data Sets such as: Trending Values, PD Pattern, Alarm PD Pattern, Spectrum Scans, Instrument Settings

Windows: ActiveX Library



Software & Data Integration

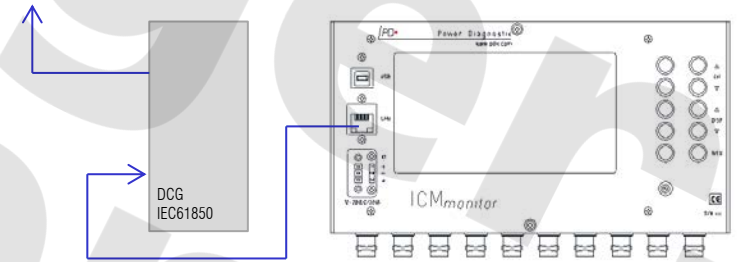
- ICM*monitor* SW runs as Service without Graphical User Interface
- Provision of ICDs for Third Party Data Integration
- Full Description of all Data Sets and 61850 relevant documents
- Provided Data Sets such as: Current Readings of NQS, Qp, Alarm Status



Software & Data Integration

IEC61850 HW 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

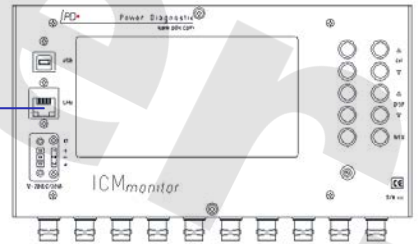


Software & Data Integration

- 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

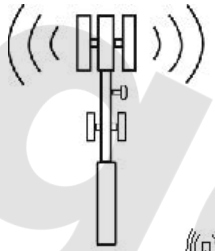
LAN Interface to third party device

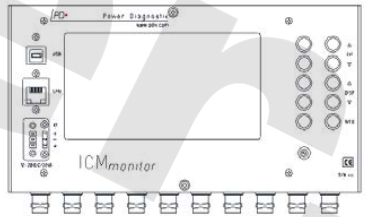


Software & Data Integration

Mobile Communication Interface MCI1

- ICM*monitor* 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

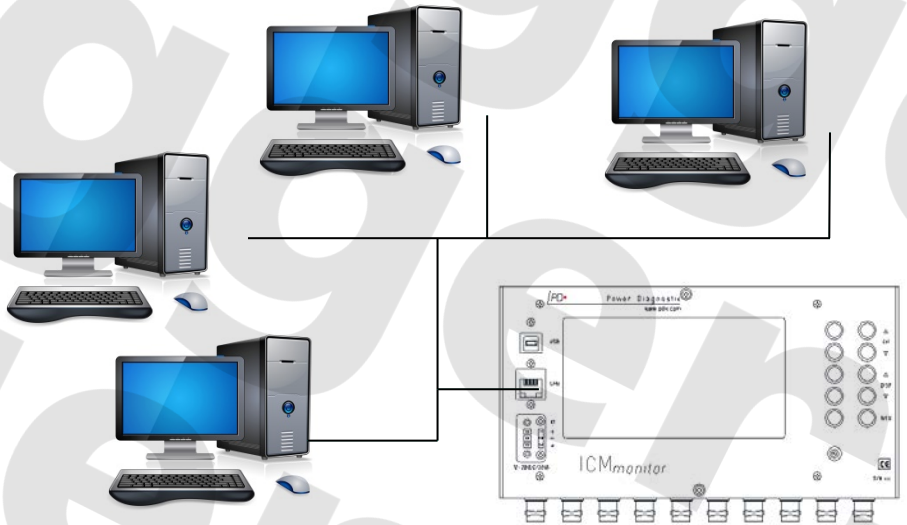




Software & Data Integration

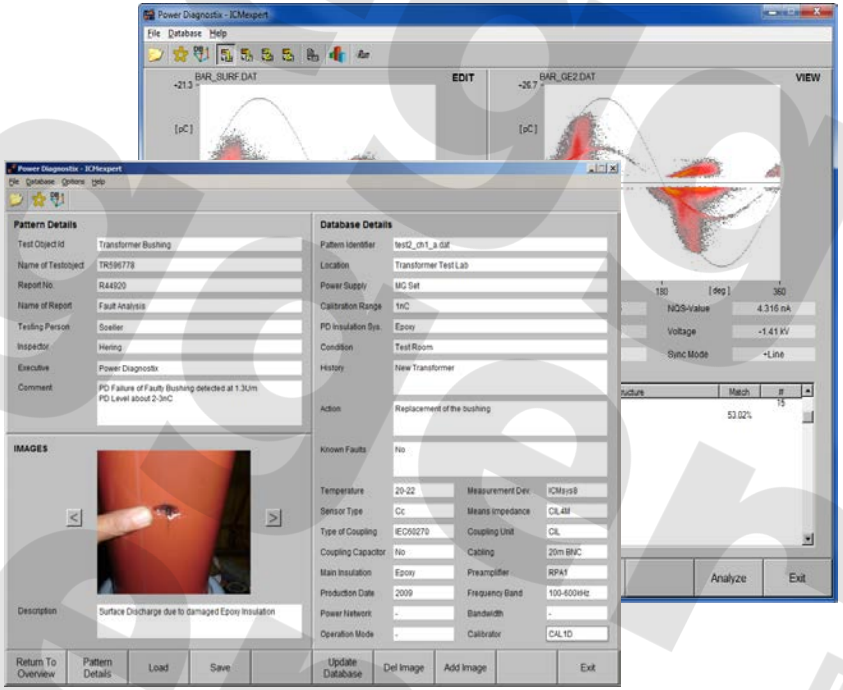
Mobile Web Server MWS1

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



Advanced Data Management

- 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



PD Monitoring on Power Transformers

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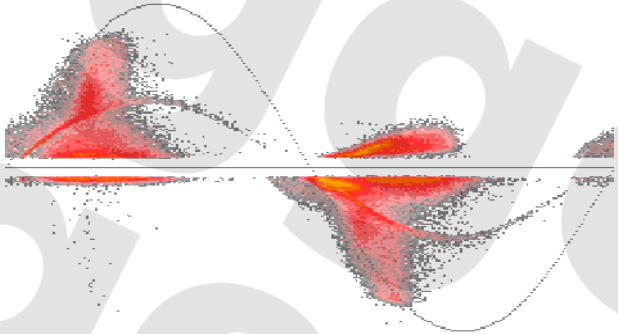


Features and Benefits

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 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, load,…monitoring
Long term data record and data consistency	Historical data can be analyzed
Multiple interfaces	Local and remote access

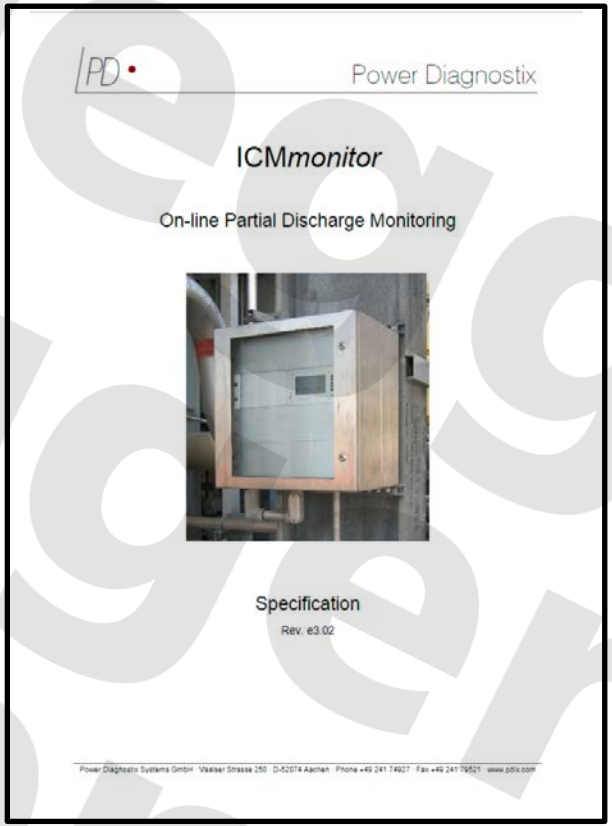
Comments on UHF based system

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

Available Information Material

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



PDM on Transformers

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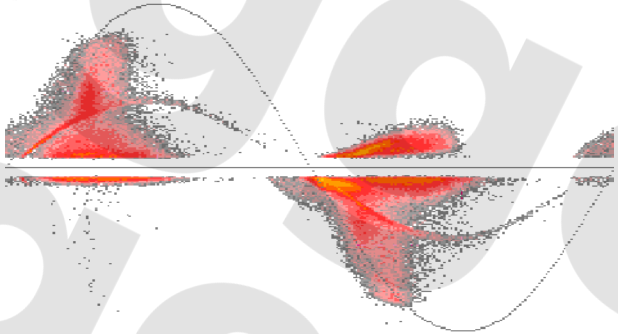

References

- 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), …

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Power Diagnostix Systems

Survey and Contact Information

Contact Information

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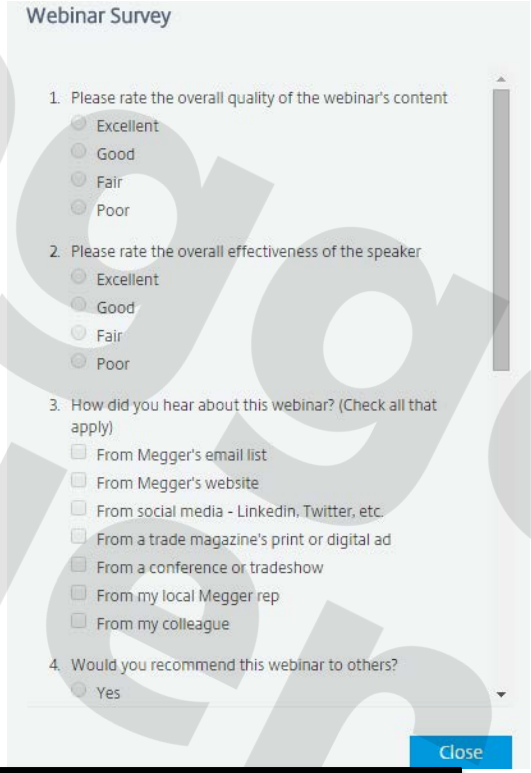

Please help us improve by filling out the survey after the webinar ends

Questions & Discussions

At Power Diagnostics Systems (PDIX) by Megger, we understand that keeping the power on is essential for the success of our customers and our business, hence we are dedicated to creating, designing and manufacturing safe, reliable, easy-to-use Partial Discharge monitoring and testing equipment backed by world-leading support and expertise.

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.