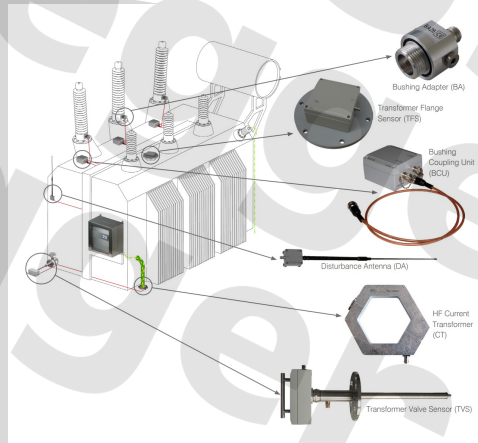


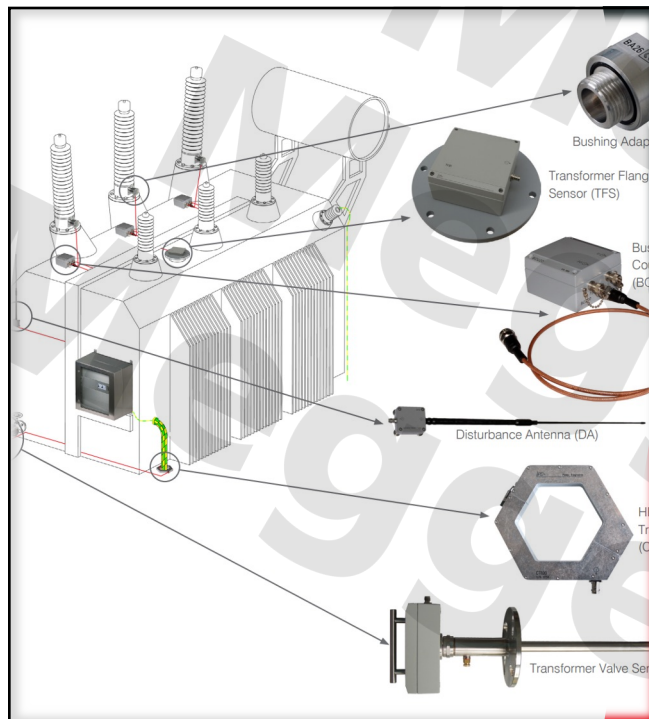


Portable PD Testing of Transformers

Sha Farhang
Applications Engineer Megger
PowerTest, NETA Orlando
March 2023



1

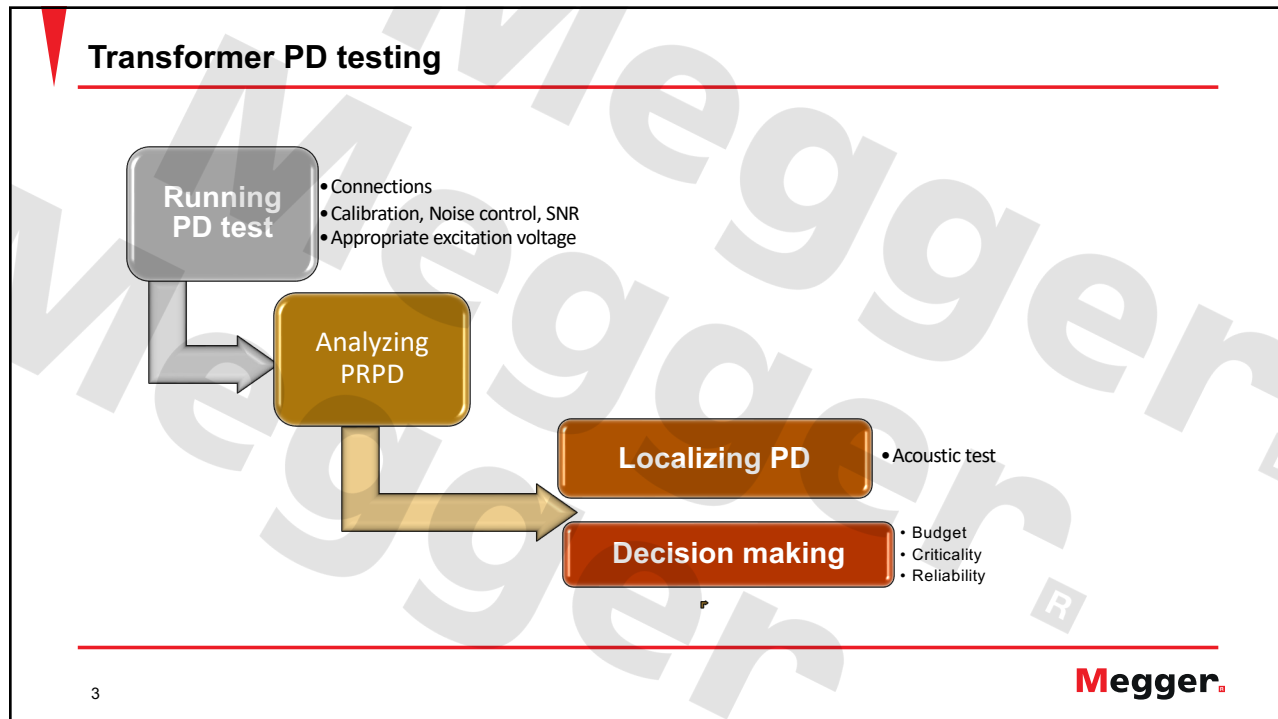


Transformer PD Testing: Online testing and basics of localizing

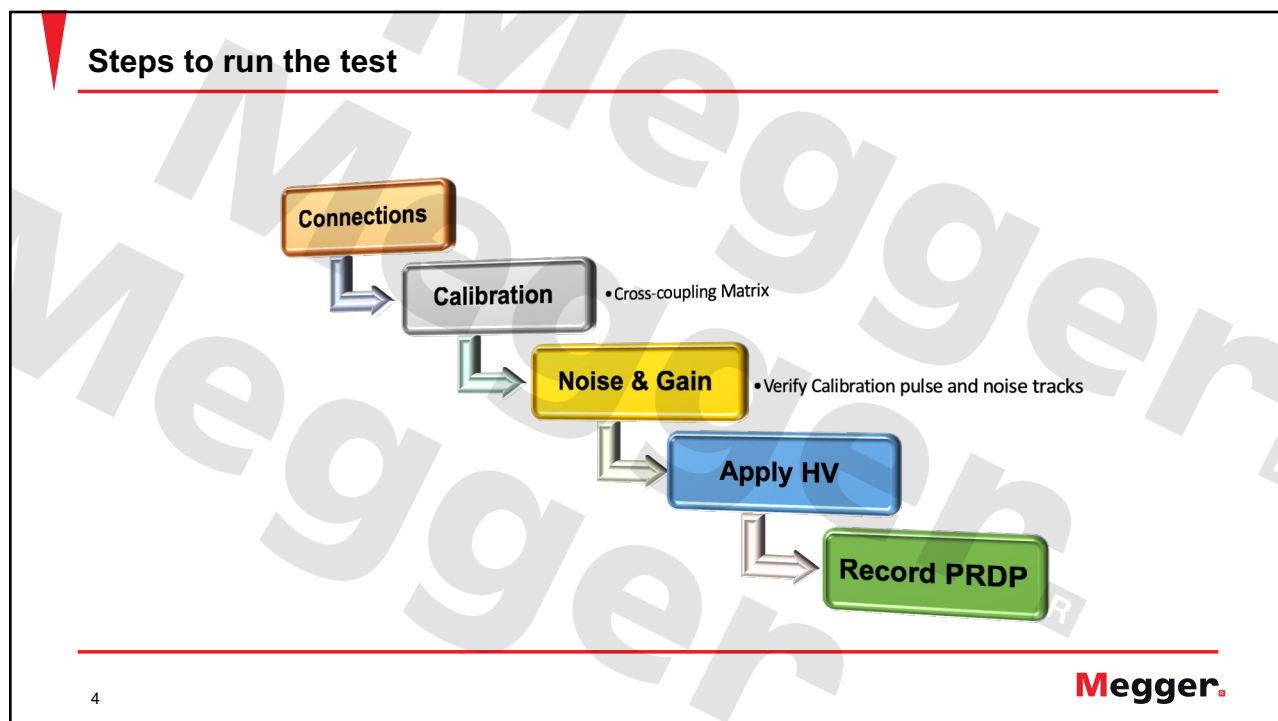
Sha Farhang
Application Engineer, Technical Support Group



2

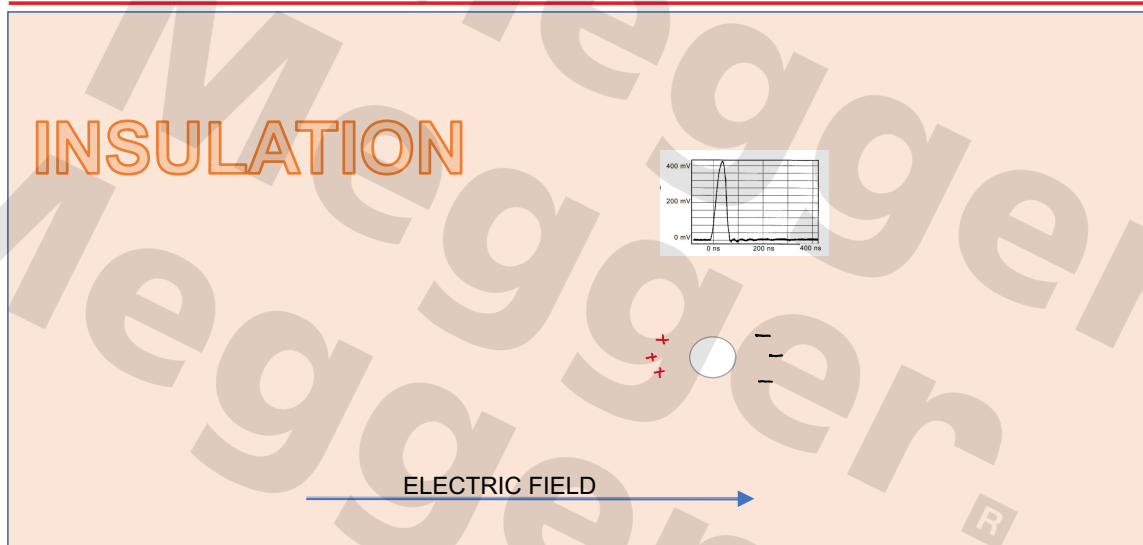


3



4

Partial discharge is a breakdown of a small area in the insulation



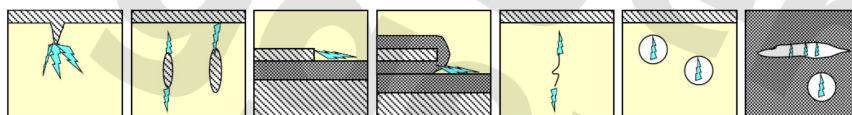
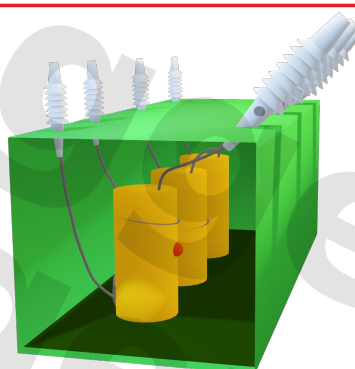
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The most common causes of PD in transformers

- Sharp points and particles
- Surface and tracking discharge
- Fiber bridges in oil
- Gas inclusions
- Humidity (Moist)



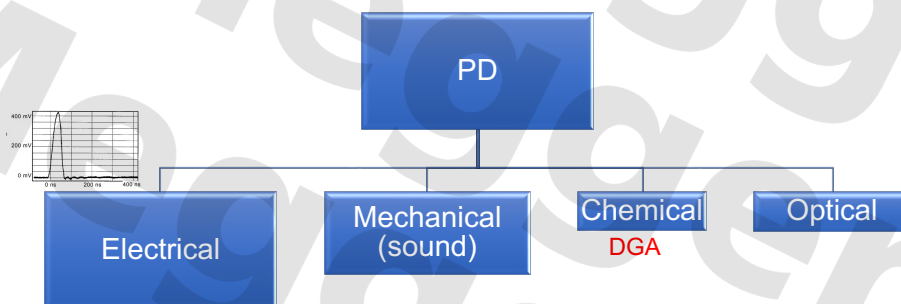
6

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6

PD EMITS ENERGY

- Each PD signal generates different measurable electrical and mechanical signals and produces chemical by-products.

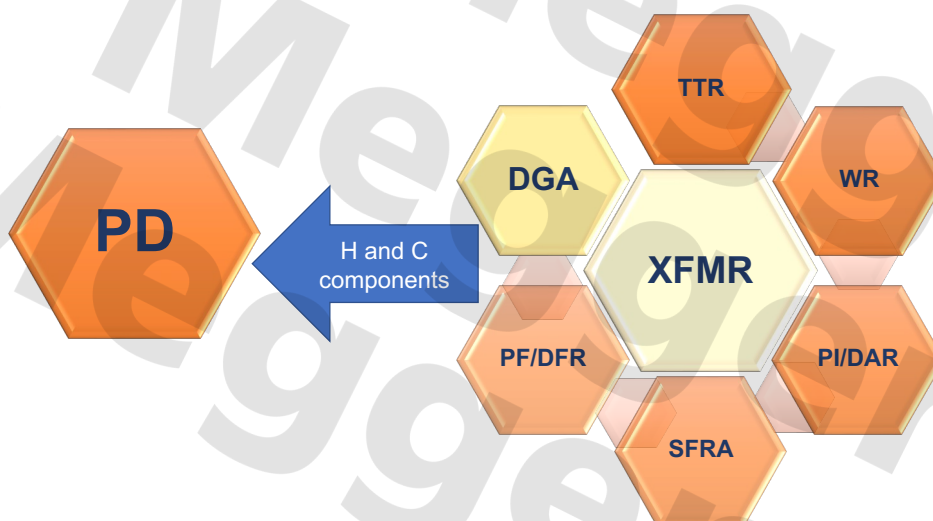


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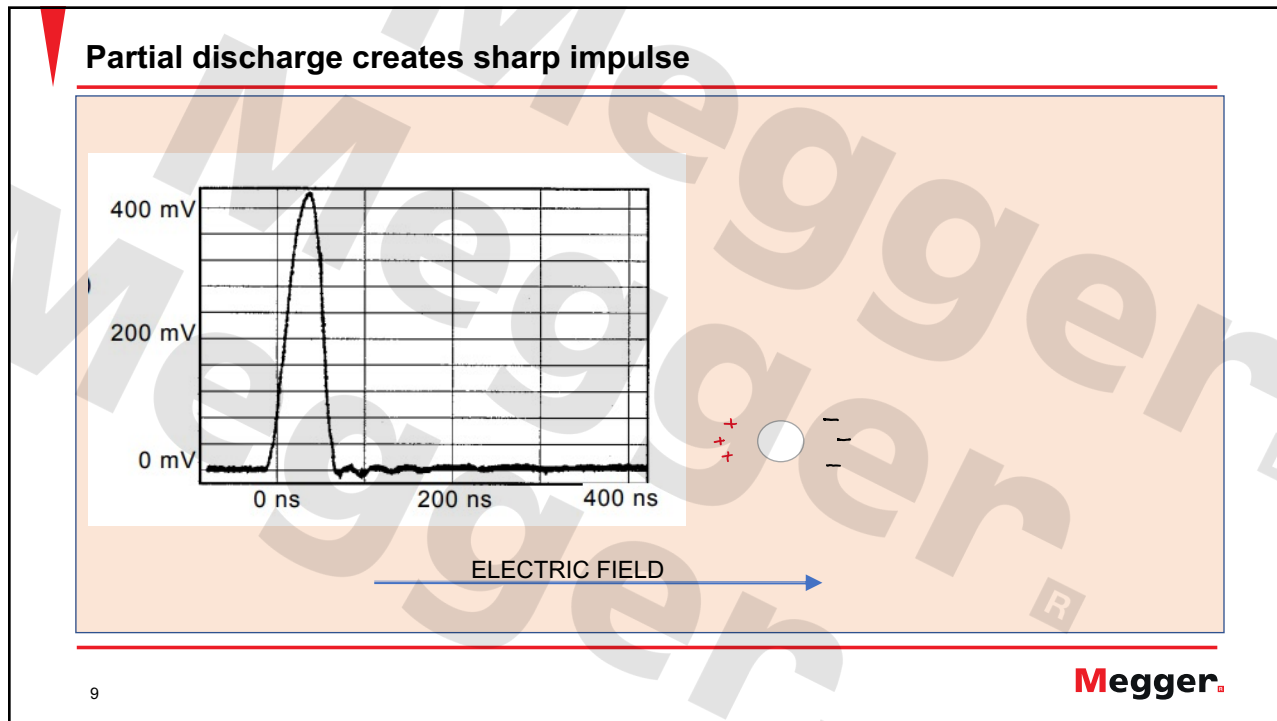
TRANSFORMER TESTING



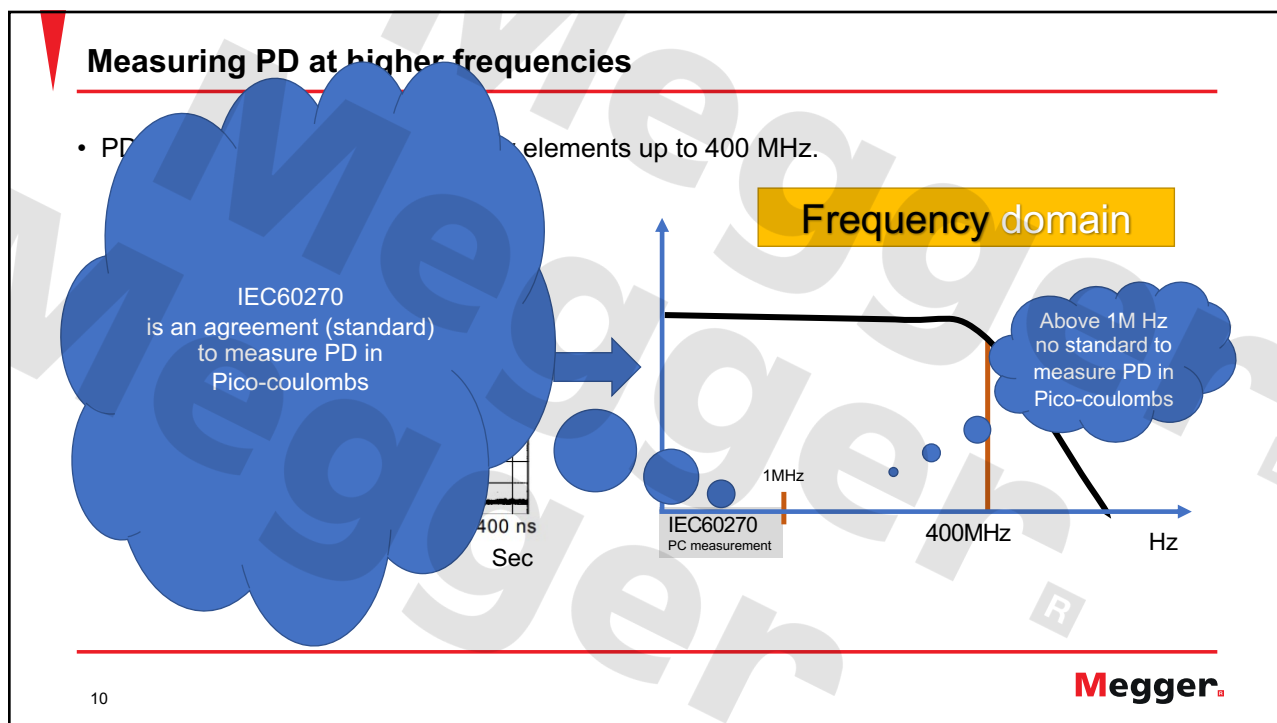
8

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9



10

IEC60270 – Conventional method

IEC 60270:2015 :

- Frequency bands:

- Wide-band $(100\text{kHz} \leq \Delta f \leq 900\text{kHz})$

Lower limit: $30\text{kHz} \leq f_1 \leq 100\text{kHz}$

Upper limit: $f_2 \leq 1\text{MHz}$

- Narrow-band $(9\text{kHz} \leq \Delta f \leq 30\text{kHz})$

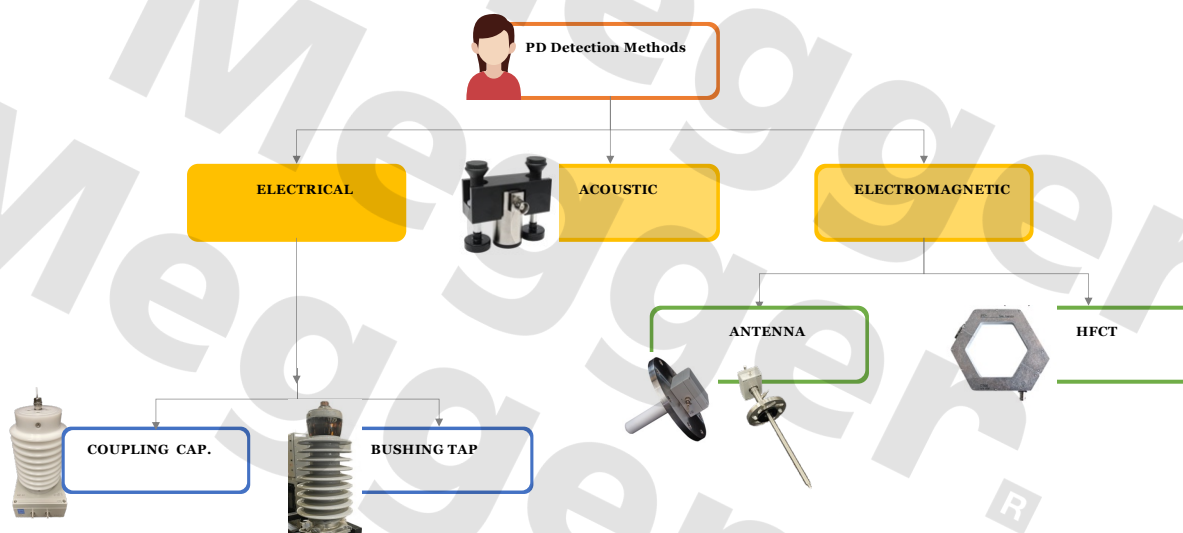
Center frequency: $50\text{kHz} \leq Cf \leq 1\text{MHz}$

11

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11

PD Detection Techniques (AT THIS PRESENTATION)

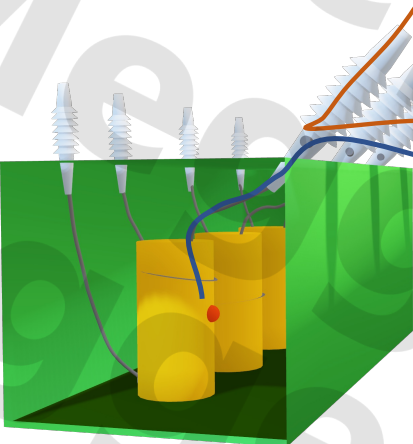


12

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12

Filtering Noise and PD



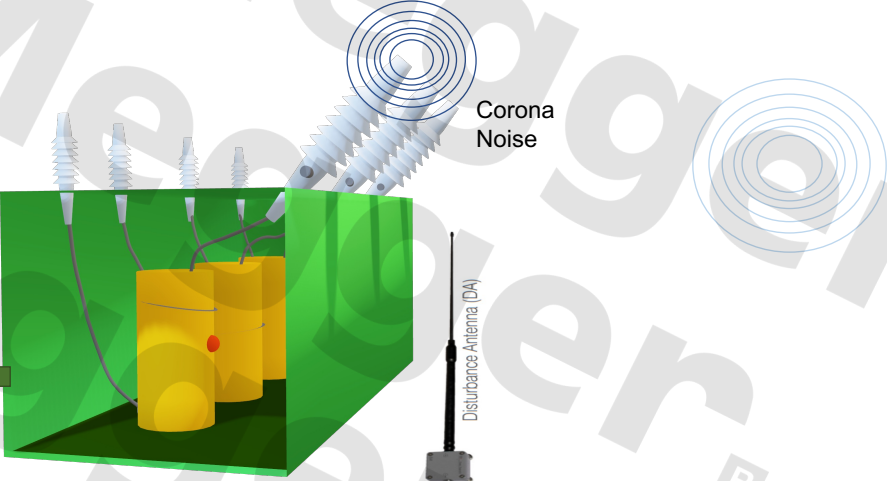
The diagram shows a 3D cutaway of a transformer with yellow windings and grey bushings. Two arrows originate from the bushings: an orange arrow labeled 'Corona Noise' and a blue arrow labeled 'PD From inside XFMR'. The transformer is set against a green background.

13

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13

Noise gating



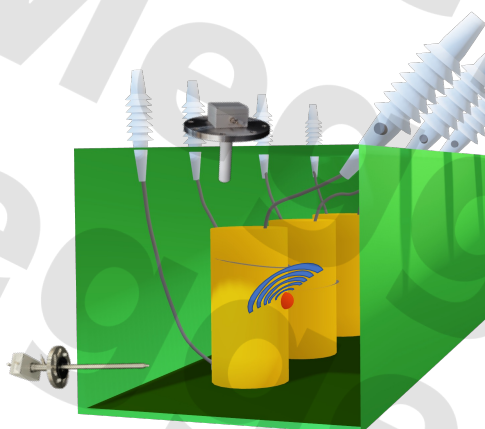
The diagram shows the same transformer cutaway as in slide 13. A 'Disturbance Antenna (DA)' is positioned to the right, with concentric circles representing 'Corona Noise' being received. A green arrow labeled 'Grounding connection' points to the transformer's base. The transformer is set against a green background.

14

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14

XFMR is a Faraday cage



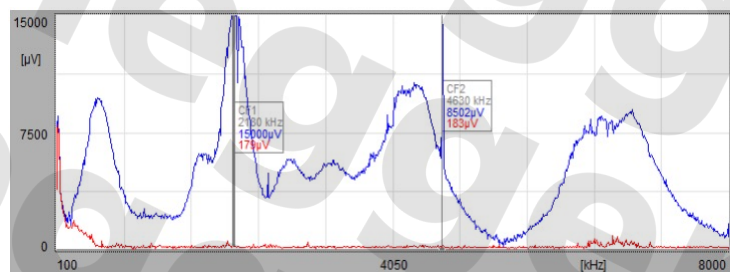
15

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15

Background Noise

- signal-to-noise spectrum upto 10M Hz

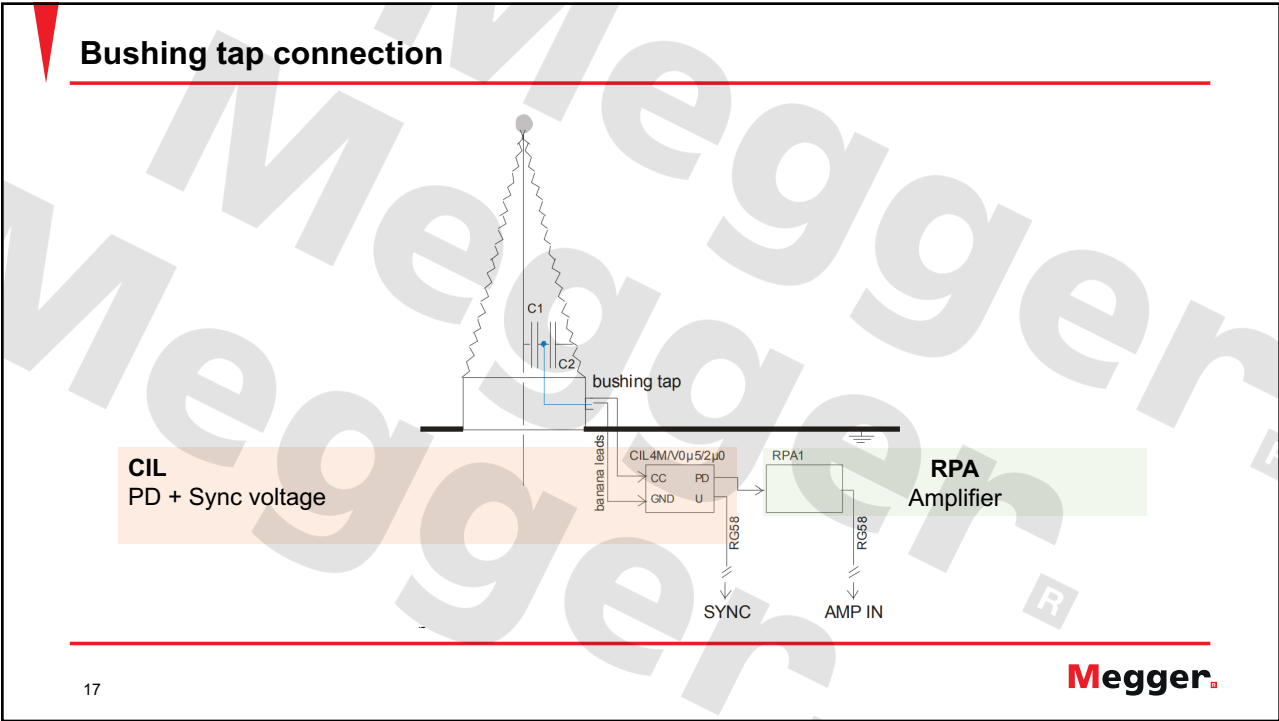


The blue trace represents the **calibrator pulse**, while the red trace shows the **ambient noise**.

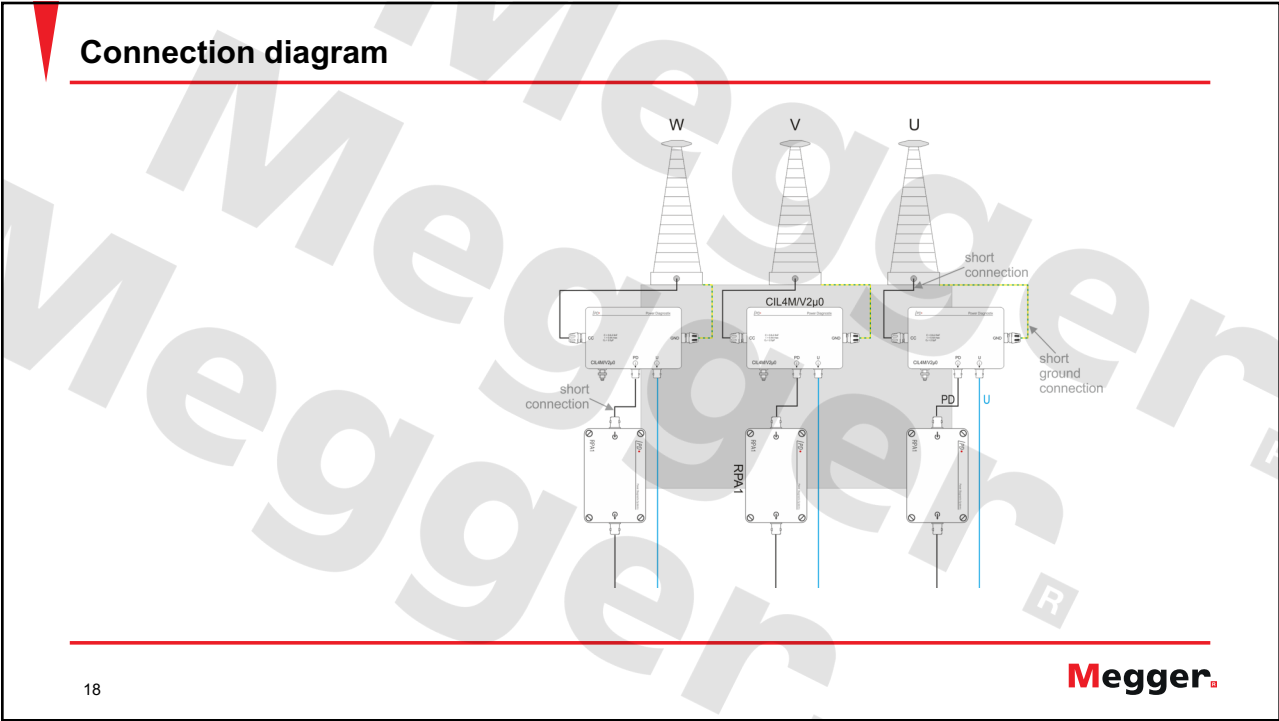
16

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16

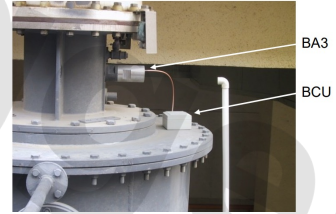
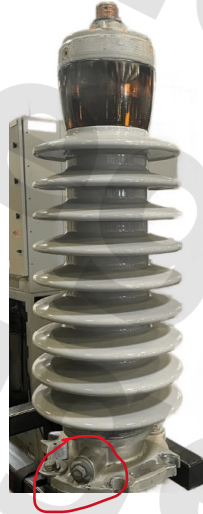


17



18

Taking signals from bushing adaptor



19

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19

Coupling capacitor



20

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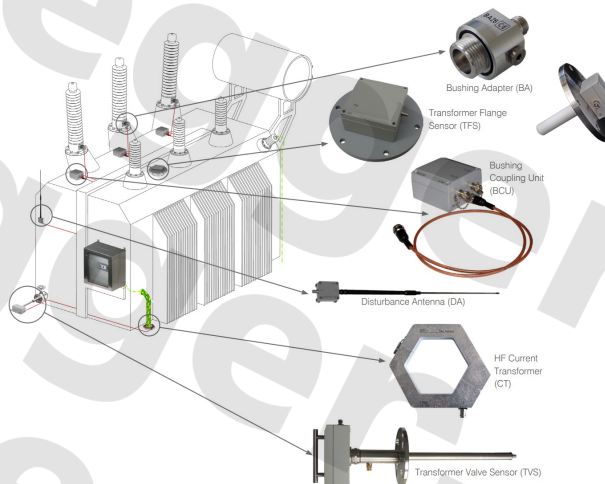
Transformer Flange Sensor TFS1

Transformer Flange Sensor TFS1

- Adapted to spare flange
- Wideband characteristic
- Oil-tight
- Built-in logarithmic UHF converter unit FCU2

Frequency range:
300 MHz – 1 GHz

Output: TNC connector



21

21

Transformer Valve Sensor TVS2

Transformer Valve Sensor TVS2

- Built-in logarithmic UHF converter unit FCU2
- For DN 40–DN 50 flanges with diameters 88–135 mm or for DN 100 flanges
- Wideband characteristic
- Oil-tight

Frequency range:
300 MHz – 1 GHz

Output: TNC connector



22

22

Test sets

ICMcompact

Simple to use.

ICMsystem

More advanced settings & Parallel measuring


ICMmonitor

Permanent monitoring

Megger

23

Bushing tap to ICMsystem



Decoupling




- Test tap via quadrupole
- Coupling capacitor
- HF-Current Transformer

Pre Amplifier

- <1MHz (IEC-60270) RPA1
- RPA for different frequency ranges or Acoustics on request

Instrument

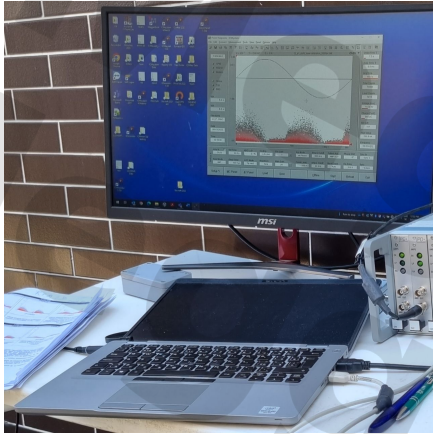
- ½ 19inch ICMsystem
- Full 19" ICMsystem

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24

Field online testing via ICMsystem

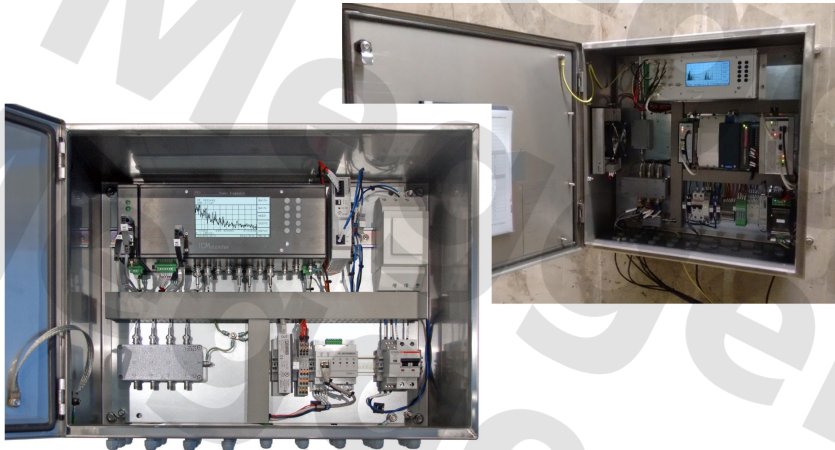


25

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25

Permanent online monitoring




26

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26

ICMsystem

ICMsystem can catch PD events simultaneously from all inputs



Minimum configuration:

- 1/2 19 inch acquisition unit
- Three acquisition channels
- Three preamplifier & Coupling Capacitors
- PD calibrator

27

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27

ICMcompact




Fig. II.6: All-in-one panel of an ICMcompact in an outdoor case with MUX4 option

28

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28

ICMsystem software

The screenshot displays the ICMsystem software interface. The main window shows a scatter plot of data points with a sinusoidal fit line. The plot axes are labeled with coordinates (X, Y, Z) and units (pc, deg). The software includes a menu bar (File, Edit, Connect, Measurement, Tools, View, Panel, Options, Help) and a toolbar. On the left, there are panels for 'Calibrated' (showing GPIB, RS232, Modem, Online, TXD, RXD, N/A, File Name: F3-12 KV, Date: 03-02-2023, Time: 09:40:21) and 'Measurement' (showing Set Time: 60.0 s, ADC LLO: 3.8 %, Coding: LIN BIP, Pre Gain: 100, Acq Mode: vs Phase, Amp U Cutoff: 800 kHz, Pattern Acq: AMP OUT, Phase Shift: 0°, Sync In: Sync 1). The bottom panel shows 'Input Mode' (AMP), 'Dead Time' (38.0 us), 'ADC Mode' (FP NRT), 'Waveform' (Acquired), 'Main Gain' (20), 'Count Level' (20 pc), 'Amp L Cutoff' (80 kHz), 'Mem Erase' (Auto), 'Div Ratio' (1000.0), and 'Sync' (+ Extern). The Megger logo is visible in the bottom right corner.

29

29

Steps to run the test

```

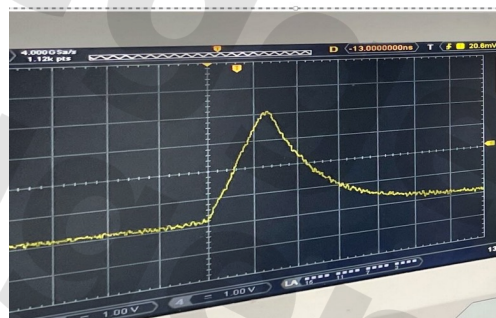
    graph TD
      A[Connections] --> B[Calibration]
      B --> C[Noise & Gain]
      C --> D[Apply HV]
      D --> E[Record PRDP]
  
```

The flowchart illustrates the steps to run the test. The steps are: Connections, Calibration (with a note: • Cross-coupling Matrix), Noise & Gain (with a note: • Verify Calibration pulse and noise tracks), Apply HV, and Record PRDP. The Megger logo is visible in the bottom right corner.

30

30

Calibrator



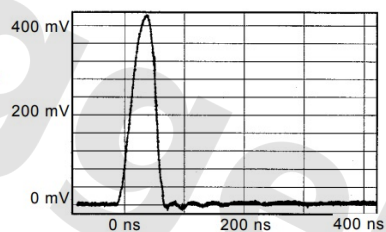
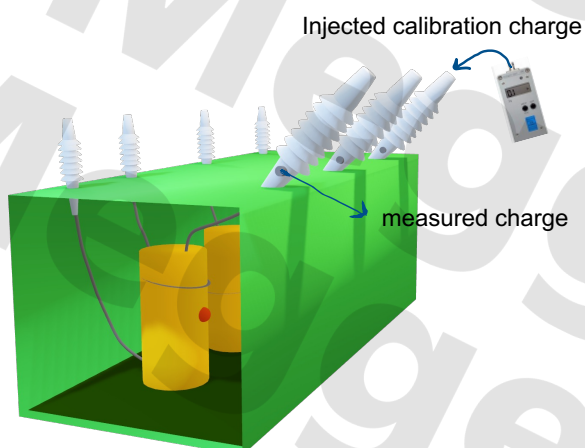
The PD calibration pulse in an oscilloscope

31



31

Calibration – Measuring in PC



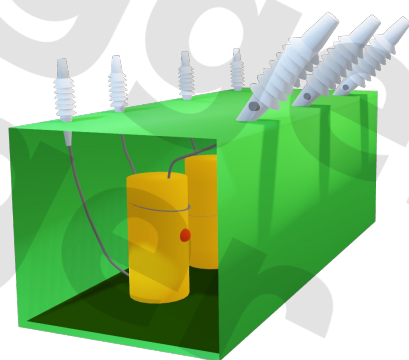
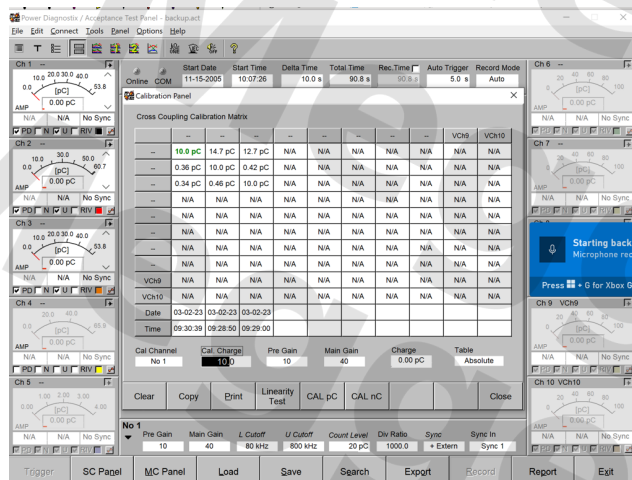
$$\varphi = \int_{t_0}^{t_1} I_c dt$$

32



32

Calibration matrix



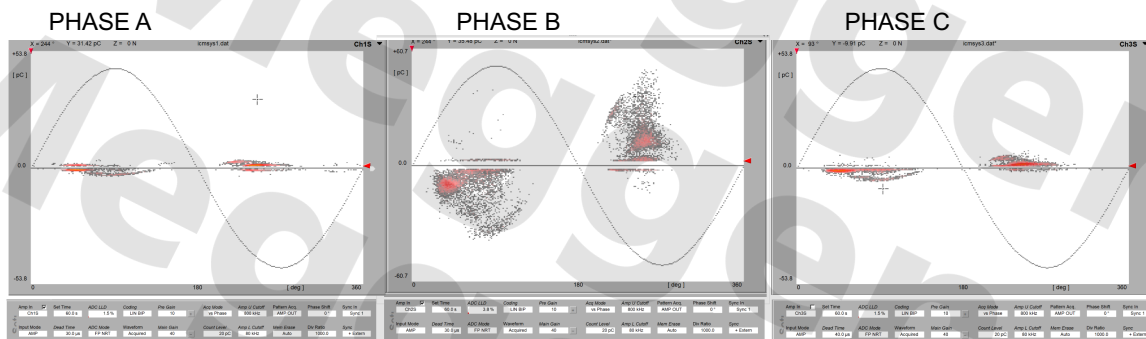
33

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33

PRPD for each phase

- Compare PRPD for each phase based on the ration of the cross-coupling matrix



34

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34

Lab condition

- Filters and low-level environment noise



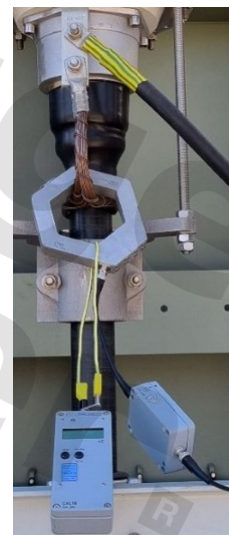
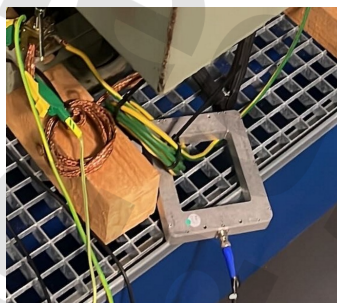
35

35

HFCT for Noise gating

Noise gating

CT100
 HF Current Transformer
 HF Current Transformer (1:10 @ 50Ohm)
 Isolated HF coupling to PD sources
 Clamp-on type
 Primary window : \varnothing 100mm (~4")
 Bandwidth (-3dB): 2.0MHz - >25MHz @ 50Ohm
 Bandwidth (-6dB): 1.2MHz - >40MHz @ 50Ohm



36

36

HFCT

- Usually for noise gating



37

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37

ICMcompact



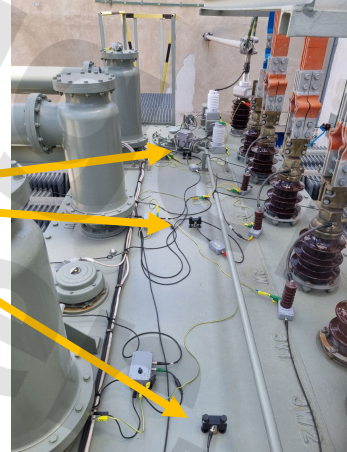
Fig. II.6: All-in-one panel of an ICMcompact in an outdoor case with MUX4 option

38

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38

Ultrasonic Partial Discharge Sensor



SFX2/50 for AS751
SFX2/30 for AS1501
Magnetic sensor fixture for temporary mounting of the acoustic sensor on a transformer tank.
RPA1D / RPA1G / RPA1F

39

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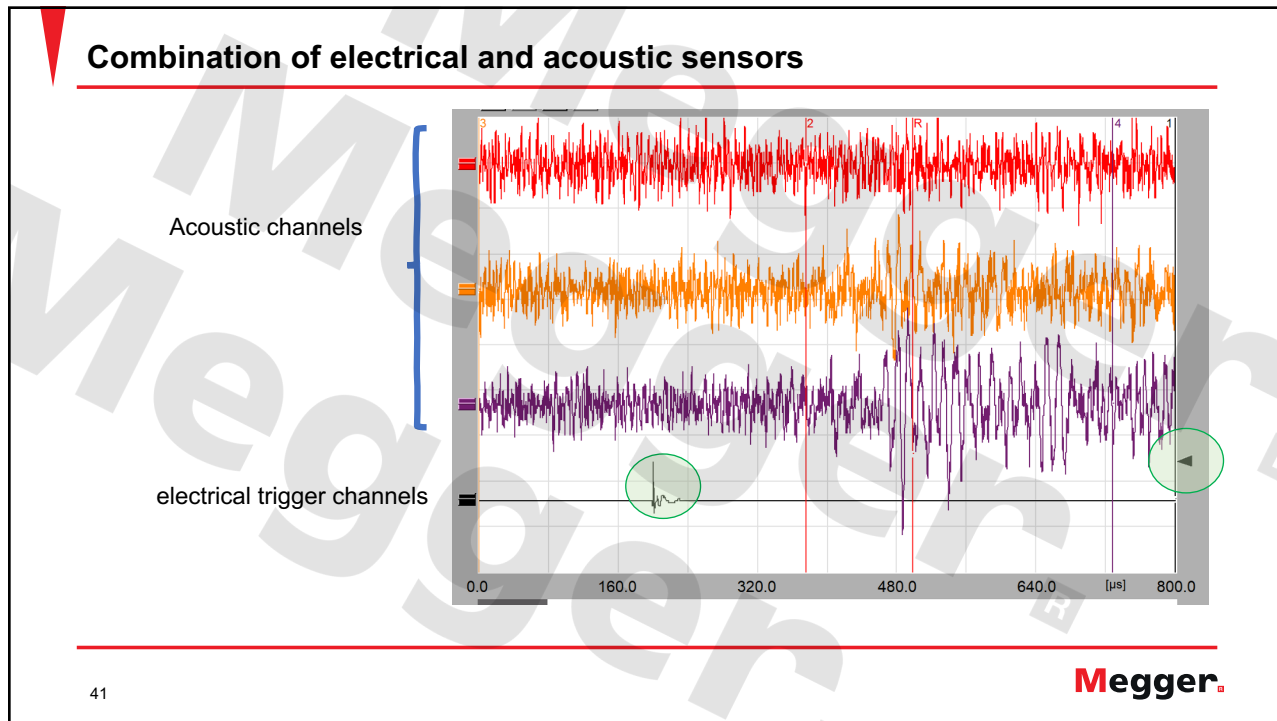
Acoustic sensors



40

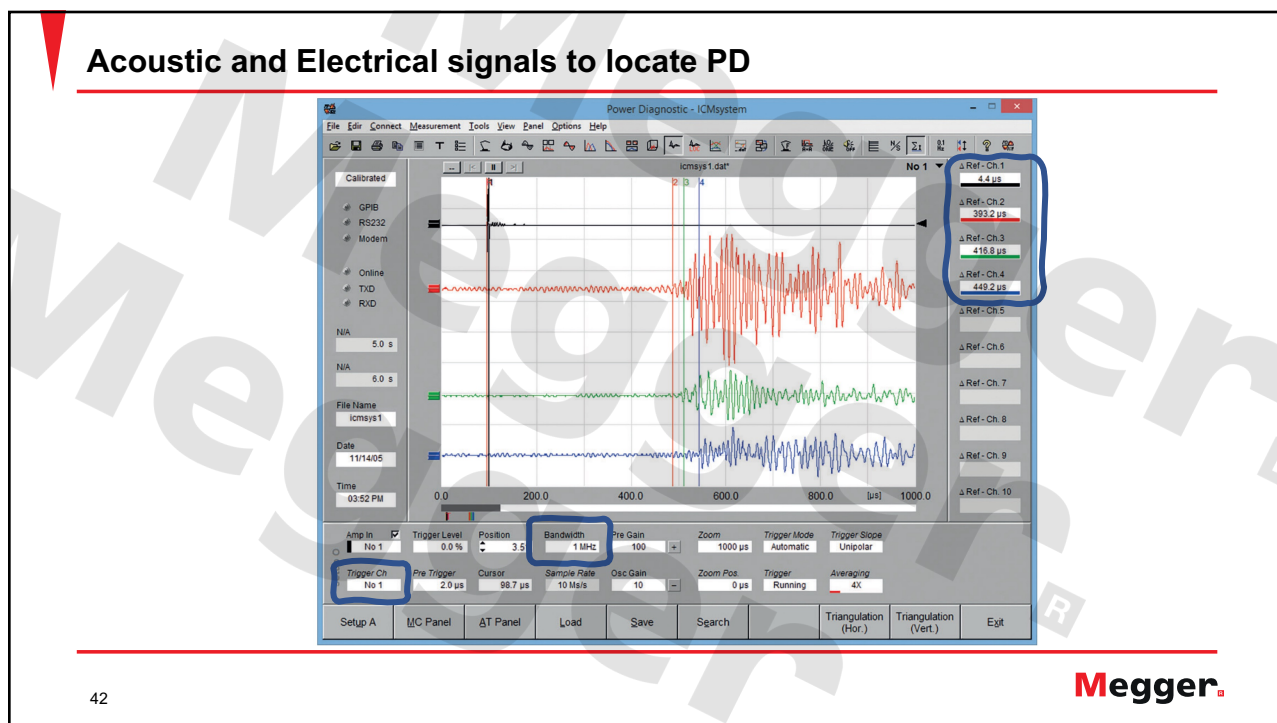
Megger

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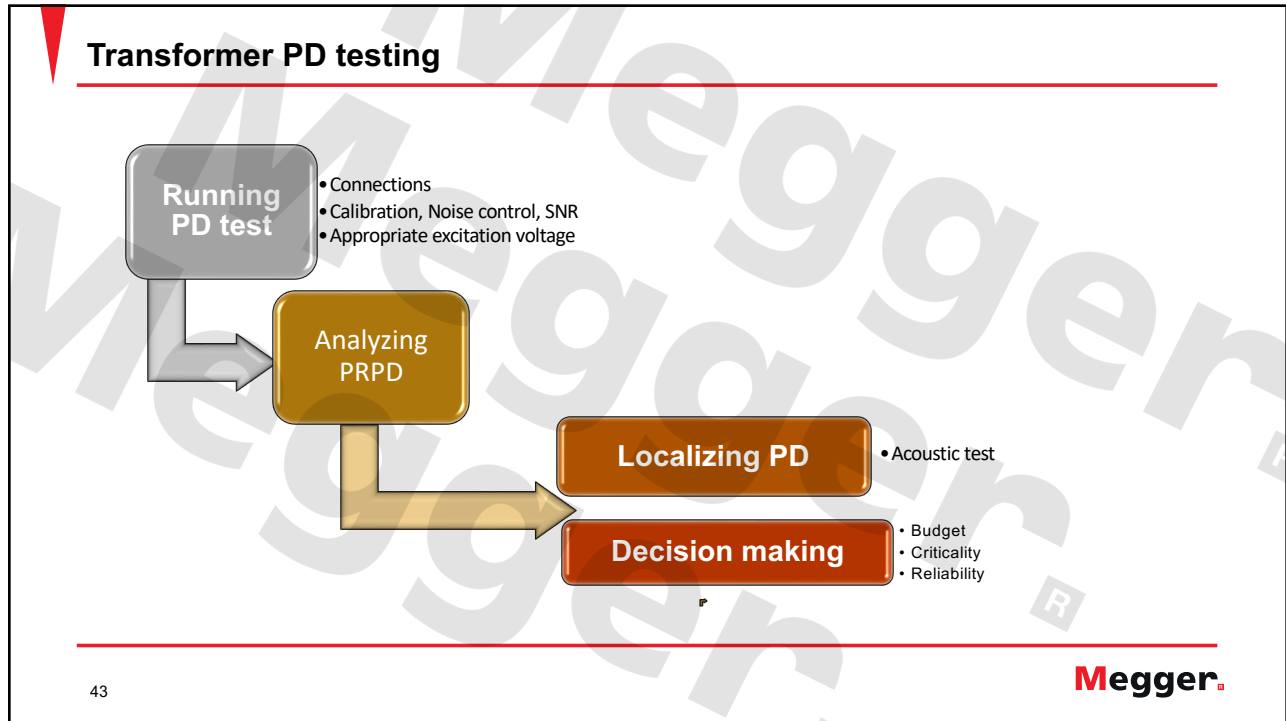
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42

42



43



44