

XIV. Szigetelésdiagnosztikai Konferencia
Bambara Hotel – Felsőtárkány (Hungary)

sebaKMT
A member of Megger Group

The New 50 Hz Slope Technology

A Comparison with former Methods through Examples





Power Networks



Communication Networks



Water Networks

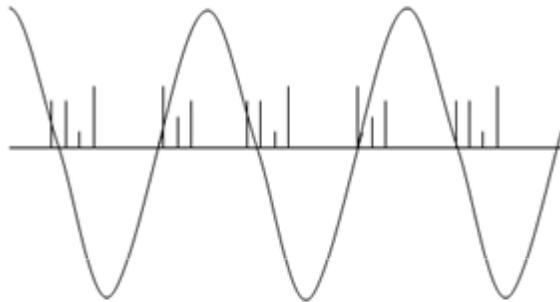


TV Inspection of Sewers



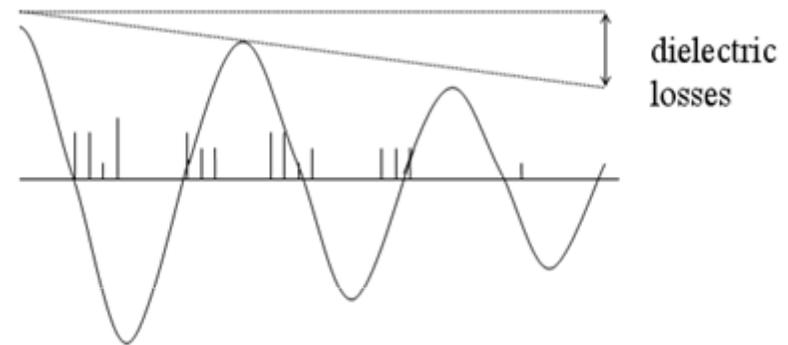
Line and Object Location

Continuous AC (20 ... 300 Hz)



PDIV
PDEV
PD Level [pC]
PD Pattern Information
Test Overvoltage Destructiveness
Dielectric Losses

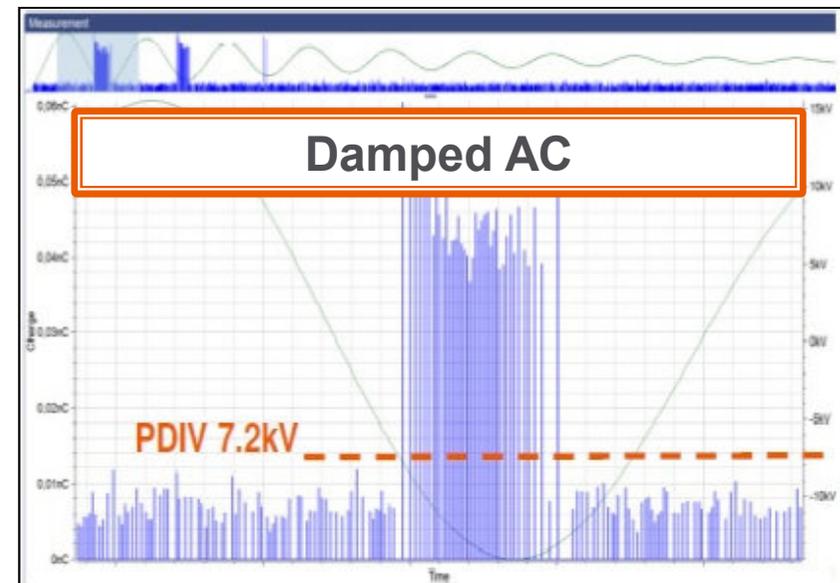
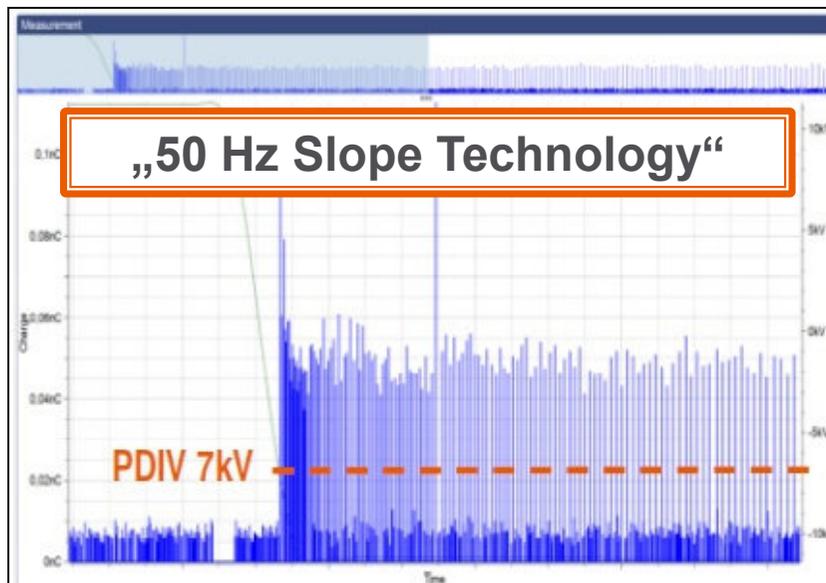
Damped AC (20 ... 300 Hz)



PDIV
PDEV
PD Level [pC]
PD Pattern Information
Test Overvoltage Destructiveness
Dielectric Losses

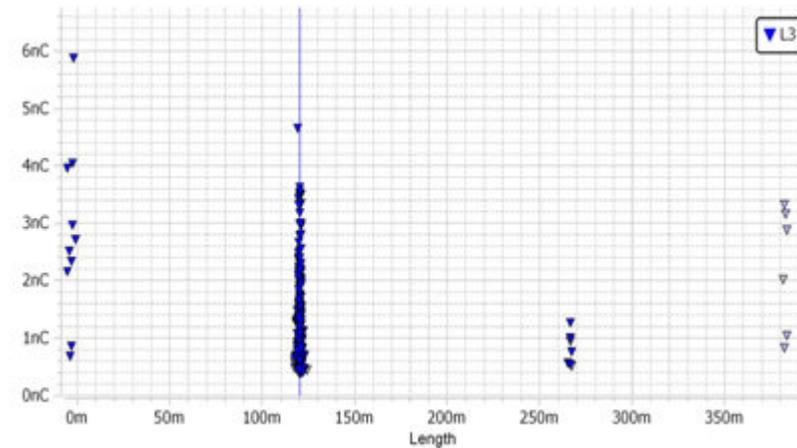
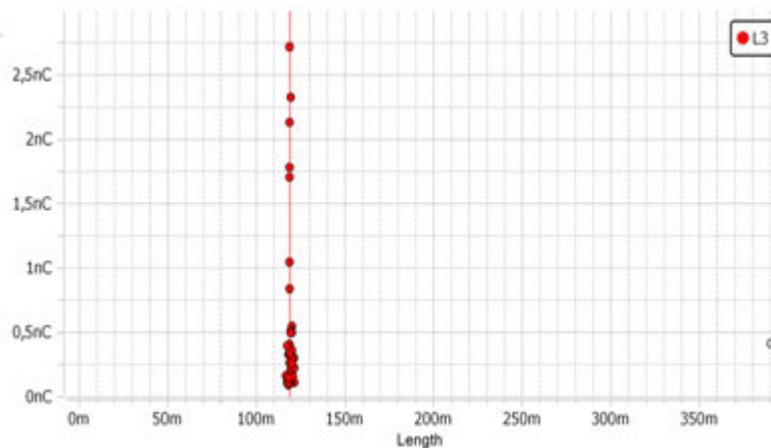
„50 Hz Slope Technology“ vs. DAC

- Using VLF CR for PD testing relative new development
- However several researches have already proven its applicability
- **PDIV comparable** at DAC & „50 Hz Slope Technology“
- Corona PD can be seen very easily at „50 Hz Slope Technology“
➔ PD also present & activ at **complete DC plateau**



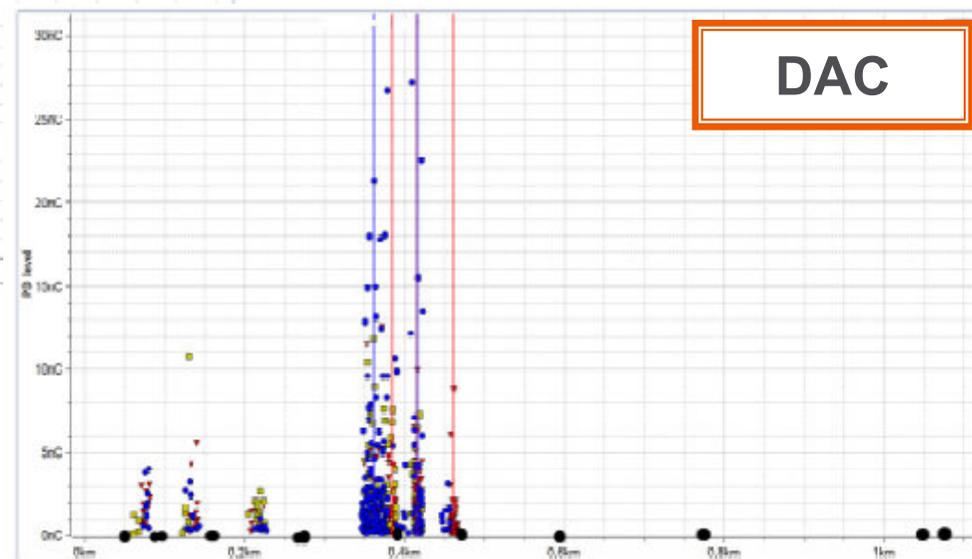
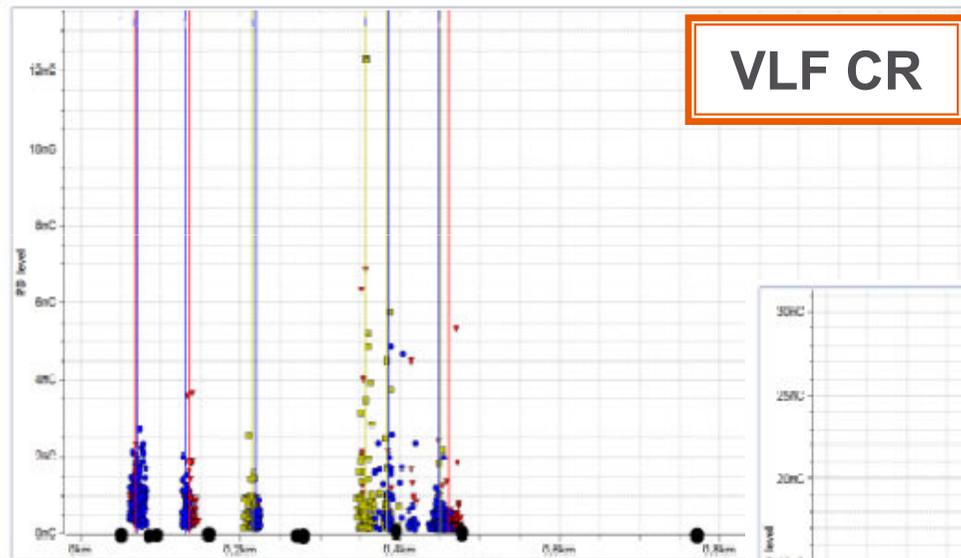
„50 Hz Slope Technology“ vs. DAC

- 12/20 kV PE/XLPE cable (390 m)
- DAC PD diagnosis up to $1.7 U_0$
- PD detected in phase L3
- PDIV above U_0
- Monitored VLF test up to $3.0 U_0$
- Additional weak spot detected (270 m)



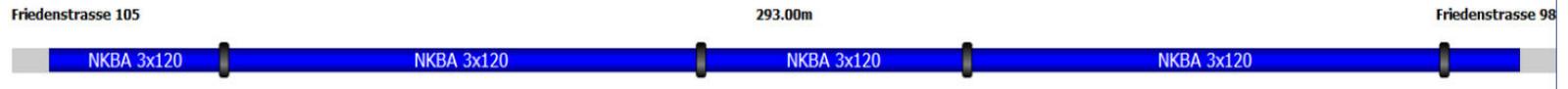
„50 Hz Slope Technology“ vs. DAC

- 6/10 kV cable with mixed insulation (1300 m)

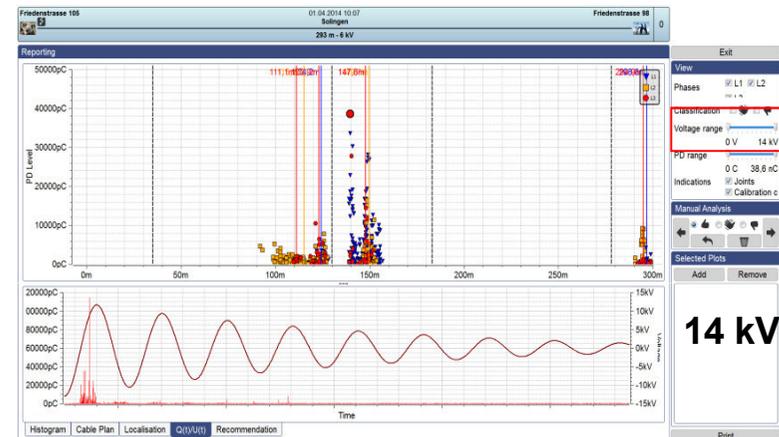
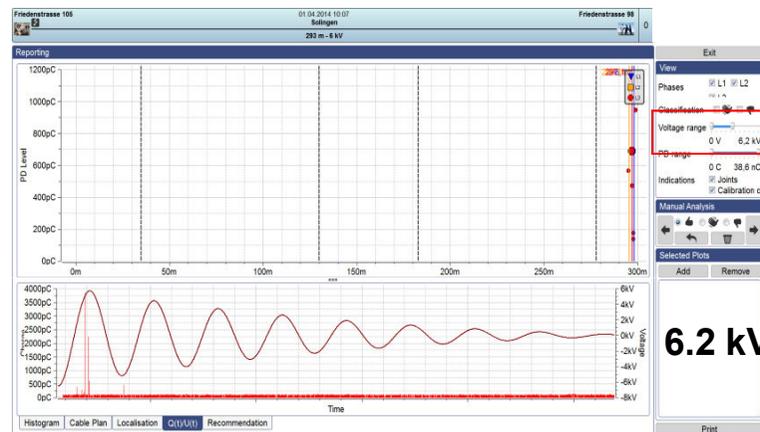


Voltage Shapes & PD-Behaviour

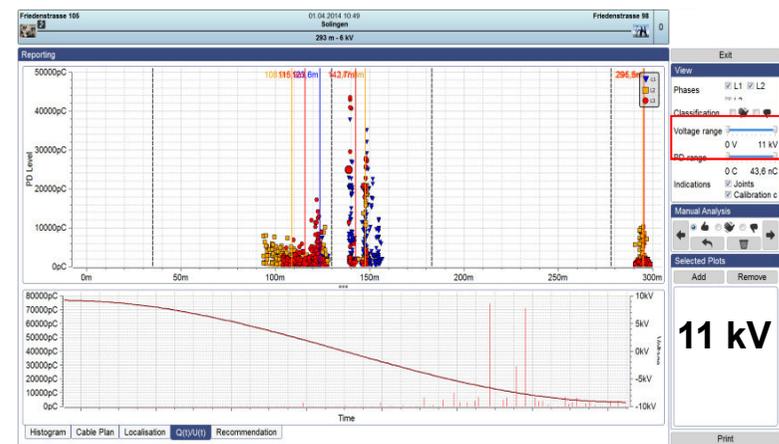
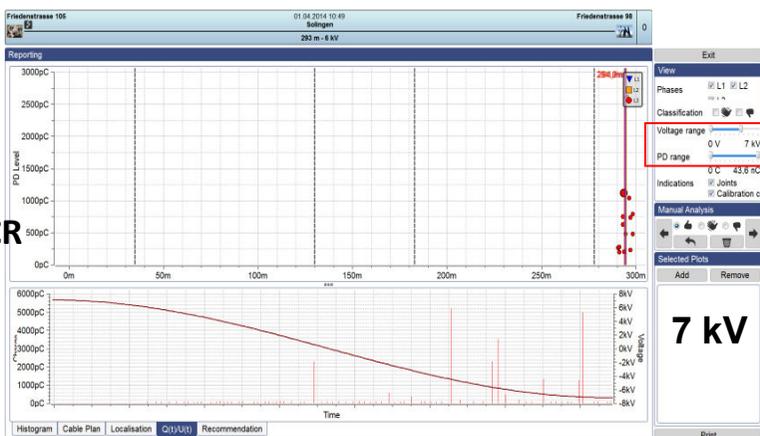
„50 Hz Slope Technology“ vs. DAC



DAC

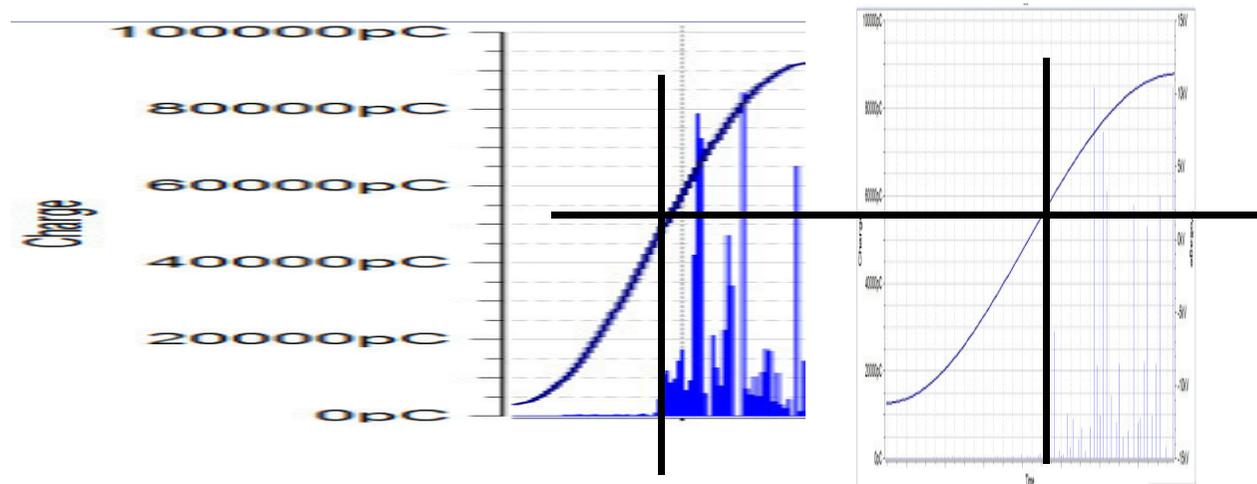
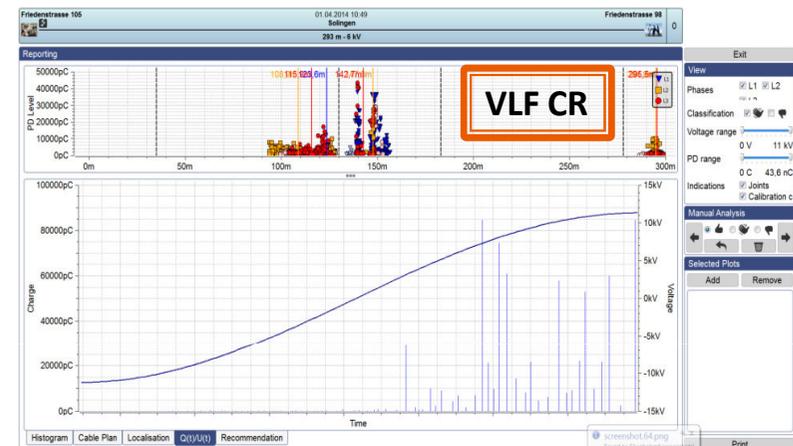
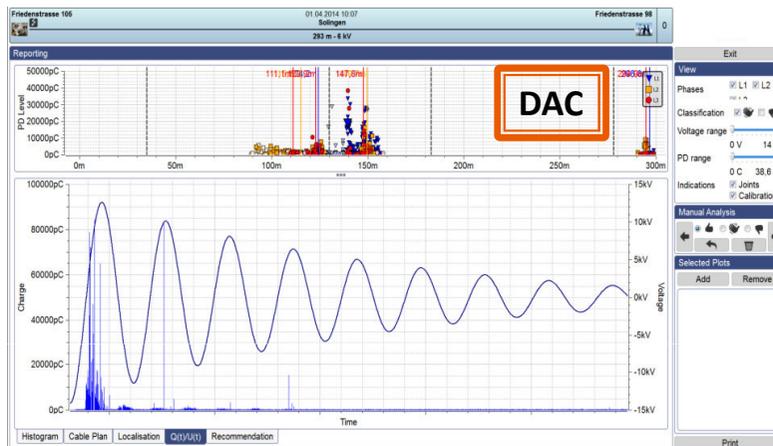


VLF CR



Voltage Shapes & PD-Behaviour

„50 Hz Slope Technology“ vs. DAC



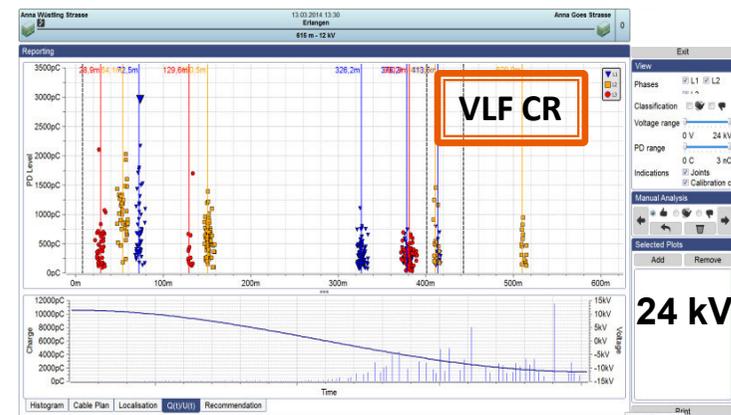
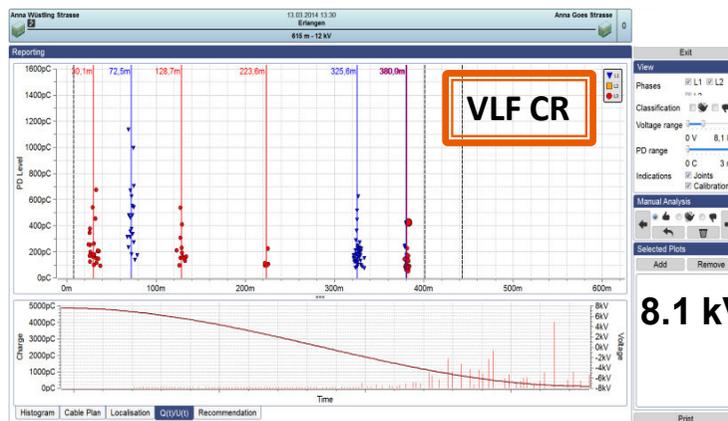
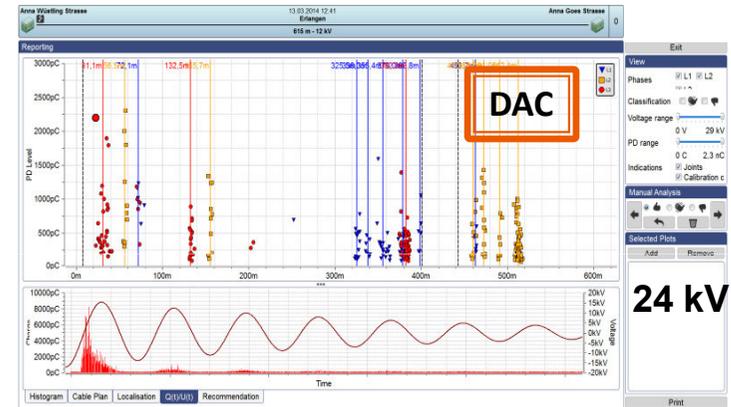
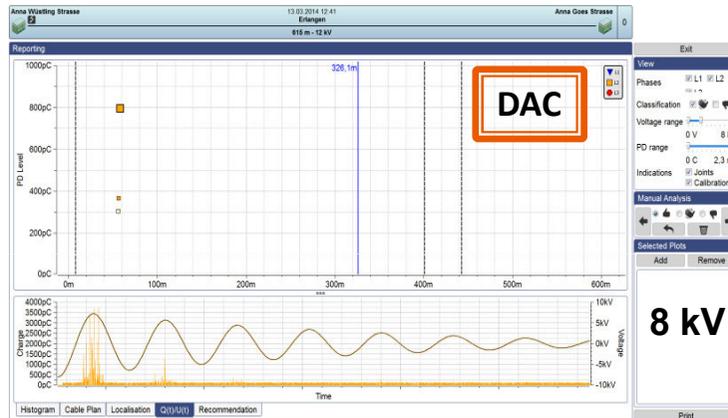
Voltage Shapes & PD-Behaviour

„50 Hz Slope Technology“ vs. DAC

Anna Wüstling Strasse

615.00m

Anna Goes Strasse



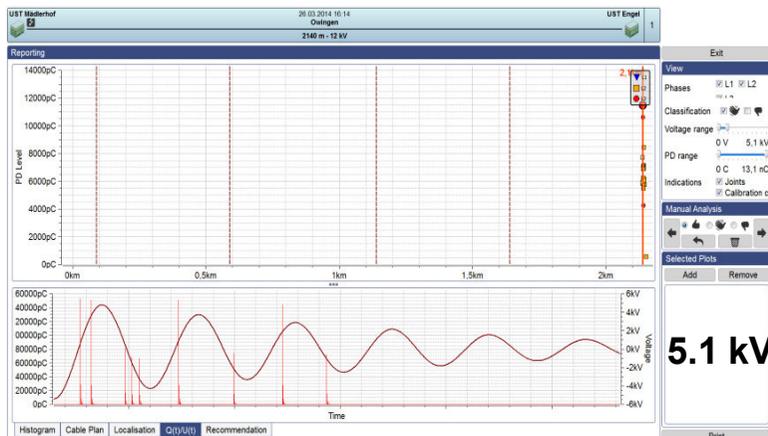
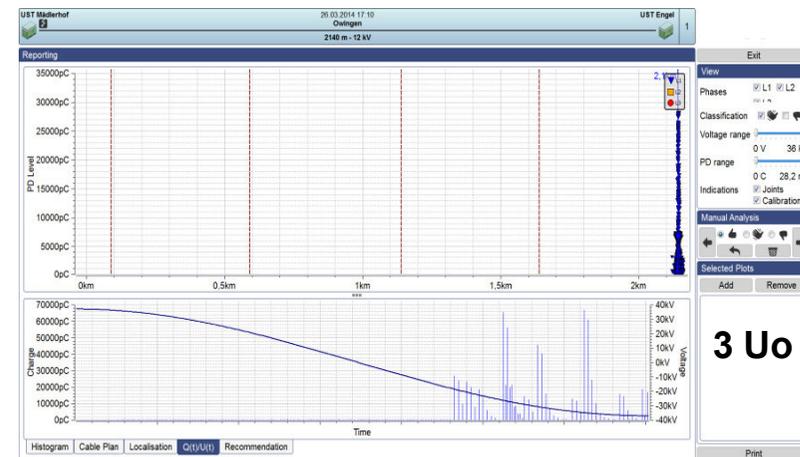
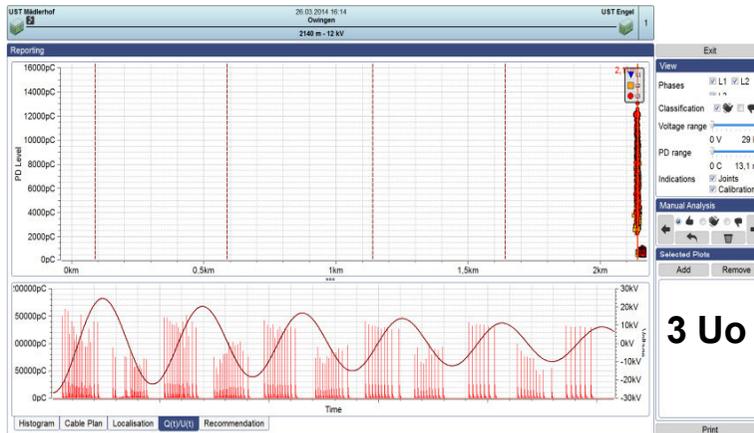
„50 Hz Slope Technology“ vs. DAC

UST Madlerhof



Heat shrink joints

Elbow terminations



- Monitored withstand test
- ➡ 3 phases parallel
- VLF CR Test; 60 Minutes; 3 U_o
- ➡ NO breakdown
- Same result of PD localization at termination

„50 Hz Slope Technology“ vs. DAC



- **Surface PD** on Elbow Connectors
- Reason: **missing grounding of outer semicon layer**
- **After grounding** PD level was significant lower
- Replacement recommended



VLF 0.1 Hz Sinusoidal vs. 50 Hz AC

- When using **VLF 0.1 Hz Sinusoidal** for PD testing we have a difference in frequency of 500/600 times
- Further decreasing frequency this can be up to 5000/6000 times
- Difference in frequency with influence on PD characteristics
 - ➔ **Not comparable with 50 Hz anymore**
 - ➔ Therefore reliable **decision making** with VLF 0.1 Hz Sinusoidal becomes **adventurous**
- Practical experience show that when using VLF 0.1 Hz Sinusoidal that **maximum 75% of all faults are identified**
 - ➔ 25% cannot be seen

- Since frequency of *oscillating waves* are in range of **50 Hz**
→ *PD Characteristics similar*

Reliable decision making possible

- **BUT:** *Different* using **VLF 0.1 Hz Sinusoidal** for PD testing



50 Hz / 0.1 Hz = 500 times
50 Hz / 0.01 Hz = 5000 times

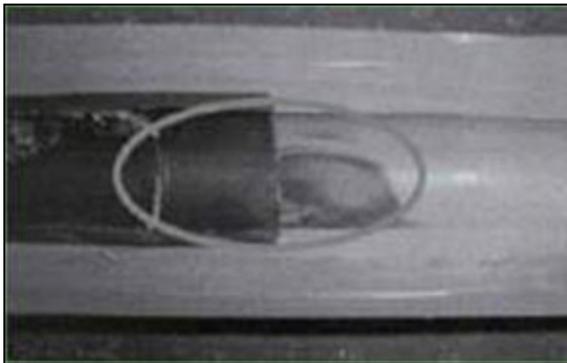


→ *PD characteristic* totally ***different*** & PD testing ***not reliable*** anymore

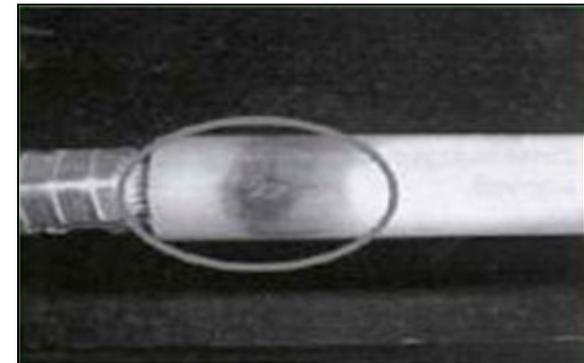
VLF 0.1 Hz Sinusoidal vs. 50 Hz AC

- Takeout from a contribution (VWEW Infotag 2004, E-On) , where *fault could not been* detected with *VLF 0.1 Hz Sinusoidal*

- Cable information:
- 12/20 kV XLPE cable (1992)
 - Length: 1605 m
 - PD defect in joint at 850 m



Breakdown Channel starts at inner Field Grading



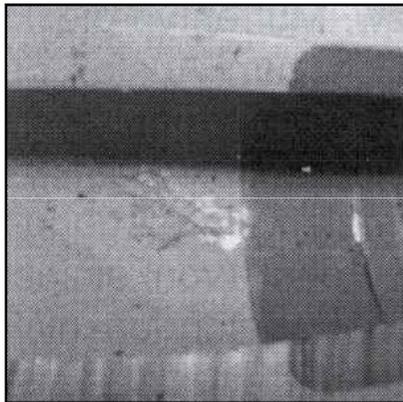
Degrading of cable insulation

- ➔ 50 Hz AC
- ➔ VLF 0.1 Hz Sinusoidal

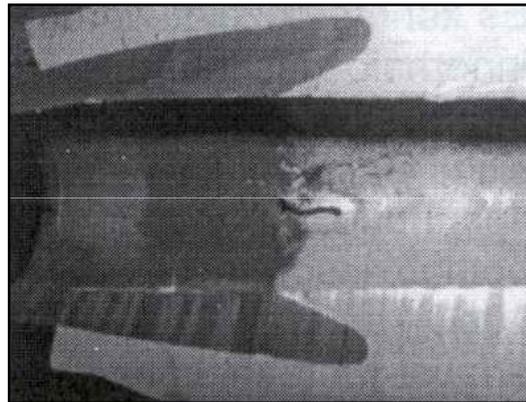
$$PDIV = U_0 = 12 \text{ kV}_{RMS}$$
$$PDIV > 2.5 U_0 = 30 \text{ kV}_{RMS}$$

VLF 0.1 Hz Sinusoidal vs. 50 Hz AC

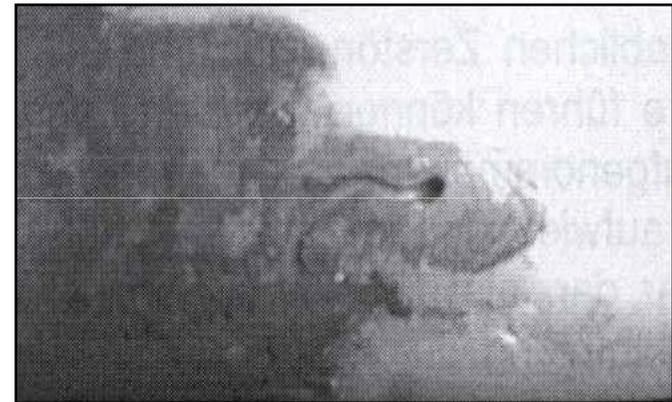
■ A few more detailed pictures



Treeing at the inner field control section of the splice insulator



Channel growth due to surface discharges at the splice insulation material



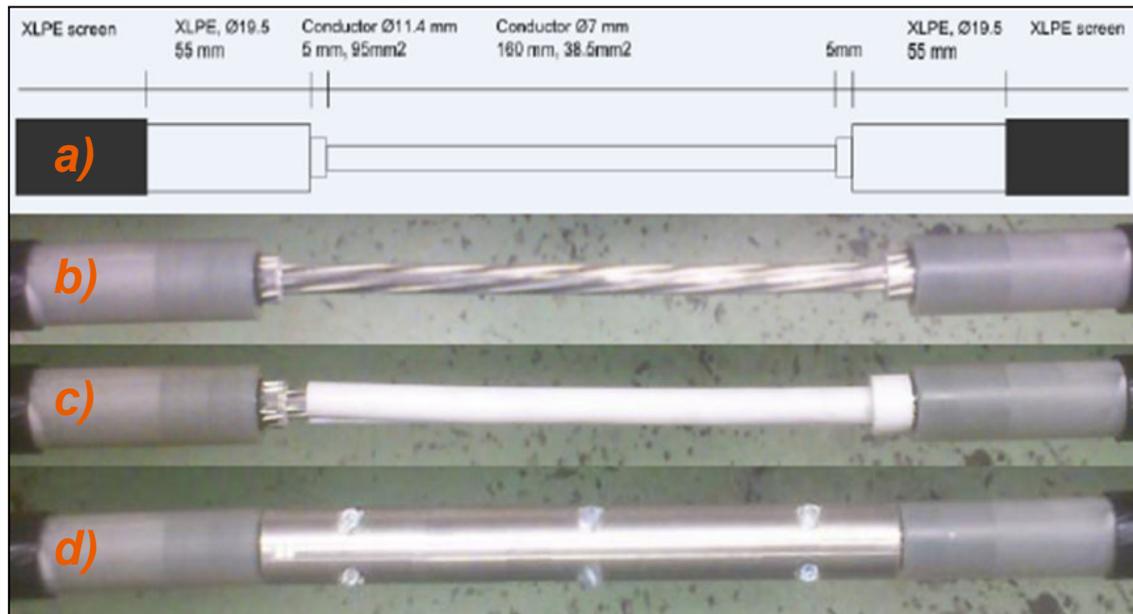
Channel growth due to surface discharge at the cable insulation material

Source: „VWEW Infotag 2004”, contribution E-On

VLF 0.1 Hz Sinusoidal vs. 50 Hz AC

■ Research project of Norwegian University of Science & Technology

Topic: „*Condition Assessment of Wind Farm Medium Voltage Cable Joints*“ (by Hans Lavoll Halvorson)



- a) Dimension drawing
- b) Reduced cross section
- c) Insulating teflon piece
- d) Metal cylinder



NTNU – Trondheim
Norwegian University of
Science and Technology

VLF 0.1 Hz Sinusoidal vs. 50 Hz AC

■ Measurement results

➔ At VLF 0.1 Hz Sinusoidal PD were only detectable at higher status of aging process

| | | 0 h of aging | | | | | |
|----------|---------------------|----------------|-------|-------|-------|--------|---------|
| | | 50 Hz | | | | | |
| Joint #1 | 2xU ₀ | | no PD | | | | |
| Joint #2 | 2xU ₀ | | no PD | | | | |
| Joint #3 | 2xU ₀ | | no PD | | | | |
| | | 136 h of aging | | | | | |
| | | 100 Hz | 50 Hz | 10 Hz | 1 Hz | 0,1 Hz | 0,01 Hz |
| Joint #1 | 2xU ₀ | no PD | | | | | |
| Joint #2 | 2xU ₀ | PD | PD | no PD | no PD | no PD | |
| Joint #3 | 2xU ₀ | PD | PD | no PD | no PD | no PD | |
| | | 256 h of aging | | | | | |
| | | 100 Hz | 50 Hz | 10 Hz | 1 Hz | 0,1 Hz | 0,01 Hz |
| Joint #1 | 2xU ₀ | PD | PD | PD | PD | PD | PD |
| Joint #1 | 1.5xU ₀ | PD | PD | PD | PD | PD | PD |
| Joint #2 | 2xU ₀ | PD | PD | PD | PD | PD | PD |
| Joint #2 | 1xU ₀ | PD | PD | PD | PD | PD | PD |
| Joint #3 | 2xU ₀ | PD | PD | PD | PD | PD | PD |
| Joint #3 | 1.75xU ₀ | PD | PD | no PD | | | |

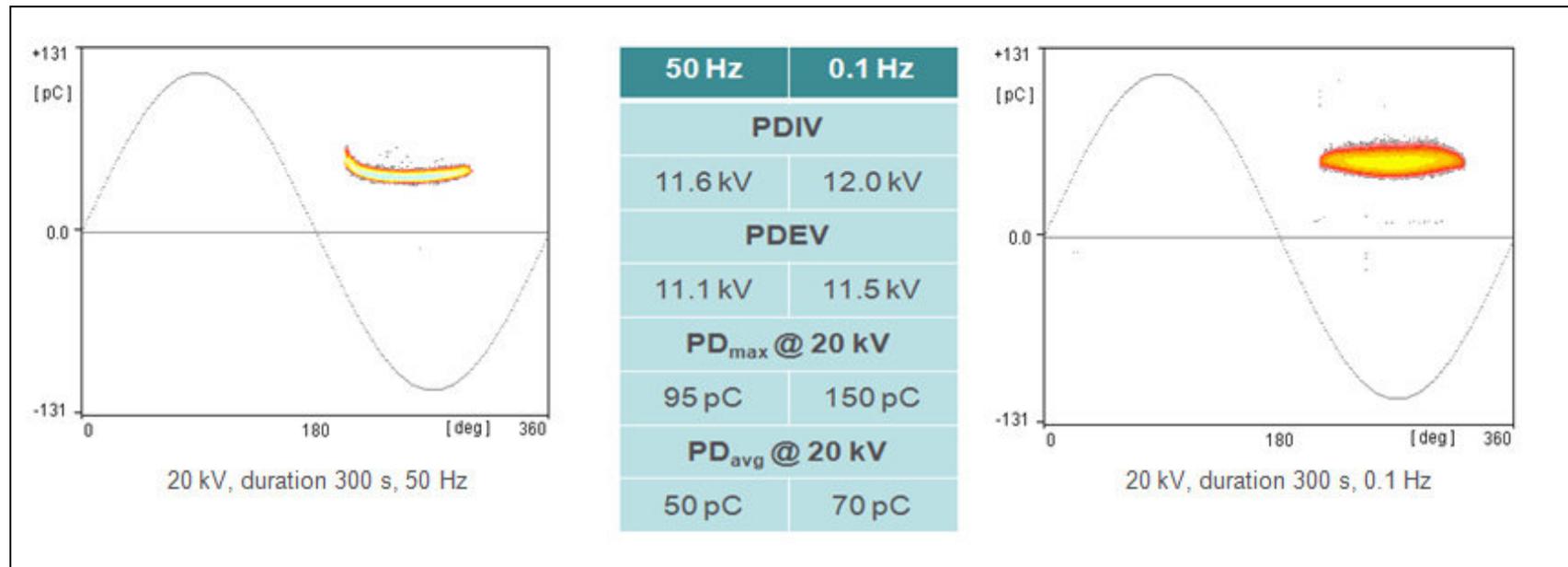
➔ *All joints PD-free*

➔ *Below 50 Hz no PD detectable*

➔ *Still differences regarding PDIV*

VLF 0.1 Hz Sinusoidal vs. 50 Hz AC

■ *Corona discharge in air*



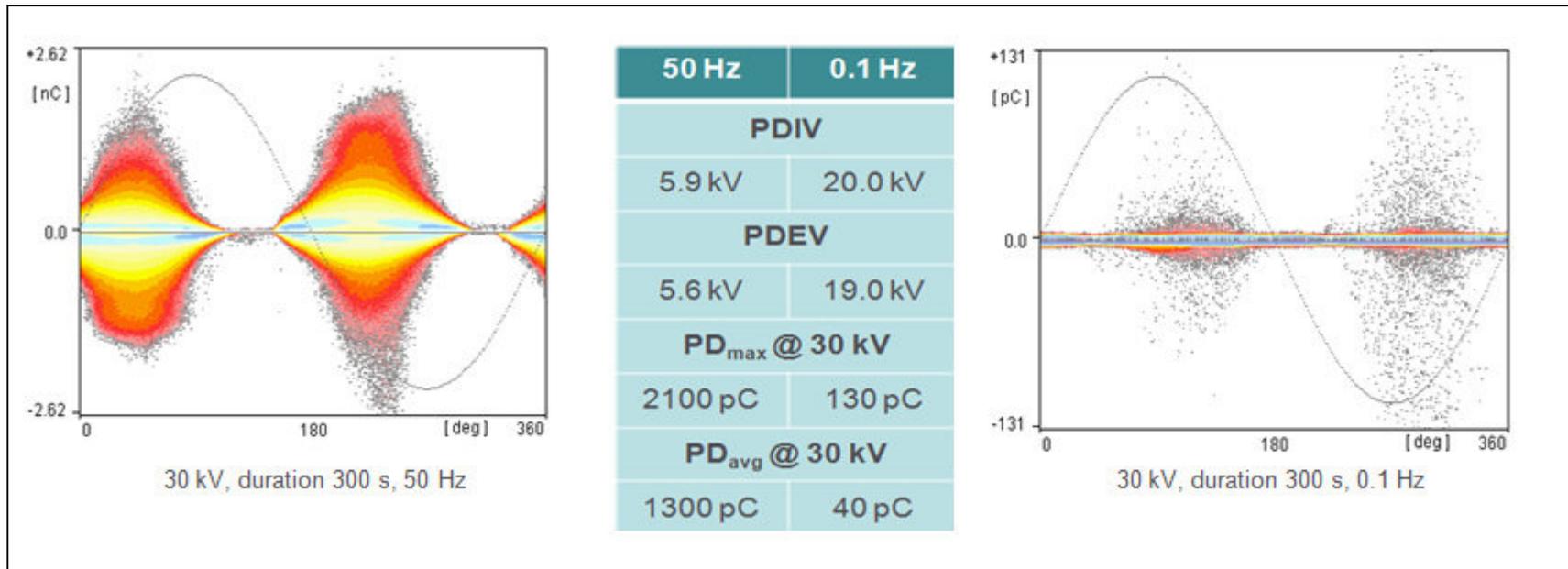
■ Result

➔ *No influence of dU/dt of test voltage at PD in air or voids*

Source: Voigt, FH Konstanz

VLF 0.1 Hz Sinusoidal vs. 50 Hz AC

■ PD at inclined boundary layers (*surface PD* on glass plate in air)



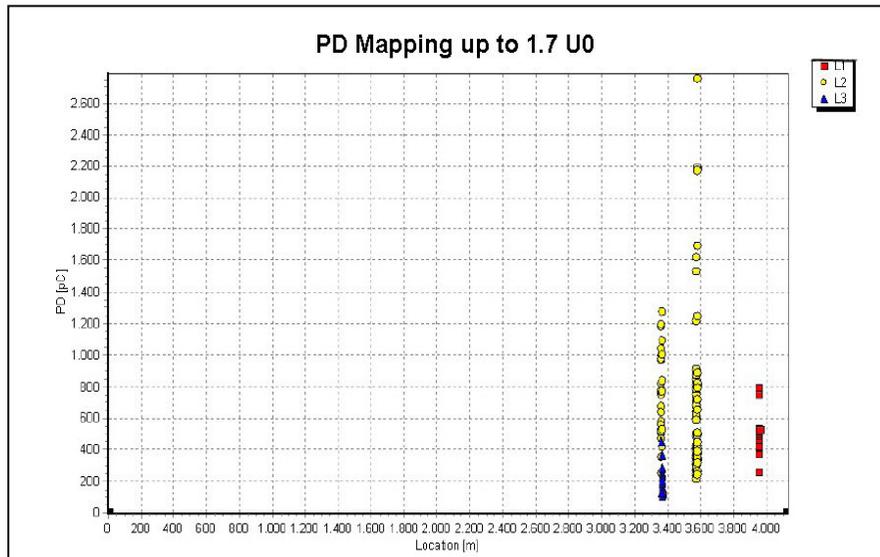
■ Result

- ➔ *Influence of dU/dt of test voltage of PD at boundary layers*
- ➔ *That means in splices or terminations*

Source: Voigt, FH Konstanz

VLF 0.1 Hz Sinusoidal vs. DAC

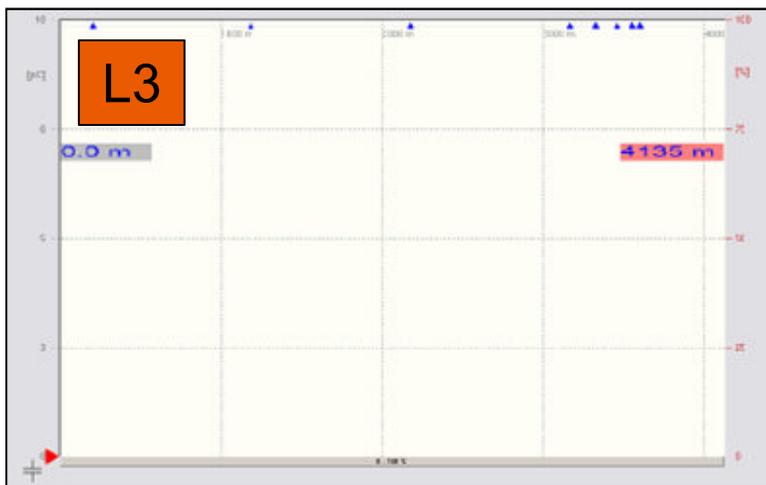
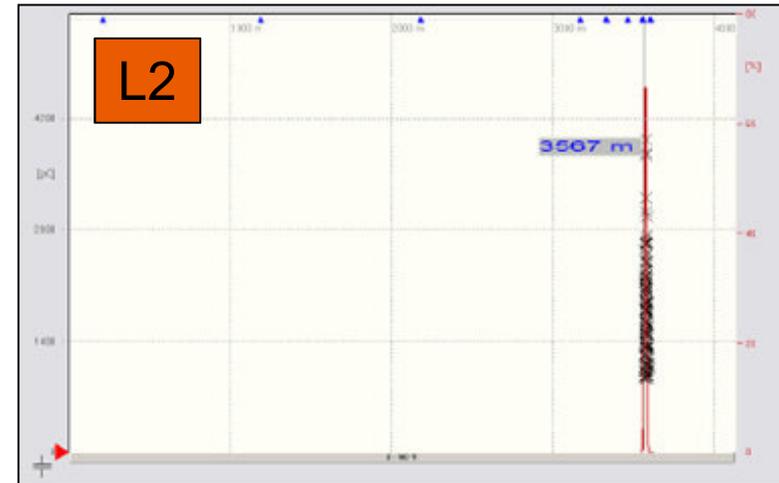
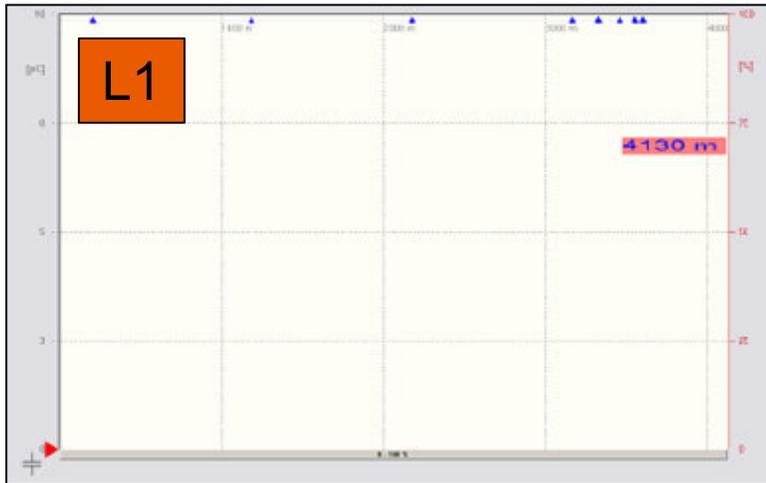
■ Comparison measurement *0.1 Hz* & *DAC*



DAC results

- PD detected & located
 - ➔ L1 @ 4 km
 - ➔ L2 @ 3.4 km & 3.6 km
 - ➔ L3 @ 3.4 km

VLF 0.1 Hz Sinusoidal vs. DAC



VLF 0.1 Hz Sinusoidal results

- PD Mapping up to $2 U_0$
- PD located at:
 - ➔ L1: PD-free
 - ➔ L2 @ 3.6 km
 - ➔ L3: PD-free



Comparability & Reproducibility of PC Characteristics

■ A take out from a paper published in 2009

Applied Voltage Frequency Dependence of Partial Discharges in Electrical Trees

Nadja Jäverberg, Hans Edin
*KTH, School of Electrical Engineering
Teknikringen 33
100 44 Stockholm, Sweden*

4. Conclusions

- Partial discharge activity at lower frequencies seems to die out. This implies that PD diagnostics is hard at low frequency.
- The PD patterns of electrical trees are quite

Source: „Applied Voltage Frequency Dependence of Partial Discharges in Electrical Trees”, N. Jäverberg, H. Edin, Proc. IR-EE-ETK, Stockholm, Sweden, 2009

Summary

- *Requirements at PD test system*
- Voltage stress of a PD test should *create comparable PD* as at operating voltage, especially for *ignition of PD & PD level*
- *Voltage shape* of PD test should be *close to 50 Hz* operating frequency
 - ➔ Using *alternative voltage shapes & frequencies*:
Correlations in relation to characteristic PD parameters must be available
- Stress of test object can be limited to U_0 or $1.7 U_0$
- Goal: *Non-destructive diagnosis*
- *Duration* of voltage stress of a PD test should be *as short as possible*
 - ➔ Requires a high PD rate at corresponding voltage shape (≈ 50 Hz)

Source: VWEW - German Energy publishing association, represented by 18 power suppliers

Question Time

sebaKMT
A member of Megger Group



Köszönöm a figyelmet!

Philipp Legler

Applications Engineer – Technical Support

E-Mail: Legler.P@sebakmt.com

Telephone: +49 (0) 35208 8429140

Mobil: +49 (0) 151 14089240

Homepage: www.sebakmt.com

Newsletter: www.sebakmt.com/news/newsletter

Facebook: www.facebook.com/sebakmt