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AMPLITUDE CONSIDERATIONS FOR TRANSFORMER UHF PD MEASUREMENTS

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ECONOMICAL ENVIRONMENT

CHALLENGES

Smart Grid technologies and alternative electrical energy generation

- Energy generation more and more decentralized
- Energy generation far away from load centers –needs to be transported over long distances
- Long bureaucratic processes to build transmission lines –importance of key equipment is shifting
- Offshore energy generation –difficult to access, n-1 availability can not be achieved

Deregulated energy markets

- Cost and price pressure on industry is increasing
- Often maintenance is outsourced
- Equipment needs to operate until it reached its real end of life

Developed markets (like Central Europe, US, Japan) are facing an aged fleet of key components

- Cost pressure are forcing utilities to keep the equipment running as long as possible
- Real life time of equipment is not know (e.g. oldest GIS installation built in 1967 –45 years “only”)

Increasing demand on new installations in especially India and China

ECONOMICAL ENVIRONMENT

SOLUTIONS

Condition base maintenance principles are more and more part of maintenance strategy

Implementation of condition monitoring is increasing (especially also in terms of comprehensive monitoring)

- In the earlier years monitoring meant the presentation of measured data without any integrated analyses
- As state of the art today, analyzing tools and expert systems are integrated and comprehensive, scalable platform solutions
- For some parameters also simulation and forecasting is available (for network operations)

Different approaches or combination of different approaches will be used (according to the needs):

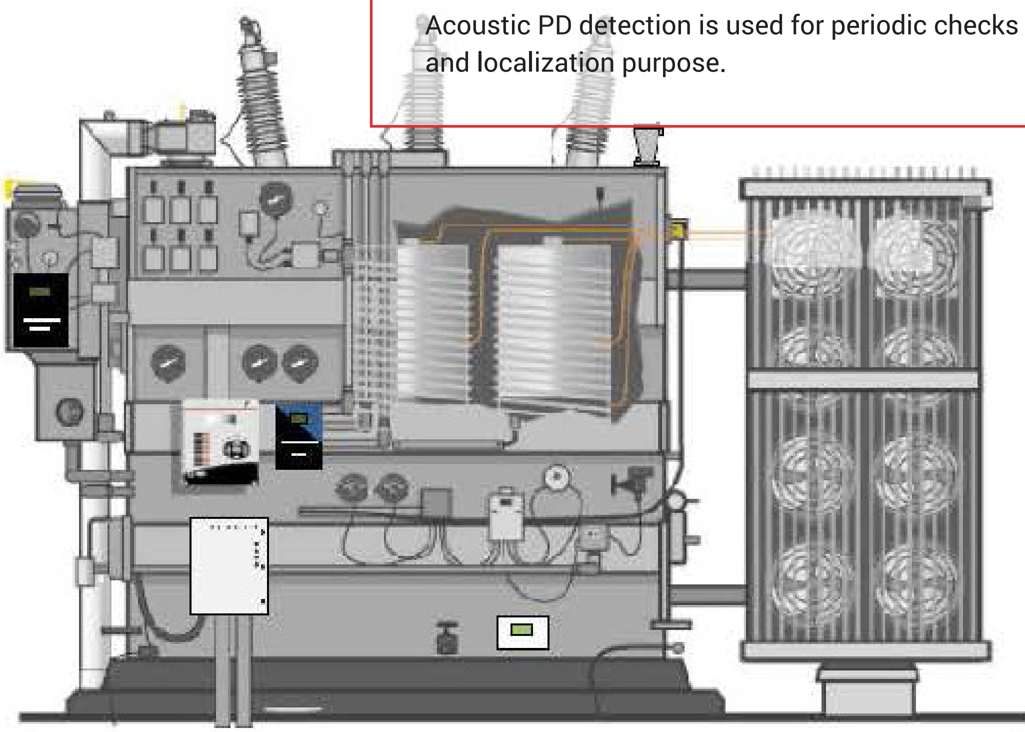
- Condition monitoring to gain economical benefit
- Condition monitoring to prevent failure
- Condition monitoring to increase maintenance intervals

PD MONITORING ON TRANSFORMERS

Electrical PD monitoring on bushing Tap is wildy used technique today.

Function principle is using Bushing as coupling capacitor according IEC 60270.

Acoustic PD detection is used for periodic checks and localization purpose.



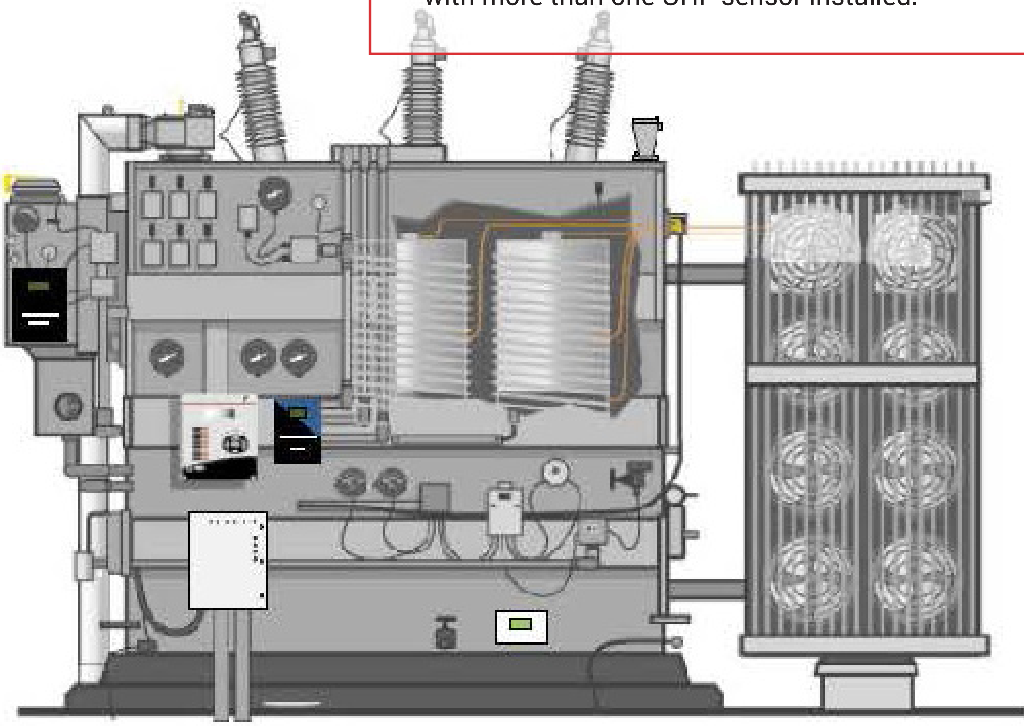
Monitoring challenges of conventional methods:

- Electrical PD signals measured on bushing Tap, origin is difficult determine (Tank? Overhead line?)
- Sensitivity is limited (low capacitance and outside disturbances)
- Acoustic measurement influenced by outside disturbances (e.g. rain, dust, pressure leakage, work close by...)
- Acoustic measurements have limits to detect PD inside winding and insulation

UHF PD MEASUREMENT

UHF Partial Discharge detection and localization are more and more established in Transformer diagnostics and monitoring over the last years.

New Transformers are increasingly manufactured with more than one UHF sensor installed.



Challenges:

- Calibration of UHF measurement in terms of pC is not possible
- Sensors are built to retrofit
- Experience level is low compared with conventional PD measurement (e.g. bushing Tap)

RISK ASSESSMENT FOR TRANSFORMER FAULTS ACCORDING PD LEVEL

SOLUTIONS

Poor impregnation caused discharges of about 1,000-2,000 pC. Large (3-5 mm in diameter) air/gas bubbles in oil resulted in discharges ranging in magnitude from 1,000 to 10,000 pC.

In general, PD level over 2500 pC(in paper) and over 10,000 pC(in oil) may be considered as destructive.

Ionization is a long-term action.

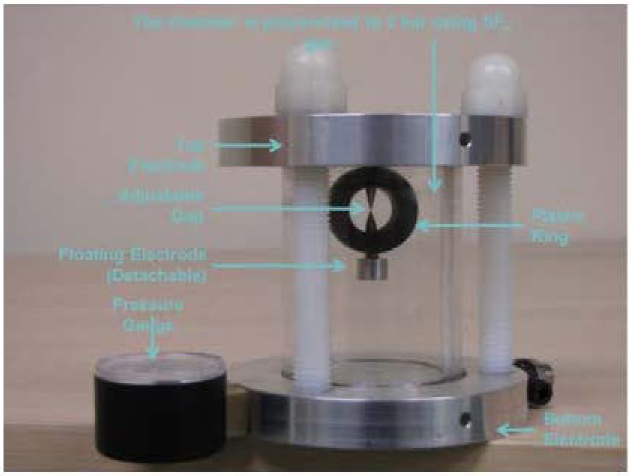
Mechanism of PD action and classification of PD for defect-free and defective insulation:

- Defect free 10-50 pC
- Normal deterioration <500 pC
- Questionable 500-1000 pC
- Defective condition 1000-2500 pC
- Faulty (Irreversible) >2500 pC
- Critical >100,000-1,000,000 pC

HOW TO ASSESS WITH UHF PD MONITORING?

Source: CIGRE WG A2.18, Life Management Techniques for Power Transformers, CIGRE (Paris) Technical Brochure 227, 2003

UHF PROPAGATION INSIDE TRANSFORMER TANK



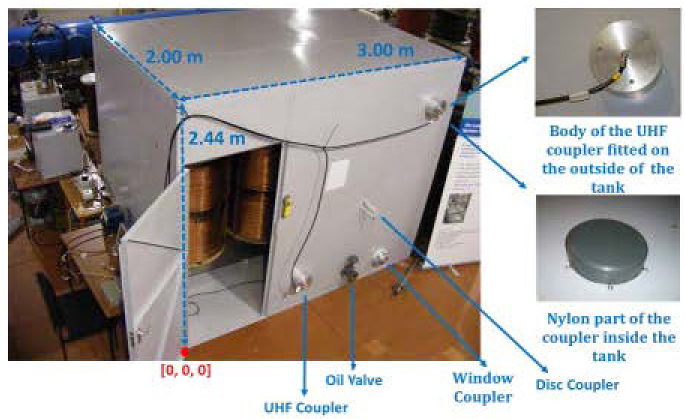
PD test cell with adjustable gap

Gap Size / mm	PD Inception Voltage / kV
0.05	4.8
0.10	7.3
0.15	8.8
0.20	10.9

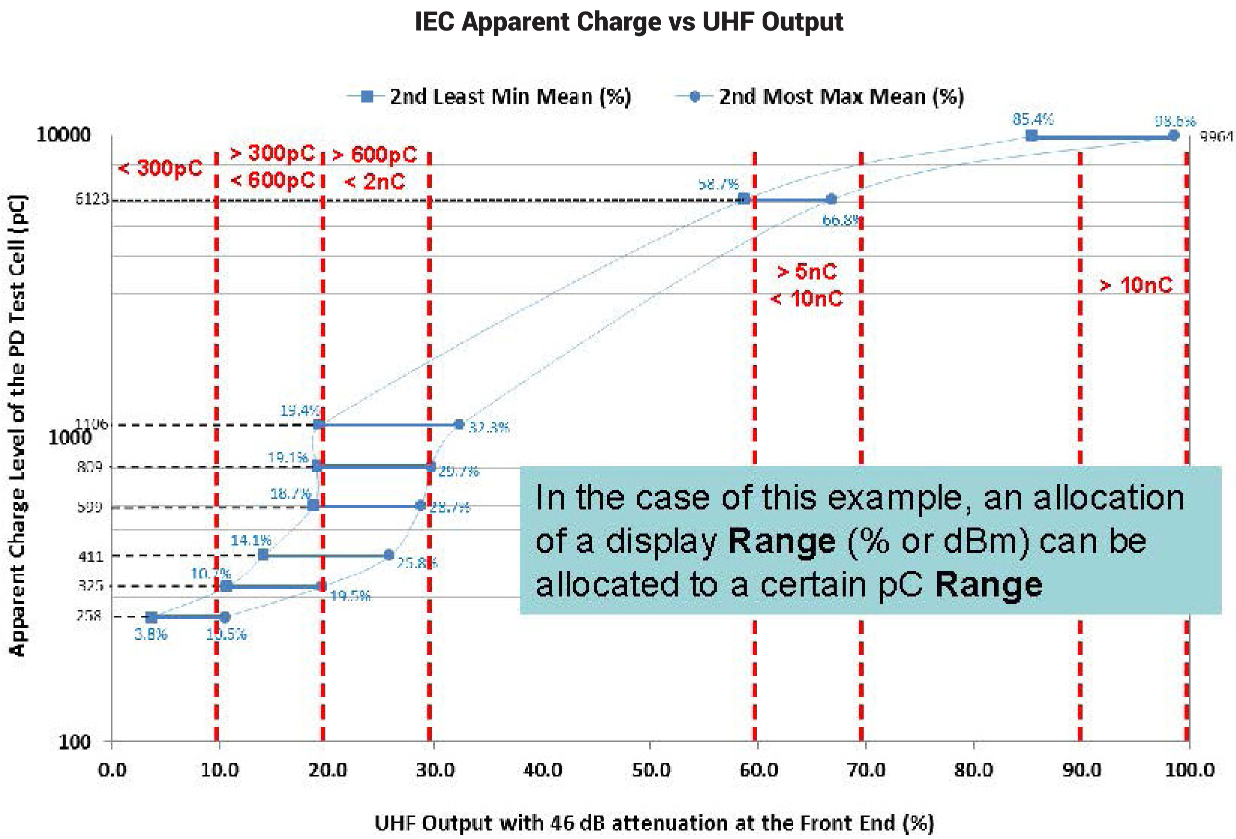
PD propagation paths and displayed value

PD Data Acquisition Point	Position Coordinate - (x, y, z) / m
Positon 1	(1.15, 0.65, 0.55)

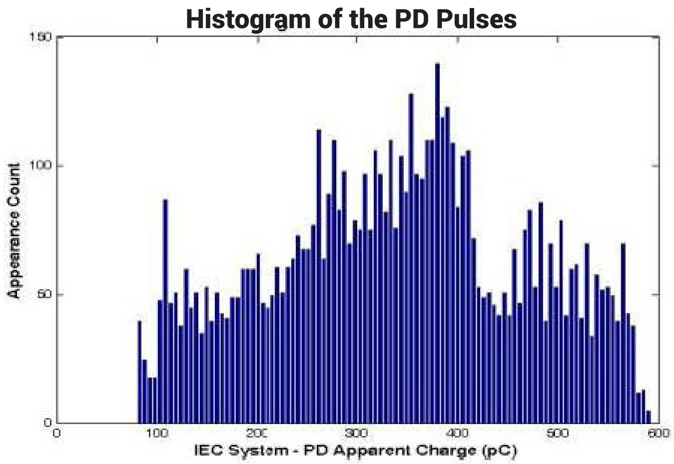
	S 1	S 2	S 3	S 4
Position 1	21.7%	29.3%	21.9%	28.9%

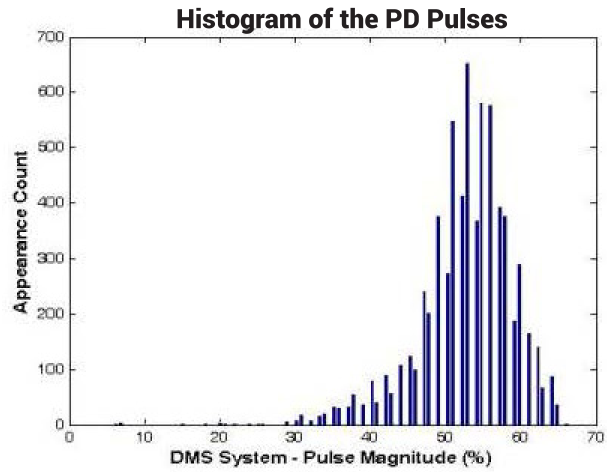


pC VS. dBm COMPARISON



PD PULSE DISTRIBUTION (TEST TANK)





PD generation: Test cell gap 0.05mm recorded in parallel with IEC 60270 system and UHF system

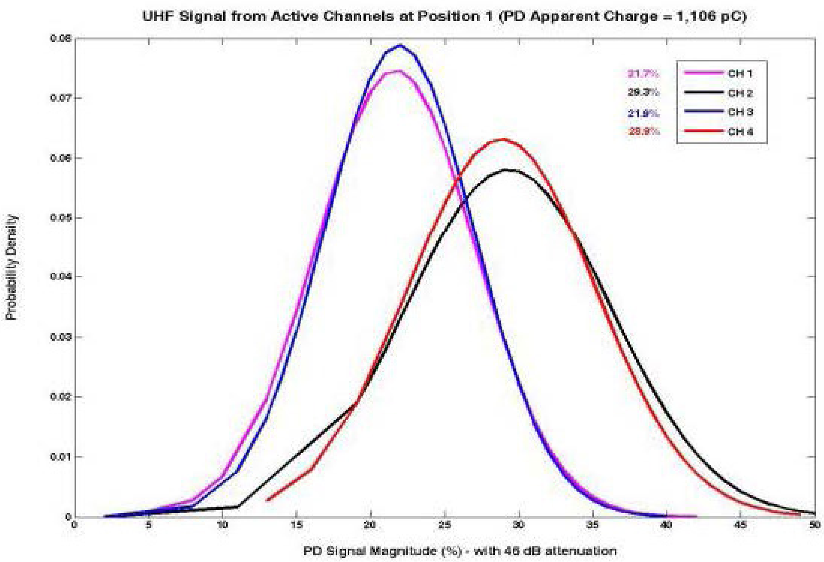
(measured in an empty test tank /1.0 x 1.0 x 1.0m/ with PD created by the PD test cell)

Repetition accuracy:

The histograms above show the repeatability for the same propagation path.

Furthermore it can be seen that the fluctuation of the measured apparent charge (measured according to IEC 60270) is between 100 and 600 pC for different discharge pulse from the same discharge source.

PD PULSE DISTRIBUTION (TRANSFORMER MODEL)



Magnitude distribution recorded with transformer model:

The magnitude distribution on the more realistic transformer model basically shows the same behavior as for the empty test cell.

dBm VS. pC DISCUSSION

Converting a dBm or percentage Range to a pC Range according to the understanding of IEC 60270 might be possible under the following condition:

- Location of discharge source is known
- A sensitivity verification (in a sense of CIGRE recommendation for GIS is carried out)
- The defect type is known
- The propagation path between discharge source and sensor is known

The pCrange information might be accurate enough to be able to assess the risk according to CIGRE recommendation.

- Localization of PD source by using UHF techniques is well known.
- Procedure for sensitivity/ amplitude verification needs to be established
- Defect type detection is possible by PD pattern analyses and localizing of PD source
- Propagation path (once the PD source is localized) is known by design information

KEY FOR TRANSFORMER PD ASSESSMENT: LOCALIZATION OF PD SOURCE

CONCLUSION

1. UHF technique effective for PD detection and localization in transformers
2. For amplitude/ sensitivity verification purpose, further discussion and investigations (also on real transformers) throughout the industry is necessary
3. To relate the UHF PD amplitude is a controversy discussion at the moment and difficult to carry out, but a rough estimation about the discharge energy might be possible
4. New CIGRE joined working group (JWG A2/D1.51); kick-off during CIGRE Paris 2014 "Improvement to Partial Discharge Measurements for Factory and Site Acceptance Tests of Power Transformers" will focus on alternative PD techniques, especially UHF

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