Study Committee D1

Materials and Emerging Test Techniques

Paper D1-PS1-11050

Optimized Deployment of Online Partial Discharge Monitoring Solutions for Distribution Grids

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Motivation

In this article, essentially it is introduced the results of the project to develop the strategy of EDP REDES ESPAÑA to deploy PD monitoring in the MV grid that can optimally cover the largest number of assets.

Monitoring **requirements to optimize the sensor deployment** are analysed as signal processing techniques, sensor bandwidth and sensor position that permits to reach the maximum sensitivity. **AI tools** have been developed **to reduce the expertise level** of the resources used for the measurements and diagnostics

BASIC CONCEPTS AND REQUIREMENTS FOR ONLINE PD MONITORING IN MV GRID

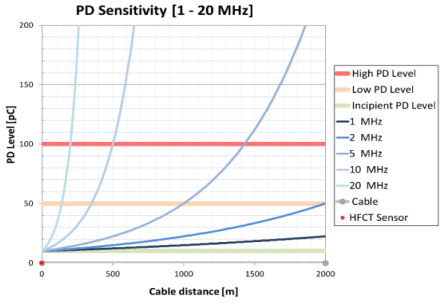
LEVEL 1: PD Detection

Monitoring to detect the existing defects (cables, switchgears, GIS, transformers). Maximum number of assets with the minimum effort and a good sensitivity. Result:

- **Discard** assets without PD **dangerous**
- Include assets with higher PD activity in **preventive action plan (investment)**.
- **Located** (Level 2) and **repaired** critical defects.
- **Follow-up** incipient defects.

1) Sensor installation for PD detection

HFCT sensors with best response between 1 MHz and 10 MHz, only one sensor for the three phases.



2) Analysis tools required for PD detection

Done by the technicians in the maintenance team of DSOs without the help of a diagnosis PD expert.

a) Automatic acquisition and noise filtering of background noise to detect very small PD pulses.
b) Automatic clustering of different PD phenomena presents in the measurement that have reached the HFCT sensor.
c) Automatic recognition of PD pattern to determine there is or there is no defect.

LEVEL 2: PD Location

1) Sensor installation for PD location

a) Localization in cable by synchronized measurements.
b) Localization in cable by reflectometry (offline).
c) Localization in switchgears/GIS/Transfo. by UHF/acoustic.

2) Analysis tools required for PD location

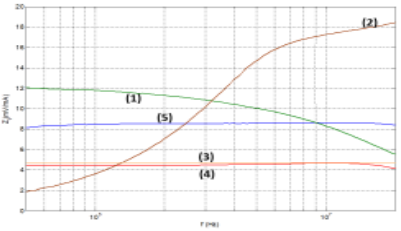
a) Automatic pulse polarity identification to distinguish the affected cable section.
b) Automatic identification of PD sources located along the cable system

NEW LOW-COST HFCT PD SENSOR

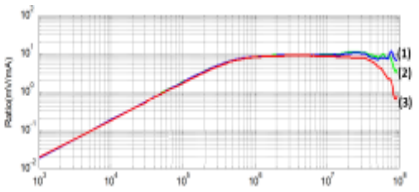
Requirements for permanent PD sensor

1) **High Transfer impedance** in range 1 MHz to 30 MHz
2) **Self-check capacity**
3) **Shielding** -40 dB
4) **Dielectric strength >** 10 kV.
5) Good **corrosion** performance.

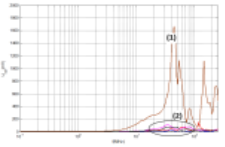
Comparison of transfer impedance different sensors.



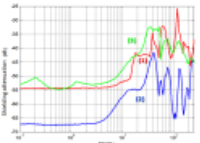
Transfer impedance new low-cost sensor. Prototype (1) without self-check coil, (2) with self-check coil, (3) self-check coil and internal shielding.



Induced interference in the measurement winding.
(1) without metal shielding
(2) with metal shielding



Shielding attenuation as function of frequency.
(1) 0.2mm copper
(2) 1mm copper
(3) 1mm aluminum



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(continued)

NEW ARTIFICIAL INTELLIGENCE TOOLS FOR DIAGNOSIS

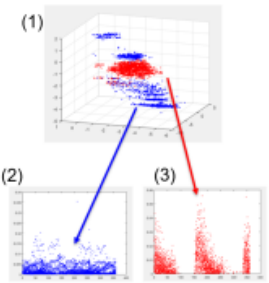
Automatic tools developed for PD Detection

1) New automatic clustering tool

$$i_1(t) = g_1(t)\,h_1(t)$$

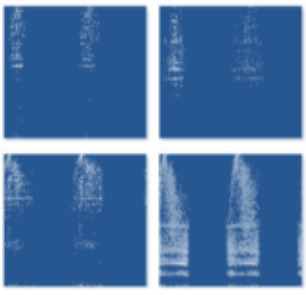
$$g_1(t) = A_1 \sin\left(\omega_1 t - \psi_1\right)$$

$$h_1(t) = \frac{1}{e^{\alpha_1(t-t_{01})} + e^{-\alpha_1(t-t_{01})}}$$



2) New pattern recognition tool

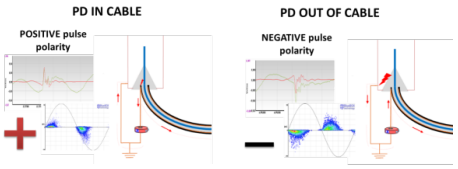
Database of 2000 real PD patterns classified by PD experts in four categories of the most common PD present in MV grid.



Type	External surface	Corona	Floating potential	Internal
External surface	92.5%	1.5%	1.2%	0.9%
Corona	8.7%	84.5%	1.3%	1.3%
Floating potential	3.0%	0.7%	87.1%	5.5%
Internal	7.6%	0.8%	13.6%	70.1%

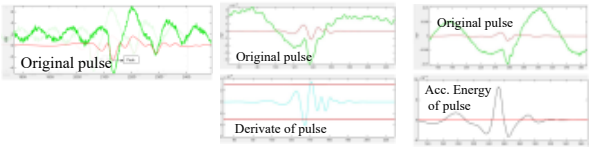
Automatic tools needed for PD Location

1) Improved automatic pulse polarity identification

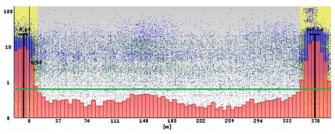


Developed methods:

a) Method of maximum	90%
b) Method of derivate	98%
c) Method of accumulated energy	65%
d) Combined method	100%



2) New automatic PD source location



DEPLOYMENT EXPERIENCE

Low-cost HFCT sensors needed to cover a total length of 2169 km of underground cable.

Sensor position	Quantity
Substation	446
Secondary substation	2892
Pole (OHL connection)	315
Total	**3653**

CONCLUSIONS

New low-cost PD sensor and the new AI tools permit to implement a viable deployment and a coherent strategy using mainly internal resources in DSO.

Key factors for an optimal deployment are HFCT sensor with high sensitivity 1MHz-10MHz beside powerful filtering to detect small PD pulses under electrical noise.

AI tools are able to automatically perform diagnostic for Level 1, PD detection. Improvement of the recognition tool to reach higher level of confidence is planned as future work.