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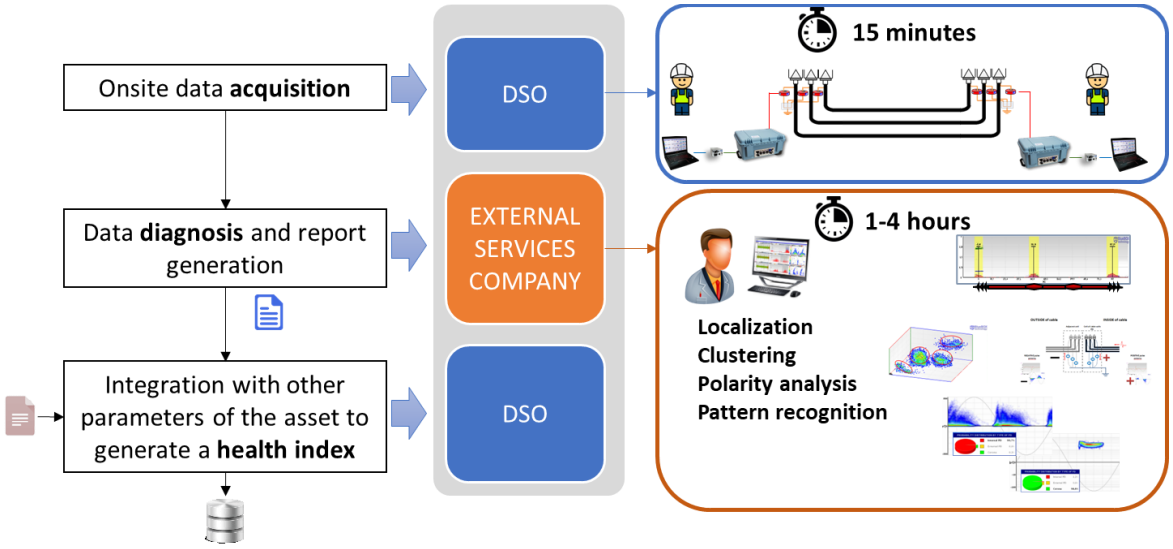
PREF. SUBJECT: PS-1
QUESTION N°: 1.08

Question 1.08: Are there other examples of the application of PD monitoring in distribution grids? If so, what assets have been targeted and with what success?

Distribution system operators like EDP Redes España have been testing cable insulation applying PD measurements during more than 20 years. Until year 2015 EDP Redes España was using mainly offline PD testing with portable very low frequency (VLF) and damped alternating current (DAC) voltage generators. From 2015, EDP has been using online PD monitoring technique to carry out periodic maintenance of the underground cables. When online PD monitoring is performed using sensors to detect PD pulses traveling far away, not only cable insulation is checked also switchgear/GIS and transformer insulation is verified.

During the last 7 years PD monitoring has been applied using portable equipment that permits to collect data during a few minutes to carry out the diagnosis of the insulation condition every 3 years. The acquisition of the data has been automated to collect high reliability data and was done by technicians of the maintenance team in the DSO but the diagnosis was covered by outsourced PD experts from an external services company.



This diagnosis is limiting the independency of the DSO to carry out the insulation condition assessment due to the lack of PD experts inside the maintenance team. The fact of using external expensive resources was that this PD monitoring was only applicable in a small set of cables every year. After years of experience applying this strategy in more than 1000 measurements with external resources support, the DSO has obtained statistical results showing that 70% of the measurements where clean without any PD defect present in the data while the other 30% had PD to be diagnosed by an advance user.

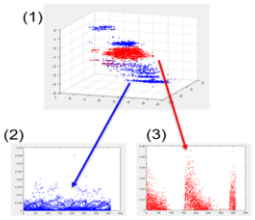
In 2018 EDP Redes España launched an R&D project to develop new low-cost HFCT sensor to be installed permanently in the distribution grid and new AI tools to determine automatically if there is or is not internal PD present in the measurement. As result of the project now DSO can perform independently measurements and diagnosis to determine if there is or is not internal

PD. Using these developments EDP is able apply independently insulation condition assessment following this strategy divided in 2 levels:

LEVEL1: PD Detection

Automatic acquisition

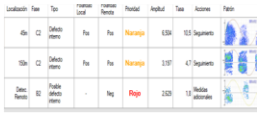
Fully automatic clustering using pulse wave shape characteristics



Neural network for recognition of physical phenomena base on phase resolved PD pattern

Type	External surface	Corona	Floating potential	Cavity
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%
Cavity	7.6%	0.8%	13.6%	70.1%

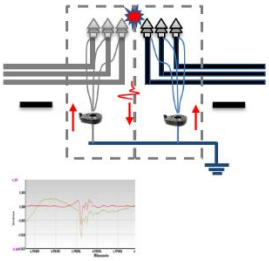
PD List



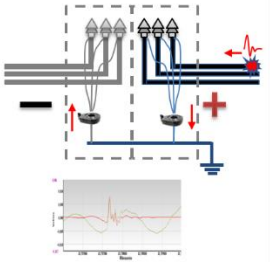
LEVEL2: PD Localization

Option A) by pulse polarity analysis

1) Localization Switchgear

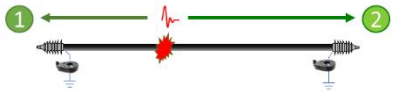


2) Localization Cable

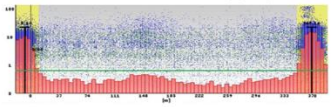


Option B) by synchronized measurement

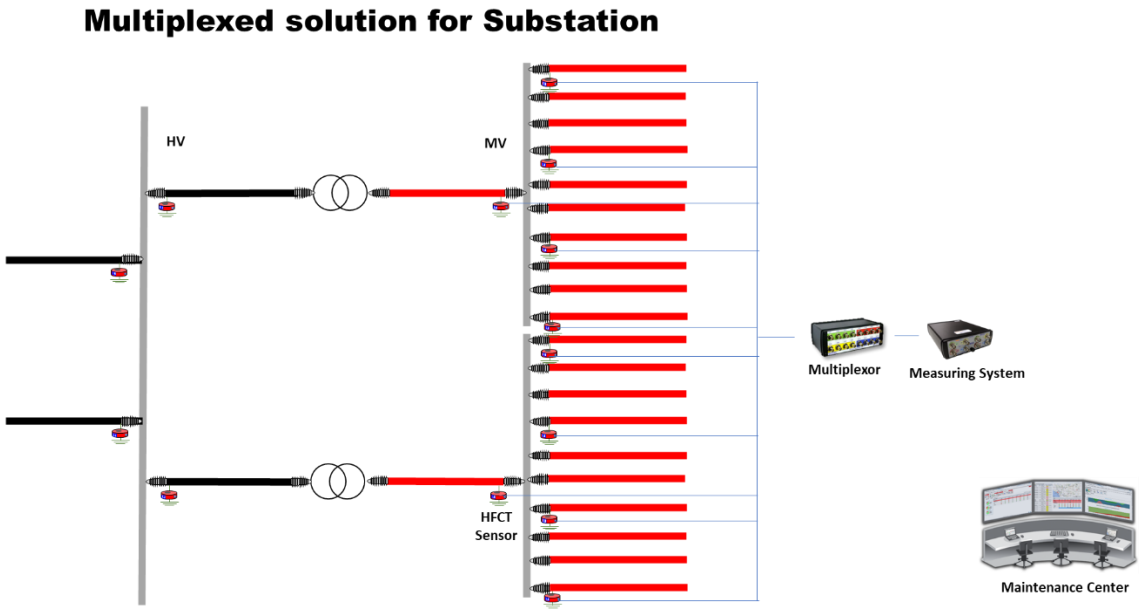
Localization along the cable with two synchronized sensors



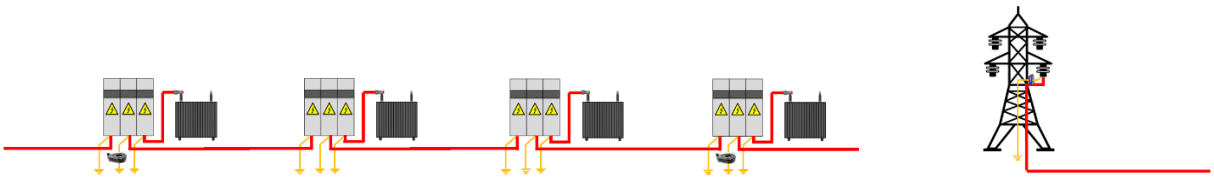
Automatic PD Mapping



Nowadays that powerful denoising techniques in combination with AI tools are reliable to detect insulation defects without needing PD experts, a new door is opened for permanent PD monitoring in distribution grids. To make viable this permanent application it is needed to find hardware designed to reduce the cost of the infrastructure maintaining the same reliability of the measurement. The most cost-effective solution is installing sensors and acquisition units with multiplexors in main substations because a lot of assets are covered with the minimum hardware and requirement for power supply, communications, and processing capability are easy to be solved.



By applying this solution most critical assets in the substation transformer, GIS/switchgear and first 1km of the cables including HV and MV are monitored, but new solutions must be developed to cover all the assets of the MV distribution grid including secondary substations and all the cables far away from the substation. High frequency measurements are the best alternative to cover the rest of the grid with an optimized permanent infrastructure but using this bandwidth it is needed a powerful filtering capability combined with AI tools that can analyze thousands of pulses collected every day by each sensor. EDP Redes España in collaboration with Ampacimon has launch a new R&D project to develop a new solution adapted to the PD monitoring at the position of secondary substations or outdoor terminations at the transition towers to connect overhead lines being able to cover the insulation condition of all the assets in the distribution grid.



This new development will permit to find different insulation defects present in the distribution grid applying clustering and recognition AI tools. Additional measurements to predict other type of defects like sheath current monitoring, temperature and humidity monitoring, fault and pre-fault localization will be integrated in the same solution to justify the investment of the permanent monitoring hardware.
Ideally with communication infrastructures already available in some of the secondary substations the AI tools could run in a cloud platform but for some other cases where this infrastructure is not available a solution with embedded AI tools in the measuring hardware and IoT communication will be developed.

To deploy this new solution will be needed to solve power supply and communication challenges in each location and a good analysis of the grid to select the optimal positions to install the permanent monitoring sensors as described in the paper ID 11050.