ScuDo
Scuola di Dottorato ~ Doctoral School
WHAT YOU ARE, TAKES YOU FAR

37 Cycle

On-line Partial Discharge Detection and Localization of Power Lines

Yuan Yan

Supervisors: Prof. I.S. Stievano, R. Trinchero, Hongjie Li

Research context and motivation

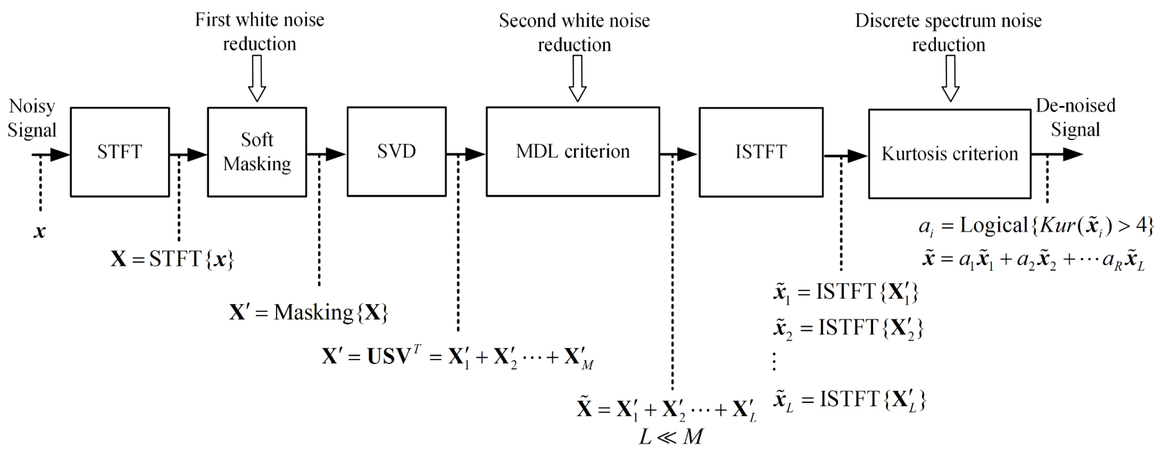
- Insulation failures in power electrical networks yield power outages, disrupting customers' daily activities and harming the economy. The solution is to conduct condition-based maintenance of the networks. **Partial discharge (PD)** detection plays a key role in this picture.
- Nowadays, many commercial digital integrated circuits are available for PD detection, integrating with ultra-wide band sensors. These sensors allow achieving advanced PD diagnosis, but on-site PD measurements turn out to be susceptible to field noise interferences. Therefore, **de-noising** is an essential step in on-site PD measurement.
- In addition, in the on-site PD diagnosis process, **PD localization** is an essential step as it provides the exact location information of the PD source, thus improving the efficiency of subsequent maintenance actions.

Addressed research questions/problems

- **High-level noise**, **variable waveforms of PD signals**, and **limited computational resource** in most commercial devices make on-site PD de-noising yet challenging.
- Achieving accurate PD localization of power distribution lines is still a issue, primarily due to **synchronization problems** and **field noise interferences**.

Novel contributions

- We developed **a fully automatic tool** for the de-noising of PD signals occurring in electrical power networks and recorded in on-site measurements [1].



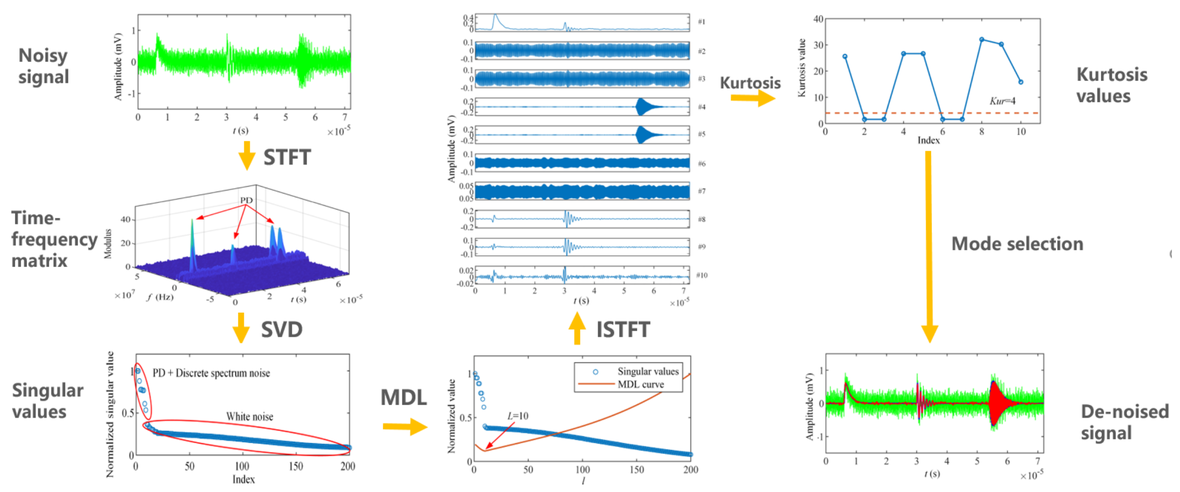
- We developed **an improved PD detection and location technique** for overhead electrical power distribution networks [2,3,4].

Submitted and published works

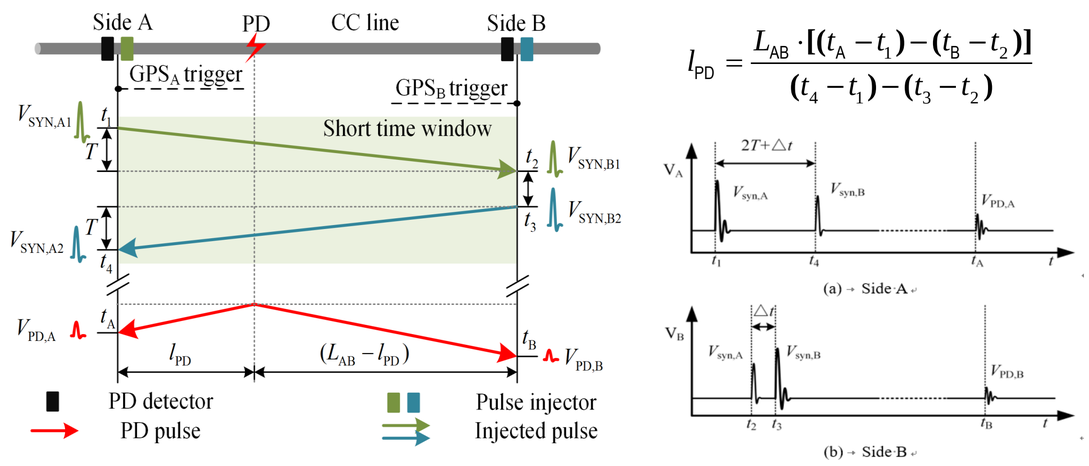
- [1] Yuan Yan , Riccardo Trinchero, Igor Simone Stievano*, Hongjie Li, and Yanzhao Xie, "*An Automatic Tool for Partial Discharge De-noising via Short Time Fourier Transform and Matrix Factorization*", IEEE Transaction on Instrumentation and Measurement.(Submitted)
- [2] Yuan Yan, Yinsong Zhao, Weisheng He, Igor S. Stievano, and Hongjie Li*, "*On-line Partial Discharge Localization of 10-kV Covered Conductor Lines*", IEEE Transaction on Power Delivery. (Submitted)
- [3] Yuan Yan, Jiaqi Tao, Riccardo Trinchero, Igor Simone Stievano, and Hongjie Li*, "*Compact Detector for Flexible Partial Discharge Monitoring of Overhead Covered Conductor Lines*", IEEE Transaction on Power Engineering letters. (Submitted)
- [4] Yuan Yan*, Peng huo, Hongjie Li, "*Robust on-line partial discharge measurement of 35-kV cables in wind farms via dual sensors*", 2022 9th International Conference on Power and Energy Systems Engineering (CPESE 2022), Energy Reports.

Adopted methodologies

- The proposed PD de-noising method consists of two steps:
  - *Step 1:* the spectral decomposition of the PD measured signal via the joint application of the **short-time Fourier transform (STFT)** and the **singular value decomposition (SVD)**.
  - *Step 2:* the estimated noiseless signal is reconstructed via a clever selection of the dominant contributions via **minimum description length (MDL)** and **kurtosis criteria.**



- The proposed PD location technique is based on the **double-sided traveling-wave method**. The method is improved by a hybrid detection technique, which integrates **a pulse-based synchronization mechanism** and a global positioning system (GPS). It is completed in three steps:



$$l_{PD} = \frac{L_{AB} \cdot [(t_A - t_1) - (t_B - t_2)]}{(t_4 - t_1) - (t_3 - t_2)}$$

- *Step 1:* the double-sided PD detectors are triggered by their respective GPS to collect the signals in the power line.
- *Step 2:* after the GPS triggers, the pulse-based synchronization mechanism is activated within a short time window (e.g., 100 μs). In this step, the synchronization error of the GPSs can be eliminated, and the propagation velocity of the power line can be estimated.
- *Step 3:* the detectors continue to collect PD data until the sampling time reaches one power frequency cycle (i.e., 20 ms) to cover enough PD pulses.

Future work

- Future works will investigate a possible application of the proposed algorithm to an **embedded system**, which may offer a cheap and effective alternative solution for on-line PD monitoring.
- Also, improvement of the proposed PD location technique for more complex power distribution networks with multiple branches and tips, which may lead to non-negligible energy attenuations and time delays of the PD signals, thus reducing the accuracy of PD detection and localization.

List of attended classes

- Enrolled in co-directed thesis project between PoliTo and XJTU, most of courses are taken in XJTU.
- @ PoliTo: 01SCSIU – Machine learning for pattern recognition (22/07/2022, 4 credits)

Politecnico di Torino

PhD program in
Electrical, Electronics and Communications Engineering