On-line Partial Discharge Detection and Localization of Power Lines

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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].

- 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:
  - 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 GPS 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)