

Paper 1083

Smart-Meter Phase Clustering in Low-Voltage Distribution Networks

// Pedro Carriço, Adriana Leal, Daniela Jordão, Bruno Galhardo ENEIDA.IO, Coimbra, Portugal

Introduction

// Low-voltage (LV) networks often lack accurate phase documentation, which is critical for load balancing and planning. This work proposes a scalable, data-driven method to identify phase connectivity using smart meter voltage data – no on-site inspection required.

Methodology



Dataset

// Source:

- 45 days of data
 - Split into three two-weeks long datasets.
- 15-minute voltage time series from smart meters (SMs)

// Scope: Two LV transformers (TXs)

- Transformer A: 89 single-phase SMs
- Transformer B: 109 single-phase SMs

// Features:

- Real-world operational data
- No labeled phase info (unsupervised setting)
- Includes voltage variability and noise



Figure 3. Methodology flowchart.

Results

- Using spectral clustering based on k-nearest neighbour graph, the method:
 - Demonstrated robustness to noise and voltage variability.
- Enabled automated mapping of phase connectivity.



Figure 1. Distribution of the real phases of the SM for all datasets.







- Accurate phase identification across both transformers.
- The lowest accuracy obtained for Batch 2 indicates that temporal variations in voltage time-series were not specific enough.



TX Batch O Batch 1 Batch 2 1.00 0.97 1.00 Α 0.97 1.00 0.45 0.65 0.68 0.67 0.53 0.58 0.41 0.44 0.61 0.44 0.37 0.35 В 0.51

Figure 4. Heatmap depicting the binary similarity matrix obtained for transformer A, for Batch O.

Table 1. Performance metrics for the best modelsacross the different transformers and batches.



Figure 2. Distribution of missing values for Transformer A and Transformer B for the three batches.



ENEIDA. O

www.eneida.io pcarrico@eneida.io

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Conclusions

// This method enables DSOs to:

- Improve load balancing
- Reduce manual verification
- Enhance observability using existing infrastructure

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