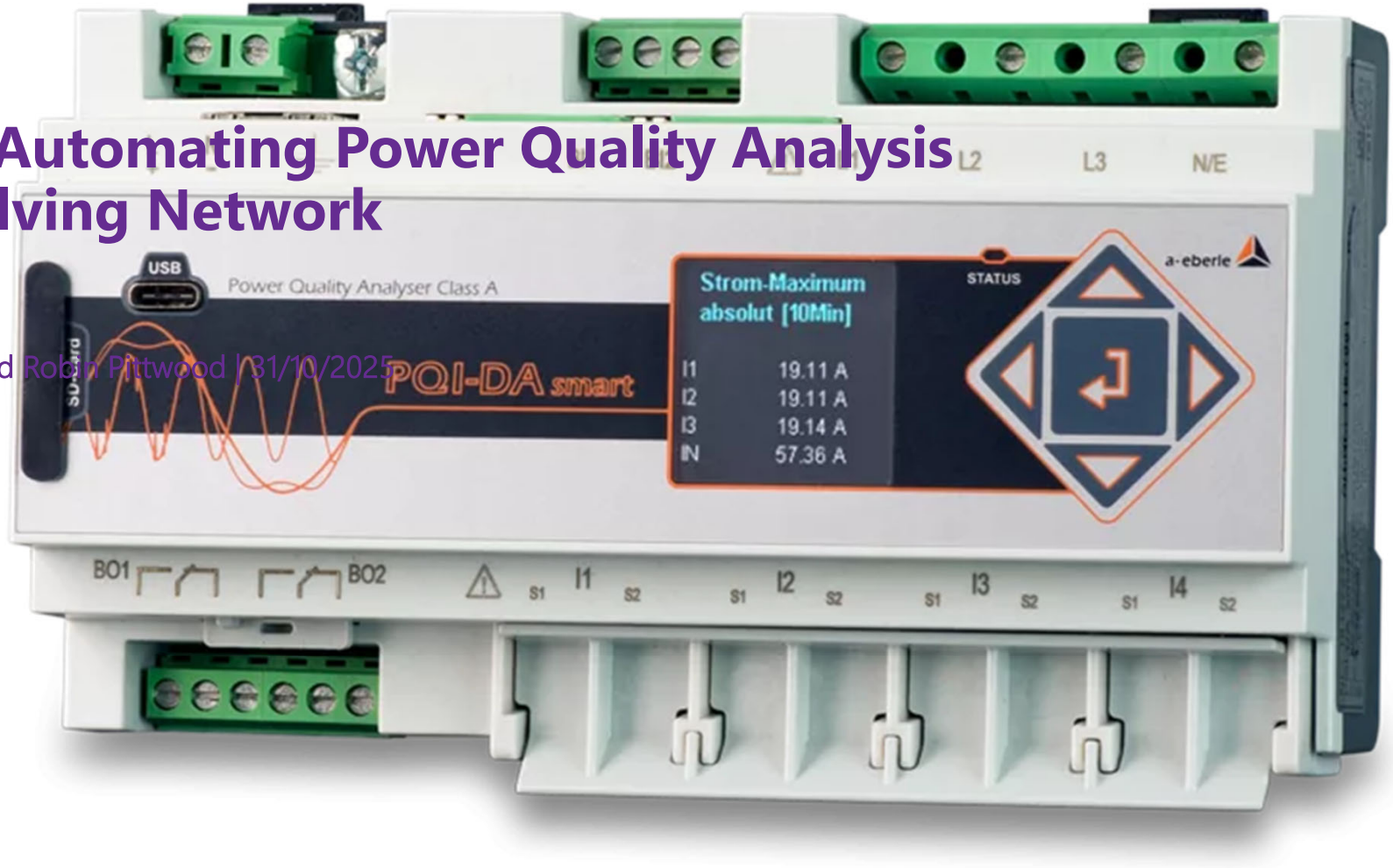
Towards Automating Power Quality Analysis in an Evolving Network

APEX 2025

Dazzle Johnson and Robin Pittwood | 31/10/2025



POWERCO

Introduction

Distributed Energy Resources (DERs) lead to increased complexity and decreased predictability

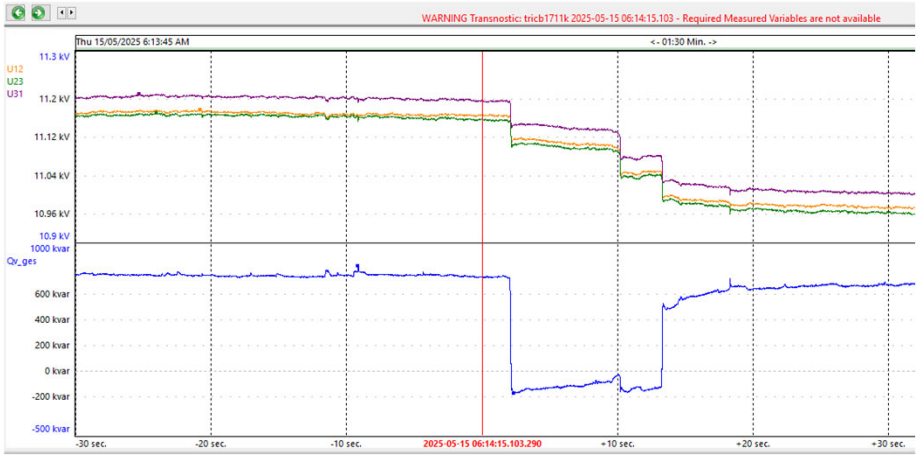
Distribution businesses are required to consider and ensure both Reliability and Power Quality (PQ)

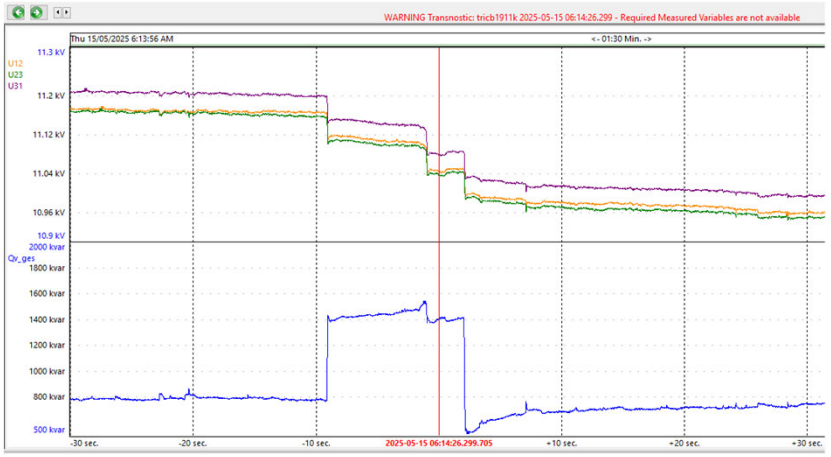
70+ Power Quality Meters (PQMs) have been deployed to monitor network health allowing a move from **reactive** to **proactive** action

The data quickly becomes overwhelming as the scale of monitoring continues to increase

How can automation and intelligent tools support Power Quality analysis and action?

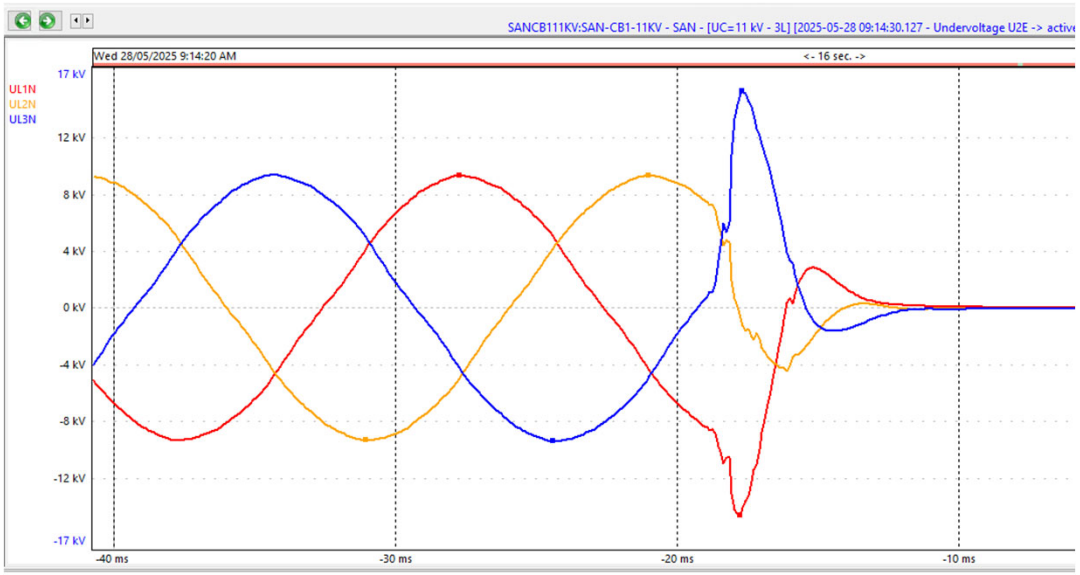
Examples of Power Quality Analysis





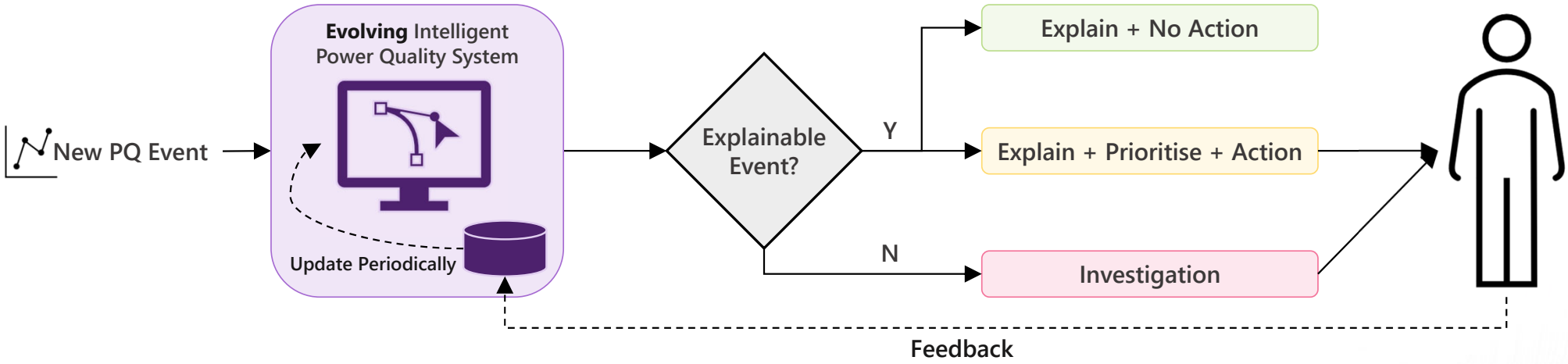
Upstream tap change in the same record as downstream tap change → 33kV tap change timing setting to be checked

Examples of Power Quality Analysis

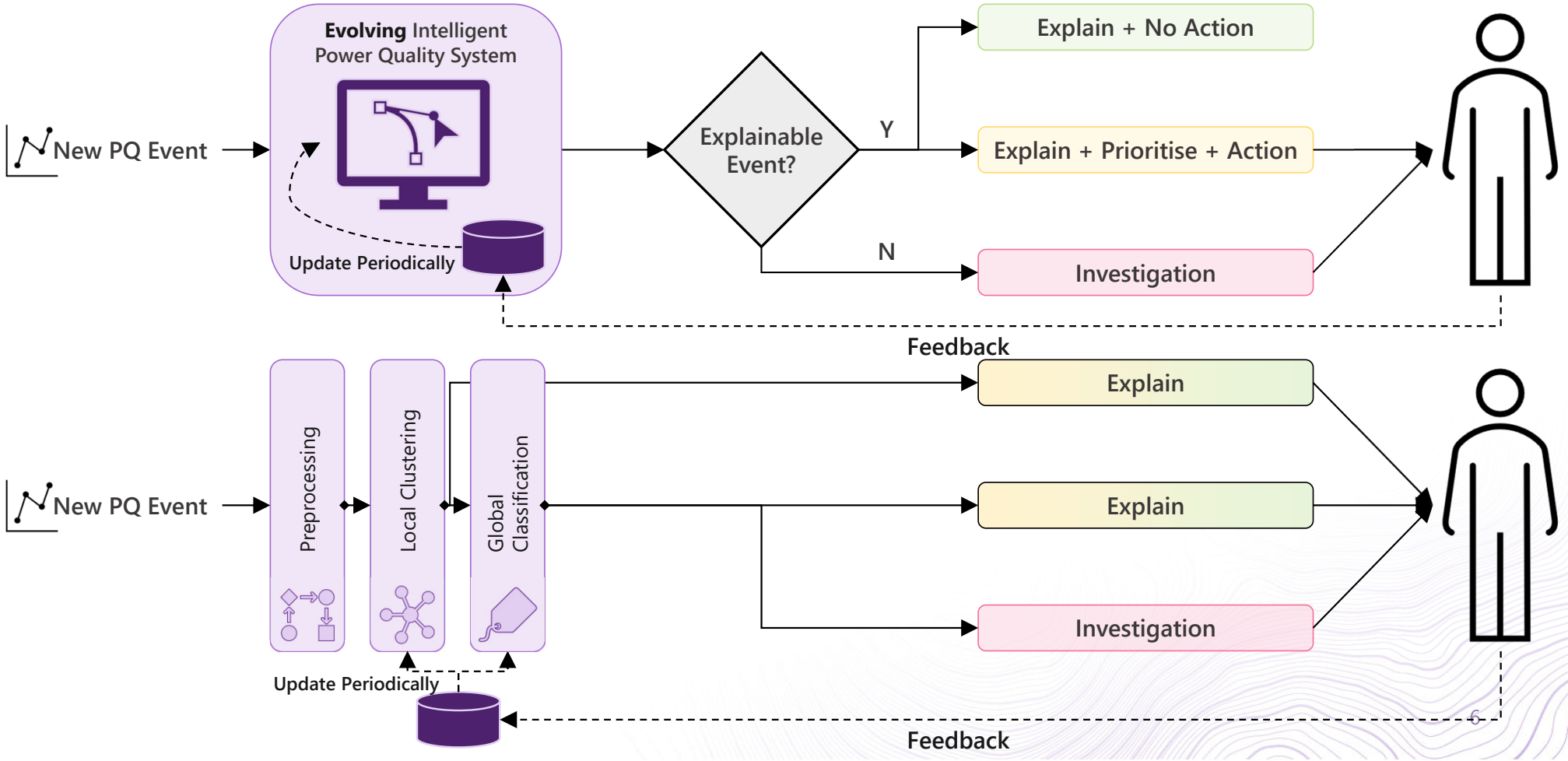


Voltage 5kV above normal peak and the voltages do not break cleanly → Check switch used to turn transformer off

Proposed Solution – EI-PQS



Proposed Solution – EI-PQS

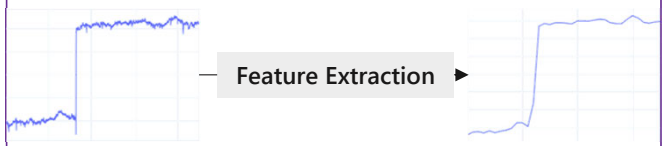


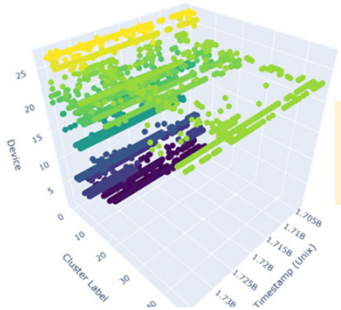
Proof-of-Concept Study

On TRMS Recordings triggered by Tap Change Operations

Feature Extraction & Local Clustering

Input: Raw PQ Multivariate Timeseries Data



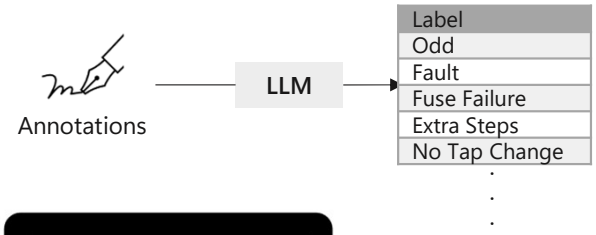


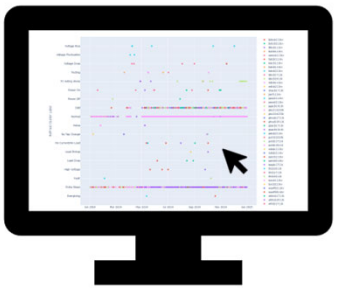
PQ Events clustered based on similarity at local device level

Output: PQ Event Clusters

Human-in-the-Loop Labelling

Input: PQ Event Clusters + Expert Annotations



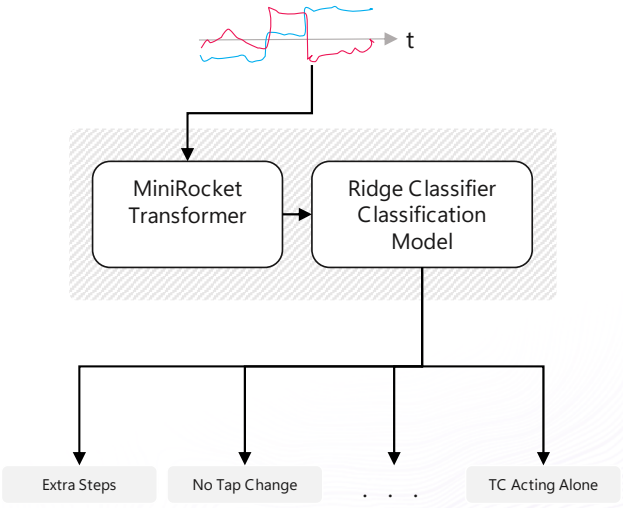


Interactive interface to assist data labelling.

Output: Labelled PQ Event Data

Supervised Learning

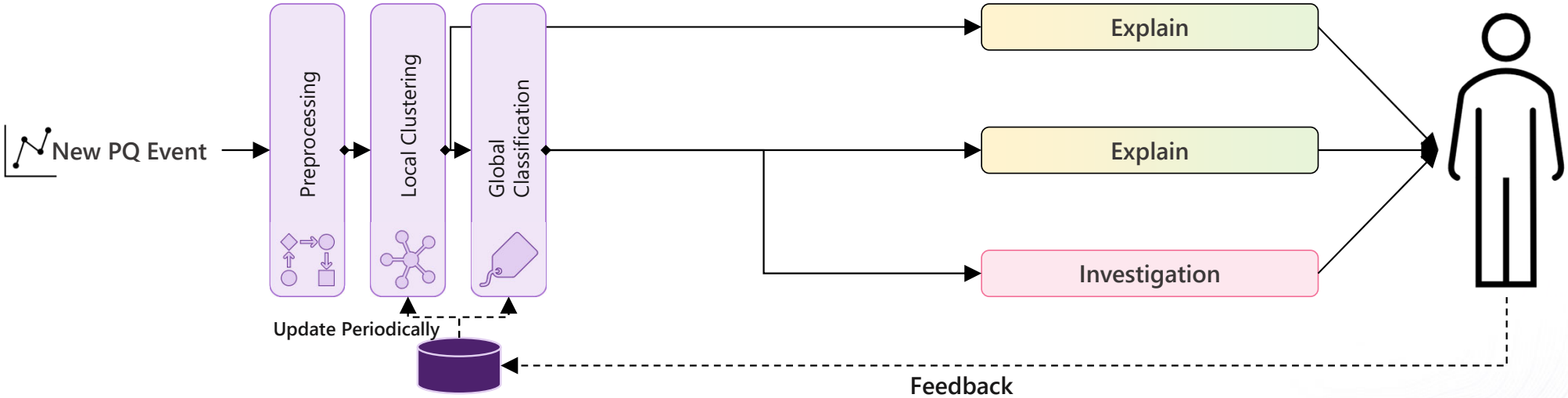
Input: Labelled PQ Event Data



Output: Global Classification Model

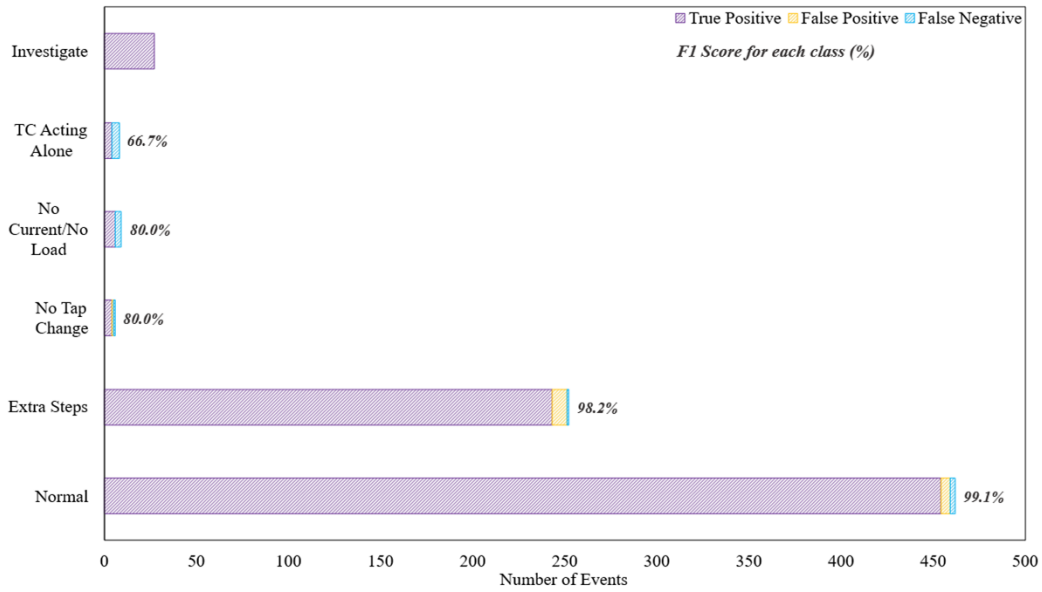
Proof-of-Concept Study

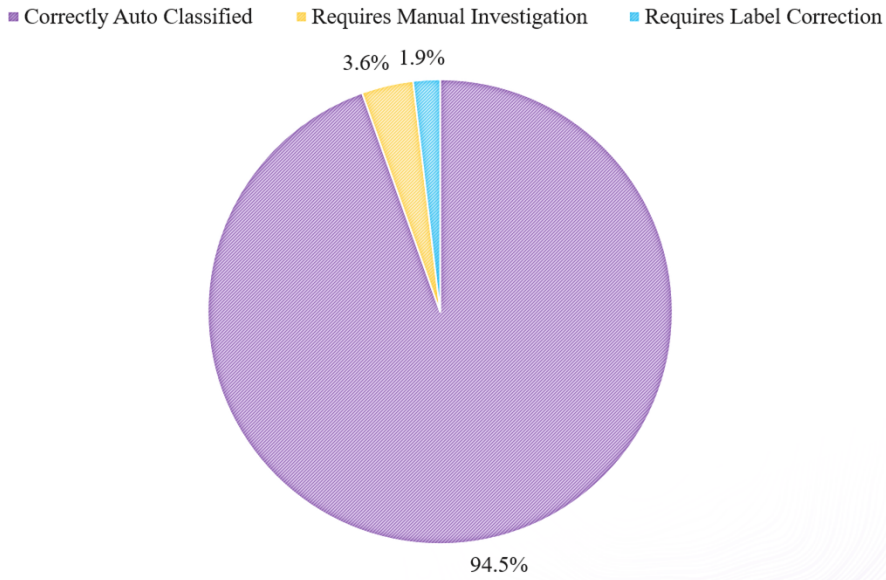
On TRMS Recordings triggered by Tap Change Operations



Proof-of-Concept Study – Experiment & Results

Tested on 752 TRMS tap change event recordings from substation/device lakcb1911k, collected January-May 2025





The system shows potential to reduce manual workload by automatically classifying events and highlighting those requiring further investigation.

Next Steps

- Expanding range of input variables
- Simulation tools to create synthetic rare training cases
- Productionising/Cloud deployment for real-time use

Summary

- PQ monitoring is critical but overwhelming
- AI and Human-in-the-loop methods can scale PQ analysis

Thank You

Questions?

Contact:

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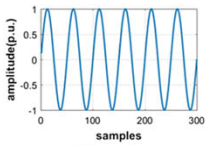
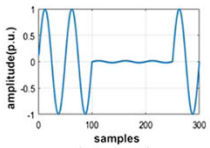
Background

- Why Power Quality matters?

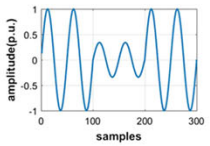
> *"[Power quality is] the concept of powering and grounding sensitive equipment in a manner that is suitable to the operation of that equipment."* – *IEEE Standard 1159-2019, IEEE Recommended Practice for Monitoring Electric Power Quality*



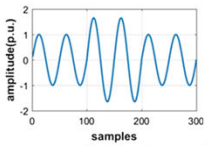
Normal



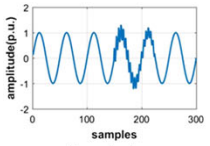
Interruption



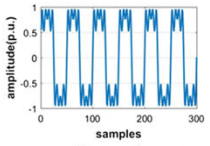
Sag



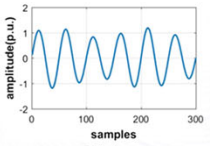
Swell



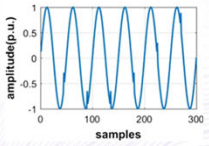
Transients



Harmonics



Flicker



Notching