Exploring Synchro-Waveform Data Analytics in Distribution Systems with Smart Meter Measurements

Lakshan Piyasinghe, Ph.D.
Hubbell Inc.

IEEE PES GM 2024
Panel: Synchro-Waveforms Data Analytics and Data-Driven Applications

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APPLIED ELECTRIFICATION RESEARCH

Outline

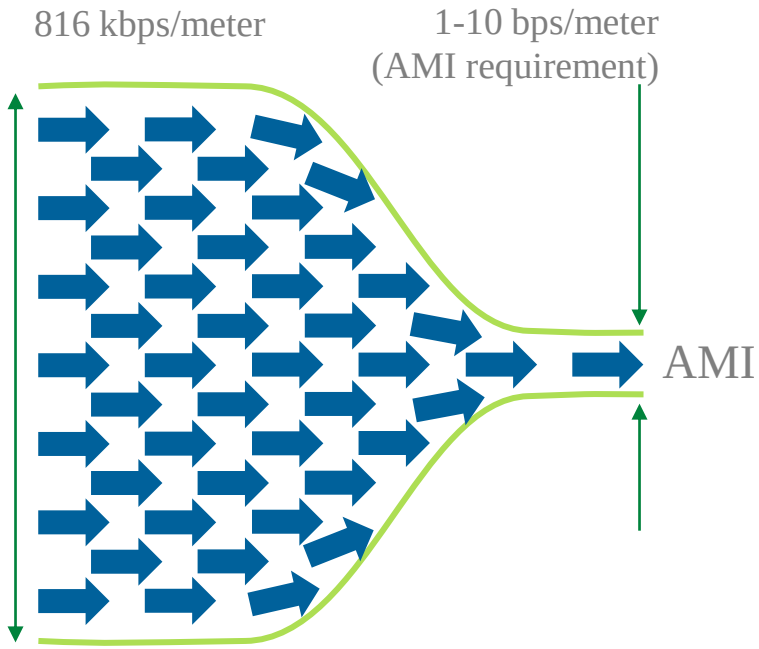
- Introduction to Next-Generation Smart Meters
- Why Use Smart Meters for Synchro-Waveform Capturing?
- Experimental Platform
  - Synchro-Waveform Capture in Low Voltage Circuits
- Real-Field Study
  - Underground Cable Faults
  - Back-feeding Events
- Conclusions and Future Work

Smart Meter Technology

Current technology

16 kHz/channel
3 channels/meter
17 bits/sample

816 kbps/meter



Next generation smart meters

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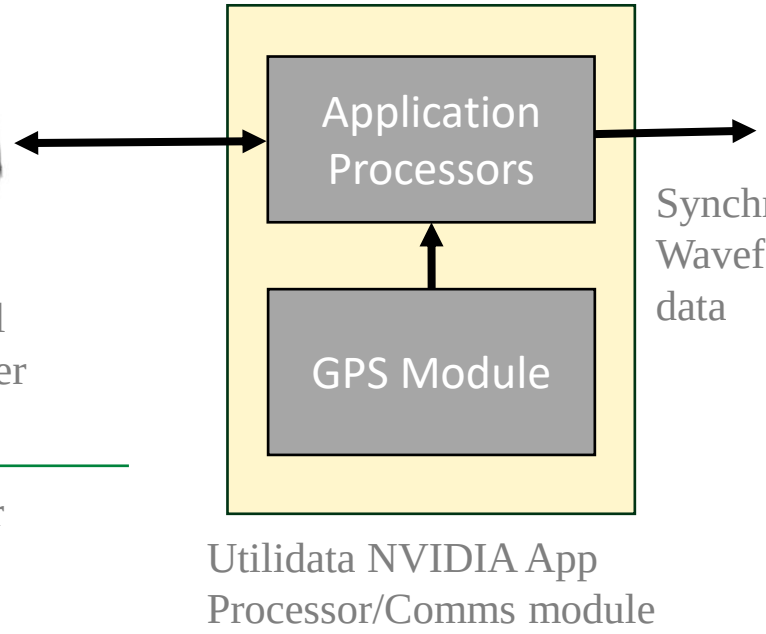
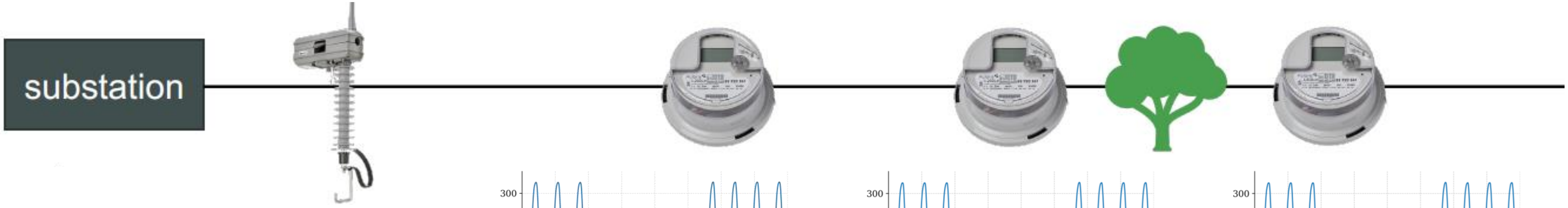
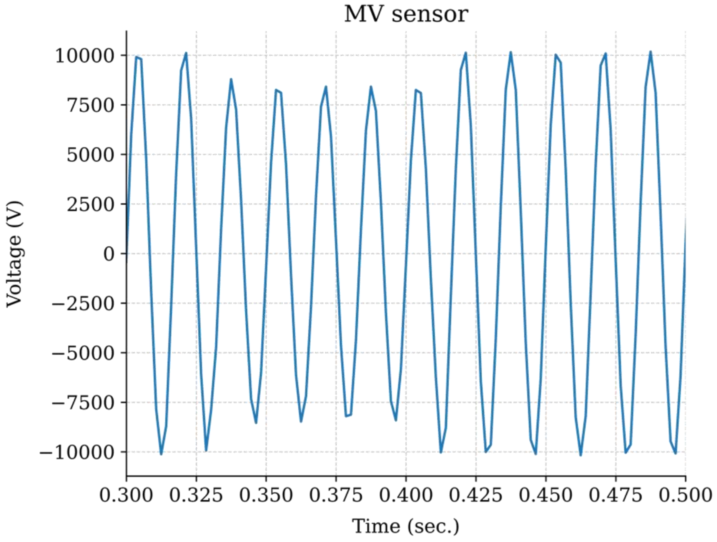


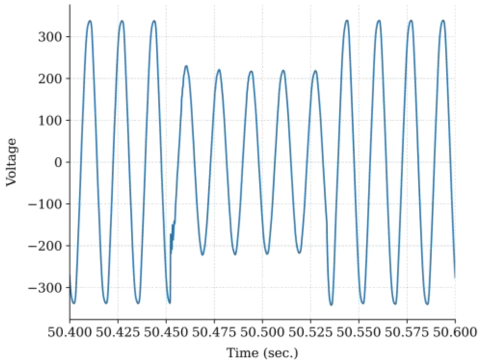
Utilidata NVIDIA App Processor/Comms module

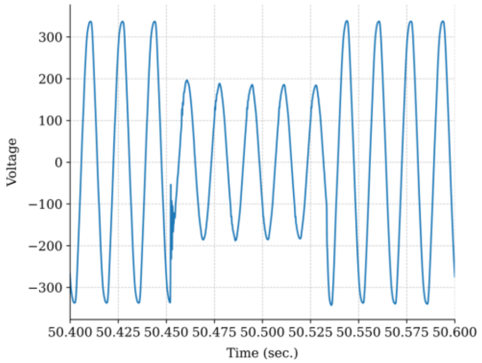
Why?

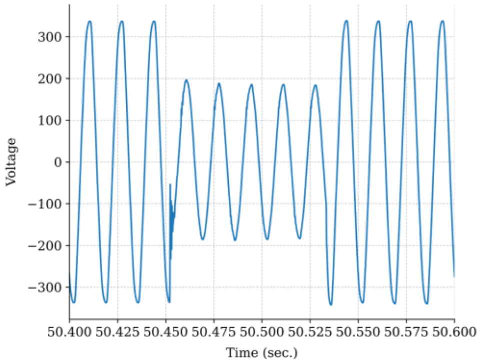
Synchro-Waveforms from Smart Meters









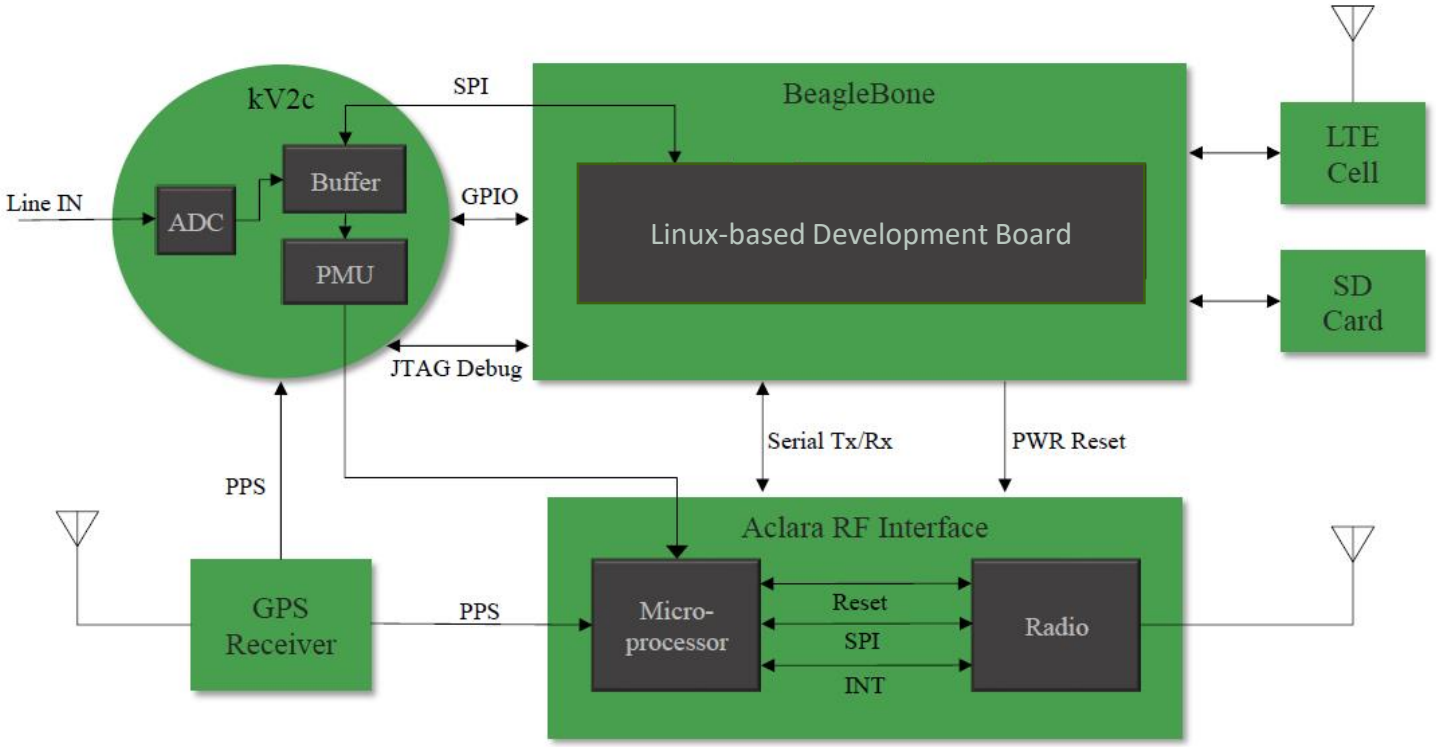


Most of the events happening on a distribution network can be observed through smart meter signal data.

Therefore, things happening in the distribution can be inferred from smart meter signal data.

Exploring the Future

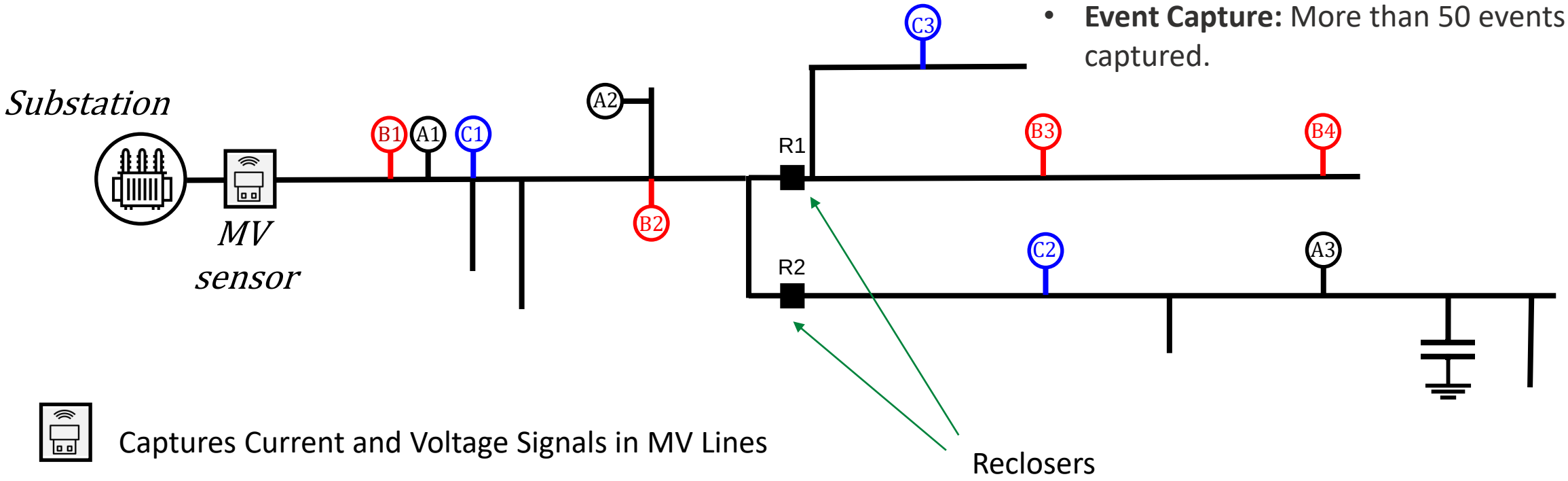
The Experimental Smart Meter Platform



A Field Experiment

A 7.2 kV distribution feeder in US

- **Feeder Length:** Approximately 3.5 miles.
- **Duration of Experiment:** Running for over 18 months.
- **Event Capture:** More than 50 events captured.



Captures Current and Voltage Signals in MV Lines

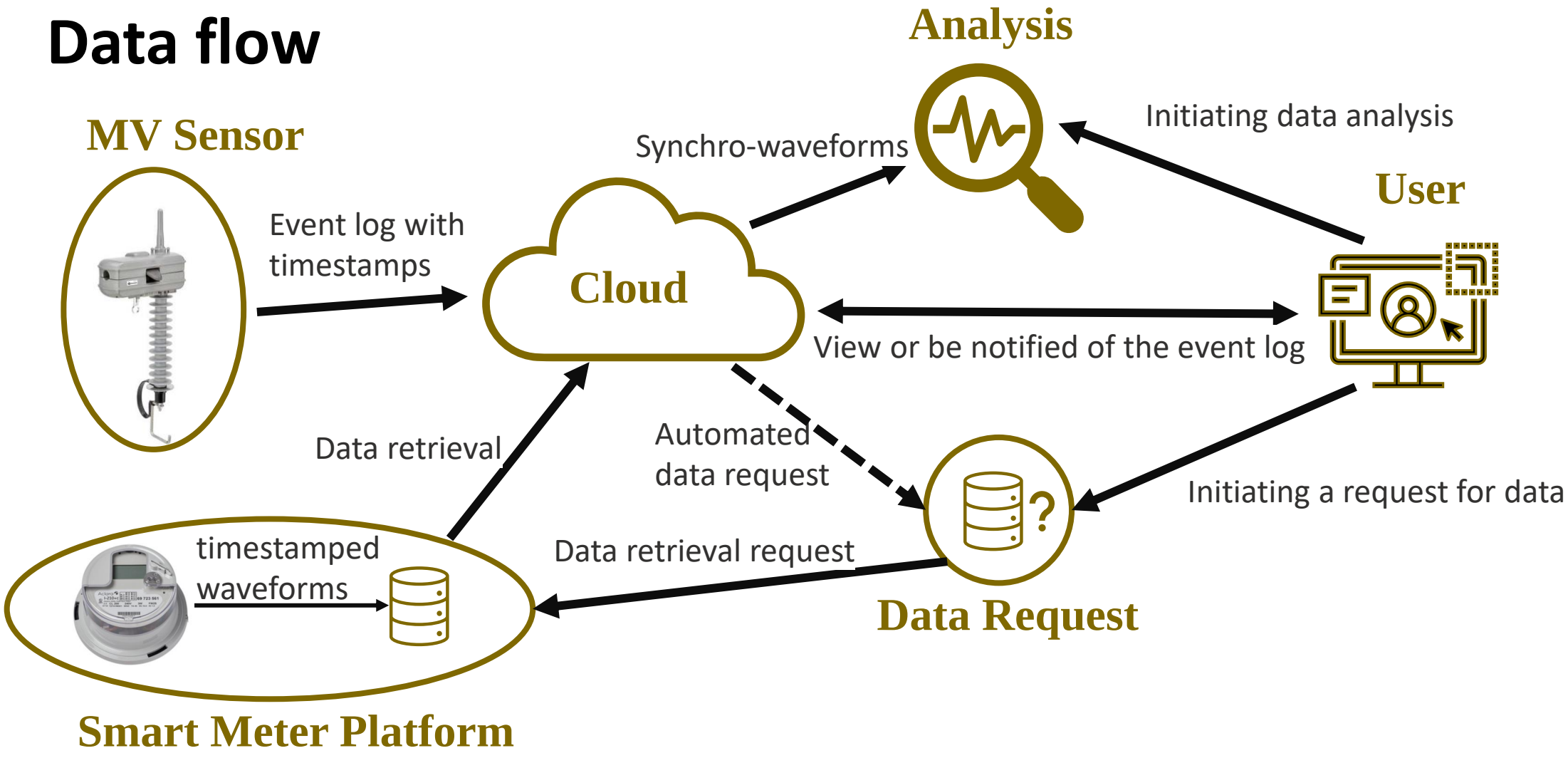
A_ A Smart Meter on Phase A Capturing LV Voltage

B_ A Smart Meter on Phase B Capturing LV Voltage

C_ A Smart Meter on Phase C Capturing LV Voltage

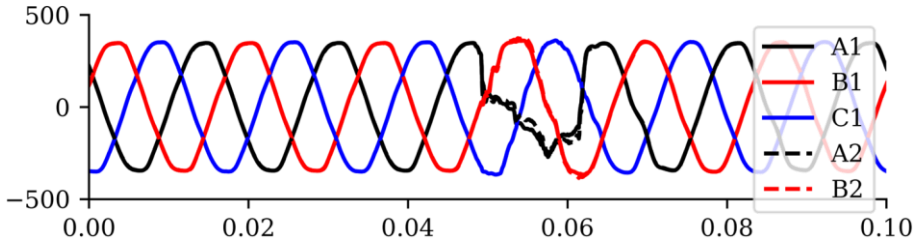
A Field Experiment

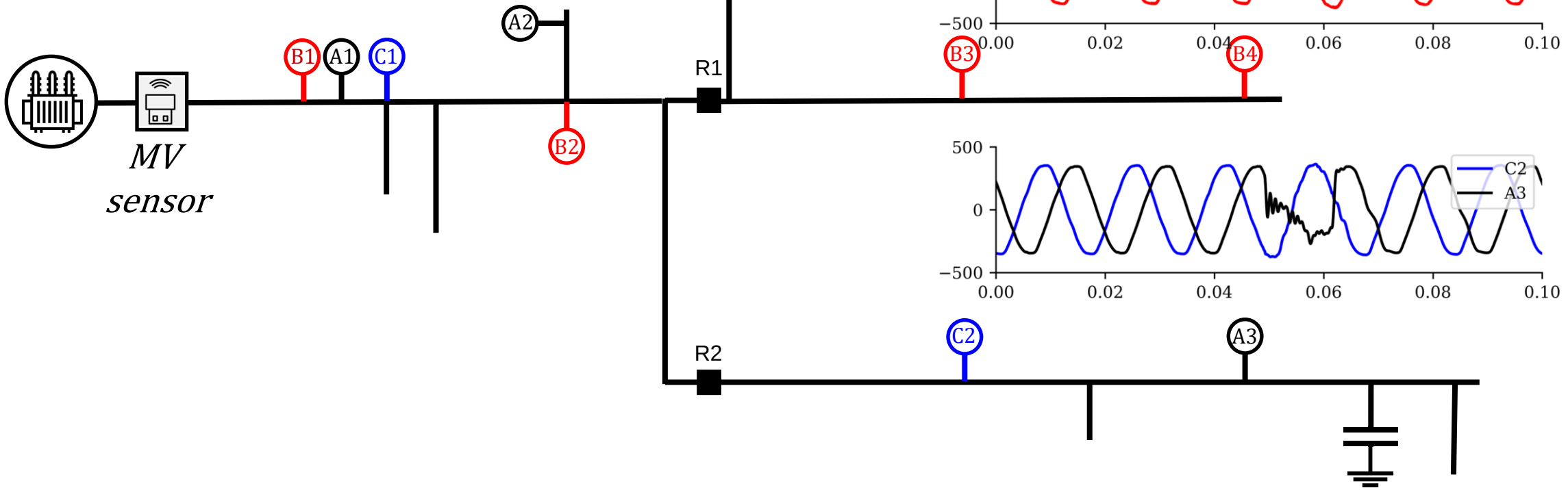
Data flow



An Underground Cable Fault

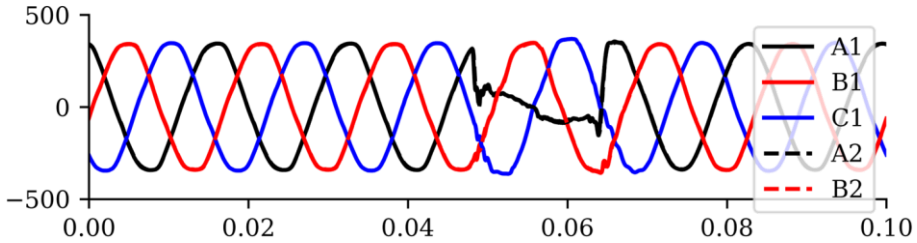
An Incipient Fault on 4/07/23

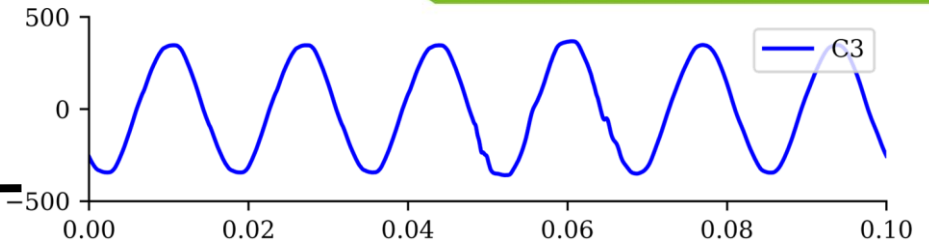


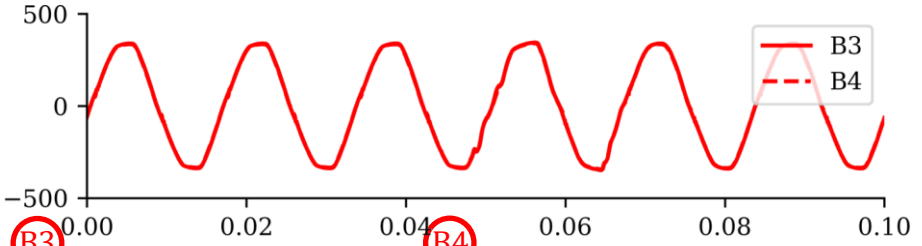


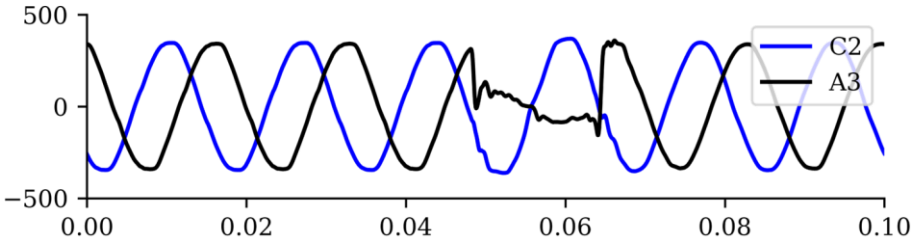
An Underground Cable Fault

An Incipient Fault on 4/27/23



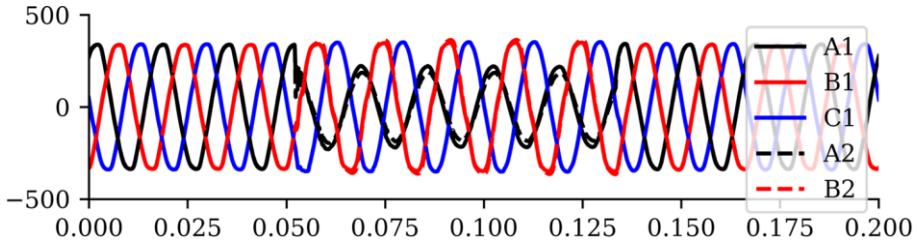






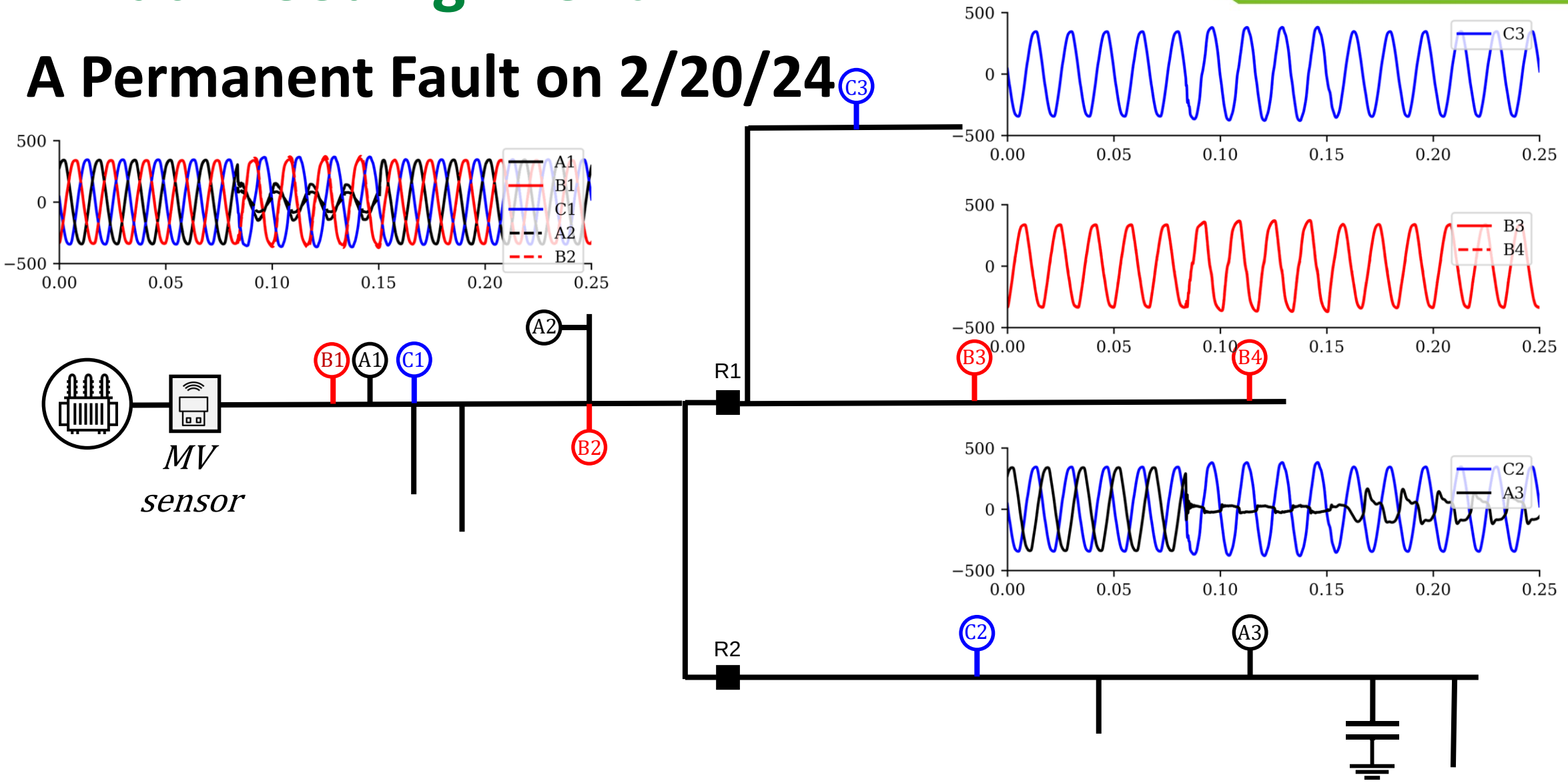
An Underground Cable Fault

A Permanent Fault on 4/29/23



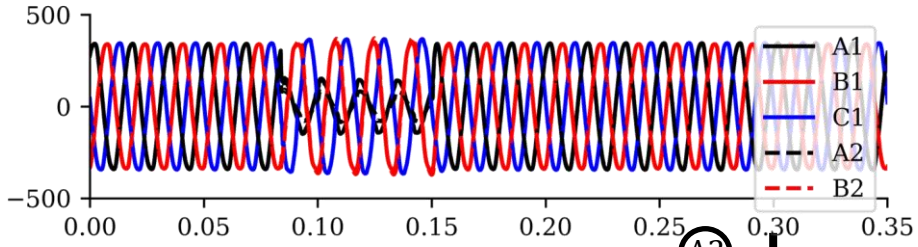
A Back-feeding Event

A Permanent Fault on 2/20/24



A Back-feeding Event

The Root Cause



- Single-Phase Recloser Operation with Downstream Three-Phase Load

Conclusions and Future Work

Conclusions:

- **Enhanced Capabilities:** Next-generation smart meters will have the ability to capture synchro-waveforms.
- **Improved System Insights:** These capabilities will provide deeper insights into identifying and locating issues within power systems without the need for additional sensors.

Future Work:

- **Algorithm Development:** Focus on developing algorithms to detect events directly from low voltage sensors, rather than relying on medium voltage (MV) line sensors.
- **Event Localization:** Identify key features to localize events, which will enable predictive maintenance and enhance system reliability.

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Thank You!

For more information:

Lakshan Piyasinghe
Staff Research Engineer
Email: lpiyasinghe@hubbell.com