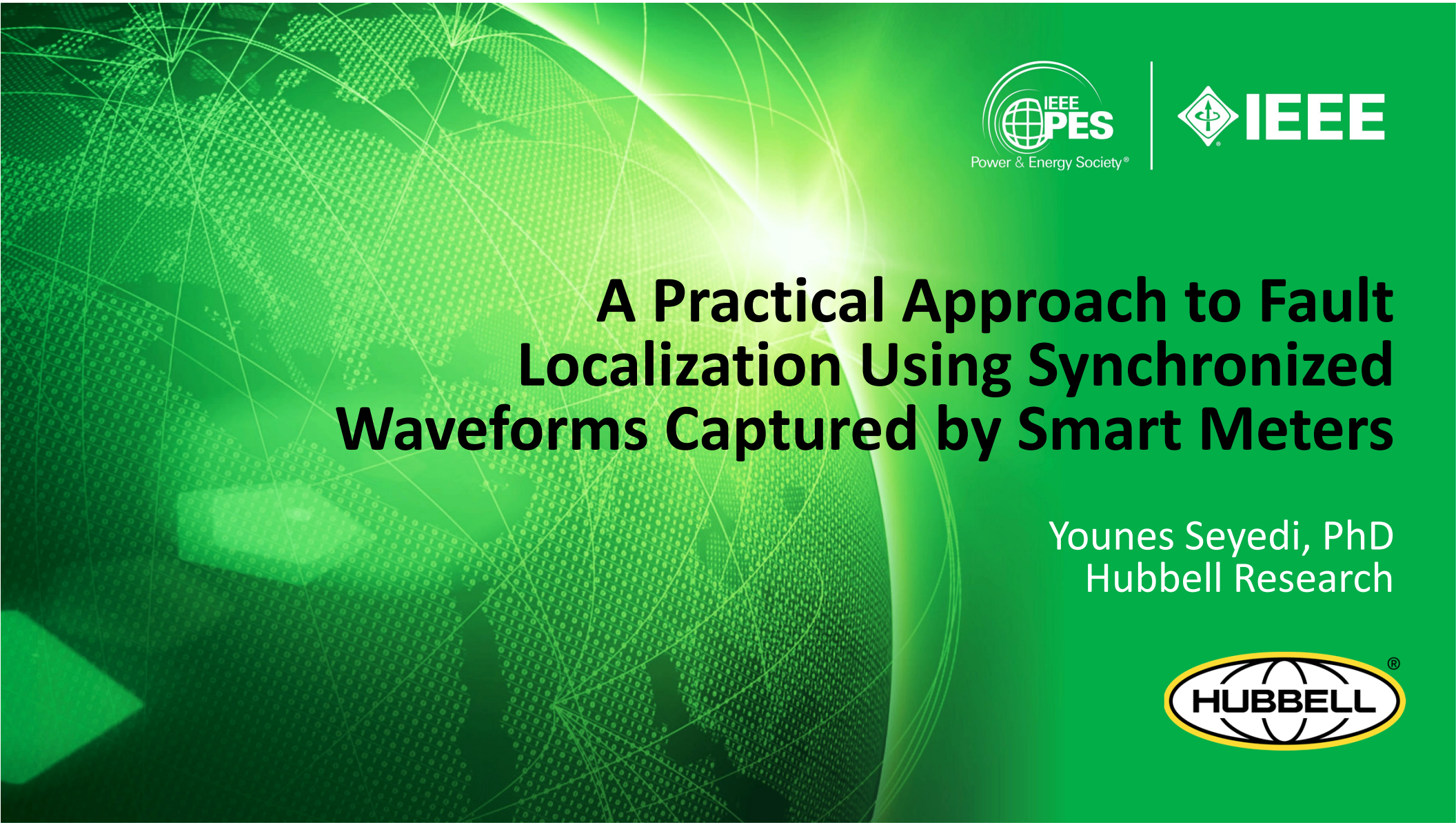


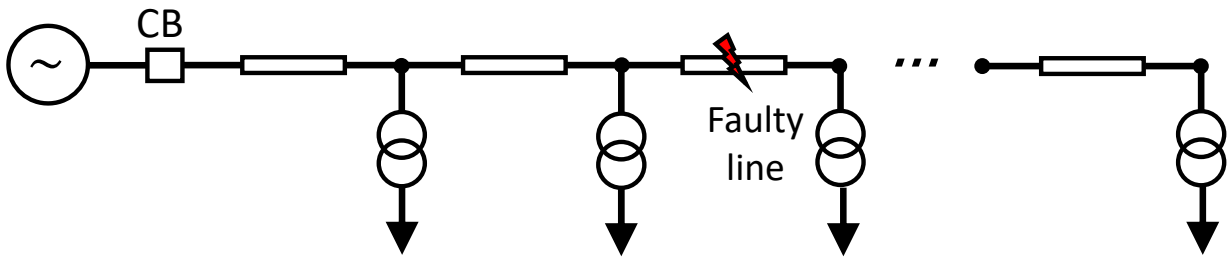
A Practical Approach to Fault Localization Using Synchronized Waveforms Captured by Smart Meters

Younes Seyedi, PhD
Hubbell Research

Faults

Localization Using Smart Meters

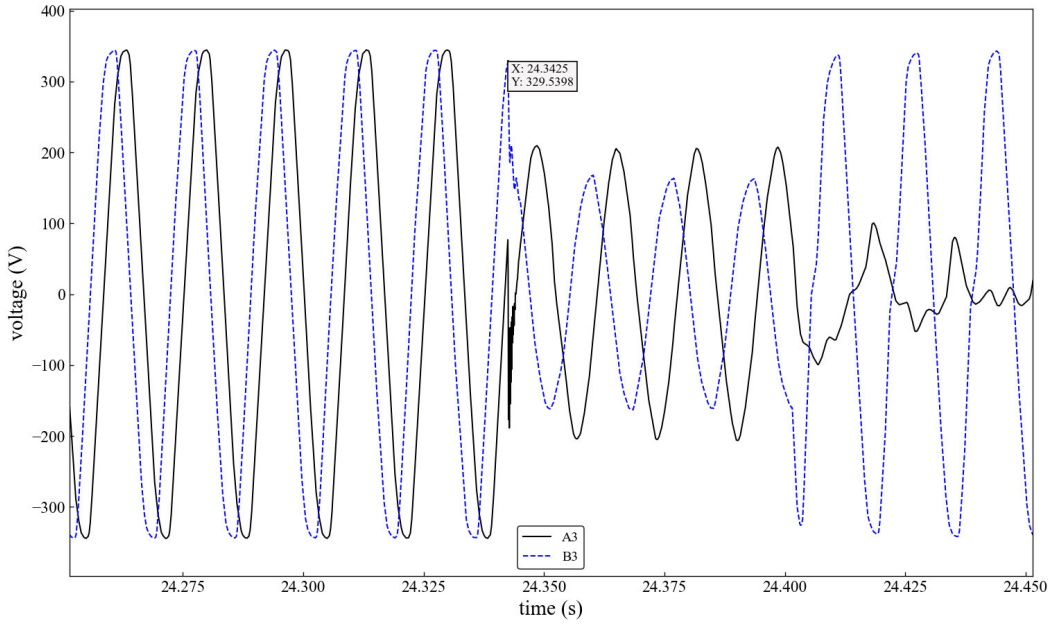
- Traditional and impedance-based localization methods have two drawbacks:
  1. They end up with multiple fault locations
  2. They need prior knowledge of the line impedance (lowers accuracy)
- Smart meters pave the way for practical methods to localize permanent/temporary faults:
  1. The localization app identifies which part of the feeder is closer to the faulty segments without prior knowledge of the line impedances. This leads to faster fault removal and shorter power outage
  2. Smart meters transmit the voltage waveforms for only a short period of time after the fault is confirmed



Faults

Voltage Waveform Captured by Meters: Case I

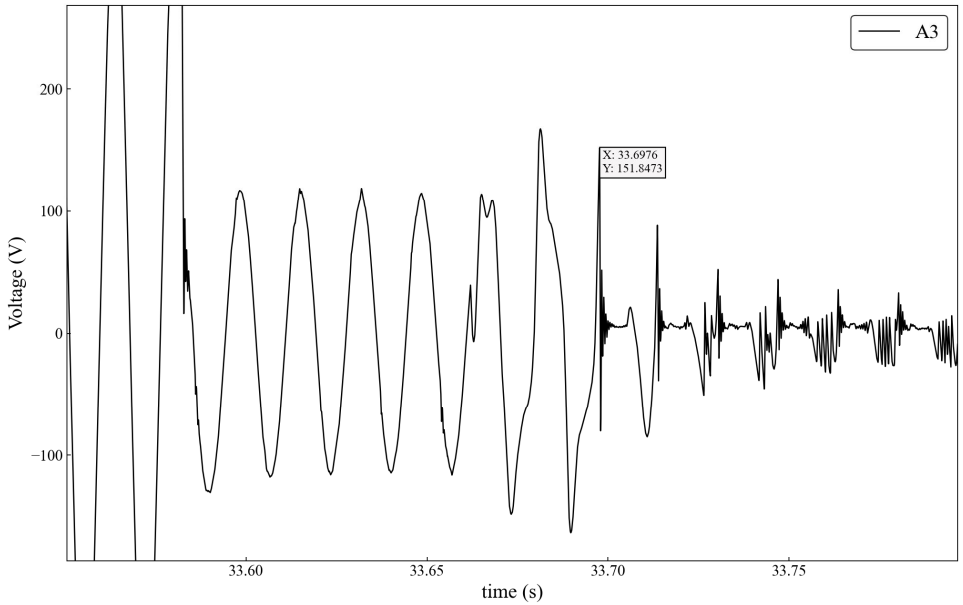
- Line-to-line fault on phases A,B
- Recloser trips on phase A : 60 ms after the fault inception



Faults

Voltage Waveform Captured by Meters: Case II

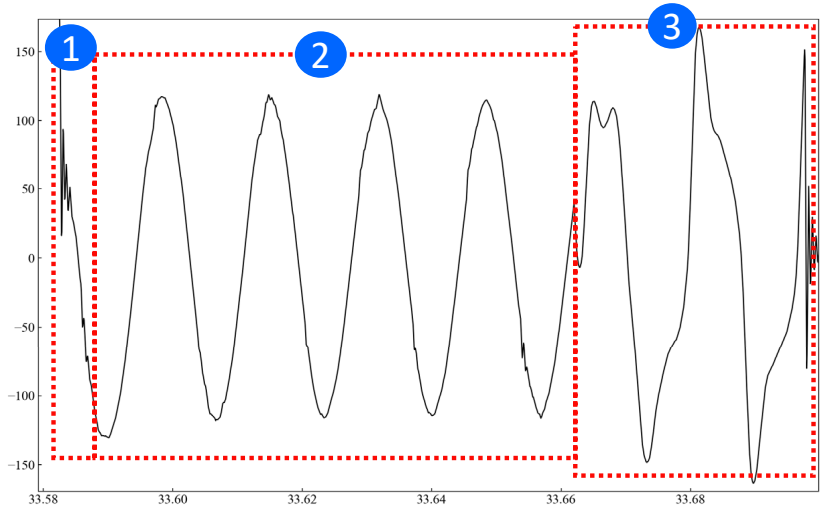
- Line-to-ground fault on phase A
- Recloser trips on phase A : 68 ms after the fault inception



Temporary/Permanent Faults

Sequence of Transient Events

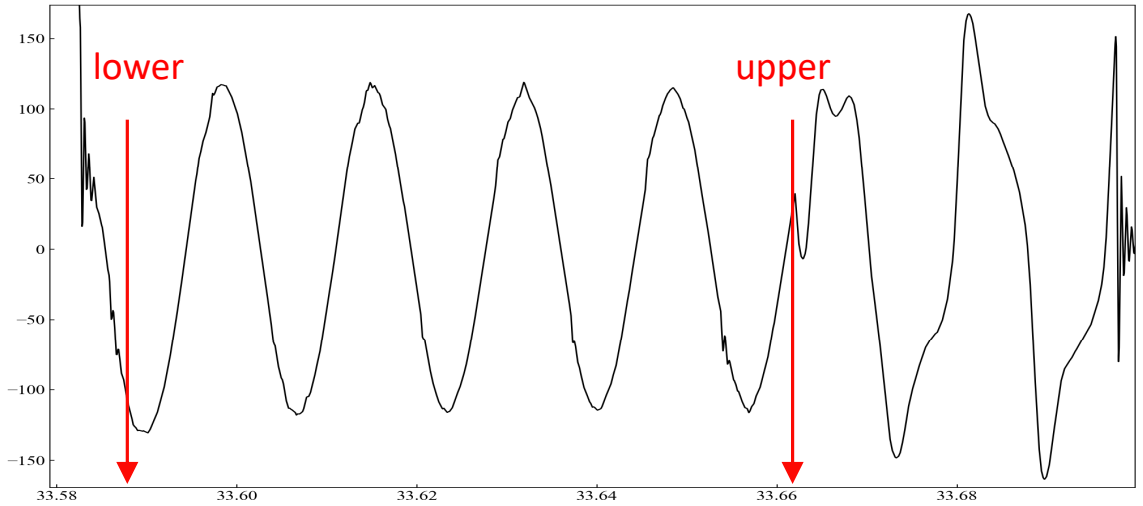
- In case of many temporary/permanent faults, the meters on the LV side observe a sequence of transients:
  1) Very high perturbation interval: immediately upon fault inception
  2) Stationary sag interval: starts shortly after the fault inception
  3) Restoration/collapse interval: starts upon circuit tripping when the voltage goes back to normal range or zero



Temporary/Permanent Faults

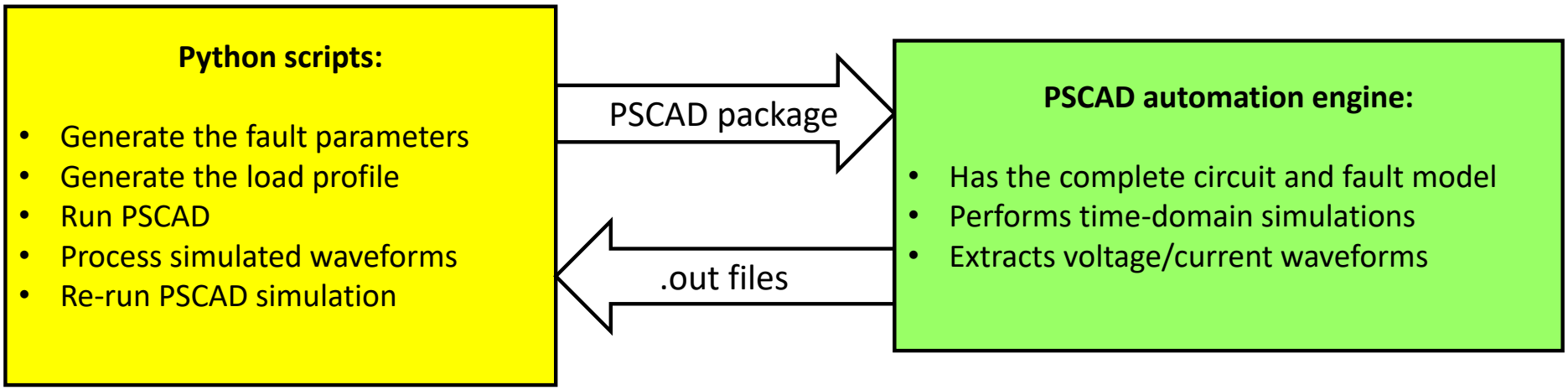
Stationary Sag Interval

- The stationary sag interval has lower harmonic distortion
- We can estimate the voltage magnitude for the fundamental component (i.e., 60 Hz) with better accuracy
- The lower and upper boundaries of this interval depend on the fault properties as well as other circuit parameters



Fault Simulation Framework

Building Datasets for Performance Assessment

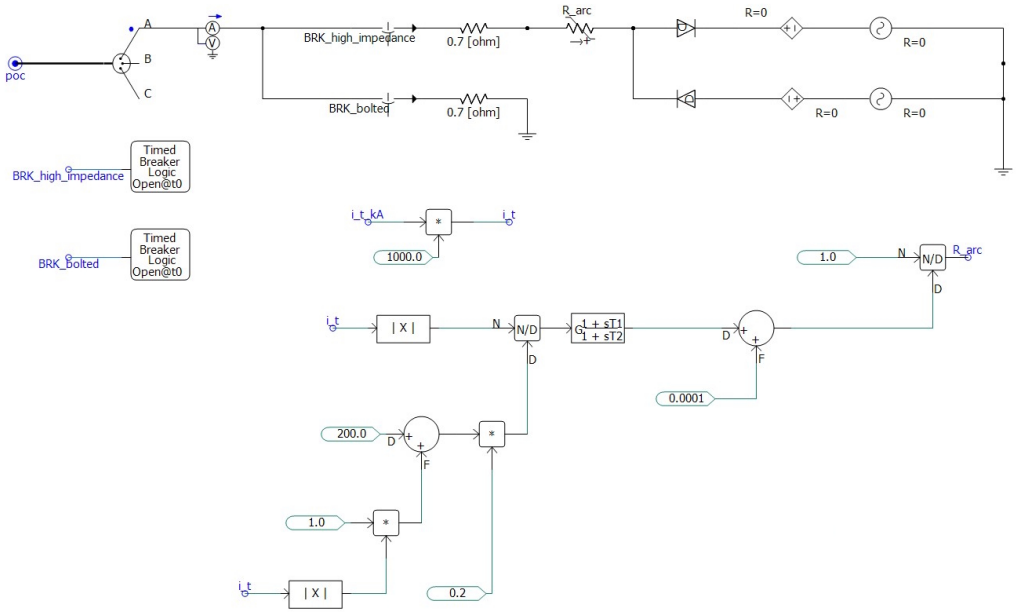


- Since real-world experiments are not feasible, a fault simulation framework generates the voltage/current waveforms and helps to study features/signatures for different types of faults under more realistic conditions and for a wide range of fault properties

Fault Simulation Framework

Fault Modeling

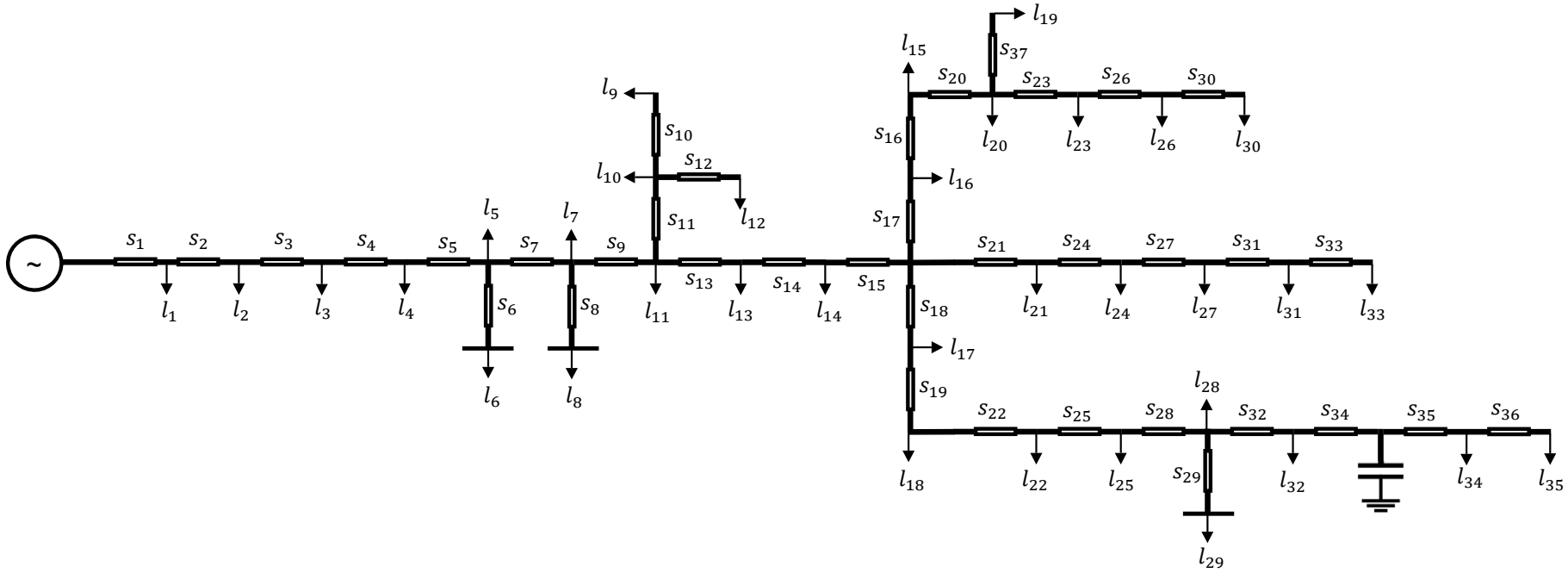
- In real-life, the fault properties, e.g., resistance, duration, inception angle, and location are random
- Depending on the fault type, arcing may repeatedly emerge and extinguish producing more complicated non-linear relationship between voltages and fault currents



Fault Simulation Framework

Benchmark Network

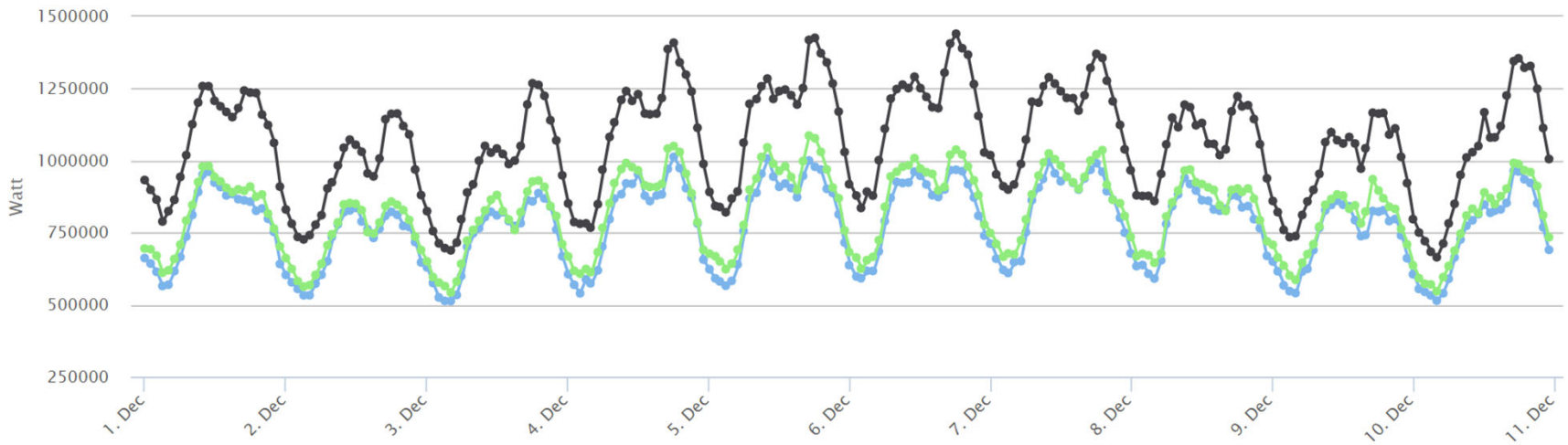
- This 35-Bus distribution system model derived for a real feeder and implemented in PSCAD
- The actual feeder is operated by a Hubbell customer in the US: employes 10 LV meters + 3 MV line sensors



Fault Simulation Framework

Load Profile

- MV line sensors at the feeder head measure the active/reactive powers flowing in each line
- These measurement help us to obtain rough estimates of the lower and upper bounds for load demand

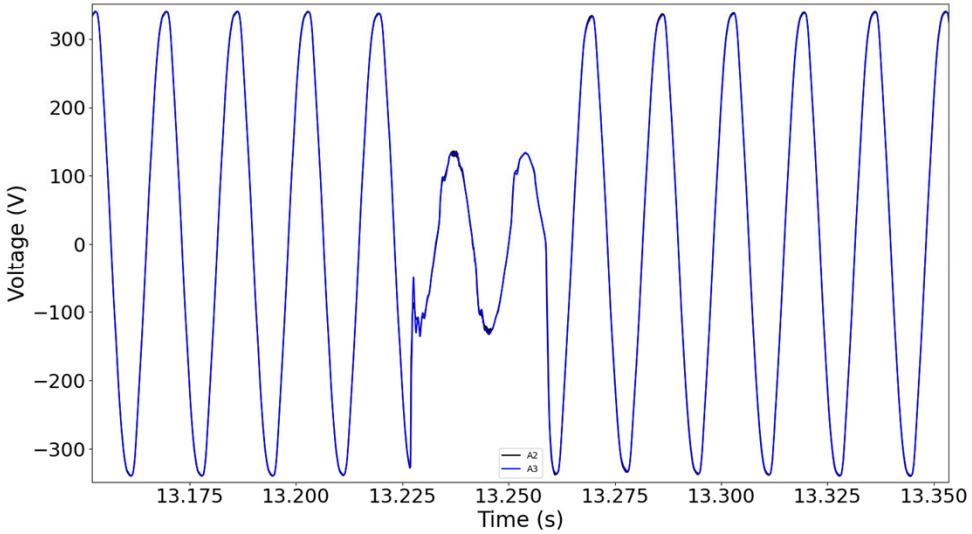


Fault Simulation Framework

Empirical & Simulated Waveforms

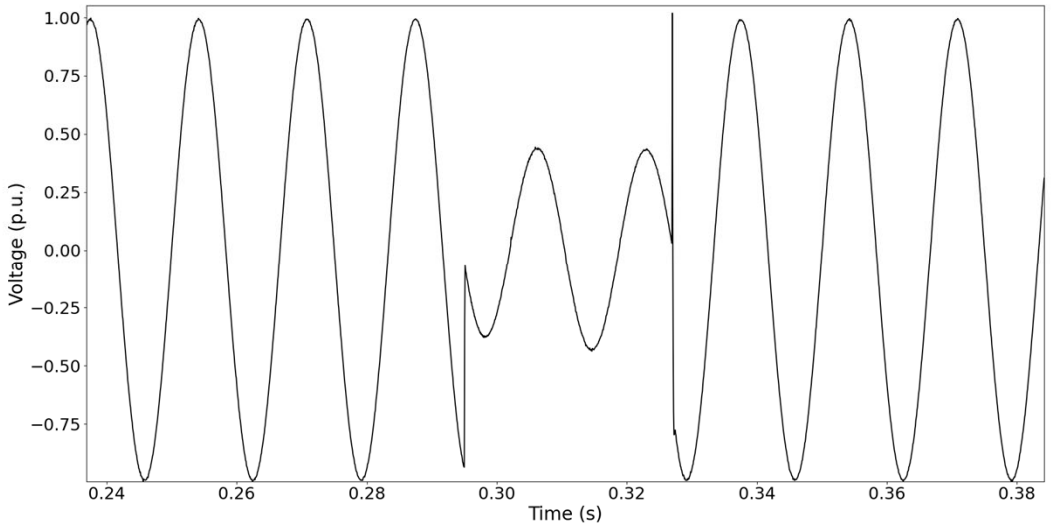
Temporary fault on phase A captured by smart meter

Date, time: 2024-06-11, 12-49



Simulated fault on phase A at the line segment s36

Arc length = 0.2 cm , fault duration = 32 ms



Thank You!

yseyedi@hubbell.com