Point On Wave Applications (POWA) Conference

Flicker Detection with Optimized Continuous Point-On-Wave (CPOW) Monitoring and Data Visualization

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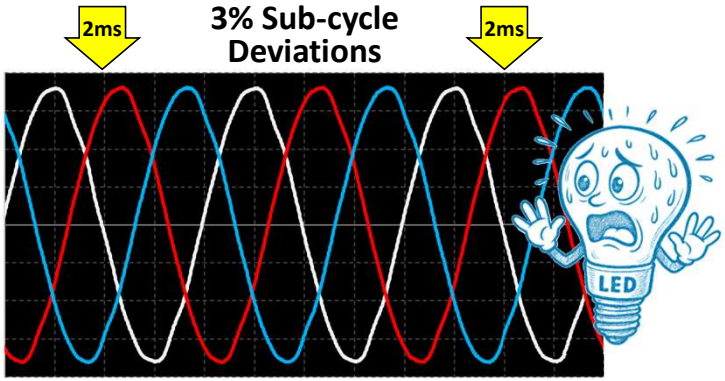
EPRI
Power Quality Monitoring and Data Analytics

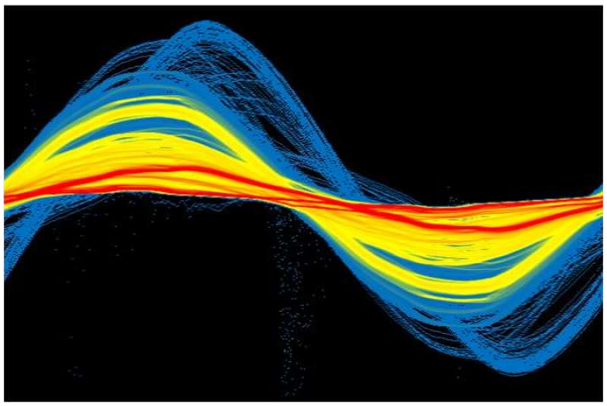
October 2025

Why we need Point-on-Wave

Why Point of Wave (PoW)

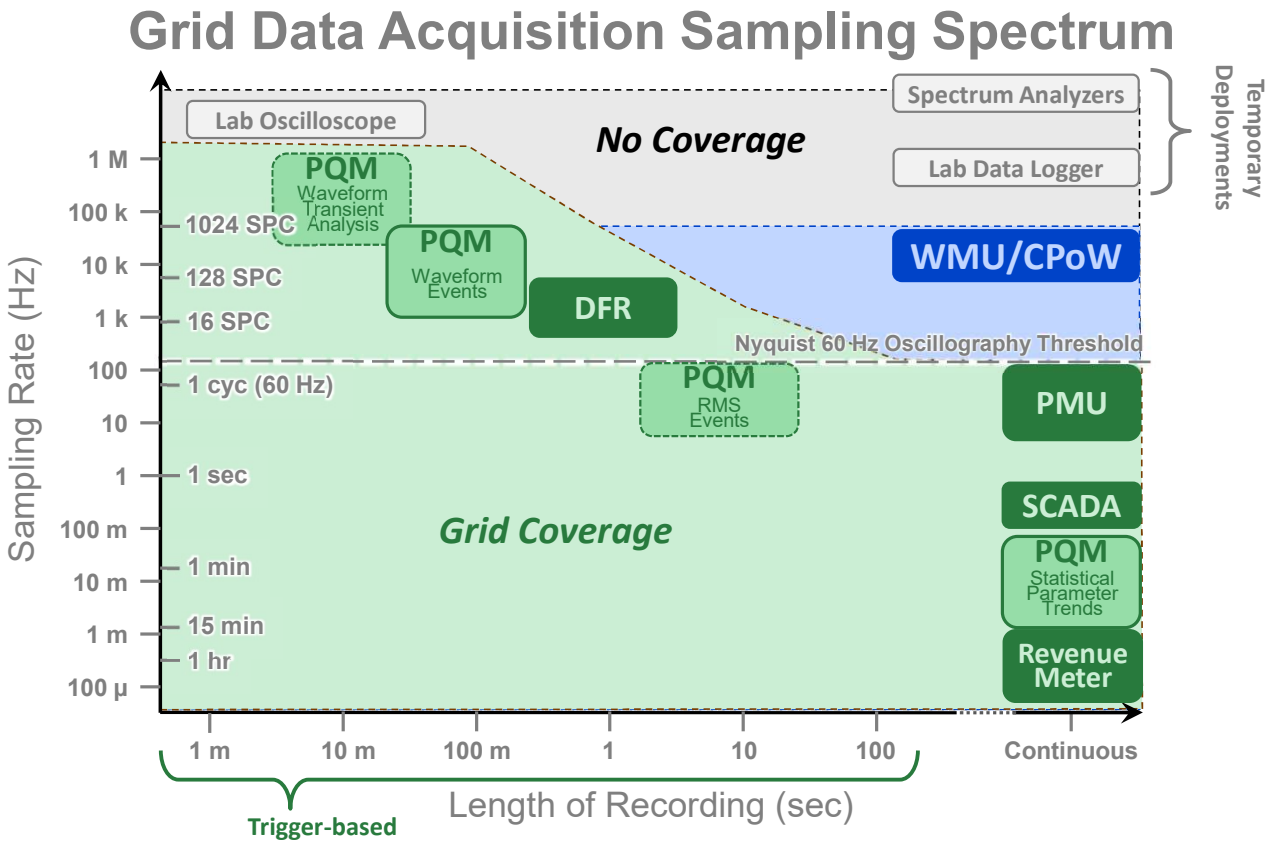
- Growing grid/load sensitivities
  - Subtle Sub-Cycle Deviations
- Incipient and high-impedance fault detection
  - Need better fault-anticipation capability.
  - Need increased knowledge of anticipatory fault signature models.
- Better understanding of Known and Unknown waveshape variations.
  - Statistical Process Control (SPC) for the product utilities create… 5-million-plus voltage-cycles per day.





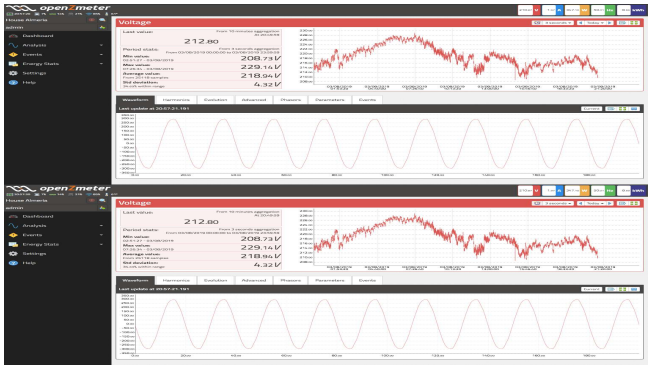
PoW Fills a Gap in Grid Data Acquisition?

- Traditional grid data acquisition (Grid-DAQ) is limited to data length and density/sampling.
- Power Quality monitoring (PQM) has recently filled gaps in this space with higher-fidelity waveform recordings than traditional DFRs and more numerous PQ trend parameters for continuous recordings.
  - There is an area between nominal voltage and triggered recording (typically 10% change threshold) that abnormal waveform variances are being missed by typical PQ monitors. There are possible signatures that can be captured and give PQ engineers early warning to imminent failures.
- PoW fills a gap in the upper-right quadrant of sample-rate vs recording-length.
- We intend to share lessons learned from EPRI field investigations and research using portable high-fidelity measurement equipment for collecting, analyzing, and presenting continuous waveform data.

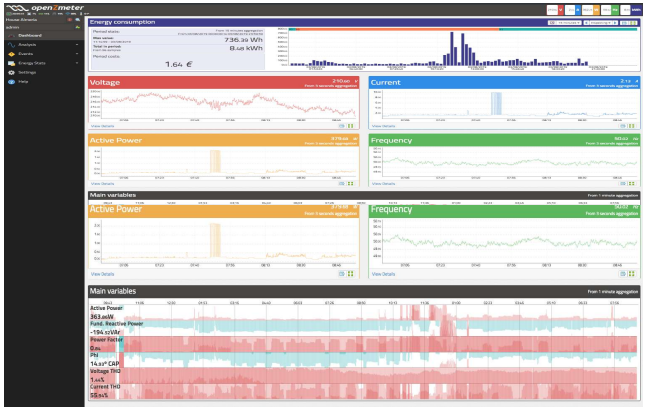


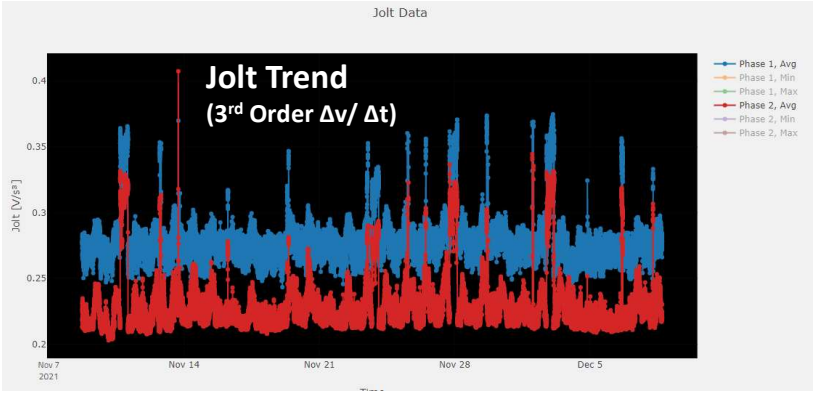
PoW Use Case

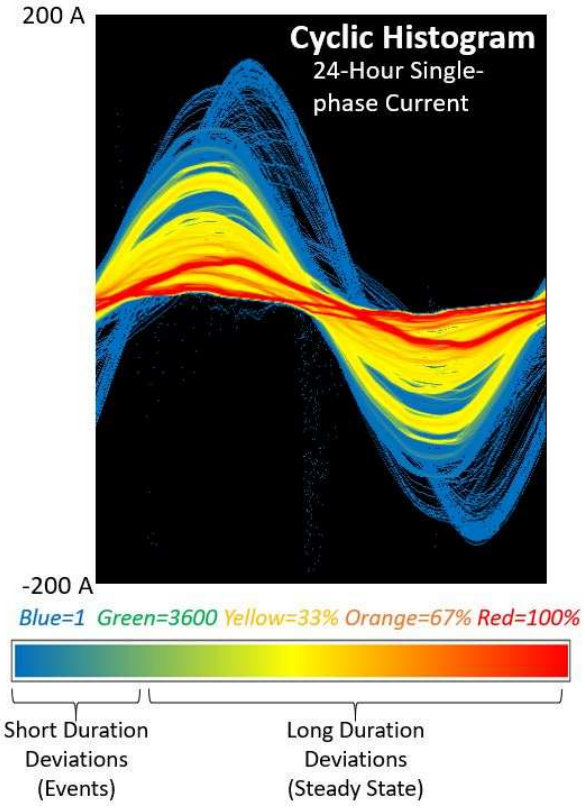
EPRI Research with Waveform Streaming



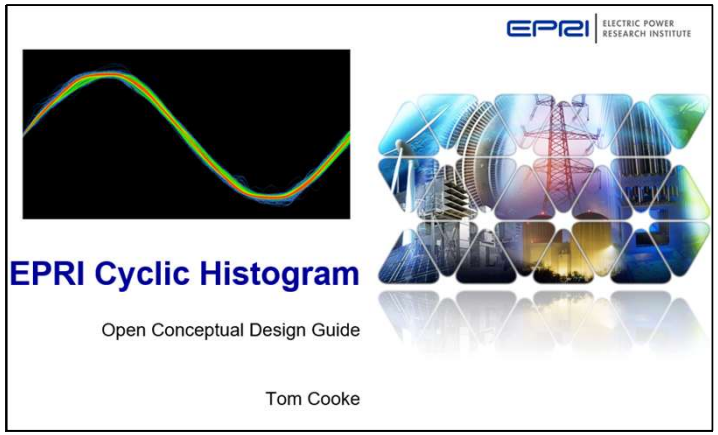
OpenZmeter







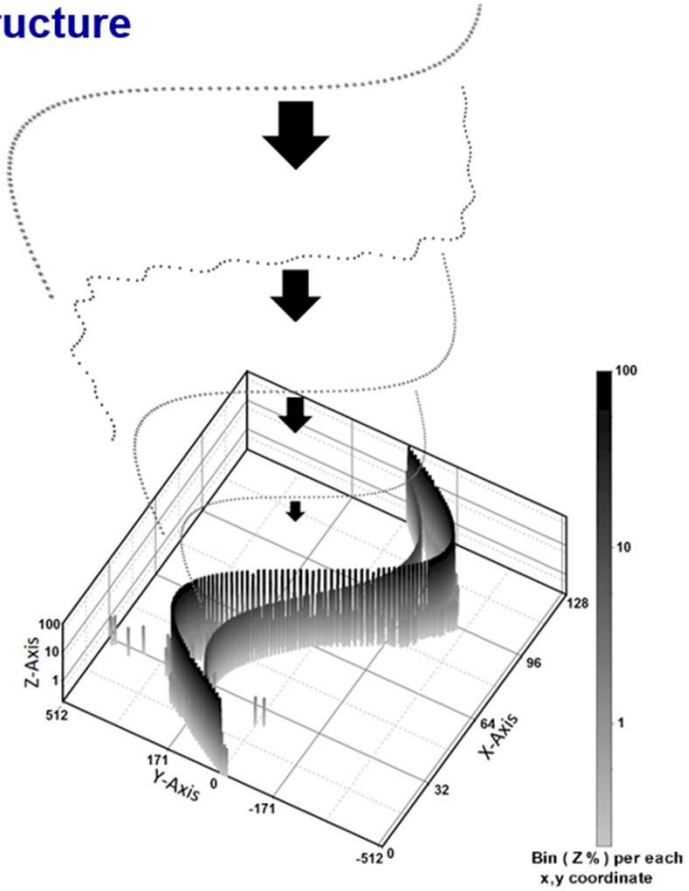
Cyclic Histogram



Basic Cyclic Histogram Structure

This Cyclic Histogram method is a three-dimensional representation of many continuous cycles of historical current or voltage waveforms in a one-cycle view.

The X and Y axes make up a given matrix of bins for a stack of Z values to be established. As a given X sample is selected, the Y value is measured and placed in the corresponding bin. The number of bins is determined by horizontal and vertical resolution.



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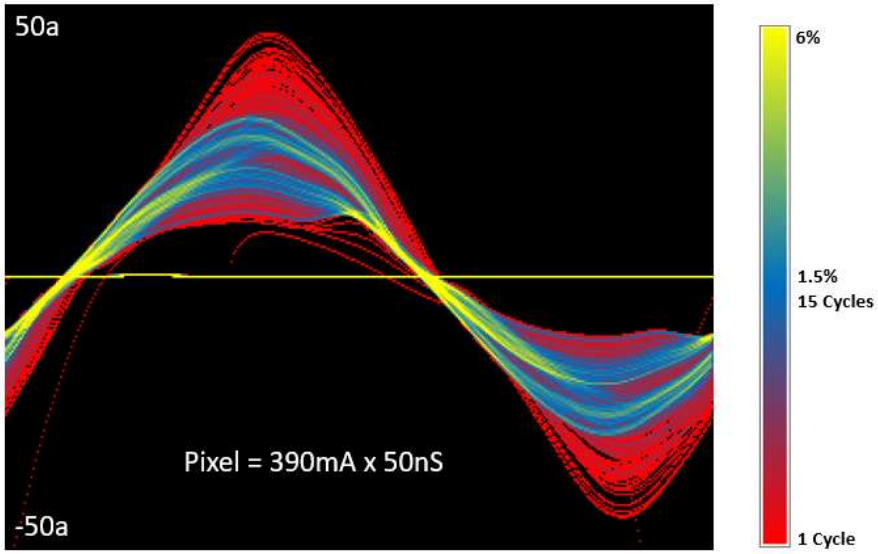
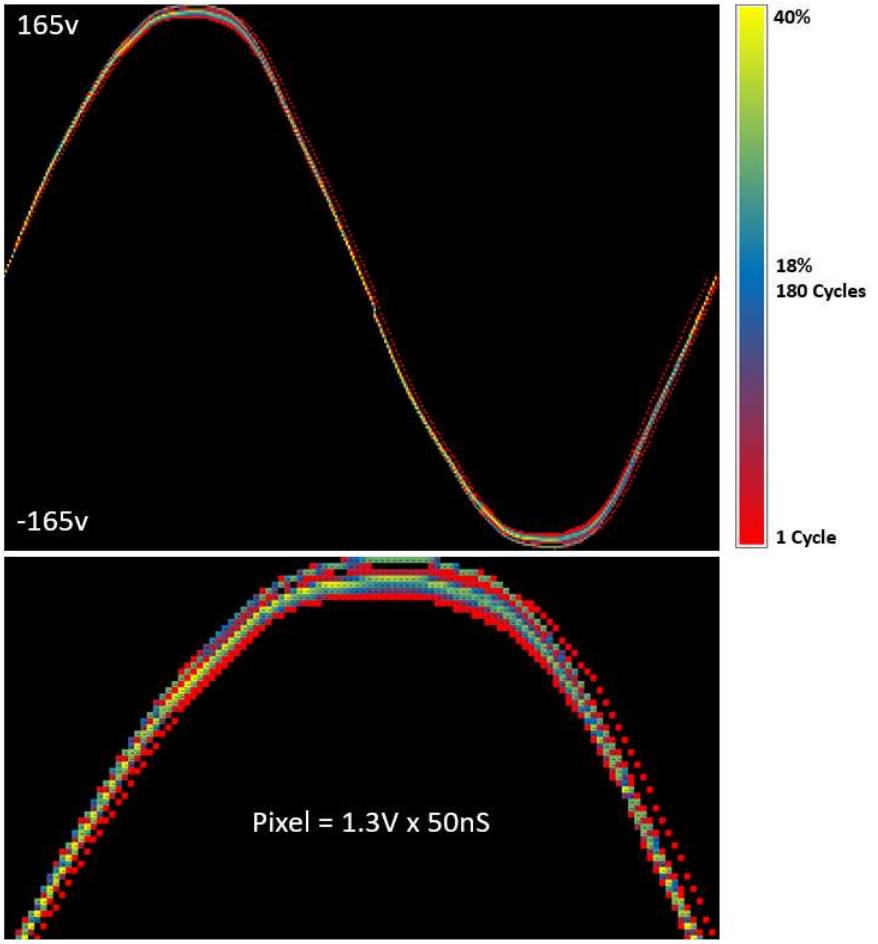
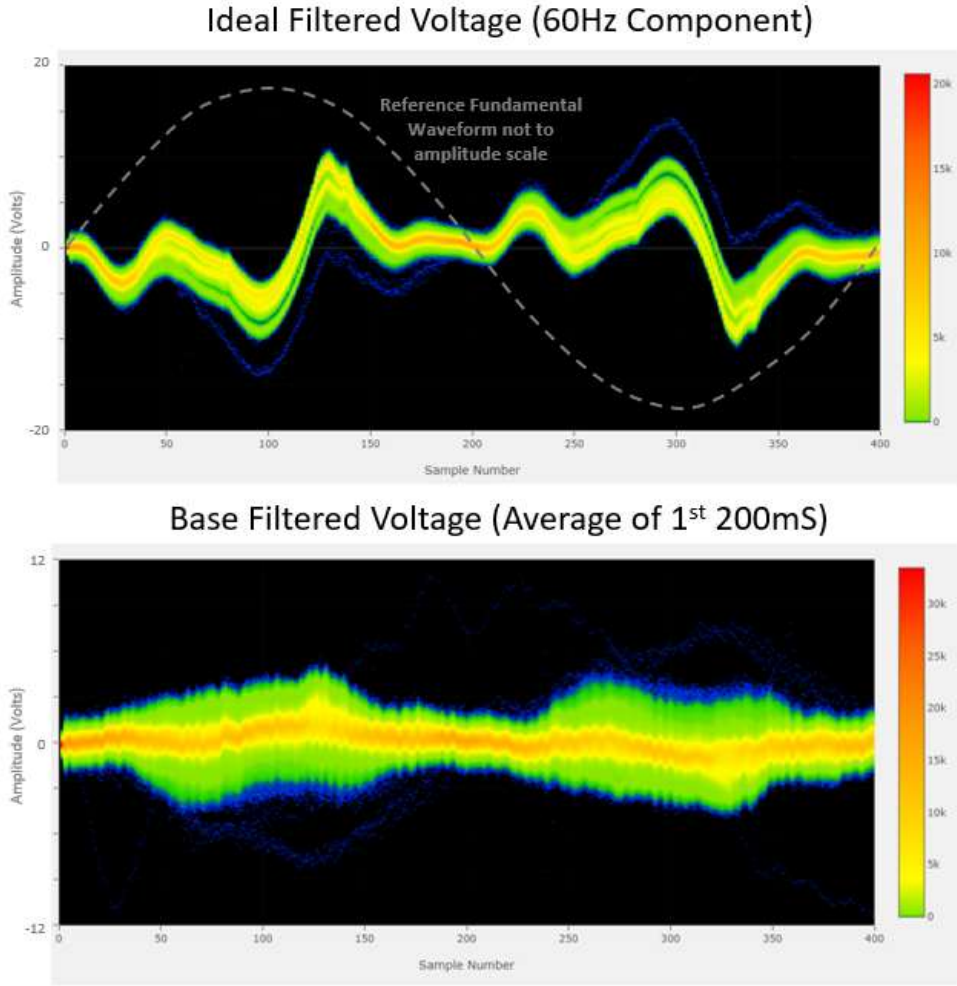
Maximizing Bin Space for Histogram



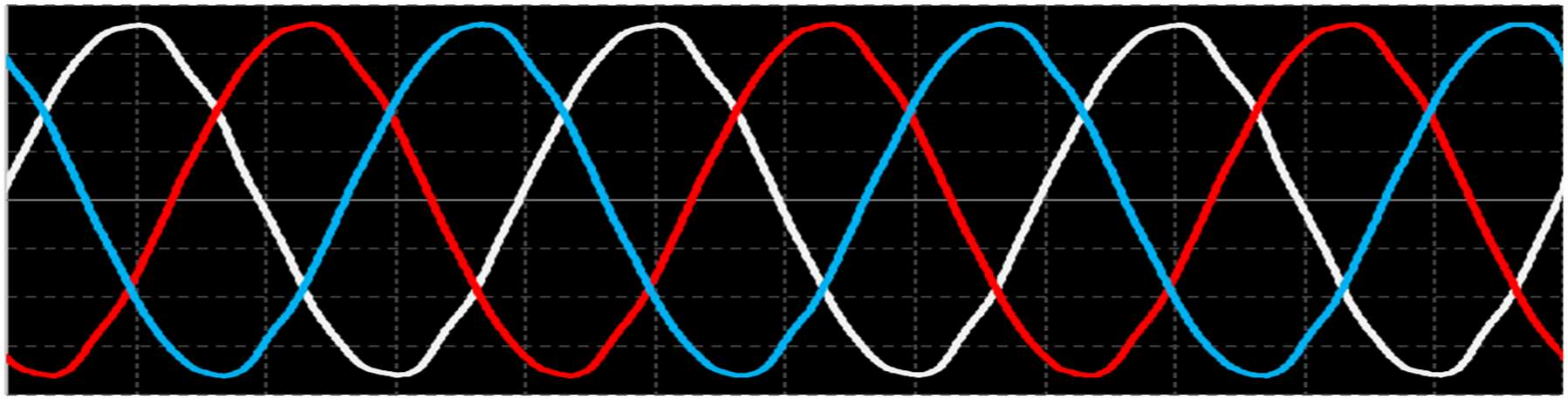


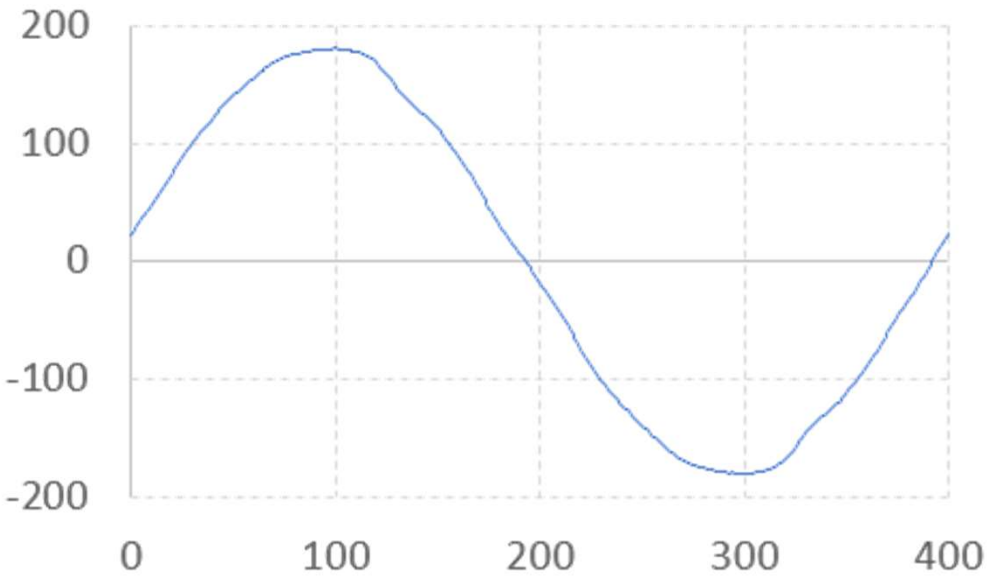
Maximizing Bin Space for Histogram

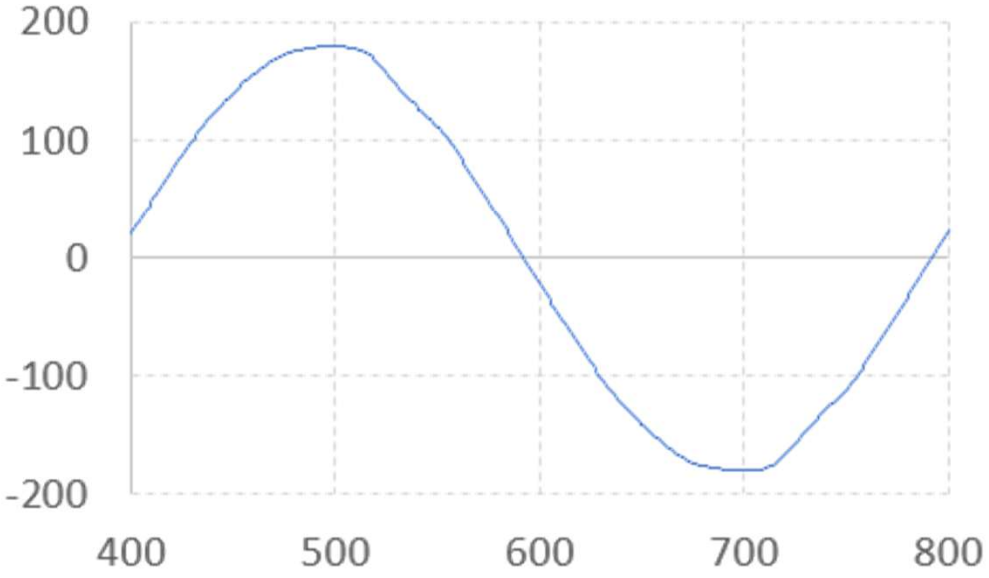
- Adding filtering to voltage waveform (Ideal, and Base)
- Adds more deviation resolution
- Ideal filters fundamental only
- Base filters the nominal waveform from a select period



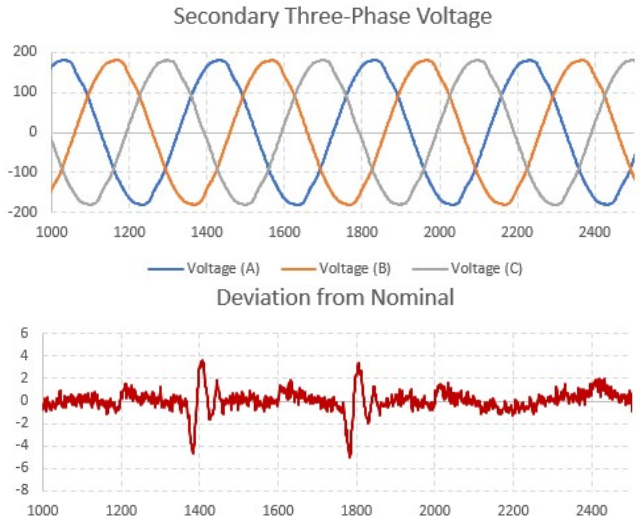
Tracking a Flicker Source

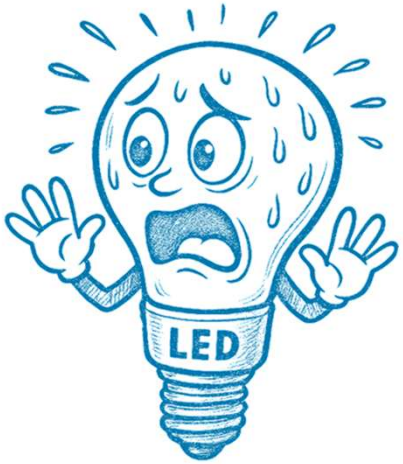


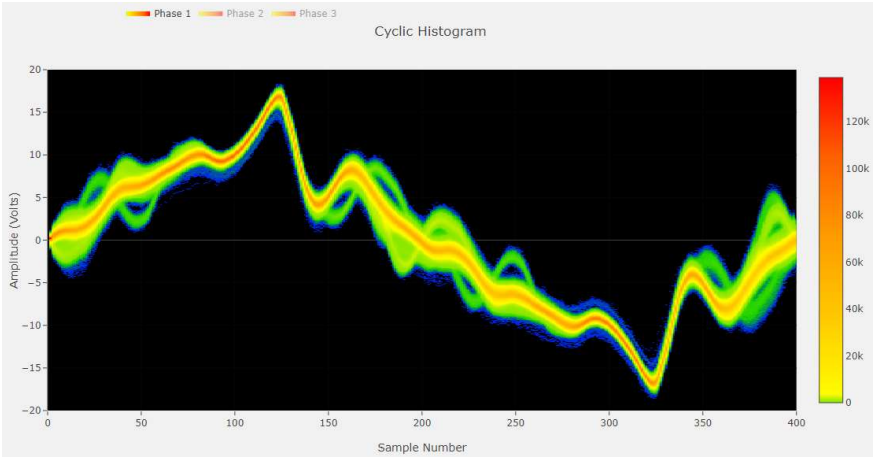


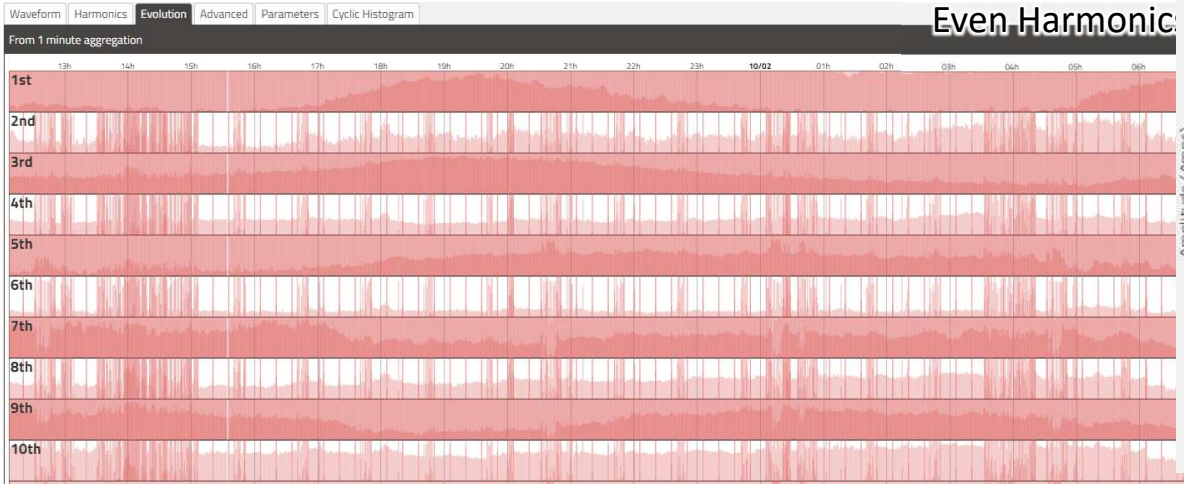


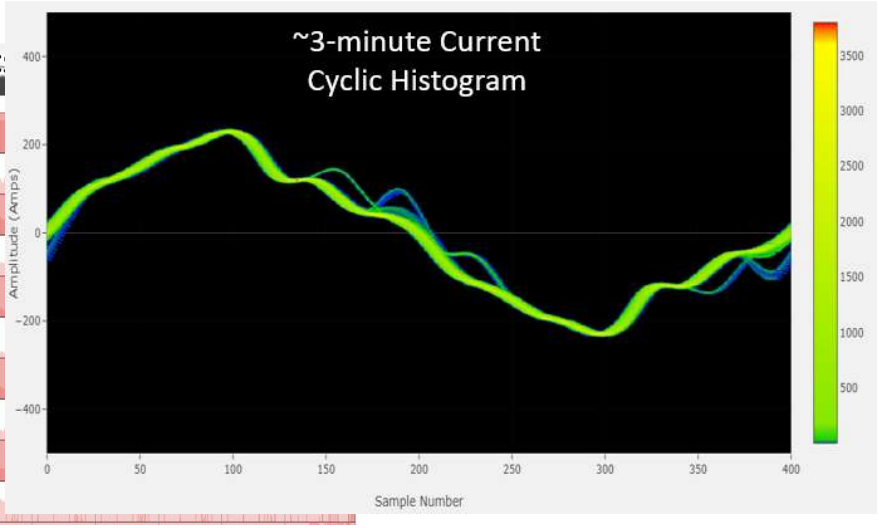
Sub-Cycle Subtle-Deviation Causing Flicker



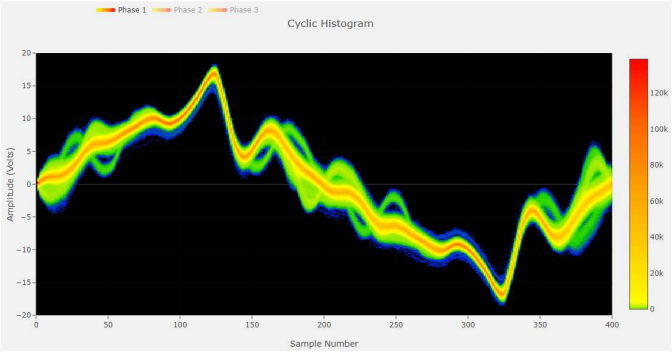


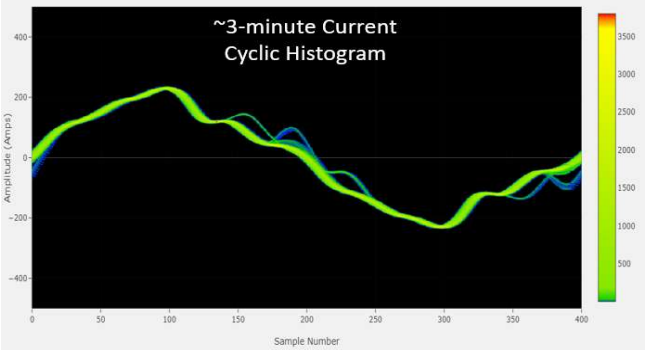


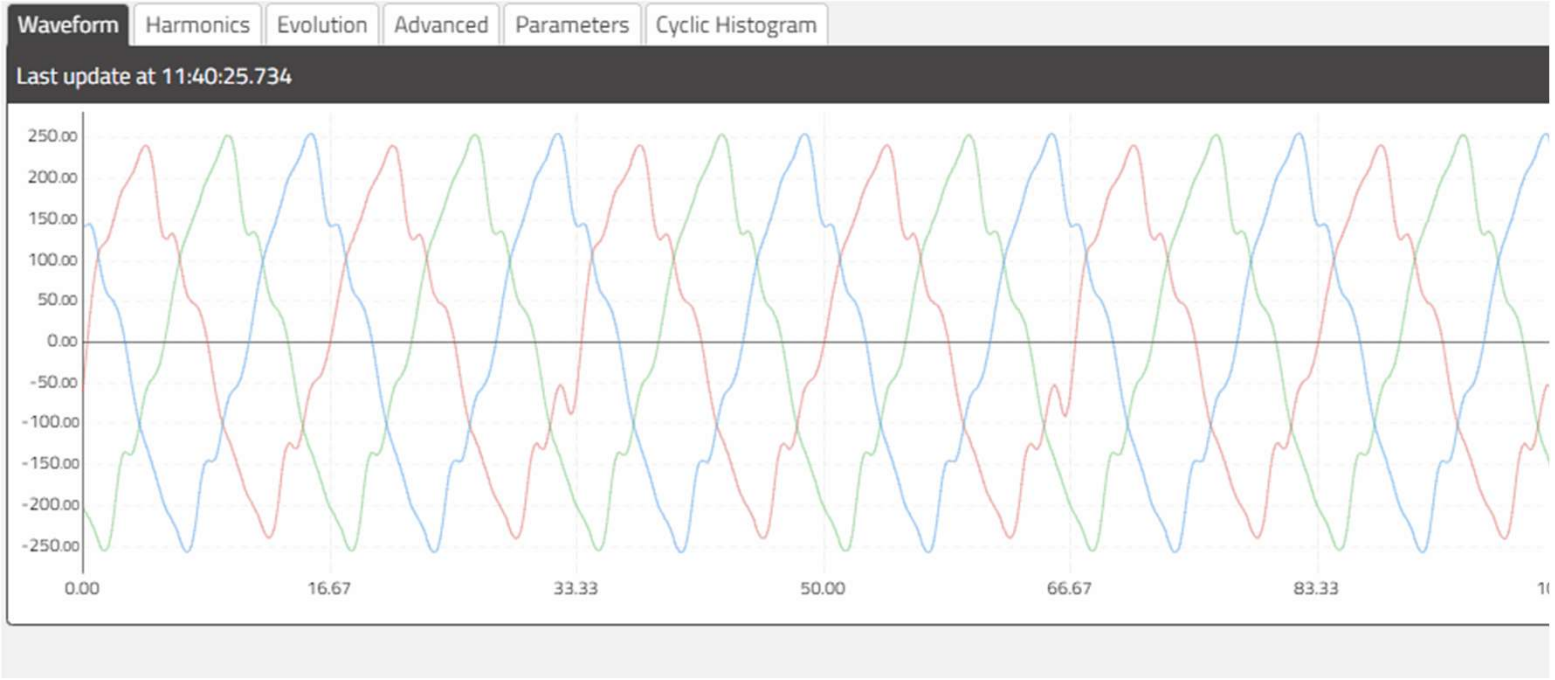




Tracking a Flicker Source

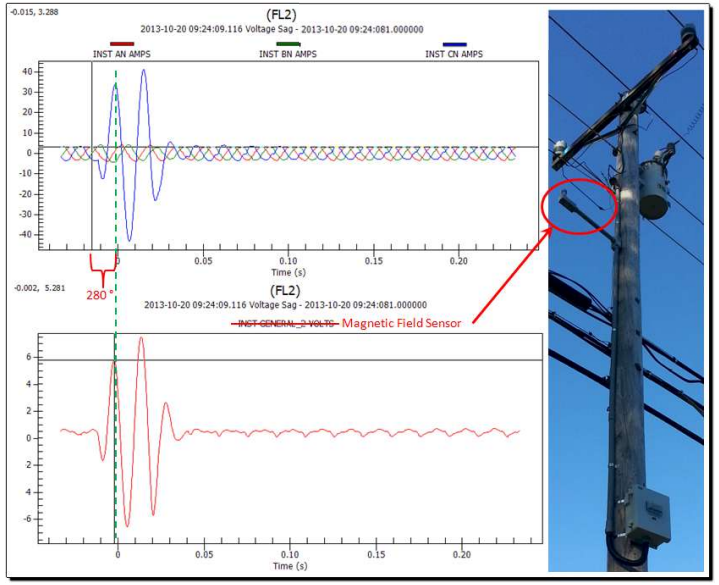


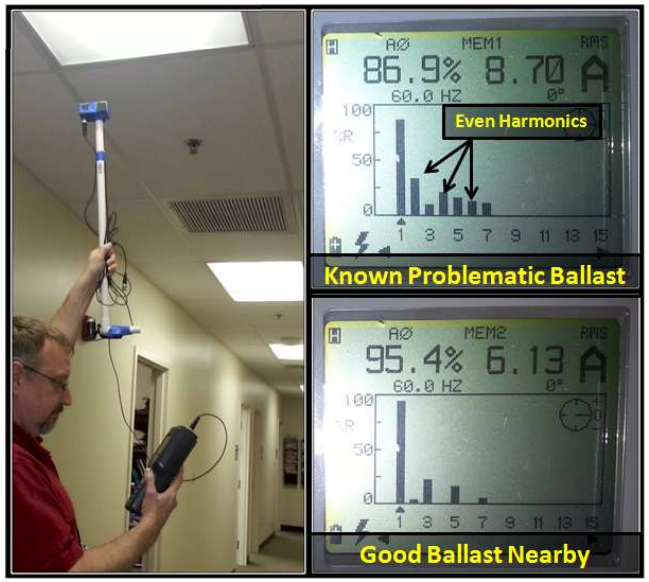


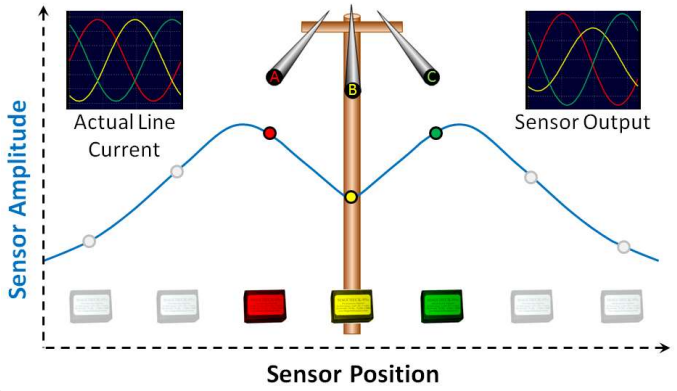


Tracking a Flicker Source

Non-Contact Net-Current Sensor







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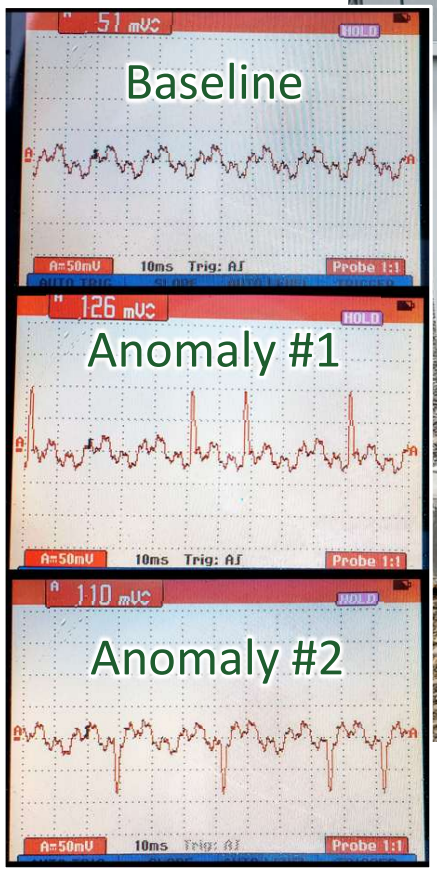
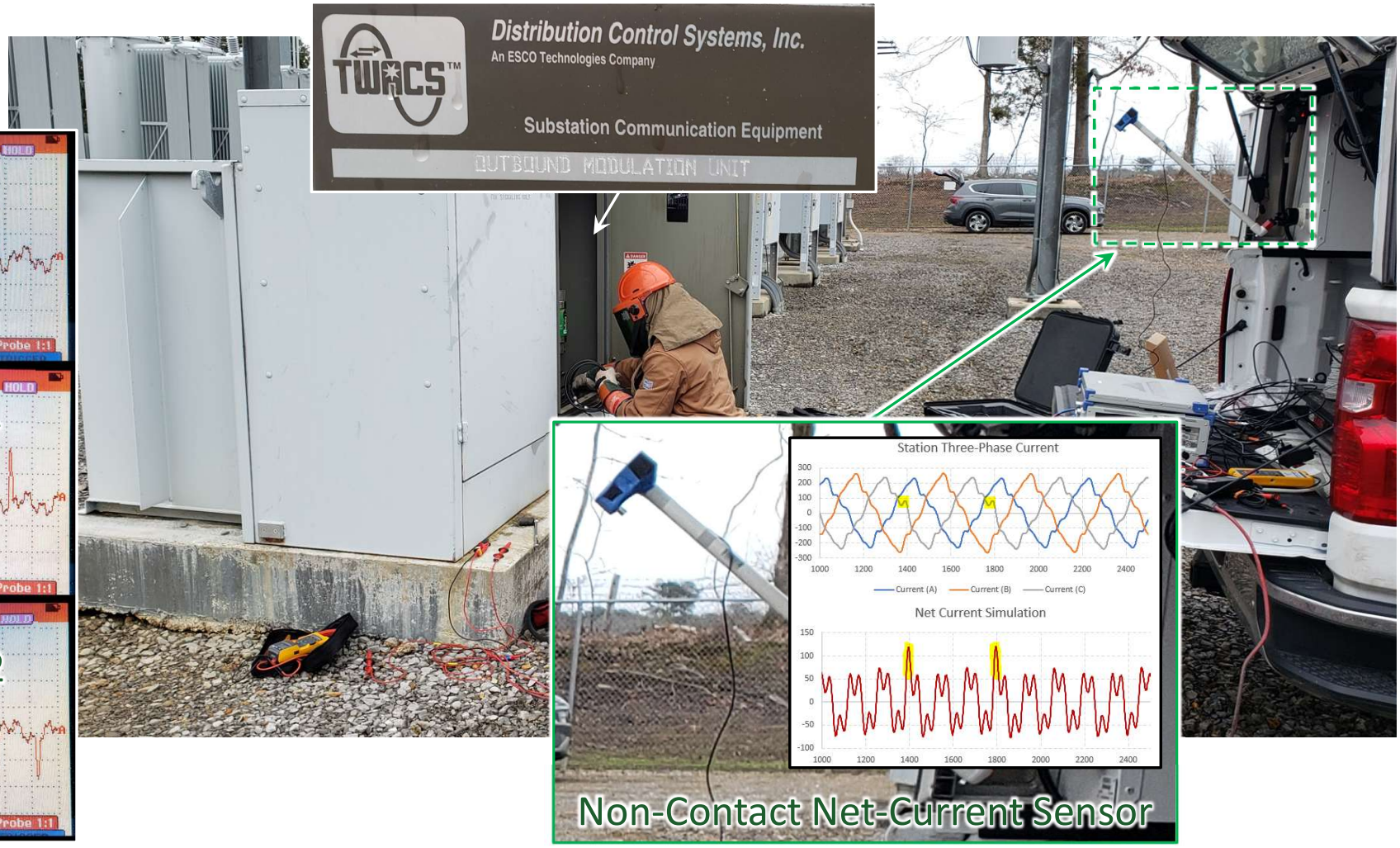
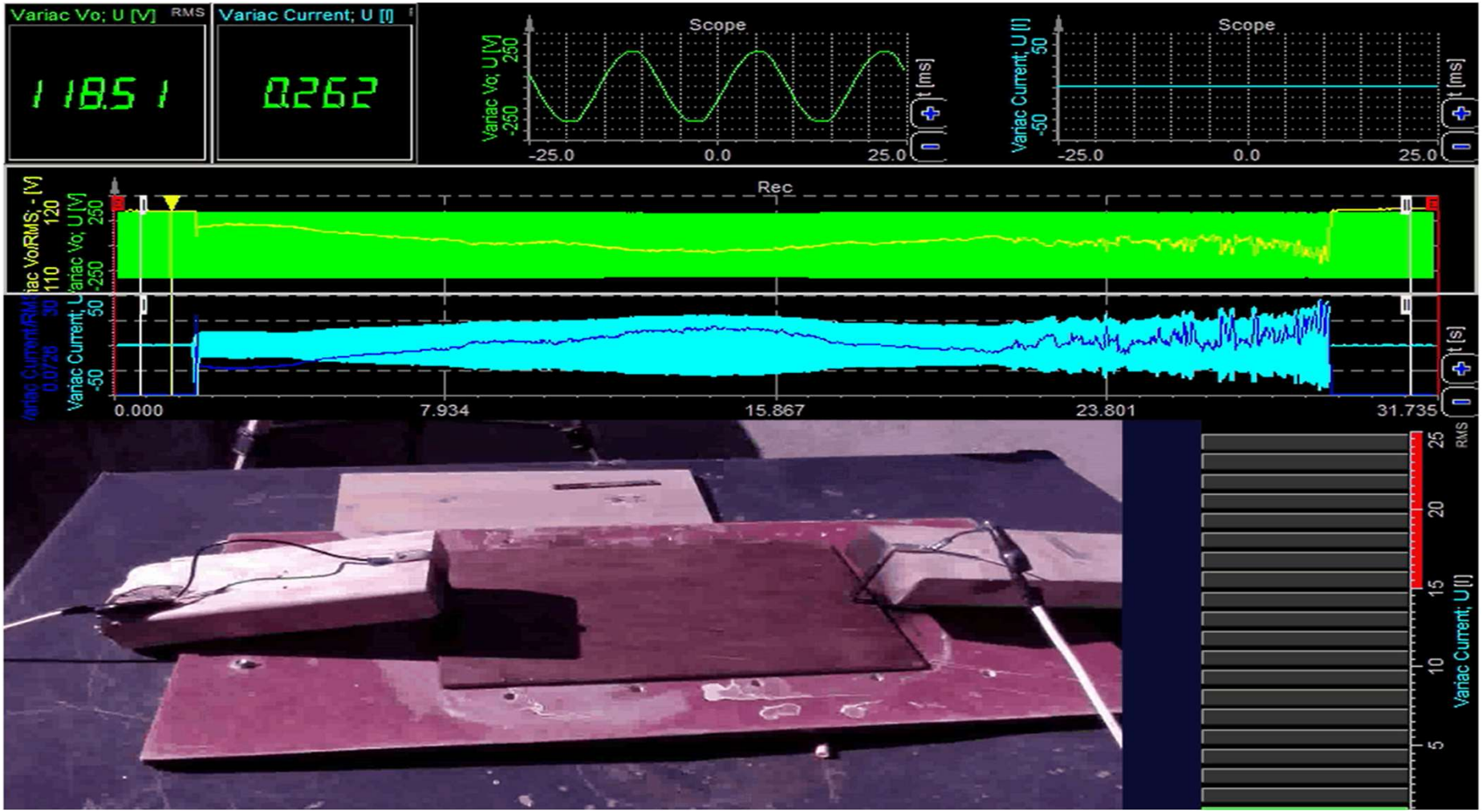
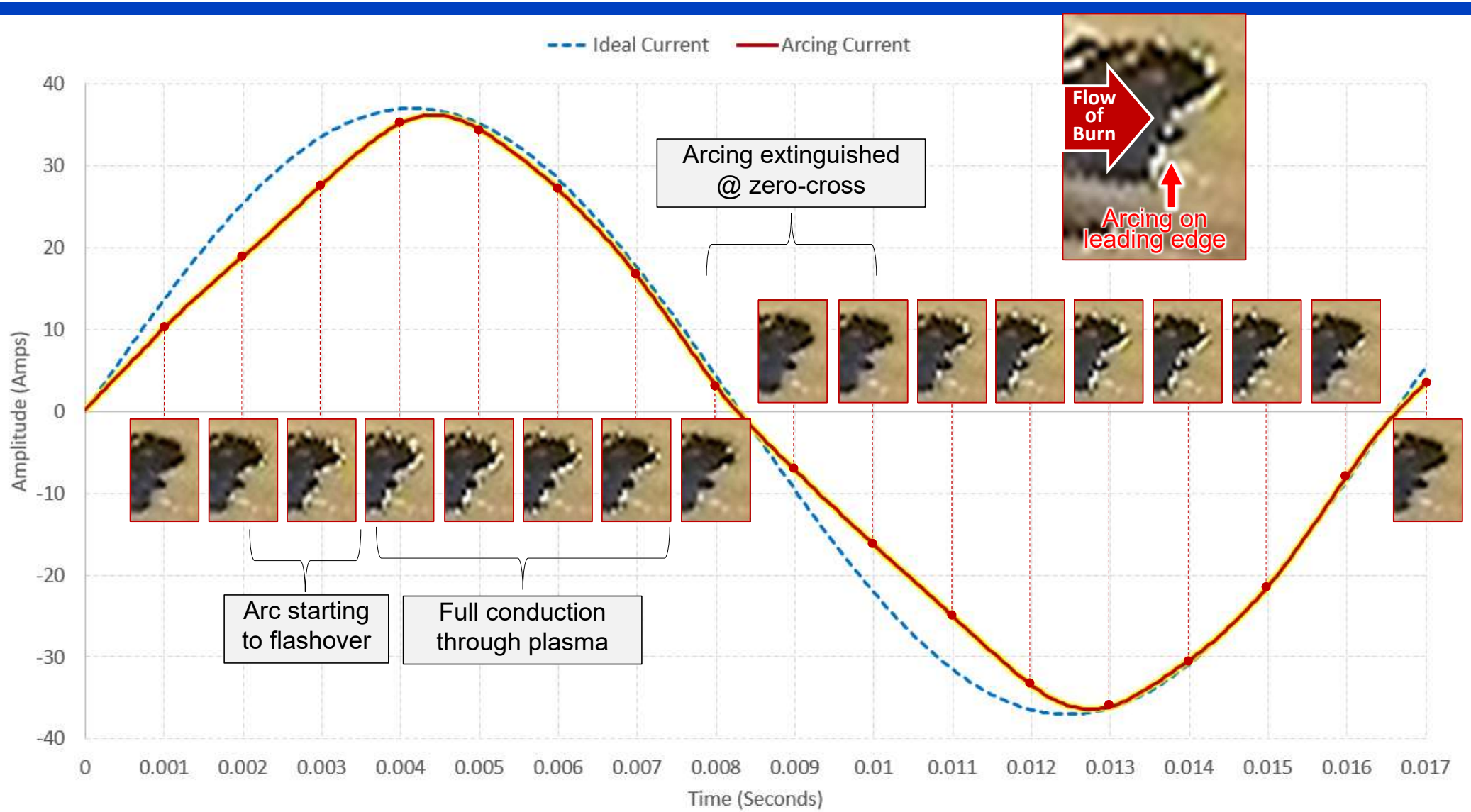
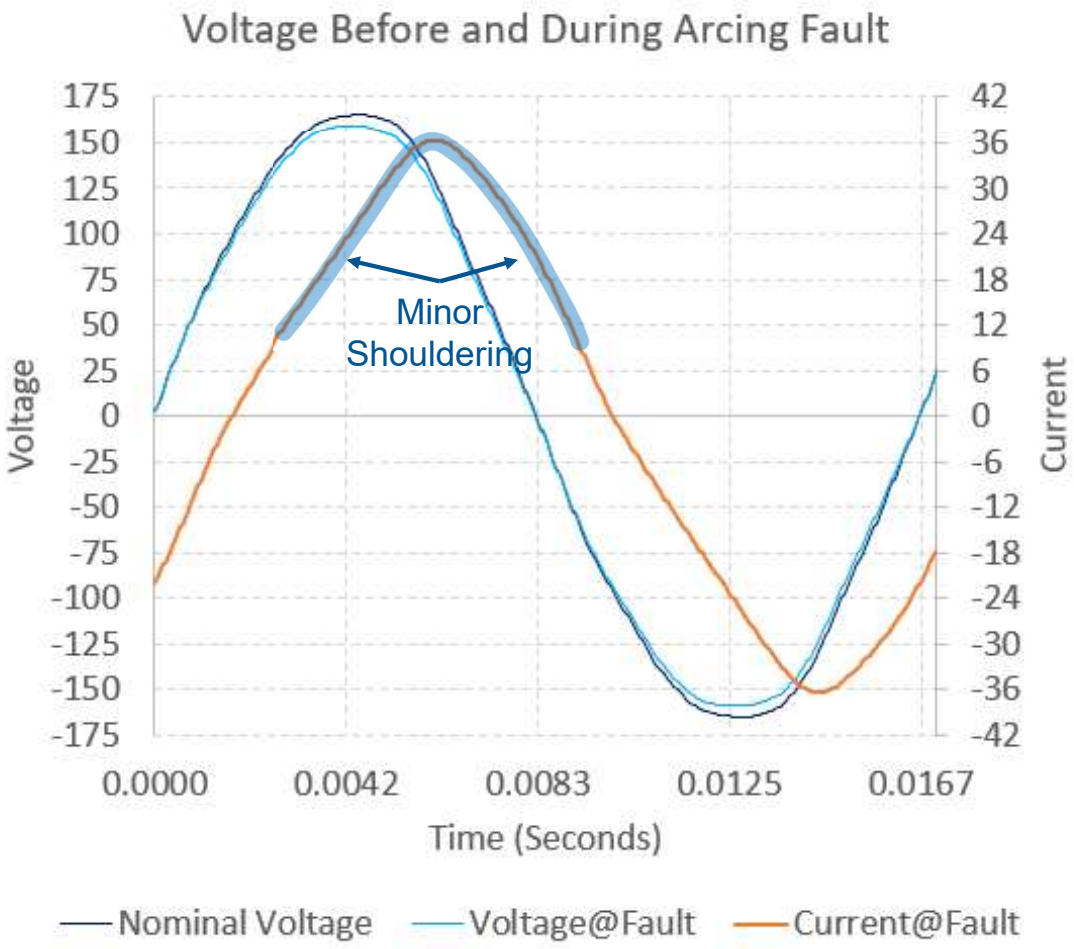


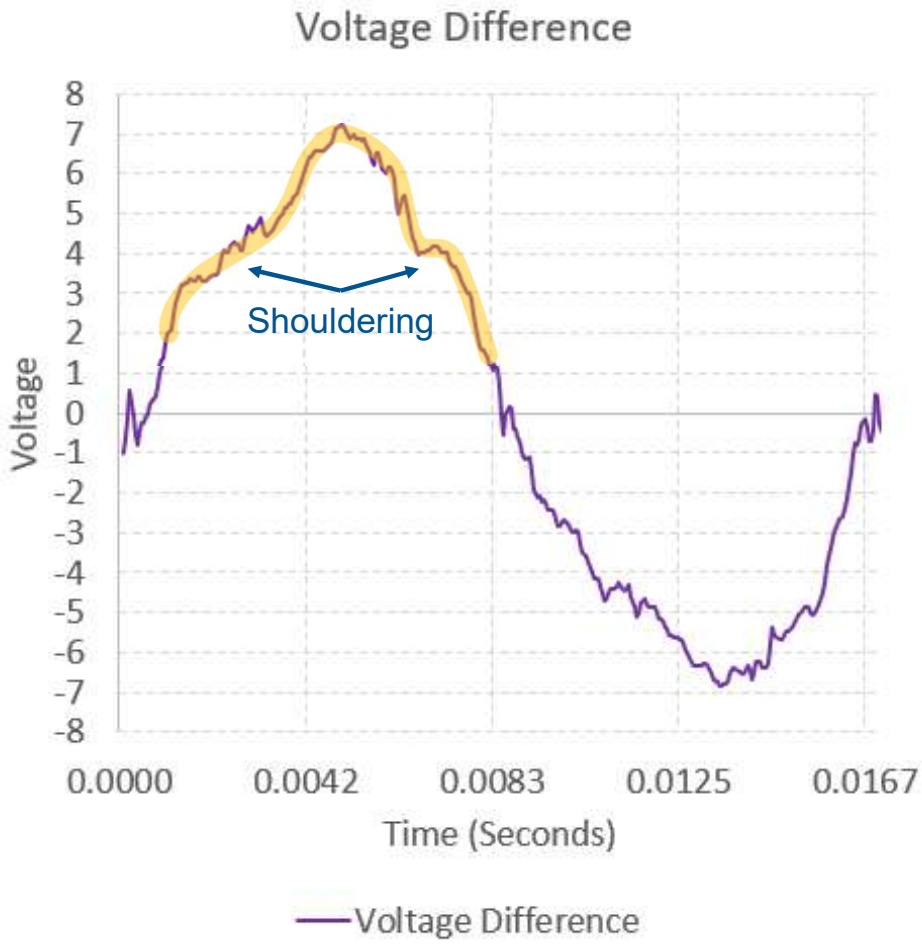


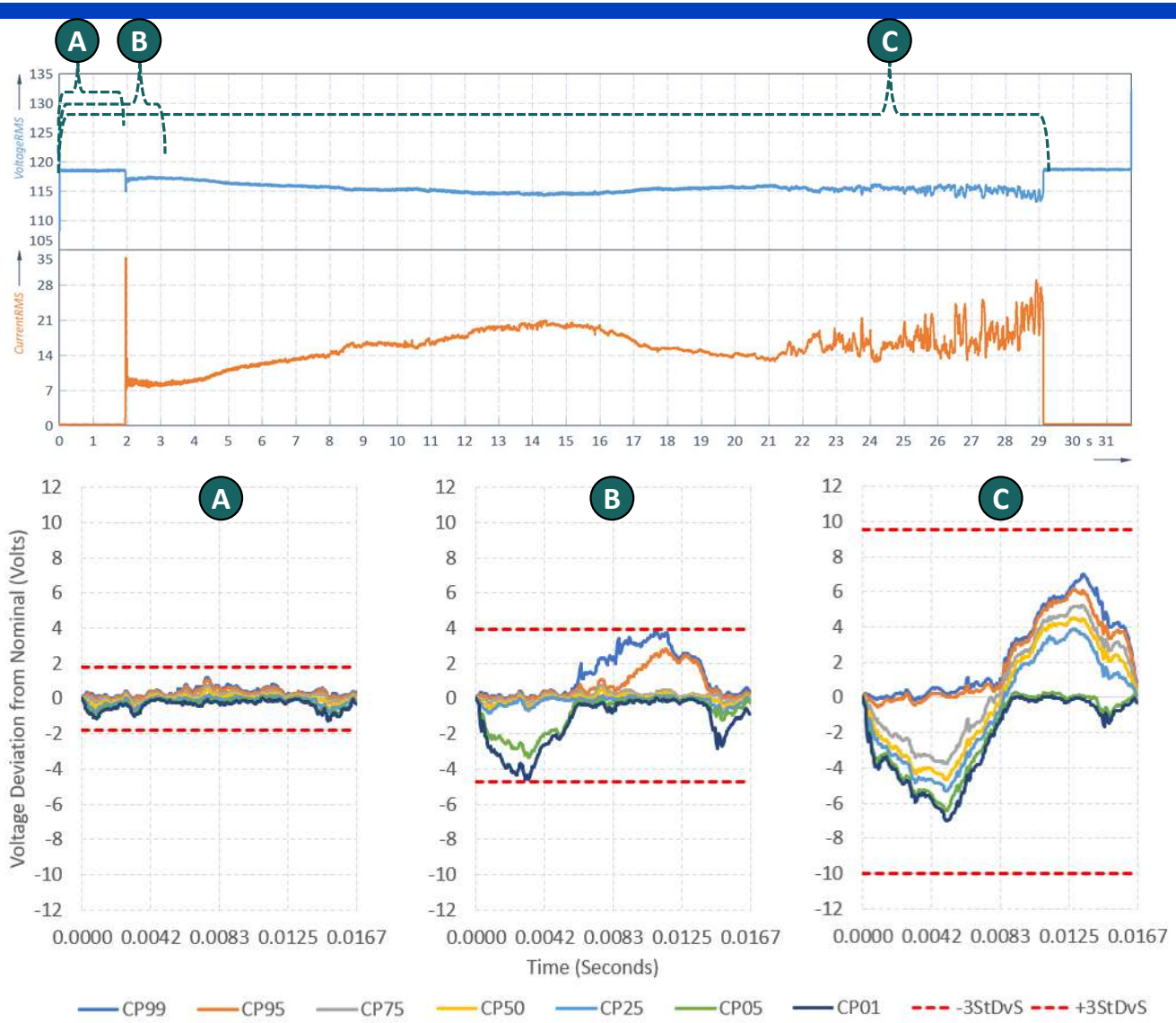
Another Source of Subtle Deviations



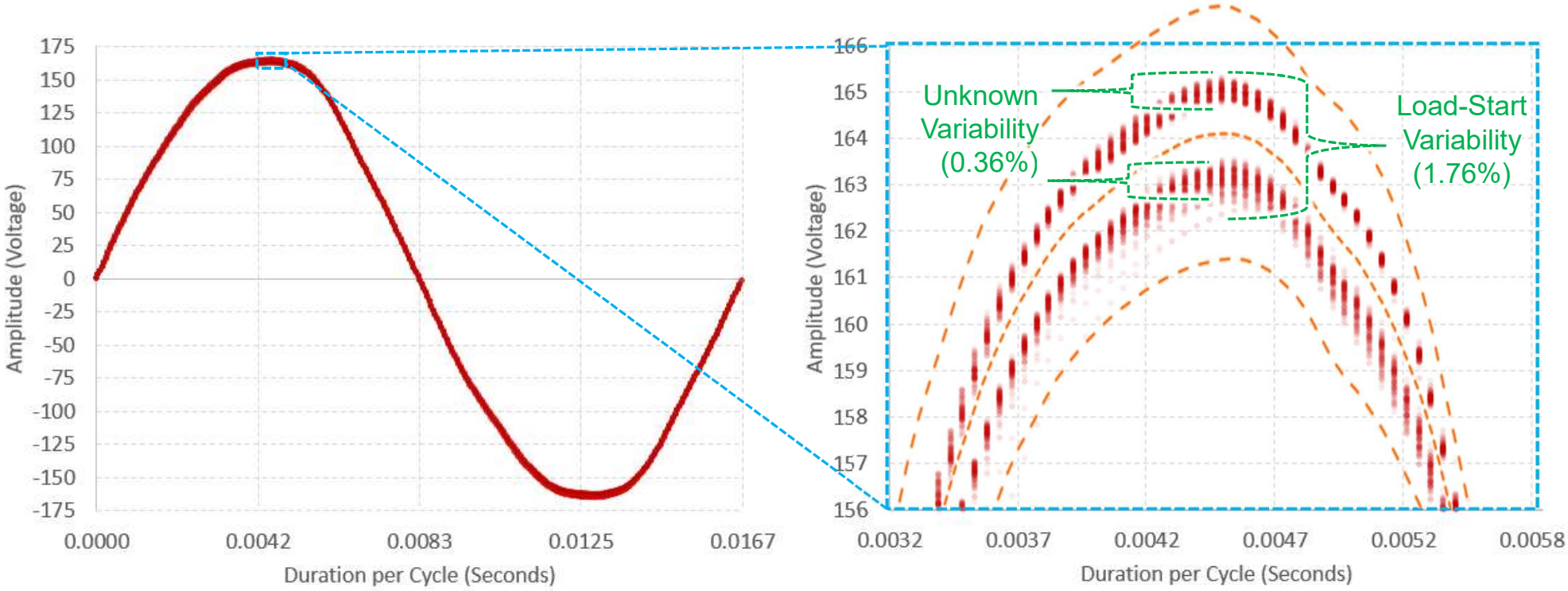




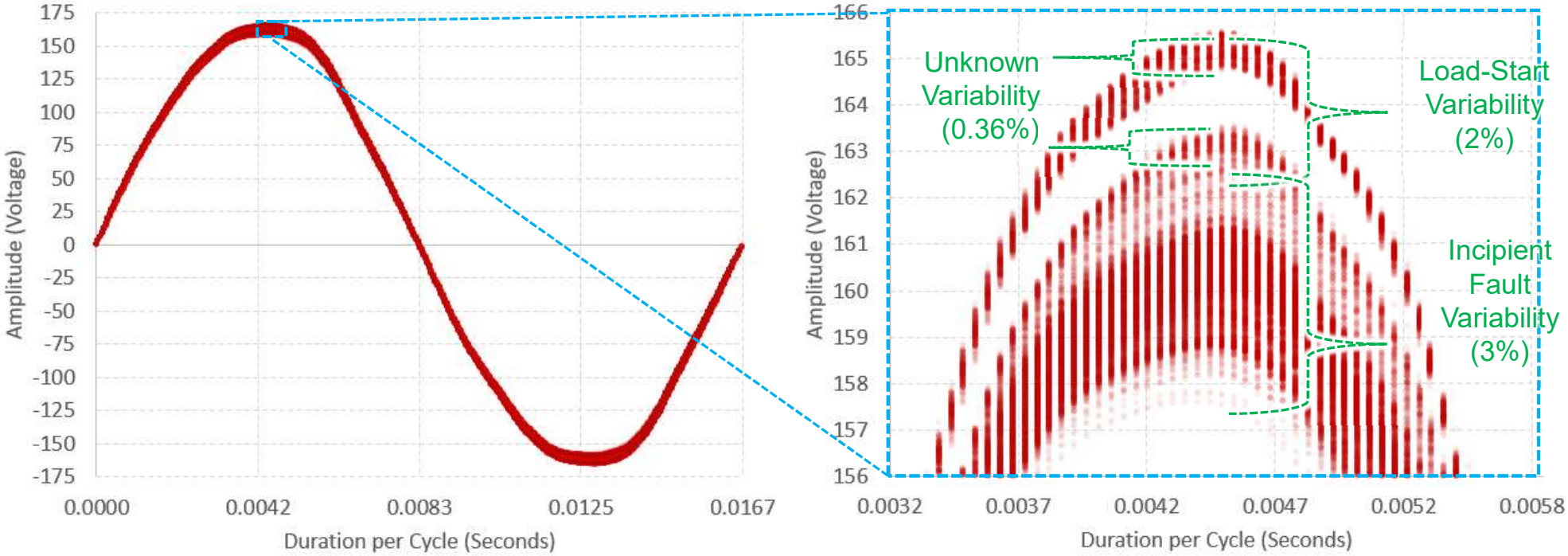




Beginning Voltage with Load Added



All, including fault



Modern Approaches to High-Impedance Fault Detection

3002012882
Final Report, November 2018

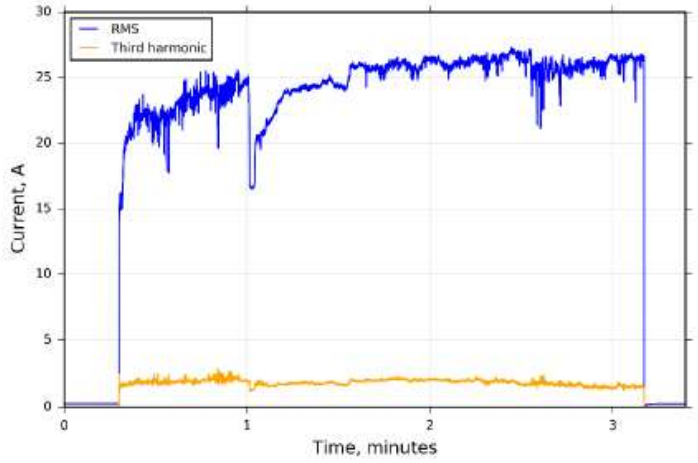


Figure 2-19
RMS current waveform for the arcing test in Figure 2-14

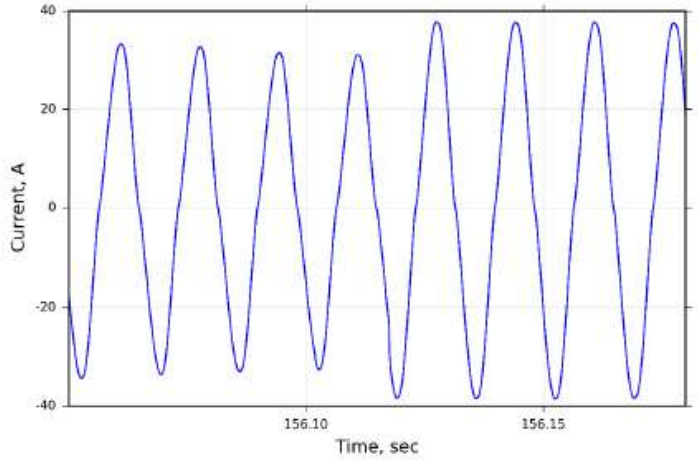
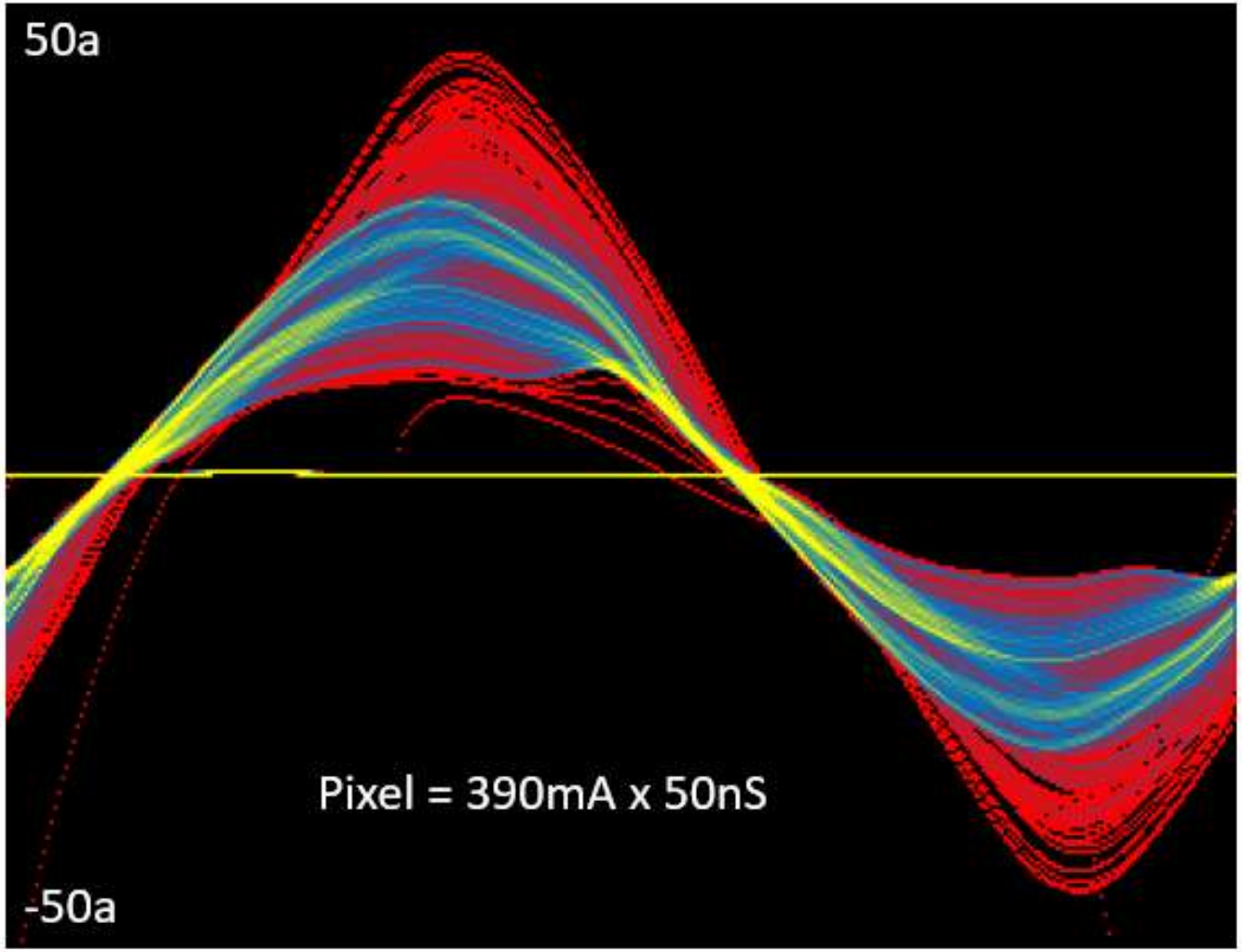


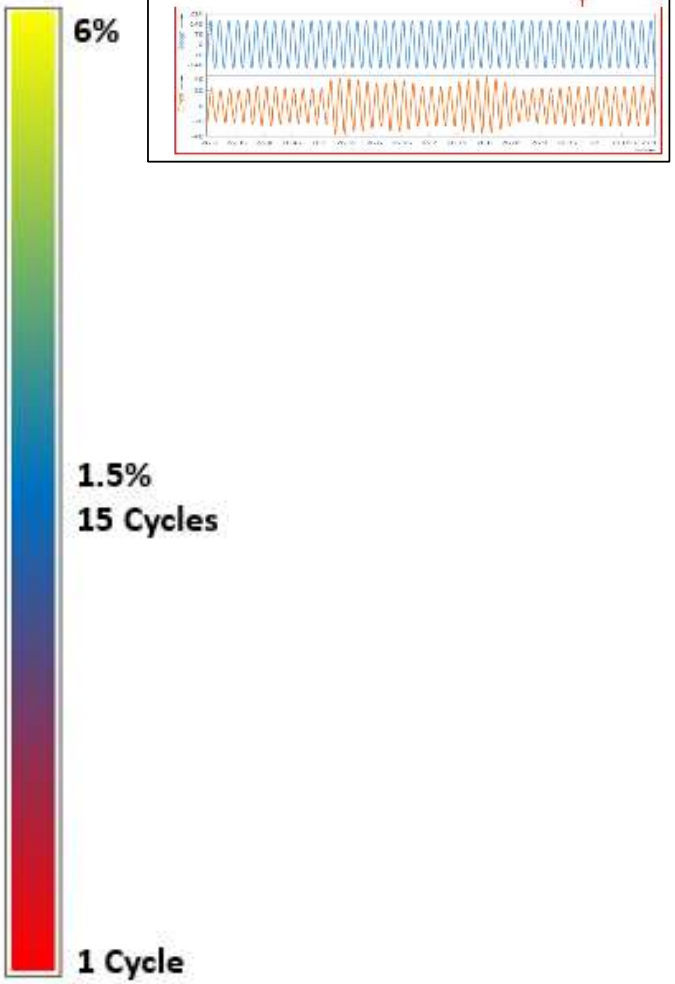
Figure 2-20
Waveform portion for the arcing test in Figure 2-14

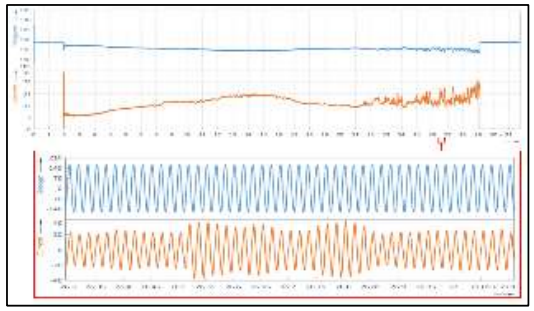
Figure 2-13
Energized conductor on asphalt (13.1 kV L-G)

Figure 2-14
Arcing on a 23-kV line (13.1 kV LG

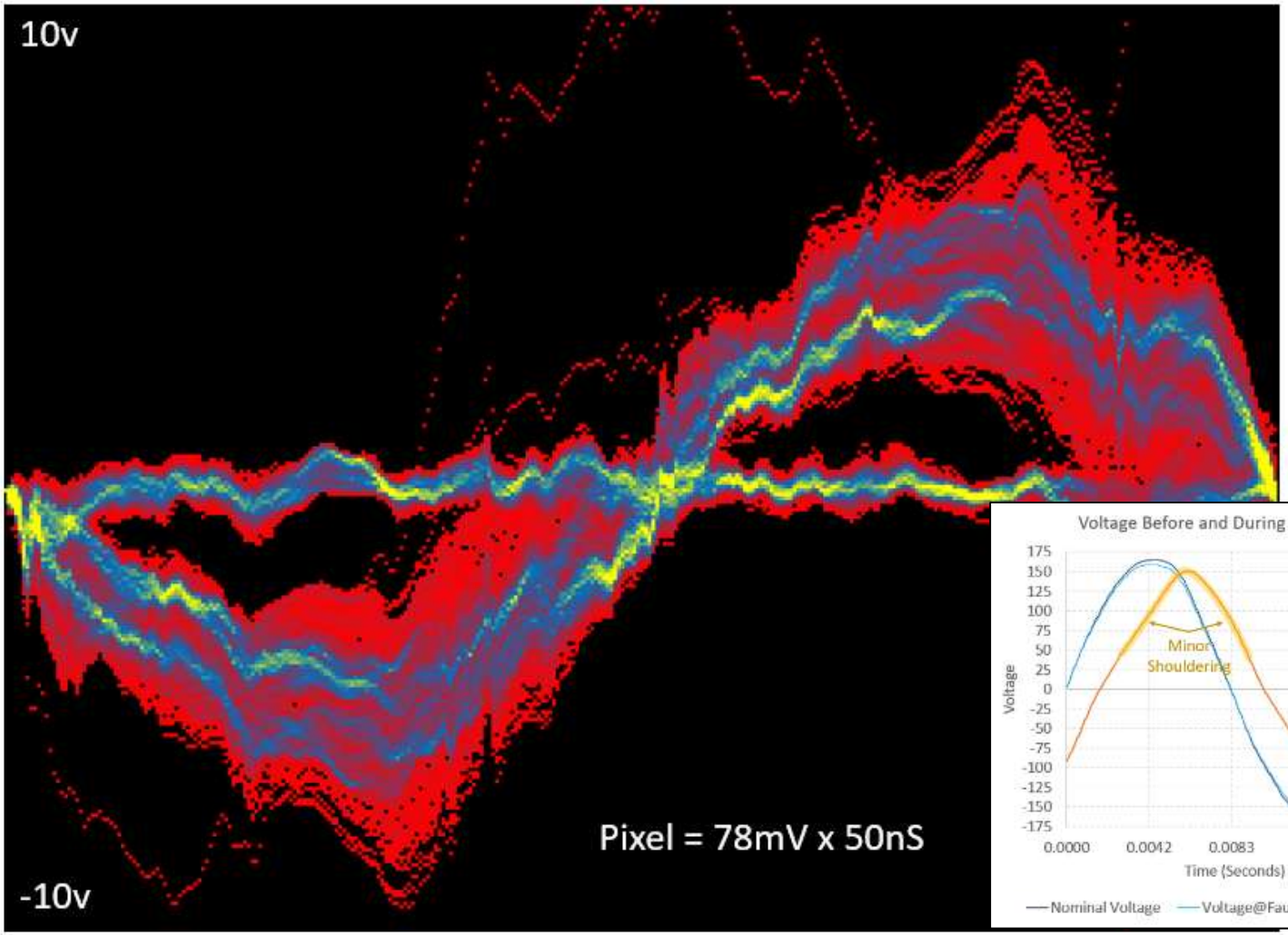
Current Waveform During 31 Sec Recording

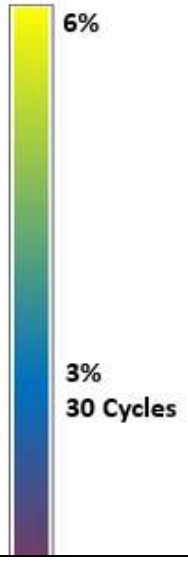


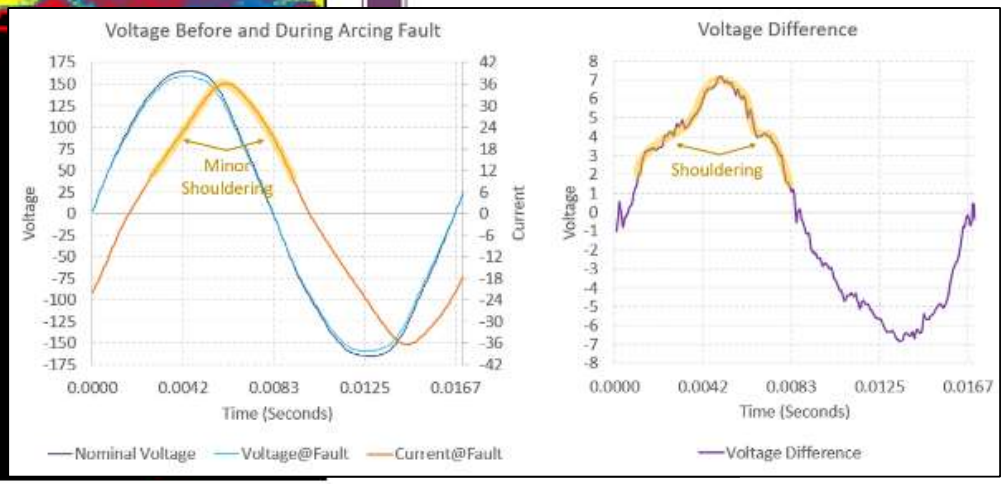




Removing Pre-Event / Nominal Voltage

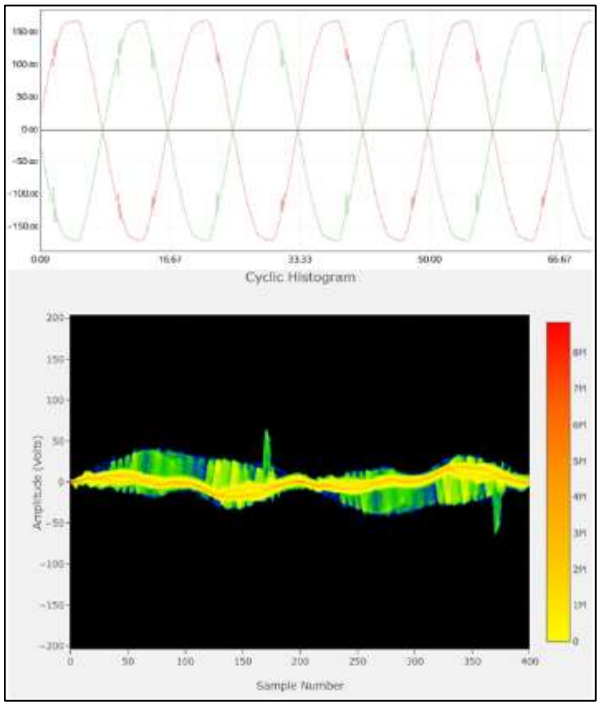


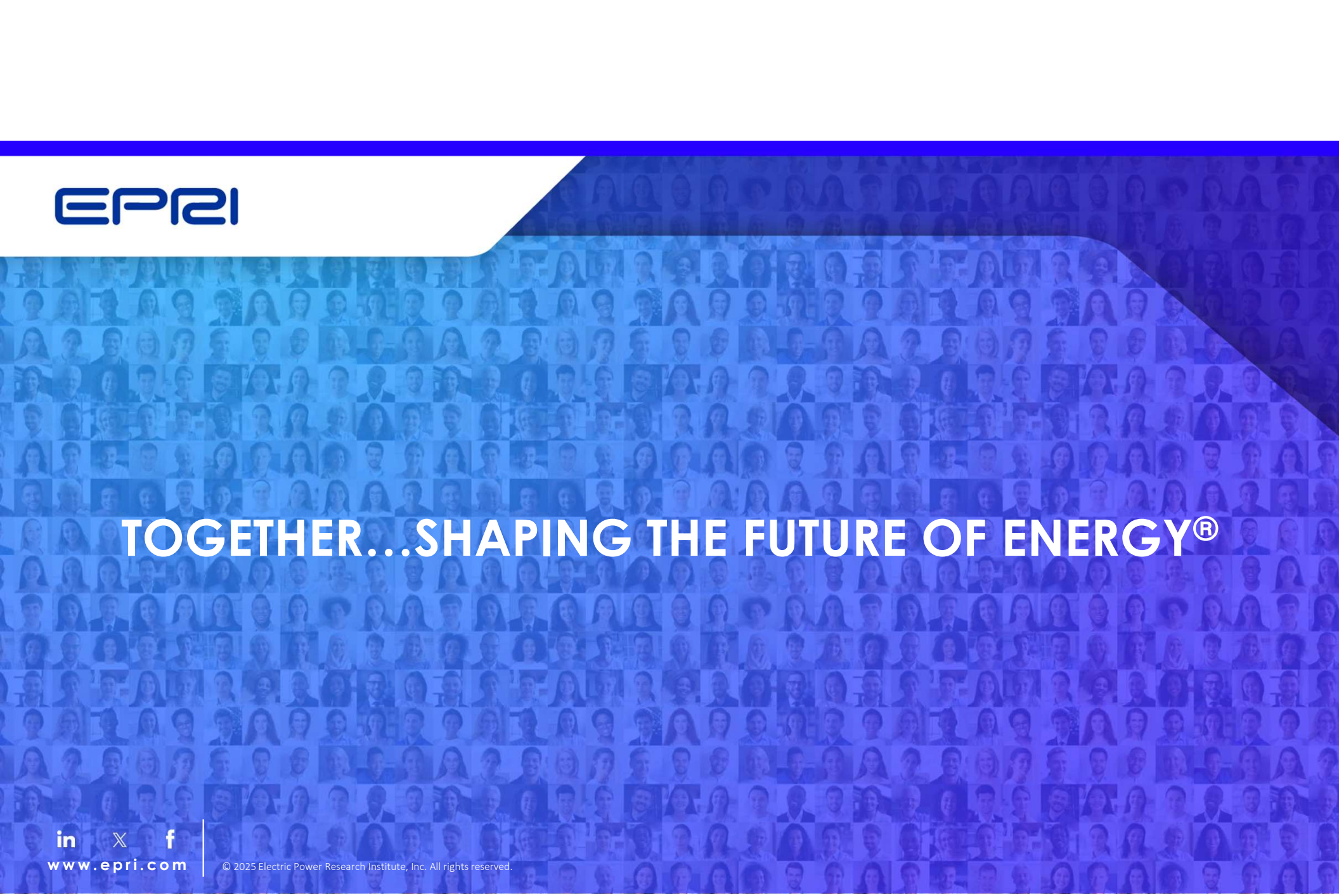




Future Opportunities

- Will continue to use this new tool and method as part of our investigations.
- We need more opportunities to capture potential incipient faults.
- TVA is deploying the Cyclic Histogram on their DFRs that capture continuous waveforms (16 samples per cycle).
- University of Tennessee Chattanooga is utilizing the OZM for development projects and experimenting with the Cyclic Histogram for machine learning methods.
- App Engineering has created a 256 SPC DFR that captures continuous waveform for the cycle histogram.





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