Synchro-Waveform Analytics From Different Data Acquisition Systems

Panel “Synchro-Waveforms Data Analytics and Applications in Power Distribution Systems”
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Data acquisition systems

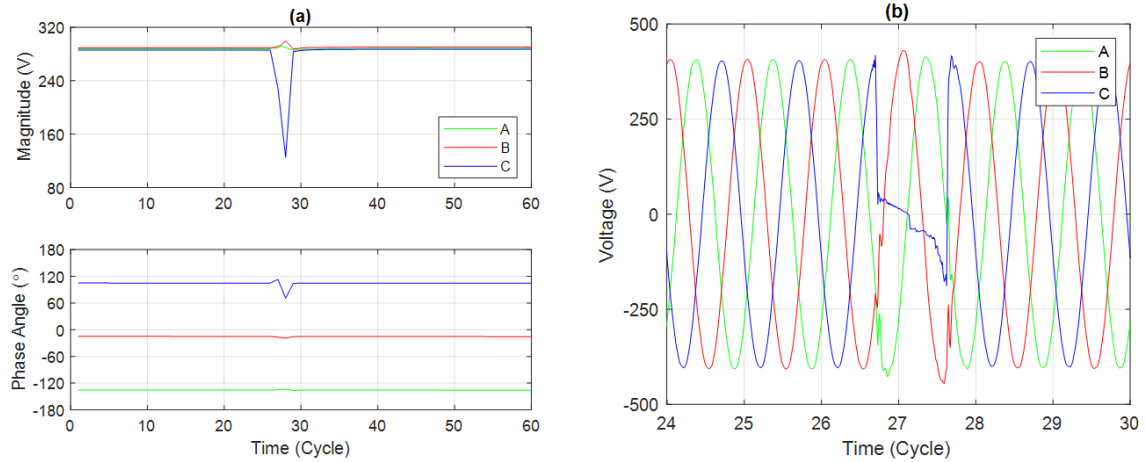
Challenges – siloed systems with different time sync methods

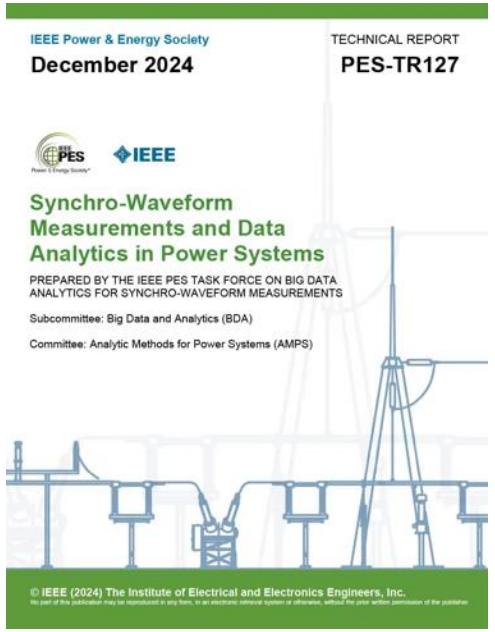
System	Typical temporal resolution	Typical time synchronization method	Waveform reporting capabilities
SCADA	Seconds to minutes	NTP	X
PMU	30 to 120 sps (samples per second)	GPS, PTP	X
RTU	Seconds	NTP	X
IED	Sub-second to minutes	NTP, PTP	△
DFR	Thousands of sps	GPS	O
PQ meter	Tens of thousands of sps	NTP, GPS	O
AMI	Minutes to hour	NTP	X

Why synchrowaveform data?

High-resolution representation of electrical phenomena

Phasor vs. waveform measurements





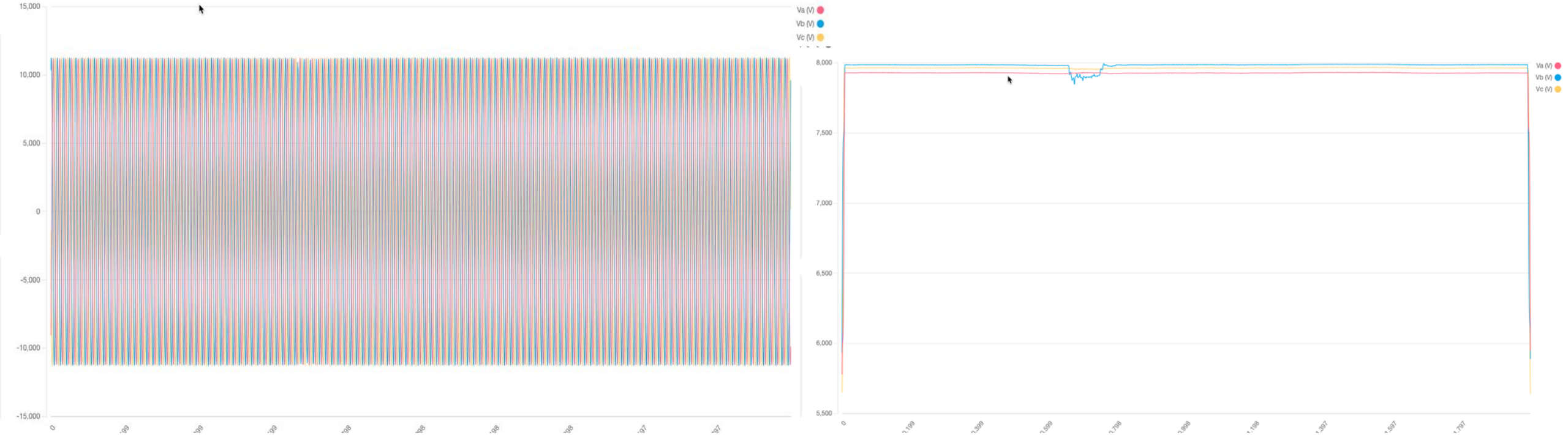
Useful for capturing subcycle/few-cycle transients
Use cases include IBR monitoring and model validation, load modeling and characterization (esp. harmonics), asset condition monitoring

J. Follum et al., Phasors or Waveforms: Considerations for Choosing Measurements to Match Your Application, April 2021, NASPI
https://www.naspi.org/sites/default/files/reference_documents/pnnl_31215_follum_phasors_waveforms.pdf

Counter-example

Rms representation may be sufficient or even easier

GESL Signature ID 78
Bad transformer voltage readings



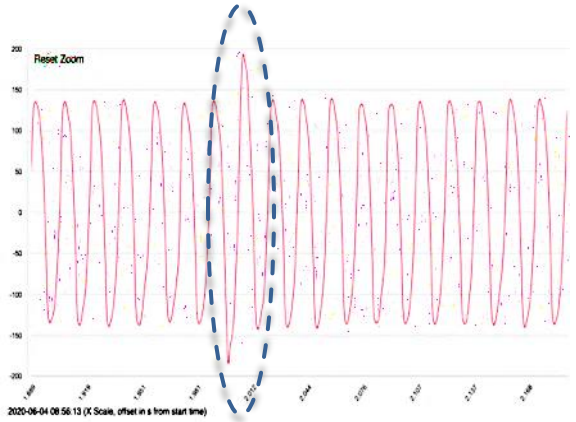
Data source: DOE Grid Event Signature Library https://gesl.ornl.gov/

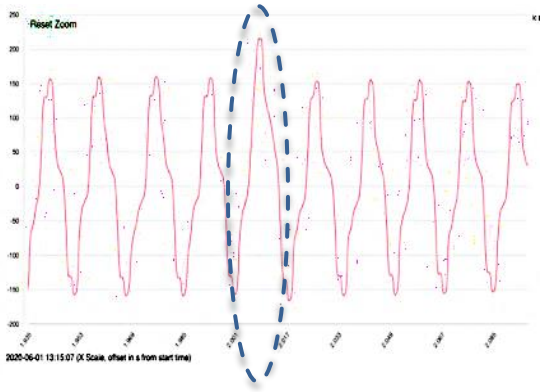
Example use case - arcing detection

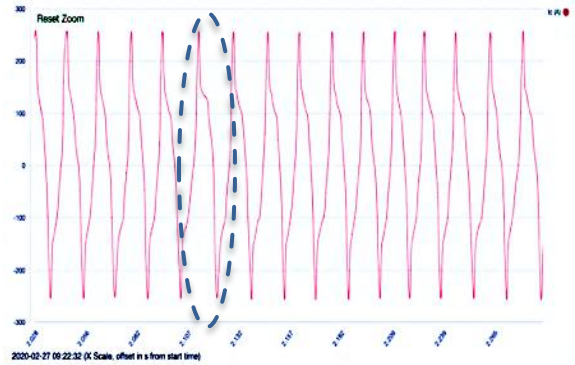
Higher-resolution recordings are more adequate

Characteristics of arcing signatures

- Slightly elevated peaks on phase current
- “Shoulders” on cycles
- Duration can be a few to several cycles
- No prominent frequency components







Waveform data used

Digital Fault Recorder

- Continuous and event data with trigger settings
  - Rms limits, frequency, 0/+/- sequence, THD, etc.
- 960 to 9,600 samples per second recording

Distribution Fault Anticipation System

- 15,360 samples per second event data
- Events labeled by proprietary algorithm

Digital fault recorder at a distribution substation
Photo courtesy of Southern California Edison

Other datasets used

SCADA
- Device status with time stamps

AMI (smart meters)
- Meter events (outage, low voltage, etc.) and locations

Outage records
- time, location, equipment involved, cause, # of customer impacted

Data Integration

SCE's Distribution Waveform Analytics Platform

Anomaly Score shows intensity of anomalies occurring on a circuit over time.

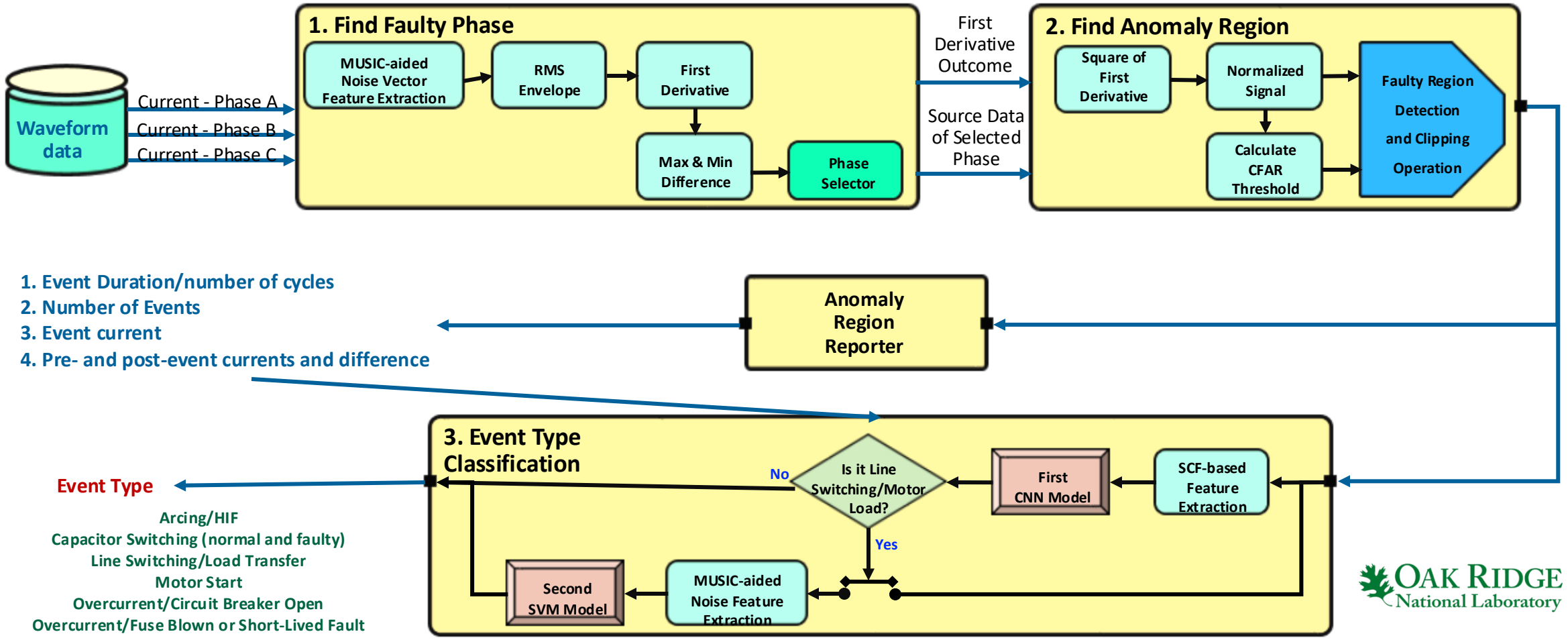
Event timeline shows the time correlation of waveform anomalies, SCADA events, and outages that have occurred on a circuit.

Chart shows features associated with waveform anomalies and allows users to select waveform anomalies for plotting.
The selected waveform plots below in addition to AMI event locations that correlate with waveform anomalies will appear on the circuit map.

This project is part of the Electric Program Investment Charge (EPIC) funded by the California utility customers under the auspices of the California Public Utilities Commission.

Event classification with waveform data

Algorithm workflow



Potentials of integrated data analytics

- Anomaly diagnostics
  - Waveform data alone does not give much insight
- Improving quality of event library
  - Correct labeling of events and integrating metadata further strengthens anomaly detection

- Distributed computing and analytics
  - Where should the data be captured and stored?
  - Where should the detection and classification algorithm be placed?
  - How to achieve both computational efficiency and data governance?

Conclusion

Analyzing waveform data from different data systems

Synchro-waveform data alone may not give sufficient insights

Data from different waveform DAQs may not be readily integrable

→ Standardized data integration framework needed

Depending on applications, disparate time sync methods can be an issue

e.g. traveling wave method vs. event labeling/identification

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