



The Grid Event Signature Library

A centralized repository for power system disturbance signature waveforms

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Towards more observable grid...

Event triggered measurements

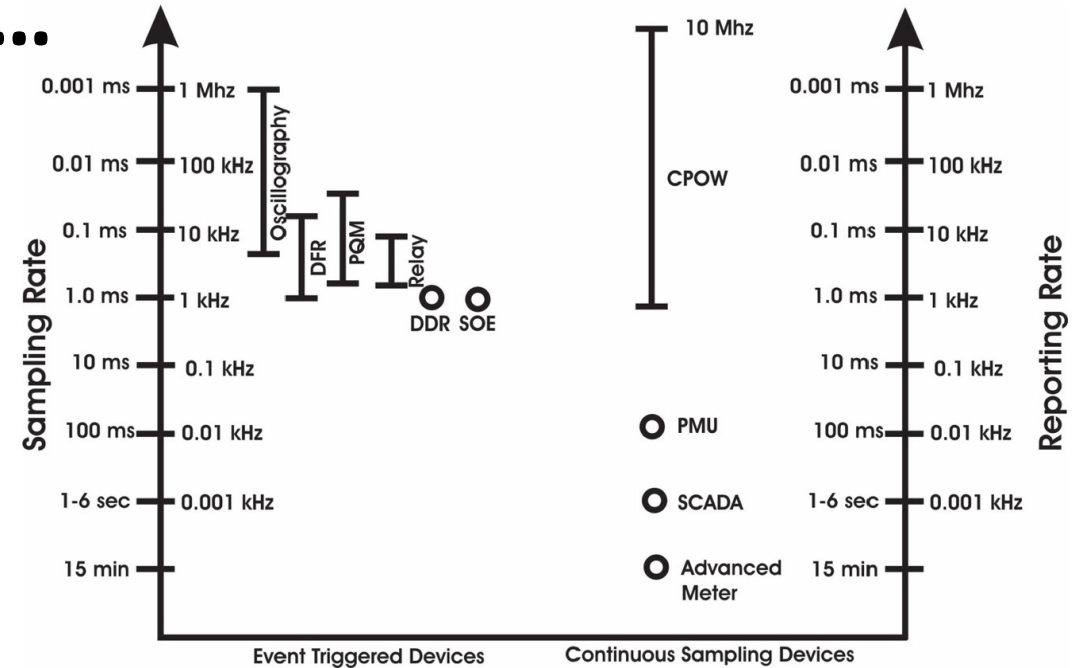
- Relays
- Digital fault recorders
- Power quality meters

Continuous measurements

- SCADA
- AMI (advanced metering infrastructure)
- PMU (phasor measurement unit)
- Point-on-wave (POW) measurements

Event records

- Outage and maintenance records
- Device activation records



Grid Monitoring devices by resolution and data continuity*

*A. Silverstein and J. Follum, "High-resolution, time-synchronized grid monitoring devices," PNNL, Tech. Rep. PNNL-29770, Mar. 2020.



AI/ML-based Grid Health Monitoring

GESL

But still one step away

Data labeling is critical to AI/ML

- MNIST
- ImageNet
- BTO Building Benchmark Datasets

Challenges exist for grid events

- Data is decentralized and inaccessible
 - Limits actionable data available for analytics
- Data is multimodal and unstandardized
 - Prevents integration of different data sources
- Data is unprocessed and unvalidated
 - Lacks critical metadata and proper labeling

THE MNIST DATABASE
of handwritten digits



<http://yann.lecun.com/exdb/mnist/>



ENERGY.gov
Office of
ENERGY EFFICIENCY &
RENEWABLE ENERGY

BENCHMARK DATASETS
of Building Environmental Conditions and Occupancy Parameters

PROBLEM
The wealth of data available from today's building systems can provide the operational insights and solutions that can optimize the operation of buildings. Ideally, such data would be securely collected at little cost with high temporal and spatial fidelity--and include all attributes relevant to building performance and occupant comfort.

BENCHMARK DATASETS PURPOSE
This project is a three-year, four-laborator collaboration to collect and curate a hand of high-resolution building systems data that have broad applicability to address highest-impact use cases.
We will collect and curate high-resolution, well-calibrated time series of building operational and indoor/outdoor

<https://syncedreview.com/>

<https://bbd.labworks.org/>

GESL

Project Overview

ORNL, LLNL, and PNNL, funded by DOE Office of Electricity, partnered to develop an open-source Grid Event Signature Library (GESL)

- Measurement data: raw data with signatures yet to be extracted
- Signature data: labeled events with data provided in specific formats

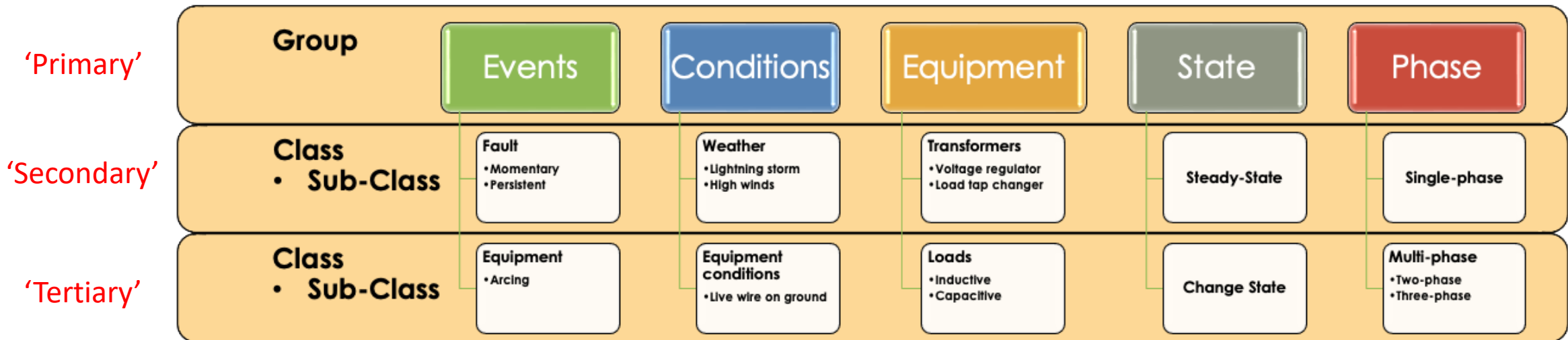
Goal

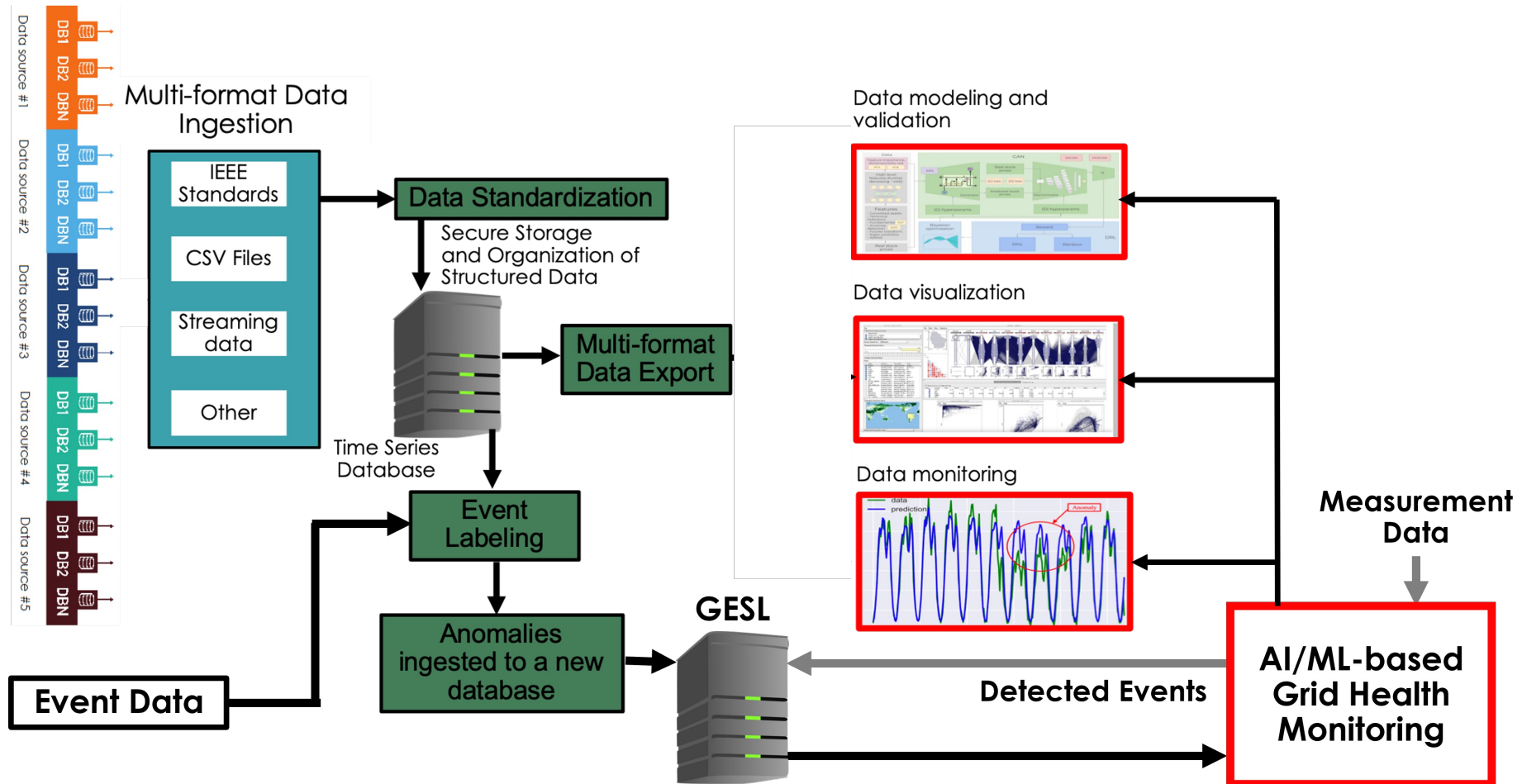
- Facilitate, tag and fuse data feeds from multiple sources
- Implement a modular architecture for expandable design
- Anonymize event sources to enable open data sharing
- Provide go-to resources for event detection and algorithm validation

GESL

Event Labeling

Hierarchy of grouped events to help organize signatures accordingly.



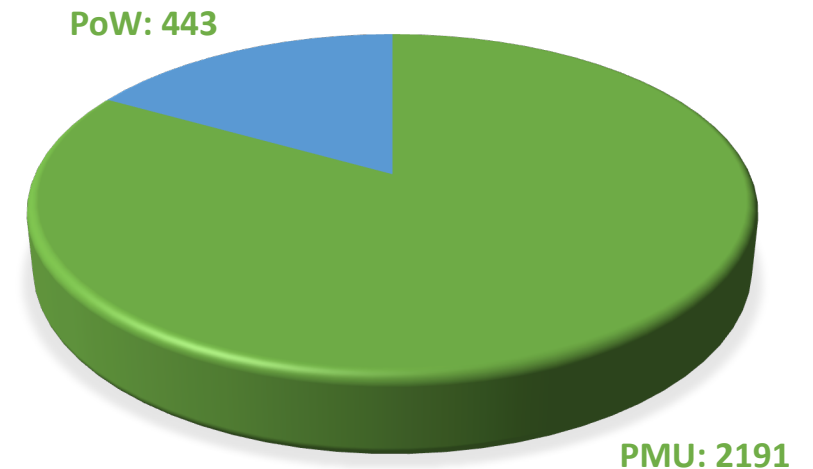


GESL

Data Types

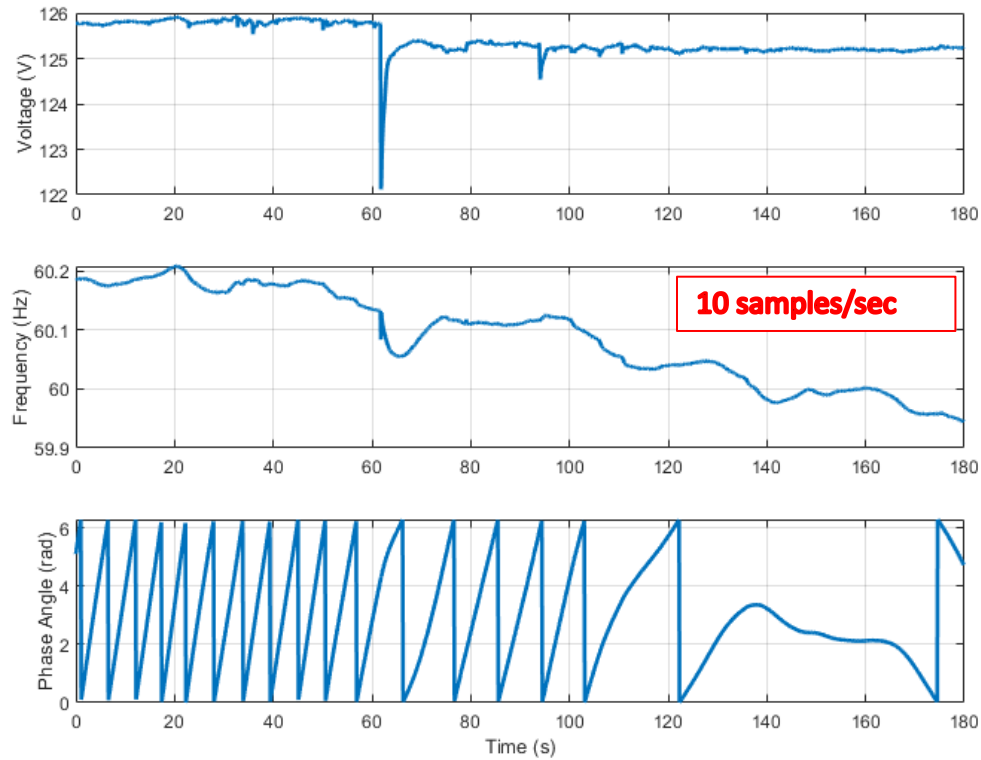
- Gaining access to data willingly provided for public release is a difficult challenge
- PoW is *even more difficult to obtain than PMU data*
 - Not as widely deployed/stored/transmitted

Types of sensor data in the GESL

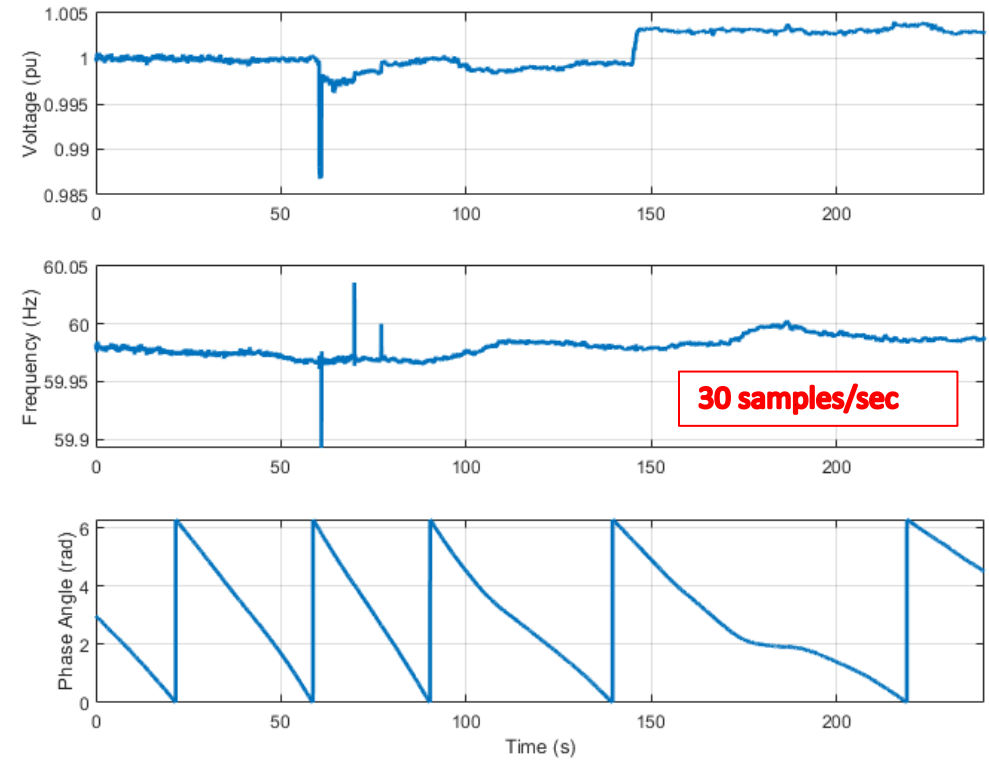


Data Sources – PMU Examples

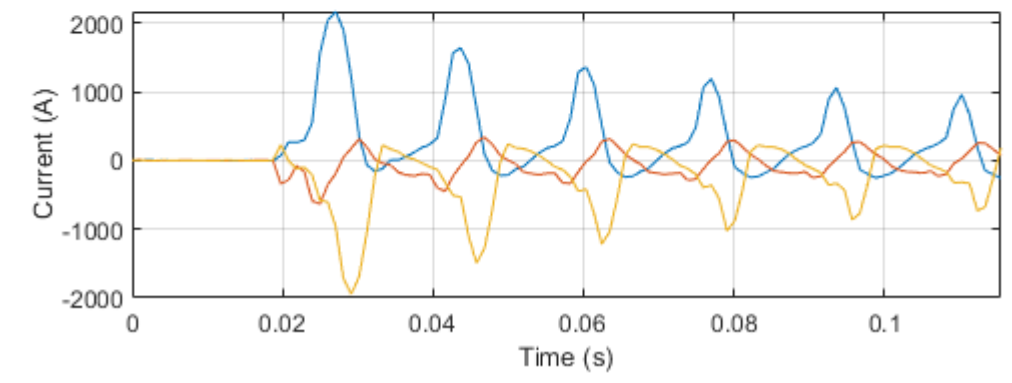
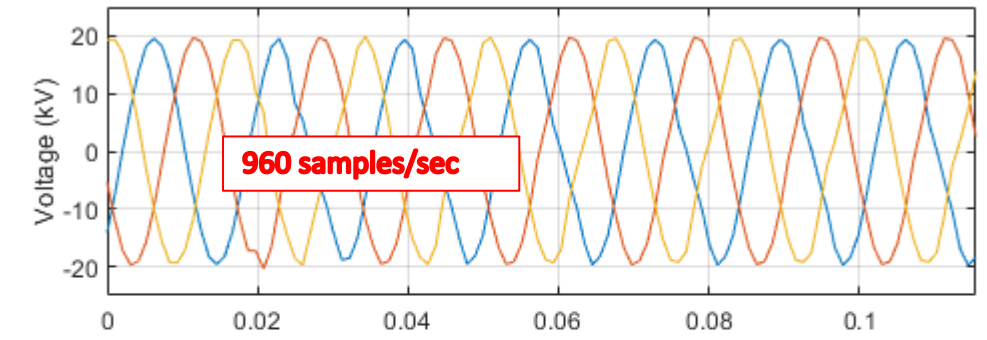
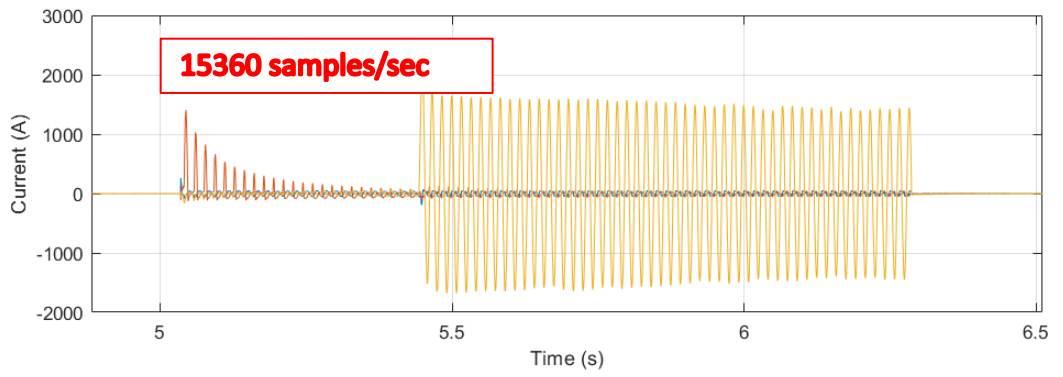
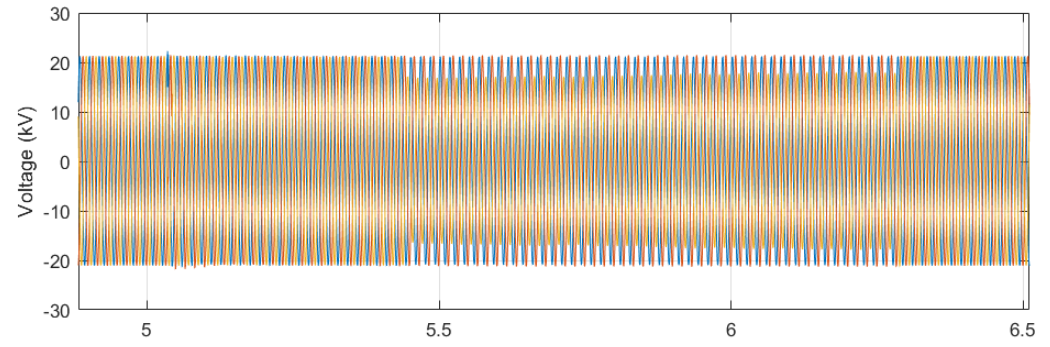
Distribution level - FNET



Transmission Level - Anonymized



Data Sources – PoW Examples



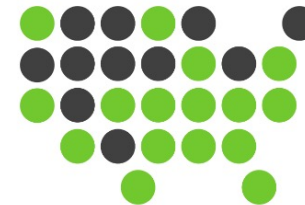
User Interface – <https://gesl.ornl.gov>



Welcome to the **GRID EVENT SIGNATURE LIBRARY**

[Signature Dashboard](#)

Welcome to the Grid Event Signature Library (GESL). This initiative, driven by the DOE's Oak Ridge National Laboratory (ORNL) and Lawrence Livermore National Laboratory (LLNL), aims to revolutionize the field of machine learning and artificial intelligence (ML/AI) as applied to power grids. Our goal is to create an accessible, well-curated, and comprehensive power grid data repository. This repository serves as a powerful tool in facilitating swift responses against malfunctions of grid infrastructure, and advancing the application of ML/AI in grid systems.



User Interface – Dashboard Search Capabilities

Grid Event Signatures



Display

Filter Criteria

Signature Id(s)

Description Contains

Event Date Range (EDT)

Data Sources

Event Tags

Uncheck All - 0 / 172 (Selected/Total)

- Conditions (0 / 16)
- Equipment (0 / 49)
- Events (0 / 64)
- Phase (0 / 26)
- State (0 / 17)

Clear

Load

Providers Summary

Data Sources

Total
10

Signatures Count
2634

Event Tags Count
5504

Event Tags Summary

Event Tags

Total
172 (5-Main Categories 38-Sub Categories 129-Class Tags)

Signatures Count
2634

Event Tags Count
5504

Conditions

- Equipment Conditions
- Natural disaster
- Weather
 - Heavy Rain
 - High Winds
 - Ice
 - Lightning Storm
 - Nonspecific Weather

0

0

0

0

29

37

24

208

122

Equipment

0

Events

0

Phase

0

State

0

To load Signatures / data, enter filter criteria on left and click on the Load button

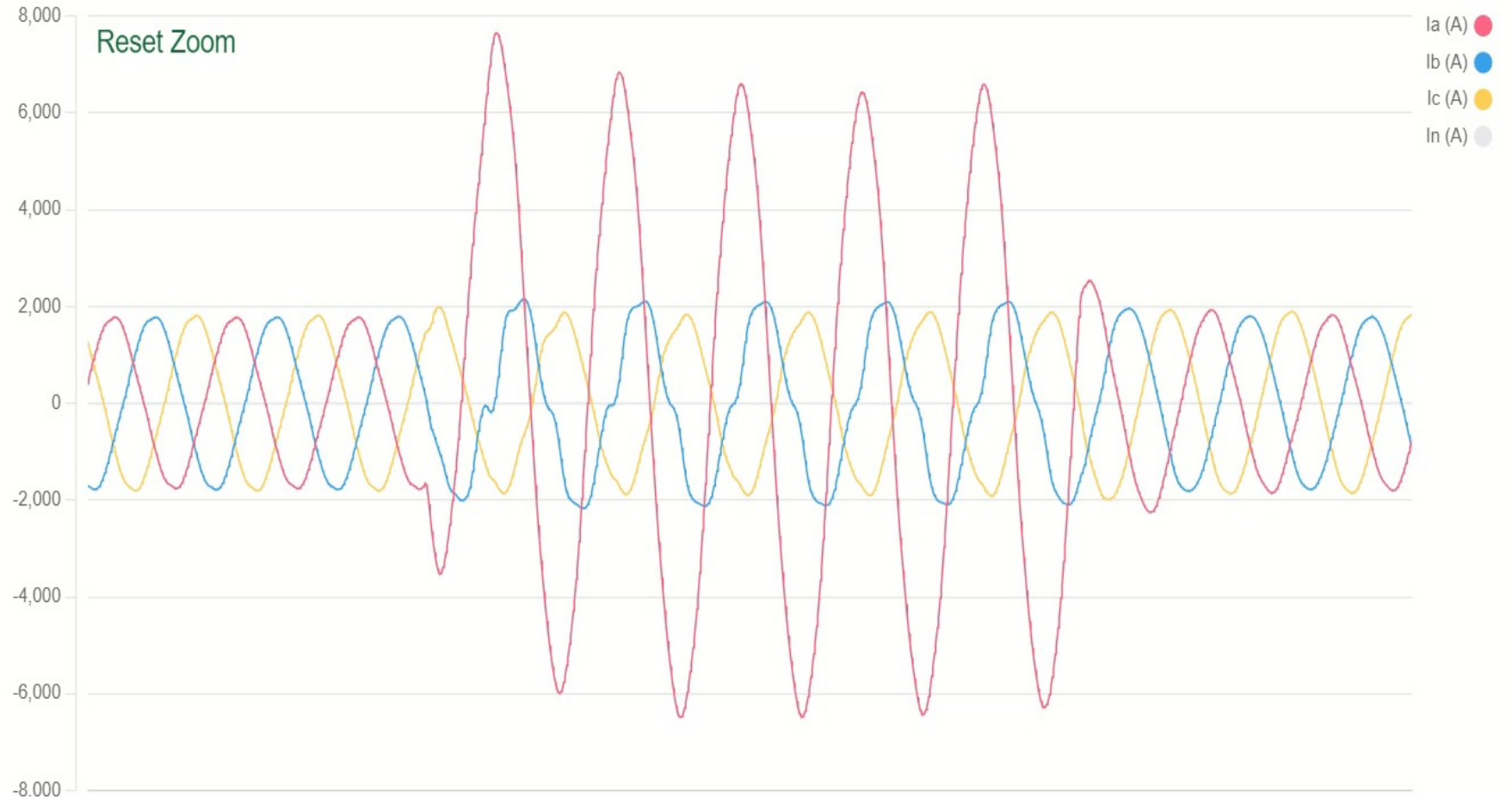
User Interface – Visualization

Waveform Signature ID: 1

Display Measurement Types



- Current (A)
 - Ia (A)
 - Ib (A)
 - Ic (A)
 - In (A)
- Voltage (V)
 - Va (V)
 - Vb (V)
 - Vc (V)



Planned Additions to GESL

- Features
 - Signature Matching Tool
 - : A “reverse image search” for grid waveforms
 - API for accessing/downloading data programmatically
 - Visual analytics capabilities
 - “Examples” page for exemplary algorithms developed using GESL data
- Design
 - Expanding website design team
- Outreach
 - Inclusion of a user community forum
 - Working group meetings
- More data!

Thank you!

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Signature Matching Tool

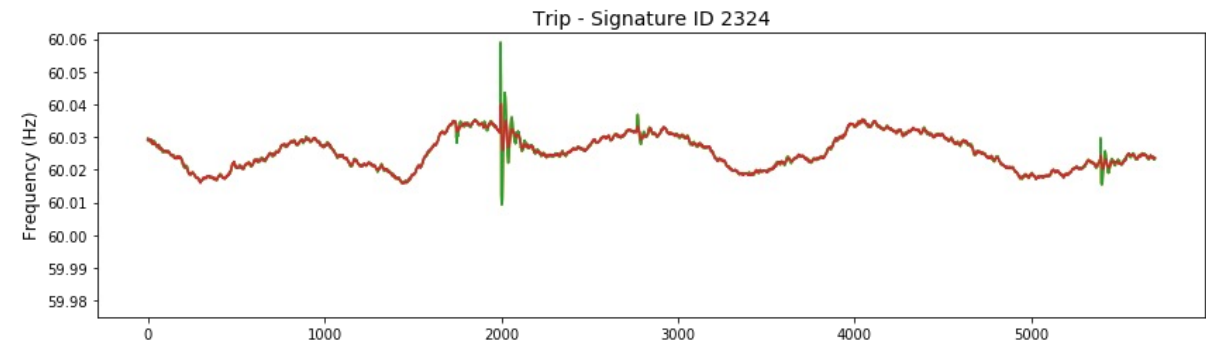
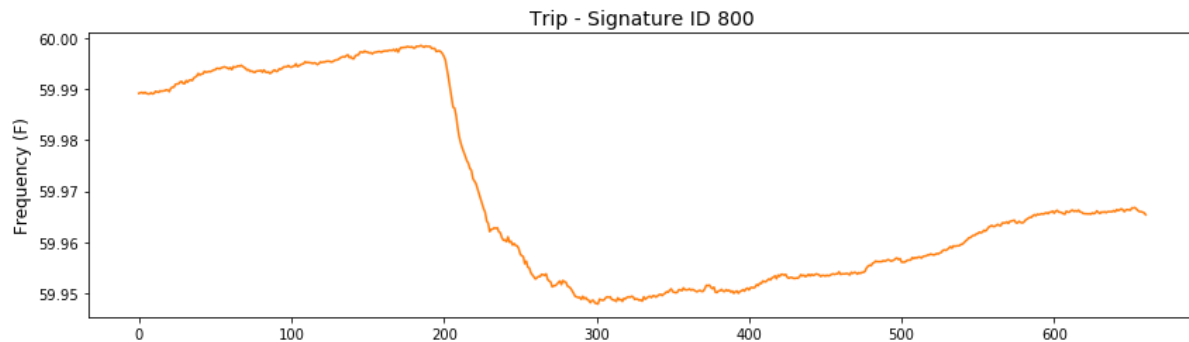
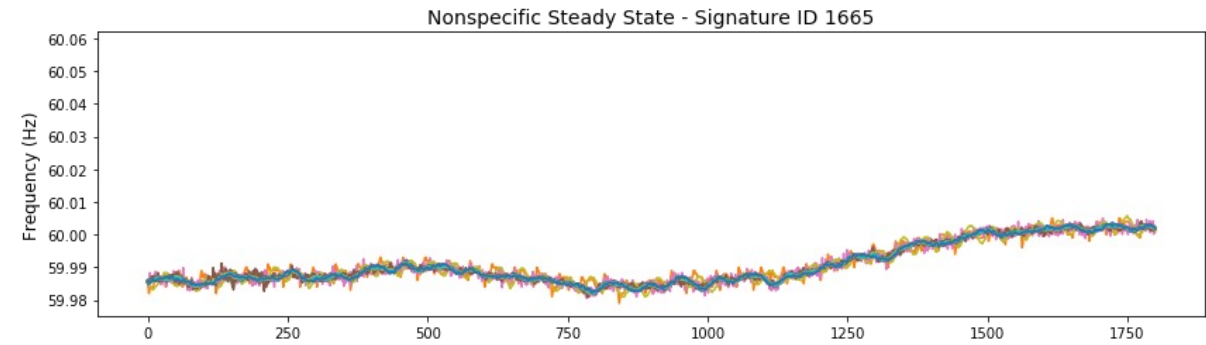
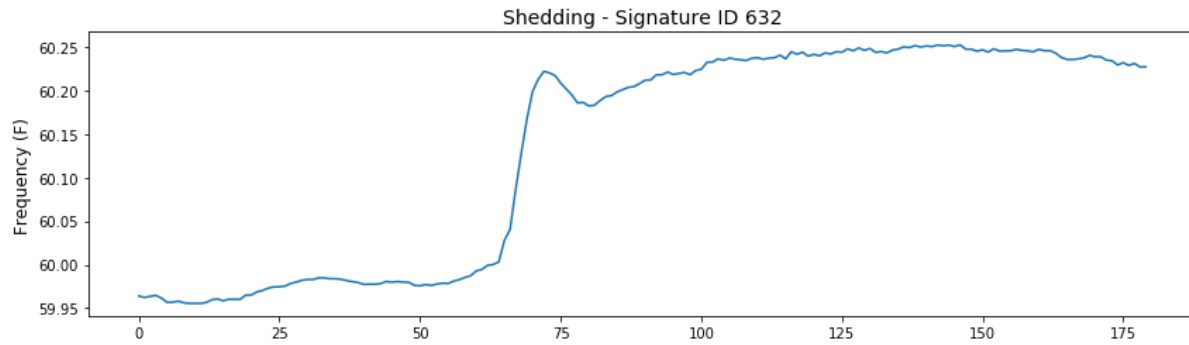
A “reverse image search” for grid
waveforms

Signature matching tool for GESL

- Objective: To provide a basic functionality to identify unlabeled signatures/unknown events based on the repository of labeled events
- Use cases
 - Identify captured event measurements
 - Classify events from different sensor measurements
 - Identify incipient failures
- Approach
 - Pre-processing of signatures
 - Standardization of signatures
 - Feature extraction
 - Statistical moments, frequency-domain analysis, dimension reduction, etc.

Classification and device types

- Binary classification of phasor measurement events
- Binary classification yields higher accuracy than multiclass classification
 - Multiclass can be cast as series of binary



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- More data!