Pacific Northwest
NATIONAL LABORATORY

IBR Synchrophasor Perspective

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U.S. DEPARTMENT OF ENERGY BATTELLE
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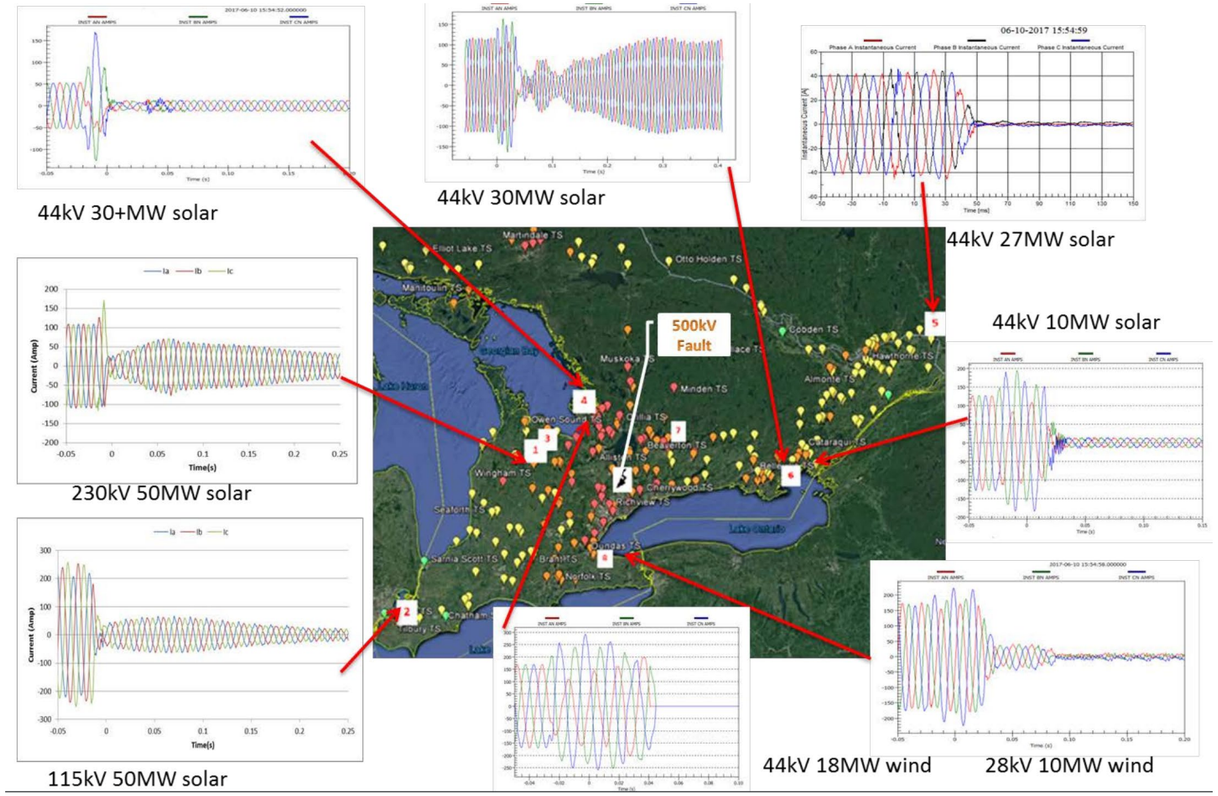
IBR Monitoring and Performance Evaluation

- Utilizing measurements at different time-scales and locations.
- Evaluating generator behavior during steady state and transients.
- Practical challenges evaluating a wide array of generators.
- Using synchorphasor vs. point on wave data.
- Bandwidth and analytics challenges.



HydroOne renewable monitoring – system wide event[1]

[1] Li, C. (2019). Inverter-Based Resource Monitoring and Event Investigations. Paper presented at the NATF/EPRI/NERC Power System Modeling Conference, Novi, MI. https://www.nerc.com/comm/PC/SAMS%20Agendas%20Highlights%20Minutes/2019_NERC-NATFEPRI_Power_System_Modeling_Workshop_Presentations.pdf

IBR Monitoring and Performance Evaluation

PROGRESS MATRIX Project – Jointly funded by OE and SETO

Project Manager – Jim Follum, PNNL

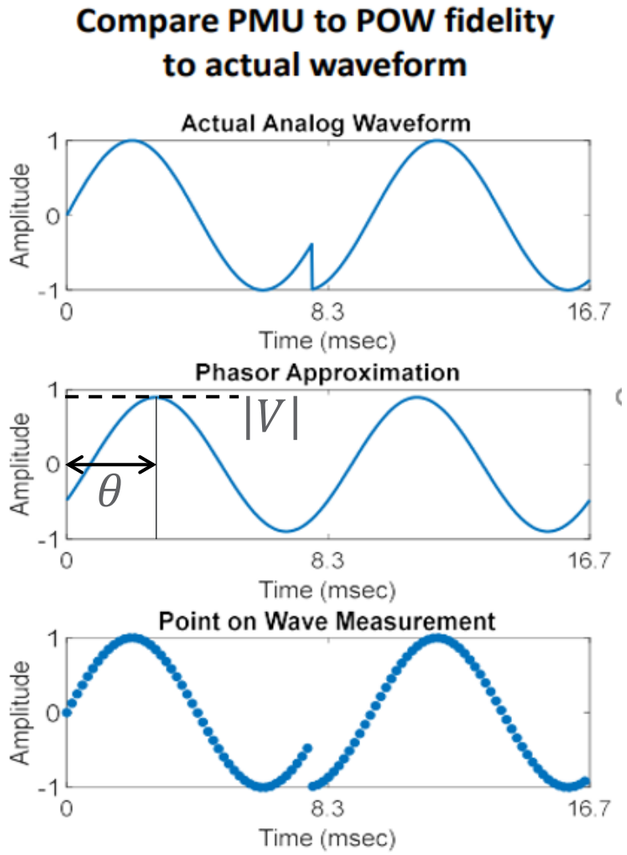
Objectives:

- Develop advanced measurement capabilities and analytics
- Accelerate adoption of IBRs
- Improve the reliability and resilience of the bulk power system

Thanks to colleague Kaustav Chatterjee for slide contributions

Measurements – where and how much?

- ❑ IBR measurements at point of interconnection – limited availability
- ❑ Bandwidth considerations for Point on Wave data.
- ❑ Maximizing the use of data available at substations.
- ❑ Align generator monitoring applications with available data.
- ❑ Sychrophasor measurement for monitoring – Generator Scorecard.
- ❑ Point on wave data for monitoring – selective data transmission.



Matching measurements to applications[1]

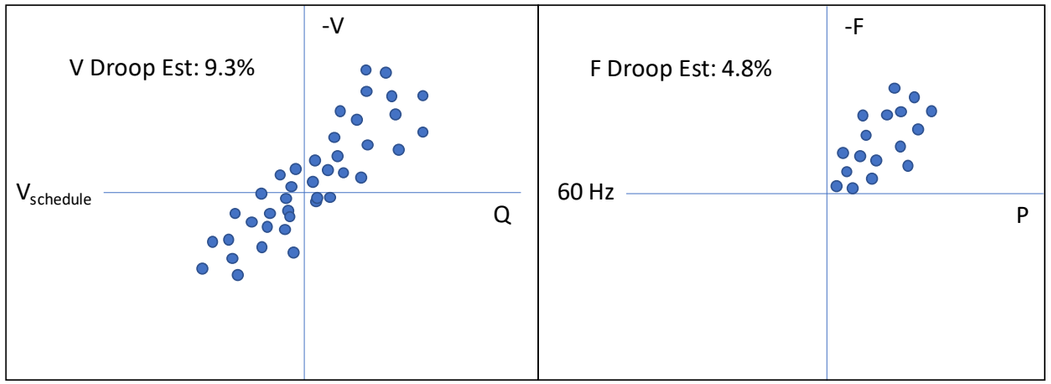
[1] Follum, J., L. Miller, P. Etingov, H. Kirkham, A. Riepnieks, X. Fan, and E. Ellwein. "Phasors or Waveforms: Considerations for Choosing Measurements to Match Your Application." Pacific Northwest National Laboratory, PNNL-31215 (2021).

Generator Scorecard

- Evaluating generator performance using PMU data
  - Is the droop maintained as indicated?
  - Is reactive power absorbed/fed as required?
  - Are voltage schedules met?
- Monitoring IBR plants across operating conditions.
- Practical challenges of measuring Frequency Response (FRM) and voltage response.
- Comparing individual generator behavior with others.
- Scan through PMU data to find events that surpass a frequency or voltage magnitude threshold.
- Capture events and “score” generator performance.
- Implemented on DOE Archive Walker based event detection and generator response scoring.

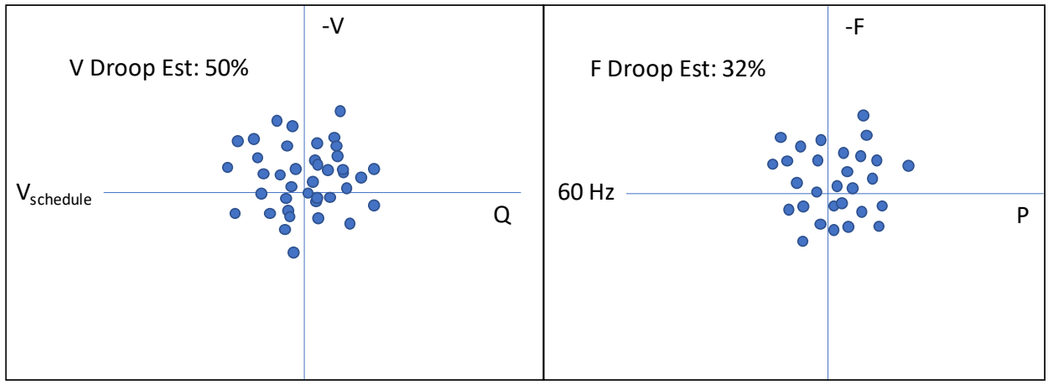
Generator 1: Pass

Ridethrough: 89 of 90 disturbances

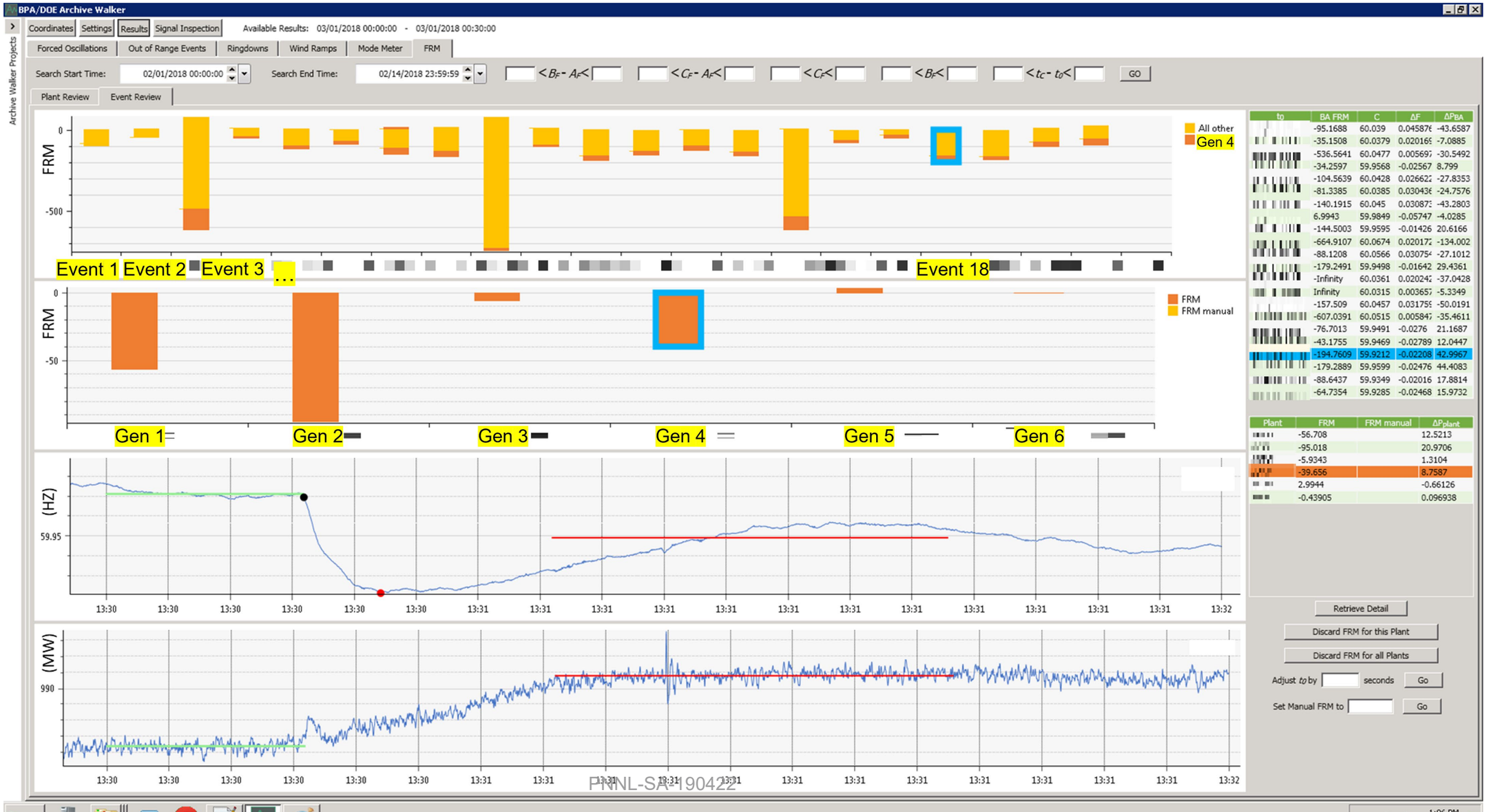


Generator 2: Fail

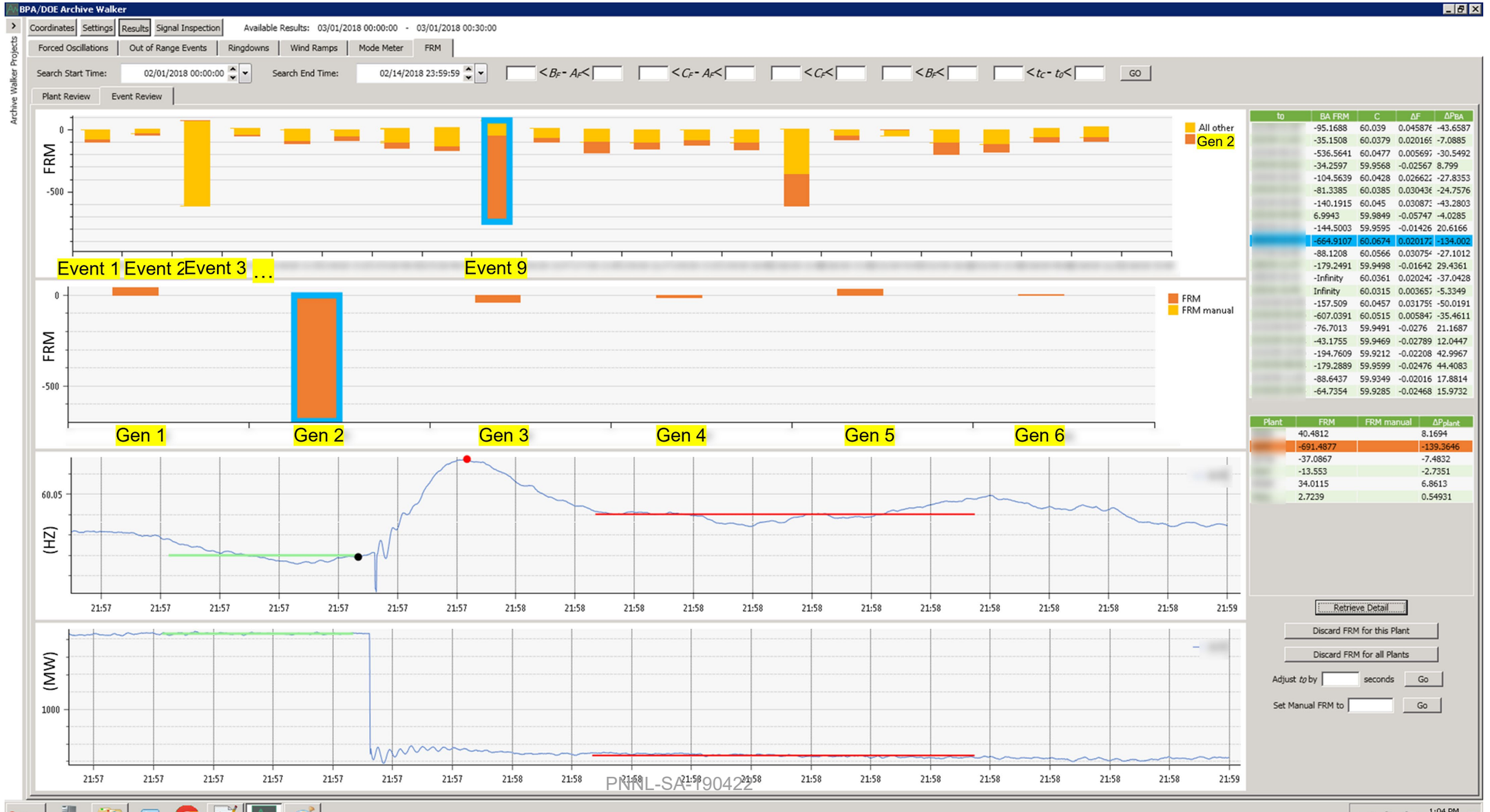
Ridethrough: 75 of 90 disturbances



Generator Scorecard - FRM

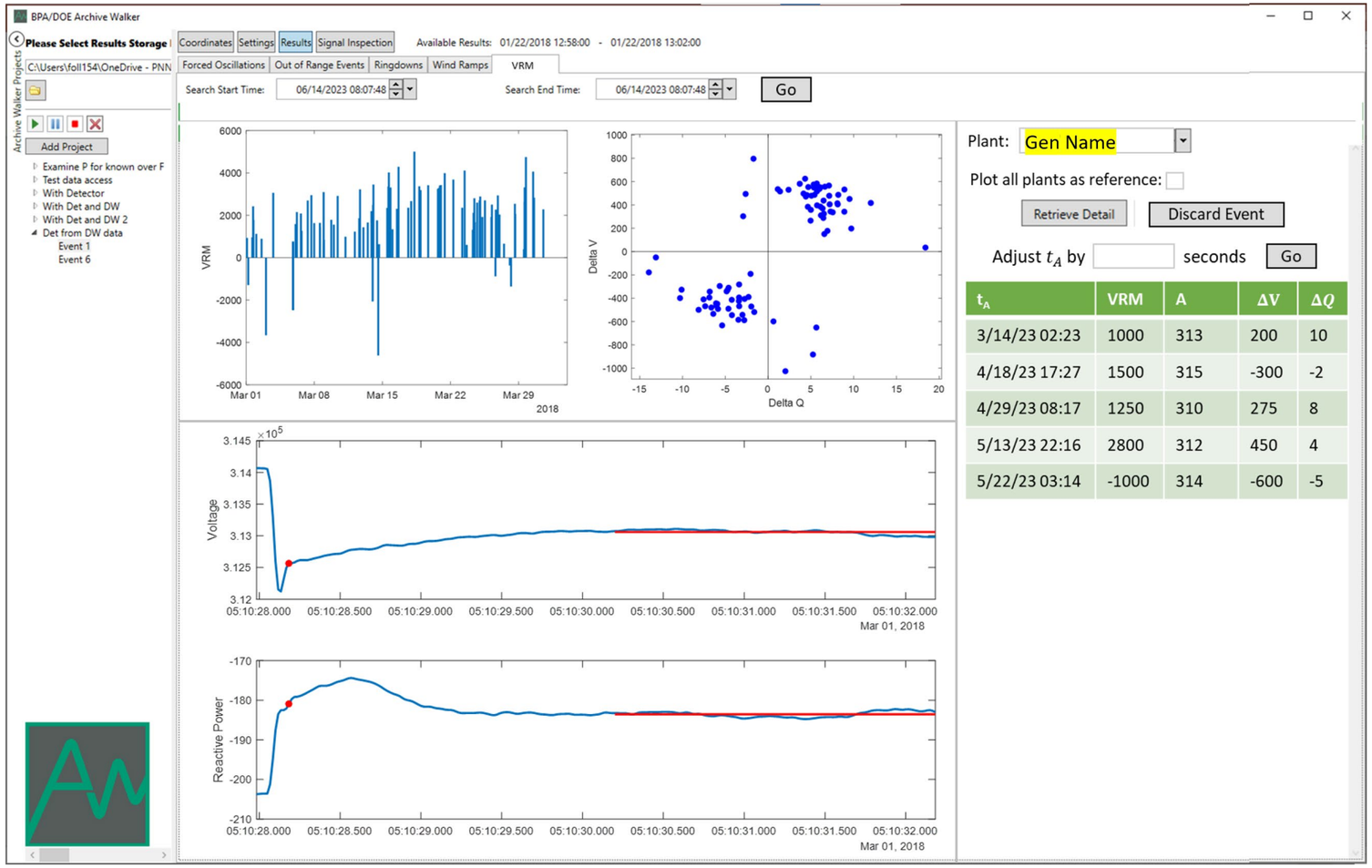


Generator Scorecard – FRM



Generator Scorecard – Voltage events

- Frequency is global but voltage is local.
- Practical challenges to evaluate voltage response from every generator in the system.
- Factors affecting voltage response – plant settings, voltage schedules, power factor, etc.
- Is the generator “usually” behaving with an expected response?

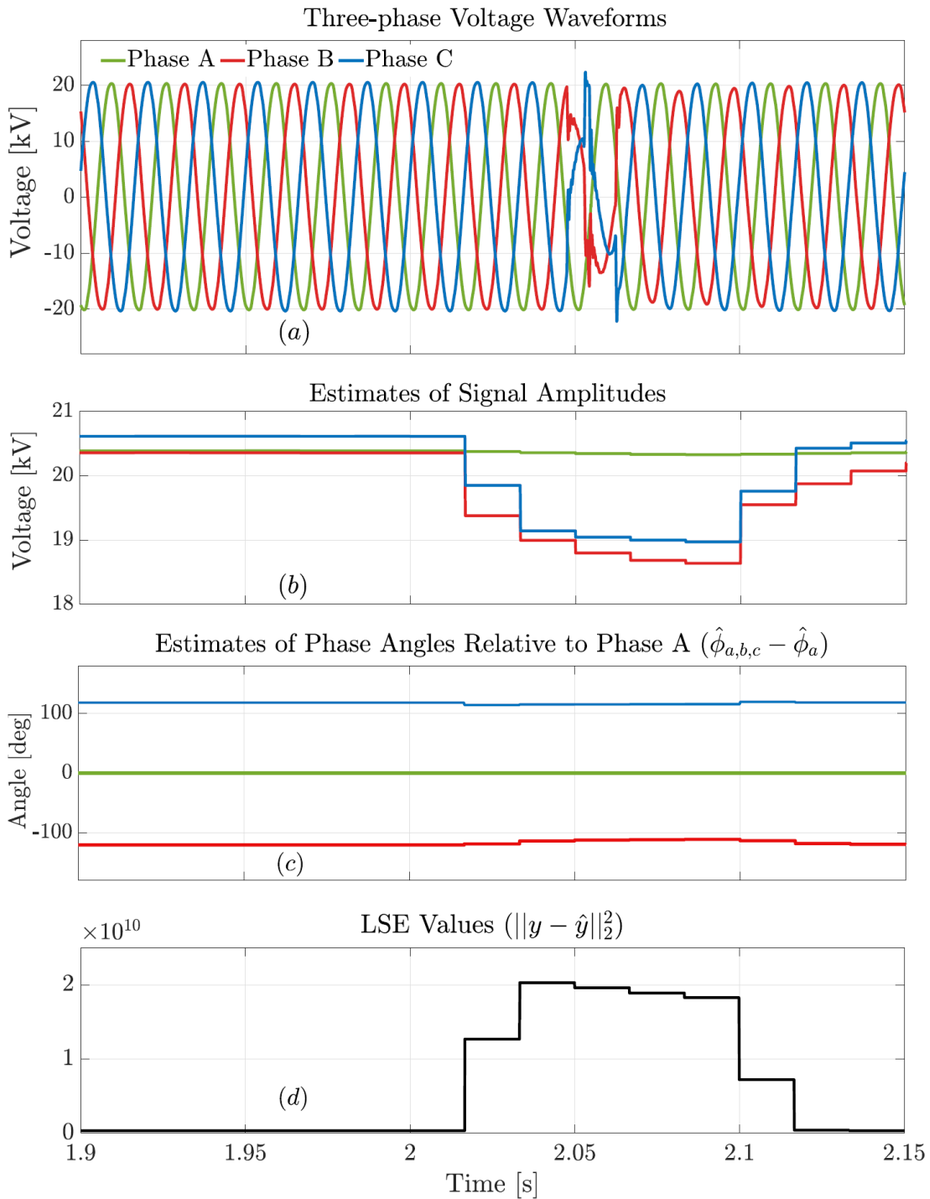


t_A	VRM	A	ΔV	ΔQ
3/14/23 02:23	1000	313	200	10
4/18/23 17:27	1500	315	-300	-2
4/29/23 08:17	1250	310	275	8
5/13/23 22:16	2800	312	450	4
5/22/23 03:14	-1000	314	-600	-5

Mockup of the voltage response portion of the Generator Scorecard

Point on Wave – IBR Monitoring

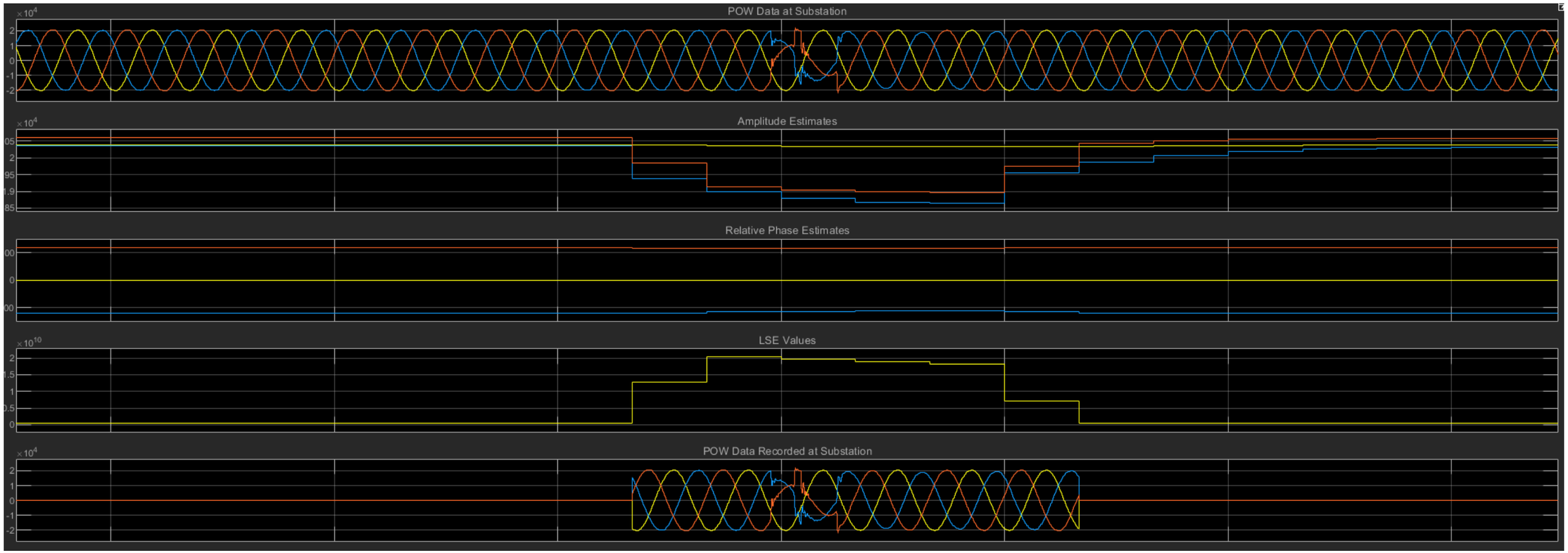
- Non-sinusoidal measurement data during events - unreliable phasor estimates. E.g. Blue Cut Fire, Canyon Fire.
- Trust flag to validate correctness of phasor measurement.
- Augmenting ability for informed decisions at the control room.
- Detecting the occurrence of an event and selectively transmitting POW data for the event window – as opposed to continuous streaming.
- A non-linear least squares based PMU algorithm with Trust Metric
- Communicating selective POW over existing communication channels.



K Chatterjee, D Tarter, J Follum, A Riepnieks, "A Nonlinear Least Squares Phasor Estimation Algorithm with a Trust Metric" Innovative Smart Grid Technologies, North America 2024 [Submitted]

Point on Wave – IBR Monitoring

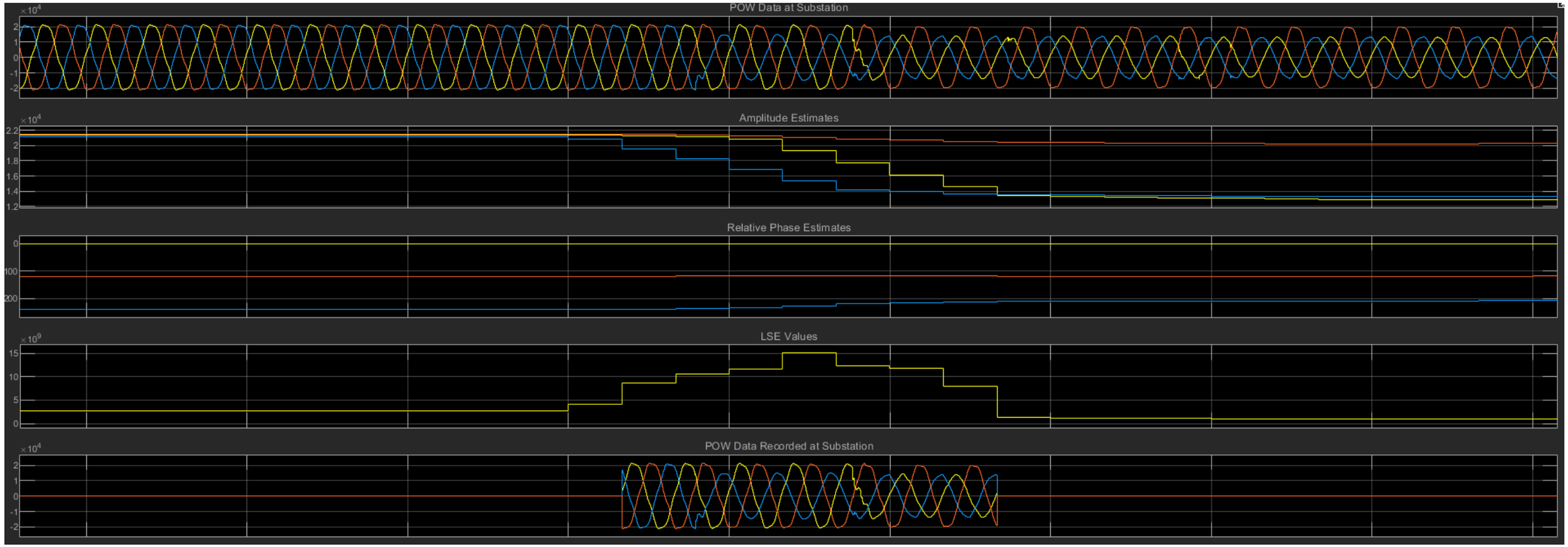
Data source: Grid Event Signature Library Event 907



ORNL, LLNL, September 15, 2023, "Grid Event Signature Library", GESL, https://gesl.ornl.gov

Point on Wave – IBR Monitoring

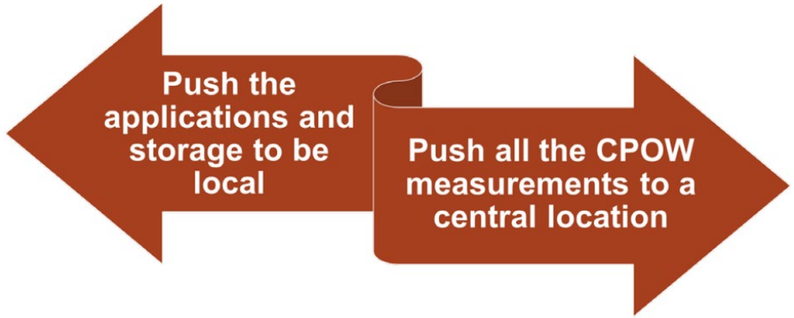
Data source: Grid Event Signature Library Event 677



ORNL, LLNL, September 15, 2023, "Grid Event Signature Library", GESL, https://gesl.ornl.gov

Summary

- The right tool for the right job in an IBR-rich grid.
- Sychrophasor data applications to monitor frequency and voltage response.
- Selective Point on Wave data transmission when PMU data trust low.
- Challenges when POW is unavailable, unreliable, has gaps.
- Future directions:
  - IBR Performance Response and Analytics Monitoring (IPRAM) Task Force.
  - IBR monitoring using Continuous Point on Wave.
  - Event capture with customizable POW triggering conditions.
  - Distributed solutions for storing and analyzing.



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Thank you

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