

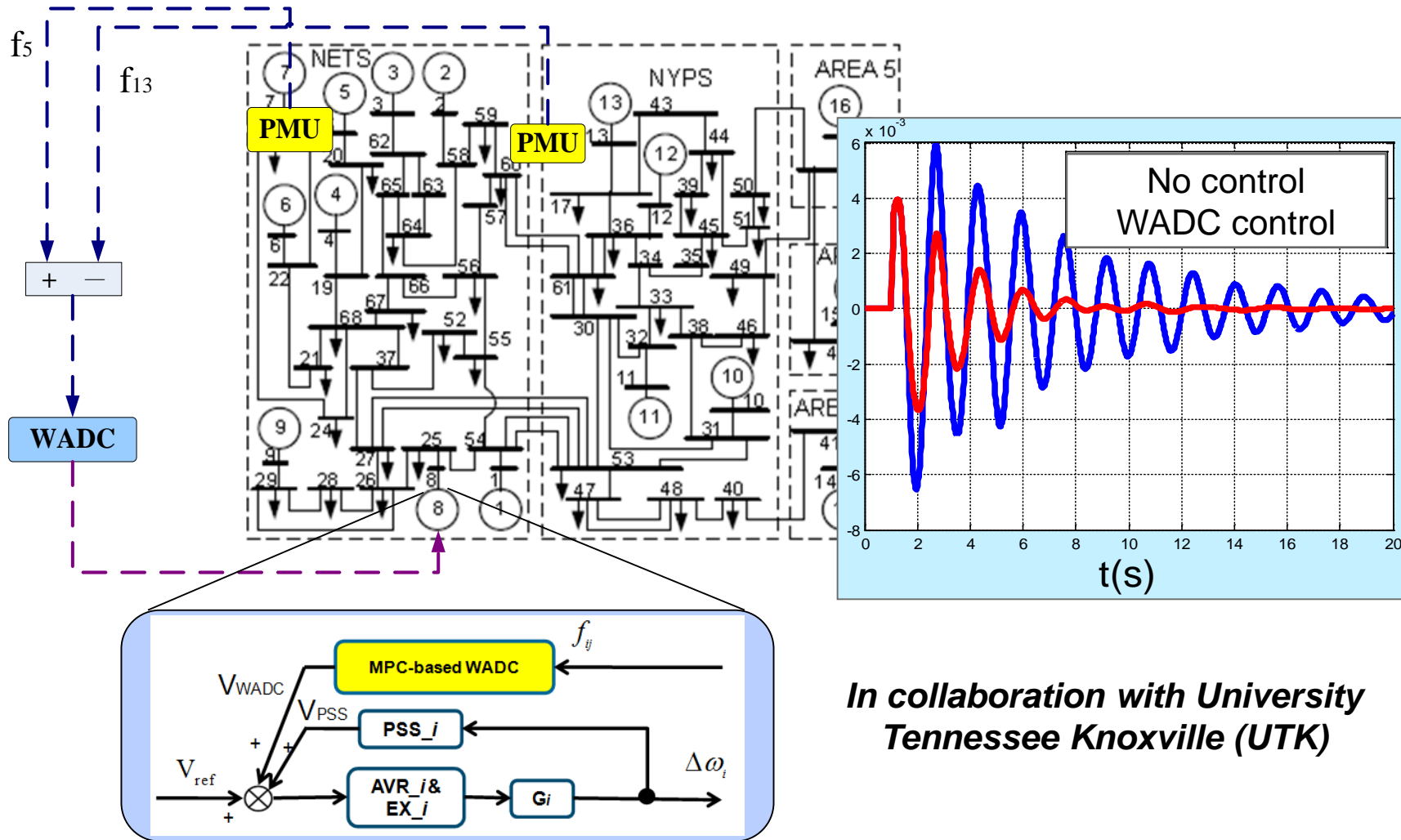
Summary of EPRI Synchrophasor Related Activities

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San Diego, CA
April 16, 2019



1. Synchrophasor-Based Wide Area Oscillations Damping Controller



*In collaboration with University
Tennessee Knoxville (UTK)*

- WADC via additional input to generator excitation system or FACTS/HVDC controller
- Adaptive controller
 - Measurement-derived transfer function model
- Ongoing case studies with NYPA, TERN (Italy) & SEC (Saudi Arabia)
- **Next: Hardware-In-the-Loop (RTDS/Opal-RT) implementation and demos**

- Improved Damping of Target Inter-area/Intra-area Oscillations Mode
- Application of Synchrophasor Technology in Closed Loop Wide Area Control

2. Data Quality Conditioning of Streaming Synchrophasor Data

- Goal: Improve synchrophasor data quality by estimating missing data and replacing bad data in synchrophasor streams
- Model free technique, no need for topology information or system parameters
- Computationally efficient for real-time implementation
- Algorithms have been tested with recorded synchrophasor data provided by EPRI members
- **Ongoing: Demos with streaming synchrophasor data hosted by utilities/ISOs**
- **Next: Collaboration with vendors for implementation in commercial platforms**

Offline SSDQ Tool

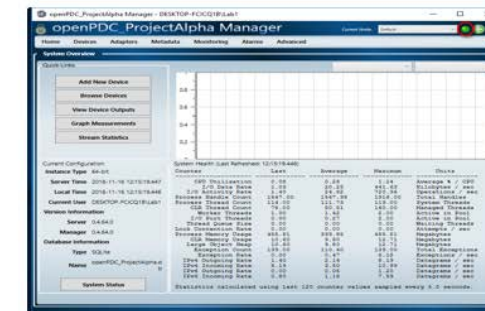


In collaboration with RPI

Online SSDQ Tool



Input Adapter



Action Adapter
SSDQ Algorithm



3. PMU Emulator

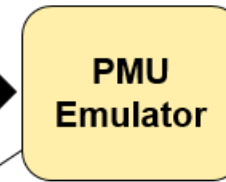
- Interfaced with power system dynamics simulators to produce “simulated synchrophasors” taking into account PMUs internal signal processing
- Ongoing: Collaboration with vendors for implementation in commercial platforms

In collaboration with WSU

Dynamics Simulation Software
(PSS/E, PSLF, TSAT etc)

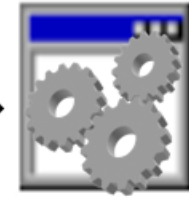


Simulated
Phasors



C37.118

Synchrophasor
Application

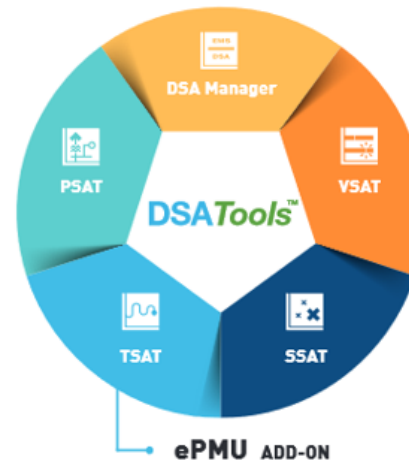


Proof-of-concept software

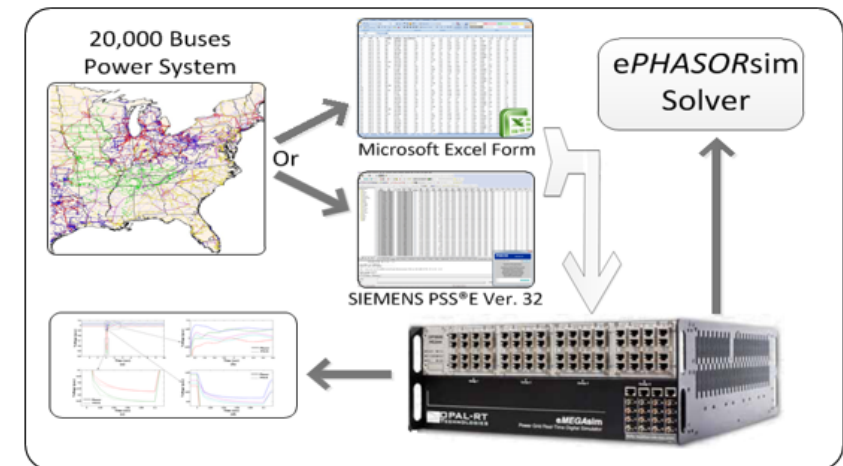


Vendor Engagement

Powertech Labs - ePMU



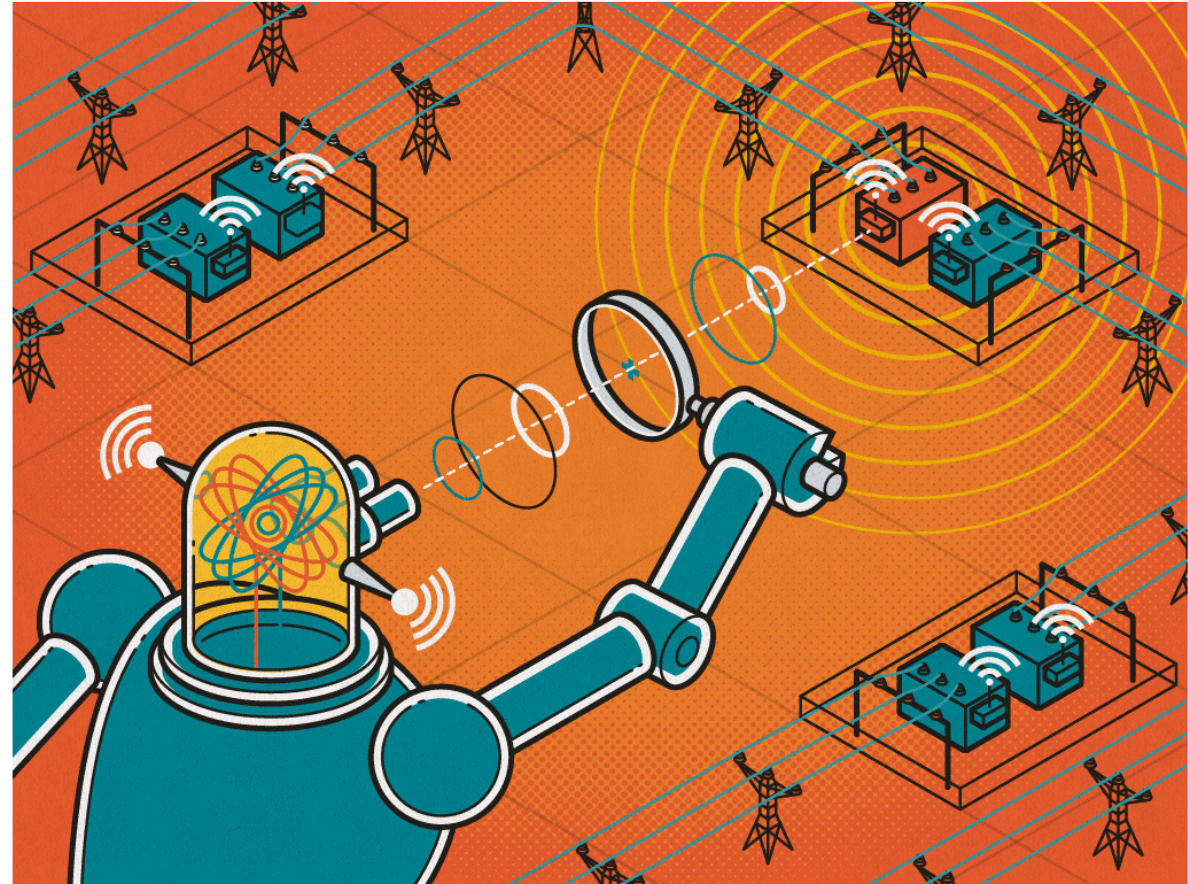
OPAL-RT - ePHASORsim



4. Machine Learning Using Synchrophasor Data

- Data mining/pattern recognition/machine learning techniques that use streaming synchrophasor data to:
 - Characterize in a near real-time environment the operating condition of the system
 - Classify secure vs insecure operating conditions
 - Identify events
 - Perform early-event detection
 - Provide guidance to operators for potential mitigation actions
 - Define metrics as precursors of system insecurity
 - Define system performance indicators (Grid Health Index)
- **Ongoing: Software development**

In collaboration with ASU



Value: Increased System Reliability Through Advanced Situational Awareness & Security Assessment

5. Synchrophasor Applications Database

Synchrophasor Applications Database

File Help

type to search

Search Clear Vendor List PMU Installations

Filter by:

Agencies

☐ AEP

☐ AESO (Canada)

☐ APG (Austria)

☐ ATC

☐ BPA

☐ Cemig Utility (Brazil)

☐ ComEd

☐ DVP

☐ Duke Energy

☐ EPRI

☒ ERCOT

☐ Entergy

☐ FINGRID (Finland)

☐ FPL

☐ Hydro-Québec (Canada)

☒ ISO-NE

☐ ISONE

☐ Jiangsu Electric Power Grid (China)

☐ LBNL

☐ MISO

☐ Manitoba Hydro (Canada)

☐ Maui Electric

☒ NYISO

☐ NYPA

☐ Norwegian Transmission Network

☒ OG&E

☐ PG&E

Search Results:

Agency Name	Application Type	Vendor Name	Tool Name
ERCOT	Situational Awareness	EPG	RTDMS
ERCOT	Oscillation Detection	EPG	RTDMS
ERCOT	Event Analysis	EPG	PGDA
ERCOT	Model Validation	Mathworks	MATLAB
ERCOT	Operator Training	Powertech Labs, Inc.	TSAT
ISO-NE	Voltage Stability	EPG	PSOT
ISO-NE	Event Detection	V&R Energy	ROSE
ISO-NE	Oscillation Detection	GE	PhasorPoint
ISO-NE	Model Validation	In-house	OSL
ISO-NE	Data Quality Management	Powertech Labs, Inc.	TSAT
NYISO	Situational Awareness	In-house	DQMS
NYISO	Voltage Stability	EPG	RTDMS
NYISO	State Estimation	ABB	Phasor Enhanced Voltage Stability
NYISO	Oscillation Detection	ABB	Phasor Enhanced State Estimator
NYISO	Event Analysis	EPG	RTDMS
NYPA	Model Validation	EPG	PGDA
OG&E	Situational Awareness	EPG	SVSMV
OG&E	Event Detection	In-house	PhasorView
OG&E	Oscillation Detection	In-house	PhasorView

EPRI ELECTRIC POWER RESEARCH INSTITUTE

Details

Alstom/GE's PhasorPoint

Description:
e-terraphasorpoint is an advanced, fully integrated, smart grid ready suite of products for the 21st century grid. Transmission operators must maintain stable operation of the power system and increase the use of assets, while aging infrastructure and a changing generation profile introduce new challenges. e-terraphasorpoint can bring great insight, reducing costs through more effective use of power system capacity, safeguarding its stability.
This flexible, scalable and extensible phasor-based Wide Area Management System (WAMS) is integrated with the e-terra solutions for Energy Management Systems (EMS), in order to:
• Transform phasor data into actionable information to improve system security and capacity.
• Coordinate WAMS and EMS to produce a unified view of the power system, enhancing operator and analyst decision-making.
• Enable strategic development of the control center systems with the critical involvement of phasor-based information sources.
Key benefits include:
• Mitigate risk of major disturbance
• Relieve transmission constraints
• Improve dynamic models
• Fulfill regulatory reporting requirements
• Improve emergency response
• Scalable – grow to the largest foreseeable systems
• Extensible – add new applications when required
Other details about the product are described in [1].
Built-In Data Quality Management:
GE's built-in functionality for data quality management includes two aspects, which are e-terraphasorpoint PDC processing and synchrophasor applications (i.e.: oscillation detection, state estimation) level data handling. The e-terraphasorpoint PDC processing provides users both live stream statistics and live PMU statistics. Live stream statistics include packet latency, percentage of time quality errors, percentage of missing data frames and last valid data frame. Whereas, live PMU statistics include percentages of GPS lock, valid data, data error and missing data. And the data handling of application level is based on three heuristics. These heuristics are at utilization of PMU data quality status information from the field of PMU.
References:
[1] "e-terraphasorpoint", GE Software Solutions.
[2] Alstom/GE, "Grid Software Solutions - Built-in Data Quality", presented at NASPI, Mar. 2016.

Figure 1: Reference Angle Selection of Alstom/GE's e-terraphasorpoint.
The figure shows a map of a power system with a highlighted area labeled 'REFERENCE'. Below the map is a color-coded bar for 'Synchronism Level (Upper/Lower Frequency Limit)' ranging from 0.000 to 1.000. The right sidebar contains buttons for 'Monitoring', 'New Entry', 'System Data', 'Model Control', 'Voltage Stability', 'Voltage Phasor', 'PMU', and 'Frequency'.

Model Validation at NYPA

Description:
NYPA has used EPRI's "Static Var System Model Validation" tool to validate the models of a STATCOM (Marcy substation) and an SVC. The generic dynamic Static Var Systems models (also developed by EPRI) were used to parameterize [1], [2]. Figure 1 [2] shows representative results of the model validation.
References:
[1] EPRI and NYPA, "Model Validation of SVC and STATCOM Using PMU Data", presented at NASPI, Oct. 2013.
[2] EPRI and NYPA, "Validation of Generic Models for Stability Analysis of two Large Static Var Systems in New York using PMU Data", presented at IEEE PES GM, Apr. 2014.

Figure 1: SVC Model Validation Using SVSMO1 Model at NYPA.
The figure contains two plots. The top plot shows 'Shunt Reactor (p.u.)' vs 'Time (seconds)' from 0 to 6000. The bottom plot shows 'Shunt Reactor (p.u.)' vs 'Time (seconds)' from 0 to 6000. Both plots compare 'Measured' (blue line) and 'Simulated' (red line) data, showing a sharp drop in the shunt reactor value around 2000 seconds.

- Entries based on publicly available documents
- For each entry, summary description of application and related references

Value: Inform utility/ISO engineers and executive management about uses cases and derived value of synchrophasor technology

Together...Shaping the Future of Electricity