

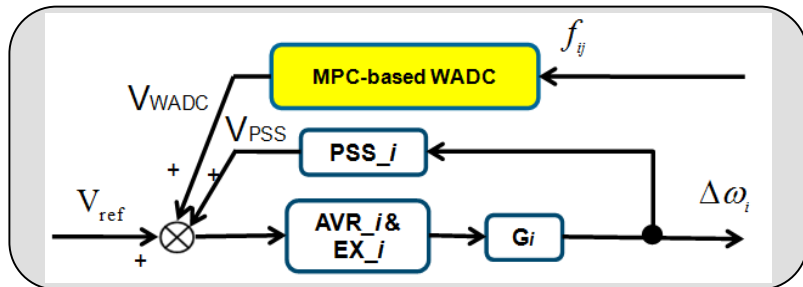
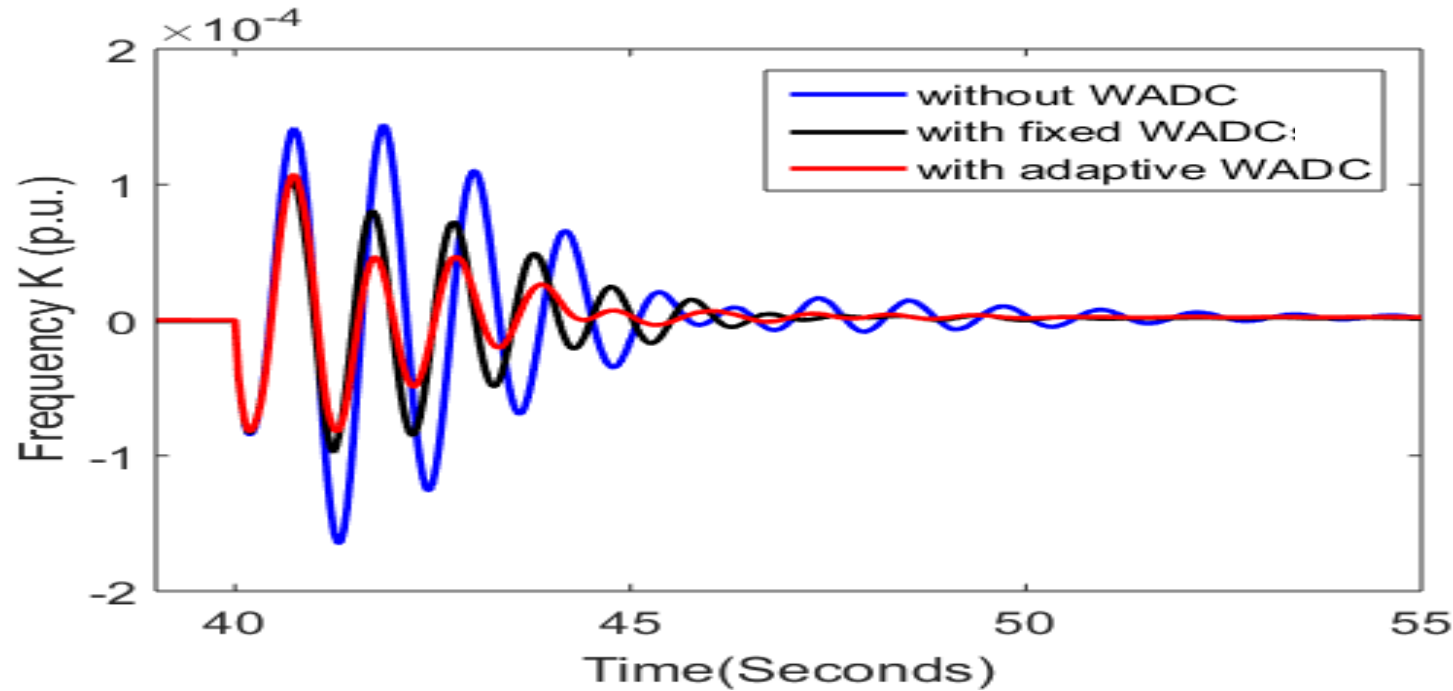
Summary of EPRI Synchrophasor Related Activities

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NASPI WG Meeting
Philadelphia, PA
October 23, 2018



1. Synchrophasor-Based Wide Area Oscillations Damping Controller



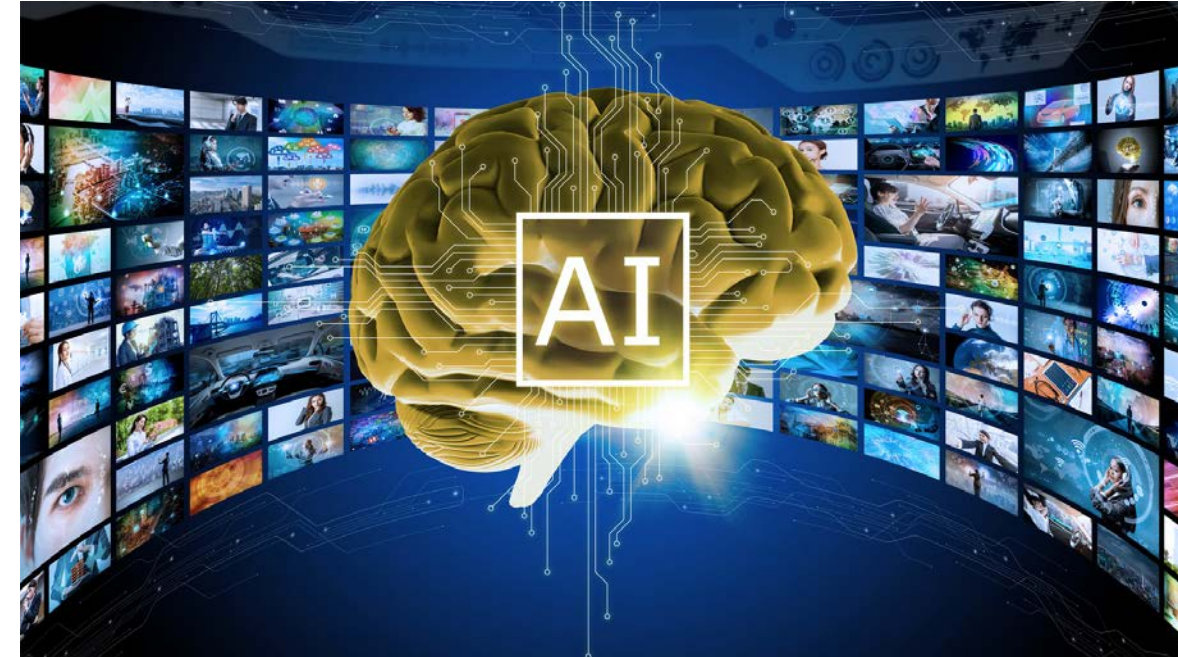
In collaboration with University Tennessee Knoxville (UTK)

- Adaptive controller
 - Measurement-derived transfer function model (Probing signal or ringdown data)
- Ongoing case studies with NYPA, TERN (Italy) & SEC (Saudi Arabia)
- Hardware-In-the-Loop implementation
 - Measurement delays
 - Missing/Bad data

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

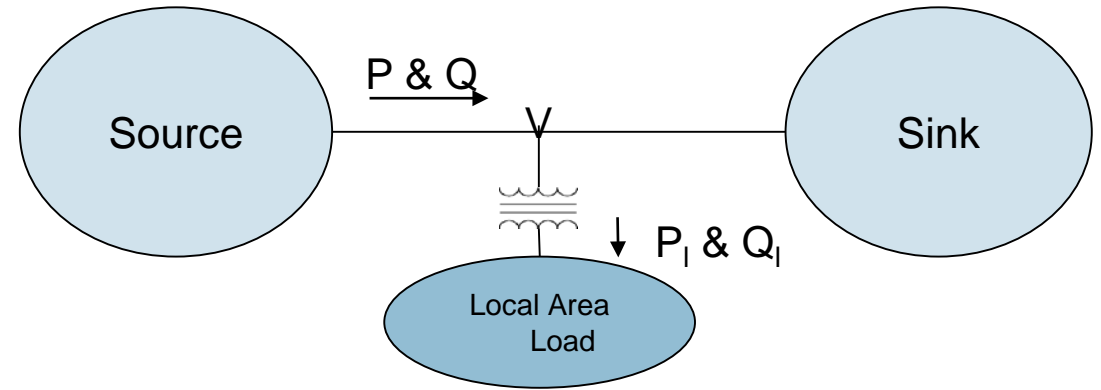
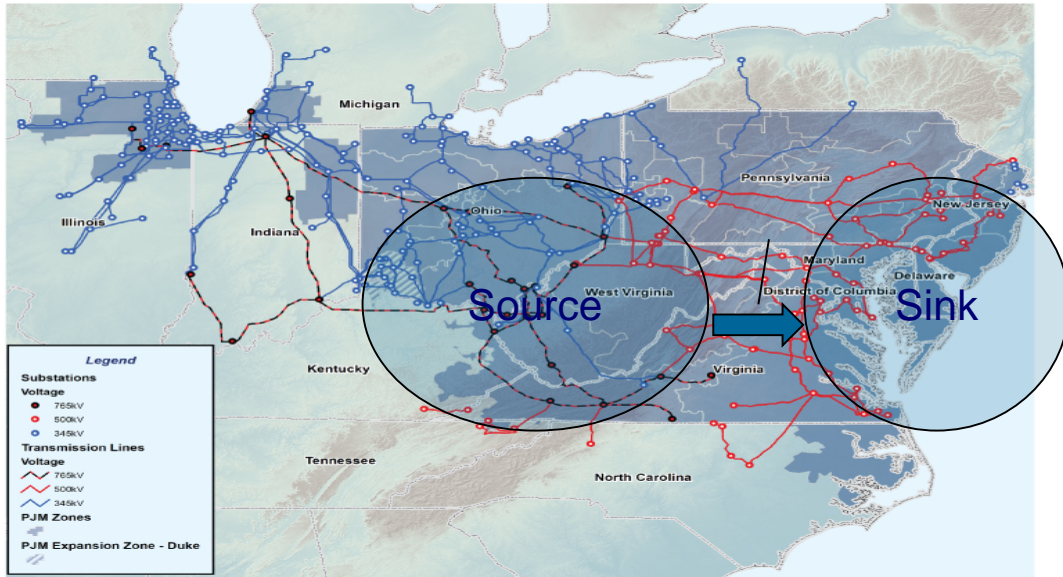
2. Data Mining and Machine Learning Techniques Using Synchrophasor Data

- Data mining/pattern recognition/machine learning techniques that use streaming synchrophasor data to:
 - Identify Events
 - Classify secure vs insecure operating conditions
 - Provide guidance to operators for potential mitigation actions
 - Define metrics as precursors of system insecurity
 - Define system performance indicators (Grid Health Index)



Value: Increased System Reliability Through Advanced Situational Awareness

3. Voltage Sensitive Static ZIP Load Model Using Synchrophasor Data



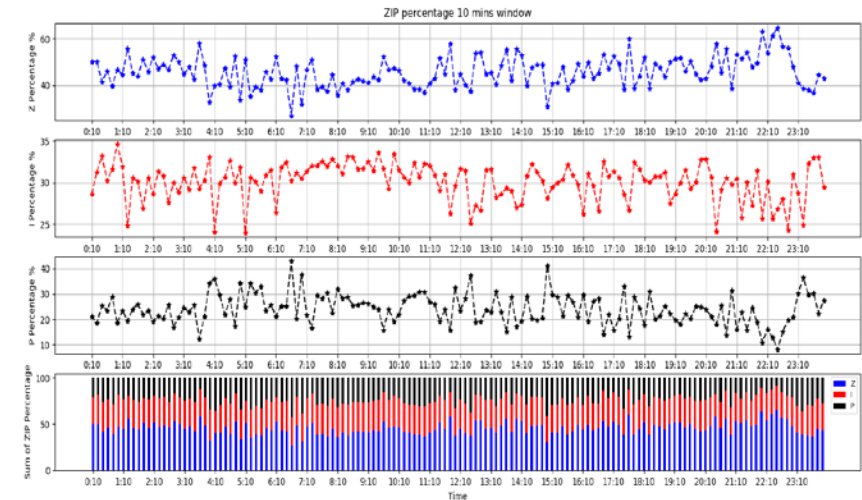
software being tested with member data

- Develop Analytical Tools to Determine Voltage Sensitivity of Local Loads
 - Use Synchrophasor data for bus voltage & load at the critical bus
 - Filter out random noise & bad data
 - Determine appropriate measurement window required

- Represent Voltage Sensitivity of Load as a ZIP Load Model

$$P_{ZIP} = P_0 [A (V/V_0)^2 + B (V/V_0) + C]$$

$$Q_{ZIP} = Q_0 [D (V/V_0)^2 + E (V/V_0) + F]$$

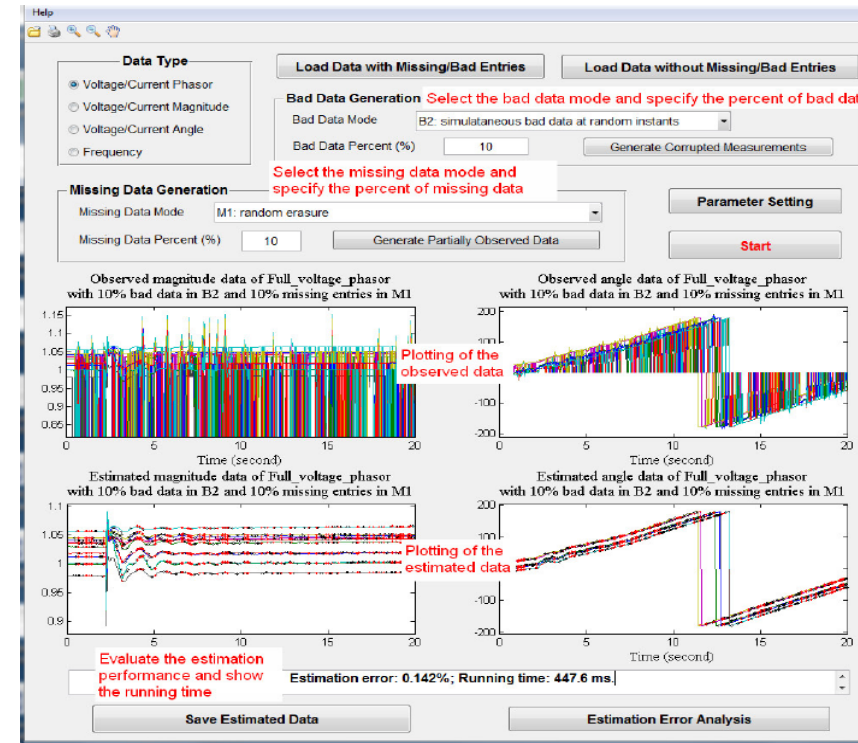


In collaboration with WSU

4. Data Quality Monitoring and Mitigation of Streaming Synchrophasor Measurements

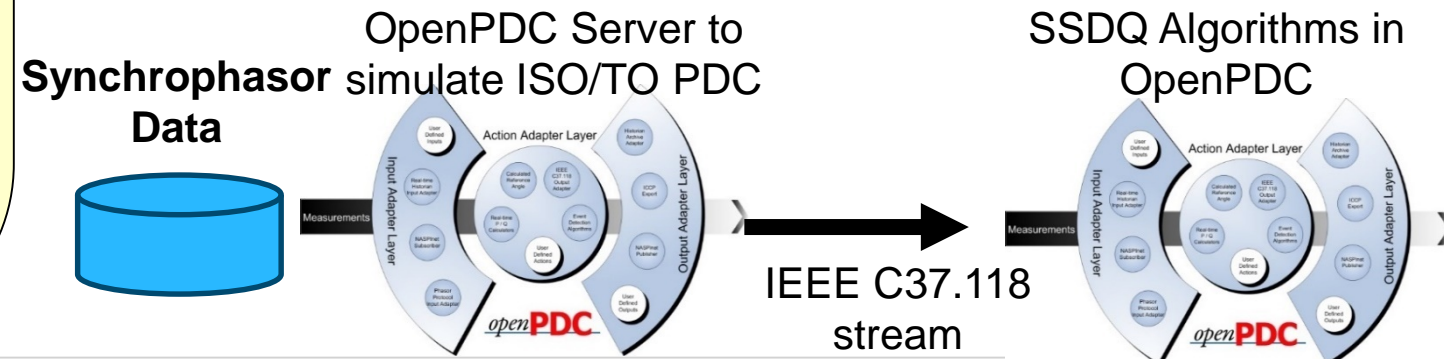
- Goal: Improve synchrophasor data quality by estimating missing data and replacing bad data in synchrophasor streams
- Model free technique, no need for topology information or system parameters
- Computationally efficient for real-time implementation
- Algorithms are being tested with recorded synchrophasor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

Offline Tool



In collaboration with RPI

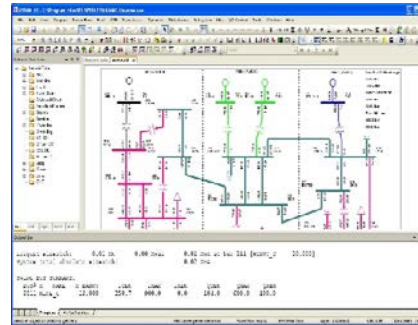
Online Tool



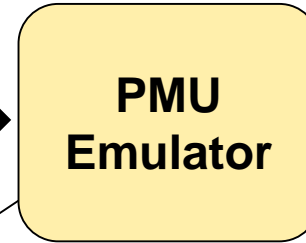
5. PMU Emulator

- Phasor values obtained from dynamic simulation tools may differ from synchrophasors measured by PMUs in the field
- How a PMU works:
 - Analog signal sampling - A/D Conversion
 - Digital filtering → magnitude attenuation & phase offset
 - Phasor estimation
 - algorithm e.g. DFT
 - window length - P & M class PMUs
- PMU Emulator: interfaced with power system dynamics simulators, and produces “simulated synchrophasors” taking into account PMUs internal signal processing

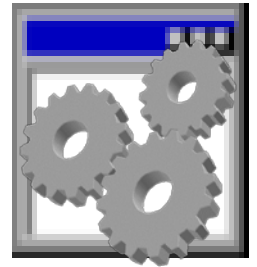
Dynamics Simulation Software (PSS/E, PSLF, TSAT etc.)



Simulated Phasors

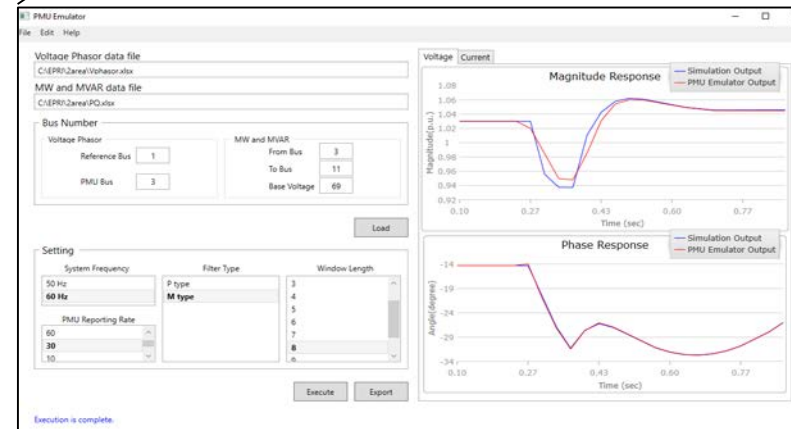


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In collaboration with WSU

software ready for implementation



- Hardware-In-the-Loop benchmarking (RTDS & hardware PMUs)
- Use cases: Model validation, synchrophasor applications offline testing (especially control applications), operator training, etc.
- Vendor PMU library
- Next: Collaboration with vendors for implementation in commercial platforms

6. Synchrophasor Applications Database

The screenshot shows the 'Synchrophasor Applications Database' application window. It features a search bar at the top with a search icon and a 'type to search' placeholder. Below the search bar are buttons for 'Search', 'Clear', 'Vendor List', and 'PMU Installations'. The main area is divided into a 'Filter by:' sidebar on the left and a 'Search Results:' table in the center. The sidebar contains a tree view of agencies and vendors, with 'ERCOT' selected. The table has four columns: 'Agency Name', 'Application Type', 'Vendor Name', and 'Tool Name'. The EPRI logo and 'ELECTRIC POWER RESEARCH INSTITUTE' text are visible at the bottom left, and an 'Apply Filter' button is at the bottom right.

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

This image shows a detailed view of the 'Filter by:' sidebar. It contains several expandable sections: 'Agencies', 'Vendors', 'ToolName', 'Application Type', 'Planning', and 'Maturity Level'. Each section has a tree view of sub-items with checkboxes. The 'Vendors' section is expanded, showing a list of vendors: ABB, EPG, EPRI, ESRI + OSIssoft, GE, In-house, Powertech Labs, Inc., Quanta Technology, V&R Energy, and WSU. The 'Application Type' section is also expanded, showing sub-sections for 'Real Time' (Event Detection, Oscillation Detection, Situational Awareness, State Estimation, Voltage Stability) and 'Planning' (Event Analysis, Model Validation). An 'Apply Filter' button is located at the bottom of the sidebar.

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



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