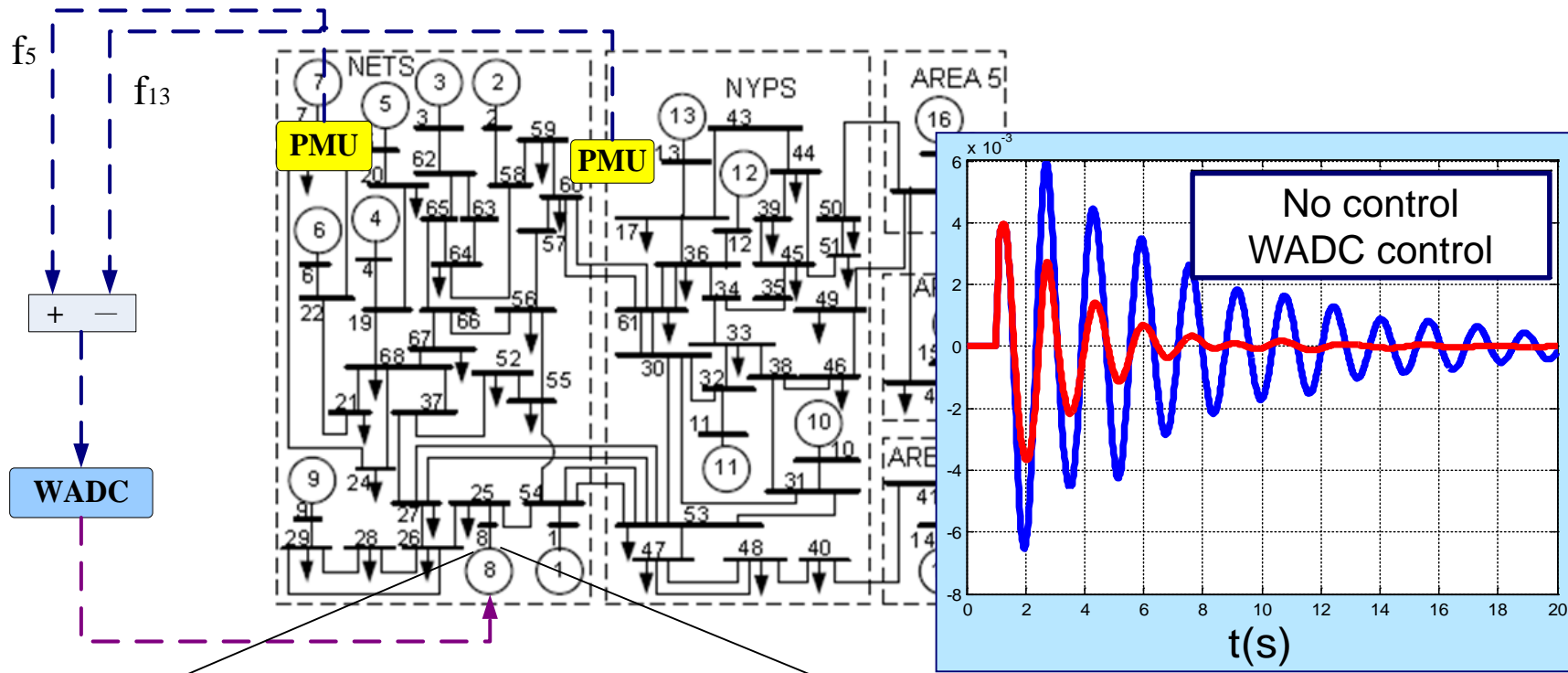
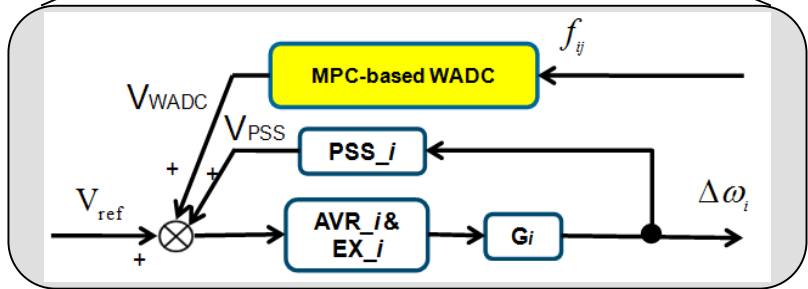


1. Synchrophasor-Based Wide Area Oscillations Damping Controller



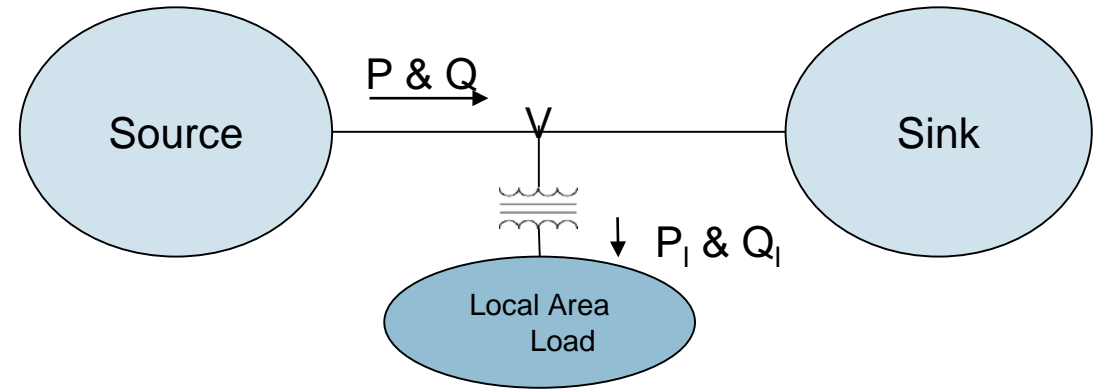
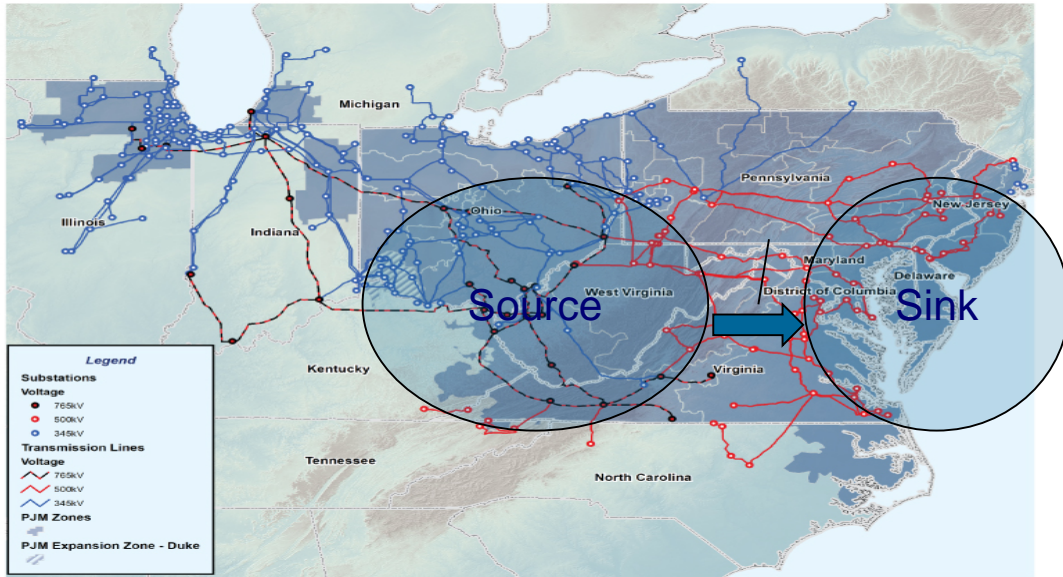
- WADC via additional input to generator excitation system or FACTS/HVDC controller
- Adaptive controller
 - Measurement-derived transfer function model
- Ongoing case studies with NYPA, TERNA (Italy) & SEC (Saudi Arabia)
- Hardware-In-the-Loop implementation
 - Measurement delays
 - Missing/Bad data



In collaboration with University Tennessee Knoxville (UTK)

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

2. Voltage Sensitive Static ZIP Load Model Using Synchrophasor Data



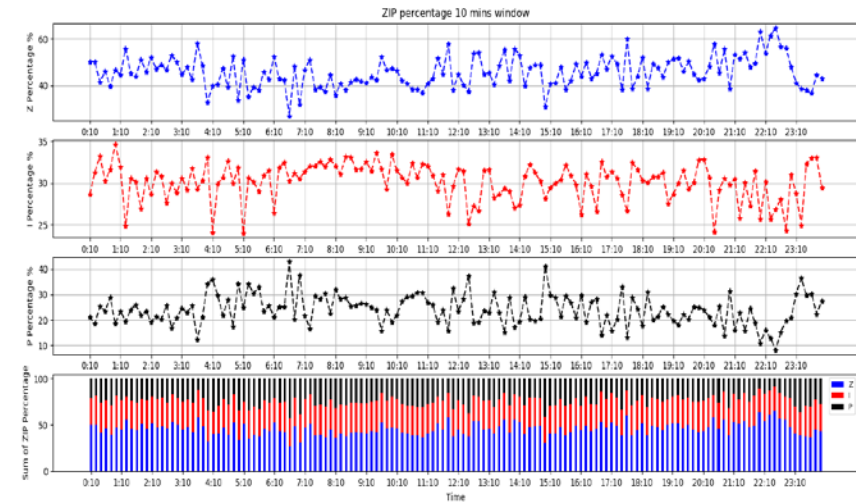
Proof-of-concept software

- 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

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

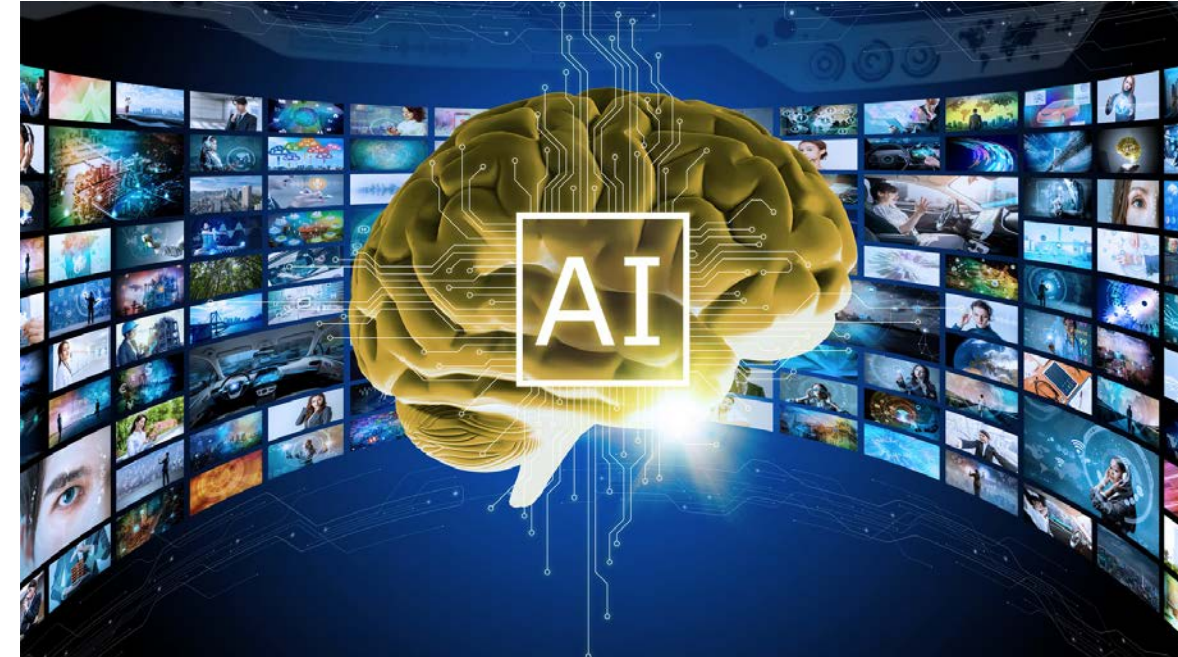
$$Q_{ZIP} = Q_0 [D (V/V_0)^2 + E (V/V_0) + F]$$



In collaboration with WSU

3. Data Mining and Machine Learning Techniques Using Synchronphasor Data

- Data mining/pattern recognition/machine learning techniques that use streaming synchronphasor 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)

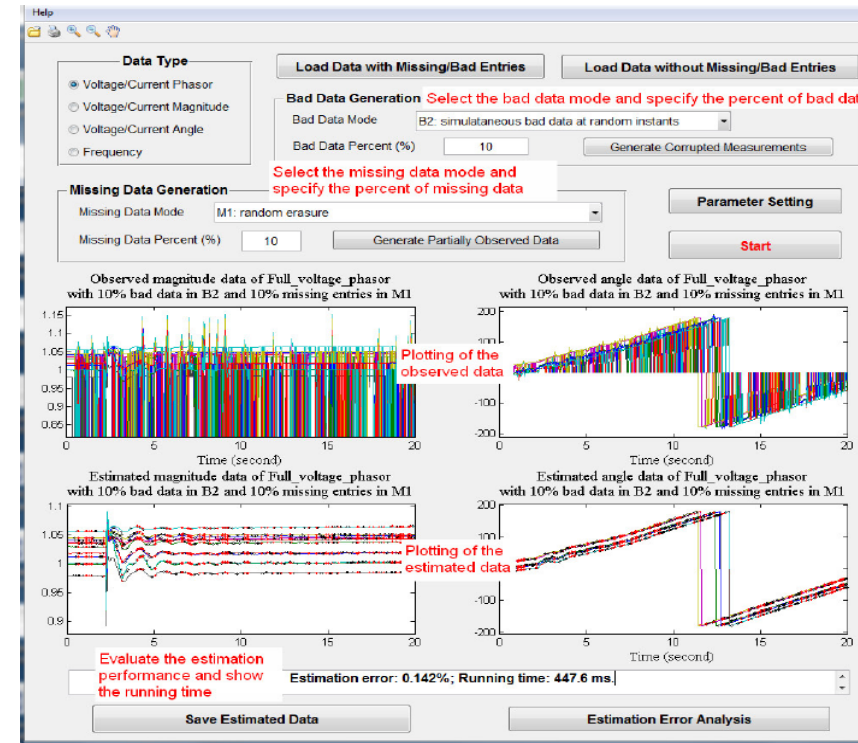


Value: Increased System Reliability Through Advanced Situational Awareness

4. Data Quality Monitoring and Mitigation of Streaming Synchrophasor Measurements

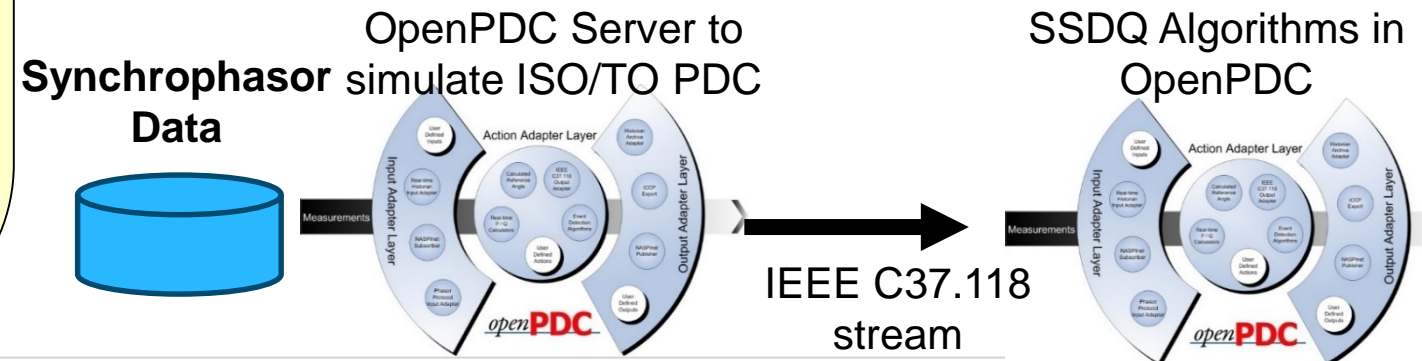
- Goal: Improve synchrophasor data quality by estimating missing data and replacing bad data in synchrophasor streams
- Model free technique, no need for topology information or system parameters
- Computationally efficient for real-time implementation
- Algorithms are being tested with recorded synchrophasor 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

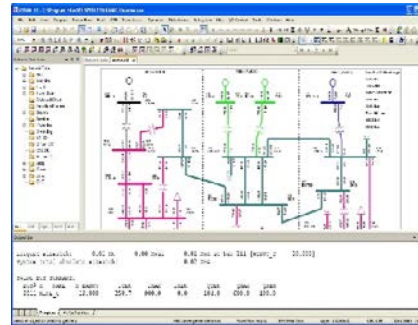
Online Tool



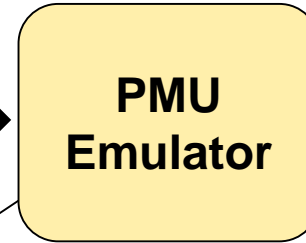
5. PMU Emulator

- 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.)



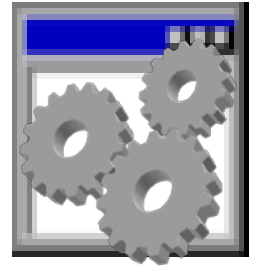
Simulated Phasors



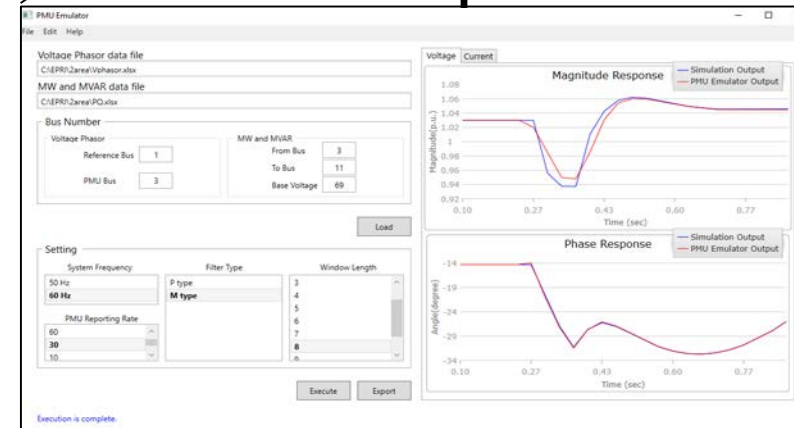
C37.118



Synchrophasor Application



Proof-of-concept software



In collaboration with WSU

- 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 button and a 'PMU Installations' button. A sidebar on the left allows filtering by agency, with 'ERCOT' selected. The main area displays a table of search results with columns for Agency Name, Application Type, Vendor Name, and Tool Name. The EPRI logo is visible in the bottom left corner.

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

The filter sidebar is titled 'Filter by:' and contains several expandable sections. The 'Agencies' section is expanded, showing a list of agencies with checkboxes. The 'Vendors' section is also expanded, showing a list of vendors with checkboxes. The 'ToolName' section is expanded, showing a list of tool names with checkboxes. The 'Application Type' section is expanded, showing a list of application types with checkboxes. The 'Maturity Level' section is expanded, showing a list of maturity levels with checkboxes. 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



Together...Shaping the Future of Electricity