Synchrophasor Data Quality Conditioning

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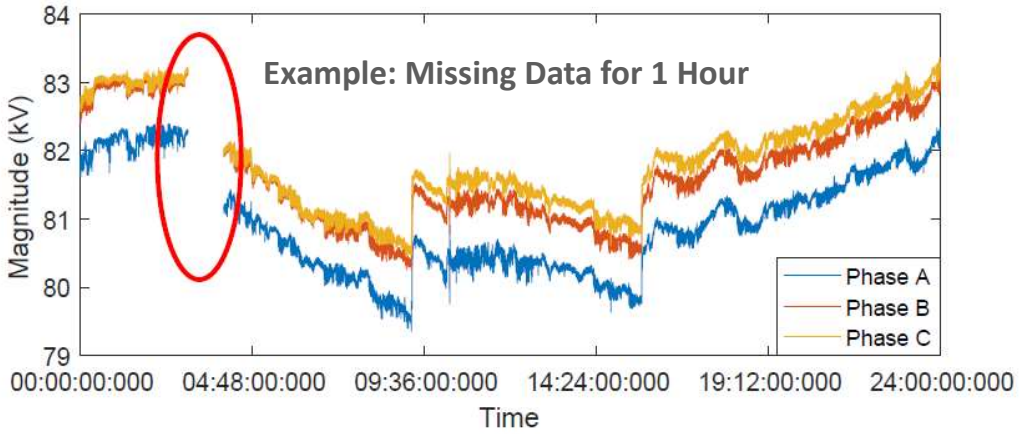
Synchrophasor Data Quality Challenges

- Synchrophasor data quality is a major factor for successful integration of synchrophasor technology in utility/ISO operations environment
- Poor synchrophasor data quality reduces the robustness and accuracy of PMU applications

1. Data Availability - Missing Data
   - Data loss
   - Delivery delays
   - PMU hardware failure etc.

2. Data Accuracy
   - Time accuracy (GPS)
   - Installation/Calibration (Instrumentation, CTs, PTs, etc.)



EPRI Work: Data Quality Conditioning of Streaming Synchrophasor Measurements

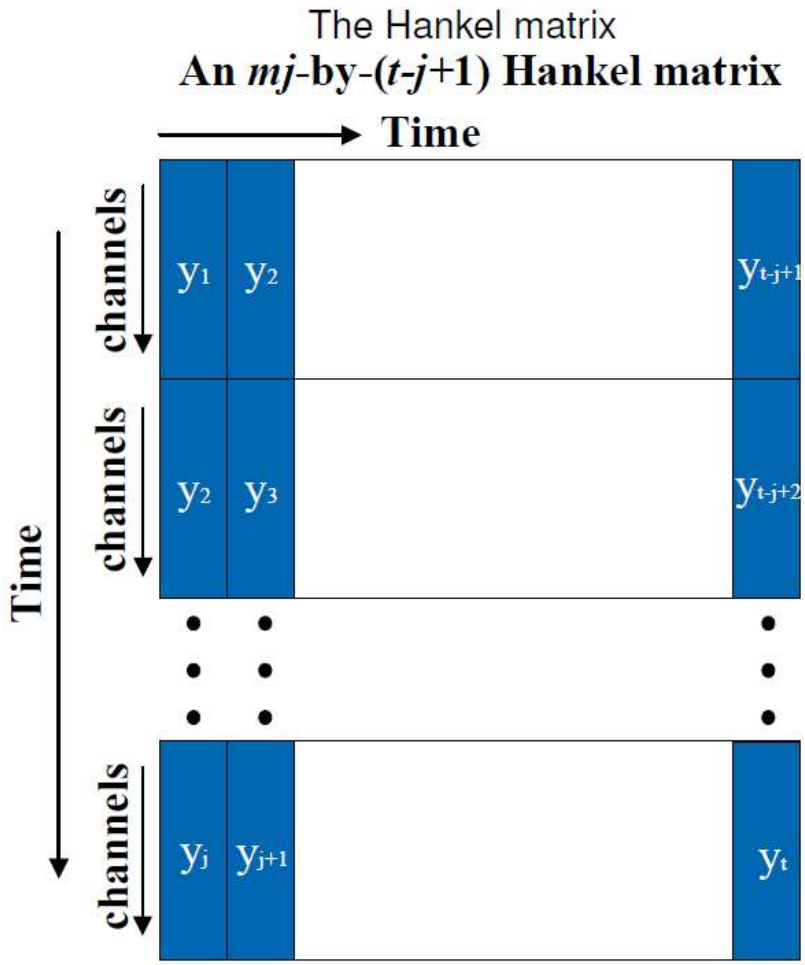
Project Goal	• Improve synchrophasor data quality by estimating missing data and replacing bad data in synchrophasor streams
Features of the Method	• Model free technique - no need for topology information or system parameters • Computationally efficient for real-time implementation
Testing & Validation	• Algorithm has been tested with recorded synchrophasor data provided by several EPRI members

Software Tools	• Streaming Synchrophasor Data Quality (SSDQ) software
	• Two Versions
	  • Offline
	  • Online

SSDQ Algorithm

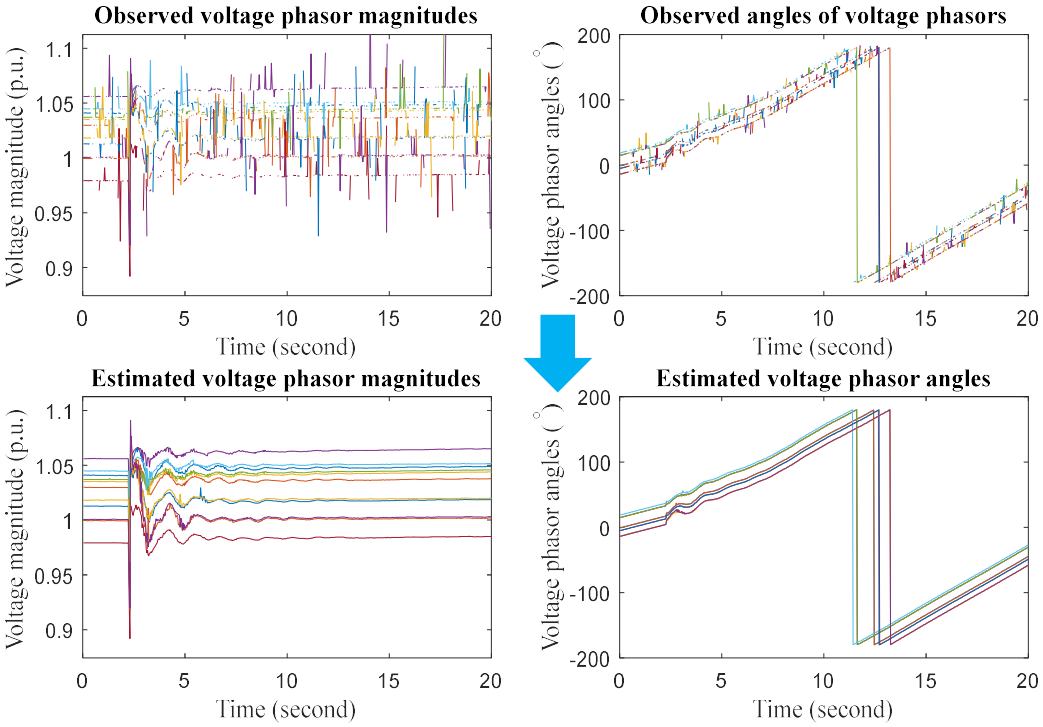
- Process *spatial-temporal blocks* of synchrophasor data collected from PMUs in electrically close regions
- Key feature: *low-rankness* of synchrophasor data blocks and their Hankel matrix.
- *Differentiation between event data and bad data*

$$\text{Event: } e(\mathcal{H}(\mathbf{Y})) \gg e(\mathcal{H}(\mathbf{Y}))$$
$$\text{Bad data: } e(\mathcal{H}(\tilde{\mathbf{Y}})) \approx e(\mathcal{H}(\mathbf{Y}))$$

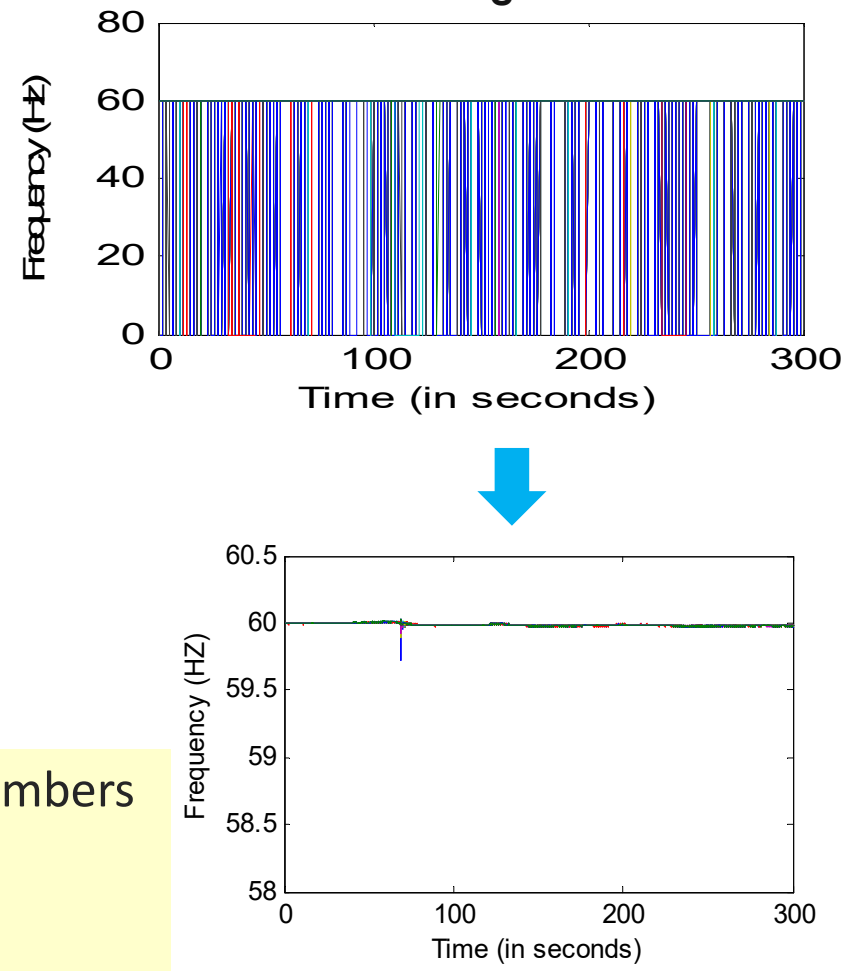


Example Results

Bad Data



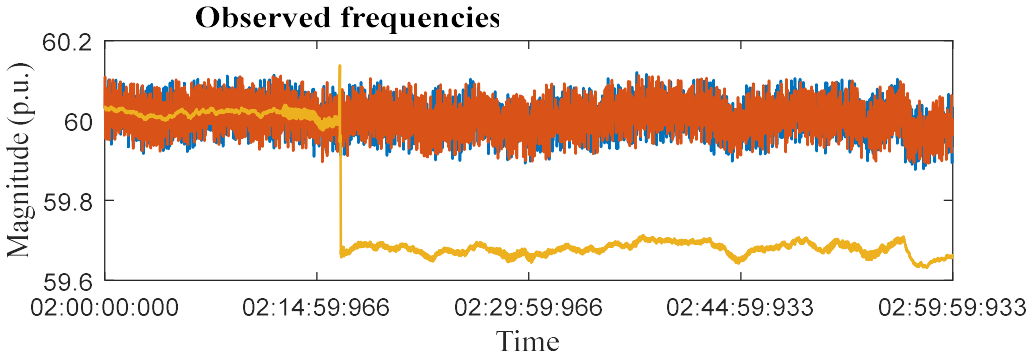
Missing Data

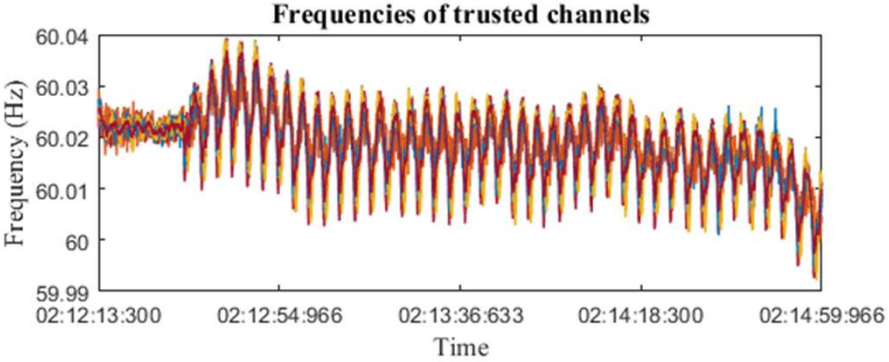


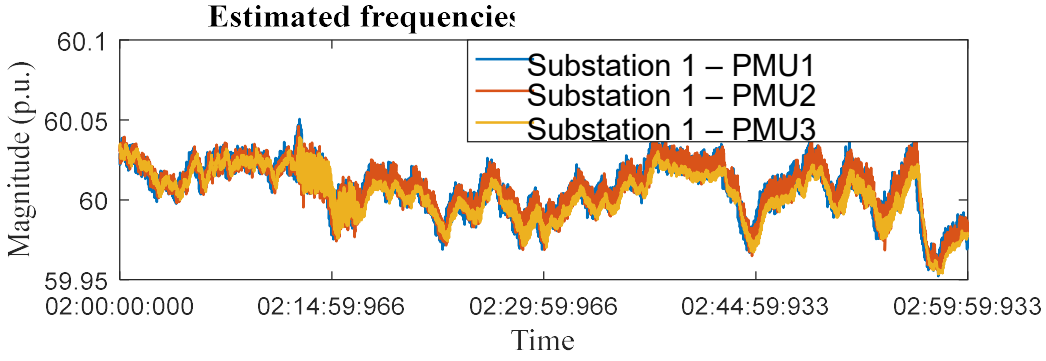
- SSDQ tested with various datasets provided by EPRI members
  - Bad measurements are identified and corrected effectively
  - Missing entries are filled in with high accuracy
  - Event data are not misidentified as bad data

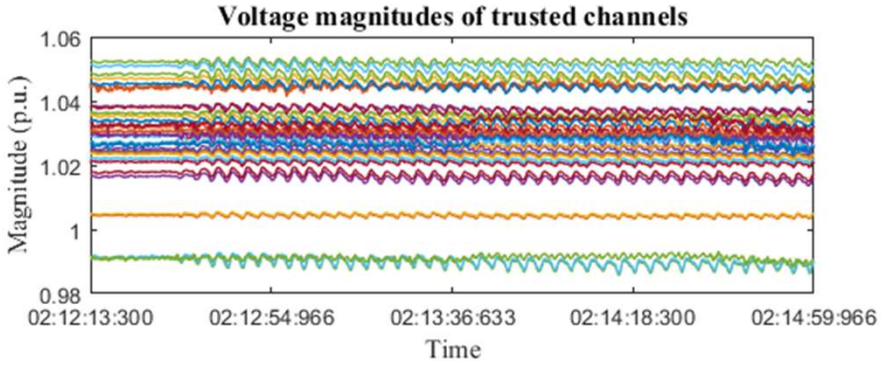
SSDQ - Entergy Case Study

- Entergy provided 1 hour of recorded synchrophasor data during a 2017 oscillations event
- Event data were not misinterpreted as bad data

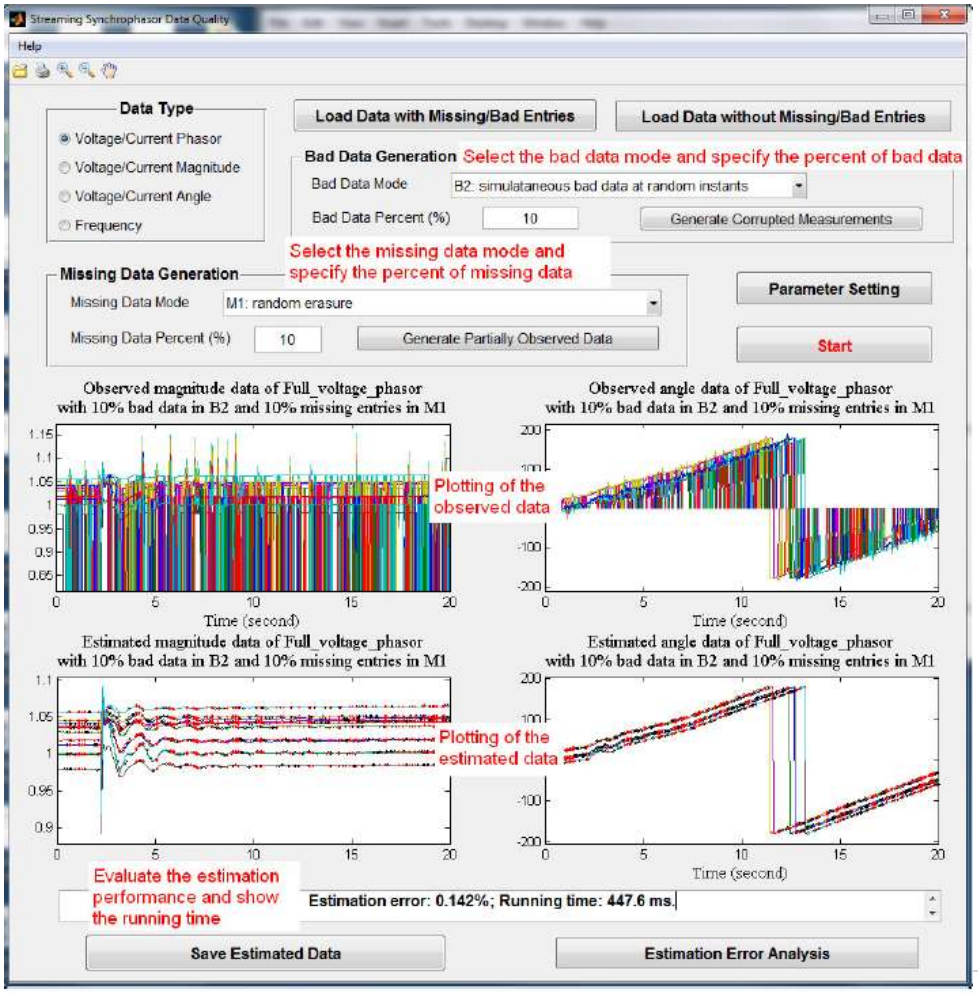








SSDQ - Matlab Based Software for Offline Testing

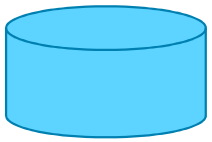


- Streaming Synchrophasor Data Quality Tool (SSDQ) – Offline version
- Detecting missing and invalid bad data, and replacing it with accurate estimated data
- Value: improve results of off-line synchrophasor applications

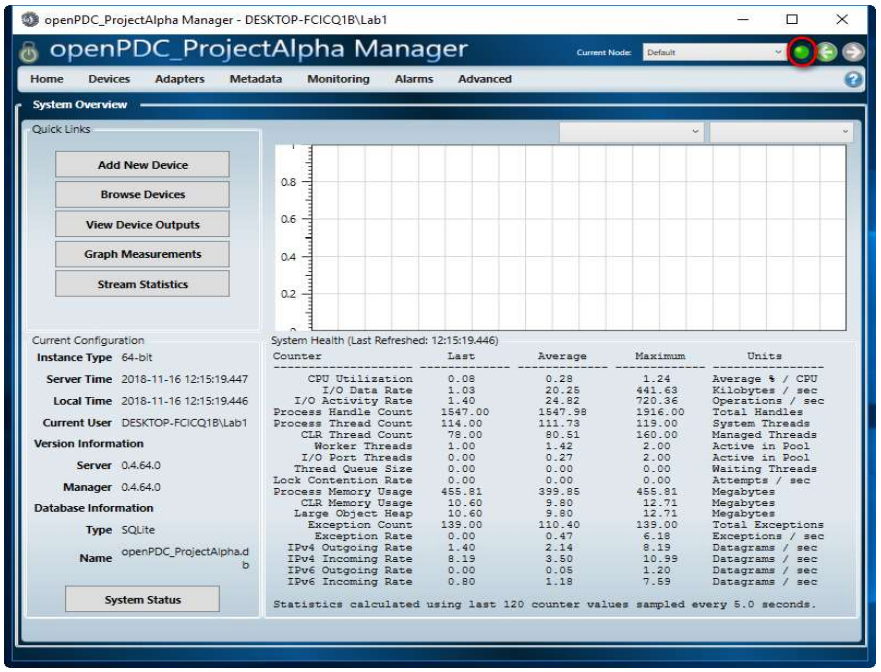
SSDQ – OpenPDC Implementation

- Streaming Synchrophasor Data Quality Tool (SSDQ) – Online version
- Algorithm implementation on GPA's OpenPDC Project Alpha
- SSDQ .dll file

PMU Data

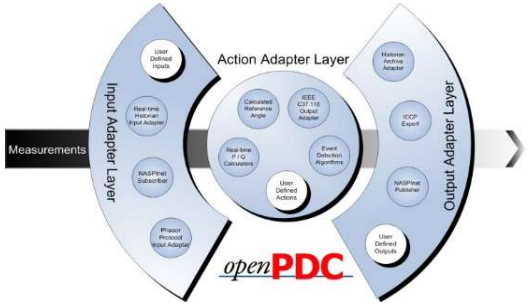


Input Adapter



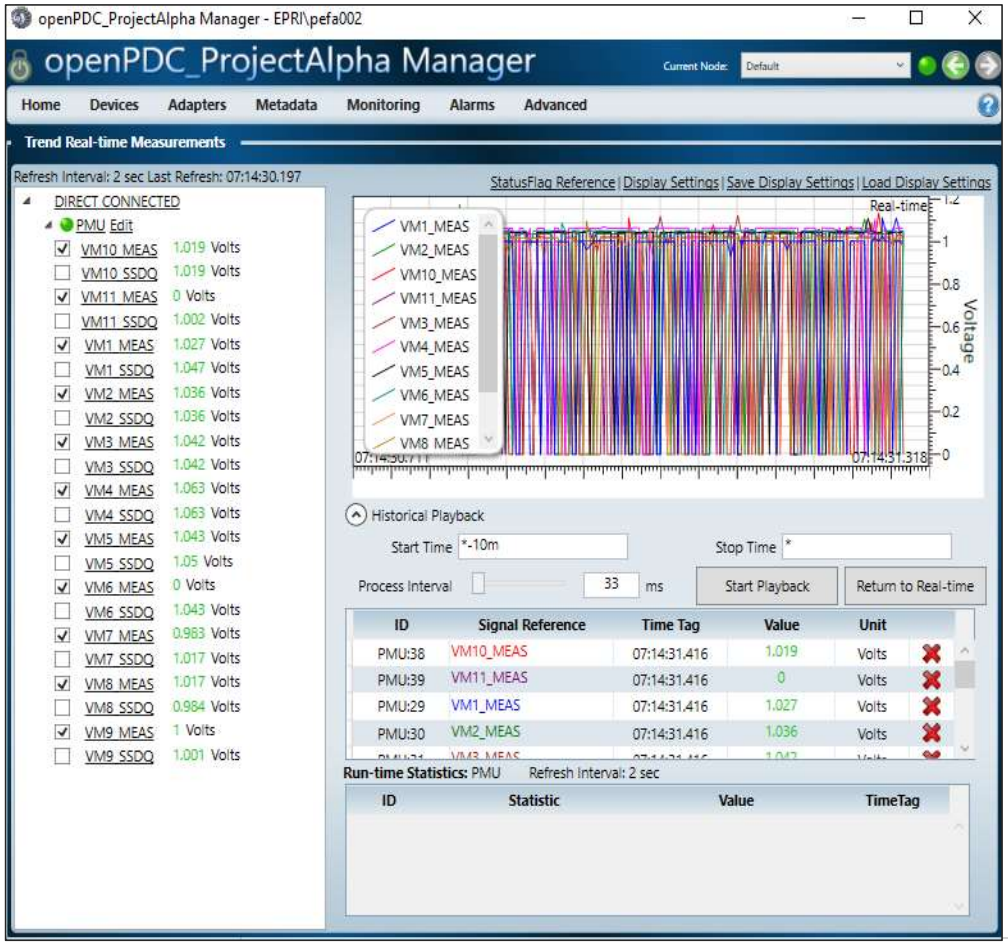
Action Adapter

SSDQ Algorithm

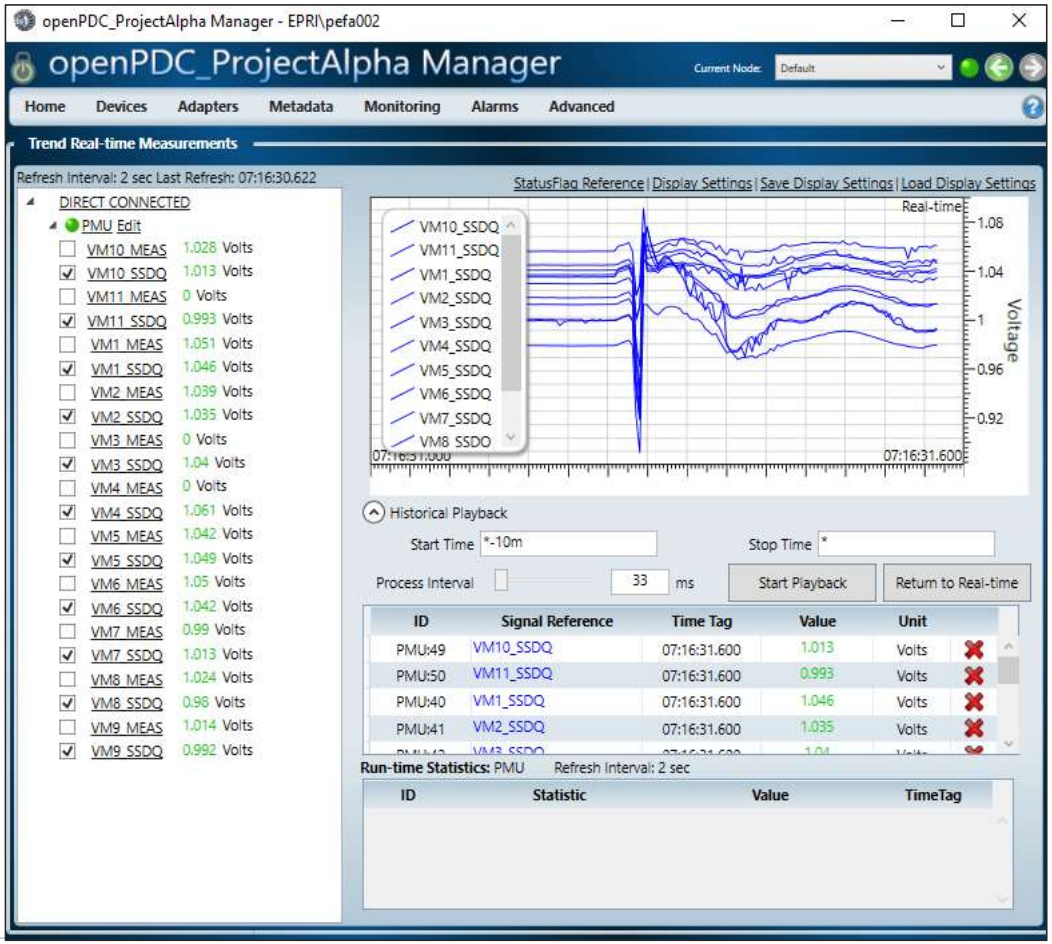


SSDQ – OpenPDC Implementation - Results

Original Measurement Set



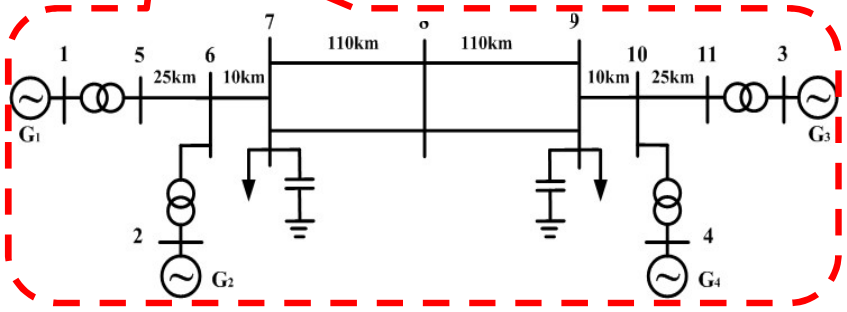
Corrected Measurement Set

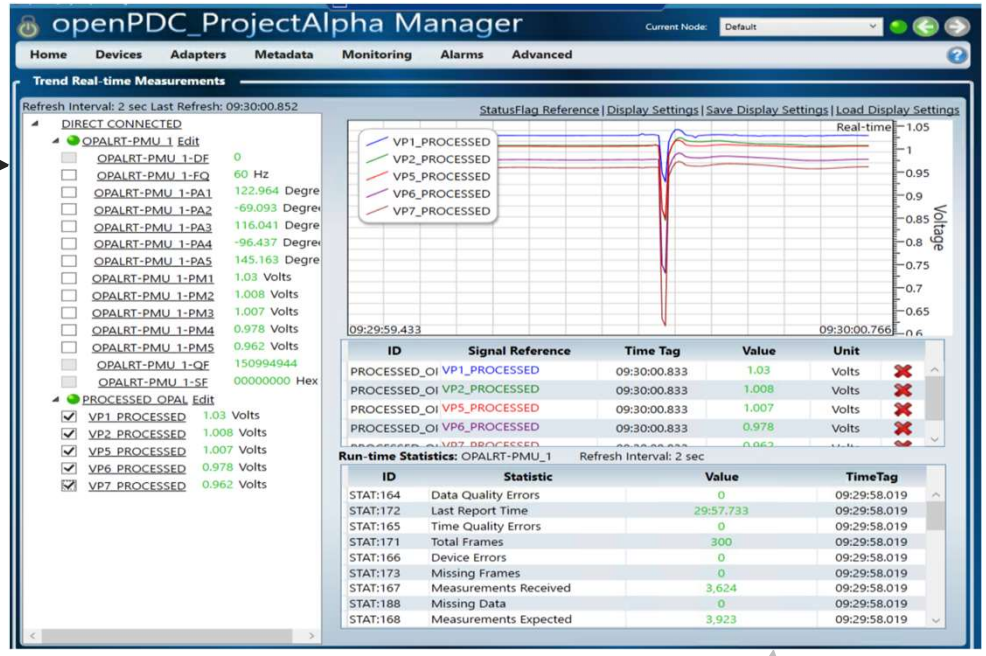


SSDQ – OpenPDC Implementation – OPAL-RT

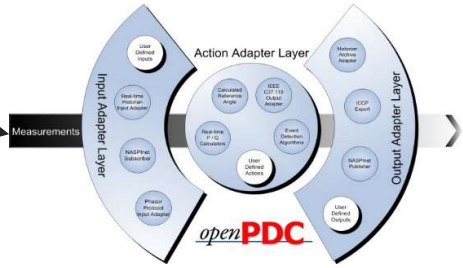
PMU stream (C37.118.2) over TCP/IP

OPAL-RT Simulator





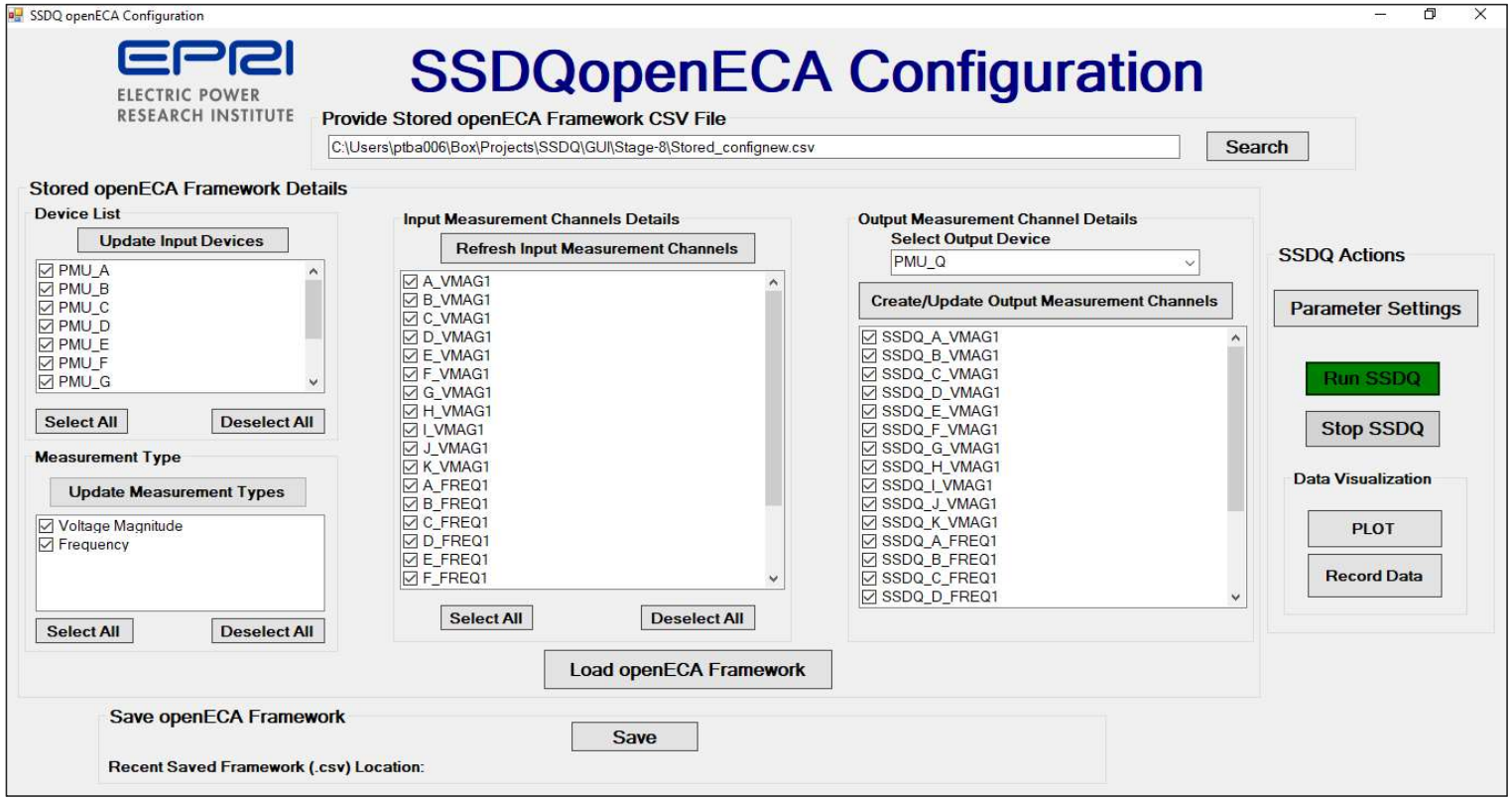
Raw PMU data



Processed PMU data

Action Adapter
SSDQ Algorithm

SSDQ – OpenECA Implementation



"The openECA platform provides a Common Analytics Interface (CAI) for integration of a diverse set of platform analytics along with structured integration of platform configuration, display and storage systems."

OpenECA: https://www.gridprotectionalliance.org/products.asp

OpenECA SSDQ

Data Source Selection

Measurement Type Selection

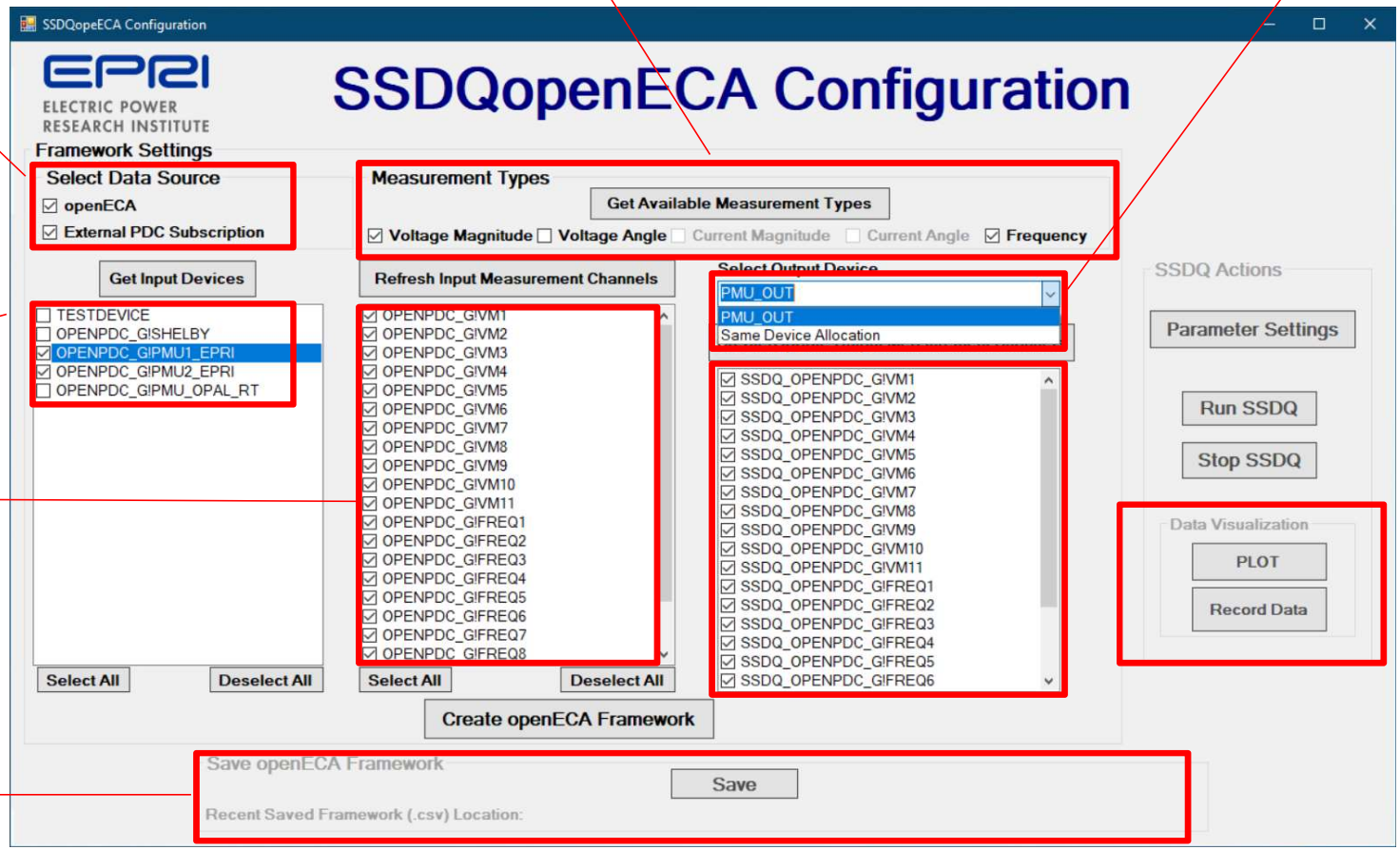
Output Channels

PMUs Selection

Input Channels Selection

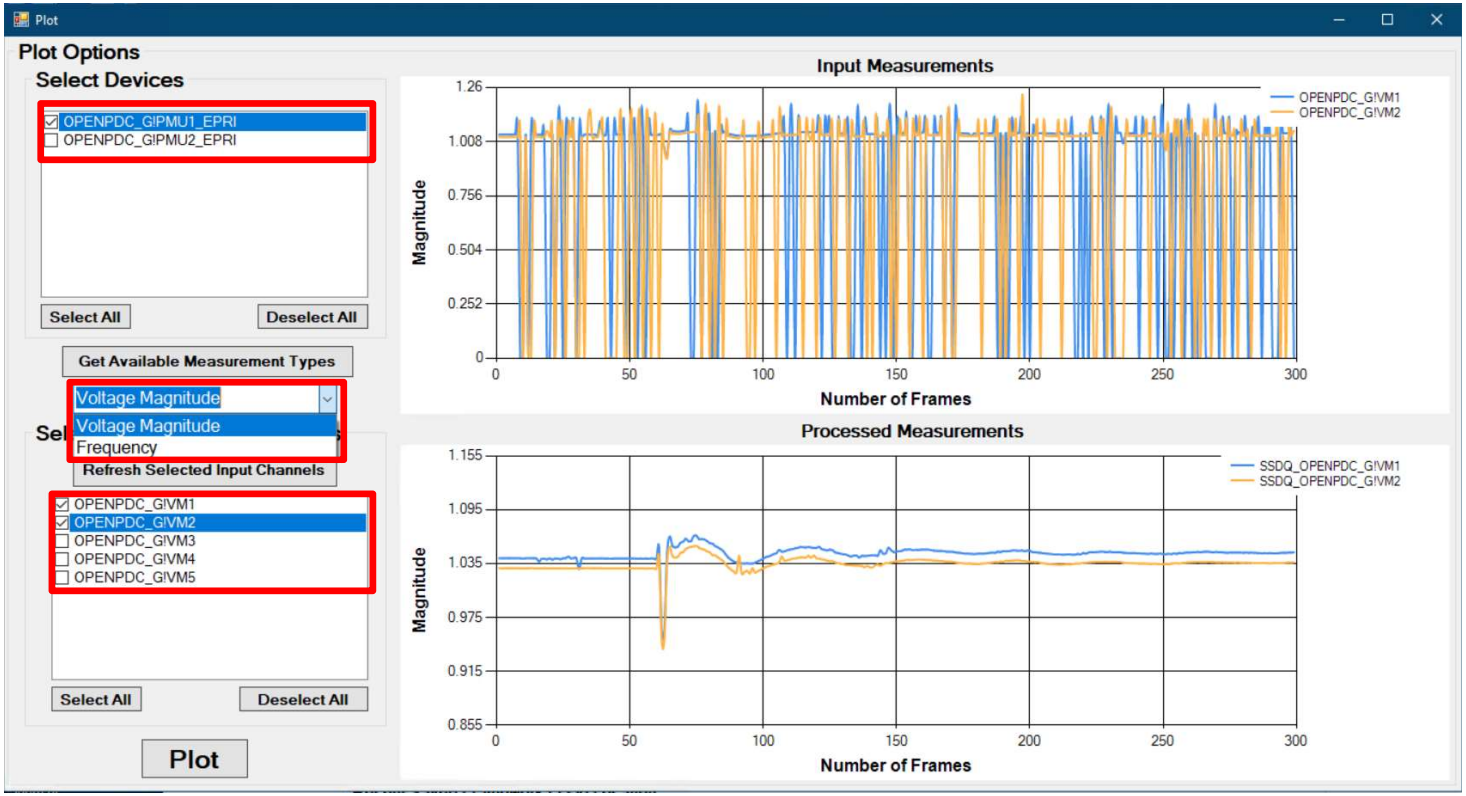
Plotting & Recording

Configuration Save



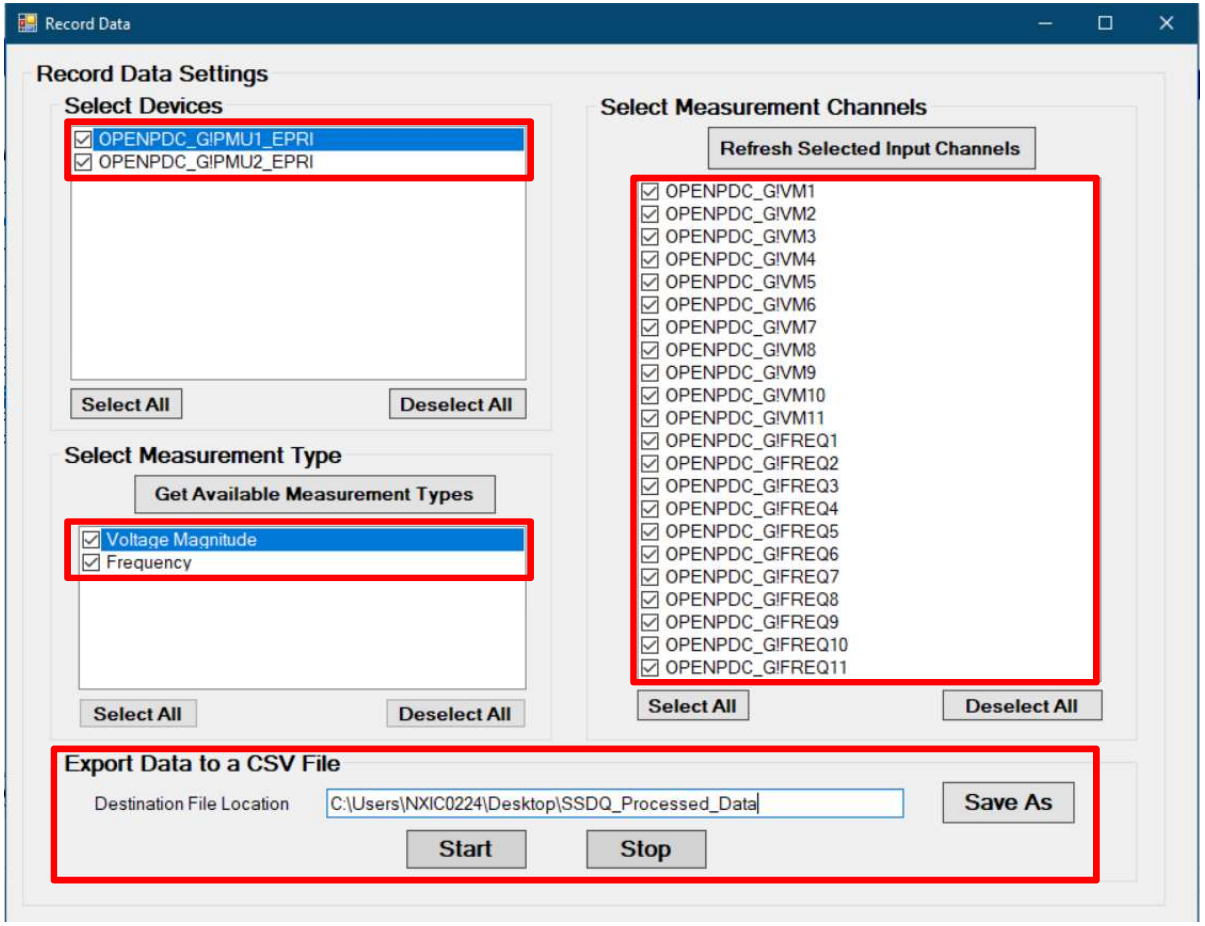
OpenECA SSDQ – Plotting

- Plots the processed measurements versus the input measurements
- Gives the option to choose the PMU device, the measurement type and the measurement channels for plotting



OpenECA SSDQ - Recording

- Records the processed measurements and the input measurements in CSV format
- Gives the option to choose the PMU device, the measurement type and the measurement channels for recording



Case Studies/Demonstrations & Vendor Engagement

- New recorded PMU datasets with missing/bad data are welcome
- Pursuing demonstrations of the OpenPDC and/or OpenECA SSDQ
- Interested for vendor engagement and implementation of the models in commercial platforms

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