Electric Power Group Presents

Maximizing Use of Synchrophasor Technology for Everyday Tasks

Welcome!

The meeting will begin at 2:00 p.m. ET / 11:00 a.m. PT Jan. 18, 2017

Today's Topic: Synchrophasor Intelligence in EMS for Use in Operations

Registration URL: https://electricpowergroup2.webex.com/
Webinar Teleconference Number: 1-650-479-3208
Access code: 666 672 715

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Maximizing Use of Synchrophasor Technology for Everyday Tasks

Synchrophasor Intelligence in EMS for Use in Operations

Integration of Synchrophasors and EMS/SCADA through ICCP

January 18, 2017

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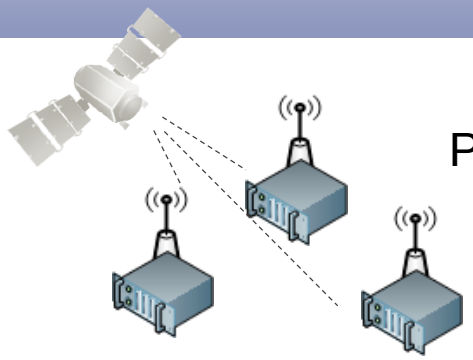
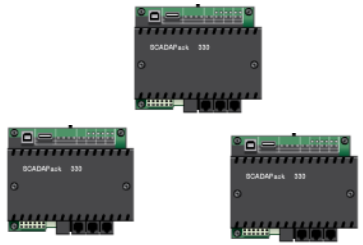
Synchrophasor & EMS Integration



PMUs

RTU's



Synchrophasor System

ICCP Gateway

EMS/SCADA

Applications with Synchrophasors

Applications with Synchrophasors and SCADA Data e.g. PhasorNXT

Applications with SCADA

Applications with SCADA and Synchrophasors e.g. One-Line Diagram with phase angles

What Will This Do?

- Enable EMS/SCADA with Synchrophasors
  - Dynamics: Oscillations, Phase Angles, Sensitivities, etc.
  - Dynamic Alarms and Composite Alarms e.g. Low Damping, Islanding
  - Frequency Disturbance Source Location
  - Transmission MW Flow Constraints
  - Improve State Estimation
  - Improve Grid Resilience
- Data Exchange with ISO's and Utilities
  - Raw PMU Measurements (voltages, currents, frequency, etc.)
  - Calculated Values (angle difference, system frequency, real/reactive power, mode, sensitivity, oscillation, etc.)
  - Alarms/Events (threshold violation, rate of change violation, composite alarms, global alarms etc.)

Synchrophasor Information Available to EMS

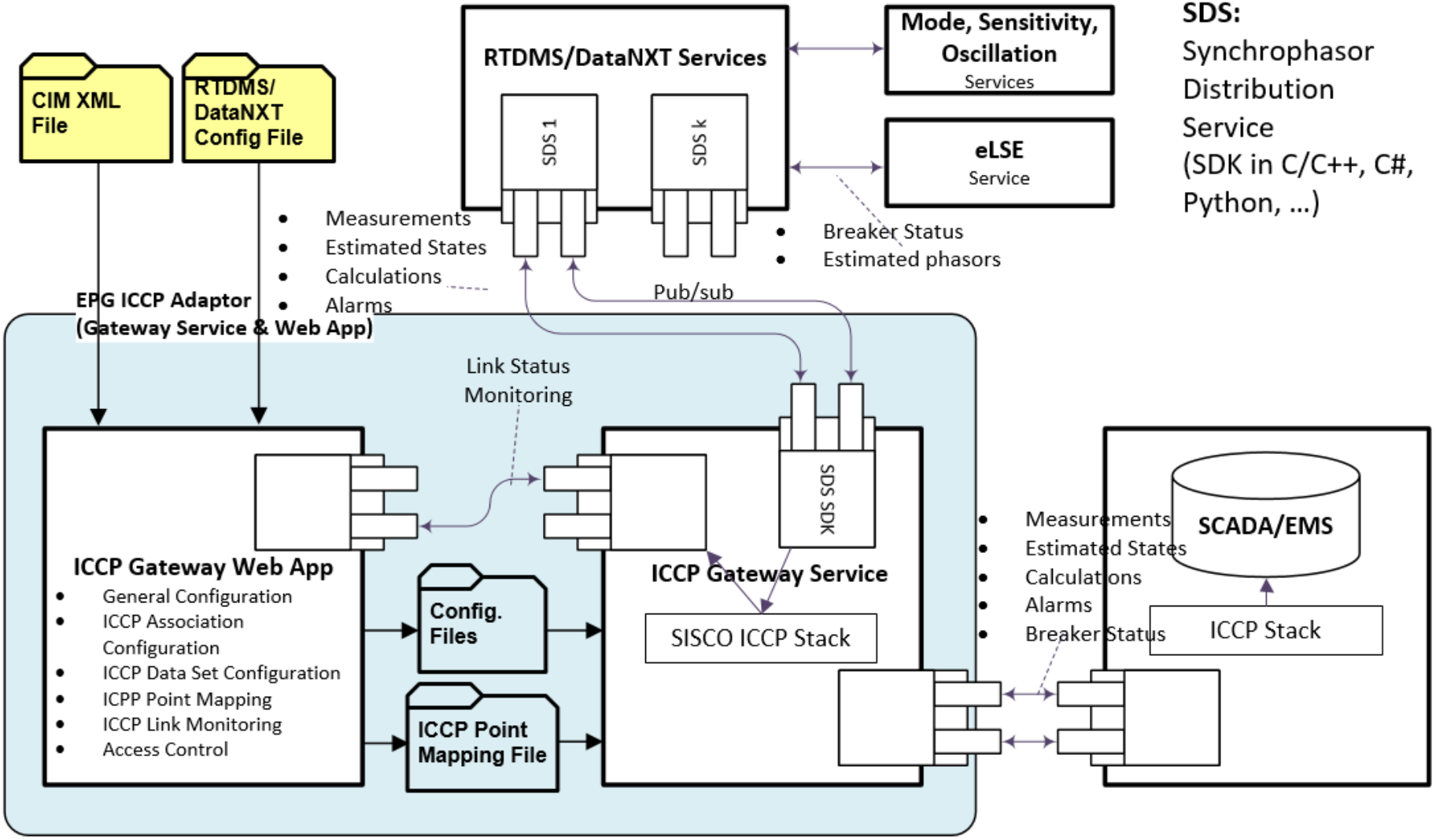
	PMU Measurements (Telemetered)	Linear State Estimator (Estimated)	Applications (Calculated)	Alarms/Events (Calculated)
1	Voltage Magnitude & Angle	Voltage Magnitude & Angle	Real & Reactive Power	Threshold Violations (Alarm)
2	Current Magnitude & Angle	Current Magnitude & Angle	Corridor Real & Reactive Power	Rate of Change Violations (Event)
3	Frequency & DF/DT		Angle Difference	Global Alarms & Global Events
4	IEEE 37.118 digitals		System Frequency	Islanding, Generation Trip, and Load Drop Events
5	IEEE 37.118 analogs		Voltage & Angle Sensitivity	Composite Alarms
6			Mode Frequency, Damping Ratio, and Energy	Oscillation & Low Damping Alarms
7			Oscillation Energy for all 4 frequency bands	High voltage/Angle Sensitivity Alarms

EPG ICCP Gateway

- Designed under the Guidance of Industry Partners
- Validated and Trustworthy Data through Synchrophasor Applications (DataNXT, RTDMS, *e*LSE, etc.)
- Independent of EMS Proprietary Protocols
- Web-based Configuration GUI
- Real Time Monitoring of Communication & Data Flow
- Extensive Logging
- Flexible Deployment – Physical, VM; Standalone, Cluster
- High Performance & High Availability
- Provides role-based access control
- Uses Field-Proven SISCO ICCP Stack

ICCP Gateway Service-Oriented Architecture

Gateway Service & Web App



ICCP Gateway Design Key Features

- Open Standards based Integration Vs. Proprietary Coupling/Bolt-on
- ICCP Gateway Service runs as Windows Service
  - Flexible Deployment
  - Decoupled from Applications (DataNXT, RTDMS, etc.) using SDS Pub/Sub interface
  - Service Oriented Architecture (SoA)
- Control Data Rate Exchange between Synchrophasor Applications and EMS/SCADA. For Example:
  - Average
  - Down-sampled

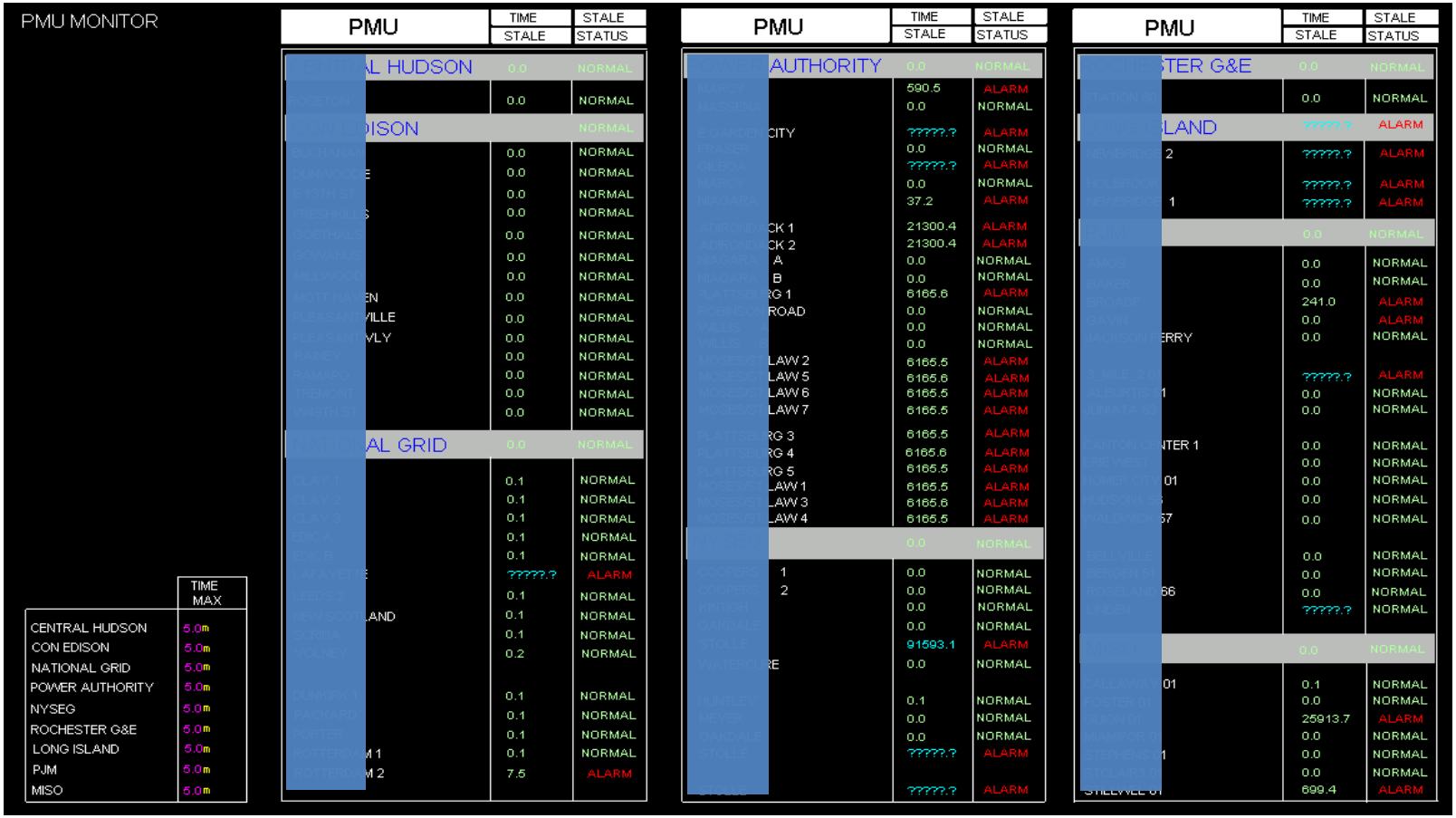
NYISO Use-Case for Using PMU data in EMS

Benefits of Providing Synchrophasor Data to EMS

- **Supplying PMU data to EMS over ICCP provides additional data not available in SCADA from the member T.O.'s and other ISO's**
- **Provides EMS with another source of data to use in its State Estimator and Intelligent Source Selection Application**
- **Pass alarms to the EMS in order to integrate RTDMS alarms into the Operator's current Alarm Monitor**
- **PI Trends using PMU data provide easy comparison to SCADA data to uncover configuration and calibration issues.**
- **Other purposes for PMU data in the EMS**
- **Currently, 1800+ ICCP points for synchrophasor data & alarm from RTDMS to EMS**

PMU Data Stale Monitor

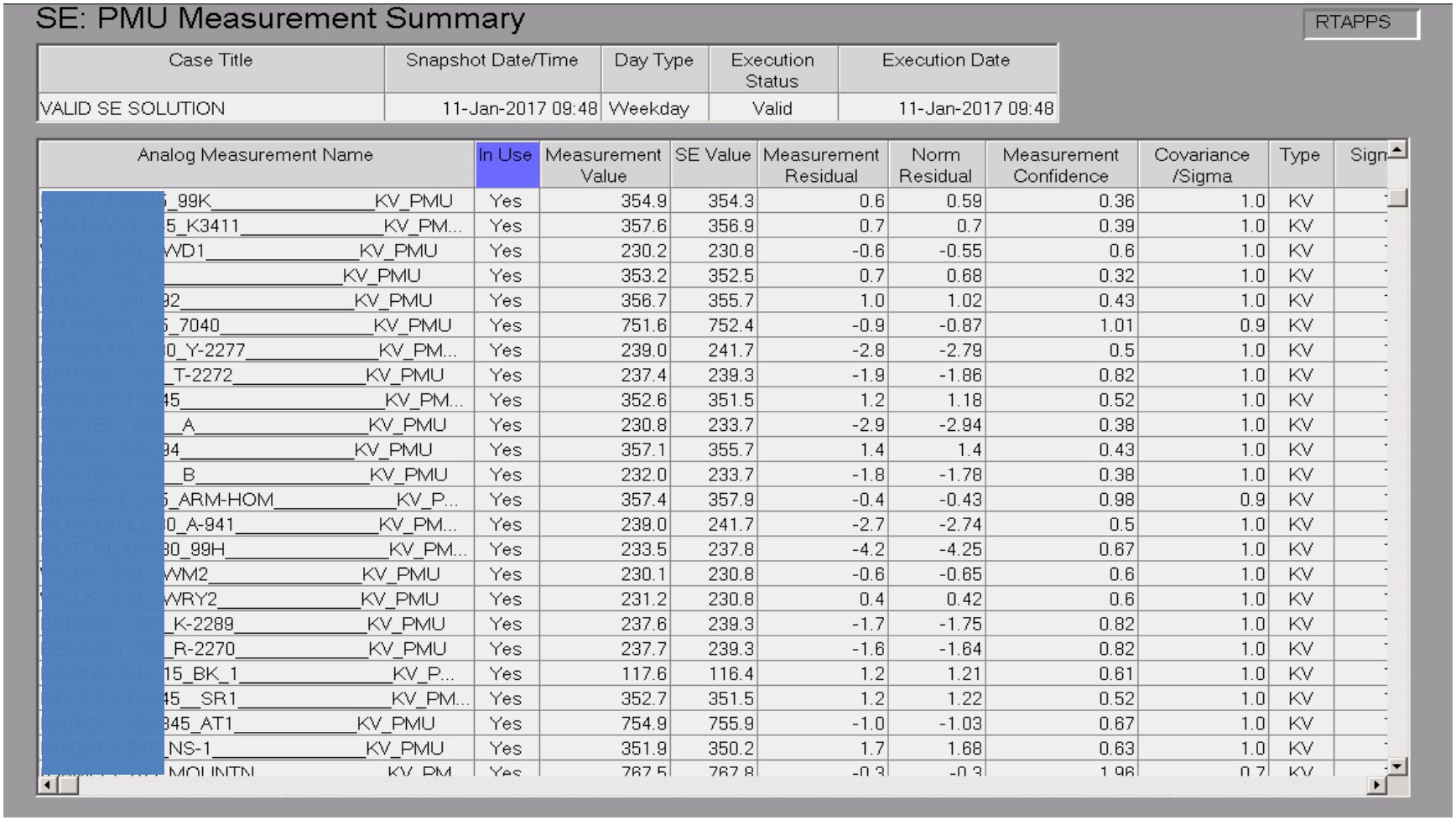
- A Monitor in EMS used by Operations Control to notify T.O.'s and ISO's when there are issues with PMU's



EMS Use-Case for using PMU data at NYISO

NEW YORK INDEPENDENT SYSTEM OPERATOR

PMU Data Used by State Estimator Application



SE: PMU Measurement Summary

RTAPPS

Case Title	Snapshot Date/Time	Day Type	Execution Status	Execution Date
VALID SE SOLUTION	11-Jan-2017 09:48	Weekday	Valid	11-Jan-2017 09:48

Analog Measurement Name	In Use	Measurement Value	SE Value	Measurement Residual	Norm Residual	Measurement Confidence	Covariance /Sigma	Type	Sign
[redacted]_99K_____KV_PMU	Yes	354.9	354.3	0.6	0.59	0.36	1.0	KV	
[redacted]5_K3411_____KV_PM...	Yes	357.6	356.9	0.7	0.7	0.39	1.0	KV	
[redacted]WD1_____KV_PMU	Yes	230.2	230.8	-0.6	-0.55	0.6	1.0	KV	
[redacted]_____KV_PMU	Yes	353.2	352.5	0.7	0.68	0.32	1.0	KV	
[redacted]82_____KV_PMU	Yes	356.7	355.7	1.0	1.02	0.43	1.0	KV	
[redacted]_7040_____KV_PMU	Yes	751.6	752.4	-0.9	-0.87	1.01	0.9	KV	
[redacted]0_Y-2277_____KV_PM...	Yes	239.0	241.7	-2.8	-2.79	0.5	1.0	KV	
[redacted]_T-2272_____KV_PMU	Yes	237.4	239.3	-1.9	-1.86	0.82	1.0	KV	
[redacted]45_____KV_PM...	Yes	352.6	351.5	1.2	1.18	0.52	1.0	KV	
[redacted]_A_____KV_PMU	Yes	230.8	233.7	-2.9	-2.94	0.38	1.0	KV	
[redacted]84_____KV_PMU	Yes	357.1	355.7	1.4	1.4	0.43	1.0	KV	
[redacted]_B_____KV_PMU	Yes	232.0	233.7	-1.8	-1.78	0.38	1.0	KV	
[redacted]_ARM-HOM_____KV_P...	Yes	357.4	357.9	-0.4	-0.43	0.98	0.9	KV	
[redacted]0_A-941_____KV_PM...	Yes	239.0	241.7	-2.7	-2.74	0.5	1.0	KV	
[redacted]80_99H_____KV_PM...	Yes	233.5	237.8	-4.2	-4.25	0.67	1.0	KV	
[redacted]WM2_____KV_PMU	Yes	230.1	230.8	-0.6	-0.65	0.6	1.0	KV	
[redacted]WRY2_____KV_PMU	Yes	231.2	230.8	0.4	0.42	0.6	1.0	KV	
[redacted]_K-2289_____KV_PMU	Yes	237.6	239.3	-1.7	-1.75	0.82	1.0	KV	
[redacted]_R-2270_____KV_PMU	Yes	237.7	239.3	-1.6	-1.64	0.82	1.0	KV	
[redacted]15_BK_1_____KV_P...	Yes	117.6	116.4	1.2	1.21	0.61	1.0	KV	
[redacted]45__SR1_____KV_PM...	Yes	352.7	351.5	1.2	1.22	0.52	1.0	KV	
[redacted]845_AT1_____KV_PMU	Yes	754.9	755.9	-1.0	-1.03	0.67	1.0	KV	
[redacted]_NS-1_____KV_PMU	Yes	351.9	350.2	1.7	1.68	0.63	1.0	KV	
[redacted]MOUNTN_____KV_PM...	Yes	767.5	767.8	-0.3	-0.3	1.98	0.7	KV	

EMS Use-Case for using PMU data at NYISO

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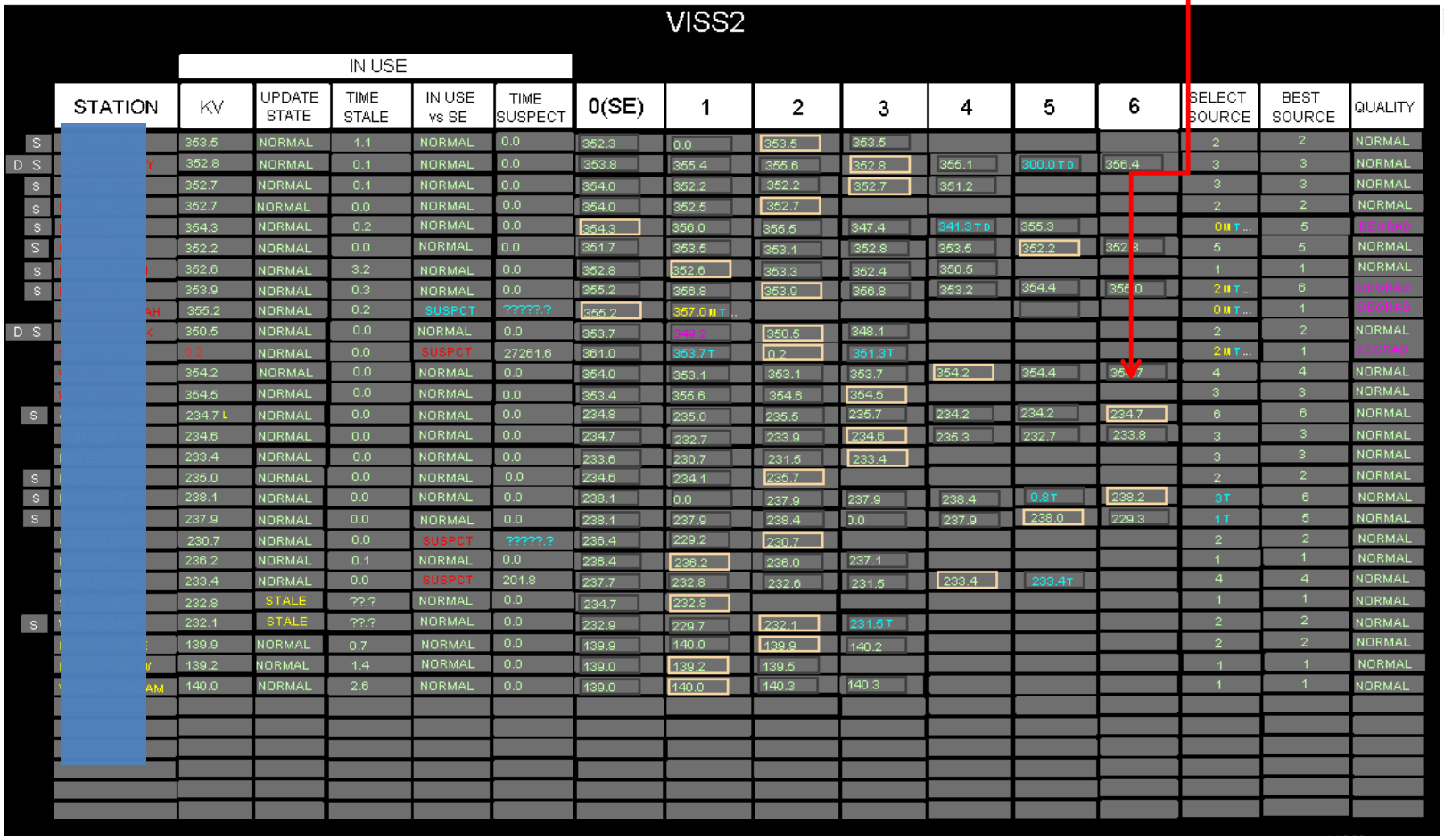
PMU Data Used in Voltage Intelligent Source Selection (Custom NYISO Application)

PMU source has been selected as best choice



EMS Use-Case for using PMU data at NYISO

NEW YORK INDEPENDENT SYSTEM OPERATOR

Synchrophasor Global Alarms

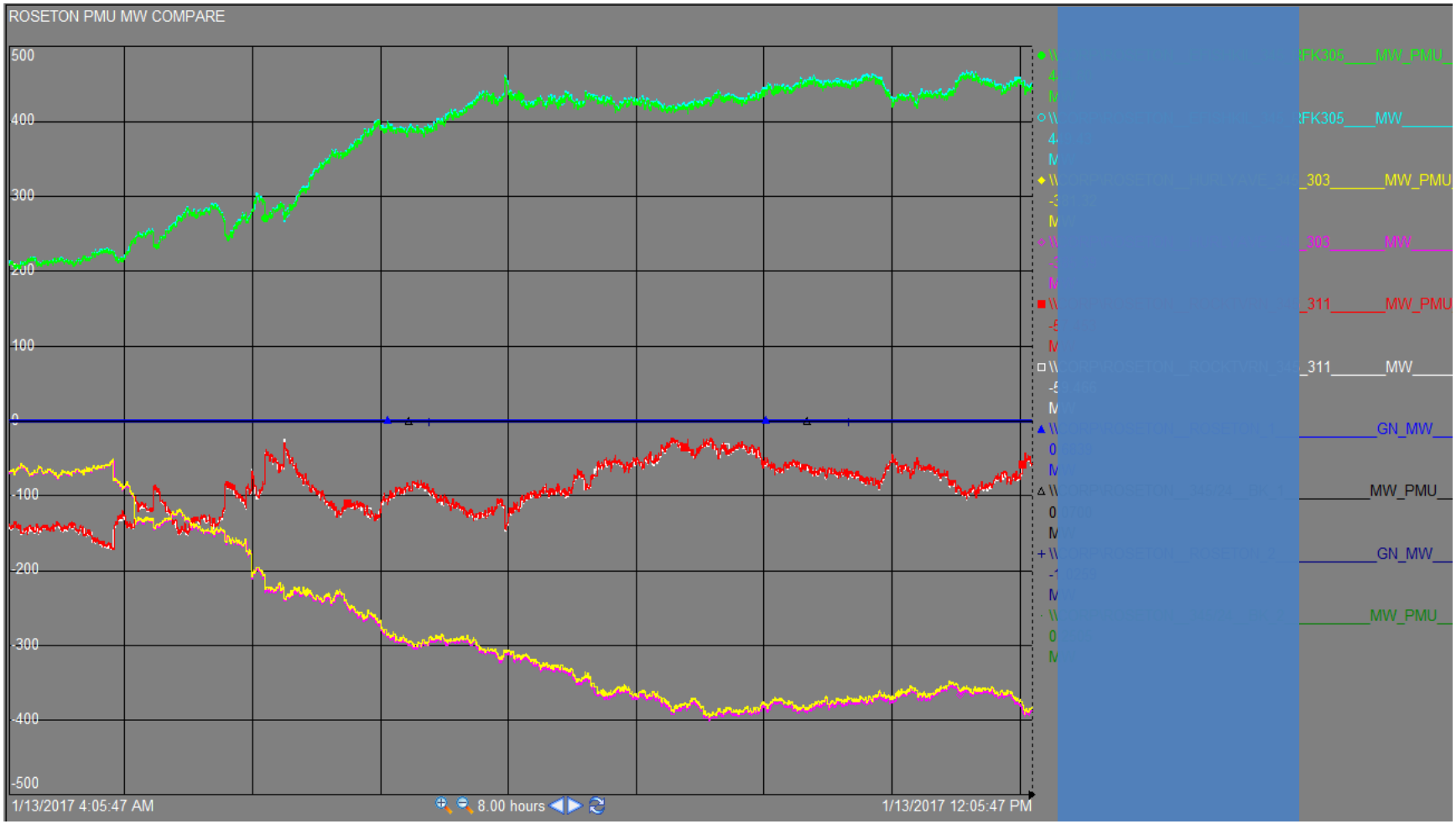
Alarm Types

PMU_ANGLE_DIFFERENCE_VIOLATION
PMU_CURRENT_MAGNITUDE_VIOLATION
PMU_CURRENT_R-O-C_VIOLATION
PMU_VOLTAGE_MAGNITUDE_VIOLATION
PMU_VOLTAGE_R-O-C_VIOLATION
PMU_FREQ_MAGNITUDE_VIOLATION
PMU_FREQ_R-O-C_VIOLATION
PMU_FLOW_MW_MAGNITUDE_VIOLATION
PMU_FLOW_MVAR_MAG_VIOLATION
PMU_INTERFACE_MW_MAG_VIOLATION
PMU_INTERFACE_MVAR_MAG_VIOLATION
PMU_SYS_FREQ_MAGNITUDE_VIOLATION
PMU_SYS_FREQ_R-O-C_VIOLATION

EMS Alarm Message

Event Date/Time	Message		
11/JAN/2017 04:44:23	Z_PMU	PMU_FREQ_R-O-C_VIOLATION	PMU Exceeds Rate-Of-Change Limit 2 RTN
11/JAN/2017 04:44:23	Z_PMU	PMU_FREQ_R-O-C_VIOLATION	PMU Exceeds Lo Rate-Of-Change Limit 1 RT
11/JAN/2017 04:44:18	Z_PMU	PMU_FREQ_R-O-C_VIOLATION	PMU Exceeds Lo Rate-Of-Change Limit 1
11/JAN/2017 04:44:18	Z_PMU	PMU_FREQ_R-O-C_VIOLATION	PMU Exceeds Rate-Of-Change Limit 2
11/JAN/2017 04:29:32	Z_PMU	PMU_VOLTAGE_R-O-C_VIOLATION	PMU Exceeds Rate-Of-Change Limit 2 RT
11/JAN/2017 04:29:32	Z_PMU	PMU_VOLTAGE_R-O-C_VIOLATION	PMU Exceeds Lo Rate-Of-Change Limit 1
11/JAN/2017 04:28:46	Z_PMU	PMU_VOLTAGE_R-O-C_VIOLATION	PMU Exceeds Lo Rate-Of-Change Limit 1
11/JAN/2017 04:28:46	Z_PMU	PMU_VOLTAGE_R-O-C_VIOLATION	PMU Exceeds Rate-Of-Change Limit 2

PI Trends to Compare SCADA Data to Synchrophasor Data



EMS Use-Case for using PMU data at NYISO

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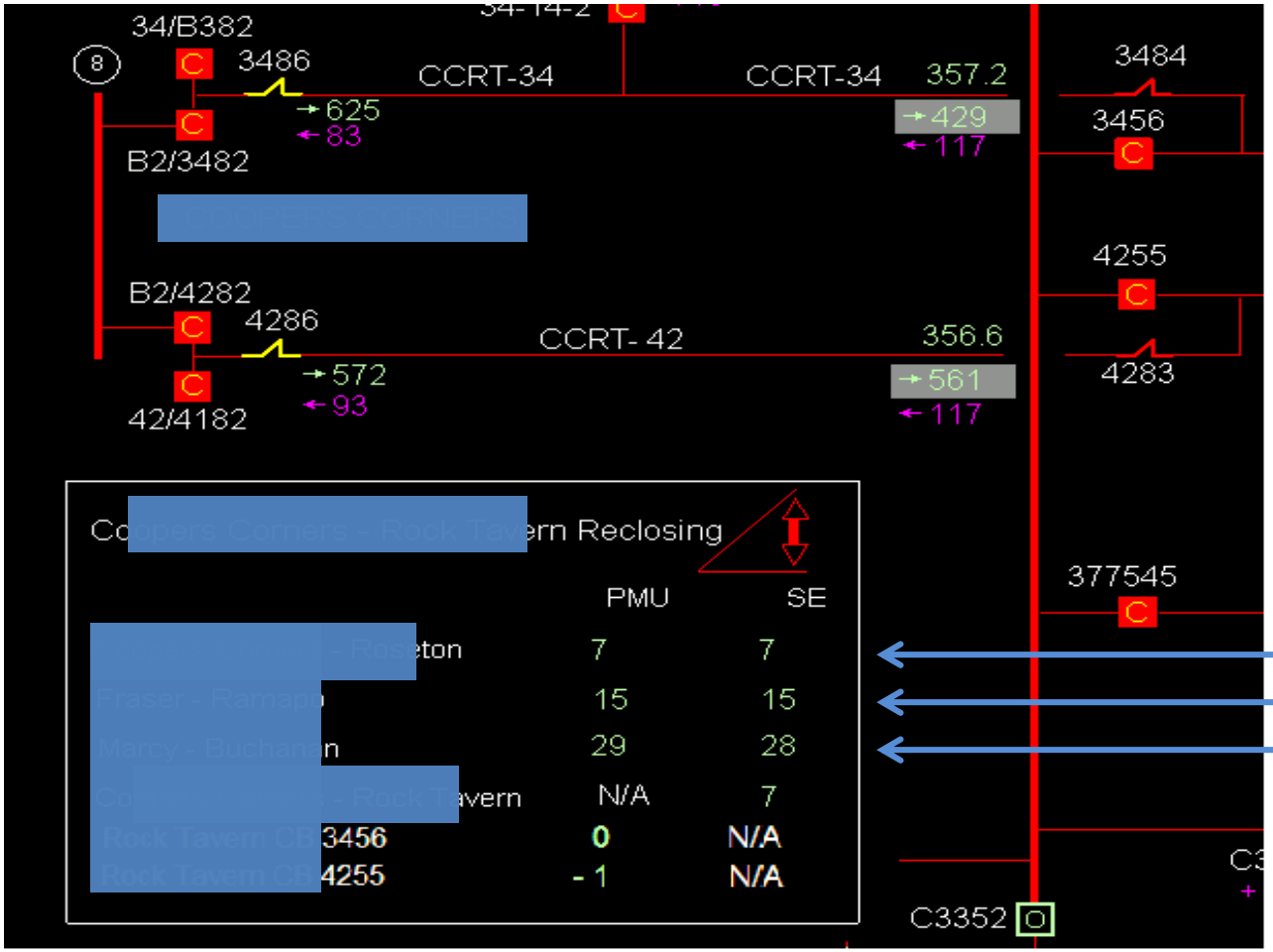
Angle Difference Used to Determine 345 KV Line Reclosures



Reclosure Angle Diff Limits
32
35
46

EMS Use-Case for using PMU data at NYISO

NEW YORK INDEPENDENT SYSTEM OPERATOR

Example of Incorporating PMU Measurements in the CAISO EMS/Control Room

CAISO Use-Case for Using PMU data in EMS

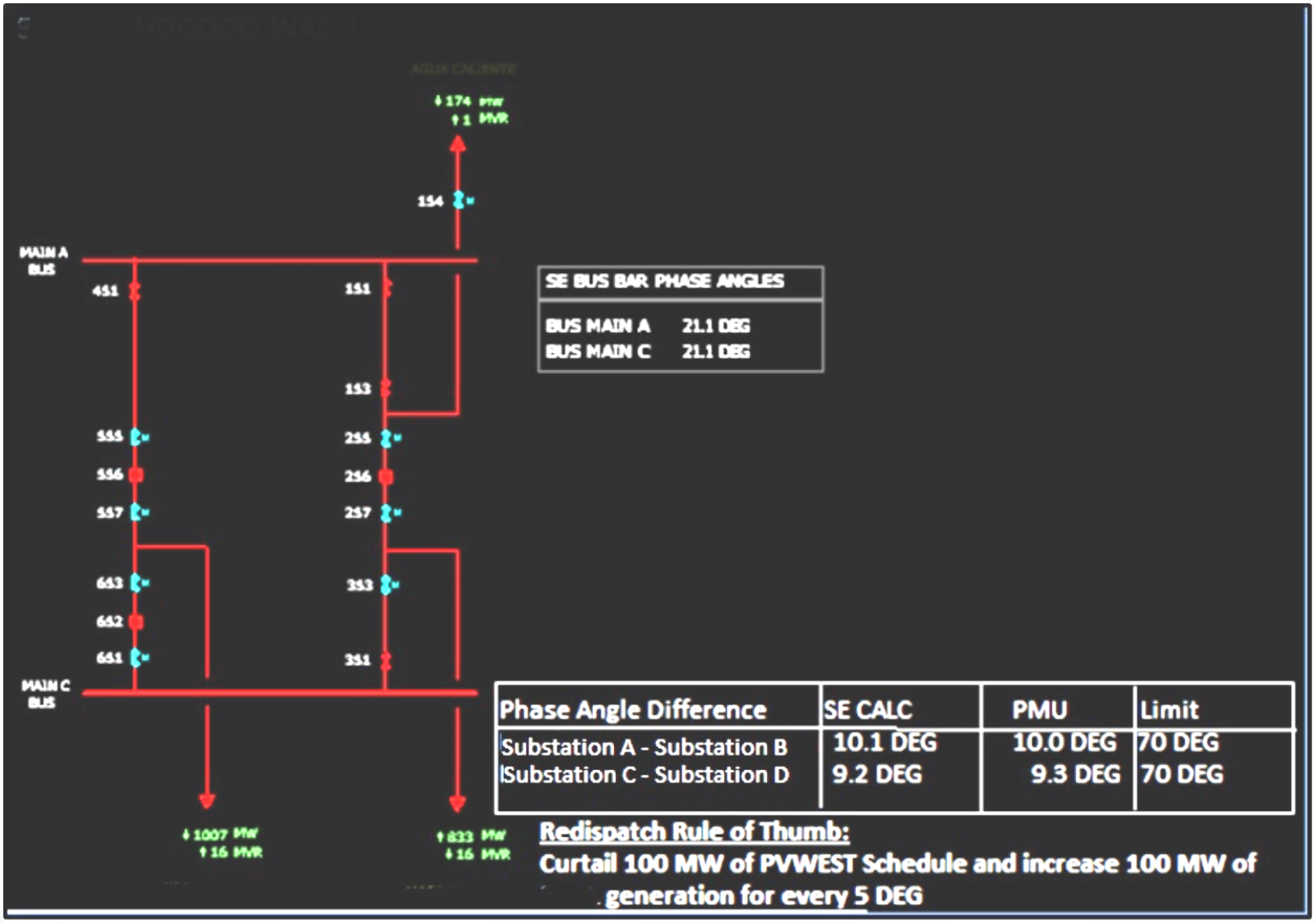
- Angle Difference Monitoring & Operation Procedure for Reclosure – Displayed on EMS One-Line
- MW Flow for Major Tie Lines used in AGC Calculation (Resiliency), e.g. COI
- Frequency Measurements for Redundant Inputs (Resiliency)
  - AGC Calculation
  - Islanding Detection
  - Black Start
- Frequency Disturbance Source Location
- Local Oscillation Detection
  - Electro-mechanical or
  - Control Issues at Power Plant
- Share Data with TOs through ICCP, e.g., Line Angle Difference Limits

CAISO Synchrophasor Activities

- CAISO will have the following capabilities
  - predict the potential phase angle difference *before* the line trip (State Estimator and contingency analysis).
  - show the actual observed phase angle difference *after* the line trip

- These functionalities will allow the system operators
  - to be prepared before the contingency
  - to know the actual system conditions after the contingency

CAISO Line Closure Procedure with Phase Angle



SE BUS BAR PHASE ANGLES	
BUS MAIN A	21.1 DEG
BUS MAIN C	21.1 DEG

Phase Angle Difference	SE CALC	PMU	Limit
Substation A - Substation B	10.1 DEG	10.0 DEG	70 DEG
Substation C - Substation D	9.2 DEG	9.3 DEG	70 DEG

Redispatch Rule of Thumb:
Curtail 100 MW of PVWEST Schedule and increase 100 MW of generation for every 5 DEG

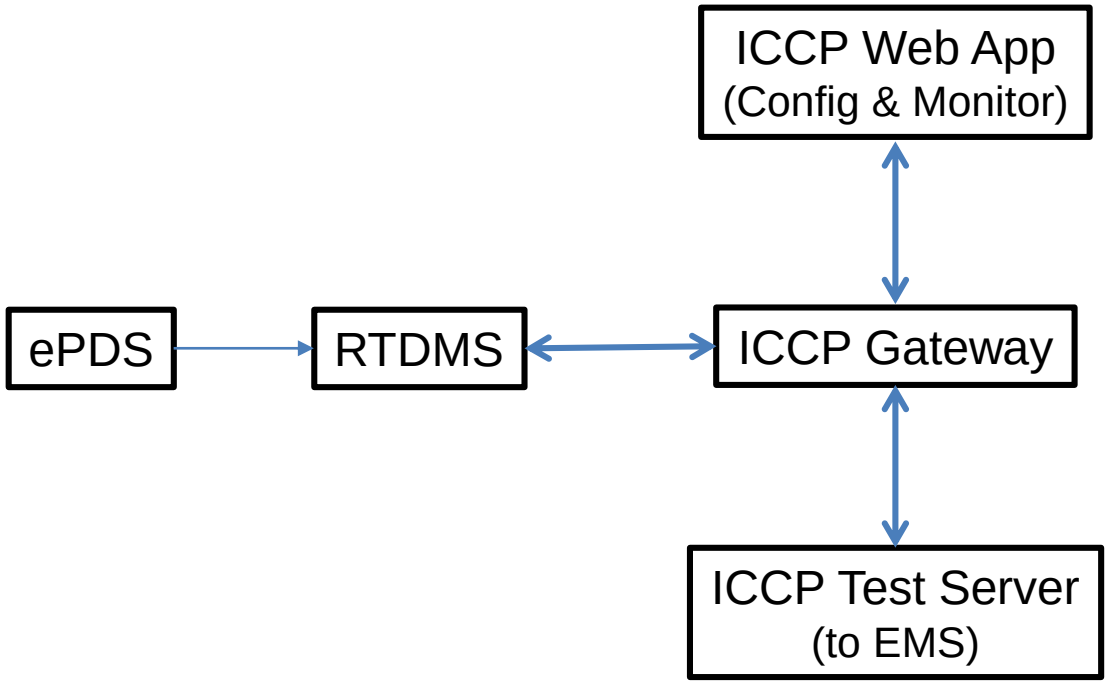
CAISO Synchrophasor Project Overview
Future Activities

- dynamic phase angle difference limit – study the usefulness of combining real-time PMU measurements with model-based programs (OMS, DSA, RTCA, etc)
- additional studies on oscillation mode detection and analysis – combined efforts with adjacent balancing authorities to write operating procedures
- linear State Estimator and hybrid solutions
  - looking at LSE to help improve data quality
- joint efforts with the Western Utilities and United States Department of Energy

Demonstration & Key Take-aways

ICCP Gateway & ICCP Web App

Demo Setup



Summary

- Bridges the Gap between Synchrophasors and EMS
- Enables companies to realize value from Synchrophasors via integration with EMS and Data Exchange
- ICCP Gateway Provides
  - Production Grade Solution
  - Commercial Off-The-Shelf
  - One ICCP Gateway with Many End-Point Connections
  - Two-way data transfer (i.e. import breaker status & limits into Synchrophasor applications)
  - Designed to meet Redundancy and High Availability Requirements
  - Easy to Configure & Monitor ICCP Links through Web Browsers Locally or Remotely
  - Built on Industry Standard SISCO Stack
  - Security Management Features for IT Administration

Q&A, Discussion

Your Practice, Use Cases, Suggestions

Q&A, Discussion

- Q&A
- Synchrophasor Application & EMS Integration
  - Your Practices
  - Use Cases
  - Pain Points
  - Suggestions
- Next Webinar Focus
  - Priority
  - Other topics

EPG Webinar Series

- Extracting large amounts of synchrophasor data efficiently for offline analysis. (August 2016)
- Quickly creating an event report that could be distributed to operators, engineers and managers. (Sept. 2016)
- System Model Validation for MOD-33 Requirement (Oct. 12)
- Configuring alarms and validate parameters to provide meaningful results for operators. (Dec 14)
- Synchrophasor Intelligence in EMS for Use in Operations (Jan 2017)
- Use Cases of Linear State Estimator Technology for Grid Resiliency (Feb 2017)
- Providing secure remote access to users in real-time for monitoring and diagnostics during normal times and emergencies.
- Using alarms & events for proactive actions
- Mining large data archives for events of different types, e.g. oscillations, generator trips etc.
- Other topics?

Thank you for participating!

If you have any questions regarding any part of the course, please contact us at Contact@electricpowergroup.com

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