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

Please mute your phone during the presentation.

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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

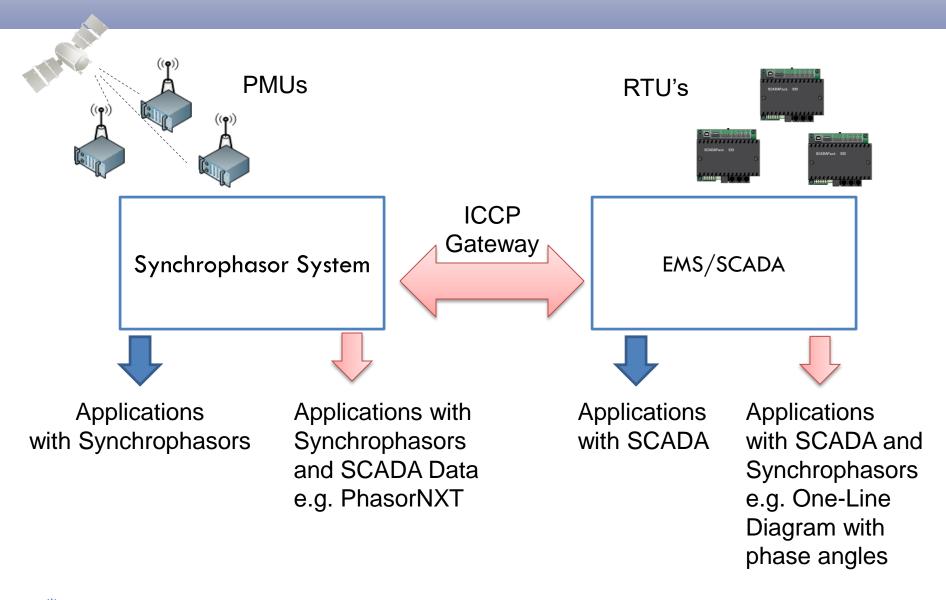
January 18, 2017

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Synchrophasor & EMS Integration



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

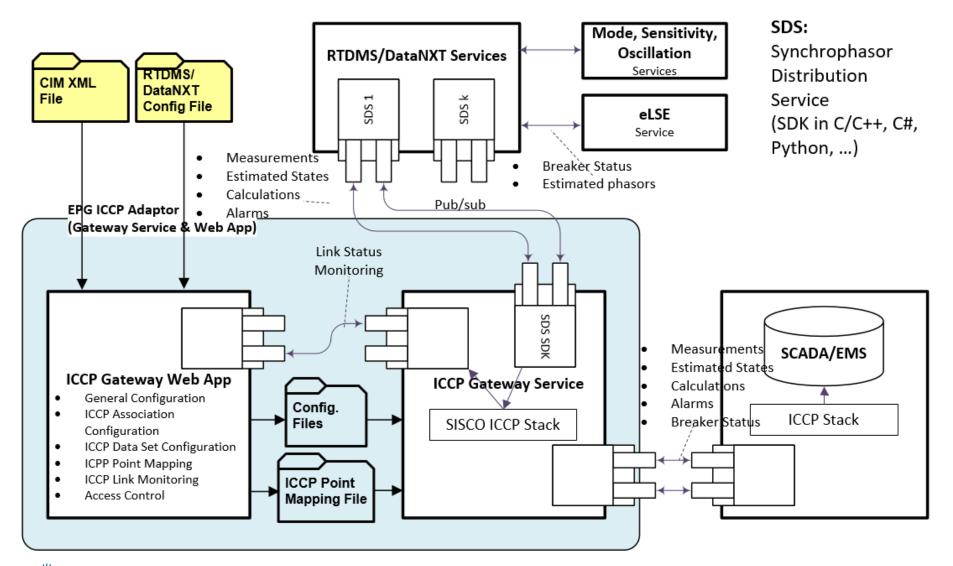


EPG ICCP Gateway

- Designed under the Guidance of Industry Partners
- Validated and Trustworthy Data through Synchrophasor Applications (DataNXT, RTDMS, eLSE, 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

PMU MONITOR	PMU	TIME	STALE STATUS	PMU	TIME	STALE	PMU	TIME	STALE STATUS
		STALE	STATUS		OTALL	STATUS		STALL	STATUS
	L HUDSON	0.0	NORMAL	AUTHORITY	0.0	NURMAL	TER G&E	0.0	NORMAL
	ROSETON	0.0	NORMAL	MARCY MASSENA	590.5 0.0	ALARM NORMAL	STATION 80	0.0	NORMAL
	DISON		NORMAL		2000.2	ALARM	LAND	77777.7	ALARM
	FLICHANAN	0.0	NORMAL	FRASER	0.0	NORMAL	NEMERIDEE 2	77777.7	ALARM
		0.0	NORMAL	GILBOA	333337.3	ALARM			
	E 13TH ST	0.0	NORMAL	MARCY	0.0	NORMAL	HOLBROOK	535555	ALARM
	FRESHKILLS	0.0	NORMAL	NIAGARA	37.2	ALARM	NEVVERIDGE 1	33335.3	ALARM
	GOETHALS	0.0	NORMAL	ADIRONDACK 1	21300.4	ALARM	PUM		NORMAL
	GOWANUS	0.0	NORMAL	ADIRONDA <mark>CK 2</mark> NIAOARA A	21300.4 0.0	ALARM NORMAL			
	MILLWOOD	0.0	NORMAL	NAGARA B	0.0	NORMAL	AMOS	0.0	NORMAL
	MOTTHAVEN	0.0	NORMAL	PLATTSBURG 1	6165.6	ALARM	BAKER	0.0	NORMAL
	PLEASANT /ILLE	0.0	NORMAL	ROBINSON ROAD	0.0	NORMAL		241.0 0.0	ALARM
		0.0	NORMAL	VVILLIS A	0.0	NORMAL	JACKSON FERRY	0.0	NORMAL
	RANEY	0.0	NORMAL		0.0	NORMAL		0.0	
	RAMAPO	0.0	NORMAL	LAW 2	6165.5 6165.6	ALARM	3 MILE 2.01	77777.7	ALARM
	TREMONT	0.0	NORMAL	MOSESIST LAW 6	6165.5	ALARM	ALBURTIS 51	0.0	NORMAL
	W49TH ST	0.0	NORMAL	MOSES/ST LAW 7	6165.5	ALARM	JUNIATA 63	0.0	NORMAL
				PLATISEURG 3	6165.5	ALARM			
	AL GRID	0.0	NORMAL	PLATTSBURG 4	6165.6	ALARM	CANTON CENTER 1	0.0	NORMAL
	0.004		NORMAL	PLATTSBURG 5	6165.5	ALARM	EREVVEST	0.0	NORMAL NORMAL
	CLAY 1	0.1	NORMAL	MOSES/STAW1	6165.5	ALARM	HOMER CITY 01	0.0 0.0	NORMAL
	CLAY 2	0.1	NORMAL	AW 3	6165.6 6165.5	ALARM	WALDWICK 57	0.0	NORMAL
	EDIC A	0.1	NORMAL		0100.0		r wellen were pr	0.0	NORMAL
	EDIC B	0.1	NORMAL		0.0	NORMAL	BELLVILLE.	0.0	NORMAL
	LAFAYETTE	22222.2	ALARM	COOPERS 1	0.0	NORMAL	BERGEN 51	0.0	NORMAL
TIME MAX	LEEDS 2	0.1	NORMAL	COOPERS 2	0.0	NORMAL	ROSELAND 66	0.0	NORMAL
	NEW SCOTLAND	0.1	NORMAL	KINTIGH	0.0	NORMAL	LINDEN	33335.5	NORMAL
CENTRAL HUDSON 5.0m	SCRIBA	0.1	NORMAL	OAKDALE	0.0	NORMAL			
CON EDISON 5.0m	VOLNEY	0.2	NORMAL	STOLLE	91593.1	ALARM	MISO		NORMAL
NATIONAL GRID 5.0m				WATERCURE	0.0	NORMAL			
POWER AUTHORITY 5.0m	DUNKIRK 1	0.1	NORMAL	LILINITI CAZ	0.1	NORMAL	CALLAWAY 01	0.1	NORMAL NORMAL
NYSEG 5.0m	PACKARD	0.1	NORMAL	MEXER	0.1	NORMAL	GLION 01	25913.7	ALARM
ROCHESTER G&E 5.0m	PORTER	0.1	NORMAL	OAKDALE	0.0	NORMAL	MIAMIFOR 0	0.0	NORMAL
LONG ISLAND 5.0m	ROTTERDA 1	0.1	NORMAL	STOLLE	33333.3	ALARM	STEPHENS CH	0.0	NORMAL
PJM 5.0m	ROTTERDAM 2	7.5	ALARM				STCLAIR3 01	0.0	NORMAL
MISO 5.0m				STOLLE	2000.2	ALARM	CONSERVACION	699.4	ALARM



PMU Data Used by State Estimator Application

SE: PMU Measurement Summary

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

A	nalog Measuremer	nt Name	In Use	Measurement Value	SE Value	Measurement Residual	Norm Residual	Measurement Confidence	Covariance /Sigma	Туре	Sign
N.SCTLND34	5 99K	KV PMU	Yes	354.9	354.3	0.6	0.59	0.36	1.0	KV	· · ·
WALDWICKS	5_K3411		Yes	357.6	356.9	0.7	0.7	0.39	1.0	KV	· · ·
WILLIS 230	WD1	KV_PMU	Yes	230.2	230.8	-0.6	-0.55	0.6	1.0	KV	
EDIC 345_/	4	KV_PMU	Yes	353.2	352.5	0.7	0.68	0.32	1.0	KV	· · ·
LEEDS 345	32	KV_PMU	Yes	356.7	355.7	1.0	1.02	0.43	1.0	KV	· ·
MASSENA 7	j_7040	KV_PMU	Yes	751.6	752.4	-0.9	-0.87	1.01	0.9	KV	· · ·
ROSELAND2	0_Y-2277	KV_PM	Yes	239.0	241.7	-2.8	-2.79	0.5	1.0	KV	
BERGEN 23	_T-2272	KV_PMU	Yes	237.4	239.3	-1.9	-1.86	0.82	1.0	KV	
ROCHESTR	45	KV_PM	Yes	352.6	351.5	1.2	1.18	0.52	1.0	KV	
PORTER 23	A	KV_PMU	Yes	230.8	233.7	-2.9	-2.94	0.38	1.0	KV	
LEEDS 345	34	KV_PMU	Yes	357.1	355.7	1.4	1.4	0.43	1.0	KV	
PORTER 23	В	KV_PMU	Yes	232.0	233.7	-1.8	-1.78	0.38	1.0	KV	
HOMER C 3	5_ARM-HOM	KV_P	Yes	357.4	357.9	-0.4	-0.43	0.98	0.9	KV	
ROSELAND2	0_A-941	KV_PM	Yes	239.0	241.7	-2.7	-2.74	0.5	1.0	KV	•
ROTTRDAM	30_99H	KV_PM	Yes	233.5	237.8	-4.2	-4.25	0.67	1.0	KV	
WILLIS 230_	VM2	KV_PMU	Yes	230.1	230.8	-0.6	-0.65	0.6	1.0	KV	
WILLIS 230_	WRY2	KV_PMU	Yes	231.2	230.8	0.4	0.42	0.6	1.0	KV	
BERGEN 23	_K-2289	KV_PMU	Yes	237.6	239.3	-1.7	-1.75	0.82	1.0	KV	
BERGEN 23	_R-2270	KV_PMU	Yes	237.7	239.3	-1.6	-1.64	0.82	1.0	KV	
ROBNSNRD	15_BK_1	KV_P	Yes	117.6	116.4	1.2	1.21	0.61	1.0	KV	
ROCHESTR	45SR1	KV_PM	Yes	352.7	351.5	1.2	1.22	0.52	1.0	KV	
MARCY 765	345_AT1	KV_PMU	Yes	754.9	755.9	-1.0	-1.03	0.67	1.0	KV	·
NIAGARA 34	NS-1	KV_PMU	Yes	351.9	350.2	1.7	1.68	0.63	1.0	KV	· · ·
		KV PM	Yee	787 5	767 8	-n 3	-U 3	1 98	ר ח	κv	

EMS Use-Case for using PMU data at NYISO



RTAPPS.

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

PMU source has been selected as best choice

	VISS2															
				IN USE												
	STATION	кv	UPDATE STATE	TIME	IN USE vs SE	TIME SUSPECT	0(SE)	1	2	3	4	5	6	SELECT SOURCE	BEST SOURCE	QUALITY
S	PANNELL RD	353.5	NORMAL	1.1	NORMAL	0.0	352.3	0.0	353.5	353.5				2	2	NORMAL
DS	anaaaanii yi <mark>y</mark>	352.8	NORMAL	0.1	NORMAL	0.0	353.8	355.4	355.6	352.8	355.1	300.0 T D	356.4	3	3	NORMAL
s	BAINEY BAST	352.7	NORMAL	0.1	NORMAL	0.0	354.0	352.2	352.2	352.7	351.2			3	3	NORMAL
s	eanney mash	352.7	NORMAL	0.0	NORMAL	0.0	354.0	352.5	352.7					2	2	NORMAL
s	RAMARO	354.3	NORMAL	0.2	NORMAL	0.0	354.3	356.0	355.5	347.4	341.3 т.р.	355.3		ОШТ	5	DEGRAD
S	ROCHESTER	352.2	NORMAL	0.0	NORMAL	0.0	351.7	353.5	353.1	352.8	353.5	352.2	352 3	5	5	NORMAL
s	ROCK TAVERI	352.6	NORMAL	3.2	NORMAL	0.0	352.8	352.6	353.3	352.4	350.5			1	1	NORMAL
S	ROBERON	353.9	NORMAL	0.3	NORMAL	0.0	355.2	356.8	353.9	356.8	353.2	354.4	355.0	2 III T	6	DEGRAD
	NOUTRI MARINE	355.2	NORMAL	0.2	SUSPCT	22222.2	355.2	357.0 ш т						ОМТ	1	DEGRAD
DS		350.5	NORMAL	0.0	NORMAL	0.0	353.7	349.2	350.5	348.1				2	2	NORMAL
		0.2	NORMAL	0.0	SUSPCT	27261.6	361.0	353.7 т	0.2	351.3T				2 м т	1	DEGRAD
	VOLNEY	354.2	NORMAL	0.0	NORMAL	0.0	354.0	353.1	353.1	353.7	354.2	354.4	35 7	4	4	NORMAL
		354.5	NORMAL	0.0	NORMAL	0.0	353.4	355.6	354.6	354.5				3	3	NORMAL
S	GARDENVILLE	234.7 L	NORMAL	0.0	NORMAL	0.0	234.8	235.0	235.5	235.7	234.2	234.2	234.7	6	6	NORMAL
	HUNTLEY	234.6	NORMAL	0.0	NORMAL	0.0	234.7	232.7	233.9	234.6	235.3	232.7	233.8	3	3	NORMAL
	MEYER	233.4	NORMAL	0.0	NORMAL	0.0	233.6	230.7	231.5	233.4				3	3	NORMAL
S	MOSES	235.0	NORMAL	0.0	NORMAL	0.0	234.6	234.1	235.7					2	2	NORMAL
S	NIAGARA E	238.1	NORMAL	0.0	NORMAL	0.0	238.1	0.0	237.9	237.9	238.4	0.8T	238.2	ЗТ	6	NORMAL
S	NIAGARAW	237.9	NORMAL	0.0	NORMAL	0.0	238.1	237.9	238.4	0.0	237.9	238.0	229.3	1 T	5	NORMAL
	OAKDALE	230.7	NORMAL	0.0	SUSPCT	33333.3	236.4	229.2	230.7					2	2	NORMAL
	BACKARD	236.2	NORMAL	0.1	NORMAL	0.0	236.4	236.2	236.0	237.1				1	1	NORMAL
	ROTTERDAM	233.4	NORMAL	0.0	SUSPCT	201.8	237.7	232.8	232.6	231.5	233.4	233.4T		4	4	NORMAL
	STOLLE RO	232.8	STALE	??.?	NORMAL	0.0	234.7	232.8						1	1	NORMAL
s	WATERCURE	232.1	STALE	??.?	NORMAL	0.0	232.9	229.7	232.1	231.5 T				2	2	NORMAL
	IORTHRORT	139.9	NORMAL	0.7	NORMAL	0.0	139.9	140.0	139.9	140.2				2	2	NORMAL
	NORTHRORTO	139.2	NORMAL	1.4	NORMAL	0.0	139.0	139.2	139.5					1	1	NORMAL
	VALLEY STRE <mark>AM</mark>	140.0	NORMAL	2.6	NORMAL	0.0	139.0	140.0	140.3	140.3				1	1	NORMAL
								I								



Synchrophasor Global Alarms

Alarm Types

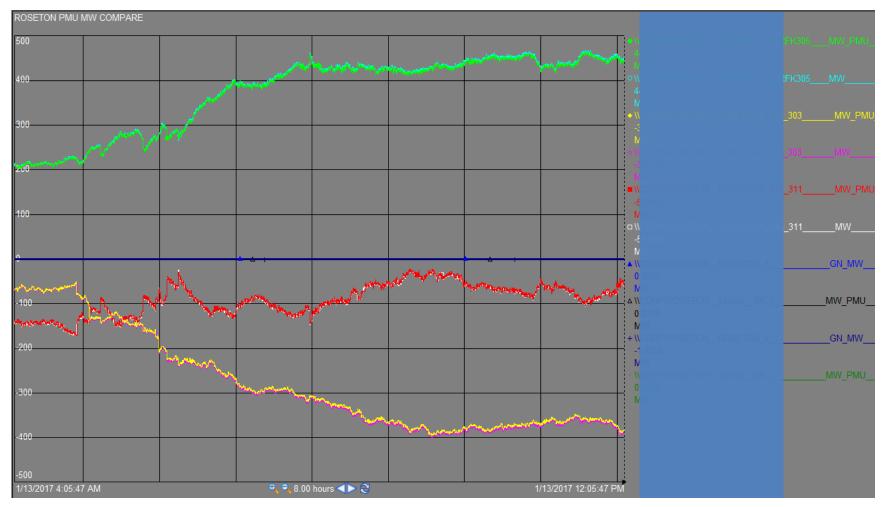
PMU_ANGLE_DIFFERENCE_VIOLATION PMU_CURRENT_MAGNITUDE_VIOLATION PMU_CURRENT_R-O-C_VIOLATION PMU_VOLTAGE_MAGNITUDE_VIOLATION PMU_VOLTAGE_R-O-C_VIOLATION PMU_FREQ_MAGNITUDE_VIOLATION PMU_FREQ_R-O-C_VIOLATION PMU_FLOW_MW_MAGNITUDE_VIOLATION PMU_FLOW_MVAR_MAG_VIOLATION PMU_INTERFACE_MW_MAG_VIOLATION PMU_SYS_FREQ_R-O-C_VIOLATION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

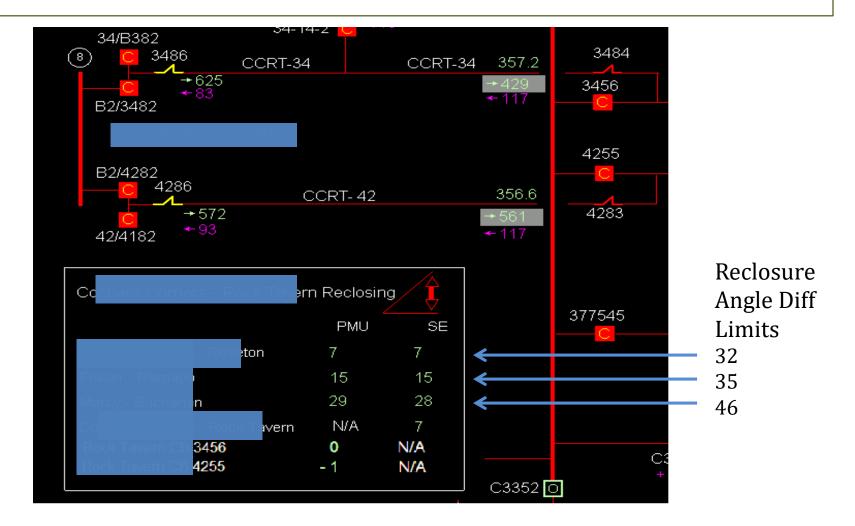


PI Trends to Compare SCADA Data to Synchrophasor Data





Angle Difference Used to Determine 345 KV Line Reclosures





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

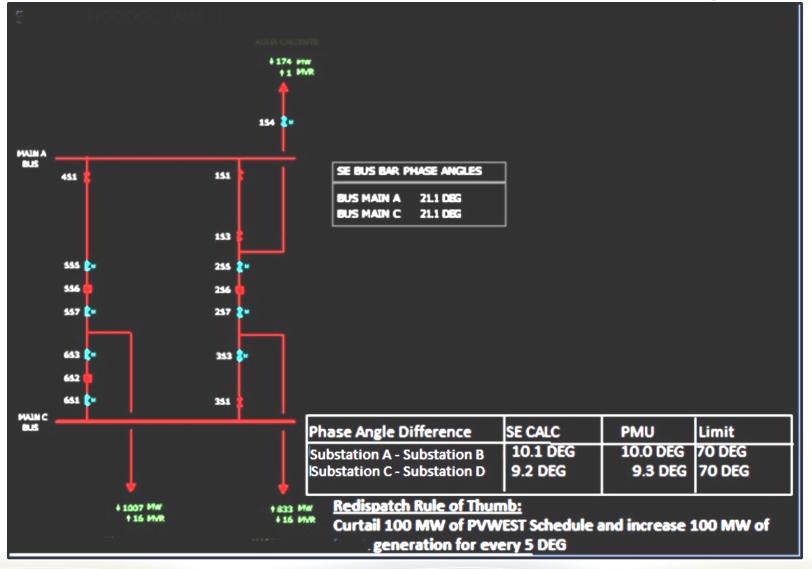


CAISO Synchrophasor Activities

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





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

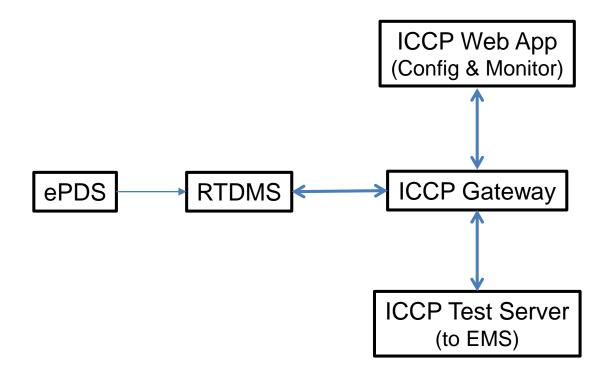


Demonstration & Key Take-aways

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 <u>Contact@electric</u>

http://electricpowergroup.com/webinars.html



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