Hybrid State Estimation at PJM

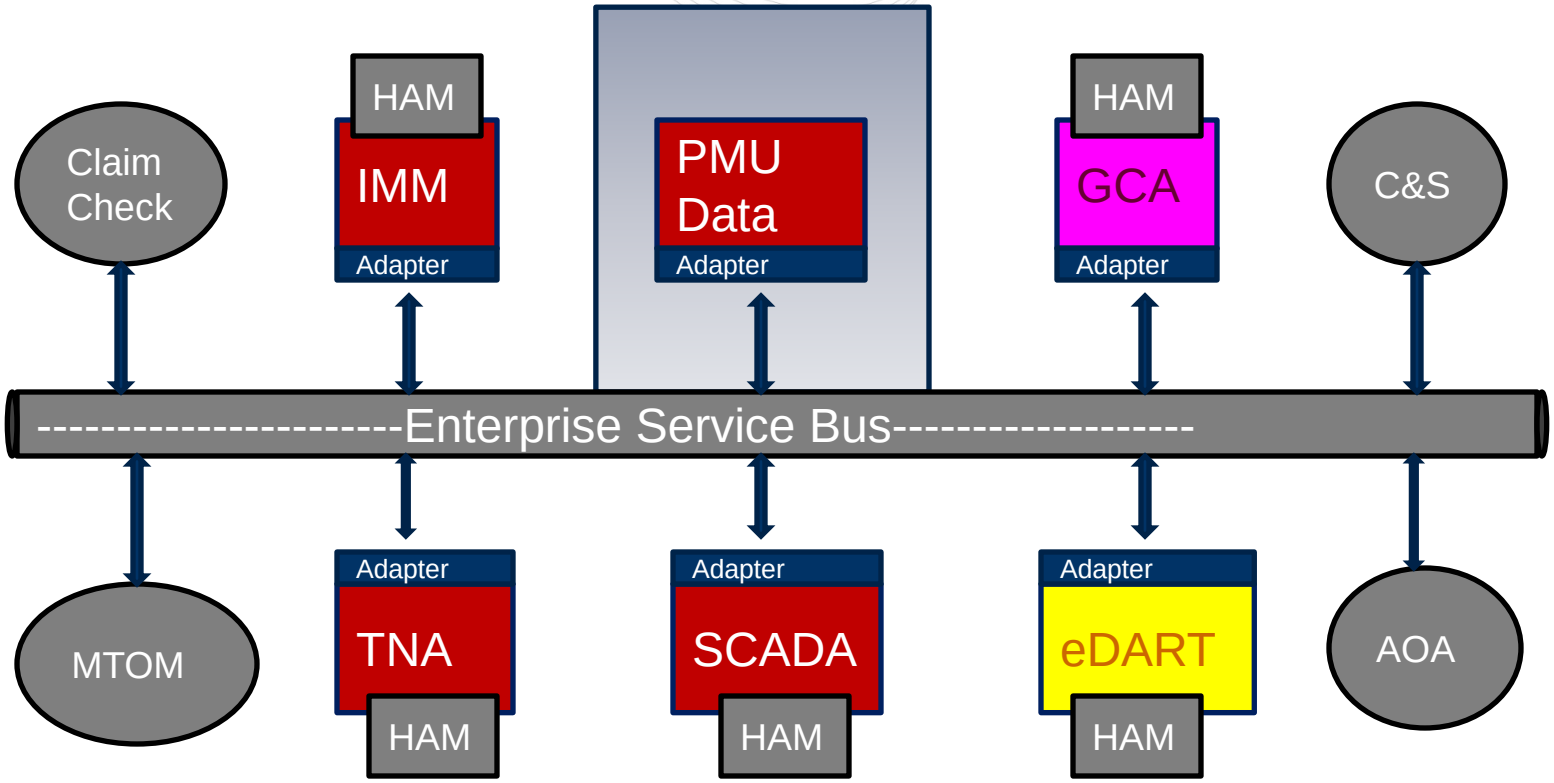
John R. Baranowski, P.E.

Sr, Consultant – EMS and Model Management

Agenda

- PJM Integration Approach
  - SOA Integration
  - Data Processing
  - EMS Integration
- Initial Hybrid SE Results
  - PMU comparison to SE
  - Modeling considerations
- Multi-day impact on SE convergence
- Next Steps

PMU Data SOA Integration



Use Published Message Definitions

EMS Toolkits

Description | Standards | A Strategic Choice for Utilities | Availability

Description

Siemens' Spectrum Power™ Shared Architecture provides the infrastructure for a utility to integrate software systems that support reliability and market operations using the principles of a Service Oriented Architecture.

In the typical utility environment, software systems are purchased from different vendors and/or internally developed, resulting in a diverse computing environment with point-to-point interfaces between these systems. Spectrum Power™ Shared Architecture provides a platform that includes an Enterprise Service Bus (ESB) and an expanded set of Spectrum Power™ Shared Architecture services, which may be used to upgrade the utility computing environment.

Spectrum Power™ Shared Architecture also includes a set of services that are commonly needed for in the operations environment such as support for high availability, system resiliency, cyber security and archive/audit.

Spectrum Power™ Shared Architecture was co-developed by Siemens Energy, Inc. and PJM Interconnection, LLC.

Business Service Components communicate via the ESB and adapters supplied by Siemens (Siemens Adapter Framework/Siemens Communications Framework) or by the user.

BSCs may use the following common or shared services:

- The Enterprise Service Bus
- Activation Orchestration Application
- Hardware and Application Monitoring
- Naming Service
- Context and State Management Service
- Cyber Security Services
- Process Orchestration
- Service Manager
- Web Services
- CIM-CIE Standard Messages

Text Size

Share this Page:

Product Finder

Choose a Product... go

Spectrum Power™ Application Programming Interface Downloads

Message Service Definitions User Guide

Case Study Download

PJM Case Study

Overview Download

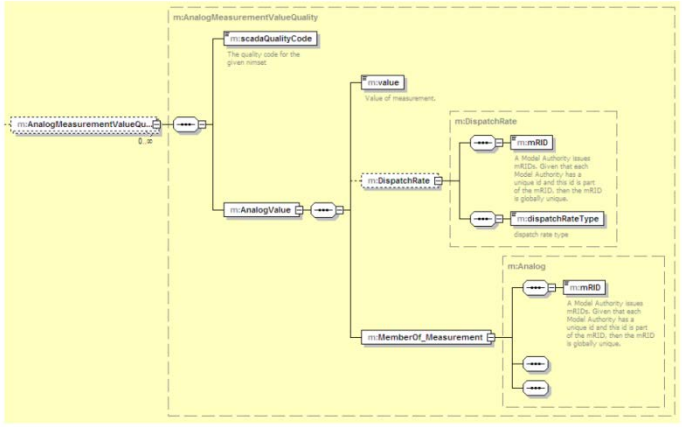
Spectrum Shared Architecture Download

Re-use Telemetry Message

13.3 Telemetry

Sender BSC	SCADA
Receiver BSCs	TNA, RTLMP, eDATA
Description	Analog and discrete measurements with quality codes; also used for dispatch rate data and net generation levels.
Services	receiveBulkAnalogTelemetry – publish/subscribe service for bulk analog telemetry data receiveBulkDigitalTelemetry – publish/subscribe service for bulk digital telemetry data receiveIncrementalDigitalTelemetry – publish/subscribe service for incremental digital telemetry data requestBulkAnalogTelemetry – request/response service for bulk analogy telemetry data requestBulkDigitalTelemetry – request/response service for bulk digital telemetry data receiveDispatchRateTelemetry – publish/subscribe service for dispatch rate data receiveNetGenerationTelemetry – publish/subscribe service for net generation data

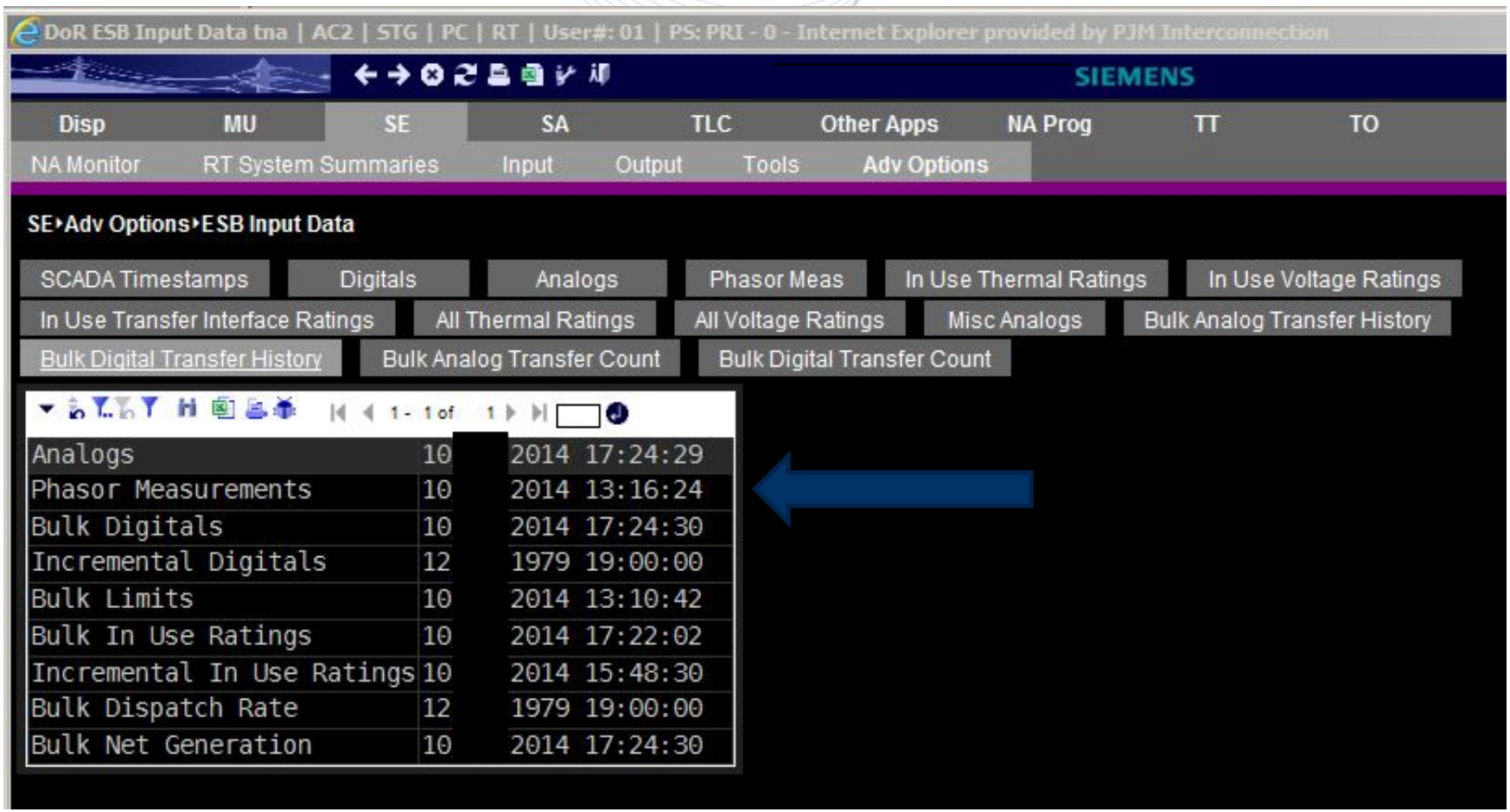
13.3.1.2 Analog Measurements



13.3.2 Sample XML

```
<?xml version="1.0" encoding="UTF-8"?>
<Telemetry xsi:schemaLocation="http://www.siemens.com/energy/sa/schemas/Telemetry/v1# Telemetry.xsd"
xmlns="http://www.siemens.com/energy/sa/schemas/Telemetry/v1#" xmlns:xsi="http://www.w3.org/2001/XMLSchema-
instance">
        <AnalogMeasurementValueQuality>
                <scadaQualityCode>12</scadaQualityCode>
                <AnalogValue>
                        <value>3.14159</value>
                        <DispatchRate>
                                <mRID>3456</mRID>
                                <dispatchRateType>Rate</dispatchRateType>
                        </DispatchRate>
                        <MemberOf_Measurement>
                                <mRID>1234</mRID>
                        </MemberOf_Measurement>
                </AnalogValue>
        </AnalogMeasurementValueQuality>
        <DiscreteMeasurementValueQuality>
                <manualReplaceIndicator>true</manualReplaceIndicator>
                <removeFromOperationIndicator>true</removeFromOperationIndicator>
                <DiscreteValue>
                        <value>23</value>
                        <MemberOf_Measurement>
                                <mRID>4567</mRID>
                        </MemberOf_Measurement>
                </DiscreteValue>
        </DiscreteMeasurementValueQuality>
        <SCADAInformation>
                <timeStamp>2008-05-30T01:02:47.1Z</timeStamp>
        </SCADAInformation>
</Telemetry>
```

Add Receiving Data Queue



PMU Message Data

SE▸Adv Options▸ESB Input Data▸Phasor Meas

SCADA Timestamps | Digitals | Analogs | Phasor Meas | In Use Thermal Ratings | In Use Voltage Ratings | In Use Transfer Interface Ratings | All Thermal Ratings | All Voltage Ratings | M

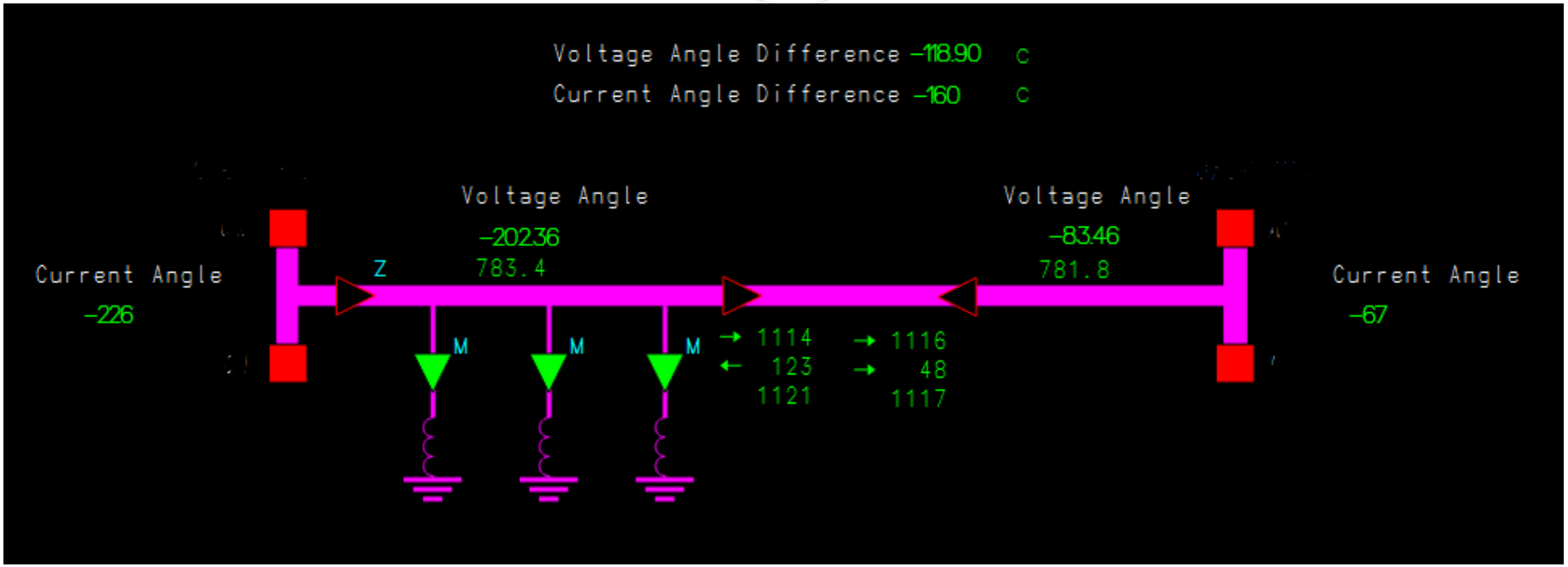
Bulk Analog Transfer History | Bulk Digital Transfer History | Bulk Analog Transfer Count | Bulk Digital Transfer Count

Phasor Measurements

1 - 25 of 122

Company	Zone	Station B1	Voltage B2	Equipment B3	Meas Type	MRID	Value	Quality Code	Meas Index
F	P	L	230 KV		NODE DEGS	0836	-222.072	9	
F	P	L	230 KV		NODE DEGS	37F8	35.656	9	
F	P	L	230 KV		NODE DEGS	1A0F	-58.432	9	
F	P	L	230 KV		LINE DEGI	1DAA	-245.104	9	
F	P	L	230 KV		LINE DEGI	A6DE	-87.696	9	
F	P	R	230 KV		NODE DEGS	33A3	229.792	9	
F	P	R	230 KV		NODE DEGS	D2C8	260.112	9	
F	P	R	230 KV		NODE DEGS	45A1	210.256	9	
F	P	R	230 KV		LINE DEGI	040A	-137.304	9	
F	P	R	230 KV		LINE DEGI	30A9	-12.280000000000001	9	
F	P	W	345 KV		NODE DEGS	C303	75.488	9	
F	P	W	345 KV		NODE DEGS	35BC	63.024	9	
F	P	W	345 KV		LINE DEGI	1385	-196.776	9	
F	P	W	345 KV		LINE DEGI	A46D	-259.384	9	
F	P	W	345 KV		XF-H DEGI	609E	21.624	9	
F	P	W	345 KV		XF-H DEGI	F27F	256.312	9	
F	P	W	345 KV		XF-H DEGI	1CC5	146.528	9	
F	P	B	230 KV		NODE DEGS	E27C	-56.88	9	
F	P	B	230 KV		NODE DEGS	1287	243.376	9	
F	P	B	230 KV		LINE DEGI	979E	10.288	9	
F	P	B	230 KV		LINE DEGI	1C9C	-76.136	9	
F	P	B	230 KV		LINE DEGI	0494	-23.8	9	
F	P	B	230 KV		LINE DEGI	B9C0	-20.624	9	
F	P	B	230 KV		LINE DEGI	82DA	260.92	9	
F	P	B	230 KV		XF-H DEGI	D704	0	9	

Integration on EMS One-lines



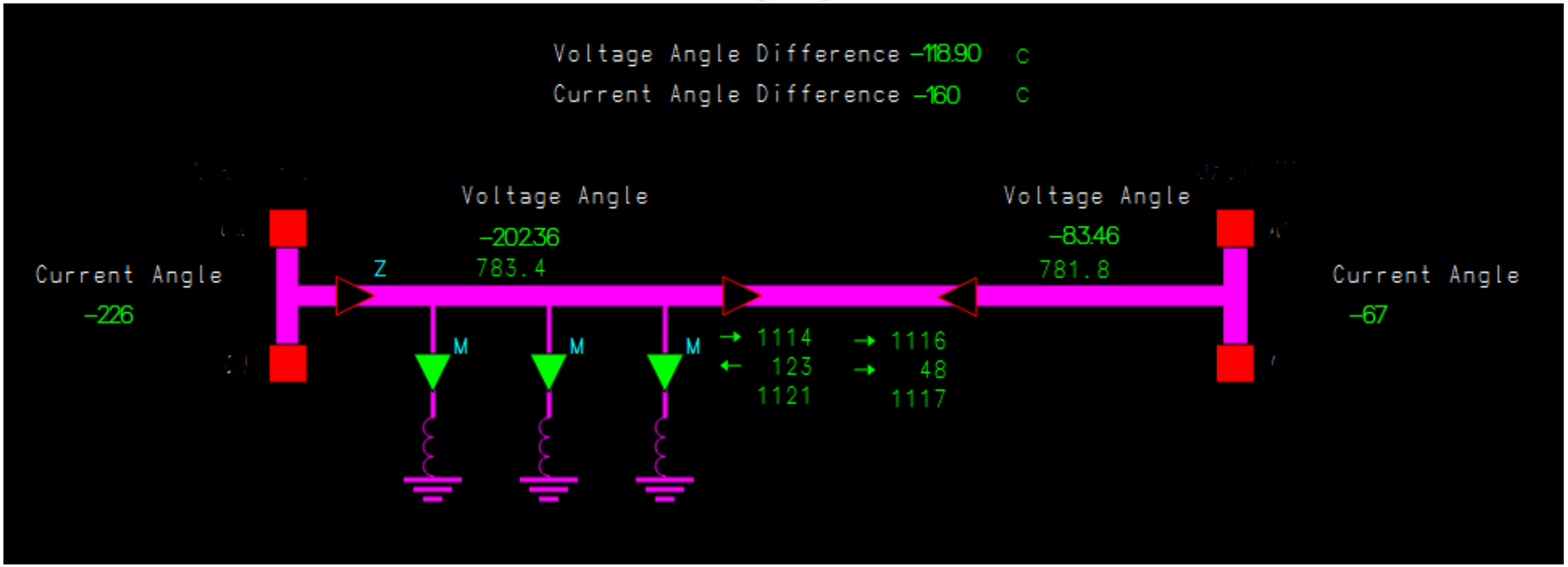
Voltage Measurement Results

Station	Voltage	Type	Meas	Est	Res	Status
Station#1	230 KV	NODE DEGS	-36.38	-35.89	-0.48	
Station#2	500 KV	NODE DEGS	0	0	0	REF MEAS
Station#3	765 KV	NODE DEGS	58.87	58.99	-0.11	
Station#4	765 KV	NODE DEGS	61.84	62.32	-0.47	
Station#5	345 KV	NODE DEGS	-35.78	78.78	-114.56	PREV ABN
Station#5	345 KV	NODE DEGS	78.86	78.78	0.09	

Current Measurement Results

Station	Voltage	Type	Meas	Est	Res	Status
Station A	230 KV	LINE DEGI	-178.48	-177.35	-2.04	
Station B	345 KV	LINE DEGI	-168.99	-168.78	0.91	
Station B	345 KV	LINE DEGI	-169.66	-168.52	-1.35	
Station C	345 KV	LINE DEGI	-103.86	-103.36	-0.82	
Station C	345 KV	LINE DEGI	-110.48	-95.4	-26.33	
Station From*	765 KV	LINE DEGI	-85.67	-94.82	15.97	
Station D	230 KV	LINE DEGI	133.1	0	0	
Station D	230 KV	LINE DEGI	33.05	0	0	
Station E	230 KV	LINE DEGI	31.92	31.55	0.83	
Station E	230 KV	LINE DEGI	31.62	32.52	-1.39	
Station F	230 KV	LINE DEGI	33.74	33.94	-0.34	
Station F	230 KV	LINE DEGI	33.35	34.54	-2.16	
Station F	230 KV	LINE DEGI	36.15	34.54	2.73	
Station F	230 KV	LINE DEGI	33.94	34.54	-0.97	
Station E	230 KV	LINE DEGI	53.09	51.73	2.12	
Station E	230 KV	LINE DEGI	52.1	51.85	0.21	
Station To*	765 KV	LINE DEGI	102.78	85.22	30.66	
Station To*	765 KV	LINE DEGI	85.43	85.45	-0.02	
Station To*	500 KV	LINE DEGI	92.38	87.09	9.26	
Station G	500 KV	LINE DEGI	136.17	142.79	-11.72	

EMS Model Considerations



Initial Test System Results

SE Convergence

		Non-convergent		Convergent	
Date	PMU's Enabled	Count of SE Runs	Average of Iteration Count	Count of SE Runs	Average of Iteration Count
13	No	74.00	81.00	399.00	19.28
	Yes	74.00	81.00	398.00	22.82
14	No	486.00	81.00	873.00	22.02
	Yes	600.00	81.00	761.00	31.22
15	No	695.00	81.00	658.00	23.38
	Yes	932.00	81.00	426.00	25.90
16	No	614.00	81.00	715.00	23.36
	Yes	598.00	81.00	740.00	26.05
17	No	27.00	81.00	431.00	25.13
	Yes	147.00	81.00	323.00	26.45
Grand Total		4247.00	81.00	5724.00	24.72

Next Steps

- **Continue to test/tune/validate Hybrid SE**
  - Increase use of existing PMU maps
  - Map additional PMU measurements
- **Move testing closer to production**
  - Improved SCADA sampling rates
  - Better SE tuning
- **Investigate discrepancies**
  - SCADA vs. Model vs. PMU vs. mapping errors
- **Additional scenario testing**
  - Loss of SCADA/stale data (RTU/ICCP link)

Questions?