

PJM PMU Placement Strategy

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Preamble

To date PJM utilizes synchrophasor data and calculations sourced from Phasor Measurement Units [PMU] both Operationally and within the Planning environment. PJM's PMU infrastructure stems largely from 85 Transmission Owner [TO] substation installations as part of the 2009 Smart Grid Investment Grant. PJM TOs continue to expand the substation installations to more than 125 transmission substations in 2015. PMU installations on the Generation Owner [GO] low-side of the generator step-up transformer [GSU] have begun to expand the PMU-network beyond the transmission system in late 2015 with the first communications from a GO to PJM anticipated in 2016.

Purpose

The intent of this document is to provide guidance with respect to PMU placement within the PJM RTO footprint with the intention of addressing gaps and redundancy with respect to model validation, Linear State Estimation measurement and observability, areas of known stability concerns, and to enhance overall situational awareness, restoration efforts, and/or event analysis within the Eastern Interconnection.

In general, PJM suggests the following approach. As work is being performed at any given substation, the substation owner (GO & TO) performs an evaluation as to whether it is feasible to install PMU and/or PMU-ready devices and communication infrastructure at the substation. Whenever a member is performing planned work around relay modifications and new BES substations, consideration should be made within that plan around the installation of PMU or PMU-ready devices. However, there are locations that PJM has a heightened interest in acquiring GPS-synchronized phasor measurement data.

Explicitly suggested PMU placement locations may be utilized by a given PJM GO or TO as part of their overall approach to PMU placement. Should PMU become pervasive enough that they effectively replace traditional Remote Terminal Unit (RTU) as default instrumentation, the need for this specific PJM strategy would be concluded.

PJM Desired Location Criteria

To derive the list contained within the Proposed PMU Locations & Intent section, PJM utilized the following criteria. The criteria was developed with respect to current industry recommendations (See [Supporting Material](#) re: NAISPI & NERC recommendations) and honed based upon PJM Operational & Planning needs.

Area of Known Stability Concern (STABILITY or S)

- *Any station with impact to the PJM RTO and/or neighboring systems within the Eastern Interconnection, which has been identified as having conditional stability concerns / limitations / restrictions.*

IROL Measurement (IROL or I)

- Any station which is utilized in the derivation of a PJM Transfer Interface which is also classified as an Interconnection Reliability Operating Limit [IROL].
NOTE: Focus would be on direct phasor measurements for pieces of equipment explicitly identified within an Interface Definition, but for the ease of assembling the list contained herein, only the substation has been identified.

Expanded Observability (OBSERVABILITY or O)

- Stations within the PJM system that further expand / add to redundancy/ complete PJM's observability with respect to the Extra High-Voltage [EHV] network or Oscillatory behavior. In addition to oscillatory situational awareness, the expansion of the EHV observability would be utilized by PJM to derive a full view of the PJM EHV system within the synchrophasor-driven PJM Linear State Estimator [LSE].

System, Generator, or Load Model Validation (MODEL or M)

- Whether utilized as part of system, generator or load model validation, this is data is utilized in order to confirm or refine the PJM Planning and Operations models with respect to dynamic reactive power resources, large industrial loads, large block loads, HVDC resources, automatic control resources, and/or Remedial Action Schemes (aka Special Protection Schemes).

PJM is engaged in the NERC Synchronized Measurement Subcommittee (operating under the NERC Planning Committee, efforts to develop an overall PMU Placement Guideline. PJM will adjust its PMU Placement Strategy as warranted based upon this NERC initiative.

[http://www.nerc.com/comm/PC/Pages/Synchronized-Measurement-Subcommittee-\(SMS\)-Scope.aspx](http://www.nerc.com/comm/PC/Pages/Synchronized-Measurement-Subcommittee-(SMS)-Scope.aspx)

Proposed PMU Locations & Intent

The substations identified below meet at least one of the [Criteria](#) identified above. Criteria use the following key:

S – Stability, i.e. Area of Known Stability Concern

I – IROL, i.e. Interconnection Reliability Operating Limit Measurement

O – Observability, i.e. Expanded Observability

M – Model; i.e., System, Generator, or Load Model Validation

TO Zone	Station	Criteria
		M
Identified		M, S
		I
		I
		M, S
		I
	M, O, S	
	I	
Locations		I
		M, S
		M, S
		I
		I
	I	
within CELL		I
		I
		I
		M, S
		I
	M, S	
	I	
Version		M, S
		M, S
		M, S
		M, S
		M, S

Identified	I
	I
	M, S
	M, S
	I, M, S
M, S	
M, S	
I	
Locations	M, S
	M, S
	M, S
	I, M, S
	M, S
M, S	
M, S	
M, S	
within CELL	I
	M, S
	I, M, S
	I, M, S
	M
I	
I	
Version	I
	M, S
	M, S
	I
	M, S
M, O, S	

¹ For these locations, the desire is for installation on the low-side of the generator step-up as well as the high-side transmission level for the purpose of Model Validation and/or Stability concerns.

² For these locations, while PMU's are already in place at the transmission level, the desire is for additional installation on the low-side of the generator step-up transformer [GSU].

Supporting Material

PJM Open Access Transmission Tariff (OATT), Attachment O, Section 8.5.3

<http://www.pjm.com/media/documents/merged-tariffs/oatt.pdf>

PJM Manual 14D: Generator Operational Requirements

<http://www.pjm.com/~media/documents/manuals/m14d.ashx>

PJM Manual 3: Transmission Operations Manual

<http://www.pjm.com/~media/documents/manuals/m03.ashx>

PJM OM-85: Real-Time TSA Use and Support Guidelines [CEII]

[Internal PJM Document]

NERC Synchronized Measurement Subcommittee: PMU Placement Guideline [under development]

[http://www.nerc.com/comm/PC/Pages/Synchronized-Measurement-Subcommittee-\(SMS\)-Scope.aspx](http://www.nerc.com/comm/PC/Pages/Synchronized-Measurement-Subcommittee-(SMS)-Scope.aspx)

U.S. DOE Smart Grid PJM Synchrophasor Technology Deployment Project

https://www.smartgrid.gov/files/PJM_Updated_Final_Project_Description.pdf