Dynamic Model Validation

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Agenda

Dynamic model validation using PMUs is:

- Regulatory requirement
- Reliability enhancement
- Value added

Regulatory Requirement

- NERC Standard MOD-033-1: Steady-State and Dynamic System Model Validation
  - Requires “Comparison of the performance of the Planning Coordinator’s portion of the existing system in a planning dynamic model to actual system response, through simulation of a dynamic local event”
  - “A dynamic local event is a disturbance on the power system that produces some measurable transient response, such as oscillations. It could involve one small area of the system or a generating plant oscillating against the rest of the grid.”

Why not traditional SCADA?

- Traditional telemetry does not have the sampling rate necessary for dynamic model validation – the higher resolution of PMUs is needed
  - Nyquist sampling theorem – a signal must be sampled at 2 times its frequency in order to be accurately captured
  - Dynamic analysis is done at a resolution of cycles, not seconds or minutes

Reliability

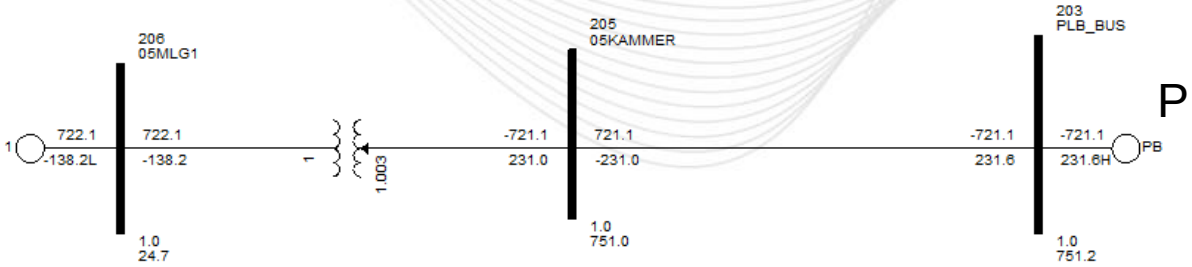
- Accurate dynamic models are essential for ensuring transmission system reliability
- Inaccurate dynamic models can lead to both false positive and false negative simulation results
  - False positives – instability in simulation that is not, or would not be present in the actual system
    - Crying wolf (the first 2 times)
  - False negatives – simulation shows stable response to an unstable contingency event in real world
    - Crying wolf (the 3rd time)

Value Added

- More widespread PMU deployment allows for dynamic model validation in “pockets”
  - Single PMU system is capable of some level of dynamic model validation, but too small to test the interaction of neighboring dynamic models with each other
  - Large scale (entire PJM footprint) is too large to pin-point error sources and extremely time-consuming to analyze
  - Pocket simulation is the best of both worlds

Single generator system

Generator model to be validated



PMU recording playback

- This method has been used to validate several generator dynamic models in the PJM footprint for MOD-033 compliance and continues to be a valuable method of validation
- However, more complex interactions between the generator and transmission system have been observed in larger scale simulation, which could not be validated by this simple system

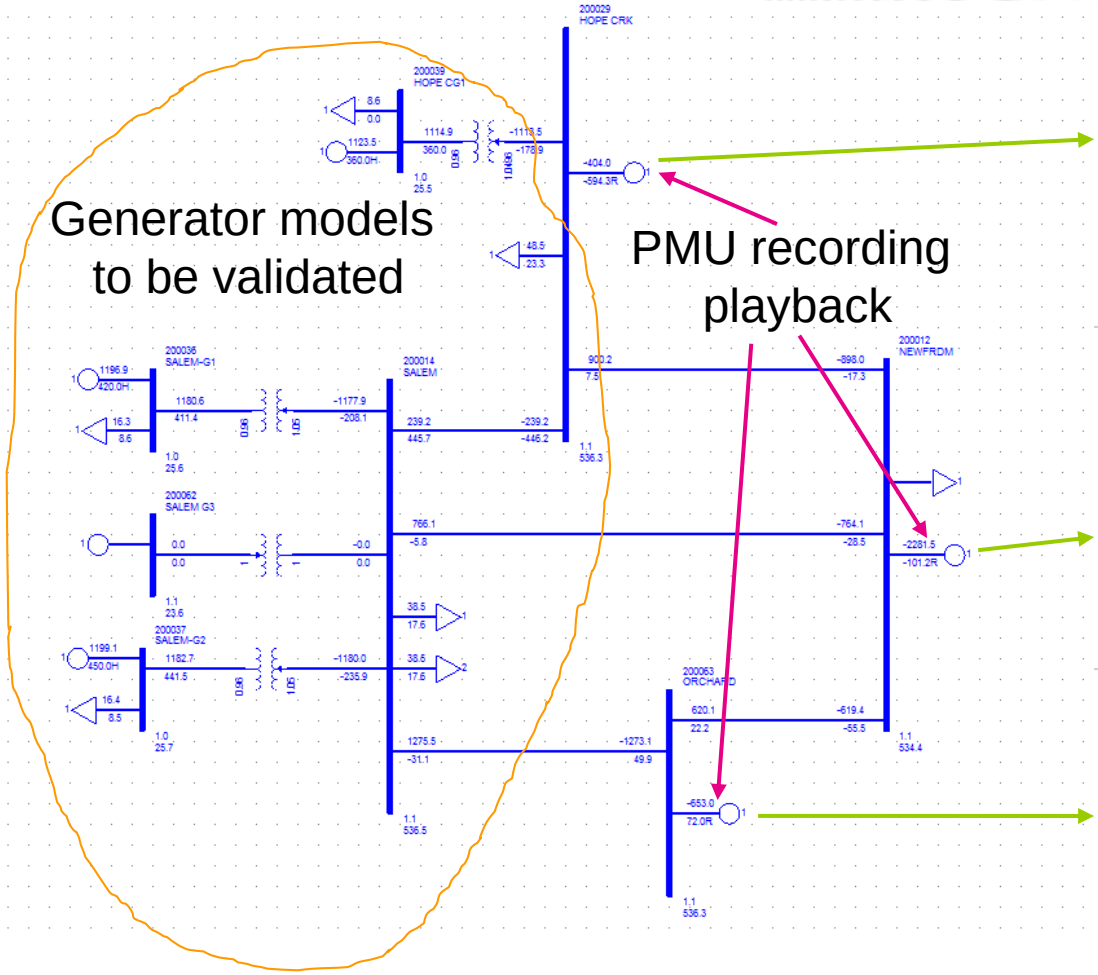
Large system

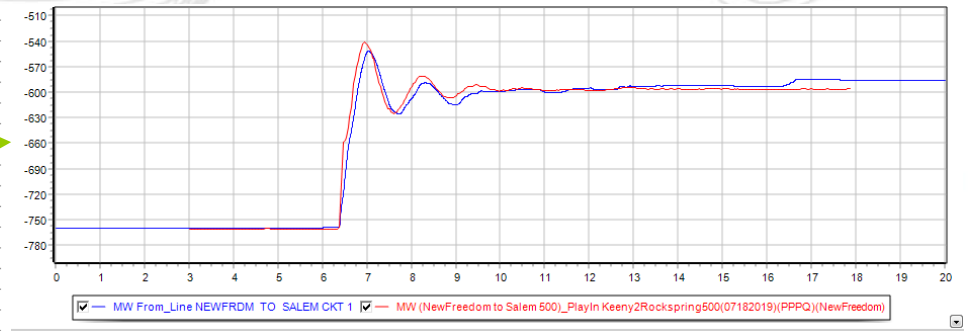
- Other ISO/RTOs have chosen to attempt to replicate dynamic events using a model consisting a large area within their footprint
  - The setup for this type of analysis is extremely time consuming
  - If discrepancies are identified between actual and simulated system behavior, identifying the culprit is difficult or impossible as several factors often contribute to the mismatch
  - The validation of dynamic models using this method has a low return on time invested

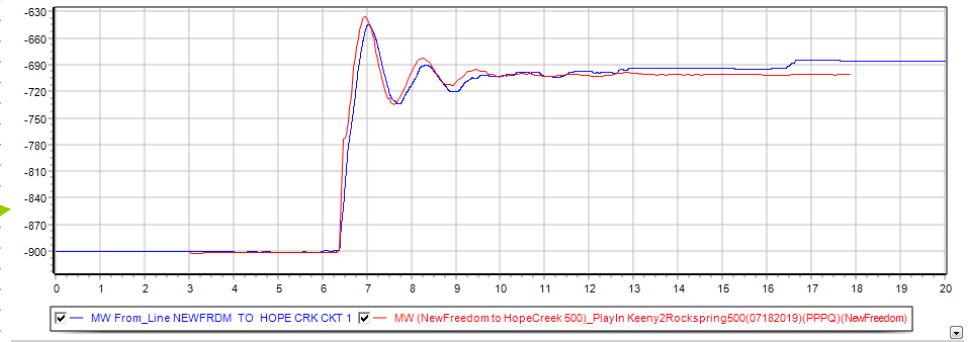
Pocket system

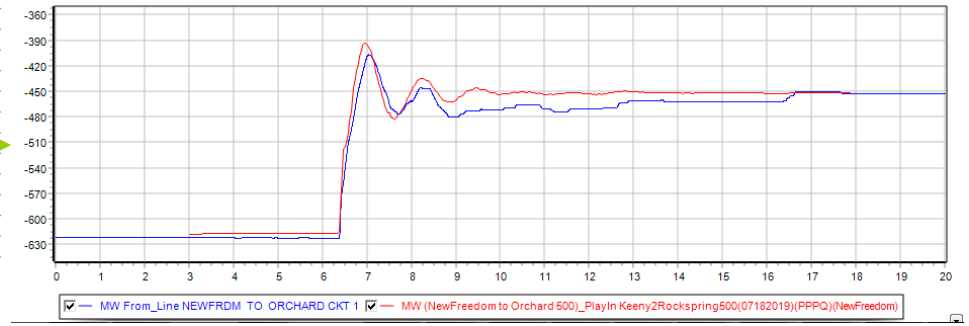
- Pocket system is an area bounded by PMUs
- Pockets of interest may contain a generators or load
- Simulation setup is only slightly more complex than the single PMU system
- Interactions within the system and with the multiple PMU recordings that bounded the pocket can be simulated and compared to measured data
- If discrepancies are identified, the number of possible contributing factors is more reasonable than in a larger system

Pocket system









Dynamic Model Validation Process

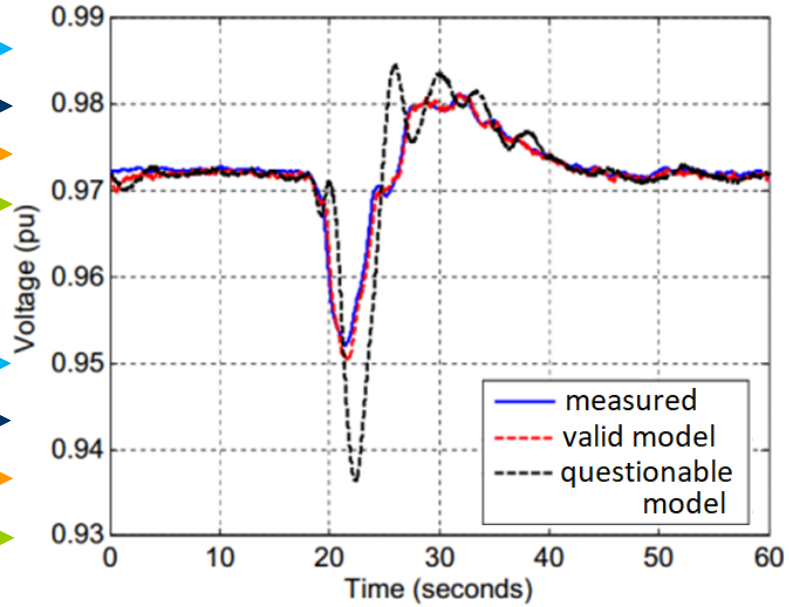
Voltage
Angle/frequency
MW
MVAR

Planning Dynamic Model

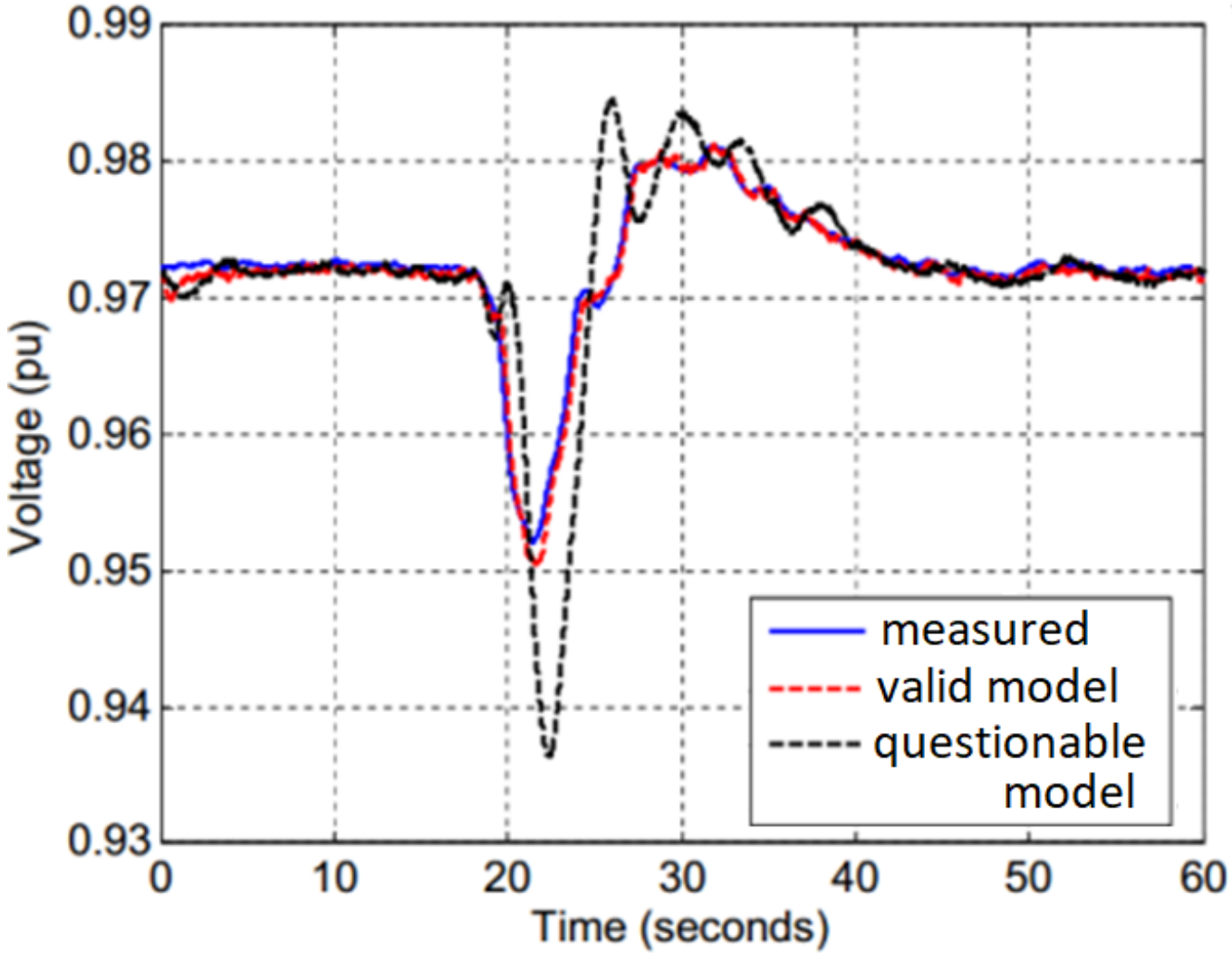
PMU data

ePDC Database

Simulation software



Dynamic Model Validation Process



Conclusion

- PMU recorded data is necessary for NERC Standard MOD-033 compliance
- The dynamic model validation that can be performed using PMU recorded data enhances the reliability of the PJM system and as a result, the Eastern Interconnection
- The pocket system dynamic model validation technique that is possible with widespread PMU deployment offers significant advantages over other methods

Demonstration