RECLAMATION Managing Water in the West

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The Knowledge Stream

Research Update

Validating and Improving Models for Power Systems

Using online "disturbance" data to help improve the accuracy of Reclamation's power system models

Bottom Line

This research provided several new methods for testing and validating computer models of powerplant generator controllers to develop more accurate methods of simulating generator systems.

Better, Faster, Cheaper

Meeting WECC and NERC requirements for modeling generator systems is vital in keeping Reclamation powerplants operating reliably. The more accurate Reclamation's power system simulations are, the better they are able to help predict potential power system instability issues and avoid outages. Moreover, this research developed improved ways to use online data, saving staff time, travel expenses, and generation outages—and getting more accurate data over a longer timeframe.

Principal Investigator

Kyle W. Clair, P.E.
Electrical Engineer
Power System Analysis and Control Group
Technical Service Center
303-445-2813
kwclair@usbr.gov

Research Office Contact

Erin Foraker
Renewable Energy Research Coordinator
303-445-3635
eforaker@usbr.gov

Problem

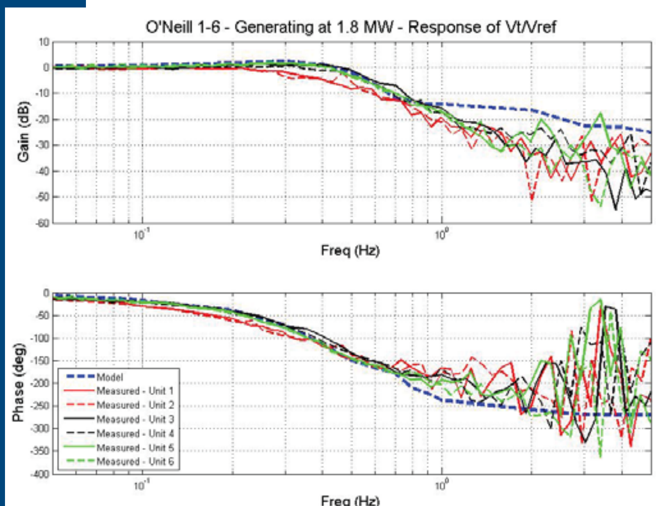
Power system operators and planners regularly perform dynamic simulations using computer models. After the power system blackouts of 1996, studies by the Western Electricity Coordinating Council (WECC) showed that many generation plant models were inaccurate and could not predict the type of system instability that led to the blackouts. To correct this inaccuracy, WECC began requiring generator owners to regularly validate the computer models representing their plants.

Validating models involves a series of staged tests and/or naturally occurring events with adequate recorded measurements of the response of the installed equipment, followed by computer simulations of the measured tests events, and then adjustments to the model until the simulation produces similar results. This has improved simulation accuracy of major dynamic events and, currently, North American Electric Reliability Corporation (NERC) standards are being drafted to require all plants in North America to regularly validate plant computer models.

However, there are no standard procedures for obtaining data, performing validations, or determining the quality of the resulting model. Consequently, model quality varies widely. Moreover, there is no listing of which tests or natural events are most important and which yield less value for the invested effort in test, measurement, and validation. To increase power system reliability, more research is needed to develop the standards that would result in best practices, economic solutions, or significantly improved models.

Solution and Results

To gain more insight into the best way to improve simulation accuracy, this Reclamation Science and Technology Program research project examined four test parameters:



Online frequency response model data versus measured data.

1. **Frequency Response Measurements.** Code was developed for the computer to simulate the online frequency response test. This provides a more complete picture of generator control systems interacting with the power system. (Previously, frequency response data in the simulation program were only available when the generator unit was offline.) This new code is used in a software package that simulates large power interconnections, so the frequency response tests of a single unit connected to the power system can be simulated under the same conditions as the actual staged tests.

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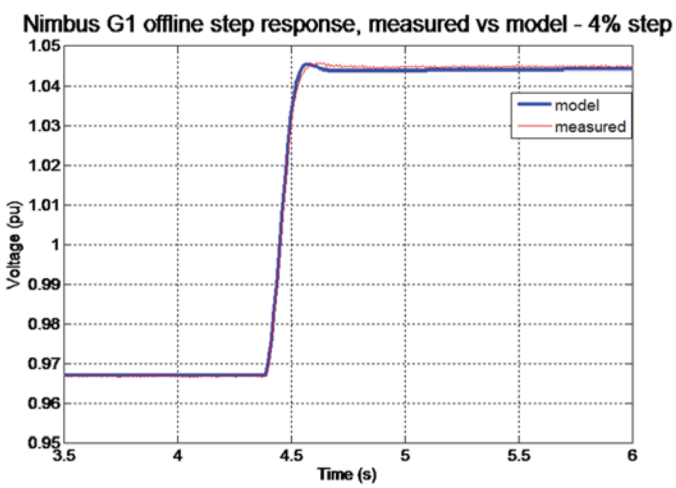
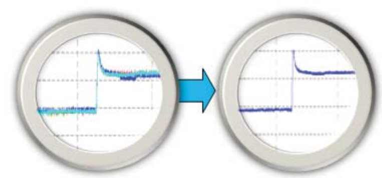
2. **Online Disturbance Data.** Typically, test engineers must go to the facility, run a series of tests on each piece of equipment, record the data, and bring it back to the office for processing. However, if the powerplant has online “disturbance” monitoring systems that record critical data (power, voltage, current, frequency, etc.), snapshots of power system events can be used to compare an event to the simulation of the same event to confirm (or improve) existing models. A new process was developed using disturbance data from online monitors at Yellowtail Powerplant, Montana, to confirm model simulations. Unfortunately, this newly developed process could not be fully tested as the recorded signals from the online monitors were inaccurate (incorrect scaling or offsets) and too slow (sampling rate was too low). The online monitoring system at the powerplant has been improved by replacing transducers and increasing the sampling rate. Once additional disturbance data are captured, this process can be fully tested.

3. **Exciter Step Response.** For WECC model validation, step response tests are typically performed by inserting a 1 percent (%) change in voltage into the exciter input and measuring the excitation system response. At Nimbus Powerplant, California, additional research tests of 2, 3, and 4% magnitudes were conducted to determine if simulated model step responses match measured data just as well for larger responses as they do for the standard 1% response. When larger step responses were performed, the exciter hit upper or lower limits and stimulated internal processing non-linearities. By performing additional larger step responses, these limit values and processing non-linearities can be proven in the test results and then used in the models.

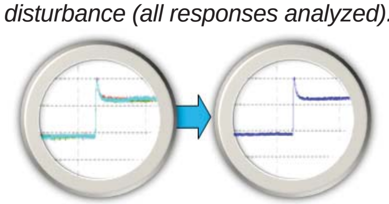


A terminal voltage response, 4% step response, measured test data versus calculated model data.

4. **Time Domain Averaging Technique.** The time domain averaging technique uses multiple step responses to create a single “clean” step response. The technique has successfully removed random noise and power system disturbance signals, while also providing users with the tools to determine step responses that contain outlying data properties (to be removed by the user) for a more accurate representation of the actual step response. One key feature of this algorithm is that it does not affect the phase response or overall shape of the response—it merely removes random and power system disturbance-based noise signals. This technique can be further refined by using standard deviations and/or other data point comparison techniques to remove outlying data points from the time domain averaging algorithms automatically.



Multiple step responses with system disturbance (all responses analyzed).



Multiple step responses with system disturbance (selected responses analyzed).

“This research is helping Reclamation become more efficient in obtaining higher quality data and validating models to save a significant amount of money and resources.”

James Zeiger
Manager, Power System Analysis and Control Group, Reclamation’s Technical Service Center

Future Plans

Reclamation has installed new transducers at the Yellowtail Powerplant to address the scaling and bandwidth issues and will plan to re-validate the disturbance data to the computer models once a significant power system disturbance is recorded. This re-validation will prove that Reclamation’s power system models can be validated using this method, as long as a detailed model development was already performed by collecting data for each individual piece of equipment at the powerplant.

Test engineer performing model validation testing.

Results of this research will be presented at the WECC modeling workshops in 2014, and beyond, to make the industry aware of Reclamation’s valuable findings.

More information

www.usbr.gov/research/projects/detail.cfm?id=1482