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United States Government **Department of Energy**

Bonneville Power Administration

memorandum

DATE: August 30, 2005

REPLY TO ATTN OF: TOM/PPOC2

SUBJECT: Performance Validation and Noise Injection Staged Tests

TO: John Haner – TOM/PPO2-2 Richard Ellison - TOD/DITT1
Peggy Olds – TOT/DITT2 T. Snodgrass – TOV/MEAD

1. Summary and Objectives

The Bonneville Power Administration (**BPA**) is planning comprehensive probing tests of WECC system dynamics under summer conditions. These tests will be performed in coordination with WECC technical groups such as the DMWG and M&VWG, and they are nominally scheduled for September 2005. The tests will include the following staged events:

- Energization of the Chief Joseph dynamic brake
- Insertion of brief sine waves and square waves by modulation of the Pacific HVDC Intertie
- Insertion of sustained random noise by modulation of the Pacific HVDC Intertie

The main objectives of these tests include the following:

A. Obtain a seasonal benchmark for dynamic performance of the WECC system

B. Develop comparative data to evaluate and refine the realism of WECC modeling tools

C. Refine and validate methods that identify power system dynamics with minimal or no use of probing signals

Low level probing will be performed intermittently over three days. Intervening periods will permit reviewing test results, adjusting the probing signal, and minimizing operator distractions. The extended test schedule will also permit system dynamics to be observed under a range of conditions.

The test is planned for the week of September 12, 2005 subject to PDCI availability as follows:

- Test Series A September 13 morning
- Test Series B September 13 afternoon
- Test Series C September 14 morning
- Test Series D September 14 afternoon
- Test Series E September 14 evening continuing into September 15 morning

Close examination of system behavior will be made before and throughout the test to confirm that system conditions are suitable for testing, and that the test is proceeding as expected. WECC members having a PDC StreamReader are invited to participate in this, and to use associated provided spectral analysis software to observe frequency domain signatures for their service areas. Extended data access at the California ISO and the Pacific Northwest National Laboratory permit almost total backup to BPA for this aspect of testing.

WAMS data from these tests will be recorded automatically. However, it is necessary that the operators of the measurement facilities assure that the recording systems are ready for this, and that the owners of the data be aware that copies of the records will be requested for analysis. Such activities will be coordinated through the WECC Disturbance Monitoring Work Group.

Previous versions of these tests are described in WECC documents such as [i], and a concise summary of tests performed in June 2000 is available as [ii]. Distinguishing features of the September 2005 tests are a strong focus on Objective C, plus greatly improved instrumentation and software for achieving this objective.

2. Test Precautions and Termination Procedure

If at any time the Test Observers, security coordinators or system operators identify conditions under which the tests should not continue then the Test Director will suspend the test sequence until those conditions are no longer present.

Reasons for suspending, modifying, or terminating the test sequence include but are not limited to the following:

- System emergency exists within the WECC
- Interconnections operating outside normal limits
- Undamped or unacceptable levels of system oscillations
- Facility operator deems that facility is unsafe for test, or that the test procedure is interfering with proper operation of that facility
- Test procedure is conflicting with a peak in operator workload

3. Sequence of Test Events

The list below shows specific test events to be performed. Times for these test events are in Pacific Daylight (Advanced) Time (PDT). Technical details of analysis performed in the Test Plan Comprehensive Report.

Low level probing will be performed intermittently over three days. Intervening periods will be used to review test results, and to adjust the probing signals accordingly. The time and the duration of specific test events can be adjusted, during the test itself, to minimize interference with smooth operation of the power system. A description of each playback file is given on page 11.

Test Series A: Seasonal benchmark for dynamic performance [Day 1 morning]

Step A1 [10:20] Insertion A1 of the Chief Joseph Dynamic Brake

Step A2 [10:25] Insertion A2 of the Chief Joseph Dynamic Brake, five minutes after Step A1

Step A3 [10:30] Apply PbfSM1 for single-mode probing ±125 MW. Waveform will be three cycles of a square wave at 0.25 Hz.

Step A4 [10:32] Apply PbfSM2 for single-mode probing ±125 MW. Waveform will be three cycles of a sine wave at 0.25 Hz.

Step A5 [10:34] Apply PbfSM3 for single-mode probing ±125 MW. Waveform will be three cycles of a sine wave at 0.70 Hz.

Test Series B: Calibration Checks on PDCI Probing Signals [Day 1 afternoon]

Step B1 [13:10] Calibration check on PlayBack File N1 (PbfR5s) for ±5 MW noise probing to determine HVDC pole response. Noise bandwidth will be 20 Hz. Adjust scaling of Probing Signal Generator (PSG) if needed.

Step B2 [13:15] Apply PbfR5s for ±5 MW noise probing to determine HVDC pole response. Expected duration is 5 minutes or less.

Step B3 [13:20] Calibration check on PbfM10s for ±10 MW noise probing of inter-area modes. Adjust PSG scaling if needed.

Step B4 [13:25] Apply PbfM10s for ±10 MW noise probing of inter-area modes. Expected duration is 10 minutes, but additional time may be needed for coordination of real-time observations at remote locations.

Step B5 [13:40] Apply PBFSM1 for single-mode probing ±125 MW. Waveform will be three cycles of a square wave at 0.25 Hz.

Step B6 [13:42] Apply PBFSM2 for single-mode probing ±125 MW. Waveform will be three cycles of a sine wave at 0.25 Hz.

Step B7 [13:44] Apply PBFSM3 for single-mode probing ±125 MW. Waveform will be three cycles of a sine wave at 0.70 Hz.

Step B8 **Assess test results to this point**.

Step B9 [14:15] If necessary, refine or replace PbfR5s and repeat step B2.

Test Series C: Refinement of PDCI Probing Signals & Procedure [Day 2 morning]

Step C1 [09:10] Apply PbfSM2 for single-mode probing ±125 MW. Waveform will be three cycles of a sine wave at 0.25 Hz.

Step C2 [09:12] Apply PbfSM3 for single-mode probing ±125 MW. Waveform will be three cycles of a sine wave at 0.70 Hz.

Step C3 [09:15] Apply PbfM20h for ±20 MW noise probing of inter-area modes. Expected duration is 20 minutes, but additional time may be needed if powerflow shifts or discrete control actions are noted during the test interval.

Step C4 [09:45] Apply PbfSM2 for single-mode probing ±125 MW. Waveform will be three cycles of a sine wave at 0.25 Hz.

Step C5 [09:47] Apply PbfSM3 for single-mode probing ±125 MW. Waveform will be three cycles of a sine wave at 0.70 Hz.

Step C4 **Assess test results to this point**.

Step C5 [10:10] Repeat Step C1 through Step C5 with alternate noise probing signals stored on the PSG. No signal exceeding ±20 MW or an rms value of 15 MW will be applied until the Test Director has confirmed that these limits are well within the acceptable operating range.

Step C6 [11:10] Repeat Step C1 through Step C5 with alternate noise probing signals stored on the PSG. No signal exceeding ±20 MW or an rms value of 15 MW will be applied until the Test Director has confirmed that these limits are well within the acceptable operating range.

Test Series D: Cross Validation of Probing Methods [Day 2 afternoon]

Step D1 [13:10] Insertion D1 of the Chief Joseph Dynamic Brake

Step D2 [13:15] Insertion D2 of the Chief Joseph Dynamic Brake, five minutes after insertion D1

Step D3 [13:20] Apply best noise probing signal obtained at Step C5. Expected duration is 20 minutes, but additional time may be needed if powerflow shifts or discrete control actions are noted during the test interval.

Step D4 [13:45] Apply PbfSM1 for single-mode probing ±125 MW. Waveform will be three cycles of a square wave at 0.25 Hz.

Step D5 [13:47] Apply PbfSM2 for single-mode probing ±125 MW. Waveform will be three cycles of a sine wave at 0.25 Hz.

Test Series E: Long Term Data Collection [Day 2 evening through Day 3 Morning]

Step E1 [xx:10] Apply best noise probing signal obtained at Step C5. Preferred duration is up to 12 sessions 40 minutes long, each starting at 10 minutes past the hour.

Step E2 [xx:52] Apply PbfSM1 for single-mode probing ±125 MW. Waveform will be three cycles of a square wave at 0.25 Hz.

Step E3 [xx:54] Apply PbfSM2 for single-mode probing ±125 MW. Waveform will be three cycles of a sine wave at 0.25 Hz.

Steps E2 and E3 will be performed at the close of each probing session in Step E1. These steps must be done during a period of North to South transfers on COI. Tests will start at 15:10 PDT September 14and continue until 0300 PDT September 15 or DC schedules drop below.

5. Operating Conditions Required For Tests

Operating Conditions for Test Series A

- Power system operation normal, with no impediments to safe testing
- Pacific HVDC Intertie (**PDCI**) in bipolar operation with North to South flow
- PDCI power at 800 MW to 2800 MW

Operating Conditions for Test Series B through E

- Power system operation normal, with no impediments to safe testing
- Pacific HVDC Intertie (**PDCI**) in bipolar operation with North to South flow
- PDCI power at 800 MW to 2800 MW
- Sufficient generation on line at John Day and The Dalles to assure that PDCI modulating power is shared across a reasonably large number of generators

[removed notes on Cranbrook to Langdon line]

6. Test Coordinator and Responsibilities

Test coordination will be as follows:

1. Jim Burns will schedule the tests through the BPA outage dispatcher.
2. Jim Burns (BPA technical staff) will post proposed test dates on the BPA Web page.
3. The day before each test, BPA will send a message on the WECC Net notifying of the tests.
4. If there are concerns about abnormal system conditions, BPA dispatcher should be contacted as early as possible to cancel a test. The test will be resumed the next hour after the system returns to normal.
5. The probing signal will be injected by an operator of Celilo converter station. The operator will clear with the BPA dispatcher before the signal injection.

A listing of contact persons and test observers with phone numbers and e-mail addresses is provided in attached.

7. Measurement Requirements

WAMS data from these tests will be recorded automatically. However, it is necessary that the operators of the measurement facilities assure that the recording systems are ready for this, and that the owners of the data be aware that copies of the records will be requested for analysis.

Required measurements for Test Series A [simplified]

- Continuous PDC, PMU and PPSM recording essential at BPA and BCHydro locations.
- Continiuous PDC, PMU and PPSM recordings highly desirable at all other WECC locations
- Continuous 240 sps recording with the Celilo PPSM required.

Required measurements for Test Series B through E

- Continuous PDC, PMU and PPSM recording required at BPA locations.
- Continuous PDC, PMU and PPSM recordings highly desirable at all other WECC locations.
- Continuous 240 sps recording with the Celilo PPSM required.

Required facilities for real-time analysis

A key objective in the proposed tests is to "Refine and validate methods that identify power system dynamics with minimal or no use of probing signals." Key real-time resources for this are PDC StreamReaders, located at key locations, plus the spectral analysis tool provided as an add-on for the PDC StreamReader. Other documents refer to this tool as Dynamic Signal Analyzer (**DSA**), and that terminology is used here.

It is essential that DSA analysis be immediately available to the Test Director throughout the test. StreamReaders with DSA are essential at Dittmer, nearly essential at Celilo, and highly desirable at PNNL Richland. These are optional but suggested at the California ISO and other organizations that have PDC StreamReaders in operation.

8. Test Preparations

The Celilo Probing Signal Generator (PSG) will be furnished with a suitable menu of playback files. These playback files will be verified on site for MW scaling and other characteristics before their use in long term probing. BPA & PNNL will work together on PSG matters.

9.0 Illustrations of Applied Test Signals

The following figures from the Test Plan Comprehensive Report are illustrative of the system response to signals that will be applied during this test.

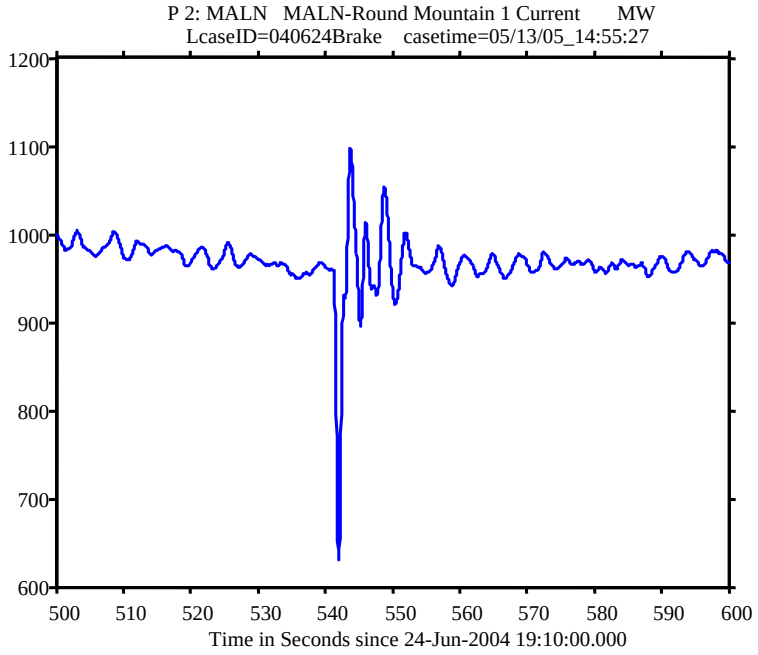

Figure 9.1 Chief Joseph Brake Application June 24, 2004.

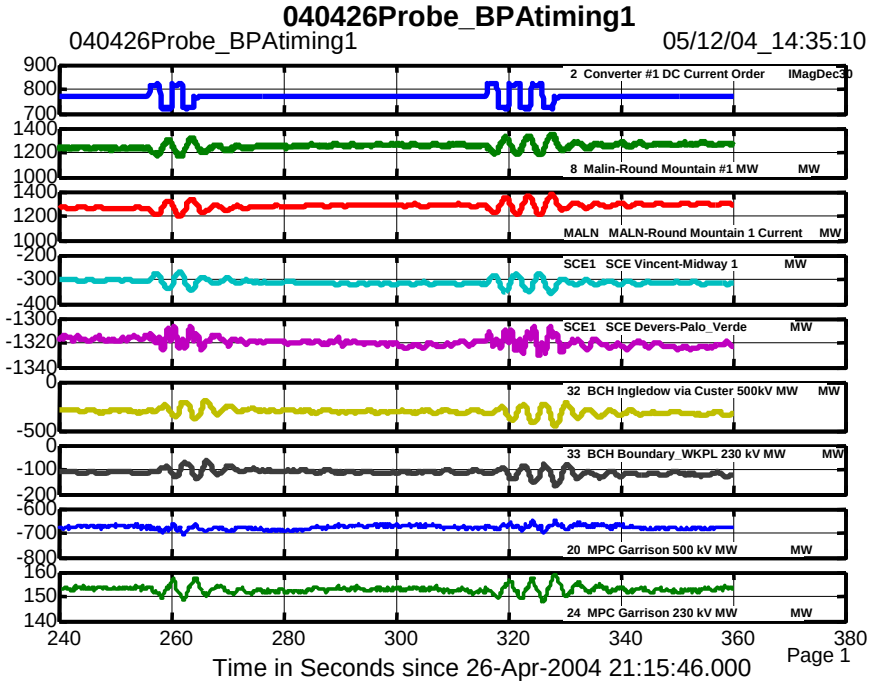

Figure 9.2. Wide area response to single mode probing on April 26, 2004.

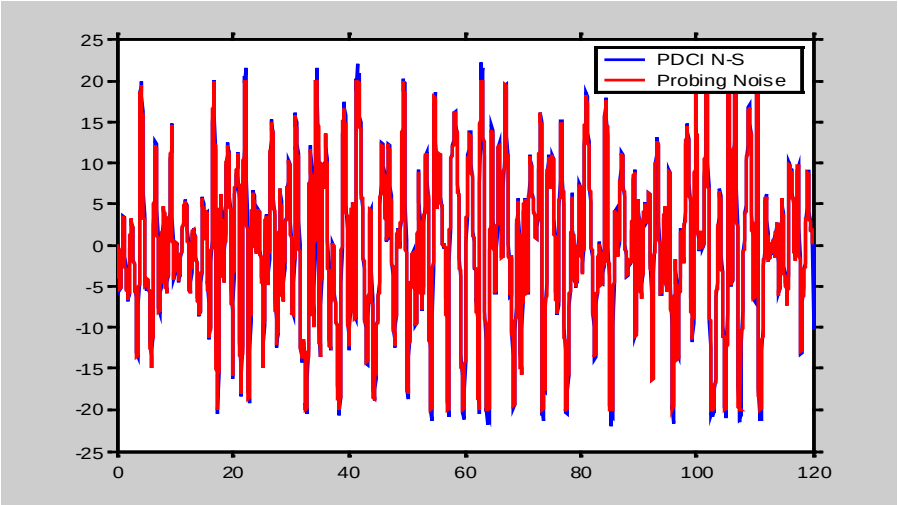

Figure 9.3. Low level noise signal applied to PDCI.

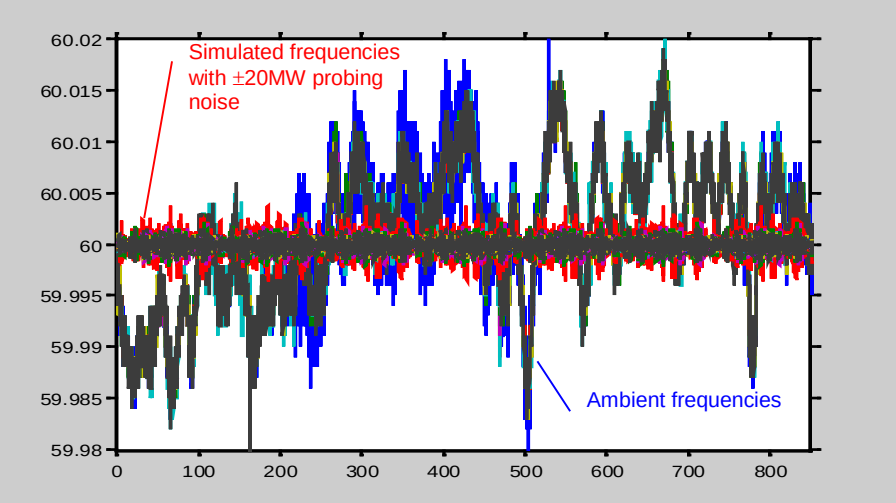

Figure 9.4. Illustration of simulated frequency response from noise signal compared to typical system ambient frequency variations for ±20 MW peak noise injection.

Additonal information on the test signals and system response is provided in the companion Test Plan Comprehensive Report.

10. Test Approvals

Submitted by:

William A. Mittelstadt – TOM
Dmitry Kosterev - TOM

Approved: _____ Date: _____
Manager, Support Services for Network Planning – TOM

Approved: _____ Date: _____
Manager, Technical Operations –TOT

Approved: _____ Date: _____
Manager, Dittmer Dispatch - TOD

Approved: _____ Date: _____
Manager, Munro Dispatch - TOV

cc:
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B. Silverstein – TO/DITT2
M. Rodrigues – TOP/PPO2-2
J. Haner – TOM/PPO2-2
R. Ellison – TOD/DITT1
P. Olds - TOT/DITT2
T. Snodgrass - TOV/MEAD
B.McManus – TOT/DITT2
J. Burns - TOT/DITT1
R. Spence – TOT/DITT2
J. Gronquist – TOT/DITT2
D. Kosterev – TOM/PPO2-2
G. Keenan – TOM/PPO2-2
W. Mittelstadt – TOM/PPO2-2
D. Chase – TFRS/CELILO
W. Litzenberger – TNP-PPO2-1
L. Anderson – TNSD-PPO2-1
Paul Shockley - TNSD-PPO2-1
K. Martin – TNT/AMPN 1
J. Bernhardsen – TO/DITT2 - NWSC
Marty O'Rourke (SPC District Engineer) - TFSS-SICKLER
Rodger Allen (SPC Craftsman) - TFSS-CHIEF JOSEPH
Dittmer Outage Dispatcher – TOD/DITT1
Dittmer System Dispatcher – TOD/DITT1 (2 copies)
Official File - TOP (ED-21-15)

WAMittelstadt/DKosterev 8/30/05 (Noise Injection Test Plan 8~30~2005.doc)

Coordination and Contact Persons List

Contact	Utility	Function	Phone	Email
Jim Burns	**BPA**	**Test Director**	**(360) 418-2331**	jwburns@bpa.gov
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Travis Smith	DWP	IPP DSM		

Playback File Table

The following table describes various types of noise signal definitions, some of which will be used in the test.

File Name	Test	Type	Band Width or Frequency	Amplitude
PbfM10h	B3,4	Multi-sine noise	1 Hz hard roll off	+/- 10 MW
PbfM20h	C3	Multi-sine noise	1 Hz hard roll off	+/- 20 MW
PbfM30h		Multi-sine noise	1 Hz hard roll off	+/- 30 MW
PbfM5s		Multi-sine noise	20 Hz soft roll off	+/- 5 MW
PbfM10s		Multi-sine noise	1 Hz soft roll off	+/- 10 MW
PbfM20s		Multi-sine noise	1 Hz soft roll off	+/- 20 MW
PbfM30s		Multi-sine noise	1 Hz soft roll off	+/- 30 MW
PbfR5s	B1,2	Random noise	20 Hz soft roll off	+/- 5 MW
PbfR10s		Random noise	1 Hz soft roll off	+/- 10 MW
PbfR20s		Random noise	1 Hz soft roll off	+/- 20 MW
PbfR20s		Random noise	1 Hz soft roll off	+/- 30 MW
PbfR10h		Random noise	1 Hz hard roll off	+/- 10 MW
PbfR20h		Random noise	1 Hz hard roll off	+/- 20 MW
PbfR20h		Random noise	1 Hz hard roll off	+/- 30 MW
PbfSM1	see text	Square single mode	3 cycle 0.25 Hz	+/- 125 MW
PbfSM2	See text	Sine single mode	3 cycle 0.25 Hz	+/- 125 MW
PbfSM3	See text	Sine single mode	3 cycle 0.7 Hz	+/- 125 MW

[i] **Interim Report on the Model Validation Tests of June 7, 2000 -- Part 1: Oscillatory Dynamics**, principal investigator J. F. Hauer. WSCC Performance Validation Task Force (PVTF) of the Modeling and Validation Work Group, October 26, 2000. Available at Internet site http://www.wecc.biz/committees/PCC/TSS/MVWG/documents/ (address out of date?)

[ii] **Dynamic Performance Validation in the Western Power System,** J. F. Hauer, M. J. Beshir, and W. A. Mittelstadt in association with WSCC work groups. APEx 2000 Conference in Kananaskis, Alberta, October 2000. (Available at ftp://ftp.bpa.gov/pub/WAMS%20Information/)