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United States Government **Department of Energy**

Bonneville Power Administration

memorandum

DATE: July 2, 2008

REPLY TO ATTN OF: TPM/DITT2

SUBJECT: Performance Validation and Noise Injection Staged Tests

TO: Melvin Rodrigues – TPP/DITT2
Peggy Olds – TOT/DITT2
Jeffrey Cook – TPM/MODD
Richard Ellison - TOD/DITT1
Ted Snodgrass – TOV/MEAD

1. Summary and Objectives

The Bonneville Power Administration (**BPA**) is planning comprehensive probing tests of WECC system dynamics under summer conditions. This test will be performed in coordination with WECC technical groups such as the DMWG and M&VWG, and is scheduled for August 12, 2008 with alternate days of August 13, 19 and 20 that may be used in the event that the test date must be changed or portions of the test must be repeated. Dates may be revised by System Operations to meet system requirements.

The test will include the following staged events:

- Energization of the Chief Joseph dynamic brake
- Insertion of brief intermediate level ±125 MW waves by modulation of the Pacific HVDC Intertie
- Insertion of sustained pseudo-random noise by modulation of the Pacific HVDC Intertie

The main objectives of these tests include the following:

A. Obtain seasonal benchmarks 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
D. Test performance of the replacement probing signal generator (PSG)
E. Evaluate effectiveness of low level probing for load identification

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 spectral analysis software to observe frequency domain signatures for their service areas. Alternate toolsets for this include Real Time Dynamic Monitor System (RTDMS) and the DOE ModeMeter. Extended data access at the California ISO and at the Pacific Northwest National Laboratory permits almost total backup there to BPA for test monitoring.

WAMS data from this test 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 (DMWG).

Previous versions of these tests are described in WECC documents such [1,2] and reports for tests performed from September 2005 through August 2006 [3]. Distinguishing features of the tests in 2005 and 2006 had a strong focus on Objective C, plus greatly improved instrumentation and software for achieving this objective. This test will again have a strong focus on Objective C. This time it will include an intermediate level probing signal that addresses frequencies in the range frequencies from 0.2 Hz to 1.0 Hz as illustrated by Figure 10. New experience will also be gained with reduced low level probing amplitudes in the range of ± 10 to ± 20 MW.

2. Operating Conditions Required For Tests

Operating Conditions for Test Series

- Power system operation normal, with no impediments to safe testing
- Pacific HVDC Intertie (**PDCI**) in bipolar operation with North to South flow
- PDCI power transfer above 800 MW and less than 2950 MW
- Langdon – Cranbrook 500 kV line in service.

3. 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).

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 14.

Test Series A: Calibration Checks on PDCI Probing Signals

Step A0 [9:00] Celilo instrumentation check using +/-10MW waveform. Check proper function of PSG using Celilo/Sylmar DC metering.

Step A1 [9:10] Calibration check on MSF-20/6/17 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 A2 [9:15] Apply MSF-20/6/17 for ±5 MW noise probing to determine HVDC pole response. Expected duration is 5 minutes or less.

Step A3 [9:20] Calibration check on MSF-1/6/100 for ±10 MW noise probing of inter-area modes. Adjust PSG scaling if needed.

Step A4 [9:25] Apply MSF-1/6/100 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 A5 [9:40] Apply PbfSM2 for single-mode probing ±125 MW. Waveform will be three cycles of a sine wave at 0.25 Hz.

Step A6 [9:42] Apply PbfSM3 for single-mode probing ±125 MW. Waveform will be three cycles of a sine wave at 0.70 Hz.

Step A7 [9:44] Apply PbfSM5 ±125 MW intermediate level short-term probing wave.

Test Series B: Noise Probing

Step B1 [10:10] Measurement of ambient noise conditions

Step B2 [10:30] Apply a ±20 MW MSF-1/6/100 for a duration of 12 periods (20 minutes).

Test Series C: Cross Validation of Probing Methods

Step C1 [13:10] Insertion B1 of the Chief Joseph Dynamic Brake

Step C2 [13:15] Insertion B2 of the Chief Joseph Dynamic Brake, five minutes after insertion B1

Step C3 [13:20] Apply a ±20 MW MSF-1/6/100 for a duration of 15 periods (25 minutes). Additional time may be needed if powerflow shifts or discrete control actions are noted during the test interval.

Step C4 [13:47] Apply PbfSM5 ±125 MW intermediate level short-term probing wave.

Step C5 [13:49] Apply PbfSM5 ±125 MW intermediate level short-term probing wave.

Test Series D: Noise Probing

Step D1 [14:10] Measurement of ambient noise conditions

Step D2 [14:11] Apply a ±10 MW MSF-1/6/100 for a duration of 21 periods (35 minutes).

Step D3 [14:47] Apply PbfSM5 ±125 MW intermediate level short-term probing wave.

Step D4 [14:49] Apply PbfSM5 ±125 MW intermediate level short-term probing wave.

Test Series E: Noise Probing

Step E1 [15:10] Measurement of ambient noise conditions

Step E2 [15:11] Apply a ±20 MW MSF-1/6/100R for a duration of 21 periods (35 minutes).

Step E3 [15:47] Apply PbfSM5 ±125 MW intermediate level short-term probing wave.

Step E4 [15:49] Apply PbfSM5 ±125 MW intermediate level short-term probing wave.

Test Series F: Noise Probing

Step F1 [16:10] Measurement of ambient noise conditions

Step F2 [16:11] Apply a ±15 MW MSF-1/6/100 for a duration of 21 periods (35 minutes).

Step F3 [16:47] Apply PbfSM5 ±125 MW intermediate level short-term probing wave.

Step F4 [16:49] Apply PbfSM5 ±125 MW intermediate level short-term probing wave.

Test Series G: Brake Application

Step G1 [17:10] Insertion B1 of the Chief Joseph Dynamic Brake.

Step G2 [17:15] Insertion B2 of the Chief Joseph Dynamic Brake, five minutes after insertion G1

Step G3 [17:20] Apply a ±20 MW MSF-1/6/100 for a duration of 15 periods (25 minutes).

Step G4 [17:47] Apply PbfSM5 ±125 MW intermediate level short-term probing wave.

Step G5 [17:49] Apply PbfSM5 ±125 MW intermediate level short-term probing wave.

5. 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 on page 13. A phone bridge will be available on the day of the test.

6. 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

- Continuous PDC, PMU and PPSM recording is required at BPA locations for the period 0800 through 1800 PDT of the test day.
- Continuous PDC, PMU and PPSM recording is highly desirable at all other WECC locations for the period 0800 through 1800 PDT of the test day where this data is available.
- Continuous recording with the Celilo PPSM is required. It is desired that the recording rate be 960 sps, but 240 sps is acceptable. Data acquisition filters must be set appropriately. To limit file size, it is highly important that the point-on-wave ac signals (signals 16 through 39) not be recorded. It is desirable that a separate recorder be installed for this sometime in the future.

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. Equivalent functionalities can also be obtained from alternate toolsets such as RTDMS and the DOE ModeMeter.

It is essential that DSA analysis be immediately available to the Test Director throughout the test. StreamReaders with DSA are essential at Dittmer and highly desirable at Celilo and PNNL Richland. It is also suggested that California ISO and other organizations that have PDC StreamReaders or alternate toolsets use them to observe test results in their service areas.

7. 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.

8. Illustrations of Applied Test Signals

The following figures are illustrative of the system response to signals that will be applied during this test. Additonal information on the test signals and system response is provided in [3] and in various other documents cited there.

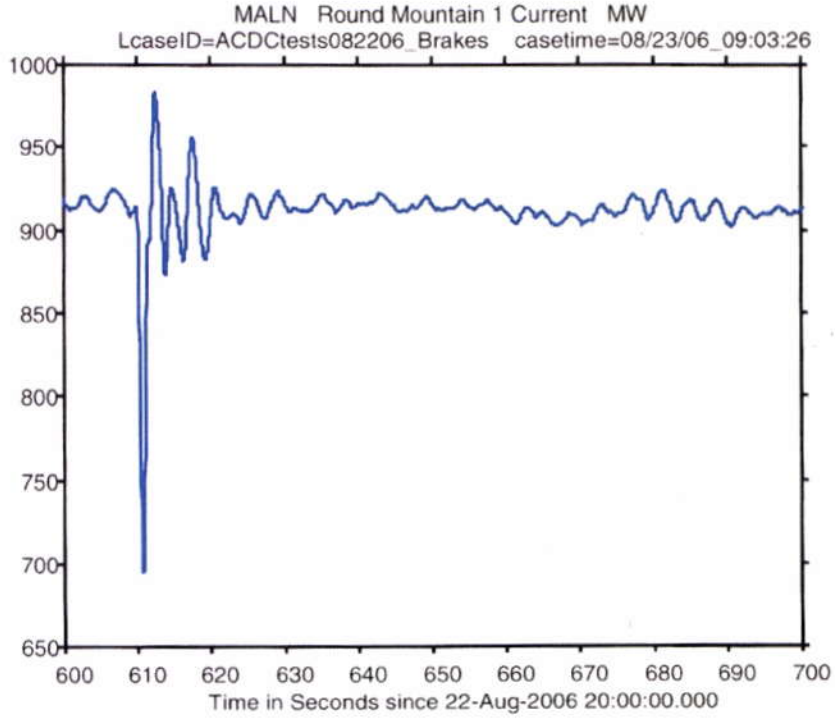

Figure 1. Malin-Round Mtn MW respionse to Chief Joseph Brake Application B1, 08/22/06

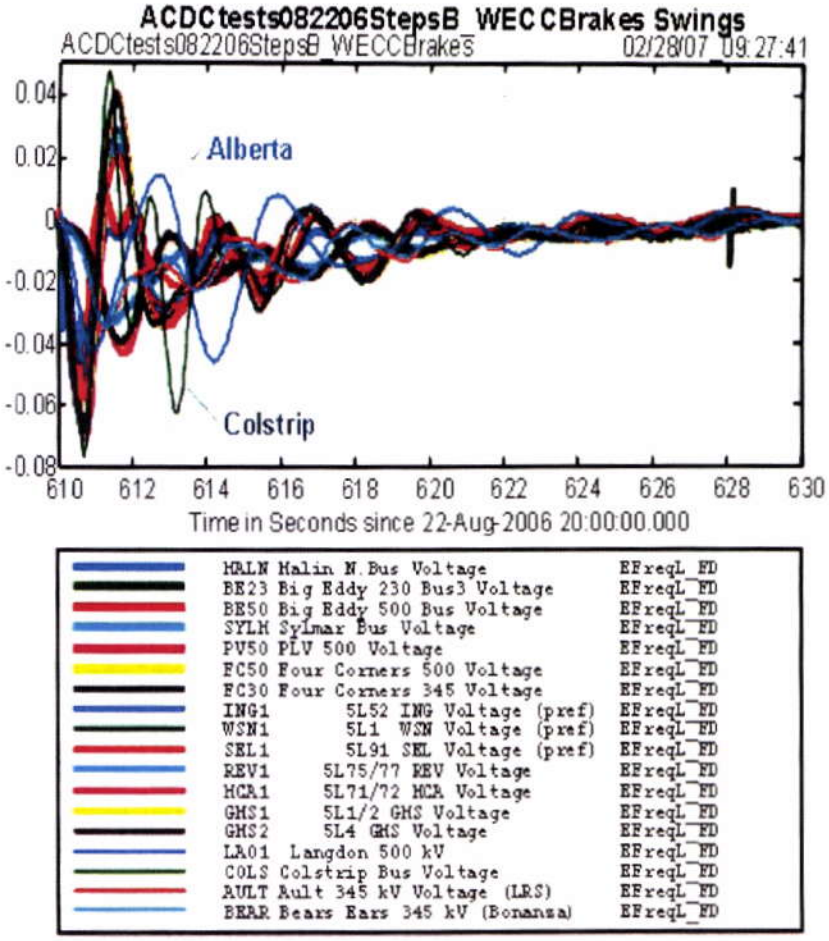

Figure 2. Frequency swings for Chief Joseph Brake Application B1, 08/22/06

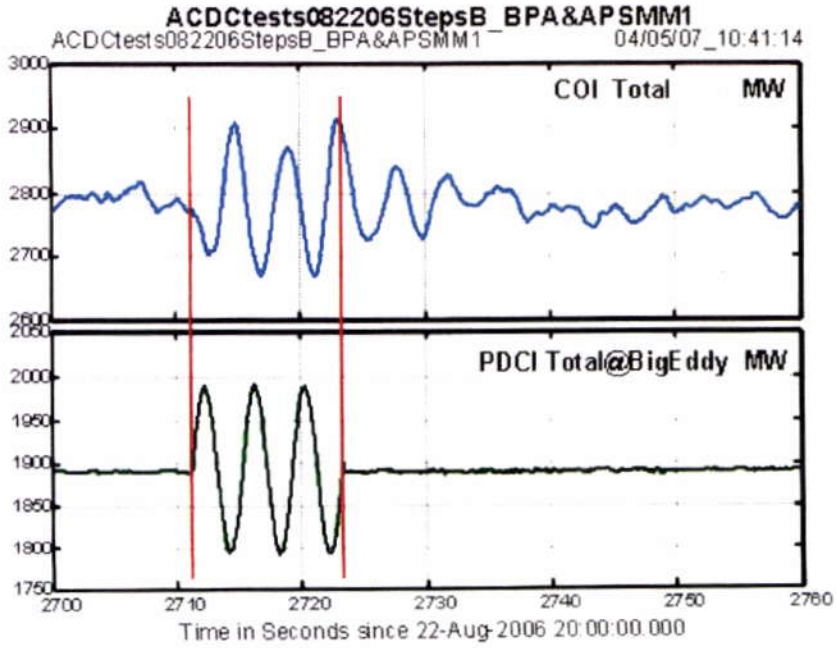

Figure 3. COI response to single mode probing event B4 on 08/22/06 (0.25 Hz).

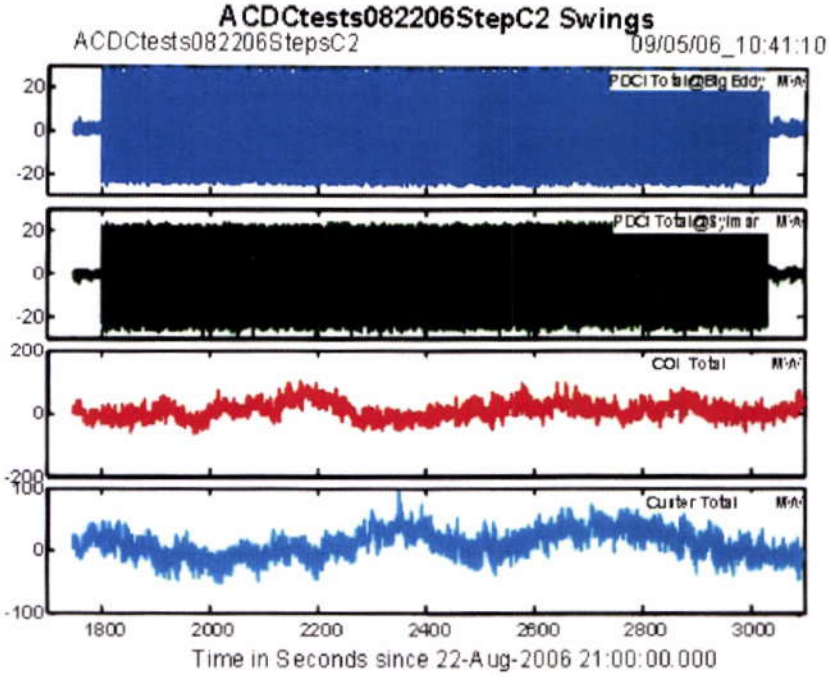

Figure 4. Response to ±25 MW noise modulation, test step C2 on 08/22/06

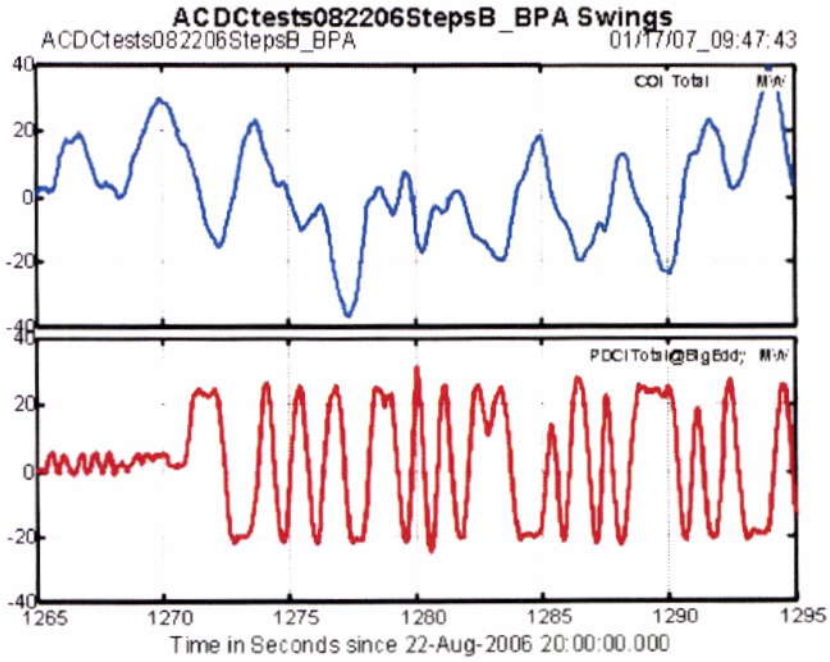

Figure 5. Startup of ±25 MW noise modulation, test step B3 on 08/22/06

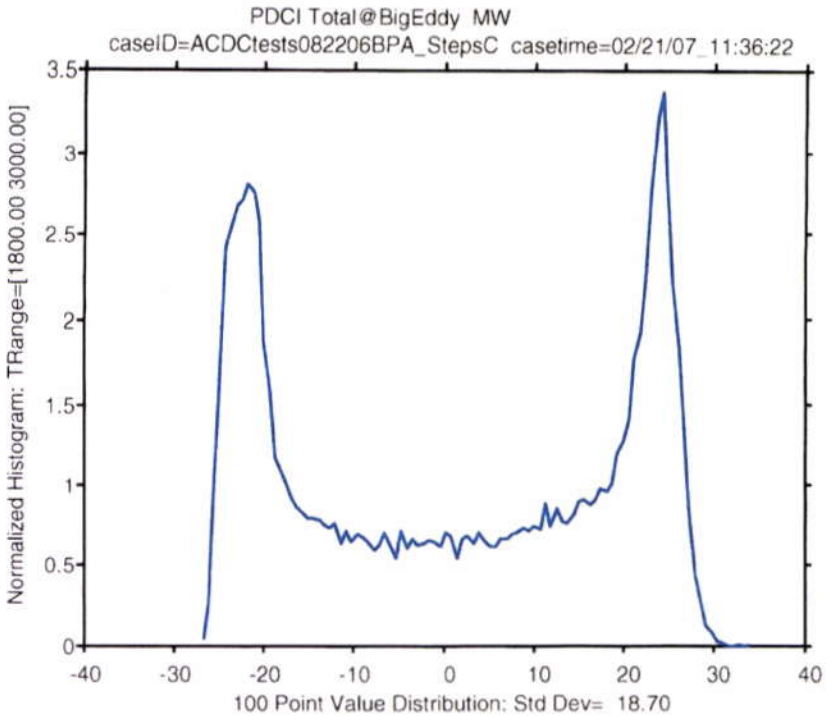

Figure 6. Histogram for Celilo DC MW response to low level noise probing, test step C2 on 08/22/06

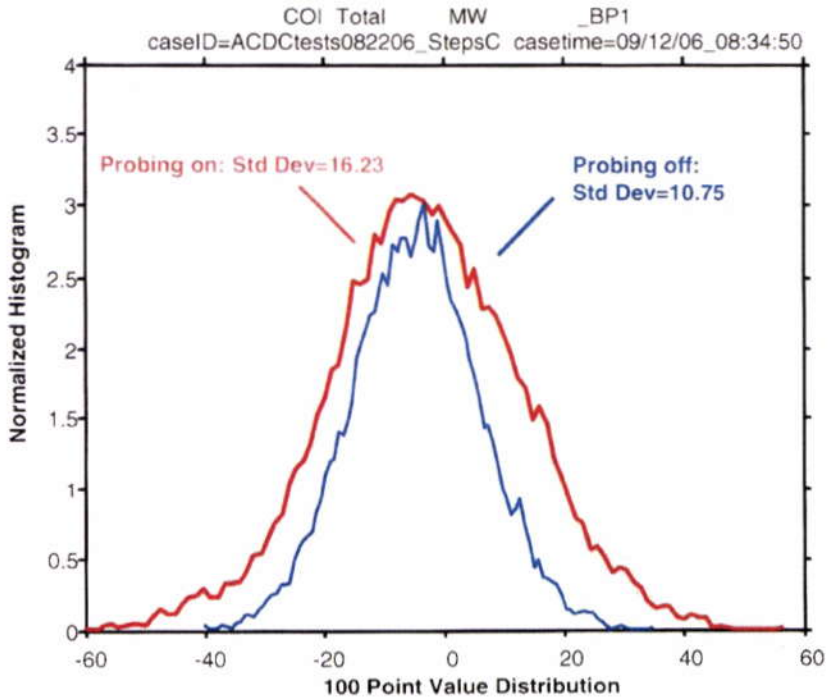

Figure 7. Histogram for COI MW response to low level noise probing, test steps C on 08/22/06

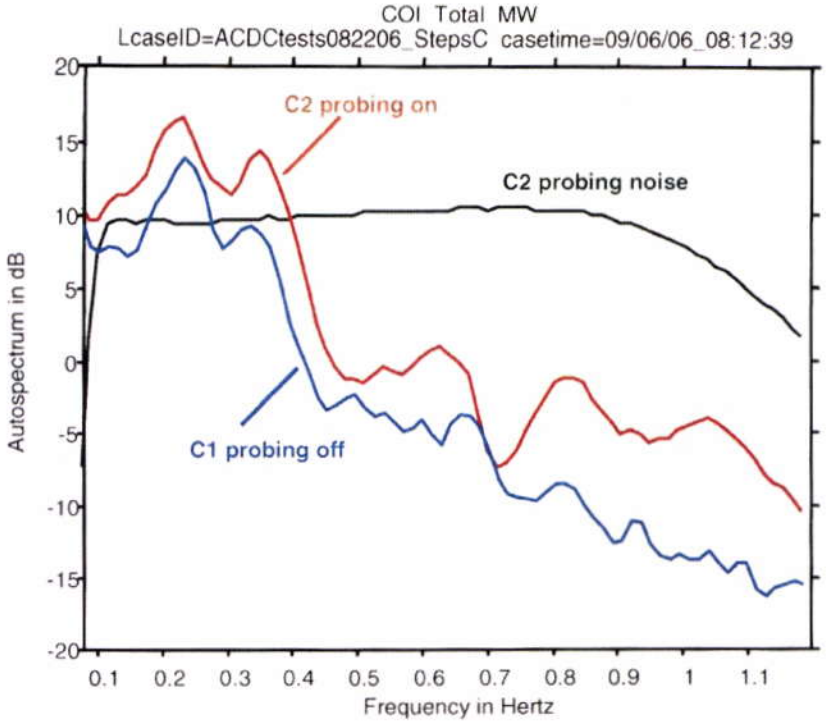

Figure 8. Key autospectra for level noise probing, test steps C on 08/22/06

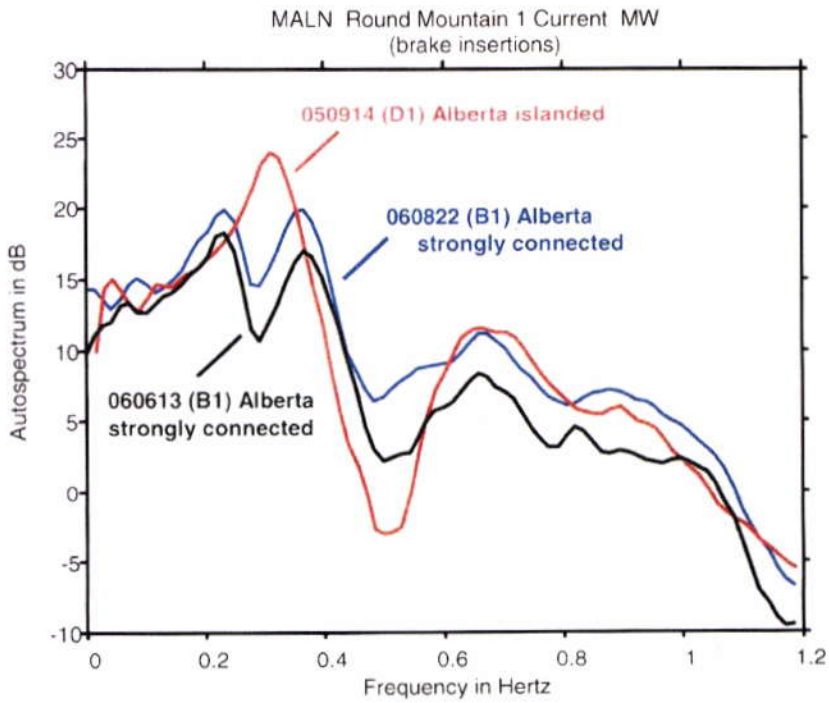

Figure 9. Efect of Albertra connection on response to insertions of the Chief Joseph dynamic brake

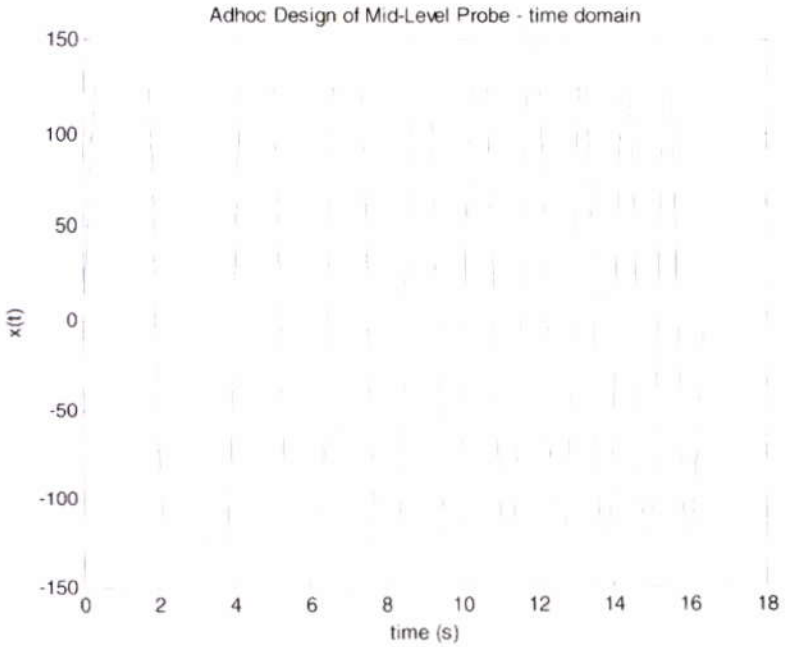

Figure 10. ±125 MW intermediate level short-term probing wave.

9. **Test Approvals**

Submitted by:

Dmitry Kosterev - TPP
William A. Mittelstadt – TPM

Approved: _____ Date: 7/10/08
Manager- Jeffrey Cook, Communications and Grid Modeling– TPM

Approved: _____ Date: 7-17-08
Manager- Peggy Olds, Technical Operations –TOT

Approved: _____ Date: 7-18-08
Manager-Richard Ellison, Dittmer Dispatch – TOD

Approved: _____ Date: 7/18/08
Manager- T. Snodgrass, Munro Dispatch – TOV

Approved: _____ Date: 7/22/08
Manager- Melvin Rodrigues, Transmission Planning – TPP

Table 1. Coordination and Contact Persons List

Contact	Utility	Function	Phone	Email
Jim Burns	BPAT	Test Director	360- 418-2331	jwburns@bpa.gov
Chief Dispachers	BPAT	All WECC dispachers		chiefdis@wscc.com
Richard Ellison	BPAT	Manager Dittmer Dispatch	360-418-2739	raellison@bpa.gov
Senior Operator	BPAT	Celilo	541-296-3615 X-300	
BPA Dispatcher	BPAT	Dittmer	360- 418-2281	
James Murphy	BPAT	Dittmer	360- 418-2413	jpmurphy@bpa.gov
Loren Anderson	BPAT	TESM-AMPN-2	360-418-2465	llanderson@bpa.gov
John Kerr	BPAT	System Operations	360-418-2340	jskerr@bpa.gov
Greg Stults	BPAT	Probing Signal System	360- 418-2680	ggstults@bpa.gov
Michael Overeem	BPAT	Celilo	541- 296-4694	mlovereem@bpa.gov
Jeff Barton	BPAT	Celilo	541- 296-4694	jgbarton@bpa.gov
Marty O'Rourke	BPAT	SPC District Engineer	509-884-1825	mtorourke@bpa.gov
Rodger Allen	BPAT	SPC Craftsman	509-884-1586	rwallen@bpa.gov
Dittmer	BPAT	BPA Monitor site	360-418-2680	
Richard W. Schwarz	NWSC	Reliability Coordinator	360-418-8149	dick@pnsc.center.com
DJ (Jack) Bernhardsen	NWSC	Reliability Coordinator	360-418-2956	jack@pnsc.center.com
Don Pape	NWSC	Reliability Coordinator	360-418-2966	dpape@wecc.biz
Greg Campbell	NWSC	Reliability Coordinator	360-418-8124	gregcampbell@nwsc.com
John Greenlaw	RMRC	Reliability Coordinator		jgreenlaw@wecc.biz
G. Tillitson	CMRC	Reliability Coordinator		gtillitson@caiso.com
Dave Strote	CGS	CGS Contact	509-377-8719	dlstrote@energy-northwest.com
John Dabney	CGS	CGS Contact	509-377-2129	jwdabney@energy-northwest.com
Ken Silver	DWP	Chief LA Load Dispatcher	818- 771-6748	kenneth.silver@ladwp.com
Bill Barlak	DWP	AC System Security	818-771-6779	william.barlak@ladwp.com
Mike Lane	DWP	Sylmar PMU	818- 771-6317	
Travis Smith	DWP	IPP DSM		
Brian Silverstein	BPAT	PCC Chair	360- 418-2122	blsilverstein@bpa.gov
Don Watkins	BPAT	OC Chair	360- 418-2344	dswatkins@bpa.gov
Tom Green	PSCO	TSS Chair	303-571-7223	thomas.green@xcelenergy.com
Perpetuo Tan	LADWP	PWG Chair	818-771-6776	perpetuo.tan@ladwp.com
Bharat Bhargava	SCE	DMWG Chair	626 302 8684	bhargab@sce.com
Dmitry Kosterev	BPAT	MVWG Chair	360-619-6671	dnkosterev@bpa.gov
Steven L. Rueckert	WECC	Validation analysis	801- 582-0353	steve@wscc.com
Henry Huang	PNNL	Data Analysis	509-372-6781	zhenyu.huang@pnl.gov
Ning Zhou	PNNL	Data Analysis	509-372-6438	ning.zhou@pnl.gov
John Hauer	PNNL	Data Analysis	509-375-4340	john.hauer@pnl.gov
John Pierre	UW	Data Analysis	307-766-4206	pierre@uwyo.edu
Dan Trudnowski	MSU	Data Analysis	406-491-2292	dtrudnowski@mtech.edu
Manu Parashar	EPG	Data Analysis	626-685-2015x130	parashar@electricpowergroup.com
Bill Mittelstadt	BPAT	Comm./Grid Modeling	503-891-2246	wmittelstadt@bpa.gpv
Telephone Bridge		System Test Bridge	360-418-8001	pass code XXXX#

Table 2. 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
MSF-20/6/17	A	Multi-sine fitted	20 Hz 6th filter	+/- 5 MW
MSF/1/6/100	A	Multi-sine fitted	1 Hz 6th order filter	+/- 5 MW
MSF/1/6/100	C	Multi-sine fitted	1 Hz 6th order filter	+/- 10 MW (5 x 2 multiplier)
MSF/1/6/100	E	Multisine fitted	1 Hz 6th order filter	+/- 15 MW (5 x 3 multiplier)
MSF/1/6/100	D,F,G	Multisine fitted	1 Hz 6th order filter	+/- 20 MW (5 x 4 multiplier)
MSF/1/6/100R	D,F,G	Reverse in time of MSF/1/6/100 above	1 Hz 6th order filter	+/- 20 MW (5 x 4 multiplier)
PbfSM2	A,B	Sine single mode	3 cycle 0.25 Hz	+/- 125 MW
PbfSM3	A	Sine single mode	3 cycle 0.7 Hz	+/- 125 MW
PbfSM5	A-E,G	Intermediate level	0.2 to 2.0 Hz sweep	+/- 125 MW

References

[1] **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.

[2] **Integrated Monitor Facilities for the Western Power System: WAMS Analysis in 2005**, J. F. Hauer, W. A. Mittelstadt, K. E. Martin, J. W. Burns, and Harry Lee. Interim report of the WECC Disturbance Monitoring Work Group, December 2005.

[3] **Use of the WECC WAMS in Staged System Tests for Validation of System Performance and Modeling: Summary Report for September 2005–August 2006,** J. F. Hauer, W. A. Mittelstadt, J W. Burns, K. E. Martin, Harry Lee, and D. J. Trudnowski. Interim report of the WECC Disturbance Monitoring Work Group, April 25, 2007. (Available at ftp://ftp.bpa.gov/pub/WAMS_Information/). Included as Chapter 14 in the **Power System Stability and Control** v2olume of **The Electric Power Engineering Handbook**, edition 2, L. L. Grigsby ed., CRC Press, Boca Raton, FL, 2007

cc:
J V. VanZandt – T/DITT2
J. Haner – TC/HANGR
L. Anderson – TESN-AMP2
M. O'Rourke (SPC District Engineer) – TFSS-SICKLER
R. Allen (SPC Craftsman) – TFSS-CHIEF JOSEPH
J. Barton – TFRS/CELILO
M. Qvereem – TFRS/CELILO
G. Stults – TNT/AMPN1
D. Watkins – TO/DITT2
J. Bernhardsen – TO/DITT2 - NWSC
R. Schwarz – TO/DITT2 - NWSC
R. Ellison - TOD/DITT1
B. McManus – TOT/DITT2
J. Burns – TOT/DITT1
J. Gronquist – TOT/ DITT2
J. Murphy – TOT/DITT2
P. Olds – TOT/DITT2
T. Snodgrass – TOV/MEAD
B. Silverstein – TP/DITT2
J. Cook – TPM/MODD
W. Mittelstadt – TPM/MODD
D. Kosterev – TPP/DITT2
M. Rodrigues – TPP/DITT2
Dittmer Outage Dispatcher – TOD/DITT1
Dittmer System Dispatcher – TOD/DITT1 (2 copies)
Official File - TPM (ED-21-15)

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