WECC Dynamic Probing Tests: Purpose and Results

Dan Trudnowski, Montana Tech
John Pierre, University of Wyoming
Ning Zhou, PNNL
Frank Tuffner, University of Wyoming
John Hauer, PNNL
Bill Mittelstadt, BPA

NASPI Meeting
Charlotte, NC
October 16-17, 2008

Funding: DOE-OE, BPA
BPA Probing Tests

• BPA routinely conducts dynamic field tests

• Test objectives
  – Obtain historical dynamic benchmarks
  – Realism of WECC simulation models
  – Benchmark mode-meter performance
Mode Meters

- All mode meters require historical data to estimate mode
- Stochastic problem – No mode meter provides a perfect estimate
- Many algorithms have been proposed – None are perfect
- Math can only do so much
- Ambient based algorithms likely not accurate enough for real-time applications
- What is their performance?
- Can we do better by probing (exciting) this system?
WECC System and PMUs
Typical Test

- Each test consists of several hours
- Each hour consists of a combination of
  - Chief Joe dynamic brake insertions
    - 1400 MW, 0.5 sec.
  - Several minutes of low-level pseudo-random Pacific DC Intertie (PDCI) modulation
    - ±10 to ±20 MW
    - 20 to 40 minutes
  - Short bursts of mid-level PDCI probing
    - ±125 MW
    - Sine wave, Square wave, and Chirp signals
Typical Hour

- Operating Conditions Changing
- Two Brake Insertions
- Pseudo-noise Probing 9 Cycles
- Two Probing Pulses
- Operating Conditions Changing

Power level (MW)

Time from 22-Aug-2006 20:00 GMT (minutes)
Low-level Multi-Sine Probing Signal

Time Domain Representation of 136 second Multisine Probing Signal

Magnitude (MW)

Frequency (Hz)
Probing vs. Ambient (8/22/2006 test)

The graph compares the real and imaginary parts of the Frequency Response Functions (FRFs) for both ambient and probing conditions. The data points are color-coded as follows:

- **Black circles**: Ambient data.
- **Red pluses**: Probing data.
- **Green squares**: All ambient data.
- **Green diamonds**: All probing data.

The y-axis represents the imaginary part (rad/sec), and the x-axis represents the real part (1/sec). The graph shows the distribution of data points for each condition, indicating the frequency response characteristics under different test conditions.
Series C - Noise Probing vs. Ambient

Multichannel Damping Ratio Standard Deviation for Given Frame Length and 21st and 23rd Order Models - 0.40 Hz mode

- Probing
  - $y = 6.8414x^{-0.7546}$
  - $R^2 = 0.9347$

- Ambient
  - $y = 1.521x^{0.3598}$
  - $R^2 = 0.9948$
Conclusions and Future Plans

• Probing provides detailed view
  – Inter-area modal frequencies and damping
  – Inter-area modal shape
• Mode estimates often not accurate enough during ambient conditions
• Mode estimates are much more accurate during probing
• PDCI low-level probing
  – AC system response below noticeable levels
  – Operational PDCI low-level probing being proposed for real-time dynamic stability security assessment
Reports and Publications


