WECC Modal Baseline Analysis Results as of June 2010

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Vancouver, BC
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Goals

- Calculate major inter-area modal properties during the 2008 operating season.
  - Spectrum
  - Damping
  - Frequency
- Base line spectrum properties of key signals.
- Correlate modal properties with intertie flows and generator outputs.
- Further detailed analysis of “interesting” conditions.

Known WECC Modes

Chief-Jo Brake Tests

Mode	6/13/2006	8/22/2006	9/14/2005, Alberta Disconnected
N-S	0.244 Hz, 9% D	0.244 Hz, 10% D	0.318 Hz, 8% D
Alberta	0.376 Hz, 9% D	0.373 Hz, 8% D	
Colstrip	0.776 Hz, 10% D	0.830 Hz, 11% D	0.889 Hz 11% D
BC	0.620 Hz, 9% D	0.642 Hz, 10% D	0.626 Hz, 15% D

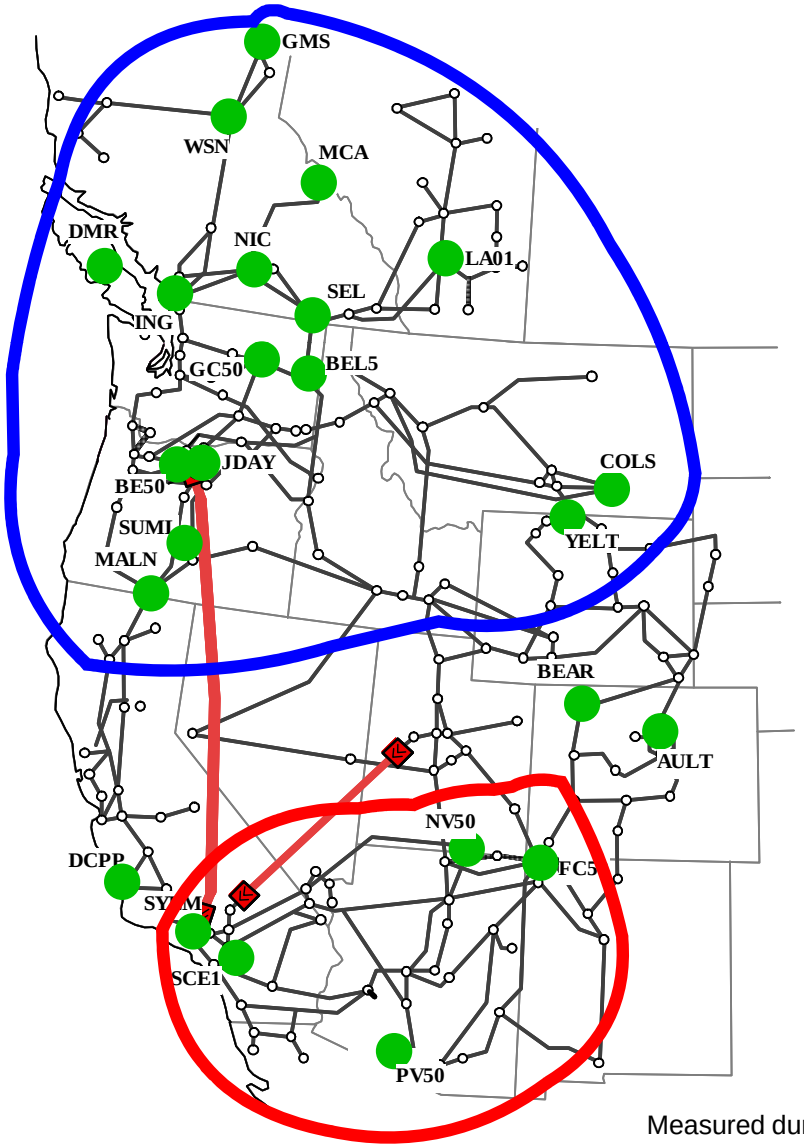
Damping of the BC mode on 09/14/05 was very high, and the estimate was quite variable.

Mode-meter estimates provide similar results.

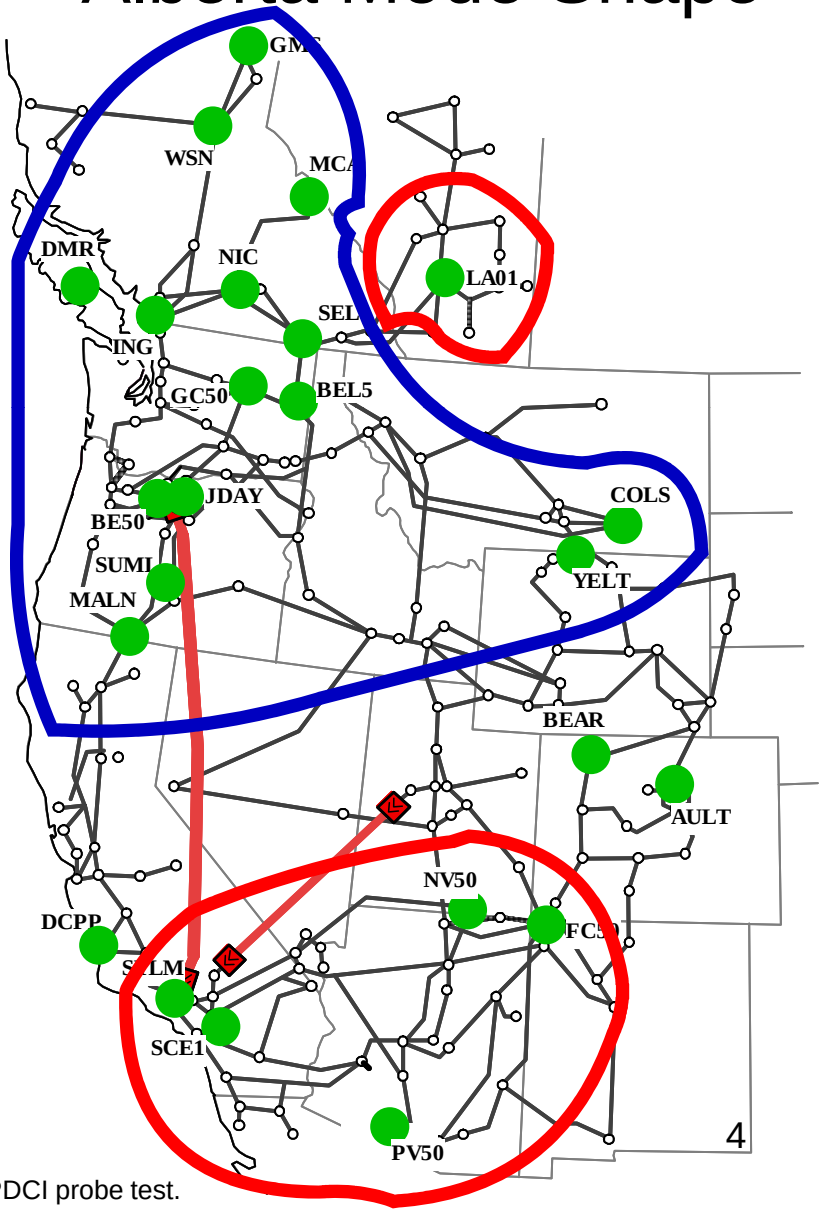
Reference: . F. Hauer, W. A. Mittelstadt, J. W. Burns, Harry Lee, D. J. Trudnowski, “Staged System Tests for Validation of WECC System Performance and Modeling: Summary Report for September 2005–August 2006, April, 2007

Alberta Connected

N-S Mode Shape

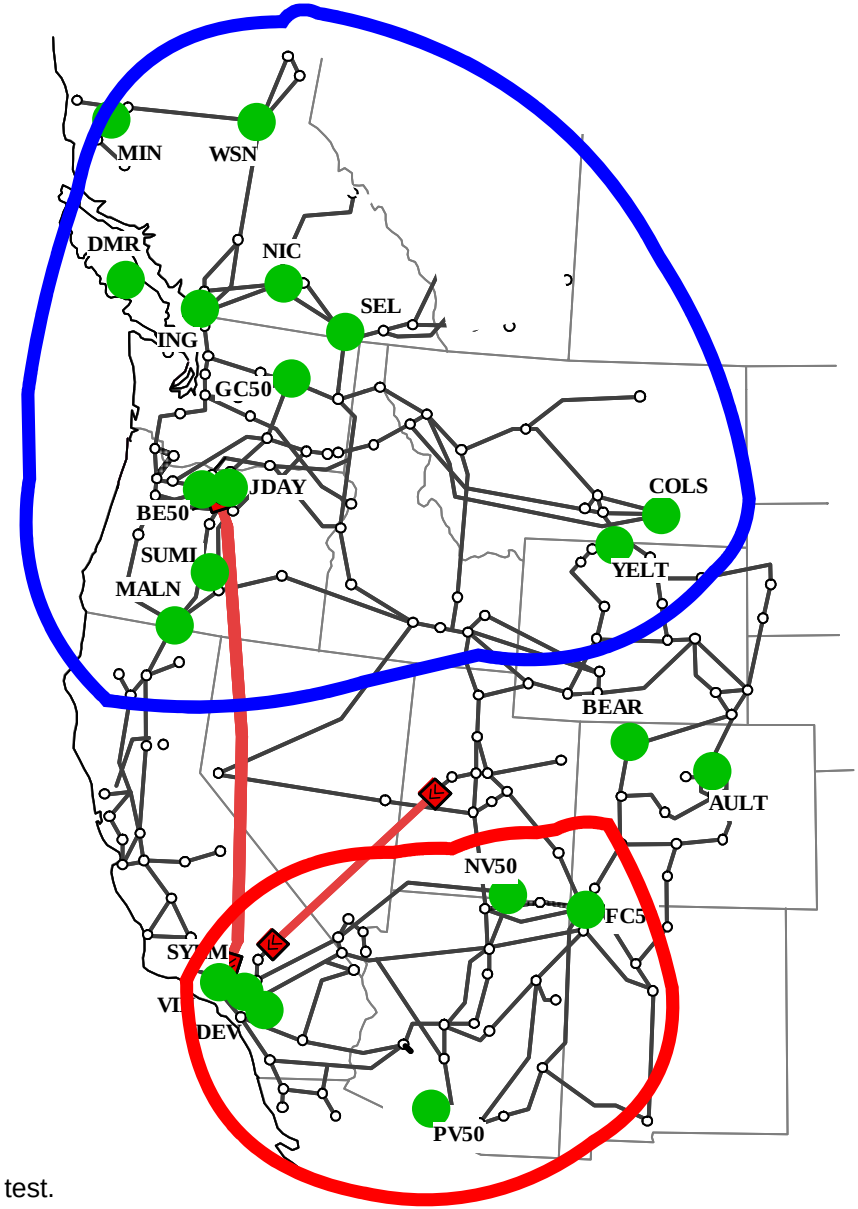


Alberta Mode Shape



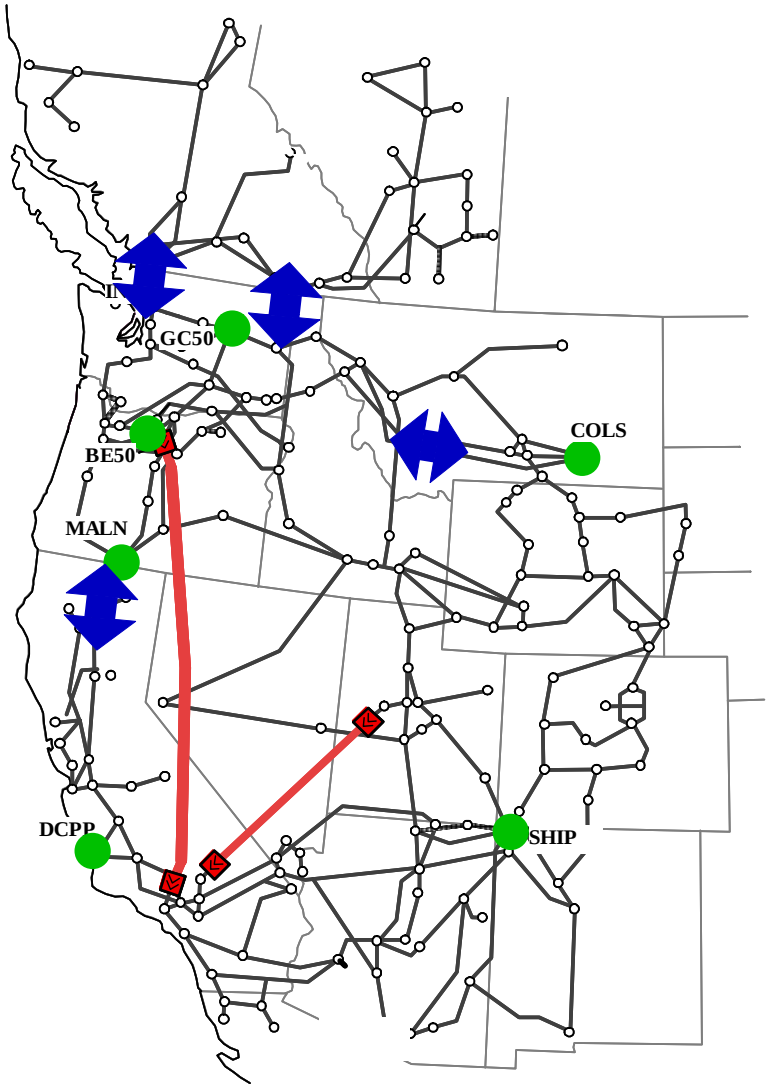
Measured during Aug. 22, 2009 PDCI probe test.

Alberta Disconnected
N-S/Alberta Mode Shape



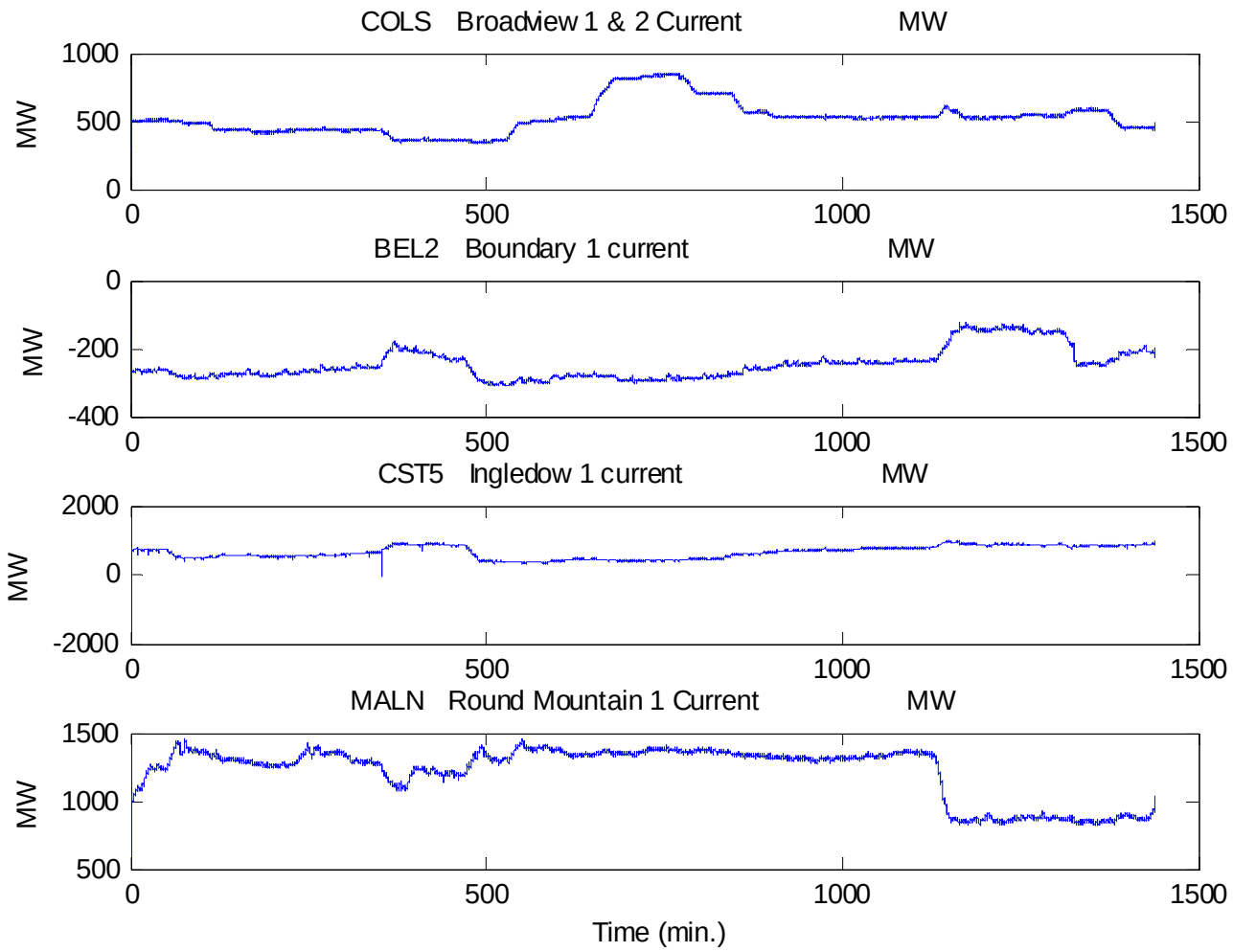
Measured during Sep 14, 2005 PDCI probe test.

Baseline Signals being Analyzed



- Colstrip voltage angle
- Big Eddy voltage angle
- Malin voltage angle
- Shiprock voltage angle (not reliable)
- Diablo Canyon voltage angle
- Relative frequency calculated from angles
- Broadview 1 & 2 MW
- Boundary 1 MW
- Ingledow 1 MW
- COI MW = Round Mountain 1 & 2 MW, C-Jack Olinda MW

Typical Day (No Events)
(6/7/2008)



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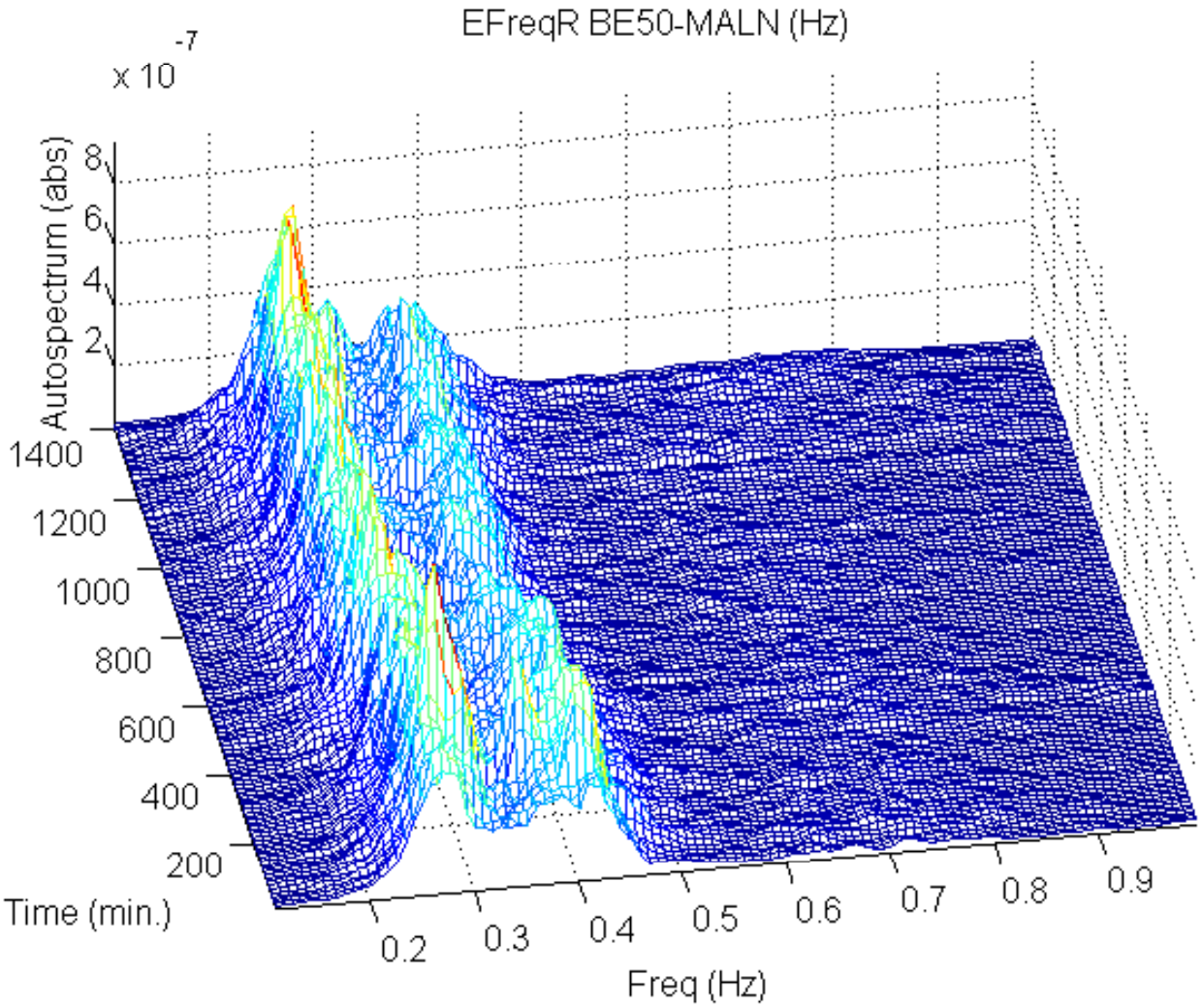
(6/7/2008)



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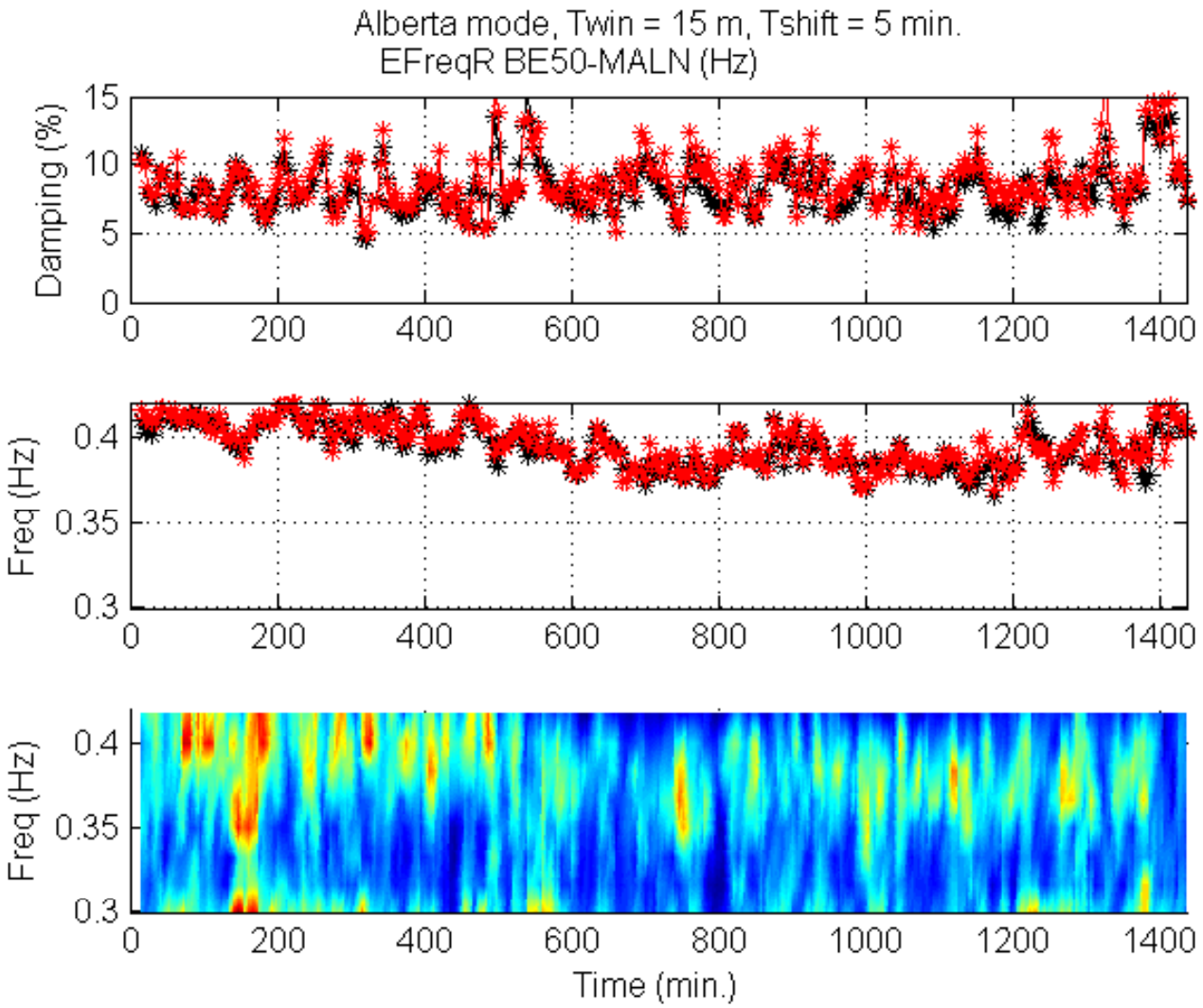
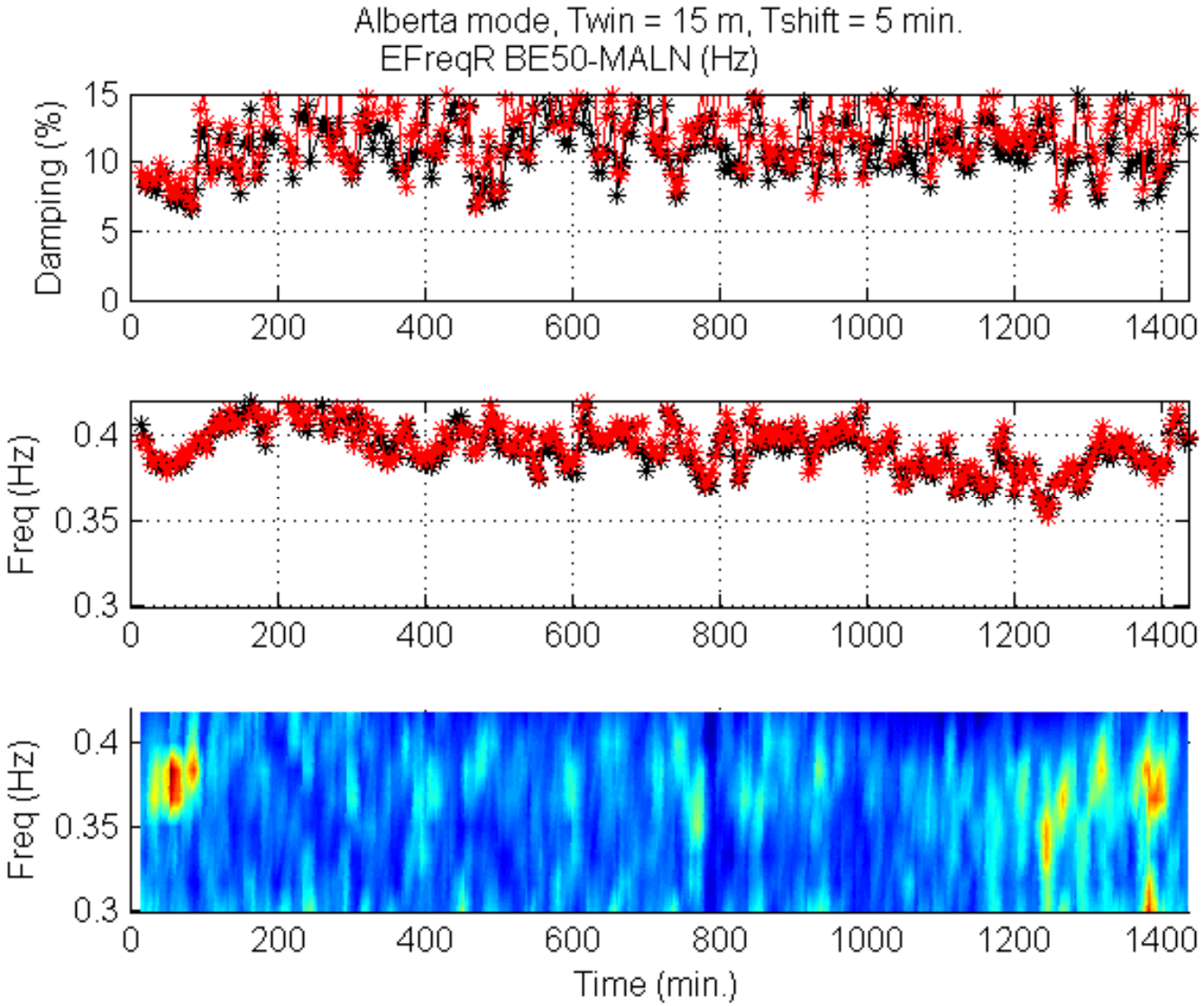
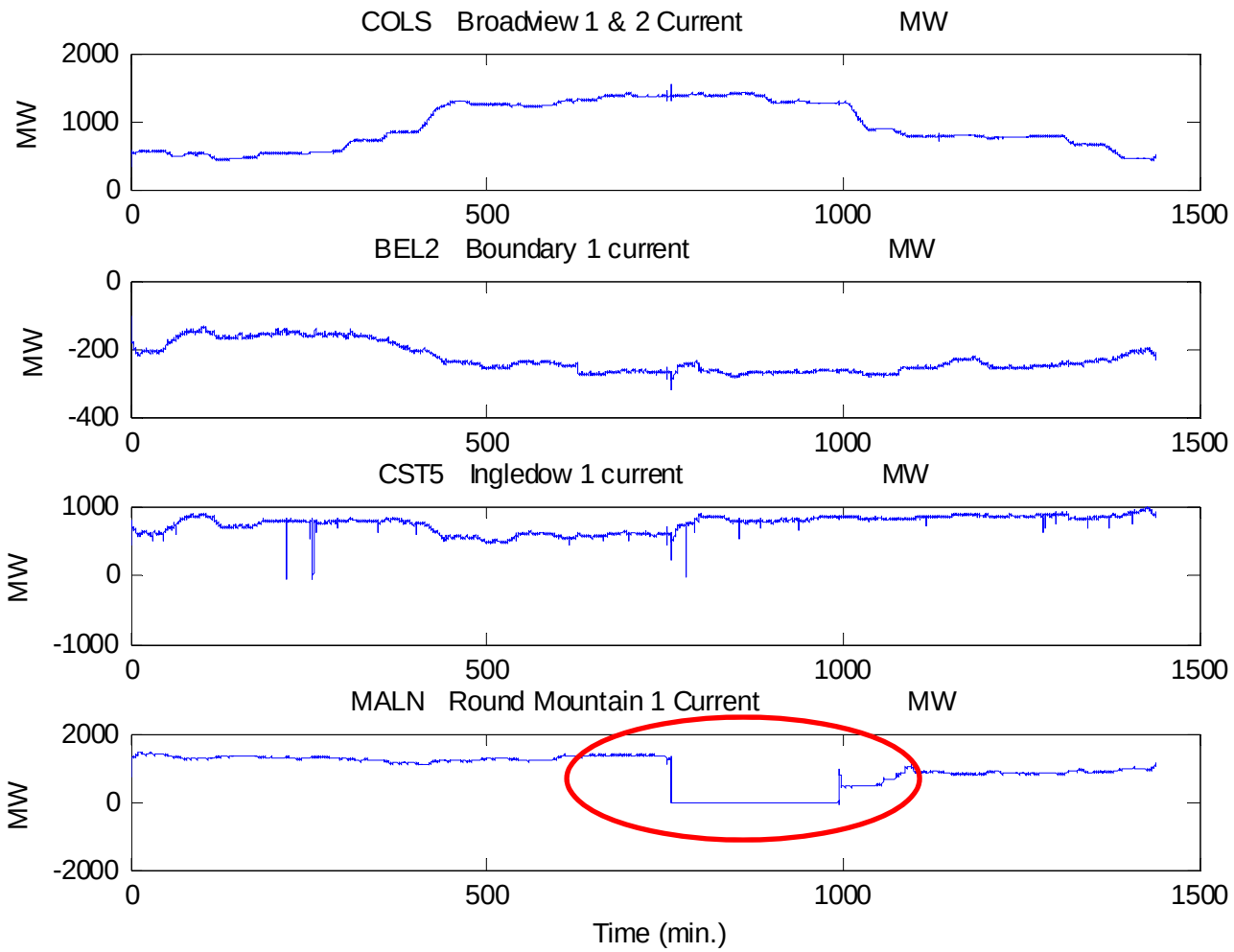


Typical Day (No Events)
(12/28/2008)



COI Trip
(6/11/2008)



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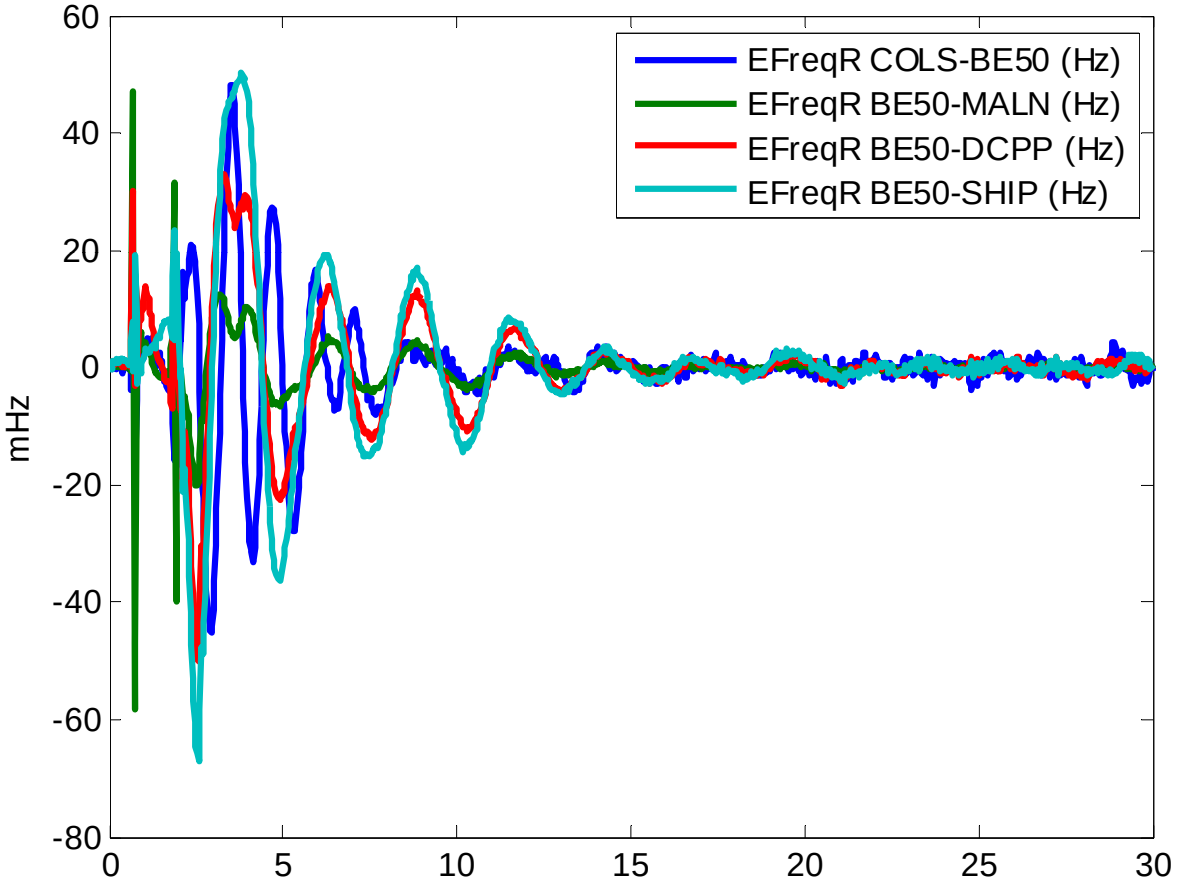

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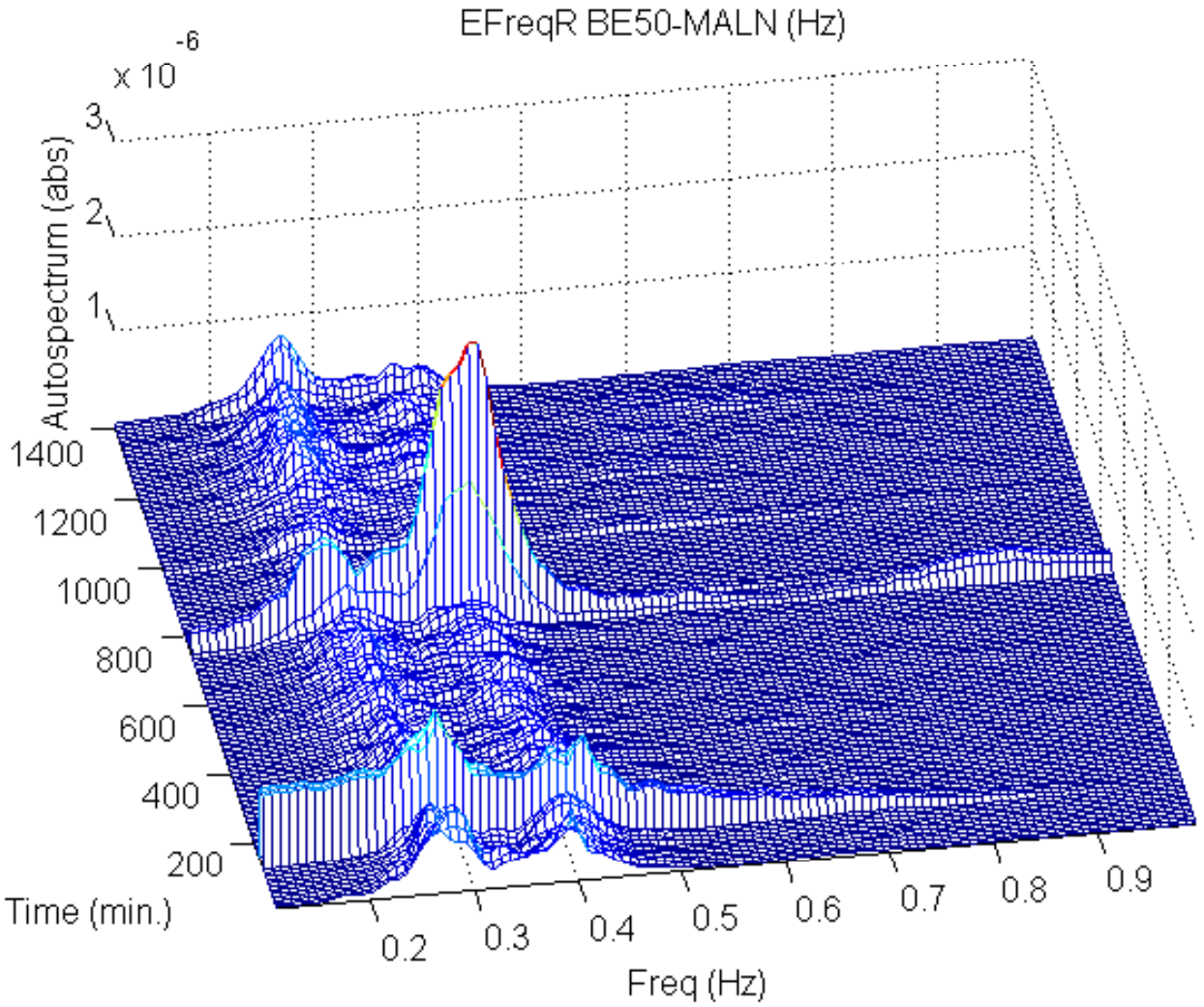
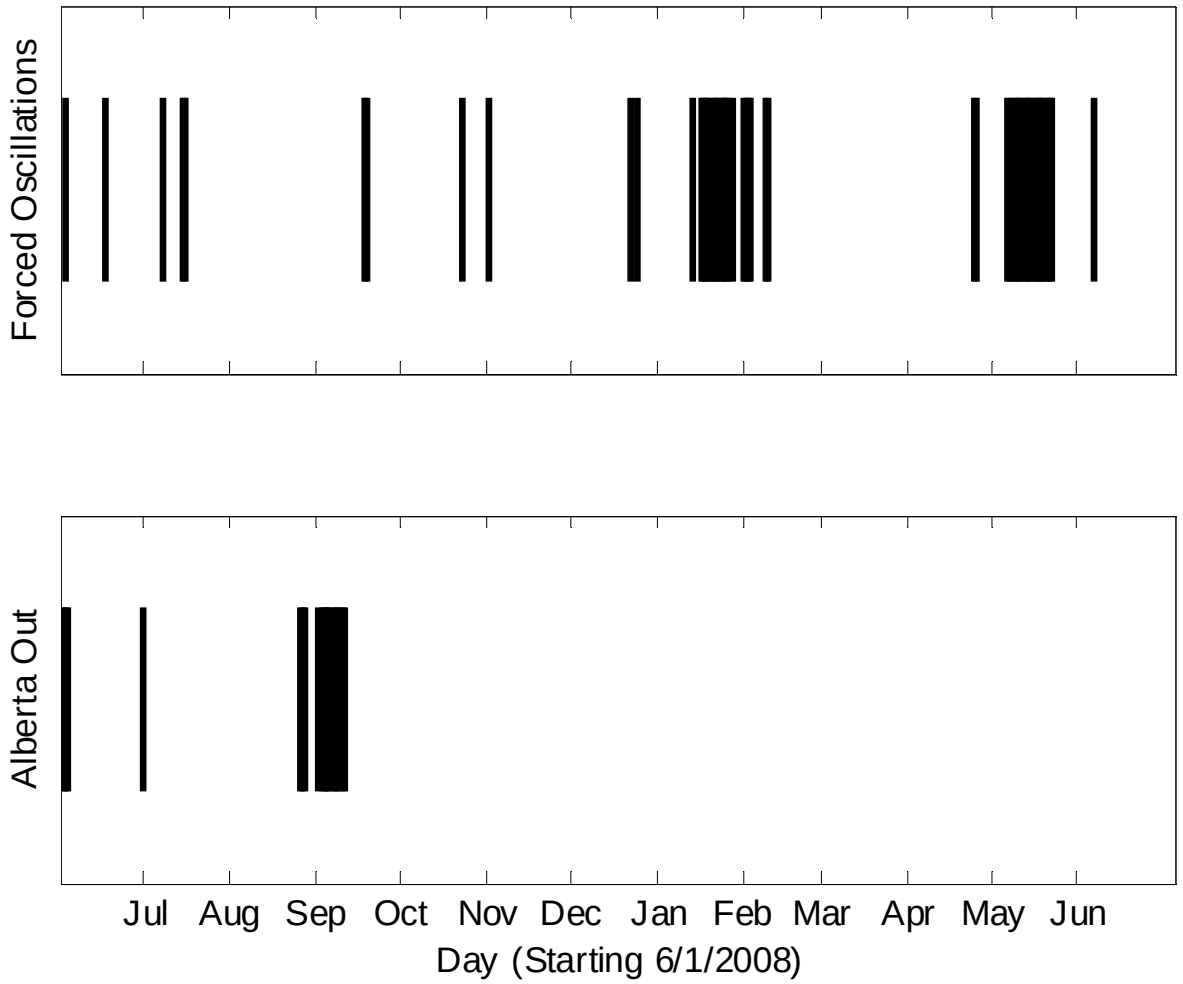
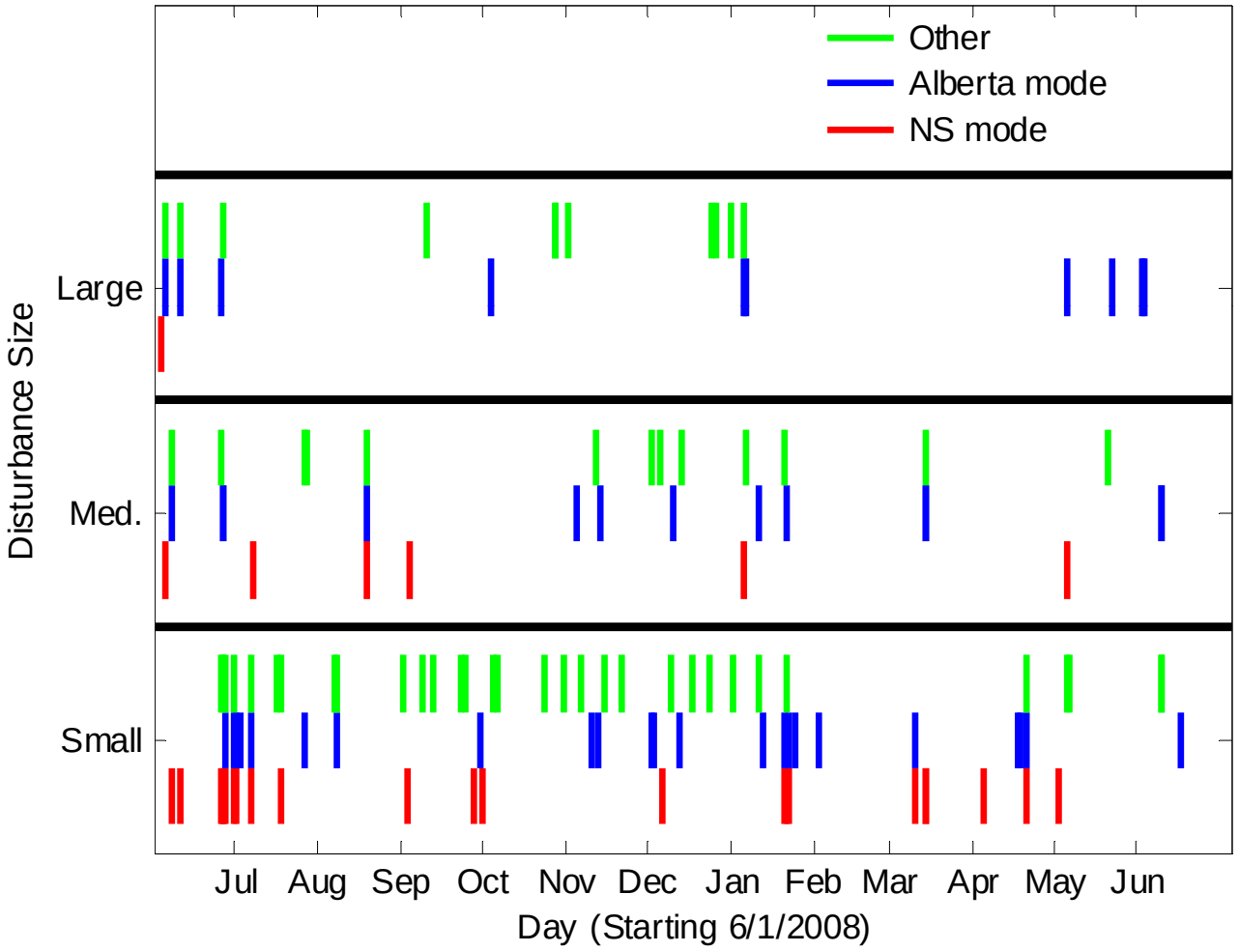


Alberta-Out and Forced-Oscillation Days



Event Days

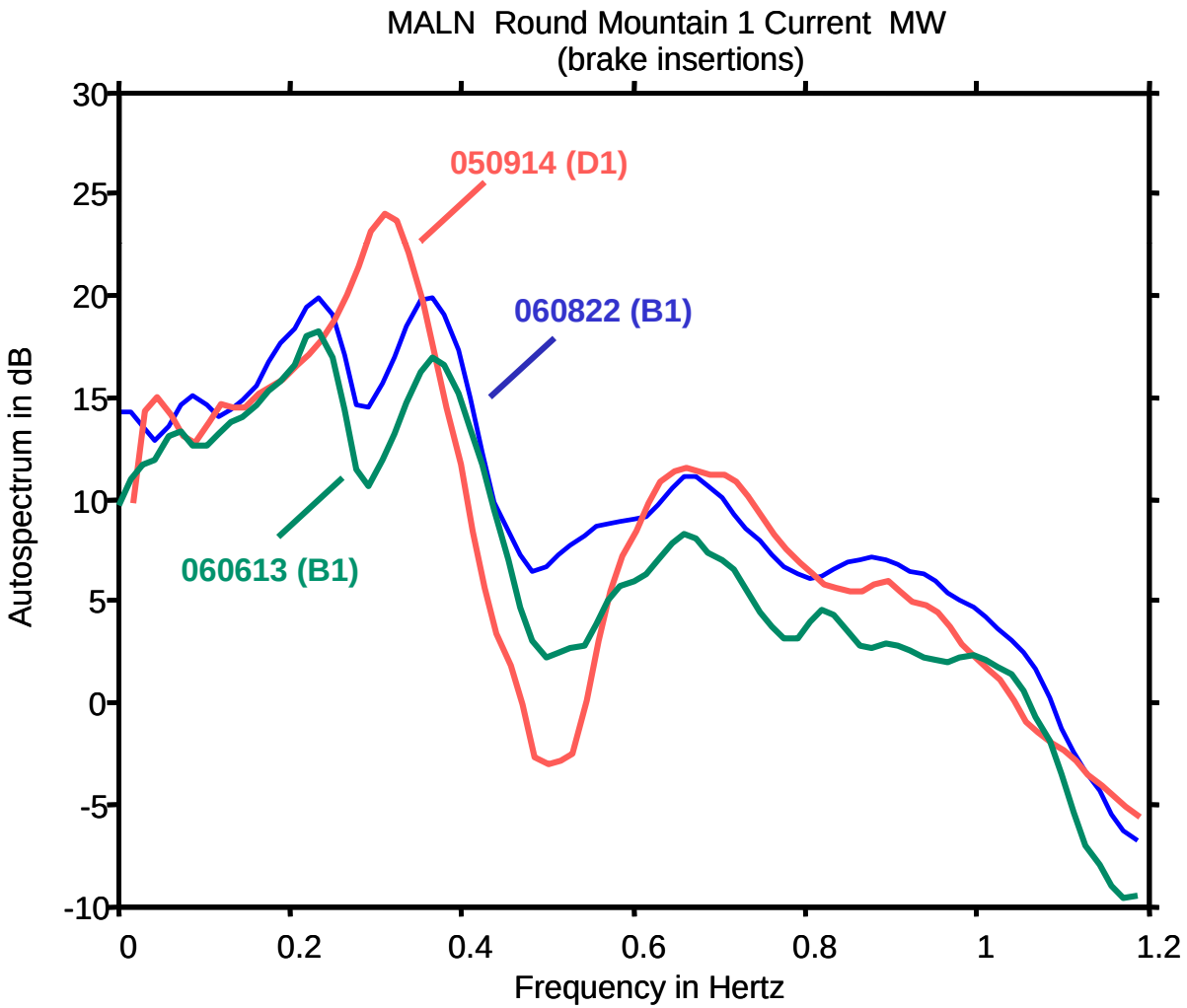

Other
Alberta mode
NS mode
Disturbance Size
Large
Med.
Small
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Day (Starting 6/1/2008)

Conclusions

- Now have expected axes scaling for key signal spectrums.
- 0.25 Hz mode damping is typically higher than 0.4 Hz mode.
- 2008 season appears to have no significant under-damped periods.
- There appears to be a seasonal change in the 0.4 Hz mode damping.
- Mode frequencies appear to have a diurnal pattern but damping does not.
- Forced oscillations are common (20 events in 2008).
- Base lining should be a continual process!
- Need wider PMU coverage.
  - Isolate modes to improve mode damping estimates
  - Mode shape
- Base lining with System Testing
  - Calibrate mode damping and shape estimates

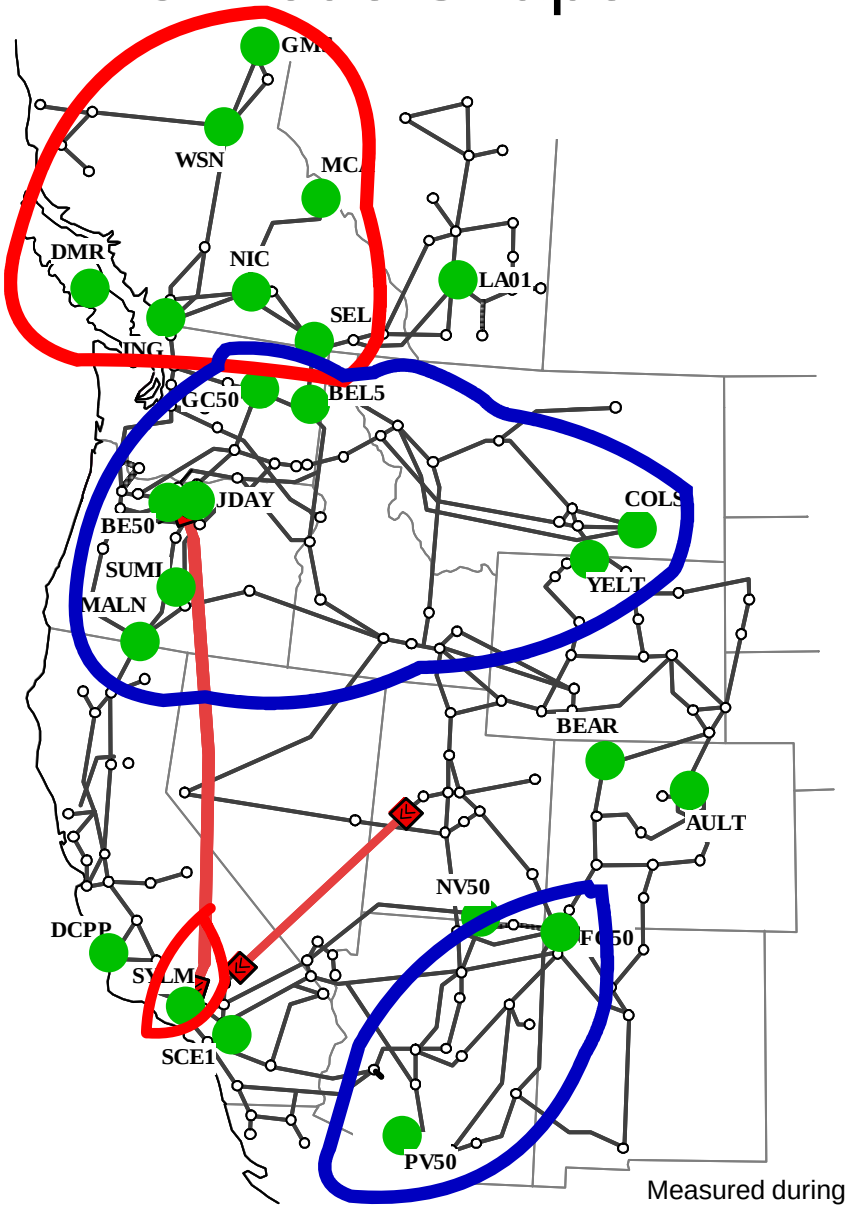
Mode estimates from brake tests

(John Hauer)

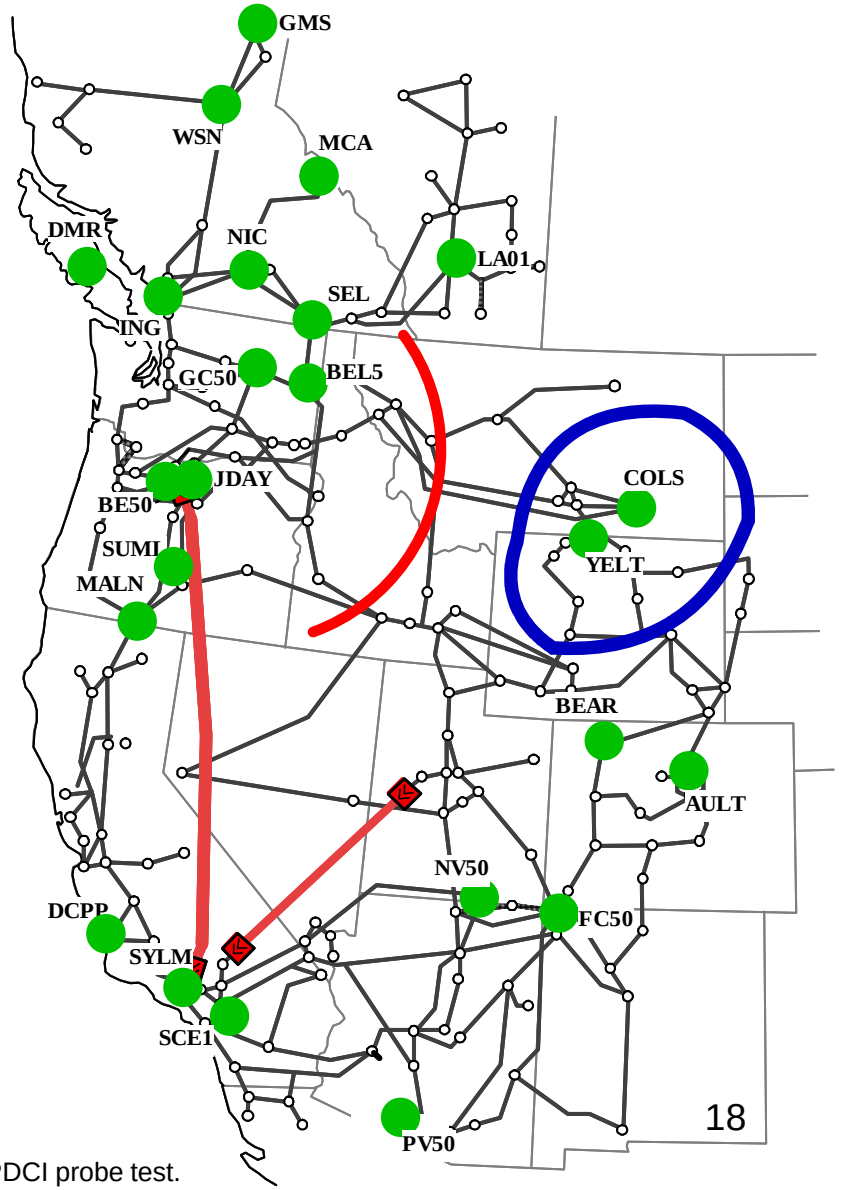


Alberta Connected

BC Mode Shape



Colstrip Mode Shape



Measured during Aug. 22, 2009 PDCI probe test.

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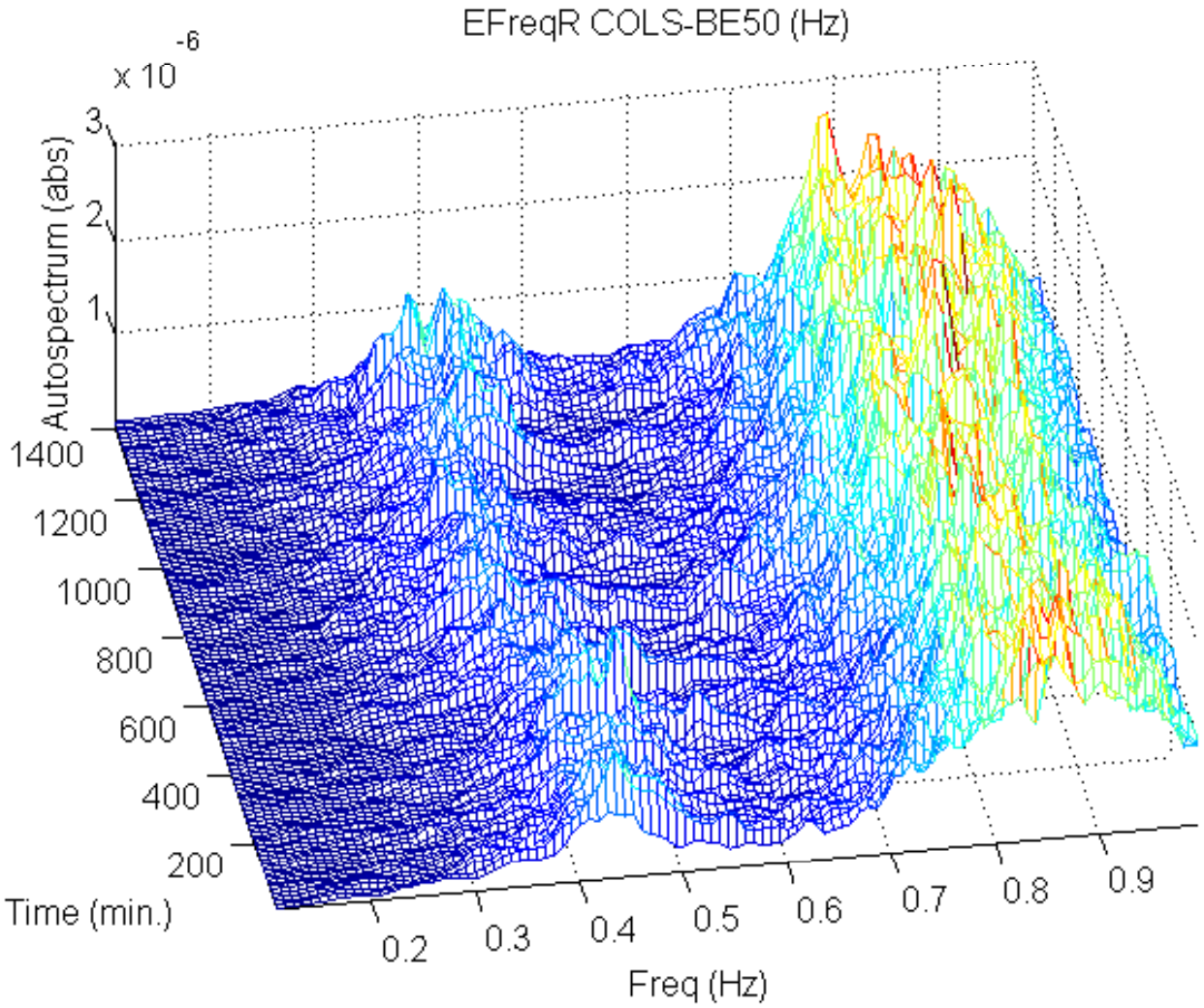
(6/7/2008)



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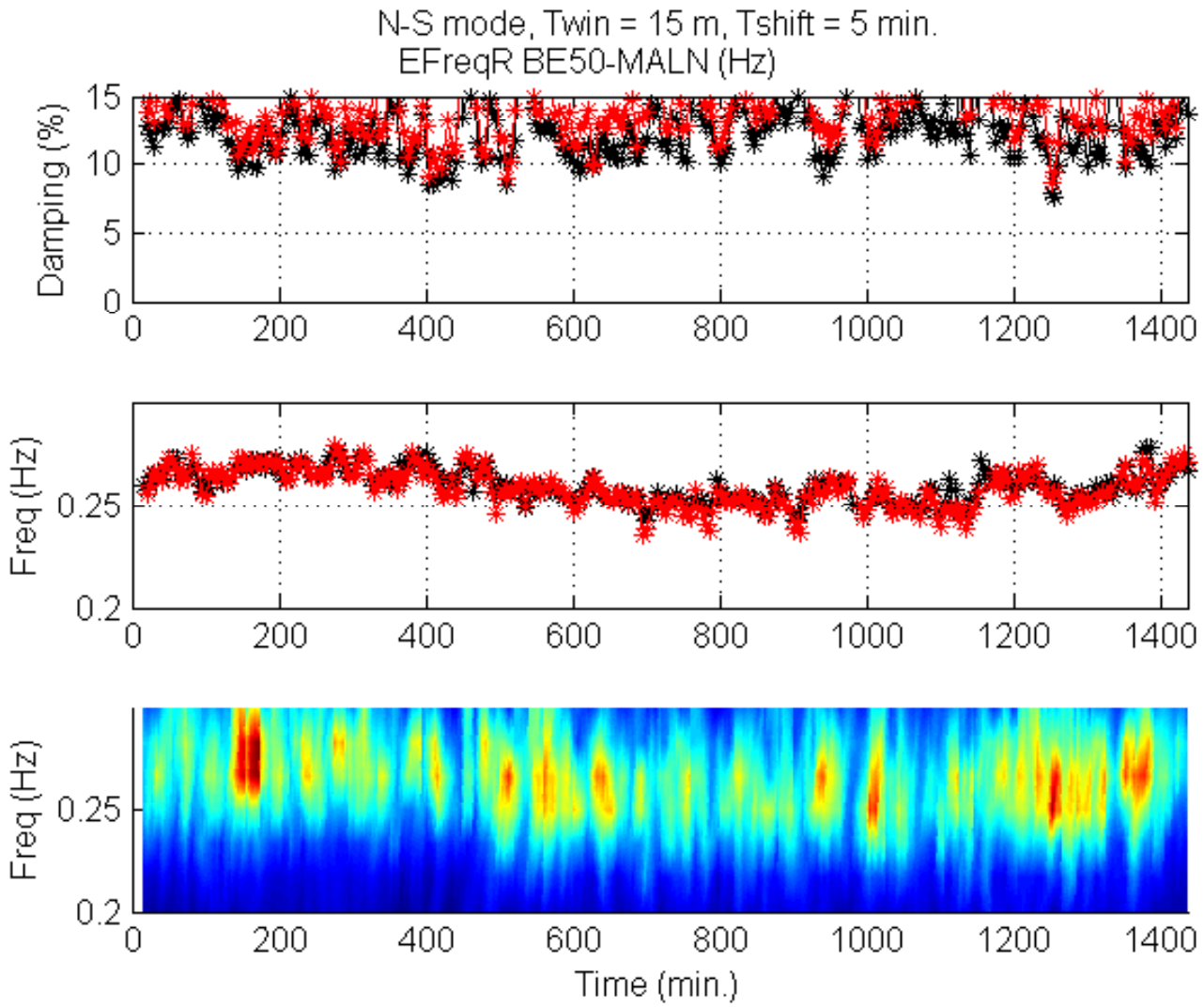

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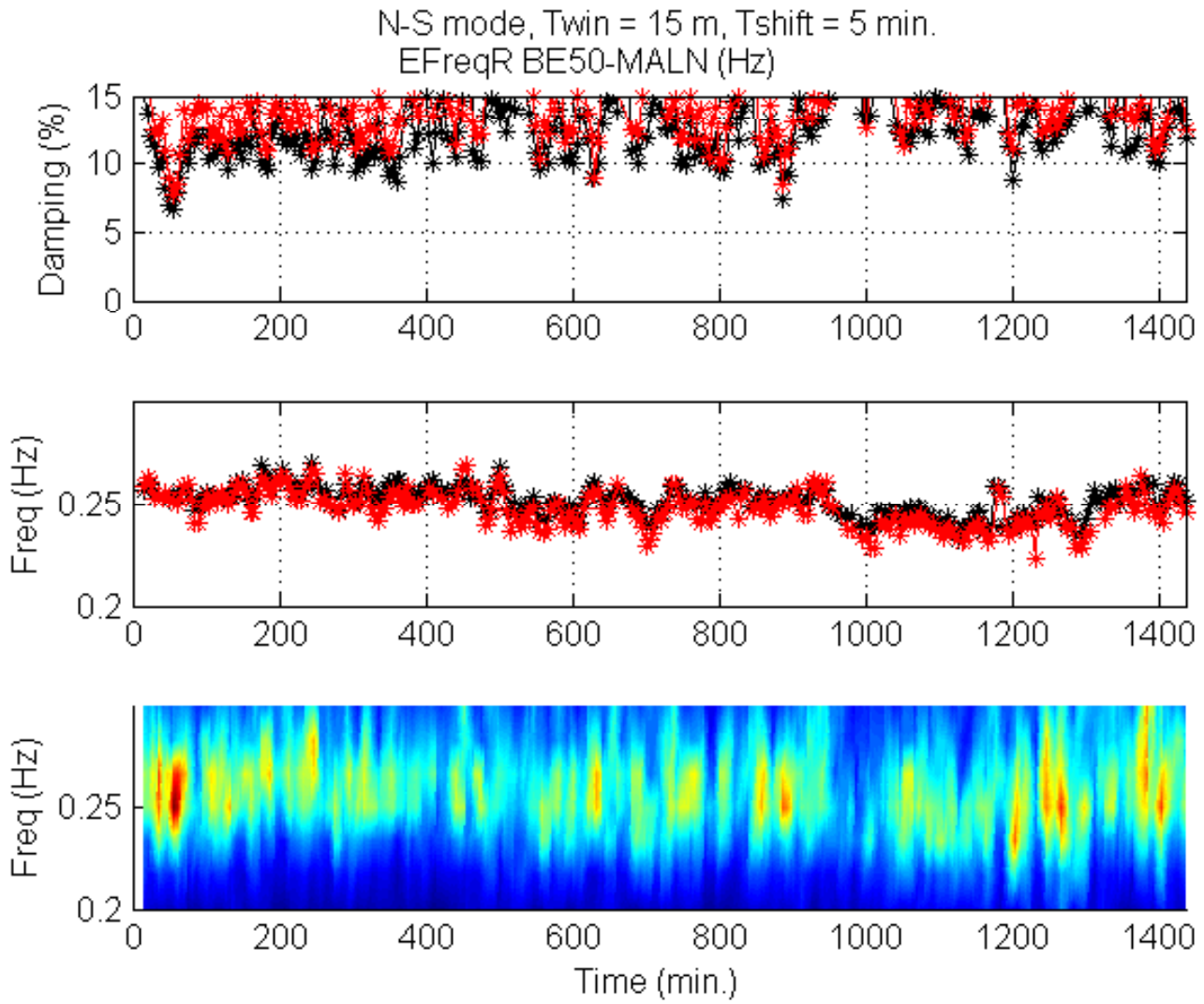
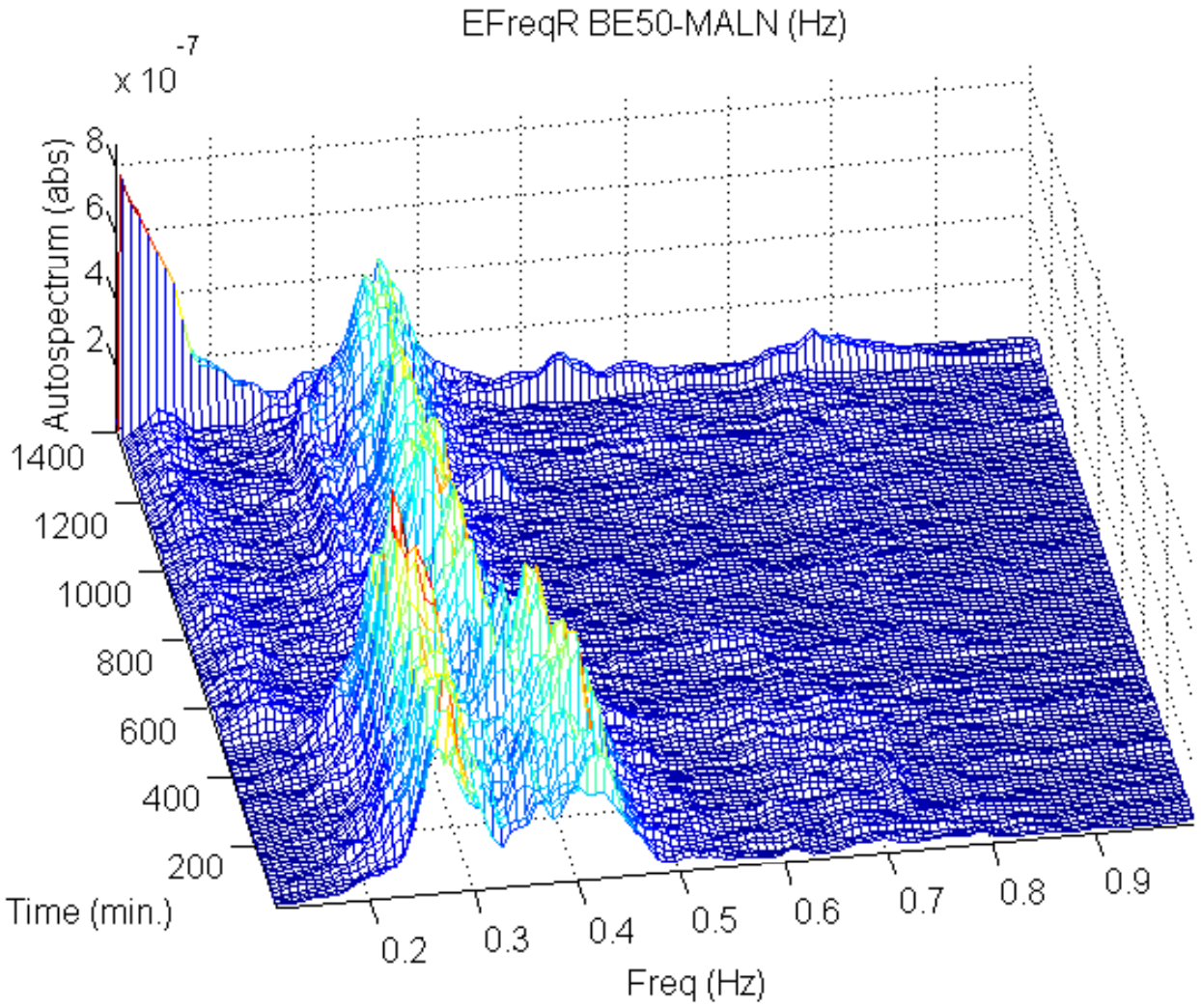


Alberta Disconnect

(6/2/2008)



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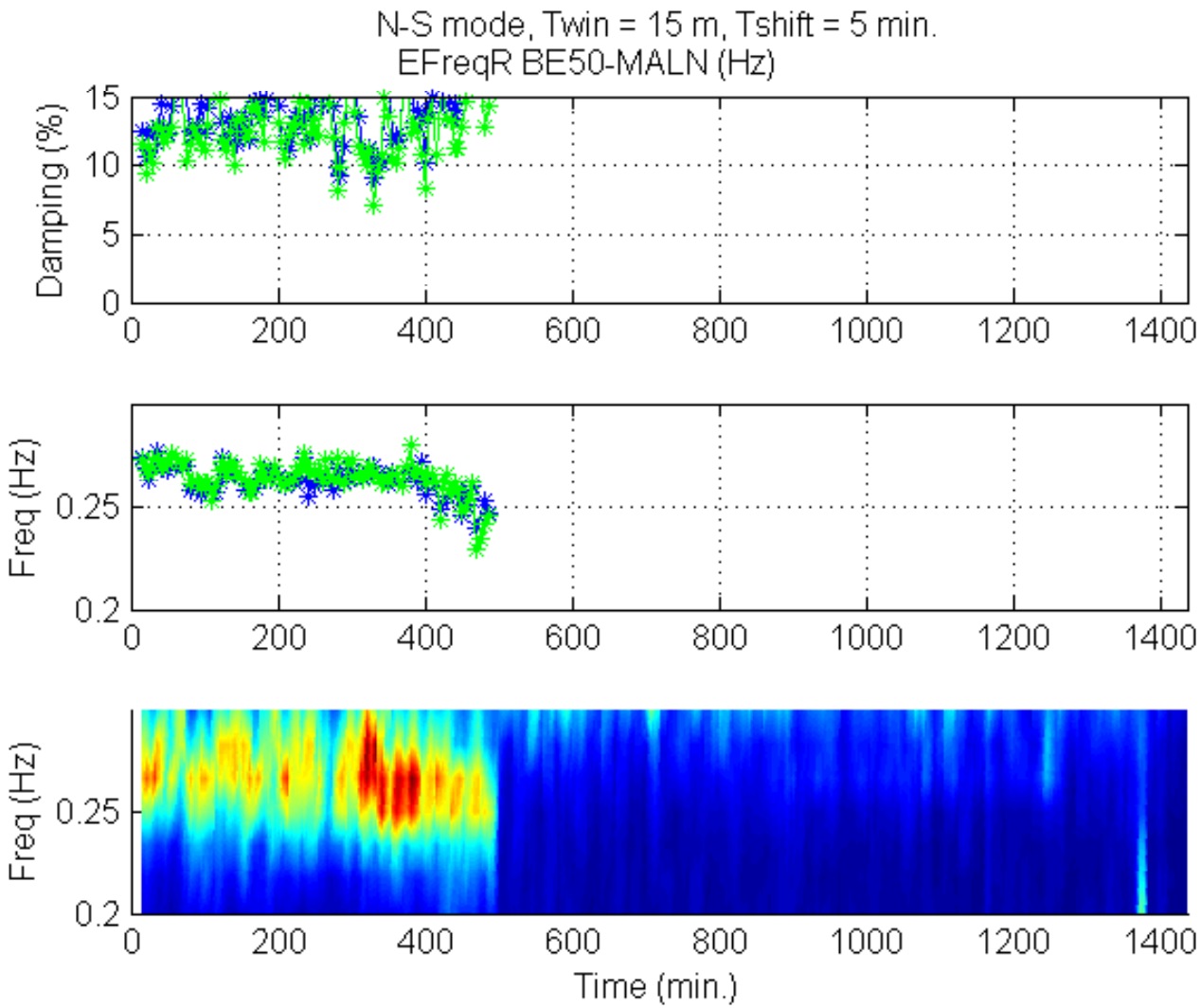

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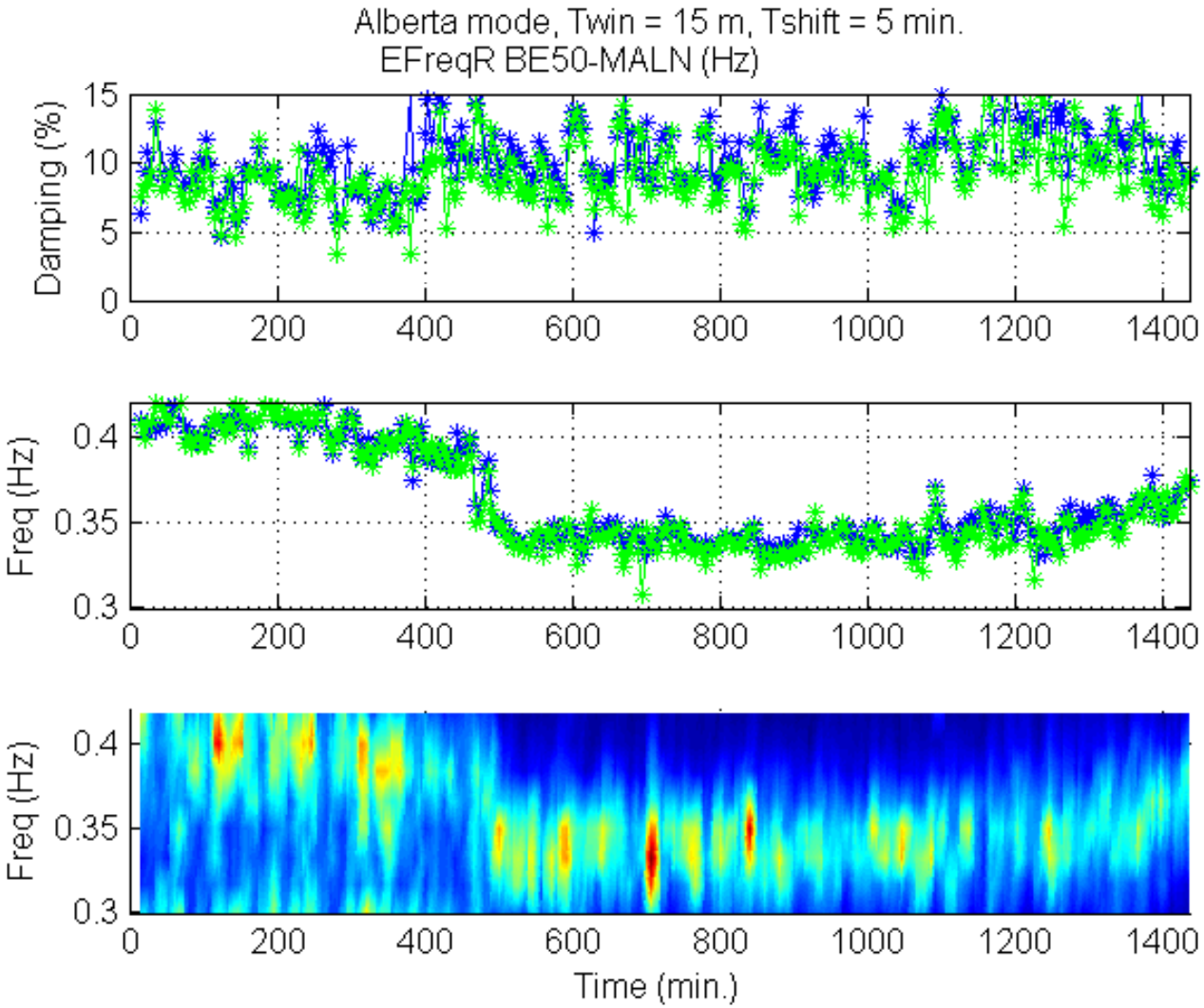
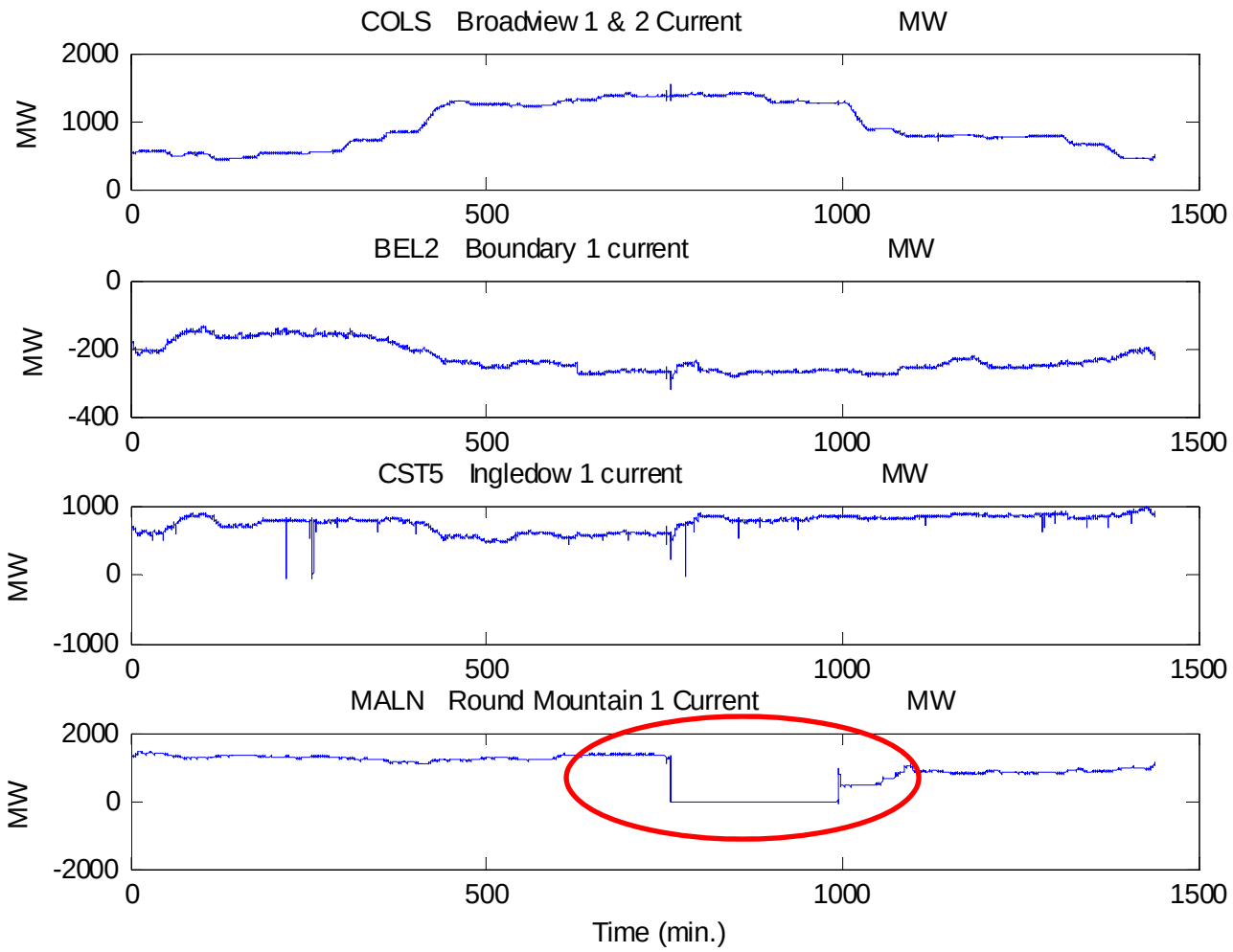


COI Trip
(6/11/2008)



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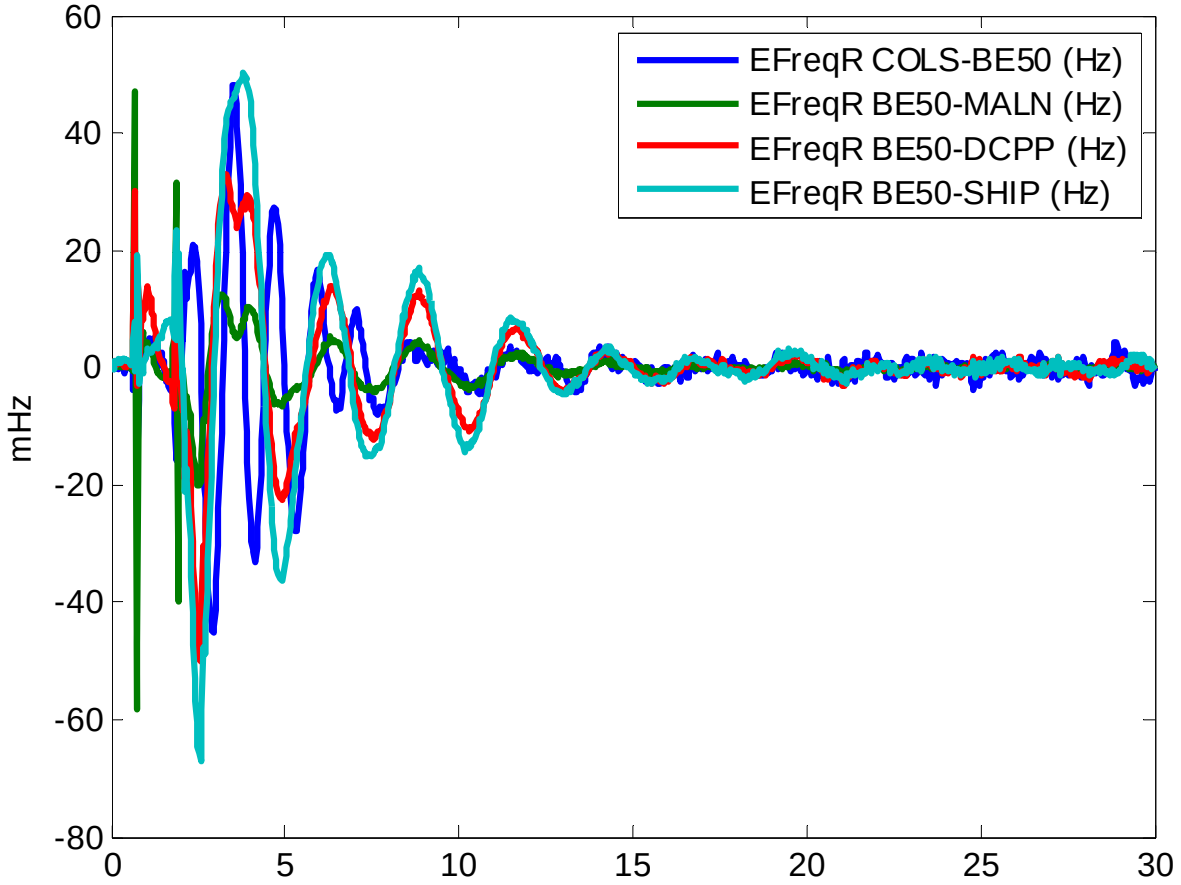

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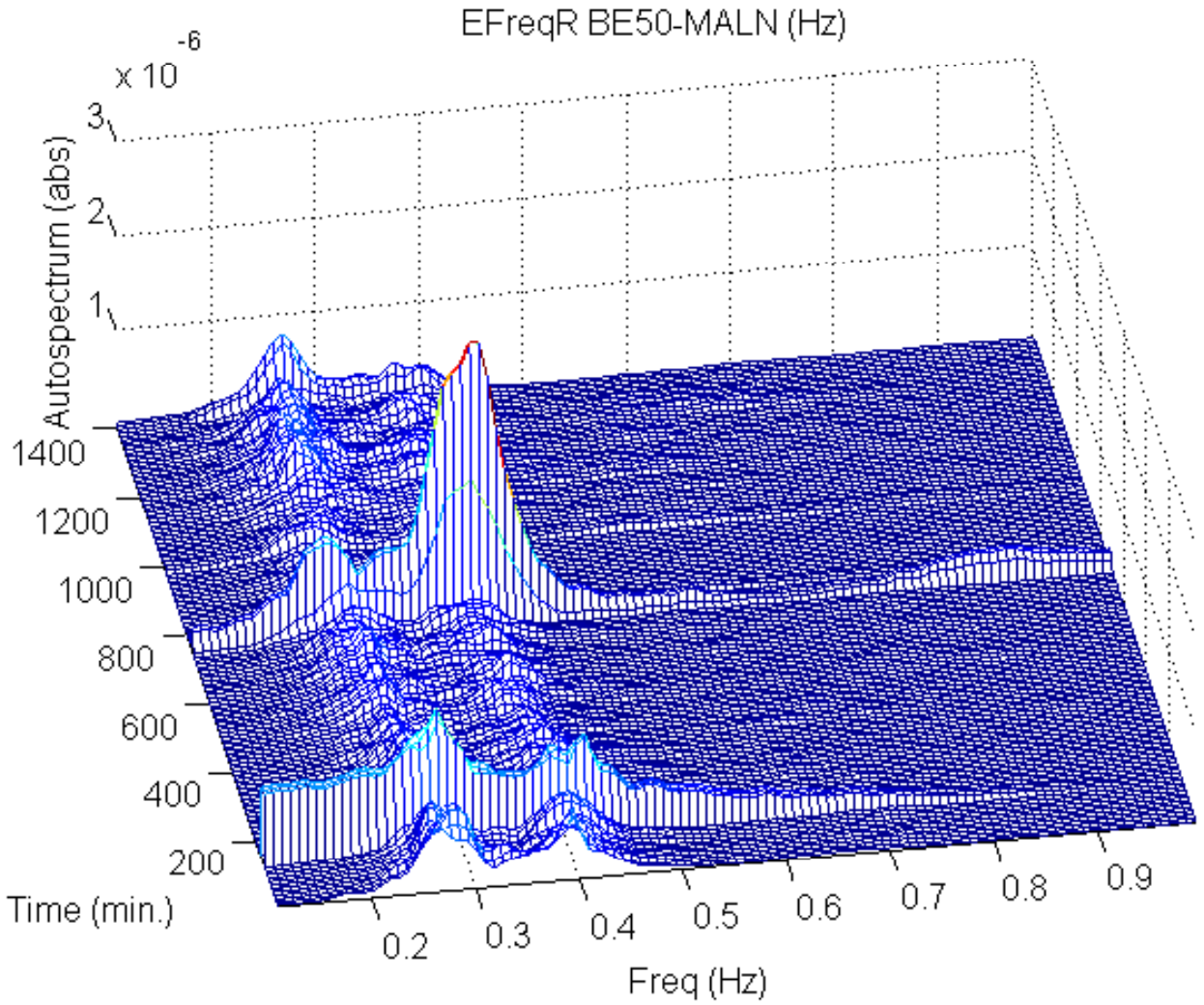

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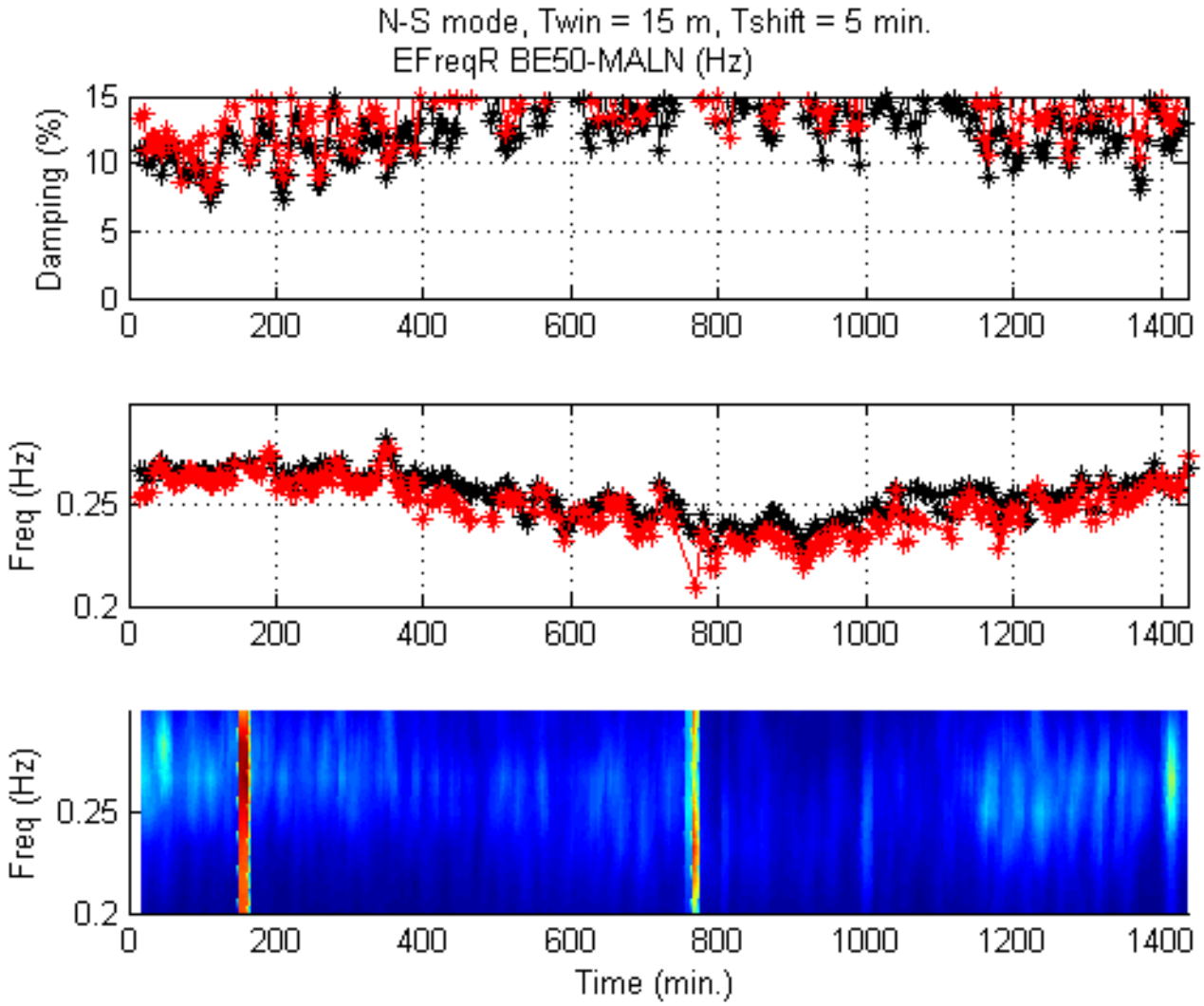

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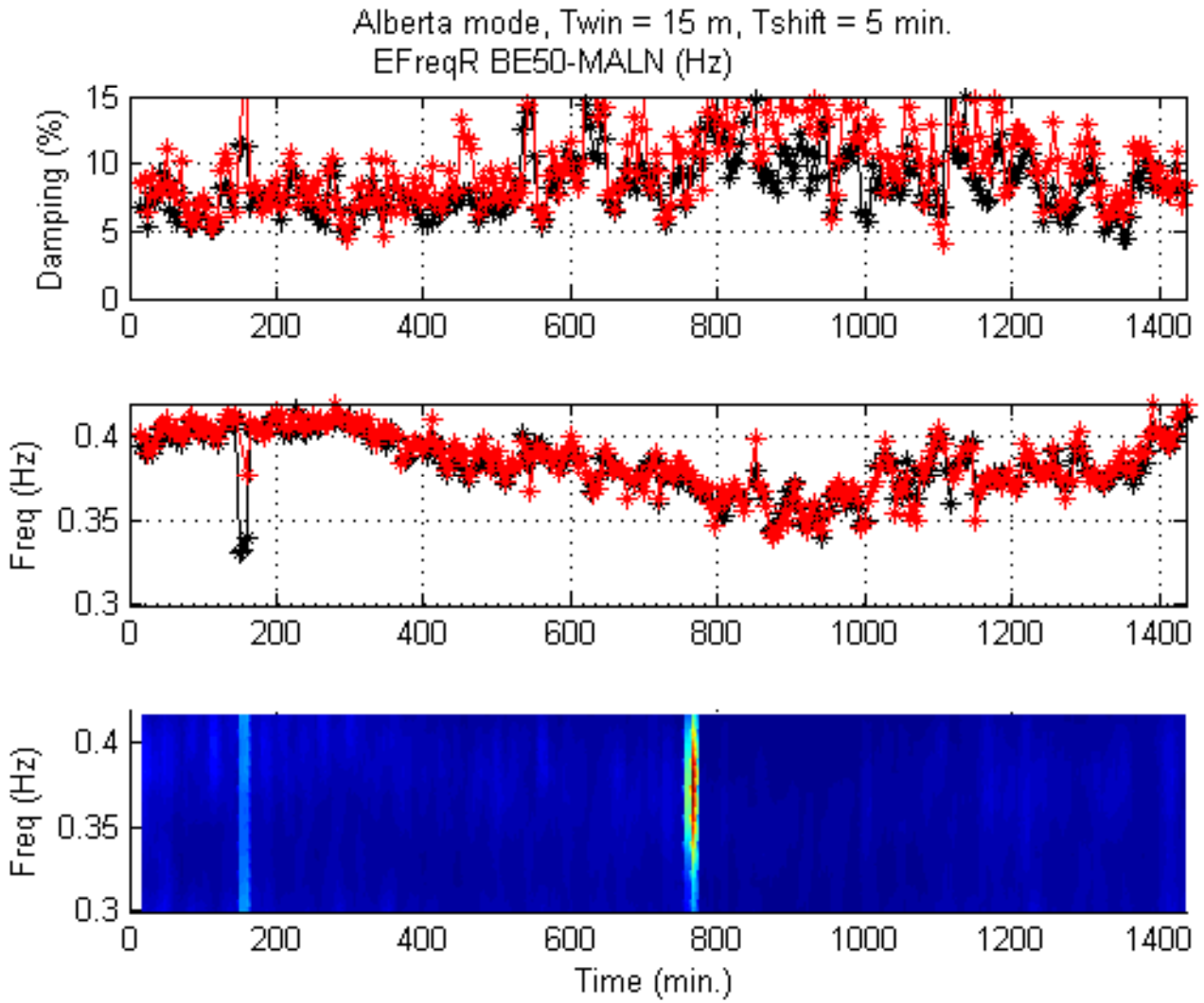

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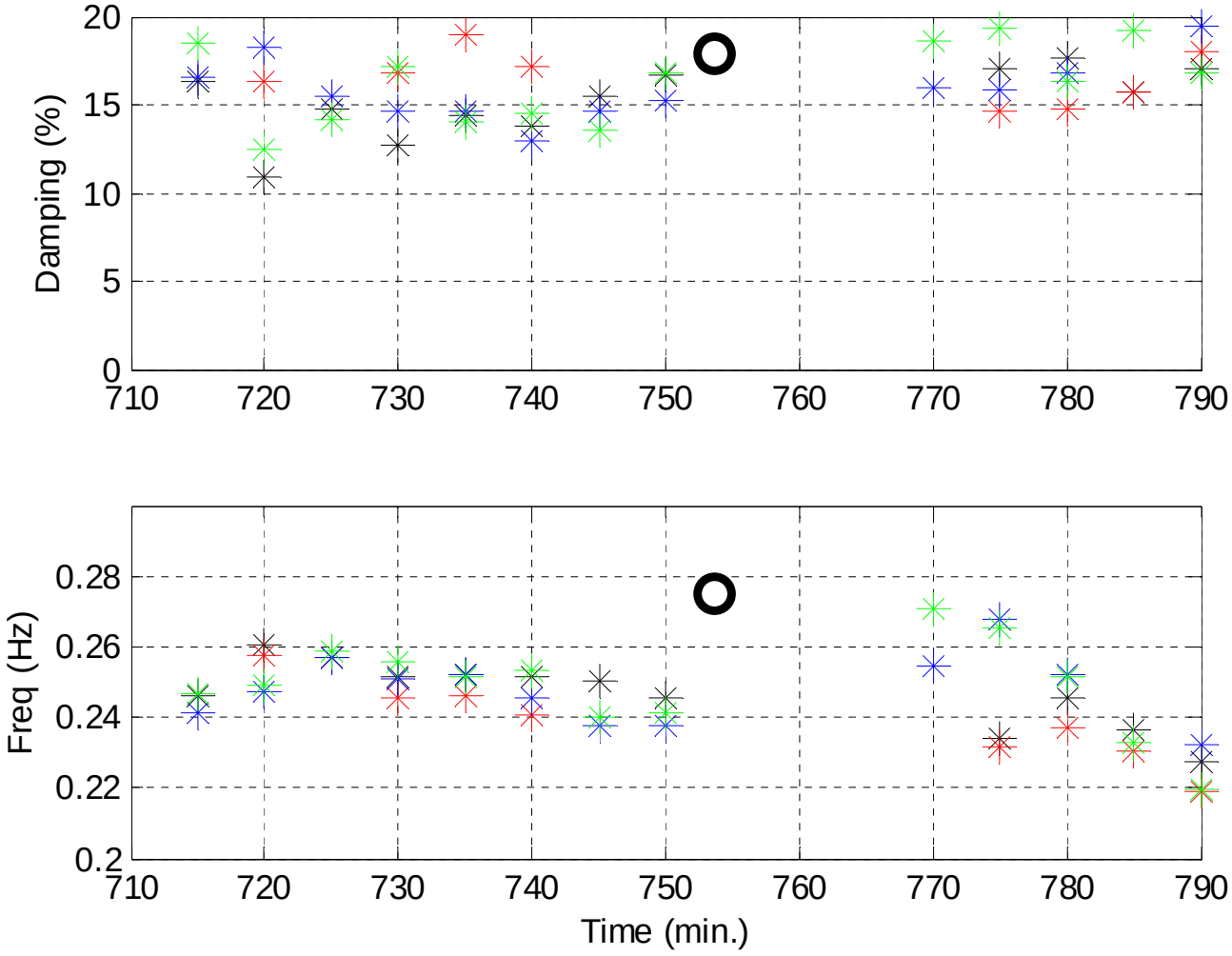

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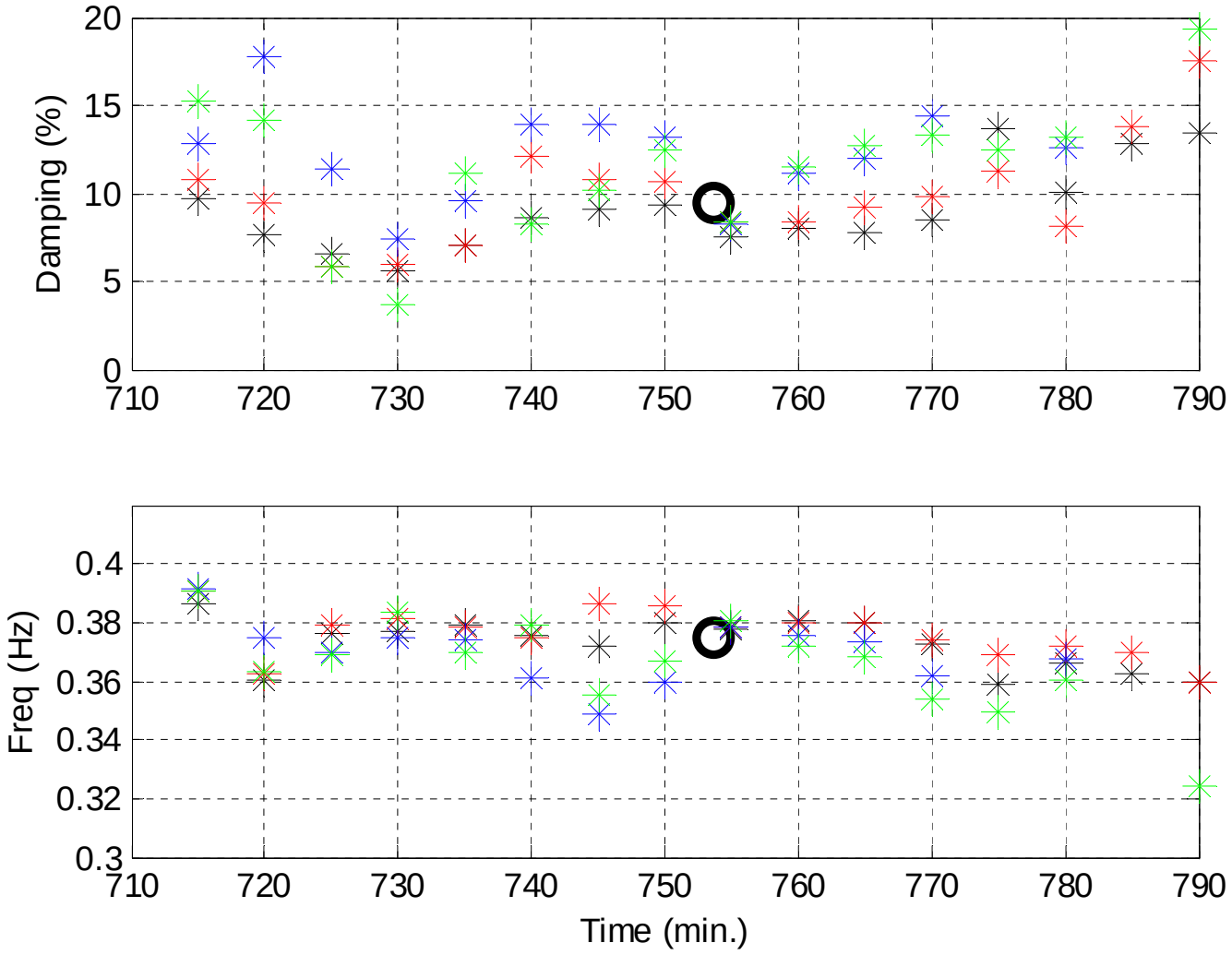

Forced Oscillation

(5/7/2009)