

New PowerWorld Modal Analysis Tools



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June 19, 2018

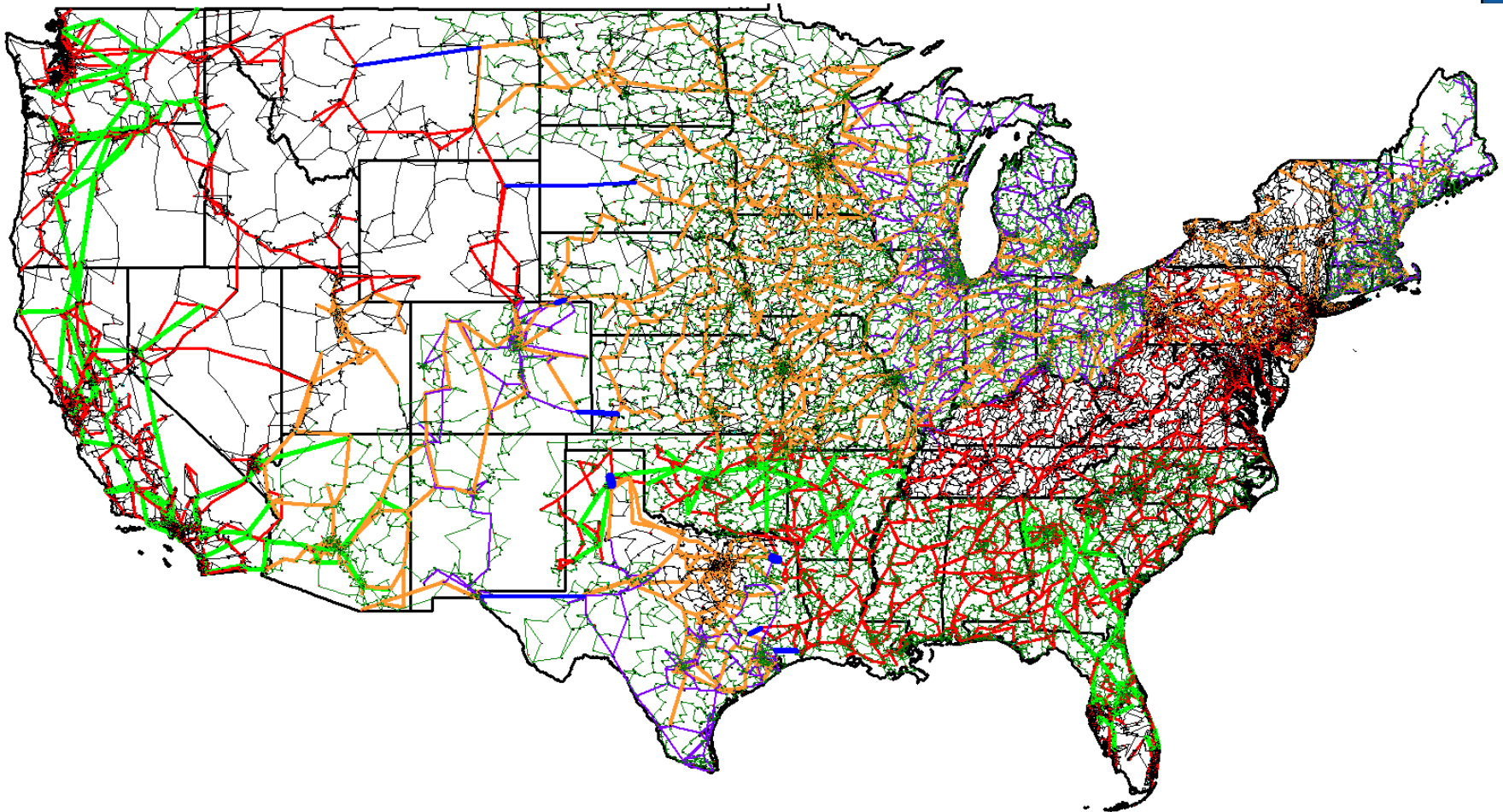


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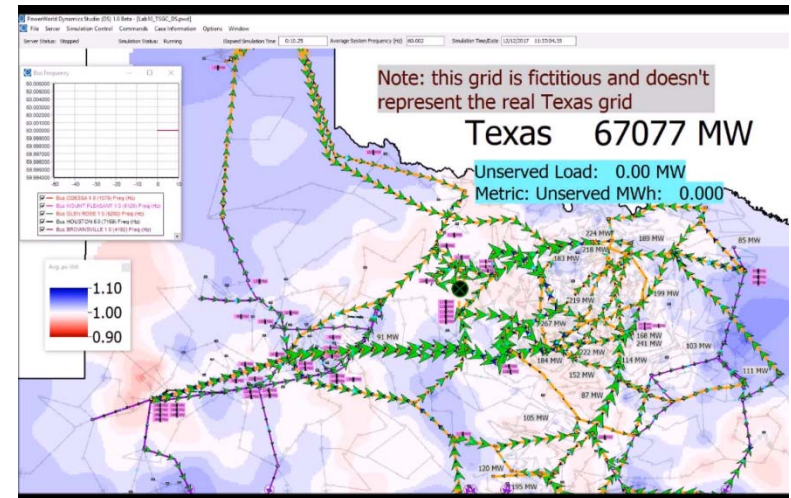
Aside: Synthetic Grids



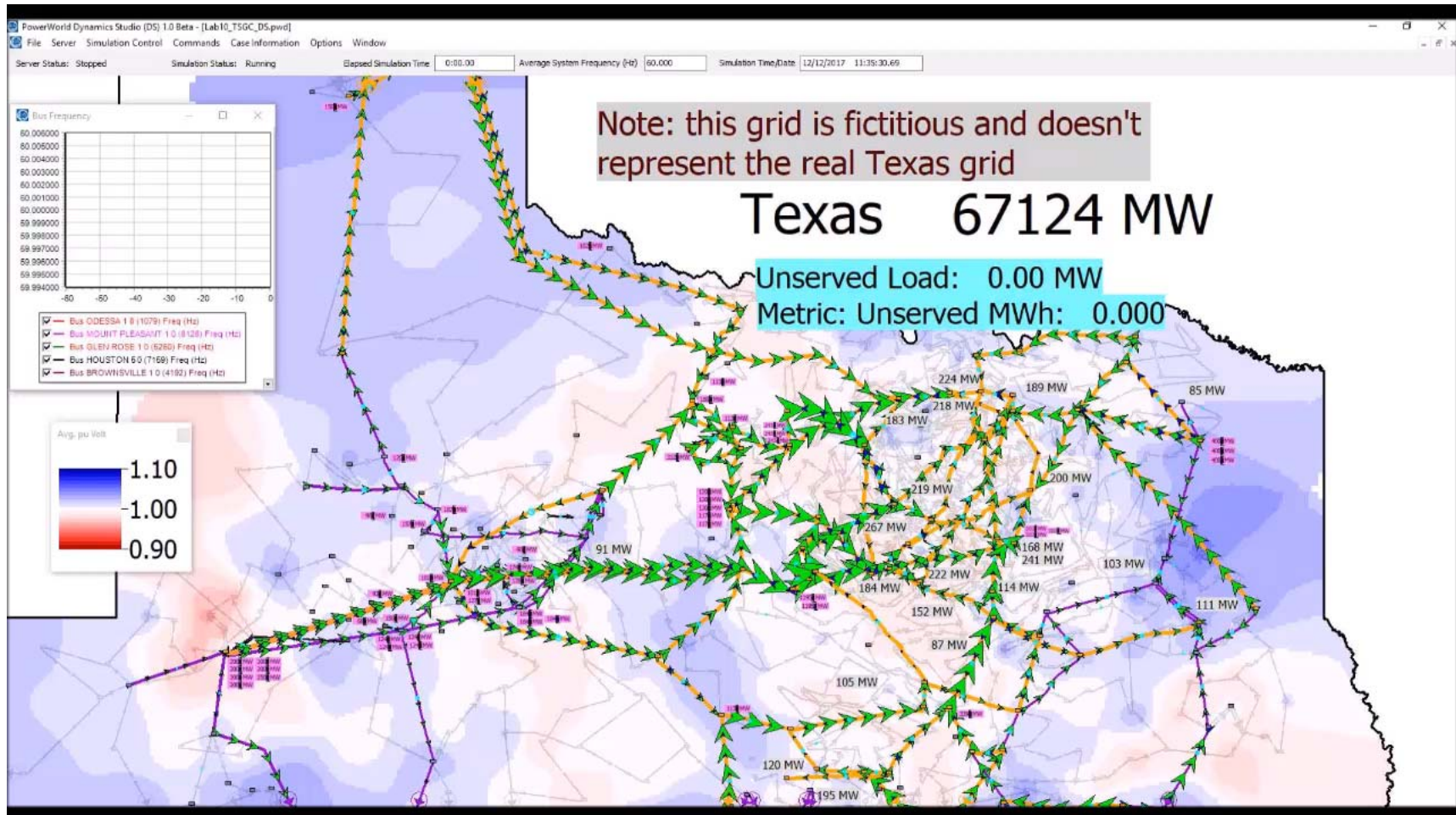
Aside: PowerWorld Dynamics Studio



- PowerWorld Dynamics Studio (DS) provides an interactive simulation environment for doing transient stability level simulations
- It can be run either stand alone, or as a server as part of a multi-user simulation
- Input cases are pwb/pwd
- It can be also used as a C37.118 data source and is currently being updated to support DNP3 control



DS Interactive Example



Overview



- Frequency domain techniques can be quite helpful in providing information about power system dynamic performance
- With version 20 PowerWorld includes a growing array of tools
 - Fast Fourier Transform (FFT) and modal analysis using a variety of methods
- Tools are available both from transient stability and from the case info displays
- Goal is to provide insight into the power system results, either from studies like transient stability or from measurements (e.g., PMUs)

Small Signal Analysis and Measurement-Based Modal Analysis



- Small signal analysis has been used for decades to determine power system frequency response
 - It is a model-based approach that considers the properties of a power system linearized about an operating point
 - PowerWorld Simulator does single-machine, infinite bus (SMIB) small signal analysis
- Measurement-based modal analysis determines the dynamic properties of a system
 - Input can either be measurements from PMUs or transient stability results

Ring-down Modal Analysis



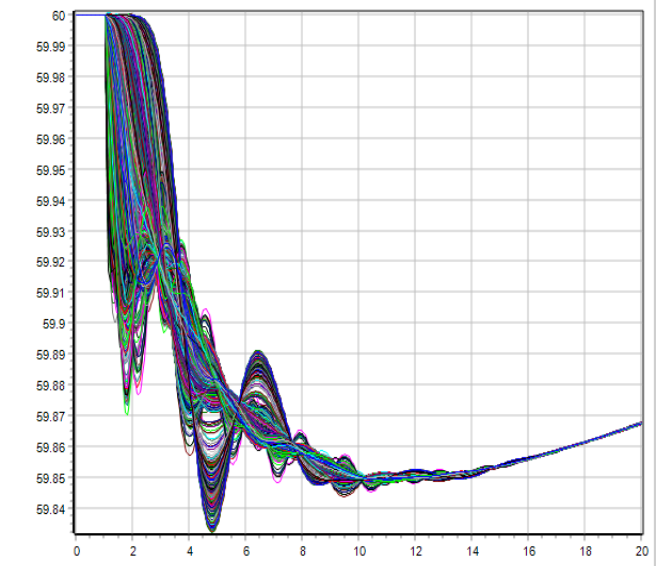
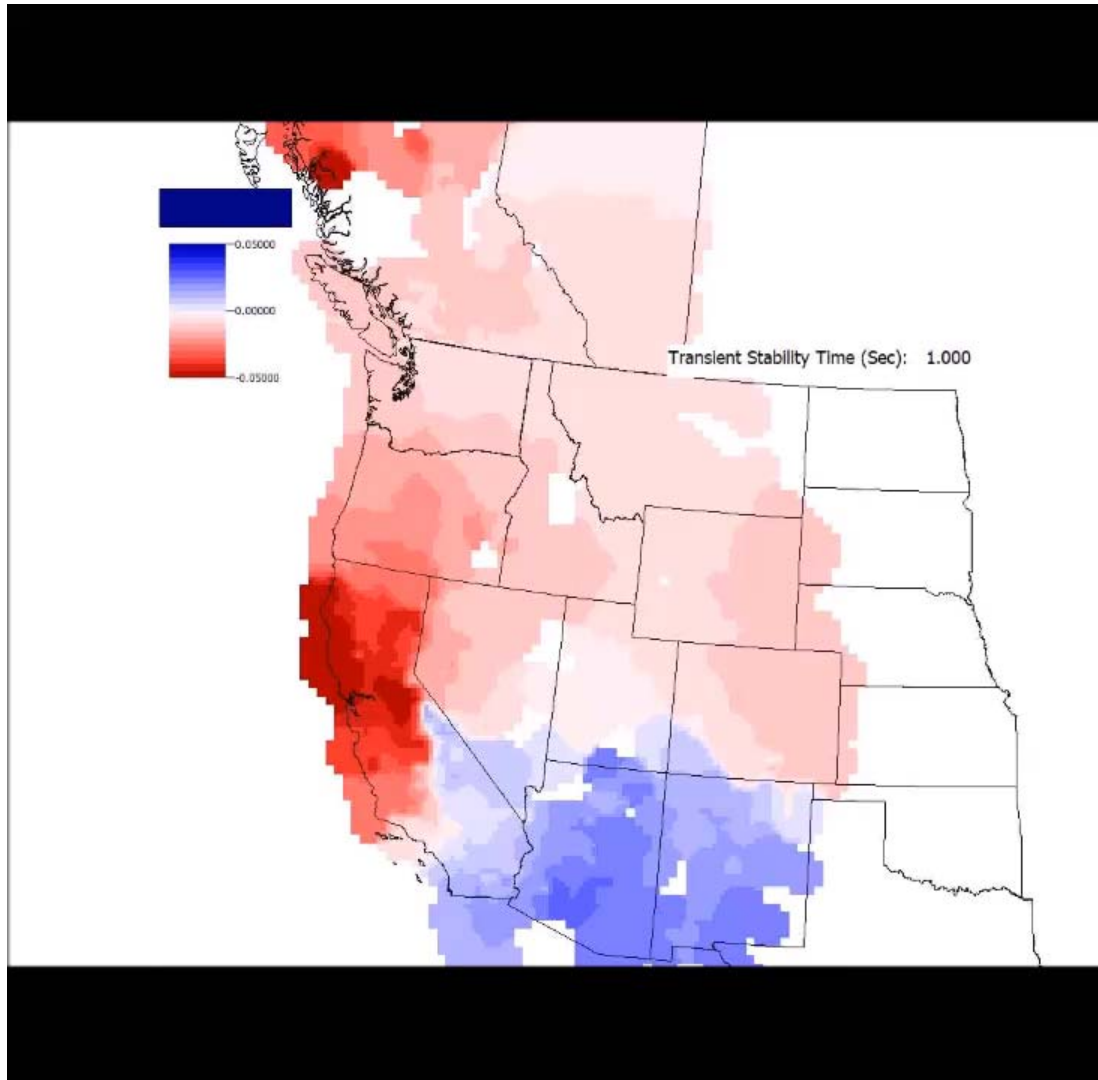
- Ring-down analysis seeks to determine the frequency and damping of key power system modes following some disturbance
- There are several different techniques, with the Prony approach the oldest (from 1795)
- Regardless of technique, the goal is to represent the response of a sampled signal as a set of exponentially damped sinusoids (modes)

$$y(t) = \sum_{i=1}^q A_i e^{\sigma_i t} \cos(\omega_i t + \phi_i) \quad \text{Damping (\%)} = \frac{-\alpha_i}{\sqrt{\alpha_i^2 + \omega_i^2}} \times 100$$

Movie of 0.611 Hz Mode



Keep in mind the mode data is being extracted from the full system response



PowerWorld Modal Analysis Techniques



- PowerWorld has implemented several modal analysis techniques
 - Variable Projection Method (VPM); the VPM was first applied to power systems at UW-Madison through BPA funding
 - Matrix Pencil Method (MPM); the MPM is the first step in the VPM, but can be used independently
 - Dynamic Model Decomposition (DMD); DMD is fast, but requires multiple signals
- For all, computation increases substantially with the number of sample points

Modal Analysis in PowerWorld

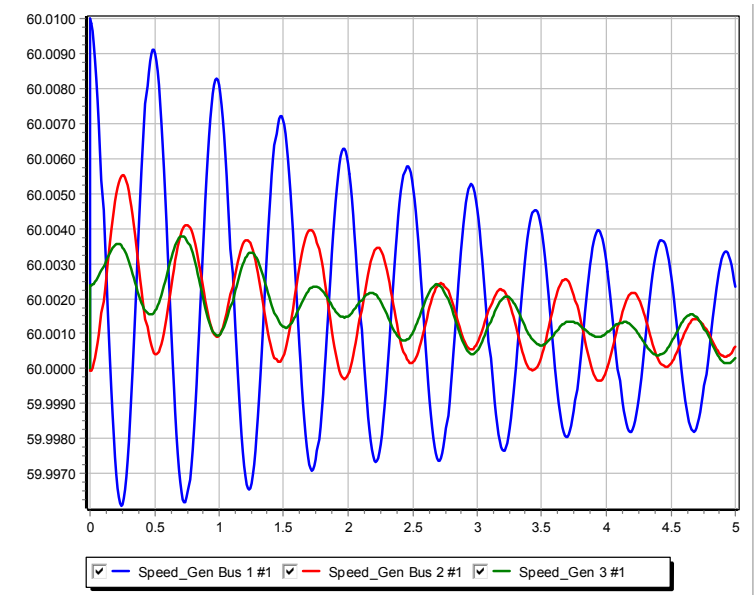
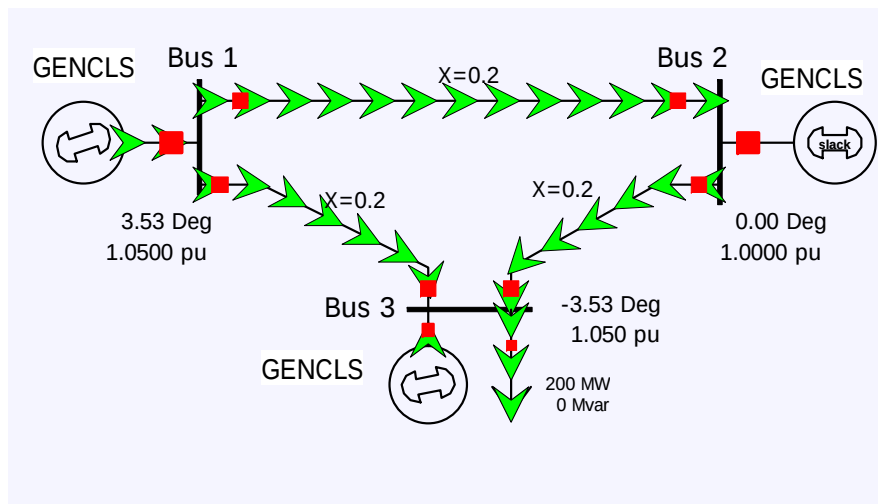


- Our goal is to make modal analysis easy to use, and easy to visualize the results
- Goal is to provide a tool that could be used with either transient stability results or actual system signals (e.g., from PMUs)
- Two ways to access in PowerWorld
 - On the Transient Stability Analysis form left menu, Modal Analysis (right below SMIB Eigenvalues)
 - By right-clicking on a transient stability or plot case information display, and selecting **Modal Analysis Selected Columns** or **Modal Analysis All Columns**

Modal Analysis: Three Generator Example



- A short fault at $t=0$ gets the below three generator case oscillating with multiple modes (mostly clearly visible for the red and the green curves)
 - CaseB3_CLS_3Gen_Damped



Simple VPM Three Generator Example



- Run the transient stability for 5 seconds
- One way to do modal analysis is on the Transient Stability Display select **Modal Analysis**, then **Open Modal Analysis Form** to display the Modal Analysis Form, load the data from the Gen_Speed Plot and click **Do Modal Analysis**
 - This does modal analysis simultaneously for all three generator speed curves (signals)
- Alternatively, select **Results from RAM**, view just the generator speed fields, right-click and select **Modal Analysis All Columns**

Transient Stability Modal Analysis Page



Key results are shown in the upper-right of the form. There are two main models, one at 2.03Hz with 1.7% damping, and one at 1.51 with 1.1% damping. The bottom portion of the display provides a summary of how well each signal was matched, and by right-clicking on the signal, provides more details

Modal Analysis Form

Modal Analysis Status: Solved at 4/27/2018 10:50:51 AM

Data Source Type

☐ From Plot ☐ File, Comtrade CFF
☐ File, WECC CSV 2 ☐ File, Comtrade CFG
☐ File, JSIS Format ☒ None, Existing Data

Calculation Method

☒ Variable Projection
☐ Matrix Pencil (Once)
☐ Optimal Matrix Pencil
☐ Dynamic Mode Decomposition

Data Source Inputs from Plots or Files

From Plot: Gen_Speed
 From File: Browse

Just Load Signals **Group Disabled for Existing Data**

Do Modal Analysis
 Save in JSIS Format Save to CSV

Data Sampling Time (Seconds) and Frequency (Hz)

Start Time: 0.0010 End Time: 5.000
 Maximum Hz: 5.000 Update Sampled Data

Results

Number of Complex and Real Modes: 3 ☒ Include Detrend in Reproduced Signals
 Lowest Percent Damping: 1.195 ☐ Subtract Reproduced from Actual
 Update Reproduced Signals

Real and Complex Modes - Editable to Change Initial Guesses

	Frequency (Hz)	Damping (%)	Largest Weighted Percentage for Mode	Signal Name of Largest Weighted Percentage for Mode	Lambda	Include in Reproduced Signal
1	2.029	1.713	99.8545	Gen Bus 1 #1 S	-0.2184	YES
2	1.513	1.195	49.8403	Gen 3 #1 Speed	-0.1136	YES
3	0.190	10.098	18.5012	Gen 3 #1 Speed	-0.1213	YES

Input Data, Actual | Sampled Input Data | Signals | Options | Reproduced Data

	Type	Name	Units	Description	Include	Include Reproduced	Detrend Parameter A	Detrend Parameter B	Post-Detrend Number Zeros	Post-Detrend Standard Deviation	Solved	Average Error, Unscaled	Average Error Scaled by S
1	Gen	Gen Bus 1 #1 Speed		Speed	YES	YES	1.0000	-0.0000	0	0.000	YES	0.0000	0.0
2	Gen	Gen Bus 2 #1 Speed		Speed	YES	YES	1.0000	-0.0000	0	0.000	YES	0.0000	0.0
3	Gen	Gen 3 #1 Speed		Speed	YES	YES	1.0000	-0.0000	0	0.000	YES	0.0000	0.0

Transient Stability

Modal Analysis Page: Some Key Fields



When used with case info displays the data source is the existing data loaded from the case info

Type	Name	Units	Description	Include	Include Reproduced	Detrend Parameter A	Parameter B
1 Gen	Gen Bus 1 #1 Speed	Speed	Speed	YES	YES	1.0000	
2 Gen	Gen Bus 2 #1 Speed	Speed	Speed	YES	YES	1.0000	
3 Gen	Gen 3 #1 Speed	Speed	Speed	YES	YES	1.0000	

Select time and calculation method. Best to select the start time after the last event. The Maximum Hz field determines the highest frequency that can be determined. Higher values result in more computation

Right-click on signal to view its dialog

Select signals to include in determining modes and the signals to include in the reproduced results

Three Generator Example: Signal Dialog



- The Signal Dialog provides details about each signal, including its modal components and a comparison between the original and reproduced signals (example for gen 3)

Modal Analysis Signal Dialog

Name: Gen 3 #1 Speed
Type: Gen
Units:
Description: Speed

☒ Include in Modal Analysis

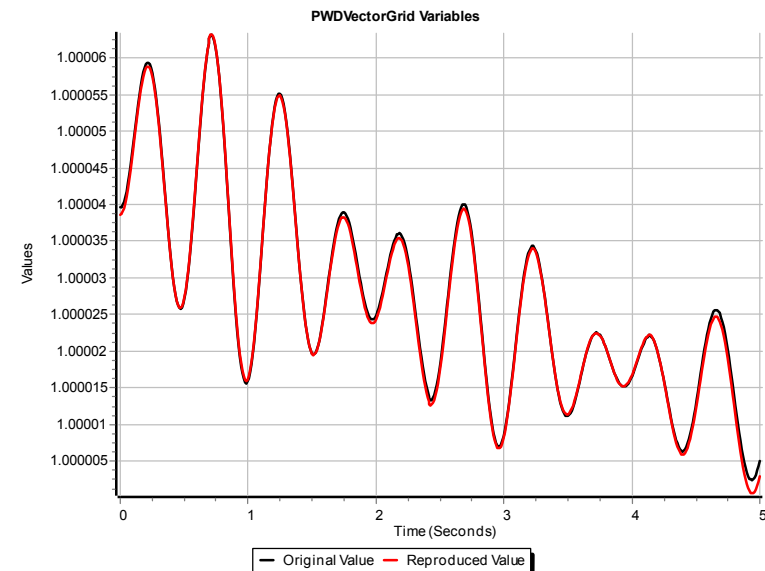
Data Detrend Parameters
Detrend Model = $A + B*(t-t_0) + C*(t-t_0)^2$ Used Detrend Model: Linear
☒ Use Case Default Detrend Model
Signal Specific Detrend Model: ☒ None ☐ Linear ☐ Constant ☐ Quadratic
Parameter A: 1.0000
Parameter B: -0.0000
Parameter C: 0.0000
Standard Deviation (SD): 0.0000

Output Summary
Average Error, Scaled by SD: 0.0000
Average Error, Unscaled: 0.0000
Cost Function Value, Scaled: 0.0088
☒ Include Detrend in Reproduced Signal
Update Reproduced

Actual Input | Sampled Input | Fast Fourier Transform Results | Modal Results | Original and Reproduced Signal Comparison

	Time (Seconds)	Original Value	Reproduced Value	Difference
1	0.001	1.000	1.000	-0.000
2	0.010	1.000	1.000	-0.000
3	0.020	1.000	1.000	-0.000
4	0.030	1.000	1.000	-0.000
5	0.040	1.000	1.000	-0.000
6	0.050	1.000	1.000	-0.000
7	0.060	1.000	1.000	-0.000
8	0.070	1.000	1.000	-0.000
9	0.080	1.000	1.000	-0.000
10	0.090	1.000	1.000	-0.000
11	0.100	1.000	1.000	-0.000
12	0.110	1.000	1.000	-0.000
13	0.120	1.000	1.000	-0.000
14	0.130	1.000	1.000	-0.000
15	0.140	1.000	1.000	-0.000
16	0.150	1.000	1.000	-0.000
17	0.160	1.000	1.000	-0.000
18	0.170	1.000	1.000	-0.000
19	0.180	1.000	1.000	-0.000
20	0.190	1.000	1.000	-0.000
21	0.200	1.000	1.000	-0.000

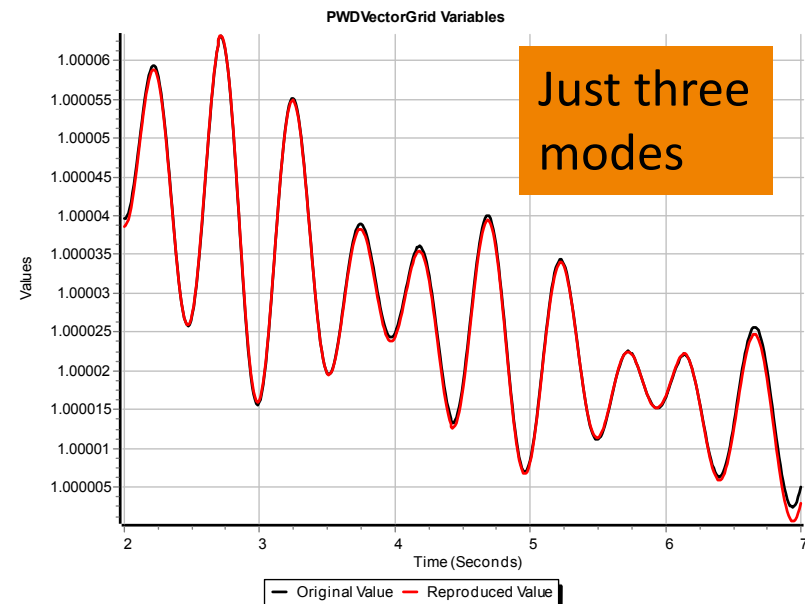
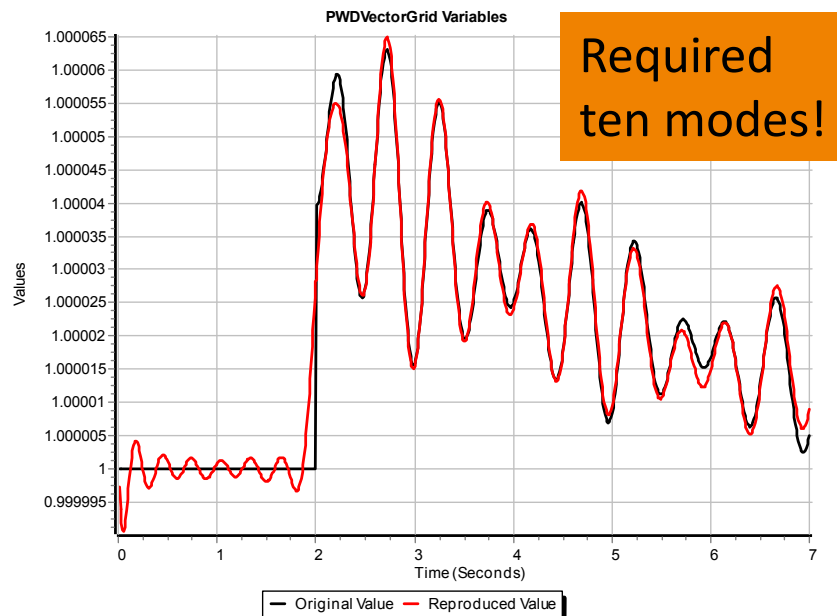
OK ? Help Print



Caution: Setting in Time Incorrectly Can Result in Unexpected Results!



- Assume the system is run with no disturbance for two seconds, and then the fault is applied
 - The incorrect approach would be to try to match the entire signal; rather just match from after the fault



Three Generator Example: Looking at Selected Modes



- The individual modes (or any combination) can also be viewed

Modal Analysis Form

Solved at 4/27/2018 10:50:51 AM

Data Source Type

☐ From Plot ☐ File, Comtrade CFF
☐ File, WECC CSV 2 ☐ File, Comtrade CFG
☐ File, JESIS Format ☒ None, Existing Data

Calculation Method

☒ Variable Projection
☐ Matrix Pencil (Once)
☐ Optimal Matrix Pencil
☐ Dynamic Mode Decomposition

Do Modal Analysis

Save in JESIS Format Save to CSV

Data Source Inputs from Plots or Files

From Plot: Gen_Speed

From File: [Browse]

Just Load Signals Group Disabled for Existing Data

Data Sampling Time (Seconds) and Frequency (Hz)

Start Time: 0.0010 End Time: 5.000
Maximum Hz: 5.000 Update Sampled Data

Results

Number of Complex and Real Modes: 3

☐ Include Detrend in Reproduced Signals
☐ Subtract Reproduced from Actual

Lowest Percent Damping: 1.195

Update Reproduced Signals

Real and Complex Modes - Editable to Change Initial Guesses

	Frequency (Hz)	Damping (%)	Largest Weighted Percentage for Mode	Signal Name of Largest Weighted Percentage for Mode	Lambda	Include Reproduced Signal
1	2.029	1.713	99.8545	Gen Bus 1 #1 S	-0.2184	NO
2	1.513	1.195	49.8403	Gen 3 #1 Speed	-0.1136	YES
3	0.190	10.098	18.5012	Gen 3 #1 Speed	-0.121	YES

Input Data, Actual Sampled Input Data Signals Options Reproduced Data

	Time (sec)	Gen Bus 1 #1 Speed	Gen Bus 2 #1 Speed	Gen 3 #1 Speed
1	0.001	-0.000	-0.000	0.000
2	0.010	-0.000	-0.000	0.000
3	0.020	-0.000	-0.000	0.000
4	0.030	-0.000	-0.000	0.000
5	0.040	-0.000	-0.000	0.000
6	0.050	-0.000	-0.000	0.000
7	0.060	-0.000	-0.000	0.000
8	0.070	-0.000	-0.000	0.000
9	0.080	-0.000	-0.000	0.000
10	0.090	-0.000	-0.000	0.000
11	0.100	-0.000	-0.000	0.000
12	0.110	-0.000	-0.000	0.000
13	0.120	-0.000	-0.000	0.000
14	0.130	-0.000	-0.000	0.000
15	0.140	-0.000	-0.000	0.000
16	0.150	-0.000	-0.000	0.000
17	0.160	-0.000	-0.000	0.000

Close Help Print

Allows the removal of the detrend

Select to update the reproduced signals

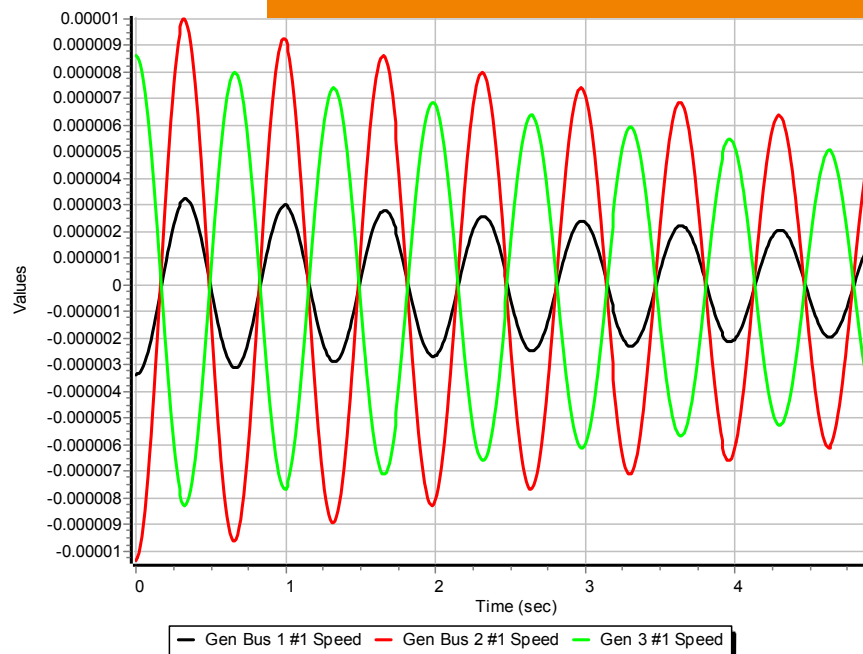
Allows inclusion of selected modes in the reproduced signals

View the reproduced signals with just the selected modes

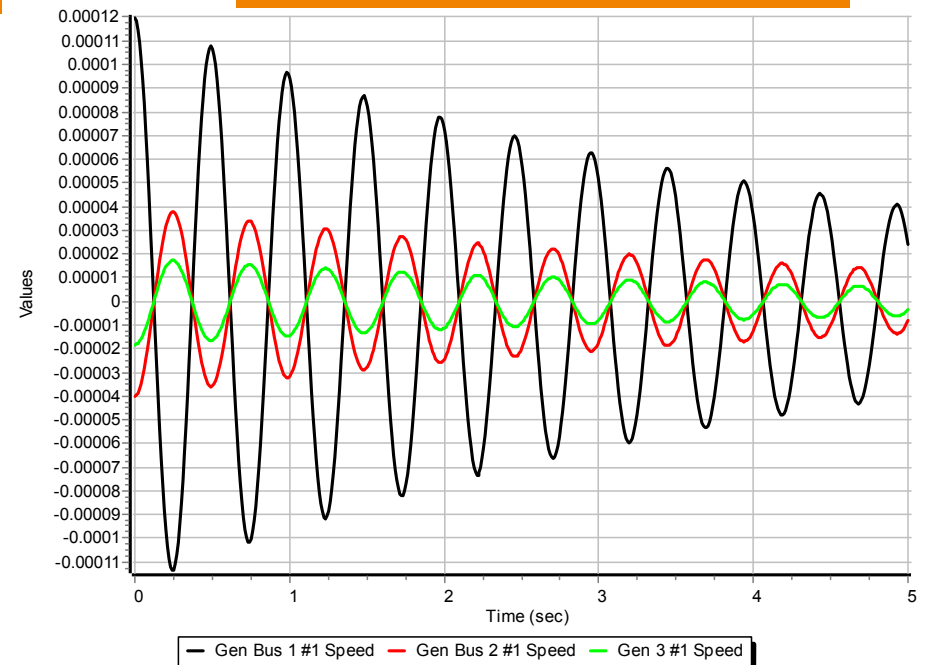
Three Generator Example: Looking at Selected Modes



1.51 Hz Mode: Generators
1 and 2 are In Phase



2.03 Hz Mode: Generators
2 and 3 are In Phase



Mode Analysis Mode Details Dialog



- The magnitude and angle of the contribution of a mode in each signal can be viewed by right-clicking on the desired mode

Modal Analysis Form

Modal Analysis Status: Solved at 4/27/2018 1:06:21 PM

Data Source Type: ☒ From Plot ☐ File, Contradict CFF ☐ File, WECC CSV 2 ☐ File, Contradict CFG ☐ File, JSSS Format ☐ None, Existing Data

Calculation Method: ☒ Variable Projection ☐ Matrix Pencil (Once) ☐ Optimal Matrix Pencil ☐ Dynamic Mode Decomposition

Data Source Inputs from Plots or Files: From Plot: Gen_Speed From File: [Browse] Just Load Signals

Data Sampling Time (Seconds) and Frequency (Hz): Start Time: 0.000 End Time: 5.000 Maximum Hz: 5.000 Update Sampled Data

Results: Number of Complex and Real Modes: 3 Lowest Percent Damping: 1.195 Include Detrend in Reproduced Signals: ☒ Subtract Reproduced from Actual: ☐ Update Reproduced Signals

Frequency (Hz)	Damping (%)	Largest Weighted Percentage for Mode	Signal Name of Largest Weighted Percentage for Mode	Lambda	Include in Reproduced Signal
2.03	1.718	99.8703	Speed \ Gen Bus 1 #1	-0.2190	YES
2	1.513	1.195	49.8803 Speed \ Gen 3 #1	-0.1137	YES
3	0.193	18.4614	Speed \ Gen 3 #1	-0.0916	YES

Input Data, Actual, Sampled Input Data, Signals, Options, Reproduced Data

Type	Name	Units	Description	Include	Include Reproduced	Detrend Parameter A	Detrend Parameter B	Post-Detrend Number Zeros	Post-Detrend Standard Deviation	Solved	Average Error, Unscaled	Average Error, Scaled by SD	Maximum Error, Unscaled	Cost Function	S. Ref.
1	Gen	Speed \ Gen Bus 1 #1		YES	YES	1.0000	-0.0000	0	0.000	YES	0.0000	0.0000	0.0000	0.0041	NO
2	Gen	Speed \ Gen Bus 2 #1		YES	YES	1.0000	-0.0000	0	0.000	YES	0.0000	0.0000	0.0000	0.0054	NO
3	Gen	Speed \ Gen 3 #1		YES	YES	1.0000	-0.0000	0	0.000	YES	0.0000	0.0000	0.0000	0.0084	NO

Right-click and select
Show Dialog

Modal Analysis Mode Details

Frequency (Hz) and Damping (%): 2.029 Hz, Damping = 1.718%

Transfer Results from Selected Column to Object Custom Floating Point Field: Custom Floating Point Field: 1 Transfer Results

Type	Name	Units	Description	Post-Detrend Standard Deviation	Angle (Deg)	Magnitude, Unscaled	Magnitude Scaled by SD	Cost Function
1	Gen	Speed \ Gen Bus 1 #1		0.000	8.630	0.000	2.183	0.0041
2	Gen	Speed \ Gen Bus 2 #1		0.000	-172.558	0.000	2.064	0.0054
3	Gen	Speed \ Gen 3 #1		0.000	-172.128	0.000	1.902	0.0084

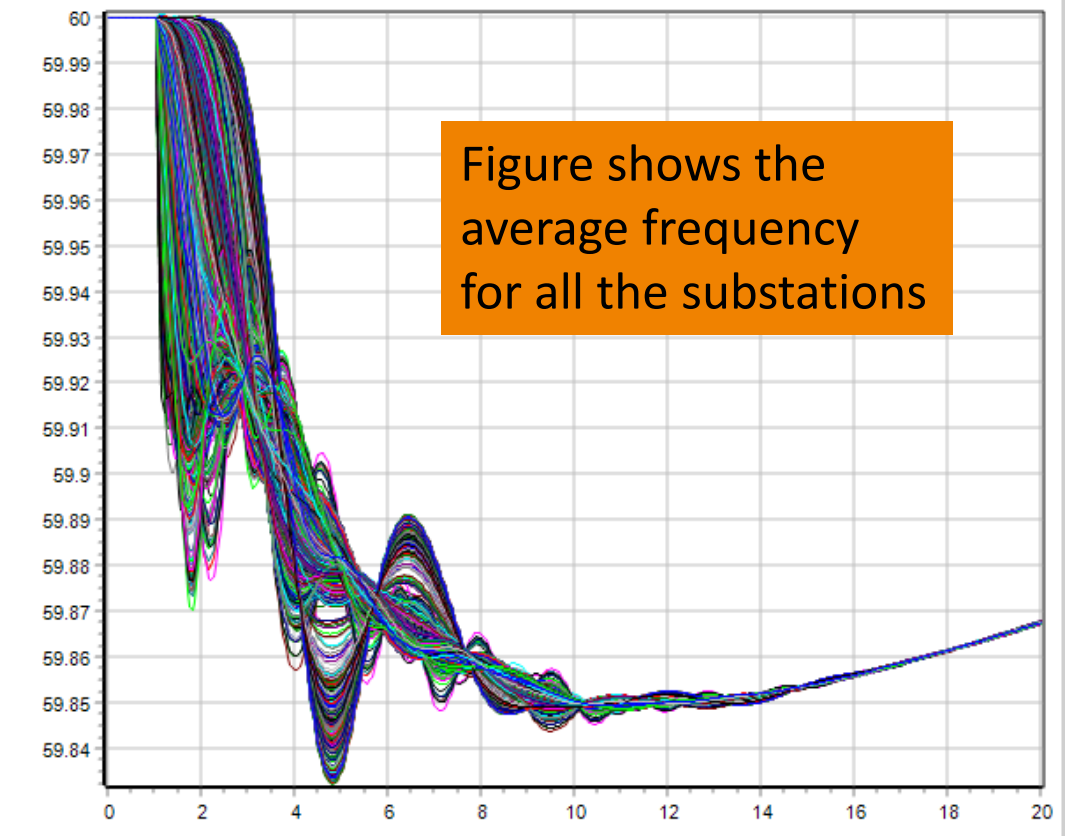
Close

Notice for the 2.03 Hz Mode
the bus 2 and 3 generators
are in phase

Larger Case Example



- This a 22,000 bus case with 8400 substations. Contingency is the double Palo Verde outage
- Goal is to provide insight into the system response
- Focus is on being able to handle many signals, which requires visualization

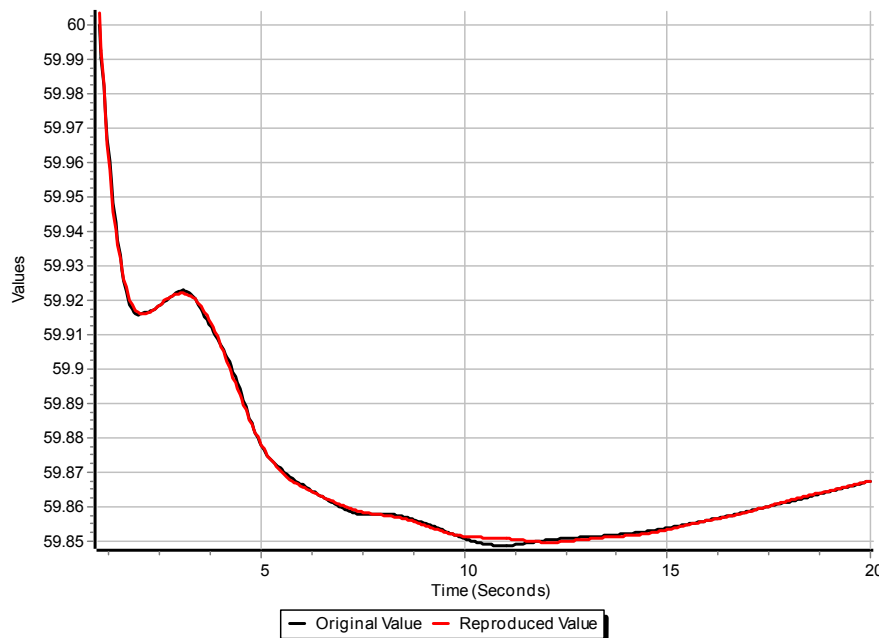


Modal Analysis With Many Signals: The Best and The Worst

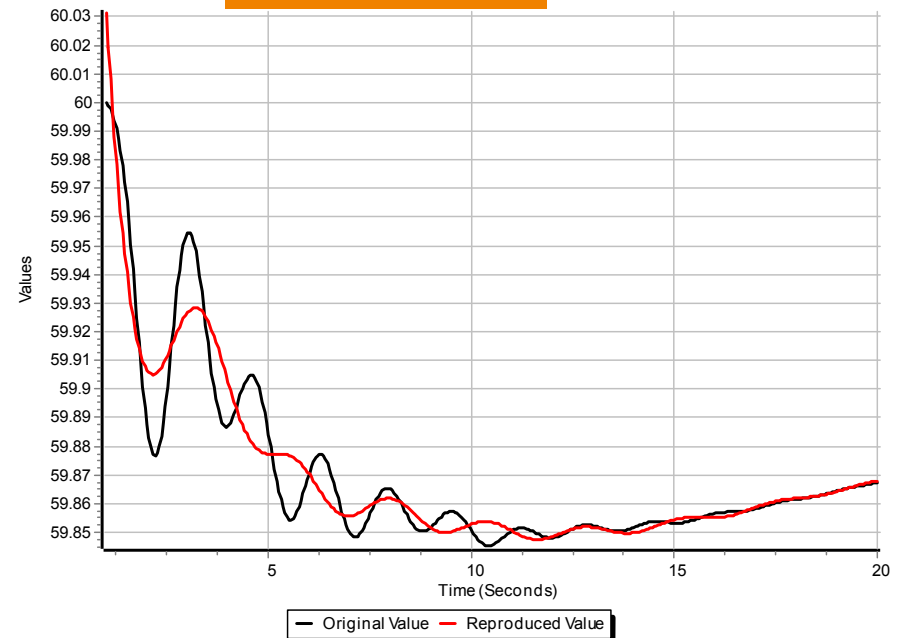


- With one signal used (sub 18004 freq) to get the modes, there are four: 0, 0.029, 0.21, 0.42Hz

Best Match



Worst Match



The robustness of this process can be quantified by looking at both the average cost function and the maximum over all 8400 signals (0.008 and 0.028 here)

Improving Modal Analysis With Many Signals



- The modal analysis can be improved by including more signals in the calculation of the modes. Yet only a small number need to be included
- For example, by just adding the signal with the highest cost function we now get a total of five modes and reduce average cost function from 0.008 to 0.0054, with the largest value reduced from 0.028 to 0.02
- The Iterative Matrix Pencil optimizes this process by iteratively adding more signals

Iterative Matrix Pencil Approach



- This approach iteratively adds the signal with the highest cost function
 - Usually about ten gives quite good results; this gives 8 modes, and reduces the average error to 0.0025 and the maximum to 0.0088

Modal Analysis Form

Modal Analysis Status: Solved at 4/28/2018 8:36:06 AM

Data Source Type

☐ From Plot
 ☐ File, Comtrade CFF
 ☐ File, WECC CSV 2
 ☐ File, Comtrade CFG
 ☐ File, JSIS Format
 ☒ None, Existing Data

Data Source Inputs from Plots or Files

From Plot: Substation_Frequency Average

From File: Browse

Just Load Signals **Group Disabled for Existing Data**

Data Sampling Time (Seconds) and Frequency (Hz)

Start Time: 1.000 End Time: 20.000

Maximum Hz: 5.000 Update Sampled Data

Calculation Method

☐ Variable Projection
 ☐ Matrix Pencil (Once)
 ☒ Optimal Matrix Pencil
 ☐ Dynamic Mode Decomposition

Do Modal Analysis

Save in JSIS Format Save to CSV

Optimal Matrix Pencil Options

Number of Iterations: 10

☒ Initial All Signals to be Not Included

Current Iteration: 10

Results

Number of Complex and Real Modes: 8

Lowest Percent Damping: -23.973

☒ Include Detrend in Reproduced Signals

☐ Subtract Reproduced from Actual

Update Reproduced Signals

Real and Complex Modes - Editable to Change Initial Guesses

	Frequency (Hz)	Damping (%)	Largest Weighted Percentage for Mode	Signal Name of Largest Weighted Percentage for Mode	Lambda	Include in Reproduced Signal
1	2.313	12.679	2.6332	Substation Sur	-1.8574	YES
2	0.864	11.654	10.7161	Substation Nev	-0.6368	YES
3	0.644	18.274	18.0253	Substation Cor	-0.7523	YES
4	0.611	11.593	36.4600	Substation Cor	-0.4484	YES
5	0.021	-23.973	92.4611	Substation ARE	0.0333	YES
6	0.000	100.000	37.6719	Substation Har	-0.4357	YES
7	0.348	15.730	18.0015	Substation Syn	-0.3484	YES
8	0.218	26.336	38.0296	Substation Syn	-0.3747	YES

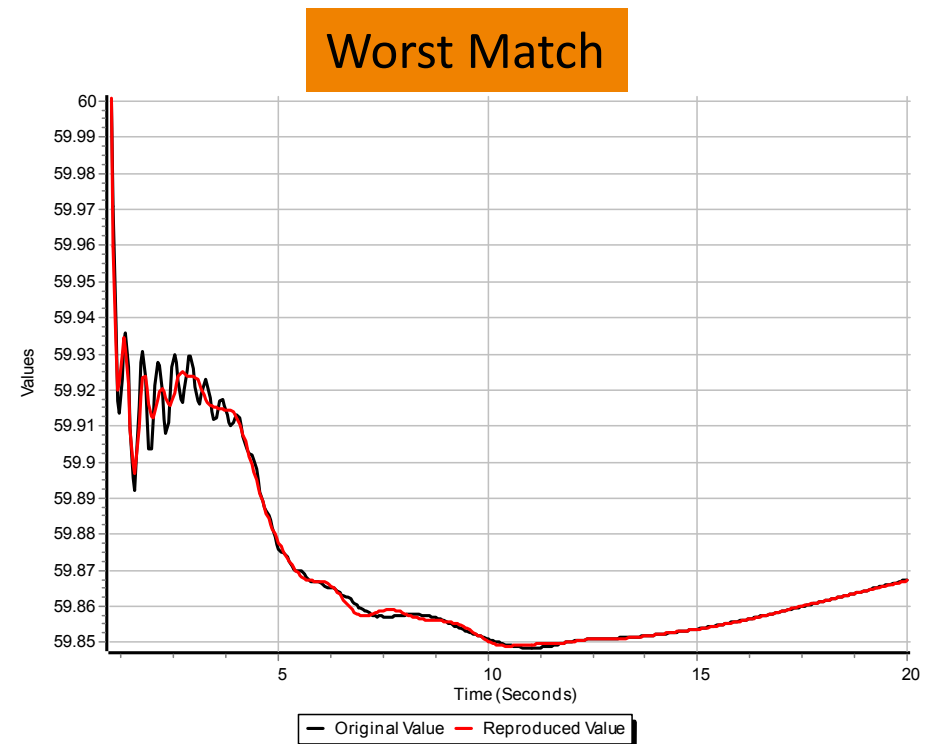
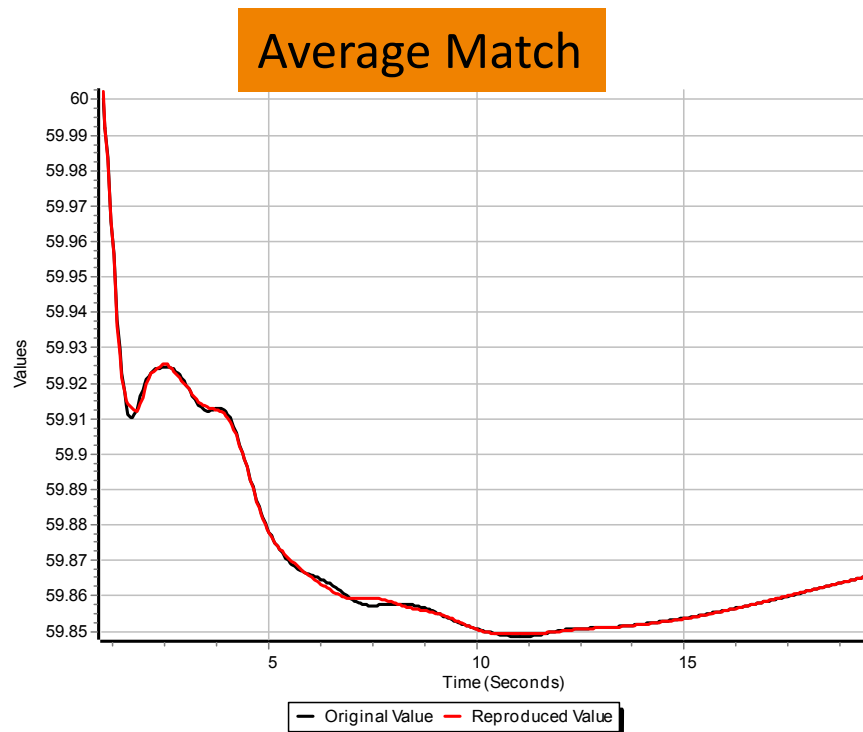
Input Data, Actual | Sampled Input Data | Signals | Options | Reproduced Data

	Time	Name	Units	Description	Include	Include	Detrend	Detrend	Post Detrend	Post Detrend	Solved	Average Error	Average
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Modal Analysis With Many Signals: The Average and The Worst



- The below figures should an average signal reproduction and the worst signal reproduction



PowerWorld Modal Analysis: Takeaways So Far



- Modal analysis can be quickly done on a large number of signals
 - Computationally is an $O(N^3)$ process where N is the number of sample points and varies linearly with the number of included signals
 - Number of sample points is automatically determined from the highest desired frequency (The Nyquist-Shannon sampling theory requires sampling at twice the highest desired frequency)
 - Determining how signals are manifested in modes is extremely fast

Mode Details



Modal Analysis Form

Modal Analysis Status: Solved at 6/15/2018 8:33:28 AM

Data Source Type:
☐ From Plot
☐ File, WECC CSV 2
☐ File, JSIS Format
☐ File, Comtrade CFF
☐ File, Comtrade CFG
☒ None, Existing Data

Data Source Inputs from Plots or Files
 From Plot: Substation_Frequency Average
 From File: Browse
 Just Load Signals **Group Disabled for Existing Data**

Data Sampling Time (Seconds) and Frequency (Hz)
 Start Time: 1.000 End Time: 20.000
 Maximum Hz: 5.000 Update Sampled Data

Calculation Method:
☐ Variable Projection
☐ Matrix Pencil (Once)
☒ Iterative Matrix Pencil
☐ Dynamic Mode Decomposition

Do Modal Analysis
 Save in JSIS Format Save to CSV

Optimal Matrix Pencil Options
 Number of Iterations: 10
☒ Initial All Signals to be Not Included
 Current Iteration: 10

Results
 Number of Complex and Real Modes: 8
 Lowest Percent Damping: -23.973
☐ Include Detrend in Reproduced Signals
☐ Subtract Reproduced from Actual
 Update Reproduced Signals

Real and Complex Modes - Editable to Change Initial Guesses

	Frequency (Hz)	Damping (%)	Largest Weighted Percentage for Mode	Signal Name of Largest Weighted Percentage for Mode	Lambda	Include in Reproduced Signal
1	2.313	12.679	2.6332	Substation Sur	-1.8574	YES
2	0.864	11.654	10.7161	Substation Nev	-0.6368	YES
3	0.644	18.274	18.0253	Substation Cor	-0.7523	YES
4	0.611	11.593	36.4600	Substation Cor	-0.4484	YES
5	0.021	-23.973	92.4611	Substation ARE	0.0333	YES
6	0.000	100.000	37.6719	Substation Har	-0.4357	YES
7	0.348	15.730	18.0015	Substation Syn	-0.3484	YES
8	0.218	26.336	38.0296	Substation Syn	-0.3747	YES

Modal Analysis Mode Details

Frequency (Hz) and Damping (%) 0.611 Hz, Damping = 11.593%

Transfer Results from Selected Column to Object Custom Floating Point Field
 Custom Floating Point Field: 1 Transfer Results

Type	Name	Units	Description	Post-Detrend Standard Deviation	Angle (Deg)	Magnitude, Unscaled	Magnitude Scaled by SD	Cost Function
1 Substation	Substation Smokey Poi		Average Freq	0.031	-179.946	0.009	0.308	0.0019
2 Substation	Substation N. Stanwoc		Average Freq	0.031	-179.802	0.009	0.308	0.0019
3 Substation	Substation Lake Good		Average Freq	0.031	-179.802	0.009	0.308	0.0019
4 Substation	Substation Sils (30004)		Average Freq	0.031	-179.758	0.009	0.308	0.0019
5 Substation	Substation Springville		Average Freq	0.022	-179.163	0.013	0.588	0.0008
6 Substation	Substation Edgecomb		Average Freq	0.031	-179.074	0.009	0.308	0.0019
7 Substation	Substation Portage (25		Average Freq	0.031	-178.785	0.009	0.308	0.0019
8 Substation	Substation Jim Creek (E		Average Freq	0.031	-178.077	0.009	0.307	0.0019
9 Substation	Substation E. Arlingtor		Average Freq	0.031	-178.037	0.009	0.307	0.0019
10 Substation	Substation Thorne (337		Average Freq	0.024	-178.022	0.015	0.620	0.0027
11 Substation	Substation Hawthorne		Average Freq	0.024	-177.984	0.015	0.620	0.0027
12 Substation	Substation Railroad (34		Average Freq	0.024	-177.984	0.015	0.620	0.0027
13 Substation	Substation Tv Peak (34		Average Freq	0.024	-177.983	0.015	0.620	0.0027
14 Substation	Substation Isom (25066		Average Freq	0.024	-177.983	0.015	0.620	0.0027
15 Substation	Substation Kincaid (34		Average Freq	0.024	-177.980	0.015	0.620	0.0027
16 Substation	Substation Milna (3495		Average Freq	0.024	-177.979	0.015	0.620	0.0027
17 Substation	Substation Borealis (25		Average Freq	0.024	-177.975	0.015	0.620	0.0027
18 Substation	Substation Tap (34956		Average Freq	0.024	-177.972	0.015	0.620	0.0027
19 Substation	Substation Sweetwater		Average Freq	0.024	-177.972	0.015	0.620	0.0027
20 Substation	Substation Bomb Dispi		Average Freq	0.024	-177.972	0.015	0.620	0.0027
21 Substation	Substation CA Border (		Average Freq	0.024	-177.971	0.015	0.620	0.0027
22 Substation	Substation Fletcher (34		Average Freq	0.024	-177.971	0.015	0.620	0.0027
23 Substation	Substation Lucky Boy (		Average Freq	0.024	-177.967	0.015	0.620	0.0027
24 Substation	Substation Scheelite (3		Average Freq	0.024	-177.943	0.015	0.620	0.0027
25 Substation	Substation Rawhide (3		Average Freq	0.024	-177.943	0.015	0.620	0.0027
26 Substation	Substation Austin (337		Average Freq	0.024	-177.113	0.011	0.465	0.0023
27 Substation	Substation AUSTIN (64		Average Freq	0.024	-177.092	0.011	0.464	0.0023
28 Substation	Substation Antelope (3		Average Freq	0.022	-176.777	0.012	0.533	0.0012
29 Substation	Substation Twilight (25		Average Freq	0.022	-176.566	0.011	0.522	0.0012
30 Substation	Substation Pastoria (33		Average Freq	0.022	-176.427	0.011	0.489	0.0008
31 Substation	Substation Dawn (2506		Average Freq	0.022	-176.418	0.011	0.521	0.0012
32 Substation	Substation Squirrel (25		Average Freq	0.022	-175.963	0.011	0.515	0.0012
33 Substation	Substation Plainview (2		Average Freq	0.022	-175.811	0.011	0.516	0.0012

Post-Detrend Standard Deviation: 0.021
 Solved: YES
 Average Un

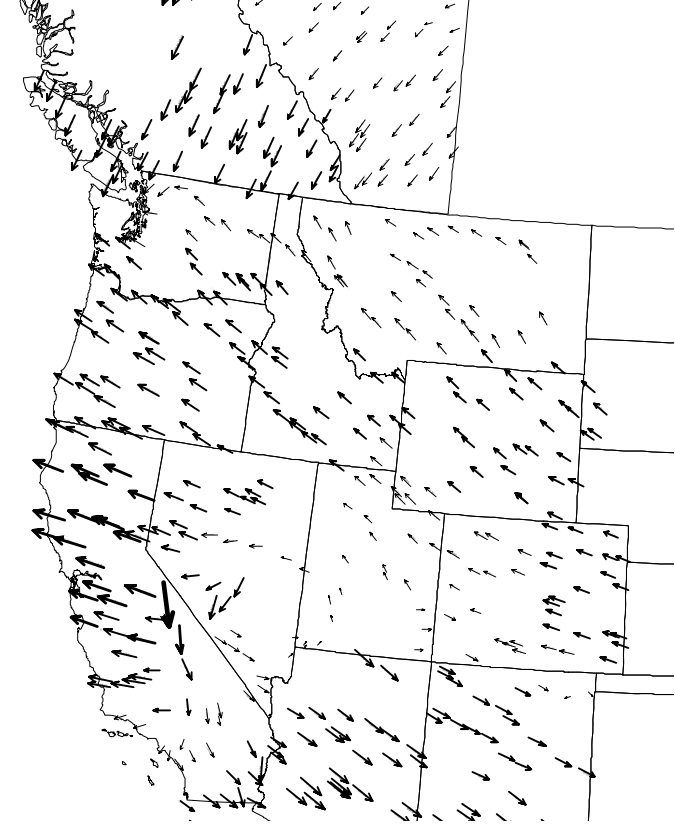
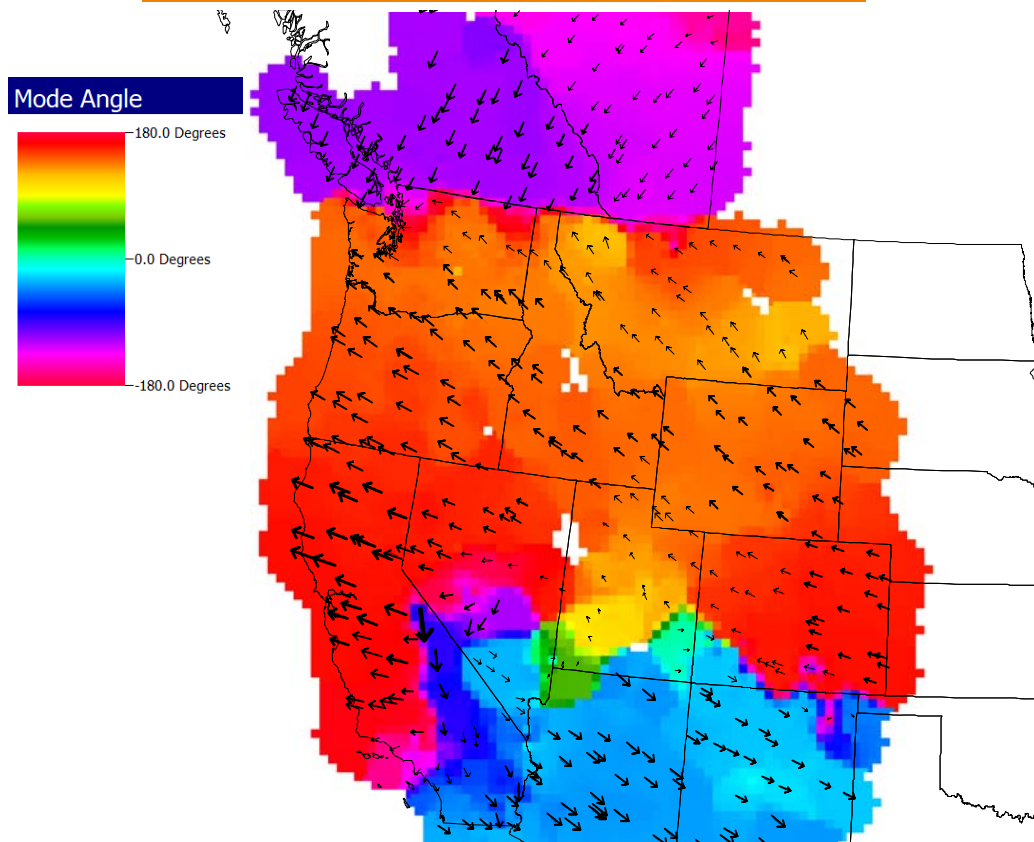
Lots of details are easily available, including being able to visualize individual modes

Visualization of 0.611 Mode



Visualization of the magnitude and angle of the mode at different locations

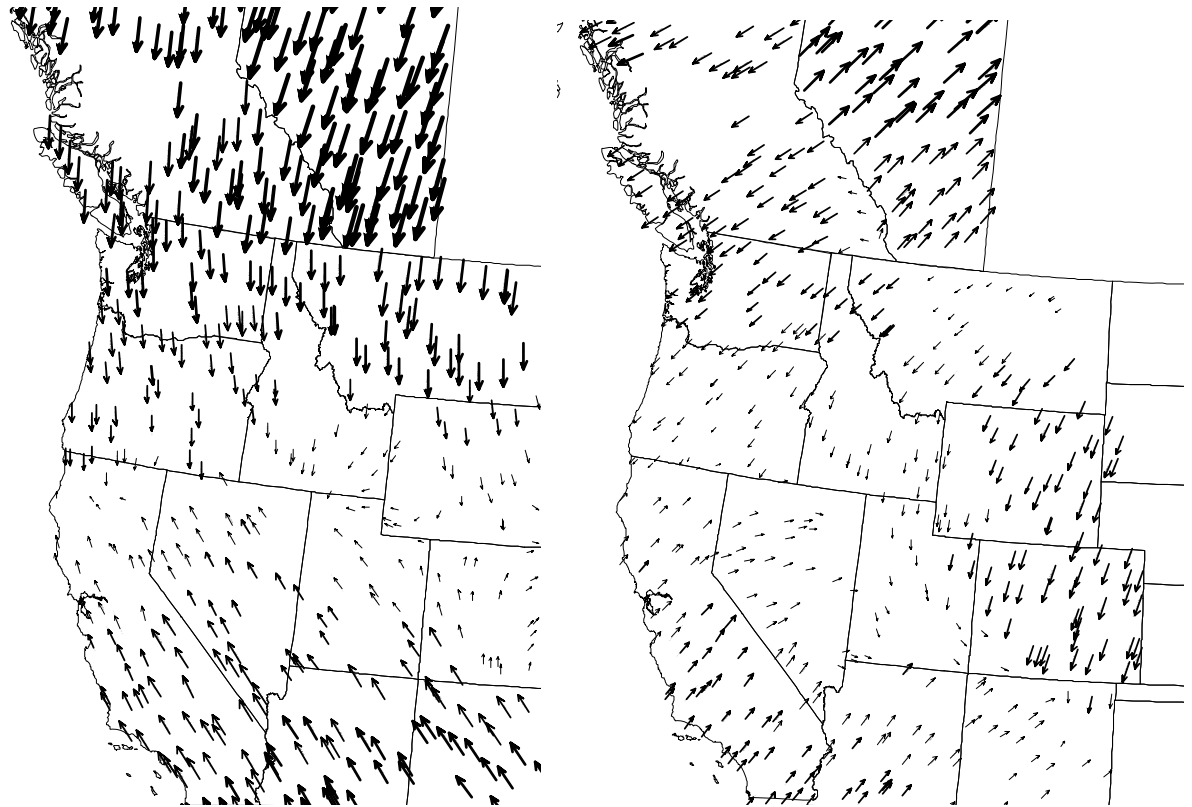
And, of course, there are many ways to visualize the values



Other Modes can be Quickly Visualized Using the Same GDV



- Just use the Mode Details Dialog to transfer values for a different mode to the Custom Float 1 and 2 fields
- Displays show the 0.218 and 0.348 Hz modes



Movie of 0.611 Hz Mode



Keep in mind the mode data is being extracted from the full system response

