Ringdown Analysis of WECC System Events

JSIS Meeting
Tempe, AZ
Jan. 21-23, 2014
Dan Trudnowski
dtrudnowski@mtech.edu
Background
Ringdown Analysis

• Prony, ERA, Matrix Pencil, etc.
• Estimates modal frequencies, damping, and shape from a transient (ringdown)
• Curve fit the following to a transient:

\[ y(t) = \sum_{i=1}^{n} B_i e^{\sigma t} \cos(2\pi f_d t + \phi_i) \]

\[ f_d = \text{Mode frequency (Hz)} \]
\[ \frac{100\sigma}{\sqrt{\sigma^2 + \omega_d}} = \text{Mode \% damping} \]
\[ B_i \angle \phi_i = \text{Residue} \cong \text{Mode shape} \]
Ringdown Analysis

• For first swing, system is often in a nonlinear condition.
• Typically need at least 2 full cycles of oscillation to obtain an accurate fit.
• Data must have a high signal-to-noise (SNR) ratio.
• Only dominant modes can be estimated.
  – Dominant = large residue, light damping.
• Best signal for Mode estimation
  – Relative Frequency
  – Can be estimated from voltage angles (better resolution).
• Requires user experience to judge accurate results!
Where to fit?

No meas noise

SNR = 20

SNR = 13

SNR = 8
Ringdown Tools
(Used by Trudnowski)

• BPA/PNNL Ringdown GUI
  – Very user friendly and good way to learn.
  – No longer supported.

• Script-driven general Prony tool
  – Easy to repeat results

• Script-driven batch WECC Prony tool
  – Specifically designed for WECC system modes
  – Automates mode selection
  – Designed to batch analyze MANY cases
  – Writes results to XLS and DOC files.
WECC Prony Tool (V3.1)

• Matlab script-driven batch Prony tool. Estimates mode frequency, damping, and shape.
• Specifically designed for WECC system-wide modes
  – NS Modes A (0.25 Hz),
  – NS Mode B (0.4 Hz)
  – EW Mode A (0.5 Hz)
  – MT-NW Mode (0.7 Hz),
  – BC-US Mode (0.6 Hz)
• Designed to batch analyze MANY cases
• Writes results to XLS and DOC files
  – Mode File: a CSV file with all mode frequency and damping estimates.
  – Shape Files: a CSV file for each mode.
  – WORD plot files: One for each input CSV file analyzed.
WECC Prony Tool – cont.

• Sliding window Prony conducted until two fits provide the same solution.
• Calculates average of specified pre-fault and/or post-fault signals.
• Main Matlab function: funPronyWECCcsvMultiCases.m