



Consulting Services

# POSITIVE SEQUENCE LOAD FLOW (PSLF\*) ZTOOLS



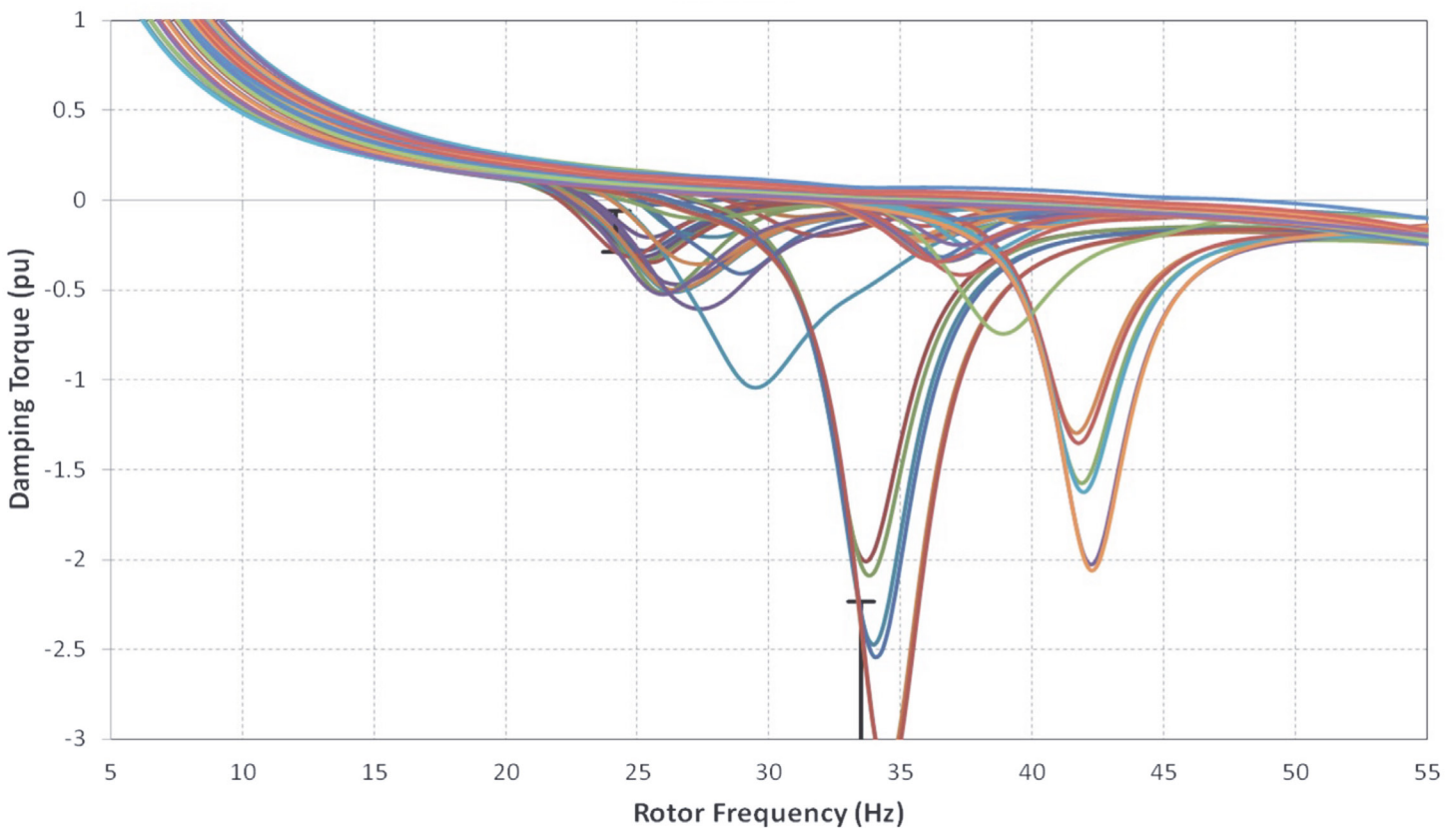
## Overview

PSLF Ztools is an add-on to PSLF that allows planners to analyze the impact of series capacitors on subsynchronous resonance (SSR) for thermal generation and subsynchronous control interaction (SSCI) for wind turbines. Ztools has been designed to allow analysis with a minimal amount of additional data and using existing PSLF databases. Ztools is used extensively by GE Vernova Consulting Services for SSR and SSCI analysis and in the design of mitigation. Results have been benchmarked against field tests, including during the commissioning of two SSR blocking filters.

Ztools analysis starts with a PSLF save case and dynamics data file, and an SStools outage and cases file. A single Ztools run can look at thousands of generation conditions, system conditions, outages and series capacitor variations.

Two types of calculations can be performed: SSR damping torque and impedance scan. Both of these involve calculating the equivalent system impedance looking into a bus or through a generator (or set of generators) over a frequency range. The frequency is typically swept over a range from 5 Hz to up to 200 Hz in steps 0.25 Hz, depending on the application. At each frequency step the network (lines, transformers, loads, shunts,...) and generator impedances are adjusted from nominal or base (e.g. 60 Hz) to the step frequency.

SSR damping torque calculations use the system impedance at each frequency step to calculate electrical system damping curves, as shown in the figure below. Conditions with possible induction generator effect (IGE) issues are also identified. Impedance scan calculations screen for conditions where unstable control interaction (SSCI) or a study wind plant could be an issue.



- Ztools has been designed for efficient and accurate evaluation of SSR and SSCI phenomena. A single execution of Ztools can perform many thousands of damping torque and/or impedance scans. Execution is controlled with the following input files.
- PSLF powerflow (.sav) file and PSLF dynamic (.dyd) file (optional). Ztools will use X<sup>n</sup> from gens data for generators that do not have a dynamic model.
- A file that contains a list of Ztools cases to run. Multiple cases of different type can be executed in one Ztools run. For example, damping torque of a thermal generator and impedance scan looking into the interconnection bus of a wind plant can be performed in one Ztools run.
- Control file that specifies the type of Ztools simulation (damping torque or impedance scan), and generator(s) or bus to scan for a Ztools simulation. The control file can also include generation and network changes to implement for the base system and all contingencies for that Ztools simulation.
- Contingency file (.otg) that describes all outages to simulate.

Ztools will write results to several different output files that can be directly imported into EXCEL for plotting. Excel macros, VBA scripts, Matlab and Python programs can be developed for mass post-processing. In addition, all conditions with potentially unstable Induction Generator Effect (IGE) and SSCI conditions are identified in a root locus-type output file that contains the frequency and estimated damping of the resonance.

**For more information, contact:**

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