



Validation and Accreditation of Transient Stability Results

Final Project Report

Power Systems Engineering Research Center

*Empowering Minds to Engineer
the Future Electric Energy System*



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Project Team

**Tom Overbye, Project Leader
University of Illinois at Urbana-Champaign**

**Mani Venkatasubramanian
Washington State University**

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Information about this project

For information about this project contact:

Thomas J. Overbye
Fox Family Professor of Electrical and Computer Engineering
University of Illinois at Urbana-Champaign
1406 W. Green St
Urbana, IL 61801
Tel: 217-333-4463
Fax: 217-333-1162
Email: Overbye@illinois.edu

Power Systems Engineering Research Center

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For additional information, contact:

Power Systems Engineering Research Center
Arizona State University
577 Engineering Research Center
Tempe, Arizona 85287-5706
Phone: 480-965-1643
Fax: 480-965-0745

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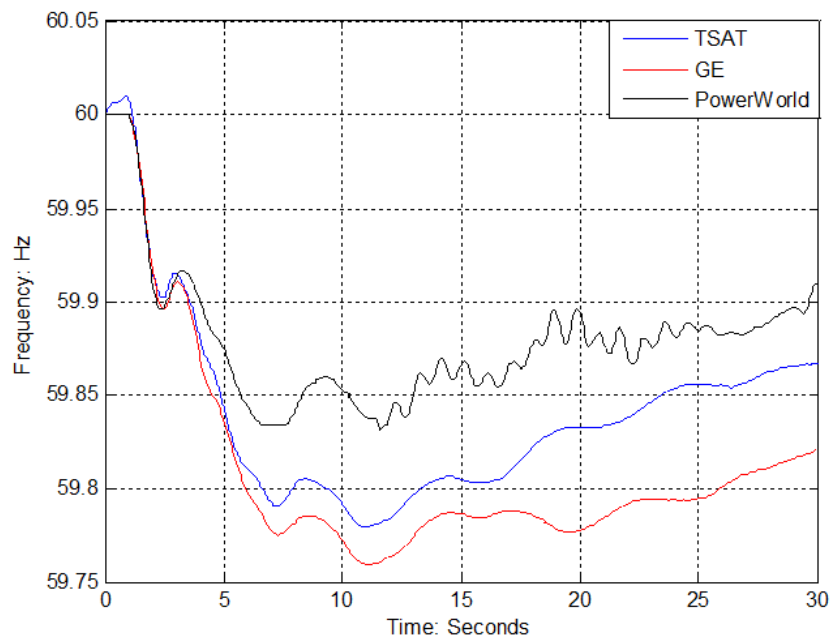
Komal Sudhir Shetye, a graduate student of Tom Overbye at the University of Illinois has co-authored this report. The authors would also like to convey special acknowledgement to the PSERC IAB member companies who provided direct assistance for this project: the Bonneville Power Administration (BPA) and PowerWorld. The assistance of Jim Gronquist from BPA has been particularly appreciated.

Executive Summary

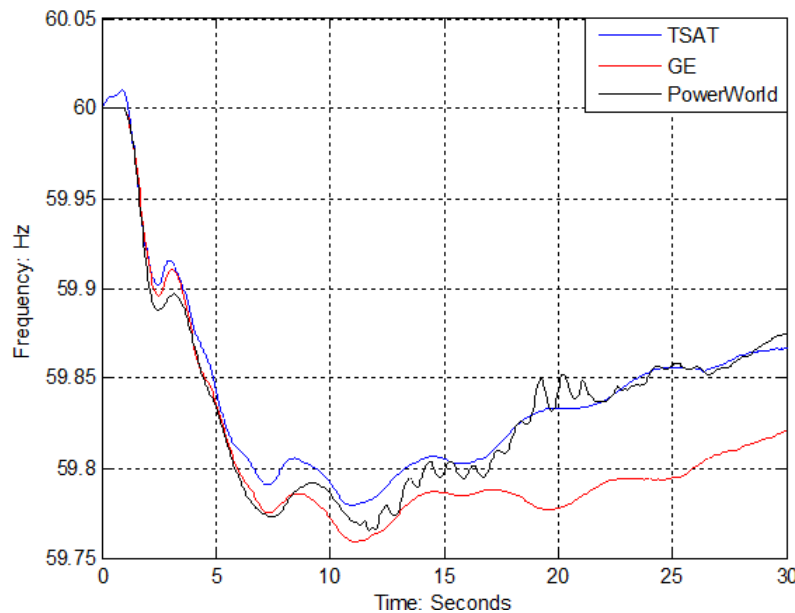
The goal of this project was to perform validation of the transient stability packages used for Bonneville Power Administration (BPA) system analysis. It is commonly thought that different transient stability packages can give different results for the same system conditions. This project is just focused on validating the packages against each other, as opposed to with real world data. The ultimate aim of this was to enhance the utilization of the BPA transmission system by using validated, real-time transient stability analysis, and to have better planning/study tools and models.

We have successfully developed a methodology to validate transient stability results and packages.

Chapter 2 describes the Starting Point. At the beginning of this project, comparisons were made for a full 17,000 bus Western Electricity Coordinating Council (WECC) case provided by BPA, using three different packages namely GE's PSLF, TSAT and PowerWorld. The graph below shows the variation in the frequency of a bus for the loss of generation contingency in the southern part of the system.

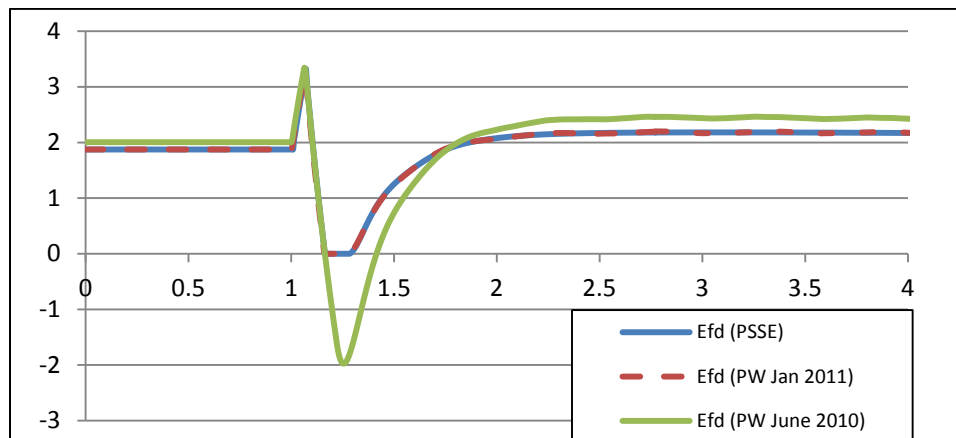


The Top-Down Approach is discussed in Chapter 4. This involved determining the individual models or components causing these variations, from the full case runs.



In this case, we determined that a bug in how the frequency deviations for the induction motor loads were being handled by PowerWorld was causing some of the frequency variation. The new run is shown in the figure above. The oscillations in the PowerWorld frequencies were tracked down to a model error. Similarly, several other model errors were tracked down using this approach.

Chapter 5 deals with our Bottom-Up Approach of validation. This consists of creating two bus equivalents for the most common WECC Generator models, and then running them in the different packages. We have validated several dynamic models using this method. Wherever discrepancies were found, we have tried to track down the cause and documented it. This has resulted in several software changes to PowerWorld with the new code often giving quite close matches. **We have validated all the major machine models and most of the exciter and stabilizer models prominently used in the WECC case.** The following figure illustrates the benefits reaped from this approach.



This graph shows a comparison of the field voltage at bus 21 for a fault on the two bus equivalent system between PSSE, and two versions of PowerWorld Simulator.

In this whole validation process, we have created a library of cases with benchmarked transient stability results that can be used by BPA to validate other software packages and thus better utilize their system. We have also reported many **data errors found in the WECC case reported in Chapter 2 to BPA that have helped improve the representation of the system as well as our validation studies.** Another major beneficial outcome has been the significant improvement in one of the participating software packages, PowerWorld and its growing compatibility with PSSE and PSLF software packages.

Chapter 6 talks about the validation of crucial Generator parameters such as saturation and also of modeling compensation. In this part, comparisons between PSLF and PowerWorld were made, while also at the same time highlighting the differences between the modeling of generators in PSLF and PSSE. PowerWorld seems to have the capability to seamlessly integrate both these types of models which aided our studies.

Chapter 7 briefly illustrates the impact of changing time steps on transient stability simulations and results. This was performed in light of the auto-correction feature that exists in PowerWorld for adjusting time constants according to the time step. We observed that, in the larger scheme of things for the 17,000 bus case, the time step and consequent auto-corrections had no significant impact on the results. Of course this holds for the selection of a reasonable time-step that doesn't compromise the stability or accuracy of the simulation.

Chapter 8 describes our most recent work with frequency comparisons between PSLF and PowerWorld. In the effort to track down the cause for the observed differences, we narrowed it down to several factors including the complex load model and software bugs in PowerWorld. Despite so many breakthroughs however, we were unable to figure out the exact cause and eliminate the discrepancies completely; thus pointing us to the future work required in Transient Stability Validation of the WECC system.

Finally, Chapter 9 documents some of the bugs we discovered in GE PSLF which were reported to GE. These were verified by the concerned authorities at GE, and are being addressed and rectified. Thus we have been reasonably successful in one of our main goals of suggesting and bringing about improvements in commercial software packages like PowerWorld and PSLF.

In Chapter 10, we discuss possible directions for future research. As concluded in Chapter 8, we need to further investigate and determine the source of the frequency discrepancies. Apart from this, other likely steps would be to perform validation of dynamic models pertaining to wind turbines, solar models etc. given the thrust on integrating renewables into the grid. A significant future agenda would be to validate these packages and their simulation results with real-world data obtained from PMUs and other sensing devices.

Student Thesis: This project is also the basis for the Master's thesis titled '**Validation of Transient Stability Results**' written by Komal Sudhir Shetye from the University of Illinois at Urbana-Champaign. This thesis will be completed in December 2011.