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IEEE Task Force on Benchmark Systems for Stability Controls: Australian Test System

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I. Introduction

Small-perturbation and transient stability analyses are performed for a simplified model of the Australian power system using the DSA Tools [1], as part of the work of the IEEE Task Force on Benchmark Systems for Stability Controls. This report and its accompanying files[1] can serve as a benchmark for future similar studies. The DSA Tools include four components, namely, PSAT, SSAT, VSAT, and TSAT, to perform power flow, small-perturbation stability, voltage stability, and transient stability analyses, respectively.

Two other studies on this system have been reported in [2] and [3]. The focus in [2] is small-perturbation stability (eigenvalue) analysis of the system under different loading conditions, whereas time-domain simulations which examine the transient stability of the system for different disturbances are mainly reported in [3].

The report is organized as follows: First, the test system is briefly described; then, the transient stability simulations with TSAT and the studied scenarios/disturbances from [2] are presented and discussed; finally, the results of eigenvalue analyses using SSAT are described.

II. System Description

This test system represents a simplified model of the eastern and southern Australian networks [2], [3]. There are 19 generators in the system synchronized at 50 Hz. The grid includes 59 buses and 104 lines with 15 kV to 500 kV voltage levels. Six power flow cases summarized in Table 1 are considered in the following sections to examine the system performance under different loading conditions. Note that Case 6 and Case 3 have the lowest and the highest loading levels, respectively.

Table 1. Summary of the six power flow cases studied.

	Generators [MW]	Loads [MVA]
Case 1	23013.71	22300 + j 2462
Case 2	21568.69	21000 + j 2251
Case 3	25411.13	24800 + j 2760
Case 4	15038.15	14806 + j 1595
Case 5	19041.64	18597 + j 1920
Case 6	14828.54	14631 + j 1595

III. Time-domain Simulations

Time-domain simulations are carried out using TSAT, based on the data provided in [2]. All the dynamic models used in [2] are recognized by TSAT and are directly imported into its environment. However, to

[1] Available [Online], http://www.sel.eesc.usp.br/ieee/index.htm

avoid input data modifications, the automatic data-correction option is disabled and a small integration time-step (1 ms) is used, so that lower limits on the TSAT models' time-constants are not enforced.

Three following disturbances are simulated in the study, with a duration of 10 s for all of them:

A. Two-phase-to-ground fault at Bus 209 at $t = 0.5$ s, and cleared in 100 ms without disconnecting any circuit elements.
B. Two-phase-to-ground fault at Bus 303 at $t = 0.5$ s, and cleared in 80 ms without disconnecting any circuit elements.
C. Two-phase-to-ground fault at Bus 506 at $t = 0.5$ s, and cleared in 100 ms without disconnecting any circuit elements.

Case 2 is used for the simulations, with the generator stabilizers in service. Various variables for generators, including stabilizer outputs, and SVCs are plotted and presented in an accompanying document, which includes a total of 297 graphs comparing TSAT and PSS/E results. The results match well with the ones reported in [2]. The differences can be attributed to some small model differences between PSS/E and TSAT. Figures 1(a) — 1(d) show the results at Bus 101 for Disturbance A.

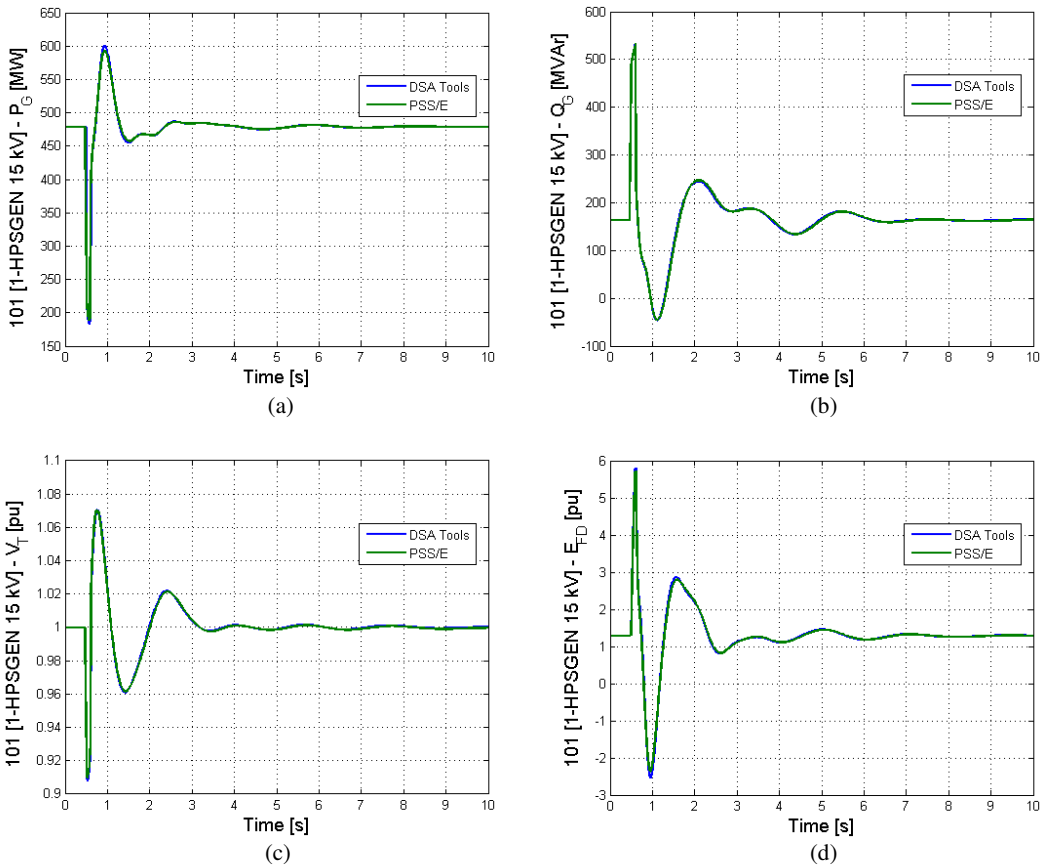

Figure 1. Time-domain simulation results at generator Bus 101 for Disturbance A.

IV. Eigenvalue Analyses

Eigenvalue analyses are performed for the system using SSAT following the studies presented in [2]. Similar to the time-domain simulation studies, all the models are imported from the files provided with [2], with SSAT recognizing all dynamic models. In SSAT, static loads are assumed to be constant power by default; in [2], on the other hand, the loads were modeled as constant impedance. However, for eigenvalue calculations, both yield the same results for the same operating point (power flow solution) since loads are static. Therefore, the default SSAT load model is used in these studies, so that the same PSS/E database can be used without changes, otherwise modifications to the input data set are required.

The examination of un-damped oscillations is of interest for these studies. Thus, a window is defined to examine the eigenvalues within a desired range, i.e. close to the imaginary axis or the right-hand side (e.g. in the range of [-1— +10 , -20 — +20]. Since there are six power flow cases and the PSSs can be on or off, there are $6 \times 2 = 12$ cases to be studied. The results for all the twelve cases are provided in an attached file in MS Excel format, showing the real and imaginary parts of the computed eigenvalues, as well as their damping ratios and frequencies, and associated dominant state variables. In these results, it can be observed that one or two zero (or very small) eigenvalues are present in all cases. One of these eigenvalues is due to the lack of an angle reference in the system; the other one corresponds to the rotor speeds, and is present because speed governors are not modeled and all generator damping factors are assumed to be zero [4].

The results associated with Cases 3 and 6 (highest and lowest loading levels) with and without stabilizers are shown in Figures 2 and 3, respectively. The damping effect of the stabilizers is clearly seen in both cases, as the eigenvalues "move" to the left side of the 10%-damping line due to the stabilizers. The results are almost identical to the ones presented in [2].

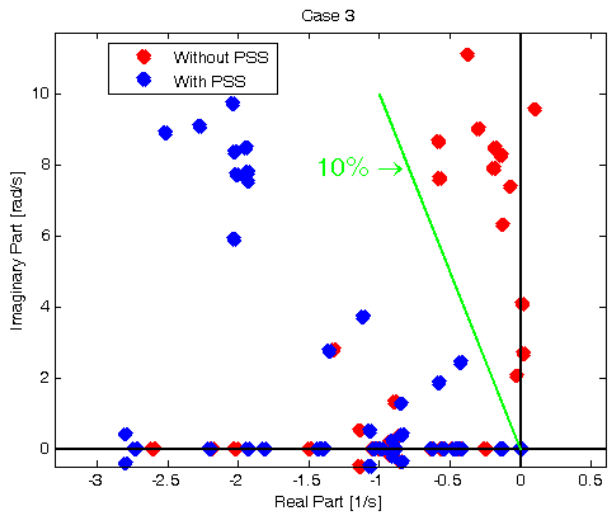

Figure 2. Case 3 eigenvalues with and without stabilizers.

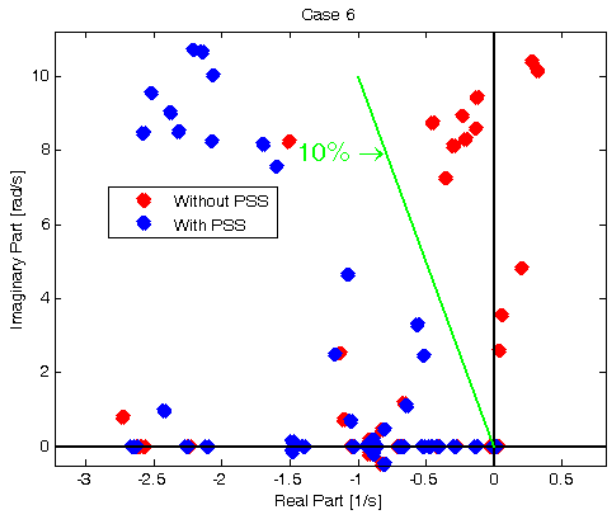

Figure 3. Case 6 eigenvalues with and without stabilizers.

V. References

[1] *DSA Tools Reference Manual*, [online] Available: http://www.dsatools.com ver. 10.

[2] Mike Gibbard and David Vowles, "*Simplified 14-generator model of the SE Australian power system,*" IEEE Task Force on Benchmark Systems for Stability Controls, June 2014.

[3] Leonardo Lima, "*Report on the 14-generator system (Australian reduced model),*" IEEE Task Force on Benchmark Systems for Stability Controls, June 2013.

[4] P. Kundur, *Power System Stability and Control,* Mc Graw Hill, EPRI Power System Engineering Series, 1994.