Presque Isle Power System Stabilizer Report

American Transmission Company, LLC

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Executive Summary

This report contains the results of a performance analysis of the new excitation systems and power system stabilizers (PSS) installed on Presque Isle units 5 through 9. These systems were installed between the summer of 2003 and February 2004, when the final excitation system and PSS were installed. Prior to summer 2003, Presque Isle units 5 through 8 had PSS installed. Therefore, this new equipment includes an additional PSS at Presque Isle (unit #9).

Due to the existing stability issues at Presque Isle, studies were performed to quantify the new equipment's dynamic performance, and determine if the existing transfer capability out of the U.P. or the effectiveness of the Remedial Action Tripping Scheme (RATS) were affected.

The results show that: 1) the transient (1st swing) stability performance at Presque Isle is equal to or slightly improved compared to the old excitation systems and PSS, and 2) the damping performance appears to be nearly equal for certain contingencies (Presque Isle-Dead River-Plains outage) or significantly improved (Plains-Morgan outage) for other contingencies.

The studies show that no changes to RATS are necessary, and the previous maximum export (Flow North) level of 460 MW should still be considered valid.

All figures referred to in this report can be found in the Appendix which corresponds to the figure name. For example, Figure A1 in is Appendix A while Figure B3 is in Appendix B.

Study Methodology

A 2002 Series 2003 Light Load MMWG stability case and dynamic models were used throughout this study. This case includes modeling of the transmission system, loads, generators, etc., of the entire Midwestern U.S. as well as most of the rest of the U.S. and Canadian systems. This light load case was used due to the fact that system stability performance is inherently worse at light loads due to the longer apparent electrical path from generation to load, and this case is therefore a worst-case scenario. This methodology is consistent with ATC practices.

The studies were performed using the Dynamics Simulation and Power Flow modules of the Power System Simulation/Engineering-28 (PSS/E, Version 28) program from Power Technologies, Inc (PTI). This program is an industry-wide accepted power flow and stability application.

The new excitation system and PSS models were developed using information provided to ATC from Presque Isle personnel on June 19, 2003. The report "WEPCO Presque Isle #5 - #9 EX2000 PSS Tuning Report" performed by General Electric, dated June 16, 2003, contained the calculated parameters for the new excitation system as well as the PSS parameters derived from a tuning study. These values were used throughout the study. The PSS/E models used included the ESST4B exciter model and the PSS2A PSS model. These PSS/E models were perfect fits for the GE models.

The existing U.P. system has a maximum export capability of 460 MW due to stability and line loading issues. The studies in this report included modeling of the most severe contingencies in the U.P. at two separate transfer levels to identify the stability performance of the new equipment. The results of these studies were used to determine if the new excitation equipment and PSS at Presque Isle are adequate to retain the existing transfer limit and the existing RATS design.

Figure A1 shows a one-line diagram of the transmission system in Northern Wisconsin and the U.P. of Michigan.

Summary of Results

Two U.P. transfer cases were developed: 260 MW export, and 460 MW export. The 460 MW export level represents the maximum allowable export from the Presque Isle area, and included modeling of all Presque Isle generation on-line and at full output and a total mine load of 92 MW. The 260 MW export case again included full output from Presque Isle, but with 300 MW of mine load at Empire and Tilden.

One inherent problem in the Presque Isle area that affects the stability performance is the shedding of Empire and Tilden mine load during fault conditions. Studies performed in this area over the years include modeling of the mine motors, and tripping of the motors if the motor terminal voltage is below 70% of nominal for 2.5 cycles or more. Previous investigations into actual system events have determined that this calculation is reasonably accurate. This methodology was utilized throughout this study.

The three major contingencies that were studied included:

1. 3-phase fault on the Presque Isle-Dead River 138 kV line near Presque Isle cleared in 5 cycles, all 300 MW of Empire/Tilden mine load shed.
2. 3-phase fault on the Plains-Morgan 345 kV line near Plains cleared in 4 cycles, no mine load shed.
3. 3-phase fault on the Presque Isle-Perch Lake 138 kV line near Presque Isle cleared in 5 cycles, all 300 MW of Empire/Tilden mine load shed

For contingency #1, the studies indicated that 231 MW of generation at Presque Isle must be tripped within 2 cycles of fault extinguishing to ensure transient (1^{st} swing) stability. Studies were then performed with the old excitation systems and PSS, with the new excitation systems and PSS, and with the new excitation systems with the new PSS disabled for comparison purposes.

Figure B1 shows that with the new EX2000 exciters on Presque Isle units #5-#9 but without the PSS on these units, the post-contingency oscillations are very large and marginally damped at best. This system response would possibly result in inadvertent transmission elements tripping due to the very large power swings, and likely lead to system collapse.

The other plot in Figure B1, with the PSS engaged, shows a well-damped response with a small rotor angle magnitude a full 20 seconds after the disturbance. This plot certainly shows that the PSS provide a significant amount of positive damping at Presque Isle.

Figures B2 and B3 show a comparison of the old excitation system/PSS and the new excitation system/PSS for two major contingencies. Figure B2 shows the simulation results for the same contingency described for Figure B1, while Figure B3 shows the results for contingency #2 (fault Plains-Morgan 345 kV) at a 460 MW transfer level and tripping of 57 MW (G4) of Presque Isle generation. These two figures show the rotor angle damping with the old exciters/PSS vs. the new exciters/PSS.

Figure B2 shows that the damping performance of the new equipment is nearly identical to the old equipment. Note that for this contingency, Presque Isle units 3, 7, and 9 were tripped, which results in stabilizers 5, 6, and 8 on-line subsequent to the generation tripping.

Figure B3, however, shows a significant improvement with the new equipment. It is likely that the biggest reason for this improvement is that this contingency only trips unit #4 at Presque Isle. Therefore, the old equipment would have stabilizers #5 through #8 available for post-contingency damping, while the new equipment would have stabilizers #5 through #9 available. This additional positive damping with the additional PSS can be readily observed in Figure B3.

Figure B4 shows the simulation results for contingency #3, the fault and trip of the Presque Isle-Perch Lake 138 kV line and the shedding of all mine load (300 MW). The plot for the old exciters/PSS show that for this contingency generator #8 would go unstable, tripping off-line via over speed protection. The plot for the new exciters/PSS, however, shows that the unit would survive the first swing and proceed to damp the post-contingency oscillations.

Therefore, the results in Figure B4 show that the new excitation and PSS systems will provide a transient stability performance of equal to or slightly better than the old equipment.

Conclusions

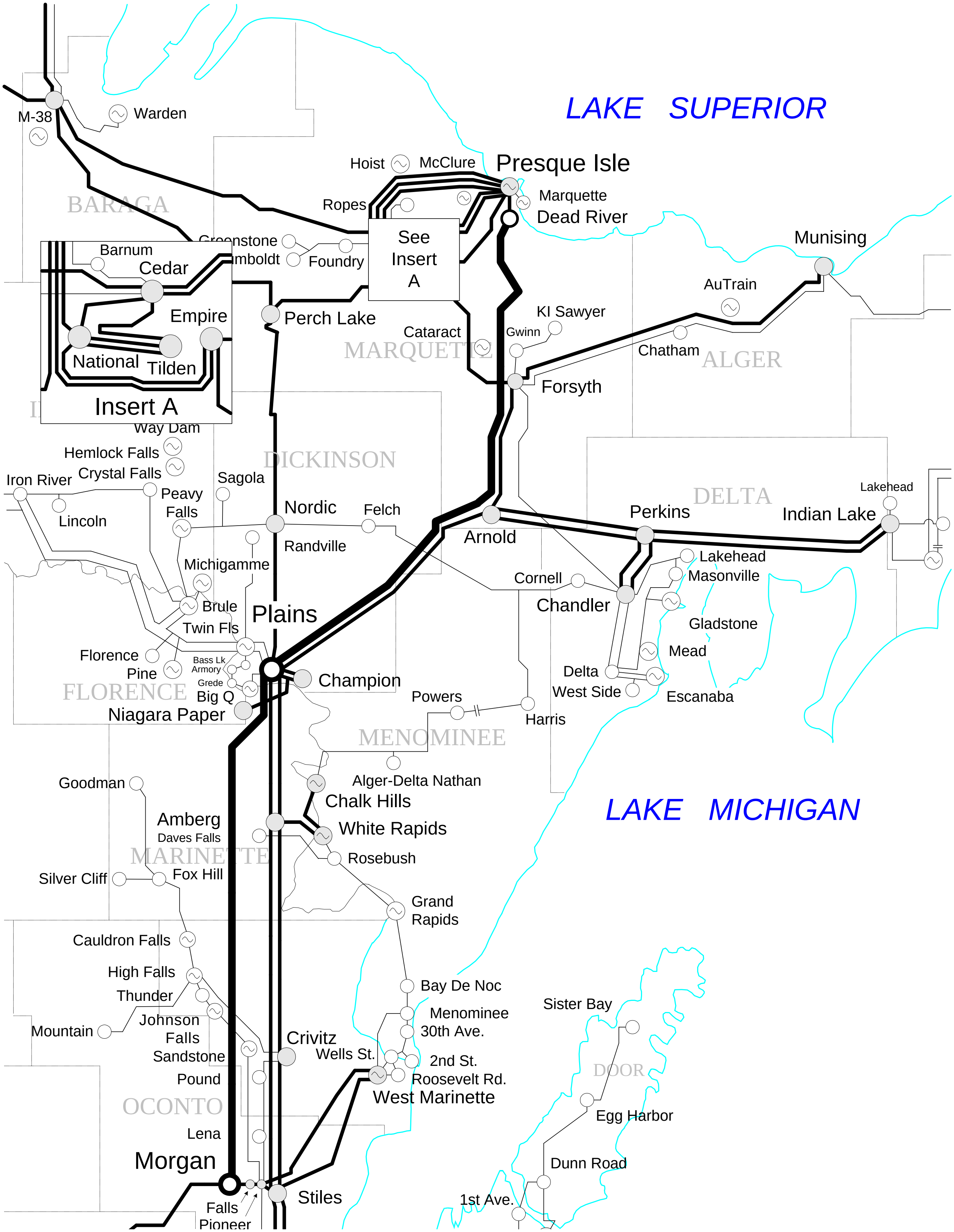
The results presented in this report show that the transient (1^{st}-swing) stability performance with the new Presque Isle excitation equipment will be equal to or better than the old equipment. In addition, the damping performance will likely be improved due to the existence of five PSS at Presque Isle versus only four Presque Isle PSS in the past.

Therefore, the addition of the new exciters and PSS at Presque Isle will not adversely affect the existing export capability in the U.P. Although the stability performance is slightly improved, line loading issues will continue to limit the export from the Presque Isle area so the export limit cannot be raised. The new excitation equipment and the existing RATS design, however, will continue to provide an adequate stability performance at Presque Isle.

APPENDIX A

Transmission System One-Line Diagram

Figure A1: One-Line Diagram Of The U.P./Northern Wisconsin Transmission System.



APPENDIX B

Stability Study Simulation Plots

Figure B1: Simulation Results, Flow North = 260 MW. Fault Presque Isle-Dead River 138 kV, Trip 300 MW Mines, Presque Isle Units 3,7,9 (231 MW). Comparison: G8 Relative Rotor Angle With New Exciters And With & Without New PSS.

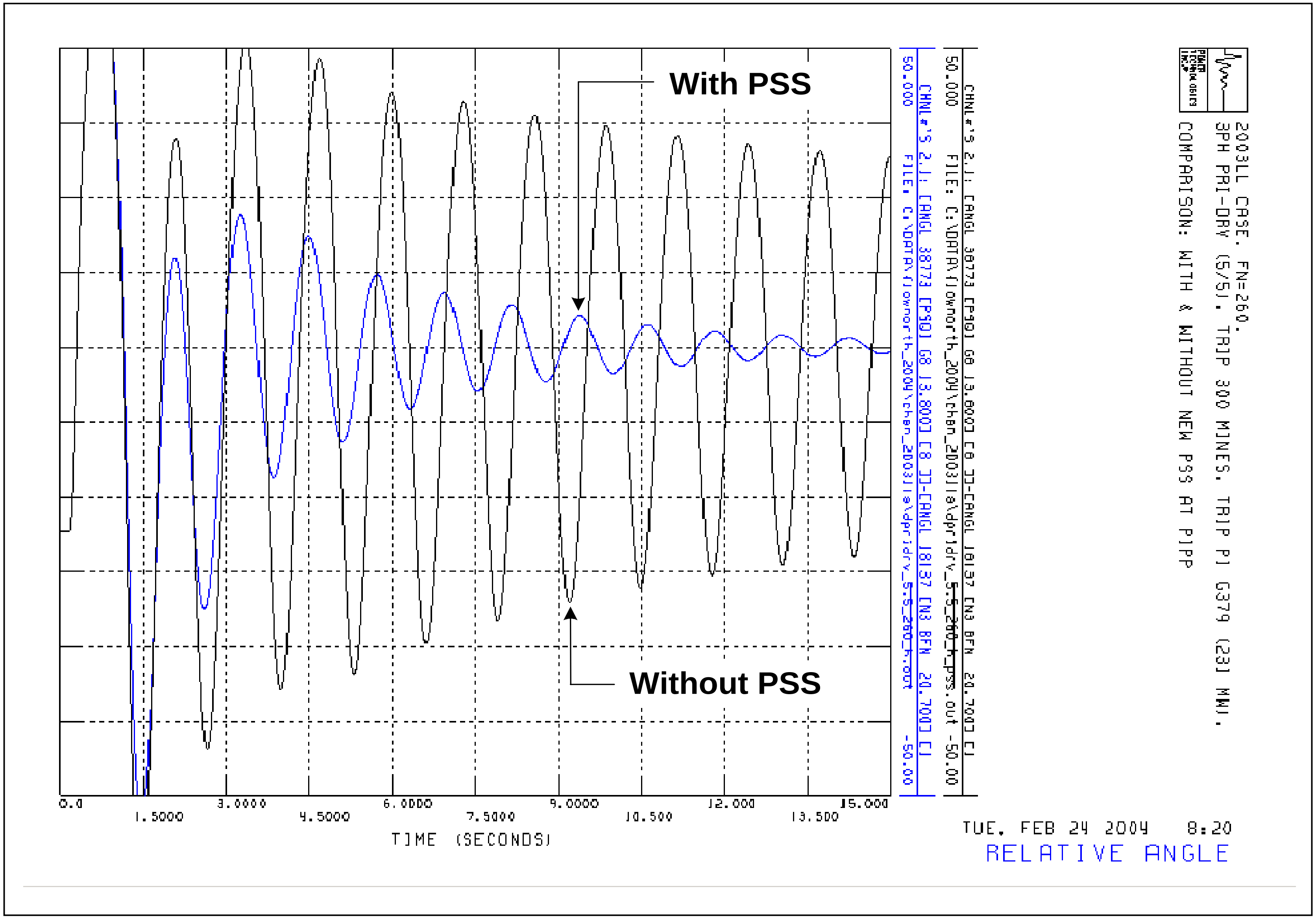


Figure B2: Simulation Results, Flow North = 260 MW. Fault Presque Isle-Dead River 138 kV, Trip 300 MW Mines, Presque Isle Units 3,7,9 (231 MW).
Comparison: G8 Relative Rotor Angle, Old Exciters/PSS Vs. New Exciters/PSS.

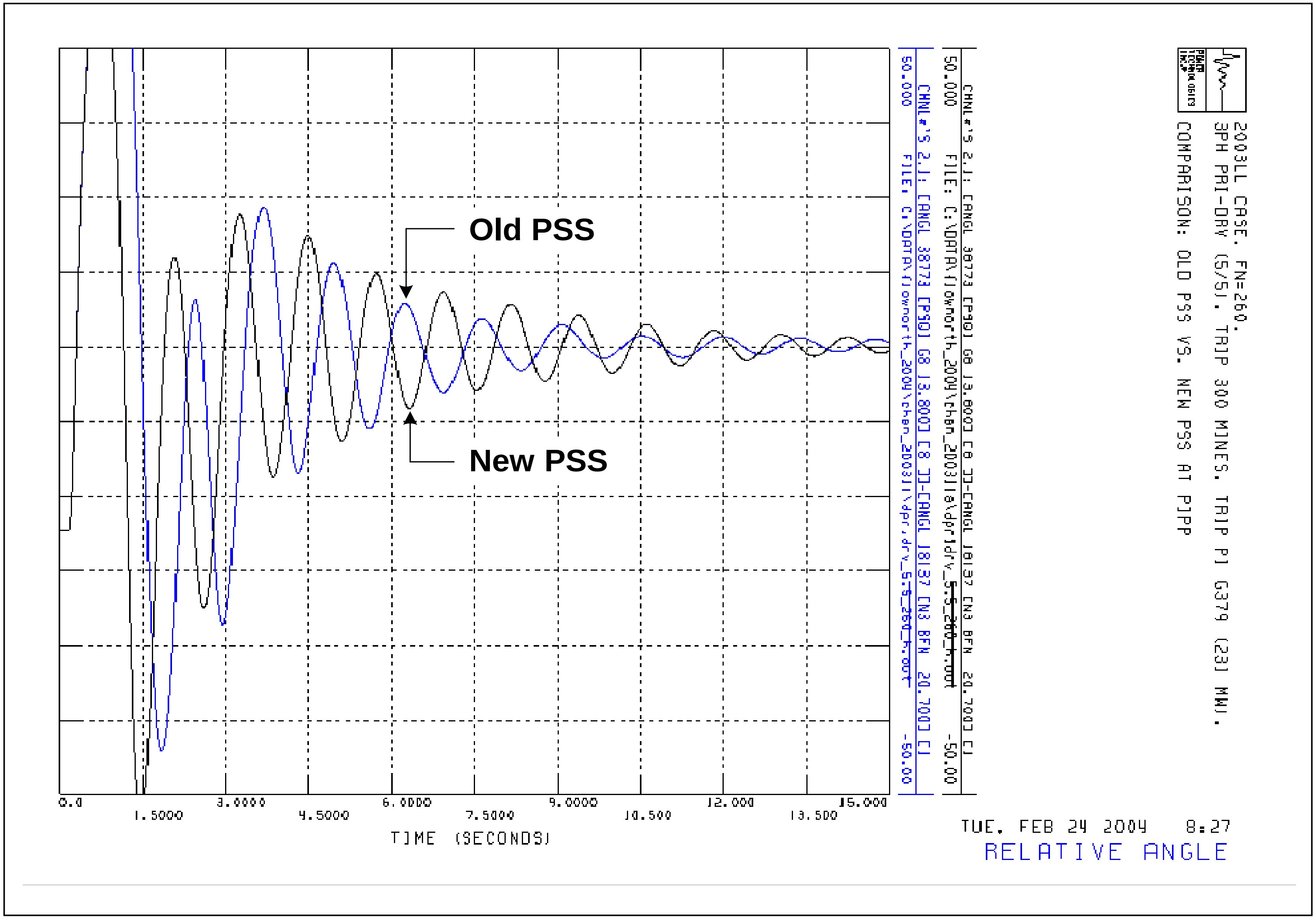


Figure B3: Simulation Results, Flow North = 460 MW. Fault Plains-Morgan 345 kV, Trip 0 MW Mines, Presque Isle Unit 4 (57 MW). Comparison: G8 Relative Rotor Angle, Old Exciters/PSS Vs. New Exciters/PSS.

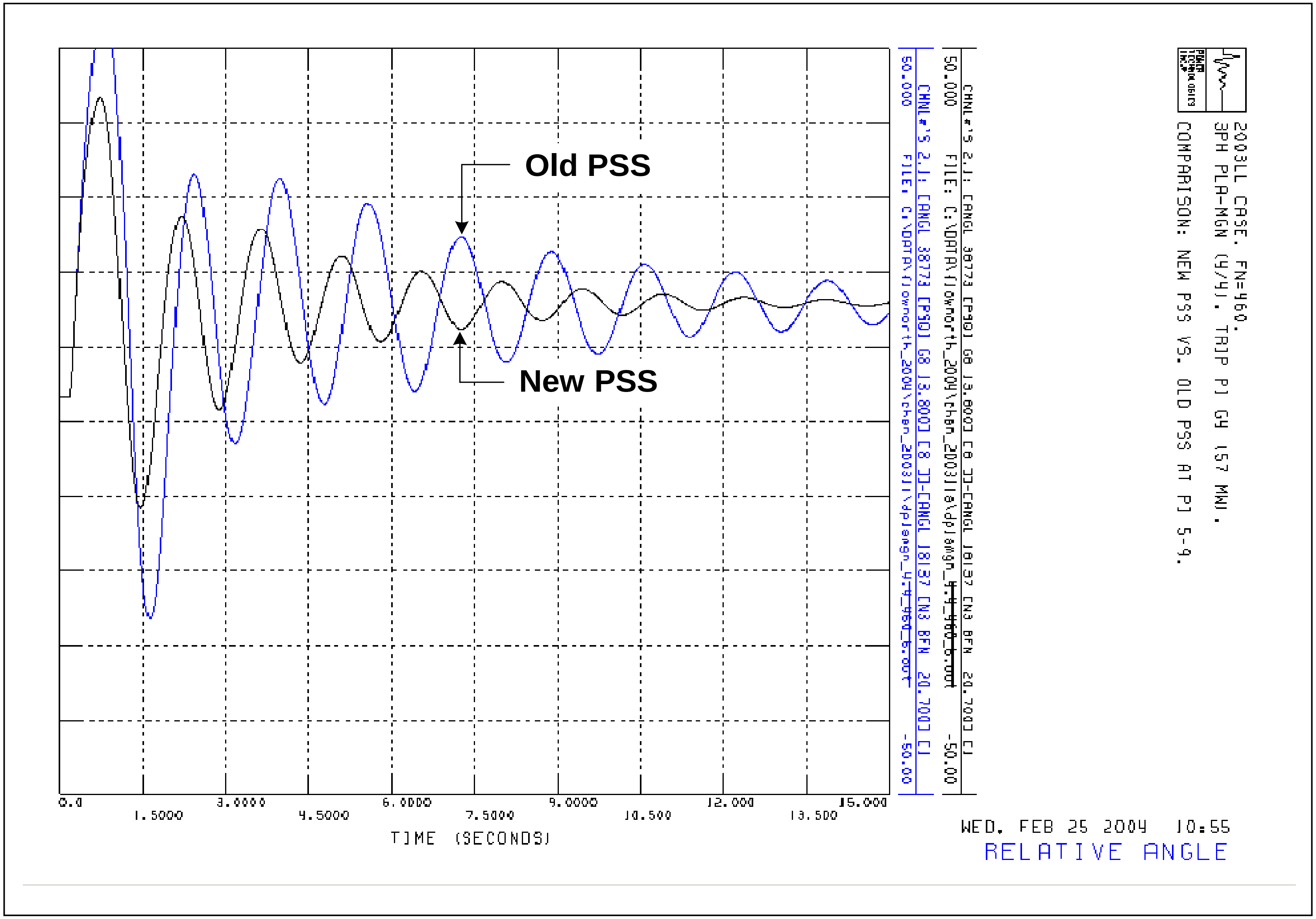


Figure B4: Simulation Results, Flow North = 260 MW. Fault Presque Isle-Perch Lake 138 kV, Trip 300 MW Mines, No Presque Isle Generation. Comparison: G8 Relative Rotor Angle, Old Exciters/PSS Vs. New Exciters/PSS.