IMP_REP_0089

Independent Electricity Market Operator

CONNECTION ASSESSMENT & APPROVAL PROCESS

Preliminary Assessment Report – Final Version

Date: December 4, 2002

Kipling GS - Replacement of Generator Runners and Main Output Transformer

CAA ID No. 2002 - 055

Long Term Forecasts & Assessments Department

Consistent Information Set Department

Disclaimer

This report has been prepared solely for the purpose of assessing, on a preliminary basis, whether the connection applicant's proposed connection with the IMO-controlled grid would have an adverse impact on the reliability of the integrated power system and whether a System Impact Assessment of the proposed connection should be conducted under Chapter 4, section 6 of the Market Rules. This report has not been prepared for any other purpose and should not be used or relied upon by any person for another purpose. In particular, this report does not address any other Market-related or any commercial aspects of the connection proposal. This report has been prepared solely for use by the Connection Applicant and the IMO in accordance with Chapter 4, section 6 of the Market Rules. The IMO assumes no responsibility to any third party for any use which it makes of this report. Any liability which the IMO may have to the Connection Applicant in respect of this report is governed by Chapter 1, section 13 of the Market Rules. The IMO may revise this report at any time, in its sole discretion, without notice to the Applicant. Although the IMO will use its best efforts to advise you of any such changes, it is the responsibility of the Connection Applicant to ensure that it is using the most recent version of this report.

This document may contain a summary of a particular *market rule*. Where provided, the summary has been used because of the length of the *market rule* itself. The reader should be aware, however, that where a *market rule* is applicable, the obligation that needs to be met is as stated in the "Market Rules". To the extent of any discrepancy or inconsistency between the provisions of a particular *market rule* and the summary, the provision of the *market rule* shall govern.

Executive Summary

This Preliminary Assessment has investigated, in isolation of any other proposed developments, the impact of the proposed replacement of generator runners and main output transformer at Kipling GS. It has been concluded that the proposal would not have any significant adverse system impact and that a System Impact Assessment would not be necessary.

The Proposal

Ontario Power Generation Inc. (OPG) is proposing to replace the runners of the generating units at one of their hydroelectric generating stations, Kipling GS. The generating station is located in northeastern Ontario and is connected to the 230kV Little Long GS to Pinard TS transmission circuit L20D. The station has two generating units with a nameplate rating of 66MVA and is capable of producing up to 150MW.

After the replacement of the runners, the active power output of the generating units, depending on water conditions, could increase by up to 10MW per unit. However, it should be noted that OPG is not changing the 66MVA nameplate rating of the generating units. The existing main output transformer bank, which consists of three single phase 13.4kV - 255/√3kV 30/40/50MVA step-up transformers, and the two 3000A generator synchronizing breakers G2T1 and G1T1 will also be replaced and upgraded to accommodate the increase in active power output of the generating units.

The proposal also includes upgrading the transformer protection to solid state technology, but the overall transformer protection scheme and the tripping matrices will not be materially modified. The governors and exciters will not be modified as well.

Compliance with Market Rules

The proposed upgrading of runners, main output transformer bank, and synchronizing breakers are in compliance with the Market Rules as long as:

1. OPG shall operate Kipling GS in such manner that the generation facilities shall be capable to produce reactive power within the range of 19.5Mvar leading and 28Mvar lagging, including the reduction of active power if necessary.
2. The positive sequence impedance of the main output transformer bank does not exceed 19% on 180MVA 235kV base such that the generating facilities are capable of producing the full MW and Mvar outputs while operating within ±5% of rated terminal voltage.

System Impact Assessment

The operations of the transmission and generating facilities are governed by the System Control Order – Northeastern System Operating Limits SCO L-0221 Version 21. The impact assessment was therefore based on operating procedures and limits stipulated in the System Control Order. Study results show that the proposal would have no adverse impact on the IMO-controlled grid.

However, it should be noted that the fault current level at Kipling GS is reaching the interrupting capability of the synchronizing breakers. To ensure adequacy of the synchronizing breakers the main output transformer bank impedance must not be substantially less than 12.85% (Base single phase 60MVA 13.4kV – 235/√3kV tap).

Customer Impact Assessment

The 'agreed draft' of this Preliminary Assessment Report was issued on October 22, 2002 and a copy was also posted on the IMO web site. Since no response has yet been received from Hydro One regarding the findings from their Customer Impact Assessment (CIA), it has been decided to issue this as the final version of the Report.

However, should any issues be raised by Hydro One's CIA that could affect the content of this Report, then they will be addressed through an Addendum.

Related Matters

The increase in Kipling GS units' output would likely increase the congestion cost in the IMO-administered markets when transmission interfaces in the northeastern Ontario system of the IMO-controlled grid such as the 'Flow South' interface become restrictive.

The IMO recommends that as part of the runner replacement work at Kipling GS, OPG installs facilities that would allow the units to automatically change from the 'condense' mode to the 'generate' mode in response to falling system frequency.

1.0 Description of Proposal

Ontario Power Generation Inc. (OPG) is proposing to replace the runners of the generating units at one of their hydroelectric generating stations, Kipling GS. The generating station is located in northeastern Ontario and is connected to the 230kV Little Long GS to Pinard TS transmission circuit L20D, owned by Hydro One Networks Inc. Figure 1 is a schematic diagram showing the connection of Kipling GS to the IMO-controlled grid.

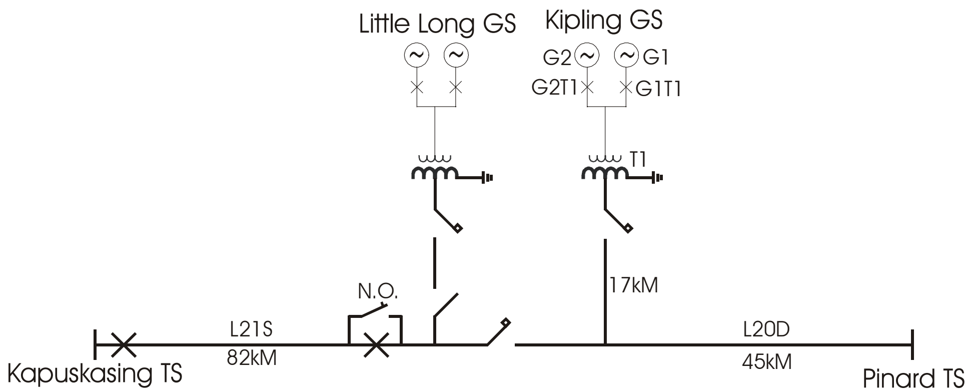

Figure 1

The station has two generating units with a nameplate rating of 66MVA and is capable of producing up to 150MW. After the replacement of the runners, the output of each generator unit is expected to increase by up to 10 MW. However, OPG will not be changing the 66MVA nameplate rating of the generating units. The existing main output transformer bank, which consists of three single phase 13.4kV - 255/√3kV 30/40/50MVA step-up transformers, and the two 3000A generator synchronizing breakers G2T1 and G1T1 will be replaced and upgraded to accommodate the increase in active power output of the generating units. The transformer protection will be upgraded to solid state but the overall transformer protection scheme and the tripping matrices will not be materially modified. The governors and the excitation systems will not be modified as well.

Table 1 lists the new and the existing specifications of the generator units, the step-up transformers, and the synchronizing breakers:

Equipment	**Existing specifications**	**New specifications**
Generator Units G1 & G2 • Rated Voltage (kV) • Nameplate Rating (MVA) • IMO's Requirements for Reactive Power (Mvar)	Per Generating Unit • 13.8 • 66 • 28 lagging; 19.5 leading	Per Generating Unit • 13.8 • 66 • 28 lagging; 19.5 leading
Step-up Transformer T1 • Rated Voltage (kV) • Thermal Rating (MVA) • Impedance (%) • In-service Off-load Tap (kV)	Single Phase Unit • 255/√3 – 13.4 • 30/40/50 • R Phase 0.278 + j6.7 W Phase 0.279 + j6.81 B Phase 0.283 + j6.73 (Base 30MVA 13.4-255/√3kV tap) • 235/√3	Single Phase Unit • 255/√3 – 13.4 • 60 • 13.4 (Base 60MVA 13.4-255/√3kV tap) 12.85 (Base 60MVA, 13.4-235/√3kV tap) • 235/√3

Table 1

Table 1 (Cont'd)

Equipment	Existing specifications	New specifications
Synchronizing Breakers		
• Rated Voltage (kV)	• 15	• 15
• Interrupting Time (ms)	• 83	• 83
• Rated Continuous Current (A)	• 3000 (71.7MVA @ 13.8kV)	• 3500 (83.7MVA @ 13.8kV)
• Symmetrical Short Circuit Capability (kA)	• 63	• 63

2.0 Assessment

This preliminary assessment is based on information included in the connection assessment application. Results presented in this report are only valid for the data provided by the applicant. If subsequent commissioning test results indicate that the new runners are producing significant higher electrical output, then additional studies might be required to re-assess the impact on the IMO-controlled grid.

Compliance with Market Rules - Generation Facility Requirements (Appendix 4.2)

The proposal will impact on reactive power capabilities, voltage variations, and connection equipment capabilities referred to in rows 1, 2, and 5 of Appendix 4.2 of the Market Rules.

Based on the information provided by the applicant, the generating units will be capable of maintaining 77.3MW active power output per unit while supplying at their terminal reactive power ranging from 28Mvar (lagging power factor) to –19.5Mvar (leading power factor) per unit. The reactive power range represents 90% lagging and 95% leading power factor based on a rated real power that is 90% of the unit nameplate MVA rating of 66MVA. This complies with the reactive power capabilities requirements outlined in Appendix 4.2.

The three single phase 30/40/50MVA step-up transformers will be replaced with three single phase 60MVA units. The Market Rules stipulate that generation facilities shall be capable of operating continuously at full output within ± 5% of the generation facility's rated terminal voltage and all plant auxiliaries shall be capable of running indefinitely within this range. After the replacement of the runners, the full output of Kipling GS will be 154.6MW + 56Mvar (lagging) or 154.6MW – 39Mvar (leading). In order to meet the requirements of the Market Rules, the positive sequence impedance of the main output transformer bank cannot be more than 19% (180MVA 235kV base), such that the full range of reactive output can be delivered for at least one system voltage while operating within ±5% of rated terminal voltage. Data provided by the applicant indicates that the impedance of the main output transformer bank will be 12.85% on 180MVA 235kV base and will be in compliance with the voltage variation requirements.

With the higher ratings of the main output transformer bank and the synchronizing breakers, these facilities will be capable of transferring the full output of the generating units. These facilities will be in compliance with the connection equipment capability requirements outlined in Appendix 4.2.

Short Circuit Assessment

Based on information provided by the applicant, Hydro One Networks Inc. has calculated and provided the expected maximum 3-phase symmetrical fault current values at Kipling GS, Little Long GS, Kapuskasing TS, and Pinard TS. Table 2 lists the fault current interrupting capabilities of the limiting breakers at these four stations and the fault current information provided by Hydro One Networks Inc.

Station Bus	Pre-Fault Voltage (kV)	Max. 3-phase Symmetrical Fault Current (kA)	Breaker Symmetrical Interrupting Capability (kA)
Kipling GS 13.8kV	13.8	76	63 Max.
Little Long GS 230kV	250	7.8	19.1 @ 250kV
Kapuskasing TS 230kV	250	5.21	50 Max.
Pinard TS 230kV	250	10.72	30.4 @ 250kV

Table 2 – Maximum 3-Phase Symmetrical Fault Current

The existing 230kV breakers at Little Long GS, Kapuskasing TS and Pinard TS are capable of interrupting the expected fault currents at these stations.

At Kipling GS, the generating units must be capable of operating continuously at full output within ± 5% of the rated terminal voltage, i.e. from 13.11kV to 14.49kV. With this range of pre-fault operating voltages, the total fault current at the Kipling GS 13.8kV bus could range from 72kA to 80kA. Information from Hydro One Networks Inc. indicates that the system behind the fault contributes about 46% while each generating unit contributes about 27% of the total fault current. The fault current that the synchronizing breaker has to interrupt is about 73% of the total fault current. The maximum fault current the synchronizing breaker has to interrupt is therefore 58.4kA (73% of 80kA). The 63kA synchronizing breakers are adequate, but the margin is less than 10%.

As the applicant will not be modifying the generator windings, the sequence impedances of the generating machine will not change. The major factor that will alter the fault current levels at Kipling GS will be the main output transformer. In order to ensure that the maximum fault current level at Kipling GS is within the interrupting capability of the synchronizing breakers, the actual impedance of the main output transformer must be very close to the impedance value, 12.85% base 180MVA 13.4/235kV tap, provided by the applicant.

Local Thermal Loading Considerations

Figure 2 is a schematic diagram of the northeastern Ontario transmission system showing the interconnected transmission circuits and main terminal stations. The northeastern Ontario system is connected to the northwest via the 230kV circuits S22A from Martindale TS and the circuits X27A and X74P from Hanmer TS. The northeastern system is connected to southern Ontario via the 500kV circuits X503X and X504E from Essa TS and the 230kV circuit D5H from Holden GS.

As shown in Figure 2, increasing the output of Kipling GS will result in higher power flow on the 230kV circuits L20D and L21S, which incorporate the generating station onto the northeastern Ontario system. It will also increase the power flows on the 'D501P and H9K', the 'P502X and A8/9K', and the 'X503/504E and D5H' interfaces.

As shown in Figure 1, both Kipling GS and Little Long GS can be isolated onto either circuit L20D or L21S. These two circuits must therefore have enough thermal capacities to carry the maximum output of both generating stations. The maximum output of Kipling GS after the replacement of runners will be 166MVA, while the maximum output of Little Long GS is 144MVA. The summer current carrying capacities of circuit L20D and L21S are 1080A (411MVA @ 220kV) and 920A (350MVA @ 220kV) respectively. These two circuits are capable of carrying the Kipling GS and Little Long GS combined maximum output of 310MVA.

After replacing the runners, the output of Kipling GS is expected to increase by 15 to 20MW, which amounts to about 1% of the total generation capacity in the northeastern Ontario system. It is unlikely that the small increase at Kipling GS will have any adverse impact on the IMO-controlled grid. In addition, the operations of the generating and transmission facilities in northeastern Ontario are governed by the System Control Order – Northeastern System Operating Limits SCO L-0221 Version 21. Extensive generation and load rejection schemes are in place to ensure that post contingency system stability is maintained and thermal loading of transmission circuits are within limits. As the operation of Kipling GS is governed by SCO L-0221 Version 21, the small increased output at Kipling GS is not expected to have any adverse impact on the thermal loading capabilities of the region.

Transient Stability Assessment

Three transient stability studies were carried out to investigate the behaviour of the Kipling generating units and the impact of the higher Kipling GS output on system stability under fault conditions. As discussed in the previous section, SCO L-0221 Version 21 governs the operations of the generating and transmission facilities, including Kipling GS, in northeastern Ontario. The transient stability studies were based on the operating security limits stipulated in SCO L-0221 Version 21 with an added 10% margin.

As there will not be any changes to the generator, the excitation system, and the governor, only the mechanical power versus water flow data in the governor model were modified to simulate the increase of output resulting from the replacement of generator runners.

Case 1 examines the post-contingency behaviour of Kipling GS for fault condition on the Little Long to Kapuskasing circuit L21S, which incorporates Kipling GS into the northeastern Ontario System. The real power output of Kipling GS was increased to 92.2MW per unit to allow for a 10% margin.

Cases 2 and 3 examine the behaviour of Kipling GS under two operating conditions specified in SCO L-0221. Case 2 examines the maximum 'Flow South' with no generation rejection operating condition while Case 3 examines the condition with P502X and A8K/A9K in parallel.

Results of transient stability studies are presented in Figures 3 to 10 as plots of machine rotor angles of representative generating stations, bus voltages of major stations, and real power flows across critical interfaces. Results show that post-contingency Kipling GS and the northeastern Ontario system will converge to stable operating condition and that with the comprehensive generation rejection scheme in place, increasing the output of Kipling GS by 20MW will not adversely impact on the IMO-controlled grid.

Table 3 summarises the studies and lists the references to the result plots.

Case	Particulars	Contingency	Stability	Plots
1	Kipling Output @ 92.2MW/unit	3-phase fault on L21S @ Little Long	Stable	Figures 3 – 4
2	Kipling Output @ 83MW/unit Flow South = 1445MW (including 10% margin) No G/R selected	Phase-Phase-Ground fault on 500kV circuit X503E @ Hanmer	Stable	Figures 5 – 7
3	Kipling Output @ 83MW/unit Flow on P502X, A8K & A9K = 748MW 703MW of generation selected for post-contingency rejection	Phase-Phase-Ground fault on 500kV circuit P502X @ Porcupine	Stable	Figures 8 – 10

Table 3

Customer Impact

The 'agreed draft' of this Preliminary Assessment Report was issued on October 22, 2002 and a copy was also posted on the IMO web site. Since no response has yet been received from Hydro One regarding the findings from their Customer Impact Assessment (CIA), it has been decided to issue this as the final version of the Report.

However, should any issues be raised by Hydro One's CIA that could affect the content of this Report, then they will be addressed through an Addendum.

3.0 Related Matters

Even though increasing the generating units' output at Kipling GS would not adversely impact the IMO-controlled grid, it would likely increase the congestion cost in the IMO-administered markets when transmission interfaces in the northeastern Ontario system of the IMO-controlled grid such as the 'Flow South' interface become restrictive. Should more stringent security criteria apply to the northeastern Ontario transmission system, the congestion cost would increase further.

Although not presently addressed in the Market Rules, the IMO is in the process of implementing changes that would require hydroelectric generating units that are operated for extended periods in the 'condense' mode to be able to respond automatically to reductions in system frequency.

The IMO therefore recommends that as part of the runner replacement work at Kipling GS, OPG installs facilities that would automatically disable the locking mechanism on the wicket gates at the station in response to falling frequency on the system. Such an arrangement will allow the units to automatically change from the 'condense' mode to the 'generate' mode in response to falling system frequency.

4.0 Recommendation

Based on the above assessment, it is recommended that a System Impact Assessment would not be necessary and a Notification of Approval for this proposal be issued to the applicant.

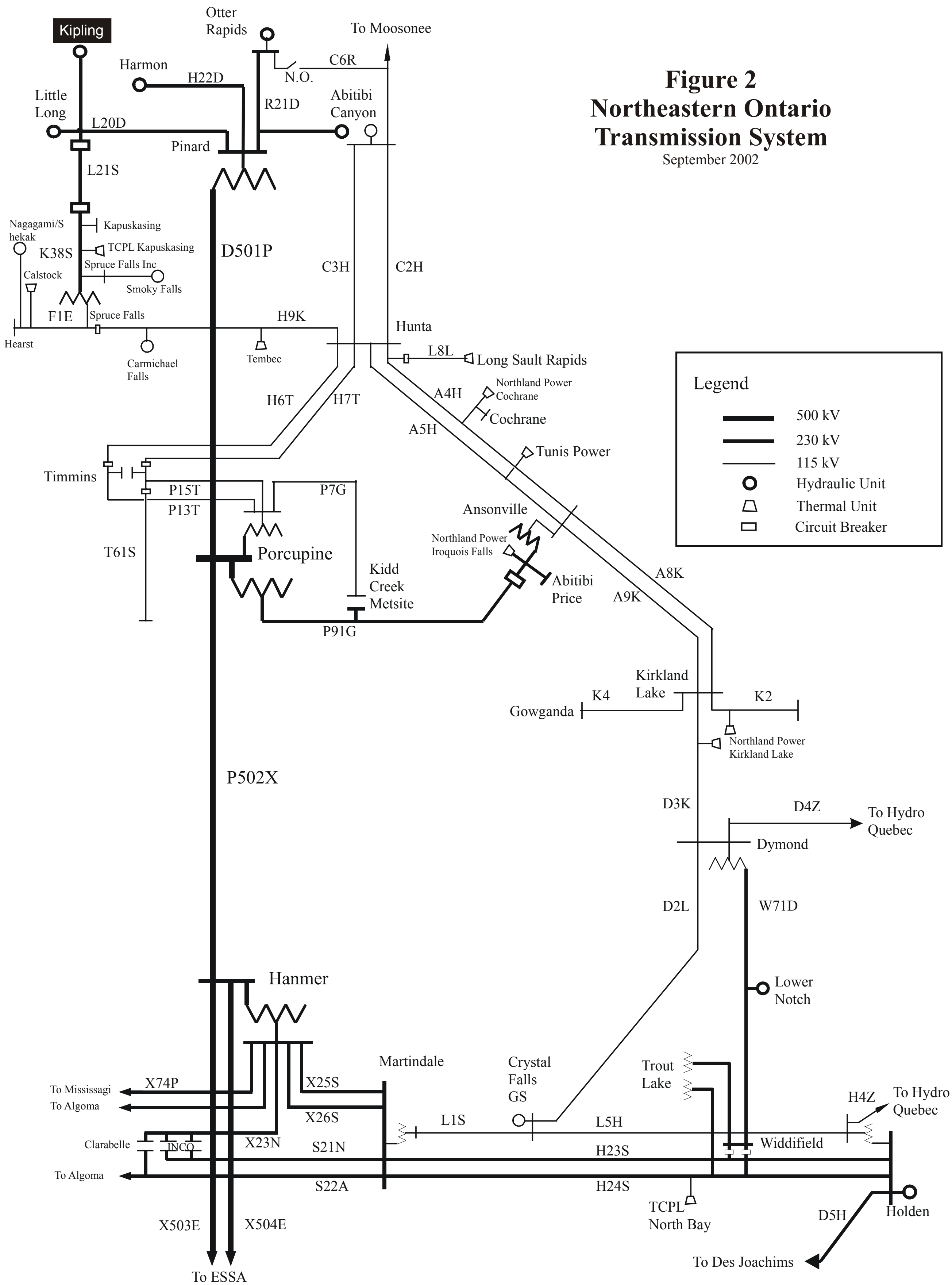

Figure 2
Northeastern Ontario Transmission System
September 2002

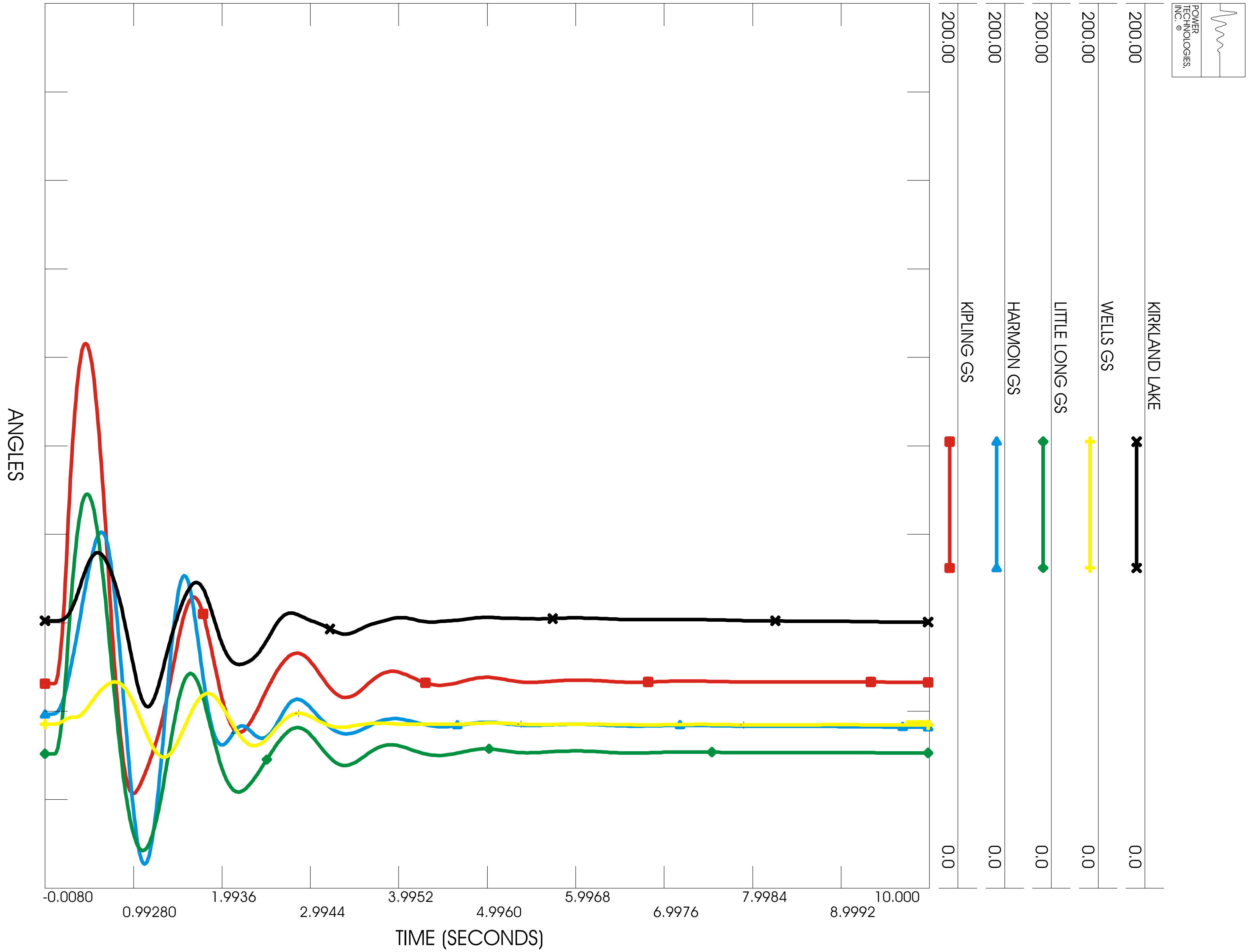

Figure 3 - Case 1: Local Stability Test

SEPT 2002

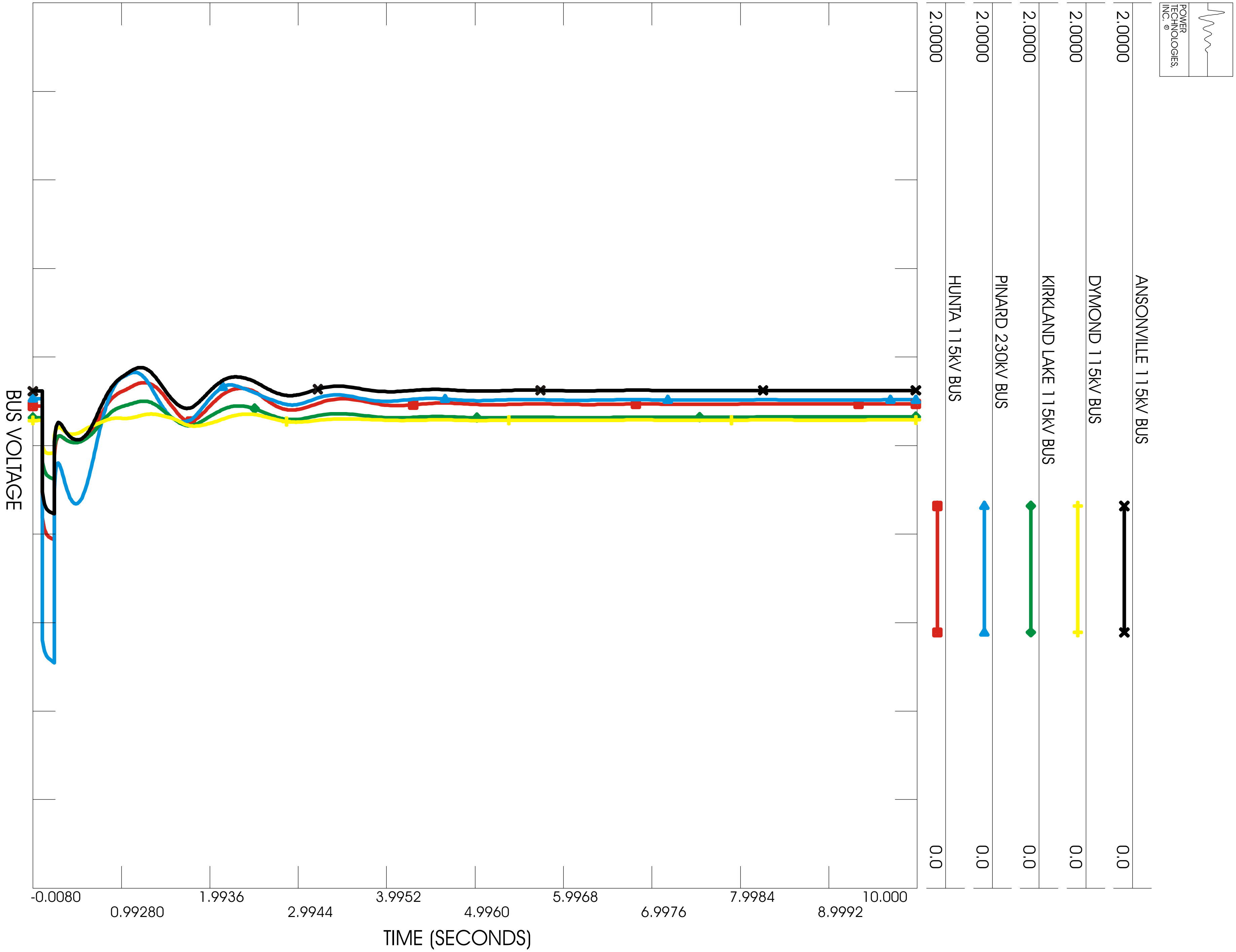

Figure 4 - Case 1: Local Stability Test

SEPT 2002

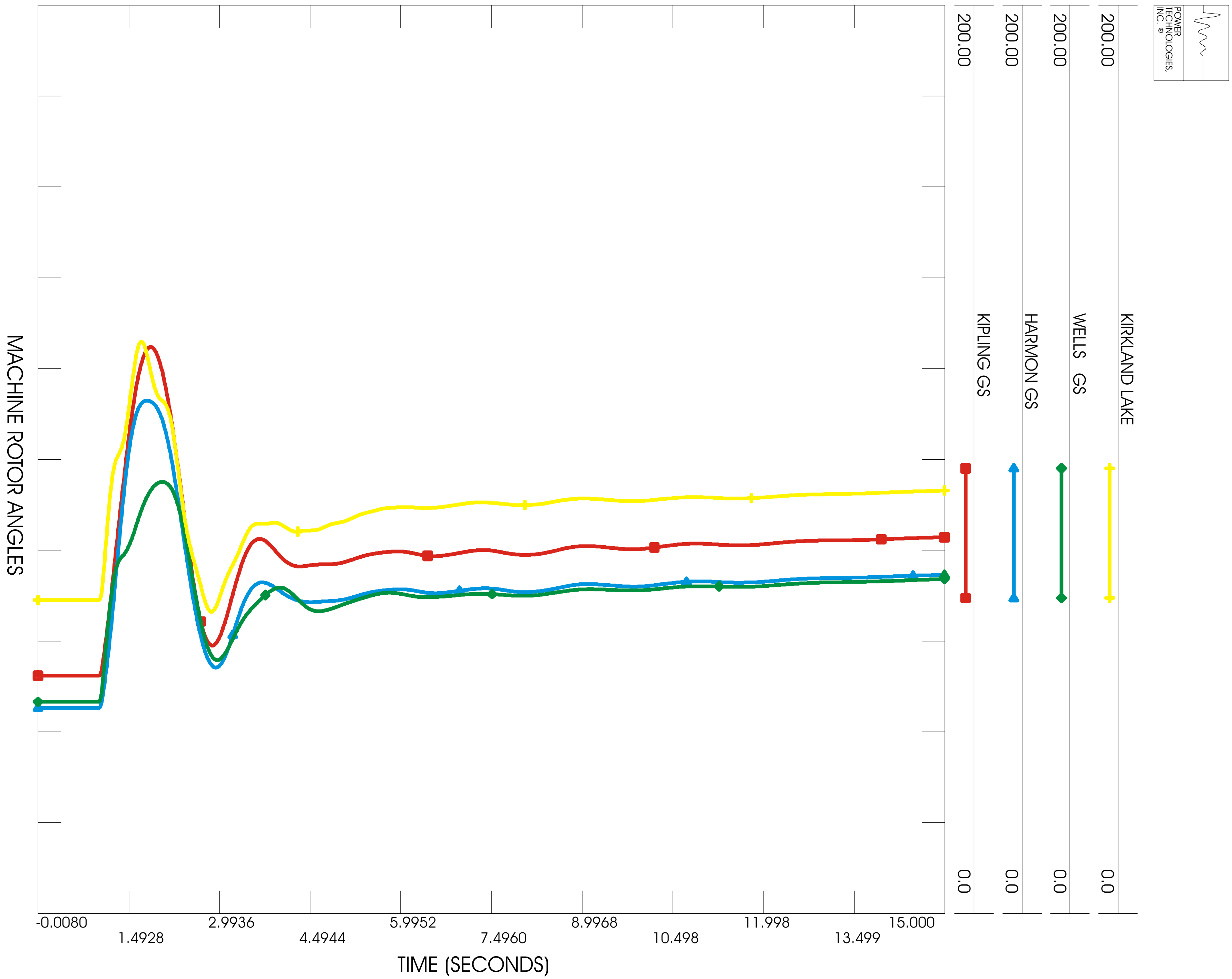

Figure 5 - Case 2: Flow South Limit Test

SEPT 2002

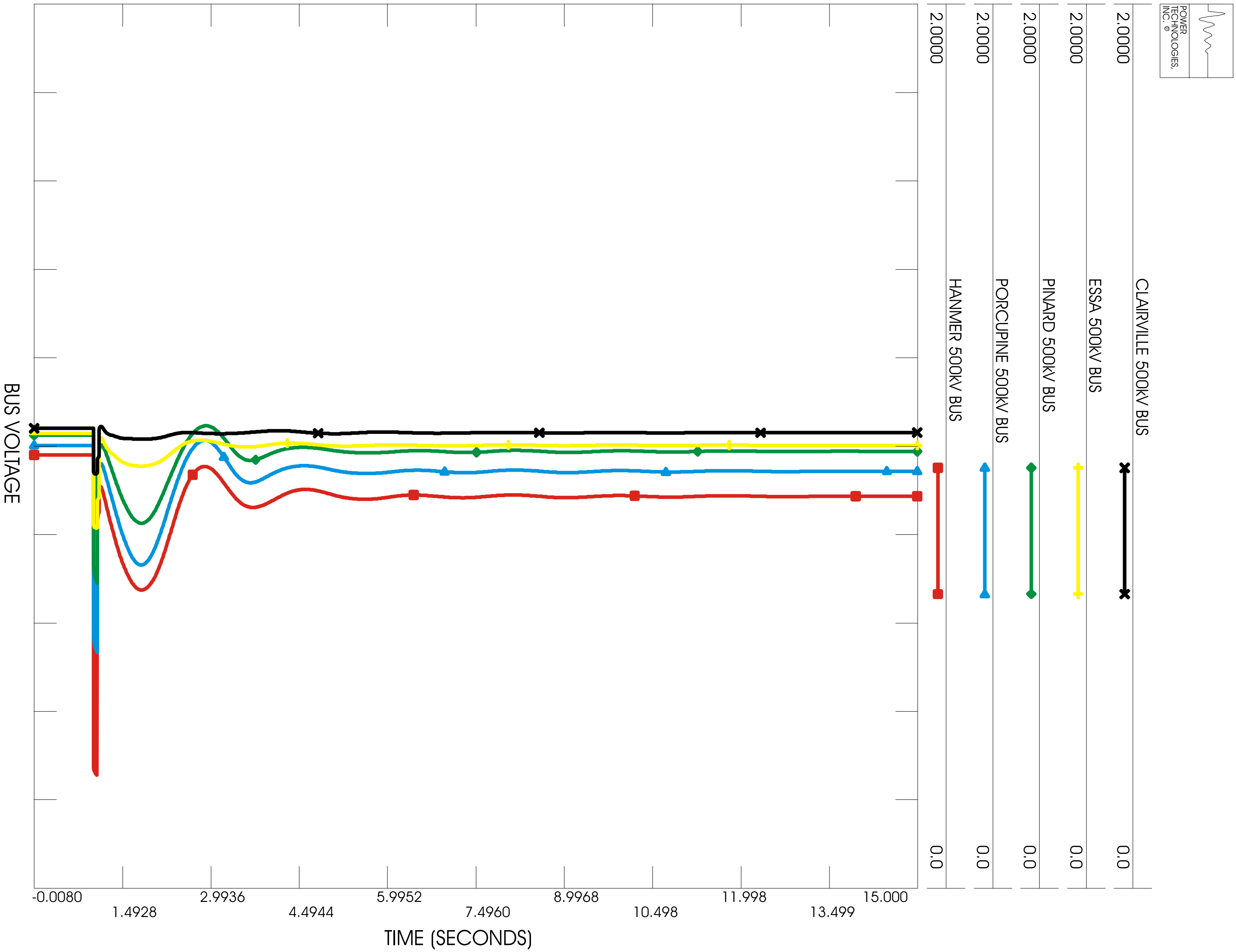

Figure 6 - Case 2: Flow South Limit Test

SEPT 2002

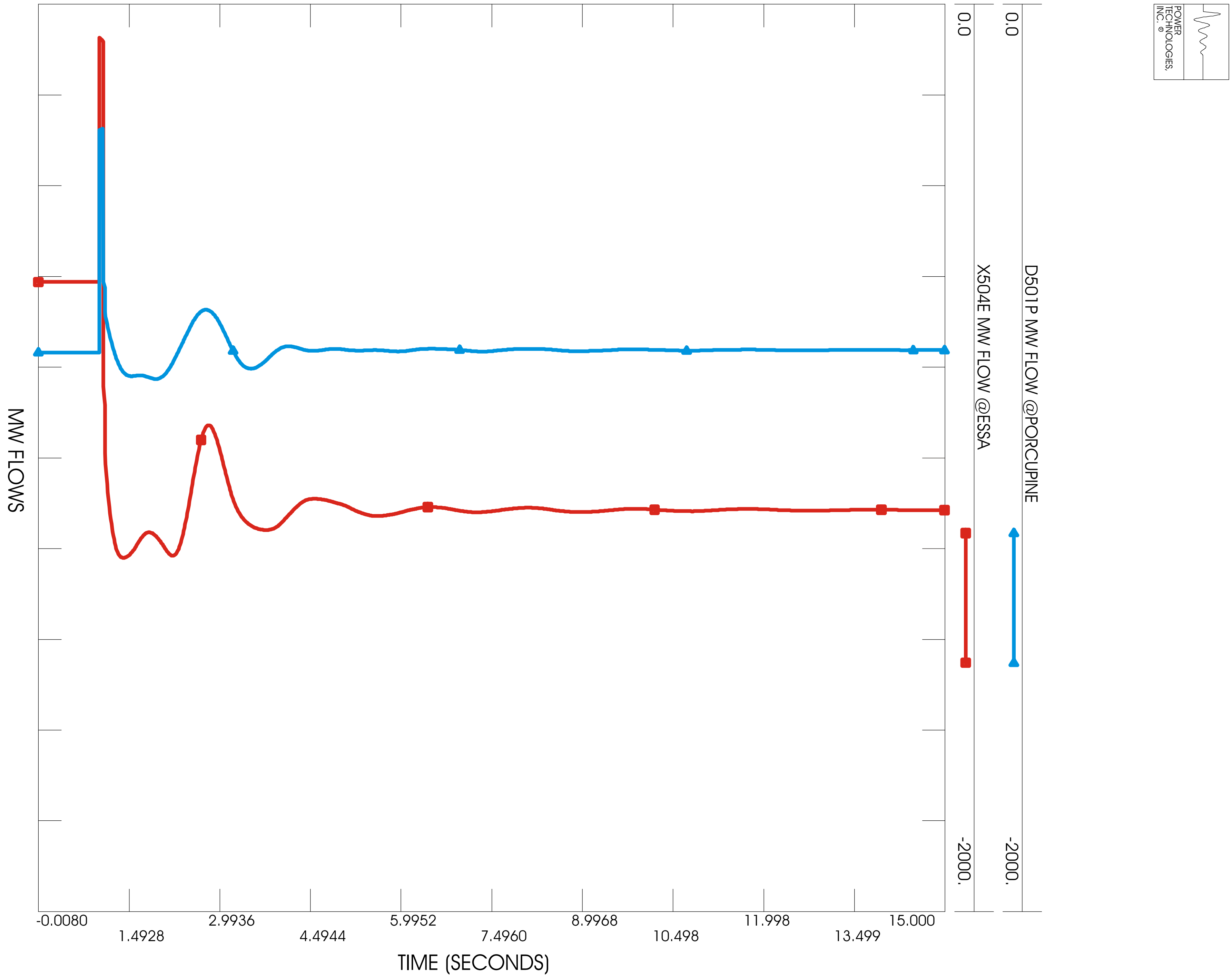

Figure 7 - Case 2: Flow South Limit Test

SEPT 2002

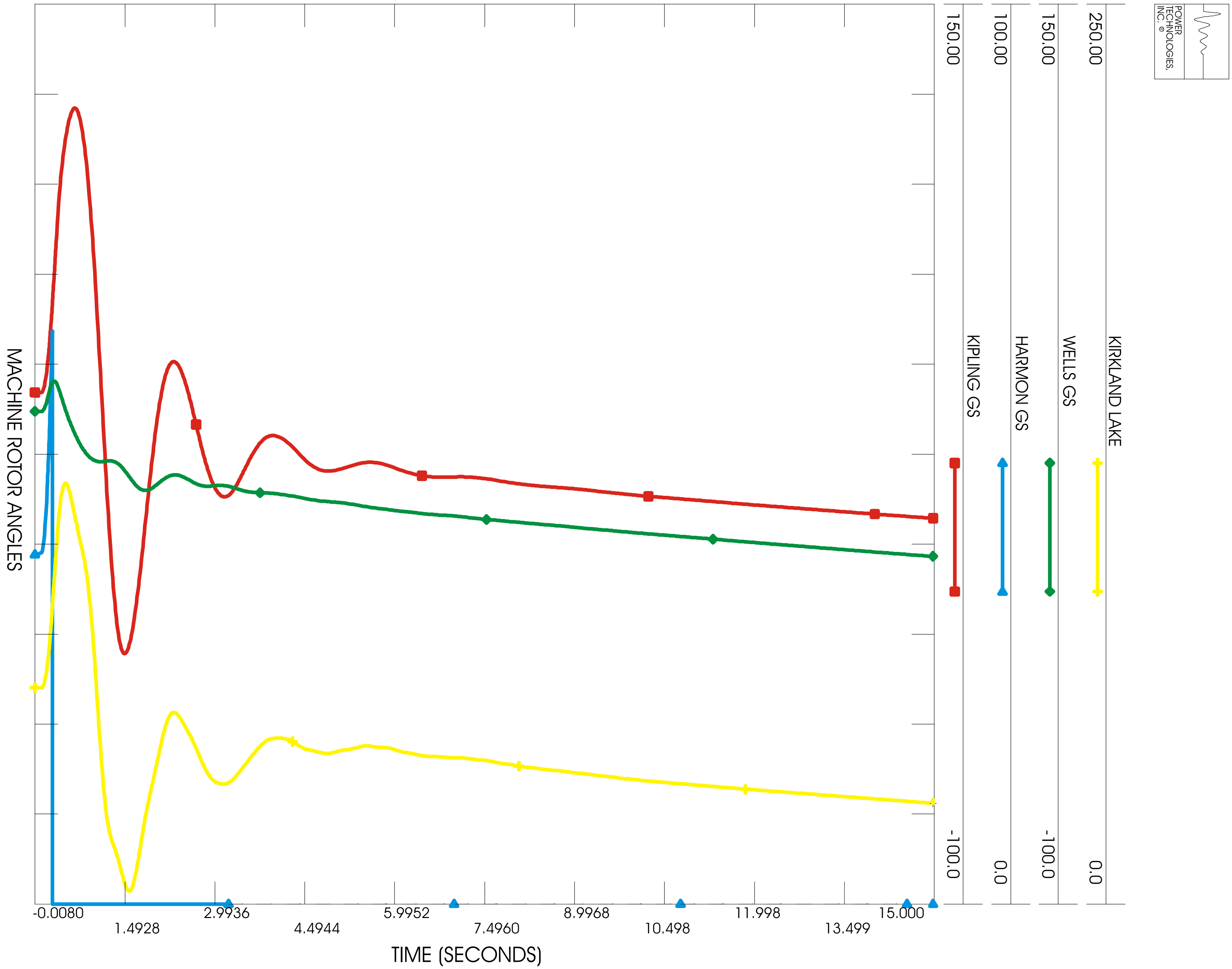

Figure 8 - Case 3: P502X A8K/A9K in Parallel Test

SEPT 2002

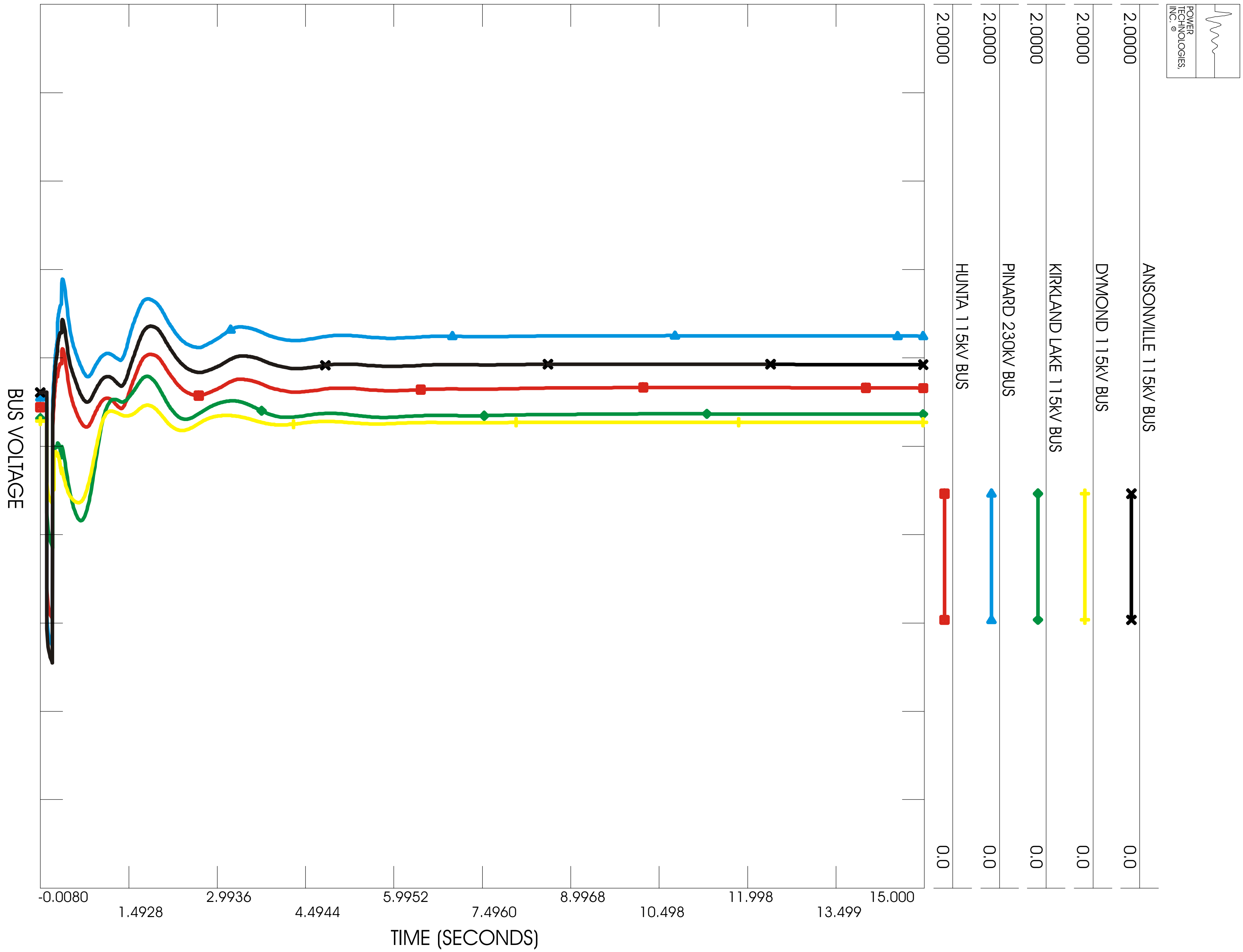

Figure 9 - Case 3: P502X A8K/A9K in Parallel Test

SEPT 2002

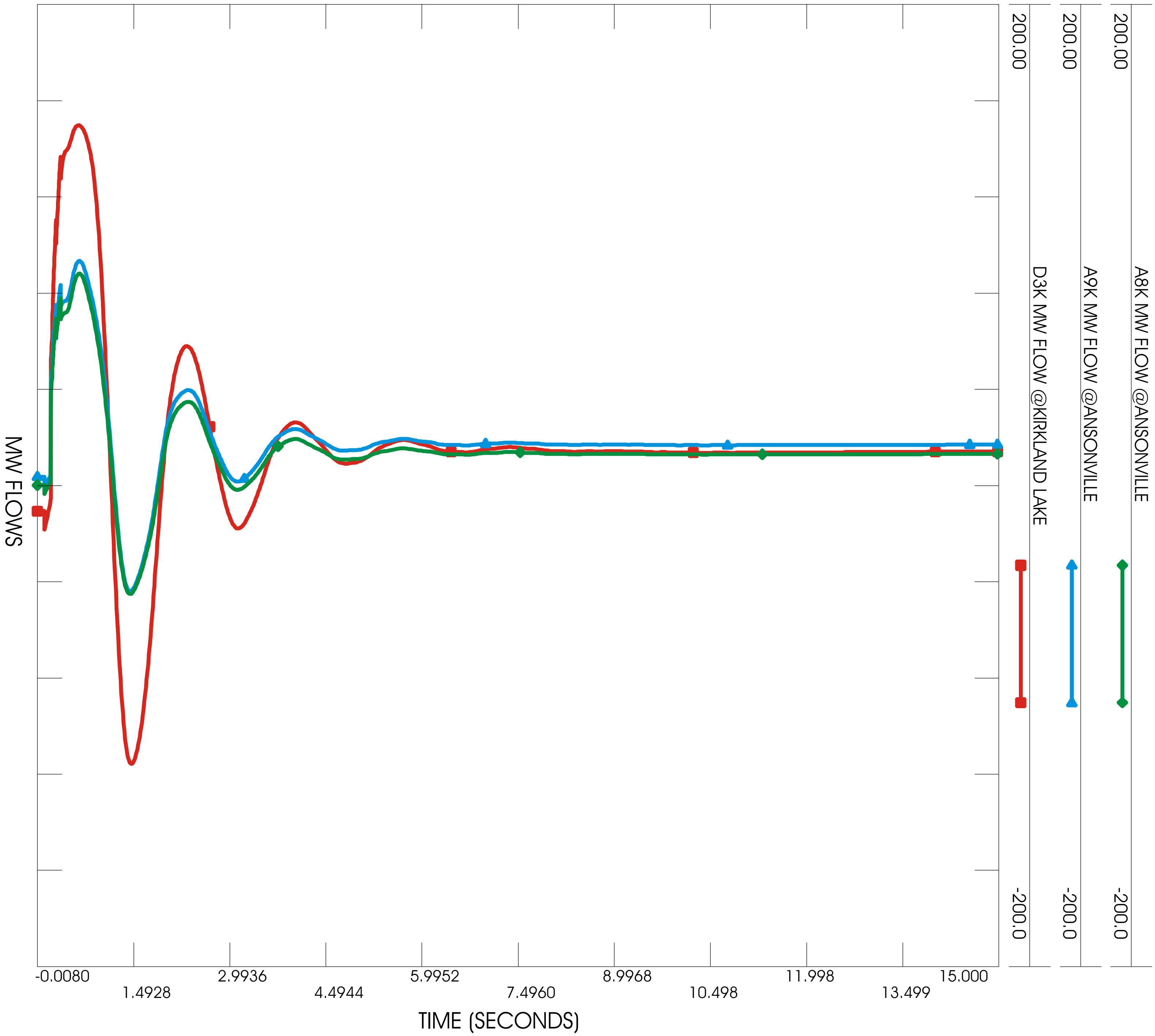

Figure 10 - Case 3: P502X A8K/A9K in Parallel Test

SEPT 2002