IESO_REP_0517

REPORT

Power to Ontario.
On Demand.

System Impact Assessment Report

Lower Mattagami Generation Development

CONNECTION ASSESSMENT & APPROVAL PROCESS

CAA ID 2006-239

Applicant: Ontario Power Generation Inc.

Market Facilitation Department

March 31st, 2010

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System Impact Assessment Report

Lower Mattagami Generation Development Project

Disclaimers

IESO

This report has been prepared solely for the purpose of assessing whether the connection applicant's proposed connection with the IESO-controlled grid would have an adverse impact on the reliability of the integrated power system and whether the IESO should issue a notice of approval or disapproval of the proposed connection under Chapter 4, section 6 of the *Market Rules*.

Approval of the proposed connection is based on information provided to the IESO by the connection applicant and the transmitter(s) at the time the assessment was carried out. The IESO assumes no responsibility for the accuracy or completeness of such information, including the results of studies carried out by the transmitter(s) at the request of the IESO. Furthermore, the connection approval is subject to further consideration due to changes to this information, or to additional information that may become available after the approval has been granted. Approval of the proposed connection means that there are no significant reliability issues or concerns that would prevent connection of the proposed facility to the IESO-controlled grid. However, connection approval does not ensure that a project will meet all connection requirements. In addition, further issues or concerns may be identified by the transmitter(s) during the detailed design phase that may require changes to equipment characteristics and/or configuration to ensure compliance with physical or equipment limitations, or with the Transmission System Code, before connection can be made.

This report has not been prepared for any other purpose and should not be used or relied upon by any person for another purpose. This report has been prepared solely for use by the connection applicant and the IESO in accordance with Chapter 4, section 6 of the *Market Rules*. The IESO assumes no responsibility to any third party for any use, which it makes of this report. Any liability which the IESO may have to the connection applicant in respect of this report is governed by Chapter 1, section 13 of the *Market Rules*. In the event that the IESO provides a draft of this report to the connection applicant, you must be aware that the IESO may revise drafts of this report at any time in its sole discretion without notice to you. Although the IESO 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.

HYDRO ONE

Special Notes and Limitations of Study Results

The results reported in this study are based on the information available to Hydro One, at the time of the study, suitable for a preliminary assessment of a new generation or load connection proposal.

The short circuit and thermal loading levels have been computed based on the information available at the time of the study. These levels may be higher or lower if the connection information changes as a result of, but not limited to, subsequent design modifications or when more accurate test measurement data is available.

This study does not assess the short circuit or thermal loading impact of the proposed connection on facilities owned by other load and generation (including OPG) customers.

In this study, short circuit adequacy is assessed only for Hydro One breakers and does not include other Hydro One facilities. The short circuit results are only for the purpose of assessing the capabilities of existing Hydro One breakers and identifying upgrades required to incorporate the proposed connection. These results should not be used in the design and engineering of new facilities for the proposed connection. The necessary data will be provided by Hydro One and discussed with the connection proponent upon request.

The ampacity ratings of Hydro One facilities are established based on assumptions used in Hydro One for power system planning studies. The actual ampacity ratings during operations may be determined in real-time and are based on actual system conditions, including ambient temperature, wind speed and facility loading, and may be higher or lower than those stated in this study.

The additional facilities or upgrades which are required to incorporate the proposed connection have been identified to the extent permitted by a preliminary assessment under the current IESO Connection Assessment and Approval process. Additional facility studies may be necessary to confirm constructability and the time required for construction. Further studies at more advanced stages of the project development may identify additional facilities that need to be provided or that require upgrading.

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IESO SYSTEM IMPACT ASSESSMENT

SIA Findings

Summary

The Ontario Power Generation (OPG) is proposing to do the following generation expansion at Lower Mattagami:

Existing Generating Facilities				
Little Long GS		Two units: 68 MW	Σ 136 MW	Σ 486 MW
Harmon GS		Two units: 70 MW	Σ 140 MW	
Kipling GS		Two units: 79 MW	Σ 158 MW	
Smoky Falls GS		Four units: 13 MW	Σ 52 MW	
Generating Facilities after expansion				
Little Long GS	(I/S date 2012)	Three units: 70 MW	Σ 210 MW	Σ 945 MW
Harmon GS	(I/S date 2012)	Three units: 78 MW	Σ 234 MW	
Kipling GS	(I/S date 2013)	Three units: 79 MW	Σ 237 MW	
Smoky Falls GS	(I/S date 2013)	Three units: 88 MW	Σ 264 MW	
			Increase from present level	*459 MW*

In order to carry out the above expansion,

(a) OPG intends to do the following modifications.

- Upgrade turbine runners in existing generators at Little Long and Harmon GS
- Install second 13.8/230 kV transformer at Little Long, Harmon and Kipling GS
- Install three new 13.8/230 kV transformers at Smoky Falls GS
- Decommission existing four generators at Smoky Falls GS
- Remove Smoky Falls GS connection to Spruce Falls
- Construct a new 4 km long, double circuit, 230 kV transmission line between Smoky Falls GS and to a designated tap-in point of the existing L20D and H22D to incorporate Smoky Falls GS

(b) Hydro One intends to do the following modifications.

- Install series capacitors at Nobel SS to provide 50 % compensation to X503E and X504E
- Install a +300/-100 Mvar SVC at the Porcupine 230 kV bus
- Install a +200/-100 Mvar SVC at the Kirkland Lake 115 kV bus
- Extend H22D from Harmon GS to Kipling GS to incorporate two Kipling units.

Additional reactive support to accommodate the large reactive losses will be provided in part by shunt capacitor banks installed at various stations across Northern Ontario. Details regarding these shunt capacitor installations are provided below:

	Station	Size	In-service Date
1	Dryden TS	2 x 50 MVAr@ 250 kV	December 2010
3	Kapuskasing TS	1 x 21.6 MVAr @ 28.8 kV	September 2010
4	Essa TS	1 x 245 MVAr @ 250 kV	September 2010
6	Pinard TS	2 x 32.4 MVAr @ 27.6 kV	December 2010
7	Hanmer TS	1 x 149 MVAr@ 220 kV	December 2010
8	Porcupine TS	2 x 100 MVAr @ 250 kV	September 2011

Note: An SIA for these shunt capacitor installations has already been completed by the IESO and can be found at http://www.ieso.ca/imoweb/pubs/caa/caa_SIAReport_2008_352.pdf

Conclusions

The IESO carried out the System Impact Assessment in order to identify the effect of this redevelopment plan on the IESO controlled grid. Based on the analysis, the following conclusions were made.

(1) The proposed project will not cause a material adverse impact on the reliability of the IESO-controlled grid provided the connection requirements given in this document are met.

(2) When all elements are in service and with the system assumptions made in this report, the transfer capability of the Flow-South interface can be increased up to 2050 MW with no generation rejection armed for contingencies to the X503E or X504E 500 kV circuits.

(3) System limitations exist to the amount of power that can flow into Hanmer on the P502X circuit and into Porcupine on the D501P circuit. If the power flows into Hanmer on P502X and into Porcupine on D501P are increased beyond the levels studied in this report or pre-contingency voltage levels are lowered , transient instability of the Lower Mattagami units and unacceptable transient voltage performance can result for a contingency to the X503E or X504E 500 kV circuits with no generation rejection armed. Expansion of the Mississagi East transfer capability provides for the opportunity to reduce the amount of flow into Hanmer on P502X, while still achieving a Flow South transfer of 2050 MW.

(4) If existing relay settings of D3K@K remain unchanged, D3K will trip for the loss of P502X.

(5) The proposed excitation systems and governors for the new generators meet IESO standards.

(6) The steady-state loadings for circuits H22D and L20D are only marginally below their thermal capability. Slight thermal overloading of the H22D and L20D circuits is possible. All other steady-state loadings for the equipments mentioned are below their continuous ratings.

(7) Post-contingency overvoltage concerns exist around the Hanmer, Porcupine, Pinard and Kapuskasing area. To mitigate overvoltage concerns, Hydro One must install switching schemes to automatically trip newly installed capacitors at Hanmer, Porcupine, Pinard and Kapuskasing.

Notification of Conditional Approval

It is recommended that a Notification of Conditional Approval be issued for Lower Mattagami generation redevelopment project subject to the IESO's Requirements for Connection listed below, all general requirements as mentioned in this report and any further requirements that may be identified by Hydro One in the Customer Impact Assessment.

IESO's Requirements for Connection

These specific requirements are in addition to the general requirements listed in section 2 of this report.

For Ontario Power Generation:

1. The generator under-frequency settings should be set such that the generators do not trip for frequency variations that are above the curve given in Figure 3.

2. The real-time monitoring of following quantities from new generators must be provided to the IESO.
    - Active power generation
    - Reactive power generation
    - Terminal breaker status
    - Terminal voltage
    - AVR and PSS status

3. The performance of installed equipment must meet or exceed the predicted performance observed in this SIA. Finalized dynamic models for the Lower Mattagami generators and their control systems must meet or exceed the equipment capability studied in this report.

4. The commissioning reports must be submitted to the IESO within 30 days of the conclusion of commissioning. The field test results should agree with simulations done using the PSS/E software.

5. OPG must install the extensions of L20D and H22D to incorporate Smoky Falls GS.

For Hydro One:

1. The following must be installed.
    - Series capacitors at Nobel SS to provide 50 % compensation to X503E and X504E
    - +300/-100 Mvar SVC at Porcupine 230 kV bus
    - +200/-100 Mvar SVC at Kirkland Lake 115 kV bus
    - Extension of H22D from Harmon GS to Kipling GS to incorporate two Kipling units.
    - Drop downs from L20D and H22D to incorporate Smoky Falls GS

2. Northeast Generation Rejection Schemes must be modified.
    - All six new generators must be included in the scheme such that they can be rejected as response to contingencies, similar to existing Lower Mattagami units.
    - The Facility Description Document FDD-1025 must be revised.

3. The relay settings of D3K must be modified.

4. The short-circuit currents should not exceed new and existing equipment ratings. Short circuit levels are shown in Table 3 of this report.

5. New or modified syncho-check and auto-reclosure settings must be provided to the IESO.

6. The performance of installed equipment must meet or exceed the predicted performance observed in the SIA.

7. To mitigate overvoltage concerns, Hydro One must install switching schemes to automatically trip newly installed capacitors at Hanmer, Porcupine, Pinard and Kapuskasing.

   These switching schemes can be implemented using automatic over-voltage based switching on the condition that voltage thresholds and time delays are suitably chosen, such that overvoltage concerns are mitigated and operating times of the switching schemes do not encroach on the ULTC operation timeframe. The newly implemented schemes must also ensure that they are properly coordinated with the existing reactor switching scheme at Pinard and with other existing SPS facilities in the area. This will likely mean that the time delays and voltage thresholds of the existing Pinard reactor switching scheme will need to be modified.

   If Hydro One is unable to meet these conditions, switching out of the capacitors at Hanmer, Porcupine, Pinard and Kapuskasing will need to be added as responses to various contingencies to the existing Moose River G/R and Northeast 115 kV L/R & G/R schemes.

For Both OPG and Hydro One:

The following requirement applies to the OPG as connection applicant and Hydro One as the transmitter.

The connection applicant is required to initiate an assessment of the existing protection systems with the transmitter who shall identify any modifications to protection equipment or settings required to incorporate the new facility. The IESO will evaluate the impact of any protection modifications and associated changes to functionality, timing, or reach on system reliability. The IESO will not assess aspects of protection systems which are solely the accountability of the connection applicant (e.g. coordination of relay protections).

To allow sufficient time to assess the impact on power system reliability, the connection applicant must submit any proposed protection changes to the IESO at least six (6) months before any actual changes are to be implemented on the existing protection systems.

Please send documentation for protection changes triggered by new or modified primary equipment (i.e. new or replacement relays) to connection.assessments@ieso.ca.

For protection changes that are not associated with new or modified equipment (i.e. protection settings changes) please send documentation to protection.settings@ieso.ca.

The IESO would deem the modifications acceptable if they do not cause any new and/or reduced operating security limits under normal operating conditions. Should the modifications be unacceptable, the IESO would require the connection applicant to investigate other mitigating measures.

IESO Recommendations

The modified connection arrangement shown below with a switching station located at Little Long SS is highly recommended by the IESO.

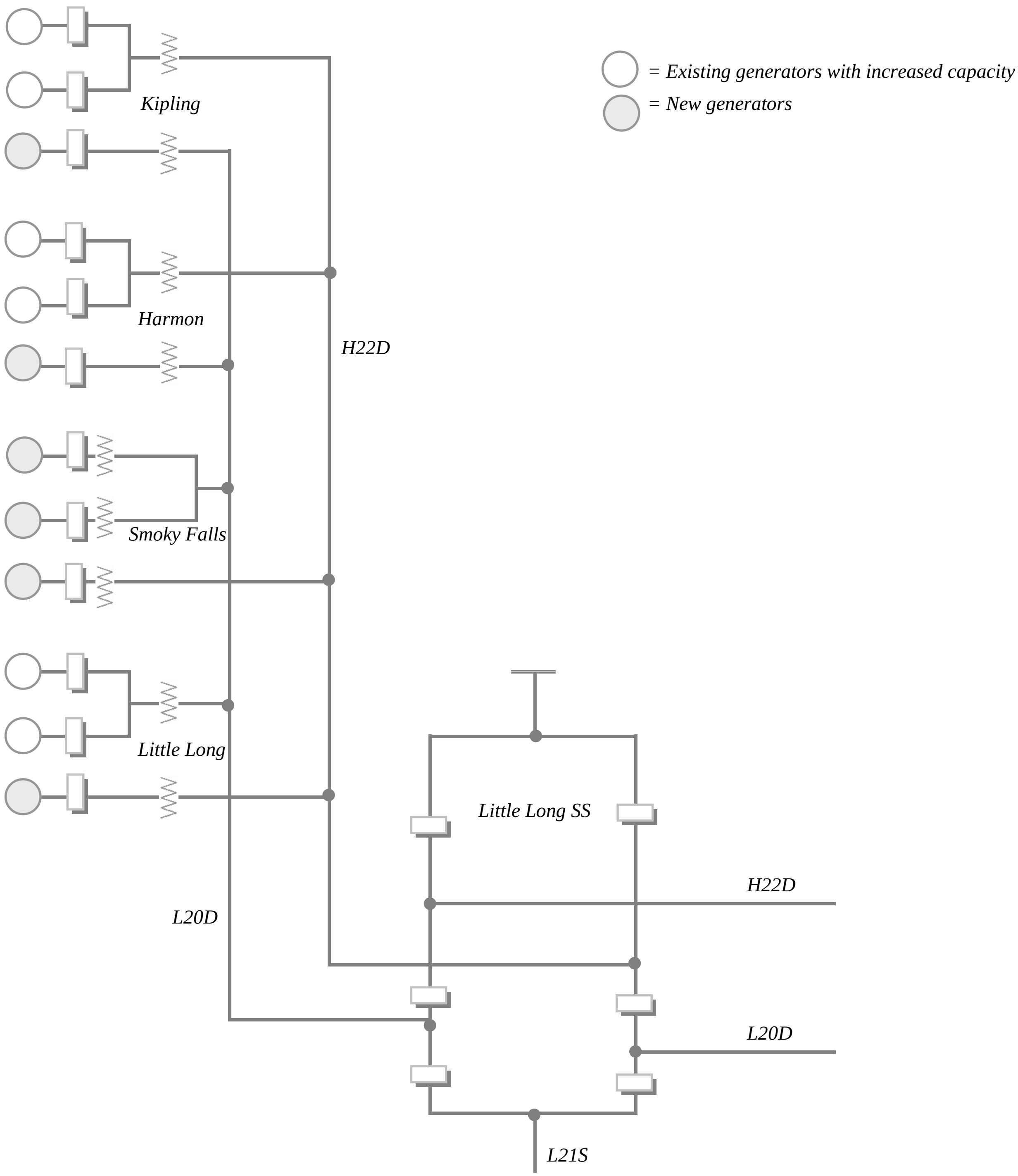


FIGURE 1 : RECOMMENDED LITTLE LONG SS CONNECTION ARRANGEMENT

This recommended arrangement provides the following reliability benefits over the proposed connection arrangement studied in this report:

- Allows limited generation capacity to continue to operate in support of the 230 kV circuit L21S in the event of a double-circuit contingency/outage involving the 230 kV circuits between Little Long SS and Pinard TS.
- Maintains a connection from Pinard TS to support the load supplied from circuit L21S in the event of a double-circuit contingency/outage involving the 230 kV circuits between Little Long SS and the generating plants.
- Allows the connection of a 100 MVAr capacitor bank to compensate local area system losses which allows for increased power flows into Porcupine and Hanmer through circuits D501P and P502X.

This recommended connection arrangement was discussed and reviewed by the IESO, OPG and Hydro One but could not be economically justified at this time.

- End of Section -

1. Project Description

The north-eastern Ontario power system covers the area north of Sudbury and east of Wawa stretching all the way to the Quebec border. The north-eastern transmission system incorporates many generation resources that are used to supply local demand and demand in southern Ontario.

Amongst many hydroelectric power plants located in northeastern Ontario, there are four generating plants that are located along the Lower Mattagami River. They are Little Long, Kipling, Harmon and Smoky Falls. Due to study revelations that each of these power generating stations has enough water flow to support additional power production, the Ontario Power Generation Inc is proposing to expand those stations to the following levels:

Capacity of the Generating Facilities following expansion			
Little Long GS	Three units: 70 MW	Σ 210 MW	Σ 945 MW
Harmon GS	Three units: 78 MW	Σ 234 MW	
Kipling GS	Three units: 79 MW	Σ 237 MW	
Smoky Falls GS	Three units: 88 MW	Σ 264 MW	
		Increase from present level	*459 MW*

The existing generators will produce more power at Little Long, Harmon and Kipling stations and each of those stations will also be equipped with a new third generator. While the runners at the existing Kipling turbines can handle the increased power production, the runners at existing turbines at Little Long and Harmon units require upgrading. The electrical equipment including generators requires no upgrades to produce the added power. The new unit at each station will be connected to L20D or H22D using a new 13.8/230 kV transformer. The existing units at Smoky Falls will be fully retired, and three new larger units will be installed and will be connected to H22D or L20D via two 4 km 230 kV transmission lines.

(a) Generation Connection Arrangement

The proposed connection arrangement is shown in Figure 2. This has been discussed with OPG and Hydro One. The resulting distribution of the generating facilities are shown below and will ensure approximately even flows on H22D and L20D circuits that will respect their continuous ratings.

Circuit	Kipling	Harmon	Smoky Falls	Little Long	Total Capacity connected
L20D	1 × 79 MW	1 × 78 MW	2 × 88 MW	2 × 70 MW	473 MW
H22D	2 × 79 MW	2 × 78 MW	1 × 88 MW	1 × 70 MW	472 MW

This arrangement will require the extension of the 230 kV circuit H22D from Harmon GS to Kipling GS to connect two Kipling units to H22D and two new 230 kV circuits from Smoky Falls GS to a designated tap-in point of the existing L20D and H22D circuits.

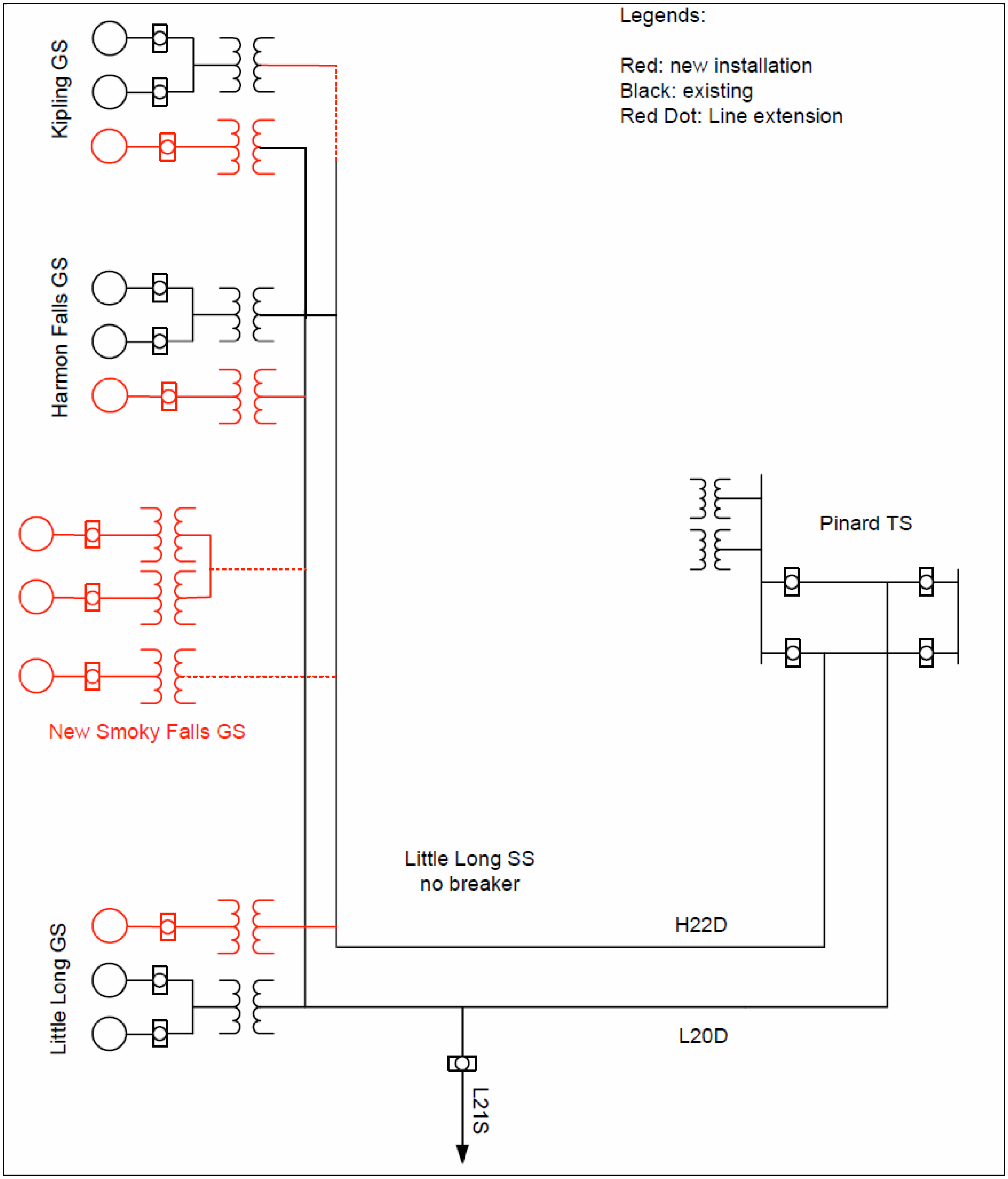


FIGURE 2 : PROPOSED LOWER MATTAGAMI CONNECTION ARRANGEMENT

– End of Section –

2. General Requirements

Generators

1. Each generator must satisfy the Generator Facility requirements in Appendix 4.2 of Market Rules.

The Market Rules (appendix 4.2, reference 1) require that the generation facility connecting to the IESO-controlled grid must have the minimum capability to supply reactive power continuously in the range of 90% lagging to 95% leading power factor based on rated active power output at its generator terminals for at least one constant 230 kV system voltage. The connection applicant shall submit the generator's capability curve to the IESO as evidence that the generator is capable of meeting the reactive power requirements.

If necessary, shunt capacitors must be installed to offset the reactive power losses within the facility in excess of the maximum allowable losses. If generators do not have dynamic reactive power capabilities as described above, dynamic reactive compensation devices must be installed to make up the deficient reactive power.

2. The generators must be able to ride through recognized contingencies on the IESO-controlled grid that do not disconnect the facility by configuration.

3. The connection and disconnection of the generators must minimize any adverse effects on the IESO-controlled grid.

Connection Equipment (Breakers, Disconnects, Transformers, Buses)

1. Appendix 4.1, reference 2 of the Market Rules states that under normal conditions voltages are maintained within the range of 220 kV to 250 kV. Thus, the IESO requires that the 230 kV equipment in Ontario must have a maximum continuous voltage rating of at least 250 kV.

   Fault interrupting devices must be able to interrupt fault current at the maximum continuous voltage of 250 kV.

If revenue metering equipment is being installed as part of this project, please be aware that revenue metering installations must comply with Chapter 6 of the IESO Market Rules for the Ontario electricity market. For more details the applicant is encouraged to seek advice from their Metering Service Provider (MSP) or from the IESO metering group.

2. The Transmission System Code (TSC), Appendix 2 establishes maximum fault levels for the transmission system. For the 230 kV system, the maximum 3 phase symmetrical fault level is 63 kA and the single line to ground (SLG) symmetrical fault level is 80 kA (usually limited to 63 kA).

   The TSC requires that new equipment be designed to sustain the fault levels in the area where the equipment is installed. If any future system enhancement results in an increased fault level higher than the equipment's capability, the connection applicant is required to replace the equipment at their own expense with higher rated equipment capable of sustaining the increased fault level, up to the TSC's maximum fault level of 63 kA for the 230 kV system.

3. The connection equipment must be designed so that the adverse effects of failure on the IESO-controlled grid are mitigated.

4. The connection equipment must be designed so that it will be fully operational in all reasonably foreseeable ambient temperature conditions. This includes ensuring that SF6 breakers are equipped with heaters to prevent freezing.

IESO Monitoring and Telemetry Data

In accordance with the telemetry requirements for a generation facility (see Appendices 4.15 and 4.19 of the Market Rules) the connection applicant must install equipment at this project with specific performance standards to provide telemetry data to the IESO. The data is to consist of certain equipment status and operating quantities which will be identified during the IESO Market Entry Process.

As part of the IESO Facility Registration/Market Entry process, the connection applicant must also complete end to end testing of all necessary telemetry points with the IESO to ensure that standards are met and that sign conventions are understood. All found anomalies must be corrected before IESO final approval to connect any phase of the project is granted.

Protection Systems

1. Protection systems must be designed to satisfy all the requirements of the Transmission System Code as specified in Schedules E, F and G of Appendix 1 and any additional requirements identified by the transmitter. New protection systems must be coordinated with existing protection systems.

2. All new facilities must be protected by two redundant protection systems according to section 8.2.1a of the TSC. These redundant protections systems must satisfy all requirements of the TSC but in particular they may not use common components, common battery banks or common secondary CT or PT windings.

3. Protective relaying must be set to ensure that transmission equipment remains in-service for voltages between 94% of the minimum continuous and 105% of the maximum continuous values in the Market Rules, Appendix 4.1.

4. The Applicant is required to have adequate provision in the design of protections and controls at the facility to allow for future installation of Special Protection Scheme (SPS) equipment.

5. Any modifications made to protection relays by the transmitter after this SIA is finalized must be submitted to the IESO as soon as possible or at least six (6) months before any modifications are to be implemented on the existing protection systems. If those modifications result in adverse impacts, the connection applicant and the transmitter must develop mitigation solutions.
   Send documentation for protection modifications triggered by new or modified primary equipment (i.e. new or replacement relays) to connection.assessments@ieso.ca.
   For protection modifications that are not associated with new or modified equipment (i.e. protection setting modifications) please send documentation to protection.settings@ieso.ca.

6. Protection systems within the generation facilities must only trip the appropriate equipment required to isolate the fault. After the facility begins commercial operation, if an improper trip of

the 230 kV circuits L20D/H22D occurs due to events within the facility, the facility may be required to be disconnected from the IESO-controlled grid until the problem is resolved.

Frequency Requirements

The facility must be capable of operating continuously for grid frequencies in the range between 59.4 Hz and 60.6 Hz as specified in Appendix 4.2, Reference 3 of the Market Rules.
The facility must be capable of operating at full active power for a limited period of time for grid frequencies as low 58.8 Hz. Generators must not trip for under-frequency system conditions that are below 60 Hz but above 57.0 Hz and above the curve shown in Figure 1.

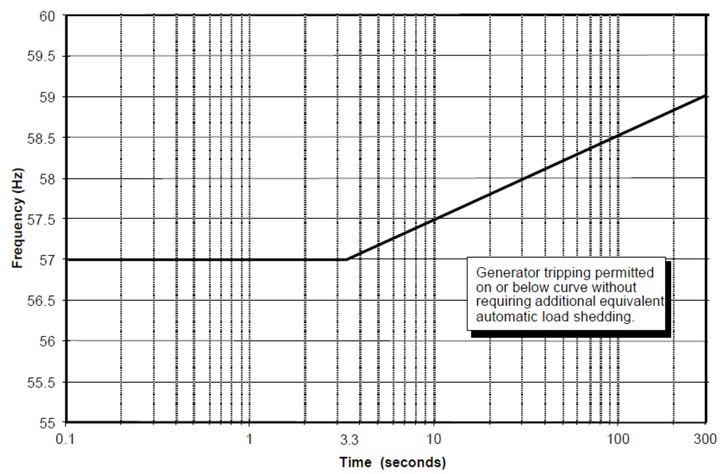


Figure 3: Setting for Grid Under-frequency Trip Protection

Miscellaneous

1. The generators must operate in the voltage control mode. Operation of the facility in power factor control or reactive power control is not acceptable.

Facility Registration/Market Entry Requirements

The connection applicant must complete the IESO Facility Registration/Market Entry process in a timely manner before IESO final approval for connection is granted. Models and data, including any controls that would be operational, must be provided to the IESO. This information should be submitted at least seven months before energization to the IESO-controlled grid, to allow the IESO to incorporate this project into IESO work systems and to perform any additional reliability studies.

As part of the IESO Facility Registration/Market Entry process, the connection applicant must provide evidence to the IESO confirming that the equipment installed meets the Market Rules requirements and matches or exceeds the performance predicted in this assessment. This evidence shall be either type tests done in a controlled environment or commissioning tests done on-site. In either case, the testing must be done not only in accordance with widely recognized standards, but also to the satisfaction of the IESO. Until this evidence is provided and found acceptable to the IESO, the Facility Registration/Market Entry process will not be considered complete and the connection applicant must accept any restrictions the IESO may impose upon this project's participation in the IESO administered market or connection to the IESO-controlled grid.

The evidence must be supplied to the IESO within 30 days after completion of commissioning tests. Failure to provide evidence may result in disconnection from the IESO-controlled grid.

If the submitted models and data differ materially from the ones used in this assessment, then further analysis of the project will need to be done by the IESO.

Reliability Standards

Prior to connecting to the IESO controlled grid, the proposed facility must be compliant with the applicable reliability standards set by the North American Electric Reliability Corporation (NERC) and the North East Power Coordinating Council (NPCC). A list of applicable standards, based on the proponent's/connection applicant's market role/OEB licence can be found here: http://www.ieso.ca/imoweb/ircp/reliabilityStandards.asp

In support of the NERC standard EOP-005, the proponent/ connection applicant may meet the restoration participant criteria. Please refer to section 3 of Market Manual 7.8 (Ontario Power System Restoration Plan) to determine its applicability to the proposed facility

The IESO monitors and assesses market participant compliance with these standards as part of the IESO Reliability Compliance Program. To find out more about this program, visit the webpage referenced above or write to ircp@ieso.ca.

Also, to obtain a better understanding of the applicable reliability obligations and find out how to engage in the standards development process, we recommend that the proponent/ connection applicant join the IESO's Reliability Standards Standing Committee (RSSC) or at least subscribe to their mailing list at rssc@ieso.ca. The RSSC webpage is located at: http://www.ieso.ca/imoweb/consult/consult_rssc.asp.

– End of Section –

3. Data Verification

The data for existing generators, excitation systems, power system stabilizers and governors remain unchanged. The data for these facilities used in the assessment are the data available in the IESO database which were provided by OPG at the time of their registration. The following are the dynamic models and data for the new generators as submitted by OPG.

(a) Generators

Following are the data for the **GENSAL** models used in the analysis.

Kipling G3

$T'_{do} = 5.0$	$T''_{do} = 0.045$	$T''_{qo} = 0.04$	$H = 3.16$	$D = 0.0$	$X_d = 0.86$
$X_q = 0.66$	$X'_d = 0.29$	$X''_d = 0.25$	$X_l = 0.12$	$S(1.0) = 0.15$	$S(1.2) = 0.5$

Little Long G3

$T'_{do} = 5.0$	$T''_{do} = 0.09$	$T''_{qo} = 0.04$	$H = 3.1$	$D = 0.0$	$X_d = 0.86$
$X_q = 0.6$	$X'_d = 0.29$	$X''_d = 0.25$	$X_l = 0.12$	$S(1.0) = 0.15$	$S(1.2) = 0.5$

Harmon G3

$T'_{do} = 5.0$	$T''_{do} = 0.09$	$T''_{qo} = 0.04$	$H = 3.1$	$D = 0.0$	$X_d = 0.86$
$X_q = 0.6$	$X'_d = 0.29$	$X''_d = 0.25$	$X_l = 0.12$	$S(1.0) = 0.15$	$S(1.2) = 0.5$

Smoky Falls G1, G2, G3

$T'_{do} = 5.0$	$T''_{do} = 0.10$	$T''_{qo} = 0.07$	$H = 3.1$	$D = 0.0$	$X_d = 0.95$
$X_q = 0.66$	$X'_d = 0.3$	$X''_d = 0.26$	$X_l = 0.13$	$S(1.0) = 0.15$	$S(1.2) = 0.5$

(b) Automatic Excitation Systems

The following are the data for the **ESST1A** models used in the analysis.

Kipling G3, Harmon G3, Little Long G3, Smoky Falls G1, G2, G3

$T_R = 0.01$	$T_C = 0.0$	$T_B = 0.0$	$T_{C1} = 0.0$	$T_{B1} = 0.0$	$K_A = 160.0$
$T_A = 0.0$	$K_C = 0.1$	$VI_{MAX} = 999.0$	$VI_{MIN} = -999.0$	$VR_{MAX} = 5.5$	$VR_{MIN} = -4.51$
$K_F = 0.0$	$T_F = 1.0$	$K_{LR} = 0.0$	$I_{LR} = 0.0$	$VA_{MAX} = 999.0$	$VA_{MIN} = -999.0$
UEL = 1	VOS = 1				

(c) Power System Stabilizers

The following are the data for the **PSS2A** models used in the analysis.

Kipling G3

$T_{W1} = 10.0$	$T_{W2} = 10.0$	$T_6 = 0.0$	$T_{W3} = 10.0$	$T_{W4} = 0.0$	$T_7 = 10.0$
$K_{S2} = 1.58$	$K_{S3} = 1.0$	$T_8 = 0.5$	$T_9 = 0.1$	$K_{S1} = 15.0$	$T_1 = 0.08$
$T_2 = 0.02$	$T_3 = 0.08$	$T_4 = 0.02$	$VST_{MAX} = 0.1$	$VST_{MIN} = -0.05$	N = 1
IC1 = 1	IC2 = 3	M = 5			

Harmon G3

$T_{W1} = 5.0$	$T_{W2} = 5.0$	$T_6 = 0.0$	$T_{W3} = 5.0$	$T_{W4} = 0.0$	$T_7 = 5.0$
$K_{S2} = 0.81$	$K_{S3} = 1.0$	$T_8 = 0.5$	$T_9 = 0.1$	$K_{S1} = 15.0$	$T_1 = 0.08$
$T_2 = 0.02$	$T_3 = 0.08$	$T_4 = 0.02$	$VST_{MAX} = 0.1$	$VST_{MIN} = -0.05$	N = 1
IC1 = 1	IC2 = 3	M = 5			

Little Long G3

$T_{W1} = 7.5$	$T_{W2} = 7.5$	$T_6 = 0.0$	$T_{W3} = 7.5$	$T_{W4} = 0.0$	$T_7 = 7.5$
$K_{S2} = 1.21$	$K_{S3} = 1.0$	$T_8 = 0.5$	$T_9 = 0.1$	$K_{S1} = 15.0$	$T_1 = 0.08$
$T_2 = 0.02$	$T_3 = 0.08$	$T_4 = 0.02$	$VST_{MAX} = 0.1$	$VST_{MIN} = -0.05$	N = 1
IC1 = 1	IC2 = 3	M = 5			

Smoky Falls G1, G2, G3

$T_{W1} = 10.0$	$T_{W2} = 10.0$	$T_6 = 0.0$	$T_{W3} = 10.0$	$T_{W4} = 0.0$	$T_7 = 10.0$
$K_{S2} = 1.61$	$K_{S3} = 1.0$	$T_8 = 0.5$	$T_9 = 0.1$	$K_{S1} = 15.0$	$T_1 = 0.08$
$T_2 = 0.02$	$T_3 = 0.08$	$T_4 = 0.02$	$VST_{MAX} = 0.1$	$VST_{MIN} = -0.05$	N = 1
IC1 = 1	IC2 = 3	M = 5			

(d) Governor

The following are the data for the **WEHGOV** models used in the analysis.

Kipling G3, Harmon G3, Smoky Falls G1,G2,G3

$R_{GATE} = 0.04$	$R_{PE} = 0.0$	$T_{PE} = 1.0$	$K_P = 2.0$	$K_I = 1.0$	$K_D = 0.2$
$T_D = 0.05$	$T_P = 0.2$	$T_{DV} = 0.2$	$T_G = 0.25$	$GT_{MXOP} = 0.05$	$GT_{MXCL} = -0.05$
$G_{MAX} = 1.0$	$G_{MIN} = 0.0$	$D_{TURB} = 0.0$	$T_W = 1.0$	$D_{BAND} = 0.0$	$D_{PV} = 0.0$
$D_{ICM} = 0.04$	$G_1 = 0.0$	$G_2 = 0.25$	$G_3 = 0.5$	$G_4 = 0.75$	$G_5 = 1.0$
$FG_1 = 0.00$	$FG_2 = 0.25$	$FG_3 = 0.5$	$FG_4 = 0.75$	$FG_5 = 1.0$	$FP_1 = 0.0$
$FP_2 = 0.2$	$FP_3 = 0.3$	$FP_4 = 0.4$	$FP_5 = 0.5$	$FP_6 = 0.6$	$FP_7 = 0.7$
$FP_8 = 0.8$	$FP_9 = 0.9$	$FP_{10} = 1.0$	$P_1 = 0.0$	$P_2 = 0.0$	$P_3 = 0.25$
$P_4 = 0.50$	$P_5 = 0.75$	$P_6 = 0.83$	$P_7 = 0.86$	$P_8 = 0.88$	$P_9 = 0.9$
$P_{10} = 0.91$					

Little Long G3

$R_{GATE} = 0.04$	$R_{PE} = 0.0$	$T_{PE} = 1.0$	$K_P = 2.0$	$K_I = 1.0$	$K_D = 0.2$
$T_D = 0.05$	$T_P = 0.2$	$T_{DV} = 0.2$	$T_G = 0.25$	$GT_{MXOP} = 0.05$	$GT_{MXCL} = -0.05$
$G_{MAX} = 1.0$	$G_{MIN} = 0.0$	$D_{TURB} = 0.0$	$T_W = 1.5$	$D_{BAND} = 0.0$	$D_{PV} = 0.0$
$D_{ICM} = 0.04$	$G_1 = 0.0$	$G_2 = 0.25$	$G_3 = 0.5$	$G_4 = 0.75$	$G_5 = 1.0$
$FG_1 = 0.00$	$FG_2 = 0.25$	$FG_3 = 0.5$	$FG_4 = 0.75$	$FG_5 = 1.0$	$FP_1 = 0.0$
$FP_2 = 0.2$	$FP_3 = 0.3$	$FP_4 = 0.4$	$FP_5 = 0.5$	$FP_6 = 0.6$	$FP_7 = 0.7$
$FP_8 = 0.8$	$FP_9 = 0.9$	$FP_{10} = 1.0$	$P_1 = 0.0$	$P_2 = 0.0$	$P_3 = 0.25$
$P_4 = 0.50$	$P_5 = 0.75$	$P_6 = 0.83$	$P_7 = 0.86$	$P_8 = 0.88$	$P_9 = 0.9$
$P_{10} = 0.91$					

(e) Thermal Capacity

The following ratings were obtained from official Hydro One network web site. The lower of the sag temperature or 93 ^{o}C has been used to calculate the continuous rating.

Circuit	Wind km/hr	Max Operating Temp	Ambient Temp.	Conductor size (kcmil), Strands, CPB	Continuous Rating
L20D	4	93 ^{o}C, 127 ^{o}C	30 ^{o}C	1277.5, 42/7, 1	1140 A
H22D	4	93 ^{o}C, 120 ^{o}C	30 ^{o}C	1277.5, 42/7, 1	1140 A
X503E	4	93 ^{o}C, 79 ^{o}C	30 ^{o}C	495.0, 22/7, 4	2270 A
X504E	4	93 ^{o}C, 73 ^{o}C	30 ^{o}C	495.0, 22/7, 4	2080 A
D5H	4	93 ^{o}C, 100 ^{o}C	30 ^{o}C	795.0, 26/7, 1	850 A
Pinard T1 (ONAN,ODAF,ODAF)					450,600,750 MVA
Pinard T2 (ONAN,OFAF,OFAF)					450,600,750 MVA

- CPB is conductors per bundle.
- For L20D and H22D, 15-min-LTR is 1260 A and 5-min-LTR is 1680 A with 75% pre-flow.
- For X503E and X504E, the lowest section rating is given.

(g) Line Impedance

The impedances per unit length for the new extensions to be built from Harmon GS to Kipling GS, and from L20D/H22D to Smoky Falls GS are assumed the same as for the existing conductors L20D/H22D.

(f) Generator step-up transformers

The following data for the new step-up transformers was provided by OPG:

<table>
<tr><th rowspan="2">Station</th><th colspan="4">Transformer Data</th></tr>
<tr><th>Voltage</th><th>Rating</th><th>Impedance</th><th>In-Service Tap</th></tr>
<tr><td>Harmon GS</td><td rowspan="4">255/13.8 kV</td><td rowspan="4">60/80/100 MVA</td><td rowspan="4">0.13 pu on 100 MVA</td><td rowspan="4">240 kV</td></tr>
<tr><td>Kipling GS</td></tr>
<tr><td>Smoky Falls GS</td></tr>
<tr><td>Little Long GS</td></tr>
</table>

- End of Section -

4. System Impact Studies

4.1 Assumptions

The following are the default assumptions unless specified.

(1) All transmission elements are in service.

(2) The 2008 summer base case is used. Then, Lower Mattagami development is incorporated to result in the following conditions. A Flow South of 2255 MW translates into an operating limit of 2255/1.1 = 2050 MW.

Ontario Primary Demand	Northeast Load	Northeast Generation
28,325 MW	1150 MW	3393 MW

Flow South	East-West Flow East	Mississagi Flow East	Flow into Hanmer on P502X	Flow into Porcupine on D501P
2255 MW	318 MW	760 MW	1374 MW	1209 MW

To test the Flow South interface at 2255 MW, the existing Mississagi East transfer limit of 550 MW had to be exceeded. This is due to the lack of sufficient generation East of Sudbury to achieve a Flow South of 2255 MW. With Aubrey and Wells units in-service and with the reactive compensation devices as outlined in (4), the existing limit of 550 MW for Mississagi East is expected to be revised to a higher value. As such, the studies performed in this SIA used a Mississagi East transfer of 760 MW. This value was selected as its represents a good estimate of what the Mississagi East limit will become once the reactive devices outlined in (4) come into service. All studies used a generator Vsched of 1.01 pu for Lower Mattagami units, while the SVCs at Kirkland Lake and Porcupine had a Vsched of 1.105 pu.

(3) All newly installed generators have the capability to operate from 0.9 lag to 0.95 lead power factor. The reactive power capability used in the analysis for each new generator in the Lower Mattagami re-development is given below which are calculated based on the above power factors.

Generator ID	Max. Cont Rating	MVA Rating	Max. reactive power generation	Max. reactive power absorption
Kipling G3	79 MW	87 MVA	37.9 Mvar	25.7 Mvar
Little Long G3	70 MW	87 MVA	33.9 Mvar	23 Mvar
Harmon G3	78 MW	87 MVA	37.8 Mvar	25.7 Mvar
Smoky Falls G1,G2,G3	88 MW	98 MVA	42.6 Mvar	29 Mvar

Table 1: Lower Mattagami Generator Reactive Power Requirements

Newly installed generators at Lower Mattagami must have the reactive capabilities as shown above.

(4) The following are in service and included in the system model:
   (a) Series capacitors at Nobel SS to provide 50 % compensation to X503E and X504E
   (b) SVC at Porcupine 230 kV bus (+300/-100 Mvar)
   (c) SVC at Kirkland Lake 115 kV bus (+200/-100 Mvar)
   (d) Shunt Capacitor Banks at Pinard 27.6 kV bus (2 x 32.4 MVAr @ 27.6 kV)
   (e) Second Shunt Capacitor Bank at Hanmer 230 kV bus (149 MVAr @ 220 kV)
   (f) Second Shunt Capacitor Bank at Essa 230 kV bus (245 MVAr @ 250 kV)
   (g) Shunt Capacitor Banks at Porcupine 230 kV bus (2 x 100 MVAr @ 250 kV)
   (h) Shunt Capacitor Bank at Kapuskasing 24.9 kV bus (21.6 MVAr @ 28.8 kV)

(5) The following reactors have been removed from service to help maximize power transfers:
   (a) Pinard Reactors R1and R2
   (b) Hanmer Reactors R1, R2, R6, R7, R8 and R9
   (c) Essa Reactors R3 and R4

4.2 Compensation for Reactive Power Losses

With the addition/expansion of Lower Mattagami generation, the flow of current would increase. As a result, the reactive power losses would increase, and this must be compensated. This reactive compensation will be provided in part by several new shunt capacitor banks to be installed by Hydro One at various stations across Northern Ontario. Details regarding these shunt capacitor installations are provided below. The SIA to study the impact of these shunt capacitors on system reliability has been completed in another SIA report and can be found using the following link: http://www.ieso.ca/imoweb/pubs/caa/caa_SIAReport_2008_352.pdf

	Station	Size
1	Kapuskasing TS	1 x 21.6 MVAr @ 28.8 kV
2	Essa TS	1 x 245 MVAr @ 250 kV
3	Pinard TS	2 x 32.4 MVAr @ 27.6 kV
4	Hanmer TS	1 x 149 MVAr@ 220 kV
5	Porcupine TS	2 x 100 MVAr @ 250 kV

4.3 Thermal Loading

The following is the summary of pre-contingency loading of equipment.

Circuit	*Loadability*
H22D (section from Little Long to Pinard)	1131/1140 = 0.99
L20D (section from Little Long to L21S)	1134/1140 = 0.99
Pinard T1, T2	618/750 = 0.82
X503E	1079/2270 = 0.48
X504E	1081/2080 = 0.52
D5H	749/850 = 0.88

Loadability = Current Flow/Cont. Amp Rating for circuits or MVA/maximum MVA rating for transformers.

The steady-state loadings for circuits H22D and L20D are only marginally below their thermal capability. Changes to the assumptions made in this report may cause slight thermal overloading of the H22D and L20D circuits. All other steady-state loadings for the equipments mentioned are below their continuous ratings.

4.4 Post-Contingency Voltage

Voltage studies were conducted to analyze the post contingency pre-ULTC and post-ULTC voltages and changes at various buses for selected contingencies.

The following maximum voltage levels are observed:

	230 kV	**500 kV**
Post-contingency	250 kV	550 kV

To ensure that voltages did not exceed the maximum levels, the following capacitors/reactors were tripped/switched in along with appropriate generation rejection, load rejection and circuit cross tripping:

Loss of D501P (VC1): Trip 2 x 149 MVAr Cap at Hanmer
Loss of P502X (VC2): Trip 1 x 149 MVAr Cap at Hanmer
Loss of H22D (VC4): Trip 2 x 149 MVAr Cap at Hanmer + Trip 2x 32.4 MVAr Cap at Pinard +
Trip 2 x 100 MVAr Cap at Porcupine +
Switch in 2 x 50 MVAr Reactor at Pinard
Loss of L20D (VC5): Trip 2 x 149 MVAr Cap at Hanmer + Trip 2x 32.4 MVAr Cap at Pinard +
Trip 2 x 100 MVAr Cap at Porcupine + Trip 1x 21.6 MVAr Cap at Kapuskasing
+ Switch in 2 x 50 MVAr Reactor at Pinard
Loss of L21S (VC6): Trip 1x 21.6 MVAr Cap at Kapuskasing
Loss of R21D (VC7): Trip 1x 149 MVAr Cap at Hanmer

Study results are provided below:

Note: Positive voltage changes represent voltage rises and negative voltage changes represent voltage declines. Loads have been converted into voltage dependent models for pre-ULTC simulations and left at constant MVA models for post-ULTC simulations.

Bus	Pre-Cont	VC1-D501P[1]				VC2-P502X[2]				VC3-X503E			
	kV	Pre ultc		Post ultc		Pre ultc		Post ultc		Pre ultc		Post ultc	
		kV	%	kV	%	kV	%	kV	%	kV	%	kV	%
500 kV Bus													
Pinard	535.7	-	-	-	-	-	-	-	-	528.8	-1.3	527.1	-1.6
Porcupine	531.3	546.4	2.8	549.5	3.4	532.6	0.2	534.0	0.5	520.6	-2.0	518.1	-2.5
Hanmer	543.8	546.3	0.5	547.1	0.6	545.2	0.3	542.8	-0.2	519.8	-4.4	514.3	-5.4
Essa	533.1	538.0	0.9	538.5	1.0	538.0	0.9	536.2	0.6	515.8	-3.2	511.0	-4.1
230 kV Bus													
Pinard	234.9	-	-	-	-	-	-	-	-	232.9	-0.8	232.4	-1.1
Porcupine	243.1	243.1	0.0	244.3	0.5	243.1	0.0	243.1	0.0	243.1	0.0	243.1	0.0
Hanmer	246.4	241.3	-2.1	241.5	-2.0	242.8	-1.5	241.5	-2.0	237.2	-3.7	234.5	-4.8
Essa	247.4	249.0	0.7	249.3	0.8	248.9	0.6	248.1	0.3	240.8	-2.7	238.1	-3.8
Kapuskasing	246.2	-	-	-	-	-	-	-	-	245.5	-0.3	245.4	-0.3
Spruce Falls	246.2	-	-	-	-	-	-	-	-	245.6	-0.2	245.5	-0.3

Notes:

(1) Total G/R = 1350 MW
Cross tripping of L21S and K38S.
Post-Flow on H9K = 58.3 MW into Hunta.

(2) Total G/R = 1550 MW
Cross tripping of circuits L21S, K38S, D501P.
Post-Flow on H9K = 59.8 MW into Hunta. Post-Flow on A9K+A8K = 7.0 MW into Ansonville

Bus	Pre-Cont	VC4-H22D				VC5-L20D[3]				VC6-L21S[4]			
	kV	Pre ultc		Post ultc		Pre ultc		Post ultc		Pre ultc		Post ultc	
		kV	%	kV	%	kV	%	kV	%	kV	%	kV	%
500 kV Bus													
Pinard	535.7	545.0	1.7	548.8	2.4	543.0	1.4	546.9	2.1	533.0	-0.5	533.0	-0.5
Porcupine	531.3	542.2	2.1	548.1	3.2	541.4	1.9	547.4	3.0	529.9	-0.3	529.9	-0.3
Hanmer	543.8	540.0	-0.7	541.2	-0.5	539.8	-0.7	540.9	-0.5	543.1	-0.1	543.1	-0.1
Essa	533.1	533.1	0.0	533.1	0.0	533.1	0.0	533.0	0.0	532.7	-0.1	532.6	-0.1
230 kV Bus													
Pinard	234.9	236.4	0.6	237.5	1.1	235.3	0.1	236.5	0.7	233.7	-0.5	233.7	-0.5
Porcupine	243.1	243.1	0.0	243.1	0.0	243.1	0.0	243.1	0.0	243.1	0.0	243.1	0.0
Hanmer	246.4	239.5	-2.8	239.9	-2.7	239.4	-2.8	239.7	-2.7	246.2	-0.1	246.1	-0.1
Essa	247.4	247.5	0.0	247.1	-0.1	247.3	0.0	247.0	-0.2	247.3	0.0	247.2	0.0
Kapuskasing	246.2	246.2	0.0	246.3	0.0	252.4	2.5	251.7	2.2	246.2	0.0	245.9	-0.1
Spruce Falls	246.2	246.3	0.0	246.3	0.0	252.4	2.5	251.7	2.2	246.3	0.0	246.0	-0.1

Notes:

(3) Post-Flow on H9K = 39.2 MW into Hunta & on Spruce Falls T7= 22.1 MW north (115 kV to 230 kV)
Cross Tripping of circuit L21S

(4) Post-Flow on H9K = 38.7 MW into Hunta & on Spruce Falls T7= 22.1 MW north (115 kV to 230 kV)

Bus	Pre-Cont	VC7-R21D			
	kV	Pre ultc		Post ultc	
		kV	%	kV	%
500 kV Bus					
Pinard	535.7	544.2	1.6	545.3	1.8
Porcupine	531.3	541.9	2.0	543.4	2.3
Hanmer	543.8	545.7	0.3	545.9	0.4
Essa	533.1	535.2	0.4	535.0	0.4
230 kV Bus					
Pinard	234.9	236.6	0.7	236.9	0.9
Porcupine	243.1	243.1	0.0	243.1	0.0
Hanmer	246.4	244.4	-0.8	244.4	-0.8
Essa	247.4	248.1	0.3	247.9	0.2
Kapuskasing	246.2	246.4	0.1	246.3	0.0
Spruce Falls	246.2	246.5	0.1	246.4	0.0

In general, most studied steady state contingencies show voltage rises. This is due to the large amount of generation rejection or generation being lost by configuration, which results in lower power flows and thus lower system losses. In order to maintain voltages below 250 kV and 550 kV for 230 kV and 500 kV buses respectively, different capacitors were tripped and for some contingencies, the existing reactors at Pinard were switched in to help lower voltages.

The slight overvoltages seen at Kapuskasing and Spruce Falls can be mitigated by tripping the L21S/K38S circuit for the loss of the L20D circuit.

The switching of all newly installed capacitors at Hanmer, Porcupine, Pinard and Kapuskasing can be implemented using an automatic voltage based switching scheme.

All capacitor switching schemes must be coordinated with each other and with the existing reactor switching scheme at Pinard. All switching schemes must be designed with appropriate time delays and voltage thresholds which ensure that all capacitor and reactor switching is completed prior to post-contingency transformer ULTC operation.

The existing reactor switching scheme at Pinard will likely require modification to its voltage thresholds and time delay settings.

If proper coordination between all switching schemes is not possible or time delays encroach on the ULTC operation timeframes, Hydro One will need to add the tripping of the capacitors at Hanmer, Porcupine, Pinard and Kapuskasing for various contingencies as additional selections to the existing Moose River and Northeast 115 kV SPS.

4.5 Transient Stability

Transient stability simulations were performed for following contingencies.

ID	Contingency (3ph fault)	Fault clearance		G/R		Circuit Cross Tripping	
		Local	Remote	Moose	NUG	L21S/K38S	D501P
TC1	X503E@X	66 ms	91 ms	-	-	-	-
TC2	D501P@P	66 ms	108 ms	180 ms	230 ms	180 ms	-
TC3	P502X@X	66 ms	91 ms	180 ms	230 ms	180 ms	@P = 91 ms, @D = 120 ms

Tripping of the appropriate capacitor banks as outlined in sections 4.4 were done 1 second after the application of the fault. Automatic tripping of capacitors are required additions to the existing Moose River and NE L/R & G/R schemes as discussed in section 4.7 of this report.

(a) X503E contingency

No generation rejection is required. The transient performance is shown in Figures 4A & 4B.

The voltage at the 500 kV bus at Porcupine remains below 80% of the nominal threshold for 370 ms. This would be in excess of the 250 ms permitted under the IESO criteria. Since there is no load connected to the Porcupine 500 kV bus, this does not represent a significant concern. The marginal violation in the time that the voltage remains below the 80% threshold capability could be addressed through the provision of a short-term overload capability for the Porcupine SVC or through a very small reduction (<10MW) in the Flow-South transfer.

While the Flow-South interface was capable of transferring 2255 MW without generation rejection for this contingency, changes to any of the assumptions made in this study can result in generator instability at Lower Mattagami and/or unacceptable voltage performance at Porcupine. In particular, extensive simulations conducted with higher power flows into Hanmer on the P502X circuit and into Porcupine on the D501P circuit or with lower pre-contingency voltages than the values used in this study would require more pre-contingency MVAr support to maintain transient stability and acceptable voltage performance with no generation rejection.

(b) D501P contingency

With the 500 kV circuit D501P lost, the net generation from Moose River plants and units supplying circuits H9K/F1E/L21S/K38S flows into Hunta SS via H9K. This would result in transient instability as well as overloading of H9K and Spruce Falls T7. Thus, approximately 1400 MW of generation is rejected followed by the cross tripping of L21S and K38S circuits (and loads connected to those circuits) to control the voltage. The following is the list of elements rejected.

Generation	Harmon G1,G2, G3, Kipling G1,G2,G3, Smoky G1,G2, G3, Little Long G1,G2,G3 Kapuskasing G1,G2, Canyon G1,G4,G5, Otter Rapid G1,G2,G3,G4 **Total = 1400 MW**
Circuits	L21S, K38S
Load	Kapuskasing, Spruce Falls **Total = 70 MW**
Capacitors	2 x Hanmer

The post-flow on H9K is 46 MW into Hunta. The transient performance is shown in Figures 5A & 5B.

(c) P502X contingency

The power system section north of Porcupine/Ansonville is connected to the rest by one 500 kV circuit P502X and two 115 kV circuits A9K and A8K. The loss of the P502X circuit results in large power flows in A8K+A9K circuits and in D3K, where the latter might possibly trip. Thus, as a response to the loss of P502X, generation is rejected to result-in post-flow on A9K+A8K below ± 40 MW along with the cross tripping of L21S, K38S (and loads connected to those circuits) and D501P circuits to control the voltage. The following is the list of elements rejected.

Generation	Harmon G1,G2, G3, Kipling G1,G2,G3, Smoky G1,G2,G3, Little Long G1,G2,G3 Kapuskasing G1,G2, Otter Rapid G1,G2,G3,G4, Northland Power Iroquois Falls G1,G2,G3 Canyon G1,G4,G5, Tunis NUG **Total = 1580 MW**
Circuits	L21S, K38S, D501P
Load	Kapuskasing, Spruce Falls **Total = 70 MW**
Capacitors	1 x Hanmer

The post-flow on A9K+A8K is 7 MW into Ansonville. The transient performance is shown in Figure 6A & 6B.

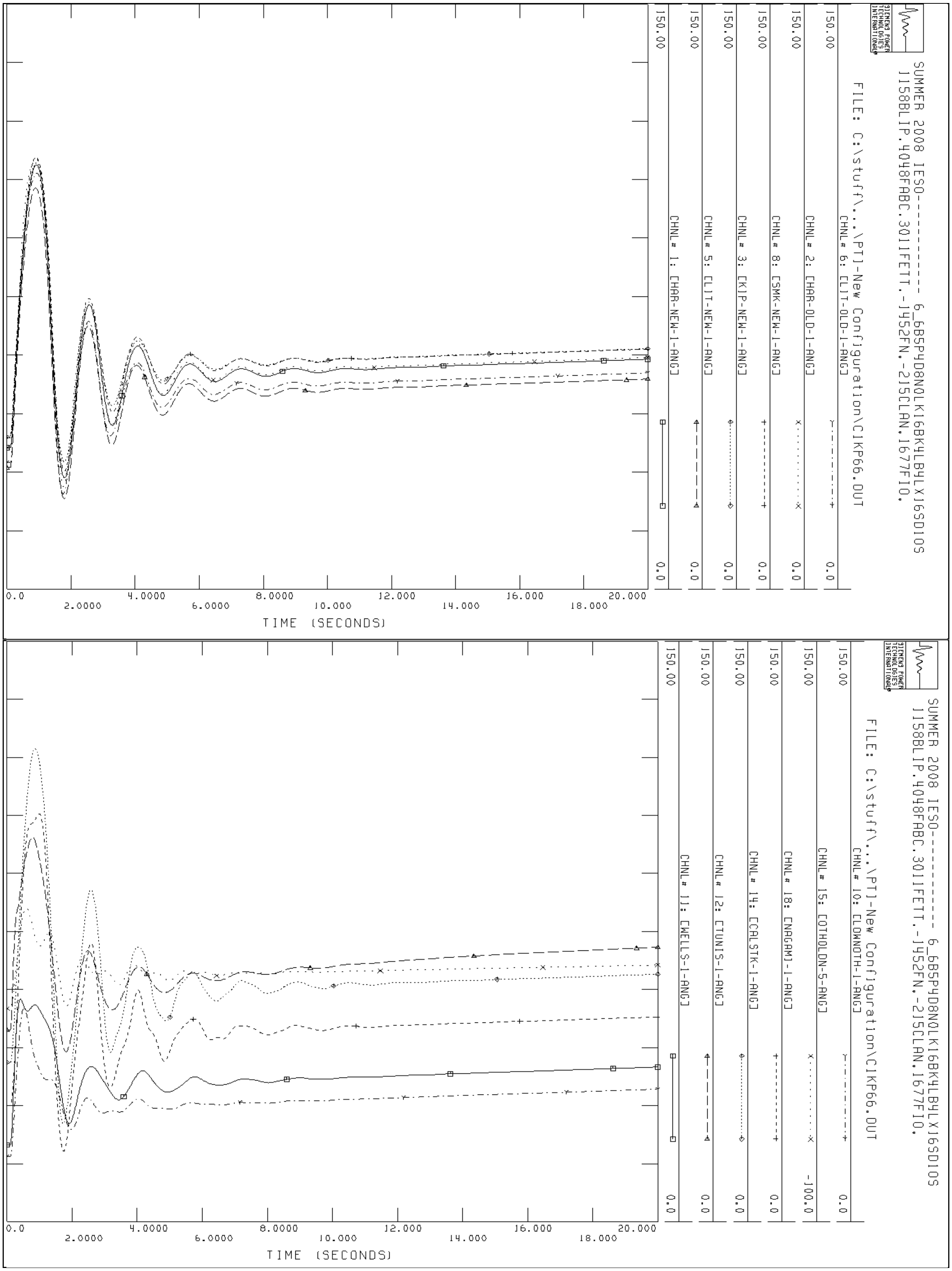


FIGURE 4A: RESPONSE TO LOSS OF X503E

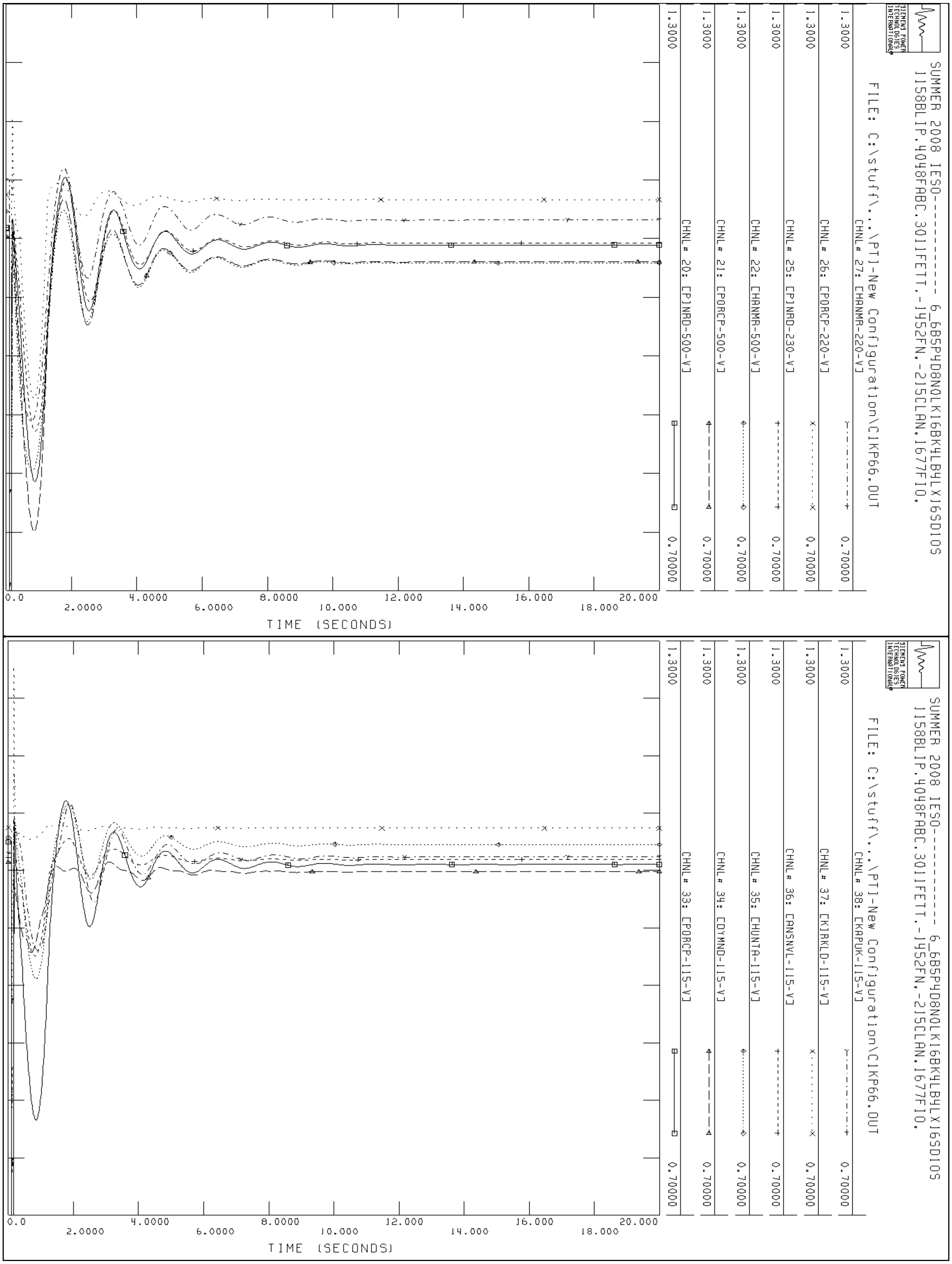


FIGURE 4B: RESPONSE TO LOSS OF X503E

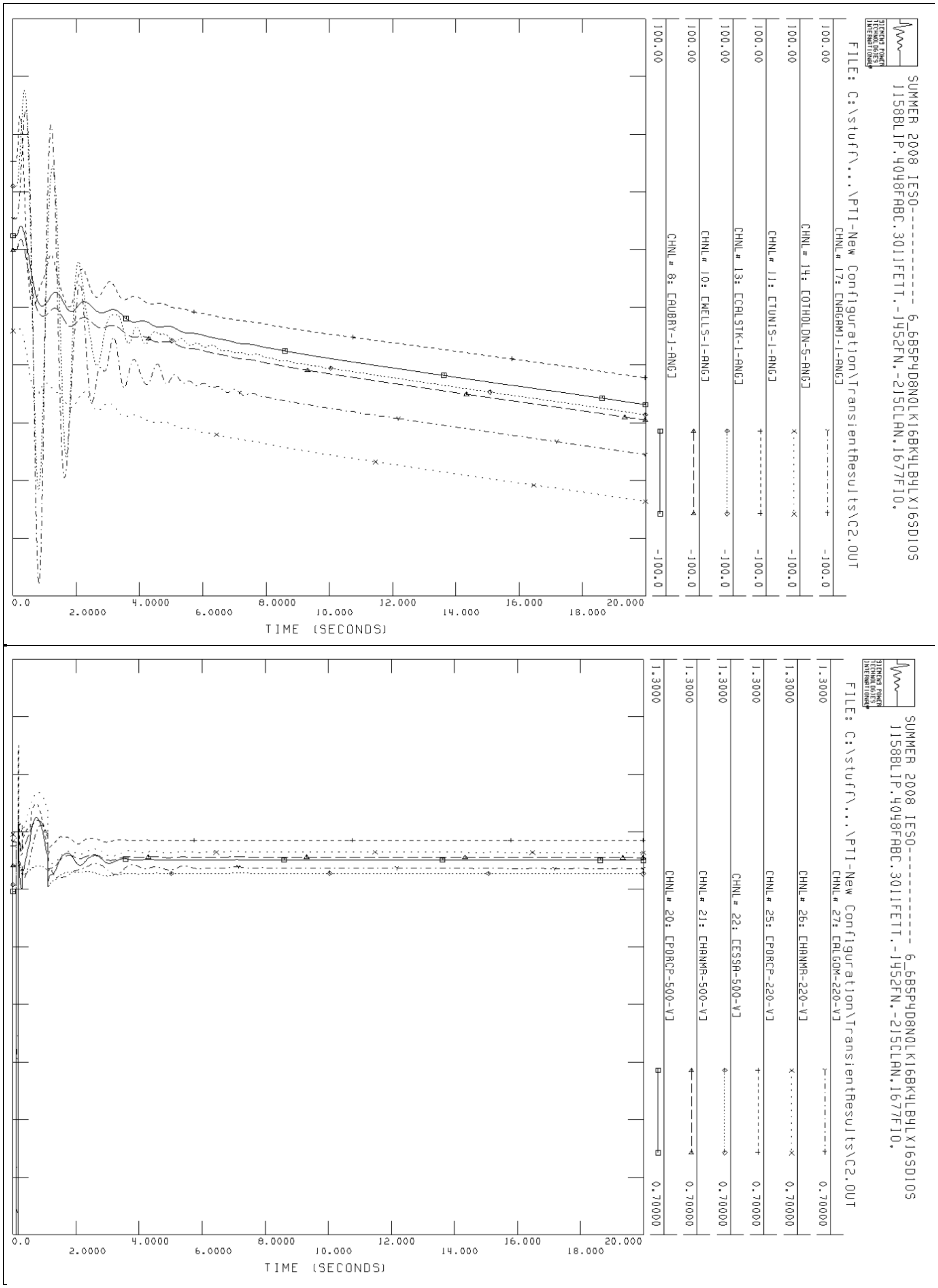


FIGURE 5A: RESPONSE TO LOSS OF D501P

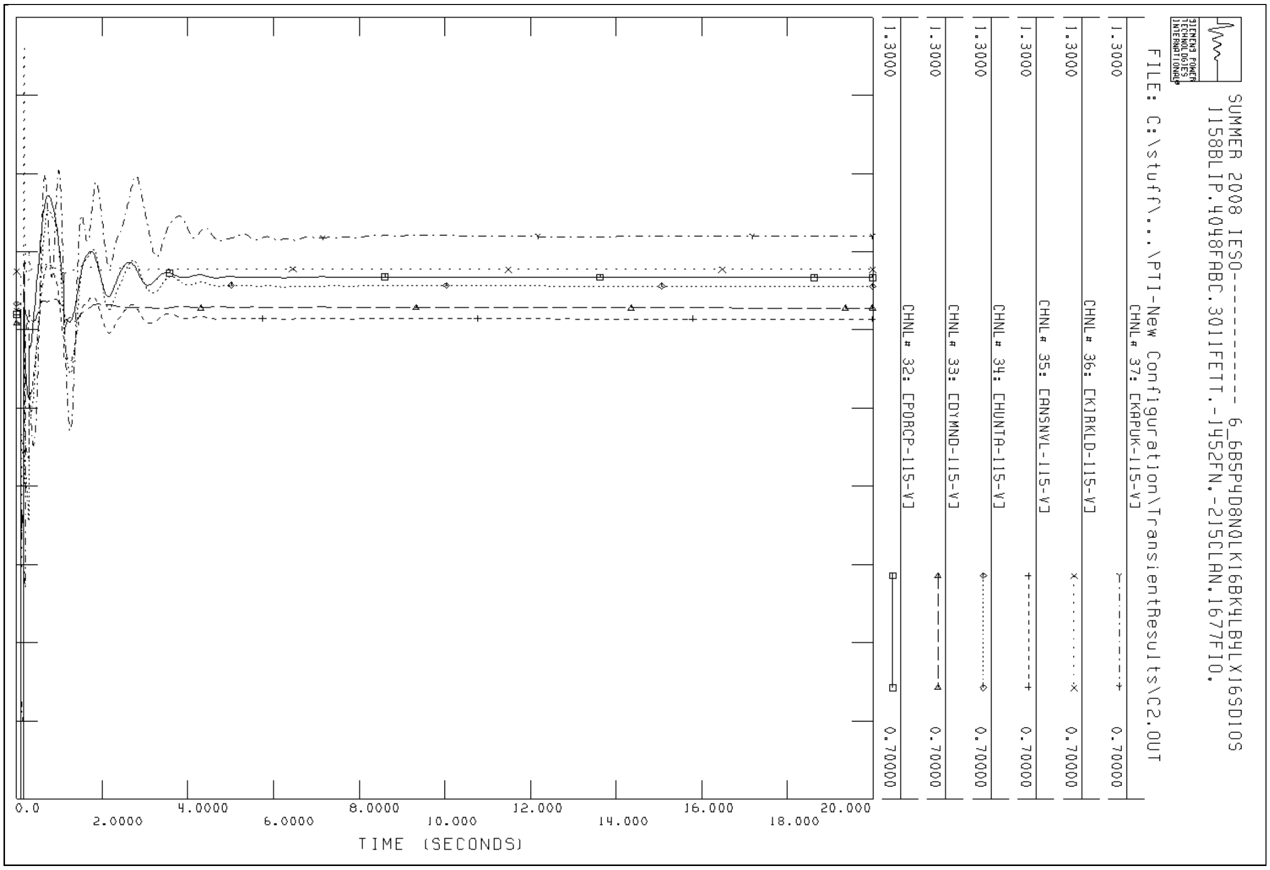


FIGURE 5B: RESPONSE TO LOSS OF D501P

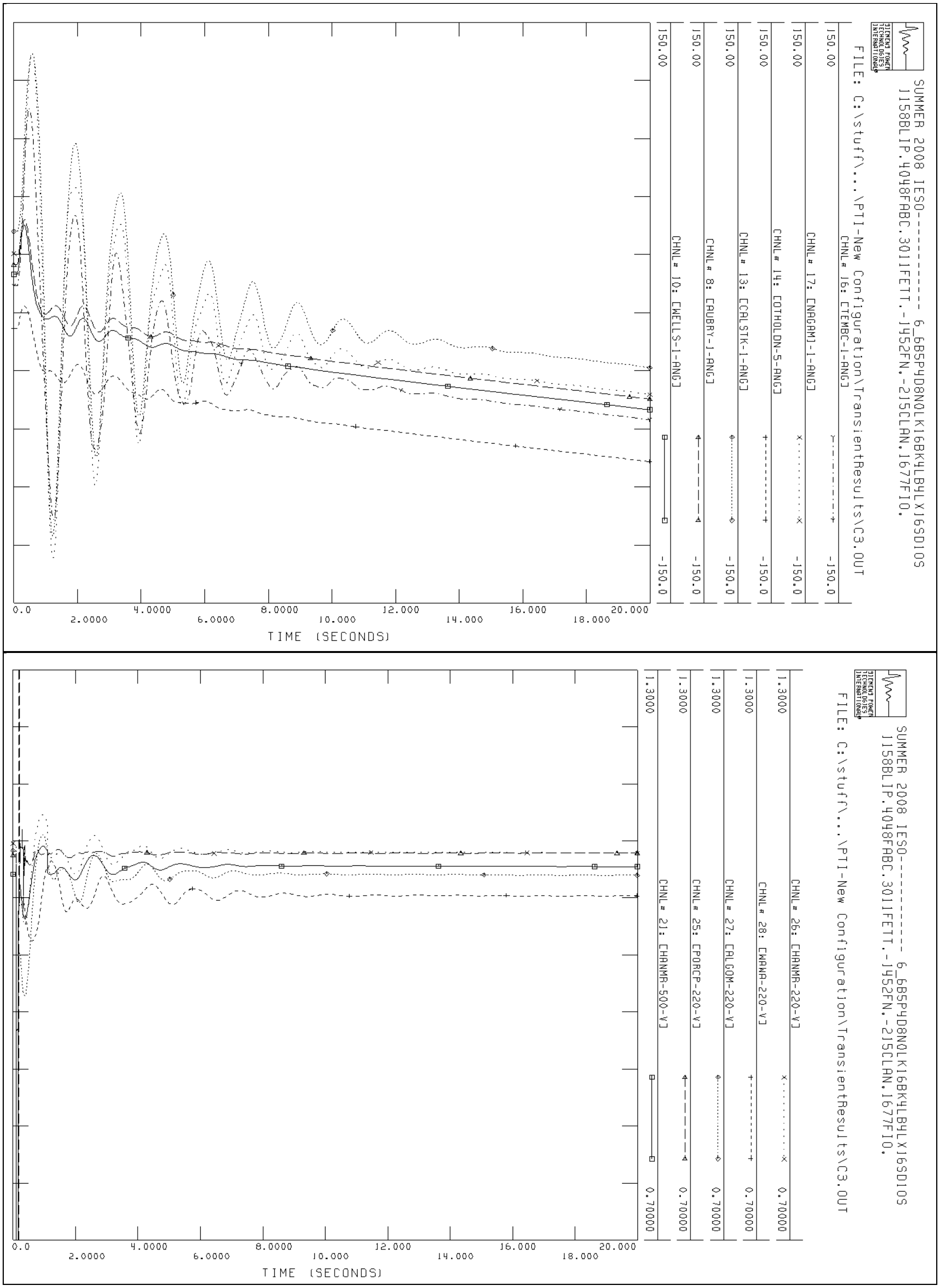


FIGURE 6A: RESPONSE TO LOSS OF P502X

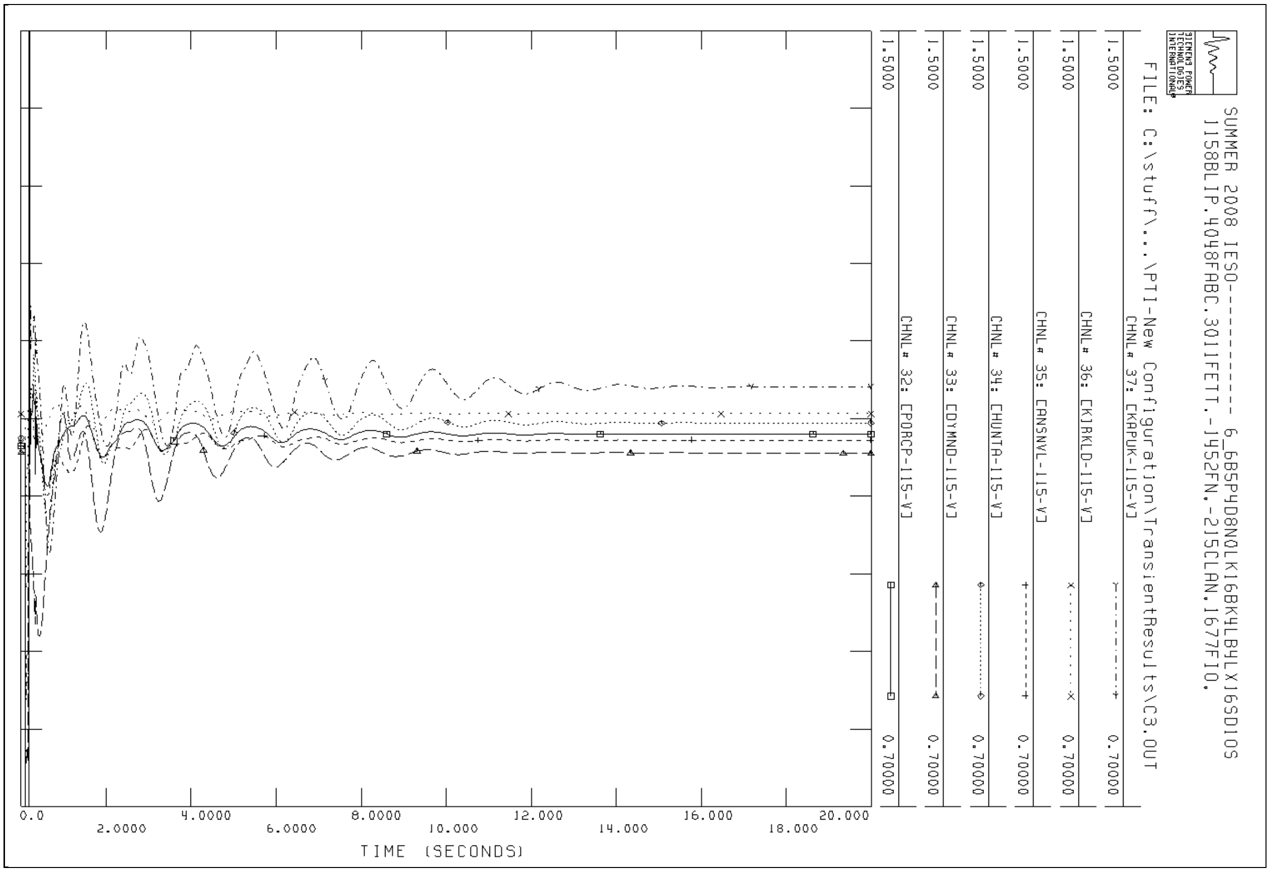


FIGURE 6B: RESPONSE TO LOSS OF P502X

4.6 Flow-South Interface

The north-eastern Ontario power system extends up to north of Sudbury and east of Wawa stretching all the way to the Quebec border. One of the key interfaces governing the operation of this section of the IESO-controlled grid is the North-South interface. The transfer across the North-South Interface is represented by the combined flow on the 230kV circuit D5H, measured at Otto Holden GS, and on the 500kV circuits X503E and X504E, measured at Essa TS. The maximum transfer capability of the Flow-South interface depends on the maintenance of transient stability of units north of North-South interface. Presently, this capability is 1300 MW with no generation rejection and 1400 MW with 100 MW of post-contingency generation rejection.

In order to accommodate all of the existing and committed generating facilities in the northeast, together with the expanded capacity at the Lower Mattagami River plants, it is required that the maximum transfer capability of the Flow-South interface be increased. The analysis done by Hydro One and the IESO has demonstrated that with the installation of the following facilities, the transfer capability of the Flow-South interface could be increased up to approximately 2050 MW pre-contingency.

- Series capacitors at Nobel SS to provide 50 % compensation to X503E and X504E
- SVC at Porcupine TS (+300/-100 Mvar)
- SVC at Kirkland Lake TS (+200/-100 Mvar)
- Northern Ontario Shunt Capacitors

The series compensation at Nobel SS, which is approximately the mid-point of X503E/X504E circuits, improves the transient stability under high Flow-South conditions by adding the effect of doubling the parallel transmission lines between Hanmer TS and Essa TS. The SVC at Porcupine and Kirkland Lake TS is mainly for the maintenance of post-contingency voltages such as for the loss of P502X. The various Northern Ontario shunt capacitors compensate system losses and provide pre-contingency voltage support.

With the increase of the Flow-South transfer up to 2050 MW, generation rejection to maintain the transient stability for various contingencies including the loss of X503E or X504E circuits will not be required with all elements in-service and under the studied system conditions, if sufficient reactive power supply is available. However, it is required to expand the northeast generation rejection scheme to include the new generators at Lower Mattagami to deal with various outage situations.

While the Flow South interface is capable of transferring 2050 MW with no generation rejection for the loss of X503E and X504E, limitations to the amount of power that can be transferred into Hanmer and Porcupine on 500 kV circuits P502X and D501P do exist. Should future generation expansion north east of Hanmer occur or load levels in this area drop, power flow through this new limit could become constrained. The expansion of the Mississagi East transfer capability provides for the opportunity to reduce the amount of flow into Hanmer and Porcupine, while still achieving a Flow South transfer of 2050 MW.

4.7 Modifications to Moose River G/R Scheme

The Moose River G/R scheme must be expanded to include all new generators at Lower Mattagami.

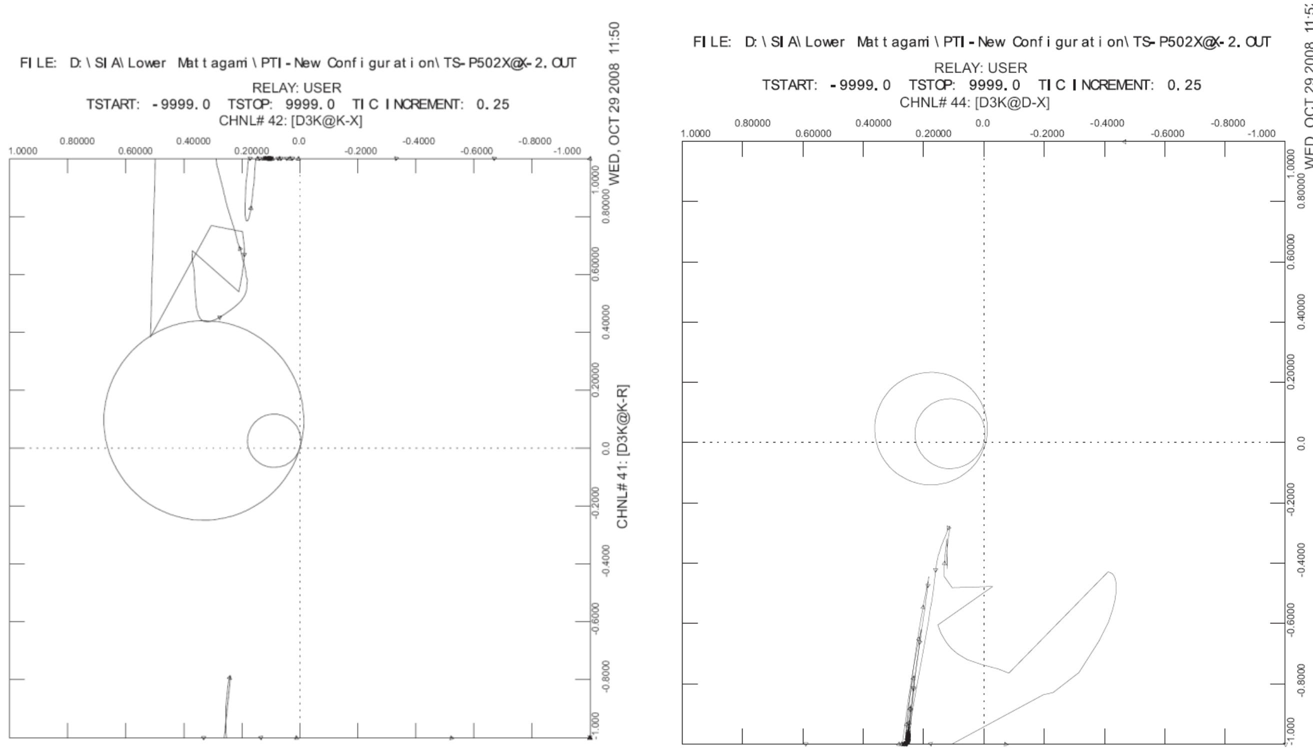
	Moose River Basin Generation Rejection Scheme						
OUTPUT: CONTROL ACTIONS		**INPUT: CONTINGENCY SIGNALS**					
		P502X	**D501P**	**X503E**	**X504E**	**X503E+X504E**	**E501V+E511V**
	Kipling G3 - new	X	X	X	X	X	X
	Harmon G3 - new	X	X	X	X	X	X
	Little Long G3 - new	X	X	X	X	X	X
	Smoky Falls G1 – new	X	X	X	X	X	X
	Smoky Falls G2 – new	X	X	X	X	X	X
	Smoky Falls G3 – new	X	X	X	X	X	X

Figure 7: Moose River G/R Scheme Expansion

4.8 Relay Margin

It is necessary that sufficient margin is maintained between apparent impedance trajectory of relays at each terminal of un-faulted circuits and the relay characteristics during transients in order to ensure those circuits are not tripped. The IESO requires that the relay margin for 115 kV circuits to be minimum 15 percent on all instantaneous relays and zero percent on all timed relays having a time delays less than or equal to 0.4 sec.

The Figure 8 shows the relay characteristics and the apparent impedance trajectory of the 115 kV circuit D3K for the loss of P502X. The trajectory for Kirkland Lake terminal of D3K enters the zone 2 characteristics. Thus, the existing relay settings will not be acceptable. If the settings are not revised,D3K will have delayed trip which makes the portion of the power system north of Kirkland Lake and Porcupine an electrical island.



D3K@K **D3K@D**

FIGURE 8 : D3K RELAY RESPONSE TO LOSS OF P502X

4.9 Excitation and Governor System Performance

The dynamic performance of the generator excitation system was simulated to check the compliance of the automatic excitation system behavior in terms of the ceiling and the speed of response to IESO standards.

- *Response Ratio Test*

The excitation system response ratio test was performed to determine the rated field voltage, Efd_{rated}, and the required positive and negative ceiling targets. During this particular test, the generator produces rated MW and MVAR according to the rated power factor. The rated power factor for Kipling, Little Long, Harmon and Smoky Falls generators are 0.90. The disturbance simulated is a large change of exciter reference.

The IESO *Market Rule* requirement is to have a *positive excitation ceiling* twice the rated Efd and a *negative excitation ceiling* of -1.4 times the rated Efd. The following is the summary of results.

Generator	Power Factor	Terminal Voltage	(a) Efd Rated	Positive Ceiling	Negative Ceiling
Kipling G3	0.90	1.0 pu	1.994 pu	5.3006/(a) = 2.67	-4.51/(a) = -2.26
Little Long G3	0.90	1.0 pu	2.007 pu	5.2993/(a) = 2.64	-4.51/(a) = -2.25
Harmon G3	0.90	1.0 pu	2.006 pu	5.2994/(a) = 2.64	-4.51/(a) = -2.25
Smoky Falls G1/G2/G3	0.90	1.0 pu	2.084 pu	5.2916/(a) = 2.54	-4.51/(a) = -2.16

- *Positive Open Circuit Test*

During this particular test, the generator operates effectively in an island. The output of the generator is zero. The terminal voltage is 1.0 pu. The disturbance simulated is an increase of the exciter reference by +5 %.

The IESO *Market Rules* requirement is the *excitation response time*, i.e the time (in seconds) for the excitation voltage to attain 95% of difference between positive ceiling voltage (2 x Efd) and rated load-field voltage under the specified conditions, must be less than 50 ms. The following equation translates the above requirement to open circuit conditions starting from Efd = Efd_{OC} at t = 0.

$$RT_{OC\_POS} = 50 * \frac{1.95\ Efd_{rated} - Efd_{oc}}{1.95\ Efd_{rated} - Efd_{rated}}$$

Therefore, using the equation above, the exciter response to the open circuit test should reach at least 1.95*Efdrated within RToc_pos seconds.

The following is the summary of results.

Generator	MW, Mvar output	Efd_{oc}	Efd Required (1.95*Efdrated)	RToc_pos Required	Efd Simulated	RT_{oc_pos} Simulated
Kipling G3	0	1.15 pu	3.888 pu	72.3 ms	5.385 pu	< 5ms
Little Long G3	0	1.15 pu	3.913 pu	72.5 ms	5.385 pu	< 5ms
Harmon G3	0	1.15 pu	3.911 pu	72.5 ms	5.385 pu	< 5ms
Smoky Falls G1	0	1.15 pu	4.064 pu	73.6 ms	5.385 pu	< 5ms

- *Negative Open Circuit Test*

During this particular test, the generator operates effectively in an island. The output of the generator is zero. The terminal voltage is 1.0 pu. The disturbance simulated is a decrease of the exciter reference by -5 %.

The IESO *Market Rules* requirement is the *excitation response time*, , i.e the time (in seconds) for the excitation voltage to attain 95% of difference between negative ceiling voltage (-1.4 x Efd) and rated load-field voltage under the specified conditions, must be less than 50 ms. The following equation translates the above requirement to open circuit conditions starting from Efd = Efd_{OC} at t = 0.

$$RT_{OC\_NEG} = 50 * \frac{1.28\ Efd_{rated} + Efd_{oc}}{1.28\ Efd_{rated} + Efd_{rated}}$$

Therefore, using the equation above, the exciter response to the open circuit test should reach at least 1.28*Efdrated within RToc_neg seconds.

Generator	MW, Mvar output	Efdoc	Efd Required (1.28*Efdrated)	RToc_neg Required	Efd Simulated	RToc_neg Simulated
Kipling G3	0	1.15 pu	-2.552 pu	40.7 ms	-4.51 pu	< 5 ms
Little Long G3	0	1.15 pu	-2.568 pu	40.6 ms	-4.51 pu	< 5 ms
Harmon G3	0	1.15 pu	-2.567 pu	40.6 ms	-4.51 pu	< 5 ms
Smoky Falls G1	0	1.15 pu	-2.668 pu	40.2 ms	-4.51 pu	< 5 ms

The above methods of finding the *Response Times* are approximations due to the operation of the generators in an island. This is a limitation of the PSS/E tool. However, since the above *Response Time* is less than 5 ms, the excitation systems would likely comply with the *Response Time* requirement if operated connected to the grid.

- *Governor Performance*

The dynamic performance of the new speed governor was simulated to check the damping of the governor and to calculate the droop. The loading of the generator was given a step-increase of 0.1 pu from an initial loading of 0.5 pu of the generator's MVA. These levels were selected to ensure that the resulting governor dynamics are not restricted by any of its limits. The test results are summarized below.

Generator	ΔPmech (pu)	ΔSpeed	ΔGate	Droop = (ΔPmech/ΔGate) x (ΔSpeed/ ΔPmech)
Kipling G3	0.1	0.0016	0.04	4%
Little Long G3	0.1	0.0016	0.04	4%
Harmon G3	0.1	0.0016	0.04	4%
Smoky Falls	0.1	0.0016	0.04	4%

The following is the summary of the compliance of generator control systems to IESO *Market Rules*.

Generator	Comply with Exciter Ceiling Requirements	Comply with Exciter Response Time Requirements	Comply with Governor Droop Requirement
Kipling G3	Yes	Yes	Yes
Little Long G3	Yes	Yes	Yes
Harmon G3	Yes	Yes	Yes
Smoky Falls G1	Yes	Yes	Yes

4.10 Short Circuit Level

The following is the summary of short circuit currents (kA) before and after Lower Mattagami Development is incorporated. The values given for Lower Mattagami GS 230 kV buses are for the greater of the L20D and H22D connection.

Bus	Before LMD				After LMD			
	Symmetrical Fault Current		Asymmetrical Fault Current		Symmetrical Fault Current		Asymmetrical Fault Current	
	3ph	LG	3ph	LG	3ph	LG	3ph	LG
Pinard 230 kV	10.96	13.86	12.70	17.34	12.97	15.99	14.79	19.84
Smoky Falls GS 230 kV	-	-	-	-	10.75	10.88	12.84	13.45
Little Long GS 230 kV	7.71	7.83	8.97	9.29	13.33	14.94	16.60	18.72
Kipling GS 230 kV	6.15	6.22	7.13	7.45	8.13	7.64	9.36	9.00
Harmon GS 230 kV	4.50	4.66	5.36	5.83	9.29	9.30	10.97	11.24
Kapuskasing 230 kV	4.96	5.20	5.98	6.43	5.46	5.58	6.49	6.81

Table 3: Short Circuit Levels

Connection equipment installed must be capable of withstanding the short circuit levels as shown above.

4.11 Real Time Monitoring

The Kipling, Harmon, Little Long and Smoky Falls generation facilities include generators that are between 20 MVA and 100 MVA. The IESO *Market Rules* defines such stations as *significant generating facilities*. The proponent must provide real-time monitoring for following quantities for each generator.

(a) Active power generation
(b) Reactive power generation
(c) Terminal breaker status
(d) Terminal voltage
(e) AVR and PSS status

All required real-time monitored data will be identified during the IESO Market Entry Process.

4.12 References

[1] SIA Report produced by IESO titled "Installation of Series Capacitors in 500 kV circuits X503E and X504E at Nobel TS and SVCs at Porcupine TS and Kirkland Lake TS", IESO_Rep_0379, May 15, 2007.

[2] SIA Report produced by IESO titled "Northern Ontario Shunt Capacitors", IESO_Rep_0563, May 31, 2009.

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