REPORT

System Impact Assessment Report

CONNECTION ASSESSMENT & APPROVAL PROCESS

Issue 1.0

FINAL REPORT

Project: Newpost Creek Hydraulic Generation
Applicant: Ontario Power Generation Inc.

CAA ID 2007-294

Market Facilitation Department

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System Impact Assessment Report

Newpost Creek Hydraulic Generation Development Project

Acknowledgement

The IESO wishes to acknowledge the assistance of Hydro One in completing this assessment.

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 conditional approval or disapproval of the proposed connection under Chapter 4, section 6 of the Market Rules.

Conditional approval of the proposed connection is based on information provided to the IESO by the connection applicant and Hydro One 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 Hydro One at the request of the IESO. Furthermore, the conditional approval is subject to further consideration due to changes to this information, or to additional information that may become available after the conditional approval has been granted.

If the connection applicant has engaged a consultant to perform connection assessment studies, the connection applicant acknowledges that the IESO will be relying on such studies in conducting its assessment and that the IESO assumes no responsibility for the accuracy or completeness of such studies including, without limitation, any changes to IESO base case models made by the consultant. The IESO reserves the right to repeat any or all connection studies performed by the consultant if necessary to meet IESO requirements.

Conditional 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, the conditional 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, the connection applicant must be aware that the IESO may revise drafts of this report at any time in its sole discretion without notice to the connection applicant. 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 the most recent version of this report is being used.

Hydro One

The results reported in this report are based on the information available to Hydro One, at the time of the study, suitable for a preliminary assessment of this transmission system reinforcement 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 facilities on load and generation customers.

In this system impact assessment, short circuit adequacy is assessed only for Hydro One circuit breakers. The short circuit results are only for the purpose of assessing the capabilities of existing Hydro One circuit breakers and identifying upgrades required to incorporate the proposed facilities. These results should not be used in the design and engineering of any new or existing facilities. The necessary data will be provided by Hydro One and discussed with any 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 facilities 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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Conclusions

This System Impact Assessment has been conducted to examine the effect of the Newpost Creek 2×12.5 MW generation facility on the reliability of the IESO-controlled grid. The conclusions from the assessment are summarized as follows:

1. The proposed project will not have a material adverse effect on the reliability of the IESO-controlled grid.

2. The increases in fault level, due to the proposed Newpost Creek GS, will not exceed the interrupting capabilities of the existing breakers on the IESO-controlled grid.

3. There are no thermal overloads of the 115 kV area transmission identified as a result of connecting the proposed Newpost Creek generation and operated up to full power.

4. For all contingency cases tested with the proposed Newpost Creek generators, all voltage declines are within the 10% pre and post-ULTC action limit. Thus, the voltage performance would meet the voltage decline criteria.

5. The dynamic simulation results show that, with Newpost Creek generators on-line, all of the simulated contingencies exhibit a stable and acceptably damped response.

Notification of Approval for Connection Proposal

It is recommended that Notification of Conditional Approval for connection be issued to Ontario Power Generation Inc., subject to IESO's Requirements for Connection listed below, and any further requirements that may be identified by Hydro One Networks Inc. in the Customer Impact Assessment.

IESO's Requirements for Connection

The IESO requirements that have been identified during this Connection Assessment for the proposed addition of the Newpost Creek generation facility are given below. The IESO approval to place the new generator in-service depends on compliance with Market Rules including the implementation of the following requirements.

Transmitter Requirements

The following requirements are applicable for Hydro One for the incorporation of Newpost Creek:

(1) The transmitter is required to change the relay settings of the 115 kV circuit C6T to account for the effect of the generation facility.

Modifications to protection relays after this SIA is finalized must be submitted to IESO as soon as possible or at least six (6) months before any modifications are to be implemented. If those modifications result in adverse impacts, the connection applicant and the transmitter must develop mitigation solutions.

Applicant Requirements

Specific Requirements: The following *specific* requirements are applicable to the applicant for the incorporation of Newpost Creek. Specific requirements pertain to the level of reactive compensation needed, operation restrictions, Special Protection Systems, upgrading of equipment and any project specific items not covered in the *general* requirements:

(1) OPG must install a motorized disconnect switch at the point of connection to the existing IESO controlled grid.

(2) The connection applicant is required to ensure that the generators that are eventually supplied and installed have an inertia larger than 1.2.

(3) The connection applicant is required to ensure that the impedance of the step-up transformer is less than 12.2% on the rating of the generator facility (28 MVA).

(4) The proposed Newpost Creek GS has to participate in the North East Special Protection Scheme to address post-contingency thermal overloading as well as to respect existing Northeast operating limits. As a minimum, the facility should be able to be selected for G/R for the loss of D501P, P502X, P91G, C2H, C3H, A4H, A5H, A4H/A5H, H6T, H7T, and H6T/H7T.

General Requirements: The proposed connection must comply with all the applicable requirements from the Transmission System Code (TSC), IESO Market Rules, and standards and criteria. The most relevant requirements are summarized below and presented in more detail in Section 2 of this report.

(1) The proposed facility must satisfy the Generator Facility Requirements in Appendix 4.2 of the Market Rules.

(2) As this facility is in northern Ontario, all new 115 kV equipment must have a maximum continuous voltage rating and the ability to interrupt fault current at a voltage of at least 132 kV.

(3) If revenue metering equipment is being installed as part of this project, it must comply with Chapter 6 of the IESO Market Rules.

(4) The new equipment must sustain the fault levels in the area where the equipment is installed. Should future system enhancements result in fault levels exceeding equipment capability, the applicant is required to replace equipment at its own expense with higher rated equipment, up to 50 kA as per the Transmission System Code for 115 kV systems.

(5) The 115 kV breakers must meet the required interrupting time of less than or equal to 5 cycles as per the Transmission System Code.

(6) The connection equipment must be designed such that adverse effects due to failure are mitigated on the IESO-controlled grid.

(7) The connection equipment must be designed for full operability in all reasonably foreseeable ambient temperature conditions.

(8) The facility must satisfy telemetry requirements as per Appendices 4.15 and 4.19 of the Market Rules. The determination of telemetry quantities and telemetry testing will be conducted during the IESO Facility Registration/Market entry process.

(9) Protection systems must satisfy requirements of the Transmission system code and specific requirements from the transmitter. New protection systems must be coordinated with existing protection systems.

(10) Protective relaying must be configured to ensure transmission equipment remains in service for voltages between 94% of minimum continuous and 105% of maximum continuous values as per Market Rules, Appendix 4.1.

(11) Protection systems within the generation facility must only trip appropriate equipment required to isolate the fault. After the facility begins commercial operation, if an improper trip of the transmission facilities occurs due to events within the generation facility, the new facility may be required to be disconnected from the IESO-controlled grid until the problem is resolved.

(12) The generator must operate in voltage control mode and shall regulate automatically voltage at a point whose impedance (based on rated apparent power and rated voltage) is not more than 13% from the highest voltage terminal based within ±0.5% of any set point within ±5% of rated voltage. If the AVR target voltage is a function of reactive output, the slope $\Delta V/\Delta Q_{max}$ shall be adjustable to 0.5%.

(13) Models and data, including any controls that would be operational, must be provided to the IESO through the IESO Facility Registration/Market Entry process at least seven months before energization to the IESO-controlled grid.

(14) During the commissioning period, a set of IESO specified tests must be performed. The commissioning report must be submitted to the IESO within 30 days of the conclusion of commissioning. Field test results should be verifiable using the PSS/E models used for this SIA.

(15) The registration of the new facilities will need to be completed through the IESO's Market Entry process before any part of the facility can be placed in-service. If the data or assumptions supplied for the registration of the facilities materially differ from those that were used for the assessment, then some of the analysis might need to be repeated.

(16) 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. 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. Failure to provide evidence may result in disconnection from the IESO-controlled grid.

(17) The proposed facility must be compliant with applicable reliability standards set by the North American Electric Reliability Corporation (NERC) and the North East Power Coordinating Council (NPCC) prior to energization to the IESO-controlled grid.

(18) The applicant may meet the restoration participant criteria as per the NERC standard EOP-005. Further details can be found in section 3 of Market Manual 7.8 (Ontario Power System Restoration Plan).

System Impact Assessment Report
Newpost Creek Hydraulic Generation

1. INTRODUCTION

Ontario Power Generation is proposing to develop a new hydraulic generation facility, Newpost Creek GS, near Cochrane, Ontario. The proposed two generators will be connected at 13.8 kV and have a nameplate rating of 14 MVA at 0.9 pf. The Maximum Continuous Rating (MCR) is expected to be 12.5 MW. The generators will be connected to the grid via a new three phase 13.8/121 kV step-up transformer rated 28 MVA and a 7 km 115 kV transmission line. This transmission line is to be connected to the existing 115 kV Hydro One circuit C6T between Otter Rapids SS and Abitibi Canyon GS.

The scheduled in-service date for the project is December 31, 2012.

This System Impact Assessment has been conducted to examine the impact on the reliability of the IESO-controlled grid by the addition of two new 12.5 MW generators at Newpost Creek.

The connection applicant provided generation facility information including connection arrangement, models and parameters for generator, governor, exciter and power system stabilizer. Based on the application materials provided by OPG the IESO performed studies and prepared a detailed report containing equipment performance test results, thermal analysis, voltage analysis and transient analysis.

– End of Section –

2. GENERAL REQUIREMENTS

Generators

The proposed facility must satisfy the generator facility requirements in Appendix 4.2 of Market Rules.

The generation facility requirements for a hydro-electric facility primarily include:

- the generation facility shall have the capability to operate continuously between 59.4Hz and 60.6Hz and for a limited period of time in the region above straight lines on a log-linear scale defined by the points (0.0s, 57.0Hz), (3.3s, 57.0Hz), and (300s, 59.0Hz);
- the generation facility shall respond to frequency increase by reducing the active power with an average droop based on maximum active power adjustable between 3% and 7% and set at 4% . Regulation deadband shall not be wider than ± 0.06%. A sustained 10% change of rated active power after 10 s in response to a constant rate of change of frequency of 0.1%/s during interconnected operation shall be achievable;
- Speed shall be controlled in a stable fashion in both interconnected and island operation. Certain types of generation, such as hydro-electric generation will require different governor control settings to achieve both a rapid response during interconnected operation and a stable response during island operation. The switch between these two settings must be automatically triggered by conditions that are subject to IESO approval. Normally either frequency alone or a combination of frequency and rate of change of frequency would be acceptable.
- the generation facility shall be able to ride through routine switching events and design criteria contingencies assuming standard fault detection, auxiliary relaying, communication, and rated breaker interrupting times unless disconnected by configuration;
- the generation facility directly connecting to the IESO-controlled grid shall have the minimum capability to supply continuously all levels of active power output for 5% deviations in terminal voltage. Rated active power is the smaller output at either rated ambient conditions (e.g. temperature, head, wind speed, solar radiation) or 90% of rated apparent power. To satisfy steady-state reactive power requirements, active power reductions to rated active power are permitted;
- the generation facility must have the capability to inject or withdraw reactive power continuously (i.e. dynamically) at a connection point up to 33% of its rated active power at all levels of active power output except where a lesser continually available capability is permitted by the IESO. 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;
- the generation facility shall regulate automatically voltage at a point whose impedance (based on rated apparent power and rated voltage) is not more than 13% from the highest

voltage terminal based within ±0.5% of any set point within ±5% of rated voltage. If the AVR target voltage is a function of reactive output, the slope $\Delta V / \Delta Q_{max}$ shall be adjustable to 0.5%. The equivalent time constants shall not be longer than 20 ms for voltage sensing and 10 ms for the forward path to the regulator output.

Connection Equipment (Breakers, Disconnects, Transformers, Buses)

Appendix 4.1, reference 2 of the Market Rules states that under normal conditions voltages in northern Ontario are maintained within the range of 113 kV to 132 kV.

The 115 kV equipment in the facility must have a maximum continuous voltage rating of at least 132 kV. Fault interrupting devices must be able to interrupt fault current at the maximum continuous voltage of 132 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 connection applicant is encouraged to seek advice from their Metering Service Provider (MSP) or from the IESO metering group.

The Transmission System Code (TSC), Appendix 2 establishes maximum fault levels for the transmission system. For the 115 kV system, the maximum 3 phase symmetrical fault level is 50 kA and the single line to ground (SLG) symmetrical fault level is 50 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 50 kA for the 115 kV system.

The Transmission System Code (TSC), Appendix 2 states that the maximum rated interrupting time for 115 kV breakers must be ≤ 5 cycles. The connection applicant shall ensure that the new breakers meet the required interrupting time as specified in the TSC.

The connection equipment must be designed so that the adverse effects of failure on the IESO-controlled grid are mitigated. This includes ensuring that all circuit breakers fail in the open position.

The connection equipment must be designed so that it will be fully operational in all reasonably foreseeable ambient temperature conditions.

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

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 (version B) and any additional requirements identified by the transmitter. New protection systems must be coordinated with existing protection systems.

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.

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. Should a future SPS be installed to improve the transfer capability in the area or to accommodate transmission reinforcement projects, the project will be required to participate in the SPS system and to install the necessary protection and control facilities to affect the required actions.

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.

Protection systems within the generation facility must only trip the appropriate equipment required to isolate the fault. After the facility begins commercial operation, if an improper trip of the 115 kV circuit E1C 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.

The autoreclosure of the new 115 kV breaker at the connection point must be blocked. Upon its opening for a contingency, it must be closed only after the IESO approval is granted. The IESO will require reduction of power generation prior to the closure of the breaker followed by gradual increase of power to avoid a power surge.

Miscellaneous

Connection Applicant is required to install at the facility a disturbance recording device with clock synchronization that meets the technical specifications provided by Hydro One. The device will be used to monitor and record the response of the facility to disturbances on the 115 kV system in order to verify the dynamic response of generators. The quantities to be recorded, the sampling rate and the trigger settings will be provided by Hydro One.

Facility Registration/Market Entry Requirements

Models and data, including any controls that would be operational, must be provided to the IESO through the IESO Facility Registration/Market Entry process at least seven months before energization to the IESO-controlled grid.

The registration of the new facilities will need to be completed through the IESO's Market Entry process before IESO final approval for connection is granted and any part of the facility can be placed in-service. If the data or assumptions supplied for the registration of the facilities materially differ from those that were used for the assessment, then some of the analysis might need to be repeated.

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. 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. Failure to provide evidence may result in disconnection from the IESO-controlled grid.

During the commissioning period, a set of IESO specified tests must be performed. The commissioning report must be submitted to the IESO within 30 days of the conclusion of commissioning. Field test results should be verifiable using the PSS/E models used for this SIA.

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 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 connection applicant may need to 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 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. PROPOSED CONNECTION

The proposed Newpost Creek GS is to have two generators of maximum capacity of 14 MVA each. This facility is to be connected to the existing 115 kV Hydro One circuit C6T between Otter Rapids SS and Abitibi Canyon GS via a new 7 km 115 kV circuit. The connection point is approximately 17 km south of Otter Rapids SS. The proposed generators with Maximum Continuous Rating (MCR) of 12.5 MW each will be connected to 115 kV through a new three phase 13.8/115 kV step-up transformer rated 28 MVA.

The proposed connection arrangement of Newpost Creek GS is shown in Figure 1.

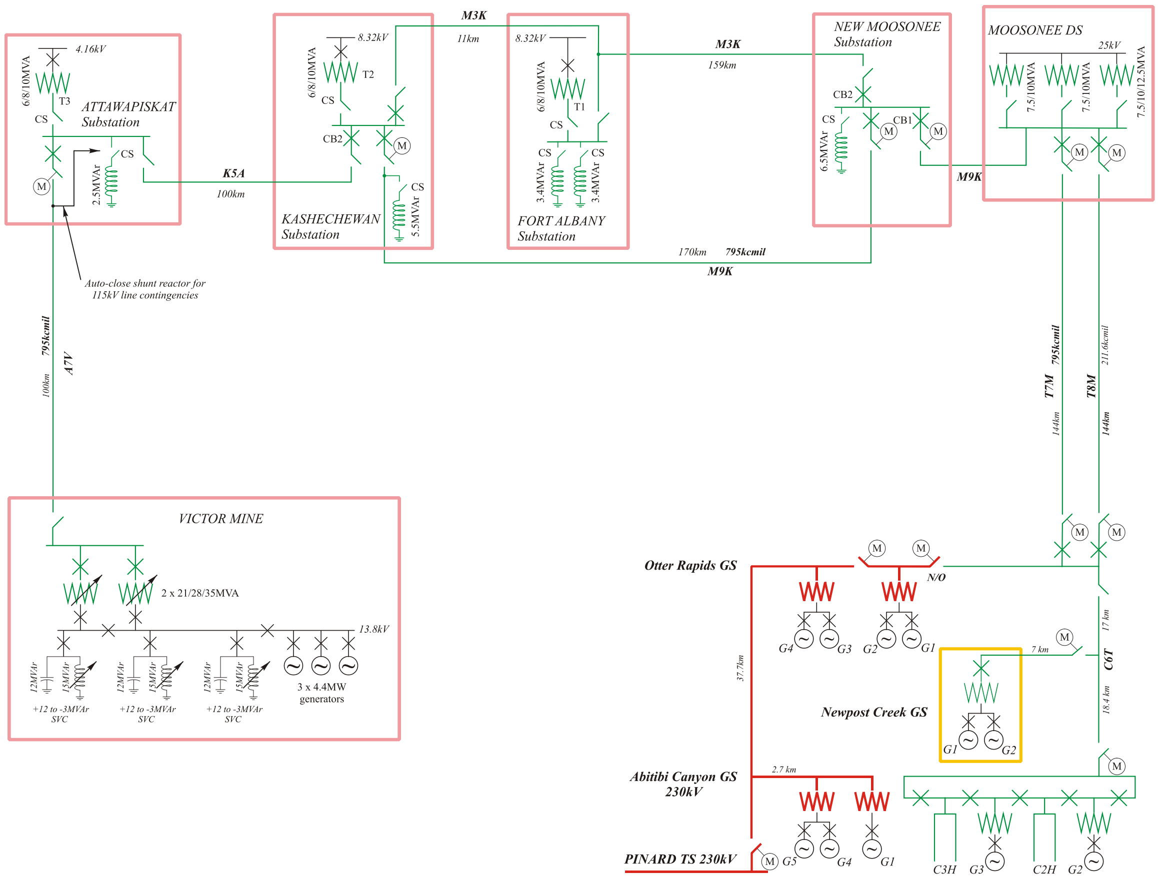

Figure 1: Connection Arrangement for Newpost Creek GS

OPG must install a motorized disconnect switch at the point of connection to the existing IESO controlled grid.

– End of Section –

4. GENERATION STATION ASSESSMENTS

4.1 MODEL AND DATA VERIFICATION

The proposed two generators at Newpost Creek GS will be identical. The parameters and the block diagrams of the PSS/E models of the generator, excitation system and speed governor used for the simulations are given in the sections below. The applicant provided these models to IESO with corresponding parameters.

4.1.1 GENERATOR MODEL

The proposed generator has a Maximum Continuous Rating of 12.5 MW at a power factor of 0.9. It will be driven by a 133.3 RPM turbine with digital governor control. The data for the generator model GENSAL are given in Table 1.

Table 1: Generator Parameters

Description	Value	Description	Value
X_d	1.0	T''_{do}	0.029
X_q	0.62	T''_{qo}	0.044
X'_d	0.36	X_l	0.165
X''_d	0.29	X_2	0.31
X''_q	0.25	X_0	0.12
R_a	0.1105	S(1.0)	0.11
T'_{do}	2.35	S(1.2)	0.55
H	1.03		

Appendix 4.2 of Market Rules requires that a synchronous generation unit should have characteristic parameters within typical ranges. Inertia, unsaturated transient impedance, transient time constants and saturation coefficients shall be within typical ranges (e.g. H > 1.2 Aero-derivative, H > 1.2 Hydraulic less than 20 MVA, H > 2.0 Hydraulic 20 MVA or larger, H > 4.0, other synchronized units, X'd < 0.5, T'do > 2.0, and S1.2 < 0.5) except where permitted by the IESO.

The connection applicant provided an inertia of 1.03 which does not meet Market Rules requirements.

The connection applicant is required to ensure that the generators that are eventually supplied and installed have an inertia larger than 1.2.

Appendix 4.2 of Market Rules requires that every synchronous generator connecting to IESO-controlled grid must have the capability to supply/absorb reactive power in the range of 0.9 lagging to 0.95 leading power factor.

> The connection applicant is required to confirm that the generator will have the capability of supplying/absorbing reactive power in the range of 0.9 lagging to 0.95 leading at rated real power and voltage. The generator will be capable to supply full active power continuously while operating at a generator terminal voltage ranging from 0.95 pu to 1.05 pu of the generator's rated terminal voltage.

It should be noted that the data provided by the connection applicant includes some parameters supplied by the manufacturer along with estimates used for the remaining parameters.

> The applicant is required to provide type test data that validates parameters and reactive capabilities of the generators. During the Market Entry process and prior to the connection of the new generator to the IESO-controlled grid OPG shall submit a detailed test plan to validate the parameters of generator, exciter and speed governor.

4.1.2 AUTOMATIC EXCITATION SYSTEM

The Model for the exciter is IEEE Type ST4B potential or compounded source-controlled rectifier excitation system model.

The block diagram of the excitation system provided by the connection applicant is shown in Figure 2. The parameters of the exciter are shown in Table 2.

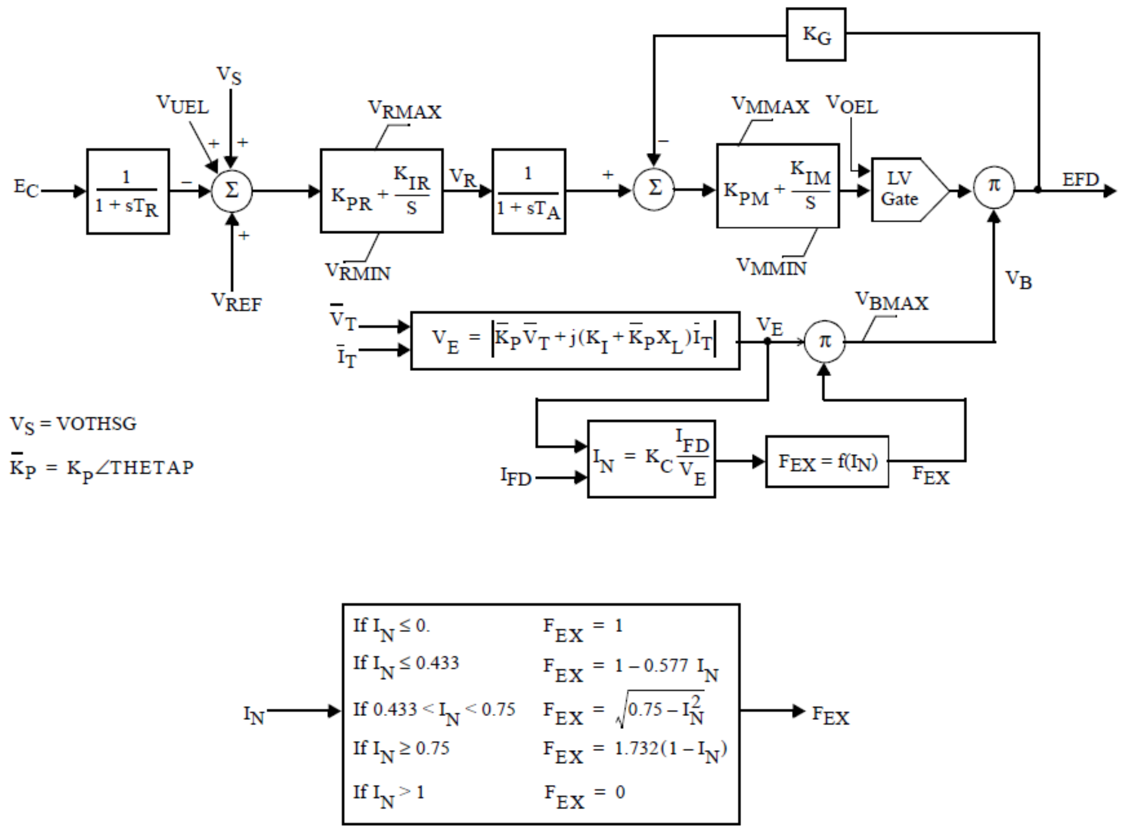

Figure 2: Block Diagram of Excitation System

Table 2: Excitation (ST4B) Parameters

Description	CONs	Parameter	Value	Units
Voltage transducer time constant	J	T_R	0.02	sec
AVR proportional gain	J+1	KPN	30	pu Efd / pu Etref
KIR, AVR integral gain	J+2	KIN	5	
Maximum voltage regulator output	J+3	V_{RMAX}	0.97	pu Ceiling
Minimum voltage regulator output (pu)	J+4	V_{RMIN}	-0.87	pu Ceiling
Voltage regulator time constant	J+5	T_A	0.01	sec
FVR (inner loop) proportional gain	J+6	K_{PM}	1	pu Efd
FVR (inner loop) integral gain	J+7	K_{IM}	0	
Maximum field regulator output	J+8	V_{MMAX}	0.97	pu Efd
Minimum field regulator output	J+9	V_{MMIN}	-0.87	pu Efd
Inner loop feedback gain	J+10	K_G	0	

Compound source potential multiplier	J+11	K_P	5	
Compound source current multiplier	J+12	K_I	0	
Maximum bridge output	J+13	V_{BMAX}	6	pu Efd
Commutating reactance drop	J+14	K_C	0.11	pu
Compound source reactance	J+15	X_L	0	
Compound source potential angle	J+16	THETAP	0	(degrees)

As per appendix 4.2 of Market Rules, each generation facility directly connected to the IESO-controlled grid shall have an Automatic Voltage Regulator with the capability to:

- Regulate automatically voltage within ±0.5% of any set point within ± 5% of rated voltage at a point whose impedance (based on rated apparent power and rated voltage) is not more than 13% from the highest voltage terminal.

- The equivalent time constants shall not be longer than 20 ms for voltage sensing and 10 ms for the forward path to the exciter output.

EXCITATION SYSTEM RESPONSE RATIO TEST

As per appendix 4.2 of Market Rules, each generation facility directly connected to the IESO-controlled grid shall have an Excitation System with the capability to:

- Provide positive and negative ceilings not less than 200% and 140% of rated field voltage at rated terminal voltage and rated field current

To evaluate the positive and negative ceilings, response ratio tests were performed.

The positive ceiling test automatically raises the reference setting of the voltage regulator by a large amount at time equal zero, with the generator initialized to its rated output at rated power factor.

Figure 3 shows that for the positive ceiling response ratio test, the exciter field voltage increased from rated value of 2.29 p.u. to ceiling voltage of 4.78 p.u which is 209% of rated field voltage.

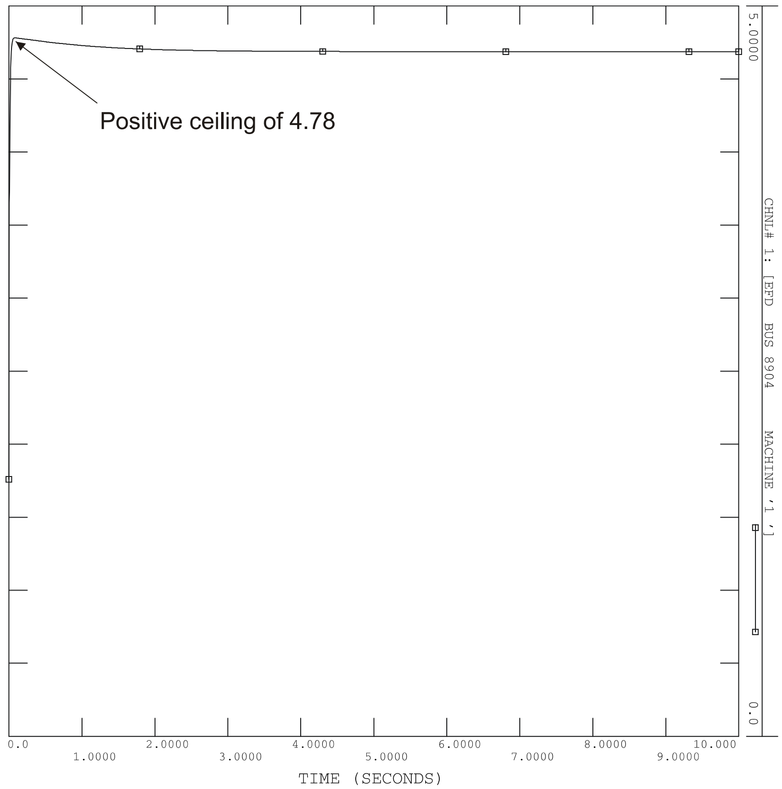

Figure 3: Response Ratio Test for Positive Ceiling

Hence the exciter at Newpost Creek meets the 200% positive ceiling requirement.

The negative ceiling test automatically lowers the reference setting of the voltage regulator by a large amount at time equal zero, with the generator initialized to its rated output at rated power factor.

Figure 4 shows that for the negative ceiling response ratio test, the exciter field voltage decreased from rated value of 2.29 p.u. to negative ceiling voltage of -4.36 p.u which is 190% of rated field voltage.

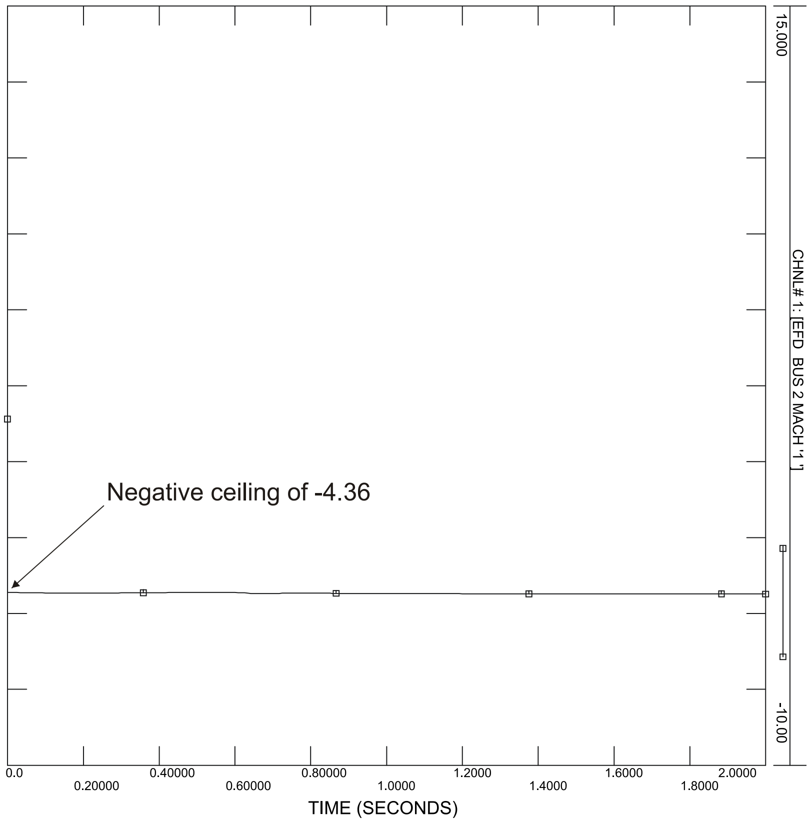

Figure 4: Response Ratio Test for Negative Ceiling

Hence the exciter at Newpost Creek meets the 140% negative ceiling requirement.

EXCITATION SYSTEM OPEN CIRCUIT RESPONSE TEST

As per appendix 4.2 of Market Rules, each generation facility directly connected to the IESO-controlled grid shall have an excitation system with the capability to:

- Provide a voltage response time to either ceiling not more than 50 ms for a 5% step change from rated voltage under open-circuit conditions

Open circuit test for +5% step change in reference voltage was performed to verify if the exciter has the capability of reaching 1.95 * Efd_{rated} starting from Efd = Efd_{rated} within 50 ms.

Figure 5 shows the open circuit test results for a +5% step change in reference voltage

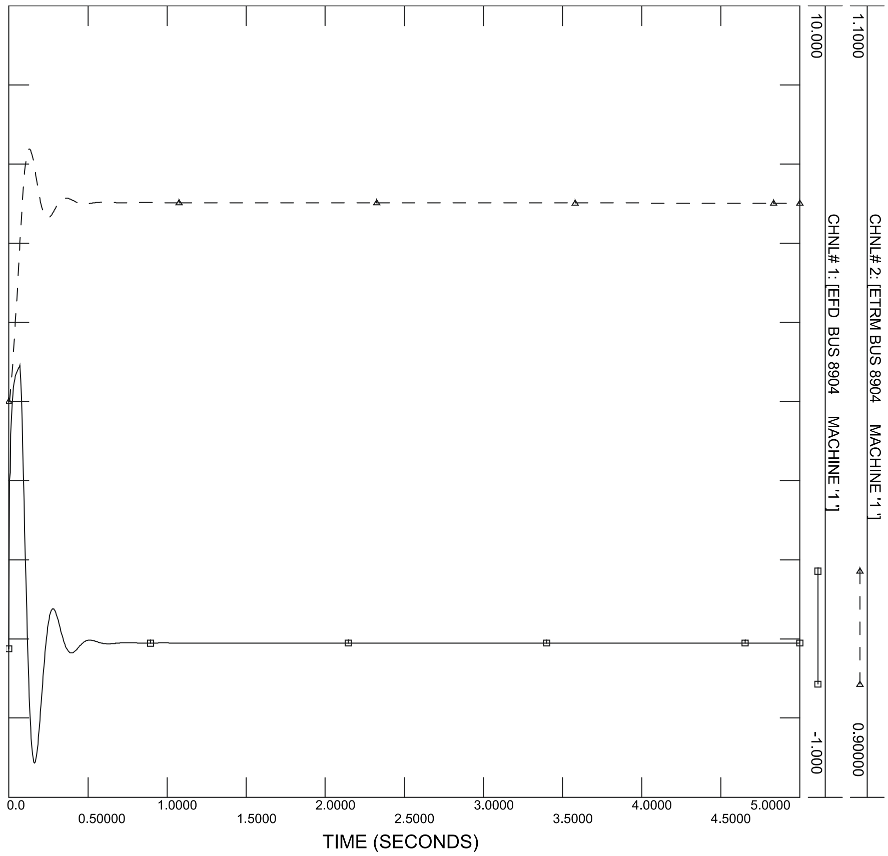

Figure 5: Open Circuit Test for +5% Reference Voltage Change

From the graph it was observed that $Efd_{initial}$ (t=0) = 1.1 = Efd_{oc}, Efd_{rated} =2.29 p.u

Therefore the required time to reach 1.95 * Efd_{rated} = 4.47 p.u is:

From the graph it was observed that Efd reaches this value at approximately 21 ms, meeting requirements.

Open circuit test for -5% step change in reference voltage was performed to verify if the exciter has the capability of reaching -1.28 * Efd_{rated} starting from Efd = Efd_{rated} within 50 ms.

Figure 6 shows the open circuit test results for a -5% step change in reference voltage

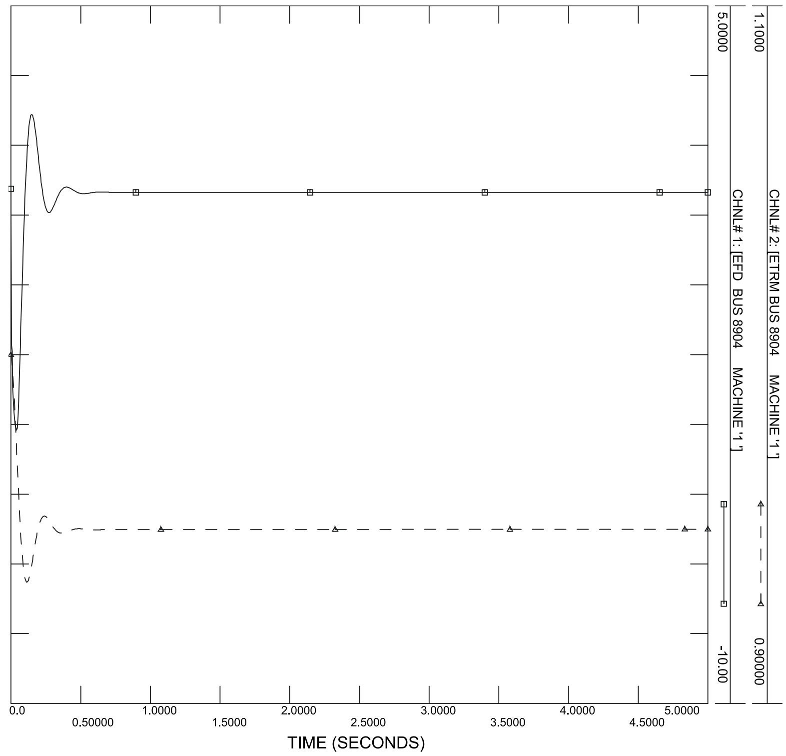

Figure 6: Open Circuit Test for -5% Reference Voltage Change

From the graph it was observed that $Efd_{initial}$ (t=0) = 1.1 = Efd_{oc}. Efd_{rated} = 2.29 p.u

Therefore the required time to reach -1.28 * Efd_{rated} = -2.93 p.u is:

From the graph it was observed that Efd reaches this value at approximately 12 ms, meeting requirements.

As per appendix 4.2 of Market Rules, each generation facility directly connected to the IESO-controlled grid shall have an Excitation System with the capability to:

- Provide a positive ceiling not less than 170% of rated field voltage at rated terminal voltage and 160% of rated field current

The block diagram of the proposed excitation system (Figure 2) shows the impact of I_{FD} on the E_{FD}. Using the settings shown in Table 2, at rated terminal voltage, V_E will be 5. Assuming I_{FD} = 1.6, results in F_{EX} = 0.98. Then, $V_B = V_E \times F_{EX}$ = 4.9. Therefore, E_{FD} can be as high as 4.7 pu ($V_B \times V_{MMAX}$) which is 205% of rated field voltage which meets Market Rules requirements.

In conclusion, the excitation system at Newpost Creek meets market rule requirements.

It should be noted that the performance of the exciter is obtained based on the estimated data.

The connection applicant is required to ensure that the performance of the equipment that is eventually supplied and installed is similar to the predicted performance or exceeds the predicted performance observed in the simulation results obtained using the above models.

4.1.3 SPEED GOVERNOR

The Market Rules state that each synchronous generation unit that is greater than 10 MVA must be equipped with a speed governor with a permanent speed droop between 3% and 7% and an intentional deadband not wider than ± 36 mHz.

The governor model used for the new generating units proposed in this study is PTI's Woodward Electric Hydro Governor model, WEHGOV. The block diagram of this model and the data for the governor model used in this study are shown in Figure 7 and Table 3, respectively.

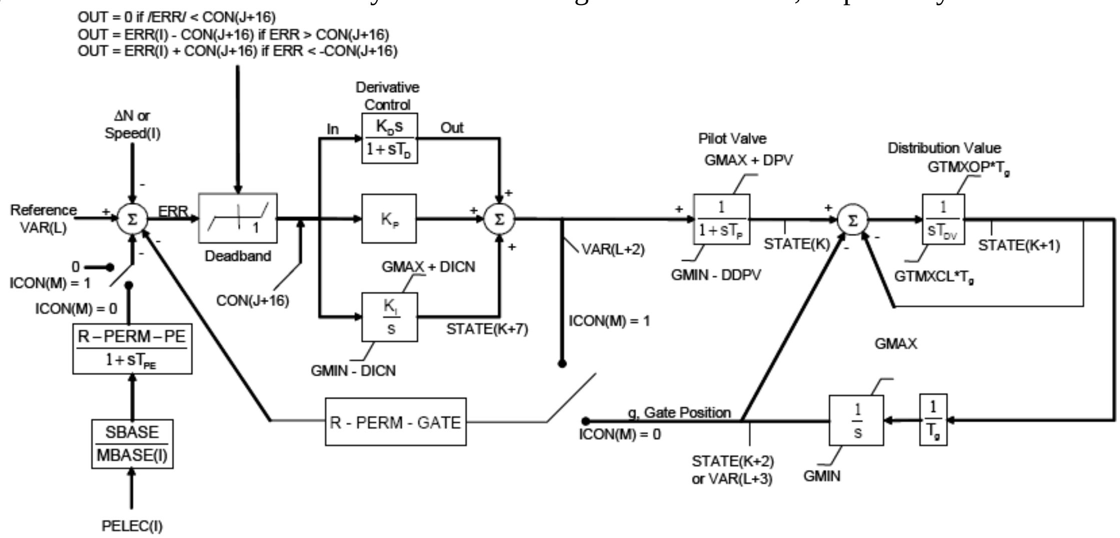

Figure 7: Block Diagram of Speed Governor

Table 3: PSS/E WEHGOV Governor Parameters

CONs	Description	Value	CONs	Description	Value
J	R-PERM-GATE	0	J+26	FLOW G3	1
J+1	R-PERM-PE	0.05	J+27	FLOW G4	1
J+2	Tpe (sec)	1	J+28	FLOW G5	1
J+3	Kp	0.45	J+29	FLOW P1	0
J+4	Ki	0.03	J+30	FLOW P2	0.15
J+5	Kd	0.1	J+31	FLOW P3	0.3
J+6	Td (sec)	0.05	J+32	FLOW P4	0.45
J+7	Tp (sec)	0.1	J+33	FLOW P5	0.6
J+8	Tdv (sec)	0.1	J+34	FLOW P6	0.7
J+9	Tg (sec)	0.3	J+35	FLOW P7	0.8
J+10	GTMXOP	0.1	J+36	FLOW P8	0.9
J+11	GTMXCL	-0.1	J+37	FLOW P9	0.95
J+12	GMAX	1	J+38	FLOW P10	1

J+13	GMIN	0	J+39	PMECH 1	-0.15
J+14	Dturb	0	J+40	PMECH 2	0
J+15	Tw (sec) 0	2	J+41	PMECH 3	0.15
J+16	Speed deadband	0 0	J+42	PMECH 4	0.30
J+17	DPV	0	J+43	PMECH 5	0.450
J+18	DICN	0.05	J+44	PMECH 6	0.600
J+19	GATE 1	0	J+45	PMECH 7	0.850
J+20	GATE 2	1	J+46	PMECH 8	0.900
J+21	GATE 3	1	J+47	PMECH 9	0.95
J+22	GATE 4	1	J+48	PMECH 10	1
J+23	GATE 5	1			
J+24	FLOW G1	0	**ICON**	#	**Value**
J+25	FLOW G2	1	M	0=power or gate	0

Simulations were performed to test the transient response for the given governor model. The results showed that the parameters were tuned to give reasonable damping and the governor has a droop of 3.8% thus meeting Market Rules' requirements.

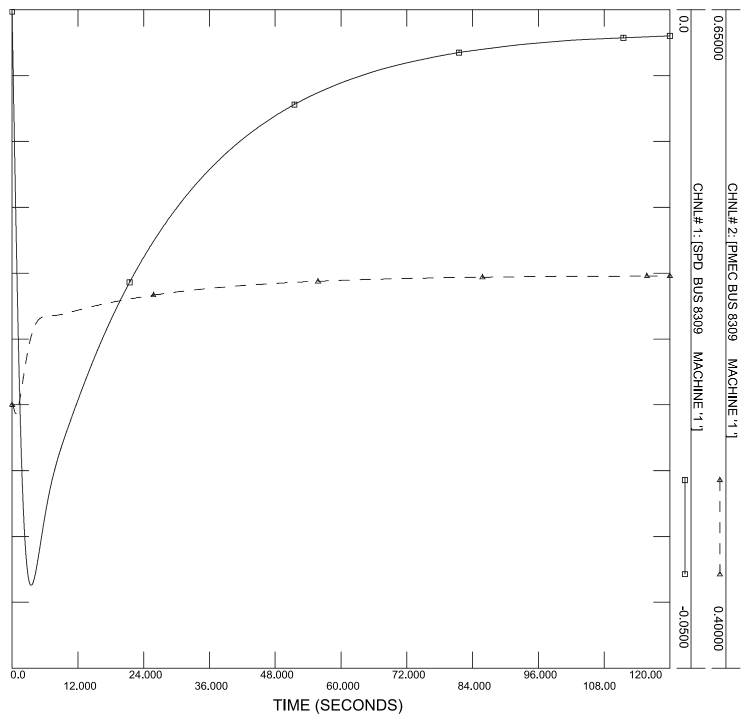

Figure 8: Response Test for Governor

4.1.4 POWER SYSTEM STABILIZER

The Market Rules, Reference 15 of Appendix 4.2 require that:

"Each synchronous generating unit that is equipped with an excitation system that meets the performance requirements stated in section 3.1.2 shall also be equipped with a power system stabilizer which shall, to the extent practicable, be tuned to increase damping torque without reducing synchronizing torque."

For Newpost Creek unit, OPG provided a digital-based PSS with dual inputs, commonly referred to as integral of accelerating power type PSS2A. The block diagram of this stabilizer is shown in Figure 9 and the parameters used are given in Table 4 below.

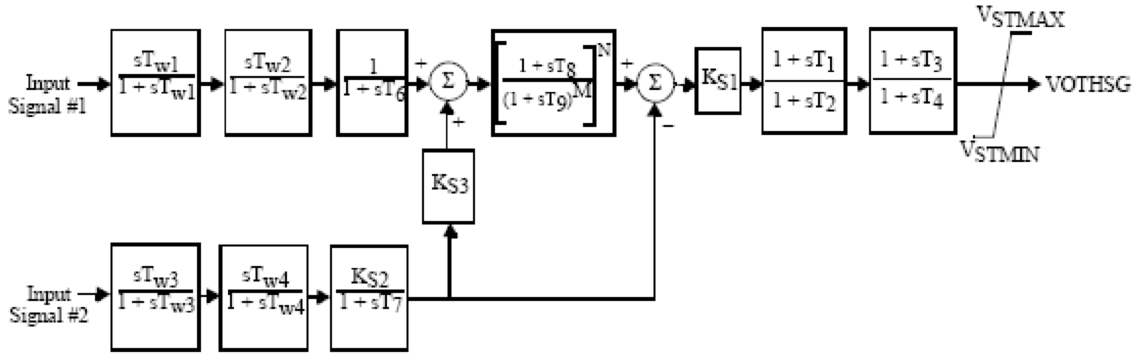

Figure 9: Block Diagram of PSS

Table 4: PSS/E PSS2A Parameters

Description	Value	Description	Value
ICS1	1	T_8	0.5
ICS2	3	T_9	0.1
M	5	K_{S1}	2.0
N	1	T_1	0.226
T_{W1}	10	T_2	0.03
T_{W2}	10	T_3	0.226
T_6	0	T_4	0.03
T_{W3}	10	V_{STMAX}	0.05
T_{W4}	0	V_{STMIN}	-0.05
T_7	5		
K_{S2}	2.27		
K_{S3}	1.0		

4.1.5 STEP-UP TRANSFORMER

Technical specifications of the step-up transformer provided by the connection applicant are listed as follows:

Transformation	125/13.8 kV
Continuous rating	28 MVA
Impedance	12.9% based on 28 MVA
Configuration	3 phase, High side: wye, Low voltage side: delta
Tapping	off-load tap changers at HV (-5% -2.5% 0% 2.5% 5.0%)

The Market Rules requirement to be able to produce rated power output at a set value for the voltage on the HV system by varying the terminal voltage by ± 5%, effectively limits the impedance of the connection to the IESO-controlled grid maximum of about 13%, based on the MVA rating of the generating facility. OPG provided that the impedance of the 7 km tap circuit is

0.028 pu based on 100 MVA which is 0.008 pu based on 28 MVA. Therefore, the impedance of the step-up transformer should be less than 12.2% on the rating of the generator facility (28 MVA) in order to meet Market Rule requirements.

The connection applicant is required to ensure that the impedance of the step-up transformer is less than 12.2% on the rating of the generator facility (28 MVA).

4.1.6 CIRCUIT BREAKERS AND DISCONNECT SWITCHES

Technical specifications of the circuit breakers provided by the connection applicant are listed in Table 5.

Table 5: Circuit Breaker and Disconnect Switch Parameters

Breakers	**LV**	**HV**
Rated voltage	15 kV	138 kV
Interrupting time	83.3 ms	83.3 ms
Interrupting media	Vacuum	SF6
Rated continuous current	1200 A	600 A
Rated symm. short circuit capability	50 kA	50 kA
Disconnect Switch	**HV**	
Rated Voltage	138	
Type	Disconnect	
Rated continuous current	600 A	
Short circuit rating	50 kA	

The system performance standards listed in the Transmission System Code requires that the 13.8 kV and 115 kV system fault level not exceed 21 kA (Sym.) and 50 kA (Sym), respectively. This indicates that 13.8 kV and 115 kV equipments must be sized to interrupt 21 kA (Sym.) 50 kA (Sym), respectively. The breakers proposed for installation at Newpost Creek meet the interrupting capability recommended by the Transmission System Code.

4.2 ON-LINE MONITORING REQUIREMENTS

The Market rules (Appendix 4.15 and Appendix 4.19) list the IESO requirements with respect to the information on generator monitoring that must be made available to the IESO on a continual basis from all generators connected to the IESO-controlled grid. It is required that at minimum, the following quantities be monitored:

- terminal voltage of the proposed generators
- active and reactive power output of the proposed generators
- status of the proposed 115 kV breaker
- status of the proposed 115 kV disconnect switch
- status of 13.8 kV terminal breakers of the proposed generators

OPG is required to install all the equipment needed to continuously monitor the information that is required by the IESO. The IESO will finalize items to be monitored during the IESO Facility Registration Process.

4.3 IMPORTANT NOTE ON MODELS AND DATA

The four components used to model the new generation include a synchronous generator model (GENSAL), an excitation model (ESST4B), a power system stabilizer model (PSS2A), and a governor model (WEHGOV). Typical data provided by OPG for these models are used in this assessment.

OPG is required to ensure that the performance of the equipment that is eventually installed meets or exceeds the predicted performance observed in the computer simulation results obtained using the models and available parameters. The applicant is required to provide type test data that validates parameters and reactive capabilities. If these data are not provided, during the Market Entry process, prior to the connection of the new generator to the IESO-controlled grid, OPG shall submit a detailed test plan to validate the parameters of generator, exciter and speed governor. The validation tests are expected to be performed during unit's commissioning testing.

– End of Section –

5. ANALYSIS OF SHORT CIRCUIT CURRENT

Fault level studies were completed by Hydro One to specifically examine the effect of the Newpost Creek generation project on fault levels at the existing facilities.

Table 6 summarizes the fault levels including both symmetric and asymmetric fault currents in kA near Newpost Creek GS. The short circuit analysis was based on the following assumptions:

- All existing generating facilities in the area are in-service
- The maximum pre-fault voltage is 132 kV

Table 6: Fault Levels Near Newpost Creek GS (NPC)

Bus	L-G/LLG (kA)				3-phase (kA)			
	No NPC		With NPC		No NPC		With NPC	
	Symm	Asym	Symm	Asym	Symm	Asym	Symm	Asym
Canyon	5.52/5.49	6.70	5.76/5.80	7.03	5.47	6.28	5.84	6.73
Otter Rapid	1.74/2.19	1.78	1.81/2.34	1.84	2.40	2.46	2.58	2.67
Moosonee	0.58/1.01	0.59	0.59/1.04	0.60	1.14	1.16	1.18	1.20
Hunta SS	5.68/4.13	5.98	5.74/4.14	6.04	9.13	9.48	9.36	9.71

The results in Table 6 generally show that there is a slight increase in fault currents with the addition of the Newpost Creek GS. The interrupting capabilities of the existing breakers at the stations listed in Table 6 were checked and it was found that the fault levels with proposed Newpost Creek project are far below the interrupting capabilities of the existing breakers. Therefore, it can be concluded that the increases in fault level, due to the proposed Newpost Creek GS, will not exceed the interrupting capabilities of the existing breakers on the IESO-controlled grid.

– End of Section –

6. CONNECTION ASSESSMENT STUDIES

Based on the application materials provided by OPG the IESO performed studies to identify any concerns on equipment thermal loading, voltage decline and transient stability due to the addition of the proposed Newpost Creek generating unit.

6.1 STUDY ASSUMPTIONS

The proposed Newpost Creek generating units are connected to Hydro One's 115 kV transmission circuit C6T which is radially connected to OPG's Abitibi Canyon GS, as shown in Figure 10. Five Nations transmission system and Victor Mine are also radially connected to C6T.

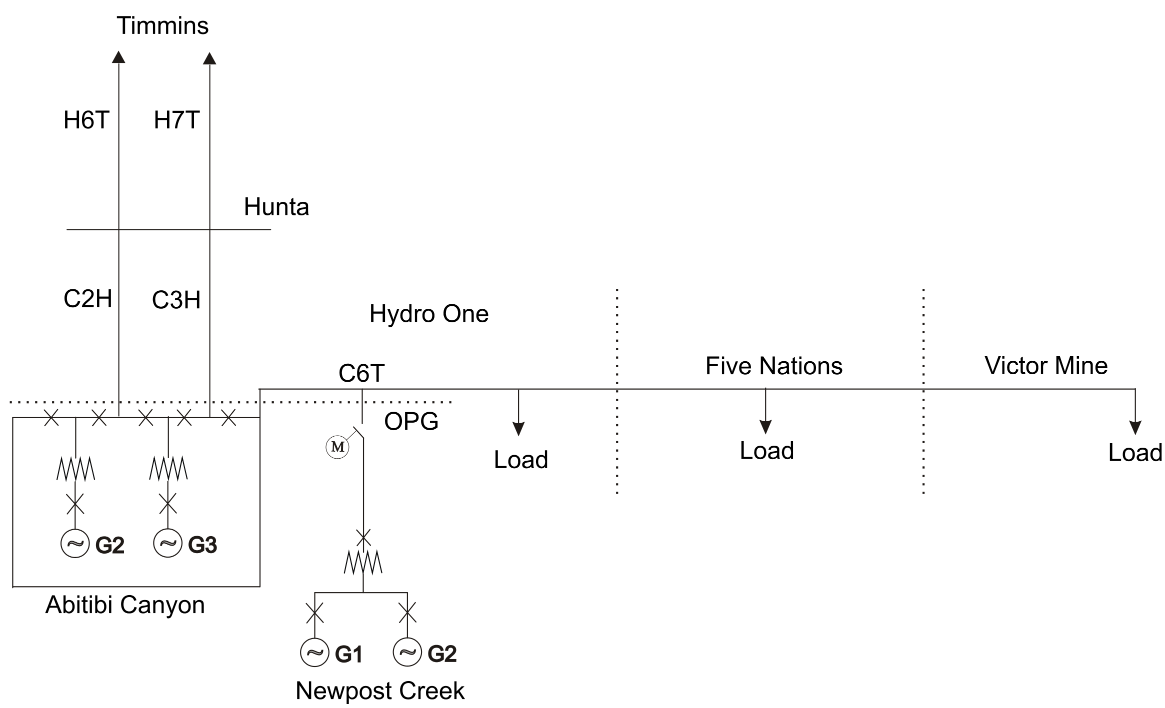

Figure 10: Simplified 115 kV connection for Newpost Creek GS

The following graph in Figure 11 shows the MW flow on C6T at Abitibi Canyon in one hour average samples during the period of January 1- December 31, 2008.

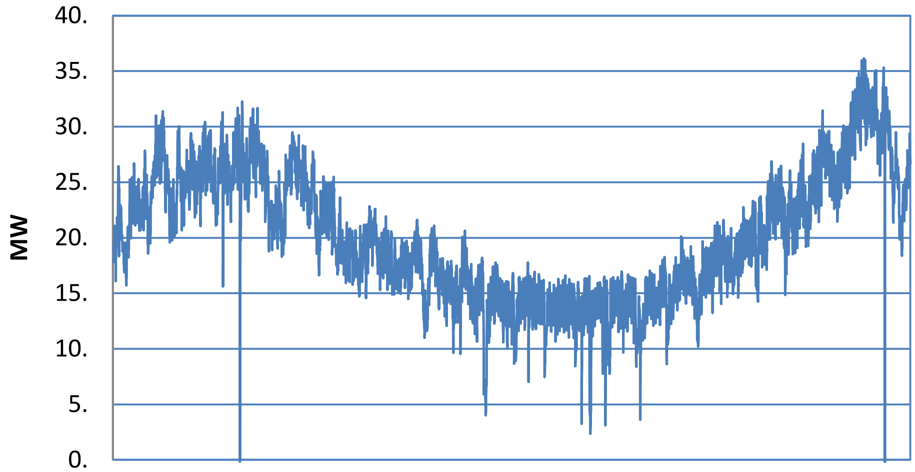

Figure 11: MW flow on C6T at Abitibi Canyon

It can be seen that generally the flow on C6T was above 10 MW during 2008. The following estimates for the future load at Moosonee DS, the Five Nations communities and Victor Mine in Table 7 were used in the SIA analysis for Victor Mine project. Power factor is 0.975 for all the loads. Five Nations Energy Inc. has confirmed that the following load forecast in Table 7 is still practical and valid.

Table 7: Forecast Loads (MW)

Location	2010	2015	2020
Moosonee	15.0	15.8	16.6
Fort Albany	2.3	2.8	3.5
Kashechewan	2.8	3.5	4.4
Attawapiskat	3.2	4.1	5.2
Victor Mine	29	29	29
Total	52.3	55.2	58.7

The following graph in Figure11 shows the 115 kV voltage at Abitibi Canyon in one hour average samples during the period of June 1- Dec 31, 2008.

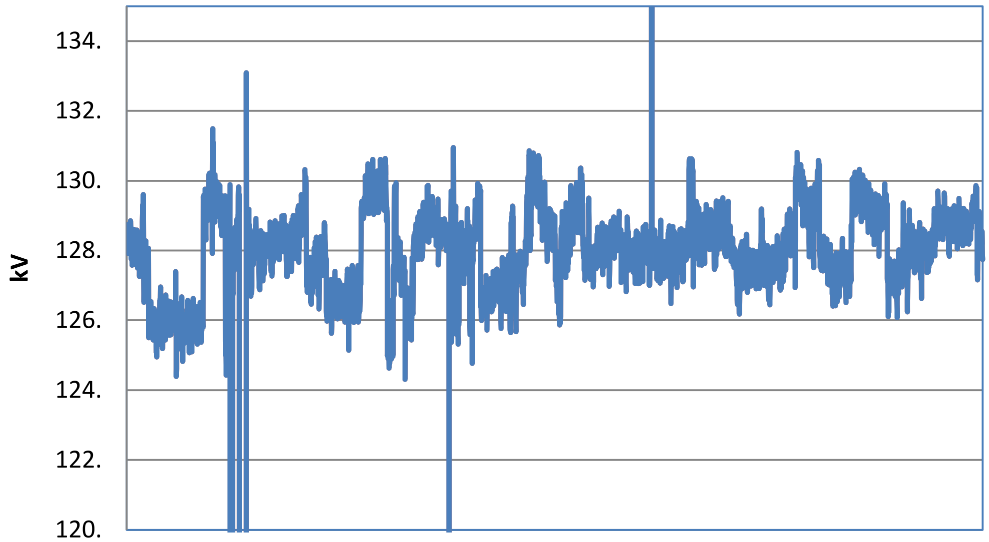

Figure 12: 115 kV Voltage at Abitibi Canyon

It can be observed that the average voltage at Abitibi Canyon is about 129 kV.

The 2010 summer base case was used as a starting point for the analysis. System generation dispatch pattern and the status of shunt elements were adjusted to achieve acceptable bus voltage level at Abitibi Canyon. The loads at Moosonee DS, the Five Nations communities and Victor Mine were adjusted for the purpose of different studies as described in the following sections. The study was performed for a system with all transmission elements in service.

The new units at Newpost Creek GS and the existing units at Abitibi Canyon were at full output unless otherwise specified.

6.2 THERMAL STUDY

This section covers an investigation of thermal capability of 115 kV circuits in NE with the addition of Newpost Creek generating units.

Load flow studies have been carried out to examine the thermal loading capability for transmission elements with the proposed Newpost Creek GS project. Since the Five Nations system and Victor Mine are radially connected to Moosonee SS the power flows on T7M, T8M and M9K are determined by the loads in Fiver Nations and Victor Mine and new proposed Newpost Creek GS will not have impact on the flows. Therefore, only the impacted circuits C6T, C2H and C3H are monitored in the thermal study.

To have maximum flow on the monitored circuits, two modifications were made for the base case:

1. Units 1 and 2 at Otter Rapids were connected to C6T with 30 MW output as indicated by OPG.
2. Loads at Moosonee DS, the Five Nations communities and Victor Mine were scaled to minimum as shown in Figure 11, i.e., 10 MW in total.

The results including pre-contingency and contingencies involving C6T are summarized in Table 8 as well as the thermal ratings of the monitored circuits. Hydro One provided the Continuous, Long Term Emergency planning thermal ratings for various circuits under summer weather conditions. The algorithm for deriving these ratings is as follows:

- *Ambient conditions*: 30ºC temperature, 4 km/hr wind speed, daytime
- *Continuous*: Rating obtained at the lesser of conductor temperature of 93 ºC or sag temperature
- *Long Term Emergency*: Rating obtained at the lesser conductor temperature of 127ºC or sag temperature

The pre-contingency flow on each transmission element is expressed as a percentage of the continuous rating and the post-contingency flow on each transmission element is expressed as a percentage of the LTE.

Table 8: Thermal Study Results

Circuit	Ratings (MVA)		Pre-Contingency		Post-Contingency	
	Cont.	LTE	MVA	%	MVA	%
C6T	109.6	109.6	57.6	52.6	-	-
C2H	199.2	199.2	91.7	46.0	180.2	90.5
C3H	207.2	207.2	90.9	43.9	180.0	86.9

The results indicate that with all elements in-service the power flows on the monitored circuits are well within the circuit continuous rating. Under the contingency involving C6T all the monitored 115 kV circuits are within the LTE ratings.

Therefore, it can be concluded that there is no thermal performance concern identified with the proposed Newpost Creek generation.

6.3 VOLTAGE ANALYSIS

Voltage studies were performed to investigate the voltage performance as the Newpost Creek GS was added to the NE system. Units 1 and 2 at Otter Rapids were connected to R21D. The most critical contingency expected for voltage drop is the loss of two units at Newpost Creek when units 2 and 3 at Abitibi Canyon are out of service. The voltages at Abitibi Canyon, Moosonee DS, Fort Albany, Kashechewan, Attawapiskat and Victor Mine were monitored. In the simulations the Newpost Creek units mode of operation was set to regulate their terminal voltage at 1.0 pu. The pre- and post-contingency voltages are shown in Table 9.

Table 9: Voltage Study Results

Bus	Pre-contingency (kV)	Post-contingency			
		Pre-ULTC (kV)	Voltage Decline (%)	Post-ULTC (kV)	Voltage Decline (%)
Canyon 115	128.9	128.9	0.00	128.9	0.00
Moosonee 115	127.4	127.1	-0.24	127.2	-0.16
Moosonee 27.6	27.6	27.5	-0.36	27.6	0.00
Fort Albany 115	126.0	125.6	-0.32	125.9	-0.08
Kashechewan 115	126.0	125.6	-0.32	125.9	-0.08

Attawapiskat 115	118.7	118.2	-0.42	118.6	-0.08
Victor Mine 115	118.1	117.5	-0.51	118.1	0.00
Victor Mine 15	15.3	15.2	-0.65	15.3	0.00

Study results show that the post-contingency voltages at monitored 115 kV buses meet the minimum required operating voltage of 108 kV. The post-contingency voltage declines at monitored buses are within the 10% criteria.

Similar with the thermal study, simulations were also performed for contingencies involving 115 kV circuits C2H and C3H. It was found that all the operating voltages and post-contingency voltage declines meet the voltage criteria.

Therefore, it can be concluded that there is no voltage performance concern identified with the proposed Newpost Creek generation.

6.4 TRANSIENT STATE ANALYSIS

Transient stability analyses were performed considering fault at Abitibi Canyon, Hunta, Porcupine, Pinard, and Hanmer. The same modified base case for thermal studies was used for transient state analysis. The contingencies shown in Table 10 were tested.

Table 10: Contingencies for Transient Study

Contingencies		Fault MVA Levels	Newpost Creek I/S	Newpost Creek O/S
SC1	Normally cleared LLG fault on C2H @ Abitibi	239-j2229	X	X
SC2	Normally cleared LLG fault on H6T @ Hunta	533-j2200	X	X
SC3	Normally cleared 3-Ph fault on D501P @ Pinard	-j2E9	X	
SC4	Normally cleared 3-Ph fault on P502X @ Porcupine	-j2E9	X	
SC5	Normally cleared 3-Ph fault on X503E @ Hanmer	-j2E9	X	

All the simulation results are shown in the Appendix. It can be concluded from the results that, with Newpost Creek new generator on-line, none of the simulated contingencies caused transient instability or undamped oscillations.

6.5 NE 115 kV LR & GR SCHEME

The North-East 115 kV Load and Generation Rejection Scheme was designed to address the problem of excess generation capacity being imposed on the underlying 115kV system under contingency conditions involving the 500 kV, 230 kV and 115 kV Systems north of Sudbury.

The proposed Newpost Creek GS is incorporated into the North-East system and it shall be added in the NE 115 kV LR & GR Scheme to address post-contingency thermal overloading as well as to respect existing Northeast operating limits. The G/R for Newpost Creek GS should be initiated upon detection of any of contingencies involving D501P, P502X, P91G, C2H, C3H, A4H, A5H, A4H/A5H, H6T, H7T, and H6T/H7T.

The proposed Newpost Creek GS has to participate in the North East Special Protection Scheme to address post-contingency thermal overloading as well as to respect existing Northeast operating limits. As a minimum, the facility should be able to be selected for G/R for the loss of D501P, P502X, P91G, C2H, C3H, A4H, A5H, A4H/A5H, H6T, H7T, and H6T/H7T.

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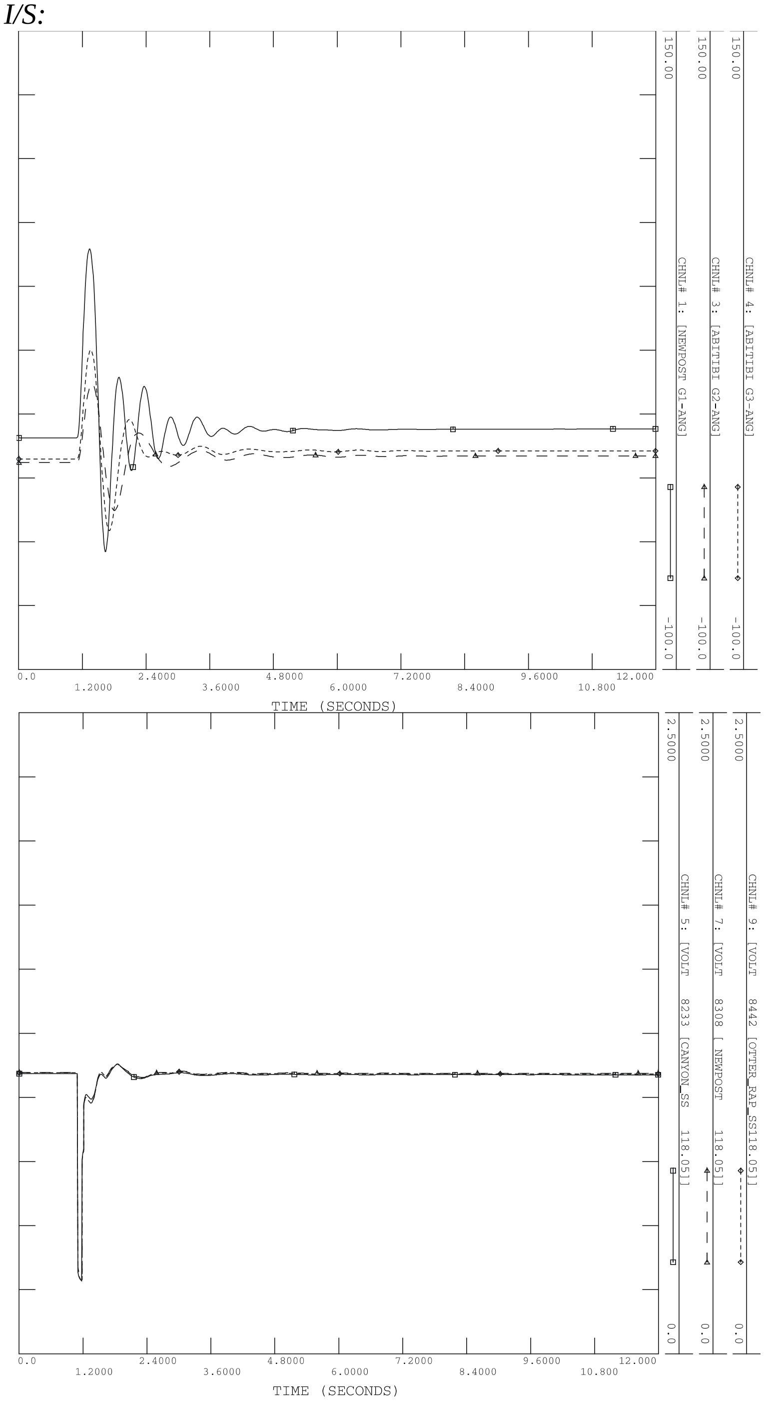
APPENDIX

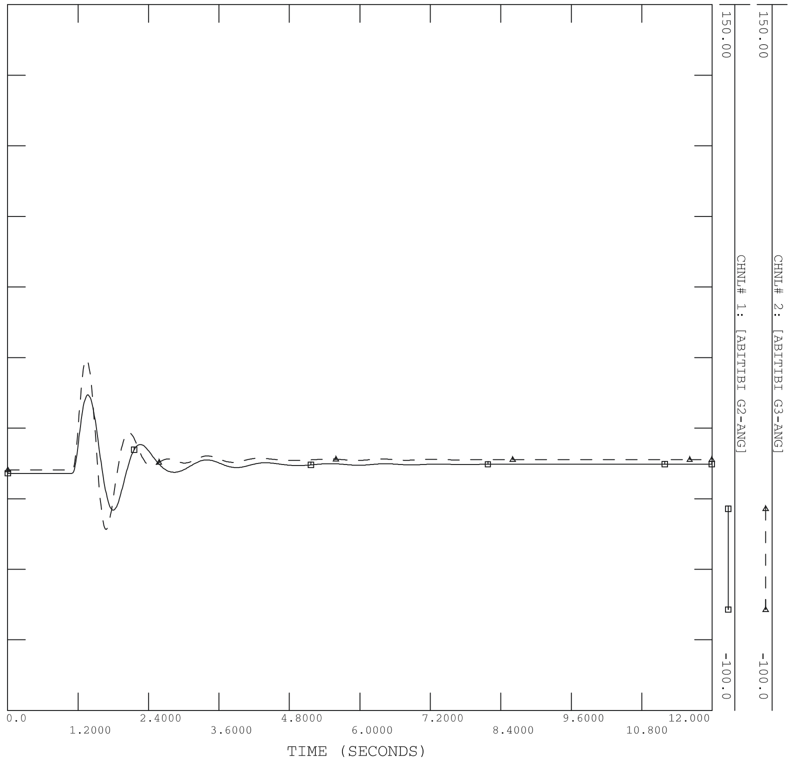
SC1 - LLG fault was applied on 115 kV circuit C2H at Abitibi. (cleared in 83 ms at Abitibi, 116 ms at Hunta)

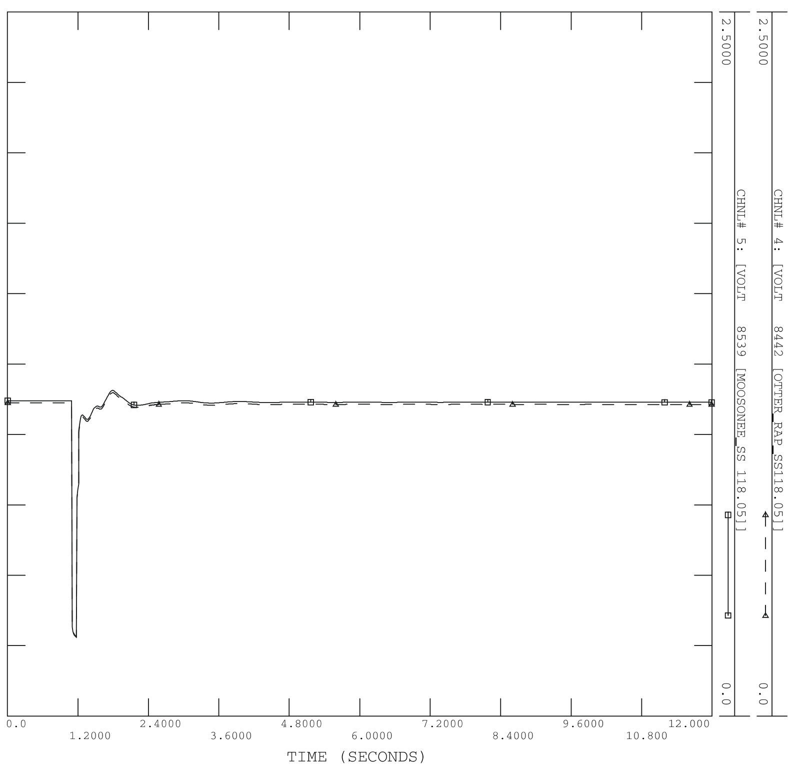
Newpost Creek I/S:



SC1 - LLG fault was applied on 115 kV circuit C2H at Abitibi. (cleared in 83 ms at Abitibi, 116 ms at Hunta)

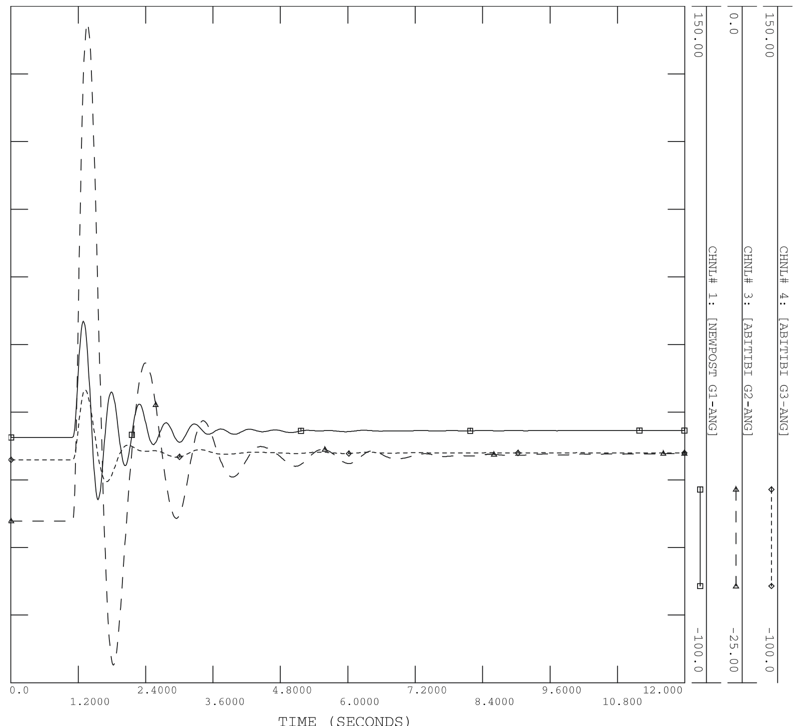
Newpost Creek O/S:

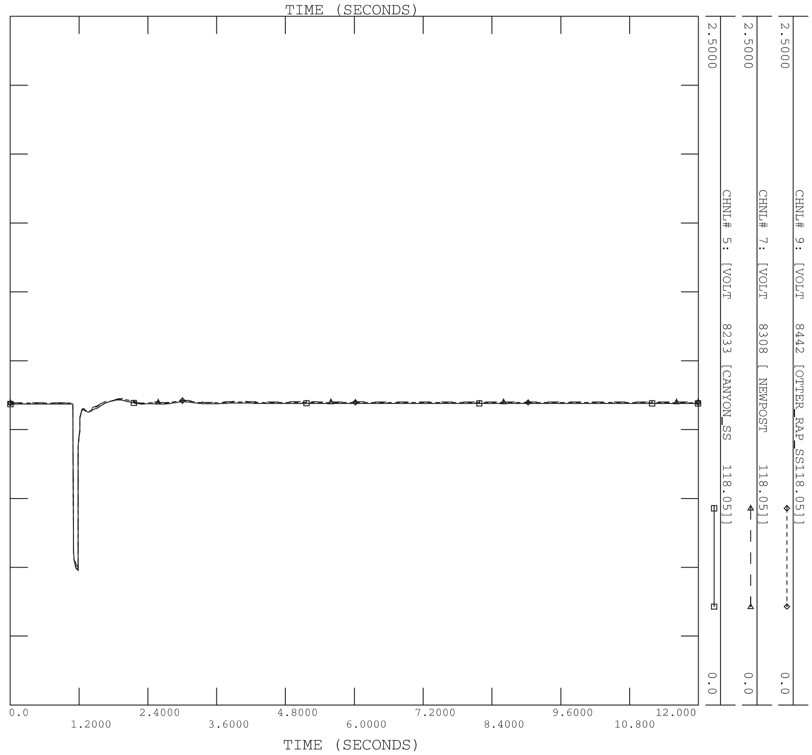




SC2 - Normally cleared LLG fault on H6T @ Hunta (cleared in 83 ms at Hunta, 116 ms at Timmins)

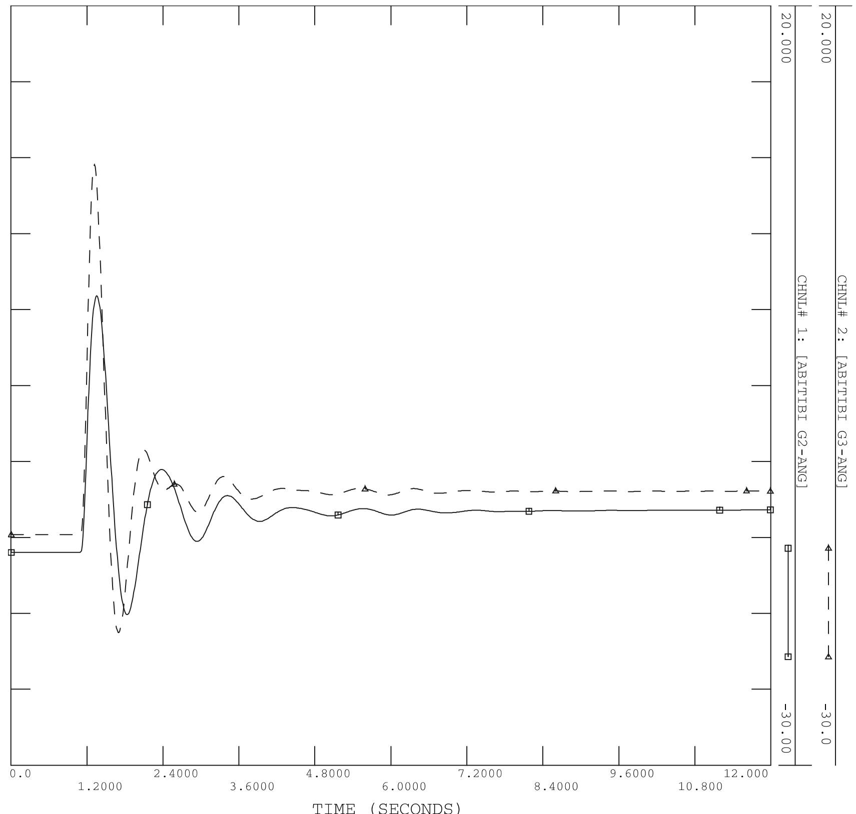
Newpost Creek I/S

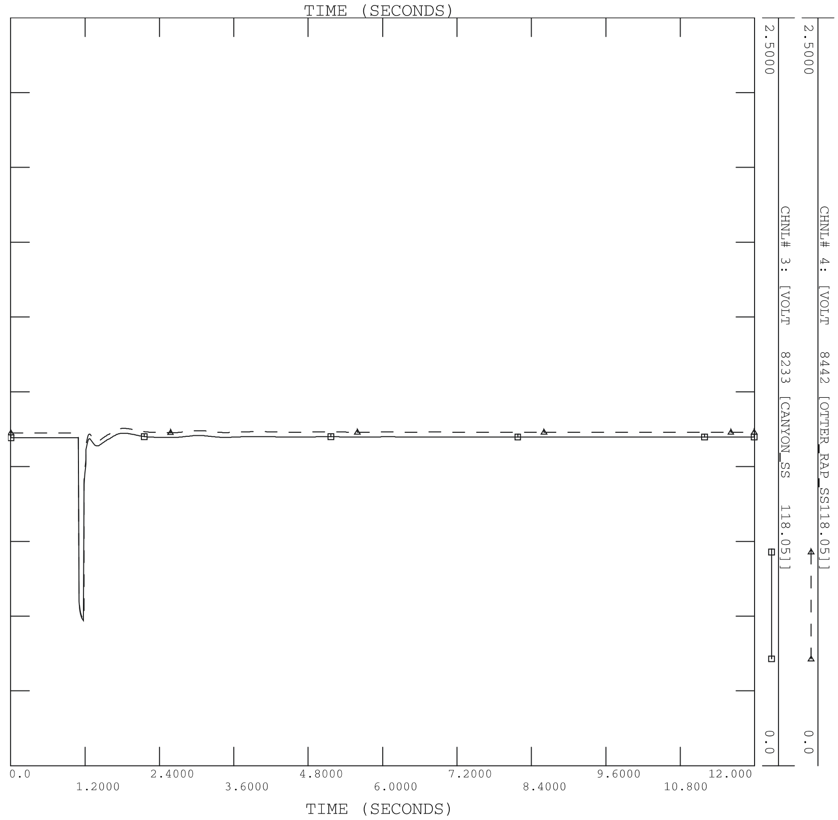




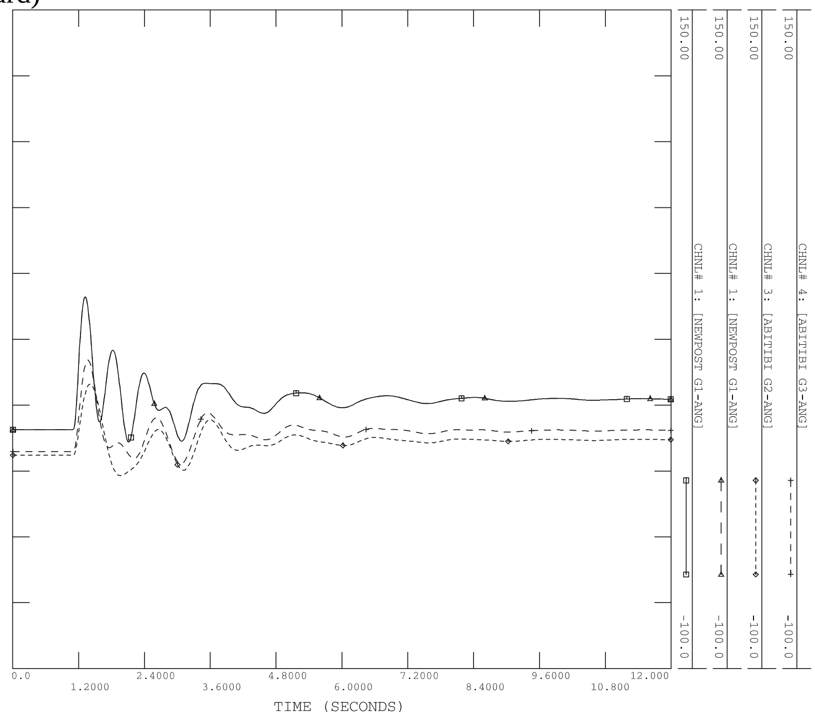
SC2 - Normally cleared LLG fault on H6T @ Hunta (cleared in 83 ms at Hunta, 116 ms at Timmins)

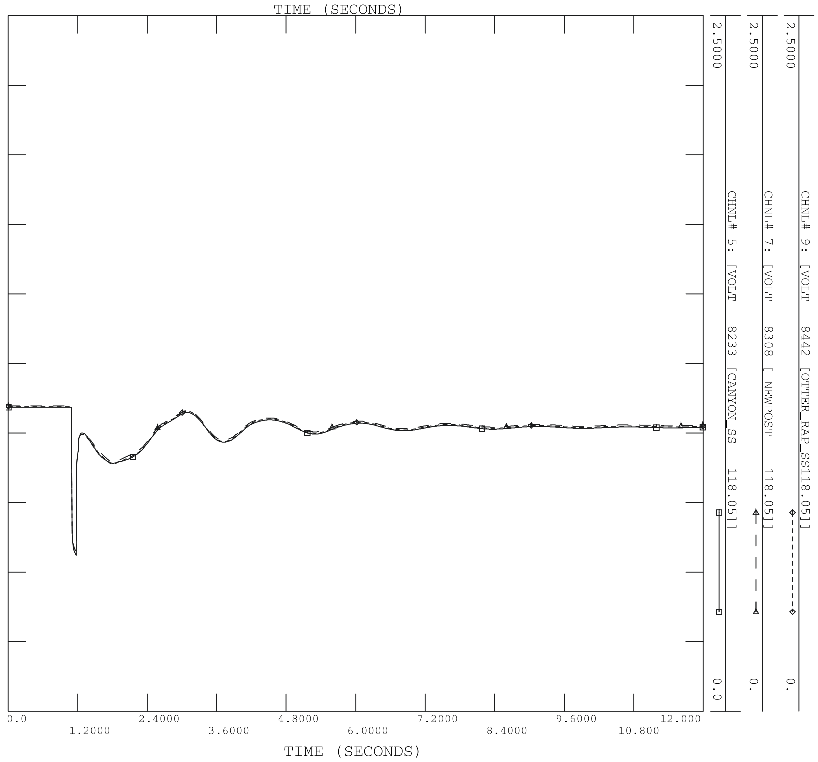
Newpost Creek O/S



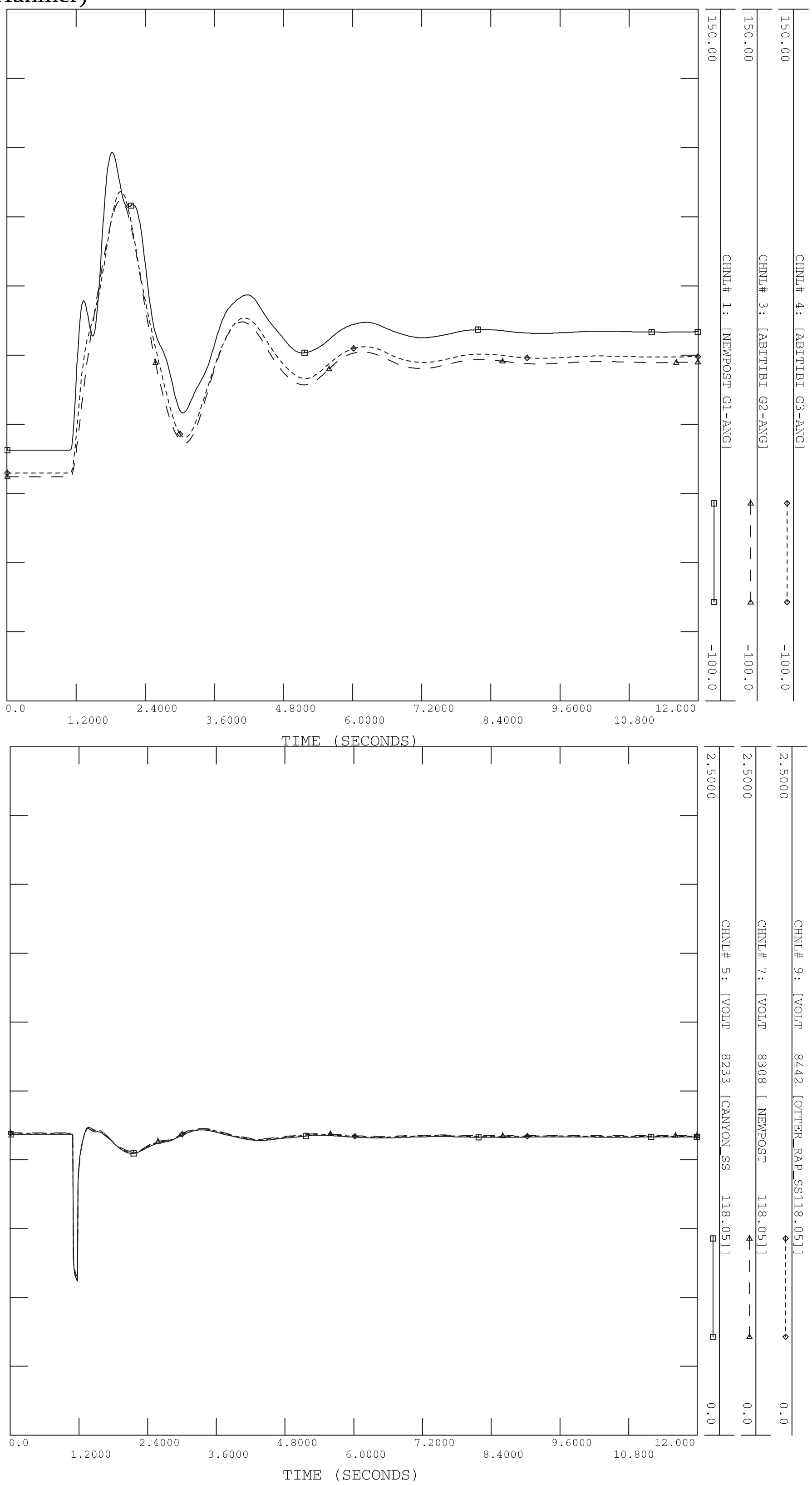


SC3 - Normally cleared three-phase fault onD501P @ Porcupine (cleared in 83 ms at Porcupine, 116 ms at Pinard)





SC4 - Normally cleared three-phase fault onP502X @ Porcupine (cleared in 83 ms at Porcupine, 116 ms at Hanmer)



SC5 - Normally cleared three-phase fault onX503E @ Hanmer (cleared in 83 ms at Hanmer, 116 ms at Essa)