April 24, 2009

Mr. Xiaodong Sun
Senior Engineer
Electrical, P&C and Compliance, Hydro Engineering
Ontario Power Generation

Dear Mr. Sun:

Mountain Chute G2 Excitation System Replacement
Notification of Approval of Connection Proposal
CAA ID Number: 2009-EX433

Thank you for the information you submitted regarding the replacement of the excitation system for G2 at Mountain Chute GS due to equipment failure.

From the information provided, our review concludes that the proposed project will not result in a material adverse effect on the reliability of the IESO-controlled grid. The IESO is therefore pleased to grant **conditional approval** for the proposed replacement subject to the implementation of the requirements detailed in the attached assessment report. OPG is required to install a new exciter which should meet Market Rules requirements for Mountain Chute G2 during the rewinding outage which is scheduled in June 2010. Any material changes to your proposal may require re-assessment by the IESO in accordance with Market Manual 2.10, and may nullify your conditional approval.

Final approval will be granted upon successful completion of the IESO Market Entry process. During this process you will be expected to demonstrate that you have fulfilled the requirements and that the facility you have installed is materially unchanged from the proposal assessed by the IESO. Please contact market.entry@ieso.ca if you have not received a Facility Registration Summary package within the next 10 days.

For further information, please contact the undersigned.

Yours truly,

Barbara Constantinescu
Manager - Market Facilitation
Telephone: (:905) 855-6209
Fax: (905) 855-6129
E-mail: Barbara.Constantinescu@ieso.ca
cc: IESO Record

Ontario Power Generation acknowledges receipt of the System Impact Assessment Report setting out the IESO requirements for final approval, and commits to fulfill these requirements, and all other applicable Market Rules, before receiving final approval to connect to the IESO-controlled grid.

Dated:_____

Per:_____

Name:_____

Title:_____

CONNECTION ASSESSMENT & APPROVAL PROCESS

ASSESSMENT SUMMARY

Applicant: Ontario Power Generation Inc.

Project: Excitation System Replacement for Mountain Chute G2

CAA ID: 2009-EX433

Final Report

Market Facilitation Department

April 24, 2009

MOUNTAIN CHUTE G2 – EXCITATION SYSTEM REPLACEMENT IESO EXPEDITED SYSTEM IMPACT ASSESSMENT – 2009-EX433

1. Project Description

Ontario Power Generation Inc. is planning to replace the existing excitation system for G2 (85 MW) at Mountain Chute GS due to equipment failure. The failed G2 exciter will be replaced with a spare exciter as a temporary solution. OPG indicated that Mountain Chute G2 is scheduled to be rewinded starting June 2010 and the a new exciter will be installed at G2 during the rewinding outage.

The temporary excitation system for Mountain Chute G2 is going to be in service on April 27, 2009.

This connection assessment study will examine the performance of the proposed temporary exciter and its impact on reliability of the IESO-controlled grid. The assessment study for the permanent exciter which will be installed in 18 months will be performed when all the model and parameters are available and provided by OPG.

2. Market Rule Requirements

The requirements for exciters on generation units rated at 10 MVA or higher are listed in Reference 12 of Appendix 4.2 in the Market Rules, as follows:

- A voltage response time no longer than 50 ms for a voltage reference step change not to exceed 5%;
- A positive ceiling voltage of at least 200% of the rated field voltage, and
- A negative ceiling voltage of at least 140% of the rated field voltage.

This performance requirement would not apply to a generation unit rated at 10 MVA or higher where the IESO determines through the connection assessment for that generation unit, that a lower requirement would not adversely impact the reliable operation of the IESO-controlled grid. In these circumstances, the synchronous generation unit shall be equipped with an excitation system with:

- An excitation system nominal response of at least 0.50 and
- A positive ceiling voltage at least 150% of rated field voltage

In addition, the requirements for power system stabilizers (PSS) are described in Reference 15 of Appendix 4.2 in the Market Rules:

- Each synchronous generating unit that is equipped with an excitation system that meets the performance requirements shall also be equipped with a power system stabilizer. The

power system stabilizer shall, to the extent practicable, be tuned to increase damping torque without reducing synchronizing torque.

3. Data Verification

The connection applicant has provided complete dynamic models for the proposed excitation system.

3.1 Excitation System Model

The proposed exciter is IEEE Type ST1A Potential Source Controlled Rectifier Exciter. The block diagram of excitation system provided by the connection applicant is shown in Figure 1. The parameters of the exciter are shown in Table 1.

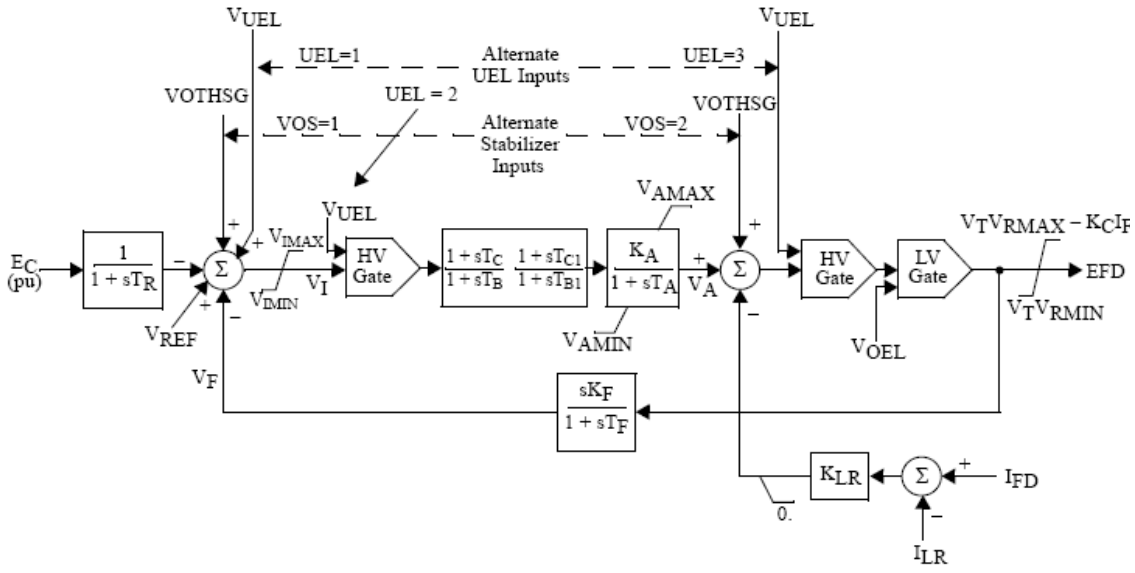

Figure 1: Block Diagram of Excitation System

Table 1: IEEE Type ST1A Model

Description	Parameter	Value
Terminal voltage transducer T.C.	Tr	0.02
AVR upper limit	V_{IMAX}	999
AVR lower limit	V_{IMIN}	-999
AVR lead time constant	T_C	0.0
AVR lag time constant	T_B	0.0
AVR lead time constant	T_{C1}	0.0
AVR lag time constant	T_{B1}	0.0
AVR gain	K_A	200
AVR time constant	T_A	0.0
Positive regulator output limit	V_{AMAX}	999
Negative regulator output limit	V_{AMIN}	-999
Positive exciter output limit (ceiling)	V_{RMAX}	3.57
Negative exciter output limit (ceiling)	V_{RMIN}	-3.45
Rectifier regulation	K_C	0.14
Exciter feedback gain	K_f	0.0
Exciter feedback time constant	T_f	1.0
Field current limiter gain	K_{LR}	34
Field current limiter setting	I_{LR}	2.91

The performance of the proposed exciter has not been verified through testing. After the installation of the proposed exciter, the proponent is required to perform commissioning tests to validate the control model and data. The test results must be supplied to the IESO within three months of the in-service date. If the actual data differs materially from the data that was used in the assessment, then the analysis will need to be repeated.

3.2 PSS Model

Ontario Power Generation Inc. has confirmed that the proposed exciter is to be equipped with a power system stabilizer. The PSS will be IEEE type dual-input signal stabilizer model, commonly referred to as integral of accelerating power type PSS2A. The block diagram of the PSS provided by the connection applicant is shown in Figure 2 and the parameters of the PSS are shown in Table 2.

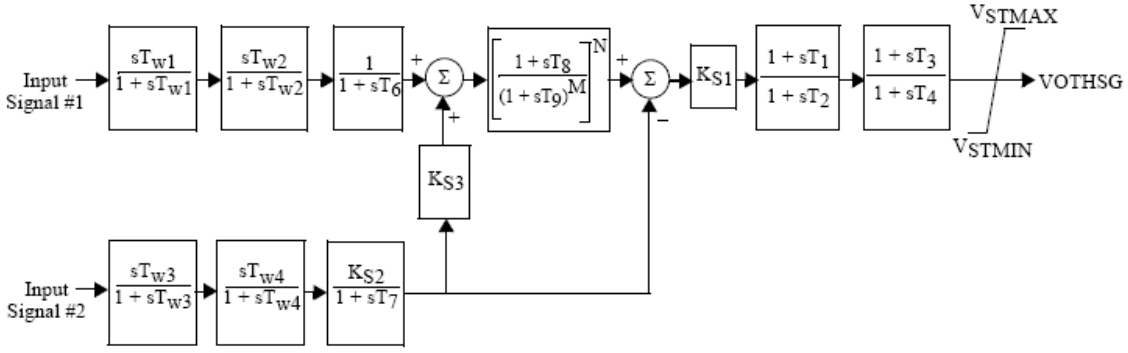

Figure 2: Block Diagram of PSS

Table 2: PSS/E PSS2A Parameters

Description	Value	Description	Value
ICS1	1	T_8	0.5
ICS2	3	T_9	0.1
M	5	K_{S1}	15
N	1	T_1	0.09
T_{W1}	10	T_2	0.04
T_{W2}	10	T_3	0.09
T_6	0	T_4	0.04
T_{W3}	10	V_{STMAX}	0.2
T_{W4}	0	V_{STMIN}	-0.006
T_7	10		
K_{S2}	1.806		
K_{S3}	1.0		

It should be noted that the data in Table 2 are preliminary and the PSS model and data are to be finalized by the connection applicants upon the completion of commissioning test and provided to the IESO in view of completing the Market Entry Process.

4. Assessments

4.1 Exciter Performance Study Results

Dynamic simulations were performed to test the transient response of the proposed excitation system and verify if the proposed exciter complies with the Market Rules requirements.

4.1.1 Response Ratio Test Results

The excitation system response ratio test was performed to determine the rated field voltage, Efd_{rated}, the required positive and negative ceiling targets and nominal response ratio.

- Required Positive Ceiling = $2 \times Efd_{rated}$ (Higher requirements) or $1.5 \times Efd_{rated}$ (Lower requirements)
- Required Negative Ceiling = $-1.4 \times Efd_{rated}$

The results of response ratio test shown in Figure 3 indicate that the exciter rated field voltage is 1.78 pu and the response ratio is 3.60.

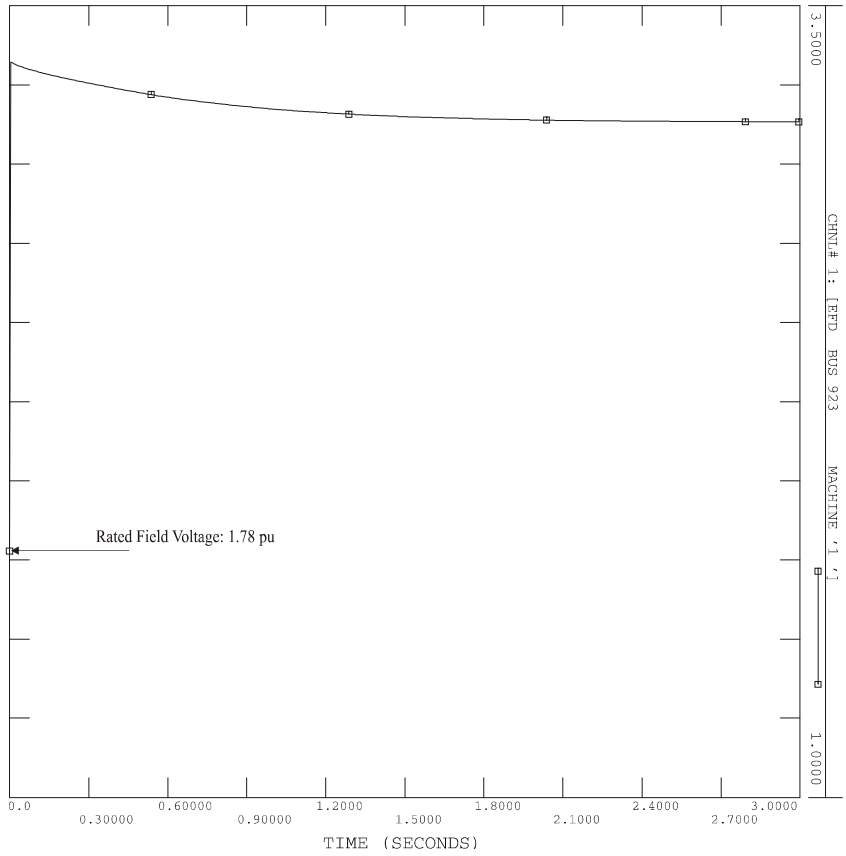

Figure 3: Response Ratio Test Results

Therefore, positive ceiling must be at least 2 × 1.78 = 3.56 pu for higher requirements or 1.5 × 1.78 = 2.67 pu for lower requirements, and negative ceiling must be at least -1.4 × 1.78 = -2.49 pu.

4.1.2 Open Circuit Test for +5% Step Change in Reference Voltage

Open circuit test for +5% step change in reference voltage was performed to verify if the exciter has the capability of reaching 2 Efd_{rated} starting from Efd =Efd_{rated} within 50 ms or meet the lower requirements.

The results of the exciter system voltage response test to a 5% step change in reference voltage are displayed in Figure 4.

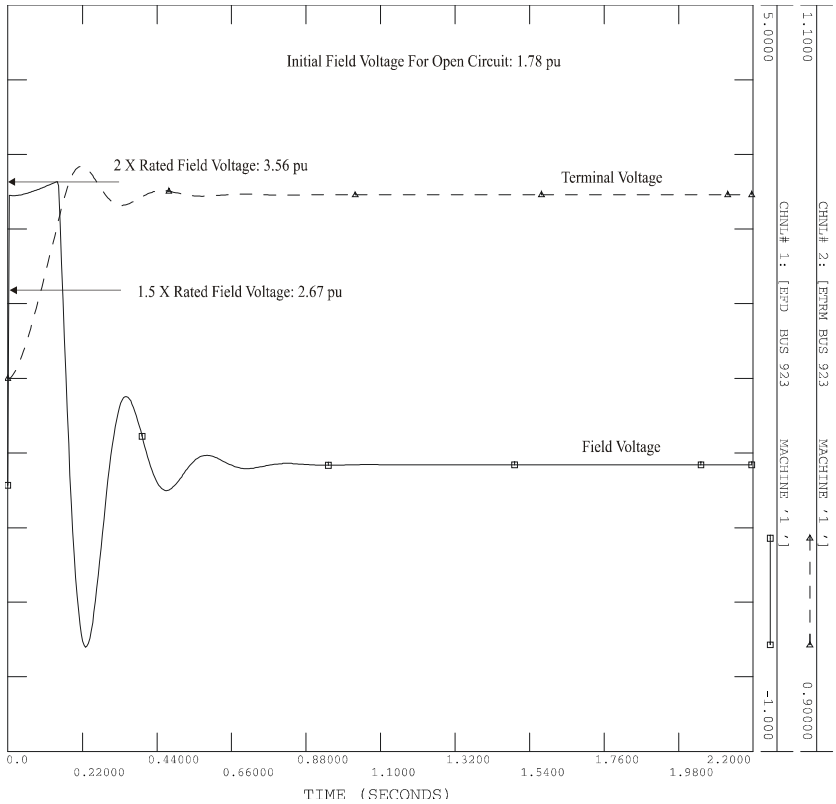

Figure 4: Open Circuit Test Results

It can be seen that the positive ceiling voltage is 3.15 and meets the above-mentioned lower requirements.

4.1.3 Open Circuit Test Results for -5% Step Change in Reference Voltage

Open circuit test for -5% step change in reference voltage was performed to verify if the exciter has the capability of reaching $-1.4Efd_{rated}$ starting from $Efd = Efd_{rated}$ within 50 ms.

The results of the exciter system voltage response test to a -5% step change in reference voltage are displayed in Figure 5.

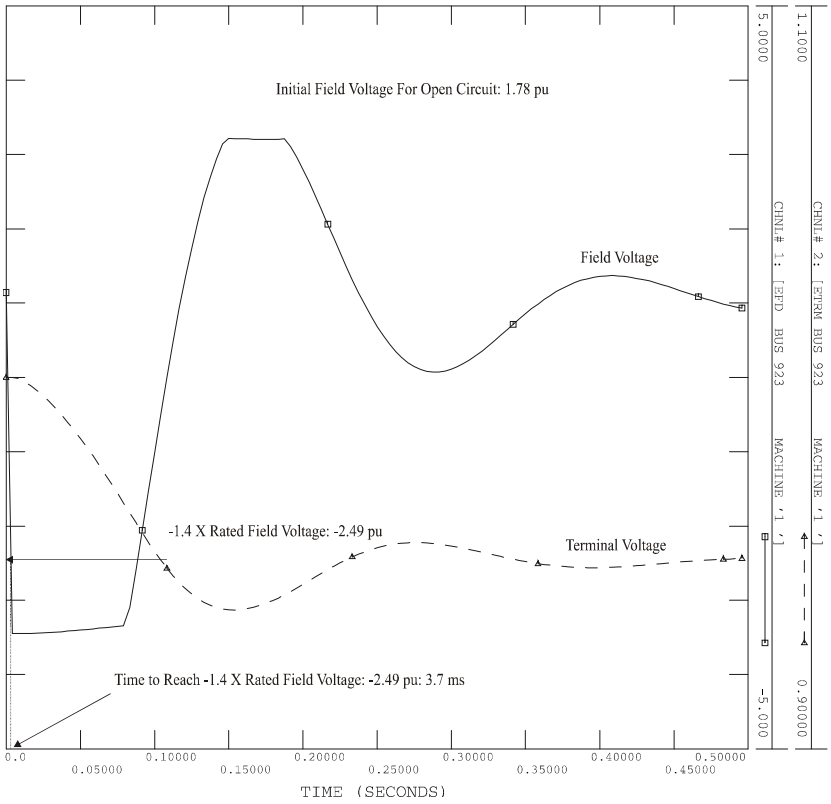

Figure 5: Open Circuit Test Results

The following equation translates the above requirement to open circuit conditions starting from Efd = Efd_{OC} at t = 0.

$$RT_{OC\_NEG} = 50 * \frac{1.4\ Efd_{rated} + Efd_{oc}}{1.4\ Efd_{rated} + Efd_{rated}} = 42\ (\text{milliseconds})$$

The time to reach -1.4 Efd_{rated} under open circuit conditions will need to be within 42 ms.

Results in Figure 5 show that the field voltage has a negative ceiling voltage of -3.5 pu which is below the required -1.4 Efd_{rated}, -2.49 pu. Examination of the plots indicates that the exciter field voltage reaches -1.4 Efd_{rated} in 3.7 ms for the proposed excitation system.

Therefore, it can be concluded that the negative ceiling voltage for the proposed exciter satisfies Market Rules requirements.

4.1.4 Summary of Exciter Response Test Results

Table 3 summarizes the key elements of the test results based on Efd_{rated} = 1.78 pu from response ratio test results.

Table 3: Open Circuit Test Results

Test Types	Positive Ceiling Tests		Negative Ceiling Tests	
Parameters	1.5×Efd_{rated}	Response Ratio	-1.4×Efd_{rated}	Response Time
Required Values	2.67	0.5	-2.49 pu	42 ms
Test Results	3.15	3.6	-3.5 pu	3.7 ms

The results show that the proposed new exciter responses based on the data provided will not meet Market Rules higher requirements but meet the lower requirements.

4.3 Dynamic Study Results

Since the proposed exciter responses only meets the lower Market Rules requirements, transient stability analyses were carried out to investigate the impact of the replacement of the exciter at Mountain Chute G2 on the reliability of the IESO-Controlled grid.

The 2010 summer base case was used as a starting point for the analysis. The outputs of generators at Mountain Chute GS and Chenaux GS were adjusted to achieve maximum MW. The study was performed for a system with all transmission elements in service.

4.3.1. Comparison the effects of high-ceiling exciter and low ceiling exciter

To compare the effects of high ceiling exciter and low ceiling exciter, transient studies were performed for a 3-phase fault on T3 at Chenaux TS with normal clearing time. The G2 VAR output, G2 terminal voltage and 230 kV voltage at Chenaux TS were investigated and the results are shown in figures 6,7 and 8, respectively.

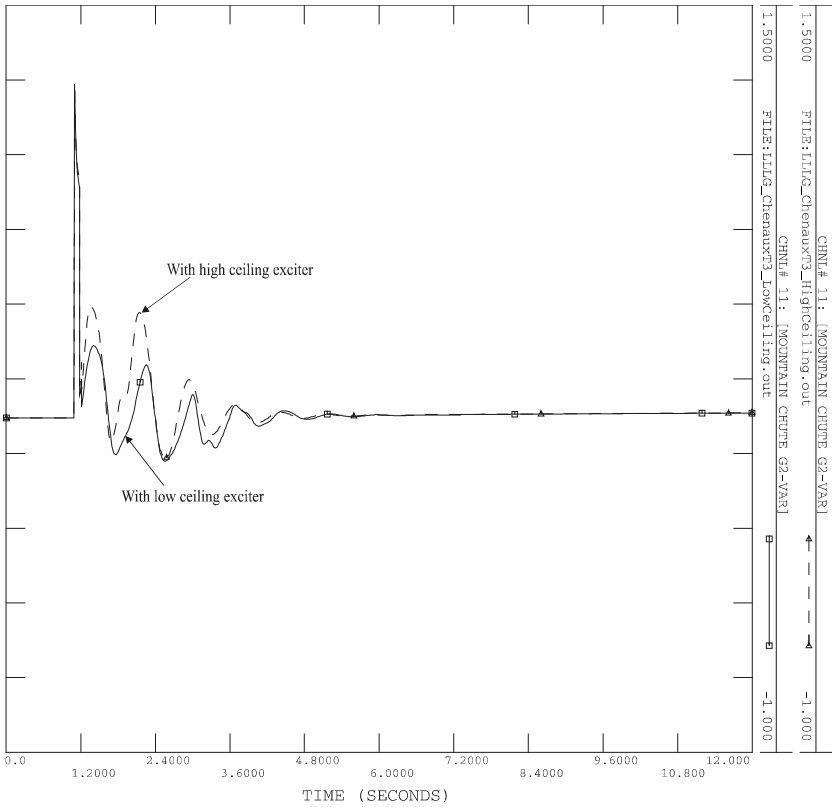

Figure 6: Simulation Results of VAR Output for G2

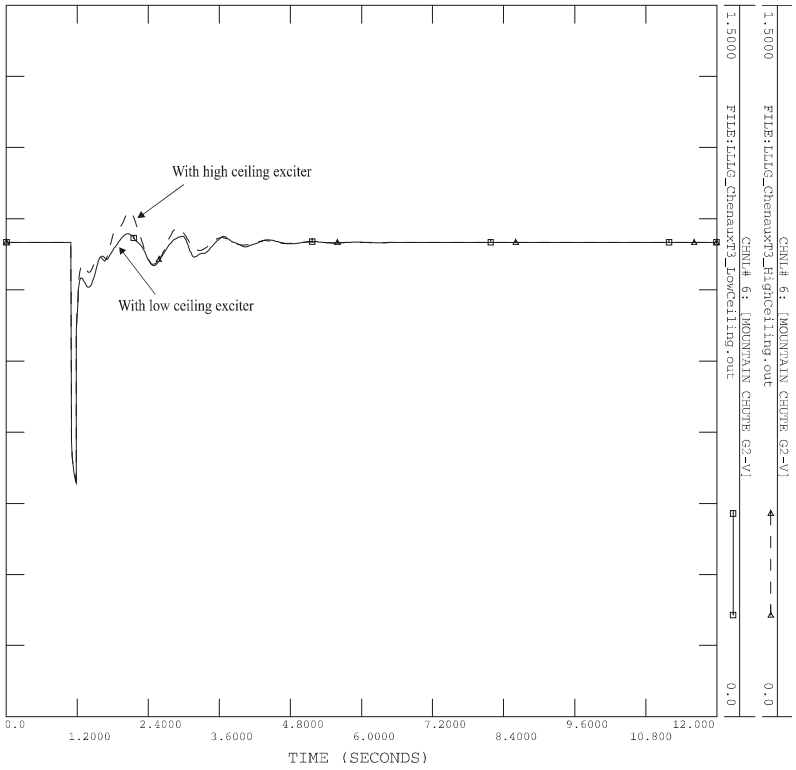

Figure 7: Simulation Results of Terminal Voltage for G2

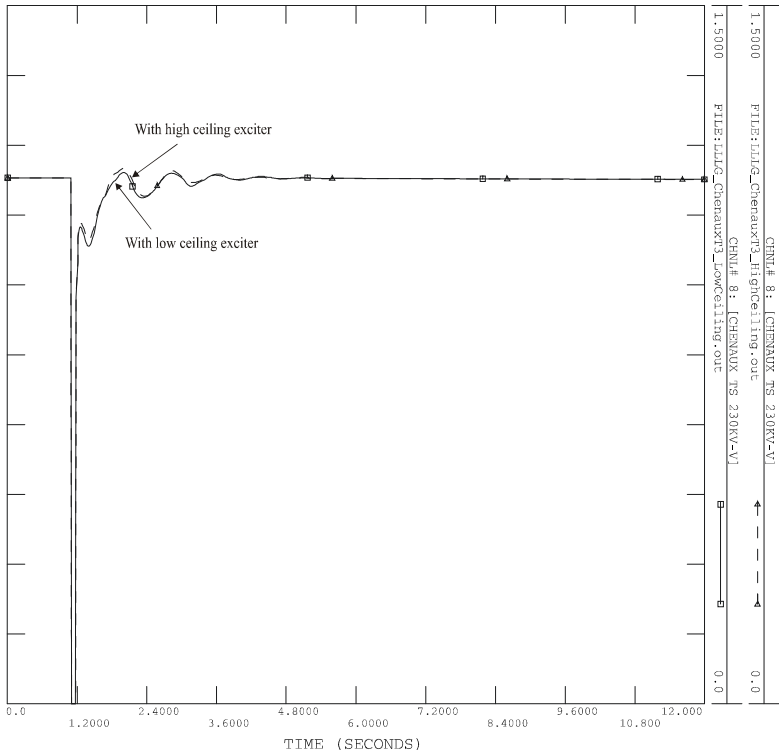

Figure 8: Simulation Results of 230 kV Voltage at Chenaux TS

The results show that with a high ceiling exciter G2 at Mountain chute will produce more reactive power during transient and the terminal voltage is a little higher. For the 230 kV voltage at Chenaux TS, the effect of voltage drop resulting from the low ceiling exciter is very slight. Therefore, it can be concluded that the impact of low ceiling exciter is not significant comparing with a high ceiling exciter but it is better to have a high ceiling exciter to contribute more to system stability.

4.3.1. Transient Study with Low Ceiling Exciter

Transient studies were performed to verify if the proposed exciter which only meets lower requirement would adversely impact the reliable operation of the IESO-controlled grid.

Contingencies involved T3 at Chenaux TS, C27P and P15C were tested. 3-phase fault was applied with normal clearing time. The excitation voltage, rotor angles, transient voltages and power flows for generators at Mountain Chute GS and Chenaux GS were investigated. Some examples of plots are shown in Figures 9, 10 and 11.

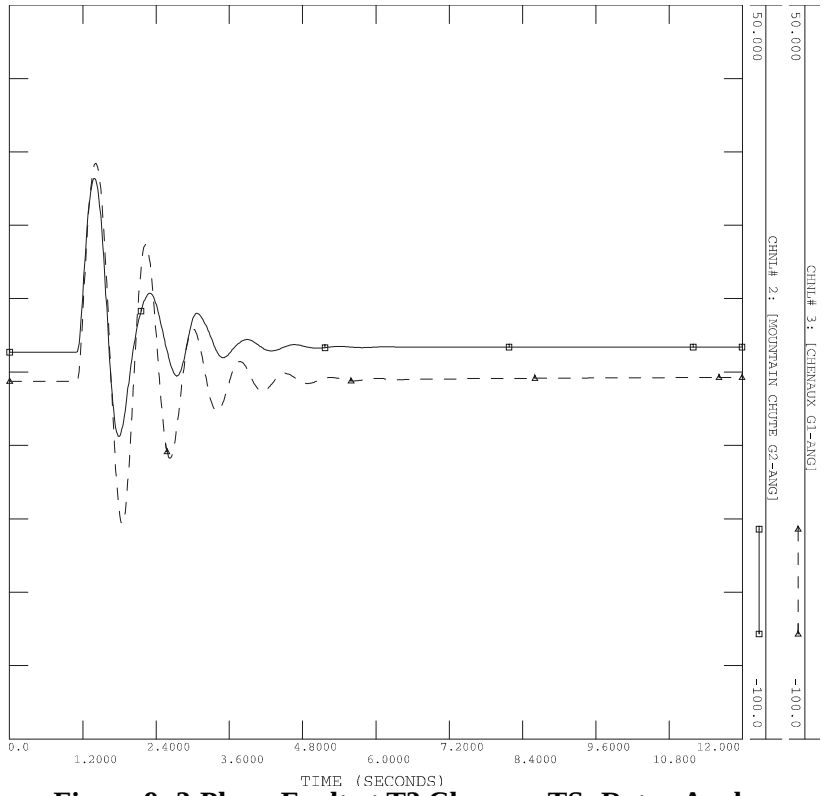

Figure 9: 3-Phase Fault at T3 Chenaux TS: Rotor Angles

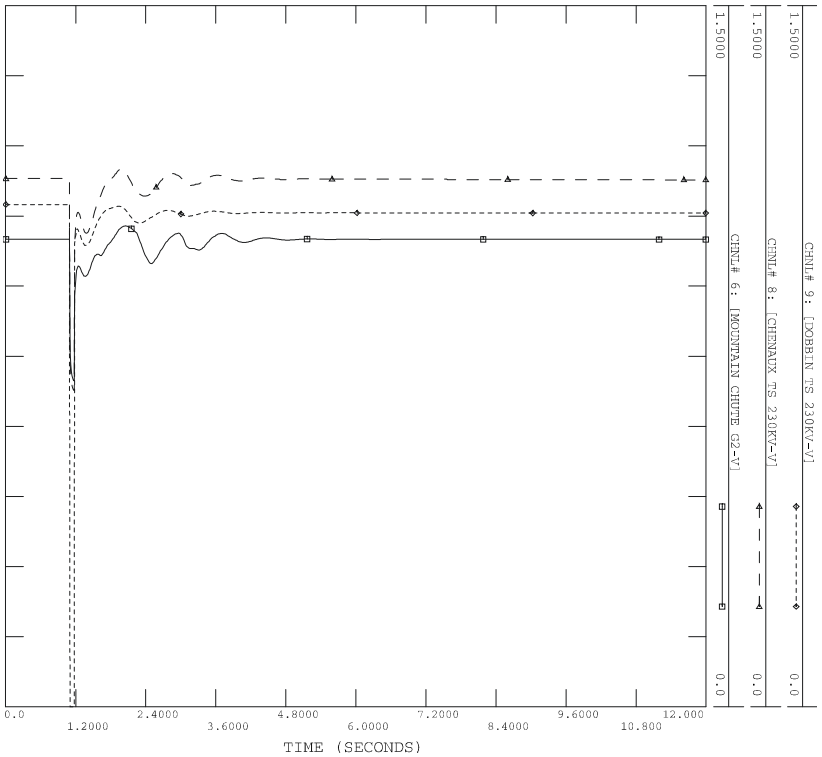

Figure 10: 3-Phase Fault at Dobbin (C27P): Voltages

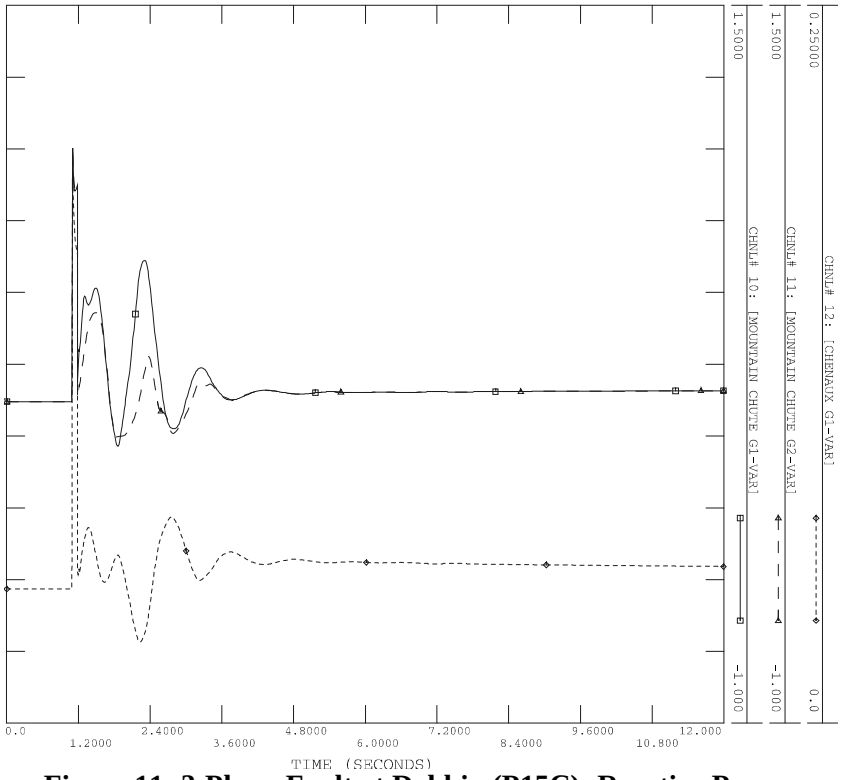

Figure 11: 3-Phase Fault at Dobbin (P15C): Reactive Power

It can be seen that the system displays stable performance and the oscillations are well damped. Therefore, based on the transient stability study results it can be concluded that the proposed replacement of the exciter at Mountain Chute G2 would not adversely impact the reliable operation of the IESO-controlled grid.

5. Conclusions and Requirements

This assessment examined the performance of the proposed exciter on G2 at Mountain Chute GS and its effect on the reliability of the IESO-controlled grid. The studies concluded that the proposed exciter meets Market Rules lower requirements and the replacement of the excitation system will not have a material adverse impact on the reliability of the IESO-controlled grid.

The applicant is required to ensure that the performance of the equipment that is supplied and installed on G2 at Mountain Chute GS is similar to the predicted performance or exceeds the predicted performance observed in the simulation results obtained using the above models.

As soon as the commissioning tests are completed and actual data is available, the connection applicant is required to provide updated block diagram models of the excitation system. Using these data the IESO will perform studies to verify the behaviour of the excitation system and establish the need for any new controls and adjustments, as part of the Market Entry Process.

OPG is required to install a new exciter which should meet Market Rules requirements for Mountain Chute G2 during the rewinding outage.

6. Notification of Approval

It is therefore recommended that a Notification of Conditional Approval of the Connection Proposal be issued to the applicant.