June 2, 2010

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

Dear Mr. Sun:

Mountain Chute G2 Rewind and Excitation System Replacement
Notification of Approval of Connection Proposal
CAA ID Number: 2010-EX466

Thank you for the information you submitted regarding the rewind and replacement of the excitation system for G2 at Mountain Chute GS.

From the information provided, our review concludes that the proposed project will not result in a material adverse impact on the reliability of the IESO-controlled grid. The IESO is therefore pleased to grant **conditional approval** for the proposed installations subject to the implementation of the requirements detailed in the attached assessment report. 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 as soon as possible prior to your energization date.

For further information, please contact the undersigned.

Yours truly,

Barbara Constantinescu
Manager - Market Facilitation
Telephone: (:905) 855-6209
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cc: IESO Record

CONNECTION ASSESSMENT
& APPROVAL PROCESS

ASSESSMENT SUMMARY

Applicant: Ontario Power Generation Inc.

Project: Generator Rewind and Excitation System Replacement for Mountain Chute G2

CAA ID: 2010-EX466

Final Report

Market Facilitation Department

June 2, 2010

GENERATOR REWIND AND EXCITATION SYSTEM REPLACEMENT FOR MOUNTAIN CHUTE G2
IESO EXPEDITED SYSTEM IMPACT ASSESSMENT – 2010-EX466

1. Project Description

Ontario Power Generation Inc. (OPG) is planning to replace the existing excitation system for G2 (75 MVA) at Mountain Chute GS, due to equipment failure. The failed G2 exciter was replaced with a spare exciter as a temporary solution in April 2009 (CAA ID 2009-EX433) and the new exciter will be installed at G2 during the rewinding outage starting August 2010. OPG indicated that the generator parameters will not be changed with the rewind.

Since OPG have stated that the machine ratings and electrical characteristics will not change, we have concluded that this rewind will not result in a material adverse impact on the reliability of the integrated power system.

This connection assessment study will examine the performance of the proposed exciter and its impact on the reliability of the IESO-controlled grid.

2. Market Rule Requirements

The requirements for exciters on generation facilities directly connected to the IESO-controlled grid are listed in Appendix 4.2 in the Market Rules, as follows:

Provide (a) Positive and negative ceilings not less than 200% and 140% of rated field voltage at rated terminal voltage and rated field current; (b) A positive ceiling not less than 170% of rated field voltage at rated terminal voltage and 160% of rated field current; (c) A voltage response time to either ceiling not more than 50 ms for a 5% step change from rated voltage under open-circuit conditions; and (d) A linear response between ceilings.

The requirements for Power System Stabilizers (PSS) on generation facilities directly connected to the IESO-controlled grid are listed in Appendix 4.2 in the Market Rules, as follows:

Provide (a) A change of power and speed input configuration; (b) Positive and negative output limits not less than ±5% of rated AVR voltage; (c) Phase compensation adjustable to limit angle error to within 30° between 0.2 and 2.0Hz under conditions specified by the IESO, and (d) Gain adjustable up to an amount that either increases damping ratio above 0.1 or elicits exciter modes of oscillation at maximum active output unless otherwise specified by the *IESO*. Due consideration will be given to inherent limitations.

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.

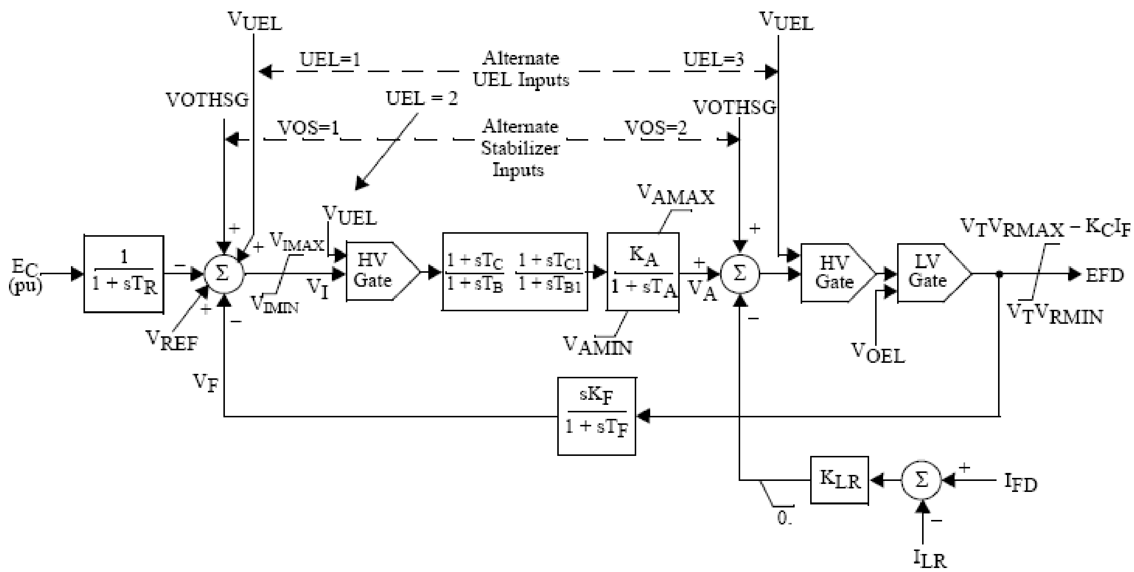

Figure 1: Block Diagram of Excitation System

Table 1: IEEE Type ST1A Model

Description	Parameter	Value
Terminal voltage transducer T.C.	Tr	0.01
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}	4.00
Negative exciter output limit (ceiling)	V_{RMIN}	-2.8
Rectifier regulation	K_C	0.088
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. 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.

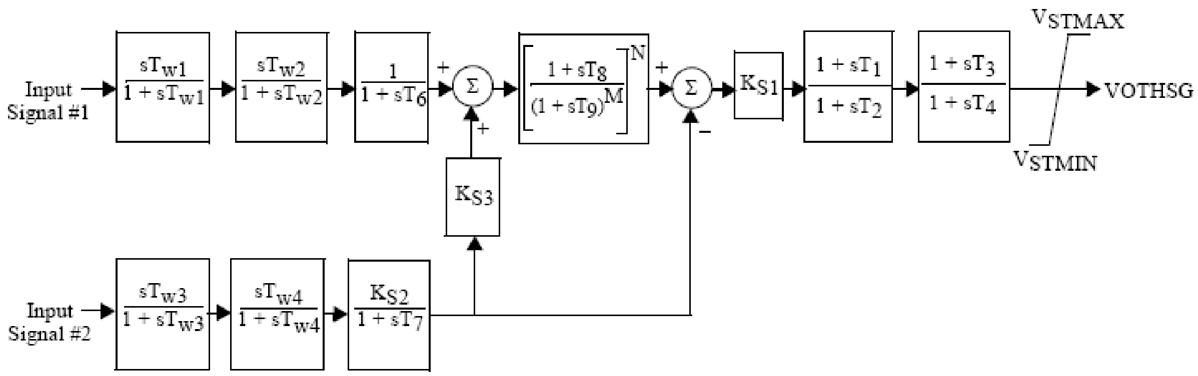

Figure 2: Block Diagram of PSS

Table 2: PSS/E PSS2A Parameters

Description	CONS	Parameter	Value	Units
First stabilizer input code	IC	ICS1	1	
First remote bus number	IC+1	REMBUS1	0	remote sensing bus (not used)
Second stabilizer input code	IC+2	ICS2	3	
Second remote bus number	IC+3	REMBUS2	0	remote sensing bus (not used)
Ramp tracking filter order	IC+4	M	5	
Ramp tracking filter order	IC+5	N	1	
Washout time constant	J	Tw1 (>0)	10	Sec
Washout time constant	J+1	Tw2	10	Sec
Filter time constant	J+2	T6	0	Sec
Washout time constant	J+3	Tw3 (>0)	10	Sec
Filter time constant [block bypassed]	J+4	Tw4	0	Sec
Washout time constant	J+5	T7	10	Sec
Gain	J+6	KS2 (= T7/2H)	1.805	
Gain	J+7	KS3	1	
Ramp-tracking filter time constant	J+8	T8	0.5	Sec
Ramp-tracking filter time constant	J+9	T9 (>0)	0.1	Sec
Stabilizer gain	J+10	KS1	15	
Phase lead time constant	J+11	T1	0.09	Sec
Phase lag time constant	J+12	T2	0.04	Sec
Phase lead time constant	J+13	T3	0.09	Sec

Phase lag time constant	J+14	T4	0.04	Sec
Output limits	J+15	VSTMAX	0.2	pu Etref
Output limits	J+16	VSTMIN	-0.06	pu Etref
Generator Apparent Power		MBASE	75	MVA
Turbine Generator Inertia		H	2.77	MW-s/MVA

It should be noted that the data in tables 1 and 2 is preliminary and the model and data for the exciter and PSS are to be finalized by the connection applicant upon the completion of commissioning tests 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 exciter requirements (a), (b) and (c) as listed in Appendix 4.2 in Market Rules.

The new excitation system was added in the PTI study case and the rated field voltage, Efd_{rated}, the rated field current, Ifd_{rated}, were determined during initialization process. Rated field current is defined at rated voltage, rated active power and required maximum continuous reactive power. The results are shown in Table 3.

Table 3: Rated Field Voltage and Current

Description	Value	Units
Rated Voltage	1.0	pu
Rated Active Power	67.5	MW
Maximum Reactive Power	33	Mvar
Rated Field Voltage	1.9	pu
Rated Field Current	1.9	pu

4.1.1 Excitation System Requirement (a)

Requirement (a): Provide positive and negative ceilings not less than 200% and 140% of rated field voltage at rated terminal voltage and rated field current.

The excitation system response ratio test was performed to investigate if the positive and negative ceiling targets meet MR requirements as listed in the excitation system requirement (a) of Appendix 4.2.

- Required Positive Ceiling = 2 × Efd_{rated}=3.8
- Required Negative Ceiling = -1.4 × Efd_{rated} =-2.7

The results of response ratio test for positive ceiling and negative ceiling are shown in Figure 3 and Figure 4, respectively.

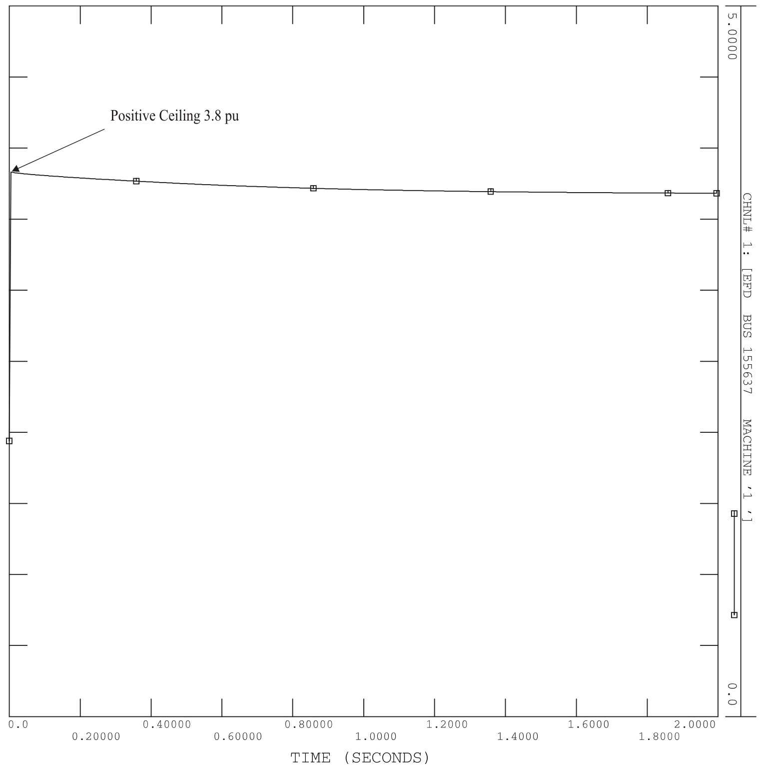

Figure 3: Response Ratio Test Results (Positive Ceiling)

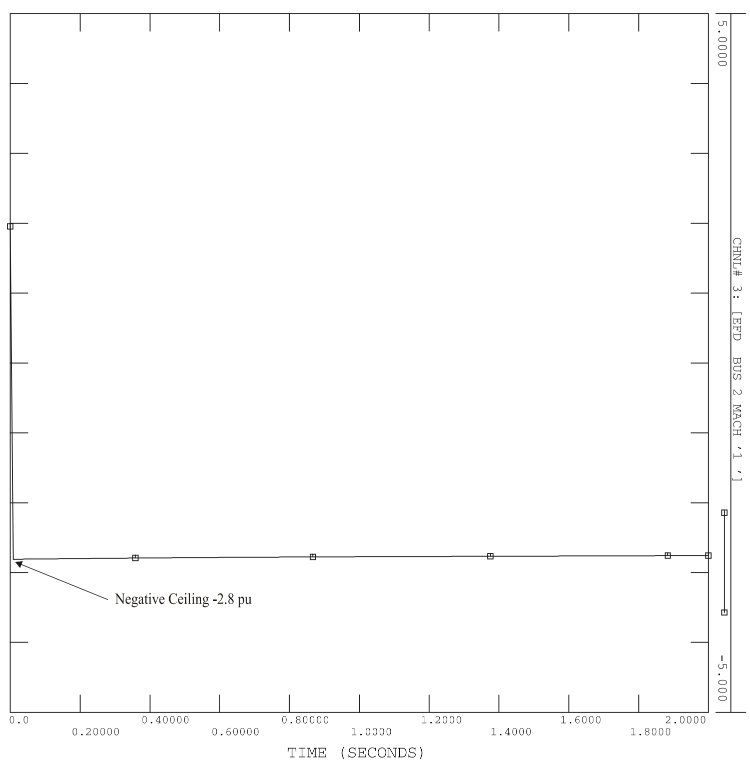

Figure 4: Response Ratio Test Results (Negative Ceiling)

The plot in Figure 3 indicates that G2 has a positive ceiling of 3.8 pu and Figure 4 shows a negative ceiling of -2.8 pu. Compared to the required positive and negative ceilings, it can be concluded that the proposed excitation system meets the Market Rules requirements.

4.1.2 Excitation System Requirement (b)

Requirement (b): 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 1) shows the limit for the Efd is VtVrmax-KcIfd. As shown in Table 1, Vrmax is 4 and Kc is 0.088. Therefore, at rated terminal voltage and 160% of rated field current, field voltage, Efd, is 3.7, which is 190% of rated field voltage meeting Market Rules requirements.

4.1.3 Excitation System Requirement (c)

Requirement (c): 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 either ceiling within 50 ms.

4.1.3.1 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 1.95 * Efd_{rated} starting from Efd = Efd_{rated} within 50 ms.

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

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

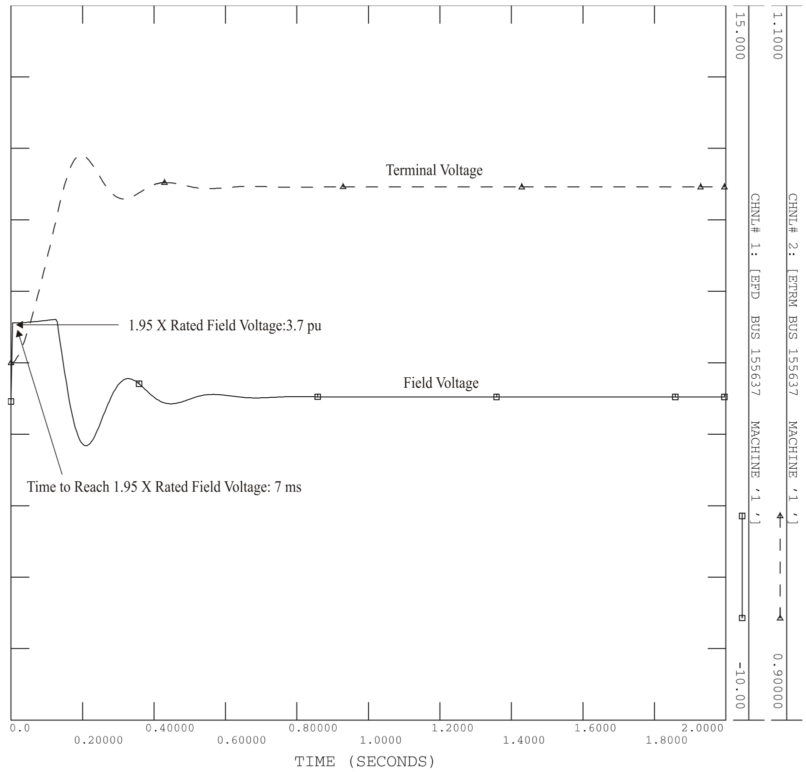

Figure 5: Open Circuit Test Results to a 5% step change in reference voltage

Figure 5 shows that Efd_{OC} = 1.15 pu at t = 0. Therefore the required time to reach 1.95 * Efd_{rated} = 3.7 pu is:

Examination of Figure 5 shows that the exciter field voltage reaches 3.7 pu in 7 ms, meeting IESO requirements.

4.1.3.2 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 -1.28*Efd_{rated} starting from Efd =Efd_{rated} within 50 ms.

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

The results of the exciter system voltage response test to a -5% step change in reference voltage are displayed in Figure 6.

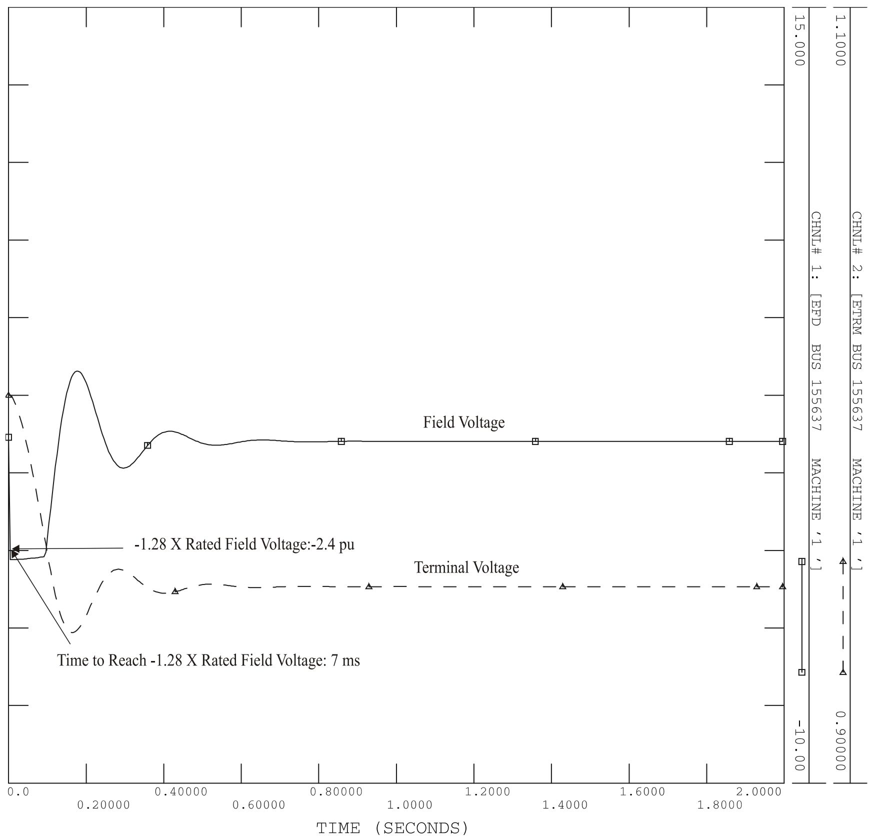

Figure 6: Open Circuit Test Results for -5% Step Change in Reference Voltage

Figure 6 shows that Efd_{OC} = 1.15 pu at t = 0. Therefore the required time to reach -1.28* Efd_{rated} = -2.4 pu is:

Examination of Figure 6 shows that, the exciter field voltage reaches approximately -2.4 pu in 7 ms, meeting IESO requirements.

4.2 Dynamic Study Results

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.

The transient stability analysis was performed for a LLG fault on the 230 kV circuit P15C at Dobbin TS with normal clearing time. Upon clearing of this fault 230 kV P15C line would be tripped and generators at Mountain Chute and Chenaux would remain connected to the system.

The excitation voltages, rotor angles, transient voltages and power flows for generators at Mountain Chute GS and Chenaux GS were investigated. An example of plots of rotor angles for Mountain Chute G1, G2 and Chenaux G1 is shown in Figure 7.

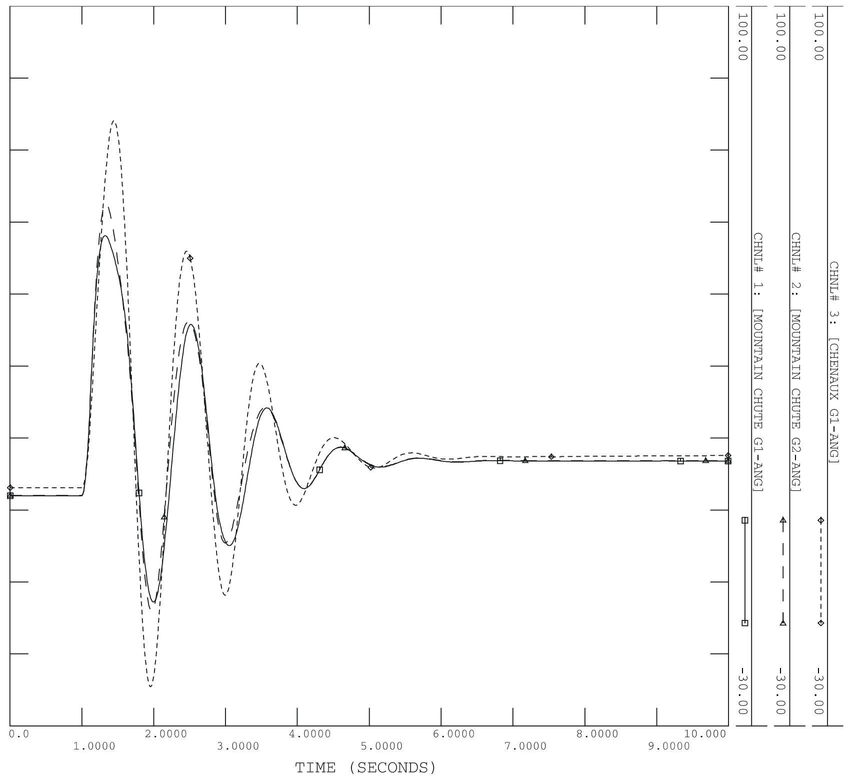

Figure 7: Simulation Results of Rotor Angles

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 requirements and the replacement of the excitation system will not have a material adverse impact on the reliability of the IESO-controlled grid.

OPG must ensure the performance of the rewound generator is no different than the original generator. 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.

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. Using the updated models and parameters in the report 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.

6. Notification of Approval

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