ADDENDUM

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System Impact Assessment Report - Addendum

Connection Assessment & Approval Process

Issue 1.0

CAA ID 2006-252

Applicant: Ontario Power Generation Inc.
Project: Beck 1 G7 Conversion
Proposed in service date: December 31, 2008

Transmission Assessments & Performance Department

December 09, 2008

Final Report - Addendum

Document ID	IESO_REP_0398
Document Name	System Impact Assessment Report - Addendum
Issue	Issue 1.0
Reason for Issue	OPG plans to convert SAB GS #1, unit G7 generator from 25 Hz to 60 Hz.
Effective Date	December 09, 2008

Document Change History

Issue	Reason for Issue	Date
1.0	New generator dynamic data – excitation system change	November 25, 2008
2.0		
3.0		
4.0		
5.0		

Related Documents

Document ID	Document Title
IESO_FORM_1536	*SIAA-Generation-Beck 1 G7 Conversion*

System Impact Assessment Report - Addendum

Beck 1 G7 Conversion

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

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

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

HYDRO ONE

Special Notes and Limitations of Study Results

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

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

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

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

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

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

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Table of Changes

Reference (Section and Paragraph)	Description of Change

1. Conclusions

1.1 Conclusions

The performed tests confirm that all conclusions of the Final SIA report are still valid upon changing the exciter type and some of the dynamic data for the proposed generator. The upgrade, conversion to 60 Hz and re-connection of Beck#1 G7 will not result in a material adverse effect on the reliability of the IESO-controlled grid. The steady state parameters of the proposed generator do not change and as a result the steady state study results presented in the final SIA report remain unchanged. The new dynamic data submitted by OPG on November 25, 2008 indicates that Beck#1 G7 satisfies all applicable Market Rules requirements for generators.

1.2 Requirements

The requirements of the associated Final SIA report remain unchanged.

– End of Section –

2. Introduction

2.1 Purpose

This assessment tested the new exciter and dynamic models submitted by OPG on November 25, 2008 for Beck#1 G7 to ensure compliance with the Market Rules. It was based on the same assumptions, procedures and guidelines as the original SIA study.

2.2 Scope

All scenarios considered for this study focused on the Allanburg 115 kV area where the proposed generator will be connected.

2.3 Requirements and limitations

- The proponent is responsible for ensuring that the performance of the equipment that is eventually supplied and installed in this generation facility is similar to the predicted performance or exceeds the predicted performance observed in the simulation results obtained using provided equipment models and data.
- The proponent is required to provide type test data that validates parameters already used in the analysis or perform commissioning tests to find new parameters of the models.

– End of Section –

3. Project Description

Updated dynamic data for the generator supplied by OPG on November 25, 2008:

Table 1: Generator ratings

Description	Parameter	Value	Units
Generator Base Power	MBASE	68.5	MVA
Turbine Maximum Continuous Rating	MCR	61.6	MW
Rated Active Power	RAP	61.6	MW
Generator Base Voltage	BASEKV	13.8	kV
Rated Speed	rpm	225	rpm
Power Factor	pf	0.9	
Rated MVA, rated pf field current	ifgrated	1045	A (dc)
Generator Base Field Current	ifgbase	578	A (dc)
Generator Base Field Voltage	efgbase	75.8	V (dc)
Generator Field Base Resistance	rfgbase	0.1312	ohm
Generator Field Winding Base Temperature	Tfgbase	75	^{o}C

Note: The proponent did not provide updated generator reactive power capability curves so it is assumed that those originally provided are still valid. They're shown in Appendix A of the SIA report.

Table 2: Generator model - GENSAL, Salient Pole Generator Model

Description	Cons	Parameter	Value	Units
D-Axis O.C. Transient Time Constant	J	T'do (>0)	7.64	sec
D-Axis O.C. Sub-Transient Time Constant	J+1	T"do (>0)	0.073	sec
Q-Axis O.C. Sub-Transient Time Constant	J+2	T"qo (>0)	0.091	sec
Inertia	J+3	H	3.4	pu
Speed Damping	J+4	D	0	pu
D-Axis Synchronous Reactance	J+5	Xd	0.812	pu
Q-Axis Synchronous Reactance	J+6	Xq	0.59	pu
D-Axis Transient Reactance	J+7	X'd	0.306	pu
D-Axis/Q-Axis Sub-Transient Reactance	J+8	X"d=X"q	0.23	pu
Leakage Reactance	J+9	Xl	0.11	pu

Open Circuit Saturation Factor	J+10	S(1.0)	0.107	pu
Open Circuit Saturation Factor	J+11	S(1.2)	0.327	pu

Table 3: Excitation System Model (Basler ECS2100 Full Static)

Description	Con	Parameter	Value	Unit
Voltage transducer time constant	J	TR	0.01	sec
AVR proportional gain	J+1	KPR	33.7	pu Efd/pu Etref
AVR integral gain	J+2	KIR	3.37	pu Efd/pu Etref
Maximum voltage regulator output	J+3	VRMAX	1	pu Ceiling
Minimum voltage regulator output	J+4	VRMIN	-0.87	pu Ceiling
Voltage regulator time constant	J+5	TA	0.01	sec
FVR (inner loop) proportional gain	J+6	KPM	1	pu Efd
FVR (inner loop) integral gain	J+7	KIM	0	
Maximum field regulator output	J+8	VMMAX	1	pu Efd
Minimum field regulator output	J+9	VMMIN	-0.87	pu Efd
Inner loop feedback gain	J+10	KG	0	
Compound source potential multiplier	J+11	KP	4.45	
Compound source current multiplier	J+12	KI	0	
Maximum bridge output	J+13	VBMAX	5.34	pu Efd
Commutating reactance drop	J+14	KC	0.072	pu
Compound source reactance	J+15	XL	0	
Compound source potential angle	J+16	THETAP	0	(degrees)

Table 4: Power System Stabilizer model - PSS2A - dual-input stabilizer model

Description	CON	Parameter	Value	Units
First stabilizer input code	IC	ICS1	1	Rotor speed deviation (pu)
First remote bus number	IC+1	REMBUS1	0	Remote sensing bus (not used)
Second stabilizer input code	IC+2	ICS2	3	Generator electrical power on MBASE (pu)
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)	15	sec

Washout time constant	J+1	Tw2	15	sec
Filter time constant	J+2	T6	0	sec
Washout time constant	J+3	Tw3 (>0)	15	sec
Filter time constant [block bypassed]	J+4	Tw4	0	sec
Washout time constant	J+5	T7	15	sec
Gain	J+6	KS2 (=T7/2H)	2.206	
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	10	
Phase lead time constant	J+11	T1	0.08	sec
Phase lag time constant	J+12	T2	0.02	sec
Phase lead time constant	J+13	T3	0.08	sec
Phase lag time constant	J+14	T4	0.02	sec
Output limits	J+15	VSTMAX	0.1	pu Etref
Output limits	J+16	VSTMIN	-0.05	pu Etref
Generator Apparent Power		MBASE	68.5	MVA
Turbine Generator Inertia		H	3.4	MW-s/MVA

Table 5: Turbine Governor Model - WSHYDD

Description	CON	Parameter	Value	Units
Intentional deadband width	J	db1	0	Hz
Intentional deadband hysteresis	J+1	err	0	Hz
Input filter time constant	J+2	Td	0.1	sec
Single derivative gain	J+3	K1	6.3	pu
Washout time constant	J+4	Tf	0.1	sec
Double derivative gain	J+5	K2	1.9	pu
Integral gain	J+6	Ki	0.25	pu
Droop	J+7	R	0.04	
Power feedback time constant	J+8	Tt	1	sec
Gate servo gain	J+9	Kg	1.4	pu
Gate servo time constant	J+10	Tp	0.2	sec

Maximum gate opening velocity	J+11	Velopen	0.07	pu/sec
Maximum gate closing velocity	J+12	Velclose	0.07	pu/sec
Maximum gate opening	J+13	Pmax	1	pu of Trate
Minimum gate opening	J+14	Pmin	0	pu of Trate
Unintentional deadband	J+15	db2	0	MW
Non-linear gain point 1	J+16	GV1	0.1	pu - gv
Non-linear gain point 1	J+17	Pgv1	0	pu – power
Non-linear gain point 2	J+18	GV2	0.6	pu - gv
Non-linear gain point 2	J+19	Pgv2	0.7	pu - power
Non-linear gain point 3	J+20	GV3	0.7	pu - gv
Non-linear gain point 3	J+21	Pgv3	0.82	pu - power
Non-linear gain point 4	J+22	GV4	0.8	pu - gv
Non-linear gain point 4	J+23	Pgv4	0.9	pu - power
Non-linear gain point 5	J+24	GV5	0.9	pu - gv
Non-linear gain point 5	J+25	Pgv5	0.95	pu – power
Turbine numerator multiplier	J+26	Aturb	-1	
Turbine denominator multiplier	J+27	Bturb (>0)	0.5	
Turbine time constant	J+28	Trub (>0)	0.9	sec
Turbine MCR	J+29	Trate	61.6	MW

– End of Section –

4. Review of connection proposal

4.1 Generator data verification

The specifications for the generator as provided by Ontario Power Generation are listed below:

Table 6: Generator data

Identifier	SAB 1 G7	
Type	Salient Pole	
Frequency (Hz)	60	
Maximum Continuous Rating (summer, winter)	61.6	61.6
Rated capability (MVA)	68.5	
Rated voltage (kV)	13.8	
Power factor	0.9	
Total rotational inertia of generator and turbine	3.2	
Speed (RPM)	225	
Normal loading ramp rates (MW/min)	68.5	68.5
Emergency loading ramp rates (MW/min)	68.5	68.5
Armature and field resistance (Ohm)	0.003	0.1312
Saturation at rated voltage (S1.0) and 20% above rated voltage (S1.2)	0.107	0.327
Base field current (A)	578	
Base field voltage (V)	75.8	
Generator model	GENSAL	
Excitation system model	ESST4B	
Power system stabilizer model	PSS2A	
Speed governor model	WSHYDD	

The proposed equipment satisfies the IESO requirements for connection.

– End of Section –

5. Transient Stability Analysis

5.1 Excitation system test results

Transient simulations were performed to determine the response ratio and open-circuit of the exciter. The rated field voltage, field voltage ceiling and voltage response time were determined. The results are shown in the figures below:

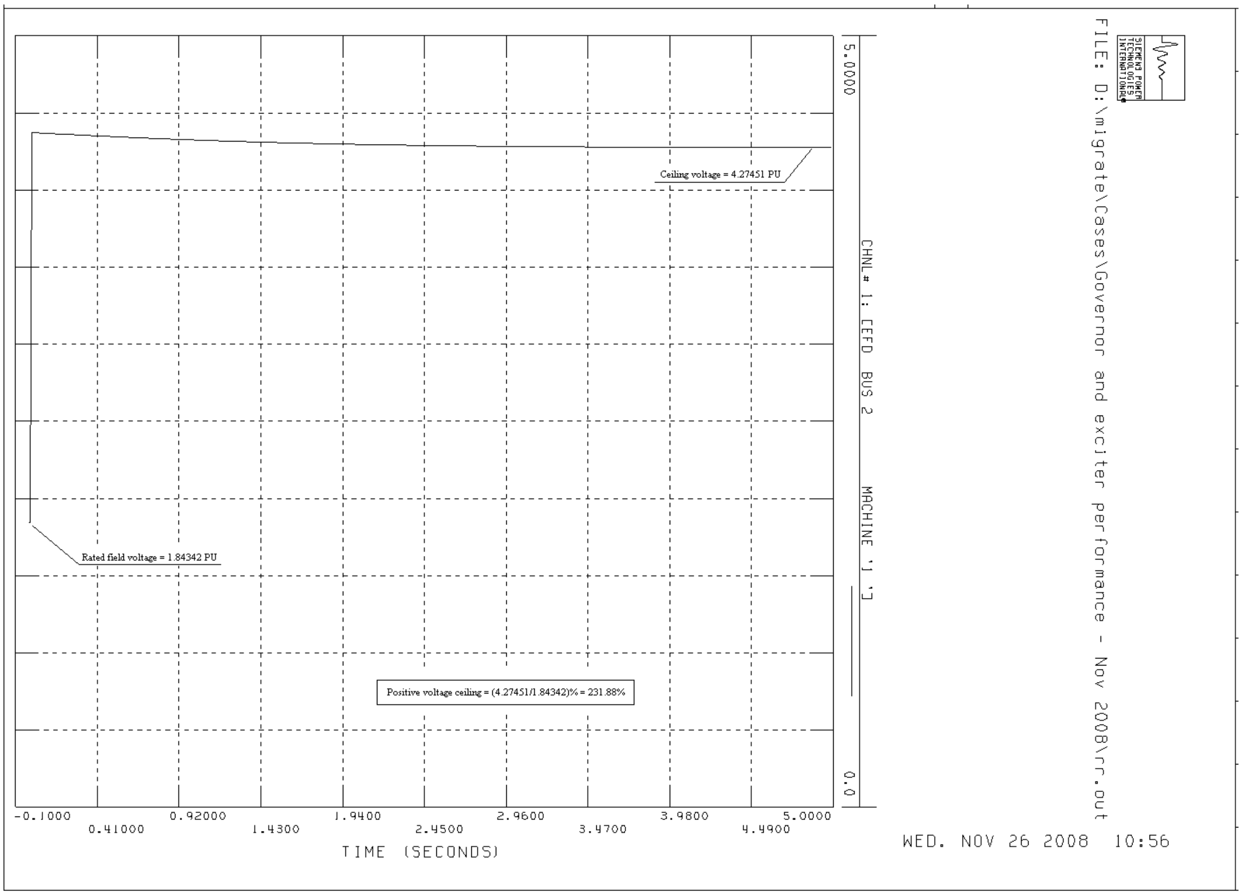

Figure 1: Ratio response test for Beck#1 G7

The above figure shows that the field voltage ceiling is higher than twice the rated field voltage.

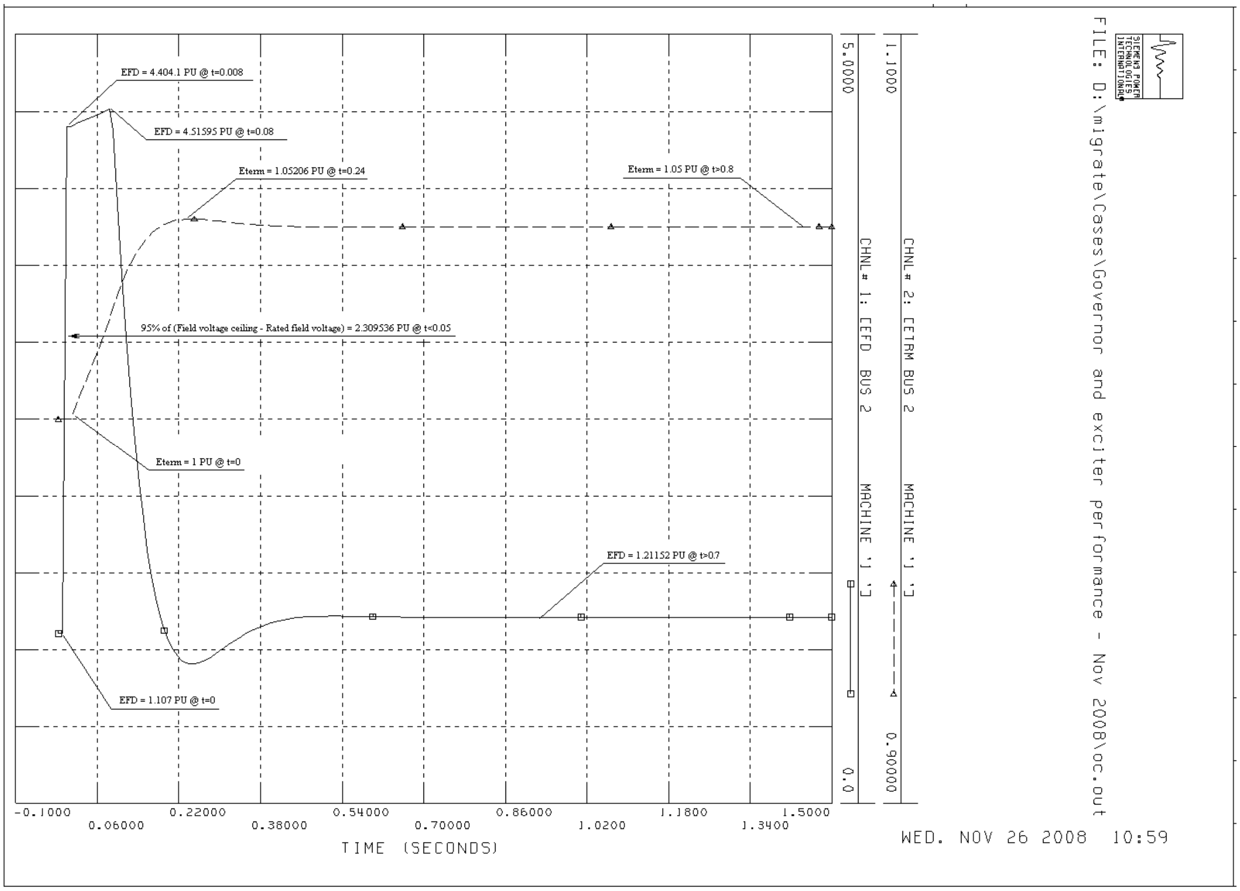

Figure 2: Open-circuit test results for Beck#1 G7

The response time of the exciter is less than 50 ms.

5.2 Speed governor test results

Transient simulation was performed to determine the speed governor speed droop which is required to be between 3% and 7%. It was determined that the speed governor droop of G7 is within this range:

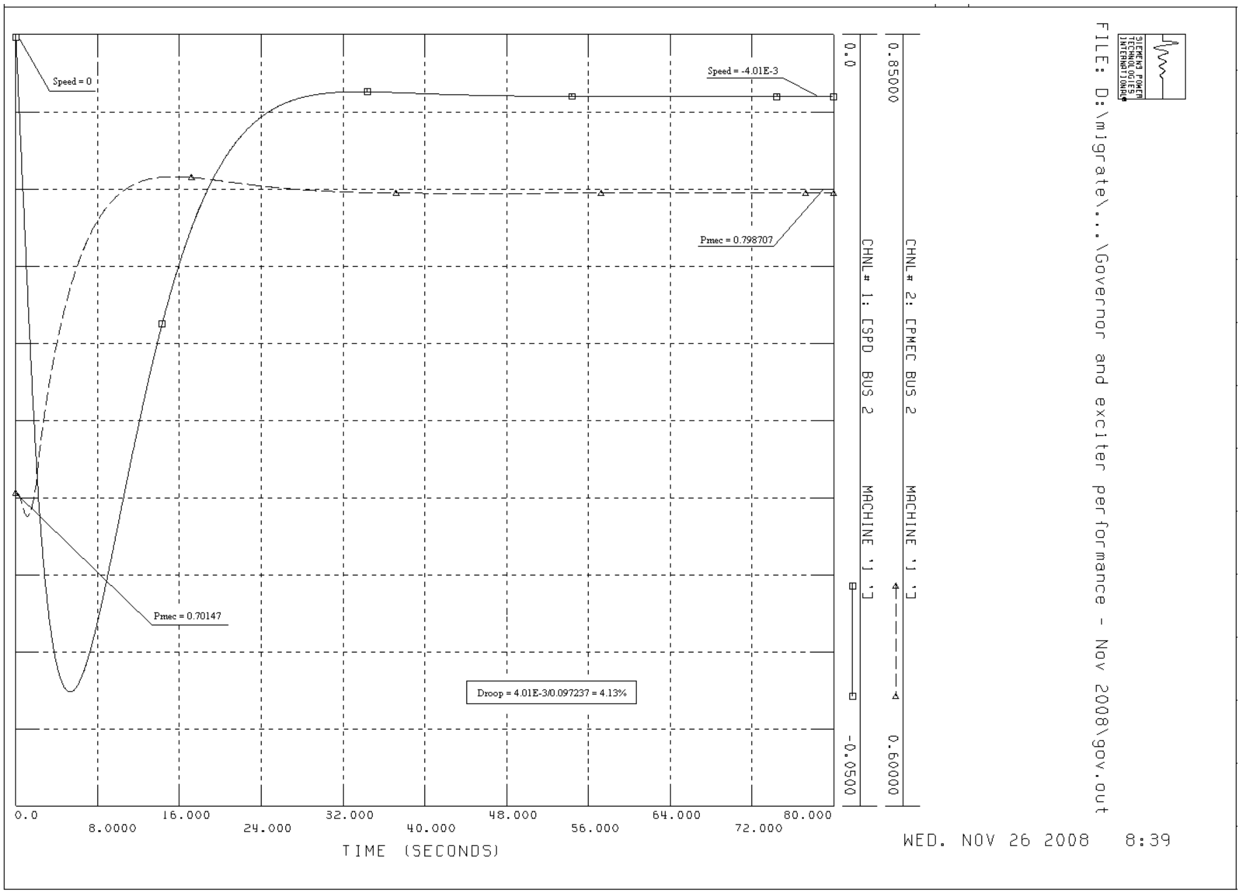

Figure 3: Governor test results for Beck#1 G7

The hydraulic governor droop of the model used in this study is 4.13 % which is within the required range.

5.3 Dynamic stability test results

The following transient stability tests were performed to determine the impact of the proposed generator unit and associated control systems on the transient stability behaviour of the system for most critical single element contingencies in the area. Machine parameters and significant bus voltages were monitored to assess the impact of the new facilities on the speed and magnitude of the transient response of the system. The results with G7 in service were compared against those with G7 out of service to determine the proposed generator's impact under the following scenarios:

- High and low demand summer 2009, loss of Q4N due to a fault close to Beck#1 GS;
- High and low demand summer 2009, loss of Q12S due to a fault close to Beck#1 GS.

It was determined that G7 presence does not substantially deteriorate the transient response of the local system.

Calculation of fault clearing time for both scenarios is provided in Appendix C of the final report.

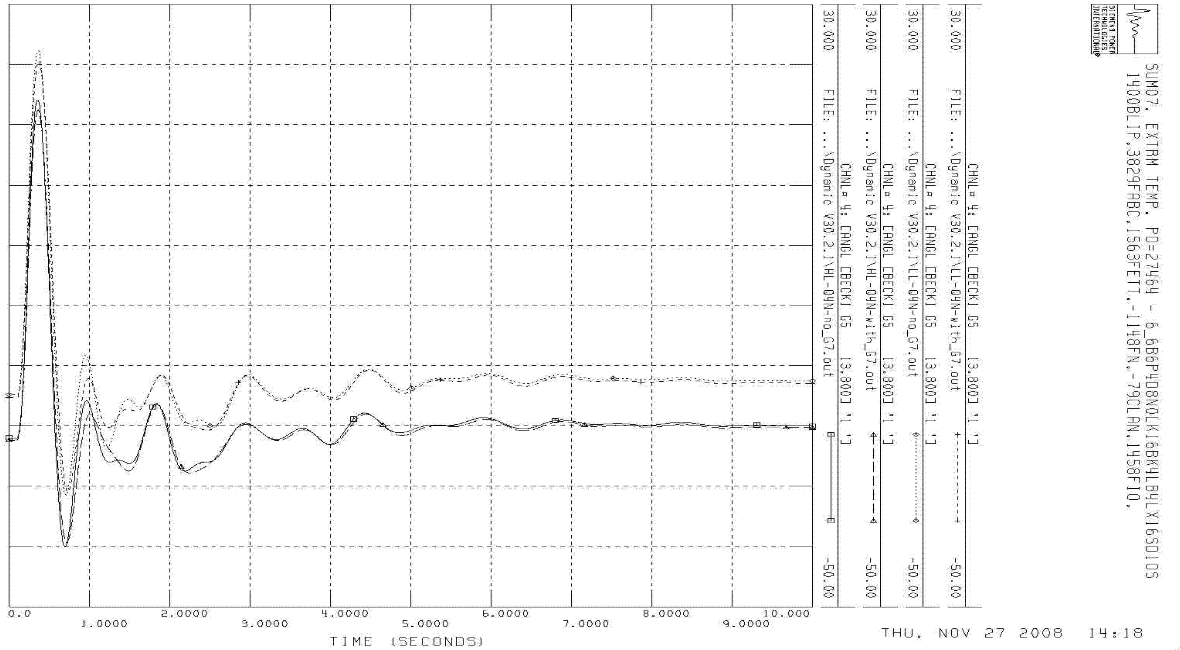

Figure 4: Beck#1 G5 angle, high and low demand scenarios, Q4N fault close to Beck#1 GS

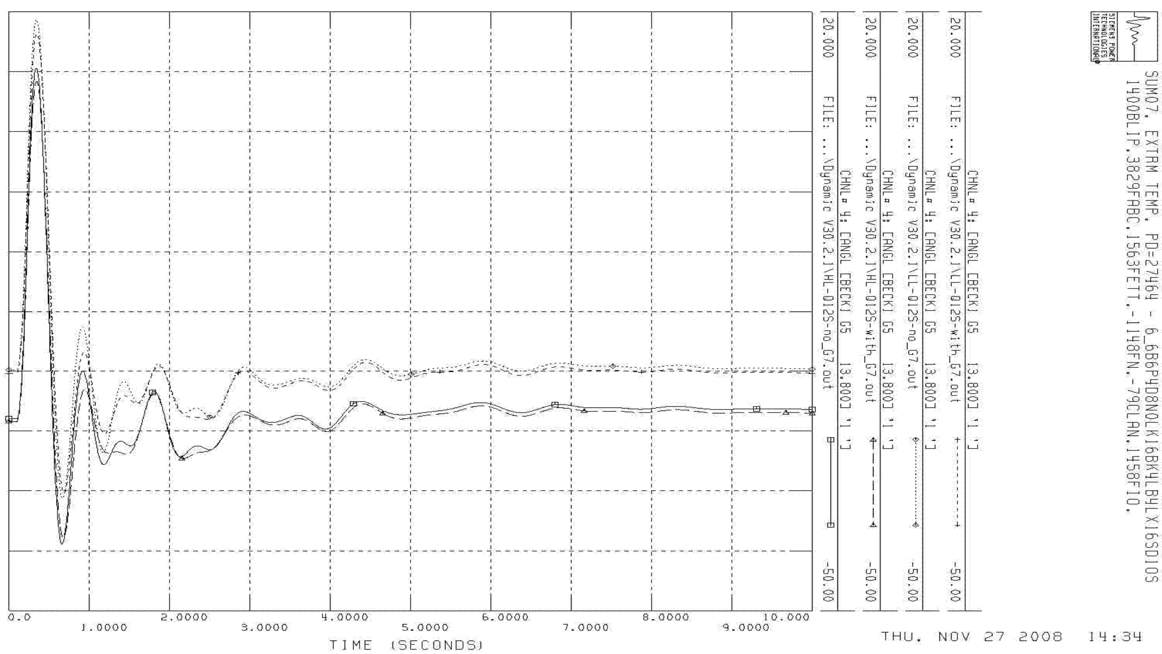

Figure 5: Beck#1 G5 angle, high and low demand scenarios, Q12S fault close to Beck#1 GS

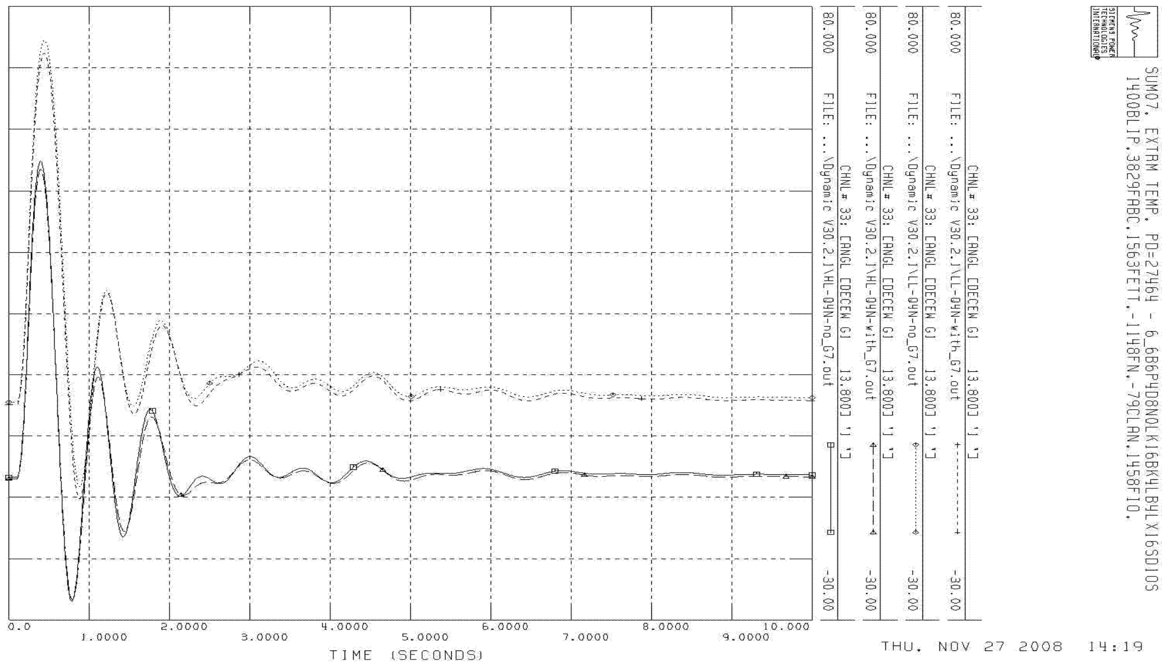

Figure 6: DeCew G1 angle, high and low demand scenarios, Q4N fault close to Beck#1 GS

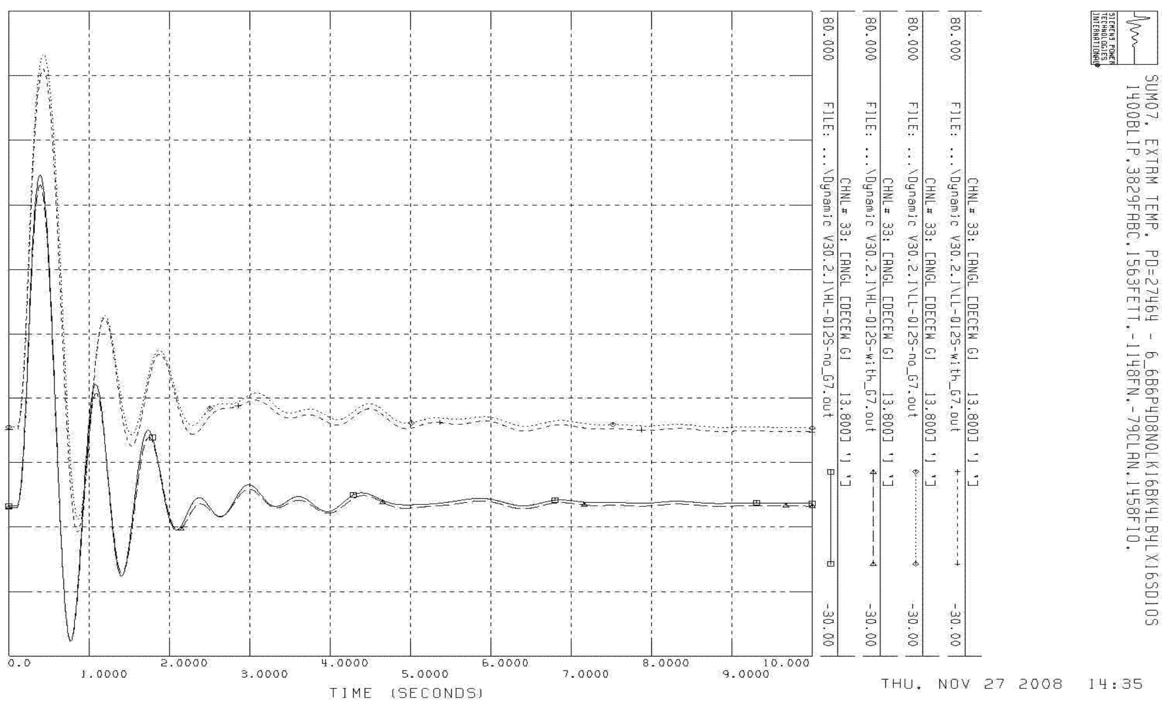

Figure 7: DeCew G1 angle, high and low demand scenarios, Q12S fault close to Beck#1 GS

The results show that, for both contingencies studied, the proposed Beck#1 G7 does not degrade the performance of existing machines at Beck#1 and DeCew Falls.

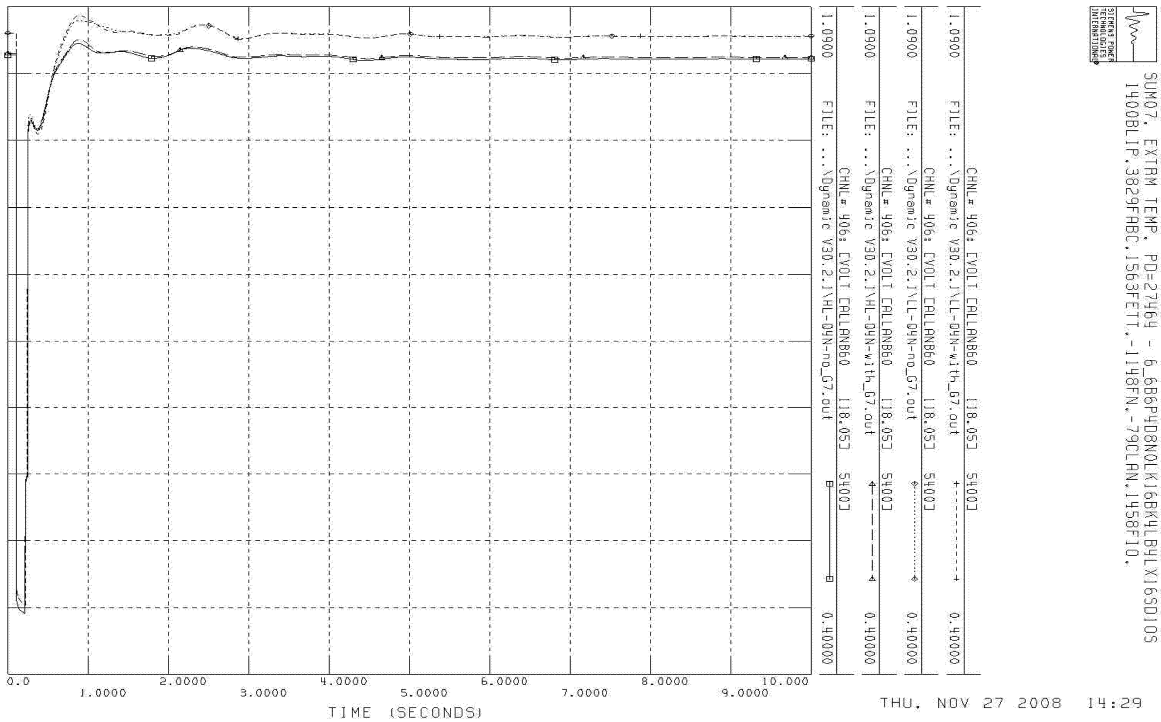

Figure 8: Allanburg 115 kV voltage, high and low demand scenarios, Q4N fault at Beck#1

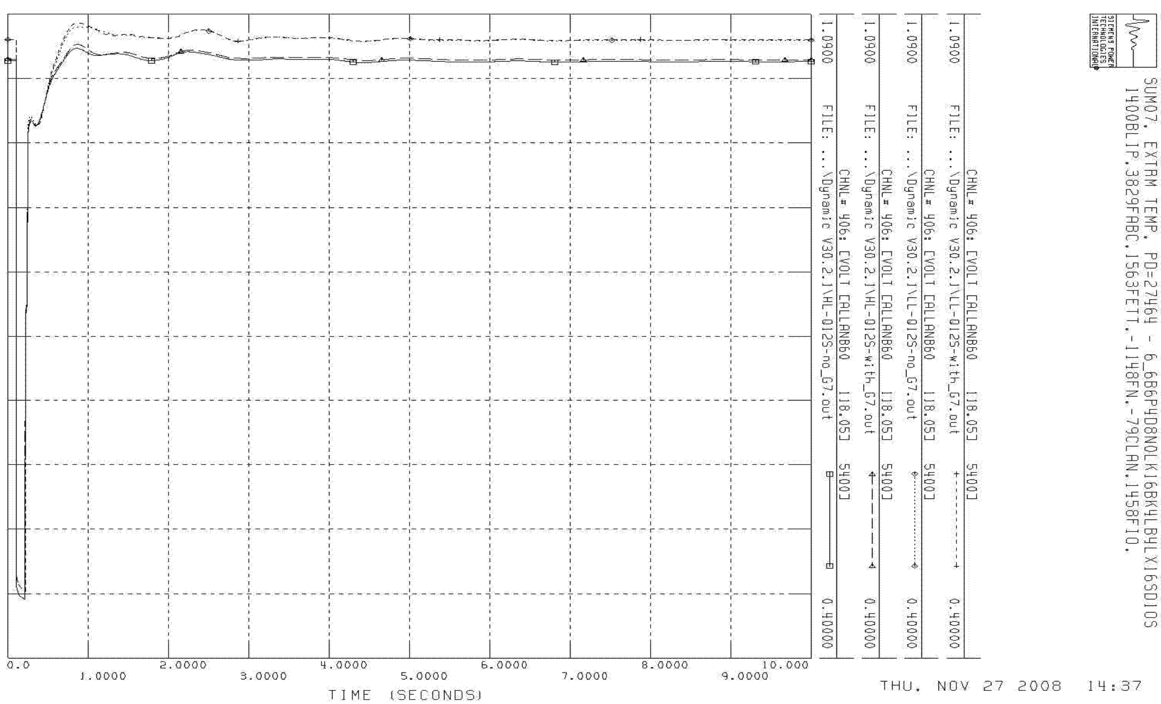

Figure 9: Allanburg 115 kV voltage, high and low demand scenarios, Q12S fault at Beck#1

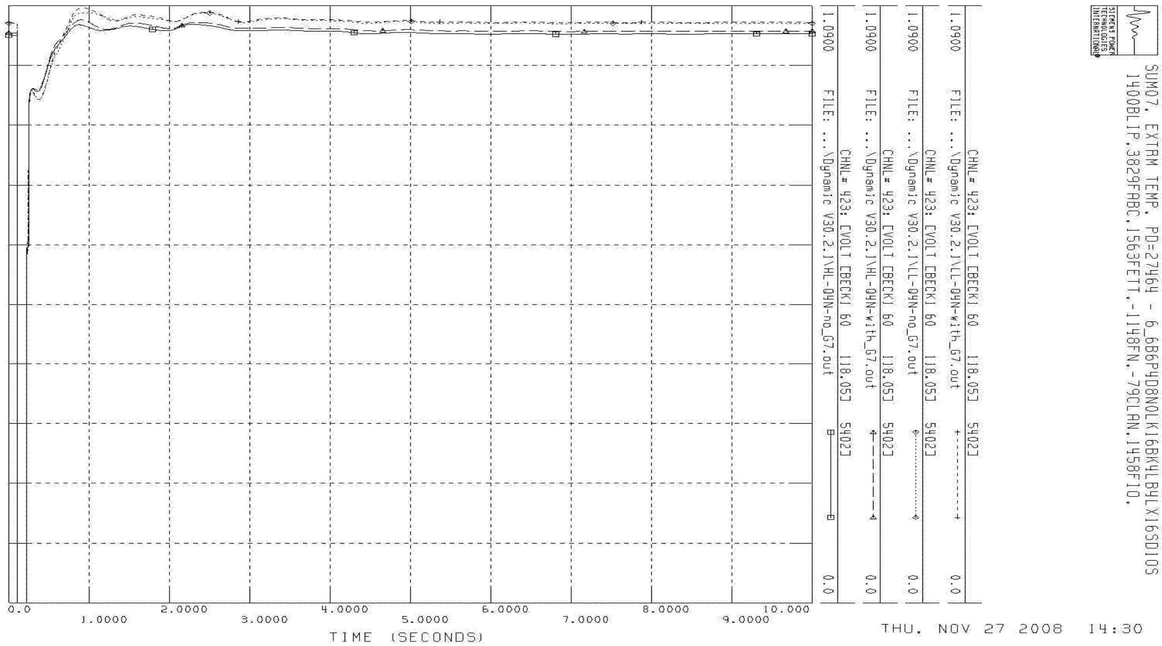

Figure 10: Beck#1 115 kV voltage, high and low demand scenarios, Q4N fault at Beck#1

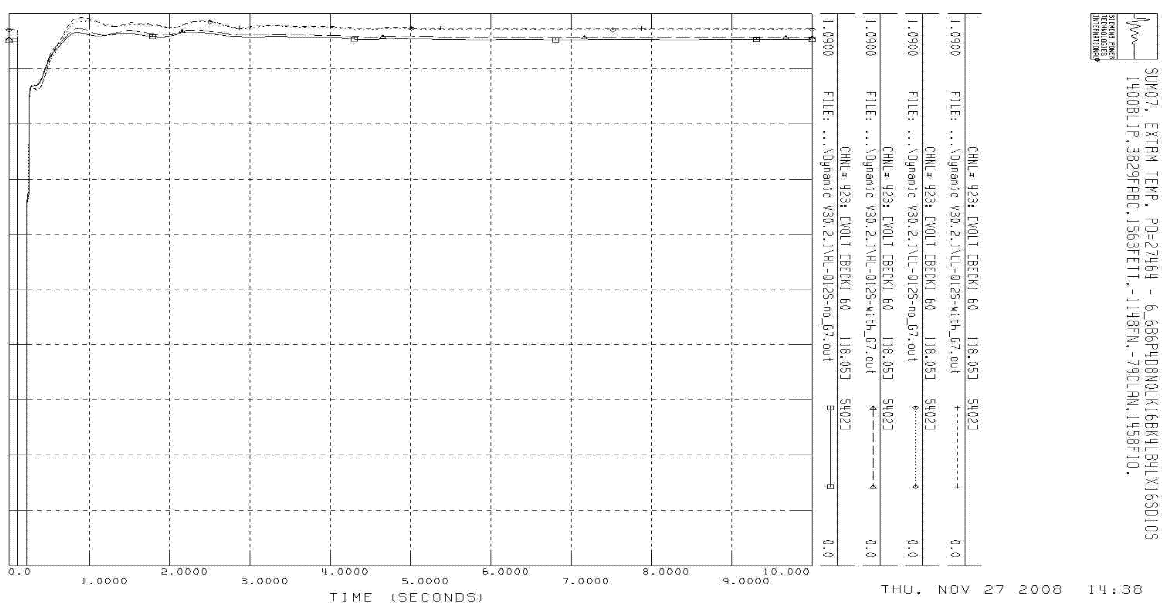

Figure 11: Beck#1 115 kV voltage, high and low demand scenarios, Q12S fault at Beck#1

The voltage, sag and duration of post-fault transient undervoltages remain virtually unchanged after connecting G7. The minimum post-contingency voltage sag remains above 70% of the nominal voltage and doesn't go below 80% of the nominal voltage for more than 250 ms within 10 seconds following the fault.

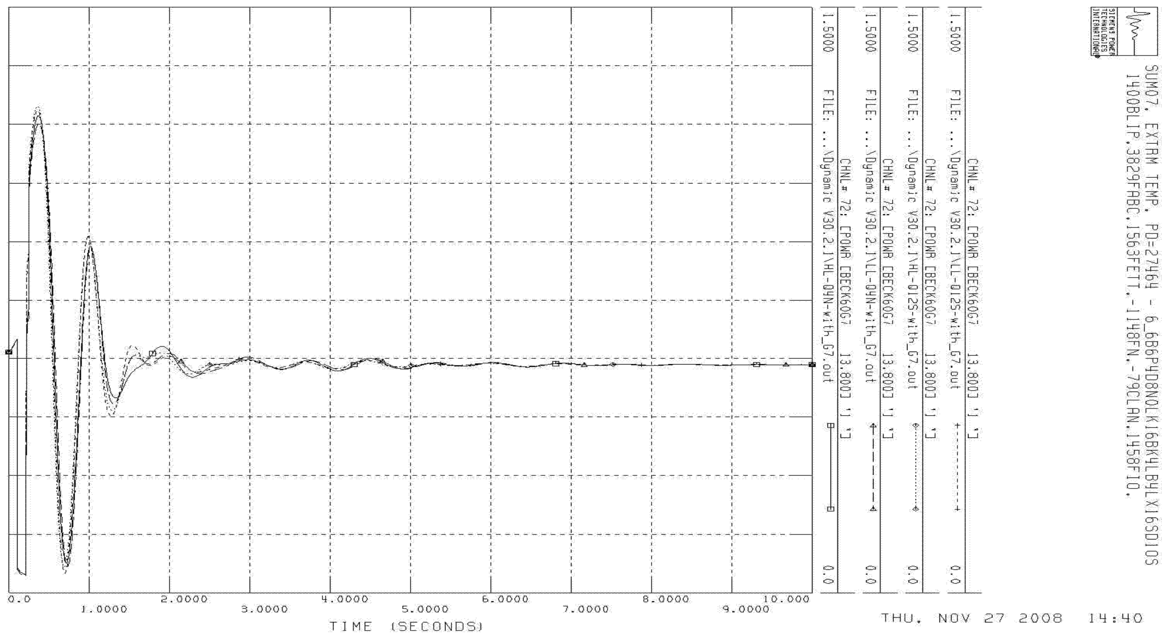

Figure 12: Beck#1 G7 P, high and low demand scenarios, Q4N/Q12S faults close to Beck#1 GS

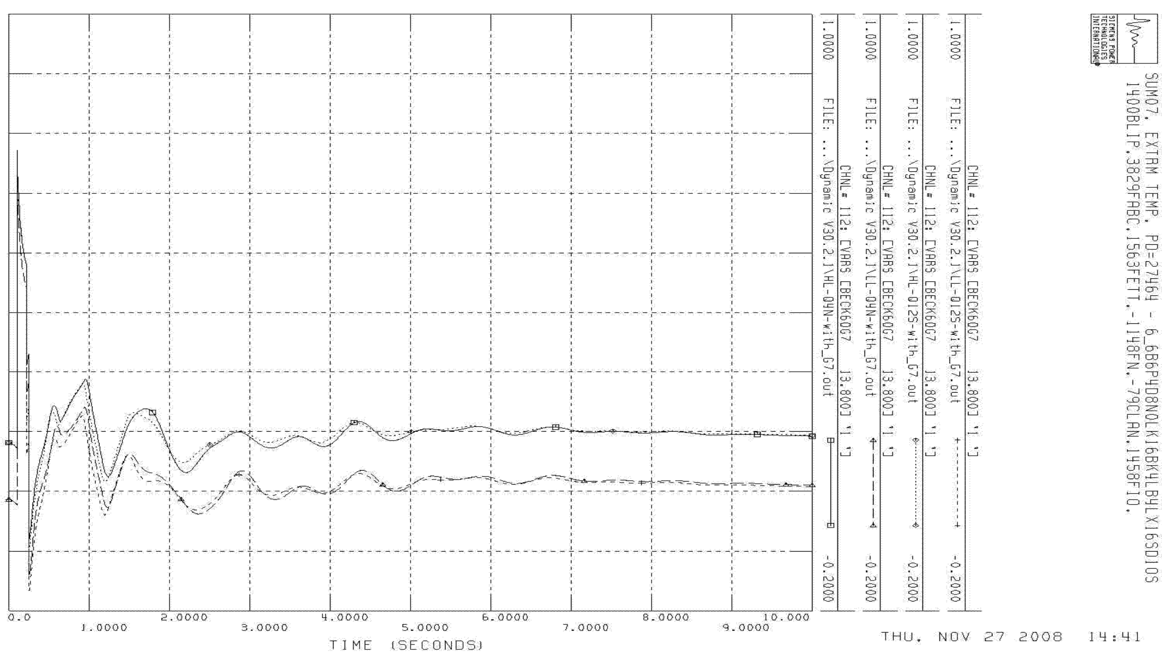

Figure 13: Beck#1 G7 Q, high and low demand scenarios, Q4N/Q12S faults close to Beck#1 GS

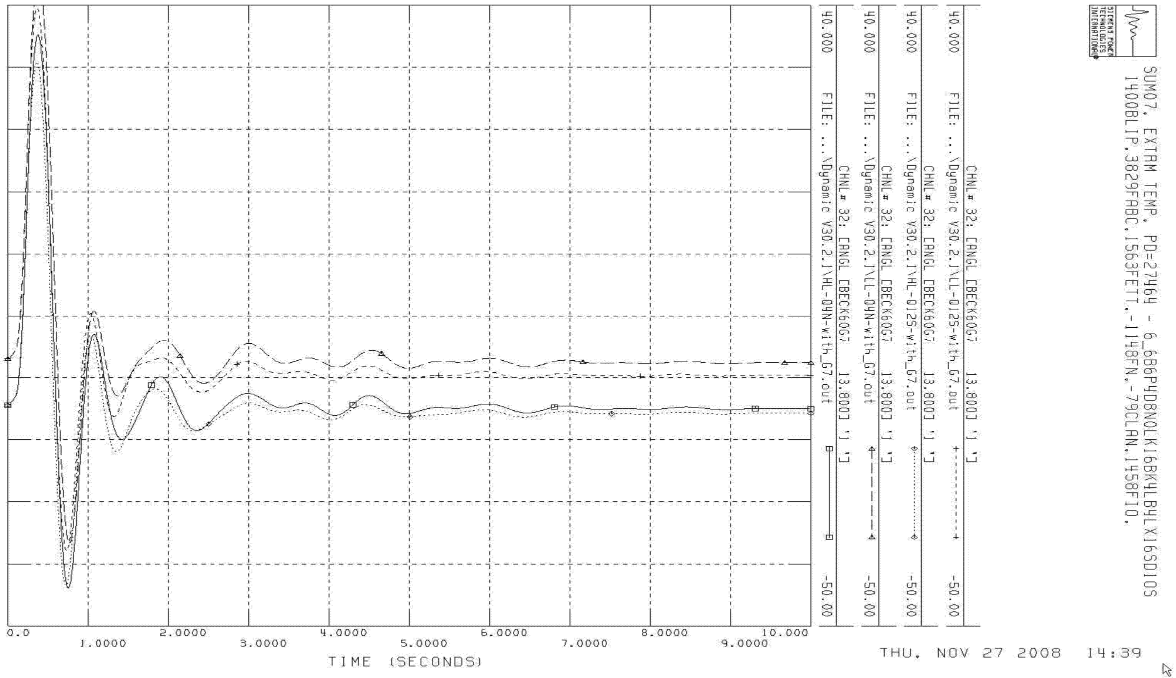

Figure 14: Beck#1 G7 angle, high and low demand scenarios, Q4N/Q12S faults close to Beck#1 GS

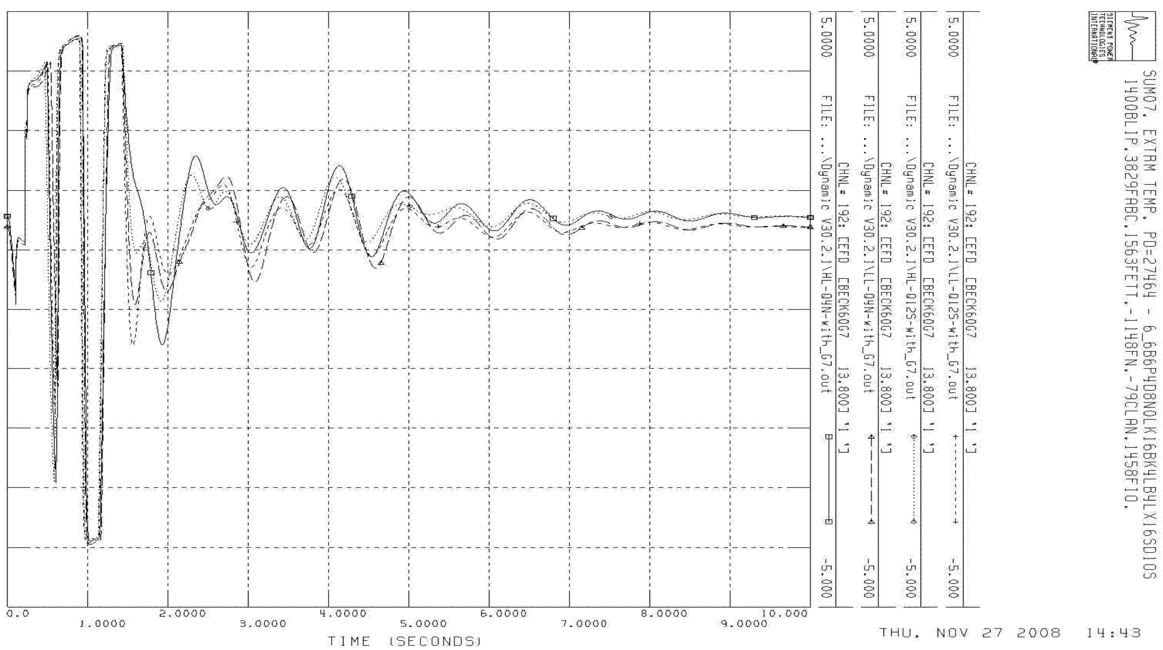

Figure 15: Beck#1 G7 Efd, high and low demand scenarios, Q4N/Q12S faults close to Beck#1 GS

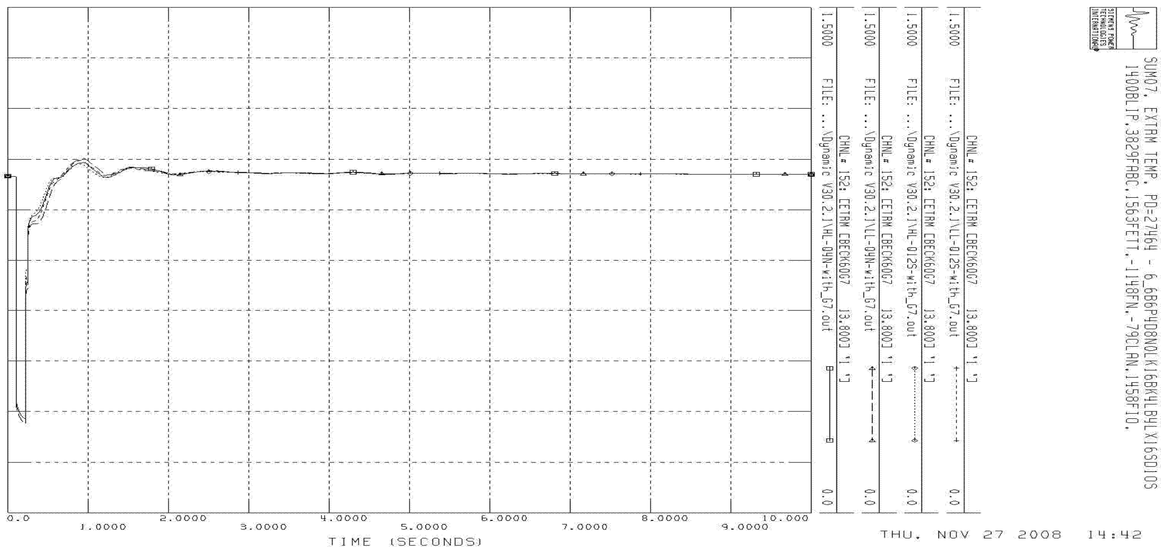

Figure 16: Beck#1 G7 Eterm, high and low demand scenarios, Q4N/Q12S faults close to Beck#1 GS

The simulation results show that post-contingency oscillations are expected to be well dumped.

The proponent is responsible for ensuring that the performance of the equipment that is eventually supplied and installed in this generation facility is similar to the predicted performance or exceeds the predicted performance observed in the simulation results obtained using provided equipment models and data.

– End of Section –

References

Document Name	Document ID

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