IESO_REP_0595

ADDENDUM

System Impact Assessment Addendum #2

Connection Assessment & Approval Process

Project: **Thorold GS CAA ID 2000-003**
Applicant: **Northland Power Inc.**

Market Facilitation Department

Date: November 6th, 2009

Document ID	IESO_REP_0595
Document Name	System Impact Assessment Addendum #2
Issue	Issue 1.0
Reason for Issue	Addendum #2 to SIA report dated March 13, 2002
Effective Date	November 6th, 2009

System Impact Assessment Addendum #2

Acknowledgement

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

Disclaimers

IESO

This addendum 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 addendum has not been prepared for any other purpose and should not be used or relied upon by any person for another purpose. This addendum 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 addendum. Any liability which the IESO may have to the connection applicant in respect of this addendum is governed by Chapter 1, section 13 of the Market Rules. In the event that the IESO provides a draft of this addendum to the connection applicant, the connection applicant must be aware that the IESO may revise drafts of this addendum 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 addendum is being used.

Hydro One

The results reported in this addendum 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 addendum, 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.

Summary

Northland Power Inc. ("Northland Power") is to construct a new 320 MVA cogeneration facility at the Abitibi Consolidated paper and mill site in City of Thorold, adjacent to the Abitibi Consolidated Inc. ("Abitibi Consolidated") owned Donohue transformer station (TS). The proposed facility called Thorold generation station (GS) is a developmental project that will consist of a single gas turbine generator (GTG1) rated at 203 MVA and a single steam turbine generator (STG2) rated at 117.7 MVA. Thorold GS is to connect to the IESO-controlled grid via a new 230 kV tap off the existing 230 kV circuit Q10P.

The proposed exciter, power system stabilizer and governor for both generators meet the applicable Market Rules performance requirements. Their installation is also expected to have no adverse impact on the reliability of the IESO-controlled grid.

Conclusions and IESO Requirements

Conclusions

The IESO carried out this addendum in order to identify the effect of the project on the IESO controlled grid. Based on the analysis, the following conclusions were made.

- The proposed project will not cause an adverse material impact on the reliability of the IESO-controlled grid provided the connection requirements given below are met.
- The proposed excitation systems for both generators at Thorold GS meet IESO standards.
- The proposed governor unit at Thorold GS meets IESO standards.
- The proposed PSS units for both generators at Thorold GS provide supplementary damping during transient contingencies.

Notification of Approval

It is recommended that a revised *Notification of Conditional Approval for Connection* be issued for the Thorold cogeneration station, subject to the requirements described below under the heading "IESO Requirements".

IESO Requirements

Provided the generator's facilities are designed and constructed to satisfy the Market Rule requirements for generators, including the requirements specified in this Addendum #2, and provided the generation facilities are connected as described in the previous Addendum #1 , Thorold GS will be approved to connect to the IESO-controlled grid and allowed to participate in the IESO-administered market.

The requirements specified below are in addition to the requirements identified in the Thorold GS Addendum #1 (IESO_REP_0337) dated July 20, 2007 and the general requirements mentioned in this report.

- The performance of all proposed equipment must meet or exceed the predicted performance observed in this addendum.
- The proposed equipment installed at Thorold GS must have the same or similiar dynamic models and parameters as specified in this addendum.

– End of Section –

Table of Contents

1. Introduction

The Preliminary System Impact Assessment report dated December 8, 2000 and the System Impact Assessment (SIA) report dated March 13, 2002 (IMO_REP_0038) have been conducted to examine the effect of the proposed Thorold generation station (GS) on the reliability of the IESO-controlled grid. In March 2006, Northland Power Inc. ("Northland Power") submitted to the IESO a revised SIA application reflecting changes to the proposed Thorold GS studied in the previous assessments. An addendum to the SIA was completed to analyze the effects of these changes on the reliability of the IESO controlled grid. All of these reports are available on the IESO website at http://www.ieso.ca/imoweb/connAssess/caa_StatusSummary-2.asp

This Addendum #2 examines the impact of the updated parameters and newly proposed dynamic models of both the gas turbine and steam turbine generator and their controls. In particular, this addendum compares the performance of the excitation systems, power system stabilizers and governor model as proposed by Northland Power against the Market Rules standards.

– End of Section –

2. Market Rules Requirements

2.1 Requirements for Exciters and PSS

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.

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.

2.2 Requirements for Governors

The requirements for governors are listed in Reference 16 of Appendix 4.2 in the Market Rules, as follows:

- Each synchronous *generation unit* with a nameplate rating of greater than 10 MVA shall be operated with a speed governor. The governor shall have a permanent speed droop that can be set in the range between 3% and 7% and the intentional deadband shall not be wider than ± 36 mHz.
- The above droop and deadband requirements shall apply to an entire combined-cycle *generation facility*.
- The governor shall be able to arrest the unit's speed, following full load rejection to prevent a trip due to over speed, and shall demonstrate stable performance with adequate damping under all operating conditions.
- Governors shall control speed in a stable fashion during both islanded and interconnected operation.
- To the extent practical governors shall provide immediate, appropriate and sustained response to abnormal frequency excursions.
- Control systems that inhibit governor response shall be automatically disabled by frequency deviations not larger than ± 100 mHz.

– End of Section –

3. Data Verification

Northland Power Inc. has provided complete dynamic models for the generators, excitation systems, power system stabilizers and the governor.

3.1 Generator Dynamic Model

Both generators are modeled with the Round Rotor Generator (GENROU) model, with the parameters given in Table 1.

CONs	Description	GTG1	STG2
J	T'_{do} (>0)	7.52	7.653
J+1	T''_{do} (>0)	0.0423	0.0433
J+2	T'_{qo} (>0)	0.591	2.5
J+3	T''_{qo} (>0)	0.088	0.15
J+4	H	5.61	3.709
J+5	D	0.0	0.0
J+6	X_d	1.83	2.02
J+7	X_q	1.72	1.92
J+8	X'_d	0.23	0.263
J+9	X'_q	0.415	0.45
J+10	$X''_d = X''_q$	0.17	0.194
J+11	X_1	0.115	0.14
J+12	S(1.0)	0.121	0.121
J+13	S(1.2)	0.514	0.51
	M_{base}	203 MVA	117.7 MVA
	PFrated	0.85	0.85
	MCR	180 MW	100 MW

Table 1: G1 and G2 Parameters

3.2 Excitation System Model

3.2.1 GTG1

The proposed exciter for the GTG1 is the IEEE Type ST4B Potential or Compounded Source-Controlled Rectifier Exciter. The block diagram of the excitation system provided by Northland Power is shown in Figure 1. The parameters of the exciter are shown in Table 2.

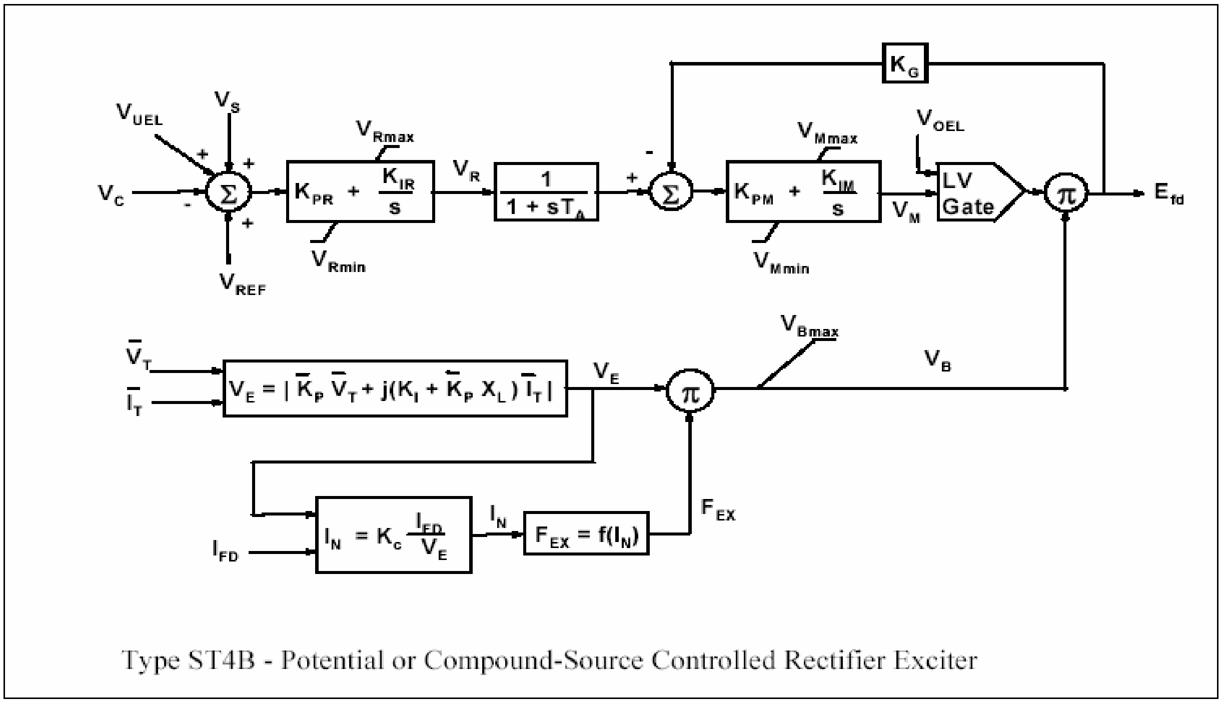

Figure 1: ST4B Excitation System Block Diagram

CONs	Value	Description
J	0.0	Tr (sec)
J+1	25.35	Kpr
J+2	2.98	Kir
J+3	1.0	Vrmax
J+4	-0.80	Vrmin
J+5	0.01	Ta (sec)
J+6	1.0	Kpm
J+7	0.0	Kim
J+8	1.0	Vmmax
J+9	-0.80	Vmmin
J+10	0.0	Kg
J+11	6.71	Kp
J+12	0.0	Ki
J+13	8.38	Vbmax
J+14	0.084	Kc
J+15	0.0	Xl
J+16	0.0	THETAP

Table 2: ST4B Excitation Model Parameters

3.2.2 STG2

The proposed exciter for the STG2 is the new non-standard ST6B Static Potential Source Excitation System with Field Current Limiter. The block diagram of the excitation system provided by Northland Power is shown in Figure 2. The parameters of the exciter are shown in Table 3.

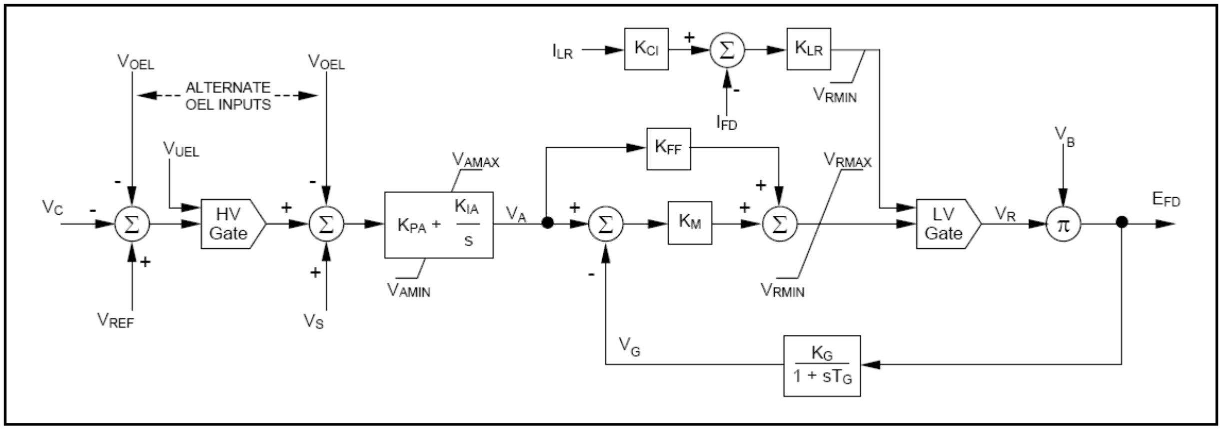

Figure 2: ST6B Excitation System Block Diagram

CONs	Value	Description
J	0.012	Tr (sec)
J+1	180	Kpa
J+2	18	Kia
J+3	0	Kda
J+4	0.01	Tda
J+5	6.25	Vamax
J+6	-5.61	Vamin
J+7	1	Kff
J+8	0	Km
J+9	1	Kci
J+10	10	Klr
J+11	4.74	Ilr
J+12	6.25	Vrmax
J+13	-5.61	Vrmin
J+14	1	Kg
J+15	0.02	Tg
Icon M	1	OEL Flag

Table 3: ST6B Excitation Model Parameters

3.3 PSS Model

The power system stabilizer for both units will be IEEE type dual-input signal stabilizer model, commonly referred to as integral of accelerating power type PSS2A. The block diagram of the PSS2A is shown in Figure 3 and the parameters of the both units are shown in Table 4.

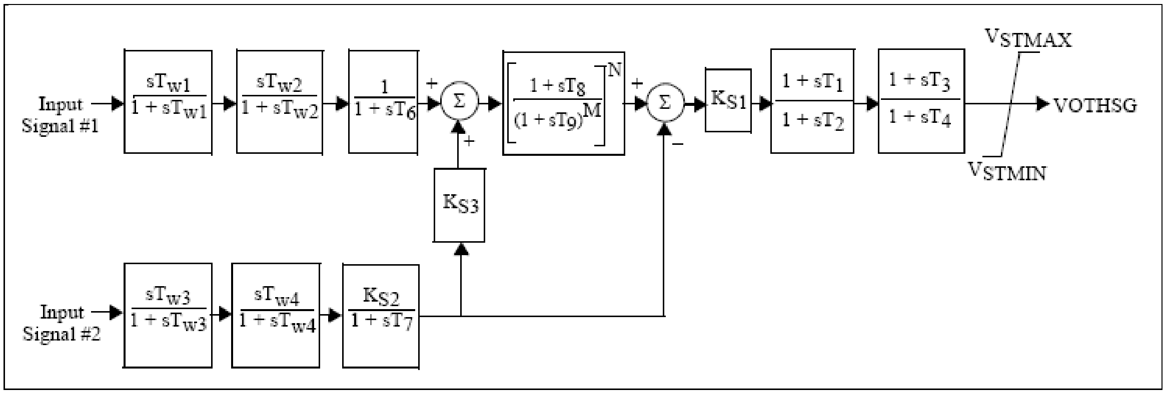

Figure 3: Block Diagram of PSS2A

CONs	Description	GTG1	STG2
J	Tw1 (>0)	7	10
J+1	Tw2	7	10
J+2	T6	0	0
J+3	Tw3 (>0)	7	10
J+4	Tw4	0	0
J+5	T7	7	10
J+6	Ks2	0.62	1.35
J+7	Ks3	1	1.0
J+8	T8	0.5	0.5
J+9	T9 (>0)	0.1	0.1
J+10	Ks1	20	10
J+11	T1	0.1	0.1
J+12	T2	0.02	0.02
J+13	T3	0.1	0.1
J+14	T4	0.02	0.02
J+15	Vstmax	0.1	0.05
J+16	Vstmin	-0.1	-0.05

ICONs	Description	GTG1	STG2
IC	Vs1 (ICS1)	1	1
IC+1	REMBUS1	0	0
IC+2	Vs2 (ICS2)	3	3
IC+3	REMBUS2	0	0
IC+4	M	5	5
IC+5	N	1	1

Table 4: PSS2A Parameters

3.4 Governor Model

Only the GTG1 will be equipped with a governor. The governor will be GGOV1 model. The block diagram of the governor is shown in Figure 4 and the parameters are shown in Table 5.

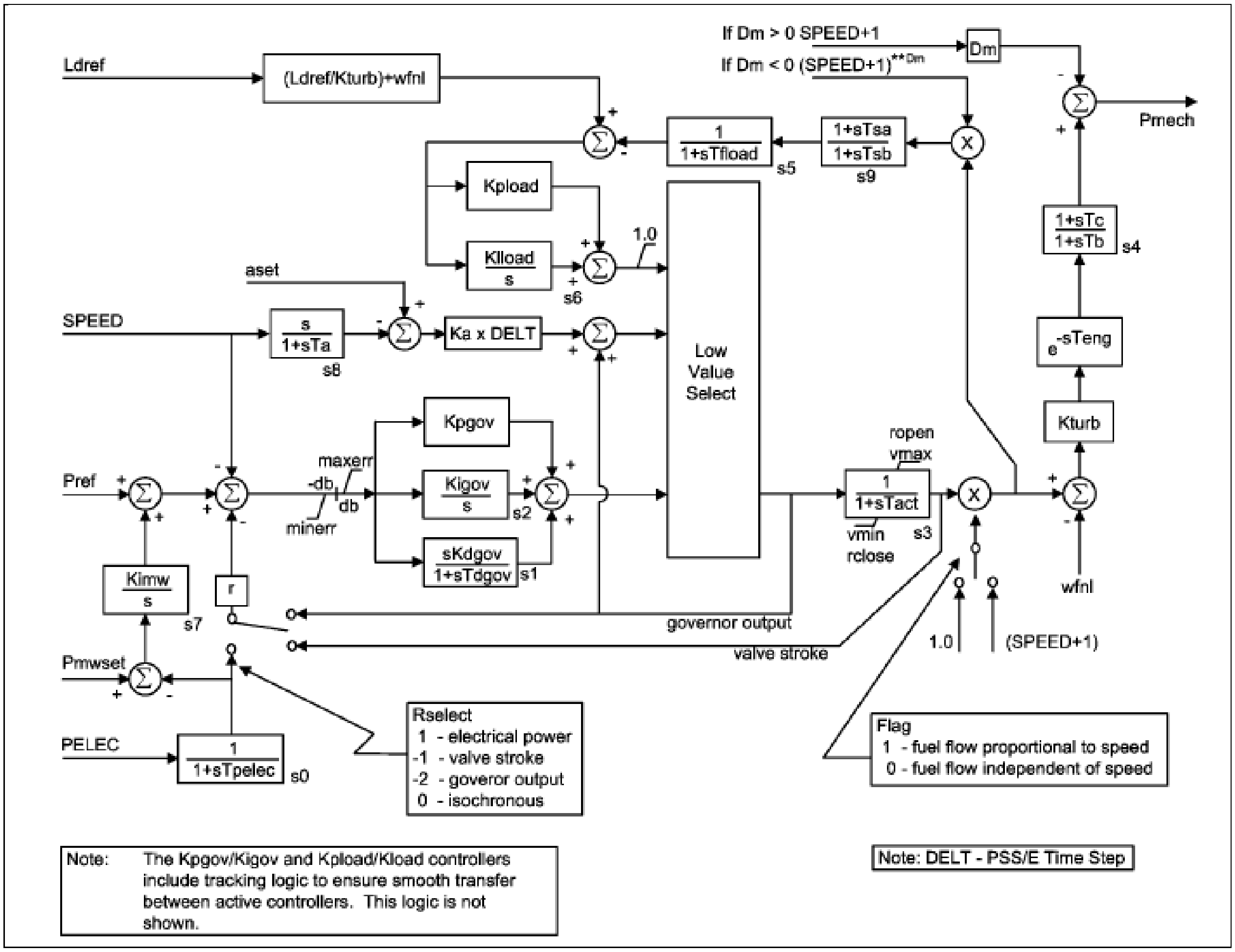

Figure 4: Block Diagram of GGOV1

ICONs	Value	Description
M	1	Rselect
M+1	1	Flag

CONs	Value	Description
J	0.04	R
J+1	0.1	Tpelec (sec)
J+2	0.05	Maxerr (pu)
J+3	-0.05	Minerr (pu)
J+4	5.5	Kpgov
J+5	1.5	Kigov
J+6	0.0	Kdgov
J+7	1.0	Tdgov (sec)
J+8	1.0	Vmax
J+9	0.17	Vmin
J+10	0.5	Tact (sec)
J+11	1.71	Kturb
J+12	0.22	Wfnl
J+13	0.1	Tb
J+14	0.0	Tc
J+15	0.0	Teng (sec)
J+16	3.0	Tfload (sec)

CONs	Value	Description
J+17	3.3	Kpload
J+18	1.0	Kiload
J+19	1.0	Ldref
J+20	0.0	Dm
J+21	1.0	Ropen (pu/sec)
J+22	-1.0	Rclose (pu/sec)
J+23	0.0	Kimw
J+24	0.01	Aset (pu)
J+25	10.0	Ka (pu)
J+26	0.1	Ta (sec)
J+27	180	Trate- Turbine Rating (MW)
J+28	0.0	db (pu)
J+29	4.0	Tsa (sec)
J+30	5.0	Tsb (sec)
J+31	99.0	Rup (pu)
J+32	-99.0	Rdown (pu)

Table 5: Governor Dynamic Model

– End of Section –

4. Assessments

4.1 Exciter Performance Study Results

Dynamic simulations were performed to test the transient response of the new 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 tests were performed to determine the rated field voltage, Efd_{rated}, and the positive and negative ceiling targets and values.

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

4.1.1.1 GTG1

The results of response ratio tests for the GTG1 are shown in Figures 6 and 7.

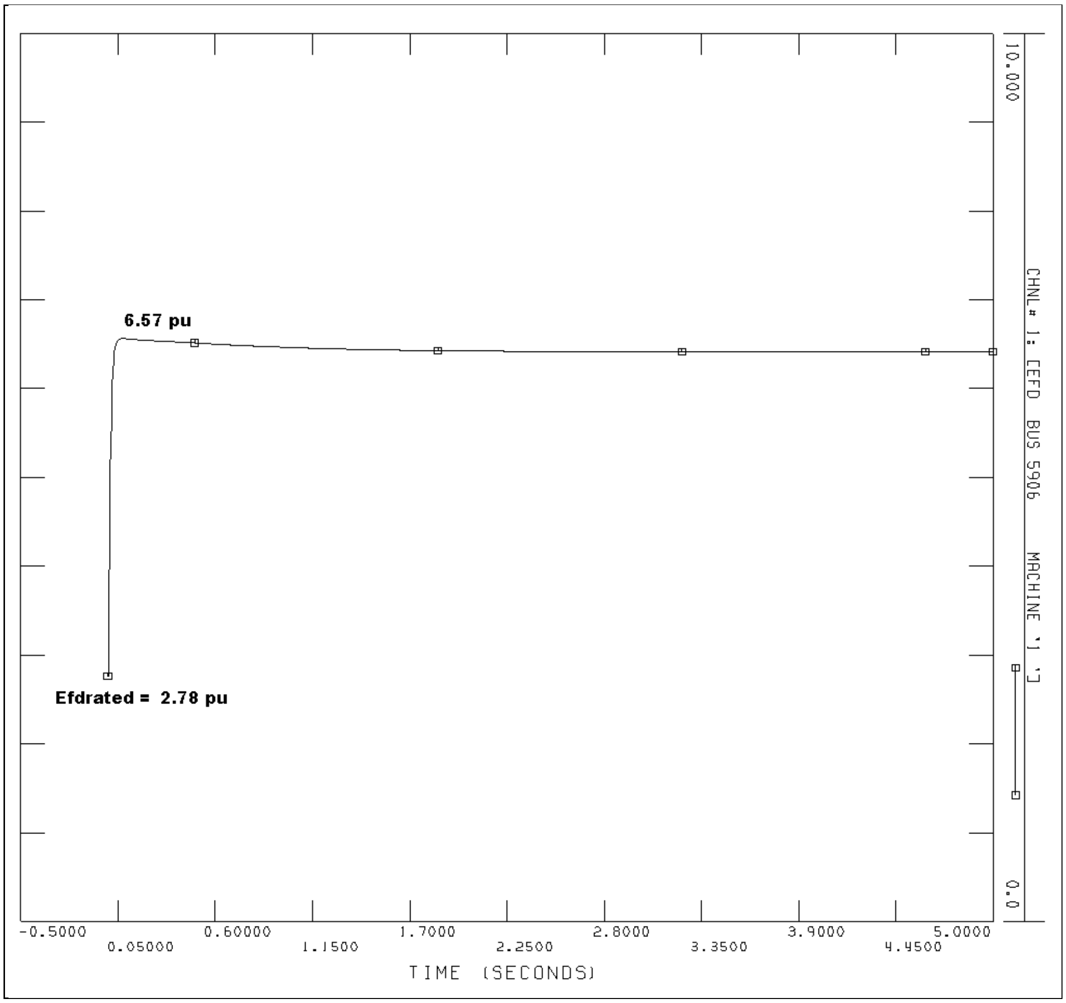

Figure 6: GTG1 Response Ratio Test Results (Positive Ceiling)

The plot indicates that the exciter rated field voltage is 2.78 pu. Therefore, positive ceiling must be at least 2 × 2.765 = 5.56 pu and negative ceiling must be at least -1.4 × 2.765 = -3.89 pu. Figure 6 also indicates that the GTG1 has a positive ceiling of 6.57 pu, meeting IESO requirements.

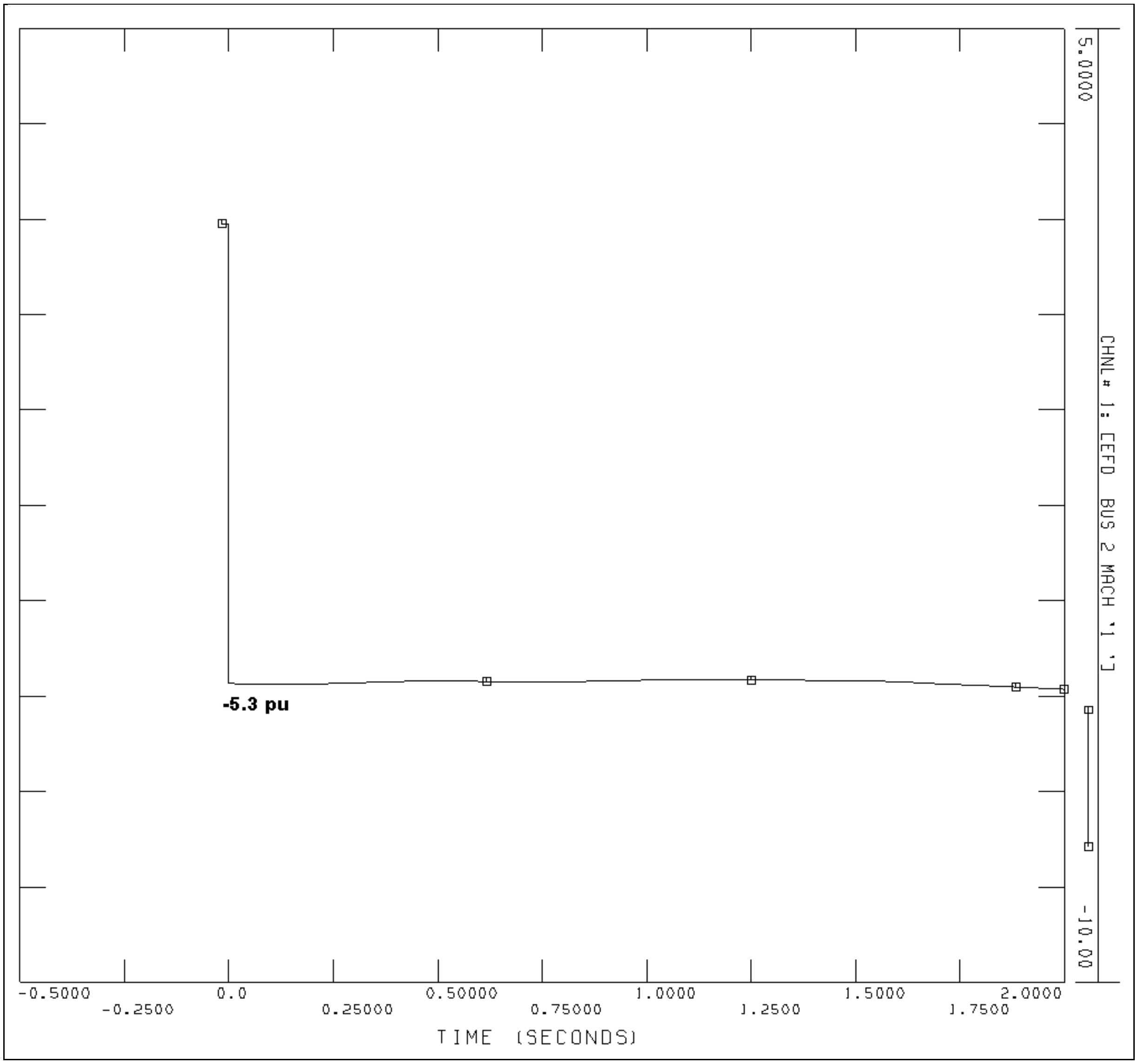

Figure 7: GTG1 Response Ratio Test Results (Negative Ceiling)

Figure 7 indicates that the GTG1 excitation systems has a negative ceiling of -5.3 pu, meeting IESO requirements.

4.1.1.2 STG2

The results of response ratio test for the STG2 are shown in Figure 8.

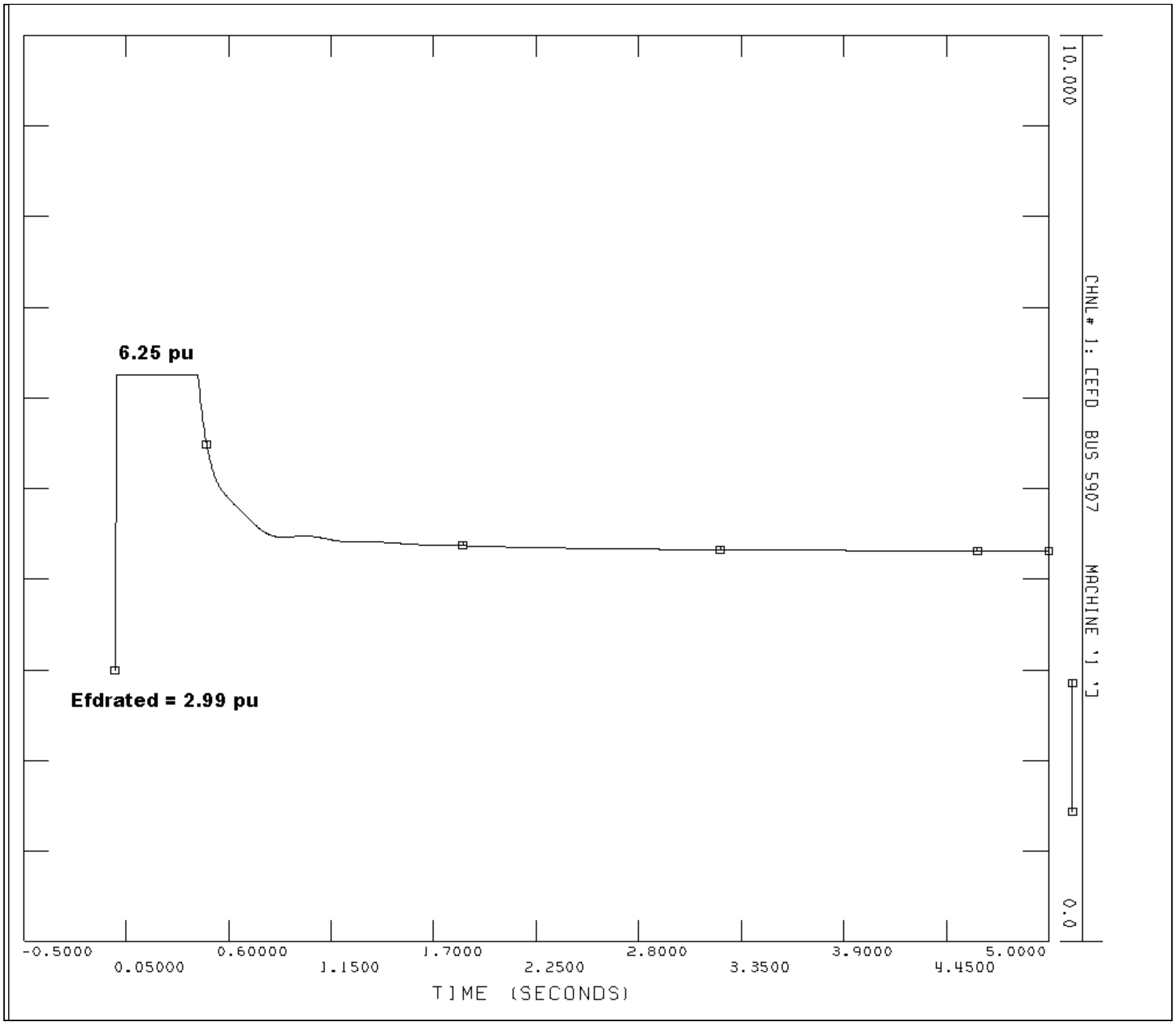

Figure 8: STG Response Ratio Test Results (Positive Ceiling)

The plot indicates that the exciter rated field voltage is 2.99 pu. Therefore, positive ceiling must be at least 2 × 2.99 = 5.98 pu and negative ceiling must be at least -1.4 × 2.99 = -4.186 pu. Figure 8 indicates that the STG2 unit has a positive ceiling of 6.25 pu, meeting IESO requirements.

Due to limitations in software, negative ceiling tests for the STG2 were not performed. Through subsequent testing of the STG2 performed under more limiting conditions (shown later in this report), the exciter was shown to reach a negative ceiling of -5.61 pu which meets and exceeds IESO requirements. Since the exciter meets and exceeds negative ceiling requirements under more limiting conditions, it will also meet IESO requirements during the response ratio test.

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 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.

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

4.1.2.1 GTG1

The results of the GTG1 exciter system voltage response test to a +5% step change in reference voltage are displayed in Figure 9.

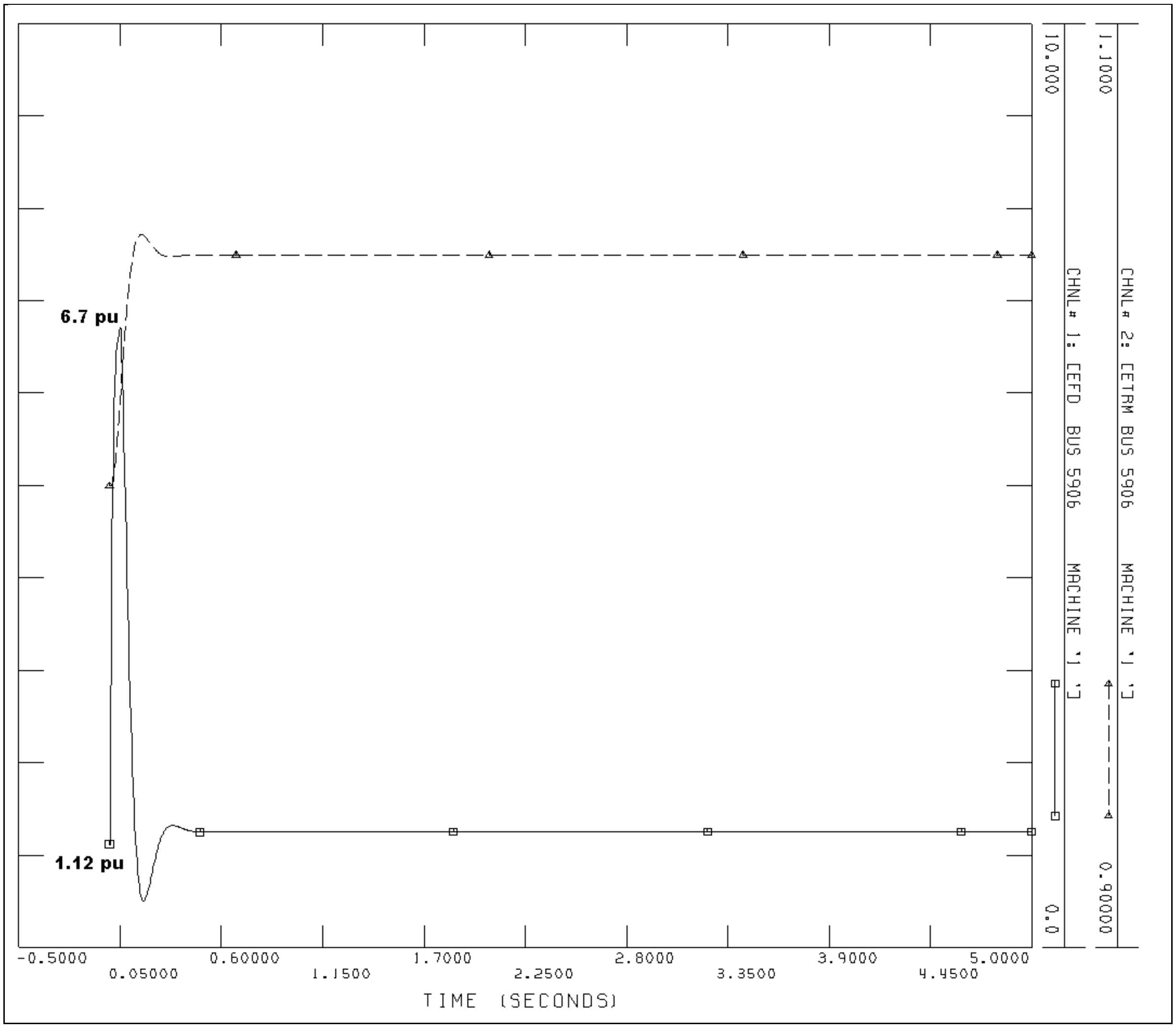

Figure 9: GTG1 Open Circuit Test Results (+5% Step Change)

Figure 9 shows that Efd_{OC} = 1.12 pu at t = 0. Therefore the required time to reach 1.95 * Efd_{rated} = 5.42 pu is:

$$RT_{OC\_POS} = 50 * \frac{1.95\ Efd_{rated} - Efd_{oc}}{1.95 Efd_{rated} - Efd_{rated}} = 81.4\ ms$$

Examination of Figure 9 shows that the exciter field voltage reaches 5.5 pu in 12.5 ms, meeting IESO requirements.

4.1.2.2 STG2

The results of the STG2 exciter system voltage response test to a +5% step change in reference voltage is displayed in Figure 10.

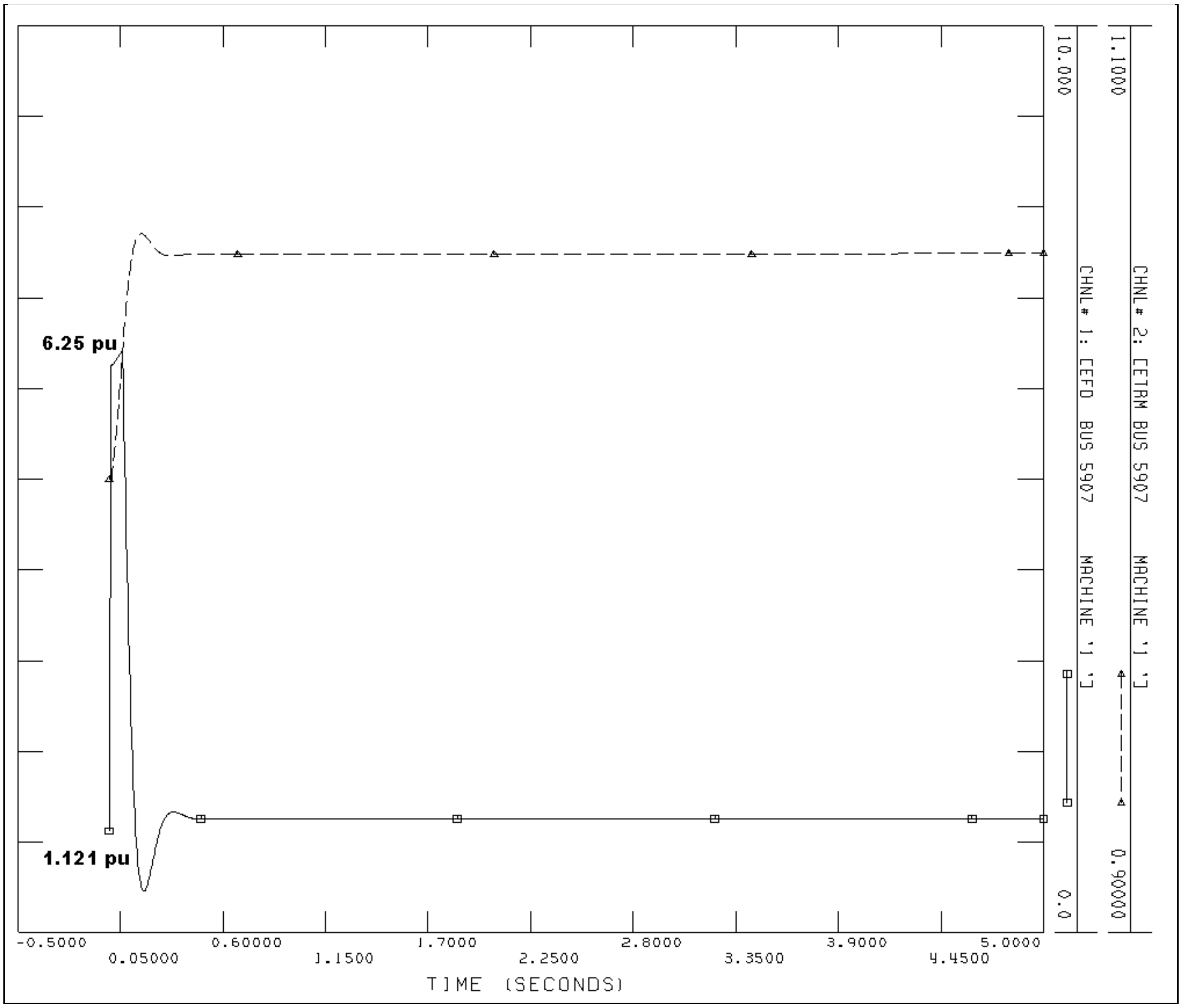

Figure 10: STG2 Open Circuit Test Results (+5% Step Change)

Figure 10 shows that Efd_{OC} = 1.121 pu at t = 0. Therefore the required time to reach 1.95* Efd_{rated} = 5.83 pu is:

$$RT_{OC\_POS} = 50 * \frac{1.95\ Efd_{rated} - Efd_{oc}}{1.95Efd_{rated} - Efd_{rated}} = 82.9\ ms$$

Examination of Figure 10 shows that the exciter field voltage reaches a positive ceiling value of 6.25 pu instantaneously satisfying IESO 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 -1.28*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.

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

4.1.3.1 GTG1

The results of the GTG1 exciter system voltage response test to a -5% step change in reference voltage is displayed in Figure 11.

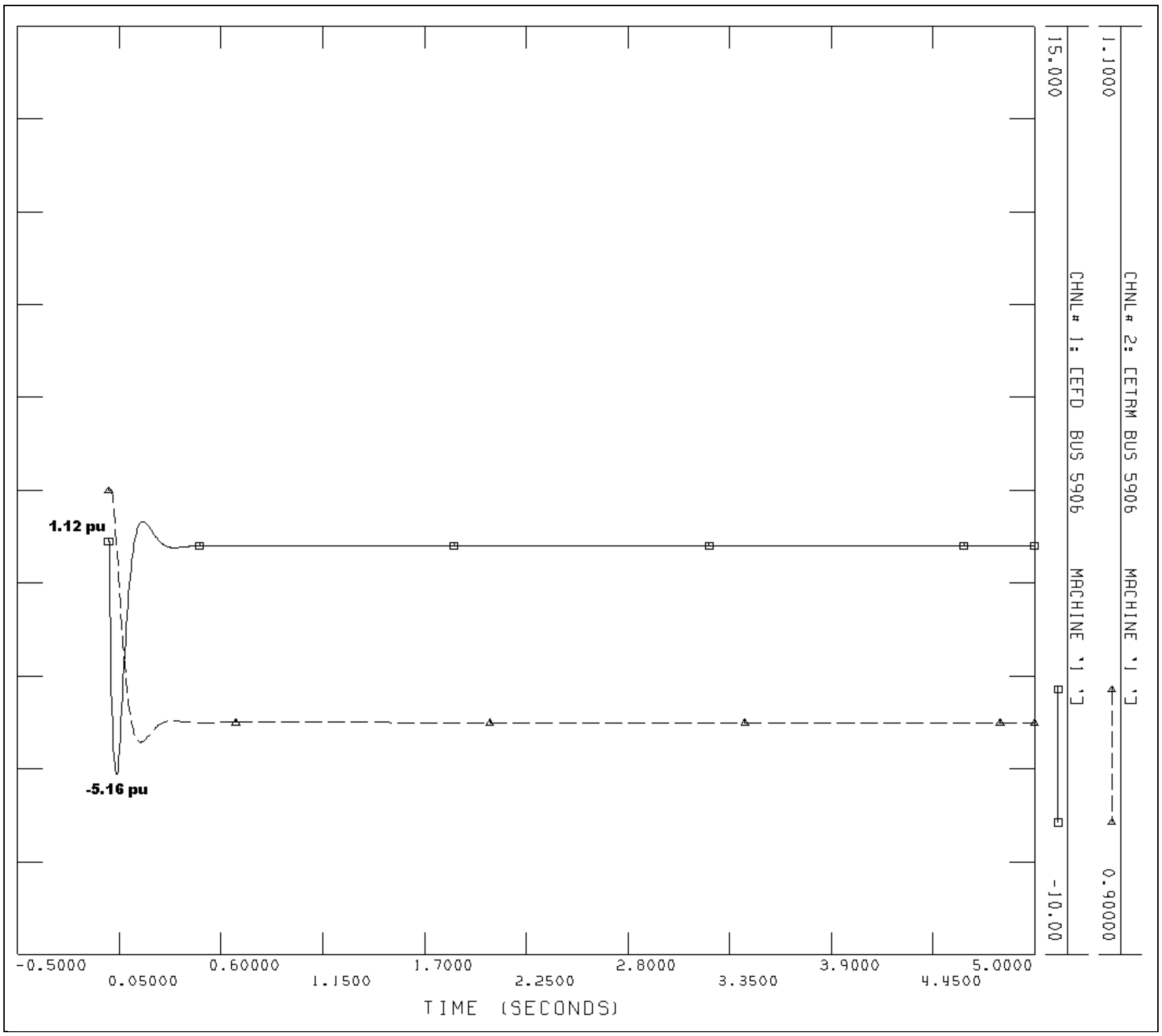

Figure 11: GTG1 Open Circuit Test Results (-5% Step Change)

Figure 11 shows that Efd_{OC} = 1.12 pu at t = 0. Therefore the required time to reach -1.28* Efd_{rated} = -3.56 pu is:

$$RT_{OC\_POS} = 50 * \frac{1.28\ Efd_{rated} + Efd_{oc}}{1.28Efd_{rated} + Efd_{rated}} = 36.9\ \text{ms}$$

Examination of Figure 11 shows that, the exciter field voltage reaches approximately 4 pu in 12.5 ms, meeting IESO requirements.

4.1.3.2 STG2

The results of the STG2 exciter system voltage response test to a -5% step change in reference voltage is displayed in Figure 12.

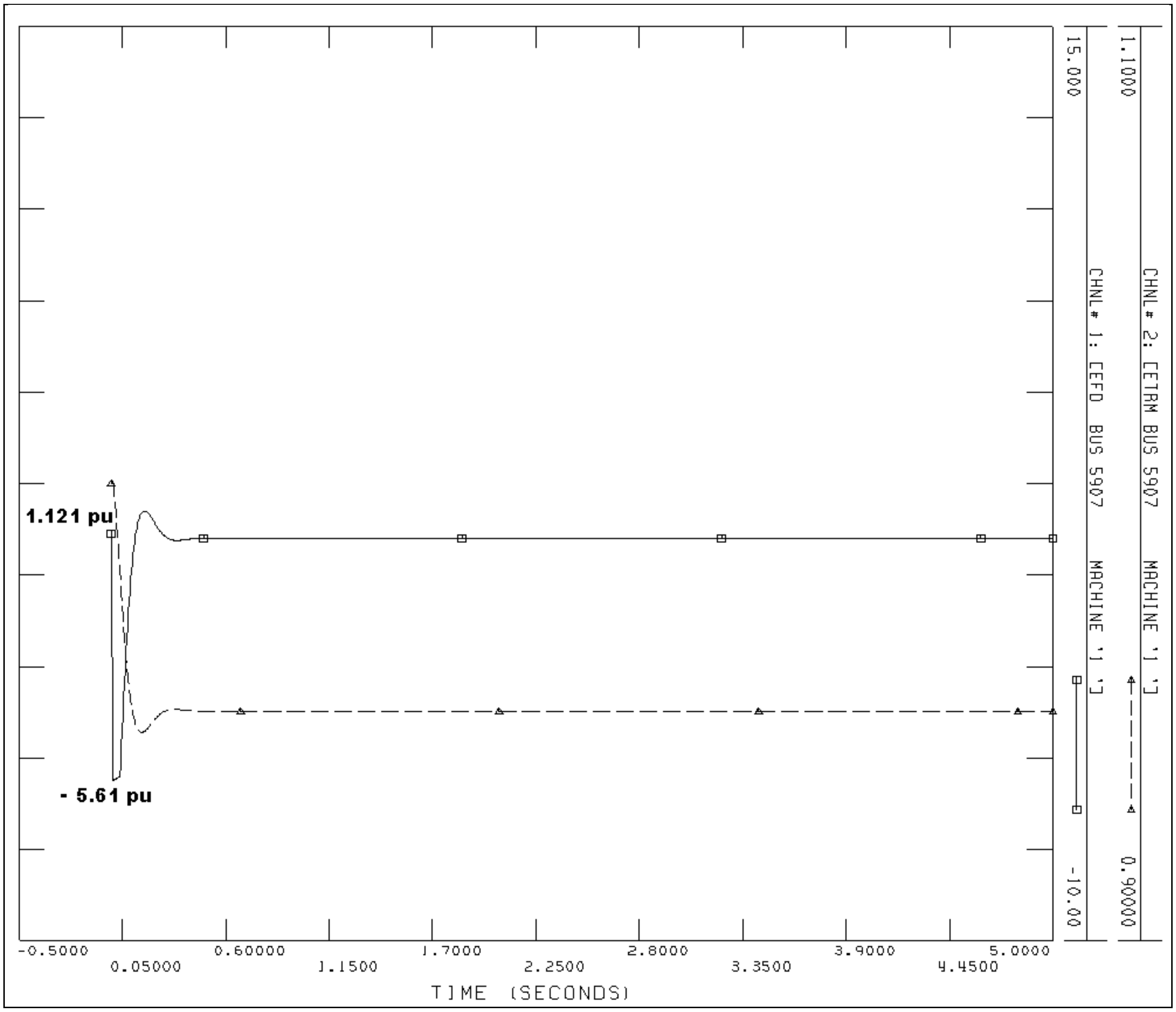

Figure 12: STG2 Open Circuit Test Results for STG (-5% Step Change)

Figure 12 shows that Efd_{OC} = 1.121 pu at t = 0. Therefore the required time to reach -1.28 * Efd_{rated} = -3.83 pu is:

$$RT_{OC\_POS} = 50 * \frac{1.28\ Efd_{rated} + Efd_{oc}}{1.28 Efd_{rated} + Efd_{rated}} = 36.3\ \text{ms}$$

Examination of Figure 12 shows that, the exciter field voltage reaches -5.61 pu instantaneously, satisfying IESO requirements.

4.1.4 Summary of Excitation System Testing

Generator	Comply with Exciter Ceiling Requirements	Comply with Exciter Response Time Requirements
Thorold GTG1	Yes	Yes
Thorold STG2	Yes	Yes

4.2 Governor Performance Study Results

Dynamic simulations were performed to verify if the transient response of the new governor meets Market Rules requirements. In this study, the generator was initially loaded to 0.5 pu and the power factor was 1. At time t = 0 seconds the load supplied by the generator was increased to 0.51 pu. The results of the governor response test to this 0.01 step change in reference load are displayed in Figure 13. Figure 13 shows a plot of both the speed deviation in per unit and the generator's mechanical power in per unit on the machine's MVA base as a function of time. Examination of the plots indicates that the steady state values for speed deviation was approximately 0.0004 pu. This corresponds to a droop of approximately 4% which satisfies the market rules requirements of 3% - 7% speed droop.

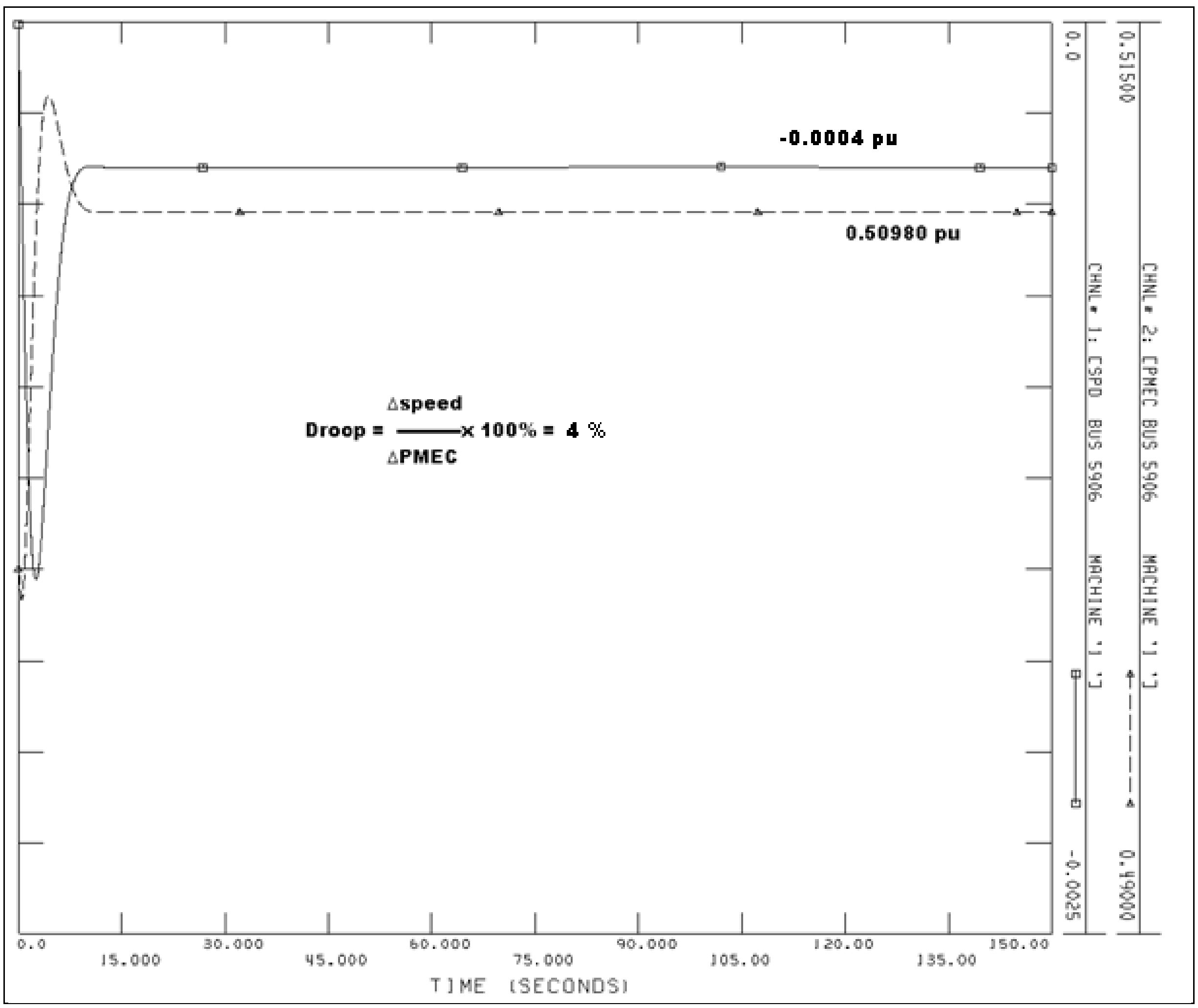

Figure 13: Governor Response Testing

4.3 Dynamic Study Results

Dynamic studies were performed to ensure stable performance and well-damped oscillations of the Thorold units during transient contingencies.

To perform the studies, two different cases were developed assuming all existing transmission facilities in-service and the following assumptions:

Parameter	Case1	Case 2
Thorold GS Output	180 + 100 = 280 MW	180 + 100 = 280 MW
Niagara Area Generation (excluding Thorold GS)	1540 MW	1780 MW
Niagara Area Load	875 MW	750 MW
Import From NY	745 MW	1155 MW
QFW Transfer	1750 MW	2500 MW
Q26M & Q35M at Middleport TS	Out-of-service	In-service

The following contingencies were studied assuming normal fault clearance:

- Contingency 1 - a simultaneous 3-phase fault on 230 kV circuits PA27 and BP76 at Beck 2
- Contingency 2 - a simultaneous 3-phase fault on 230 kV circuits Q25BM and Q23BM at Beck 2

Figures 14 and 15 show the rotor angle responses of both generators to Contingency 1, under Case 1 study conditions, with and without their PSS units in service. The results indicate that the proposed PSS units for each generator provide supplementary damping and improve rotor angle oscillations.

Figures 16-18 show the rotor angle responses of both generators to the rest of the studied contingencies under both study conditions. The figures all show stable and well damped transient behaviour for both generators.

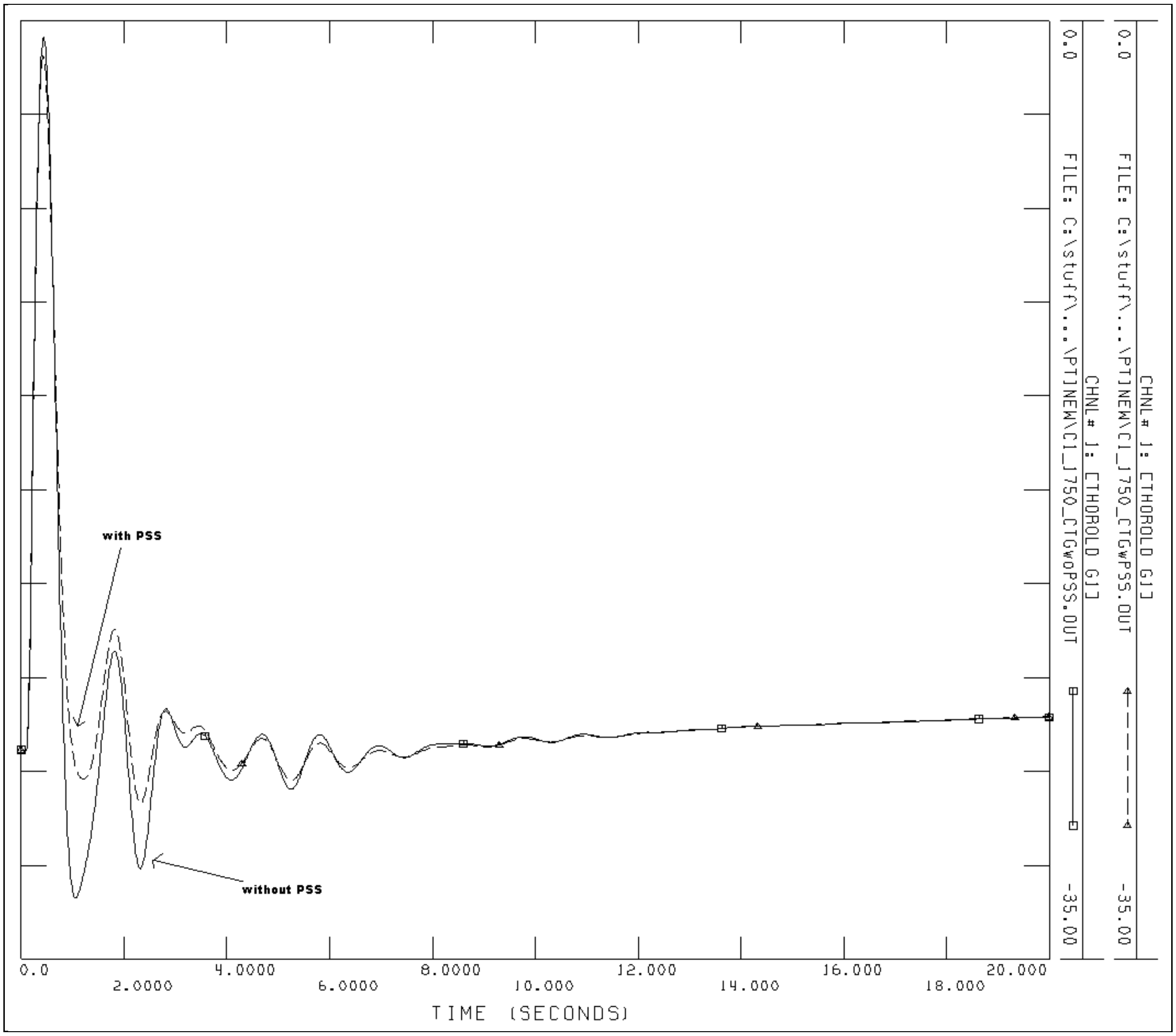

Figure 14: GTG1 Rotor Angle, Case 1, Contingency C1 with and without PSS

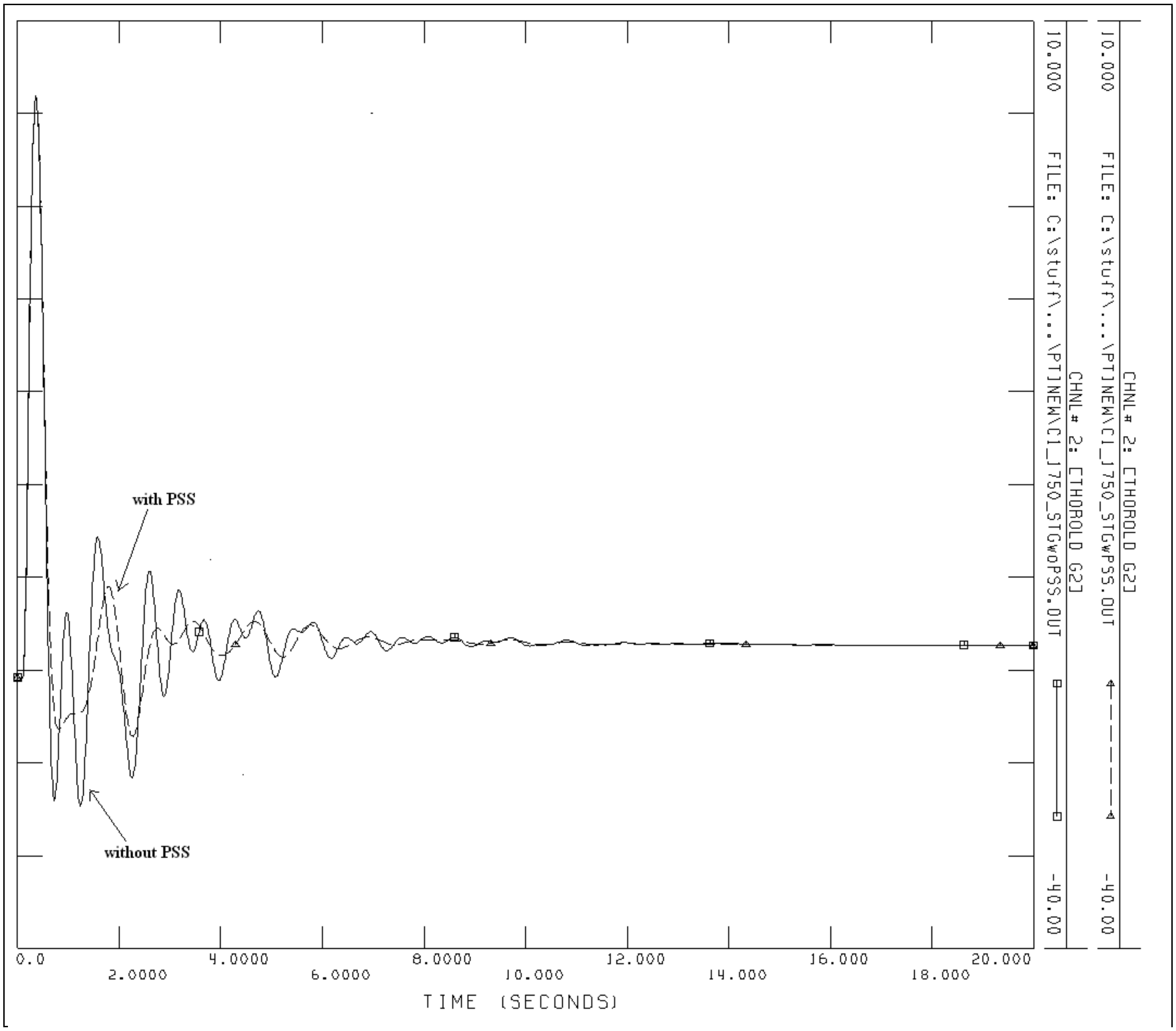

Figure 15: STG2 Rotor Angle, Case 1, Contingency C1 with and without PSS

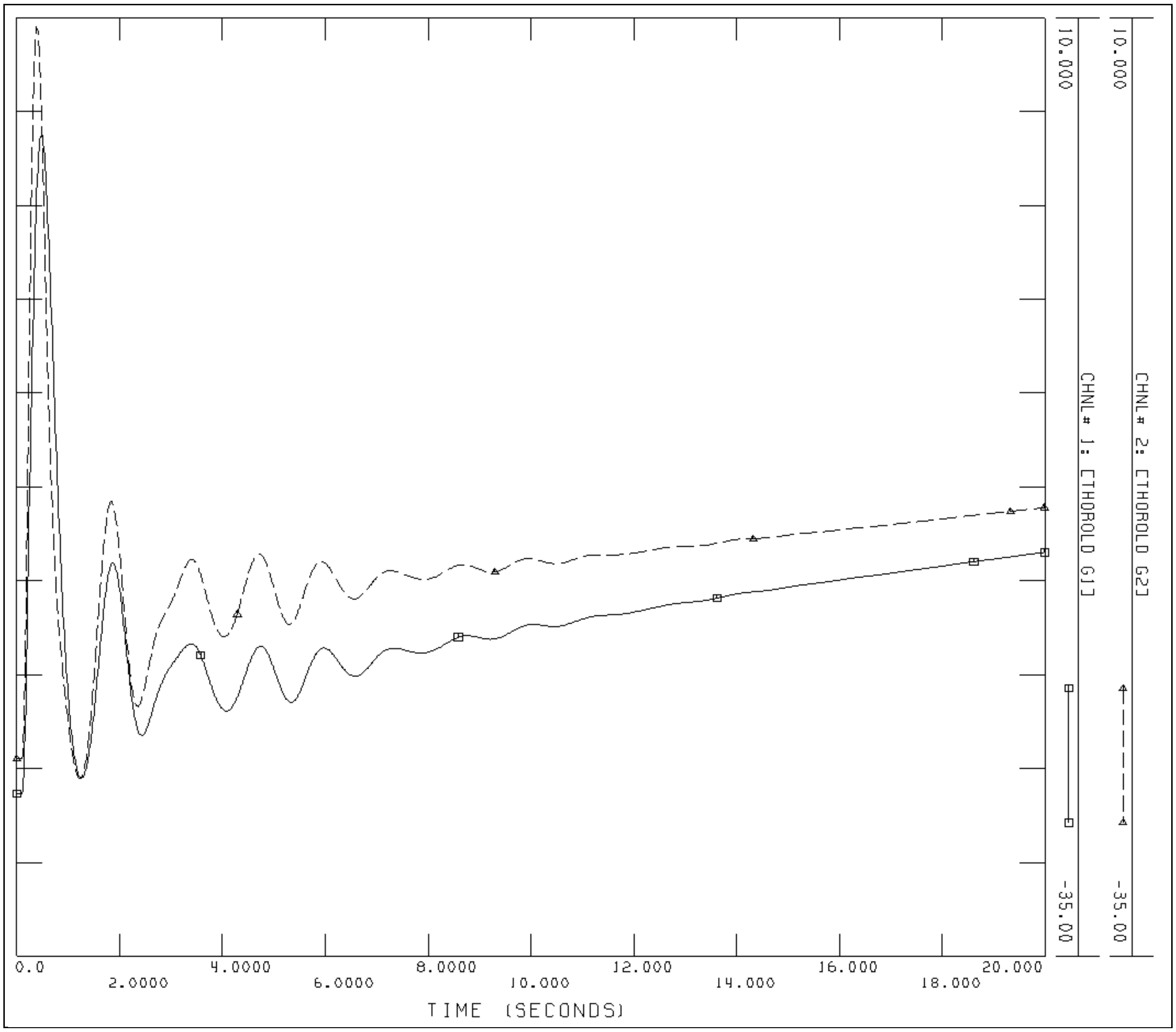

Figure 16: GTG1 + STG2 Rotor Angles, Case 1, Contingency C2

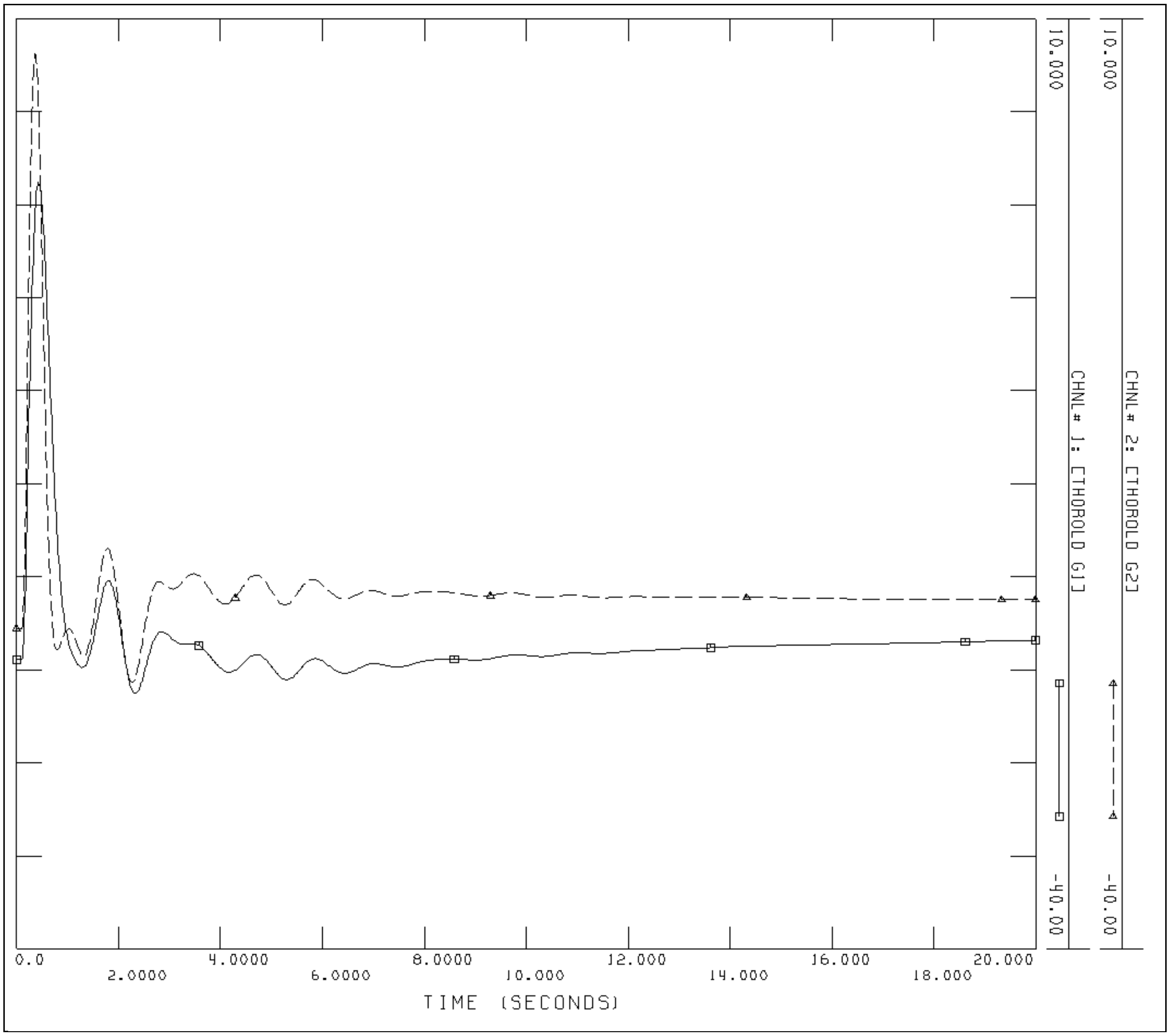

Figure 17: GTG1 + STG2 Rotor Angles, Case 2, Contingency C1

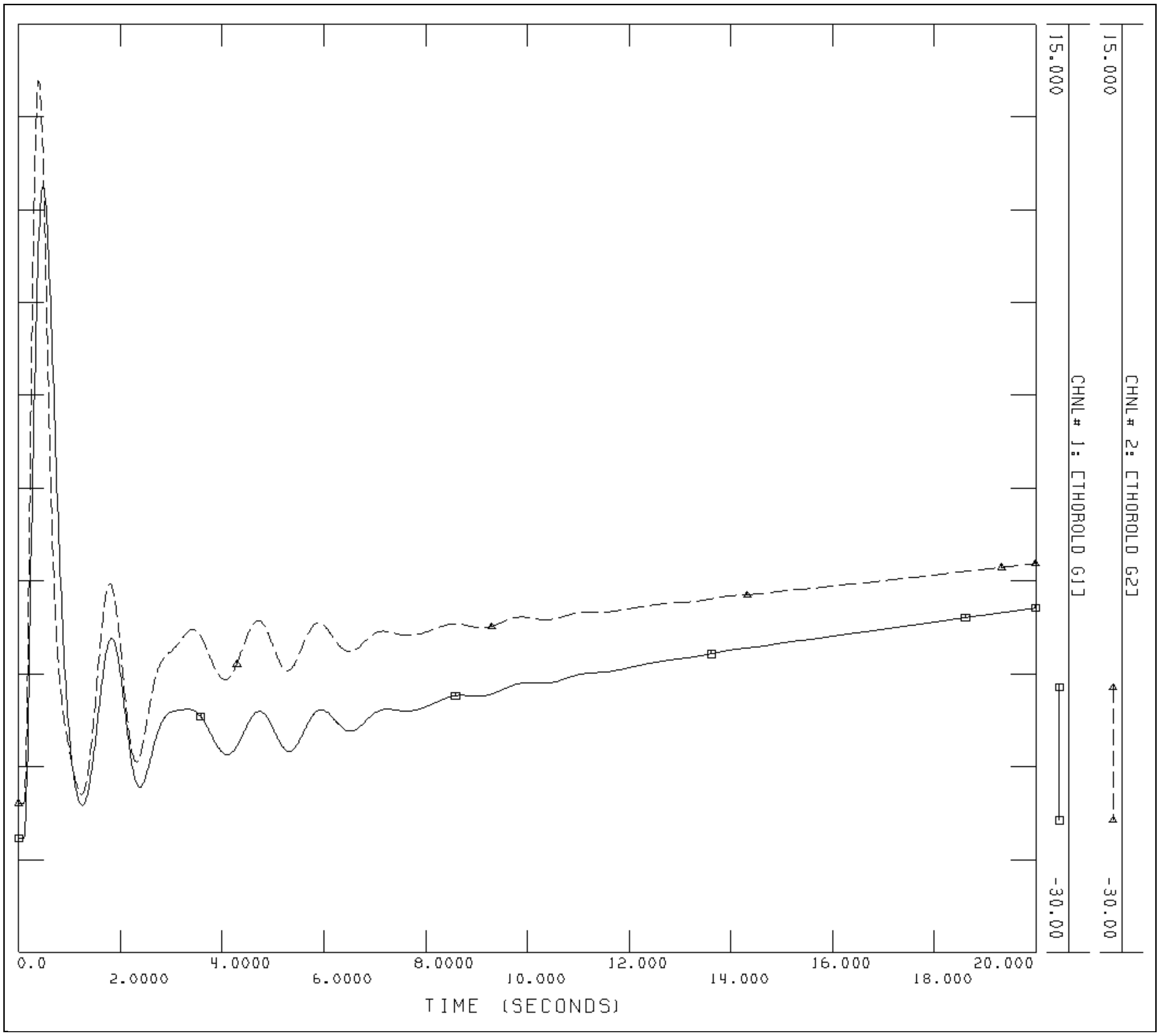

Figure 18: GTG1 + STG2 Rotor Angles, Case 2, Contingency C2

-End of Document-