IESO_REP_0437

REPORT

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System Impact Assessment Report

CONNECTION ASSESSMENT & APPROVAL PROCESS

Issue 1.0

FINAL REPORT

Project: AELP Generation Development
Applicant: Algoma Energy L.P.

CAA ID 2004-175

Transmission Assessments & Performance Department

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System Impact Assessment Report

AELP Generation Development Project

Acknowledg ement

The IESO wishes to acknowledge the assistance of Great Lakes Power Limited (GLPL) and 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, software developers, Hydro One and GLPL at the time the assessment was carried out. The IESO assumes no responsibility for the accuracy or completeness of such information, mathematical models, including the results of studies carried out by Hydro One/GLPL 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.

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.

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, 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 the connection applicant 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.

Transmitter(s)

The results given in this System Impact Assessment report are based on the information available 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.

The short circuit results are only for the purpose of assessing the capabilities of existing 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 the transmitter(s) and discussed with any connection proponent upon request.

The ampacity ratings of transmission facilities are established based on assumptions used by the transmitter (s) for power system planning studies. The actual ampacity ratings during operations may be determined in realtime 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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System Impact Assessment Report

Conclusions

This System Impact Assessment has been conducted to examine the effect of the AELP 103 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 AELP generation, will not exceed the interrupting capabilities of the existing breakers on the IESO-controlled grid.

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

4. The performance of the proposed exciter does not meet Market Rules requirements.

5. Contingency involved P21G/P22G resulted in an unacceptable voltage at Wawa TS in Flow East scenario. The output of the new generating unit at Algoma Energy should be limited at 80 MW if the gross ESAI plant load at Patrick St. is at or below the base of 105 MW.

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

7. The dynamic simulation results show that, with AELP new generator 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 AELP, subject to IESO's Requirements for Connection listed below, and any further requirements that may be identified by GLP 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 AELP 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.

1. AELP must complete the IESO Market Entry/Facility Registration process in a timely manner before IESO final approval for connection is granted. Models and data, including any controls that would be operational, must be provided to the IESO. This information should be submitted at least seven months before first connection if the proposed generator, to allow the IESO to incorporate the new facilities into IESO work systems and to perform any additional reliability studies.

   If the submitted models and data differ materially from the ones used in this assessment, then further analysis of the proposed project will need to be done by the IESO.

2. AELP is required to 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. This evidence shall be either type tests done in a controlled environment or commissioning tests done on-site. In either case, the testing must be done not only in accordance with widely recognized standards, but also to the satisfaction of the IESO. Until this evidence is provided, AELP must accept any restrictions the IESO may impose upon AELP generation.

   The evidence must be supplied to the IESO within three months of the in-service date.

3. The connection applicant is required to revise settings for the proposed exciter and ensure that the performance of the equipment meet Market Rules requirement. During the Market Entry process and prior to the connection of the new generator to the IESO-controlled grid AELP shall submit the revised settings of the exciter.

4. It is required that for under frequency system conditions, the generator does not trip for frequency variations as described in 3.4 of this report.

5. AELP must implement Under Frequency load shedding to ensure that for any operation of the islanding scheme at least an amount of load is shed equal to generation lost within their facility. During the Market Entry process and prior to the connection of the new generator to the IESO-controlled grid AELP shall submit the detailed UF setting and location as well as total load involved.

6. The facility must operate in the voltage control mode. Operation of the facility in power factor control or reactive power control is not acceptable unless required or approved by the IESO.

7. With respect to the protection and telecommunication requirements, the new generator protections will have to be coordinated with the existing schemes. The existing distribution protection settings must be revised, as required.

8. AELP is responsible for ensuring that adequate monitoring of the new facility is available according to Appendix 4 of Market Rules. The IESO will finalize items to be monitored during the IESO Facility Registration Process.

9. AELP must limit the output of the proposed generator below 80 MW if the gross ESAI plant load at Patrick St. is at or below the base of 105MW.

System Impact Assessment Report
AELP Generation Development

1. INTRODUCTION

The Algoma Energy L.P. (AELP) is proposing to develop a new generation facility (AELP GS) consisting of a steam turbine. The proposed generator will have a nameplate rating of 121 MVA at 0.85 pf. The future rated active power is expected to be 103 MW. However, the facility will be boiler limited with no current commitments to add boiler capacity so the maximum active power output of the generator will be 80 MW. The steam turbine generator will be connected to the main station of the mill via a new three phase 13.8/34.5 kV step-up transformer rated 122 MVA. The generator will be embedded in the ESSAR Steel Algoma distribution system at Patrick St TS. A single line diagram of the proposed connection is shown in Figure 1.

The predicted in service date for the project is in May 2009.

This System Impact Assessment has been conducted to examine the impact on the reliability of the IESO-controlled grid by the addition of a new 103 MW generator at AELP.

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 AELP the IESO performed studies and prepared a detailed report containing equipment performance test results, thermal analysis, voltage analysis and transient state analysis. The transient study results are attached to this SIA report as an Appendix.

– End of Section –

2. PROPOSED CONNECTION

The proposed AELP GS will consist of one 13.8 kV, 103 MW, 3600 rpm round rotor steam generator. The generator is to be connected to the 34.5 kV bus the main station of the mill via a 13.8/34.5 kV step-up transformer. Thus the new generator will be embedded in AELP distribution system at Patrick St. TS.

Patrick St. TS has six transformers supplying the local load. Transformers 10T1, T6 and T7 supply power to Bus 10 Feeder and Praxair Substation while transformers T1, T2 and T3 provide power to the loads at Buses 301 310, 306, 304, 307 302. The proposed new generation unit will be connected to a new 313 bus which is between Bus 302 and 304.

The Patrick St. TS is connected to the GLP Third Line TS through three 115 kV circuits: #1 Algoma, #2 Algoma and #3 Algoma. The Third Line TS is connected to the Hydro One's Mississagi TS via 230 kV circuits P21G/P22G and to GLP's Mackay via 230 kV circuit K24G.

The proposed connection arrangement of AELP GS as well as the existing local distribution and transmission system is shown in Figure 1.

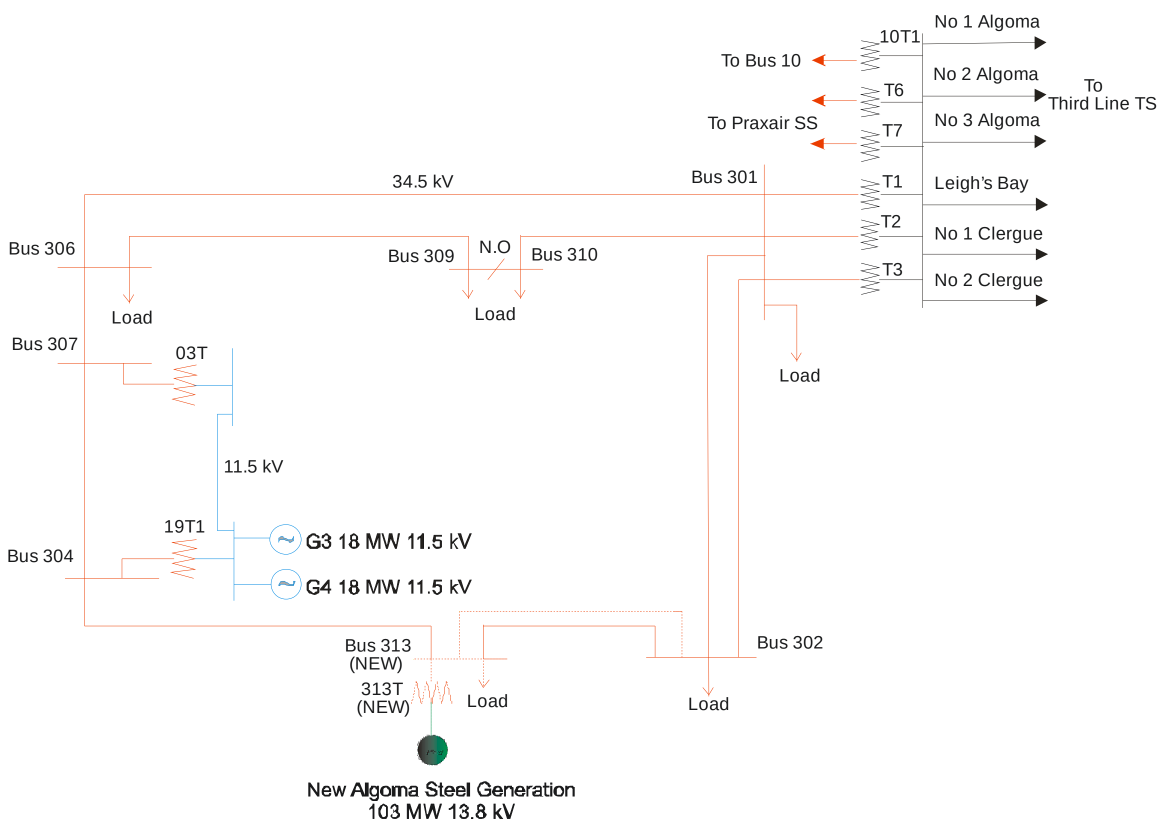


Figure 1. Proposed AELP Generation Connection Diagram

– End of Section –

3. GENERATION STATION ASSESSMENTS

3.1 MODEL AND DATA VERIFICATION

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.

3.1.1 GENERATOR MODEL

The proposed generator has a rated active power of 103 MW at a power factor of 0.85. It will be driven by a 3600 RPM steam turbine with digital governor control. The data for the generator model GENROU are given in Table 1.

Table 1. Generator Parameters

Description	Value	Description	Value
X_d	2.13	T''_{do}	0.05
X_q	1.96	T''_{qo}	0.05
X'_d	0.22	X_l	0.108
X''_d	0.155	X_2	0.151
R_a	0.07	X_0	0.083
T'_{do}	13.1	S(1.0)	0.125
H	2.02	S(1.2)	0.526

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 active 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.

The connection applicant confirmed that although their facility will be boiler limited and the maximum active power output of the generator will 80 MW, the proposed generator will be able to produce full rated reactive power based on rated active power (103 MW).

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

3.1.2 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.

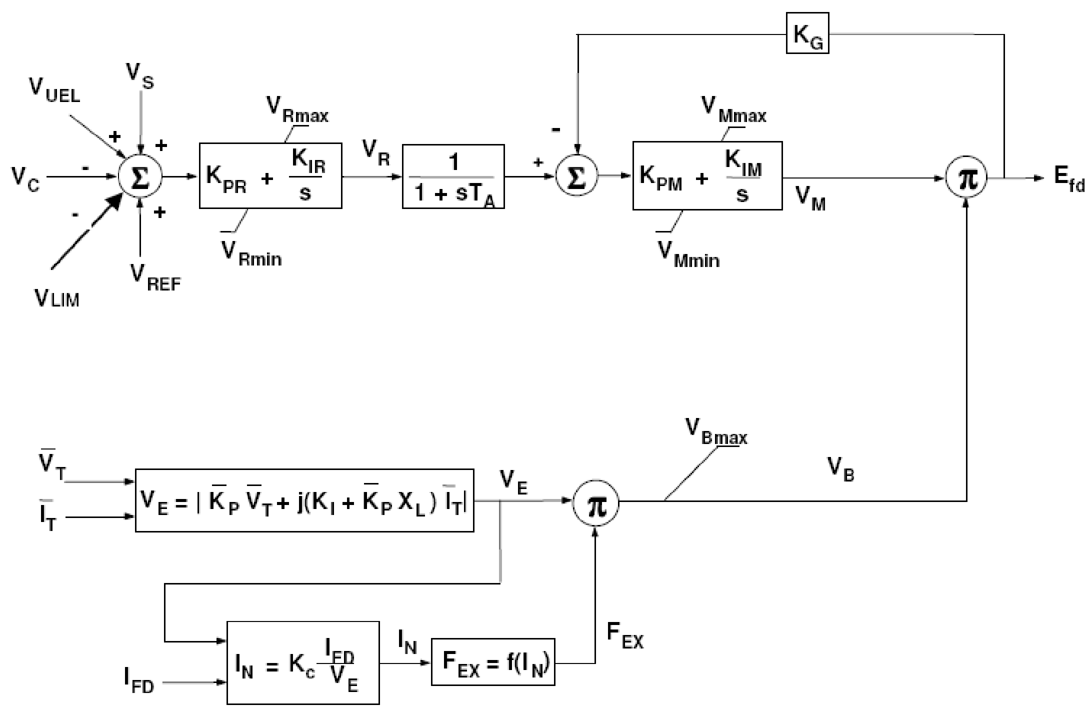


Figure 2. Block Diagram of Excitation System

Table 2. Excitation (ST4B) Parameters

Description	Parameter	Value	Units
Voltage regulator proportional gain	K_{PR}	50	
Voltage regulator integral gain	K_{IR}	25	
Voltage regulator proportional gain	K_{PM}	1	
Voltage regulator integral gain	K_{IM}	0	
Feedback gain constant of the inner loop field regulator	K_G	0	
Voltage regulator time constant	T_A	0.03	Sec
Maximum voltage regulator output	V_{Rmax}	5.9	p.u
Minimum voltage regulator output	V_{Rmin}	-4.7	p.u
Maximum voltage regulator output	V_{Mmax}	5.9	p.u
Minimum voltage regulator output	V_{Mmin}	-4.7	p.u

Available exciter voltage	V_{Bmax}	1.0	p.u
Potential circuit gain coefficient	K_I	0	
Reactance associated with potential source	X_L	0	
Potential circuit gain coefficient	K_P	1.1	
Rectifier loading factor proportional to commutating reactance	K_C	0.029	

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

- A voltage response time not 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.

The results of the exciter system voltage response test to a 5% step change in reference voltage are displayed in *Automatic Excitation System Performance* section in the Appendix. Examination of the plots indicates that the exciter field voltage reaches 95% of the excitation ceiling voltage in about 53 ms, thus violating the above-mentioned requirements.

The results of the exciter system response ratio test shown in the Appendix indicate that the exciter ceiling voltage exceeds the Market Rules requirements. The test results show that the ceiling voltage is 5.9 pu which is above 200% of the rated 2.8 pu. Thus, the exciter meets the voltage response time and ceiling voltage requirements given in Appendix 4.2 of Market Rules.

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

The connection applicant is required to revise settings for the proposed exciter as required to ensure that the performance of the equipment that is eventually supplied and installed meet Market Rules requirement. During the Market Entry process and prior to the connection of the new generator to the IESO-controlled grid AELP shall submit the revised settings of the exciter.

3.1.3 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 IEEE Standard Governor. The block diagram of this model and the data for the governor model used in this study are shown in Figure 3 and Table 3, respectively.

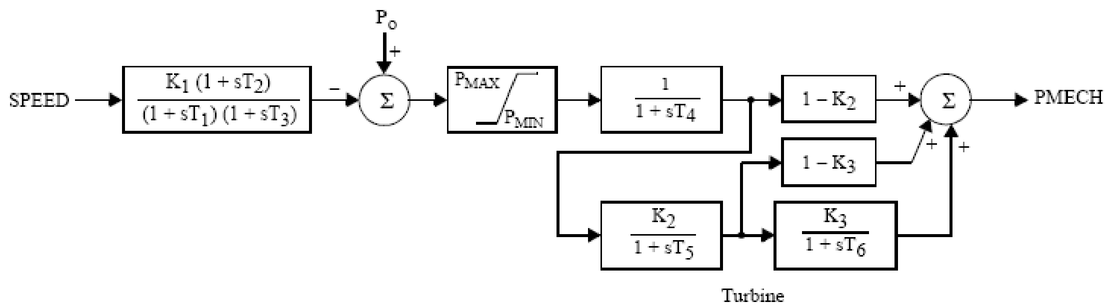


Figure 3. Block Diagram of Speed Governor

Table 3. IEEE Standard Governor Parameters

Description	**Parameter**	**Value**	**Units**
Controller lag	T_1	0.004	Sec
Controller lead compensation	T_2	0.02	Sec
Governor lag (>0)	T_3	0.35	Sec
Delay due to steam inlet volumes associated with steam chest and inlet piping	T_4	0.06	Sec
Reheater delay including hot and cold leads (sec)	T_5	0	Sec
Delay due to IP-LP turbine, crossover pipes, and LP end hoods	T_6	0	Sec
1/per unit regulation	K_1	20	
Fraction	K_2	0	
Fraction	K_3	0	
Upper power limit	P_{MAX}	102.7	
Lower power limit	P_{MIN}	0	

Simulations were performed to test the transient response for the given governor model and the results are attached in the Appendix. The results showed that the parameters were tuned to give reasonable damping and the governor has a droop of 4% thus meeting Market Rules' requirements.

3.1.4 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."

AELP provided PSS2B model but without the parameter settings. The block diagram of this stabilizer is shown in Figure 4. AELP confirmed that the setting will be provided to the IESO after the commissioning.

For the purpose of assessment, typical settings for PSS2B as shown in Table 4 were used in the simulations.

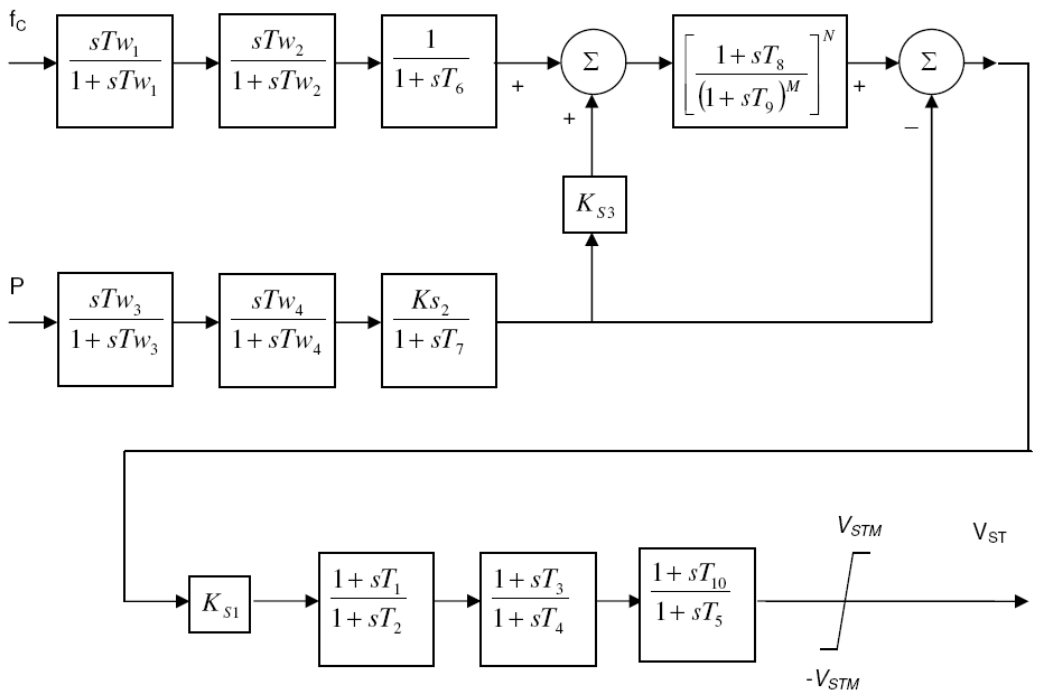


Figure 4. Block Diagram of PSS

Table 4. PSS/E PSS2B Parameters

Description	Parameter	Value	Units
Total PSS Gain	K_{s1}	10	p.u.
Power Branch Gain	K_{s2}	0.8518	p.u.
Power Signal to Frequency Branch Adding Gain	K_{s3}	1	p.u.
Washout Time Constant	T_{w1}	2	sec
Washout Time Constant	T_{w2}	2	sec
LP Filter Time Constant	T_6	0	sec
Washout Time Constant	T_{w3}	2	sec
Washout Time Constant	T_{w4}	0	sec
LP Filter Time Constant	T_7	2	sec
Torsional Filter Time Constant	T_8	0.5	sec
Torsional Filter Time Constant	T_9	0.1	sec
Grade of Torsional Filter	M	5	
Grade of Torsional Filter	N	1	
Phase Lead Time Constant	T_1	0.6	sec
Phase Lag Time Constant	T_2	0.015	sec
Phase Lead Time Constant	T_3	0.05	sec
Phase Lag Time Constant	T_4	0.01	sec
Phase Lag Time Constant	T_5	5.0	sec
Phase Lead Time Constant	T_{10}	0.6	sec
PSS Output Limit	V_{STMAX}	0.1	p.u.
PSS Output Limit	V_{STMIN}	-0.1	p.u.

As soon as the commissioning tests are completed and actual data is available, the connection applicant is required to provide an updated block diagram model and data of the PSS. The IESO will perform additional studies to verify the behaviour of the PSS and establish the need for any new controls and adjustments, as part of the Facility Registration Process.

3.1.5 STEP-UP TRANSFORMER

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

Transformation	34.5/13.8 kV
Continuous rating	73/97/122 MVA
Impedance	8% based on 73 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%)

3.2 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:

- status of terminal breaker of the proposed generator
- active power outputs of the proposed generator
- total net MW load at AELP and the MW load included in the islanding scheme and associated UF scheme

AELP 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.

3.3 PROTECTION SYSTEM REQUIREMENTS

With respect to the protection and telecommunication requirements, the new generator protections will have to be coordinated with the existing schemes. AELP has the obligation to revise protection settings at the generation facility interconnection point to ensure that they are coordinated with the distribution system protections. The existing distribution protection settings must be revised, as required.

3.4 GENERATOR UNDER FREQUENCY TRIPPING REQUIREMENT

The Market Rules (Appendix 4.2) require that the generators be able to operate continuously at full power for system frequencies between 59.4 to 60.6 Hz. For under-frequency system conditions, the generators shall not trip for frequency variations that are above the curve shown in Figure 5.

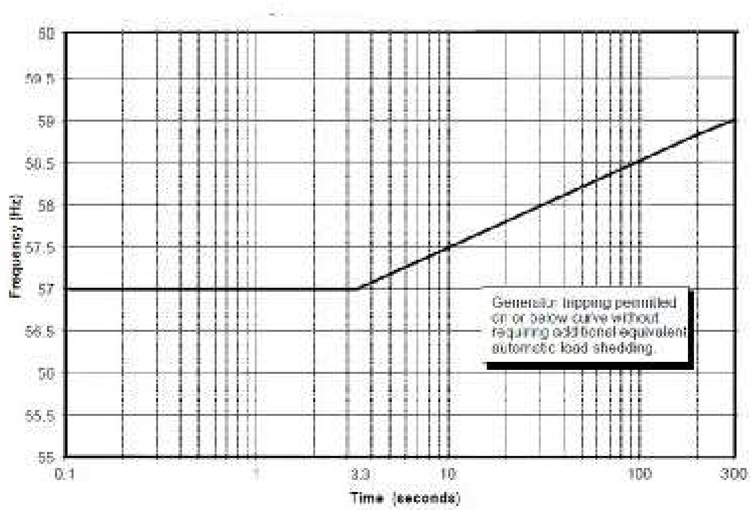


Figure 5. Standard for Setting Underfrequency Trip Protection

It is required that for under-frequency system conditions, the new generator shall not trip for frequency variations that are above the curve shown in Figure 5.

AELP confirmed that the above requirement for generator under frequency tripping would be respected.

3.5 ISLANDING SCHEME

AELP is proposing to install a scheme to form an island which will include about 55 MW load, the existing 2×18 MW generators and the proposed 103 MW generator. The islanding scheme is designed based on under frequency and over frequency protections with the following settings:

- UF = 59.5 Hz, t = 0.1s
- OF = 60.25 Hz, t = 0.5s

The islanding scheme could result in a reduction of about 80 MW generation from the perspective of the IESO-controlled grid when the system frequency drops to 59.5 Hz which violates the requirement in 3.4 for generator under frequency tripping. AELP is proposing to implement UF load shedding to ensure that during a UF event an amount of load is shed equal to generation lost within their facility.

> AELP must implement Under Frequency load shedding to ensure that for any operation of the islanding scheme at least an amount of load is shed equal to generation lost within their facility. During the Market Entry process and prior to the connection of the new generator to the IESO-controlled grid AELP shall submit the detailed UF setting and location as well as total load involved.

The IESO understand that the UF load shedding will be installed and available with the new generator in service. Should the UF not be implemented and operational when the new generator is in service, the IESO may restrict the output of the generation to a value equivalent to the amount of load in the potential island.

3.6 UNDERFREQUENCY LOAD SHEDDING

The Market Rules (Chapter 5 section 10.4) require that each distributor and connected wholesale customer, in conjunction with the relevant transmitter, make arrangements to enable the automatic disconnection of up to 35% of its peak demand for conditions of system under-frequency.

GLP confirmed that ESSAR Steel Algoma Inc. (ESSAR Steel Algoma) distribution system is not part of the UFLS at GLP. Therefore For the new unit will not be tripped with the shedding load and the load tripped with the islanding scheme will not be counted in this UF loading shedding.

3.7 PACTRICK ST. TS POWER FACTOR

The Market Rules require that wholesale customers and distributors connected to the IESO-controlled grid shall operate at a power factor within the range of 90% lagging to 90% leading as measured at the defined meter point.

The operation records indicated an average power factor of 0.94 at Patrick St. TS meeting Market Rules requirements.

As indicated by the connection applicant, the proposed generation unit will operate in the voltage control mode. By operating in the voltage control mode, the proposed AELP facility will generate about 100 MW active power and 50 MVAr reactive power when the load at Essar Steel Algoma is high and the output of other generation in GLP is low. In this case the power factor will remain above 0.9. However, when the load at AELP is base load and other units in GLP are at full output, the proposed AELP generator will inject about 100 MW active power and only 3-5 MVAr reactive power. Thus the active power as measured at the Patrick St. TS defined meter point would be reduced, while the reactive power would remain roughly unchanged. Under these conditions, the load power factor at Patrick St. TS, as measured at the defined meter point, would become lower. However, since the output of generation is maximum and the load is base load in the area the voltage is not a concern.

Since the violation of power factor requirements occur only when the voltages in the area are high, it will not be necessary to install shunt capacitors and a lower power factor would be allowed.

3.8 IMPORTANT NOTE ON MODELS AND DATA

The four components used to model the new generation include a synchronous generator model (GENROU), an excitation model (ST4B), a power system stabilizer model (PSS2B), and a governor model (IEESGO). Typical data provided by AELP for these models are used in this assessment.

AELP must complete the IESO Market Entry/Facility Registration process in a timely manner before IESO final approval for connection is granted. Models and data, including any controls that would be operational, must be provided to the IESO. This information should be submitted at least seven months before first connection of the proposed generator, to allow the IESO to incorporate the new facilities into IESO work systems and to perform any additional reliability studies.

If the submitted models and data differ materially from the ones used in this assessment, then further analysis of the proposed project will need to be done by the IESO.

AELP 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. This evidence shall be either type tests done in a controlled environment or commissioning tests done on-site. In either case, the testing must be done not only in accordance with widely recognized standards, but also to the satisfaction of the IESO. Until this evidence is provided, AELP must accept any restrictions the IESO may impose upon the connection of the proposed generator.

The evidence must be supplied to the IESO within three months of the in-service date.

– End of Section –

4. ANALYSIS OF SHORT CIRCUIT CURRENT

Fault level studies were completed by GLP to specifically examine the effect of the AELP generation project on fault levels at existing facilities. The studies were performed with following assumptions:

- All transmission elements, Prince Wind Farm and all local generation in service
- Transmission Reinforcement project and new Gartshore TS complete
- Pre-fault bus voltage: 260 kV for 230 kV buses and 132 kV for 115 kV buses
- Breaker opening time = 50 ms for asymmetrical

Table 5 summarizes the fault levels including both symmetric and asymmetric fault currents in kA near Algoma Energy generation.

Table 5 Fault Levels Near Algoma Steel Generation

BUS BAR		Symmetrical Fault Current in KA		Asymmetrical Fault Current in KA	
		3-phase	L-G	3-phase	L-G
230 kV Bus Third Line	Existing	8.12	9.31	8.37	9.49
	With New Gen.	8.67	9.78	8.90	9.93
115 kV Bus Third Line	Existing	14.02	18.82	14.55	19.43
	With New Gen.	15.64	20.74	16.14	21.30
115 kV Bus Patrick St	Existing	13.46	17.17	14.13	17.90
	With New Gen.	15.29	19.12	16.02	19.89
115 kV Bus Clergue TS	Existing	12.55	14.21	12.87	14.68
	With New Gen.	14.02	15.44	14.27	15.85
230 kV Bus MacKay TS	Existing	5.38	5.10	5.53	5.10
	With New Gen.	5.47	5.16	5.62	5.16
115 kV Bus MacKay TS	Existing	7.66	9.52	8.06	9.77
	With New Gen.	7.75	9.61	8.14	9.85
230 kV Bus Wawa TS	Existing	6.61	6.55	6.75	6.83
	With New Gen.	6.67	6.59	6.80	6.87
230 kV Bus Mississagi TS	Existing	10.94	10.63	11.86	11.58
	With New Gen.	11.18	10.78	12.09	11.72

The results in Table 5 show that there is a slight increase in fault currents with the addition of the AELP generation. The interrupting capabilities of the existing breakers at the stations listed in Table 5 were checked and it was found that generally the fault levels with the proposed AELP project are below the interrupting capabilities of the existing breakers but there are instances where the SC magnitudes are encroaching on the interrupting limits. GLP has advised that these older breakers are being replaced in 2008/2009 and 2010 and will all have at least a 40 kA interrupting capability.

– End of Section –

5. CONNECTION ASSESSMENT STUDIES

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

5.1 STUDY ASSUMPTIONS

5.1.1 SIMPLIFIED SYSTEM IMPEDANCE SKETCH

The proposed Algoma Energy generating unit will be embedded in ESSAR Steel Algoma Inc. (ESSAR Steel Algoma) distribution system at St. Patrick TS. The proposed connection arrangement of Algoma Energy GS as well as the existing ESSAR Steel Algoma distribution, ESSAR Steel Algoma transformation station and GLP transmission system was shown in Figure 1.

The distribution system is not presented in the IESO's base case. Since this SIA study is focused on the impact on the transmission system, the distribution system at ESSAR Steel Algoma is simplified as shown in Figure 6 and incorporated in the base case as provided by the proponent.

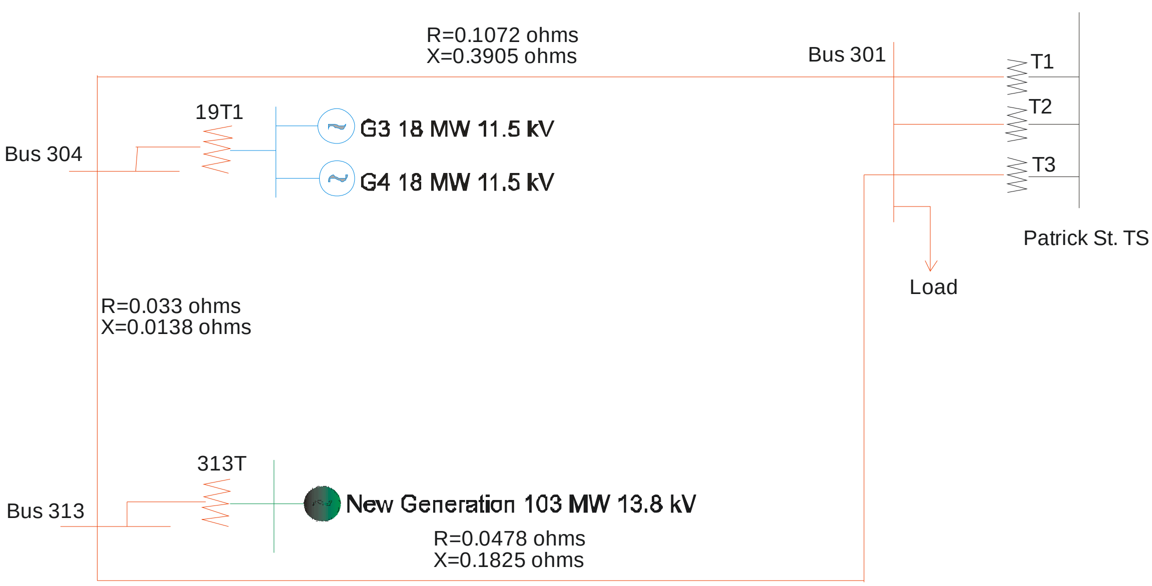


Figure 6. Simplified Distribution System

It should be noted that all the loads shown in Figure 1 were aggregated to one load at Bus 301.

The impedances of the equivalent circuits were shown in the figure and the impedances of the transformers are shown in Table 7.

Table 7 Transformer Impedance

Transformer	Base MVA	%Z	X/R
301T1	60	6.78	30
301T2	60	6.8	30
301T3	30	9.1	25
19T1	25	6.9	25
313T	73	8	40

Although the maximum active power output of the generator will be 80 MW due to boiler limitation, the rated active power of 103 MW was used in this study.

5.1.2 LOAD AT PATRICK ST TS

The IESO operation records indicated a large swing for the load at Patrick St. TS. The following graphs show the MW and MVAr flows through six transformers at Patrick St. TS in 5 seconds average samples during the period of 22:00 – 24:00 March 6, 2007.

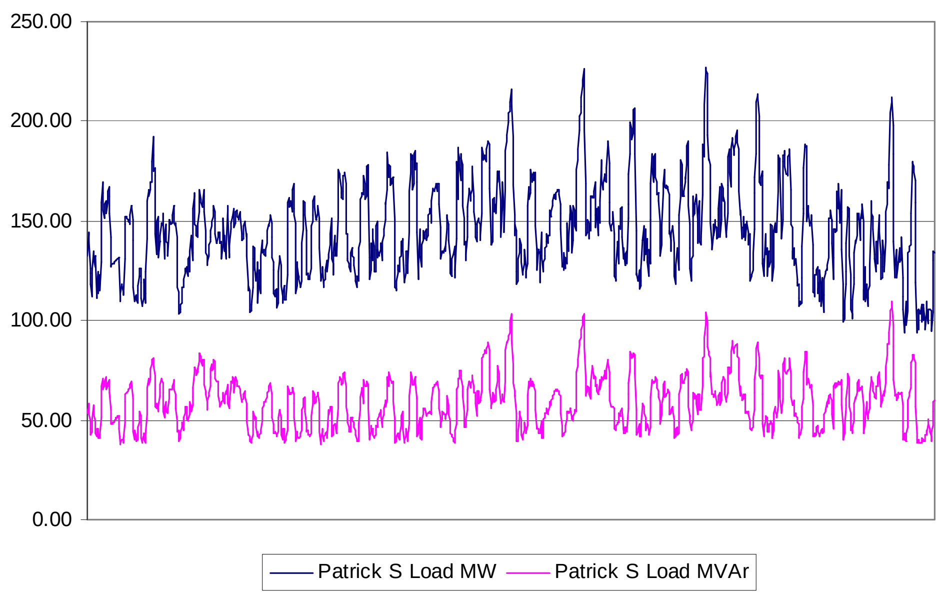


Figure 7 Power Flow at Patrick St. TS on March 6, 2007

It can be seen that it took less than 1 minute for the load to go from 120 MW to 220 MW and less than one minute to return to 120 MW. The proponent indicated that they have three facilities that contribute the majority of the load swings. To get a 100 MW swing would required at least the larger two in service which are connected behind bus 301. The third one which can caused about 20 MW power swing is connected at bus 312.

The IESO operation records also indicated the base load at Patrick St. TS on May 3, 2007. The following graphs show the MW and MVAr flows through six transformers at Patrick St. TS in 5 seconds average samples during the period of 9:00 – 11:00 May 3, 2007.

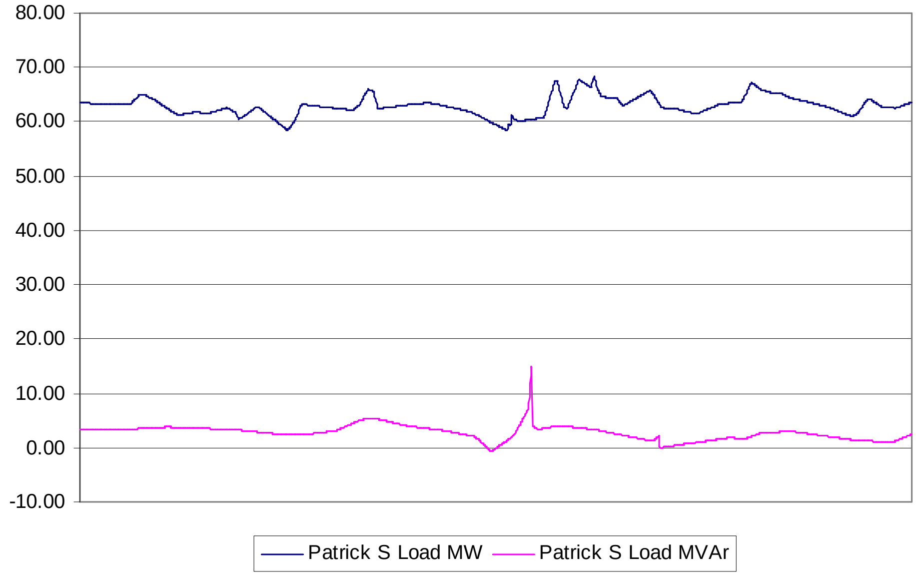


Figure 8 Power Flow at Patrick St. TS on March 6, 2007

It should be noted that the load shown in the graphs are seen after the displacement from G3 and G4. As indicated by AELP, G3 and G4 generally run around 25 MW.

The operation records indicated an average power factor of 0.94 at Patrick St. TS. A power factor of 0.9 will be assumed for the load at Patrick St. TS.

Based on the IESO operation records and information provided by AELP, three different levels of load will be used in this SIA study as shown in Table 7.

Table 7 Loads at Patrick St. TS

	Bus 301		10T1		T6&T7		Total	
	MW	MVAr	MW	MVAr	MW	MVAr	MW	MVAr
Load 1 (Peak)	222.0	107.4	15.0	7.3	15.0	7.3	252.0	122.0
Load 2 (Peak Base)	110.0	53.2	15.0	7.3	15.0	7.3	140.0	67.8
Load 3 (Base)	90.0	43.6	7.5	3.6	7.5	3.6	105.0	50.8

5.1.3 STUDIED CASES

The winter 2007-2008 base case was used as a starting point for the analysis. The system generation MW dispatch pattern and phase shifters were adjusted to achieve acceptable maximum flow levels across the Wawa and Mississagi interfaces. Thus two cases for maximum transfers at Wawa TS and Mississagi TS were derived:

1. Flow West: 500 MW flow west at Mississagi TS on A23P, A24P, and X74P, or 350 MW flow west at Wawa TS on W21M and W22M.

2. Flow East: 550 MW flow east at Mississagi TS on A23P, A24P, and X74P, 490 MW flow east on P25/26W and K24G or 325 MW flow east at Wawa TS on W21M and W22M.

System generation MVAR dispatch pattern and the status of shunt elements were adjusted to achieve acceptable bus voltage levels. The minimum base case voltages for the 230 kV buses in NW as indicated in SCO are shown in Table 8.

Table 8 Minimum 230 kV Voltage in NW

230 kV Station	Minimum Voltage (kV)
Kenora, Fort Frances, Dryden, Mackenzie	230
Lakehead, Marathon, Wawa, Third Line, Mississagi, Algoma	235

For thermal studies, the new unit at Algoma Energy GS and the existing units at Clergue GS, Lake Superior Power and Prince WGS were at full output. For voltage decline studies, the new unit at Algoma Energy GS was at full output while all other units in that area were at minimum output. In addition, in the voltage decline studies the active power loads were converted into constant current and constant admittance loads equally and the reactive power loads were converted only into constant admittance loads.

5.2 THERMAL STUDY

This section covers an investigation of thermal capability of 230 kV and 115 kV circuits in NW with the addition of Algoma Energy generating unit.

The criteria applied in assessing the thermal loading capability of the 230 kV circuits is the following:

- With all elements in-service, loading of any line shall be within their continuous rating.

- For the single circuit contingency, post-contingency flow on any circuit shall not exceed the limited time rating (LTR).

The ratings used to evaluate the thermal capability of the local transmission system provided by GLPL and Hydro One are shown in Table 9. The ratings were calculated for the summer peak conditions, i.e. temperature of 30°C, wind speed of 4 km/h and for the day time. Pre-load dependant LTRs were calculated assuming circuit pre-contingency loading of 75%.

Table 9 Thermal Ratings (Amps/MVA)

No. 1 Algoma		No. 2 and 3 Algoma		P21G/P22G		K24G/W23K	
Continuous	**LTR**	**Continuous**	**LTR**	**Continuous**	**LTR**	**Continuous**	**LTR**
538/107	578/115	672/134	751/150	983/392	1089/434	1265/504	1955/779
P26W		**W22M**		**A24P**		**X74P**	
Continuous	**LTR**	**Continuous**	**LTR**	**Continuous**	**LTR**	**Continuous**	**LTR**
810/323	1000/399	810/323	1000/399	1257/501	1445/576	1216/484	1795/715

There are ten element-out contingencies, defined in Table 10.

Table 10 Element-out Contingencies

No.	Definition
VC1	Loss of No 1 Algoma (Patrick St-Third Line, 115 kV)
VC2	Loss of No 2 Algoma (Patrick St-Third Line, 115 kV)
VC3	Loss of P21G (Third Line-Missisagi, 230 kV)
VC4	Loss of P21G/P22G (Third Line-Mississagi, 230 kV)
VC5	Loss of K24G (Third Line-MacKay, 230 kV)
VC6	Loss of W23K (Wawa-MacKay, 230 kV)
VC7	Loss of P26W (Wawa-Mississagi, 230 kV)
VC8	Loss of W22M (Marathon-Wawa 230 kV)
VC9	Loss of A23P (Mississagi-Algoma 230 kV)
VC10	Loss of Algoma Energy Gen at max MW

As provided by GLPL, 230 kV double circuits P21G/P22G are sitting on common towers for 4.2 km. Therefore, the loss of both P21G and P22G is a recognized contingency according to the recognized contingency definition in the IESO-Controlled Grid Operating Policies. The following statements are stated in Appendix B: Reliability Standards and Security Criteria:

"When the *IESO-controlled grid* is in *normal operating state*, operating *security limits* will be based on the following recognized contingencies:

(ii) Simultaneous permanent phase to ground faults on the same or different phases of each of two adjacent transmission circuits on a multiple transmission circuit tower, with normal fault clearing. If multiple circuit towers are used only for station entrance and exit purposes, and if they do not exceed five towers at each station, this condition is an acceptable risk and is excluded."

Based on the system configuration, loss of P21G/P22G at Third line (VC4) results in transformer T1 at Third Line TS out of service and Echo River TS radially supplied by Mississagi TS since P22G line was assumed out of service between Third Line TS and Echo River TS pre-contingency. For contingency VC5, all the units at Prince WGS will be out of service due to a contingency associated with K24G. For contingencies VC7 and VC8, transformers T2 and T1 at Wawa TS are out of service, respectively.

With the addition of the new generation unit at Algoma Energy, the worst case for thermal studies is the base load at Patrick St TS and maximum output at all the units in the area including the new proposed unit at Algoma Energy. Therefore, only load 3 shown in Table 6 was used in the thermal studies.

5.2.1 FLOW EAST SCENARIO

The thermal study results including pre and post contingency flows for flow east cases are summarized in Table 11. The percentage of continuous rating for pre contingencies and percentage of LTR for post-contingency flow are also shown in the table.

Table 11 Pre and Post Contingency Circuit Loadings for Flow East Cases (MVA)

Scenario	No. 1 Algoma	No. 2 Algoma	No. 3 Algoma	P22G	K24G	W23K	P26W	W22M	A24P	X74P
Pre. C.	41.9	41.9	41.9	145.2	320.5	101.1	147	145.8	193.1	164.7
	39.2%	31.3%	31.3%	37.0%	63.6%	20.1%	45.5%	45.1%	38.5%	34.0%
VC1	-	62.2	62.2	145.2	320.4	101.2	147	145.8	193	164.7
		41.5%	41.5%	33.5%	41.1%	13.0%	36.8%	25.3%	39.9%	23.0%
VC2	62.2	-	62.2	145.2	320.4	101.2	147	145.8	193	164.7
	54.1%		41.5%	33.5%	41.1%	13.0%	36.8%	25.3%	39.9%	23.0%
VC3	41.6	41.6	41.6	239.1	298	75.3	159	144.2	191.4	163.1
	36.2%	27.7%	27.7%	55.1%	38.3%	9.7%	39.8%	25.0%	39.5%	22.8%
VC4	28.4	28.4	28.4	-	100.6	162.2	263.7	140.4	176.3	149.4
	24.7%	18.9%	18.9%		12.9	20.8%	66.1%	24.4%	36.4%	20.9%
VC5	35.2	35.2	35.2	28.9	-	34.8	186.1	146.9	127.3	100.3
	30.6%	23.5%	23.5%	6.7%		4.5%	46.6%	25.5%	26.3%	14.0%
VC6	42.5	42.5	42.5	95.1	244.1	-	194	143.3	190.6	162.4
	37.0%	28.3%	28.3%	21.9%	31.3%		48.6%	24.9%	39.4%	22.7%
VC7	35.9	35.9	35.9	182.2	379.4	176.9	207.9	142.4	189.5	161.2
	31.2%	23.9%	23.9%	42.0%	48.7%	22.7%	52.1%	24.7%	39.2%	22.5%
VC8	34.2	34.2	34.2	142.1	311.6	120	146.5	309.8	183.7	154.4
	29.7%	22.8%	22.8%	32.7%	40.0%	15.4%	36.7%	53.8%	38.0%	21.6%
VC9	40.2	40.2	40.2	144.6	320.7	101.1	146.4	145.4	351.6	198
	35.0%	26.8%	26.8%	33.3%	41.2%	13.0%	36.7%	25.2%	72.6%	27.7%
VC10	27.4	27.4	27.4	100.0	329.9	115.3	141.6	147.3	160.5	132.6
	23.8%	18.3%	18.3%	23.0%	42.4%	14.8%	35.5%	25.6%	33.2%	18.5%

The results indicate that with all elements in-service the power flows on the monitored 230 kV and 115 kV circuits are well within the circuit continuous rating and under any one of the above contingencies flows on all the circuits are well within the LTR.

It should be noted the double contingency involved P21G/P22G or for single contingency with the companion circuit out of service (VC4) resulted in a voltage problem at Wawa TS. The voltage at Wawa 230 kV bus was found below 208 kV. Further simulations indicated that the output of new unit at Algoma Energy must be limited at 85 MW to maintain the voltage at Wawa at an acceptable level (108 kV). The results shown in the table for VC4 were obtained when the output of the new generating unit at Algoma Energy was 85 MW. Considering 5% margin, the output of the generator should be limited at 80 MW.

AELP indicated that the new generation unit will be operated as self-scheduling. Thus the proposed generator can specify its operating schedule and operate without dispatch instructions from the IESO. AELP confirmed that the facility will be producing less than 80MW if the gross ASI plant load at Patrick St. is at or below the base of 105MW. The facility is consuming byproduct fuels from the steelmaking processes with virtually no ability to store those fuels so that MW production is coupled to MW consumption.

AELP is required to limit the output of the proposed generator below 80 MW if the gross ASI plant load at Patrick St. is at or below the base of 105MW.

5.2.2 FLOW WEST SCENARIO

Similarly, the thermal study results including pre and post contingency flows for flow west cases are summarized in Table 12.

Table 12 Pre and Post Contingency Circuit Loadings for Flow West Cases (MVA)

Scenario	No. 1 Algoma	No. 2 Algoma	No. 3 Algoma	P22G	K24G	W23K	P26W	W22M	A24P	X74P
Pre. C.	42.5	42.5	42.5	7.6	85	143.5	97.4	177	52.3	79.1
	39.7%	31.7%	31.7%	1.9%	16.9%	28.5%	30.2%	54.8%	10.4%	16.3%
VC1	-	63	63	7.4	84.8	143.5	97.4	177	52.4	79.2
		47.0%	47.0%	1.9%	10.9%	18.3%	30.2%	54.8%	10.5%	16.4%
VC2	63	-	63	7.4	84.8	143.5	97.4	177	52.4	79.2
	58.9%		47.0%	1.9%	10.9%	18.3%	30.2%	54.8%	10.5%	16.4%
VC3	40.7	40.7	40.7	21.5	83.4	144.4	96.7	176.9	51.9	78.8
	38.0%	30.4%	30.4%	5.5%	10.7%	18.5%	29.9%	54.8%	10.4%	16.3%
VC4	34.2	34.2	34.2	-	57.9	291.8	47.7	177.7	5.7	23.3
	32.0%	25.5%	25.5%		7.4%	37.5%	14.8%	55.0%	1.1%	4.8%
VC5	31.7	31.7	31.7	59.4	-	48.4	136.7	170.9	114.4	141.5
	29.6%	23.7%	23.7%	15.2%		6.2%	42.3%	52.9%	22.8%	29.2%
VC6	40.2	40.2	40.2	71.5	208.2	-	162.6	172	49.9	77.2
	37.6%	30.0%	30.0%	18.2%	26.7%		50.3%	53.3%	10.0%	16.0%
VC7	38.9	38.9	38.9	36.2	49.8	198.7	145.8	171	73.9	100.8
	36.4%	29.0%	29.0%	9.2%	6.39%	25.5%	45.1%	52.9%	14.8%	20.8%
VC8	35.7	35.7	35.7	7.5	75.2	151	106.3	365.9	55.5	82.8
	33.4%	26.6%	26.6%	1.9%	9.7%	19.4%	32.9%	113.3%	11.1%	17.1%
VC9	42.1	42.1	42.1	6.3	86.3	142.5	96.4	116	95.2	87.3
	39.3%	31.4%	31.4%	1.6%	11.1%	18.3%	29.8%	35.9%	19.0%	18.0%
VC10	24.6	24.6	24.6	50.1	100.5	126.4	100.1	171.9	83.9	110.6
	23.0%	18.4%	18.4%	12.8%	12.9%	16.2%	31.0%	53.2%	16.7%	22.9%

The results indicate that with all elements in-service the power flows on the monitored 230 kV and 115 kV circuits are well within the circuit continuous rating and under any one of the above contingencies flows on all the circuits are well within the LTR.

It should be noted the contingency involved P21G/P22G (VC4), i.e., one is outage and the other is associated with contingency, will initiate L/R as indicated in the GLP SCO: The GLP Instantaneous L/R scheme. The available selections in the preferred order of arming sequence are:

1. Sault St. Marie PUC supplied by Third Line TS.
2. St. Marys Paper Ltd supplied by Clergue TS
3. Essar Steel Algoma Inc. & Flakeboard Company Limited This selection opens the three Algoma circuits at Third Line TS. It creates an electrical island consisting of the loads at Essar Steel Algoma Inc., St. Marys Paper Ltd. and Flakeboard Company Limited plus the generation from Lake Superior Power and Clergue GS.

To test the impact of the new generation unit at Algoma Energy, the first two actions were taken in the simulations for VC4.

Therefore, it can be concluded that there is no thermal concern identified with the proposed Algoma Energy generation.

5.3 VOLTAGE ANALYSIS

Voltage studies were performed to investigate the voltage performance as the Algoma Energy GS was added to the ESSAR Steel Algoma distribution system.

It is obvious that the addition of the proposed generation unit would improve the voltage profile for the local area.

Similar to the cases adjusted for thermal study, two cases, Flow East and Flow West, were set up for voltage studies.

The most critical contingency expected for voltage drop is the loss of the proposed unit at Algoma Energy with full output when all the other units in that area were at minimum output. So in the voltage study cases, three units at Clergue GS were set at 5 MW each and units at Lake Superior Power and Prince WGS were put out of service.

In the simulations the Algoma Energy unit mode of operation was set to regulate its terminal voltage at 1.0 pu.

The voltages at Patrick St, Clergue TS, Third Line, Mississagi, MacKay and Wawa were monitored. The pre- and post-contingency voltages for flow east and flow west are shown in Tables 13 and 14, respectively.

Table 13 Voltage Declines For Flow East Case

Bus	Pre-contingency (kV)	Post-contingency			
		Pre-ULTC (kV)	Voltage Decline (%)	Post-ULTC (kV)	Voltage Decline (%)
Patrick 115 kV	122.2	116.9	4.3%	119.5	2.2%
Clergue 115 kV	122.0	116.3	4.6%	119.4	2.1%
Third Line 115 kV	123.5	118.8	3.8%	121.6	1.5%
Third Line 230 kV	235.0	227.4	3.2%	221.6	5.7%

Mississagi 230 kV	243.9	240.2	1.5%	237.4	2.7%
MacKay 115 kV	121.5	119.5	1.6%	119.1	2.0%
MacKay 230 kV	238.8	233.7	2.1%	230.3	3.6%
Wawa 115 kV	124.5	122.9	1.3%	122.0	2.0%
Wawa 230 kV	244.1	240.0	1.7%	237.5	2.7%

Table 14 Voltage Declines For Flow West Case

Bus	Pre-contingency (kV)	Post-contingency			
		Pre-ULTC (kV)	Voltage Decline (%)	Post-ULTC (kV)	Voltage Decline (%)
Patrick 115 kV	122.6	116.3	5.1%	119.0	2.9%
Clergue 115 kV	122.5	116.3	5.1%	119.0	2.9%
Third Line 115 kV	123.8	118.0	4.7%	120.8	2.4%
Third Line 230 kV	235.1	225.3	4.2%	220.1	6.4%
Mississagi 230 kV	242.6	236.3	2.6%	232.8	4.0%
MacKay 115 kV	120.8	117.9	2.4%	118.1	2.2%
MacKay 230 kV	242.5	235.9	2.7%	231.8	4.4%
Wawa 115 kV	126.7	124.3	1.9%	122.5	3.3%
Wawa 230 kV	246.5	241.7	1.9%	238.0	3.4%

Study results show that the pre- and post-contingency voltages meet the minimum required operating voltage. The post-contingency voltage declines at all the monitored buses are within the 10% criteria.

Therefore, it can be concluded that there is no voltage concern identified with the proposed Algoma Energy generation.

5.4 TRANSIENT STATE ANALYSES

Transient stability analyses were performed considering fault at Patrick St, Third Line, Mississagi, MacKay and Wawa. The following contingencies were tested.

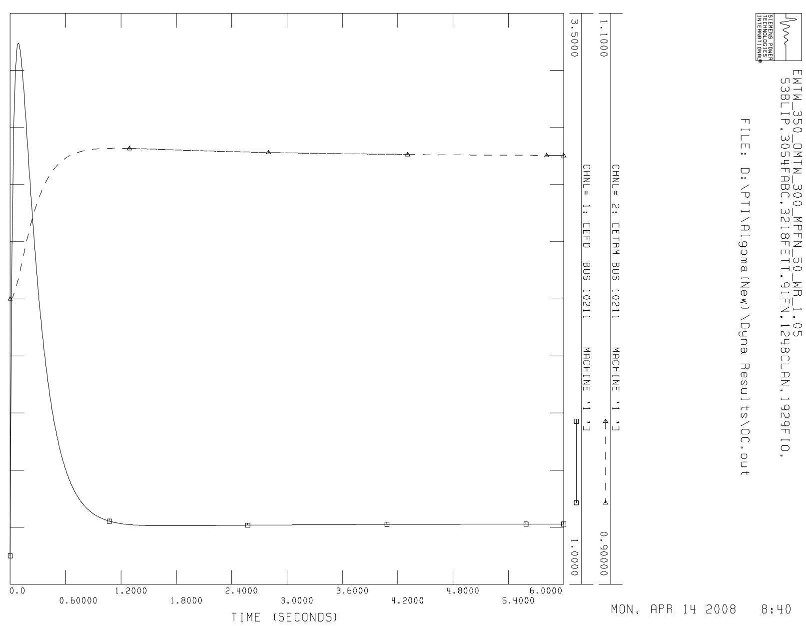
Table 15 Contingencies for Transient Studies

Contingencies		Fault MVA Levels	AELP I/S	AELP O/S
SC1	Normally cleared LLG fault on No. 1 Algoma @ Patrick	959-j8058	X	X
SC2	Normally cleared LLG fault on P21G @ Third Line	814-j6855	X	X
SC3	Normally cleared LLG fault on K24G @ Third Line	814-j6855	X	
SC4	Normally cleared LLG fault on W23K @ Mackay	411-j3426	X	
SC5	Normally cleared LLG fault on W22M @ Wawa	460-j4145	X	
SC6	Normally cleared LLG fault on P26W @ Wawa	460-j4145	X	
SC7	Normally cleared LLG fault on P25W @ Mississagi	727-j6967	X	
SC8	Normally cleared LLG fault on P22G @ Mississagi	727-j6967	X	
SC9	Normally cleared LLG fault on X74P @ Mississagi	727-j6967	X	

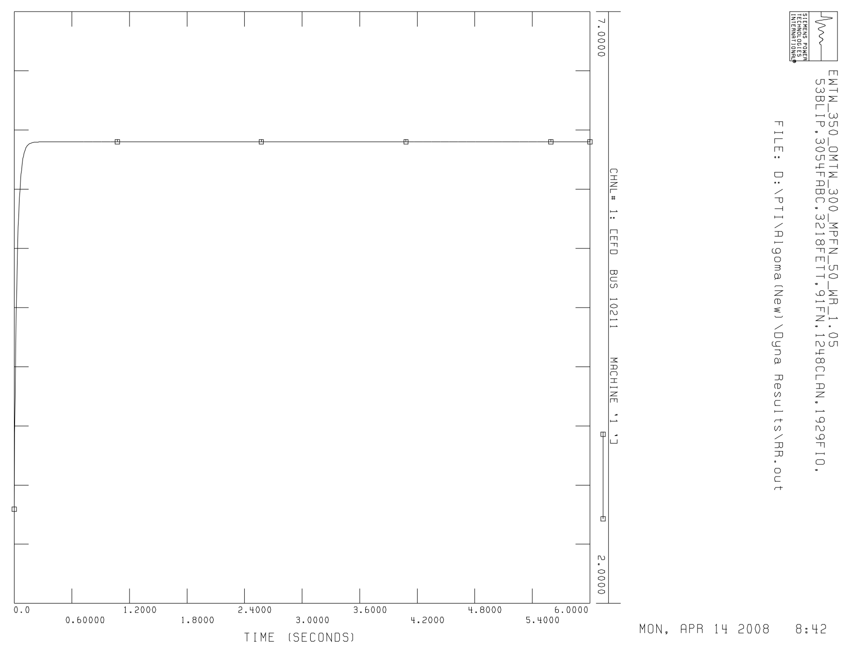
All the simulation results are shown in the Appendix. It can be concluded from the results that, with AELP new generator on-line, none of the simulated contingencies caused transient instability or undamped oscillations.

APPENDIX

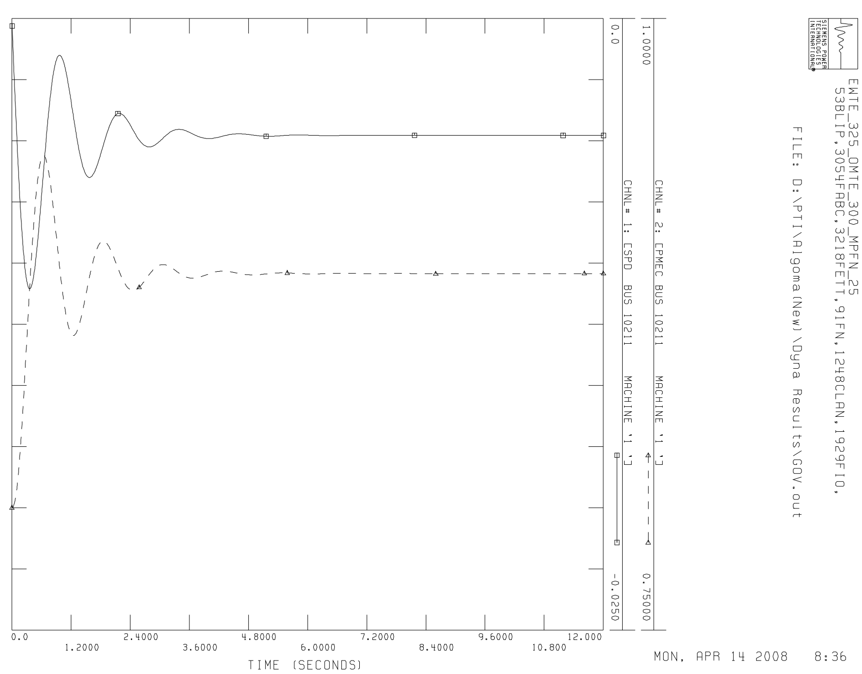
Automatic Excitation System Performance
Open Circuit Test



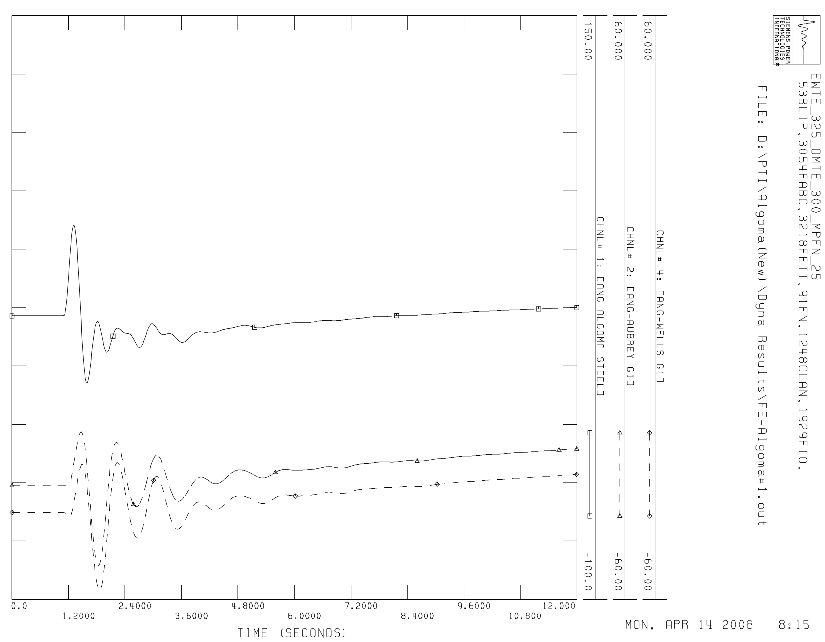
Response Ratio Test



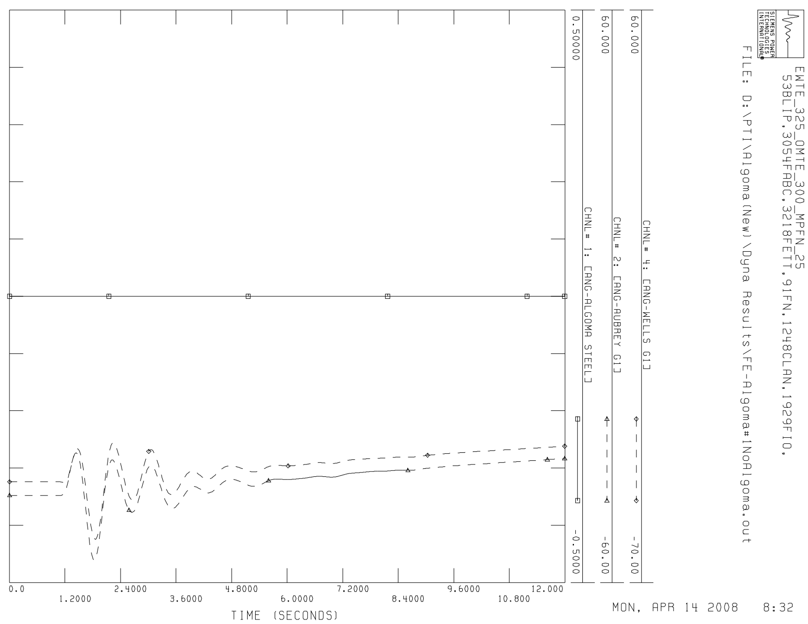
Speed Governor Performance



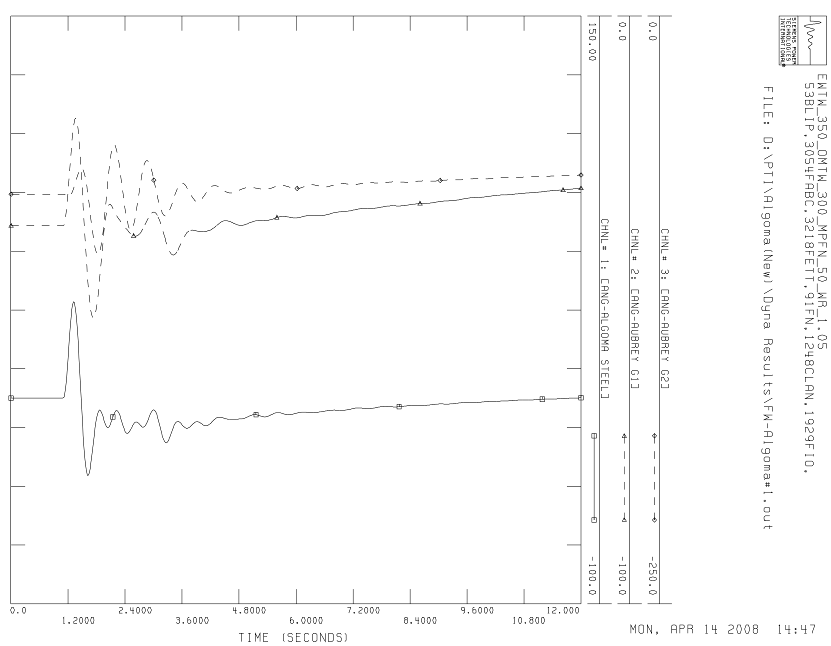
SC1 - LLG fault was applied on 115 kV circuit Algoma #1 at Patrick St TS. (cleared in 83 ms at Patrick St TS, 116 ms at Third Line Ts)
Flow East - AELP I/S:



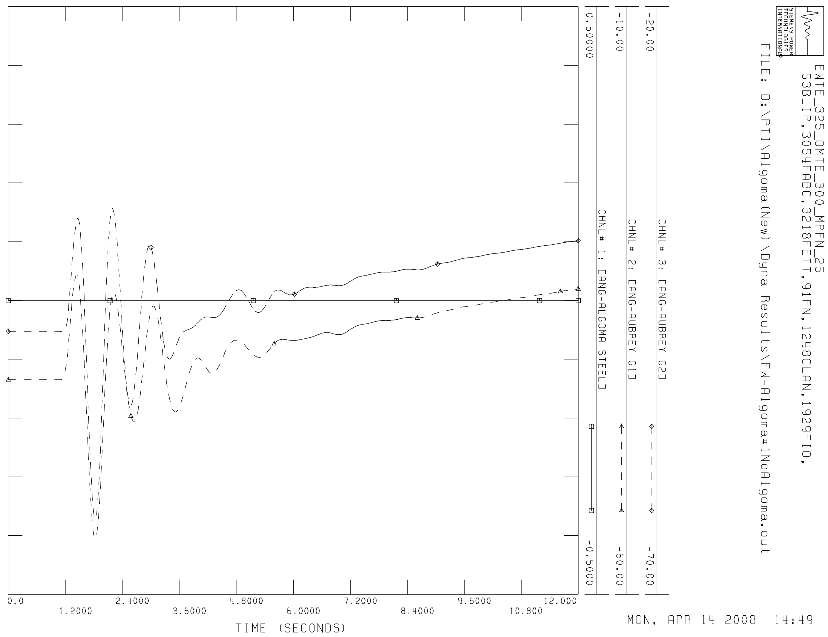
Flow East - AELP O/S:



SC1 - LLG fault was applied on 115 kV circuit Algoma #1 at Patrick St TS. (cleared in 83 ms at Patrick St TS, 116 ms at Third Line Ts)
Flow West - AELP I/S:

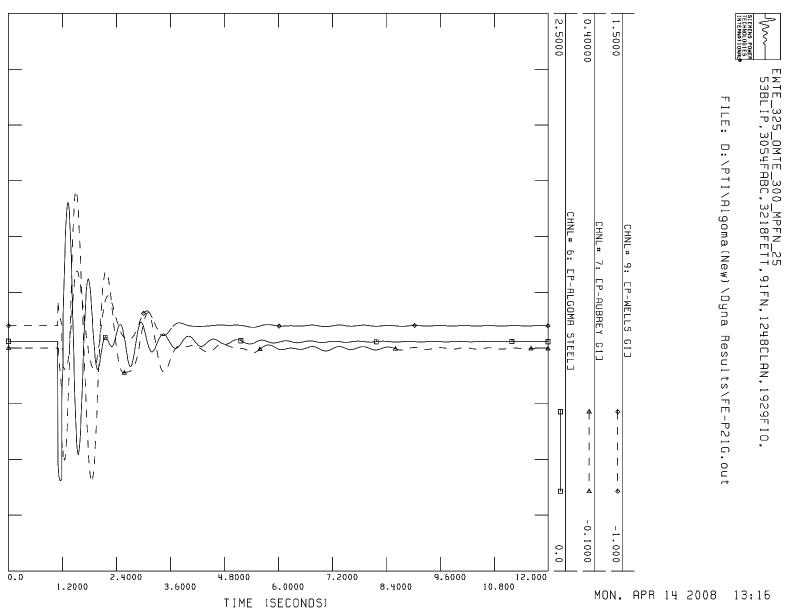


Flow West - AELP O/S:

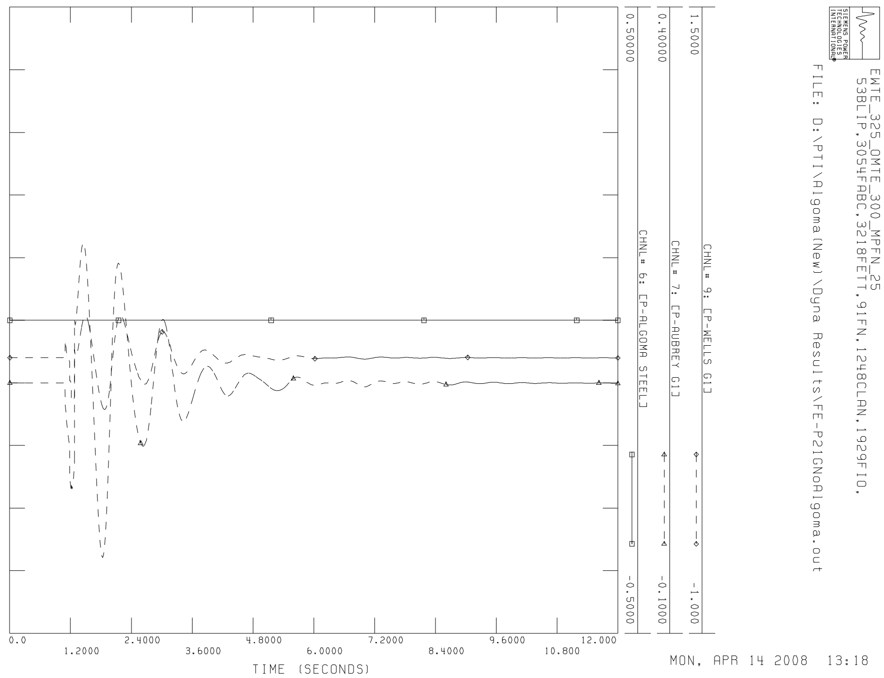


SC2 - Normally cleared LLG fault on P21G @ Third Line (cleared in 83 ms at Third Line, 116 ms at Mississagi)

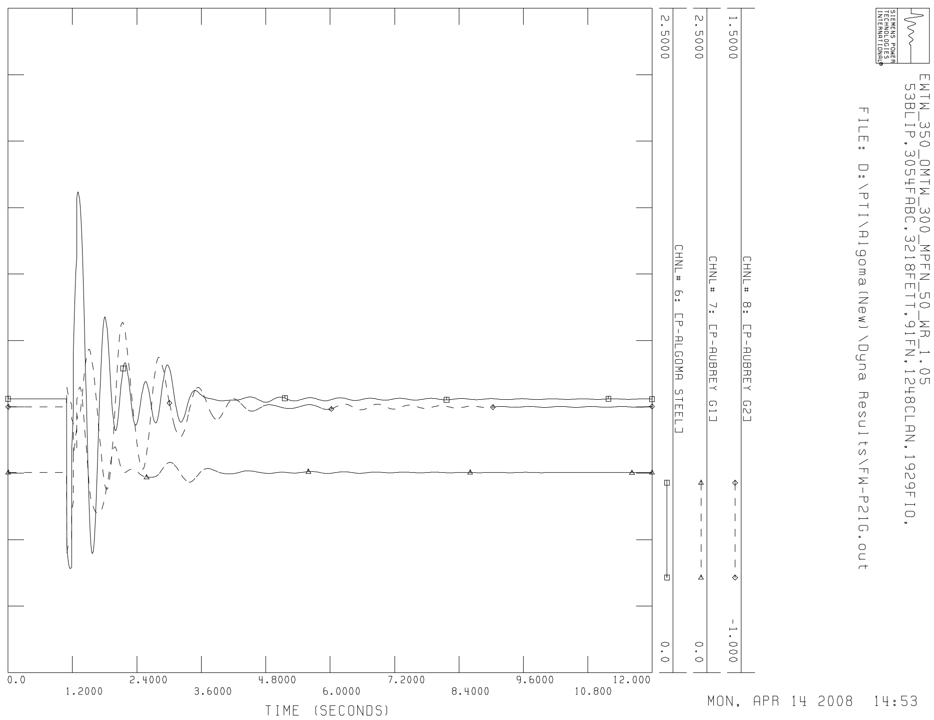
Flow East - AELP I/S



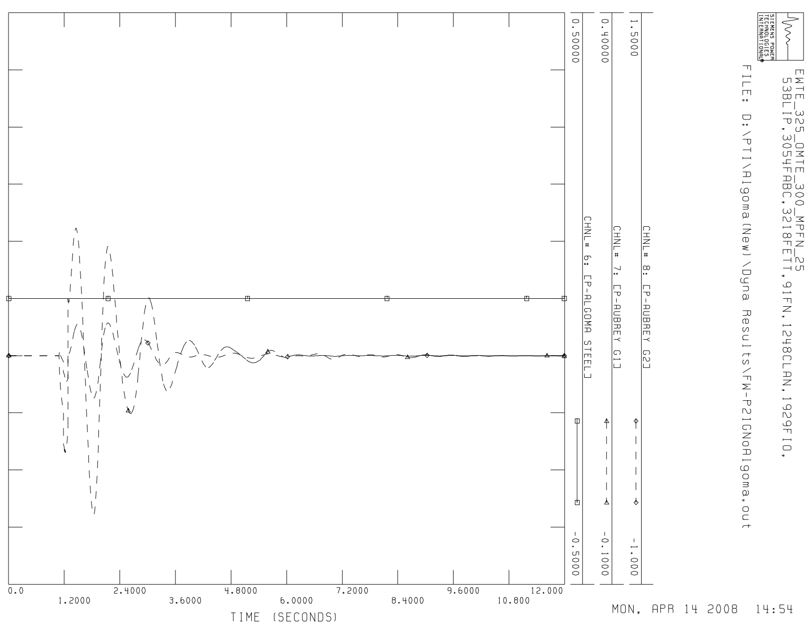
Flow East - AELP O/S



SC2 - Normally cleared LLG fault on P21G @ Third Line (cleared in 83 ms at Third Line, 116 ms at Mississagi)
Flow West - AELP I/S

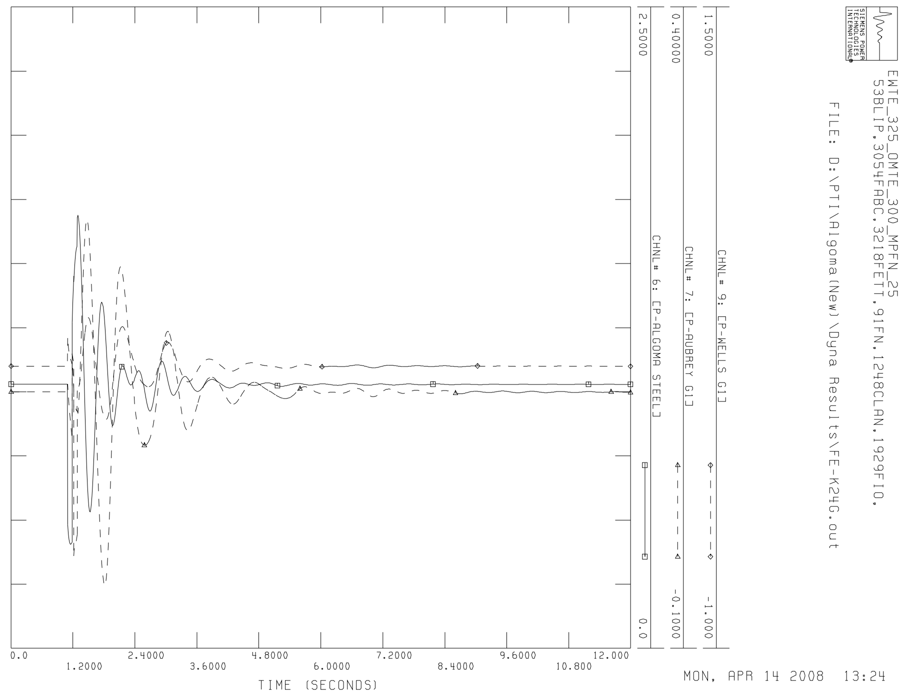


Flow West - AELP O/S

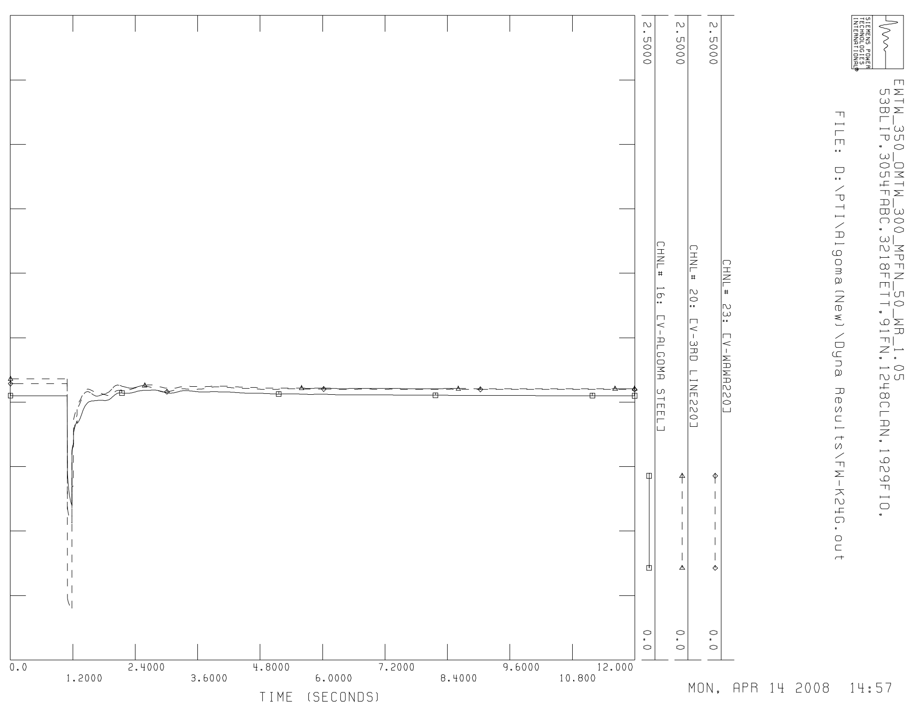


SC3 - Normally cleared LLG fault on K24G @ Third Line (cleared in 83 ms at Third Line, 116 ms at MacKay)

Flow East

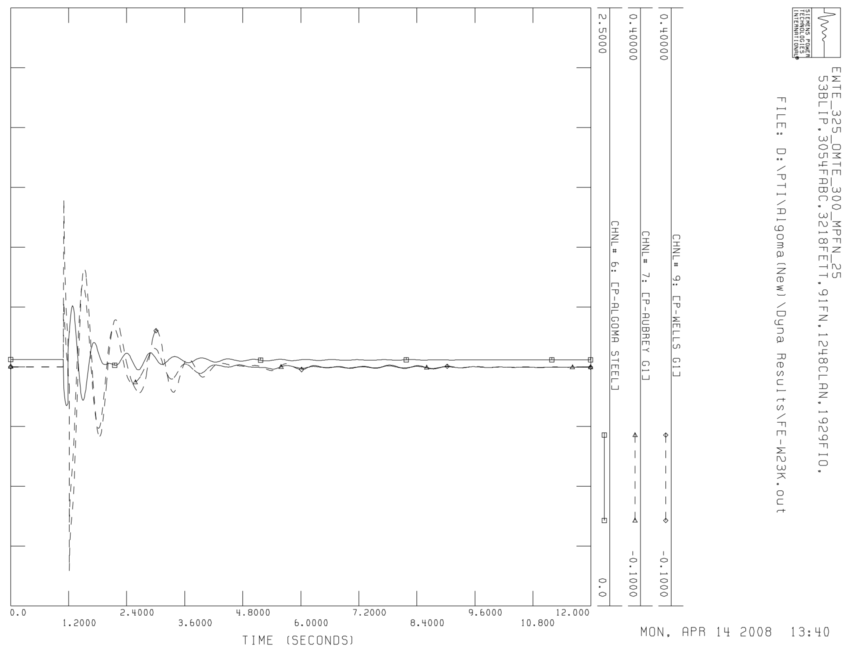


Flow West

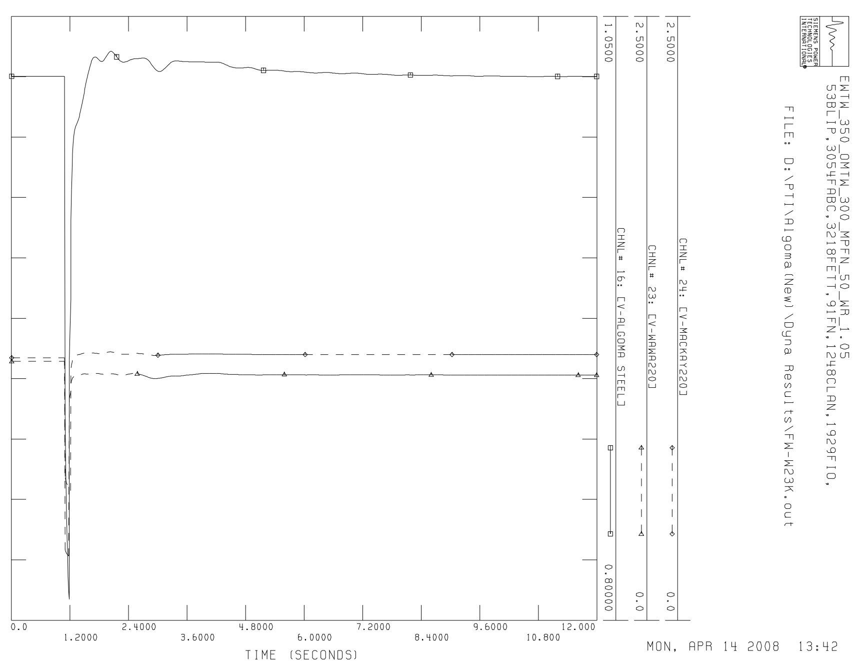


SC4 - Normally cleared LLG fault on W23K @ MacKay (cleared in 83 ms at MacKay, 116 ms at Wawa)

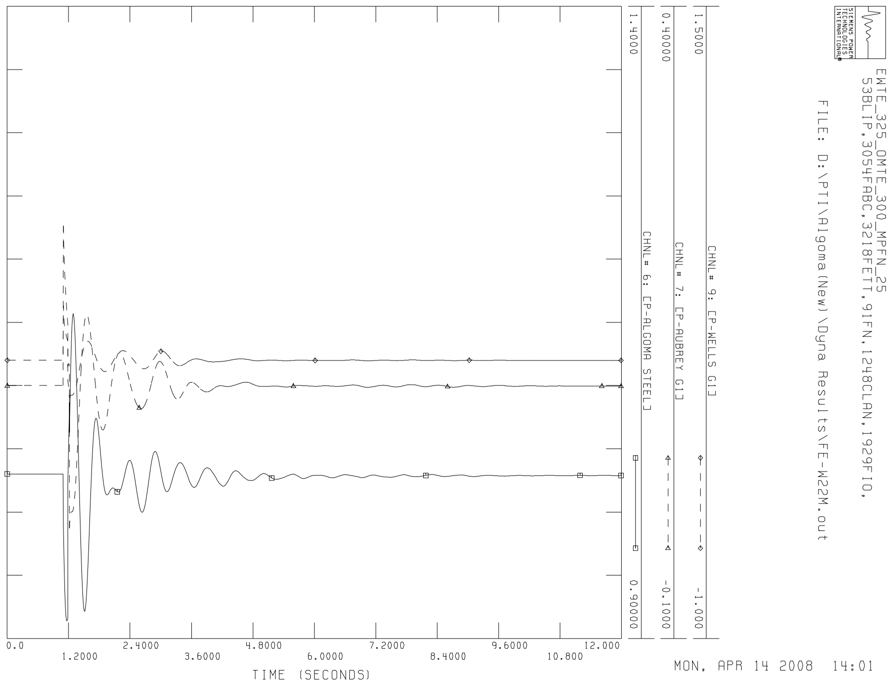
Flow East



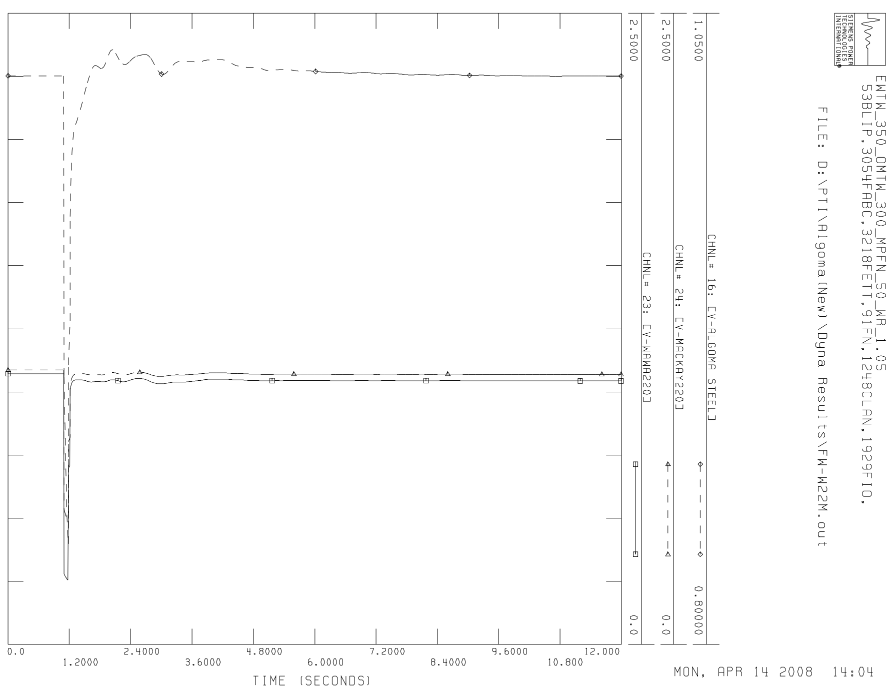
Flow West



SC5 - Normally cleared LLG fault on W22M @ Wawa (cleared in 83 ms at Wawa, 116 ms at Marathon)
Flow East

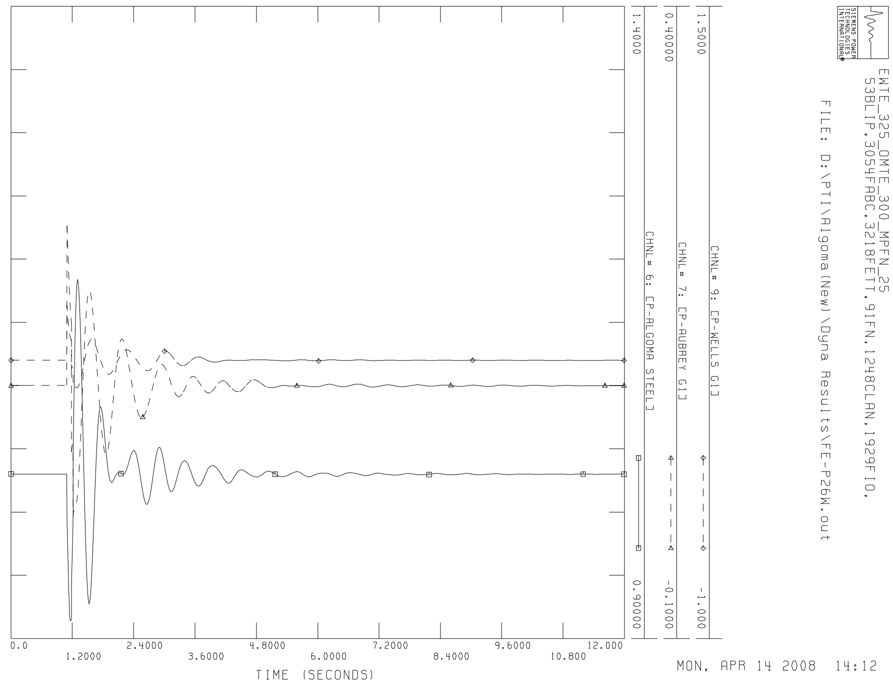


Flow West

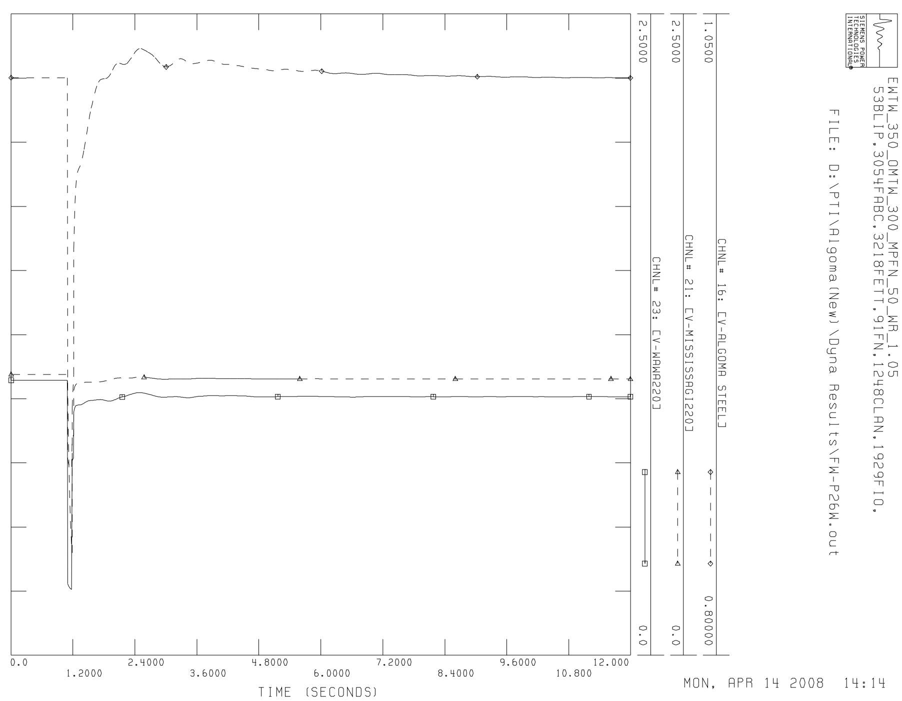


SC6 - Normally cleared LLG fault on P26W @Wawa (cleared in 83 ms at Wawa, 116 ms at Mississagi)

Flow East

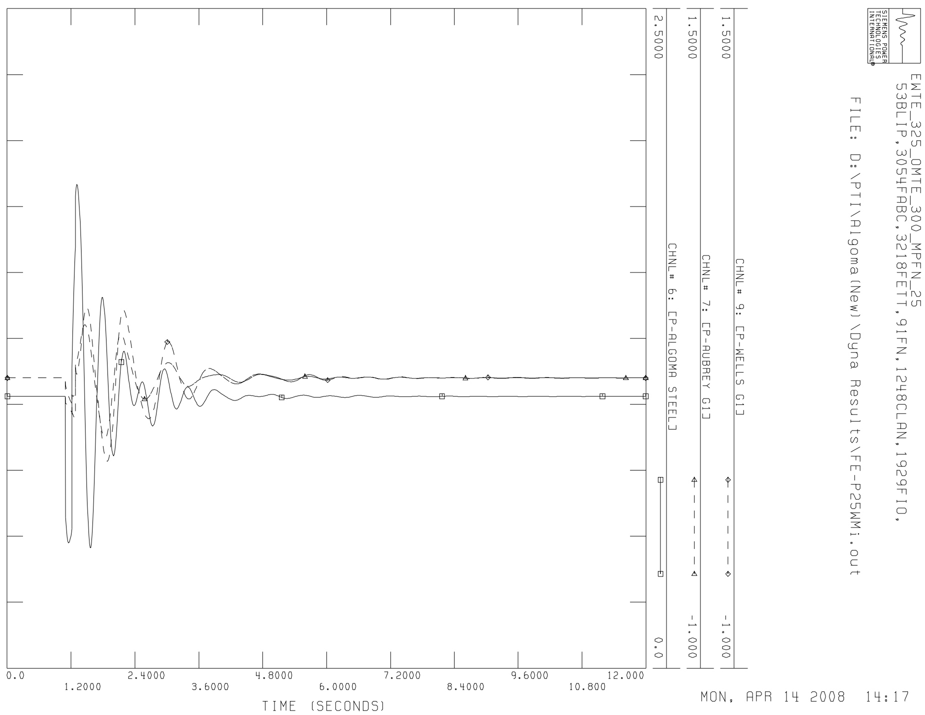


Flow West

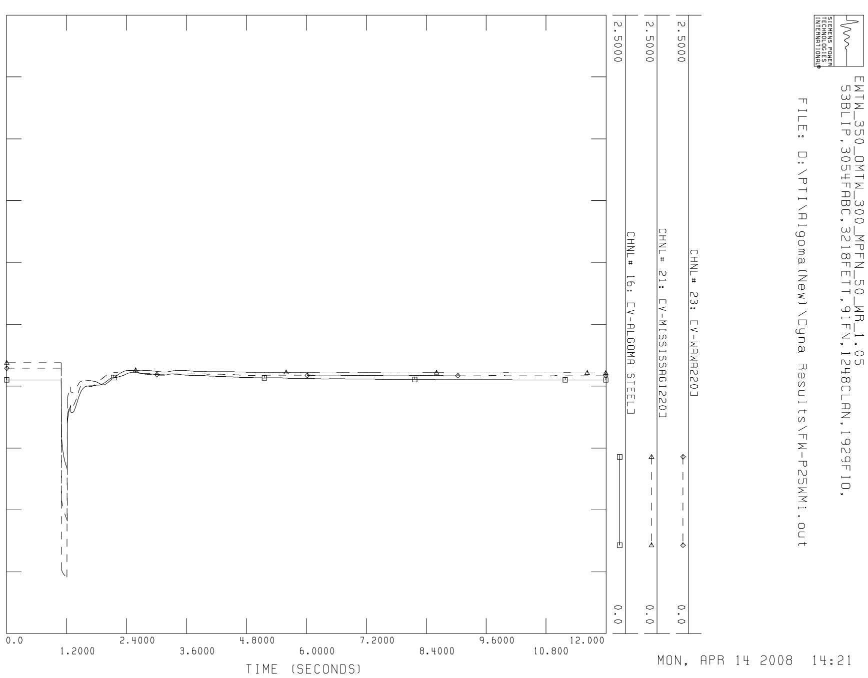


SC7 - Normally cleared LLG fault on P25W @ Mississagi (cleared in 83 ms at Mississagi , 116 ms at Wawa)

Flow East

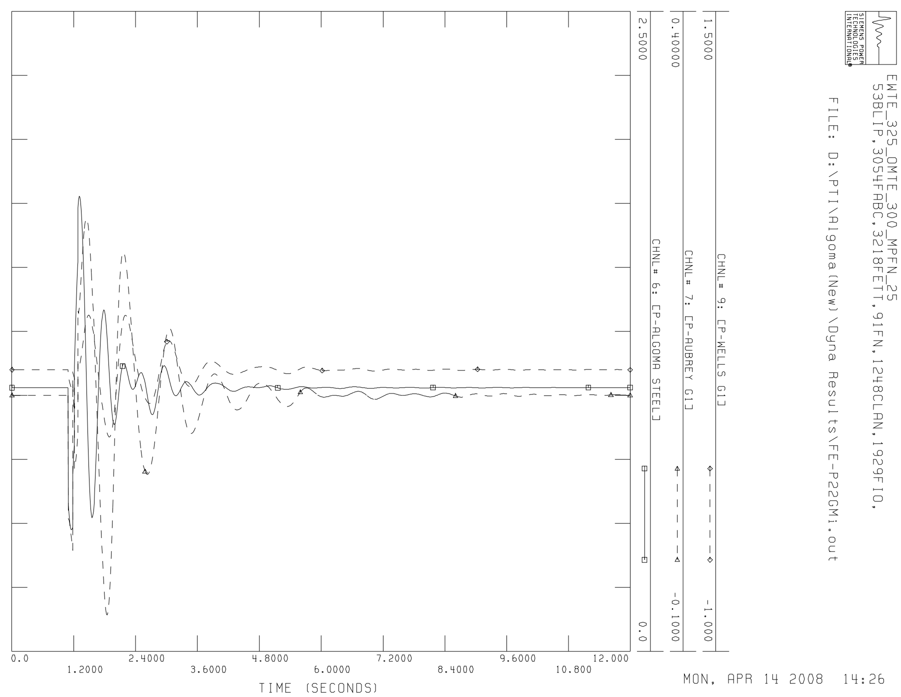


Flow West

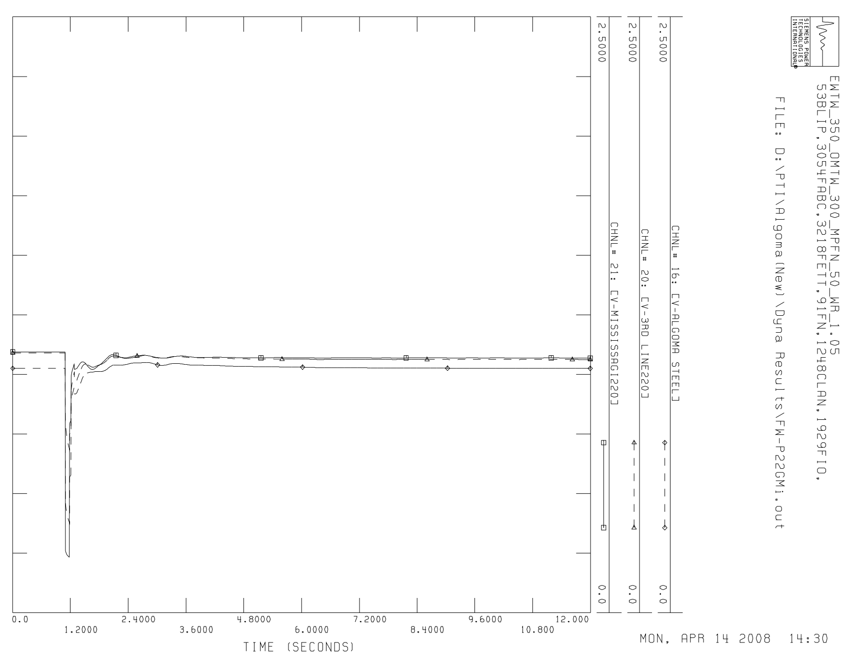


SC8 - Normally cleared LLG fault on P22G @Mississagi (cleared in 83 ms at Mississagi, 116 ms at Third Line)

Flow East

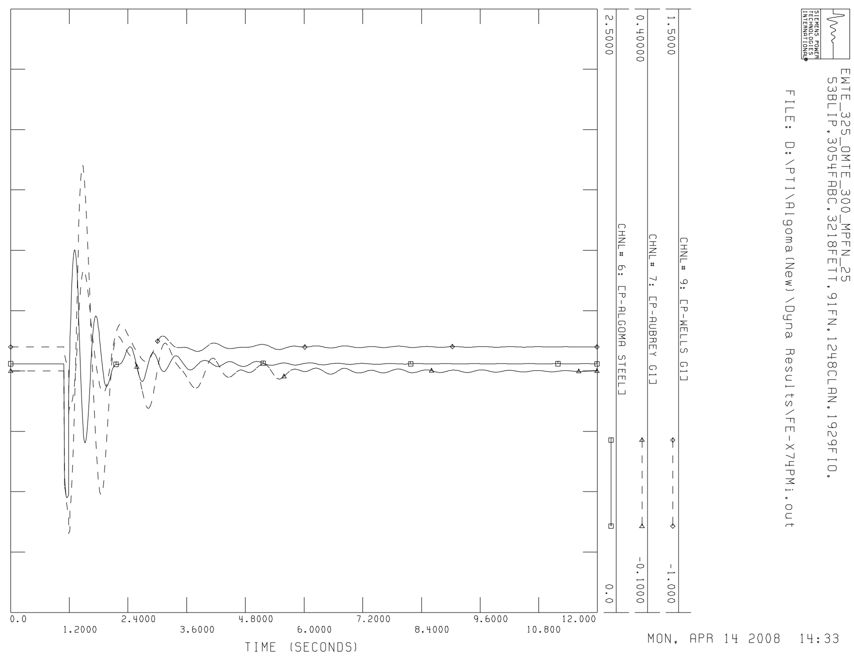


Flow West



SC9 - Normally cleared LLG fault on X74P @ Mississagi (cleared in 83 ms at Mississagi, 116 ms at Hanmer)

Flow East



Flow West