IESO_REP_0587

REPORT

Power to Ontario.
On Demand.

System Impact Assessment Report

Talbot
Wind Generation Station (WGS)

CONNECTION ASSESSMENT & APPROVAL PROCESS

Final Report

CAA ID 2008-335

Applicant: Renewable Energy Systems Canada Inc.

Market Facilitation Department

November 26, 2009

Document ID	IESO_REP_0587
Document Name	System Impact Assessment Report
Issue	Issue 1.0
Reason for Issue	First issue
Effective Date	November 26, 2009

System Impact Assessment Report

Talbot Wind Generation Project

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 OPG) 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.

Table of Contents

Table of Contents v
SIA Findings 6
Summary **6**
Conclusions and Recommendations **6**
IESO's Requirements for Connection **7**
Notification of Conditional Approval **8**
1. **Project Description** 9
2. General Requirements 10
3.1 Proposed Connection Arrangement **14**
3.2 Existing System **15**
4. Data Verification 18
4.1 Generator **18**
4.2 Transformer **18**
4.3 Circuit Breakers and Switches **18**
5. **Fault Level Assessment** 19
6. System Impact Studies 23
6.1 Assumptions and Background **23**
6.2 Protection Impact Assessment **23**
6.3 Thermal Analysis **24**
6.4 Voltage Analysis **27**
6.5 Reactive Power Compensation **29**
6.5.1 Dynamic Reactive Power Compensation **29**
6.5.2 Static Reactive Power Compensation **29**
6.6 Transient Analysis **30**
6.7 Low-voltage ride through capability **31**
6.8 Wind Farm Management System **32**
Appendix A **33**
Appendix B **37**

SIA Findings

Renewable Energy Systems Canada Inc. is developing a new 98.9 MW wind power generation farm in Chatham. The project was awarded a contract under the government RES III, and is expected to start commercial operation in the fall of 2010.

Summary

This Assessment examined the impact of injecting 98.9 MW of wind power generation into the provincial grid via 230 kV circuit W45LC east of Chatham on the reliability of the IESO-controlled grid.

The following conclusions and recommendations were made.

Conclusions and Recommendations

Conclusions:

The analysis concluded that:

(1) The proposed wind farm does not have a material adverse impact to the reliability of the IESO-controlled grid.

(2) The post-contingency voltage declines are within IESO criteria.

(3) None of the recognized contingencies cause any material adverse impact to the transient performance of the IESO-controlled grid.

(4) Special protection schemes existing in Windsor area can continue to be used as specified in the IESO operational instructions.

(5) The new wind farm is not required to be part of any special protection scheme.

(6) The connection impedance between the wind turbine generators and the IESO-controlled grid exceeds the limit derived from Market Rules requirements, resulting in reactive power deficiency. To compensate for this deficiency reactive compensation devices have to be installed as indicated in Section 6.5 of this SIA.

(7) The proposed arrangement with in-line breakers in the Protection Impact Assessment (PIA) is a practical and acceptable approach for solving protection coordination issues.

(8) The change of the 34.5 kV winding configuration from delta to wye grounded is currently being analyzed by Hydro One and the IESO, and the results may be addressed in an SIA addendum.

Recommendations:

(1) The proponent provides a copy of the functionalities of the Wind Farm Management System (WFMS) to the IESO.

(2) The transmitter changes the relay settings of W45LC terminal stations to account for the effect on apparent impedance due to power injection from the wind farm.

IESO's Requirements for Connection

The following requirements for the incorporation of Talbot WGS to W45LC have been identified.

(1) The connection arrangement must be changed to reflect the findings of the Protection Impact Assessment (PIA), i.e., in-line breakers on W45LC should be installed as requested.

(2) A static compensation of 24 MVAr must be connected to the collector bus. This must constitute 2 steps of 12 MVAr each. The capacitors will need to be auto-switched via suitable over/under voltage settings.

(3) RES Canada proposed a voltage control scheme in which the WTG and capacitors are set to control HV while the main transformer ULTC on high voltage side is set to control LV. The IESO is investigating the proposed scheme and the scheme may be subject to modifications during the Market Entry process.

(4) The generators should not trip for contingencies except for which the generators will be removed by configuration. If generators trip for contingencies for which they are not removed by configuration, the LVRT capability must be upgraded.

(5) During the commissioning period, a set of IESO specified tests must be performed. The commissioning report must be submitted to the IESO within 30 days of the conclusion of commissioning. The field test results should be verifiable using the PSS/E models used for this SIA.

(6) All protection systems must be supplied from separate batteries and separate communication paths.

(7) The autoreclosure of the new 230 kV tap breaker at the connection point must be blocked. Upon its opening for a contingency, it must be closed only after the IESO approval is granted. The IESO will require reduction of power generation prior to the closure of the breaker followed by gradual increase of power to avoid a power surge.

(8) The generators should not trip for frequency variations that are above the curve in Figure 1.

(9) The applicant is responsible for providing real-time telemetering of following variables to the IESO.

- Active and reactive power measured either at 34.5 kV or 230 kV side of the transformer
- status of new 34.5 kV and 230 kV breakers and disconnect switches
- 230 kV and 34.5 kV voltages at the transformer station
- in service status of the Wind Farm Management System (WFMS)
- voltage controlling set point

Additional telemetry requirements may be identified if necessary by the IESO during Market Entry process.

(10) If the Wind Farm Management System (WFMS) is unavailable, each generator must control its own terminal voltage while capacitors continue to control HV voltage.

(11) A disturbance monitoring device must be installed. The applicant is required to provide disturbance data to the IESO upon request.

(12) The registration of the new facilities will need to be completed through the IESO's Market Entry process before any part of the facility can be placed in-service. If the data or assumptions supplied for the registration of the facilities materially differ from those that were used for the assessment, then some of the analysis might need to be repeated.

Notification of Conditional Approval

From the information provided, our review concludes that the proposed changes will not result in a material adverse impact on the reliability of the IESO-controlled grid. It is recommended that a Notification of Conditional Approval be issued for Talbot WGS subject that the requirements listed in this report will be implemented.

1. Project Description

The Renewable Energy Systems Canada Inc. (RES) has proposed to develop a 98.9 MW wind farm located in the County of Chatham-Kent near Ridgetown, west Ontario, known as Talbot Wind Farm which has been awarded a Power Purchase Agreement with Ontario Power Authority. It is expected that commercial operation will start in the fall of 2010.

The Talbot Wind Farm will be connected to Hydro One's 230-kV circuits W45LC via a new 230-kV 65/85/115-MVA interconnection substation located about 10.5 km far from the Hydro One right-of-way. The substation is connected to the 230-kV circuits by means of a selector switching system. The new substation will consist of one 246/34.5/13.8 kV transformer, one 230-kV circuit breakers and associated switchgears, four 34.5-kV buses, and four collector line breakers.

The development will consist of a total forty three Siemens SMK223 wind turbine generators with a rated power output of 2.3 MW each. Two back-to-back AC/DC links and a 2.6 MVA, 0.06 pu reactance (on 2.6 MVA base), 0.69/34.5 kV transformer connects each generator to one of the four 34.5 kV collector circuits C1, C2, C3 or C4. Each collector circuit will have following number of generators.

Siemens SMK223 (2.55 MVA, 2.3 MW each)					
Circuit ID	C1	C2	C3	C4	Total
Number of generators	11	11	10	11	43
Maximum MW	25.3	25.3	23.0	25.3	98.9

– End of Section –

2. General Requirements

Generators

1. Each generator must satisfy the Generator Facility requirements in Appendix 4.2 of Market Rules.

The Market Rules (appendix 4.2, reference 1) require that the generation facility connecting to the IESO-controlled grid must have the minimum capability to supply reactive power continuously in the range of 90% lagging to 95% leading power factor based on active power output at its generator terminals for at least one constant 230 kV system voltage. The connection applicant shall submit the generator's reactive capability curve to the IESO as evidence that the generator is capable of meeting the reactive power requirements.

If necessary, shunt capacitors must be installed to offset the reactive power losses within the facility in excess of the maximum allowable losses. If generators do not have dynamic reactive power capabilities as described above, dynamic reactive compensation devices must be installed to make up the deficient reactive power.

2. The generators must be able to ride through recognized contingencies on the IESO-controlled grid that does not disconnect the facility by configuration.

3. The connection and disconnection of the generators must minimize any adverse effects on the IESO-controlled grid.

Connection Equipment (Breakers, Disconnects, Transformers, Buses)

1. Appendix 4.1, reference 2 of the Market Rules states that under normal conditions voltages are maintained within the range of 220 kV to 250 kV. Thus, the IESO requires that the 230 kV equipment in Ontario must have a maximum continuous voltage rating of at least 250 kV.

   Fault interrupting devices must be able to interrupt fault current at the maximum continuous voltage of 250 kV.

If revenue metering equipment is being installed as part of this project, please be aware that revenue metering installations must comply with Chapter 6 of the IESO Market Rules for the Ontario electricity market. For more details the applicant is encouraged to seek advice from their Metering Service Provider (MSP) or from the IESO metering group.

2. The Transmission System Code (TSC), Appendix 2 establishes maximum fault levels for the transmission system. For the 230 kV system, the maximum 3 phase symmetrical fault level is 63 kA and the single line to ground (SLG) symmetrical fault level is 80 kA (usually limited to 63 kA).

   The TSC requires that new equipment be designed to sustain the fault levels in the area where the equipment is installed. If any future system enhancement results in an increased fault level higher than the equipment's capability, the connection applicant is required to replace the equipment at their own expense with higher rated equipment capable of sustaining the increased fault level, up to the TSC’s maximum fault level of 63 kA for the 230 kV system.

3. The connection equipment must be designed so that the adverse effects of failure on the IESO-controlled grid are mitigated.

4. The connection equipment must be designed so that it will be fully operational in all reasonably foreseeable ambient temperature conditions. This includes ensuring that SF6 breakers are equipped with heaters to prevent freezing.

IESO Monitoring and Telemetry Data

In accordance with the telemetry requirements for a generation facility (see Appendices 4.15 and 4.19 of the Market Rules) the connection applicant must install equipment at this project with specific performance standards to provide telemetry data to the IESO. The data is to consist of certain equipment status and operating quantities which will be identified during the IESO Market Entry Process.

As part of the IESO Facility Registration/Market Entry process, the connection applicant must also complete end to end testing of all necessary telemetry points with the IESO to ensure that standards are met and that sign conventions are understood. All found anomalies must be corrected before IESO final approval to connect any phase of the project is granted.

Protection Systems

1. Protection systems must be designed to satisfy all the requirements of the Transmission System Code as specified in Schedules E, F and G of Appendix 1 and any additional requirements identified by the transmitter. New protection systems must be coordinated with existing protection systems.

2. Facilities designated as essential to power system reliability must be protected by two redundant protection systems according to section 8.2.1a of the TSC. These redundant protections systems must satisfy all requirements of the TSC but in particular they may not use common components, common battery banks or common secondary CT or PT windings.

This facility is designated as essential to power system reliability and therefore the above protection requirements apply.

3. Protective relaying must be set to ensure that transmission equipment remains in-service for voltages between 94% of the minimum continuous and 105% of the maximum continuous values in the Market Rules, Appendix 4.1.

4. The Applicant is required to have adequate provision in the design of protections and controls at the facility to allow for future installation of Special Protection Scheme (SPS) equipment.

5. Any modifications made to protection relays by the transmitter after this SIA is finalized must be submitted to the IESO as soon as possible or at least six (6) months before any modifications are to

be implemented on the existing protection systems. If those modifications result in adverse impacts, the connection applicant and the transmitter must develop mitigation solutions.

Send documentation for protection modifications triggered by new or modified primary equipment (i.e. new or replacement relays) to connection.assessments@ieso.ca.

For protection modifications that are not associated with new or modified equipment (i.e. protection setting modifications) please send documentation to protection.settings@ieso.ca.

6. Protection systems within the generation facility must only trip the appropriate equipment required to isolate the fault. After the facility begins commercial operation, if an improper trip of the 230 kV circuits W45LC occurs due to events within the facility, the facility may be required to be disconnected from the IESO-controlled grid until the problem is resolved.

Frequency Requirements

The facility must be capable of operating continuously for grid frequencies in the range between 59.4 Hz and 60.6 Hz as specified in Appendix 4.2, Reference 3 of the Market Rules.
The facility must be capable of operating at full active power for a limited period of time for grid frequencies as low 58.8 Hz. Generators must not trip for under-frequency system conditions that are below 60 Hz but above 57.0 Hz and above the curve shown in **Error! Reference source not found.**.

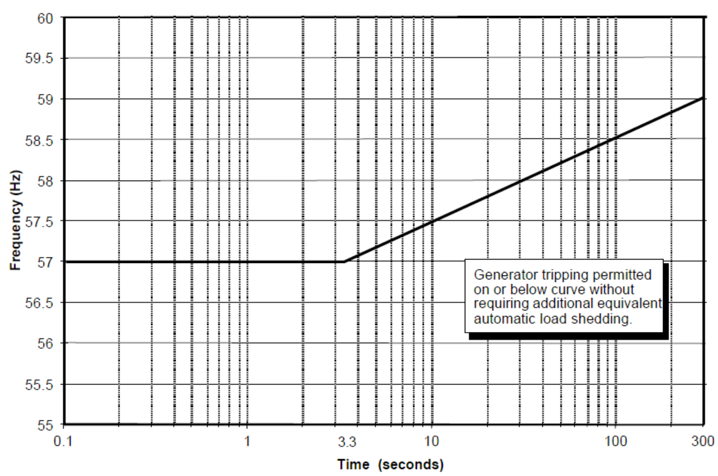


Figure 1: Setting for Grid Under-frequency Trip Protection

Miscellaneous

1. The generators must operate in the voltage control mode. Operation of the facility in power factor control or reactive power control is not acceptable.

2. Connection Applicant is required to install at the facility a disturbance recording device with clock synchronization that meets the technical specifications provided by Hydro One. The device will be used to monitor and record the response of the facility to disturbances on the 230 kV system in

order to verify the dynamic response of generators. The quantities to be recorded, the sampling rate and the trigger settings will be provided by Hydro One.

Facility Registration/Market Entry Requirements

The connection applicant must complete the IESO Facility Registration/Market Entry 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 energization to the IESO-controlled grid, to allow the IESO to incorporate this project into IESO work systems and to perform any additional reliability studies.

As part of the IESO Facility Registration/Market Entry process, the connection applicant 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 and found acceptable to the IESO, the Facility Registration/Market Entry process will not be considered complete and the connection applicant must accept any restrictions the IESO may impose upon this project's participation in the IESO administered market or connection to the IESO-controlled grid.

The evidence must be supplied to the IESO within 30 days after completion of commissioning tests. Failure to provide evidence may result in disconnection from the IESO-controlled grid.

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

Reliability Standards

Prior to connecting to the IESO controlled grid, the proposed facility must be compliant with the applicable reliability standards set by the North American Electric Reliability Corporation (NERC) and the North East Power Coordinating Council (NPCC). A list of applicable standards, based on the proponent's/connection applicant's market role/OEB licence can be found here:

http://www.ieso.ca/imoweb/ircp/reliabilityStandards.asp

In support of the NERC standard EOP-005, the proponent/ connection applicant may meet the restoration participant criteria. Please refer to section 3 of Market Manual 7.8 (Ontario Power System Restoration Plan) to determine its applicability to the proposed facility.
The IESO monitors and assesses market participant compliance with these standards as part of the IESO Reliability Compliance Program. To find out more about this program, visit the webpage referenced above or write to ircp@ieso.ca.

Also, to obtain a better understanding of the applicable reliability obligations and find out how to engage in the standards development process, we recommend that the proponent/ connection applicant join the IESO's Reliability Standards Standing Committee (RSSC) or at least subscribe to their mailing list at rssc@ieso.ca. The RSSC webpage is located at: http://www.ieso.ca/imoweb/consult/consult_rssc.asp.

– End of Section –

3. Review of Connection Proposal

3.1 Proposed Connection Arrangement

The proposed connection arrangement is shown in Figure 2.

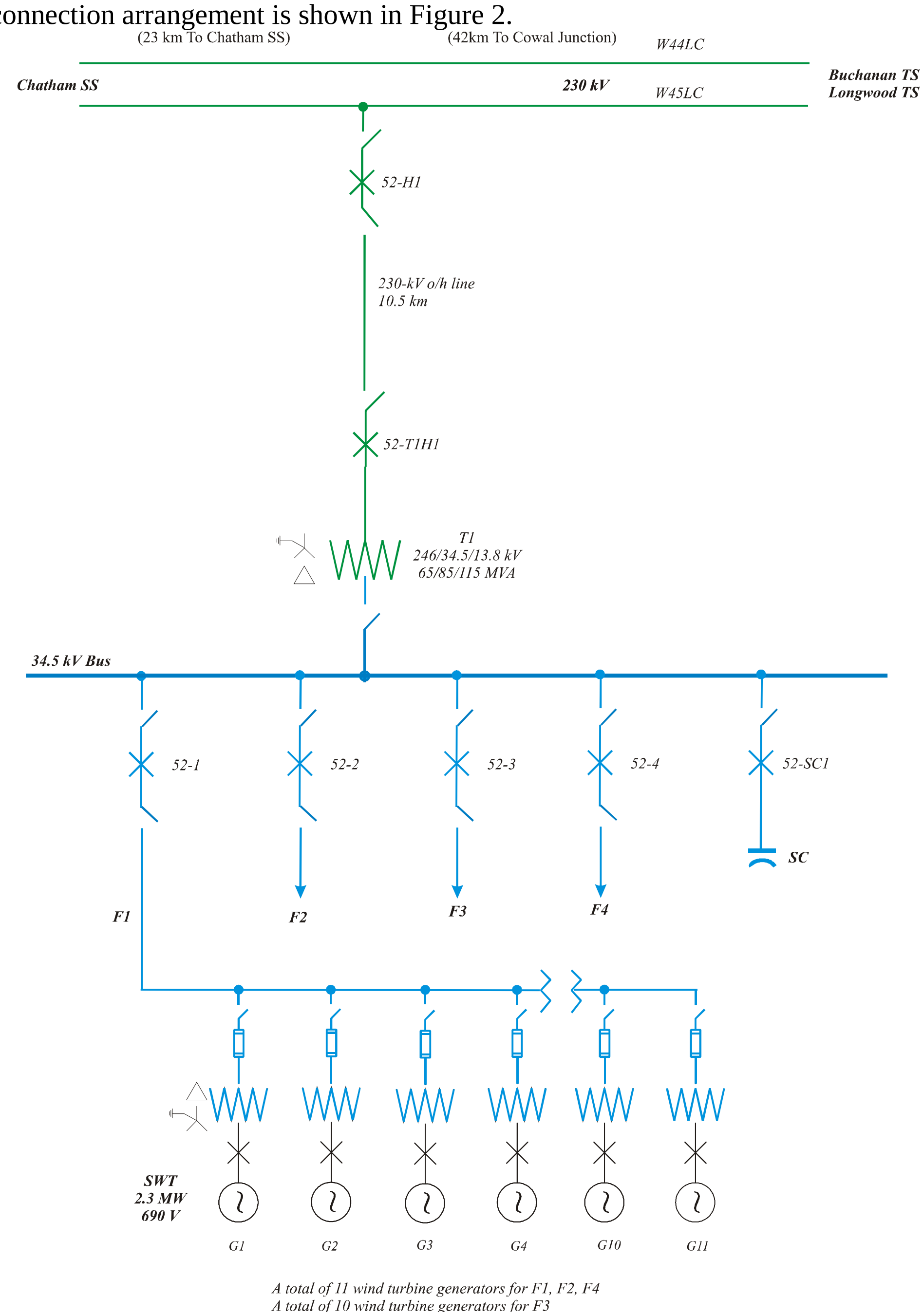


Figure 2: Proposed Connection Arrangement

3.2 Existing System

The graphs below display the MW flow on W45LC at Chatham TS, Longwood TS and Buchanan TS and 230 kV voltages at these stations. These are hourly average samples from Jan 1 to Dec 31, 2008 obtained from IESO real-time data. Positive MW means flow out of the station.

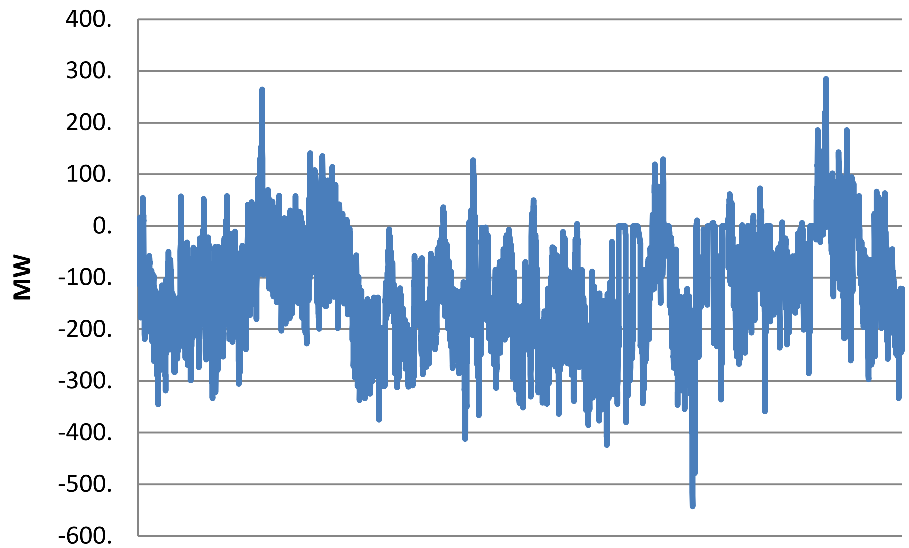


Figure 3: MW flow on W45LC at Chatham TS

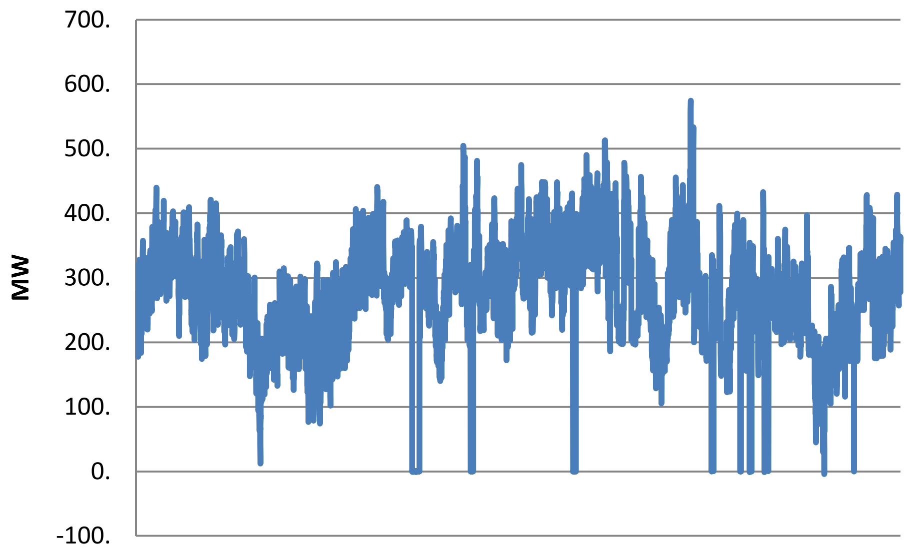


Figure 4: MW flow on W45LC at Longwood TS

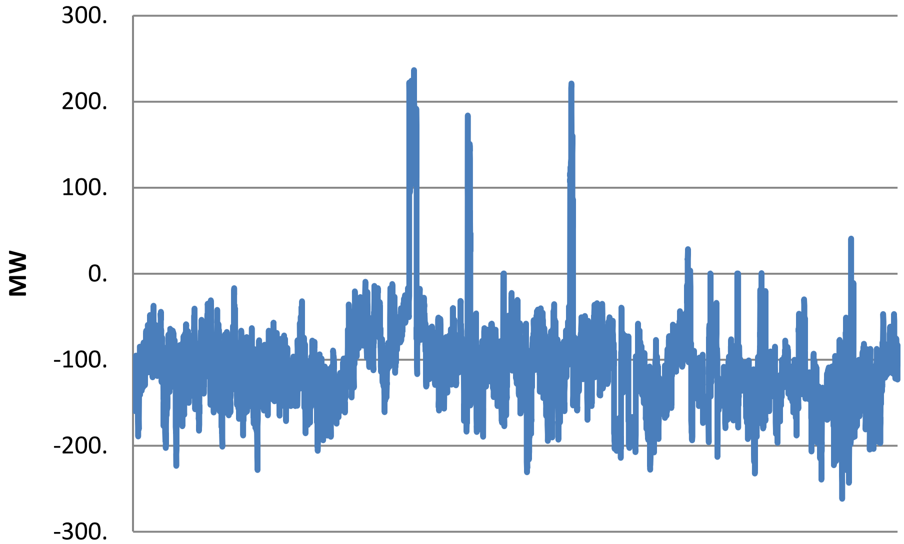


Figure 5: MW flow on W45LC at Buchanan TS

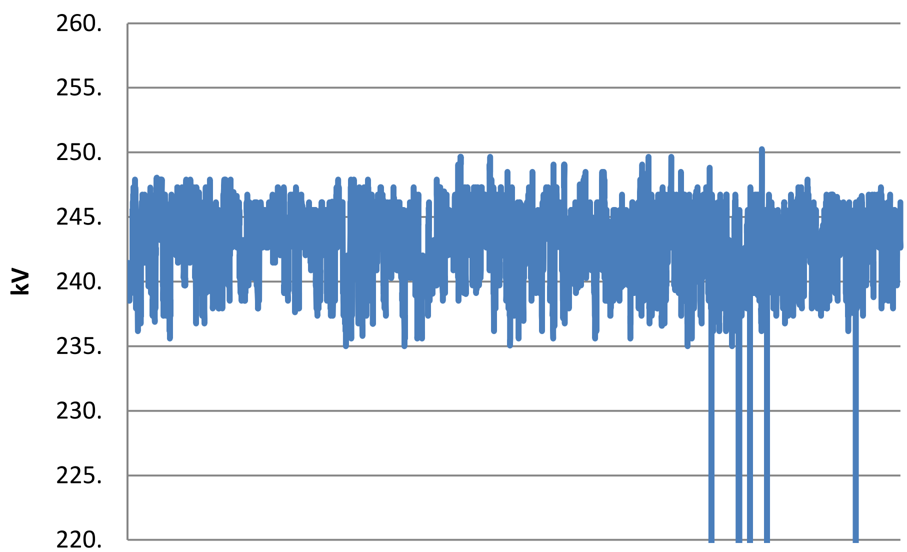


Figure 6: Voltage at Chatham TS

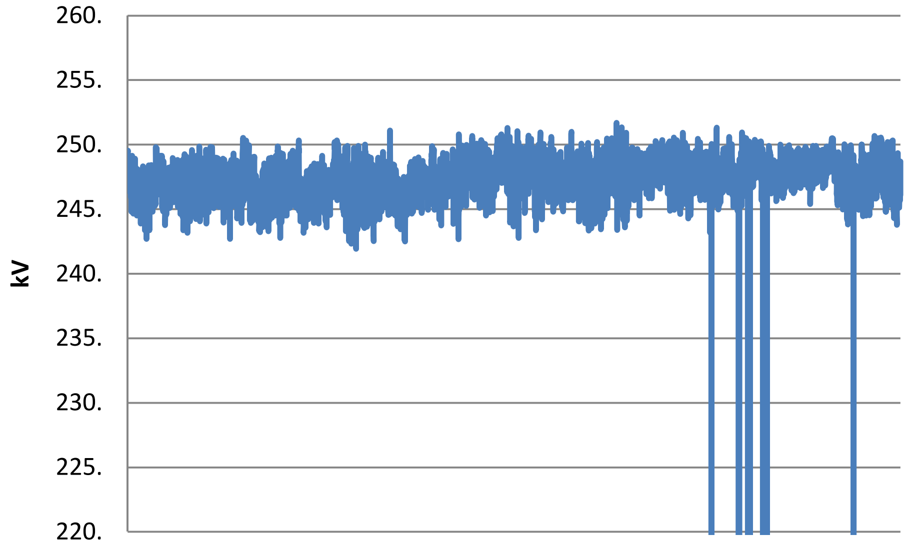


Figure 7: Voltage at Longwood TS

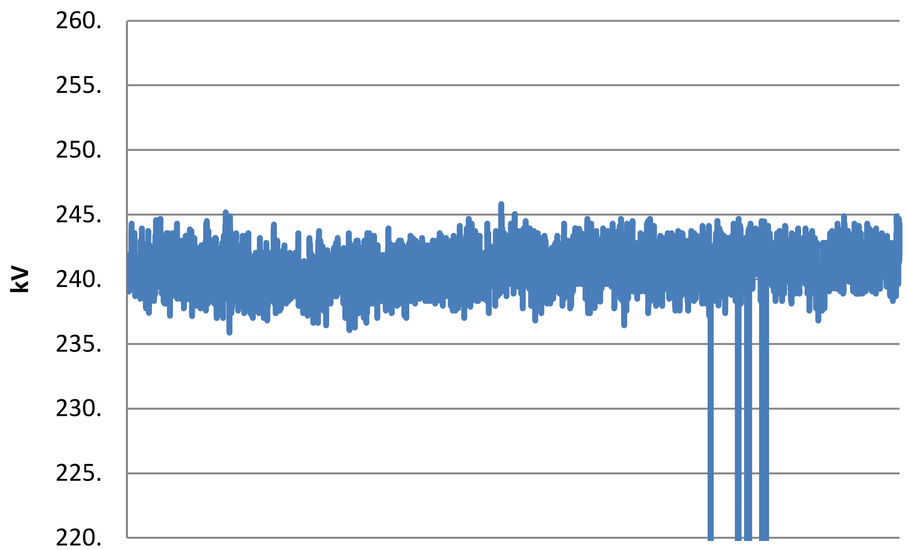


Figure 8: Voltage at Buchanan TS

The followings can be observed.

	Chatham TS	Longwood TS	Buchanan TS
Average voltage (kV)	243	247	241
Max W45LC MW (MW)	284	574	237
Min W45LC MW (MW)	-542	-3.9	-261

4. Data Verification

4.1 Generator

The Market Rules (appendix 4.2, reference 1) require that the generation facility connecting to the IESO-controlled grid must have the minimum capability to supply reactive power continuously in the range of 90% lagging to 95% leading power factor based on active power output at its generator terminals for at least one constant 230 kV system voltage. The connection applicant shall submit the generator's reactive capability curve to the IESO as evidence that the generator is capable of meeting the reactive power requirements.

The details of the generator data used in this assessment are given in Appendix A.

4.2 Transformer

Specifications for the 34.5/230 kV step-up transformer is listed below.

Transformation	246/34.5/13.8 kV
Rating	65/85/115 MVA ONAN/ONAF/ONAF
Impedance	0.07 pu based on 65 MVA
Configuration	3 phase, high side: wye grounded, low side: delta, Tertiary: delta
Tapping	under-load tap changers at HV (215.25 kV to 264.45 kV in 32 steps)

The connection applicant indicated a change of the 34.5 kV winding configuration from delta to wye grounded. This change is currently being analyzed at Hydro One and the IESO and any conclusions and requirements may be addressed in an SIA addendum.

4.3 Circuit Breakers and Switches

Specifications of the isolation devices provided by the connection applicant are listed below. The incomplete data must be provided to the IESO.

Breakers and switches	LV	HV
Rated line-to-line voltage	34.5 kV	250 kV
Interrupting time	-	50 ms
Rated continuous current	-	2000 A
Rated short circuit breaking current	-	63 kA

– End of Section –

5. Fault Level Assessment

Fault level studies were completed by Hydro One to examine the effects of the Talbot Wind Farm on fault levels at existing facilities in the area. Studies were performed to analyze the fault levels with and without Talbot and other proposed wind farms in the surrounding area. The short circuit study was carried out with the following facilities and system assumptions:

The 6 RES III awarded projects:

- Kruger Energy Chatham Wind Project
- Greenwich Windfarm
- Talbot Windfarm
- Raleigh Wind Energy Centre
- Byran Wind Project
- Gosfield Wind Project

Base case conditions:
<u>Northwestern & Northeastern system</u>

Existing facilities

- Atikokan GS
- Thunder Bay G2 & G3
- Prince I & II WGS
- Terrace Bay Pulp CTS STG1 & STG2
- Umbata GS (M2W)
- GLP transmission system reinforcement

New facilities

- Wawatay G4
- Lac Seul GS
- Algoma Steel GS
- Lakehead TS SVC
- Mississagi TS SVC
- Series capacitors at Nobel SS in each of the 500kV circuits X503E & X504E to provide 50% compensation for the line reactance
- Porcupine TS & Kirkland Lake TS SVC
- Mattagami expansion (Upper and Lower Mattagami)

<u>The rest of the system</u>

Existing generation facilities

8 Bruce units
4 Darlington units
6 Pickering units
8 Nanticoke units
4 Lambton units
4 Lennox units
All hydraulic generation

GTAA (44 kV buses at Bramalea TS and Woodbridge TS)
TransAlta Douglas (44 kV buses at Bramalea TS)
TransAlta Sarnia (N6S/N7S)
West Windsor Power (J2N)
Brighton Beach (J20B/J1B)
Imperial Oil (N6S/N7S)
Greenfield Energy Centre (Lambton SS)
St. Clair Energy Centre (L25N & L27N)

All constructed wind farms including:

Erie Shores WGS (W8T)
Kingsbridge WGS (Goderich TS)
Amaranth WGS – Amaranth I (B4V) & Amaranth II (B5V)
Ripley WGS (B22D/B23D)
Prince I & II WGS (K24)
Underwood (B4V/B5V)
Kruger Port Alma (C23Z/C24Z)

New generation facilities
Committed wind generation:

- Wolf Island (X4H & X2H)
- Kingsbridge II (159 MW)

Other New generation:

- Sithe Goreway GS (V41H(V72RS)/V42H(V73RS))
- Thorold GS (Q10P)
- East Windsor Cogen (E8F & E9F) + existing Ford generation
- Beck I G7 conversion to 60 Hz
- Greenfield South GS (R24C)
- Halton Hills GS (T38B/T39B)
- Portlands GS (Hearn SS)
- Bruce standby generators

Transmission system configuration

Existing system with the following upgrades:

Bruce x Orangeville 230 kV circuits up-rated
Hurontario SS in service with R19T+V41H(V72RS) open from R21T+V42H(V73RS) (230 kV circuits V41H(V72RS) and V42H (V73RS) extended and connected from Cardiff TS to Hurontario SS)
Allanburg x Middleport 230 kV circuits (Q35M and Q26M) installed
Claireville TS 230 kV re-configured as per SIA CAA ID 2006-220 and operated ***open***
V75R terminated at Richview for a total of six 230 kV circuits between Claireville TS and RichviewTS
Two 245 Mvar (@ 230 kV) shunt capacitor banks installed at Orangeville TS and Detweiler TS, one per station
Four 250 Mvar (@ 250 kV) shunt capacitor banks installed at Middleport TS
Two 250 Mvar (@ 250 kV) shunt capacitor banks installed at Nanticoke TS
One 250 Mvar (@ 250 kV) shunt capacitor banks installed at Buchanan TS
LV shunt capacitor banks installed at Meadowvale and Halton TS
Essa-Stayner 115 kV circuit replaced by 2 x 230 kV circuits; Stayner TS converted to 230 kV; 230/115 kV auto installed to supply Meaford TS
New 230/115 kV autotransformer at Cambridge-Preston TS

1250 MW HVDC line ON-HQ in service
Tilbury West DS second connection point for DESN arrangement using K2Z and K6Z
Windsor area transmission reinforcement :

- 230 kV transmission line from Sandwich JCT (C21J/C22J) to Lauzon TS
- New 230/27.6 DESN, Leamington TS, that will connect C21J and C22J and supply part of the existing Kingsville TS load
- Replace Keith 230/115 kV T11 and T12 transformers
- 115 kV circuits J3E and J4E upgrades

System Assumptions

Lambton TS 230 kV operated ***open***
Richview TS 230 kV operated ***open***
Claireville TS 230 kV operated ***open***
Leaside TS 230 kV operated ***open***
Leaside TS 115 kV operated ***open***
Middleport TS 230 kV bus operated ***open***
Hearn SS 115 kV bus operated ***open –*** as required in the Portlands SIA
Cooksville TS 230 kV bus operated ***closed***
Cherrywood TS north & south 230kV buses operated ***open***
All capacitors in service
All tie-lines in service and phase shifters on neutral taps
Maximum voltages on the buses

The following table summarizes the symmetric fault levels near Windsor area and corresponding breaker ratings.

Bus	All Wind Farms O/S		All Wind Farms I/S		Breaker Ratings Symmetrical (kA) (1)
	Total Fault Current Symmetrical (kA)		Total Fault Current Symmetrical (kA)		
	3-phase fault	L-G	3-phase fault	L-G	
Chatham 230 kV	21.9	14.7	24.5	15.4	32.8
Lambton 230 kV	47.7	50.9	48.0	51.1	65 / 70 (2)
Lambton A 230 kV	43.8	46.9	44.1	47.1	65 / 70 (2)
Keith 230 kV	20.0	22.3	20.3	22.6	43.3
Keith 115 kV	26.9	31.7	27.1	32.1	39.3
Lauzon 115 kV	24.4	27.1	25.2	27.2	40
Scott 230 kV	44.8	41.6	45.0	41.7	50
Scott 115 kV	20.5	24.4	20.5	24.4	50
Buchanan230 kV	32.6	27.6	33.0	27.4	50
Buchanan 115 kV	26.4	30.8	26.5	30.9	50
Longwood 500 kV	24.4	24.1	24.6	24.2	63
Longwood 230 kV	41.7	48.9	42.2	49.3	63

(1) Worst case rating
(2) The 65 kA rating applies to breakers PL4 & KL4; the 70kA rating to remaining 230 kV breakers at Lambton SS.

The results show that the fault levels in the surrounding area of the Windsor area are below the symmetrical breaker ratings. Fault levels increase slightly when all the wind farms are in service with the highest increase at Chatham of 2.6 kA.

Further studies were performed assuming that Port Alma WGS and Kruger WGS are connected to C23Z during an outage of C24Z. The results show there is very slight difference in the fault levels.

Therefore, it can be concluded that the increases in fault level, due to the proposed Talbot WGS, will not exceed the interrupting capabilities of the existing breakers on the IESO-controlled grid.

– End of Section –

6. System Impact Studies

This connection assessment was carried out to identify the effect of the proposed facility on thermal loading of transmission interfaces in the vicinity, the system voltages for pre/post contingencies, the ability of the facility to control voltage and the transient performance of the system.

6.1 Assumptions and Background

Following sections summarizes the study assumptions and the background information required for the analysis

- The study was performed for a system with all transmission elements in service.
- For this connection assessment the summer 2010 base case was used as a starting point and then one system representation was developed with stressed transmission lines in Southwest area as follows,

Ontario PD (Load + Losses)	West Zone Generation	West Zone Load	BLIP	J5D	FABC
29200 MW	5650 MW	3300 MW	-1524 MW	150 MW to Ont	4350 MW
Wind plants	Kruger Port Alma	Kruger Chatham	Raleigh	Gosfield@K2Z	Talbot@W44LC
	101 MW	101 MW	79 MW	50 MW	99 MW
West of Chatham Generation			West of Chatham Load		
1200 MW			1100 MW		

- Part of transmission upgrades proposed to Windsor area is incorporated. That includes:
  - Install a new 230/27.6 kV DESN, Leamington TS that will connect circuits C21J and C22J and supply part of the existing Kingsville TS load.
  - Replace Keith transformers T11 and T12

  The following projects are not included due to uncertain in-service date as indicated by Hydro One:
  - Establish a 230 kV connection between Lauzon TS and Sandwich Junction on C21J/C22J
  - Upgrade 115 kV circuits J3E and J4E.

- For voltage decline studies, the MW loads were converted into constant current and admittance loads equally. The MVAr loads were converted only into constant admittance loads.

6.2 Protection Impact Assessment

A Protection Impact Assessment (PIA) was performed by Hydro One to examine the impact of the new generators on existing transmission system protections. The existing protections for W45LC at Chatham TS, Longwood and Buchanan TS were described in the PIA report and the proposed protection solutions and settings were analyzed based on preliminary fault calculations. In addition, the requirements for communication, supervisory and control, and digital fault recording were presented.

The existing zone 1 settings at Chatham SS will be reduced and will not reach the HV tap at Talbot Wind facility. As a result, the overlap of zone 1 protections at Chatham - Buchanan and Chatham - Longwood will be lost and about 35 km of W45LC will be covered only by zone 2 protection. Faults beyond the zone 1 reach from either terminal will be cleared by zone 2 blocking scheme with 50 ms time delay. In the following stability study dynamic simulations will be performed to examine the impact of the 50 ms delay in the clearing time on the system reliability and wind farm operation.

For Zone 2 Protection Settings, the existing line protection settings will have to be revised to allow for the connection of the new Talbot generation. Preliminary fault calculation study indicated that the line apparent impedance as seen from Buchanan terminal will be approx. 0.3 pu (300 km) with the proposed connection of Talbot Wind Farm. This impedance represents 300% of the line impedance to Chatham.

The new setting may jeopardize the protection stability due to dynamic power swings and heavy load transfers on circuit W45LC. Due to large line impedances coupled with high line loadings adequate relaying coverage would not be possible.

To avoid the possibility of zone 2 time protection operation for stable power swings the PIA study recommended to sectionalize circuit W45LC and build a new Switching Station at the tap to Talbot wind farm. The proposed arrangement of the new switching station is shown in Figure 9. It is recommended to replace the existing directional comparison scheme with line differential protection for the sections of circuit W45LC between new SS, Buchanan and Longwood (W45LT), new SS and Chatham SS (C45T).

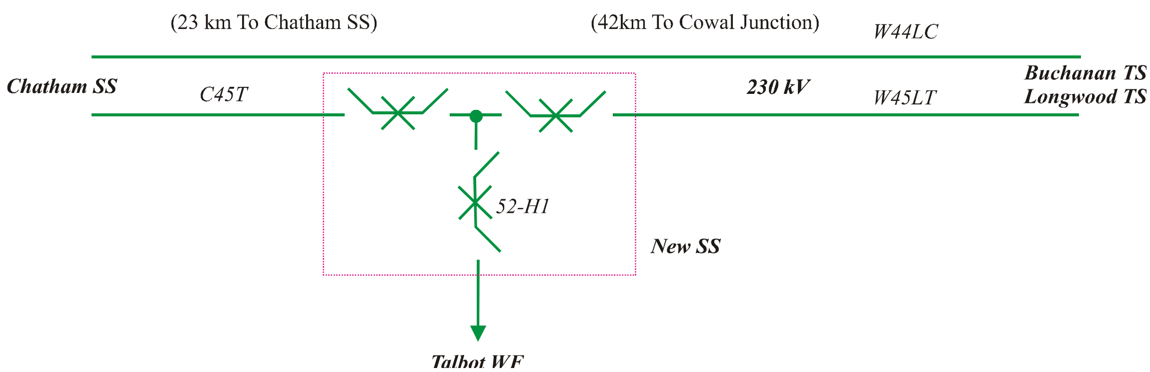


Figure 9: Proposed arrangement of the new SS

It should be noted that the existing DESN station Edgeware TS and the new station Stuart TS connecting to W44LC/W45LT will be included in the line differential zone Buchanan – Longwood - New SS. The pickup settings of the differential relay will have to be set to accommodate this load. To prevent operation of the differential protection for faults on the LV side at DESN stations the differential protection will have to be supervised by the distance element. If this is not possible, blocking channels from DESN stations will have to be incorporated. In this case the operation of differential protection on W45LT will be time delayed to allow for receipt of blocking signal.

The IESO concluded that the proposed arrangement in the PIA is a practical and acceptable approach for solving protection coordination issues and the security of Talbot WF will be improved by connecting to the system when either new section of C45T or W45LT is out of service. Therefore, this SIA study is carried out based on the proposed arrangement and the impact of the proposed arrangement and protection settings on the reliability of the IESO-controlled grid is examined.

6.3 Thermal Analysis

The summer day-time ratings of circuits (based on most restricting section) near Talbot WGS under 35ºC and 5 km/h conditions are as follows.

Circuit	Wind km/hr	Sag Temp	Ambient Temp.	Conductor Size (kcmil), Strands	Continuous Rating	15-min LTR
K2Z	4	133 °C	35 °C	477, 26/7	800 A	940 A
K6Z	4	150 °C	35 °C	336, 26/7	690 A	770 A
J3E	4	127 °C	35 °C	795.0, 26/7	810 A	1070 A
J4E	4	127 °C	35 °C	795.0, 26/7	810 A	1000 A
C23Z	4	132 °C	35 °C	1192.5, 54/19	1060 A	1670 A
C24Z	4	116 °C	35 °C	795.0, 26/7	840 A	1130 A
C21J,C22J	4	116 °C	35 °C	795.0, 26/7	840 A	1130 A
Z1E, Z7E	4	127 °C	35 °C	997.2, 21/7	910 A	1380 A
W44LC, W45LC (WC)	4	150 °C	35 °C	1307.4, 28/19	1110 A	2000 A
W44LC, W45LC (LC)	4	127 °C	35 °C	1843.2, 72/7	1350 A	2170 A

- The lower of the sag temp or 93 °C is used to calculate the continuous rating (for pre-contingency)
- The sag temp is used to calculate the 15-min LTR (for immediate post-contingency)

Pre-contingency analysis

The following are the pre-contingency flows for various circuits in the local area prior to and after the connection of Talbot. The largest flow on each circuit is expressed in Amperes and percentage of continuous rating as well. Two scenarios were studied considering the connection of Kruger Chatham and Port Alma wind farms.

Option 1: Kruger Chatham and Port Alma wind farms are connected to K23Z
Option 2: Kruger Chatham and Port Alma wind farms as well as Raleigh WGS are connected to K23Z during the outage of K24Z.

Circuit	**Before the Connection of Talbot**				**After the Connection of Talbot**			
	Option 1		**Option 2**		**Option 1**		**Option 2**	
	Amps	**%**	**Amps**	**%**	**Amps**	**%**	**Amps**	**%**
J3E	986	121.7	987.0	121.9	928	114.6	1011	124.8
J4E	990	122.2	990.0	122.2	926	114.3	999	123.3
C23Z	255	24.1	373.0	35.2	223	21.0	441	41.6
C24Z	343	40.8	222.0	26.4	309	36.8	0	0.0
C21J	387	46.1	387.0	46.1	397	47.3	374	44.5
C22J	379	45.1	379.0	45.1	389	46.3	369	43.9
Z1E	885	97.3	886.0	97.4	820	90.1	894	98.2
Z7E	878	96.5	878.0	96.5	828	91.0	882	96.9
W44LC	978	88.1	974	87.7	995	89.6	991	89.3
C45T	795	71.6	800	72.1	672	60.5	677	61.0
W45LC	978	88.1	974	87.7	1023	92.2	1018	91.7

The flows from the table above indicate that prior to the Talbot connection, J3E/J4E are overloaded pre-contingency. With the connection of Talbot, J3E/J4E remain overloaded. The results of this pre-contingency analysis indicate that for peak load conditions, the thermal capability of the 115 kV lines from Keith to Essex is not adequate. This is an existing system problem, and it is not a result of the proposed wind generating station. The subsequent analysis of this presentation was carried out with J3E/J4E overloaded pre-contingency.

Post-contingency analysis

The following are the post-contingency loadings of the monitored circuits including loading in ampers, 15-min LTR and percentage of loading over LTR.

Circuit	**Pre-contingency : Option 1 C23Z = Raleigh C24Z = Port Alma + Chatham**			
	Contingency			
	C21J+C22J+T12	**W44LC**	**C45T**	**W45LT**
J3E	1140/1070 = 1.07	884/1070=0.82	891/1070=0.83	880/1070=0.82
J4E	1138/1000 = 1.14	876/1000=0.87	885/1000=0.89	873/1000=0.87
C23Z	195/1670 = 0.12	232/1670=0.88	215/1670=0.13	234/1670=0.14
C24Z	357/1130 = 0.32	352/1130=0.13	335/1130=0.30	354/1130=0.31
C21J	0	346/1130=0.31	355/1130=0.31	341/1130=0.30
C22J	0	3381130=0.31	347/1130=0.30	333/1130=0.29
Z1E	1039/1380 = 0.75	800/1380=0.30	806/1380=0.58	797/1380=0.58
Z7E	1032/1380 = 0.75	792/1380 =0.57	799/1380=0.58	790/1380=0.57
W44LC	1041/2000 = 0.52	0	1075/2000=0.54	1260/2000=0.63
C45T	705/2000=0.35	962/2000=0.48	0	238/2000=0.12
W45LT	1011/2000 = 0.51	1279/2000=0.64	793/2000=0.40	0

Circuit	Pre-contingency : Option 2 C23Z = Raleigh + Port Alma + Chatham C24Z = O/S		
	Contingency		
	W44LC	**C45T**	**W45LT**
J3E	876/1070=0.82	885/1070=0.83	873/1070=0.82
J4E	884/1000=0.88	892/1000=0.89	880/1000=0.88
C23Z	384/1670=0.23	380/1670=0.22	380/1670=0.23
C24Z	200/1670=0.12	196/1670=0.12	202/1670=0.12
C21J	345/1130=0.31	355/1130=0.31	341/1130=0.30
C22J	338/1130=0.30	347/1130=0.31	334/1130=0.30
Z1E	562/1380 = 0.41	798/1380=0.58	789/1380=0.57
Z7E	572/1380 = 0.41	800/1380=0.58	797/1380=0.58
W44LC	1013/2000 = 0.51	1076/2000=0.54	1260/2000=0.63
C45T	959/2000=0.47	0	238/2000=0.12
W45LT	1279/2000=0.64	790/2000=0.40	0

Ignoring the overloads of lines J4E and J3E, the results for 2008 extreme weather indicate that the post flows are within STR given that the sufficient control actions are initiated. It must be emphasized that these percentages are based on a rating obtained with 95 % pre-load value where in most cases the actual pre-load values are below this threshold. There does not appear to be instances of overloading other than on J4E and J3E.

From the (post contingency flow/pre-contingency flow) ratios for lines J4E and J3E, it can be seen that the loss of C24Z or the loss of C23Z+C24Z will cause the J4E and J3E to be overloaded even more than they are already in pre-contingency. Note that the loss of C24Z causes the loss of the Kruger facility.

6.4 Voltage Analysis

The voltage decline studies were performed with the Talbot facility connected to the circuit W45LC. For pre-ULTC and post-ULTC, the declines are calculated after MW loads are converted into constant current and admittance loads equally and the MVAr loads are converted fully into constant admittance loads. Both declines of pre-ULTC and post-ULTC values are given in the following tables.

Pre-ULTC Voltage Declines											
Contingency	Chatham 230 kV	Longwood 230 kV	Buchanan 230 kV	Lauzon 230 kV	Lauzon 115 kV	Keith 230 kV	Keith 115 kV	Essex 115 kV	K6Z@K 115 kV	Talbot 230 kV	Talbot 35 kV
K2Z	0.00	-0.08	-0.17	0.00	0.00	0.00	0.00	0.00	-0.81	0.00	0.00
J2N	-0.13	0.04	0.00	-0.43	-0.41	-0.34	-0.66	-0.50	-0.49	-0.04	0.00

J5D	0.13	-0.04	-0.09	0.09	0.16	0.25	0.16	0.17	0.16	0.13	0.28
J3E+J4E	-1.47	-0.37	-0.47	-3.86	-3.28	-0.21	0.16	-3.31	-3.40	-1.04	-0.56
Z7E+Z1E	0.42	0.24	0.17	2.87	4.50	-0.04	-0.33	-0.58	4.53	0.25	0.28
Brighton Beach	0.21	0.20	0.21	0.09	0.16	0.21	0.16	0.17	0.16	0.38	0.56
C23Z	-0.21	-0.08	-0.17	-2.17	-1.47	-0.25	-0.58	-1.16	-1.54	-0.13	0.00
C24Z	0.67	-0.12	-0.21	-0.91	-0.74	0.00	-0.25	-0.58	-0.73	0.63	0.56
C23Z+C24Z	1.01	0.00	-0.04	-6.47	-4.83	-0.63	-1.89	-3.73	-4.94	0.92	0.84
C21J+C22J+T12	0.38	-0.04	-0.17	0.48	0.25	-0.21	0.41	0.25	0.24	0.25	0.28
C45T	1.34	-0.24	-0.30	1.65	1.06	0.38	0.49	0.83	0.97	2.21	0.28
W45LT	1.43	-0.81	-2.51	1.74	1.15	0.42	0.49	0.83	1.05	1.59	0.00
W44LC+W45LC	2.56	-0.53	-2.98	2.39	1.64	0.68	0.74	1.24	1.54	0.00	0.00

Post-ULTC Voltage Declines											
Contingency	Chatham 230 kV	Longwood 230 kV	Buchanan 230 kV	Lauzon 230 kV	Lauzon 115 kV	Keith 230 kV	Keith 115 kV	Essex 115 kV	K6Z@K 115 kV	Talbot 230 kV	Talbot 35 kV
K2Z	0.00	-0.08	-0.17	0.00	-0.08	0.00	0.00	-0.08	-0.97	0.00	0.00
J2N	0.13	0.08	0.04	0.09	0.25	0.04	0.25	0.25	0.24	0.21	0.28
J5D	0.13	0.00	-0.09	0.09	0.16	0.25	0.16	0.17	0.16	0.17	0.28
J3E+J4E	-1.39	-0.33	-0.47	-3.43	-2.87	-0.21	0.16	-2.90	-2.59	-1.00	-0.56
Z7E+Z1E	0.00	0.16	0.09	1.56	2.87	-0.13	-0.41	-0.58	-0.08	-0.08	0.00
Brighton Beach	0.25	0.24	0.26	0.09	0.16	0.21	0.16	0.17	0.16	0.38	0.56
C23Z	-0.21	-0.08	-0.13	-2.04	-1.39	-0.25	-0.58	-1.08	-1.30	-0.08	0.00
C24Z	0.71	-0.12	-0.17	-0.91	-0.74	0.00	-0.25	-0.58	-0.73	0.67	0.56
C23Z+C24Z	1.05	0.00	-0.04	-5.21	-3.85	-0.46	-1.48	-2.98	-3.72	0.92	0.84
C21J+C22J+T12	0.42	-0.04	-0.17	0.48	18.26	-0.21	0.41	0.25	0.24	0.25	0.28
C45T	1.30	-0.24	-0.30	1.65	1.06	0.38	0.49	0.83	0.97	2.21	0.28
W45LT	1.47	-0.73	-1.87	1.74	1.15	0.42	0.49	0.91	1.05	1.63	0.00
W44LC+W45LC	2.52	-0.45	-2.26	2.34	1.64	0.63	0.74	1.24	1.54	0.00	0.00

Only the single contingencies are needed to be respected in Windsor 115 kV local area. However, the double contingencies are simulated to check any voltage concerns in Windsor area. It can be concluded that all the voltage declines are less than 10.0 % which meets the voltage decline criteria.

6.5 Reactive Power Compensation

6.5.1 Dynamic Reactive Power Compensation

The following summarizes the IESO required level of dynamic reactive power and the available capability of SMK223 from Siemens document "Reactive Power Capability" (Document PG-R3-30-0000-0113-03).

	Terminal Voltage	Active Power	Reactive Power Capability/Turbine
IESO Required	1.0 pu	1.0 pu	$Q_{gen} = 2.55 \times \sin[\cos^{-1}(0.9)] = 1.11$ Mvar
			$Q_{abs} = 2.55 \times \sin[\cos^{-1}(0.95)] = 0.8$ Mvar
SMK223 Capability	1.0 pu	1.0 pu	$Q_{gen} = 2.3 \times 0.55 = 1.26$ Mvar
			$Q_{abs} = 2.3 \times 0.55 = 1.26$ Mvar

The SMK223 generators can deliver IESO required dynamic reactive power to the generator terminal at rated power and at rated voltage. Thus, the IESO has determined that there is no need to install any additional dynamic reactive power compensation device.

6.5.2 Static Reactive Power Compensation

Talbot Wind Farm must have the same capability to supply reactive power continuously as required of a synchronous generator with the same apparent power, as measured at the point of connection to the IESO-controlled grid. With this assumption, Talbot Wind Farm must have a minimum capability of supplying approximately **+35 MVAr** (capacitive) to **-33 MVAr** (inductive) at the connection point for at least one constant 230 kV system voltage at all active power outputs.

Load flow studies were performed to justify a need for static reactive compensation. Besides the conditions described in the section '*Model and Data*', additional simulation conditions for these load flow studies include that:

- The 230-kV voltages at Chatham and Longwood are about 243 and 246 kV, respectively;
- The terminal voltages of the WTGs vary between 0.95 pu and 1.05 pu;

The inductive capability of the generation facility was assessed with the WTGs operating at full active power output. The voltage at the connection point is about 243 kV. The 230 kV tap of the step-up transformer at the Wind Farm Substation is set to the position of 246 kV. The WTG units are operated to control the terminal voltages to their lowest values. The generation facility can absorb a maximum reactive power of **33.6 MVAr** at the connection points, indicating that Talbot Wind Farm meet the inductive reactive power requirement.

The capacitive capability of the generation facility was assessed with the WTGs operating at full active power output. The voltage at the connection point is about 243 kV. The 230 kV tap of the step-up transformer at the Wind Farm Substation is set to the position of 252 kV. The generation facility can supply a maximum reactive power of **10.9 MVAr** at the connection points when the WTG units are operated to control the terminal voltages to their highest values. This indicates that static reactive compensation is required to be installed at collector bus to meet the capacitive reactive power requirement.

Capacitor banks, with equipment capacity of **24 MVAr@34.5 kV,** installed at the 34.5 kV bus will increase the reactive power injection at the connection point. With these capacitor banks, the wind farm can supply a maximum reactive power of **+35.6 MVAr** at the connection point, which meets the capacitive reactive requirement**.**

Voltage change due to capacitor switching

Switching study was carried out to investigate the effect of the new LV shunt capacitor banks on the voltage changes.

Following summarizes the change in voltage due to switching of a single capacitor of 21 MVAr at the collector bus. All generators are made to operate at a fixed power factor to prevent their dynamic reactive power capability changes bus voltages, so that the ΔV is only due to capacitor switching. The ΔV has been tested when generators offer no voltage support and at the worst condition, i.e. the generators absorb maximum reactive power so that the ΔV due to cap switching is maximum. The transformers ULTCs have been locked.

LV			**HV**		
PRE	**POST**	**%**	**PRE**	**POST**	**%**
34.9	35.9	2.87	242.0	243.6	0.66

The IESO allows ΔV on a single capacitor switching to be no more than 4%. It appears switching of a single capacitor of 24 MVAr produces less than 4 % voltage increase. However, it is necessary to supply the 24 MVAr in 2 steps to increase the operational flexibility.

6.6 Transient Analysis

Transient stability analyses were performed considering fault in Windsor area with the proposed Talbot WGS in-service. Eleven contingencies were tested. They include a permanent three-phase fault on a circuit (SC1-SC9), simultaneous permanent phase to ground faults on different phases of each of two adjacent circuits on a multiple circuit tower cleared with normal fault clearing time (SC10- SC11).

It should be noted that based on Protection Impact Assessment reports for the wind projects in Southwest from HO, part of C23Z/C24Z will be covered only by zone 2 protections. To allow for a blocking signal the clearing timing of the zone 2 faults will be delayed by 50 ms. As described in the Section 6.2, line differential protection will be applied for the sections of circuit W45LC, between new SS, Buchanan and Longwood (W45LT), new SS and Chatham SS (C45T). Due the DESNs connected to W45LT, 50 ms time for receipt of blocking signal is applied for the operation of differential protection on W45LT.

Contingencies	
SC1	Normally cleared LLLG fault on K6Z @ Lauzon
SC2	Normally cleared LLLG fault on C22J@Chatham
SC3	LLLG fault on C24Z @ Lauzon cleared by Zone 2 protection
SC4	Normally cleared LLLG fault on J4E @ Keith
SC5	Normally cleared LLLG fault on Z7E @ Lauzon
SC6	Normally cleared LLLG fault on W44LC @ Chatham
SC7	Normally cleared LLLG fault on L28C @ Chatham
SC8	Normally cleared LLLG fault on W45LT@Talbot SS

SC9	Normally cleared LLLG fault on C45T@Talbot SS
SC10	Normally cleared LG fault on C21J + LG fault on C22J @ Chatham
SC11	Normally cleared LG fault on L28C + LG fault on L29C @ Chatham

The Appendix B show the transient curves. None of the contingencies caused any adverse significant impact on IESO-controlled grid. It can be concluded from the results that, with Talbot WGS on-line, none of the simulated contingencies caused transient instability or undamped oscillations.

6.7 Low-voltage ride through capability

As any other generators, the MK II is expected to trip only for contingencies which removes the generator by configuration or abnormal conditions such as severe and sustained under-voltage, over-voltage, under-frequency, over-frequency etc. The severity of under-voltage seen by generator terminals is to be temporarily mitigated by the LVRT capability. The LVRT feature is implemented by injection of additional reactive current by the grid side AC/DC converter to maintain generator terminal voltage in the event of a disturbance in the power system that caused terminal voltage to drop.

The implementation of LVRT should not require any instant modification to under-voltage protection settings. In PSS/E model for MK II, the LVRT feature accompanies a change of under-voltage setting as shown below (From Siemens Document “UserInputData-SMK223_InputData_SWT-2.3-101_VS_60 Hz_V1.2.xls”.

Voltage range	*Event*
1.00 – 0.85 pu	No trip
0.85 – 0.5 pu	Relay 1 trips in 3.1 sec
0.5 – 0.15 pu	Relay 2 trips in 1.835 sec
0.15 – 0.0 pu	Relay 3 trips in 0.24 sec

In order to examine the need for low voltage ride through (LVRT) capability, the three phase fault on W45LT at Talbot SS with normal clearing time plus 50 ms for receipt of blocking signal were simulated. These particular contingencies are electrically much closer to the new generation facility than other contingencies. Thus, they could potentially have a greater impact on the terminal voltage of the facility. The variation of the terminal voltage of the new generation facility is plotted in Figure 10 below. It can be seen that the duration during which the generator terminal voltage drops below 0.5 pu is about 0.13 sec. Therefore, fault ride through capabilities of the wind turbines is adequate.

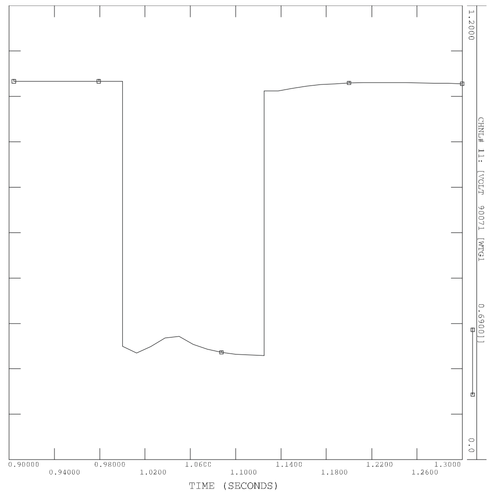


Figure 10: Terminal Voltage of Wind Generator During 3-phase fault at Talbot SS

The LVRT capability must be demonstrated during commissioning by monitoring several variables under a set of IESO specified field tests and the result should be verifiable using the PSS/E model.

6.8 Wind Farm Management System

The Wind Farm Management System (WGSMS) must coordinate the voltage control process. The proponent must submit a description of the functionalities of the WGSMS, including the coordination between the automatic capacitor switching and generator reactive power production to control the voltage at a desired point. This document also must contain the settings of the automatic capacitor switching scheme. If the WGSMS is unavailable, the IESO requires each generator controls its own terminal voltage.

– End of Report –

Appendix A

Base and Loadflow Information			
Prated	2.3	Machine Active Power Rating (MW)	SEM
Vrated	0.69	Stator Voltage Rating (kV)	
Frated	60	Rated network frequency (Hz)	FBA
Busbar	90200	Connection busbar number	
Gen ID	1	Generator Identifier	
Rg	0.0000	Generator Resistance in Loadflow (Rs, pu)	RSO
Xg	0.6415	Generator Reactance in Loadflow (Xd'', pu)	XSO
Srated	2.6	Unit Transformer Rating (MVA)	Note
Rt	0.0084	Unit Transformer Resistance (pu)	Note
Xt	0.06	Unit Transformer Reactance (pu)	Note
ICONS	**Value**	**Description**	**Ref:**
M	2	Model Version Number	
M+1	1	Reactive control mode (1=voltage)	
M+2	1	Fault Ride Through mode (1=enabled)	
M+3	1	Enable Under-voltage relay 1	
M+4	1	Enable Under-voltage relay 2	
M+5	1	Enable Under-voltage relay 3	
M+6	1	Enable Over-voltage relay 1	
M+7	1	Enable Over-voltage relay 2	
M+8	1	Enable Under-frequency relay 1	
M+9	1	Enable Under-frequency relay 2	
M+10	1	Enable Over-frequency relay 1	
CONs	**Value**	**Description**	**Ref:**
J	54.62		
J+1	1.0927		
J+2	15.591		
J+3	0.1458		
J+4	128.61		
J+5	1.2471		
J+6	1.1432		
J+7	1.1109		
J+8	1.0003		
J+9	1.40		
J+10	1.10		
J+11	0.10		
J+12	22		
J+13	100000		
J+14	2		
J+15	100000		

J+16	2.00		
J+17	0.15		
J+18	0.40		
J+19	0.090		
J+20	0.090		
J+21	0.160		
J+22	1.00		
J+23	2.9		
J+24	58.6		
J+25	0.90		
J+26	50.00		
J+27	10.00		
J+28	0.499		
J+29	24.9		
J+30	1.0878		
J+31	0.0022		
J+32	0.1348		
J+33	0.040		
J+34	2.10		
J+35	0.70		
J+36	1.20		
J+37	0.70		
J+38	1.89		
J+39	2.00		
J+40	0.82		
J+41	0.50		
J+42	0.40		
J+43	4.00		
J+44	1.225	Air density	
J+45	15.00	User defined wind speed for rated power operation (m/s)	
J+46	1		
J+47	0.1739		
J+48	0.6522		
J+49	1.0069		
J+50	13.05		
J+51	-101.5		
J+52	-56.39		
J+53	0.15		
J+54	7.0		
J+55	-8.0		
J+56	45.0	Maximum pitch angle	
J+57	-2	Minimum pitch angle	
J+58	2.0		
J+59	0.060		
J+60	0.9655		
J+61	-4.7283		
J+62	-0.6755		
J+63	0.2174		

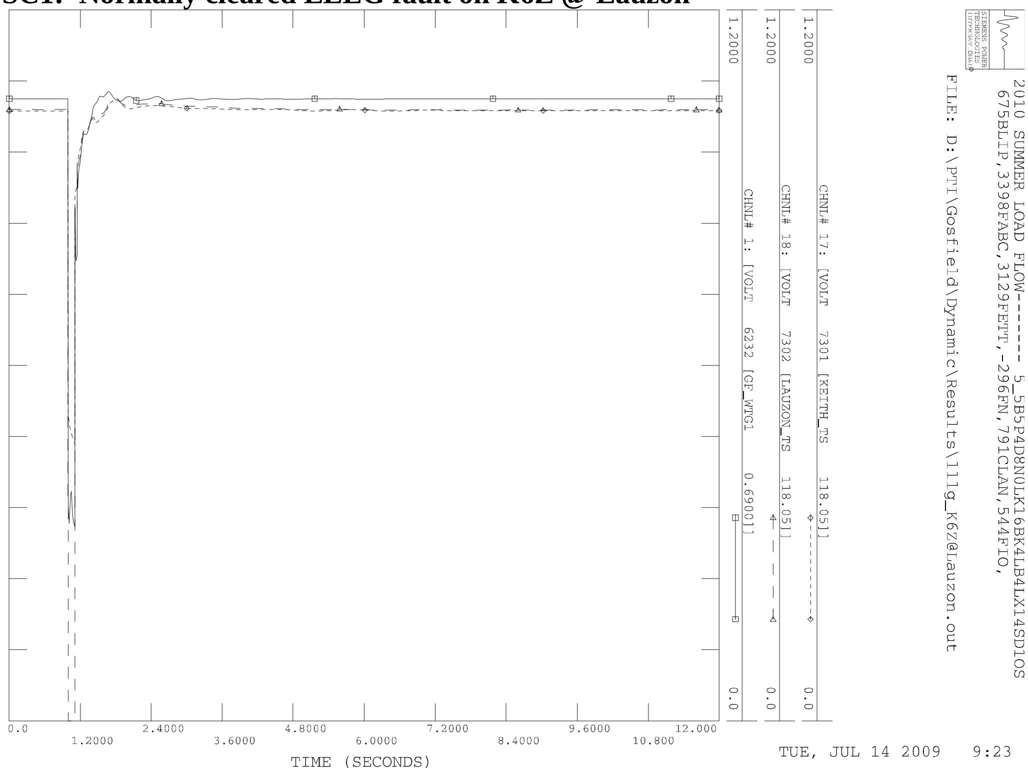
J+64	-0.2174		
J+65	1.00		
J+66	0.85	Under Voltage Relay 1 - Voltage Setting (pu)	
J+67	3.000	Under Voltage Relay 1 - Time Setting (s)	
J+68	0.100	Under Voltage Relay 1 - Relay activation time (s)	
J+69	0.50	Under Voltage Relay 2 - Voltage Setting (pu)	
J+70	1.735	Under Voltage Relay 2 - Time Setting (s)	
J+71	0.100	Under Voltage Relay 2 - Relay activation time (s)	
J+72	0.15	Under Voltage Relay 3 - Voltage Setting (pu)	Not
J+73	0.140	Under Voltage Relay 3 - Time Setting (s)	Not
J+74	0.100	Under Voltage Relay 3 - Relay activation time (s)	Not
J+75	0.85	Under Voltage Relay 3 - Voltage Setting (pu)	
J+76	0.075	Under Voltage Relay 3 - Time Setting (s)	
J+77	0.000	Under Voltage Relay 3 - Relay activation time (s)	
J+78	1.10	Over Voltage Relay 1 - Voltage Setting (pu)	
J+79	1.000	Over Voltage Relay 1 - Time Setting (s)	
J+80	0.000	Over Voltage Relay 1 - Relay activation time (s)	
J+81	1.20	Over Voltage Relay 2 - Voltage Setting (pu)	
J+82	0.200	Over Voltage Relay 2 - Time Setting (s)	
J+83	0.000	Over Voltage Relay 2 - Relay activation time (s)	
J+84	0.95	Under Frequency Relay 1 - Frequency Setting (pu)	
J+85	10.000	Under Frequency Relay 1 - Time Setting (s)	
J+86	0.000	Under Frequency Relay 1 - Relay activation time (s)	
J+87	0.94	Under Frequency Relay 2 - Frequency Setting (pu)	
J+88	0.100	Under Frequency Relay 2 - Time Setting (s)	
J+89	0.000	Under Frequency Relay 2 - Relay activation time (s)	
J+90	1.04	Over Frequency Relay 1 - Frequency Setting (pu)	
J+91	0.100	Over Frequency Relay 1 - Time Setting (s)	
J+92	0.000	Over Frequency Relay 1 - Relay activation time (s)	
J+93	0.10		
J+94	11.47		
J+95	22.91		
J+96	1.836		
J+97	0.050		
J+98	0.025		

DYRE Data (auto-generated from datasheet information. Copy/paste into DYRE file.)

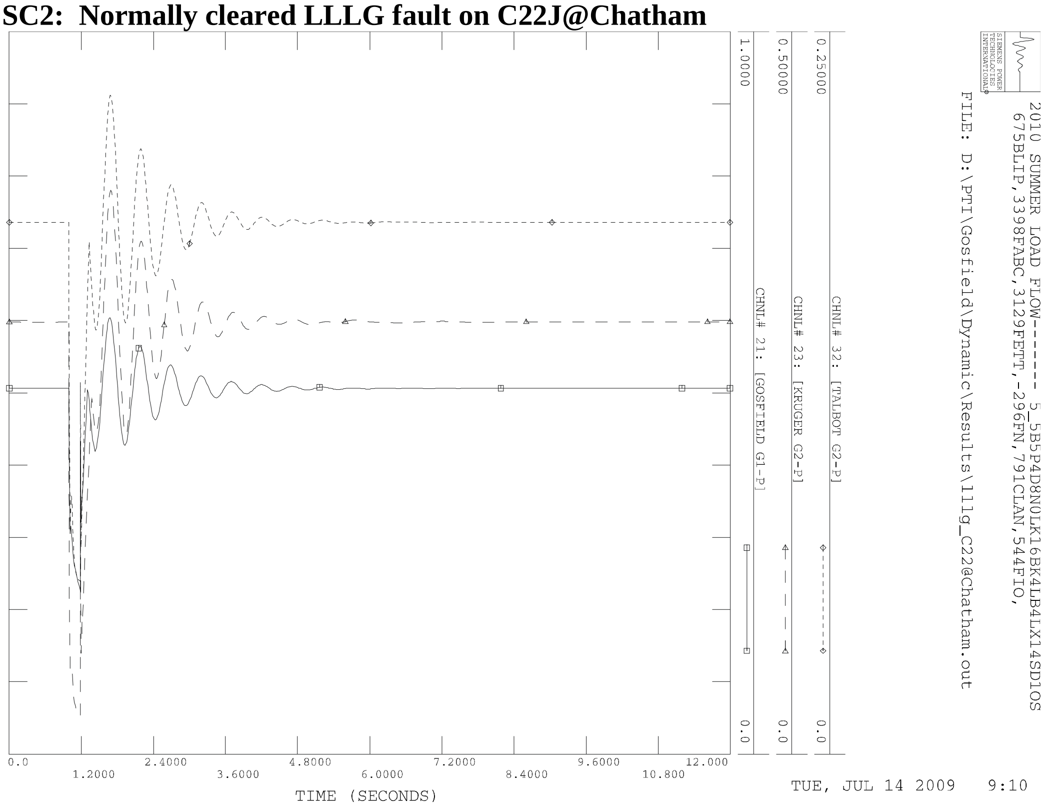
```
 / SMK223 V1.2, 2.3 MW Turbine Data
90200 'USRMDL' 1 'SMK223' 1 1    11 99 20 78
  2 1 1 1 1 1 1 1 1 1 1 54.62 1.0927 15.591 0.1458 128.61 1.2471 1.1432 1.1109 1.0003 1.40 1.10 0.10 22 100000 2 100000
  2.00 0.15 0.40 0.090 0.090 0.160 1.00 2.9 58.6 0.90 50.00 10.00 0.499 24.9 1.0878 0.0022 0.1348 0.040 2.10 0.70 1.20
  0.70 1.89 2.00 0.82 0.50 0.40 4.00 1.225 15.00 1 0.1739 0.6522 1.0069 13.05 -101.5 -56.39 0.15 7.0 -8.0 45.0 -2 2.0 0.060
  0.9655 -4.7283 -0.6755 0.2174 -0.2174 1.00 0.85 3.000 0.100 0.50 1.735 0.100 0.15 0.140 0.100 0.85 0.075 0.000 1.10 1.000 0.000
  1.20 0.200 0.000 0.95 10.000 0.000 0.94 0.100 0.000 1.04 0.100 0.000 0.10 11.47 22.91 1.836 0.050 0.025 /
```

Appendix B

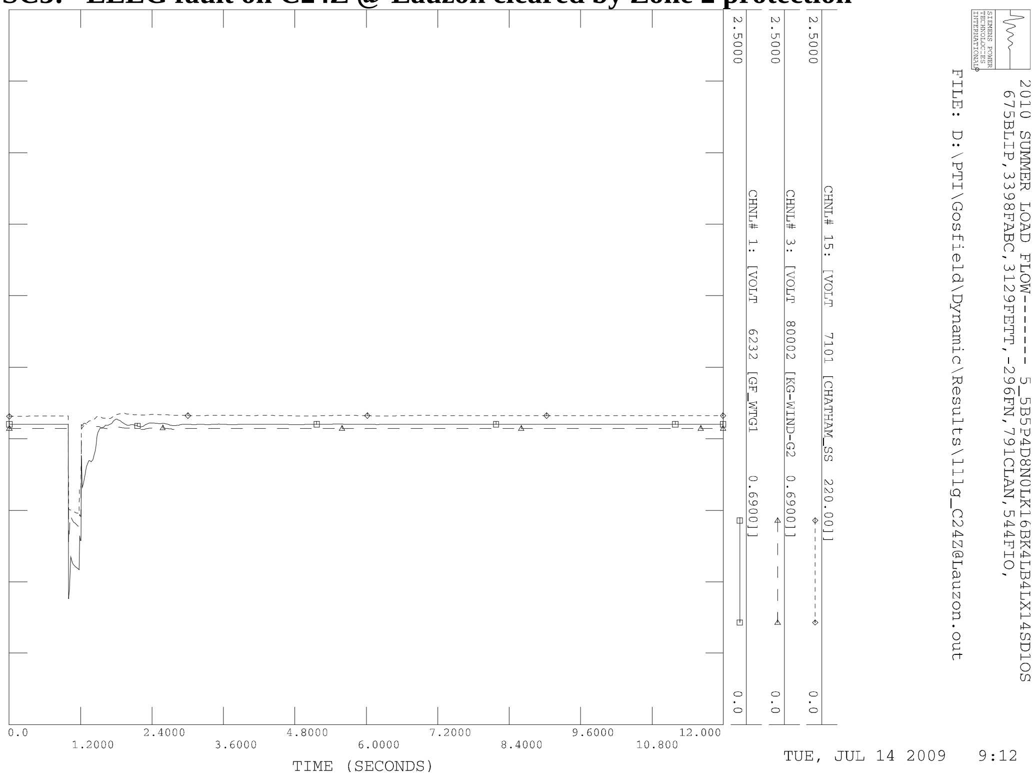
SC1: Normally cleared LLLG fault on K6Z @ Lauzon



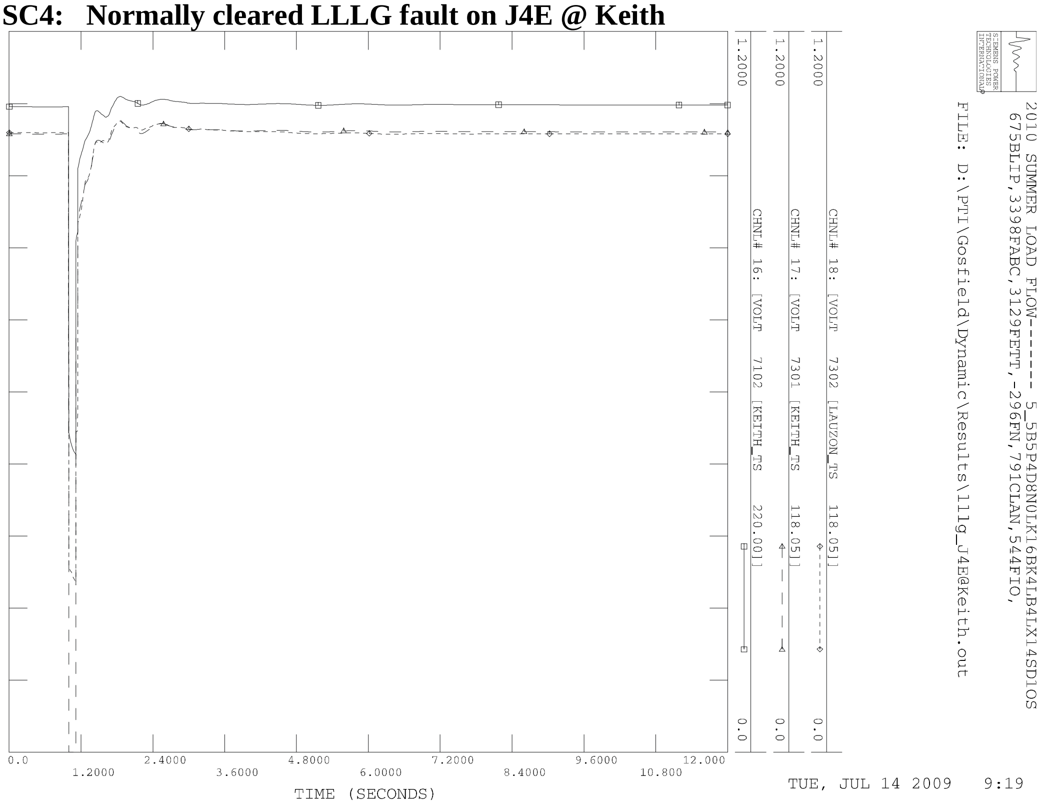
SC2: Normally cleared LLLG fault on C22J@Chatham



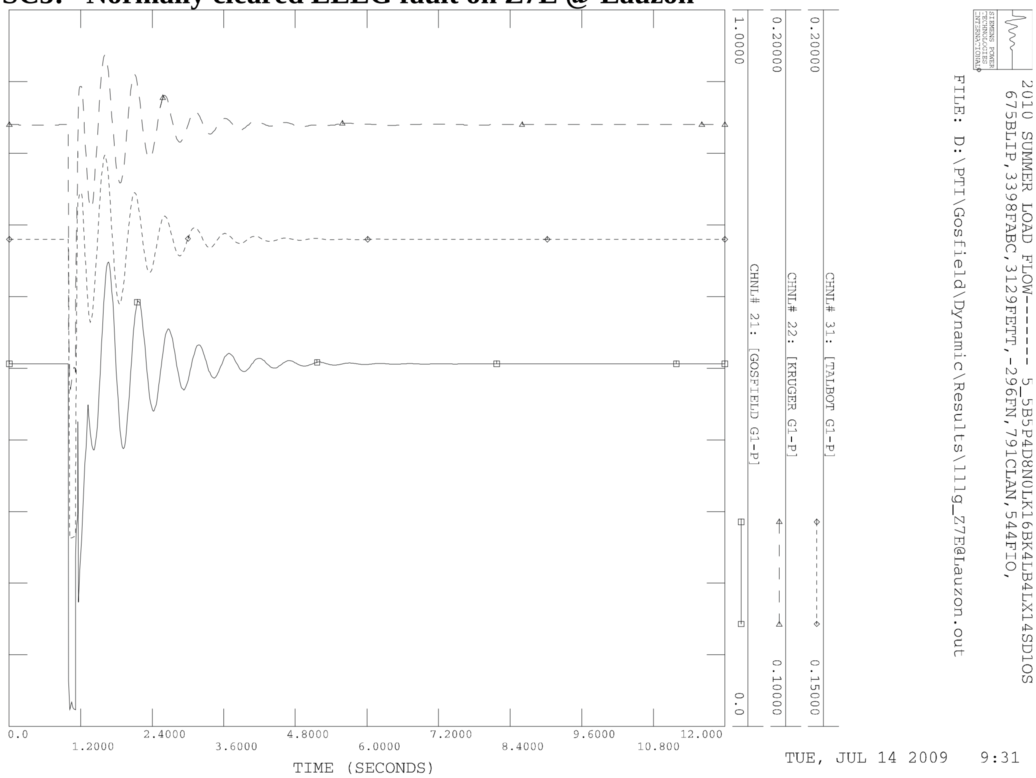
SC3: LLLG fault on C24Z @ Lauzon cleared by Zone 2 protection



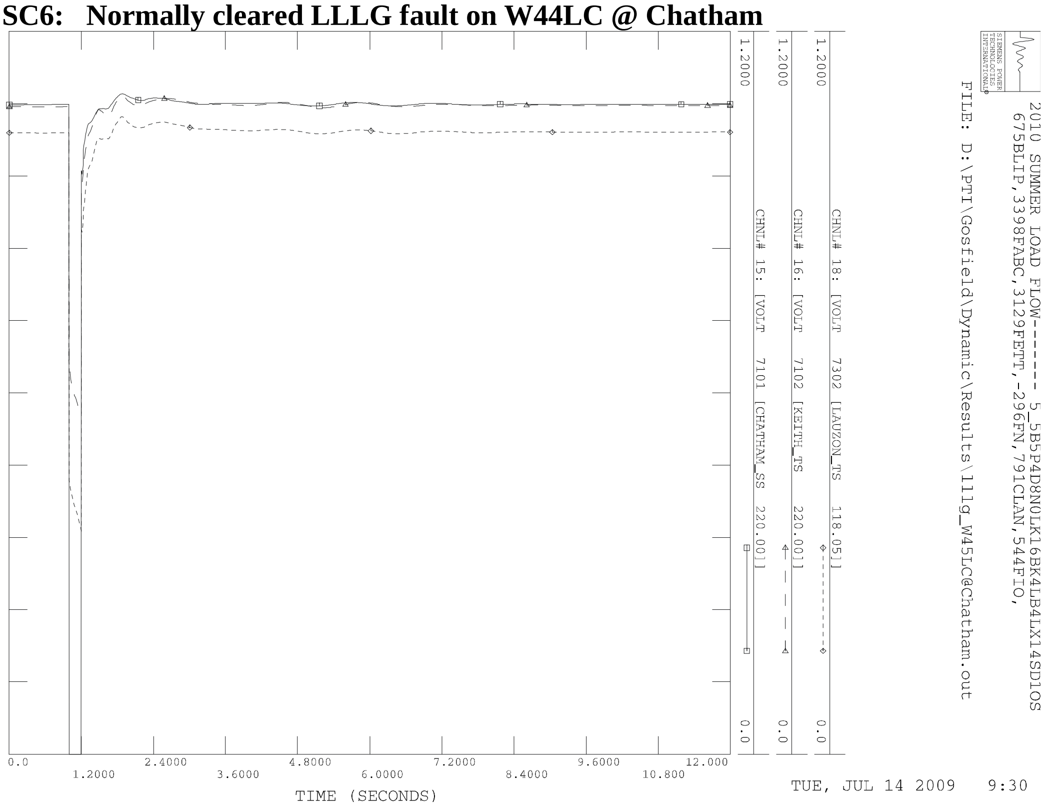
SC4: Normally cleared LLLG fault on J4E @ Keith



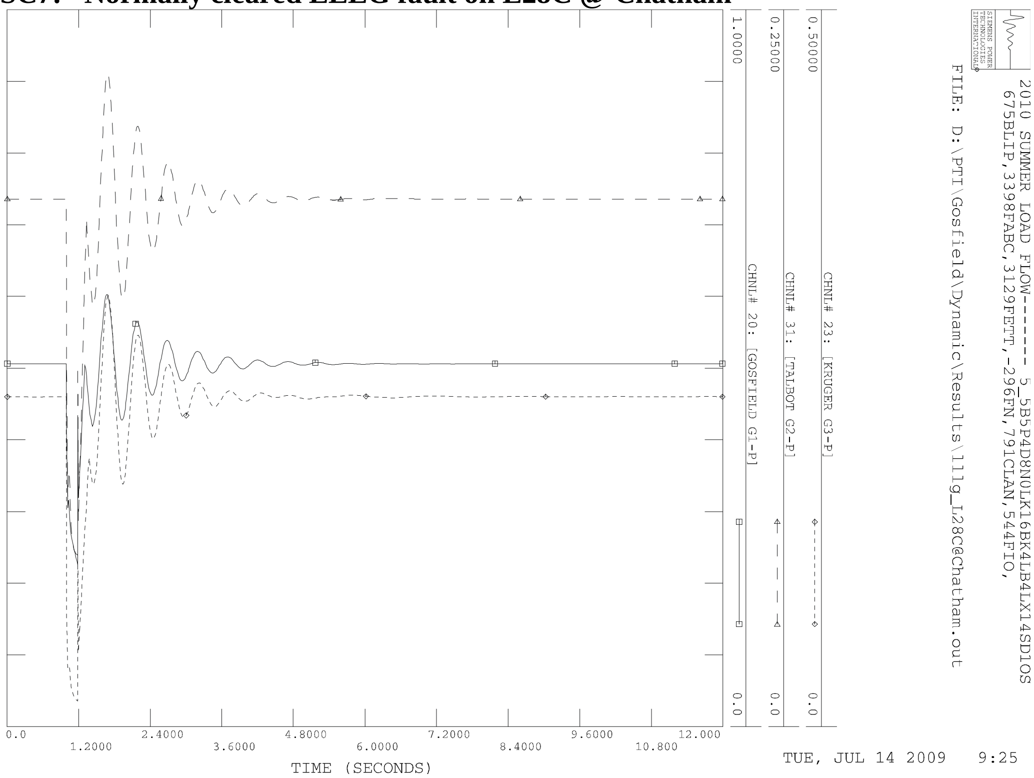
SC5:   Normally cleared LLLG fault on Z7E @ Lauzon



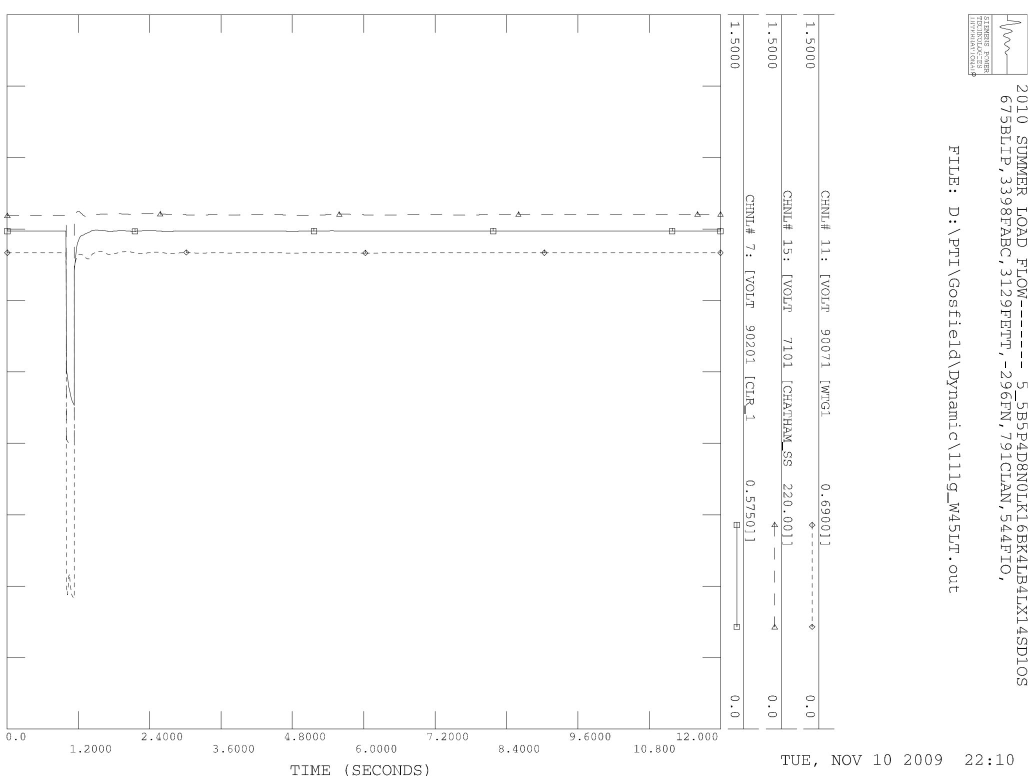
SC6:   Normally cleared LLLG fault on W44LC @ Chatham



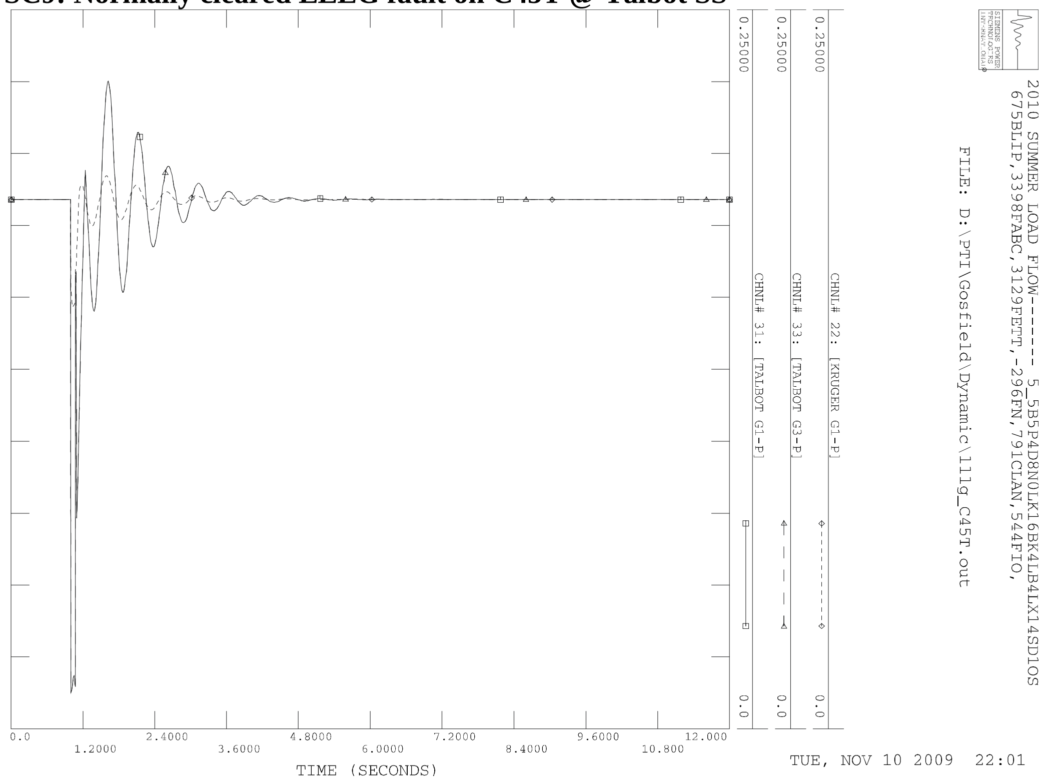
SC7: Normally cleared LLLG fault on L28C @ Chatham



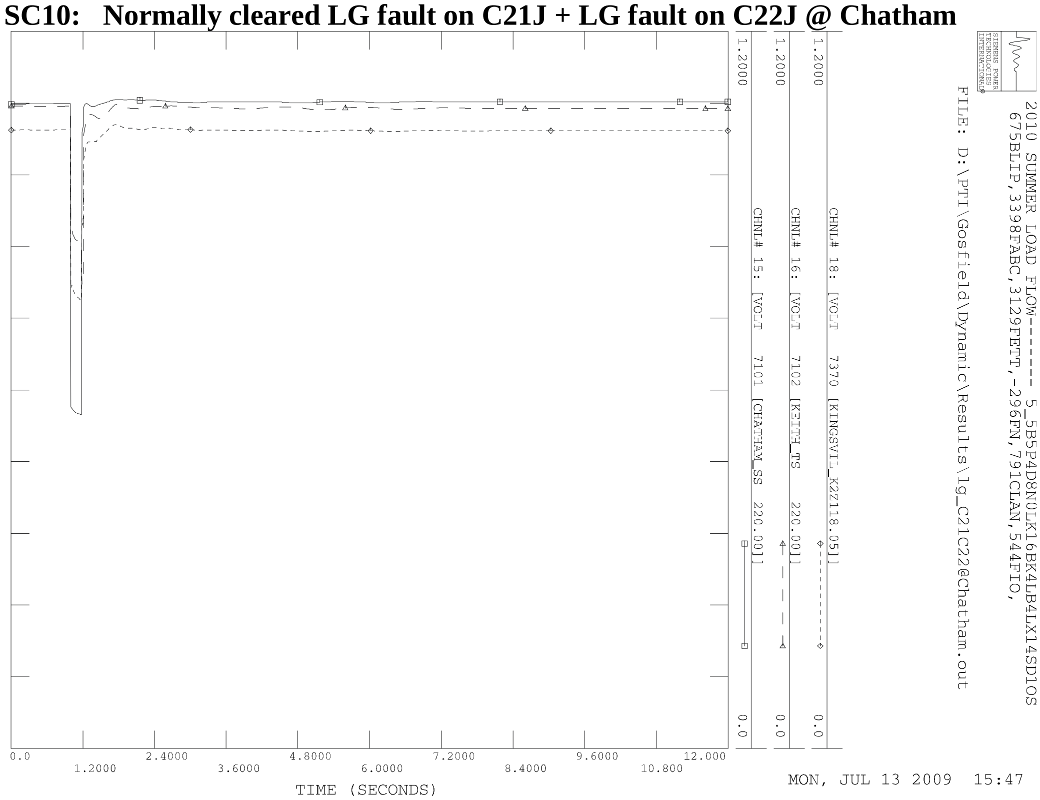
C8: Normally cleared LLLG fault on W45LT @ Talbot SS



SC9: Normally cleared LLLG fault on C45T @ Talbot SS



SC10: Normally cleared LG fault on C21J + LG fault on C22J @ Chatham



SC11: Normally cleared LG fault on L28C + LG fault on L29C @ Chatham