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CONNECTION ASSESSMENT & APPROVAL PROCESS

PRELIMINARY ASSESSMENT REPORT: 2nd Addendum

For the Proposed 600MW Portlands Energy Centre Project

by Ontario Power Generation Inc. at Hearn GS.

CAA ID No. 2001-040

Consistent Information Set Department, and
Long Term Forecasts & Assessments Department

FINAL Version

Date: 15th March 2005

2nd Addendum to the Preliminary Assessment Report

For the Proposed 600MW Portlands Energy Centre at Hearn GS

Acknowledgement

The IESO wishes to acknowledge the assistance of Hydro One in completing some of the studies for 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 the most recent version of this report is being used.

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 system impact assessment of a new generation or load connection proposal.

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

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

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.

ONTARIO POWER GENERATION Inc.: PORTLANDS ENERGY CENTRE

2nd Addendum to the Preliminary Assessment Report for the Proposed 600MW Development at Hearn GS

1. Introduction

Ontario Power Generation Inc. has notified the IESO that they now plan to install only a single steam-turbine generating unit at their proposed combined-cycle generating facility on the site of the former Hearn Generating Station.

Instead of installing the two identical trains consisting of a single 234MVA gas-turbine unit coupled with a single 115.6MVA steam-turbine unit that were the subject of the 1st Addendum, it is now proposed to install a single 265MVA steam-turbine unit to operate with two 225MVA gas-turbine units.

This 2nd Addendum summarises the results of the IESO's assessment of the impact that this new arrangement would be expected to have on the IESO-controlled grid.

2. Connection Arrangement

Diagram 1 shows the approved connection arrangement for the Portlands Energy Centre as originally proposed with two steam-turbine generating units.

Diagram 2 shows the arrangement that it is now proposed to install with only a single steam-turbine unit.

[It should also be noted that since Addendum No. 1 was issued, Hydro One has consolidated the 115kV switchgear at Hearn SS; removing all of the idle/redundant equipment and modifying the nomenclature of the remaining breakers accordingly.]

3. Revised Data

The following Table summarises the principal data values that were used for the fault level studies that were included in Addendum No. 1 together with those that were used for the studies covered by this Addendum:

Generator Data:				
		Rating	*Sub-transient Reactance*	
Addendum No.1	Gas-Turbine Generator	234MVA	16.6% on 234MVA_{base}	
	Steam-turbine Generator	115.6MVA	17.0% on 115.6MVA_{base}	
Addendum No. 2	Gas-Turbine Generator	225MVA	18.5% on 225MVA_{base}	
	Steam-turbine Generator	265MVA	25.0% on 265MVA_{base}	
Step-up Transformer Data:				
		Rating	*Reactance*	
			Positive Seq.	*Zero Seq.*
Addendum No.1	For the Gas-turbine Units	235MVA	13.0% on 235MVA_{base}	90% of positive sequence impedance
	For the Steam-turbine Units	115MVA	13.0% on 115MVA_{base}	
Addendum No.2	For the Gas-turbine Units	235MVA	13.0% on 235MVA_{base}	
	For the Steam-turbine Unit	280MVA	13.7% on 280MVA_{base}	12.4%

4. *Fault Level Results*

Since the 1st Addendum was issued on 27th August 2003, decisions have been taken regarding the following developments within the GTA and the system model that was used for this analysis was modified accordingly:

- To cease operation of the Lakeview Generating Station as of 30th April 2005
- To establish the new 500/230kV Parkway Transformer Station, and
- To establish a new 230kV busbar at Cooksville TS and to reconfigure the circuits between Applewood Junction and Cooksville TS.

  [Although the installation of the series capacitors in circuit L24CR at Cooksville TS under this Project has been placed on hold until the results of the Government RFP are known, they were included in the system model.]

In addition, the following generating facilities were included in the system model:

Generating Facilities Included in the Analysis			
Sithe-Goreway Project:	2 x 345MVA	gas-turbine units	Connected to the 230kV circuits V72R & V73R via a common 230kV busbar
	1 x 384MVA	steam-turbine unit	
Sithe-Southdown Project:	2 x 345MVA	gas-turbine units	Connected to the 230kV circuits B15C & B16C via a common 230kV busbar
	1 x 384MVA	steam-turbine unit	
Boralex-Mississauga Project:	3 x 71.2MVA	gas-turbine units	Connected to the 230kV circuit V72R
GTAA Project	2 x 71.2MVA	gas-turbine units	With the gas-turbine units connected to 44kV feeders from Bramalea TS, & the steam-turbine unit connected to a 44kV feeder from Woodbridge TS.
	1 x 45MVA	steam-turbine unit	

The results obtained from these fault level studies have been summarised in Table 1.

Studies were also performed for the condition with all of the Projects in the above Table out-of-service. The fault level results for the 115kV busbars at Hearn SS and Leaside TS that were obtained from these studies have been summarised in Table 2.

4.1 *Comments on the Fault Level Analysis*

Although the fault level studies performed for the 1st Addendum examined a different system model that included the Lakeview Generating Station but excluded both the new Parkway TS and the new 230kV busbar at Cooksville TS, it is interesting to compare the earlier results with those in Table 1.

The fault levels at the 115kV busbars at Hearn SS and Leaside TS obtained from the studies performed for the 1st Addendum have been summarised in Tables 3 & 4.

The differences in the respective fault levels are shown in the following Table:

Differences in the Fault Levels in this Addendum & those from the 1st Addendum (with no neutral reactors)					
		Symmetrical		*Asymmetrical*	
		3-phase	*L-G*	*3-phase*	*L-G*
Hearn SS					
West	*Addendum 1*	27.65kA	29.78kA	35.69kA	38.41kA
	This Addendum	27.61kA	28.96kA	35.01kA	37.04kA
	Difference	***-0.04kA***	***-0.82kA***	***-0.68kA***	***-1.37kA***
East	*Addendum 1*	24.72kA	26.10kA	29.96kA	31.66kA
	This Addendum	25.62kA	26.90kA	31.36kA	33.00kA
	Difference	***+0.90kA***	***+0.80kA***	***+1.40kA***	***+1.34kA***
Leaside TS					
West	*Addendum 1*	32.66kA	36.07kA	42.29kA	45.20kA
	This Addendum	32.57kA	35.60kA	42.14kA	44.60kA
	Difference	***-0.09kA***	***-0.47kA***	***-0.15kA***	***-0.60kA***
East	*Addendum 1*	29.41kA	33.44kA	38.17kA	41.90kA
	This Addendum	30.10kA	34.10kA	39.34kA	42.73kA
	Difference	***+0.69kA***	***+0.66kA***	***+1.17kA***	***+0.83kA***

The results summarised in this Table show that the proposed changes in the ratings of the generating units to be installed at the Portlands Energy Centre would result in a small net *reduction* in the fault levels on the western halves of the 115kV busbars at Hearn SS and Leaside TS, while those on the eastern halves would result in a small net *increase*.

However, although the increased capacity of the steam-turbine portion of the Portlands Energy Centre has resulted in higher fault levels on the eastern halves of the 115kV busbars at Hearn SS and Leaside TS, they still remain lower than those on the western halves of these busbars.

Furthermore, while the fault levels on the western halves of the 115kV busbars at Hearn SS and Leaside TS have all been reduced, Table 1 shows that those at Hearn SS would still exceed the ratings of the existing 115kV switchgear at that location. For the 3-phase fault condition at Hearn SS, the asymmetrical fault level of 35.01kA would be higher than the breaker ratings (34.1kA). However, after taking account of the various fault infeeds, as shown in Diagram 3, the fault interrupting duties imposed on the individual breakers would remain within their ratings. Consequently, the three phase fault condition would not be issue for the existing breakers at Hearn SS.

However, for the single line-to-ground fault condition, where a number of the fault infeeds would be zero, the 37.04kA fault level would exceed the 34.1kA rating of several of the breakers. To address this situation, it had previously been proposed in the 1st Addendum, that reactors rated at 2.8 ohms should be installed in the neutral connections of the generator transformers of the two gas-turbine units. As shown in Table 1, these reactors would reduce the asymmetrical fault levels on the critical western half of the Hearn 115kV busbar from 37.04kA to just 31.33kA. This would be well within the 34.1kA rating of the existing breakers.

Table 2 shows that the reductions that would occur in the fault levels at Hearn SS and Leaside TS if the following Projects were not developed:

- Sithe-Goreway
- Sithe-Southdown
- Boralex-Mississauga
- GTAA

This Table also shows the incremental changes in the fault levels from those in Table 1 for the condition with the above Projects in-service. These indicate that the above Projects would have only a minimal effect on the fault levels at Hearn SS (~ 0.17kA) and Leaside TS (~ 0.3kA).

It is also worth noting that the asymmetrical fault levels for a single line-to-ground fault would still exceed the breaker ratings at Hearn SS, even without these Projects in operation, and therefore, regardless of the status of these Projects, the installation of neutral reactors would still be necessary.

5. *Transfer Capability from the Hearn 115kV busbar*

Diagram 4 has been reproduced from Diagram 6 from the original PA Report for this Project.

The original analysis indicated that the maximum transfer away from the eastern half of the Hearn 115kV busbar that could be accommodated without overloading the remaining circuits under contingency conditions involving one of the four 115kV circuits would be approximately 241MVA. This would be marginally adequate for the 238.5MW steam-turbine unit that it is proposed to connect to this half of the Hearn busbar.

However, it should be noted that the proposed open-points on the Hearn 115kV busbar have been changed since the original transfer assessment was completed, and circuit H2JK is now to be associated with the eastern half of the Hearn busbar, as shown in Diagram 2. This would result in the portion of the load at Esplanade TS that is connected to circuit H2JK being supplied directly from the new steam-turbine generating unit. The net effect would therefore be a reduction in the amount of power that would have to be accommodated by the four 115kV circuits to Leaside.

Consequently, with this revised system configuration, the 241MVA transfer capability of these four circuits would therefore be adequate to accommodate the full net output of the higher-rated steam-turbine unit that it is proposed to connect to the eastern half of the Hearn busbar, while continuing to respect a single-circuit contingency.

6. *Generation Rejection & Cross-Tripping Scheme*

Diagram 26 in the 1st Addendum provided the functional specification for the Generation Rejection & Cross-Tripping Scheme, based on a four-unit development for the Portlands Energy Centre.

The proposed reduction in the number of generating units would allow this Scheme to be simplified, as shown in Diagram 5.

7. *Incremental Voltage Changes*

The arrangement that was the subject of the 1st Addendum consisted of two separate trains, so that the maximum amount of generation capacity that could be lost in response to a trip of a steam-turbine unit would be approximately 275MW, representing the combined output of one gas-turbine unit (190MW) and one steam-turbine unit (85MW).

However, OPG has confirmed that for the new three-unit arrangement, the heat-recovery steam-generators associated with the gas-turbine units are to include by-passes which will allow them to continue to operate *without* the steam-turbine unit in-service. Consequently, a trip involving the steam-turbine unit would NOT automatically remove both gas-turbine units from service.

Furthermore, since the output of the steam-turbine unit is directly dependent on the heat-recovery steam-generators associated with the gas-turbine units, then the maximum change in output that could occur would be approximately 309MW, representing the capacity of one of the gas-turbine units (190MW), together with half the capacity of the steam-turbine unit (119MW).

Studies were therefore performed with only a single gas-turbine unit in-service and with the steam-turbine unit operating at half capacity to determine the voltage declines that would result from the loss of this amount of generation capacity, during peak-load periods. The results of these studies, which used a conservative, constant MVA representation for the loads, are summarised in the following Table:

Voltage Declines for the Loss of the Entire Portlands Energy Centre							
		Pre Tripping of the PEC	*Post Tripping of the Portlands Energy Centre*				
			Pre Tap-changer Action		*Post Tap-changer Action*		
Hearn SS: 115kV	*West*	123.59kV	118.75kV	*-3.92%*	119.96kV	*-2.94%*
	East	126.66kV	123.24kV	*-2.70%*	124.19kV	*-1.95%*
Leaside TS: 115kV	*West*	124.31kV	120.16kV	*-3.34%*	121.29kV	*-2.43%*
	East	126.41kV	123.26kV	*-2.49%*	124.20kV	*-1.75%*

These results show that the voltage declines would be within the IESO's 5% criterion for the loss of generating capacity.

8. Exciters, Power System Stabilisers & Governors

8.1 Data Supplied

The data that were provided or assumed for the Portlands Energy Centre Project and that were used in the analysis to assess the performance of the equipment are summarised in the following Diagrams:

		PTI Model Used
Diagram 6	Generator Parameters	GENROU
Diagram 7	Excitation System for the Steam-turbine generating unit	ESST1A
Diagram 8	Power System Stabiliser for the Steam-turbine generating unit	IEE2ST
Diagram 9	Excitation System for the Gas-turbine generating units	ESST4B
Diagram 10	Power System Stabiliser for the Gas-turbine generating units	PSS2A
Diagram 11	Governor for the Steam-turbine generating unit	IEESGO
Diagram 12	Governor for the Gas-turbine generating units (assumed)	GAST

8.2 Exciter Performance

Response Ratio Test

Diagram 13 shows the results for the initial 1.0-second period of the response ratio test for a large increase in the reference set points for the voltage regulators.

This shows that the exciter field voltages would increase by the following amounts in response to the imposed change in the reference settings:

- for the steam-turbine exciters: an increase from 2.53 pu to 6.10 pu equivalent to 241%
- for the gas-turbine exciters: an increase from 2.75 pu to 6.39 pu equivalent to 232%

This Diagram also shows the nominal responses of the respective exciters.

These are as follows:

- for the exciters on the gas-turbine units: a response ratio of 5.2
- for the exciters on the steam-turbine units: a response ratio of 5.6

Open-Circuit Step Response

Diagram 14 shows the open-circuit response over the initial 1.0-second period to a step change of 5% in the generator terminal voltage.

This shows that the exciter of the steam-turbine unit will reach a voltage of 3.10 pu within 50-milliseconds, while the exciters on the gas-turbine units will reach a voltage of 5.39 pu.

8.3 Comments on the Performance of the Exciters

Diagram 13 shows that the exciters on the gas-turbine & the steam-turbine units are able to achieve a ceiling voltage of at least twice the rated field voltage as required by the Market Rules.

The Market Rules also require that the exciters have a voltage response time no longer than 50 milliseconds. This means that the exciters are required to attain a field voltage of 95% of the difference between the rated load field voltage and the ceiling voltage within a maximum time of 50-milliseconds.

Since the rated load field voltages for the exciters on the steam-turbine & gas-turbine units are 2.53 pu & 2.75 pu, respectively (from Diagram 13), then the minimum requirement under the Market Rules is that the exciters be able to reach the following ceiling voltages within 50 milliseconds:

- for the exciter on the steam-turbine unit — a ceiling voltage of at least: 2.40 pu.
- for the exciters on the gas-turbine units — a ceiling voltage of at least: 2.61 pu

Diagram 14 confirms that the exciters on both the steam-turbine & the gas-turbine units would be able to achieve ceiling voltages in excess of these minimum values within the 50-millisecond period.

Excitation Systems

Based on the data provided, the exciters that it is proposed to install on the Portlands Energy Centre Project would comply with the more stringent requirements of the Market Rules as stated in the approved amendment to Reference 12 of Appendix 4.2.

8.4 Governor Responses

Diagram 15 shows the response of the respective governors to a 10% change in the electrical loading on the machines.

The response of both types of governor would be acceptable to the IESO.

However, it should be noted that while the droop settings of the governors are required to be adjustable within the range of 3% to 7%, the actual droop setting for the *entire* combined-cycle facility is to have a composite value of no more than 5%.

8.5 Verification of Machine & Transformer Parameters and the Exciter/Power System Stabiliser Settings

The IESO requires evidence to be provided confirming the validity of the data used in this assessment.

This should consist of the following documentation:

Generators

- Copies of the type-test to IEEE Standard 115 for each of the different generating units that are to be installed on this Project or the results from equivalent on-site tests.
- Generator Commissioning Tests:

  Specifically -
  - results to confirm the saturation curves;
  - results to demonstrate the capability to achieve the stated values of Q_{max} and Q_{min};
  - tabulated results displaying the following values for a selected range of outputs:

    Power (P)   Reactive Power (Q)   Terminal Voltage (V_{Term})   Field Current (I_f)

Generator Step-up Transformers

- Copies of the results from the tests performed in accordance with IEEE Standard C57.12.90

Generator Controls

Provide documentation to demonstrate compliance with the Market Rules.

Specifically:

For the Excitation Systems -

- that the voltage response time is not longer than 50msec for a maximum step change of 5% in the voltage reference;
- that the positive ceiling voltage is at least 200% of the rated field voltage; and
- that the negative ceiling voltage is at least 140% of the rated field voltage

For the Power System Stabilisers -

- provide the results from a series of response tests at different stabiliser gain settings that were performed to determined the preferred gain setting

For the Speed Governors -

- that the deadband is less than ± 36mHz;
- that the composite speed droop for the entire facility is 5% or better; and
- that the outer loop controls do not interfere with the governor response to frequency deviations.

9. *Constant Power Factor versus Constant Voltage Mode of Operation*

Although it is a requirement that the generating units have the capability of operating either to maintain their output at a constant power factor or to maintain a constant voltage at their terminals, the IESO requires that the latter, Constant Voltage mode of operation be used. The generating units should therefore be operated to control their respective terminal voltages to set values, and that these set-points be adjusted periodically, upon instructions from the IESO, to ensure that the prevailing reactive power requirements of the system are satisfied.

10. *IESO Requirements for the Incorporation of the 600MW Portlands Energy Centre*

This assessment has confirmed that the IESO's requirements, as detailed in the 1st Addendum to the Preliminary Assessment Report, will remain unchanged for the new configuration and capacity of the Portlands Energy Centre.

For completeness, these requirements have been repeated below for the asymmetrical connection arrangement with both gas-turbine units connected to the western half of the Hearn 115kV busbar and with the single steam-turbine unit connected to the eastern half:

IESO's Requirements for Connection

- *EITHER:*
  - Replace the three breakers H7E, H5E & H8LC with higher-rated units, together with the replacement of any of the existing buswork and associated facilities that are determined to be inadequately rated.

  OR

  - Include provisions for the installation of a 7.5mH neutral reactor on each of the generator step-up transformers for the two gas-turbine units and, when informed by the IESO of a requirement for the reactors to be installed, undertake the necessary work.

    Furthermore, when instructed by IESO, undertake the removal (isolation) of the neutral reactors to coincide with any subsequent system changes that would make them redundant.
- Interchange the 230kV circuits C3L & C17L at their Leaside terminals.
- Replace any skywires on the 115kV overhead lines whose short-circuit capabilities are determined to be inadequate.
- Install a generation rejection and cross-tripping scheme (see Diagram 5).

  The above measures assume that with all, or half of the Portlands Energy Centre Project in-service, the 230kV and the 115kV busbars at Leaside TS will be operated ***open***, and -

  - the 115kV busbar at Hearn SS will be operated ***open*** at breaker positions ***6P7 & 2A3***, and
  - the 115kV busbars at Terauley TS will be operated ***closed***.
- Incorporate the three generating units, via individual 115kV breakers, on to separate positions on the existing 115kV busbar at Hearn SS as shown in Diagram 2. A motorised 115kV disconnect switch is to be included in each connection at the Hearn SS end, to provide a point of demarcation between the Hydro One facilities and those of OPG Inc.
- Connect a station service transformer to one of the gas-turbine units and connect a second station service transformer to the steam-turbine unit. Operate with the station service busbar normally-open.
- Operate the generating units so that a constant, pre-set voltage is maintained at their terminals.

AND

Where data have had to be assumed, Ontario Power Generation Inc. will be responsible for ensuring that the equipment that is eventually installed meets or exceeds the values that were used (so as to result in a better performance than that shown in the stability plots). In addition, OPG Inc. will need to ensure that the input to the power system stabiliser produces a unit damping torque that is in-phase with any changes in the speed of the generator.

It is also strongly recommended that as data become available (and in advance of formal submission to Facilities Registration) they be submitted to the IESO for review to ensure that the values comply with the data that were used in this assessment, as well as with any assumptions that were made.

11. Customer Impact Assessment

Hydro One Networks Inc. has informed the IESO that, since the revised configuration of the Portlands Energy Centre, together with the approved additions to the transmission system, will result in only marginal changes to the fault levels that were recorded in the 1st Addendum, the conclusions from their original CIA for this Project will remain valid.

12. Notification of Approval of the Connection Proposal

This 2nd Addendum to the original PA Report for the Portlands Energy Centre has examined the effect that a change from a 4-unit development to one with only three generating units, together with an associated increase in the Project's capacity, would have on the IESO-controlled grid.

This assessment has concluded that the proposed change in the Project's configuration, in association with the incorporation of additional facilities on the transmission system, will not affect the conclusions from the 1st Addendum. It is therefore recommended that a revised Notification of Approval to Connect be issued for this modified Project.

TABLE 1 - Summary of the Fault Level Results for a 3-Unit Configuration of the Portlands Energy Centre - Connected Asymmetrically

			Symmetrical			***Asymmetrical***			***Breaker Ratings***	
			3-phase	***L-G Neutral Reactors***		***3-phase***	***L-G Neutral Reactors***		***Symmetrical***	***Asymmetrical***
				None	***2.8ohm***		***None***	***2.8ohm***		
Hearn 115kV Busbars		*West*	27.61kA	28.96kA	24.81kA	***35.01kA***	***37.04kA***	31.33kA	***31.4kA***	***34.1kA***
		East	25.62kA	26.90kA	26.88kA	31.36kA	33.00kA	32.98kA		
Leaside 115kV Busbars		*West*	32.57kA	35.60kA	34.86kA	42.14kA	44.60kA	43.68kA	***39.3kA***	***45.5kA***
		East	30.10kA	34.10kA	34.10kA	39.34kA	42.73kA	42.73kA		
Manby 115kV Busbars		*West*	28.83kA	34.01kA	-	37.96kA	43.98kA	-	***38.8kA*** *(minimum)*	***45.5kA*** *(minimum)*
		East	28.35kA	33.79kA	-	37.31kA	44.09kA	-		
Manby 230kV Busbars		*West*	45.48kA	43.64kA	-	52.49kA	49.44kA	-	***70.0kA***	***80.4kA***
		East	46.33kA	44.04kA	-	53.46kA	49.15kA	-		
Richview 230kV Busbars	*A1H1*	*West*	61.27kA	57.44kA	-	73.58kA	60.83kA	-	***69.5kA***	***83.4kA***
	A2H2	*East*	62.28kA	58.71kA	-	75.18kA	64.40kA	-		
Claireville 230kV Busbar			72.25kA	***81.12kA***	***81.12kA***	92.05kA	***99.21kA***	***99.21kA***	***80.0kA***	***96.0kA***
Cherrywood 230kV Busbars		*DK1*	49.62kA	53.83kA	-	64.11kA	68.21kA	-	***60.0kA*** *(minimum)*	***70.3kA*** *(minimum)*
		DK2	46.27kA	50.71kA	-	60.98kA	64.90kA	-		
		DK3	46.24kA	49.50kA	-	60.48kA	63.36kA	-		
		DK4	47.41kA	51.37kA	-	61.49kA	65.09kA	-		
Parkway TS 230kV Busbar			57.92kA	66.93kA	-	73.61kA	81.86kA	-	***80.0kA***	***96.0kA***
Cooksville TS 230kV Busbar			50.72kA	45.81kA	-	59.29kA	49.39kA	-	***63.0kA***	***76.0kA***

TABLE 2 - Summary of the Fault Level Results for a 3-Unit Configuration of the Portlands Energy Centre - Connected Asymmetrically

Without the Sithe-Southdown, Sithe-Goreway, Boralex-Mississauga and GTAA Projects

		Symmetrical		Asymmetrical		Breaker Ratings	
		3-phase	L-G	3-phase	L-G	Symmetrical	Asymmetrical
Hearn 115kV Busbars	West	27.47kA	28.86kA	***34.84kA***	***36.91kA***	***31.4kA***	***34.1kA***
	Δ	-0.14kA	-0.10kA	-0.17kA	-0.13kA		
	East	25.47kA	26.79kA	31.53kA	32.87kA		
	Δ	-0.15kA	-0.11kA	-0.17kA	-0.13kA		
Leaside 115kV Busbars	West	32.33kA	35.41kA	41.83kA	44.37kA	***39.3kA***	***45.5kA***
	Δ	-0.24kA	-0.19kA	-0.31kA	-0.23kA		
	East	29.88kA	33.91kA	39.05kA	42.49kA		
	Δ	-0.22kA	-0.19kA	-0.29kA	-0.24kA		

TABLE 3 - [Results extracted from Table 8 of the 1st Addendum]

Fault Levels at Hearn TS with the 115kV Busbar at Hearn TS Split Vertically

For a 4-unit Configuration of the Portlands Energy Centre - Connected Asymmetrically

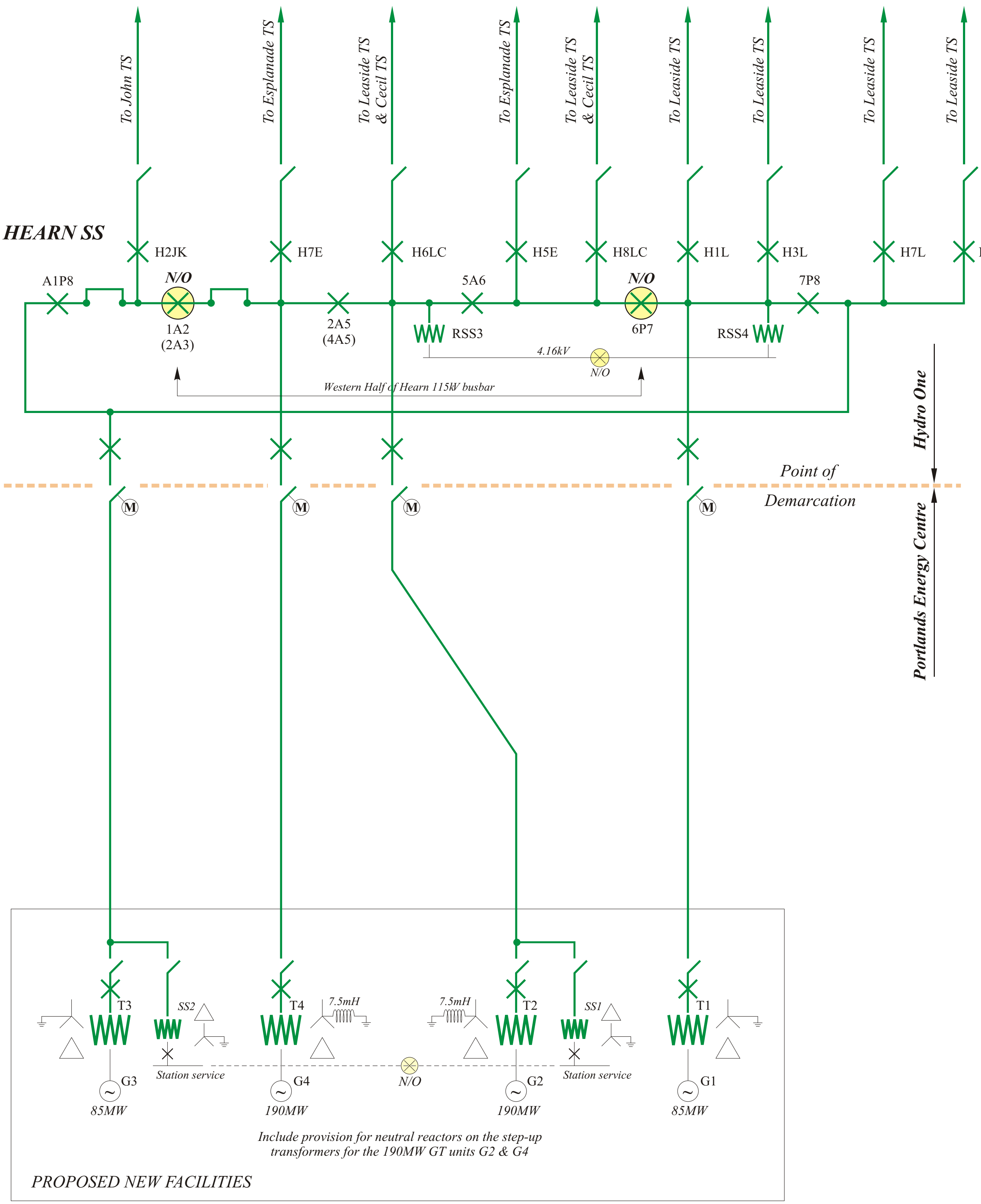
Fault Levels on the 115kV busbar at HEARN TS for a Pre-fault Voltage of 127kV							
Leaside 230kV & 115kV Busbars 'Open' ; Hearn 115kV Busbar 'Open' vertically; & Terauley TS 'Closed'							
		Symmetrical		Asymmetrical		Breaker Ratings	
		3-phase	L-G	3-phase	L-G	Symmetrical	Asymmetrical
With No Neutral Reactors	West	27.65kA	29.78kA	***35.69kA***	***38.41kA***	***31.4kA***	***34.1kA***
	East	24.72kA	26.10kA	29.96kA	31.66kA		
With 5Ω Neutral Reactors	West	27.65kA	24.97kA	***35.69kA***	31.23kA		
	East	24.72kA	26.08kA	29.96kA	31.63kA		
With 2Ω Neutral Reactors	West	27.65kA	26.89kA	***35.69kA***	***34.20kA***		
	East	24.72kA	26.09kA	29.96kA	31.64kA		

TABLE 4 - [Results extracted from Table 7 of the 1st Addendum]

Fault Levels at Leaside TS with the 115kV Busbar at Hearn TS Split Vertically

For a 4-unit Configuration of the Portlands Energy Centre - Connected Asymmetrically

Fault Levels on the 115kV busbar at LEASIDE TS for a Pre-fault Voltage of 127kV							
Leaside 230kV & 115kV Busbars 'Open' ; Hearn 115kV Busbar 'Open' vertically; & Terauley TS 'Closed'							
		Symmetrical		***Asymmetrical***		***Breaker Ratings***	
		3-phase	***L-G***	***3-phase***	***L-G***	***Symmetrical***	***Asymmetrical***
With No Neutral Reactors	*West*	32.66kA	36.07kA	42.29kA	45.20kA	***39.3kA***	***45.5kA***
	East	29.41kA	33.44kA	38.17kA	41.90kA		
With 5Ω Neutral Reactors	*West*	32.66kA	35.14kA	42.29kA	44.04kA		
	East	29.41kA	33.44kA	38.17kA	41.90kA		
With 2Ω Neutral Reactors	*West*	32.66kA	35.56kA	42.29kA	44.55kA		
	East	29.41kA	33.44kA	38.17kA	41.90kA		

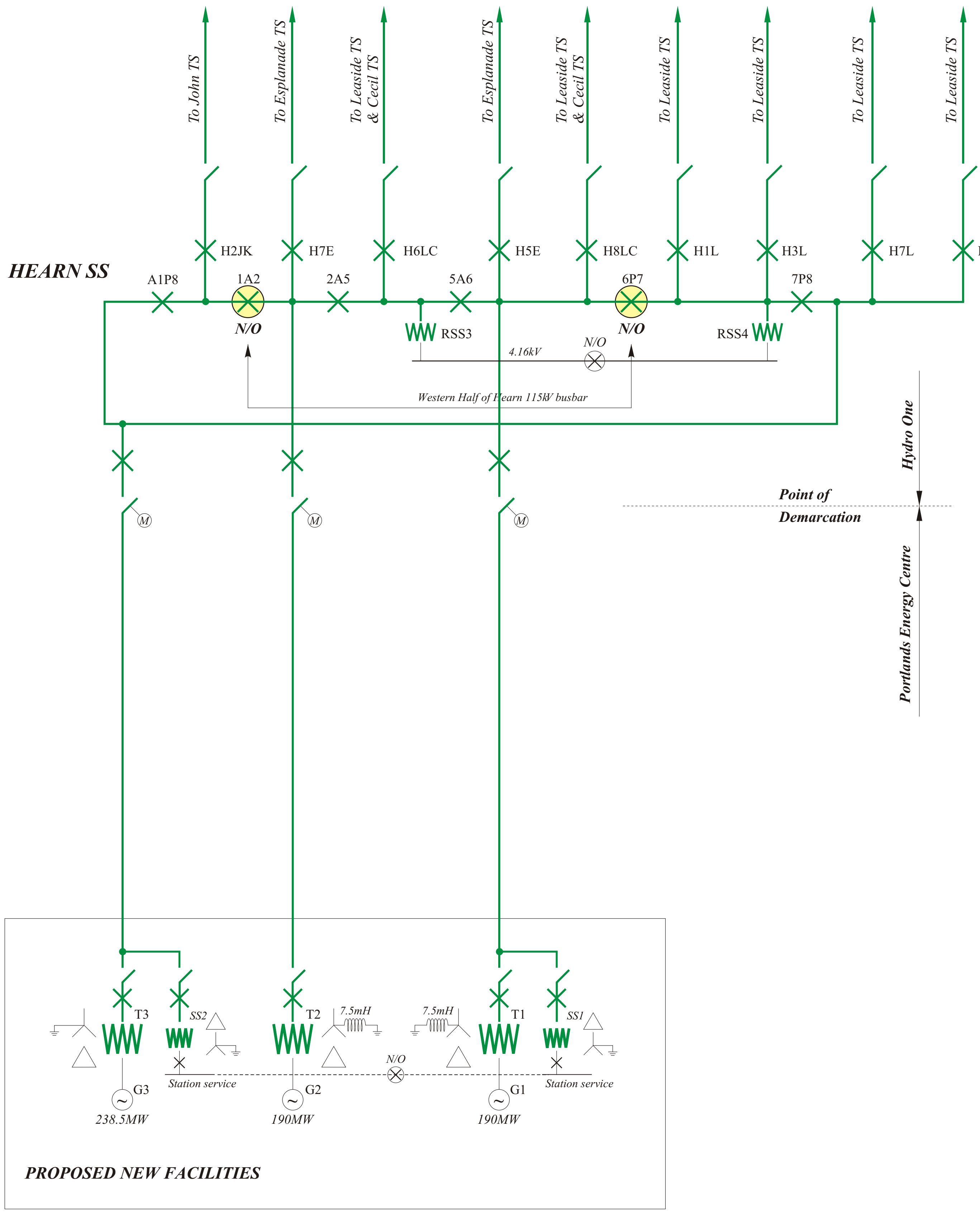


Portlands Energy Centre
'Asymmetrical' Connection Arrangement

DIAGRAM 1

19th September 2004

(Based on Diagram 27 from Addendum No.1)

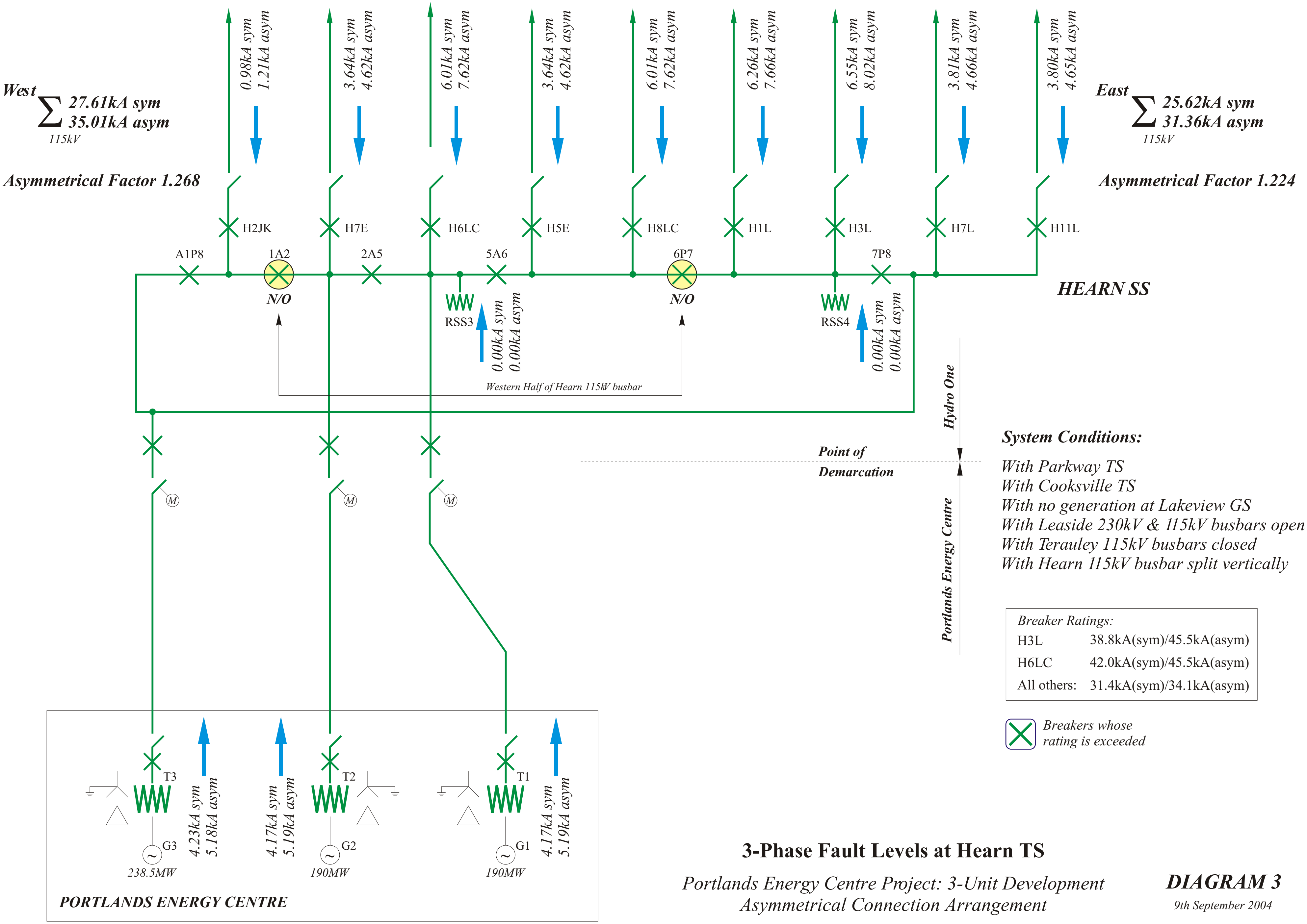


Portlands Energy Centre: 3-Unit Development
'Asymmetrical' Connection Arrangement

DIAGRAM 2

29th September 2004

Values for a pre-fault voltage of 127kV



3-Phase Fault Levels at Hearn TS

Portlands Energy Centre Project: 3-Unit Development
Asymmetrical Connection Arrangement

DIAGRAM 3

9th September 2004

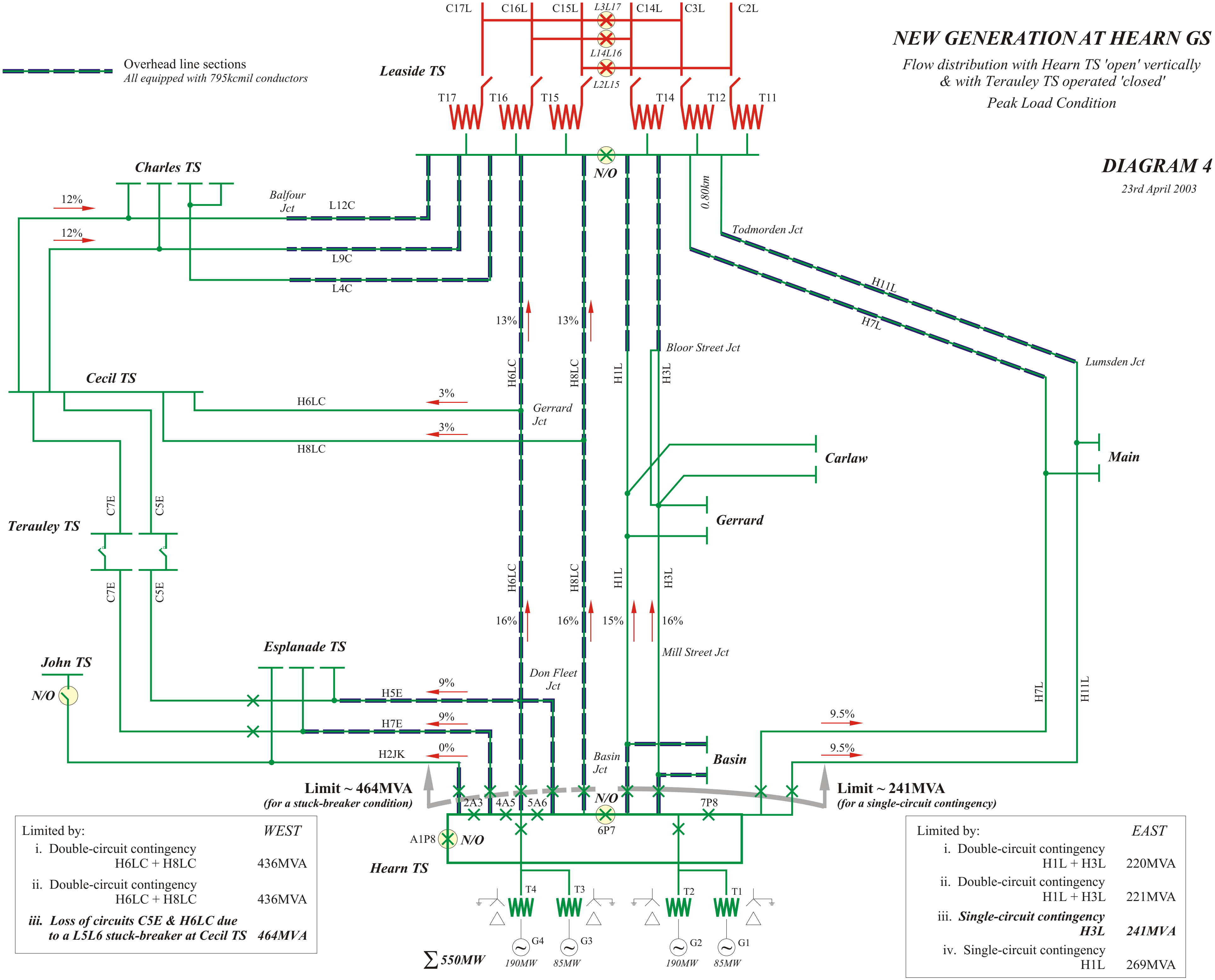
NEW GENERATION AT HEARN GS

Flow distribution with Hearn TS 'open' vertically & with Terauley TS operated 'closed'

Peak Load Condition

DIAGRAM 4

23rd April 2003



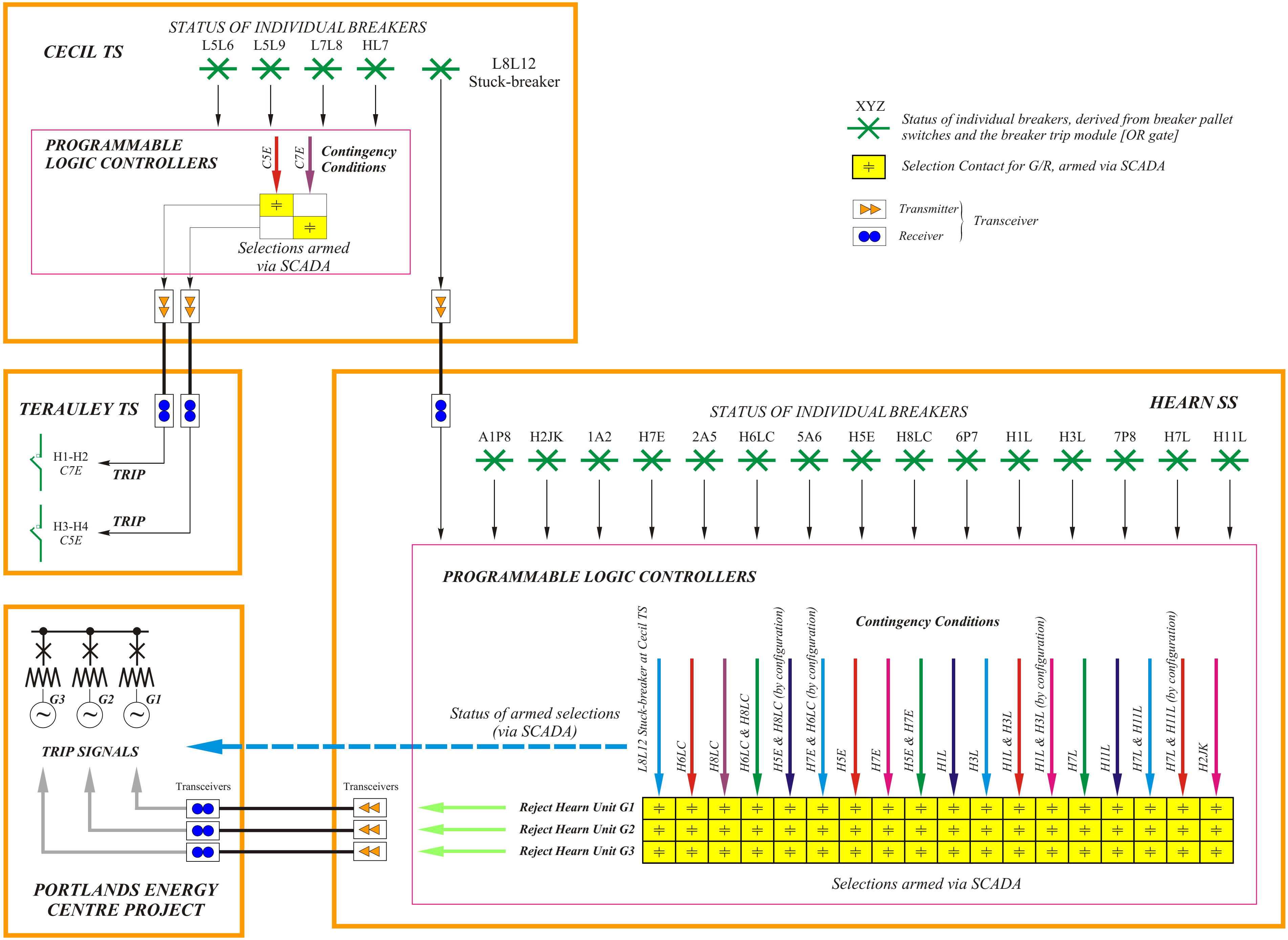


DIAGRAM 5

Revised: 23rd September 2004

Hearn Generation Rejection & Cross-Tripping Scheme

Based on Diagram 26 from the 1st Addendum

Values used in Transient Stability Analysis

		Steam-turbine Generating Unit 265MVA	*Gas-turbine Generating Units 225MVA*
Power Factor		0.90	0.90
Terminal Voltage		18kV	18kV
Open-Circuit Transient Time Constant - direct axis	T'_{do}	7.40 secs	5.70 secs
Open-Circuit Sub-Transient Time Constant - direct axis	T''_{do}	0.033 secs	0.034 secs
Open-Circuit Transient Time Constant - quadrature axis	T'_{qo}	0.56 secs	0.57 secs
Open-Circuit Sub-Transient Time Constant - quadrature axis	T''_{qo}	0.060 secs	0.070 secs
Synchronous Reactance - direct axis (Unsaturated)	X_d	1.74 pu	1.97 pu
Synchronous Reactance - quadrature axis (Unsaturated)	X_q	2.20 pu	1.88 pu
Transient Reactance - direct axis (Unsaturated)	X'_d	0.260 pu	0.240 pu
Transient Reactance - quadrature axis (Unsaturated)	X'_q	0.440 pu	0.440 pu
Sub-Transient Reactance (Unsaturated)	$X''_d = X''_q$	0.250 pu	0.185 pu
Leakage Reactance	X_l	0.195 pu	0.140 pu
Inertia Constant	H	4.6kW-sec/kVA	5.2kW-sec/kVA
Speed Damping	D	0.0	0.0
Saturation Factors	S (1.0)	0.08	0.05
	S (1.2)	0.25	0.46

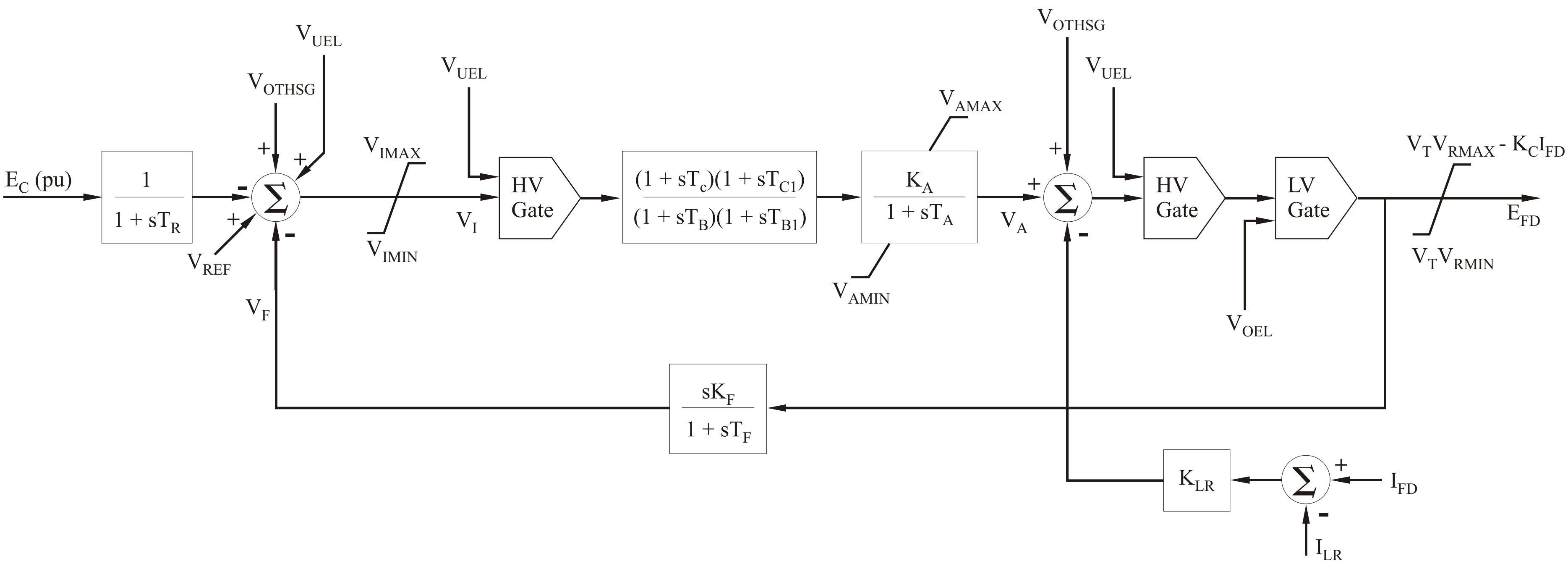
Portlands Energy Centre Project

GENROU Model
(Round Rotor Generator Model)

Data supplied for the steam-turbine & gas-turbine generating units

DIAGRAM 6

13th January 2005



Values used in Transient Stability Analysis

K_A	400.0	T_A	0.03 sec
K_C	0.00	T_B	5.40 sec
K_F	0.00	T_{B1}	0.00 sec
K_{LR}	0.00	T_C	0.70 sec
I_{LR}	0.00	T_{C1}	0.00 sec
V_{AMAX}	6.1	T_F (> 0)	0.05 sec
V_{AMIN}	-4.3	T_R	0.00 sec
V_{IMAX}	0.3		
V_{IMIN}	-0.3		
V_{RMAX}	6.1		
V_{RMIN}	-4.3		

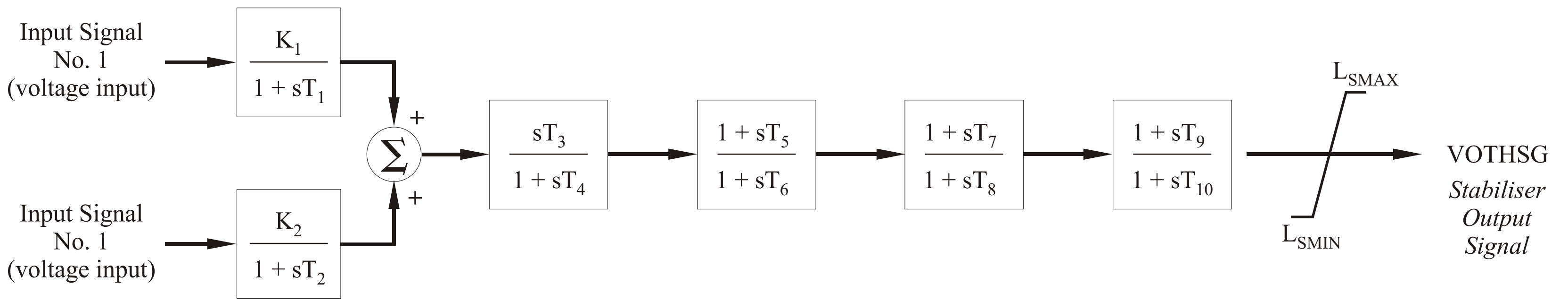
Portlands Energy Centre Project

ESST1A Excitation System
(IEEE Type ST1A)

Data supplied for the Steam-turbine generating unit

DIAGRAM 7

13th January 2005



Values used in Transient Stability Analysis

ICS1	5	T_1	0.03 sec
IB1	0	T_2	0.00 sec
ICS2	5	T_3	2.00 sec
IB2	0	T_4 (> 0)	2.00 sec
K_1	-0.8	T_5	0.15 sec
K_2	0	T_6	0.25 sec
L_{SMAX}	0.1	T_7	1.00 sec
L_{SMIN}	-0.1	T_8	1.00 sec
		T_9	0.00 sec
		T_{10}	0.00 sec

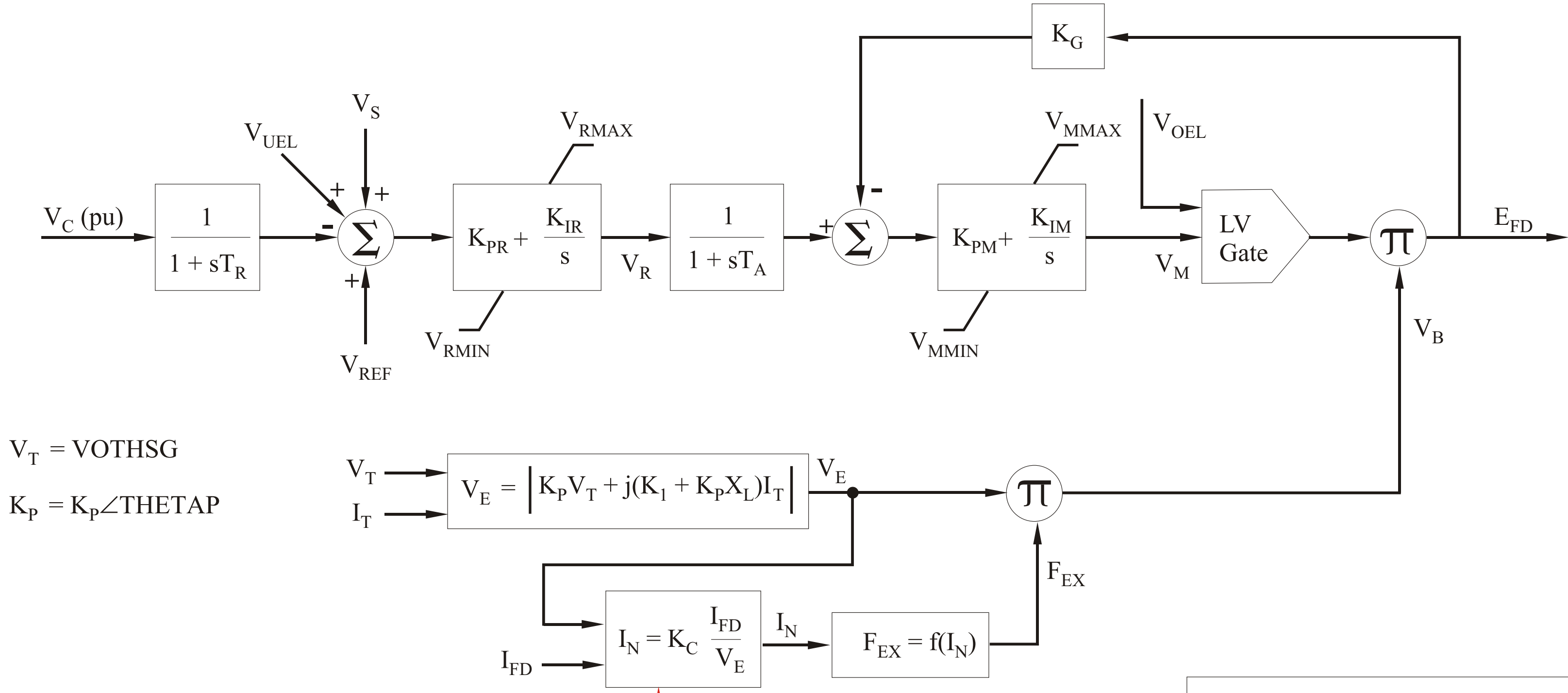
Portlands Energy Centre Project

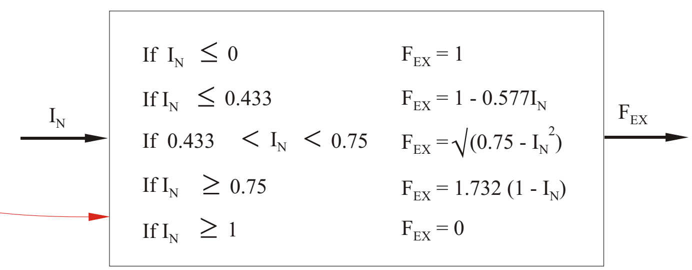
IEE2ST Power System Stabiliser Model

Data supplied for the steam-turbine generating units

DIAGRAM 8

13th January 2005





Values used in the Transient Stability Analysis

K_I	0.00	T_A	0.01 sec
K_C	0.08	T_R	0.00 sec
K_G	0.00	V_{BMAX}	8.18
K_P	6.54	V_{MMAX}	1.00
K_{IM}	0.00	V_{MMIN}	-0.87
K_{IR}	15.28	V_{RMAX}	1.00
K_{PM}	1.00	V_{RMIN}	-0.87
K_{PR}	15.28	X_L	0.00
		THETAP	0.00

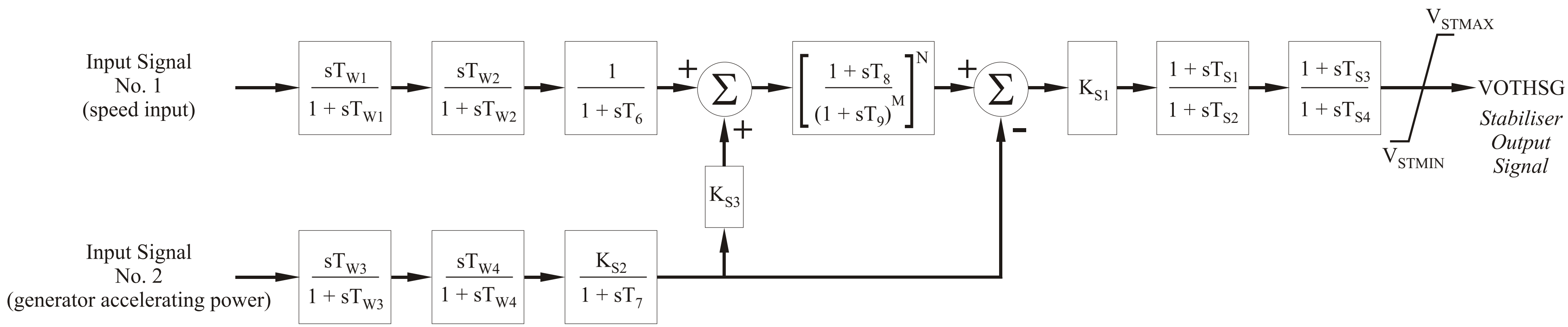
Portlands Energy Centre Project

ESST4B Excitation System Model
(IEEE ST4B Model)

Data supplied for the gas-turbine generating units

DIAGRAM 9

13th January 2005



Values used in Transient Stability Analysis

ICS1	1	T_1	0.15 sec
ICS2	4	T_2	0.03 sec
REMBUS1	0	T_3	0.15 sec
REMBUS2	0	T_4	0.03 sec
M	5	T_6	0.00 sec
N	1	T_7	2.00 sec
K_{S1}	1.6	T_8	0.50 sec
K_{S2}	0.175	T_9	0.10 sec
K_{S3}	1.0	T_{W1}	2.00 sec
V_{STMAX}	0.1	T_{W2}	2.00 sec
V_{STMIN}	-0.1	T_{W3}	2.00 sec
		T_{W4}	0.00 sec

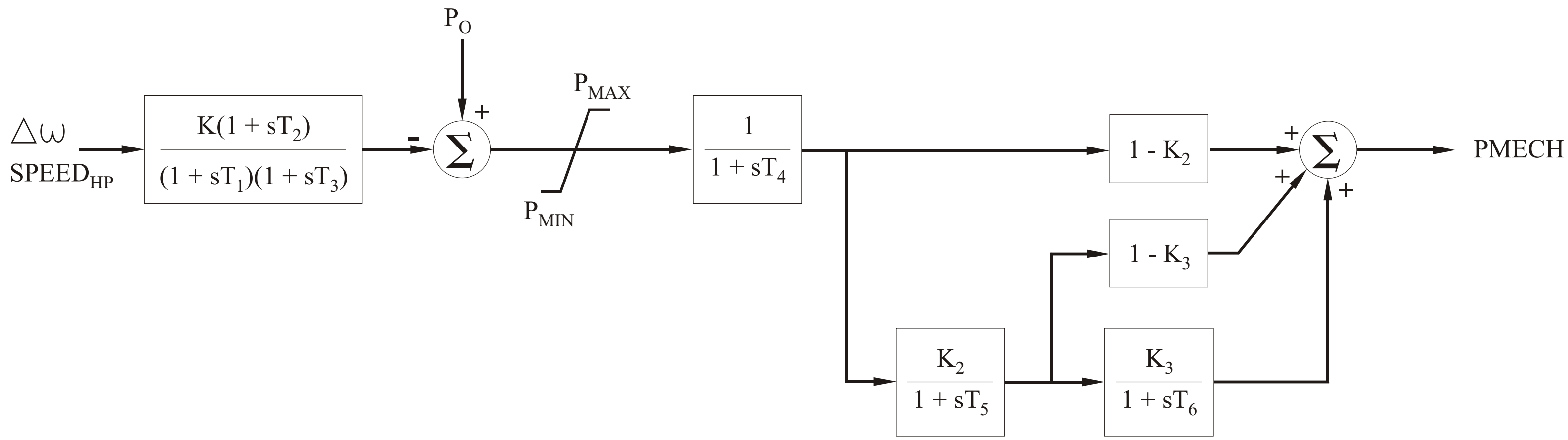
Portlands Energy Centre Project

PSS2A Power System Stabiliser Model
(IEEE Dual-Input Stabiliser)

Data supplied for the gas-turbine generating units

DIAGRAM 10

13th January 2005



Values used in Transient Stability Analysis

K_1	20.000	T_1	0.000 sec
K_2	0.736	T_2	0.000 sec
K_3	0.353	T_3	0.200 sec
P_{MAX}	1.100	T_4	0.465 sec
P_{MIN}	0.050	T_5	0.200 sec
		T_6	0.389 sec

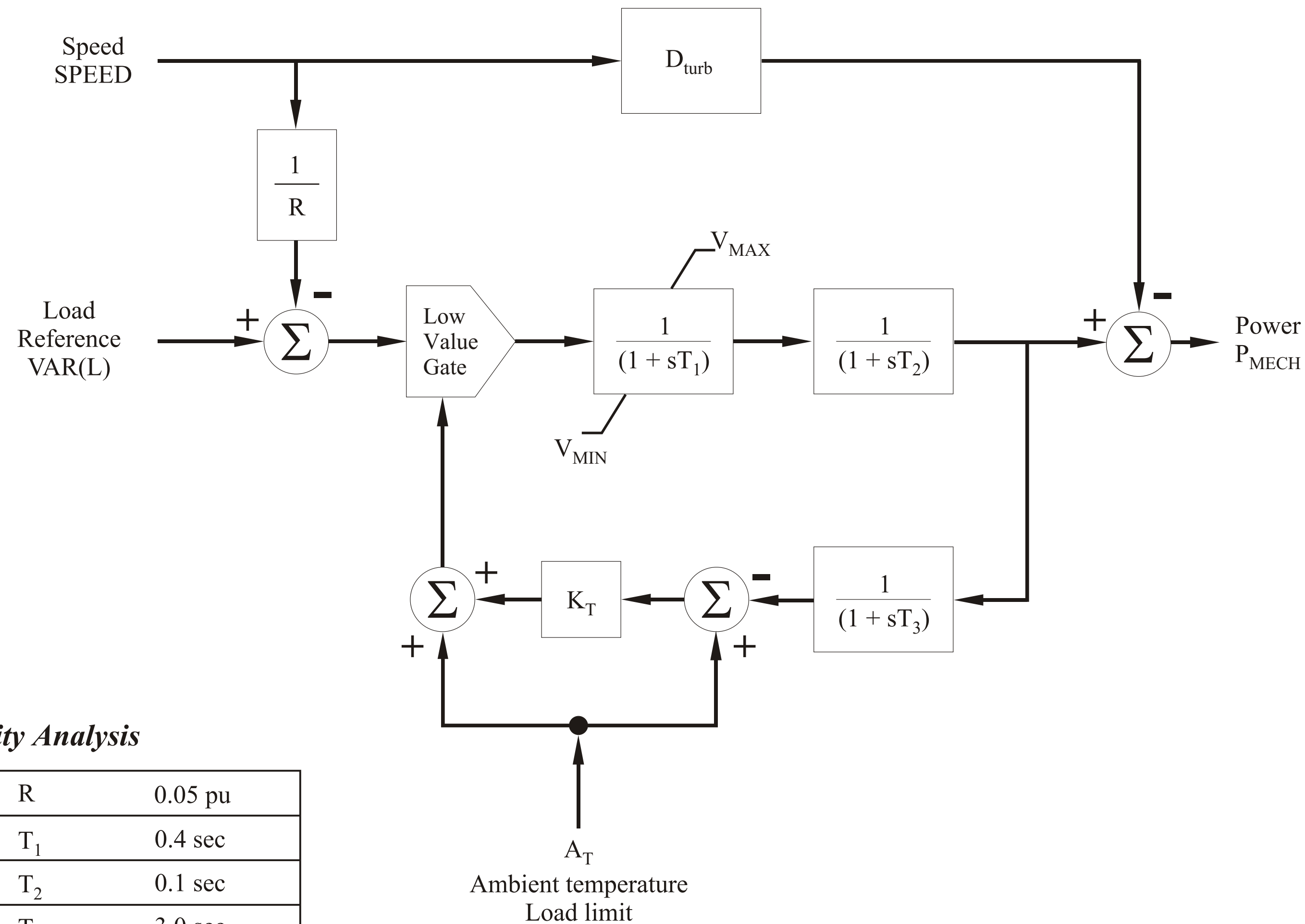
Portlands Energy Centre Project

IEESGO Governor Model

Data used for the steam-turbine unit

DIAGRAM 11

3rd December 2004



Values used in Transient Stability Analysis

Speed droop	R	0.05 pu
Time constants	T_1	0.4 sec
	T_2	0.1 sec
	T_3	3.0 sec
Ambient temperature load limit	A_T	1.00
Constant	K_T	2.0
Maximum fuel valve opening	V_{MAX}	1.00 pu
Minimum fuel valve opening	V_{MIN}	-0.05 pu
Turbine damping factor	D_{turb}	0.0

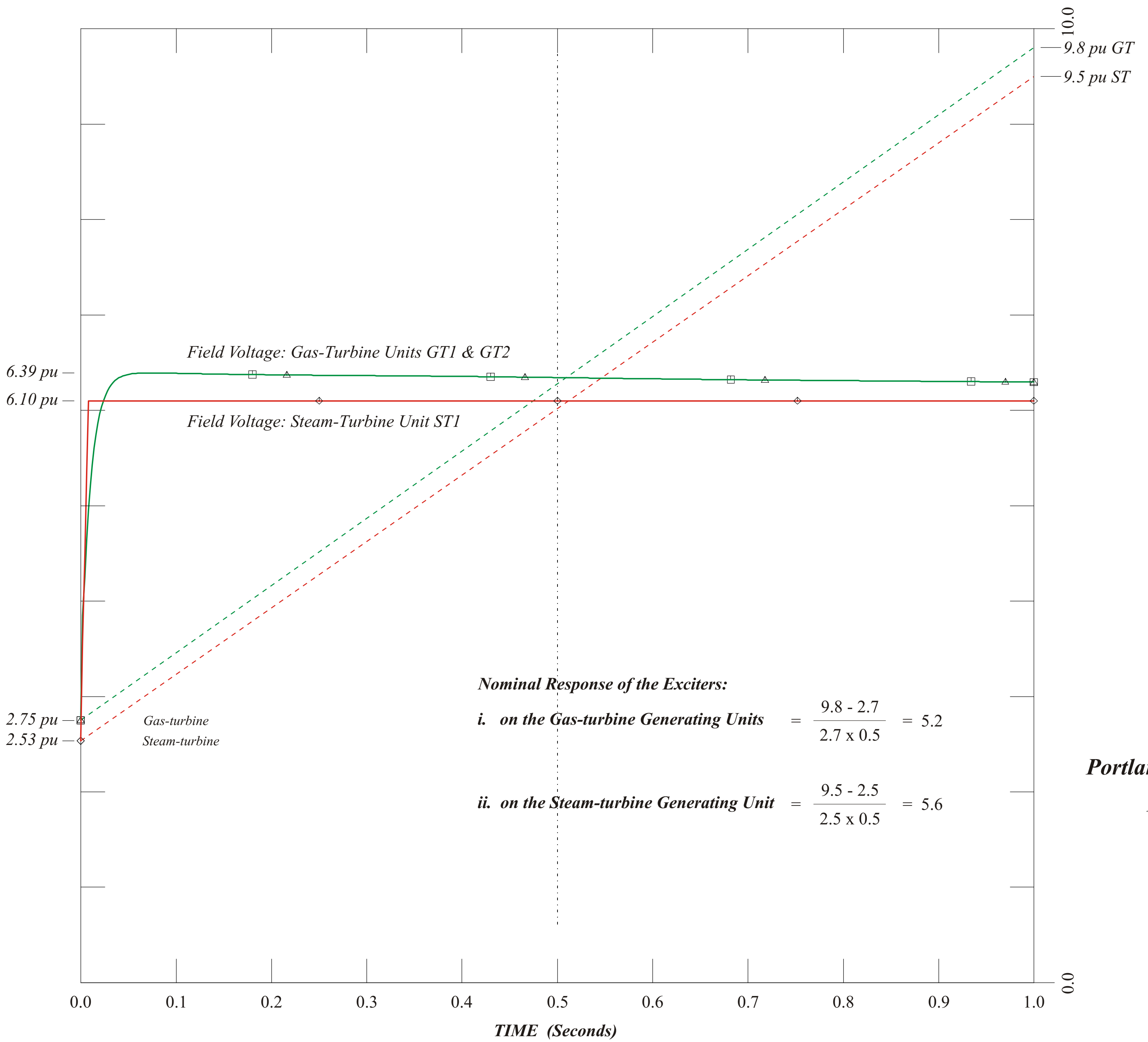
Portlands Energy Centre Project

GAST Model
(Gas Turbine Governor)

Data assumed for the two gas-turbine units

DIAGRAM 12

4th December 2004



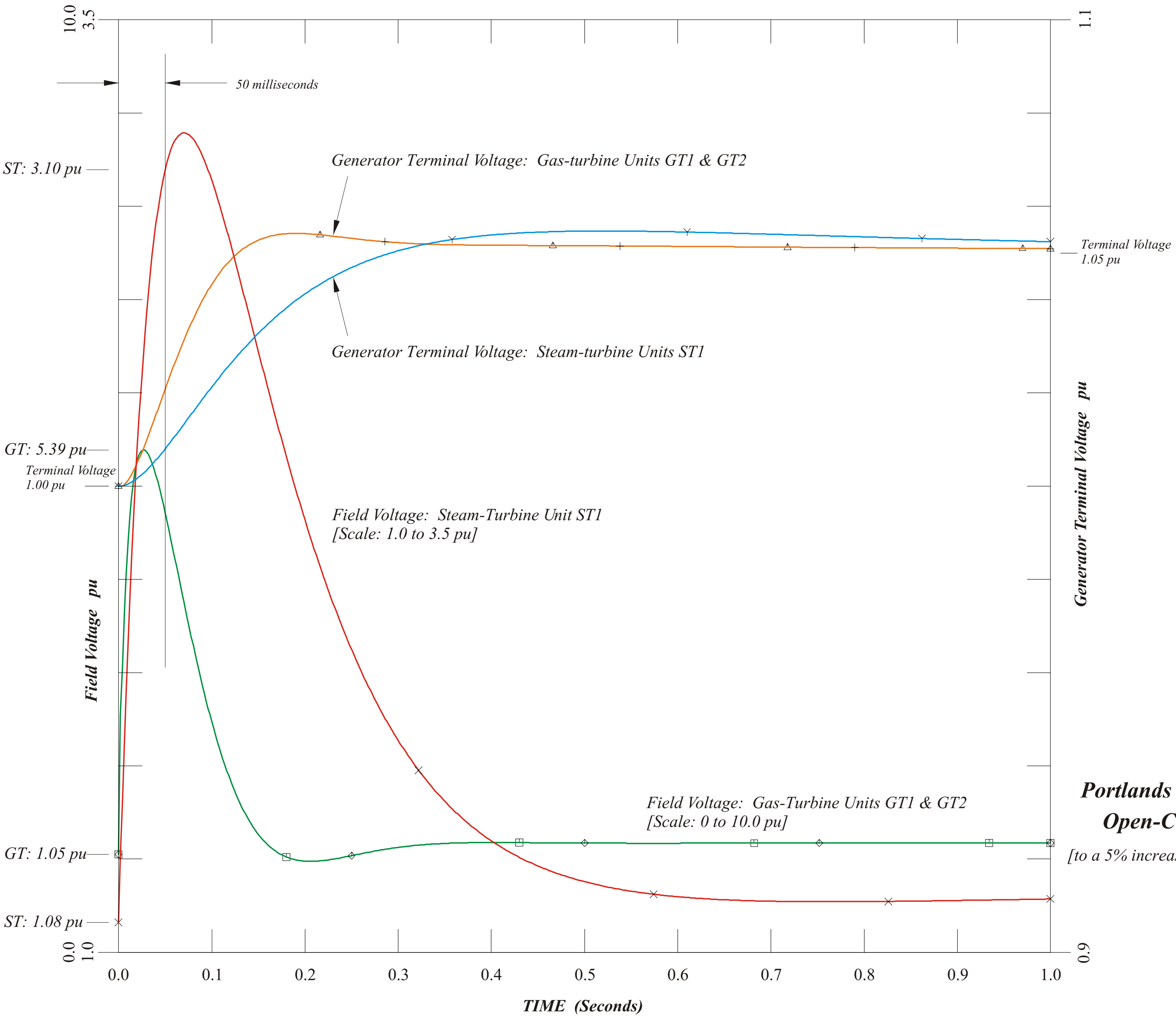
Portlands Energy Centre Project

Response Ratio Test

[Expanded time scale]

DIAGRAM 13

4th December 2004

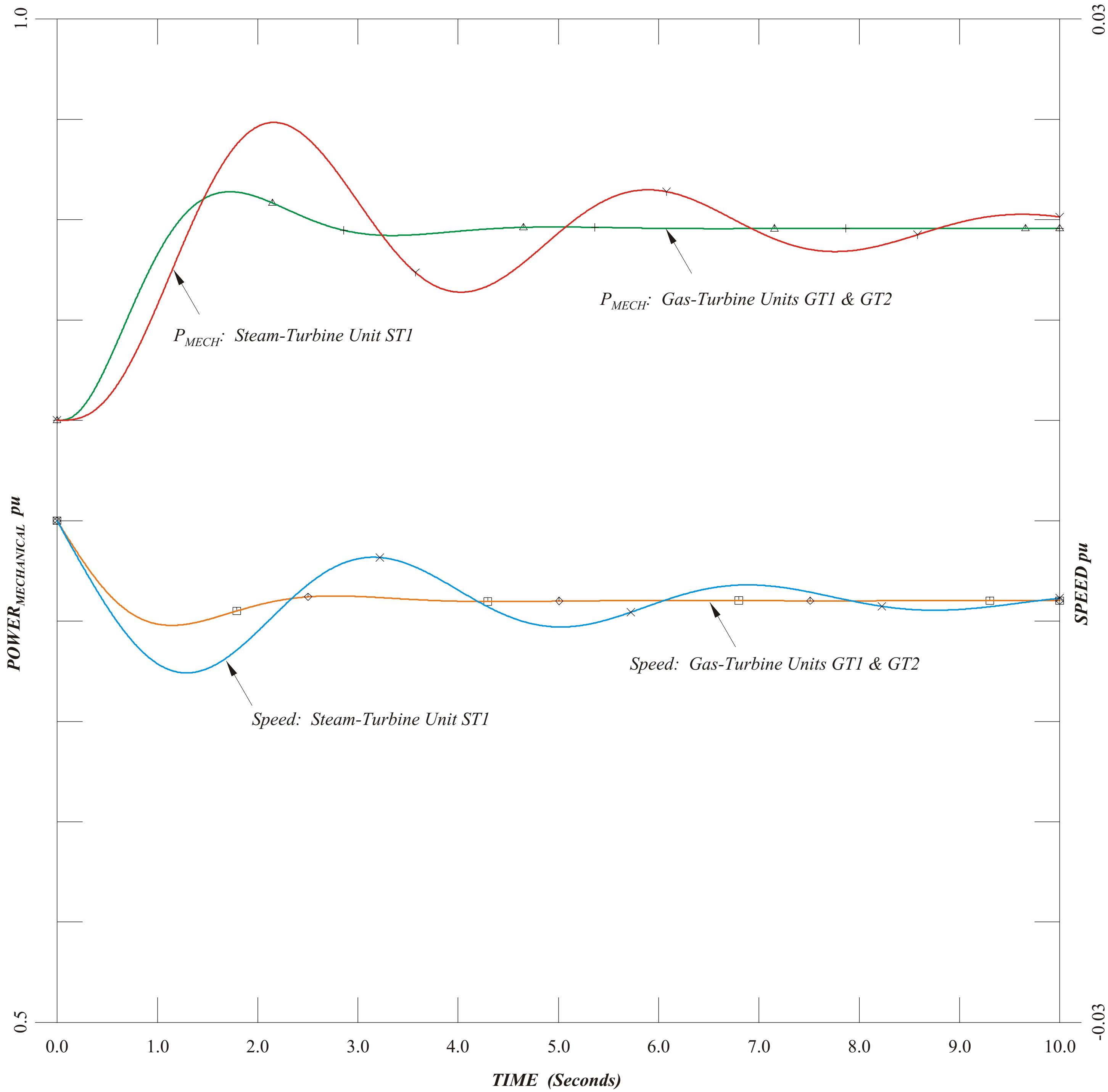


Portlands Energy Centre Project
Open-Circuit Step Response

[to a 5% increase in generator terminal voltage]

DIAGRAM 14

14th January 2005



Portlands Energy Centre Project

Governor Responses

DIAGRAM 15

17th January 2005