

CONNECTION ASSESSMENT & APPROVAL PROCESS

SYSTEM IMPACT ASSESSMENT REPORT:

Addendum No. 2

*For the ATCO Canada Corp. Development at Keith TS -
Proposed Increase in Capacity to 730MVA*

CAA ID No. 2000-011

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

FINAL Version

Date: 19th March 2004

2nd Addendum to the System Impact Assessment Report

For the Brighton Beach Project at Keith TS

Acknowledgement

The IMO wishes to acknowledge the assistance of Hydro One in completing some of the studies for this assessment.

Disclaimers

IMO

This report has been prepared solely for the purpose of assessing whether the connection applicant's proposed connection with the IMO-controlled grid would have an adverse impact on the reliability of the integrated power system and whether the IMO 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 IMO by the connection applicant and the transmitter(s) at the time the assessment was carried out. The IMO 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 IMO. 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 IMO-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 IMO in accordance with Chapter 4, section 6 of the Market Rules. The IMO assumes no responsibility to any third party for any use, which it makes of this report. Any liability which the IMO 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 IMO provides a draft of this report to the connection applicant, you must be aware that the IMO may revise drafts of this report at any time in its sole discretion without notice to you. Although the IMO 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.

1. Introduction

The original Preliminary Assessment Report, dated 26th September 2000, and the subsequent System Impact Assessment, dated 1st December 2000, examined the impact on the IMO-controlled grid of the *Brighton Beach Project*, composed of the following generating units:

- Two 210MVA (180MW) gas-turbine units, and
- One 260MVA (220MW) steam-turbine unit

One of the gas-turbine units is to be connected to the 115kV busbar at Keith TS, while the remaining gas-turbine unit and the steam-turbine unit are to be connected to the 230kV busbar.

Since receiving approval to connect to the IMO-controlled grid, generating units with the following ratings are now being installed:

- Two 234MVA (200MW) gas-turbine units, and
- One 265MVA (225MW) steam-turbine unit.

As before, one of the gas-turbine units is to be connected to the 115kV busbar at Keith TS, while the remaining units are to be connected to the 230kV busbar.

Diagram 1 shows the incorporation arrangement for the Brighton Beach Project.

This Addendum examines the potential impact that the increase in the rating of the generating units could have on the IMO-controlled grid. In addition, it examines the performance of the exciters that are to be installed on the generating units.

2. Transmission Facilities in the Windsor Area

Diagram 2 shows the existing transmission facilities in the Windsor area.

Keith TS is located at the western extremity, while Lauzon TS is located at the eastern end of the local 115kV supply system for the Windsor area. Two 115MVA 230/115kV auto-transformers at Keith TS, and two 250MVA 230/115kV auto-transformers at Lauzon TS connect the 230kV system to the local 115kV system.

The 115kV system consists of two 115kV circuits between Keith TS and Lauzon TS, via Essex TS, with two 115kV cabled circuits from Essex TS supplying the major automotive plant loads.

The principal 115kV circuits in the Windsor area are rated as follows:

Ratings for the Principal 115kV Circuits in the Windsor Area (at 124kV)				
		Sag Temperature	Continuous at 93°C	Emergency at 127°C or the sag temp., if lower
J3E	Keith TS to Essex TS	150°C	850A (183MVA)	1090A (234MVA)
J4E		116°C		1020A (219MVA)
Z1E	Lauzon TS to Essex TS	127°C	950A (204MVA)	1220A (262MVA)
Z7E				

3. Existing Generating Facilities in the Windsor Area

The West Windsor Power facility, which consists of a 101MW gas-turbine generating unit and a 30MW steam-turbine generating unit, is connected directly into the 115kV busbar at Keith TS via circuit J2N. This facility typically delivers approximately 118MW to the system.

The TransAlta (Windsor) facility, which consists of a 42MW gas-turbine generating unit and a 31MW steam-turbine generating unit, is connected on to the circuit Z1E, between Lauzon TS and Essex TS. This facility typically delivers approximately 72MW to the system.

4. Windsor Area Overload Protection Scheme

Under contingency conditions involving the 230kV and 115kV facilities in the area, overloading of the following auto-transformers and 115kV circuits can occur:

- Auto-transformers T11 & T12 at Keith TS
- 115kV circuits J3E & J4E, between Keith TS and Essex TS
- 115kV circuits Z1E & Z7E, between Lauzon TS and Essex TS

In addition, the loss of the 230/115kV connection at Lauzon TS (both auto-transformers out-of-service) or the loss of one of the 115kV circuits from Lauzon TS to Kingsville TS (circuits K2Z & K6Z) can result in excessively low voltages at Kingsville TS.

The Windsor Area Overload Protection Scheme was developed to address these conditions, either by initiating load rejection (for low voltages in the Kingsville area), or by splitting the 115kV system between Keith TS and Lauzon TS at Essex TS.

Alternatives for splitting the Windsor Area 115kV system at Essex TS

The two alternative modes for splitting the Windsor area 115kV system are as follows:

Mode 1: This results in the following distribution of loads between the two supply points -

From Keith TS Crawford TS, Ford Aluminum, Essex TS and all the automotive plant loads supplied from circuits E8F & E9F (circuit E8F becomes idle)

From Lauzon TS Ford EEP and Walker TSs Nos. 1 & 2.

Mode 2: This results in the following distribution of loads between the two supply points -

From Keith TS Crawford TS & Ford Aluminum

From Lauzon TS Ford EEP, Walker TSs Nos. 2 & 2, Essex TS, and all the automotive plant loads supplied from circuits E8F & E9F

Diagram 3 shows the two alternatives for splitting the 115kV system at Essex TS.

The intent of the splitting of the 115kV system at Essex TS is to eliminate any through-flows on the 115kV system between Keith TS to Lauzon TS that would contribute to post-contingency overloading of the 115kV circuits or of the auto-transformers at Keith TS.

Enhancements to the Windsor Area Overload Protection Scheme

As a condition for the connection of the Brighton Beach Project to the IMO-controlled grid, enhancements were required to be made to the existing Windsor Area Overload Protection Scheme as follows:

- change the existing Scheme from one that responds to overload conditions to a connectivity-based Scheme i.e. individual contingency conditions are to be detected by the change in status of specific breakers.
- include the capability to initiate rejection of the Brighton Beach generating units in response to a range of different contingency conditions.
- include the capability to initiate either a Mode 1 or a Mode 2 split of the 115kV system at Essex TS for each distinct contingency condition.

This work has now been completed.

5. Loads in the Windsor Area

Table 1 summarises the load forecast for those loads in the Windsor area that are supplied directly from the following 115kV circuits:

- circuits J3E & J4E between Keith TS and Essex TS
- circuits Z1E & Z7E between Lauzon TS and Essex TS
- circuits E8F & E9F radially connected to Essex TS

Transformer Station	Summer Peak Load (MVA)							
	2003	2004	2005	2006	2007	2008	2009	2010
Crawford TS	90	91	92	93	94	95	96	97
Walker TS No. 1	74	62	63	64	65	66	67	68
Walker TS No. 2	73	74	75	76	77	78	79	80
Essex TS	46	46	47	47	48	48	48	49
<i>Sub-total</i>	<i>283</i>	<i>273</i>	<i>277</i>	<i>280</i>	<i>284</i>	<i>287</i>	<i>290</i>	<i>294</i>
<i>Total Windsor Area Automotive Load</i>								
• Supplied from circuits Z1E & Z7E	30	30	30	30	30	30	30	30
• Supplied from circuits E8F & E9F	131	133	134	136	138	139	141	143
<i>Sub-total</i>	<i>161</i>	<i>163</i>	<i>164</i>	<i>166</i>	<i>168</i>	<i>169</i>	<i>171</i>	<i>173</i>
Total 115kV-connected Loads	444	436	441	446	452	456	461	467

These loads were used in the analysis.

6. AES Project near Leamington

When the original System Impact Assessment for the 1st Sarnia-Windsor Cluster was performed, AES Endeavor Inc. had indicated that, subject to the necessary approvals from the IMO, they would be proceeding with their proposed 625MVA Project near Leamington. This Project was to have been incorporated on to the two 230kV circuits, C23Z & C24Z between Lauzon TS and Chatham TS.

This generation facility would have resulted in increased transfers into the Windsor area via Lauzon TS, effectively reducing the transfers through the 115kV system from Keith TS.

AES Endeavor Inc. has recently informed the IMO that they are no longer pursuing this Project and it has therefore been formally withdrawn from the IMO Queue.

7. *Review of the Flows on the 115kV System*

Analysis has shown that for the following operating condition, the transfers on circuits J3E & J4E would be marginally in excess of their *continuous* summertime rating, under peak load conditions for the summer-2004:

- *With zero transfers into Ontario from Michigan via the J5D Interconnection.*
- With no AES Project.
- With the ATCO Project operating at its previously approved output of 580MW.
- With both the West Windsor Power and the TransAlta (Sarnia) Projects operating at their full output.

The flows on circuits J3E & J4E would be approximately 210MVA relative to their *continuous* ratings of 183MVA.

The corresponding flows at Keith TS through each of the two 115MVA auto-transformers, T11 & T12, would be approximately 75MVA.

If simultaneous transfers were being made into Ontario from Michigan via the J5D Interconnection, or if the loads in the Windsor area were to be higher than forecast, then the degree of overloading would increase accordingly.

It should be noted, however, that the flows would remain within the *emergency* ratings for these circuits (219MVA for J4E & 234MVA for J3E). Furthermore, if a subsequent contingency were to occur, the Windsor Area Overload Protection Scheme would be employed to respect the ratings of these circuits by initiating generation rejection and/or splitting of the local 115kV system at Essex TS.

Effect of Increasing the Output from the Brighton Beach Project

An increase of 45MW in the output of the Brighton Beach Project to 625MW would be expected to result in an increase of approximately 12MVA in the individual flows on circuits J3E & J4E. This would be sufficient to result in the *emergency* summertime ratings of these circuits to be exceeded.

8. *Imports from Michigan*

Approximately 10% of any transfer into Ontario across the Ontario-Michigan Interface via the J5D Interconnection would be expected to flow through the 115kV Windsor area system. Consequently, for a typical import of 300MW, the individual flows on circuits would increase by approximately 15MW/17MVA.

With the existing generation, together with the Brighton Beach Project in-service, the increased flows on circuits J3E & J4E that would occur whenever transfers are being made from Michigan to Ontario would therefore be expected to result in their *emergency* ratings being exceeded.

Hydro One has indicated that they are considering a plan that would involve replacing the two 115MVA auto-transformers at Keith TS with units rated at 250MVA and reconductoring circuits J3E & J4E to achieve *continuous* ratings of approximately 320MVA per circuit.

Should this plan proceed, then the local Windsor area system would be capable of accommodating maximum transfers from Michigan while all the local generating facilities are in-service and operating at their full output. It would, however, require generation rejection and/or splitting of the 115kV system in the Windsor area to be initiated in response to contingency conditions.

9. *Proposed Operating Regime*

It has been agreed with Hydro One that, on the assumption circuits J3E & J4E will be reconducted within the near future, these circuits can be operated to their *emergency* rating (based on sag temperatures of 127°C & 116°C for circuits J3E & J4E, respectively) instead of respecting their *continuous* rating (based on a maximum conductor temperature of 93°C). Since it is expected that the conductors will be replaced, any subsequent degradation in their useful life would not be an issue.

10. Exciter & AVR Responses

The models and associated data used in the studies to examine the exciter response were as follows:

Diagram 4	Excitation System Model: ESST4B	Data for both the steam-turbine & gas-turbine units
Diagram 5	Governor Model: IEEEG1	Data for the steam-turbine unit
Diagram 6	Governor Model: GAST	Data for the two gas-turbine units
Diagram 7	Power System Stabiliser Model: PSS2A	Data for both the steam-turbine & gas-turbine units

Response Ratio Test

The following Diagrams show the respective responses for the individual generator to a large increase in the reference setting of the voltage regulator, when each generator has been initialised to its rated output at rated power factor:

Diagram 8	265MVA Steam-turbine Unit G-1:	Incorporated into the 230kV busbar at Keith TS
Diagram 9	234MVA Gas-turbine Unit G-1A:	Incorporated into the 115kV busbar at Keith TS
Diagram 10	234MVA Gas-turbine Unit G-1B:	Incorporated into the 230kV busbar at Keith TS

In each case the field voltages are shown to reach a ceiling value of at least twice the field voltage at rated output within a period of 50 milliseconds.

These responses would therefore meet the Excitation System Performance standard, as detailed under Reference 12 of Appendix 4.2 of the Market Rules.

Open-Circuit Response Test

The following Diagrams show the Open-circuit Responses of the individual generating units, when operating at rated speed, to a step-change of 5% in the reference set-point of the voltage regulators:

Diagram 11	265MVA Steam-turbine Unit G-1:	Incorporated into the 230kV busbar at Keith TS
Diagram 12	234MVA Gas-turbine Unit G-1A:	Incorporated into the 115kV busbar at Keith TS
Diagram 13	234MVA Gas-turbine Unit G-1B:	Incorporated into the 230kV busbar at Keith TS

These show that the revised terminal voltage for each generating unit would be achieved in just over a second, with a well damped response.

11. Fault Level Analysis

The following Table details the principal parameters for the equipment that was originally proposed for the Brighton Beach Project, and for the equipment that has now been supplied.

A comparison of the two sets of parameters shows that while the combined capacity of the generating units has increased by approximately 8% (from 680MVA to 733MVA), the sub-transient reactance of the generating units that have been supplied is approximately 18% higher for the gas-turbine units and 33% higher for the steam-turbine unit. However, the impedance of the step-up transformers is now approximately 5% (on 100MVA_{base}), compared to the value of approximately 7% that was used in the original studies.

These changes in the generator and transformer parameters is expected to result in an increase of approximately 10% in the fault contributions to the 230kV & 115kV busbars at Keith TS from the new facilities.

Equipment Parameters for the Brighton Beach Project			
	Steam-turbine STG-1	Gas-turbine CTG-1A	Gas-turbine CTG-1B
1. As used in the Original Assessment			
Machine Rating	260MVA	210MVA	210MVA
Sub-transient reactance x''_d	0.165	0.165	0.165
Step-up Transformer Rating	260MVA	220MVA	220MVA
Transformer reactance	0.17 on 260MVA	0.17 on 220MVA	0.17 on 220MVA
2. As supplied			
Machine Rating	265MVA	234MVA	234MVA
Sub-transient reactance x''_d	0.220	0.195	0.195
Step-up Transformer Rating	169/224/280MVA	136/180/225MVA	136/180/225MVA
Transformer reactance	0.118 on 280MVA	0.118 on 225MVA	0.1244 on 225MVA

The Table below, which has been extracted from the original Preliminary Assessment Report for the Brighton Beach Project, shows the margin between the projected fault levels at the 230kV & 115kV busbars at Keith TS and the equipment ratings.

If the fault level contributions from the Brighton Beach Project were to increase by a further 10% there would still be an adequate margin between the projected fault levels and the rating of the existing breakers.

Fault Level Results extracted from the original Preliminary Assessment Report						
Fault levels on the 230kV busbar at Keith TS for a Pre-fault Voltage of 250kV						
	Symmetrical Fault		Asymmetrical Fault		Breaker Capability	
	3-phase	L-G	3-phase	L-G	Symmetrical	Asymmetrical
Existing	13.3kA	13.2kA	16.2kA	15.7kA	43.3kA	48.6kA
With the ATCO Project	19.34kA	20.23kA	24.23kA	24.41kA		
<i>Increase:</i>	<i>6.04kA</i>	<i>7.03kA</i>	<i>8.03kA</i>	<i>8.71kA</i>		
Fault levels on the 115kV busbar at Keith TS for a Pre-fault Voltage of 127kV						
	Symmetrical Fault		Asymmetrical Fault		Breaker Capability	
	3-phase	L-G	3-phase	L-G	Symmetrical	Asymmetrical
Existing	16.4kA	19.8kA	20.6kA	24.9kA	Various: From 39.3kA To 42.0kA	Various: 45.5kA
With the ATCO Project	22.05kA	26.42kA	28.02kA	33.48kA		
<i>Increase:</i>	<i>5.65kA</i>	<i>6.62kA</i>	<i>7.42kA</i>	<i>8.58kA</i>		

It was therefore decided that additional fault level studies were not warranted.

12. Conclusions

This Assessment has concluded that, during the period until the 115kV circuits J3E & J4E are uprated, the larger units that it is now proposed to install at the Brighton Beach Project will increase in the possibility that congestion will occur, especially during the summer months.

Furthermore, once circuits J3E & J4E are updated so that the *continuous* rating of each of these circuits is increased to *at least* 250MVA, then subject to all transmission elements being in-service and the transfer across the BLIP Interface respecting the negative-BLIP limit, it should be possible to accommodate the full output of the larger capacity Brighton Beach Project together with a 300MW transfer into Ontario across the J5D Interconnection.

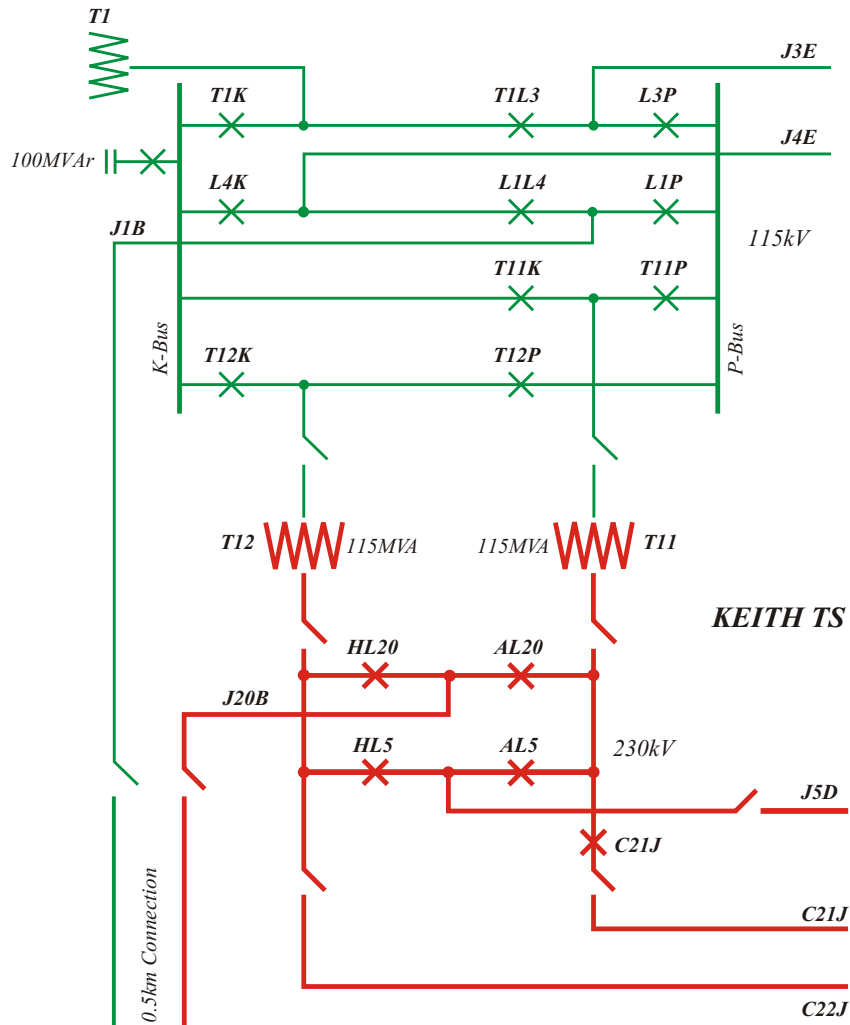
Apart from increasing the possibility that congestion will occur on the 115kV system in Windsor, it has been concluded that the equipment that it is now proposed to install at the Brighton Beach Project will have no adverse impact on the IMO-controlled grid.

13. Customer Impact Assessment

Since the new generating units represent an increase of less than 8% in the rating of the generating facility, the impact of the larger facility on local customers will be minor, and Hydro One Networks Inc. has therefore notified the IMO that a formal Customer Impact Assessment will not be required.

14. Notification of Approval of the Connection Proposal

Since this 2nd Addendum to the original System Impact Assessment dated 1st December 2000 has concluded that the increase in the rating of the individual units at the Brighton Beach Project will have no adverse impact on the IMO-controlled grid, it is therefore recommended that a revised *Notification of Approval for Connection* be issued for this Project.



KEITH TS

Incorporation Arrangement for Brighton Beach GS

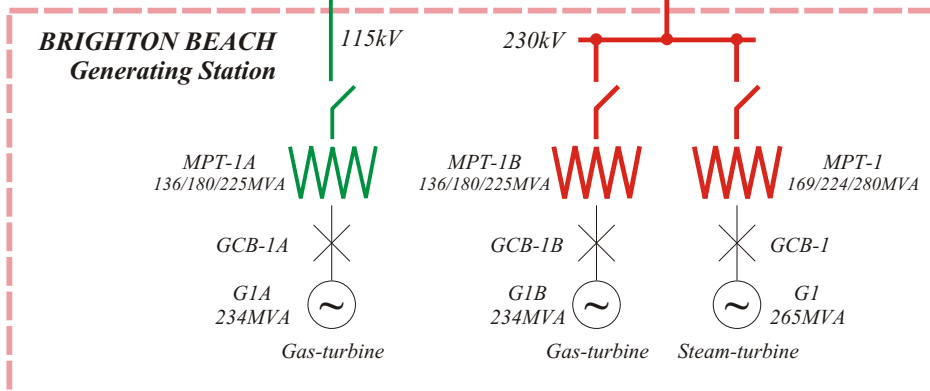
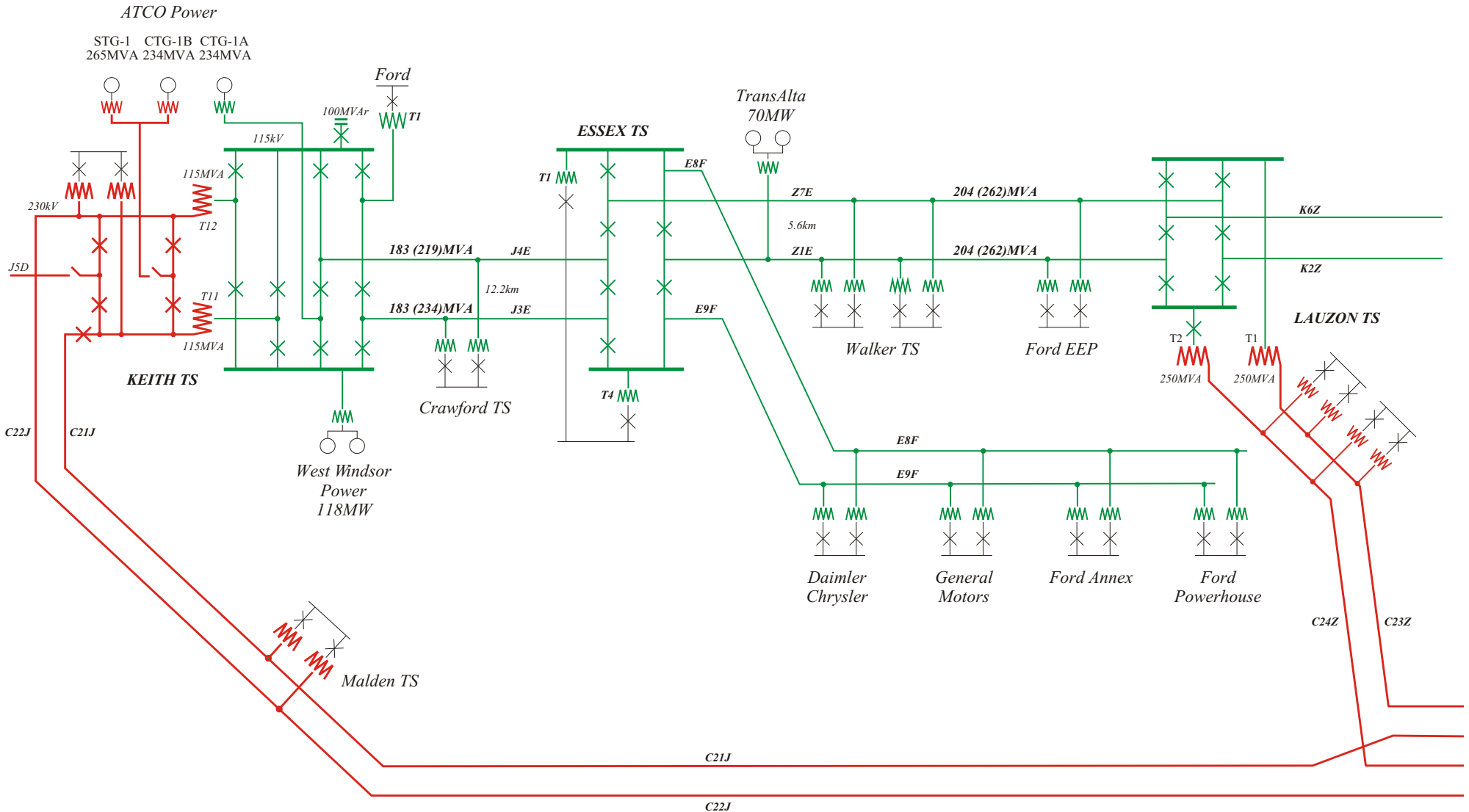


DIAGRAM 1

19th September 2003



Ratings at 124kV: Continuous (Emergency)

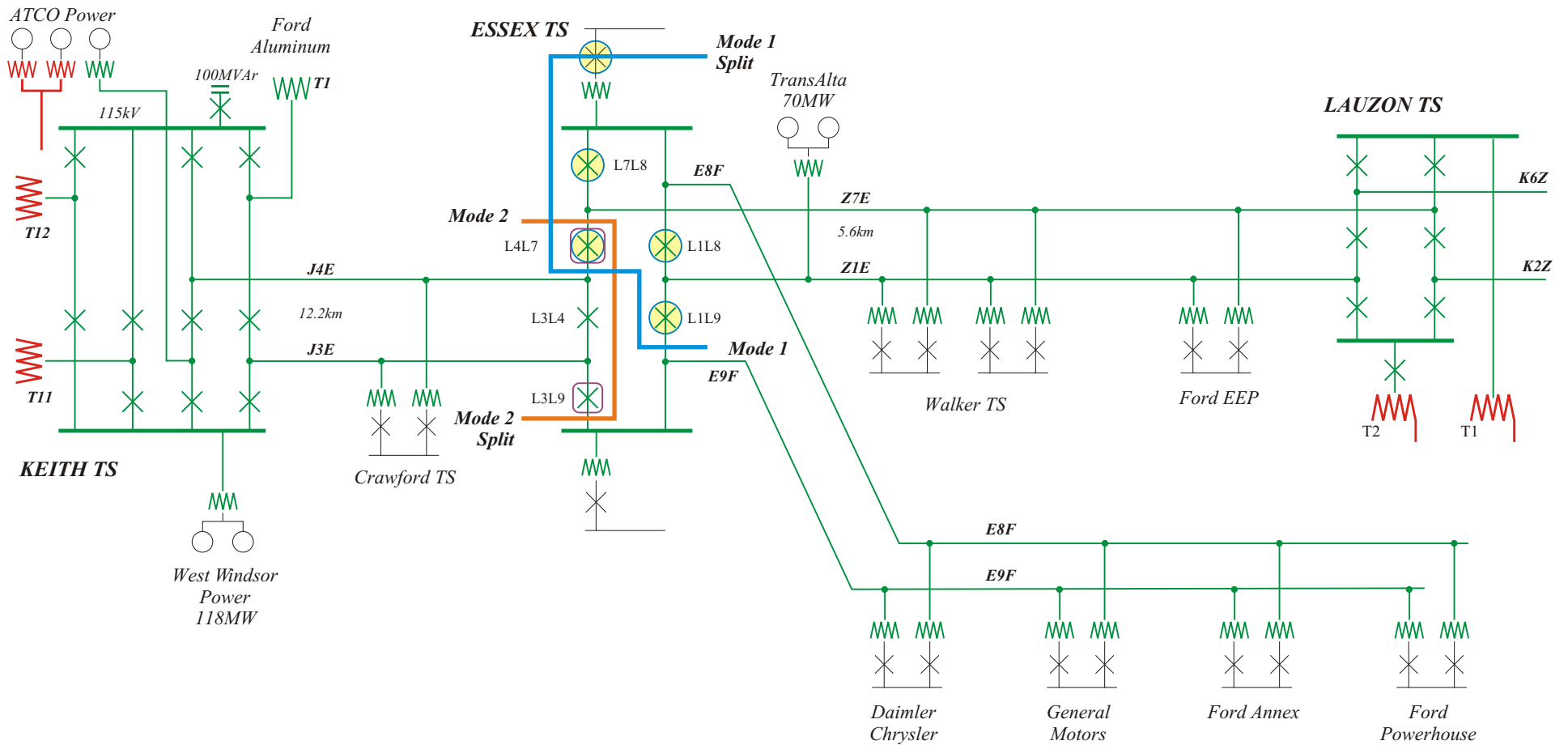
At an ambient temperature of 30°C & a wind-speed of 4km/hr

Conductor Temperature: 93°C for Continuous Rating
127°C for Emergency Rating

Transmission Facilities in the Windsor Area

DIAGRAM 2

19th September 2003



Breakers that would need to be opened for a Mode 1 Split of the 115kV system



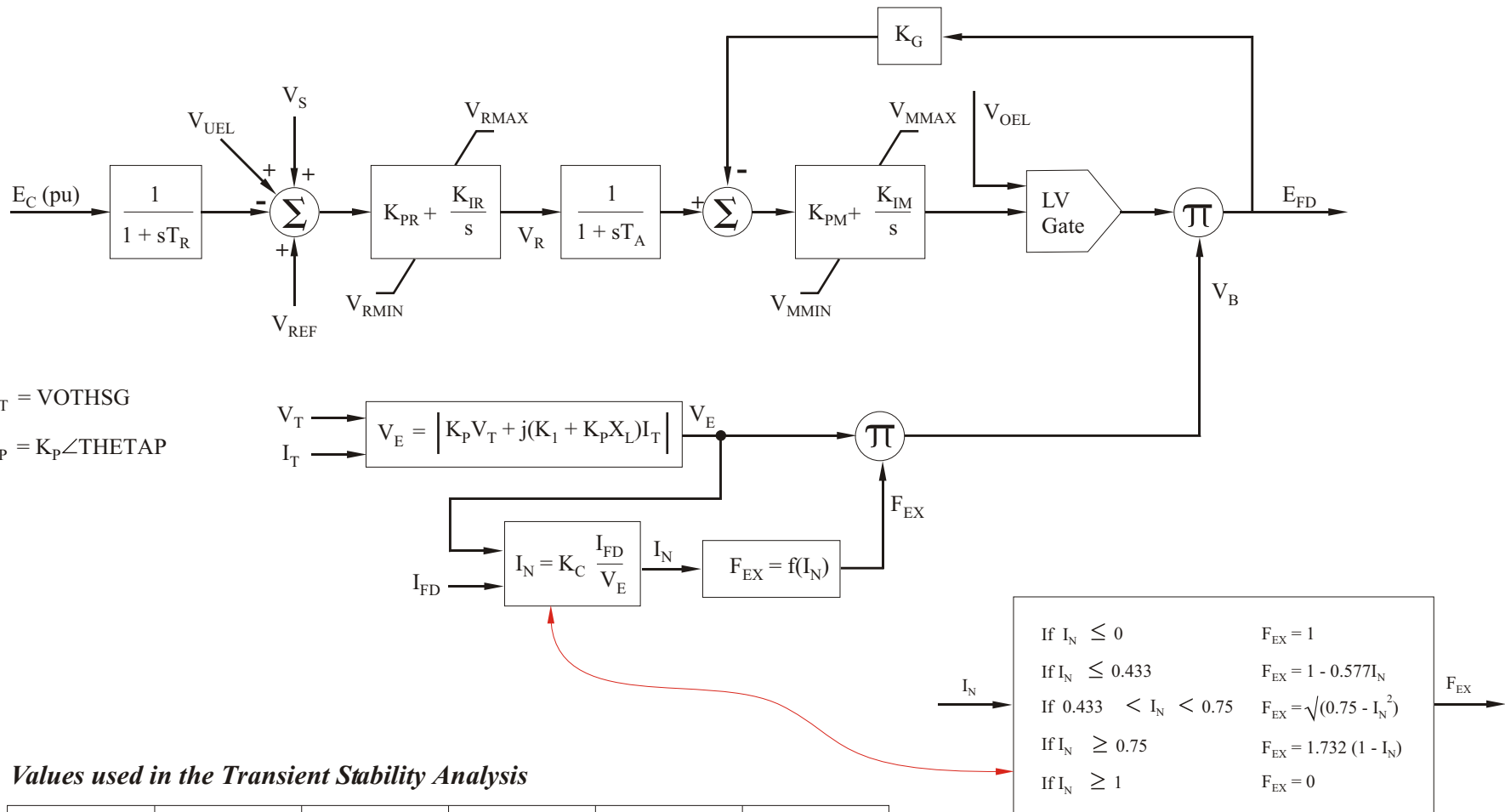
Breakers that would open for a Mode 2 Split of the 115kV system

Windsor Area Overload Protection Scheme

Options Available for Splitting the Windsor Area 115kV System

DIAGRAM 3

19th September 2003



Values used in the Transient Stability Analysis

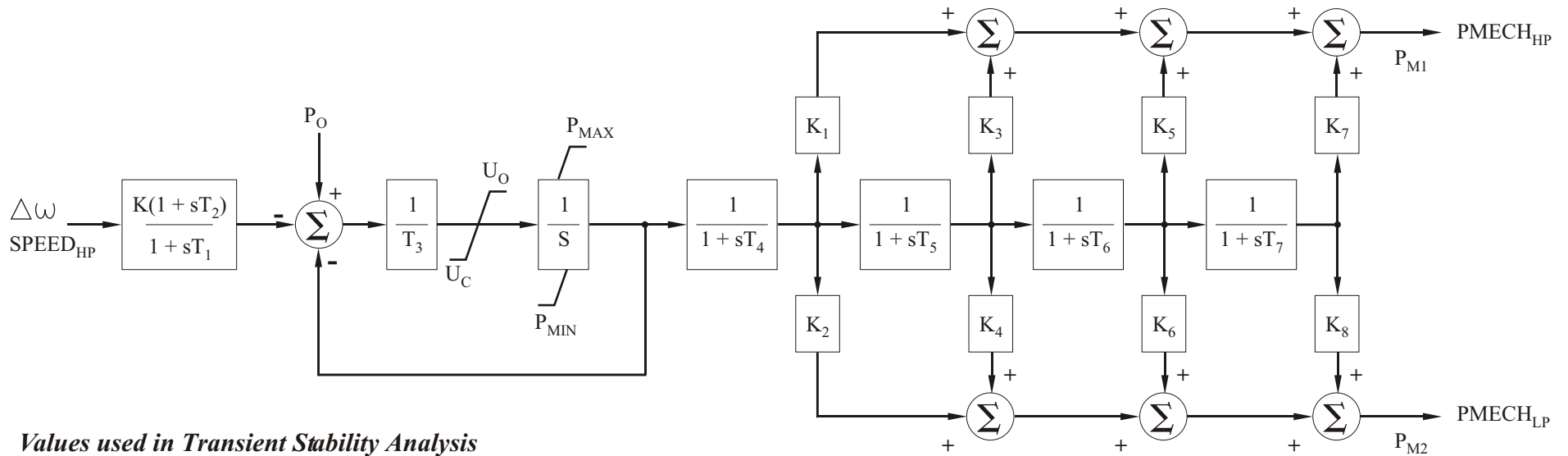
	<i>Steam-turbine</i>	<i>Gas-turbines</i>		<i>Steam-turbine</i>	<i>Gas-turbines</i>
K_1	0.00	0.00	T_A	0.01 sec	0.01 sec
K_C	0.10	0.09	T_R	0.00 sec	0.00 sec
K_G	0.00	0.00	V_{BMAX}	9.58	8.73
K_p	7.66	6.98	V_{MMAX}	1.00	1.00
K_{IM}	0.00	0.00	V_{MMIN}	-0.87	-0.87
K_{IR}	2.61	2.86	V_{RMAX}	1.00	1.00
K_{PM}	1.00	1.00	V_{RMIN}	-0.87	-0.87
K_{PR}	2.61	2.86	X_L	0.00	0.00
			THETAP	0.00	0.00

ESST4B Excitation System Model
(IEEE ST4B Model)

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

DIAGRAM 4

15th September 2003



Values used in Transient Stability Analysis

K	20.00	T ₁	0.00 sec
K ₁	0.224	T ₂	0.00 sec
K ₂	0.00	T ₃	0.15 sec
K ₃	0.395	T ₄	0.275 sec
K ₄	0.00	T ₅	0.10 sec
K ₅	0.381	T ₆	0.30 sec
K ₆	0.00	T ₇	0.00 sec
K ₇	0.00	U _O	0.012
K ₈	0.00	U _C	-0.012
		P _{MAX}	1.00
		P _{MIN}	0.00

IEEEG1 Governor Model

Data used for the steam-turbine unit at the Brighton Beach Project

~ which therefore reduces to

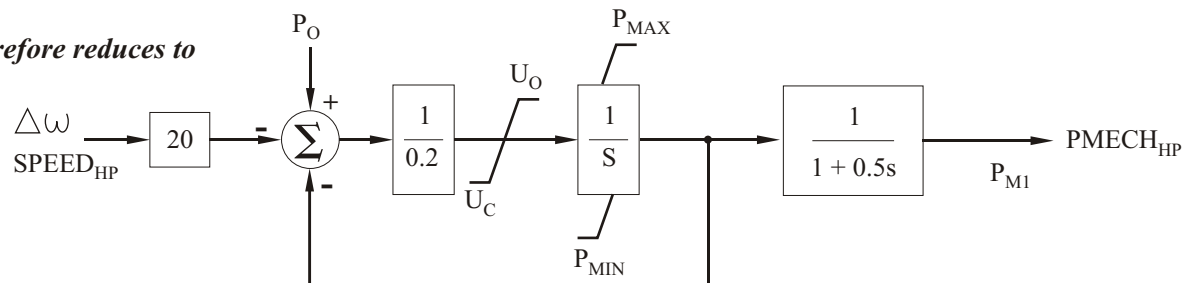
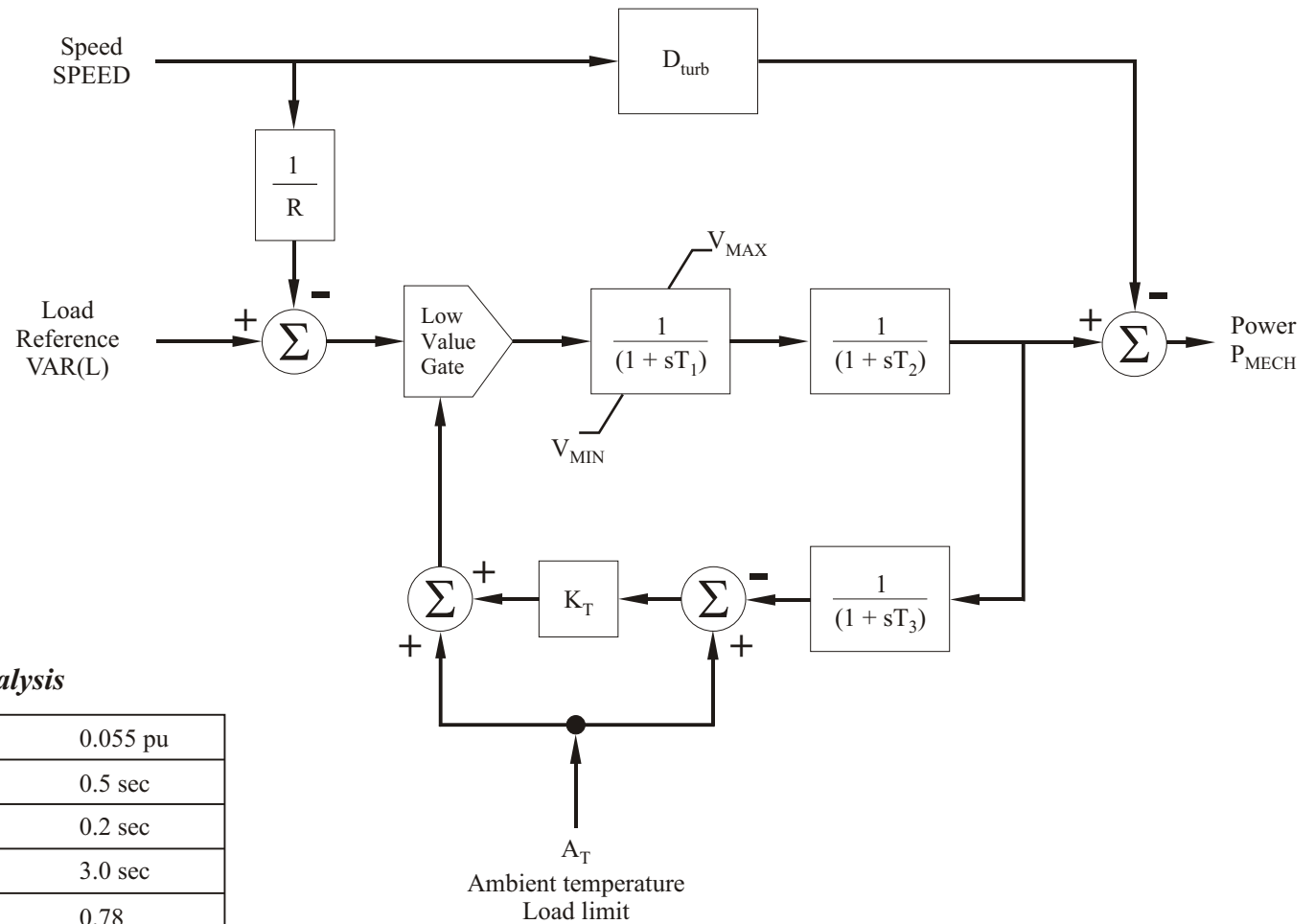


DIAGRAM 5

16th September 2003



***GAST Model
(Gas Turbine Governor)***

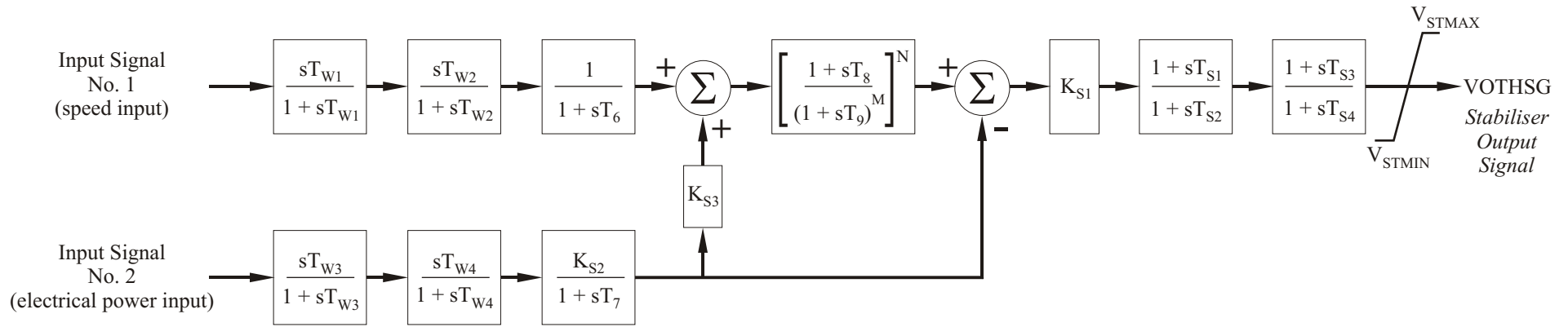
Values used in Transient Stability Analysis

Speed droop	R	0.055 pu
Time constants	T ₁	0.5 sec
	T ₂	0.2 sec
	T ₃	3.0 sec
Ambient temperature load limit	A _T	0.78
Constant	K _T	3.0
Maximum fuel valve opening	V _{MAX}	0.95 pu
Minimum fuel valve opening	V _{MIN}	0.00 pu
Turbine damping factor	D _{turb}	0.0

Data used for the two gas-turbine units at the Brighton Beach Project

DIAGRAM 6

16th September 2003



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

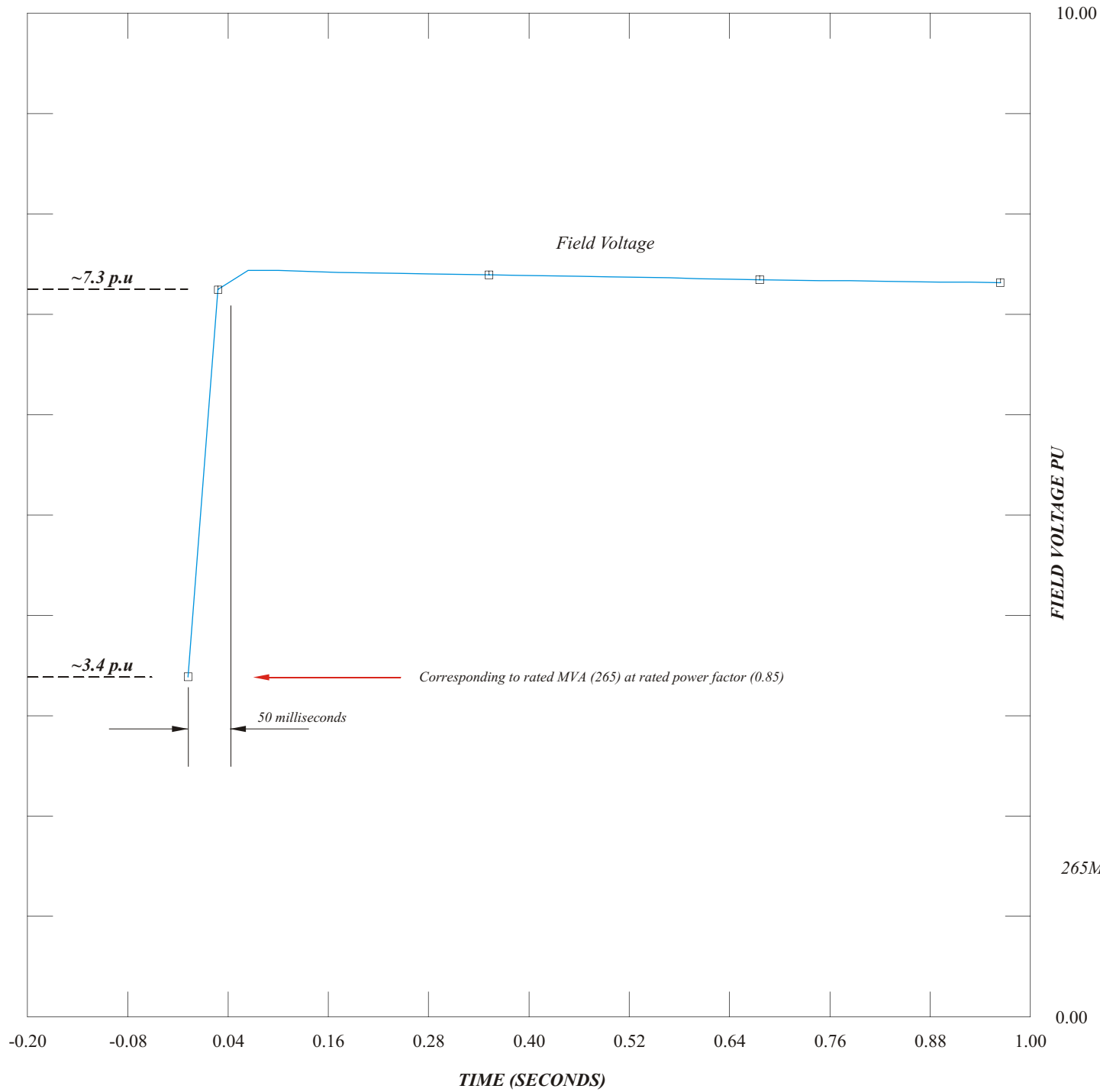
Values used in Transient Stability Analysis

	<i>Steam-turbine</i>	<i>Gas-turbines</i>		<i>Steam-turbine</i>	<i>Gas-turbines</i>
ICS1	1	1	T ₁	0.15 sec	0.15 sec
ICS2	3	3	T ₂	0.03 sec	0.03 sec
REMBUS1	0	0	T ₃	0.15 sec	0.15 sec
REMBUS2	0	0	T ₄	0.03 sec	0.03 sec
M	5	5	T ₆	0.00 sec	0.00 sec
N	1	1	T ₇	2.00 sec	2.00 sec
K _{S1}	10	10	T ₈	0.50 sec	0.50 sec
K _{S2}	0.211	0.2064	T ₉	0.10 sec	0.10 sec
K _{S3}	1.0	1.0	T _{W1}	2.00 sec	2.00 sec
V _{STMAX}	0.1	0.1	T _{W2}	2.00 sec	2.00 sec
V _{STMIN}	-0.1	-0.1	T _{W3}	2.00 sec	2.00 sec
			T _{W4}	0.00 sec	0.00 sec

Data used for the Brighton Beach Project

DIAGRAM 7

15th September 2003



10.00

FIELD VOLTAGE PU

Field Voltage

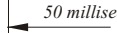
~7.3 p.u

~3.4 p.u

Corresponding to rated MVA (265) at rated power factor (0.85)



50 milliseconds



0.00

-0.20 -0.08 0.04 0.16 0.28 0.40 0.52 0.64 0.76 0.88 1.00

TIME (SECONDS)

0.00

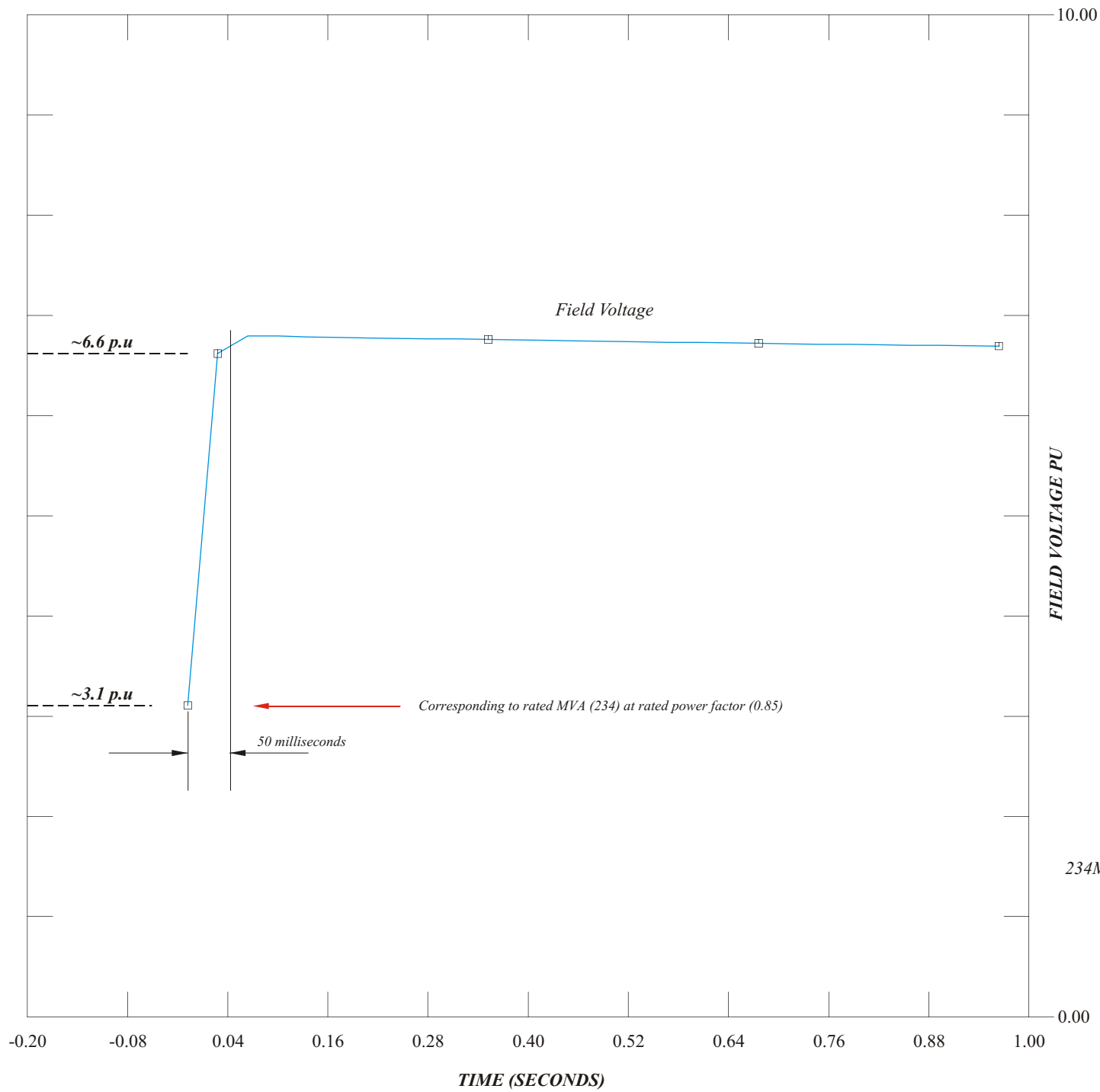
Brighton Beach Project:

265MVA Steam-turbine unit G-1 - Incorporated at 230kV

Response Ratio Test

DIAGRAM 8

10th September 2003

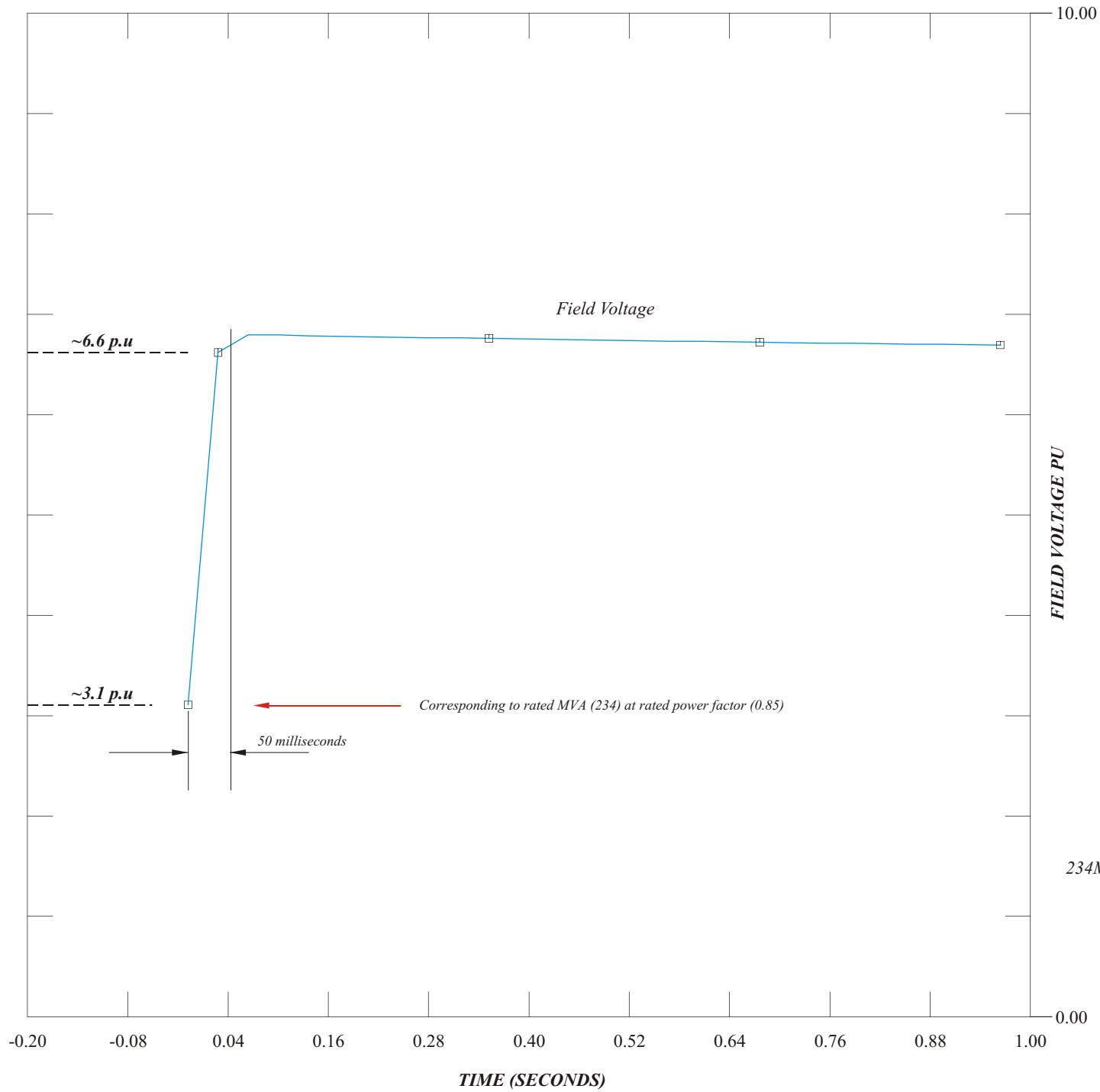


Brighton Beach Project:
 234MVA Gas-turbine unit G1A - Incorporated at 115kV

Response Ratio Test

DIAGRAM 9

10th September 2003

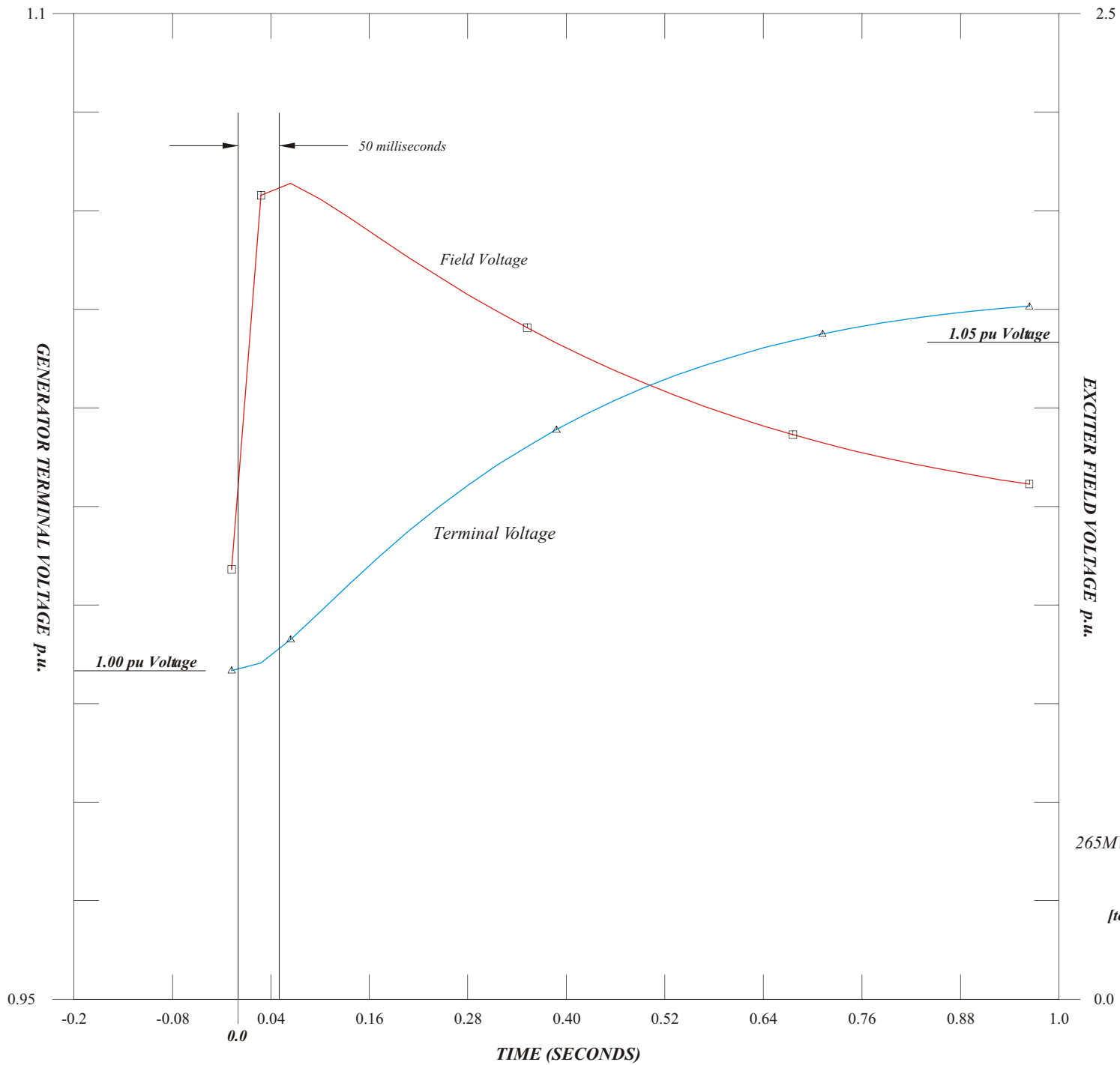


Brighton Beach Project:
 234MVA Gas-turbine unit G1B - Incorporated at 230kV

Response Ratio Test

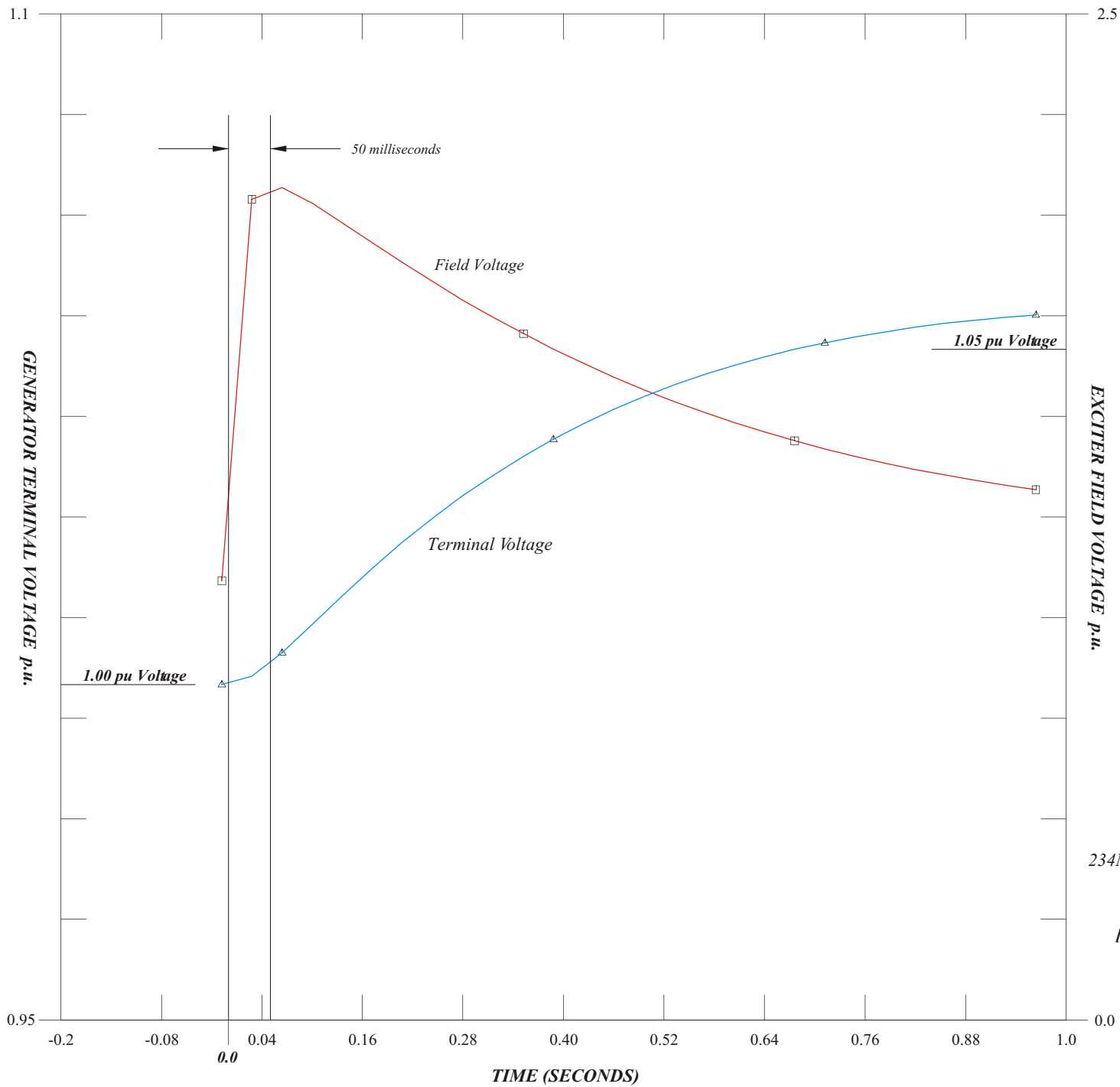
DIAGRAM 10

10th September 2003



Brighton Beach Project:
 265MVA Steam-turbine unit G-1 - Incorporated at 230kV

Open-Circuit Step-Response
 [to a 5% increase in generator terminal voltage]

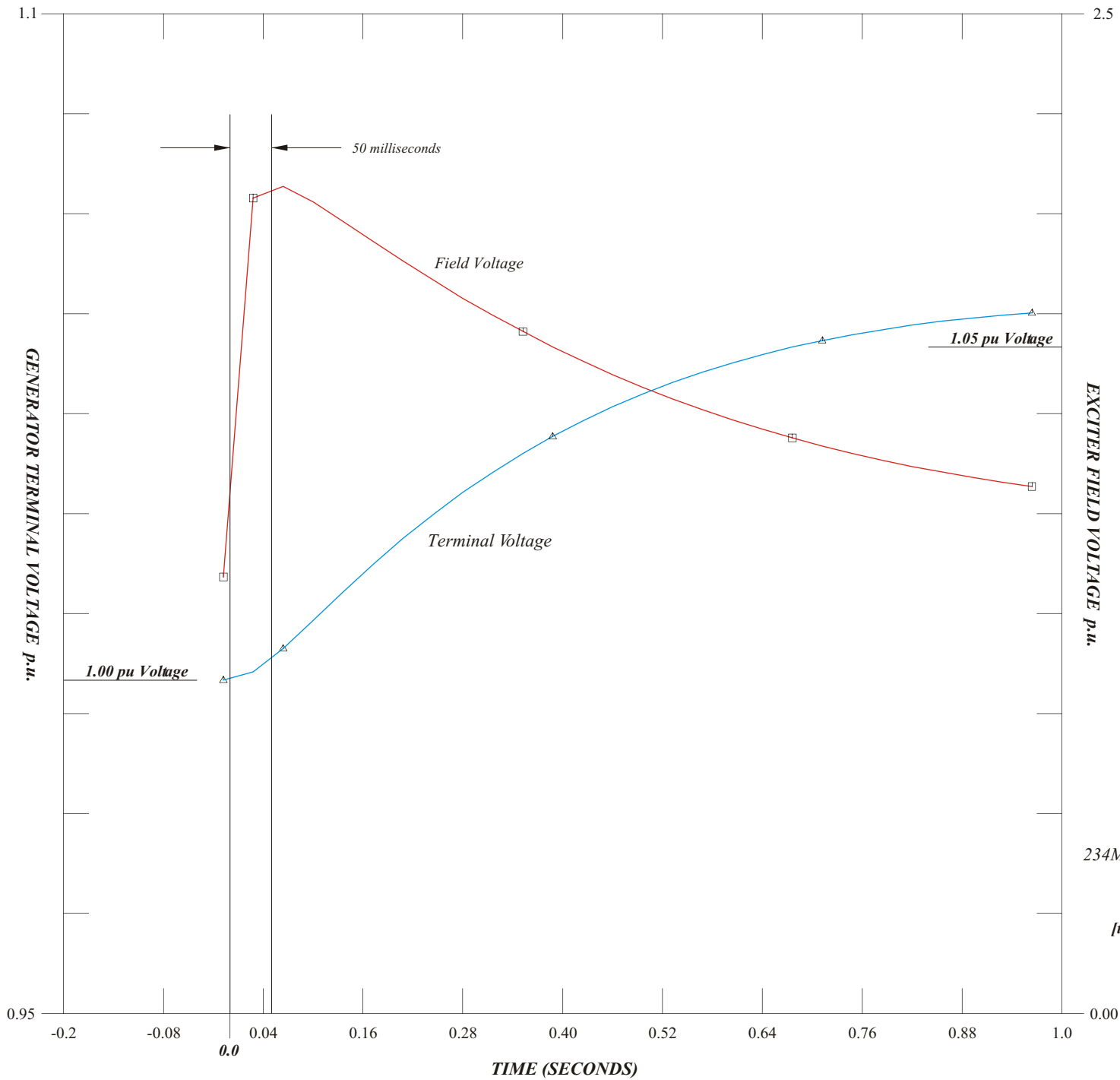


Brighton Beach Project:
 234MVA Gas-turbine unit G1A - Incorporated at 115kV

Open-Circuit Step-Response
 [to a 5% increase in generator terminal voltage]

DIAGRAM 12

3rd September 2003



Brighton Beach Project:
 234MVA Gas-turbine unit G1B - Incorporated at 230kV

Open-Circuit Step-Response
 [to a 5% increase in generator terminal voltage]

DIAGRAM 13

3rd September 2003