Southwest Power Pool

Impact Restudy
For Interconnection Request
GEN-2008-023

SPP Generation
Interconnection Studies

GEN-2008-023

July 2011

Executive Summary

This report contains the findings of a restudy of GEN-2008-023. The GEN-2008-023 interconnection request was studied as part of the DISIS-2009-001 Definitive Impact Study, Cluster Group #7, which was originally posted on January 31, 2010. With the power factor requirements and all network upgrades in service, GEN-2008-023 will meet FERC Order #661A low voltage ride through (LVRT) requirements, and the transmission system will remain stable.

This restudy was performed to evaluate the effects of a turbine manufacturer model change. The original study was for the GE 1.5MW wind turbine generator for 150.0MW total. This restudy is for the GE 1.6MW wind turbine generator for 148.8MW total. The requested In-Service Date is 12/1/2010. This restudy looked at interconnection at the Hobart Junction 138kV substation.

The findings of this restudy show that no stability problems were found during summer or winter peak conditions due to the model change of these generators.

Power factor analysis was performed. The facility will be required to maintain a 95% lagging (providing vars) and 95% leading (absorbing vars) power factor a the point of interconnection.

With the assumptions outlined in this report, GEN-2008-023 should be able to reliably connect to the SPP transmission grid.

Nothing in this study should be construed as a guarantee of transmission service. If the customer wishes to sell power from the facility, a separate request for transmission service shall be requested on Southwest Power Pool’s OASIS by the Customer.

Southwest Power Pool, Inc. (SPP)

GEN-2008-023 Re-Study Analysis

Final Report

PXE-0497
Revision #01

July 2011

Submitted By:
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Title: **GEN-2008-023 Re-Study Analysis: Final Report PXE-0497**
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EXECUTIVE SUMMARY

SPP requested an Interconnection System Impact Re-study. The Interconnection System Impact Re-study required a Power Factor Analysis and a Stability Analysis detailing the impacts of the study interconnecting project as shown in Table ES-1.

Table ES-1
Interconnection Project Evaluated

Request	Size (MW)	Wind Turbine Model	Point of Interconnection
GEN-2008-023	148.8	G.E. 1.6MW	Hobart Junction 138kV (511463)

SUMMARY OF POWER FACTOR ANALYSIS

The Power Factor Analysis shows that GEN-2008-023 has a power factor requirement of 0.9650 leading (absorbing) to 1.0 unity at the point of interconnection .

SUMMARY OF STABILITY ANALYSIS

The Stability Analysis determined that no wind turbine tripping or system instability occurs from interconnecting GEN-2008-023 at 100% output. A three-phase fault on the Southwest to Washita 138 kV line (FLT21-3PH) resulted in the voltage at GEN-2008-037 recovering slightly above 0.95 p.u. with oscillations. A 40 Mvar switched capacitor located at bus WF 34_5A (573572) improved the voltage recovery to acceptable levels. The capacitor is an interconnection requirement for GEN-2008-037 and is not affected by the GEN-2008-023 project.

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SECTION 1: OBJECTIVES

The objective of this report is to provide Southwest Power Pool, Inc. (SPP) with the deliverables for the "GEN-2008-023 Impact Restudy-01." SPP requested an Interconnection System Impact Restudy for GEN-2008-023, which requires a Power Factor Analysis, a Stability Analysis, and an Impact Study Report.

SECTION 2: BACKGROUND

The Siemens Power Technologies, Inc. PSS/E power system simulation program Version 30.3.3 was used for this study. SPP provided the stability database cases for both summer peak[1] and winter peak[2] seasons and a list of contingencies to be examined. The model includes the study project, concurrent projects, and the previously queued projects as listed in Table 2-1, Table 2-2 and Table 2-3, respectively. Refer to Appendix A for the steady-state and dynamic model data for the study projects. A power flow one-line diagram of GEN-2008-023 interconnection project is shown in Figure 2-1.

The Power Factor analysis will determine the power factor at the point of interconnection for the wind interconnection project for pre-contingency and post-contingency conditions. Table 2-4 lists the contingencies developed from the three-phase fault definitions provided in the Group's interconnection impact study request.

The Stability Analysis will determine the impacts of the new interconnecting project on the stability and voltage recovery of the nearby system and the ability of the interconnecting project to meet FERC Order 661A. If problems with stability or voltage recovery are identified, the need for reactive compensation or system upgrades will be investigated. Three-phase and single-phase faults will be examined as listed in Table 2-4.

[1] *MDWG_2010_2011SP_DISIS-2010-001-G7.sav – summer peak filename.*

[2] *MDWG_2010_2011WP_DISIS-2010-001-G7.sav – winter peak filename.*

Table 2-1
Interconnection Project Evaluated

Request	Size (MW)	Wind Turbine Model	Point of Interconnection
GEN-2008-023	148.8	G.E. 1.6MW	Hobart Junction 138kV (511463)

Table 2-2
Concurrent Projects Included

Request	Size (MW)	Wind Turbine Model	Point of Interconnection
GEN-2008-037	100.8	Vestas V90 1.8MW	Washita 138kV (521089)
GEN-2009-030	100.8	GE 1.6MW	Weatherford 138kV (511532)
GEN-2009-060	85.5	GE 1.5MW	Gotebo 69kV (520925)

Table 2-3
Previously Queued Nearby Interconnection Projects Included

Request	Size (MW)	Wind Turbine Model	Point of Interconnection
Blue Canyon I	74	CIMTR	Washita 138kV (521089)
Blue Canyon II (GEN-2003-004)	151	Vestas V80	Washita 138kV (521089)
Weatherford	147	G.E. 1.5MW	Weatherford 138kV (511506)
GEN-2003-005	100	G.E. 1.5MW	Anadarko – Paradise 138kV (521129)
GEN-2006-002	101	G.E. 1.5MW and 1.6MW	Sweetwater 230kV (511541)
GEN-2006-035	224	Gamesa	Sweetwater 230kV (511541)
GEN-2006-043	99	G.E. 1.5MW	Sweetwater 230kV (511541)
GEN-2007-032	150	Acciona 1.5MW	Clinton Jct. – Clinton 138kV (560939)
GEN-2007-043	200	G.E. 1.5MW	Cimarron – Anadarko 345kV (210431)
GEN-2007-052	150	Gas Turbine	Anadarko 138kV (520814)
GEN-2009-016	100.8	G.E. 1.6MW	Falcon Road 138KV (511511)

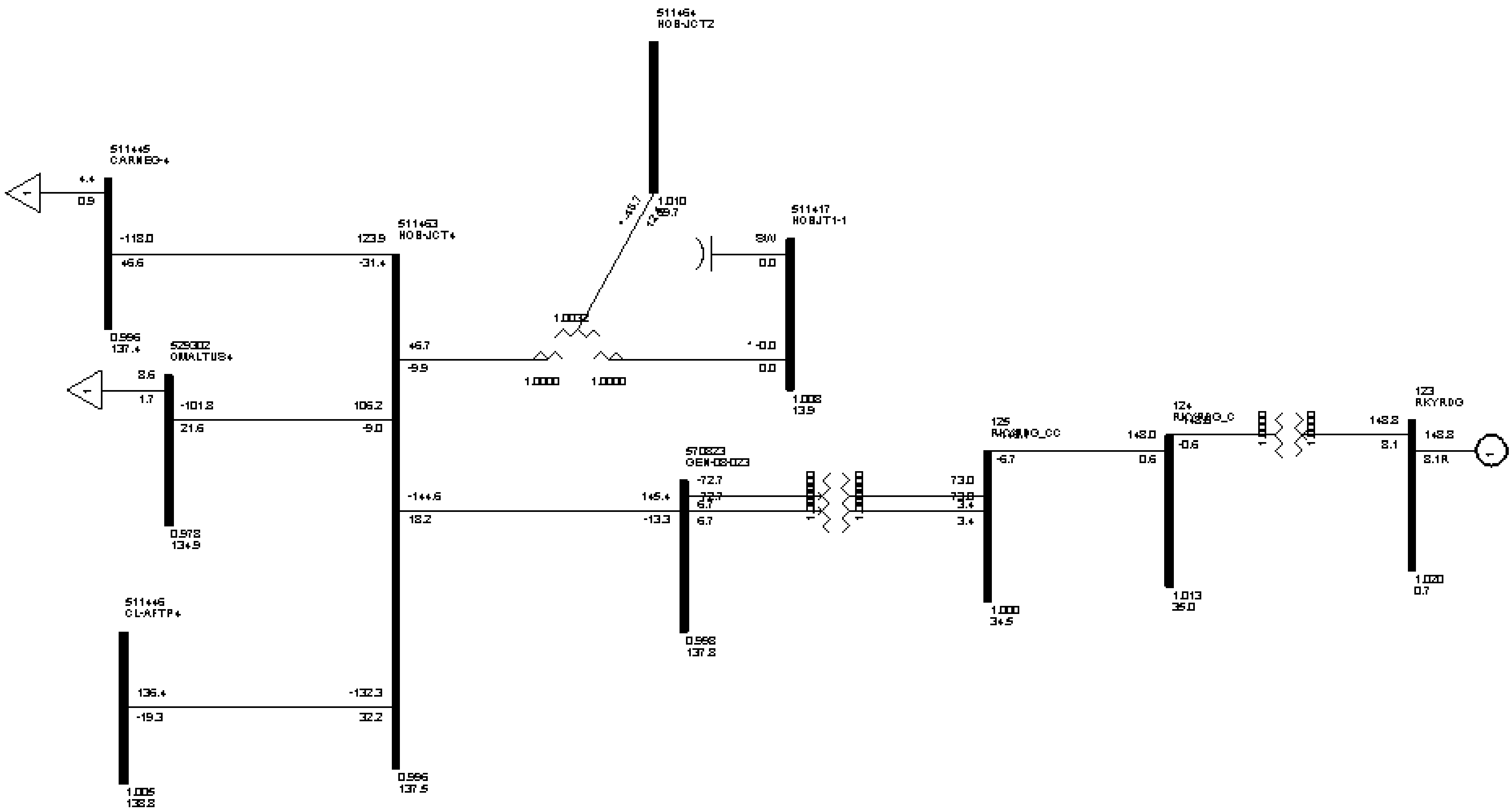

Figure 2-1. Power flow one-line diagram for interconnection project GEN-2008-023.

Table 2-4
Case List with Contingency Description

Cont. No.	Cont. Name	Description
1	FLT01-3PH	3 phase fault on the Hobart Jct (511463) to Carnegie South (511445) 138kV line, near Hobart Jct. a. Apply fault at Hobart Jct. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
2	FLT02-1PH	*Single phase fault and sequence like previous*
3	FLT03-3PH	3 phase fault on the Hobart Jct. (511463) to Clinton Airbase Tap (511446) 138kV line, near Hobart Jct. a. Apply fault at Hobart Jct. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
4	FLT04-1PH	*Single phase fault and sequence like previous*
5	FLT05-3PH	3 phase fault on the Hobart Jct. (511463) to Altus (529302) 138kV line, near Hobart Jct. a. Apply fault at Hobart Jct. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
6	FLT06-1PH	*Single phase fault and sequence like previous*
7	FLT07-3PH	3 phase fault on the Carnegie South (511445) to Southwest (511477) 138kV line, near Carnegie South. a. Apply fault at Carnegie South. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
8	FLT08-1PH	*Single phase fault and sequence like previous*
9	FLT09-3PH	3 phase fault on the Elk City (511458) to Clinton AFB (511446) 138kV line, near Elk City. a. Apply fault at the Elk City 138kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
10	FLT10-1PH	*Single phase fault and sequence like previous*
11	FLT11-3PH	3 phase fault on the Elk City (511458) to Clinton Jct. (511485) 138kV line, near Elk City. a. Apply fault at the Elk City 138kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
12	FLT12-1PH	*Single phase fault and sequence like previous*
13	FLT13-3PH	3 phase fault on the Elk City (511458) to Falcon Road (511511) 138kV line, near Elk City. a. Apply fault at the Elk City 138kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.

Table 2-4 (continued)

Case List with Contingency Description

Cont. No.	Cont. Name	Description
14	FLT14-1PH	*Single phase fault and sequence like previous*
15	FLT15-3PH	3 phase fault on the Red Hill (521116) to Morewood Switch (521001) 138kV line, near Red Hill. a. Apply fault at Red Hill. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
16	FLT16-1PH	*Single phase fault and sequence like previous*
17	FLT17-3PH	3 phase fault on the Altus Jct. (511440) to Snyder (511435) 138kV line, near Altus Jct. a. Apply fault at Altus Jct. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
18	FLT18-1PH	*Single phase fault and sequence like previous*
19	FLT19-3PH	3 phase fault on the Altus Tap (511448) to Russell (521043) 138kV line, near Altus Tap. a. Apply fault at Altus Tap 138kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
20	FLT20-1PH	*Single phase fault and sequence like previous*
21	FLT21-3PH	3 phase fault on the Southwest (511477) to Washita (521089) 138kV line, near Southwest. a. Apply fault at Southwest 138kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
22	FLT22-1PH	*Single phase fault and sequence like previous*
23	FLT23-3PH	3 phase fault on the Southwest (511477) to Anadarko (520814) 138kV line, near Anadarko. a. Apply fault at Anadarko 138kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
24	FLT24-1PH	*Single phase fault and sequence like previous*
25	FLT25-3PH	3 phase fault on the Southwest (511477) to Verden (511421) 138kV line, near Verden. a. Apply fault at Verden 138kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
26	FLT26-1PH	*Single phase fault and sequence like previous*
27	FLT27-3PH	3 phase fault on the Southwest (511477) to Elgin Jct. (511421) 138kV line, near Elgin Jct.. a. Apply fault at Elgin Jct. 138kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.

Table 2-4 (continued)
Case List with Contingency Description

Cont. No.	Cont. Name	Description
28	FLT28-1PH	*Single phase fault and sequence like previous*
29	FLT29-3PH	3 phase fault on the Hobart Jct. 138kV (511463) to 69kV (511464) transformer near the 138kV bus. a. Apply fault at Hobart Jct. 138kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer
30	FLT30-3PH	3 phase fault on the Elk City 138kV (511458) to 230kV (511490) transformer, near the 138kV bus. a. Apply fault at the Elk City 138kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
31	FLT31-3PH	3 phase fault on the Elk City 138kV (511458) to 69kV (511459) transformer, near the 138kV bus. a. Apply fault at the Elk City 138kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
32	FLT32-3PH	3 phase fault on the Gracemont 345kV (515800) to 138kV (515802) transformer, near the 138kV bus. a. Apply fault at the Gracemont 138kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.

SECTION 3: POWER FACTOR ANALYSIS

Task Objective

The objective of this task is to quantify the power factor at the point of interconnection for the wind farm during base case and system contingencies.

Approach

Both winter peak and summer peak power flows provided by SPP were examined prior to the Power Factor Analysis to ensure they contained the proposed study projects modeled at 100% of the nameplate rating and any concurrent projects and previously queued projects listed in Tables 2-2 and 2-3. There was no suspect power flow data in the study area. The proposed study projects at the point of interconnection were turned off during the power factor analysis. The wind farm was then replaced by a generator modeled at the point of interconnection bus with the same real power (MW) capability as the wind farm and open limits for the reactive power set points (Mvar). The generator was set to hold the scheduled bus voltage. Contingencies from the three-phase fault definitions provided in Table 2-4 were then applied and the reactive power required to maintain the bus voltage was recorded.

The interconnecting wind farm GEN-2008-023 was disabled at bus 123 and a generator was placed at the 138 kV POI Hobart Junction (Bus 511463). The generator was modeled with PGEN = 148.8 MW, QMin = -9999 Mvar, and QMax = 9999 Mvar. All buses and transformers connected between bus 123 and 541163 were disabled. The scheduled voltage for GEN-2008-023 was 1.000 p.u. for summer peak and winter peak conditions.

Results

The power factor was calculated for summer and winter peak conditions. Table 3-1 shows the power factor results for GEN-2008-023 (148.8 MW). Note that a positive Q (Mvar) output illustrates that the generator is absorbing reactive power from the system, implying a leading power factor; a negative Q (Mvar) illustrates that the generator is supplying reactive power to the system, implying a lagging power factor.

Summary

The Power Factor Analysis shows that GEN-2008-023 has a power factor requirement of 0.9650 leading (absorbing) to 1.0 unity at the point of interconnection.

Table 3-1
Power Factor Analysis
GEN-2008-023 (Pgen = 148.8 MW)*

	Summer			Winter		
Case	**pf**		**Q** (MVAR)**	**pf**		**Q** (MVAR)**
Base	0.9909	leading	20.1740	0.9959	leading	13.4864
C1	1.0000	leading	1.0513	0.9990	leading	6.6197
C3	0.9757	leading	33.4258	0.9733	leading	35.0900
C5	0.9656	leading	40.0713	0.9854	leading	25.6946
C7	0.9999	leading	1.6567	0.9985	leading	8.0736
C9	0.9754	leading	33.5943	0.9717	leading	36.1616
C11	0.9964	leading	12.7376	0.9996	leading	3.9897
C13	0.9908	leading	20.3470	0.9957	leading	13.9057
C15	0.9979	leading	9.5686	1.0000	lagging	-0.7094
C17	0.9888	leading	22.4867	0.9948	leading	15.1860
C19	0.9930	leading	17.7176	0.9977	leading	10.2020
C21	0.9931	leading	17.6353	0.9947	leading	15.3431
C23	0.9910	leading	20.0713	0.9960	leading	13.4296
C25	0.9908	leading	20.3741	0.9954	leading	14.3369
C27	0.9921	leading	18.7921	0.9964	leading	12.5820
C29	0.9924	leading	18.4369	0.9979	leading	9.6539
C30	0.9678	leading	38.7045	0.9650	leading	40.4271
C31	0.9977	leading	10.0170	0.9997	leading	3.8703
C32	0.9919	leading	19.0305	0.9954	leading	14.2799

* The scheduled voltage for GEN-2008-023 was 1.000 p.u. for summer peak and winter peak conditions.

** A positive Q (Mvar) output illustrates the generator is absorbing Mvars from the system, which implies a leading power factor; negative Q (Mvar) output shows the generator is supplying Mvars to the system implying a lagging power factor.

SECTION 4: STABILITY ANALYSIS

Objective

The objective of the stability analysis was to determine the impacts of the new wind farm at Hobart Junction on the stability and voltage recovery of the nearby system. If problems with stability or voltage recovery were identified the need for reactive compensation or system upgrades were investigated.

Approach

Both winter peak and summer peak power flows provided by SPP were examined prior to the Stability Analysis to ensure they contained the proposed study projects modeled at 100% of the nameplate rating and any concurrent projects and previously queued projects listed in Tables 2-2 and 2-3. There was no suspect power flow data in the study area. The dynamic datasets were also verified and stable initial system conditions (i.e., "flat lines") were achieved. One model, the Vestas V90 1.8 MW turbine, initialized with an error with Pmech on the order of 10^5. Three-phase and single line-to-ground faults listed in Table 2-4 were examined. Single-phase fault impedances were calculated to result in a voltage of approximately 60% of the pre-fault voltage. Refer to Table 4-1 for a list of the calculated single-phase fault impedances used for the analysis.

Bus voltages and previously queued generation in the study area were monitored in addition to the bus voltages in the following areas:

- 520 AEPW
- 524 OKGE
- 525 WFEC
- 526 SPS
- 531 MIDW
- 534 SUNC
- 536 WERE

The results of the analysis determined if reactive compensation or system upgrades were required to obtain acceptable system performance. If additional reactive compensation was required, the size, type, and location were determined. The proposed reactive reinforcements would ensure the wind farm meets FERC Order 661A low voltage requirements and return the wind farm to its pre-disturbance operating voltage. If the results indicated the need for fast responding reactive support, dynamic support such as an SVC or STATCOM was investigated. If tripping of the prior queued projects was observed during the stability analysis (for under/over voltage or under/over frequency) the simulations were re-ran with the prior queued project's voltage and frequency tripping disabled. No tripping occurred during the analysis.

If stability problems were identified, the maximum acceptable generation level for the GEN-2008-023 to operate without causing any stability problems was quantified. Stability analysis results indicated that GEN-2008-023 can interconnect at 100% output power.

Results

Refer to Table 4-2 for a summary of the Stability Analysis results. Figure 4-1 shows the response of GEN-2008-023 during a three-phase fault (FLT03-3PH) during winter peak conditions. Figures 4-2 and 4-3 show selected bus voltages in the study area during FLT03-3PH, which is a representative case for the “worst” delayed voltage recovery. Figure 4-4 shows the response of GEN-2008-023 during a three-phase fault on the low-side of the Elk City 138/230 kV transformer (FLT30-3PH) during winter peak conditions. Figures 4-5 and 4-6 show selected bus voltages in the study area during FLT30-3PH, which is a representative case for the “worst” voltage dips.

A three-phase fault on the Southwest to Washita 138 kV line (FLT21-3PH) resulted in the voltage at GEN-2008-037 recovering slightly above 0.95 p.u. with oscillations. A previous SPP project study observed oscillations in the GEN-2003-004 Vestas V80 models when bus voltages approached 0.9 p.u. and concluded a 55 Mvar switched capacitor was needed at the 34.5 kV bus WF 34_5A (573572) of GEN-2008-037.

A few cases resulted in buses in area 520 AEPW having depressed voltages after the fault event. These buses were isolated from generation under study when the faulted line is dropped. Table 4-2, Ref. No. 29, 30, and 31 show the pre- and post-contingency voltages for these buses. Figure 4-10 shows selected area 520 AEPW voltages during a three-phase fault on the high-side of the Elk City 138/69 kV transformer (FLT31-3PH) during winter peak conditions. Bus HAMJCT 2 (511531) in Figure 4-7 is the worst case for voltage recovery.

Table 4-1
Calculated Single-Phase Fault Impedances

Ref. No.	Casename	Single-Phase Fault Impedance (MVA)	Ref. No.	Casename	Single-Phase Fault Impedance (MVA)
2	FLT02-1PH	-1000	16	FLT16-1PH	-1250
4	FLT04-1PH	-1000	18	FLT18-1PH	-687.5
6	FLT06-1PH	-1000	20	FLT20-1PH	-625
8	FLT08-1PH	-1125	22	FLT22-1PH	-5250
10	FLT10-1PH	-1625	24	FLT24-1PH	-5000
12	FLT12-1PH	-1625	26	FLT26-1PH	-1500
14	FLT14-1PH	-1625	28	FLT28-1PH	-1625

Table 4-2
Stability Analysis Summary of Results

Ref. No.	Casename	Summer		Winter	
		Stable?	Acceptable Voltages?	Stable?	Acceptable Voltages?
1	FLT01-3PH	Yes	Yes	Yes	Yes
2	FLT02-1PH	Yes	Yes	Yes	Yes
3	FLT03-3PH	Yes	Yes	Yes	Yes
4	FLT04-1PH	Yes	Yes	Yes	Yes
5	FLT05-3PH	Yes	Yes	Yes	Yes
6	FLT06-1PH	Yes	Yes	Yes	Yes
7	FLT07-3PH	Yes	Yes	Yes	Yes
8	FLT08-1PH	Yes	Yes	Yes	Yes
9	FLT09-3PH	Yes	Yes	Yes	Yes
10	FLT10-1PH	Yes	Yes	Yes	Yes
11	FLT11-3PH	Yes	Yes	Yes	Yes
12	FLT12-1PH	Yes	Yes	Yes	Yes
13	FLT13-3PH	Yes	Yes	Yes	Yes
14	FLT14-1PH	Yes	Yes	Yes	Yes
15	FLT15-3PH	Yes	Yes	Yes	Yes
16	FLT16-1PH	Yes	Yes	Yes	Yes
17	FLT17-3PH	Yes	Yes	Yes	Yes

Table 4-2 (continued)
Stability Analysis Summary of Results

<table>
<tr><th rowspan="2">Ref. No.</th><th rowspan="2">Casename</th><th colspan="3">Summer</th><th colspan="3">Winter</th></tr>
<tr><th>Stable?</th><th colspan="2">Acceptable Voltages?</th><th>Stable?</th><th colspan="2">Acceptable Voltages?</th></tr>
<tr><td>18</td><td>FLT18-1PH</td><td>Yes</td><td colspan="2">Yes</td><td>Yes</td><td colspan="2">Yes</td></tr>
<tr><td>19</td><td>FLT19-3PH</td><td>Yes</td><td colspan="2">Yes</td><td>Yes</td><td colspan="2">Yes</td></tr>
<tr><td>20</td><td>FLT20-1PH</td><td>Yes</td><td colspan="2">Yes</td><td>Yes</td><td colspan="2">Yes</td></tr>
<tr><td>21</td><td>FLT21-3PH</td><td>Yes</td><td colspan="2">Yes</td><td>Yes</td><td colspan="2">Yes</td></tr>
<tr><td>22</td><td>FLT22-1PH</td><td>Yes</td><td colspan="2">Yes</td><td>Yes</td><td colspan="2">Yes</td></tr>
<tr><td>23</td><td>FLT23-3PH</td><td>Yes</td><td colspan="2">Yes</td><td>Yes</td><td colspan="2">Yes</td></tr>
<tr><td>24</td><td>FLT24-1PH</td><td>Yes</td><td colspan="2">Yes</td><td>Yes</td><td colspan="2">Yes</td></tr>
<tr><td>25</td><td>FLT25-3PH</td><td>Yes</td><td colspan="2">Yes</td><td>Yes</td><td colspan="2">Yes</td></tr>
<tr><td>26</td><td>FLT26-1PH</td><td>Yes</td><td colspan="2">Yes</td><td>Yes</td><td colspan="2">Yes</td></tr>
<tr><td>27</td><td>FLT27-3PH</td><td>Yes</td><td colspan="2">Yes</td><td>Yes</td><td colspan="2">Yes</td></tr>
<tr><td>28</td><td>FLT28-1PH</td><td>Yes</td><td colspan="2">Yes</td><td>Yes</td><td colspan="2">Yes</td></tr>
<tr><td rowspan="6">29</td><td rowspan="6">FLT29-3PH</td><td rowspan="6">Yes</td><td colspan="2">R-AMOCO2 (511432)</td><td rowspan="6">Yes</td><td colspan="2">HOB-JCT2 (511464)</td></tr>
<tr><td>Pre-Fault</td><td>Post-Fault</td><td>Pre-Fault</td><td>Post-Fault</td></tr>
<tr><td>1.00</td><td>0.91</td><td>1.02</td><td>0.92</td></tr>
<tr><td colspan="2">HOBART-2 (511465)</td><td colspan="2">ROSVTAP2 (511444)</td></tr>
<tr><td>Pre-Fault</td><td>Post-Fault</td><td>Pre-Fault</td><td>Post-Fault</td></tr>
<tr><td>1.01</td><td>0.87</td><td>1.00</td><td>0.95</td></tr>
<tr><td rowspan="9">30</td><td rowspan="9">FLT30-3PH</td><td rowspan="9">Yes</td><td colspan="2" rowspan="9">Yes</td><td rowspan="9">Yes</td><td colspan="2">LONEWLF2 (520982)</td></tr>
<tr><td>Pre-Fault</td><td>Post-Fault</td></tr>
<tr><td>1.01</td><td>0.96</td></tr>
<tr><td colspan="2">SHAM 3WT (512107)</td></tr>
<tr><td>Pre-Fault</td><td>Post-Fault</td></tr>
<tr><td>0.98</td><td>0.93</td></tr>
<tr><td colspan="2">SHAMW 2WT (512106)</td></tr>
<tr><td>Pre-Fault</td><td>Post-Fault</td></tr>
<tr><td>0.98</td><td>0.95</td></tr>
</table>

Table 4-2 (continued)
Stability Analysis Summary of Results

<table>
<tr><th rowspan="2">Ref. No.</th><th rowspan="2">Casename</th><th colspan="2">Summer</th><th colspan="3">Winter</th></tr>
<tr><th>Stable?</th><th>Acceptable Voltages?</th><th>Stable?</th><th colspan="2">Acceptable Voltages?</th></tr>
<tr><td rowspan="4">31</td><td rowspan="4">FLT31-3PH</td><td rowspan="4">Yes</td><td rowspan="4">Yes</td><td rowspan="4">Yes</td><td colspan="2">ELKCTY-2 (511459)</td></tr>
<tr><td>Pre-Fault
1.02</td><td>Post-Fault
0.85</td></tr>
<tr><td colspan="2">HAMJCT 2 (511531)</td></tr>
<tr><td>Pre-Fault
1.01</td><td>Post-Fault
0.84</td></tr>
<tr><td>32</td><td>FLT32-3PH</td><td>Yes</td><td>Yes</td><td>Yes</td><td colspan="2">Yes</td></tr>
</table>

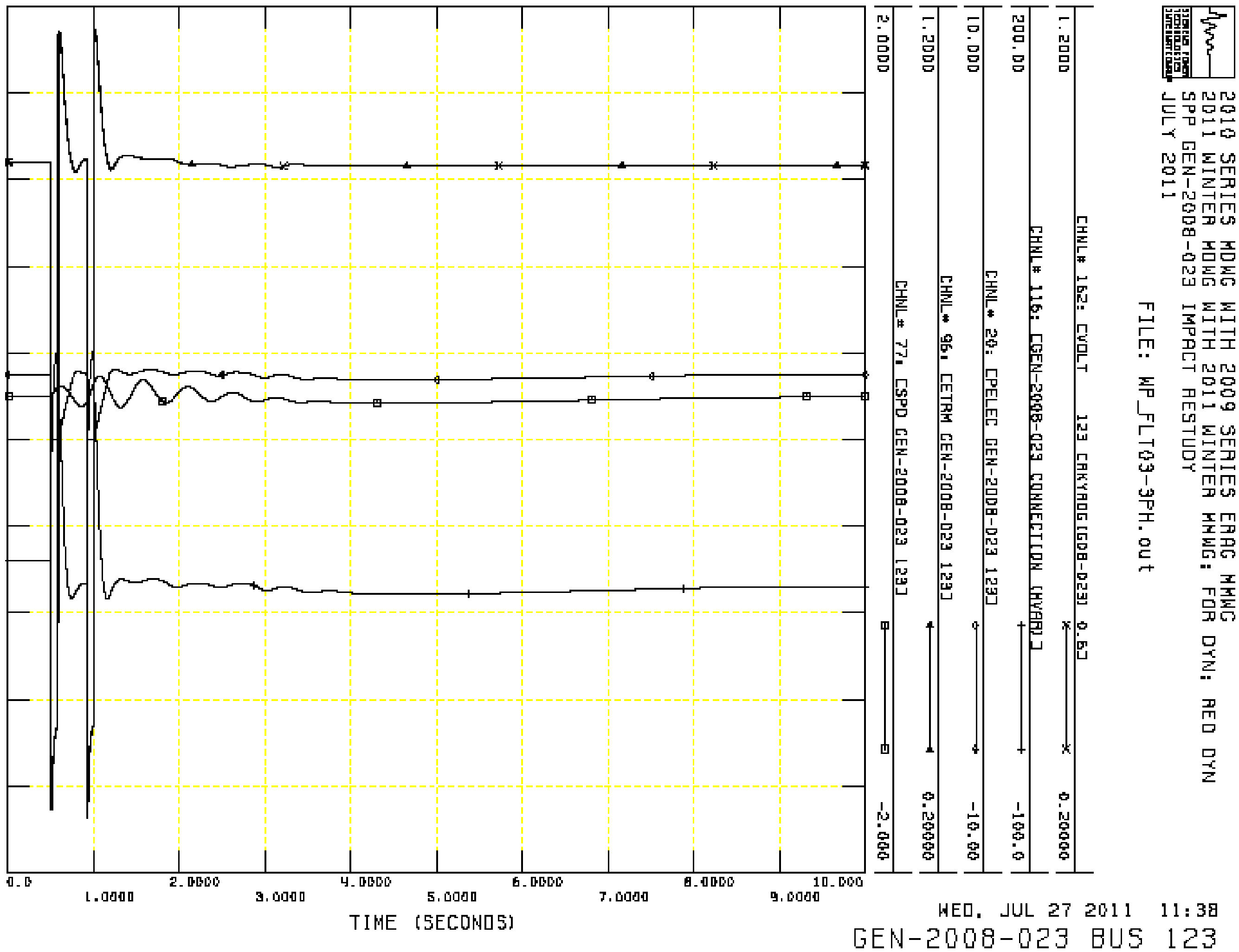

Figure 4-1. Response of GEN-2008-023 project during case FLT03-3PH for winter peak conditions.

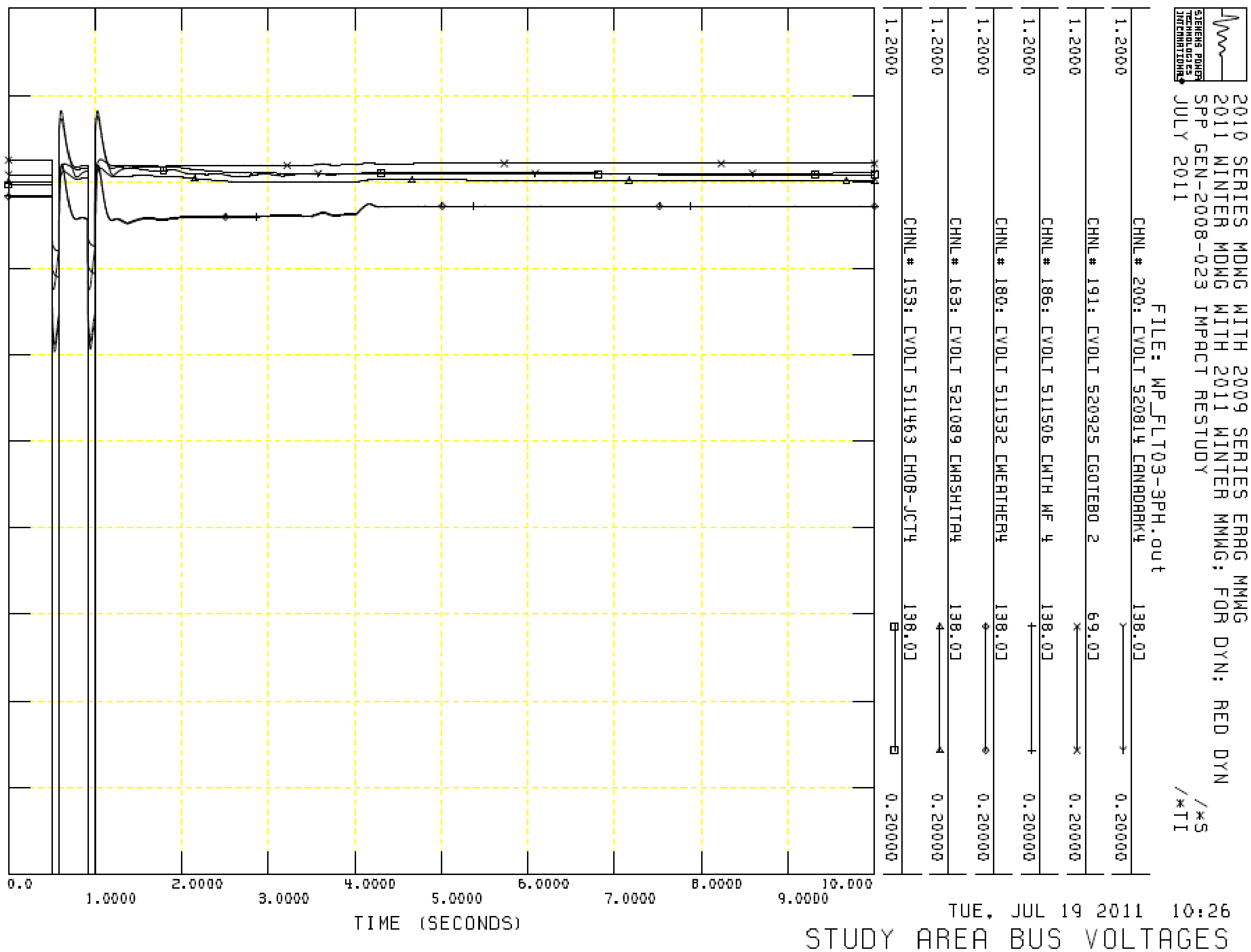

Figure 4-2. Response of selected area bus voltages for case FLT03-3PH for winter peak conditions.

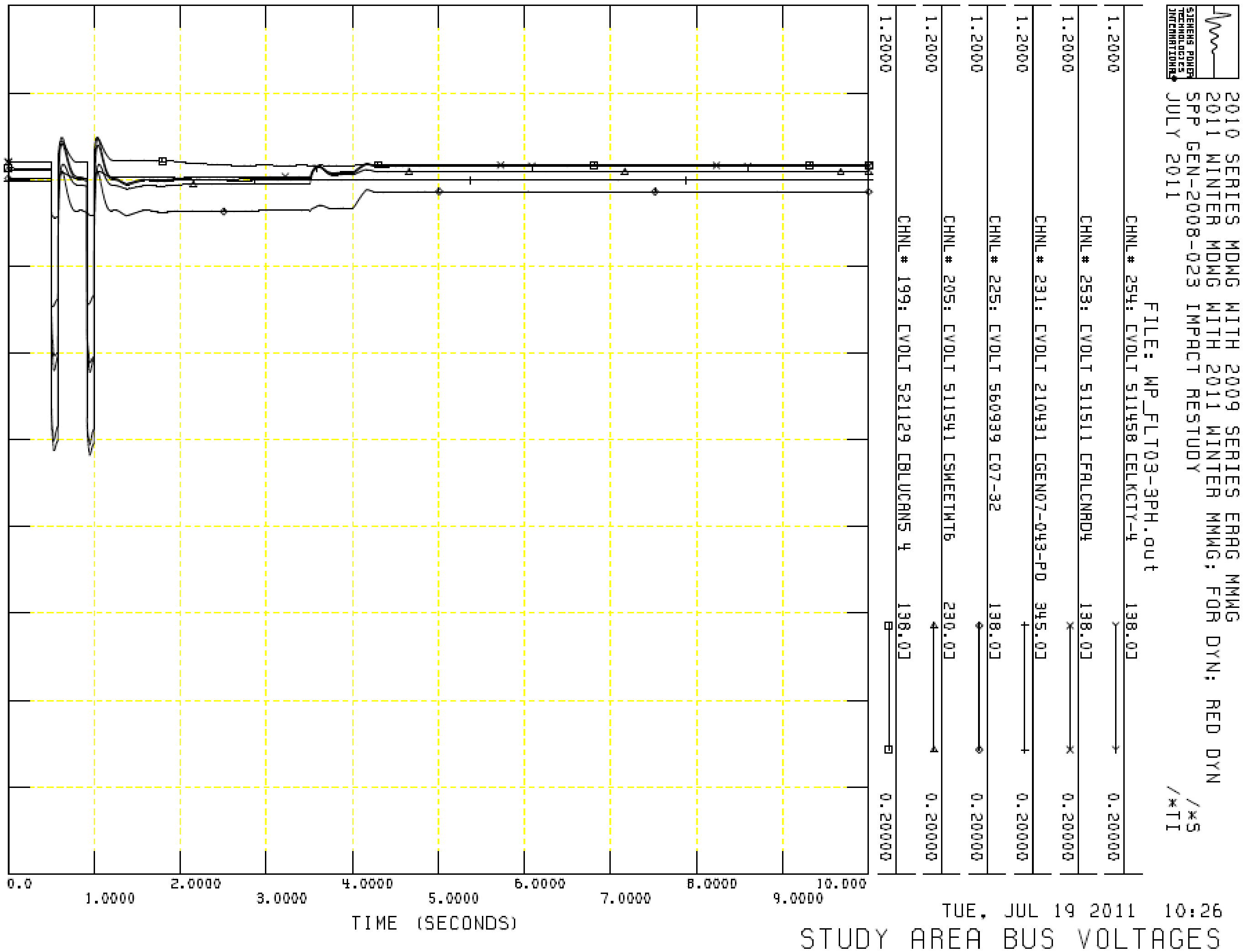

Figure 4-3. Response of selected area bus voltages for case FLT03-3PH for winter peak conditions.

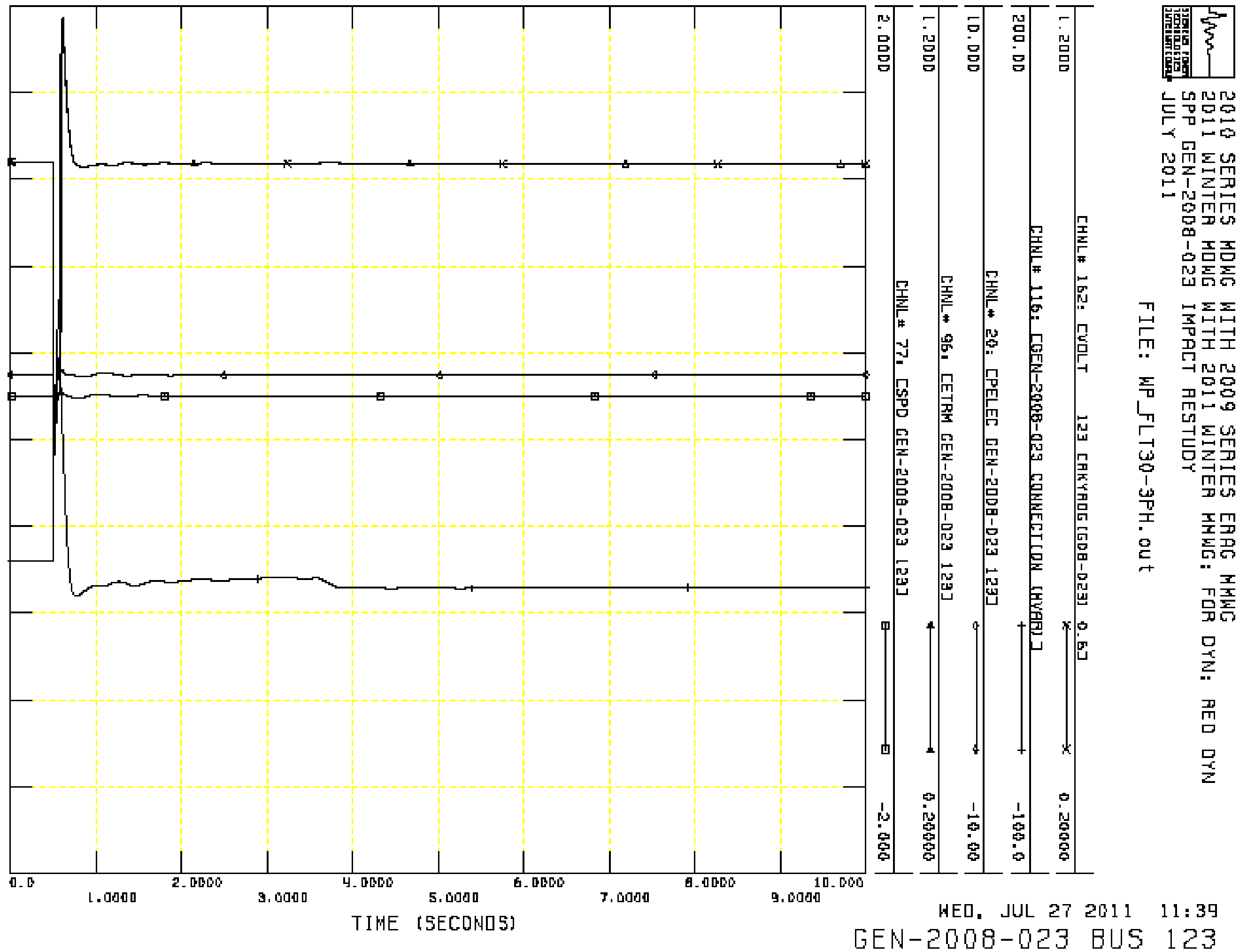

Figure 4-4. Response of GEN-2008-023 project during case FLT30-3PH for winter peak conditions.

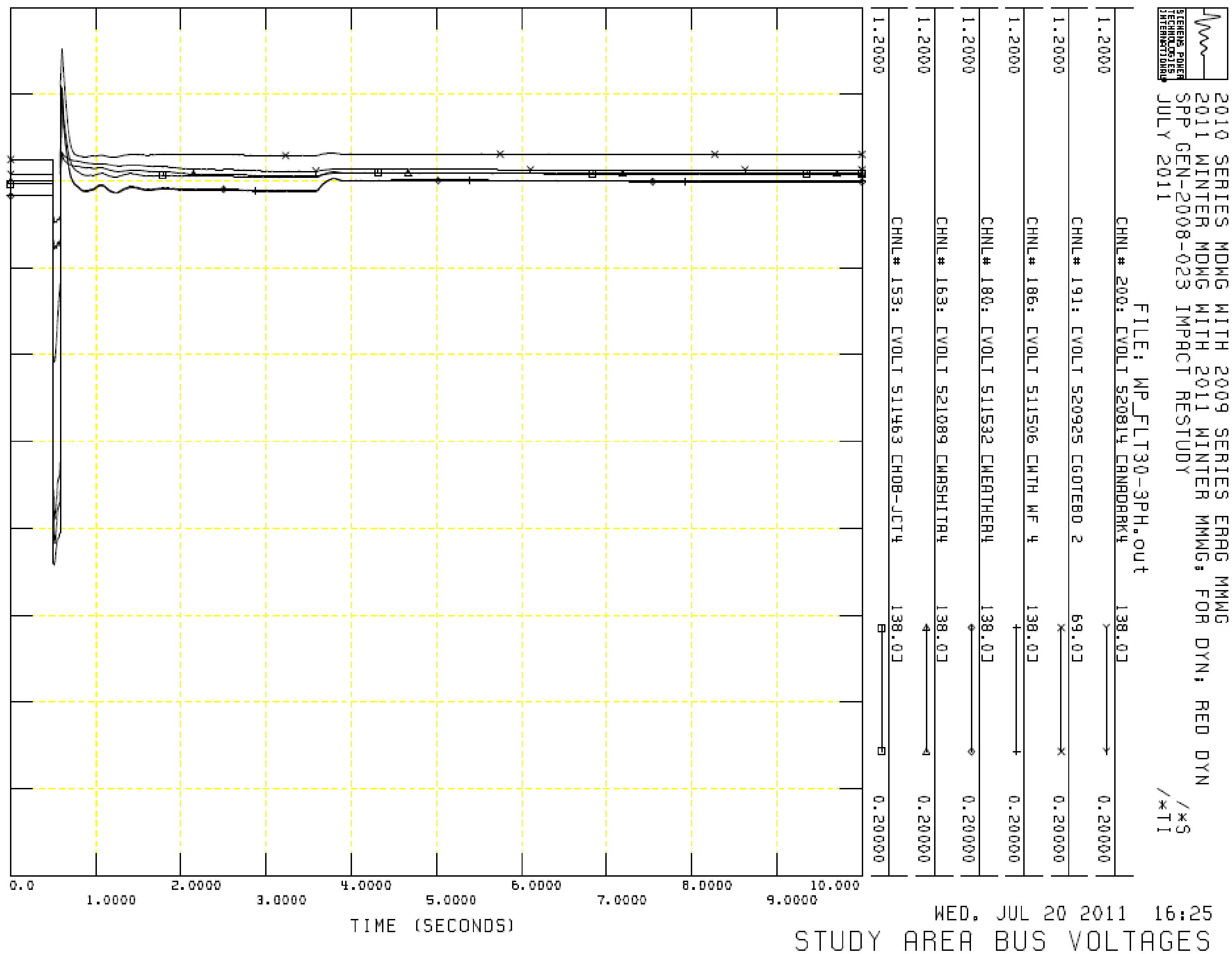

Figure 4-5. Response of selected area bus voltages for case FLT30-3PH for winter peak conditions.

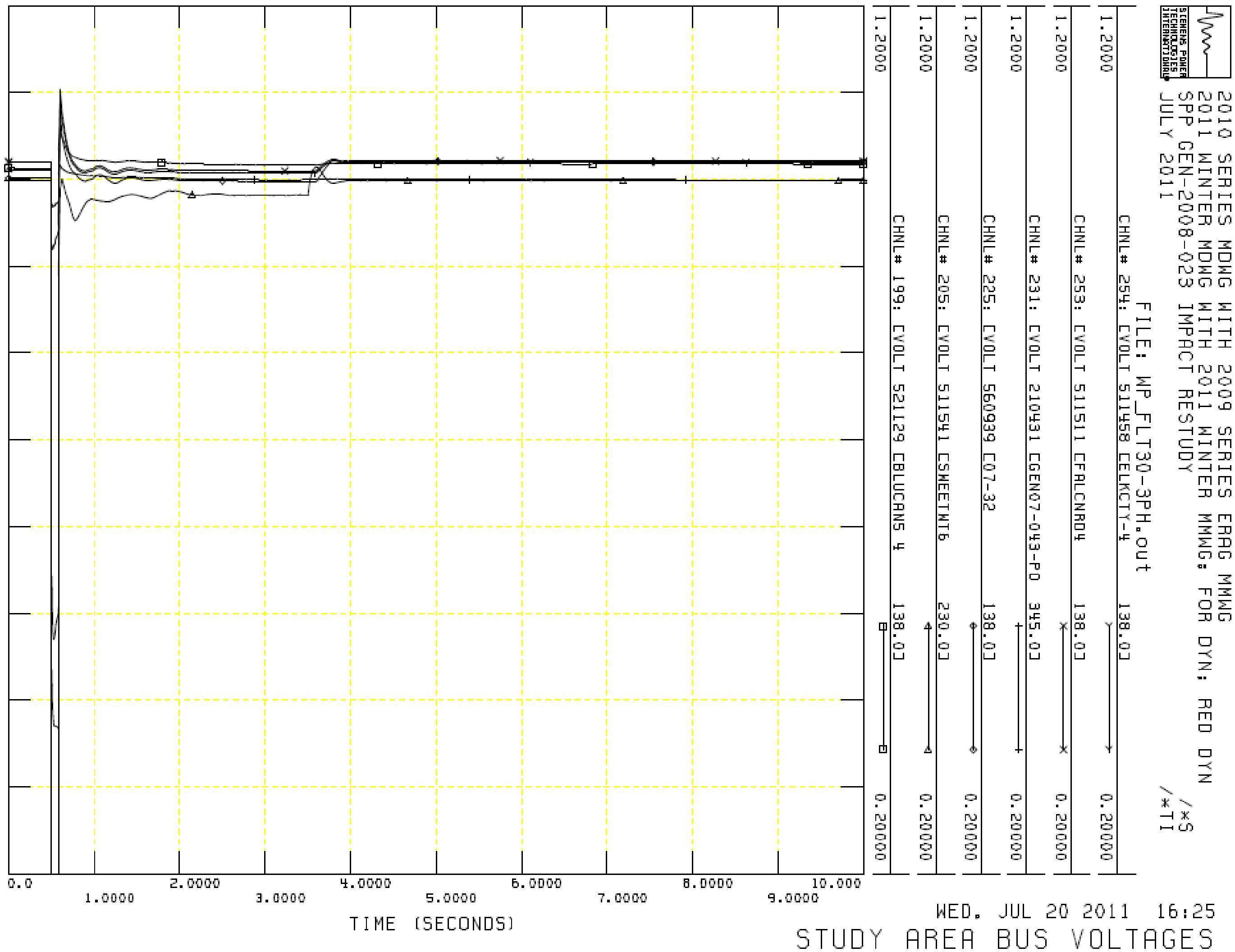

Figure 4-6. Response of selected area bus voltages for case FLT30-3PH for winter peak conditions.

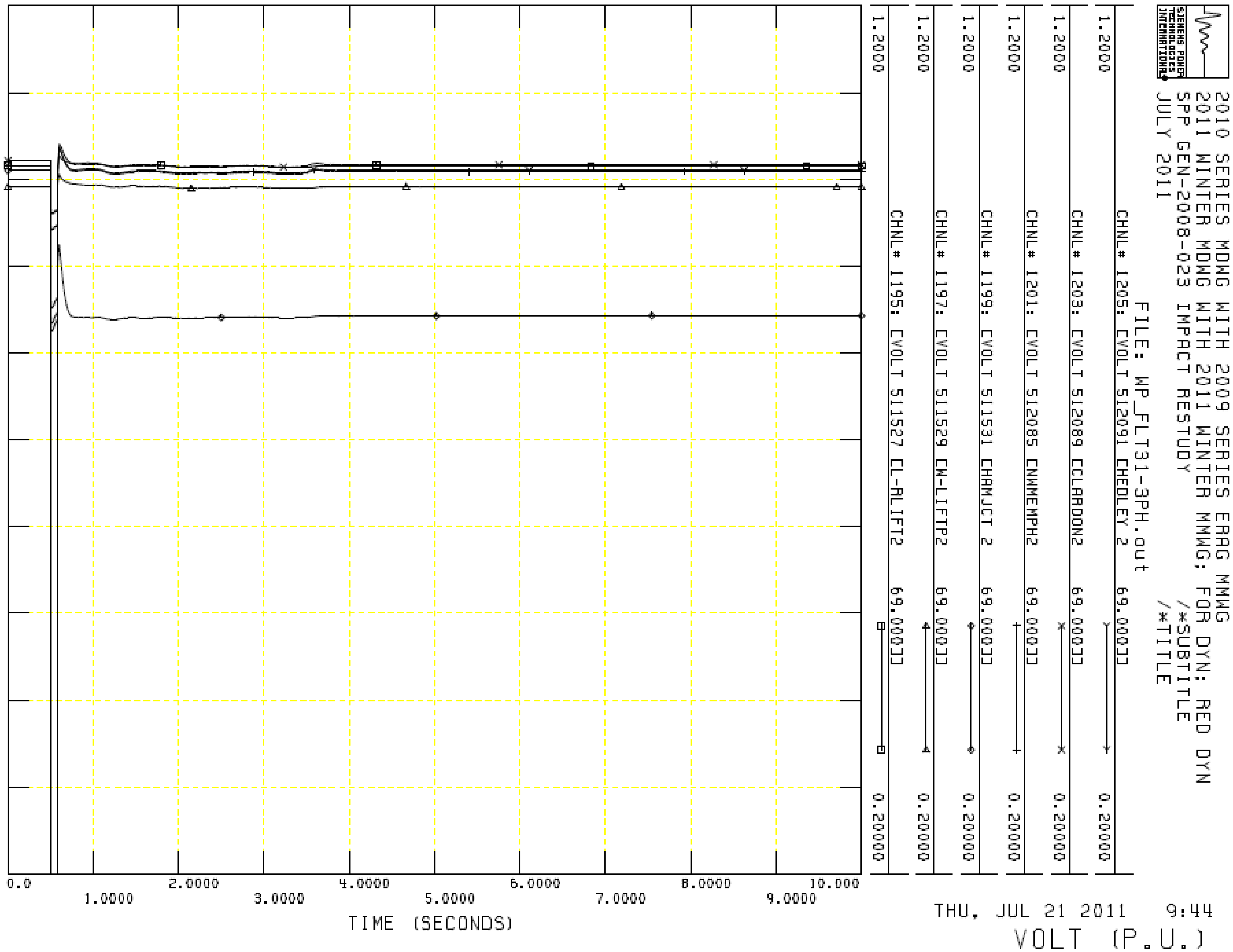

Figure 4-7. Response of selected area voltages during case FLT31-3PH for winter peak conditions.

Summary

The Stability Analysis determined that no wind generator tripping or system instability occurs by interconnecting GEN-2008-023 at 100% output. A three-phase fault on the Southwest to Washita 138 kV line (FLT21-3PH) resulted in the voltage at GEN-2008-037 recovering slightly above 0.95 p.u. with oscillations. This is a previously known condition that SPP has studied and is not caused by the addition of GEN-2008-023. Refer to Appendix B and Appendix C for the stability plots of the study area and nearby system's bus voltage and generator's angle and speed response during the disturbance for the summer peak and winter peak conditions, respectively.

SECTION 5: CONCLUSIONS

Power Factor Analysis

The Power Factor Analysis shows that GEN-2008-023 has a power factor requirement of 0.9650 leading (absorbing) to 1.0 unity at the point of interconnection.

Stability Analysis

The Stability Analysis determined that no wind turbine tripping or system instability occurs from interconnecting GEN-2008-023 at 100% output. A three-phase fault on the Southwest to Washita 138 kV line (FLT21-3PH) resulted in the voltage at GEN-2008-037 recovering slightly above 0.95 p.u. with oscillations. This is a previously known condition that SPP has studied and is not caused by the addition of GEN-2008-023.