Southwest Power Pool

Impact Study For Generation Interconnection Request GEN-2005-010

SPP Tariff Studies

(#GEN-2005-010)

January 2006

Executive Summary

<OMITTED TEXT> (Customer) has requested an Impact Study under the Southwest Power Pool Open Access Transmission Tariff (OATT) for interconnection of up to a 160 MW wind powered generation facility in Bailey County, Texas to the transmission system of Southwestern Public Service Company (SPS/Xcel Energy). The total wind farm output was lowered to 160MW from the 232.5MW studied in the Feasibility Study dated October, 2005. The wind powered generation facility was studied with eighty (80) individual Gamesa G87 2.0 MW wind turbines. The requested in-service date for the 160MW facility is December 31, 2006. This Impact study addresses the dynamic stability effects of interconnecting the plant to the rest of the SPS/Xcel transmission system as well as readdressing the need for reactive compensation required by the wind farm because of the use of the Gamesa turbines.

The generation facility will interconnect to the southern most Tolk-Roosevelt 230kV line via a new 230-34.5kV substation. The 34.5kV substation will have feeder connections to the wind turbine collection circuits.

Three seasonal base cases were used in the study to analyze the stability impacts of the proposed generation facility. The cases studied were the 2006 winter peak, 2007 fall case, and the 2009 summer peak case. There were several variations of the 2009 summer leading case used. Each case was modified to include prior queued projects that are discussed in the body of the report. The Gamesa G87 wind turbines were modeled using information provided by the manufacturer. Twenty contingencies were simulated.

Due to the reactive power consumption of the Gamesa turbines and losses on the collector system, a minimum of two (2) 6MVAR capacitor banks are necessary for reactive compensation for the wind farm and for exporting power from the interconnection point. There should be one bank installed on the 34.5kV bus of each substation transformer in the Customer’s interconnection substation. The Interconnection Agreement shall require these capacitor banks.

Stability Study results show that the transmission system remains stable for all simulated contingencies studied.

Further Stability study results show that the wind farm will meet the ‘Transitional’ provisions of FERC Order #661A’s Low Voltage Ride Through (LVRT) provisions.

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.

1.0 Introduction

<OMITTED TEXT> (Customer) has requested an Impact Study under the Southwest Power Pool Open Access Transmission Tariff (OATT) for interconnecting up to a 160 MW wind powered generation facility in Bailey County, Texas to the transmission system of Southwestern Public Service Company (SPS/Xcel Energy). The 160 MW output was reduced from the 232.5 MW that was analyzed in the Feasibility Study. The wind powered generation facility studied was comprised of forty (40) individual 2.0MW Gamesa G87 wind turbines. The requested in-service date for the 160 MW facility is December 31, 2006. The wind powered generation facility will interconnect to the existing southern Roosevelt-Tolk 230kV line. This optional study will only address the stability and reactive compensation issues associated with the Gamesa turbines.

2.0 Purpose

The purpose of the Interconnection System Impact Study is to evaluate the impact of the proposed interconnection on the reliability of the Transmission System. The Impact Study considers the Base Case as well as all Generating Facilities (and with respect to (iii) below, any identified Network Upgrades associated with such higher queued interconnection) that, on the date the Interconnection System Impact Study is commenced: (i) are directly interconnected to the Transmission System; (ii) are interconnected to Affected Systems and may have an impact on the Interconnection Request; (iii) have a pending higher queued Interconnection Request to interconnect to the Transmission System; and (iv) have no Queue Position but have executed an LGIA or requested that an unexecuted LGIA be filed with FERC.

There are several previously queued projects ahead of this request in the SPP Generation Interconnection queue. It was assumed for purposes of this study that not all of those projects would be in-service if this project is built. Any changes to this assumption, i.e. one or more of the previously queued projects not included in the study signing an interconnection agreement, may require a re-study of this request at the expense of the customer. Other wind farms which have higher queue priority than this request, were modeled in this case.

Nothing in this System Impact Study constitutes a request for transmission service or confers upon the Interconnection Customer any right to receive transmission service.

3.0 Facilities

3.1 Generating Facility

The generating facility was studied with the assumption that it would be using the Gamesa G87 2.0 MW wind turbines. The nameplate rating of each turbine is 2000kW with a machine base of 2030kVA. The turbine output voltage is 690V. The Gamesa turbines utilize a doubly fed induction-generator. The generator synchronous speed is 1800 rpm, and a variable frequency power converter tied to the generator rotor allows the generator to operate at speeds ranging from 1020 rpm to 2340 rpm. Nominal speed at 2.0MW power output is 2015 rpm. The power converter allows the generator to produce power at a power factor of 0.95 lagging (producing vars) to 0.9 leading (absorbing vars). The power factor is settable at each WTG or by the Plant SCADA system.

3.2 Interconnection Facility

The Customer has proposed an interconnection facility, which would connect to the SPS/Xcel Energy transmission system via a new substation located in Bailey County, Texas on the existing southern most Roosevelt – Tolk 230kV circuit. The new substation would be configured to accept a terminal from an adjacent 230/34.5kV transformation substation containing two transformers that serves the wind powered generation facility.

Analysis of the reactive compensation requirements of the wind farm determined the need for two (2) 34.5kV, 6 MVAR capacitor banks to be located on the secondary side of each substation transformer. These are necessary for reactive compensation for the wind farm (turbine and collector system losses) and for exporting power from the interconnection point. Stability analysis reveals that the reactive compensation does not need to be dynamic (SVC). This need is further discussed in sections 4.6 and 4.7.

The total cost for adding a new 230kV switching station, the required interconnection facility is estimated at $2,502,000. This cost does not include building the 230kV line from the Customer substation to the new substation on the Roosevelt-Tolk 230 kV line. The one-line diagram from the Feasibility Study is shown in Figure 1.

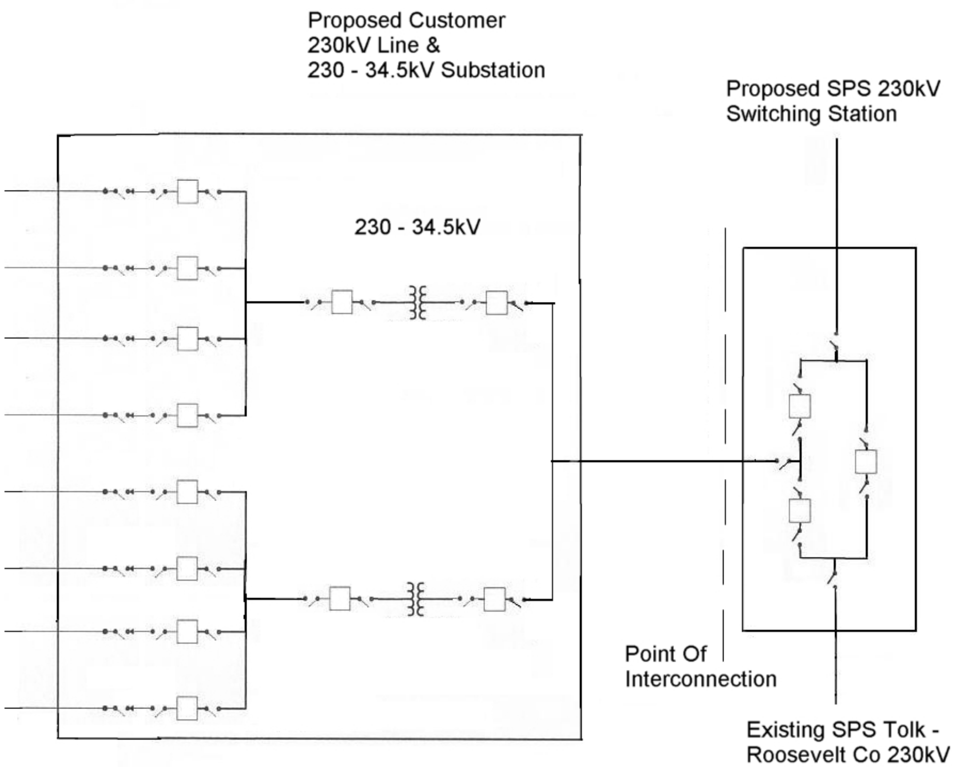


Figure 1: Proposed Interconnection
(Final substation design to be determined)

4.0 Stability Analysis

4.1 Objective

The objective of the stability study is to determine the impact on system stability of connecting the proposed GEN-2005-010 wind farm to SPP's 230 kV transmission system.

4.2 Equivalent Modeling of the Wind Generating Facility

The rated output of the generation facility is 160MW, comprised of (40) Gamesa G87 wind turbines. The base voltage of the Gamesa turbine is 690 V, and a generator step up transformer (GSU) of 2500kVA connects each unit to the high side of 34.5kV. The rated power output of each turbine is 2.0 MW while the actual power output depends on the wind.

In performing a system impact study, the wind farm generation from the study customer and previously queued customers is dispatched into the SPP footprint.

The generating facility 230/34.5 substation will consist of (2) 230/34.5kV transformer with an impedence assumed to be 9.375% on a 52 MVA OA Base with a top rating of 86MVA. From the one-lines received from the customer, on the 34.5kV side of each transformer, 3 feeder circuits each will extend from the Customer's 230/34.5kV substation. The feeders will consist of 14, 13, 13, 14, 13, and 13 wind turbines respectively on each circuit.

4.3 Modeling of the Wind Turbines in the Power Flow

In order to simplify the model of the wind farm while capturing the effect of the different impedances of cables (due to change of the conductor size and length), the wind turbines connected to the same 34.5kV feeder end points were aggregated into one equivalent unit. An equivalent impedance of that feeder is represented in the load flow database by taking the equivalent series impedances of the different feeders connecting the wind turbines. Using this approach, the wind farm was modeled with equivalent units as shown in Figure 2. The number of individual wind turbines that are aggregated at each bus is shown.

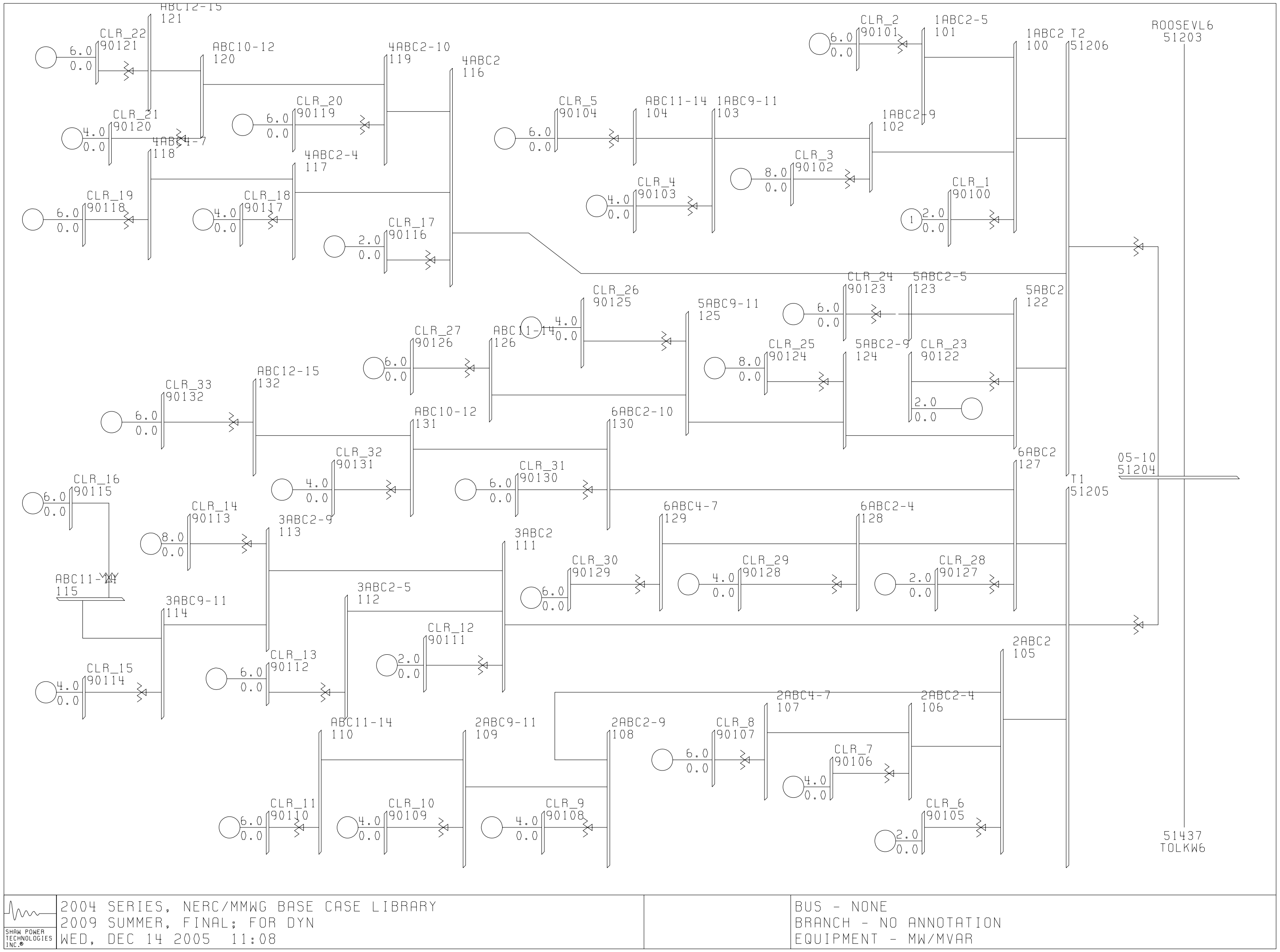


Figure 2. _One-Line Drawing of the GEN-2005-010 Facility

4.4 Modeling of the Wind Turbines for the Stability Simulation

4.4.1 Machine Dynamics Data

The Gamesa G87 generators have a nameplate rating of 2.0 MW with a machine base of 2030kVA. The turbine output voltage is 690V. The Gamesa turbines utilize a doubly fed induction-generator. The generator synchronous speed is 1800 rpm, and a variable frequency power converter tied to the generator rotor allows the generator to operate at speeds ranging from 1020 rpm to 2340 rpm. Nominal speed at 2.0MW power output is 2015 rpm. The power converter allows the generator to produce power at a power factor of 0.95 lagging (producing vars) to 0.9 leading (absorbing vars). The power factor is settable at each WTG or by the Plant SCADA system.

The wind turbine manufacturer provided a wind turbine model package for use on PTI's PSS/E simulation software. This package was used exclusively in modeling this wind farm. The model package used is version 5.3 received from the Customer on October 27, 2005.

The Gamesa model package consists of an IPLAN that creates modeling data in the PSSE loadflow as well as creating a dynamic record that can be read into the program. Also included are several object code files that were linked into the dynamic libraries already being used for the network.

The wind farm was dispatched directly by the user to the level specified (100% rated power). For most of the simulations in this study, it was assumed the turbines would operate at 1.0 unity power factor. However, in determining whether additional reactive compensation was necessary for the wind farm, varying power factors were also studied for the summer case. This is explained further in sections 4.6 and 4.7. Default protection schemes were used for the turbines.

4.4.2 Turbine Protection Schemes

The Gamesa turbines have an under-voltage/over-voltage protection scheme and an under-frequency/over-frequency protection scheme. The various protection schemes are designed to protect the wind turbines in the case of system disturbances that can cause damage to the mechanical systems or power electronics on board the turbine. Generally, the protection schemes will disconnect the generator from the electric grid if the sampled frequency or voltage is outside of a specified band for a specified amount of time.

FERC Order #661A places specific requirements on wind farms through its Low Voltage Ride Through (LVRT) provisions. For Interconnection Agreements signed before December 31, 2006, wind farms shall stay on line for faults at the point of interconnection (POI) that draw the voltage down to 0.15 pu at the POI (Customer's 230kV bus). For Agreements signed after December 31, 2006, wind farms shall stay on line for faults at the POI that draws the voltage down at the POI to 0.0 pu.

The voltage protection scheme provided by Gamesa is outlined in Table 1.

Voltage	Time Limit
1.1pu +	3.6 cycles (0.06s)
0.90pu-1.1pu	Continuous Operation
0.75pu – 0.90pu	2.55 seconds
0.60pu – 0.75pu	2.05 seconds
0.45pu – 0.60pu	1.575 seconds
0.30pu – 0.45 pu	1.1 seconds
0.15pu - 0.30pu	0.625 seconds
< 0.15pu	2.4 cycles (0.04s)

Table 1: Gamesa Turbine Voltage Protection

The frequency protection scheme provided by Gamesa is outlined in Table 2 below:

Frequency	Time Limit
57-62 HZ	Continuous Operation
Below 57Hz	3 cycles (0.05 s)
Above 62 Hz	3 cycles (0.05 s)

Table 2: Gamesa Turbine Frequency Protection

4.5 Contingencies Simulated

Twenty (20) contingencies were considered for the transient stability simulations which included three phase faults, as well as single phase line faults, at the locations defined by SPP. Single-phase line faults were simulated by applying a fault impedance to the positive sequence network at the fault location to represent the effect of the negative and zero sequence networks on the positive sequence network. The fault impedance was computed to give a positive sequence voltage at the specified fault location of approximately 60% of pre-fault voltage. This method is in agreement with SPP current practice.

The faults that were defined and simulated are as follows:

1. **FLT_1_1PH –** Single phase line to ground fault on the Tolk – Eddy 345kV line at the midpoint of the line.
    a. Apply fault at the middle of the Tolk-Eddy 345kV line
    b. Clear fault after 5 cycles by removing the line (including the 230/345kV autos at both ends) from service.
    a. Wait 20 cycles, and then re-close the line into the fault.
    b. Leave fault on for 5 cycles, then trip and lock out the line.

2. **FLT_1_3PH –** Three phase line to ground fault same as FLT_1_1PH

3. **FLT_2_1PH –** Single phase line to ground fault on the Tolk – Roosevelt 230kV line (northern line) at the midpoint of the line
    a. Apply fault at the middle of the Tolk-Roosevelt 230kV line
    c. Clear fault after 5 cycles by removing the line from service.
    d. Wait 20 cycles, and then re-close the line into the fault.
    e. Leave fault on for 5 cycles, then trip and lock out the line.

4. **FLT_2_3PH –** Three phase line to ground fault same FLT_2_1PH

5. **FLT_3_1PH –** Single phase line to ground fault on the Oasis - GEN-2001-036 230kV line near Oasis
    a. Apply fault at the Oasis 230kV bus
    b. Clear fault after 5 cycles by removing the line from service
    c. Wait 20 cycles, then reclose the line into the fault
    d. Leave fault on for 5 cycles, then trip and lock out the line

6. **FLT_3_3PH –** Three phase line to ground fault same as FLT_3_1PH

7. **FLT_4_1PH –** Single phase line to ground fault on the Tolk - Plant X 230kV near Tolk
    a. Apply fault at the Tolk 230kV bus
    b. Clear fault after 5 cycles by removing the line from service.
    c. Wait 20 cycles, and then re-close the line into the fault.
    d. Leave fault on for 5 cycles, then trip and lock out the line

8. **FLT_4_3PH –** Three phase line to ground fault same as FLT_4_1PH

9. **FLT_5_1PH** – Single phase line to ground fault on the Tolk – Tuco 345kV near Tuco
    a. Apply fault at the Tuco 345kV bus
    b. Clear fault after 3 cycles by tripping the line
    c. Wait 20 cycles then reclose the line into the fault
    d. Leave fault on for 3 cycles, then trip the line out

10. **FLT_5_3PH –** Three phase line to ground same as FLT_5_1PH

11. **FLT_6_1PH**- SLG Fault on the Oasis-Norris 115kV line near Oasis
    a. Apply fault at Oasis 230kV bus
    b. Clear fault after 5 cycles by removing the line from service
    c. Wait 20 cycles and reclose the line back into the fault
    d. After 5 cycles, disconnect the line and lock out

12. **FLT_6_3PH –** Three phase line to ground same as FLT_6_1PH

13. **FLT_7_1_PH –** SLG Fault on the Tuco-Oklaunion 345kV line near Tuco
    a. Apply fault at Tuco 345kV bus
    b. Clear fault after 5 cycles by removing the line from service
    c. Wait 20 cycles and reclose the line back into the fault
    d. After 5 cycles, disconnect the line and lock out

14. **FLT_7_3PH –** Three phase line to ground same as FLT_6_1PH

15. **FLT_8_1_PH –** SLG Fault on the Cunningham-Eddy County 230kV line near Cunningham
    a. Apply fault at Cunningham 230kV bus
    b. Clear fault after 5 cycles by removing the line from service
    c. Wait 20 cycles and reclose the line back into the fault
    d. After 5 cycles, disconnect the line and lock out

16. **FLT_8_3PH –** Three phase line to ground same as FLT_8_1PH

17. **FLT_9_3PH -** Three phase line to ground fault at the Point of Interconnection
    a. Apply fault at the Point of Interconnection (Sand Hills 230kV bus)
    b. Clear fault after 5 cycles by removing the Sand Hills-Tolk 230kV line from service
    c. Wait 20 cycles and reclose back into the fault
    d. After 5 cycles, disconnect and lock out

18. **FLT_10_3PH –** Three phase line to ground fault at the Point of Interconnection
    a. Apply fault at the Point of Interconnection (Sand Hills 230kV bus)
    b. Clear fault after 5 cycles by removing the Sand Hills-Roosevelt 230kV line from service
    c. Wait 20 cycles and reclose back into the fault
    d. After 5 cycles, disconnect and lock out

19. **FLT_11_3PH –** 9 cycle fault at the Point of Interconnection that produces 0.15 pu voltage at the POI (for FERC Order #661A compliance)
    a. Apply fault at the Point of Interconnection (Sand Hills 230kV bus)
    b. Clear fault after 9 cycles

20. **FLT_12_3PH –** 9 cycle fault at the Point of Interconnection that produces 0.0 pu voltage at the POI (for FERC Order #661A compliance)
    a. Apply fault at the Point of Interconnection (Sand Hills 230kV bus)
    b. Clear fault after 9 cycles

4.6 Further Model Preparation

The contingencies were simulated for the following scenarios

- 2009 Summer Peak Loading (Turbines running at 100% except where noted)
    - Case #1 (All contingencies)
        - Turbines running at 1.0 PF
        - No capacitor banks
        - All turbine protection schemes in operation

- Case #2 (All contingencies)
    - Turbines running at 1.0 PF
    - No capacitor banks
    - Frequency tripping disabled on turbines

- Case #3 (All contingencies)
    - Turbines running at 98.5 lagging (producing vars)
    - 6 MVAR capacitor banks on each transformer
    - Frequency tripping disabled

- Case #4 (Contingencies #4,#6, and #8)
    - Turbines running at 0.95 leading
    - Wind farm running at 0.96 leading (added 18MVAR capacitor bank on each transformer)
    - Frequency tripping disabled

- Case #5 (Contingencies #4, #6, #8)
    - Turbines running so that entire wind farm operates at 0.95 lagging
    - No capacitor banks
    - Frequency tripping disabled

- Case #6 (All contingencies)
    - Turbines running at 20% production
    - Turbines operating at 98% lagging
    - No capacitor banks
    - Frequency tripping disabled

- 2006 Winter Peak Loading (All contingencies)
    - Turbines running at 100% production

- 2007 Fall Loading (All contingencies)
    - Turbines running at 100% production

Early runs indicated the wind farm would trip for contingency FLT_4_3_PH for frequency excursion. The runs were made again in order to determine if they system remained stable without frequency tripping.

The contingencies were run under a variety of power factor conditions in order to more fully study the reactive compensation requirements of the facility.

The previously queued projects which were added to the stability base case are summarized in Table 4.

Study Plant	Total MW
GEN-2001-033	80
GEN-2001-036	180

Table 4 – Summary of Prior Queued Projects

4.7 Results

Early runs were made for all three seasons including the 2009 summer peak Case #1. In the lower load cases (winter and fall), the previously queued projects that were modeled (GEN-2001-033 and GEN-2001-036) tripped off for several contingencies. However, the results were a stable transmission system for all contingencies so the GEN-2005-010 project does not cause a problem for system reliability.

In Contingency FLT_4_3PH the wind farm tripped off-line due to frequency excursion. The 2009 summer peak runs were made again without frequency tripping; the results were the wind farm stayed on-line for all contingencies as well as a stable transmission system. These results are shown in 2009 summer peak Case #2. All winter and fall simulations were made with the frequency tripping disabled.

When the wind farm is modeled with the wind turbines operating at the default 1.0 pf, the wind farm collector circuit and substation transformer losses result in the need for a 12 MVAR capacitor bank on each substation transformer. The Gamesa turbines are capable of producing vars at up to a 0.95 lagging power factor. However, with all turbines running at 0.95 lagging, high voltages are observed at the turbine busses on the order of 1.10 pu. Further analysis revealed that with the turbines operating at 0.985 leading power factor, an acceptable turbine voltage was observed at around 1.05-1.06 pu. Running the turbines at this power factor requires the installation of a 34.5kV, 6MVAR capacitor bank on each substation transformer for a total of two banks in the substation in order for the wind farm to operate at unity during the summer peak. Stability analysis was performed on this configuration and is shown in the 2009 summer peak Case #3 results.

Additional limited sensitivities in regard to power factor were also performed. Limited runs were made with the wind farm operating at 0.96 leading power factor and 0.95 lagging power factor in the 2009 summer peak. It was found the system would remain stable for this extreme of power factors at the plant.

An additional run was made with the turbines running at 20% production. This reduced output from the turbines was chosen to closer simulate actual conditions during the summer peak. Results did not change from the 100% production runs.

<u>FERC Order #661A Compliance</u> – Four simulations were made explicitly for determining compliance with FERC Order #661A. This request will fall under the ‘Transitional’ clause of the Order’s Low Voltage Ride Through (LVRT) provisions if

an Interconnection Agreement is signed before December 31, 2006. The 'Transitional' clause states that the turbines should stay on line for a 9 cycle fault that produces 0.15 pu voltage at the point of interconnection.

Fault FLT_12_3PH simulates conditions specified in the 'Transitional' clause of Order #661A. The Gamesa turbines are able to stay on line for this fault.

If an Interconnection Agreement is not signed by December 31, 2006, this request will fall under the regular LVRT provisions. These provision require the wind farm to stay on line for a 9 cycle fault that produces 0.0 pu voltage at the point of interconnection. Fault FLT_13_3PH simulates this condition. For this fault, half of the wind farm stayed on line, but the other half tripped off due to undervoltage. Therefore, the wind farm would not comply with the regular provisions of the order.

<u>Results Table -</u>Results for all the disturbances simulated are summarized in Table 5. The results indicate that for all of the simulated contingencies, the transmission system remains stable and oscillations are well damped.

FAULT	FAULT DEFINITION	2009SP Case 1	2009SP Case 2	2009SP Case 3	2009SP Case 4	2009SP Case 5	2009 SP Case 6	2006 WP	2007 FA
FLT_1_1PH	Single phase line to ground fault on the Tolk-Eddy 345kV line at the midpoint of the line	STABLE	STABLE	n/a	n/a	n/a	STABLE	STABLE -PQ2-	STABLE -PQ2-
FLT_1_3PH	Three phase fault the same as FLT_1_1PH	STABLE	STABLE	STABLE	n/a	n/a	STABLE	STABLE -PQ2-	STABLE -PQ2-
FLT_2_1PH	Single phase line to ground fault on the Tolk-Roosevelt northern 230kV line at the midpoint of the line	STABLE	STABLE	STABLE	n/a	n/a	STABLE	STABLE	STABLE
FLT_2_3PH	Three phase fault the same as FLT_2_1PH	STABLE -PQ1-	STABLE -PQ1-	STABLE -PQ1-	STABLE	STABLE	STABLE -PQ1-	STABLE -PQ2-	STABLE -PQ2-
FLT_3_1PH	Single phase line to ground fault on the Oasis-GEN-2001-036 230kV line near Oasis	STABLE	STABLE	STABLE	n/a	n/a	STABLE	STABLE -PQ2-	STABLE -PQ2-
FLT_3_3PH	Three phase fault the same as FLT_3_1PH	STABLE -PQ1- -PQ2-	STABLE -PQ1- -PQ2-	STABLE -PQ1- -PQ2-	STABLE -PQ1- -PQ2-	STABLE -PQ1- -PQ2-	STABLE -PQ1- -PQ2-	STABLE -PQ1- -PQ2-	STABLE -PQ1- -PQ2-
FLT_4_1PH	Single phase line to ground fault on the Tolk-Plant X 230kV near Tolk	STABLE	STABLE	STABLE	n/a	n/a	STABLE	STABLE -PQ2-	STABLE -PQ2-
FLT_4_3PH	Three phase fault the same as FLT_4_1PH	STABLE -OF- -PQ1- -PQ2-	STABLE -PQ1- -PQ2-	STABLE -PQ1- -PQ2-	STABLE -OV- -PQ1- -PQ2-	STABLE -PQ1- -PQ2-	STABLE -OF- -PQ1- -PQ2-	STABLE -PQ1- -PQ2-	STABLE -PQ1- -PQ2-
FLT_5_1PH	Single phase line to ground fault on the Tolk-Tuco 345kV line near Tuco	STABLE	STABLE	STABLE	n/a	n/a	STABLE	STABLE	STABLE
FLT_5_3PH	Three phase fault the same as FLT_5_1PH	STABLE	STABLE	STABLE	n/a	n/a	STABLE	STABLE -PQ2-	STABLE -PQ2-
FLT_6_1PH	Single phase line to ground fault on the Oasis – Norris 115kV line near Norris	STABLE	STABLE	STABLE	n/a	n/a	STABLE	STABLE	STABLE

FLT_6_3PH	Three phase fault the same as FLT_6_1PH	STABLE -PQ1-	STABLE -PQ1-	STABLE -PQ1-	n/a	n/a	STABLE -PQ1-	STABLE -PQ1- -PQ2-	STABLE -PQ1- -PQ2-
FLT_7_1PH	Single phase line to ground fault on the Tuco-Oklaunion 345kV line near tuco	STABLE	STABLE	STABLE	n/a	n/a	STABLE	STABLE	STABLE
FLT_7_3PH	Three phase fault the same as FLT_7_1PH	STABLE	STABLE	STABLE	n/a	n/a	STABLE	STABLE	STABLE
FLT_8_1PH	Single phase line to ground fault on the Cunningham-Eddy County 230kV line near Cunningham	STABLE	STABLE	STABLE	n/a	n/a	STABLE	STABLE	STABLE
FLT_8_3PH	Three phase fault the same as FLT_8_1PH	STABLE	STABLE	STABLE	n/a	n/a	STABLE	STABLE	STABLE
FLT_9_3PH	Three phase fault near the POI on the Tolk 230kV line	n/a	STABLE	n/a	n/a	n/a	n/a	n/a	n/a
FLT_10_3PH	Three phase fault near the POI on the Roosevelt 230kV line	n/a	STABLE						
FLT_11_3PH	9 cycle fault at the POI that produce 0.15 pu voltage	n/a	STABLE	n/a	n/a	n/a	n/a	n/a	n/a
FLT_12_3PH	9 cycle fault at the POI that produces 0.0 pu voltage	n/a	-UV-	n/a	n/a	n/a	n/a	n/a	n/a

Table Key
UV – Undervoltage trip of GEN-2005-010
OF – Over Frequency trip of GEN-2005-010
PQ1 – Trip of Previous Queued project #1 (GEN-2001-033)
PQ2 – Trip of Previous Queued project #2 (GEN-2001-036)

Table 5. SUMMARY OF FAULT SIMULATION RESULTS

5.0 Conclusion

No stability concerns presently exist for the GEN-2005-010 wind farm as proposed and studied using eighty (80) Gamesa G87 2.0 MW wind turbines. The wind farm and the transmission system remain stable for all contingencies studied

The Network Upgrade cost of interconnecting the Customer project approximately $2,502,000. This figure does not address the cost of the Customer substation, the 6 MVAR capacitor banks to be installed in the Customer substation, or the transmission line between the Customer substation and the SPS/Excel switching substation located on the Tolk – Roosevelt 230kV line.

The Customer will be responsible for installing two 34.5kV, 6 MVAR capacitor banks in its substation on the 34.5kV bus of each substation transformer to bring the power factor at the point of interconnection to unity.

The wind farm meets the 'Transitional' provisions of FERC Order #661A LVRT, but would not meet the full provisions of the order.

The costs do not include any costs associated with the deliverability of the energy to final customers. These costs are determined by separate studies if the Customer requests transmission service through Southwest Power Pool's OASIS. It should be noted that the models used for simulation do not contain all SPP transmission service.

APPENDIX A.

SELECTED STABILITY PLOTS

All Plots available upon request

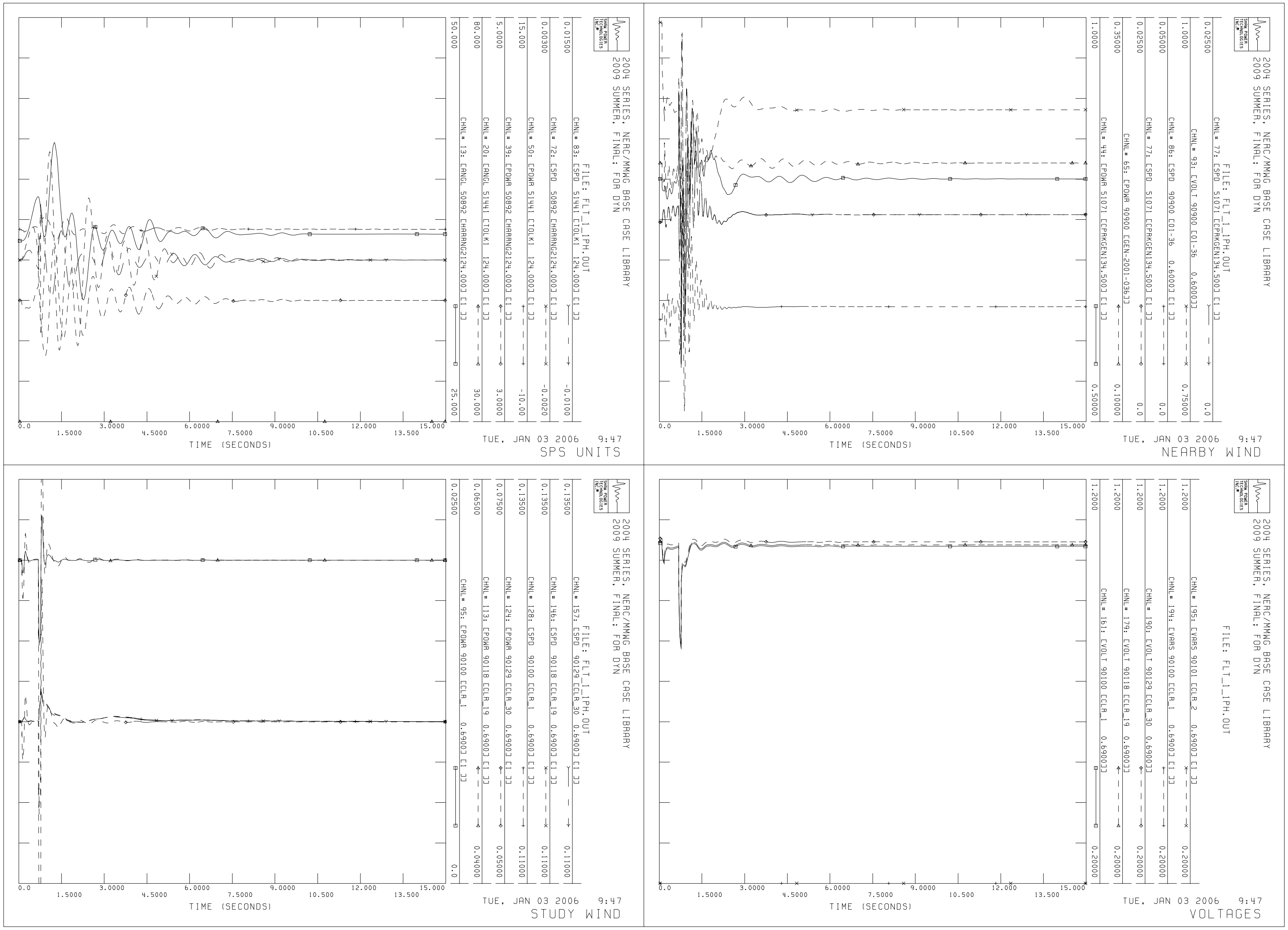
Page A2 – 2009 SP - Contingency FLT_1_1_PH

Page A3 – 2009 SP - Contingency FLT_4_3_PH

Page A4 – 2006 WP - Contingency FLT_3_3_PH

Page A5 – 2006 WP - Contingency FLT_4_3_PH

Page A6 – 2007 FA - Contingency FLT_6_3_PH


2004 SERIES, NERC/MMWG BASE CASE LIBRARY
2009 SUMMER, FINAL; FOR DYN
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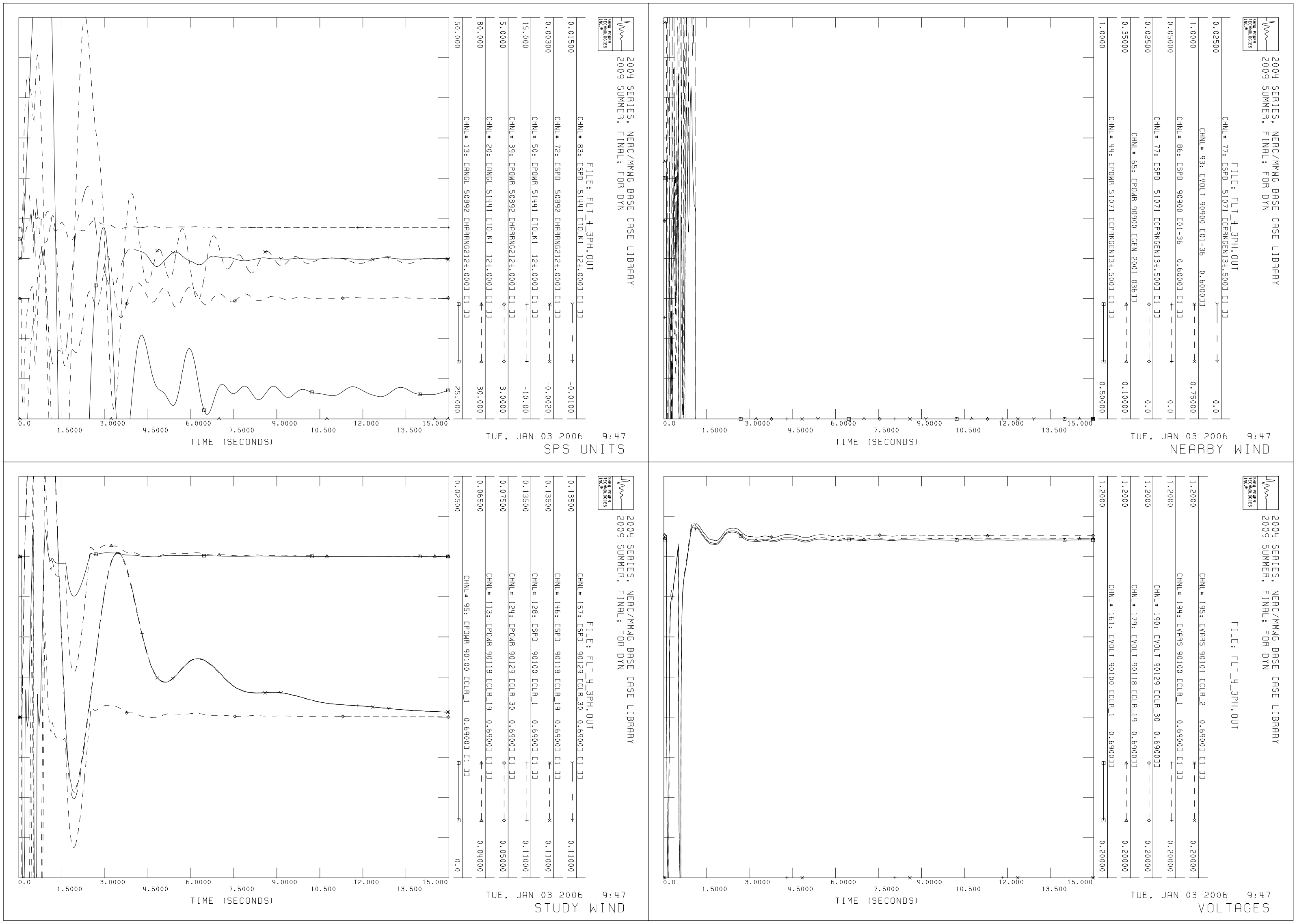
TIME (SECONDS)
TUE, JAN 03 2006 9:47
SPS UNITS
NEARBY WIND
STUDY WIND
VOLTAGES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2009 SUMMER, FINAL; FOR DYN
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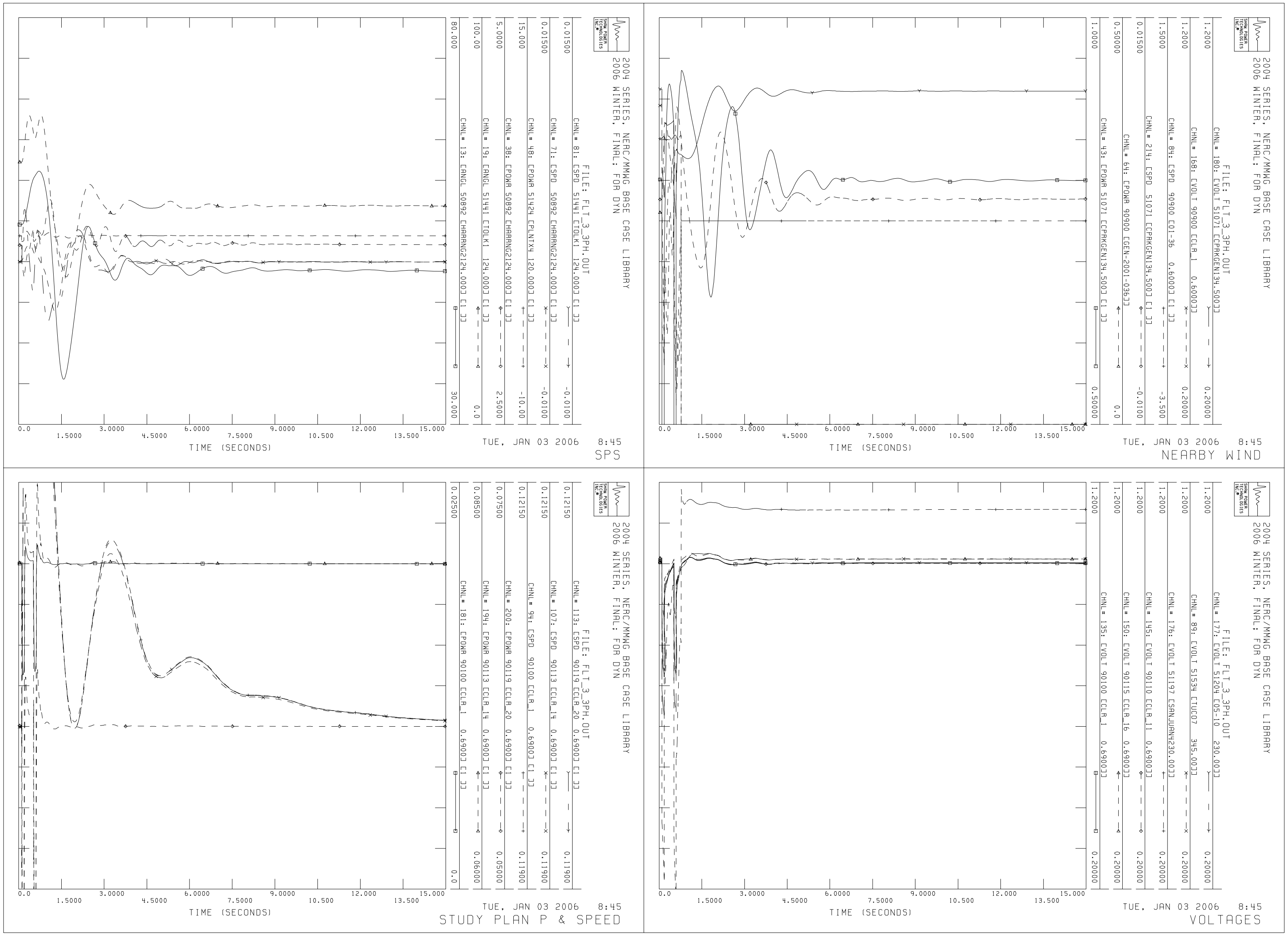
TIME (SECONDS)
TUE, JAN 03 2006 9:47
SPS UNITS
NEARBY WIND
STUDY WIND
VOLTAGES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NEARBY WIND
STUDY PLAN P & SPEED
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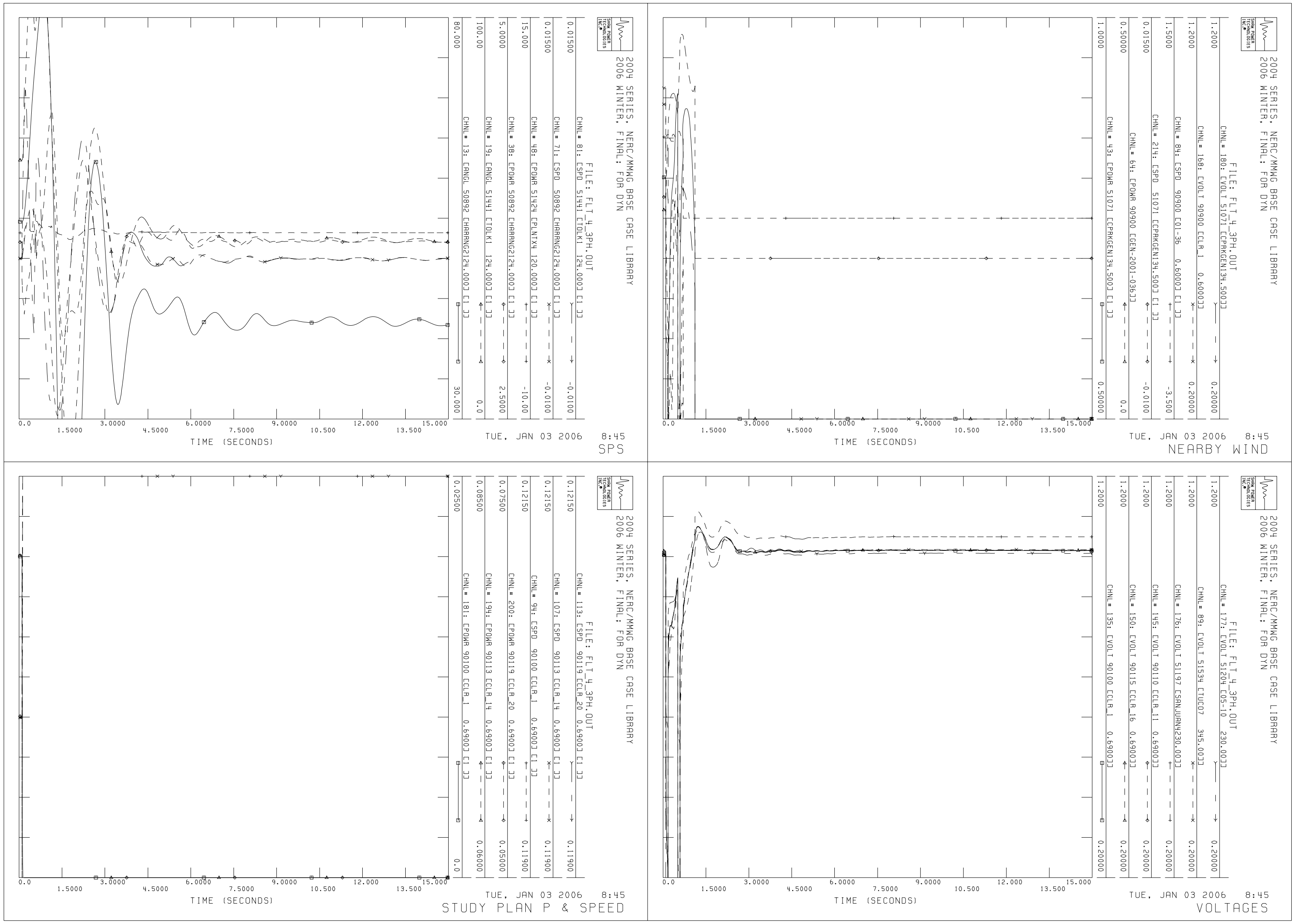
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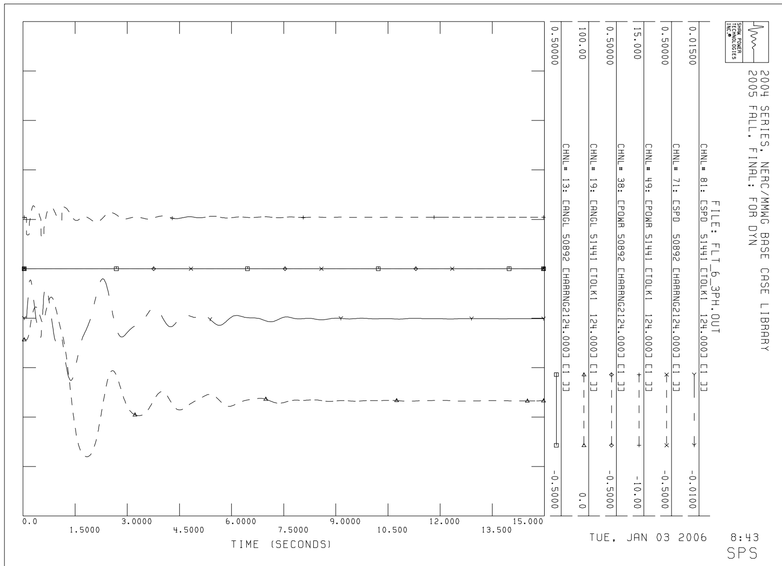
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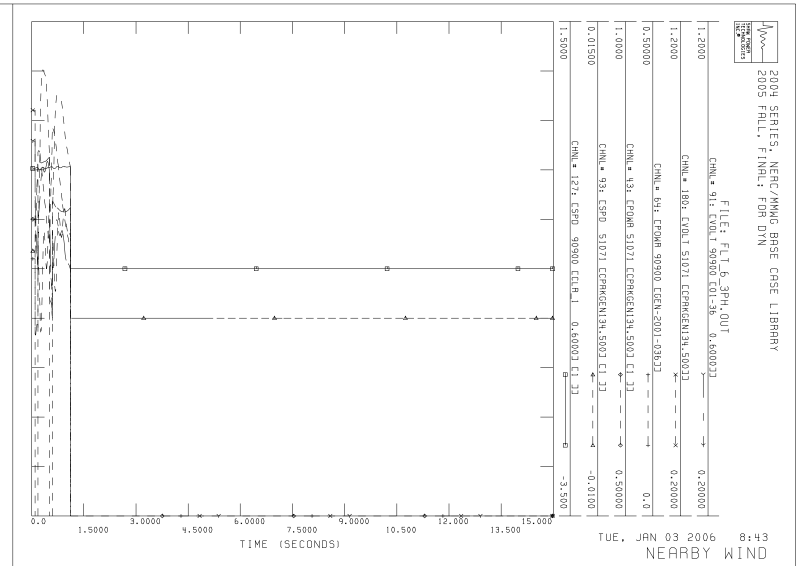
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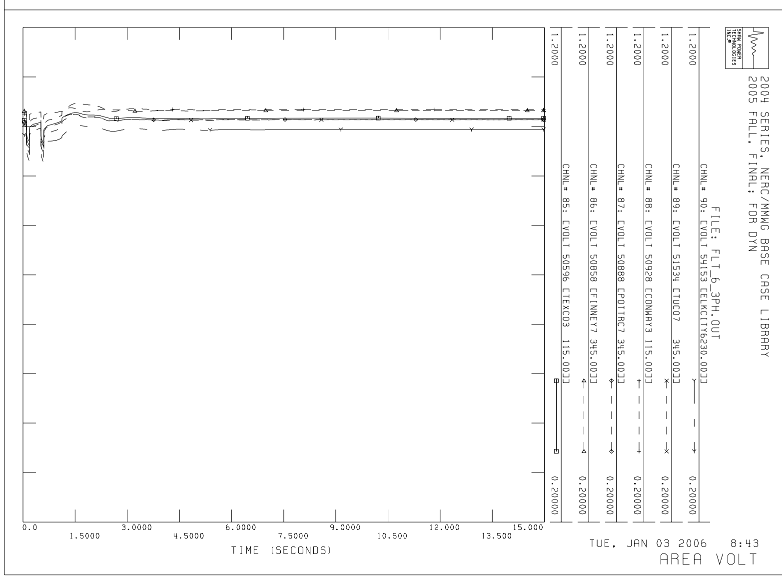
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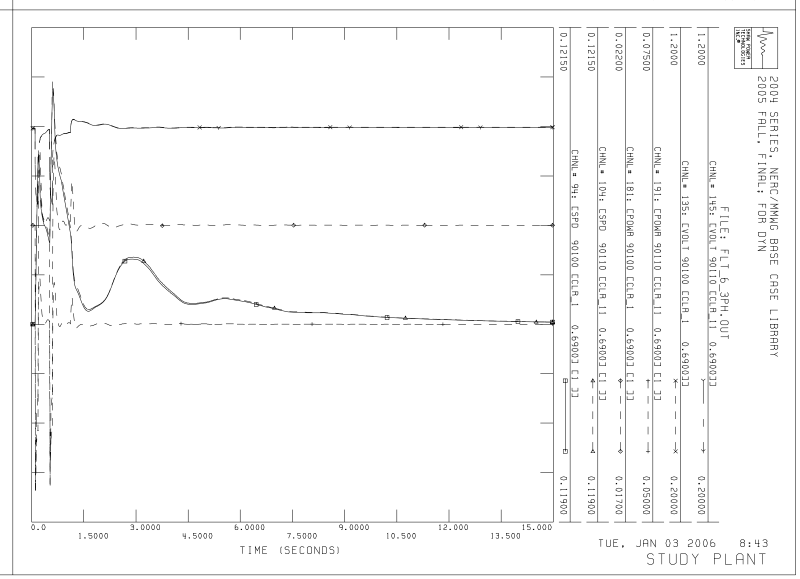
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