Southwest Power Pool

Impact Study For Generation Interconnection Request GEN-2001-014

SPP Tariff Studies

(#GEN-2001-014)

October 2006

Executive Summary

<OMITTED TEXT> (Customer) has requested an Impact Study under the Southwest Power Pool Open Access Transmission Tariff (OATT) for interconnection of a 94.5 MW wind powered generation facility in Harper County, Oklahoma to the transmission system of Western Farmers Electric Cooperative (WFEC). The wind powered generation facility was studied with forty-five (45) individual Suzlon S88 2.1MW wind turbines. The requested in-service date for the 94.5MW facility is April 15, 2007. This Impact study addresses the dynamic stability effects of interconnecting the plant to the rest of the SPP transmission system as well as addressing the need for reactive compensation required by the wind farm because of the use of the Suzlon turbines.

The generation facility will interconnect into the Fort Supply 138kV substation owned by WFEC. The interconnection facilities required are estimated to cost $2,080,000. From Fort Supply substation, the Customer will build a 138kV connection to its 138/34.5kV collector substation. This 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 2007 summer peak case, the 2007 winter peak, and the 2011 summer peak. The Suzlon S88 2.1MW wind turbines were modeled using information provided by the manufacturer. Ten contingencies were simulated.

Stability Analysis of the request using the latest dynamic model from the manufacturer indicate that under certain conditions the Suzlon wind turbines may not operate in a stable manner causing problems for the transmission system. For the condition of the outage of the 138kV circuit from Fort Supply to Mooreland (via Iodine) it is imperative that the Customer capacitor banks be in service, despite the scenario that high normal system voltages prior to this outage may have caused the capacitor banks to have been automatically placed out of service. To accomplish this goal the Customer may have to adjust, among other things, the de-energized tap changer of the Customer 138/34.5kV substation transformer.

The Customer has proposed to install two (2) 34.5kV, 12 Mvar capacitor banks in their 138/34.5kV substation for reactive compensation of the wind farm. Analysis has shown that these capacitor banks are adequate for compensating for the reactive losses of the Customer substation transformer and the wind turbine collector circuits. The Customer shall insure that at least one of these banks shall be in service regardless of the time of year when the wind farm is operating at substantial output (>30-40% nameplate). Customer shall indicate to SPP and WFEC how this requirement will be accomplished.

If it is not possible to place the capacitor banks in service at all times, a dynamic reactive device such as a STATCOM may be required
Stability Analysis shows that at 94.5 MW, with the required capacitor banks in service, the transmission system will remain stable for all simulated contingencies studied.

Further Stability study results show that in with all previously mentioned conditions 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 a 94.5 MW wind powered generation facility in Harper County, Oklahoma to the transmission system of Western Farmers Electric Cooperative (WFEC). The wind powered generation facility studied was proposed to comprise of forty-five (45) individual 2.1MW Suzlon S88 wind turbines. This generation interconnection request was originally studied in 2001 with Enron wind turbines (now G.E.). The requested in-service date for the 94.5MW facility is April 15, 2007. The wind powered generation facility will interconnect into the existing WFEC Fort Supply 138kV substation. This impact study will only address the stability and reactive compensation issues associated with switching from G.E. turbines to Suzlon 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.

This particular request was first made in 2001. An interconnection agreement (IA) was executed in 2004 and the IA has since been placed into suspension. For this request, there are no previously queued projects in the immediate area ahead of this request in the SPP Generation Interconnection queue. It was assumed for purposes of this study that previously queued 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 Suzlon S88 2.1MW wind turbines. The nameplate rating of each turbine is 2100kW with a machine base of 2283kVA. The turbine output voltage is 600V. The turbine runs at 0.92 leading power factor (absorbing vars) without power factor correction. Each turbine contains (14) 68kVar capacitor banks in parallel to the generator for each turbine to operate approximately at unity power factor at the generator terminals.

3.2 Interconnection Facility

The Customer has proposed an interconnection facility, which would connect to the WFEC transmission system at the Fort Supply substation 138kV bus. A three breaker ring bus addition to the Fort Supply substation is necessary to accommodate the wind farm.

Transmission Service has been requested for this wind farm facility, and service has been granted for at least a portion of the output of this facility through the SPP Aggregate Study Transmission Service Request (TSR) process. Results from the TSR study indicated that the existing Fort Supply 138/69kV autotransformer would overload under certain contingency situations. To alleviate this condition, a second Fort Supply autotransformer is being installed under the Transmission Service Agreement. The second Fort Supply autotransformer is being included in the transmission network model for this study.

The information provided by the Customer indicated the Customer plans to install two (2) 34.5kV, 12 MVAR capacitor banks at the Customer substation for a total of 24MVAR. Analysis of the reactive compensation requirements of the wind farm has determined that the Customer proposed capacitor banks are adequate to handle the reactive power losses for the transformer and the wind turbine collector system of the wind farm. As will be explained later in the stability analysis section of this study, the substation should be configured such that that at least one of the capacitor banks should be in service at all times, regardless of the time of year, that the wind farm is operating. Customer shall indicate to SPP and WFEC how this requirement will be accomplished.

The total cost for adding the 138kV three breaker ring bus the Fort Supply substation, is $2,080,000. This cost does not include the Customer 138/34.5kV substation, the 34.5kV capacitor banks, or the 138kV connection from the wind farm to the WFEC substation. This cost also does not include the cost of installing the second Fort Supply 138/69kV autotransformer, which is included in the Transmission Service Agreement for this particular wind farm. The one-line diagram for this configuration is shown in Figure 1.

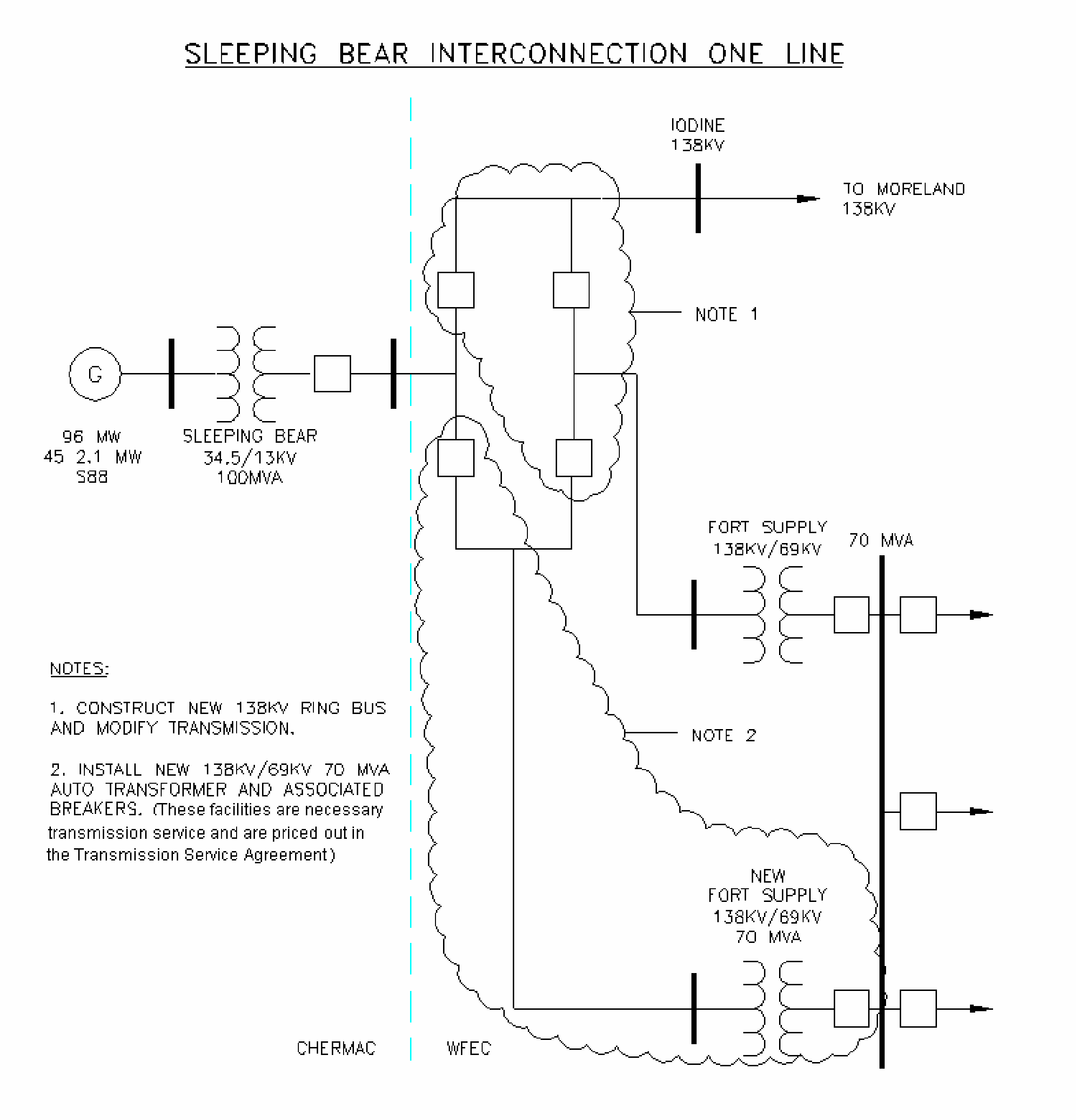


Figure 1: Proposed Interconnection Configuration
(Final substation design to be determined)

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-2001-014 wind farm to SPP's 138 kV transmission system using the proposed Suzlon wind turbines.

4.2 Equivalent Modeling of the Wind Generating Facility

The rated output of the generation facility is 94.5MW, comprised of forty-five (45) Suzlon S88 wind turbines. The base voltage of the Suzlon turbine is 600V, 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 2.1 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 138/34.5kV substation will consist of (1) 115/34.5kV transformer reported to have an impedence of 10% on a 60 MVA OA base with a top rating of 100MVA. From the one-lines received from the customer, on the 34.5kV side of the transformer, four feeder circuits will extend from the Customer's 138/34.5kV substation. The feeders will consist of 7, 11, 13, and 14 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.

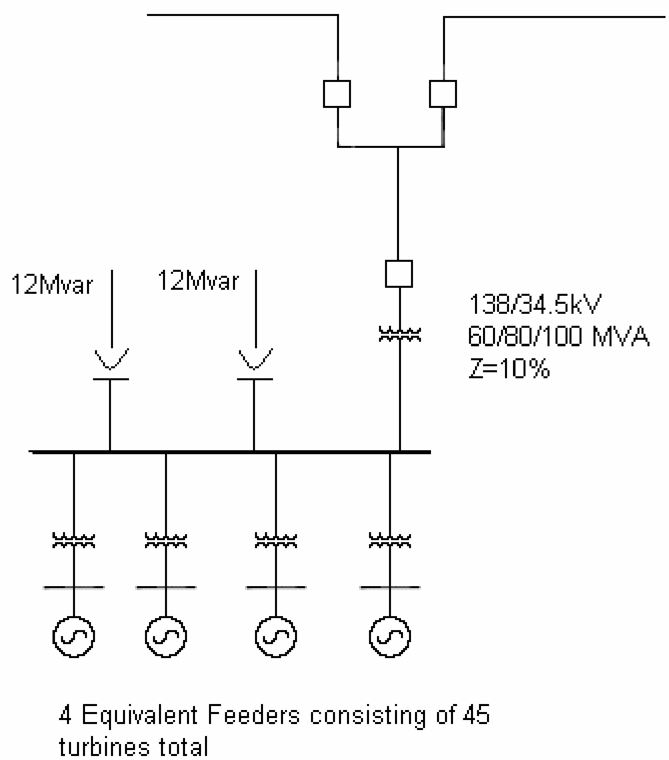


Figure 2. One-Line Drawing of the GEN-2001-014 Facility

4.4 Modeling of the Wind Turbines for the Stability Simulation

4.4.1 Machine Dynamics Data

The Suzlon S88 generators have a nameplate rating of 2100kW with a machine base of 2283kVA. The turbine output voltage is 600V. The turbines produce power at 0.92 leading power without power factor correction. Each turbine contains fourteen (14) 68kVar capacitor banks in parallel with the generator for an approximate unity power factor at the generator terminals.

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 2.01a received from the Customer in September, 2006.

The Suzlon model package consists of an Excel spreadsheet that creates a dynamic record that can be pasted into a PTI PSS/E dyre file. Also included is an object code file that was linked into the dynamic libraries already being used for the network.

The generator values provided by the Customer and manufacturer are listed below in Table 1.

Parameter	Value
BASE KV	0.600
WTG MBASE	2.283
TRANSFORMER MBASE	2.5
TRANSFORMER R ON TRANSFORMER BASE	0.001
TRANSFORMER X ON TRANSFORMER BASE	0.06
GTAP	1.0
PMAX	2.1
PMIN	0.0
RA	0.0053
LA	0.2116
R_ROT_MACH (ohms)	0.0036
INERTIA	0.50

Table 1. Suzlon 2.1 MW Wind Generator Data

The wind farm was dispatched directly by the user to the level specified (100% rated power). For this study, it was assumed the turbines would operate at 1.0 unity power factor.

For what was considered worst case situations, other dispatch levels were tested as well (50% and 20%).

4.4.2 Turbine Protection Schemes

The Suzlon 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.

The voltage protection scheme provided by Suzlon is outlined in Table 2.

Voltage	Time Limit
1.2pu +	4.8 cycles (0.08s)
1.15pu-1.2pu	60 seconds
0.90pu-1.15pu	Continuous Operation
0.80pu – 0.90pu	60 seconds
0.60pu – 0.80pu	2.8 seconds
0.40pu – 0.60pu	1.6 seconds
0.15pu – 0.40 pu	0.7 seconds
< 0.15pu	0.08 seconds

Table 2: Suzlon Turbine Voltage Protection

The frequency protection scheme provided by Suzlon is outlined in Table 3 below:

Frequency	Time Limit
57-63 HZ	Continuous Operation
Below 57Hz	12 cycles (0.2 s)
Above 63 Hz	12 cycles (0.2 s)

Table 3: Suzlon Turbine Frequency Protection

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 (Fort Supply 138kV 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.

4.5 Contingencies Simulated

Ten (10) 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 listed in Table 4.

Table 4. Contingencies Evaluated

Cont. No.	*Cont. Name*	*Description*
1	*FLT13PH*	3 phase fault on the Fort Supply (55920) to Iodine (55957) 138 kV line, near Fort Supply. a. Apply fault at the Fort Supply bus. b. Clear fault after 5 cycles by tripping the line from Fort Supply-Iodine. 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	FLT21PH	*Single phase fault and sequence like Cont. No. 1*
3	FLT33PH	3 phase fault on the Mooreland (55999) to Morewood Switch (56001) 138 kV line, near Moorewood Switch. a. Apply fault at the Moorewood Switch bus. b. Clear fault after 5 cycles by tripping the line from Mooreland-Moorewood. 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	FLT41PH	*Single phase fault and sequence like Cont. No. 3*
5	FLT53PH	3 phase fault on the Fort Supply autotransformer (55920-55919) on the 69kV bus a. Apply fault at the Fort Supply 69kV bus. b. Clear fault after 5 cycles by tripping the autotransformer.
6	FLT61PH	*Single phase fault and sequence like Cont. No. 5*
7	FLT73PH	3 phase fault on the Fort Supply (55919) to Woodward (56096) 69 kV line, near Fort Supply. a. Apply fault at the Fort Supply bus. b. Clear fault after 5 cycles by tripping the line from Fort Supply-Woodward. 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	FLT81PH	*Single phase fault and sequence like Cont. No.7*
9	FLT93PH	3 phase fault on the Woodward (54785) – Iodine (OG&E) (54796) 138kV line near Woodward. a. Apply fault at the Woodward bus. b. Clear fault after 5 cycles by tripping the line from Woodward-Iodine. 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	FLT101PH	*Single phase fault and sequence like Cont. No.7*

4.6 Model Preparation

The 2006 series of the Southwest Power Pool Stability models and dynamic databases were used for this study. The previously compiled object code from Suzlon was linked to the SPP base case code and the test case model was built. The contingencies from the previous section were simulated for the following seasons

- 2007 Summer Peak Loading
- 2007 Winter Peak Loading
- 2011 Summer Peak Loading

The previously queued projects which were added to the stability base case are summarized in Table 5.

Study Plant	Total MW
None	

Table 5. – Summary of Prior Queued Projects

4.7 <u>Results</u>

Results are summarized in Table 6.

For contingencies FLT33PH – FLT101PH, the wind farm operates in a stable manner and the transmission system remains stable.

Under certain conditions, for FLT13PH and FLT21PH, the wind turbines were not found to operate in a stable manner. When the 138kV circuit from Fort Supply to Mooreland (via Iodine) is opened and all wind farm output is forced into the WFEC 69kV transmission system, the turbines were found to oscillate under certain conditions.

The situation most susceptible to this condition was the low loading season, the 2007 winter season studied. It was observed in the model that under normal conditions the voltages in the Fort Supply could be quite high, over 1.02 pu. These high voltage conditions may cause the 12MVAR capacitor on the 69kV bus at Fort Supply to be automatically placed out of service by the capacitor bank relay scheme. These same high voltage conditions could also cause the Customer capacitor banks to be placed out of service as well. It was found that if both the Fort Supply capacitor bank and the Customer capacitor banks were not in service during the low load period, that unacceptable oscillations would occur for both FLT13PH and FLT21PH. Please see Figure 3. These oscillations seem to be the result of a lack of voltage recovery ability for the Suzlon turbines after the fault at the 138kV bus. After the fault, the voltage at the turbine buses recovers only to about 0.90pu.

The simulation was run again forcing the capacitor banks at the Customer substation to be in operation. It was found that the turbines would operate in a stable manner if the capacitor banks were in service. Please see Figure 4.

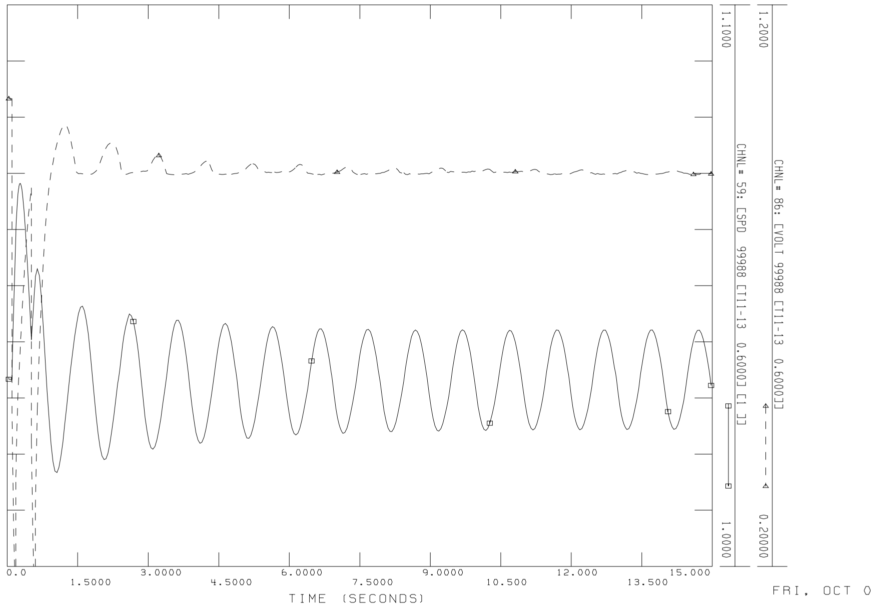


Figure 3. Speed & Voltage of Suzlon Turbines for FLT13PH (no capacitors)

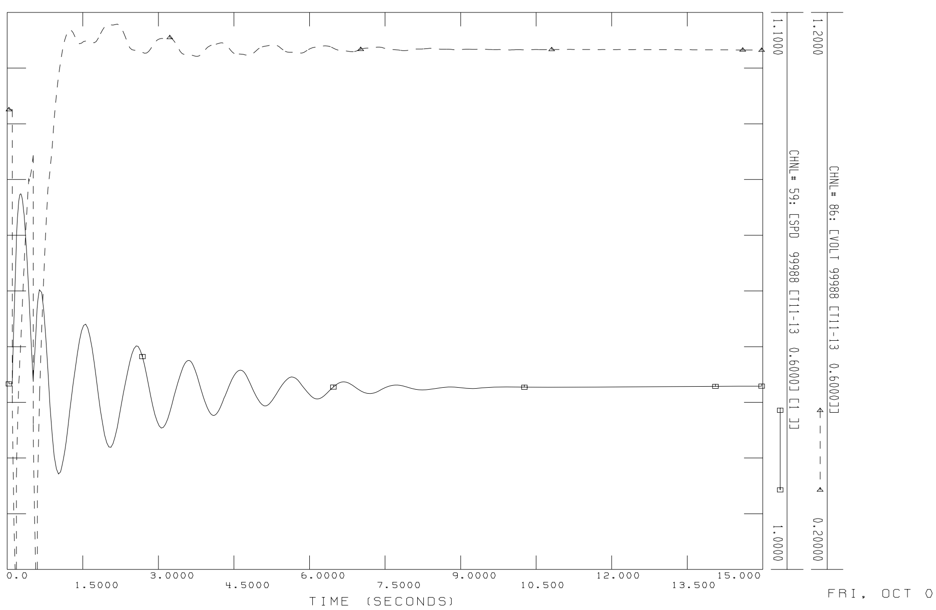


Figure 4. Speed & Voltage of Suzlon Turbines for FLT13PH (with capacitors)

However, issues were also encountered that if all capacitors happened to be in service in the winter, that voltages may be too high at the wind turbine buses and may cause the turbines to instantaneously trip for overvoltage. The turbines will trip instantaneously if turbine voltages exceed 1.20 pu. It was found, however, that by adjusting the de-energized tap changer of the 138/34.5kV substation that the capacitor banks could be left in service while maintaining acceptable voltages at the wind turbines.

If it is not possible to place the capacitor banks in service at all times, a dynamic reactive device such as a STATCOM may be required to maintain acceptable bus voltages at the wind farm and alleviate unacceptable oscillations.

FERC Order #661A Compliance – Contingency FLT13PH and FLT33PH were simulated also to determine compliance with FERC Order #661A. This request will fall under the 'Transitional' clause of the Order's Low Voltage Ride Through (LVRT) provisions as it is intended that a revised Interconnection Agreement will be executed before December 31, 2006. The 'Transitional' clause states that the turbines should stay on line for a 5-9 cycle fault that produces 0.15 pu voltage at the point of interconnection. For this study, the fault duration was treated the same as the other faults simulated (5 cycles).

By installing the Customer proposed capacitor banks, and configuring the substation to insure that capacitor banks will be in operation at all times, this wind farm will meet Order #661A low voltage ride through requirements.

TABLE 6. Stability Study Results

FAULT	FAULT DEFINITION	2007 SP	2007 WP	2011 SP
FLT13PH	Three phase fault on the Fort Supply – Iodine 138kV line near Fort Supply.	STABLE	STABLE	STABLE
FLT21PH	Single phase fault same as above	STABLE	STABLE	STABLE
FLT33PH	Three phase fault on the Mooreland – Moorewood Switch 138kV line near Moorewood Switch.	STABLE	STABLE	STABLE
FLT41PH	Single phase fault same as above	STABLE	STABLE	STABLE
FLT53PH	Three phase fault on the Fort Supply 138/69kV autotransformer	STABLE	STABLE	STABLE
FLT61PH	Single phase fault same as above	STABLE	STABLE	STABLE
FLT73PH	Three phase fault on the Fort Supply – Woodward 69kV line near Woodward.	STABLE	STABLE	STABLE
FLT81PH	Single phase fault same as above	STABLE	STABLE	STABLE
FLT93PH	Three phase fault on the Woodward – Iodine 138kV line near Woodward	STABLE	STABLE	STABLE
FLT101PH	Single phase fault same as above	STABLE	STABLE	STABLE

5.0 Conclusion

As long as the Customer capacitor banks are in service when the wind farm is operating, no stability concerns exist for the GEN-2001-014 wind farm at the 94.5MW output level. Under these conditions, the transmission system remains stable for all contingencies studied.

The Network Upgrade cost of interconnecting the Customer project is approximately $2,080,000. This figure does not address the cost of the Customer substation, the Customer transmission line, or the Customer 34.5kV capacitor banks. This cost also does not include the Fort Supply autotransformer addition that is being installed under the Transmission Service agreement for this wind farm.

In order for the wind farm to meet the LVRT provisions of FERC Order #661A, the Customer will be required to insure that the Customer capacitor banks do not trip off due to high system voltage under normal conditions. This may be accomplished by adjusting the de-energized tap changer of the 138/34.5 kV substation transformer.

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.

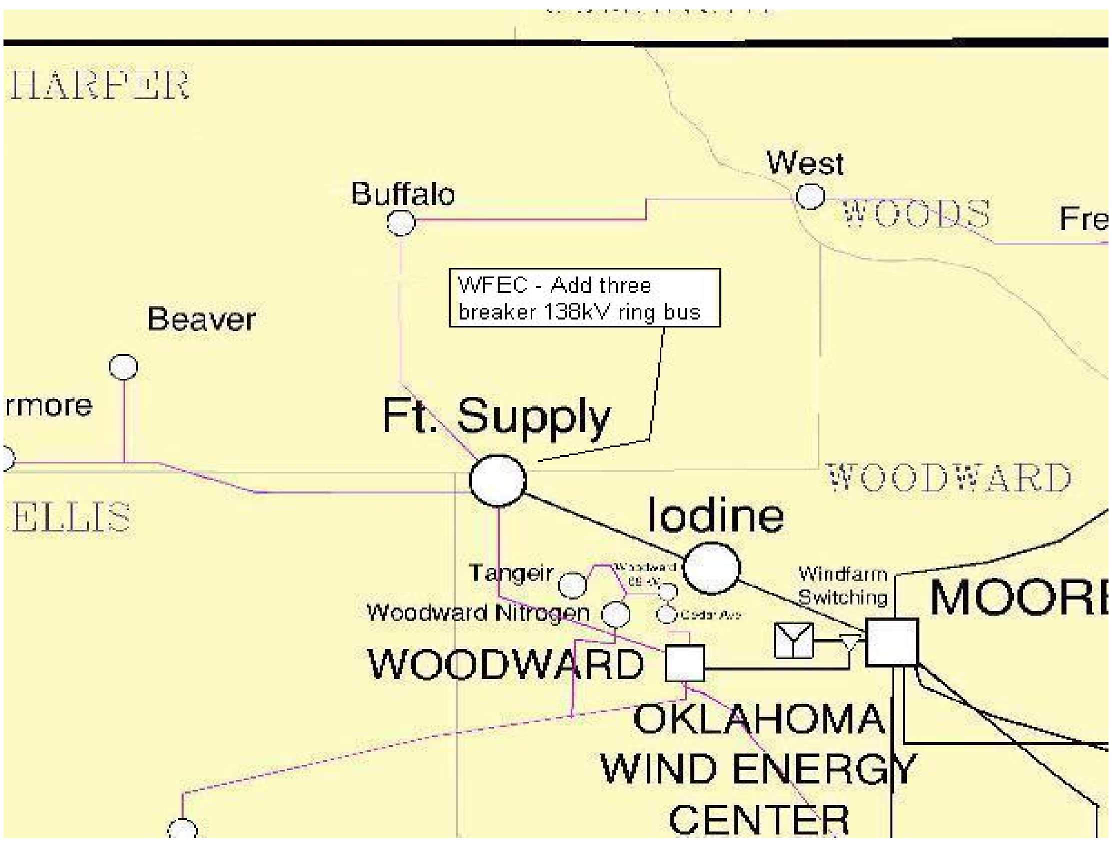
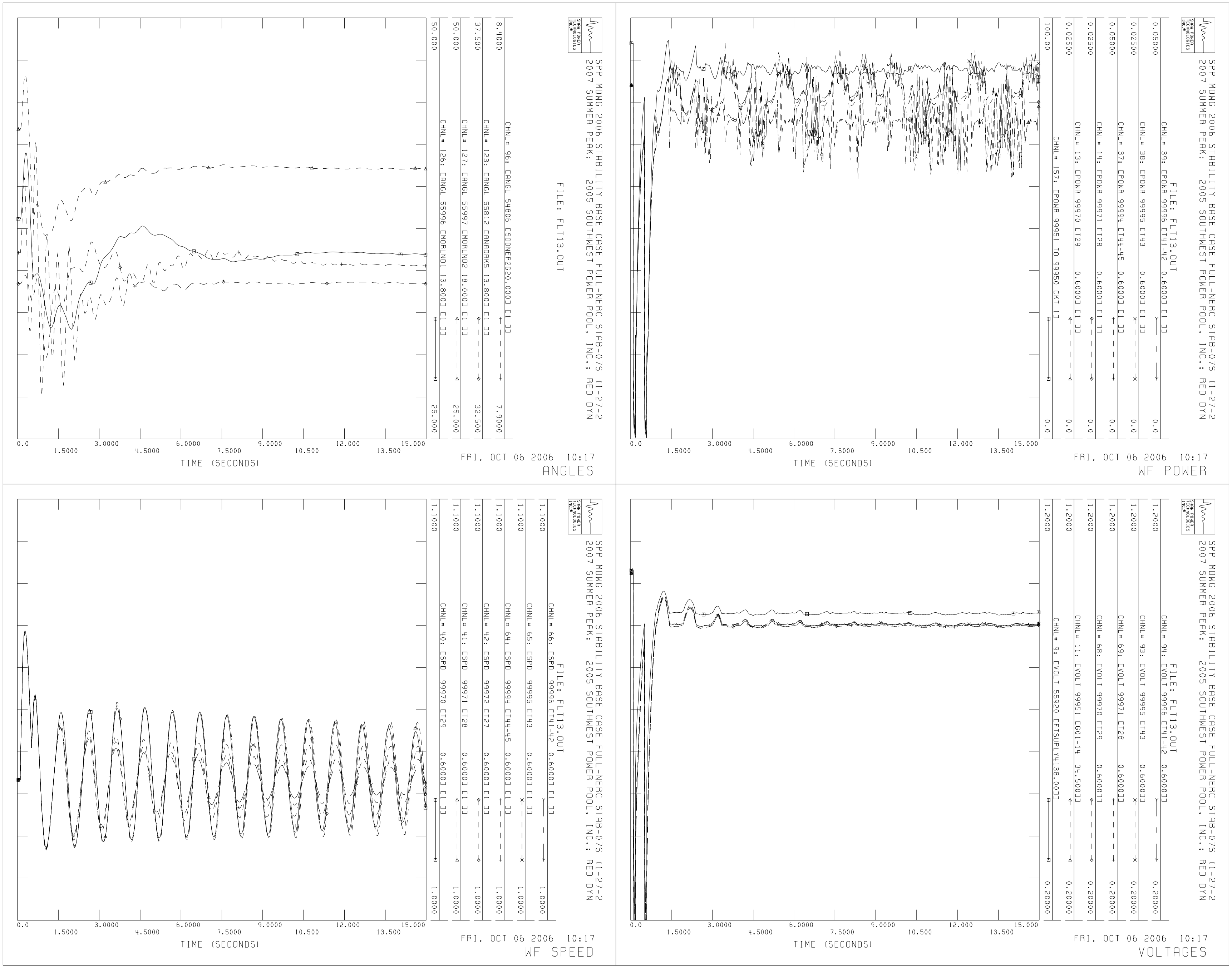


Figure 5. Map of the Area

APPENDIX A.

STABILITY PLOTS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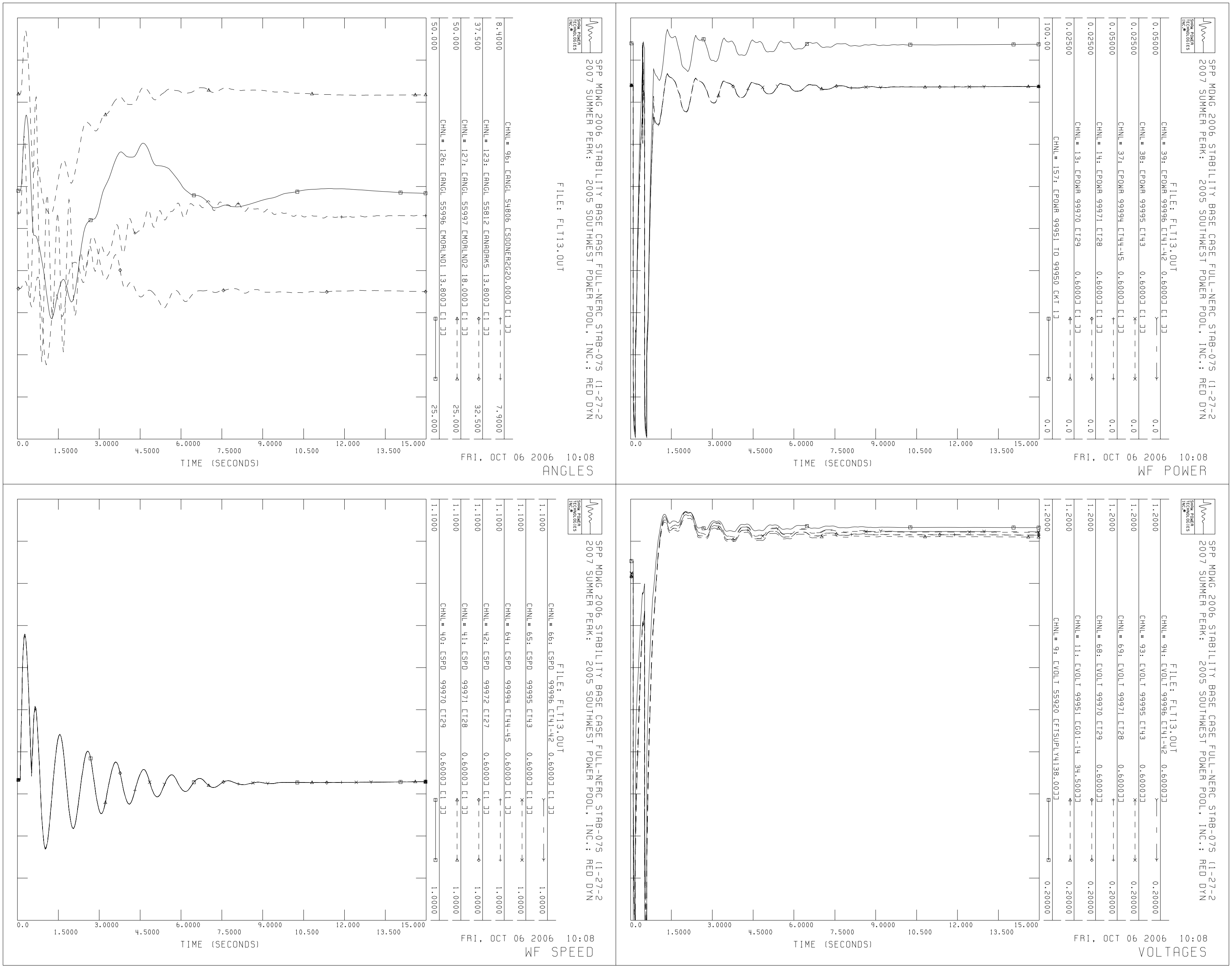
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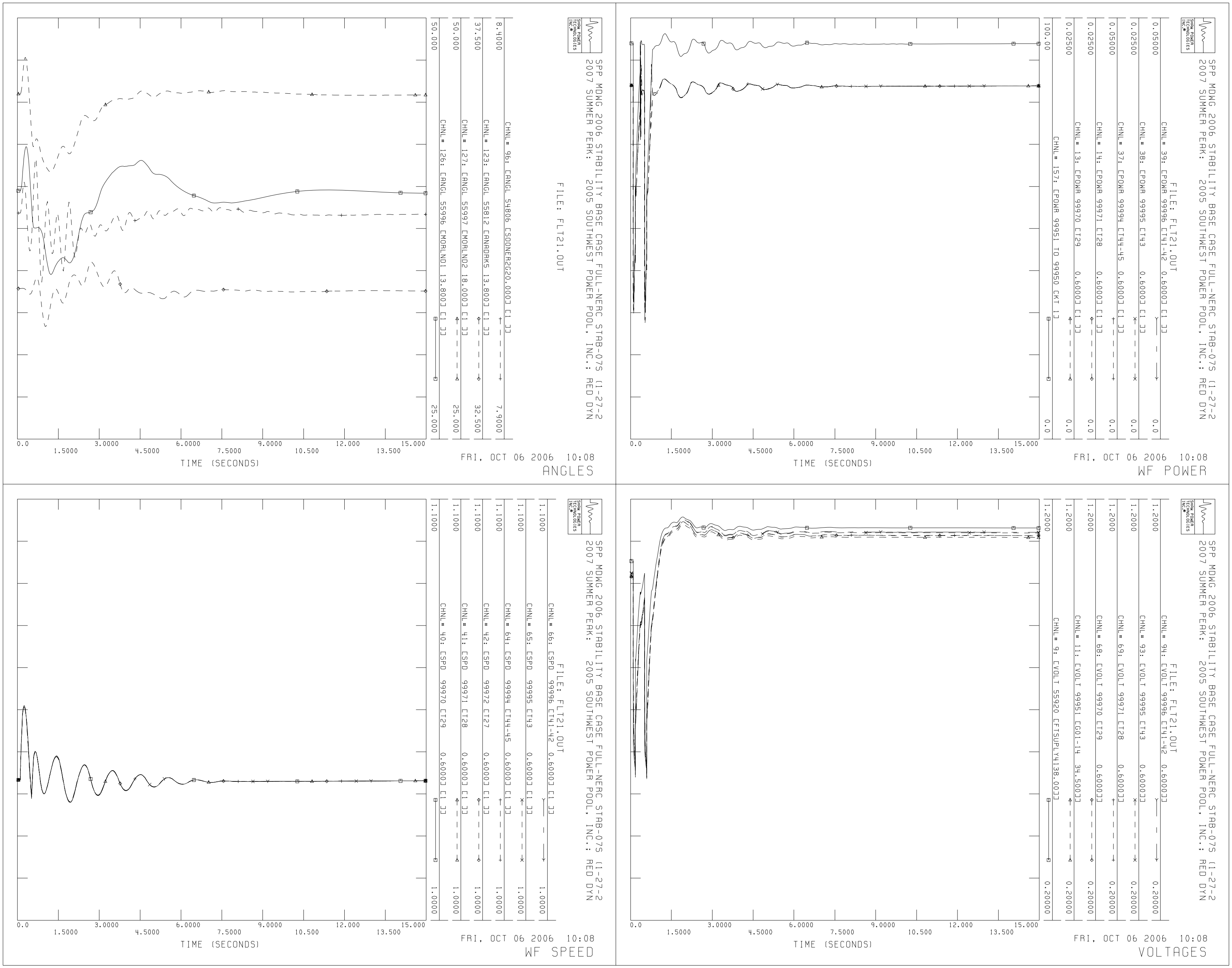
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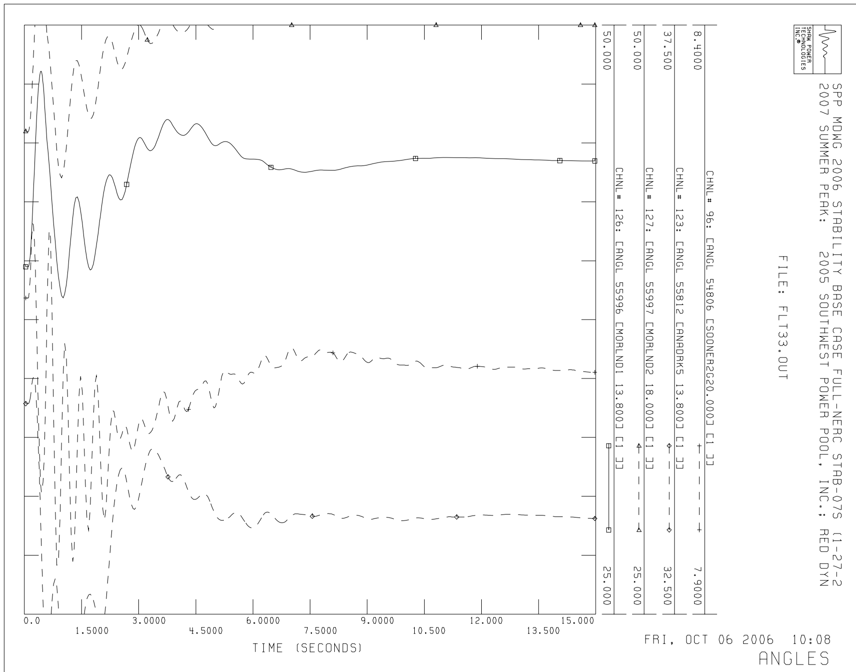
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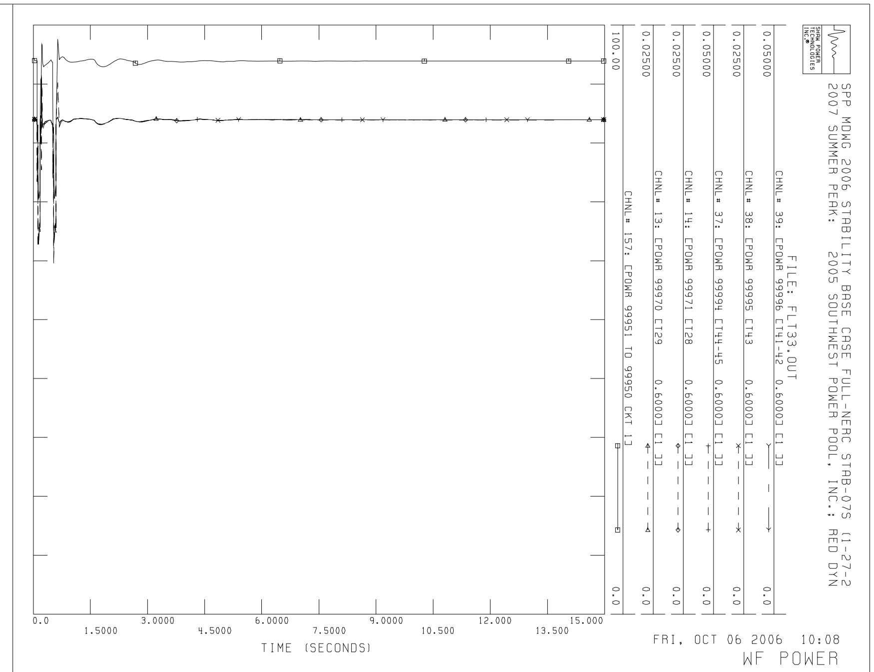
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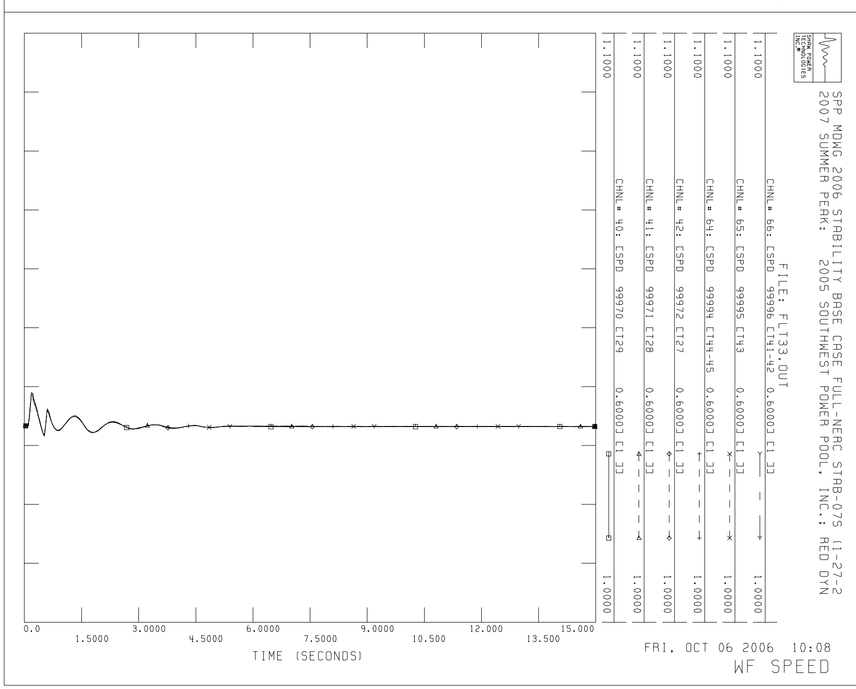
CHNL# 38: [POWR 99995 [T43 0.6000] [1]] 0.02500 0.0
CHNL# 37: [POWR 99994 [T44-45 0.6000] [1]] 0.05000 0.0
CHNL# 14: [POWR 99971 [T28 0.6000] [1]] 0.02500 0.0
CHNL# 13: [POWR 99970 [T29 0.6000] [1]] 0.02500 0.0
CHNL# 157: [POWR 99951 TO 99950 CKT 1] 100.00 0.0
TIME (SECONDS)
FRI, OCT 06 2006 10:08
WF POWER


SPP MDWG 2006 STABILITY BASE CASE FULL-NERC STAB-07S (1-27-2
2007 SUMMER PEAK: 2005 SOUTHWEST POWER POOL, INC.; RED DYN
FILE: FLT33.OUT
CHNL# 66: [SPD 99996 [T41-42 0.6000] [1]] 1.1000 1.0000
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CHNL# 64: [SPD 99994 [T44-45 0.6000] [1]] 1.1000 1.0000
CHNL# 42: [SPD 99972 [T27 0.6000] [1]] 1.1000 1.0000
CHNL# 41: [SPD 99971 [T28 0.6000] [1]] 1.1000 1.0000
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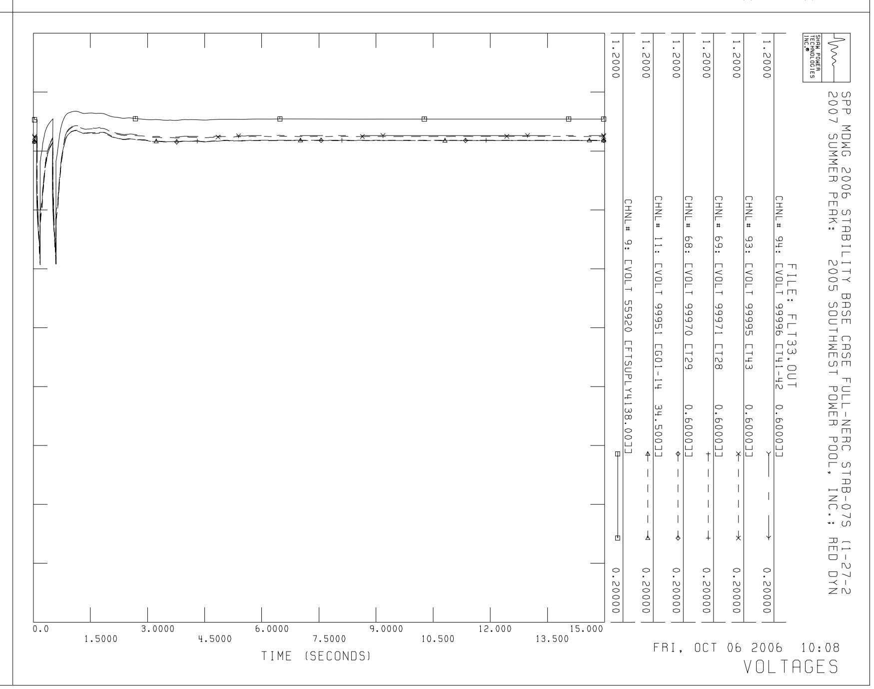
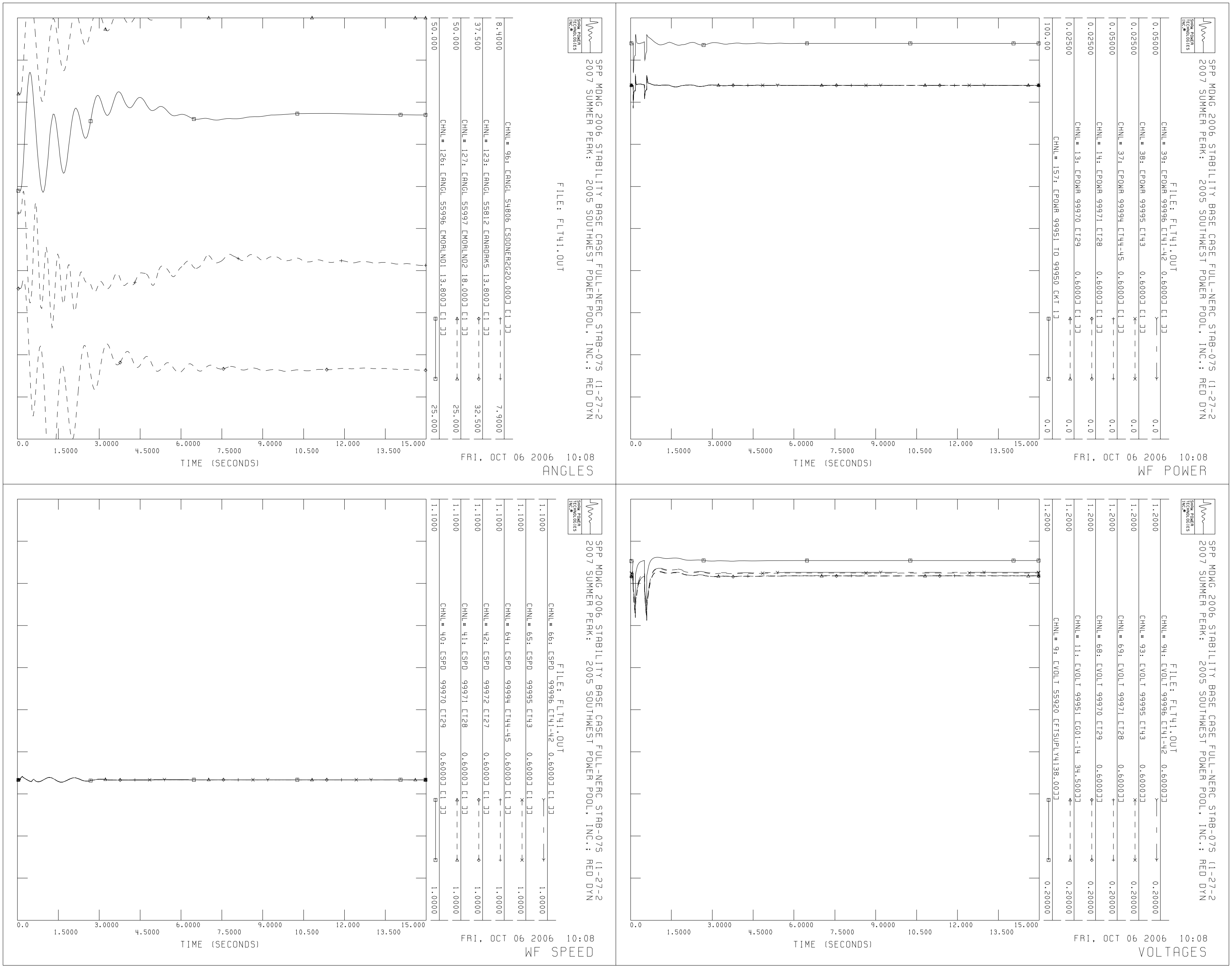
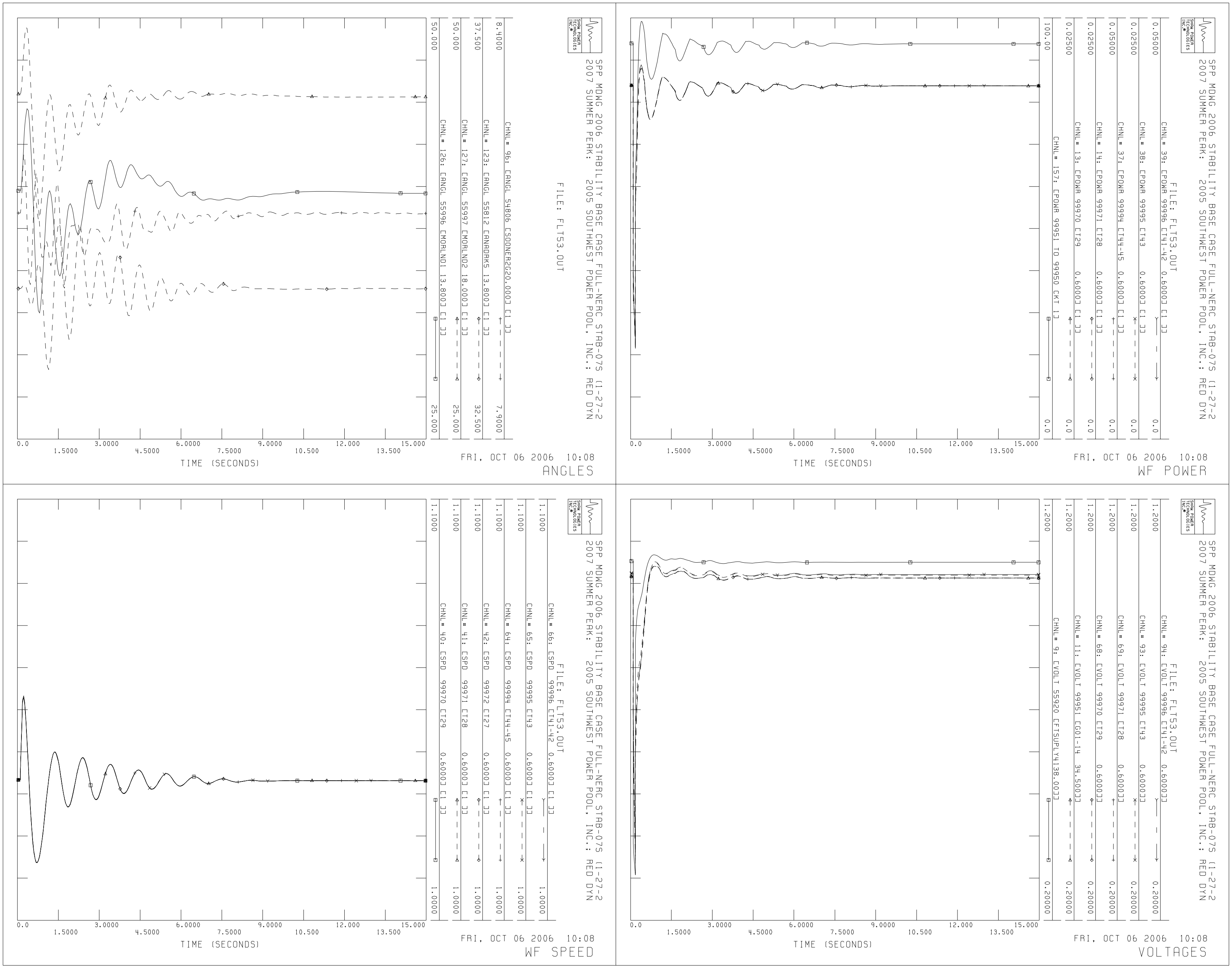
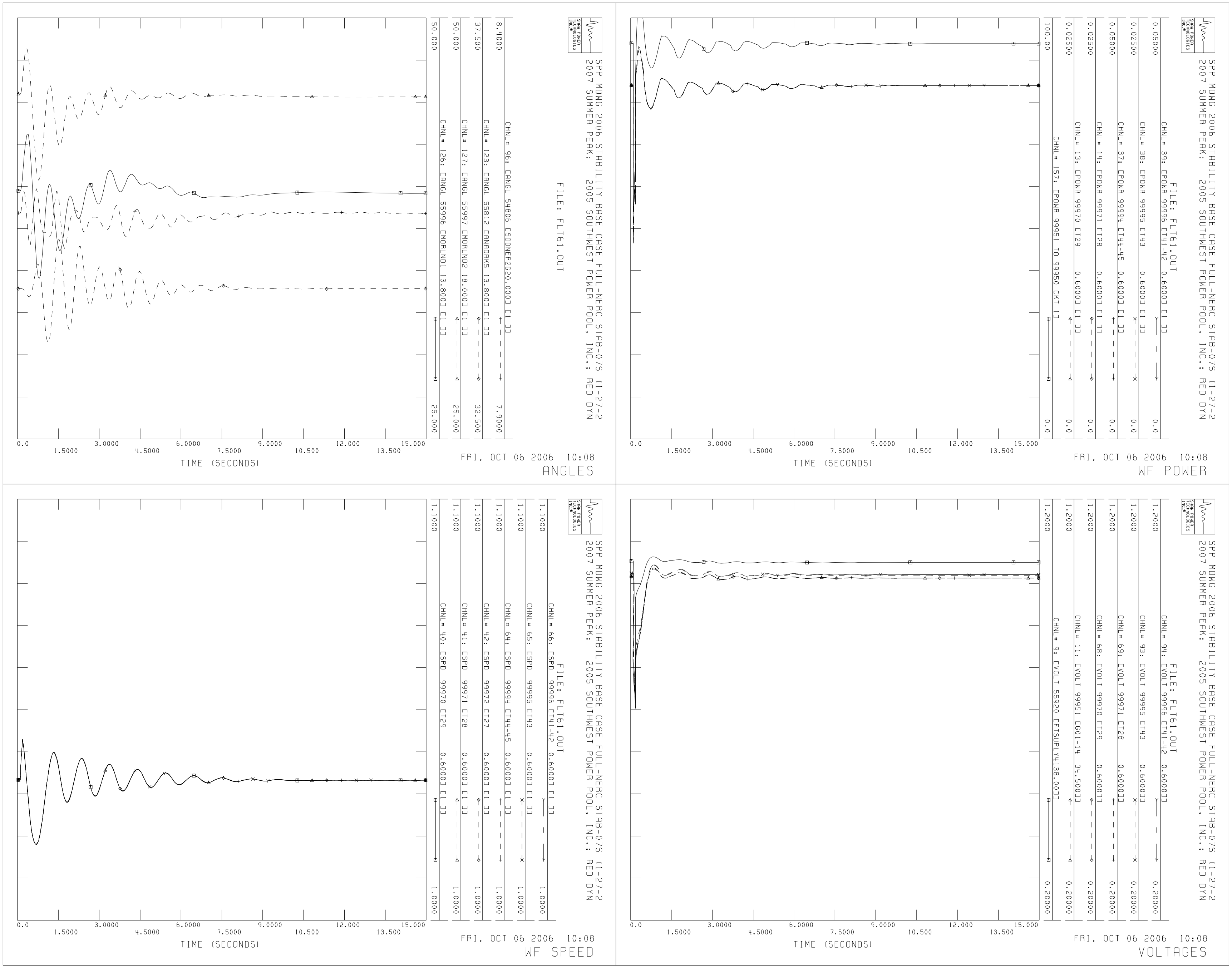
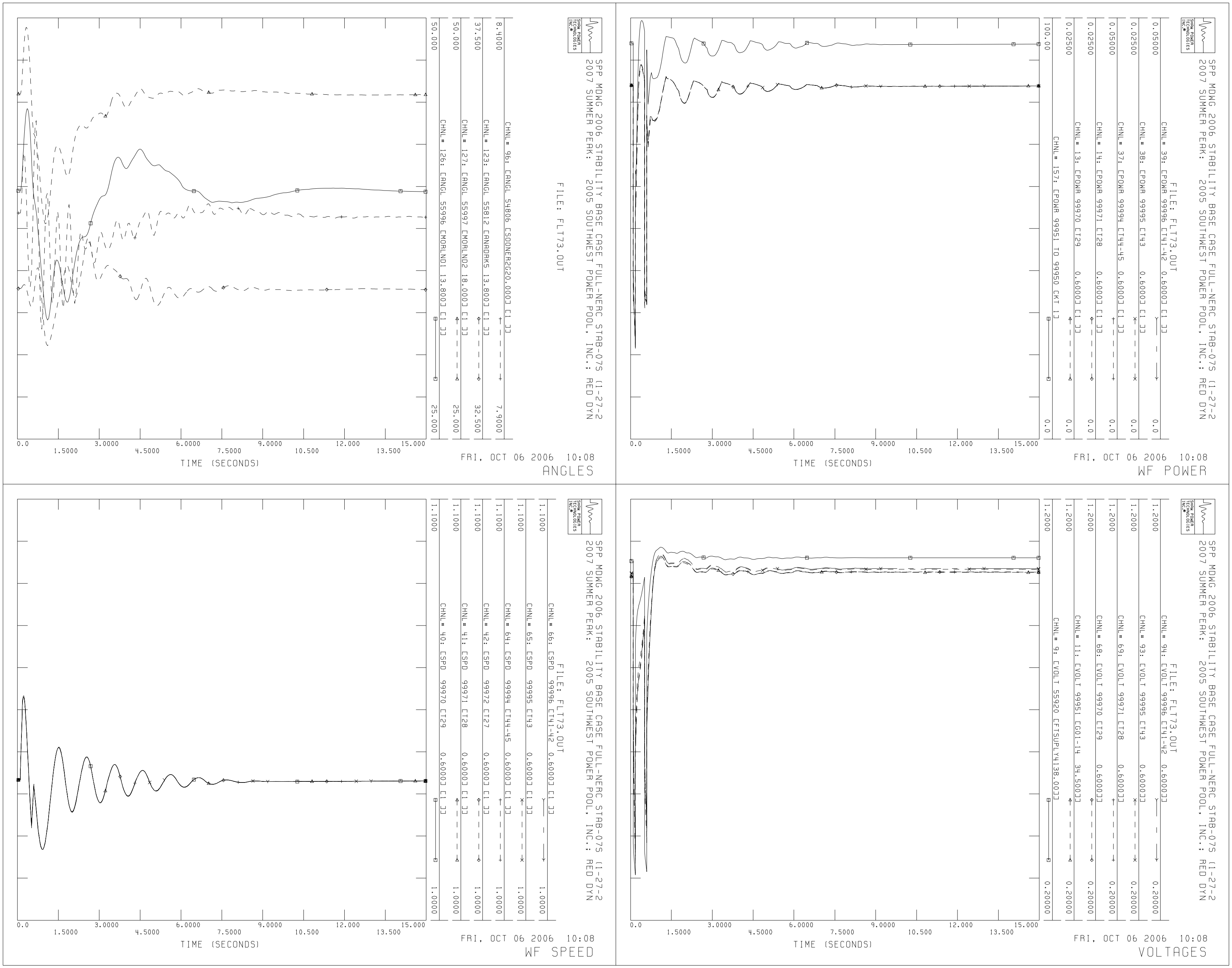
TIME (SECONDS)
FRI, OCT 06 2006 10:08
WF SPEED

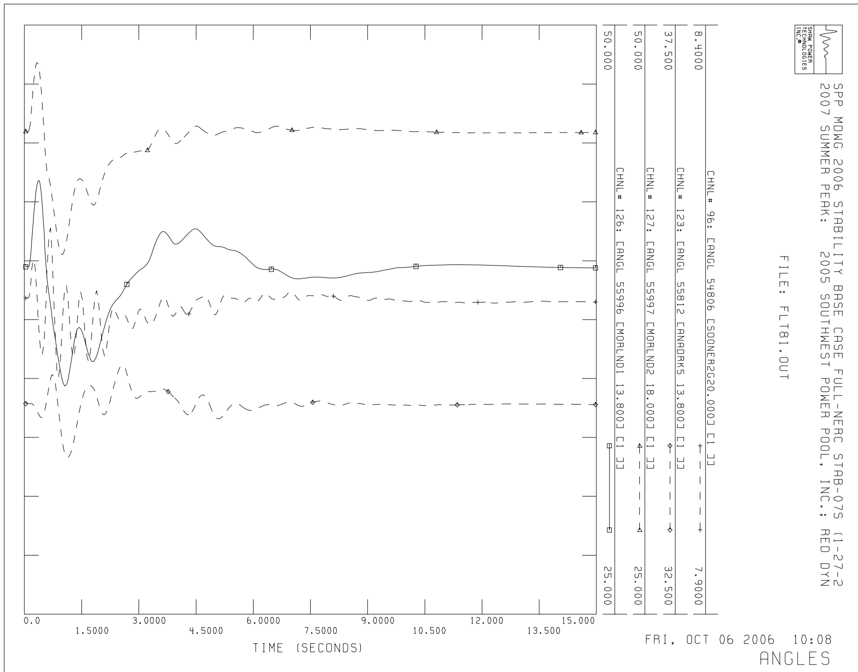

SPP MDWG 2006 STABILITY BASE CASE FULL-NERC STAB-07S (1-27-2
2007 SUMMER PEAK: 2005 SOUTHWEST POWER POOL, INC.; RED DYN
FILE: FLT33.OUT
CHNL# 94: [VOLT 99996 [T41-42 0.6000]] 1.2000 0.20000
CHNL# 93: [VOLT 99995 [T43 0.6000]] 1.2000 0.20000
CHNL# 69: [VOLT 99971 [T28 0.6000]] 1.2000 0.20000
CHNL# 68: [VOLT 99970 [T29 0.6000]] 1.2000 0.20000
CHNL# 11: [VOLT 99951 [G01-14 34.500]] 1.2000 0.20000
CHNL# 9: [VOLT 55920 [FTSUPLY4138.00]] 1.2000 0.20000
TIME (SECONDS)
FRI, OCT 06 2006 10:08
VOLTAGES

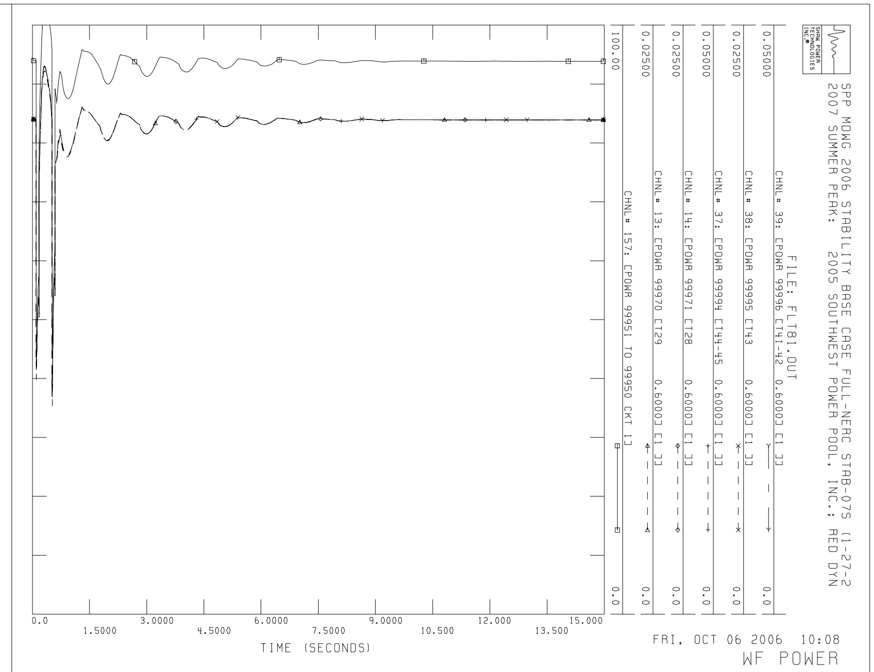

SPP MDWG 2006 STABILITY BASE CASE FULL-NERC STAB-07S (1-27-2
2007 SUMMER PEAK: 2005 SOUTHWEST POWER POOL, INC.; RED DYN
FILE: FLT41.OUT
TIME (SECONDS)
FRI, OCT 06 2006 10:08
ANGLES
WF POWER
WF SPEED
VOLTAGES

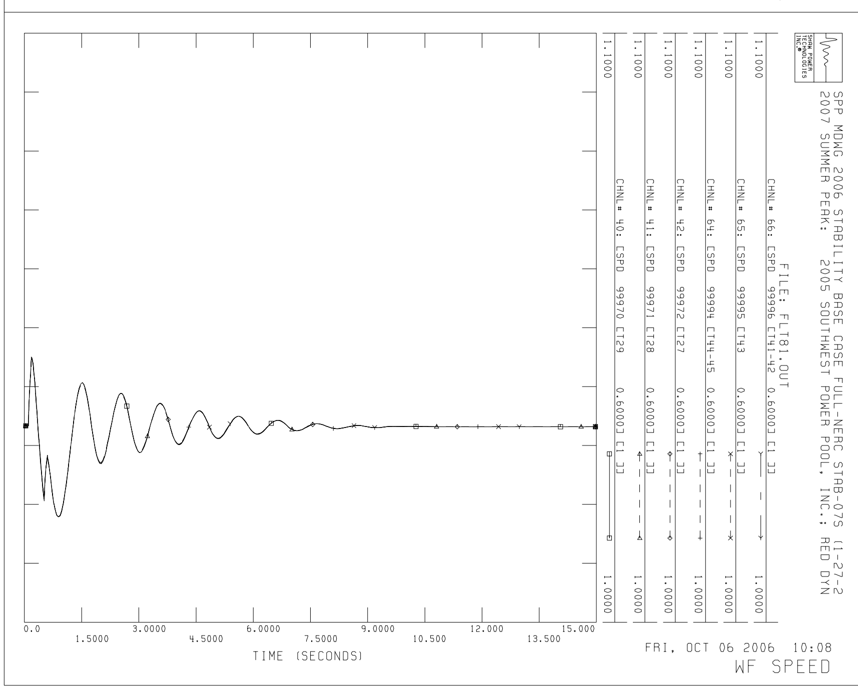

SPP MDWG 2006 STABILITY BASE CASE FULL-NERC STAB-07S (1-27-2
2007 SUMMER PEAK: 2005 SOUTHWEST POWER POOL, INC.: RED DYN
FILE: FLT53.OUT
CHNL# 96: [ANGL 54806 [SOONER2G20.000] [1]]
CHNL# 123: [ANGL 55812 [ANADRK5 13.800] [1]]
CHNL# 127: [ANGL 55997 [MORLND2 18.000] [1]]
CHNL# 126: [ANGL 55996 [MORLND1 13.800] [1]]
TIME (SECONDS)
FRI, OCT 06 2006 10:08
ANGLES
CHNL# 39: [POWR 99996 [T41-42 0.600] [1]]
CHNL# 38: [POWR 99995 [T43 0.600] [1]]
CHNL# 37: [POWR 99994 [T44-45 0.600] [1]]
CHNL# 14: [POWR 99971 [T28 0.600] [1]]
CHNL# 13: [POWR 99970 [T29 0.600] [1]]
CHNL# 157: [POWR 99951 TO 99950 CKT 1]
TIME (SECONDS)
FRI, OCT 06 2006 10:08
WF POWER
CHNL# 66: [SPD 99996 [T41-42 0.600] [1]]
CHNL# 65: [SPD 99995 [T43 0.600] [1]]
CHNL# 64: [SPD 99994 [T44-45 0.600] [1]]
CHNL# 42: [SPD 99972 [T27 0.600] [1]]
CHNL# 41: [SPD 99971 [T28 0.600] [1]]
CHNL# 40: [SPD 99970 [T29 0.600] [1]]
TIME (SECONDS)
FRI, OCT 06 2006 10:08
WF SPEED
CHNL# 94: [VOLT 99996 [T41-42 0.600]]
CHNL# 93: [VOLT 99995 [T43 0.600]]
CHNL# 69: [VOLT 99971 [T28 0.600]]
CHNL# 68: [VOLT 99970 [T29 0.600]]
CHNL# 11: [VOLT 99951 [G01-14 34.500]]
CHNL# 9: [VOLT 55920 [FTSUPLY4138.00]]
TIME (SECONDS)
FRI, OCT 06 2006 10:08
VOLTAGES

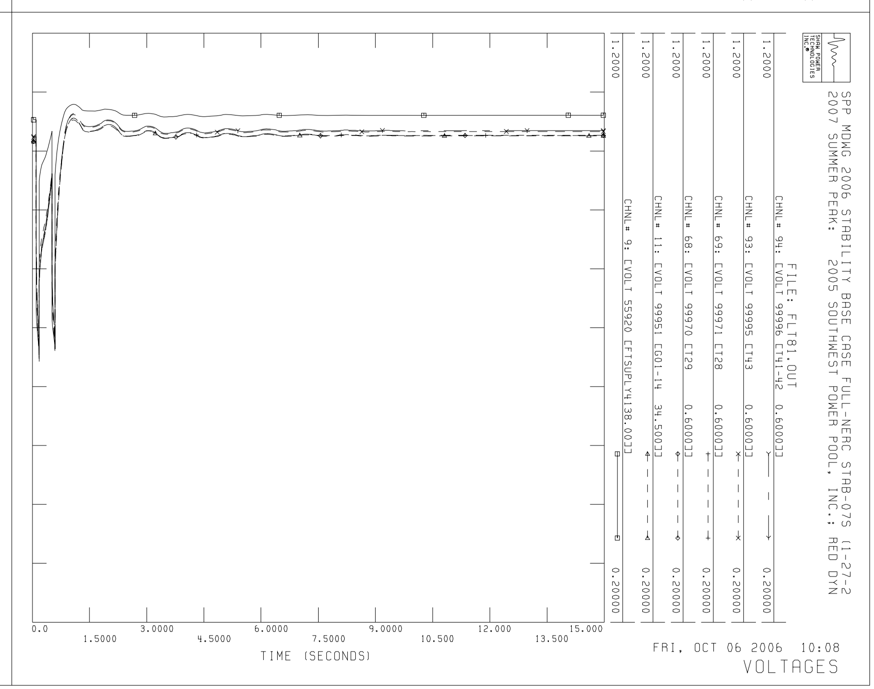

SPP MDWG 2006 STABILITY BASE CASE FULL-NERC STAB-07S (1-27-2
2007 SUMMER PEAK: 2005 SOUTHWEST POWER POOL, INC.; RED DYN
FILE: FLT61.OUT
CHNL# 96: [ANGL 54806 [SOONER2G20.000] [1]]
CHNL# 123: [ANGL 55812 [ANADRKS 13.800] [1]]
CHNL# 127: [ANGL 55997 [MORLND2 18.000] [1]]
CHNL# 126: [ANGL 55996 [MORLND1 13.800] [1]]
TIME (SECONDS)
FRI, OCT 06 2006 10:08
ANGLES
CHNL# 39: [POWR 99996 [T41-42 0.6000] [1]]
CHNL# 38: [POWR 99995 [T43 0.6000] [1]]
CHNL# 37: [POWR 99994 [T44-45 0.6000] [1]]
CHNL# 14: [POWR 99971 [T28 0.6000] [1]]
CHNL# 13: [POWR 99970 [T29 0.6000] [1]]
CHNL# 157: [POWR 99951 TO 99950 CKT 1]
FRI, OCT 06 2006 10:08
WF POWER
CHNL# 66: [SPD 99996 [T41-42 0.6000] [1]]
CHNL# 65: [SPD 99995 [T43 0.6000] [1]]
CHNL# 64: [SPD 99994 [T44-45 0.6000] [1]]
CHNL# 42: [SPD 99972 [T27 0.6000] [1]]
CHNL# 41: [SPD 99971 [T28 0.6000] [1]]
CHNL# 40: [SPD 99970 [T29 0.6000] [1]]
FRI, OCT 06 2006 10:08
WF SPEED
CHNL# 94: [VOLT 99996 [T41-42 0.6000]]
CHNL# 93: [VOLT 99995 [T43 0.6000]]
CHNL# 69: [VOLT 99971 [T28 0.6000]]
CHNL# 68: [VOLT 99970 [T29 0.6000]]
CHNL# 11: [VOLT 99951 [G01-14 34.500]]
CHNL# 9: [VOLT 55920 [FTSUPLY4138.00]]
FRI, OCT 06 2006 10:08
VOLTAGES

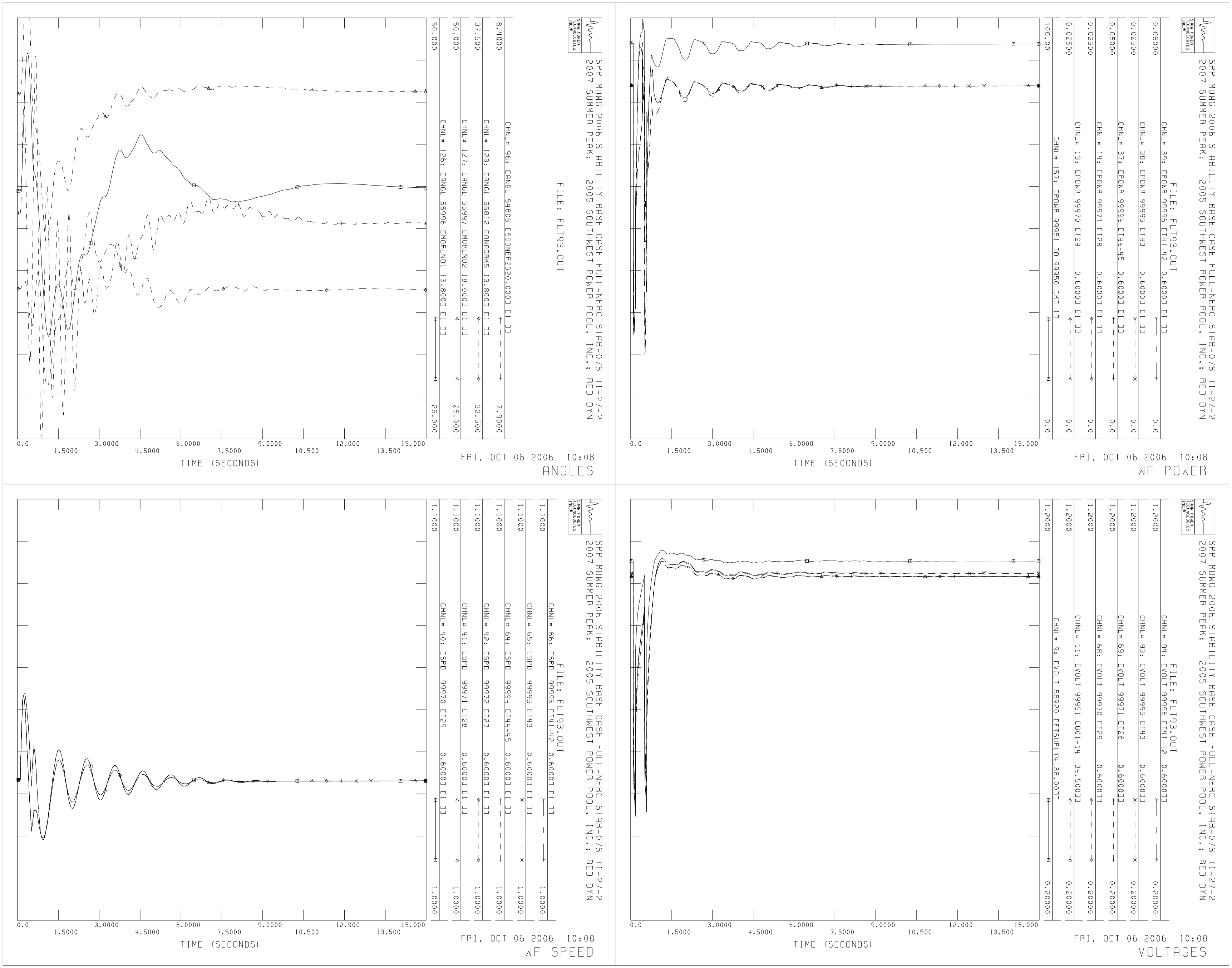

SPP MDWG 2006 STABILITY BASE CASE FULL-NERC STAB-07S (1-27-2
2007 SUMMER PEAK: 2005 SOUTHWEST POWER POOL, INC.: RED DYN
FILE: FLT73.OUT
CHNL# 96: [ANGL 54806 [SOONER2G20.000] [1]]
CHNL# 123: [ANGL 55812 [ANADRK5 13.800] [1]]
CHNL# 127: [ANGL 55997 [MORLND2 18.000] [1]]
CHNL# 126: [ANGL 55996 [MORLND1 13.800] [1]]
TIME (SECONDS)
FRI, OCT 06 2006 10:08
ANGLES
CHNL# 39: [POWR 99996 [T41-42 0.6000] [1]]
CHNL# 38: [POWR 99995 [T43 0.6000] [1]]
CHNL# 37: [POWR 99994 [T44-45 0.6000] [1]]
CHNL# 14: [POWR 99971 [T28 0.6000] [1]]
CHNL# 13: [POWR 99970 [T29 0.6000] [1]]
CHNL# 157: [POWR 99951 TO 99950 CKT 1]
WF POWER
CHNL# 66: [SPD 99996 [T41-42 0.6000] [1]]
CHNL# 65: [SPD 99995 [T43 0.6000] [1]]
CHNL# 64: [SPD 99994 [T44-45 0.6000] [1]]
CHNL# 42: [SPD 99972 [T27 0.6000] [1]]
CHNL# 41: [SPD 99971 [T28 0.6000] [1]]
CHNL# 40: [SPD 99970 [T29 0.6000] [1]]
WF SPEED
CHNL# 94: [VOLT 99996 [T41-42 0.6000]]
CHNL# 93: [VOLT 99995 [T43 0.6000]]
CHNL# 69: [VOLT 99971 [T28 0.6000]]
CHNL# 68: [VOLT 99970 [T29 0.6000]]
CHNL# 11: [VOLT 99951 [G01-14 34.500]]
CHNL# 9: [VOLT 55920 [FTSUPLY4138.00]]
VOLTAGES


SPP MDWG 2006 STABILITY BASE CASE FULL-NERC STAB-07S (1-27-2
2007 SUMMER PEAK: 2005 SOUTHWEST POWER POOL, INC.: RED DYN
FILE: FLT81.OUT
CHNL# 96: [ANGL 54806 [SOONER2G20.000] [1]] 8.4000 7.9000
CHNL# 123: [ANGL 55812 [ANADRK5 13.800] [1]] 37.500 32.500
CHNL# 127: [ANGL 55997 [MORLND2 18.000] [1]] 50.000 25.000
CHNL# 126: [ANGL 55996 [MORLND1 13.800] [1]] 50.000 25.000
TIME (SECONDS)
FRI, OCT 06 2006 10:08
ANGLES

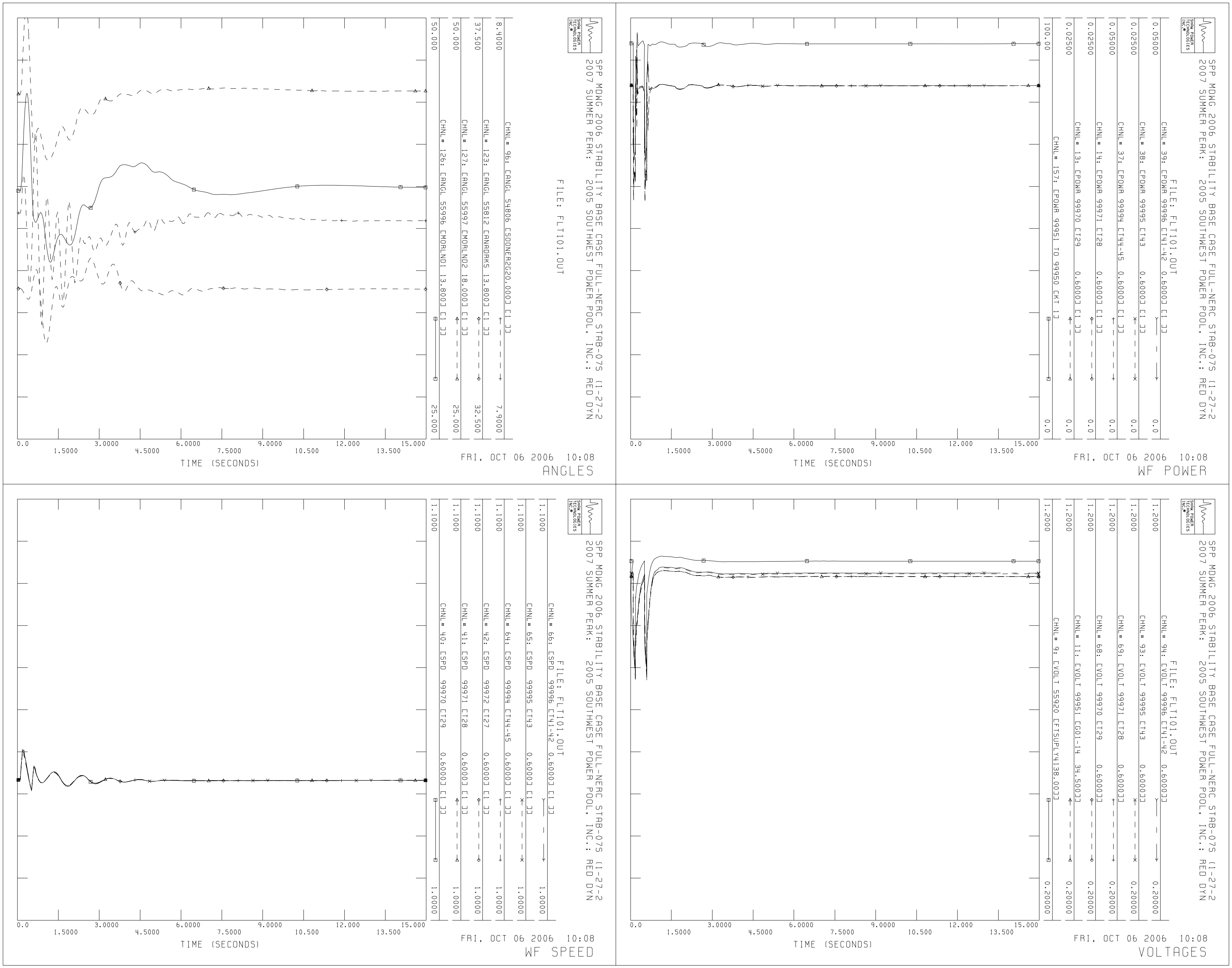

SPP MDWG 2006 STABILITY BASE CASE FULL-NERC STAB-07S (1-27-2
2007 SUMMER PEAK: 2005 SOUTHWEST POWER POOL, INC.: RED DYN
FILE: FLT81.OUT
CHNL# 39: [POWR 99996 [T41-42 0.6000] [1]] 0.05000 0.0
CHNL# 38: [POWR 99995 [T43 0.6000] [1]] 0.02500 0.0
CHNL# 37: [POWR 99994 [T44-45 0.6000] [1]] 0.05000 0.0
CHNL# 14: [POWR 99971 [T28 0.6000] [1]] 0.02500 0.0
CHNL# 13: [POWR 99970 [T29 0.6000] [1]] 0.02500 0.0
CHNL# 157: [POWR 99951 TO 99950 CKT 1] 100.00 0.0
TIME (SECONDS)
FRI, OCT 06 2006 10:08
WF POWER

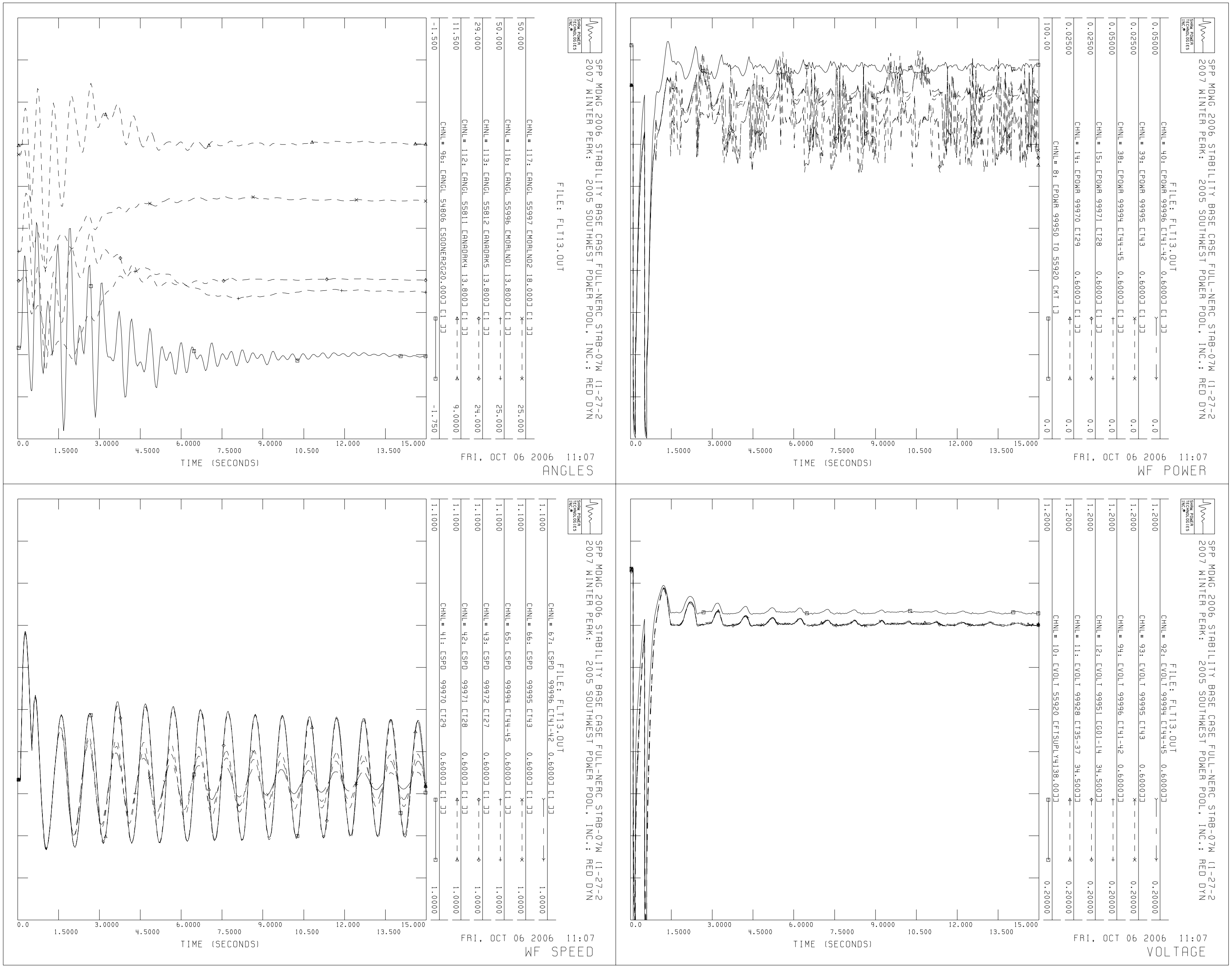

SPP MDWG 2006 STABILITY BASE CASE FULL-NERC STAB-07S (1-27-2
2007 SUMMER PEAK: 2005 SOUTHWEST POWER POOL, INC.: RED DYN
FILE: FLT81.OUT
CHNL# 66: [SPD 99996 [T41-42 0.6000] [1]] 1.1000 1.0000
CHNL# 65: [SPD 99995 [T43 0.6000] [1]] 1.1000 1.0000
CHNL# 64: [SPD 99994 [T44-45 0.6000] [1]] 1.1000 1.0000
CHNL# 42: [SPD 99972 [T27 0.6000] [1]] 1.1000 1.0000
CHNL# 41: [SPD 99971 [T28 0.6000] [1]] 1.1000 1.0000
CHNL# 40: [SPD 99970 [T29 0.6000] [1]] 1.1000 1.0000
TIME (SECONDS)
FRI, OCT 06 2006 10:08
WF SPEED

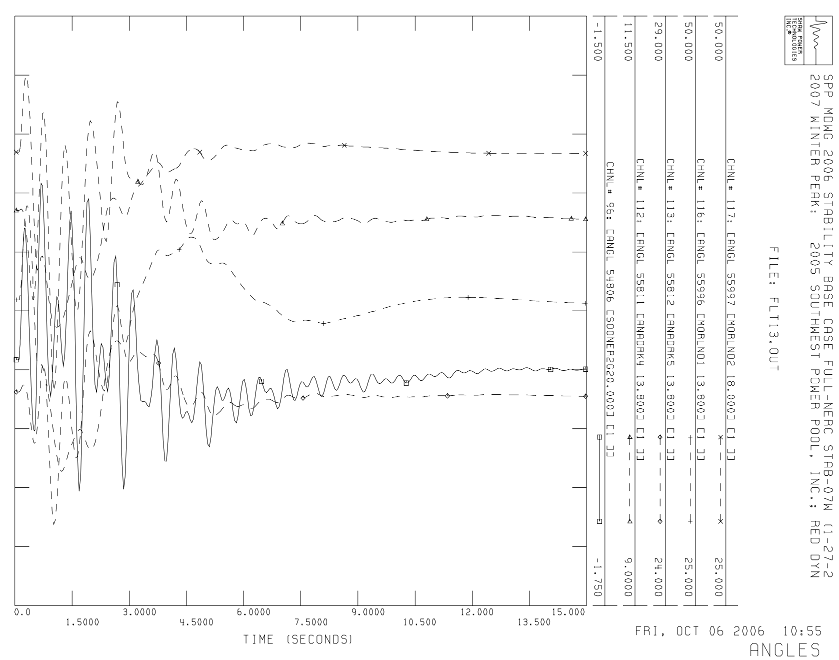

SPP MDWG 2006 STABILITY BASE CASE FULL-NERC STAB-07S (1-27-2
2007 SUMMER PEAK: 2005 SOUTHWEST POWER POOL, INC.: RED DYN
FILE: FLT81.OUT
CHNL# 94: [VOLT 99996 [T41-42 0.6000]] 1.2000 0.20000
CHNL# 93: [VOLT 99995 [T43 0.6000]] 1.2000 0.20000
CHNL# 69: [VOLT 99971 [T28 0.6000]] 1.2000 0.20000
CHNL# 68: [VOLT 99970 [T29 0.6000]] 1.2000 0.20000
CHNL# 11: [VOLT 99951 [G01-14 34.500]] 1.2000 0.20000
CHNL# 9: [VOLT 55920 [FTSUPLY4138.00]] 1.2000 0.20000
TIME (SECONDS)
FRI, OCT 06 2006 10:08
VOLTAGES

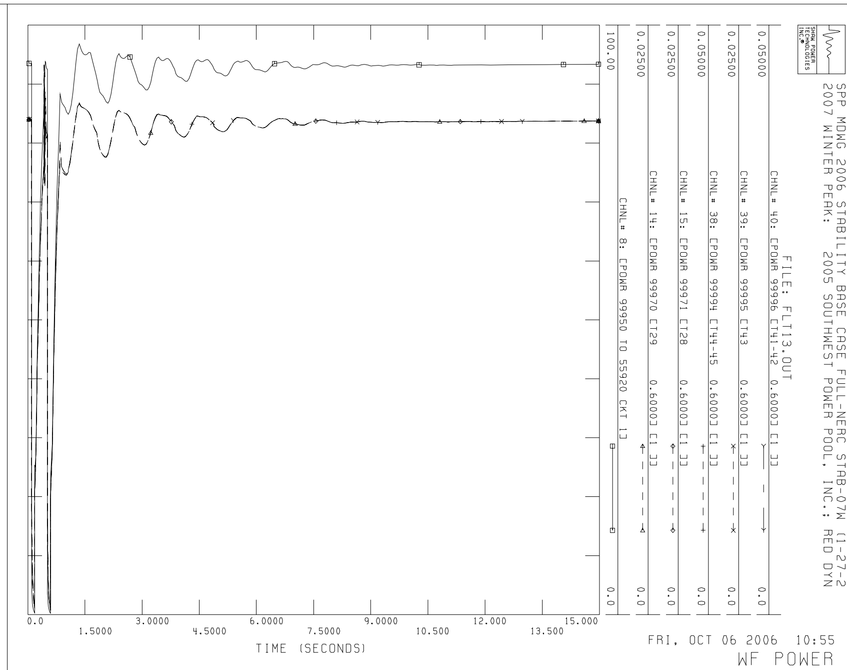


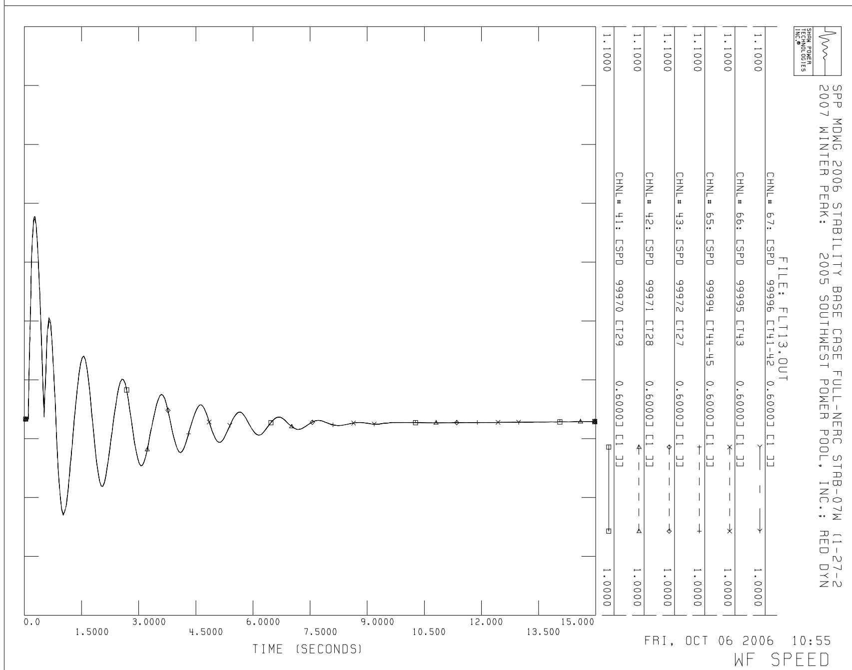
SPP MDWG 2006 STABILITY BASE CASE FULL-NERC STAB-07S (1-27-2
2007 SUMMER PEAK: 2005 SOUTHWEST POWER POOL, INC.; RED DYN
FILE: FLT93.OUT
CHNL# 96: [ANGL 54806 [SOONER2G20.000] [1]]
CHNL# 123: [ANGL 55812 [ANADRK5 13.800] [1]]
CHNL# 127: [ANGL 55997 [MORLND2 18.000] [1]]
CHNL# 126: [ANGL 55996 [MORLND1 13.800] [1]]
TIME (SECONDS)
FRI, OCT 06 2006 10:08
ANGLES
CHNL# 39: [POWR 99996 [T41-42 0.6000] [1]]
CHNL# 38: [POWR 99995 [T43 0.6000] [1]]
CHNL# 37: [POWR 99994 [T44-45 0.6000] [1]]
CHNL# 14: [POWR 99971 [T28 0.6000] [1]]
CHNL# 13: [POWR 99970 [T29 0.6000] [1]]
CHNL# 157: [POWR 99951 TO 99950 CKT 1]
WF POWER
CHNL# 66: [SPD 99996 [T41-42 0.6000] [1]]
CHNL# 65: [SPD 99995 [T43 0.6000] [1]]
CHNL# 64: [SPD 99994 [T44-45 0.6000] [1]]
CHNL# 42: [SPD 99972 [T27 0.6000] [1]]
CHNL# 41: [SPD 99971 [T28 0.6000] [1]]
CHNL# 40: [SPD 99970 [T29 0.6000] [1]]
WF SPEED
CHNL# 94: [VOLT 99996 [T41-42 0.6000]]
CHNL# 93: [VOLT 99995 [T43 0.6000]]
CHNL# 69: [VOLT 99971 [T28 0.6000]]
CHNL# 68: [VOLT 99970 [T29 0.6000]]
CHNL# 11: [VOLT 99951 [G01-14 34.500]]
CHNL# 9: [VOLT 55920 [FTSUPLY4138.00]]
VOLTAGES

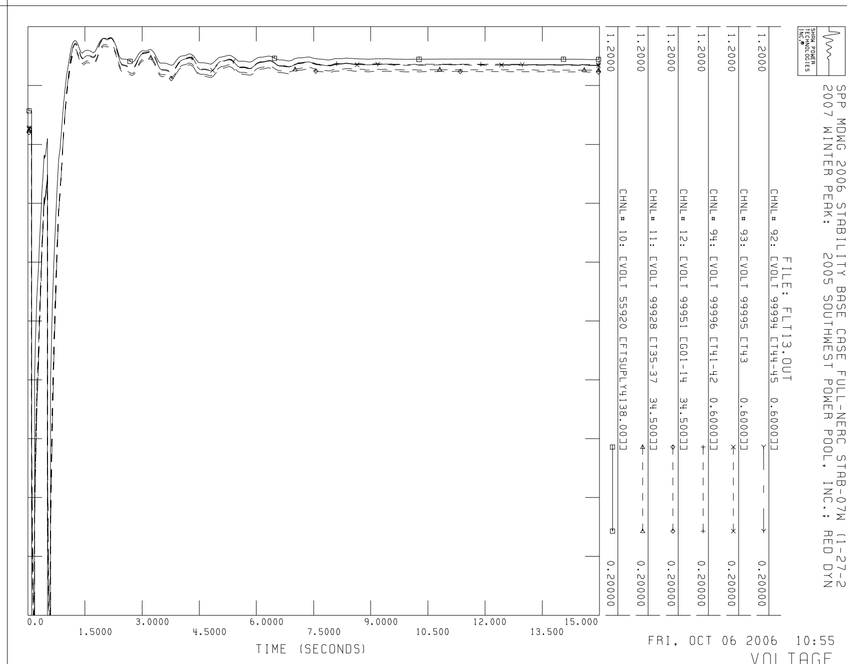

SPP MDWG 2006 STABILITY BASE CASE FULL-NERC STAB-07S (1-27-2
2007 SUMMER PEAK: 2005 SOUTHWEST POWER POOL, INC.; RED DYN
FILE: FLT101.OUT
FRI, OCT 06 2006 10:08
TIME (SECONDS)
ANGLES
WF POWER
WF SPEED
VOLTAGES

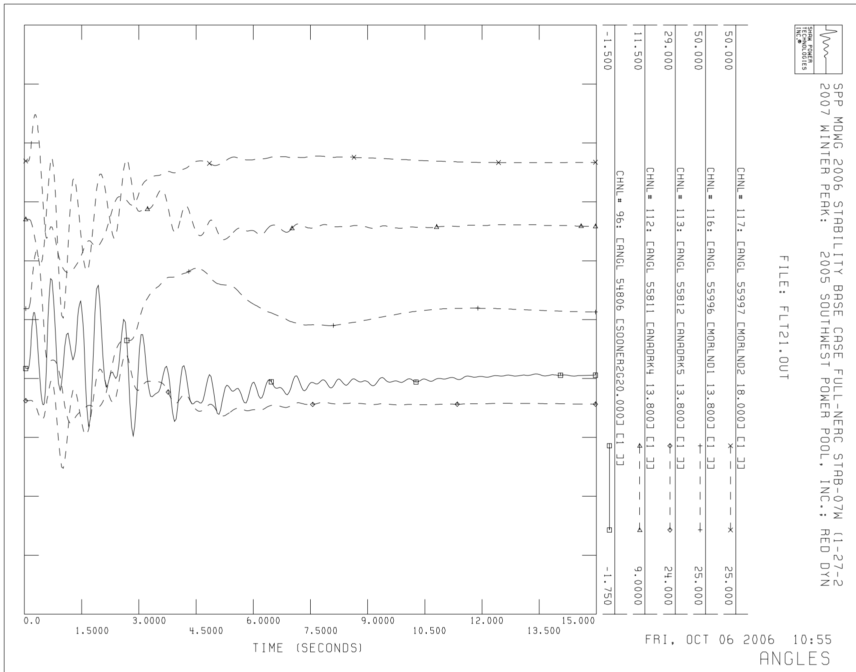
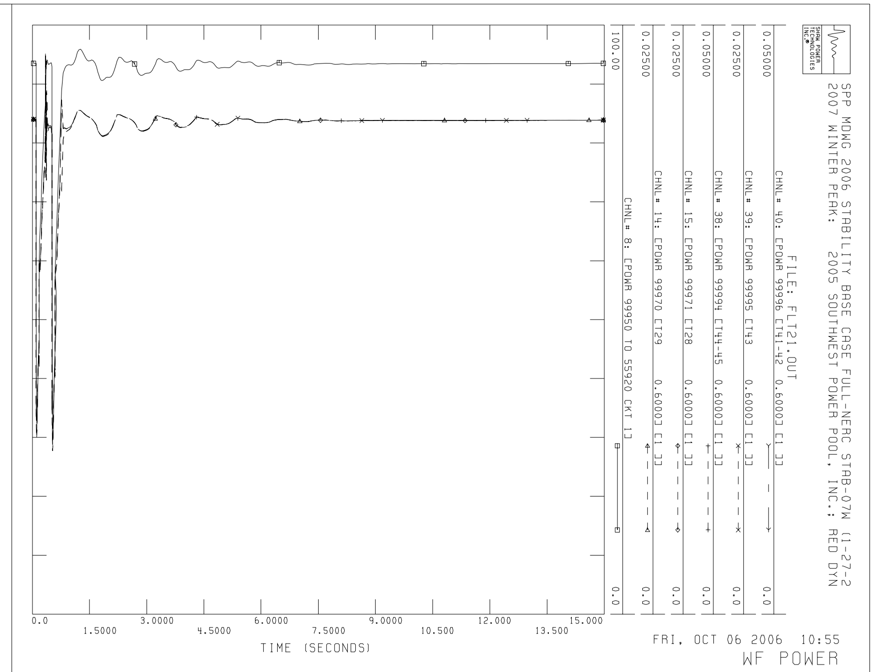
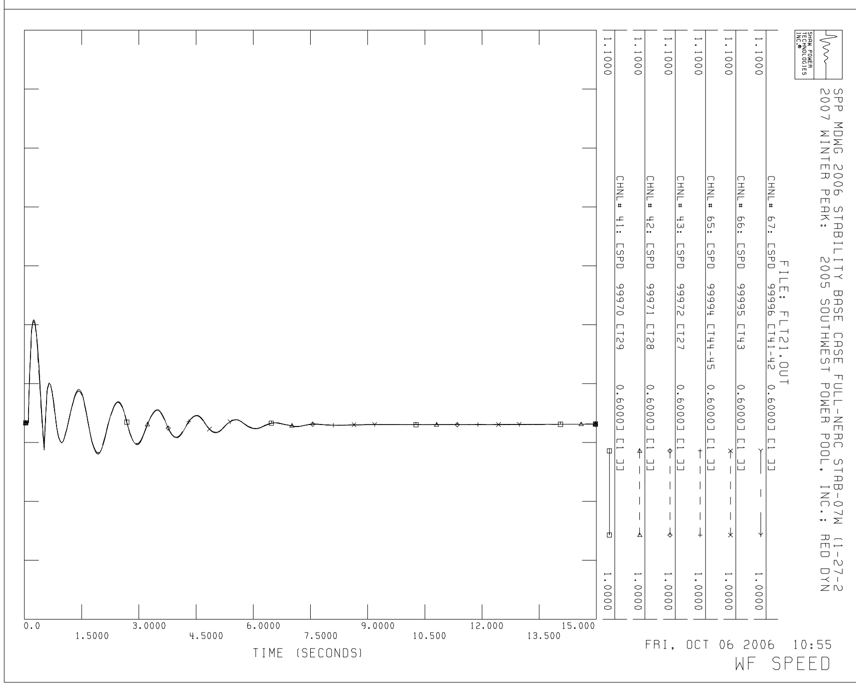
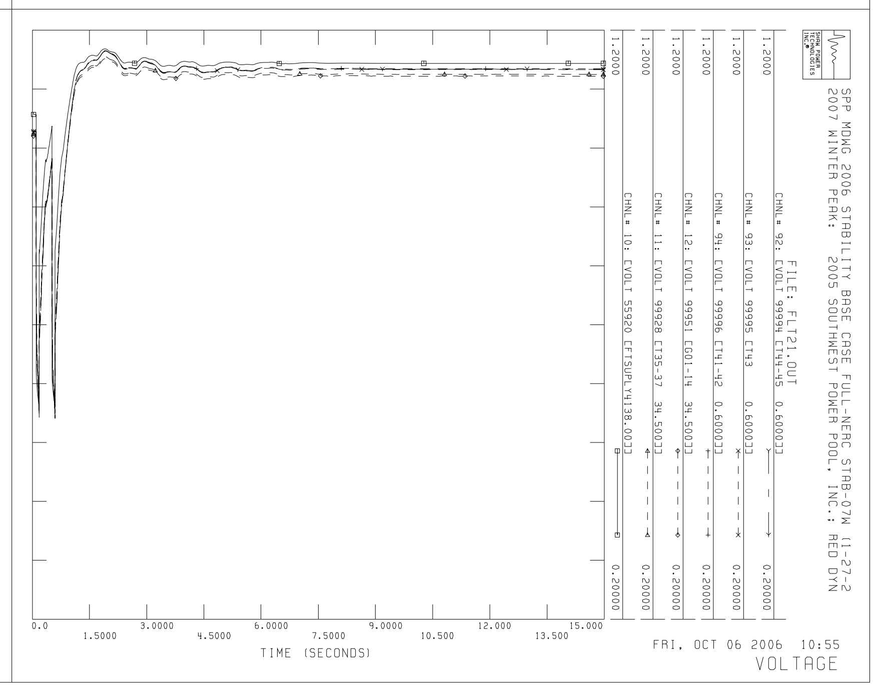

ANGLES
WF POWER
WF SPEED
VOLTAGE
TIME (SECONDS)
FRI, OCT 06 2006 11:07


SPP MDWG 2006 STABILITY BASE CASE FULL-NERC STAB-07W (1-27-2
2007 WINTER PEAK: 2005 SOUTHWEST POWER POOL, INC.; RED DYN
FILE: FLT13.OUT
CHNL# 117: [ANGL 55997 [MORLND2 18.000] [1]]
CHNL# 116: [ANGL 55996 [MORLND1 13.800] [1]]
CHNL# 113: [ANGL 55812 [ANADRK5 13.800] [1]]
CHNL# 112: [ANGL 55811 [ANADRK4 13.800] [1]]
CHNL# 96: [ANGL 54806 [SOONER2G20.000] [1]]
TIME (SECONDS)
FRI, OCT 06 2006 10:55
ANGLES


SPP MDWG 2006 STABILITY BASE CASE FULL-NERC STAB-07W (1-27-2
2007 WINTER PEAK: 2005 SOUTHWEST POWER POOL, INC.; RED DYN
FILE: FLT13.OUT
CHNL# 40: [POWR 99996 [T41-42 0.6000] [1]]
CHNL# 39: [POWR 99995 [T43 0.6000] [1]]
CHNL# 38: [POWR 99994 [T44-45 0.6000] [1]]
CHNL# 15: [POWR 99971 [T28 0.6000] [1]]
CHNL# 14: [POWR 99970 [T29 0.6000] [1]]
CHNL# 8: [POWR 99950 TO 55920 CKT 1]
TIME (SECONDS)
FRI, OCT 06 2006 10:55
WF POWER


SPP MDWG 2006 STABILITY BASE CASE FULL-NERC STAB-07W (1-27-2
2007 WINTER PEAK: 2005 SOUTHWEST POWER POOL, INC.; RED DYN
FILE: FLT13.OUT
CHNL# 67: [SPD 99996 [T41-42 0.6000] [1]]
CHNL# 66: [SPD 99995 [T43 0.6000] [1]]
CHNL# 65: [SPD 99994 [T44-45 0.6000] [1]]
CHNL# 43: [SPD 99972 [T27 0.6000] [1]]
CHNL# 42: [SPD 99971 [T28 0.6000] [1]]
CHNL# 41: [SPD 99970 [T29 0.6000] [1]]
TIME (SECONDS)
FRI, OCT 06 2006 10:55
WF SPEED


SPP MDWG 2006 STABILITY BASE CASE FULL-NERC STAB-07W (1-27-2
2007 WINTER PEAK: 2005 SOUTHWEST POWER POOL, INC.; RED DYN
FILE: FLT13.OUT
CHNL# 92: [VOLT 99994 [T44-45 0.6000]]
CHNL# 93: [VOLT 99995 [T43 0.6000]]
CHNL# 94: [VOLT 99996 [T41-42 0.6000]]
CHNL# 12: [VOLT 99951 [G01-14 34.500]]
CHNL# 11: [VOLT 99928 [T35-37 34.500]]
CHNL# 10: [VOLT 55920 [FTSUPLY4138.00]]
TIME (SECONDS)
FRI, OCT 06 2006 10:55
VOLTAGE


SPP MDWG 2006 STABILITY BASE CASE FULL-NERC STAB-07W (1-27-2
2007 WINTER PEAK: 2005 SOUTHWEST POWER POOL, INC.; RED DYN
FILE: FLT21.OUT
CHNL# 117: [ANGL 55997 [MORLND2 18.000] [1]]
CHNL# 116: [ANGL 55996 [MORLND1 13.800] [1]]
CHNL# 113: [ANGL 55812 [ANADRK5 13.800] [1]]
CHNL# 112: [ANGL 55811 [ANADRK4 13.800] [1]]
CHNL# 96: [ANGL 54806 [SOONER2G20.000] [1]]
TIME (SECONDS)
FRI, OCT 06 2006 10:55
ANGLES

SPP MDWG 2006 STABILITY BASE CASE FULL-NERC STAB-07W (1-27-2
2007 WINTER PEAK: 2005 SOUTHWEST POWER POOL, INC.; RED DYN
FILE: FLT21.OUT
CHNL# 40: [POWR 99996 [T41-42 0.6000] [1]]
CHNL# 39: [POWR 99995 [T43 0.6000] [1]]
CHNL# 38: [POWR 99994 [T44-45 0.6000] [1]]
CHNL# 15: [POWR 99971 [T28 0.6000] [1]]
CHNL# 14: [POWR 99970 [T29 0.6000] [1]]
CHNL# 8: [POWR 99950 TO 55920 CKT 1]
TIME (SECONDS)
FRI, OCT 06 2006 10:55
WF POWER

SPP MDWG 2006 STABILITY BASE CASE FULL-NERC STAB-07W (1-27-2
2007 WINTER PEAK: 2005 SOUTHWEST POWER POOL, INC.; RED DYN
FILE: FLT21.OUT
CHNL# 67: [SPD 99996 [T41-42 0.6000] [1]]
CHNL# 66: [SPD 99995 [T43 0.6000] [1]]
CHNL# 65: [SPD 99994 [T44-45 0.6000] [1]]
CHNL# 43: [SPD 99972 [T27 0.6000] [1]]
CHNL# 42: [SPD 99971 [T28 0.6000] [1]]
CHNL# 41: [SPD 99970 [T29 0.6000] [1]]
TIME (SECONDS)
FRI, OCT 06 2006 10:55
WF SPEED

SPP MDWG 2006 STABILITY BASE CASE FULL-NERC STAB-07W (1-27-2
2007 WINTER PEAK: 2005 SOUTHWEST POWER POOL, INC.; RED DYN
FILE: FLT21.OUT
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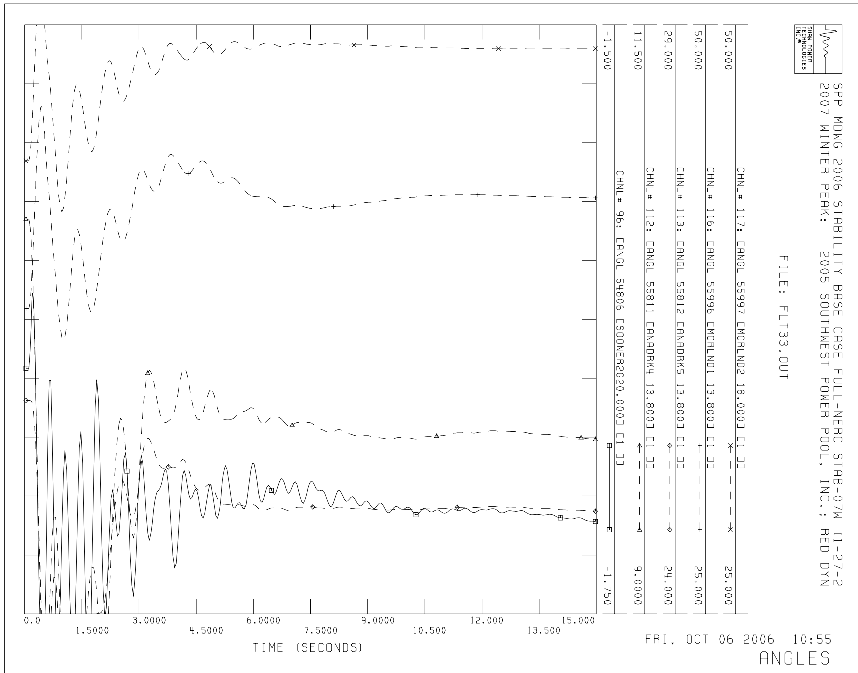
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2007 WINTER PEAK: 2005 SOUTHWEST POWER POOL, INC.; RED DYN
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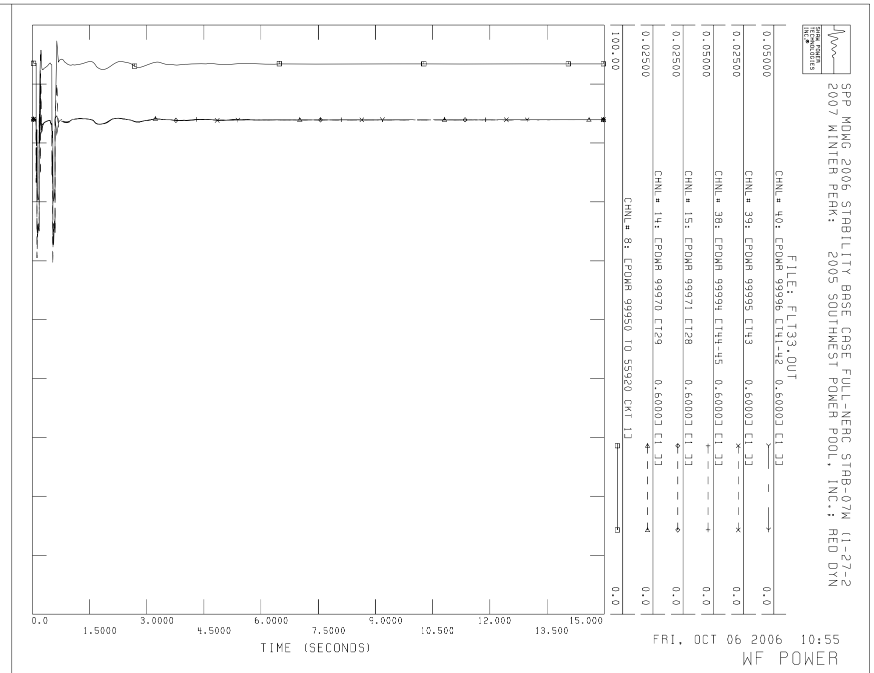
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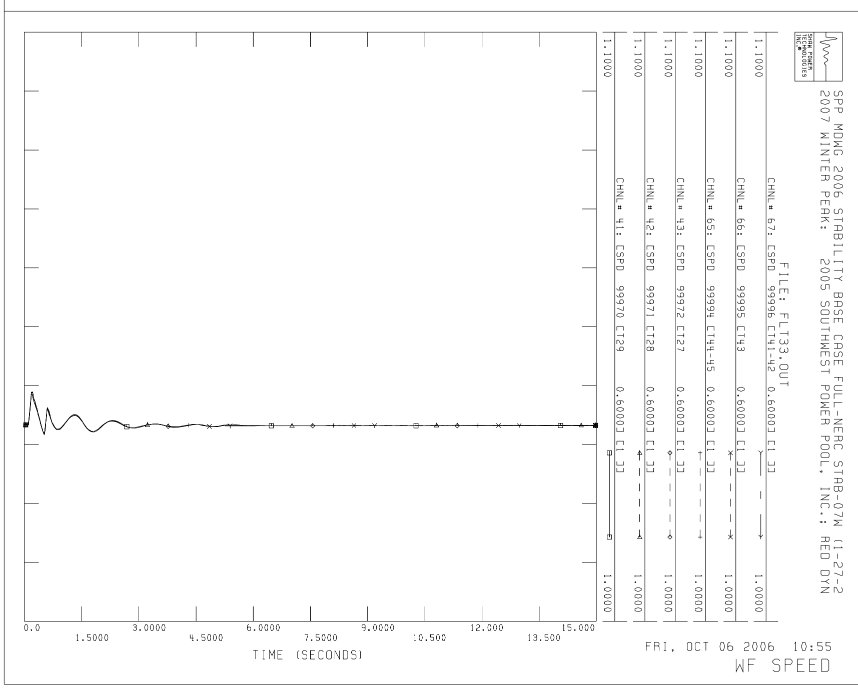
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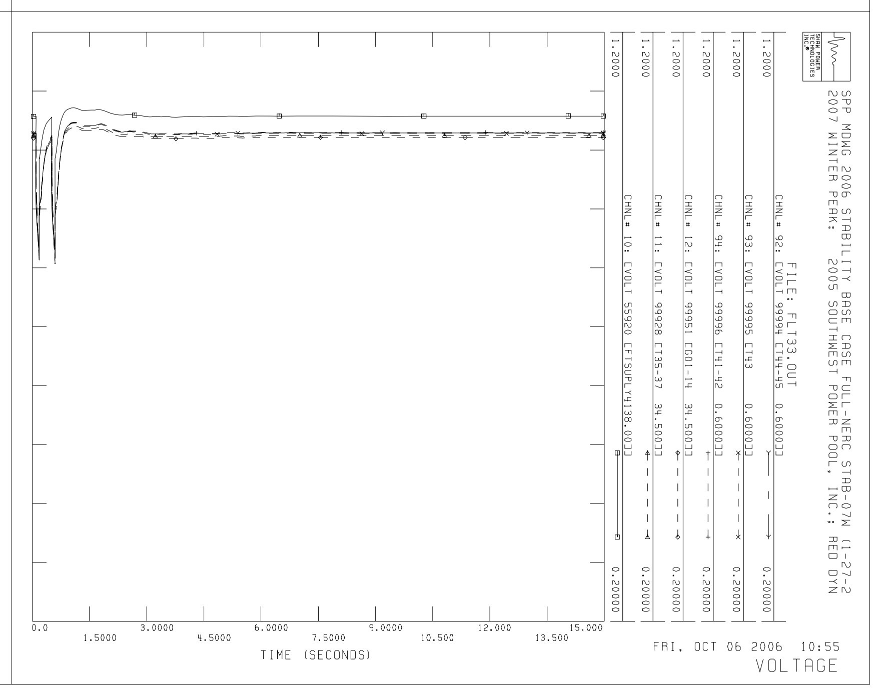
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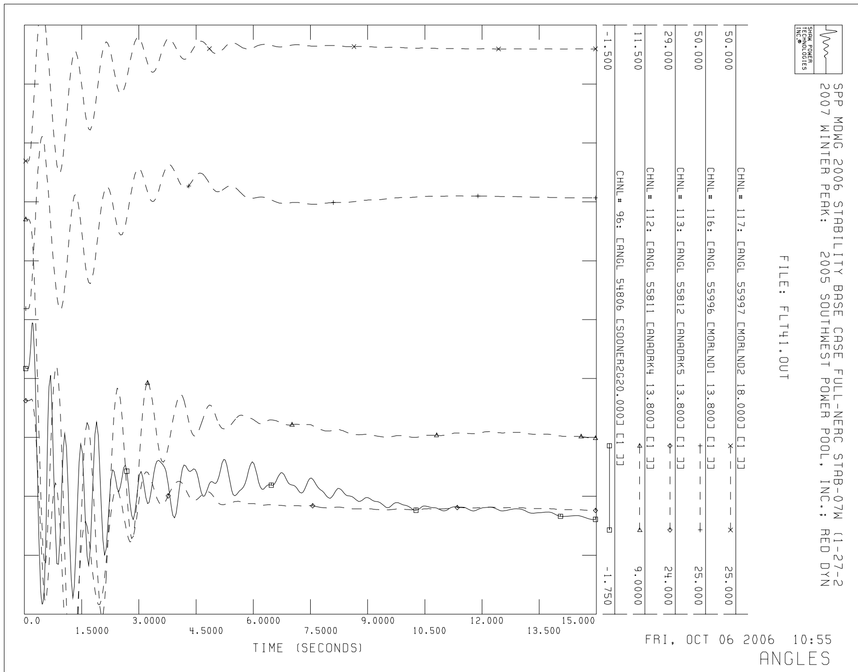
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CHNL# 116: [ANGL 55996 [MORLND1 13.800] [1]]
CHNL# 113: [ANGL 55812 [ANADRK5 13.800] [1]]
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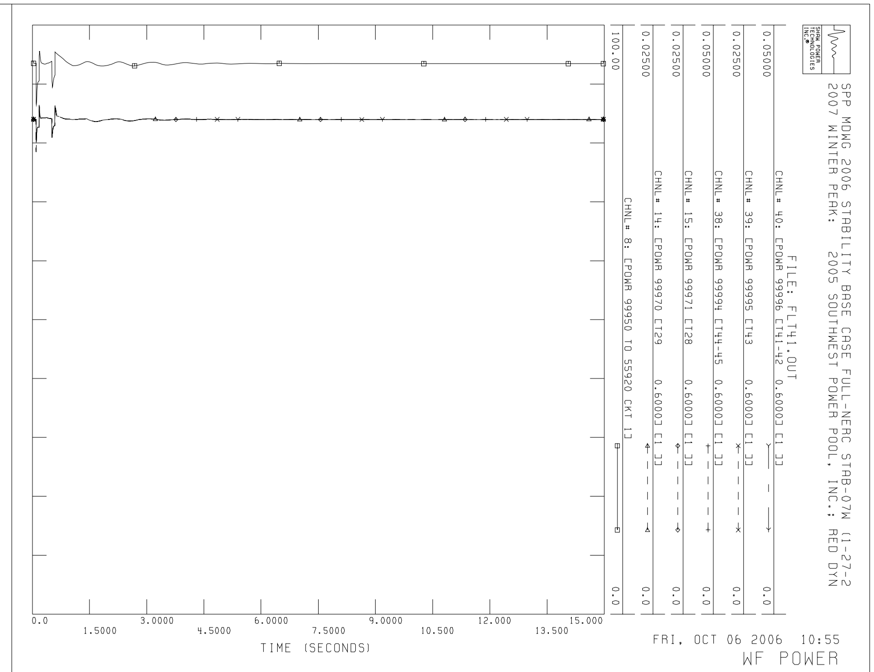
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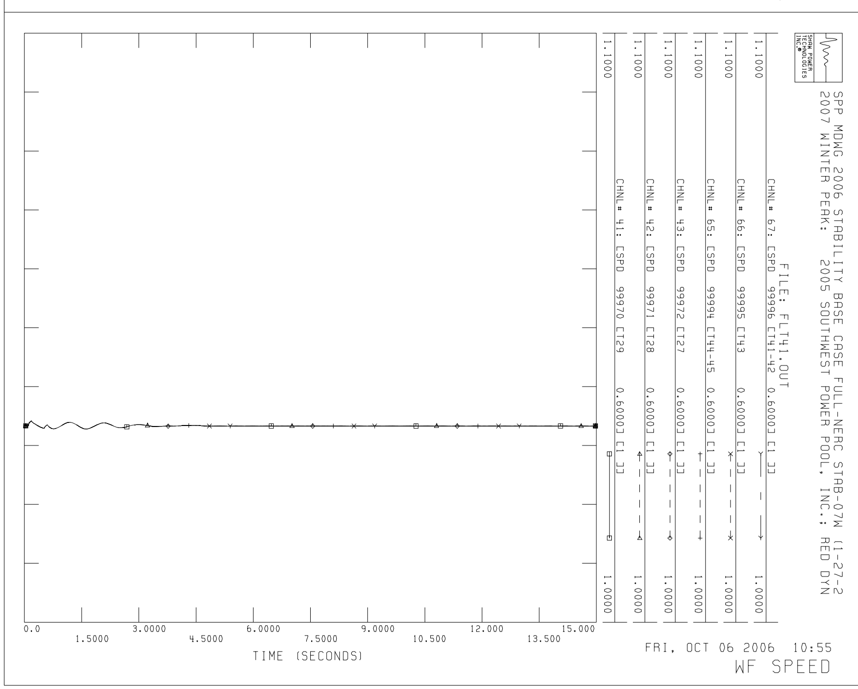
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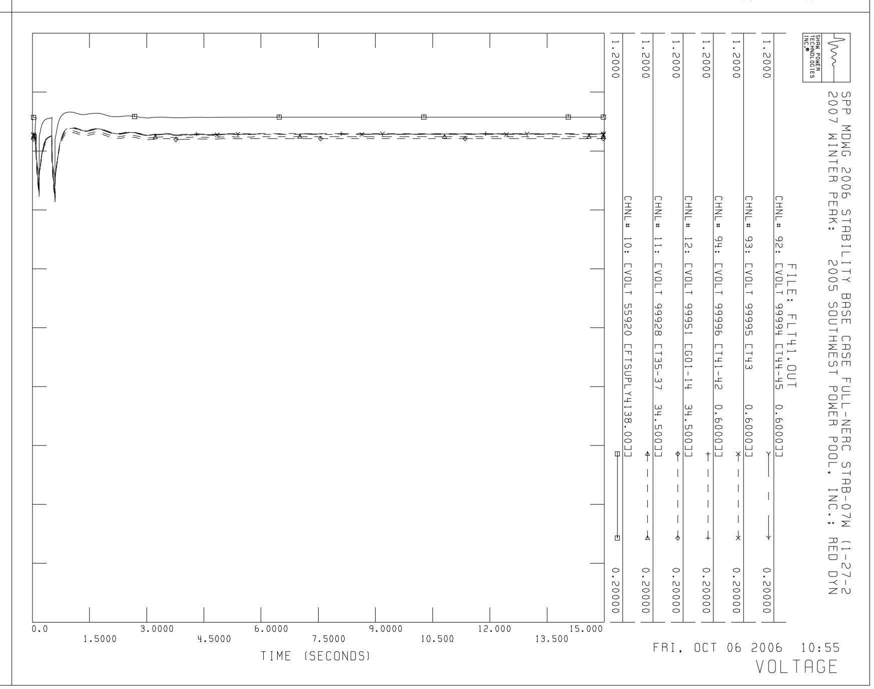
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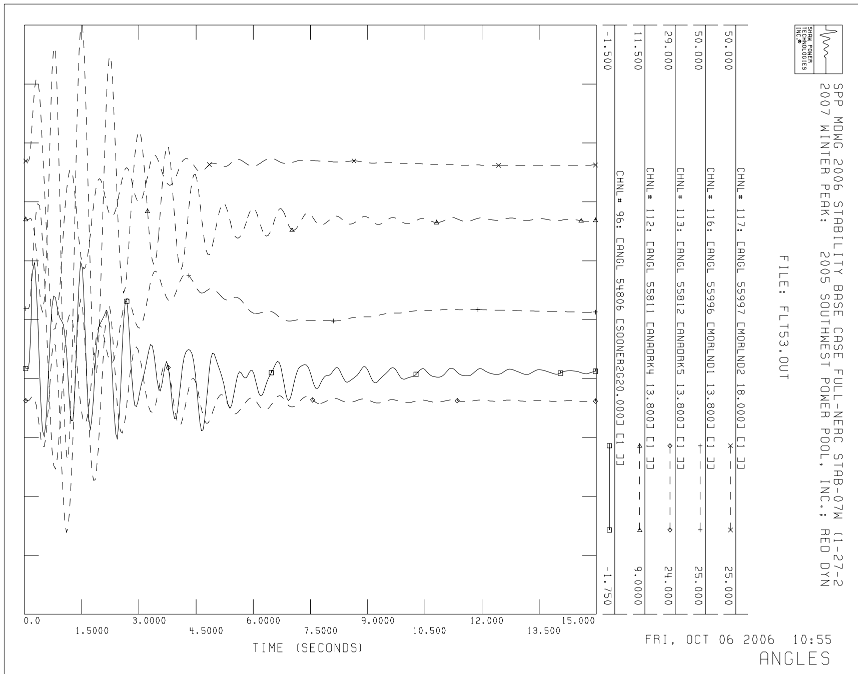
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CHNL# 116: [ANGL 55996 [MORLND1 13.800] [1]]
CHNL# 113: [ANGL 55812 [ANADRK5 13.800] [1]]
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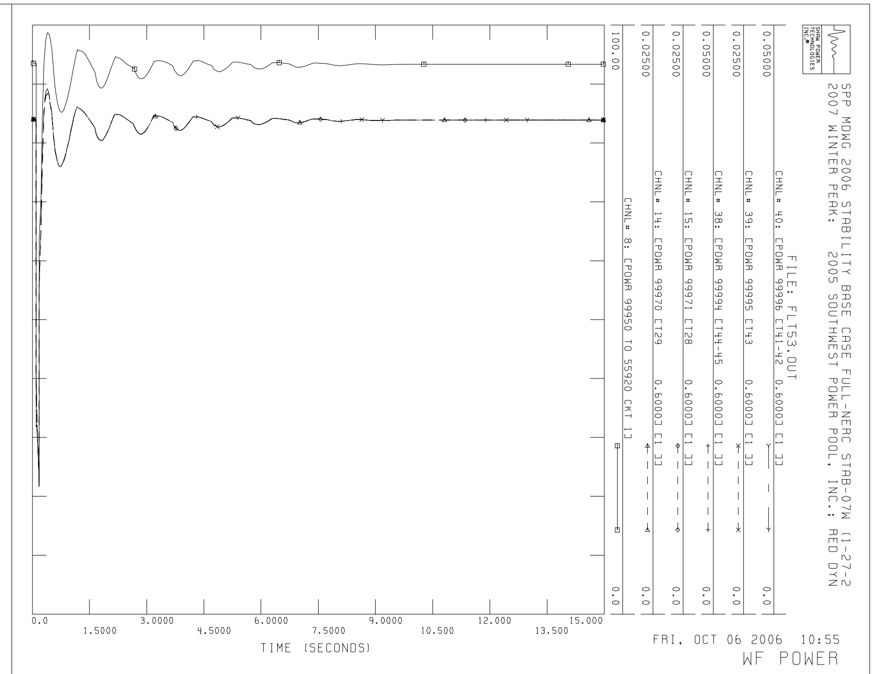
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CHNL# 15: [POWR 99971 [T28 0.6000] [1]]
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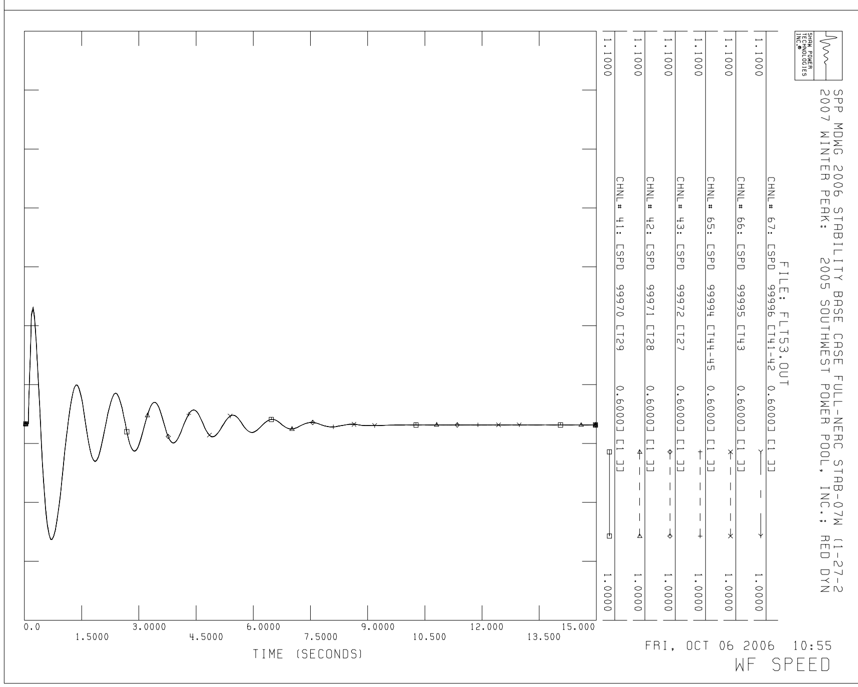
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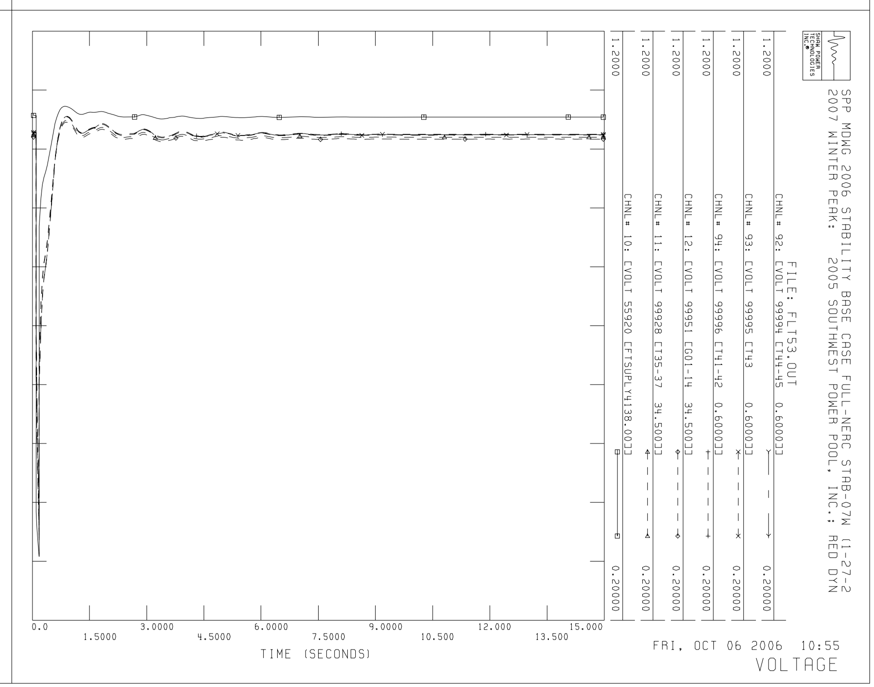
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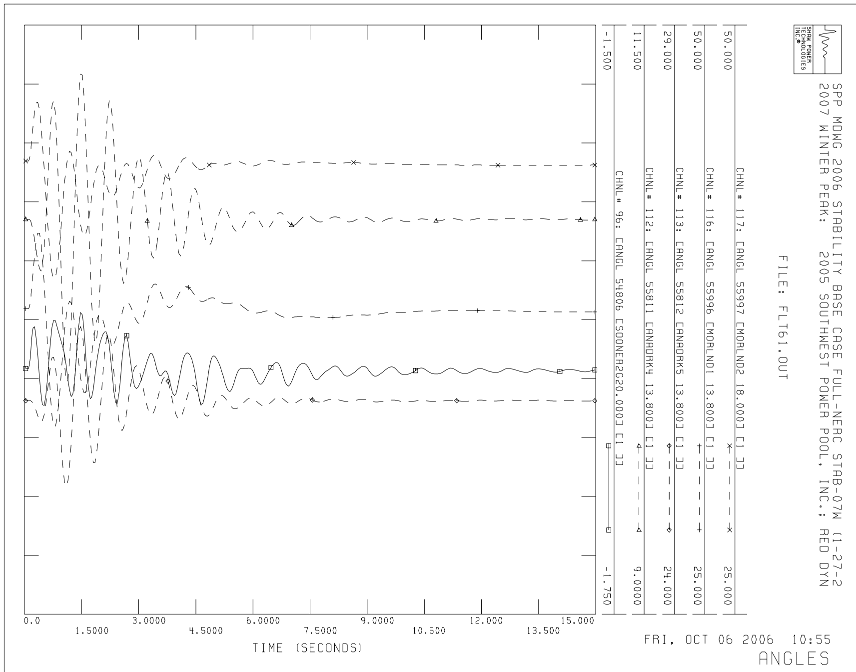
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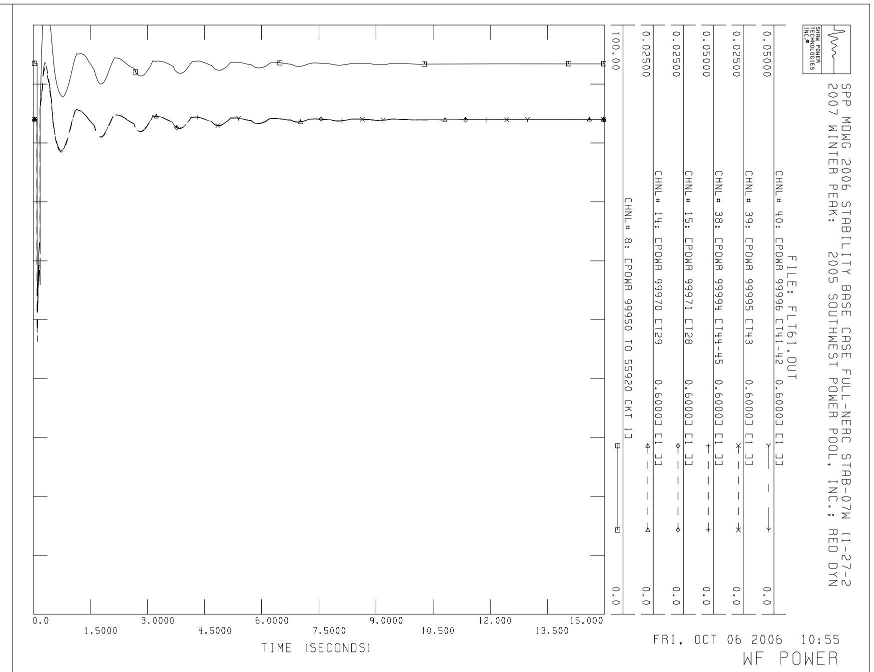
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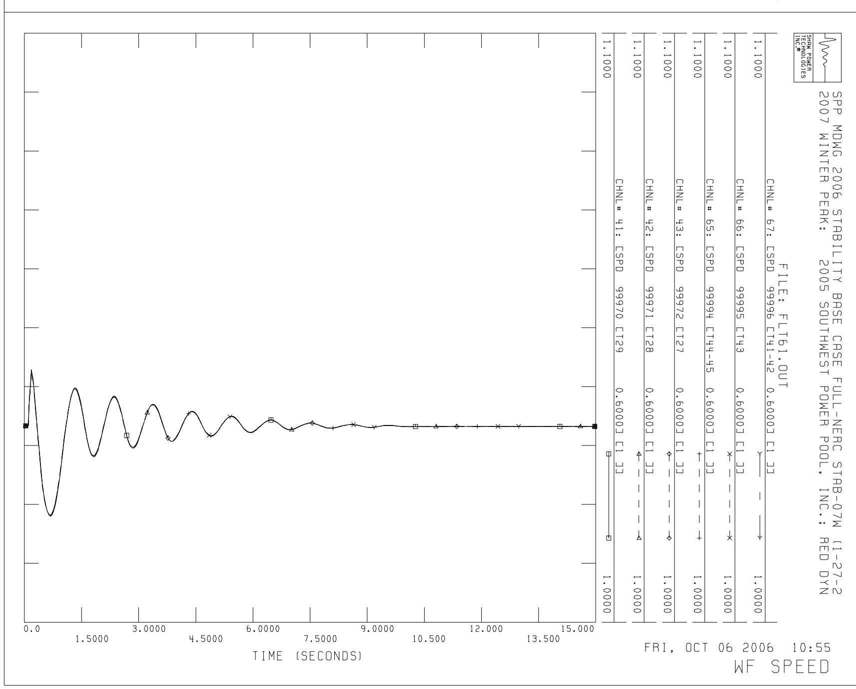
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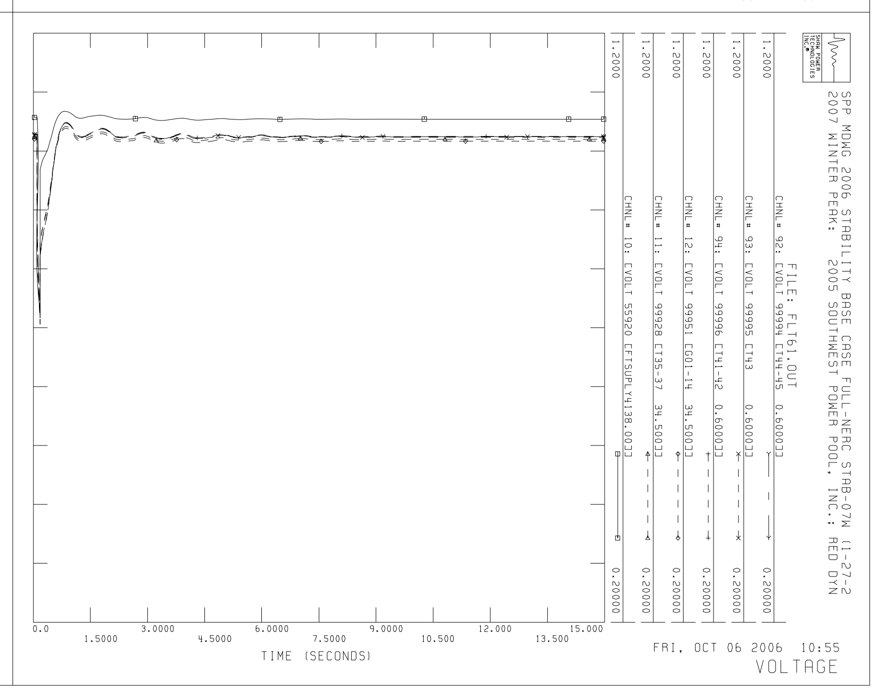
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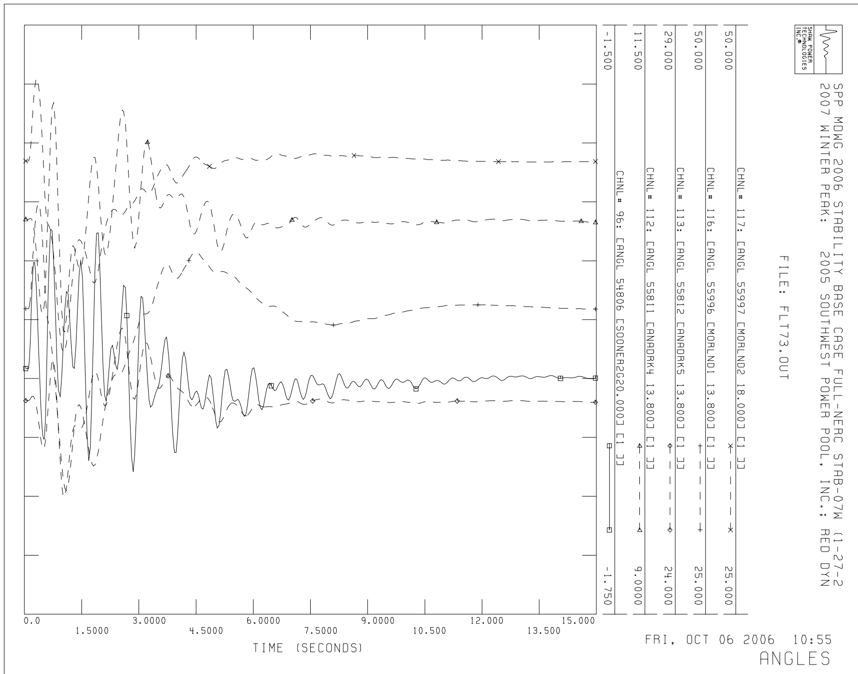
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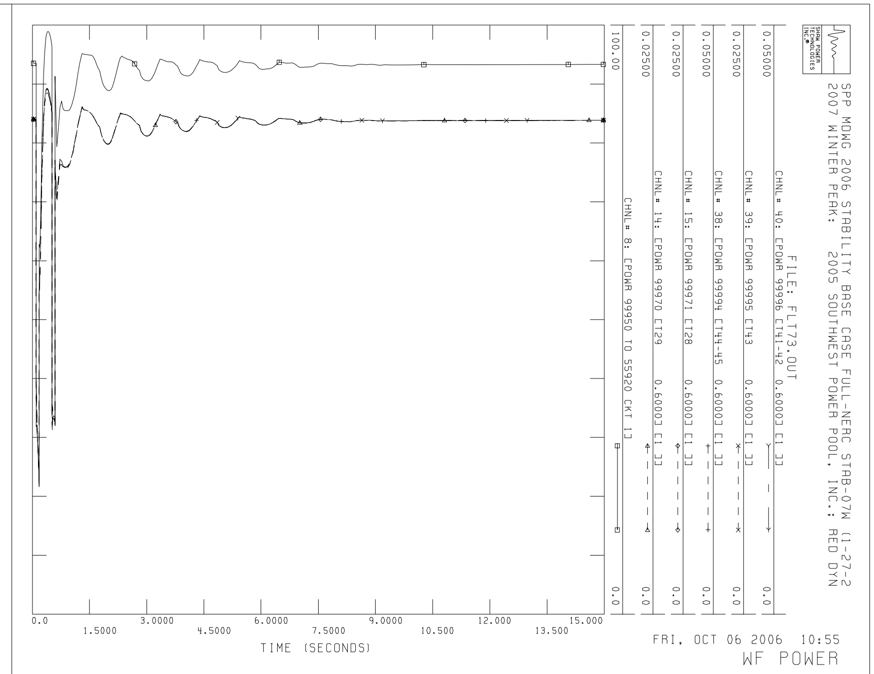
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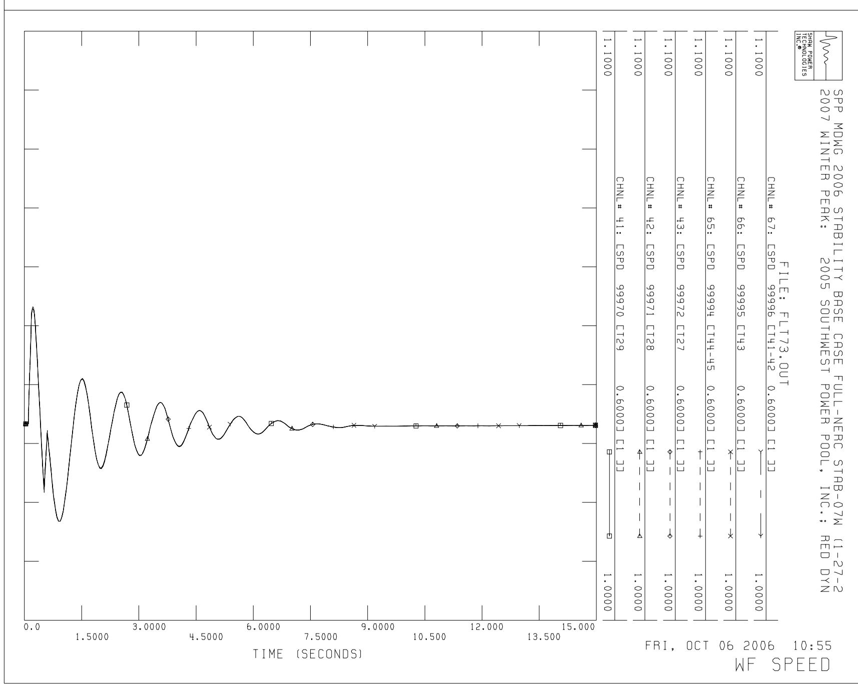
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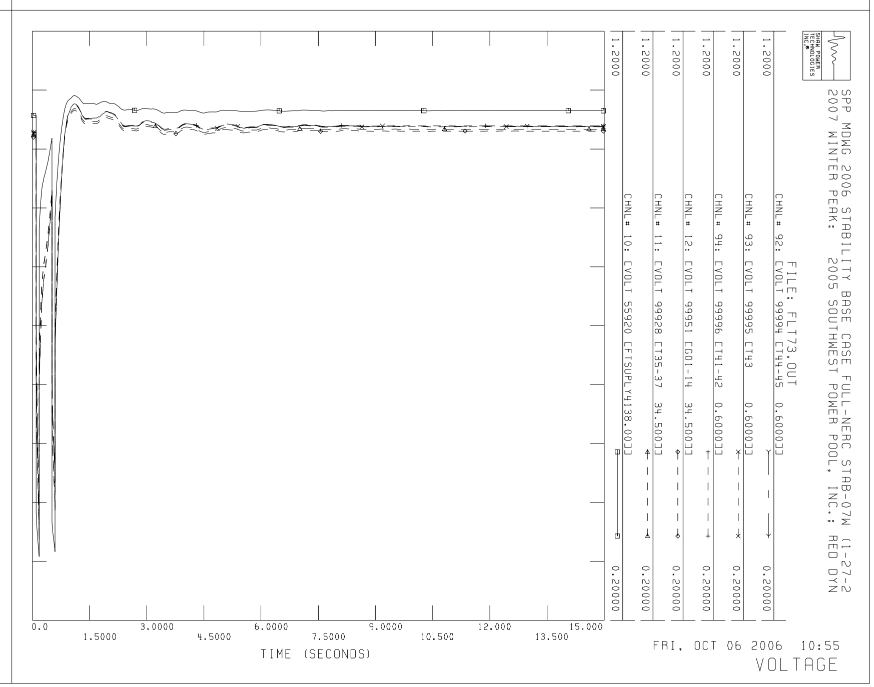
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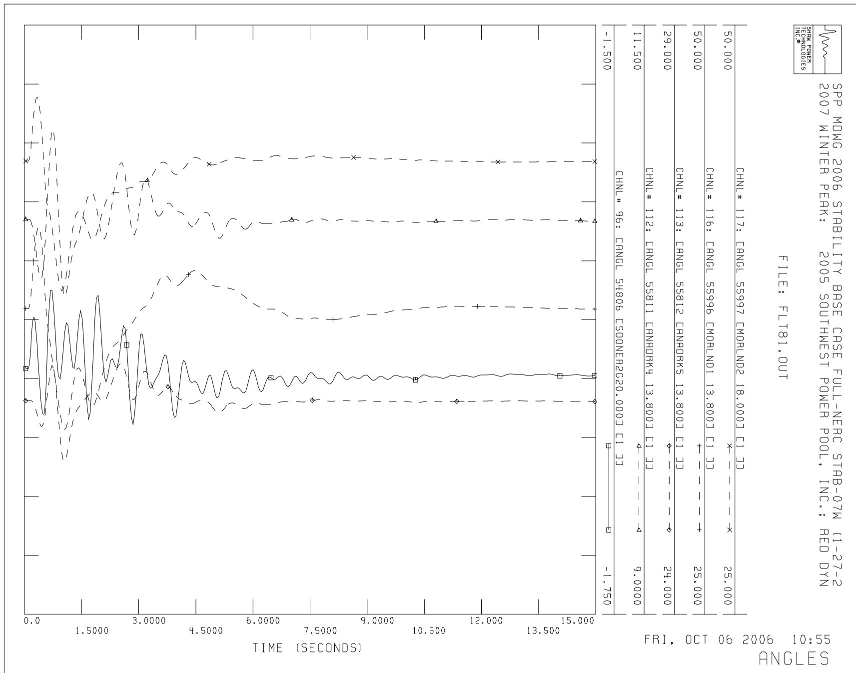
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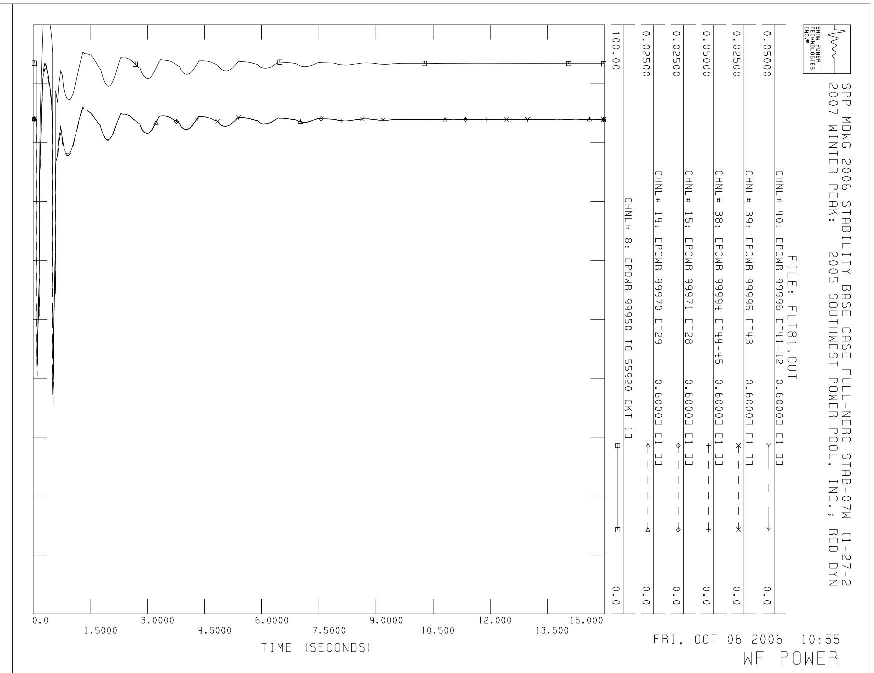
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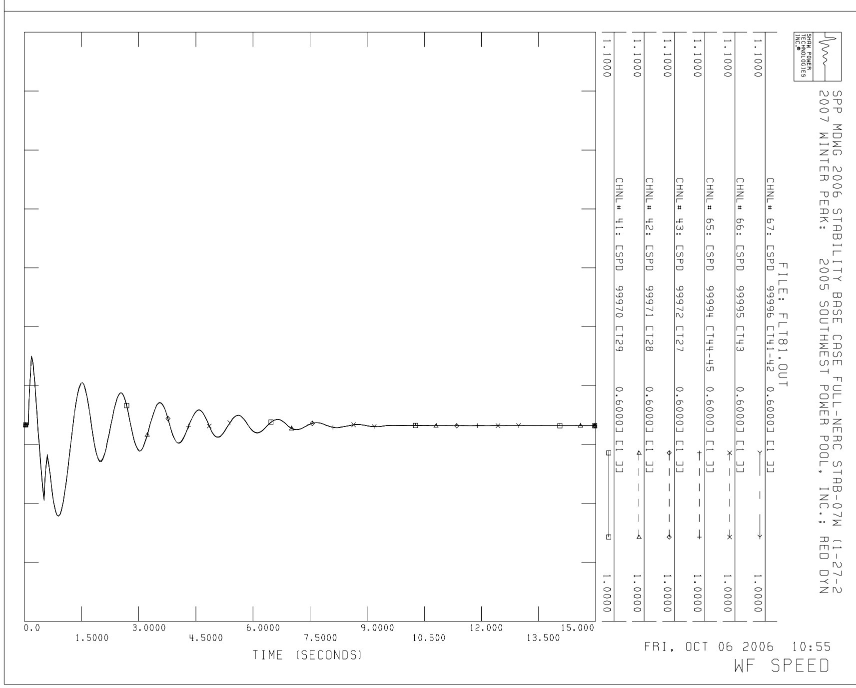
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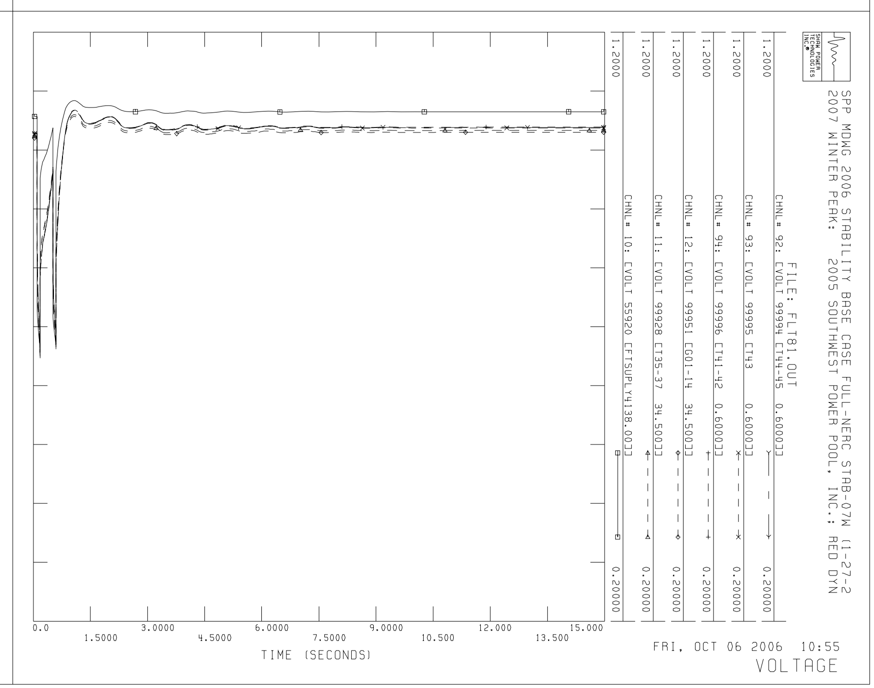
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TIME (SECONDS)
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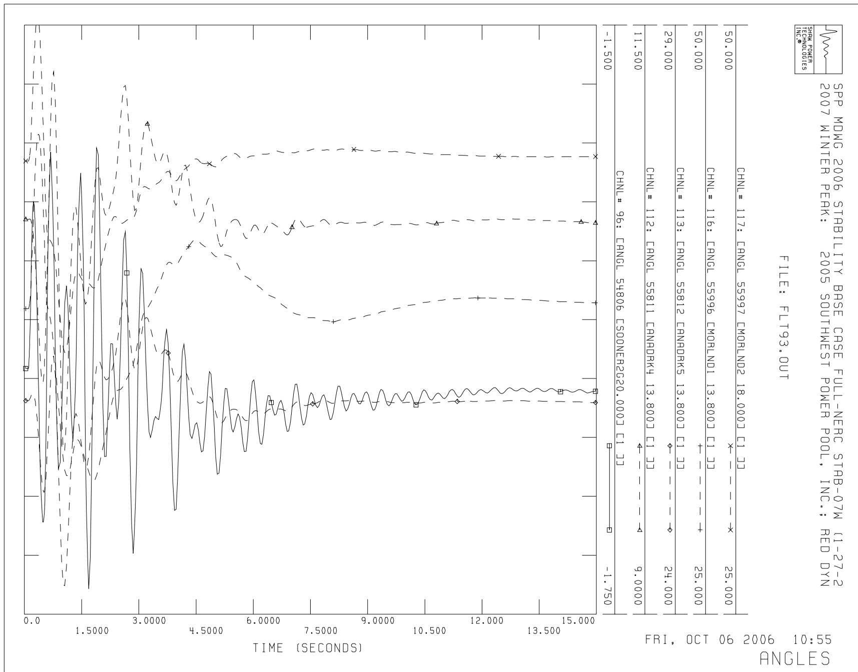
VOLTAGE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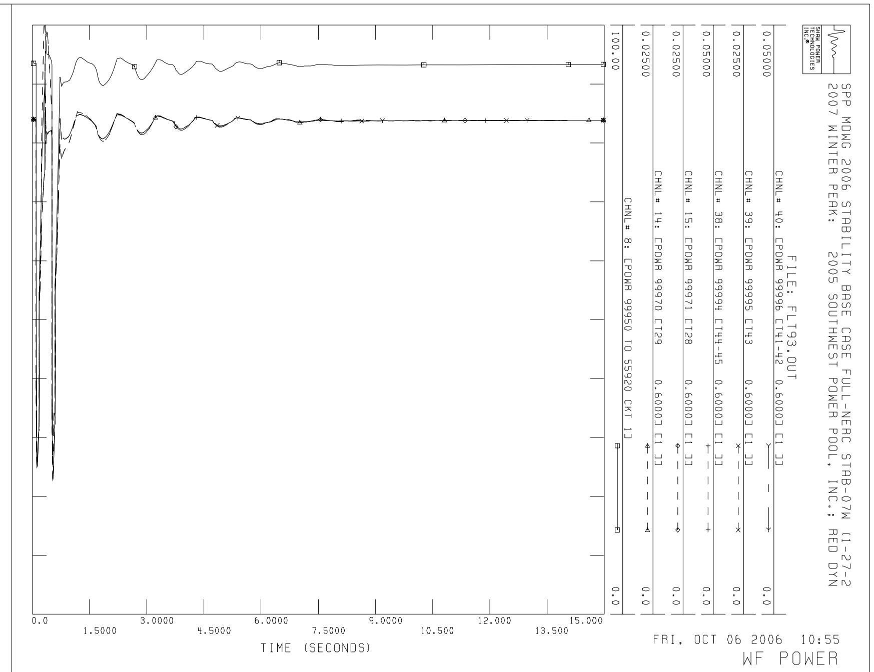
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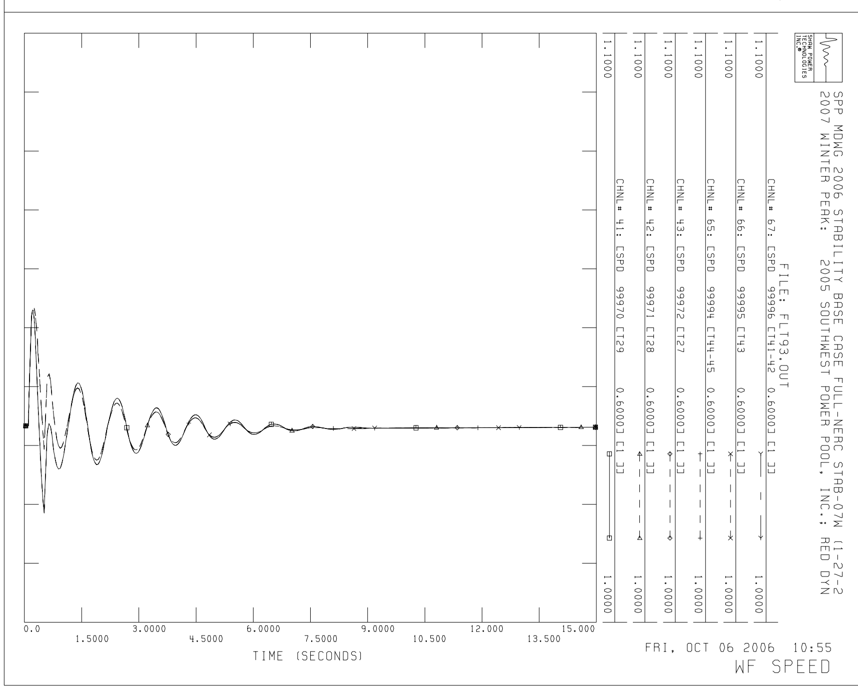
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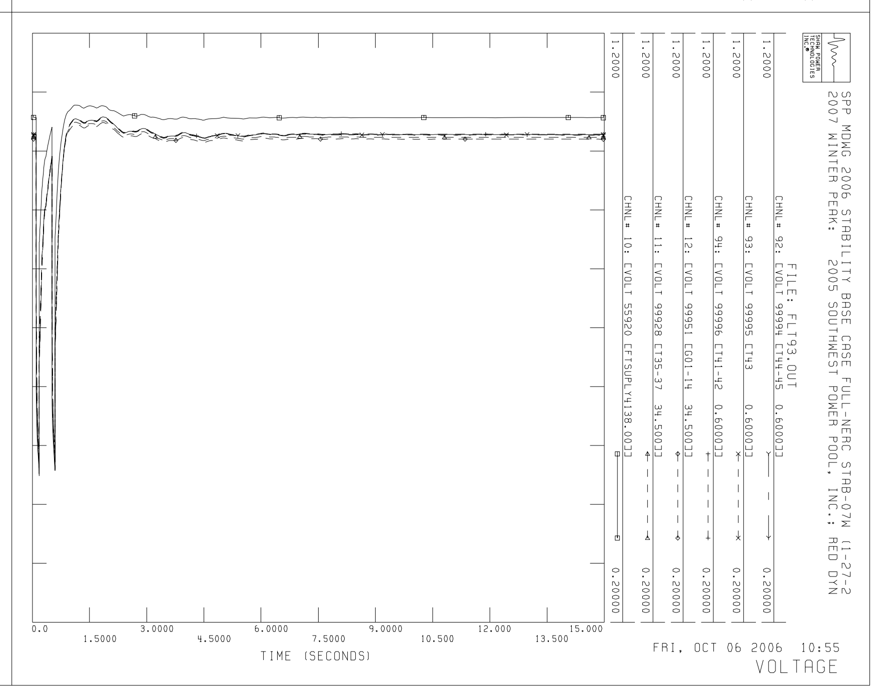
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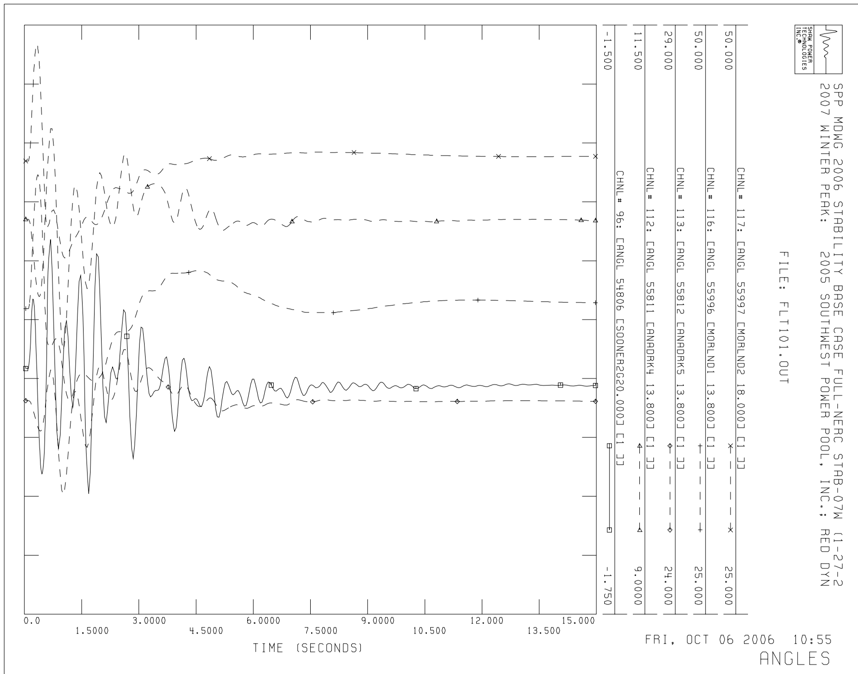
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2007 WINTER PEAK: 2005 SOUTHWEST POWER POOL, INC.; RED DYN
FILE: FLT101.OUT
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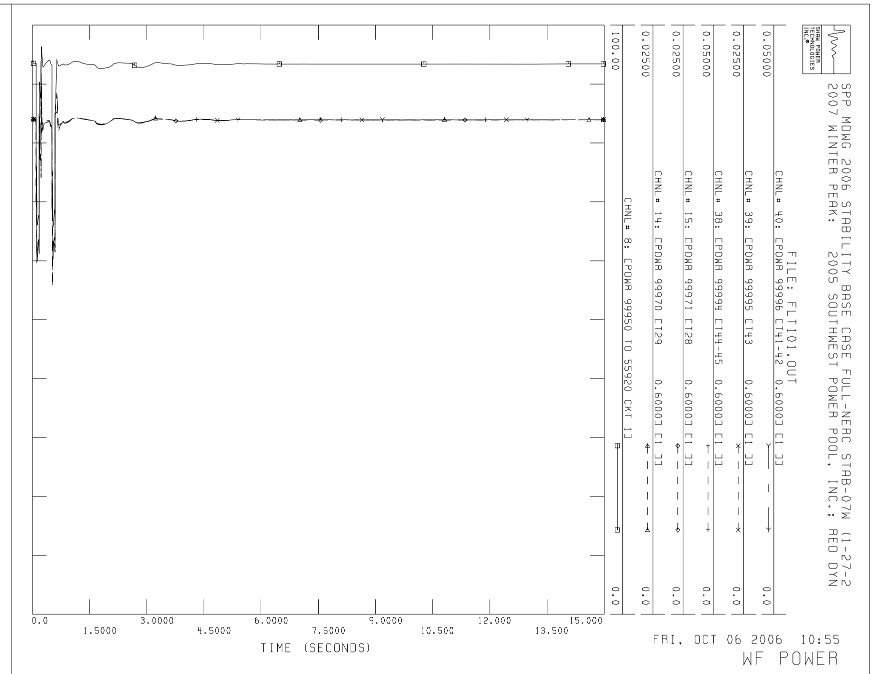
ANGLES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2007 WINTER PEAK: 2005 SOUTHWEST POWER POOL, INC.; RED DYN
FILE: FLT101.OUT
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CHNL# 39: [POWR 99995 [T43 0.6000] [1]]
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CHNL# 15: [POWR 99971 [T28 0.6000] [1]]
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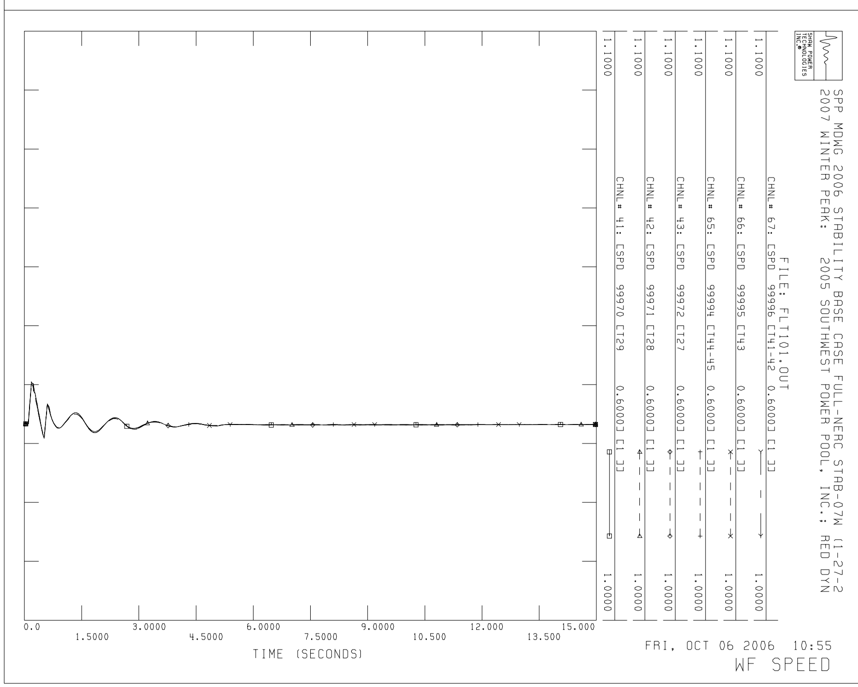
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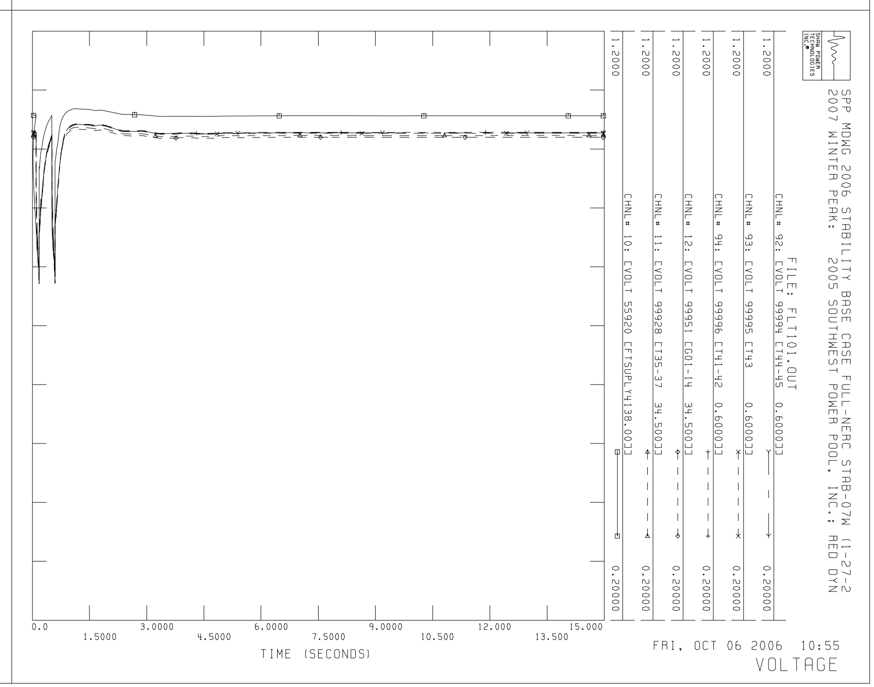
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2007 WINTER PEAK: 2005 SOUTHWEST POWER POOL, INC.; RED DYN
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CHNL# 93: [VOLT 99995 [T43 0.6000]]
CHNL# 94: [VOLT 99996 [T41-42 0.6000]]
CHNL# 12: [VOLT 99951 [G01-14 34.500]]
CHNL# 11: [VOLT 99928 [T35-37 34.500]]
CHNL# 10: [VOLT 55920 [FTSUPLY4138.00]]
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VOLTAGE