Southwest Power Pool

Impact Study For Generation Interconnection Request GEN-2006-027

SPP Tariff Studies

(#GEN-2006-027)

February, 2007

Executive Summary

<OMITTED TEXT> (Customer) has requested an Impact Study under the Southwest Power Pool Open Access Transmission Tariff (OATT) for interconnecting a 310MW(summer) / 380MW(winter) gas turbine generating facility in Lyon County, Kansas to the transmission system of Westar Energy. The generation facility studied was comprised of four GE LM6000 combustion turbines and one GE 7FA combustion turbine. The requested in-service date for the facility is May 1, 2008.

The generation facility will interconnect into a new switching station to be located near the existing Lang substation. The new station will have a 345kV bus built in a breaker-and-a-half configuration. The bus will have three GSU terminals and four line terminals to Morris County, Swissvale, Wichita, and Lang. The existing lines currently terminated at Lang will be terminated into the new substation. This substation facility and line work is estimated to cost $23,298,275. This facility description and cost will be prepared in greater detail when and if the Customer chooses to execute a Facility Study Agreement.

Stability Study results show that the addition of the studied generation does not degrade transmission system stability for the contingencies studied.

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 310MW(summer)/380MW(winter) gas turbine generating facility in Lyon County, Kansas to the transmission system of Kansas Gas & Electric Company, an affiliate of Westar. The generation facility studied was comprised of four GE LM6000 combustion turbines and one GE 7FA combustion turbine. The requested in-service date for the facility is May 1, 2008. The generation facility will interconnect into a new station near the existing Lang substation.

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 in the immediate area ahead of this request in the SPP Generation Interconnection queue. It was assumed for purposes of this study that 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 generation interconnection requests 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 that was studied included five combustion turbine generators. The facility included four GE LM6000 combustion turbines with a nominal 40MW(summer)/50MW(winter) rating. There were two 345/13.8kV GSU transformers with two LM6000s on each GSU. The facility also includes a GE 7FA combustion turbine with a nominal 150MW(summer) / 180MW(winter) rating. The 7FA turbine is connected to the 345kV bus via its own 345/18.0kV GSU.

3.2 Interconnection Facility

The Customer has proposed an interconnection facility, which would connect to the Westar Energy transmission system via a new 345kV substation located in Lyon County, Kansas near the existing Westar Lang substation. The new substation will be configured in a breaker-and-a-half configuration to accept terminals from the three GSU transformers, and four line terminals to Morris County, Wichita, Swissvale, and Lang substations.

The total cost for adding a new 345kV switching station, the required interconnection facility is estimated at $23,298,275. This cost does not include the Customer facilities up to the point of interconnection. These estimates will be refind when and if the Customer chooses to execute a Facility Study Agreement and have the SPP and the Transmission Owner conduct the Facility Study. These facility costs are shown in Tables 1 and 2. The one-line diagram for this configuration is shown in Figure 1.

Table 1: Direct Assignment Facilities

Facility	ESTIMATED COST (2006 DOLLARS)
Customer – 345kV-GSU voltage Substation facilities.	*
Customer – 345kV facilities between Customer facilities and Westar 345kV switching station	*
Customer - Right-of-Way for Customer facilities.	*
Total	*****

Note: *Estimates of cost to be determined by Customer.

Table 2: Required Interconnection Network Upgrade Facilities

Facility	ESTIMATED COST (2006 DOLLARS)
Westar – Build 345kV switching station in a breaker-and-a-half configuration. Initial layout of the station to have 345kV circuit breakers, associated switches, steel, relaying and associated equipment. Station to include terminals to the three generators and line terminals to Lang, Swissvale, Wichita, and Morris County substations	$22,798,275
Westar – 345kV transmission work	$500,000
Total	**$23,298,275**

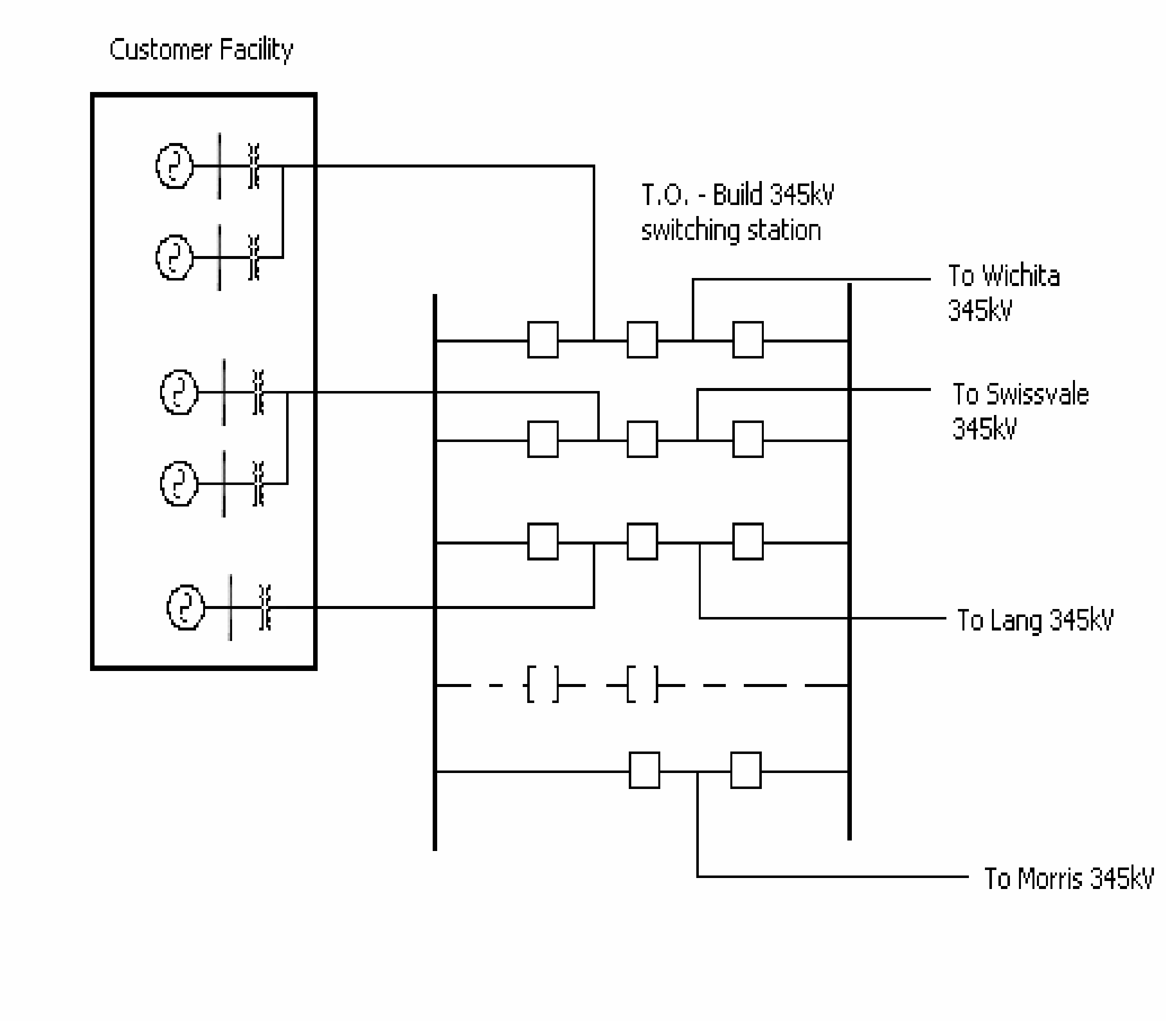

Figure 1: Proposed Interconnection Configuration #1
(Final substation design to be determined in Facility Study)

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-2006-027 generating facility to the Westar 345kV transmission system.

Using Planning Standards approved by NERC, the following stability definition was applied in the Transient Stability Analysis:

“Power system stability is defined as that condition in which the differences of the angular positions of synchronous machine rotors become constant following an aperiodic system disturbance.”

Stability analysis was performed using Siemens-PTI’s PSS/E dynamics program V29. Disturbances such as three-phase and single-phase line faults were simulated for the specified durations, including re-closing, and the synchronous machine rotor angles were monitored to make sure they maintained synchronism following the fault removal.

4.2 Modeling of the Generators for the Stability Simulation

4.2.1 GE LM 6000s

The proposed GEN-2006-027 project is comprised of four GE LM 6000 combustion turbines nominally rated 40MW(summer)/50MW(winter). Two sets of two turbines are each connected to a 345/13.8kV GSU transformer rated 72/120MVA with a 10% impedence on the 72MVA base.

From the information provided by the Customer, the following PTI data sets were compiled and loaded into the SPP stability database for a standard winter case (2007wp) and summer case (2011sp). Minor modifications were made to the data sets provided by the Customer in order to make the dynamic model initialize.

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-----------------------------------------------------------------------------------------------
REPORT FOR ALL MODELS                    BUS 56755 [G06-27 113.800] MODELS

** GENROU **  BUS X-- NAME --X BASEKV MC    C O N S     S T A T E S
       56755     G06-27 1 13.800 1  146026-146039  55671-55676

         MBASE     Z S O R C E        X T R A N      GENTAP
          71.7  0.00000+J 0.18100  0.00000+J 0.00000  1.00000

 T'D0 T''D0  T'Q0 T''Q0     H   DAMP   XD     XQ     X'D        X'Q     X''D    XL
 9.76 0.040  2.95 0.050   1.19 16.00 2.3500 2.1500 0.2450 0.2450 0.1810 0.1300

              S(1.0)  S(1.2)
                0.1380  0.5140

** IEEET2 **  BUS X-- NAME --X BASEKV MC    C O N S     S T A T E S     VAR
         56755     G06-27 1 13.800 1  146096-146109  55701-55705   10414

   TR     KA     TA   VRMAX   VRMIN     KE     TE     KF     TF1    TF2
 0.022 2894.00  0.100 47.000   0.000   1.000  1.200  0.017  0.600  1.200

    E1     S(E1)    E2     S(E2)       KE VAR
 5.6600  2.4400  7.5700  5.2400        0.0000
```

```
** IEESGO **  BUS X-- NAME --X BASEKV MC    C O N S     S T A T E S     VAR
   56755     G06-27 1 13.800 1  146169-146179  55725-55729   10418

     T1    T2     T3    T4    T5    T6    K1    K2    K3   PMAX  PMIN
 7.890 0.010  0.010 0.010  0.10  0.01  20.2  0.00  0.00  1.20  0.50
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```

4.2.2 <u>GE 7FA</u>

The proposed GEN-2006-027 project is comprised of one GE 7FA combustion turbine nominally rated 150MW(summer)/180MW(winter). The combustion turbine is connected to a 345/18.0kV GSU transformer rated 129/215MVA with a 10% impedence on the 129MVA base.

From the information provided by the Customer, the following PTI data sets were compiled and loaded into the SPP stability database for a standard winter case (2007wp) and summer case (2011sp).). Minor modifications were made to the data sets provided by the Customer in order to make the dynamic model initialize.

```
-----------------------------------------------------------------------------------------------
REPORT FOR ALL MODELS                       BUS 56757 [G06-27 318.000] MODELS


** GENROU **  BUS X-- NAME --X BASEKV MC    C O N S     S T A T E S
        56757     G06-27 3 18.000 1  146082-146095  55695-55700

        MBASE     Z S O R C E        X T R A N      GENTAP
        222.0  0.00000+J 0.18500  0.00000+J 0.00000  1.00000

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                    S(1.0)  S(1.2)
                    0.0560  0.5400

** ESST4B **  BUS X-- NAME --X BASEKV MC    C O N S     S T A T E S
        56757     G06-27 3 18.000 1  146152-146168  55721-55724

   TR    KPR     KIR    VRMAX    VRMIN    TA     KPM     KIM    VMMAX   VMMIN
 0.000   3.570   3.570   1.000  -0.870   0.010   1.000   0.000   1.000  -0.870

        KG      KP      KI   VBMAX     KC      XL    THETAP
      0.000   5.600   0.000   7.000   0.170  0.0000   0.000

** GAST2A **  BUS X-- NAME --X BASEKV MC    C O N S     S T A T E S     V A R S
        56757     G06-27 3 18.000 1  146213-146243  55745-55757   10422-10425

   W      X     Y     Z    ETD    TCD    TRATE    T    MAX    MIN   ECR   K3
 20.00 0.000 0.050  1.00  0.020  0.100  173.00  0.25  1.07   0.25  0.010 0.770

    A     B     C    TF     KF     K5     K4      T3     T4     TT    T5
  1.00  0.05  1.00  0.40  0.000  0.000  0.800   15.00  2.500  450.0  3.30

           AF1    BF1    AF2    BF2    CF2      TR      K6       TC
          700.0  550.0 -0.299  1.300  0.500  955.0  0.230  955.0
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```

4.3 Initializing the Model

The information from Section 4.2 along with generator information from the prior queued projects was loaded into the SPP dynamics database and the SPP dynamics powerflow models for each season. The models were initialized and simulated a no-disturbance run for 20 seconds.

4.4 Contingencies Simulated

Twenty-two (22) 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 3.

Table 3. Contingencies Evaluated

Cont. No.	Cont. Name	Description
1	FLT13PH	3 phase fault on the Lang (56769) to Swissvale (56774) 345 kV line, near Lang. a. Apply fault at the Lang bus. b. Clear fault after 5 cycles by tripping the line from Lang - Swissvale. 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 Lang (56769) to Morris County (56770) 345 kV line, near Lang. a. Apply fault at the Lang bus. b. Clear fault after 5 cycles by tripping the line from Lang – Morris County. 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 Lang (56769) to Wichita (56796) 345 kV line, near Lang. a. Apply fault at the Lang bus. b. Clear fault after 5 cycles by tripping the line from Lang-Wichita. 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	FLT61PH	*Single phase fault and sequence like Cont. No. 5*
7	FLT73PH	3 phase fault on the Swissvale (56774) to Stilwell (57968) 345 kV line, near Swissvale. a. Apply fault at the Swissvale bus. b. Clear fault after 5 cycles by tripping the line from Swissvale-Stilwell. 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 JEC N (56766) to Hoyt (56765) 345 kV line, near JEC N. a. Apply fault at the JEC N bus. b. Clear fault after 5 cycles by tripping the line from JEC N-Hoyt. 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. 9*
11	FLT113PH	3 phase fault on the Benton (56791) to Wolf Creek (56797) 345 kV line, near Benton. a. Apply fault at the Benton bus.

Cont. No.	Cont. Name	Description
		b. Clear fault after 5 cycles by tripping the line from Benton-Wolf Creek. 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	FLT121PH	*Single phase fault and sequence like Cont. No.11*
13	FLT133PH	3 phase fault on the Morris County (56863) to Swissvale (56856) 230 kV line, near Morris County. a. Apply fault at the Morris County bus. b. Clear fault after 5 cycles by tripping the line from Morris County-Swissvale. 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.
14	FLT141PH	*Single phase fault and sequence like Cont. No.13*
15	FLT153PH	3 phase fault on the Lang (57304) to East Street (57301) 115 kV line, near Lang. a. Apply fault at the Lang bus. b. Clear fault after 5 cycles by tripping the line from Lang-East Street. 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	FLT161PH	*Single phase fault and sequence like Cont. No.15*
17	FLT173PH	3 phase fault on the Lang (57304) to Reading (57306) 115 kV line, near Lang. a. Apply fault at the Lang bus. b. Clear fault after 5 cycles by tripping the line from Lang-Reading. 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	FLT181PH	*Single phase fault and sequence like Cont. No.17*
19	FLT193PH	3 phase fault on the Lang (57304) to Prairie (57307) 115 kV line, near Lang. a. Apply fault at the Lang bus. b. Clear fault after 5 cycles by tripping the line from Lang-Prairie. 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	FLT201PH	*Single phase fault and sequence like Cont. No.19*
21	FLT213PH	3 phase fault on the Lang autotransformer (56769-57304) on the 345 kV bus. a. Apply fault at the Lang 345 kV bus. b. Clear fault after 5 cycles by tripping the autotransformer.
22	FLT223PH	*Single phase fault and sequence like Cont. No.21*

4.5 Results

Results are summarized in Table 4. The results indicate that for all contingencies, except FLT93PH, the transmission system remains stable.

It was determined that the JEC-Hoyt 345kV line outage was also an unstable contingency in the base case. Therefore, this instability was not caused by the addition of the GEN-2006-027 study plant. The simulation was run again including tripping off of JEC #2 immediately after locking out the line, which is the proposed mitigation for this contingency. The result was a stable system.

Table 4. SUMMARY OF FAULT SIMULATION RESULTS

FAULT	FAULT DEFINITION	2011 SP	2007 WP
FLT13PH	Three phase fault on the Lang to Swissvale 345kV line, near Lang	STABLE	STABLE
FLT21PH	Single phase fault same as above	STABLE	STABLE
FLT33PH	Three phase fault on the Lang to Morris County 345kV line near Lang.	STABLE	STABLE
FLT41PH	Single phase fault same as above	STABLE	STABLE
FLT53PH	Three phase fault on the Lang to Wichita 345kV line near Lang.	STABLE	STABLE
FLT61PH	Single phase fault same as above	STABLE	STABLE
FLT73PH	Three phase fault on the Swissvale to Stillwell 345kV line near Swissvale.	STABLE	STABLE
FLT81PH	Single phase fault same as above	STABLE	STABLE
FLT93PH	Three phase fault on the Jeffrey Energy Center-Hoyt 345kV line near Jeffrey	STABLE	UNSTABLE
FLT93PH_trip JEC #2	Three phase fault on the Jeffrey Energy Center-Hoyt 345kV line near Jeffrey; trip off JEC #2	n/a	STABLE
FLT101PH	Single phase fault same as above	STABLE	STABLE
FLT113PH	Three phase fault on the Benton to Wolf Creek 345kV line near Benton.	STABLE	STABLE
FLT121PH	Single phase fault same as above	STABLE	STABLE
FLT133PH	Three phase fault on the Morris County to Swissvale 345kV line near Morris County kV line, near Midian.	STABLE	STABLE
FLT141PH	Single phase fault same as above	STABLE	STABLE
FLT153PH	Three Phase fault on the Lang to East Street 115kV line near Lang	STABLE	STABLE
FLT161PH	Single phase fault same as above	STABLE	STABLE
FLT173PH	Three Phase fault on the Lang to Reading 115kV line near Lang.	STABLE	STABLE
FLT181PH	Single phase fault same as above	STABLE	STABLE
FLT193PH	Three Phase fault on the Lang to Prairie 115kV line near Lang.	STABLE	STABLE
FLT201PH	Single phase fault same as above	STABLE	STABLE
FLT213PH	Three Phase fault on the Lang autotransformer	STABLE	STABLE
FLT221PH	Single phase fault same as above	STABLE	STABLE

5.0 Conclusion

No stability concerns presently exist for the GEN-2006-027 generation interconnection request as proposed and studied using four GE LM 6000s combustion turbines and one GE 7FA turbine. The wind farm and the transmission system remain stable for all contingencies studied with the exception of the outage of Hoyt-Jeffrey Energy Center 345kV line. This outage was unstable before the addition of the generation. The system is stable when JEC #2 is tripped off immediately after tripping out the line.

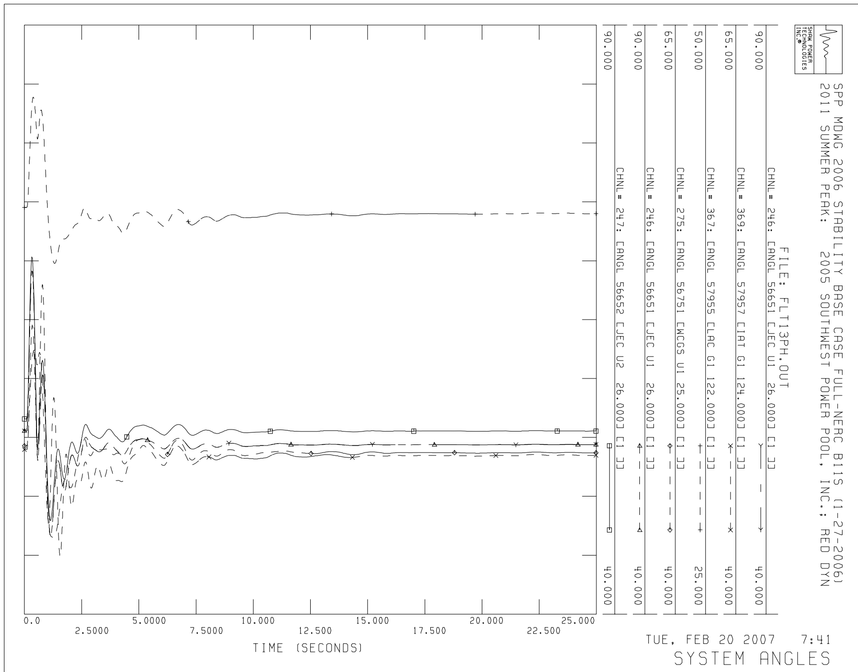
The Network Upgrade cost of interconnecting the Customer project is approximately $23,298,275. This figure does not address the cost of the Customer facilities up to the point of interconnection.

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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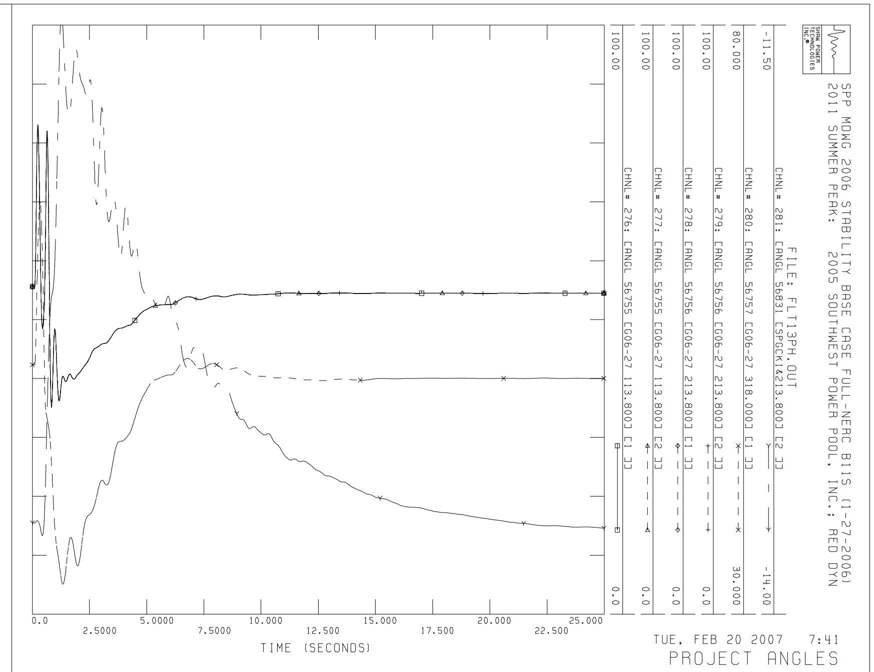
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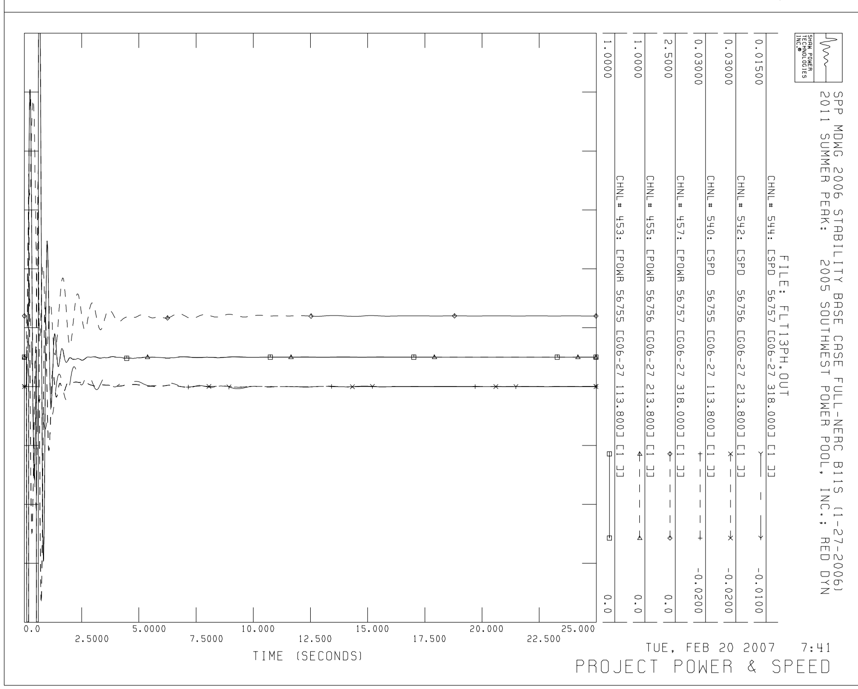
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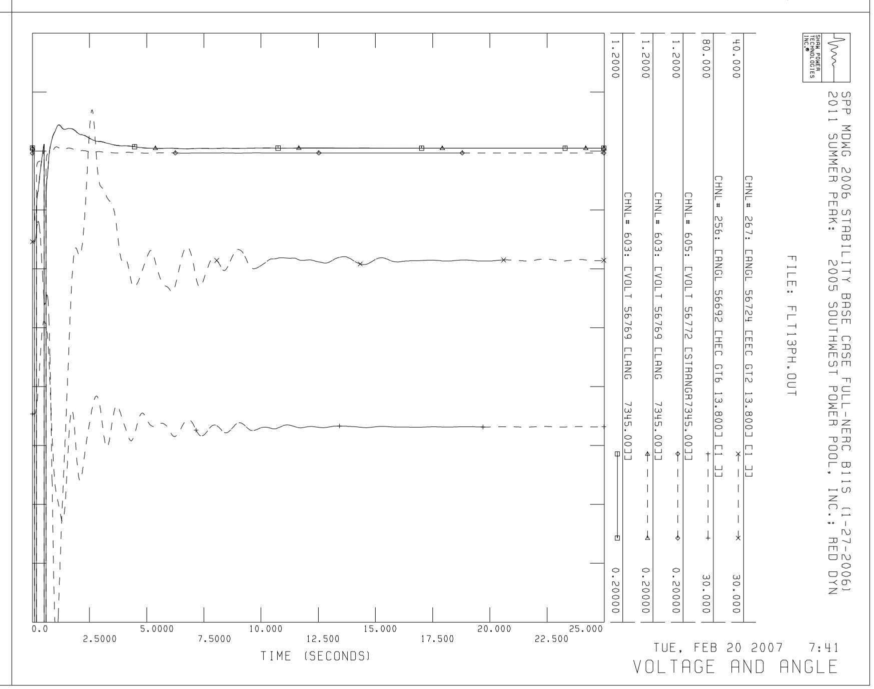
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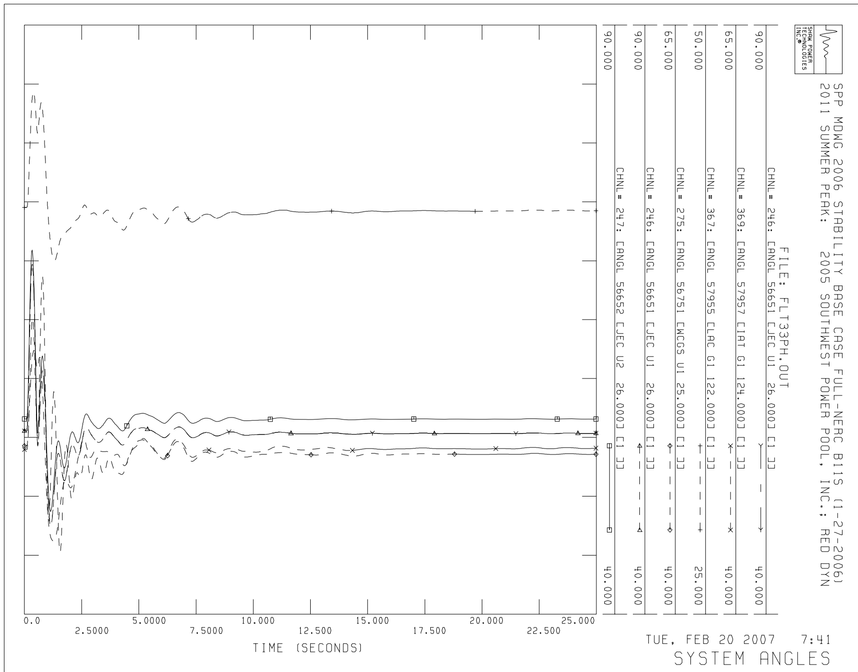
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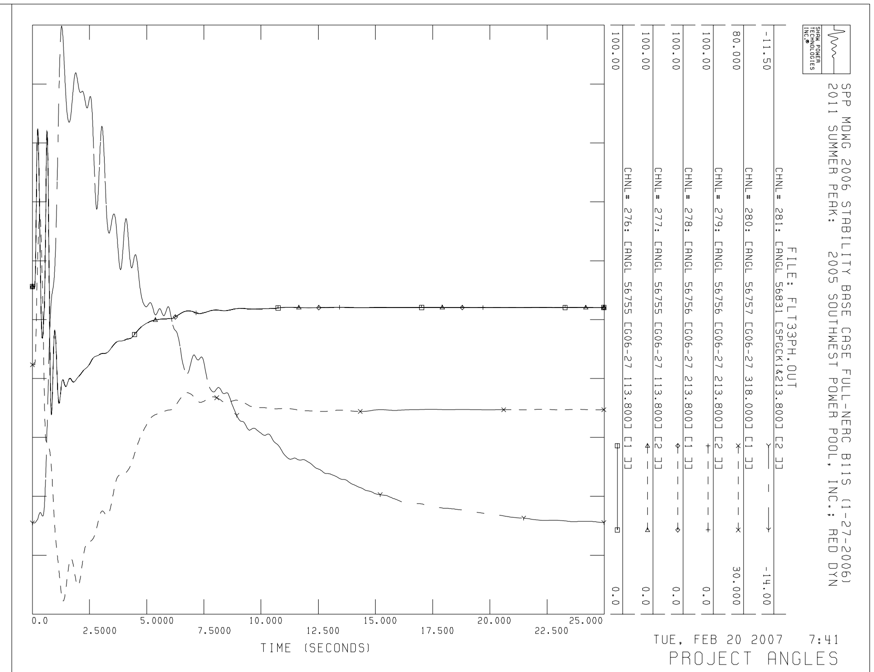
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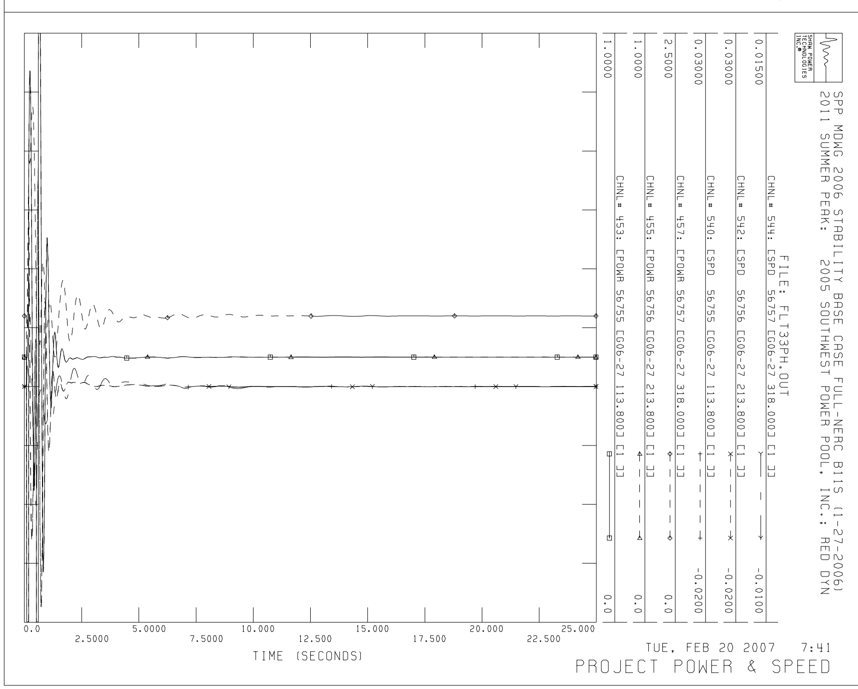
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2011 SUMMER PEAK: 2005 SOUTHWEST POWER POOL, INC.; RED DYN
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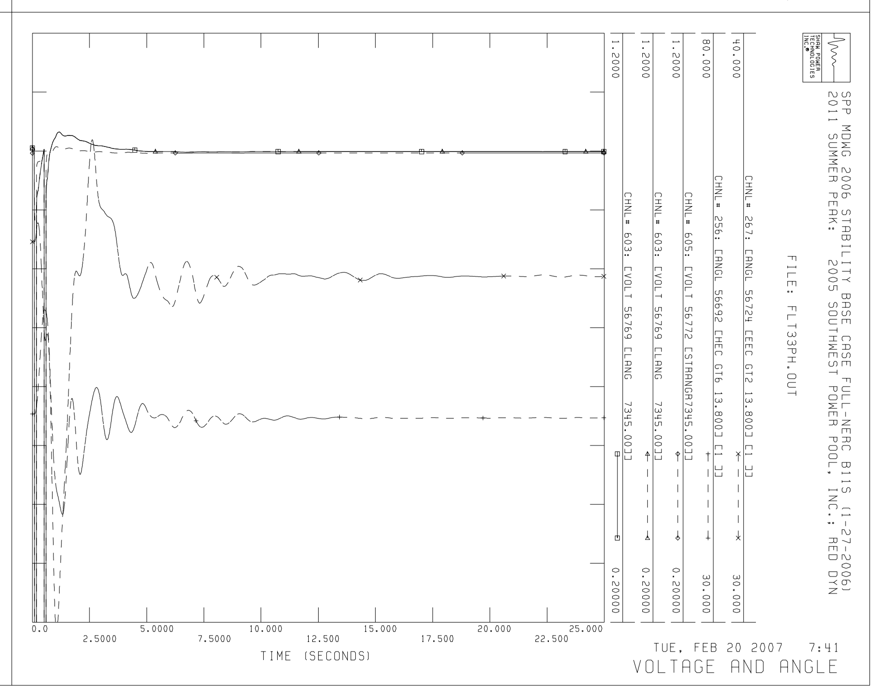
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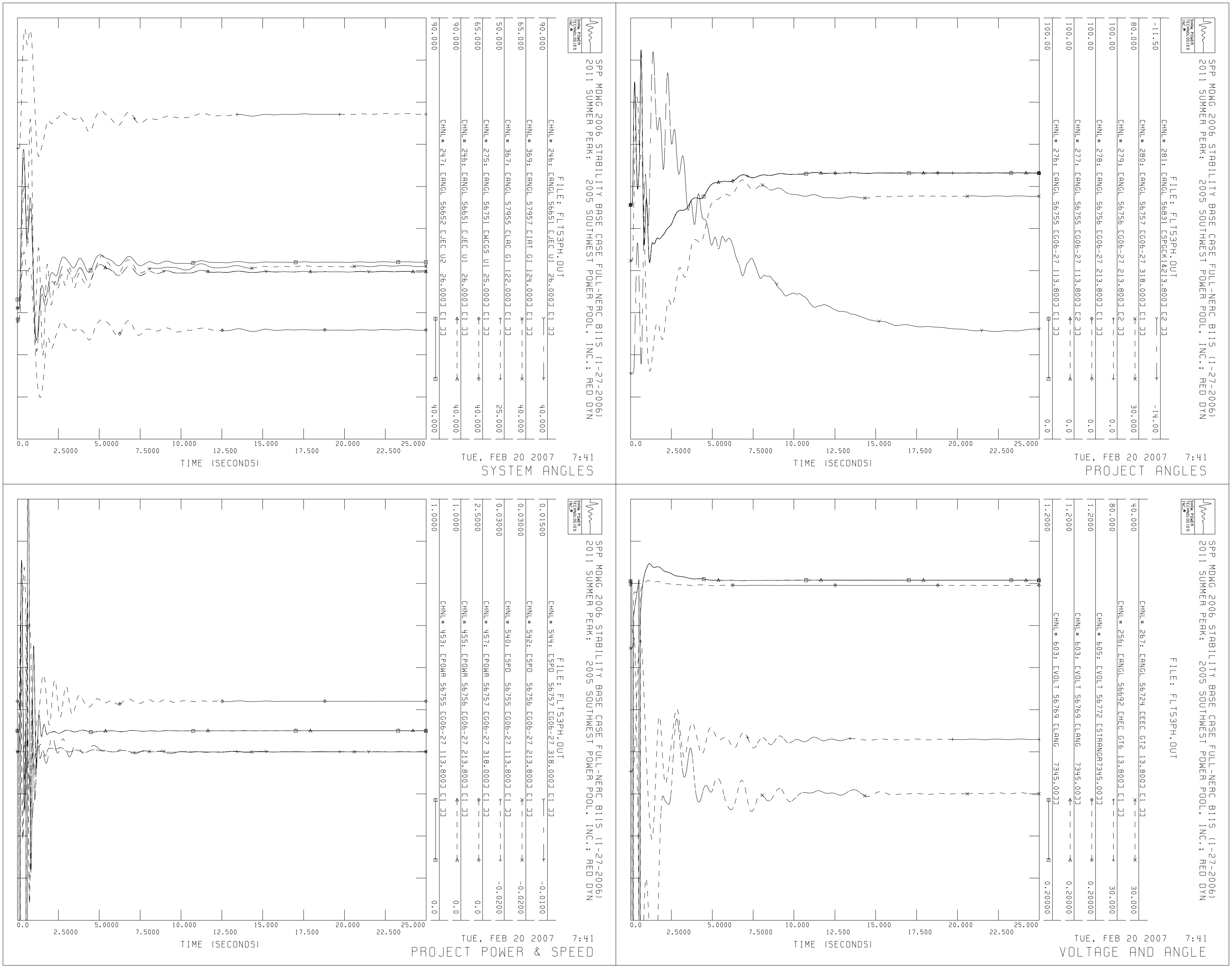
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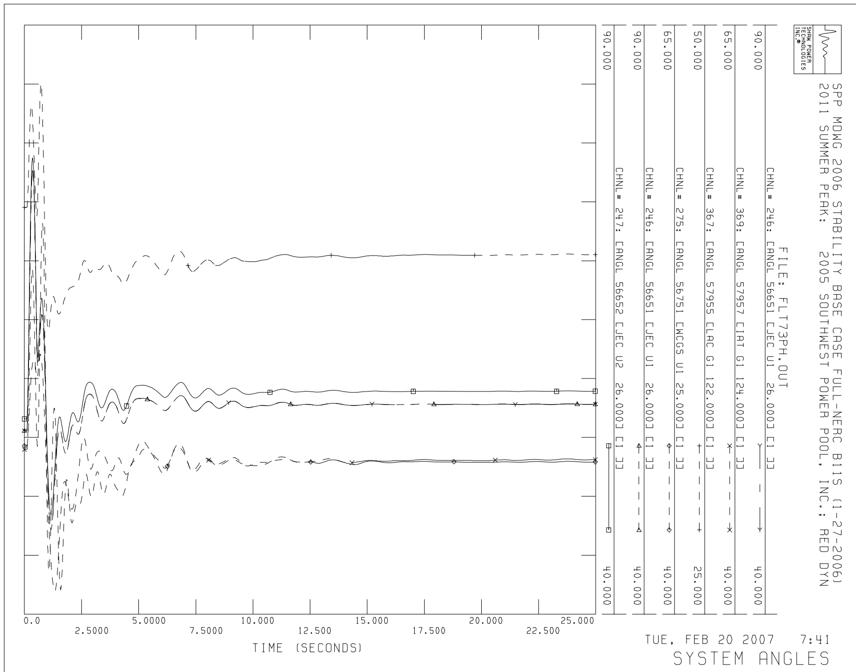
PROJECT ANGLES
PROJECT POWER & SPEED
VOLTAGE AND ANGLE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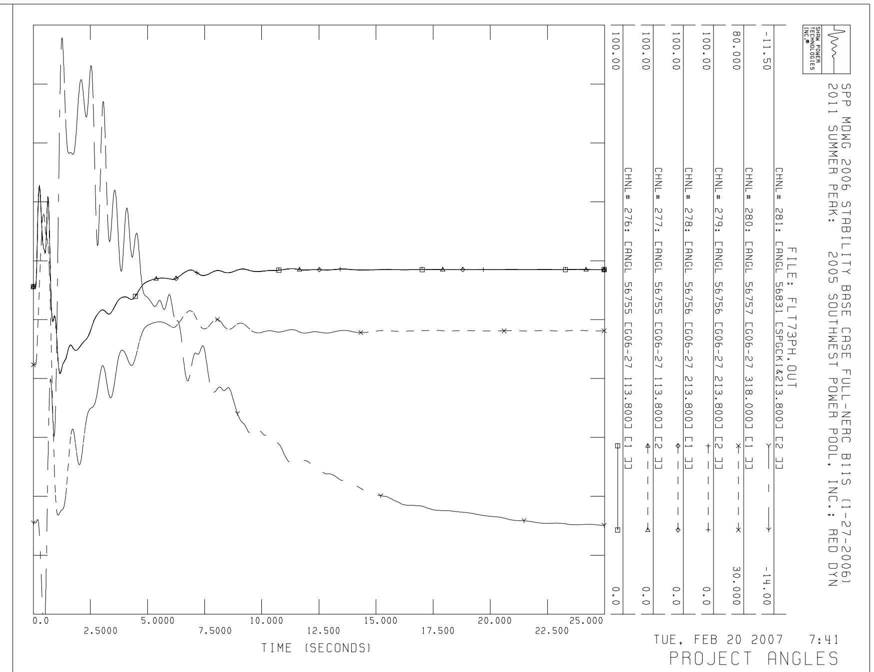
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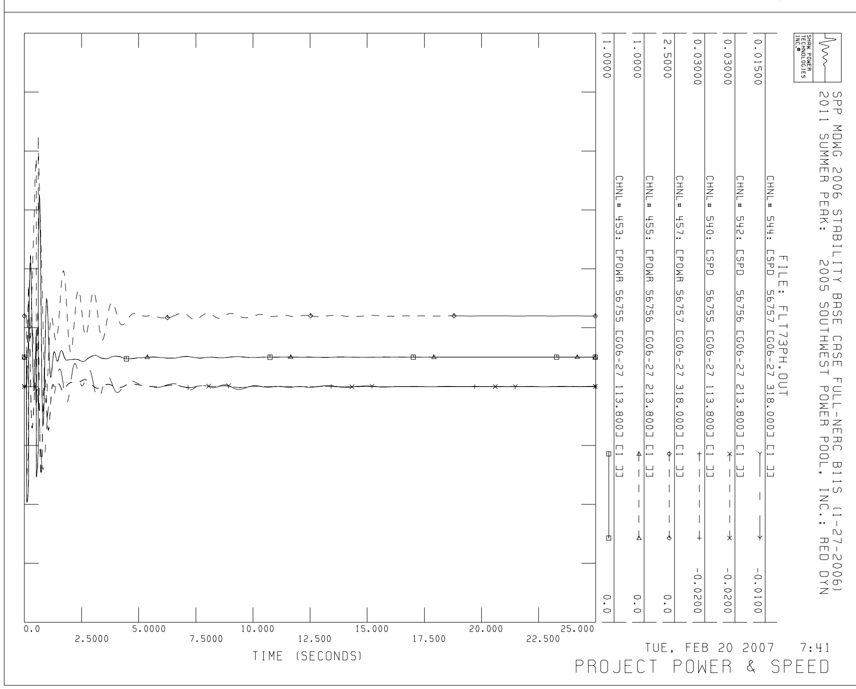
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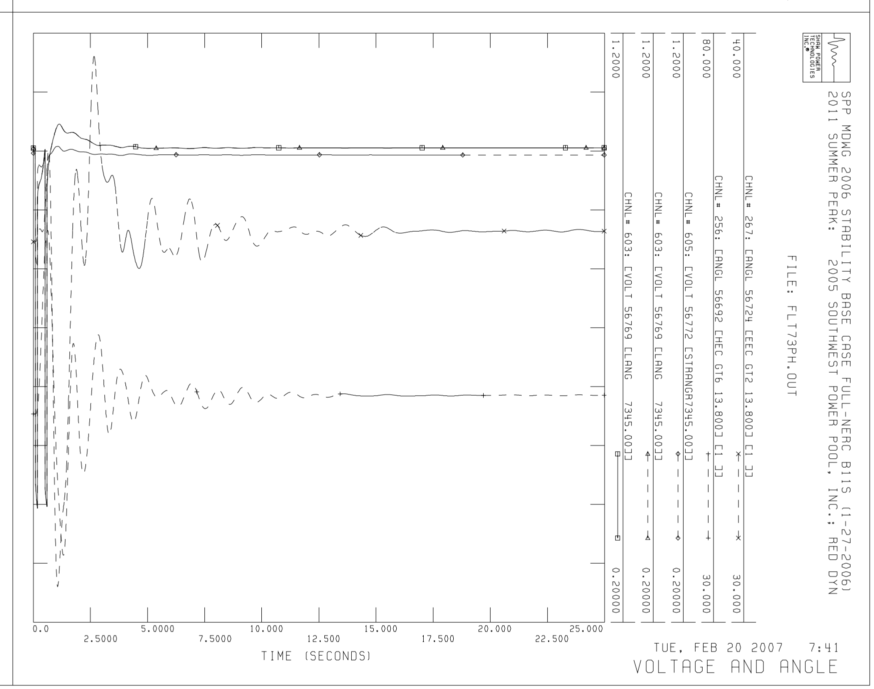
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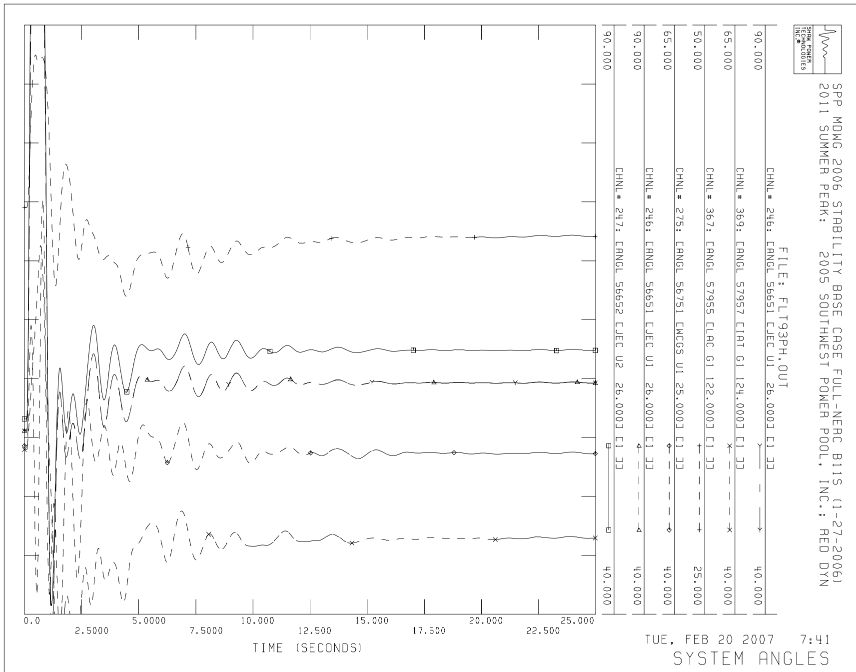
VOLTAGE AND ANGLE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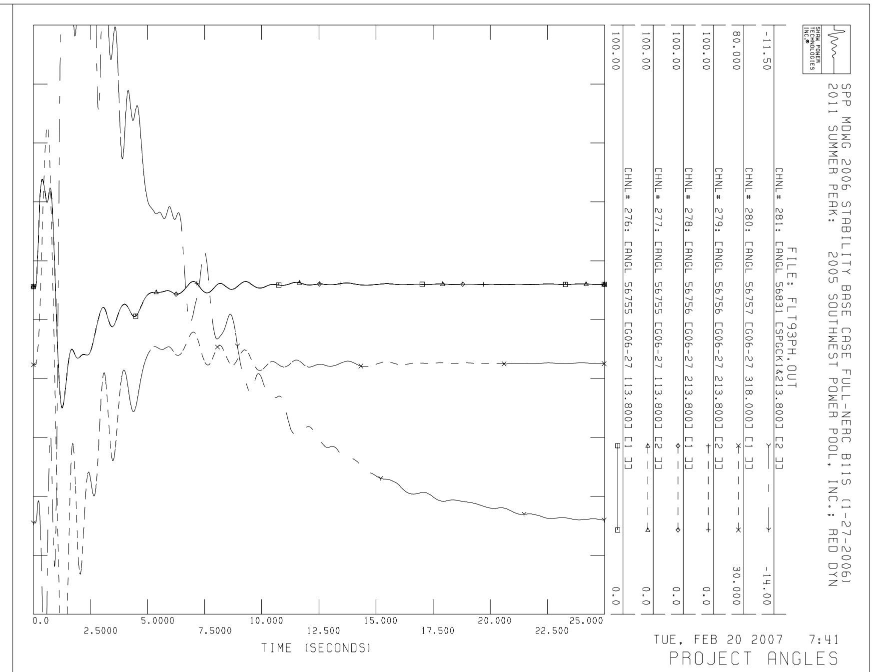
SYSTEM ANGLES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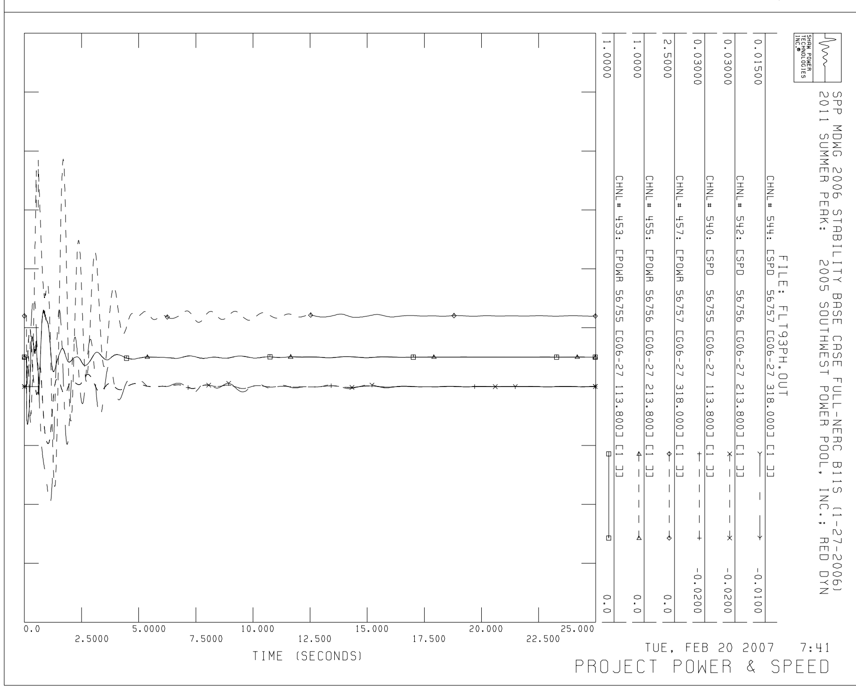
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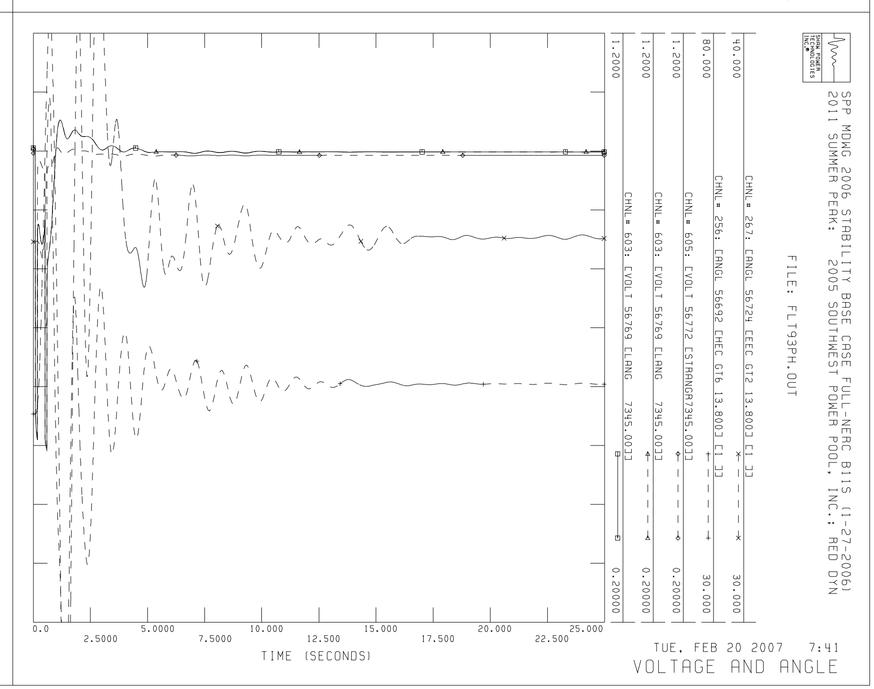
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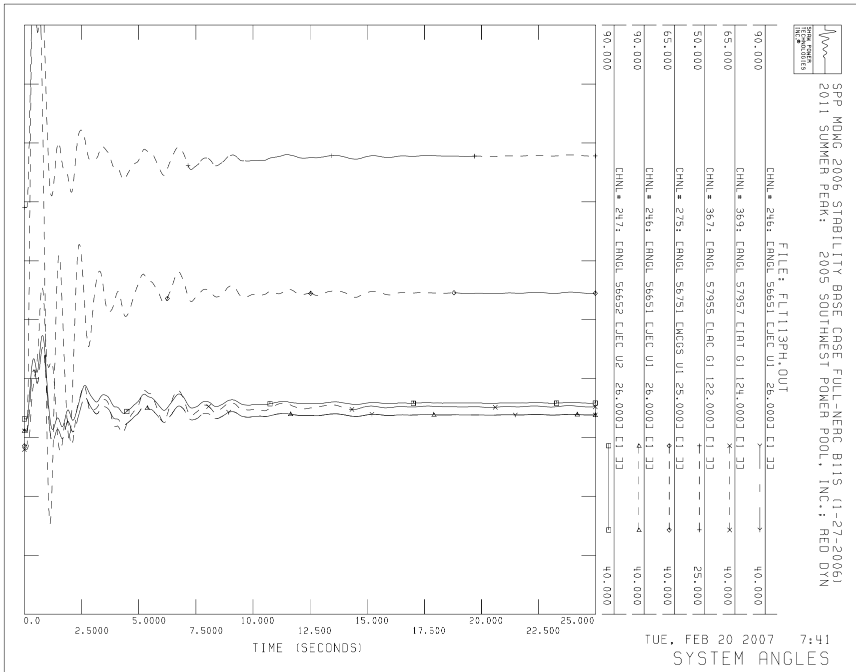
VOLTAGE AND ANGLE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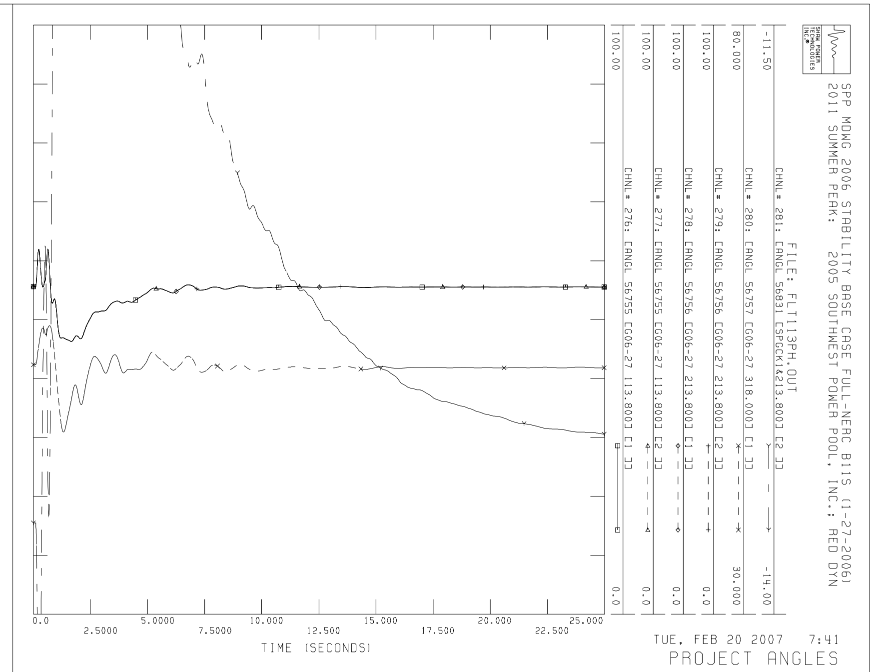
SYSTEM ANGLES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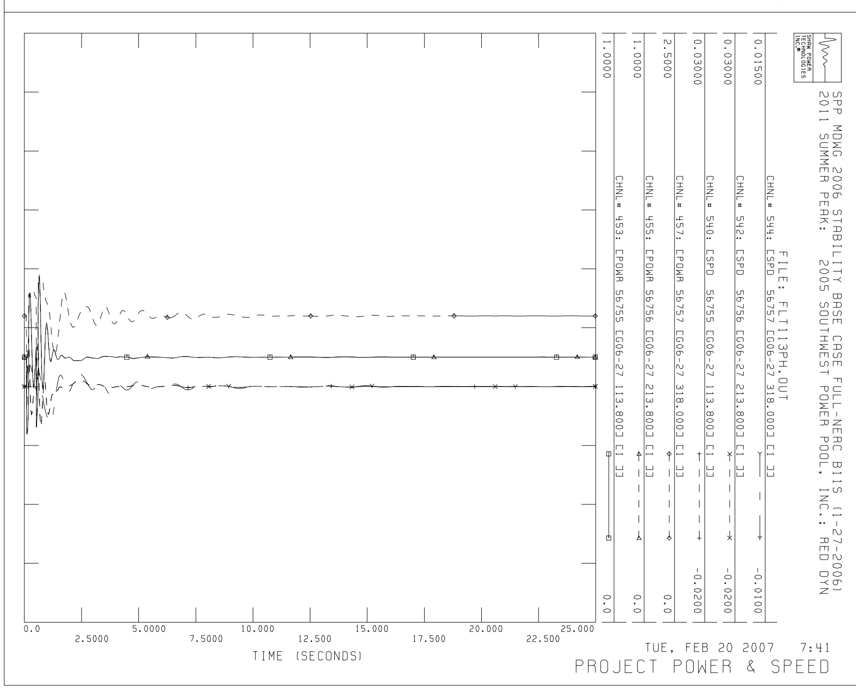
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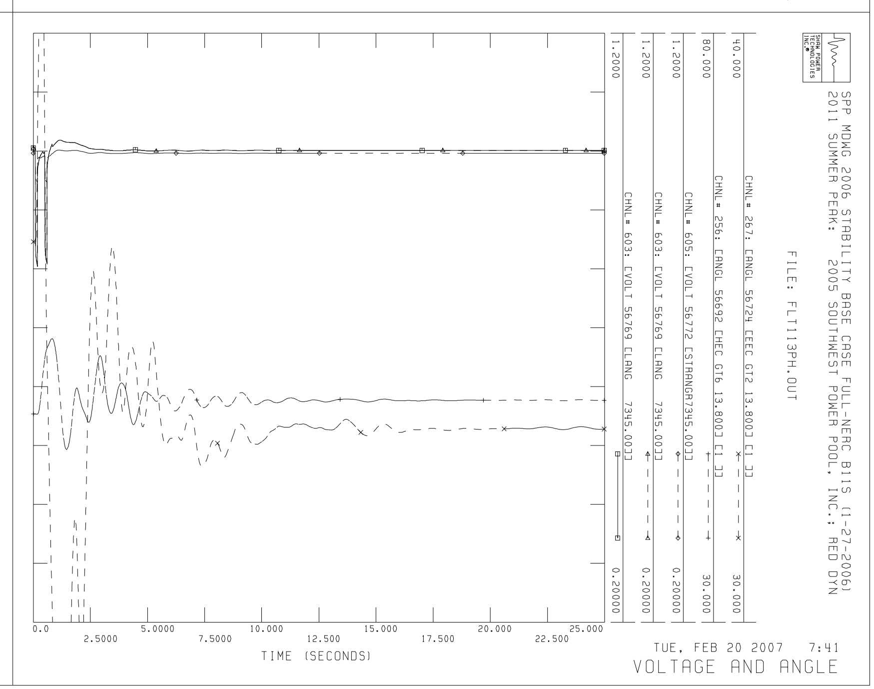
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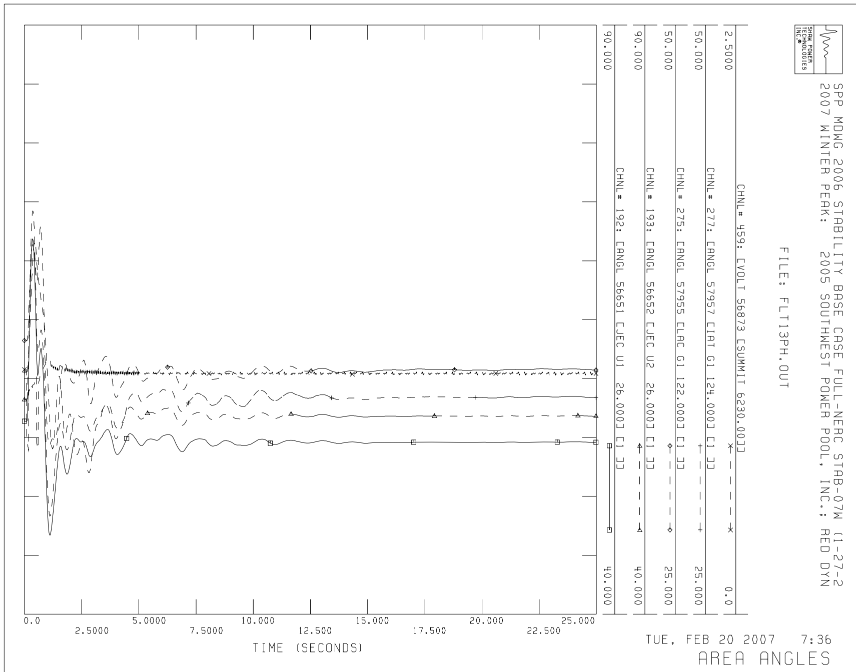
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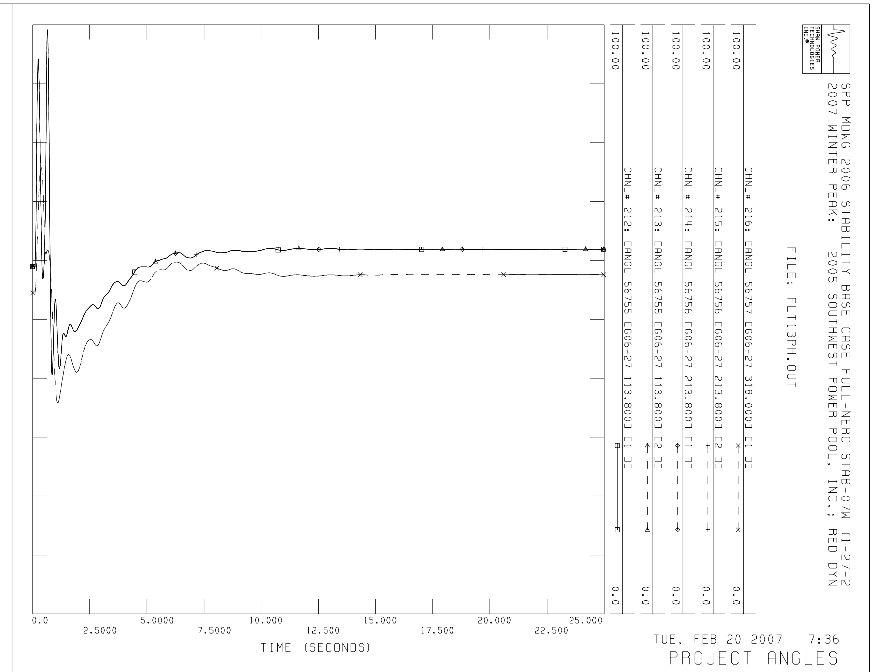
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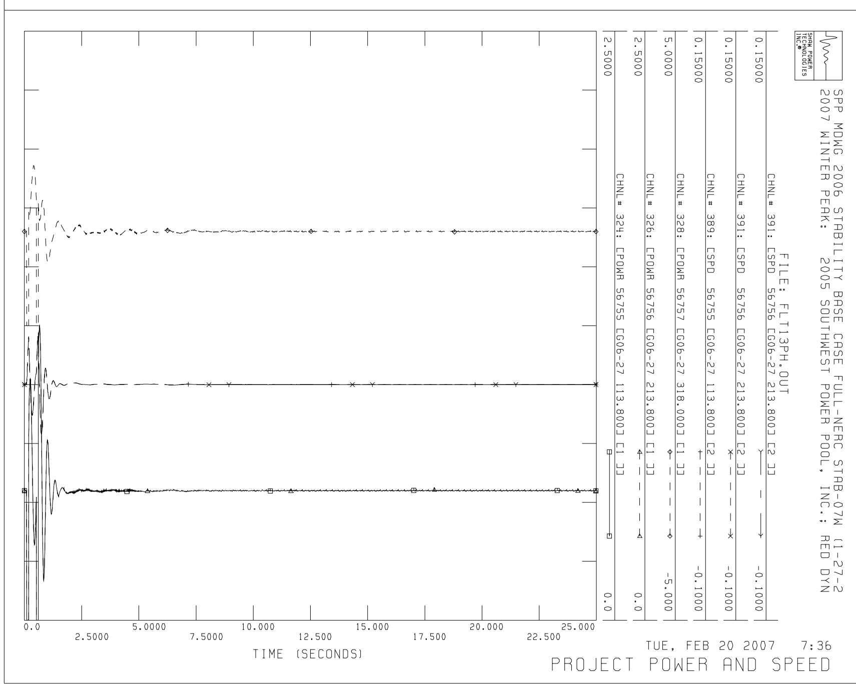
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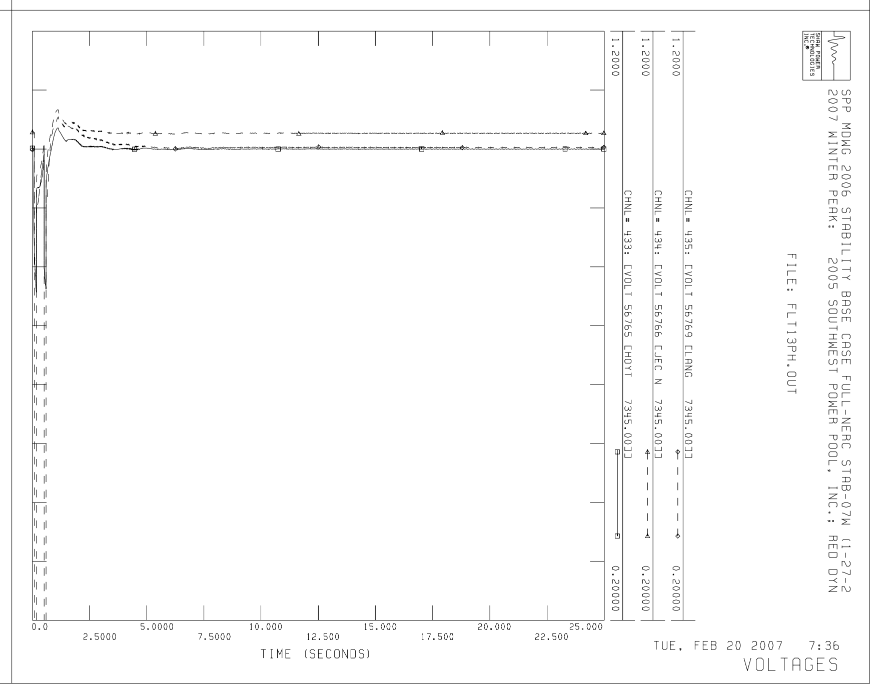
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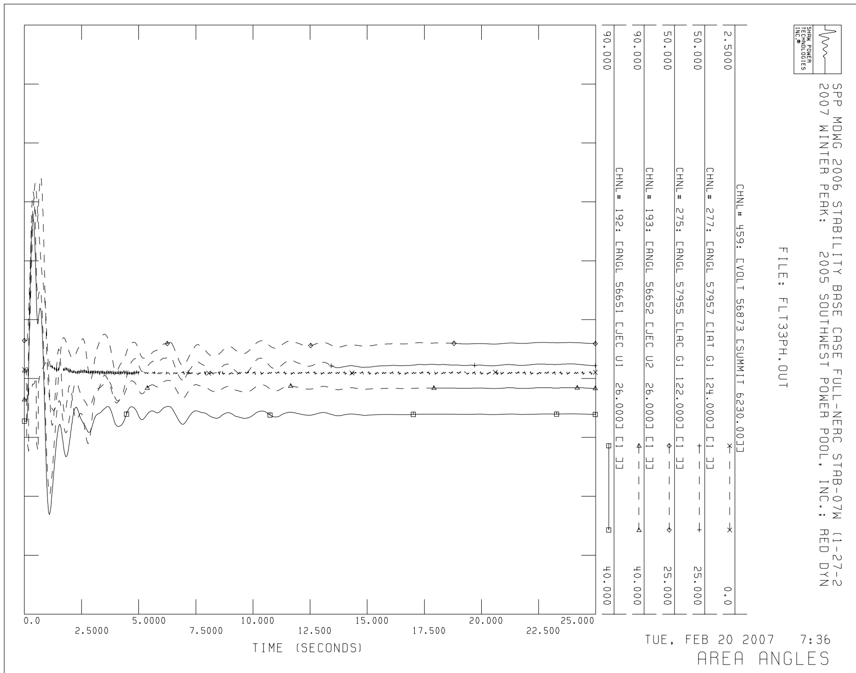
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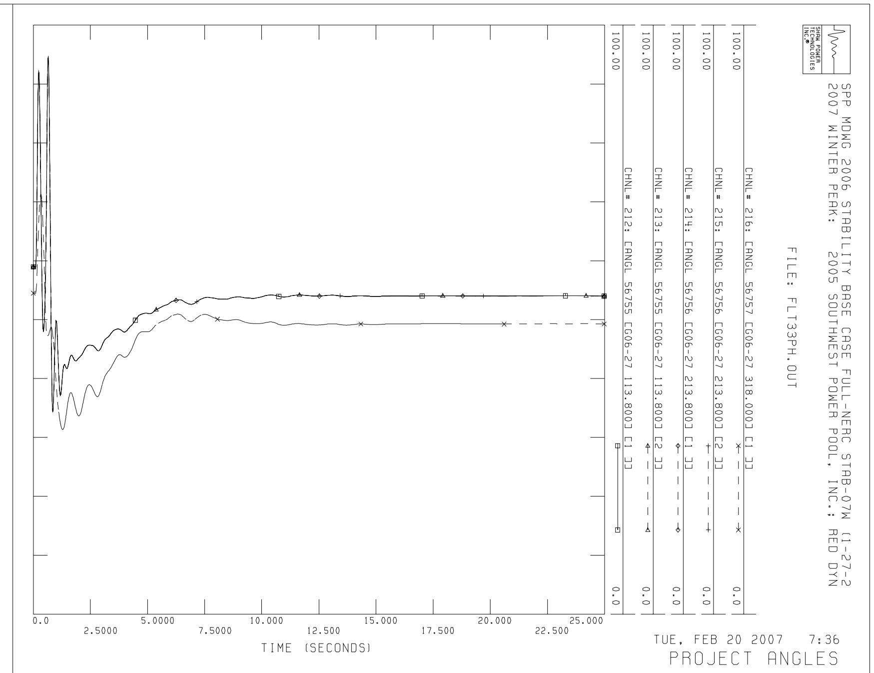
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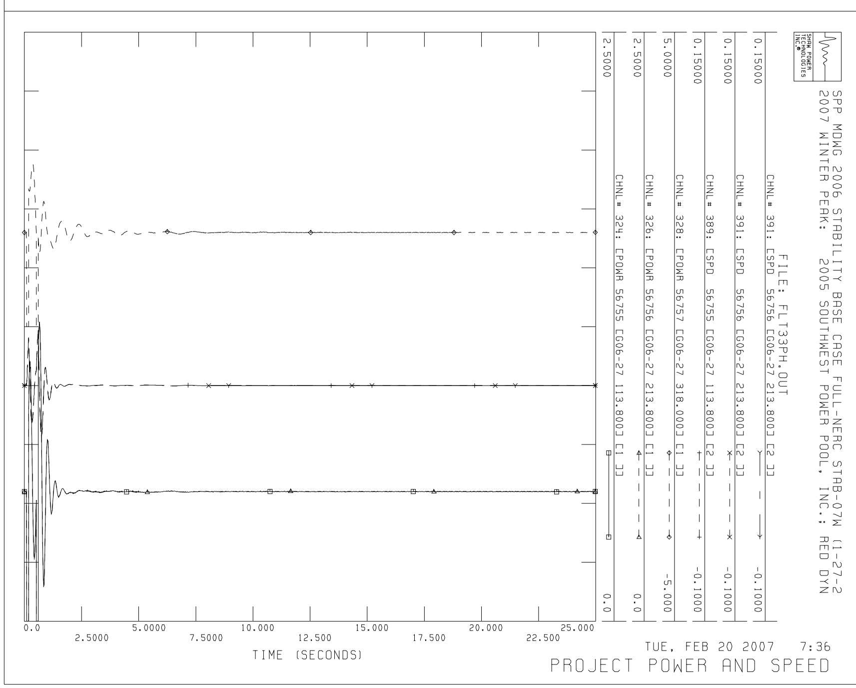
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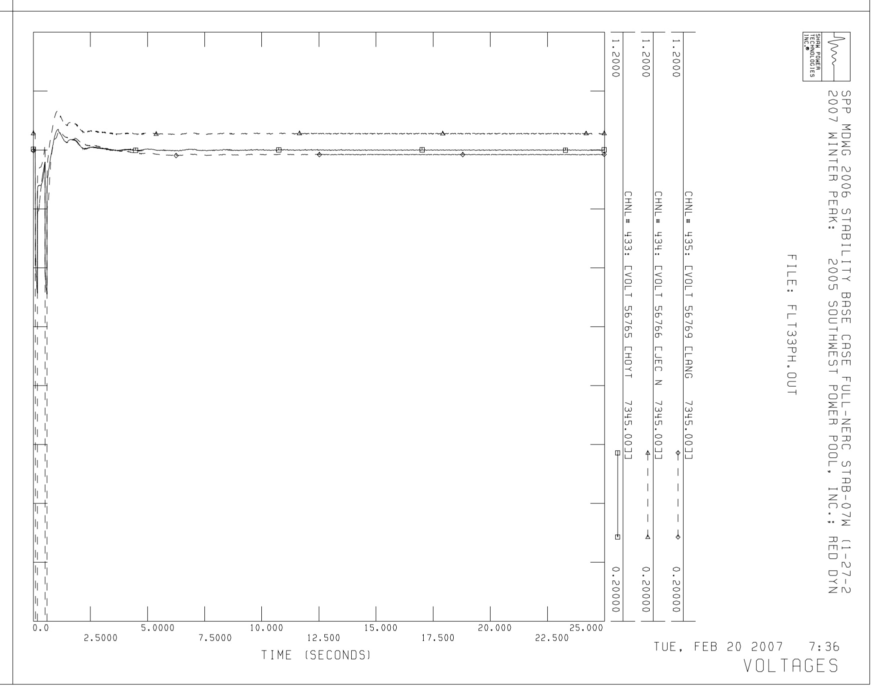
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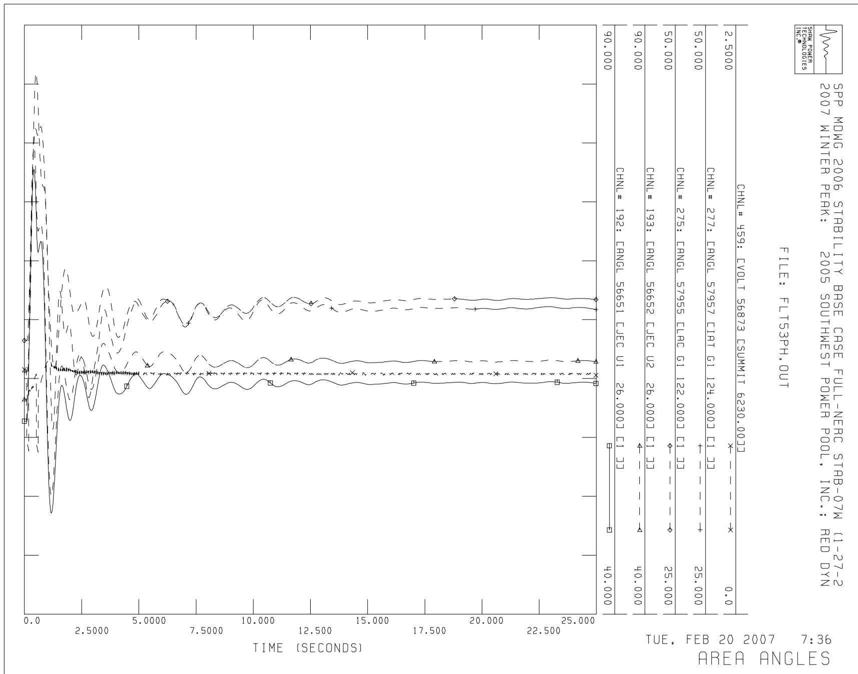
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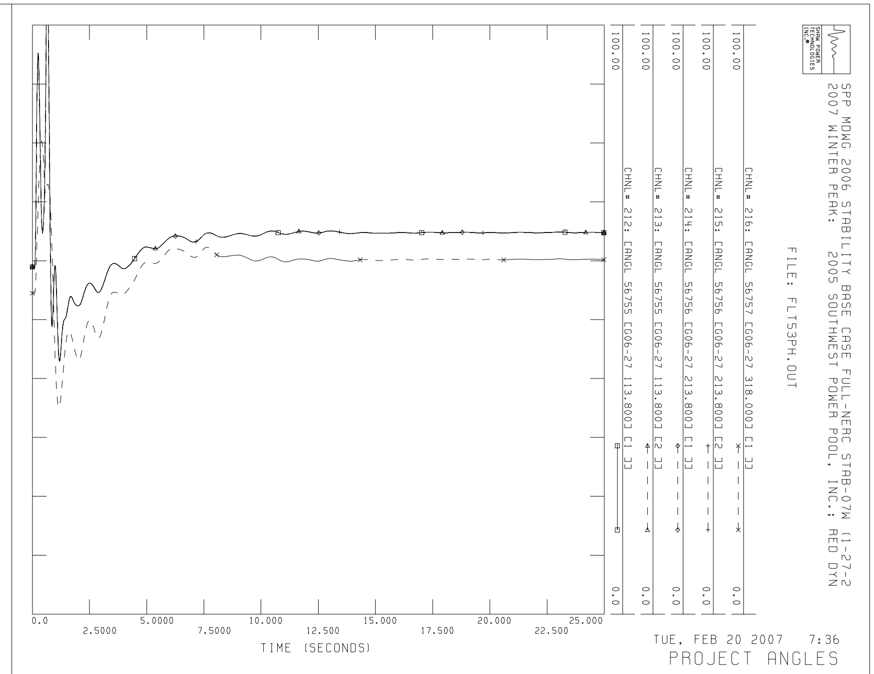
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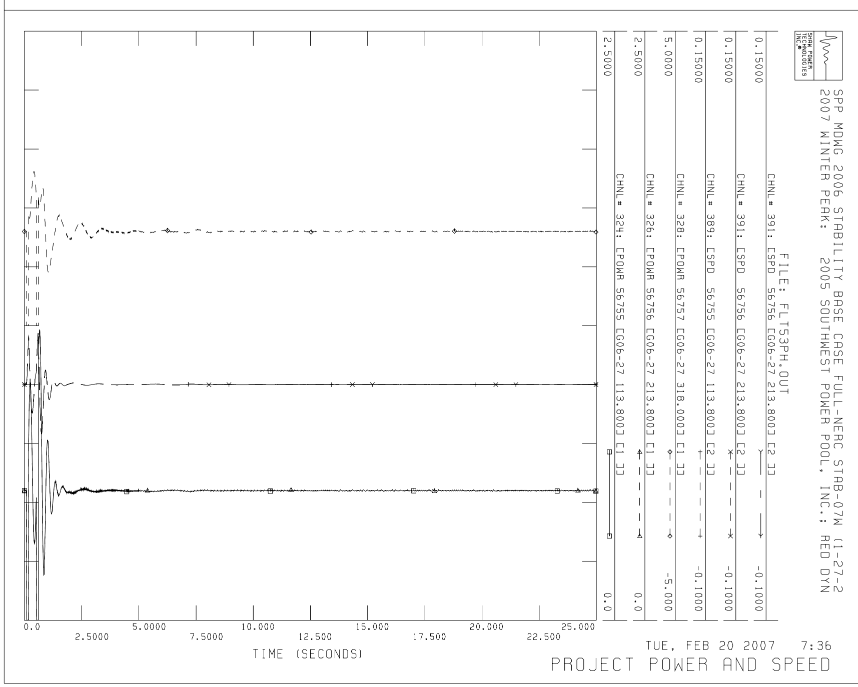
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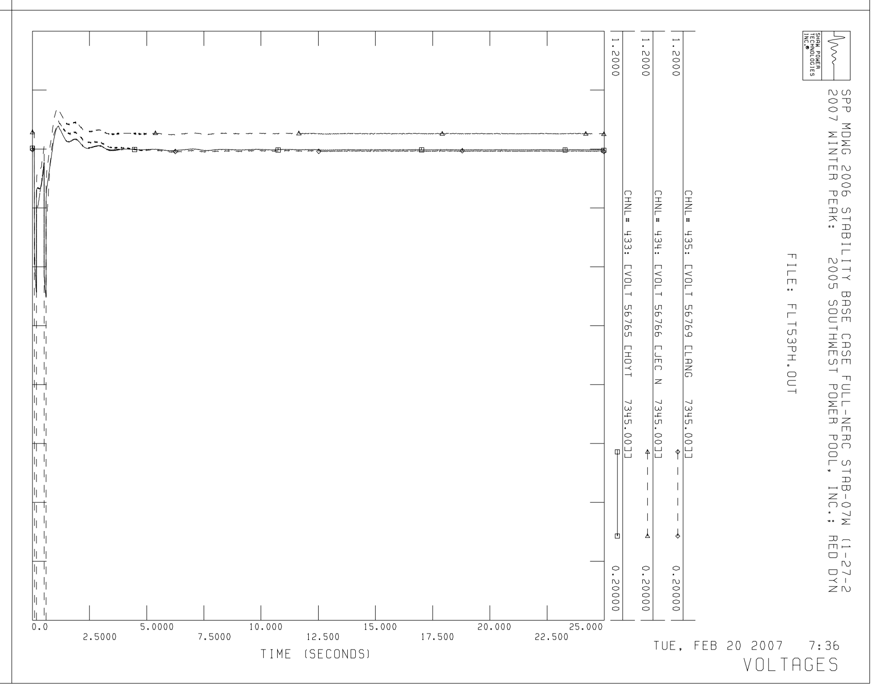
PROJECT POWER AND SPEED

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2007 WINTER PEAK: 2005 SOUTHWEST POWER POOL, INC.; RED DYN
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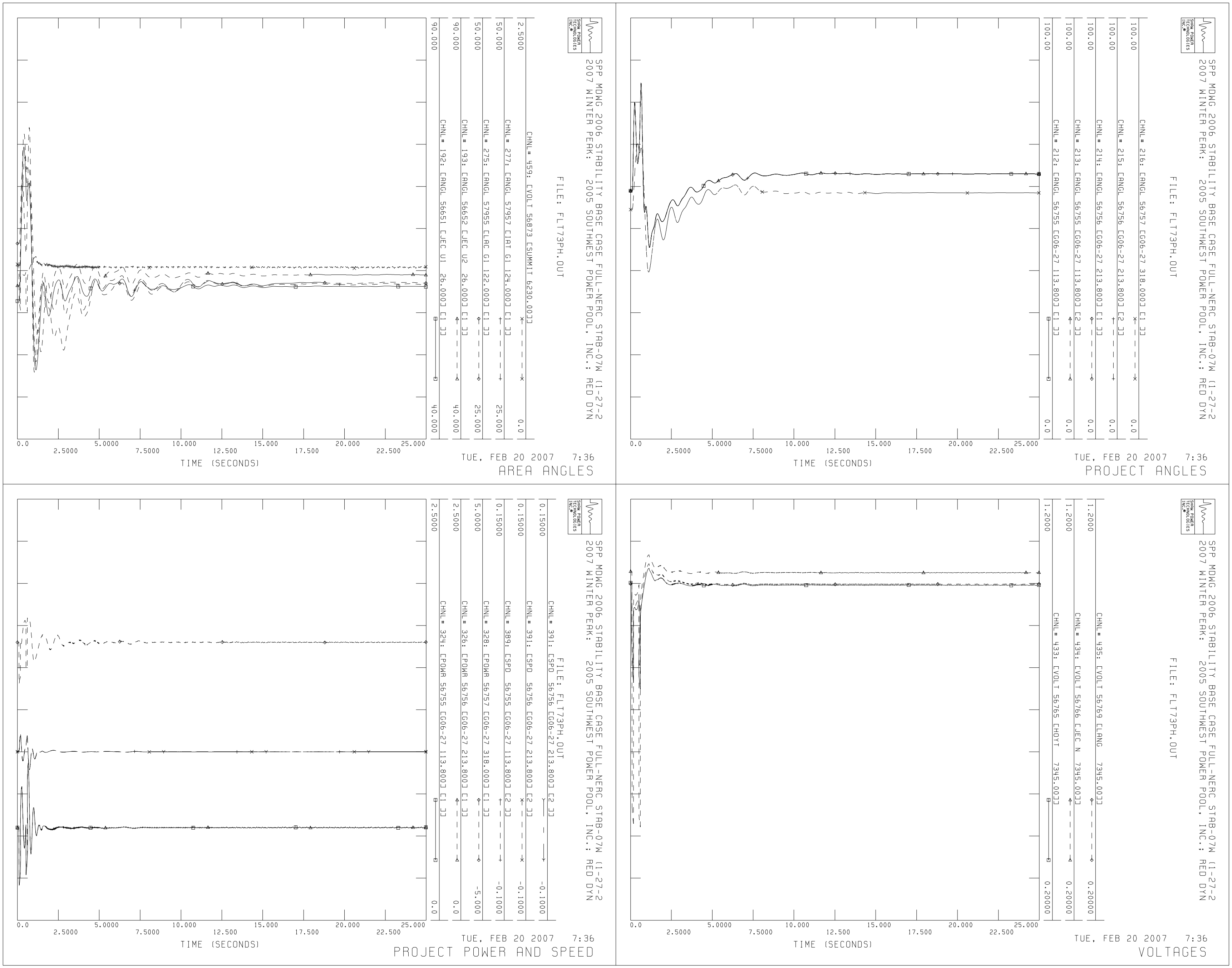
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PROJECT POWER AND SPEED
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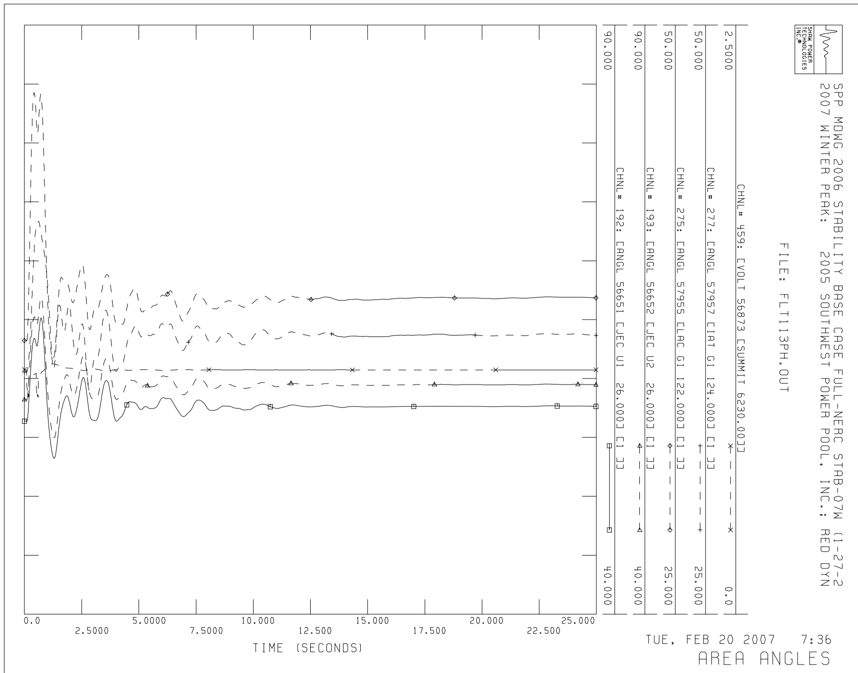
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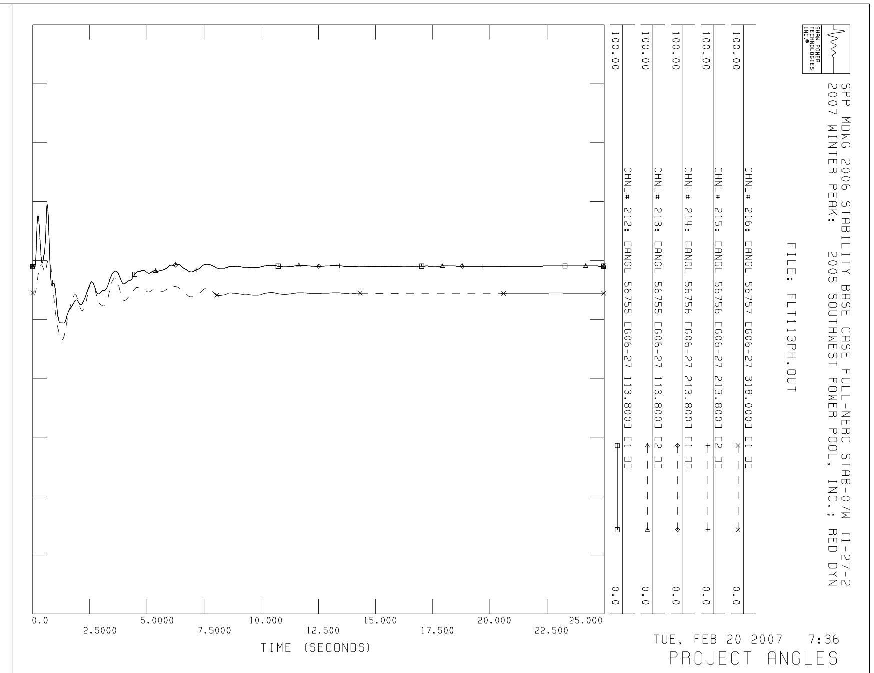
AREA ANGLES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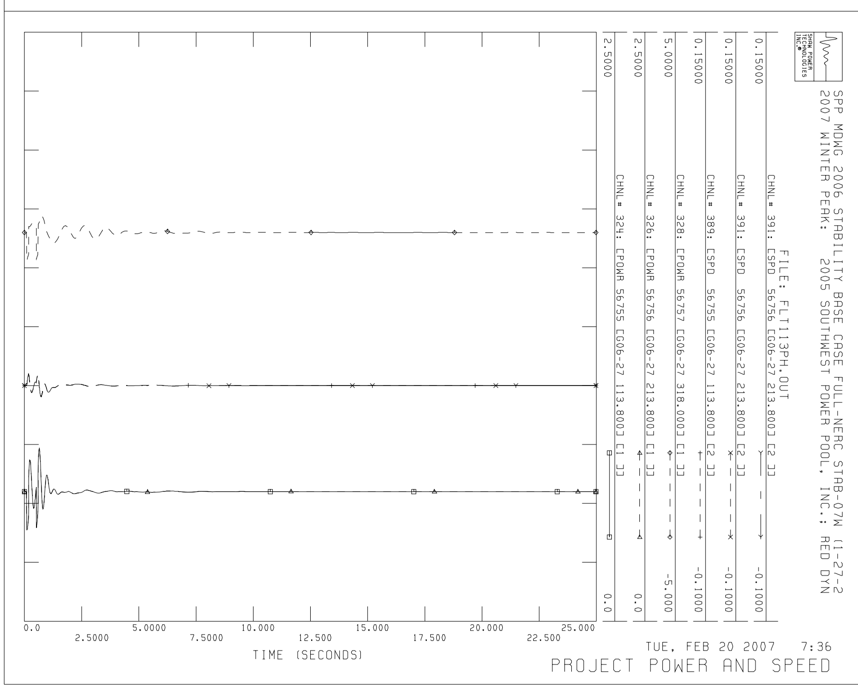
PROJECT ANGLES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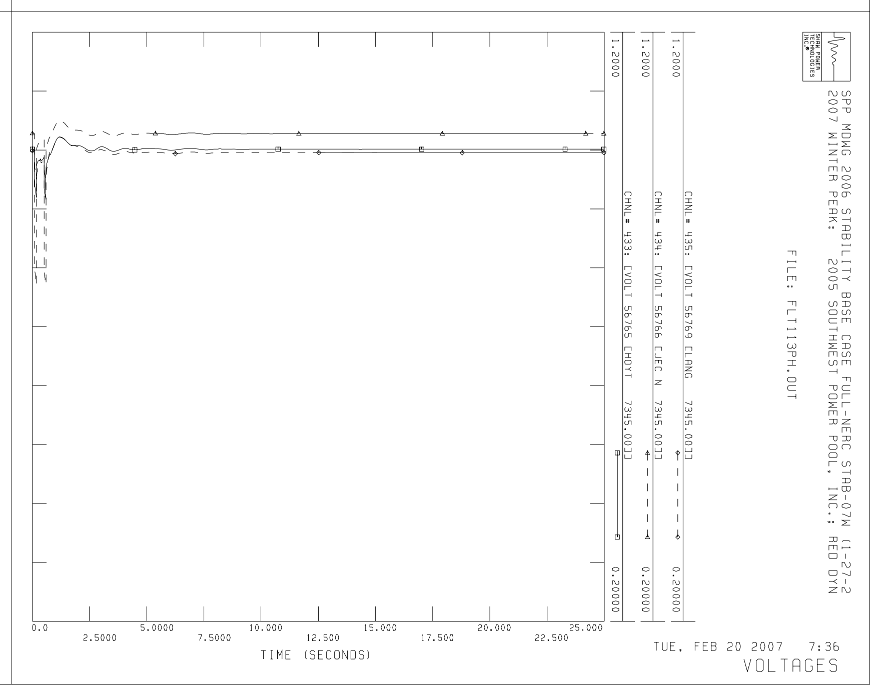
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