SPP Southwest Power Pool

Impact Study for Generation Interconnection Request GEN–2005–024

SPP Coordinated Planning
(#GEN-2005-024)

August 2006

Summary

Pursuant to the tariff and at the request of the Southwest Power Pool (SPP), ABB Inc. Electric Systems Consulting (ABB) performed the following Impact Study to satisfy the Impact Study Agreement executed by the requesting customer and SPP for SPP Generation Interconnection request Gen-2005-024. The request for interconnection was placed with SPP in accordance SPP's Open Access Transmission Tariff, which covers new generation interconnections on SPP's transmission system.

Interconnection Facilities

No new interconnection facilities were found to be needed because of the Impact Study. Estimates for the Interconnection Facilities were given in the Feasibility Study. These estimates have been refined as follows in Table 1 and Table 2. **These costs do not include any cost that might be associated with short circuit study results**. These costs and a further refinement of the facilities listed in Table 1 and Table 2 will be determined when and if a Facility Study is conducted.

Table 1: Direct Assigned Facilities

Facility	ESTIMATED COST (2006 DOLLARS)
AEPW – Build 0.3 miles of 138kV transmission line from generator GSU to Riverside 138kV substation	$448,100
Total	**$448,100**

Table 2: Interconnection Facility Network Upgrades

Facility	ESTIMATED COST (2006 DOLLARS)
AEPW – Add 138kV bus, breaker, switches and metering in the existing Riverside Substation for a new terminal.	$1,121,100
Total	**$1,121,100**

POWER SYSTEMS DIVISION
GRID SYSTEMS - CONSULTING

IMPACT STUDY FOR GENERATION INTERCONNECTION REQUEST GEN-2005-024

FINAL REPORT

REPORT NO.: 2006-11337-R0
Issued: August 25, 2006

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Power Systems Division
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Legal Notice

ABB Inc – Grid Systems - Consulting

Technical Report

Southwest Power Pool	**No.** 2006-11337-R0	
Impact Study for Generation Interconnection Request GEN-2005-024	August 25, 2006	# Pages 20

Author(s):	**Reviewed by:**	**Approved by:**
Shu Liu	Bill Quaintance	Willie Wong

Executive Summary

Southwest Power Pool (SPP) has commissioned ABB Inc., to perform a Generation Interconnection Impact study for a simple cycle gas turbine power plant in Tulsa County, Oklahoma with 168MW Summer Peak and 177MW Winter Peak output. This Combustion Turbine project will be interconnected into the existing Riverside Power substation in the control area of American Electric Power West (AEPW). This plant will comprise two combustion turbine-generators. The interconnection study includes the stability analysis. The feasibility (power flow) study was not performed as a part of this study.

The objective of this study is to evaluate the impact on system stability after connecting the GEN-2005-024 to the interconnection point and its effect on the nearby transmission system and generating stations. The study is performed on two system scenarios: 2007 Winter Peak and the 2011 Summer Peak, provided by SPP.

The SPP system will be stable following all the simulated faults with the proposed GEN-2005-024 project in-service. Based on the results of this stability analysis, it can be concluded that the proposed GEN-2005-024 project does not adversely impact the stability of the SPP system.

The results of this analysis are based on available data and assumptions made at the time of conducting this study. If any of the data and/or assumptions made in developing the study model change, the results provided in this report may not apply.

Rev No.	Revision Description	Date	Authored by	Reviewed by	Approved by
0	Final Report	8/25/06	Shu Liu	Bill Quaintance	Willie Wong
DISTRIBUTION: Charles Hendrix – Southwest Power Pool					

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1 INTRODUCTION

Southwest Power Pool (SPP) has commissioned ABB inc., to perform a Generation Interconnection Impact study for a simple cycle gas turbine in Tulsa County, Oklahoma with 168MW Summer Peak and 177MW Winter Peak output. This Combustion Turbine project will be interconnected into the existing Riverside Power substation in the control area of American Electric Power West (AEPW). This plant will comprise two combustion turbine-generators. The interconnection study includes stability analysis. The feasibility (power flow) study was not performed as a part of this study.

The objective of the impact study is to evaluate the impact on system stability after connecting the GEN-2005-024 to the interconnection point and its effect on the nearby transmission system and generating stations. The study is performed on two system scenarios: 2007 Winter Peak and the 2011 Summer Peak. Figure 1-1 shows the Point of interconnection for the GEN-2005-024. Figure 1-2 shows the schematic diagram for the interconnection of GEN-2005-024.

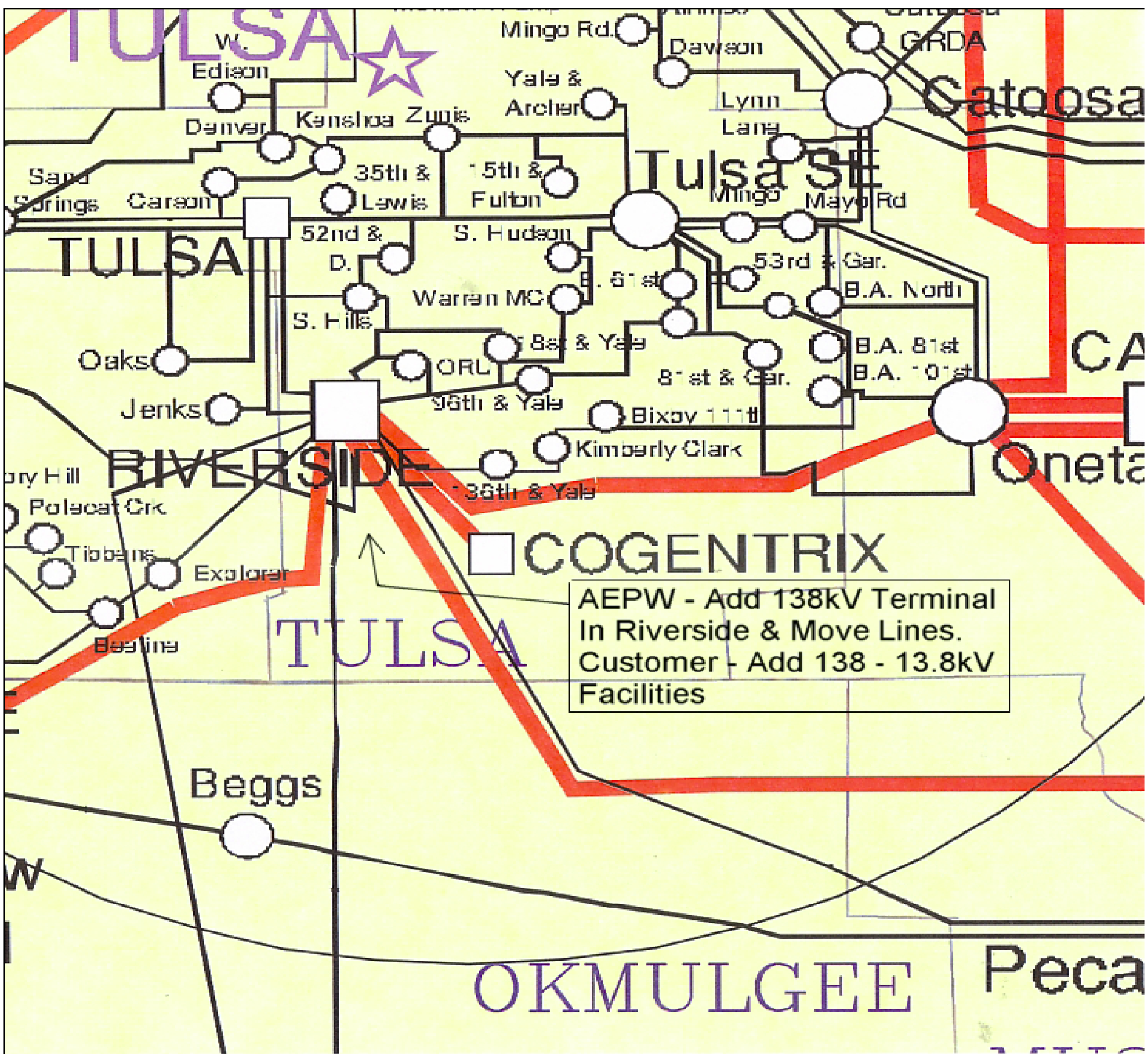

Figure 1-1: GEN-2005-024 Point of Interconnection

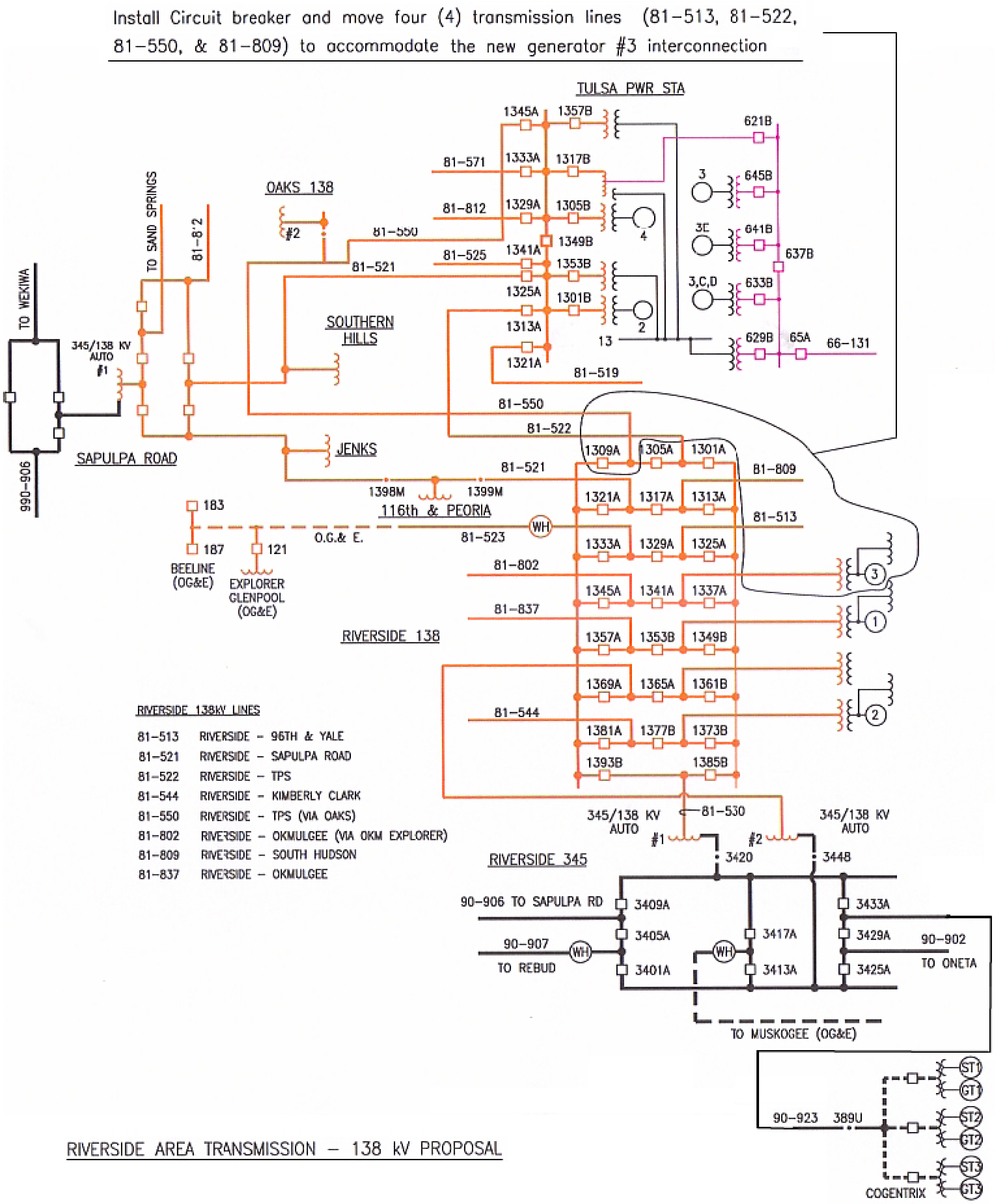

Figure 1-2: Schematic diagram for the interconnection of GEN-2005-024

2 STABILITY ANALYSIS

In this study, ABB investigated the stability of the system for the faults in the vicinity of the proposed plant as defined by SPP. The faults involve three-phase and single-phase faults cleared by primary protection, re-closing with the fault still on, and then permanently clearing the fault with primary protection.

2.1 STABILITY ANALYSIS METHODOLOGY

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.

Single-phase line faults were simulated with the standard method of applying fault impedance to the positive sequence network 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 fault location of approximately 60% of pre-fault voltage, which is a typical value.

2.2 STUDY MODEL DEVELOPMENT

The study model consists of power flow cases and dynamics databases, developed as follows.

Power Flow Case

SPP provided two (2) Pre-project PSS/E power flow cases called “*SP011-GEN-2005-022.SAV*” representing the Summer Peak conditions of the SPP system for the year 2011 and the “*WP07-GEN-2005-022.SAV*” representing the Winter Peak conditions of the SPP system for the year 2007. Cogentrix (adjacent to Riverside) and Calpine (on the other side of Tulsa) generators were turned on in the pre-project cases and the generation was displaced by scaling up load in Entergy (area 151) and TVA (area 147) respectively.

The proposed GEN-2005-024 project is comprised of two combustion turbine-generators. The two units will be connected to the Riverside 138kV station by a three winding 138/13.8/13.8kV step-up transformer. The proposed project was added to the Pre-project cases and the generation was dispatched against the S.W.S unit in Caddo County (in AEPW). See Table 2-1 for details. Two Powerflow cases with GEN-2005-024 were established:

SP011-GEN-2005-024.SAV
WP07-GEN-2005-024.SAV
Figure 2-1 and Figure 2-2 shows the Powerflow diagram for the local area of Riverside station with GEN-2005-024 in-service (Summer Peak 2011 and Winter Peak 2007 system conditions, respectively).

Table 2-1: GEN-2005-022 project details

System condition	MW	Location	Point of Interconnection	Sink
Summer Peak	168	Tulsa Co., OK	Riverside Substation 138kV	S.W.S Unit at Caddo (AEPW)
Winter Peak	177	Tulsa Co., OK	Riverside Substation 138kV	S.W.S Unit at Caddo (AEPW)

Stability Database

SPP provided the stability database in the form of a PSS/E dynamic snapshot file "*SP011-GEN-2005-022.SNP*" to model the Summer Peak stability dynamics database for 2011 and "*WP07-GEN-2005-022.SNP*" to model the Winter Peak stability dynamics database for the year 2007. The provided files required the use of PSS/E version 29.

The stability data for GEN-2005-024 was appended to the Pre-GEN-2005-024 snapshot. The Powerflow and stability model representation for GEN-2005-024 are included in Appendix A.

Table 2-2 lists the disturbances simulated for stability analysis. All transmission lines were assumed to have re-closing enabled. All faults were simulated for 10 seconds.

Table 2-2: List of Faults for Stability Analysis

FAULT	FAULT DESCRIPTION
FLT_1_3PH	a. Apply Fault at Sapulpa Road (53886). b. Clear Fault after 3.5 cycles by removing the line from (53795-53765-53771-53886) c. Wait 6 cycles, and then re-close the line in (b) into the fault. d. Leave fault on for 3.5 cycles, then trip the line in (b) and remove fault.
FLT_2_1PH	SLG fault same as FLT_1_3PH
FLT_3_3PH	a. Apply Fault at Riverside (53795). b. Clear Fault after 3.5 cycles by removing the line from (53795-53787-53859) c. Wait 6 cycles, and then re-close the line in (b) into the fault. d. Leave fault on for 3.5 cycles, then trip the line in (b) and remove fault.
FLT_4_1PH	SLG fault same as FLT_3_3PH
FLT_5_3PH	a. Apply Fault at Riverside (53795). b. Clear Fault after 3.5 cycles by removing the line from (53795-53800) c. Wait 6 cycles, and then re-close the line in (b) into the fault. d. Leave fault on for 3.5 cycles, then trip the line in (b) and remove fault.
FLT_6_1PH	SLG same as FLT_5_3PH
FLT_7_3PH	a. Apply Fault at Okmulgee (54023). b. Clear Fault after 3.5 cycles by removing the line from (53795-54023) c. Wait 6 cycles, and then re-close the line in (b) into the fault. d. Leave fault on for 3.5 cycles, then trip the line in (b) and remove fault.
FLT_8_1PH	SLG same as FLT_7_3PH
FLT_9_3PH	a. Apply Fault at Riverside (53795). b. Clear Fault after 3.5 cycles by removing the line from (53795-55248-55247) c. Wait 6 cycles, and then re-close the line in (b) into the fault. d. Leave fault on for 3.5 cycles, then trip the line in (b) and remove fault.
FLT_10_1PH	SLG same as FLT_9_3PH
FLT_11_3PH	a. Apply Fault at Riverside 345kV (53794). b. Clear Fault after 3.5 cycles by removing the branch from (53794-53785)
FLT_12_1PH	SLG same as FLT_11_3PH
FLT_13_3PH	a. Apply Fault at Riverside 345kV (53794). b. Clear Fault after 3.5 cycles by removing the line from (53794-55224) c. Wait 6 cycles, and then re-close the line in (b) into the fault. d. Leave fault on for 3.5 cycles, then trip the line in (b) and remove fault.
FLT_14_1PH	SLG same as FLT_13PH
FLT_15_3PH	a. Apply Fault at Riverside (53795). b. Clear Fault after 3.5 cycles by removing the line from (53795-53867-53825-53821-53776-53847) c. Wait 6 cycles, and then re-close the line in (b) into the fault. d. Leave fault on for 3.5 cycles, then trip the line in (b) and remove fault.
FLT_16_1PH	SLG same as FLT_15_3PH

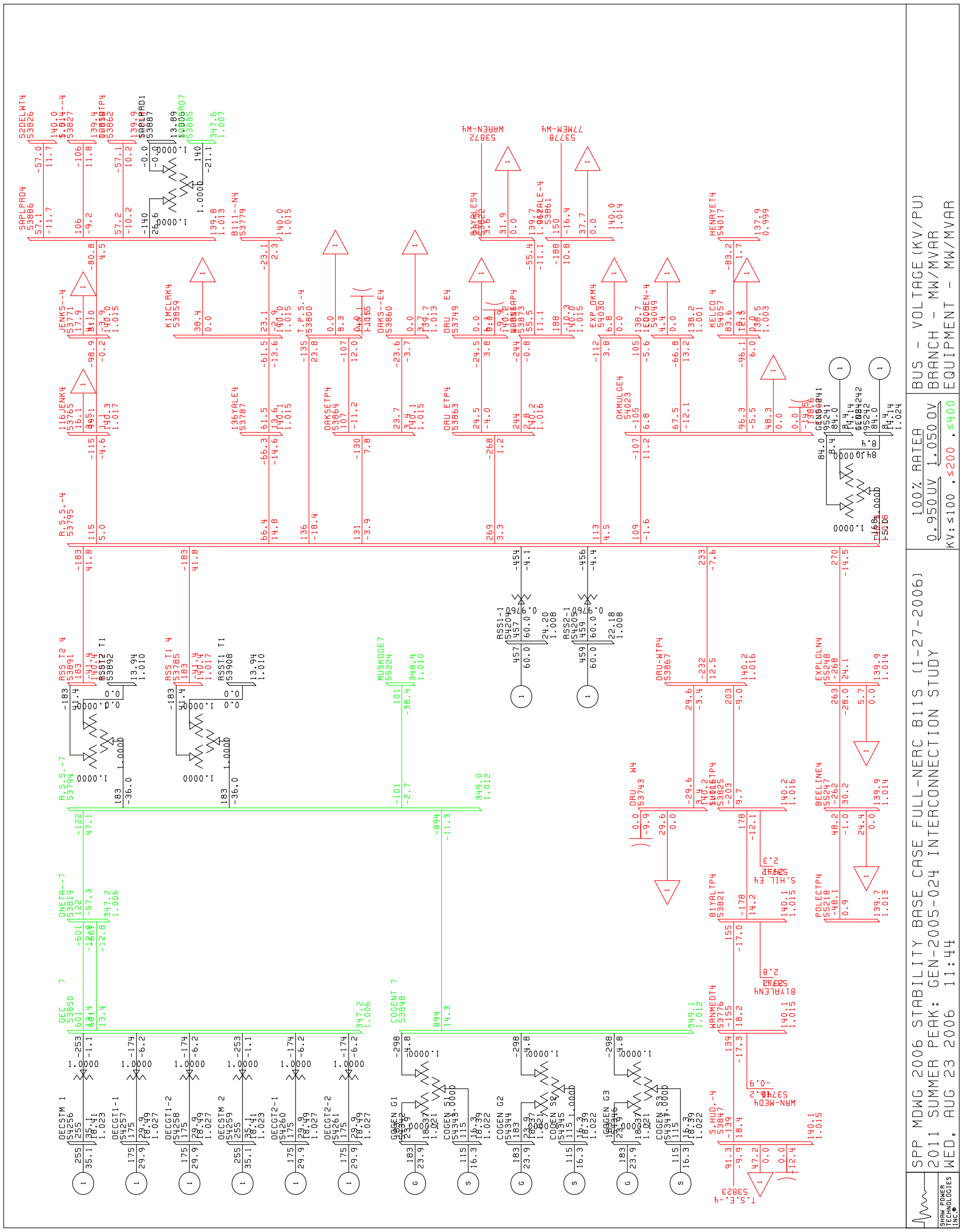

Figure 2-1: Powerflow diagram for GEN-2005-024 (Summer Peak 2011)

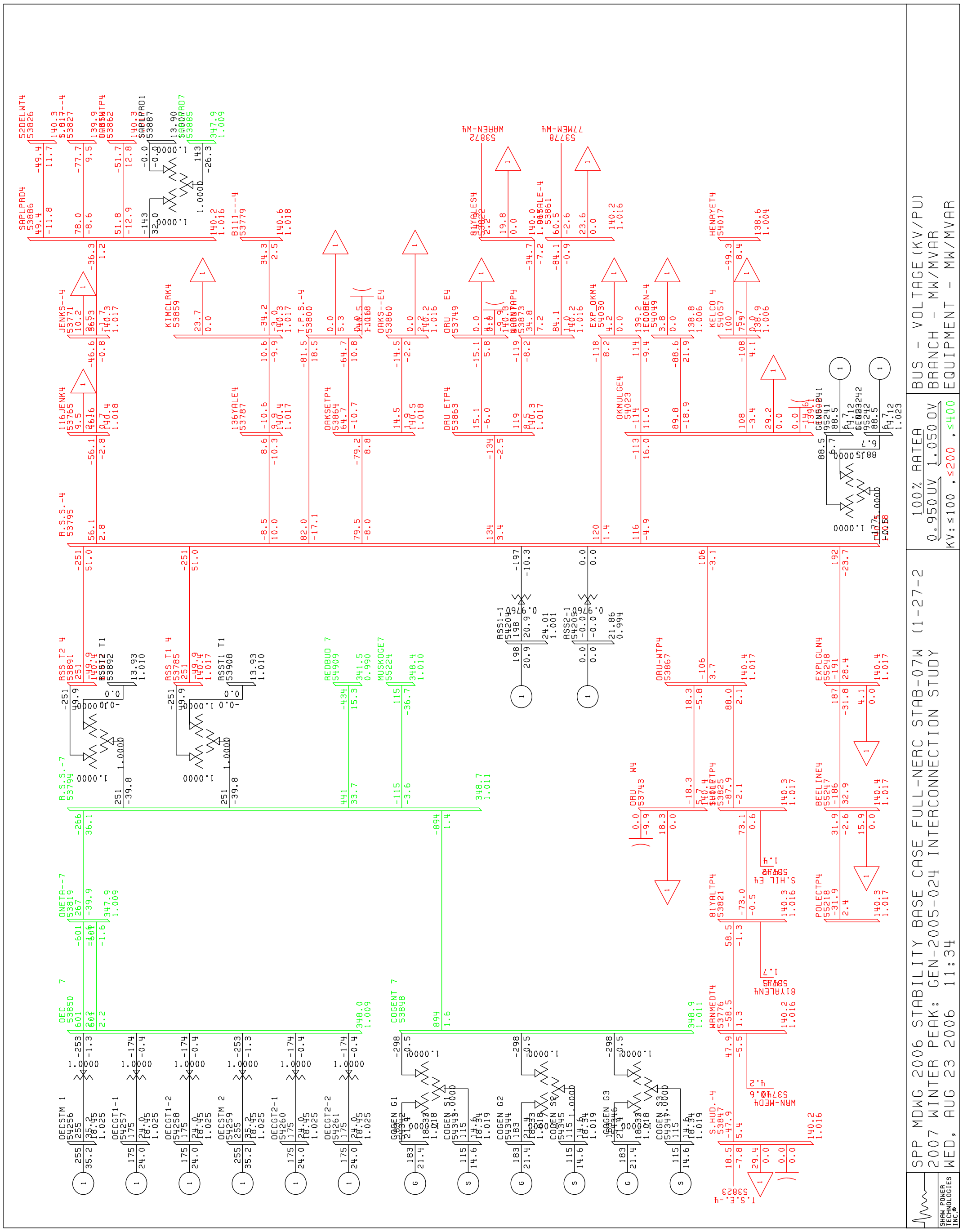

Figure 2-2: Powerflow diagram for GEN-2005-024 (Winter Peak 2007)

2.3 STUDY RESULTS

The results for all the disturbances simulated are summarized in Table 2-3.

The plots for all the simulated faults are included in Appendix B.

The results of the simulation indicate that the SPP system will be stable following all the simulated faults in both Summer Peak and Winter Peak system conditions**.**

The Cogentrix units have larger amplitude oscillation than other local units following '*FLT_13_3PH*' in both Summer Peak 2011 and Winter Peak 2007 system conditions. The same fault was repeated on the case without GEN-2005-024 units. Simulation of this case showed similar results as Post-GEN-2005-024 case. Thus, the Cogentrix oscillations are not caused by GEN-2005-024.

Exciter Response

In the previous study of identical units in the GEN-2005-022 study, it was found that the EXAC2 excitation system model responded very slowly for a modern excitation system. Further investigation showed that parameters Ka and Kb needed significant adjustment to be realistic (they were changed to Ka = 200 and Kb = 5, respectively). In this study of GEN-2005-024, the EXAC2 model was used as given by the developer. It is recommended that this model be revalidated at the time of commissioning of the new GEN-2005-024 plant.

Table 2-3: Results for Stability Analysis

FAULT	Summer Peak 2011	Winter Peak 2007
FLT_1_3PH	STABLE	STABLE
FLT_2_1PH	STABLE	STABLE
FLT_3_3PH	STABLE	STABLE
FLT_4_1PH	STABLE	STABLE
FLT_5_3PH	STABLE	STABLE
FLT_6_1PH	STABLE	STABLE
FLT_7_3PH	STABLE	STABLE
FLT_8_1PH	STABLE	STABLE
FLT_9_3PH	STABLE	STABLE
FLT_10_1PH	STABLE	STABLE
FLT_11_3PH	STABLE	STABLE
FLT_12_1PH	STABLE	STABLE
FLT_13_3PH	STABLE	STABLE
FLT_14_1PH	STABLE	STABLE
FLT_15_3PH	STABLE	STABLE
FLT_16_1PH	STABLE	STABLE

3 CONCLUSIONS

The objective of this study is to evaluate the impact on system stability after connecting the GEN-2005-024 to the interconnection point and its effect on the nearby transmission system and generating stations. The study is performed on two system scenarios: 2007 Winter Peak and the 2011 Summer Peak, provided by SPP.

The SPP system will be stable following all the simulated faults with the proposed GEN-2005-024 project in-service. Based on the results of stability analysis it can be concluded that the proposed GEN-2005-024 project does not adversely impact the stability of the SPP system. The EXAC2 model parameters should be revalidated at plant commissioning.

The results of this analysis are based on available data and assumptions made at the time of conducting this study. If any of the data and/or assumptions made in developing the study model change, the results provided in this report may not apply.

Appendix A - LOADFLOW AND DYNAMIC DATA FOR GEN-2005-024

A.1 POWER FLOW DATA

A.1.1 2011 SUMMER PEAK

```
0,   100.00          / PSS/E-29.5    TUE, AUG 15 2006  11:18
SPP MDWG 2006 STABILITY BASE CASE FULL-NERC B11S (1-27-2006)
2011 SUMMER PEAK: GEN-2005-024 INTERCONNECTION STUDY
95241,'GEN5-241',  13.8000,2,     0.000,     0.000, 520, 201,1.02430,  20.6641,   1
95242,'GEN5-242',  13.8000,2,     0.000,     0.000, 520, 201,1.02430,  20.6641,   1
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95241,'1 ',    84.000,     8.352,    32.000,   -30.000,1.01800,53795,   101.800,
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1,1.0000
95242,'1 ',    84.000,     8.352,    32.000,   -30.000,1.01800,53795,   101.800,
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1,1.0000
0 / END OF GENERATOR DATA, BEGIN BRANCH DATA
0 / END OF BRANCH DATA, BEGIN TRANSFORMER DATA
95241,53795,95242,'1 ',1,2,1,   0.00000,   0.00000,2,'GEN05-24',1,   1,1.0000
   0.00180,   0.11999,  120.00,   0.00180,   0.11999,  120.00,   0.00215,   0.27299,
120.00,1.01857,  15.4138
1.00000,   0.000,   0.000,  100.00,  100.00,  100.00, 0,     0, 1.10000, 0.90000,
1.10000, 0.90000,  33, 0, 0.00000, 0.00000
1.00000,   0.000,   0.000,  200.00,  200.00,  200.00
1.00000,   0.000,   0.000,  100.00,  100.00,  100.00
0 / END OF TRANSFORMER DATA, BEGIN AREA DATA
 520,53715, -1311.000,     1.000,'AEPW    '
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0 / END OF TWO-TERMINAL DC DATA, BEGIN VSC DC LINE DATA
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0 / END OF MULTI-TERMINAL DC DATA, BEGIN MULTI-SECTION LINE DATA
0 / END OF MULTI-SECTION LINE DATA, BEGIN ZONE DATA
 201,'TULSA   '
0 / END OF ZONE DATA, BEGIN INTER-AREA TRANSFER DATA
0 / END OF INTER-AREA TRANSFER DATA, BEGIN OWNER DATA
   1,'1          '
0 / END OF OWNER DATA, BEGIN FACTS DEVICE DATA
0 / END OF FACTS DEVICE DATA
```

A.1.2 2007 WINTER PEAK

```
0,   100.00          / PSS/E-29.5    TUE, AUG 15 2006  11:14
SPP MDWG 2006 STABILITY BASE CASE FULL-NERC STAB-07W (1-27-2
2007 WINTER PEAK: GEN-2005-024 INTERCONNECTION STUDY
95241,'GEN5-241',  13.8000,2,     0.000,     0.000, 520, 201,1.02297,  24.6380,   1
95242,'GEN5-242',  13.8000,2,     0.000,     0.000, 520, 201,1.02297,  24.6380,   1
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0 / END OF LOAD DATA, BEGIN GENERATOR DATA
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1,1.0000
95242,'1 ',    88.500,     6.736,    74.000,   -44.000,1.01820,53795,   101.800,
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1,1.0000
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120.00,1.01946,  19.1021
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0 / END OF SWITCHED SHUNT DATA, BEGIN IMPEDANCE CORRECTION DATA
0 / END OF IMPEDANCE CORRECTION DATA, BEGIN MULTI-TERMINAL DC DATA
0 / END OF MULTI-TERMINAL DC DATA, BEGIN MULTI-SECTION LINE DATA
0 / END OF MULTI-SECTION LINE DATA, BEGIN ZONE DATA
 201,'TULSA   '
0 / END OF ZONE DATA, BEGIN INTER-AREA TRANSFER DATA
0 / END OF INTER-AREA TRANSFER DATA, BEGIN OWNER DATA
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A.2 DYNAMICS DATA

```
     PTI INTERACTIVE POWER SYSTEM SIMULATOR--PSS/E      TUE, AUG 15 2006  11:21
SPP MDWG 2006 STABILITY BASE CASE FULL-NERC B11S (1-27-2006)
2011 SUMMER PEAK: ⌐ 2005 SOUTHWEST POWER POOL, INC.; RED DYN

PLANT MODELS

REPORT FOR ALL MODELS                            BUS 95241 [GEN5-24113.800] MODELS


** GENROU **  BUS X-- NAME --X BASEKV MC    C O N S     S T A T E S
            95241     GEN5-241 13.800 1  146092-146105  55702-55707

            MBASE     Z S O R C E         X T R A N       GENTAP
            101.8  0.00000+J 0.15000  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
12.80 0.050  3.90 0.050   5.60  0.00 1.9800 1.8100 0.2080 0.3000 0.1500 0.1000

                               S(1.0)  S(1.2)
                               0.1100  0.5100


** EXAC2 **   BUS X-- NAME --X BASEKV MC    C O N S     S T A T E S
            95241     GEN5-241 13.800 1  146120-146142  55714-55718

   TR       TB       TC       KA       TA     VAMAX   VAMIN     KB    VRMAX   VRMIN
  0.010    1.000    1.000  1000.0    0.010    7.210  -7.210     1.0    29.1   -29.1

       TE       KL       KH       KF       TF       KC       KD       KE       VLR
      1.300    4.000    0.000    0.049    1.000    0.100    0.770    1.000    9.368

                          E1       S(E1)      E2      S(E2)
                        3.0440    0.0080    4.0580    0.0140


** GAST2A **  BUS X-- NAME --X BASEKV MC    C O N S     S T A T E S      V A R S
            95241     GEN5-241 13.800 1  146166-146196  55724-55736    11909-11912

   W      X      Y      Z     ETD     TCD     TRATE    T     MAX    MIN    ECR   K3
  25.00 0.000 0.050  1.00  0.040  0.200   80.00  0.12  1.20  -0.10  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  0.200  0.800   15.00  2.500  917.0  3.30

                AF1     BF1     AF2     BF2     CF2     TR     K6      TC
               700.0   550.0 -0.300   1.300   0.500 1006.0   0.230  2000.0
```

```
     PTI INTERACTIVE POWER SYSTEM SIMULATOR--PSS/E      TUE, AUG 15 2006  11:21
SPP MDWG 2006 STABILITY BASE CASE FULL-NERC B11S (1-27-2006)
2011 SUMMER PEAK: ⌐ 2005 SOUTHWEST POWER POOL, INC.; RED DYN

PLANT MODELS

REPORT FOR ALL MODELS                              BUS 95242 [GEN5-24213.800] MODELS


** GENROU **  BUS X-- NAME --X BASEKV MC    C O N S     S T A T E S
            95242     GEN5-242 13.800 1  146106-146119  55708-55713

            MBASE     Z S O R C E         X T R A N       GENTAP
            101.8  0.00000+J 0.15000  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
12.80 0.050  3.90 0.050   5.60  0.00 1.9800 1.8100 0.2080 0.3000 0.1500 0.1000

                               S(1.0)  S(1.2)
                               0.1100  0.5100


** EXAC2 **   BUS X-- NAME --X BASEKV MC    C O N S     S T A T E S
            95242     GEN5-242 13.800 1  146143-146165  55719-55723

   TR      TB      TC      KA      TA     VAMAX   VAMIN     KB    VRMAX   VRMIN
  0.010   1.000   1.000  1000.0   0.010   7.210  -7.210     1.0    29.1   -29.1

      TE      KL      KH      KF      TF      KC      KD      KE      VLR
    1.300   4.000   0.000   0.049   1.000   0.100   0.770   1.000   9.368

                          E1      S(E1)     E2     S(E2)
                        3.0440   0.0080   4.0580   0.0140


** GAST2A **  BUS X-- NAME --X BASEKV MC    C O N S     S T A T E S     V A R S
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    A     B     C     TF     KF     K5     K4      T3     T4     TT     T5
   1.00  0.05  1.00  0.40  0.000  0.200  0.800   15.00  2.500  917.0  3.30

                 AF1    BF1    AF2    BF2    CF2    TR     K6     TC
                700.0  550.0 -0.300  1.300  0.500 1006.0  0.230 2000.0
```

Appendix B - SIMULATION PLOTS FOR STABILITY ANALYSIS