SPP Southwest Power Pool

Impact Study For Generation Interconnection Request GEN-2006-038

SPP Tariff Studies

(#GEN-2006-038)

September 2007

Summary

Pursuant to the tariff and at the request of the Southwest Power Pool (SPP), Black & Veatch performed the following Impact Study to satisfy the Impact Study Agreement executed by the requesting Customer and SPP for SPP Generation Interconnection request #GEN-2006-038.

The Impact Study determined that the GEN-2006-038 interconnection request will require a stabilizer to dampen oscillations that were observed during the analysis.

Interconnection Facilities

The interconnection of this generator will require the addition of two 345kV terminals into the proposed 345kV switchyard to be built at Western Farmers Hugo power station. The proposed switchyard is to include at a minimum terminals to a 345/138kV autotransformer and a 345kV line terminal to Valliant. The addition of this generating unit will bring the number of terminals to five. These three additional terminals include a terminal for the generator, a terminal for the auxiliary transformer, and a line terminal to Sunnyside (mentioned below). The bus configuration will most likely be a breaker-and-a-half.

The Interconnection Customer will be required to pay for the installation two 345kV terminals into the 345kV bus at Hugo. The terminals the Customer will pay for will be the generator (GSU) terminal and the auxiliary (RAT) terminal. The estimated cost of these facilities is $3,000,000.

The Impact Study determined that the GEN-2006-038 interconnection request will need additional transmission reinforcements to maintain a stable transmission system. The generator was found to be unstable for the loss of the proposed Hugo – Valliant 345kV transmission line. SPP tested different options as indicated in the Study and determined the best available option to mitigate the instability of the generator would be the addition of a Hugo – Sunnyside 345kV transmission line.

The latest E&C costs for the Hugo – Sunnyside 345kV line have been given in SPP-2006-AG3-AFS-7 study for transmission service. The cost of this line is estimated at $50,750,000. The cost of this line has been assigned to the various transmission customers of SPP-2006-AG3.

In the event the Hugo – Sunnyside 345kV line is not built for SPP-2006-AG3, then the Interconnection Customer will be responsible for the cost to build this line. Alternately, a restudy may be conducted in order to find a less costly alternative.

Other Alternatives

The Impact Study left open the possibility of the Customer lowering its generation interconnection request to approximately 400MW in order to alleviate the unit instability. If the Customer chooses this option, a full restudy will need to be conducted using the parameters of a 400MW generator.

Table 1: Required Interconnection Network Upgrade Facilities

FACILITY	ESTIMATED COST (2007 DOLLARS)
WFEC – Install two (2) 345kV line terminals into the Hugo 345kV switchyard. This switchyard is already proposed to be built.	$3,000,000
Total	**$3,000,000**

Table 2: Additional Required Interconnection Network Upgrade Facilities (if Transmission Customers in SPP-2006-AG3 do not build Hugo-Sunnyside)

FACILITY	ESTIMATED COST (2007 DOLLARS)
WFEC – Install one (1) 345kV line terminal into the Hugo 345kV switchyard. This switchyard is already proposed to be built	$2,000,000
WFEC – Install 345kV transmission line from Hugo – Sunnyside	$48,000,000
OKGE – Install one 345kV breaker and line terminal at Sunnyside 345kV	$750,000
Total	**$50,750,000**

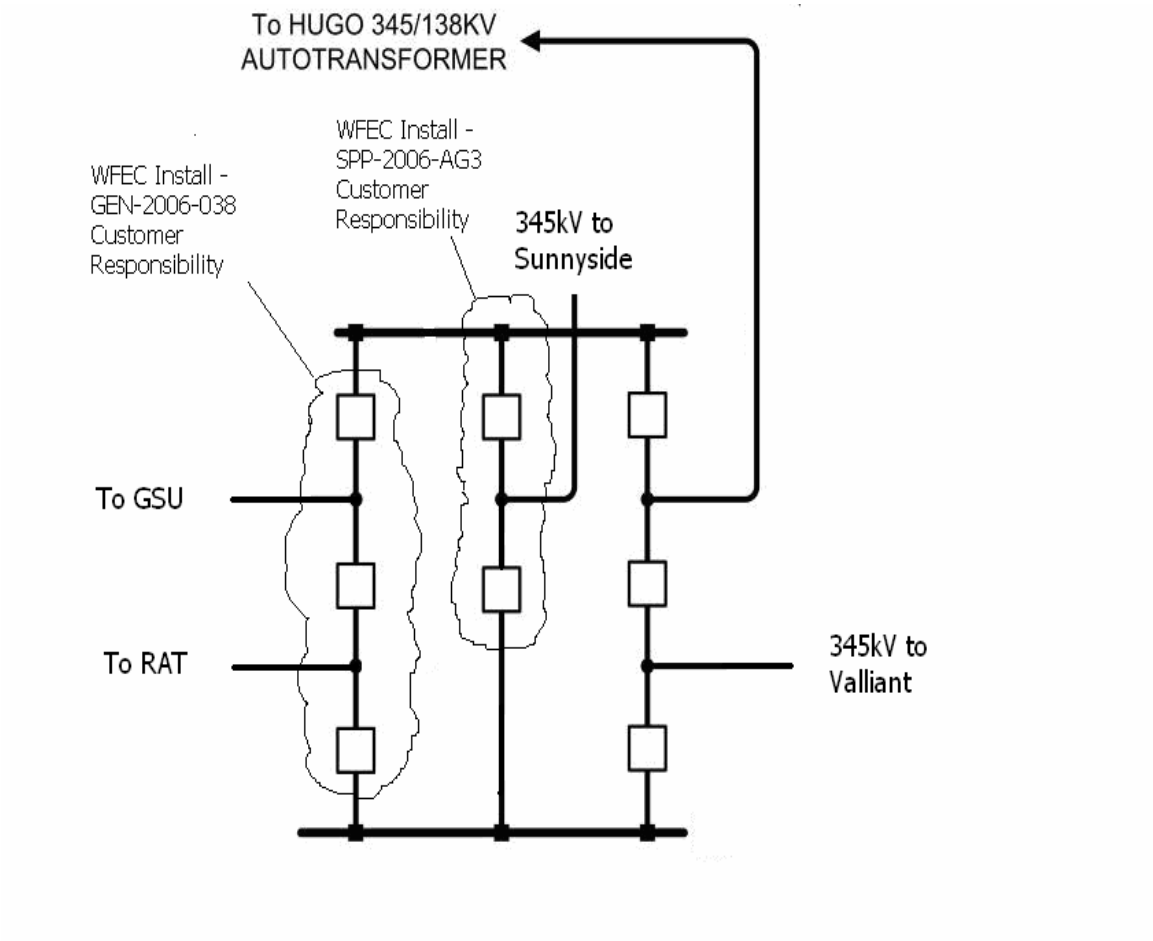

Figure 1: Proposed Interconnection
(Final substation design to be determined)

IMPACT STUDY FOR SPP GENERATION

QUEUE POSITION GEN-2006-038

SOUTHWEST POWER POOL (SPP)

September 4, 2007

Final Report

By

BLACK & VEATCH

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EXECUTIVE SUMMARY

A transient stability study has been performed for Southwest Power Pool (SPP) Interconnection Queue Position Gen-2006-038 as part of the System Impact Study. The Interconnection Queue Position Gen-2006-038 is a coal-fired steam turbine generator with a capacity of 800 MW located in Choctaw County, Oklahoma. The generation facility will be interconnected to the Hugo 345kV substation on the Western Farmers Electric Cooperative (WFEC) transmission system.

The 2012 summer peak and 2008 winter peak load flow case together with the SPP MDWG 2007 stability model were used as the base case for the transient stability analysis. The study was performed using PTI's PSS/E program, which is an industry-wide accepted power system simulation program.

Transient Stability studies were conducted with the total capacity of 800 MW in the summer and the winter. Twenty (20) contingencies were considered for each of the scenarios.

The study has shown that system would be unstable for faults FLT13 and FLT21, with the addition of Gen-2006-038. These are the contingencies which cause Hugo – Valliant 345 kV line trip following the disturbances. However, the system was found to be stable with a stabilizer and a new 345 kV transmission line between Hugo and Sunnyside. The system was also found to be stable if Gen-2006-038 was considered to be 400 MW, instead of 800 MW.

If any previously queued projects that were included in this study drop out then this System Impact Study may have to be revised to determine the impacts of this Interconnection Customer's project on SPS transmission facilities.

1. INTRODUCTION

This report discusses the results of a transient stability study performed for Southwest Power Pool (SPP) Interconnection Queue Position Gen-2006-038.

The Interconnection Queue Position Gen-2006-038 is a generating facility with a coal fired steam turbine generator of total capacity of 800 MW. The generating facility will be located in Choctaw County, Oklahoma within the service territory of Western Farmers Electric Cooperative (WFEC) and will be interconnected to Hugo 345 kV substation. The system one line diagram of the area near the Queue Position Gen-2006-038 is shown below.

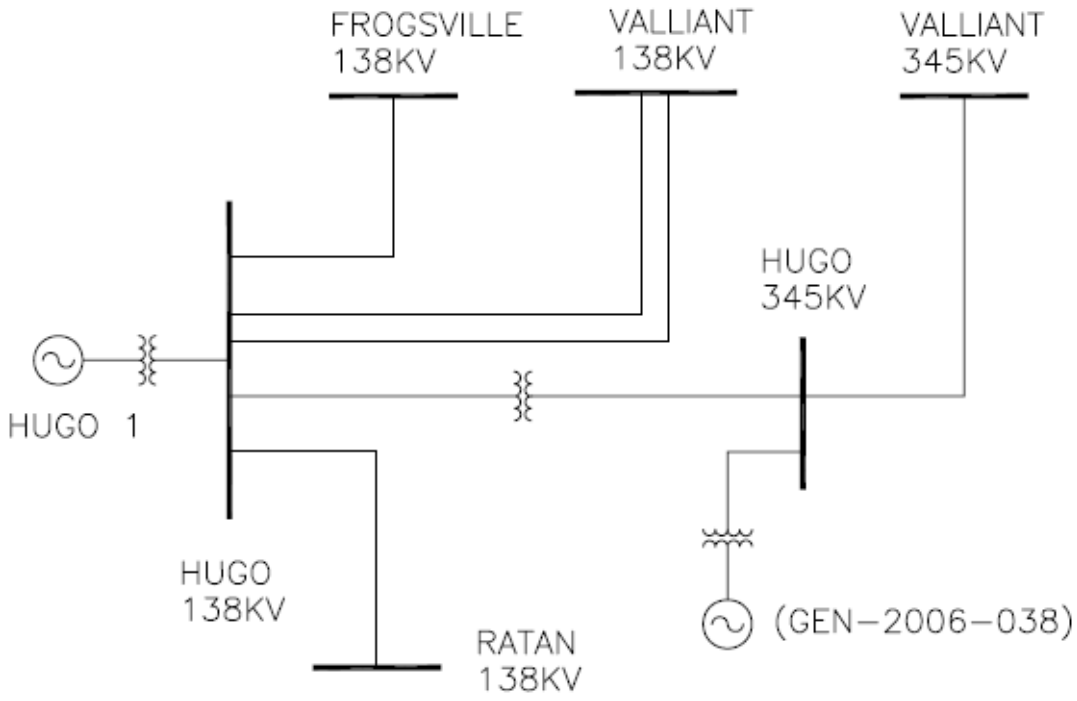


Figure 1: System One Line Diagram near GEN-2006-038

Transient Stability studies were conducted for summer and winter cases with the 100% total capacity, i.e., 800 MW. The data for the new turbine generator were provided by the Customer for the study.

2. STABILITY STUDY CRITERIA

The SPP MDWG 2007 series 2012 summer peak and 2008 winter peak load flow cases together with the SPP MDWG 2007 stability model database were used as the base case for the transient stability analysis. These models were provided by SPP.

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 difference of the angular positions of synchronous machine rotor becomes constant following an aperiodic system disturbance."

Disturbances such as three phase and single phase line faults were simulated for a specified duration and the synchronous machine rotor angles were monitored for their synchronism following the fault removal.

The ability of the wind generators to stay connected to the grid during the disturbances and during the fault recovery was also monitored.

3. SIMULATION CASES

Transient Stability studies were conducted with the Gen-2006-038 output at 100% for two scenarios, i.e., (i) 2012 summer peak load and (ii) 2008 winter peak load.

Table 1 indicates the contingencies which were studied.

Fault Number	Fault Definition
FLT1_3PH	Three phase fault on the Hugo - Valliant 345 kV line, near Hugo, with one shot reclosing after 20 cycles.
FLT2_1PH	Single phase fault on the Hugo - Valliant 345 kV line, near Hugo, with one shot reclosing after 20 cycles.
FLT3_3PH	Three phase fault on the Hugo 345/138kV autotransformer – 345 kV bus.
FLT4_1PH	Single phase fault on the Hugo 345/138kV autotransformer – 345 kV bus.
FLT5_3PH	Three phase fault on the Hugo - Valliant 138 kV line, near Hugo, with one shot reclosing after 20 cycles.
FLT6_1PH	Single phase fault on the Hugo - Valliant 138 kV

	line, near Hugo, with one shot reclosing after 20 cycles.
FLT7_3PH	Three phase fault on the Hugo - Valliant 138 kV line, near Hugo with one shot reclosing after 20 cycles.
FLT8_1PH	Single phase fault on the Hugo - Valliant 138 kV line, near Hugo with one shot reclosing after 20 cycles.
FLT9_3PH	Three phase fault on the Hugo - Frogville 138 kV line, near Hugo with one shot reclosing after 20 cycles.
FLT10_1PH	Single phase fault on the Hugo - Frogville 138 kV line, near Hugo with one shot reclosing after 20 cycles.
FLT11_3PH	Three phase fault on the Hugo - Rattan 138 kV line, near Hugo with one shot reclosing after 20 cycles.
FLT12_1PH	Single phase fault on the Hugo - Rattan 138 kV line, near Hugo with one shot reclosing after 20 cycles.
FLT13_3PH	Three phase fault on the Valliant – Pittsburgh 345 kV line, near Valliant with one shot reclosing after 20 cycles.
FLT14_1PH	Single phase fault on the Valliant – Pittsburgh 345 kV line, near Valliant with one shot reclosing after 20 cycles.
FLT15_3PH	Three phase fault on the Valliant - Lydia 345 kV line, near Valliant with one shot reclosing after 20 cycles.
FLT16_1PH	Single phase fault on the Valliant - Lydia 345 kV line, near Valliant with one shot reclosing after 20 cycles.
FLT17_3PH	Three phase fault on the Seminole - Pittsburgh 345 kV line, near Pittsburgh with one shot reclosing after 20 cycles.
FLT18_1PH	Single phase fault on the Seminole - Pittsburgh 345 kV line, near Pittsburgh with one shot reclosing after 20 cycles.
FLT19_3PH	Three phase fault on the Muskogee - Pittsburgh 345 kV line, near Pittsburgh with one shot reclosing after 20 cycles.
FLT20_1PH	Single phase fault on the Muskogee - Pittsburgh 345 kV line, near Pittsburgh with one shot reclosing after 20 cycles.

4. SIMULATION MODEL

Gen-2006-038 is a coal-fired steam turbine generator. The following are the main parameters of the turbine generator unit and Table 2 shows the electrical parameters of the generators.

Rated Power : 900 MW
Voltage : 24,500 V
Rated Power Factor : 0.90

The Customer also provided the following Generator Step-up Transformers impedance and the control parameters as shown in the Appendix:

Transformer Impedance: 10 % on 1100 MVA

The generating unit was considered to be connected with the Hugo 345 kV substation directly via GSU.

No additional transmission lines were added to either the winter or summer load flow cases.

Description	Value
Open Circuit Transient Time Constant, T'D0	6.0
Open Circuit Subtransient Time Constant, T"D0	0.031
Open Circuit Quadrature axis Time Constant, T'Q0	0.05
Open Circuit Quadrature axis Subtransient Time Constant,T"Q0	0.5
Inertia Constant, H	4.33
Synchronous reactance, XD	2.18
Quadrature axis reactance, XQ	2.14
Transient Reactance, X'D	0.335
Quadrature axis Transient Reactance, X'Q	0.532
Sub transient Reactance, X"D	0.266
Leakage reactance, XL	0.199

Table 2: Generator Parameters

5. STUDY ASSUMPTIONS

The following assumptions were made in the Study:

1. The wind speed over the entire wind farm (in prior queued projects) was assumed to be uniform and constant during the study period.
2. The generations in the SPP control area were scaled down to accommodate the new generation as indicated in Table 3.

Scenario	Generation within SPP	
	Summer	Winter
With the Gen-2006-038	41,048 MW	29,822 MW
Without the Gen-2006-038	40,248 MW	29,022 MW

Table 3: SPP Dispatches

6. SIMULATION RESULTS

Initial simulation was carried out for 20 seconds without any disturbance to verify the numerical stability of the model and was confirmed to be stable.

Table 4 provides the summary of the stability studies for Gen-2006-038.

Fault Number	Summer Peak	Winter Peak
FLT1_3PH	Unstable	Unstable
FLT2_1PH	Unstable	Unstable
FLT3_3PH	- -	- -
FLT4_1PH	- -	- -
FLT5_3PH	- -	- -
FLT6_1PH	- -	- -
FLT7_3PH	- -	- -
FLT8_1PH	- -	- -
FLT9_3PH	- -	- -
FLT10_1PH	- -	- -
FLT11_3PH	- -	- -
FLT12_1PH	- -	- -
FLT13_3PH	- -	- -
FLT14_1PH	- -	- -

FLT15_3PH	- -	- -
FLT16_1PH	- -	- -
FLT17_3PH	- -	- -
FLT18_1PH	- -	- -
FLT19_3PH	- -	- -
FLT20_1PH	- -	- -

UV : Tripped due to low voltage
OV : Tripped due to high voltage
UF : Tripped due to low frequency
OF : Tripped due to high frequency
PQ : Prior queued projects tripped.
S : Stability issues encountered
- - : System Stable

Table 4 : Stability Study Results Summary

The study has shown that system would be unstable for faults FLT13 and FLT21, with the addition of Gen-2006-038. These are the contingencies which cause Hugo – Valliant 345 kV line trip following the disturbances.

Figure 2 shows the system response for FLT1_3PH in summer peak load case.

Simulations were also carried out with reduced output for Gen-2006-038 and the system was found to be stable at 400 MW.

As possible transmission solutions to fix the stability problem at 100% output, the following options were tested with 800 MW output for Gen-2006-038 output:

1. A new 345 kV transmission line between Hugo and Sunnyside
2. A 2nd 345/138 kV auto transformer at Hugo
3. Interconnecting Gen-2006-38 to 138 kV bus, instead of 345 kV bus

Of the three options listed above, only the Option-1 (a new 345 kV transmission line between Hugo and Sunnyside) was found to be workable. System instability was still encountered for the other two options.

With the new 345kV line from Hugo to Sunnyside, oscillations were observed for the above mentioned faults. When a stabilizer was modeled, the oscillations observed were acceptable.

Figure 3 shows the system response for FLT1_3PH in summer peak load case with a stabilizer and a new 345 kV line between Hugo and Sunnyside.

7. SUMMARY

A transient stability analysis was conducted for the SPP Interconnection Generation Queue Position Gen-2006-038 with the maximum output of 800 MW in summer and winter cases. The study was conducted for two different power flow scenarios, i.e., one for 2012 summer peak load and the other for 2008 winter peak load. The study has indicated instability problem for FLT13 and FLT21 contingencies. However, the system was found to be stable with a stabilizer and a new 345 kV transmission line between Hugo and Sunnyside or at a reduced output of 400 MW.

Disclaimer

If any previously queued projects that were included in this study drop out, then this System Impact Study may have to be revised to determine the impacts of this Interconnection Customer's project on SPS transmission facilities. Since this is also a preliminary System Impact Study, not all previously queued projects were assumed to be in service in this System Impact Study. If any of those projects are constructed, then this System Impact Study may have to be revised to determine the impacts of this Interconnection Customer's project on SPS transmission facilities. In accordance with FERC and SPP procedures, the study cost for restudy shall be borne by the Interconnection Customer.

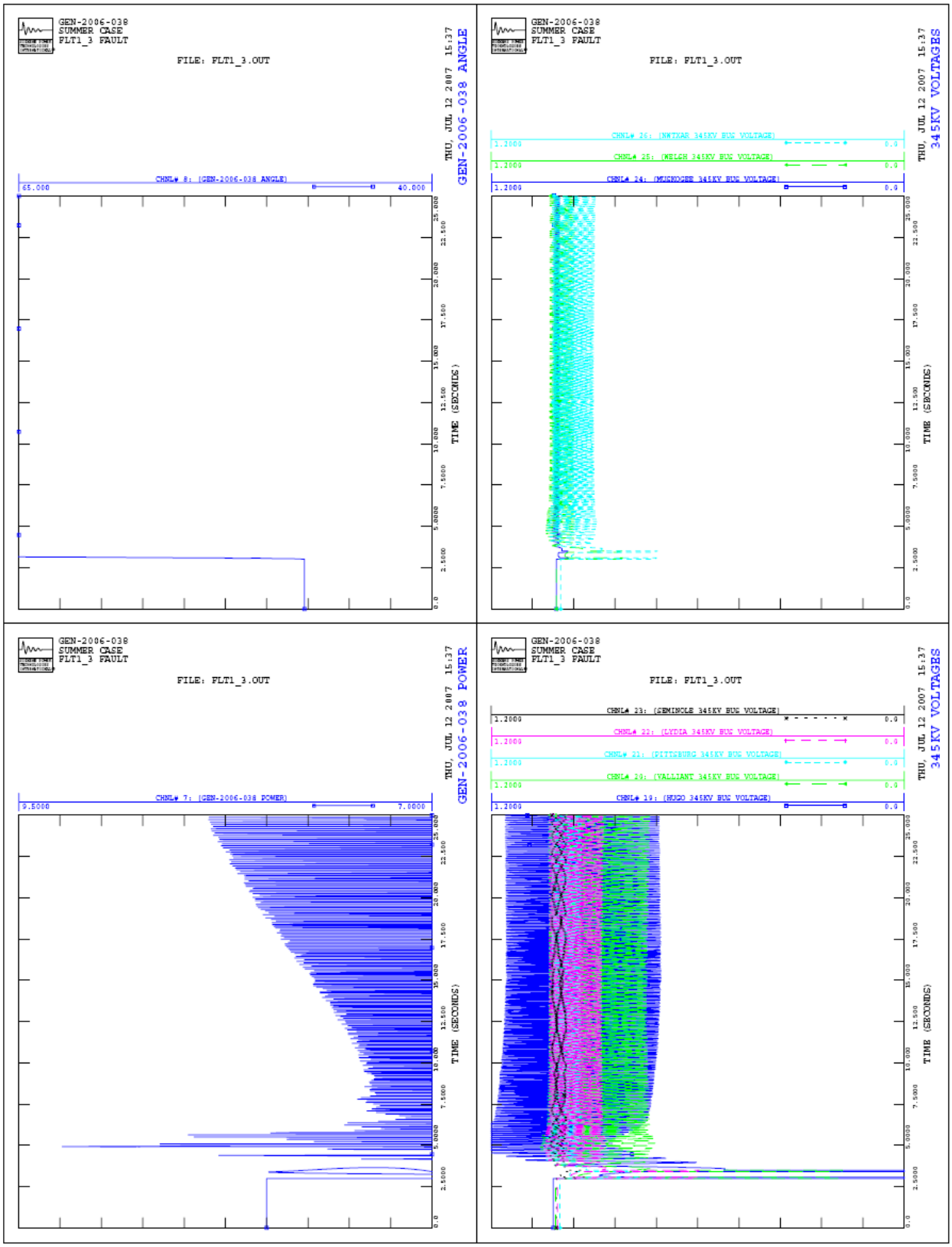


Figure 2 : System Responses with 100% output of Gen-2006-038

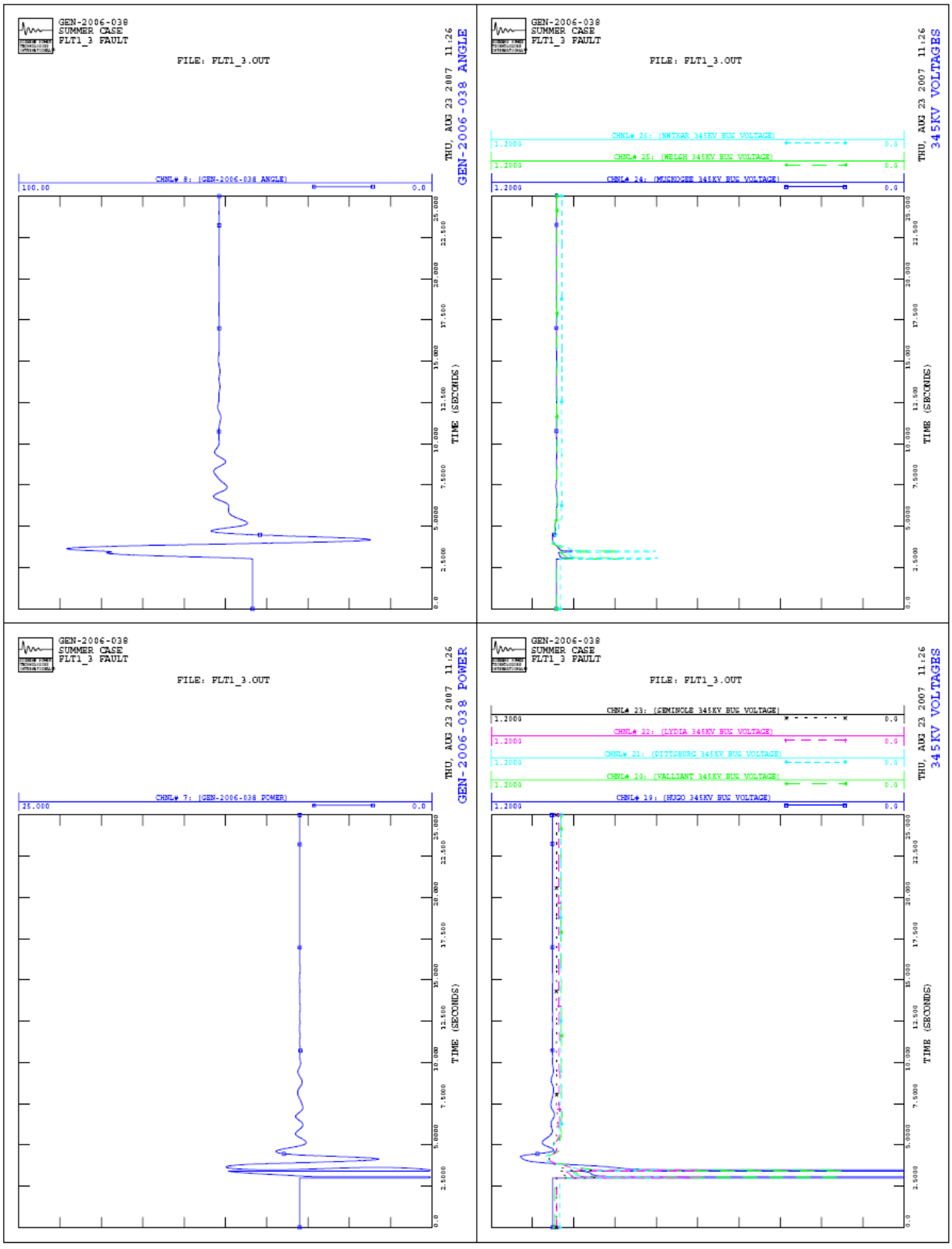
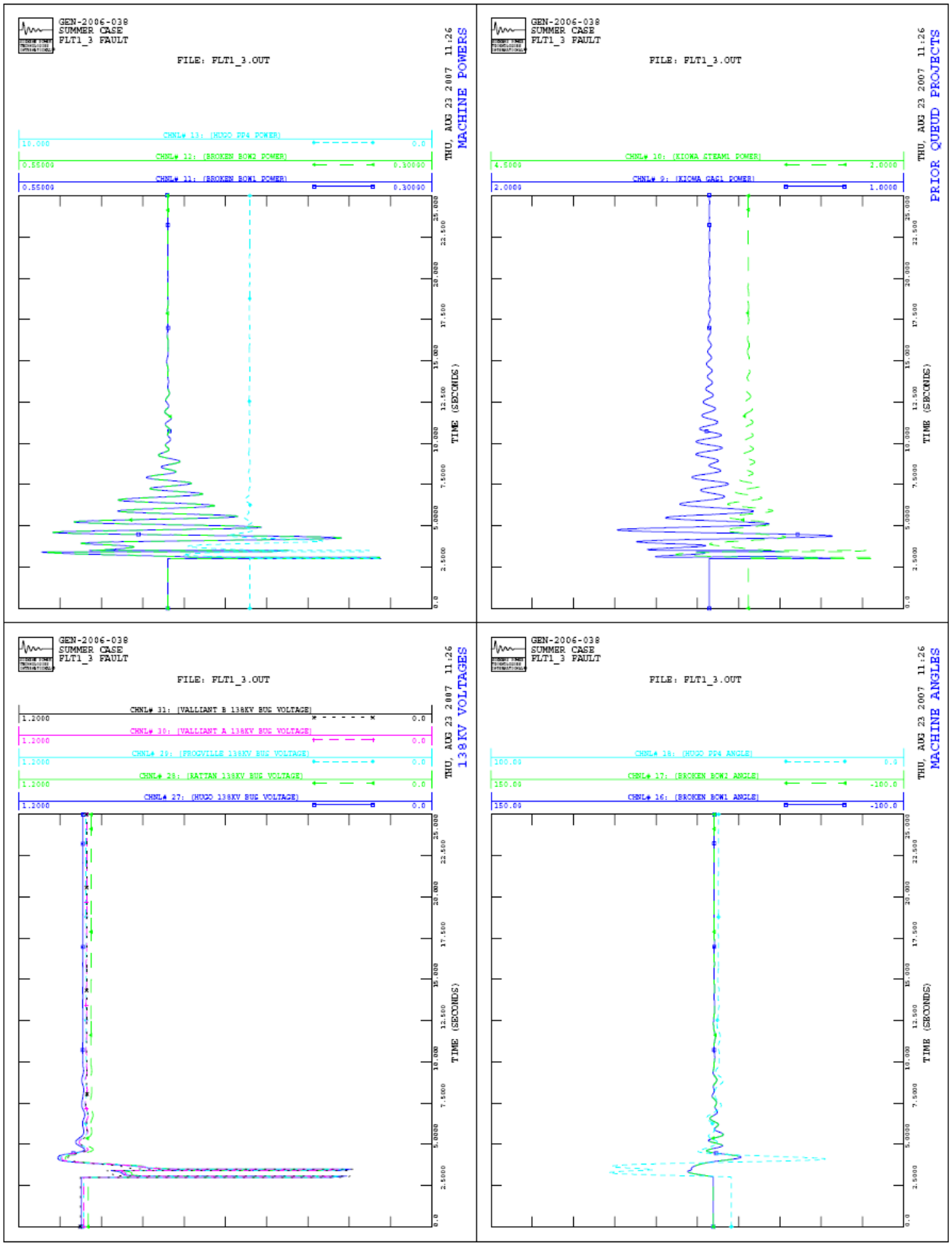


Figure 3 : System Responses with 100% output of Gen-2006-038 and with new Hugo-Sunnyside line

Figure 3 : System Responses with 100% output of Gen-2006-038 and with new Hugo-Sunnyside line (Cont'd)



Appendix

Exciter Data

Model Name	ESST1A
TR	0.01
VIMAX	0.17
VIMIN	-0.15
TC	0.75
TB	13.85
TC1	1.0
TB1	1.0
KA	1000.0
TA	0.01
VAMAX	5.0
VAMIN	-4.5
VRMAX	5.0
VRMIN	-4.5
KC	0.0
KF	0.0
TF	1.0
KLR	0.0
ILR	1.0

Governor Data

Model Name	IEEESGO
T1	0.0
T2	0.0
T3	0.02
T4	1.962
T5	0.0
T6	0.66
K1	20.0
K2	0.68
K3	0.53
PMAX	1.1
PMIN	0.05

Power Systems Stabilizer Data

Model Name	PSS2A
Input 1	Rotor Speed Deviation
Input 2	Gen Elect Power
TW1	2.0
TW2	2.0
T6	0.0
TW3	2.0
TW4	0.0
T7	2.0
KS2	0.302
KS3	1.0
T8	0.5
T9	0.1
KS1	10.0
T1	0.15
T2	0.03
T3	0.15
T4	0.03
VSTMAX	0.1
VSTMIN	-0.1