POWER SYSTEMS DIVISION
GRID SYSTEMS CONSULTING

STABILITY ANALYSIS FOR FACILITY STUDY OF PID-226

FINAL REPORT

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Prepared for:
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ABB Inc – Grid Systems Consulting

Technical Report

Southwest Power Pool, Inc.	**No.** 2009-E3350-R1	
Facility Study for PID-226	Date: 8/21/2009	# Pages 45

Author(s):	**Reviewed by:**	**Approved by:**
Trinadh Dwibhashyam	Amit Kekare	Willie Wong

Executive Summary

Southwest Power Pool, Inc (SPP) at the request of Entergy Services Inc. has commissioned ABB Inc. to perform a stability analysis for Facility study of PID-226, which is a request for 206 MW uprate of existing G. Gulf Unit #1 in the Entergy transmission system.

A system impact study for the PID-226 has previously been completed. The objective of this study was to supplement the stability analysis performed in the system impact study for PID-226 Project. To that end, selected faults at G. Gulf 500 kV substation were simulated and a Critical Clearing Time Analysis was performed at G. Gulf 500 kV substation. The study was performed on 2012 Summer Peak case, provided by SPP/Entergy.

The system was stable following all simulated normally cleared and stuck-breaker faults. No voltage criteria violation was observed following simulated faults.

The Critical Clearing times at G. Gulf 500 kV substations are within the capabilities of the existing protection systems. The smallest CCT at G. Gulf 500 kV substation was 5 + 15 cycles for a fault involving loss of G. Gulf – B. Wilson 500 kV.

Based on the results of stability analysis it can be concluded that proposed PID-226 project does not adversely impact the stability of the Entergy System in the local area. Also, PID-226 does not adversely impact the Critical Clearing time at G. Gulf 500 kV substations. Hence, no transmission reinforcements and/ or upgrades were identified for the interconnection of the PID-226 project.

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	Draft Report	8/21/09	Trinadh	A. Kekare	W. Wong
1	Updated per Entergy comments	8/27/09	Trinadh	A. Kekare	W. Wong
2	Updated for Ray Braswell 500 kV fault results	02/19/10	Trinadh	A. Kekare	W. Wong
DISTRIBUTION: Daniel Epperson – Southwest Power Pool, Inc. Brad Finkbeiner – Southwest Power Pool, Inc. Mukund Chander – Entergy Services Inc.					

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1 INTRODUCTION

Southwest Power Pool, Inc. (SPP) at the request of Entergy Services Inc. has commissioned ABB Inc. to perform a stability analysis for Facility Study of PID-226, which is a request for 206 MW uprate of the existing G. Gulf Unit in the Entergy transmission system.

A system impact study[1] for the PID-226 has previously been completed. The objective of this study was to supplement the stability analysis performed in the system impact study for PID-226 Project. The study was performed on 2012 Summer Peak case, provided by Entergy. Figure 1-1 shows the location of the G. Gulf Unit with proposed 206 MW increase of generation.

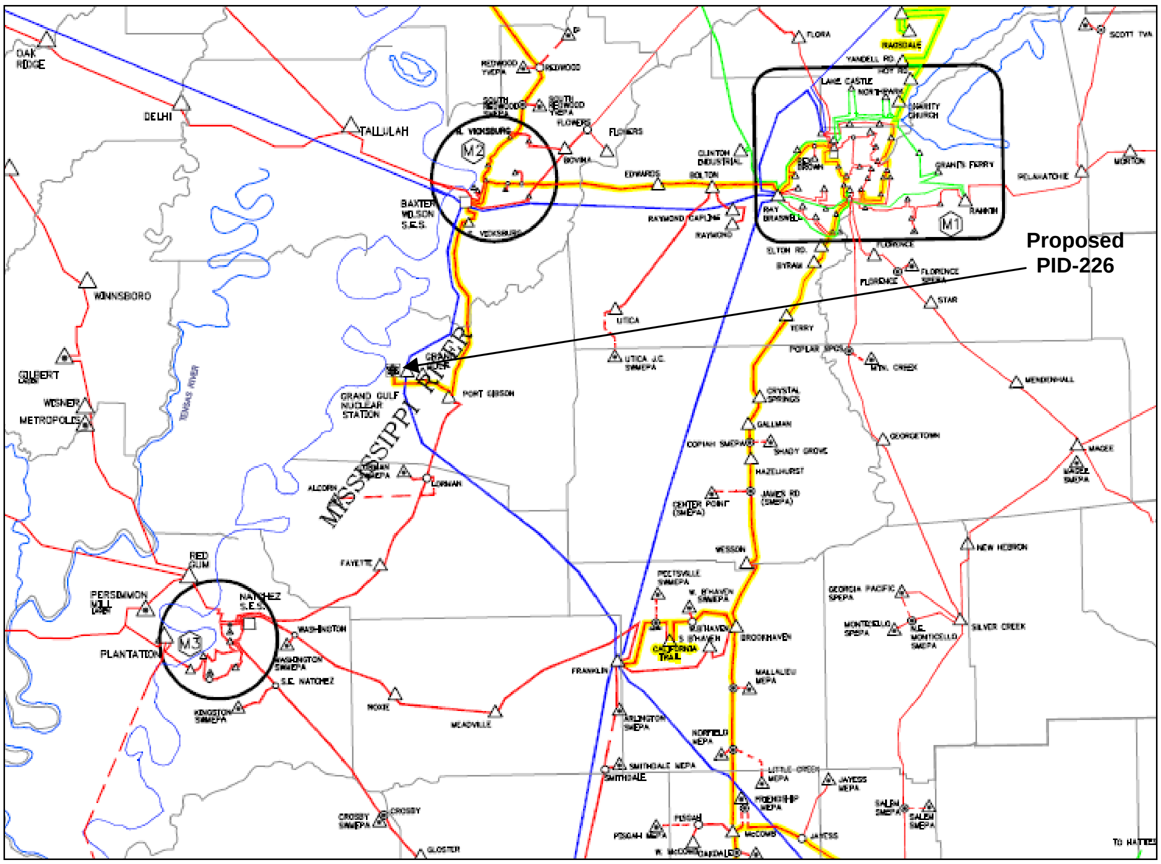


Figure 1-1 PID 226 Project location

[1] “Stability Analysis for PID-226 System Impact study”, March 30, 2009

2 STABILITY ANALYSIS

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 V30.3.2. Three-phase and single-phase line faults were simulated for the specified duration and synchronous machine rotor angles and wind turbine generator speeds were monitored to check whether synchronism is maintained following fault removal.

Based on the Entergy study criteria, three-phase faults with normal clearing and delayed clearing were simulated.

Stability analysis was performed using the PSS/E dynamics program, which only simulates the positive sequence network. Unbalanced faults involve the positive, negative, and zero sequence networks. For unbalanced faults, the equivalent fault admittance must be inserted in the PSS/E positive sequence model between the faulted bus and ground to simulate the effect of the negative and zero sequence networks. For a single-line-to-ground (SLG) fault, the fault admittance equals the inverse of the sum of the positive, negative and zero sequence Thevenin impedances at the faulted bus. Since PSS/E inherently models the positive sequence fault impedance, the sum of the negative and zero sequence Thevenin impedances needs to be added and entered as the fault impedance at the faulted bus.

For three-phase faults, a fault admittance of –j2E9 is used (essentially infinite admittance or zero impedance). For the single phase stuck breaker faults, the fault admittances considered are mentioned in Table 2-4.

Transient Voltage Criteria

In addition to criteria for the stability of the machines, Entergy has evaluation criteria for the transient voltage dip as follows:

- 3-phase fault or single-line-ground fault with normal clearing resulting in the loss of a single component (generator, transmission circuit or transformer) or a loss of a single component without fault:
  Not to exceed 20% for more than 20 cycles at any bus
  Not to exceed 25% at any load bus
  Not to exceed 30% at any non-load bus

- 3-phase faults with normal clearing resulting in the loss of two or more components (generator, transmission circuit or transformer), and SLG fault with delayed clearing resulting in the loss of one or more components:

Not to exceed 20% for more than 40 cycles at any bus
Not to exceed 30% at any bus

The duration of the transient voltage dip excludes the duration of the fault. The transient voltage dip criteria will not be applied to three-phase faults followed by stuck breaker conditions unless the determined impact is extremely widespread.

The voltages at all local buses (above 115 kV) were monitored during each of the fault cases as appropriate.

As there is no specific voltage dip criteria for three-phase stuck breaker faults, the results of these faults were compared with the most stringent voltage dip criteria of - not to exceed 20 % for more than 20 cycles.

Critical Clearing Time (CCT) Analysis
An evaluation of the critical clearing times was carried out for faults on lines and transformers in the G. Gulf 500 kV substation

Critical Clearing Time assessment was performed on 2012 summer peak system conditions.

Critical Clearing Time (CCT) was calculated for a three-phase stuck-breaker fault on each branch connected to G. Gulf 500 kV substation. CCT is defined as the longest fault clearing time for which stability is maintained.

Independent pole operation (IPO) was assumed for breakers in both switchyards, with breaker failure occurring on only a single phase. This results in a three-phase fault becoming a single-phase fault at the normal clearing time. The single phase fault is then cleared by backup protection.

The Normal Clearing Time was kept equal to the normal value (5 cycles on 500 kV and 6 cycles on 230 kV) and the backup clearing time was varied to find the CCT. All machines in the Entergy system were monitored for stability.

2.2 STUDY MODEL DEVELOPMENT

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

Power Flow Case

A Powerflow case "EN12S08_Final_U2_With Upgrades_unconv.sav" representing the 2012 Summer Peak conditions was provided by SPP/ Entergy.

Two prior-queued projects, PID-223 and PID-224, were added to the base case. Thus a pre-project powerflow case was established and named as 'PRE-PID-226.sav'.

The proposed PID-226 project is a 206 MW uprate at G. Gulf Unit. The additional 206 MW was dispatched against the White Bluff Unit #1. Table 2-1 summarizes the dispatch. Thus a post-project power flow case with PID-226 was established and named as 'POST-PID-226.sav'.

Table 2-1 PID-226 project details

System condition	MW	Point of Interconnection	Sink
2012 Summer Peak	206	G. Gulf (#336821)	White Bluff Unit 1 (#337652)

Figure 2-1 shows the PSS/E one-line diagram for the local area WITH the PID-226 project, for 2012 Summer Peak system conditions.

Stability Database

A base case stability database was provided by SPP/Entergy in a PSSE *.dyr file format ('red11S_newnum.dyr').

To create a dynamic database (a snapshot file) for PRE-PID-226 powerflow case, stability data for PID-223 and PID-224 and the dynamic data in 'dystop.dyr' was appended to the base case stability database.

After the proposed uprate of the G. Gulf unit the total MW output of the plant will be 1544 MW, higher than the existing maximum limit (0.90 p.u. on 1600 MVA) on the Governor. For the stability analysis purpose, to avoid the initial condition errors, the limit was changed from 0.90 p.u to 0.97 p.u. on 1600 MVA base. Given the large system under consideration impact of such assumption will not be significant. The pre-project stability database was updated to create dynamic database for Post-PID-226 powerflow case.

The data provided at the Interconnection Request for PID-226 is included in Appendix A. The PSS/E power flow and stability data for PID-226, used for this study, are included in Appendix B.

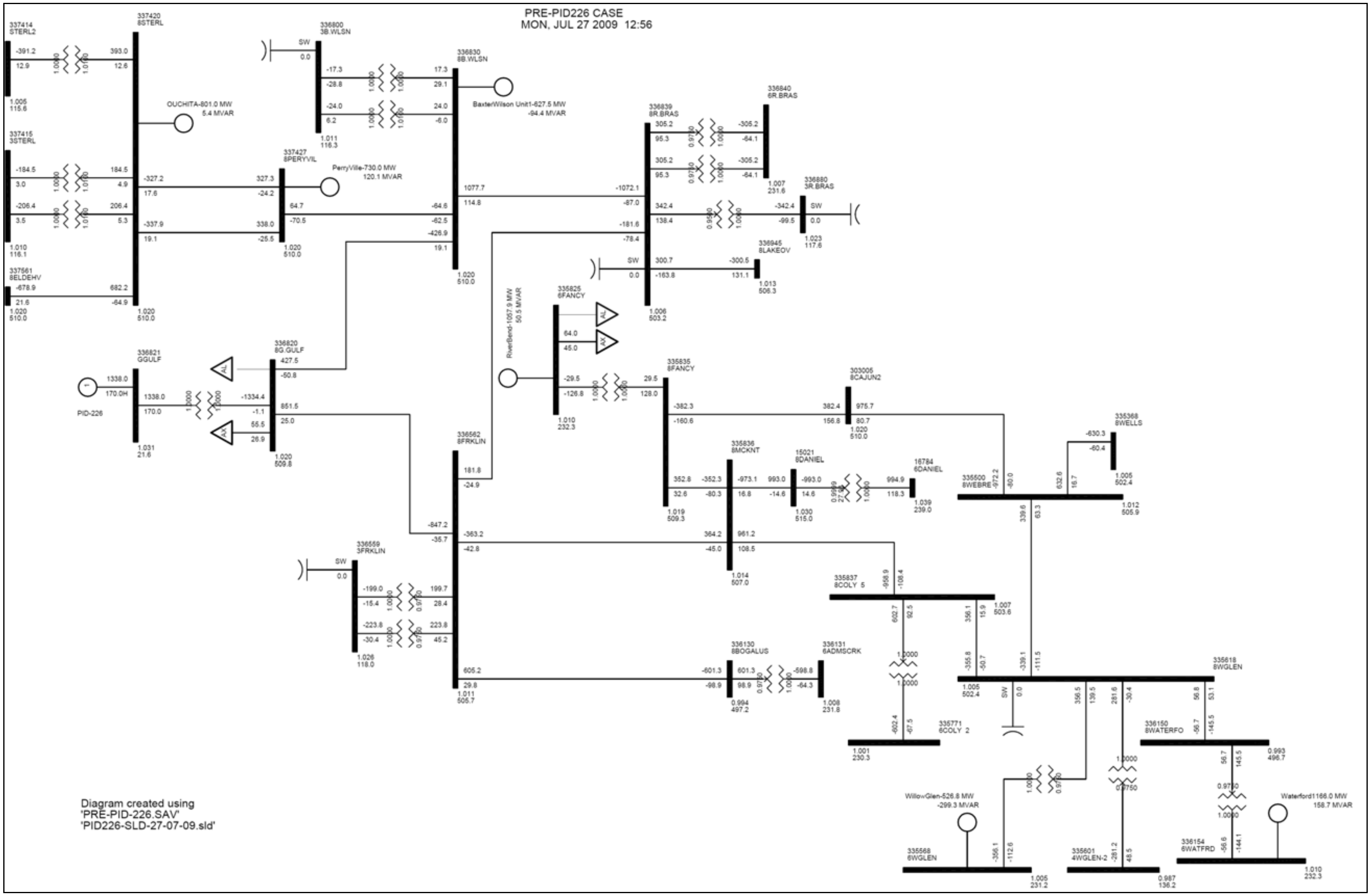


Figure 2-1 One-line Diagram of the local area without PID-226 (2012 Summer Peak)

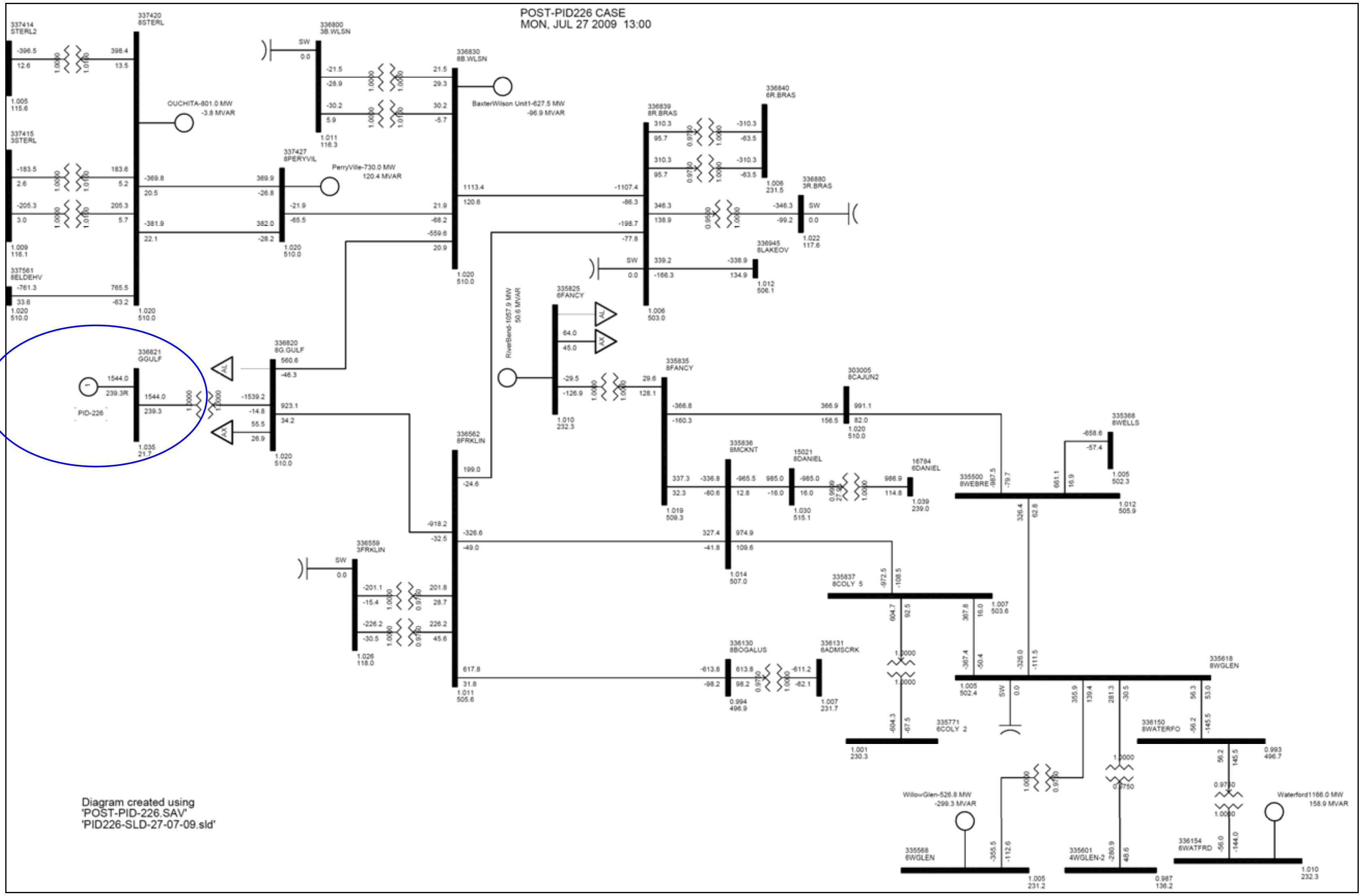


Figure 2-2 One-line Diagram of the local area <u>with</u> PID-226 (2012 Summer Peak)

2.3 TRANSIENT STABILITY ANALYSIS

Stability simulations were run to examine the transient behavior of the G. Gulf Unit and impact of the proposed uprate on the Entergy system. Stability analysis was performed using the following procedure. First, three-phase faults with normal clearing were simulated. Next, the three-phase stuck breaker (IPO: 3PH-1PH) faults were simulated. The fault clearing times used for the simulations are given inTable 2-2.

Table 2-2: Fault Clearing Times

Contingency at kV level	Normal Clearing	Delayed Clearing
500	5 cycles	5+9 cycles

The breaker failure scenario was simulated with the following sequence of events:

1) At the normal clearing time for the primary breakers, the faulted line is tripped at the far end from the fault by normal breaker opening.

2) The fault remains in place for Three-phase stuck-breaker (IPO: 3PH-1PH) faults. The fault admittances is changed to Thevenin equivalent admittance of single phase faults.

3) The fault is then cleared by back-up clearing. If the system was found to be unstable, then the fault was repeated without the proposed PID-226 project.

All line trips are assumed to be permanent (i.e. no high speed re-closure).

Table 2-3 and Table 2-4 list all the fault cases that were simulated in this study.

Fifteen (15) three phase normally cleared and twenty seven (27) three-phase stuck breaker converted into single-line-to-ground fault (following Independent Pole Operation of breakers) were simulated.

For all cases analyzed, the initial disturbance was applied at t = 0.1 seconds. The breaker clearing was applied at the appropriate time following this fault inception.

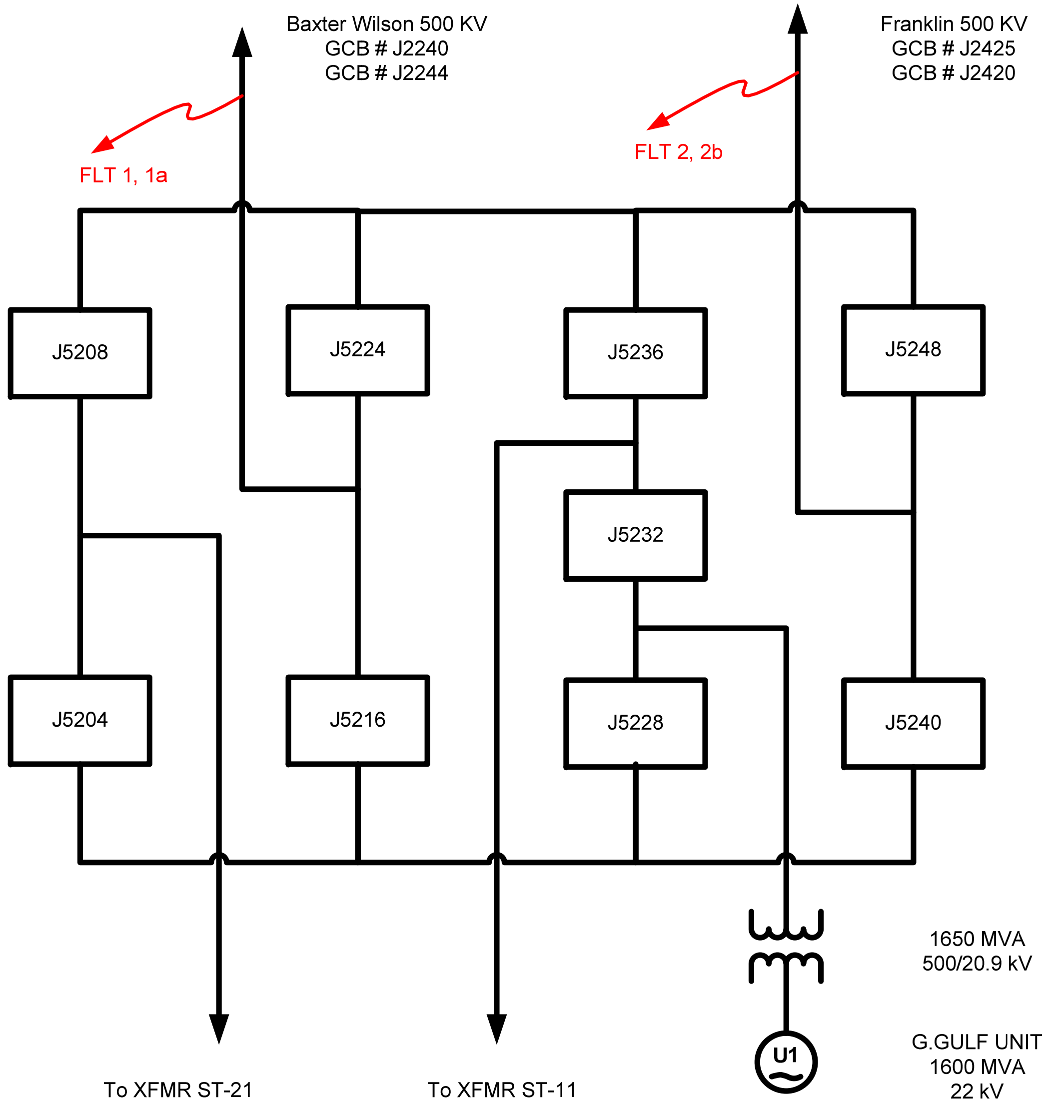
Table 2-3 List of 3 Phase faults simulated for stability analysis

CASE	LOCATION	TYPE	CLEARING TIME (cycles)	BREAKER TRIP #	TRIPPED FACILITIES
FAULT-1	G. Gulf - B. Wilson 500 kV	3 PH	5	J5224, J5216, J2240, J2244	G. Gulf - B. Wilson 500 kV
FAULT-2	G. Gulf - Franklin 500 kV	3 PH	5	J2425, J2420, J5248, J5240	G. Gulf - Franklin 500 kV
FAULT-3	B. Wilson - Perryville 500 kV	3 PH	5	R7372,R9872, J2233, J2218	B. Wilson - Perryville 500 kV
FAULT-4	B. Wilson - Ray Braswell 500 kV	3 PH	5	J4928, J4920, J2230, J2233	B. Wilson - Ray Braswell 500 kV
FAULT-5	B. Wilson 500/115 kV transformer #1	3 PH	5	J2214, J2222,	B. Wilson 500/115 kV transformer #1
FAULT-6	Ray Braswell - Franklin 500 kV	3 PH	5	J2404, J2408, J4908, J4904	Ray Braswell - Franklin 500 kV
FAULT-7	Ray Braswell - Lakeover 500 kV	3 PH	5	J4928,J4908, J9218, J9234	Ray Braswell - Lakeover 500 kV
FAULT-8	Ray Braswell - B. Wilson 500 kV	3 PH	5	J4928, J4920, J2230, J2233	Ray Braswell - B. Wilson 500 kV
FAULT-9	Ray Braswell 500/ 115 kV Transformer #1	3 PH	5	J4904, J4917	Ray Braswell 500/ 115 kV Transformer #1
FAULT-10	Ray Braswell 500/ 230 kV Transformer #1	3 PH	5	J4917, J4920	Ray Braswell 500/ 230 kV Transformer #1
FAULT-11	Franklin - McKinight 500 kV	3 PH	5	BRK#21105, BRK#21110, J2416,2412	Franklin - McKinight 500 kV
FAULT-12	Franklin - Bogal USA - Adams Creek 500 kV	3 PH	5	S4402, S4405, J2416, J2420	Franklin - Bogal USA - Adams Creek 500 kV
FAULT-13	Franklin - Ray Braswell 500 kV	3 PH	5	J2404, J2408, J4908, J4904	Franklin - Ray Braswell 500 kV
FAULT-14	Franklin - G. Gulf 500 kv	3 PH	5	J2425, J2420, J5248, J5240	Franklin - G. Gulf 500 kv
FAULT-15	Franklin 500/115 kV transformer #1	3 PH	5	J2425, J2404	Franklin 500/115 kV transformer #1

Table 2-4 List of 3 PhaseStuck Brekaer (IPO: 3PH-1PH) faults simulated for stability analysis

CASE	LOCATION	TYPE	CLEARING TIME (cycles)		SLG FAULT IMPEDANCE (MVA)	STUCK BREAKER #	PRIMARY BREAKER TRIP #	SECONDARY BREAKER TRIP	TRIPPED FACILITIES
			PRIMARY	Back-up					
FAULT-1a	G. Gulf - B. Wilson 500 kV	3 PH/SLG	5	9	640.02-j8505.34	J5224	J5216, J2240, J2244	J5208, J5236, J5248	G. Gulf - B. Wilson 500 kV
FAULT-2b	G. Gulf - Franklin 500 kV	3 PH/SLG	5	9	640.02-j8505.34	J5248	J2425, J2420, J5240	J5208, J5236, J5224	G. Gulf - Franklin 500 kV
FAULT-3a	B. Wilson - Perryville 500 kV	3 PH/SLG	5	9	779.96-j8641.41	J2233	R7372,R9872, J2218	J2230, J4928, J4920	B. Wilson - Perryville 500 kV; B. wilson Ray Braswell 500 kV
FAULT-3b	B. Wilson - Perryville 500 kV	3 PH/SLG	5	9	779.96-j8641.41	J2218	R7372,R9872, J2233	J2214, J2252, J2225	B. Wilson - Perryville 500 kV; B. Wilson 500/115 kV transformer#1
FAULT-4a	B. Wilson - Ray Braswell 500 kV	3 PH/SLG	5	9	779.96-j8641.41	J2233	J4928, J4920, J2230	R7372,R9872, J2218	B. Wilson - Ray Braswell 500 kV; B. Wilson - Perryville 500 kV
FAULT-4b	B. Wilson - Ray Braswell 500 kV	3 PH/SLG	5	9	779.96-j8641.41	J2230	J4928, J4920, J2233	J2240, J2236, J2222	B. Wilson - Ray Braswell 500 kV
FAULT-5a	B. Wilson 500/115 kV transformer #1	3 PH/SLG	5	9	779.96-j8641.41	J2214	J2222	J2218, J2252, J2225	B. Wilson 500/115 kV transformer #1
~~FAULT-6a~~	~~Ray Braswell - Franklin 500 kV~~	~~3 PH/SLG~~	~~5~~	~~9~~	~~765.3-j6686.74~~	~~J4908~~	~~J2404, J2408, J4904~~	~~J4928, J9218, J9234~~	~~Ray Braswell - Franklin 500 kV; Ray Braswell - Lakeover 500 kV~~
~~FAULT-6b~~	~~Ray Braswell - Franklin 500 kV~~	~~3 PH/SLG~~	~~5~~	~~9~~	~~765.3-j6686.74~~	~~J4904~~	~~J2404, J2408, J4908~~	~~J4917~~	~~Ray Braswell - Franklin 500 Kv; Ray Braswell 500/115 kV transformer #1~~
~~FAULT-7a~~	~~Ray Braswell - Lakeover 500 kV~~	~~3 PH/SLG~~	~~5~~	~~9~~	~~765.3-j6686.74~~	~~J4928~~	~~J4908, J9218, J9234~~	~~J2230, J2233, J4920~~	~~Ray Braswell - Lakeover 500 kV; Ray Braswell - B. Wilson 500 kV~~
~~FAULT-7b~~	~~Ray Braswell - Lakeover 500 kV~~	~~3 PH/SLG~~	~~5~~	~~9~~	~~765.3-j6686.74~~	~~J4908~~	~~J4928, J9218, J9234~~	~~J4904, J2404, J2408~~	~~Ray Braswell - Lakeover 500 kV, Ray Braswell - Franklin 500 kV~~
~~FAULT-8a~~	~~Ray Braswell - B. Wilson 500 kV~~	~~3 PH/SLG~~	~~5~~	~~9~~	~~765.3-j6686.74~~	~~J4928~~	~~J4920, J2230, J2233~~	~~J4908, J9218, J9234~~	~~Ray Braswell - B. Wilson 500 kV; Ray Braaswell - Lakeover 500 kV~~
~~FAULT-8b~~	~~Ray Braswell - B. Wilson 500 kV~~	~~3 PH/SLG~~	~~5~~	~~9~~	~~765.3-j6686.74~~	~~J4920~~	~~J4928, J2230, J2233~~	~~J4917~~	~~Ray Braswell - B. Wilson 500 kV; Ray Braswell 500/230 kV transformer #1~~
~~FAULT-9a~~	~~Ray Braswell 500/ 115 kV Transformer #1~~	~~3 PH/SLG~~	~~5~~	~~9~~	~~765.3-j6686.74~~	~~J4904~~	~~J4917~~	~~J2404, J2408, J4908~~	~~Ray Braswell 500/ 115 kV Transformer #1; Ray Braswell - Franklin 500 kV~~

CASE	LOCATION	TYPE	CLEARING TIME (cycles)		SLG FAULT IMPEDANCE (MVA)	STUCK BREAKER #	PRIMARY BREAKER TRIP #	SECONDARY BREAKER TRIP	TRIPPED FACILITIES
			PRIMARY	Back-up					
~~FAULT-9b~~	~~Ray Braswell 500/ 115 kV Transformer #1~~	~~3 PH/SLG~~	~~5~~	~~9~~	~~765.3-j6686.74~~	~~J4917~~	~~J4904~~	~~J4920~~	~~Ray Braswell 500/ 115 kV Transformer #1; Ray Braswell 500/230 kV transformer #1~~
~~FAULT-10a~~	~~Ray Braswell 500/ 230 kV Transformer #1~~	~~3 PH/SLG~~	~~5~~	~~9~~	~~765.3-j6686.74~~	~~J4920~~	~~J4917~~	~~J4928, J2230, J2233~~	~~Ray Braswell 500/ 230 kV Transformer #1; Ray Braswell - B. Wilson 500 kV~~
~~FAULT-10b~~	~~Ray Braswell 500/ 230 kV Transformer #1~~	~~3 PH/SLG~~	~~5~~	~~9~~	~~765.3-j6686.74~~	~~J4917~~	~~J4920~~	~~J4904~~	~~Ray Braswell 500/ 115 kV Transformer #1; Ray Braswell 500/230 kV transformer #1~~
FAULT-11a	Franklin - McKinight 500 kV	3 PH/SLG	5	9	823.73-j5887.89	J2416	BRK#21105, BRK#21110, J2412	J2420, S4402, S4405	Franklin - McKinight 500 kV; Franklin - Bogal USA - Adams Creek 500 kV
FAULT-11b	Franklin - McKinight 500 kV	3 PH/SLG	5	9	823.73-j5887.89	J2412	BRK#21105, BRK#21110, J2416	J2408	Franklin - McKinight 500 kV; Franklin 500/115 kV transformer #1
FAULT-12a	Franklin - Bogal USA - Adams Creek 500 kV	3 PH/SLG	5	9	823.73-j5887.89	J2416	S4402, S4405, J2420	BRK #21105, BRK#21110, J2412	Franklin - Bogal USA - Adams Creek 500 kV; Franklin - McKnight 500 kV
FAULT-12b	Franklin - Bogal USA - Adams Creek 500 kV	3 PH/SLG	5	9	823.73-j5887.89	J2420	S4402, S4405, J2416	J2420	Franklin - Bogal USA - Adams Creek 500 Kv; Franklin - G. Gulf 500 kV
FAULT-13a	Franklin - Ray Braswell 500 kV	3 PH/SLG	5	9	823.73-j5887.89	J2404	J2408, J4904, J4908	J2425	Franklin - Ray Braswell 500 Kv, Franklin 500/115 kV transformer #1
FAULT-13b	Franklin - Ray Braswell 500 kV	3 PH/SLG	5	9	823.73-j5887.89	J2408	J2404, J4908, J4904	J2412	Franklin - Ray Braswell 500 kV; Franklin 500/115 kV transformer #2
FAULT-14a	Franklin - G. Gulf 500 kv	3 PH/SLG	5	9	823.73-j5887.89	J2425	J2420, J5248, J5240	J2404	Franklin - G. Gulf 500 kV; Franklin 500/115 kV transformer #1
FAULT-14b	Franklin - G. Gulf 500 kv	3 PH/SLG	5	9	823.73-j5887.89	J2420	J5248, J5240, J2425	J2416, S4402, S4405	Franklin - G. Gulf 500 kV; Franklin - Bogal USA - Adams Creek 500 kV
FAULT-15a	Franklin 500/115 kV transformer #1	3 PH/SLG	5	9	823.73-j5887.89	J2404	J2425	J2408, J4904, J4908	Franklin 500/115 kV transformer #1; Franklin - Ray Braswell 500 kV
FAULT-15b	Franklin 500/115 kV transformer #1	3 PH/SLG	5	9	823.73-j5887.89	J2425	J2404	J2420, J5248, J5240	Franklin 500/115 kV transformer #1; Franklin - G. Gulf 500 kV


Baxter Wilson 500 KV
GCB # J2240
GCB # J2244
Franklin 500 KV
GCB # J2425
GCB # J2420
FLT 1, 1a
FLT 2, 2b
J5208
J5224
J5236
J5248
J5232
J5204
J5216
J5228
J5240
1650 MVA
500/20.9 kV
U1
G.GULF UNIT
1600 MVA
22 kV
To XFMR ST-21
To XFMR ST-11

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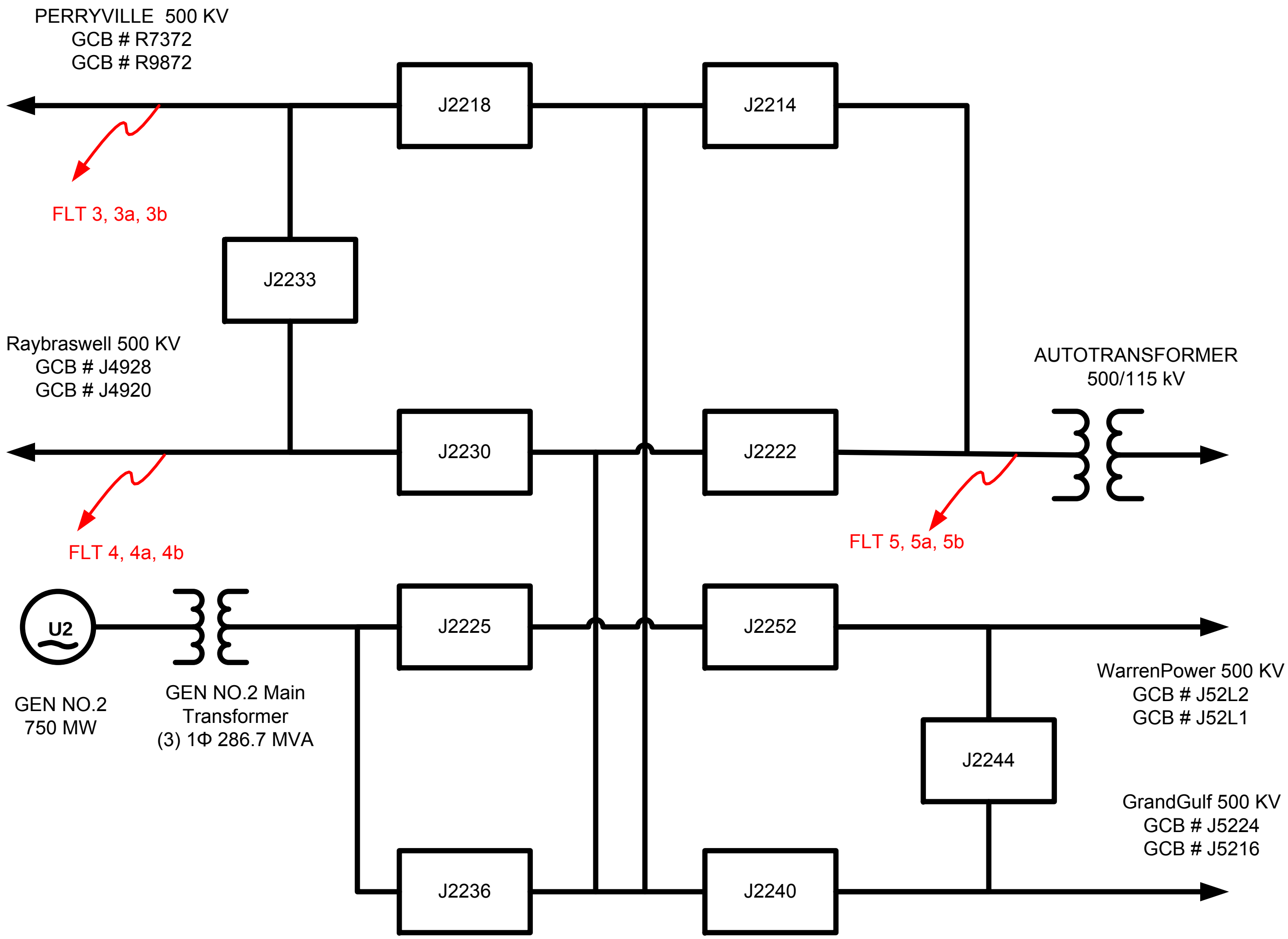
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J2214
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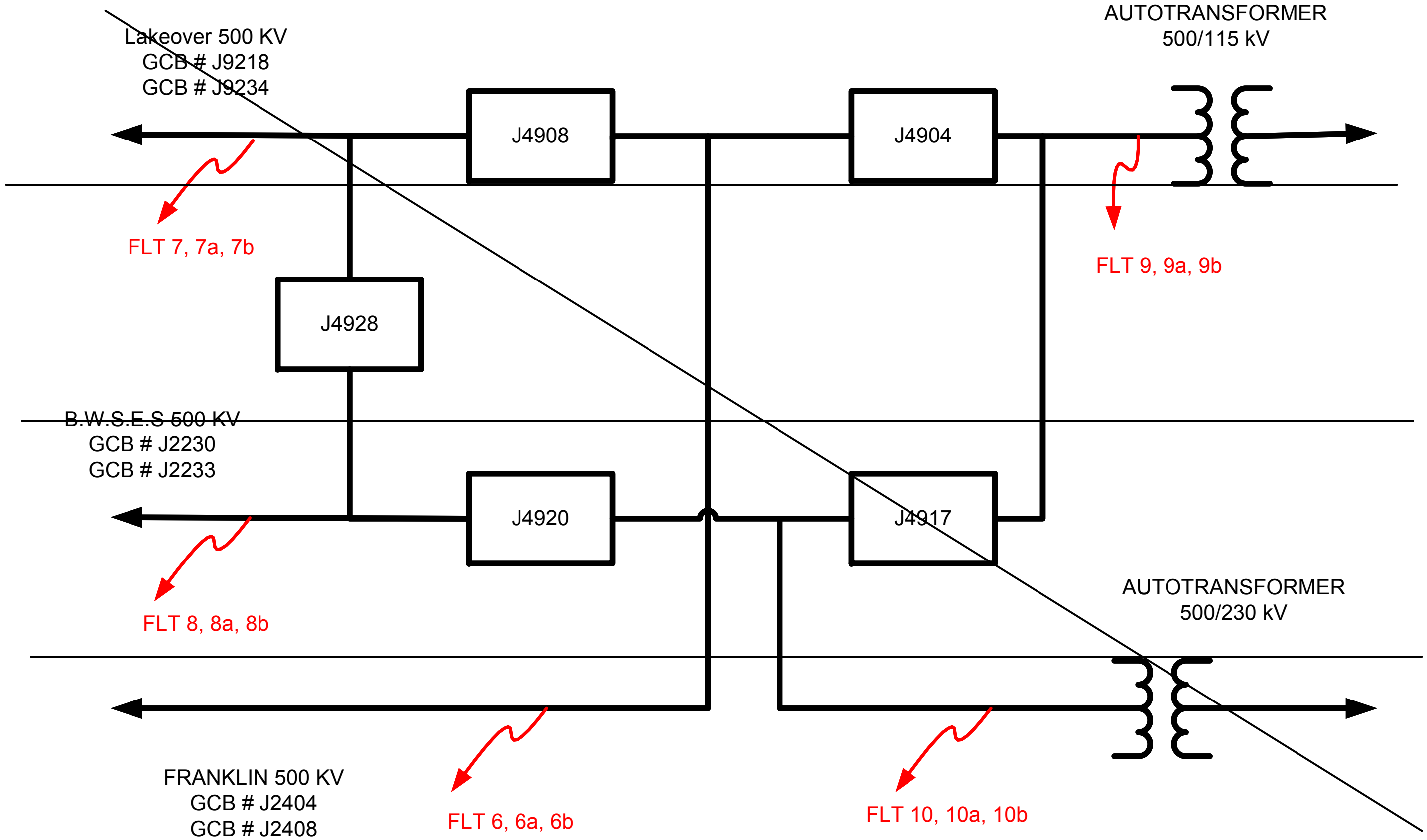
J2233
Raybraswell 500 KV
GCB # J4928
GCB # J4920
J2230
J2222
AUTOTRANSFORMER
500/115 kV
FLT 4, 4a, 4b
FLT 5, 5a, 5b
U2
J2225
J2252
GEN NO.2
750 MW
GEN NO.2 Main
Transformer
(3) 1Φ 286.7 MVA
WarrenPower 500 KV
GCB # J52L2
GCB # J52L1
J2244
GrandGulf 500 KV
GCB # J5224
GCB # J5216
J2236
J2240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GCB # J9234
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500/115 kV
J4908
J4904
FLT 7, 7a, 7b
FLT 9, 9a, 9b
J4928
B.W.S.E.S 500 KV
GCB # J2230
GCB # J2233
J4920
J4917
AUTOTRANSFORMER
500/230 kV
FLT 8, 8a, 8b
FRANKLIN 500 KV
GCB # J2404
GCB # J2408
FLT 6, 6a, 6b
FLT 10, 10a, 10b

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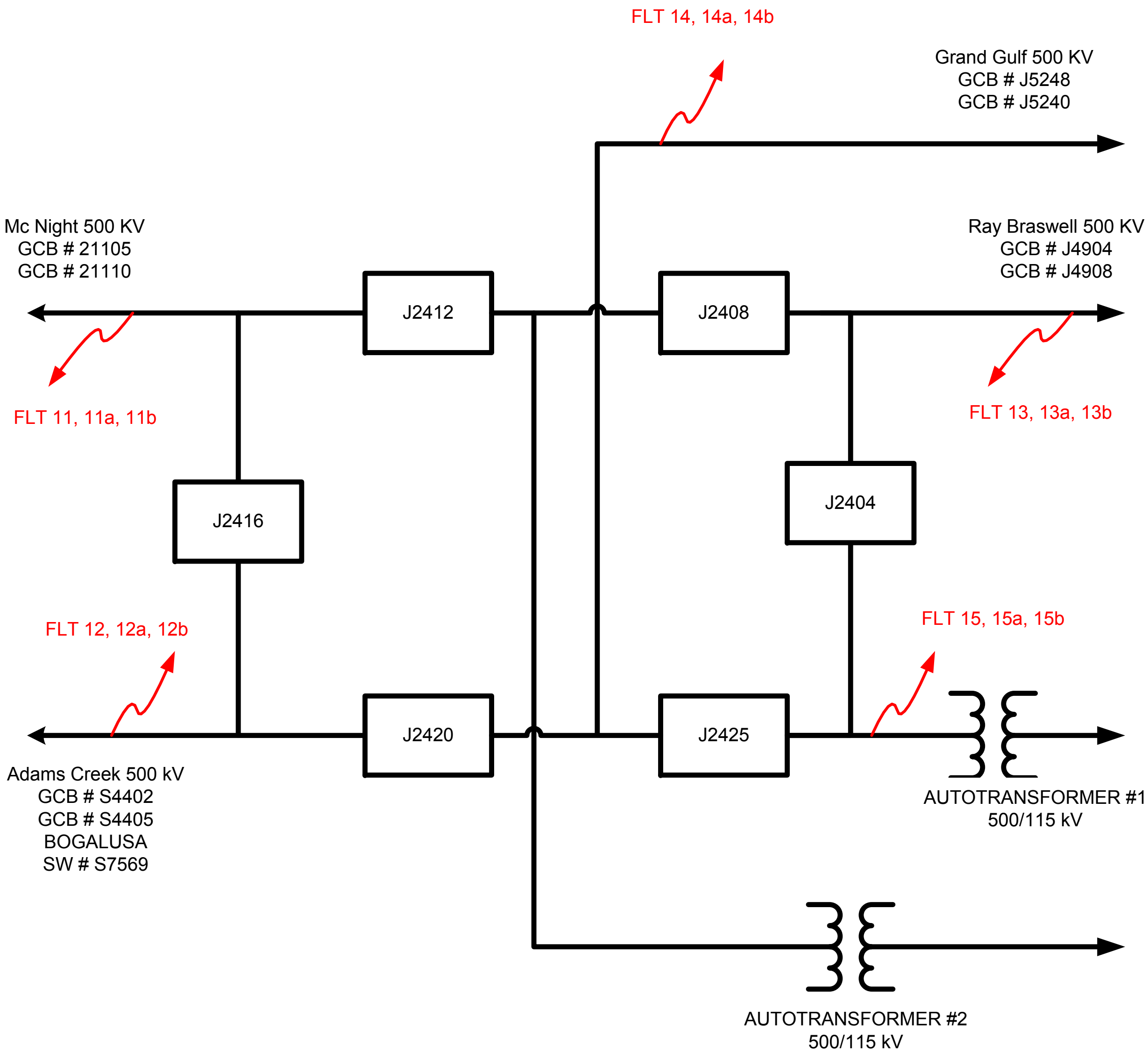

FLT 14, 14a, 14b
Grand Gulf 500 KV
GCB # J5248
GCB # J5240
Mc Night 500 KV
GCB # 21105
GCB # 21110
J2412
J2408
Ray Braswell 500 KV
GCB # J4904
GCB # J4908
FLT 11, 11a, 11b
FLT 13, 13a, 13b
J2416
J2404
FLT 12, 12a, 12b
FLT 15, 15a, 15b
J2420
J2425
Adams Creek 500 kV
GCB # S4402
GCB # S4405
BOGALUSA
SW # S7569
AUTOTRANSFORMER #1
500/115 kV
AUTOTRANSFORMER #2
500/115 kV

Table 2-5 Results of faults simulated for stability analysis

CASE	PRE-PID226		POST-PID226	
	Stable	Acceptable Voltages	Stable	Acceptable Voltages
	?	?	?	?
FAULT-1	Not tested		Y	Y
FAULT-2	Not tested		Y	Y
FAULT-3	Not tested		Y	Y
FAULT-4	Not tested		Y	Y
FAULT-5	Not tested		Y	Y
FAULT-6	Not tested		Y	Y
FAULT-7	Not tested		Y	Y
FAULT-8	Not tested		Y	Y
FAULT-9	Not tested		Y	Y
FAULT-10	Not tested		Y	Y
FAULT-11	Not tested		Y	Y
FAULT-12	Not tested		Y	Y
FAULT-13	Not tested		Y	Y
FAULT-14	Not tested		Y	Y
FAULT-15	Not tested		Y	Y
FAULT-1a	Not tested		Y	Y
FAULT-2b	Not tested		Y	Y
FAULT-3a	Not tested		Y	Y
FAULT-3b	Not tested		Y	Y
FAULT-4a	Not tested		Y	Y
FAULT-4b	Not tested		Y	Y
FAULT-5a	Not tested		Y	Y
~~FAULT-6a~~	~~Not tested~~		~~Y~~	~~Y~~
~~FAULT-6b~~	~~Not tested~~		~~Y~~	~~Y~~
~~FAULT-7a~~	~~Not tested~~		~~Y~~	~~Y~~
~~FAULT-7b~~	~~Not tested~~		~~Y~~	~~Y~~
~~FAULT-8a~~	~~Not tested~~		~~Y~~	~~Y~~
~~FAULT-8b~~	~~Not tested~~		~~Y~~	~~Y~~
~~FAULT-9a~~	~~Not tested~~		~~Y~~	~~Y~~
~~FAULT-9b~~	~~Not tested~~		~~Y~~	~~Y~~
~~FAULT-10a~~	~~Not tested~~		~~Y~~	~~Y~~
~~FAULT-10b~~	~~Not tested~~		~~Y~~	~~Y~~
FAULT-11a	Not tested		Y	Y
FAULT-11b	Not tested		Y	Y
FAULT-12a	Not tested		Y	Y
FAULT-12b	Not tested		Y	Y
FAULT-13a	Not tested		Y	Y
FAULT-13b	Not tested		Y	Y
FAULT-14a	Not tested		Y	Y
FAULT-14b	Not tested		Y	Y
FAULT-15a	Not tested		Y	Y
FAULT-15b	Not tested		Y	Y

The system was found to be STABLE following all the simulated faults.

Figure 2-3 and Figure 2-4 show plots for the G. Gulf unit response and the voltage recovery at POI following two selected faults.

Transient Voltage Recovery

The voltages at all buses in the Entergy system (above 115 kV) were monitored during each of the fault cases as appropriate. No Voltage criteria violation was observed following a normally cleared three-phase fault.

As there are no specific voltage dip criteria for three-phase fault converted into single-phase stuck breaker faults, the results of these faults were compared with the most stringent voltage dip criteria - not to exceed 20 % for more than 20 cycles. After comparison against the voltage-criteria, no voltage criteria violation was observed with the proposed uprate of G. Gulf unit (PID-226) case.

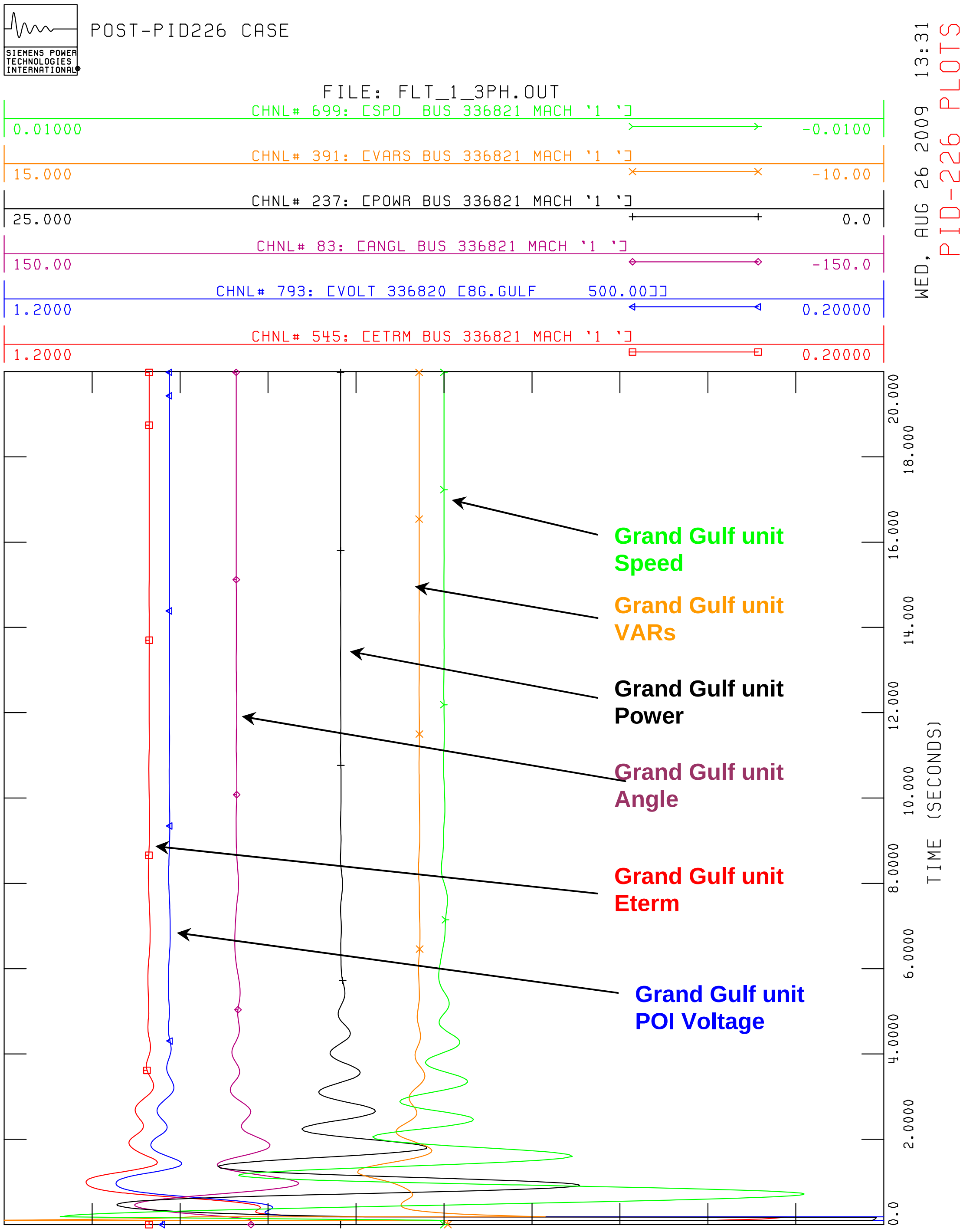


Figure 2-3 PID-226 Machine parameters for FLT_1_3PH

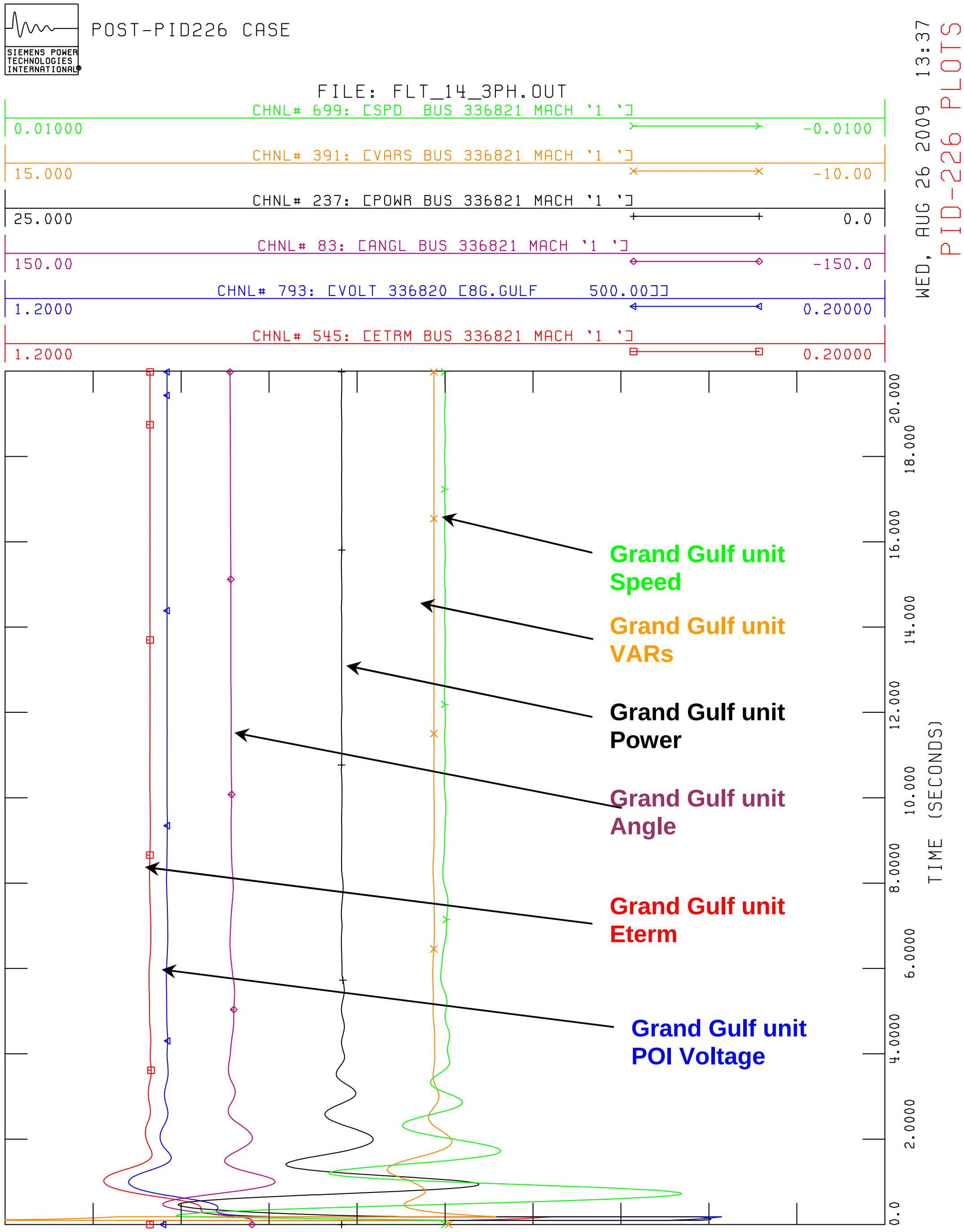


Figure 2-4 PID-226 Machine parameters for Fault _14_3PH

2.4 Critical Clearing Time Analysis

Evaluation of Critical Clearing Time (CCT) was carried out for faults at G. Gulf 500 kV substation. Two 3 phase stuck breaker (IPO operation) faults - Fault 1a and Fault 2b - at G. Gulf 500 kV substation were considered.

The primary Clearing Time was kept equal to the normal value (5 cycles on 500 kV and 6 cycles on 230 kV) and the backup clearing time was varied to find the CCT.

Table 2-6 shows the Critical Clearing Times calculated for the simulated faults with PID-222. Figure 2-5 and Figure 2-6 shows the excursions in the speed of G. Gulf unit following the two faults for both, WITH and WITHOUT PID-226 project.

Table 2-6: CCT Results

CASE	LOCATION	CCT (in cycles)		
		Primary clearing	Back-up Clearing	
			WITHOUT PID-226	WITH PID-226
FAULT_1a	G. Gulf - B. Wilson 500 kV	5	41	15
FAULT_2b	G. Gulf - Franklin 500 kV	5	46	18

It can be seen from the results that the smallest CCT at G. Gulf 500 kV substation was 5 + 15 cycles for a fault involving loss of G. Gulf – B. Wilson 500 kV line. The lowest critical clearing time 20 cycles (=5 + 15 cycles) is still larger than Entergy's standard clearing time of14 cycles (= 5 + 9 cycles) for 500 kV breakers.

Based on the results of critical clearing time analysis it can be concluded that proposed PID-226 project (206 MW uprate of G. Gulf Unit#1) does not adversely impact the critical clearing at G. gulf 500 kV substation.

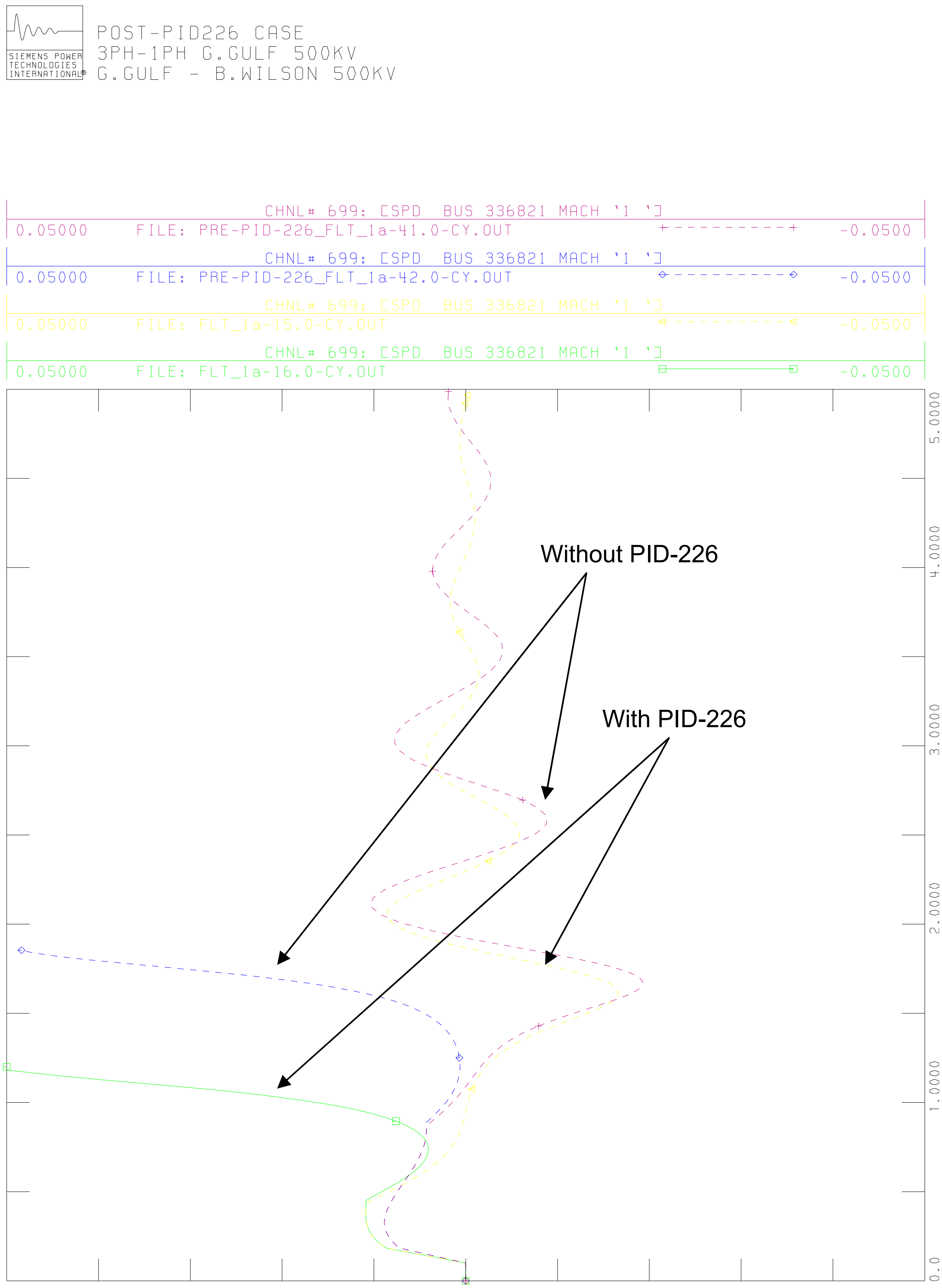


Figure 2-5 Critical Clearing Time comparison following Fault 1a

ABB

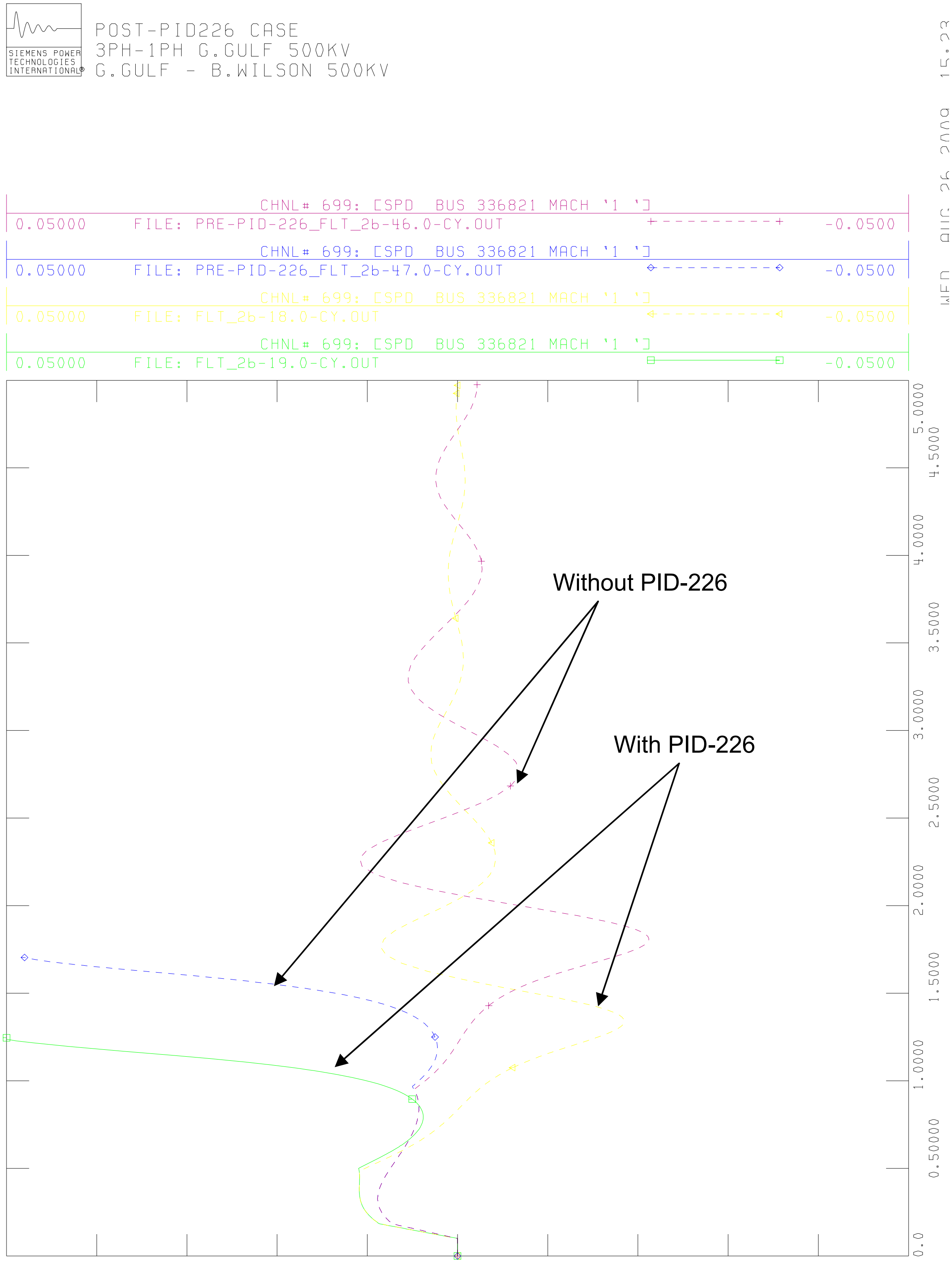


Figure 2-6 Critical Clearing Time comparison following Fault 2b

3 CONCLUSIONS

Southwest Power Pool, Inc (SPP) at the request of Entergy Services Inc. has commissioned ABB Inc. to perform a stability analysis for Facility study of PID-226, which is a request for 206 MW uprate of existing G. Gulf Unit #1 in the Entergy transmission system.

A system impact study for the PID-226 has previously been completed. The objective of this study was to supplement the stability analysis performed in the system impact study for PID-226 Project. To that end, selected faults at G. Gulf 500 kV substation were simulated and a Critical Clearing Time Analysis was performed at G. Gulf 500 kV substation. The study was performed on 2012 Summer Peak case, provided by SPP/Entergy.

The system was stable following all simulated normally cleared and stuck-breaker faults. No voltage criteria violation was observed following simulated faults.

The Critical Clearing times at G. Gulf 500 kV substations are within the capabilities of the existing protection systems. The smallest CCT at G. Gulf 500 kV substation was 5 + 15 cycles for a fault involving loss of G. Gulf – B. Wilson 500 kV.

Based on the results of stability analysis it can be concluded that proposed PID-226 project does not adversely impact the stability of the Entergy System in the local area. Also, PID-226 does not adversely impact the Critical Clearing time at G. Gulf 500 kV substations. Hence, no transmission reinforcements and/ or upgrades were identified for the interconnection of the PID-226 project.

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 DATA PROVIDED BY CUSTOMER

Attachment A to Appendix 1
Interconnection Request

LARGE GENERATING FACILITY DATA

UNIT RATINGS

kVA 1600000 °F 95 Voltage 22000
Power Factor 0.9 lag
Speed (RPM) 1800 Connection (e.g. Wye) Wye
Short Circuit Ratio 0.75 Frequency, Hertz 60
Stator Amperes at Rated kVA 41989 Field Volts ______
Max Turbine MW 1525 °F 95

COMBINED TURBINE-GENERATOR-EXCITER INERTIA DATA

Inertia Constant, H = 4.5112 kW sec/kVA
Moment-of-Inertia, WR^2 = 9644006 lb. ft.^{2}

REACTANCE DATA (PER UNIT-RATED KVA)

	DIRECT AXIS		QUADRATURE AXIS	
Synchronous – saturated	X_{dv}	1.292	X_{qv}	1.258
Synchronous – unsaturated	X_{di}	1.551	X_{qi}	1.473
Transient – saturated	X'_{dv}	0.380	X'_{qv}	0.751
Transient – unsaturated	X'_{di}	0.417	X'_{qi}	0.832
Subtransient – saturated	X''_{dv}	0.243	X''_{qv}	0.255
Subtransient – unsaturated	X''_{di}	0.288	X''_{qi}	0.302
Negative Sequence – saturated	$X2_v$	0.249		
Negative Sequence – unsaturated	$X2_i$	0.295		
Zero Sequence – saturated	$X0_v$	0.181		
Zero Sequence – unsaturated	$X0_i$	0.151		
Leakage Reactance	Xl_m	0.245		

FIELD TIME CONSTANT DATA (SEC)

Open Circuit	T'_{do}	6.286	T'_{qo}	0.382
Three-Phase Short Circuit Transient	T'_{d3}	1.446	T'_{q}	0.501
Line to Line Short Circuit Transient	T'_{d2}	2.062		
Line to Neutral Short Circuit Transient	T'_{d1}	2.211		
Short Circuit Subtransient	T''_{d}	0.030	T''_{q}	0.043
Open Circuit Subtransient	T''_{do}	0.047	T''_{qo}	0.123

ARMATURE TIME CONSTANT DATA (SEC)

Three Phase Short Circuit	T_{a3}	0.361
Line to Line Short Circuit	T_{a2}	0.361
Line to Neutral Short Circuit	T_{a1}	0.314

NOTE: If requested information is not applicable, indicate by marking "N/A."

MW CAPABILITY AND PLANT CONFIGURATION LARGE GENERATING FACILITY DATA

ARMATURE WINDING RESISTANCE DATA (PER UNIT)

Positive	R_1	0.003656
Negative	R_2	0.04775
Zero	R_0	0.00253

Rotor Short Time Thermal Capacity I_2^2t = 5.47

Field Current at Rated kVA, Armature Voltage and PF = 8580 amps

Field Current at Rated kVA and Armature Voltage, 0 PF = 11400 amps

Three Phase Armature Winding Capacitance = 1.464 microfarad

Field Winding Resistance = 0.0405 ohms 20 °C

Armature Winding Resistance (Per Phase) = 0.0004794 ohms 20 °C

CURVES

Provide Saturation, Vee, Reactive Capability, Capacity Temperature Correction curves. Designate normal and emergency Hydrogen Pressure operating range for multiple curves.

Please refer to Attachment 1.

GENERATOR STEP-UP TRANSFORMER DATA RATINGS

Capacity Self-cooled/Maximum Nameplate
1650000 / 1650000 kVA

Voltage Ratio(Generator Side/System side/Tertiary)
20.9 / 500 / none kV

Winding Connections (Low V/High V/Tertiary V (Delta or Wye))
Delta / Wye / none

Fixed Taps Available
+7.5% / +5% / +2.5% / 0 / -2.5%

Present Tap Setting
Nominal

IMPEDANCE

Positive Z_1 (on self-cooled kVA rating) 0.1627 % 46.41 X/R

Zero Z_0 (on self-cooled kVA rating) 0.1627 % 46.41 X/R

EXCITATION SYSTEM DATA

Identify appropriate IEEE model block diagram of excitation system and power system stabilizer (PSS) for computer representation in power system stability simulations and the corresponding excitation system and PSS constants for use in the model.

Please refer to attachment 2.

GOVERNOR SYSTEM DATA

Identify appropriate IEEE model block diagram of governor system for computer representation in power system stability simulations and the corresponding governor system constants for use in the model.

Please refer to attachment 3.

WIND GENERATORS

Number of generators to be interconnected pursuant to this Interconnection Request:

____

Elevation: _______________ _____ Single Phase _____ Three Phase

Inverter manufacturer, model name, number, and version:

____

List of adjustable setpoints for the protective equipment or software:

____

Note: A completed General Electric Company Power Systems Load Flow (PSLF) data sheet or other compatible formats, such as IEEE and PTI power flow models, must be supplied with the Interconnection Request. If other data sheets are more appropriate to the proposed device, then they shall be provided and discussed at Scoping Meeting.

INDUCTION GENERATORS

(*) Field Volts: ________________
(*) Field Amperes: ______________
(*) Motoring Power (kW): ________
(*) Neutral Grounding Resistor (If Applicable): ____________
(*) I_2^2t or K (Heating Time Constant): ____________
(*) Rotor Resistance: ____________
(*) Stator Resistance: ____________
(*) Stator Reactance: _____________
(*) Rotor Reactance: _____________
(*) Magnetizing Reactance: ___________
(*) Short Circuit Reactance: ___________
(*) Exciting Current: ________________
(*) Temperature Rise: ________________
(*) Frame Size: _______________
(*) Design Letter: _____________
(*) Reactive Power Required In Vars (No Load): ________
(*) Reactive Power Required In Vars (Full Load): ________
(*) Total Rotating Inertia, H: ________Per Unit on KVA Base

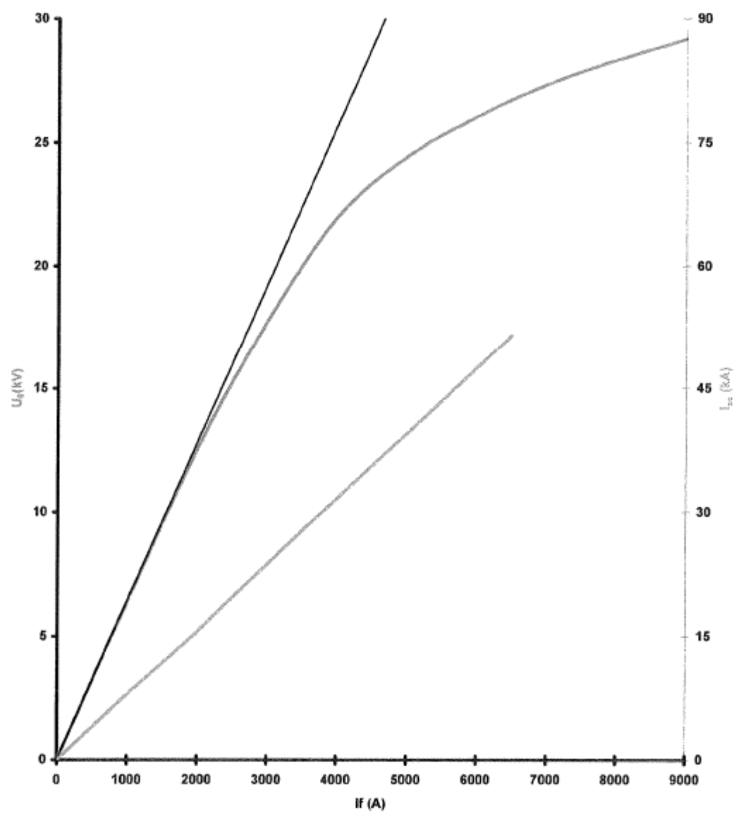
Note: Please consult Transmission Provider prior to submitting the Interconnection Request to determine if the information designated by (*) is required.

GENERATOR **Grand Gulf 1 - Uprate**

Open Circuit Voltage and Short Circuit Current

Generator - Typ: THFF 180/76-18

S_N =	1600 MVA	PF =	0.90	I_{f0} =	4000 A
U_N =	22.00 kV	f_N =	60 Hz	I_{fN} =	8580 A
I_N =	41.989 kA	$T_{Cold\ Gas}$ =	40.0 °C		



SIEMENS Dr. Klocke Rev. 000

Energy Sector E F PR GN EN PL 42 2009-06-11

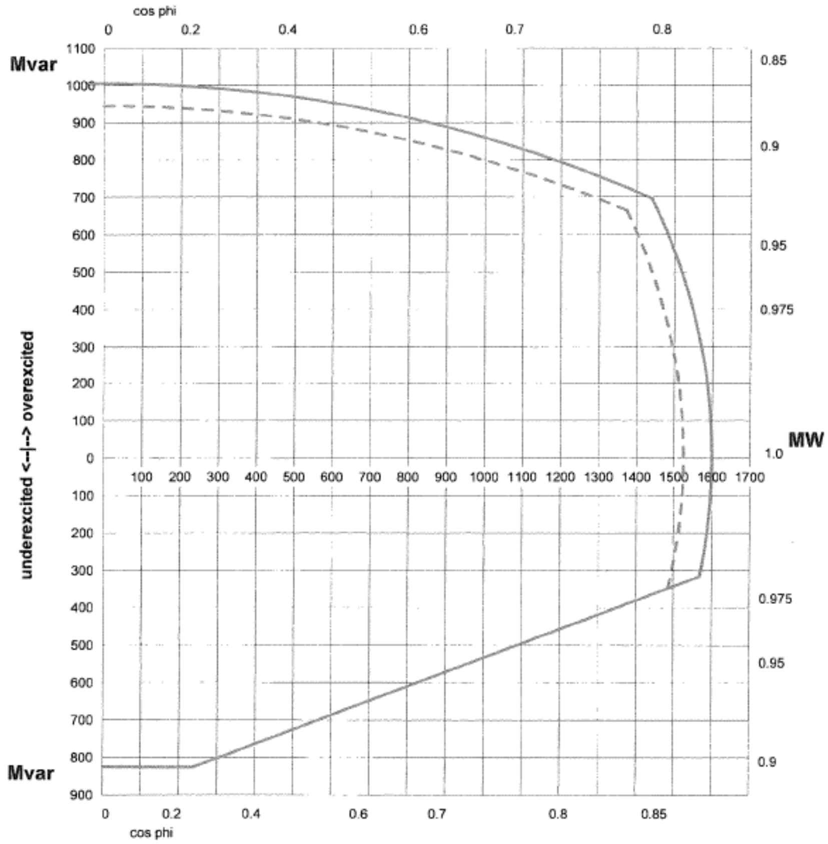
ATTACHMENT 1

Sheet 1 of 3

Turbogenerators

Grand Gulf 1 - Uprate to 1600 MVA
Reactive Capability Curve

Generator Type		**THFF 180/76-18**				
		uprate (———)		**prev. (— — —)**		
Apparent Power	S	1600.00	MVA	1525.00	MVA	
Armature Voltage	U	22.00	kV			
Armature Current	I	41.989	kA	40.021	kA	
Frequency	f	60.0	Hz			
Power Factor	P.F.	0.900		0.900		
H2-Pressure (gauge)	pe	5.170	bar	4.140	bar	
Cold Gas Temperature	Tk	40.0	°C	40.0	°C	



Siemens AG
Power Generation

GN EN PL42 / Jun 10, 2009
Generator Systems Engineering Mlh

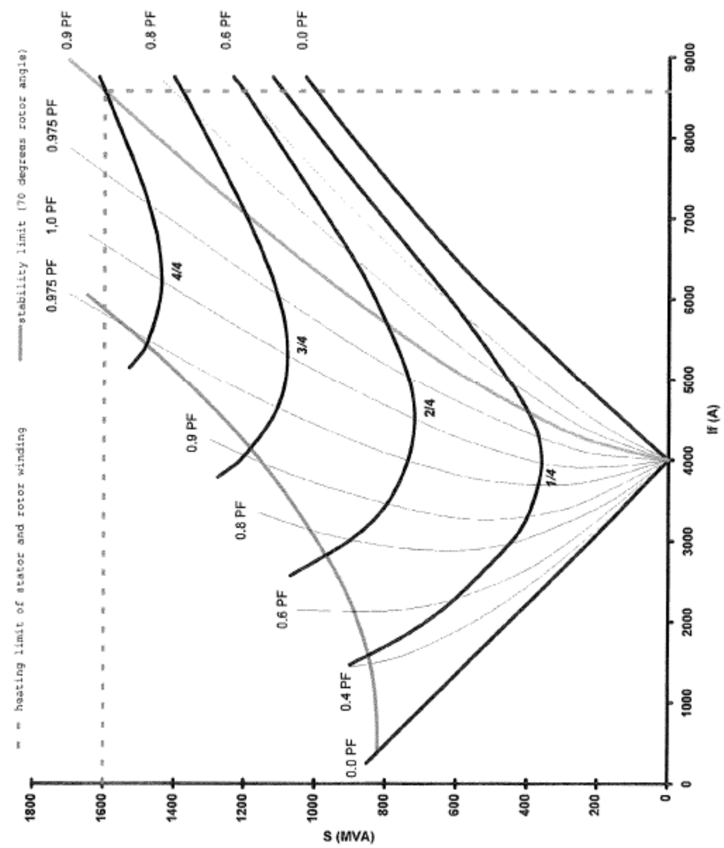
ATTACHMENT 1
Sheet 2 of 3

GENERATOR | **Grand Gulf 1 - Uprate**

V-Curves at Rated Voltage

Generator - Typ: THFF 180/76-18

S_N =	1600 MVA	PF =	0.90	I_{f0} =	4000 A
U_N =	22.00 kV	f_N =	60 Hz	I_{fN} =	8580 A
I_N =	41.989 kA	$T_{Cold\ Gas}$ =	40.0 °C		



V-Curves Refer to Apparent Power

SIEMENS Dr. Klocke Rev. 000

Energy Sector E F PR GN EN PL 42 2009-06-10

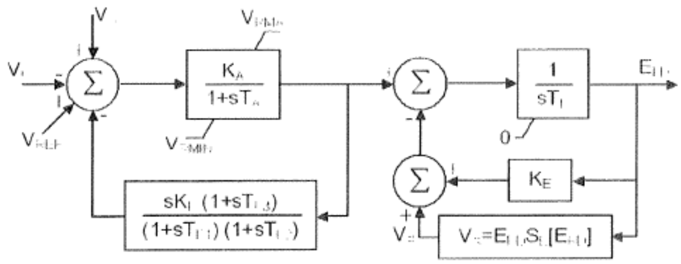
ATTACHMENT 1

Sheet 3 of 3

GRAND GULF

IEEE TYPE AC5A EXCITATION SYSTEM MODEL DATA

K_A = 600 p.u.	T_A = 0.10 sec.
K_F = 0.02 p.u.	T_{F1} = 1.0 sec.
T_{F2} = 0.13 sec.	T_{F3} = 0
T_E = 0.22 sec.	T_R = 0.2 sec.
S_{E1} = 0.73	EFD_1 = 3.7 p.u.
S_{E2} = 0.73	EFD_2 = 2.8 p.u.
K_E = 1.0 p.u.	
V_{Rmax} = 6.4 p.u.	V_{Rmin} = -6.4 p.u.



IEEE Type AC5A Excitation System Model

Reference: IEEE Standard 421.5-2005, "IEEE Recommended Practice for Excitation System Models for Power System Stability Studies"

Excitation system model data 061120. By J.D. Hurley. 12-7153. 12-7154.doc
Printed: 12/7/2006 2:02:21 PM

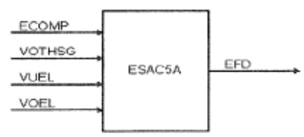
Siemens Westinghouse Confidential

ESAC5A

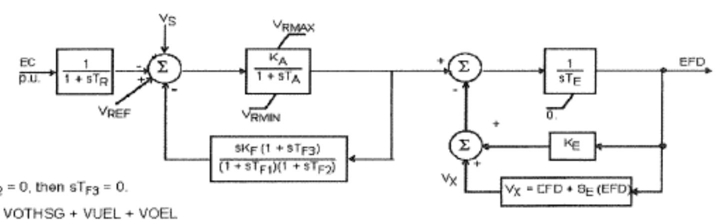
IEEE Type AC5A Excitation System

This model is located at system bus # ________ IBUS,
machine # ________ I.
This model uses CONs starting with # ________ J,

CONs	#	Value	Description
J		0.2	T_R (Seconds)
J+1		600	K_A
J+2		0.1	T_A (Seconds)
J+3		6.4	V_{RMAX} Or Zero
J+4		-6.4	V_{RMIN}
J+5		1	K_E Or Zero
J+6		0.22	$T_E > 0$ (Seconds)
J+7		0.02	K_F
J+8		1.0	$T_{F1} > 0$ (Seconds)
J+9		0.13	T_{F2} (Seconds)
J+10		0	T_{F3} (Seconds)
J+11		3.7	E_1
J+12		0.73	$S_E(E_1)$
J+13		2.8	E_2
J+14		0.73	$S_E(E_2)$



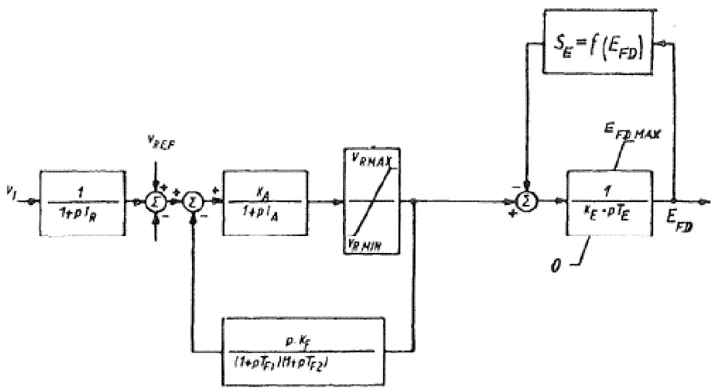
IBUS, 'ESAC5A', I, T_R, K_A, T_A, V_{RMAX}, V_{RMIN}, K_E, T_E, K_F, T_{F1}, T_{F2}, T_{F3}, E_1, $S_E(E_1)$, E_2, $S_E(E_2)$/



If $T_{F2} = 0$, then $sT_{F3} = 0$.
V_S = VOTHSG + VUEL + VOEL

SIEMENS

Excitation System
Thyrisiem
Computer Representation 1)



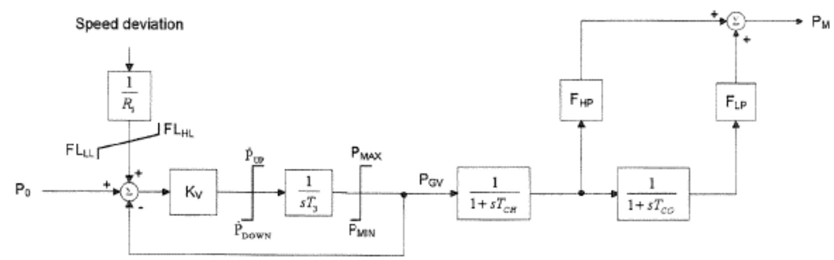
T_R = 0.20 s	K_A = 600	E_{FDMAX} = 3.7	V_{RMAX} = 6.4
T_A = 0.10 s	K_F = 0.02	S_{EMAX} = } 0.73	V_{RMIN} = −6.4
T_{F1} = 1.0 s	K_E = 1.0	$S_{E0.75MAX}$ = } 0.73	
T_{F2} = 0.13 s			
T_E = 0.22 s			

1) According to IEEE

E111/Ro
17-03-82

Fig.2.1.

Steam Turbine Model for System Dynamic Studies for Grand Gulf



- Limit Speed Droop Rate $R_1 = 0.05$
- Limited High Frequency Response Low Limit $FL_{LL} = -1$ pU
- Limited High Frequency Response High Limit $FL_{HL} = 1$ pU
- Position-Controller Gain $K_V = 20$
- Control Valve Time Constant $T_3 = 1.5$s
  (Fast closing $T_3 = 0.15$s)

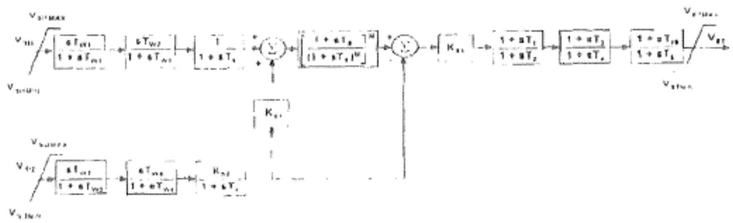
- P_0 = Initial Power when Simulation started (pU)
- P_{GV} = Power at Valve Outlet
- P_M = Mechanical Power Steam Turbine
- Power Limits imposed by Valve: $P_{MAX} = 1$ pU
  $P_{MIN} = 0$ pU
- Limits on Rate of Change of Power imposed by Control Valve Rate Limits: $\dot{P}_{UP} = 1$
  $\dot{P}_{DOWN} = -1$
- HP Turbine Load Fraction $F_{HP} = 0.35$
- HP Turbine Time Constant $T_{CH} = 0.25$s
- LP Turbine Load Fraction $F_{LP} = 0.65$
- LP Turbine and Cross-over Pipe Time Constant $T_{CO} = 2.75$s

see: "Dynamic Models for Steam and Hydro Turbines in Power System Studies", IEEE Committee Report, 1973
No Consideration of Nonlinearities of Main Steam Control Valve. LP-Valve is fully open.

Siemens PG P11M3, Bennauer, 21 June 2006

Fig.3.1.

TYPICAL EX2000 Power System Stabilizer (PSS)
IPS90995GD
TYPICAL DATA, NOT FOR DESIGN PURPOSES



Ref. IEEE 421.5-1992 Type PSS2A

Note: Parameters shown with ranges give the typical or useful ranges actual setting ranges are usually much wider.

VSI1 = speed input   VSI2 = electrical power input

VSI1max, VSI1min - input #1 limits +/- 0.08 pu (fixed)

VSI2max, VSI2min - input #2 limits +/- 1.25 pu (fixed)

*T1 = lead #1 0.15 (range 0.1 - 2.0 sec)   *T2 = lag #1 0.03 (range 0.01 - 1.0 sec)

*T3 = lead #2 0.15 (range 0.1 - 2.0 sec)   *T4 = lag #2 0.03 (range 0.01 - 1.0 sec)

T5 = lag #3 0.0 (fixed not used in GE design) can be used if there are three lead lags or for equivalent torsional filter time constant which may be required for some units (determined by studies)

T6 = 0.0 (fixed)   *T7 = TW 2.0 sec (range 2 - 15 sec)

T8 = 0.5 sec (fixed)   T9 = 0.1 sec (fixed)

T10 = Lag #3 = 0.0 (fixed not used in GE design)

N = 1 (fixed)   M = 5 (fixed)

*KS1 = PSS gain = 8 - (range 3 - 20 typical)

KS2 = 0.202 = TW/(2H) - where H = combined turbine-gen. inertia constant

KS3 = 1.0

VSTmax = (range 0.05 to 0.1)   VSTmin = (range -0.05 to -0.1)

TW1 = TW see note on T7 above   TW2 = TW see note on T7 above

TW3 = TW see note on T7 above   TW4 = 0.0 (fixed)

* Note: Lead/Lags and Gain must be Determined by Studies

HCS 3-19-2002

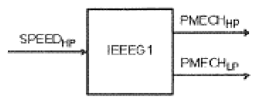
IEEEG1

IEEE Type 1 Speed-Governing Model

This model is located at system bus # ______ IBUS,
machine # ______ I.
This Mmodel may be located at system bus # 0 JBUS,
machine # 0 M.
This model uses CONs starting with # ______ J,

NOTE: JBUS and JM are set to zero for non-cross compound. **(Note: this is a non-cross compound unit)**

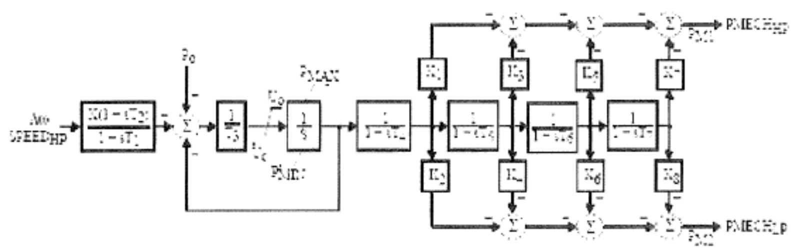
CONs	#	Value	Description
J		12	K
J+1		0	T_1 (Seconds)
J+2		0	T_2 (Seconds)
J+3		0.075	T_3 (>0)(Seconds)
J+4		0.60	U_O (p.u./Seconds)
J+5		-0.60	U_C (<0.)(p.u./Seconds)
J+6		0.9	P_{MAX}(p.u. on Machine MVA Rating)
J+7		0	P_{MIN}(p.u. on Machine MVA Rating)
J+8		0.25	T_4(Seconds)
J+9		0.35	K_1
J+10		0	K_2
J+11		2.75	T_5 (Seconds)
J+12		0.65	K_3
J+13		0	K_4
J+14		0	T_6(Seconds)
J+15		0	K_5
J+16		0	K_6
J+17		0	T_7(Seconds)
J+18		0	K_7
J+19		0	K_8



ATTACHMENT 3
Sheet 2 of 2

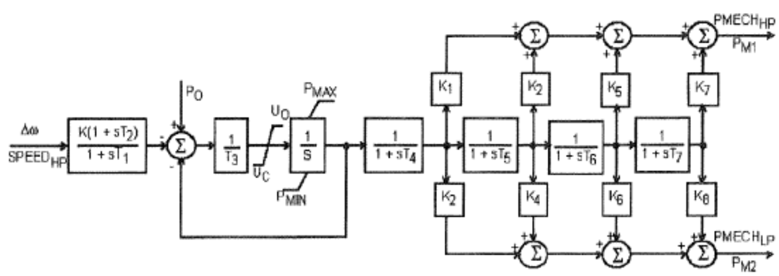
Correct Model: Note that K3 is properly represented.

GOVERNOR MODEL DATA SHEETS
IEEEG1 — Power Technologies, Inc.



Incorrect Model: Note that there are two blocks with K2 and no block with K3.

IBUS, 'IEEEG1', I, JBUS, M, K, T_1, T_2, T_3, U_o, U_c, P_{MAX}, P_{MIN}, T_4, K_1, K_2, T_5, K_3, K_4, T_6, K_5, K_6, T_7, K_7, K_8/



APPENDIX B LOAD FLOW AND STABILITY DATA IN PSSE FORMAT

Loadflow Data

```
336821,'1 ', 1544.000,   0.000,   330.000,  -330.000,1.02000,336820,  1600.000,
0.003656,   0.2880,   0.00000,   0.00000,1.00000,1,  100.0,  1544.000,   150.000,
1,1.0000
0 / END OF GENERATOR DATA, BEGIN BRANCH DATA
0 / END OF BRANCH DATA, BEGIN TRANSFORMER DATA
336820,336821,     0,'1 ',1,2,1,   0.00000,   0.00000,2,'            ',1,   1,1.0000
   0.0035,   0.1627,   1650.00
1.00000,   0.000,   0.000,  1650.00,  1650.00,  1650.00, 0,      0, 1.07500, 0.97500,
1.07500, 0.97500, 5, 0, 0.00000, 0.00000
1.00000,   0.000
0 / END OF TRANSFORMER DATA, BEGIN AREA DATA
0 / END OF AREA DATA, BEGIN TWO-TERMINAL DC DATA
0 / END OF TWO-TERMINAL DC DATA, BEGIN VSC DC LINE DATA
0 / END OF VSC DC LINE DATA, BEGIN SWITCHED SHUNT DATA
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
0 / END OF ZONE DATA, BEGIN INTER-AREA TRANSFER DATA
0 / END OF INTER-AREA TRANSFER DATA, BEGIN OWNER DATA
0 / END OF OWNER DATA, BEGIN FACTS DEVICE DATA
0 / END OF FACTS DEVICE DATA
```

Dynamics Data

```
REPORT FOR ALL MODELS                BUS 336821 [GGULF      21.000] MODELS


 ** GENROU **  BUS X-- NAME --X BASEKV MC    C O N S     S T A T E S
          336821 GGULF       21.000 1  130656-130669  51167-51172

           MBASE     Z S O R C E        X T R A N      GENTAP
          1600.0  0.00366+J 0.28800  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
  6.29 0.047  0.38 0.123   4.51  0.00 1.5510 1.4730 0.4170 0.8320 0.2880 0.2450

                            S(1.0)  S(1.2)
                            0.2000  0.5000


 ** PSS2A **   BUS X-- NAME --X BASEKV MC    C O N S     S T A T E S     V A R S     I C O N S
          336821 GGULF       21.000 1  130670-130686  51173-51188   8396-8399    4483-4488

                 IC1 REMBUS1     IC2 REMBUS2       M       N
                  1       0       3       0       5       1

      TW1      TW2      T6       TW3      TW4      T7       KS2      KS3
     2.000    2.000    0.000    2.000    0.000    2.000    0.202    1.000

      T8       T9      KS1       T1       T2       T3       T4     VSTMAX   VSTMIN
     0.500    0.100    8.000    0.150    0.030    0.150    0.030    0.100   -0.100


 ** ESAC5A **  BUS X-- NAME --X BASEKV MC    C O N S     S T A T E S     VAR
          336821 GGULF       21.000 1  130687-130701  51189-51193    8400

   TR      KA     TA   VRMAX   VRMIN    KE     TE     KF     TF1    TF2    TF3
  0.200  600.00  0.100  6.400  -6.400  1.000  0.220  0.020  1.000  0.130  0.000

                 E1     S(E1)    E2     S(E2)       KE VAR
               3.7000  0.7300  2.8000  0.7300       0.0000
```

```
** IEEEG1 **  BUS X-- NAME --X BASEKV MC    C O N S     S T A T E S     V A R S
        336821 GGULF       21.000 1  130702-130721  51194-51199    8401-8402

    K      T1      T2      T3     UO      UC    PMAX   PMIN     T4      K1
  12.00   0.000   0.000   0.075  0.600  -0.600 0.9700 0.0000   0.250   0.350

   K2      T5      K3      K4      T6      K5      K6      T7      K7      K8
 0.000   2.750   0.650   0.000   0.000   0.000   0.000   0.000   0.000   0.000
```

APPENDIX C PLOTS FOR STABILITY SIMULATIONS