GEN-2015-045

Impact Restudy for Generator Modification

Published April 2019
By SPP Generator Interconnections Dept.

REVISION HISTORY

DATE OR VERSION NUMBER	AUTHOR	CHANGE DESCRIPTION
04/05/2019	SPP	Initial report issued.

CONTENTS

SUMMARY

The GEN-2015-045 Interconnection Customer has requested a modification to its 20 MW Interconnection Request. This system impact restudy was performed to determine the effects of reducing the installed capacity from the previously requested 20 MW to 10.3 MW and relocating the generator connection from GEN-2015-092 to GEN-2014-057. The point of interconnection (POI) for GEN-2015-045 remains at the American Electric Power (AEPW) Lawton East Side-Sunnyside (Terry Road) 345kV.

This study was performed by Siemens PTI to determine whether the request for modification is considered Material. A short circuit analysis, power factor analysis, a low-wind/no-wind condition analysis, and stability analysis was performed for this modification request. The study report follows this executive summary.

The generating facility will be required to maintain a 95% lagging (providing VARs) and 95% leading (absorbing VArs) power factor at the POI. The interconnection customer does not require installation of additional reactive power support to offset the capacitive effect on the transmission network caused by the project's transmission line and collector system during low-wind/no-wind conditions.

The restudy showed that no stability problems were found during the summer and the winter peak conditions. Additionally, the project wind farm was found to stay connected during the contingencies that were studied and, therefore, will meet the Low Voltage Ride Through (LVRT) requirements of FERC Order #661A. The requested modification is not considered Material.

It should be noted that this study analyzed the requested modification to reduce the installed capacity from 20 MW to 10.3 MW and relocate the generator connection from GEN-2015-092 to GEN-2014-057. Powerflow analysis was not performed. This study analyzed many of the most probable contingencies, but it is not an all-inclusive list and cannot account for every operational situation. It is likely that the customer may be required to reduce its generation output to 0 MW, also known as curtailment, under certain system conditions to allow system operators to maintain the reliability of the transmission network.

Nothing in this study should be construed as a guarantee of transmission service or delivery rights. If the customer wishes to obtain deliverability to final customers, a separate request for transmission service must be requested on Southwest Power Pool's OASIS by the customer.

A: CONSULTANT'S MATERIAL MODIFICATION STUDY REPORT

See next page for the Consultant's Material Modification Study report.

Siemens PTI Report Number: R021-19

GEN-2015-045 Impact Restudy for BESS Modification

Prepared for

Southwest Power Pool

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Siemens PTI Project Number 62OT-001388-B-S-Y

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Revision History

Date	Rev.	Description
March 27, 2019	1	Report revised based on comments from SPP
March 11, 2019	0	Initial draft for review

Contents

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Executive Summary

The customer for interconnection Request for GEN-2015-045 has requested a modification to its request. The modification request includes the reduction of installed capacity from previously requested 20 MW to 10.3 MW. Additionally, the generator connection will be moved from GEN-2015-092 to GEN-2014-057. Siemens PTI was retained to conduct a System Impact Study to assess the effects of proposed modifications on Southwest Power Pool (SPP) power system.

The study was performed using 2017 Winter Peak, 2018 Summer Peak, and 2026 Summer Peak stability packages provided to Siemens PTI by SPP. The packages include the power flow data, sequence data and the dynamic model data for SPP system. The proposed changes were applied to the cases with project at its full output and stability was tested using computer simulations.

Reactive power analysis, short circuit analysis for buses up to 5 levels away from the point of interconnection and transient stability simulations for multiple fault scenarios were performed as a part of this study.

The results of the reactive power analysis illustrate that the project does not add capacitive contribution to the shared point of connection with GEN-2014-057. The Interconnection Customer does not require installation of additional reactive support to prevent reactive power injection into the transmission system during low and zero generation scenarios.

Power factor requirements for the interconnecting facility will be in guidance with SPP Open Access Transmission Tariff. The interconnecting customer is required to meet 0.95 lagging (providing vars) and 0.95 leading (absorbing vars) power factor at the Point of Interconnection.

For transient stability simulations, the model parameters of the project were added to the stability package and 20-second flat runs were simulated to ensure proper initialization and dynamic response. A total of 48 faults including three phase faults, prior outage, and stuck breaker scenarios were simulated for each stability package to evaluate project's dynamic response. The faults were chosen from the list provided and approved by SPP based on their proximity and relevance to the project and system topology. The analysis shows good response from the project to the system transients. The project stays on-line and shows a stable response during fault simulations.

This report concludes that the requested modifications to the interconnection request do not cause any adverse effects on SPP system.

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Section

1

Introduction

Siemens PTI performed a System Impact Study to analyze the impact of requested modifications to GEN-2015-045 interconnection on SPP system. The project will have installed capacity of 10.3 MW with 12 x 0.858 MW HICO Inverters. This report describes the electrical model used for the project and summarizes the results of the study.

Figure 1-1 shows the previous configuration of the project. The project was connected to GEN-2015-092 and had installed capacity of 20 MW. Figure 1-2 shows the new power flow model used to represent the project for this study. The project is connected to the system in a radial arrangement through 168 MVA main transformer and 26-mile gen-tie transmission line. Siemens PTI investigated the ratings for main transformers for GEN-2015-092 and GEN-2014-057 and the interconnecting customer confirmed the nominal voltage of the high side of the main transformer to be 354 kV. Thus, the effective nominal tap for these transformers were changed from 1.00 to 1.026 to accurately model the equipment. Per the modification request, the following changes were made to the existing power flow cases:

- The installed MW capacity for the generating facility was reduced from 20 MW to 10.3 MW.
- The generator connection was changed from GEN-2015-092 to GEN-2014-057.

The power flow data and dynamic model parameters used for GEN-2015-045 in this study are provided in Appendix A.

The report contains the results of reactive power analysis, short circuit analysis and dynamic stability analysis using the modified data. The study was performed using the stability packages mentioned below.

1. 2017 Winter Peak
2. 2018 Summer Peak
3. 2026 Summer Peak

The analysis was performed PSS®E version 33.12 software. The response of the model is described in following sections.

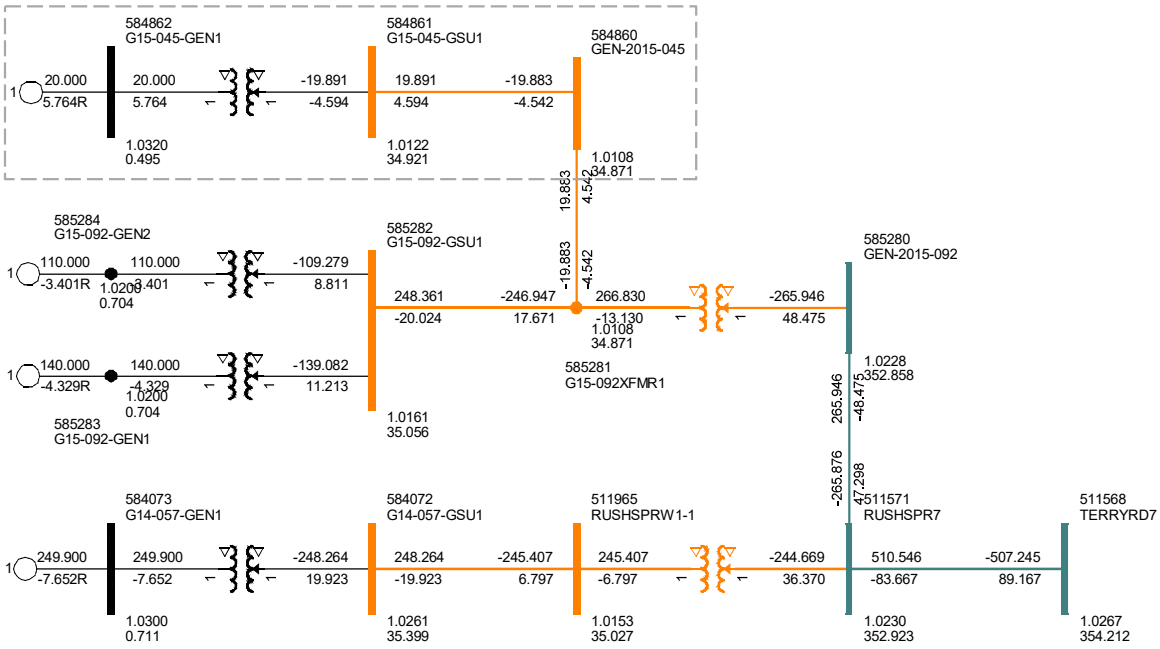

Figure 1-1. Previous Configuration for GEN-2015-045

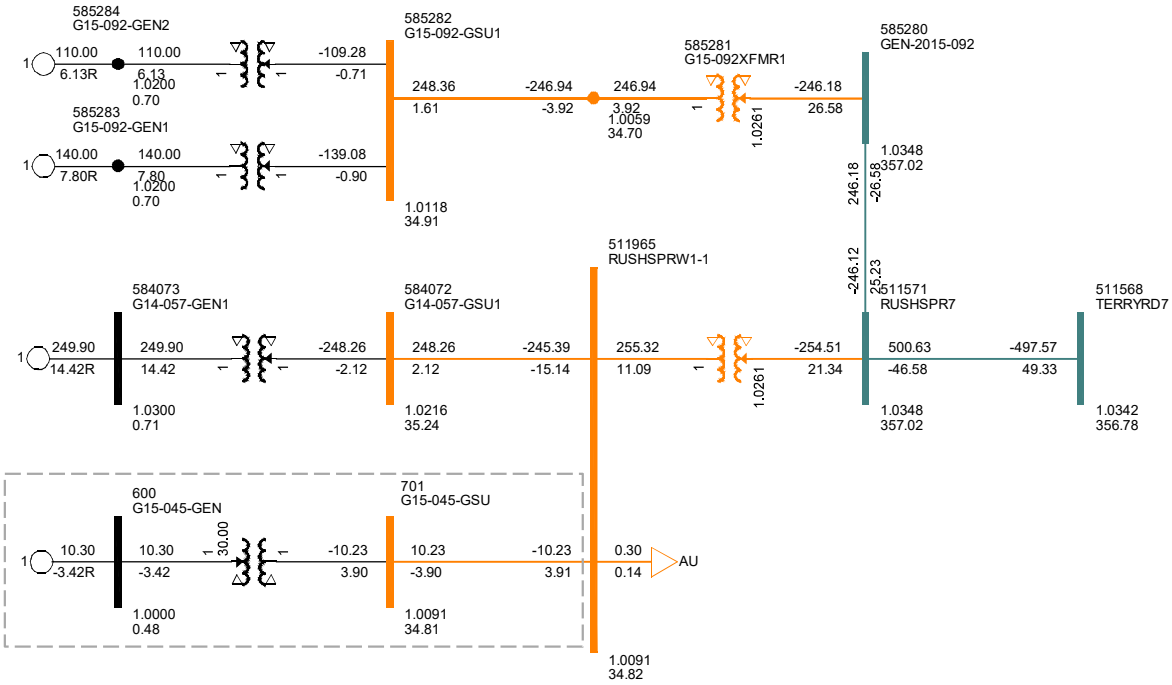

Figure 1-2: New Configuration for GEN-2015-045

Section

2

Reactive Power Analysis

Reactive power analysis was performed to calculate the shunt inductance capacity required to offset the capacitive effects of the project's collector system and transmission lines on the point of interconnection for a low wind / no wind scenario.

The analysis was performed for 2017 Winter Peak, 2018 Summer Peak and 2026 Summer Peak cases. For this purpose, the generator status was set to out-of-service for all the units connected to same POI while their respective collector systems and transmission network remained in service for low or no wind conditions.

Figure 2-1 below displays the results of the reactive power study for 2017 Winter Peak case with previous configuration of the project. As previously defined by the studies of GEN-015-092 and GEN-2014-057, 3.8 Mvar and 35 Mvar shunt reactors were added to the simulated case to compensate for the capacitive effects from the collector systems of the respective projects during low/no wind scenarios.

Figure 2-2 shows the results of the analysis after modification for 2017 Winter Peak case. The shunt reactors defined for the GEN-2014-057, and GEN-2015-092 were kept in the case.

The comparison of Figure 2-1 and Figure 2-2 illustrates that the project has no capacitive contribution to the flow at the POI during low/no wind scenario.

The analysis concludes that the project does not require additional means of reactive power control as it reduces the net reactive flow into the main transformer it shares with GEN-2014-057.

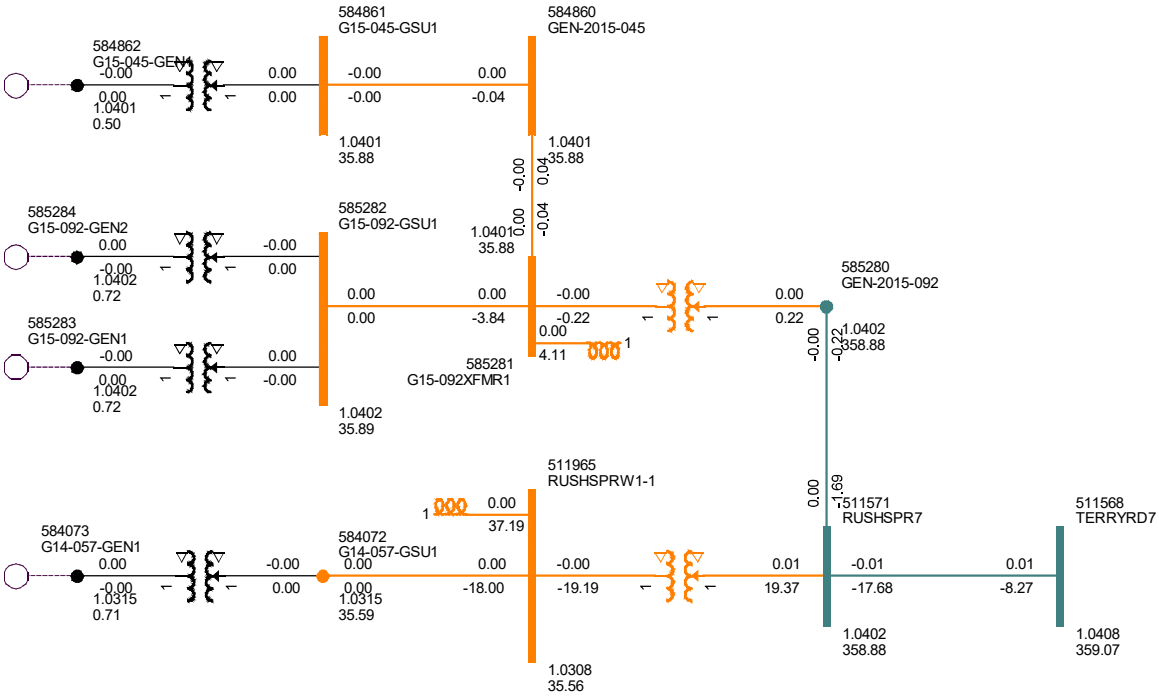

Figure 2-1: Reactive Power Analysis results for 2017 Winter Peak case with GEN-2015-045 before modification

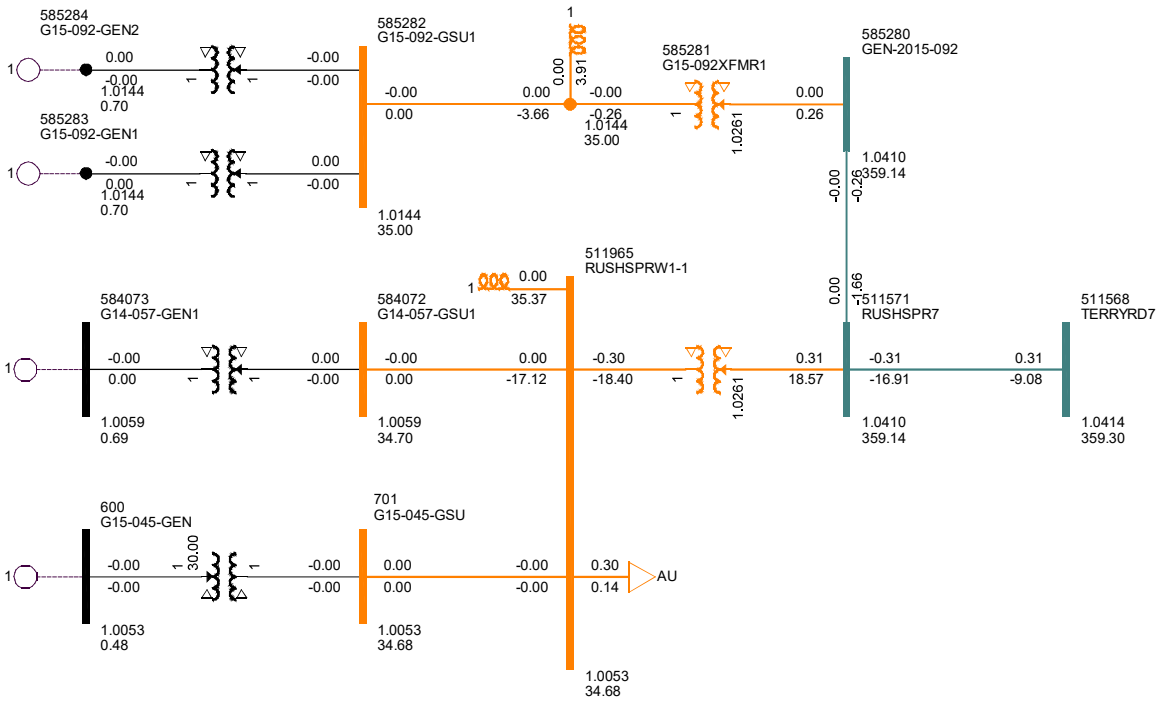

Figure 2-2. Reactive Power Analysis results for 2017 Winter Peak case with GEN-2015-045 after modification

Section

3

Short Circuit Analysis

The short circuit analysis was performed on 2017 Winter Peak, 2018 Summer Peak and 2026 Summer Peak power flows using modified model data.

The analysis involved applying 3-phase faults and single-phase faults on buses located up to five levels away from the point of interconnection. The detailed results for this study are available in Appendix B.

Table 3-1 provides a summary of change in fault currents in percentages. The table provides the maximum percentage increase in fault currents at POI in 3 cases with modified models. The analysis shows no major effects of the new configuration on SPP system.

Table 3-1: Increase in fault currents due to modification of models

Case	Maximum increase – 3-phase faults (%)	Maximum increase – Single phase faults (%)
2017WP	0.27%	0.47%
2018SP	0.23%	0.43%
2026SP	0.23%	0.43%

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Section

4

Stability Analysis

The transient stability was tested using the data from the modification request in 2017 Winter Peak, 2018 Summer Peak and 2026 Summer Peak stability packages using PSS®E version 33.12 software.

Steady state response was verified in these scenarios by simulating a 20 seconds flat run to ensure proper initialization. Transient stability was tested using rigorous fault simulations including three phase faults, faults with prior outage and stuck breaker scenarios. 48 faults were selected from faults provided by SPP and faults used in DISIS-2015-002 report submitted to SPP for GEN-2015-045 based on their geographical closeness to the project and system topology.

The descriptions of the faults used are provided in Appendix C. Table 4-1 summarizes the results of the transient stability analysis. The project showed a stable response to system transients caused by the faults. The results of the fault simulations have been attached as plots in Appendix D.

Table 4-1: Transient Stability Analysis results

Fault	2017WP	2018SP	2026SP
FLT1-3PH	Stable	Stable	Stable
FLT2-3PH	Stable	Stable	Stable
FLT3-3PH	Stable	Stable	Stable
FLT4-3PH	Stable	Stable	Stable
FLT5-3PH	Stable	Stable	Stable
FLT6-3PH	Stable	Stable	Stable
FLT7-3PH	Stable	Stable	Stable
FLT8-3PH	Stable	Stable	Stable
FLT9-3PH	Stable	Stable	Stable
FLT11-3PH	Stable	Stable	Stable
FLT12-SB	Stable	Stable	Stable
FLT13-SB	Stable	Stable	Stable
FLT15-3PH	Stable	Stable	Stable
FLT16-SB	Stable	Stable	Stable
FLT18-3PH	Stable	Stable	Stable
FLT19-3PH	Stable	Stable	Stable
FLT20-3PH	Stable	Stable	Stable
FLT21-SB	Stable	Stable	Stable
FLT22-3PH	Stable	Stable	Stable

Fault	2017WP	2018SP	2026SP
FLT23-3PH	Stable	Stable	Stable
FLT24-SB	Stable	Stable	Stable
FLT25-SB	Stable	Stable	Stable
FLT26-PO	Stable	Stable	Stable
FLT27-PO	Stable	Stable	Stable
FLT28-PO	Stable	Stable	Stable
FLT29-PO	Stable	Stable	Stable
FLT30-PO	Stable	Stable	Stable
FLT31-PO	Stable	Stable	Stable
FLT32-PO	Stable	Stable	Stable
FLT33-PO	Stable	Stable	Stable
FLT51-SB	Stable	Stable	Stable
FLT14-3PH_1	Stable	Stable	Stable
FLT15-3PH_1	Stable	Stable	Stable
FLT16-3PH_1	Stable	Stable	Stable
FLT17-3PH_1	Stable	Stable	Stable
FLT19-3PH_1	Stable	Stable	Stable
FLT20-3PH_1	Stable	Stable	Stable
FLT22-3PH_1	Stable	Stable	Stable
FLT26-3PH_1	Stable	Stable	Stable
FLT27-3PH_1	Stable	Stable	Stable
FLT29-3PH_1	Stable	Stable	Stable
FLT31-3PH_1	Stable	Stable	Stable
FLT39-PO_1	Stable	Stable	Stable
FLT43-SB_1	Stable	Stable	Stable
FLT45-SB_1	Stable	Stable	Stable
FLT23-3PH_1	Stable	Stable	Stable
FLT24-3PH_1	Stable	Stable	Stable
FLT41-PO_1	Stable	Stable	Stable

Section

5

Conclusion

Siemens PTI performed this study to assess the impact of the requested modifications to interconnecting GEN-2015-045 BESS facility. The changes include reduction in installed capacity to 10.3 MW and relocation of the generator connection to GEN-2014-057.

The reactive power analysis performed to estimate the size of shunt reactor required to offset the capacitive effects of the project's collector system and transmission line during no wind/ low wind scenario indicates that no additional reactive power support is required owing to no capacitive contribution from the project.

The short circuit analysis showed the project does not have any major adverse effects on the system. The maximum increase in fault current is 0.27% and 0.47% for 3-phase faults and single-phase faults in 2017 Winter Peak scenario.

The stability analysis demonstrates project's stable response to system transients. There were no impacts on SPP system stability and recovery during the simulations. The project stayed on-line for all fault simulations and showed a good recovery and stable operation.

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Appendix

A

Modeling Data for GEN-2015-045

A.1 Power flow data

```
GEN-2015-045 BATTERY 10.3 MW (12 X 1.0MVA)
SPP
   600,'G15-045-GEN ',   0.4800,2,   1,   1,   1,1.00000,  70.6396,1.10000,0.90000,1.10000,0.90000
   701,'G15-045-GSU ',  34.5000,1,   1,   1,   1,1.01414,  38.0857,1.10000,0.90000,1.10000,0.90000
0 / END OF BUS DATA, BEGIN LOAD DATA
511965,'AU',1,   1,   1,     0.300,     0.145,     0.000,     0.000,     0.000,     0.000,   1,1,0
0 / END OF LOAD DATA, BEGIN FIXED SHUNT DATA
0 / END OF FIXED SHUNT DATA, BEGIN GENERATOR DATA
   600,'1 ',    10.300,    -4.632,     6.160,    -6.160,1.00000,     0,    12.000, 0.00000E+0, 1.00000E+0, 0.00000E+0,
0.00000E+0,1.00000,1,  100.0,    10.300,     0.000,   1,1.0000,   0,   1.0,   0,   1.0,   0,   1.0,1, 1.0000
0 / END OF GENERATOR DATA, BEGIN BRANCH DATA
   701,511965,'1 ', 3.86000E-4, 2.16800E-3,   0.00000,    0.00,    0.00,    0.00,  0.00000,  0.00000,  0.00000,
0.00000,1,2,   0.00,   1,1.0000
0 / END OF BRANCH DATA, BEGIN TRANSFORMER DATA
   600,   701,     0,'1 ',1,2,1, 0.00000E+00, 0.00000E+00,1,'XFR-BT      ',1,   1,1.0000,   0,1.0000,   0,1.0000,
0,1.0000,'            '
 8.36800E-3, 5.94140E-2,    14.40
1.00000,   0.000,  30.000,    14.40,    14.40,    14.40, 0,      0, 1.05000, 0.95000, 1.05000, 0.95000,   3, 0,
0.00000, 0.00000,  0.000
1.00000,   0.000
0 / END OF TRANSFORMER DATA, BEGIN AREA DATA
Q
```

A.2 Dynamics model data

```
// GEN-2015-045 Battery 10MW
// 11 x HICO 0.91MW / 1.0MVA
    600 'USRMDL' 1  'REGCAU1'  101   1    1   14    3    4      1
         0.10000E-01   10.000      0.10000      -3.0000       1.0000
          1.1000      0.10000       0.0000     -0.12000      0.10000
          0.0000       999.11      -999.11      0.65000      /
    600 'USRMDL' 1  'REECCU1'  102    0    5    45   7   6
          0          0       1       0       1
         0.90000          1.1000         0.50000E-01    -0.10000E-01     0.10000
          2.0000         0.12000        -0.10000E-01      0.0000         0.50000E-01
         0.60000        -0.60000          1.1000          0.90000          1.0000
          1.0000         0.90000          100.00          0.10000          99.000
         -99.000          1.0000         -1.0000          1.2000         0.20000
         0.45000         0.10000         0.47000         0.80000         0.89500
         0.80000         0.91000          1.0000         0.45000         0.10000
         0.47000         0.80000         0.89500         0.80000         0.91000
          1.0000         0.10000E+06      1.0000          1.0000          0.0000      /
   6001 'VTGTPAT'     600      600  '1 '   -99.000   1.1000    1.0000      0.10000E-01  /
   6002 'VTGTPAT'     600      600  '1 '   -99.000   1.1500   0.50000      0.10000E-01  /
   6003 'VTGTPAT'     600      600  '1 '   -99.000   1.1750   0.20000      0.10000E-01  /
   6004 'VTGTPAT'     600      600  '1 '   -99.000   1.2000   0.10000E-01  0.10000E-01  /
   6005 'VTGTPAT'     600      600  '1 '   0.45000   99.000   0.15000      0.10000E-01  /
   6006 'VTGTPAT'     600      600  '1 '   0.65000   99.000   0.30000      0.10000E-01  /
   6007 'VTGTPAT'     600      600  '1 '   0.75000   99.000    2.0000      0.10000E-01  /
   6008 'VTGTPAT'     600      600  '1 '   0.90000   99.000    3.0000      0.10000E-01  /
```

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Appendix

B

Short Circuit Analysis Results

The detailed results for short circuit analysis are presented below

Bus #	Bus Name	Levels Away	Fault current (Amperes)					
			2017WP		2018SP		2026SP	
			3 PH	SLG	3 PH	SLG	3 PH	SLG
511568	TERRYRD7	POI	9886	7053	10014	7090	10039	7086
511468	L.E.S.-7	0	12824	10442	13169	10581	13298	10617
515136	SUNNYSD7	0	10907	9860	11009	9909	10998	9893
511411	LES#5-1	1	28228	0	28209	0	28267	0
511414	LES#4-1	1	47606	0	47736	0	47697	0
511456	O.K.U.-7	1	5205	3462	5247	3471	5284	3470
511467	L.E.S.-4	1	24027	23915	24812	24432	25180	24626
514809	JOHNCO 7	1	9929	8105	10001	8133	9981	8115
515135	SUNNYSD4	1	18234	20799	18354	20889	18329	20860
515405	SUNYSD 1	1	42248	0	42195	0	42140	0
515762	SUNNYSD1	1	64494	0	64509	0	64422	0
560088	G16-063-TAP	1	7662	5425	7702	5439	7681	5421
585280	GEN-2015-092	1	6195	0	6236	0	6237	0
587744	G16-091-TAP	1	14403	10192	14822	10309	14958	10337
510907	PITTSB-7	2	13668	9984	13788	10029	13754	10002
511415	LES#2-1	2	15550	0	15559	0	15520	0
511416	LES#1-1	2	14364	0	14370	0	14333	0
511423	FLE TAP4	2	8640	5958	8947	6032	9050	6052
511437	COMANC-4	2	17863	14214	18273	14387	18466	14451
511439	LWSTAP 4	2	11459	8096	11650	8141	11710	8142
511466	L.E.S.-2	2	16321	18039	16538	18206	16579	18221
511474	SHERID4	2	12242	8709	12462	8765	12533	8766
511486	ELGINJT4	2	9725	7522	10082	7636	10203	7668
511494	COMMTAP4	2	21105	19253	21705	19580	21974	19691
511565	OKLAUN HVDC7	2	5191	3454	5233	3463	5269	3461
514808	JOHNCO 4	2	15298	15455	15369	15495	15340	15470
514810	JOHNCO11	2	39760	0	39761	0	39716	0
515137	UNIROY 4	2	12599	10532	12645	10524	12628	10511
515144	LONEGRV4	2	13206	12175	13257	12182	13238	12165
515164	ROCKYPT4	2	10497	8392	10516	8381	10503	8371
515561	CARTRCO4	2	8393	7213	8386	7196	8378	7188
515800	GRACMNT7	2	16472	12275	17075	12468	17268	12519
521157	HUGO 7	2	11412	10666	11483	10714	11341	10510
525832	TUCO_INT 7	2	10637	11848	11362	12767	13495	14460
584780	GEN-2015-036	2	7799	0	7841	0	7822	0
587430	GEN-2016-063	2	7574	0	7613	0	7592	0
587740	GEN-2016-091	2	12888	0	13215	0	13318	0
587770	GEN-2016-095	2	10820	0	11033	0	11096	0
599891	OKLAUN 7	2	4462	0	4491	0	4490	0

Bus #	Bus Name	Levels Away	Fault current (Amperes)					
			2017WP		2018SP		2026SP	
			3 PH	SLG	3 PH	SLG	3 PH	SLG
510911	VALIANT7	3	13555	12137	13655	12200	13508	12055
510925	KIOWA 7	3	13434	9660	13550	9702	13517	9676
511412	ELGJT1-1	3	10480	0	10440	0	10420	0
511422	FLETCHR4	3	7918	5398	8170	5456	8254	5470
511431	LWS S4	3	10998	7697	11172	7736	11226	7735
511436	COMANC-2	3	9732	6432	9814	6455	9828	6453
511469	LGORE-N2	3	8091	5987	8135	5981	8131	5970
511470	LGORE-S2	3	7050	5343	7087	5338	7081	5323
511487	ELGINJT2	3	8583	8494	8667	8524	8688	8528
511488	112GORE4	3	12564	9003	12804	9064	12887	9071
511512	RPPAPER4	3	11859	8400	12069	8449	12137	8452
511537	ARTVLTP4	3	11639	8058	11840	8101	11902	8100
511563	ELSWORTH 4	3	9644	7411	10006	7524	10128	7557
511851	COM1-1	3	71666	74218	72840	75381	73891	76438
511852	COM2-1	3	45062	49823	45665	50468	46624	51515
514801	MINCO 7	3	17255	14386	17696	14563	17744	14568
515045	SEMINOL7	3	26041	26911	26687	27355	26648	27317
515120	RUSSET-4	3	11383	9158	11397	9152	11374	9142
515122	SXMLCKT4	3	11208	8668	11239	8671	11221	8660
515129	RATLIFF4	3	6515	5510	6506	5492	6498	5485
515130	POOLVIL4	3	8217	6976	8209	6959	8201	6951
515150	CANEYCK4	3	8649	6330	8658	6310	8635	6316
515163	ROCKYPT2	3	7884	7922	7866	7896	7858	7889
515172	SPRNDAL4	3	11537	9551	11558	9538	11542	9528
515372	ARDWEST4	3	12445	10332	12488	10322	12471	10310
515415	CHEEKTP4	3	11961	10557	11998	10554	11981	10540
515422	C-RIVER7	3	9709	7459	9764	7480	9756	7472
515563	ORIGINW4	3	5207	5661	5192	5642	5189	5638
515754	ROCKYPT1	3	5885	0	5858	0	5853	0
515801	GRCMNT11	3	45006	0	45680	0	46013	0
515802	GRACMNT4	3	24519	24492	27510	26315	28980	27163
520948	HUGO PP4	3	22960	26239	23039	26304	23002	26220
521189	HUGO TERTA	3	8309	0	8328	0	8092	0
525824	TUCO_TR1 1	3	31796	0	31992	0	32319	0
525825	TUCO_TR2 1	3	23895	0	24071	0	24227	0
525830	TUCO_INT 6	3	19329	21602	21410	23579	23944	25550
525845	ELK_2 1	3	42887	65199	43420	65797	44594	66815
525850	ELK_CT1	3	10546	11666	11262	12566	13353	14197
529304	OMDUNCN4	3	6678	4764	6709	4745	6721	4741
560078	G16-037-TAP	3	7935	3949	7987	3945	7995	3938
584781	G15-036-XF-1	3	51822	0	51967	0	51820	0
584784	G15-036-XF-2	3	51781	0	51925	0	51779	0
585060	GEN-2015-068	3	8921	0	9410	0	10783	0
585270	GEN-2015-093	3	9805	0	9989	0	10040	0
587431	G16-063XFMR1	3	18109	0	18135	0	18137	0
587434	G16-063XFMR2	3	18131	0	18157	0	18159	0
587741	G16-091XFMR1	3	30595	0	30680	0	30677	0
587771	G16-095XFMR1	3	32259	0	32233	0	32196	0
587794	G16-097-TAP	3	10855	7618	11640	7827	11933	7904
587964	G16-120-TAP	3	7163	4192	7277	4226	7565	4285
590001	OKLEHV24	3	5290	0	5323	0	5323	0
590002	OKLAUN1G	3	89574	88746	90152	89312	90135	89302

Bus #	Bus Name	Levels Away	Fault current (Amperes)					
			2017WP		2018SP		2026SP	
			3 PH	SLG	3 PH	SLG	3 PH	SLG
590003	OKLEHV14	3	5405	0	5439	0	5439	0
590004	OK1TERT	3	10802	0	10869	0	10927	0
508072	NWTXARK7	4	13326	12256	13413	12308	13236	12136
508298	LYDIA 7	4	12831	10287	12918	10333	12713	10163
510918	VALIANT4	4	15031	16794	15097	16851	14986	16713
510938	VALN2-1	4	39515	0	39580	0	39235	0
510939	VALN3-1	4	32681	0	32728	0	32440	0
510946	C-RIVER4	4	12987	10932	13021	10942	13045	10949
510947	C-RIVER1	4	27441	0	27461	0	27412	0
511428	LG-YEAR4	4	11802	8304	12009	8352	12078	8355
511451	CYRIL--2	4	4736	3496	4735	3474	4734	3467
511453	DUNCAN-4	4	6471	4621	6501	4597	6513	4593
511461	FT.SILL2	4	6035	4121	6057	4103	6050	4095
511471	LWS-NTP4	4	11576	7930	11773	7971	11836	7970
511473	PO.HILL2	4	5908	4289	5922	4273	5922	4266
511477	S.W.S.-4	4	23103	22592	30837	26871	34659	28695
511503	LAW WC2	4	4632	3228	4640	3216	4631	3204
511509	53CACHE4	4	11618	8029	11818	8071	11881	8070
511510	LAIRGST4	4	12165	8692	12391	8747	12467	8753
511524	L-DISTP2	4	8984	5829	9052	5846	9062	5842
511538	ARTVILL4	4	8478	5627	8580	5639	8601	5630
511553	CHISHOLM7	4	6352	2613	6369	2605	6367	2599
511853	COM3-1	4	37351	40448	37984	41112	38167	41302
511944	KIOWA G1	4	58058	50801	58204	50891	58057	50762
511945	KIOWA G2	4	58058	50958	58204	51047	58057	50918
511946	KIOWA S1	4	31423	38824	31476	38883	31397	38784
511947	KIOWA S2	4	31423	34000	31476	34048	31397	33962
511948	KIOWA G3	4	58058	50723	58204	50813	58057	50684
511949	KIOWA G4	4	58058	62423	58204	62548	58057	62390
514901	CIMARON7	4	31632	28564	33372	29438	33277	29362
514908	ARCADIA7	4	24816	25973	25976	26803	26044	27206
514934	DRAPER 7	4	20690	18144	21371	18323	21286	18249
515041	SEMINL2G	4	190236	131705	190413	131567	190937	131929
515042	SEMINL3G	4	184847	141234	184953	141088	185481	141491
515044	SEMINOL4	4	39126	44563	39892	45219	39854	45171
515121	MILLCKT4	4	11062	8462	11093	8465	11075	8453
515128	RATLIFF2	4	5188	6026	5165	5994	5157	5985
515131	FOX 4	4	6804	5385	6796	5369	6789	5362
515134	PRARPNT4	4	5475	4010	5464	3995	5455	3988
515138	CARTER 4	4	12634	10796	12671	10786	12653	10774
515143	WOLFCRK4	4	9601	7914	9617	7901	9604	7891
515147	GLASSES4	4	8203	5980	8208	5963	8192	5965
515149	MADINDT4	4	8194	5968	8199	5951	8183	5953
515151	LTLCITY4	4	7207	5164	7216	5143	7199	5137
515162	FNDTION4	4	11733	10162	11759	10152	11742	10140
515224	MUSKOGE7	4	28380	32206	28987	32728	28788	32572
515420	SCMMRCT2	4	9118	7754	9096	7721	9086	7715
515444	MCNOWND7	4	17206	14346	17644	14522	17692	14527
515458	BORDER 7	4	5461	3186	5480	3191	5508	3198
515549	MNCWND37	4	11914	9849	12097	9915	12108	9908
515564	ORIGIN11	4	12971	17535	12920	17466	12918	17462
515565	ORIGIN21	4	13176	17784	13125	17714	13123	17711

Bus #	Bus Name	Levels Away	Fault current (Amperes)					
			2017WP		2018SP		2026SP	
			3 PH	SLG	3 PH	SLG	3 PH	SLG
515566	ORIGINT1	4	24549	0	24449	0	24444	0
515567	ORIGINT2	4	24865	0	24763	0	24760	0
515676	MRIETAT2	4	2227	1585	2218	1571	2216	1569
515752	RATLIFF1	4	10107	0	10037	0	10023	0
515756	SEMINO11	4	36936	0	36998	0	36949	0
515757	SEMINO21	4	23078	0	23099	0	23067	0
515781	RUSSET11	4	1921	2396	1916	2389	1915	2388
515782	RUSSET21	4	5035	0	5019	0	5017	0
520411	SAWYER4	4	10767	7721	10771	7713	10680	7628
520814	ANADARK4	4	24676	28617	28556	31902	31490	34250
520918	FROGVIL4	4	11409	8220	11417	8213	11325	8125
520947	HUGO1	4	113632	84075	113755	84091	113662	83770
521044	RUSSETT4	4	11311	9078	11326	9072	11303	9063
521067	TEXOMAJ4	4	8591	6280	8599	6259	8576	6265
521079	VALLANT4	4	9699	6539	9713	6540	9624	6464
521089	WASHITA4	4	22499	20285	26501	22205	28307	23003
521122	HOWE 4	4	11103	8557	11133	8560	11116	8548
521125	CHEEK_4	4	9573	7789	9584	7775	9571	7765
525213	SWISHER 6	4	10713	8431	10950	8528	11044	8539
525524	TOLK_EAST 6	4	24755	30264	27153	32542	27451	32802
525819	TUCO_TR3 1	4	23578	0	23631	0	23550	0
525820	TUCO_SVC 1	4	35633	38368	37683	40501	42186	45161
525821	TUCO_TR4 1	4	29335	0	29451	0	29381	0
525828	TUCO_INT 3	4	19102	21035	19961	21780	20367	21962
525840	ANTELOPE_1 6	4	19179	21348	21247	23292	23749	25217
525844	ELK_1 1	4	43502	0	47516	68318	49001	69499
525957	HALE_WNDCL16	4	8721	8297	9044	8520	9387	8706
526161	CARLISLE 6	4	10718	8767	11191	8971	14036	11540
526337	JONES 6	4	17392	20664	20291	23384	21509	24597
584782	G15-036-GSU1	4	43285	0	43367	0	43237	0
584785	G15-036-GSU2	4	40291	0	40357	0	40234	0
585061	G15-068-XF-1	4	33774	0	34287	0	35501	0
585271	G15-093XFMR1	4	30271	0	30295	0	30271	0
587230	GEN-2016-037	4	7244	0	7281	0	7284	0
587432	G16-063-GSU1	4	17625	0	17648	0	17655	0
587435	G16-063-GSU2	4	17698	0	17722	0	17728	0
587742	G16-091-GSU1	4	28966	0	29042	0	29038	0
587772	G16-095-GSU1	4	31460	0	31426	0	31389	0
587790	GEN-2016-097	4	9089	0	9589	0	9774	0
587960	GEN-2016-120	4	5828	0	5883	0	6028	0
587970	GEN-2016-175	4	4769	0	4807	0	4907	0
588200	GEN-2016-129	4	5399	0	5419	0	5371	0
505602	S BROWN4	5	8361	6643	8398	6630	8375	6613
507455	TURK 7	5	9194	7132	9231	7147	9121	7057
508071	NWTXARK4	5	24997	25175	25127	25257	24832	24941
508100	NWTEX1-1	5	29182	0	29187	0	28787	0
508101	NWTEX2-1	5	28986	0	28986	0	28593	0
508359	WELSH 7	5	20840	22425	21013	22552	20540	22022
509745	CLARKSV7	5	19816	16561	20258	16750	20039	16670
510866	V-WEYCO4	5	9943	8519	9972	8535	9893	8461
510886	IDABEL-4	5	6965	5168	6979	5170	6921	5123
510901	HUGO---4	5	3547	2945	3551	2945	3523	2920

Bus #	Bus Name	Levels Away	Fault current (Amperes)					
			2017WP		2018SP		2026SP	
			3 PH	SLG	3 PH	SLG	3 PH	SLG
510910	VALIANT2	5	7466	8823	7485	8840	7422	8764
510937	VALN1-1	5	9150	0	9160	0	9077	0
510951	TALAWANDA 4	5	9685	7432	9692	7425	9767	7458
511410	DUNC2-1	5	8064	0	7915	0	7897	0
511413	SWS#1--1	5	6495	0	6464	0	6470	0
511421	VERDEN 4	5	9308	6608	9848	6730	10058	6785
511429	L AIRGS4	5	11391	8023	11584	8067	11648	8069
511430	LWS N4	5	10340	6952	10492	6979	10537	6974
511445	CARNEG-4	5	7458	5506	7843	5611	7992	5656
511450	CORNVIL2	5	6585	6964	6583	6935	6590	6933
511452	DUNCAN-2	5	6367	6197	6315	6137	6314	6130
511476	S.W.S.-2	5	4240	4888	4289	4918	4317	4940
511483	NORGE--4	5	10967	7665	11423	7745	11600	7785
511500	CACHE4	5	8196	5848	8302	5869	8335	5866
511525	LDISPOS2	5	5100	3224	5119	3227	5119	3223
511526	L-RLITP2	5	7542	4743	7584	4749	7589	4745
511552	DUNCHERTP4	5	6176	3179	6202	3149	6212	3145
511557	CHISHOLM6	5	8738	6972	8763	6968	8763	6960
511558	CHISHOLM1	5	30098	0	30004	0	29940	0
511566	PERNELL4	5	4549	3249	4538	3236	4530	3230
511846	SWS1-1	5	27464	28611	27997	28884	59508	60294
511847	SWS2-1	5	27464	28611	58701	59630	59482	60320
511848	SWS3-1	5	50188	57189	88782	95944	91270	97926
511849	SWS NG4	5	24477	0	61053	50118	62216	50964
511850	SWS NG5	5	24524	0	24930	0	62281	50999
514880	NORTWST7	5	30321	28126	32809	29466	32679	29385
514898	CIMARON4	5	41931	39196	43483	40123	43139	39897
514907	ARCADIA4	5	39040	40159	41766	42040	41444	41934
514909	REDBUD 7	5	23836	25092	24744	25756	25093	26382
514933	DRAPER 4	5	37980	38167	39538	39174	39291	38927
515040	SEMINL1G	5	194149	150648	195912	151605	195780	151493
515055	MAUD 4	5	19635	14794	20157	14954	20139	14941
515100	PAOLI- 4	5	10397	8177	10429	8177	10402	8156
515117	ARBUCKL4	5	15953	12154	16013	12165	15990	12147
515127	WLDHRST2	5	5095	5733	5072	5701	5064	5693
515132	DUNDEE 4	5	6321	5062	6315	5044	6305	5038
515142	DILLARD4	5	7688	6176	7692	6158	7682	6151
515152	BROWNTP4	5	8244	6502	8279	6488	8256	6472
515158	MADLIND4	5	7650	5456	7652	5439	7639	5441
515160	MRIETA 2	5	2055	1451	2046	1438	2045	1436
515166	ARDMORE2	5	9833	8463	9816	8430	9804	8423
515171	CHIKSAW4	5	12364	11211	12399	11206	12380	11193
515178	PARKLN 4	5	16696	12697	16783	12727	16764	12702
515196	MILLCRK4	5	9119	6672	9136	6670	9122	6661
515223	MUSKOG4G	5	232630	138321	234170	138820	234014	138857
515225	MUSKOG5G	5	230501	139810	232011	140314	231801	140314
515226	MUSKOG6G	5	191423	128653	192665	129156	192552	129185
515235	PECANCK7	5	21325	19192	21858	19470	21727	19396
515302	FTSMITH7	5	10124	10340	10182	10366	9796	10084
515375	WWRDEHV7	5	19263	15863	19498	15973	19522	15988
515419	COMMRCT2	5	9166	7613	9145	7581	9134	7576
515443	MNCOWND1	5	29436	38967	29431	38944	29378	38871

Bus #	Bus Name	Levels Away	Fault current (Amperes)					
			2017WP		2018SP		2026SP	
			3 PH	SLG	3 PH	SLG	3 PH	SLG
515445	MNCOWNDT	5	52081	0	52012	0	51908	0
515497	MATHWSN7	5	30592	25010	32137	25647	32055	25589
515531	VANOSTP4	5	13575	8843	13632	8854	13612	8838
515550	MNCWND31	5	25939	34709	25930	34683	25883	34617
515551	MNCWND3T	5	47204	0	47139	0	47045	0
515570	MAYSVLT4	5	5856	4111	5848	4098	5836	4089
515610	FSHRTAP7	5	16681	14203	17072	14368	17028	14332
515643	HONEYCK4	5	9239	7710	9241	7694	9231	7687
515700	ARCADI41	5	68693	0	69558	0	69345	0
515703	ARCADI21	5	49448	51712	49745	52212	49613	52104
515704	ARCADI31	5	45285	0	45531	0	45412	0
515714	CIMARO11	5	37909	0	37906	0	37799	0
515715	CIMARO21	5	53362	0	53395	0	53244	0
515720	DRAPER31	5	49892	0	50069	0	49873	0
515721	DRAPER41	5	49892	0	50069	0	49873	0
515792	DRAPER21	5	69863	0	70637	0	70172	0
520211	HARPER2	5	23200	25354	26566	27861	29068	29617
520419	GARVIN4	5	6371	4115	6379	4114	6317	4068
520422	SEQUOYAHJ4	5	23495	25833	26952	28442	29523	30269
520810	ANADARK2	5	14155	16870	14543	17205	14772	17405
520811	ANADRK4	5	55227	39827	55776	40007	56071	40093
520812	ANADRK5	5	55283	39846	55835	40026	56132	40113
520813	ANADRK6	5	55221	39824	55771	40004	56066	40091
520923	GEORGIA4	5	15010	12525	16241	13020	17085	13357
520972	LEBANON4	5	5936	4133	5924	4107	5908	4127
521017	ONEY 4	5	10029	6395	10583	6490	10806	6533
521031	POCASET4	5	7488	5017	7631	5031	7709	5036
521036	RATTAN 4	5	6987	4519	6976	4507	6906	4454
521066	TEXOMA 4	5	6332	4030	6323	4010	6315	4016
521088	WASHITA2	5	9208	9526	9347	9591	9430	9642
521098	WSTBANK4	5	7377	4600	7369	4586	7300	4535
521101	GENCO1 4	5	32248	6677	32749	6687	30417	0
521102	GENCO2 4	5	32311	6679	32811	6688	30481	0
521103	SLKHILLS 4	5	7841	2782	7937	2766	7988	2767
521110	ORME1	5	29988	0	51257	34793	51547	34868
521111	ORME2	5	29988	0	30258	0	51547	34868
521112	ORME3	5	29988	0	30258	0	51547	34868
521129	BLUCAN5 4	5	5716	3574	5804	3583	5857	3589
521179	WASHTERT	5	10346	0	10295	0	10296	0
521181	ADRKTERT	5	20304	0	20341	0	20386	0
522823	LP-MILWAKEE6	5	10070	8080	10486	8252	13570	11066
522870	LP-HOLLY 6	5	13479	13353	15101	14385	17208	16795
524911	ROSEVELT_S 6	5	8716	2927	8870	2915	8958	2932
525211	SWISHER_TR11	5	16084	0	15481	0	15190	0
525212	SWISHER 3	5	11860	10838	11622	10410	11500	10219
525454	HALE_CNTY 3	5	10220	8223	10390	8260	10441	8251
525461	NEWHART 6	5	11221	9134	11556	9234	11597	9204
525481	PLANT_X 6	5	19565	19517	22961	21521	23186	21614
525543	TOLK_TAP 6	5	24755	30264	27153	32542	27451	32802
525561	TOLK_1 1	5	159444	137244	165260	139683	166133	140101
525780	FLOYD_CNTY 3	5	6081	5122	6121	5121	6150	5112
525814	TUCO_TR7 1	5	4062	0	4041	0	4039	0

Bus #	Bus Name	Levels Away	Fault current (Amperes)					
			2017WP		2018SP		2026SP	
			3 PH	SLG	3 PH	SLG	3 PH	SLG
525816	TUCO_INT2 2	5	4613	5035	4603	5011	4594	4981
525822	TUCO_TR5 1	5	4854	0	4800	0	4818	0
525823	TUCO_TR6 1	5	4811	0	4757	0	4775	0
525826	TUCO_INT 2	5	7848	8887	7830	8829	7915	8896
525841	ANTELOPE_A 1	5	23731	0	39873	42554	40398	43042
525842	ANTELOPE_B 1	5	23731	0	39873	42555	40398	43042
525843	ANTELOPE_C 1	5	23731	0	23881	0	40394	43040
525951	HALE_WND1 1	5	27985	0	28383	0	28775	0
526076	STANTON_W 3	5	8974	6339	9115	6378	9225	6450
526157	CRLSLE_TR1 1	5	91212	0	92773	0	96687	0
526160	CARLISLE 3	5	12712	11598	13096	11916	13250	12188
526269	LUBBCK_STH 6	5	15842	15806	17932	17155	19437	18966
526298	LUBBCK_EST 3	5	14454	14487	15060	14841	15292	14987
526299	LUBBCK_EST 6	5	12007	11710	13233	12464	13687	12752
526331	JONES_1 1	5	54735	0	87350	76349	88922	77365
526332	JONES_2 1	5	80828	72893	83332	74247	84748	75206
526333	JONES_3 1	5	128227	99382	130246	100612	131911	101780
526334	JONES_4 1	5	94756	91059	96600	92315	97920	93405
526525	WOLFFORTH 6	5	12734	10635	13471	10966	13940	11338
526677	GRASSLAND 6	5	6227	5198	6524	5326	6620	5352
560050	G15-031-TAP	5	9209	6704	9343	6733	9379	6718
580043	G10-046-GEN1	5	39037	26206	39853	26695	40380	26974
583090	G1149&G1504	5	4968	0	4982	0	5005	0
584060	GEN-2015-057	5	8226	0	8297	0	8296	0
585062	G15-068-GSU1	5	33042	0	33530	0	34675	0
585080	GEN-2015-071	5	5873	0	5884	0	5880	0
587231	G16-037XFMR1	5	44830	0	44753	0	44681	0
587370	GEN-2016-056	5	5832	0	5952	0	6559	0
587433	G16-063-GEN1	5	825940	647326	826945	648044	828365	649179
587436	G16-063-GEN2	5	826420	646715	827429	647434	828839	648559
587791	G16-097XFMR1	5	15042	0	15083	0	15114	0
587961	G16-120XFMR1	5	29751	0	29745	0	29831	0
587965	G16-120XFMR2	5	29080	0	29075	0	29163	0
587971	G16-175XFMR1	5	25320	0	25311	0	25374	0
588201	G16-129XFMR1	5	15806	0	15811	0	15645	0
599145	G1140G1204U1	5	12485	0	12435	0	12434	0
599146	G1140G1204U2	5	12898	0	12847	0	12846	0
599153	HALE_COXFMR2	5	28220	0	28620	0	29013	0

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Appendix

C

Transient Stability Analysis Faults Descriptions

Number	Fault	Description
1	FLT1-3PH	3 phase fault on VALIANT7 345 kV (510911) to PITTSB-7 345 kV (510907) line CKT 1, near VALIANT7. a. Apply fault at the VALIANT7 345 kV bus. b. Clear fault after 5 cycles and trip the faulted line. 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	FLT2-3PH	3 phase fault on VALIANT7 345 kV (510911) to LYDIA 345 kV (508298) line CKT 1, near VALIANT7. a. Apply fault at the VALIANT7 345 kV bus. b. Clear fault after 5 cycles and trip the faulted line. 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.
3	FLT3-3PH	3 phase fault on VALIANT7 345 kV (510911) to NWTXARK7 345 kV (508072) line CKT 1, near VALIANT7. a. Apply fault at the VALIANT7 345 kV bus. b. Clear fault after 5 cycles and trip the faulted line. 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	FLT4-3PH	3 phase fault on VALIANT7 345 kV (510911) to HUGO 345 kV (521157) line CKT 1, near VALIANT7. a. Apply fault at the VALIANT7 345 kV bus. b. Clear fault after 5 cycles and trip the faulted line. 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.
5	FLT5-3PH	3 phase fault on VALIANT4 138 kV (510918) to VALIANT7 345 kV (510911) to VALN2-1 13.8 kV (510938) transformer CKT 2, near VALIANT7. a. Apply fault at the VALIANT7 345 kV bus. b. Clear fault after 5 cycles and trip the faulted line.

Number	Fault	Description
6	FLT6-3PH	3 phase fault on HUGO 345 kV (521157) to G16-063-TAP 345 kV (560088) line CKT 1, near HUGO. a. Apply fault at the HUGO 345 kV bus. b. Clear fault after 5 cycles and trip the faulted line. 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.
7	FLT7-3PH	3 phase fault on HUGO 345 kV (521157) to HUGO PP4 138 kV (520948) to HUGO TERTA 13.8 kV (521189) transformer CKT 1, near HUGO. a. Apply fault at the HUGO 345 kV bus. b. Clear fault after 5 cycles and trip the faulted line.
8	FLT8-3PH	3 phase fault on LYDIA 345 kV (508298) to WELSH 345 kV (508359) line CKT 1, near LYDIA. a. Apply fault at the LYDIA 345 kV bus. b. Clear fault after 5 cycles and trip the faulted line. 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.
9	FLT9-3PH	3 phase fault on NWTXARK7 345 kV (508072) to LYDIA 345 kV (508298) line CKT 1, near LYDIA. a. Apply fault at the LYDIA 345 kV bus. b. Clear fault after 5 cycles and trip the faulted line. 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	FLT11-3PH	3 phase fault on PITTSB-7 345 kV (510907) to SEMINOL7 345 kV (515045) line CKT 1, near PITTSB-7. a. Apply fault at the PITTSB-7 345 kV bus. b. Clear fault after 5 cycles and trip the faulted line. 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.

Number	Fault	Description
11	FLT12-SB	Stuck Breaker at NWTXARK7 (508072) a. Apply single phase fault at the NWTXARK7 345 kV bus. b. Clear fault after 16 cycles and trip the following elements. - VALIANT7 345 kV (510911) to NWTXARK7 345 kV (508072) line CKT 1 - NWTXARK7 345 kV (508072) to LYDIA 345 kV (508298) line CKT 1
12	FLT13-SB	Stuck Breaker at VALIANT7 (510911) a. Apply single phase fault at the VALIANT7 345 kV bus. b. Clear fault after 16 cycles and trip the following elements. - VALIANT4 138 kV (510918) to VALIANT7 345 kV (510911) to VALN2-1 13.8 kV (510938) transformer CKT 2 - VALIANT4 138 kV (510918) to VALIANT7 345 kV (510911) to VALN3-1 13.8 kV (510939) transformer CKT 1
13	FLT15-3PH	3 phase fault on PITTSB-7 345 kV (510907) to JOHNCO 7 345 kV (514809) line CKT 1, near PITTSB-7. a. Apply fault at the PITTSB-7 345 kV bus. b. Clear fault after 5 cycles and trip the faulted line. 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	FLT16-SB	Stuck Breaker at PITTSB-7 (510907) a. Apply single phase fault at the PITTSB-7 345 kV bus. b. Clear fault after 16 cycles and trip the following elements. - PITTSB-7 345 kV (510907) to JOHNCO 7 345 kV (514809) line CKT 1 - PITTSB-7 345 kV (510907) to SEMINOL7 345 kV (515045) line CKT 1
15	FLT18-3PH	3 phase fault on FROGVIL4 138 kV (520918) to HUGO PP4 138 kV (520948) line CKT 1, near HUGO PP4. a. Apply fault at the HUGO PP4 138 kV bus. b. Clear fault after 5 cycles and trip the faulted line. 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.

Number	Fault	Description
16	FLT19-3PH	3 phase fault on SUNNYSD7 345 kV (515136) to JOHNCO 7 345 kV (514809) line CKT 1, near SUNNYSD7. a. Apply fault at the SUNNYSD7 345 kV bus. b. Clear fault after 5 cycles and trip the faulted line. 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.
17	FLT20-3PH	3 phase fault on G16-063-TAP 345 kV (560088) to SUNNYSD7 345 kV (515136) line CKT 1, near G16-063-TAP. a. Apply fault at the G16-063-TAP 345 kV bus. b. Clear fault after 5 cycles and trip the faulted line. 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	FLT21-SB	Stuck Breaker at SUNNYSD7 (515136) a. Apply single phase fault at the SUNNYSD7 345 kV bus. b. Clear fault after 16 cycles and trip the following elements. - SUNNYSD7 345 kV (515136) to JOHNCO 7 345 kV (514809) line CKT 1 - SUNNYSD7 345 kV (515136) to TERRYRD7 345 kV (511568) line CKT 1
19	FLT22-3PH	3 phase fault on PITTSB-7 345 kV (510907) to C-RIVER7 345 kV (515422) line CKT 1, near PITTSB-7. a. Apply fault at the PITTSB-7 345 kV bus. b. Clear fault after 5 cycles and trip the faulted line. 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	FLT23-3PH	3 phase fault on NWTXARK7 345 kV (508072) to TURK 345 kV (507455) line CKT 1, near NWTXARK7. a. Apply fault at the NWTXARK7 345 kV bus. b. Clear fault after 5 cycles and trip the faulted line. 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.

Number	Fault	Description
21	FLT24-SB	Stuck Breaker at WELSH (508359) a. Apply single phase fault at the WELSH 345 kV bus. b. Clear fault after 16 cycles and trip the following elements. - LYDIA 345 kV (508298) to WELSH 345 kV (508359) line CKT 1 - NWTXARK7 345 kV (508072) to WELSH 345 kV (508359) line CKT 1
22	FLT25-SB	Stuck Breaker at NWTXARK7 (508072) a. Apply single phase fault at the NWTXARK7 345 kV bus. b. Clear fault after 16 cycles and trip the following elements. - TURK 345 kV (507455) to NWTXARK7 345 kV (508072) line CKT 1 - NWTXARK4 138 kV (508071) to NWTXARK7 345 kV (508072) to NWTEX1-1 13.8 kV (508100) transformer CKT 1
23	FLT26-PO	Prior Outage of VALIANT4 138 kV (510918) to VALIANT7 345 kV (510911) to VALN2-1 13.8 kV (510938) transformer CKT 2; 3 phase fault on VALIANT4 138 kV (510918) to VALIANT7 345 kV (510911) to VALN3-1 13.8 kV (510939) transformer CKT 1, near VALIANT7. a. Apply fault at the VALIANT7 345 kV bus. b. Clear fault after 5 cycles and trip the faulted line.
24	FLT27-PO	Prior Outage of VALIANT7 345 kV (510911) to HUGO 345 kV (521157) line CKT 1; 3 phase fault on VALIANT7 345 kV (510911) to PITTSB-7 345 kV (510907) line CKT 1, near VALIANT7. a. Apply fault at the VALIANT7 345 kV bus. b. Clear fault after 5 cycles and trip the faulted line. 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.

Number	Fault	Description
25	FLT28-PO	Prior Outage of VALIANT7 345 kV (510911) to NWTXARK7 345 kV (508072) line CKT 1; 3 phase fault on VALIANT7 345 kV (510911) to LYDIA 345 kV (508298) line CKT 1, near VALIANT7. a. Apply fault at the VALIANT7 345 kV bus. b. Clear fault after 5 cycles and trip the faulted line. 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.
26	FLT29-PO	Prior Outage of NWTXARK4 138 kV (508071) to NWTXARK7 345 kV (508072) to NWTEX1-1 13.8 kV (508100) CKT 1; 3 phase fault on NWTXARK4 138 kV (508071) to NWTXARK7 345 kV (508072) to NWTEX2-1 13.8 kV (508101) transformer CKT 2, near NWTXARK7. a. Apply fault at the NWTXARK7 345 kV bus. b. Clear fault after 5 cycles and trip the faulted line.
27	FLT30-PO	Prior Outage of VALIANT4 138 kV (510918) to HUGO PP4 138 kV (520948) line CKT 1; 3 phase fault on HUGO PP4 138 kV (520948) to VALLANT4 138 kV (521079) line CKT 1, near HUGO PP4. a. Apply fault at the HUGO PP4 138 kV bus. b. Clear fault after 5 cycles and trip the faulted line. 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.
28	FLT31-PO	Prior Outage of LYDIA 345 kV (508298) to WELSH 345 kV (508359) line CKT 1; 3 phase fault on NWTXARK7 345 kV (508072) to WELSH 345 kV (508359) line CKT 1, near NWTXARK7. a. Apply fault at the NWTXARK7 345 kV bus. b. Clear fault after 5 cycles and trip the faulted line. 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.

Number	Fault	Description
29	FLT32-PO	Prior Outage of PITTSB-7 345 kV (510907) to JOHNCO 7 345 kV (514809) line CKT 1; 3 phase fault on PITTSB-7 345 kV (510907) to VALIANT7 345 kV (510911) line CKT 1, near VALIANT7. a. Apply fault at the VALIANT7 345 kV bus. b. Clear fault after 5 cycles and trip the faulted line. 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.
30	FLT33-PO	Prior Outage of NWTXARK4 138 kV (508071) to NWTXARK7 345 kV (508072) to NWTEX2-1 13.8 kV (508101) CKT 2; 3 phase fault on TURK 345 kV (507455) to NWTXARK7 345 kV (508072) line CKT 1, near NWTXARK7. a. Apply fault at the NWTXARK7 345 kV bus. b. Clear fault after 5 cycles and trip the faulted line. 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.
31	FLT51-SB	Stuck Breaker at SUNNYSD4 (515135) a. Apply single phase fault at the SUNNYSD4 138 kV bus. b. Clear fault after 16 cycles and trip the following elements. - SUNNYSD4 138 kV (515135) to SUNNYSD7 345 kV (515136) to SUNNYSD1 13.8 kV (515762) transformer CKT 1 - SUNNYSD7 345 kV (515136) to SUNNYSD4 138 kV (515135) to SUNYSD 1 13.8 kV (515405) transformer CKT 1
32	FLT14-3PH_1	3 phase fault on the Johnston County (514809) to Sunnyside (515136) 345kV line, near Johnston County. a. Apply fault at the Johnston County 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line. 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.

Number	Fault	Description
33	FLT15-3PH_1	3 phase fault on the Johnston County (514809) to Pittsburg (510907) 345kV line, near Johnston County. a. Apply fault at the Johnston County 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line. 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.
34	FLT16-3PH_1	3 phase fault on the Johnston County 345kV (514809) to Johnston County 138kV (514808) to Johnston County 13.8kV (514810) Transformer CKT 1, near Johnston County 345kV. a. Apply fault at the Johnston County 345kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
35	FLT17-3PH_1	3 phase fault on the Pittsburg (510907) to Kiowa (510925) 345kV line, near Pittsburg. a. Apply fault at the Pittsburg 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line. 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.
36	FLT19-3PH_1	3 phase fault on the Pittsburg (510907) to Valiant (510911) 345kV line, near Pittsburg. a. Apply fault at the Pittsburg 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line. 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.
37	FLT20-3PH_1	3 phase fault on the Pittsburg (510907) to Cimarron River (515422) 345kV line, near Pittsburg. a. Apply fault at the Pittsburg 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line. 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.

Number	Fault	Description
38	FLT22-3PH_1	3 phase fault on the Sunnyside 345kV (515136) to Sunnyside 138kV (515135) to Sunnyside 13.8kV (515762) transformer CKT 1, near Sunnyside 345kV. a. Apply fault at the Sunnyside 345kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
39	FLT26-3PH_1	3 phase fault on the L.E.S. (511468) to O.K.U. (511456) 345kV line, near L.E.S. a. Apply fault at the L.E.S 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line. 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.
40	FLT27-3PH_1	3 phase fault on the L.E.S. 345kV (511468) to L.E.S 138kV (511467) to L.E.S. 13.8kV (511411) CKT 2, near L.E.S. a. Apply fault at the L.E.S 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
41	FLT29-3PH_1	3 phase fault on the Gracemont (515800) to Minco (514801) 345kV line, near Gracemont. a. Apply fault at the Gracemont 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line. 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.
42	FLT31-3PH_1	3 phase fault on the Gracemont 345kV (515800) to Gracemont 138kV (515802) to Gracemont 13.8kV (515801) transformer CKT 1, near Gracemont. a. Apply fault at the Gracemont 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
43	FLT39-PO_1	Prior Outage of Pittsburg to Seminole 345kV. 3 phase fault on the Pittsburg – Cimarron River 345kV line. a. Prior outage Pittsburg (510907) to Seminole (515045) 345kV (solve network for steady state solution). b. 3 phase fault on the Pittsburg (510907) to Cimarron River (515422) 345kV, near Pittsburg 345kV. c. Leave fault on for 5 cycles, then trip the faulted line in (b).

Number	Fault	Description
44	FLT43-SB_1	Johnston County 345kV Stuck Breaker a. Apply single phase fault at the Johnston County (514809) 345kV bus on the Johnston County – Pittsburg (510907) 345kV line. b. Wait 16 cycles, and then drop Johnston County (514809) to Pittsburg (510907) 345kV line. c. Trip Johnston County (514809) 345kV to Johnston County (514808) 138kV to Johnston County (514810) 13.8kV transformer CKT 1and remove the fault.
45	FLT45-SB_1	Sunnyside 345kV Stuck Breaker a. Apply single phase fault at Sunnyside (515136) 345kV bus on Sunnyside – Johnston County (514809) 345kV line. b. Wait 16 cycles, and then drop Sunnyside (515136) to Johnston County (514809) 345kV line. c. Trip Sunnyside (515136) to Hugo (521157) 345kV line and remove the fault.
46	FLT23-3PH_1	3 phase fault on the TERRYRD7 (511568) to L.E.S.-7 (511468) 345kV line, near TERRYRD7. a. Apply fault at the TERRYRD7 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line. 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.
47	FLT24-3PH_1	3 phase fault on the TERRYRD7 (511568) to SUNNYSD7 (515136) 345kV line, near TERRYRD7. a. Apply fault at the TERRYRD7 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line. 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.
48	FLT41-PO_1	Prior Outage of TERRYRD7 to L.E.S.-7 345kV. 3 phase fault on the TerryRd. a. Prior outage TERRYRD7 (511568) to L.E.S.-7 (511468) 345kV (solve network for steady state solution). b. 3 phase fault on the Sunnyside (515136) to G16-063-T (560088) 345kV, near Sunnyside 345kV. c. Leave fault on for 5 cycles, then then trip the faulted line in (b).

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Appendix

D

Transient Stability Plots

Transient stability plots are provided in a separate PDF file

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