Southwest Power Pool

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DEFINITIVE INTERCONNECTION SYSTEM IMPACT STUDY 2016-002-2 STABILITY ANALYSIS REPORT

By Generator Interconnection Department

Published June 2020

REVISION HISTORY

DATE	AUTHOR	VERSION
4/26/2019	SPP	DISIS-2016-002-1: Initial restudy of Group 6 due to current queued withdrawals.
12/18/2019	SPP	DISIS-2016-002-2: Restudy of Group 6 due to current queued withdrawals. .
12/19/2019	SPP	Update LOIS values for Group 6, DISIS-2016-002 requests.
2/20/2020	SPP	Posted Group 6 Stability Report, removed "Stability Pending" note from Executive Summary tab.
2/28/2020	SPP	Updated to correct POI information in the "Requests" tab.
3/23/2020	SPP	DISIS-2016-002-2: Restudy of Group 4, 7, 8, 9, 15, 16, & 17
6/30/2020	SPP	DISIS-2016-002-2: Current study requests included in re-analysis of Groups 4, 7, 8, 9, 15 (and GEN-2016-094 was included as "In-Group" for Group 15 as a sensitivity), & 16 due to Topology Errors and Rating Updates. Group 6 was included in original restudy, however, results were not impacted by the topology and rating updates.

CONTENTS

OVERVIEW

Pursuant to the Southwest Power Pool (SPP) Open Access Transmission Tariff (OATT), SPP has conducted this Definitive Interconnection System Impact Study (DISIS) for generation interconnection requests received during the DISIS Queue Cluster Window which closed on November 30, 2016.

The primary objective of this DISIS is to identify the system constraints, transient instabilities, and over-dutied equipment associated with connecting the generation to the area transmission system. The Impact Study and other subsequent Interconnection Studies are designed to identify required Transmission Owner Interconnection Facilities, Network Upgrades and other Direct Assignment Facilities needed to inject power into the grid at each specific point of interconnection.

The stability analysis for Definitive Interconnection System Impact Study 2016-002 Groups 1, 2, 4, 10, 12, 13, and 14 per the SPP grouping methodology was not analyzed for this restudy and previously identified restudy results remain valid. Refer to the following link to access these study reports:
http://opsportal.spp.org/documents/studies/files/2016_Generation_Studies/DISIS%202016-002_SixthPosting_Final.pdf

The stability analysis for Definitive Interconnection System Impact Study 2016-002 Groups 3 and 18 per the SPP grouping methodology was not analyzed as no DISIS-2016-002 interconnection requests were assigned to these groups.

Groups 5 and 11 per the SPP grouping methodology remain inactive and are reserved.

This specific report pertains to the stability analysis for Definitive Interconnection System Impact Study 2016-002-2 Groups 6, 7, 8, 9, 15, 16, and 17 per the SPP grouping methodology.

New requests for each study group as well as prior-queued requests are listed in the Requests tab of the DISIS Results Workbook.

The DISIS Manual Version 1.0 posted on http://opsportal.spp.org/Studies/Gen contains details about the DISIS process, methodology, definitions, and useful links. Please review the DISIS Manual or contact gistudies@spp.org for more information about the study process.

GROUP 1 STABILITY ANALYSIS

The Group 1 stability analysis was not performed again for this restudy. This group was not analyzed for this restudy and previously identified restudy results remain valid.

GROUP 2 STABILITY ANALYSIS

The Group 2 stability analysis was not performed again for this restudy. This group was not analyzed for this restudy and previously identified restudy results remain valid.

GROUP 3 STABILITY ANALYSIS

The Group 3 stability analysis was not performed. No DISIS-2016-002 interconnection requests were assigned to this group.

GROUP 4 STABILITY ANALYSIS

The Group 4 stability analysis was not performed again for this restudy. This group was not analyzed for this restudy and previously identified restudy results remain valid.

GROUP 5 (INACTIVE)

Group 5 remains inactive and is reserved.

GROUP 6 STABILITY ANALYSIS

The Group 6 cases included the following previously assigned system upgrades:

- Eddy County to Kiowa 345kV circuit 1
- TUCO to Yoakum 345kV circuit 1
- Hobbs to Yoakum 345kV circuit 1

The Group 6 cases included the following system adjustments of dispatching, to maximum output, generation interconnected at the same or adjacent substations to a current study request:

- Hobbs units: GEN-2015-099
- Cunningham and Maddox units (sensitivity only): GEN-2015-099
- Tolk units: GEN-2016-123, GEN-2016-124 & GEN-2016-125

Note: a sensitivity dispatch with the Cunningham and Maddox units at maximum output was performed to further evaluate fault events near the GEN-2015-099 request.

Additionally, to evaluate the planned conversion of the Tolk units to operate normally as synchronous condensers except during Summer Peaks, the 2017 Winter Peak case included a reduction to the Tolk unit 1 maximum net output to 175 MW and switched off Tolk unit 2.

The Group 6 stability analysis for this area was performed by Mitsubishi Electric Power Products, Inc. (MEPPI).

With the new requests modeled, violations of stability damping, voltage recovery, or steady-state voltage criteria were observed. The following upgrades identified in the power flow analysis were tested in the stability analysis:

- Crossroads 345kV 100 MVAR switched shunt capacitors
- Oklaunion 345kV 200 MVAR switched shunt capacitors

With all previously-assigned and currently-assigned Network Upgrades placed in service, no violations were observed, including violations of low-voltage ride-through requirements, for the probable P1 and P4 Planning Events studied in both the Group 6 cases and the GEN-2015-099 sensitivity dispatch.

Evaluation of P6, prior outage, Planning Events involving circuits terminating at the following substations determined that a system adjustment involving curtailment of up to 200 MW from generating facilities may be required following a prior outage to achieve acceptable system response for a subsequent fault event:

- Border 345kV
- Crossroads 345kV
- Eddy County 345kV
- Hitchland 345kV
- Kiowa 345kV
- Potter County 345kV
- Tolk 345kV
- TUCO 345kV
- Woodward 345kV

Following the interconnection of each request or completion of these upgrade, it is recommended that the Transmission Owner(s) for the New Mexico and Texas Panhandle area (AEPW, OKGE & SWPS) evaluate any applicable operational guide(s) and Corrective Action Plans utilized in transmission planning assessment.

With all previously-assigned and currently-assigned Network Upgrades placed in service and the identified system adjustments, no violations were observed, including violations of low-voltage ride-through requirements, for the probable P6 Planning Events studied in both the Group 6 cases and the GEN-2015-099 sensitivity dispatch.

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Southwest Public Service Company (SPS)

System Impact Study for SPP Group 06 Scenario D

Technical Report

REP-0640
Revision #03

February 2020

Submitted By:
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Report Revision Table

Revision	Reason for Revision	Date	Author
0	Issued Technical Report	11/8/2019	JTF/NWT
1	Updated report based on SPP comments	12/18/2019	NWT
2	Address additional SPP comments	12/18/2019	NWT
3	Analysis performed on sensitivity dispatch	2/19/2020	NWT

Title: **System Impact Study for SPP Group 06 Scenario D: Technical Report REP-0640**
Date: February 2020

Author: Jacob.T. Fritz; Engineer I, Power Systems Engineering Division *Jacob T. Fritz*
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EXECUTIVE SUMMARY

Southwest Public Service Company (SPS) requested a stability analysis, under the direction of SPP, to examine the impacts of several requests in Group 06 of SPP's DISIS-2015-002, DISIS-2016-001, & DISIS-2016-002 system impact study. The system impact study required a Stability Analysis detailing the impacts of the DISIS-2016-002 interconnecting projects as shown in Table ES-1.

Table ES-1
DISIS-2016-002-2 Interconnection Projects Evaluated for Group 6 Scenario D

Request	Size (MW)	Generator Model	Point of Interconnection
GEN-2015-099 (SD)	73.3	Solar (587673)	Maddox 115kV (528355)
ASGI-2016-009 (SD)	3	Wind (588472)	Wolfforth (526483) 115kV
GEN-2016-121 (SD)	110	Solar (587993)	Roadrunner 115kV (528025)
GEN-2016-123 (SD)	298	Wind (588003, 588006)	Crossroads 345kV (527656)
GEN-2016-124 (SD)	150	Wind (588013)	Crossroads 345kV (527656)
GEN-2016-125 (SD)	74	Wind (588023)	Crossroads 345kV (527656)
GEN-2016-177 (SD)	17	Gas Turbine	XTO - Cornell 12.47kV

Refer to Table ES-2 for the scenario studied as part of this system impact study. The SD column identifies the generation requests that were studied as part of the Scenario D.

Table ES-2
List of Study Requests and Scenarios Studied

Study	Queue Number	Capacity	Type	Point of Interconnection	Inclusion of Request
DISIS-2015-002	GEN-2015-020	100	Solar	Oasis 115kV	EXC
	GEN-2015-056	101.2	Wind	Crossroads 345kV	EXC
DISIS-2016-001	GEN-2015-041	5	CT	TUCO 345kV	SD
	ASGI-2016-002	0.35 (uprate)	Wind	SP - Yuma 115kV	SD
	ASGI-2016-004	10	Wind	Palo Duro 115kV	SD
	GEN-2016-015	100	Solar	Andrews County 230kV	EXC
	GEN-2016-056	200	Wind	Carlisle 230kV	EXC
	GEN-2016-062	250.7	Wind	Andrews County 230kV	EXC
	GEN-2016-069	31.4	Solar	Chaves County 115kV	EXC
DISIS-2016-002	ASGI-2016-009	3	Wind	Wolfforth 115kV	SD
	GEN-2015-099	73.3	Solar	Maddox 115kV	SD
	GEN-2016-121	110	Solar	Roadrunner 115kV	SD
	GEN-2016-123	298	Wind	Crossroads 345kV	SD
	GEN-2016-124	150	Wind	Crossroads 345kV	SD
	GEN-2016-125	74	Wind	Crossroads 345kV	SD
	GEN-2016-171	64	Solar	Hobbs - Yoakum 230kV	EXC
	GEN-2016-172	231	Wind	Newhart 115kV	EXC
	GEN-2016-177	17	Gas Turbine	XTO - Cornell 12.47kV	SD

SD = Included in Scenario D dispatch

EXC = Excluded from Scenario D dispatch

To mitigate the thermal constraints identified in the steady-state analysis, refer to Table ES-3 for a list of upgrades proposed to be implemented for DISIS-2016-002-2 Scenario D.

SUMMARY OF STABILITY ANALYSIS

DISIS-2016-002-2 Scenario D

The Stability Analysis determined that there were several contingencies in all three seasonal cases that resulted in steady-state divergence, low post-fault steady-state voltages, or system instability when all generation interconnection requests were at 100% output. To mitigate the steady-state divergence issues, the following steady-state upgrades were implemented in the DISIS-2016-002-2 Scenario D cases:

- Install at least 100 Mvar capacitor bank(s) at Crossroads 345kV (steady-state mitigation)
- Install at least 200 Mvar capacitor bank(s) at OKU 345kV (steady-state mitigation)

Prior outage fault events involving circuits terminating at Border 345kV, Crossroads 345kV, Eddy County 345kV, Hitchland 345kV, Kiowa 345kV, Potter County 345kV, Tolk 345kV, TUCO 345kV, and Woodward 345kV resulted in curtailment of up to 200MW from generating facilities following a prior outage in order for acceptable system response for a subsequent fault event in all three seasons.

Note for faults at Crossroads 345kV, Vestas wind turbine generators were observed to enter and exit low voltage ride through mode with the user-written model Vestas VWCOR6. Updating these study requests to the user-written Vestas Generic Model Structure V7 dynamic model improved the plant response and recovered within SPP Performance Criteria. In accordance with FERC Order 661-A, the interconnecting customer will need to ensure that the design of the facilities does not trip generation for a fault at the Point of Interconnection ("POI") and allows for system recovery.

After implementing the above upgrade, the contingency analysis was simulated for all contingencies. With these upgrades, the Stability Analysis determined that there was no wind turbine tripping or system instability observed as a result of interconnecting all study projects at 100% output.

Additionally, a sensitivity analysis was performed for faults local to GEN-2015-099. For this sensitivity, the Hobbs, Cunningham, and Maddox generating units were scaled to maximum capacity. It was determined all faults local to Hobbs, Cunningham, and Maddox substations recovered within SPP Performance Criteria when all generation interconnection requests were at 100% output.

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SECTION 1: OBJECTIVES

The objective of this report is to provide Southwest Public Service Company (SPS) with the deliverables for the "Southwest Public Service Company (SPS) (Group 06) System Impact Restudy." SPS requested an Interconnection System Impact Study for six (6) generation interconnections queued to DISIS-2016-002 for the following seasons:

- Stability Analysis
  - 2017 Winter Peak
  - 2018 Summer Peak
  - 2026 Summer Peak

The Interconnection System Impact Study required a Stability Analysis and an Impact Study Report.

SECTION 2: BACKGROUND

The Stability Analyses determined the impacts of the new interconnecting projects on the transient stability and voltage recovery of the nearby system and the ability of the interconnecting projects to meet FERC Order 661A. The Siemens Power Technologies International PSS/E Version 33.10.0 was used for this study. Southwest Power Pool (SPP) provided the stability database cases for the study conditions listed in Section 1. A list of study projects for DISIS-2016-002-2 Scenario D can be observed in Table 2-1. Refer to Appendix A for the steady-state and dynamic model data for the study projects listed here. A power flow one-line diagram for each generation interconnection project is shown in Figures 2-1 through 2-5. Note that the one-line diagrams represent the 2017 Winter Peak stability case.

Table 2-1
DISIS-2016-002-2 Group 06 Interconnection Projects Evaluated

Request	Size (MW)	Generator Model	Point of Interconnection
GEN-2015-099 (SD)	73.3	Solar (587673)	Maddox 115kV (528355)
ASGI-2016-009 (SD)	3	Wind (588472)	Wolfforth (526483) 115kV
GEN-2016-121 (SD)	110	Solar (587993)	Roadrunner 115kV (528025)
GEN-2016-123 (SD)	298	Wind (588003, 588006)	Crossroads 345kV (527656)

GEN-2016-124 (SD)	150	Wind (588013)	Crossroads 345kV (527656)
GEN-2016-125 (SD)	74	Wind (588023)	Crossroads 345kV (527656)
GEN-2016-177 (SD)	17	Gas Turbine	XTO - Cornell 12.47kV

Refer to Table 2-2 for the list of prior queued requests that were included in the stability cases. For this group study, the contingency lists were modified from the previous DISIS-2016-002-2 Group 6 studies previously performed by MEPPI which includes three-phase faults, single line-to-ground faults, and prior outage conditions.

Table 2-2
Previously Queued Group 06 Interconnection Projects Included

Request	Request (MW)	Generator Model	Point of Interconnection
GEN-2001-033	180	WT1G1 (524890, 524896)	San Juan Tap 115kV (524885)
GEN-2001-036	80	WT1G1 (599138)	Norton 115kV (524502)
GEN-2006-018	168.1	GENSAL	Tuco 230kV (525830)
GEN-2006-026	502	GENROU (527901, 527902, 527903)	Hobbs 115kV(527891) Hobbs 230kV (527894)
GEN-2008-022	300	Vestas	Tap on Eddy County – Tolk 345kV line (G08-022-POI, 560007)
GEN-2010-006	150	GENROU	Jones_bus2 230kV(526337)
ASGI-2010-010	42.2	GENSAL	Lovington 115kV (528334)
ASGI-2010-020	29.9	GE 2.3MW	Tap LE-Tatum to LE-Crsroads 69kV (AS10-020-POI, 560360)
ASGI-2010-021	15	Mitsubishi MPS-1000A 1.0MW	Tap LE-Saundrtp to LE-Anderson 69kV (ASGI-021-POI, 560364)
ASGI-2011-001	27.3	Suzlon 2.1MW	Lovington 115kV (528334)
ASGI-2011-003	10	Sany 2.0MW	Hendricks 69kV (525943)

Request	Request (MW)	Generator Model	Point of Interconnection
ASGI-2011-004	19.8	Sany 1.8MW	Crosby 69kV (525915)
GEN-2011-025	79.96	GE 1.79MW	Tap on Floyd County - Crosby County 115kV line (G11-025-POI, 562004)
GEN-2011-045	205	GENROU	Jones_bus2 230kV (526337)
GEN-2011-046	23	GENROU	Quay County 115kV (524472)
GEN-2011-048/ GEN-2012-036	172/182	GENROU	Mustang 230kV (527151)
GEN-2012-001	61.2	CCWE 3.6MW (WT4)	Tap Grassland to Borden 230kV (526679)
ASGI-2012-002/ ASGI-2013-005	19.8	Vestas 1.65MW V82	FE-Clovis 115kV (524808)
GEN-2012-020	477.12	GE 1.68MW	Tuco 230kV (525830)
GEN-2004-015/GEN-2012-034	157	GENROU (unit 4; 527164)	Mustang 230kV (527151)
GEN-2006-015/GEN-2012-035	157	GENROU (unit 5; 527165)	Mustang 230kV (527151)
GEN-2012-037	196/203	GENROU (525844)	Tuco 345kV (525832)
GEN-2013-016	191/203	GE 7FA Gas CT 208 MW	Tuco 345 kV (525832)
ASGI-2013-002	18.4	Siemens 2.3MW VS (583613)	Tucumcari 115kV (524509)
ASGI-2013-003	18.4	Siemens 2.3MW VS (583623)	Clovis 115kV (524808)
GEN-2013-022	24.2	Solaron 500kW (583313)	Caprock 115kV (524486)
GEN-2013-027	148.4	Siemens 2.3/2.415	Tap on Yoakum to Tolk 230kV (562480)
GEN-2014-033	70	17 X GE Prolec 4MVA, 2 X GE Prolec 1 MVA, & 5 X Schneider XC680 0.680 MVA PV inverter	Chaves County 115kV

Request	Request (MW)	Generator Model	Point of Interconnection
GEN-2014-034	70	17 X GE Prolec 4MVA PVinverter	Chaves County 115kV
GEN-2014-035	30	8 X GE Prolec 4MVA PV inverter	Chaves County 115kV
GEN-2014-040	319.7	GE 2.3 MW	Castro 115 kV (524746)
ASGI-2015-002/ASGI-2016-002	2.35	Vestas V110 VCSS 2.35 MW	SP-Yuma 69kV (526469)
GEN-2015-014	150.0	Vestas V110 2.0MW (584563)	Tap on Cochran – LG Plains 115kV (560030)
ASGI-2016-002	2.00	GE 2.0MW (584723)(wind)	Hurlwood Substation 69/12.47kV) [Yuma Interchange 115/69kV (526469)]
ASGI-2016-004	10	3 x Alstom 3.2 MW & 4 x Renewtech 100 kW (587574/587573) (wind)	Palo Duro 115 kV (524530)

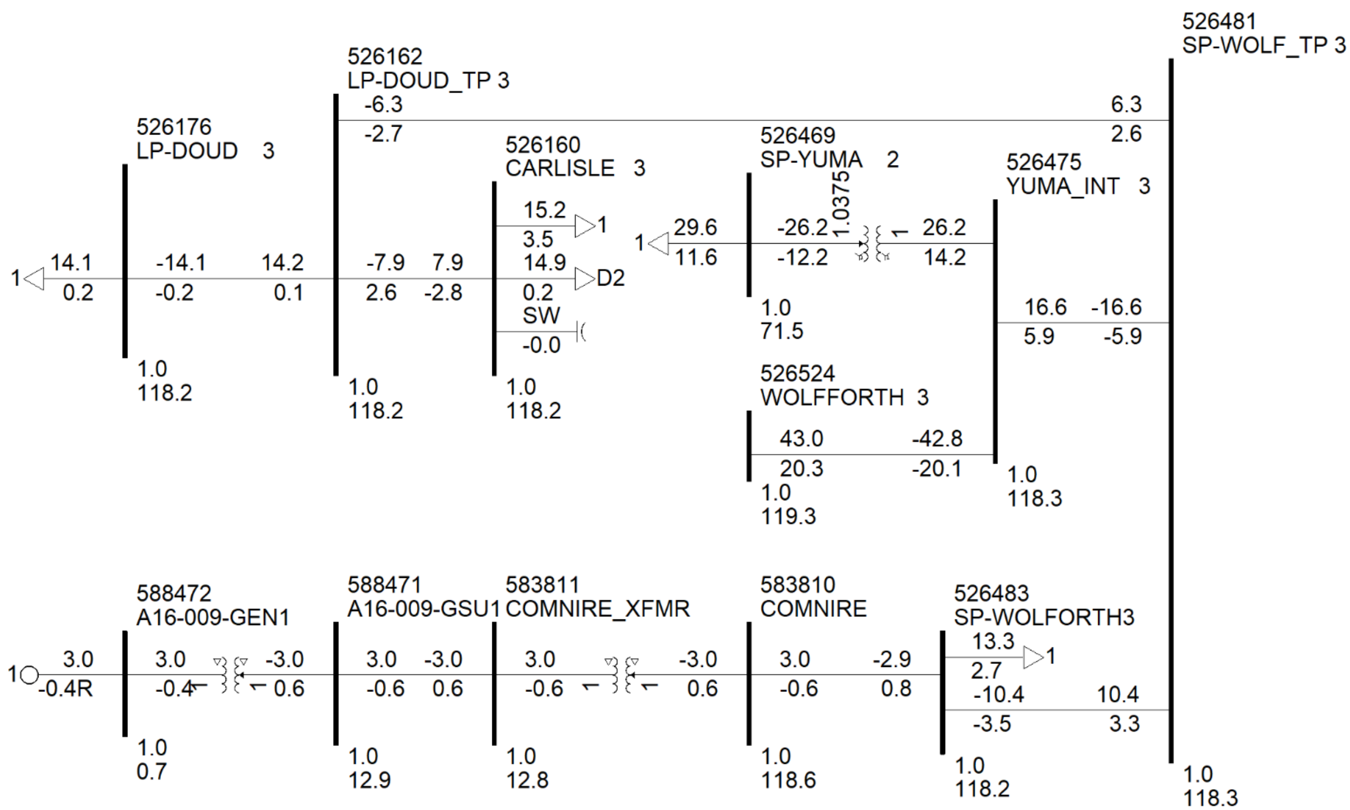

Figure 2-1. Power flow one-line diagram for study request at the Wolfforth Substation 115 kV (ASGI-2016-009).

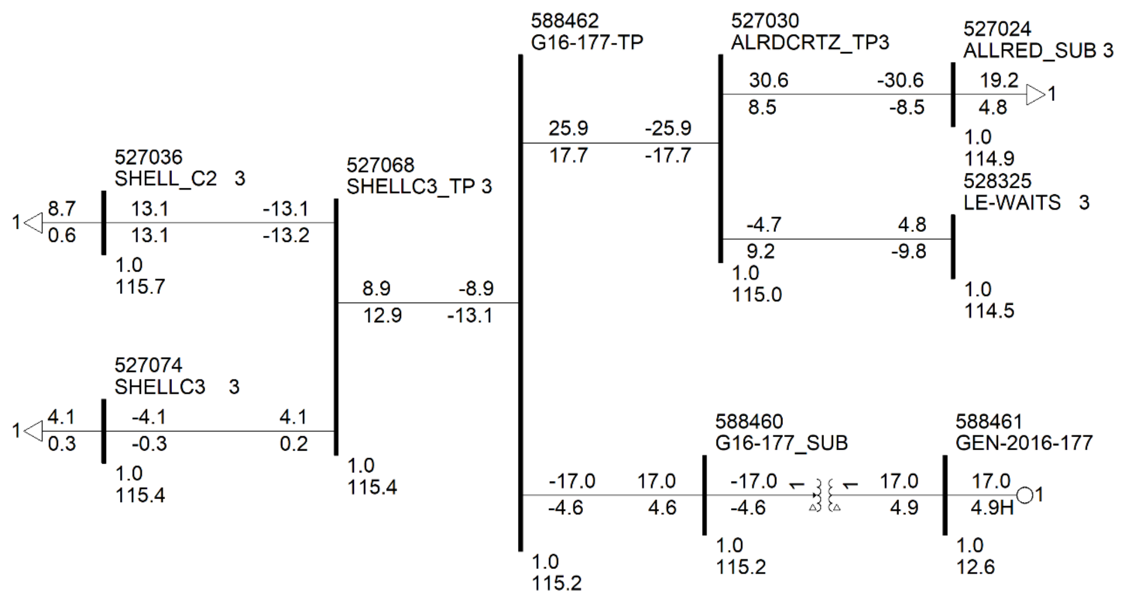

Figure 2-2. Power flow one-line diagram for study request on the XTO to Cornell 115 kV line (GEN-2016-177).

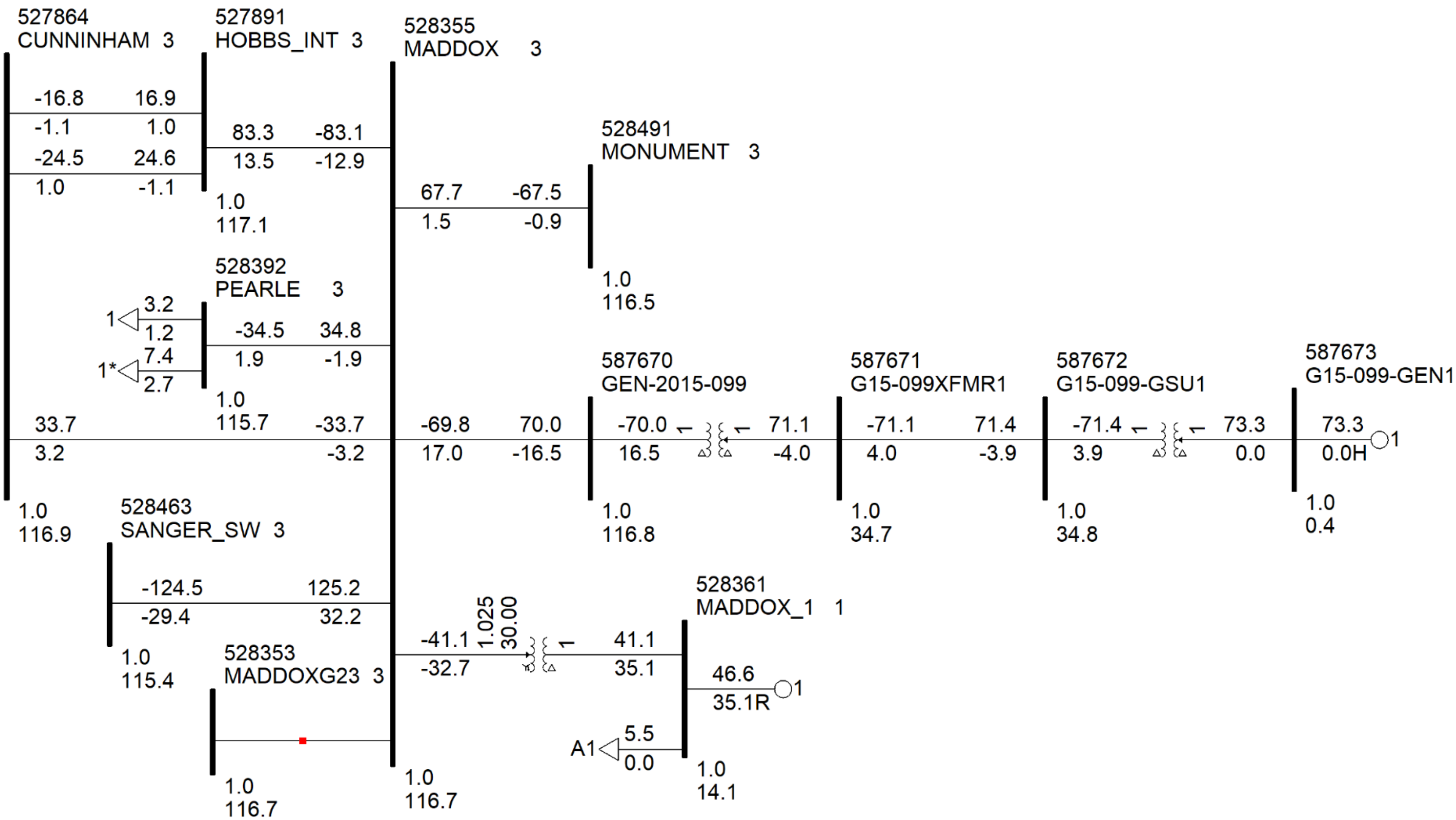

Figure 2-3. Power flow one-line diagram for study request at the Hobbs 115 kV POI (GEN-2015-099).

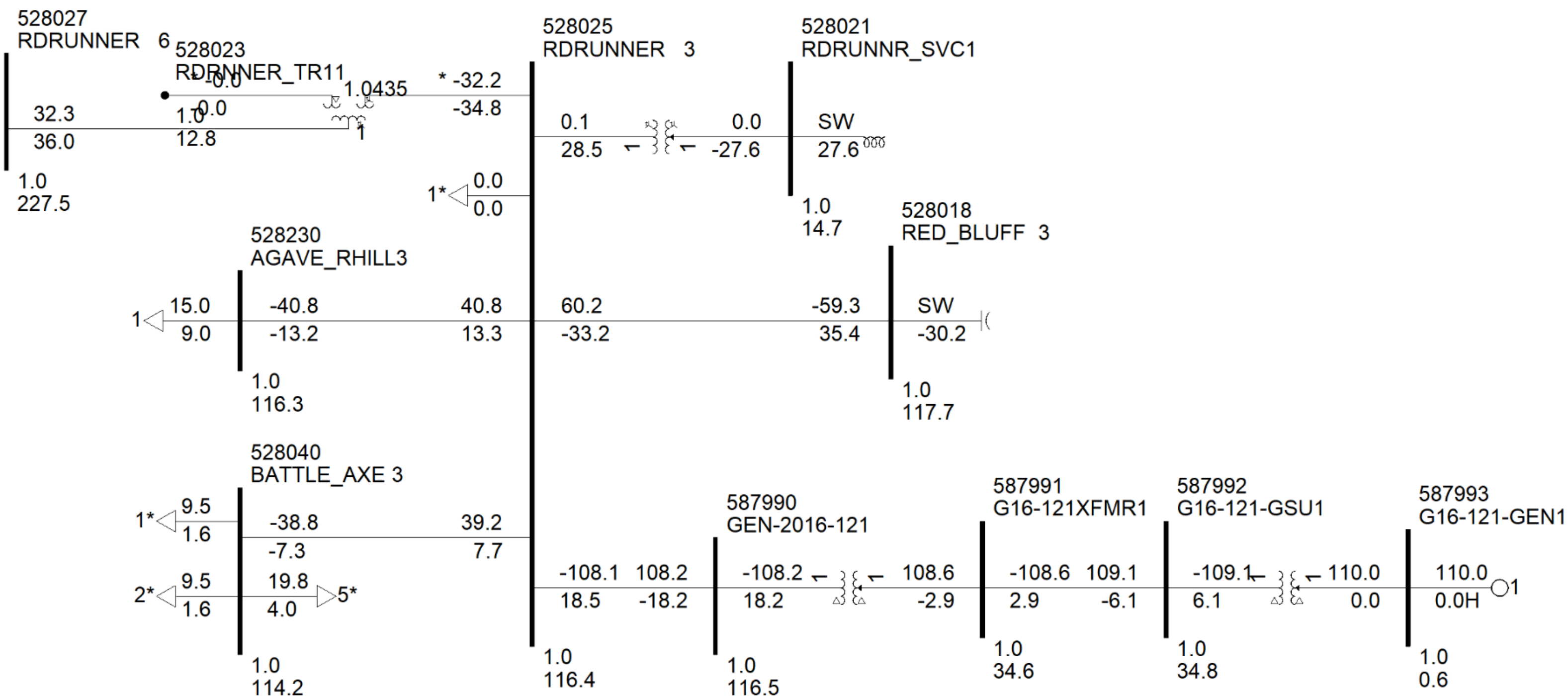

Figure 2-4. Power flow one-line diagram for study request at Roadrunner 115 kV (GEN-2016-121).

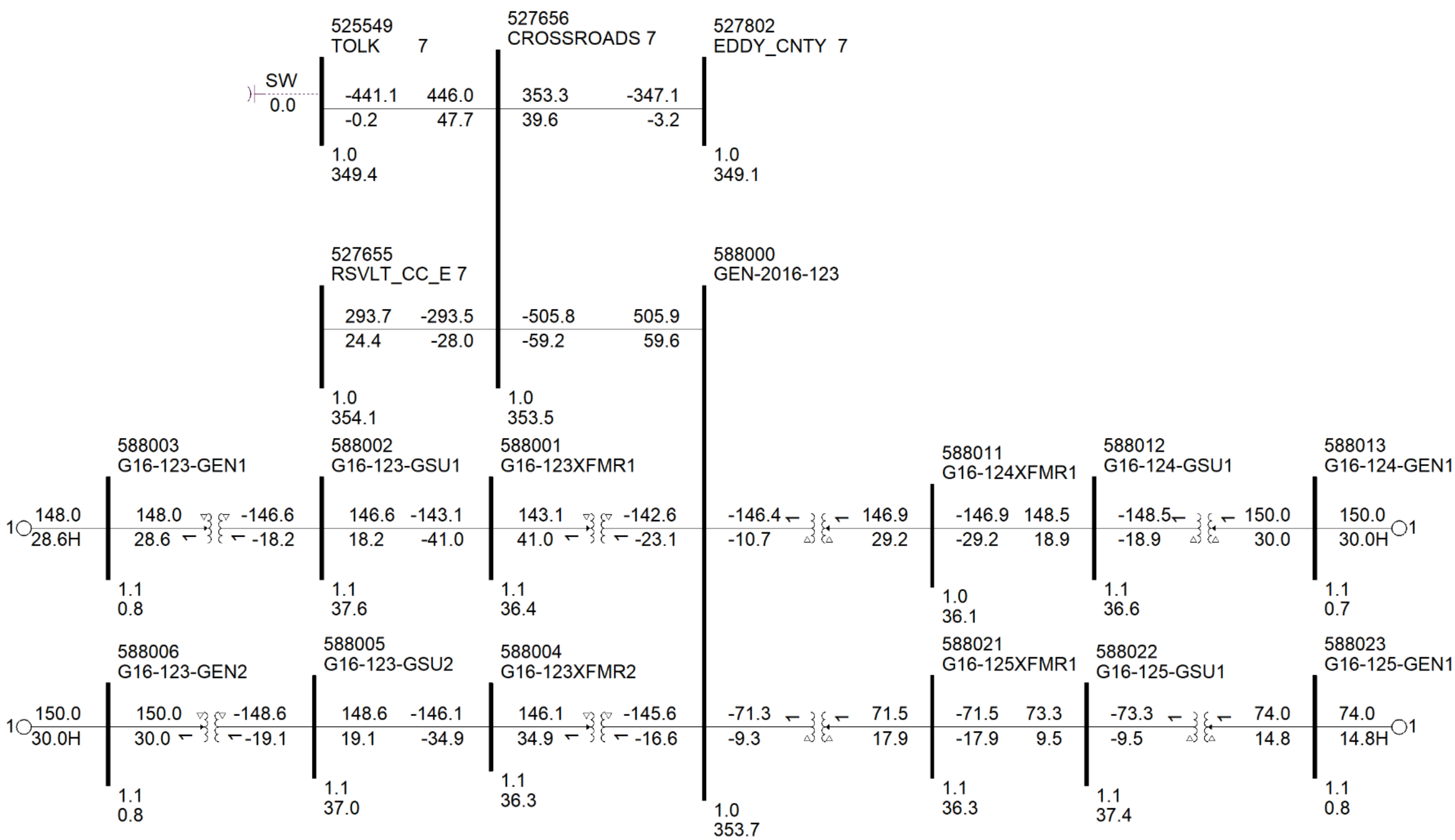

Figure 2-5. Power flow one-line diagram for study requests at Crossroads 345 kV (GEN-2016-123, -124, and -125).

SECTION 3: STABILITY ANALYSIS

The objective of the Stability Analysis was to determine the impacts of the generator interconnections on the stability and voltage recovery on the SPP transmission system. If problems with stability or voltage recovery were identified, the need for reactive compensation or system upgrades was investigated.

3.1 DISIS-2016-002-2 Scenario D

The following section describes the approach, dispatch, and results for the DISIS-2016-002-2 study requests for Scenario D.

3.1.1 DISIS-2016-002-2 Scenario D Approach

SPP provided MEPPI with the DISIS-2016-002-1 stability datasets and the following three power flow cases:

- 17W_DIS16021_G06
- 18S_DIS16021_G06
- 26S_DIS16021_G06

The cases above were used with the DISIS-2016-002 stability datasets and were dispatched with out-of-group requests queued through DISIS-2016-002 as well as in-group requests as outlined in Table 2-1 and Table 2-2. Each case was examined prior to the Stability Analysis to ensure the case contained any previously queued projects listed in Table 2-3 and previously assigned upgrades. The following DISIS-2015-002-7 upgrades were removed from the power flow cases prior to running the analysis:

- Border Capacitive Reactive Support (remove 100 MVAR)
- Deaf Smith Capacitive Reactive Support (remove 60 MVAR)
- Oklaunion Capacitive Reactive Support (remove 100 MVAR, existing HVDC 3x30 MVAR remain)
- Deaf Smith to Plant X 230kV line (revert Rate A/B to 318.69 MVA)
- Newhart to Plant X 230kV line (revert Rate A/B to 318.69 MVA)

The following DISIS-2016-001-3 upgrades were removed from the power flow cases prior to running the analysis:

- Beaver County to Clark County 345kV line
- Border to Chisholm 345kV line
- Crawfish Draw 345kV Substation (reinstate Border to Tuco 345 kV line and O.K.U. to Tuco 345 kV line)

- Crawfish Draw to Tolk 345kV line
- Tolk to Potter County 345kV line
- Andrews 230 kV transformers 1 and 2 uprate (revert Rate A/B to 168 MVA)
- Shamrock Capacitive Reactive Support (remove 10 MVAR)
- Oklaunion Capacitive Reactive Support (remove 20 MVAR)

The new Tierra Blanca substation was implemented in all study cases. The new substation will update the topology of the existing Deaf Smith 115kV substation and will consist of the following lines:

- Tierra Blanca to Deaf Smith West 115kV
- Tierra Blanca to Deaf Smith East 115kV
- Tierra Blanca to DS#21 115kV
- Tierra Blanca to Hereford 115kV circuits 1 and 2
- Tierra Blanca to NE Hereford 115kV

Additionally, the Kiowa to Eddy County 345kV line (previously assigned upgrade) was added to the power flow cases prior to running the analysis as determined from the steady-state analysis. Refer to Table 3-1 for the status of higher queued requests, DISIS-2016-001 requests, DISIS-2016-002, and select DISIS-2017-001 requests.

Table 3-1
Projects Included in DISIS-2016-002-2 Scenario D Analysis

Request	DISIS Queue	Status	Size	Point of Interconnection
GEN-2010-046	DISIS-2010-002	Offline	56 MW	Tuco Interchange (525830) 230kV
GEN-2015-056	DISIS-2015-002	Offline	101.2 MW	Crossroads (527656) 345kV
GEN-2015-041	DISIS-2015-002	Online	196/203MW	Tuco Interchange (525832) 345kV
GEN-2016-015	DISIS-2016-001	Offline	100 MW	Andrews (528604) 230kV
GEN-2016-056	DISIS-2016-001	Offline	200 MW	Carlisle (526161) 230kV
GEN-2016-062	DISIS-2016-001	Offline	250.7 MW	Andrews (528604) 230kV
GEN-2016-069	DISIS-2016-001	Offline	31.35 MW	Chaves County (527482) 115kV
GEN-2016-177	DISIS-2016-002	Online	17 MW	XTO Cornell (527033) 115kV
GEN-2015-020	DISIS-2015-002	Offline	100 MW	Oasis (524874) 115kV
GEN-2015-099	DISIS-2016-002	Online	73.3 MW	Maddox 115kV (528355)
ASGI-2016-002	DISIS-2016-001	Online	0.35 MW uprate	SP Yuma (526469) 69kV
ASGI-2016-004	DISIS-2016-001	Online	10 MW	Palo Duro (524530) 115kV
ASGI-2016-009	DISIS-2016-002	Online	3 MW	Wolfforth Substation (526483) 115kV
GEN-2016-121	DISIS-2016-002	Online	110 MW	Road Runner (528025) 115kV
GEN-2016-123	DISIS-2016-002	Online	298 MW	Crossroads (527656) 345 kV

Request	DISIS Queue	Status	Size	Point of Interconnection
GEN-2016-124	DISIS-2016-002	Online	150 MW	Crossroads (527656) 345 kV
GEN-2016-125	DISIS-2016-002	Online	74 MW	Crossroads (527656) 345 kV
GEN-2016-171	DISIS-2017-001	Offline	60.8 MW	Hobbs Interchange (527894) 230kV
GEN-2016-172	DISIS-2017-001	Offline	231 MW	Newhart (525460) 115kV

A select set of generators no longer in close proximity to study units were scaled to reflect the MDWG dispatch adjusted for system scaling to accommodate dispatch of study requests. Refer to Table 3-2 for a list of generation that was in close proximity to DISIS-2016-002-2 requests. The analysis was initially performed with the default MDWG dispatch for the Cunningham and Maddox units. Refer to Section 3.2 for a sensitivity analysis with the Cunningham and Maddox units scaled to 100% of their real power output.

After implementing the previously assigned upgrades and study requests, the stability dataset was examined to ensure there was no suspect data in the study area. The dynamic datasets were also verified and stable initial system conditions (i.e., "flat lines") were achieved. Three-phase and single phase-to-ground faults listed in Table 2-3 were examined. Single-phase fault impedances were calculated for each season to result in a voltage of approximately 60% of the pre-fault voltage. Refer to Table 3-3 for contingencies examined in the Stability Analysis for the DISIS-2016-002-2 Scenario D requests and Table 3-4 for a list of the calculated single-phase fault impedances utilized.

Table 3-2
Group 06 Conventional Generation Dispatch for DISIS-2016-002-2 Scenario D

Generation	Bus	DISIS-2016-002-2 Group 06 – Scenario D			
		Close Proximity	17W	18S	26S
Hobbs Plant 1	527901	Yes	145.0	145.0	145.0
Hobbs Plant 2	527902	Yes	144.0	144.0	144.0
Hobbs Plant 3	527903	Yes	213.0	213.0	213.0
Cunningham unit 1	527881	Yes	Offline	Offline	Offline
Cunningham unit 2	527882	Yes	112.2	147.8	Offline
Cunningham unit 3	527883	Yes	Offline	92.3	92.2
Cunningham unit 4	527884	Yes	97.3	92.3	92.2
Maddox unit 1	528361	Yes	45.9	73.9	89.3
Maddox unit 2	528362	Yes	Offline	Offline	Offline
Maddox unit 3	528363	Yes	Offline	Offline	7.8
Tuco (Elk) unit 1	525844	No	203.0	196.0	196.0
Tuco (Elk) unit 2	525845	No	203.0	191.0	191.0
Antelope A	525841	No	54.4	55.1	55.2
Antelope B	525842	No	54.9	55.1	55.2
Antelope C	525843	No	54.9	55.1	55.2
Tolk unit 1	525561	Yes	205.5	563.0	563.0

Tolk unit 2	525562	Yes	Offline	557.9	557.9
Mustang unit 1	527161	No	115.4	124.6	130.5
Mustang unit 2	527162	No	115.4	124.6	130.5
Mustang unit 3	527163	No	122.7	132.4	138.6
Mustang unit 4	527164	No	88.6	121.6	128.8
Mustang unit 5	527165	No	Offline	122.4	128.8
Mustang unit 6	527166	No	Offline	129.5	141.1
Plant X unit 1	525491	No	Offline	Offline	37.0
Plant X unit 2	525492	No	Offline	58.8	74.6
Plant X unit 3	525493	No	72.6	58.8	83.8
Plant X unit 4	525494	No	Offline	94.2	162.9
Gaines Units	offline	No	Offline	Offline	Offline

Table 3-3
Case List with Stability Analysis Contingency Description for DISIS-2016-002-2 Requests

Cont. Name	Description
FLT01-3PH	3 phase fault on the GEN-2016-177-Tap (588462) to ALRDCRTZ Tap (527030) 115 kV line circuit 1, near GEN-2016-177-Tap. a. Apply fault at the GEN-2016-177-Tap 115 kV 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.
FLT02-3PH	3 phase fault on the GEN-2016-177-Tap (588462) to Shell Tap (527068) 115 kV line circuit 1, near GEN-2016-177-Tap. a. Apply fault at the GEN-2016-177-Tap 115 kV 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.
FLT03-3PH	3 phase fault on the Shell Tap (527068) to Shell C2 (527036) 115 kV line circuit 1, near Shell Tap. a. Apply fault at the Shell Tap 115 kV 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.
FLT04-3PH	3 phase fault on the ALRDCRTZ Tap (527030) to ALLRED Sub (527024) 115 kV line circuit 1, near ALRDCRTZ Tap. a. Apply fault at the ALRDCRTZ Tap 115 kV 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.
FLT05-3PH	3 phase fault on the ALRDCRTZ Tap (527030) to LE-WAITS (528325) 115 kV line circuit 1, near ALRDCRTZ Tap. a. Apply fault at the ALRDCRTZ Tap 115 kV 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.
FLT14-SB	**Single phase fault with stuck breaker at Shell Tap (527068)** a. Apply fault at the Shell Tap 115 kV bus. b. Clear fault after 16 cycles and trip the following elements c. Shell Tap (527068) – GEN-2016-177-Tap (588462) 115 kV d. Shell Tap (527068) – Shell C2 (527036) 115 kV

Cont. Name	Description
FLT15-SB	**Single phase fault with stuck breaker at ALRDCRTZ (527030)** a. Apply fault at the ALRDCRTZ 115 kV bus. b. Clear fault after 16 cycles and trip the following elements c. ALRDCRTZ (527030) – ALLRED Sub (527024) 115 kV d. ALRDCRTZ (527030) – LE-WAITS (528325) 115 kV
FLT19-PO	**Prior Outage of GEN-2016-177-Tap 115 kV (588462) to Shell Tap 115 kV (527068) circuit 1;** 3 phase fault on the LE-LOVINGTON (528618) to LE-NRTH_INT (528334) transformer, near LE-NRTH_INT. a. Apply fault at the LE-NRTH_INT 115 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
FLT20-PO	**Prior Outage of GEN-2016-177-Tap 115 kV (588462) to Shell Tap 115 kV (527068) circuit 1;** 3 phase fault on the ALRDCRTZ Tap (527030) to LE-WAITS (528325) 115 kV line circuit 1, near ALRDCRTZ Tap. a. Apply fault at the ALRDCRTZ Tap 115 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
FLT21-PO	**Prior Outage of LE-LOVINGTON (528618) to LE-NRTH_INT (528334) xfmr 1;** 3 phase fault on the ALRDCRTZ Tap (527030) to LE-WAITS (528325) 115 kV line circuit 1, near ALRDCRTZ Tap. a. Apply fault at the ALRDCRTZ Tap 115 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
FLT22-PO	**Prior Outage of LE-LOVINGTON (528618) to LE-NRTH_INT (528334) xfmr 1;** 3 phase fault on the GEN-2016-177-Tap (588462) to Shell Tap (527068) 115 kV line circuit 1, near GEN-2016-177-Tap. a. Apply fault at the GEN-2016-177-Tap 115 bus. b. Clear fault after 5 cycles by tripping the faulted line.
FLT23-PO	**Prior Outage of LE-NRTH_INT (528334) to LE-WAITS (528325) circuit 1;** 3 phase fault on the ALRDCRTZ Tap (527030) to ALLRED Sub (527024) 115 kV line circuit 1, near ALRDCRTZ Tap. a. Apply fault at the ALRDCRTZ Tap 115 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
FLT24-PO	**Prior Outage of LE-NRTH_INT (528334) to LE-WAITS (528325) circuit 1;** 3 phase fault on the GEN-2016-177-Tap (588462) to Shell Tap (527068) 115 kV line circuit 1, near GEN-2016-177-Tap. a. Apply fault at the GEN-2016-177-Tap 115 bus. b. Clear fault after 5 cycles by tripping the faulted line.

Cont. Name	Description
FLT26-3PH	3 phase fault on the Wolfforth (526524) to Yuma (526475) 115 kV line, near Wolfforth a. Apply fault at the Wolfforth 115 kV 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.
FLT27-3PH	3 phase fault on the Wolfforth (526524) to Terry County (526736) 115 kV line, near Wolfforth a. Apply fault at the Wolfforth 115 kV 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.
FLT28-3PH	3 phase fault on the Wolfforth 115 kV (526524) to Wolfforth 230 kV (526525) to Wolfforth 13.2 kV (526522) XFMR CKT 1, near Wolfforth 115 kV. a. Apply fault at the Wolfforth 115 kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
FLT29-3PH	3 phase fault on the Terry County (526736) to Denver North (527130) 115 kV line, near Terry County a. Apply fault at the Terry County 115 kV 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.
FLT30-3PH	3 phase fault on the Terry County (526736) to LG-Clauene (526491) 115 kV line, near Terry County a. Apply fault at the Terry County 115 kV 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.
FLT31-3PH	3 phase fault on the Terry County (526736) to Sulphur (527262) 115 kV line, near Terry County a. Apply fault at the Terry County 115 kV 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.

Cont. Name	Description
FLT32-3PH	3 phase fault on the Terry County (526736) to Prentice (526792) 115 kV line, near Terry County a. Apply fault at the Terry County 115 kV 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.
FLT33-3PH	3 phase fault on the Terry County 115/69/13.2 kV (526736/526735/526733) transformer circuit 1, near Terry County 115 kV. a. Apply fault at the Terry County 115 kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
FLT34-3PH	3 phase fault on the Yuma (526475) to SP-Wolfforth Tap (526481) 115 kV line, near Yuma a. Apply fault at the Yuma 115 kV 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.
FLT35-3PH	3 phase fault on the Wolfforth (526525) to Sundown (526435) 230 kV line, near Wolfforth a. Apply fault at the Wolfforth 230 kV 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.
FLT36-3PH	3 phase fault on the Wolfforth (526525) to Lubbock South (526269) 230 kV line, near Wolfforth a. Apply fault at the Wolfforth 230 kV 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.
FLT37-3PH	3 phase fault on the Wolfforth (526525) to Carlisle (526161) 230 kV line, near Wolfforth a. Apply fault at the Wolfforth 230 kV 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.

Cont. Name	Description
FLT38-3PH	3 phase fault on the SP-Wolfforth Tap (526481) to LP-Doud Tap (526162) 115 kV line, near SP-Wolfforth Tap a. Apply fault at the SP-Wolfforth Tap 115 kV 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.
FLT40-SB	**Single phase fault with stuck breaker at Wolfforth (526524)** a. Apply fault at the Wolfforth 115 kV bus. b. Clear fault after 16 cycles and trip the following elements c. Wolfforth (526524) – Yuma (526475) 115 kV d. Wolfforth (526524) – Terry County (526736) 115 kV
FLT41-SB	**Single phase fault with stuck breaker at Wolfforth (526524)** a. Apply fault at the Wolfforth 115 kV bus. b. Clear fault after 16 cycles and trip the following elements c. Wolfforth 115 kV (526524)/230 kV (526525)/13.2 kV (526522) xfmr d. Wolfforth (526524) – Terry County (526736) 115 kV
FLT43-SB	**Single phase fault with stuck breaker Terry County (526736)** a. Apply fault at the Terry County 115 kV bus. b. Clear fault after 16 cycles and trip the following elements c. Terry County (526736) – Prentice (526792) 115 kV d. Terry County (526736) – Sulphur (527262) 115 kV
FLT44-SB	**Single phase fault with stuck breaker Terry County (526736)** a. Apply fault at the Terry County 115 kV bus. b. Clear fault after 16 cycles and trip the following elements c. Terry County (526736) – Denver (527130) 115 kV d. Terry County (526736) – LG-Clauene (526491) 115 kV
FLT45-PO	**Prior Outage of the Wolfforth (526524) to Terry County (526736) 115 kV line circuit 1;** 3 phase fault on the Wolfforth 115 kV (526524)/230 kV (526525)/13.2 kV (526522) transformer, near Wolfforth. a. Apply fault at the Wolfforth 115 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
FLT46-PO	**Prior Outage of the Wolfforth (526524) to Terry County (526736) 115 kV line circuit 1;** 3 phase fault on the Wolfforth (526524) to Yuma (526475) 115 kV line, near Wolfforth a. Apply fault at the Wolfforth 115 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.

Cont. Name	Description
FLT47-PO	**Prior Outage of the Wolfforth (526524) to Yuma (526475) 115 kV line circuit 1;** 3 phase fault on the Wolfforth 115 kV (526524)/230 kV (526525)/13.2 kV (526522) transformer, near Wolfforth. a. Apply fault at the Wolfforth 115 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
FLT48-PO	**Prior Outage of the Wolfforth (526524) to Yuma (526475) 115 kV line circuit 1;** 3 phase fault on the Wolfforth (526524) to Terry County (526736) 115 kV line circuit 1, near Wolfforth. a. Apply fault at the Wolfforth 115 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
FLT49-PO	**Prior Outage of the SP-Wolfforth Tap (526481) to SP-Wolfforth (526483) 115 kV line circuit 1;** 3 phase fault on the SP-Wolfforth Tap (526481) to LP-Doud (526162) 115 kV line circuit 1, near SP-Wolfforth Tap. a. Apply fault at the SP-Wolfforth Tap 115 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
FLT50-3PH	3 phase fault on the Plant X (525481) to Deaf Smith (524623) 230 kV line circuit 1, near Plant X. a. Apply fault at the Plant X 230 kV 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.
FLT51-3PH	3 phase fault on the Deaf Smith (524623) to Plant X (525481) 230 kV line circuit 1, near Deaf Smith. a. Apply fault at the Deaf Smith 230 kV 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.
FLT52-3PH	3 phase fault on the Deaf Smith (524623) to Bushland (524267) 230 kV line circuit 1, near Deaf Smith. a. Apply fault at the Deaf Smith 230 kV 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.
FLT53-3PH	3 phase fault on the Deaf Smith 230/115/13.2 kV (524623/524622/524620) transformer circuit 1, near Deaf Smith 230 kV. a. Apply fault at the Deaf Smith 230 kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.

Cont. Name	Description
FLT54-3PH	3 phase fault on the Bushland (524267) to Potter County (523959) 230 kV line circuit 1, near Bushland. a. Apply fault at the Bushland 230 kV 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.
FLT55-3PH	3 phase fault on the Plant X (525481) to Tolk East (525524) 230 kV line circuit 2, near Plant X. a. Apply fault at the Plant X 230 kV 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.
FLT56-3PH	3 phase fault on the Plant X (525481) to Newhart (525461) 230 kV line circuit 1, near Plant X. a. Apply fault at the Plant X 230 kV 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.
FLT57-3PH	3 phase fault on the Plant X (525481) to Tolk West (525531) 230 kV line circuit 1, near Plant X. a. Apply fault at the Plant X 230 kV 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.
FLT58-3PH	3 phase fault on the Plant X (525481) to Sundown (526435) 230 kV line circuit 1, near Plant X. a. Apply fault at the Plant X 230 kV 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.
FLT59-3PH	3 phase fault on the Plant X 230/115/13.2 kV (525481/525480/525479) transformer circuit 1, near Plant X 230 kV. a. Apply fault at the Plant X 230 kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.

Cont. Name	Description
FLT60-SB	**Single phase fault with stuck breaker** on the Tolk West (525531) to Plant X (525481) 230 kV circuit 1 line, near Tolk West. a. Apply fault at the Tolk West 230 kV bus. b. Run 5 cycles, and then open Plant X end of the faulted line. c. Run 10 cycles, and then clear the fault and disconnect Tolk West 230 kV bus (525531).
FLT61-SB	**Single phase fault with stuck breaker** on the Tolk East (525524) to Plant X (525481) 230 kV line circuit 2, near Tolk East. a. Apply fault at the Tolk East 230 kV bus. b. Run 5 cycles, and then open Plant X end of the faulted line. c. Run 10 cycles, and then clear the fault and disconnect Tolk East 230 kV bus (525524).
FLT62-SB	**Single phase fault with stuck breaker at Bushland (524623) 230 kV** a. Apply fault at the Bushland 230 kV bus. b. Clear fault after 16 cycles and trip the following elements c. Bushland (524267) – Deaf Smith (524623) 230 kV d. Bushland (524267) – Potter County (523959) 230 kV e. Bushland (524267) – Wildor (524290) 230 kV f. Bushland 230/115 kV transformer (524267/524266/524263)
FLT63-SB	**Single phase fault with stuck breaker at Plant X (525481) 230 kV** a. Apply fault at the Plant X 230 kV bus. b. Clear fault after 16 cycles and trip the following elements c. Plant X (525481) – Deaf Smith (525623) 230 kV d. Plant X (525481) – Newhart (525461) 230 kV
FLT64-SB	**Single phase fault with stuck breaker at Plant X (525481) 230 kV** a. Apply fault at the Plant X 230 kV bus. b. Clear fault after 16 cycles and trip the following elements c. Plant X (525481) – Tolk West (525531) 230 kV d. Plant X (525481) – Sundown (526435) 230 kV
FLT65-SB	**Single phase fault with stuck breaker at Plant X (525481) 230 kV** a. Apply fault at the Plant X 230 kV bus. b. Clear fault after 16 cycles and trip the following elements c. Plant X 230/115/13.2 kV (525481/525480/525479) transformer d. Plant X (525481) – Newhart (525461) 230 kV
FLT66-PO	**Prior Outage of the Plant X 230/115/13.2 kV (525481/525480/525479) transformer circuit 1;** 3 phase fault on the Plant X 230 kV (525481) to Sundown (526435) 230 kV line circuit 1, near Plant X. a. Apply fault at the Plant X 230 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.

Cont. Name	Description
FLT67-PO	**Prior Outage of the Plant X 230/115/13.2 kV (525481/525480/525479) transformer circuit 1;** 3 phase fault on the Deaf Smith (524623) to Bushland (524267) 230 kV line circuit 1, near Deaf Smith. a. Apply fault at the Deaf Smith 230 kV bus. b. Clear fault after 5 cycles by tripping the faulted line
FLT68-PO	**Prior Outage of the Plant X (525481) to Sundown (526435) 230 kV Line;** 3 phase fault on the Plant X 230 kV (525481) to Tolk East (525524) 230 kV line circuit 2, near Plant X. a. Apply fault at the Plant X 230 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
FLT69-PO	**Prior Outage of the Plant X (525481) to Sundown (526435) 230 kV Line;** 3 phase fault on the Plant X (525481) to Deaf Smith (524623) 230 kV line circuit 1, near G15-039-Tap. a. Apply fault at the G15-039-Tap 230 kV bus. b. Clear fault after 5 cycles by tripping the faulted line
FLT70-PO	**Prior Outage of the Deaf Smith (524623) to Bushland (524267) 230 kV Line;** 3 phase fault on the Deaf Smith 230 kV to Plant X (525481) 230 kV line circuit 1, near Deaf Smith. a. Apply fault at the Deaf Smith 230 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
FLT71-PO	**Prior Outage of the Deaf Smith (524623) to Bushland (524267) 230 kV Line;** 3 phase fault on the Plant X (525481) to Newhart (525461) 230 kV line circuit 1, near Newhart. a. Apply fault at the Plant X 230 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
FLT72-3PH	3 phase fault on the Mustang (527149) to Amoco Wasson (526784) 230 kV line circuit 1, near Mustang. a. Apply fault at the Mustang 230 kV 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.
FLT73-3PH	3 phase fault on the Mustang 230/115/13.2 kV (527149/527146/527143) transformer circuit 1, near Mustang 230 kV. a. Apply fault at the Mustang 230 kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.

Cont. Name	Description
FLT74-3PH	3 phase fault on the Mustang (527149) to Yoakum (526935) 230 kV line circuit 1, near Mustang. a. Apply fault at the Mustang 230 kV 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.
FLT75-3PH	3 phase fault on the Mustang (527149) to Seminole (527276) 230 kV line circuit 1, near Mustang. a. Apply fault at the Mustang 230 kV 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.
FLT76-3PH	3 phase fault on the Seminole 230/115/13.2 kV (527276/527275/527273) transformer circuit 1, near Seminole 230 kV. a. Apply fault at the Seminole 230 kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
FLT77-3PH	3 phase fault on the Yoakum (526935) to G13-027-TAP (562480) 230 kV line, near Yoakum. a. Apply fault at the Yoakum 230 kV 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.
FLT78-3PH	3 phase fault on the Yoakum (526935) to Amoco (526460) 230 kV line, near Yoakum. a. Apply fault at the Yoakum 230 kV 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.
FLT79-3PH	3 phase fault on the Yoakum (526935) to G1579&G1580T (560059) 230 kV line, near Yoakum. a. Apply fault at the Yoakum 230 kV 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.

Cont. Name	Description
FLT80-3PH	3 phase fault on the Yoakum (526935) to OxyBru Tap (527009) 230 kV line, near Yoakum. a. Apply fault at the Yoakum 230 kV 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.
FLT81-3PH	3 phase fault on the Yoakum 230/115/13.2 kV (526935/526935/526931) transformer circuit 1, near Yoakum 230 kV. a. Apply fault at the Yoakum 230 kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
FLT82-3PH	3 phase fault on the Amoco Wasson (526784) to OxyBru Tap (527009) 230 kV line circuit 1, near Amoco Wasson. a. Apply fault at the Amoco Wasson 230 kV 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.
FLT83-3PH	3 phase fault on the Mustang (527146) to Denver North (527130) 115 kV line circuit 1, near Mustang. a. Apply fault at the Mustang 115 kV 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.
FLT84-3PH	3 phase fault on the Mustang (527146) to Seagraves (527202) 115 kV line circuit 1, near Mustang. a. Apply fault at the Mustang 115 kV 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.
FLT85-3PH	3 phase fault on the Mustang (527146) to Denver South (527136) 115 kV line circuit 1, near Mustang. a. Apply fault at the Mustang 115 kV 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.

Cont. Name	Description
FLT86-3PH	3 phase fault on the Mustang (527146) to Shell Co (527062) 115 kV line circuit 1, near Mustang. a. Apply fault at the Mustang 115 kV 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.
FLT87-3PH	3 phase fault on the Seagraves (527202) to LG-PLSHILL (527194) 115 kV line circuit 1, near Seagraves. a. Apply fault at the Seagraves 115 kV 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.
FLT88-3PH	3 phase fault on the Seagraves (527202) to Sulphur (527262) 115 kV line circuit 1, near Seagraves. a. Apply fault at the Seagraves 115 kV 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.
FLT89-3PH	3 phase fault on the Denver North (527136) to Shell (527036) 115 kV line circuit 1, near Denver North. a. Apply fault at the Denver North 115 kV 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.
FLT90-3PH	3 phase fault on the Denver North (527136) to San Andreas (527105) 115 kV line circuit 1, near Denver North. a. Apply fault at the Denver North 115 kV 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.
FLT91-3PH	3 phase fault on the Denver North 115/69/13.2 kV (527130/527125/527122) transformer circuit 2, near Denver North. a. Apply fault at the Denver North 115 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.

Cont. Name	Description
FLT92-SB	**Single phase fault with stuck breaker at Mustang (527149)** a. Apply fault at the Mustang 230 kV bus. b. Clear fault after 16 cycles and trip the following elements c. Mustang 230/115/13.2 kV (527149/527146/527143) transformer d. Mustang (527149) – Amoco Wasson (526784) 230 kV
FLT93-SB	**Single phase fault with stuck breaker at Mustang (527149)** a. Apply fault at the Mustang 230 kV bus. b. Clear fault after 16 cycles and trip the following elements c. Mustang (527149) – Seminole (527276) 230 kV d. Mustang (527149) – Amoco Wasson (526784) 230 kV
FLT94-SB	**Single phase fault with stuck breaker** on the Yoakum (526935) to G13-027-Tap (562480) 230 kV line, near Yoakum. a. Apply fault at the Yoakum 230 kV bus. b. Run 5 cycles, and then open G13-027-Tap end of the faulted line. c. Run 10 cycles, and then clear the fault and open Yoakum end of the line in (b) and trip Yoakum 230/115/13.2 kV (526935/526934/526931) transformer circuit 1.
FLT95-SB	**Single phase fault with stuck breaker** on the Yoakum (526935) to Amoco-SS (526460) 230 kV line, near Yoakum. a. Apply fault at the Yoakum 230 kV bus. b. Run 5 cycles, and then open Amoco-SS end of the faulted line. c. Run 10 cycles, and then clear the fault and trip Yoakum 230 kV (526935) bus.
FLT96-SB	**Single phase fault with stuck breaker at Mustang (527146)** a. Apply fault at the Mustang 115 kV bus. b. Clear fault after 16 cycles and trip the following elements c. Mustang 230/115/13.2 kV (527149/527146/527143) transformer d. Mustang (527146) – Denver South (527136) 115 kV
FLT97-SB	**Single phase fault with stuck breaker at Mustang (527146)** a. Apply fault at the Mustang 115 kV bus. b. Clear fault after 16 cycles and trip the following elements c. Mustang (527146) – Seagraves (527202) 115 kV d. Mustang (527146) – Denver North (527130) 115 kV
FLT98-SB	**Single phase fault with stuck breaker at Mustang (527146)** a. Apply fault at the Mustang 115 kV bus. b. Clear fault after 16 cycles and trip the following elements c. Mustang (527146) – Denver South (527136) 115 kV d. Mustang (527146) – Denver North (527130) 115 kV

Cont. Name	Description
FLT99-SB	**Single phase fault with stuck breaker at Mustang (527146)** a. Apply fault at the Mustang 115 kV bus. b. Clear fault after 16 cycles and trip the following elements c. Mustang (527146) – Shell County (527062) 115 kV d. Mustang (527146) – Seagraves (527202) 115 kV
FLT100-PO	**Prior Outage of the Mustang (527149) to Seminole (527276) 230 kV line circuit 1;** 3 phase fault on the Mustang (527149) to Yoakum (526935) 230 kV line circuit 1, near Mustang. a. Apply fault at the Mustang 230 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
FLT101- PO	**Prior Outage of the Mustang (527149) to Seminole (527276) 230 kV line circuit 1;** 3 phase fault on the Mustang (527149) to Amoco Wasson (526784) 230 kV line circuit 1, near Mustang. a. Apply fault at the Mustang 230 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
FLT102- PO	**Prior Outage of the Mustang (527149) to Yoakum (526935) 230 kV line circuit 1;** 3 phase fault on the Mustang (527149) to Seminole (527276) 230 kV line circuit 1, near Mustang. a. Apply fault at the Mustang 230 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
FLT103- PO	**Prior Outage of the Mustang (527149) to Yoakum (526935) 230 kV line circuit 1;** 3 phase fault on the Mustang (527149) to Amoco Wasson (526784) 230 kV line circuit 1, near Mustang. a. Apply fault at the Mustang 230 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
FLT104- PO	**Prior Outage of the Mustang (527146) to Denver North (527130) 115 kV line circuit 1;** 3 phase fault on the Mustang (527146) to Denver South (527136) 115 kV line circuit 2, near Mustang. a. Apply fault at the Mustang 115 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
FLT105- PO	**Prior Outage of the Mustang (527146) to Denver North (527130) 115 kV line circuit 1;** 3 phase fault on the Mustang (527146) to Shell Co (527062) 115 kV line circuit 1, near Mustang. a. Apply fault at the Mustang 115 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.

Cont. Name	Description
FLT106- PO	**Prior Outage of the Mustang (527149) 230 kV to Mustang (527146) 115 kV transformer, circuit 1;** 3 phase fault on the Mustang (527146) to Denver North (527130) 115 kV line circuit 1, near Mustang. a. Apply fault at the Mustang 115 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
FLT107- PO	**Prior Outage of the Mustang (527146) to Shell County (527062) 115 kV line circuit 1;** 3 phase fault on the Mustang (527146) to Denver South (527136) 115 kV line circuit 2, near Mustang. a. Apply fault at the Mustang 115 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
FLT108-3PH	3 phase fault on the Maddox (528355) to Cunningham (527864) 115 kV line circuit 1, near Maddox. a. Apply fault at the Maddox 115 kV 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.
FLT109-3PH	3 phase fault on the Maddox (528355) to Hobbs Interchange (527891) 115 kV line circuit 1, near Maddox. a. Apply fault at the Maddox 115 kV 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.
FLT110-3PH	3 phase fault on the Maddox (528355) to Pearle (528392) 115 kV line circuit 1, near Maddox. a. Apply fault at the Maddox 115 kV 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.
FLT111-3PH	3 phase fault on the Maddox (528355) to Sanger Switch (528463) 115 kV line circuit 1, near Maddox. a. Apply fault at the Maddox 115 kV 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.

Cont. Name	Description
FLT112-3PH	3 phase fault on the Maddox (528355) to Monument (528491) 115 kV line circuit 1, near Maddox. a. Apply fault at the Maddox 115 kV 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.
FLT113-3PH	3 phase fault on the Cunningham (527864) to Monument Tap (528568) 115 kV line circuit 1, near Cunningham. a. Apply fault at the Cunningham 115 kV 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.
FLT114-3PH	3 phase fault on the Cunningham (527864) to Buckeye Tap (528348) 115 kV line circuit 1, near Cunningham. a. Apply fault at the Cunningham 115 kV 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.
FLT115-3PH	3 phase fault on the Cunningham (527864) to Quahada (528394) 115 kV line circuit 1, near Cunningham. a. Apply fault at the Cunningham 115 kV 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.
FLT116-3PH	3 phase fault on the Cunningham (527864) to Hobbs Interchange (527891) 115 kV line circuit 1, near Cunningham. a. Apply fault at the Cunningham 115 kV 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.
FLT117-3PH	3 phase fault on the Cunningham 230/115/13.2 kV (527864/527867/527863) transformer circuit 1, near Cunningham. a. Apply fault at the Cunningham 115 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.

Cont. Name	Description
FLT118-3PH	3 phase fault on the Hobbs Interchange (527891) to LE-West (528333) 115 kV line circuit 1, near Hobbs Interchange. a. Apply fault at the Hobbs Interchange 115 kV 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.
FLT119-3PH	3 phase fault on the Hobbs Interchange (527891) to Bensing (528333) 115 kV line circuit 1, near Hobbs Interchange. a. Apply fault at the Hobbs Interchange 115 kV 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.
FLT120-3PH	3 phase fault on the Hobbs Interchange (527891) to Millen (528435) 115 kV line circuit 1, near Hobbs Interchange. a. Apply fault at the Hobbs Interchange 115 kV 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.
FLT121-3PH	3 phase fault on the Hobbs Interchange 230/115/13.2 kV (527891/527894/527890) transformer 1, near Hobbs Interchange. a. Apply fault at the Hobbs Interchange 115 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
FLT122-3PH	3 phase fault on the Monument (528491) to West Hobbs (528498) 115 kV line circuit 1, near Monument. a. Apply fault at the Monument 115 kV 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.
FLT123-SB	**Single phase fault with stuck breaker at Maddox (528355)** a. Apply fault at the Maddox 115 kV bus. b. Clear fault after 16 cycles and trip the following elements c. Maddox (528355) – Cunningham (527864) 115 kV d. Maddox (528355) – Hobbs Interchange (527891) 115 kV
FLT124-SB	**Single phase fault with stuck breaker at Maddox (528355)** a. Apply fault at the Maddox 115 kV bus. b. Clear fault after 16 cycles and trip the following elements c. Maddox (528355) – Cunningham (527864) 115 kV d. Maddox (528355) – Monument (528491) 115 kV

Cont. Name	Description
FLT125-SB	**Single phase fault with stuck breaker at Maddox (528355)** a. Apply fault at the Maddox 115 kV bus. b. Clear fault after 16 cycles and trip the following elements c. Maddox (528355) – Sanger Switch (528463) 115 kV d. Maddox (528355) – Pearle (528392) 115 kV
FLT126-SB	**Single phase fault with stuck breaker at Maddox (528355)** a. Apply fault at the Maddox 115 kV bus. b. Clear fault after 16 cycles and trip the following elements c. Maddox (528355) – Sanger Switch (528463) 115 kV d. Maddox (528355) – Monument (528491) 115 kV
FLT127-SB	**Single phase fault with stuck breaker at Cunningham (527864)** a. Apply fault at the Cunningham 115 kV bus. b. Clear fault after 16 cycles and trip the following elements c. Cunningham (527864) – Hobbs Interchange (527891) 115 kV circuit 1 d. Cunningham (527864) – Hobbs Interchange (527891) 115 kV circuit 2
FLT128-SB	**Single phase fault with stuck breaker at Cunningham (527864)** a. Apply fault at the Cunningham 115 kV bus. b. Clear fault after 16 cycles and trip the following elements c. Cunningham (527864) – Buckeye Tap (528348) 115 kV d. Cunningham (527864) – Monument Tap (528568) 115 kV
FLT129-SB	**Single phase fault with stuck breaker at Hobbs Interchange (527891)** a. Apply fault at the Hobbs Interchange 115 kV bus. b. Clear fault after 16 cycles and trip the following elements c. Hobbs Interchange (527891) – Millen (528435) 115 kV d. Hobbs Interchange (527891) – Bensing (528433) 115 kV
FLT130-SB	**Single phase fault with stuck breaker at Hobbs Interchange (527891)** a. Apply fault at the Hobbs Interchange 115 kV bus. b. Clear fault after 16 cycles and trip the following elements c. Hobbs Interchange 230/115/13.2 kV (527891/527894/527890) transformer circuit 1 d. Hobbs Interchange 230/115/13.2 kV (527891/527894/527889) transformer circuit 2
FLT131-PO	**Prior Outage of the Maddox (528355) to Cunningham (527864) 115 kV line circuit 1;** 3 phase fault on the Maddox (528355) to Hobbs Interchange (527891) 115 kV line circuit 1, near Maddox. a. Apply fault at the Maddox 115 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.

Cont. Name	Description
FLT132-PO	**Prior Outage of the Maddox (528355) to Cunningham (527864) 115 kV line circuit 1;** 3 phase fault on the Maddox (528355) to Pearle (528392) 115 kV line circuit 1, near Maddox. a. Apply fault at the Maddox 115 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
FLT133-PO	**Prior Outage of the Maddox (528355) to Cunningham (527864) 115 kV line circuit 1;** 3 phase fault on the Maddox (528355) to Sanger Switch (528463) 115 kV line circuit 1, near Maddox. a. Apply fault at the Maddox 115 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
FLT134-PO	**Prior Outage of the Maddox (528355) to Sanger Switch (528463) 115 kV line circuit 1;** 3 phase fault on the Maddox (528355) to Cunningham (527864) 115 kV line circuit 1, near Maddox. a. Apply fault at the Maddox 115 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
FLT135-PO	**Prior Outage of the Maddox (528355) to Sanger Switch (528463) 115 kV line circuit 1;** 3 phase fault on the Maddox (528355) to Hobbs Interchange (527891) 115 kV line circuit 1, near Maddox. a. Apply fault at the Maddox 115 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
FLT136-PO	**Prior Outage of the Maddox (528355) to Sanger Switch (528463) 115 kV line circuit 1;** 3 phase fault on the Maddox (528355) to Monument (528491) 115 kV line circuit 1, near Maddox. a. Apply fault at the Maddox 115 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
FLT137-PO	**Prior Outage of the Maddox (528355) to Sanger Switch (528463) 115 kV line circuit 1;** 3 phase fault on the Maddox (528355) to Pearle (587670) 115 kV line circuit 1, near Maddox. a. Apply fault at the Maddox 115 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
FLT138-3PH	3 phase fault on the Swisher (525212) to Kress (525192) 115 kV line circuit 1, near Swisher. a. Apply fault at the Swisher 115 kV 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.

Cont. Name	Description
FLT139-3PH	3 phase fault on the Swisher 230/115/13.2 kV (525213/525212/525211) transformer circuit 1, near Swisher 115 kV. a. Apply fault at the Swisher 115 kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
FLT140-3PH	3 phase fault on the Kress (525192) to Kress Rural (525225) 115 kV line circuit 1, near Kress. a. Apply fault at the Kress 115 kV 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.
FLT141-3PH	3 phase fault on the Kress (525192) to Newhart (525460) 115 kV line circuit 1, near Kress. a. Apply fault at the Kress 115 kV 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.
FLT142-3PH	3 phase fault on the Kress (525192) to Tulia Tap (525179) 115 kV line circuit 1, near Kress. a. Apply fault at the Kress 115 kV 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.
FLT143-3PH	3 phase fault on the Kress (525192) to Hale County (525454) 115 kV line circuit 1, near Kress. a. Apply fault at the Kress 115 kV 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.
FLT144-3PH	3 phase fault on the Kress 115/69/13.2 kV (525192/525191/525190) transformer circuit 1, near Kress 115 kV. a. Apply fault at the Kress 115 kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
FLT145-3PH	3 phase fault on the Swisher (525213) to Tuco (525830) 230 kV line circuit 1, near Swisher. a. Apply fault at the Swisher 230 kV 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.

Cont. Name	Description
FLT146-3PH	3 phase fault on the Swisher (525213) to Newhart (525461) 230 kV line circuit 1, near Swisher. a. Apply fault at the Swisher 230 kV 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.
FLT147-3PH	3 phase fault on the Swisher (525213) to AMA South (524415) 230 kV line circuit 1, near Swisher. a. Apply fault at the Swisher 230 kV 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.
FLT148-SB	**Single phase fault with stuck breaker at Swisher (525213) 230 kV** a. Apply fault at the Swisher 230 kV bus. b. Clear fault after 16 cycles and trip the following elements c. Swisher (525213) – Newhart (525461) 230 kV d. Swisher 230/115/13.2 kV (525213/525212/525211) transformer
FLT149-SB	**Single phase fault with stuck breaker at Swisher (525213) 230 kV** a. Apply fault at the Swisher 230 kV bus. b. Clear fault after 16 cycles and trip the following elements c. Swisher (525213) – Tuco (525830) 230 kV d. Swisher 230/115/13.2 kV (525213/525212/525211) transformer
FLT150-SB	**Single phase fault with stuck breaker at Swisher (525213) 230 kV** a. Apply fault at the Swisher 230 kV bus. b. Clear fault after 16 cycles and trip the following elements c. Swisher (525213) – Newhart (525461) 230 kV d. Swisher (525213) – AMA South (524415) 230 kV
FLT151-SB	**Single phase fault with stuck breaker at Kress (525192) 115 kV** a. Apply fault at the Kress 115 kV bus. b. Clear fault after 16 cycles and trip the following elements c. Kress (525192) – Tulia Tap (525179) 115 kV d. Kress (525192) – Kress Rural (525225) 115 kV
FLT152-SB	**Single phase fault with stuck breaker at Kress (525192) 115 kV** a. Apply fault at the Kress 115 kV bus. b. Clear fault after 16 cycles and trip the following elements c. Kress (525192) – Newhart (525460) 115 kV d. Kress (525192) – Hale County (525454) 115 kV

Cont. Name	Description
FLT153-PO	**Prior Outage of the Swisher (525213) to Tuco (525830) 230 kV line circuit 1;** 3 phase fault on the Swisher (525212) to Kress (525192) 115 kV line circuit 1, near Swisher. a. Apply fault at the Swisher 115 kV bus. b. Clear fault after 5 cycles by tripping the faulted line
FLT154-PO	**Prior Outage of the Swisher (525213) to Tuco (525830) 230 kV line circuit 1;** 3 phase fault on the Swisher (525212) to Newhart (525461) 230 kV line circuit 1, near Swisher. a. Apply fault at the Swisher 115 kV bus. b. Clear fault after 5 cycles by tripping the faulted line
FLT155-PO	**Prior Outage of the Swisher (525213) to Tuco (525830) 230 kV line circuit 1;** 3 phase fault on the Kress (525192) to Newhart (525460) 115 kV line circuit 1, near Swisher. a. Apply fault at the Swisher 115 kV bus. b. Clear fault after 5 cycles by tripping the faulted line
FLT156-PO	**Prior Outage of the Swisher (525213) Tuco (525830) 230 kV line circuit 1;** 3 phase fault on the Kress (525192) to Tulia Tap (525179) 115 kV line circuit 1, near Swisher. a. Apply fault at the Swisher 115 kV bus. b. Clear fault after 5 cycles by tripping the faulted line
FLT157-PO	**Prior Outage of the Swisher (525212) to Kress (525192) 115 kV line circuit 1;** 3 phase fault on the Swisher (525213) to Newhart (525461) 230 kV line circuit 1, near Swisher. a. Apply fault at the Swisher 115 kV bus. b. Clear fault after 5 cycles by tripping the faulted line
FLT158-PO	**Prior Outage of the Swisher (525212) to Kress (525192) 115 kV line circuit 1;** 3 phase fault on the Swisher (525213) to Tuco (525830) 230 kV line circuit 1, near Swisher. a. Apply fault at the Swisher 115 kV bus. b. Clear fault after 5 cycles by tripping the faulted line
FLT159-3PH	3 phase fault on the Ozark Mahoning (526770) to Lakeview (526631) 69 kV line circuit 1, near Ozark Mahoning. a. Apply fault at the Ozark Mahoning 69 kV 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.

Cont. Name	Description
FLT160-3PH	3 phase fault on the LG-Dixon (526711) to Ozark Mahoning (526770) 69 kV line circuit 1, near LG-Dixon. a. Apply fault at the LG-Dixon 69 kV 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.
FLT161-3PH	3 phase fault on the Brownfield (526754) to LG-Brownfield (526747) 69 kV line circuit 1, near Brownfield. a. Apply fault at the Brownfield 69 kV 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.
FLT162-3PH	3 phase fault on the Brownfield (526754) to Brownfield Tap (526761) 69 kV line circuit 1, near Brownfield. a. Apply fault at the Brownfield 69 kV 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.
FLT163-3PH	3 phase fault on the Terry County (526735) to LG-DOCWEBR (526506) 69 kV line circuit 1, near Swisher. a. Apply fault at the Terry County 69 kV 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.
FLT164-SB	**Single phase fault with stuck breaker at Terry County (526735) 69 kV** a. Apply fault at the Terry County 69 kV bus. b. Clear fault after 16 cycles and trip the following elements c. Terry County (526735) – LG-DOCWEBR (526506) 69 kV d. Terry County 115/69/13.2 kV (526736/526735/526733) transformer
FLT165-PO	**Prior Outage of the Terry County 115/69/13.2 kV (526736/526735/526733) transformer circuit 1;** 3 phase fault on the Terry County (526735) to LG-DOCWEBR (526506) 69 kV line circuit 1, near Swisher. a. Apply fault at the Terry County 69 kV bus. b. Clear fault after 5 cycles by tripping the faulted line

Cont. Name	Description
FLT166-3PH	3 phase fault on the Bailey County (525028) to Curry (524822) 115 kV line circuit 1, near Bailey County. a. Apply fault at the Bailey County 115 kV 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.
FLT167-3PH	3 phase fault on the Bailey County 115/69/13.2 kV (525028/525027/525025) transformer circuit 1, near Bailey County 115 kV. a. Apply fault at the Bailey County 115 kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
FLT168-3PH	3 phase fault on the Bailey County (525028) to EMU&VLY Tap (525019) 115 kV line circuit 1, near Bailey County. a. Apply fault at the Bailey County 115 kV 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.
FLT169-3PH	3 phase fault on the Curry (524822) to DS#20 (524669) 115 kV line circuit 1, near Curry. a. Apply fault at the Curry 115 kV 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.
FLT170-3PH	3 phase fault on the Curry (524822) to Norris Tap (524764) 115 kV line circuit 1, near Curry. a. Apply fault at the Curry 115 kV 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.
FLT171-3PH	3 phase fault on the Curry (524822) to E_Clovis (524773) 115 kV line circuit 1, near Curry. a. Apply fault at the Curry 115 kV 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.

Cont. Name	Description
FLT172-3PH	3 phase fault on the Curry (524822) to FE_Clovis2 (524838) 115 kV line circuit 1, near Curry. a. Apply fault at the Curry 115 kV 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.
FLT173-3PH	3 phase fault on the Curry (524822) to Roosevelt (524908) 115 kV line circuit 2, near Curry. a. Apply fault at the Curry 115 kV 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.
FLT174-3PH	3 phase fault on the Curry 115/69/13.2 kV (524822/524821/524819) transformer circuit 1, near Curry 115 kV. a. Apply fault at the Curry 115 kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
FLT175-3PH	3 phase fault on the EMU&VLY Tap (525019) to Plant X (525480) 115 kV line circuit 1, near EMU&VLY Tap. a. Apply fault at the EMU&VLY Tap 115 kV 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.
FLT176-3PH	3 phase fault on the EMU&VLY Tap (525019) to EMULESH&VLY (525019) 115 kV line circuit 1, near EMU&VLY Tap. a. Apply fault at the EMU&VLY Tap 115 kV 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.
FLT177-SB	**Single phase fault with stuck breaker at Curry 115 kV (524822)** a. Apply fault at the Curry 115 kV bus. b. Clear fault after 16 cycles and trip the following elements c. Curry (524822) – Bailey County (525028) 115 kV d. Curry (524822) – FE-Clovis (524838) 115 kV
FLT178-SB	**Single phase fault with stuck breaker at Curry 115 kV (524822)** a. Apply fault at the Curry 115 kV bus. b. Clear fault after 16 cycles and trip the following elements c. Curry (524822) – Norris TP (524764) 115 kV d. Curry (524822) – Bailey County (525028) 115 kV

Cont. Name	Description
FLT179-SB	**Single phase fault with stuck breaker at Curry 115 kV (524822)** a. Apply fault at the Curry 115 kV bus. b. Clear fault after 16 cycles and trip the following elements c. Curry (524822) – Roosevelt (524908) 115 kV d. Curry (524822) – FE-Clovis (524838) 115 kV
FLT180-SB	**Single phase fault with stuck breaker at Curry 115 kV (524822)** a. Apply fault at the Curry 115 kV bus. b. Clear fault after 16 cycles and trip the following elements c. Curry (524822) –DS#20 (524669) 115 kV d. Curry (524822) – FE-Clovis (524838) 115 kV
FLT182-SB	**Single phase fault with stuck breaker at Bailey County 115 kV (525028)** a. Apply fault at the Bailey County 115 kV bus. b. Clear fault after 16 cycles and trip the following elements c. Bailey County 115/69/13.2 kV (525028/525027/525025) transformer d. Bailey County (525028) – Curry (524822) 115 kV
FLT183-PO	**Prior Outage of Bailey County 115 kV (525028) to EMU&VLY Tap 115 kV (525019) circuit 1;** 3 phase fault on Bailey County 115 kV (525028) to Curry 115 kV (524822) circuit 1, near Bailey County. a. Apply fault at the Bailey County 115 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
FLT184-PO	**Prior Outage of Bailey County 115 kV (525028) to EMU&VLY Tap 115 kV (525019) circuit 1;** 3 phase fault on Bailey County 115/69/13.2 kV (525028/525027/525025) transformer circuit 1, near Bailey County. a. Apply fault at the Bailey County 115 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
FLT185-PO	**Prior Outage of Roosevelt 115 kV (524908) to Curry 115 kV (524822) circuit 1;** 3 phase fault on Curry 115 kV (524822) to Bailey County 115 kV (525028) circuit 1, near Curry. a. Apply fault at the Curry 115 kV bus. b. Clear fault after 5 cycles by tripping the faulted line
FLT186-PO	**Prior Outage of Roosevelt 115 kV (524908) to Curry 115 kV (524822) circuit 1;** 3 phase fault on Curry 115 kV (524822) to DS#20 115 kV (524669) circuit 1, near Curry. a. Apply fault at the Curry 115 kV bus. b. Clear fault after 5 cycles by tripping the faulted line

Cont. Name	Description
FLT187-PO	**Prior Outage of Bailey County 115 kV (525028) to Curry 115 kV (524822) circuit 1;** 3 phase fault on Bailey County 115 kV (525028) to EMU&VLY Tap (525019) cicuit 1, near Bailey County. a. Apply fault at the Bailey County 115 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
FLT188-PO	**Prior Outage of Bailey County 115 kV (525028) to Curry 115 kV (524822) circuit 1;** 3 phase fault on Bailey County 115/69/13.2 kV (525028/525027/525025) transformer circuit 1, near Bailey County. a. Apply fault at the Bailey County 115 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
FLT191-3PH	3 phase fault on the Tuco (525832) to OKU (511456) 345 kV line circuit 1, near Tuco. a. Apply fault at the Tuco 345 kV 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.
FLT192-3PH	3 phase fault on the Tuco 345/230/13.2 kV (525832/525830/525824) transformer circuit 1, near Tuco 345 kV bus. a. Apply fault at the Tuco 345 kV bus. b. Clear fault after 5 cycles by tripping the transformer
FLT193-3PH	3 phase fault on the Tuco (525832) to Border (515458) 345 kV line circuit 1, near Tuco. a. Apply fault at the Tuco 345 kV 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.
FLT195-3PH	3 phase fault on the OKU (511456) to L.E.S (511468) 345 kV line circuit 1, near OKU. a. Apply fault at the OKU 345 kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Block DC Line
FLT197-3PH	3 phase fault on the Tuco (525830) to Jones (526337) 230 kV line circuit 1, near Tuco. a. Apply fault at the Tuco 230 kV 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.

Cont. Name	Description
FLT199-3PH	3 phase fault on the Tuco (525830) to Tolk East (525524) 230 kV line circuit 1, near Tuco. a. Apply fault at the Tuco 230 kV 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.
FLT200-3PH	3 phase fault on the Tuco (525830) to Carlisle (526161) 230 kV line circuit 1, near Tuco. a. Apply fault at the Tuco 230 kV 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.
FLT201-3PH	3 phase fault on the Woodward (515375) to Thistle (539801) 345 kV line circuit 1, near Woodward. a. Apply fault at the Woodward 345 kV 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.
FLT202-3PH	3 phase fault on the Woodward (515375) to G16-003-Tap (560071) 345 kV line circuit 1, near Woodward. a. Apply fault at the Woodward 345 kV 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.
FLT203-3PH	3 phase fault on the Woodward (515375) to Tatonga (515407) 345 kV line circuit 1, near Woodward. a. Apply fault at the Woodward 345 kV 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.
FLT205-3PH	3 phase fault on the Woodward 345/138/13.2 kV (515375/515376/515795) transformer circuit 1, near Woodward. a. Apply fault at the Woodward 345 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
FLT206-SB	**Single phase fault with stuck breaker at Tuco (525832)** a. Apply fault at the Tuco 345 kV bus. b. Clear fault after 16 cycles and trip the following elements c. Tuco 345/230/13.2 kV (525832/525830/525824) transformer d. Tuco (525832) – OKU (511456) 345 kV Circuit #1

Cont. Name	Description
FLT207-SB	**Single phase fault with stuck breaker at Tuco (525832)** a. Apply fault at the Tuco 345 kV bus. b. Clear fault after 16 cycles and trip the following elements c. Tuco 345/230/13.2 kV (525832/525830/525824) transformer d. Tuco (525832) – Border (515458) 345 kV Circuit #1
FLT209-SB	**Single phase fault with stuck breaker at Woodward (515375)** a. Apply fault at the Woodward 345 kV bus. b. Clear fault after 16 cycles and trip the following elements c. Woodward (515375) – Thistle (539801) 345 kV d. Woodward (515375) – Tatonga (515407) 345 kV
FLT210-SB	**Single phase fault with stuck breaker at Woodward (515375)** a. Apply fault at the Woodward 345 kV bus. b. Clear fault after 16 cycles and trip the following elements c. Woodward (515375) – Border (515458) 345 kV d. Woodward (515375) – G16-003-Tap (515407) 345 kV
FLT211-SB	**Single phase fault with stuck breaker at Woodward (515375)** a. Apply fault at the Woodward 345 kV bus. b. Clear fault after 16 cycles and trip the following elements c. Woodward (515375) – Tatonga (515407) 345 kV d. Woodward (515375) – Border (515458) 345 kV
FLT212-PO	**Prior Outage of the Tuco 345/230/13.2 kV (525832/525830/525824) transformer circuit 1;** 3 phase fault on the Woodward (515375) to Border (515458) 345 kV line circuit 1, near Woodward. a. Apply fault at the Woodward 345 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
FLT213-PO	**Prior Outage of the Tuco 345/230/13.2 kV (525832/525830/525824) transformer circuit 1;** 3 phase fault on the Tuco (525832) to Oklaunion (511456) 345 kV line circuit 1, near Tuco. a. Apply fault at the Tuco 345 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
FLT214-PO	**Prior Outage of the Tuco (525832) to Border (515458) 345 kV line circuit 1;** 3 phase fault on the Woodward (515375) to Tatonga (515407) 345 kV line circuit 1, near Woodward. a. Apply fault at the Woodward 345 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.

Cont. Name	Description
FLT215-PO	**Prior Outage of the Tuco (525832) to Border (515458) 345 kV line circuit 1;** 3 phase fault on the Woodward (515375) to Thistle (539801) 345 kV line circuit 1, near Woodward. a. Apply fault at the Woodward 345 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
FLT216-PO	**Prior Outage of the Tuco (525832) to Border (515458) 345 kV line circuit 1;** 3 phase fault on the Woodward (515375) to G07621119-20 (515599) 345 kV line circuit 1, near Woodward. a. Apply fault at the Woodward 345 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
FLT217-PO	**Prior Outage of the Tuco (525832) to Border (515458) 345 kV line circuit 1;** 3 phase fault on the Tuco (525832) to OKU (511456) 345 kV line circuit 1, near Tuco. a. Apply fault at the Tuco 345 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
FLT218-PO	**Prior Outage of the Tuco (525832) to Border (515458)345 kV line circuit 1;** 3 phase fault on the Tuco 345/230/13.2 kV (525832/525830/525824) transformer circuit 1, near Tuco 345 kV bus. a. Apply fault at the Tuco 345 kV bus. b. Clear fault after 5 cycles by tripping the transformer
FLT219-3PH	3 phase fault on the Roadrunner (528025) to Red Bluff (528017) 115 kV line circuit 1, near Roadrunner. a. Apply fault at the Roadrunner 115 kV 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.
FLT220-3PH	3 phase fault on the Roadrunner (528025) to Battle Axe (528040) 115 kV line circuit 1, near Roadrunner. a. Apply fault at the Roadrunner 115 kV 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.
FLT221-3PH	3 phase fault on the Roadrunner (528025) to Agave Hills (528230) 115 kV line circuit 1, near Roadrunner. a. Apply fault at the Roadrunner 115 kV 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.

Cont. Name	Description
FLT222-3PH	3 phase fault on the Roadrunner 345/115/13.2 kV (528025/528027/528023) transformer circuit 1, near Roadrunner. a. Apply fault at the Roadrunner 115 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
FLT223-3PH	3 phase fault on the Roadrunner (528027) to Kiowa (527965) 345 kV line circuit 1, near Roadrunner (17W fault is Roadrunner to Potash JCT (527963) 230 kV). a. Apply fault at the Roadrunner 345 kV 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.
FLT224-3PH (17W)	3 phase fault on the Potash Junction (527963) to Cunningham (527865) 230 kV line circuit 1, near Potash Junction. a. Apply fault at the Potash Junction 230 kV 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.
FLT224-3PH (18S,26S)	3 phase fault on the Kiowa (527965) to Hobbs (527896) 345 kV line circuit 1, near Kiowa. a. Apply fault at the Kiowa 345 kV 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.
FLT225-3PH (17W)	3 phase fault on the Potash Junction (527963) to Pecos (528179) 230 kV line circuit 1, near Potash Junction. a. Apply fault at the Potash Junction 230 kV 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.
FLT225-3PH (18S, 26S)	3 phase fault on the Kiowa (527965) to North Loving (528185) 345 kV line circuit 1, near Kiowa. a. Apply fault at the Kiowa 345 kV 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.
FLT226-3PH (17W)	3 phase fault on the Potash Junction 230/115/13.2 kV (527963/527962/527958) transformer circuit 1, near Potash Junction. a. Apply fault at the Potash Junction 230 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.

Cont. Name	Description
FLT226-3PH (18S, 26S)	3 phase fault on the Kiowa 345/115/13.2 kV (527965/527962/527964) transformer circuit 1, near Kiowa. a. Apply fault at the Kiowa 345 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
FLT227-3PH	3 phase fault on the Ponderosa Tap (528239) to Ochoa (528232) 115 kV line circuit 1, near Ponderosa Tap. a. Apply fault at the Ponderosa Tap 115 kV 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.
FLT228-3PH	3 phase fault on the Red Bluff (528018) to Wolf Camp Tap (528235) 115 kV line circuit 1, near Red Bluff. a. Apply fault at the Red Bluff 115 kV 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.
FLT229-3PH	3 phase fault on the Red Bluff (528018) to Sand Dunes (528016) 115 kV line circuit 1, near Red Bluff. a. Apply fault at the Red Bluff 115 kV 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.
FLT230-SB	**Single phase fault with stuck breaker at Roadrunner (528025)** a. Apply fault at the Roadrunner 115 kV bus. b. Clear fault after 16 cycles and trip the following elements c. Roadrunner (528025) – Red Bluff (528018) 115 kV d. Roadrunner (528025) – Agave Hills (528230) 115 kV
FLT231-SB	**Single phase fault with stuck breaker at Roadrunner (528025)** a. Apply fault at the Roadrunner 115 kV bus. b. Clear fault after 16 cycles and trip the following elements c. Roadrunner 345/115/13.2 kV (528025/528027/528023) transformer d. Roadrunner (528025) – Agave Hills (528230) 115 kV
FLT232-SB	**Single phase fault with stuck breaker at Roadrunner (528025)** a. Apply fault at the Roadrunner 115 kV bus. b. Clear fault after 16 cycles and trip the following elements c. Roadrunner 345/115/13.2 kV (528025/528027/528023) transformer d. Roadrunner (528025) – Battle Axe (528040) 115 kV

Cont. Name	Description
FLT233-PO	**Prior Outage of the Roadrunner (528025) to Agave Hill (528230) 115 kV line circuit 1;** 3 phase fault on the Roadrunner (528025) to Battle Axe (528040) 115 kV line circuit 1, near Roadrunner. a. Apply fault at the Roadrunner 115 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
FLT234-PO	**Prior Outage of the Roadrunner (528025) to Agave Hill (528230) 115 kV line circuit 1;** 3 phase fault on the Roadrunner (528025) to Red Bluff (528018) 115 kV line circuit 1, near Roadrunner. a. Apply fault at the Roadrunner 115 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
FLT235-PO	**Prior Outage of the Roadrunner (528025) to Agave Hill (528230) 115 kV line circuit 1;** 3 phase fault on the Roadrunner 345/115/13.2 kV (528025/528027/528023) transformer circuit 1, near Roadrunner. a. Apply fault at the Roadrunner 115 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
FLT236-PO	**Prior Outage of the Roadrunner (528025) to Red Bluff (528018) 115 kV line circuit 1;** 3 phase fault on the Roadrunner (528025) to Battle Axe (528040) 115 kV line circuit 1, near Roadrunner. a. Apply fault at the Roadrunner 115 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
FLT237-PO	**Prior Outage of the Roadrunner (528025) to Red Bluff (528018) 115 kV line circuit 1;** 3 phase fault on the Roadrunner (528025) to Agave Hill (528230) 115 kV line circuit 1, near Roadrunner. a. Apply fault at the Roadrunner 115 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
FLT238-PO	**Prior Outage of the Roadrunner (528025) to Red Bluff (528018) 115 kV line circuit 1;** 3 phase fault on the Roadrunner 345/115/13.2 kV (528025/528027/528023) transformer circuit 1, near Roadrunner. a. Apply fault at the Roadrunner 115 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
FLT239-3PH	3 phase fault on the Crossroads (527656) to Tolk (525549) 345 kV line circuit 1, near Crossroads. a. Apply fault at the Crossroads 345 kV 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.

Cont. Name	Description
FLT241-3PH	3 phase fault on the Crossroads (527656) to Eddy County (527802) 345 kV line circuit 1, near Crossroads. a. Apply fault at the Crossroads 345 kV 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.
FLT242-3PH	3 phase fault on the Tolk East (525524) to Roosevelt (524911) 230 kV line circuit 1, near Tolk East. a. Apply fault at the Tolk East 230 kV 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.
FLT244-3PH	3 phase fault on the Eddy North (527799) to 7-Rivers (528095) 230 kV line circuit 1, near Eddy North. a. Apply fault at the Eddy North 230 kV 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.
FLT245-3PH	3 phase fault on the Eddy North (527799) to Cunningham (527865) 230 kV line circuit 1, near Eddy North. a. Apply fault at the Eddy North 230 kV 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.
FLT246-3PH	3 phase fault on the Eddy North (527799) to Chaves County (527483) 230 kV line circuit 1, near Eddy North. a. Apply fault at the Eddy North 230 kV 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.
FLT247-3PH	3 phase fault on the Eddy North 230/115/13.2 kV (527799/527798/527797) transformer circuit 1, near Eddy North. a. Apply fault at the Eddy North 230 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.

Cont. Name	Description
FLT248-SB	**Single phase fault with stuck breaker at Crossroads (527656)** a. Apply fault at the Crossroads 345 kV bus. b. Clear fault after 16 cycles and trip the following elements c. Crossroads (527656) – Tolk (525549) 345 kV d. Crossroads (527656) – Roosevelt East (527655) 345 kV
FLT249-SB	**Single phase fault with stuck breaker at Crossroads (527656)** a. Apply fault at the Crossroads 345 kV bus. b. Clear fault after 16 cycles and trip the following elements c. Crossroads (527656) – Tolk (525549) 345 kV d. Crossroads (527656) – Eddy County (527802) 345 kV
FLT250-SB	**Single phase fault with stuck breaker at Crossroads (527656)** a. Apply fault at the Crossroads 345 kV bus. b. Clear fault after 16 cycles and trip the following elements c. Crossroads (527656) – Eddy County (527802) 345 kV d. Crossroads (527656) – Roosevelt East (527655) 345 kV
FLT251-PO	**Prior Outage of the Tolk 345/230 kV (525549/525543/525537) transformer circuit 1;** 3 phase fault on the Eddy County (527802) to Kiowa (527965) 345 kV line circuit 1, near Eddy County. a. Apply fault at the Eddy County 345 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
FLT253-PO	**Prior Outage of the Eddy County (527802) to Kiowa (527965) 345 kV line circuit 1;** 3 phase fault on the Crossroads (527656) to Tolk (525549) 345 kV line circuit 1, near Crossroads. a. Apply fault at the Crossroads 345 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
FLT262-3PH	3 phase fault on the Hobbs (527894) to Andrews (528604) 230 kV line circuit 1, near Hobbs. a. Apply fault at the Hobbs 230 kV 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.
FLT263-3PH	3 phase fault on the Andrews 345/115/13.2 kV (528604/528602/528601) transformer circuit 1, near Andrews 345. a. Apply fault at the Andrews 345 kV bus. b. Clear fault after 5 cycles by tripping the transformer

Cont. Name	Description
FLT264-3PH	3 phase fault on the G1579&G1580T (560059) to Yoakum (526935) 230 kV line circuit 1, near G1579&G1580T. a. Apply fault at the G1579&G1580T 230 kV 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.
FLT265-3PH	3 phase fault on the G1579&G1580T (560059) to Hobbs (527894) 230 kV line circuit 1, near G1579&G1580T. a. Apply fault at the G1579&G1580T 230 kV 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.
FLT266-SB	**Single phase fault with stuck breaker at Hobbs (527894) 230 kV** a. Apply fault at the Hobbs 230 kV bus. b. Clear fault after 16 cycles and trip the following elements c. Hobbs (527894) – Cunningham (527867) 230 kV d. Hobbs 230/115/13.2 kV (527894/527891/527889) transformer
FLT267-SB	**Single phase fault with stuck breaker at Hobbs (527894) 230 kV** a. Apply fault at the Hobbs 230 kV bus. b. Clear fault after 16 cycles and trip the following elements c. Hobbs (527894) – G1579&G1580T (560059) 230 kV d. Hobbs 230/115/13.2 kV (527894/527891/527889) transformer
FLT268-SB	**Single phase fault with stuck breaker at Hobbs (527894) 230 kV** a. Apply fault at the Hobbs 230 kV bus. b. Clear fault after 16 cycles and trip the following elements c. Hobbs (527894) – G1579&G1580T (560059) 230 kV d. Hobbs (527894) – Cunningham (527867) 230 kV
FLT270-PO	**Prior Outage of the Hobbs (527894) to Cunningham (527865) 230 kV line circuit 1;** 3 phase fault on the Hobbs 230/115/13.2 kV (527894/527891/527890) transformer 1, near Hobbs. a. Apply fault at the Hobbs 230 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
FLT271-PO	**Prior Outage of the Hobbs (527894) to Cunningham (527865) 230 kV line circuit 1;** 3 phase fault on the G1579&G1580T (560059) to Hobbs (527894) 230 kV line circuit 1, near G1579&G1580T. a. Apply fault at the G1579&G1580T 230 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.

Cont. Name	Description
FLT272-PO	**Prior Outage of the Hobbs (527894) to Cunningham (527865) 230 kV line circuit 1;** 3 phase fault on the G1579&G1580T (560059) to Yoakum (526935) 230 kV line circuit 1, near G1579&G1580T. a. Apply fault at the G1579&G1580T 230 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
FLT273-PO	**Prior Outage of the Hobbs (527894) to Andrews (528604) 230 kV line circuit 1;** 3 phase fault on the Hobbs 230/115/13.2 kV (527894/527891/527890) transformer 1, near Hobbs. a. Apply fault at the Hobbs 230 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
FLT274-PO	**Prior Outage of the Hobbs (527894) to Andrews (528604) 230 kV line circuit 1;** 3 phase fault on the G1579&G1580T (560059) to Hobbs (527894) 230 kV line circuit 1, near G1579&G1580T. a. Apply fault at the G1579&G1580T 230 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
FLT275-PO	**Prior Outage of the Hobbs (527894) to Andrews (528604) 230 kV line circuit 1;** 3 phase fault on the G1579&G1580T (560059) to Yoakum (526935) 230 kV line circuit 1, near G1579&G1580T. a. Apply fault at the G1579&G1580T 230 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
FLT278-PO	**Prior Outage of the Hobbs (527896) to Kiowa (527965) 345 kV line circuit 1;** 3 phase fault on the Hobbs (527896) to Yoakum (526936) 345 kV line circuit 1, near Hobbs. a. Apply fault at the Hobbs 345 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
FLT279-PO	**Prior Outage of the Hobbs (527896) to Kiowa (527965) 345 kV line circuit 1;** 3 phase fault on the Hobbs 345/230/13.2 kV (527896/527894/527895) transformer circuit 1, near Hobbs. a. Apply fault at the Hobbs 345 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
FLT280-3PH	3 phase fault on the Newhart (525460) to Kress (525192) 115 kV line circuit 1, near Newhart. a. Apply fault at the Newhart 115 kV 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.

Cont. Name	Description
FLT281-3PH	3 phase fault on the Newhart (525460) to Castro County (524746) 115 kV line circuit 1, near Newhart. a. Apply fault at the Newhart 115 kV 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.
FLT282-3PH	3 phase fault on the Newhart (525460) to Hart Industries (525124) 115 kV line circuit 1, near Newhart. a. Apply fault at the Newhart 115 kV 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.
FLT283-3PH	3 phase fault on the Newhart 230/115/13.2 kV (525460/525461/525459) transformer circuit 1, near Newhart. a. Apply fault at the Newhart 115 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
FLT284-3PH	3 phase fault on the Newhart (525461) to Swisher (525461) 230 kV line circuit 1, near Newhart. a. Apply fault at the Newhart 230 kV 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.
FLT285-3PH	3 phase fault on the Newhart (525461) to Plant X (525481) 230 kV line circuit 1, near Newhart. a. Apply fault at the Newhart 230 kV 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.
FLT286-3PH	3 phase fault on the Newhart (525461) to Potter County (523959) 230 kV line circuit 1, near Newhart. a. Apply fault at the Newhart 230 kV 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.

Cont. Name	Description
FLT287-3PH	3 phase fault on the Castro County (524746) to DS#21 (524734) 115 kV line circuit 1, near Castro County. a. Apply fault at the Castro County 115 kV 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.
FLT289-3PH	3 phase fault on the Castro County (524746) to DS#22 (534694) 115 kV line circuit 1, near Castro County. a. Apply fault at the Castro County 115 kV 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.
FLT290-3PH	3 phase fault on the Castro County (524746) to BC-Kelly (525050) 115 kV line circuit 1, near Castro County. a. Apply fault at the Castro County 115 kV 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.
FLT291-3PH	3 phase fault on the Castro County 115/69/13.2 kV (524746/524745/524744) transformer circuit 1, near Castro County. a. Apply fault at the Castro County 115 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
FLT292-SB	**Single phase fault with stuck breaker at Newhart (525460) 115 kV** a. Apply fault at the Newhart 115 kV bus. b. Clear fault after 16 cycles and trip the following elements c. Newhart (525460) – Kress (525192) 115 kV d. Newhart 230/115/13.2 kV (525461/565460/525459) transformer
FLT293-SB	**Single phase fault with stuck breaker at Newhart (525460) 115 kV** a. Apply fault at the Newhart 115 kV bus. b. Clear fault after 16 cycles and trip the following elements c. Newhart (525460) – Hart Industries (525124) 115 kV d. Newhart (525460) – Castro County (524746) 115 kV
FLT294-SB	**Single phase fault with stuck breaker at Castro County (524746) 115 kV** a. Apply fault at the Castro County 115 kV bus. b. Clear fault after 16 cycles and trip the following elements c. Castro County (524746) – DS#21 (524734) 115 kV d. Castro County (524746) – DS#22 (524694) 115 kV

Cont. Name	Description
FLT295-SB	**Single phase fault with stuck breaker at Castro County (524746) 115 kV** a. Apply fault at the Castro County 115 kV bus. b. Clear fault after 16 cycles and trip the following elements c. Castro County (524746) – Newhart (525460) 115 kV d. Castro County (524746) – BC-Kelly (525050) 115 kV
FLT296-PO	**Prior Outage of the Newhart (525460) to Hart Industries (525124) 115 kV line circuit 1;** 3 phase fault on the Newhart (525460) to Castro County (524746) 115 kV line circuit 1, near Newhart. a. Apply fault at the Newhart 115 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
FLT297-PO	**Prior Outage of the Newhart (525460) to Hart Industries (525124) 115 kV line circuit 1;** 3 phase fault on the Newhart (525460) to Kress (525192) 115 kV line circuit 1, near Castro County. a. Apply fault at the Castro County 115 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
FLT298-PO	**Prior Outage of the Newhart (525460) to Hart Industries (525124) 115 kV line circuit 1;** 3 phase fault on the Newhart 230/115/13.2 kV (525460/525461/525459) transformer circuit 1, near Newhart. a. Apply fault at the Newhart 115 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
FLT299-PO	**Prior Outage of the Newhart (525460) to Castro County (524746) 115 kV line circuit 1;** 3 phase fault on the Newhart (525460) to Hart Industries (525124) 115 kV line circuit 1, near Newhart. a. Apply fault at the Newhart 115 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
FLT300-PO	**Prior Outage of the Newhart (525460) to Castro County (524746) 115 kV line circuit 1;** 3 phase fault on the Newhart (525460) to Kress (525192) 115 kV line circuit 1, near Newhart. a. Apply fault at the Newhart 115 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
FLT301-PO	**Prior Outage of the Newhart (525460) to Castro County (524746) 115 kV line circuit 1;** 3 phase fault on the Newhart 230/115/13.2 kV (525460/525461/525459) transformer circuit 1, near Newhart. a. Apply fault at the Newhart 115 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.

Cont. Name	Description
FLT302-PO	**Prior Outage of the Newhart 230/115/13.2 kV (525461/525460/525459) transformer circuit 1;** 3 phase fault on the Newhart (525460) to Hart Industries (525124) 115 kV line circuit 1, near Newhart. a. Apply fault at the Newhart 115 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
FLT303-PO	**Prior Outage of the Newhart 230/115/13.2 kV (525461/525460/525459) transformer circuit 1;** 3 phase fault on the Newhart (525460) to Kress (525192) 115 kV line circuit 1, near Newhart. a. Apply fault at the Newhart 115 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
FLT304-PO	**Prior Outage of the Newhart 230/115/13.2 kV (525461/525460/525459) transformer circuit 1;** 3 phase fault on the Newhart (525460) to Castro County (524746) 115 kV line circuit 1, near Newhart. a. Apply fault at the Newhart 115 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
FLT318-3PH	3 phase fault on the Potter County (523961) to Hitchland (523097) 345 kV line circuit 1, near Potter County. a. Apply fault at the Potter County 345 kV 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.
FLT319-3PH	3 phase fault on the Potter County 345/230/13 kV (523961/523959/523957) transformer circuit 1, near Potter County. a. Apply fault at the Potter County 345 kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
FLT322-3PH	3 phase fault on the Chisholm (511553) to G16-037-Tap (560078) 345 kV line circuit 1, near Chisholm. a. Apply fault at the Chisholm 345 kV 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.
FLT324-3PH	3 phase fault on the Border (515458) to Woodward (515375) 345 kV line circuit 1, near Border. a. Apply fault at the Border 345 kV 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.

Cont. Name	Description
FLT325-3PH	3 phase fault on the Eddy County (527802) to Kiowa (527956) 345 kV line circuit 1, near Eddy County. a. Apply fault at the Eddy County 345 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
FLT326-3PH	3 phase fault on the Kiowa (527956) to Eddy County (527802) 345 kV line circuit 1, near Kiowa. a. Apply fault at the Kiowa 345 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
FLT327-PO	**Prior Outage of the Potter County (523961) to Hitchland (523097) 345 kV line circuit 1;** 3 phase fault on the Tuco (525832) to OKU (511456) 345 kV line circuit 1, near Tuco. a. Apply fault at the Tuco 345 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
FLT328-PO	**Prior Outage of the Potter County (523961) to Hitchland (523097) 345 kV line circuit 1;** 3 phase fault on the Border (515458) to Woodward (515375) 345 kV line circuit 1, near Border. a. Apply fault at the Border 345 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.

Table 3-4
Calculated Single-Phase Fault Impedances for DISIS-2016-002-2 Contingencies

Cont. Name	Single-Phase Fault Impedance (MVA)				Cont. Name	Single-Phase Fault Impedance (MVA)		
	2017 Winter	2018 Summer	2026 Summer			2017 Winter	2018 Summer	2026 Summer
FLT14_SB	-1375.0	-1375.0	-1375.0		FLT149_SB	-2812.5	-2812.5	-2812.5
FLT15_SB	-1125.0	-1125.0	-1125.0		FLT150_SB	-2812.5	-2812.5	-2812.5
FLT40_SB	-1375.0	-1375.0	-1500.0		FLT151_SB	-1625.0	-1500.0	-1500.0
FLT41_SB	-1375.0	-1375.0	-1500.0		FLT152_SB	-1625.0	-1500.0	-1500.0
FLT43_SB	-1250.0	-1250.0	-1375.0		FLT164_SB	-500.0	-500.0	-562.5
FLT44_SB	-1250.0	-1250.0	-1375.0		FLT177_SB	-1375.0	-1375.0	-1375.0
FLT60_SB	-6062.5	-5656.3	-6062.5		FLT178_SB	-1375.0	-1375.0	-1375.0
FLT61_SB	-6062.5	-5656.3	-6062.5		FLT179_SB	-1375.0	-1375.0	-1375.0
FLT62_SB	-1875.0	-1750.0	-1875.0		FLT180_SB	-1375.0	-1375.0	-1375.0
FLT63_SB	-6062.5	-5656.3	-6062.5		FLT182_SB	-687.5	-625.0	-750.0
FLT64_SB	-6062.5	-5656.3	-6062.5		FLT206_SB	-8500.0	-8906.3	-10125.0
FLT65_SB	-6062.5	-5656.3	-6062.5		FLT207_SB	-8500.0	-8906.3	-10125.0
FLT92_SB	-4031.3	-3828.1	-4437.5		FLT209_SB	-7687.5	-8500.0	-8500.0
FLT93_SB	-4031.3	-3828.1	-4437.5		FLT210_SB	-7687.5	-8500.0	-8500.0
FLT94_SB	-2406.3	-2203.1	-2406.3		FLT211_SB	-7687.5	-8500.0	-8500.0
FLT95_SB	-2101.6	-2101.6	-2406.3		FLT230_SB	-875.0	-1062.5	-1125.0
FLT96_SB	-2812.5	-2812.5	-3015.6		FLT231_SB	-875.0	-1062.5	-1125.0
FLT97_SB	-2812.5	-2812.5	-3015.6		FLT232_SB	-875.0	-1062.5	-1125.0
FLT98_SB	-2812.5	-2812.5	-3015.6		FLT248_SB	-3421.9	-3218.8	-3625.0
FLT99_SB	-2812.5	-2812.5	-3015.6		FLT249_SB	-3421.9	-3218.8	-3625.0
FLT123_SB	-3218.8	-3218.8	-3421.9		FLT250_SB	-3421.9	-3218.8	-3625.0
FLT124_SB	-3218.8	-3218.8	-3421.9		FLT266_SB	-4031.3	-4437.5	-4437.5
FLT125_SB	-3218.8	-3218.8	-3421.9		FLT267_SB	-4031.3	-4437.5	-4437.5
FLT126_SB	-3218.8	-3218.8	-3421.9		FLT268_SB	-4031.3	-4437.5	-4437.5
FLT127_SB	-3421.9	-3421.9	-3421.9		FLT292_SB	-2203.1	-2101.6	-2101.6
FLT128_SB	-3421.9	-3421.9	-3421.9		FLT293_SB	-2203.1	-2101.6	-2101.6
FLT129_SB	-3828.1	-4031.3	-4031.3		FLT294_SB	-1375.0	-1250.0	-1250.0
FLT130_SB	-3828.1	-4031.3	-4031.3		FLT295_SB	-1375.0	-1250.0	-1250.0
FLT148_SB	-2812.5	-2812.5	-2812.5					

Bus voltages, machine rotor angles, and previously queued generation in the study area were monitored in addition to bus voltages and machine rotor angles in the following areas:

- 520 AEPW
- 524 OKGE
- 525 WFEC
- 526 SPS
- 531 MIDW
- 534 SUNC
- 536 WERE

Requested and previously queued generation outside the above study area was also monitored. The results of the analysis determined if reactive compensation or system upgrades were required to obtain acceptable system performance. If additional reactive compensation was required, the size, type, and location were determined. The proposed reactive reinforcements would ensure the wind or solar farm meets FERC Order 661A low voltage requirements and return the wind or solar farm to its pre-disturbance operating voltage. If the results indicated the need for fast responding reactive support, dynamic support such as an SVC or STATCOM was investigated. If tripping of the prior queued projects was observed during the stability analysis (for under/over voltage or under/over frequency) the simulations were re-ran with the prior queued project's voltage and frequency tripping disabled.

3.1.2 DISIS-2016-002-2 Scenario D Stability Analysis Results

The DISIS-2016-002-2 Scenario D Stability Analysis determined that there were multiple contingencies in all seasonal cases that resulted in steady-state divergence issues and poor post-fault voltage recovery when all generation interconnection requests were at 100% output.

Refer to Table 3-5 for a summary of the DISIS-2016-002-2 Scenario D Stability Analysis results for the contingencies listed in Table 2-3. Table 3-5 is a summary of the stability results for the 2017 Winter Peak, 2018 Summer Peak, and 2026 Summer Peak conditions for the DISIS-2016-002-2 Scenario D requests and states whether the system remained stable or generation tripped offline, if acceptable voltage recovery was observed after the fault was cleared, and if the voltage recovered to above 0.9 p.u. and below 1.1 p.u. post fault steady-state conditions. Voltage recovery criteria includes ensuring that the transient voltage recovery is between 0.7 p.u. and 1.2 p.u. and ending in a steady-state voltage (for N-1 contingencies) at the pre-contingent level or at least above 0.9 p.u. and below 1.1. p.u. Refer to Appendix B, Appendix C, and Appendix D for a complete set of plots for all contingencies for 2017 Winter Peak, 2018 Summer Peak, and 2026 Summer Peak conditions, respectively.

Table 3-5
DISIS-2016-002-2 Scenario D Stability Analysis Summary of Results for 2017 Winter, 2018 Summer, and 2026 Summer Peak Conditions

Cont. No.	Cont. Name	2017 Winter Peak				2018 Summer Peak				2026 Summer Peak			
		Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability
		Less than 0.70 p.u.	Greater than 1.20 p.u.			Less than .70 p.u.	Greater than 1.20 p.u.			Less than .70 p.u.	Greater than 1.20 p.u.		
1	FLT01-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
2	FLT02-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
3	FLT03-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
4	FLT04-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
5	FLT05-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
6	FLT14-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
7	FLT15-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
8	FLT19-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
9	FLT20-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
10	FLT21-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
11	FLT22-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
12	FLT23-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
13	FLT24-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
14	FLT26-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
15	FLT27-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
16	FLT28-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
17	FLT29-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
18	FLT30-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
19	FLT31-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
20	FLT32-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
21	FLT33-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
22	FLT34-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
23	FLT35-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
24	FLT36-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
25	FLT37-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
26	FLT38-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
27	FLT40-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
28	FLT41-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
29	FLT43-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
30	FLT44-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
31	FLT45-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
32	FLT46-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
33	FLT47-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
34	FLT48-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable

Table 3-5 (continued)
DISIS-2016-002-2 Scenario D Stability Analysis Summary of Results for 2017 Winter, 2018 Summer, and 2026 Summer Peak Conditions

Cont. No.	Cont. Name	2017 Winter Peak				2018 Summer Peak				2026 Summer Peak			
		Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability
		Less than 0.70 p.u.	Greater than 1.20 p.u.			Less than .70 p.u.	Greater than 1.20 p.u.			Less than .70 p.u.	Greater than 1.20 p.u.		
35	FLT49-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
36	FLT50-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
37	FLT51-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
38	FLT52-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
39	FLT53-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
40	FLT54-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
41	FLT55-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
42	FLT56-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
43	FLT57-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
44	FLT58-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
45	FLT59-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
46	FLT60-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
47	FLT61-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
48	FLT62-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
49	FLT63-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
50	FLT64-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
51	FLT65-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
52	FLT66-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
53	FLT67-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
54	FLT68-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
55	FLT69-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
56	FLT70- PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
57	FLT71- PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
58	FLT72-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
59	FLT73-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
60	FLT74-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
61	FLT75-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
62	FLT76-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
63	FLT77-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
64	FLT78-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
65	FLT79-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
66	FLT80-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
67	FLT81-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
68	FLT82-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable

Table 3-5 (continued)
DISIS-2016-002-2 Scenario D Stability Analysis Summary of Results for 2017 Winter, 2018 Summer, and 2026 Summer Peak Conditions

Cont. No.	Cont. Name	2017 Winter Peak				2018 Summer Peak				2026 Summer Peak			
		Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability
		Less than 0.70 p.u.	Greater than 1.20 p.u.			Less than .70 p.u.	Greater than 1.20 p.u.			Less than .70 p.u.	Greater than 1.20 p.u.		
69	FLT83-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
70	FLT84-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
71	FLT85-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
71	FLT86-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
72	FLT87-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
73	FLT88-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
74	FLT89-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
75	FLT90-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
76	FLT91-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
77	FLT92-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
78	FLT93-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
79	FLT94-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
80	FLT95-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
81	FLT96-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
82	FLT97-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
83	FLT98-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
84	FLT99-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
85	FLT100-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
86	FLT101-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
87	FLT102-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
88	FLT103-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
89	FLT104-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
90	FLT105-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
91	FLT106-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
92	FLT107-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
93	FLT108-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
94	FLT109-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
95	FLT110-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
96	FLT111-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
97	FLT112-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
98	FLT113-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
99	FLT114-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
100	FLT115-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
101	FLT116-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable

Table 3-5 (continued)
DISIS-2016-002-2 Scenario D Stability Analysis Summary of Results for 2017 Winter, 2018 Summer, and 2026 Summer Peak Conditions

Cont. No.	Cont. Name	2017 Winter Peak				2018 Summer Peak				2026 Summer Peak			
		Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability
		Less than 0.70 p.u.	Greater than 1.20 p.u.			Less than .70 p.u.	Greater than 1.20 p.u.			Less than .70 p.u.	Greater than 1.20 p.u.		
102	FLT117-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
103	FLT118-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
104	FLT119-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
105	FLT120-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
106	FLT121-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
107	FLT122-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
108	FLT123-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
109	FLT124-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
110	FLT125-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
111	FLT126-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
112	FLT127-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
113	FLT128-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
114	FLT129-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
115	FLT130-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
116	FLT131-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
117	FLT132-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
118	FLT133-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
119	FLT134-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
120	FLT135-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
121	FLT136-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
122	FLT137-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
123	FLT138-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
124	FLT139-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
125	FLT140-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
126	FLT141-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
127	FLT142-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
128	FLT143-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
129	FLT144-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
130	FLT145-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
131	FLT146-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
132	FLT147-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
133	FLT148-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
134	FLT149-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
135	FLT150-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable

Table 3-5 (continued)
DISIS-2016-002-2 Scenario D Stability Analysis Summary of Results for 2017 Winter, 2018 Summer, and 2026 Summer Peak Conditions

Cont. No.	Cont. Name	2017 Winter Peak				2018 Summer Peak				2026 Summer Peak			
		Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability
		Less than 0.70 p.u.	Greater than 1.20 p.u.			Less than .70 p.u.	Greater than 1.20 p.u.			Less than .70 p.u.	Greater than 1.20 p.u.		
136	FLT151-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
137	FLT152-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
138	FLT153-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
139	FLT154-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
140	FLT155-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
141	FLT156-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
142	FLT157-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
143	FLT158-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
144	FLT159-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
145	FLT160-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
146	FLT161-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
147	FLT162-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
148	FLT163-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
149	FLT164-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
150	FLT165-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
151	FLT166-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
152	FLT167-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
153	FLT168-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
154	FLT169-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
155	FLT170-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
156	FLT171-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
157	FLT172-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
158	FLT173-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
159	FLT174-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
160	FLT175-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
161	FLT176-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
162	FLT177-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
163	FLT178-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
164	FLT179-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
165	FLT180-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
166	FLT182-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
167	FLT183-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
168	FLT184-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
169	FLT185-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
170	FLT186-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable

Table 3-5 (continued)
DISIS-2016-002-2 Scenario D Stability Analysis Summary of Results for 2017 Winter, 2018 Summer, and 2026 Summer Peak Conditions

Cont. No.	Cont. Name	2017 Winter Peak				2018 Summer Peak				2026 Summer Peak			
		Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability
		Less than 0.70 p.u.	Greater than 1.20 p.u.			Less than .70 p.u.	Greater than 1.20 p.u.			Less than .70 p.u.	Greater than 1.20 p.u.		
171	FLT187-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
172	FLT188-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
173	FLT191-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
174	FLT192-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
175	FLT193-3PH	-	-	Compliant	Stable	-	-	Not Compliant	Stable	-	-	Compliant	Stable
176	FLT195-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
177	FLT197-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
178	FLT199-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
179	FLT200-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
180	FLT201-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
181	FLT202-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
182	FLT203-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
183	FLT205-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
184	FLT206-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
185	FLT207-SB	-	-	Not Compliant	Stable	-	-	Not Compliant	Stable	-	-	Compliant	Stable
186	FLT209-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
187	FLT210-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
188	FLT211-SB	-	-	Not Compliant	Stable	-	-	Not Compliant	Stable	-	-	Compliant	Stable
189	FLT212-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
190	FLT213-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
191	FLT214-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
192	FLT215-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
193	FLT216-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
194	FLT217-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
195	FLT218-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
196	FLT219-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
197	FLT220-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
198	FLT221-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
199	FLT222-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
200	FLT223-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
201	FLT224-3PH (17W)	-	-	Compliant	Stable								
202	FLT224-3PH (18S,26S)					-	-	Compliant	Stable	-	-	Compliant	Stable
203	FLT225-3PH (17W)	-	-	Compliant	Stable								
204	FLT225-3PH (18S, 26S)					-	-	Compliant	Stable	-	-	Compliant	Stable
205	FLT226-3PH (17W)	-	-	Compliant	Stable								

Table 3-5 (continued)
DISIS-2016-002-2 Scenario D Stability Analysis Summary of Results for 2017 Winter, 2018 Summer, and 2026 Summer Peak Conditions

Cont. No.	Cont. Name	2017 Winter Peak				2018 Summer Peak				2026 Summer Peak			
		Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability
		Less than 0.70 p.u.	Greater than 1.20 p.u.			Less than .70 p.u.	Greater than 1.20 p.u.			Less than .70 p.u.	Greater than 1.20 p.u.		
206	FLT226-3PH (18S, 26S)	[redacted]				-	-	Compliant	Stable	-	-	Compliant	Stable
207	FLT227-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
208	FLT228-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
209	FLT229-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
210	FLT230-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
211	FLT231-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
212	FLT232-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
213	FLT233-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
214	FLT234-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
215	FLT235-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
216	FLT236-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
217	FLT237-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
218	FLT238-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
219	FLT239-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Oscillation
220	FLT241-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Not Compliant	Stable
221	FLT242-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
222	FLT244-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
223	FLT245-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
224	FLT246-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
225	FLT247-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
226	FLT248-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
227	FLT249-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
228	FLT250-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
229	FLT251-PO	Steady-State Divergence				Steady-State Divergence				Steady-State Divergence			
230	FLT253-PO	-	-	Compliant	Units Trip	-	-	Compliant	Units Trip	-	-	Compliant	Units Trip
231	FLT262-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
232	FLT263-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
233	FLT264-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
234	FLT265-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
235	FLT266-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
236	FLT267-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
237	FLT268-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
238	FLT270-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
239	FLT271-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
240	FLT272-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable

Table 3-5 (continued)
DISIS-2016-002-2 Scenario D Stability Analysis Summary of Results for 2017 Winter, 2018 Summer, and 2026 Summer Peak Conditions

Cont. No.	Cont. Name	2017 Winter Peak				2018 Summer Peak				2026 Summer Peak			
		Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability
		Less than 0.70 p.u.	Greater than 1.20 p.u.			Less than .70 p.u.	Greater than 1.20 p.u.			Less than .70 p.u.	Greater than 1.20 p.u.		
241	FLT273-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
242	FLT274-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
243	FLT275-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
244	FLT278-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
245	FLT279-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
246	FLT280-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
247	FLT281-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
248	FLT282-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
249	FLT283-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
250	FLT284-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
251	FLT285-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
252	FLT286-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
253	FLT287-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
254	FLT289-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
255	FLT290-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
256	FLT291-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
257	FLT292-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
258	FLT293-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
259	FLT294-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
260	FLT295-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
261	FLT296-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
262	FLT297-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
263	FLT298-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
264	FLT299-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
265	FLT300-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
266	FLT301-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
267	FLT302-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
268	FLT303-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
269	FLT304-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
270	FLT318-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
271	FLT319-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
272	FLT322-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
273	FLT324-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
274	FLT325-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
275	FLT326-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
276	FLT327-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
277	FLT328-PO	-	-	Not Compliant	Stable	-	-	Not Compliant	Stable	-	-	Compliant	Stable

Summary of Results

It was observed for faults at Crossroads 345kV that the existing dynamic models for Vestas wind turbine generators interconnected at Crossroads 345kV did not provide an adequate response returning to the initial power factor set point following fault recovery and thus were observed to enter and exit low voltage ride through mode with the user-written model Vestas VWCOR6. The Vestas turbines are expected to provide voltage control, a variable power factor set point dynamically adjusting with system conditions. Therefore, the dynamic models for GEN-2016-123, GEN-2016-124, and GEN-2016-125 were updated to the user-written Vestas Generic Model Structure V7 version of the Vestas dynamic models. With these updated models and power plant controller, it was observed that the study requests at Crossroads 345kV remained online and recovered successfully for a fault at Crossroads 345kV. Note the reactive power output for these machines is required to be set by the PSS/E user according to the User Model. In order to achieve a stable response, the reactive power output should be set such that the terminal voltage of each equivalent generator is between 1.03 p.u. and 1.05 p.u. for all steady-state conditions.

FLT251-PO, a prior outage contingency that resulted in the prior loss of the Tolk 345/230kV transformer, which removes the Crossroads 345kV outlet path to Tolk, followed by a fault and loss of the Eddy County to Kiowa 345kV, resulted in steady-state divergence when taking the Tolk 345/230kV transformer out of service. To mitigate this divergence issue, a 100 MVAR capacitor bank(s), which was determined as mitigation in the power flow analysis, was added to the Crossroads 345kV bus for all three seasons. The size of this capacitor was determined in power flow and identified the 17WP season as the limiting case. After adding this capacitor, the steady-state divergence issues associated with the outage of this transformer and the Crossroads to Tolk 345kV line were resolved. However, for a subsequent fault that results in the loss of Eddy County to Kiowa 345kV, generation curtailment was required for all three seasons. The following curtailment of generating facilities interconnected at Crossroads 345kV was required during the outage of the Crossroads to Tolk 345kV circuit or the Tolk 345/230kV transformers for the following seasons:

- 17WP total generation curtailment: 200 MW
- 18SP total generation curtailment: 200 MW
- 26SP total generation curtailment: 50 MW

FLT253-PO, a prior outage contingency that resulted in the loss of the Eddy County to Kiowa 345kV line followed by a fault resulting in the loss of the Crossroads to Tolk 345kV, required updates to the modeling of the reactive power output of GEN-2016-123, GEN-2016-124, and GEN-2016-125 as mitigation for the observed unit tripping. The reactive power output of these study requests required a set point that absorbed reactive power in order to reduce voltages at Crossroads 345kV following the 3-phase fault. Refer to Table 3-6 for the reactive power output and generator terminal voltage set points that were required to mitigate the study request tripping.

Table 3-6
Reactive Power and Generator Terminal Voltages near Crossroads 345kV for FLT253-PO

Bus Number	Request	ID	Pgen (MW)	17W		18S		26S	
				Eterm (p.u.)	Qgen (MVAR)	Eterm (p.u.)	Qgen (MVAR)	Eterm (p.u.)	Qgen (MVAR)
588003	GEN-2016-123	1	148	0.993	-10	0.988	-10	0.991	-10
588006	GEN-2016-123	2	150	0.988	-5	0.984	-5	0.986	-5
588013	GEN-2016-124	1	150	0.969	-10	0.973	-5	0.985	0
588023	GEN-2016-125	1	74	0.969	-10	0.984	-5	0.987	-5
577120	GEN-2008-022	3	50	0.976	0	0.971	0	0.974	0
599157	Roosevelt Wind	1	124	0.982	0	0.978	0	0.980	0
599159	Roosevelt Wind	2	126	1.002	10	0.998	10	1.000	10

Several faults resulted in low post-fault steady-state voltage at Oklaunion 345kV. For 17WP conditions, FLT207-SB, FLT211-SB, and FLT328-PO were all observed to have low post-fault steady-state voltages at Oklaunion 345kV. The steady-state analysis identified the need for 200 MVAR of static reactive support (capacitor bank) at Oklaunion 345kV and was implemented as mitigation for these faults. With the addition of the static reactive support, all post-steady-state voltage violations were mitigated. Refer to Figure 3-1 for a representative voltage plot of Oklaunion 345kV with and without mitigation for FLT207-SB (SLG stuck breaker fault resulting in the loss of the Tuco 345/230kV transformer and Tuco to Border 345kV line).

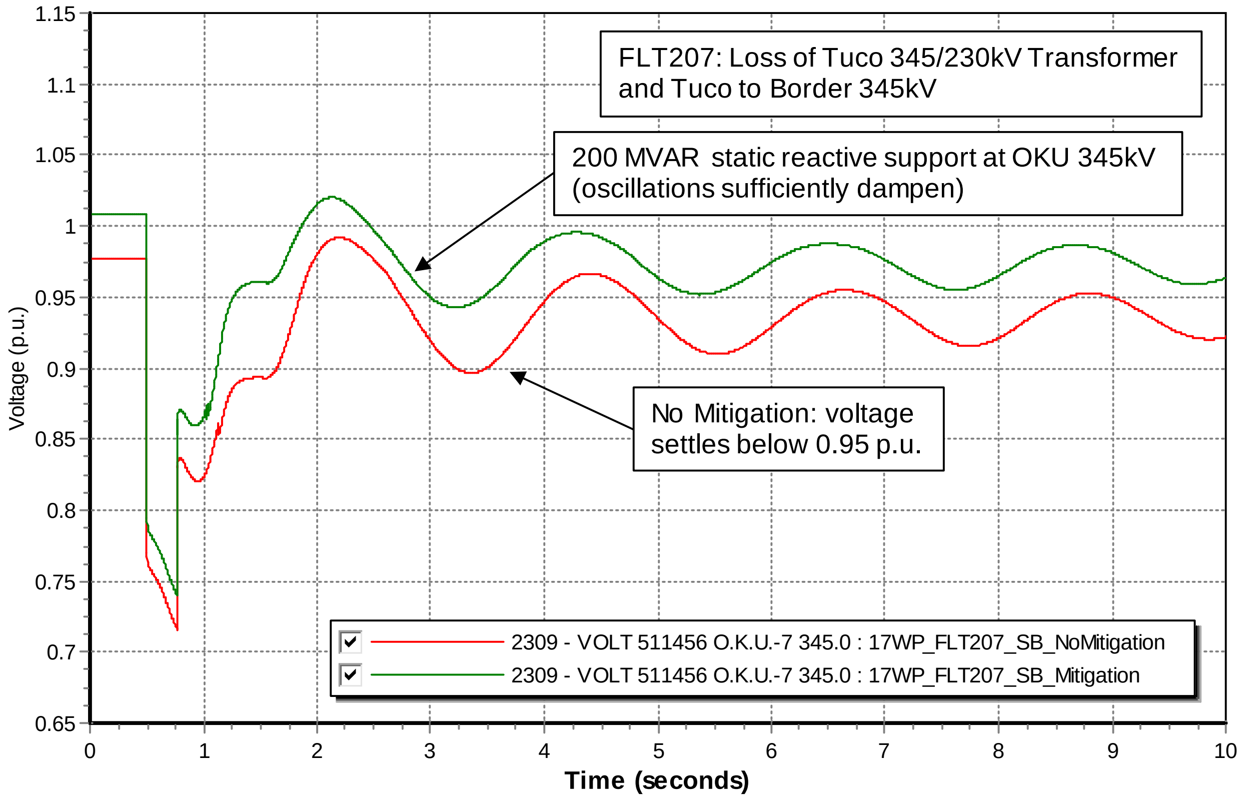

Figure 3-1: Representative plot of Oklaunion 345kV voltage for FLT207-SB for 17WP conditions.

It was determined that FLT328-PO, prior outage of Potter County to Hitchland 345kV followed by the loss of Border to Woodward 345kV, resulted in low post-fault steady-state voltages at OKU 345kV with the additional 200 MVAR of static reactive support. In addition to the static reactive support at OKU 345kV, 200 MW of generation curtailment of up to 200MW from generating facilities is required for 17WP and 18SP conditions. Refer to Figure 3-2 for a representative voltage plot of the OKU 345kV bus voltage for FLT328-PO with and without generation curtailment mitigation.

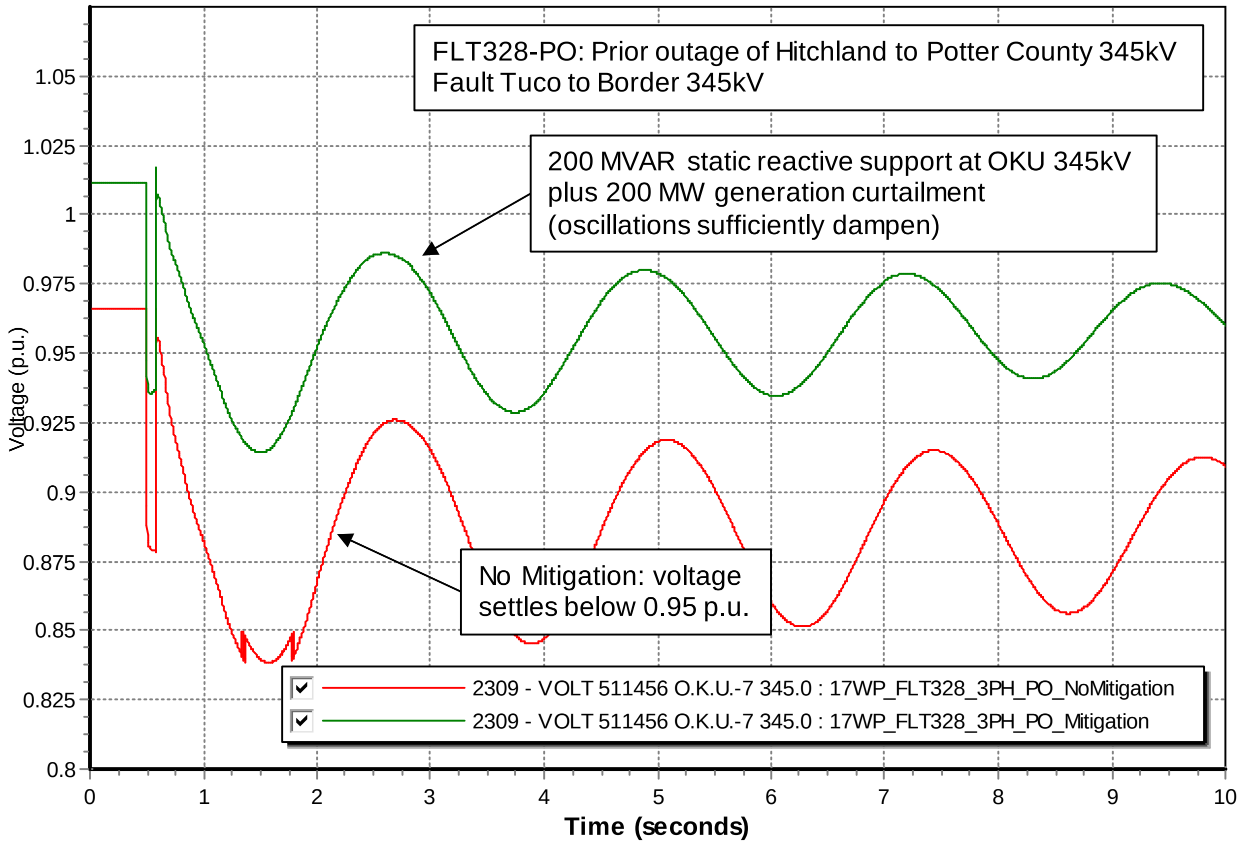

Figure 3-2: Representative plot of Oklaunion 345kV voltage for FLT228-PO for 17WP conditions.

Prior outage fault events involving circuits terminating at Border 345kV, Crossroads 345kV, Eddy County 345kV, Hitchland 345kV, Kiowa 345kV, Potter County 345kV, Tolk 345kV, TUCO 345kV, and Woodward 345kV resulted in curtailment of up to 200MW from generating facilities following the prior outage in order for acceptable system response for all three seasons.

FLT242-3PH, which is a three-phase reclose fault that results in the loss of the Tolk East to Roosevelt 230kV line was observed to experience a delayed voltage recovery within SPP criteria for the 26SP case. Slow voltage recovery was observed near Tolk 230kV and the Curry 115kV area. Refer to Figure 3-3 for a representative plot of area bus voltages and Figure 3-4 for a representative plot of area generation. It was observed that this fault was a limiting contingency but all voltages and rotor angles recovered within SPP Performance Criteria.

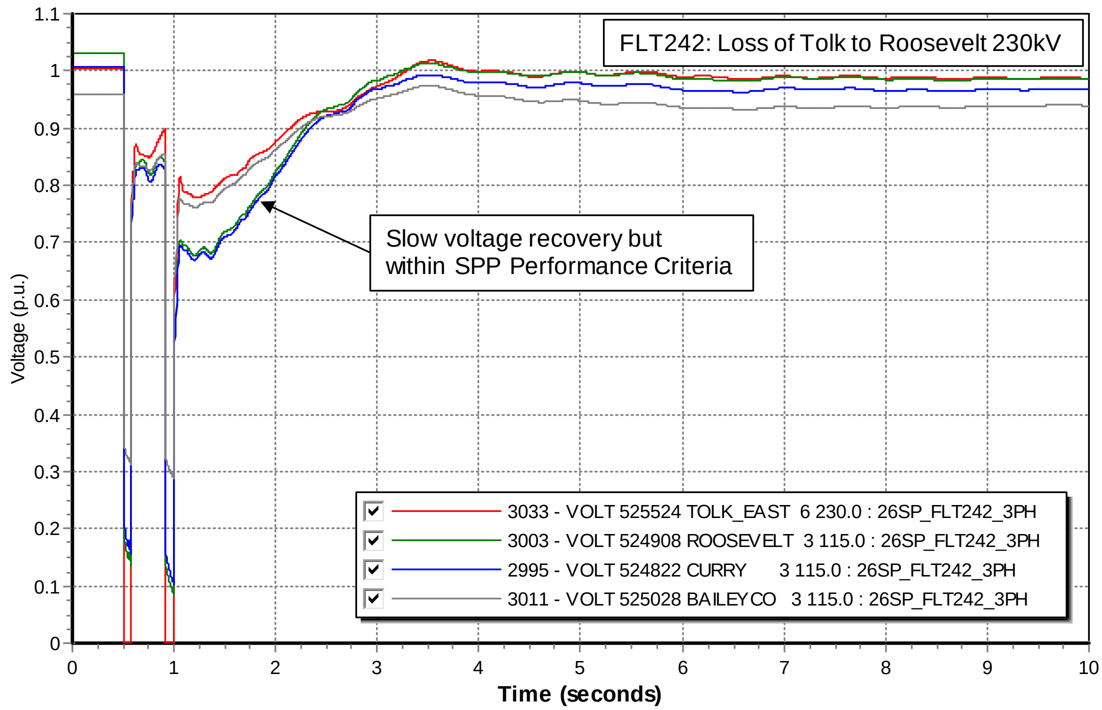

Figure 3-3: Representative plot of area bus voltages for FLT242-3PH for 26SP conditions.

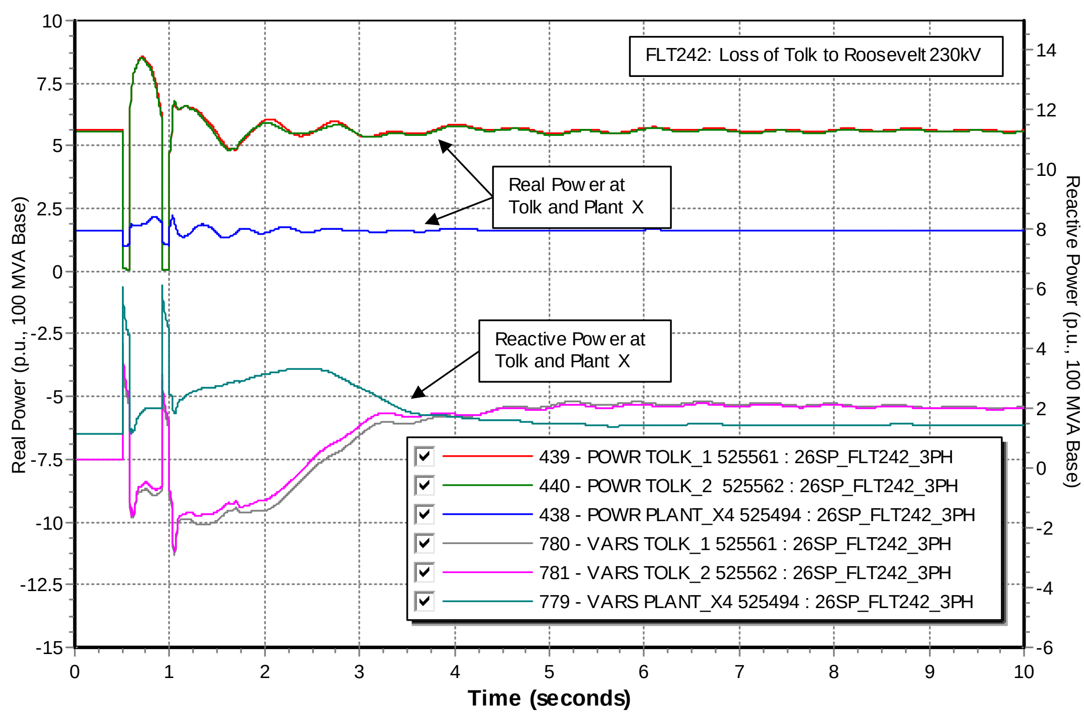

Figure 3-4: Representative plot of area generation for FLT242-3PH for 26SP conditions.

3.2 DISIS-2016-002-2 Sensitivity Analysis

A sensitivity analysis was performed as part of the DISIS-2016-002-2 study to analyze the impact of generation local to the current study request GEN-2015-099. The Stability Analysis performed in Section 3.1 was studied with the Cunningham and Maddox generation units at the dispatch provided in the MDWG stability cases. The Cunningham and Maddox generation units were scaled to 100% of maximum real power output. Generation in the SPP study area was scaled to maintain generation and load balance. Refer to Table 3-7 for the generation dispatch utilized for the sensitivity analysis. Refer to Table 3-8 for a select set of contingencies local to study request GEN-2015-099.

Table 3-7
Group 06 Conventional Generation Dispatch for Sensitivity Analysis

Generation	Bus	DISIS-2016-002-2 Group 06 – Scenario D			
		Close Proximity	17W	18S	26S
Hobbs Plant 1	527901	Yes	145.0	145.0	145.0
Hobbs Plant 2	527902	Yes	144.0	144.0	144.0
Hobbs Plant 3	527903	Yes	213.0	213.0	213.0
Cunningham unit 1	527881	Yes	Offline	Offline	Offline
Cunningham unit 2	527882	Yes	204	204	Offline
Cunningham unit 3	527883	Yes	108	108	108
Cunningham unit 4	527884	Yes	107	107	107
Maddox unit 1	528361	Yes	115	115	115
Maddox unit 2	528362	Yes	57.7	57.7	Offline
Maddox unit 3	528363	Yes	10	10	10
Tuco (Elk) unit 1	525844	No	201.0	195.2	195.8
Tuco (Elk) unit 2	525845	No	201.0	190.2	190.8
Antelope A	525841	No	54.4	54.9	55.1
Antelope B	525842	No	54.4	54.9	55.1
Antelope C	525843	No	54.4	54.9	55.1
Tolk unit 1	525561	Yes	205.5	563.0	563.0
Tolk unit 2	525562	Yes	Offline	557.9	557.9
Mustang unit 1	527161	No	115.4	124.6	130.5
Mustang unit 2	527162	No	115.4	124.6	130.5
Mustang unit 3	527163	No	122.7	132.4	138.6

Mustang unit 4	527164	No	88.6	121.6	128.8
Mustang unit 5	527165	No	Offline	122.4	128.8
Mustang unit 6	527166	No	Offline	129.5	141.1
Plant X unit 1	525491	No	Offline	Offline	37.0
Plant X unit 2	525492	No	Offline	58.8	74.6
Plant X unit 3	525493	No	72.6	58.8	83.8
Plant X unit 4	525494	No	Offline	94.2	162.9
Gaines Units	offline	No	Offline	Offline	Offline

Table 3-8
Case List for Sensitivity Analysis

Cont. Name	Description
FLT108-3PH	3 phase fault on the Maddox (528355) to Cunningham (527864) 115 kV line circuit 1, near Maddox. a. Apply fault at the Maddox 115 kV 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.
FLT109-3PH	3 phase fault on the Maddox (528355) to Hobbs Interchange (527891) 115 kV line circuit 1, near Maddox. a. Apply fault at the Maddox 115 kV 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.
FLT110-3PH	3 phase fault on the Maddox (528355) to Pearle (528392) 115 kV line circuit 1, near Maddox. a. Apply fault at the Maddox 115 kV 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.
FLT111-3PH	3 phase fault on the Maddox (528355) to Sanger Switch (528463) 115 kV line circuit 1, near Maddox. a. Apply fault at the Maddox 115 kV 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.

Cont. Name	Description
FLT112-3PH	3 phase fault on the Maddox (528355) to Monument (528491) 115 kV line circuit 1, near Maddox. a. Apply fault at the Maddox 115 kV 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.
FLT113-3PH	3 phase fault on the Cunningham (527864) to Monument Tap (528568) 115 kV line circuit 1, near Cunningham. a. Apply fault at the Cunningham 115 kV 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.
FLT114-3PH	3 phase fault on the Cunningham (527864) to Buckeye Tap (528348) 115 kV line circuit 1, near Cunningham. a. Apply fault at the Cunningham 115 kV 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.
FLT115-3PH	3 phase fault on the Cunningham (527864) to Quahada (528394) 115 kV line circuit 1, near Cunningham. a. Apply fault at the Cunningham 115 kV 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.
FLT116-3PH	3 phase fault on the Cunningham (527864) to Hobbs Interchange (527891) 115 kV line circuit 1, near Cunningham. a. Apply fault at the Cunningham 115 kV 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.
FLT117-3PH	3 phase fault on the Cunningham 230/115/13.2 kV (527864/527867/527863) transformer circuit 1, near Cunningham. a. Apply fault at the Cunningham 115 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.

Cont. Name	Description
FLT118-3PH	3 phase fault on the Hobbs Interchange (527891) to LE-West (528333) 115 kV line circuit 1, near Hobbs Interchange. a. Apply fault at the Hobbs Interchange 115 kV 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.
FLT119-3PH	3 phase fault on the Hobbs Interchange (527891) to Bensing (528333) 115 kV line circuit 1, near Hobbs Interchange. a. Apply fault at the Hobbs Interchange 115 kV 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.
FLT120-3PH	3 phase fault on the Hobbs Interchange (527891) to Millen (528435) 115 kV line circuit 1, near Hobbs Interchange. a. Apply fault at the Hobbs Interchange 115 kV 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.
FLT121-3PH	3 phase fault on the Hobbs Interchange 230/115/13.2 kV (527891/527894/527890) transformer 1, near Hobbs Interchange. a. Apply fault at the Hobbs Interchange 115 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
FLT123-SB	**Single phase fault with stuck breaker at Maddox (528355)** a. Apply fault at the Maddox 115 kV bus. b. Clear fault after 16 cycles and trip the following elements c. Maddox (528355) – Cunningham (527864) 115 kV d. Maddox (528355) – Hobbs Interchange (527891) 115 kV
FLT124-SB	**Single phase fault with stuck breaker at Maddox (528355)** a. Apply fault at the Maddox 115 kV bus. b. Clear fault after 16 cycles and trip the following elements c. Maddox (528355) – Cunningham (527864) 115 kV d. Maddox (528355) – Monument (528491) 115 kV
FLT125-SB	**Single phase fault with stuck breaker at Maddox (528355)** a. Apply fault at the Maddox 115 kV bus. b. Clear fault after 16 cycles and trip the following elements c. Maddox (528355) – Sanger Switch (528463) 115 kV d. Maddox (528355) – Pearle (528392) 115 kV

Cont. Name	Description
FLT126-SB	**Single phase fault with stuck breaker at Maddox (528355)** a. Apply fault at the Maddox 115 kV bus. b. Clear fault after 16 cycles and trip the following elements c. Maddox (528355) – Sanger Switch (528463) 115 kV d. Maddox (528355) – Monument (528491) 115 kV
FLT127-SB	**Single phase fault with stuck breaker at Cunningham (527864)** a. Apply fault at the Cunningham 115 kV bus. b. Clear fault after 16 cycles and trip the following elements c. Cunningham (527864) – Hobbs Interchange (527891) 115 kV circuit 1 d. Cunningham (527864) – Hobbs Interchange (527891) 115 kV circuit 2
FLT128-SB	**Single phase fault with stuck breaker at Cunningham (527864)** a. Apply fault at the Cunningham 115 kV bus. b. Clear fault after 16 cycles and trip the following elements c. Cunningham (527864) – Buckeye Tap (528348) 115 kV d. Cunningham (527864) – Monument Tap (528568) 115 kV
FLT129-SB	**Single phase fault with stuck breaker at Hobbs Interchange (527891)** a. Apply fault at the Hobbs Interchange 115 kV bus. b. Clear fault after 16 cycles and trip the following elements c. Hobbs Interchange (527891) – Millen (528435) 115 kV d. Hobbs Interchange (527891) – Bensing (528433) 115 kV
FLT130-SB	**Single phase fault with stuck breaker at Hobbs Interchange (527891)** a. Apply fault at the Hobbs Interchange 115 kV bus. b. Clear fault after 16 cycles and trip the following elements c. Hobbs Interchange 230/115/13.2 kV (527891/527894/527890) transformer circuit 1 d. Hobbs Interchange 230/115/13.2 kV (527891/527894/527889) transformer circuit 2
FLT131-PO	**Prior Outage of the Maddox (528355) to Cunningham (527864) 115 kV line circuit 1;** 3 phase fault on the Maddox (528355) to Hobbs Interchange (527891) 115 kV line circuit 1, near Maddox. a. Apply fault at the Maddox 115 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
FLT132-PO	**Prior Outage of the Maddox (528355) to Cunningham (527864) 115 kV line circuit 1;** 3 phase fault on the Maddox (528355) to Pearle (528392) 115 kV line circuit 1, near Maddox. a. Apply fault at the Maddox 115 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.

Cont. Name	Description
FLT133-PO	**Prior Outage of the Maddox (528355) to Cunningham (527864) 115 kV line circuit 1;** 3 phase fault on the Maddox (528355) to Sanger Switch (528463) 115 kV line circuit 1, near Maddox. a. Apply fault at the Maddox 115 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
FLT134-PO	**Prior Outage of the Maddox (528355) to Sanger Switch (528463) 115 kV line circuit 1;** 3 phase fault on the Maddox (528355) to Cunningham (527864) 115 kV line circuit 1, near Maddox. a. Apply fault at the Maddox 115 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
FLT135-PO	**Prior Outage of the Maddox (528355) to Sanger Switch (528463) 115 kV line circuit 1;** 3 phase fault on the Maddox (528355) to Hobbs Interchange (527891) 115 kV line circuit 1, near Maddox. a. Apply fault at the Maddox 115 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
FLT136-PO	**Prior Outage of the Maddox (528355) to Sanger Switch (528463) 115 kV line circuit 1;** 3 phase fault on the Maddox (528355) to Monument (528491) 115 kV line circuit 1, near Maddox. a. Apply fault at the Maddox 115 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
FLT137-PO	**Prior Outage of the Maddox (528355) to Sanger Switch (528463) 115 kV line circuit 1;** 3 phase fault on the Maddox (528355) to Pearle (587670) 115 kV line circuit 1, near Maddox. a. Apply fault at the Maddox 115 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
FLT224-3PH	3 phase fault on the Kiowa (527965) to Hobbs (527896) 345 kV line circuit 1, near Hobbs. a. Apply fault at the Hobbs 345 kV 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.
FLT262-3PH	3 phase fault on the Hobbs (527894) to Andrews (528604) 230 kV line circuit 1, near Hobbs. a. Apply fault at the Hobbs 230 kV 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.

Cont. Name	Description
FLT265-3PH	3 phase fault on the G1579&G1580T (560059) to Hobbs (527894) 230 kV line circuit 1, near G1579&G1580T. a. Apply fault at the G1579&G1580T 230 kV 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.
FLT266-SB	**Single phase fault with stuck breaker at Hobbs (527894) 230 kV** a. Apply fault at the Hobbs 230 kV bus. b. Clear fault after 16 cycles and trip the following elements c. Hobbs (527894) – Cunningham (527867) 230 kV d. Hobbs 230/115/13.2 kV (527894/527891/527889) transformer
FLT267-SB	**Single phase fault with stuck breaker at Hobbs (527894) 230 kV** a. Apply fault at the Hobbs 230 kV bus. b. Clear fault after 16 cycles and trip the following elements c. Hobbs (527894) – G1579&G1580T (560059) 230 kV d. Hobbs 230/115/13.2 kV (527894/527891/527889) transformer
FLT268-SB	**Single phase fault with stuck breaker at Hobbs (527894) 230 kV** a. Apply fault at the Hobbs 230 kV bus. b. Clear fault after 16 cycles and trip the following elements c. Hobbs (527894) – G1579&G1580T (560059) 230 kV d. Hobbs (527894) – Cunningham (527867) 230 kV
FLT270-PO	**Prior Outage of the Hobbs (527894) to Cunningham (527865) 230 kV line circuit 1;** 3 phase fault on the Hobbs 230/115/13.2 kV (527894/527891/527890) transformer 1, near Hobbs. a. Apply fault at the Hobbs 230 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
FLT271-PO	**Prior Outage of the Hobbs (527894) to Cunningham (527865) 230 kV line circuit 1;** 3 phase fault on the G1579&G1580T (560059) to Hobbs (527894) 230 kV line circuit 1, near G1579&G1580T. a. Apply fault at the G1579&G1580T 230 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
FLT272-PO	**Prior Outage of the Hobbs (527894) to Cunningham (527865) 230 kV line circuit 1;** 3 phase fault on the G1579&G1580T (560059) to Yoakum (526935) 230 kV line circuit 1, near G1579&G1580T. a. Apply fault at the G1579&G1580T 230 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.

Cont. Name	Description
FLT273-PO	**Prior Outage of the Hobbs (527894) to Andrews (528604) 230 kV line circuit 1;** 3 phase fault on the Hobbs 230/115/13.2 kV (527894/527891/527890) transformer 1, near Hobbs. a. Apply fault at the Hobbs 230 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
FLT274-PO	**Prior Outage of the Hobbs (527894) to Andrews (528604) 230 kV line circuit 1;** 3 phase fault on the G1579&G1580T (560059) to Hobbs (527894) 230 kV line circuit 1, near G1579&G1580T. a. Apply fault at the G1579&G1580T 230 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
FLT275-PO	**Prior Outage of the Hobbs (527894) to Andrews (528604) 230 kV line circuit 1;** 3 phase fault on the G1579&G1580T (560059) to Yoakum (526935) 230 kV line circuit 1, near G1579&G1580T. a. Apply fault at the G1579&G1580T 230 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
FLT329-3PH	3 phase fault on the Hobbs (527896) to Yoakum (526936) 345 kV line circuit 1, near Hobbs. a. Apply fault at the Hobbs 345 kV 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.

3.2.1 DISIS-2016-002-2 Sensitivity Analysis Results

The DISIS-2016-002-2 Sensitivity Analysis determined that there no voltage stability or generation tripping offline for the local faults to Hobbs, Cunningham, and Maddox substations when all generation interconnection requests were at 100% output. All voltages and rotor angles recovered within SPP Performance Criteria.

Refer to Table 3-9 for a summary of the DISIS-2016-002-2 Sensitivity Analysis results for the contingencies listed in Table 3-8. Table 3-9 is a summary of the sensitivity results for 2017 Winter Peak, 2018 Summer Peak, and 2026 Summer Peak conditions and states whether the system remained stable or generation tripped offline, if acceptable voltage recovery was observed after the fault was cleared, and if the voltage recovered to above 0.9 p.u. and below 1.1 p.u. post fault steady-state conditions. Refer to Appendix E, Appendix F, and Appendix G for a complete set of plots for all contingencies for 2017 Winter Peak, 2018 Summer Peak, and 2026 Summer Peak conditions, respectively.

Table 3-9
DISIS-2016-002-2 Sensitivity Analysis Summary of Results

Sens. Cont. No.	Cont. Name	2017 Winter Peak				2018 Summer Peak				2026 Summer Peak			
		Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability
		Less than 0.70 p.u.	Greater than 1.20 p.u.			Less than .70 p.u.	Greater than 1.20 p.u.			Less than .70 p.u.	Greater than 1.20 p.u.		
1	FLT108-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
2	FLT109-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
3	FLT110-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
4	FLT111-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
5	FLT112-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
6	FLT113-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
7	FLT114-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
8	FLT115-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
9	FLT116-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
10	FLT117-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
11	FLT118-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
12	FLT119-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
13	FLT120-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
14	FLT121-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
15	FLT122-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
16	FLT123-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
17	FLT124-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
18	FLT125-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
19	FLT126-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
20	FLT127-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
21	FLT128-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
22	FLT129-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
23	FLT130-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
24	FLT131-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
25	FLT132-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
26	FLT133-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
27	FLT134-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
28	FLT135-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
29	FLT136-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
30	FLT137-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable

Table 3-9 (continued)
DISIS-2016-002-2 Sensitivity Analysis Summary of Results

Sens. Cont. No.	Cont. Name	2017 Winter Peak				2018 Summer Peak				2026 Summer Peak			
		Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability
		Less than 0.70 p.u.	Greater than 1.20 p.u.			Less than .70 p.u.	Greater than 1.20 p.u.			Less than .70 p.u.	Greater than 1.20 p.u.		
31	FLT224-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
32	FLT262-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
33	FLT265-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
34	FLT266-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
35	FLT267-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
36	FLT268-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
37	FLT270-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
38	FLT271-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
39	FLT272-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
40	FLT273-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
41	FLT274-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
42	FLT275-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
43	FLT329-3H	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable

SECTION 4: CONCLUSIONS

Summary of Stability Analysis

The Stability Analysis determined that there were several contingencies in all three seasonal cases that resulted in steady-state divergence, low post-fault steady-state voltages, or system instability when all generation interconnection requests were at 100% output. To mitigate the steady-state divergence issues, the following steady-state upgrades were implemented in the DISIS-2016-002-2 Scenario D cases:

- Install at least 100 Mvar capacitor bank(s) at Crossroads 345kV (steady-state mitigation)
- Install at least 200 Mvar capacitor bank(s) at OKU 345kV (steady-state mitigation)

Prior outage fault events involving circuits terminating at Border 345kV, Crossroads 345kV, Eddy County 345kV, Hitchland 345kV, Kiowa 345kV, Potter County 345kV, Tolk 345kV, TUCO 345kV, and Woodward 345kV resulted in curtailment of up to 200MW from generating facilities following the prior outage in order for acceptable system response for all three seasons.

Note for faults at Crossroads 345kV, Vestas wind turbine generators were observed to enter and exit low voltage ride through mode with the user-written model Vestas VWCOR6. Updating these study requests to the user-written Vestas Generic Model Structure V7 dynamic model improved the plant response and recovered within SPP Performance Criteria. In accordance with FERC Order 661-A, the interconnecting customer will need to ensure that the design of the facilities does not trip generation for a fault at the Point of Interconnection ("POI") and allows for system recovery.

After implementing the above upgrades, the contingency analysis was simulated for all contingencies. With the upgrades, the Stability Analysis determined that there was no wind turbine tripping or system instability observed as a result of interconnecting all study projects at 100% output.

Additionally, a sensitivity analysis was performed for faults local to GEN-2015-099. For this sensitivity, the Hobbs, Cunningham, and Maddox generating units were scaled to maximum capacity. It was determined all faults local to Hobbs, Cunningham, and Maddox substations recovered within SPP Performance Criteria when all generation interconnection requests were at 100% output.

GROUP 7 STABILITY ANALYSIS

The consultant noted in the prior DISIS-2016-002 Group 07 analysis that for certain faults, the Blue Canyon Windpower II generating facility comprised of the higher queued requests GEN-2003-004, GEN-2004-023, & GEN-2005-003 exhibited a simulation numerical issue; the GNET command was implemented for that facility. This model adjustment was applied to the DISIS-2016-002-2 Group 07 analysis.

The Group 7 cases included the following system adjustments of dispatching, to maximum output, generation interconnected at the same or adjacent substations to a current study request:

- Southwestern Station & Anadarko units: GEN-2016-097

The Group 7 stability analysis for this area was performed by S&C Electric Company (S&C).

With the new requests modeled, violations of stability damping, voltage recovery, or steady-state voltage criteria were observed.

Evaluation of P1 Planning Event FLT-67 on Border to Woodward EHV 345kV circuit 1 resulted in momentary high voltage at Border 345kV above 1.2pu as specified in SPP Disturbance Performance Requirements. Border 345kV is the Point of Interconnection for North Rim Wind Energy (GEN-2011-049 & GEN-2015-004) generating facility comprised of full size converter (inverter) generators represented in PSS®E dynamic simulation with the SWTGU1 and SWTEU1 user-written models.

As resolving simulation numerical issue of higher queued requests requires analysis beyond the scope of this study, it is recommended that the Generator Owner(s) of the North Rim Wind Energy generating facility perform model validation to improve the PSS/E model response and if necessary coordinate with the Transmission Owner(s) (OKGE & SWPS) to evaluate any applicable operational guide(s) and Corrective Action Plans utilized in transmission planning assessment.

Evaluation of P6, prior outage, Planning Event involving Gracemont 345kV/138kV transformer and Southwestern Power Station to Washita 138kV circuits, FLT-27, determined that a system adjustment involving curtailment of all DISIS-2016-002 Group 7 requests did not adequately improve the system response. A system adjustment involving curtailment of Southwestern Station & Anadarko units by at least 62 MW was found to remedy the observed oscillations.

Alternately, as the FLT-27 oscillations may be exhibited from a simulation numerical issue. Implementing the GNET command on the higher queued Blue Canyon Windpower generating facility request GEN-2001-026 (in addition to the adjacent Blue Canyon Windpower II generating facility from GEN-2003-004, GEN-2004-023, & GEN-2005-003) was found to remedy the observed oscillations.

As resolving simulation numerical issue of higher queued requests requires analysis beyond the scope of this study, it is recommended that the Generator Owner(s) of the Blue Canyon Windpower and Blue Canyon Windpower II generating facilities perform model validation to improve the PSS/E model response and if necessary coordinate with the Transmission Owner(s) (AEPW, OKGE, & WFEC) to evaluate any applicable operational guide(s) and Corrective Action Plans utilized in transmission planning assessment.

Evaluation of P6, prior outage, Planning Events involving Chisholm to Sweetwater 230kV and Grapevine to Wheeler 230kV circuits determined that a system adjustment involving curtailment of generation from generating facilities may be required following a prior outage to achieve acceptable system response for a subsequent fault event. For the scenarios studied, curtailment to approximately 240 MW at Sweetwater 230kV is required following a circuit outage. Actual system conditions may require output reduction of GEN-2016-132, Elk City II Wind (GEN-2006-002), Dempsey Ridge Wind Farm (GEN-2006-035), and Elk City Wind (GEN-2006-043) to maintain the reliability of the transmission network.

It is recommended that the Transmission Owner(s) for the Sweetwater 230kV area (AEPW & SWPS) evaluate any applicable operational guide(s) and Corrective Action Plans utilized in transmission planning assessment.

With all previously-assigned and currently-assigned Network Upgrades placed in service and identified system adjustments applied, no violations were observed (except as noted earlier), including violations of low-voltage ride-through requirements, for the probable contingencies studied.

S&C ELECTRIC COMPANY
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DISIS-2016-002-2 (GROUP 07)

LITTLE ROCK, AR

SOUTHWEST POWER POOL

DEFINITIVE INTERCONNECTION SYSTEM IMPACT STUDY

S&C PROJECT NUMBER: 15824

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FINAL REPORT

CONFIDENTIAL

MARCH 17, 2020

S&C ELECTRIC COMPANY
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DISCLAIMER

REPORT REVISION HISTORY:

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1. Executive Summary

S&C Electric Company (S&C) performed a Definitive Interconnection System Impact Study (the "original study"), DISIS-2016-002 (Group 7), in response to a request through Southwest Power Pool (SPP) Tariff. After the original study, the following updates were implemented to the study cases:

- Increase of the rating of GEN-2002-005 from 118.5MW to 123MW (increase of the equivalent unit reflects the GIA and queue capacity).
- Decrease of the rating of GEN-2006-035 from 224MW to 132MW (removal of the unbuilt equivalent unit to reflect the amended GIA and queue capacity).
- Removal of GEN-2016-037, a request that returned to the DISIS queue (DISIS-2017-001), and corresponding tap on Chisholm-Gracemont 345kV circuit 1.
- Removal of withdrawn GEN-2015-071, GEN-2015-084, & GEN-2015-085 requests.
- Removal of no longer previously assigned upgrades Border-Chisholm circuits 1 & 2.

As a result, S&C has performed the DISIS-2016-002-2 restudy (Group 7), considering these changes.

Group 7 consists of four (4) interconnection requests (GEN-2016-091, GEN-2016-095, GEN-2016-097, and GEN-2016-132).

S&C has performed dynamic stability analysis for Group 7 under Cluster scenarios. The cluster studies were performed using three (3) cluster base cases (2017 Winter Peak (WP), 2018 Summer Peak (SP), and 2026 SP) provided by SPP. In the cluster studies, all four interconnection requests and prior-queued projects were studied at 100% of nameplate MW capacity.

Initially, based on the findings in the original study DISIS-2016-002 and communication with SPP, dynamic data updates have been applied to the case studies, as follows:

- Due to a simulation numerical issue, PSS/E GNET command was used to replace the generator and dynamic model of the prior-queued Blue Canyon Windpower II generating facility equivalent model located at bus 599003 (GEN-2003-004, GEN-2004-023, GEN-2005-003) with a converted load equivalent to the steady-state facility output.

- To reflect the FERC Order 661-A requirement to prevent tripping during the fault period, under-voltage protection settings (tripping time 1, 'GXX048' CON J+10, increased from 0.04 sec to 0.625 sec) of Dempsey Ridge Wind Farm generating facility equivalent unit located at bus 599049 (GEN-2006-035) were modified.

The dynamic stability simulations indicated that except for the following contingencies, per SPP Disturbance Performance Requirements, the system remains stable under each studied contingency and that all studied interconnection projects stay online during and after the contingencies simulated:

- FLT-77: Prior Outage of Chisholm-Sweetwater 230kV line; 3-phase fault on Grapevine-Wheeler 230kV line, near Wheeler.
- FLT-78: Prior Outage of Grapevine-Wheeler 230kV line; 3-phase fault on Chisholm-Sweetwater 230kV line, near Sweetwater.

For contingencies FLT-77 and FLT-78, several tripping actions and voltage recovery violations were observed in all the study cases around Sweetwater 230 kV bus, which is the Point of Interconnection (POI) of the study project GEN-2016-132. It should be noted that, contingencies FLT-77 and FLT-78 cause all generation interconnected to Sweetwater 230kV bus (337.82MW total from GEN-2006-002, GEN-2006-035, GEN-2006-043, and GEN-2016-132) to be connected radially to Sweetwater-Wheeler 230kV circuit in the post-contingency condition. Furthermore, Sweetwater-Wheeler 230kV circuit would be connected radially to 230kV/115kV step-down transformer at Wheeler station in the post contingency condition.

In order to mitigate these issues for N-1-1 contingencies of FLT-77 and FLT-78, the total generation output from all generating units interconnected to the Sweetwater 230kV bus was found in the study cases to require curtailment to between 240 MW and 250 MW to maintain system reliability following the outage of either the Chisholm-Sweetwater 230kV circuit or the Grapevine-Wheeler 230kV circuit. With the mitigation plans of active power reduction, the system does not show any stability issues for these contingencies.

Furthermore, it has been observed that the bus voltage at Border 345kV substation surpasses the voltage limit of 1.2pu as specified in SPP Disturbance Performance Requirements for all the study cases for the following contingency:

- FLT-67: 3-phase fault on Border-Woodward EHV 345kV line, near Border.

It should be noted that the over voltage observed for this bus is immediately upon fault clearing and is momentary, > 1 cycle in duration, likely caused by the post-fault terminal voltage spikes observed at the nearby North Rim Wind Energy (GEN-2011-049 & GEN-2015-004) generating facility full size converter (inverter) equivalent generators at buses 583093 and 583096, which are modelled using SWTGU1 and SWTEU1 user-written models. Such post-fault spikes are not uncommon in inverter models used in positive-sequence power system simulation tools such as PSS®E and do not typically represent the field behavior of actual equipment.

In addition, for contingency FLT-27, although no tripping occurred, abnormal oscillations were observed in all three study cases in the area close to Washita 138kV substation. FLT-27 is defined as follows:

- FLT-27: Prior Outage of Gracemont 345kV/138kV transformer; 3-phase fault on Washita-Southwestern Power Station 138kV line, near Southwestern Power Station.

S&C performed further investigations to uncover the cause of abnormal oscillations observed for FLT-27. First, the dynamic stability studies were repeated with the DISIS-2016-002 (Group 7) interconnection requests projects disconnected from the study cases. Similar oscillations were observed in the simulation results, which confirms that observed oscillations were not caused by the addition of the study generators.

Furthermore, testing was repeated with the total dispatch of synchronous (non-wind) generators around the area of Washita 138kV, Gracemont 138kV and Anadarko 138kV substations (Southwestern Power Station 653.7MW from units 1-5; Orme 150MW from GEN-2007-052; Anardarko 352MW from units 1-6; Cogen 100MW from units 1-2) curtailed by 62 MW from 1255.7 MW to 1193.7 MW. Testing indicated that under the curtailed output scenario, the abnormal oscillation issue was resolved.

Finally, testing was also repeated with the Blue Canyon Windpower generating facility (GEN-2001-026) equivalent unit modeled as a ‘WT1G1’ type 1 generic wind turbine generator at bus 599006 GNETed without generation curtailment. Again, testing indicated that with both the Blue Canyon Windpower and Blue Canyon Windpower II each GNETed, the abnormal oscillation issue was resolved. Therefore, it is concluded that the abnormal oscillations observed for FLT-27 contingency likely represent a modelling issue with the existing case.

It is recommended that the Generator Owner(s) of the Blue Canyon Windpower and Blue Canyon Windpower II generating facilities perform model validation to improve the PSS/E model response and if necessary coordinate with the Transmission Owner to develop any necessary Operation Guides and Corrective Action Plans.

Finally, S&C has performed a short-circuit analysis for the 2018 Summer Peak and 2026 Summer Peak under Group 7 Cluster and reported short-circuit results at all buses up to five (5) levels away from the POI of the study projects.

2. INTRODUCTION

S&C Electric Company (S&C) performed a Definitive Interconnection System Impact Study (the "original study"), DISIS-2016-002 (Group 7), in response to a request through Southwest Power Pool (SPP) Tariff. After the original study, the following updates were implemented to the study cases:

- Increase of the rating of GEN-2002-005 from 118.5MW to 123MW (increase of the equivalent unit reflects the GIA and queue capacity)
- Decrease of the rating of GEN-2006-035 from 224MW to 132MW (removal of equivalent unit to reflect the amended GIA and queue capacity)
- Removal of GEN-2016-037, a request that returned to the DISIS queue (DISIS-2017-001), and corresponding tap on Chisholm-Gracemont 345kV circuit 1
- Removal of withdrawn GEN-2015-071, GEN-2015-084, & GEN-2015-085 requests
- Removal of no longer previously assigned upgrades Border-Chisholm circuits 1 & 2

As a result, S&C has performed the restudy for DISIS-2016-002-2 (Group 7), considering these changes. In summary, a total of 587.5 MW generation has been removed from the previously queued projects for this restudy of group 7. Generation was balanced by scaling up other generators in the SPP footprint.

Group 7 consists of four (4) new interconnection requests listed in Table 2-1 and fifteen (15) previously queued projects listed in Table 2-2.

Table 2-1: DISIS-2016-002-2 (Group 7) Generation Interconnection Requests

Request	Size (MW)	Generator Model	Point of Interconnection
GEN-2016-091	303.6	Siemens 2.3MW VS	Tap Gracemont-Lawton East Side 345kV (587744)
GEN-2016-095	200	Vestas V110 VCSS 2.0MW	Tap Gracemont - Lawton East Side 345 kV (587744)
GEN-2016-097	100	Vestas V110 VCSS 2.0MW	Tap Southwestern-Fletcher Tap 138 kV (587794)
GEN-2016-132	(6.12MW update of GEN-2006-002)	GE 1.62MW	Sweetwater 230 kV (511541)

Table 2-2: Prior Queued (Group 7) Projects

Request	Size (MW)	Generator Model	Point of Interconnection
GEN-2001-026	74.25	NEG Micon 1.65MW	Washita 138 kV (521089)
GEN-2002-005	123	Acciona 1.5MW	Red Hills Tap 138 kV (521116)
GEN-2003-004/ GEN-2004-023/ GEN-2005-003	151.2	Vestas V80 1.8MW	Washita 138 kV (521089)
GEN-2003-005/ GEN-2011-037	105.6	G.E. 1.6MW	Anadarko - Paradise (Blue Canyon) 138 kV (521129)
GEN-2003-022/ GEN-2004-020/ GEN-2016-051	156.8	GE 1.6MW	Weatherford 138 kV (511506)
GEN-2006-002	100.8	GE 1.5/1.6MW	Sweetwater 230 kV (511541)
GEN-2006-035	132	Gamesa G87 2.0MW	Sweetwater 230 kV (511541)
GEN-2006-043	98.9	Siemens 93m 2.3MW	Sweetwater 230 kV (511541)
GEN-2007-052	150	GE LM6000 CT 50MW	Anadarko 138 kV (520814)
GEN-2008-023	148.8	GE 1.6MW	Hobart Junction 138 kV (511463)
GEN-2008-037	99	Vestas V90 VCUS 1.8 MW	Slick Hills 138 kV (521089)
GEN-2011-049/ GEN-2015-004	303.6	Siemens VS 2.3MW	Border 345 kV (515458)
GEN-2012-028	74	Vestas V110 VCSS 2.0 MW	Gotebo 69kV (520925)
GEN-2015-013	119.952	Eaton Power Xpert Solar Inverters 1.666MW	Snyder 138 kV (521052)
GEN-2015-055	40	Advanced Energy AE 500NX 0.5MW solar inverters	Erick 138 kV (520903)

3. Transmission System and Study Area

Group 7 is connected to the Southwestern Oklahoma Area. For the dynamic stability studies, the following areas were monitored in the analysis:

- American Electric Power West (AEPW, Area #520)
- Oklahoma Gas & Electric (OKGE, Area #524)
- Southwestern Public Service (SPS, Area #526)
- Midwest Energy (MIDW, Area #531)
- Sunflower Electric Power Corporation (SUNC, Area #534)
- Westar Energy, Inc. (WERE, Area #536)

4. Power Flow Base Cases

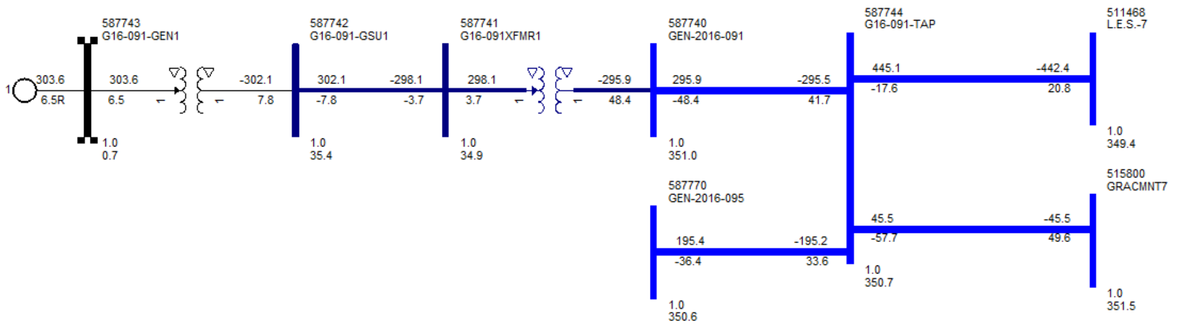
DISIS-2016-002-2 (Group 7) and prior-queued projects were modeled as aggregated generating units in the base cases from SPP.

The Cluster Scenario Base Cases include:

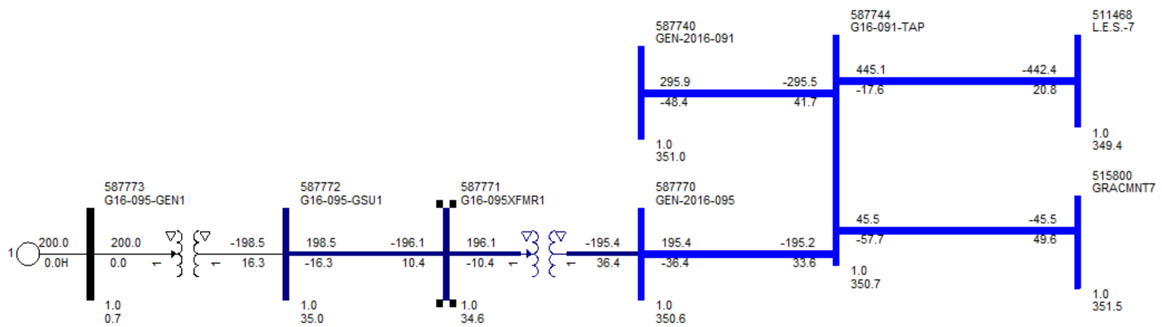
- **MDWG16-17W_DIS16021_G07.sav** – 2017 Winter Peak Cluster Base Case for Group 7. New interconnection requests and prior queued projects at 100% output power.
- **MDWG16-18S_DIS16021_G07.sav** – 2018 Summer Peak Cluster Base Case for Group 7. New interconnection requests and prior queued projects at 100% output power.
- **MDWG16-26S_DIS16021_G07.sav** – 2026 Summer Peak Cluster Base Case for Group 7. New interconnection requests and prior queued projects at 100% output power.

5. Power Flow Model

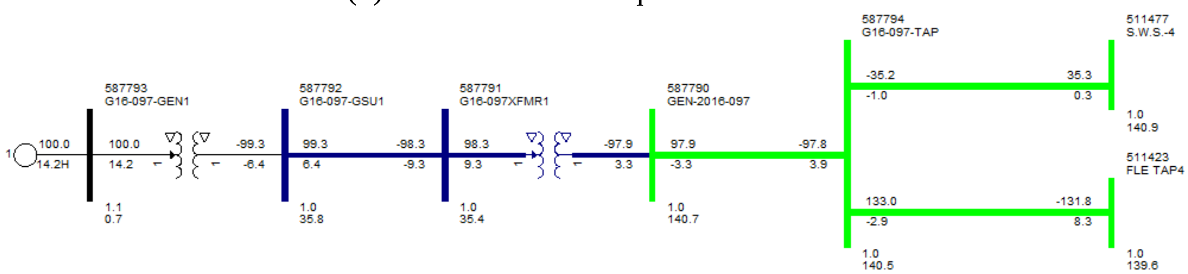
S&C created one-line diagrams depicted in Figure 1 for each interconnection request.



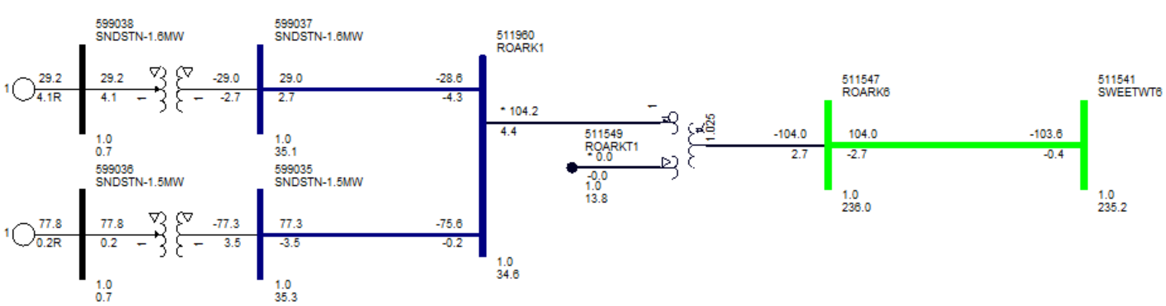
(a) Interconnection request GEN-2016-091



(b) Interconnection request GEN-2016-095



(c) Interconnection request GEN-2016-097



(d) Interconnection request GEN-2016-132

Figure 1: One-line Diagrams of the Interconnection Request Projects

6. Dynamic Stability Analysis

6.1. Assumptions

Dynamic stability analysis was performed for all the SPP contingencies listed in Appendix A. S&C modified several of the previously identified contingencies in the DISIS-2016-002 study. The modifications were mainly due to network modifications related to this restudy as detailed in section 2.

Three phase faults were simulated as bolted faults, while single line-to-ground faults were simulated under the assumption that a single line-to-ground fault will cause a 40% drop in the positive-sequence voltage at the fault location.

6.2. Stability Criteria

Dynamic stability studies were performed to ensure system stability following critical faults on the system. The system is considered stable if the following conditions are met:

(1) Disturbances including three-phase and single-phase to ground faults, should not cause synchronous and asynchronous plants to disconnect from the transmission grid.

(2) The angular positions of synchronous machine rotor become constant following an aperiodic system disturbance.

(3) Voltage magnitudes and frequencies at terminals of asynchronous generators should not exceed magnitudes and durations that will cause protection elements to operate. Furthermore, the response after the disturbance needs to be studied at the terminals of the machine to ensure that there are no sustained oscillations in power output, speed, frequency, etc.

(4) Voltage magnitudes and angles after the disturbance should settle to a constant and acceptable operating level. Frequencies should settle to the acceptable range within nominal 60 Hz power frequency.

In addition, performance of the transmission system is measured against the SPP Disturbance Criteria Requirements on Angular oscillations and Transient Voltage Recovery, as detailed in

Appendix B. Dynamic stability plots for all the Cluster scenarios are provided in Appendix C. Dynamic data for all study interconnection requests for Group 7 is provided in Appendix D.

6.3. DYNAMIC STABILITY RESULTS

The dynamic stability study was performed for the three base case scenarios: 2017 WP, 2018 SP, and 2026 SP for all the SPP contingencies listed in Appendix A. The dynamic data were updated based on the findings in the original study DISIS-2016-002 and communication with SPP, as follows:

- Due to a simulation numerical issue, PSS/E GNET command was used to replace the generator and dynamic model of the prior-queued Blue Canyon Windpower II generating facility equivalent model located at bus 599003 (GEN-2003-004, GEN-2004-023, GEN-2005-003) with a converted load equivalent to the steady-state facility output.
- To reflect the FERC Order 661-A requirement to prevent tripping during the fault period, under-voltage protection settings (tripping time 1, 'GXX048' CON J+10, increased from 0.04 sec to 0.625 sec) of Dempsey Ridge Wind Farm generating facility equivalent unit located at bus 599049 (GEN-2006-035) were modified.

Initially, the base case dynamic data was analyzed, and stable initial runs were obtained. Then, time-domain simulations were performed to evaluate the dynamic performance of the system under the identified contingencies listed in Appendix A. System dynamic voltage recovery and post-disturbance steady state performance under the identified contingencies were also checked against SPP voltage recovery criteria. Additionally, simulation logs were scanned to identify any tripped generators during simulations.

The dynamic stability analysis shows that except for the following contingencies, per SPP Disturbance Performance Requirements, the system remains stable under each studied contingency and that all studied interconnection projects stay online during and after studied contingencies:

- FLT-77: Prior Outage of Chisholm-Sweetwater 230kV line; 3-phase fault on Grapevine-Wheeler 230kV line, near Wheeler.

- FLT-78: Prior Outage of Grapevine-Wheeler 230kV line; 3-phase fault on Chisholm-Sweetwater 230kV line, near Sweetwater.

The detailed dynamic stability plots of select channels for all simulated contingences for each peak season are provided in Appendices C-1 to C-3.

For contingencies FLT-77 and FLT-78, several tripping actions and voltage recovery violations were observed in all study cases around the Sweetwater 230 kV bus, which is the POI of study project GEN-2016-132. The list of tripping elements for these contingencies for each case study is provided in Table 6-1. Furthermore, Table 6-2 presents the maximum and post-contingency voltage of Wheeler 230kV bus for these two contingencies, which shows several violations. As an example, Figure 2 shows the voltage response of Wheeler 230kV bus for contingencies FLT-78 and FLT-77 in the 2018 SP base case. It is noted that the voltage is recovered after the tripping of the generators connected to the Sweetwater 230kV substation and the Sweetwater-Wheeler 230 kV line by the SLNSO1 relay.

Table 6-1: Elements Tripped for Contingencies FLT-77 and FLT-78 in Different Case Studies

Case	FLT-77	FLT-78
2017 WP	• DEMPSEY_WTG1 [599049] unit 1 tripped on overspeed	• DEMPSEY_WTG1 [599049] unit 1 tripped on overspeed
2018 SP	• SWEETWT6- STLN-DEMARC6 ckt 1 [523779-511541] tripped with relay SLNOS1#1 • DEMPSEY_WTG1 [599049] unit 1 tripped on over speed • SNDSTN-1.5MW [599036] unit 1 tripped on over voltage • SNDSTN-1.6MW [599038] unit 1 tripped on over voltage • ELK_CITY_WG1 [599051] unit 1 tripped on over voltage	• DEMPSEY_WTG1 [599049] unit 1 tripped on over speed • SNDSTN-1.5MW [599036] unit 1 tripped on under voltage • SNDSTN-1.6MW [599038] unit 1 tripped on under voltage
2026 SP	• DEMPSEY_WTG1 [599049] unit 1 tripped on over speed • SNDSTN-1.5MW [599036] unit 1 tripped on under voltage • SNDSTN-1.6MW [599038] unit 1 tripped on under voltage	• DEMPSEY_WTG1 [599049] unit 1 tripped on overspeed

Table 6-2: Wheeler 230kV Voltage Perfromance for FLT-77 and FLT-78 in Different Case Studies

Case	FLT-77	FLT-78
2017 WP	• Post-contingency Voltage: 1.026 pu • Max Voltage: 1.153 pu	• Post-contingency Voltage: 1.026 pu • Max Voltage: 1.156 pu
2018 SP	• Post-contingency Voltage: 1.074 pu • Max Voltage: 1.172 pu	• **Post-contingency Voltage: 1.106 pu** • Max Voltage: 1.1806 pu
2026 SP	• Post-contingency Voltage: 1.097 pu • Max Voltage: 1.163 pu	• Post-contingency Voltage: 1.049 pu • **Max Voltage: 1.236 pu**

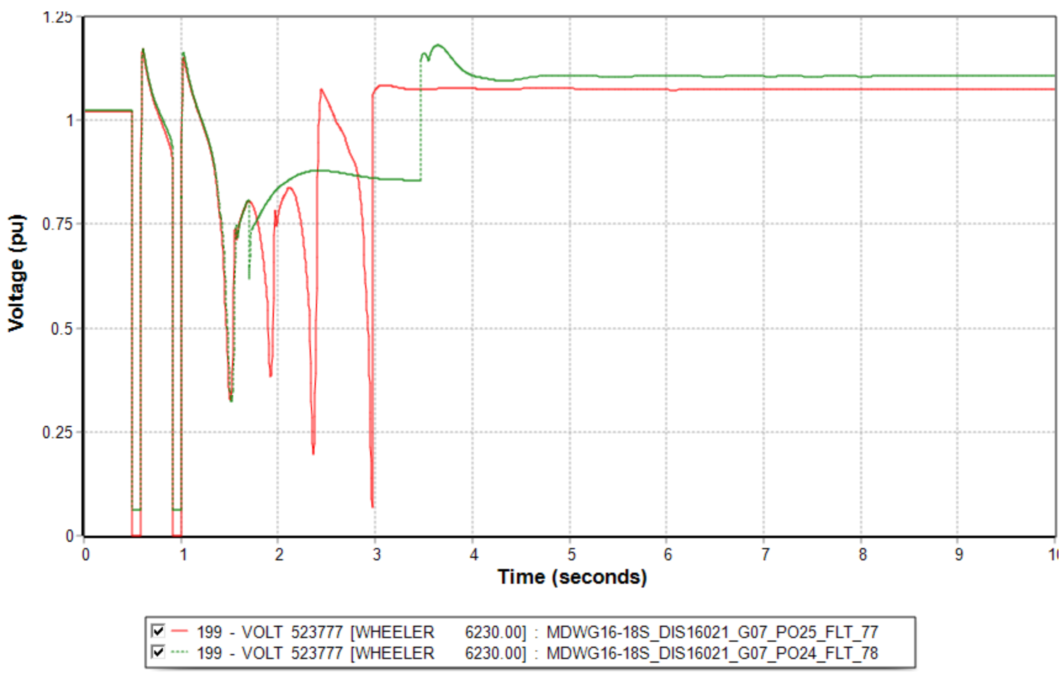


Figure 2: Wheeler 230kV Voltage Response for FLT-77 and FLT-78 in 2018 SP Case

It should be noted that, contingencies FLT-77 and FLT-78 cause all generation interconnected to Sweetwater 230kV bus (337.82MW total from GEN-2006-002, GEN-2006-035, GEN-2006-043, and GEN-2016-132) to be radially connected to Sweetwater-Wheeler 230kV circuit in the post-contingency condition. Furthermore, Sweetwater-Wheeler 230kV circuit would be radially connected to the 230kV/115kV step-down transformer at Wheeler station in the post contingency condition.

In order to mitigate these issues for N-1-1 contingencies of FLT-77 and FLT-78, the total generation output from all generating units interconnected to Sweetwater 230kV bus was found in the study cases to require curtailment for the outage of either Chisholm-Sweetwater 230kV circuit or Grapevine-Wheeler 230kV circuit. Table 6-3 provides details of mitigation plan for these two contingencies in different case studies. With the active power reduction, the system does not show any stability issues for these contingencies. As an example, Figure 5 demonstrates the voltage response of the Wheeler 230kV bus for contingencies FLT-77 and FLT-78 in the 2018 SP case with respective mitigation plans.

Detailed plots of the dynamic stability results for these two contingencies for each peak season, with curtailed dispatch of Sweetwater 230kV generation, are given in Appendices C-4 to C-6.

Table 6-3: Contingencies FLT-77 and FLT-78 Mitigation Plans in Different Case Studies

Generators	Original Output (MW)	Contingency	Prior Outage	Reduced Output (MW)		
				2017WP	2018SP	2026SP
Dempsey Wind (599049), Elk City II Wind Farm (599038, 599036), Elk City Wind Energy Center (599051)	338	FLT-77	Chisholm-Sweetwater 230kV line	240	250	250
		FLT-78	Grapevine-Wheeler 230kV line	240	240	250

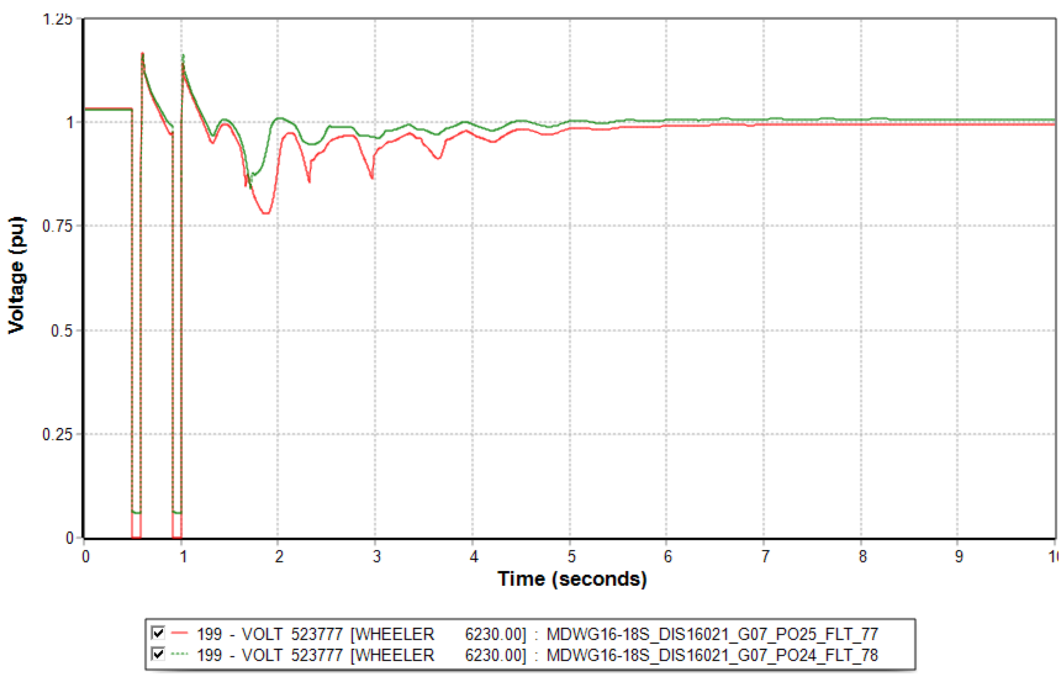


Figure 3: Wheeler 230kV Voltage Response for FLT-77 and FLT 78 in 2018 SP Case with Sweetwater 230kV Generating Units Dispatched at 250 MW and 240 MW, respectievly

Furthermore, it has been observed that bus voltage at Border 345kV substation surpasses the voltage limit of 1.2 pu as specified in SPP Disturbance Performance Requirements for all the study cases for the following contingency:

- FLT-67: 3-phase fault on Border-Woodward EHV 345kV line, near Border.

As an example, Figure 4 demonstrates the voltage response of Border 345kV substation during the contingency FLT-67 in 2018 SP case, which shows the voltage violation in the form of spikes when the fault at the Border 345kV is cleared. As can be seen from the figure the terminal voltage of these units reaches 1.5 pu when the fault is cleared. It should be noted that the over voltage observed for this bus is immediately upon fault clearing and is momentary, > 1 cycle in duration, likely caused by the post-fault terminal voltage spikes observed at the nearby North Rim Wind Energy (GEN-2011-049 & GEN-2015-004) generating facility full size converter (inverter) equivalent generators at buses 583093 and 583096, which are modelled using SWTGU1 and SWTEU1 user-written models. Such post-fault spikes are not uncommon in inverter models used in positive-sequence power system simulation tools such as PSS®E and do not typically represent the field behavior of actual equipment.

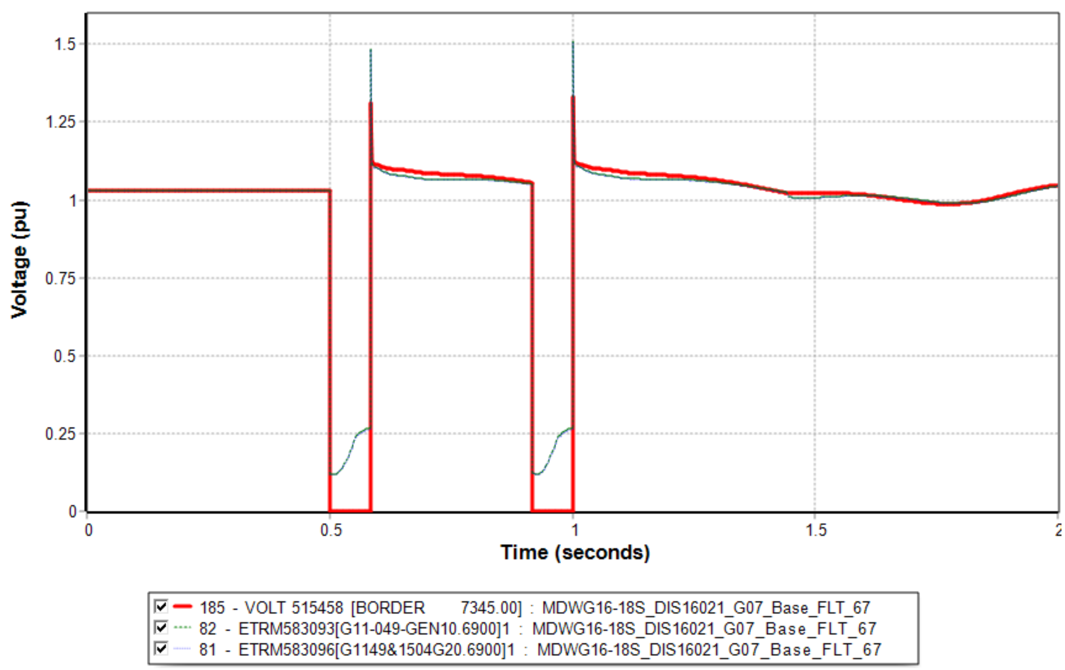


Figure 4: Border 345kV Voltage and Generators at Buses 583093 and 583096 Terminal Voltage Responses for FLT-67 in 2018 SP Case

Additionally, for contingency FLT-27, although no tripping occurred, abnormal oscillations were observed in all three study cases in the area close to the Washita 138kV substation. FlT-27 is defined as follows:

- FLT-27: Prior Outage of Gracemont 345kV/138kV transformer; 3-phase fault on Washita-Southwestern Power Station 138kV line, near Southwestern Power Station.

S&C performed further investigations to uncover the cause of abnormal oscillations observed for FLT-27. First, the dynamic stability studies were repeated with the DISIS-2016-002 (Group 7)interconnection requests projects disconnected from the study cases. Similar oscillations were observed in the simulation results, which confirms that observed oscillations were not caused by the addition of the study generators.

Furthermore, testing was repeated with the total dispatch of synchronous (non-wind) generators around the area of Washita 138kV, Gracemont 138kV and Anadarko 138kV substations (Southwestern Power Station 653.7MW from units 1-5; Orme 150MW from GEN-2007-052; Anardarko 352MW from units 1-6; Cogen 100MW from units 1-2) curtailed by 62 MW from 1255.7 MW to 1193.7 MW. Testing indicated that under the curtailed output scenario, the abnormal oscillation issue was resolved.

Finally, testing was also repeated with the Blue Canyon Windpower generating facility (GEN-2001-026) equivalent unit modeled as a ‘WT1G1’ type 1 generic wind turbine generator at bus GNETed without generation curtailment. Again, testing indicated that with both the Blue Canyon Windpower and Blue Canyon Windpower II each GNETed, the abnormal oscillation issue was resolved. Therefore, it is concluded that the abnormal oscillations observed for FLT-27 contingency likely represent a modelling issue with the existing case.

It is recommended that the Generator Owner(s) of the Blue Canyon Windpower and Blue Canyon Windpower II generating facilities perform model validation to improve the PSS/E model response and if necessary coordinate with the Transmission Owner to develop any necessary Operation Guides and Corrective Action Plans.

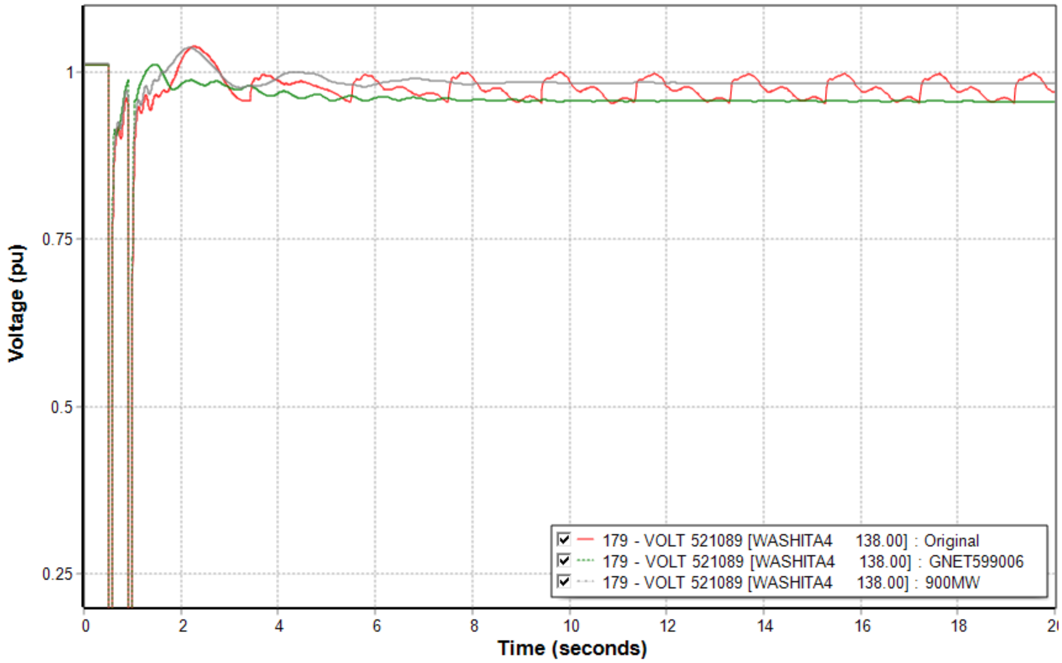


Figure 5: Washita 138kV Voltage Response for FLT-27 in (a) Original 2026 SP Case, (b) 2026 SP Case with 599006 GNETed, and (c) 2026 SP case with Generation Curtailment

7. SHORT-CIRCUIT STUDY

A short-circuit study has been performed on the power flow models for the 2018 SP and 2026 SP seasons for each queued generator in Group 7. The short-circuit analysis includes applying a 3-phase fault on buses up to 5 levels away from the POI of each interconnection request project. PSS®E "Automatic Sequence Fault Calculation (ASCC)" fault analysis module was used for short-circuit analysis. The results of the short-circuit analysis have been recorded for all the buses up to five levels away from the point of interconnection of each interconnection request project. Summary tables for the results of the short-circuit study are provided in Appendix E.

8. Conclusions and Recommendations

S&C Electric Company (S&C) performed a Definitive Interconnection System Impact Study (the "original study"), DISIS-2016-002 (Group 7), in response to a request through Southwest Power Pool (SPP) Tariff.

The dynamic stability simulations indicated that except for the following contingencies, per SPP Disturbance Performance Requirements, the system remains stable under each studied contingency and that all studied interconnection projects stay online during and after the contingencies simulated:

- FLT-77: Prior Outage of Chisholm-Sweetwater 230kV line; 3-phase fault on Grapevine-Wheeler 230kV line, near Wheeler.
- FLT-78: Prior Outage of Grapevine-Wheeler 230kV line; 3-phase fault on Chisholm-Sweetwater 230kV line, near Sweetwater.

For contingencies FLT-77 and FLT-78, several tripping actions and voltage recovery violations were observed in all the study cases around Sweetwater 230 kV bus, which is the Point of Interconnection (POI) of the study project GEN-2016-132. It should be noted that, contingencies FLT-77 and FLT-78 cause all generation interconnected to Sweetwater 230kV bus (337.82MW total from GEN-2006-002, GEN-2006-035, GEN-2006-043, and GEN-2016-132) to be connected radially to Sweetwater-Wheeler 230kV circuit in the post-contingency condition. Furthermore, Sweetwater-Wheeler 230kV circuit would be connected radially to 230kV/115kV step-down transformer at Wheeler station in the post contingency condition.

In order to mitigate these issues for N-1-1 contingencies of FLT-77 and FLT-78, the total generation output from all generating units interconnected to the Sweetwater 230kV bus was found in the study cases to require curtailment to between 240 MW and 250 MW to maintain system reliability following the outage of either the Chisholm-Sweetwater 230kV circuit or the Grapevine-Wheeler 230kV circuit. With the mitigation plans of active power reduction, the system does not show any stability issues for these contingencies.

Furthermore, it has been observed that the bus voltage at Border 345kV substation surpasses the voltage limit of 1.2pu as specified in SPP Disturbance Performance Requirements for all the study cases for the following contingency:

- FLT-67: 3-phase fault on Border-Woodward EHV 345kV line, near Border.

It should be noted that the over voltage observed for this bus is immediately upon fault clearing and is momentary, > 1 cycle in duration, likely caused by the post-fault terminal voltage spikes observed at the nearby North Rim Wind Energy (GEN-2011-049 & GEN-2015-004) generating facility full size converter (inverter) equivalent generators at buses 583093 and 583096, which are modelled using SWTGU1 and SWTEU1 user-written models. Such post-fault spikes are not uncommon in inverter models used in positive-sequence power system simulation tools such as PSS®E and do not typically represent the field behavior of actual equipment.

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Finally, testing was also repeated with the Blue Canyon Windpower generating facility (GEN-2001-026) equivalent unit modeled as a 'WT1G1' type 1 generic wind turbine generator at bus 599006 GNETed without generation curtailment. Again, testing indicated that with both the Blue Canyon Windpower and Blue Canyon Windpower II each GNETed, the abnormal oscillation issue was resolved. Therefore, it is concluded that the abnormal oscillations observed for FLT-27 contingency does likely represent a modelling issue with the existing case.

It is recommended that the Generator Owner(s) of the Blue Canyon Windpower and Blue Canyon Windpower II generating facilities perform model validation to improve the PSS/E model response and if necessary coordinate with the Transmission Owner to develop any necessary Operation Guides and Corrective Action Plans.

A short-circuit study has been performed on the power flow models for the 2018 Summer Peak Season and 2026 Summer Peak Season for each generator. A 3-phase fault is applied on buses up to 5 levels away from the POI of each interconnection request project and the results of the study have been presented.

APPENDIX A

SPP GROUP 7 FAULT DEFINITIONS

Table 8-1: Group 7 Fault Definitions

Cont. No.	Cont. Name	Description
1	FLT01-3PH	**3-phase fault on G16-097-TAP 138.0 kV (587794) to FLE TAP4 138.0 kV (511423) line CKT 1, near G16-097-TAP.** a. Apply fault at the G16-097-TAP 138.0 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	FLT02-3PH	**3-phase fault on G16-097-TAP 138.0 kV (587794) to S.W.S.-4 138.0 kV (511477) line CKT 1, near G16-097-TAP.** a. Apply fault at the G16-097-TAP 138.0 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	FLT03-3PH	**3-phase fault on S.W.S.-4 138.0 kV (511477) to ELSWORTH 138.0 kV (511563) line CKT 1, near S.W.S.-4.** a. Apply fault at the S.W.S.-4 138.0 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	FLT04-3PH	**3-phase fault on L.E.S.-4 138.0 kV (511467) to ELGINJT4 138.0 kV (511486) line CKT 1, near L.E.S.-4.** a. Apply fault at the L.E.S.-4 138.0 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	FLT05-3PH	**3-phase fault on L.E.S.-4 138.0 kV (511467) to SHERID4 138.0 kV (511474) line CKT 1, near L.E.S.-4**. a. Apply fault at the L.E.S.-4 138.0 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.
6	FLT06-3PH	**3-phase fault on L.E.S.-4 138.0 kV (511467) to LWSTAP4 138.0 kV (511439) line CKT 1, near L.E.S.-4.** a. Apply fault at the L.E.S.-4 138.0 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	FLT07-3PH	**3-phase fault on S.W.S.-4 138.0 kV (511477) to VERDEN 4 138.0 kV (511421) line CKT 1, near S.W.S.-4.** a. Apply fault at the S.W.S.-4 138.0 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.
8	FLT08-3PH	**3-phase fault on S.W.S.-4 138.0 kV (511477) to CARNEG-4 138.0 kV (511445) line CKT 1, near S.W.S.-4.** a. Apply fault at the S.W.S.-4 138.0 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	FLT09-3PH	**3-phase fault on S.W.S.-4 138.0 kV (511477) to ANADARK4 138.0 kV (520814) line CKT 1, near S.W.S.-4.** a. Apply fault at the S.W.S.-4 138.0 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	FLT10-3PH	**3-phase fault on S.W.S.-4 138.0 kV (511477) to WASHITA4 138.0 kV (521089) line CKT 1, near S.W.S.-4.** a. Apply fault at the S.W.S.-4 138.0 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.
11	FLT11-3PH	**3-phase fault on GRACMNT4 138.0 kV (515802) to GRACMNT7 345.0 kV (515800) to GRCMNT11 13.80 kV (515801) transformer CKT 1, near GRACMNT7.** a. Apply fault at the GRACMNT7 345.0 kV bus. b. Clear fault after 5 cycles and trip the faulted line.
12	FLT12-SB	**Stuck Breaker at L.E.S.-4 (511467)** a. Apply single phase fault at the L.E.S.-4 138.0 kV bus. b. Clear fault after 16 cycles and trip the following elements. - L.E.S.-4 138.0 kV (511467) to FLE TAP4 138.0 kV (511423) line CKT 1 - L.E.S.-4 138.0 kV (511467) to ELGINJT4 138.0 kV (511486) line CKT 1
13	FLT13-SB	**Stuck Breaker at L.E.S.-4 (511467)** a. Apply single phase fault at the L.E.S.-4 138.0 kV bus. b. Clear fault after 16 cycles and trip the following elements. - L.E.S.-4 138.0 kV (511467) to SHERID4 138.0 kV (511474) line CKT 1 - L.E.S.-4 138.0 kV (511467) to LWSTAP4 138.0 kV (511439) line CKT 1
14	FLT14-SB	**Stuck Breaker at L.E.S.-4 (511467)** a. Apply single phase fault at the L.E.S.-4 138.0 kV bus. b. Clear fault after 16 cycles and trip the following elements. - L.E.S.-4 138.0 kV (511467) to L.E.S.-7 345.0 kV (511468) to LES#4-1 13.80 kV (511414) transformer CKT 1 - L.E.S.-4 138.0 kV (511467) to L.E.S.-7 345.0 kV (511468) to LES#5-1 13.80 kV (511411) transformer CKT 2

15	FLT15-SB	**Stuck Breaker at S.W.S.-4 (511477)** a. Apply single phase fault at the S.W.S.-4 138.0 kV bus. b. Clear fault after 16 cycles and trip the following elements. - G16-097-TAP 138.0 kV (587794) to S.W.S.-4 138.0 kV (511477) line CKT 1 - S.W.S.-4 138.0 kV (511477) to ELSWORTH 138.0 kV (511563) line CKT 1
16	FLT16-SB	**Stuck Breaker at S.W.S.-4 (511477)** a. Apply single phase fault at the S.W.S.-4 138.0 kV bus. b. Clear fault after 16 cycles and trip the following elements. - S.W.S.-4 138.0 kV (511477) to VERDEN 4 138.0 kV (511421) line CKT 1 - S.W.S.-4 138.0 kV (511477) to NORGE--4 138.0 kV (511483) line CKT 1
17	FLT17-SB	**Stuck Breaker at S.W.S.-4 (511477)** a. Apply single phase fault at the S.W.S.-4 138.0 kV bus. b. Clear fault after 16 cycles and trip the following elements. - S.W.S.-4 138.0 kV (511477) to ANADARK4 138.0 kV (520814) line CKT 1 - S.W.S.-4 138.0 kV (511477) to WASHITA4 138.0 kV (521089) line CKT 1
18	FLT18-SB	**Stuck Breaker at ANADARK4 (520814)** a. Apply single phase fault at the ANADARK4 138.0 kV bus. b. Clear fault after 16 cycles and trip the following elements. - S.W.S.-4 138.0 kV (511477) to ANADARK4 138.0 kV (520814) line CKT 1 - GRACMNT4 138.0 kV (515802) to ANADARK4 138.0 kV (520814) line CKT 1
19	FLT19-PO	**Prior Outage of G16-097-TAP 138.0 kV (587794) to FLE TAP4 138.0 kV (511423) line CKT 1;** 3-phase fault on S.W.S.-4 138.0 kV (511477) to ELSWORTH 138.0 kV (511563) line CKT 1, near S.W.S.-4. a. Apply fault at the S.W.S.-4 138.0 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	FLT20-PO	**Prior Outage of L.E.S.-4 138.0 kV (511467) to SHERID4 138.0 kV (511474) line CKT 1;** 3-phase fault on L.E.S.-4 138.0 kV (511467) to LWSTAP4 138.0 kV (511439) line CKT 1, near L.E.S.-4. a. Apply fault at the L.E.S.-4 138.0 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.
21	FLT21-PO	**Prior Outage of L.E.S.-4 138.0 kV (511467) to L.E.S.-7 345.0 kV (511468) to LES#4-1 13.80 kV (511414) transformer CKT 1;** 3-phase fault on L.E.S.-4 138.0 kV (511467) to L.E.S.-7 345.0 kV (511468) to LES#5-1 13.80 kV (511411) transformer CKT 2, near L.E.S.-4. a. Apply fault at the L.E.S.-4 138.0 kV bus. b. Clear fault after 5 cycles and trip the faulted line.

22	FLT22-PO	**Prior Outage of G16-097-TAP 138.0 kV (587794) to S.W.S.-4 138.0 kV (511477) line CKT 1;** 3-phase fault on L.E.S.-4 138.0 kV (511467) to ELGINJT4 138.0 kV (511486) line CKT 1, near L.E.S.-4. a. Apply fault at the L.E.S.-4 138.0 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.
23	FLT23-PO	**Prior Outage of S.W.S.-4 138.0 kV (511477) to VERDEN 4 138.0 kV (511421) line CKT 1;** 3-phase fault on S.W.S.-4 138.0 kV (511477) to NORGE--4 138.0 kV (511483) line CKT 1, near S.W.S.-4. a. Apply fault at the S.W.S.-4 138.0 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.
24	FLT24-PO	**Prior Outage of S.W.S.-4 138.0 kV (511477) to ANADARK4 138.0 kV (520814) line CKT 1;** 3-phase fault on S.W.S.-4 138.0 kV (511477) to WASHITA4 138.0 kV (521089) line CKT 1, near S.W.S.-4. a. Apply fault at the S.W.S.-4 138.0 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.
25	FLT25-PO	**Prior Outage of ANADARK4 138.0 kV (520814) to GRACMNT4 138.0 kV (515802) line CKT 1;** 3-phase fault on S.W.S.-4 138.0 kV (511477) to ANADARK4 138.0 kV (520814) line CKT 1, near S.W.S.-4. a. Apply fault at the S.W.S.-4 138.0 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	FLT26-PO	**Prior Outage of S.W.S.-4 138.0 kV (511477) to WASHITA4 138.0 kV (521089) line CKT 1;** 3-phase fault on S.W.S.-4 138.0 kV (511477) to ANADARK4 138.0 kV (520814) line CKT 1, near S.W.S.-4. a. Apply fault at the S.W.S.-4 138.0 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.
27	FLT27-PO	**Prior Outage of GRACMNT4 138.0 kV (515802) to GRACMNT7 345.0 kV (515800) to GRCMNT11 13.80 kV (515801) transformer CKT 1;** 3-phase fault on S.W.S.-4 138.0 kV (511477) to WASHITA4 138.0 kV (521089) line CKT 1, near S.W.S.-4. a. Apply fault at the S.W.S.-4 138.0 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	FLT28-3PH	**3-phase fault on SWEETWT6 230.0 kV (511541) to CHISHOLM6 230.0 kV (511557) line CKT 1, near SWEETWT6.** a. Apply fault at the SWEETWT6 230.0 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.
29	FLT29-3PH	**3-phase fault on SWEETWT6 230.0 kV (511541) to STLN-DEMARC6 230.0 kV (523779) line CKT 1, near SWEETWT6.** a. Apply fault at the SWEETWT6 230.0 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	FLT30-3PH	**3-phase fault on WHEELER 230.0 kV (523777) to GRAPEVINE 230.0 kV (523771) line CKT 1, near WHEELER.** a. Apply fault at the WHEELER 230.0 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	FLT31-3PH	**3-phase fault on WHEELER 230.0 kV (523777) to WHEELER 115.0 kV (523776) to WHEELER_TR11 13.19 kV (523774) transformer CKT 1, near WHEELER.** a. Apply fault at the WHEELER 230.0 kV bus. b. Clear fault after 5 cycles and trip the faulted line.
32	FLT32-3PH	**3-phase fault on CHISHOLM6 230.0 kV (511557) to CHISHOLM7 345.0 kV (511553) to CHISHOLM1 13.19 kV (511558) transformer CKT 1, near CHISHOLM6.** a. Apply fault at the CHISHOLM6 230.0 kV bus. b. Clear fault after 5 cycles and trip the faulted line.
33	FLT33-3PH	**3-phase fault on CHISHOLM6 230.0 kV (511557) to ELKCITY6 230.0 kV (511490) line CKT 1, near CHISHOLM6.** a. Apply fault at the CHISHOLM6 230.0 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.
34	FLT34-SB	**Stuck Breaker at WHEELER (523777)** a. Apply single phase fault at the WHEELER 230.0 kV bus. b. Clear fault after 16 cycles and trip the following elements. - WHEELER 230.0 kV (523777) to GRAPEVINE 230.0 kV (523771) line CKT 1 - WHEELER 230.0 kV (523777) to WHEELER 115.0 kV (523776) to WHEELER_TR11 13.19 kV (523774) transformer CKT 1

35	FLT35-SB	**Stuck Breaker at CHISHOLM6 (511557)** a. Apply single phase fault at the CHISHOLM6 230.0 kV bus. b. Clear fault after 16 cycles and trip the following elements. - CHISHOLM6 230.0 kV (511557) to CHISHOLM7 345.0 kV (511553) to CHISHOLM1 13.19 kV (511558) transformer CKT 1 - CHISHOLM6 230.0 kV (511557) to ELKCITY6 230.0 kV (511490) line CKT 1
36	FLT36-PO	**Prior Outage of WHEELER 230.0 kV (523777) to GRAPEVINE 230.0 kV (523771) line CKT 1;** 3-phase fault on WHEELER 230.0 kV (523777) to WHEELER 115.0 kV (523776) to WHEELER_TR11 13.19 kV (523774) transformer CKT 1, near WHEELER. a. Apply fault at the WHEELER 230.0 kV bus. b. Clear fault after 5 cycles and trip the faulted line.
37	FLT37-PO	**Prior Outage of SWEETWT6 230.0 kV (511541) to CHISHOLM6 230.0 kV (511557) line CKT 1;** 3-phase fault on WHEELER 230.0 kV (523777) to WHEELER 115.0 kV (523776) to WHEELER_TR11 13.19 kV (523774) transformer CKT 1, near WHEELER. a. Apply fault at the WHEELER 230.0 kV bus. b. Clear fault after 5 cycles and trip the faulted line.
38	FLT38-PO	**Prior Outage of CHISHOLM6 230.0 kV (511557) to CHISHOLM7 345.0 kV (511553) to CHISHOLM1 13.19 kV (511558) transformer CKT 1**; 3-phase fault on CHISHOLM6 230.0 kV (511557) to ELKCITY6 230.0 kV (511490) line CKT 1, near CHISHOLM6. a. Apply fault at the CHISHOLM6 230.0 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.
39	FLT39-PO	**Prior Outage of SWEETWT6 230.0 kV (511541) to STLN-DEMARC6 230.0 kV (523779) line CKT 1;** 3-phase fault on CHISHOLM6 230.0 kV (511557) to CHISHOLM7 345.0 kV (511553) to CHISHOLM1 13.19 kV (511558) transformer CKT 1, near CHISHOLM6. a. Apply fault at the CHISHOLM6 230.0 kV bus. b. Clear fault after 5 cycles and trip the faulted line.
40	FLT40-PO	**Prior Outage of CHISHOLM6 230.0 kV (511557) to ELKCITY6 230.0 kV (511490) line CKT 1;** 3-phase fault on WHEELER 230.0 kV (523777) to GRAPEVINE 230.0 kV (523771) line CKT 1, near WHEELER. a. Apply fault at the WHEELER 230.0 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.
41	FLT41-PO	**Prior Outage of CHISHOLM6 230.0 kV (511557) to ELKCITY6 230.0 kV (511490) line CKT 1;** 3-phase fault on CHISHOLM6 230.0 kV (511557) to CHISHOLM7 345.0 kV

		(511553) to CHISHOLM1 13.19 kV (511558) transformer CKT 1, near CHISHOLM6. a. Apply fault at the CHISHOLM6 230.0 kV bus. b. Clear fault after 5 cycles and trip the faulted line.
42	FLT42-3PH	**3-phase fault on G16-091-TAP 345.0 kV (587744) to GRACMNT7 345.0 kV (515800) line CKT 1, near G16-091-TAP.** a. Apply fault at the G16-091-TAP 345.0 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.
43	FLT43-3PH	**3-phase fault on G16-091-TAP 345.0 kV (587744) to L.E.S.-7 345.0 kV (511468) line CKT 1, near G16-091-TAP.** a. Apply fault at the G16-091-TAP 345.0 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.
44	FLT44-3PH	**3-phase fault on GRACMNT7 345.0 kV (515800) to CHISHOLM7 345.0 kV (511553) line CKT 1, near GRACMNT7.** a. Apply fault at the GRACMNT7 345.0 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.
45	FLT45-3PH	**3-phase fault on GRACMNT7 345.0 kV (515800) to MINCO 345.0 kV (514801) line CKT 1, near GRACMNT7.** a. Apply fault at the GRACMNT7 345.0 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.
46	FLT46-3PH	**3-phase fault on MINCO 345.0 kV (514801) to CIMARON7 345.0 kV (514901) line CKT 1, near MINCO.** a. Apply fault at the MINCO 345.0 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.
47	FLT47-3PH	**3-phase fault on L.E.S.-7 345.0 kV (511468) to TERRYRD7 345.0 kV (511568) line CKT 1, near L.E.S.-7**. a. Apply fault at the L.E.S.-7 345.0 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.
48	FLT48-3PH	**3-phase fault on TERRYRD7 345.0 kV (511568) to SUNNYSD7 345.0 kV (515136) line CKT 1, near TERRYRD7**. a. Apply fault at the TERRYRD7 345.0 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.
49	FLT49-3PH	**3-phase fault on L.E.S.-7 345.0 kV (511468) to O.K.U.-7 345.0 kV (511456) line CKT 1, near L.E.S.-7.** a. Apply fault at the L.E.S.-7 345.0 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.
50	FLT50-3PH	**3-phase fault on O.K.U.-7 345.0 kV (511456) to TUCO_INT 345.0 kV (525832) line CKT 1, near O.K.U.-7.** a. Apply fault at the O.K.U.-7 345.0 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.
51	FLT51-3PH	**3-phase fault on L.E.S.-7 345.0 kV (511468) to L.E.S.-4 138.0 kV (511467) to LES#5-1 13.80 kV (511411) transformer CKT 2, near L.E.S.-7.** a. Apply fault at the L.E.S.-7 345.0 kV bus. b. Clear fault after 5 cycles and trip the faulted line.
52	FLT52-3PH	**3-phase fault on FLE TAP4 138.0 kV (511423) to L.E.S.-4 138.0 kV (511467) line CKT 1, near FLE TAP4.** a. Apply fault at the FLE TAP4 138.0 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.
53	FLT53-SB	**Stuck Breaker at GRACMNT7 (515800)** a. Apply single phase fault at the GRACMNT7 345.0 kV bus. b. Clear fault after 16 cycles and trip the following elements. - GRACMNT7 345.0 kV (515800) to CHISHOLM7 345.0 kV (511553) line CKT 1 - GRACMNT7 345.0 kV (515800) to GRACMNT4 138.0 kV (515802) to GRCMNT11 13.80 kV (515801) transformer CKT 1
54	FLT54-SB	**Stuck Breaker at GRACMNT7 (515800)** a. Apply single phase fault at the GRACMNT7 345.0 kV bus. b. Clear fault after 16 cycles and trip the following elements. - GRACMNT7 345.0 kV (515800) to MINCO 345.0 kV (514801) line CKT 1 - GRACMNT7 345.0 kV (515800) to GRACMNT4 138.0 kV (515802) to GRCMNT11 13.80 kV (515801) transformer CKT 1
55	FLT55-SB	**Stuck Breaker at L.E.S.-7 (511468)** a. Apply single phase fault at the L.E.S.-7 345.0 kV bus. b. Clear fault after 16 cycles and trip the following elements. - L.E.S.-7 345.0 kV (511468) to TERRYRD7 345.0 kV (511568) line CKT 1 - L.E.S.-7 345.0 kV (511468) to O.K.U.-7 345.0 kV (511456) line CKT 1
56	FLT56-SB	**Stuck Breaker at L.E.S.-7 (511468)** a. Apply single phase fault at the L.E.S.-7 345.0 kV bus.

		b. Clear fault after 16 cycles and trip the following elements. - L.E.S.-7 345.0 kV (511468) to TERRYRD7 345.0 kV (511568) line CKT 1 - L.E.S.-7 345.0 kV (511468) to L.E.S.-4 138.0 kV (511467) to LES#5-1 13.80 kV (511411) transformer CKT 2
57	FLT57-PO	**Prior Outage of G16-091-TAP 345.0 kV (587744) to GRACMNT7 345.0 kV (515800) line CKT 1;** 3-phase fault on L.E.S.-7 345.0 kV (511468) to TERRYRD7 345.0 kV (511568) line CKT 1, near L.E.S.-7. a. Apply fault at the L.E.S.-7 345.0 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.
58	FLT58-PO	**Prior Outage of G16-091-TAP 345.0 kV (587744) to GRACMNT7 345.0 kV (515800) line CKT 1;** 3-phase fault on O.K.U.-7 345.0 kV (511456) to TUCO_INT 345.0 kV (525832) line CKT 1, near O.K.U.-7. a. Apply fault at the O.K.U.-7 345.0 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.
59	FLT59-PO	**Prior Outage of G16-091-TAP 345.0 kV (587744) to GRACMNT7 345.0 kV (515800) line CKT 1;** 3-phase fault on TERRYRD7 345.0 kV (511568) to SUNNYSD7 345.0 kV (515136) line CKT 1, near TERRYRD7. a. Apply fault at the TERRYRD7 345.0 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.
60	FLT60-PO	**Prior Outage of G16-091-TAP 345.0 kV (587744) to L.E.S.-7 345.0 kV (511468) line CKT 1;** 3-phase fault on GRACMNT7 345.0 kV (515800) to GRACMNT4 138.0 kV (515802) to GRCMNT11 13.80 kV (515801) transformer CKT 1, near GRACMNT7. a. Apply fault at the GRACMNT7 345.0 kV bus. b. Clear fault after 5 cycles and trip the faulted line.
61	FLT61-PO	**Prior Outage of G16-091-TAP 345.0 kV (587744) to L.E.S.-7 345.0 kV (511468) line CKT 1;** 3-phase fault on GRACMNT7 345.0 kV (515800) to CHISHOLM7 345.0 kV (511553) line CKT 1, near GRACMNT7. a. Apply fault at the GRACMNT7 345.0 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.

62	FLT62-PO	**Prior Outage of L.E.S.-7 345.0 kV (511468) to TERRYRD7 345.0 kV (511568) line CKT 1;** 3-phase fault on L.E.S.-7 345.0 kV (511468) to O.K.U.-7 345.0 kV (511456) line CKT 1, near L.E.S.-7. a. Apply fault at the L.E.S.-7 345.0 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.
63	FLT63-PO	**Prior Outage of L.E.S.-7 345.0 kV (511468) to O.K.U.-7 345.0 kV (511456) line CKT 1;** 3-phase fault on L.E.S.-7 345.0 kV (511468) to TERRYRD7 345.0 kV (511568) line CKT 1, near L.E.S.-7. a. Apply fault at the L.E.S.-7 345.0 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.
64	FLT64-PO	**Prior Outage of GRACMNT4 138.0 kV (515802) to GRACMNT7 345.0 kV (515800) to GRCMNT11 13.80 kV (515801) transformer CKT 1;** 3-phase fault on GRACMNT7 345.0 kV (515800) to CHISHOLM7 345.0 kV (511553) line CKT 1, near GRACMNT7. a. Apply fault at the GRACMNT7 345.0 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.
65	FLT65-SB	**Stuck Breaker at GRACMNT7 (515800)** a. Apply single phase fault at the GRACMNT7 345.0 kV bus. b. Clear fault after 16 cycles and trip the following elements. - MINCO 345.0 kV (514801) to GRACMNT7 345.0 kV (515800) line CKT 1 - CHISHOLM7 345.0 kV (511553) to GRACMNT7 345.0 kV (515800) line CKT 1
66	FLT66-PO	**Prior Outage of G16-091-TAP 345.0 kV (587744) to L.E.S.-7 345.0 kV (511468) line CKT 1;** 3-phase fault on GRACMNT7 345.0 kV (515800) to MINCO 345.0 kV (514801) line CKT 1, near GRACMNT7. a. Apply fault at the GRACMNT7 345.0 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.
67	FLT67-3PH	**3-phase fault on BORDER 345.0 kV (515458) to WWRDEHV7 345.0 kV (515375) line CKT 1, near BORDER.** a. Apply fault at the BORDER 345.0 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.

68	FLT68-SB	**Stuck Breaker at CHISHOLM7 (511553)** a. Apply single phase fault at the CHISHOLM7 345.0 kV bus. b. Clear fault after 16 cycles and trip the following elements. - CHISHOLM6 230.0 kV (511557) to CHISHOLM7 345.0 kV (511553) to CHISHOLM1 13.19 kV (511558) transformer CKT 1 - CHISHOLM7 345.0 kV (511553) to GRACMNT7 345.0 kV (515800) line CKT 1
69	FLT69-PO	**Prior Outage of WWRDEHV7 345.0 kV (515375) to BORDER 345.0 kV (515458) line CKT 1;** 3-phase fault on MINCO 345.0 kV (514801) to CIMARON7 345.0 kV (514901) line CKT 1, near MINCO. a. Apply fault at the MINCO 345.0 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.
70	FLT70-PO	**Prior Outage of MINCO 345.0 kV (514801) to GRACMNT7 345.0 kV (515800) line CKT 1;** 3-phase fault on G16-091-TAP 345.0 kV (587744) to L.E.S.-7 345.0 kV (511468) line CKT 1, near G16-091-TAP. a. Apply fault at the G16-091-TAP 345.0 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.
71	FLT71-PO	**Prior Outage of G16-091-TAP 345.0 kV (587744) to L.E.S.-7 345.0 kV (511468) line CKT 1;** 3-phase fault on MINCO 345.0 kV (514801) to CIMARON7 345.0 kV (514901) line CKT 1, near MINCO. a. Apply fault at the MINCO 345.0 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.
72	FLT72-SB	**Stuck Breaker at SUNNYSD7 (515136)** a. Apply single phase fault at the SUNNYSD7 345.0 kV bus. b. Clear fault after 16 cycles and trip the following elements. - SUNNYSD7 345.0 kV (515136) to G16-063-TAP 345.0 kV (560088) line CKT 1 - SUNNYSD7 345.0 kV (515136) to TERRYRD7 345.0 kV (511568) line CKT 1
73	FLT73-SB	**Stuck Breaker at SUNNYSD7 (515136)** a. Apply single phase fault at the SUNNYSD7 345.0 kV bus. b. Clear fault after 16 cycles and trip the following elements. - SUNNYSD7 345.0 kV (515136) to G16-063-TAP 345.0 kV (560088) line CKT 1 - SUNNYSD7 345.0 kV (515136) to JOHNCO 7 345.0 kV (514809) line CKT 1
74	FLT74-SB	**Stuck Breaker at SUNNYSD7 (515136)** a. Apply single phase fault at the SUNNYSD7 345.0 kV bus. b. Clear fault after 16 cycles and trip the following elements. - SUNNYSD7 345.0 kV (515136) to SUNNYSD4 138.0 kV (515135) to SUNYSD

		1 13.80 kV (515405) transformer CKT 1 - SUNNYSD4 138.0 kV (515135) to SUNNYSD7 345.0 kV (515136) to SUNNYSD1 13.80 kV (515762) transformer CKT 1
75	FLT75-PO	**Prior Outage of MINCO 345.0 kV (514801) to CIMARON7 345.0 kV (514901) line CKT 1;** 3-phase fault on G16-091-TAP 345.0 kV (587744) to L.E.S.-7 345.0 kV (511468) line CKT 1, near G16-091-TAP. a. Apply fault at the G16-091-TAP 345.0 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.
76	FLT76-SB	**Stuck Breaker at GRACMNT4 (515802)** a. Apply single phase fault at the GRACMNT4 138.0 kV bus. b. Clear fault after 16 cycles and trip the following elements. - GRACMNT4 138.0 kV (515802) to WASHITA4 138.0 kV (521089) line CKT 1 - GRACMNT4 138.0 kV (515802) to WASHITA4 138.0 kV (521089) line CKT 2
77	FLT77-PO	**Prior Outage of SWEETWT6 230.0 kV (511541) to CHISHOLM6 230.0 kV (511557) line CKT 1;** 3-phase fault on WHEELER 230.0 kV (523777) to GRAPEVINE 230.0 kV (523771) line CKT 1, near WHEELER. a. Apply fault at the WHEELER 230.0 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.
78	FLT78-PO	**Prior Outage of WHEELER 230.0 kV (523777) to GRAPEVINE 230.0 kV (523771) line CKT 1;** 3-phase fault on SWEETWT6 230.0 kV (511541) to CHISHOLM6 230.0 kV (511557) line CKT 1, near SWEETWT6. a. Apply fault at the SWEETWT6 230.0 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.

APPENDIX B

SOUTHWEST POWER POOL DISTURBANCE PERFORMANCE REQUIREMENTS

(SUBMITTED IN A SEPARATE FILE; AVAILABLE FROM SPP UPON REQUEST)

APPENDIX C

DYNAMIC STABILITY PLOTS FOR CLUSTER SCENARIO (SUBMITTED IN SEPARATE FILES FROM APPENDIX C-1 TO C-6; AVAILABLE FROM SPP UPON REQUEST)

The original dynamic data-set (Select Contingencies):

- C-1 Group 7 Cluster Dynamic Stability Plots for 2017 Winter Peak Case
- C-2 Group 7 Cluster Dynamic Stability Plots for 2018 Summer Peak Case
- C-3 Group 7 Cluster Dynamic Stability Plots for 2026 Summer Peak Case

The dynamic data-set after the mitigation (FLT-77 and FLT-78):

- C-4 Group 7 Cluster Dynamic Stability Plots for 2017 Winter Peak Case
- C-5 Group 7 Cluster Dynamic Stability Plots for 2018 Summer Peak Case
- C-6 Group 7 Cluster Dynamic Stability Plots for 2026 Summer Peak Case

Each contingency consists of (42) subplots:

- Subplot #1 is the system phase angle channels in the snapshot file provided by SPP.
- Subplot #2 to Subplot #28 are results for (27) generators in the scope of study.
- Subplots #29 to Subplot #35 are frequencies at the POI buses in the scope of study.
- Subplots #36 to Subplot #42 are voltages at the POI buses in the scope of study.

APPENDIX D

DYNAMIC DATA OF INTERCONNECTION GENERATORS (SUBMITTED IN A SEPARATE FILE WHICH WILL BE AVAILABLE FROM SPP UPON REQUEST)

APPENDIX E

SHORT-CIRCUIT STUDY RESULTS

Table 8-2: GROUP 7 18SP Short-Circuit Study Results

Bus No	Bus Name	Short Circuit Current (A)	Bus No	Bus Name	Short Circuit Current (A)
GEN-2016-091					
510907	PITTSB-7 345.00	13400.5	584780	GEN-2015-036345.00	7693.3
511456	O.K.U.-7 345.00	5049.2	584951	G15-057XFMR134.500	16001.8
511468	L.E.S.-7 345.00	12787.9	585270	GEN-2015-093345.00	9604.2
511553	CHISHOLM7 345.00	5049.5	585271	G15-093XFMR134.500	29858.6
511565	OKLAUN HVDC7345.00	5035.6	585272	G15-093-GSU134.500	29094.1
511568	TERRYRD7 345.00	9829.0	585273	G15-093-GEN10.6900	991653.2
511571	RUSHSPR7 345.00	6353.7	585274	G15-093-GEN20.6900	894004.1
511965	RUSHSPRW1-1 34.500	26467.7	585280	GEN-2015-092345.00	6163.8
514801	MINCO 7 345.00	17136.9	585281	G15-092XFMR134.500	26334.4
514809	JOHNCO 7 345.00	9794.1	587300	G16-045-SUB1345.00	1593.7
514880	NORTWST7 345.00	32018.2	587304	G16-045-SUB2345.00	1550.0
514881	SPRNGCK7 345.00	22899.5	587380	G16-057-SUB1345.00	1570.1
514901	CIMARON7 345.00	32521.4	587384	G16-057-SUB2345.00	1490.0
514908	ARCADIA7 345.00	25759.6	587430	GEN-2016-063345.00	7395.3
514934	DRAPER 7 345.00	20838.8	587740	GEN-2016-091345.00	12719.8
515045	SEMINOL7 345.00	26013.8	587741	G16-091XFMR134.500	30978.3
515136	SUNNYSD7 345.00	10765.2	587742	G16-091-GSU134.500	29569.9
515375	WWRDEHV7 345.00	18903.1	587743	G16-091-GEN10.6900	1334151.4
515407	TATONGA7 345.00	15804.3	587744	G16-091-TAP 345.00	14208.4
515444	MCNOWND7 345.00	17087.3	587770	GEN-2016-095345.00	10653.5
515458	BORDER 7345.00	5095.7	587771	G16-095XFMR134.500	31579.2
515497	MATHWSN7 345.00	31307.8	587772	G16-095-GSU134.500	30788.0
515549	MNCWND37 345.00	11813.0	587773	G16-095-GEN10.6900	1501577.1
515600	KNGFSHR7 345.00	11364.0	590001	OKLEHV24 138.00	5172.5

515605	CANADN7 345.00	11746.8	590002	OKLAUN1G 24.000	87674.5
515610	FSHRTAP7 345.00	16663.8	590003	OKLEHV14 138.00	5290.1
515800	GRACMNT7 345.00	16105.2	599891	OKLAUN 7 345.00	4367.2
515875	REDNGTN7 345.00	17973.0			
515939	MNCWND47 345.00	6604.8			
521157	HUGO 7 345.00	11080.2			
525832	TUCO_INT 7345.00	9523.8			
525844	ELK_1 118.000	45020.4			
525845	ELK_2 1 18.000	41216.2			
525850	ELK_CT1 345.00	9452.5			
560088	G16-063-TAP 345.00	7483.5			
583090	G1149&G1504 345.00	4681.1			
584060	GEN-2015-057345.00	8793.1			
584072	G14-057-GSU134.500	24616.4			
GEN-2016-095					
510907	PITTSB-7 345.00	13400.5	584780	GEN-2015-036345.00	7693.3
511456	O.K.U.-7 345.00	5049.2	584951	G15-057XFMR134.500	16001.8
511468	L.E.S.-7 345.00	12787.9	585270	GEN-2015-093345.00	9604.2
511553	CHISHOLM7 345.00	5049.5	585271	G15-093XFMR134.500	29858.6
511565	OKLAUN HVDC7345.00	5035.6	585272	G15-093-GSU134.500	29094.1
511568	TERRYRD7 345.00	9829.0	585273	G15-093-GEN10.6900	991653.2
511571	RUSHSPR7 345.00	6353.7	585274	G15-093-GEN20.6900	894004.1
511965	RUSHSPRW1-1 34.500	26467.7	585280	GEN-2015-092345.00	6163.8
514801	MINCO 7 345.00	17136.9	585281	G15-092XFMR134.500	26334.4
514809	JOHNCO 7 345.00	9794.1	587300	G16-045-SUB1345.00	1593.7
514880	NORTWST7 345.00	32018.2	587304	G16-045-SUB2345.00	1550.0
514881	SPRNGCK7 345.00	22899.5	587380	G16-057-SUB1345.00	1570.1
514901	CIMARON7 345.00	32521.4	587384	G16-057-SUB2345.00	1490.0

514908	ARCADIA7 345.00	25759.6	587430	GEN-2016-063345.00	7395.3
514934	DRAPER 7 345.00	20838.8	587740	GEN-2016-091345.00	12719.8
515045	SEMINOL7 345.00	26013.8	587741	G16-091XFMR134.500	30978.3
515136	SUNNYSD7 345.00	10765.2	587742	G16-091-GSU134.500	29569.9
515375	WWRDEHV7 345.00	18903.1	587743	G16-091-GEN10.6900	1334151.4
515407	TATONGA7 345.00	15804.3	587744	G16-091-TAP 345.00	14208.4
515444	MCNOWND7 345.00	17087.3	587770	GEN-2016-095345.00	10653.5
515458	BORDER 7345.00	5095.7	587771	G16-095XFMR134.500	31579.2
515497	MATHWSN7 345.00	31307.8	587772	G16-095-GSU134.500	30788.0
515549	MNCWND37 345.00	11813.0	587773	G16-095-GEN10.6900	1501577.1
515600	KNGFSHR7 345.00	11364.0	590001	OKLEHV24 138.00	5172.5
515605	CANADN7 345.00	11746.8	590002	OKLAUN1G 24.000	87674.5
515610	FSHRTAP7 345.00	16663.8	590003	OKLEHV14 138.00	5290.1
515800	GRACMNT7 345.00	16105.2	599891	OKLAUN 7 345.00	4367.2
515875	REDNGTN7 345.00	17973.0			
515939	MNCWND47 345.00	6604.8			
521157	HUGO 7 345.00	11080.2			
525832	TUCO_INT 7345.00	9523.8			
525844	ELK_1 118.000	45020.4			
525845	ELK_2 1 18.000	41216.2			
525850	ELK_CT1 345.00	9452.5			
560088	G16-063-TAP 345.00	7483.5			
583090	G1149&G1504 345.00	4681.1			
584060	GEN-2015-057345.00	8793.1			
584072	G14-057-GSU134.500	24616.4			
GEN-2016-097					
511421	VERDEN 4 138.00	9872.3	520211	HARPER2 138.00	29814.9
511422	FLETCHR4 138.00	8074.1	520404	MDCPRK4 138.00	5309.8

511423	FLE TAP4 138.00	8851.6	520422	SEQUOYAHJ4 138.00	30293.1
511428	LG-YEAR4 138.00	11790.5	520501	BRIDGECR 138.00	6854.3
511431	LWS S4 138.00	10957.7	520510	NAPLESTP 138.00	9140.2
511437	COMANC-4 138.00	17829.0	520512	BC SW 4 138.00	6988.0
511439	LWSTAP 4 138.00	11427.3	520811	ANADRK4 13.800	55575.7
511445	CARNEG-4 138.00	7831.9	520812	ANADRK5 13.800	55636.8
511446	CL-AFTP4 138.00	6393.1	520813	ANADRK6 13.800	55569.7
511449	CORNVIL4 138.00	16779.2	520814	ANADARK4 138.00	32411.6
511453	DUNCAN-4 138.00	6393.5	520827	BINGERJ4 138.00	7505.8
511458	ELKCTY-4 138.00	10388.8	520867	CORN TP4 138.00	14250.8
511463	HOB-JCT4 138.00	6797.7	520870	CYRIL 2 138.00	7829.3
511467	L.E.S.-4 138.00	24334.9	520900	EMPIRE 4 138.00	4600.8
511471	LWS-NTP4 138.00	11544.7	520911	FLETCHR2 138.00	6225.2
511474	SHERID4 138.00	12209.5	520912	FLETCH-4 138.00	6121.0
511477	S.W.S.-4 138.00	34111.6	520923	GEORGIA4 138.00	17218.0
511483	NORGE--4 138.00	11437.9	521010	NIJECT 4 138.00	5366.1
511486	ELGINJT4 138.00	9953.9	521017	ONEY 4 138.00	10682.8
511488	112GORE4 138.00	12574.6	521024	PARADSE4 138.00	5617.4
511491	RUSHSPT4 138.00	8121.9	521031	POCASET4 138.00	7661.6
511492	SANTAFE4 138.00	8480.1	521050	SICKLES4 138.00	6267.8
511494	COMMTAP4 138.00	21262.3	521072	TUTTLE 4 138.00	6545.5
511501	TUTTLE4 138.00	10929.1	521089	WASHITA4 138.00	28047.7
511502	N29CHIK4 138.00	10441.7	521101	GENCO1 4 13.800	33049.8
511508	BLANCHD4 138.00	5788.3	521102	GENCO2 4 13.800	33113.3
511509	53CACHE4 138.00	11585.6	521103	SLKHILLS 4 138.00	7904.5
511510	LAIRGST4 138.00	12171.6	521110	ORME1 13.800	51066.6
511512	RPPAPER4 138.00	11844.9	521111	ORME2 13.800	51066.6
511515	TEXAS 4 138.00	5756.5	521112	ORME3 13.800	51066.6

511516	ALEX BR4 138.00	6304.1	521129	BLUCAN5 4 138.00	5894.2
511535	CLIN-AF4 138.00	4885.8	529302	OMALTUS4 138.00	4363.6
511537	ARTVLTP4 138.00	11605.7	529304	OMDUNCN4 138.00	6591.2
511538	ARTVILL4 138.00	8403.1	583100	GEN-2011-050138.00	6865.7
511554	RKY_RDG4 138.00	5283.7	583900	GEN-2014-020138.00	10929.1
511562	ROUNDCK4 138.00	6646.7	587790	GEN-2016-097138.00	9580.0
511563	ELSWORTH 4138.00	9882.3	587791	G16-097XFMR134.500	14949.6
511564	MARTHA 4 138.00	4250.6	587792	G16-097-GSU134.500	14748.9
511575	LEONARD4 138.00	10929.1	587793	G16-097-GEN10.6900	739888.1
511846	SWS1-1 14.400	58350.7	587794	G16-097-TAP 138.00	11688.3
511847	SWS2-1 14.400	58633.3	599004	BLUCAN2-CB1 34.500	17858.8
511848	SWS3-1 24.000	89929.8	599007	BLUCAN-CB1 34.500	13451.3
511851	COM1-1 13.800	72268.8	599021	BLUCAN5-LVB134.500	10682.7
511852	COM2-1 13.800	45456.7	599022	BLUCAN5-CB1 34.500	10153.4
515055	MAUD 4 138.00	19546.4	599095	BCVI_HVB 138.00	7880.5
515802	GRACMNT4 138.00	28782.3	599096	BCVI_LVB 34.500	15520.6
GEN-2016-132					
511490	ELKCITY6 230.00	6173.4	523779	STLN-DEMARC6230.00	6183.0
511541	SWEETWT6 230.00	6648.9	523977	HARRNG_WST 6230.00	26336.5
511542	BUFFCK6 230.00	5183.3	523978	HARRNG_MID 6230.00	26336.5
511544	DEMPSEY6 230.00	4482.3	524023	NICHOLS_3 122.000	94726.4
511547	ROARK6 230.00	4214.3	524044	NICHOLS 6230.00	25536.0
511557	CHISHOLM6 230.00	7573.4	524415	AMA_SOUTH 6230.00	13397.8
511961	DEMPSEY1 34.500	13466.5	599047	DEMPSEY_GSU134.500	12977.6
523551	HUTCHISON 6230.00	7099.9	599049	DEMPSEY_WTG10.6900	519768.6
523771	GRAPEVINE 6230.00	5601.7			
523777	WHEELER 6230.00	5480.1			

Table 8-3: GROUP 7 18SP Short-Circuit Study Results

Bus No	Bus Name	Short Circuit Current (A)	Bus No	Bus Name	Short Circuit Current (A)
GEN-2016-091					
510907	PITTSB-7 345.00	13329.0	584780	GEN-2015-036345.00	7655.1
511456	O.K.U.-7 345.00	5098.5	584951	G15-057XFMR134.500	15959.9
511468	L.E.S.-7 345.00	12816.7	585270	GEN-2015-093345.00	9594.2
511553	CHISHOLM7 345.00	5052.9	585271	G15-093XFMR134.500	29829.8
511565	OKLAUN HVDC7345.00	5084.5	585272	G15-093-GSU134.500	29067.9
511568	TERRYRD7 345.00	9821.5	585273	G15-093-GEN10.6900	991001.7
511571	RUSHSPR7 345.00	6344.1	585274	G15-093-GEN20.6900	893407.1
511965	RUSHSPRW1-1 34.500	26402.7	585280	GEN-2015-092345.00	6154.3
514801	MINCO 7 345.00	17087.9	585281	G15-092XFMR134.500	26266.5
514809	JOHNCO 7 345.00	9747.8	587300	G16-045-SUB1345.00	1590.1
514880	NORTWST7 345.00	31806.6	587304	G16-045-SUB2345.00	1547.2
514881	SPRNGCK7 345.00	22780.2	587380	G16-057-SUB1345.00	1566.6
514901	CIMARON7 345.00	32306.0	587384	G16-057-SUB2345.00	1487.3
514908	ARCADIA7 345.00	25763.9	587430	GEN-2016-063345.00	7369.0
514934	DRAPER 7 345.00	20655.9	587740	GEN-2016-091345.00	12717.0
515045	SEMINOL7 345.00	25848.4	587741	G16-091XFMR134.500	30943.1
515136	SUNNYSD7 345.00	10728.4	587742	G16-091-GSU134.500	29540.2
515375	WWRDEHV7 345.00	18934.1	587743	G16-091-GEN10.6900	1332982.3
515407	TATONGA7 345.00	15788.9	587744	G16-091-TAP 345.00	14207.9
515444	MCNOWND7 345.00	17038.4	587770	GEN-2016-095345.00	10648.5
515458	BORDER 7345.00	5152.7	587771	G16-095XFMR134.500	31541.0
515497	MATHWSN7 345.00	31147.7	587772	G16-095-GSU134.500	30757.4
515549	MNCWND37 345.00	11780.1	587773	G16-095-GEN10.6900	1500492.4
515600	KNGFSHR7 345.00	11317.8	590001	OKLEHV24 138.00	5171.0

515605	CANADN7 345.00	11696.9	590002	OKLAUN1G 24.000	87657.0
515610	FSHRTAP7 345.00	16584.7	590003	OKLEHV14 138.00	5289.4
515800	GRACMNT7 345.00	16096.1	599891	OKLAUN 7 345.00	4366.3
515875	REDNGTN7 345.00	17924.8			
515939	MNCWND47 345.00	6586.7			
521157	HUGO 7 345.00	10955.8			
525832	TUCO_INT 7345.00	11609.2			
525844	ELK_1 118.000	47274.7			
525845	ELK_2 1 18.000	43066.9			
525850	ELK_CT1 345.00	11502.6			
560088	G16-063-TAP 345.00	7456.7			
583090	G1149&G1504 345.00	4728.9			
584060	GEN-2015-057345.00	8768.9			
584072	G14-057-GSU134.500	24555.2			
GEN-2016-095					
510907	PITTSB-7 345.00	13329.0	584780	GEN-2015-036345.00	7655.1
511456	O.K.U.-7 345.00	5098.5	584951	G15-057XFMR134.500	15959.9
511468	L.E.S.-7 345.00	12816.7	585270	GEN-2015-093345.00	9594.2
511553	CHISHOLM7 345.00	5052.9	585271	G15-093XFMR134.500	29829.8
511565	OKLAUN HVDC7345.00	5084.5	585272	G15-093-GSU134.500	29067.9
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511571	RUSHSPR7 345.00	6344.1	585274	G15-093-GEN20.6900	893407.1
511965	RUSHSPRW1-1 34.500	26402.7	585280	GEN-2015-092345.00	6154.3
514801	MINCO 7 345.00	17087.9	585281	G15-092XFMR134.500	26266.5
514809	JOHNCO 7 345.00	9747.8	587300	G16-045-SUB1345.00	1590.1
514880	NORTWST7 345.00	31806.6	587304	G16-045-SUB2345.00	1547.2
514881	SPRNGCK7 345.00	22780.2	587380	G16-057-SUB1345.00	1566.6
514901	CIMARON7 345.00	32306.0	587384	G16-057-SUB2345.00	1487.3

514908	ARCADIA7 345.00	25763.9	587430	GEN-2016-063345.00	7369.0
514934	DRAPER 7 345.00	20655.9	587740	GEN-2016-091345.00	12717.0
515045	SEMINOL7 345.00	25848.4	587741	G16-091XFMR134.500	30943.1
515136	SUNNYSD7 345.00	10728.4	587742	G16-091-GSU134.500	29540.2
515375	WWRDEHV7 345.00	18934.1	587743	G16-091-GEN10.6900	1332982.3
515407	TATONGA7 345.00	15788.9	587744	G16-091-TAP 345.00	14207.9
515444	MCNOWND7 345.00	17038.4	587770	GEN-2016-095345.00	10648.5
515458	BORDER 7345.00	5152.7	587771	G16-095XFMR134.500	31541.0
515497	MATHWSN7 345.00	31147.7	587772	G16-095-GSU134.500	30757.4
515549	MNCWND37 345.00	11780.1	587773	G16-095-GEN10.6900	1500492.4
515600	KNGFSHR7 345.00	11317.8	590001	OKLEHV24 138.00	5171.0
515605	CANADN7 345.00	11696.9	590002	OKLAUN1G 24.000	87657.0
515610	FSHRTAP7 345.00	16584.7	590003	OKLEHV14 138.00	5289.4
515800	GRACMNT7 345.00	16096.1	599891	OKLAUN 7 345.00	4366.3
515875	REDNGTN7 345.00	17924.8			
515939	MNCWND47 345.00	6586.7			
521157	HUGO 7 345.00	10955.8			
525832	TUCO_INT 7345.00	11609.2			
525844	ELK_1 118.000	47274.7			
525845	ELK_2 1 18.000	43066.9			
525850	ELK_CT1 345.00	11502.6			
560088	G16-063-TAP 345.00	7456.7			
583090	G1149&G1504 345.00	4728.9			
584060	GEN-2015-057345.00	8768.9			
584072	G14-057-GSU134.500	24555.2			
GEN-2016-097					
511421	VERDEN 4 138.00	9855.4	520211	HARPER2 138.00	29791.4
511422	FLETCHR4 138.00	8065.6	520404	MDCPRK4 138.00	5309.3

511423	FLE TAP4 138.00	8843.2	520422	SEQUOYAHJ4 138.00	30269.8
511428	LG-YEAR4 138.00	11807.1	520501	BRIDGECR 138.00	6810.3
511431	LWS S4 138.00	10967.5	520510	NAPLESTP 138.00	9100.0
511437	COMANC-4 138.00	17888.7	520512	BC SW 4 138.00	6981.0
511439	LWSTAP 4 138.00	11439.2	520811	ANADRK4 13.800	55511.2
511445	CARNEG-4 138.00	7831.7	520812	ANADRK5 13.800	55572.3
511446	CL-AFTP4 138.00	6400.9	520813	ANADRK6 13.800	55505.3
511449	CORNVIL4 138.00	16738.3	520814	ANADARK4 138.00	32390.2
511453	DUNCAN-4 138.00	6376.9	520827	BINGERJ4 138.00	7495.4
511458	ELKCTY-4 138.00	10428.2	520867	CORN TP4 138.00	14210.0
511463	HOB-JCT4 138.00	6811.8	520870	CYRIL 2 138.00	7807.9
511467	L.E.S.-4 138.00	24439.5	520900	EMPIRE 4 138.00	4592.6
511471	LWS-NTP4 138.00	11558.2	520911	FLETCHR2 138.00	6203.8
511474	SHERID4 138.00	12224.4	520912	FLETCH-4 138.00	6114.7
511477	S.W.S.-4 138.00	34124.2	520923	GEORGIA4 138.00	17197.6
511483	NORGE--4 138.00	11410.1	521010	NIJECT 4 138.00	5356.6
511486	ELGINJT4 138.00	9946.7	521017	ONEY 4 138.00	10671.4
511488	112GORE4 138.00	12595.5	521024	PARADSE4 138.00	5615.8
511491	RUSHSPT4 138.00	8100.6	521031	POCASET4 138.00	7630.2
511492	SANTAFE4 138.00	8458.3	521050	SICKLES4 138.00	6258.0
511494	COMMTAP4 138.00	21334.7	521072	TUTTLE 4 138.00	6508.9
511501	TUTTLE4 138.00	10889.8	521089	WASHITA4 138.00	28043.2
511502	N29CHIK4 138.00	10418.4	521101	GENCO1 4 13.800	32983.3
511508	BLANCHD4 138.00	5767.2	521102	GENCO2 4 13.800	33046.7
511509	53CACHE4 138.00	11598.7	521103	SLKHILLS 4 138.00	7896.3
511510	LAIRGST4 138.00	12191.0	521110	ORME1 13.800	51008.7
511512	RPPAPER4 138.00	11860.4	521111	ORME2 13.800	51008.7
511515	TEXAS 4 138.00	5740.7	521112	ORME3 13.800	51008.7

511516	ALEX BR4 138.00	6287.0	521129	BLUCAN5 4 138.00	5891.7
511535	CLIN-AF4 138.00	4887.3	529302	OMALTUS4 138.00	4391.8
511537	ARTVLTP4 138.00	11618.7	529304	OMDUNCN4 138.00	6575.6
511538	ARTVILL4 138.00	8403.2	583100	GEN-2011-050138.00	6847.6
511554	RKY_RDG4 138.00	5289.6	583900	GEN-2014-020138.00	10889.8
511562	ROUNDCK4 138.00	6628.9	587790	GEN-2016-097138.00	9571.1
511563	ELSWORTH 4138.00	9874.9	587791	G16-097XFMR134.500	14930.3
511564	MARTHA 4 138.00	4270.7	587792	G16-097-GSU134.500	14732.6
511575	LEONARD4 138.00	10889.8	587793	G16-097-GEN10.6900	739265.8
511846	SWS1-1 14.400	58383.2	587794	G16-097-TAP 138.00	11679.3
511847	SWS2-1 14.400	58660.9	599004	BLUCAN2-CB1 34.500	17842.6
511848	SWS3-1 24.000	90112.9	599007	BLUCAN-CB1 34.500	13440.8
511851	COM1-1 13.800	72849.5	599021	BLUCAN5-LVB134.500	10667.3
511852	COM2-1 13.800	46007.9	599022	BLUCAN5-CB1 34.500	10139.4
515055	MAUD 4 138.00	19415.4	599095	BCVI_HVB 138.00	7872.4
515802	GRACMNT4 138.00	28765.9	599096	BCVI_LVB 34.500	15507.0
GEN-2016-132					
511490	ELKCITY6 230.00	6187.0	523779	STLN-DEMARC6230.00	6192.5
511541	SWEETWT6 230.00	6661.5	523977	HARRNG_WST 6230.00	26356.8
511542	BUFFCK6 230.00	5191.6	523978	HARRNG_MID 6230.00	26356.8
511544	DEMPSEY6 230.00	4487.6	524023	NICHOLS_3 122.000	95028.3
511547	ROARK6 230.00	4220.1	524044	NICHOLS 6230.00	25565.4
511557	CHISHOLM6 230.00	7586.7	524415	AMA_SOUTH 6230.00	13408.6
511961	DEMPSEY1 34.500	13488.8	599047	DEMPSEY_GSU134.500	13002.1
523551	HUTCHISON 6230.00	7092.2	599049	DEMPSEY_WTG10.6900	521309.9
523771	GRAPEVINE 6230.00	5597.3			
523777	WHEELER 6230.00	5485.3			

GROUP 8 STABILITY ANALYSIS

NERC MOD-026 and MOD-027 model validation studies were recently completed for the Wolf Creek Nuclear plant. The prior analysis, DISIS-2016-002, did not include this model update for the Wolf Creek Nuclear plant. This DISIS-2016-002-2 Group 08 analysis incorporates the most updated models for the Wolf Creek Nuclear plant.

The Group 8 cases included the following system adjustments of dispatching, to maximum output, generation interconnected at the same or adjacent substations to a current study request:

- Sooner & Spring Creek units: GEN-2016-100, GEN-2016-101, GEN-2016-119, & GEN-2016-128
- West Pawhuska unit: prior DISIS-2016-002 requests
- Northeastern units & GRDA Energy Center: GEN-2016-133 – GEN-2016-146

The Group 8 stability analysis for this area was performed by Mitsubishi Electric Power Products (MEPPI).

With the new requests modeled, voltage instability, violations of voltage recovery criteria, and generation tripping off were observed for faults near Riverside 345kV the Point of Interconnection for requests GEN-2016-133 through GEN-2016-146 and for fault events FLT151-3PH, FLT186-3PH, FLT187-3PH, FLT205-SB, and FLT208-SB on the Wolf Creek to Waverly to LaCygne 345kV circuits.

To mitigate the voltage instability, violations of voltage recovery criteria, and generation tripping off the following upgrades were implemented in each season:

- Disabling voltage protection relays for requests GEN-2016-133 through GEN-2016-146
- Blackberry to Wolf Creek 345kV circuit 1 (previously and current assigned mitigation in DISIS-2016-001-5) or Emporia to Wolf Creek 345kV circuit 1 (previously and no longer assigned as mitigation in DISIS-2016-001-4)

MEPPI noted that for certain contingencies GEN-2016-133 through GEN-2016-146 tripped offline due to overvoltage protection. With overvoltage protection disabled these projects remained online. Prior to completion of Facility Study these interconnection customers must provide SPP a modified project design that will meet the voltage ride through requirements of FERC Order #661A.

Tuning or replacing the Wolf Creek AVR was evaluated as mitigation and was determined to be insufficient to resolve the observed instability. This upgrade, if implemented, may reduce the required curtailment under P6 Planning Event prior outage conditions.

With all previously-assigned and currently-assigned Network Upgrades placed in service, no violations were observed, including violations of low-voltage ride-through requirements, for the probable P1 and P4 Planning Events studied.

Evaluation of P6, prior outage, Planning Events involving Blackberry to Wolf Creek and Wolf Creek to Waverly to LaCygne 345kV circuits determined that a system adjustment involving curtailment of generation from generating facilities may be required following a prior outage to achieve acceptable system response for a subsequent fault event.

Following the interconnection of each request or completion of the Blackberry to Wolf Creek 345kV circuit 1 upgrade, it is recommended that the Transmission Owner for the Wolf Creek Generating Facility area (WERE/Evergy) evaluate any applicable operational guide(s) and Corrective Action Plans utilized in transmission planning assessment. Actual system conditions may require output reduction of Waverly Wind, Wolf Creek, and any other (i.e. GEN-2016-162, GEN-2016-163, etc.) generating facilities that contribute to a system constraint.

With all previously-assigned and currently-assigned Network Upgrades placed in service and the identified system adjustments, no violations were observed, including violations of low-voltage ride-through requirements, for the probable P6 Planning Events studied.

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Southwest Power Pool, Inc. (SPP)

DISIS-2016-002-2 (Group 08) Definitive Impact Study

Final Report

REP-0401
Revision #04

March 2020

Submitted By:
Mitsubishi Electric Power Products, Inc. (MEPPI)
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Report Revision Table

Revision	Report Revision Table	Date	Approved
0	Issue Draft Report for review for DISIS-2016-002-1	12/15/2018	NWT
1	Address SPP comments and perform analysis with Wolf Creek to Emporia Energy Center 345kV	05/06/2019	NWT
2	Perform analysis with updated mitigation solutions for DISIS-2016-002-1	03/13/2020	NWT
3	Address SPP comments and issue Final Report	03/18/2020	NWT
4	Address SPP comments	03/20/2020	NWT

Title: **DISIS-2016-002-2 (Group 08) Definitive Impact Study: Final Report REP-0401**
Date: March 2020
Author: Nicholas Tenza; Senior Engineer, Power Systems Engineering Division *Nicholas Tenza*
Approved: Donald Shoup; General Manager, Power Systems Engineering Division *Donald Shoup*

EXECUTIVE SUMMARY

SPP requested a Definitive Interconnection System Impact Study (DISIS). The DISIS required a Stability Analysis and a Short Circuit Analysis detailing the impacts of the interconnecting projects as shown in Table ES-1.

Table ES-1
Interconnection Projects Evaluated

Request	Size (MW)	Generator Model	Point of Interconnection
GEN-2016-100	100	Wind (587803)	Tap Sooner-Spring Creek 345kV (587804)
GEN-2016-101	195	Wind (587813)	Tap Sooner-Spring Creek 345kV (587804)
GEN-2016-119	600	Wind (587953, 587958)	Tap Spring Creek-Sooner 345 kV (587804)
GEN-2016-128	176	Wind (588193)	Woodring 345kV Substation (514715)
GEN-2016-133	187.5	Wind	Riverside 345kV Substation (509782)
GEN-2016-134	187.5	Wind	Riverside 345kV Substation (509782)
GEN-2016-135	100	Wind	Riverside 345kV Substation (509782)
GEN-2016-136	75	Wind	Riverside 345kV Substation (509782)
GEN-2016-137	187.5	Wind	Riverside 345kV Substation (509782)
GEN-2016-138	187.5	Wind	Riverside 345kV Substation (509782)
GEN-2016-139	100	Wind	Riverside 345kV Substation (509782)
GEN-2016-140	75	Wind	Riverside 345kV Substation (509782)
GEN-2016-141	350	Wind	Riverside 345kV Substation (509782)
GEN-2016-142	350	Wind	Riverside 345kV Substation (509782)
GEN-2016-143	175	Wind	Riverside 345kV Substation (509782)
GEN-2016-144	175	Wind	Riverside 345kV Substation (509782)
GEN-2016-145	175	Wind	Riverside 345kV Substation (509782)
GEN-2016-146	175	Wind	Riverside 345kV Substation (509782)
GEN-2016-153	134	Wind (588363)	Viola 345kV (532798)

Request	Size (MW)	Generator Model	Point of Interconnection
GEN-2016-162	252	Wind (588323)	Benton 345kV (532791)
GEN-2016-163	252	Wind (588333)	Benton 345kV(532791)

SUMMARY OF STABILITY ANALYSIS

The Stability Analysis determined that with the Wolf Creek NERC MOD-026 and MOD-027 model validation updates several P1, P4, and P6 events that include a fault on a circuit connected to either Waverly or Wolf Creek 345kV substations resulted in undamped rotor angle oscillations, voltages below the acceptable recovery voltage, voltage collapse, and generation instability when all generation interconnection requests were at 100% output. The Stability Analysis also determined that events across the Group 8 study area resulted in generation tripping (study projects GEN-2016-133 through GEN-2016-146) when all generation interconnection requests were at 100% output for several P1, P4, and P6 events. Additionally, for several faults near the Riverside 345 kV station, the study projects GEN-2016-133 through GEN-2016-146 were required to have voltage protection disabled to prevent the units from tripping offline due to high voltages after clearing the fault.

The following transmission upgrade options were observed to mitigate the system instability observed for all contingencies:

- Wolf Creek to Emporia Energy Center 345kV circuit (previously and no longer assigned as mitigation in DISIS-2016-001-4)
- Wolf Creek to Blackberry 345kV circuit (previously and current assigned mitigation in DISIS-2016-001-5)

This analysis identified the potential requirement of generation curtailment at Wolf Creek for certain prior outage conditions including Wolf Creek to Blackberry 345kV circuit #1, Wolf Creek to Waverly 345kV circuit #1, or Waverly to LaCygne 345kV circuit #1. The Transmission Owner is advised to update the existing Wolf Creek Operating Guide accordingly once the Wolf Creek to Blackberry 345kV circuit #1 is complete. Note if the upgraded circuit of Wolf Creek to Blackberry 345kV is replaced with Wolf Creek to Emporia Energy Center 345kV circuit #1, the same results apply to the alternate circuit.

It is recommended that the interconnection customer(s) for GEN-2016-133 through GEN-2016-146 re-examine the design of the interconnection request(s) due to the projects tripping offline, does not meet FERC Order 661A criteria, when voltage protection is enabled.

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SECTION 1: OBJECTIVES

The objective of this report is to provide Southwest Power Pool, Inc. (SPP) with the deliverables for the "DISIS-2016-002-2 (Group 08) Definitive Impact Study." SPP requested an Interconnection System Impact Study for twenty-one (21) generation interconnections for 2017 Winter Peak, 2018 Summer Peak, and 2026 Summer Peak, which requires a Stability Analysis and Short Circuit Analysis.

SECTION 2: BACKGROUND

The Siemens Power Technologies International PSS/E power system simulation program Version 33.10.0 was used for this study. SPP provided the stability database cases for 2017 Winter Peak, 2018 Summer Peak, and 2026 Summer Peak conditions and the list of contingencies to be examined were created by MEPPI. The model includes the study projects shown in Table 2-1 and the previously queued projects listed in Table 2-2. Refer to Appendix A for the steady-state and dynamic model data for the study projects. A power flow one-line diagram for each generation interconnection project is shown in Figures 2-1 through 2-5. Note that the one-line diagrams represent the 2017 Winter Peak case.

The Stability Analysis determined the impacts of the new interconnecting projects on the stability and voltage recovery of the nearby system and the ability of the interconnecting projects to meet FERC Order 661A. SPP Performance Criteria violations for stability and voltage recovery were identified, adjustment of transmission line in power flow case was investigated. Three-phase faults and single line-to-ground faults were examined as listed in Table 2-3.

Table 2-1: Interconnection Projects Evaluated

Request	Size (MW)	Generator Model	Point of Interconnection
GEN-2016-100	100	Wind (587803)	Tap Sooner-Spring Creek 345kV (587804)
GEN-2016-101	195	Wind (587813)	Tap Sooner-Spring Creek 345kV (587804)
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GEN-2016-134	187.5	Wind	Riverside 345kV Substation (509782)
GEN-2016-135	100	Wind	Riverside 345kV Substation (509782)
GEN-2016-136	75	Wind	Riverside 345kV Substation (509782)
GEN-2016-137	187.5	Wind	Riverside 345kV Substation (509782)
GEN-2016-138	187.5	Wind	Riverside 345kV Substation (509782)
GEN-2016-139	100	Wind	Riverside 345kV Substation (509782)
GEN-2016-140	75	Wind	Riverside 345kV Substation (509782)
GEN-2016-141	350	Wind	Riverside 345kV Substation (509782)
GEN-2016-142	350	Wind	Riverside 345kV Substation (509782)
GEN-2016-143	175	Wind	Riverside 345kV Substation (509782)
GEN-2016-144	175	Wind	Riverside 345kV Substation (509782)
GEN-2016-145	175	Wind	Riverside 345kV Substation (509782)
GEN-2016-146	175	Wind	Riverside 345kV Substation (509782)
GEN-2016-153	134	Wind (588363)	Viola 345kV (532798)
GEN-2016-162	252	Wind (588323)	Benton 345kV (532791)
GEN-2016-163	252	Wind (588333)	Benton 345kV(532791)

Table 2-2: Previously Queued Nearby Interconnection Projects Included

Request	Size (MW)	Generator Model	Point of Interconnection
GEN-2002-004	153.0	GE.1.5MW	Latham 345kV (532800)
GEN-2005-013	199.8	Vestas V90 VCSS 1.8MW	Caney River 345kV (532780)
GEN-2007-025/GEN-2010-005	598.4	GE 1.6MW & Vestas V110 2.0MW	Viola 345kV (532798)
GEN-2008-013	300	GE 1.68/2.4MW	Hunter 345kV (515476)
GEN-2008-021	42 uprate 1261 Summer 1283 Winter	GENROU	Wolf Creek 345kV (532797)
GEN-2008-098/ GEN-2010-003	199	Gamesa G114 2.0/2.1MW	Waverly 345kV (532799)
GEN-2009-025	59.8	Siemens 93m 2.3MW	Nardins 69kV (515528)
ASGI-2010-006 (AECI request GIA-27)	150	GE 1.5MW	Remington 138kV (301369)
GEN-2010-055	4.8	Caterpiller 1.6MW	Wekiwa 138kV (509757)
GEN-2011-057	150	Vestas V110 2.0MW	Creswell 138kV (532981)
GEN-2012-032	299	Siemens 108m 2.3MW	Open Sky 345kV (515621)
GEN-2012-033/GEN-2015-062	102.56	GE 1.79/1.8MW	Tap and Tie South 4th - Bunch Creek & Enid Tap - Fairmont (GEN-2012-033T) 138kV (514815)
GEN-2012-041	121.5 Winter 85.3 Summer	Thermal	Ranch Road 345kV (515576)
GEN-2013-012	137 uprate 1420	GENROU	Redbud 345kV (514909)

Request	Size (MW)	Generator Model	Point of Interconnection
GEN-2013-028	559.5	Gas CT (CC) 360MW, Steam (CC) 199.5MW	Tap on Tulsa N to GRDA1 345kV (512865)
GEN-2013-029	299	Siemens 108m VS 2.3MW	Renfrow 345kV(515543)
GEN-2014-001	199.5	Gamesa 2.1MW	Tap Wichita to Emporia Energy Center 345kV (562476)
GEN-2014-028	35 uprate 259 Winter 256 Summer	Thermal – CT 142MW, Thermal – ST 17MW	Riverton 161kV (547469)
GEN-2014-064	248.4	GE 107m 2.3MW	Otter 138kV (514708)
ASGI-2014-014	56.4 Winter 54.3 Summer	Wartsila 18V50SG 18.8MW	Ferguson 69kV (512664)
GEN-2015-001/GEN-2016-031	201.3	Vestas V126 GridStreamer 3.3MW	Ranch Road 345kV (515576)
GEN-2015-015	154.6	Siemens 108m 2.415MW	Tap Medford Tap – Coyote 138kV (560031)
GEN-2015-016	200	Vestas V110 2.0MW	Tap Marmaton - Centerville 161kV (560029)
GEN-2015-024	217.8	GE 116m 1.8MW	Tap Thistle - Wichita 345kV Dbl CKT (560033)
GEN-2015-025	215.95	GE 1.79/1.8MW	Tap Thistle - Wichita 345kV Dbl CKT (560033)
ASGI-2015-004	54.300 Summer 56.364 Winter	Wartsila 18V50SG 18.788MW	Coffeyville Municipal Light & Power Northern Industrial Park Substation 69kV (512735)

Request	Size (MW)	Generator Model	Point of Interconnection
GEN-2015-034	200	Vestas V136 GridStreamer 3.45MW	Ranch Road 345kV (515576)
GEN-2015-047	297.8	GE 2.3/2.5MW	Sooner 345kV (514803)
GEN-2015-052	300	Vestas V110 VCSS 2.0MW	Tap on Opensky (515621) to RoseHill (532794) 345kV (560053)
GEN-2015-063	299.25	Acciona 125m 3.15MW	Tap on Woodring (514715) to Matthewson (515497) 345kV (560055)
GEN-2015-066	248.4	GE 2.3MW	Tap on Cleveland (512694) to Sooner (514803) 345 kV (560056)
GEN-2015-069	300	Vestas V110 VCSS 2.0MW	Union Ridge 230kV (532874)
GEN-2015-073	200.1	Vestas V126 GridStreamer 3.45MW	Emporia Energy Center 345kV (532768)
GEN-2015-090	220	G.E. 2.0MW	Wichita (532796)-Thistle (539801) 345kV Tap (GEN-2015-024 (560033) 345kV)
GEN-2016-009	29	Allen Bradley 14.5MW	Osage 69kV (514742)
GEN-2016-022	151.8	Vestas V126 GridStreamer 3.45MW	Ranch Road 345kV (515576)
GEN-2016-032	200	Vestas V110 VCSS 2.0MW	Tap Marshall (514733)- Cottonwood Creek (514827) 138kV, (G16-032-TAP, 560077)
GEN-2016-061	250.7	GE 2.3MW	Tap Woodring (514715) – Sooner (514803) 345kV (G16-061-TAP, 560084)
GEN-2016-068	250	GE 2.0MW	Woodring 345kV (514715)

Request	Size (MW)	Generator Model	Point of Interconnection
GEN-2016-071	200.1	GE 2.3MW	Chilocco 138kV (521198)
GEN-2016-073	220	GE 2.0MW	Tap on Thistle (539801) to Wichita (532796) 345kV, ckt1&2 (Buffalo Flats 345kV; 560033)
ASGI-2017-008 (AECI request GIA-59)	158.6 (withdrawal not reflected in study)	GE 2.3MW & 2.5MW	Tap on Remington (301369) to Shidler (510403) 138 kV (588314)

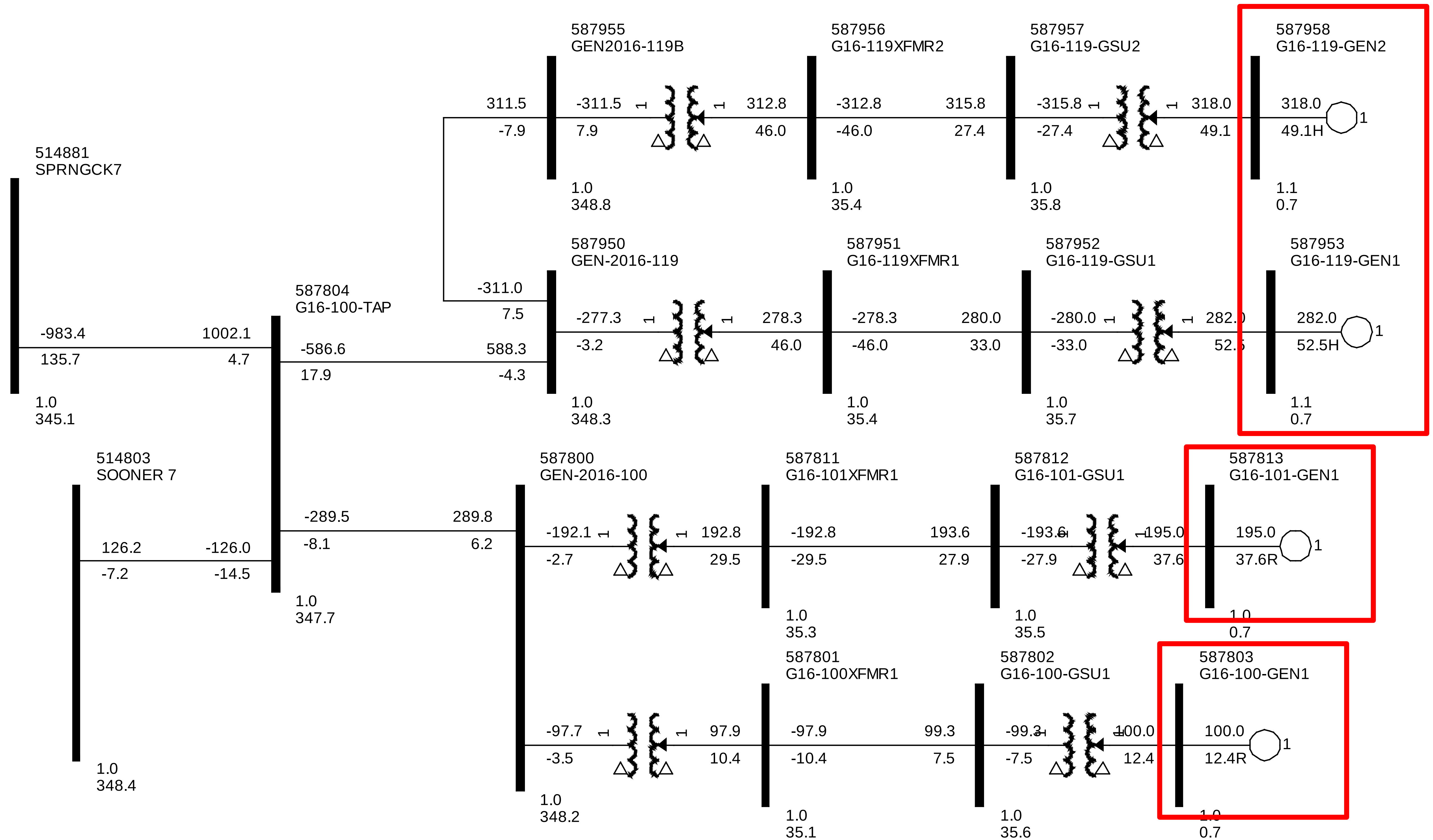

Figure 2-1. Power flow one-line diagram for interconnection project at Sooner to Spring Creek 345 kV POI (GEN-2016-100, GEN-2016-101, GEN-2016-119).

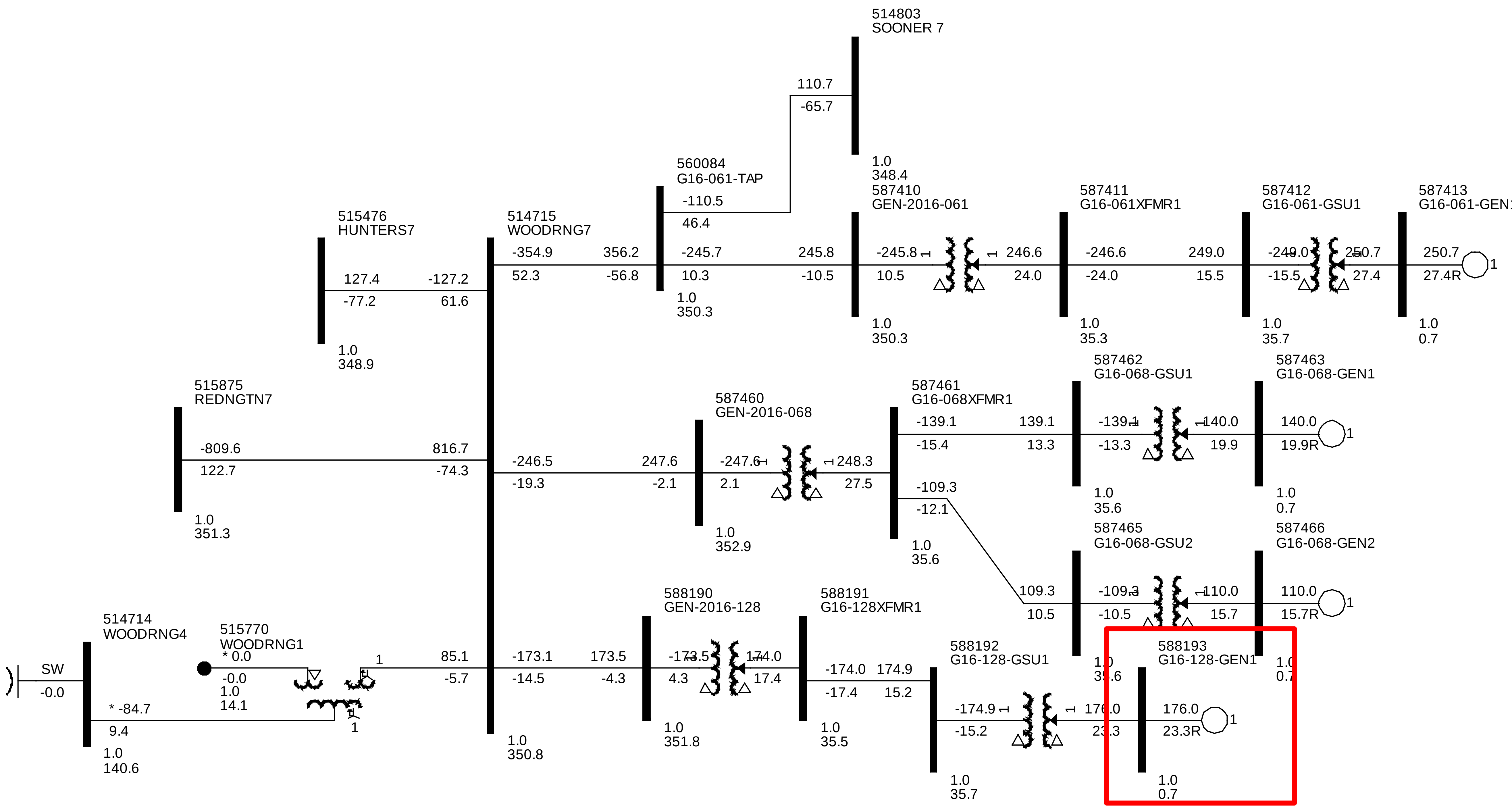

Figure 2-2. Power flow one-line diagram for interconnection project at the Woodring 345 kV POI (GEN-2016-128).

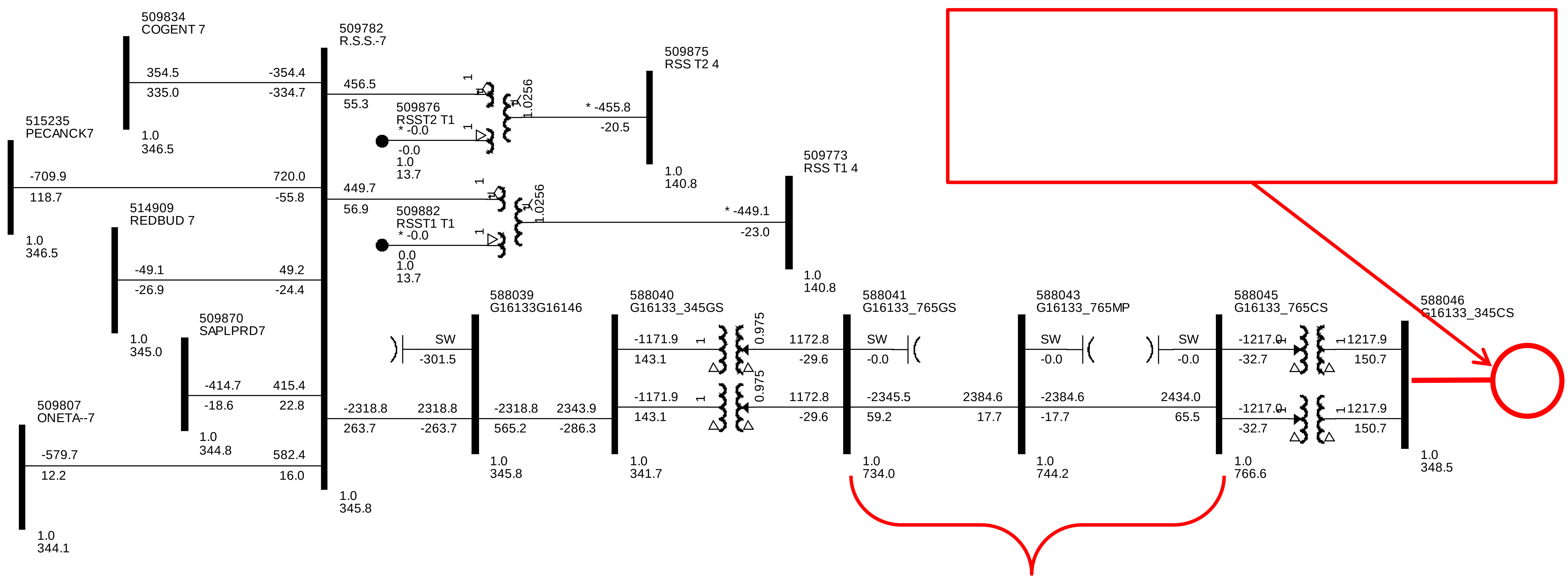

Figure 2-3. Power flow one-line diagram for interconnection project at the Riverside 345 kV POI (GEN-2016-133, GEN-2016-134, GEN-2016-135, GEN-2016-136, GEN-2016-137, GEN-2016-138, GEN-2016-139, GEN-2016-140, GEN-2016-141, GEN-2016-142, GEN-2016-143,GEN-2016-144, GEN-2016-145, and GEN-2016-146).

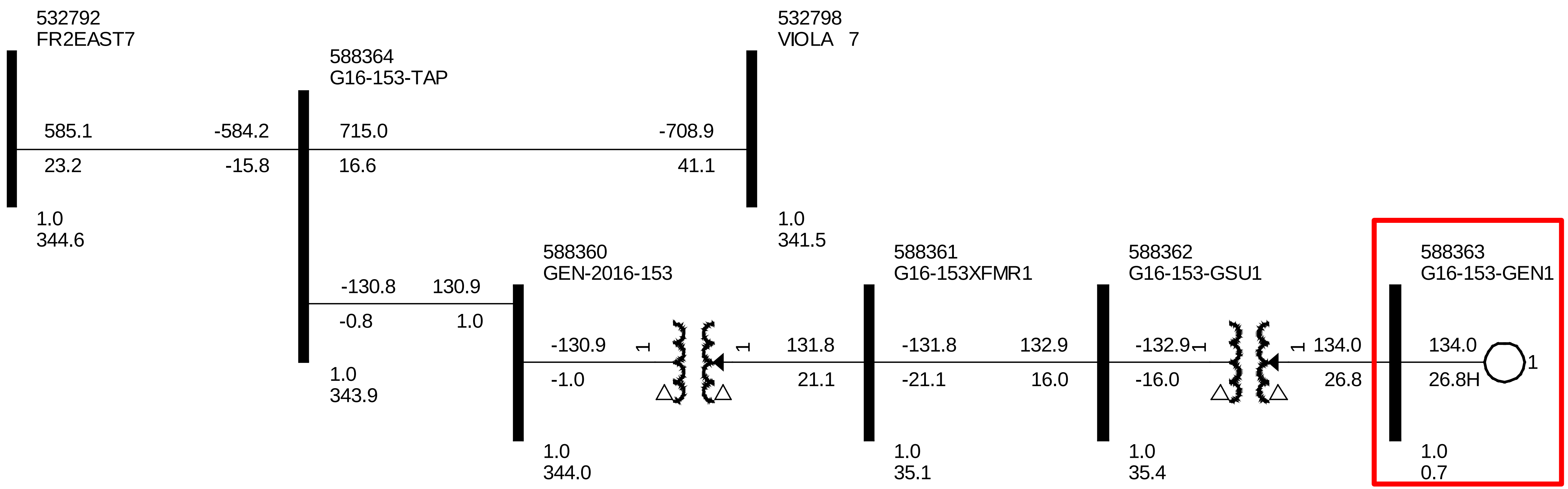

Figure 2-4. Power flow one-line diagram for interconnection project at Viola 345 kV POI (GEN-2016-153).

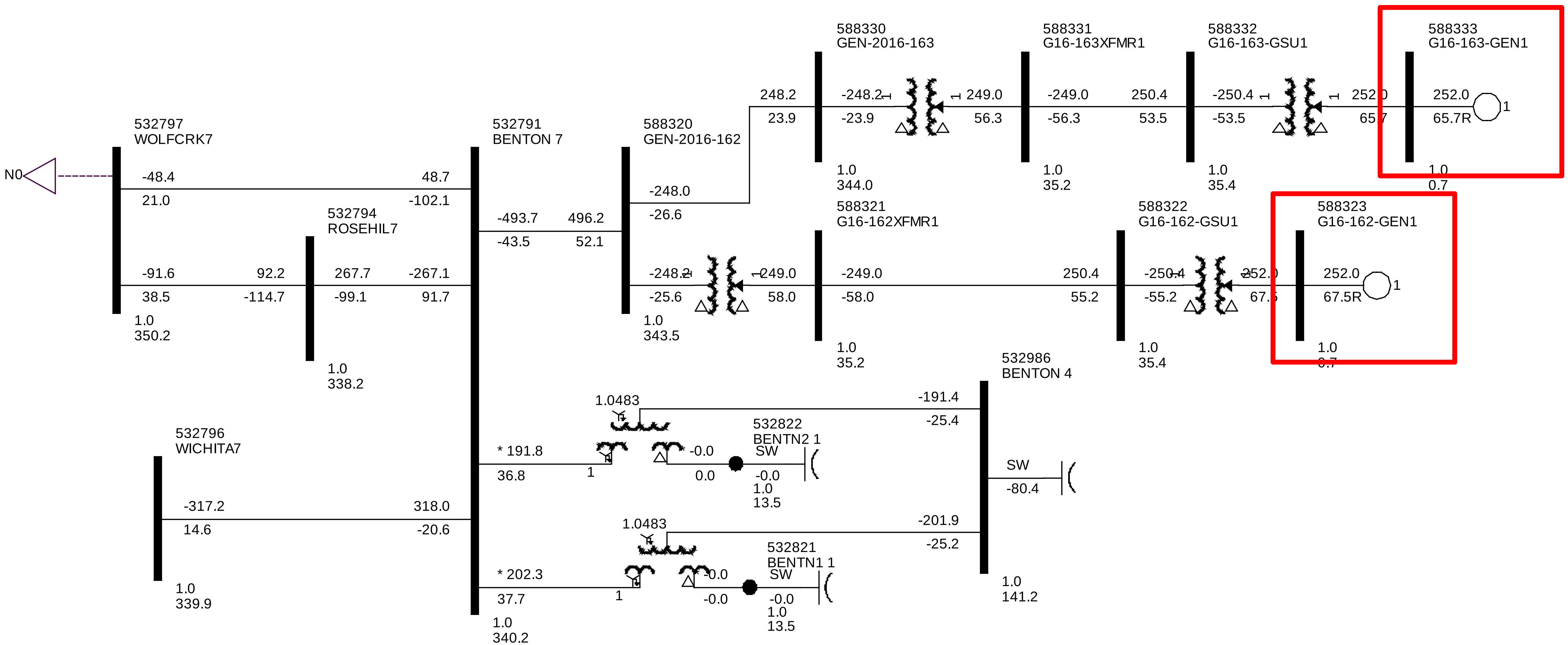

Figure 2-5. Power flow one-line diagram for interconnection project at the Benton 345 kV POI (GEN-2016-162 and GEN-2016-163).

Table 2-3: Case List with Contingency Description

Cont. No.	Cont. Name	Description
1	FLT01-3PH	3 phase fault on the Midian (532990) to Butler (532987) 138kV line, near Midian. a. Apply fault at the Midian 138kV 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.
2	FLT02-3PH	3 phase fault on the Midian (532990) to Benton (532986) 138kV line, near Midian. a. Apply fault at the Midian 138kV 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.
3	FLT03-3PH	3 phase fault on the Midian 138/69/13.2kV (532990/533597/533082) transformer, near Midian. a. Apply fault at the Midian 138kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
4	FLT04-3PH	3 phase fault on the Benton (532986) to Chisholm (533035) 138kV line, near Benton. a. Apply fault at the Benton 138kV 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.
5	FLT05-3PH	3 phase fault on the Benton (532986) to 29th (533024) 138kV line, near Benton. a. Apply fault at the Benton 138kV 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.
6	FLT06-3PH	3 phase fault on the Benton (532986) to Belaire (532988) 138kV line, near Benton. a. Apply fault at the Benton 138kV 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.
7	FLT07-3PH	3 phase fault on the Benton 345/138/13.8kV (532791/532986/532822) transformer, near Benton. a. Apply fault at the Benton 138kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
8	FLT08-3PH	3 phase fault on the Butler (532987) to Altoona (533001) 138kV line, near Butler. a. Apply fault at the Butler 138kV 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.
9	FLT09-3PH	3 phase fault on the Butler (532987) to Butler (532989) 138kV line, near Butler. a. Apply fault at the Butler 138kV 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.
10	FLT10-3PH	3 phase fault on the Butler 138/69kV (532987/533583) transformer, near Butler. a. Apply fault at the Butler 138kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
11	FLT11-PO	**Prior outage of the Midian (532990) – Butler (532987) 138kV line** 3 phase fault on the Midian (532990) – Benton (532986) 138kV line, near Midian. a. Apply fault at the Midian 138kV 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.
12	FLT12-PO	**Prior outage of the Midian (532990) – Butler (532987) 138kV line** 3 phase fault on the Midian 138/69/13.2kV (532990/533597/533082) transformer, near Midian. a. Apply fault at the Midian 138kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
13	FLT13-PO	**Prior outage of the Midian (532990) – Benton (532986) 138kV line** 3 phase fault on the Midian 138/69/13.2kV (532990/533597/533082) transformer, near Midian. a. Apply fault at the Midian 138kV bus. b. Clear fault after 5 cycles by tripping the faulted line.

Cont. No.	Cont. Name	Description
14	FLT14-PO	**Prior outage of the Midian (532990) –Butler Tap (532989) 138kV line** 3 phase fault on the Midian (532990) – Benton (532986) 138kV line, near Midian. a. Apply fault at the Midian 138kV 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.
15	FLT15-SB	**Stuck Breaker on Midian – Benton 138kV circuit 1 line** a. Apply single-phase fault at Midian (532990) on the 138kV bus. b. After 16 cycles, trip the Midian – Benton (532986) 138kV circuit 1 line c. Trip the Midian – Butler (532987) 138kV circuit 1 line, and remove the fault
16	FLT16-SB	**Stuck Breaker on Midian – Benton 138kV circuit 1 line** a. Apply single-phase fault at Midian (532990) on the 138kV bus. b. After 16 cycles, trip the Midian – Benton (532986) 138kV circuit 1 line c. Trip the Midian 138/69/13.2kV (532990/533597/533082) transformer, and remove the fault
17	FLT17-SB	**Stuck Breaker on Midian – Butler 138kV circuit 1 line** a. Apply single-phase fault at Midian (532990) on the 138kV bus. b. After 16 cycles, trip the Midian – Butler (532987) 138kV circuit 1 line c. Trip the Midian 138/69/13.2kV (532990/533597/533082) transformer, and remove the fault
18	FLT18-SB	**Stuck Breaker on Butler (532987) – Butler Tap (532989) 138kV circuit 1 line** a. Apply fault at Butler (532987) on the 138kV bus. b. After 16 cycles, trip the Butler – Altoona 138 kV circuit 1 line c. Trip the Butler (532987) – Butler Tap (532989) 138kV circuit 1 line, and remove the fault
19	FLT19-SB	**Stuck Breaker on Midian 138/69/13.2kV (532990/533597/533082) transformer** a. Apply single-phase fault at Midian (532990) on the 138kV bus. b. After 16 cycles, trip the Midian 138/69/13.2kV (532990/533597/533082) transformer c. Trip the Midian – Butler (532987) 138kV circuit 1 line, and remove the fault
20	FLT20-SB	**Stuck Breaker on Midian 138/69/13.2kV (532990/533597/533082) transformer** a. Apply single-phase fault at Midian (532990) on the 138kV bus. b. After 16 cycles, trip the Midian 138/69/13.2kV (532990/533597/533082) transformer c. Trip the Midian – Benton (532986) 138kV circuit 1 line, and remove the fault
21	FLT21-3PH	3 phase fault on the Hunters (515476) to Renfro (515543) 345kV line, near Hunters. a. Apply fault at the Hunters 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.
22	FLT22-3PH	3 phase fault on the Chisholm (515477) 345kV to Hunters (515476) 345kV line, near Hunters. a. Apply fault at the Hunters 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.
23	FLT23-3PH	3 phase fault on the Renfrow (515543) to Viola (532798) 345kV line, near Renfro. a. Apply fault at the Renfro 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.
24	FLT24-3PH	3 phase fault on the Renfrow (515543) 345/(515544) 138/(515545) 13.8kV transformer, near Renfrow 345. a. Apply fault at the Renfrow 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
25	FLT25-3PH	3 phase fault on the Renfrow (515544) to MDFRDTP4 (515569) 345kV circuit 1 line, near Renfrow. a. Apply fault at the Renfrow 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.
26	FLT26-3PH	3 phase fault on the Hunters (515476) to Woodring (514715) 345kV circuit 1 line, near Hunters. a. Apply fault at the Hunters 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.

Cont. No.	Cont. Name	Description
27	FLT27-3PH	3 phase fault on the Renfrow (515544) to Renfrow (520409) 345kV circuit 1 line, near Hunters. a. Apply fault at the Hunters 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.
28	FLT28-PO	**Prior outage on the Renfrow (515543) 345/ (515544) 138/ (515545) 13.8kV transformer** 3 phase fault on the Renfrow (515543) to Viola (532798) 345kV line, near Renfrow. a. Apply fault at the Renfrow 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.
29	FLT29-PO	**Prior outage of the G16-072-Tap (560086) – Hunters (515476) 345kV line** 3 phase fault on the Renfrow (515543) – Viola (532798) 345kV line, near Renfrow. a. Apply fault at the Renfrow 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.
30	FLT30-PO	**Prior outage on the Renfrow (515543) 345/ (515544) 138/ (515545) 13.8kV transformer** 3 phase fault on the Renfrow (515543) to Hunters (515476) 345kV line, near Renfrow. a. Apply fault at the Renfrow 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.
31	FLT31-PO	**Prior outage on the Renfrow (515543) 345/ (515544) 138/ (515545) 13.8kV transformer** 3 phase fault on the Renfrow (515544) to MDFRDTPH (515569) 345kV line, near Renfrow. a. Apply fault at the Renfrow 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.
32	FLT32-PO	**Prior outage of the Hunters (515476) – Woodring (514715) 345kV line** 3 phase fault on the Renfrow (515544) to MDFRDTPH (515569) 345kV line, near Renfrow. a. Apply fault at the Renfrow 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.
33	FLT33-PO	**Prior outage of the Renfrow (515543) – Viola (532798) 345kV line** 3 phase fault on the Hunters (515476) – Renfrow (515543) 345kV line, near Hunters. a. Apply fault at the Hunters 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	FLT34-SB	**Stuck Breaker on Renfrow– Hunters 345kV circuit 1 line** a. Apply single-phase fault at Renfrow (515543) on the 345kV bus. b. After 16 cycles, trip the Renfrow (515543) 345/(515544) 138/(515545) 13.8kV transformer c. Trip the Renfrow – Hunters (515476) 345 kV circuit 1 line, and remove the fault
35	FLT35-SB	**Stuck Breaker on Renfrow – Viola 345kV circuit 1 line** a. Apply single-phase fault at Renfrow (515543) on the 345kV bus. b. After 16 cycles, trip the Renfrow 345/138/13.8kV (515543/515544/515545) transformer c. Trip the Renfrow – Viola (532798) 345 kV circuit 1 line, and remove the fault
36	FLT36-SB	**Stuck Breaker on Renfrow – Hunters 345kV circuit 1 line** a. Apply single-phase fault at Renfrow (515543) on the 345kV bus. b. After 16 cycles, trip the Renfrow – Viola (532798) 345 kV circuit 1 line, and remove the fault c. Trip the Renfrow – Hunters (515476) 345kV circuit 1 line, and remove the fault
37	FLT37-3PH	3 phase fault on the G16-100-TAP (587804) to Spring Creek (514881) 345kV line, near G16-100-TAP. a. Apply fault at the G16-100-TAP 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.

Cont. No.	Cont. Name	Description
38	FLT38-3PH	3 phase fault on the G16-100-TAP (587804) to Sooner (514803) 345kV line, near G16-100-TAP. a. Apply fault at the G16-100-TAP 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.
39	FLT39-3PH	3 phase fault on the Sooner 345/138/13.8kV (514803/514802/515760) transformer, near Sooner. a. Apply fault at the Sooner 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
40	FLT40-3PH	3 phase fault on the Sooner (514803) to Ranch Road (515576) 345kV line, near Sooner. a. Apply fault at Sooner 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.
41	FLT41-3PH	3 phase fault on the Sooner (514803) to Thunder (515894) 345kV line, near Sooner. a. Apply fault at Sooner 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	FLT42-3PH	3 phase fault on the Sooner (514803) to G15-066T (560056) 345kV line, near Sooner. a. Apply fault at the Sooner 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.
43	FLT43-3PH	3 phase fault on the Sooner (514803) to G16-061-Tap (560084) 345kV line, near Sooner. a. Apply fault at the Sooner 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.
44	FLT44-3PH	3 phase fault on the Spring Creek (514881) to Northwest (514880) 345kV line, near Spring Creek. a. Apply fault at the Spring Creek 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.
45	FLT45-3PH	3 phase fault on the Spring Creek (514881) to G16-100-TAP (587804) 345kV line, near Spring Creek. a. Apply fault at the Spring Creek 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.
46	FLT46-3PH	3 phase fault on the Sooner (514803) to G16-100-TAP (587804) 345kV line, near Sooner. a. Apply fault at the Sooner 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	FLT47-PO	**Prior outage of the G16-100-Tap – Sooner (514803) 345kV circuit 1 line** 3 phase fault on the Sooner (514803) – G16-061 Tap (560084) 345kV line, near Sooner. a. Apply fault at the Sooner 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	FLT48-PO	**Prior outage of the G16-100-Tap – Sooner (514803) 345kV circuit 1 line** 3 phase fault on the Sooner (514803) – Ranch Road (515576) 345kV line, near G16-100-Tap. a. Apply fault at the Sooner 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.
49	FLT49-PO	**Prior outage of the G16-100-Tap – Sooner (514803) 345kV circuit 1 line** 3 phase fault on the Sooner 345/138/13.8kV (514803/514802/515760) transformer, near Sooner. a. Apply fault at the G16-100-Tap 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.

Cont. No.	Cont. Name	Description
50	FLT50-SB	**Stuck Breaker on Northwest7 – Spring Creek 345kV circuit 1 line** a. Apply single-phase fault at Northwest7 (514880) on the 345kV bus. b. After 16 cycles, trip the Northwest7 – Arcadia (514908) 345kV circuit 1 line c. Trip the NorthWst7 (514880) – Spring Creek (514881) 345kV circuit 1 line, and remove the fault
51	FLT51-PO	**Prior outage of the Sooner (514803) – G15-066T (560056) 345kV line** 3 phase fault on the Ranch Road (515576) – Sooner (514803) 345kV line, near Ranch Road. a. Apply fault at the Ranch Road 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.
52	FLT52-PO	**Prior outage of the Sooner (514803) – Ranch Road (515576) 345kV line** 3 phase fault on the Sooner (514803) – G16-100-TAP (587804) 345kV line, near Sooner. a. Apply fault at the Sooner 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.
53	FLT53-PO	**Prior outage of the Sooner (514803) – Ranch Road (515576) 345kV line** 3 phase fault on the Sooner 345/138/13.8kV (514803/514802/515760) transformer, near Sooner. a. Apply fault at the Sooner 345kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer and remove fault.
54	FLT54-PO	**Prior outage of the Sooner (514803) – Ranch Road (515576) 345kV line** 3 phase fault on the Sooner (514803) – Thunder (515894) 345kV line, near Sooner. a. Apply fault at the Sooner 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
55	FLT55-PO	**Prior outage of the Spring Creek (514881) – Northwest (514880) 345kV line** 3 phase fault on the Sooner (514803) –Ranch Road (515576) 345kV line, near Sooner. a. Apply fault at the Sooner 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.
56	FLT56-PO	**Prior outage of the Spring Creek (514881) – G16-100-TAP (587804) 345kV line** 3 phase fault on the Sooner (514803) –Ranch Road (515576) 345kV line, near Sooner. a. Apply fault at the Sooner 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.
57	FLT57-SB	**Stuck Breaker on Sooner – G16-100-TAP 345kV circuit 1 line** a. Apply single-phase fault at Sooner (514803) on the 345kV bus. b. After 16 cycles, trip the Sooner – G16-100-TAP (587804) 345kV circuit 1 line c. Trip the Sooner – Ranch Road (515576) 345kV circuit 1 line, and remove the fault
58	FLT58-SB	**Stuck Breaker on Sooner – G15-066T 345kV circuit 1 line** a. Apply single-phase fault at Sooner (514803) on the 345kV bus. b. After 16 cycles, trip the Sooner – G15-066T (560056) 345kV circuit 1 line c. Trip the Sooner – Ranch Road (515576) 345kV circuit 1 line, and remove the fault
59	FLT59-SB	**Stuck Breaker on Northwest7 – Mathewson 345kV circuit 1 line** a. Apply single-phase fault at Northwest7 (514880) on the 345kV bus. b. After 16 cycles, trip the Northwest7 – Arcadia (514908) 345kV circuit 1 line c. Trip the Northwest (514880) – Mathewson (515497) 345kV circuit 1 line, and remove the fault
60	FLT60-3PH	3 phase fault on the Shidler (510403) to Fairfat Tap (510377) 138kV line, near Shidler. a. Apply fault at the Shidler 138kV 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.
61	FLT61-3PH	3 phase fault on the Fairfax Tap (510377) to Webber Tap (510376) 138kV line, near Shidler. a. Apply fault at the Shidler 138kV 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.

Cont. No.	Cont. Name	Description
62	FLT62-3PH	3 phase fault on the Webber Tap (510376) to Osage (514743) 138kV line, near Webber Tap. a. Apply fault at the Webber Tap 138kV 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.
63	FLT63-3PH	3 phase fault on the Webber Tap (510376) to Fairfax Tap (510377) 138kV line, near Webber Tap. a. Apply fault at the Webber Tap 138kV 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.
64	FLT64-3PH	3 phase fault on the Shidler (510403) to WPAWWHSKY4 (510382) 138kV line, near Hardy. a. Apply fault at the Shidler 138kV 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.
65	FLT65-3PH	3 phase fault on the Osage (514743) to Marland Tap (514770) 138kV line, near Osage. a. Apply fault at the Osage 138kV 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.
66	FLT66-3PH	3 phase fault on the Osage (514743) to White Eagle (514761) 138kV line, near Osage. a. Apply fault at the Osage 138kV 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.
67	FLT67-3PH	3 phase fault on the Osage (514743) to Sooner Pump Tap (514798) 138kV line, near Osage. a. Apply fault at the Osage 138kV 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.
68	FLT68-3PH	3 phase fault on the Osage 138/69/13.2kV (514743/514742/515745) transformer circuit 1, near Osage. a. Apply fault at the Osage 138kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
69	FLT69-3PH	3 phase fault on the Osage 138/69/13.2kV (514743/514742/515744) transformer circuit 2, near Osage. a. Apply fault at the Osage 138kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
70	FLT70-3PH	3 phase fault on the Osage (514743) to Standing Bear (514758) 138kV line, near Osage. a. Apply fault at the Osage 138kV 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.
71	FLT71-PO	**Prior outage of the Osage (514743) – Maryland Tap (514770) 138kV line** 3 phase fault on the Webber Tap (510376) – Osage (514743) 138kV line, near Webber Tap. a. Apply fault at the Webber Tap 138kV 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.
72	FLT72-PO	**Prior outage of the Webber Tap (510376) – Fairfax Tap (510377) 138kV line** 3 phase fault on the Osage (514743) to White Eagle (514761) 138kV line, near Webber County. a. Apply fault at the Webber County 138kV 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.
73	FLT73-PO	**Prior outage of the Webber Tap (510376) – Osage (514743) 138kV line** 3 phase fault on the Osage (514743) to Standing Bear (514758) 138kV line, near Webber County. a. Apply fault at the Osage 138kV 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.

Cont. No.	Cont. Name	Description
74	FLT74-PO	**Prior outage on the Osage (514743) – Standing Bear (514758) 138kV line** 3 phase fault on the Osage (514743) – White Eagle (514761) 138kV line, near Osage. a. Apply fault at the Osage 138kV 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.
75	FLT75-SB	**Stuck Breaker on Osage (514743) 138kV – Webber Tap (510376) circuit 1 line** a. Apply single-phase fault at Osage on the 138kV bus. b. After 16 cycles, trip the Osage – Standing Bear (514758) 138kV circuit 1 line c. Trip the Osage – Webber Tap 138kV circuit 1 line, and remove the fault
76	FLT76-SB	**Stuck Breaker on Osage (514743) 138kV – Webber Tap (510376) circuit 1 line** a. Apply single-phase fault at Osage on the 138kV bus. b. After 16 cycles, trip the Osage – White Eagle (514761) 138kV circuit 1 line c. Trip the Osage – Webber Tap 138kV circuit 1 line, and remove the fault
77	FLT77-SB	**Stuck Breaker on Osage (514743) 138kV – Webber Tap (510376) circuit 1 line** a. Apply single-phase fault at Osage on the 138kV bus. b. After 16 cycles, trip the Osage – SNRPMPT4 (514798) 138kV circuit 1 line c. Trip the Osage – Webber Tap 138kV circuit 1 line, and remove the fault
78	FLT78-SB	**Stuck Breaker on Osage – Marland Tap 138kV circuit 1 line** a. Apply single-phase fault at Osage (514743) on the 138kV bus. b. After 16 cycles, trip the Osage – Webber Tap (510376) 138kV circuit 1 line c. Trip the Osage – Marland Tap (514770) 138kV circuit 1 line, and remove the fault
79	FLT79-3PH	3 phase fault on the Woodring 345/138/13.8kV (514715/514714/515770) transformer, near Woodring. a. Apply fault at the Woodring 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
80	FLT80-3PH	3 phase fault on the Woodring (514715) to Redington (515875) 345kV line, near Woodring. a. Apply fault at the Woodring 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.
81	FLT81-3PH	3 phase fault on the Woodring (514715) to G16-061-Tap (560084) 345kV line, near Woodring. a. Apply fault at the Woodring 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.
82	FLT82-3PH	3 phase fault on the Redington (515875) to Mathewson (515497) 345kV line, near Redington. a. Apply fault at the Redington 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.
83	FLT83-3PH	3 phase fault on the Mathewson (515497) to Northwest7 (514880) 345kV line, near Mathewson. a. Apply fault at the Mathewson 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.
84	FLT84-3PH	3 phase fault on the Woodring (514714) to Otter (514708) 345kV line, near Woodring. a. Apply fault at the Woodring 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.
85	FLT85-PO	**Prior outage of the Woodring (514715) – Redington (515875) 345kV line** 3 phase fault on the Woodring 345/138/13.8kV (514715/514714/515770) transformer, near Woodring. a. Apply fault at the Woodring 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
86	FLT86-PO	**Prior outage of the Woodring (514715) – Hunters (514476) 345kV line** 3 phase fault on the Woodring (514715) to Redington (515875) 345kV line, near Woodring. a. Apply fault at the Woodring 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.

Cont. No.	Cont. Name	Description
87	FLT87-PO	**Prior outage of the Woodring (514715) – Hunters (514476) 345kV line** 3 phase fault on the G16-061-Tap (560084) to Sooner (514803) 345kV line, near Sooner. a. Apply fault at the Sooner 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.
88	FLT88-PO	**Prior outage of the Woodring 345/138/13.8kV (514715/514714/515770) transformer** 3 phase fault on the Woodring (514715) to Redington (515875) 345kV line, near Woodring. a. Apply fault at the Woodring 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.
89	FLT89-PO	**Prior outage of the Woodring 345/138/13.8kV (514715/514714/515770) transformer** 3 phase fault on the Woodring (514715) to Hunters (515476) 345kV line, near Woodring. a. Apply fault at the Woodring 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.
90	FLT90-SB	**Stuck Breaker on Woodring – Hunters 345kV circuit 1 line** a. Apply single-phase fault at Woodring (514715) on the 345kV bus. b. After 16 cycles, trip the Woodring – Hunters (515476) 345kV circuit 1 line c. Trip the Woodring – Redington (515875) 345kV circuit 1 line, and remove the fault
91	FLT91-SB	**Stuck Breaker on Mathewson – Northwest7 345kV circuit 1 line** a. Apply single-phase fault at Mathewson (515497) on the 345kV bus. b. After 16 cycles, trip the Mathewson – Northwest7 (514880) 345kV circuit 1 line c. Trip the Mathewson – Tatonga (515407) 345kV circuit 1 line, and remove the fault
92	FLT92-SB	**Stuck Breaker on Woodring – Hunters 345kV circuit 1 line** a. Apply single-phase fault at Woodring (514715) on the 345kV bus. b. After 16 cycles, trip the Woodring – Hunters (515476) 345kV circuit 1 line c. Trip the Woodring 345/138/13.8kV (514715/514714/515770) transformer, and remove the fault
93	FLT93-SB	**Stuck Breaker on Woodring – Redington 345kV circuit 1 line** a. Apply single-phase fault at Woodring (514715) on the 345kV bus. b. After 16 cycles, trip the Woodring – Redington (515875) 345kV circuit 1 line c. Trip the Woodring 345/138/13.8kV (514715/514714/515770) transformer, and remove the fault
94	FLT94-SB	**Stuck Breaker on Woodring – Redington 345kV circuit 1 line** a. Apply single-phase fault at Woodring (514715) on the 345kV bus. b. After 16 cycles, trip the Woodring – Redington (515875) 345kV circuit 1 line c. Trip the Woodring – G16-061-Tap (560084) 345kV circuit 1 line, and remove the fault
95	FLT95-3PH	3 phase fault on the Tulsa North (509852) to N.E.S (510406) 345kV line, near Tulsa North. a. Apply fault at the Tulsa North 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.
96	FLT96-3PH	3 phase fault on the Tulsa North (509852) to Grec Tap (512865) 345kV line, near Tulsa North. a. Apply fault at the Tulsa North 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.
97	FLT97-3PH	3 phase fault on the Tulsa North (509852) to Cleveland (512694) 345kV line, near Tulsa North. a. Apply fault at the Tulsa North 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.
98	FLT98-3PH	3 phase fault on the Tulsa North (509852) to Wekiwa (509755) 345kV line, near Tulsa North. a. Apply fault at the Tulsa North 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.
99	FLT99-3PH	3 phase fault on the Tulsa North 345/138/34.5kV (509852/509895/509894) transformer, near Tulsa North. a. Apply fault at the Tulsa North 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.

Cont. No.	Cont. Name	Description
100	FLT100-3PH	3 phase fault on the N.E.S (510406) to Oneta (509807) 345kV line, near N.E.S. a. Apply fault at the N.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.
101	FLT101-3PH	3 phase fault on the N.E.S (510406) to Delaware (510380) 345kV line, near N.E.S. a. Apply fault at the N.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.
102	FLT102-3PH	3 phase fault on the Grec Tap (512865) to GRDA1 (512650) 345kV line, near Grec Tap a. Apply fault at the Grec Tap 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.
103	FLT103-3PH	3 phase fault on the Tulsa North (509817) to P&PWTP4 (509851) 138 kV line, near Tulsa North a. Apply fault at the Tulsa North 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.
104	FLT104-3PH	3 phase fault on the Wekiwa (509757) to P&PWTP4 (509851) 138 kV line, near Wekiwa a. Apply fault at the Wekiwa 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.
105	FLT105-3PH	3 phase fault on the Cleveland (512694) to G15-066T (560056) 345kV line, near Cleveland a. Apply fault at the Cleveland 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.
106	FLT106-3PH	3 phase fault on the Cleveland 345/138/13.8kV (512694/512729/512817) transformer, near Cleveland a. Apply fault at the Cleveland 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
107	FLT107-3PH	3 phase fault on the Wekiwa 345/138/34.5kV (509755/509757/509879) transformer, near Wekiwa a. Apply fault at the Wekiwa 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
108	FLT108-3PH	3 phase fault on the Wekiwa (509755) to SAPLPRD (509870) 345kV line, near Wekiwa a. Apply fault at the Wekiwa 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.
109	FLT109-PO	**Prior outage of the Tulsa North 345/138/34.5kV (509852/509895/509894) transformer** 3 phase fault on the Tulsa North (509852) to Cleveland (512694) 345kV line, near Tulsa North. a. Apply fault at the Tulsa North 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.
110	FLT110-PO	**Prior outage of the Tulsa North 345/138/34.5kV (509852/509895/509894) transformer** 3 phase fault on the Tulsa North (509852) to N.E.S. (510406) 345kV line, near Tulsa North. a. Apply fault at the Tulsa North 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.
111	FLT111-PO	**Prior outage of the Tulsa North 345/138/34.5kV (509852/509895/509894) transformer** 3 phase fault on the Tulsa North (509852) to Grec Tap (512865) 345kV line, near Tulsa North. a. Apply fault at the Tulsa North 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.

Cont. No.	Cont. Name	Description
112	FLT112-PO	**Prior outage of the Tulsa North (509852) to Wekiwa (509755) 345kV line, near Tulsa North.** 3 phase fault on the Tulsa North (509852) to Grec Tap (512865) 345kV line, near Tulsa North. a. Apply fault at the Tulsa North 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.
113	FLT113-PO	**Prior outage of the Tulsa North (509852) to Wekiwa (509755) 345kV line, near Tulsa North.** 3 phase fault on the Tulsa North (509852) to N.E.S. (510406) 345kV line, near Tulsa North. a. Apply fault at the Tulsa North 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.
114	FLT114-PO	**Prior outage of the Tulsa North (509852) to Cleveland (512694) 345kV line, near Tulsa North.** 3 phase fault on the Tulsa North (509852) to Grec Tap (512865) 345kV line, near Tulsa North. a. Apply fault at the Tulsa North 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.
115	FLT115-PO	**Prior outage of the Tulsa North (509852) to Cleveland (512694) 345kV line, near Tulsa North.** 3 phase fault on the Tulsa North (509852) to Wekiwa (509744) 345kV line, near Tulsa North. a. Apply fault at the Tulsa North 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.
116	FLT116-PO	**Prior outage of the Tulsa North (509852) to N.E.S. (510406) 345kV line, near Tulsa North.** 3 phase fault on the Tulsa North (509852) to Wekiwa (509744) 345kV line, near Tulsa North. a. Apply fault at the Tulsa North 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.
117	FLT117-PO	**Prior outage of the Tulsa North (509852) to N.E.S. (510406) 345kV line, near Tulsa North.** 3 phase fault on the Tulsa North (509852) to Cleveland (512694) 345kV line, near Tulsa North. a. Apply fault at the Tulsa North 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.
118	FLT118-SB	**Stuck Breaker on Tulsa North – Cleveland 345kV circuit 1 line** a. Apply single-phase fault at Tulsa North (509852) on the 345kV bus. b. After 16 cycles, trip the Tulsa North – Cleveland (512694) 345kV circuit 1 line c. Trip the Tulsa North – N.E.S. (510406) 345kV circuit 1 line, and remove the fault
119	FLT119-SB	**Stuck Breaker on Tulsa North – Cleveland 345kV circuit 1 line** a. Apply single-phase fault at Tulsa North (509852) on the 345kV bus. b. After 16 cycles, trip the Tulsa North – Cleveland (512694) 345kV circuit 1 line c. Trip the Tulsa North 345/138/34.5kV (509852/509895/509894) transformer, and remove the fault.
120	FLT120-SB	**Stuck Breaker on Tulsa North – N.E.S. 345kV circuit 1 line** a. Apply single-phase fault at Tulsa North (509852) on the 345kV bus. b. After 16 cycles, trip the Tulsa North – N.E.S. (510406) 345kV circuit 1 line c. Trip the Tulsa North 345/138/34.5kV (509852/509895/509894) transformer, and remove the fault.
121	FLT121-SB	**Stuck Breaker on Tulsa North – N.E.S. 345kV circuit 1 line** a. Apply single-phase fault at Tulsa North (509852) on the 345kV bus. b. After 16 cycles, trip the Tulsa North – N.E.S. (510406) 345kV circuit 1 line c. Trip the Tulsa North – Grec Tap (512865) 345kV circuit 1 line, and remove the fault.
122	FLT122-SB	**Stuck Breaker on Tulsa North – Wekiwa 345kV circuit 1 line** a. Apply single-phase fault at Tulsa North (509852) on the 345kV bus. b. After 16 cycles, trip the Tulsa North – Wekiwa (509755) 345kV circuit 1 line c. Trip the Tulsa North – Grec Tap (512865) 345kV circuit 1 line, and remove the fault.
123	FLT123-SB	**Stuck Breaker on Tulsa North – Wekiwa 345kV circuit 1 line** a. Apply single-phase fault at Tulsa North (509852) on the 345kV bus. b. After 16 cycles, trip the Tulsa North – Wekiwa (509755) 345kV circuit 1 line c. Trip the Tulsa North 345/138/34.5kV (509894/509895/509894) transformer, and remove the fault.

Cont. No.	Cont. Name	Description
124	FLT124-SB	**Stuck Breaker on Tulsa North 345/138/34.5kV (509852/509895/509894) transformer** a. Apply single-phase fault at Tulsa North (509852) on the 345kV bus. b. After 16 cycles, trip the Tulsa North 345/138/34.5kV (509894/509895/509894) transformer c. Trip the Tulsa North – Grec Tap (512865) 345kV circuit 1 line, and remove the fault.
125	FLT125-3PH	3 phase fault on the Buffalo Flats (532782) to Thistle (539801) 345kV circuit 1 line, near Buffalo Flats. a. Apply fault at the Buffalo Flats 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.
126	FLT126-3PH	3 phase fault on the Buffalo Flats (532782) to Thistle (539801) 345kV circuit 2 line, near Buffalo Flats. a. Apply fault at the Buffalo Flats 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.
127	FLT127-3PH	3 phase fault on the Thistle 345/138/13.8kV (539801/539802/539804) transformer a. Apply fault at the Thistle 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line and remove fault.
128	FLT128-3PH	3 phase fault on the Wichita 345/138/13.8kV (532796/532829/533040) transformer a. Apply fault at the Wichita 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line and remove fault.
129	FLT129-3PH	3 phase fault on the Thistle (539801) to Woodward (535375) 345kV circuit 1 line, near Thistle. a. Apply fault at the Thistle 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.
130	FLT130-3PH	3 phase fault on the Viola (532798) to Wichita (532796) 345kV circuit 1 line, near Viola. a. Apply fault at the Viola 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.
131	FLT131-3PH	3 phase fault on the Thistle (539801) to Woodward (535375) 345kV circuit 2 line, near Viola. a. Apply fault at the Thistle 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.
132	FLT132-3PH	3 phase fault on the Wichita (532796) to Benton (532791) 345kV circuit 1 line, near Wichita. a. Apply fault at the Wichita 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.
133	FLT133-3PH	3 phase fault on the Wichita (532796) to Reno (532771) 345kV circuit 1 line, near Wichita. a. Apply fault at the Wichita 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.
134	FLT134-3PH	3 phase fault on the Wichita (532796) to Buffalo Flats (532782) 345kV circuit 1 line, near Wichita. a. Apply fault at the Wichita 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.
135	FLT135-PO	**Prior outage of the Buffalo Flats (532782) to Thistle (539801) 345kV line** 3 phase fault on the Thistle (539801) to Woodward (535375) 345kV line, near Thistle. a. Apply fault at the Thistle 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.

Cont. No.	Cont. Name	Description
136	FLT136-PO	**Prior outage of the Benton (532791) to Wichita (532796) 345kV line** 3 phase fault on the Wichita (532796) to Viola (532798) 345kV line, near Wichita. a. Apply fault at the Wichita 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.
137	FLT137-PO	**Prior outage of the Buffalo Flats (532782) to Thistle (539801) 345kV line 1** 3 phase fault on the Buffalo Flats (532792) to Thistle (539801) 345kV line 2, near Buffalo Flats. a. Apply fault at the Buffalo Flats 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.
138	FLT138-PO	**Prior outage of the Buffalo Flats (532782) to Wichita (532796) 345kV line 1** 3 phase fault on the Buffalo Flats (532792) to Wichita (532796) 345kV line 2, near Buffalo Flats. a. Apply fault at the Buffalo Flats 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.
139	FLT139-SB	**Stuck Breaker on Wichita (532796) to Benton (532791) circuit 1 line** a. Apply single-phase fault at Wichita on the 345kV bus. b. After 16 cycles, trip the Wichita – Reno (532771) 345kV circuit 1 line c. Trip the Wichita – Benton 345kV circuit 1 line, and remove the fault.
140	FLT140-SB	**Stuck Breaker on Wichita (532796) – Reno (532771) 345kV circuit 1 line** a. Apply single-phase fault at Wichita (532791) on the 345kV bus. b. After 16 cycles, trip the Wichita – Buffalo Flats (532782) 345kV circuit 1 line c. Trip the Wichita – Reno 345kV circuit 1 line, and remove the fault.
141	FLT141-SB	**Stuck Breaker on Wichita (532796) – Reno (532771) circuit 1 line** a. Apply single-phase fault at Wichita (532791) on the 345kV bus. b. After 16 cycles, trip the Wichita – Buffalo Flats (532782) 345kV circuit 2 line c. Trip the Wichita – Reno 345kV circuit 1 line, and remove the fault.
142	FLT142-SB	**Stuck Breaker on Wichita – Viola 345kV circuit 1 line** a. Apply single-phase fault at Wichita (532796) on the 345kV bus. b. After 16 cycles, trip the Wichita (532796) – Buffalo Flats (532798) 345kV circuit 1 line c. Trip the Wichita – Viola (532798) 345kV circuit 1 line, and remove the fault.
143	FLT143-SB	**Stuck Breaker on to Thistle (539801) – Woodward (535375) circuit 1 line** a. Apply single-phase fault at Thistle on the 345kV bus. b. After 16 cycles, trip the Thistle – Buffalo Flats (532782) 345kV circuit 1 line c. Trip the Thistle – Woodward 345 kV line, and remove the fault.
144	FLT144-SB	**Stuck Breaker on Thistle (539801) – Buffalo Flats (532782) 345kV circuit 1 line** a. Apply single-phase fault at Thistle on the 345kV bus. b. After 16 cycles, trip the Thistle – Buffalo Flats (532782) 345kV circuit 2 line c. Trip the Thistle – Buffalo Flats (532782) 345kV circuit 1 line, and remove the fault.
145	FLT145-3PH	3 phase fault on the Benton (532791) to Rose Hill (532794) 345kV circuit 1 line, near Benton. a. Apply fault at the Benton 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.
146	FLT146-3PH	3 phase fault on the Rose Hill (532794) to Lathams (532800) 345kV circuit 1 line, near Rose Hill. a. Apply fault at the Rose Hill 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.
147	FLT147-3PH	3 phase fault on the Benton (532791) to Wolf Creek (532797) 345kV circuit 1 line, near Benton. a. Apply fault at the Benton 345kV bus. b. Clear fault after 3.6 cycles by tripping the faulted line.
148	FLT148-3PH	3 phase fault on the Rose Hill 345/138/13.8kV (532794/533062/532826) transformer a. Apply fault at the Benton 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.

Cont. No.	Cont. Name	Description
149	FLT149-3PH	3 phase fault on the Benton 345/138/13.8kV (532791/532986/532821) transformer a. Apply fault at the Benton 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
150	FLT150-3PH	3 phase fault on the Rose Hill (532794) to Wolf Creek (532797) 345kV circuit 1 line, near Rose Hill. a. Apply fault at the Rose Hill 345kV bus. b. Clear fault after 3.6 cycles by tripping the faulted line.
151	FLT151-3PH	3 phase fault on the Wolf Creek (532797) to Waverly (532799) 345kV circuit 1 line, near Wolf Creek. a. Apply fault at the Wolf Creek 345kV bus. b. Clear fault after 3.6 cycles by tripping the faulted line and remove fault.
152	FLT152-3PH	3 phase fault on the Wolf Creek 345/69/17 (532797/532962/533653) transformer. a. Apply fault at the Wolf Creek 345kV bus. b. Clear fault after 3.6 cycles by tripping the faulted line.
153	FLT153-3PH	3 phase fault on the Rosehill 345/138/13.8 kV (532794/533062/532831) transformer. a. Apply fault at the Rosehill 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
154	FLT154-PO	**Prior outage of the Benton to Rosehill (532794) 345kV line** 3 phase fault on the Benton (532791) to Wichita (532796) 345kV line, near Benton. a. Apply fault at the Benton 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.
155	FLT155-PO	**Prior outage of the Wolf Creek (532797) to Benton (532791) 345kV line** 3 phase fault on the Benton (532791) to Rosehill (532794) 345kV line, near Benton. a. Apply fault at the Benton 345kV bus. b. Clear fault after 3.6 cycles by tripping the faulted line.
156	FLT156-PO	**Prior outage of the Benton to Rosehill (532794) 345kV line** 3 phase fault on the Benton 345/138/13.8kV (532791/532986/532822) transformer a. Apply fault at the Benton 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
157	FLT157-PO	**Prior outage of the Benton 345/138/13.8kV (532791/532986/532821) transformer** 3 phase fault on the Benton (532791) to Wolf Creek (532797) 345kV line, near Benton. a. Apply fault at the Benton 345kV bus. b. Clear fault after 3.6 cycles by tripping the faulted line.
158	FLT158-PO	**Prior outage of the Benton 345/138/13.8kV (532791/532986/532821) transformer** 3 phase fault on the Benton 345/138/13.8kV (532791/532986/532822) transformer a. Apply fault at the Benton 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
159	FLT159-SB	**Stuck Breaker on Benton – Rosehill 345kV circuit 1 line** a. Apply single-phase fault at Benton (532791) on the 345kV bus. b. After 16 cycles, trip the Benton – Rosehill (532794) 345kV circuit 1 line c. Trip the Benton – Wolf Creek (532797) 345kV circuit 1 line, and remove the fault.
160	FLT160-SB	**Stuck Breaker on Benton – Rosehill 345kV circuit 1 line** a. Apply single-phase fault at Benton (532791) on the 345kV bus. b. After 16 cycles, trip the Benton – Rosehill (532794) 345kV circuit 1 line c. Trip the Benton 345/138/13.8kV (532791/532986/532822) transformer
161	FLT161-SB	**Stuck Breaker on Benton 345/138/13.8kV (532791/532986/532821) transformer** a. Apply single-phase fault at Benton (532791) on the 345kV bus. b. After 16 cycles, trip the Benton 345/138/13.8kV (532791/532986/532821) transformer c. Trip the Benton 345/138/13.8kV (532791/532986/532822) transformer
162	FLT162-SB	**Stuck Breaker on Benton 345/138/13.8kV (532791/532986/532821) transformer** a. Apply single-phase fault at Benton (532791) on the 345kV bus. b. After 16 cycles, trip the Benton 345/138/13.8kV (532791/532986/532821) transformer c. Trip the Benton – Wolf Creek (532797) 345kV circuit 1 line, and remove the fault.

Cont. No.	Cont. Name	Description
163	FLT163-3PH	3 phase fault on the Creswell 138/69/13.2kV (532981/533543/533080) transformer, near Creswell. a. Apply fault at the Creswell 69kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer and remove fault.
164	FLT164-3PH	3 phase fault on the Creswell (533543) to Oak2 (533547) 69kV circuit 1 line, near Creswell. a. Apply fault at the Creswell 69kV 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.
165	FLT165-3PH	3 phase fault on the Creswell (533543) to SC7Cres2 (533555) 69kV circuit 1 line, near Creswell. a. Apply fault at the Creswell 69kV 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.
166	FLT166-3PH	3 phase fault on the Creswell (533543) to SC4Rome2 (533553) 69kV circuit 1 line, near Creswell. a. Apply fault at the Creswell 69kV 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.
167	FLT167-3PH	3 phase fault on the Creswell (533543) to Creswels2 (533573) 69kV circuit 1 line, near Creswell. a. Apply fault at the Creswell 69kV 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.
168	FLT168-3PH	3 phase fault on the Creswels2 (533573) to Paris (533548) 69kV circuit 1 line, near Creswels2. a. Apply fault at the Creswels2 69kV 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.
169	FLT169-3PH	3 phase fault on the Creswels2 138/69/13.2kV (532981/533573/533081) transformer, near Creswels2. a. Apply fault at the Creswels2 69kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
170	FLT170-3PH	3 phase fault on the Oak 2 (533547) to PrairieJ2 (533563) 69kV circuit 1 line, near Oak 2. a. Apply fault at the Oak 2 69kV 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.
171	FLT171-3PH	3 phase fault on the Oak 2 (533547) to Rainbow2 (533549) 69kV circuit 1 line, near Oak 2. a. Apply fault at the Oak 2 69kV 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.
172	FLT172-3PH	3 phase fault on the Oak 2 (533547) to Strothr2 (533556) 69kV circuit 1 line, near Oak 2. a. Apply fault at the Oak 2 69kV 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.
173	FLT173-PO	**Prior outage of the Creswell to Oak 2 (533547) 69kV line** 3 phase fault on the Creswell (533543) to Creswls2 (533573) 69kV line, near Creswell. a. Apply fault at the Creswell 69kV 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.
174	FLT174-PO	**Prior outage of the Creswell to Oak 2 (533547) 69kV line** 3 phase fault on the Creswell (533543) to SC4Rome2 (533560) 69kV line, near Creswell. a. Apply fault at the Creswell 69kV 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.

Cont. No.	Cont. Name	Description
175	FLT175-PO	**Prior outage of the Creswell to Oak 2 (533547) 69kV line** 3 phase fault on the Creswell (533543) to Creswell 138/69/13.2kV (532981/533543/533080) transformer a. Apply fault at the Creswell 69kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
176	FLT176-PO	**Prior outage of the Creswell 138/69/13.2kV (532981/533543/533080) transformer** 3 phase fault on the Creswell (533543) to Creswls2 (533573) 69kV line, near Creswell. a. Apply fault at the Creswell 69kV 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.
177	FLT177-PO	**Prior outage of the Creswell 138/69/13.2kV (532981/533543/533080) transformer** 3 phase fault on the Creswell (533543) to SC4Rome2 (533553) 69kV line, near Creswell. a. Apply fault at the Creswell 69kV 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.
178	FLT178-SB	**Stuck Breaker on Creswell – Creswls2 345kV circuit 1 line** a. Apply single-phase fault at Creswell (533543) on the 69kV bus. b. After 16 cycles, trip the Creswell – Creswls2 (533573) 69kV circuit 1 line c. Trip the Creswell – Oak 2 (533547) 69kV circuit 1 line, and remove the fault.
179	FLT179-SB	**Stuck Breaker on Creswell – Creswls2 345kV circuit 1 line** a. Apply single-phase fault at Creswell (533543) on the 69kV bus. b. After 16 cycles, trip the Creswell – Creswls2 (533573) 69kV circuit 1 line c. Trip the Creswels2 138/69/13.2kV (532981/533543/533080) transformer, and remove the fault.
180	FLT180-3PH	3 phase fault on the LaCygne (542981) to Stilwell (542968) 345kV circuit 1 line, near LaCygne. a. Apply fault at the LaCygne 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.
181	FLT181-3PH	3 phase fault on the LaCygne (542981) to West Gardner (542965) 345kV circuit 1 line, near LaCygne. a. Apply fault at the LaCygne 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.
182	FLT182-3PH	3 phase fault on the LaCygne (542981) to Neosho (532793) 345kV circuit 1 line, near LaCygne. a. Apply fault at the LaCygne 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.
183	FLT183-3PH	3 phase fault on the Neosho (532793) to Blackberry (300739) 345kV circuit 1 line, near Neosho. a. Apply fault at the Neosho 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.
184	FLT184-3PH	3 phase fault on the Neosho (532793) to Caney River (532780) 345kV circuit 1 line, near Neosho. a. Apply fault at the Neosho 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.
185	FLT185-3PH	3 phase fault on the Rose Hill (532794) to Lathams (532800) 345kV circuit 1 line, near Rose Hill. a. Apply fault at the Rose Hill 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.
186	FLT186-3PH	3 phase fault on the Waverly (532799) to LaCygne (542981) 345kV circuit 1 line, near Waverly. a. Apply fault at the Waverly 345kV bus. b. Clear Waverly end of the line after 3.6 cycles
187	FLT187-3PH	3 phase fault on the Wolf Creek (532797) to Waverly (532799) 345kV circuit 1 line, near Waverly. a. Apply fault at the Waverly 345kV bus. b. Clear fault after 3.6 cycles by tripping the faulted line and remove fault.

Cont. No.	Cont. Name	Description
188	FLT188-PO	**Prior outage of the Wolf Creek (532797) to Waverly (532799) 345kV line** a. Trip the Wolf Creek to Waverly 345 kV line. b. Solve for powerflow steady state. Then the following stability contingency: 3 phase fault on the Wolf Creek (532797) to Rose Hill (532794) 345kV line, near Wolf Creek. a. Apply fault at the Wolf Creek 345kV bus. b. Clear fault after 3.6 cycles by tripping the faulted line and remove fault.
189	FLT189-PO	**Prior outage of the Wolf Creek (532797) to Rose Hill (532794) 345kV line** a. Trip the Wolf Creek to Rose Hill 345 kV line. b. Solve for powerflow steady state. Then the following stability contingency: 3 phase fault on the Wolf Creek (532797) to Benton (532791) 345kV line, near Wolf Creek. a. Apply fault at the Wolf Creek 345kV bus. b. Clear fault after 3.6 cycles by tripping the faulted line.
190	FLT190-3PH	3 phase fault on the RSS7 (509782) to SAPLPRD7 (509870) 345kV line, near RSS7. a. Apply fault at the RSS7 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.
191	FLT191-3PH	3 phase fault on the RSS7 (509782) to Pecan Creek (515235) 345kV line, near RSS7. a. Apply fault at the RSS7 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.
192	FLT192-3PH	3 phase fault on the RSS7 (509782) to Oneta (509807) 345kV line, near RSS7. a. Apply fault at the RSS7 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.
193	FLT193-3PH	3 phase fault on the RSS7 (509782) to Redbud7 (514909) 345kV line, near RSS7. a. Apply fault at the RSS7 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.
194	FLT194-3PH	3 phase fault on the Pecan Creek (515235) to Muskoge (515224) 345kV line, near Pecan Creek. a. Apply fault at the Pecan Creek 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.
195	FLT195-3PH	3 phase fault on the Arcadia (514908) to REDBUD7 (514909) 345kV line, near Arcadia. a. Apply fault at the Arcadia 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.
196	FLT196-PO	**Prior outage on the Tulsa North (509852) – NES (510406) 345kV circuit 1 line** 3 phase fault on the RSS7 (509782) – SAPLPRD7 (509870) 345k circuit 1 line, near RSS7. a. Apply fault at the RSS7 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.
197	FLT197-PO	**Prior outage on the Oneta (509807) – CLARKSV7 (509745) 345kV circuit 1 line** 3 phase fault on the RSS7 (509782) – SAPLPRD7 (509870) 345kV circuit 1 line, near RSS7. a. Apply fault at the RSS7 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.

Cont. No.	Cont. Name	Description
198	FLT198-PO	**Prior outage on the Pecan Creek (515235) – Muskoge (515224) 345kV circuit 2 line** 3 phase fault on the Pecan Creek (515235) – Muskoge (515224) 345kV circuit 1 line. a. Apply fault at the Pecan Creek 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.
199	FLT199-3PH	3 phase fault on the RSS7 (509782) 345/(509773) 138/(509882) 13.8kV transformer, near RSS7 345. a. Apply fault at the RSS 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
200	FLT200-3PH	3 phase fault on the SAPLPRD7 (509870) 345/(509871) 138/(509872) 13.8kV transformer, near SAPLPRD7 345. a. Apply fault at the SAPLPRD7 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
201	FLT201-PO	**Prior outage on the RSS7 (509782) 345/ (509875) 138/ (509876) 13.8kV circuit 1 transformer** 3 phase fault on the RSS7 (509782) 345/(509773) 138/(509882) 13.8kV transformer, near RSS7. a. Apply fault at the RSS7 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
202	FLT202-SB	**Stuck Breaker on RSS7 (509782) – SAPLPRD7 (509870) 345kV circuit 1 line** a. Apply single-phase fault at RSS7 on the 345kV bus. b. After 16 cycles, trip the RSS7 – Redbud (514909) 345kV circuit 1 line c. Trip the RSS7 – SAPLPRD7 345kV circuit 1 line, and remove the fault
203	FLT203-SB	**Stuck Breaker on RSS7 (509782) – SAPLPRD7 (509870) 345kV circuit 1 line** a. Apply single-phase fault at RSS7 on the 345kV bus. b. After 16 cycles, trip the RSS7 345/138/13.8kV (509782/509773/509882) circuit 1 transformer c. Trip the RSS7 – SAPLPRD7 345kV circuit 1 line, and remove the fault
204	FLT204-SB	**Stuck Breaker on Pecan Creek (515235) – Muskoge (515224) 345kV circuit 1 line** a. Apply single-phase fault at Pecan Creek on the 345kV bus. b. After 16 cycles, trip the Pecan Creek 345/161/13.8kV (515235/515234/515749) transformer c. Trip the Pecan Creek – Muskoge 345kV circuit 1 line, and remove the fault
205	FLT205-SB	**Stuck Breaker on Wolf Creek – Waverly 345kV circuit 1 line** a. Apply single-phase fault at Wolf Creek (532797) on the 345kV bus. b. After 3.6 cycles, trip the Wolf Creek – Waverly (532799) 345kV circuit 1 line c. After 6.6 additional cycles, trip Wolf Creek 345/69kV transformer (532797/533653/532962) and remove fault.
206	FLT206-SB	**Stuck Breaker on Wolf Creek – Benton 345kV circuit 1 line** a. Apply single-phase fault at Wolf Creek (532797) on the 345kV bus. b. After 3.6 cycles, trip the Wolf Creek – Benton (532791) 345kV circuit 1 line c. After 6.6 additional cycles, remove fault.
207	FLT207-SB	**Stuck Breaker on Wolf Creek – Rose Hill 345kV circuit 1 line** a. Apply single-phase fault at Wolf Creek (532797) on the 345kV bus. b. After 3.6 cycles, trip the Wolf Creek – Rose Hill (532794) 345kV circuit 1 line c. After 6.6 additional cycles, remove fault.
208	FLT208-SB	**Stuck Breaker on Wolf Creek – Waverly 345kV circuit 1 line** a. Apply single-phase fault at Wolf Creek (532797) on the 345kV bus. b. After 3.6 cycles, trip the Wolf Creek – Waverly (532799) 345kV circuit 1 line c. After 6.6 additional cycles, remove fault.
209	FLT209-SB	**Stuck Breaker on Wolf Creek 345/69kV transformer circuit 1 line** a. Apply single-phase fault at Wolf Creek (532797) on the 345kV bus. b. After 3.6 cycles, trip Wolf Creek 345/69kV transformer (532797/533653/532962) c. After 6.6 additional cycles, remove fault.

Cont. No.	Cont. Name	Description
210	FLT210-PO	**Prior outage of the LaCygne (542981) – Waverly (532799) 345kV line** a. Trip LaCygne (542981) – Waverly (532799) 345kV line b. Solve for powerflow steady state Then the following stability contingency: 3 phase fault on the Wolf Creek (532797) – Rose Hill (532794) 345kV line, near Wolf Creek. a. Apply fault at the Wolf Creek 345kV bus. b. Clear fault after 3.6 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 3.6 cycles, then trip the line in (b) and remove fault.
211	FLT211-PO	**Prior outage of the LaCygne (542981) – Waverly (532799) 345kV line** a. Trip LaCygne (542981) – Waverly (532799) 345kV line b. Solve for powerflow steady state Then the following stability contingency: 3 phase fault on the Wolf Creek (532797) – Benton (532791) 345kV line, near Wolf Creek. a. Apply fault at the Wolf Creek 345kV bus. b. Clear fault after 3.6 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 3.6 cycles, then trip the line in (b) and remove fault.
212	FLT212-PO	**Prior outage of the LaCygne (542981) – Waverly (532799) 345kV line** a. Trip LaCygne (542981) – Waverly (532799) 345kV line b. Solve for powerflow steady state Then the following stability contingency: 3 phase fault on the LaCygne (542981) – West Gardner (542965) 345kV line, near LaCygne. a. Apply fault at the LaCygne 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.
213	FLT213-PO	**Prior outage of the LaCygne (542981) – Waverly (532799) 345kV line** a. Trip LaCygne (542981) – Waverly (532799) 345kV line b. Solve for powerflow steady state Then the following stability contingency: 3 phase fault on the LaCygne (542981) – Stilwell (542968) 345kV line, near LaCygne. a. Apply fault at the LaCygne 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.
214	FLT214-PO	**Prior outage of the LaCygne (542981) – Waverly (532799) 345kV line** a. Trip LaCygne (542981) – Waverly (532799) 345kV line b. Solve for powerflow steady state Then the following stability contingency: 3 phase fault on the LaCygne (542981) – Neosho (532793) 345kV line, near LaCygne. a. Apply fault at the LaCygne 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.
215	FLT215-PO	**Prior outage on the Waverly (532799) – LaCygne (542981) 345kV line** a. Trip LaCygne (542981) – Waverly (532799) 345kV line b. Solve for powerflow steady state 3 phase fault on the Wolf Creek (532797) – Waverly (532799) 345kV line, near Wolf Creek. a. Apply fault at the Wolf Creek 345kV bus. b. Clear fault after 3.6 cycles by tripping the faulted line.

Cont. No.	Cont. Name	Description
216	FLT216-PO	**Prior outage on the Wolf Creek (532797) – Benton (532791) 345kV line** a. Reduce Wolf Creek to 700 MW net b. Reduce Waverly output to 0 MW c. Solve for powerflow steady state 3 phase fault on the Waverly (532799) – LaCygne (542981) 345kV line, near Waverly. a. Apply fault at the Waverly 345kV bus. b. Clear fault after 3.6 cycles by tripping the faulted line.
217	FLT217-PO	**Prior outage on the Wolf Creek (532797) – Benton (532791) 345kV line** a. Reduce Wolf Creek to 700 MW net b. Reduce Waverly output to 0 MW c. Solve for powerflow steady state 3 phase fault on the Wolf Creek (532797) – Waverly (532799) 345kV line, near Wolf Creek. a. Apply fault at the Wolf Creek 345kV bus. b. Clear fault after 3.6 cycles by tripping the faulted line.
218	FLT218-PO	**Prior outage on the Wolf Creek (532797) – Benton (532791) 345kV line** a. Reduce Wolf Creek to 700 MW net b. Reduce Waverly output to 0 MW c. Solve for powerflow steady state 3 phase fault on the Wolf Creek (532797) – Rose Hill (532794) 345kV line, near Wolf Creek. a. Apply fault at the Wolf Creek 345kV bus. b. Clear fault after 3.6 cycles by tripping the faulted line.
219	FLT219-PO	**Prior outage on the Wolf Creek (532797) – Rose Hill (532794) 345kV line** a. Reduce Wolf Creek to 700 MW net b. Reduce Waverly output to 0 MW c. Solve for powerflow steady state 3 phase fault on the Waverly (532799) – LaCygne (542981) 345kV line, near Waverly. a. Apply fault at the Waverly 345kV bus. b. Clear fault after 3.6 cycles by tripping the faulted line.
220	FLT220-PO	**Prior outage on the Wolf Creek (532797) – Rose Hill (532794) 345kV line** a. Reduce Wolf Creek to 700 MW net b. Reduce Waverly output to 0 MW c. Solve for powerflow steady state 3 phase fault on the Wolf Creek (532797) – Benton (532791) 345kV line, near Wolf Creek. a. Apply fault at the Wolf Creek 345kV bus. b. Clear fault after 3.6 cycles by tripping the faulted line.
221	FLT221-PO	**Prior outage on the Wolf Creek (532797) – Rose Hill (532794) 345kV line** a. Reduce Wolf Creek to 700 MW net b. Reduce Waverly output to 0 MW c. Solve for powerflow steady state 3 phase fault on the Wolf Creek (532797) – Waverly (532799) 345kV line, near Wolf Creek. a. Apply fault at the Wolf Creek 345kV bus. b. Clear fault after 3.6 cycles by tripping the faulted line.
222	FLT222-PO	**Prior outage on the Wolf Creek (532797) – Waverly (532799) 345kV line** a. Reduce Wolf Creek to 700 MW net b. Solve for powerflow steady state 3 phase fault on the Wolf Creek (532797) – Benton (532791) 345kV line, near Wolf Creek. a. Apply fault at the Wolf Creek 345kV bus. b. Clear fault after 3.6 cycles by tripping the faulted line.

Cont. No.	Cont. Name	Description
223	FLT223-PO	**Prior outage on the Wolf Creek (532797) – Waverly (532799) 345kV line** a. Reduce Wolf Creek to 700 MW net b. Solve for powerflow steady state 3 phase fault on the Wolf Creek (532797) – Rose Hill (532794) 345kV line, near Wolf Creek. a. Apply fault at the Wolf Creek 345kV bus. b. Clear fault after 3.6 cycles by tripping the faulted line.

SECTION 3: STABILITY ANALYSIS

The objective of the Stability Analysis was to determine the impacts of the Group 08 generator interconnection study requests on the stability and voltage recovery on the SPP transmission system.

3.1 Approach

SPP provided MEPPI with the following three power flow cases:

- MDWG16-17W_DIS16021_G08
- MDWG16-18S_DIS16021_G08
- MDWG16-26S_DIS16021_G08

Each case was examined prior to the Stability Analysis to ensure the case contained the proposed study projects and any previously queued projects listed in Tables 2-1 and 2-2, respectively. Refer to Table 3-1 for requests that have been withdrawn or dispatch updated in the current study models. There was no suspect power flow data in the study area. The dynamic datasets were also verified and stable initial system conditions (i.e., "flat lines") were achieved. Three-phase and single phase-to-ground faults listed in Table 2-3 were examined. The SCMU function internal to PSS/E was utilized to apply single phase-to-ground faults.

Table 3-1: Summary of Changes Made to Study Cases

Ref. No.	Study Request	POI	Status	Existing Pgen (MW)	New Pgen (MW)
1	GEN-2002-004	Latham 345kV	In-Service	199.5	153
2	GEN-2015-030	Sooner 345kV	Withdrawn	200.1	0 (offline)
3	GEN-2015-083	Belle Plain 138kV	Withdrawn	125	0 (offline)
4	GEN-2016-024	Midian 138kV	Withdrawn	55.9	0 (offline)
5	GEN-2016-048	Sooner 138kV	Withdrawn	82.3	0 (offline)
6	GEN-2016-060	Belle Plain 138kV	Withdrawn	25.3	0 (offline)
7	GEN-2016-072	Renfrow 345kV	Withdrawn	300	0 (offline)
8	GEN-2016-127	Shidler 138kV	Withdrawn	200.1	0 (offline)
9	GEN-2016-128	Woodring 345kV	In-Service	252	176
10	GEN-2016-148	Hardy 138kV	Withdrawn	150	0 (offline)
11	GEN-2016-173	Creswell 69kV	Withdrawn	42	0 (offline)

Bus voltages, machine rotor angles, and previously queued generation in the study area were monitored in addition to bus voltages and machine rotor angles in the following areas:

- 520 AEPW
- 524 OKGE
- 525 WFEC
- 526 SPS
- 531 MIDW
- 534 SUNC
- 536 WERE
- 540 GMO
- 541 KCPL

Requested and previously queued generation outside the above study area were also monitored.

Additionally, the NERC MOD-026 and MOD-027 model validation studies were recently completed for the Wolf Creek Nuclear plant. This study incorporates the most updated models for the Wolf Creek Nuclear plant as follows:

- Generator: GENTPJ
- Excitation System: EXAC3
- Turbine-Governor: None
- Voltage Regulator Current Compensation: COMP
- Minimum Excitation Limiter: MNLEX3
- Maximum Excitation Limiter: MAXEX2

3.2 Stability Analysis Results

The Stability Analysis determined that several P1, P4, and P6 events that include a fault on a circuit connected to either Waverly or Wolf Creek 345kV substations resulted in undamped rotor angle oscillations, voltages below the acceptable recovery voltage, voltage collapse, and generation instability when all generation interconnection requests were at 100% output. The Stability Analysis also determined that events across the Group 8 study area resulted in generation tripping (study projects GEN-2016-133 through GEN-2016-146) when all generation interconnection requests were at 100% output for several P1, P4, and P6 events. Additionally, for several faults near the Riverside 345 kV station, the study projects GEN-2016-133 through GEN-2016-146 were required to have voltage protection disabled to prevent the units from tripping offline due to high voltages after clearing the fault. Refer to Table 3-2 for a list of faults this action was required (notified as “Gen Trip”).

Refer to Table 3-2 for a summary of the Stability Analysis results for the contingencies listed in Table 2-3. Table 3-2 is a summary of the stability results for the 2017 Winter Peak, 2018 Summer Peak, and 2026 Summer Peak conditions and states whether the system remained stable or generation tripped offline, if acceptable voltage recovery was observed after the fault was cleared, and if the voltage recovered to above 0.9 p.u. and below 1.1 p.u. post fault steady-state conditions. Voltage recovery criteria includes ensuring that the transient voltage recovery is between 0.7 p.u. within 2.5 seconds after the fault is cleared and 1.2 p.u. at any point after the fault is cleared and ending in a steady-state voltage (for N-1 contingencies) at the pre-contingent level or at least above 0.9 p.u. and below 1.1. p.u.

Refer to Appendix B, Appendix C, and Appendix D, for a complete set of plots for all contingencies for 2017 Winter Peak, 2018 Summer Peak, and 2026 Summer Peak conditions, respectively. The plots reflect all contingencies with the appropriate mitigation applied.

Table 3-2: Stability Analysis Summary of Results for 2017 Winter, 2018 Summer, and 2026 Summer Peak Conditions

Cont. No.	Cont. Name	2017 Winter Peak				2018 Summer Peak				2026 Summer Peak			
		Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability
		Less than .70 p.u.	Greater than 1.20 p.u.			Less than .70 p.u.	Greater than 1.20 p.u.			Less than .70 p.u.	Greater than 1.20 p.u.		
1	FLT01-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
2	FLT02-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
3	FLT03-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
4	FLT04-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
5	FLT05-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
6	FLT06-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
7	FLT07-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
8	FLT08-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
9	FLT09-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
10	FLT10-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
11	FLT11-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
12	FLT12-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
13	FLT13-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
14	FLT14-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
15	FLT15-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
16	FLT16-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
17	FLT17-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
18	FLT18-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
19	FLT19-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
20	FLT20-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
21	FLT21-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
22	FLT22-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
23	FLT23-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
24	FLT24-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
25	FLT25-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
26	FLT26-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
27	FLT27-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
28	FLT28-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable

Table 3-2 (continued): Stability Analysis Summary of Results for 2017 Winter, 2018 Summer, and 2026 Summer Peak Conditions

Cont. No.	Cont. Name	2017 Winter Peak				2018 Summer Peak				2026 Summer Peak			
		Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability
		Less than .70 p.u.	Greater than 1.20 p.u.			Less than .70 p.u.	Greater than 1.20 p.u.			Less than .70 p.u.	Greater than 1.20 p.u.		
29	FLT29-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
30	FLT30-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
31	FLT31-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
32	FLT32-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
33	FLT33-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
34	FLT34-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
35	FLT35-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
36	FLT36-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
37	FLT37-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
38	FLT38-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
39	FLT39-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
40	FLT40-3PH	-	-	Compliant	Gen Trip	-	-	Compliant	Gen Trip	-	-	Compliant	Stable
41	FLT41-3PH	-	-	Compliant	Gen Trip	-	-	Compliant	Gen Trip	-	-	Compliant	Gen Trip
42	FLT42-3PH	-	-	Compliant	Gen Trip	-	-	Compliant	Gen Trip	-	-	Compliant	Gen Trip
43	FLT43-3PH	-	-	Compliant	Gen Trip	-	-	Compliant	Gen Trip	-	-	Compliant	Stable
44	FLT44-3PH	-	-	Compliant	Gen Trip	-	-	Compliant	Gen Trip	-	-	Compliant	Gen Trip
45	FLT45-3PH	-	-	Compliant	Gen Trip	-	-	Compliant	Stable	-	-	Compliant	Stable
46	FLT46-3PH	-	-	Compliant	Gen Trip	-	-	Compliant	Gen Trip	-	-	Compliant	Stable
47	FLT47-PO	-	-	Compliant	Gen Trip	-	-	Compliant	Stable	-	-	Compliant	Stable
48	FLT48-PO	-	-	Compliant	Gen Trip	-	-	Compliant	Stable	-	-	Compliant	Stable
49	FLT49-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
50	FLT50-SB	-	-	Compliant	Gen Trip	-	-	Compliant	Gen Trip	-	-	Compliant	Gen Trip
51	FLT51-PO	-	-	Compliant	Gen Trip	-	-	Compliant	Stable	-	-	Compliant	Stable
52	FLT52-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
53	FLT53-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
54	FLT54-PO	-	-	Compliant	Gen Trip	-	-	Compliant	Gen Trip	-	-	Compliant	Gen Trip
55	FLT55-PO	-	-	Compliant	Gen Trip	-	-	Compliant	Gen Trip	-	-	Compliant	Gen Trip
56	FLT56-PO	-	-	Compliant	Gen Trip	-	-	Compliant	Gen Trip	-	-	Compliant	Gen Trip
57	FLT57-SB	-	-	Compliant	Gen Trip	-	-	Compliant	Gen Trip	-	-	Compliant	Gen Trip
58	FLT58-SB	-	-	Compliant	Gen Trip	-	-	Compliant	Gen Trip	-	-	Compliant	Gen Trip

Table 3-2 (continued): Stability Analysis Summary of Results for 2017 Winter, 2018 Summer, and 2026 Summer Peak Conditions

Cont. No.	Cont. Name	2017 Winter Peak				2018 Summer Peak				2026 Summer Peak			
		Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability
		Less than .70 p.u.	Greater than 1.20 p.u.			Less than .70 p.u.	Greater than 1.20 p.u.			Less than .70 p.u.	Greater than 1.20 p.u.		
59	FLT59-SB	-	-	Compliant	Gen Trip	-	-	Compliant	Gen Trip	-	-	Compliant	Gen Trip
60	FLT60-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
61	FLT61-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
62	FLT62-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
63	FLT63-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
64	FLT64-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
65	FLT65-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
66	FLT66-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
67	FLT67-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
68	FLT68-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
69	FLT69-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
70	FLT70-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
71	FLT71-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
72	FLT72-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
73	FLT73-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
74	FLT74-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
75	FLT75-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
76	FLT76-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
77	FLT77-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
78	FLT78-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
79	FLT79-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
80	FLT80-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
81	FLT81-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
82	FLT82-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
83	FLT83-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
84	FLT84-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
85	FLT85-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
86	FLT86-PO	-	-	Compliant	Gen Trip	-	-	Compliant	Gen Trip	-	-	Compliant	Gen Trip
87	FLT87-PO	-	-	Compliant	Gen Trip	-	-	Compliant	Gen Trip	-	-	Compliant	Gen Trip
88	FLT88-PO	-	-	Compliant	Gen Trip	-	-	Compliant	Gen Trip	-	-	Compliant	Gen Trip

Table 3-2 (continued): Stability Analysis Summary of Results for 2017 Winter, 2018 Summer, and 2026 Summer Peak Conditions

Cont. No.	Cont. Name	2017 Winter Peak				2018 Summer Peak				2026 Summer Peak			
		Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability
		Less than .70 p.u.	Greater than 1.20 p.u.			Less than .70 p.u.	Greater than 1.20 p.u.			Less than .70 p.u.	Greater than 1.20 p.u.		
89	FLT89-PO	-	-	Compliant	Gen Trip	-	-	Compliant	Gen Trip	-	-	Compliant	Gen Trip
90	FLT90-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
91	FLT91-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
92	FLT92-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
93	FLT93-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
94	FLT94-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
95	FLT95-3PH	-	-	Compliant	Gen Trip	-	-	Compliant	Gen Trip	-	-	Compliant	Gen Trip
96	FLT96-3PH			Compliant	Gen Trip	-	-	Compliant	Gen Trip	-	-	Compliant	Gen Trip
97	FLT97-3PH	-	-	Compliant	Gen Trip	-	-	Compliant	Gen Trip	-	-	Compliant	Gen Trip
98	FLT98-3PH	-	-	Compliant	Gen Trip	-	-	Compliant	Gen Trip	-	-	Compliant	Gen Trip
99	FLT99-3PH	-	-	Compliant	Gen Trip	-	-	Compliant	Gen Trip	-	-	Compliant	Gen Trip
100	FLT100-3PH	-	-	Compliant	Gen Trip	-	-	Compliant	Gen Trip	-	-	Compliant	Gen Trip
101	FLT101-3PH	-	-	Compliant	Gen Trip	-	-	Compliant	Gen Trip	-	-	Compliant	Gen Trip
102	FLT102-3PH	-	-	Compliant	Gen Trip	-	-	Compliant	Stable	-	-	Compliant	Stable
103	FLT103-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
104	FLT104-3PH	-	-	Compliant	Gen Trip	-	-	Compliant	Gen Trip	-	-	Compliant	Gen Trip
105	FLT105-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
106	FLT106-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
107	FLT107-3PH	-	-	Compliant	Gen Trip	-	-	Compliant	Gen Trip	-	-	Compliant	Gen Trip
108	FLT108-3PH	-	-	Compliant	Gen Trip	-	-	Compliant	Gen Trip	-	-	Compliant	Gen Trip
109	FLT109-PO	-	-	Compliant	Gen Trip	-	-	Compliant	Gen Trip	-	-	Compliant	Gen Trip
110	FLT110-PO	-	-	Compliant	Gen Trip	-	-	Compliant	Gen Trip	-	-	Compliant	Gen Trip
111	FLT111-PO	-	-	Compliant	Gen Trip	-	-	Compliant	Gen Trip	-	-	Compliant	Gen Trip
112	FLT112-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
113	FLT113-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
114	FLT114-PO	-	-	Compliant	Gen Trip	-	-	Compliant	Gen Trip	-	-	Compliant	Gen Trip
115	FLT115-PO	-	-	Compliant	Gen Trip	-	-	Compliant	Gen Trip	-	-	Compliant	Gen Trip
116	FLT116-PO	-	-	Compliant	Gen Trip	-	-	Compliant	Gen Trip	-	-	Compliant	Gen Trip
117	FLT117-PO	-	-	Compliant	Gen Trip	-	-	Compliant	Gen Trip	-	-	Compliant	Gen Trip
118	FLT118-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable

Table 3-2 (continued): Stability Analysis Summary of Results for 2017 Winter, 2018 Summer, and 2026 Summer Peak Conditions

Cont. No.	Cont. Name	2017 Winter Peak				2018 Summer Peak				2026 Summer Peak			
		Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability
		Less than .70 p.u.	Greater than 1.20 p.u.			Less than .70 p.u.	Greater than 1.20 p.u.			Less than .70 p.u.	Greater than 1.20 p.u.		
119	FLT119-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
120	FLT120-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
121	FLT121-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
122	FLT122-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
123	FLT123-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
124	FLT124-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
125	FLT125-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
126	FLT126-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
127	FLT127-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
128	FLT128-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
129	FLT129-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
130	FLT130-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
131	FLT131-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
132	FLT132-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
133	FLT133-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
134	FLT134-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
135	FLT135-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
136	FLT136-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
137	FLT137-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
138	FLT138-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
139	FLT139-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
140	FLT140-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
141	FLT141-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
142	FLT142-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
143	FLT143-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
144	FLT144-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
145	FLT145-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
146	FLT146-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable

Table 3-2 (continued): Stability Analysis Summary of Results for 2017 Winter, 2018 Summer, and 2026 Summer Peak Conditions

Cont. No.	Cont. Name	2017 Winter Peak				2018 Summer Peak				2026 Summer Peak			
		Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability
		Less than .70 p.u.	Greater than 1.20 p.u.			Less than .70 p.u.	Greater than 1.20 p.u.			Less than .70 p.u.	Greater than 1.20 p.u.		
147	FLT147-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
148	FLT148-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
149	FLT149-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
150	FLT150-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
151	FLT151-3PH	-	-	V < 0.9 p.u. Undamped	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
152	FLT152-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
153	FLT153-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
154	FLT154-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
155	FLT155-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
156	FLT156-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
157	FLT157-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
158	FLT158-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
159	FLT159-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
160	FLT160-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
161	FLT161-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
162	FLT162-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
163	FLT163-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
164	FLT164-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
165	FLT165-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
166	FLT166-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
167	FLT167-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
168	FLT168-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
169	FLT169-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
170	FLT170-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
171	FLT171-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
172	FLT172-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable

Table 3-2 (continued): Stability Analysis Summary of Results for 2017 Winter, 2018 Summer, and 2026 Summer Peak Conditions

Cont. No.	Cont. Name	2017 Winter Peak				2018 Summer Peak				2026 Summer Peak			
		Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability
		Less than .70 p.u.	Greater than 1.20 p.u.			Less than .70 p.u.	Greater than 1.20 p.u.			Less than .70 p.u.	Greater than 1.20 p.u.		
173	FLT173-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
174	FLT174-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
175	FLT175-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
176	FLT176-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
177	FLT177-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
178	FLT178-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
179	FLT179-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
180	FLT180-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
181	FLT181-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
182	FLT182-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
183	FLT183-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
184	FLT184-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
185	FLT185-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
186	FLT186-3PH	-	-	V < 0.9 p.u. Undamped	Stable	-	-	Undamped	Stable	-	-	Undamped	Stable
187	FLT187-3PH	-	-	Undamped	Stable	-	-	Undamped	Stable	-	-	Undamped	Stable
188	FLT188-PO	Voltage Collapse				Voltage Collapse				Voltage Collapse			
189	FLT189-PO	-	-	Undamped	Stable	-	-	Undamped	Stable	-	-	Undamped	Stable
190	FLT190-3PH	-	-	Compliant	Gen Trip	-	-	Compliant	Gen Trip	-	-	Compliant	Gen Trip
191	FLT191-3PH	-	-	Compliant	Gen Trip	-	-	Compliant	Gen Trip	-	-	Compliant	Gen Trip
192	FLT192-3PH	-	-	Compliant	Gen Trip	-	-	Compliant	Gen Trip	-	-	Compliant	Gen Trip
193	FLT193-3PH	-	-	Compliant	Gen Trip	-	-	Compliant	Gen Trip	-	-	Compliant	Gen Trip
194	FLT194-3PH	-	-	Compliant	Gen Trip	-	-	Compliant	Gen Trip	-	-	Compliant	Gen Trip
195	FLT195-3PH	-	-	Compliant	Gen Trip	-	-	Compliant	Gen Trip	-	-	Compliant	Gen Trip
196	FLT196-PO	-	-	Compliant	Gen Trip	-	-	Compliant	Gen Trip	-	-	Compliant	Gen Trip
197	FLT197-PO	-	-	Compliant	Gen Trip	-	-	Compliant	Gen Trip	-	-	Compliant	Gen Trip
198	FLT198-PO	-	-	Compliant	Gen Trip	-	-	Compliant	Gen Trip	-	-	Compliant	Gen Trip

Table 3-2 (continued): Stability Analysis Summary of Results for 2017 Winter, 2018 Summer, and 2026 Summer Peak Conditions

Cont. No.	Cont. Name	2017 Winter Peak				2018 Summer Peak				2026 Summer Peak			
		Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability
		Less than .70 p.u.	Greater than 1.20 p.u.			Less than .70 p.u.	Greater than 1.20 p.u.			Less than .70 p.u.	Greater than 1.20 p.u.		
199	FLT199-3PH	-	-	Compliant	Gen Trip	-	-	Compliant	Gen Trip	-	-	Compliant	Gen Trip
200	FLT200-3PH	-	-	Compliant	Gen Trip	-	-	Compliant	Gen Trip	-	-	Compliant	Gen Trip
201	FLT201-PO	-	-	Compliant	Gen Trip	-	-	Compliant	Gen Trip	-	-	Compliant	Gen Trip
202	FLT202-SB	-	-	Compliant	Gen Trip	-	-	Compliant	Gen Trip	-	-	Compliant	Gen Trip
203	FLT203-SB	-	-	Compliant	Gen Trip	-	-	Compliant	Gen Trip	-	-	Compliant	Gen Trip
204	FLT204-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
205	FLT205-SB	-	-	Undamped	Stable	-	-	Undamped	Stable	-	-	Undamped	Stable
206	FLT206-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
207	FLT207-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
208	FLT208-SB	-	-	Undamped	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
209	FLT209-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
210	FLT210-PO	-	-	Undamped	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
211	FLT211-PO	-	-	Undamped	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
212	FLT212-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
213	FLT213-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
214	FLT214-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
215	FLT215-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
216	FLT216-PO	Voltage Collapse				Voltage Collapse				Voltage Collapse			
217	FLT217-PO	Voltage Collapse				Voltage Collapse				Voltage Collapse			
218	FLT218-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
219	FLT219-PO	Voltage Collapse				Voltage Collapse				Voltage Collapse			
220	FLT220-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
221	FLT221-PO	Voltage Collapse				Voltage Collapse				Voltage Collapse			
222	FLT222-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
223	FLT223-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable

As observed in the Stability Results table, the limiting study year was the 17WP case as each fault event with violations in any seasonal case were observed for this seasonal case. The results and figures discussed in this section are from the 17WP case and represent the limiting conditions for all study years.

It was determined that the DISIS-2016-001-5 identified upgrade of Wolf Creek to Blackberry 345kV or the DISIS-2016-001-4 previously (no longer) assigned upgrade of Wolf Creek to Emporia Energy Center 345kV circuits, independently, are acceptable mitigation options for all violations observed except for the high voltage tripping of study projects GEN-2016-133 through GEN-2016-146.

For FLT151-3PH and FLT187-3PH, a three phase fault on the Wolf Creek to Waverly 345kV circuit and FLT186-3PH, a three phase fault on the Waverly to LaCygne 345kV circuit, undamped oscillations at Wolf Creek and low voltages at Neosho 345kV were observed for the case without mitigation. With the Wolf Creek to Blackberry 345kV line included as mitigation (or Wolf Creek to Emporia Energy Center 345kV line) in the power flow case, the voltage at Neosho 345 kV recovers within SPP performance criteria and the rotor angle oscillations quickly dampen at Wolf Creek. Refer to Figure 3-1 for a representative voltage plot of the Neosho 345kV bus voltage before and after the addition of the transmission line from Wolf Creek to Emporia Energy Center 345kV line for FLT186. It can be observed that after the transmission line is implemented, the voltage recovers to above 0.9 p.u. which is an acceptable voltage.

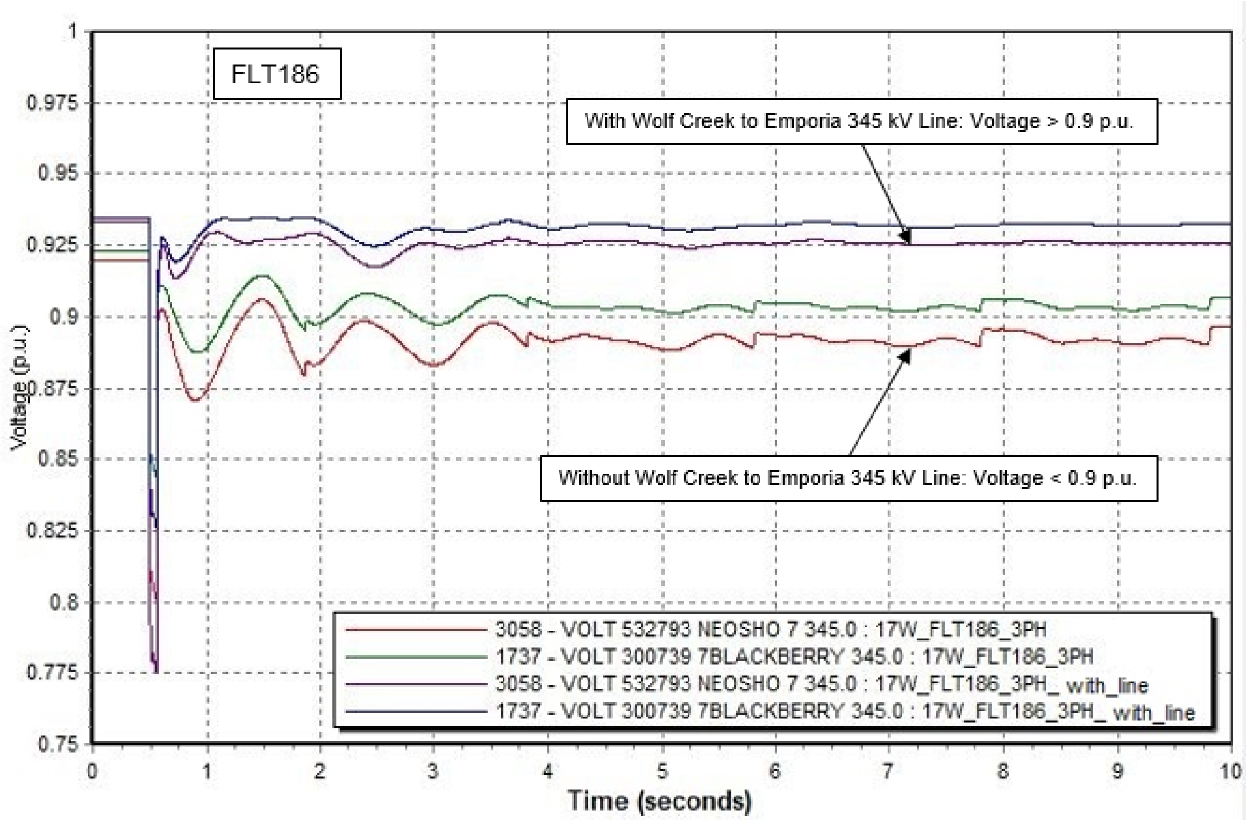

Figure 3-1: Representative plot of Neosho 345kV bus voltage for 2017 Winter Peak conditions with and without the Wolf Creek to Emporia 345kV line.

Refer to Figure 3-2 and Figure 3-3 for a representative voltage plot of the Neosho 345kV bus voltage and Wolf Creek rotor angles, respectively, before and after the addition of the transmission line from Wolf Creek to Blackberry 345kV line for FLT151. It can be observed that after the transmission line is implemented, the voltage recovers to above 0.9 p.u. which is an acceptable voltage and the Wolf Creek rotor angles quickly damp and are within acceptable SPP Performance Criteria.

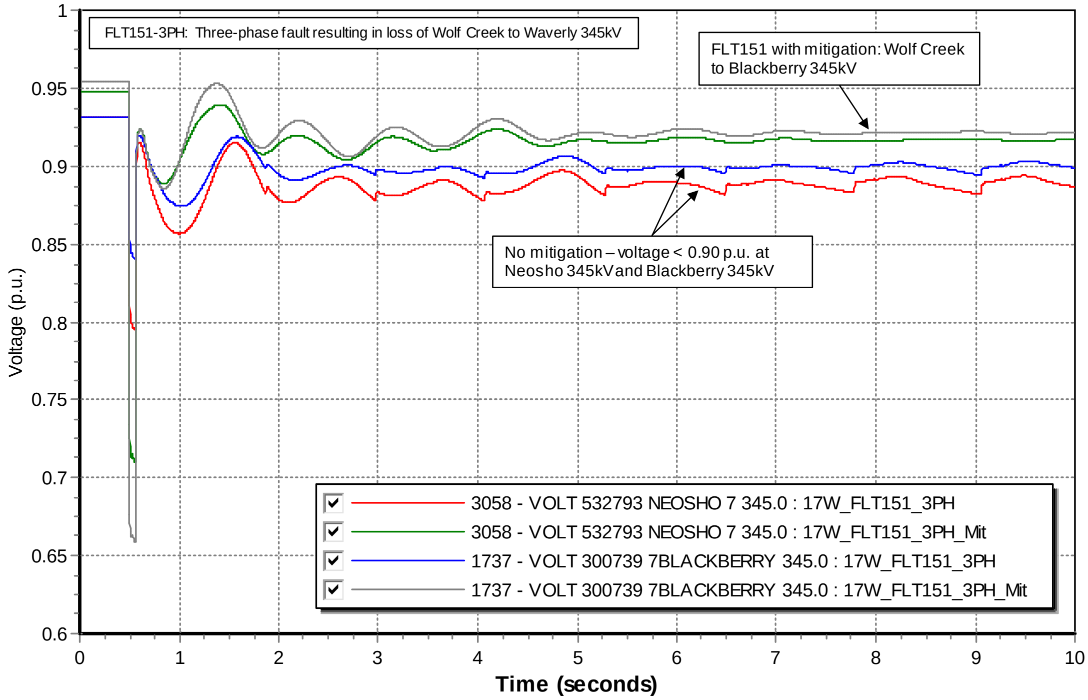

Figure 3-2: Representative plot of Neosho 345kV bus voltage for 2017 Winter Peak conditions with and without the Wolf Creek to Blackberry 345kV line.

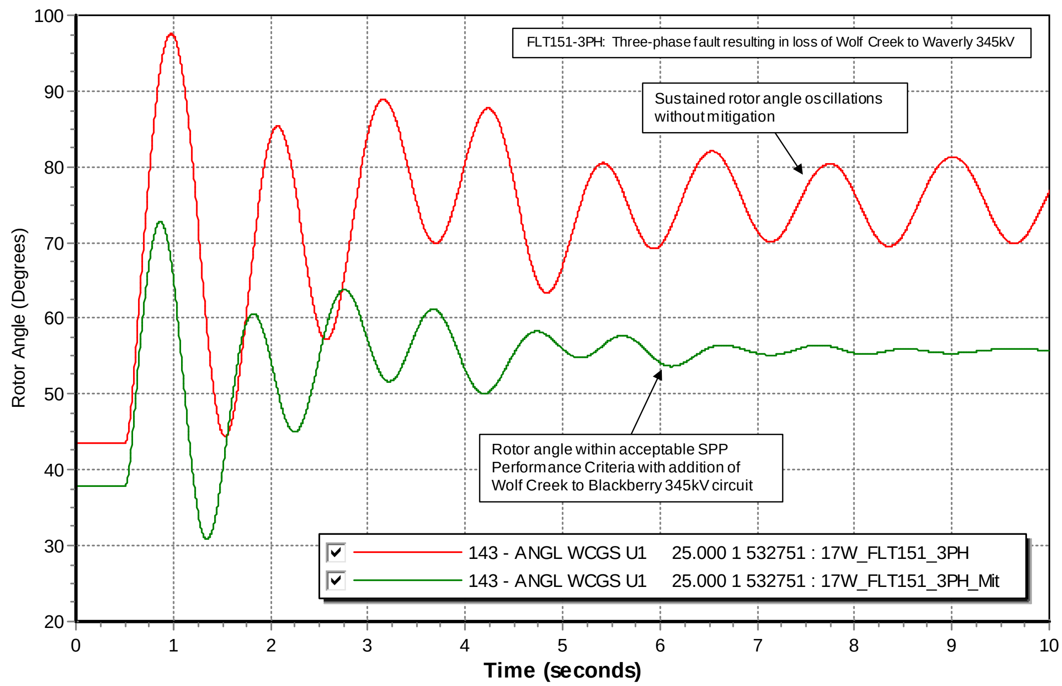

Figure 3-3: Representative rotor angle plot for 2017 Winter Peak conditions with and without the Wolf Creek to Blackberry 345kV line.

Note when the Wolf Creek to Blackberry 345kV circuit is constructed and energized FLT151, FLT186, and FLT187 without the identified upgrade would be considered a P6 event with the Wolf Creek to Blackberry 345kV circuit out of service. These events were observed to result in undamped rotor angle oscillations at Wolf Creek and would need to be mitigated for the P6 event with the Wolf Creek to Blackberry 345kV circuit as the prior outage. In addition to the transmission circuit upgrade, the Wolf Creek AVR upgrade from DISIS-2016-001-5 Group 08 System Impact Study was evaluated for the prior outage of Wolf Creek to Blackberry 345kV and Wolf Creek at full output. It was determined the Wolf Creek AVR upgrade is not adequate to remove the existing Wolf Creek OP Guide. Therefore, the prior outage of the Wolf Creek to Blackberry 345kV circuit should be added to the existing Wolf Creek OP Guide.

FLT151 and FLT187 are mitigated when Wolf Creek is reduced to 950 MW net output. Refer to Figure 3-4 to compare rotor angle oscillations at Wolf Creek for FLT151 with Wolf Creek to Blackberry 345kV circuit included for the following scenarios:

- FLT151: Three-phase fault on the Wolf Creek to Waverly 345kV circuit
    - P6 event with prior outage of Wolf Creek to Blackberry 345kV circuit and no generation curtailment
    - P1 event with Wolf Creek to Blackberry 345kV circuit in-service
    - P6 event with prior outage of Wolf Creek to Blackberry 345kV circuit and updated Wolf Creek OP Guide implemented
    - P6 event with prior outage of Wolf Creek to Blackberry 345kV circuit, no generation curtailment, and tuned AVR upgrade with power system stabilizer

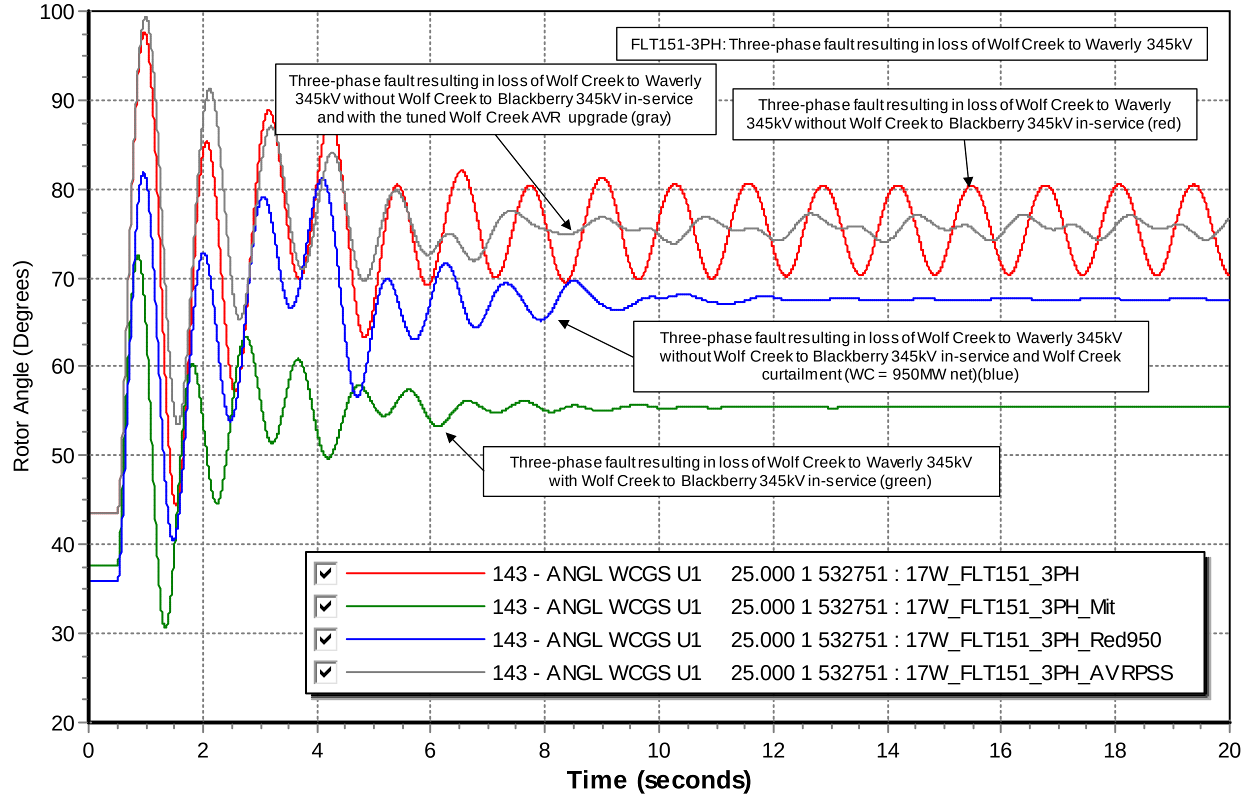

Figure 3-4: Representative rotor angle plot for 2017 Winter Peak conditions for FLT151 P1 and P6 events at Wolf Creek.

FLT186 is mitigated when Wolf Creek is reduced to 800 MW net output. Refer to Figure 3-5 to compare rotor angle oscillations at Wolf Creek for FLT186 with Wolf Creek to Blackberry 345kV circuit included for the following scenarios:

- FLT186: Three-phase fault on the Waverly to LaCygne 345kV circuit
  - P6 event with prior outage of Wolf Creek to Blackberry 345kV circuit and no generation curtailment
  - P1 event with Wolf Creek to Blackberry 345kV circuit in-service
  - P6 event with prior outage of Wolf Creek to Blackberry 345kV circuit and updated Wolf Creek OP Guide implemented
  - P6 event with prior outage of Wolf Creek to Blackberry 345kV circuit, no generation curtailment, and tuned AVR upgrade with power system stabilizer

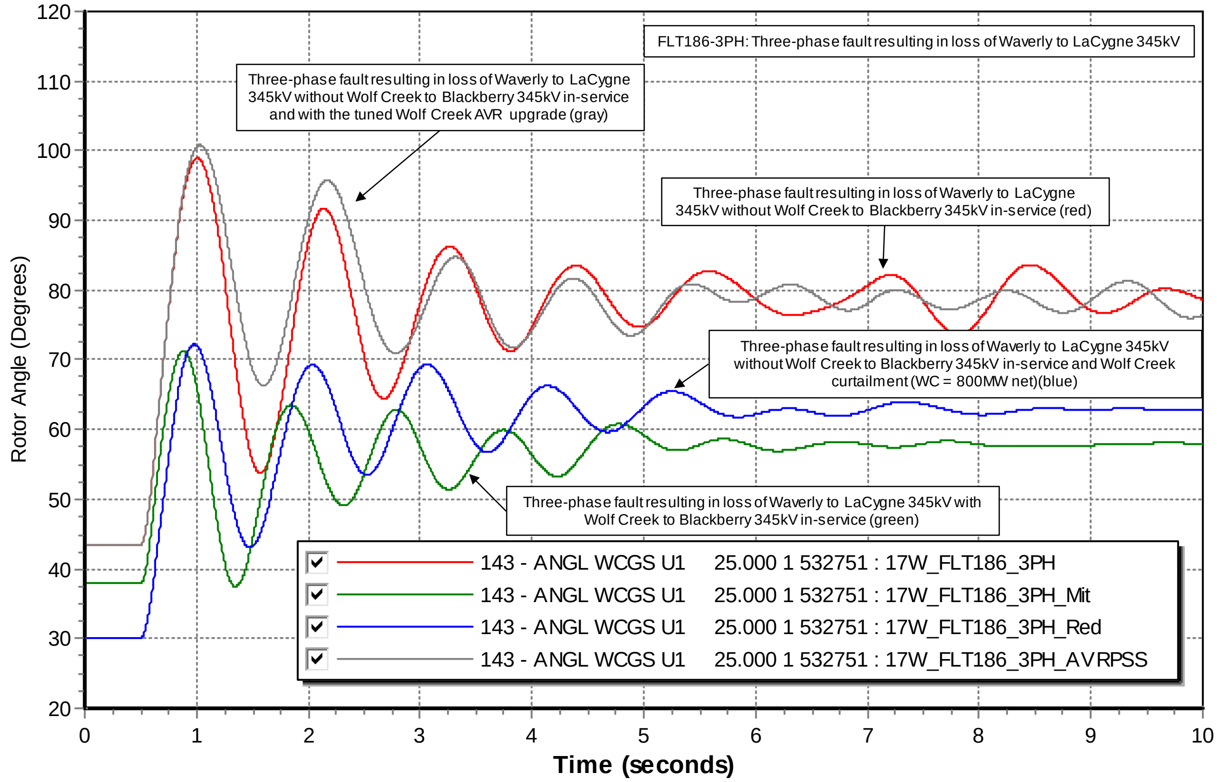

Figure 3-5: Representative rotor angle plot for 2017 Winter Peak conditions for FLT186 P1 and P6 events at Wolf Creek.

Two stuck breaker faults at Wolf Creek, which involved the Wolf Creek to Waverly 345kV circuit, were observed to result in undamped oscillations at Wolf Creek. FLT208-SB, which is a single line-to-ground fault on the Wolf Creek to Waverly 345kV circuit. Wolf Creek to Waverly 345kV clears in 3.6 cycles and back-up protection clears the fault at Wolf Creek 6.6 cycles later (total fault time of 10.2 cycles), resulted in undamped oscillations at Wolf Creek prior to the energization of the Wolf Creek to Blackberry 345kV circuit. Refer to Figure 3-6 and Figure 3-7 for representative bus voltage and rotor angle plots, respectively, for area equipment and stations.

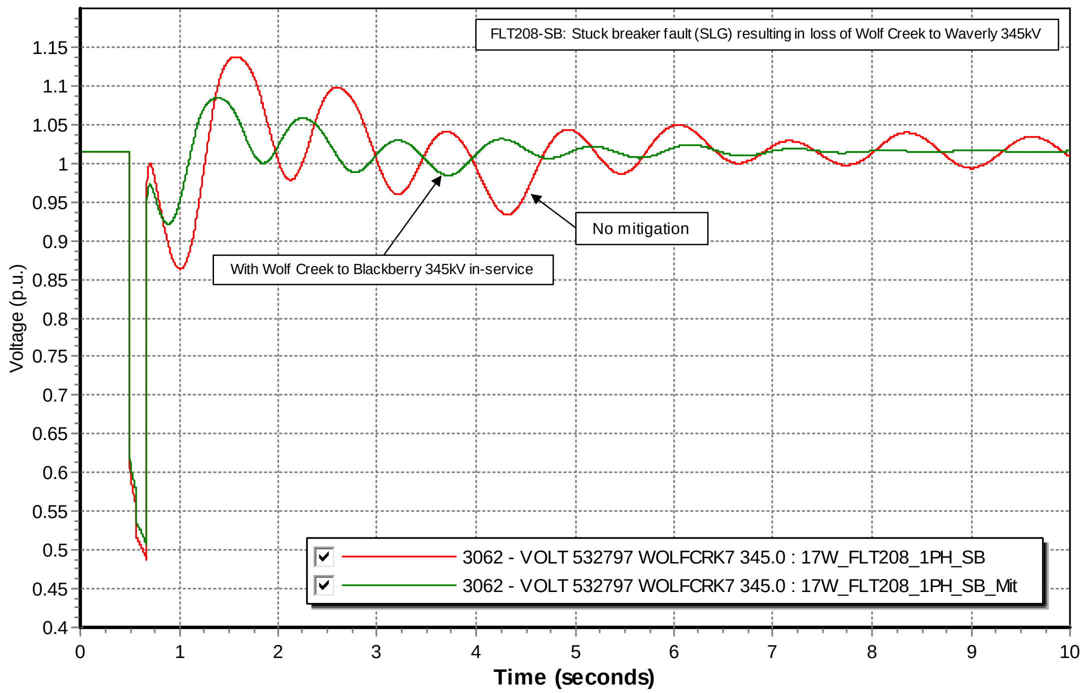

Figure 3-6: Representative bus voltage plot for 2017 Winter Peak conditions for a stuck breaker fault at Wolf Creek 345kV.

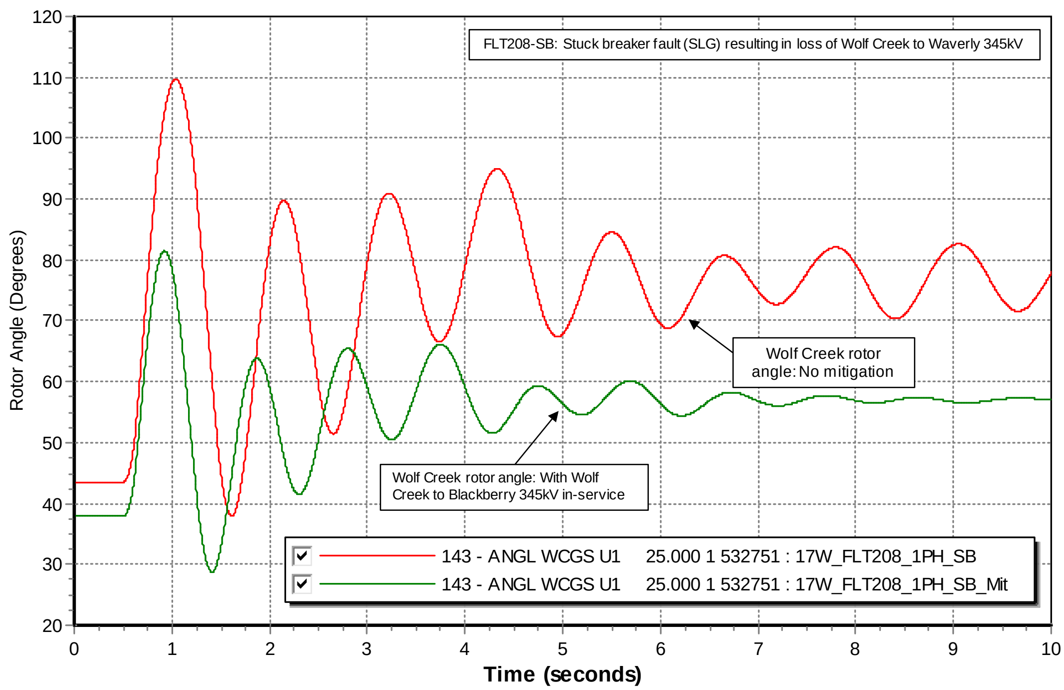

Figure 3-7: Representative rotor angle plot for 2017 Winter Peak conditions for a stuck breaker fault at Wolf Creek 345kV.

With the addition of the Wolf Creek to Blackberry 345kV or Wolf Creek to Emporia Energy Center 345kV transmission line, it was determined that Wolf Creek may be dispatched at full output for fault events with a prior outage of either Benton to Wolf Creek 345kV or Rose Hill to Wolf Creek 345kV circuits and maintain system stability for a given three-phase fault at Wolf Creek 345kV. For FLT188-PO, a prior outage of Wolf Creek to Waverly 345kV line followed by a three-phase fault that results in loss of Wolf Creek to Rose Hill 345kV line (no generation curtailment), the voltages and rotor angles recovered within SPP Performance Criteria with mitigation implemented. Refer to Figure 3-8 for a plot of bus voltages at Wolf Creek 345kV and surrounding buses with and without the Wolf Creek to Blackberry 345kV circuit. Refer to Figure 3-9 and Figure 3-10 for representative rotor angle and real power plots, respectively, of Wolf Creek with and without mitigation. Note FLT188-PO and FLT223-PO have the same prior outages and apply the same three-phase fault, however, FLT188-PO does not curtail the Wolf Creek unit while FLT223-PO implements the Wolf Creek OP Guide.

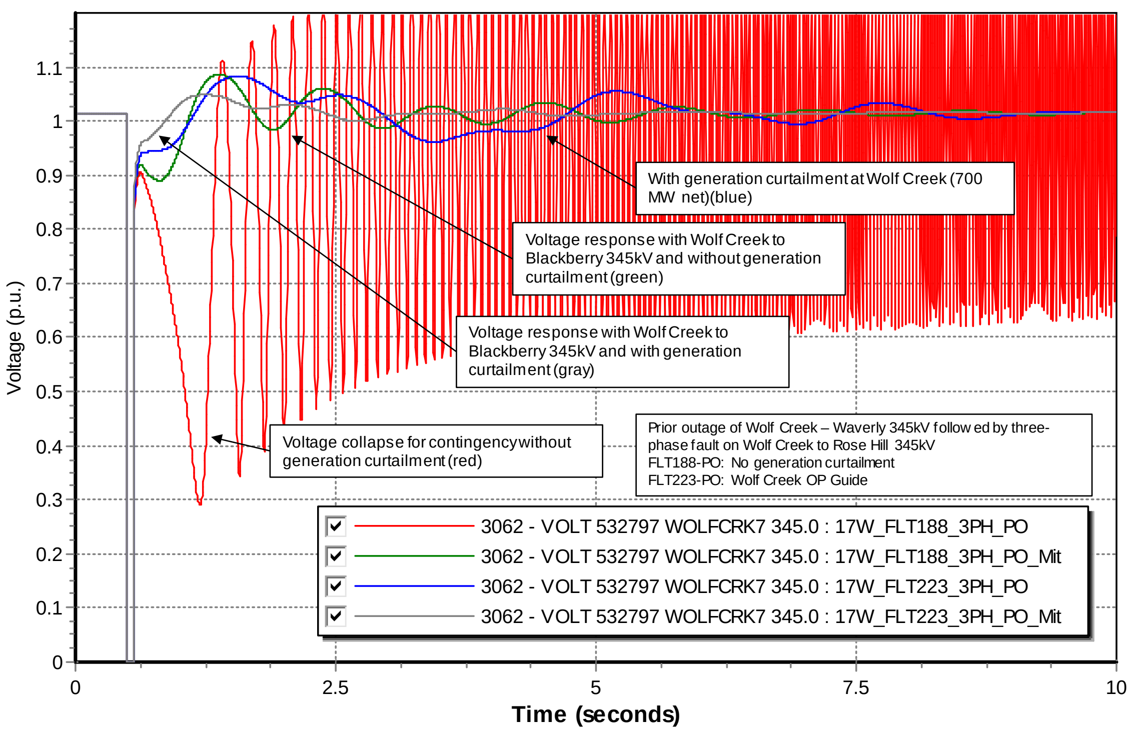

Figure 3-8: Representative voltage plot of Wolf Creek 345kV for the prior outage of Wolf Creek to Waverly 345kV followed by the loss of Wolf Creek to Rose Hill 345kV.

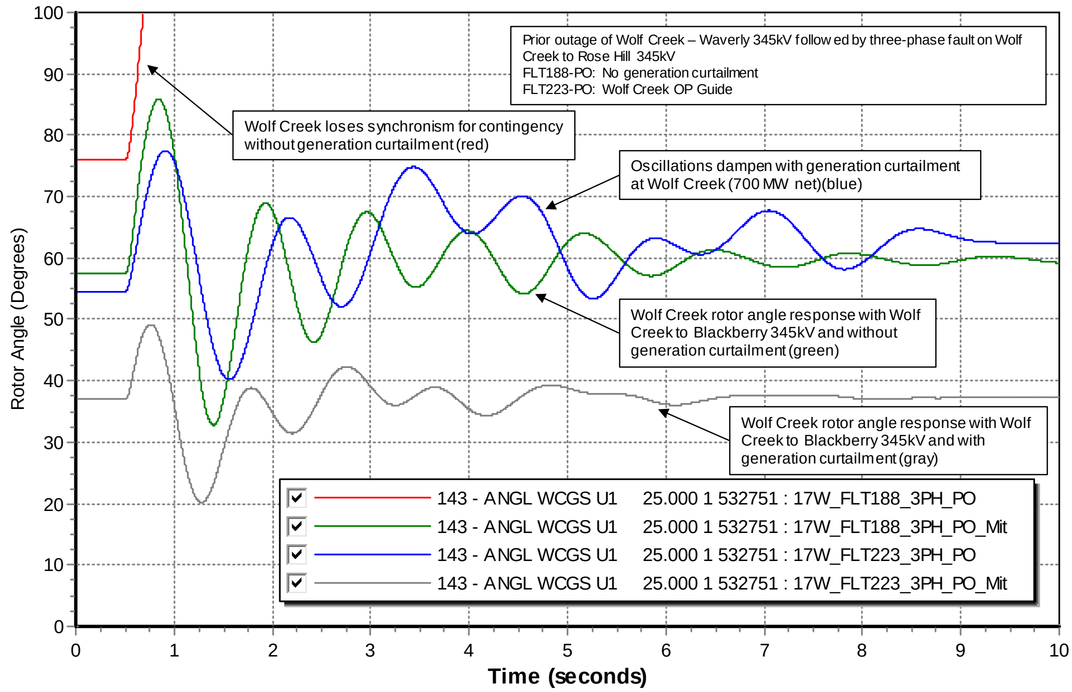

Figure 3-9: Representative rotor angle plot of Wolf Creek for the prior outage of Wolf Creek to Waverly 345kV followed by the loss of Wolf Creek to Rose Hill 345kV.

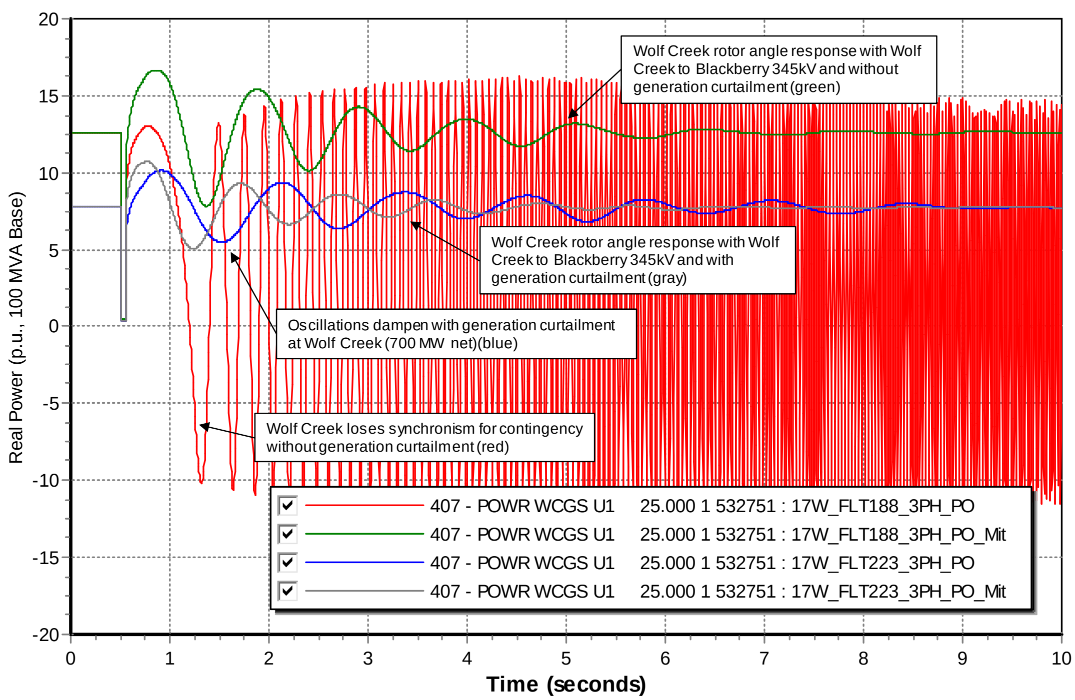

Figure 3-10: Representative real power plot of Wolf Creek for the prior outage of Wolf Creek to Waverly 345kV followed by the loss of Wolf Creek to Rose Hill 345kV.

Although the Wolf Creek to Blackberry 345kV or Wolf Creek to Emporia Energy Center 345kV circuits mitigated several prior outage contingencies at Wolf Creek, generation curtailment is required in addition to the identified mitigation solution options for the prior outage of either Waverly to LaCygne 345kV or Blackberry to Wolf Creek 345kV circuits. FLT210-PO and FLT211-PO both involve the prior outage of the Waverly to LaCygne 345kV followed by a three-phase fault at Wolf Creek 345kV. It was observed that output reduction to Waverly wind farm and/or Wolf Creek may be required to achieve an acceptable response within SPP Performance Criteria. Refer to Figure 3-11 for a representative rotor angle plot of Wolf Creek with no mitigation, with the Wolf Creek to Blackberry 345kV circuit, and with the Wolf Creek to Blackberry 345kV circuit and Waverly wind farm offline. It can be observe with only the Wolf Creek to Blackberry 345kV circuit, undamped oscillations are observed at Wolf Creek and reduction at Waverly wind farm and/or Wolf Creek may be required.

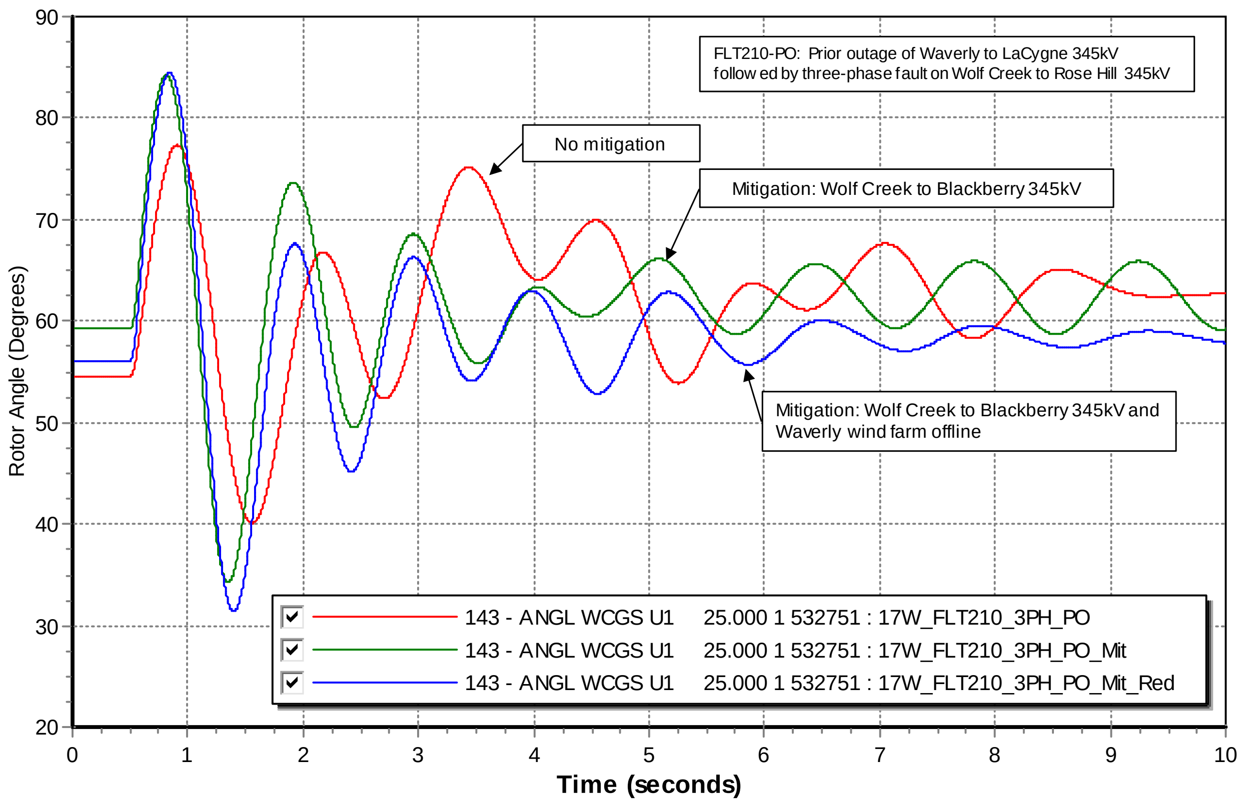

Figure 3-11: Representative rotor angle plot of Wolf Creek for the prior outage of LaCygne to Waverly 345kV followed by the loss of Wolf Creek to Rose Hill 345kV.

The projects GEN-2016-133 through GEN-2016-146 are attempting to interconnect 2,500 MW of wind generation through a 360 mile 765 kV line. In addition to this, the wind turbines are acting in voltage control mode with a 0.90 power factor. In steady state, compensation of approximately 2,100 MVars of line charging current is provided primarily by the active current flow (2,500 MW) across this circuit and injected into the transmission system. During the fault, reactive current is prioritized over real current and is being injected into the system from the wind turbines. Upon clearing of the fault, real current ramps up from approximately 25% of the initial value to 100% within approximately 250 milliseconds (15 cycles) but the dynamic reactive power capability of the wind turbines is not able to react either quick enough or adequately to dampen the voltage overshoot observed at the wind turbine terminals. This overshoot is the result of both the momentary uncompensated line charging current and the response time of the wind turbines to a drastic change in reactive power required. As a result, the wind plant trips on overvoltage protection. Refer to Figure 3-12 for a plot of the grid side and inverter side bus voltage along the 765kV circuit and Figure 3-13 for a plot of the real and reactive power across the 765kV circuit. Refer to Figure 3-14 for a representative voltage plot at the generator terminals and Riverside 345 kV POI for FLT192. FLT192 is a three phase, reclose fault that results in the loss of the Riverside to Oneta 345 kV line. It can be observed that following the second fault, the generator terminal voltage rises to above 1.3 p.u. Note this also occurs for a non-reclose fault (i.e. upon fault clearing). Refer to Figure 3-14 for a plot of the real and reactive power of GEN-2016-133 which shows the reactive current injection spike following the clearing of the fault.

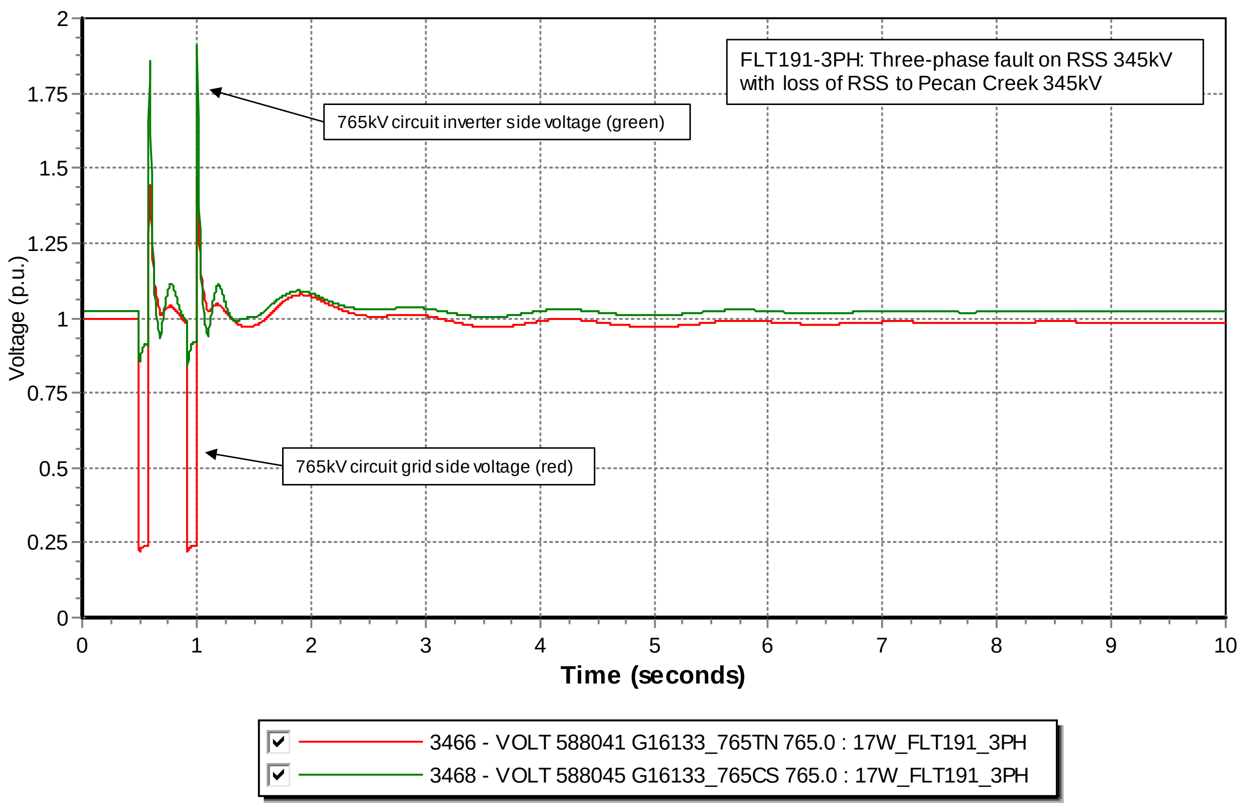

Figure 3-12: Representative voltage plot of Riverside 765kV voltages for 2017 WP conditions.

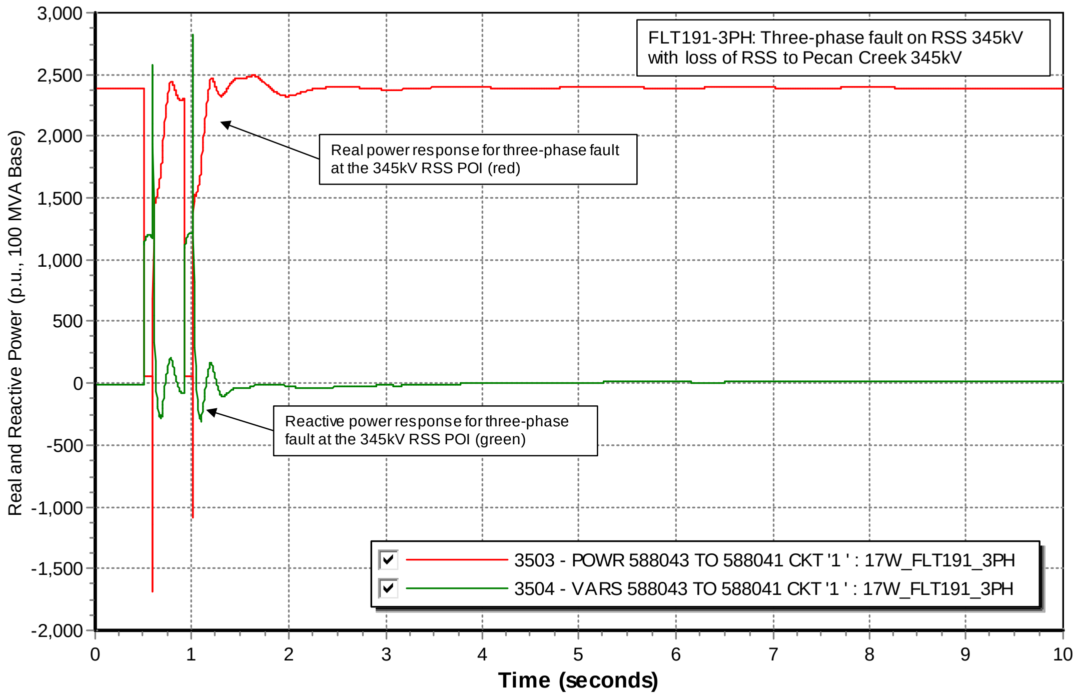

Figure 3-13: Representative real and reactive power plot along the Riverside 765 kV circuit for 2017 Winter Peak conditions.

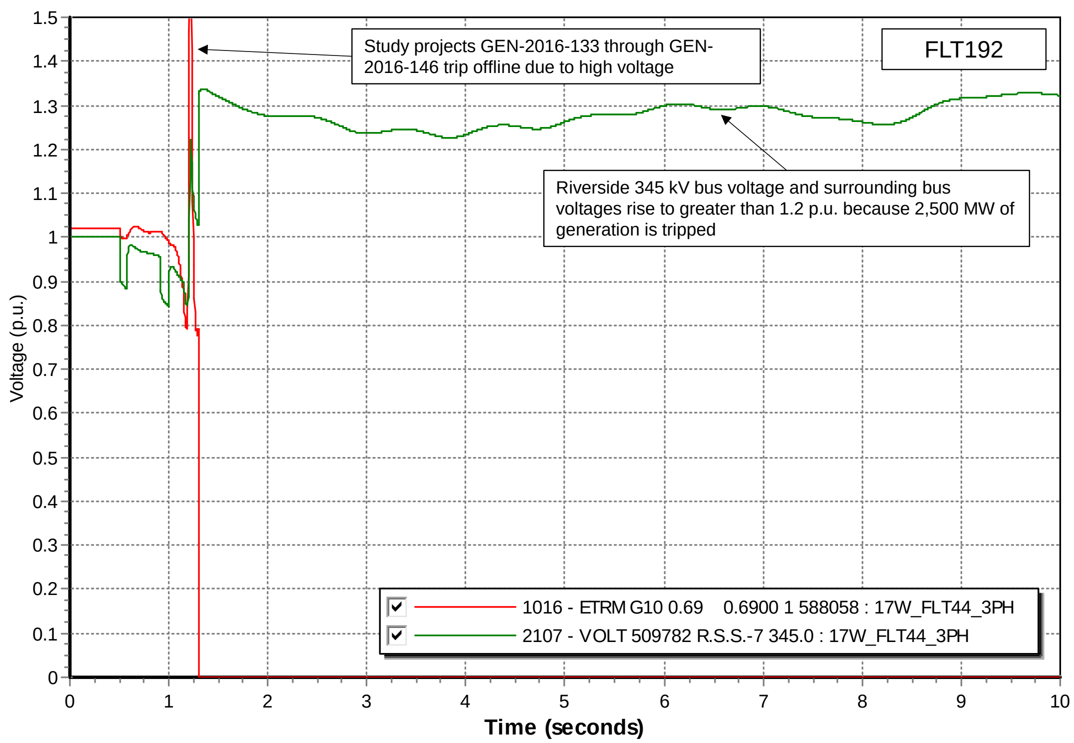

Figure 3-14: Representative plot of Riverside area voltages for 2017 Winter Peak conditions.

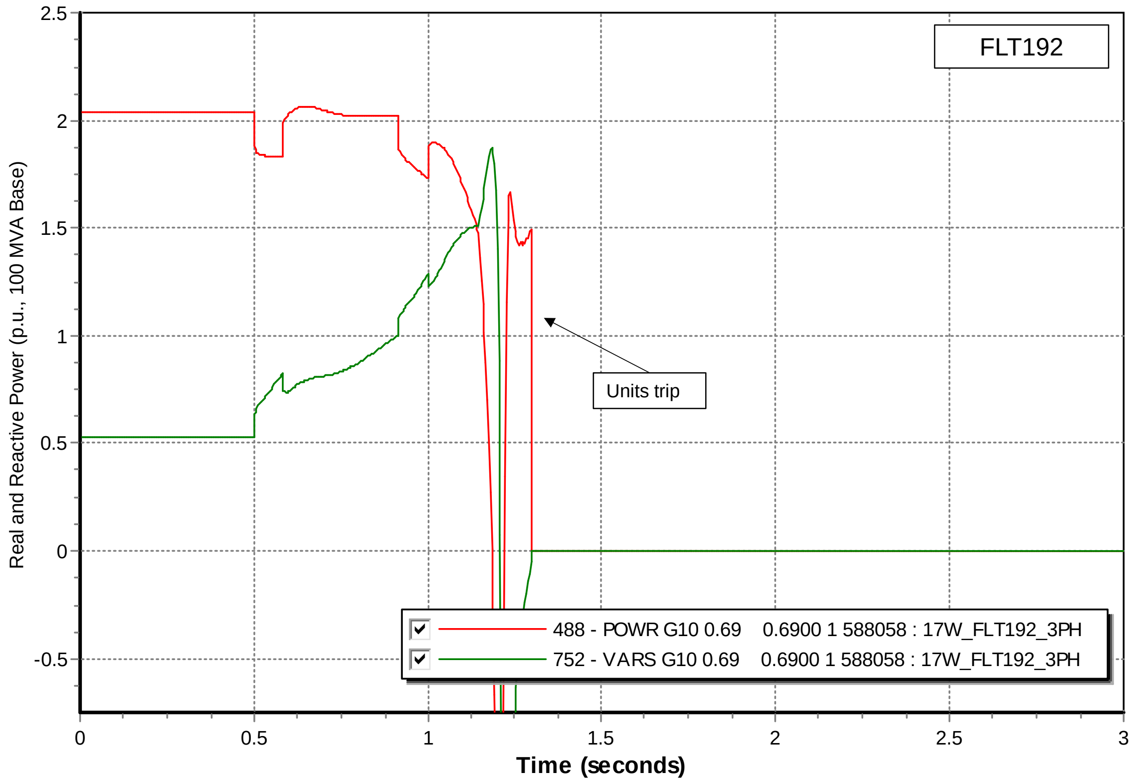

Figure 3-15: Representative plot of Riverside generation real and reactive power for 2017 Winter Peak conditions.

Figures 3-16 and Figure 3-17 are representative plots of FLT192 with the voltage protection for GEN-2016-133 through GEN-2016-146 disabled. It is recommended the interconnection customer re-examine the design of the interconnection request. As a result of this study and with the current design configuration, GEN-2016-133 through GEN-2016-146 does not meet FERC Order 661A criteria.

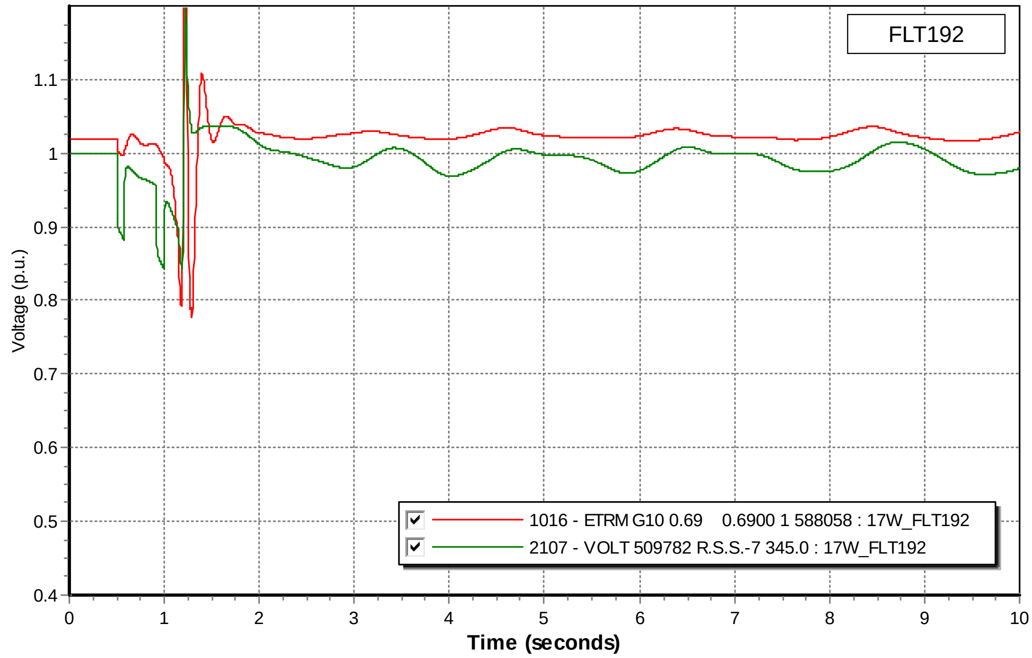

Figure 3-16: Representative plot of Riverside area voltages for 2017 Winter Peak conditions with high voltage tripping disabled.

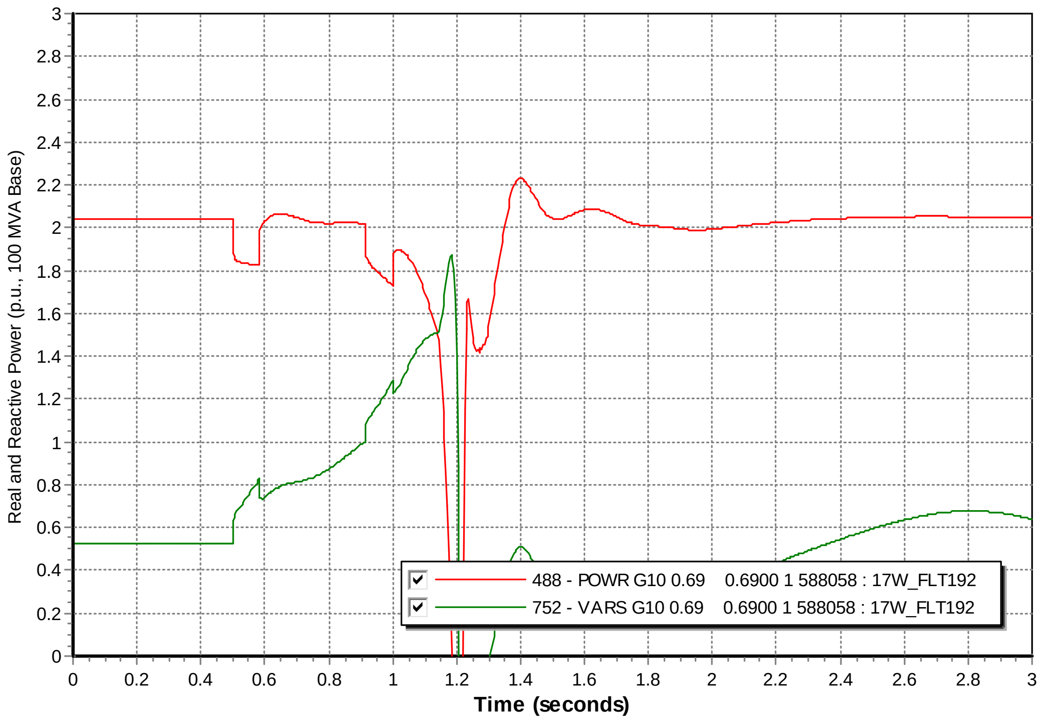

Figure 3-17: Representative plot of Riverside generation real and reactive power for 2017 Winter Peak conditions with high voltage tripping disabled.

SECTION 4: CONCLUSIONS

Summary of Stability Analysis

The Stability Analysis determined that with the Wolf Creek NERC MOD-026 and MOD-027 model validation updates several P1, P4, and P6 events that include a fault on a circuit connected to either Waverly or Wolf Creek 345kV substations resulted in undamped rotor angle oscillations, voltages below the acceptable recovery voltage, voltage collapse, and generation instability when all generation interconnection requests were at 100% output. The Stability Analysis also determined that events across the Group 8 study area resulted in generation tripping (study projects GEN-2016-133 through GEN-2016-146) when all generation interconnection requests were at 100% output for several P1, P4, and P6 events. Additionally, for several faults near the Riverside 345 kV station, the study projects GEN-2016-133 through GEN-2016-146 were required to have voltage protection disabled to prevent the units from tripping offline due to high voltages after clearing the fault. The following transmission upgrade options were observed to mitigate the system instability observed for all contingencies:

- Wolf Creek to Emporia Energy Center 345kV circuit (previously and no longer assigned as mitigation in DISIS-2016-001-4)
- Wolf Creek to Blackberry 345kV circuit (previously and current assigned mitigation in DISIS-2016-001-5)

This analysis identified the potential requirement of generation curtailment at Wolf Creek for certain prior outage conditions including Wolf Creek to Blackberry 345kV circuit #1, Wolf Creek to Waverly 345kV circuit #1, or Waverly to LaCygne 345kV circuit #1. The Transmission Owner is advised to update the existing Wolf Creek Operating Guide accordingly once the Wolf Creek to Blackberry 345kV circuit #1 is complete. Note if the upgraded circuit of Wolf Creek to Blackberry 345kV is replaced with Wolf Creek to Emporia Energy Center 345kV circuit #1, the same results apply to the alternate circuit.

It is recommended that the interconnection customer(s) for GEN-2016-133 through GEN-2016-146 re-examine the design of the interconnection request(s) due to the projects tripping offline, does not meet FERC Order 661A criteria, when voltage protection is enabled.

APPENDIX A: STEADY-STATE AND DYNAMIC MODEL DATA

Base Case Power Flows

Three base case power flows were provided to MEPPI by SPP:

- MDWG16-17W_DIS16021_G08.sav
- MDWG16-18S_DIS16021_G08.sav
- MDWG16-26S_DIS16021_G08.sav

Three dynamic files were provide to MEPPI by SPP:

- MDWG16-17W_DIS16021_G08.dyr
- MDWG16-18S_DIS16021_G08.dyr
- MDWG16-26S_DIS16021_G08.dyr

GEN-2016-100

- Wind Farm Size: 100 MW
- Interconnection:
  - Voltage: 345 kV
  - POI: Tap Sooner – Spring Creek 345 kV (Bus 587804)
  - Transformer: 345/34.5 kV step-up transformer
    - MVA: 225 Winding MVA
    - Voltage: 345/34.5 kV
    - Z: 10%
  - Transmission Line:
    - R = 0.000442 p.u.
    - X = 0.003780 p.u.
    - B = 0.049594 p.u.
- Collector System Equivalent Model:
  - Transmission Line:
    - R = 0.015600 p.u.
    - X = 0.020200 p.u.
    - B = 0.045680 p.u.
- Wind Farm Parameters – GE 2.5 MW
  - Machine Terminal Voltage: 0.7 kV
  - Rated Power: 100 MW
  - Number of Wind Turbines: 40
  - Generator Step-Up Transformer:
    - MVA: 210.6 Winding MVA
    - High Voltage: 34.5 kV
    - Low Voltage: 0.7 kV
    - Z: 5.7%

The dynamic data for GEN-2016-100 is shown below:

```
587803 'USRMDL' 1  'GEWTG2'  1 1 4 18 3 5
   0    40        0        0
    2.5000      0.80000      0.50000      0.90000      1.2200      1.2000
    2.0000      0.40000      0.80000      10.000       0.20000E-01 0.0000
    0.0000      0.50000      0.16700      0.90000      0.92500     0.0000    /
587803 'USRMDL' 1  'GEWTE2'  4 0 12 67 18 9
         587803         0              0              1              0              0
          0         0              0              1              0              0
   0.15000       2.000      1.0000      0.0000      0.0000      0.50000E-01  3.0000
   0.60000      1.1200      0.40000E-01 0.43600     -0.43600     1.1000       0.20000E-01
   0.45000           -0.45000          60.000           0.10000           0.90000
    1.1000           40.000            0.50000          1.4500            0.50000E-01
    0.50000E-01       1.0000           0.15000          0.96000           0.99600
    1.0040            1.0400           1.00000          1.0000            1.00000
    0.40000           1.0000           0.20000          1.0000            0.25000
   -1.0000           14.0000           25.000           3.0000           -0.90000
    8.0000            0.2000           10.000           1.0000            1.7000
    1.22              1.2500           5.0000           0.0000            0.0000
    0.000             0.25000E-02      1.0000           5.5000            0.10000
   -1.0000            0.10000          0.0000           0.10000          -0.10000
    0.70000           0.12000         -0.12000    /
587803 'USRMDL' 1 'GEWTT1'          5    0    1    5    4    3   0
     2.9600      0.0000        0.0000        1.8800        1.5000     /
587803 'USRMDL' 1 'GEWGD1'        505    0    1    6    0    4   0
     9999.0      5.0000        30.000        9999.0        9999.0
     30.000    /
587803 'USRMDL' 1 'GEWTA2'        505    0    0    9    1    4
     20.000      0.0000        27.000       -4.0000        0.0000        1.2250
     56.500      104.00        1200.0      /
587803 'USRMDL'  0 'GEWTP2'       505    0    1    10   3    3   0
     0.30000      150.00        25.000        3.0000        30.000
    -4.0000       27.000       -10.000        10.000        1.0000     /
58780300  'USRMSC' 'GEWPLT2' 512  0  2  0  0  17               587803      '1 '     /
58780301 'VTGIPAI' 587803 587803  '1'   0.400   5.000   1.000   0.08 /
58780302 'VTGIPAI' 587803 587803  '1'   0.600   5.000   1.700   0.08 /
58780303 'VTGIPAI' 587803 587803  '1'   0.700   5.000   2.500   0.08 /
58780304 'VTGIPAI' 587803 587803  '1'   0.750   5.000   3.000   0.08 /
58780305 'VTGIPAI' 587803 587803  '1'   0.850   5.000  10.000   0.08 /
58780306 'VTGIPAI' 587803 587803  '1'   0.900   5.000 600.000   0.08 /
58780307 'VTGIPAI' 587803 587803  '1'   0.000   1.101   1.000   0.08 /
58780308 'VTGIPAI' 587803 587803  '1'   0.000   1.150   0.500   0.08 /
58780309 'VTGIPAI' 587803 587803  '1'   0.000   1.175   0.200   0.08 /
58780310 'VTGIPAI' 587803 587803  '1'   0.000   1.200   0.100   0.08 /
58780311 'VTGIPAI' 587803 587803  '1'   0.000   1.300   0.010   0.08 /
```

GEN-2016-101

- Wind Farm Size: 195 MW
- Interconnection:
  - Voltage: 345 kV
  - POI: Tap Sooner – Spring Creek 345 kV (Bus 587804)
  - Transformer: 345/34.5 kV step-up transformer
    - MVA: 225 Winding MVA
    - Voltage: 345/34.5 kV
    - Z: 10%
  - Transmission Line:
    - R = 0.000442 p.u.
    - X = 0.003780 p.u.
    - B = 0.049594 p.u.
- Collector System Equivalent Model:
  - Transmission Line:
    - R = 0.002340 p.u.
    - X = 0.002220 p.u.
    - B = 0.023580 p.u.
- Wind Farm Parameters – Vestas V110 VCSS 2.0 MW
  - Machine Terminal Voltage: 0.7 kV
  - Rated Power: 195 MW
  - Number of Wind Turbines: 100
  - Generator Step-Up Transformer:
    - MVA: 210.6 Winding MVA
    - High Voltage: 34.5 kV
    - Low Voltage: 0.7 kV
    - Z: 5.7%

The dynamic data for GEN-2016-101 is shown below:

```
/
587813 'USRMDL' 1  'GEWTG2'  1 1 4 18 3 5
   0    78        0        0
     2.5000      0.80000      0.50000      0.90000      1.2200      1.2000
     2.0000      0.40000      0.80000       10.000     0.20000E-01  0.0000
     0.0000      0.50000      0.16700      0.90000     0.92500      0.0000    /
587813 'USRMDL' 1  'GEWTE2'  4 0 12 67 18 9
         587813       0              0               1             0             0
          0         0              0               1             0             0
    0.15000        2.000       1.0000       0.0000      0.0000    0.50000E-01   3.0000
    0.60000       1.1200       0.40000E-01  0.43600    -0.43600    1.1000       0.20000E-01
    0.45000           -0.45000          60.000             0.10000            0.90000
     1.1000           40.000             0.50000            1.4500             0.50000E-01
     0.50000E-01       1.0000             0.15000            0.96000            0.99600
     1.0040            1.0400             1.00000            1.0000             1.00000
     0.40000           1.0000             0.20000            1.0000             0.25000
    -1.0000           14.0000            25.000             3.0000            -0.90000
     8.0000            0.2000            10.000             1.0000             1.7000
     1.22              1.2500             5.0000             0.0000             0.0000
     0.000             0.25000E-02        1.0000             5.5000             0.10000
    -1.0000            0.10000            0.0000             0.10000           -0.10000
     0.70000           0.12000           -0.12000    /
587813 'USRMDL' 1 'GEWTT1'          5    0    1    5    4    3   0
      2.9600       0.0000       0.0000       1.8800       1.5000    /
587813 'USRMDL' 1 'GEWGD1'        505    0    1    6    0    4   0
      9999.0       5.0000       30.000       9999.0       9999.0
      30.000    /
587813 'USRMDL' 1 'GEWTA2'        505    0    0    9    1    4
      20.000       0.0000       27.000      -4.0000       0.0000       1.2250
      56.500       104.00       1200.0     /
587813 'USRMDL'  0 'GEWTP2'       505    0    1    10   3    3   0
      0.30000       150.00       25.000       3.0000       30.000
     -4.0000        27.000      -10.000       10.000       1.0000     /
58781300  'USRMSC' 'GEWPLT2' 512  0  2  0  0  17                587813        '1 '     /
58781301 'VTGIPAI' 587813 587813  '1'   0.40000   5.000   1.000   0.08 /
58781302 'VTGIPAI' 587813 587813  '1'   0.60000   5.000   1.700   0.08 /
58781303 'VTGIPAI' 587813 587813  '1'   0.70000   5.000   2.500   0.08 /
58781304 'VTGIPAI' 587813 587813  '1'   0.75000   5.000   3.000   0.08 /
58781305 'VTGIPAI' 587813 587813  '1'   0.85000   5.000  10.000   0.08 /
58781306 'VTGIPAI' 587813 587813  '1'   0.90000   5.000 600.000   0.08 /
58781307 'VTGIPAI' 587813 587813  '1'   0.00000   1.101   1.000   0.08 /
58781308 'VTGIPAI' 587813 587813  '1'   0.00000   1.150   0.500   0.08 /
58781309 'VTGIPAI' 587813 587813  '1'   0.00000   1.175   0.200   0.08 /
58781310 'VTGIPAI' 587813 587813  '1'   0.00000   1.200   0.100   0.08 /
58781311 'VTGIPAI' 587813 587813  '1'   0.00000   1.300   0.010   0.08 /
/
```

GEN-2016-119

- Generator Size: 600 MW
- Interconnection:
  - Voltage: 345 kV
  - POI: Tap Sooner – Spring Creek 345 kV (Bus 587804)
  - Transformer 1: 138/34.5 kV step-up transformer
    - MVA: 360 Winding MVA
    - Voltage: 345/34.5kV
    - Z: 12.5%
  - Transformer 2: 138/34.5 kV step-up transformer
    - MVA: 360 Winding MVA
    - Voltage: 345/34.5kV
    - Z: 12.5%
  - Transmission Line 1:
    - R = 0.000500 p.u.
    - X = 0.009040 p.u.
    - B = 0.167440 p.u.
  - Transmission Line 2:
    - R = 0.000520 p.u.
    - X = 0.005100 p.u.
    - B = 0.219790 p.u.
- Collector System Equivalent Model:
  - Transmission Line 1:
    - R = 0.002300 p.u.
    - X = 0.003700 p.u.
    - B = 0.147880 p.u.
  - Transmission Line 2:
    - R = 0.003200 p.u.
    - X = 0.005100 p.u.
    - B = 0.219790 p.u.
- Wind Farm Parameters – Vestas V110 2.00 MW
  - Inverter Terminal Voltage: 0.7 kV
  - Rated Power: 600 MW
  - Number of Wind Turbines: 300
    - Generator Step-Up Transformer 1:
      - MVA: 296.1 Winding MVA
      - High Voltage: 34.5 kV
      - Low Voltage: 0.7 kV
      - Z: 7.8%

- Generator Step-Up Transformer 2:
  - MVA: 333.9 Winding MVA
  - High Voltage: 34.5 kV
  - Low Voltage: 0.7 kV
  - Z: 7.8%

The dynamic data for GEN-2016-119 is shown below:

```
/ V110 VCSS 2.0 MW 60 Hz Mk10 (VestasWT_7_6_0_PSSE32.lib)
/
587953 'USRMDL' '1'  'VWCOR6' 1 1 2 45 23 104 1 0
 2000.0000 690.0000 903.3041 700.0000 2.6200 0.9676 0.0232
 1.9807 8.3333 1.9807 8.3333 30.0000 0.2000 1.2000
 0.1000 0.0012 0.9925 0.0474 1.6118 0.0000 351.8584
 161.5343 0.0300 0.0000 0.0300 0.3000 0.0000 1.0000
 0.3183 4.9736 2812227.1900 43.2960 90.0120 600000.0000 3.0000
 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
 0.0000 0.0000 0.0000/
0 'USRMDL' 0 'VWVAR6' 8 0 2 0 0 30 587953 '1'  /
0 'USRMDL' 0 'VWLVR6' 8 0 3 65 10 35 587953 '1' 1
 0.9000 0.0010 0.1500 18.6316 74.5430 74.5430 74.5430
 0.5000 1.0000 2.6200 0.9676 1.2000 0.5000 690.0000
 903.3041 0.3500 0.0500 0.2500 0.0200 3.0000 4.0000
 9999.0000 0.0232 0.9000 0.9000 0.0500 0.0000 0.0100
 0.0000 2.0000 0.0000 1.0000 0.0000 0.0000 0.0000
 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
 0.0000 0.0000 /
0 'USRMDL' 0 'VWPWR6' 8 0 3 30 7 10 587953 '1' 1
 1.0000 0.5000 -0.5000 0.6988 0.8844 0.9800 0.9600
 0.2000 0.2000 1.0000 1.0000 0.0000 0.0000 0.1000
 0.1000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
 0.0000 0.0000 /
0 'USRMDL' 0 'VWMEC6' 8 0 2 10 8 0 587953 '1'
 2000.0000 422.2301 4736.7543 420.7500 83.5000 6188.8071 39.3992
 0.0000 0.0000 0.0000 /
0 'USRMDL' 0 'VWMEA6' 8 0 2 10 8 5 587953 '1'
 0.1000 0.1000 0.1000 0.0000 0.0000 0.0000 0.0000
 0.0000 0.0000 0.0000/
0 'USRMDL' 0 'VWVPR6' 0 2 7 30 0 18 587953 '1'  1 1 0 0 0
 0.8500 11.0000 0.8500 11.0000 0.9000 60.0000 1.1000
 60.0000 1.1500 2.0000 1.2000 0.0800 1.2500 0.0050
 1.2500 0.0050 0.0000 0.0000 0.0000 0.0000 0.0000
 0.0000 0.0000 0.1500 0.8000 2.7000 0.8500 3.5000
 0.9000 5.0000 /
0 'USRMDL' 0 'VWFPR6' 0 2 3 12 0 7 587953 '1'  0
 56.4000 0.2000 56.4000 0.2000 56.4000 0.2000 63.6000
 0.2000 63.6000 0.2000 63.6000 0.2000 /
/
```

```
/
/ 30 X Vestas V110 VCSS 2.000 MW 60Hz Mk10 wind Generators (VestasWT_7_8_1_PSSE33.lib)
/  7 X Vestas V110 VCSS 1.905 MW 60Hz Mk10 wind Generators (VestasWT_7_8_1_PSSE33.lib)
/ (30 2.000MW units)
/ 587958 'USRMDL' '1'  'VWCO81' 1 1 2 45 23 104 1 0
/  2000.0000    690.0000    901.7885    700.0000    2.6200      0.6786      0.0160
/  0.4503       94.2478     0.4503      94.2478     30.0000     0.2000      1.2000
/  0.1000       0.0018      0.7018      0.0384      1.3298      0.0000      422.2301
/  184.6106 0.0300      0.0000      0.0300      0.3000      0.0000      0.0000
/  0.0000       0.0000      0.0000      0.0000      0.0000      0.0000      3.0000
/  0.0000       4736.7543   0.0000      0.0000      0.0000      0.0000      0.0000
/  0.0000       0.0000      0.0000 /
/ 0 'USRMDL' 0 'VWVA81' 8 0 2 0 0 30 587958 '1'/
/ 0 'USRMDL' 0 'VWLV81' 8 0 3 65 10 35 587958 '1' 1
/  0.8500       0.0010      0.0700      19.2489     76.9992     76.9992     76.9992
/  2.0000       0.0000      1.5625      0.9948      1.4400      2000.0000   690.0000
/  1.0000       0.3500      0.0500      0.2500      0.0200      3.0000      4.0000
/  9999.0000    0.0193      -12.0000    0.8500      0.0500      0.0000      0.0100
/  60.0000      1.0000      1.0000      1.0000      0.0000      0.0000      0.0000
/  100.0000 0.0002      0.0095      1.0000      0.0000      40.0000     1.0000
/  0.0000       0.0000      0.1700      0.0000      0.2000      1.0000      0.0000
/  1.1500       1.1000      0.0000      0.0000      0.0000      0.0000      0.2000
/  40.0000      777.0000    15.0000     0.0000      1.0000      1.4637      0.0000
/  0.0000       0.0000 /
/ 0 'USRMDL' 0 'VWPW81' 8 0 3 40 7 30 587958 '1' 0
/  1.0000       0.5000      -0.5000     -0.5762     1.5454      0.9496      0.9496
/  0.2000       0.2000      0.4500      0.4500      0.0000      0.0000      0.0159
/  0.0159       0.0000      0.0250      0.0250      0.0000      0.0100      0.0200
/  0.0300       3.0000      3.1000      3.2000      1.0000      1.4000      0.0000
/  0.0000       1.0000      5.0000      5.0000      6.0000      0.0001      0.0000
/  0.0000       0.0000      0.0000      0.0000      0.0000 /
/ 0 'USRMDL' 0 'VWME81' 8 0 2 10 8 0 587958 '1'
/  2000.0000    422.2301    4736.7543   1246.6332   85.8900     0.0000      0.0000
/  3824.4671    33.2614     0.0000 /
/ 0 'USRMDL' 0 'VWM781' 8 0 2 10 8 5 587958 '1'
/  0.0159       0.0159      0.1000      0.1000      0.0000      0.0000      0.0000
/  0.0000       0.0000      0.0000 /
/ 0 'USRMDL' 0 'VWVP81' 0 2 7 30 0 18 587958 '1'  1 1 0 0 0
/  0.8000       2.6000      0.8000      2.6000      0.9000      60.0000     1.1100
/  300.0000 1.1600      30.0000     1.2400      0.1000      1.2400      0.1000
/  1.2400       0.1000      0.0000      0.0000      0.0000      0.0000      0.0000
/  0.0000       0.0000      0.4500      0.8000      2.6000      0.8000      2.6000
/  0.8000       2.6000 /
/ 0 'USRMDL' 0 'VWFP81' 0 2 3 12 0 7 587958 '1'  0
/  56.4000      0.2000      56.4000     0.2000      56.4000     0.2000      63.6000
/  0.2000       63.6000     0.2000      63.6000     0.2000 /
/
```

GEN-2016-128

- Wind Farm Size: 176 MW
- Interconnection:
  - Voltage: 345 kV
  - POI: Woodring 345 kV (bus 514715)
  - Transformer: 345/34.5 kV step-up transformers
    - MVA: 200 Winding MVA
    - Voltage: 345/34.5kV
    - Z: 9%
  - Transmission Line:
    - R = 0.001274 p.u.
    - X = 0.012974 p.u.
    - B = 0.218400 p.u.
- Collector System Equivalent Model:
  - Transmission Line:
    - R = 0.003120 p.u.
    - X = 0.002840 p.u.
    - B = 0.028100 p.u.
- Wind Farm Parameters – GE 2.0 MW
  - Machine Terminal Voltage: 0.7 kV
  - Rated Power: 176 MW
  - Number of Wind Turbines: 88
    - Generator Step-Up Transformer:
      - MVA: 202.4 Winding MVA
      - High Voltage: 34.5 kV
      - Low Voltage: 0.7 kV
      - Z: 5.7%

The dynamic data for GEN-2016-128 is shown below:

```
/
588193  'USRMDL'  1  'GEWTG2'  1 1 4 18 3 5
           0          88          0           0
     2.0000E+00  0.8000     0.5000     0.9000     1.2200     1.2000
     2.0000      0.4000     0.8000     10.000     0.2000E-01 0.0000
     0.0000      0.5000     0.1670     0.9000     0.9250     0.0000    /
588193  'USRMDL'  1  'GEWTE2'  4 0 12 67 18 9
       588193          0          0           1          0          0
          0          0          0           1          0          0
     0.1500       2.000     1.0000     0.0000     0.0000     0.5000E-01  3.0000
     0.6000      1.1200     0.4000E-01 0.4360    -0.4360     1.1000      0.2000E-01
     0.4500     -0.4500      60.00     0.1000     0.9000
     1.1000       40.00     0.5000      1.450     0.5000E-01
     0.5000E-01   1.000     0.1500     0.9600     0.9960
     1.0040       1.040      1.000     1.0000     1.0000
     0.4000       1.000     0.2000      1.000     0.2500
     -1.000       14.00      25.00      3.000    -0.9000
     8.0000      0.2000      10.00      1.000      1.700
     1.2200       1.250      5.000      0.000      0.000
     0.0000      0.2500E-02  1.000      5.500     0.1000
    -1.0000      0.1000      0.000     0.1000    -0.1000
     0.7000      0.1200    -0.1200    /
588193  'USRMDL'  1  'GEWTT1'        5    0    1    5    4    3   0
     2.5965      0.0000     0.0000     1.8800     1.5000    /
588193 'USRMDL'  1 'GEWGD1' 505    0    1    6    0    4   0
      9999.0      5.0000     30.000     9999.0      9999.0       30.000    /
588193 'USRMDL'  1 'GEWTA2' 505   0    0    9    1    4
      20.000      0.0000     27.000    -4.0000      0.0000      1.2250
      50.000      93.900     1200.0    /
588193 'USRMDL'  1 'GEWTP2' 505    0    1    10    3    3   0
      0.3000      150.00     25.000     3.0000      30.000
     -4.0000      27.000    -10.000     10.000      1.0000    /
58819300   'USRMSC' 'GEWPLT2' 512  0  2  0  0  17      588193   '1'    /
58819301 'FRQTPAT'        588193    588193   '1' 56.5   62.5   1   0.08/
58819302 'VTGTPAT'        588193    588193   '1' 0.10  5.000  0.500  0.08 /
58819303 'VTGTPAT'        588193    588193   '1' 0.20  5.000  0.625  0.08 /
58819304 'VTGTPAT'        588193    588193   '1' 0.40  5.000  1.000  0.08 /
58819305 'VTGTPAT'        588193    588193   '1' 0.60  5.000  1.700  0.08 /
58819306 'VTGTPAT'        588193    588193   '1' 0.75  5.000  2.200  0.08 /
58819307 'VTGTPAT'        588193    588193   '1' 0.85  5.000  10.00  0.08 /
58819308 'VTGTPAT'        588193    588193   '1' 0.90  5.000  600.0  0.08 /
58819309 'VTGTPAT'        588193    588193   '1' 0.00  1.101  1.000  0.08 /
58819310 'VTGTPAT'        588193    588193   '1' 0.00  1.150  0.500  0.08 /
58819311 'VTGTPAT'        588193    588193   '1' 0.00  1.175  0.200  0.08 /
58819312 'VTGTPAT'        588193    588193   '1' 0.00  1.200  0.100  0.08 /
58819313 'VTGTPAT'        588193    588193   '1' 0.00  1.300  0.010  0.08 /
/
```

GEN-2016-133 – GEN-2016-146 (G1)

- Wind Farm Size: 200 MW
- Interconnection:
    - Voltage: 345 kV
    - POI: Tulsa North 345 kV (bus 509852)
    - Transformer 1: 345/765 kV step-up transformers
        - MVA: 2877 Winding MVA
        - Voltage: 345/34.5kV
        - Z: 8%
    - Transformer 2: 345/765 kV step-up transformers
        - MVA: 2877 Winding MVA
        - Voltage: 345/34.5kV
        - Z: 8%
    - Transformer 3: 765/345 kV step-up transformers
        - MVA: 2877 Winding MVA
        - Voltage: 345/34.5kV
        - Z: 8%
    - Transformer 4: 765/345 kV step-up transformers
        - MVA: 2877 Winding MVA
        - Voltage: 345/34.5kV
        - Z: 8%
    - Transmission Line 1:
        - R = 0.000596 p.u.
        - X = 0.014090 p.u.
        - B = 9.513000 p.u.
    - Transmission Line 2:
        - R = 0.000596 p.u.
        - X = 0.014090 p.u.
        - B = 9.513000 p.u.
- Collector System Equivalent Model:
    - Transmission Line 1:
        - R = 0.005829 p.u.
        - X = 0.007163 p.u.
        - B = 0.106230 p.u.
    - Transmission Line 2:
        - R = 0.000306 p.u.
        - X = 0.003449 p.u.
        - B = 0.062630 p.u.
    - Transformer:
        - MVA: 136 Winding MVA

      - High Voltage: 765 kV
      - Low Voltage: 34.5 kV
      - Z: 8.5%
- Wind Farm Parameters – GE 2.5 MW
  - Machine Terminal Voltage: 0.7 kV
  - Rated Power: 200 MW
  - Number of Wind Turbines: 80
    - Generator Step-Up Transformer 1:
      - MVA: 224 Winding MVA
      - High Voltage: 34.5 kV
      - Low Voltage: 0.7 kV
      - Z: 5.7%

The dynamic data for GEN-2016-133 – GEN-2016-146 (G1) is shown below:

```
/ (GEN-2016-133 - GEN-2016-146) WTG G1
 588067 'USRMDL' 1  'GEWTG0501'  1   1     30   59   11   29
     588067 1 0 0 0 0 0 0 0 0  0 0 0 0 0 0 0 0 0 0  0 0 0 0 0 0 0 0 0 0
     1.0000       1.0000      15.000       0.0500       0.0000       0.0000
    -1.5000       1.5000      20.000       3.0000       0.9000       1.1000
    0.70000       1.5000      5.0000       0.20000E-01  0.0000       0.50000
    0.90000       1.0000      0.0000       0.0000       1.2300       1.2300
     100.00       0.1000      0.50000E-01  0.1000       3.5000       0.50000E-01
     1.0000       -1.000      5.0000       9999.0       -1.000       5.0000
     9999.0       -1.000      5.0000       9999.0       -1.000       5.0000
     9999.0       -1.000      5.0000       9999.0       -1.000       5.0000
     9999.0       -1.000      5.0000       9999.0       50.000       70.000
     9999.0       50.000      70.000       9999.0       9999.0   /
  588067 'USRMDL' 1  'GEWTE0501'  4   0     9   68   15  293
     588067        0       1        0        1        0   0       0       0
    0.01000       1.1000     0.90000       1.1100       1.7000
     10.000      0.20000       66.00       1.2000       0.4500       0.0330
     1.0000      0.10000    0.15000E-01  0.50000E-01  0.15000E-01  0.50000E-01
    0.20000     0.20000E-01 0.15000E-01  0.15000      5.0000       0.20000E-01
    0.40000      0.22000     0.22000       1.0000     0.70000E-02  0.50000E-01
     0.0000       0.0000      0.0000       0.5000       0.0000      -0.10000
    0.10000      -1.0000      1.0000      0.10000      0.15000       0.0000
    0.15000      0.00200    -0.00200
    0.48400     -0.48400     0.48400     -0.48400     0.10000E-01
    0.45000       1.1000      1.1000      0.60000      0.60000      -1.0000
    -1.0000     -0.60000    -0.60000     -0.60000     -0.60000      -1.3000
    -1.3000       0.0000     0.80000      0.90000       1.1000       1.2000
     1.3000    /
  588067 'USRMDL' 1  'GEWTA0501'  5 0  4   43   15  163
    0         0         1         0
     2.5000       14.000     0.30000      0.50000E-1   150.00       25.000
     3.0000      0.60000      3.0000       30.000       27.000       0.0000
     10.000       1.1200      0.0000      0.45000       2.9600       0.6200
     1.1100       1.5000      144.00       1.0000      0.15000       1.0000
     0.9500      0.40000     0.96000      0.99600       1.0040       1.0400
     1.0000      0.20000      0.0000     0.25000E-02   1.0000       5.5000
    0.10000      -1.0000     0.10000       0.0000      0.15000       5.0000
     200.00      /
/  58806700 'VTGIPAI' 588067 588067  '1'   0.400   5.000   1.000   0.08 /
/  58806701 'VTGIPAI' 588067 588067  '1'   0.600   5.000   1.700   0.08 /
/  58806702 'VTGIPAI' 588067 588067  '1'   0.700   5.000   2.500   0.08 /
/  58806703 'VTGIPAI' 588067 588067  '1'   0.750   5.000   3.000   0.08 /
/  58806704 'VTGIPAI' 588067 588067  '1'   0.850   5.000  10.000   0.08 /
/  58806705 'VTGIPAI' 588067 588067  '1'   0.900   5.000 600.000   0.08 /
/  58806706 'VTGIPAI' 588067 588067  '1'   0.000   1.101   1.000   0.08 /
/  58806707 'VTGIPAI' 588067 588067  '1'   0.000   1.150   0.500   0.08 /
/  58806708 'VTGIPAI' 588067 588067  '1'   0.000   1.175   0.200   0.08 /
/  58806719 'VTGIPAI' 588067 588067  '1'   0.000   1.200   0.100   0.08 /
/  58806710 'VTGIPAI' 588067 588067  '1'   0.000   1.300   0.010   0.08 /
```

GEN-2016-133 – GEN-2016-146 (G2)

- Wind Farm Size: 200 MW
- Interconnection:
  - Voltage: 345 kV
  - POI: Tulsa North 345 kV (bus 509852)
  - Transformer 1: 345/765 kV step-up transformers
    - MVA: 2877 Winding MVA
    - Voltage: 345/34.5kV
    - Z: 8%
  - Transformer 2: 345/765 kV step-up transformers
    - MVA: 2877 Winding MVA
    - Voltage: 345/34.5kV
    - Z: 8%
  - Transformer 3: 765/345 kV step-up transformers
    - MVA: 2877 Winding MVA
    - Voltage: 345/34.5kV
    - Z: 8%
  - Transformer 4: 765/345 kV step-up transformers
    - MVA: 2877 Winding MVA
    - Voltage: 345/34.5kV
    - Z: 8%
  - Transmission Line 1:
    - R = 0.000596 p.u.
    - X = 0.014090 p.u.
    - B = 9.513000 p.u.
  - Transmission Line 2:
    - R = 0.000596 p.u.
    - X = 0.014090 p.u.
    - B = 9.513000 p.u.
- Collector System Equivalent Model:
  - Transmission Line 1:
    - R = 0.008966 p.u.
    - X = 0.012637 p.u.
    - B = 0.151140 p.u.
  - Transmission Line 2:
    - R = 0.000306 p.u.
    - X = 0.003449 p.u.
    - B = 0.062630 p.u.
  - Transformer:
    - MVA: 136 Winding MVA

        - High Voltage: 765 kV
        - Low Voltage: 34.5 kV
        - Z: 8.5%
- Wind Farm Parameters – GE 2.5 MW
    - Machine Terminal Voltage: 0.7 kV
    - Rated Power: 200 MW
    - Number of Wind Turbines: 80
        - Generator Step-Up Transformer 1:
            - MVA: 224 Winding MVA
            - High Voltage: 34.5 kV
            - Low Voltage: 0.7 kV
            - Z: 5.7%

The dynamic data for GEN-2016-133 – GEN-2016-146 (G2) is shown below:

```
/ (GEN-2016-133 - GEN-2016-146) WTG G2
 588068 'USRMDL' 1  'GEWTG0501'  1   1     30   59   11   29
      588068 1 0 0 0 0 0 0 0 0  0 0 0 0 0 0 0 0 0 0  0 0 0 0 0 0 0 0 0 0
      1.0000       1.0000       15.000       0.0500       0.0000       0.0000
     -1.5000       1.5000       20.000       3.0000       0.9000       1.1000
     0.70000       1.5000       5.0000      0.20000E-01   0.0000       0.50000
     0.90000       1.0000       0.0000       0.0000       1.2300       1.2300
      100.00       0.1000      0.50000E-01   0.1000       3.5000      0.50000E-01
      1.0000       -1.000       5.0000       9999.0       -1.000       5.0000
      9999.0       -1.000       5.0000       9999.0       -1.000       5.0000
      9999.0       -1.000       5.0000       9999.0       -1.000       5.0000
      9999.0       -1.000       5.0000       9999.0       50.000       70.000
      9999.0       50.000       70.000       9999.0       9999.0   /
  588068 'USRMDL' 1  'GEWTE0501'  4   0     9   68   15  293
      588068        0         1         0         1          0   0        0       0
     0.01000       1.1000      0.90000       1.1100       1.7000
      10.000      0.20000       66.00        1.2000       0.4500       0.0330
      1.0000      0.10000     0.15000E-01  0.50000E-01  0.15000E-01  0.50000E-01
     0.20000     0.20000E-01  0.15000E-01  0.15000       5.0000      0.20000E-01
     0.40000      0.22000      0.22000       1.0000     0.70000E-02  0.50000E-01
      0.0000       0.0000       0.0000       0.5000       0.0000     -0.10000
     0.10000      -1.0000       1.0000      0.10000      0.15000       0.0000
     0.15000      0.00200     -0.00200
     0.48400     -0.48400      0.48400     -0.48400     0.10000E-01
     0.45000       1.1000       1.1000      0.60000      0.60000      -1.0000
     -1.0000     -0.60000     -0.60000     -0.60000     -0.60000      -1.3000
     -1.3000       0.0000      0.80000      0.90000       1.1000       1.2000
      1.3000    /
  588068 'USRMDL' 1  'GEWTA0501'  5 0  4   43   15  163
     0          0          1          0
      2.5000       14.000      0.30000      0.50000E-1   150.00       25.000
      3.0000      0.60000       3.0000       30.000       27.000       0.0000
      10.000       1.1200       0.0000      0.45000       2.9600       0.6200
      1.1100       1.5000       144.00       1.0000      0.15000       1.0000
      0.9500      0.40000      0.96000      0.99600       1.0040       1.0400
      1.0000      0.20000       0.0000     0.25000E-02    1.0000       5.5000
     0.10000      -1.0000      0.10000       0.0000      0.15000       5.0000
      200.00      /
/  58806800 'VTGTPAT' 588068 588068  '1'   0.400   5.000   1.000   0.08 /
/  58806801 'VTGTPAT' 588068 588068  '1'   0.600   5.000   1.700   0.08 /
/  58806802 'VTGTPAT' 588068 588068  '1'   0.700   5.000   2.500   0.08 /
/  58806803 'VTGTPAT' 588068 588068  '1'   0.750   5.000   3.000   0.08 /
/  58806804 'VTGTPAT' 588068 588068  '1'   0.850   5.000  10.000   0.08 /
/  58806805 'VTGTPAT' 588068 588068  '1'   0.900   5.000 600.000   0.08 /
/  58806806 'VTGTPAT' 588068 588068  '1'   0.000   1.101   1.000   0.08 /
/  58806807 'VTGTPAT' 588068 588068  '1'   0.000   1.150   0.500   0.08 /
/  58806808 'VTGTPAT' 588068 588068  '1'   0.000   1.175   0.200   0.08 /
/  58806819 'VTGTPAT' 588068 588068  '1'   0.000   1.200   0.100   0.08 /
/  58806810 'VTGTPAT' 588068 588068  '1'   0.000   1.300   0.010   0.08 /
```

GEN-2016-133 – GEN-2016-146 (G3)

- Wind Farm Size: 200 MW
- Interconnection:
  - Voltage: 345 kV
  - POI: Tulsa North 345 kV (bus 509852)
  - Transformer 1: 345/765 kV step-up transformers
    - MVA: 2877 Winding MVA
    - Voltage: 345/34.5kV
    - Z: 8%
  - Transformer 2: 345/765 kV step-up transformers
    - MVA: 2877 Winding MVA
    - Voltage: 345/34.5kV
    - Z: 8%
  - Transformer 3: 765/345 kV step-up transformers
    - MVA: 2877 Winding MVA
    - Voltage: 345/34.5kV
    - Z: 8%
  - Transformer 4: 765/345 kV step-up transformers
    - MVA: 2877 Winding MVA
    - Voltage: 345/34.5kV
    - Z: 8%
  - Transmission Line 1:
    - R = 0.000596 p.u.
    - X = 0.014090 p.u.
    - B = 9.513000 p.u.
  - Transmission Line 2:
    - R = 0.000596 p.u.
    - X = 0.014090 p.u.
    - B = 9.513000 p.u.
- Collector System Equivalent Model:
  - Transmission Line 1:
    - R = 0.005829 p.u.
    - X = 0.007163 p.u.
    - B = 0.106230 p.u.
  - Transmission Line 2:
    - R = 0.000302 p.u.
    - X = 0.003367 p.u.
    - B = 0.061180 p.u.
  - Transformer:
    - MVA: 136 Winding MVA

- High Voltage: 765 kV
- Low Voltage: 34.5 kV
- Z: 8.5%

- Wind Farm Parameters – GE 2.5 MW
  - Machine Terminal Voltage: 0.7 kV
  - Rated Power: 200 MW
  - Number of Wind Turbines: 80
    - Generator Step-Up Transformer 1:
      - MVA: 224 Winding MVA
      - High Voltage: 34.5 kV
      - Low Voltage: 0.7 kV
      - Z: 5.7%

The dynamic data for GEN-2016-133 – GEN-2016-146 (G3) is shown below:

```
/ (GEN-2016-133 - GEN-2016-146) WTG G3
 588077 'USRMDL' 1  'GEWTG0501'  1   1      30   59   11   29
     588077 1 0 0 0 0 0 0 0 0  0 0 0 0 0 0 0 0 0 0  0 0 0 0 0 0 0 0 0 0
     1.0000       1.0000      15.000       0.0500       0.0000       0.0000
    -1.5000       1.5000      20.000       3.0000       0.9000       1.1000
    0.70000       1.5000      5.0000       0.20000E-01  0.0000       0.50000
    0.90000       1.0000      0.0000       0.0000       1.2300       1.2300
     100.00       0.1000     0.50000E-01   0.1000       3.5000      0.50000E-01
     1.0000      -1.000       5.0000       9999.0      -1.000        5.0000
     9999.0      -1.000       5.0000       9999.0      -1.000        5.0000
     9999.0      -1.000       5.0000       9999.0      -1.000        5.0000
     9999.0      -1.000       5.0000       9999.0       50.000       70.000
     9999.0       50.000      70.000       9999.0       9999.0   /
  588077 'USRMDL' 1  'GEWTE0501'  4   0      9   68   15  293
     588077        0        1        0        1        0   0       0       0
    0.01000       1.1000      0.90000      1.1100       1.7000
     10.000      0.20000       66.00       1.2000       0.4500       0.0330
     1.0000      0.10000     0.15000E-01  0.50000E-01  0.15000E-01  0.50000E-01
    0.20000      0.20000E-01 0.15000E-01  0.15000      5.0000       0.20000E-01
    0.40000      0.22000     0.22000      1.0000       0.70000E-02  0.50000E-01
     0.0000       0.0000      0.0000       0.5000       0.0000      -0.10000
    0.10000      -1.0000      1.0000      0.10000      0.15000       0.0000
    0.15000      0.00200    -0.00200
    0.48400     -0.48400     0.48400     -0.48400      0.10000E-01
    0.45000       1.1000      1.1000      0.60000      0.60000      -1.0000
    -1.0000     -0.60000    -0.60000     -0.60000     -0.60000      -1.3000
    -1.3000       0.0000     0.80000      0.90000       1.1000       1.2000
     1.3000    /
  588077 'USRMDL' 1  'GEWTA0501'  5 0  4   43   15  163
    0          0          1          0
     2.5000       14.000      0.30000      0.50000E-1   150.00       25.000
     3.0000      0.60000      3.0000       30.000       27.000       0.0000
     10.000       1.1200      0.0000      0.45000       2.9600       0.6200
     1.1100       1.5000      144.00       1.0000      0.15000       1.0000
     0.9500      0.40000     0.96000      0.99600       1.0040       1.0400
     1.0000      0.20000      0.0000      0.25000E-02   1.0000       5.5000
    0.10000      -1.0000     0.10000       0.0000      0.15000       5.0000
     200.00      /
/  58807700 'VTGTPAT' 588077 588077  '1'   0.400   5.000   1.000   0.08 /
/  58807701 'VTGTPAT' 588077 588077  '1'   0.600   5.000   1.700   0.08 /
/  58807702 'VTGTPAT' 588077 588077  '1'   0.700   5.000   2.500   0.08 /
/  58807703 'VTGTPAT' 588077 588077  '1'   0.750   5.000   3.000   0.08 /
/  58807704 'VTGTPAT' 588077 588077  '1'   0.850   5.000  10.000   0.08 /
/  58807705 'VTGTPAT' 588077 588077  '1'   0.900   5.000 600.000   0.08 /
/  58807706 'VTGTPAT' 588077 588077  '1'   0.000   1.101   1.000   0.08 /
/  58807707 'VTGTPAT' 588077 588077  '1'   0.000   1.150   0.500   0.08 /
/  58807708 'VTGTPAT' 588077 588077  '1'   0.000   1.175   0.200   0.08 /
/  58807719 'VTGTPAT' 588077 588077  '1'   0.000   1.200   0.100   0.08 /
/  58807710 'VTGTPAT' 588077 588077  '1'   0.000   1.300   0.010   0.08 /
```

GEN-2016-133 – GEN-2016-146 (G4)

- Wind Farm Size: 200 MW
- Interconnection:
  - Voltage: 345 kV
  - POI: Tulsa North 345 kV (bus 509852)
  - Transformer 1: 345/765 kV step-up transformers
    - MVA: 2877 Winding MVA
    - Voltage: 345/34.5kV
    - Z: 8%
  - Transformer 2: 345/765 kV step-up transformers
    - MVA: 2877 Winding MVA
    - Voltage: 345/34.5kV
    - Z: 8%
  - Transformer 3: 765/345 kV step-up transformers
    - MVA: 2877 Winding MVA
    - Voltage: 345/34.5kV
    - Z: 8%
  - Transformer 4: 765/345 kV step-up transformers
    - MVA: 2877 Winding MVA
    - Voltage: 345/34.5kV
    - Z: 8%
  - Transmission Line 1:
    - R = 0.000596 p.u.
    - X = 0.014090 p.u.
    - B = 9.513000 p.u.
  - Transmission Line 2:
    - R = 0.000596 p.u.
    - X = 0.014090 p.u.
    - B = 9.513000 p.u.
- Collector System Equivalent Model:
  - Transmission Line 1:
    - R = 0.005829 p.u.
    - X = 0.007163 p.u.
    - B = 0.106230 p.u.
  - Transmission Line 2:
    - R = 0.000535 p.u.
    - X = 0.005990 p.u.
    - B = 0.108610 p.u.
  - Transformer:
    - MVA: 136 Winding MVA

        - High Voltage: 765 kV
        - Low Voltage: 34.5 kV
        - Z: 8.5%
- Wind Farm Parameters – GE 2.5 MW
    - Machine Terminal Voltage: 0.7 kV
    - Rated Power: 200 MW
    - Number of Wind Turbines: 80
        - Generator Step-Up Transformer 1:
            - MVA: 224 Winding MVA
            - High Voltage: 34.5 kV
            - Low Voltage: 0.7 kV
            - Z: 5.7%

The dynamic data for GEN-2016-133 – GEN-2016-146 (G4) is shown below:

```
/ (GEN-2016-133 - GEN-2016-146) WTG G4
 588078 'USRMDL' 1  'GEWTG0501'  1   1     30   59   11   29
     588078 1 0 0 0 0 0 0 0 0  0 0 0 0 0 0 0 0 0 0  0 0 0 0 0 0 0 0 0 0
     1.0000       1.0000       15.000       0.0500       0.0000       0.0000
    -1.5000       1.5000       20.000       3.0000       0.9000       1.1000
    0.70000       1.5000       5.0000     0.20000E-01    0.0000       0.50000
    0.90000       1.0000       0.0000       0.0000       1.2300       1.2300
     100.00       0.1000     0.50000E-01    0.1000       3.5000     0.50000E-01
     1.0000       -1.000       5.0000       9999.0       -1.000       5.0000
     9999.0       -1.000       5.0000       9999.0       -1.000       5.0000
     9999.0       -1.000       5.0000       9999.0       -1.000       5.0000
     9999.0       -1.000       5.0000       9999.0       50.000       70.000
     9999.0       50.000       70.000       9999.0       9999.0   /
  588078 'USRMDL' 1  'GEWTE0501'  4   0     9   68   15  293
     588078         0         1         0         1        0   0        0        0
    0.01000       1.1000      0.90000       1.1100       1.7000
     10.000      0.20000        66.00       1.2000       0.4500       0.0330
     1.0000      0.10000    0.15000E-01  0.50000E-01  0.15000E-01  0.50000E-01
    0.20000    0.20000E-01  0.15000E-01  0.15000        5.0000     0.20000E-01
    0.40000      0.22000      0.22000       1.0000     0.70000E-02  0.50000E-01
     0.0000       0.0000       0.0000       0.5000       0.0000     -0.10000
    0.10000      -1.0000       1.0000      0.10000      0.15000       0.0000
    0.15000      0.00200     -0.00200
    0.48400     -0.48400      0.48400     -0.48400    0.10000E-01
    0.45000       1.1000       1.1000      0.60000      0.60000      -1.0000
    -1.0000     -0.60000     -0.60000     -0.60000     -0.60000      -1.3000
    -1.3000       0.0000      0.80000      0.90000       1.1000       1.2000
     1.3000     /
  588078 'USRMDL' 1  'GEWTA0501'  5 0  4   43   15  163
    0         0         1         0
     2.5000       14.000      0.30000      0.50000E-1   150.00       25.000
     3.0000      0.60000       3.0000       30.000       27.000       0.0000
     10.000       1.1200       0.0000      0.45000       2.9600       0.6200
     1.1100       1.5000       144.00       1.0000      0.15000       1.0000
     0.9500      0.40000      0.96000      0.99600       1.0040       1.0400
     1.0000      0.20000       0.0000     0.25000E-02    1.0000       5.5000
    0.10000      -1.0000      0.10000       0.0000      0.15000       5.0000
     200.00      /
/  58807800 'VTGTPAT' 588078 588078  '1'   0.400   5.000   1.000   0.08 /
/  58807801 'VTGTPAT' 588078 588078  '1'   0.600   5.000   1.700   0.08 /
/  58807802 'VTGTPAT' 588078 588078  '1'   0.700   5.000   2.500   0.08 /
/  58807803 'VTGTPAT' 588078 588078  '1'   0.750   5.000   3.000   0.08 /
/  58807804 'VTGTPAT' 588078 588078  '1'   0.850   5.000  10.000   0.08 /
/  58807805 'VTGTPAT' 588078 588078  '1'   0.900   5.000 600.000   0.08 /
/  58807806 'VTGTPAT' 588078 588078  '1'   0.000   1.101   1.000   0.08 /
/  58807807 'VTGTPAT' 588078 588078  '1'   0.000   1.150   0.500   0.08 /
/  58807808 'VTGTPAT' 588078 588078  '1'   0.000   1.175   0.200   0.08 /
/  58807819 'VTGTPAT' 588078 588078  '1'   0.000   1.200   0.100   0.08 /
/  58807810 'VTGTPAT' 588078 588078  '1'   0.000   1.300   0.010   0.08 /
```

GEN-2016-133 – GEN-2016-146 (G5)

- Wind Farm Size: 200 MW
- Interconnection:
    - Voltage: 345 kV
    - POI: Tulsa North 345 kV (bus 509852)
    - Transformer 1: 345/765 kV step-up transformers
        - MVA: 2877 Winding MVA
        - Voltage: 345/34.5kV
        - Z: 8%
    - Transformer 2: 345/765 kV step-up transformers
        - MVA: 2877 Winding MVA
        - Voltage: 345/34.5kV
        - Z: 8%
    - Transformer 3: 765/345 kV step-up transformers
        - MVA: 2877 Winding MVA
        - Voltage: 345/34.5kV
        - Z: 8%
    - Transformer 4: 765/345 kV step-up transformers
        - MVA: 2877 Winding MVA
        - Voltage: 345/34.5kV
        - Z: 8%
    - Transmission Line 1:
        - R = 0.000596 p.u.
        - X = 0.014090 p.u.
        - B = 9.513000 p.u.
    - Transmission Line 2:
        - R = 0.000596 p.u.
        - X = 0.014090 p.u.
        - B = 9.513000 p.u.
- Collector System Equivalent Model:
    - Transmission Line 1:
        - R = 0.008966 p.u.
        - X = 0.012637 p.u.
        - B = 0.151140 p.u.
    - Transmission Line 2:
        - R = 0.000535 p.u.
        - X = 0.005990 p.u.
        - B = 0.108610 p.u.
    - Transformer:
        - MVA: 136 Winding MVA

        - High Voltage: 765 kV
        - Low Voltage: 34.5 kV
        - Z: 8.5%
- Wind Farm Parameters – GE 2.5 MW
    - Machine Terminal Voltage: 0.7 kV
    - Rated Power: 200 MW
    - Number of Wind Turbines: 80
        - Generator Step-Up Transformer 1:
            - MVA: 224 Winding MVA
            - High Voltage: 34.5 kV
            - Low Voltage: 0.7 kV
            - Z: 5.7%

The dynamic data for GEN-2016-133 – GEN-2016-146 (G5) is shown below:

```
/ (GEN-2016-133 - GEN-2016-146) WTG G5
 588087 'USRMDL' 1  'GEWTG0501'  1   1     30   59   11   29
     588087 1 0 0 0 0 0 0 0 0 0  0 0 0 0 0 0 0 0 0 0  0 0 0 0 0 0 0 0 0 0
     1.0000      1.0000      15.000      0.0500      0.0000      0.0000
    -1.5000      1.5000      20.000      3.0000      0.9000      1.1000
    0.70000      1.5000      5.0000     0.20000E-01  0.0000     0.50000
    0.90000      1.0000      0.0000      0.0000      1.2300      1.2300
     100.00      0.1000    0.50000E-01   0.1000      3.5000    0.50000E-01
     1.0000     -1.000       5.0000      9999.0     -1.000       5.0000
     9999.0     -1.000       5.0000      9999.0     -1.000       5.0000
     9999.0     -1.000       5.0000      9999.0     -1.000       5.0000
     9999.0     -1.000       5.0000      9999.0      50.000      70.000
     9999.0      50.000      70.000      9999.0      9999.0   /
  588087 'USRMDL' 1  'GEWTE0501'  4   0     9   68   15  293
     588087        0         1         0         1         0   0        0        0
    0.01000      1.1000     0.90000      1.1100      1.7000
     10.000     0.20000      66.00       1.2000      0.4500      0.0330
     1.0000     0.10000   0.15000E-01 0.50000E-01 0.15000E-01 0.50000E-01
    0.20000   0.20000E-01 0.15000E-01 0.15000      5.0000    0.20000E-01
    0.40000     0.22000     0.22000      1.0000   0.70000E-02 0.50000E-01
     0.0000      0.0000      0.0000      0.5000      0.0000    -0.10000
    0.10000     -1.0000      1.0000     0.10000     0.15000      0.0000
    0.15000     0.00200    -0.00200
    0.48400    -0.48400     0.48400    -0.48400   0.10000E-01
    0.45000      1.1000      1.1000     0.60000     0.60000     -1.0000
    -1.0000    -0.60000    -0.60000    -0.60000    -0.60000     -1.3000
    -1.3000      0.0000     0.80000     0.90000      1.1000      1.2000
     1.3000    /
  588087 'USRMDL' 1  'GEWTA0501'  5 0  4   43   15  163
    0         0         1         0
     2.5000      14.000     0.30000     0.50000E-1  150.00      25.000
     3.0000     0.60000      3.0000      30.000      27.000      0.0000
     10.000      1.1200      0.0000     0.45000      2.9600      0.6200
     1.1100      1.5000      144.00      1.0000     0.15000      1.0000
     0.9500     0.40000     0.96000     0.99600      1.0040      1.0400
     1.0000     0.20000      0.0000     0.25000E-02  1.0000      5.5000
    0.10000     -1.0000     0.10000      0.0000     0.15000      5.0000
     200.00      /
/  58808700 'VTGTPAT' 588087 588087  '1'   0.400   5.000   1.000   0.08 /
/  58808701 'VTGTPAT' 588087 588087  '1'   0.600   5.000   1.700   0.08 /
/  58808702 'VTGTPAT' 588087 588087  '1'   0.700   5.000   2.500   0.08 /
/  58808703 'VTGTPAT' 588087 588087  '1'   0.750   5.000   3.000   0.08 /
/  58808704 'VTGTPAT' 588087 588087  '1'   0.850   5.000  10.000   0.08 /
/  58808705 'VTGTPAT' 588087 588087  '1'   0.900   5.000 600.000   0.08 /
/  58808706 'VTGTPAT' 588087 588087  '1'   0.000   1.101   1.000   0.08 /
/  58808707 'VTGTPAT' 588087 588087  '1'   0.000   1.150   0.500   0.08 /
/  58808708 'VTGTPAT' 588087 588087  '1'   0.000   1.175   0.200   0.08 /
/  58808719 'VTGTPAT' 588087 588087  '1'   0.000   1.200   0.100   0.08 /
/  58808710 'VTGTPAT' 588087 588087  '1'   0.000   1.300   0.010   0.08 /
```

GEN-2016-133 – GEN-2016-146 (G6)

- Wind Farm Size: 200 MW
- Interconnection:
  - Voltage: 345 kV
  - POI: Tulsa North 345 kV (bus 509852)
  - Transformer 1: 345/765 kV step-up transformers
    - MVA: 2877 Winding MVA
    - Voltage: 345/34.5kV
    - Z: 8%
  - Transformer 2: 345/765 kV step-up transformers
    - MVA: 2877 Winding MVA
    - Voltage: 345/34.5kV
    - Z: 8%
  - Transformer 3: 765/345 kV step-up transformers
    - MVA: 2877 Winding MVA
    - Voltage: 345/34.5kV
    - Z: 8%
  - Transformer 4: 765/345 kV step-up transformers
    - MVA: 2877 Winding MVA
    - Voltage: 345/34.5kV
    - Z: 8%
  - Transmission Line 1:
    - R = 0.000596 p.u.
    - X = 0.014090 p.u.
    - B = 9.513000 p.u.
  - Transmission Line 2:
    - R = 0.000596 p.u.
    - X = 0.014090 p.u.
    - B = 9.513000 p.u.
- Collector System Equivalent Model:
  - Transmission Line 1:
    - R = 0.008966 p.u.
    - X = 0.012637 p.u.
    - B = 0.151140 p.u.
  - Transmission Line 2:
    - R = 0.000535 p.u.
    - X = 0.005990 p.u.
    - B = 0.108610 p.u.
  - Transformer:
    - MVA: 136 Winding MVA

        - High Voltage: 765 kV
        - Low Voltage: 34.5 kV
        - Z: 8.5%
- Wind Farm Parameters – GE 2.5 MW
    - Machine Terminal Voltage: 0.7 kV
    - Rated Power: 200 MW
    - Number of Wind Turbines: 80
        - Generator Step-Up Transformer 1:
            - MVA: 224 Winding MVA
            - High Voltage: 34.5 kV
            - Low Voltage: 0.7 kV
            - Z: 5.7%

The dynamic data for GEN-2016-133 – GEN-2016-146 (G6) is shown below:

```
/ (GEN-2016-133 - GEN-2016-146) WTG G6
 588088 'USRMDL' 1  'GEWTG0501'  1   1     30   59   11   29
     588088 1 0 0 0 0 0 0 0 0  0 0 0 0 0 0 0 0 0 0  0 0 0 0 0 0 0 0 0 0
     1.0000       1.0000       15.000       0.0500       0.0000       0.0000
    -1.5000       1.5000       20.000       3.0000       0.9000       1.1000
    0.70000       1.5000       5.0000       0.20000E-01  0.0000       0.50000
    0.90000       1.0000       0.0000       0.0000       1.2300       1.2300
     100.00       0.1000       0.50000E-01  0.1000       3.5000       0.50000E-01
     1.0000       -1.000       5.0000       9999.0       -1.000       5.0000
     9999.0       -1.000       5.0000       9999.0       -1.000       5.0000
     9999.0       -1.000       5.0000       9999.0       -1.000       5.0000
     9999.0       -1.000       5.0000       9999.0       50.000       70.000
     9999.0       50.000       70.000       9999.0       9999.0   /
 588088 'USRMDL' 1  'GEWTE0501'  4   0     9   68   15  293
     588088       0        1        0        1       0   0      0       0
    0.01000       1.1000       0.90000      1.1100       1.7000
     10.000       0.20000      66.00        1.2000       0.4500       0.0330
     1.0000       0.10000      0.15000E-01  0.50000E-01  0.15000E-01  0.50000E-01
    0.20000       0.20000E-01  0.15000E-01  0.15000      5.0000       0.20000E-01
    0.40000       0.22000      0.22000      1.0000       0.70000E-02  0.50000E-01
     0.0000       0.0000       0.0000       0.5000       0.0000      -0.10000
    0.10000      -1.0000       1.0000       0.10000      0.15000      0.0000
    0.15000       0.00200     -0.00200
    0.48400      -0.48400      0.48400     -0.48400      0.10000E-01
    0.45000       1.1000       1.1000       0.60000      0.60000     -1.0000
    -1.0000      -0.60000     -0.60000     -0.60000     -0.60000     -1.3000
    -1.3000       0.0000       0.80000      0.90000      1.1000       1.2000
     1.3000    /
 588088 'USRMDL' 1  'GEWTA0501'  5 0  4   43   15  163
    0         0         1         0
     2.5000       14.000       0.30000      0.50000E-1   150.00       25.000
     3.0000       0.60000      3.0000       30.000       27.000       0.0000
     10.000       1.1200       0.0000       0.45000      2.9600       0.6200
     1.1100       1.5000       144.00       1.0000       0.15000      1.0000
     0.9500       0.40000      0.96000      0.99600      1.0040       1.0400
     1.0000       0.20000      0.0000       0.25000E-02  1.0000       5.5000
    0.10000      -1.0000       0.10000      0.0000       0.15000      5.0000
     200.00      /
/  58808800 'VTGTPAT' 588088 588088  '1'   0.400   5.000   1.000   0.08 /
/  58808801 'VTGTPAT' 588088 588088  '1'   0.600   5.000   1.700   0.08 /
/  58808802 'VTGTPAT' 588088 588088  '1'   0.700   5.000   2.500   0.08 /
/  58808803 'VTGTPAT' 588088 588088  '1'   0.750   5.000   3.000   0.08 /
/  58808804 'VTGTPAT' 588088 588088  '1'   0.850   5.000  10.000   0.08 /
/  58808805 'VTGTPAT' 588088 588088  '1'   0.900   5.000 600.000   0.08 /
/  58808806 'VTGTPAT' 588088 588088  '1'   0.000   1.101   1.000   0.08 /
/  58808807 'VTGTPAT' 588088 588088  '1'   0.000   1.150   0.500   0.08 /
/  58808808 'VTGTPAT' 588088 588088  '1'   0.000   1.175   0.200   0.08 /
/  58808819 'VTGTPAT' 588088 588088  '1'   0.000   1.200   0.100   0.08 /
/  58808810 'VTGTPAT' 588088 588088  '1'   0.000   1.300   0.010   0.08 /
```

GEN-2016-133 – GEN-2016-146 (G7)

- Wind Farm Size: 200 MW
- Interconnection:
  - Voltage: 345 kV
  - POI: Tulsa North 345 kV (bus 509852)
  - Transformer 1: 345/765 kV step-up transformers
    - MVA: 2877 Winding MVA
    - Voltage: 345/34.5kV
    - Z: 8%
  - Transformer 2: 345/765 kV step-up transformers
    - MVA: 2877 Winding MVA
    - Voltage: 345/34.5kV
    - Z: 8%
  - Transformer 3: 765/345 kV step-up transformers
    - MVA: 2877 Winding MVA
    - Voltage: 345/34.5kV
    - Z: 8%
  - Transformer 4: 765/345 kV step-up transformers
    - MVA: 2877 Winding MVA
    - Voltage: 345/34.5kV
    - Z: 8%
  - Transmission Line 1:
    - R = 0.000596 p.u.
    - X = 0.014090 p.u.
    - B = 9.513000 p.u.
  - Transmission Line 2:
    - R = 0.000596 p.u.
    - X = 0.014090 p.u.
    - B = 9.513000 p.u.
- Collector System Equivalent Model:
  - Transmission Line 1:
    - R = 0.008966 p.u.
    - X = 0.012637 p.u.
    - B = 0.151140 p.u.
  - Transmission Line 2:
    - R = 0.000316 p.u.
    - X = 0.003557 p.u.
    - B = 0.064380 p.u.
  - Transformer:
    - MVA: 136 Winding MVA

        - High Voltage: 765 kV
        - Low Voltage: 34.5 kV
        - Z: 8.5%
- Wind Farm Parameters – GE 2.5 MW
    - Machine Terminal Voltage: 0.7 kV
    - Rated Power: 200 MW
    - Number of Wind Turbines: 80
        - Generator Step-Up Transformer 1:
            - MVA: 224 Winding MVA
            - High Voltage: 34.5 kV
            - Low Voltage: 0.7 kV
            - Z: 5.7%

The dynamic data for GEN-2016-133 – GEN-2016-146 (G7) is shown below:

```
/ (GEN-2016-133 - GEN-2016-146) WTG G7
 588097 'USRMDL' 1  'GEWTG0501'  1   1     30   59   11   29
     588097 1 0 0 0 0 0 0 0 0  0 0 0 0 0 0 0 0 0 0  0 0 0 0 0 0 0 0 0 0
     1.0000       1.0000       15.000       0.0500       0.0000       0.0000
    -1.5000       1.5000       20.000       3.0000       0.9000       1.1000
    0.70000       1.5000       5.0000       0.20000E-01  0.0000       0.50000
    0.90000       1.0000       0.0000       0.0000       1.2300       1.2300
     100.00       0.1000      0.50000E-01   0.1000       3.5000      0.50000E-01
     1.0000       -1.000       5.0000       9999.0       -1.000       5.0000
     9999.0       -1.000       5.0000       9999.0       -1.000       5.0000
     9999.0       -1.000       5.0000       9999.0       -1.000       5.0000
     9999.0       -1.000       5.0000       9999.0       50.000       70.000
     9999.0       50.000       70.000       9999.0       9999.0   /
  588097 'USRMDL' 1  'GEWTE0501'  4   0     9   68   15  293
     588097        0        1        0        1        0   0        0        0
    0.01000       1.1000      0.90000       1.1100       1.7000
     10.000      0.20000       66.00        1.2000       0.4500       0.0330
     1.0000      0.10000     0.15000E-01  0.50000E-01  0.15000E-01  0.50000E-01
    0.20000      0.20000E-01 0.15000E-01  0.15000       5.0000      0.20000E-01
    0.40000      0.22000      0.22000       1.0000      0.70000E-02  0.50000E-01
     0.0000       0.0000       0.0000       0.5000       0.0000     -0.10000
    0.10000      -1.0000       1.0000      0.10000      0.15000       0.0000
    0.15000      0.00200     -0.00200
    0.48400     -0.48400      0.48400     -0.48400      0.10000E-01
    0.45000       1.1000       1.1000      0.60000      0.60000      -1.0000
    -1.0000     -0.60000     -0.60000     -0.60000     -0.60000      -1.3000
    -1.3000       0.0000      0.80000      0.90000       1.1000       1.2000
     1.3000    /
  588097 'USRMDL' 1  'GEWTA0501'  5 0  4   43   15  163
    0         0         1         0
     2.5000       14.000      0.30000      0.50000E-1   150.00       25.000
     3.0000      0.60000       3.0000       30.000       27.000       0.0000
     10.000       1.1200       0.0000      0.45000       2.9600       0.6200
     1.1100       1.5000       144.00       1.0000      0.15000       1.0000
     0.9500      0.40000      0.96000      0.99600       1.0040       1.0400
     1.0000      0.20000       0.0000      0.25000E-02   1.0000       5.5000
    0.10000      -1.0000      0.10000       0.0000      0.15000       5.0000
     200.00    /
/  58809700 'VTGTPAT' 588097 588097  '1'   0.400   5.000   1.000   0.08 /
/  58809701 'VTGTPAT' 588097 588097  '1'   0.600   5.000   1.700   0.08 /
/  58809702 'VTGTPAT' 588097 588097  '1'   0.700   5.000   2.500   0.08 /
/  58809703 'VTGTPAT' 588097 588097  '1'   0.750   5.000   3.000   0.08 /
/  58809704 'VTGTPAT' 588097 588097  '1'   0.850   5.000  10.000   0.08 /
/  58809705 'VTGTPAT' 588097 588097  '1'   0.900   5.000 600.000   0.08 /
/  58809706 'VTGTPAT' 588097 588097  '1'   0.000   1.101   1.000   0.08 /
/  58809707 'VTGTPAT' 588097 588097  '1'   0.000   1.150   0.500   0.08 /
/  58809708 'VTGTPAT' 588097 588097  '1'   0.000   1.175   0.200   0.08 /
/  58809719 'VTGTPAT' 588097 588097  '1'   0.000   1.200   0.100   0.08 /
/  58809710 'VTGTPAT' 588097 588097  '1'   0.000   1.300   0.010   0.08 /
```

GEN-2016-133 – GEN-2016-146 (G8)

- Wind Farm Size: 200 MW
- Interconnection:
  - Voltage: 345 kV
  - POI: Tulsa North 345 kV (bus 509852)
  - Transformer 1: 345/765 kV step-up transformers
    - MVA: 2877 Winding MVA
    - Voltage: 345/34.5kV
    - Z: 8%
  - Transformer 2: 345/765 kV step-up transformers
    - MVA: 2877 Winding MVA
    - Voltage: 345/34.5kV
    - Z: 8%
  - Transformer 3: 765/345 kV step-up transformers
    - MVA: 2877 Winding MVA
    - Voltage: 345/34.5kV
    - Z: 8%
  - Transformer 4: 765/345 kV step-up transformers
    - MVA: 2877 Winding MVA
    - Voltage: 345/34.5kV
    - Z: 8%
  - Transmission Line 1:
    - R = 0.000596 p.u.
    - X = 0.014090 p.u.
    - B = 9.513000 p.u.
  - Transmission Line 2:
    - R = 0.000596 p.u.
    - X = 0.014090 p.u.
    - B = 9.513000 p.u.
- Collector System Equivalent Model:
  - Transmission Line 1:
    - R = 0.005829 p.u.
    - X = 0.007163 p.u.
    - B = 0.106230 p.u.
  - Transmission Line 2:
    - R = 0.000316 p.u.
    - X = 0.003557 p.u.
    - B = 0.064380 p.u.
  - Transformer:
    - MVA: 136 Winding MVA

- High Voltage: 765 kV
- Low Voltage: 34.5 kV
- Z: 8.5%

- Wind Farm Parameters – GE 2.5 MW
  - Machine Terminal Voltage: 0.7 kV
  - Rated Power: 200 MW
  - Number of Wind Turbines: 80
    - Generator Step-Up Transformer 1:
      - MVA: 224 Winding MVA
      - High Voltage: 34.5 kV
      - Low Voltage: 0.7 kV
      - Z: 5.7%

The dynamic data for GEN-2016-133 – GEN-2016-146 (G8) is shown below:

```
/ (GEN-2016-133 - GEN-2016-146) WTG G8
 588098 'USRMDL' 1  'GEWTG0501'  1   1     30   59   11   29
     588098 1 0 0 0 0 0 0 0 0  0 0 0 0 0 0 0 0 0 0  0 0 0 0 0 0 0 0 0 0
     1.0000      1.0000       15.000       0.0500       0.0000       0.0000
    -1.5000      1.5000       20.000       3.0000       0.9000       1.1000
    0.70000      1.5000       5.0000      0.20000E-01   0.0000       0.50000
    0.90000      1.0000       0.0000       0.0000       1.2300       1.2300
     100.00      0.1000      0.50000E-01   0.1000       3.5000      0.50000E-01
     1.0000      -1.000       5.0000       9999.0       -1.000       5.0000
     9999.0      -1.000       5.0000       9999.0       -1.000       5.0000
     9999.0      -1.000       5.0000       9999.0       -1.000       5.0000
     9999.0      -1.000       5.0000       9999.0       50.000       70.000
     9999.0      50.000       70.000       9999.0       9999.0   /
  588098 'USRMDL' 1  'GEWTE0501'  4   0     9   68   15  293
     588098        0        1        0        1        0   0        0        0
    0.01000      1.1000      0.90000       1.1100       1.7000
     10.000     0.20000        66.00       1.2000       0.4500       0.0330
     1.0000     0.10000      0.15000E-01  0.50000E-01  0.15000E-01  0.50000E-01
    0.20000     0.20000E-01  0.15000E-01  0.15000       5.0000      0.20000E-01
    0.40000     0.22000      0.22000       1.0000      0.70000E-02  0.50000E-01
     0.0000      0.0000       0.0000       0.5000       0.0000     -0.10000
    0.10000     -1.0000       1.0000      0.10000      0.15000       0.0000
    0.15000     0.00200     -0.00200
    0.48400    -0.48400      0.48400     -0.48400      0.10000E-01
    0.45000      1.1000       1.1000      0.60000      0.60000      -1.0000
    -1.0000    -0.60000     -0.60000     -0.60000     -0.60000      -1.3000
    -1.3000      0.0000      0.80000      0.90000       1.1000       1.2000
     1.3000    /
  588098 'USRMDL' 1  'GEWTA0501'  5 0  4   43   15  163
    0         0         1         0
     2.5000      14.000       0.30000      0.50000E-1   150.00       25.000
     3.0000     0.60000       3.0000       30.000       27.000       0.0000
     10.000      1.1200       0.0000      0.45000       2.9600       0.6200
     1.1100      1.5000       144.00       1.0000      0.15000       1.0000
     0.9500     0.40000      0.96000      0.99600       1.0040       1.0400
     1.0000     0.20000       0.0000      0.25000E-02   1.0000       5.5000
    0.10000     -1.0000      0.10000       0.0000      0.15000       5.0000
     200.00     /
/  58809800 'VTGTPAT' 588098 588098  '1'   0.400   5.000   1.000   0.08 /
/  58809801 'VTGTPAT' 588098 588098  '1'   0.600   5.000   1.700   0.08 /
/  58809802 'VTGTPAT' 588098 588098  '1'   0.700   5.000   2.500   0.08 /
/  58809803 'VTGTPAT' 588098 588098  '1'   0.750   5.000   3.000   0.08 /
/  58809804 'VTGTPAT' 588098 588098  '1'   0.850   5.000  10.000   0.08 /
/  58809805 'VTGTPAT' 588098 588098  '1'   0.900   5.000 600.000   0.08 /
/  58809806 'VTGTPAT' 588098 588098  '1'   0.000   1.101   1.000   0.08 /
/  58809807 'VTGTPAT' 588098 588098  '1'   0.000   1.150   0.500   0.08 /
/  58809808 'VTGTPAT' 588098 588098  '1'   0.000   1.175   0.200   0.08 /
/  58809819 'VTGTPAT' 588098 588098  '1'   0.000   1.200   0.100   0.08 /
/  58809810 'VTGTPAT' 588098 588098  '1'   0.000   1.300   0.010   0.08 /
```

GEN-2016-133 – GEN-2016-146 (G9)

- Wind Farm Size: 200 MW
- Interconnection:
  - Voltage: 345 kV
  - POI: Tulsa North 345 kV (bus 509852)
  - Transformer 1: 345/765 kV step-up transformers
    - MVA: 2877 Winding MVA
    - Voltage: 345/34.5kV
    - Z: 8%
  - Transformer 2: 345/765 kV step-up transformers
    - MVA: 2877 Winding MVA
    - Voltage: 345/34.5kV
    - Z: 8%
  - Transformer 3: 765/345 kV step-up transformers
    - MVA: 2877 Winding MVA
    - Voltage: 345/34.5kV
    - Z: 8%
  - Transformer 4: 765/345 kV step-up transformers
    - MVA: 2877 Winding MVA
    - Voltage: 345/34.5kV
    - Z: 8%
  - Transmission Line 1:
    - R = 0.000596 p.u.
    - X = 0.014090 p.u.
    - B = 9.513000 p.u.
  - Transmission Line 2:
    - R = 0.000596 p.u.
    - X = 0.014090 p.u.
    - B = 9.513000 p.u.
- Collector System Equivalent Model:
  - Transmission Line 1:
    - R = 0.008966 p.u.
    - X = 0.012637 p.u.
    - B = 0.151140 p.u.
  - Transmission Line 2:
    - R = 0.000307p.u.
    - X = 0.003460 p.u.
    - B = 0.062630 p.u.
  - Transformer:
    - MVA: 136 Winding MVA

- High Voltage: 765 kV
- Low Voltage: 34.5 kV
- Z: 8.5%

- Wind Farm Parameters – GE 2.5 MW
  - Machine Terminal Voltage: 0.7 kV
  - Rated Power: 200 MW
  - Number of Wind Turbines: 80
    - Generator Step-Up Transformer 1:
      - MVA: 224 Winding MVA
      - High Voltage: 34.5 kV
      - Low Voltage: 0.7 kV
      - Z: 5.7%

The dynamic data for GEN-2016-133 – GEN-2016-146 (G9) is shown below:

```
/ (GEN-2016-133 - GEN-2016-146) WTG G9
 588057 'USRMDL' 1  'GEWTG0501'  1   1     30   59   11   29
     588057 1 0 0 0 0 0 0 0 0  0 0 0 0 0 0 0 0 0 0  0 0 0 0 0 0 0 0 0 0
     1.0000      1.0000      15.000      0.0500      0.0000      0.0000
    -1.5000      1.5000      20.000      3.0000      0.9000      1.1000
    0.70000      1.5000      5.0000      0.20000E-01 0.0000      0.50000
    0.90000      1.0000      0.0000      0.0000      1.2300      1.2300
     100.00      0.1000     0.50000E-01  0.1000      3.5000     0.50000E-01
     1.0000      -1.000      5.0000      9999.0      -1.000      5.0000
     9999.0      -1.000      5.0000      9999.0      -1.000      5.0000
     9999.0      -1.000      5.0000      9999.0      -1.000      5.0000
     9999.0      -1.000      5.0000      9999.0      50.000      70.000
     9999.0      50.000      70.000      9999.0      9999.0   /
  588057 'USRMDL' 1  'GEWTE0501'  4   0     9   68   15  293
     588057        0         1         0         1        0   0        0        0
    0.01000      1.1000     0.90000      1.1100      1.7000
     10.000     0.20000       66.00      1.2000      0.4500      0.0330
     1.0000     0.10000     0.15000E-01 0.50000E-01 0.15000E-01 0.50000E-01
    0.20000     0.20000E-01 0.15000E-01 0.15000      5.0000     0.20000E-01
    0.40000     0.22000     0.22000      1.0000     0.70000E-02 0.50000E-01
     0.0000      0.0000      0.0000      0.5000      0.0000     -0.10000
    0.10000     -1.0000      1.0000     0.10000     0.15000      0.0000
    0.15000     0.00200    -0.00200
    0.48400    -0.48400     0.48400    -0.48400     0.10000E-01
    0.45000      1.1000      1.1000     0.60000     0.60000     -1.0000
    -1.0000    -0.60000    -0.60000    -0.60000    -0.60000     -1.3000
    -1.3000      0.0000     0.80000     0.90000      1.1000      1.2000
     1.3000    /
  588057 'USRMDL' 1  'GEWTA0501'  5 0  4   43   15  163
    0        0         1         0
     2.5000      14.000      0.30000     0.50000E-1   150.00      25.000
     3.0000     0.60000      3.0000      30.000      27.000      0.0000
     10.000      1.1200      0.0000     0.45000      2.9600      0.6200
     1.1100      1.5000      144.00      1.0000     0.15000      1.0000
     0.9500     0.40000     0.96000     0.99600      1.0040      1.0400
     1.0000     0.20000      0.0000     0.25000E-02  1.0000      5.5000
    0.10000     -1.0000     0.10000      0.0000     0.15000      5.0000
     200.00      /
/  58805700 'VTGTPAT' 588057 588057  '1'   0.400   5.000   1.000   0.08 /
/  58805701 'VTGTPAT' 588057 588057  '1'   0.600   5.000   1.700   0.08 /
/  58805702 'VTGTPAT' 588057 588057  '1'   0.700   5.000   2.500   0.08 /
/  58805703 'VTGTPAT' 588057 588057  '1'   0.750   5.000   3.000   0.08 /
/  58805704 'VTGTPAT' 588057 588057  '1'   0.850   5.000  10.000   0.08 /
/  58805705 'VTGTPAT' 588057 588057  '1'   0.900   5.000 600.000   0.08 /
/  58805706 'VTGTPAT' 588057 588057  '1'   0.000   1.101   1.000   0.08 /
/  58805707 'VTGTPAT' 588057 588057  '1'   0.000   1.150   0.500   0.08 /
/  58805708 'VTGTPAT' 588057 588057  '1'   0.000   1.175   0.200   0.08 /
/  58805719 'VTGTPAT' 588057 588057  '1'   0.000   1.200   0.100   0.08 /
/  58805710 'VTGTPAT' 588057 588057  '1'   0.000   1.300   0.010   0.08 /
```

GEN-2016-133 – GEN-2016-146 (G10)

- Wind Farm Size: 200 MW
- Interconnection:
    - Voltage: 345 kV
    - POI: Tulsa North 345 kV (bus 509852)
    - Transformer 1: 345/765 kV step-up transformers
        - MVA: 2877 Winding MVA
        - Voltage: 345/34.5kV
        - Z: 8%
    - Transformer 2: 345/765 kV step-up transformers
        - MVA: 2877 Winding MVA
        - Voltage: 345/34.5kV
        - Z: 8%
    - Transformer 3: 765/345 kV step-up transformers
        - MVA: 2877 Winding MVA
        - Voltage: 345/34.5kV
        - Z: 8%
    - Transformer 4: 765/345 kV step-up transformers
        - MVA: 2877 Winding MVA
        - Voltage: 345/34.5kV
        - Z: 8%
    - Transmission Line 1:
        - R = 0.000596 p.u.
        - X = 0.014090 p.u.
        - B = 9.513000 p.u.
    - Transmission Line 2:
        - R = 0.000596 p.u.
        - X = 0.014090 p.u.
        - B = 9.513000 p.u.
- Collector System Equivalent Model:
    - Transmission Line 1:
        - R = 0.005829 p.u.
        - X = 0.007163 p.u.
        - B = 0.106230 p.u.
    - Transmission Line 2:
        - R = 0.000307 p.u.
        - X = 0.003460 p.u.
        - B = 0.062630 p.u.
    - Transformer:
        - MVA: 136 Winding MVA

        - High Voltage: 765 kV
        - Low Voltage: 34.5 kV
        - Z: 8.5%
- Wind Farm Parameters – GE 2.5 MW
    - Machine Terminal Voltage: 0.7 kV
    - Rated Power: 200 MW
    - Number of Wind Turbines: 80
        - Generator Step-Up Transformer 1:
            - MVA: 224 Winding MVA
            - High Voltage: 34.5 kV
            - Low Voltage: 0.7 kV
            - Z: 5.7%

The dynamic data for GEN-2016-133 – GEN-2016-146 (G10) is shown below:

```
/ (GEN-2016-133 - GEN-2016-146) WTG G10
 588058 'USRMDL' 1  'GEWTG0501'  1   1     30   59   11   29
     588058 1 0 0 0 0 0 0 0 0  0 0 0 0 0 0 0 0 0 0  0 0 0 0 0 0 0 0 0 0
     1.0000       1.0000      15.000      0.0500      0.0000      0.0000
    -1.5000       1.5000      20.000      3.0000      0.9000      1.1000
    0.70000       1.5000      5.0000      0.20000E-01 0.0000      0.50000
    0.90000       1.0000      0.0000      0.0000      1.2300      1.2300
     100.00       0.1000     0.50000E-01  0.1000      3.5000     0.50000E-01
     1.0000       -1.000      5.0000      9999.0      -1.000      5.0000
     9999.0       -1.000      5.0000      9999.0      -1.000      5.0000
     9999.0       -1.000      5.0000      9999.0      -1.000      5.0000
     9999.0       -1.000      5.0000      9999.0      50.000      70.000
     9999.0       50.000      70.000      9999.0      9999.0   /
  588058 'USRMDL' 1  'GEWTE0501'  4   0     9   68   15  293
     588058        0        1        0        1       0   0       0       0
    0.01000       1.1000     0.90000      1.1100      1.7000
     10.000      0.20000       66.00      1.2000      0.4500      0.0330
     1.0000      0.10000     0.15000E-01 0.50000E-01 0.15000E-01 0.50000E-01
    0.20000      0.20000E-01 0.15000E-01 0.15000      5.0000      0.20000E-01
    0.40000      0.22000     0.22000      1.0000      0.70000E-02 0.50000E-01
     0.0000       0.0000      0.0000      0.5000      0.0000     -0.10000
    0.10000      -1.0000      1.0000     0.10000     0.15000      0.0000
    0.15000      0.00200    -0.00200
    0.48400     -0.48400     0.48400    -0.48400     0.10000E-01
    0.45000       1.1000      1.1000     0.60000     0.60000     -1.0000
    -1.0000     -0.60000    -0.60000    -0.60000    -0.60000     -1.3000
    -1.3000       0.0000     0.80000     0.90000      1.1000      1.2000
     1.3000     /
  588058 'USRMDL' 1  'GEWTA0501'  5 0  4   43   15  163
    0        0         1         0
     2.5000       14.000      0.30000     0.50000E-1  150.00      25.000
     3.0000      0.60000      3.0000      30.000      27.000      0.0000
     10.000       1.1200      0.0000     0.45000      2.9600      0.6200
     1.1100       1.5000      144.00      1.0000     0.15000      1.0000
     0.9500      0.40000     0.96000     0.99600      1.0040      1.0400
     1.0000      0.20000      0.0000     0.25000E-02  1.0000      5.5000
    0.10000      -1.0000     0.10000      0.0000     0.15000      5.0000
     200.00      /
/  58805800 'VTGTPAT' 588058 588058  '1'   0.400   5.000   1.000   0.08 /
/  58805801 'VTGTPAT' 588058 588058  '1'   0.600   5.000   1.700   0.08 /
/  58805802 'VTGTPAT' 588058 588058  '1'   0.700   5.000   2.500   0.08 /
/  58805803 'VTGTPAT' 588058 588058  '1'   0.750   5.000   3.000   0.08 /
/  58805804 'VTGTPAT' 588058 588058  '1'   0.850   5.000  10.000   0.08 /
/  58805805 'VTGTPAT' 588058 588058  '1'   0.900   5.000 600.000   0.08 /
/  58805806 'VTGTPAT' 588058 588058  '1'   0.000   1.101   1.000   0.08 /
/  58805807 'VTGTPAT' 588058 588058  '1'   0.000   1.150   0.500   0.08 /
/  58805808 'VTGTPAT' 588058 588058  '1'   0.000   1.175   0.200   0.08 /
/  58805819 'VTGTPAT' 588058 588058  '1'   0.000   1.200   0.100   0.08 /
/  58805810 'VTGTPAT' 588058 588058  '1'   0.000   1.300   0.010   0.08 /
```

GEN-2016-133 – GEN-2016-146 (G11)

- Wind Farm Size: 250 MW
- Interconnection:
  - Voltage: 345 kV
  - POI: Tulsa North 345 kV (bus 509852)
  - Transformer 1: 345/765 kV step-up transformers
    - MVA: 2877 Winding MVA
    - Voltage: 345/34.5kV
    - Z: 8%
  - Transformer 2: 345/765 kV step-up transformers
    - MVA: 2877 Winding MVA
    - Voltage: 345/34.5kV
    - Z: 8%
  - Transformer 3: 765/345 kV step-up transformers
    - MVA: 2877 Winding MVA
    - Voltage: 345/34.5kV
    - Z: 8%
  - Transformer 4: 765/345 kV step-up transformers
    - MVA: 2877 Winding MVA
    - Voltage: 345/34.5kV
    - Z: 8%
  - Transmission Line 1:
    - R = 0.000596 p.u.
    - X = 0.014090 p.u.
    - B = 9.513000 p.u.
  - Transmission Line 2:
    - R = 0.000596 p.u.
    - X = 0.014090 p.u.
    - B = 9.513000 p.u.
- Collector System Equivalent Model:
  - Transmission Line 1:
    - R = 0.005829 p.u.
    - X = 0.007163 p.u.
    - B = 0.106230 p.u.
  - Transmission Line 2:
    - R = 0.000302 p.u.
    - X = 0.003400 p.u.
    - B = 0.061480 p.u.
  - Transformer:
    - MVA: 136 Winding MVA

        - High Voltage: 765 kV
        - Low Voltage: 34.5 kV
        - Z: 8.5%
- Wind Farm Parameters – GE 2.5 MW
    - Machine Terminal Voltage: 0.7 kV
    - Rated Power: 250 MW
    - Number of Wind Turbines: 100
        - Generator Step-Up Transformer 1:
            - MVA: 224 Winding MVA
            - High Voltage: 34.5 kV
            - Low Voltage: 0.7 kV
            - Z: 5.7%

The dynamic data for GEN-2016-133 – GEN-2016-146 (G11) is shown below:

```
/ (GEN-2016-133 - GEN-2016-146) WTG G11
 588107 'USRMDL' 1  'GEWTG0501'  1   1     30   59   11   29
     588107 1 0 0 0 0 0 0 0 0  0 0 0 0 0 0 0 0 0 0  0 0 0 0 0 0 0 0 0 0
     1.0000      1.0000      15.000      0.0500      0.0000      0.0000
    -1.5000      1.5000      20.000      3.0000      0.9000      1.1000
    0.70000      1.5000      5.0000    0.20000E-01   0.0000      0.50000
    0.90000      1.0000      0.0000      0.0000      1.2300      1.2300
     100.00      0.1000    0.50000E-01   0.1000      3.5000    0.50000E-01
     1.0000      -1.000      5.0000      9999.0      -1.000      5.0000
     9999.0      -1.000      5.0000      9999.0      -1.000      5.0000
     9999.0      -1.000      5.0000      9999.0      -1.000      5.0000
     9999.0      -1.000      5.0000      9999.0      50.000      70.000
     9999.0      50.000      70.000      9999.0      9999.0   /
  588107 'USRMDL' 1  'GEWTE0501'  4   0     9   68   15  293
     588107        0        1        0        1        0   0       0       0
    0.01000      1.1000     0.90000      1.1100      1.7000
     10.000     0.20000       66.00      1.2000      0.4500      0.0330
     1.0000     0.10000   0.15000E-01 0.50000E-01 0.15000E-01 0.50000E-01
    0.20000   0.20000E-01 0.15000E-01  0.15000      5.0000   0.20000E-01
    0.40000     0.22000     0.22000      1.0000   0.70000E-02 0.50000E-01
     0.0000      0.0000      0.0000      0.5000      0.0000     -0.10000
    0.10000     -1.0000      1.0000     0.10000     0.15000      0.0000
    0.15000     0.00200    -0.00200
    0.48400    -0.48400     0.48400    -0.48400   0.10000E-01
    0.45000      1.1000      1.1000     0.60000     0.60000     -1.0000
    -1.0000    -0.60000    -0.60000    -0.60000    -0.60000     -1.3000
    -1.3000      0.0000     0.80000     0.90000      1.1000      1.2000
     1.3000    /
  588107 'USRMDL' 1  'GEWTA0501'  5 0  4   43   15  163
    0         0         1         0
     2.5000      14.000      0.30000     0.50000E-1   150.00      25.000
     3.0000     0.60000      3.0000       30.000      27.000      0.0000
     10.000      1.1200      0.0000      0.45000      2.9600      0.6200
     1.1100      1.5000      144.00       1.0000     0.15000      1.0000
     0.9500     0.40000     0.96000      0.99600      1.0040      1.0400
     1.0000     0.20000      0.0000    0.25000E-02    1.0000      5.5000
    0.10000     -1.0000     0.10000       0.0000     0.15000      5.0000
     250.00      /
/  58810700 'VTGTPAT' 588107 588107  '1'   0.400   5.000   1.000   0.08 /
/  58810701 'VTGTPAT' 588107 588107  '1'   0.600   5.000   1.700   0.08 /
/  58810702 'VTGTPAT' 588107 588107  '1'   0.700   5.000   2.500   0.08 /
/  58810703 'VTGTPAT' 588107 588107  '1'   0.750   5.000   3.000   0.08 /
/  58810704 'VTGTPAT' 588107 588107  '1'   0.850   5.000  10.000   0.08 /
/  58810705 'VTGTPAT' 588107 588107  '1'   0.900   5.000 600.000   0.08 /
/  58810706 'VTGTPAT' 588107 588107  '1'   0.000   1.101   1.000   0.08 /
/  58810707 'VTGTPAT' 588107 588107  '1'   0.000   1.150   0.500   0.08 /
/  58810708 'VTGTPAT' 588107 588107  '1'   0.000   1.175   0.200   0.08 /
/  58810719 'VTGTPAT' 588107 588107  '1'   0.000   1.200   0.100   0.08 /
/  58810710 'VTGTPAT' 588107 588107  '1'   0.000   1.300   0.010   0.08 /
```

GEN-2016-133 – GEN-2016-146 (G12)

- Wind Farm Size: 250 MW
- Interconnection:
    - Voltage: 345 kV
    - POI: Tulsa North 345 kV (bus 509852)
    - Transformer 1: 345/765 kV step-up transformers
        - MVA: 2877 Winding MVA
        - Voltage: 345/34.5kV
        - Z: 8%
    - Transformer 2: 345/765 kV step-up transformers
        - MVA: 2877 Winding MVA
        - Voltage: 345/34.5kV
        - Z: 8%
    - Transformer 3: 765/345 kV step-up transformers
        - MVA: 2877 Winding MVA
        - Voltage: 345/34.5kV
        - Z: 8%
    - Transformer 4: 765/345 kV step-up transformers
        - MVA: 2877 Winding MVA
        - Voltage: 345/34.5kV
        - Z: 8%
    - Transmission Line 1:
        - R = 0.000596 p.u.
        - X = 0.014090 p.u.
        - B = 9.513000 p.u.
    - Transmission Line 2:
        - R = 0.000596 p.u.
        - X = 0.014090 p.u.
        - B = 9.513000 p.u.
- Collector System Equivalent Model:
    - Transmission Line 1:
        - R = 0.008966 p.u.
        - X = 0.012637 p.u.
        - B = 0.151140 p.u.
    - Transmission Line 2:
        - R = 0.000302 p.u.
        - X = 0.003400 p.u.
        - B = 0.061480 p.u.
    - Transformer:
        - MVA: 136 Winding MVA

        - High Voltage: 765 kV
        - Low Voltage: 34.5 kV
        - Z: 8.5%
- Wind Farm Parameters – GE 2.5 MW
    - Machine Terminal Voltage: 0.7 kV
    - Rated Power: 250 MW
    - Number of Wind Turbines: 100
        - Generator Step-Up Transformer 1:
            - MVA: 224 Winding MVA
            - High Voltage: 34.5 kV
            - Low Voltage: 0.7 kV
            - Z: 5.7%

The dynamic data for GEN-2016-133 – GEN-2016-146 (G12) is shown below:

```
/ (GEN-2016-133 - GEN-2016-146) WTG G12
 588108 'USRMDL' 1  'GEWTG0501'  1   1     30   59   11   29
     588108 1 0 0 0 0 0 0 0 0  0 0 0 0 0 0 0 0 0  0 0 0 0 0 0 0 0 0
     1.0000       1.0000       15.000       0.0500       0.0000       0.0000
    -1.5000       1.5000       20.000       3.0000       0.9000       1.1000
    0.70000       1.5000       5.0000      0.20000E-01   0.0000       0.50000
    0.90000       1.0000       0.0000       0.0000       1.2300       1.2300
     100.00       0.1000     0.50000E-01    0.1000       3.5000      0.50000E-01
     1.0000       -1.000       5.0000       9999.0       -1.000       5.0000
     9999.0       -1.000       5.0000       9999.0       -1.000       5.0000
     9999.0       -1.000       5.0000       9999.0       -1.000       5.0000
     9999.0       -1.000       5.0000       9999.0       50.000       70.000
     9999.0       50.000       70.000       9999.0       9999.0   /
  588108 'USRMDL' 1  'GEWTE0501'  4   0     9   68   15  293
     588108         0         1         0         1        0   0        0        0
    0.01000       1.1000      0.90000       1.1100       1.7000
     10.000      0.20000       66.00        1.2000       0.4500       0.0330
     1.0000      0.10000     0.15000E-01  0.50000E-01  0.15000E-01  0.50000E-01
    0.20000    0.20000E-01   0.15000E-01  0.15000       5.0000      0.20000E-01
    0.40000      0.22000      0.22000       1.0000     0.70000E-02  0.50000E-01
     0.0000       0.0000       0.0000       0.5000       0.0000     -0.10000
    0.10000      -1.0000       1.0000      0.10000      0.15000       0.0000
    0.15000      0.00200     -0.00200
    0.48400     -0.48400      0.48400     -0.48400     0.10000E-01
    0.45000       1.1000       1.1000      0.60000      0.60000      -1.0000
    -1.0000     -0.60000     -0.60000     -0.60000     -0.60000      -1.3000
    -1.3000       0.0000      0.80000      0.90000       1.1000       1.2000
     1.3000    /
  588108 'USRMDL' 1  'GEWTA0501'  5 0  4   43   15  163
    0         0         1         0
     2.5000       14.000      0.30000      0.50000E-1   150.00       25.000
     3.0000      0.60000       3.0000       30.000       27.000       0.0000
     10.000       1.1200       0.0000      0.45000       2.9600       0.6200
     1.1100       1.5000       144.00       1.0000      0.15000       1.0000
     0.9500      0.40000      0.96000      0.99600       1.0040       1.0400
     1.0000      0.20000       0.0000     0.25000E-02   1.0000       5.5000
    0.10000      -1.0000      0.10000       0.0000      0.15000       5.0000
     250.00      /
/  58810800 'VTGTPAT' 588108 588108  '1'   0.400   5.000   1.000   0.08 /
/  58810801 'VTGTPAT' 588108 588108  '1'   0.600   5.000   1.700   0.08 /
/  58810802 'VTGTPAT' 588108 588108  '1'   0.700   5.000   2.500   0.08 /
/  58810803 'VTGTPAT' 588108 588108  '1'   0.750   5.000   3.000   0.08 /
/  58810804 'VTGTPAT' 588108 588108  '1'   0.850   5.000  10.000   0.08 /
/  58810805 'VTGTPAT' 588108 588108  '1'   0.900   5.000 600.000   0.08 /
/  58810806 'VTGTPAT' 588108 588108  '1'   0.000   1.101   1.000   0.08 /
/  58810807 'VTGTPAT' 588108 588108  '1'   0.000   1.150   0.500   0.08 /
/  58810808 'VTGTPAT' 588108 588108  '1'   0.000   1.175   0.200   0.08 /
/  58810819 'VTGTPAT' 588108 588108  '1'   0.000   1.200   0.100   0.08 /
/  58810810 'VTGTPAT' 588108 588108  '1'   0.000   1.300   0.010   0.08 /
/
```

GEN-2016-153

- Wind Farm Size: 134 MW
- Interconnection:
  - Voltage: 345 kV
  - POI: Tap Viola – Flat Ridge 2 East 345 kV (Bus 588364)
  - Transformer: 138/34.5 kV step-up transformer
    - MVA: 140 Winding MVA
    - Voltage: 138/34.5 kV
    - Z: 9.8%
  - Transmission Line:
    - R = 0.000360 p.u.
    - X = 0.001130 p.u.
    - B = 0.000000 p.u.
- Collector System Equivalent Model:
  - Transmission Line:
    - R = 0.006510 p.u.
    - X = 0.006020 p.u.\
    - B = 0.058880 p.u.
- Wind Farm Parameters – Vestas V110 Mk10D OptiSpeed 2.0 MW
  - Machine Terminal Voltage: 0.7 kV
  - Rated Power: 134 MW
  - Number of Wind Turbines: 67
  - Generator Step-Up Transformer:
    - MVA: 140.7 Winding MVA
    - High Voltage: 34.5 kV
    - Low Voltage: 0.7 kV
    - Z: 9%

The dynamic data for GEN-2016-153 is shown below:

```
/
/ 588363 'USRMDL' '1'  'VWCO81' 1 1 2 45 23 104 1 0
/  2000.0000    690.0000    901.7885    700.0000    2.6200     0.6786     0.0160
/  0.4503   94.2478     0.4503  94.2478     30.0000     0.2000     1.2000
/  0.1000   0.0018      0.7018      0.0384      1.3298      0.0000      422.2301
/  184.6106 0.0300      0.0000      0.0300      0.3000      0.0000      0.0000
/  0.0000   0.0000      0.0000      0.0000      0.0000      0.0000      3.0000
/  0.0000   4736.7543   0.0000      0.0000      0.0000      0.0000      0.0000
/  0.0000   0.0000      0.0000 /
/ 0 'USRMDL' 0 'VWVA81' 8 0 2 0 0 30 588363 '1'/
/ 0 'USRMDL' 0 'VWLV81' 8 0 3 65 10 35 588363 '1' 1
/  0.8500   0.0010      0.0700      18.6662     74.6683     74.6683     74.6683
/  2.0000   0.0000      1.5152      0.8796      1.4400      2000.0000   690.0000
/  1.0000   0.3500      0.0500      0.2500      0.0200      3.0000      4.0000
/  9999.0000    0.0160      -12.0000    0.9000      0.0500      0.0000      0.0100
/  60.0000  1.0000      1.0000      1.0000      0.0000      0.0000      0.0000
/  100.0000 0.0001      0.0070      1.0000      0.0000      40.0000     1.0000
/  0.0000   0.0000      0.1700      0.0000      0.2000      1.0000      1.0000
/  1.1500   1.1000      2.0000      0.0000      0.0000         0.0000      0.2000
/  40.0000  777.0000    15.0000     0.0000      1.0000      1.4637      0.0000
/  0.0000   0.0000 /
/ 0 'USRMDL' 0 'VWPW81' 8 0 3 40 7 30 588363 '1' 0
/  1.0000   0.5000      -0.5000     -0.9995     1.9038      0.9800      0.9600
/  0.2000   0.2000      0.4500      0.4500      0.0000      0.0000      0.0159
/  0.0159   1.0000      0.0250      0.0250      0.0000         0.8500      0.9000
/  0.9300       1.0800      1.1000      1.2000      1.0000      1.4000      0.0000
/  0.0000       1.0000      5.0000          5.0000          6.0000          0.0250          0.0000
/  0.0000       0.0000          0.0000          0.0000          0.0000/
/ 0 'USRMDL' 0 'VWME81' 8 0 2 10 8 0 588363 '1'
/  2000.0000    422.2301    4736.7543   1246.6332   85.8900     0.0000      0.0000
/  3824.4671    33.2614     0.0000 /
/ 0 'USRMDL' 0 'VWM781' 8 0 2 10 8 5 588363 '1'
/  0.0159   0.0159      0.1000      0.1000      0.0000      0.0000      0.0000
/  0.0000   0.0000      0.0000 /
/ 0 'USRMDL' 0 'VWVP81' 0 2 7 30 0 18 588363 '1'  1 1 0 0 0
/  0.8500   11.0000     0.8500      11.0000     0.9000      60.0000     1.1000
/  3600.0000    1.1600      1800.0000       1.2400      60.0000     1.3600          30.0000
/  1.3600       30.0000     0.0000      0.0000      0.0000      0.0000      0.0000
/  0.0000   0.0000      0.1500      0.8000      3.0000      0.8000      3.0000
/  0.8000   3.0000 /
/ 0 'USRMDL' 0 'VWFP81' 0 2 3 12 0 7 588363 '1'  0
/  56.4000  0.2000      56.4000     0.2000      56.4000     0.2000      63.6000
/  0.2000   63.6000     0.2000      63.6000     0.2000 /
/
```

GEN-2016-162

- Wind Farm Size: 252 MW
- Interconnection:
  - Voltage: 345 kV
  - POI: Benton 345 kV (Bus 532791)
  - Transformer: 345/34.5 kV step-up transformer
    - MVA: 290 Winding MVA
    - Voltage: 345/34.5 kV
    - Z: 9%
  - Transmission Line:
    - R = 0.000980 p.u.
    - X = 0.009980 p.u.
    - B = 0.168000 p.u.
- Collector System Equivalent Model:
  - Transmission Line:
    - R = 0.002243 p.u.
    - X = 0.002049 p.u.
    - B = 0.038782 p.u.
- Wind Farm Parameters – GE 2.0 MW
  - Machine Terminal Voltage: 0.7 kV
  - Rated Power: 252 MW
  - Number of Wind Turbines: 126
  - Generator Step-Up Transformer:
    - MVA: 289.8 Winding MVA
    - High Voltage: 34.5 kV
    - Low Voltage: 0.7 kV
    - Z: 5.7%

The dynamic data for GEN-2016-162 is shown below:

```
/
/
588323   'USRMDL' 1  'GEWTG2'  1 1 4 18 3 5
       0  126       0         0
        2.0000     0.80000     0.50000     0.90000      1.2200     1.2000
        2.0000     0.40000     0.80000      10.000     0.20000E-01  0.0000
        0.0000     0.50000     0.16700     0.90000     0.92500     0.0000    /
588323   'USRMDL' 1  'GEWTE2'  4 0 12 67 18 9
         588323        0            0             1           0           0
             0        0            0             1           0           0
       0.15000      2.000      1.0000      0.0000      0.0000      0.50000E-01  3.0000
       0.60000      1.1200     0.40000E-01 0.43600    -0.43600      1.1000      0.20000E-01
       0.45000          -0.45000          60.000           0.10000          0.90000
        1.1000           40.000           0.50000          1.4500           0.50000E-01
       0.50000E-01       1.0000           0.15000          0.96000          0.99600
        1.0040           1.0400            0.99999          0.99999          0.99999
       0.40000           1.0000           0.20000          1.0000           0.25000
       -1.0000           14.0000           25.000           3.0000          -0.90000
        8.0000           0.2000           10.000           1.0000           1.7000
        1.22             1.2500           5.0000           0.0000           0.0000
         0.000           0.25000E-02       1.0000          5.5000           0.10000
       -1.0000           0.10000           0.0000          0.10000          -0.10000
       0.70000           0.12000          -0.12000    /
588323   'USRMDL' 1  'GEWTT1'        5    0    1    5    4    3   0
         3.7000      0.0000      0.0000       1.8800      1.5000    /
588323 'USRMDL'  1 'GEWGD1' 505    0    1   6    0    4   0
         9999.0      5.0000      30.000       9999.0      9999.0          30.000    /
588323 'USRMDL'  1 'GEWTA2' 505   0    0    9    1    4
         20.000      0.0000      27.000      -4.0000      0.0000       1.2250
         58.0        104.000     1200.0    /
588323 'USRMDL'  1 'GEWTP2' 505    0    1    10    3    3   0
        0.30000      150.00      25.000       3.0000      30.000
        -4.0000      27.000     -10.000       10.000      1.0000    /
58832300  'USRMSC'  'GEWPLT2'  512  0  2  0  0  17  588323  '1'/
58832301 'FRQTPAT'          588323    588323   '1' 56.5   62.5   1   0.08/
58832302 'VTGTPAT'          588323    588323   '1' 0.15  5     0.2  0.08 /
58832303 'VTGTPAT'          588323    588323   '1' 0.3   5     0.7  0.08 /
58832304 'VTGTPAT'          588323    588323   '1' 0.5   5     1.2  0.08 /
58832305 'VTGTPAT'          588323    588323   '1' 0.75  5     1.9  0.08 /
58832306 'VTGTPAT'          588323    588323   '1' 0     1.1   1    0.08 /
58832307 'VTGTPAT'          588323    588323   '1' 0     1.15  0.1  0.08 /
/
```

GEN-2016-163

- Wind Farm Size: 252 MW
- Interconnection:
    - Voltage: 345 kV
    - POI: Benton 345 kV (Bus 532791)
    - Transformer: 345/34.5 kV step-up transformer
        - MVA: 290 Winding MVA
        - Voltage: 345/34.5 kV
        - Z: 9%
    - Transmission Line 1:
        - R = 0.000245 p.u.
        - X = 0.002495 p.u.
        - B = 0.042000 p.u.
    - Transmission Line 2:

        - R = 0.000980 p.u.
        - X = 0.009980 p.u.
        - B = 0.168000 p.u.
- Collector System Equivalent Model:
    - Transmission Line:
        - R = 0.002243 p.u.
        - X = 0.002049 p.u.
        - B = 0.038782 p.u.
- Wind Farm Parameters – GE 2.0 MW
    - Machine Terminal Voltage: 0.7 kV
    - Rated Power: 252 MW
    - Number of Wind Turbines: 126
    - Generator Step-Up Transformer:
        - MVA: 289.8 Winding MVA
        - High Voltage: 34.5 kV
        - Low Voltage: 0.7 kV
        - Z: 5.7%

The dynamic data for GEN-2016-163 is shown below:

```
/
588333   'USRMDL' 1  'GEWTG2'  1 1 4 18 3 5
      0  126         0         0
       2.0000      0.80000      0.50000      0.90000      1.2200      1.2000
       2.0000      0.40000      0.80000      10.000       0.20000E-01 0.0000
       0.0000      0.50000      0.16700      0.90000      0.92500     0.0000     /
588333   'USRMDL' 1  'GEWTE2'  4 0 12 67 18 9
        588333         0            0              1            0            0
            0        0            0              1            0            0
      0.15000      2.000       1.0000       0.0000       0.0000      0.50000E-01  3.0000
      0.60000      1.1200      0.40000E-01  0.43600      -0.43600    1.1000       0.20000E-01
      0.45000          -0.45000          60.000            0.10000            0.90000
       1.1000            40.000          0.50000            1.4500            0.50000E-01
      0.50000E-01       1.0000           0.15000            0.96000            0.99600
       1.0040            1.0400           0.99999            0.99999            0.99999
      0.40000            1.0000          0.20000            1.0000             0.25000
      -1.0000            14.0000          25.000             3.0000            -0.90000
       8.0000           0.2000          10.000             1.0000             1.7000
       1.22             1.2500          5.0000             0.0000             0.0000
        0.000           0.25000E-02      1.0000            5.5000             0.10000
      -1.0000           0.10000          0.0000            0.10000            -0.10000
      0.70000           0.12000         -0.12000     /
588333   'USRMDL' 1  'GEWTT1'        5    0    1    5    4    3   0
        3.7000      0.0000       0.0000       1.8800       1.5000    /
588333 'USRMDL'  1 'GEWGD1' 505    0    1    6    0    4   0
        9999.0      5.0000       30.000       9999.0       9999.0          30.000    /
588333 'USRMDL'  1 'GEWTA2' 505   0    0    9    1    4
        20.000      0.0000       27.000       -4.0000      0.0000        1.2250
        58.0        104.000      1200.0    /
588333 'USRMDL'  1 'GEWTP2' 505    0    1    10    3    3   0
       0.30000      150.00       25.000       3.0000       30.000
       -4.0000      27.000       -10.000      10.000       1.0000    /
58833300  'USRMSC'  'GEWPLT2'  512  0  2  0  0  17  588333  '1'/
58833301 'FRQTPAT'             588333     588333   '1' 56.5   62.5   1   0.08/
58833302 'VTGTPAT'             588333     588333   '1' 0.15  5     0.2  0.08 /
58833303 'VTGTPAT'             588333     588333   '1' 0.3   5     0.7  0.08 /
58833304 'VTGTPAT'             588333     588333   '1' 0.5   5     1.2  0.08 /
58833305 'VTGTPAT'             588333     588333   '1' 0.75  5     1.9  0.08 /
58833306 'VTGTPAT'             588333     588333   '1' 0     1.1   1    0.08 /
58833307 'VTGTPAT'             588333     588333   '1' 0     1.15  0.1  0.08 /
/
```

APPENDIX B: PLOTS FOR 2017 WINTER PEAK CONDITIONS

Plots available upon request

APPENDIX C: PLOTS FOR 2018 SUMMER PEAK CONDITIONS

Plots available upon request

APPENDIX D: PLOTS FOR 2026 SUMMER PEAK CONDITIONS

Plots available upon request

GROUP 9 STABILITY ANALYSIS

The previously evaluated Group 9 cases included the following previously assigned system upgrades which were removed prior to this analysis:

- SPP R Plan (NTC 200220)
  - Thedford 345/115/13.8 kV transformer
  - Gerald Gentleman Station to Thedford 345 kV circuit #1
  - Holt County to Thedford 345 kV circuit #1
- Gerald Gentleman Station to Keystone 345 kV circuit #2
- Keystone to Sidney 345 kV circuit #2
- Reroute the Laramie River Station to Stegall 345 kV line through the GEN-2016-023 Substation and equipment necessary to achieve a fault clearing within 5 cycles

The Group 9 cases included the following system adjustments of dispatching, to maximum output, generation interconnected at the same or adjacent substations to a current study request:

- Laramie River Station units: GEN-2016-110
- Sheldon units: GEN-2016-096
- Gerald Gentleman Station units: GEN-2016-074 & GEN-2016-106
- Neal units: prior DISIS-2016-002 requests

Note: a sensitivity dispatch was performed to further evaluate the Gerald Gentleman Station registered NERC flowgate #6006.

The Group 9 stability analysis for this area was performed by Mitsubishi Electric Power Products (MEPPI).

With the new requests modeled, violations of stability damping criteria and voltage recovery criteria were observed for several fault events in the Nebraska area. The following upgrades identified in the power flow analysis were tested in the stability analysis:

- SPP R Plan (NTC 200220)
  - Thedford 345/115/13.8 kV transformer
  - Gerald Gentleman Station to Thedford 345 kV circuit #1
  - Holt County to Thedford 345 kV circuit #1

- Addition of Keystone to Red Willow 345kV circuit #1
- Addition of Post Rock to Red Willow 345kV circuit #1
- Addition of Antelope to Holt 345kV circuit #1

With all previously-assigned and currently-assigned Network Upgrades placed in service, no violations were observed, including violations of low-voltage ride-through requirements, for the probable P1 and P4 Planning Events studied using both the normal group dispatch and the additional dispatch scenario to evaluate the Gerald Gentleman Station registered NERC flowgate #6006.

Evaluation of P6, prior outage, Planning Events involving circuits terminating at the following substations determined that a system adjustment involving curtailment of up to 480 MW from generating facilities may be required following a prior outage to achieve acceptable system response for a subsequent fault event:

- GEN-2016-110 Tap 345kV
- Keystone 345kV
- Laramie River Station 345kV
- Sidney 345kV
- Sidney 230kV
- Stegall 345kV

Following the interconnection of each request or completion of these upgrade, it is recommended that the Transmission Owner(s) for the western Nebraska area (BEPC, NPPD, & WAPA) evaluate any applicable operational guide(s) and Corrective Action Plans utilized in transmission planning assessment.

With all previously-assigned and currently-assigned Network Upgrades placed in service and the identified system adjustments, no violations were observed, including violations of low-voltage ride-through requirements, for the probable P6 Planning Events studied.

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Southwest Power Pool, Inc. (SPP)

DISIS-2016-002-2 (Group 09) Definitive Impact Study

Final Report

REP-0884
Revision #01

June 2020

Submitted By:
Mitsubishi Electric Power Products, Inc. (MEPPI)
Power Systems Engineering Division
Warrendale, PA

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Report Revision Table

Revision	Report Revision Table	Date	Approved
0	Issue Draft Report for review	06/19/2020	NWT
1	Address SPP comments, Issue Final Report	06/29/2020	NWT

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Title: **DISIS-2016-002-2 (Group 09) Definitive Impact Study: Final Report REP-0884**
Date: June 2020
Author: Nicholas Tenza; Senior Engineer, Power Systems Engineering Division *Nicholas Tenza*
Reviewed: Samir Dahal; Principal Engineer, Power Systems Engineering Division *Samir Dahal*
Approved: Donald Shoup; General Manager, Power Systems Engineering Division *Donald J. Shoup*

EXECUTIVE SUMMARY

SPP requested a Definitive Interconnection System Impact Study (DISIS). The DISIS required a Stability Analysis detailing the impacts of the interconnecting projects as shown in Table ES-1.

Table ES-1
Interconnection Projects Evaluated

Request	Size (MW)	Generator Model	Point of Interconnection
GEN-2016-074	200	Vestas 2.0 MW (587683)	Sweetwater 345kV (640374)
GEN-2016-096	227.7	Siemens 2.3 MW (587783, 587787)	Tap Moore – Pauline 345kV (560062)
GEN-2016-106	400	Vestas 2.0 MW (587853)	Gentleman 345kV (640183)
GEN-2016-110	152	GE 2.0 MW (587873)	Tap Laramie River – Stegall 345kV (587874)
GEN-2016-147	40	GE PV Solar 2.0 MW (588223)	Sidney 115kV (653572)

SUMMARY OF STABILITY ANALYSIS

The Stability Analysis determined that there were multiple contingencies across all seasons and dispatch scenarios that resulted in voltage collapse/instability, generation tripping offline, and poor post-fault voltage recovery when all generation interconnection requests were at 100% output. The voltage collapse/instability was observed in the vicinity of Gerald Gentleman Station, Laramie River Station, and Holt Station for P1 and P4 fault events.

The P4 events at Gerald Gentleman Station that resulted in voltage collapse/instability could be mitigated by the following solution options:

- GGS Solution Option #1: Build a 345kV circuit from Keystone to Red Willow to Post Rock.
    - This solution option is valid with and without the R-Plan Network Upgrade:
        - Thedford 345/115/13.8 kV transformer
        - Gerald Gentleman Station to Thedford 345kV circuit #1
        - Holt County to Thedford 345kV circuit #1
- GGS Solution Option #2: Rebuild Gerald Gentleman Station with a double bus double breaker configuration.
- GGS Solution Option #3: Build the R-Plan Network Upgrade and install at least 325 Mvar of fast dynamic reactive support (SVC) at Keystone 345kV.

The power flow analysis performed by SPP has identified the need for the Keystone to Red Willow to Post Rock 345kV circuit to alleviate several constraints. Therefore, after determining that the Keystone to Red Willow to Post Rock 345kV circuit mitigated the voltage collapse/instability for P4 events at Gerald Gentleman Station, the Keystone to Red Willow to Post Rock 345kV circuit was included in the remaining solution options.

It was determined that P1 and P4 events near Laramie River Station 345kV resulted in voltage collapse/instability. The critical clearing time for P1 events near Laramie River Station 345kV was determined to be greater than 5 cycles. After discussion with the Transmission Owner, faults on the nearby 345kV transmission system have a 4 cycle clearing time so no additional mitigation is required for P1 events near Laramie River Station 345kV.

For P4 events near Laramie River Station, the GGS Solution Option #1 above (Build a 345kV circuit from Keystone to Red Willow to Post Rock, with and without the R-Plan Network Upgrade) mitigated the voltage collapse/instability for the Normal Dispatch Scenario and High GGS Sensitivity Dispatch Scenario.

It was determined that P1 and P4 events near Holt County 345kV resulting in the outage of the Holt County to Grand Island 345kV circuit also may result in voltage stable concerns. Either the R-Plan or an Antelope to Holt County 345kV circuit #1 upgrade provide an additional outlet at Holt County that resolves the observed instability or updating the Grand Prairie Wind Units to the latest Vestas Generic Model Structure V7 with power plant controller.

The power flow analysis performed by SPP has also identified the need for both the R-Plan and an Antelope to Holt County 345kV circuit #1 to alleviate all constraints. Therefore, after determining that these upgrades mitigated the voltage collapse/instability for the fault events evaluated in this stability analysis, each was included in the remaining solution evaluation below:

- Solution Option #4
    - Keystone to Red Willow to Post Rock 345kV circuit #1
    - R-Plan Network Upgrade
    - Antelope to Holt County 345kV circuit #1

The solution option identified above mitigated the voltage collapse/instability observed for P1 and P4 evaluated in all seasons and dispatch scenarios. However, with the complete solution set generation curtailment is required for several prior outage conditions, P6 events. With each of the identified upgrades above in-service, prior outage conditions, in anticipation of a subsequent fault event, required additional generation curtailment for the Normal Dispatch Scenario and High GGS Sensitivity Dispatch Scenario for circuits terminated at the following stations:

- GEN-2016-110 POI station 345kV
- Keystone 345kV
- Laramie River Station 345kV
- Sidney 345kV
- Sidney 230kV
- Stegall 345kV

Following the prior outages as described above, in order to maintain system stability following the three phase faults, the analysis determined that curtailing generation by up to 480 MW in the vicinity of Laramie River Station and Sidney 345kV resulted in a stable response with no generation tripping or system instability observed.

With the identified upgrades and curtailment above, the Stability Analysis determined that there was no generation tripping or system instability observed as a result of interconnecting all study projects at 100% output.

SECTION 1: OBJECTIVES

The objective of this report is to provide Southwest Power Pool, Inc. (SPP) with deliverables for the DISIS-2016-002-2 (Group 09) Study. SPP requested an Interconnection System Impact Study for five (5) generation interconnections for 2017 Winter Peak, 2018 Summer Peak, and 2026 Summer Peak, which requires a Stability Analysis and an Impact Study Report.

SECTION 2: BACKGROUND

The Siemens Power Technologies International PSS/E power system simulation program Version 33.10 was used for this study. The stability cases for 2017 Winter Peak, 2018 Summer Peak, and 2026 Summer Peak cases under normal dispatch and Gerald Gentleman Station dispatch (referred to as High GGS Sensitivity Scenario) conditions and studied contingencies were utilized from the DISIS-2016-002 Group 09 study. The models include the DISIS-2016-002 study projects shown in Table 2-1 and the previously queued projects listed in Table 2-2. The withdrawn DISIS-2016-001 study projects shown in Table 2-3 and withdrawn MISO projects shown in Table 2-4 were removed from the study models to reflect current system configurations. Refer to Section 3.1 for the changes made to the base cases to reflect the removal of previously assigned Network Upgrades and study projects associated with DISIS-2016-002 conditions.

A power flow one-line diagram for each generation interconnection project is shown in Figures 2-1 through 2-5. Note that the one-line diagrams represent 2017 Winter Peak conditions.

The Stability Analysis determined the impacts of the new interconnecting projects on the stability and voltage recovery of the nearby system and the ability of the interconnecting projects to meet FERC Order 661A. If problems with stability or voltage recovery are identified, the need for reactive compensation or system upgrades were investigated. Three-phase faults and single line-to-ground faults were examined as listed in Table 2-5 prior to any mitigation implemented.

Prior studies, including DISIS-2015-001 and DISIS-2016-001, modeled the Grand Prairie generating facility with the user-written PSS/E Model for Vestas OptiSpeed™ Wind Turbines Version 7.6. This study used the updated user-written Vestas Generic Model Structure V7 to represent these generating facilities in the study models. In discussions with the Grand Prairie generating facility turbine vendor regarding the previously observed instability, SPP was advised to replace the PSS/E Vestas WTG user-written model with the newer version of the Vestas WTG user-written model. This newer user-written model version incorporates the dynamic adjustment of the reactive power set point value during simulation to more accurately reproduce the WTG capabilities with voltage regulation as a standard feature in all Vestas wind turbine projects. The dynamic data file (dyre) parameters, appropriate to represent the Grand Prairie project specific design, were provided by the vendor.

Table 2-1: Interconnection Projects Evaluated

Request	Size (MW)	Generator Model	Point of Interconnection
GEN-2016-074	200	Vestas 2.0 MW (587683)	Sweetwater 345kV (640374)
GEN-2016-096	227.7	Siemens 2.3 MW (587783, 587787)	Tap Moore – Pauline 345kV (560062)
GEN-2016-106	400	Vestas 2.0 MW (587853)	Gentleman Substation 345kV (640183)
GEN-2016-110	152	GE 2.0 MW (587873)	Tap Laramie River – (GEN-2016-110 Tap) Stegall 345kV (587874)
GEN-2016-147	40	GE PV Solar 2.0 MW (588223)	Sidney 115 kV Sub (653572)

Table 2-2: Previously Queued Nearby Interconnection Projects Included

Request	Size (MW)	Generator Model	Point of Interconnection
Beatrice Power Station	250	Thermal 80/90MW	Beatrice 115kV (640088)
Broken Bow	7.3		Broken Bow 115kV (640089)
Buffalo County Solar	10		Kearney Northeast (640249)
Burt County Wind	12		Tekamah & Oakland 115kV (640300)
Burwell	3.3		Ord 115kV (640308)
Columbus Hydro	45	Hydro 15MW	Columbus 115kV (640136)
North Platte - Lexington	66.7	Hydro 21.6/23.5MW	Multiple: Jeffrey 115kV, John_1 115kV, John_2 115kV (640238, 640240, 640242)
Ord	10.8		Ord 115kV (640308)
Stuart	1.8		Ainsworth 115kV (640051)
Ft Randle Hydro	352	Hydro 44/45MW	Ft Randle (WAPA) 230kV & 115kV (652510)
Gavins Pt Hydro	102	Hydro 34MW	Gavins Point (WAPA) 115kV (652511)
Spirit Mound Heat	120	Thermal 60MW	Spirit Mound (WAPA) 115kV (659121)
GEN-2003-021N	74.25	Vestas V82 1.65MW	Ainsworth Wind Tap 115kV (640050)
GEN-2004-023N	75	Thermal 75MW	Columbus 115kV (640119)
GEN-2006-020N	42.3	Vestas V190 VCUS 1.815MW, Vestas V90 VCRS 3.0MW	Bloomfield 115kV (640084)
GEN-2006-037N1	73.1	GE 1.7MW	Broken Bow North 115kV (640089)
GEN-2006-038N005	80	GE 1.6MW	Broken Bow North 115kV (640089)
GEN-2006-038N019	81	GE 1.5MW	Petersburg 115kV (640444)
GEN-2006-044N	40.5	GE 1.5MW	Petersburg 115kV (640444)

Request	Size (MW)	Generator Model	Point of Interconnection
GEN-2007-011N08	81	Vestas V90 VCRS 3.0MW	Bloomfield 115kV (640084)
GEN-2007-017IS/GEN-2007-018IS	400	Vestas 2.0MW	Tap Ft. Thompson – Grand Island 345kV (Grand Prairie, 652532)
GEN-2008-086N02/GEN-2014-032	211.22	GE 100m 1.79MW	Meadow Grove 230kV (640540)
GEN-2008-119O	60	GE 1.5MW	S1399 161kV (646399)
GEN-2008-123N	89.7	GE 103m 1.79/2/2.3MW	Tap Pauline – Guide Rock (Rosemont 115kV 560134)
GEN-2009-040	72	Vestas V110 VCSS 2.0MW	Marshall 115kV (533303)
GEN-2010-051	198.9	GE 100m 1.7MW	Tap on the Twin Church – Hoskins 230kV line (560347)
GEN-2011-018/GEN-2013-008/GEN-2014-004	78.76	GE 100m 1.79MW, GE 97.4m 1.79MW	Steele County 115kV (640426)
GEN-2011-027	120.25	GE 1.85MW	Tap Twin Church-Hoskins 230kV (560347)
GEN-2011-056	3.6 MW increase (Pmax=21.6MW)	Hydro 21.6MW	Jeffrey 115kV (640238)
GEN-2011-056A	3.6 MW increase (Pmax=21.6MW)	Hydro 21.6MW	Johnson 1 115kV (640240)
GEN-2011-056B	4.5 MW increase (Pmax=23.5MW)	Hydro 23.5MW	Johnson 2 115kV (640242)
GEN-2012-021	4.8 MW increase	Thermal 4.8MW	Terry Bundy Generating Station 115kV (650275)
GEN-2013-002	50.6	Siemens 108m 2.3MW	Monolith 115kV (640591)
GEN-2013-019	73.6	Siemens 108m 2.3MW	Monolith 115kV (640591)
GEN-2013-032	204	GE 97.4m 1.7MW	Antelope 115kV (640521)
GEN-2014-013	73.39	GE 100m 1.79MW	Meadow Grove 230kV (640540)

Request	Size (MW)	Generator Model	Point of Interconnection
GEN-2014-031	35.8	GE 1.79MW	Meadow Grove 230kV (640540)
GEN-2014-039	73.34	Vestas V110 VCSS 1.905/2.0MW	Friend 115kV (640174)
GEN-2015-007	160	GE 116m 2.0MW	Hoskins 345kV (640226)
GEN-2015-023	300.72	GE 100m 1.79MW	Holt County 345kV (640510)
GEN-2015-076	158.4	Vestas V117 GridStreamer 3.3MW	Belden 115kV (640080)
GEN-2015-088	300	Vestas V100 VCSS 2.0MW	Tap on Moore (640277) to Pauline (640312) 345kV (560062)
GEN-2015-089	200	GE 2.0MW	Utica 230kV (652526)
GEN-2016-021	300	Vestas V110 VCSS 2.0MW	Hoskins 345kV (640226)
GEN-2016-043	226.8	Vestas V136 3.6MW	Hoskins 345kV (640226)
GEN-2016-050	250.7	GE 2.3MW	Axtell (640065)-Post Rock (530583) 345kV (560082)
GEN-2016-075	50	Vestas V110 VCSS 2.0MW	Tap Ft. Thompson – Grand Island 345kV (Grand Prairie 652532)

Table 2-3: SPP Interconnection Projects Removed from the Model

Request	Size (MW)	Generator Model (Gen Bus Number)	Point of Interconnection
GEN-2010-041	10.5	GE 1.5MW (580071)	S1399 161kV (646399)
GEN-2015-053	50	GE 2.5MW (wind; 583783 & 583786)	Antelope 115kV (640521)
GEN-2015-087	66	Vestas V100 2.0 MW (wind; 585233)	Tap on Fairbury (640169) to Hebron (640218) 115kV
GEN-2016-023	150.5	GE 2.0MW and 1.79MW Wind (587093, 587095)	Tap Sidney (659426) - Laramie River (659131) 345kV (560075)
GEN-2016-029	150.5	GE 2.0MW and 1.79MW Wind (587193,587195)	Tap Sidney (659426) - Laramie River (659131) 345kV (560075)
GEN-2016-165	202	GE 2.0 MW (588343)	Tap Holt County – Grand Prairie 345kV (588344)

Table 2-4: MISO Interconnection Projects Removed from the Model

Request	Size (MW)	Generator Model (Gen Bus Number)	Point of Interconnection
J414	120	Vestas V110 2.0 MW (84143)	Freeborn 161 kV (631180)
J415	200	GE Wind Turbine (84150, 84155, 84158, 84159)	Quinn – Blackhawk 345kV (84151)
J439	500	Vestas V110 2.0 MW (84397, 84398)	Obrien – Kossuth 345kV (84390)
J459	200	Vestas V110 2.0 MW (84593)	Big Stone South – Brookings County 345kV (84590)
J489	151.8	GE Wind Turbine (61421)	Big Stone – Ellendale 345kV (61418)
J511	200	Vestas V110 2.0 MW (85115, 85116)	Stanton 230 kV (615901)
J525	33	Solar (68922)	Lake Wilson – Hadley 69 kV (618920)
J575	100	GE Wind Turbine (85753)	Brookings County 345kV (601031)

J577	100	GE Wind Turbine (85773)	Brookings County 345kV (601031)
J593	224	Vestas V110 2.0 MW (85934)	Tioga 230 kV (661084)
J594	300	Vestas V110 2.0 MW (859441, 859442)	Jackson North 161 kV (631210)
J596	100	Vestas V110 2.0 MW (85965)	Morris – Moro 115 kV (85961)
J597	300	Vestas V110 2.0 MW (859741, 859742)	Brookings County 345kV (601031)
J599	200	Vestas V110 2.0 MW (85994)	Glenham 230 kV (661038)
J637	98	Gamesa Wind (86375)	Big Stone South – Brookings County 345kV (86371)
J638	204	Gamesa Wind (863841, 863842)	Big Stone South – Brookings County 345kV (86371)

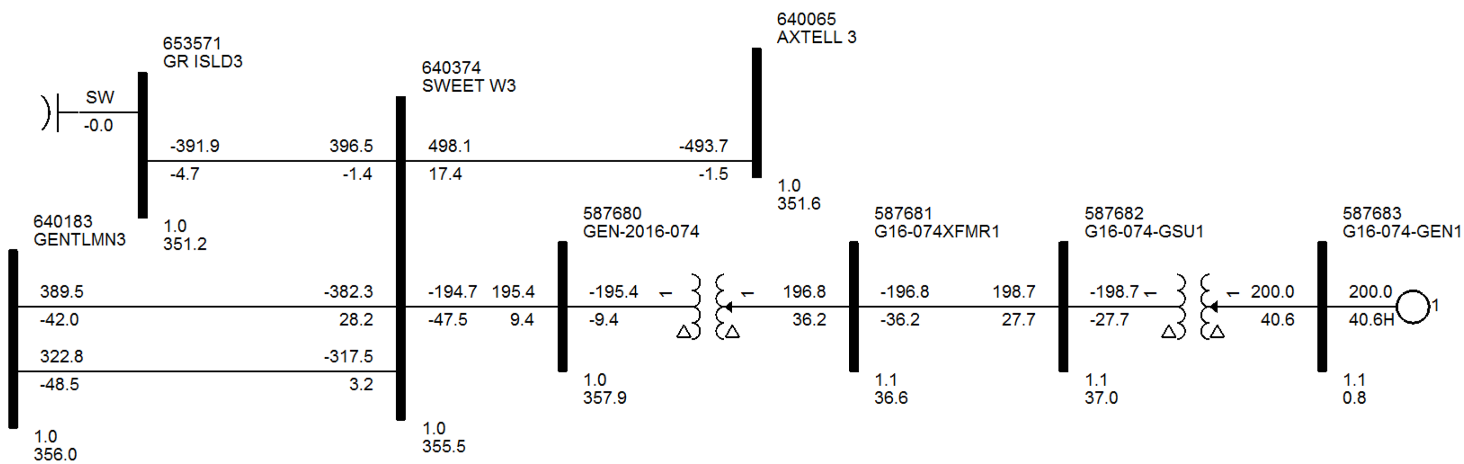

Figure 2-1. Power flow one-line diagram for interconnection project at Sweetwater 345kV (GEN-2016-074).

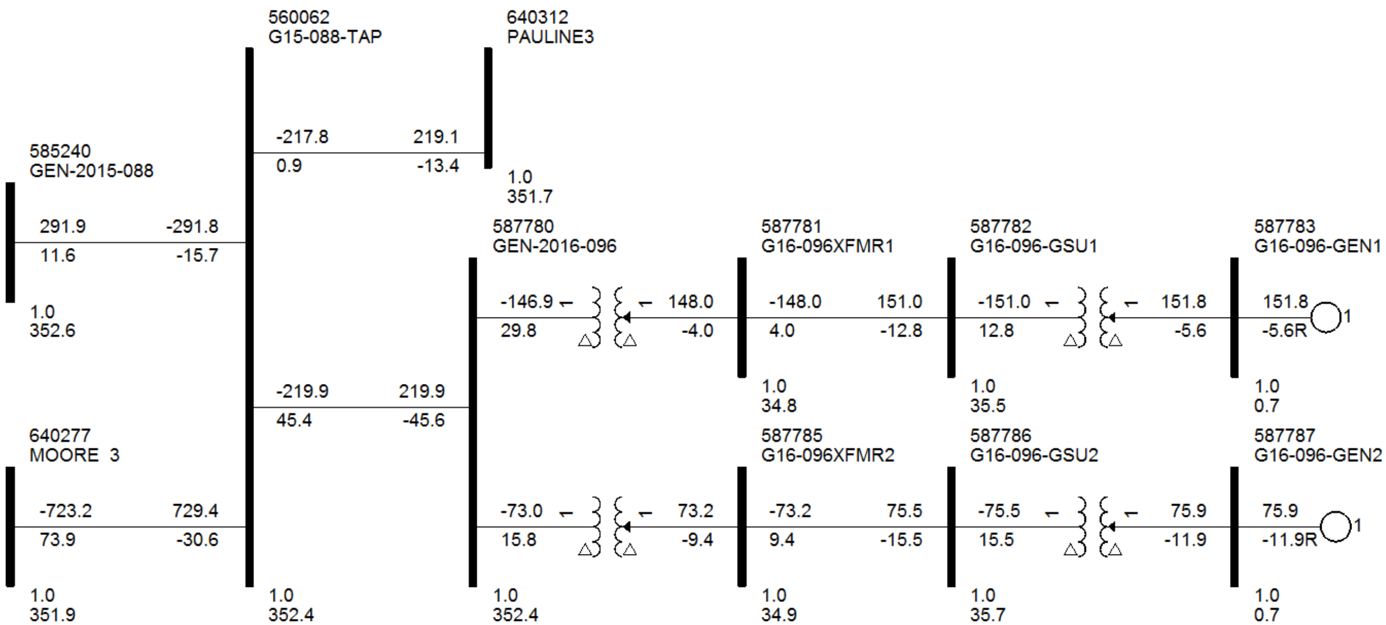

Figure 2-2. Power flow one-line diagram for interconnection project at GEN-2015-088 Tap 45 kV (GEN-2016-096).

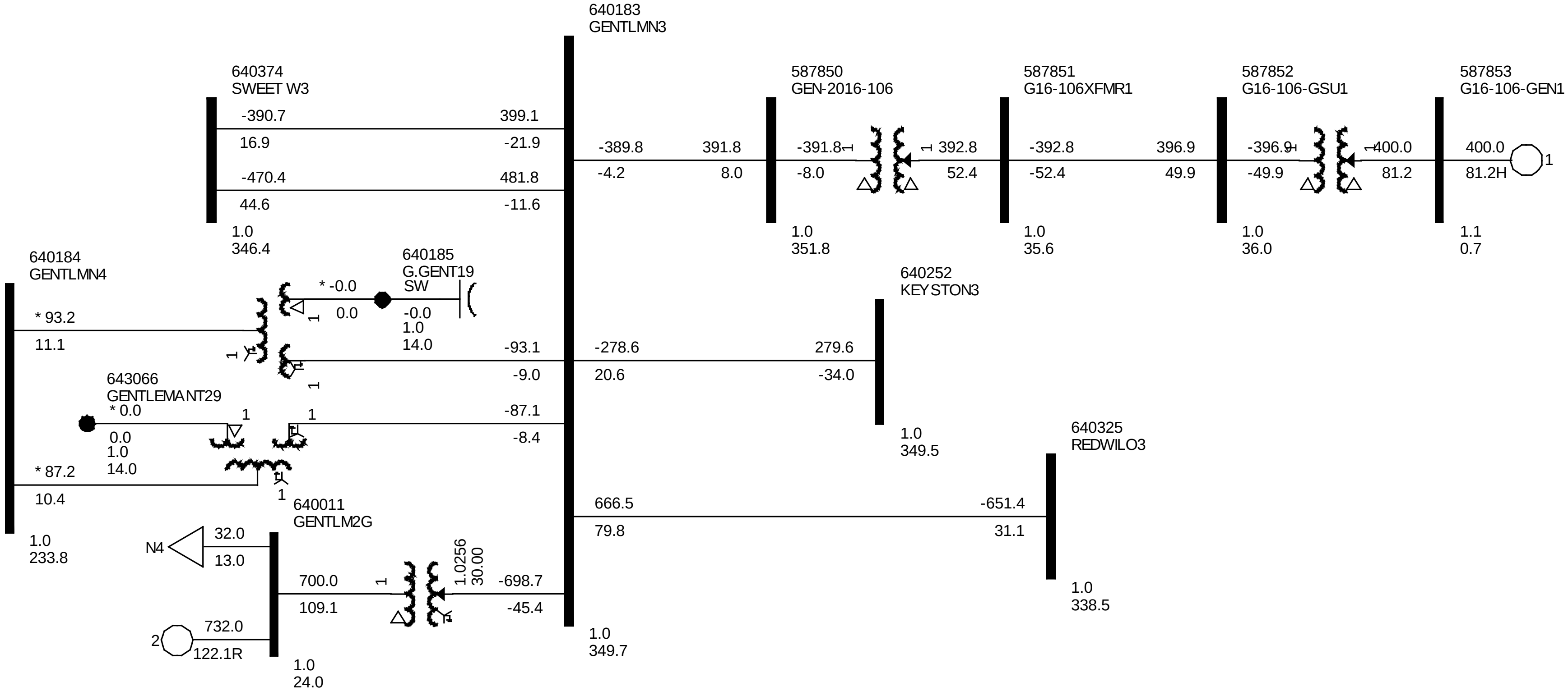

Figure 2-3. Power flow one-line diagram for interconnection project at Gentleman Substation 345kV (GEN-2016-106).

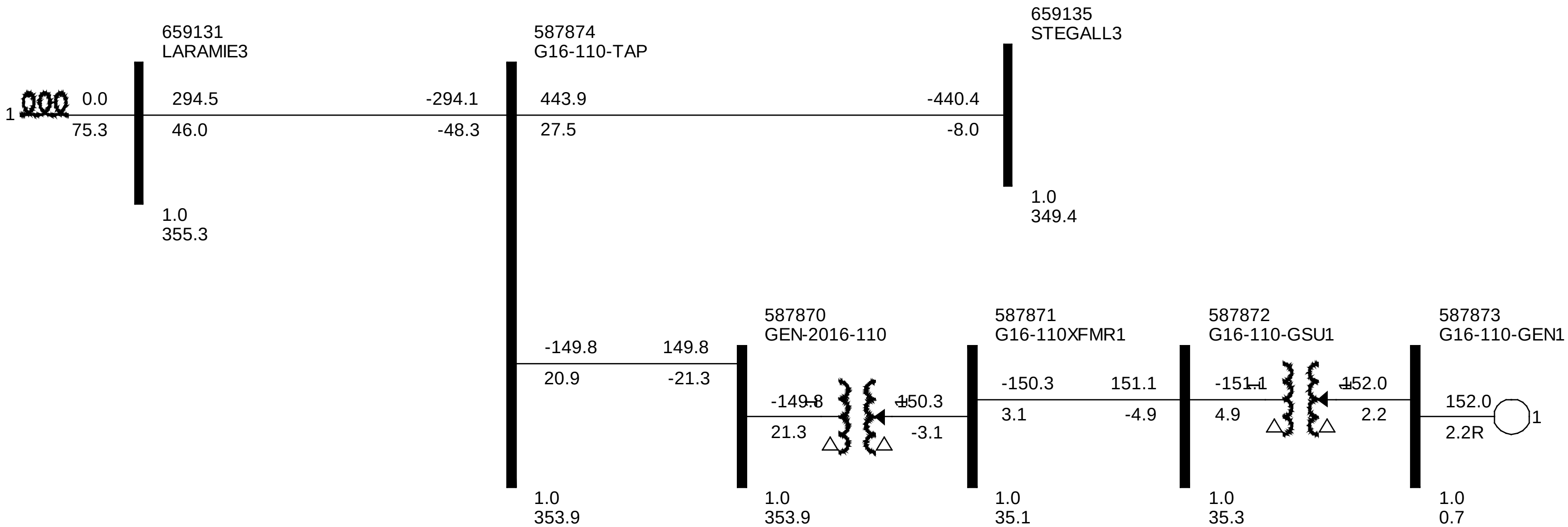

Figure 2-4. Power flow one-line diagram for interconnection project at Laramie River – Stegall Tap 345kV (GEN-2016-110).

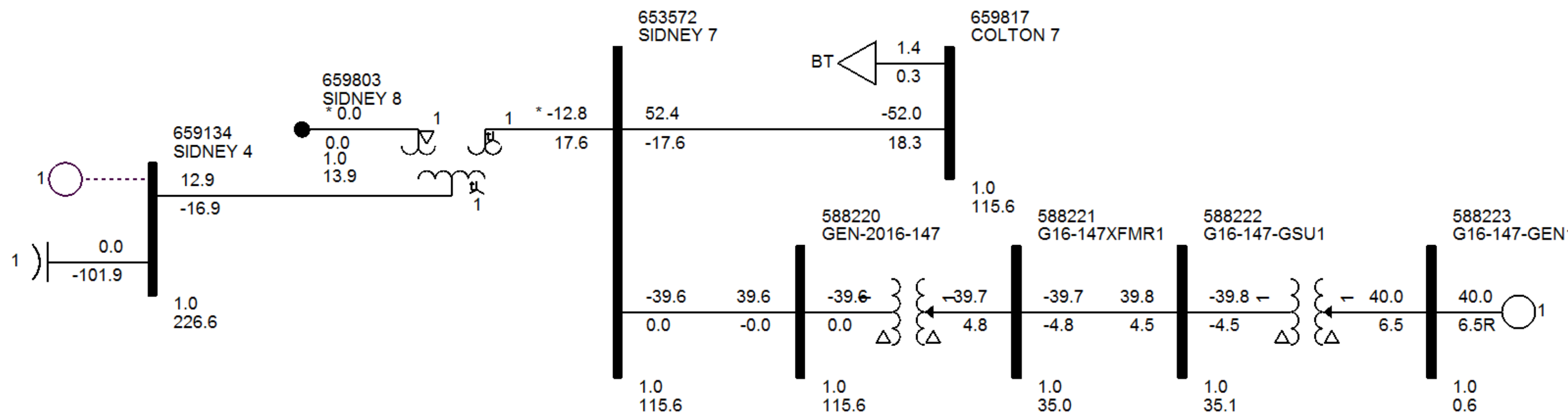

Figure 2-5. Power flow one-line diagram for interconnection project at Sidney 115 kV (GEN-2016-147).

Table 2-5: Case List with Contingency Description

Ref. No.	Cont. Name	Description
1	FLT01-3PH	3 phase fault on the G16-110-Tap (587874) to Stegall (659135) 345kV line circuit 1, near G16-110-Tap. a. Apply fault at the G16-110-Tap 345kV bus. b. Clear fault after 6 cycles by tripping the faulted line.
2	FLT02-3PH	3 phase fault on the G16-110-Tap (587874) to Laramie (659131) 345kV line circuit 1, near G16-110-Tap. a. Apply fault at the G16-110-Tap 345kV bus. b. Clear fault after 6 cycles by tripping the faulted line.
3	FLT03-3PH	3 phase fault on the Laramie (659131) to Sidney LNX (659426) to Sidney (659133) 345kV line circuit 1, near Laramie. a. Apply fault at the Laramie 345kV bus. b. Clear fault after 6 cycles by tripping the faulted line.
4	FLT04-3PH	3 phase fault on the Laramie (659131) to G16-110-TAP (587874) 345kV line circuit 1, near Laramie. a. Apply fault at the Laramie 345kV bus. b. Clear fault after 6 cycles by tripping the faulted line.
5	FLT05-3PH	3 phase fault on the Sidney (659133) to SIDNEY1-LNX (659425) to Keystone (640252) 345kV line circuit 1, near Sidney. a. Apply fault at the Sidney 345kV bus. b. Clear fault after 6 cycles by tripping the faulted line.
6	FLT06-3PH	3 phase fault on the Sidney 345/230/13.8kV (659133/659210/659168) Transformer, near Sidney. a. Apply fault at the Sidney 345kV bus. b. Clear fault after 6 cycles by tripping the faulted line.
7	FLT07-3PH	3 phase fault on the Sidney (659133) to Stegall (659135) 345kV line circuit 1, near Sidney. a. Apply fault at the Sidney 345kV bus. b. Clear fault after 6 cycles by tripping the faulted line.
8	FLT08-3PH	3 phase fault on the Sidney (659133) to SIDNEY2-LNX (659426) to Laramie (659131) 345kV line circuit 1, near Sidney. a. Apply fault at the Sidney 345kV bus. b. Clear fault after 6 cycles by tripping the faulted line.

Table 2-5: Case List with Contingency Description

Ref. No.	Cont. Name	Description
9	FLT09-3PH	3 phase fault on the Sidney (659134) to Sidney West (652584) 230kV line circuit 1, near Sidney. a. Apply fault at the Sidney 230 kV bus. b. Clear fault after 6 cycles, trip the faulted line, and remove the fault. c. Block the DC tie at SIDNEY 4.
10	FLT10-3PH	3 phase fault on the Ogalala (640302) to Sidney (659134) 230 kV line circuit 1, near Ogalala. a. Apply fault at the Ogalala 230kV bus. b. Clear fault after 6 cycles and trip the faulted line and remove fault.
11	FLT11-3PH	3 phase fault on the Ogalala 230/115/13.8kV (640302/640304/643115) Transformer circuit 1, near Ogalala 230 kV. a. Apply fault at the Ogalala 230 kV bus. b. Clear fault after 6 cycles and trip the faulted transformer.
12	FLT12-3PH	3 phase fault on the Ogalala (640302) to Gentleman (640184) 230 kV line circuit 1, near Ogalala. a. Apply fault at the Ogalala 230kV bus. b. Clear fault after 6 cycles and trip the faulted line and remove fault.
13	FLT13-3PH	3 phase fault on the Gentleman (640183) to Keystone (640252) 345kV line circuit 1, near Gentleman. a. Apply fault at the Gentleman 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
14	FLT14-3PH	3 phase fault on the Gentleman 345/230/13.8kV (640183/640184/643066) Transformer, near Gentleman. a. Apply fault at the Gentleman 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
15	FLT15-3PH	3 phase fault on the Gentleman 345/230/13.8kV (640183/640184/640185) Transformer, near Gentleman. a. Apply fault at the Gentleman 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
16	FLT16-3PH	3 phase fault on the Gentleman (640183) to Red Willow (640325) 345kV line circuit 1, near Gentleman. a. Apply fault at the Gentleman 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.

Table 2-5: Case List with Contingency Description

Ref. No.	Cont. Name	Description
17	FLT17-3PH	3 phase fault on the Gentleman (640183) to Sweetwater (640374) 345kV line circuit 1, near Gentleman. a. Apply fault at the Gentleman 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
18	FLT18-3PH	3 phase fault on the Keystone (640252) to Gentleman (640183) 345kV line circuit 1, near Keystone. a. Apply fault at the Keystone 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
19	FLT19-3PH	3 phase fault on the Keystone (640252) to SIDNEY1-LNX (659425) to Sidney (659133) 345kV line circuit 1, near Keystone. a. Apply fault at the Keystone 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
20	FLT20-3PH	3 phase fault on the Keystone 345/115/13.8kV (640252/640253/640254) Transformer, near Keystone. a. Apply fault at the Keystone 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
21	FLT21-3PH	3 phase fault on the Holt County (640510) to GRPRAR1-LNX3 (652832) to Grand Prairie (652532) 345kV line circuit 1, near Holt County. a. Apply fault at the Holt County 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
22	FLT22-3PH	3 phase fault on the Holt County (640510) to GRISLD-LNX3 (653871) to Grand Island (653571) 345kV line circuit 1, near Holt County. a. Apply fault at the Holt County 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
23	FLT23-3PH	3 phase fault on the Grand Prairie (652532) to GRPRAR1-LNX3 (652832) to Holt County (640510) 345kV line circuit 1, near Grand Prairie. a. Apply fault at the Grand Prairie 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
24	FLT24-3PH	3 phase fault on the Grand Prairie (652532) to GRPRAR2-LNX3 (652833) to FTTHOM2-LNX3 (652807) to Ft Thompson (652506) 345kV line circuit 1, near Grand Prairie. a. Apply fault at the Grand Prairie 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.

Table 2-5: Case List with Contingency Description

Ref. No.	Cont. Name	Description
25	FLT25-3PH	3 phase fault on the Grand Island (653571) to GRISLD-LNX3 (653871) to Holt County (640510) 345kV line circuit 1, near Grand Island. a. Apply fault at the Grand Island 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
26	FLT26-3PH	3 phase fault on the Grand Island (653571) to Sweetwater (640374) 345kV line circuit 1, near Grand Island. a. Apply fault at the Grand Island 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
27	FLT27-3PH	3 phase fault on the Grand Island (653571) to McCool (640271) 345kV line circuit 1, near Grand Island. a. Apply fault at the Grand Island 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
28	FLT28-3PH	3 phase fault on the Grand Island 345/115/13.8kV (653571/640200/653314) Transformer, near Grand Island. a. Apply fault at the Grand Island 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
29	FLT29-3PH	3 phase fault on the Sweetwater (640374) to Axtell (640065) 345kV line circuit 1, near Sweetwater. a. Apply fault at the Sweetwater 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
30	FLT30-3PH	3 phase fault on the Sweetwater (640374) to Grand Island (653571) 345kV line circuit 1, near Sweetwater. a. Apply fault at the Sweetwater 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
31	FLT31-3PH	3 phase fault on the Sweetwater (640374) to Gentleman (640183) 345kV line circuit 1, near Sweetwater. a. Apply fault at the Sweetwater 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
32	FLT32-3PH	3 phase fault on the Axtell (640065) to Pauline (640312) 345kV line circuit 1, near Axtell. a. Apply fault at the Axtell 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.

Table 2-5: Case List with Contingency Description

Ref. No.	Cont. Name	Description
33	FLT33-3PH	3 phase fault on the Axtell 345/115/13.8kV (640065/640066/640067) Transformer, near Axtell. a. Apply fault at the Axtell 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
34	FLT34-3PH	3 phase fault on the Axtell (640065) to G16-050-Tap (560082) 345kV line circuit 1, near Axtell. a. Apply fault at the Axtell 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
35	FLT35-3PH	3 phase fault on the G16-050-Tap (560082) to Post Rock (530583) 345kV line circuit 1, near G16-050-Tap. a. Apply fault at the G16-050-Tap 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
36	FLT36-3PH	3 phase fault on the Stegall 3 (659135) to Sidney (659133) 345kV line circuit 1, near Stegall 3. a. Apply fault at the Stegall 3 345kV bus. b. Clear fault after 6 cycles by tripping the faulted line.
37	FLT37-3PH	3 phase fault on the Stegall 345/230/13.8kV (659135/659206/659167) Transformer, near Stegall3. a. Apply fault at the Stegall 345kV bus. b. Clear fault after 6 cycles by tripping the faulted line.
38	FLT38-3PH	3 phase fault on the Stegall 3 (659135) to G16-110-Tap (587874) 345kV line circuit 1, near Stegall 3. a. Apply fault at the Stegall 3 345kV bus. b. Clear fault after 6 cycles by tripping the faulted line.
39	FLT39-3PH	3 phase fault on the Sidney (653572/659134/659803) 115/230/13.8kV transformer, near Sidney. a. Apply fault at the Sidney 115kV bus. b. Clear fault after 6.5 cycles by tripping the faulted line.
40	FLT40-3PH	3 phase fault on the Sidney (653572) to Colton (659817) 115kV line circuit 1, near Sidney. a. Apply fault at the Sidney 115kV bus. b. Clear fault after 6.5 cycles by tripping the faulted line.

Table 2-5: Case List with Contingency Description

Ref. No.	Cont. Name	Description
41	FLT41-3PH	3 phase fault on the Colton (659817) to Chappel (653300) 115kV line circuit 1, near Colton. a. Apply fault at the Colton 115kV bus. b. Clear fault after 6.5 cycles by tripping the faulted line.
42	FLT42-3PH	3 phase fault on the Sidney (659134) to Sidney Transformer (659210) 230kV line circuit 1, near Sidney. a. Apply fault at the Sidney 230kV bus. b. Clear fault after 6 cycles by tripping the faulted line.
43	FLT43-3PH	3 phase fault on the Chappel (653300) to JULSTAP7 (640246) 115kV line circuit 1, near Colton. a. Apply fault at the Chappel 115kV bus. b. Clear fault after 6.5 cycles by tripping the faulted line.
44	FLT44-3PH	3 phase fault on the Pauline (640312) to G15-088-Tap (560062) 345kV line circuit 1, near Pauline. a. Apply fault at the Pauline 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
45	FLT45-3PH	3 phase fault on the Pauline (640312) to Axtell (640065) 345kV line circuit 1, near Pauline. a. Apply fault at the Pauline 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
46	FLT46-3PH	3 phase fault on the Pauline (640312/640313/640315) 345/115/13.8kV transformer, near Pauline. a. Apply fault at the Pauline 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
47	FLT47-3PH	3 phase fault on the Moore (640277) to Cooper (640139) 345kV line circuit 1, near Moore. a. Apply fault at the Moore 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
48	FLT48-3PH	3 phase fault on the Moore (640277) to Rokeby (650189) 345kV line circuit 1, near Moore. a. Apply fault at the Moore 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.

Table 2-5: Case List with Contingency Description

Ref. No.	Cont. Name	Description
49	FLT49-3PH	3 phase fault on the Moore (640277) to NW68HOLDRG3 (650114) 345kV line circuit 1, near Moore. a. Apply fault at the Moore 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
50	FLT50-3PH	3 phase fault on the Moore (640277) to G15-088-Tap (560062) 345kV line circuit 1, near Moore. a. Apply fault at the Moore 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
51	FLT51-3PH	3 phase fault on the Moore/Sheldon (640277/640278/640280) 345/115/13.8kV transformer, near Moore. a. Apply fault at the Moore 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
52	FLT52-SB	**Stegall 345kV Stuck Breaker Scenario 1** a. Apply single phase fault at the Stegall (659135) 345kV bus. b. Wait 16 cycles and remove fault. c. Trip Stegall (659135) to G16-110-Tap (587874) 345kV line circuit 1. d. Trip Stegall (659135) to Sidney (659133) 345kV line circuit 1
53	FLT53-SB	**Stegall 345kV Stuck Breaker Scenario 2** a. Apply single phase fault at the Stegall (659135) 345kV bus. b. Wait 16 cycles and remove fault. c. Trip Stegall 345/230/13.8kV (659135/659206/659167) Transformer d. Trip Stegall 345/115/13.8kV (659135/640530/640531) Transformer
54	FLT54-SB	**Sidney 230 kV Stuck Breaker Scenario 1** a. Apply single phase fault at the Sidney (659134) 230kV bus. b. Wait 16 cycles and remove fault. c. Trip Sidney (659134) to Sidney Transformer (659210) 230kV line circuit 1. d. Trip Sidney (659134) to Ogalala (640302) 230kV line circuit 1. e. Block the DC tie at SIDNEY 4 f. Drop shunt at SIDNEY 4

Table 2-5: Case List with Contingency Description

Ref. No.	Cont. Name	Description
55	FLT55-SB	**Sidney 230 kV Stuck Breaker Scenario 2** a. Apply single phase fault at the Sidney (659134) 230kV bus. b. Wait 16 cycles and remove fault. c. Trip Sidney (659134) to Sidney Transformer (659210) 230kV line circuit 1. d. Trip Sidney (659134) 230 kV / (653572) 115 kV / (659803) 13.8 kV transformer circuit 1. e. Block the DC tie at SIDNEY 4 f. Drop shunt at SIDNEY 4
56	FLT56-SB	**Sidney 115 kV Stuck Breaker** a. Apply single phase fault at the Sidney (653572) 115kV bus. b. Wait 16 cycles and remove fault. c. Trip Sidney (653572) to Colton (659817) 115kV line circuit 1. d. Trip Sidney (653572/659134/659803) 115/230/13.8kV transformer.
57	FLT57-SB	**Keystone 345kV Stuck Breaker Scenario 1** a. Apply single phase fault at the Keystone (640252) 345kV b. Run 16 cycles, remove fault. c. Trip line from Keystone (640252) to SIDNEY-LNX (659425) to Sidney (659133) 345kV line circuit 1 d. Trip line from Keystone (640252) to Gentleman (640183) 345kV line circuit 1
58	FLT58-SB	**Keystone 345kV Stuck Breaker Scenario 2** a. Apply single phase fault at the Keystone (640252) 345kV b. Run 16 cycles, remove fault. c. Trip line from Keystone (640252) to Gentleman (640183) 345kV line circuit 1 d. Disconnect three winding transformer at bus 640252/640253/640254
59	FLT59-SB	**Gentleman 345kV Stuck Breaker Scenario 1** a. Apply single phase fault at the Gentleman (640183) 345kV bus. b. Wait 13.5 cycles and remove fault. c. Trip Gentleman (640183) to Keystone (640252) 345kV line circuit 1. d. Trip Gentleman 345/230/13.8kV (640183/640184/640185) Transformer.
60	FLT60-SB	**Reserved**
61	FLT61-SB	**Gentleman 345kV Stuck Breaker Scenario 2** a. Apply single phase fault at the Gentleman (640183) 345kV bus. b. Wait 13.5 cycles and remove fault. c. Trip Gentleman (640183) to Sweetwater (640374) 345kV line circuit 2. d. Trip Gentleman (640183) to Red Willow (640325) 345kV line circuit 1.

Table 2-5: Case List with Contingency Description

Ref. No.	Cont. Name	Description
62	FLT62-SB	**Reserved**
63	FLT63-SB	**Holt County 345kV Stuck Breaker Scenario 1** a. Apply single phase fault at the Holt County (640510) 345kV bus. b. Wait 16 cycles and remove fault. c. Trip Holt County (640510) to GR ISLD-LNX (653871) to Grand Island (653571) 345kV line circuit 1
64	FLT64-SB	**Gentleman 230 kV Stuck Breaker Scenario 1** a. Apply single phase fault at the Gentleman (640184) 230kV bus. b. Wait 15.5 cycles and remove fault. c. Trip Gentleman (640184) to Ogalala (640302) 230kV line circuit 1. d. Trip Gentleman 345/230/13.8kV (640183/640184/640185) Transformer.
65	FLT65-SB	**Sweetwater 345kV Stuck Breaker Scenario 1** a. Apply single phase fault at the Sweetwater (640374) 345kV bus. b. Wait 16 cycles and remove fault. c. Trip Sweetwater (640374) to Gentleman (640183) 345kV line circuit 1. d. Trip Sweetwater (640374) to Axtell (640065) 345kV line circuit 1.
66	FLT66-SB	**Sweetwater 345kV Stuck Breaker Scenario 2** a. Apply single phase fault at the Sweetwater (640374) 345kV bus. b. Wait 16 cycles and remove fault. c. Trip Sweetwater (640374) to Gentleman (640183) 345kV line circuit 2. d. Trip Sweetwater (640374) to Grand Island (653571) 345kV line circuit 1.
67	FLT67-SB	**Sweetwater 345kV Stuck Breaker Scenario 3** a. Apply single phase fault at the Sweetwater (640374) 345kV bus. b. Wait 16 cycles and remove fault. c. Trip Sweetwater (640374) to Axtell (640065) 345kV line circuit 1. d. Trip Sweetwater (640374) to Grand Island (653571) 345kV line circuit 1.
68	FLT68-SB	**Pauline 345kV Stuck Breaker Scenario 1** a. Apply single phase fault at the Pauline (640312) 345kV bus. b. Wait 16 cycles and remove fault. c. Trip Pauline 345/115/13.8kV (640312/640313/640315) transformer. d. Trip Pauline (640312) to Axtell (640065) 345kV line circuit 1.

Table 2-5: Case List with Contingency Description

Ref. No.	Cont. Name	Description
69	FLT69-SB	**Pauline 345kV Stuck Breaker Scenario 2** a. Apply single phase fault at the Pauline (640312) 345kV bus. b. Wait 16 cycles and remove fault. c. Trip Pauline 345/115/13.8kV (640312/640313/640315) transformer. d. Trip Pauline (640312) to G15-088-TAP (560062) 345kV line circuit 1.
70	FLT70-SB	**Moore 345kV Stuck Breaker Scenario 1** a. Apply single phase fault at the Moore (640277) 345kV bus. b. Wait 16 cycles and remove fault. c. Trip Moore 345/115/13.8kV (640277/640278/640280) transformer. d. Trip Moore (640277) to McCool (640271) 345kV line circuit 1.
71	FLT71-SB	**Moore 345kV Stuck Breaker Scenario 2** a. Apply single phase fault at the Moore (640277) 345kV bus. b. Wait 16 cycles and remove fault. c. Trip Moore (640277) to NW68HOLDRG3 (650114) 345kV line circuit 1. d. Trip Moore (640277) to 103&ROKEBY3 (650189) 345kV line circuit 1.
72	FLT72-SB	**Moore 345kV Stuck Breaker Scenario 3** a. Apply single phase fault at the Moore (640277) 345kV bus. b. Wait 16 cycles and remove fault. c. Trip Moore (640277) to Cooper (640139) 345kV line circuit 1. d. Trip Moore (640277) to G15-088-TAP (560062) 345kV line circuit 1.
73	FLT73-SB	**Grand Island 345kV Stuck Breaker Scenario** a. Apply fault at the Grand Island 345kV bus. b. Clear fault after 16 cycles and trip the following elements c. Trip Grand Island (653571) to GR ISLD-LNX3 (653871) to Holt County (640510) 345kV circuit 1 d. Trip Grand Island (653571) to Sweetwater (640374) 345kV circuit 1
74	FLT74-PO	**Prior outage on the Sidney (659133) – Laramie (659131) 345kV line circuit 1** 3 phase fault on the Stegall (659135) to Sidney (659133) 345kV line circuit 1, near Stegall. a. Apply fault at the Stegall 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.

Table 2-5: Case List with Contingency Description

Ref. No.	Cont. Name	Description
75	FLT75-PO	**Prior outage on the G16-110-TAP (587874) – Stegall (659135) 345kV line circuit 1** 3 phase fault on the Sidney (659133) to Stegall (659135) 345kV line circuit 1, near Sidney. a. Apply fault at the Sidney 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
76	FLT76-PO	**Prior outage on the G16-110-TAP (587874) – Stegall (659135) 345kV line circuit 1** 3 phase fault on the Sidney (659133) to SIDNEY-LNX (659425) to Keystone (640252) 345kV line circuit 1, near Sidney. a. Apply fault at the Sidney 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
77	FLT77-PO	**Prior outage on the Sidney (659133) – Stegall (659135) 345kV line circuit 1** 3 phase fault on the Sidney (659133) to SIDNEY-LNX (659425) to Keystone (640252) 345kV line circuit 1, near Sidney. a. Apply fault at the Sidney 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
78	FLT78-PO	**Prior outage on the Sidney (659133) – Stegall (659135) 345kV line circuit 1** 3 phase fault on the Sidney (659133) to SIDNEY2-LNX (659426) to Laramie (659131) 345kV line circuit 1, near Sidney. a. Apply fault at the Sidney 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
79	FLT79-PO	**Prior outage on the Sidney (659133) – Stegall (659135) 345kV line circuit 1** 3 phase fault on the Sidney 345/230/13.8kV (659133/659210/659168) Transformer, near Sidney. a. Apply fault at the Sidney 345kV bus. b. Clear fault after 6 cycles by tripping the faulted line.
80	FLT80-PO	**Prior outage on the Sidney (659134) – Sidney Transformer (659210) 230 kV line circuit 1** 3 phase fault on the Sidney (659133) to Stegall (659135) 345kV line circuit 1, near Sidney. a. Apply fault at the Sidney 345kV bus. b. Clear fault after 6 cycles by tripping the faulted line.

Table 2-5: Case List with Contingency Description

Ref. No.	Cont. Name	Description
81	FLT81-PO	**Prior outage on the Sidney (659134) – Sidney Transformer (659210) 230 kV line circuit 1** 3 phase fault on the Sidney (659133) to SIDNEY-LNX (659425) to Keystone (640252) 345kV line circuit 1, near Sidney. a. Apply fault at the Sidney 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
82	FLT82-PO	**Prior outage on the Sidney (659134) – Sidney Transformer (659210) 230 kV line circuit 1** 3 phase fault on the Sidney (659133) to SIDNEY2-LNX (659426) to Laramie (659131) 345kV line circuit 1, near Sidney. a. Apply fault at the Sidney 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
83	FLT83-PO	**Prior outage on the Sweetwater (640374) – Axtell (640065) 345kV line circuit 1** 3 phase fault on the Sweetwater (640374) to Grand Island (653571) 345kV line circuit 1, near Sweetwater. a. Apply fault at the Sweetwater 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
84	FLT84-PO	**Prior outage on the Sweetwater (640374) – Axtell (640065) 345kV line circuit 1** 3 phase fault on the Sweetwater (640374) to Gentleman (640183) 345kV line circuit 1, near Sweetwater. a. Apply fault at the Sweetwater 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
85	FLT85-PO	**Prior outage on the Sweetwater (640374) – Gentleman (640183) 345kV line circuit 1** 3 phase fault on the Sweetwater (640374) to Grand Island (653571) 345kV line circuit 1, near Sweetwater. a. Apply fault at the Sweetwater 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.

Table 2-5: Case List with Contingency Description

Ref. No.	Cont. Name	Description
86	FLT86-PO	**Prior outage on the Sweetwater (640374) – Gentleman (640183) 345kV line circuit 1** 3 phase fault on the Sweetwater (640374) to Axtell (640065) 345kV line circuit 1, near Sweetwater. a. Apply fault at the Sweetwater 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
87	FLT87-PO	**Prior outage on the Sweetwater (640374) – Gentleman (640183) 345kV line circuit 1** 3 phase fault on the Sweetwater (640374) to Gentleman (640183) 345kV line circuit 2, near Sweetwater. a. Apply fault at the Sweetwater 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
88	FLT88-PO	**Prior outage on the Pauline 345/115/13.8kV (640312/640313/640315) transformer** 3 phase fault on the Pauline (640312) to Axtell (640065) 345kV line circuit 1, near Pauline. a. Apply fault at the Pauline 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
89	FLT89-PO	**Prior outage on the Pauline 345/115/13.8kV (640312/640313/640315) transformer** 3 phase fault on the Pauline (640312) to G15-088-Tap (560062) 345kV line circuit 1, near Pauline. a. Apply fault at the Pauline 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
90	FLT90-PO	**Prior outage on the Pauline 345/115/13.8kV (640312/640313/640315) transformer** 3 phase fault on the G15-088-Tap (560062) to Moore (640277) 345kV line circuit 1, near G15-088-Tap. a. Apply fault at the G15-088-Tap 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.

Table 2-5: Case List with Contingency Description

Ref. No.	Cont. Name	Description
91	FLT91-PO	**Prior outage on the Moore (640277) - COOPER 3 (640139) 345kV kV line circuit 1** 3 phase fault on the Moore (640277) to COOPER 3 (640139) 345kV line circuit 1, near Moore. a. Apply fault at the Moore 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
92	FLT92-PO	**Prior outage on the Moore (640277) - COOPER 3 (640139) 345kV kV line circuit 1** 3 phase fault on the Moore (640277) to 103&ROKEBY3 (650189) 345kV line circuit 1, near Moore. a. Apply fault at the Moore 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
93	FLT93-PO	**Prior outage on the Moore (640277) - COOPER 3 (640139) 345kV kV line circuit 1** 3 phase fault on the Moore (640277) to NW68HOLDRG3 (650114) 345kV line circuit 1, near Moore. a. Apply fault at the Moore 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
94	FLT94-PO	**Prior outage on the Moore (640277) - COOPER 3 (640139) 345kV kV line circuit 1** 3 phase fault on the G15-088-Tap (560062) to Pauline (640312) 345kV line circuit 1, near G15-088-Tap. a. Apply fault at the G15-088-Tap 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
95	FLT95-PO	**Prior outage on the Gentleman (640183/640184/640185) 345/230/13.8kV transformer** 3 phase fault on the Gentleman (640183) to Keystone (640252) 345kV line circuit 1, near Gentleman. a. Apply fault at the Gentleman 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.

Table 2-5: Case List with Contingency Description

Ref. No.	Cont. Name	Description
96	FLT96-PO	**Prior outage on the Gentleman (640183/640184/640185) 345/230/13.8kV transformer** 3 phase fault on the Gentleman (640183) to Red Willow (640325) 345kV line circuit 1, near Gentleman. a. Apply fault at the Gentleman 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
97	FLT97-PO	**Prior outage on the Gentleman (640183/640184/640185) 345/230/13.8kV transformer** 3 phase fault on the Gentleman (640183) to Sweetwater (640374) 345kV line circuit 1, near Gentleman. a. Apply fault at the Gentleman 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
98	FLT98-PO	**Prior Outage of Sidney (653572) to Colton (659817) 115kV line circuit 1;** 3 phase fault on the Sidney (653572/659134/659803) 115/230/13.8kV transformer, near Sidney. a. Apply fault at the Sidney 115kV bus. b. Clear fault after 6.5 cycles by tripping the faulted line.
99	FLT99-PO	**Prior Outage of Grand Prairie 345kV (652532) to GRPRAR1-LNX3 (652832) to Holt County (640510) 345kV CKT 1;** 3 phase fault on the Grand Island (653571) to Sweetwater (640374) 345kV line circuit 1, near Grand Island. a. Apply fault at the Grand Island 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
100	FLT100-PO	**Prior Outage of Grand Prairie 345kV (652532) to GRPRAR1-LNX3 (652832) to Holt County (640510) 345kV CKT 1;** 3 phase fault on the Grand Island (653571) to McCool (640271) 345kV line circuit 1, near Grand Island. a. Apply fault at the Grand Island 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
101	FLT101-SB	**Red Willow 345kV Stuck Breaker Scenario 1** a. Apply single phase fault at the Red Willow (640325) 345kV bus. b. Wait 16 cycles and remove fault. c. Trip Red Willow (640325/640326/640327) 345/115kV transformer. d. Trip Red Willow (640325) to Mingo (531451) 345kV line circuit 1.

Table 2-5: Case List with Contingency Description

Ref. No.	Cont. Name	Description
102	FLT102-SB	**Red Willow 345kV Stuck Breaker Scenario 2** a. Apply single phase fault at the Red Willow (640325) 345kV bus. b. Wait 16 cycles and remove fault. c. Trip Red Willow (640325) to Gentleman (640183) 345kV line circuit 1. d. Trip Red Willow (640325) to Mingo (531451) 345kV line circuit 1.
103	FLT103-SB	**Post Rock 345kV Stuck Breaker Scenario 1** a. Apply single phase fault at the Post Rock (530583) 345kV b. Run 16 cycles, remove fault. c. Trip Post Rock (530583) to GEN-2016-050-Tap (560082) 345kV line circuit 1 d. Trip Post Rock (530583) to Spearville (531469) 345kV line circuit 1
104	FLT104-SB	**Post Rock 345kV Stuck Breaker Scenario 2** a. Apply single phase fault at the Post Rock (530583) 345kV b. Run 16 cycles, remove fault. c. Trip Post Rock (530583/530584/530673) 345/230kV transformer d. Trip Post Rock (530583) to Spearville (531469) 345kV line circuit 1

Table 2-6: Additional Contingencies with Mitigation Implemented

Ref. No.	Cont. Name	Description
105	FLT105-3PH	3 phase fault on the Holt County (640510) to Thedford (640500) 345kV line circuit 1, near Holt County. a. Apply fault at the Holt County 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
106	FLT106-3PH	3 phase fault on the Thedford (640500) to Holt County (640510) 345kV line circuit 1, near Thedford. a. Apply fault at the Thedford 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
107	FLT107-3PH	3 phase fault on the Thedford (640500) to Gentleman (640183) 345kV line circuit 1, near Thedford. a. Apply fault at the Thedford 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
108	FLT108-3PH	3 phase fault on the Thedford 345/115/13.8kV (640500/640381/640570) Transformer, near Thedford. a. Apply fault at the Thedford 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
109	FLT109-SB	**Thedford 345kV Stuck Breaker Scenario 1** a. Apply single phase fault at the Thedford (640500) 345kV bus. b. Wait 16 cycles and remove fault. c. Trip Thedford (640500) to Holt County (640510) 345kV line circuit 1. d. Trip Thedford (640500) to Gentleman (640183) 345kV line circuit 1
110	FLT110-SB	**Holt County 345kV Stuck Breaker Scenario 2** a. Apply single phase fault at the Holt County (640510) 345kV bus. b. Wait 16 cycles and remove fault. c. Trip Holt County (640510) to Thedford (640500) 345kV line circuit 1. d. Trip Holt County (640510) to Antelope 345kV circuit 1.
111	FLT111-SB	**Holt County 345kV Stuck Breaker Scenario 3** a. Apply single phase fault at the Holt County (640510) 345kV bus. b. Wait 16 cycles and remove fault. c. Trip Holt County (640510) to GEN-2015-023 (584650) 345kV line circuit 1. d. Trip Holt County (640510) to Antelope 345kV circuit 1.

Table 2-6: Additional Contingencies with Mitigation Implemented

Ref. No.	Cont. Name	Description
112	FLT112-SB	**Holt County 345kV Stuck Breaker Scenario 4** a. Apply single phase fault at the Holt County (640510) 345kV bus. b. Wait 16 cycles and remove fault. c. Trip Holt County (640510) to GR ISLD-LNX (653871) to Grand Island (653571) 345kV line circuit 1. d. Trip Holt County (640510) to GRPRAR1-LNX3 (652832) to Grand Prairie (652532 345kV line circuit 1
113	FLT113-SB	**Gentleman 345kV Stuck Breaker Scenario 6** a. Apply single phase fault at the Gentleman (640183) 345kV bus. b. Wait 13.5 cycles and remove fault. c. Trip Gentleman (640183) to Sweetwater (640374) 345kV line circuit 1. d. Trip Gentleman (640183) to Thedford (640500) 345kV line circuit 1.
114	FLT114-PO	**Prior Outage of Thedford (640500) to Gentleman (640183) 345kV line circuit 1;** 3 phase fault on the Holt County (640510) to GR ISLD-LNX (653871) to Grand Island (653571) 345kV line circuit 1, near Holt County a. Apply fault at the Holt County 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
115	FLT115-PO	**Prior Outage of Thedford (640500) to Gentleman (640183) 345kV line circuit 1;** 3 phase fault on the Holt County (640510) to GRPRAR1-LNX3 (652832) to Grand Prairie (652532) 345kV line circuit 1, near Holt County a. Apply fault at the Holt County 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
116	FLT116-PO	**Prior Outage of Thedford (640500) to Holt County (640510) 345kV line circuit 1;** 3 phase fault on the Holt County (640510) to GR ISLD-LNX (653871) to Grand Island (653571) 345kV line circuit 1, near Holt County a. Apply fault at the Holt County 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
117	FLT117-PO	**Prior Outage of Thedford (640500) to Holt County (640510) 345kV line circuit 1;** 3 phase fault on the Holt County (640510) to GRPRAR1-LNX3 (652832) to Grand Prairie (652532) 345kV line circuit 1, near Holt County a. Apply fault at the Holt County 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.

Table 2-6: Additional Contingencies with Mitigation Implemented

Ref. No.	Cont. Name	Description
118	FLT118-PO	**Prior Outage of Thedford (640500) to Holt County (640510) 345kV line circuit 1;** 3 phase fault on the Gentleman (640183) to Keystone (640252) 345kV line circuit 1, near Gentleman. a. Apply fault at the Gentleman 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
119	FLT119-PO	**Prior Outage of Thedford (640500) to Holt County (640510) 345kV line circuit 1;** 3 phase fault on the Gentleman (640183) to Red Willow (640374) 345kV line circuit 1, near Gentleman. a. Apply fault at the Gentleman 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
120	FLT120-PO	**Prior Outage of Thedford (640500) to Holt County (640510) 345kV line circuit 1;** 3 phase fault on the Gentleman (640183) to Sweetwater (640374) 345kV line circuit 1, near Gentleman. a. Apply fault at the Gentleman 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
121	FLT121-SB	**Red Willow 345kV Stuck Breaker Scenario 3** a. Apply single phase fault at the Red Willow (640325) 345kV bus. b. Wait 16 cycles and remove fault. c. Trip Red Willow (640325) to Keystone (640252) 345kV line circuit 1. d. Trip Red Willow (640325) to Post Rock (530583) 345kV line circuit 1.
122	FLT122-SB	**Keystone 345kV Stuck Breaker Scenario 3** a. Apply single phase fault at the Keystone (640252) 345kV b. Run 16 cycles, remove fault. c. Trip line from Keystone (640252) to SIDNEY-LNX (659425) to Sidney (659133) 345kV line circuit 1 d. Trip line from Keystone (640252) to Red Willow (640325) 345kV line circuit 1
123	FLT123-SB	**Keystone 345kV Stuck Breaker Scenario 4** a. Apply single phase fault at the Keystone (640252) 345kV b. Run 16 cycles, remove fault. c. Trip line from Keystone (640252) to Gentleman (640183) 345kV line circuit 1 d. Trip line from Keystone (640252) to Red Willow (640325) 345kV line circuit 1

Table 2-6: Additional Contingencies with Mitigation Implemented

Ref. No.	Cont. Name	Description
124	FLT124-SB	**Keystone 345kV Stuck Breaker Scenario 5** a. Apply single phase fault at the Keystone (640252) 345kV b. Run 16 cycles, remove fault. c. Trip line from Keystone (640252) to Red Willow (640325) 345kV line circuit 1 d. Disconnect three winding transformer at bus 640252/640253/640254
125	FLT125-SB	**Post Rock 345kV Stuck Breaker Scenario 3** a. Apply single phase fault at the Post Rock (530583) 345kV b. Run 16 cycles, remove fault. c. Trip Post Rock (530583) to Red Willow (640325) 345kV line circuit 1 d. Trip Post Rock (530583) to Spearville (531469) 345kV line circuit 1
126	FLT126-SB	**Post Rock 345kV Stuck Breaker Scenario 4** a. Apply single phase fault at the Post Rock (530583) 345kV b. Run 16 cycles, remove fault. c. Trip Post Rock (530583) to GEN-2016-050-Tap (560082) 345kV line circuit 1 d. Trip Post Rock (530583) to Red Willow (640325) 345kV line circuit 1
127	FLT127-3PH	3 phase fault on the Holt County (640510) to Antelope (640520) 345kV line circuit 1, near Holt County. a. Apply fault at the Holt County 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
128	FLT128-3PH	3 phase fault on the Keystone (640252) to Red Willow (640325) 345kV line circuit 1, near Keystone. a. Apply fault at the Keystone 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
129	FLT129-3PH	3 phase fault on the Red Willow (640325) to Post Rock (530583) 345kV line circuit 1, near Red Willow. a. Apply fault at the Red Willow 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.

SECTION 3: STABILITY ANALYSIS

The objective of the Stability Analysis was to determine the impacts of the generator interconnections on the stability and voltage recovery on the SPP transmission system. If problems with stability or voltage recovery were identified, the need for reactive compensation or Network Upgrades was investigated.

3.1 Approach

MEPPI utilized the three (3) following DISIS-2016-002-1 Normal Dispatch Scenario power flow cases and dynamic databases:

- MDWG16-17W_DIS16021_G09
- MDWG16-18S_DIS16021_G09
- MDWG16-26S_DIS16021_G09

MEPPI utilized the three (3) following DISIS-2016-002-1 High GGS Sensitivity Dispatch Scenario power flow cases and dynamic databases:

- MDWG16-17W_DIS16021_G09_GGS
- MDWG16-18S_DIS16021_G09_GGS
- MDWG16-26S_DIS16021_G09_GGS

Each case was examined prior to the Stability Analysis to ensure the case contained the proposed study projects and any previously queued projects listed in Tables 2-1 and 2-2 respectively. The Normal Dispatch Scenario and High GGS Sensitivity Scenario included previously assigned upgrades that were identified to mitigate violations of stability damping criteria, voltage recovery criteria, and generation tripping previously identified in the DISIS-2016-002 Group 09[1] System Impact Study, published on April 24, 2019 by SPP Generator Interconnections Department. The following previously assigned upgrades were removed from the DISIS-2016-002 Group 09 cases prior to running the analysis:

- SPP R Plan
    - Thedford 345/115/13.8 kV transformer
    - Gerald Gentleman Station to Thedford 345kV circuit #1
    - Holt County to Thedford 345kV circuit #1
- Gerald Gentleman Station to Keystone 345kV circuit #2
- Keystone to Sidney 345kV circuit #2
- GEN-2016-023/029 Tap on the Laramie River Station to Sidney 345kV circuit #1

[1] http://opsportal.spp.org/documents/studies/files/2016_Generation_Studies/DISIS-2016-001-4_Final_Rev2.pdf

- GEN-2016-023/029 Tap on the Laramie River Station to Stegall 345kV circuit #1

After updating the power flow cases with the above changes and dispatching units local to the study area according to SPP criteria, there was no suspect power flow data in the study area. The dynamic datasets were also verified and stable initial system conditions (i.e., “flat lines”) were achieved. Three-phase and single phase-to-ground faults listed in Table 2-5 were examined. Single-phase fault impedances were calculated for each season to result in a voltage of approximately 60% of the pre-fault voltage. Refer to Table 3-1 for a list of the calculated single-phase fault impedances.

Table 3-1: Calculated Single-Phase Fault Impedances

[1]Ref. No.	Cont. Name	Faulted Bus	Single-Phase Fault Impedance (MVA)		
			2017 Winter	2018 Summer	2026 Summer
1	FLT52-SB	Stegall (659135) 345kV	-1750.0	-1750.0	-1750.0
2	FLT53-SB	Stegall (659135) 345kV	-1750.0	-1750.0	-1750.0
3	FLT54-SB	Sidney (659134) 230 kV	-1375.0	-1375.0	-1375.0
4	FLT55-SB	Sidney (659134) 230 kV	-1375.0	-1375.0	-1375.0
5	FLT56-SB	Sidney (653572) 115 kV	-562.5	-562.5	-562.5
6	FLT57-SB	Keystone (640252) 345kV	-3218.8	-3218.8	-3218.8
7	FLT58-SB	Keystone (640252) 345kV	-3218.8	-3218.8	-3218.8
8	FLT59-SB	Gentleman (640183) 345kV	-5656.3	-5656.3	-6062.5
11	FLT61-SB	Gentleman (640183) 345kV	-5656.3	-5656.3	-6062.5
13	FLT63-SB	Holt County (640510) 345kV	-2531.2	-2265.6	-2398.4
14	FLT64-SB	Gentleman (640184) 230kV	-4640.6	-4640.6	-4843.8
15	FLT65-SB	Sweetwater (640374) 345kV	-4031.3	-4031.3	-4031.3
16	FLT66-SB	Sweetwater (640374) 345kV	-4031.3	-4031.3	-4031.3
17	FLT67-SB	Sweetwater (640374) 345kV	-4031.3	-4031.3	-4031.3
18	FLT68-SB	Pauline (640312) 345kV	-3015.6	-3218.8	-3218.8
19	FLT69-SB	Pauline (640312) 345kV	-3015.6	-3218.8	-3218.8
20	FLT70-SB	Moore (640277) 345kV	-7687.5	-8500.0	-8500.0
21	FLT71-SB	Moore (640277) 345kV	-7687.5	-8500.0	-8500.0
22	FLT72-SB	Moore (640277) 345kV	-7687.5	-8500.0	-8500.0
23	FLT73-SB	Grand Island (653571) 345kV	-4437.5	-4437.5	-4437.5
101	FLT102-SB	Red Willow (640325) 345kV	-2265.6	-2265.6	-2265.6
102	FLT101-SB	Red Willow (640325) 345kV	-2265.6	-2265.6	-2265.6
103	FLT103-SB	Post Rock (530583) 345kV	-2796.8	-3062.5	-3062.5
104	FLT104-SB	Post Rock (530583) 345kV	-2796.8	-3062.5	-3062.5
109	FLT109-SB	Thedford (640500) 345kV	-2406.3	-2406.3	-2406.3
110	FLT110-SB	Holt County (640510) 345kV	-2796.8	-2796.8	-2796.8

[1]Ref. No.	Cont. Name	Faulted Bus	Single-Phase Fault Impedance (MVA)		
			2017 Winter	2018 Summer	2026 Summer
111	FLT111-SB	Holt County (640510) 345kV	-2796.8	-2796.8	-2796.8
112	FLT112-SB	Holt County (640510) 345kV	-2796.8	-2796.8	-2796.8
113	FLT113-SB	Gentleman (640183) 345kV	-6250.0	-6250.0	-6250.0
121	FLT121-SB	Red Willow (640325) 345kV	-3328.0	-3328.0	-3593.0
122	FLT122-SB	Keystone (640510) 345kV	-3593.0	-3859.0	-3859.0
123	FLT123-SB	Keystone (640510) 345kV	-3593.0	-3859.0	-3859.0
124	FLT124-SB	Keystone (640510) 345kV	-3593.0	-3859.0	-3859.0
125	FLT125-SB	Post Rock (530583) 345kV	-3593.0	-3593.0	-3593.0
126	FLT126-SB	Post Rock (530583) 345kV	-3593.0	-3593.0	-3593.0

(1) Refer to Table 2-3 for a description of the contingency scenario. Note the fault impedances were recalculated for each change in topology (i.e. mitigation cases)

Bus voltages, machine rotor angles, and previously queued generation in the study area were monitored in addition to bus voltages and machine rotor angles in the following areas:

- 534 SUNC
- 536 WERE
- 540 GMO
- 541 KCPL
- 635 MEC
- 640 NPPD
- 645 OPPD
- 650 LES
- 652 WAPA

Requested and previously queued generation outside the above study area was also monitored.

The results of the analysis determined if reactive compensation or system upgrades were required to obtain acceptable system performance. If additional reactive compensation was required, the size, type, and location were determined. The proposed reactive reinforcements would ensure the wind or solar farm meets FERC Order 661A low voltage requirements and return the wind or solar farm to its pre-disturbance operating voltage. If the results indicated the need for fast responding reactive support, dynamic support such as an SVC or STATCOM was investigated.

3.2 Normal Dispatch Stability Analysis Results

The Normal Dispatch Stability Analysis determined that there were multiple contingencies across all seasons that resulted in voltage collapse/instability, generation tripping offline, and poor post-fault voltage recovery when all generation interconnection requests were at 100% output. The 2017 Winter Peak ("17WP"), 2018 Summer Peak ("18SP") and 2026 Summer Peak ("26SP") cases were observed to result in voltage collapse and voltage instability in the Gentleman 345kV and Laramie River Station 345kV local area.

Refer to Table 3-2 for a summary of the Stability Analysis results without additional reinforcements for the contingencies listed in Table 2-5. Table 3-2 is a summary of the stability results for the 17WP, 18SP, and 26SP conditions and states whether the system remained stable or generation tripped offline, if acceptable voltage recovery was observed after the fault was cleared, and if the voltage recovered to above 0.9 p.u. and below 1.1 p.u. post fault steady-state conditions. Voltage recovery criteria includes ensuring that the transient voltage recovery is between 0.7 p.u. and 1.2 p.u. and ending in a steady-state voltage (for N-1 contingencies) at the pre-contingent level or at least above 0.9 p.u. and below 1.1. p.u.

It was observed that the limiting faults for the normal dispatch scenarios were NERC Category P1 events near Laramie River Station 345kV as well as Holt 345kV and NERC Category P4 events at Gentleman 345kV. After examining the results without additional reinforcements, the previously studied R-Plan Network Upgrade was investigated to determine the impacts of the following additional transmission elements:

- SPP R Plan
    - Thedford 345/115/13.8 kV transformer
    - Gerald Gentleman Station to Thedford 345kV circuit #1
    - Holt County to Thedford 345kV circuit #1

Refer to Table 3-3 for a summary of the Stability Analysis results with the R-Plan Network Upgrade in-service for the contingencies listed in Table 2-5 and additional contingencies listed in Table 2-6. Table 3-3 is a summary of the stability results for the 17WP, 18SP, and 26SP conditions and states whether the system remained stable or generation tripped offline, if acceptable voltage recovery was observed after the fault was cleared, and if the voltage recovered to above 0.9 p.u. and below 1.1 p.u. post fault steady-state conditions.

Table 3-2: Summary of Results for 17WP, 18SP, and 26SP Conditions without Reinforcements

Ref. No.	Fault Number	2017 Winter Peak				2018 Summer Peak				2026 Summer Peak			
		Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability
		Less than 0.7 p.u.	Greater than 1.2 p.u.			Less than 0.7 p.u.	Greater than 1.2 p.u.			Less than 0.7 p.u.	Greater than 1.2 p.u.		
1	FLT01-3PH	Voltage Collapse				Voltage Collapse				Voltage Collapse			
2	FLT02-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
3	FLT03-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
4	FLT04-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
5	FLT05-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
6	FLT06-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
7	FLT07-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
8	FLT08-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
9	FLT09-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
10	FLT10-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
11	FLT11-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
12	FLT12-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
13	FLT13-3PH	Voltage Collapse				No	No	Compliant	Stable	No	No	Compliant	Stable
14	FLT14-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
15	FLT15-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
16	FLT16-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
17	FLT17-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
18	FLT18-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
19	FLT19-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
20	FLT20-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
21	FLT21-3PH	No	No	Volt oscliiations	Stable	No	No	Volt oscliiations	Stable	No	No	Volt oscliiations	Stable
22	FLT22-3PH	No	No	Volt oscliiations	G16-075 instability	No	No	Volt oscliiations	G16-075 instability	No	No	Volt oscliiations	G16-075 instability
23	FLT23-3PH	No	Yes	High voltages	Stable	No	Yes	High voltages	Stable	No	Yes	High voltages	G16-075 trips
24	FLT24-3PH	No	No	Volt oscliiations	G16-075 instability	No	No	Volt oscliiations	G16-075 instability	No	No	Volt oscliiations	G16-075 instability
25	FLT25-3PH	No	No	Volt oscliiations	G16-075 instability	No	No	Volt oscliiations	G16-075 instability	No	No	Volt oscliiations	G16-075 instability
26	FLT26-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable

Table 3-2: Summary of Results for 17WP, 18SP, and 26SP Conditions without Reinforcements (cont.)

Ref. No.	Fault Number	2017 Winter Peak				2018 Summer Peak				2026 Summer Peak			
		Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability
		Less than 0.7 p.u.	Greater than 1.2 p.u.			Less than 0.7 p.u.	Greater than 1.2 p.u.			Less than 0.7 p.u.	Greater than 1.2 p.u.		
27	FLT27-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
28	FLT28-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
29	FLT29-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
30	FLT30-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
31	FLT31-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
32	FLT32-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
33	FLT33-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
34	FLT34-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
35	FLT35-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
36	FLT36-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
37	FLT37-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
38	FLT38-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
39	FLT39-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
40	FLT40-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
41	FLT41-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
42	FLT42-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
43	FLT43-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
44	FLT44-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
45	FLT45-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
46	FLT46-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
47	FLT47-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
48	FLT48-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
49	FLT49-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
50	FLT50-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
51	FLT51-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
52	FLT52-SB	No	No	Low post-fault voltage Sidney 345kV	Stable	No	No	Low post-fault voltage Sidney 345kV	Stable	No	No	Compliant	Stable

Table 3-2: Summary of Results for 17WP, 18SP, and 26SP Conditions without Reinforcements (cont.)

Ref. No.	Fault Number	2017 Winter Peak				2018 Summer Peak				2026 Summer Peak			
		Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability
		Less than 0.7 p.u.	Greater than 1.2 p.u.			Less than 0.7 p.u.	Greater than 1.2 p.u.			Less than 0.7 p.u.	Greater than 1.2 p.u.		
53	FLT53-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
54	FLT54-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
55	FLT55-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
56	FLT56-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
57	FLT57-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
58	FLT58-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
59	FLT59-SB	Voltage Collapse				No	No	Compliant	Stable	No	No	Compliant	Stable
61	FLT61-SB	Voltage Collapse				No	No	Compliant	Stable	No	No	Compliant	Stable
63	FLT63-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
64	FLT64-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
65	FLT65-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
66	FLT66-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
67	FLT67-SB	Voltage Collapse				No	No	Low post-fault voltage: Mingo 345kV	Stable	No	No	Compliant	Stable
68	FLT68-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
69	FLT69-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
70	FLT70-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
71	FLT71-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
72	FLT72-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
73	FLT73-SB	No	No	Volt oscliiations	G16-075 instability	No	No	Volt oscliiations	G16-075 instability	No	No	Volt oscliiations	G16-075 instability
74	FLT74-PO	Voltage Collapse				Voltage Collapse				Voltage Collapse			
75	FLT75-PO	Voltage Collapse				Voltage Collapse				Voltage Collapse			
76	FLT76-PO	Voltage Collapse				Voltage Collapse				Voltage Collapse			
77	FLT77-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable

Table 3-2: Summary of Results for 17WP, 18SP, and 26SP Conditions without Reinforcements (cont.)

Ref. No.	Fault Number	2017 Winter Peak				2018 Summer Peak				2026 Summer Peak			
		Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability
		Less than 0.7 p.u.	Greater than 1.2 p.u.			Less than 0.7 p.u.	Greater than 1.2 p.u.			Less than 0.7 p.u.	Greater than 1.2 p.u.		
78	FLT78-PO	Voltage Collapse				Voltage Collapse				Voltage Collapse			
79	FLT79-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
80	FLT80-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
81	FLT81-PO	Voltage Collapse				Voltage Collapse				Voltage Collapse			
82	FLT82-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
83	FLT83-PO	Voltage Collapse				No	No	Low post-fault voltage: Mingo 345kV	Stable	No	No	Low post-fault voltage: Mingo 345kV	Stable
84	FLT84-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
85	FLT85-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
86	FLT86-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
87	FLT87-PO	Voltage Collapse				No	No	Compliant	Stable	No	No	Compliant	Stable
88	FLT88-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
89	FLT89-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
90	FLT90-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
91	FLT91-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
92	FLT92-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
93	FLT93-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
94	FLT94-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
95	FLT95-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
96	FLT96-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
97	FLT97-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
98	FLT98-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
99	FLT99-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
100	FLT100-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
101	FLT101-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
102	FLT102-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
103	FLT103-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
104	FLT104-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable

Table 3-3: Summary of Results for 17WP, 18SP, and 26SP Conditions with R-Plan Network Upgrade

Ref. No.	Fault Number	2017 Winter Peak				2018 Summer Peak				2026 Summer Peak			
		Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability
		Less than 0.7 p.u.	Greater than 1.2 p.u.			Less than 0.7 p.u.	Greater than 1.2 p.u.			Less than 0.7 p.u.	Greater than 1.2 p.u.		
1	FLT01-3PH	Voltage Collapse				Voltage Collapse				Voltage Collapse			
2	FLT02-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
3	FLT03-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
4	FLT04-3PH	No	No	Compliant	Stable	Voltage Collapse				No	No	Compliant	Stable
5	FLT05-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
6	FLT06-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
7	FLT07-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
8	FLT08-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
9	FLT09-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
10	FLT10-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
11	FLT11-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
12	FLT12-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
13	FLT13-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
14	FLT14-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
15	FLT15-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
16	FLT16-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
17	FLT17-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
18	FLT18-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
19	FLT19-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
20	FLT20-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
21	FLT21-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
22	FLT22-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
23	FLT23-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
24	FLT24-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
25	FLT25-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
26	FLT26-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable

Table 3-3: Summary of Results for 17WP, 18SP, and 26SP Conditions with R-Plan Network Upgrade (cont.)

Ref. No.	Fault Number	2017 Winter Peak				2018 Summer Peak				2026 Summer Peak			
		Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability
		Less than 0.7 p.u.	Greater than 1.2 p.u.			Less than 0.7 p.u.	Greater than 1.2 p.u.			Less than 0.7 p.u.	Greater than 1.2 p.u.		
27	FLT27-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
28	FLT28-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
29	FLT29-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
30	FLT30-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
31	FLT31-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
32	FLT32-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
33	FLT33-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
34	FLT34-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
35	FLT35-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
36	FLT36-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
37	FLT37-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
38	FLT38-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
39	FLT39-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
40	FLT40-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
41	FLT41-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
42	FLT42-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
43	FLT43-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
44	FLT44-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
45	FLT45-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
46	FLT46-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
47	FLT47-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
48	FLT48-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
49	FLT49-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
50	FLT50-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
51	FLT51-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
52	FLT52-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable

Table 3-3: Summary of Results for 17WP, 18SP, and 26SP Conditions with R-Plan Network Upgrade (cont.)

Ref. No.	Fault Number	2017 Winter Peak				2018 Summer Peak				2026 Summer Peak			
		Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability
		Less than 0.7 p.u.	Greater than 1.2 p.u.			Less than 0.7 p.u.	Greater than 1.2 p.u.			Less than 0.7 p.u.	Greater than 1.2 p.u.		
53	FLT53-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
54	FLT54-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
55	FLT55-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
56	FLT56-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
57	FLT57-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
58	FLT58-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
59	FLT59-SB	Voltage Collapse				No	No	Compliant	Stable	No	No	Compliant	Stable
61	FLT61-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
63	FLT63-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
64	FLT64-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
65	FLT65-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
66	FLT66-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
67	FLT67-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
68	FLT68-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
69	FLT69-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
70	FLT70-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
71	FLT71-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
72	FLT72-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
73	FLT73-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
74	FLT74-PO	Voltage Collapse				Voltage Collapse				Voltage Collapse			
75	FLT75-PO	Voltage Collapse				Voltage Collapse				Voltage Collapse			
76	FLT76-PO	Voltage Collapse				Voltage Collapse				Voltage Collapse			
77	FLT77-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable

Table 3-3: Summary of Results for 17WP, 18SP, and 26SP Conditions with R-Plan Network Upgrade (cont.)

Ref. No.	Fault Number	2017 Winter Peak				2018 Summer Peak				2026 Summer Peak			
		Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability
		Less than 0.7 p.u.	Greater than 1.2 p.u.			Less than 0.7 p.u.	Greater than 1.2 p.u.			Less than 0.7 p.u.	Greater than 1.2 p.u.		
78	FLT78-PO	Voltage Collapse				Voltage Collapse				Voltage Collapse			
79	FLT79-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
80	FLT80-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
81	FLT81-PO	Voltage Collapse				Voltage Collapse				Voltage Collapse			
82	FLT82-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
83	FLT83-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
84	FLT84-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
85	FLT85-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
86	FLT86-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
87	FLT87-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
88	FLT88-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
89	FLT89-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
90	FLT90-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
91	FLT91-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
92	FLT92-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
93	FLT93-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
94	FLT94-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
95	FLT95-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
96	FLT96-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
97	FLT97-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
98	FLT98-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
99	FLT99-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
100	FLT100-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
101	FLT101-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
102	FLT102-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
103	FLT103-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable

Table 3-3: Summary of Results for 17WP, 18SP, and 26SP Conditions with R-Plan Network Upgrade (cont.)

Ref. No.	Fault Number	2017 Winter Peak				2018 Summer Peak				2026 Summer Peak			
		Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability
		Less than 0.7 p.u.	Greater than 1.2 p.u.			Less than 0.7 p.u.	Greater than 1.2 p.u.			Less than 0.7 p.u.	Greater than 1.2 p.u.		
104	FLT104-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
105	FLT105-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
106	FLT106-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
107	FLT107-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
108	FLT108-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
109	FLT109-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
110	FLT110-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
111	FLT111-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
112	FLT112-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
113	FLT113-SB	Voltage/System Oscillations				No	No	Compliant	Stable	No	No	Compliant	Stable
114	FLT114-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
115	FLT115-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
116	FLT116-PO	No	No	Volt oscliiations	G16-075 instability	No	No	Volt oscliiations	G16-075 instability	No	No	Volt oscliiations	G16-075 instability
117	FLT117-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
118	FLT118-PO	Voltage Collapse				No	No	Compliant	Stable	No	No	Compliant	Stable
119	FLT119-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
120	FLT120-PO	No	Yes	High voltages	G16-106 trips	No	No	Compliant	Stable	No	No	Compliant	Stable

With the R-Plan Network Upgrade in-service, it was observed that the network upgrade mitigated several P1 and P4 events near Gentleman 345kV, Holt County 345kV, Grand Island 345kV, Grand Prairie 345kV, and Sweetwater 345kV. However, voltage collapse and instability was still observed for P1 events at the GEN-2016-110-Tap 345kV and P4 events at Gentleman 345kV. The following faults were observed to be mitigated with the R-Plan Network Upgrade:

- **FLT13-3PH (17WP)**: 3 phase fault on the Gentleman (640183) to Keystone (640252) 345kV line circuit 1, near Gentleman.
- **FLT21-3PH**: 3 phase fault on the Holt County (640510) to GRPRAR1-LNX3 (652832) to Grand Prairie (652532) 345kV line circuit 1, near Holt County.
- **FLT22-3PH**: 3 phase fault on the Holt County (640510) to GRISLD-LNX3 (653871) to Grand Island (653571) 345kV line circuit 1, near Holt County.
- **FLT23-3PH**: 3 phase fault on the Grand Prairie (652532) to GRPRAR1-LNX3 (652832) to Holt County (640510) 345kV line circuit 1, near Grand Prairie.
- **FLT24-3PH**: 3 phase fault on the Grand Prairie (652532) to GRPRAR2-LNX3 (652833) to FTTHOM2-LNX3 (652807) to Ft Thompson (652506) 345kV line circuit 1, near Grand Prairie.
- **FLT25-3PH**: 3 phase fault on the Grand Island (653571) to GRISLD-LNX3 (653871) to Holt County (640510) 345kV line circuit 1, near Grand Island.
- **FLT52-SB**: Stegall 345kV Stuck Breaker Scenario 1
  - Trip Stegall (659135) to G16-110-Tap (587874) 345kV line circuit 1
  - Trip Stegall (659135) to Sidney (659133) 345kV line circuit 1
- **FLT61-SB (17WP)**: Gentleman 345kV Stuck Breaker Scenario 3
  - Trip Gentleman (640183) to Sweetwater (640374) 345kV line circuit 2
  - Trip Gentleman (640183) to Red Willow (640325) 345kV line circuit 1.
- **FLT67-SB**: Sweetwater 345kV Stuck Breaker Scenario 3
  - Trip Sweetwater (640374) to Axtell (640065) 345kV line circuit 1
  - Trip Sweetwater (640374) to Grand Island (653571) 345kV line circuit 1
- **FLT73-SB**: Grand Island 345kV Stuck Breaker Scenario
  - Trip Grand Island (653571) to GR ISLD-LNX3 (653871) to Holt County (640510) 345kV circuit 1
  - Trip Grand Island (653571) to Sweetwater (640374) 345kV circuit 1

Refer to Figure 3-1 for a representative voltage plot for FLT13-3PH, which is a P1 event at Gentleman 345kV, resulting in the loss of the Gentleman to Keystone 345kV circuit.

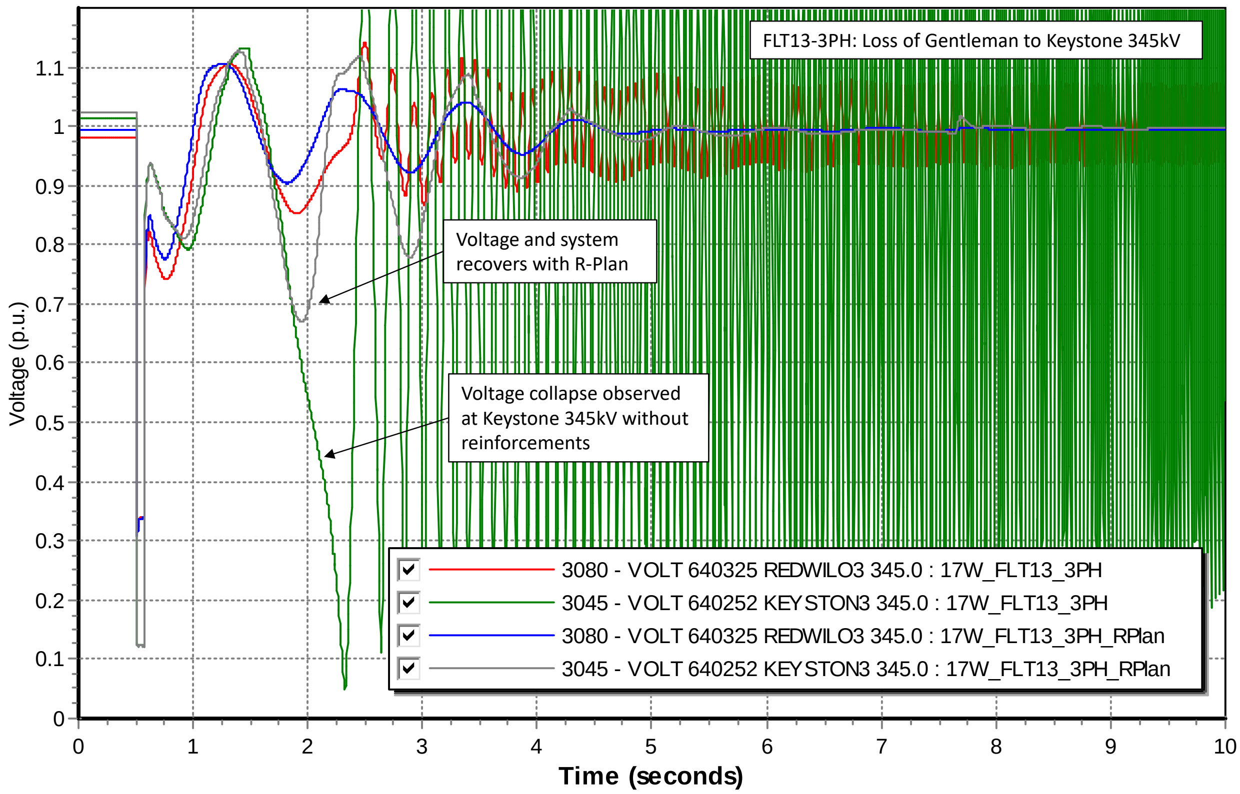

Figure 3-1: Representative voltage plot of local bus voltage for the loss of Gentleman to Keystone 345kV (17WP).

The R-Plan Network Upgrade did not improve the response for the following fault events:

- **FLT01-3PH**: 3 phase fault on the GEN-2016-110-Tap to Stegall 345kV line circuit 1, near GEN-2016-110-Tap.
- **FLT04-3PH (18SP)**: 3 phase fault on the Laramie River Station (659131) to GEN-2016-110-TAP (587874) 345kV line circuit 1, near Laramie River Station.
- **FLT59-SB (17WP)**: Gentleman 345kV Stuck Breaker Scenario 1
  - Trip Gentleman (640183) to Keystone (640252) 345kV line circuit 1
  - Trip Gentleman (640183/640184) 345/230kV Transformer

It was observed that the limiting faults for the normal dispatch scenarios were NERC Category P1 events at Laramie River Station 345kV and GEN-2016-110-Tap 345kV and NERC Category P4 events at Gentleman 345kV. The following faults were observed to be the most limiting contingencies:

- **FLT01-3PH**: 3 phase fault on the GEN-2016-110-Tap to Stegall 345kV line circuit 1, near GEN-2016-110-Tap.
- **FLT04-3PH**: 3 phase fault on the Laramie River Station to GEN-2016-110-TAP 345kV line circuit 1, near Laramie River Station.
- **FLT59-SB (17WP)**: Gentleman 345kV Stuck Breaker Scenario 1
  - Trip Gentleman (640183) to Keystone (640252) 345kV line circuit 1
  - Trip Gentleman (640183/640184) 345/230kV Transformer
- **FLT113-SB**: Gentleman 345kV Stuck Breaker Scenario 6
  - Trip Gentleman to Sweetwater 345kV line circuit 1
  - Trip Gentleman to Thedford 345kV line circuit 1

3.2.1 Gerald Gentleman Station Mitigation

It was observed that several of the limiting faults occurred for NERC Category P4 events at the Gerald Gentleman Station. Losing multiple lines out of Gentleman 345kV resulted in inadequate voltage support near Red Willow 345kV and Keystone 345kV stations. Mitigation was investigate for faults at Gentleman 345kV and determined the following are minimal Network Upgrades required (independent):

- GGS Option #1: Keystone to Red Willow to Post Rock 345kV
  - Solution set with or without the R-Plan network upgrade
- GGS Option #2: Rebuild Gerald Gentleman Station with a double bus double breaker configuration
- GGS Option #3: R-Plan Network Upgrade and reactive support at Keystone 345kV (+325 Mvar)

The limiting seasons for the normal dispatch scenario and faults near Gentleman 345kV was the 2017 Winter Peak season. Refer to Figure 3-2 for a representative voltage plot for FLT59 which is a P4 event at Gentleman 345kV resulting in the loss of Gentleman to Keystone 345kV and the Gentleman 345/230kV transformer. Figure 3-2 includes the response of the Keystone 345kV bus with no mitigation and with the three independent mitigation options. It can be observed that all three mitigation options resolve the voltage collapse associated with FLT59.

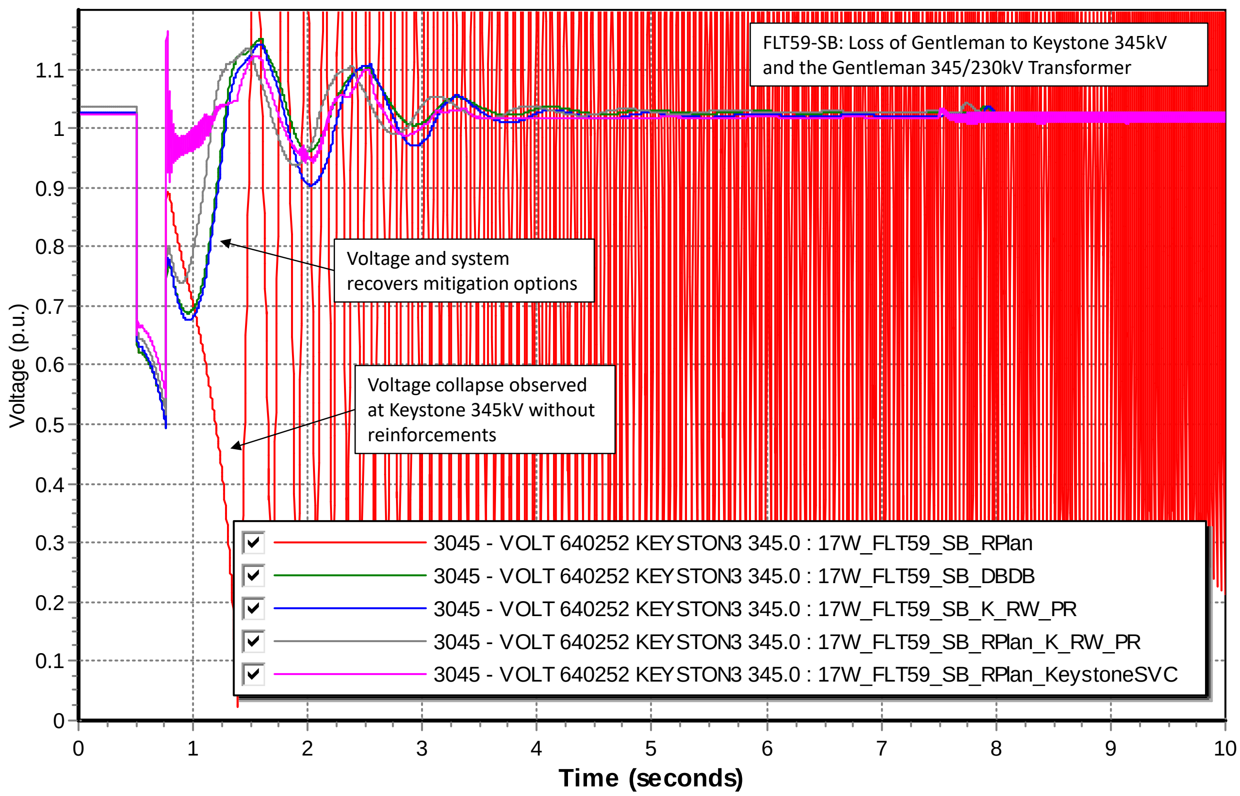

Figure 3-2: Representative voltage plot for FLT59 with and without network upgrades for 17WP conditions.

3.2.2 Overall Mitigation Solutions for Normal Dispatch Scenario

The power flow analysis performed by SPP has identified the need for the Keystone to Red Willow to Post Rock 345kV circuit to alleviate several constraints. Therefore, after determining that the Keystone to Red Willow to Post Rock 345kV circuit mitigated the voltage collapse/instability for P4 events at Gerald Gentleman Station, the Stability Analysis proceeded with this transmission circuit as a required Network Upgrade as to not introduce any unnecessary mitigation solutions for this analysis.

To mitigate the voltage collapse/instability, generation tripping offline, and poor post-fault steady-state voltages after the addition of the Keystone to Red Willow to Post Rock 345kV transmission circuit, several additional mitigation options were further discussed with SPP and investigated to determine the effectiveness of the resolving all voltage stability and generator stability issues observed in Table 3-2 and Table 3-3. Refer to Table 3-4 for a summary of several mitigation options investigated.

Note it was determined fault events near Laramie River Station 345kV and GEN-2016-110-Tap 345kV were observed to have a critical clearing time greater than 5 cycles. After discussion with the Transmission Owner, it was determined that P1 events out of Laramie River Station 345kV have a 4 cycle clearing time which meets the critical clearing time determined from this analysis. With the Keystone to Red Willow to Post Rock 345kV transmission circuit, no additional Network Upgrades are required for P1 events at Laramie River Station 345kV or GEN-2016-110-Tap 345kV.

Table 3-4: Overall Mitigation Solution Options

Network Upgrade Option	Option 1	Option 2	Option 3	Option 4
R-Plan		X		X
Reduce Fault Clear Time at G16-110-Tap/Laramie	X	X	X	X
Keystone - Red Willow 345kV Circuit #1	X	X	X	X
Red Willow - Post Rock 345kV Circuit #1	X	X	X	X
Antelope - Holt County 345kV			X	X

The mitigation options in Table 3-4 were applied to each normal dispatch scenario to determine the effectiveness of the Network Upgrades. It was determined all four mitigation solutions in Table 3-4 successfully mitigated all P1 and P4 events simulated.

For FLT01-3PH, a three-phase fault event (P1) that results in the loss of the GEN-2016-110-Tap to Stegall 345kV circuit #1, was observed to cause voltage collapse in the vicinity of Sidney and Stegall. Although each of the four identified solutions in Table 3-4 mitigate the voltage collapse issues observed, the voltage collapse is also mitigated by only reducing the clearing time for breakers at GEN-2016-110-Tap 345kV (i.e. no other Network Upgrades required). Refer to Figure 3-3 for a representative voltage plot for a P1 event out of GEN-2016-110-Tap 345kV for the 18SP scenario with no Network Upgrades compared to all four solution options in Table 3-4. It can be observed that a fault clearing time greater than 5 cycles (6 cycles) results in voltage instability. Reducing the clearing time to 5 cycles results in a stable and acceptable response for fault events at Laramie River Station and GEN-2016-110-Tap.

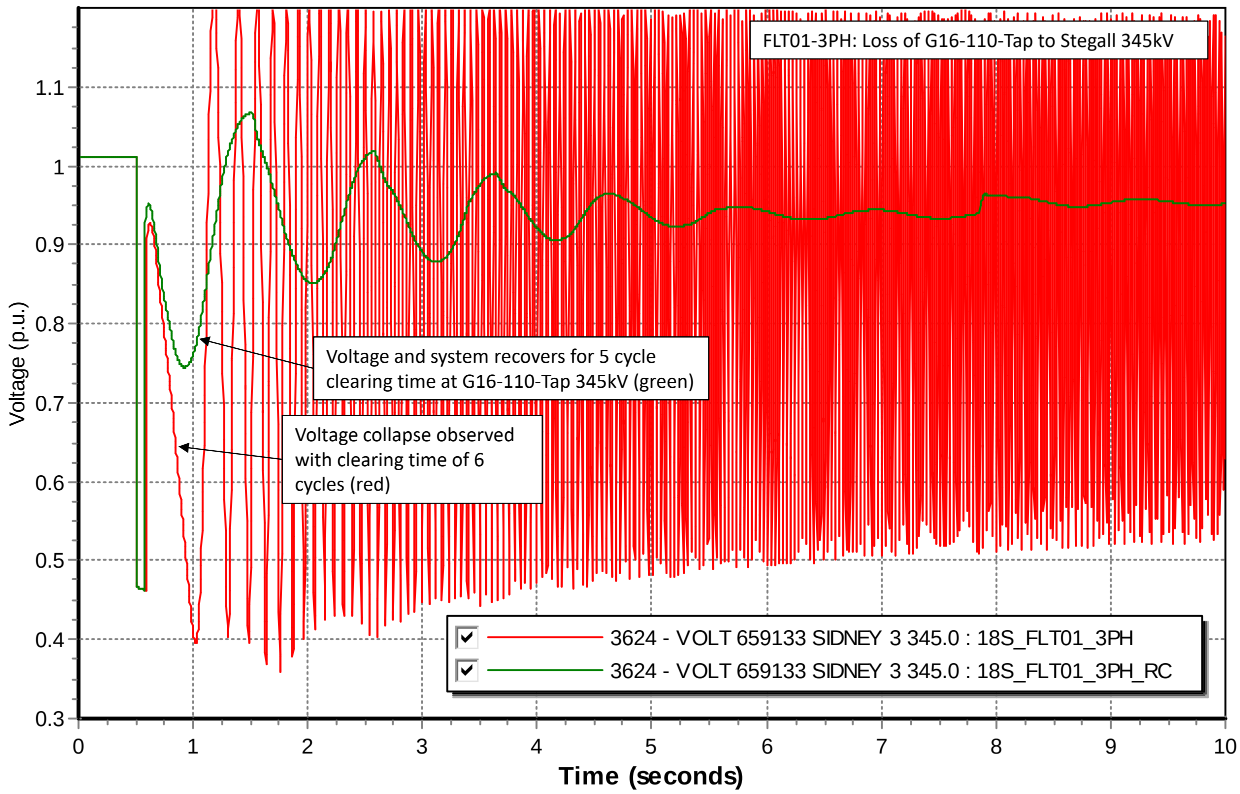

Figure 3-3: Representative voltage plot for FLT01 for 18SP conditions comparing critical clearing times.

Prior studies, including DISIS-2015-001 and DISIS-2016-001, modeled the generating facilities interconnecting at Grand Prairie 345 kV substation with the user-written PSS/E Model for Vestas OptiSpeed™ Wind Turbines Version 7.6. This study used the updated user-written Vestas Generic Model Structure V7 to represent these generating facilities in the study models. The study also evaluated the impact of the user-written Vestas Power Plant Controller Model on the system response. The updated model provided an improved system response. Refer to Figure 3-4 for a representative voltage plot of Holt County 345kV for FLT22-3PH, loss of the Holt County to Grand Island 345kV circuit. With the older/existing model representing the Grand Prairie wind units, the units activate Low Voltage Ride-Through ("LVRT") mode and cause system instability. With the updated Vestas model, the units are able to sustain voltage and the response to the fault is acceptable according to SPP Performance Criteria.

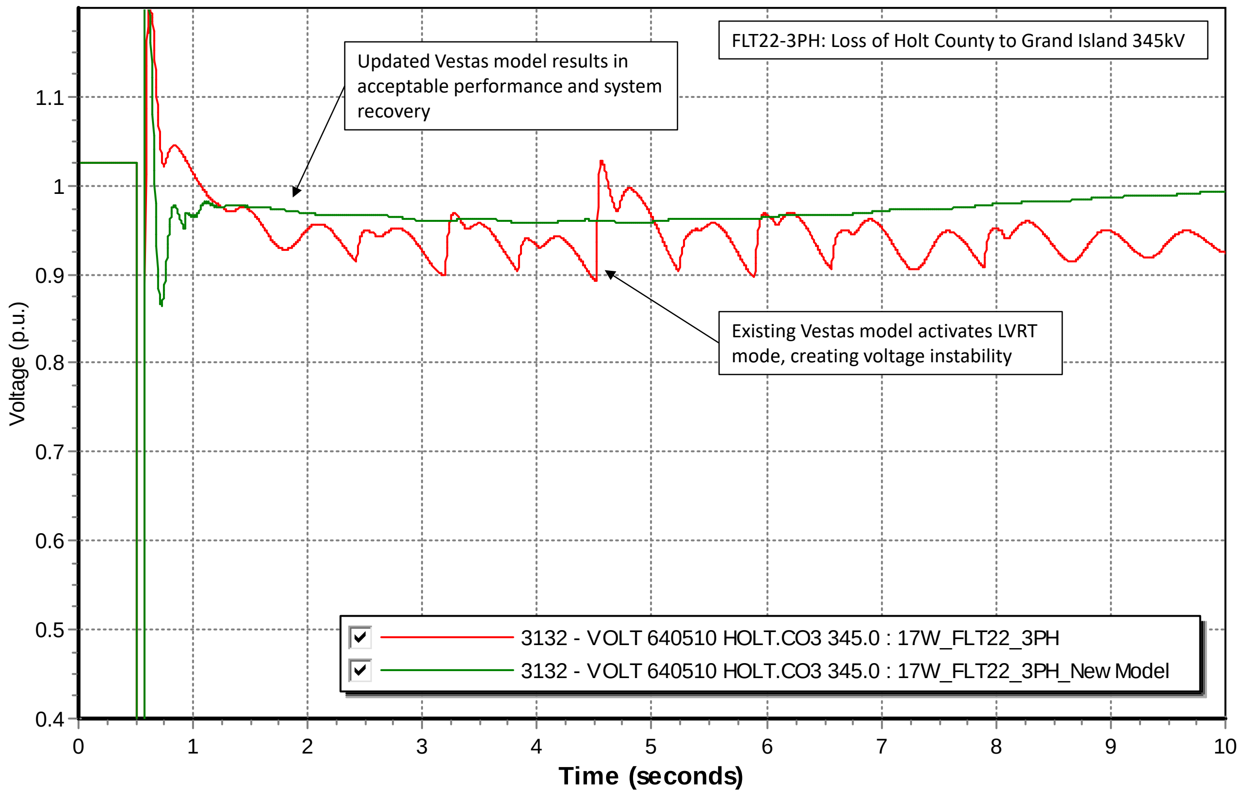

Figure 3-4: Representative voltage plot for FLT22 for 17WP conditions comparing the Grand Prairie dynamic models.

For FLT59-SB, a stuck breaker fault event (P4) that results in the loss of the Gentleman to Gentleman to Keystone 345kV circuit #1 and the Gentleman 345/230kV transformer, was observed to cause voltage collapse in the vicinity of Axtell and Keystone. The four identified mitigation solutions in Table 3-4 mitigate the voltage collapse issues observed. Refer to Figure 3-5 for a representative voltage plot for a P4 event out of Gentleman 345kV for the 17WP scenario with no Network Upgrades compared to all four solution options in Table 3-4. It can be observed that without any Network Upgrades, the fault results in voltage collapse/instability. All four mitigation options improve the response after the fault is cleared and results in a stable and acceptable response.

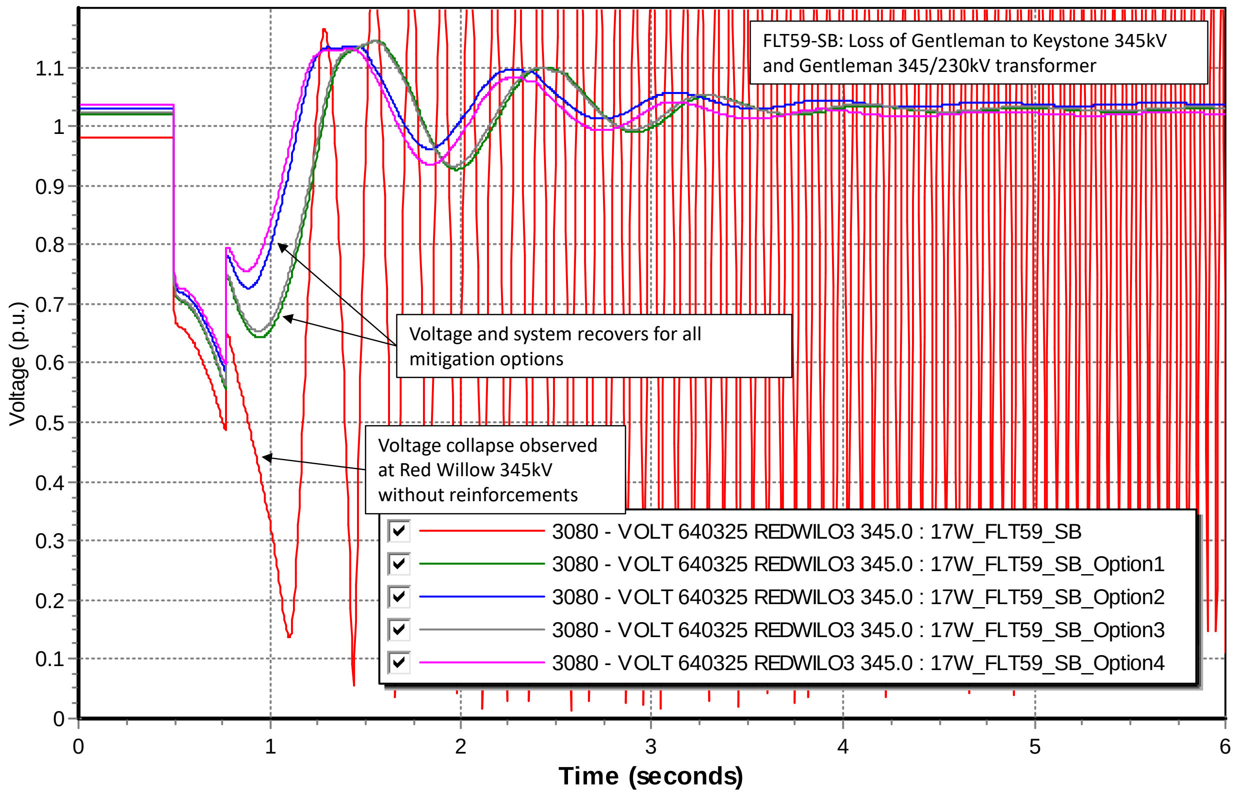

Figure 3-5: Representative voltage plot for FLT59 for 17WP conditions comparing results with no Network Upgrades and identified Network Upgrades.

The power flow analysis performed by SPP identified the need for both the R-Plan and an Antelope to Holt County 345kV circuit #1 to alleviate all constraints. Therefore, after determining that these upgrades mitigated the voltage collapse/instability for the fault events evaluated in this stability analysis, each was included in the remaining solution evaluation.

Refer to Table 3-5 for a summary of the Stability Analysis results with Option 4 implemented as the mitigation solution for all contingencies. Table 3-5 is a summary of the stability results for the 17WP, 18SP, and 26SP conditions and states whether the system remained stable or generation tripped offline, if acceptable voltage recovery was observed after the fault was cleared, and if the voltage recovered to above 0.9 p.u. and below 1.1 p.u. post fault steady-state conditions.

Table 3-5: Summary of Results for 17WP, 18SP, and 26SP Conditions with Solution Option 4

Ref. No.	Fault Number	2017 Winter Peak				2018 Summer Peak				2026 Summer Peak			
		Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability
		Less than 0.7 p.u.	Greater than 1.2 p.u.			Less than 0.7 p.u.	Greater than 1.2 p.u.			Less than 0.7 p.u.	Greater than 1.2 p.u.		
1	FLT01-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
2	FLT02-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
3	FLT03-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
4	FLT04-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
5	FLT05-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
6	FLT06-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
7	FLT07-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
8	FLT08-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
9	FLT09-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
10	FLT10-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
11	FLT11-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
12	FLT12-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
13	FLT13-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
14	FLT14-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
15	FLT15-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
16	FLT16-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
17	FLT17-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
18	FLT18-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
19	FLT19-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
20	FLT20-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
21	FLT21-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
22	FLT22-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
23	FLT23-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
24	FLT24-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
25	FLT25-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
26	FLT26-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable

Table 3-5: Summary of Results for 17WP, 18SP, and 26SP Conditions with Solution Option 4 (cont.)

Ref. No.	Fault Number	2017 Winter Peak				2018 Summer Peak				2026 Summer Peak			
		Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability
		Less than 0.7 p.u.	Greater than 1.2 p.u.			Less than 0.7 p.u.	Greater than 1.2 p.u.			Less than 0.7 p.u.	Greater than 1.2 p.u.		
27	FLT27-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
28	FLT28-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
29	FLT29-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
30	FLT30-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
31	FLT31-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
32	FLT32-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
33	FLT33-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
34	FLT34-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
35	FLT35-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
36	FLT36-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
37	FLT37-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
38	FLT38-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
39	FLT39-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
40	FLT40-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
41	FLT41-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
42	FLT42-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
43	FLT43-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
44	FLT44-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
45	FLT45-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
46	FLT46-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
47	FLT47-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
48	FLT48-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
49	FLT49-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
50	FLT50-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
51	FLT51-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
52	FLT52-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable

Table 3-5: Summary of Results for 17WP, 18SP, and 26SP Conditions with Solution Option 4 (cont.)

Ref. No.	Fault Number	2017 Winter Peak				2018 Summer Peak				2026 Summer Peak			
		Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability
		Less than 0.7 p.u.	Greater than 1.2 p.u.			Less than 0.7 p.u.	Greater than 1.2 p.u.			Less than 0.7 p.u.	Greater than 1.2 p.u.		
53	FLT53-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
54	FLT54-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
55	FLT55-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
56	FLT56-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
57	FLT57-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
58	FLT58-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
59	FLT59-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
61	FLT61-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
63	FLT63-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
64	FLT64-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
65	FLT65-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
66	FLT66-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
67	FLT67-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
68	FLT68-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
69	FLT69-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
70	FLT70-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
71	FLT71-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
72	FLT72-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
73	FLT73-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
74	FLT74-PO	Voltage Collapse				Voltage Collapse				Voltage Collapse			
75	FLT75-PO	Voltage Collapse				Voltage Collapse				Voltage Collapse			
76	FLT76-PO	Voltage Collapse				Voltage Collapse				Voltage Collapse			
77	FLT77-PO	Voltage Collapse				Voltage Collapse				No	No	Compliant	Stable
78	FLT78-PO	Voltage Collapse				Voltage Collapse				Voltage Collapse			
79	FLT79-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
80	FLT80-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
81	FLT81-PO	Voltage Collapse				Voltage Collapse				Voltage Collapse			

Table 3-5: Summary of Results for 17WP, 18SP, and 26SP Conditions with Solution Option 4 (cont.)

Ref. No.	Fault Number	2017 Winter Peak				2018 Summer Peak				2026 Summer Peak			
		Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability
		Less than 0.7 p.u.	Greater than 1.2 p.u.			Less than 0.7 p.u.	Greater than 1.2 p.u.			Less than 0.7 p.u.	Greater than 1.2 p.u.		
82	FLT82-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
83	FLT83-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
84	FLT84-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
85	FLT85-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
86	FLT86-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
87	FLT87-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
88	FLT88-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
89	FLT89-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
90	FLT90-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
91	FLT91-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
92	FLT92-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
93	FLT93-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
94	FLT94-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
95	FLT95-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
96	FLT96-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
97	FLT97-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
98	FLT98-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
99	FLT99-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
100	FLT100-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
101	FLT101-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
102	FLT102-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
103	FLT103-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
104	FLT104-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
105	FLT105-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
106	FLT106-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
107	FLT107-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable

Table 3-5: Summary of Results for 17WP, 18SP, and 26SP Conditions with Solution Option 4 (cont.)

Ref. No.	Fault Number	2017 Winter Peak				2018 Summer Peak				2026 Summer Peak			
		Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability
		Less than 0.7 p.u.	Greater than 1.2 p.u.			Less than 0.7 p.u.	Greater than 1.2 p.u.			Less than 0.7 p.u.	Greater than 1.2 p.u.		
108	FLT108-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
109	FLT109-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
110	FLT110-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
111	FLT111-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
112	FLT112-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
113	FLT113-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
114	FLT114-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
115	FLT115-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
116	FLT116-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
117	FLT117-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
118	FLT118-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
119	FLT119-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
120	FLT120-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
121	FLT121-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
122	FLT122-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
123	FLT123-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
124	FLT124-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
125	FLT125-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
126	FLT126-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
127	FLT127-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
128	FLT128-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
129	FLT129-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable

3.2.3 Curtailment for P6 Events for the Normal Dispatch Scenario

The mitigation solution options identified in Section 3.2.2 relieved the voltage collapse and voltage instability issues for all P1 and P4 events studied. However, there were several prior outage conditions near Sidney and GEN-2016-110-Tap that resulted in a voltage collapse with Option 4, which includes the following Network Upgrades:

- SPP R-Plan
  - Thedford 345/115/13.8 kV transformer
  - Gerald Gentleman Station to Thedford 345kV circuit #1
  - Holt County to Thedford 345kV circuit #1
- Keystone to Red Willow to Post Rock 345kV circuit #1
- Antelope to Holt County 345kV circuit #1

The following prior outage contingencies resulted in voltage collapse with the above Network Upgrades in-service:

- **FLT74-PO**: Prior outage on the Sidney – Laramie River Station 345kV line circuit 1
  - 3 phase fault on the Stegall to Sidney 345kV line circuit 1, near Stegall.
- **FLT75-PO**: Prior outage on the G16-110-TAP – Stegall 345kV line circuit 1
  - 3 phase fault on the Sidney to Stegall 345kV line circuit 1, near Sidney.
- **FLT76-PO**: Prior outage on the G16-110-TAP – Stegall 345kV line circuit 1
  - 3 phase fault on the Sidney to Keystone 345kV line circuit 1, near Sidney.
- **FLT77-PO**: Prior outage on the Sidney – Stegall 345kV line circuit 1
  - 3 phase fault on the Sidney to Keystone 345kV line circuit 1, near Sidney.
- **FLT78-PO**: Prior outage on the Sidney – Stegall 345kV line circuit 1
  - 3 phase fault on the Sidney to Laramie River Station 345kV line circuit 1, near Sidney.
- **FLT81-PO**: Prior outage on the Sidney – Sidney Transformer 230 kV line circuit 1
  - 3 phase fault on the Sidney to Keystone 345kV line circuit 1, near Sidney.

For prior outage conditions that result in a voltage collapse or are observe to have voltage/system instability, generation curtailment in the vicinity of the faults was investigated. Refer to Table 3-6 for a summary of the generation curtailment required for each prior outage condition listed above for the Option 4 mitigation solution (full mitigation). Approximately 800 MW of generation capacity in the vicinity of Laramie River Station and Sydney was evaluated for curtailment as a system adjustment as mitigation and included:

- GEN-2016-110
- GEN-2016-147
- Laramie River Station

Table 3-6: Generation Curtailment for Prior Outage Conditions for Solution Option 4

Fault Number	Generation Curtailment (%/MW)		
	17WP	18SP	26SP
FLT74-PO	60% 480 MW	50% 400 MW	50% 400 MW
FLT75-PO	20% 160 MW	20% 160 MW	20% 160 MW
FLT76-PO	30% 240 MW	30% 240 MW	30% 240 MW
FLT77-PO	10% 80 MW	10% 80 MW	None
FLT78-PO	60% 480 MW	60% 480 MW	50% 400 MW
FLT81-PO	50% 400 MW	50% 400 MW	50% 400 MW

*Total generation in Laramie/Sidney vicinity is 800 MW

The limiting prior outage faults that required the highest amount of generation curtailment were prior outages out of Sidney 345kV. FLT74-PO, prior outage of Sidney to Laramie River Station 345kV, and FLT78-PO, prior outage of Sidney to Stegall 345kV, each resulted in requiring 480 MW of generation curtailment in the Laramie River Station 345kV and Sidney 345kV vicinity to mitigate the voltage collapse/instability observed. Refer to Figure 3-6 for a representative voltage plot of area bus voltages for FLT78-PO for 17WP conditions. Refer to Figure 3-7 for a representative rotor angle plot for the Laramie River Station generation. This fault was observed to result in voltage collapse/instability in the vicinity of Laramie River Station and Sidney 345kV without generation curtailment. In addition to Solution Option #4, curtailing generation by 480 MW in the vicinity of Laramie River Station and Sidney 345kV mitigates the observed stability issue.

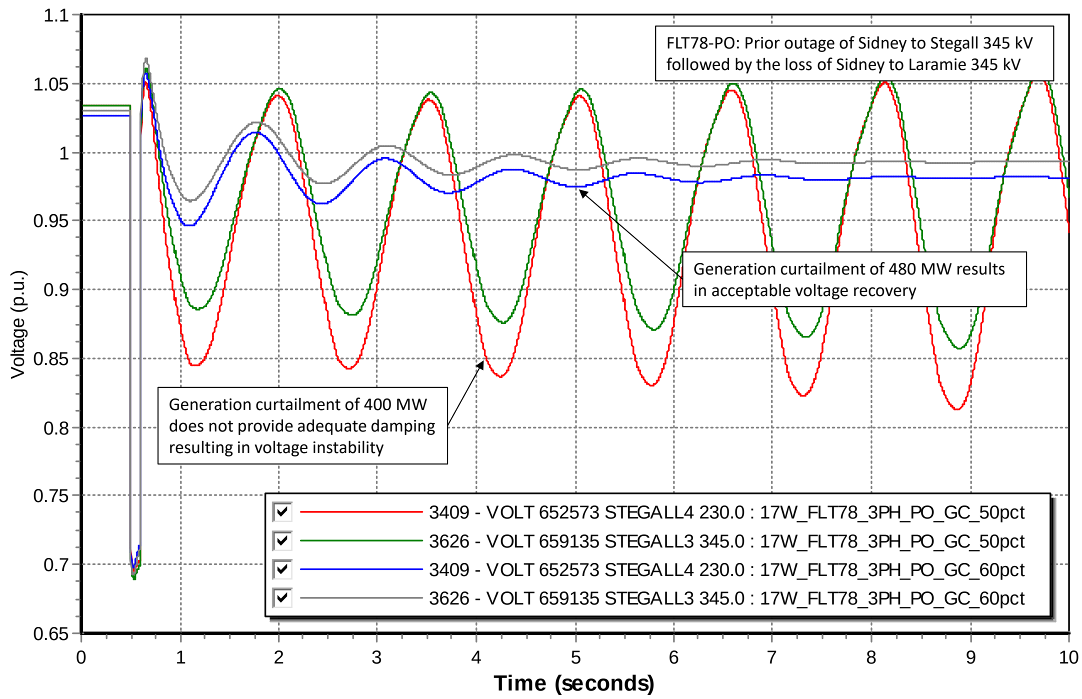

Figure 3-6: Representative voltage plot of FLT78-PO with generation curtailment for 2017 Winter Peak conditions.

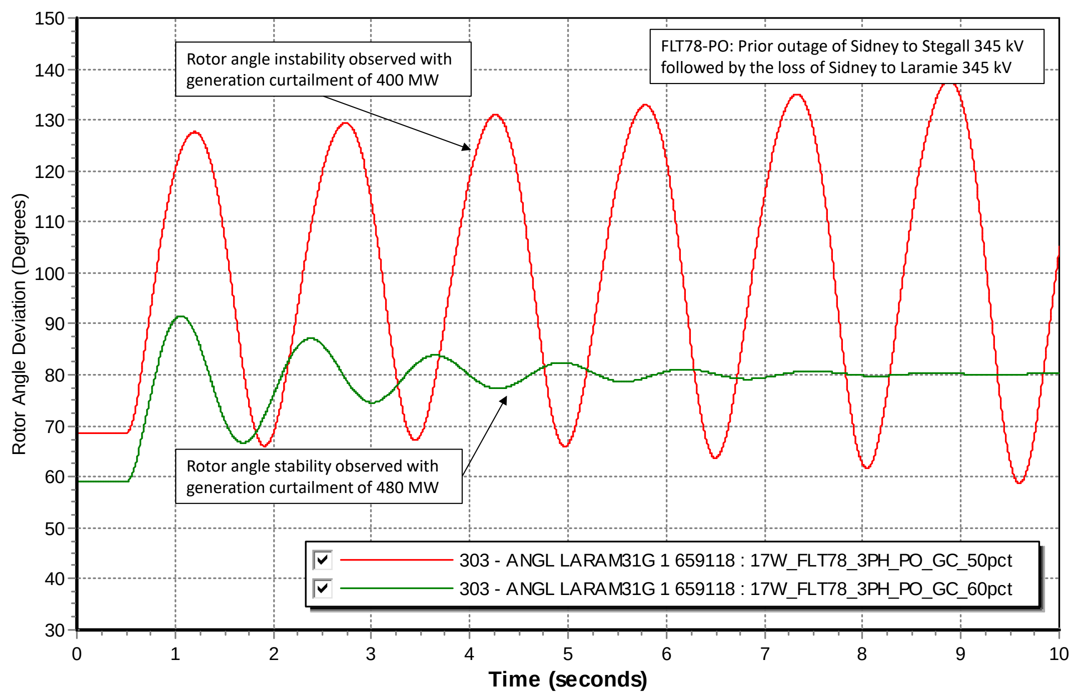

Figure 3-7: Representative rotor angle plot of FLT78-PO with generation curtailment for 2017 Winter Peak conditions.

Refer to Table 3-7 for generation curtailment required for Solution Option #1 through Solution Option #4 for the prior outage events that result in voltage collapse/instability. It was determined that the solution options have negligible impact on the required generation curtailment amounts for prior outage conditions in the Laramie River Station and Sidney region. The scope of this stability analysis is not comprehensive of all potential prior outage events. The Transmission Owner in the vicinity of Laramie River Station and Sidney 345kV, Basin Electric Power Cooperative, may need to further evaluate and update Operational Guides for maintaining system reliability during circuit outages in the vicinity of Laramie River Station and Sidney 345kV.

Table 3-7: Generation Curtailment for Prior Outage Conditions for All Mitigation Options

Solution Option	Generation Curtailment (%/MW)					
	17WP		18SP		26SP	
	FLT74-PO	FLT78-PO	FLT74-PO	FLT78-PO	FLT74-PO	FLT78-PO
Option 1	60% 480 MW	60% 480 MW	50% 400 MW	60% 480 MW	50% 400 MW	50% 400 MW
Option 2	60% 480 MW	60% 480 MW	50% 400 MW	60% 480 MW	50% 400 MW	50% 400 MW
Option 3	60% 480 MW	60% 480 MW	50% 400 MW	60% 480 MW	50% 400 MW	50% 400 MW
Option 4	60% 480 MW	60% 480 MW	50% 400 MW	60% 480 MW	50% 400 MW	50% 400 MW

*Total generation in Laramie/Sidney vicinity is 800 MW

Refer to Appendix B, Appendix C, and Appendix D for a complete set of plots for all contingencies for 2017 Winter Peak, 2018 Summer Peak, and 2026 Summer Peak conditions, respectively. The plots for all three seasons can be provided upon request.

3.3 Normal Dispatch Scenario Summary of Results

The analysis of the Normal Dispatch Scenario determined mitigation is required to alleviate voltage instability issues in the Gerald Gentleman Station vicinity and the Laramie vicinity for select P1 and P4 events. It was determined that a new 345kV circuit from Keystone to Red Willow to Post Rock would alleviate the voltage instability near Gentleman 345kV. Alternatively, the Gentleman station could be re-configured to a double bus double breaker station or installation of reactive support at Keystone in addition to the R-Plan would also alleviate the voltage stability issues.

It was also determined that no additional mitigation is required for the additional contingencies in Table 2-6 (Keystone, Red Willow, and Post Rock P4 events) after the addition of the Keystone to Red Willow to Post Rock 345kV circuit. All additional contingencies resulted in acceptable voltage and rotor angle recovery following the P1 or P4 event as applied in Table 2-6.

For P1 events at Laramie 345kV or GEN-2016-110-Tap 345kV, system stability was maintained for faults cleared in 5 cycles prior to any mitigation implemented. The addition of the mitigation options (Keystone to Red Willow to Post Rock 345kV) did not impact these critical clearing times.

For P1 events out of Holt County 345kV, it was determined system stability was maintained provided the Grand Prairie Wind Units and GEN-2016-075 utilized the latest Vestas model with the included power plant controller.

3.4 High GGS Sensitivity Stability Analysis Results

The High GGS Sensitivity Scenario Stability Analysis was performed on the three seasons as identified previously: 17WP, 18SP, and 26SP. The analysis was completed similar to the Normal Dispatch Scenario; the analysis was first completed without any mitigation and then performed with the R-Plan Network Upgrade in-service.

The High GGS Sensitivity Stability Analysis determined that there were multiple contingencies across all seasons that resulted in system/voltage instability, generation tripping offline, and poor post-fault voltage recovery when all generation interconnection requests were at 100% output. The 17WP, 18SP, and 26SP cases were observed to result in voltage collapse and voltage instability in the Gentleman 345kV and Laramie River Station 345kV local area.

Refer to Table 3-8 for a summary of the High GGS Sensitivity Stability Analysis results without additional reinforcements for the contingencies listed in Table 2-5. Table 3-8 is a summary of the stability results for the 17WP, 18SP, and 26SP conditions and states whether the system remained stable or generation tripped offline, if acceptable voltage recovery was observed after the fault was cleared, and if the voltage recovered to above 0.9 p.u. and below 1.1 p.u. post fault steady-state conditions. Voltage recovery criteria includes ensuring that the transient voltage recovery is between 0.7 p.u. and 1.2 p.u. and ending in a steady-state voltage (for N-1 contingencies) at the pre-contingent level or at least above 0.9 p.u. and below 1.1. p.u.

It was observed that the limiting faults for the High GGS Sensitivity scenarios were NERC Category P1 events near Laramie River Station 345kV as well as Holt 345kV and NERC Category P4 events at Gentleman 345kV. After examining the results without additional reinforcements, the previously studied R-Plan Network Upgrade was investigated to determine the impacts of the following additional transmission elements:

- SPP R Plan
    - Thedford 345/115/13.8 kV transformer
    - Gerald Gentleman Station to Thedford 345kV circuit #1
    - Holt County to Thedford 345kV circuit #1

Refer to Table 3-9 for a summary of the High GGS Sensitivity Stability Analysis results with the R-Plan Network Upgrade in-service for the contingencies listed in Table 2-5 and additional contingencies listed in Table 2-6. Table 3-9 is a summary of the stability results for the 17WP, 18SP, and 26SP conditions and states whether the system remained stable or generation tripped offline, if acceptable voltage recovery was observed after the fault was cleared, and if the voltage recovered to above 0.9 p.u. and below 1.1 p.u. post fault steady-state conditions.

Table 3-8: GGS Sensitivity Summary of Results for 2017 Winter, 2018 Summer, and 2026 Summer Peak Conditions

Ref. No.	Fault Number	2017 Winter Peak - GGS				2018 Summer Peak - GGS				2026 Summer Peak - GGS			
		Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability
		Less than 0.7 p.u.	Greater than 1.2 p.u.			Less than 0.7 p.u.	Greater than 1.2 p.u.			Less than 0.7 p.u.	Greater than 1.2 p.u.		
1	FLT01-3PH	Voltage Collapse				Voltage Collapse				Voltage Collapse			
2	FLT02-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
3	FLT03-3PH	Voltage Collapse				Voltage Collapse				Voltage Collapse			
4	FLT04-3PH	Voltage Collapse				Voltage Collapse				Voltage Collapse			
5	FLT05-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
6	FLT06-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
7	FLT07-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
8	FLT08-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
9	FLT09-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
10	FLT10-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
11	FLT11-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
12	FLT12-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
13	FLT13-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
14	FLT14-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
15	FLT15-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
16	FLT16-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
17	FLT17-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
18	FLT18-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
19	FLT19-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
20	FLT20-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
21	FLT21-3PH	No	No	Volt oscliiations	Stable	No	No	Volt oscliiations	Stable	No	No	Volt oscliiations	Stable
22	FLT22-3PH	No	No	Volt oscliiations	G16-075 instability	No	No	Volt oscliiations	G16-075 instability	No	No	Volt oscliiations	G16-075 instability
23	FLT23-3PH	No	Yes	High voltages	G16-075 trips	No	Yes	High voltages	G16-075 trips	No	Yes	High voltages	G16-075 trips
24	FLT24-3PH	No	No	Volt oscliiations	G16-075 instability	No	No	Volt oscliiations	G16-075 instability	No	No	Volt oscliiations	G16-075 instability
25	FLT25-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Volt oscliiations	G16-075 instability
26	FLT26-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable

Table 3-8: GGS Sensitivity Summary of Results for 2017 Winter, 2018 Summer, and 2026 Summer Peak Conditions (cont.)

Ref. No.	Fault Number	2017 Winter Peak - GGS				2018 Summer Peak - GGS				2026 Summer Peak - GGS			
		Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability
		Less than 0.7 p.u.	Greater than 1.2 p.u.			Less than 0.7 p.u.	Greater than 1.2 p.u.			Less than 0.7 p.u.	Greater than 1.2 p.u.		
27	FLT27-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
28	FLT28-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
29	FLT29-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
30	FLT30-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
31	FLT31-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
32	FLT32-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
33	FLT33-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
34	FLT34-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
35	FLT35-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
36	FLT36-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
37	FLT37-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
38	FLT38-3PH	No	No	Volt oscliiations	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
39	FLT39-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
40	FLT40-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
41	FLT41-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
42	FLT42-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
43	FLT43-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
44	FLT44-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
45	FLT45-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
46	FLT46-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
47	FLT47-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
48	FLT48-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
49	FLT49-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
50	FLT50-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
51	FLT51-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
52	FLT52-SB	No	No	Low post-fault voltage Sidney 345kV	Stable	No	No	Low post-fault voltage Sidney 345kV	Stable	No	No	Compliant	Stable

Table 3-8: GGS Sensitivity Summary of Results for 2017 Winter, 2018 Summer, and 2026 Summer Peak Conditions (cont.)

Ref. No.	Fault Number	2017 Winter Peak - GGS				2018 Summer Peak - GGS				2026 Summer Peak - GGS			
		Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability
		Less than 0.7 p.u.	Greater than 1.2 p.u.			Less than 0.7 p.u.	Greater than 1.2 p.u.			Less than 0.7 p.u.	Greater than 1.2 p.u.		
53	FLT53-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
54	FLT54-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
55	FLT55-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
56	FLT56-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
57	FLT57-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
58	FLT58-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
59	FLT59-SB	Voltage Collapse				No	No	Compliant	Stable	No	No	Compliant	Stable
61	FLT61-SB	Voltage Collapse				No	No	Compliant	Stable	No	No	Compliant	Stable
63	FLT63-SB	No	No	Low voltage: Grand Prairie	Stable	No	No	Low voltage: Grand Prairie	Stable	No	No	Low voltage: Grand Prairie	Stable
64	FLT64-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
65	FLT65-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
66	FLT66-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
67	FLT67-SB	Voltage Collapse				No	No	Low post-fault voltage: Mingo 345kV	Stable	No	No	Low post-fault voltage: Mingo 345kV	Stable
68	FLT68-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
69	FLT69-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
70	FLT70-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
71	FLT71-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
72	FLT72-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
73	FLT73-SB	No	No	Volt oscliiations	G16-075 instability	No	No	Volt oscliiations	G16-075 instability	No	No	Volt oscliiations	G16-075 instability
74	FLT74-PO	No	No	Compliant	Stable	Voltage Collapse				Voltage Collapse			
75	FLT75-PO	Steady-State Divergence				Steady-State Divergence				Steady-State Divergence			
76	FLT76-PO	Steady-State Divergence				Steady-State Divergence				Steady-State Divergence			
77	FLT77-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable

Table 3-8: GGS Sensitivity Summary of Results for 2017 Winter, 2018 Summer, and 2026 Summer Peak Conditions (cont.)

Ref. No.	Fault Number	2017 Winter Peak - GGS				2018 Summer Peak - GGS				2026 Summer Peak - GGS			
		Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability
		Less than 0.7 p.u.	Greater than 1.2 p.u.			Less than 0.7 p.u.	Greater than 1.2 p.u.			Less than 0.7 p.u.	Greater than 1.2 p.u.		
78	FLT78-PO	Voltage Collapse				Voltage Collapse				Voltage Collapse			
79	FLT79-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
80	FLT80-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
81	FLT81-PO	Voltage Collapse				Voltage Collapse				Voltage Collapse			
82	FLT82-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
83	FLT83-PO	Voltage Collapse				No	No	Low post-fault voltage: Mingo 345kV	Stable	No	No	Low post-fault voltage: Mingo 345kV	Stable
84	FLT84-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
85	FLT85-PO	Steady-State Divergence				Steady-State Divergence				No	No	Compliant	Stable
86	FLT86-PO	Steady-State Divergence				Steady-State Divergence				No	No	Compliant	Stable
87	FLT87-PO	Steady-State Divergence				Steady-State Divergence				No	No	Compliant	Stable
88	FLT88-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
89	FLT89-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
90	FLT90-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
91	FLT91-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
92	FLT92-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
93	FLT93-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
94	FLT94-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
95	FLT95-PO	Voltage Collapse				No	No	Compliant	Stable	No	No	Compliant	Stable
96	FLT96-PO	No	Yes	High voltages	G16-106 trips	No	No	Compliant	Stable	No	No	Compliant	Stable
97	FLT97-PO	No	Yes	High voltages	G16-106 trips	No	No	Compliant	Stable	No	No	Compliant	Stable
98	FLT98-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
99	FLT99-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
100	FLT100-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
101	FLT101-SB	No	No	Low voltage	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
102	FLT102-SB	No	No	Low voltage	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
103	FLT103-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
104	FLT104-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable

Table 3-9: GGS Sensitivity Summary of Results for 17WP, 18SP, and 26SP Conditions with R-Plan Network Upgrade

Ref. No.	Fault Number	2017 Winter Peak - GGS				2018 Summer Peak - GGS				2026 Summer Peak - GGS			
		Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability
		Less than 0.7 p.u.	Greater than 1.2 p.u.			Less than 0.7 p.u.	Greater than 1.2 p.u.			Less than 0.7 p.u.	Greater than 1.2 p.u.		
1	FLT01-3PH	Voltage Collapse				Voltage Collapse				Voltage Collapse			
2	FLT02-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
3	FLT03-3PH	Voltage Collapse				Voltage Collapse				Voltage Collapse			
4	FLT04-3PH	Voltage Collapse				Voltage Collapse				Voltage Collapse			
5	FLT05-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
6	FLT06-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
7	FLT07-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
8	FLT08-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
9	FLT09-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
10	FLT10-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
11	FLT11-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
12	FLT12-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
13	FLT13-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
14	FLT14-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
15	FLT15-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
16	FLT16-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
17	FLT17-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
18	FLT18-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
19	FLT19-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
20	FLT20-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
21	FLT21-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
22	FLT22-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
23	FLT23-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
24	FLT24-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
25	FLT25-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
26	FLT26-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable

Table 3-9: GGS Sensitivity Summary of Results for 17WP, 18SP, and 26SP Conditions with R-Plan Network Upgrade (cont.)

Ref. No.	Fault Number	2017 Winter Peak - GGS				2018 Summer Peak - GGS				2026 Summer Peak - GGS			
		Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability
		Less than 0.7 p.u.	Greater than 1.2 p.u.			Less than 0.7 p.u.	Greater than 1.2 p.u.			Less than 0.7 p.u.	Greater than 1.2 p.u.		
27	FLT27-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
28	FLT28-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
29	FLT29-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
30	FLT30-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
31	FLT31-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
32	FLT32-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
33	FLT33-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
34	FLT34-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
35	FLT35-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
36	FLT36-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
37	FLT37-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
38	FLT38-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
39	FLT39-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
40	FLT40-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
41	FLT41-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
42	FLT42-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
43	FLT43-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
44	FLT44-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
45	FLT45-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
46	FLT46-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
47	FLT47-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
48	FLT48-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
49	FLT49-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
50	FLT50-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
51	FLT51-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
52	FLT52-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable

Table 3-9: GGS Sensitivity Summary of Results for 17WP, 18SP, and 26SP Conditions with R-Plan Network Upgrade (cont.)

Ref. No.	Fault Number	2017 Winter Peak - GGS				2018 Summer Peak - GGS				2026 Summer Peak - GGS			
		Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability
		Less than 0.7 p.u.	Greater than 1.2 p.u.			Less than 0.7 p.u.	Greater than 1.2 p.u.			Less than 0.7 p.u.	Greater than 1.2 p.u.		
53	FLT53-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
54	FLT54-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
55	FLT55-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
56	FLT56-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
57	FLT57-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
58	FLT58-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
59	FLT59-SB	Voltage Collapse				No	No	Compliant	Stable	No	No	Compliant	Stable
60	FLT60-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
61	FLT61-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
62	FLT62-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
63	FLT63-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
64	FLT64-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
65	FLT65-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
66	FLT66-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
67	FLT67-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
68	FLT68-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
69	FLT69-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
70	FLT70-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
71	FLT71-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
72	FLT72-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
73	FLT73-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
74	FLT74-PO	Voltage Collapse				Voltage Collapse				Voltage Collapse			
75	FLT75-PO	Voltage Collapse				Voltage Collapse				Voltage Collapse			
76	FLT76-PO	Voltage Collapse				Voltage Collapse				Voltage Collapse			
77	FLT77-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable

Table 3-9: GGS Sensitivity Summary of Results for 17WP, 18SP, and 26SP Conditions with R-Plan Network Upgrade (cont.)

Ref. No.	Fault Number	2017 Winter Peak - GGS				2018 Summer Peak - GGS				2026 Summer Peak - GGS			
		Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability
		Less than 0.7 p.u.	Greater than 1.2 p.u.			Less than 0.7 p.u.	Greater than 1.2 p.u.			Less than 0.7 p.u.	Greater than 1.2 p.u.		
78	FLT78-PO	Voltage Collapse				Voltage Collapse				Voltage Collapse			
79	FLT79-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
80	FLT80-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
81	FLT81-PO	Voltage Collapse				Voltage Collapse				Voltage Collapse			
82	FLT82-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
83	FLT83-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
84	FLT84-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
85	FLT85-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
86	FLT86-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
87	FLT87-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
88	FLT88-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
89	FLT89-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
90	FLT90-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
91	FLT91-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
92	FLT92-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
93	FLT93-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
94	FLT94-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
95	FLT95-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
96	FLT96-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
97	FLT97-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
98	FLT98-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
99	FLT99-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
100	FLT100-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
101	FLT101-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
102	FLT102-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
103	FLT103-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable

Table 3-9: GGS Sensitivity Summary of Results for 17WP, 18SP, and 26SP Conditions with R-Plan Network Upgrade (cont.)

Ref. No.	Fault Number	2017 Winter Peak - GGS				2018 Summer Peak - GGS				2026 Summer Peak - GGS			
		Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability
		Less than 0.7 p.u.	Greater than 1.2 p.u.			Less than 0.7 p.u.	Greater than 1.2 p.u.			Less than 0.7 p.u.	Greater than 1.2 p.u.		
104	FLT104-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
105	FLT105-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
106	FLT106-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
107	FLT107-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
108	FLT108-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
109	FLT109-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
110	FLT110-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
111	FLT111-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
112	FLT112-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
113	FLT113-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
114	FLT114-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
115	FLT115-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
116	FLT116-PO	No	No	Volt oscliiations	G16-075 instability	No	No	Volt oscliiations	G16-075 instability	No	No	Volt oscliiations	G16-075 instability
117	FLT117-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
118	FLT118-PO	Voltage Collapse				No	No	Compliant	Stable	No	No	Compliant	Stable
119	FLT119-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
120	FLT120-PO	No	Yes	High voltages	G16-106 trips	No	No	Compliant	Stable	No	No	Compliant	Stable

With the R-Plan Network Upgrade in-service, it was observed that the network upgrade mitigated several P1 and P4 events near Gentleman 345kV, Holt County 345kV, Grand Island 345kV, Grand Prairie 345kV, and Sweetwater 345kV. The R-Plan Network Upgrade mitigated the steady-state divergence for a prior outage of the G16-110-Tap to Stegall 345kV line, however, the prior outage fault resulted in voltage collapse/instability.

After the addition of the R-Plan Network Upgrade, the following P1 and P4 faults were observed to result in voltage collapse/instability:

- **FLT01-3PH**: 3 phase fault on the G16-110-Tap to Stegall 345kV line circuit 1, near G16-110-Tap.
- **FLT03-3PH**: 3 phase fault on the Laramie River Station to Sidney 345kV line circuit 1, near Laramie River Station.
- **FLT04-3PH**: 3 phase fault on the Laramie River Station to G16-110-TAP (587874) 345kV line circuit 1, near Laramie River Station.
- **FLT59-SB**: Gentleman 345kV Stuck Breaker Scenario 1
    - Trip Gentleman (640183) to Keystone (640252) 345kV line circuit 1
    - Trip Gentleman (640183/640184) 345/230kV Transformer

3.4.1 Gerald Gentleman Station Mitigation

It was observed that several of the limiting faults occurred for NERC Category P4 events at the Gerald Gentleman Station. Losing multiple lines out of Gentleman 345kV resulted in inadequate voltage support near Red Willow 345kV and Keystone 345kV stations. Mitigation was investigate for faults at Gentleman 345kV and determined the following are minimal network upgrades required (independent):

- GGS Option #1: Keystone to Red Willow to Post Rock 345kV
    - Solution set with or without the R-Plan network upgrade
- GGS Option #2: Rebuild Gentleman 345kV with a double bus double breaker configuration
- GGS Option #3: R-Plan network upgrade and reactive support at Keystone 345kV (+200 Mvar)

The limiting seasons for the High GGS Sensitivity dispatch scenario and faults near Gentleman 345kV was the 2017 Winter Peak season. Refer to Figure 3-8 for a representative voltage plot for FLT59 which is a P4 event at Gentleman 345kV resulting in the loss of Gentleman to Sweetwater 345kV and Gentleman to Keystone 345kV. Figure 3-8 includes the response of the Keystone 345kV bus with no mitigation and with the three independent mitigation options. It can be observed that all three mitigation options resolve the voltage collapse associated with FLT59.

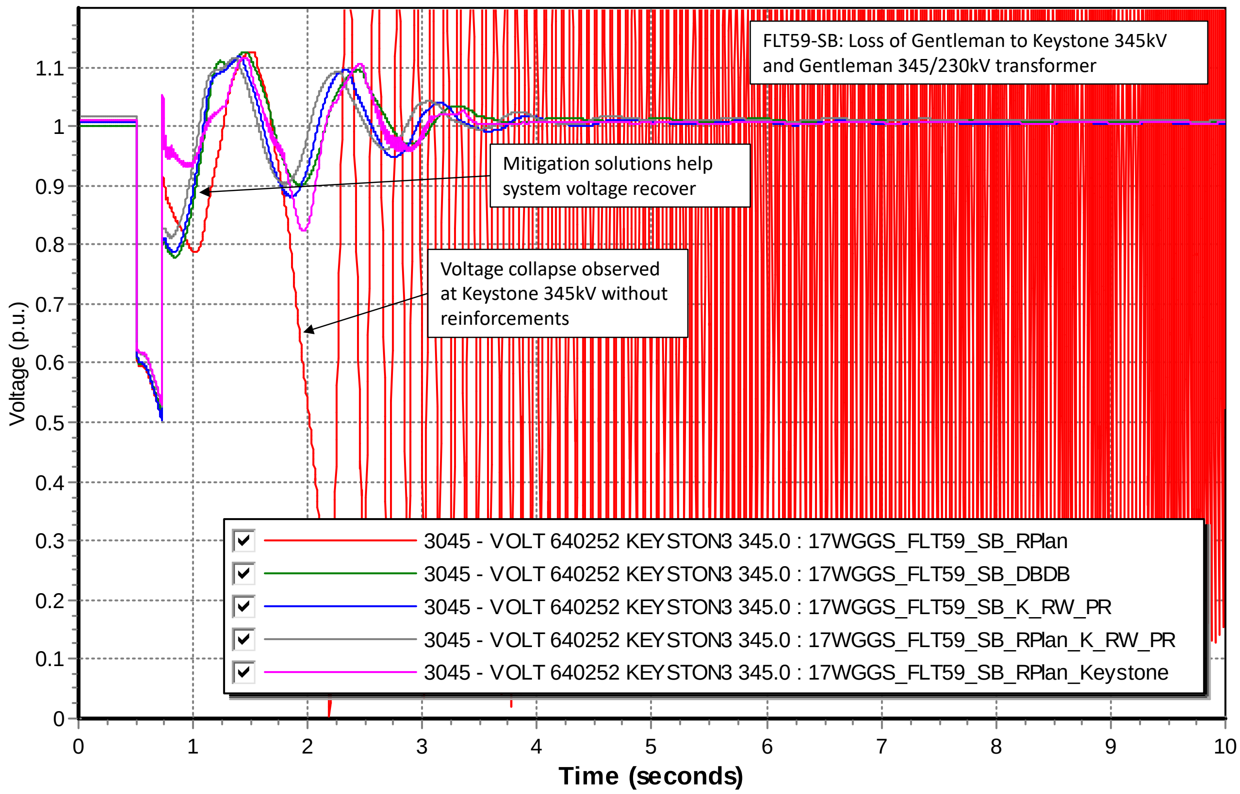

Figure 3-8: Representative voltage plot for FLT59 with and without network upgrades for 17WP conditions for the High GGS Sensitivity scenario.

3.4.2 Overall Mitigation Solutions for High GGS Sensitivity Dispatch Scenario

The power flow analysis performed by SPP, and Normal Dispatch Scenario, has identified the need for the Keystone to Red Willow to Post Rock 345kV circuit to relieve thermal constraints and voltage stability issues. Therefore, the High GGS Sensitivity Stability Analysis proceeded with this transmission circuit as a required Network Upgrade as to not introduce any unnecessary mitigation solutions for this analysis.

To mitigate the voltage collapse/instability, generation tripping offline, and poor post-fault steady-state voltages after the addition of the Keystone to Red Willow to Post Rock 345kV transmission circuit, several additional mitigation options were further discussed with SPP and investigated to determine the effectiveness of the resolving all voltage stability and generator stability issues observed in Table 3-8 and Table 3-9. Refer to Table 3-10 for a summary of several mitigation options investigated.

Note, similar to the Normal Dispatch Scenario, it was determined fault events near Laramie River Station 345kV and G16-110-Tap 345kV were observed to have a critical clearing time greater than

5 cycles. After discussion with the Transmission Owner, it was determined that P1 events out of Laramie River Station 345kV have a 4 cycle clearing time which meets the critical clearing time determined from this analysis. No additional Network Upgrades are required for P1 events at Laramie River Station 345kV or G16-110-Tap 345kV.

Table 3-10: Overall Mitigation Solution Options for the High GGS Sensitivity

Network Upgrade Option	Option 1	Option 2	Option 3	Option 4
R-Plan		X		X
Reduce Fault Clear Time at G16-110-Tap/Laramie	X	X	X	X
Keystone - Red Willow 345kV Circuit #1	X	X	X	X
Red Willow - Post Rock 345kV Circuit #1	X	X	X	X
Antelope - Holt County 345kV			X	X

The mitigation options in Table 3-10 were applied to each High GGS Sensitivity scenario to determine the effectiveness of the network upgrades. It was determined all four mitigation solutions in Table 3-10 successfully mitigated all P1 and P4 events simulated.

For FLT04-3PH, a three-phase fault event (P1) that results in the loss of the Laramie River Station to G16-110-Tap 345kV circuit #1, was observed to cause voltage collapse in the vicinity of Sidney and Stegall. Although the four identified mitigation solutions in Table 3-8 mitigate the voltage collapse issues observed, only reducing the clearing time for faults at Laramie River Station and GEN-2016-110-Tap are required. Refer to Figure 3-9 for a representative voltage plot for a P1 event out of Laramie River Station 345kV for the 17WP scenario comparing the critical clearing times. It can be observed that a fault clearing time greater than 5 cycles (6 cycles) results in voltage instability. Reducing the clearing time to 5 cycles, without Network Upgrades, results in a stable and acceptable response.

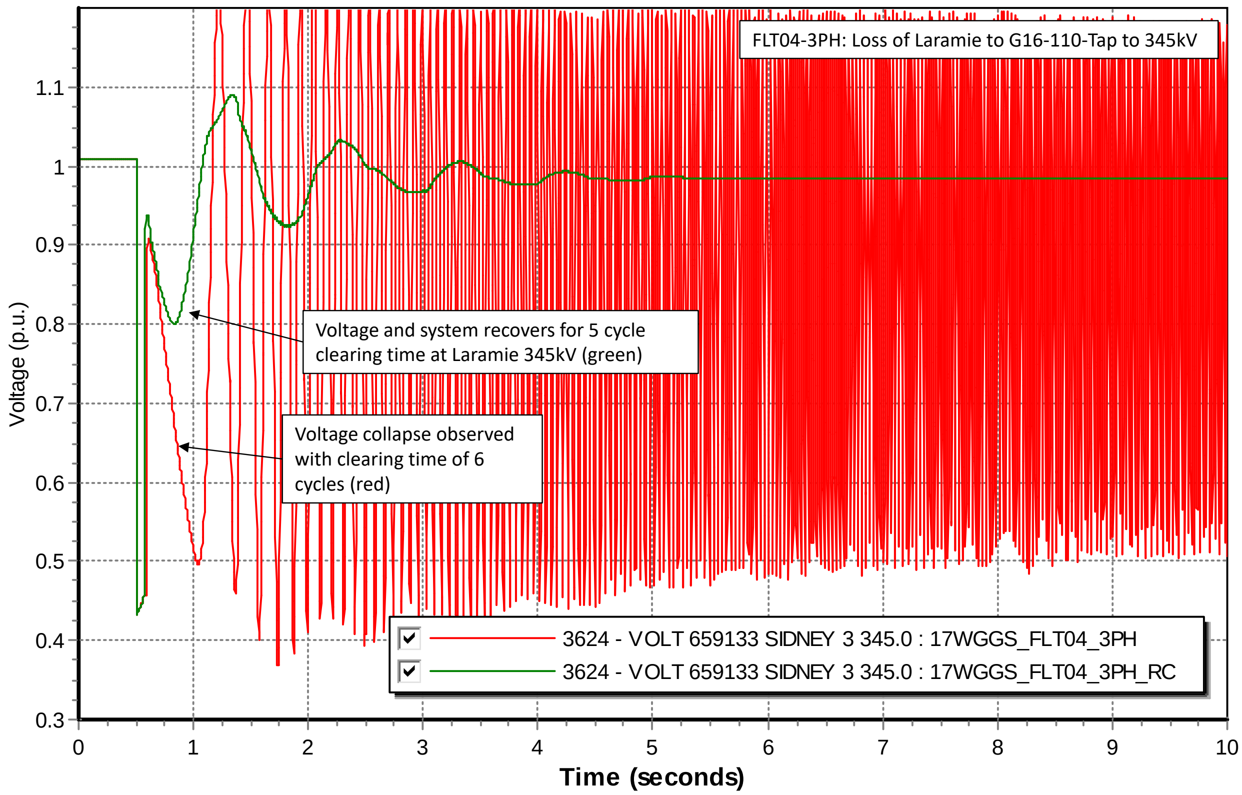

Figure 3-9: Representative voltage plot for FLT04 for GGS 17WP conditions comparing critical clearing times.

For FLT59-SB, a stuck breaker fault event (P4) that results in the loss of the Gentleman to Keystone 345kV circuit #1 and the Gentleman 345/230kV transformer, was observed to cause voltage collapse in the vicinity of Red Willow and Keystone. The four identified mitigation solutions in Table 3-8 mitigate the voltage collapse issues observed. Refer to Figure 3-10 for a representative voltage plot for a P4 event out of Gentleman 345kV for the 17WP scenario with no Network Upgrades compared to all four solution options in Table 3-8. It can be observed that without any Network Upgrades, the fault results in voltage collapse/instability. All four mitigation options improve the response after the fault is cleared and results in a stable and acceptable response.

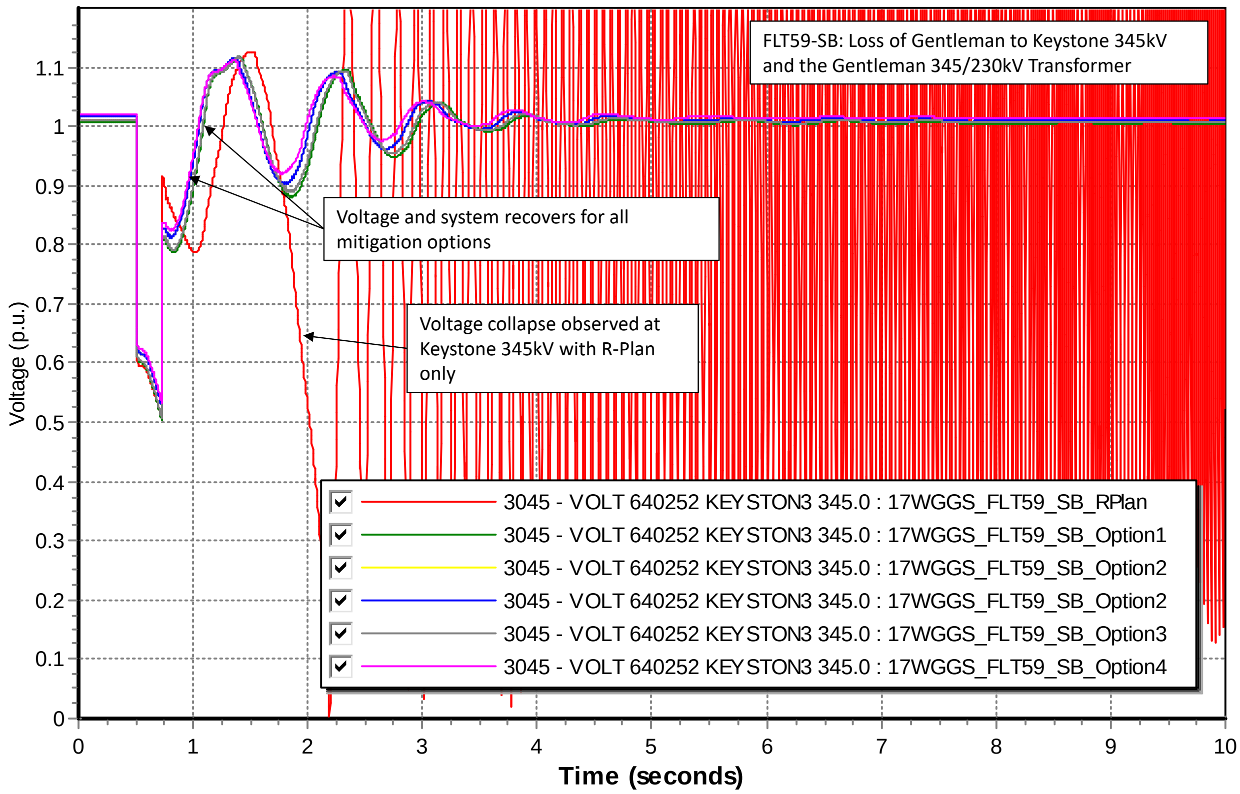

Figure 3-10: Representative voltage plot for FLT59 for 17WP conditions comparing results with the R-Plan Network Upgrade and additional identified Network Upgrades.

Refer to Table 3-11 for a summary of the High GGS Sensitivity Stability Analysis results with Option 4 implemented as the mitigation solution for all contingencies. Table 3-11 is a summary of the stability results for the 17WP, 18SP, and 26SP conditions and states whether the system remained stable or generation tripped offline, if acceptable voltage recovery was observed after the fault was cleared, and if the voltage recovered to above 0.9 p.u. and below 1.1 p.u. post fault steady-state conditions.

Table 3-11: High GGS Sensitivity Summary of Results for 17WP, 18SP, and 26SP Conditions with Solution Option 4

Ref. No.	Fault Number	2017 Winter Peak - GGS				2018 Summer Peak - GGS				2026 Summer Peak - GGS			
		Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability
		Less than 0.7 p.u.	Greater than 1.2 p.u.			Less than 0.7 p.u.	Greater than 1.2 p.u.			Less than 0.7 p.u.	Greater than 1.2 p.u.		
1	FLT01-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
2	FLT02-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
3	FLT03-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
4	FLT04-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
5	FLT05-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
6	FLT06-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
7	FLT07-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
8	FLT08-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
9	FLT09-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
10	FLT10-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
11	FLT11-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
12	FLT12-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
13	FLT13-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
14	FLT14-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
15	FLT15-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
16	FLT16-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
17	FLT17-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
18	FLT18-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
19	FLT19-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
20	FLT20-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
21	FLT21-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
22	FLT22-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
23	FLT23-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
24	FLT24-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
25	FLT25-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
26	FLT26-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable

Table 3-11: High GGS Sensitivity Summary of Results for 17WP, 18SP, and 26SP Conditions with Solution Option 4 (cont.)

Ref. No.	Fault Number	2017 Winter Peak - GGS				2018 Summer Peak - GGS				2026 Summer Peak - GGS			
		Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability
		Less than 0.7 p.u.	Greater than 1.2 p.u.			Less than 0.7 p.u.	Greater than 1.2 p.u.			Less than 0.7 p.u.	Greater than 1.2 p.u.		
27	FLT27-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
28	FLT28-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
29	FLT29-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
30	FLT30-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
31	FLT31-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
32	FLT32-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
33	FLT33-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
34	FLT34-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
35	FLT35-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
36	FLT36-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
37	FLT37-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
38	FLT38-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
39	FLT39-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
40	FLT40-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
41	FLT41-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
42	FLT42-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
43	FLT43-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
44	FLT44-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
45	FLT45-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
46	FLT46-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
47	FLT47-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
48	FLT48-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
49	FLT49-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
50	FLT50-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
51	FLT51-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
52	FLT52-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable

Table 3-11: High GGS Sensitivity Summary of Results for 17WP, 18SP, and 26SP Conditions with Solution Option 4 (cont.)

Ref. No.	Fault Number	2017 Winter Peak - GGS				2018 Summer Peak - GGS				2026 Summer Peak - GGS			
		Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability
		Less than 0.7 p.u.	Greater than 1.2 p.u.			Less than 0.7 p.u.	Greater than 1.2 p.u.			Less than 0.7 p.u.	Greater than 1.2 p.u.		
53	FLT53-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
54	FLT54-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
55	FLT55-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
56	FLT56-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
57	FLT57-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
58	FLT58-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
59	FLT59-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
61	FLT61-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
63	FLT63-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
64	FLT64-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
65	FLT65-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
66	FLT66-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
67	FLT67-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
68	FLT68-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
69	FLT69-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
70	FLT70-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
71	FLT71-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
72	FLT72-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
73	FLT73-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
74	FLT74-PO	Voltage Collapse				Voltage Collapse				Voltage Collapse			
75	FLT75-PO	Voltage Collapse				Voltage Collapse				Voltage Collapse			
76	FLT76-PO	Voltage Collapse				Voltage Collapse				Voltage Collapse			
77	FLT77-PO	No	No	Compliant	Stable	Voltage Collapse				No	No	Compliant	Stable
78	FLT78-PO	Voltage Collapse				Voltage Collapse				Voltage Collapse			
79	FLT79-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
80	FLT80-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable

Table 3-11: High GGS Sensitivity Summary of Results for 17WP, 18SP, and 26SP Conditions with Solution Option 4 (cont.)

Ref. No.	Fault Number	2017 Winter Peak - GGS				2018 Summer Peak - GGS				2026 Summer Peak - GGS			
		Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability
		Less than 0.7 p.u.	Greater than 1.2 p.u.			Less than 0.7 p.u.	Greater than 1.2 p.u.			Less than 0.7 p.u.	Greater than 1.2 p.u.		
81	FLT81-PO	Voltage Collapse				Voltage Collapse				Voltage Collapse			
82	FLT82-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
83	FLT83-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
84	FLT84-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
85	FLT85-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
86	FLT86-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
87	FLT87-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
88	FLT88-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
89	FLT89-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
90	FLT90-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
91	FLT91-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
92	FLT92-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
93	FLT93-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
94	FLT94-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
95	FLT95-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
96	FLT96-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
97	FLT97-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
98	FLT98-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
99	FLT99-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
100	FLT100-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
101	FLT101-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
102	FLT102-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
103	FLT103-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
104	FLT104-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
105	FLT105-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
106	FLT106-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable

Table 3-11: High GGS Sensitivity Summary of Results for 17WP, 18SP, and 26SP Conditions with Solution Option 4 (cont.)

Ref. No.	Fault Number	2017 Winter Peak - GGS				2018 Summer Peak - GGS				2026 Summer Peak - GGS			
		Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability
		Less than 0.7 p.u.	Greater than 1.2 p.u.			Less than 0.7 p.u.	Greater than 1.2 p.u.			Less than 0.7 p.u.	Greater than 1.2 p.u.		
107	FLT107-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
108	FLT108-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
109	FLT109-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
110	FLT110-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
111	FLT111-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
112	FLT112-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
113	FLT113-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
114	FLT114-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
115	FLT115-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
116	FLT116-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
117	FLT117-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
118	FLT118-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
119	FLT119-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
120	FLT120-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
121	FLT121-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
122	FLT122-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
123	FLT123-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
124	FLT124-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
125	FLT125-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
126	FLT126-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
127	FLT127-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
128	FLT128-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
129	FLT129-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable

3.4.3 Curtailment for P6 Events for the High GGS Sensitivity Dispatch Scenario

The mitigation solution options identified in Section 3.3.2 relieved the voltage collapse and voltage instability issues for all P1 and P4 events studied. However, there were several prior outage conditions near Sidney and G16-110-Tap that resulted in a voltage collapse with Option 4, which includes the following Network Upgrades:

- SPP R-Plan
  - Thedford 345/115/13.8 kV transformer
  - Gerald Gentleman Station to Thedford 345kV circuit #1
  - Holt County to Thedford 345kV circuit #1
- Keystone to Red Willow to Post Rock 345kV circuit #1
- Antelope to Holt County 345kV circuit #1

The following prior outage contingencies resulted in voltage collapse with the above Network Upgrades in-service:

- **FLT74-PO**: Prior outage on the Sidney – Laramie 345kV line circuit 1
  - 3 phase fault on the Stegall to Sidney 345kV line circuit 1, near Stegall.
- **FLT75-PO**: Prior outage on the G16-110-TAP – Stegall 345kV line circuit 1
  - 3 phase fault on the Sidney to Stegall 345kV line circuit 1, near Sidney.
- **FLT76-PO**: Prior outage on the G16-110-TAP – Stegall 345kV line circuit 1
  - 3 phase fault on the Sidney to Keystone 345kV line circuit 1, near Sidney.
- **FLT78-PO**: Prior outage on the Sidney – Stegall 345kV line circuit 1
  - 3 phase fault on the Sidney to Laramie 345kV line circuit 1, near Sidney.
- **FLT81-PO**: Prior outage on the Sidney – Sidney Transformer 230 kV line circuit 1
  - 3 phase fault on the Sidney to Keystone 345kV line circuit 1, near Sidney.

For prior outage conditions that result in a voltage collapse or are observe to have voltage/system instability, generation curtailment in the vicinity of the faults was investigated. Refer to Table 3-12 for a summary of the generation curtailment required for each prior outage condition listed above for the Option 4 mitigation solution (full mitigation).

Table 3-12: Generation Curtailment for Prior Outages for Solution Option #4 (GGS)

Fault Number	Generation Curtailment (%/MW)		
	17WP - GGS	18SP - GGS	26SP - GGS
FLT74-PO	60% 480 MW	60% 480 MW	50% 400 MW
FLT75-PO	20% 160 MW	20% 160 MW	20% 160 MW
FLT76-PO	30% 240 MW	30% 240 MW	30% 240 MW
FLT77-PO	None	10% 80 MW	None
FLT78-PO	60% 480 MW	60% 480 MW	50% 400 MW
FLT81-PO	50% 400 MW	50% 400 MW	50% 400 MW

*Total generation in Laramie/Sidney vicinity is 800 MW

The limiting prior outage faults that required the highest amount of generation curtailment were prior outages out of Sidney 345kV. FLT74-PO, prior outage of Sidney to Laramie River Station 345kV, and FLT78-PO, prior outage of Sidney to Stegall 345kV, each resulted in requiring 480 MW of generation curtailment in the Laramie River Station 345kV and Sidney 345kV vicinity to mitigate the voltage collapse/instability observed. Refer to Figure 3-11 for a representative voltage plot of area bus voltages for FLT78-PO for 18SP conditions. Refer to Figure 3-12 for a representative rotor angle plot for the Laramie River Station generation. This fault was observed to result in voltage collapse/instability in the vicinity of Laramie River Station and Sidney 345kV without generation curtailment. In addition to Solution Option #4, curtailing generation by 480 MW in the vicinity of Laramie River Station and Sidney 345kV mitigates the observed stability issue.

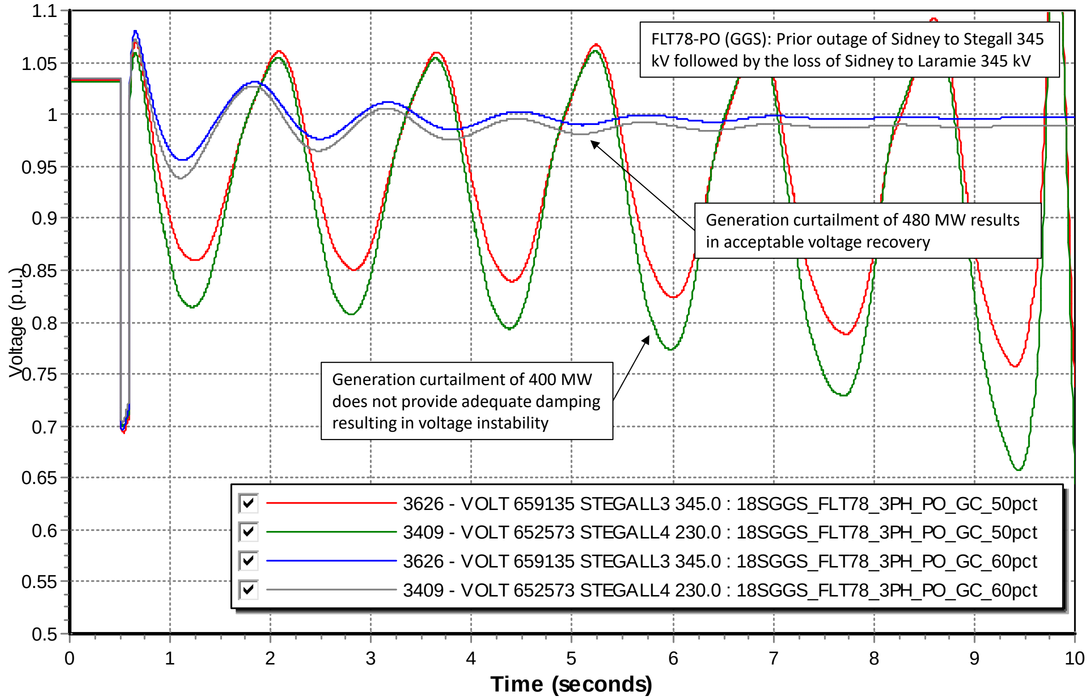

Figure 3-11: Representative voltage plot of FLT78-PO with generation curtailment for 18SP for the High GGS Sensitivity Scenario.

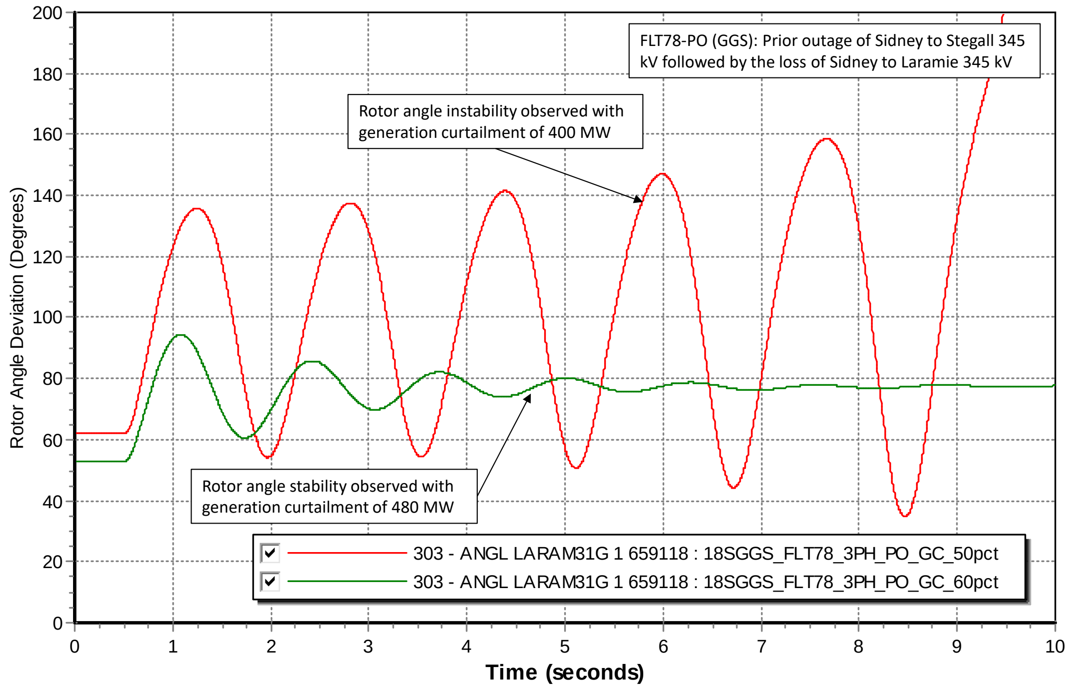

Figure 3-12: Representative rotor angle plot of FLT78-PO with generation curtailment for 18SP for the High GGS Sensitivity Scenario.

Refer to Table 3-13 for generation curtailment required for Solution Option #1 through Solution Option #4 for the prior outage events that result in voltage collapse/instability. It was determined that the solution options have negligible impact on the required generation curtailment amounts for prior outage conditions in the Laramie River Station and Sidney region. The scope of this stability analysis is not comprehensive of all potential prior outage events. The Transmission Owner in the vicinity of Laramie River Station and Sidney 345kV, Basin Electric Power Cooperative, may need to further evaluate and update Operational Guides for maintaining system reliability during circuit outages in the vicinity of Laramie River Station and Sidney 345kV.

Table 3-13: Generation Curtailment for Prior Outage Conditions for All Mitigation Options for the GGS Scenario

Solution Option	Generation Curtailment (%/MW)					
	17WP - GGS		18SP - GGS		26SP - GGS	
	FLT74-PO	FLT78-PO	FLT74-PO	FLT78-PO	FLT74-PO	FLT78-PO
Option 1	60% 480 MW	60% 480 MW	60% 480 MW	60% 480 MW	50% 400 MW	50% 400 MW
Option 2	60% 480 MW	60% 480 MW	60% 480 MW	60% 480 MW	50% 400 MW	50% 400 MW
Option 3	60% 480 MW	60% 480 MW	60% 480 MW	60% 480 MW	50% 400 MW	50% 400 MW
Option 4	60% 480 MW	60% 480 MW	60% 480 MW	60% 480 MW	50% 400 MW	50% 400 MW

*Total generation in Laramie/Sidney vicinity is 800 MW

Refer to Appendix E, Appendix F, and Appendix G for a complete set of plots for all contingencies for 2017 Winter Peak, 2018 Summer Peak, and 2026 Summer Peak High GGS conditions, respectively. The plots for all three seasons can be provided upon request.

3.5 High GGS Dispatch Scenario Summary of Results

The analysis of the High GGS Dispatch Scenario determined mitigation is required to alleviate voltage instability issues in the Gerald Gentleman Station vicinity and the Laramie vicinity for select P1 and P4 events. It was determined that a new 345kV circuit from Keystone to Red Willow to Post Rock would alleviate the voltage instability near Gentleman 345kV. Alternatively, the Gentleman station could be re-configured to a double bus double breaker station or installation of reactive support at Keystone in addition to the R-Plan would also alleviate the voltage stability issues.

It was also determined that no additional mitigation is required for the additional contingencies in Table 2-6 (Keystone, Red Willow, and Post Rock P4 events) after the addition of the Keystone to Red Willow to Post Rock 345kV circuit. All additional contingencies resulted in acceptable voltage and rotor angle recovery following the P1 or P4 event as applied in Table 2-6.

For P1 events at Laramie 345kV or GEN-2016-110-Tap 345kV, system stability was maintained for faults cleared in 5 cycles prior to any mitigation implemented. The addition of the mitigation options (Keystone to Red Willow to Post Rock 345kV) did not impact these critical clearing times.

For P1 events out of Holt County 345kV, it was determined system stability was maintained provided the Grand Prairie Wind Units and GEN-2016-075 utilized the latest Vestas model with the included power plant controller.

SECTION 4: CONCLUSION

Summary of Stability Analysis

The Stability Analysis determined that there were multiple contingencies across all seasons and dispatch scenarios that resulted in voltage collapse/instability, generation tripping offline, and poor post-fault voltage recovery when all generation interconnection requests were at 100% output. The voltage collapse/instability was observed in the vicinity of Gerald Gentleman Station, Laramie River Station, and Holt Station for P1 and P4 fault events.

The P4 events at Gerald Gentleman Station that resulted in voltage collapse/instability could be mitigated by the following solution options:

- GGS Solution Option #1: Build a 345kV circuit from Keystone to Red Willow to Post Rock.
    - This solution option is valid with and without the R-Plan Network Upgrade:
        - Thedford 345/115/13.8 kV transformer
        - Gerald Gentleman Station to Thedford 345kV circuit #1
        - Holt County to Thedford 345kV circuit #1
- GGS Solution Option #2: Rebuild Gerald Gentleman Station with a double bus double breaker configuration.
- GGS Solution Option #3: Build the R-Plan Network Upgrade and install at least 325 Mvar of fast dynamic reactive support (SVC) at Keystone 345kV.

The power flow analysis performed by SPP has identified the need for the Keystone to Red Willow to Post Rock 345kV circuit to alleviate several constraints. Therefore, after determining that the Keystone to Red Willow to Post Rock 345kV circuit mitigated the voltage collapse/instability for P4 events at Gerald Gentleman Station, the Keystone to Red Willow to Post Rock 345kV circuit was included in the remaining solution options.

It was determined that P1 and P4 events near Laramie River Station 345kV resulted in voltage collapse/instability. The critical clearing time for P1 events near Laramie River Station 345kV was determined to be greater than 5 cycles. After discussion with the Transmission Owner, faults on the nearby 345kV transmission system have a 4 cycle clearing time so no additional mitigation is required for P1 events near Laramie River Station 345kV.

For P4 events near Laramie River Station, the GGS Solution Option #1 above (Build a 345kV circuit from Keystone to Red Willow to Post Rock, with and without the R-Plan Network Upgrade) mitigated the voltage collapse/instability for the Normal Dispatch Scenario and High GGS Sensitivity Dispatch Scenario.

It was determined that P1 and P4 events near Holt County 345kV resulting in the outage of the Holt County to Grand Island 345kV circuit also may result in voltage stable concerns. Either the R-Plan or an Antelope to Holt County 345kV circuit #1 upgrade provide an additional outlet at Holt County that resolves the observed instability or updating the Grand Prairie Wind Units to the latest Vestas Generic Model Structure V7 with power plant controller.

The power flow analysis performed by SPP has also identified the need for both the R-Plan and an Antelope to Holt County 345kV circuit #1 to alleviate all constraints. Therefore, after determining that these upgrades mitigated the voltage collapse/instability for the fault events evaluated in this stability analysis, each was included in the remaining solution evaluation below:

- Solution Option #4
    - Keystone to Red Willow to Post Rock 345kV circuit #1
    - R-Plan Network Upgrade
    - Antelope to Holt County 345kV circuit #1

The solution option identified above mitigated the voltage collapse/instability observed for P1 and P4 evaluated in all seasons and dispatch scenarios. However, with the complete solution set generation curtailment is required for several prior outage conditions, P6 events. With each of the identified upgrades above in-service, prior outage conditions, in anticipation of a subsequent fault event, required additional generation curtailment for the Normal Dispatch Scenario and High GGS Sensitivity Dispatch Scenario for circuits terminated at the following stations:

- GEN-2016-110 POI station 345kV
- Keystone 345kV
- Laramie River Station 345kV
- Sidney 345kV
- Sidney 230kV
- Stegall 345kV

Following the prior outages as described above, in order to maintain system stability following the three phase faults, the analysis determined that curtailing generation by up to 480 MW in the vicinity of Laramie River Station and Sidney 345kV resulted in a stable response with no generation tripping or system instability observed.

With the identified upgrades and curtailment above, the Stability Analysis determined that there was no generation tripping or system instability observed as a result of interconnecting all study projects at 100% output.

APPENDIX A: STEADY STATE AND DYNAMIC MODEL DATA

Base Case Power Flows

Three base case power flows were provided to MEPPI by SPP:

- MDWG16-17W_DIS16021_G09.sav
- MDWG16-18S_DIS16021_G09.sav
- MDWG16-26S_DIS16021_G09.sav

Three GGS Sensitivity base case power flows were provided to MEPPI by SPP:

- MDWG16-17W_DIS16021_G09GGS.sav
- MDWG16-18S_DIS16021_G09GGS.sav
- MDWG16-26S_DIS16021_G09GGS.sav

Three dynamic files were provided to MEPPI by SPP:

- MDWG16-17W_DIS16021_G09.dyr
- MDWG16-18S_DIS16021_G09.dyr
- MDWG16-26S_DIS16021_G09.dyr

Updates Applied to Base Case

Removal of:

- SPP R Plan
  - Thedford 345/115/13.8 kV transformer
  - Gerald Gentleman Station to Thedford 345kV circuit #1
  - Holt County to Thedford 345kV circuit #1
- DISIS-2016-001 withdrawn upgrades:
  - Gerald Gentleman Station to Keystone 345kV circuit #2
  - Keystone to Sidney 345kV circuit #2
  - GEN-2016-023/029 Tap on the Laramie River Station to Sidney 345kV circuit #1
  - GEN-2016-023/029 Tap on the Laramie River Station to Stegall 345kV circuit #1
- SPP Withdrawn requests:
  - GEN-2010-041
  - GEN-2015-053
  - GEN-2015-087
  - GEN-2016-023
  - GEN-2016-029
  - GEN-2016-165
- MISO withdrawn requests:
  - J414
  - J415
  - J439
  - J459
  - J489
  - J511

- J525
- J575
- J577
- J593
- J594
- J596
- J597
- J599
- J637
- J638

Request Data:

GEN-2016-074

- Wind Farm Size: 200 MW
- Interconnection:
  - Voltage: 345kV
  - POI: Sweetwater 345kV (640374)
  - Transformer: 345/34.5 kV step-up transformer
    - MVA: 156 Winding MVA
    - Z: 11.8%
- Collector System Equivalent Model:
  - Transmission Line:
    - R = 0.00528 p.u.
    - X = 0.00628 p.u.
    - B = 0.0944 p.u.
- Wind Farm Parameters
  - Vestas V110 2.0 MW
  - Machine Terminal Voltage: 0.7 kV
  - Rated Power: 200 MW
  - Number of Wind Turbines: 100
  - Generator Step-Up Transformer:
    - MVA: 210 Winding MVA
    - Z: 7.75%

The following is the dynamic data for GEN-2016-074:

```
/
587683 'USRMDL' '1'  'VWCOR6' 1 1 2 45 23 104 1 0
 2000.0000 690.0000 903.3041 700.0000 2.6200 0.9676 0.0232
 1.9807 8.3333 1.9807 8.3333 30.0000 0.2000 1.2000
 0.1000 0.0012 0.9925 0.0474 1.6118 0.0000 351.8584
 161.5343 0.0300 0.0000 0.0300 0.3000 0.0000 1.0000
 0.3183 4.9736 2812227.1900 43.2960 90.0120 600000.0000 3.0000
 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
 0.0000 0.0000 0.0000/
0 'USRMDL' 0 'VWVAR6' 8 0 2 0 0 30 587683 '1'  /
0 'USRMDL' 0 'VWLVR6' 8 0 3 65 10 35 587683 '1' 1
 0.9000 0.0010 0.1500 18.6316 74.5430 74.5430 74.5430
 0.5000 1.0000 2.6200 0.9676 1.2000 0.5000 690.0000
 903.3041 0.3500 0.0500 0.2500 0.0200 3.0000 4.0000
 9999.0000 0.0232 0.9000 0.9000 0.0500 0.0000 0.0100
 0.0000 2.0000 0.0000 1.0000 0.0000 0.0000 0.0000
 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
 0.0000 0.0000 /
0 'USRMDL' 0 'VWPWR6' 8 0 3 30 7 10 587683 '1' 1
 1.0000 0.5000 -0.5000 0.6988 0.8844 0.9800 0.9600
 0.2000 0.2000 1.0000 1.0000 0.0000 0.0000 0.1000
 0.1000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
 0.0000 0.0000 /
0 'USRMDL' 0 'VWMEC6' 8 0 2 10 8 0 587683 '1'
 2000.0000 422.2301 4736.7543 420.7500 83.5000 6188.8071 39.3992
 0.0000 0.0000 0.0000 /
0 'USRMDL' 0 'VWMEA6' 8 0 2 10 8 5 587683 '1'
 0.1000 0.1000 0.1000 0.0000 0.0000 0.0000 0.0000
 0.0000 0.0000 0.0000/
0 'USRMDL' 0 'VWVPR6' 0 2 7 30 0 18 587683 '1'  1 1 0 0 0
 0.8500 11.0000 0.8500 11.0000 0.9000 60.0000 1.1000
 60.0000 1.1500 2.0000 1.2000 0.0800 1.2500 0.0050
 1.2500 0.0050 0.0000 0.0000 0.0000 0.0000 0.0000
 0.0000 0.0000 0.1500 0.8000 2.7000 0.8500 3.5000
 0.9000 5.0000 /
0 'USRMDL' 0 'VWFPR6' 0 2 3 12 0 7 587683 '1'  0
 56.4000 0.2000 56.4000 0.2000 56.4000 0.2000 63.6000
 0.2000 63.6000 0.2000 63.6000 0.2000 /
/
```

GEN-2016-096

- Wind Farm Size: 227.7 MW
- Interconnection:
  - Voltage: 345kV
  - POI: G15-088-TAP 345kV (560062)
  - Transformer #1: 345/34.5 kV step-up transformer
    - MVA: 100 Winding MVA
    - Z: 12.0%

- Transformer #2: 345/34.5 kV step-up transformer
  - MVA: 100 Winding MVA
  - Z: 12.0%
- Collector System Equivalent Model:
  - Transmission Line #1:
    - R = 0.014 p.u.
    - X = 0.01826 p.u.
    - B = 0.12261 p.u.
  - Transmission Line #2:
    - R = 0.04197 p.u.
    - X = 0.05936 p.u.
    - B = 0.08998 p.u.
- Wind Farm Parameters
  - Siemens 2.3 MW
  - Machine Terminal Voltage: 0.7 kV
  - Rated Power: 227.7 MW
  - Number of Wind Turbines: 99
  - Generator Step-Up Transformer #1:
    - MVA: 181.5 Winding MVA
    - Z: 5.97%
  - Generator Step-Up Transformer #2:
    - MVA: 90.75 Winding MVA
    - Z: 5.97%

The following is the dynamic data for GEN-2016-096:

```
/
587783  'USRMDL' 1 'SWTGU2'   101   1   0   22   5   16
 0.010   0.010   2.000   1.200   0.020   0.100   11.473   0.044
 0.300   1.000   1.000   0.300   1.000   1.000    0.300   1.000
 1.000   0.000   0.000   0.000   0.000   0.000 /
/
587783   'USRMDL' 1 'SWTEU2'   102   0    12   97   18   35
  0   0   1   0   1   0   0   0   0   0   0   0
  0.000     0.037     9.980     0.050     1.000     1.000   0.000    0.050    0.950   0.030
  1.080     0.030   15.000    15.000     0.217     -0.217   1.250    1.181    1.200   1.066
  0.992     1.042     1.000     1.103     0.142     0.025   0.000    0.000    0.000   0.000
  1.250     1.250     1.000     0.500     0.200     0.100   0.925    0.025    2.000   500.000
  0.900     1.000     0.900     0.800     0.500     0.100   0.600    0.250    0.050   3.000
  0.700     0.875    200.000     0.025     1.111     1.000   20.000   -20.000    0.000   2.000
  0.000     1.000     1.200     0.100     0.500     0.500   0.000    10.000    10.000   100.000
  0.000     0.800     0.900     1.000     0.040     0.000   0.800    0.830    1.000   1.000
  1.000   5.000    0.000     0.000     0.000     0.000     0.000    -38.000    0.190    0.975
  7.500   0.000   0.000   146.410   1.000   1.041   146.410 /
58778300  'VTGTPAT' 587783  587783  '1'  0.9  5  200  0.05  /
58778301  'VTGTPAT' 587783  587783  '1'  0.85  5  11  0.05  /
58778302  'VTGTPAT' 587783  587783  '1'  0.7  5  2.6  0.05  /
58778303  'VTGTPAT' 587783  587783  '1'  0.4  5  1.6  0.05  /
58778304  'VTGTPAT' 587783  587783  '1'  0.15  5  0.85  0.05  /
58778305  'VTGTPAT' 587783  587783  '1'  0  1.1  1  0.05  /
58778306  'VTGTPAT' 587783  587783  '1'  0  1.2  0.15  0.05  /
58778307  'FRQTPAT' 587783  587783  '1'  57  100  0.2  0  /
58778308  'FRQTPAT' 587783  587783  '1'  0  62  0.2  0  /
/
587787  'USRMDL' 1 'SWTGU2'   101   1   0   22   5   16
 0.010   0.010   2.000   1.200   0.020   0.100   11.473   0.044
 0.300   1.000   1.000   0.300   1.000   1.000    0.300   1.000
 1.000   0.000   0.000   0.000   0.000   0.000 /
/
587787   'USRMDL' 1 'SWTEU2'   102   0    12   97   18   35
  0   0   1   0   1   0   0   0   0   0   0   0
  0.000     0.037     9.980     0.050     1.000     1.000   0.000    0.050    0.950   0.030
  1.080     0.030   15.000    15.000     0.217     -0.217   1.250    1.181    1.200   1.066
  0.992     1.042     1.000     1.103     0.142     0.025   0.000    0.000    0.000   0.000
  1.250     1.250     1.000     0.500     0.200     0.100   0.925    0.025    2.000   500.000
  0.900     1.000     0.900     0.800     0.500     0.100   0.600    0.250    0.050   3.000
  0.700     0.875    200.000     0.025     1.111     1.000   20.000   -20.000    0.000   2.000
  0.000     1.000     1.200     0.100     0.500     0.500   0.000    10.000    10.000   100.000
  0.000     0.800     0.900     1.000     0.040     0.000   0.800    0.830    1.000   1.000
  1.000   5.000    0.000     0.000     0.000     0.000     0.000    -38.000    0.190    0.975
  7.500   0.000   0.000   146.410   1.000   1.041   146.410 /
58778700  'VTGTPAT' 587787  587787  '1'  0.9  5  200  0.05  /
58778701  'VTGTPAT' 587787  587787  '1'  0.85  5  11  0.05  /
58778702  'VTGTPAT' 587787  587787  '1'  0.7  5  2.6  0.05  /
58778703  'VTGTPAT' 587787  587787  '1'  0.4  5  1.6  0.05  /
58778704  'VTGTPAT' 587787  587787  '1'  0.15  5  0.85  0.05  /
58778705  'VTGTPAT' 587787  587787  '1'  0  1.1  1  0.05  /
58778706  'VTGTPAT' 587787  587787  '1'  0  1.2  0.15  0.05  /
58778707  'FRQTPAT' 587787  587787  '1'  57  100  0.2  0  /
58778708  'FRQTPAT' 587787  587787  '1'  0  62  0.2  0  /
/
```

GEN-2016-106

- Wind Farm Size: 400 MW
- Interconnection:
  - Voltage: 345kV
  - POI: Gentleman 345kV (640183)
  - Transformer: 345/34.5 kV step-up transformer
    - MVA: 266 Winding MVA
    - Z: 8.0%
- Collector System Equivalent Model:
  - Transmission Line:
    - R = 0.00273 p.u.
    - X = 0.0033 p.u.
    - B = 0.06874 p.u.
- Wind Farm Parameters
  - Vestas V110 2.0 MW
  - Machine Terminal Voltage: 0.7 kV
  - Rated Power: 400 MW
  - Number of Wind Turbines: 200
  - Generator Step-Up Transformer:
    - MVA: 420 Winding MVA
    - Z: 8.95%

The following is the dynamic data for GEN-2016-106:

```
/
/ Replaces VWC081
/
/
/ V110 VCSS 2.0 MW 60 Hz Mk10 (VestasWT_7_6_0_PSSE32.lib)
/
587853 'USRMDL' '1'  'VWCOR6' 1 1 2 45 23 104 1 0
 2000.0000 690.0000 903.3041 700.0000 2.6200 0.9676 0.0232
 1.9807 8.3333 1.9807 8.3333 30.0000 0.2000 1.2000
 0.1000 0.0012 0.9925 0.0474 1.6118 0.0000 351.8584
 161.5343 0.0300 0.0000 0.0300 0.3000 0.0000 1.0000
 0.3183 4.9736 2812227.1900 43.2960 90.0120 600000.0000 3.0000
 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
 0.0000 0.0000 0.0000/
0 'USRMDL' 0 'VWVAR6' 8 0 2 0 0 30 587853 '1'  /
0 'USRMDL' 0 'VWLVR6' 8 0 3 65 10 35 587853 '1' 1
 0.9000 0.0010 0.1500 18.6316 74.5430 74.5430 74.5430
 0.5000 1.0000 2.6200 0.9676 1.2000 0.5000 690.0000
 903.3041 0.3500 0.0500 0.2500 0.0200 3.0000 4.0000
 9999.0000 0.0232 0.9000 0.9000 0.0500 0.0000 0.0100
 0.0000 2.0000 0.0000 1.0000 0.0000 0.0000 0.0000
 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
 0.0000 0.0000 /
0 'USRMDL' 0 'VWPWR6' 8 0 3 30 7 10 587853 '1' 1
 1.0000 0.5000 -0.5000 0.6988 0.8844 0.9800 0.9600
 0.2000 0.2000 1.0000 1.0000 0.0000 0.0000 0.1000
 0.1000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
 0.0000 0.0000 /
0 'USRMDL' 0 'VWMEC6' 8 0 2 10 8 0 587853 '1'
 2000.0000 422.2301 4736.7543 420.7500 83.5000 6188.8071 39.3992
 0.0000 0.0000 0.0000 /
0 'USRMDL' 0 'VWMEA6' 8 0 2 10 8 5 587853 '1'
 0.1000 0.1000 0.1000 0.0000 0.0000 0.0000 0.0000
 0.0000 0.0000 0.0000/
0 'USRMDL' 0 'VWVPR6' 0 2 7 30 0 18 587853 '1'  1 1 0 0 0
 0.8500 11.0000 0.8500 11.0000 0.9000 60.0000 1.1000
 60.0000 1.1500 2.0000 1.2000 0.0800 1.2500 0.0050
 1.2500 0.0050 0.0000 0.0000 0.0000 0.0000 0.0000
 0.0000 0.0000 0.1500 0.8000 2.7000 0.8500 3.5000
 0.9000 5.0000 /
0 'USRMDL' 0 'VWFPR6' 0 2 3 12 0 7 587853 '1'  0
 56.4000 0.2000 56.4000 0.2000 56.4000 0.2000 63.6000
 0.2000 63.6000 0.2000 63.6000 0.2000 /
/Back-up after editing
 /0 'USRMDL' 0 'VWVPR6' 0 2 7 30 0 18 587853 '1'  1 1 0 0 0
/ 0.8500 11.0000 0.8500 11.0000 0.9000 60.0000 1.1000
/ 60.0000 1.1500 2.0000 1.2000 0.0800 1.2500 0.0050
/ 1.2500 0.0050 0.0000 0.0000 0.0000 0.0000 0.0000
/ 0.0000 0.0000 0.1500 0.8000 2.7000 0.8500 3.5000
/ 0.9000 5.0000 /
/
```

GEN-2016-110

- Wind Farm Size: 152 MW
- Interconnection:
  - Voltage: 345kV
  - POI: Tap Laramie River to Stegall 345kV (587874)
  - Transformer: 345/34.5 kV step-up transformer
    - MVA: 108 Winding MVA
    - Z: 9.0%
- Collector System Equivalent Model:
  - Transmission Line:
    - R = 0.003609 p.u.
    - X = 0.003271 p.u.
    - B = 0.024205 p.u.
- Wind Farm Parameters
  - GE 2.0 MW
  - Machine Terminal Voltage: 0.7 kV
  - Rated Power: 152 MW
  - Number of Wind Turbines: 76
  - Generator Step-Up Transformer:
    - MVA: 174.8 Winding MVA
    - Z: 5.7%

The following is the dynamic data for GEN-2016-110:

```
/
587873   'USRMDL' 1  'GEWTG2'  1 1 4 18 3 5
       0  76         0         0
        2.0000      0.80000      0.50000      0.90000       1.2200       1.2000
        2.0000      0.40000      0.80000       10.000      0.20000E-01   0.0000
        0.0000      0.50000      0.16700      0.90000      0.92500       0.0000    /
587873   'USRMDL' 1  'GEWTE2'  4 0 12 67 18 9
         587873          0             0                1                0                0
            0         0             0                1                0                0
       0.15000       2.000        1.0000       0.0000       0.0000      0.50000E-01   3.0000
       0.60000       1.1200       0.40000E-01  0.43600     -0.43600      1.1000      0.20000E-01
       0.45000          -0.45000         60.000           0.10000           0.90000
        1.1000           40.000          0.50000           1.4500           0.50000E-01
       0.50000E-01       1.0000          0.15000          0.96000           0.99600
        1.0040           1.0400           0.99999           0.99999           0.99999
       0.40000           1.0000          0.20000           1.0000           0.25000
       -1.0000           14.0000           25.000            3.0000           -0.90000
        8.0000           0.2000           10.000           1.0000           1.7000
        1.22             1.2500           5.0000           0.0000           0.0000
         0.000           0.25000E-02       1.0000           5.5000           0.10000
       -1.0000           0.10000          0.0000           0.10000          -0.10000
       0.70000           0.12000         -0.12000    /
587873   'USRMDL' 1  'GEWTT1'         5    0    1    5    4    3    0
         3.7000        0.0000        0.0000        1.8800        1.5000     /
587873 'USRMDL'  1 'GEWGD1' 505    0    1   6    0    4   0
         9999.0        5.0000        30.000        9999.0        9999.0          30.000    /
587873 'USRMDL'  1 'GEWTA2' 505   0    0    9    1    4
         20.000        0.0000        27.000       -4.0000        0.0000        1.2250
         58.0         104.000       1200.0     /
587873 'USRMDL'  1 'GEWTP2' 505    0    1    10    3    3    0
        0.30000        150.00        25.000        3.0000        30.000
        -4.0000        27.000       -10.000        10.000        1.0000     /
58787300  'USRMSC'  'GEWPLT2'  512  0  2  0  0  17  587873  '1'/
58787301 'FRQTPAT'           587873     587873   '1' 56.5    62.5   1    0.08/
58787302 'VTGTPAT'           587873     587873   '1' 0.15  5     0.2  0.08 /
58787303 'VTGTPAT'           587873     587873   '1' 0.3   5     0.7  0.08 /
58787304 'VTGTPAT'           587873     587873   '1' 0.5   5     1.2  0.08 /
58787305 'VTGTPAT'           587873     587873   '1' 0.75  5     1.9  0.08 /
58787306 'VTGTPAT'           587873     587873   '1' 0     1.1   1    0.08 /
58787307 'VTGTPAT'           587873     587873   '1' 0     1.15  0.1  0.08 /
/
```

GEN-2016-147

- Solar Farm Size: 40 MW
- Interconnection:
  - Voltage: 115 kV
  - POI: Sidney 115 kV
  - Transformer: 115/34.5 kV step-up transformer
    - MVA: 27 Winding MVA
    - Z: 8.5%
- Collector System Equivalent Model:
  - Transmission Line:
    - R = 0.006296 p.u.
    - X = 0.002961 p.u.
    - B = 0.003298 p.u.

- Solar Farm Parameters
  - GE 2.0 MW Solar Inverters
  - Machine Terminal Voltage: 0.6 kV
  - Rated Power: 40 MW
  - Number of Solar Inverters: 20
  - Generator Step-Up Transformer:
    - MVA: 46 Winding MVA
    - Z: 5.9%

The following is the dynamic data for GEN-2016-147:

```
/
 588223 'USRMDL' 1 'GEPVG' 1 1 2 13 3 5
        0 0
        40.000      9999.0      1.2000      2.0000      5.0000      0.20000E-01
        0.0000      0.0000      0.50000     0.16700     0.90000     0.98
        0.0000 /
 588223 'USRMDL' 1 'GEPVE' 4 0 8 27 8 8
        588223  0  0  1  1       0       0   0
        0.1500      18.000      5.0000      0.000       0.0000      1.0000      -1.0000
        1.1112      0.0200      0.1000      0.900       1.1000      120.00       0.5500
        1.5500      0.0500      0.0500      1.000       1.1200      1.1200       1.1200
        5.0000      0.0400      0.0000      0.100      -0.100      0.7000 /
 58822300 'VTGTPAT' 588223 588223 1 0.001 5.00  0.20  0.15 /
 58822301 'VTGTPAT' 588223 588223 1 0.43  5.00  0.40  0.15 /
 58822302 'VTGTPAT' 588223 588223 1 0.63  5.00  2.10  0.15 /
 58822303 'VTGTPAT' 588223 588223 1 0.73  5.00  3.10  0.15 /
 58822304 'VTGTPAT' 588223 588223 1 0.89  5.00  10.0  0.15 /
 58822305 'VTGTPAT' 588223 588223 1 0     1.241 0.001 0.15 /
 58822306 'VTGTPAT' 588223 588223 1 0     1.240 0.250 0.15 /
 58822307 'VTGTPAT' 588223 588223 1 0     1.200 0.600 0.15 /
 58822308 'VTGTPAT' 588223 588223 1 0     1.180 1.100 0.15 /
 58822309 'VTGTPAT' 588223 588223 1 0     1.110 10.00 0.15 /
/
```

APPENDIX B: PLOTS FOR 2017 WINTER PEAK CONDITIONS WITH NORMAL DISPATCH

Plots available upon request

APPENDIX C: PLOTS FOR 2018 SUMMER PEAK CONDITIONS WITH NORMAL DISPATCH

Plots available upon request

APPENDIX D: PLOTS FOR 2026 SUMMER PEAK CONDITIONS WITH NORMAL DISPATCH

Plots available upon request

APPENDIX E: PLOTS FOR 2017 WINTER PEAK CONDITIONS WITH HIGH GGS DISPATCH

Plots available upon request

APPENDIX F: PLOTS FOR 2018 SUMMER PEAK CONDITIONS WITH HIGH GGS DISPATCH

Plots available upon request

APPENDIX G: PLOTS FOR 2026 SUMMER PEAK CONDITIONS WITH HIGH GGS DISPATCH

Plots available upon request

GROUP 10 STABILITY ANALYSIS

The Group 10 stability analysis was not performed again for this restudy. This group was not analyzed for this restudy and previously identified restudy results remain valid.

GROUP 11 (INACTIVE)

Group 11 remains inactive and is reserved.

GROUP 12 STABILITY ANALYSIS

The Group 12 stability analysis was not performed again for this restudy. This group was not analyzed for this restudy and previously identified restudy results remain valid.

GROUP 13 STABILITY ANALYSIS

The Group 13 stability analysis was not performed again for this restudy. This group was not analyzed for this restudy and previously identified restudy results remain valid.

GROUP 14 STABILITY ANALYSIS

The Group 14 stability analysis was not performed again for this restudy. This group was not analyzed for this restudy and previously identified restudy results remain valid.

GROUP 15 STABILITY ANALYSIS

The Group 15 cases included the following previously assigned system upgrades:

- SPP R Plan (NTC 200220)
    - Thedford 345/115/13.8 kV transformer
    - Gerald Gentleman Station to Thedford 345 kV circuit #1
    - Holt County to Thedford 345 kV circuit #1

The Group 15 cases included the following system adjustments of dispatching, to maximum output, generation interconnected at the same or adjacent substations to a current study request:

- Aberdeen, Groton, & Redfield units: GEN-2016-164
- Big Bend & Leland Olds units: GEN-2016-092

The Group 15 stability analysis for this area was performed by Burns & McDonnell Engineering Company, Inc. (B&McD).

With the new requests modeled, violations of stability damping criteria and voltage recovery criteria were not observed. There were no impacts on the stability performance of the SPP system.

With all previously-assigned and currently-assigned Network Upgrades placed in service and identified system adjustments applied, no violations were observed, including violations of low-voltage ride-through requirements, for the probable contingencies studied.

Definitive Interconnection System Impact Study

Southwest Power Pool

DISIS-2016-002-2 (Group 15)
Project No. 111374
Final Report V1

03/17/2020

Definitive Interconnection System Impact Study

prepared for

Southwest Power Pool
DISIS-2016-002-2 (Group 15)
Little Rock, AR

Project No. 111374

03/17/2020

prepared by

Burns & McDonnell Engineering Company, Inc.
Houston, Texas

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(AVAILABLE UPON REQUEST TO SPP)

EXECUTIVE SUMMARY

Southwest Power Pool (SPP) retained Burns & McDonnell to perform a Definitive Interconnection System Impact Study (DISIS) for the DISIS-2016-002-2 (Group 15) requests. This study included stability analysis and short circuit analysis to identify impacts on the transmission system caused by the interconnections of the Group 15 requests.

The DISIS-2016-002-2 Group 15 requests consist of 4 wind projects, and the summary of the requests is shown in Table ES-1. Of the 4 wind projects, GEN-2016-164 request is for a capacity increase based on an existing wind project. The interconnection request GEN-2016-164 was withdrawn from the SPP queue following the commencement of this study and was not removed from the analysis.

Table ES-1: DISIS-2016-002-2 Group 15 Interconnection Requests

Request	Size (MW)	Generator Model	Point of Interconnection
GEN-2016-036	44.6	GE 2.3MW & 2.5MW WTG (587713 & 587714)	Granite Falls 115kV Sub
GEN-2016-087	98.9	GE 2.3MW WTG (587723)	Bismarck-Glenham 230kV
GEN-2016-092	174.8	GE 2.3MW WTG (587753)	Tap Leland Olds-Ft Thompson 345kV
GEN-2016-164	7.92 (uprate to GEN-2009-018IS; withdrawal of uprate not reflected in study)	GE 1.62MW WTG (659289)	Groton 115kV substation

The dynamic stability analysis was performed using PSS/E v. 33.9. For the DISIS-2016-002-2 (Group 15), all four requests were each modeled at its maximum requested capacity. The stability analysis evaluated the transmission system for three load scenarios (2017 Winter Peak, 2018 Summer Peak and 2026 Summer Peak) through simulating 85 faults (three-phase faults and single-line-to-ground faults) under normal conditions and prior outage conditions. Of all the fault events simulated, there were no machine rotor angle damping or transient voltage recovery violations within the DISIS-2016-002-2 (Group 15) study areas.

The short circuit analysis was performed using PSS/E v.33.9. The short circuit analysis evaluated the system for the 2018 Summer Peak and 2026 Summer Peak cases. Three-phase fault currents were calculated for the 69 kV and above buses within 5 buses of generator's point of interconnection. The short circuit impacts are listed in Section 4.

1.0 INTRODUCTION

Burns & McDonnell was retained by Southwest Power Pool (SPP) to perform a Definitive Interconnection System Impact Study (DISIS) of the DISIS-2016-002-2 (Group 15). This study focused on stability analysis and short circuit analysis to identify the impacts on the transmission system caused by the interconnections of Group 15 requests which includes four requests GEN-2016-036, GEN-2016-087, GEN-2016-092, and GEN-2016-164.

The DISIS-2016-002-2 Group 15 requests consist of all wind projects, and GEN-2016-164 request is for a capacity increase based on an existing wind project. The Group 15 request summary is shown in Table 1-1. The interconnection request GEN-2016-164 from the SPP queue as well interconnection requests within the MISO and WAPA queues were withdrawn following the commencement of this study. These withdrawals were not reflected in the analysis as outlined within the report tables.

Table 1-1: DISIS-2016-002-2 Group 15 Interconnection Requests

Request	Size (MW)	Generator Model	Point of Interconnection
GEN-2016-036	44.6	GE 2.3MW & 2.5MW WTG (587713 & 587714)Wind	Granite Falls 115kV Sub
GEN-2016-087	98.9	GE 2.3MW WTG (587723)Wind	Bismarck-Glenham 230kV
GEN-2016-092	174.8	GE 2.3MW WTG (587753)Wind	Tap Leland Olds-Ft Thompson 345kV
GEN-2016-164	7.92 (uprate to GEN-2009-018IS; withdrawal of uprate not reflected in study)	GE 1.62MW WTG (659289)	Groton 115kV substation

1.1 Study Scope

This study is presented in the following five main parts:

1. Introduction
2. Study Assumptions
3. Stability Analysis
4. Short Circuit Analysis
5. Conclusions

1.2 Limitations

In the preparation of this report, the information provided to Burns & McDonnell by others was used by Burns & McDonnell to make certain assumptions with respect to conditions which may exist in the future. While Burns & McDonnell believes the assumptions made are reasonable for the purposes of this report, Burns & McDonnell makes no representation that the conditions assumed will, in fact, occur. In addition, while Burns & McDonnell has no reason to believe that the information provided by others, and on which this report is based, is inaccurate in any material respect, Burns & McDonnell has not independently verified such information and cannot guarantee its accuracy or completeness. To the extent that actual future conditions differ from those assumed herein or from the information provided to Burns & McDonnell, the actual results will vary from those presented.

2.0 STUDY ASSUMPTIONS

The stability analysis was performed using the PTI PSS/E software version 33.9.

2.1 Disturbance Performance Requirement

The following SPP Disturbance Performance Requirements were applied to the Bulk Electric System for the stability analysis. These requirements establish the minimum requirements for machine rotor angle damping and transient voltage recovery.

2.1.1 Rotor Angle Damping Requirement

The machine rotor angles shall exhibit well damped angular oscillations and acceptable power swings following a disturbance on the Bulk Electric System for all NERC events. Well damped angular oscillation is defined as:

1. The Successive Positive Peak Ratio (SPPR) must be less than or equal to 0.95 where SPPR is calculated as:

$$SPPR = \frac{\text{Peak Rotor Angle of 2nd Positive Swing Peak}}{\text{Peak Rotor Angle of 1st Positive Swing Peak}} \leq 0.95$$

Or, Damping Factor % = (1 – SPPR) x 100% ≥ 5%

The machine rotor angle damping ratio may be determined by appropriate modal analysis (i.e. Prony Analysis) where the following equivalent requirement must be met:

Damping Ratio ≥ 0.0081633

2. Successive Positive Peak Ratio Five (SPPR5) must be less than or equal to 0.774 where SPPR5 is calculated as follows:

$$SPPR5 = \frac{\text{Peak Rotor Angle of 5th Positive Swing Peak}}{\text{Peak Rotor Angle of 1st Positive Swing Peak}} \leq 0.774$$

Or, Damping Factor % = (1 – SPPR5) x 100% ≥ 22.6%

The machine rotor angle damping ratio may be determined by appropriate modal analysis (i.e. Prony Analysis) where the following equivalent requirement must be met:

Damping Ratio ≥ 0.0081633.

Burns & McDonnell only calculated these damping values where oscillations were not well damped by the end of the simulation through visual inspection.

2.1.2 Transient Voltage Recovery Requirement:

Bus voltages on the Bulk Electric System shall recover above 0.70 per unit, 2.5 seconds after the fault is cleared. Bus voltages shall not swing above 1.20 per unit after the fault is cleared, unless affected transmission system elements are designed to handle the rise above 1.2 per unit. All post-transient voltages must fall between the 0.90 per unit and 1.10 per unit range at the end of simulations. The pre-fault voltages shall be checked to ensure they fall within the 0.90 per unit and 1.10 per unit.

2.2 Study System

The study system consisted of facilities at or above 100 kV within five (5) buses away from each point of interconnection. Machines interconnected within this study area were monitored for the study.

2.3 Study Models

The stability analysis was performed using models developed from the 2016 Southwest Power Pool (SPP) Model Development Working Group (MDWG) PSS/E models. The base cases provided by SPP model the 2017 Winter Peak, 2018 Summer Peak and 2026 Summer Peak study conditions. The cases were developed with all the interconnection requests added to the base case with dispatch adjustments made per SPP's supplied dispatch requirements.

A single-line diagram for GEN-2016-036, GEN-2016-087, GEN-2016-092 and GEN-2016-164 is provided in Figure 2-1, Figure 2-2, Figure 2-3 and Figure 2-4, respectively.

Figure 2-1: GEN-2016-036 Single-line Diagram

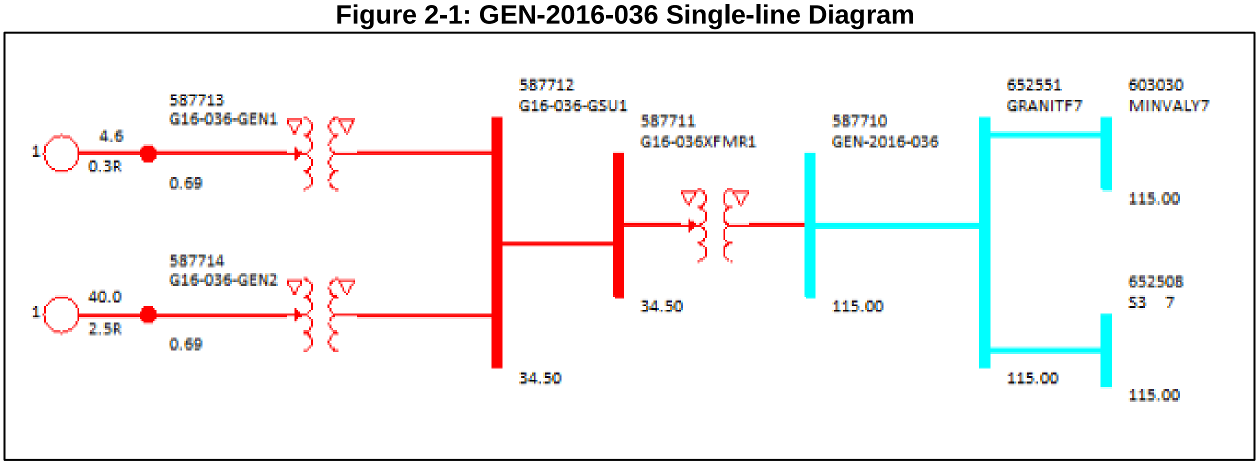


Figure 2-2: GEN-2016-087 Single-line Diagram

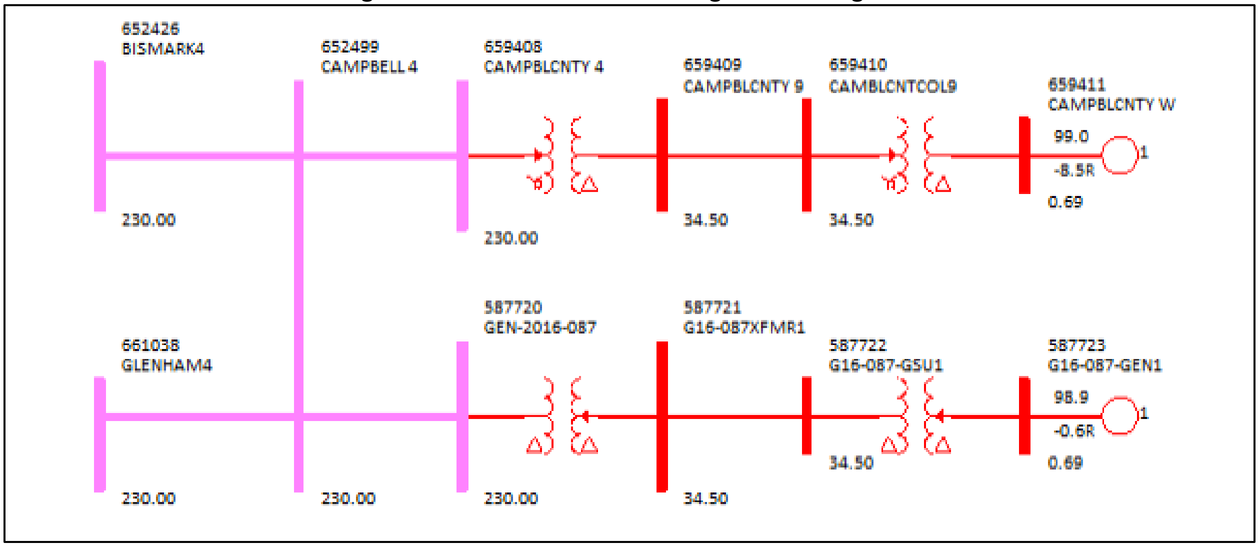


Figure 2-3: GEN-2016-092 Single-line Diagram

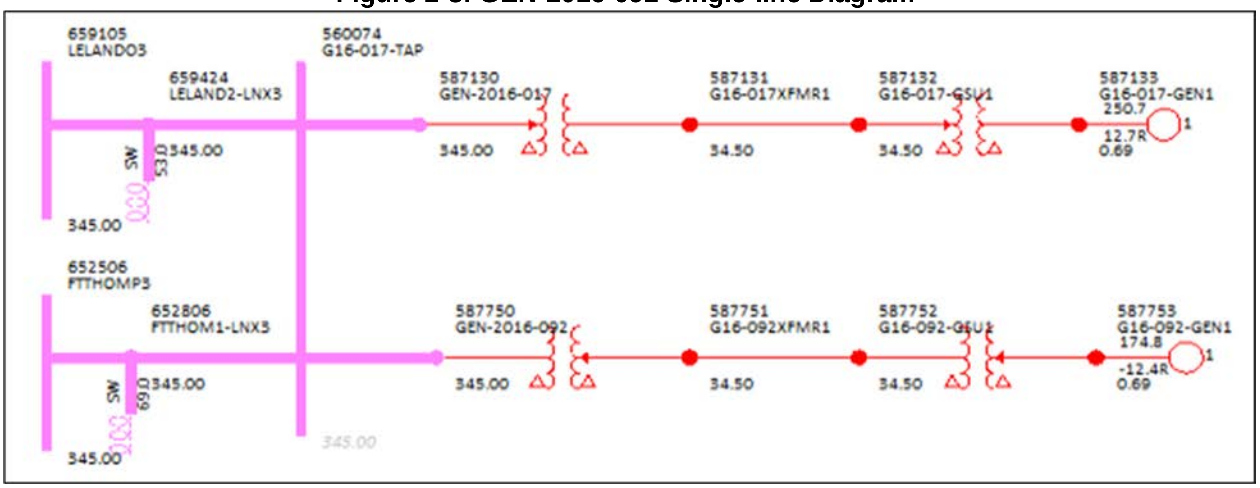
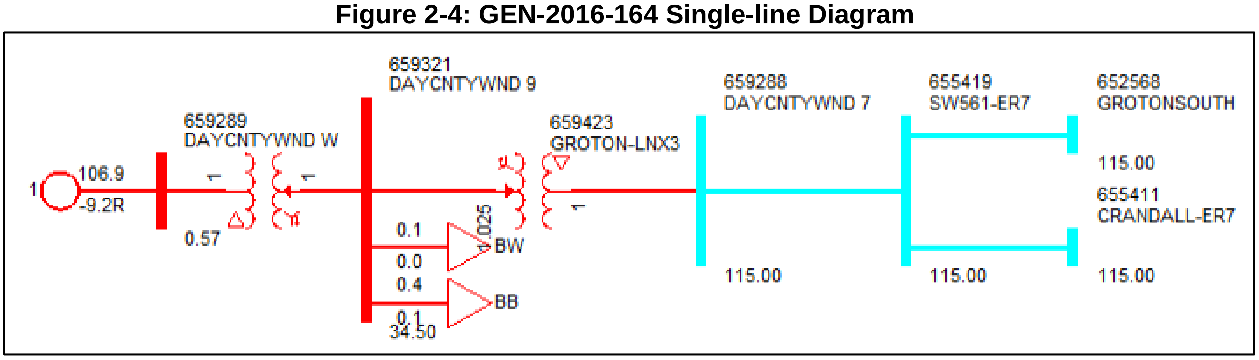


Figure 2-4: GEN-2016-164 Single-line Diagram



2.4 Prior Queued Projects

All study cases contained the Prior Queued Projects listed in Table 2-1 below.

Table 2-1: Prior Queued Projects

Request	Size (MW)	Generator Model	Point of Interconnection
G176	99	WT3 Generic Wind	Yankee 115kV (603191)
G255	100.23	WT3 Generic Wind	Yankee 115kV (603191)
G586	30	WT4 Generic Wind	Yankee 115kV (603191)
G736	200.48	GE 1.79MW WTG	Big Stone South 230kV (620322)
H081	200	Vestas V110 2.0MW WTG	Tap Brookings - Lyons County 345kV (601077)
J414	120 (withdrawal not reflected in study)	Vestas V110 2.0MW WTG	Freeborn 161kV (631180)
J415	200 (withdrawal not reflected in study)	GE 2.3MW & 2.5MW WTG	Emery – Blackhawk 345kV (84151)
J432	98	Gamesa 2.0MW WTG	Brookings 345kV (601031)
J436	150	Vestas V110 VCSS 2.0MW WTG	Big Stone South-Ellendale 345kV (50416)
J437	150	Vestas V110 VCSS 2.0MW WTG	Big Stone South-Ellendale 345kV (50416)
J439	500 (withdrawal not reflected in study)	Vestas V110 2.0MW WTG	Obrien – Kossuth 345 kV line (84390)
J442	200	GE 2.0MW WTG	Big Stone South 230 kV (620322)
J455	300	Vestas V110 2.0MW WTG	Kossuth-Obrien 345 kV(55368)
J459	200 (withdrawal not reflected in study)	Vestas V110 2.0MW WTG	Big Stone - Brookings 345kV (84590)
J460	200	Vestas V110 2.0MW WTG	Tap Brookings - Lyons County 345kV (61041)
J485	46.85	GENSAL	West Side Substation (625447)
J488	151.8	GE WTG	Tap Big Stone - Ellendale 345kV (50416)
J489	151.8 (withdrawal not reflected in study)	GE WTG	Tap Big Stone - Ellendale 345kV (50416)
J493	150	Vestas V136 3.45MW WTG	Big Stone - Brookings 345 kV Substation (71031)
J510	326.9	GENROU	Tap Brookings - Big Stone 345kV (71031)
J512	250.0	Vestas V110 2.0MW & V136 3.6MW WTG	Nobles-Fenton 115kV (85121)
J523	50.0	REGCAU1 Solar	Adams 161 kV (631122)
J525	50 (withdrawal not reflected in study)	REGCAU1 Solar	Lake Wilson 69kV (618920)
J526	300	GE 2.5MW WTG	Tap Brookings - Big Stone 345kV (72031)
J529	250	Vestas V110 2.0MW WTG	Obrien-Kossuth 345 kV (75368)
J569	100.0	Siemens 2.5MW WTG	Rock County 161kV (602039)
J575	100.0 (withdrawal not reflected in study)	GE 2.5MW WTG	Brookings County 345 kV (601031)
J577	102.8 (withdrawal not reflected in study)	GE 2.5MW WTG	Brookings County 345 kV (601031)

Request	Size (MW)	Generator Model	Point of Interconnection
J587	200.0	Vestas V110 2.0MW WTG	Brookings-H081 345kV (61041)
J590	90.0	Vestas V110 2.0MW WTG	Obrien-Kossuth 345 kV (75368)
J594	300.0 (withdrawal not reflected in study)	Vestas V110 2.0MW WTG	Jackson North 161kV (631210)
J596	100.0 (withdrawal not reflected in study)	Vestas V110 2.0MW WTG	Morris-Moro 115kV (85961)
J597	300.0 (withdrawal not reflected in study)	Vestas V110 2.0MW WTG	Brookings County 345kV (601031)
J614	66.0	Vestas V110 2.0MW WTG	Rice 161kV (613330)
J637	98.0 (withdrawal not reflected in study)	Gamesa 2.0MW WTG	Big Stone - Brookings 345 kV (86371)
J638	204.0 (withdrawal not reflected in study)	Gamesa 2.0MW WTG	Big Stone - Brookings 345 kV (86371)
GEN-2002-009IS	40.5	GE 1.5MW WTG	Fort Thompson 69kV (652276)
GEN-2003-016IS	97.4	GENROU	Groton 115kV (652512)
GEN-2006-008IS	97.4	GENROU	Groton 115kV (652512)
GEN-2007-004IS/GEN-2007-016IS	321	GENROU	White 345kV (652537)
GEN-2007-013IS/GEN-2007-014IS/GEN-2010-003IS	184	GE 1.5MW WTG	Wessington Springs 230kV (652607)
GEN-2009-001IS	200	GE 1.6MW WTG	Groton-Watertown 345kV (652175)
GEN-2009-018IS	99	GE 1.5MW WTG	Groton 115kV (652512)
GEN-2010-001IS	99	GE 1.8MW WTG	Bismarck-Glenham 230kV (652499)
GEN-2012-014IS	100.34 (withdrawal not reflected in study)	GE 1.7MW WTG	Groton 115kV (652512)
GEN-2013-009IS	20.35	GE 1.85MW WTG	Redfield NW 115kV (660015)
GEN-2014-001IS	103.7	GE 1.7MW WTG	Newell-Maurine 115kV (652005)
ASGI-2016-005	20	GE 2.5MW WTG	Tap White Lake - Stickeny 69kV (652252)
ASGI-2016-006	20 (withdrawal not reflected in study)	GE 2.5MW WTG	Mitchall (660008)
ASGI-2016-007	20	GE 2.5MW WTG	Kimball 69kV (652252)
GEN-2016-017	250.7	GE 2.3MW WTG	Tap Fort Thompson (652806) – Leland olds (659105) 345kV, (G16-017-TAP, 560074)

3.0 STABILITY ANALYSIS

Burns & McDonnell performed stability analysis to identify impacts on the system stability resulting from the interconnection of DISIS-2016-002-2 (Group 15) requests.

3.1 Methodology

The stability analysis was performed using DISIS-2016-002-2 (Group 15) study cases. The power flow models and associated dynamics database were initialized (no-fault test) to confirm that there were no errors in both the initial conditions of the system and in the dynamic data. The dynamics model data for the DISIS-2016-002-2 (Group 15) requests is provided in Appendix A. The stability analysis was performed using PSS/E version 33.9.

During the fault simulations, the active power (PELEC), reactive power (QELEC), terminal voltage (ETERM) and speed (SPD) were monitored for the GEN-2016-036, GEN-2016-087, GEN-2016-092 and GEN-2016-164 generation interconnection requests and prior queued projects listed in Table 1-1 and Table 2-1. The study area for the stability analysis is defined as five (5) buses away from the POI of each request. The machine rotor angle for synchronous machines and speed for asynchronous machines within this study area including those within 10 areas, 600 (XEL), 608 (MP), 613 (SMMPA), 615 (GRE), 620 (OTP), 640 (NPPD), 645 (OPPD), 650 (LES), 652 (WAPA) and 661 (MDU) were monitored. In addition, the voltages of all 100 kV and above buses within the study area were monitored.

3.2 Fault Definitions

Burns & McDonnell developed fault description for eighty-five (85) normal clearing, stuck breaker, and prior outage contingency events. All contingency events studied are listed in Table 3-1, Table 3-2, Table 3-3 and Table 3-4 for local fault on GEN-2016-036, GEN-2016-087, GEN-2016-092 and GEN-2016-164, respectively. These contingencies were applied for the 2017 Winter Peak, 2018 Summer Peak and 2026 Summer Peak study models.

Table 3-1: Fault Definitions for GEN-2016-036

Fault Name	Contingency (Fault) Description
036FLT02_R-3PH	**3 Phase Fault on Granite Falls (652551) 115 kV Bus to Canby (620211) 115 kV Line, CKT 1**
	a. Apply Fault at the Granite Falls (652551) 115 kV Bus
	b. Clear Fault after 5 Cycles and Trip the Faulted 115 kV Line (652551-620211, CKT 1)
	c. Wait 20 Cycles, and then reclose the line in (b) back into the Fault
	d. Leave Fault on for 5 Cycles, then Trip the Line in (b) and Clear the Fault
036FLT03_R-3PH	**3 Phase Fault on Granite Falls (652551) 115 kV Bus to MinValley (603030) 115 kV Line, CKT 1**
	a. Apply Fault at the Granite Falls (652551) 115 kV Bus
	b. Clear Fault after 5 Cycles and Trip the Faulted 115 kV Line (652551-603030, CKT 1)
	c. Wait 20 Cycles, and then reclose the line in (b) back into the Fault
	d. Leave Fault on for 5 Cycles, then Trip the Line in (b) and Clear the Fault
036FLT04_R-3PH	**3 Phase Fault on Granite Falls (652551) 115 kV Bus to S3 (652508) 115 kV Line, CKT 1**
	a. Apply Fault at the Granite Falls (652551) 115 kV Bus

Fault Name	Contingency (Fault) Description
	b. Clear Fault after 5 Cycles and Trip the Faulted 115 kV Line (652551-652508, CKT 1)
	c. Wait 20 Cycles, and then reclose the line in (b) back into the Fault
	d. Leave Fault on for 5 Cycles, then Trip the Line in (b) and Clear the Fault
036FLT07_R-3PH	**3 Phase Fault on Granite Falls (652550) 230 kV Bus to MinValley Tap (602008) 230 kV Line, CKT 1**
	a. Apply Fault at the Granite Falls (652550) 230 kV Bus
	b. Clear Fault after 5 Cycles and Trip the Faulted 230 kV Line (652550-602008, CKT 1)
	c. Wait 20 Cycles, and then reclose the line in (b) back into the Fault
	d. Leave Fault on for 5 Cycles, then Trip the Line in (b) and Clear the Fault
036FLT08_R-3PH	**3 Phase Fault on Granite Falls (652550) 230 kV Bus to MinValley Tap (602009) 230 kV Line, CKT 1**
	a. Apply Fault at the Granite Falls (652550) 230 kV Bus
	b. Clear Fault after 5 Cycles and Trip the Faulted 230 kV Line (652550-602009, CKT 1)
	c. Wait 20 Cycles, and then reclose the line in (b) back into the Fault
	d. Leave Fault on for 5 Cycles, then Trip the Line in (b) and Clear the Fault
036FLT09_R-3PH	**3 Phase Fault on Granite Falls (652550) 230 kV Bus to Appeldorn (652582) 230 kV Line, CKT 1**
	a. Apply Fault at the Granite Falls (652550) 230 kV Bus
	b. Clear Fault after 5 Cycles and Trip the Faulted 230 kV Line (652550-652582, CKT 1)
	c. Wait 20 Cycles, and then reclose the line in (b) back into the Fault
	d. Leave Fault on for 5 Cycles, then Trip the Line in (b) and Clear the Fault
036FLT10_R-3PH	**3 Phase Fault on Granite Falls (652550) 230 kV Bus to Morris (652554) 230 kV Line, CKT 1**
	a. Apply Fault at the Granite Falls (652550) 230 kV Bus
	b. Clear Fault after 5 Cycles and Trip the Faulted 230 kV Line (652550-652554, CKT 1)
	c. Wait 20 Cycles, and then reclose the line in (b) back into the Fault
	d. Leave Fault on for 5 Cycles, then Trip the Line in (b) and Clear the Fault
036FLT11_R-3PH	**3 Phase Fault on Granite Falls (652550) 230 kV Bus to Blair (652503) 230 kV Line, CKT 1**
	a. Apply Fault at the Granite Falls (652550) 230 kV Bus
	b. Clear Fault after 5 Cycles and Trip the Faulted 230 kV Line (652550-652503, CKT 1)
	c. Wait 20 Cycles, and then reclose the line in (b) back into the Fault
	d. Leave Fault on for 5 Cycles, then Trip the Line in (b) and Clear the Fault
036FLT12_R-3PH	**3 Phase Fault on Granite Falls (652550) 230 kV Bus to GRE-Willmarth (619975) 230 kV Line, CKT 1**
	a. Apply Fault at the Granite Falls (652550) 230 kV Bus
	b. Clear Fault after 5 Cycles and Trip the Faulted 230 kV Line (652550-619975, CKT 1)
	c. Wait 20 Cycles, and then reclose the line in (b) back into the Fault
	d. Leave Fault on for 5 Cycles, then Trip the Line in (b) and Clear the Fault
036FLT02-PO1	**Prior Outage: Granite Falls (652551) 115 kV Bus to MinValley (603030) 115 kV Line, CKT 1 (PO1)**
	3 Phase Fault on Granite Falls (652551) 115 kV Bus to Canby (620211) 115 kV Line, CKT 1
	a. Apply Fault at the Granite Falls (652551) 115 kV Bus
	b. Clear Fault after 5 Cycles and Trip the Faulted 115 kV Line (652551-620211, CKT 1)
	c. Wait 20 Cycles, and then reclose the line in (b) back into the Fault
	d. Leave Fault on for 5 Cycles, then Trip the Line in (b) and Clear the Fault
036FLT04-PO1	**Prior Outage: Granite Falls (652551) 115 kV Bus to MinValley (603030) 115 kV Line, CKT 1 (PO1)**
	3 Phase Fault on Granite Falls (652551) 115 kV Bus to S3 (652508) 115 kV Line, CKT 1
	a. Apply Fault at the Granite Falls (652551) 115 kV Bus
	b. Clear Fault after 5 Cycles and Trip the Faulted 115 kV Line (652551-652508, CKT 1)
	c. Wait 20 Cycles, and then reclose the line in (b) back into the Fault
	d. Leave Fault on for 5 Cycles, then Trip the Line in (b) and Clear the Fault
036FLT05-PO1	**Prior Outage: Granite Falls (652551) 115 kV Bus to MinValley (603030) 115 kV Line, CKT 1 (PO1)**
	3 Phase Fault on Granite Falls (652551) 115 kV Bus to Granite Falls (652550) 115/230 kV Transformer, CKT 2
	a. Apply Fault at the Granite Falls (652551) 115 kV Bus
	b. Clear Fault after 5 Cycles and Trip the Faulted 115/230 kV Transformer (652551-652550, CKT 2)
036FLT06-PO1	**Prior Outage: Granite Falls (652551) 115 kV Bus to MinValley (603030) 115 kV Line, CKT 1 (PO1)**
	3 Phase Fault on Granite Falls (652551) 115 kV Bus to Granite Falls (652298) 115/69 kV Transformer, CKT 1
	a. Apply Fault at the Granite Falls (652551) 115 kV Bus
	b. Clear Fault after 5 Cycles and Trip the Faulted 115/69 kV Transformer (652551-652298, CKT 1)
036FLT02-PO2	**Prior Outage: Granite Falls (652551) 115 kV Bus to Granite Falls (652550) 115/230 kV Transformer, CKT 1 (PO2)**
	3 Phase Fault on Granite Falls (652551) 115 kV Bus to Canby (620211) 115 kV Line, CKT 1
	a. Apply Fault at the Granite Falls (652551) 115 kV Bus
	b. Clear Fault after 5 Cycles and Trip the Faulted 115 kV Line (652551-620211, CKT 1)
	c. Wait 20 Cycles, and then reclose the line in (b) back into the Fault
	d. Leave Fault on for 5 Cycles, then Trip the Line in (b) and Clear the Fault
036FLT03-PO2	**Prior Outage: Granite Falls (652551) 115 kV Bus to Granite Falls (652550) 115/230 kV Transformer, CKT 1 (PO2)**
	3 Phase Fault on Granite Falls (652551) 115 kV Bus to MinValley (603030)115 kV Line, CKT 1

Fault Name	Contingency (Fault) Description
	a. Apply Fault at the Granite Falls (652551) 115 kV Bus
	b. Clear Fault after 5 Cycles and Trip the Faulted 115 kV Line (652551-603030, CKT 1)
	c. Wait 20 Cycles, and then reclose the line in (b) back into the Fault
	d. Leave Fault on for 5 Cycles, then Trip the Line in (b) and Clear the Fault
036FLT04-PO2	**Prior Outage: Granite Falls (652551) 115 kV Bus to Granite Falls (652550) 115/230 kV Transformer, CKT 1 (PO2)**
	3 Phase Fault on Granite Falls (652551) 115 kV Bus to S3 (652508) 115 kV Line, CKT 1
	a. Apply Fault at the Granite Falls (652551) 115 kV Bus
	b. Clear Fault after 5 Cycles and Trip the Faulted 115 kV Line (652551-652508, CKT 1)
	c. Wait 20 Cycles, and then reclose the line in (b) back into the Fault
	d. Leave Fault on for 5 Cycles, then Trip the Line in (b) and Clear the Fault
036FLT05-PO2	**Prior Outage: Granite Falls (652551) 115 kV Bus to Granite Falls (652550) 115/230 kV Transformer, CKT 1 (PO2)**
	3 Phase Fault on Granite Falls (652551) 115 kV Bus to Granite Falls (652550) 115/230 kV Transformer, CKT 2
	a. Apply Fault at the Granite Falls (652551) 115 kV Bus
	b. Clear Fault after 5 Cycles and Trip the Faulted 115/230 kV Transformer (652551-652550, CKT 2)
036FLT06-PO2	**Prior Outage: Granite Falls (652551) 115 kV Bus to Granite Falls (652550) 115/230 kV Transformer, CKT 1 (PO2)**
	3 Phase Fault on Granite Falls (652551) 115 kV Bus to Granite Falls (652298) 115/69 kV Transformer, CKT 1
	a. Apply Fault at the Granite Falls (652551) 115 kV Bus
	b. Clear Fault after 5 Cycles and Trip the Faulted 115/69 kV Transformer (652551-652298, CKT 1)
036FLT07-PO3	**Prior Outage: Granite Falls (652550) 230 kV Bus to Blair (652503) 230 kV Line, CKT 1 (PO3)**
	3 Phase Fault on Granite Falls (652550) 230 kV Bus to MinValley Tap (602008) 230 kV Line, CKT 1
	a. Apply Fault at the Granite Falls (652550) 230 kV Bus
	b. Clear Fault after 5 Cycles and Trip the Faulted 230 kV Line (652550-602008, CKT 1)
	c. Wait 20 Cycles, and then reclose the line in (b) back into the Fault
	d. Leave Fault on for 5 Cycles, then Trip the Line in (b) and Clear the Fault
036FLT08-PO3	**Prior Outage: Granite Falls (652550) 230 kV Bus to Blair (652503) 230 kV Line, CKT 1 (PO3)**
	3 Phase Fault on Granite Falls (652550) 230 kV Bus to MinValley Tap (602009) 230 kV Line, CKT 1
	a. Apply Fault at the Granite Falls (652550) 230 kV Bus
	b. Clear Fault after 5 Cycles and Trip the Faulted 230 kV Line (652550-602009, CKT 1)
	c. Wait 20 Cycles, and then reclose the line in (b) back into the Fault
	d. Leave Fault on for 5 Cycles, then Trip the Line in (b) and Clear the Fault
036FLT09-PO3	**Prior Outage: Granite Falls (652550) 230 kV Bus to Blair (652503) 230 kV Line, CKT 1 (PO3)**
	3 Phase Fault on Granite Falls (652550) 230 kV Bus to Appeldorn (652582) 230 kV Line, CKT 1
	a. Apply Fault at the Granite Falls (652550) 230 kV Bus
	b. Clear Fault after 5 Cycles and Trip the Faulted 230 kV Line (652550-652582, CKT 1)
	c. Wait 20 Cycles, and then reclose the line in (b) back into the Fault
	d. Leave Fault on for 5 Cycles, then Trip the Line in (b) and Clear the Fault
036FLT10-PO3	**Prior Outage: Granite Falls (652550) 230 kV Bus to Blair (652503) 230 kV Line, CKT 1 (PO3)**
	3 Phase Fault on Granite Falls (652550) 230 kV Bus to Morris (652554) 230 kV Line, CKT 1
	a. Apply Fault at the Granite Falls (652550) 230 kV Bus
	b. Clear Fault after 5 Cycles and Trip the Faulted 230 kV Line (652550-652554, CKT 1)
	c. Wait 20 Cycles, and then reclose the line in (b) back into the Fault
	d. Leave Fault on for 5 Cycles, then Trip the Line in (b) and Clear the Fault
036FLT12-PO3	**Prior Outage: Granite Falls (652550) 230 kV Bus to Blair (652503) 230 kV Line, CKT 1 (PO3)**
	3 Phase Fault on Granite Falls (652550) 230 kV Bus to GRE-Willmar (619975) 230 kV Line, CKT 1
	a. Apply Fault at the Granite Falls (652550) 230 kV Bus
	b. Clear Fault after 5 Cycles and Trip the Faulted 230 kV Line (652550-619975, CKT 1)
	c. Wait 20 Cycles, and then reclose the line in (b) back into the Fault
	d. Leave Fault on for 5 Cycles, then Trip the Line in (b) and Clear the Fault
036FLT03-SB	**Single Phase Fault with Stuck Breaker on Granite Falls (652551) 115 kV Bus**
	a. Apply Fault at the Granite Falls (652551) 115 kV Bus
	b. Clear Fault after 16 Cycles and Trip the Following Elements:
	* Granite Falls to MinValley 115 kV Line (652551 - 603030)
	* Granite Falls to Granite Falls 115/230 kV Transformer (652551 - 652550)
036FLT10-SB	**Single Phase Fault with Stuck Breaker on Granite Falls (652550) 230 kV Bus**
	a. Apply Fault at the Granite Falls (652550) 230 kV Bus
	b. Clear Fault after 16 Cycles and Trip the Following Elements:
	* Granite Falls to Morris 230 kV Line (652550 - 652554)
	* Granite Falls 230/115 kV Transformer (652550 - 652551)
	* Granite Falls to Minnesota Valley 230 kV Line (652550 - 602009)
	* Granite Falls to AppelDorn 230 kV Line (652550 - 652582)
036FLT11-SB	**Single Phase Fault with Stuck Breaker on Granite Falls (652550) 230 kV Bus**

Fault Name	Contingency (Fault) Description
	a. Apply Fault at the Granite Falls (652550) 230 kV Bus
	b. Clear Fault after 16 Cycles and Trip the Following Elements:
	* Granite Falls to Blair 230 kV Line (652550 - 652503)
	* Granite Falls 230/115 kV Transformer (652550 - 652551)
	* Granite Falls to Minnesota Valley 230 kV Line (652550 - 602008)
	* Granite Falls to Willmar 230 kV Line (652550 - 619975)

Table 3-2: Fault Definitions for GEN-2016-087

Fault Name	Contingency (Fault) Description
087FLT03_R-3PH	**3 Phase Fault on Campbell (652499) 230 kV Bus to Bismark (652426) 230 kV Line, CKT 1**
	a. Apply Fault at the Campbell (652499) 230 kV Bus
	b. Clear Fault after 5 Cycles and Trip the Faulted 230 kV Line (652499-652426, CKT 1)
	c. Wait 20 Cycles, and then reclose the line in (b) back into the Fault
	d. Leave Fault on for 5 Cycles, then Trip the Line in (b) and Clear the Fault
087FLT04_R-3PH	**3 Phase Fault on Campbell (652499) 230 kV Bus to Glenham (661038) 230 kV Line, CKT 1**
	a. Apply Fault at the Campbell (652499) 230 kV Bus
	b. Clear Fault after 5 Cycles and Trip the Faulted 230 kV Line (652499-661038, CKT 1)
	c. Wait 20 Cycles, and then reclose the line in (b) back into the Fault
	d. Leave Fault on for 5 Cycles, then Trip the Line in (b) and Clear the Fault
087FLT05_R-3PH	**3 Phase Fault on Bismark (652426) 230 kV Bus to Ward (652296) 230 kV Line, CKT 1**
	a. Apply Fault at the Bismark (652426) 230 kV Bus
	b. Clear Fault after 5 Cycles and Trip the Faulted 230 kV Line (652426-652296, CKT 1)
	c. Wait Cycles, and then reclose the line in (b) back into the Fault
	d. Leave Fault on for 5 Cycles, then Trip the Line in (b) and Clear the Fault
087FLT06_R-3PH	**3 Phase Fault on Bismark (652426) 230 kV Bus to Washburn (652456) 230 kV Line, CKT 1**
	a. Apply Fault at the Bismark (652426) 230 kV Bus
	b. Clear Fault after 5 Cycles and Trip the Faulted 230 kV Line (652426-652456, CKT 1)
	c. Wait 20 Cycles, and then reclose the line in (b) back into the Fault
	d. Leave Fault on for 5 Cycles, then Trip the Line in (b) and Clear the Fault
087FLT07_R-3PH	**3 Phase Fault on Bismark (652426) 230 kV Bus to Weber (659128) 230 kV Line, CKT 1**
	a. Apply Fault at the Bismark (652426) 230 kV Bus
	b. Clear Fault after 5 Cycles and Trip the Faulted 230 kV Line (652426-659128, CKT 1)
	c. Wait 20 Cycles, and then reclose the line in (b) back into the Fault
	d. Leave Fault on for 5 Cycles, then Trip the Line in (b) and Clear the Fault
087FLT08_R-3PH	**3 Phase Fault on Bismark (652426) 230 kV Bus to Jamestown (652444) 230 kV Line, CKT 1**
	a. Apply Fault at the Bismark (652426) 230 kV Bus
	b. Clear Fault after 5 Cycles and Trip the Faulted 230 kV Line (652426-652444, CKT 1)
	c. Wait 20 Cycles, and then reclose the line in (b) back into the Fault
	d. Leave Fault on for 5 Cycles, then Trip the Line in (b) and Clear the Fault
087FLT09_R-3PH	**3 Phase Fault on Bismark (652426) 230 kV Bus to Hilken (652466) 230 kV Line, CKT 1**
	a. Apply Fault at the Bismark (652426) 230 kV Bus
	b. Clear Fault after 5 Cycles and Trip the Faulted 230 kV Line (652426-652466, CKT 1)
	c. Wait 20 Cycles, and then reclose the line in (b) back into the Fault
	d. Leave Fault on for 5 Cycles, then Trip the Line in (b) and Clear the Fault
087FLT12_R-3PH	**3 Phase Fault on Glenham (661038) 230 kV Bus to Whitlock (652527) 230 kV Line, CKT 1**
	a. Apply Fault at the Glenham (661038) 230 kV Bus
	b. Clear Fault after 5 Cycles and Trip the Faulted 230 kV Line (661038-652527, CKT 1)
	c. Wait 20 Cycles, and then reclose the line in (b) back into the Fault
	d. Leave Fault on for 5 Cycles, then Trip the Line in (b) and Clear the Fault
087FLT06-PO1	**Prior Outage: Campbell (652499) 230 kV Bus to Glenham (661038) 230 kV Line, CKT 1 (PO1)**
	3 Phase Fault on Bismark (652426) 230 kV Bus to Washburn (652456) 230 kV Line, CKT 1
	a. Apply Fault at the Bismark (652426) 230 kV Bus
	b. Clear Fault after 5 Cycles and Trip the Faulted 230 kV Line (652426-652456, CKT 1)
	c. Wait 20 Cycles, and then reclose the line in (b) back into the Fault
	d. Leave Fault on for 5 Cycles, then Trip the Line in (b) and Clear the Fault
087FLT08-PO1	**Prior Outage: Campbell (652499) 230 kV Bus to Glenham (661038) 230 kV Line, CKT 1 (PO1)**
	3 Phase Fault on Bismark (652426) 230 kV Bus to Jamestown (652444) 230 kV Line, CKT 1
	a. Apply Fault at the Bismark (652426) 230 kV Bus
	b. Clear Fault after 5 Cycles and Trip the Faulted 230 kV Line (652426-652444, CKT 1)
	c. Wait 20 Cycles, and then reclose the line in (b) back into the Fault
	d. Leave Fault on for 5 Cycles, then Trip the Line in (b) and Clear the Fault

Fault Name	Contingency (Fault) Description
087FLT09-PO1	**Prior Outage: Campbell (652499) 230 kV Bus to Glenham (661038) 230 kV Line, CKT 1 (PO1)**
	3 Phase Fault on Bismark (652426) 230 kV Bus to Hilken (652466) 230 kV Line, CKT 1
	a. Apply Fault at the Bismark (652426) 230 kV Bus
	b. Clear Fault after 5 Cycles and Trip the Faulted 230 kV Line (652426-652466, CKT 1)
	c. Wait 20 Cycles, and then reclose the line in (b) back into the Fault
	d. Leave Fault on for 5 Cycles, then Trip the Line in (b) and Clear the Fault
087FLT07-SB	**Single Phase Fault with Stuck Breaker on Bismark (652426) 230 kV Bus**
	a. Apply Fault at the Bismark (652426) 230 kV Bus
	b. Clear Fault after 16 Cycles and Trip the Following Elements:
	* Bismark to Weber 230 kV Line (652426 - 659128)
	* Bismark to Cambell County 230 kV Line (652426 - 652499)
	* Bismark 230/115 kV Transformer (652426 - 652427)
	* Bismark to Hilken 230 kV Line (652426 - 652466)
087FLT08-SB	**Single Phase Fault with Stuck Breaker on Bismark (652426) 230 kV Bus**
	a. Apply Fault at the Bismark (652426) 230 kV Bus
	b. Clear Fault after 16 Cycles and Trip the Following Elements:
	* Bismark to Washburn 230 kV Line (652426 - 652456)
	* Bismark to Ward 230 kV Line (652426 - 652296)
	* Bismark 230/115 kV Transformer (652426 - 652427)
	* Bismark to Jamestown 230 kV Line (652426 - 652444)
087FLT12-SB	**Single Phase Fault with Stuck Breaker on Glenham (661038) 230 kV Bus**
	a. Apply Fault at the Glenham (661038) 230 kV Bus
	b. Clear Fault after 16 Cycles and Trip the Following Elements:
	* Glenham to Whitlock 230 kV Line (661038-652527)
	* Glenham 230/115 kV Transformer (661038-661035, CKT 1)

Table 3-3: Fault Definitions for GEN-2016-092

Fault Name	Contingency (Fault) Description
92-103FLT04_R-3PH	**3 Phase Fault on G16-017-Tap (560074) 345 kV Bus to Leland Olds (659105) 345 kV Line, CKT 1**
	a. Apply Fault at the G16-017-Tap (560074) 345 kV Bus
	b. Clear Fault after 5 Cycles and Trip the Faulted 345 kV Line (560074-659105, CKT 1)
	c. Wait 20 Cycles, and then reclose the line in (b) back into the Fault
	d. Leave Fault on for 5 Cycles, then Trip the Line in (b) and Clear the Fault
92-103FLT05_R-3PH	**3 Ph Fault on G16-017-Tap (560074) 345 kV Bus to Fort Thompson (652506) 345 kV Line, CKT 1**
	a. Apply Fault at the G16-017-Tap (560074) 345 kV Bus
	b. Clear Fault after 5 Cycles and Trip the Faulted 345 kV Line (560074-652506, CKT 1)
	c. Wait 20 Cycles, and then reclose the line in (b) back into the Fault
	d. Leave Fault on for 5 Cycles, then Trip the Line in (b) and Clear the Fault
92-103FLT07_R-3PH	**3 Phase Fault on Leland Olds (659105) 345 kV Bus to Antelope Valley (659101) 345 kV Line, CKT 2**
	a. Apply Fault at the Leland Olds (659105) 345 kV Bus
	b. Clear Fault after 5 Cycles and Trip the Faulted 345 kV Line (659105-659101, CKT 2)
	c. Wait 20 Cycles, and then reclose the line in (b) back into the Fault
	d. Leave Fault on for 5 Cycles, then Trip the Line in (b) and Clear the Fault
92-103FLT10_R-3PH	**3 Phase Fault on Leland Olds (659105) 345 kV Bus to Groton (659160) 345 kV Line, CKT 1**
	a. Apply Fault at the Leland Olds (659105) 345 kV Bus
	b. Clear Fault after 5 Cycles and Trip the Faulted 345 kV Line (659105-659160, CKT 1)
	c. Wait 20 Cycles, and then reclose the line in (b) back into the Fault
	d. Leave Fault on for 5 Cycles, then Trip the Line in (b) and Clear the Fault
92-103FLT11_R-3PH	**3 Phase Fault on Fort Thompson (652506) 345 kV Bus to Grand Prairie (652532) 345 kV Line, CKT 1**
	a. Apply Fault at the Fort Thompson (652506) 345 kV Bus
	b. Clear Fault after 5 Cycles and Trip the Faulted 345 kV Line (652506-652532, CKT 1)
	c. Wait 20 Cycles, and then reclose the line in (b) back into the Fault
	d. Leave Fault on for 5 Cycles, then Trip the Line in (b) and Clear the Fault
92-103FLT13_R-3PH	**3 Phase Fault on Grand Prairie (652532) 345 kV Bus to Holt Co. (640510) 345 kV Line, CKT 1**
	a. Apply Fault at the Grand Prairie (652532) 345 kV Bus
	b. Clear Fault after 5 Cycles and Trip the Faulted 345 kV Line (652532-640510, CKT 1)
	c. Wait 20 Cycles, and then reclose the line in (b) back into the Fault
	d. Leave Fault on for 5 Cycles, then Trip the Line in (b) and Clear the Fault

Fault Name	Contingency (Fault) Description
92-103FLT15_R-3PH	**3 Phase Fault on Antelope Valley (659101) 345 kV Bus to Broadland (659120) 345 kV Line, CKT 1**
	a. Apply Fault at the Antelope Valley (659101) 345 kV Bus
	b. Clear Fault after 5 Cycles and Trip the Faulted 345 kV Line (659101-659120, CKT 1)
	c. Wait 20 Cycles, and then reclose the line in (b) back into the Fault
	d. Leave Fault on for 5 Cycles, then Trip the Line in (b) and Clear the Fault
92-103FLT11-PO1	**Prior Outage: G16-017-Tap (560074) 345 kV Bus to Leland Olds (659105) 345 kV Line, CKT1 (PO1)**
	3 Phase Fault on Fort Thompson (652506) 345 kV Bus to Grand Prairie (652532) 345 kV Line, CKT 1
	a. Apply Fault at the Fort Thompson (652506) 345 kV Bus
	b. Clear Fault after 5 Cycles and Trip the Faulted 345 kV Line (652506-652532, CKT 1)
	c. Wait 20 Cycles, and then reclose the line in (b) back into the Fault
	d. Leave Fault on for 5 Cycles, then Trip the Line in (b) and Clear the Fault
92-103FLT07-PO2	**Prior Outage: G16-017-Tap (560074) 345 kV to Fort Thompson (652506) 345 kV Line, CKT 1 (PO2)**
	3 Phase Fault on Leland Olds (659105) 345 kV to Antelope Valley (659101) 345 kV Line, CKT 1
	a. Apply Fault at the Leland Olds (659105) 345 kV Bus
	b. Clear Fault after 5 Cycles and Trip the Faulted 345 kV Line (659105-659101, CKT 1)
	c. Wait 20 Cycles, and then reclose the line in (b) back into the Fault
	d. Leave Fault on for 5 Cycles, then Trip the Line in (b) and Clear the Fault
92-103FLT09-PO2	**Prior Outage: G16-017-Tap (560074) 345 kV Bus to Fort Thompson (652506) 345 kV Line, CKT 1 (PO2)**
	3 Phase Fault on Leland Olds (659105) 345 kV Bus to Leland Olds (659106) 345/230 kV Transformer, CKT 1
	a. Apply Fault at the Leland Olds (659105) 345 kV Bus
	b. Clear Fault after 5 Cycles and Trip the Faulted 345/230 kV Transformer (659105-659106, CKT 1)
92-103FLT10-PO2	**Prior Outage: G16-017-Tap (560074) 345 kV Bus to Fort Thompson (652506) 345 kV Line, CKT 1 (PO2)**
	3 Phase Fault on Leland Olds (659105) 345 kV Bus to Groton (659160) 345 kV Line, CKT 1
	a. Apply Fault at the Leland Olds (659105) 345 kV Bus
	b. Clear Fault after 5 Cycles and Trip the Faulted 345 kV Line (659105-659160, CKT 1)
	c. Wait 20 Cycles, and then reclose the line in (b) back into the Fault
	d. Leave Fault on for 5 Cycles, then Trip the Line in (b) and Clear the Fault
92-103FLT04-PO3	**Prior Outage: G16-165-Tap (588344) to Holt County (640510) 345 kV Line, CKT 1 (PO3)**
	3 Phase Fault on G16-017-Tap (560074) 345 kV Bus to Leland Olds (659105) 345 kV Line, CKT 1
	a. Apply Fault at the G16-017-Tap (560074) 345 kV Bus
	b. Clear Fault after 5 Cycles and Trip the Faulted 345 kV Line (560074-659105, CKT 1)
	c. Wait 20 Cycles, and then reclose the line in (b) back into the Fault
	d. Leave Fault on for 5 Cycles, then Trip the Line in (b) and Clear the Fault
92-103FLT11-PO4	**Prior Outage: Thompson (652507) to Randall (652509) 230 kV Line, CKT 1 (PO4)**
	3 Phase Fault on Fort Thompson (652506) 345 kV to Grand Prairie (652532) 345 kV Line, CKT 1
	a. Apply Fault at the Fort Thompson (652506) 345 kV Bus
	b. Clear Fault after 5 Cycles and Trip the Faulted 345 kV Line (652506-652532, CKT 1)
	c. Wait 20 Cycles, and then reclose the line in (b) back into the Fault
	d. Leave Fault on for 5 Cycles, then Trip the Line in (b) and Clear the Fault
92-103FLT11-PO5	**Prior Outage: Storla (659122) to Wessington (652607) 230kV Line, CKT 1 (PO5)**
	3 Phase Fault on Fort Thompson (652506) 345 kV to Grand Prairie (652532) 345 kV Line, CKT 1
	a. Apply Fault at the Fort Thompson (652506) 345 kV Bus
	b. Clear Fault after 5 Cycles and Trip the Faulted 345 kV Line (652506-652532, CKT 1)
	c. Wait 20 Cycles, and then reclose the line in (b) back into the Fault
	d. Leave Fault on for 5 Cycles, then Trip the Line in (b) and Clear the Fault
92-103FLT07-SB	**Single Phase Fault with Stuck Breaker on Leland Olds (659105) 345 kV Bus**
	a. Apply Fault at the Leland Olds (659105) 345 kV Bus
	b. Clear Fault after 16 Cycles and Trip the Following Elements:
	* Leland Olds to Antelope Valley 345 kV Line (659105 - 659101)
	* Leland Olds to Leland Olds 345/230 kV Transformer (659105 - 659106 - 659202)
92-103FLT10-SB	**Single Phase Fault with Stuck Breaker on Leland Olds (659105) 345 kV Bus**
	a. Apply Fault at the Leland Olds (659105) 345 kV Bus
	b. Clear Fault after 16 Cycles and Trip the Following Elements:
	* Leland Olds 345/230 kV Transformer (659105 - 659106 - 659201)
	* Leland Olds to Groton 345 kV Line (659105 - 659160)
92-103FLT11-SB	**Single Phase Fault with Stuck Breaker on Fort Thompson (652506) 345 kV Bus**
	a. Apply Fault at the Fort Thompson (652506) 345 kV Bus
	b. Clear Fault after 16 Cycles and Trip the Following Elements:
	* Fort Thompson to Grand Prairie 345 kV Line (652506 - 652532)
	* Fort Thompson to Fort Thompson 345/230 kV Transformer (652506 - 652507)

Table 3-4: Fault Definitions for GEN-2016-164

Fault Name	Contingency (Fault) Description
164FLT01_R-3PH	**3 Phase Fault on Groton (652512) 115 kV Bus to Groton South (652568) 115 kV Line, CKT 1**
	a. Apply Fault at the Groton (652512) 115 kV Bus
	b. Clear Fault after 5 Cycles and Trip the Faulted 115 kV Line (652512-652568, CKT 1)
	c. Wait 20 Cycles, and then reclose the line in (b) back into the Fault
	d. Leave Fault on for 5 Cycles, then Trip the Line in (b) and Clear the Fault
164FLT02_R-3PH	**3 Phase Fault on Groton (652512) 115 kV Bus to Bristol (652533) 115 kV Line, CKT 1**
	a. Apply Fault at the Groton (652512) 115 kV Bus
	b. Clear Fault after 5 Cycles and Trip the Faulted 115 kV Line (652512-652533, CKT 1)
	c. Wait 20 Cycles, and then reclose the line in (b) back into the Fault
	d. Leave Fault on for 5 Cycles, then Trip the Line in (b) and Clear the Fault
164FLT04_R-3PH	**3 Phase Fault on Groton (652512) 115 kV Bus to Aberdeen (660001) 115 kV Line, CKT 1**
	a. Apply Fault at the Groton (652512) 115 kV Bus
	b. Clear Fault after 5 Cycles and Trip the Faulted 115 kV Line (652512-660001, CKT 1)
	c. Wait 20 Cycles, and then reclose the line in (b) back into the Fault
	d. Leave Fault on for 5 Cycles, then Trip the Line in (b) and Clear the Fault
164FLT07_R-3PH	**3 Phase Fault on Groton (652512) / Groton South (652568) 115 kV Bus to Ordway (652534) 115 kV Line, CKT 1**
	a. Apply Fault at the Groton (652512) / Groton South (652568) 115 kV Bus
	b. Clear Fault after 5 Cycles and Trip the Faulted 115 kV Line (652568-652534, CKT 2)
	c. Wait 20 Cycles, and then reclose the line in (b) back into the Fault
	d. Leave Fault on for 5 Cycles, then Trip the Line in (b) and Clear the Fault
164FLT09_R-3PH	**3 Phase Fault on Groton (652512) / Groton South (652568) 115 kV Bus to Redfield (652535) 115 kV Line, CKT 1**
	a. Apply Fault at the Groton (652512) / Groton South (652568) 115 kV Bus
	b. Clear Fault after 5 Cycles and Trip the Faulted 115 kV Line (652568-652535, CKT 1)
	c. Wait 20 Cycles, and then reclose the line in (b) back into the Fault
	d. Leave Fault on for 5 Cycles, then Trip the Line in (b) and Clear the Fault
164FLT12_R-3PH	**3 Phase Fault on Groton (569160) 345 kV Bus to G09_001IST (652175) 345 kV Line, CKT 1**
	a. Apply Fault at the Groton (569160) 345 kV Bus
	b. Clear Fault after 5 Cycles and Trip the Faulted 345 kV Line (569160-652175, CKT 1)
	c. Wait 20 Cycles, and then reclose the line in (b) back into the Fault
	d. Leave Fault on for 5 Cycles, then Trip the Line in (b) and Clear the Fault
164FLT13_R-3PH	**3 Phase Fault on Groton (569160) 345 kV Bus to Leland Olds (659105) 345 kV Line, CKT 1**
	a. Apply Fault at the Groton (569160) 345 kV Bus
	b. Clear Fault after 5 Cycles and Trip the Faulted 345 kV Line (569160-659105, CKT 1)
	c. Wait 20 Cycles, and then reclose the line in (b) back into the Fault
	d. Leave Fault on for 5 Cycles, then Trip the Line in (b) and Clear the Fault
164FLT14_R-3PH	**3 Phase Fault on G09_001IST (652175) 345 kV Bus to Watertown (652529) 345 kV Line, CKT 1**
	a. Apply Fault at the G09_001IST (652175) 345 kV Bus
	b. Clear Fault after 5 Cycles and Trip the Faulted 345 kV Line (652175-652529, CKT 1)
	c. Wait 20 Cycles, and then reclose the line in (b) back into the Fault
	d. Leave Fault on for 5 Cycles, then Trip the Line in (b) and Clear the Fault
164FLT15_3PH	**3 Phase Fault on Groton (652512) / Groton South (652568) 115 kV Bus to Groton (659160) 115/345 kV Transformer, CKT 1**
	a. Apply Fault at the Groton (652512) / Groton South (652568) 115 kV Bus
	b. Clear Fault after 5 Cycles and Trip the Faulted Transformer (652512/652568-659160, CKT 1)
164FLT07-PO1	**Prior Outage: Groton (652512) 115 kV Bus to Groton South (652568) 115 kV Line, CKT 1 (PO1)**
	3 Phase Fault on Groton South (652568) 115 kV Bus to Ordway (652534) 115 kV Line, CKT 1
	a. Apply Fault at the Groton (652512) / Groton South (652568) 115 kV Bus
	b. Clear Fault after 5 Cycles and Trip the Faulted 115 kV Line (652568-652534, CKT 2)
	c. Wait 20 Cycles, and then reclose the line in (b) back into the Fault
	d. Leave Fault on for 5 Cycles, then Trip the Line in (b) and Clear the Fault
164FLT09-PO1	**Prior Outage: Groton (652512) 115 kV Bus to Groton South (652568) 115 kV Line, CKT 1 (PO1)**
	3 Phase Fault on Groton South (652568) 115 kV Bus to Redfield (652535) 115 kV Line, CKT 1
	a. Apply Fault at the Groton South (652568) 115 kV Bus
	b. Clear Fault after 5 Cycles and Trip the Faulted 115 kV Line (652568-652535, CKT 1)
	c. Wait 20 Cycles, and then reclose the line in (b) back into the Fault
	d. Leave Fault on for 5 Cycles, then Trip the Line in (b) and Clear the Fault
164FLT12-PO1	**Prior Outage: Groton (652512) 115 kV Bus to Groton South (652568) 115 kV Line, CKT 1 (PO1)**
	3 Phase Fault on Groton (569160) 345 kV Bus to G09_001IST (652175) 345 kV Line, CKT 1
	a. Apply Fault at the Groton (569160) 345 kV Bus

Fault Name	Contingency (Fault) Description
	b. Clear Fault after 5 Cycles and Trip the Faulted 345 kV Line (569160-652175, CKT 1)
	c. Wait 20 Cycles, and then reclose the line in (b) back into the Fault
	d. Leave Fault on for 5 Cycles, then Trip the Line in (b) and Clear the Fault
164FLT13-PO1	**Prior Outage: Groton (652512) 115 kV Bus to Groton South (652568) 115 kV Line, CKT 1 (PO1)**
	3 Phase Fault on Groton (569160) 345 kV Bus to Leland Olds (659105) 345 kV Line, CKT 1
	a. Apply Fault at the Groton (569160) 345 kV Bus
	b. Clear Fault after 5 Cycles and Trip the Faulted 345 kV Line (569160-659105, CKT 1)
	c. Wait 20 Cycles, and then reclose the line in (b) back into the Fault
	d. Leave Fault on for 5 Cycles, then Trip the Line in (b) and Clear the Fault
164FLT14-PO1	**Prior Outage: Groton (652512) 115 kV Bus to Groton South (652568) 115 kV Line, CKT 1 (PO1)**
	3 Phase Fault on G09_001IST (652175) 345 kV Bus to Watertown (652529) 345 kV Line, CKT 1
	a. Apply Fault at the G09_001IST (652175) 345 kV Bus
	b. Clear Fault after 5 Cycles and Trip the Faulted 345 kV Line (652175-652529, CKT 1)
	c. Wait 20 Cycles, and then reclose the line in (b) back into the Fault
	d. Leave Fault on for 5 Cycles, then Trip the Line in (b) and Clear the Fault
164FLT15-PO1	**Prior Outage: Groton (652512) 115 kV Bus to Groton South (652568) 115 kV Line, CKT 1 (PO1)**
	3 Phase Fault on Groton South (652568) 115 kV Bus to Groton (659160) 115/345 kV Transformer, CKT 1
	a. Apply Fault at the Groton South (652568) 115 kV Bus
	b. Clear Fault after 5 Cycles and Trip the Faulted Transformer (652568-659160, CKT 1)
164FLT01-PO2	**Prior Outage: Groton (652512) / Groton South (652568) 115 kV Bus to Groton (659160) 115/345 kV Transformer, CKT 1 (PO2)**
	3 Phase Fault on Groton South (652568) 115 kV Bus to Groton (652512) 115 kV Line, CKT 1
	a. Apply Fault at the Groton South (652568) 115 kV Bus
	b. Clear Fault after 5 Cycles and Trip the Faulted 115 kV Line (652568-652512, CKT 1)
	c. Wait 20 Cycles, and then reclose the line in (b) back into the Fault
	d. Leave Fault on for 5 Cycles, then Trip the Line in (b) and Clear the Fault
164FLT07-PO2	**Prior Outage: Groton (652512) / Groton South (652568) 115 kV Bus to Groton (659160) 115/345 kV Transformer, CKT 1 (PO2)**
	3 Phase Fault on Groton (652512) / Groton South (652568) 115 kV Bus to Ordway (652534) 115 kV Line, CKT 2
	a. Apply Fault at the Groton South (652568) 115 kV Bus
	b. Clear Fault after 5 Cycles and Trip the Faulted 115 kV Line (652568-652534, CKT 2)
	c. Wait 20 Cycles, and then reclose the line in (b) back into the Fault
	d. Leave Fault on for 5 Cycles, then Trip the Line in (b) and Clear the Fault
164FLT09-PO2	**Prior Outage: Groton (652512) / Groton South (652568) 115 kV Bus to Groton (659160) 115/345 kV Transformer, CKT 1 (PO2)**
	3 Phase Fault on Groton (652512) / Groton South (652568) 115 kV Bus to Redfield (652535) 115 kV Line, CKT 1
	a. Apply Fault at the Groton South (652568) 115 kV Bus
	b. Clear Fault after 5 Cycles and Trip the Faulted 115 kV Line (652568-652535, CKT 1)
	c. Wait 20 Cycles, and then reclose the line in (b) back into the Fault
	d. Leave Fault on for 5 Cycles, then Trip the Line in (b) and Clear the Fault
164FLT13-PO2	**Prior Outage: Groton (652512) / Groton South (652568) 115 kV Bus to Groton (659160) 115/345 kV Transformer, CKT 1 (PO2)**
	3 Phase Fault on Groton (569160) 345 kV Bus to Leland Olds (659105) 345 kV Line, CKT 1
	a. Apply Fault at the Groton (569160) 345 kV Bus
	b. Clear Fault after 5 Cycles and Trip the Faulted 345 kV Line (569160-659105, CKT 1)
	c. Wait 20 Cycles, and then reclose the line in (b) back into the Fault
	d. Leave Fault on for 5 Cycles, then Trip the Line in (b) and Clear the Fault
164FLT14-PO2	**Prior Outage: Groton (652512) / Groton South (652568) 115 kV Bus to Groton (659160) 115/345 kV Transformer, CKT 1 (PO2)**
	3 Phase Fault on G09_001IST (652175) 345 kV Bus to Watertown (652529) 345 kV Line, CKT 1
	a. Apply Fault at the G09_001IST (652175) 345 kV Bus
	b. Clear Fault after 5 Cycles and Trip the Faulted 345 kV Line (652175-652529, CKT 1)
	c. Wait 20 Cycles, and then reclose the line in (b) back into the Fault
	d. Leave Fault on for 5 Cycles, then Trip the Line in (b) and Clear the Fault
164FLT01-PO3	**Prior Outage: G09_001IST (652175) 345 kV Bus to Watertown (652529) 345 kV Line, CKT 1 (PO3)**
	3 Phase Fault on Groton (652512) 115 kV Bus to Groton South (652568) 115 kV Line, CKT 1
	a. Apply Fault at the Groton (652512) 115 kV Bus
	b. Clear Fault after 5 Cycles and Trip the Faulted 115 kV Line (652512-652568, CKT 1)
	c. Wait 20 Cycles, and then reclose the line in (b) back into the Fault
	d. Leave Fault on for 5 Cycles, then Trip the Line in (b) and Clear the Fault
164FLT02-PO3	**Prior Outage: G09_001IST (652175) 345 kV Bus to Watertown (652529) 345 kV Line, CKT 1 (PO3)**

Fault Name	Contingency (Fault) Description
	3 Phase Fault on Groton (652512) 115 kV Bus to Bristol (652533) 115 kV Line, CKT 1
	a. Apply Fault at the Groton (652512) 115 kV Bus
	b. Clear Fault after 5 Cycles and Trip the Faulted 115 kV Line (652512-652533, CKT 1)
	c. Wait 20 Cycles, and then reclose the line in (b) back into the Fault
	d. Leave Fault on for 5 Cycles, then Trip the Line in (b) and Clear the Fault
164FLT04-PO3	**Prior Outage: G09_001IST (652175) 345 kV Bus to Watertown (652529) 345 kV Line, CKT 1 (PO3)**
	3 Phase Fault on Groton (652512) 115 kV Bus to Aberdeen (660001) 115 kV Line, CKT 1
	a. Apply Fault at the Groton (652512) 115 kV Bus
	b. Clear Fault after 5 Cycles and Trip the Faulted 115 kV Line (652512-660001, CKT 1)
	c. Wait 20 Cycles, and then reclose the line in (b) back into the Fault
	d. Leave Fault on for 5 Cycles, then Trip the Line in (b) and Clear the Fault
164FLT07-PO3	**Prior Outage: G09_001IST (652175) 345 kV Bus to Watertown (652529) 345 kV Line, CKT 1 (PO3)**
	3 Phase Fault on Groton (652512) / Groton South (652568) 115 kV Bus to Ordway (652534) 115 kV Line, CKT 1
	a. Apply Fault at the Groton (652512) / Groton South (652568) 115 kV Bus
	b. Clear Fault after 5 Cycles and Trip the Faulted 115 kV Line (652568-652534, CKT 2)
	c. Wait 20 Cycles, and then reclose the line in (b) back into the Fault
	d. Leave Fault on for 5 Cycles, then Trip the Line in (b) and Clear the Fault
164FLT09-PO3	**Prior Outage: G09_001IST (652175) 345 kV Bus to Watertown (652529) 345 kV Line, CKT 1 (PO3)**
	3 Phase Fault on Groton (652512) / Groton South (652568) 115 kV Bus to Redfield (652535) 115 kV Line, CKT 1
	a. Apply Fault at the Groton (652512) / Groton South (652568) 115 kV Bus
	b. Clear Fault after 5 Cycles and Trip the Faulted 115 kV Line (652568-652535, CKT 1)
	c. Wait 20 Cycles, and then reclose the line in (b) back into the Fault
	d. Leave Fault on for 5 Cycles, then Trip the Line in (b) and Clear the Fault
164FLT13-PO3	**Prior Outage: G09_001IST (652175) 345 kV Bus to Watertown (652529) 345 kV Line, CKT 1 (PO3)**
	3 Phase Fault on Groton (569160) 345 kV Bus to Leland Olds (659105) 345 kV Line, CKT 1
	a. Apply Fault at the Groton (569160) 345 kV Bus
	b. Clear Fault after 5 Cycles and Trip the Faulted 345 kV Line (569160-659105, CKT 1)
	c. Wait 20 Cycles, and then reclose the line in (b) back into the Fault
	d. Leave Fault on for 5 Cycles, then Trip the Line in (b) and Clear the Fault
164FLT01-SB	**Single Phase Fault with Stuck Breaker on Groton (652512) 115 kV Bus**
	a. Apply Fault at the Groton (652512) 115 kV Bus
	b. Clear Fault after 16 Cycles and Trip the Following Elements:
	* Groton to Aberdeen 115 kV Line (652512 - 660001)
	* Groton to Bristol 115 kV Line (652512 - 652533)
	* Groton 115 kV Switched Shunts (652512)
	* Groton to Groton 115/69 kV Transformers (652512 - 652250 & 652512 - 652253)
164FLT12-SB	**Single Phase Fault with Stuck Breaker on Groton (659160) 345 kV Bus**
	a. Apply Fault at the Groton (659160) 345 kV Bus
	b. Clear Fault after 16 Cycles and Trip the Following Elements:
	* Groton to Leland Olds 345 kV Line (659160 - 659105)
	* Groton to G09_001IST 345 kV Line (659160 - 652175)
	* Groton 345/115 kV Transformer (659160 - 652568)
	* Groton 345 kV bus (659160)

Single-line-to-ground (SLG) fault impedance values were determined by applying a three-phase fault on the base case such that the fault produced a 0.6 p.u. voltage value on the faulted bus. This SLG fault impedance was used for the SLG faults in stuck breaker fault.

3.3 Results

Table 3-5 summarizes result for the machine rotor angle damping requirement and transient voltage recovery criteria for all the faults studied. There were no machine rotor angle damping or transient voltage recovery violations within the DISIS-2016-002-2 (Group 15) study for the simulated fault events. The dynamic stability plots are provided in Appendix B.

Table 3-5: Dynamic Stability Results

Fault	2017WP	2018SP	2026SP
036FLT02_R-3PH	Stable	Stable	Stable
036FLT03_R-3PH	Stable	Stable	Stable
036FLT04_R-3PH	Stable	Stable	Stable
036FLT07_R-3PH	Stable	Stable	Stable
036FLT08_R-3PH	Stable	Stable	Stable
036FLT09_R-3PH	Stable	Stable	Stable
036FLT10_R-3PH	Stable	Stable	Stable
036FLT11_R-3PH	Stable	Stable	Stable
036FLT12_R-3PH	Stable	Stable	Stable
036FLT02-PO1	Stable	Stable	Stable
036FLT04-PO1	Stable	Stable	Stable
036FLT05-PO1	Stable	Stable	Stable
036FLT06-PO1	Stable	Stable	Stable
036FLT02-PO2	Stable	Stable	Stable
036FLT03-PO2	Stable	Stable	Stable
036FLT04-PO2	Stable	Stable	Stable
036FLT05-PO2	Stable	Stable	Stable
036FLT06-PO2	Stable	Stable	Stable
036FLT07-PO3	Stable	Stable	Stable
036FLT08-PO3	Stable	Stable	Stable
036FLT09-PO3	Stable	Stable	Stable
036FLT10-PO3	Stable	Stable	Stable
036FLT12-PO3	Stable	Stable	Stable
036FLT03-SB	Stable	Stable	Stable
036FLT10-SB	Stable	Stable	Stable
036FLT11-SB	Stable	Stable	Stable
087FLT03_R-3PH	Stable	Stable	Stable
087FLT04_R-3PH	Stable	Stable	Stable
087FLT05_R-3PH	Stable	Stable	Stable
087FLT06_R-3PH	Stable	Stable	Stable
087FLT07_R-3PH	Stable	Stable	Stable
087FLT08_R-3PH	Stable	Stable	Stable
087FLT09_R-3PH	Stable	Stable	Stable
087FLT12_R-3PH	Stable	Stable	Stable
087FLT06-PO1	Stable	Stable	Stable
087FLT08-PO1	Stable	Stable	Stable
087FLT09-PO1	Stable	Stable	Stable
087FLT07-SB	Stable	Stable	Stable
087FLT08-SB	Stable	Stable	Stable
087FLT12-SB	Stable	Stable	Stable
92-103FLT04_R-3PH	Stable	Stable	Stable
92-103FLT05_R-3PH	Stable	Stable	Stable
92-103FLT07_R-3PH	Stable	Stable	Stable
92-103FLT10_R-3PH	Stable	Stable	Stable
92-103FLT11_R-3PH	Stable	Stable	Stable
92-103FLT13_R-3PH	Stable	Stable	Stable
92-103FLT15_R-3PH	Stable	Stable	Stable
92-103FLT11-PO1	Stable	Stable	Stable
92-103FLT07-PO2	Stable	Stable	Stable
92-103FLT09-PO2	Stable	Stable	Stable
92-103FLT10-PO2	Stable	Stable	Stable
92-103FLT04-PO3	Stable	Stable	Stable
92-103FLT11-PO4	Stable	Stable	Stable

Fault	2017WP	2018SP	2026SP
92-103FLT11-PO5	Stable	Stable	Stable
92-103FLT07-SB	Stable	Stable	Stable
92-103FLT10-SB	Stable	Stable	Stable
92-103FLT11-SB	Stable	Stable	Stable
164FLT01_R-3PH	N/A	Stable	Stable
164FLT02_R-3PH	Stable	Stable	Stable
164FLT04_R-3PH	Stable	Stable	Stable
164FLT07_R-3PH	Stable	Stable	Stable
164FLT09_R-3PH	Stable	Stable	Stable
164FLT12_R-3PH	Stable	Stable	Stable
164FLT13_R-3PH	Stable	Stable	Stable
164FLT14_R-3PH	Stable	Stable	Stable
164FLT15_3PH	Stable	Stable	Stable
164FLT07-PO1	N/A	Stable	Stable
164FLT09-PO1	N/A	Stable	Stable
164FLT12-PO1	N/A	Stable	Stable
164FLT13-PO1	N/A	Stable	Stable
164FLT14-PO1	N/A	Stable	Stable
164FLT15-PO1	N/A	Stable	Stable
164FLT01-PO2	N/A	Stable	Stable
164FLT07-PO2	Stable	Stable	Stable
164FLT09-PO2	Stable	Stable	Stable
164FLT13-PO2	Stable	Stable	Stable
164FLT14-PO2	Stable	Stable	Stable
164FLT01-PO3	N/A	Stable	Stable
164FLT02-PO3	Stable	Stable	Stable
164FLT04-PO3	Stable	Stable	Stable
164FLT07-PO3	Stable	Stable	Stable
164FLT09-PO3	Stable	Stable	Stable
164FLT13-PO3	Stable	Stable	Stable
164FLT01-SB	N/A	Stable	Stable
164FLT12-SB	Stable	Stable	Stable

N/A: not applicable because of the network configuration.

4.0 SHORT CIRCUIT ANALYSIS

Burns & McDonnell performed short circuit analysis to identify impacts on the system resulting from the interconnection of DISIS-2016-002-2 (Group 15) requests. The analysis was performed using version 33.9 of the PTI PSS/E software. The following sections outline the methodology and results of the analysis.

4.1 Methodology

The short circuit analysis was performed using the 2018 and 2026 Summer Peak models. Three-phase fault currents were calculated for the 69 kV and above buses within 5 buses of generator's point of interconnection.

4.2 Short Circuit Analysis Results

Table 4-1 through Table 4-4 summarize the three-phase fault currents observed for facilities two buses away from each queue project for the 2018 and 2026 Summer Peak cases. Details of the fault current for facilities within 5 buses from the generator's point of interconnection is provided in Appendix C.

Table 4-1: 2018 & 2026 Summer Peak GEN-2016-036 Three-Phase Fault Currents

Bus Dist. From POI	BUS NUMBER	BUS NAME	Voltage (kV)	AREA	ZONE	3 Phase Fault Current (kA)	
						2018SP	2026SP
0	652551	GRANITF7	115	652	1604	17.377	17.484
1	603030	MINVALY7	115	600	606	16.380	16.451
1	620211	CANBY 7	115	620	648	3.890	4.108
1	652508	S3 7	115	652	1604	9.167	9.183
1	652550	GRANITF4	230	652	1604	12.983	13.071
1	652297	GRANITF9	13	652	1604	28.731	28.767
1	652292	GRANITF2	13	652	1604	25.907	25.937
1	652298	GRANITF8	69	652	1604	4.554	4.558
1	652288	GRANITE	13	652	1604	5.140	5.141
2	603177	MAYNARD7	115	600	603	7.221	7.233
2	603257	MINVALY	115	600	606	16.267	16.338
2	605045	MINNVAL8	69	600	606	9.419	9.432
2	613310	REDFLST7	115	600	631	6.428	6.435
2	602008	MINVALT4	230	600	606	12.850	12.934
2	605729	MN VLY6	13	600	606	25.932	25.954
2	605723	MN VLY5	13	600	606	19.019	19.030
2	620111	CANBY 9	41	620	648	2.554	2.585
2	620173	DAWS TP7	115	620	648	3.074	3.150
2	620212	BURR 7	115	620	648	3.558	3.831
2	652552	MARS ER7	115	652	1604	8.333	8.346
2	658072	ERIE RD7	115	600	1627	12.502	12.531
2	602009	MNVLTAP4	230	600	606	12.811	12.894
2	619975	GRE-WILL	230	615	643	5.188	5.222
2	652503	BLAIR 4	230	652	1604	9.857	9.908

Bus Dist. From POI	BUS NUMBER	BUS NAME	Voltage (kV)	AREA	ZONE	3 Phase Fault Current (kA)	
						2018SP	2026SP
2	652554	MORRIS 4	230	652	1605	4.809	4.801
2	652582	APPLEDOR	230	652	1604	7.095	7.122
2	617911	GRE-PNNC	69	615	643	3.315	3.316

Table 4-2: 2018 & 2026 Summer Peak GEN-2016-087 Three-Phase Fault Currents

Bus Dist. From POI	BUS NUMBER	BUS NAME	Voltage (kV)	AREA	ZONE	3 Phase Fault Current (kA)	
						2018SP	2026SP
0	652499	CAMPBELL	230	652	1605	4.634	4.643
1	652426	BISMARK4	230	652	1605	13.438	13.895
1	659408	CAMPBLCN	230	652	1628	4.210	4.218
1	661038	GLENHAM4	230	652	1636	4.862	4.869
2	652296	WARD 4	230	652	1628	11.820	12.257
2	652444	JAMESTN4	230	652	1605	8.260	8.344
2	652456	WASHBRN4	230	652	1605	9.994	10.045
2	652466	HILKEN 4	230	652	1604	8.483	8.569
2	659128	WEBER 4	230	652	1628	4.808	4.849
2	652427	BISMARK7	115	652	1605	14.191	14.857
2	652467	BISMARK2	12	652	1605	27.515	27.809
2	652392	BISMARK9	12	652	1605	27.515	27.809
2	659409	CAMPBLCN	34	652	1628	16.176	16.191
2	85991	J599	230	652	1636	3.933	3.936
2	652527	WHITLOK4	230	652	1604	4.857	4.859
2	661035	GLENHAM7	115	661	1636	4.704	4.707
2	661600	GLENHAM9	41	661	1636	6.130	6.132
2	655652	BIS EXPR	115	652	1628	14.191	14.857

Table 4-3: 2018 & 2026 Summer Peak GEN-2016-092 Three-Phase Fault Currents

Bus Dist. From POI	BUS NUMBER	BUS NAME	Voltage (kV)	AREA	ZONE	3 Phase Fault Current (kA)	
						2018SP	2026SP
0	560074	G16-017-	345	652	1604	5.963	5.965
1	587130	GEN-2016	345	652	1604	5.917	5.919
1	652806	FTTHOM1-	345	652	1604	9.116	9.122
1	659424	LELAND2-	345	652	1628	16.510	16.553
1	652506	FTTHOMP3	345	652	1604	9.116	9.122
1	659105	LELANDO3	345	652	1628	16.510	16.553
1	652807	FTTHOM2-	345	652	1604	9.116	9.122
1	652507	FTTHOMP4	230	652	1604	20.159	20.183
1	659422	LELAND1-	345	652	1628	16.510	16.553
1	659106	LELANDO4	230	652	1628	22.757	22.829
2	587131	G16-017X	34	652	1604	23.764	23.767
2	652273	FTTHMP19	13	652	1604	25.989	25.992
2	652274	FTTHMP29	13	652	1604	25.990	25.992
2	588210	GEN-2016	345	652	1628	11.253	11.272
2	659101	ANTELOP3	345	652	1628	16.339	16.382
2	659111	LELAN32G	20	652	1629	128.198	128.262
2	659201	LELNDOLD	13	652	1628	33.964	33.975
2	659202	LELNDOLD	13	652	1628	26.386	26.391

Bus Dist. From POI	BUS NUMBER	BUS NAME	Voltage (kV)	AREA	ZONE	3 Phase Fault Current (kA)	
						2018SP	2026SP
2	652833	GRPRAR2-	345	652	1604	6.800	6.810
2	587764	G16-094-	230	652	1604	12.997	13.005
2	652276	FTTHOMP8	69	652	1604	4.424	4.424
2	652509	FTRANDL4	230	652	1604	10.836	10.859
2	652514	HURON 4	230	652	1604	10.782	10.802
2	652516	LAKPLAT4	230	652	1604	5.589	5.593
2	652519	OAHE 4	230	652	1604	14.144	14.151
2	652540	BIGBND14	230	652	1604	11.963	11.970
2	652541	BIGBND24	230	652	1604	11.887	11.894
2	652606	LETCHER4	230	652	1604	4.723	4.731
2	652607	WESSINGT	230	652	1604	6.797	6.802
2	659218	COTEAU	345	652	1628	16.339	16.382
2	659420	ANTELOP-	345	652	1628	16.339	16.382
2	659423	GROTON-L	345	652	1628	6.178	6.198
2	587030	GEN-2016	230	652	659	7.350	7.357
2	615901	GRE-STAN	230	615	643	16.674	16.999
2	652441	GARRISN4	230	652	1605	11.388	11.431
2	652456	WASHBRN4	230	652	1605	9.994	10.045
2	659108	LOGAN 4	230	652	1628	5.304	5.124
2	659110	LELAN41G	22	652	1629	85.213	85.250
2	659109	BASIN 7	115	652	1628	5.183	5.185
2	659200	BASIN 9	13	652	1628	13.860	13.861
2	652532	GR PRAIR	345	652	1604	6.800	6.810
2	659160	GROTON 3	345	652	1628	6.178	6.198
2	652832	GRPRAR1-	345	652	1604	6.800	6.810

Table 4-4: 2018 & 2026 Summer Peak GEN-2016-164 Three-Phase Fault Currents

Bus Dist. From POI	BUS NUMBER	BUS NAME	Voltage (kV)	AREA	ZONE	3 Phase Fault Current (kA)	
						2018SP	2026SP
0	652512	GROTON 7	115	652	1604	18.153	18.187
0	652568	GROTONSO	115	652	1604	18.153	18.187
1	652250	GROTON18	69	652	1604	4.122	4.123
1	652253	GROTON2	69	652	1604	1.856	1.856
1	652533	BRISTOL7	115	652	1604	4.620	4.633
1	659028	G12_014I	115	652	1604	5.662	5.665
1	660001	ABDNSBT7	115	652	1634	7.602	7.604
1	652534	ORDWAY 7	115	652	1604	9.564	9.573
1	652535	REDFELD7	115	652	1604	4.108	4.109
1	655419	SW561-ER	115	652	1632	6.696	6.699
1	659275	GROTONB7	115	652	1628	17.649	17.680
1	659160	GROTON 3	345	652	1628	6.178	6.198
1	659161	GROTON 9	13	652	1628	24.214	24.222
1	659423	GROTON-L	345	652	1628	6.178	6.198
2	655256	FERNEY-E	69	652	1632	2.780	2.781
2	655267	GROTON-E	69	652	1632	2.266	2.266
2	655395	NWPS509-	69	652	1632	4.113	4.114
2	652289	BRISTOL8	69	652	1604	2.731	2.734
2	652522	SUMMIT-7	115	652	1604	4.577	4.633
2	659029	G12_014I	34	652	1604	9.629	9.631

Bus Dist. From POI	BUS NUMBER	BUS NAME	Voltage (kV)	AREA	ZONE	3 Phase Fault Current (kA)	
						2018SP	2026SP
2	660000	ABDNJCT7	115	652	1634	5.580	5.581
2	660002	REDFLD 7	115	652	1634	4.193	4.194
2	652290	ORDWAY 8	69	652	1604	5.490	5.492
2	652432	EDGELEY7	115	652	1605	4.029	4.031
2	652291	REDFELD8	69	652	1604	2.803	2.803
2	652515	HURON 7	115	652	1604	14.992	15.009
2	655411	CRANDALL	115	652	1632	6.410	6.413
2	659288	DAYCNTYW	115	652	1628	5.234	5.235
2	659272	GROTON	13	652	1629	65.137	65.153
2	659274	GROTON	13	652	1629	65.137	65.153
2	652175	G09_001I	345	652	659	6.347	6.380
2	659422	LELAND1-	345	652	1628	16.510	16.553
2	659105	LELANDO3	345	652	1628	16.510	16.553
2	659424	LELAND2-	345	652	1628	16.510	16.553
2	659106	LELANDO4	230	652	1628	22.757	22.829

5.0 CONCLUSIONS

The purpose of this study was to evaluate the impacts of the DISIS-2016-002-2 (Group 15) generation interconnection requests on the SPP transmission system. Short circuit analysis and stability analysis were performed for the evaluation.

The stability analysis evaluated the transmission system for three load scenarios (2017 Winter Peak, 2018 Summer Peak and 2026 Summer Peak) through simulating 85 faults (three-phase faults and single-line-to-ground faults) under normal conditions and prior outage conditions. For all the events simulated, there were no machine rotor angle damping or transient voltage recovery violations within the DISIS-2016-002-2 (Group 15) study area.

The short circuit analysis evaluated the system for the 2018 and 2026 Summer Peak cases. Three-phase fault currents were calculated for the 69 kV and above buses within 5 buses of generator's point of interconnection. The short circuit results are listed in Section 4.

It should be noted that the results of this study are based on available data and assumptions made at the time of this study. If any of the data and/or assumptions change, the results provided in this report may not apply.

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GROUP 16 STABILITY ANALYSIS

The Group 16 cases included the following system adjustments of dispatching, to maximum output, generation interconnected at the same or adjacent substations to a current study request:

- Antelope Valley Station units: GEN-2016-130
- Garrison & Leland Olds units: GEN-2016-130

The Group 16 stability analysis for this area was performed by POWER-tek Global Inc. (Power-tek).

With the new requests modeled, violations of stability damping criteria and voltage recovery criteria were observed for fault events involving circuits terminated at the Judson 345kV, Tande 345kV, and GRE Stanton 230kV substations. The following upgrades were tested in the stability analysis:

- Adjust, during simulation, the GEN-2015-046 reactive power set point
- Reconfigure Judson 345kV to double breaker double bus

An addendum study was performed that included case updates as a sensitivity analysis to evaluate the stability analysis impacts in the vicinity of Tande 345kV from the removal of withdrawn requests and modification to the GEN-2015-046 request. Among other updates, the sensitivity analysis included removal of the 224 MW withdrawn MISO request J593, with a POI on the 230kV system at Tioga substation, which is in the electrical vicinity of Tande 345/230kV substation the POI (345kV) for GEN-2016-151.

The results from the addendum sensitivity determined that the previously observed violations of stability damping criteria and voltage recovery criteria for fault events involving circuits terminated at the Judson 345kV and Tande 345kV substations were resolved with the model updates. The previously identified mitigations, to adjust reactive power set point and reconfigure Judson 345kV to double breaker double bus, are not required.

Power-tek noted that for faults simulated at GRE Stanton 230kV substation that the adjacent GRE coal units were observed to lose synchronism even though the remainder of the transmission system remained stable. It is recommended that the Generator Owner(s) of the GRE coal generating facility perform model validation to improve the PSS/E model response and if necessary coordinate with the Transmission Owner (GRE) to evaluate any applicable operational guide(s) and Corrective Action Plans utilized in transmission planning assessment.

With all previously-assigned and currently-assigned Network Upgrades placed in service, no violations were observed except the GRE-coal instability, including violations of low-voltage ride-through requirements, for the probable P1 and P4 Planning Events studied.

Evaluation of P6, prior outage, Planning Events involving Judson to Tande 345kV and Neset to Tioga 230kV circuits, determined that a system adjustment involving curtailment of approximately 320 MW of generation from GEN-2015-046 & GEN-2016-151 generating facilities may be required following a prior outage to achieve acceptable system response for a subsequent fault event. Evaluation also included a scenario with DPA-2018-August-918 identified upgrades (NTC 210560: Northshore 230 kV Substation, Neset - Northshore 230 kV circuit 1, & Northshore 230/115 kV transformer; NTC 210559: Northshore - New Town 115 kV circuit 1). With these upgrades in-service, the curtailment required to achieve system stability reduced to between 125 MW and 65 MW depending upon the modeled equivalent generator voltage schedules.

Following the interconnection of each request or completion of these upgrade, it is recommended that the Transmission Owner(s) for the western North Dakota area (BEPC & WAPA) evaluate any applicable operational guide(s) and Corrective Action Plans utilized in transmission planning assessment.

With all previously-assigned and currently-assigned Network Upgrades placed in service and the identified system adjustments, no violations were observed, including violations of low-voltage ride-through requirements, for the probable P6 Planning Events studied.

Southwest Power Pool Inc. (SPP)

Definitive Impact Study

DISIS-2016-002-2 (Group 16)-Revised

Draft Report Submitted to
Southwest Power Pool Inc.
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TABLE OF CONTENTS

1. Executive Summary

The DISIS-2016-002-2 (Group 16) Revise Impact Study is a generation interconnection study performed by POWER-tek Global Inc. for Southwest Power Pool (SPP). This report presents the results of impact study comprising of short circuit and stability analyses for the proposed interconnection projects under DISIS-2016-002-2 (Group 16) Revise ("The Projects") as described in Table 1.1 below:

Table 1.1: Interconnection Request

Request	Size (MW)	Generator Model	Point of Interconnection (POI)
GEN-2016-130	202	GE 2.0MW WTG (588213)	Leland Olds 345kV (659105)
GEN-2016-151	202	GE 2.0MW WTG (588283)	Tande 345kV Sub (659336)
GEN-2016-155	103.68 (withdrawal of GEN-2016-155, 1.28MW uprate of GEN-2007-015IS, not reflected in study)	GE 1.62MW WTG (659366)	Hilken 230kV switching station (652466)

Short circuit analysis up to 5 Buses away from each point of interconnection (POI) and transient stability simulations were performed for the Projects in service at its full output. SPP provided three base cases for Winter-2017, Summer-2018, and Summer-2026, each comprising of a power flow, sequence data and corresponding dynamics database. The previous queued request projects were already modeled in the base cases.

Stability analysis results indicate system instability for few contingencies involving circuits connected to Judson 345kV, Tande 345kV, Neset 230kV, GRE Stanton 230kV i.e.:

- Winter-2017 scenario: FLT18-PO, FLT102-PO, and FLT105-SB.
- Summer-2018 Scenario: FLT16-3PH, FLT18-PO, FLT102-PO, FLT103-PO, and FLT105-SB.
- Summer-2026 Scenario: FLT18-PO, FLT102-PO, and FLT105-SB.
- In general, FLT81-3PH, FLT82-3PH, and FLT83-3PH (during all scenarios) shows unstable response for only two machines i.e., GRE-COAL 41G (615001) and GRE-COAL 41G (615002). However, other system response is stable.

In order to solve these critical contingencies, the following transmission updates/reconfiguration have been proposed:

1. FLT16-3PH is unstable only in summer-2018 conditions, In the transient run, after the line tripping, adjust GEN-2015-046 machine at bus 584873 the auxiliary model VWVAR6 VAR L+1 power factor set point from 0.991 (40 MVar) to 0.98 (60.9 MVAR). This modified fault definition, FLT16A-3PH, shows stable response.

2. FLT81-3PH, FLT82-3PH, and FLT83-3pH are tested with reduced fault clearing time. However, the machines response for GRE-COAL 41G (615001) and GRE-COAL 41G (615002) are not found satisfactory, loss of synchronism observed. As further investigation, the governor model for these machines were tested by replacing from IEEEG1 type to the updated WSIEG1 type along-with and remove (switch offline) the withdrawn J511 (buses 85111-85116) request. Even with these changes, the machines responses were not stable. Therefore, it is suggested that SPP should coordinate with GRE to for further investigation on these two machines.
3. For FLT18-PO, FLT102-PO, and FLT103-PO Generation Curtailment (100MW between GEN-2015-046 and GEN-2016-151) was found to mitigate the instability.
4. For FLT105-SB, the issue appeared to be actually power transfer limitation for the simultaneous loss of multiple circuits at Judson 345kV and not the deficiency of reactive power at Tande 345kV. In order to address this, different scenarios were tested i.e., Reconfigure Judson 345kV substation to double breaker double bus configuration and tripping of One circuit during stuck breaker event, Changing the POI for GEN-2016-151 to Tande 230 kV, Generation Curtailment, Transmission Upgrades (additional transformers and line circuits), DPA-2018-August-918 identified upgrades, DPA-2018-August-918 identified upgrades converted from 230kV to 345kV, Consideration of SVC at 345kV TANDE OR consideration of SVC at 230kV TANDE (with and without shifting of GEN-2016-151 POI to Tande 230kV). It is important to note here that some of the proposals work fine for the satisfactory results for FLT105-SB. Following are among these workable solutions:

- DPA-2018-August-918 identified upgrades converted from 230kV to 345kV (as defined below in scenario FLT105F8-SB)
- Consideration of a 50 MVAR SVC at 345kV Bus (as defined below in scenario FLT105F6-SB)
- Addition of Tande 345kV/230kV Transformer circuit 2 (as defined below in scenario FLT105F4-SB)
- Reduction of GEN-2016-151 from 202MW to 25MW (as defined below in scenario FLT105F1-SB)
- Reconfigure Judson 345kV Substation from ring bus to double breaker double bus (as defined below in scenarios FLT105A-SB, FLT105B-SB, & FLT105C-SB)

Since all the proposed upgrades requiring additional transmission facilities are associated with significant cost, it is recommended that Judson 345kV Substation be reconfigured such that only one circuit should be considered tripped during stuck breaker event i.e., during stuck breaker event only a single circuit; Judson to Tande 345kV, Judson to Patent Gate 345kV, or Judson 345/230kV transformer be considered.

With the above recommendations there are no impacts on the stability performance of the SPP system during cluster scenarios for the contingencies tested on the provided base cases. For all contingencies evaluated, the study machines stayed on-line and stable for all simulated faults. The project stability simulations specified test disturbances did not show instability problems in the SPP system. Any oscillations were damped out.

2. Introduction

2.1. Project Overview and Assumptions

The DISIS-2016-002-2 (Group 16) Revise Impact Study is a generation interconnection study performed by POWER-tek Global Inc. for SPP. This report presents the results of impact study comprising of short circuit analysis and stability analyses for the proposed interconnection projects under DISIS-2016-002-2 (Group 16) Revise ("The Projects") as described in Table 2.1.1 below:

Table 2.1.1: Interconnection requests

Request	Size (MW)	Generator Model	Point of Interconnection (POI)
GEN-2016-130	202	GE 2.0MW WTG (588213)	Leland Olds 345kV (659105)
GEN-2016-151	202	GE 2.0MW WTG (588283)	Tande 345kV Sub (659336)
GEN-2016-155	103.68 (withdrawal of GEN-2016-155, 1.28MW uprate of GEN-2007-015IS, not reflected in study)	GE 1.62MW WTG (659366)	Hilken 230kV switching station (652466)

Figure 2.1.1, 2.1.2, and 2.1.3, shows the single line diagram for the interconnection of the Projects to present and planned system of SPP. This arrangement was modeled and studied in power flow cases for these projects.

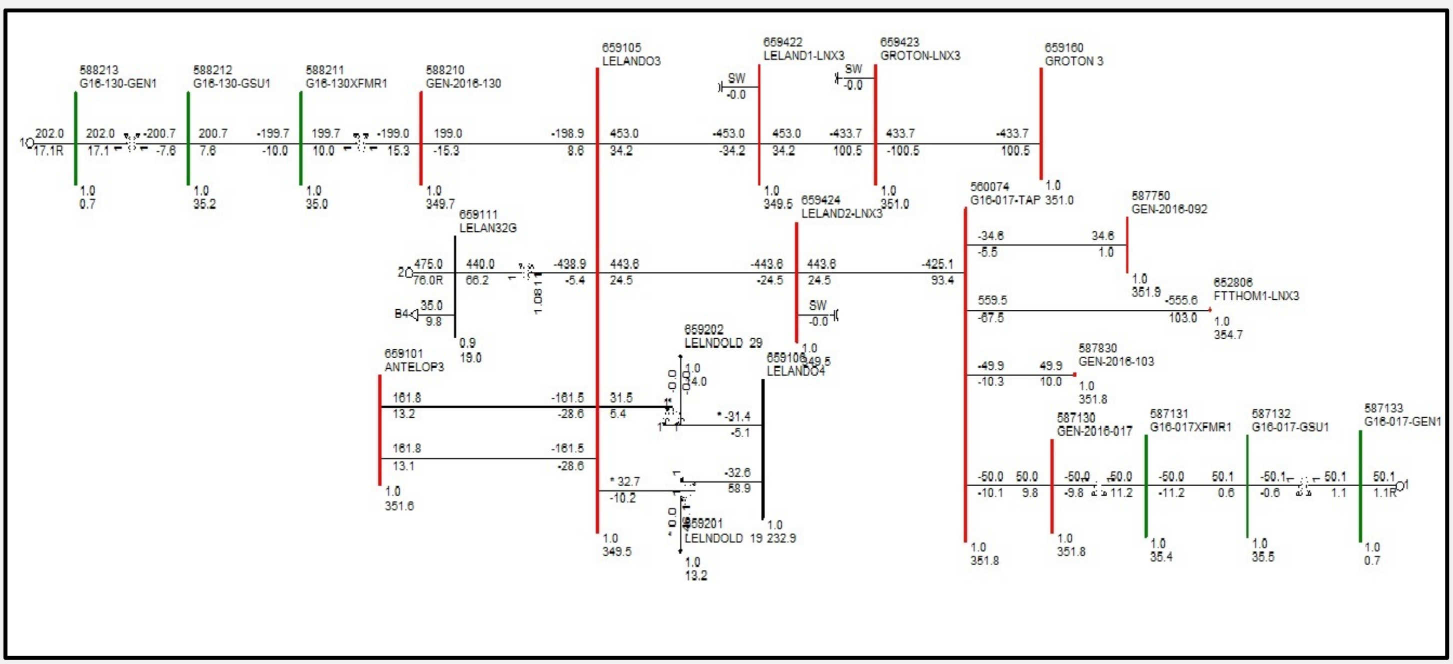

Figure 2.1.1: Power flow single line diagram for GEN-2016-130 and surrounding system components

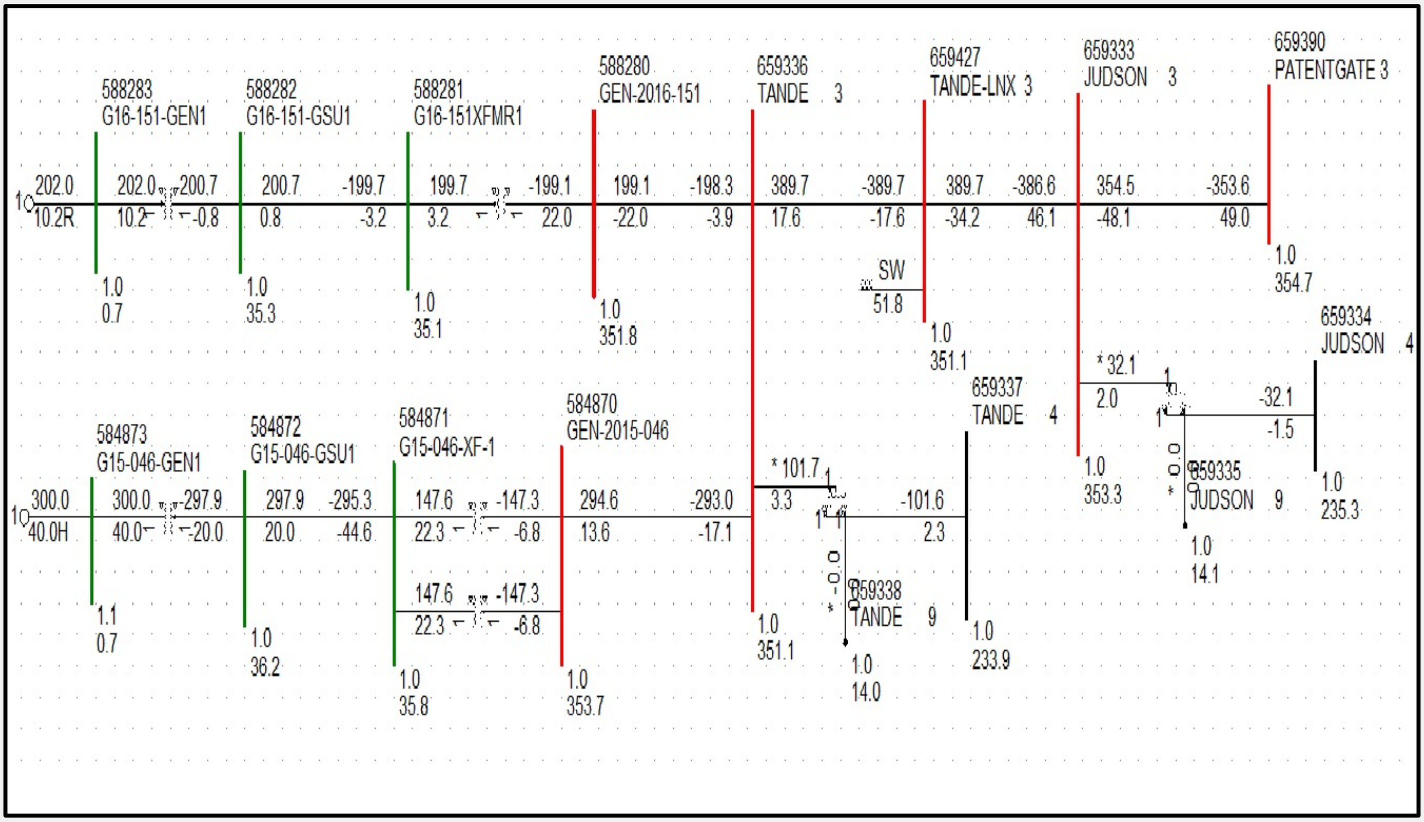

Figure 2.1.2: Power flow single line diagram for GEN-2016-151 and surrounding system components

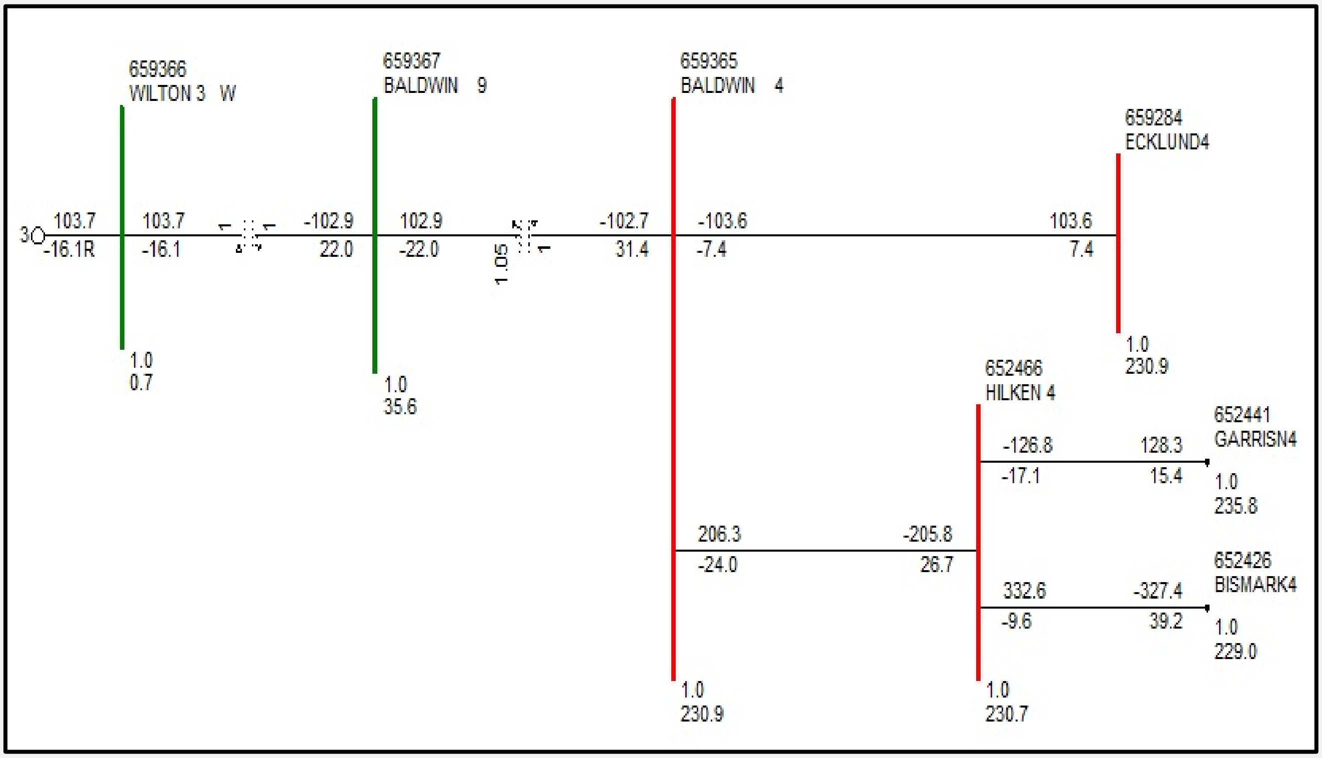

Figure 2.1.3: Power flow single line diagram for GEN-2016-155 and surrounding system components

Appendix-D contains the machines, interconnection, and machines user model parameters.

Table 2.1.2 below shows the list of prior queued projects modeled in the base case.

Table 2.1.2: List of previous queued request projects

Request	Size (MW)	Wind Turbine Model	Point of Interconnection
Coyote	453	GENROU	Coyote 345kV (661016)
G380	149.1	Suzlon S88 2.1MW	Rugby 115kV (620379)
G408	11.88	WT1 Generic Wind	Tap McHenry - Souris 115kV (605634)
G502	50.6	W4GUR Wind	Milton Young 230kV (657756)
G645/G788	102.6	GENROU	Ladish 115kV (620270)
G723	7	GENSAL	Heskett 115kV (661043)
G752	150	WT3 Generic Wind	Tap Bison - Hettinger 230kV (661047)
G830	99	GENCLS	GRE McHenry 115kV (615348)
J003	19.5	WT3 Generic Wind	Baker 115kV (661005)
J249	180	WT3 Generic Wind	MDU Tatanka 230kV (661096)
J262/J263	200	Vestas V100 2.0MW	Jamestown 345 (620269)
J290	150	Vestas V100 2.0MW	Tap Glenboro South - Rugby 230kV (602057)
J316	150	GE 1.7045MW	MDU 230 kV Tatanka-Ellendale line (11117)
J511	200 (withdrawal not reflected in study)	Vestas V110 2MW	Stanton 230kV (615901)
J593	224 (withdrawal not	Vestas V110 2MW	Tioga 4 230kV (661084)

Request	Size (MW)	Wind Turbine Model	Point of Interconnection
	reflected in study)		
MPC01300	455	GENROU	Square Butte 230kV (657756)
MPC02100	100	GE 2.0MW WTG	Center-Mandan 230kV (657741)
Young1	274	GENROU	Center 230kV (657751)
GEN-2005-008IS/GEN-2016-052	52.8 (withdrawal of GEN-2016-052, 3.3MW uprate of GEN-2005-008IS, not reflected in study)	GE 1.6MW	Hilken 230kV [Ecklund 230kV] (652466)
GEN-2006-015IS/GEN-2016-053	52.8 (withdrawal of GEN-2016-053, 3.3MW uprate of GEN-2006-015IS, not reflected in study)	GE 1.6MW	Hilken 230kV [Ecklund 230kV] (652466)
GEN-2007-015IS	102.4	GE 1.6MW WTG (659366)	Hilken 230kV [Ecklund 230kV] (652466)
GEN-2009-026IS	106.5	GENROU	Dickenson-Heskett 230kV (652468)
GEN-2011-005IS/GEN-2012-005IS/GEN-2012-007IS	141	GENROU	Williston 115kV (652421)
GEN-2012-002IS	47	GENROU	Watford City 115/230kV (652408)
GEN-2012-004IS/GEN-2012-008IS	94	GENROU	Williston-Ch. Creek 230kV (652216)
GEN-2012-006IS	141	GENROU	Williston-Ch. Creek 230kV (659391)

Request	Size (MW)	Wind Turbine Model	Point of Interconnection
GEN-2012-012IS	75 (withdrawal not reflected in study)	GE 2.678MW	Wolf Point-Circle 115kV (910007)
GEN-2014-006IS	113.3	GENSAL	Williston 115kV (659430)
GEN-2014-010IS	150	Vestas V110 VCSS 2.0MW	Neset 115kV (659139)
GEN-2014-014IS	149.73	GE 1.715/1.79MW	Belfield-Rhame 230kV (659448)
GEN-2015-046	300	Vestes V110 2.0MW	Tande 345kV (659336)
GEN-2015-096	149.03	GE 2.0MW	Tap Belfied - Rhame 230kV (659448)
GEN-2016-004	201.6	Vestas V110 VCSS 2.0MW, Vestas V136 3.6MW	Leland Olds 230kV (659106)

ATC (Available Transfer Capability) studies were not performed as part of this study. These studies will be required at the time transmission service is actually requested. Additional transmission upgrades may be required based on that analysis.

Study assumptions in general have been based on the specific information and data provided by SPP. The accuracy of the conclusions contained within this study is dependent on the assumptions made with respect to other generation additions and transmission improvements planned by other entities. Changes in the assumptions of the timing of other generation additions or transmission improvements may affect this study's conclusions.

2.2. Objectives

The objectives of the study are to determine the impact on system stability of interconnecting the proposed power plants to SPP's transmission system.

2.3. Models and Simulations Tools Used

Version 33.7 of the Siemens, PSS/E^{TM} power system simulation program was used in this study.

SPP provided its latest stability database cases for Winter-2017, Summer-2018, and Summer-2026 peak seasons. The Project's PSS/E model had been developed prior to this study and was included in the power flow case and the dynamics database. Machines, interconnection and dynamic model data for the Project plants is provided in Appendix D.

Power flow single line diagram of the projects in summer 2018 peak condition is shown in Figure 2.1.1, 2.1.2, and 2.1.3 respectively. These figures show that each wind farm model includes representation of the radial transmission line and the substation transformer from transmission voltage (230kV and 345kV) to the collector system voltage (34.5V). The remainder of each wind farm is represented by lumped equivalents including a generator, a step-up transformer, and collector system impedance.

No special modeling is required of line relays in these cases, except for the special modeling related to the wind-turbine tripping.

All generators in Areas 356, 600, 615, 620, 635, 640, 645, 652, and 661 were monitored.

3. Short Circuit Analysis

The short circuit analysis out five buses away was performed for 2018 and 2026 summer peak cases for each interconnection request under project cluster scenario of DISIS-2016-002-2 (Group 16) Revise. No outage was assumed in the system model.

3.1. Short Circuit Result for 2018 Summer Peak Case

The short circuit results for summer-2018 scenario at the POI are tabulated below.

3.1.1. Short Circuit Result for Leland Olds 345kV (659105)

The results of the short circuit analysis for GEN-2016-130 POI i.e., Leland Olds 345kV (659105) and five bus levels away are tabulated below in Table 3.1.1.

Table 3.1.1: Short circuit results for Leland Olds 345kV (659105)

Bus #	Bus Name	Level Away	Fault Current (Amperes)
			3 PH
659105	LELANDO3 345.0	0 LEVELS AWAY	17197.1
588210	GEN-2016-130345.0	1 LEVELS AWAY	11921.9
659101	ANTELOP3 345.0	1 LEVELS AWAY	17048.1
659106	LELANDO4 230.0	1 LEVELS AWAY	23940.4
659111	LELAN32G 20.00	1 LEVELS AWAY	137104.7
659201	LELNDOLD 1913.80	1 LEVELS AWAY	36965.9
659202	LELNDOLD 2913.80	1 LEVELS AWAY	28466.6
659422	LELAND1-LNX3345.0	1 LEVELS AWAY	17197.1
659424	LELAND2-LNX3345.0	1 LEVELS AWAY	17197.1

Bus #	Bus Name	Level Away	Fault Current (Amperes)
			3 PH
560074	G16-017-TAP 345.0	2 LEVELS AWAY	6907.4
587030	GEN-2016-004230.0	2 LEVELS AWAY	7977.1
588211	G16-130XFMR134.50	2 LEVELS AWAY	27378.5
615901	GRE-STANTON4230.0	2 LEVELS AWAY	17454.2
652441	GARRISN4 230.0	2 LEVELS AWAY	12146.9
652456	WASHBRN4 230.0	2 LEVELS AWAY	10849.2
659103	ANTEL31G 23.00	2 LEVELS AWAY	150791.8
659107	ANTEL32G 23.00	2 LEVELS AWAY	150791.8
659108	LOGAN 4 230.0	2 LEVELS AWAY	5897.6
659109	BASIN 7 115.0	2 LEVELS AWAY	5719.9
659110	LELAN41G 22.00	2 LEVELS AWAY	90019
659183	CHAR.CK3 345.0	2 LEVELS AWAY	10818.6
659200	BASIN 9 13.80	2 LEVELS AWAY	17039.4
659212	DGC 3345.0	2 LEVELS AWAY	16300.8
659218	COTEAU 3345.0	2 LEVELS AWAY	17048.1
659384	ROUNDUP 3345.0	2 LEVELS AWAY	9148.5
659420	ANTELOP-LNX3345.0	2 LEVELS AWAY	17048.1
659423	GROTON-LNX3 345.0	2 LEVELS AWAY	6015.9
85111	J511 230.0	3 LEVELS AWAY	7154.7
587031	G16-004XFMR134.50	3 LEVELS AWAY	25139.8
587130	GEN-2016-017345.0	3 LEVELS AWAY	6850.2
587750	GEN-2016-092345.0	3 LEVELS AWAY	6181.5
587830	GEN-2016-103345.0	3 LEVELS AWAY	6851.3
588212	G16-130-GSU134.50	3 LEVELS AWAY	26677.2
615600	GRE-COAL CR4230.0	3 LEVELS AWAY	17110.2
615900	GRE-COAL TP4230.0	3 LEVELS AWAY	15116.8
652325	WASHBRN9 41.80	3 LEVELS AWAY	4108.4
652420	NSALEM 7 115.0	3 LEVELS AWAY	1995.9
652424	BELFELD3 345.0	3 LEVELS AWAY	6905.2

Bus #	Bus Name	Level Away	Fault Current (Amperes)
			3 PH
652426	BISMARK4 230.0	3 LEVELS AWAY	14847.9
652442	GARRISN7 115.0	3 LEVELS AWAY	13727.8
652444	JAMESTN4 230.0	3 LEVELS AWAY	9207.8
652457	GARISN1G 13.80	3 LEVELS AWAY	64114.2
652458	GARISN2G 13.80	3 LEVELS AWAY	64080.7
652459	GARISN3G 13.80	3 LEVELS AWAY	64047.4
652466	HILKEN 4 230.0	3 LEVELS AWAY	9281.6
652806	FTTHOM1-LNX3345.0	3 LEVELS AWAY	10080.5
657756	SQBUTTE4 230.0	3 LEVELS AWAY	21255
659143	BLAISDELL 4230.0	3 LEVELS AWAY	5716.4
659155	LOGAN 7 115.0	3 LEVELS AWAY	9902.7
659160	GROTON 3 345.0	3 LEVELS AWAY	6015.9
659182	CHAR.CK7 115.0	3 LEVELS AWAY	14959.3
659208	LOGAN 913.80	3 LEVELS AWAY	21407.3
659211	CHARCREEK 1913.80	3 LEVELS AWAY	30286.6
659214	DGC NB5301B913.80	3 LEVELS AWAY	30086.6
659215	DGC NB5302A913.80	3 LEVELS AWAY	21179.6
659219	COT 13.8T1 913.80	3 LEVELS AWAY	25691.2
659220	DGC NB5301A913.80	3 LEVELS AWAY	30260.8
659221	DGC NB5302B913.80	3 LEVELS AWAY	46036.3
659222	COTEAU1 869.00	3 LEVELS AWAY	10620.1
659231	COT 13.8T2 913.80	3 LEVELS AWAY	25528.8
659232	DGC________913.80	3 LEVELS AWAY	21833.7
659233	DGC 4230.0	3 LEVELS AWAY	7467.6
659302	CHAR.CK4 230.0	3 LEVELS AWAY	11834
659318	CHARCREEK 2913.80	3 LEVELS AWAY	25256.6
659319	CHARCREEK 3913.80	3 LEVELS AWAY	33230
659385	ROUNDUP 7115.0	3 LEVELS AWAY	13381.2
659386	ROUNDUP 913.80	3 LEVELS AWAY	26643

Bus #	Bus Name	Level Away	Fault Current (Amperes)
			3 PH
659390	PATENTGATE 3345.0	3 LEVELS AWAY	7317.3
659421	BRDLAND-LNX3345.0	3 LEVELS AWAY	4334
85112	J511 COL 34.50	4 LEVELS AWAY	23538.4
587032	G16-004-GSU134.50	4 LEVELS AWAY	22079.1
587035	G16-004-GSU234.50	4 LEVELS AWAY	23560
587131	G16-017XFMR134.50	4 LEVELS AWAY	26497.4
587751	G16-092XFMR134.50	4 LEVELS AWAY	21169.8
587831	G16-103XFMR134.50	4 LEVELS AWAY	26473.1
588213	G16-130-GEN10.690	4 LEVELS AWAY	1043676.8
603023	MALLARD7 115.0	4 LEVELS AWAY	10049
608602	SQBEAST4 230.0	4 LEVELS AWAY	21255
615001	GRE-COAL 41G22.00	4 LEVELS AWAY	143926.2
615002	GRE-COAL 42G22.00	4 LEVELS AWAY	143004.5
615347	GRE-MCHENRY4230.0	4 LEVELS AWAY	6344.8
615601	GRE-COAL FM869.00	4 LEVELS AWAY	8889.9
615602	GRE-COALFM1T12.47	4 LEVELS AWAY	18631.6
615603	GRE-COALFM2T12.47	4 LEVELS AWAY	18549.2
620381	UNDERWD4 230.0	4 LEVELS AWAY	13973.3
652175	G09_001IST 345.0	4 LEVELS AWAY	6507.2
652207	JAMEST29 13.20	4 LEVELS AWAY	24134.8
652208	JAMEST19 13.20	4 LEVELS AWAY	24195.9
652216	WATFORD4 230.0	4 LEVELS AWAY	6635.4
652220	BELFELD29 13.80	4 LEVELS AWAY	27897.4
652221	BELFELD9 13.80	4 LEVELS AWAY	27196.4
652296	WARD 4 230.0	4 LEVELS AWAY	13046.9
652392	BISMARK9 12.47	4 LEVELS AWAY	31640
652416	DEVAUL 7 115.0	4 LEVELS AWAY	1454.8
652419	KILDEER7 115.0	4 LEVELS AWAY	8514.4
652425	BELFELD4 230.0	4 LEVELS AWAY	9603.4

Bus #	Bus Name	Level Away	Fault Current (Amperes)
			3 PH
652427	BISMARK7 115.0	4 LEVELS AWAY	15805.8
652435	FARGO 4 230.0	4 LEVELS AWAY	11478.3
652445	JAMESTN7 115.0	4 LEVELS AWAY	11047.2
652449	MAX 7 115.0	4 LEVELS AWAY	6312.4
652460	GARISN4G 13.80	4 LEVELS AWAY	41779.3
652461	GARISN5G 13.80	4 LEVELS AWAY	41772.2
652467	BISMARK29 12.47	4 LEVELS AWAY	31640.4
652499	CAMPBELL 4 230.0	4 LEVELS AWAY	5101.5
652506	FTTHOMP3 345.0	4 LEVELS AWAY	10080.5
652568	GROTONSOUTH 115.0	4 LEVELS AWAY	15094.3
652590	SNAKECR7 115.0	4 LEVELS AWAY	5689.2
655643	VOLTAIR -CP7115.0	4 LEVELS AWAY	8591.3
655657	SWMINOT -CP7115.0	4 LEVELS AWAY	6908.5
655833	GRSYBTTP-MK7115.0	4 LEVELS AWAY	13947.3
655853	BEARCREK-MK7115.0	4 LEVELS AWAY	10265.9
655893	DUNNCENTRMK7115.0	4 LEVELS AWAY	5392.8
657751	CENTER 4 230.0	4 LEVELS AWAY	19568.6
657759	PICKERT4 230.0	4 LEVELS AWAY	4701.6
657791	CENTER 3 345.0	4 LEVELS AWAY	12379.5
657848	YNG2 4 230.0	4 LEVELS AWAY	17800.4
657947	CENTR1TE 13.80	4 LEVELS AWAY	48336.6
657948	CENTR2TE 13.80	4 LEVELS AWAY	48339.9
659120	BRDLAND3 345.0	4 LEVELS AWAY	4334
659128	WEBER 4 230.0	4 LEVELS AWAY	5312.4
659144	BLAISDELL 7115.0	4 LEVELS AWAY	7575.2
659161	GROTON 9 13.80	4 LEVELS AWAY	26670.6
659164	BLAISDELL 913.80	4 LEVELS AWAY	26985
659184	R.RIDER7 115.0	4 LEVELS AWAY	4621.2
659185	FOUREYES 7115.0	4 LEVELS AWAY	3928.7

Bus #	Bus Name	Level Away	Fault Current (Amperes)
			3 PH
659226	DGC 3001B 913.80	4 LEVELS AWAY	29137.3
659227	DGC 3004B 913.80	4 LEVELS AWAY	29826
659228	DGC 1452 913.80	4 LEVELS AWAY	23249.6
659229	DGC 1721 913.80	4 LEVELS AWAY	24914.7
659234	DGC NB5301E913.80	4 LEVELS AWAY	23903.6
659235	DGC NB5301D913.80	4 LEVELS AWAY	17030.8
659236	DGC UREA 869.00	4 LEVELS AWAY	7929.3
659333	JUDSON 3345.0	4 LEVELS AWAY	6884.6
659365	BALDWIN 4230.0	4 LEVELS AWAY	8161.1
659387	KUMMERRIDGE3345.0	4 LEVELS AWAY	3908
659391	PATENTGATE 7115.0	4 LEVELS AWAY	16544.3
659392	PATENTGATE1913.80	4 LEVELS AWAY	26970.9
659393	PATENTGATE2913.80	4 LEVELS AWAY	26970.9
659543	PICKCITY RR7115.0	4 LEVELS AWAY	9743.6
661084	TIOGA4 4 230.0	4 LEVELS AWAY	10046
85113	J511 COL 2 34.50	5 LEVELS AWAY	20742.9
85114	J511 COL 3 34.50	5 LEVELS AWAY	22180.1
85931	J593 230.0	5 LEVELS AWAY	6037.1
587033	G16-004-GEN10.690	5 LEVELS AWAY	237474
587036	G16-004-GEN20.650	5 LEVELS AWAY	885021.6
587132	G16-017-GSU134.50	5 LEVELS AWAY	25365.1
587720	GEN-2016-087230.0	5 LEVELS AWAY	5101.5
587752	G16-092-GSU134.50	5 LEVELS AWAY	17279.5
587832	G16-103-GSU134.50	5 LEVELS AWAY	24035.7
602006	SHEYNNE4 230.0	5 LEVELS AWAY	12517.7
603280	MAGIC CITY 7115.0	5 LEVELS AWAY	7683.3
608597	SQBP1DC4 230.0	5 LEVELS AWAY	21255
608599	SQBP2DC4 230.0	5 LEVELS AWAY	21255
608600	BISONMP4 230.0	5 LEVELS AWAY	6198.4

Bus #	Bus Name	Level Away	Fault Current (Amperes)
			3 PH
608818	OLIVER19 34.50	5 LEVELS AWAY	10363.6
608830	OLIVER29 34.50	5 LEVELS AWAY	7781.5
615348	GRE-MCHENRY7115.0	5 LEVELS AWAY	8645
615349	GRE-MCHENRYT12.47	5 LEVELS AWAY	15608.5
615903	GRE-BALTA 4230.0	5 LEVELS AWAY	7212.4
620167	PICKERT9 41.60	5 LEVELS AWAY	2652.5
620290	HARVEY 4 230.0	5 LEVELS AWAY	5333.8
620369	JAMESTN3 345.0	5 LEVELS AWAY	5855
652174	G09_001IS_1 34.50	5 LEVELS AWAY	25212.3
652222	MAX 9 41.60	5 LEVELS AWAY	5509.6
652257	DEVAUL 8 69.00	5 LEVELS AWAY	1411.3
652273	FTTHMP19 13.80	5 LEVELS AWAY	29665.7
652274	FTTHMP29 13.80	5 LEVELS AWAY	29668.8
652320	JAMESTN9 41.80	5 LEVELS AWAY	4579.1
652408	WATFORD7 115.0	5 LEVELS AWAY	7749
652413	MEDORA 4 230.0	5 LEVELS AWAY	5334.5
652417	DICKNSN4 230.0	5 LEVELS AWAY	7188.9
652422	HALIDAY7 115.0	5 LEVELS AWAY	5145.2
652428	CARNGTN7 115.0	5 LEVELS AWAY	2908.8
652432	EDGELEY7 115.0	5 LEVELS AWAY	4397.8
652434	FARGOSVC 13.20	5 LEVELS AWAY	41517
652436	FARGO 7 115.0	5 LEVELS AWAY	11634.9
652437	GRNDFKS4 230.0	5 LEVELS AWAY	7634.5
652440	NELSON 7 115.0	5 LEVELS AWAY	7786.8
652452	RUGBY 7 115.0	5 LEVELS AWAY	8846.8
652454	VALLEYC7 115.0	5 LEVELS AWAY	4860.3
652464	DENBIGH TAP7115.0	5 LEVELS AWAY	4840.6
652471	WATFORD9 13.20	5 LEVELS AWAY	19637.4
652472	WATFORD29 13.20	5 LEVELS AWAY	13827.7

Bus #	Bus Name	Level Away	Fault Current (Amperes)
			3 PH
652507	FTTHOMP4 230.0	5 LEVELS AWAY	21686.7
652512	GROTON 7 115.0	5 LEVELS AWAY	15094.1
652529	WATERTN3 345.0	5 LEVELS AWAY	11241.9
652534	ORDWAY 7 115.0	5 LEVELS AWAY	9175.3
652535	REDFELD7 115.0	5 LEVELS AWAY	4456.5
652553	MOORHED4 230.0	5 LEVELS AWAY	7820.9
652807	FTTHOM2-LNX3345.0	5 LEVELS AWAY	10080.5
655419	SW561-ER7 115.0	5 LEVELS AWAY	6852.1
655641	BTHOLD -CP7115.0	5 LEVELS AWAY	5782.6
655642	WARDTERT-CP912.47	5 LEVELS AWAY	21862.6
655647	BIS WARD-CP7115.0	5 LEVELS AWAY	7997.6
655652	BIS EXPR-CP7115.0	5 LEVELS AWAY	15805.8
655655	RUTHVILL-CP7115.0	5 LEVELS AWAY	5490.4
655661	DGLASCRK-CP7115.0	5 LEVELS AWAY	3994.5
655834	GRASSYBT-MK7115.0	5 LEVELS AWAY	7155.9
655835	LITTLKNF-MK7115.0	5 LEVELS AWAY	7551.2
655836	OAKDALE -MK7115.0	5 LEVELS AWAY	8555.4
655844	TIMBERCK-MK7115.0	5 LEVELS AWAY	9341.5
655850	IDEAL -MK7115.0	5 LEVELS AWAY	11220.7
655851	NRTHWEST-MK7115.0	5 LEVELS AWAY	11834.5
655856	G8 -MK7115.0	5 LEVELS AWAY	7222.7
655891	KILLDEER-MK7115.0	5 LEVELS AWAY	8439.2
655916	PALERMO -MW7115.0	5 LEVELS AWAY	5624.5
655944	PLAZA -MW7115.0	5 LEVELS AWAY	5345.3
657741	ROUGHRIDER 4230.0	5 LEVELS AWAY	15745.9
657748	CENTER2G 20.00	5 LEVELS AWAY	149780.8
657749	CENTER1G 22.00	5 LEVELS AWAY	86529.5
657923	PICKERT8 69.00	5 LEVELS AWAY	3246.4
657951	CNTSHNT3 345.0	5 LEVELS AWAY	12379.5

Bus #	Bus Name	Level Away	Fault Current (Amperes)
			3 PH
659129	NBCS5 KLDR1G13.80	5 LEVELS AWAY	8628
659138	NESET 4 230.0	5 LEVELS AWAY	10046
659181	BICNTNL7 115.0	5 LEVELS AWAY	3591.7
659204	BROADLAND 913.80	5 LEVELS AWAY	26344.8
659205	BRDLAND4 230.0	5 LEVELS AWAY	10666.6
659275	GROTONB7 115.0	5 LEVELS AWAY	14475.4
659284	ECKLUND4 230.0	5 LEVELS AWAY	8161.1
659300	STANTONTAP 7115.0	5 LEVELS AWAY	8018.5
659309	S HEART 4230.0	5 LEVELS AWAY	9603.4
659334	JUDSON 4230.0	5 LEVELS AWAY	9021.5
659335	JUDSON 913.80	5 LEVELS AWAY	37013.2
659349	LSSSWTCHST 7115.0	5 LEVELS AWAY	12345
659362	WHEELOCK 4230.0	5 LEVELS AWAY	7162.7
659367	BALDWIN 934.50	5 LEVELS AWAY	16694.4
659368	TIMBERCREEK4230.0	5 LEVELS AWAY	6755
659388	KUMMERRIDGE7115.0	5 LEVELS AWAY	9191
659389	KUMMERRIDG1913.80	5 LEVELS AWAY	23508.7
659394	KUMMERRIDG2913.80	5 LEVELS AWAY	23508.7
659408	CAMPBLCNTY 4230.0	5 LEVELS AWAY	4631.9
659427	TANDE-LNX 3345.0	5 LEVELS AWAY	5909.1
659448	DAGLUM 4230.0	5 LEVELS AWAY	6678.4
661016	COYOTE 3 345.0	5 LEVELS AWAY	8624.8
661029	ESTBMRK7 115.0	5 LEVELS AWAY	15789.5
661038	GLENHAM4 230.0	5 LEVELS AWAY	5377
661053	MANDAN 4 230.0	5 LEVELS AWAY	15294.8
661085	TIOGA4 7 115.0	5 LEVELS AWAY	9935.5
661900	TIOGA4 9 13.80	5 LEVELS AWAY	20125.4
672603	BDV 4 230.0	5 LEVELS AWAY	5010.7

3.1.2. Short Circuit Result for Tande 345kV (659336)

The results of the short circuit analysis for GEN-2016-151 POI i.e., Tande 345kV (659336) and five bus levels away are tabulated below in Table 3.1.2.

Table 3.1.2: Short circuit results for Tande 345kV (659336)

Bus #	Bus Name	Level Away	Fault Current (Amperes)
			3 PH
659336	TANDE 3345.0	0 LEVELS AWAY	5909.1
584870	GEN-2015-046345.0	1 LEVELS AWAY	4898.6
588280	GEN-2016-151345.0	1 LEVELS AWAY	3909.2
659337	TANDE 4230.0	1 LEVELS AWAY	9565
659338	TANDE 913.80	1 LEVELS AWAY	37038
659427	TANDE-LNX 3345.0	1 LEVELS AWAY	5909.1
584871	G15-046-XF-134.50	2 LEVELS AWAY	39676.7
588281	G16-151XFMR134.50	2 LEVELS AWAY	20282.3
659138	NESET 4 230.0	2 LEVELS AWAY	10046
659333	JUDSON 3345.0	2 LEVELS AWAY	6884.6
584872	G15-046-GSU134.50	3 LEVELS AWAY	39611.2
588282	G16-151-GSU134.50	3 LEVELS AWAY	19954.2
659139	NESET 7 115.0	3 LEVELS AWAY	9855.6
659146	NESET 9 13.80	3 LEVELS AWAY	20080.7
659334	JUDSON 4230.0	3 LEVELS AWAY	9021.5
659335	JUDSON 913.80	3 LEVELS AWAY	37013.2
659390	PATENTGATE 3345.0	3 LEVELS AWAY	7317.3
661084	TIOGA4 4 230.0	3 LEVELS AWAY	10046
85931	J593 230.0	4 LEVELS AWAY	6037.1
584873	G15-046-GEN10.690	4 LEVELS AWAY	2056899.5
588283	G16-151-GEN10.690	4 LEVELS AWAY	839517.3
652400	WILISTN4 230.0	4 LEVELS AWAY	9370.9
655909	HESS GAS-MW7115.0	4 LEVELS AWAY	8814.3

Bus #	Bus Name	Level Away	Fault Current (Amperes)
			3 PH
655930	WHTEARTH-MW7115.0	4 LEVELS AWAY	9419.4
655947	PWRSLKTP-MW7115.0	4 LEVELS AWAY	6616.9
655952	NTIOGA-MW 7115.0	4 LEVELS AWAY	8814.3
659143	BLAISDELL 4230.0	4 LEVELS AWAY	5716.4
659183	CHAR.CK3 345.0	4 LEVELS AWAY	10818.6
659362	WHEELOCK 4230.0	4 LEVELS AWAY	7162.7
659387	KUMMERRIDGE3345.0	4 LEVELS AWAY	3908
659391	PATENTGATE 7115.0	4 LEVELS AWAY	16544.3
659392	PATENTGATE1913.80	4 LEVELS AWAY	26970.9
659393	PATENTGATE2913.80	4 LEVELS AWAY	26970.9
661085	TIOGA4 7 115.0	4 LEVELS AWAY	9935.5
661900	TIOGA4 9 13.80	4 LEVELS AWAY	20125.4
672603	BDV 4 230.0	4 LEVELS AWAY	5010.7
85932	J593 COL1 34.50	5 LEVELS AWAY	30709.9
652391	WILLISTON27 115.0	5 LEVELS AWAY	16803.5
652421	WILISTN7 115.0	5 LEVELS AWAY	16803.5
652424	BELFELD3 345.0	5 LEVELS AWAY	6905.2
652621	WILISTN9 13.20	5 LEVELS AWAY	25146.6
652622	WILISTN29 13.20	5 LEVELS AWAY	25146.6
655844	TIMBERCK-MK7115.0	5 LEVELS AWAY	9341.5
655850	IDEAL -MK7115.0	5 LEVELS AWAY	11220.7
655851	NRTHWEST-MK7115.0	5 LEVELS AWAY	11834.5
655856	G8 -MK7115.0	5 LEVELS AWAY	7222.7
655902	PVALLEY -MW7115.0	5 LEVELS AWAY	5887.6
655946	POWERSLK-MW7115.0	5 LEVELS AWAY	4510.1
655948	LIBERTY -MW7115.0	5 LEVELS AWAY	6117.2
655953	WSTBNKTP-MW7115.0	5 LEVELS AWAY	8814.3
659101	ANTELOP3 345.0	5 LEVELS AWAY	17048.1
659108	LOGAN 4 230.0	5 LEVELS AWAY	5897.6

Bus #	Bus Name	Level Away	Fault Current (Amperes)
			3 PH
659144	BLAISDELL 7115.0	5 LEVELS AWAY	7575.2
659164	BLAISDELL 913.80	5 LEVELS AWAY	26985
659182	CHAR.CK7 115.0	5 LEVELS AWAY	14959.3
659211	CHARCREEK 1913.80	5 LEVELS AWAY	30286.6
659302	CHAR.CK4 230.0	5 LEVELS AWAY	11834
659318	CHARCREEK 2913.80	5 LEVELS AWAY	25256.6
659319	CHARCREEK 3913.80	5 LEVELS AWAY	33230
659349	LSSSWTCHST 7115.0	5 LEVELS AWAY	12345
659363	WHEELOCK 7115.0	5 LEVELS AWAY	7249.9
659364	WHEELOCK 913.80	5 LEVELS AWAY	28690.1
659368	TIMBERCREEK4230.0	5 LEVELS AWAY	6755
659384	ROUNDUP 3345.0	5 LEVELS AWAY	9148.5
659388	KUMMERRIDGE7115.0	5 LEVELS AWAY	9191
659389	KUMMERRIDG1913.80	5 LEVELS AWAY	23508.7
659394	KUMMERRIDG2913.80	5 LEVELS AWAY	23508.7
661080	STANLEY7 115.0	5 LEVELS AWAY	3843.6
661086	TIOGA7 7 115.0	5 LEVELS AWAY	8376.1
672602	BDX 4 230.0	5 LEVELS AWAY	4322.1

3.1.3. Short Circuit Result for Hilken 230kV switching station (652466)

The results of the short circuit analysis for GEN-2016-155 POI i.e., Hilken 230kV switching station (652466) and five bus levels away are tabulated below in Table 3.1.3.

Table 3.1.3: Short circuit results for Hilken 230kV switching station (652466)

Bus #	Bus Name	Level Away	Fault Current (Amperes)
			3 PH
652466	HILKEN 4 230.0	0 LEVELS AWAY	9281.6
652426	BISMARK4 230.0	1 LEVELS AWAY	14847.9
652441	GARRISN4 230.0	1 LEVELS AWAY	12146.9

Bus #	Bus Name	Level Away	Fault Current (Amperes)
			3 PH
659365	BALDWIN 4230.0	1 LEVELS AWAY	8161.1
652296	WARD 4 230.0	2 LEVELS AWAY	13046.9
652392	BISMARK9 12.47	2 LEVELS AWAY	31640
652427	BISMARK7 115.0	2 LEVELS AWAY	15805.8
652442	GARRISN7 115.0	2 LEVELS AWAY	13727.8
652444	JAMESTN4 230.0	2 LEVELS AWAY	9207.8
652456	WASHBRN4 230.0	2 LEVELS AWAY	10849.2
652457	GARISN1G 13.80	2 LEVELS AWAY	64114.2
652458	GARISN2G 13.80	2 LEVELS AWAY	64080.7
652459	GARISN3G 13.80	2 LEVELS AWAY	64047.4
652467	BISMARK29 12.47	2 LEVELS AWAY	31640.4
652499	CAMPBELL 4 230.0	2 LEVELS AWAY	5101.5
659106	LELANDO4 230.0	2 LEVELS AWAY	23940.4
659128	WEBER 4 230.0	2 LEVELS AWAY	5312.4
659284	ECKLUND4 230.0	2 LEVELS AWAY	8161.1
659367	BALDWIN 934.50	2 LEVELS AWAY	16694.4
587030	GEN-2016-004230.0	3 LEVELS AWAY	7977.1
587720	GEN-2016-087230.0	3 LEVELS AWAY	5101.5
615901	GRE-STANTON4230.0	3 LEVELS AWAY	17454.2
652207	JAMEST29 13.20	3 LEVELS AWAY	24134.8
652208	JAMEST19 13.20	3 LEVELS AWAY	24195.9
652325	WASHBRN9 41.80	3 LEVELS AWAY	4108.4
652435	FARGO 4 230.0	3 LEVELS AWAY	11478.3
652445	JAMESTN7 115.0	3 LEVELS AWAY	11047.2
652449	MAX 7 115.0	3 LEVELS AWAY	6312.4
652460	GARISN4G 13.80	3 LEVELS AWAY	41779.3
652461	GARISN5G 13.80	3 LEVELS AWAY	41772.2
652590	SNAKECR7 115.0	3 LEVELS AWAY	5689.2
655642	WARDTERT-CP912.47	3 LEVELS AWAY	21862.6

Bus #	Bus Name	Level Away	Fault Current (Amperes)
			3 PH
655643	VOLTAIR -CP7115.0	3 LEVELS AWAY	8591.3
655647	BIS WARD-CP7115.0	3 LEVELS AWAY	7997.6
655652	BIS EXPR-CP7115.0	3 LEVELS AWAY	15805.8
657759	PICKERT4 230.0	3 LEVELS AWAY	4701.6
659105	LELANDO3 345.0	3 LEVELS AWAY	17197.1
659108	LOGAN 4 230.0	3 LEVELS AWAY	5897.6
659109	BASIN 7 115.0	3 LEVELS AWAY	5719.9
659110	LELAN41G 22.00	3 LEVELS AWAY	90019
659200	BASIN 9 13.80	3 LEVELS AWAY	17039.4
659201	LELNDOLD 1913.80	3 LEVELS AWAY	36965.9
659202	LELNDOLD 2913.80	3 LEVELS AWAY	28466.6
659322	ECKLUNDWND1934.50	3 LEVELS AWAY	23944.8
659323	ECKLUNDWND2934.50	3 LEVELS AWAY	23943.5
659366	WILTON 3 W0.690	3 LEVELS AWAY	592719.2
659408	CAMPBLCNTY 4230.0	3 LEVELS AWAY	4631.9
659543	PICKCITY RR7115.0	3 LEVELS AWAY	9743.6
661029	ESTBMRK7 115.0	3 LEVELS AWAY	15789.5
661038	GLENHAM4 230.0	3 LEVELS AWAY	5377
661053	MANDAN 4 230.0	3 LEVELS AWAY	15294.8
85111	J511 230.0	4 LEVELS AWAY	7154.7
85991	J599 230.0	4 LEVELS AWAY	4342.2
560998	WILTON COL2 34.50	4 LEVELS AWAY	20478.1
579294	WILTON COL1 34.50	4 LEVELS AWAY	20633.3
587031	G16-004XFMR134.50	4 LEVELS AWAY	25139.8
587721	G16-087XFMR134.50	4 LEVELS AWAY	12553.8
588210	GEN-2016-130345.0	4 LEVELS AWAY	11921.9
602006	SHEYNNE4 230.0	4 LEVELS AWAY	12517.7
615348	GRE-MCHENRY7115.0	4 LEVELS AWAY	8645
615600	GRE-COAL CR4230.0	4 LEVELS AWAY	17110.2

Bus #	Bus Name	Level Away	Fault Current (Amperes)
			3 PH
615900	GRE-COAL TP4230.0	4 LEVELS AWAY	15116.8
620167	PICKERT9 41.60	4 LEVELS AWAY	2652.5
652222	MAX 9 41.60	4 LEVELS AWAY	5509.6
652320	JAMESTN9 41.80	4 LEVELS AWAY	4579.1
652420	NSALEM 7 115.0	4 LEVELS AWAY	1995.9
652428	CARNGTN7 115.0	4 LEVELS AWAY	2908.8
652432	EDGELEY7 115.0	4 LEVELS AWAY	4397.8
652434	FARGOSVC 13.20	4 LEVELS AWAY	41517
652436	FARGO 7 115.0	4 LEVELS AWAY	11634.9
652437	GRNDFKS4 230.0	4 LEVELS AWAY	7634.5
652440	NELSON 7 115.0	4 LEVELS AWAY	7786.8
652454	VALLEYC7 115.0	4 LEVELS AWAY	4860.3
652464	DENBIGH TAP7115.0	4 LEVELS AWAY	4840.6
652468	HEBRON 4 230.0	4 LEVELS AWAY	5597.4
652527	WHITLOK4 230.0	4 LEVELS AWAY	5331.6
652553	MOORHED4 230.0	4 LEVELS AWAY	7820.9
655644	NBISMRCK-CP7115.0	4 LEVELS AWAY	10213.9
655648	CIRCLE K-CP7115.0	4 LEVELS AWAY	6086.9
655661	DGLASCRK-CP7115.0	4 LEVELS AWAY	3994.5
657741	ROUGHRIDER 4230.0	4 LEVELS AWAY	15745.9
657756	SQBUTTE4 230.0	4 LEVELS AWAY	21255
657923	PICKERT8 69.00	4 LEVELS AWAY	3246.4
659101	ANTELOP3 345.0	4 LEVELS AWAY	17048.1
659111	LELAN32G 20.00	4 LEVELS AWAY	137104.7
659143	BLAISDELL 4230.0	4 LEVELS AWAY	5716.4
659155	LOGAN 7 115.0	4 LEVELS AWAY	9902.7
659208	LOGAN 913.80	4 LEVELS AWAY	21407.3
659300	STANTONTAP 7115.0	4 LEVELS AWAY	8018.5
659409	CAMPBLCNTY 934.50	4 LEVELS AWAY	17744.7

Bus #	Bus Name	Level Away	Fault Current (Amperes)
			3 PH
659422	LELAND1-LNX3345.0	4 LEVELS AWAY	17197.1
659424	LELAND2-LNX3345.0	4 LEVELS AWAY	17197.1
661009	BISEXP 7 115.0	4 LEVELS AWAY	13390.9
661035	GLENHAM7 115.0	4 LEVELS AWAY	5450.3
661042	HESKETT4 230.0	4 LEVELS AWAY	14557.6
661054	MANDAN 7 115.0	4 LEVELS AWAY	18714.3
661060	LINTON 7 115.0	4 LEVELS AWAY	1494.2
661119	26TH&D 7 115.0	4 LEVELS AWAY	14322.3
661600	GLENHAM9 41.60	4 LEVELS AWAY	7765.4
661908	MANDAN 9 13.80	4 LEVELS AWAY	38310
10651	G830_SUB 115.0	5 LEVELS AWAY	5545.8
83021	J302 POI 230.0	5 LEVELS AWAY	6149.7
85112	J511 COL 34.50	5 LEVELS AWAY	23538.4
85992	J599 COL1 34.50	5 LEVELS AWAY	24913.3
560074	G16-017-TAP 345.0	5 LEVELS AWAY	6907.4
587032	G16-004-GSU134.50	5 LEVELS AWAY	22079.1
587035	G16-004-GSU234.50	5 LEVELS AWAY	23560
587050	GEN-2016-007115.0	5 LEVELS AWAY	4370.8
587722	G16-087-GSU134.50	5 LEVELS AWAY	11822.4
588211	G16-130XFMR134.50	5 LEVELS AWAY	27378.5
603018	SHEYNNE7 115.0	5 LEVELS AWAY	14569.4
603023	MALLARD7 115.0	5 LEVELS AWAY	10049
605634	VELVA TAP 115.0	5 LEVELS AWAY	7167.7
605724	SHEYENNE5 9 13.80	5 LEVELS AWAY	15695.2
605730	SHEYENNE6 9 13.80	5 LEVELS AWAY	15557.1
608602	SQBEAST4 230.0	5 LEVELS AWAY	21255
615001	GRE-COAL 41G22.00	5 LEVELS AWAY	143926.2
615002	GRE-COAL 42G22.00	5 LEVELS AWAY	143004.5
615347	GRE-MCHENRY4230.0	5 LEVELS AWAY	6344.8

Bus #	Bus Name	Level Away	Fault Current (Amperes)
			3 PH
615349	GRE-MCHENRYT12.47	5 LEVELS AWAY	15608.5
615601	GRE-COAL FM869.00	5 LEVELS AWAY	8889.9
615602	GRE-COALFM1T12.47	5 LEVELS AWAY	18631.6
615603	GRE-COALFM2T12.47	5 LEVELS AWAY	18549.2
620336	AUDUBON4 230.0	5 LEVELS AWAY	5970.6
620381	UNDERWD4 230.0	5 LEVELS AWAY	13973.3
652201	GRNDFKS9 12.47	5 LEVELS AWAY	54986.8
652203	FARGO 8 69.00	5 LEVELS AWAY	13736.3
652204	VALLEYC8 69.00	5 LEVELS AWAY	2868.2
652321	CARNGTN9 41.80	5 LEVELS AWAY	3036.2
652322	EDGELEY9 41.80	5 LEVELS AWAY	4148.7
652323	FARGO 9 41.80	5 LEVELS AWAY	2160.2
652328	EDGELEY 19 13.20	5 LEVELS AWAY	5723.5
652416	DEVAUL 7 115.0	5 LEVELS AWAY	1454.8
652417	DICKNSN4 230.0	5 LEVELS AWAY	7188.9
652423	BARLOW 7 115.0	5 LEVELS AWAY	2887.3
652433	EDGELEY8 69.00	5 LEVELS AWAY	3125.1
652443	GRNDFKS7 115.0	5 LEVELS AWAY	11887.4
652453	TOWNER 7 115.0	5 LEVELS AWAY	5033.3
652534	ORDWAY 7 115.0	5 LEVELS AWAY	9175.3
652554	MORRIS 4 230.0	5 LEVELS AWAY	5328.3
652587	MOORHED7 115.0	5 LEVELS AWAY	6911.6
652613	VALLEYC9 13.20	5 LEVELS AWAY	6069.5
652638	ENDERLIN 7 115.0	5 LEVELS AWAY	3655.6
652821	SULLYBT-LNX3230.0	5 LEVELS AWAY	7133.6
655646	GVPINES -CP7115.0	5 LEVELS AWAY	5263.6
655657	SWMINOT -CP7115.0	5 LEVELS AWAY	6908.5
655662	ROSEGLEN-CP7115.0	5 LEVELS AWAY	3864.8
657707	CALEDON7 115.0	5 LEVELS AWAY	3715

Bus #	Bus Name	Level Away	Fault Current (Amperes)
			3 PH
657742	OLIVERWND3 4230.0	5 LEVELS AWAY	11234
657751	CENTER 4 230.0	5 LEVELS AWAY	19568.6
657754	MAPLE R4 230.0	5 LEVELS AWAY	13873.3
657755	PRAIRIE4 230.0	5 LEVELS AWAY	8513.6
657791	CENTER 3 345.0	5 LEVELS AWAY	12379.5
657848	YNG2 4 230.0	5 LEVELS AWAY	17800.4
657947	CENTR1TE 13.80	5 LEVELS AWAY	48336.6
657948	CENTR2TE 13.80	5 LEVELS AWAY	48339.9
658080	MPSBROOK 115.0	5 LEVELS AWAY	7182.2
659103	ANTEL31G 23.00	5 LEVELS AWAY	150791.8
659107	ANTEL32G 23.00	5 LEVELS AWAY	150791.8
659144	BLAISDELL 7115.0	5 LEVELS AWAY	7575.2
659164	BLAISDELL 913.80	5 LEVELS AWAY	26985
659183	CHAR.CK3 345.0	5 LEVELS AWAY	10818.6
659190	NDPRAIRWND 7115.0	5 LEVELS AWAY	7786.8
659212	DGC 3345.0	5 LEVELS AWAY	16300.8
659218	COTEAU 3345.0	5 LEVELS AWAY	17048.1
659273	WILTON 2 W0.690	5 LEVELS AWAY	748557.6
659280	POMONA 7 115.0	5 LEVELS AWAY	3559.4
659294	WILTON 1 W0.690	5 LEVELS AWAY	750696.1
659305	ROUGHRDRMGS7115.0	5 LEVELS AWAY	10130.2
659384	ROUNDUP 3345.0	5 LEVELS AWAY	9148.5
659400	NDSUNFLWR 4230.0	5 LEVELS AWAY	5033.7
659410	CAMBLCNTCOL934.50	5 LEVELS AWAY	16748.3
659420	ANTELOP-LNX3345.0	5 LEVELS AWAY	17048.1
659423	GROTON-LNX3 345.0	5 LEVELS AWAY	6015.9
661008	BEULAH 7 115.0	5 LEVELS AWAY	10386.1
661030	STEIN 7 115.0	5 LEVELS AWAY	13551.8
661037	BOWDLE 7 115.0	5 LEVELS AWAY	1897.6

Bus #	Bus Name	Level Away	Fault Current (Amperes)
			3 PH
661039	MOBRIDG7 115.0	5 LEVELS AWAY	3275.7
661043	HESKETT7 115.0	5 LEVELS AWAY	18697.3
661051	STH9TH 7 115.0	5 LEVELS AWAY	12010.9
661067	MANDANW7 115.0	5 LEVELS AWAY	13690
661084	TIOGA4 4 230.0	5 LEVELS AWAY	10046
661906	HESKETT9 13.80	5 LEVELS AWAY	31878.9

3.2. Short Circuit Result for 2026 Summer Peak Case

The short circuit results for summer-2026 scenario at the POI are tabulated below.

3.2.1. Short Circuit Result for Leland Olds 345kV (659105)

The results of the short circuit analysis for GEN-2016-130 POI i.e., Leland Olds 345kV (659105) and five bus levels away are tabulated below in Table 3.2.1.

Table 3.2.1: Short circuit results for Leland Olds 345kV (659105)

Bus #	Bus Name	Level Away	Fault Current (Amperes)
			3 PH
659105	LELANDO3 345.0	0 LEVELS AWAY	17340.2
588210	GEN-2016-130345.0	1 LEVELS AWAY	11988.9
659101	ANTELOP3 345.0	1 LEVELS AWAY	17194.5
659106	LELANDO4 230.0	1 LEVELS AWAY	24131.5
659111	LELAN32G 20.00	1 LEVELS AWAY	137310
659201	LELNDOLD 1913.80	1 LEVELS AWAY	36994.3
659202	LELNDOLD 2913.80	1 LEVELS AWAY	28482.5
659422	LELAND1-LNX3345.0	1 LEVELS AWAY	17340.2
659424	LELAND2-LNX3345.0	1 LEVELS AWAY	17340.2
560074	G16-017-TAP 345.0	2 LEVELS AWAY	6888.4
587030	GEN-2016-004230.0	2 LEVELS AWAY	7995.2
588211	G16-130XFMR134.50	2 LEVELS AWAY	27405.2

Bus #	Bus Name	Level Away	Fault Current (Amperes)
			3 PH
615901	GRE-STANTON4230.0	2 LEVELS AWAY	17831.6
652441	GARRISN4 230.0	2 LEVELS AWAY	12213
652456	WASHBRN4 230.0	2 LEVELS AWAY	10927.5
659103	ANTEL31G 23.00	2 LEVELS AWAY	151175.2
659107	ANTEL32G 23.00	2 LEVELS AWAY	151175.2
659108	LOGAN 4 230.0	2 LEVELS AWAY	5755.3
659109	BASIN 7 115.0	2 LEVELS AWAY	5739.3
659110	LELAN41G 22.00	2 LEVELS AWAY	90115.9
659183	CHAR.CK3 345.0	2 LEVELS AWAY	11022.5
659200	BASIN 9 13.80	2 LEVELS AWAY	17058.1
659212	DGC 3345.0	2 LEVELS AWAY	16434.6
659218	COTEAU 3345.0	2 LEVELS AWAY	17194.5
659384	ROUNDUP 3345.0	2 LEVELS AWAY	9269.5
659420	ANTELOP-LNX3345.0	2 LEVELS AWAY	17194.5
659423	GROTON-LNX3 345.0	2 LEVELS AWAY	6773.3
85111	J511 230.0	3 LEVELS AWAY	7210.1
587031	G16-004XFMR134.50	3 LEVELS AWAY	25161.6
587130	GEN-2016-017345.0	3 LEVELS AWAY	6831.6
587750	GEN-2016-092345.0	3 LEVELS AWAY	6166.3
587830	GEN-2016-103345.0	3 LEVELS AWAY	6832.6
588212	G16-130-GSU134.50	3 LEVELS AWAY	26701.9
615600	GRE-COAL CR4230.0	3 LEVELS AWAY	17307
615900	GRE-COAL TP4230.0	3 LEVELS AWAY	15312.1
652325	WASHBRN9 41.80	3 LEVELS AWAY	4115.3
652420	NSALEM 7 115.0	3 LEVELS AWAY	2001.2
652424	BELFELD3 345.0	3 LEVELS AWAY	7001.6
652426	BISMARK4 230.0	3 LEVELS AWAY	15414.2
652442	GARRISN7 115.0	3 LEVELS AWAY	13820
652444	JAMESTN4 230.0	3 LEVELS AWAY	9325.5

Bus #	Bus Name	Level Away	Fault Current (Amperes)
			3 PH
652457	GARISN1G 13.80	3 LEVELS AWAY	64170.2
652458	GARISN2G 13.80	3 LEVELS AWAY	64136.6
652459	GARISN3G 13.80	3 LEVELS AWAY	64103.2
652466	HILKEN 4 230.0	3 LEVELS AWAY	9389.7
652806	FTTHOM1-LNX3345.0	3 LEVELS AWAY	10012.4
657756	SQBUTTE4 230.0	3 LEVELS AWAY	23310.2
659143	BLAISDELL 4230.0	3 LEVELS AWAY	5740.3
659155	LOGAN 7 115.0	3 LEVELS AWAY	9175.6
659160	GROTON 3 345.0	3 LEVELS AWAY	6773.3
659182	CHAR.CK7 115.0	3 LEVELS AWAY	15115.8
659208	LOGAN 913.80	3 LEVELS AWAY	20949.7
659211	CHARCREEK 1913.80	3 LEVELS AWAY	30362.4
659214	DGC NB5301B913.80	3 LEVELS AWAY	30108.4
659215	DGC NB5302A913.80	3 LEVELS AWAY	21189.3
659219	COT 13.8T1 913.80	3 LEVELS AWAY	25754.9
659220	DGC NB5301A913.80	3 LEVELS AWAY	30284.6
659221	DGC NB5302B913.80	3 LEVELS AWAY	46081.7
659222	COTEAU1 869.00	3 LEVELS AWAY	10673
659231	COT 13.8T2 913.80	3 LEVELS AWAY	25591.5
659232	DGC________913.80	3 LEVELS AWAY	21843.8
659233	DGC 4230.0	3 LEVELS AWAY	7487.1
659302	CHAR.CK4 230.0	3 LEVELS AWAY	12053.2
659318	CHARCREEK 2913.80	3 LEVELS AWAY	25323.5
659319	CHARCREEK 3913.80	3 LEVELS AWAY	33345.3
659385	ROUNDUP 7115.0	3 LEVELS AWAY	13509.7
659386	ROUNDUP 913.80	3 LEVELS AWAY	26699.9
659390	PATENTGATE 3345.0	3 LEVELS AWAY	7432.7
659421	BRDLAND-LNX3345.0	3 LEVELS AWAY	4350.2
85112	J511 COL 34.50	4 LEVELS AWAY	23613.7

Bus #	Bus Name	Level Away	Fault Current (Amperes)
			3 PH
587032	G16-004-GSU134.50	4 LEVELS AWAY	22095.1
587035	G16-004-GSU234.50	4 LEVELS AWAY	23578.2
587131	G16-017XFMR134.50	4 LEVELS AWAY	26477.2
587751	G16-092XFMR134.50	4 LEVELS AWAY	21156.4
587831	G16-103XFMR134.50	4 LEVELS AWAY	26452.9
588213	G16-130-GEN10.690	4 LEVELS AWAY	1044365
603023	MALLARD7 115.0	4 LEVELS AWAY	8467
608602	SQBEAST4 230.0	4 LEVELS AWAY	23310.2
615001	GRE-COAL 41G22.00	4 LEVELS AWAY	144566.2
615002	GRE-COAL 42G22.00	4 LEVELS AWAY	143627.3
615347	GRE-MCHENRY4230.0	4 LEVELS AWAY	6476.4
615601	GRE-COAL FM869.00	4 LEVELS AWAY	8905.3
615602	GRE-COALFM1T12.47	4 LEVELS AWAY	18643.5
615603	GRE-COALFM2T12.47	4 LEVELS AWAY	18560.9
620381	UNDERWD4 230.0	4 LEVELS AWAY	14094.9
652175	G09_001IST 345.0	4 LEVELS AWAY	6987.2
652207	JAMEST29 13.20	4 LEVELS AWAY	24186.2
652208	JAMEST19 13.20	4 LEVELS AWAY	24247.4
652216	WATFORD4 230.0	4 LEVELS AWAY	6946.5
652220	BELFELD29 13.80	4 LEVELS AWAY	27964.4
652221	BELFELD9 13.80	4 LEVELS AWAY	27272.8
652296	WARD 4 230.0	4 LEVELS AWAY	13577.7
652392	BISMARK9 12.47	4 LEVELS AWAY	32015.6
652416	DEVAUL 7 115.0	4 LEVELS AWAY	1458.7
652419	KILDEER7 115.0	4 LEVELS AWAY	8596.7
652425	BELFELD4 230.0	4 LEVELS AWAY	9751.7
652427	BISMARK7 115.0	4 LEVELS AWAY	16654.4
652435	FARGO 4 230.0	4 LEVELS AWAY	11594.9
652445	JAMESTN7 115.0	4 LEVELS AWAY	11138.3

Bus #	Bus Name	Level Away	Fault Current (Amperes)
			3 PH
652449	MAX 7 115.0	4 LEVELS AWAY	6263.9
652460	GARISN4G 13.80	4 LEVELS AWAY	41839.8
652461	GARISN5G 13.80	4 LEVELS AWAY	41832.7
652467	BISMARK29 12.47	4 LEVELS AWAY	32016
652499	CAMPBELL 4 230.0	4 LEVELS AWAY	5116.5
652506	FTTHOMP3 345.0	4 LEVELS AWAY	10012.4
652568	GROTONSOUTH 115.0	4 LEVELS AWAY	19803.6
652590	SNAKECR7 115.0	4 LEVELS AWAY	5712.3
655643	VOLTAIR -CP7115.0	4 LEVELS AWAY	8293
655657	SWMINOT -CP7115.0	4 LEVELS AWAY	6654.1
655833	GRSYBTTP-MK7115.0	4 LEVELS AWAY	14083.4
655853	BEARCREK-MK7115.0	4 LEVELS AWAY	10369
655893	DUNNCENTRMK7115.0	4 LEVELS AWAY	5419.9
657751	CENTER 4 230.0	4 LEVELS AWAY	21130.5
657759	PICKERT4 230.0	4 LEVELS AWAY	4797.2
657791	CENTER 3 345.0	4 LEVELS AWAY	13061
657848	YNG2 4 230.0	4 LEVELS AWAY	19069.5
657947	CENTR1TE 13.80	4 LEVELS AWAY	48960.2
657948	CENTR2TE 13.80	4 LEVELS AWAY	48961.4
659120	BRDLAND3 345.0	4 LEVELS AWAY	4350.2
659128	WEBER 4 230.0	4 LEVELS AWAY	5366.3
659144	BLAISDELL 7115.0	4 LEVELS AWAY	7683.3
659161	GROTON 9 13.80	4 LEVELS AWAY	27788.8
659164	BLAISDELL 913.80	4 LEVELS AWAY	27024.5
659184	R.RIDER7 115.0	4 LEVELS AWAY	4645.4
659185	FOUREYES 7115.0	4 LEVELS AWAY	3945.2
659226	DGC 3001B 913.80	4 LEVELS AWAY	29159.6
659227	DGC 3004B 913.80	4 LEVELS AWAY	29849
659228	DGC 1452 913.80	4 LEVELS AWAY	23263

Bus #	Bus Name	Level Away	Fault Current (Amperes)
			3 PH
659229	DGC 1721 913.80	4 LEVELS AWAY	24929.3
659234	DGC NB5301E913.80	4 LEVELS AWAY	23921.3
659235	DGC NB5301D913.80	4 LEVELS AWAY	17039.9
659236	DGC UREA 869.00	4 LEVELS AWAY	7957.4
659333	JUDSON 3345.0	4 LEVELS AWAY	6985.3
659365	BALDWIN 4230.0	4 LEVELS AWAY	8238.5
659387	KUMMERRIDGE3345.0	4 LEVELS AWAY	3949.7
659391	PATENTGATE 7115.0	4 LEVELS AWAY	16767.6
659392	PATENTGATE1913.80	4 LEVELS AWAY	27043.8
659393	PATENTGATE2913.80	4 LEVELS AWAY	27043.8
659543	PICKCITY RR7115.0	4 LEVELS AWAY	9789
661084	TIOGA4 4 230.0	4 LEVELS AWAY	10271.5
85113	J511 COL 2 34.50	5 LEVELS AWAY	20799.9
85114	J511 COL 3 34.50	5 LEVELS AWAY	22244.5
85931	J593 230.0	5 LEVELS AWAY	6095.4
587033	G16-004-GEN10.690	5 LEVELS AWAY	237493.4
587036	G16-004-GEN20.650	5 LEVELS AWAY	885447.6
587132	G16-017-GSU134.50	5 LEVELS AWAY	25346.6
587720	GEN-2016-087230.0	5 LEVELS AWAY	5116.5
587752	G16-092-GSU134.50	5 LEVELS AWAY	17270.7
587832	G16-103-GSU134.50	5 LEVELS AWAY	24019.4
602006	SHEYNNE4 230.0	5 LEVELS AWAY	12638.8
602052	WARD CO 4 230.0	5 LEVELS AWAY	4167.8
608597	SQBP1DC4 230.0	5 LEVELS AWAY	23310.2
608599	SQBP2DC4 230.0	5 LEVELS AWAY	23310.2
608600	BISONMP4 230.0	5 LEVELS AWAY	8491
608818	OLIVER19 34.50	5 LEVELS AWAY	10392.8
608830	OLIVER29 34.50	5 LEVELS AWAY	7810.2
615348	GRE-MCHENRY7115.0	5 LEVELS AWAY	8334.8

Bus #	Bus Name	Level Away	Fault Current (Amperes)
			3 PH
615349	GRE-MCHENRYT12.47	5 LEVELS AWAY	15591.8
615903	GRE-BALTA 4230.0	5 LEVELS AWAY	7018.9
620167	PICKERT9 41.60	5 LEVELS AWAY	2660.7
620290	HARVEY 4 230.0	5 LEVELS AWAY	5270.7
620369	JAMESTN3 345.0	5 LEVELS AWAY	5928.1
652174	G09_001IS_1 34.50	5 LEVELS AWAY	25729.9
652222	MAX 9 41.60	5 LEVELS AWAY	5499.8
652257	DEVAUL 8 69.00	5 LEVELS AWAY	1415.6
652273	FTTHMP19 13.80	5 LEVELS AWAY	29623.5
652274	FTTHMP29 13.80	5 LEVELS AWAY	29626.6
652320	JAMESTN9 41.80	5 LEVELS AWAY	4576.1
652408	WATFORD7 115.0	5 LEVELS AWAY	8468.3
652413	MEDORA 4 230.0	5 LEVELS AWAY	5388.4
652417	DICKNSN4 230.0	5 LEVELS AWAY	7288.5
652422	HALIDAY7 115.0	5 LEVELS AWAY	5176.5
652428	CARNGTN7 115.0	5 LEVELS AWAY	2946.5
652432	EDGELEY7 115.0	5 LEVELS AWAY	4431.9
652434	FARGOSVC 13.20	5 LEVELS AWAY	41677.1
652436	FARGO 7 115.0	5 LEVELS AWAY	11738.2
652437	GRNDFKS4 230.0	5 LEVELS AWAY	8171.7
652440	NELSON 7 115.0	5 LEVELS AWAY	7533.5
652452	RUGBY 7 115.0	5 LEVELS AWAY	8671.4
652454	VALLEYC7 115.0	5 LEVELS AWAY	4902.1
652464	DENBIGH TAP7115.0	5 LEVELS AWAY	4851.4
652471	WATFORD9 13.20	5 LEVELS AWAY	20137.4
652472	WATFORD29 13.20	5 LEVELS AWAY	14067.3
652507	FTTHOMP4 230.0	5 LEVELS AWAY	21319.4
652512	GROTON 7 115.0	5 LEVELS AWAY	19803.1
652529	WATERTN3 345.0	5 LEVELS AWAY	11716.9

Bus #	Bus Name	Level Away	Fault Current (Amperes)
			3 PH
652534	ORDWAY 7 115.0	5 LEVELS AWAY	10554.9
652535	REDFELD7 115.0	5 LEVELS AWAY	4548
652553	MOORHED4 230.0	5 LEVELS AWAY	7874.4
652807	FTTHOM2-LNX3345.0	5 LEVELS AWAY	10012.4
655419	SW561-ER7 115.0	5 LEVELS AWAY	7382.7
655641	BTHOLD -CP7115.0	5 LEVELS AWAY	5813.9
655642	WARDTERT-CP912.47	5 LEVELS AWAY	21967
655647	BIS WARD-CP7115.0	5 LEVELS AWAY	8132.7
655652	BIS EXPR-CP7115.0	5 LEVELS AWAY	16654.4
655655	RUTHVILL-CP7115.0	5 LEVELS AWAY	5140.8
655661	DGLASCRK-CP7115.0	5 LEVELS AWAY	4016.1
655834	GRASSYBT-MK7115.0	5 LEVELS AWAY	7192.2
655835	LITTLKNF-MK7115.0	5 LEVELS AWAY	7592.3
655836	OAKDALE -MK7115.0	5 LEVELS AWAY	8653.9
655844	TIMBERCK-MK7115.0	5 LEVELS AWAY	9441.4
655850	IDEAL -MK7115.0	5 LEVELS AWAY	11337.7
655851	NRTHWEST-MK7115.0	5 LEVELS AWAY	11958.7
655856	G8 -MK7115.0	5 LEVELS AWAY	7278.6
655891	KILLDEER-MK7115.0	5 LEVELS AWAY	8521.5
655916	PALERMO -MW7115.0	5 LEVELS AWAY	5718.8
655944	PLAZA -MW7115.0	5 LEVELS AWAY	5434.4
657741	ROUGHRIDER 4230.0	5 LEVELS AWAY	16631.4
657748	CENTER2G 20.00	5 LEVELS AWAY	152845.3
657749	CENTER1G 22.00	5 LEVELS AWAY	87528.1
657923	PICKERT8 69.00	5 LEVELS AWAY	3263.9
657951	CNTSHNT3 345.0	5 LEVELS AWAY	13061
659129	NBCS5 KLDR1G13.80	5 LEVELS AWAY	8634.9
659138	NESET 4 230.0	5 LEVELS AWAY	10271.5
659181	BICNTNL7 115.0	5 LEVELS AWAY	3615.7

Bus #	Bus Name	Level Away	Fault Current (Amperes)
			3 PH
659204	BROADLAND 913.80	5 LEVELS AWAY	26375.5
659205	BRDLAND4 230.0	5 LEVELS AWAY	10746.1
659275	GROTONB7 115.0	5 LEVELS AWAY	19236.1
659284	ECKLUND4 230.0	5 LEVELS AWAY	8238.5
659300	STANTONTAP 7115.0	5 LEVELS AWAY	8050.7
659309	S HEART 4230.0	5 LEVELS AWAY	9751.7
659334	JUDSON 4230.0	5 LEVELS AWAY	9206.2
659335	JUDSON 913.80	5 LEVELS AWAY	37178.2
659349	LSSSWTCHST 7115.0	5 LEVELS AWAY	12425.3
659362	WHEELOCK 4230.0	5 LEVELS AWAY	7272.8
659367	BALDWIN 934.50	5 LEVELS AWAY	16737.5
659368	TIMBERCREEK4230.0	5 LEVELS AWAY	6924.3
659372	LARSON 4230.0	5 LEVELS AWAY	6358.1
659388	KUMMERRIDGE7115.0	5 LEVELS AWAY	9280.8
659389	KUMMERRIDG1913.80	5 LEVELS AWAY	23581.2
659394	KUMMERRIDG2913.80	5 LEVELS AWAY	23581.2
659408	CAMPBLCNTY 4230.0	5 LEVELS AWAY	4644.1
659427	TANDE-LNX 3345.0	5 LEVELS AWAY	5968.4
659448	DAGLUM 4230.0	5 LEVELS AWAY	6751.5
661016	COYOTE 3 345.0	5 LEVELS AWAY	8817
661029	ESTBMRK7 115.0	5 LEVELS AWAY	16640.3
661038	GLENHAM4 230.0	5 LEVELS AWAY	5391.1
661053	MANDAN 4 230.0	5 LEVELS AWAY	16273.3
661085	TIOGA4 7 115.0	5 LEVELS AWAY	10087.1
661900	TIOGA4 9 13.80	5 LEVELS AWAY	20210.2

3.2.2. Short Circuit Result for Tande 345kV (659336)

The results of the short circuit analysis for GEN-2016-151 POI i.e., Tande 345kV (659336) and five bus levels away are tabulated below in Table 3.2.2.

Table 3.2.2: Short circuit results for Tande 345kV (659336)

Bus #	Bus Name	Level Away	Fault Current (Amperes)
			3 PH
659336	TANDE 3345.0	0 LEVELS AWAY	5968.4
584870	GEN-2015-046345.0	1 LEVELS AWAY	4931.8
588280	GEN-2016-151345.0	1 LEVELS AWAY	3932.9
659337	TANDE 4230.0	1 LEVELS AWAY	9762
659338	TANDE 913.80	1 LEVELS AWAY	37187.6
659427	TANDE-LNX 3345.0	1 LEVELS AWAY	5968.4
584871	G15-046-XF-134.50	2 LEVELS AWAY	39794.3
588281	G16-151XFMR134.50	2 LEVELS AWAY	20330.9
659138	NESET 4 230.0	2 LEVELS AWAY	10271.5
659333	JUDSON 3345.0	2 LEVELS AWAY	6985.3
584872	G15-046-GSU134.50	3 LEVELS AWAY	39710.5
588282	G16-151-GSU134.50	3 LEVELS AWAY	19999.7
659139	NESET 7 115.0	3 LEVELS AWAY	10017.9
659146	NESET 9 13.80	3 LEVELS AWAY	20172.4
659334	JUDSON 4230.0	3 LEVELS AWAY	9206.2
659335	JUDSON 913.80	3 LEVELS AWAY	37178.2
659390	PATENTGATE 3345.0	3 LEVELS AWAY	7432.7
661084	TIOGA4 4 230.0	3 LEVELS AWAY	10271.5
85931	J593 230.0	4 LEVELS AWAY	6095.4
584873	G15-046-GEN10.690	4 LEVELS AWAY	2059819.9
588283	G16-151-GEN10.690	4 LEVELS AWAY	840980.6
652400	WILISTN4 230.0	4 LEVELS AWAY	9576.1
655909	HESS GAS-MW7115.0	4 LEVELS AWAY	8951.6
655930	WHTEARTH-MW7115.0	4 LEVELS AWAY	9571.5
655947	PWRSLKTP-MW7115.0	4 LEVELS AWAY	6675

Bus #	Bus Name	Level Away	Fault Current (Amperes)
			3 PH
655952	NTIOGA-MW 7115.0	4 LEVELS AWAY	8951.6
659143	BLAISDELL 4230.0	4 LEVELS AWAY	5740.3
659183	CHAR.CK3 345.0	4 LEVELS AWAY	11022.5
659362	WHEELOCK 4230.0	4 LEVELS AWAY	7272.8
659372	LARSON 4230.0	4 LEVELS AWAY	6358.1
659387	KUMMERRIDGE3345.0	4 LEVELS AWAY	3949.7
659391	PATENTGATE 7115.0	4 LEVELS AWAY	16767.6
659392	PATENTGATE1913.80	4 LEVELS AWAY	27043.8
659393	PATENTGATE2913.80	4 LEVELS AWAY	27043.8
661085	TIOGA4 7 115.0	4 LEVELS AWAY	10087.1
661900	TIOGA4 9 13.80	4 LEVELS AWAY	20210.2
85932	J593 COL1 34.50	5 LEVELS AWAY	30831.1
652391	WILLISTON27 115.0	5 LEVELS AWAY	17138.1
652421	WILISTN7 115.0	5 LEVELS AWAY	17138.1
652424	BELFELD3 345.0	5 LEVELS AWAY	7001.6
652621	WILISTN9 13.20	5 LEVELS AWAY	25245.6
652622	WILISTN29 13.20	5 LEVELS AWAY	25245.6
655844	TIMBERCK-MK7115.0	5 LEVELS AWAY	9441.4
655850	IDEAL -MK7115.0	5 LEVELS AWAY	11337.7
655851	NRTHWEST-MK7115.0	5 LEVELS AWAY	11958.7
655856	G8 -MK7115.0	5 LEVELS AWAY	7278.6
655902	PVALLEY -MW7115.0	5 LEVELS AWAY	5975.8
655946	POWERSLK-MW7115.0	5 LEVELS AWAY	4540.5
655948	LIBERTY -MW7115.0	5 LEVELS AWAY	6161.5
655953	WSTBNKTP-MW7115.0	5 LEVELS AWAY	8951.6
659101	ANTELOP3 345.0	5 LEVELS AWAY	17194.5
659108	LOGAN 4 230.0	5 LEVELS AWAY	5755.3
659144	BLAISDELL 7115.0	5 LEVELS AWAY	7683.3
659164	BLAISDELL 913.80	5 LEVELS AWAY	27024.5

Bus #	Bus Name	Level Away	Fault Current (Amperes)
			3 PH
659182	CHAR.CK7 115.0	5 LEVELS AWAY	15115.8
659211	CHARCREEK 1913.80	5 LEVELS AWAY	30362.4
659302	CHAR.CK4 230.0	5 LEVELS AWAY	12053.2
659318	CHARCREEK 2913.80	5 LEVELS AWAY	25323.5
659319	CHARCREEK 3913.80	5 LEVELS AWAY	33345.3
659349	LSSSWTCHST 7115.0	5 LEVELS AWAY	12425.3
659363	WHEELOCK 7115.0	5 LEVELS AWAY	7328.5
659364	WHEELOCK 913.80	5 LEVELS AWAY	28800.8
659368	TIMBERCREEK4230.0	5 LEVELS AWAY	6924.3
659373	LARSON 7115.0	5 LEVELS AWAY	4433.7
659374	LARSON 913.80	5 LEVELS AWAY	27997.2
659384	ROUNDUP 3345.0	5 LEVELS AWAY	9269.5
659388	KUMMERRIDGE7115.0	5 LEVELS AWAY	9280.8
659389	KUMMERRIDG1913.80	5 LEVELS AWAY	23581.2
659394	KUMMERRIDG2913.80	5 LEVELS AWAY	23581.2
661080	STANLEY7 115.0	5 LEVELS AWAY	3895.5
661086	TIOGA7 7 115.0	5 LEVELS AWAY	8476.3
672603	BDV 4 230.0	5 LEVELS AWAY	5407.6

3.2.3. Short Circuit Result for Hilken 230kV switching station (652466)

The results of the short circuit analysis for GEN-2016-155 POI i.e., Hilken 230kV switching station (652466) and five bus levels away are tabulated below in Table 3.2.3.

Table 3.2.3: Short circuit results for Hilken 230kV switching station (652466)

Bus #	Bus Name	Level Away	Fault Current (Amperes)
			3 PH
652466	HILKEN 4 230.0	0 LEVELS AWAY	9389.7
652426	BISMARK4 230.0	1 LEVELS AWAY	15414.2
652441	GARRISN4 230.0	1 LEVELS AWAY	12213

Bus #	Bus Name	Level Away	Fault Current (Amperes)
			3 PH
659365	BALDWIN 4230.0	1 LEVELS AWAY	8238.5
652296	WARD 4 230.0	2 LEVELS AWAY	13577.7
652392	BISMARK9 12.47	2 LEVELS AWAY	32015.6
652427	BISMARK7 115.0	2 LEVELS AWAY	16654.4
652442	GARRISN7 115.0	2 LEVELS AWAY	13820
652444	JAMESTN4 230.0	2 LEVELS AWAY	9325.5
652456	WASHBRN4 230.0	2 LEVELS AWAY	10927.5
652457	GARISN1G 13.80	2 LEVELS AWAY	64170.2
652458	GARISN2G 13.80	2 LEVELS AWAY	64136.6
652459	GARISN3G 13.80	2 LEVELS AWAY	64103.2
652467	BISMARK29 12.47	2 LEVELS AWAY	32016
652499	CAMPBELL 4 230.0	2 LEVELS AWAY	5116.5
659106	LELANDO4 230.0	2 LEVELS AWAY	24131.5
659128	WEBER 4 230.0	2 LEVELS AWAY	5366.3
659284	ECKLUND4 230.0	2 LEVELS AWAY	8238.5
659367	BALDWIN 934.50	2 LEVELS AWAY	16737.5
587030	GEN-2016-004230.0	3 LEVELS AWAY	7995.2
587720	GEN-2016-087230.0	3 LEVELS AWAY	5116.5
615901	GRE-STANTON4230.0	3 LEVELS AWAY	17831.6
652207	JAMEST29 13.20	3 LEVELS AWAY	24186.2
652208	JAMEST19 13.20	3 LEVELS AWAY	24247.4
652325	WASHBRN9 41.80	3 LEVELS AWAY	4115.3
652435	FARGO 4 230.0	3 LEVELS AWAY	11594.9
652445	JAMESTN7 115.0	3 LEVELS AWAY	11138.3
652449	MAX 7 115.0	3 LEVELS AWAY	6263.9
652460	GARISN4G 13.80	3 LEVELS AWAY	41839.8
652461	GARISN5G 13.80	3 LEVELS AWAY	41832.7
652590	SNAKECR7 115.0	3 LEVELS AWAY	5712.3
655642	WARDTERT-CP912.47	3 LEVELS AWAY	21967

Bus #	Bus Name	Level Away	Fault Current (Amperes)
			3 PH
655643	VOLTAIR -CP7115.0	3 LEVELS AWAY	8293
655647	BIS WARD-CP7115.0	3 LEVELS AWAY	8132.7
655652	BIS EXPR-CP7115.0	3 LEVELS AWAY	16654.4
657759	PICKERT4 230.0	3 LEVELS AWAY	4797.2
659105	LELANDO3 345.0	3 LEVELS AWAY	17340.2
659108	LOGAN 4 230.0	3 LEVELS AWAY	5755.3
659109	BASIN 7 115.0	3 LEVELS AWAY	5739.3
659110	LELAN41G 22.00	3 LEVELS AWAY	90115.9
659200	BASIN 9 13.80	3 LEVELS AWAY	17058.1
659201	LELNDOLD 1913.80	3 LEVELS AWAY	36994.3
659202	LELNDOLD 2913.80	3 LEVELS AWAY	28482.5
659322	ECKLUNDWND1934.50	3 LEVELS AWAY	24019.2
659323	ECKLUNDWND2934.50	3 LEVELS AWAY	24017.3
659366	WILTON 3 W0.690	3 LEVELS AWAY	593695.4
659408	CAMPBLCNTY 4230.0	3 LEVELS AWAY	4644.1
659543	PICKCITY RR7115.0	3 LEVELS AWAY	9789
661029	ESTBMRK7 115.0	3 LEVELS AWAY	16640.3
661038	GLENHAM4 230.0	3 LEVELS AWAY	5391.1
661053	MANDAN 4 230.0	3 LEVELS AWAY	16273.3
85111	J511 230.0	4 LEVELS AWAY	7210.1
85991	J599 230.0	4 LEVELS AWAY	4349.2
560998	WILTON COL2 34.50	4 LEVELS AWAY	20523.9
579294	WILTON COL1 34.50	4 LEVELS AWAY	20681.1
587031	G16-004XFMR134.50	4 LEVELS AWAY	25161.6
587721	G16-087XFMR134.50	4 LEVELS AWAY	12564.5
588210	GEN-2016-130345.0	4 LEVELS AWAY	11988.9
602006	SHEYNNE4 230.0	4 LEVELS AWAY	12638.8
615348	GRE-MCHENRY7115.0	4 LEVELS AWAY	8334.8
615600	GRE-COAL CR4230.0	4 LEVELS AWAY	17307

Bus #	Bus Name	Level Away	Fault Current (Amperes)
			3 PH
615900	GRE-COAL TP4230.0	4 LEVELS AWAY	15312.1
620167	PICKERT9 41.60	4 LEVELS AWAY	2660.7
652222	MAX 9 41.60	4 LEVELS AWAY	5499.8
652320	JAMESTN9 41.80	4 LEVELS AWAY	4576.1
652420	NSALEM 7 115.0	4 LEVELS AWAY	2001.2
652428	CARNGTN7 115.0	4 LEVELS AWAY	2946.5
652432	EDGELEY7 115.0	4 LEVELS AWAY	4431.9
652434	FARGOSVC 13.20	4 LEVELS AWAY	41677.1
652436	FARGO 7 115.0	4 LEVELS AWAY	11738.2
652437	GRNDFKS4 230.0	4 LEVELS AWAY	8171.7
652440	NELSON 7 115.0	4 LEVELS AWAY	7533.5
652454	VALLEYC7 115.0	4 LEVELS AWAY	4902.1
652464	DENBIGH TAP7115.0	4 LEVELS AWAY	4851.4
652468	HEBRON 4 230.0	4 LEVELS AWAY	5662.2
652527	WHITLOK4 230.0	4 LEVELS AWAY	5340
652553	MOORHED4 230.0	4 LEVELS AWAY	7874.4
655644	NBISMRCK-CP7115.0	4 LEVELS AWAY	10569.7
655648	CIRCLE K-CP7115.0	4 LEVELS AWAY	6174.1
655661	DGLASCRK-CP7115.0	4 LEVELS AWAY	4016.1
657741	ROUGHRIDER 4230.0	4 LEVELS AWAY	16631.4
657756	SQBUTTE4 230.0	4 LEVELS AWAY	23310.2
657923	PICKERT8 69.00	4 LEVELS AWAY	3263.9
659101	ANTELOP3 345.0	4 LEVELS AWAY	17194.5
659111	LELAN32G 20.00	4 LEVELS AWAY	137310
659143	BLAISDELL 4230.0	4 LEVELS AWAY	5740.3
659155	LOGAN 7 115.0	4 LEVELS AWAY	9175.6
659208	LOGAN 913.80	4 LEVELS AWAY	20949.7
659300	STANTONTAP 7115.0	4 LEVELS AWAY	8050.7
659409	CAMPBLCNTY 934.50	4 LEVELS AWAY	17769

Bus #	Bus Name	Level Away	Fault Current (Amperes)
			3 PH
659422	LELAND1-LNX3345.0	4 LEVELS AWAY	17340.2
659424	LELAND2-LNX3345.0	4 LEVELS AWAY	17340.2
661009	BISEXP 7 115.0	4 LEVELS AWAY	14055.9
661035	GLENHAM7 115.0	4 LEVELS AWAY	5464
661042	HESKETT4 230.0	4 LEVELS AWAY	15451.6
661054	MANDAN 7 115.0	4 LEVELS AWAY	21340
661060	LINTON 7 115.0	4 LEVELS AWAY	1505.8
661119	26TH&D 7 115.0	4 LEVELS AWAY	15088.2
661600	GLENHAM9 41.60	4 LEVELS AWAY	7779.6
661908	MANDAN 9 13.80	4 LEVELS AWAY	39539.6
10651	G830_SUB 115.0	5 LEVELS AWAY	5454.2
83021	J302 POI 230.0	5 LEVELS AWAY	6191.1
85112	J511 COL 34.50	5 LEVELS AWAY	23613.7
85992	J599 COL1 34.50	5 LEVELS AWAY	24933.4
560074	G16-017-TAP 345.0	5 LEVELS AWAY	6888.4
587032	G16-004-GSU134.50	5 LEVELS AWAY	22095.1
587035	G16-004-GSU234.50	5 LEVELS AWAY	23578.2
587050	GEN-2016-007115.0	5 LEVELS AWAY	4395.1
587722	G16-087-GSU134.50	5 LEVELS AWAY	11831.4
588211	G16-130XFMR134.50	5 LEVELS AWAY	27405.2
603018	SHEYNNE7 115.0	5 LEVELS AWAY	14689.1
603023	MALLARD7 115.0	5 LEVELS AWAY	8467
605634	VELVA TAP 115.0	5 LEVELS AWAY	7113.4
605724	SHEYENNE5 9 13.80	5 LEVELS AWAY	15713.9
605730	SHEYENNE6 9 13.80	5 LEVELS AWAY	15575.4
608602	SQBEAST4 230.0	5 LEVELS AWAY	23310.2
615001	GRE-COAL 41G22.00	5 LEVELS AWAY	144566.2
615002	GRE-COAL 42G22.00	5 LEVELS AWAY	143627.3
615347	GRE-MCHENRY4230.0	5 LEVELS AWAY	6476.4

Bus #	Bus Name	Level Away	Fault Current (Amperes)
			3 PH
615349	GRE-MCHENRYT12.47	5 LEVELS AWAY	15591.8
615601	GRE-COAL FM869.00	5 LEVELS AWAY	8905.3
615602	GRE-COALFM1T12.47	5 LEVELS AWAY	18643.5
615603	GRE-COALFM2T12.47	5 LEVELS AWAY	18560.9
620336	AUDUBON4 230.0	5 LEVELS AWAY	5972.5
620381	UNDERWD4 230.0	5 LEVELS AWAY	14094.9
652201	GRNDFKS9 12.47	5 LEVELS AWAY	56711.9
652203	FARGO 8 69.00	5 LEVELS AWAY	13085.6
652204	VALLEYC8 69.00	5 LEVELS AWAY	2827.4
652321	CARNGTN9 41.80	5 LEVELS AWAY	3016.4
652322	EDGELEY9 41.80	5 LEVELS AWAY	4163.4
652323	FARGO 9 41.80	5 LEVELS AWAY	2161.7
652328	EDGELEY 19 13.20	5 LEVELS AWAY	5732
652416	DEVAUL 7 115.0	5 LEVELS AWAY	1458.7
652417	DICKNSN4 230.0	5 LEVELS AWAY	7288.5
652423	BARLOW 7 115.0	5 LEVELS AWAY	2919
652433	EDGELEY8 69.00	5 LEVELS AWAY	3138.7
652443	GRNDFKS7 115.0	5 LEVELS AWAY	12656.7
652453	TOWNER 7 115.0	5 LEVELS AWAY	5046.8
652534	ORDWAY 7 115.0	5 LEVELS AWAY	10554.9
652554	MORRIS 4 230.0	5 LEVELS AWAY	5327.3
652587	MOORHED7 115.0	5 LEVELS AWAY	6952.4
652613	VALLEYC9 13.20	5 LEVELS AWAY	6091.2
652638	ENDERLIN 7 115.0	5 LEVELS AWAY	3685.9
652821	SULLYBT-LNX3230.0	5 LEVELS AWAY	7141.6
655646	GVPINES -CP7115.0	5 LEVELS AWAY	5331.1
655657	SWMINOT -CP7115.0	5 LEVELS AWAY	6654.1
655662	ROSEGLEN-CP7115.0	5 LEVELS AWAY	3896
657707	CALEDON7 115.0	5 LEVELS AWAY	3750.3

Bus #	Bus Name	Level Away	Fault Current (Amperes)
			3 PH
657742	OLIVERWND3 4230.0	5 LEVELS AWAY	11670.4
657751	CENTER 4 230.0	5 LEVELS AWAY	21130.5
657754	MAPLE R4 230.0	5 LEVELS AWAY	14003.6
657755	PRAIRIE4 230.0	5 LEVELS AWAY	9207.1
657791	CENTER 3 345.0	5 LEVELS AWAY	13061
657848	YNG2 4 230.0	5 LEVELS AWAY	19069.5
657947	CENTR1TE 13.80	5 LEVELS AWAY	48960.2
657948	CENTR2TE 13.80	5 LEVELS AWAY	48961.4
658080	MPSBROOK 115.0	5 LEVELS AWAY	7258.2
659103	ANTEL31G 23.00	5 LEVELS AWAY	151175.2
659107	ANTEL32G 23.00	5 LEVELS AWAY	151175.2
659144	BLAISDELL 7115.0	5 LEVELS AWAY	7683.3
659164	BLAISDELL 913.80	5 LEVELS AWAY	27024.5
659183	CHAR.CK3 345.0	5 LEVELS AWAY	11022.5
659190	NDPRAIRWND 7115.0	5 LEVELS AWAY	7533.5
659212	DGC 3345.0	5 LEVELS AWAY	16434.6
659218	COTEAU 3345.0	5 LEVELS AWAY	17194.5
659273	WILTON 2 W0.690	5 LEVELS AWAY	749212.4
659280	POMONA 7 115.0	5 LEVELS AWAY	3576.3
659294	WILTON 1 W0.690	5 LEVELS AWAY	751366.2
659305	ROUGHRDRMGS7115.0	5 LEVELS AWAY	10858.9
659384	ROUNDUP 3345.0	5 LEVELS AWAY	9269.5
659400	NDSUNFLWR 4230.0	5 LEVELS AWAY	5085.4
659410	CAMBLCNTCOL934.50	5 LEVELS AWAY	16768.6
659420	ANTELOP-LNX3345.0	5 LEVELS AWAY	17194.5
659423	GROTON-LNX3 345.0	5 LEVELS AWAY	6773.3
661008	BEULAH 7 115.0	5 LEVELS AWAY	10466
661030	STEIN 7 115.0	5 LEVELS AWAY	14285.1
661037	BOWDLE 7 115.0	5 LEVELS AWAY	1901.6

Bus #	Bus Name	Level Away	Fault Current (Amperes)
			3 PH
661039	MOBRIDG7 115.0	5 LEVELS AWAY	3284.2
661043	HESKETT7 115.0	5 LEVELS AWAY	21802.1
661051	STH9TH 7 115.0	5 LEVELS AWAY	12592.3
661067	MANDANW7 115.0	5 LEVELS AWAY	14905.9
661084	TIOGA4 4 230.0	5 LEVELS AWAY	10271.5
661906	HESKETT9 13.80	5 LEVELS AWAY	32872.6

4. Stability Analysis for Cluster Scenario

4.1. Faults Simulated

One hundred and five (105) faults were considered for the transient stability simulations which included three phase faults, as well as single phase line faults. Single-phase line faults were simulated by applying fault impedance to the positive sequence network at the fault location. As per the SPP current practice to compute the fault levels, the fault impedance was computed to give a positive sequence voltage at the specified fault location of approximately 60% of pre-fault voltage.

Concurrently and previously queued projects as respectively shown in Table-1 and Table-2 of the study request as well as areas number 356, 600, 615, 620, 635, 640, 645, 652, and 661 were monitored during all the simulations. Table 4.1.1 shows the list of simulated contingencies. This Table also shows the fault clearing time and the time delay before re-closing for all the study contingencies.

Simulations were performed with a 0.1-second steady-state run followed by the appropriate disturbance as described in Table 4.1.1. Simulations were run for minimum 20-second duration to confirm proper machine damping.

Table 4.1.1 summarizes the overall results for all faults simulations of cluster scenario. Complete sets of plots for Winter-2017, Summer-2018, and Summer-2026 peak seasons for each fault are included in Appendices A, B and C respectively. Some additional scenarios were tested for FLT105-SB, and the complete set of plots are included in Appendix B Addendum.

The machines under study as well as the prior queued projects and requested monitored areas produce an exhaustive list for plotting. Therefore, for each contingency description, only four (4) plots sheets are included in the Appendices (i.e. Page-1, Page-2, Page-3, and page-4) that respectively represents the machines quantities under this study, prior queued machine quantities, and machine and bus voltages for different areas. Overall for each season there are 96 channel plots for each of the one-hundred and five (105) contingency descriptions as well as sixteen (16) contingency mitigation scenarios and nineteen (19) additional contingency mitigation scenarios of FLT105-SB for Summer-2018 only.

Table 4.1.1: List of simulated faults for cluster scenario stability analysis

Cont. #	Contingency Name	Description	2017 Winter Results	2018 Summer Results	2026 Summer Results
1	FLT01-3PH	3 phase fault on the Antelope Valley Station (659101) to Charlie Creek (659183) 345kV line circuit 1, near Antelope Valley Station. a. Apply fault at the Antelope Valley Station 345kV bus. b. Clear fault after 6 cycles by tripping the faulted line.	Stable	Stable	Stable
2	FLT02-3PH	3 phase fault on the Roundup 345/115/13.8kV (659384/659385/659386) transformer, near Roundup 345kV. a. Apply fault at the Roundup 345kV bus. b. Clear fault after 6 cycles by tripping the faulted transformer.	Stable	Stable	Stable
3	FLT03-3PH	3 phase fault on CHAR.CK (659183) to BELFELD (652424) 345kV line circuit 1, near CHAR.CK. a. Apply fault at the CHAR.CK 345 bus. b. Clear fault after 6 cycles by tripping the faulted line.	Stable	Stable	Stable
4	FLT04-3PH	3 phase fault on CHAR.CK (659183) to ROUNDUP (659384) 345kV line circuit 1, near CHAR.CK. a. Apply fault at the CHAR.CK 345 bus. b. Clear fault after 6 cycles by tripping the faulted line.	Stable	Stable	Stable
5	FLT05-3PH	3 phase fault on CHAR.CK (659183) to PATENTGATE (659390) 345kV line circuit 1, near CHAR.CK. a. Apply fault at the CHAR.CK 345 bus. b. Clear fault after 6 cycles by tripping the faulted line.	Stable	Stable	Stable
6	FLT06-3PH	3 phase fault on the CHAR.CK 345/230/13.8kV (659183/659302/659319) transformer, near CHAR.CK. a. Apply fault at the CHAR.CK 345kV bus. b. Clear fault after 6 cycles by tripping the faulted transformer.	Stable	Stable	Stable
7	FLT07-3PH	3 phase fault on the CHAR.CK 345/115/13.8kV (659183/659182/659211) transformer, near CHAR.CK. a. Apply fault at the CHAR.CK 345kV bus. b. Clear fault after 6 cycles by tripping the faulted transformer.	Stable	Stable	Stable
8	FLT08-3PH	3 phase fault on Neset (659139) to Tioga (661085) to 115kV line circuit 1, near Neset. a. Apply fault at the Neset 115 bus. b. Clear fault after 6 cycles by tripping the faulted line.	Stable	Stable	Stable
9	FLT09-3PH	3 phase fault on Neset (659139) to Tioga North (655952) to 115kV line circuit 1, near Neset. a. Apply fault at the Neset 115 bus. b. Clear fault after 6 cycles by tripping the faulted line.	Stable	Stable	Stable
10	FLT10-3PH	3 phase fault on Neset (659139) to Powers Lake (655947) to 115kV line circuit 1, near Neset. a. Apply fault at the Neset 115 bus. b. Clear fault after 6 cycles by tripping the faulted line.	Stable	Stable	Stable

Cont. #	Contingency Name	Description	2017 Winter Results	2018 Summer Results	2026 Summer Results
11	FLT11-3PH	3 phase fault on Neset (659139) to Whitearth Tap (655930) to 115kV line circuit 1, near Neset. a. Apply fault at the Neset 115 bus. b. Clear fault after 6 cycles by tripping the faulted line.	Stable	Stable	Stable
12	FLT12-3PH	3 phase fault on Neset (659139) to Hess Gas (655909) to 115kV line circuit 1, near Neset. a. Apply fault at the Neset 115 bus. b. Clear fault after 6 cycles by tripping the faulted line.	Stable	Stable	Stable
13	FLT13-3PH	3 phase fault on PATENTGATE (659390) to JUDSON (659333) 345kV line circuit 1, near PATENTGATE. a. Apply fault at the PATENTGATE 345 bus. b. Clear fault after 6 cycles by tripping the faulted line.	Stable	Stable	Stable
14	FLT14-3PH	3 phase fault on PATENTGATE (659390) to KUMMERRIDGE (659387) 345kV line circuit 1, near PATENTGATE. a. Apply fault at the PATENTGATE 345 bus. b. Clear fault after 6 cycles by tripping the faulted line.	Stable	Stable	Stable
15	FLT15-3PH	3 phase fault on the PATENTGATE 345/115/13.8kV (659390/659391/659392) transformer, near PATENTGATE. a. Apply fault at the PATENTGATE 345kV bus. b. Clear fault after 6 cycles by tripping the faulted transformer.	Stable	Stable	Stable
16	FLT16-3PH	3 phase fault on JUDSON (659333) to TANDE-LNX (659427) to TANDE (659336) 345kV line circuit 1, near JUDSON. a. Apply fault at the JUDSON 345 bus. b. Clear fault after 6 cycles by tripping the faulted line.	Stable	Un-Stable	Stable
16A	FLT16A-3PH	3 phase fault on JUDSON (659333) to TANDE-LNX (659427) to TANDE (659336) 345kV line circuit 1, near JUDSON. a. Apply fault at the JUDSON 345 bus. b. Clear fault after 6 cycles by tripping the faulted line. c. adjust GEN-2015-046 machine at bus 584873 auxiliary model VWVAR6 VAR L+1 power factor set point from 0.991 (40 MVar) to 0.98 (60.9 MVAR)	Stable	Stable	Stable
17	FLT17-3PH	3 phase fault on the JUDSON 345/230/13.8kV (659333/659334/659335) transformer, near JUDSON. a. Apply fault at the JUDSON345kV bus. b. Clear fault after 6 cycles by tripping the faulted transformer.	Stable	Stable	Stable
18	FLT18-3PH	Prior Outage of TANDE 345/230/13.8kV (659336/659337/659338) transformer CKT 1; 3 phase fault on PATENTGATE (659390) to JUDSON (659333) 345kV line circuit 1, near PATENTGATE. a. Apply fault at the PATENTGATE 345 bus. b. Clear fault after 6 cycles by tripping the faulted line.	Un-Stable	Un-Stable	Un-Stable

Cont. #	Contingency Name	Description	2017 Winter Results	2018 Summer Results	2026 Summer Results
18A	FLT18A-3PH	**With Generation Curtailment as a system adjustment for mitigation** Prior Outage of TANDE 345/230/13.8kV (659336/659337/659338) transformer CKT 1 Curtail GEN-2015-046 and GEN-2016-151 by 100MW; 3 phase fault on PATENTGATE (659390) to JUDSON (659333) 345kV line circuit 1, near PATENTGATE. a. Apply fault at the PATENTGATE 345 bus. b. Clear fault after 6 cycles by tripping the faulted line.	Stable	Stable	Stable
19	FLT19-3PH	3 phase fault on the NESET 230/115/13.8kV (659138/659139/659146) transformer, near NESET 230kV. a. Apply fault at the NESET 230kV bus. b. Clear fault after 6 cycles by tripping the faulted transformer.	Stable	Stable	Stable
20	FLT20-3PH	3 phase fault on the TANDE 345/230/13.8kV (659336/659337/659338) transformer, near TANDE. a. Apply fault at the TANDE 345kV bus. b. Clear fault after 6 cycles by tripping the faulted transformer.	Stable	Stable	Stable
21	FLT21-3PH	3 phase fault on TIOGA (661084) to NESET (659138) 230kV line circuit 1, near TIOGA. a. Apply fault at the TIOGA 230kV bus. b. Clear fault after 6 cycles by tripping the faulted line.	Stable	Stable	Stable
22	FLT22-3PH	3 phase fault on TIOGA (661084) to BLAISDELL (659143) 230kV line circuit 1, near TIOGA. a. Apply fault at the TIOGA 230kV bus. b. Clear fault after 6 cycles by tripping the faulted line.	Stable	Stable	Stable
23	FLT23-3PH	3 phase fault on TIOGA (661084) to WHEELOCK (659362) 230kV line circuit 1, near TIOGA. a. Apply fault at the TIOGA 230kV bus. b. Clear fault after 6 cycles by tripping the faulted line.	Stable	Stable	Stable
24	FLT24-3PH	3 phase fault on TIOGA (661084) to BDV (672603) 230kV line circuit 1, near TIOGA. 3 phase fault on TIOGA (661084) to LARSON (659372) 230kV line circuit 1, near TIOGA (for 2026 Scenario) a. Apply fault at the TIOGA 230kV bus. b. Clear fault after 6 cycles by tripping the faulted line.	Stable	Stable	Stable
25	FLT25-3PH	3 phase fault on the TIOGA 230/115/13.8kV (661084/661085/661900) transformer, near TIOGA. a. Apply fault at the TIOGA 345kV bus. b. Clear fault after 6 cycles by tripping the faulted transformer.	Stable	Stable	Stable

Cont. #	Contingency Name	Description	2017 Winter Results	2018 Summer Results	2026 Summer Results
26	FLT26-3PH	3 phase fault on ANTELOP (659101) to ANTELOP_LNX (659420) to BRDLAND_LNX (659421) to BRDLAND (659120) 345kV line circuit 1, near ANTELOP. a. Apply fault at the ANTELOP 345kV bus. b. Clear fault after 6 cycles by tripping the faulted line.	Stable	Stable	Stable
27	FLT27-3PH	3 phase fault on ANTELOP (659101) to LELANDO (659105) 345kV line circuit 1, near ANTELOP. a. Apply fault at the ANTELOP 345kV bus. b. Clear fault after 6 cycles by tripping the faulted line.	Stable	Stable	Stable
28	FLT28-3PH	3 phase fault on ANTELOP (659101) to ROUNDUP (659384) 345kV line circuit 1, near ANTELOP. a. Apply fault at the ANTELOP 345kV bus. b. Clear fault after 6 cycles by tripping the faulted line.	Stable	Stable	Stable
29	FLT29-3PH	3 phase fault on the LELANDO 345/230/13.8kV (659105/659106/659201) transformer, near LELANDO. a. Apply fault at the LELANDO 345kV bus. b. Clear fault after 6 cycles by tripping the faulted transformer.	Stable	Stable	Stable
30	FLT30-3PH	3 phase fault on LELANDO (659105) to LELAND2_LNX (659424) to G16-017 TAP (560074) 345kV circuit 1, near LELANDO. a. Apply fault at the LELANDO 345kV bus. b. Clear fault after 6 cycles by tripping the faulted line.	Stable	Stable	Stable
31	FLT31-3PH	3 phase fault on LELANDO (659105) to LELAND1_LNX (659422) to GROTON_LNX (659423) to GROTON (659160) 345kV circuit 1, near LELANDO. a. Apply fault at the LELANDO 345kV bus. b. Clear fault after 6 cycles by tripping the faulted line.	Stable	Stable	Stable
32	FLT32-3PH	3 phase fault on G16-017-TAP (560074) to FTTHOM (652806) to FTTHOMP (652506) 345kV line circuit 1, near G16-017-TAP. a. Apply fault at the G16-017-TAP 345kV bus. b. Clear fault after 6 cycles by tripping the faulted line.	Stable	Stable	Stable
33	FLT33-3PH	3 phase fault on the FTTHOMP 345/230/13.8kV (652506/652507/652274) transformer, near FTTHOMP. a. Apply fault at the FTTHOMP 345kV bus. b. Clear fault after 6 cycles by tripping the faulted transformer.	Stable	Stable	Stable
34	FLT34-3PH	3 phase fault on FTTHOMP (652506) to FTTHOM_LNX (652807) to GRPRAR_LNX (652833) to GRPRAR_LNX (652532) 345kV line circuit 1, near FTTHOMP. a. Apply fault at the FTTHOMP 345kV bus. b. Clear fault after 6 cycles by tripping the faulted line.	Stable	Stable	Stable
35	FLT35-3PH	3 phase fault on FTTHOMP (652507) to WESSINGTON (652607) 230kV line circuit 1, near FTTHOMP. a. Apply fault at the FTTHOMP 230kV bus. b. Clear fault after 6 cycles by tripping the faulted line.	Stable	Stable	Stable

Cont. #	Contingency Name	Description	2017 Winter Results	2018 Summer Results	2026 Summer Results
36	FLT36-3PH	3 phase fault on FTTHOMP (652507) to FTRANDL (652509) 230kV line circuit 1, near FTTHOMP. a. Apply fault at the FTTHOMP 230kV bus. b. Clear fault after 6 cycles by tripping the faulted line.	Stable	Stable	Stable
37	FLT37-3PH	3 phase fault on FTTHOMP (652507) to LETCHER (652606) 230kV line circuit 1, near FTTHOMP. a. Apply fault at the FTTHOMP 230kV bus. b. Clear fault after 6 cycles by tripping the faulted line.	Stable	Stable	Stable
38	FLT38-3PH	3 phase fault on FTTHOMP (652507) to HURON (652514) 230kV line circuit 2, near FTTHOMP. a. Apply fault at the FTTHOMP 230kV bus. b. Clear fault after 6 cycles by tripping the faulted line.	Stable	Stable	Stable
39	FLT39-3PH	3 phase fault on FTTHOMP (652507) to LAKPLAT (652516) 230kV line circuit 1, near FTTHOMP. a. Apply fault at the FTTHOMP 230kV bus. b. Clear fault after 6 cycles by tripping the faulted line.	Stable	Stable	Stable
40	FLT40-3PH	3 phase fault on HURON (652514) to WATERTN (652530) 230kV line circuit 2, near HURON. a. Apply fault at the HURON 230kV bus. b. Clear fault after 6 cycles by tripping the faulted line.	Stable	Stable	Stable
41	FLT41-3PH	3 phase fault on HURON (652514) to CARPENTER (652614) 230kV line circuit 1, near HURON. a. Apply fault at the HURON 230kV bus. b. Clear fault after 6 cycles by tripping the faulted line.	Stable	Stable	Stable
42	FLT42-3PH	3 phase fault on the Huron 230/115/13.328kV (652514/652515/652281) transformer, near Huron 230kV. a. Apply fault at the Huron 230kV bus. b. Clear fault after 6 cycles by tripping the faulted transformer.	Stable	Stable	Stable
43	FLT43-3PH	3 phase fault on the Hilken (652466) to Garrison (652441) 230kV line circuit 1, near Hilken. a. Apply fault at the Hilken 230kV bus. b. Clear fault after 6 cycles by tripping the faulted line.	Stable	Stable	Stable
44	FLT44-3PH	3 phase fault on the Hilken (652466) to Bismark (652426) 230kV line circuit 1, near Hilken. a. Apply fault at the Hilken 230kV bus. b. Clear fault after 6 cycles by tripping the faulted line.	Stable	Stable	Stable
45	FLT45-3PH	3 phase fault on the Bismark (652426) to Jamestown (652444) 230kV line circuit 1, near Bismark. a. Apply fault at the Bismark 230kV bus. b. Clear fault after 6 cycles by tripping the faulted line.	Stable	Stable	Stable
46	FLT46-3PH	3 phase fault on the Bismark (652426) to Weber (659128) 230kV line circuit 1, near Bismark. a. Apply fault at the Bismark 230kV bus. b. Clear fault after 6 cycles by tripping the faulted line.	Stable	Stable	Stable

Cont. #	Contingency Name	Description	2017 Winter Results	2018 Summer Results	2026 Summer Results
47	FLT47-3PH	3 phase fault on the Bismark (652426) to Campbell (652499) 230kV line circuit 1, near Bismark. a. Apply fault at the Bismark 230kV bus. b. Clear fault after 6 cycles by tripping the faulted line.	Stable	Stable	Stable
48	FLT48-3PH	3 phase fault on the Bismark (652426) to Ward (652296) 230kV line circuit 1, near Bismark. a. Apply fault at the Bismark 230kV bus. b. Clear fault after 6 cycles by tripping the faulted line.	Stable	Stable	Stable
49	FLT49-3PH	3 phase fault on the Bismark 230/115/12.4kV (652426/652427/652392) transformer circuit 1, near Bismark. a. Apply fault at the Bismark 230kV bus. b. Clear fault after 6 cycles by tripping the faulted line.	Stable	Stable	Stable
50	FLT50-SB	**Garrison 230 kV (652441) Stuck Breaker Scenario 1** a. Apply single line to ground fault at the Garrison 230kV bus. b. Clear fault after 16 cycles and trip the following elements c. Garrison (652441) – Leland Olds (659106) 230kV	Stable	Stable	Stable
51	FLT51-SB	**Garrison 230 kV (652441) Stuck Breaker Scenario 2** a. Apply single line to ground fault at the Garrison 230kV bus. b. Clear fault after 16 cycles and trip the following elements c. Garrison (652441) – Jamestown (652444) 230kV	Stable	Stable	Stable
52	FLT52-SB	**Bismark 230 kV (652426) Stuck Breaker Scenario 1** a. Apply single line to ground fault at the Bismark 230kV bus. b. Clear fault after 16 cycles and trip the following elements c. Bismark (652426) – Campbell County (652499) 230kV d. Bismark (652426) – Hilken (652466) 230kV e. Bismark (652426/652427/652392) 230/115/12.47kV f. Bismark (652426) – Weber (659128) 230kV	Stable	Stable	Stable
53	FLT53-SB	**Bismark 230 kV (652426) Stuck Breaker Scenario 2** a. Apply single line to ground fault at the Bismark 230kV bus. b. Clear fault after 16 cycles and trip the following elements c. Bismark (652426) – Washburn (652456) 230kV d. Bismark (652426) – Jamestown (652444) 230kV e. Bismark (652426/652427/652467) 230/115/12.47kV f. Bismark (652426) – Ward (652296) 230kV	Stable	Stable	Stable

Cont. #	Contingency Name	Description	2017 Winter Results	2018 Summer Results	2026 Summer Results
54	FLT54-3PH	**Prior Outage of Hilken 230 kV (652466) to Bismark 230 kV (652426) CKT 1;** 3 phase fault on the Garrison (652441) to Jamestown (652444) 230kV line circuit 1, near Garrison. a. Apply fault at the Garrison 230kV bus. b. Clear fault after 6 cycles by tripping the faulted line.	Stable	Stable	Stable
55	FLT55-SB	**ANTELOPE (659101) 345KV Stuck Breaker Scenario** a. Apply single line to ground fault at the ANTELOP 345kV bus. b. Run 4 cycles and leave fault on c. Trip BRDLAND_LNX (659421) to BRDLAND (659120) 345kV line d. Run 8 cycles, then clear fault e. Trip COTEAU loads (bus #659222, 659219, 659231, 659218, 659236, 659420) f. Trip ANTELOP (659101) to ANTELOP_LNX (659420) to BRDLAND_LNX (659421) 345kV line	Stable	Stable	Stable
56	FLT56-SB	**LELANDO (659105) 345KV Stuck Breaker Scenario 1** a. Apply single line to ground fault at the LELANDO 345kV bus. b. Run 4 cycles and leave fault on c. Trip LELANDO (659105) to LELAND2_LNX (659424) to G16-017-TAP (5600514) 345kV line d. Run 10 cycles, then clear fault	Stable	Stable	Stable
57	FLT57-SB	**LELANDO (659105) 345KV Stuck Breaker Scenario 2** a. Apply single line to ground fault at the LELANDO 345kV bus. b. Run 4 cycles and leave fault on c. Trip GROTON_LNX (659423) to GROTON (659160) 345kV line d. Run 8 cycles, then clear fault e. Trip LELANDO (659105) to LELAND1_LNX (659422) to GROTON_LNX (659423) 345kV line f. Trip LELANDO (659105/659106/659201) 345/230/13.8kV transformer	Stable	Stable	Stable
58	FLT58-3PH	3 phase fault on Tioga (661085) to Stanley (661080) 115kV line circuit 1, near Tioga. a. Apply fault at the Tioga 115 bus. b. Clear fault after 6 cycles by tripping the faulted line.	Stable	Stable	Stable
59	FLT59-3PH	3 phase fault on Tioga (661085) to Tioga (661086) 115kV line circuit 1, near Tioga (661085). a. Apply fault at the Tioga (661085) 115 bus. b. Clear fault after 6 cycles by tripping the faulted line.	Stable	Stable	Stable

Cont. #	Contingency Name	Description	2017 Winter Results	2018 Summer Results	2026 Summer Results
60	FLT60-3PH	3 phase fault on WILISTN4 (652400) to WHEELOCK (659362) 230kV line circuit 1, near WILISTN4. a. Apply fault at the WILISTN4 230kV bus. b. Clear fault after 6 cycles by tripping the faulted line.	Stable	Stable	Stable
61	FLT61-3PH	3 phase fault on WILISTN4 (652400) to TIMBERCREEK (659368) 230kV line circuit 1, near WILISTN4. a. Apply fault at the WILISTN4 230kV bus. b. Clear fault after 6 cycles by tripping the faulted line.	Stable	Stable	Stable
62	FLT62-3PH	3 phase fault on the WILISTN4 230/115/13.8kV (652400/652391/652622) transformer, near WILISTN4. a. Apply fault at the WILISTN4 345kV bus. b. Clear fault after 6 cycles by tripping the faulted transformer.	Stable	Stable	Stable
63	FLT63-3PH	3 phase fault on Leland Old (659106) to GRE Stanton (615901) 230kV line circuit 1, near Leland Old. a. Apply fault at the Leland Old 230kV bus. b. Clear fault after 6 cycles by tripping the faulted line.	Stable	Stable	Stable
64	FLT64-3PH	3 phase fault on Leland Old (659106) to Garrison (652441) 230kV line circuit 1, near Leland Old. a. Apply fault at the Leland Old 230kV bus. b. Clear fault after 6 cycles by tripping the faulted line.	Stable	Stable	Stable
65	FLT65-3PH	3 phase fault on Leland Old (659106) to Washburn (652456) 230kV line circuit 1, near Leland Old. a. Apply fault at the Leland Old 230kV bus. b. Clear fault after 6 cycles by tripping the faulted line.	Stable	Stable	Stable
66	FLT66-3PH	3 phase fault on Leland Old (659106) to Logan (659108) 230kV line circuit 1, near Leland Old. a. Apply fault at the Leland Old 230kV bus. b. Clear fault after 6 cycles by tripping the faulted line.	Stable	Stable	Stable
67	FLT67-3PH	3 phase fault on the LELANDO 230/Basin 115/13.8kV (659106/659109/659200) transformer, near LELANDO. a. Apply fault at the LELANDO 230kV bus. b. Clear fault after 6 cycles by tripping the faulted transformer.	Stable	Stable	Stable
68	FLT68-3PH	3 phase fault on GROTON (652175) to Watertown (652529) 345kV circuit 1, near GROTON. a. Apply fault at the GROTON 345kV bus. b. Clear fault after 6 cycles by tripping the faulted line.	Stable	Stable	Stable
69	FLT69-3PH	3 phase fault on the GROTON 345/115/13.8kV (659160/652568/659161) transformer, near GROTON 345kV. a. Apply fault at the GROTON 345kV bus. b. Clear fault after 6 cycles by tripping the faulted transformer.	Stable	Stable	Stable

Cont. #	Contingency Name	Description	2017 Winter Results	2018 Summer Results	2026 Summer Results
70	FLT70-3PH	3 phase fault on Watertown (652529/652829) to White (652537) 345kV circuit 1, near Watertown. a. Apply fault at the Watertown 345kV bus. b. Clear fault after 6 cycles by tripping the faulted line.	Stable	Stable	Stable
71	FLT71-3PH	3 phase fault on the Watertown 345/115/13.8kV (652529/652530/652237) transformer, near Watertown 345kV. a. Apply fault at the Watertown 345kV bus. b. Clear fault after 6 cycles by tripping the faulted transformer.	Stable	Stable	Stable
72	FLT72-3PH	3 phase fault on Groton South (652568) to GROTONB7 (659275) 115kV circuit 1, near Groton South. a. Apply fault at the Groton South 115kV bus. b. Clear fault after 6 cycles by tripping the faulted line.	Stable	Stable	Stable
73	FLT73-3PH	3 phase fault on Groton South (652568) to SW561-ER7 (655419) 115kV circuit 1, near Groton South. a. Apply fault at the Groton South 115kV bus. b. Clear fault after 6 cycles by tripping the faulted line.	Stable	Stable	Stable
74	FLT74-3PH	3 phase fault on Groton South (652568) to ORDWAY (652534) 115kV circuit 1, near Groton South. a. Apply fault at the Groton South 115kV bus. b. Clear fault after 6 cycles by tripping the faulted line.	Stable	Stable	Stable
75	FLT75-3PH	3 phase fault on Groton South (652568) to GROTON (652512) 115kV circuit 1, near Groton South. a. Apply fault at the Groton South 115kV bus. b. Clear fault after 6 cycles by tripping the faulted line.	Stable	Stable	Stable
76	FLT76-3PH	3 phase fault on Groton South (652568) to REDFELD (652535) 115kV circuit 1, near Groton South. a. Apply fault at the Groton South 115kV bus. b. Clear fault after 6 cycles by tripping the faulted line.	Stable	Stable	Stable
77	FLT77-3PH	3 phase fault on Garrison (652441) to Jamestown (652444) 230kV line circuit 1, near Garrison. a. Apply fault at the Garrison 230kV bus. b. Clear fault after 6 cycles by tripping the faulted line.	Stable	Stable	Stable
78	FLT78-3PH	3 phase fault on the Garrison 230/115kV (652441/652442) transformer, near Garrison 230kV. a. Apply fault at the Garrison 230kV bus. b. Clear fault after 6 cycles by tripping the faulted transformer.	Stable	Stable	Stable
79	FLT79-3PH	3 phase fault on Logan (659108) to BLAISDELL (659143) 230kV line circuit 1, near Logan. a. Apply fault at the Logan 230kV bus. b. Clear fault after 6 cycles by tripping the faulted line.	Stable	Stable	Stable
80	FLT80-3PH	3 phase fault on the Logan 230/115/13.8kV (659108/659155/659208) transformer, near Logan 230kV. a. Apply fault at the Logan 230kV bus. b. Clear fault after 6 cycles by tripping the faulted transformer.	Stable	Stable	Stable

Cont. #	Contingency Name	Description	2017 Winter Results	2018 Summer Results	2026 Summer Results
81	FLT81-3PH	3 phase fault on GRE Stanton (615901) to Square Butte (657756) 230kV line circuit 1, near GRE Stanton. a. Apply fault at the GRE Stanton 230kV bus. b. Clear fault after 6 cycles by tripping the faulted line.	GRE-COAL 41G (615001) and GRE-COAL 41G (615002) Unstable Other System is Stable		
81 A	FLT81A-3PH	**Reduced Fault Clearing time (3-Cycles)** 3 phase fault on GRE Stanton (615901) to Square Butte (657756) 230kV line circuit 1, near GRE Stanton. a. Apply fault at the GRE Stanton 230kV bus. b. Clear fault after 3 cycles by tripping the faulted line.	GRE-COAL 41G (615001) and GRE-COAL 41G (615002) Unstable Other System is Stable		
81 B	FLT81B-3PH	**Change Governor Model from IEEEG1 to WSIEG1, and remove (switch offline) the J511 (buses 85111-85116) request** 3 phase fault on GRE Stanton (615901) to Square Butte (657756) 230kV line circuit 1, near GRE Stanton. a. Apply fault at the GRE Stanton 230kV bus. b. Clear fault after 6 cycles by tripping the faulted line.	GRE-COAL 41G (615001) and GRE-COAL 41G (615002) Unstable Other System is Stable		
82	FLT82-3PH	3 phase fault on GRE Stanton (615901) to GRE Coal (615600) 230kV line circuit 1, near GRE Stanton. a. Apply fault at the GRE Stanton 230kV bus. b. Clear fault after 6 cycles by tripping the faulted line.	GRE-COAL 41G (615001) and GRE-COAL 41G (615002) Unstable Other System is Stable		
82 A	FLT82A-3PH	**Reduced Fault Clearing time (3-Cycles)** 3 phase fault on GRE Stanton (615901) to GRE Coal (615600) 230kV line circuit 1, near GRE Stanton. a. Apply fault at the GRE Stanton 230kV bus. b. Clear fault after 3 cycles by tripping the faulted line.	GRE-COAL 41G (615001) and GRE-COAL 41G (615002) Unstable Other System is Stable		
82 B	FLT82B-3PH	**Change Governor Model from IEEEG1 to WSIEG1, and remove (switch offline) the J511 (buses 85111-85116) request** 3 phase fault on GRE Stanton (615901) to GRE Coal (615600) 230kV line circuit 1, near GRE Stanton. a. Apply fault at the GRE Stanton 230kV bus. b. Clear fault after 6 cycles by tripping the faulted line.	GRE-COAL 41G (615001) and GRE-COAL 41G (615002) Unstable Other System is Stable		
83	FLT83-3PH	3 phase fault on GRE Stanton (615901) to GRE Coal tap (615900) 230kV line circuit 1, near GRE Stanton. a. Apply fault at the GRE Stanton 230kV bus. b. Clear fault after 6 cycles by tripping the faulted line.	GRE-COAL 41G (615001) and GRE-COAL 41G (615002) Unstable Other System is Stable		
83 A	FLT83A-3PH	**Reduced Fault Clearing time (3-Cycles)** 3 phase fault on GRE Stanton (615901) to GRE Coal tap (615900) 230kV line circuit 1, near GRE Stanton. a. Apply fault at the GRE Stanton 230kV bus. b. Clear fault after 3 cycles by tripping the faulted line.	GRE-COAL 41G (615001) and GRE-COAL 41G (615002) Unstable Other System is Stable		
83 B	FLT83B-3PH	**Change Governor Model from IEEEG1 to WSIEG1, and remove (switch offline) the J511 (buses 85111-85116) request** 3 phase fault on GRE Stanton (615901) to GRE Coal tap (615900) 230kV line circuit 1, near GRE Stanton. a. Apply fault at the GRE Stanton 230kV bus. b. Clear fault after 6 cycles by tripping the faulted line.	GRE-COAL 41G (615001) and GRE-COAL 41G (615002) Unstable Other System is Stable		

Cont. #	Contingency Name	Description	2017 Winter Results	2018 Summer Results	2026 Summer Results
84	FLT84-3PH	3 phase fault on FTTHOMP (652507) to OAHE (652519) 230kV line circuit 3, near FTTHOMP. a. Apply fault at the FTTHOMP 230kV bus. b. Clear fault after 6 cycles by tripping the faulted line.	Stable	Stable	Stable
85	FLT85-3PH	3 phase fault on the Campbell (652499) to Glenham (661038) 230kV line circuit 1, near Campbell. a. Apply fault at the Campbell 230kV bus. b. Clear fault after 6 cycles by tripping the faulted line.	Stable	Stable	Stable
86	FLT86-3PH	3 phase fault on the Ward (652296) to Mandan (661053) 230kV line circuit 1, near Ward. a. Apply fault at the Ward 230kV bus. b. Clear fault after 6 cycles by tripping the faulted line.	Stable	Stable	Stable
87	FLT87-3PH	3 phase fault on the Ward 230/115/12.47kV (652296/655647/655642) transformer, near Ward 230kV. a. Apply fault at the Ward 230kV bus. b. Clear fault after 6 cycles by tripping the faulted transformer.	Stable	Stable	Stable
88	FLT88-3PH	3 phase fault on the Jamestown (652444) to Weber (659128) 230kV line circuit 1, near Jamestown. a. Apply fault at the Jamestown 230kV bus. b. Clear fault after 6 cycles by tripping the faulted line.	Stable	Stable	Stable
89	FLT89-3PH	3 phase fault on the Jamestown (652444) to Fargo (652435) 230kV line circuit 1, near Jamestown. a. Apply fault at the Jamestown 230kV bus. b. Clear fault after 6 cycles by tripping the faulted line.	Stable	Stable	Stable
90	FLT90-3PH	3 phase fault on the Jamestown (652444) to Pickert (657759) 230kV line circuit 1, near Jamestown. a. Apply fault at the Jamestown 230kV bus. b. Clear fault after 6 cycles by tripping the faulted line.	Stable	Stable	Stable
91	FLT91-3PH	3 phase fault on the Jamestown 230/115/12.47kV (652444/652445/652208) transformer, near Jamestown 230kV. a. Apply fault at the Jamestown 230kV bus. b. Clear fault after 6 cycles by tripping the faulted transformer.	Stable	Stable	Stable
92	FLT92-3PH	3 phase fault on the Garrison (652442) to Max (652449) 115kV line circuit 1, near Garrison. a. Apply fault at the Garrison 115kV bus. b. Clear fault after 6 cycles by tripping the faulted line.	Stable	Stable	Stable
93	FLT93-3PH	3 phase fault on the Garrison (652442) to Pick City (659543) 115kV line circuit 1, near Garrison. a. Apply fault at the Garrison 115kV bus. b. Clear fault after 6 cycles by tripping the faulted line.	Stable	Stable	Stable

Cont. #	Contingency Name	Description	2017 Winter Results	2018 Summer Results	2026 Summer Results
94	FLT94-3PH	3 phase fault on the Garrison (652442) to Voltair (655643) 115kV line circuit 1, near Garrison. a. Apply fault at the Garrison 115kV bus. b. Clear fault after 6 cycles by tripping the faulted line.	Stable	Stable	Stable
95	FLT95-3PH	3 phase fault on the Garrison (652442) to Snake Creek (652590) 115kV line circuit 1, near Garrison. a. Apply fault at the Garrison 115kV bus. b. Clear fault after 6 cycles by tripping the faulted line.	Stable	Stable	Stable
96	FLT96-PO	Prior Outage of Hilken 230 kV (652466) to Bismark 230 kV (652426) CKT 1; 3 phase fault on the Garrison (652441) to Leland Old (659106) 230kV line circuit 1, near Garrison. a. Apply fault at the Garrison 230kV bus. b. Clear fault after 6 cycles by tripping the faulted line.	Stable	Stable	Stable
97	FLT97-PO	Prior Outage of Hilken 230 kV (652466) to Garrison (652441) 230 kV CKT 1; 3 phase fault on the Campbell (652499) to Glenham (661038) 230kV line circuit 1, near Campbell. a. Apply fault at the Campbell 230kV bus. b. Clear fault after 6 cycles by tripping the faulted line.	Stable	Stable	Stable
98	FLT98-PO	Prior Outage of Leland Old 345kV (659105) to Antelope Valley Station (659101) 345kV CKT 2; 3 phase fault on ANTELOP (659101) to LELANDO (659105) 345kV line circuit 1, near ANTELOP. a. Apply fault at the ANTELOP 345kV bus. b. Clear fault after 6 cycles by tripping the faulted line.	Stable	Stable	Stable
99	FLT99-PO	Prior Outage of G16-017-TAP (560074) to FTTHOM (652806) to FTTHOMP (652506) 345kV CKT 1; 3 phase fault on LELANDO (659105) to LELAND1_LNX (659422) to GROTON_LNX (659423) to GROTON (659160) 345kV circuit 1, near LELANDO. a. Apply fault at the LELANDO 345kV bus. b. Clear fault after 6 cycles by tripping the faulted line.	Stable	Stable	Stable
100	FLT100-PO	Prior Outage of LELANDO 345/230/13.8kV (659105/659106/659202) transformer CKT 1; 3 phase fault on the LELANDO 345/230/13.8kV (659105/659106/659201) transformer, near LELANDO. a. Apply fault at the LELANDO 345kV bus. b. Clear fault after 6 cycles by tripping the faulted transformer.	Stable	Stable	Stable

Cont. #	Contingency Name	Description	2017 Winter Results	2018 Summer Results	2026 Summer Results
101	FLT101-PO	Prior Outage of TANDE 345/230/13.8kV (659336/659337/659338) transformer CKT 1; 3 phase fault on the JUDSON 345/230/13.8kV (659333/659334/659335) transformer, near JUDSON. a. Apply fault at the JUDSON345kV bus. b. Clear fault after 6 cycles by tripping the faulted transformer.	Stable	Stable	Stable
102	FLT102-PO	Prior Outage of JUDSON (659333) to TANDE-LNX (659427) to TANDE (659336) 345kV line circuit 1; 3 phase fault on TIOGA (661084) to NESET (659138) 230kV line circuit Z, near TIOGA. a. Apply fault at the TIOGA 230kV bus. b. Clear fault after 6 cycles by tripping the faulted line.	**Un-Stable**	**Un-Stable**	**Un-Stable**
102 A	FLT102A-PO	**With Generation Curtailment as a system adjustment for mitigation** Prior Outage of JUDSON (659333) to TANDE-LNX (659427) to TANDE (659336) 345kV line circuit 1 Curtail GEN-2015-046 and GEN-2016-151 by 100MW; 3 phase fault on TIOGA (661084) to NESET (659138) 230kV line circuit Z, near TIOGA. a. Apply fault at the TIOGA 230kV bus. b. Clear fault after 6 cycles by tripping the faulted line.	Stable	Stable	Stable
103	FLT103-PO	Prior Outage of JUDSON (659333) to TANDE-LNX (659427) to TANDE (659336) 345kV line circuit 1; 3 phase fault on the NESET 230/115/13.8kV (659138/659139/659146) transformer, near NESET 230kV. a. Apply fault at the NESET 230kV bus. b. Clear fault after 6 cycles by tripping the faulted transformer.	Stable	**Un-Stable**	Stable
103 A	FLT103A-PO	**With Generation Curtailment as a system adjustment for mitigation** Prior Outage of JUDSON (659333) to TANDE-LNX (659427) to TANDE (659336) 345kV line circuit 1 Curtail GEN-2015-046 and GEN-2016-151 by 100MW; 3 phase fault on the NESET 230/115/13.8kV (659138/659139/659146) transformer, near NESET 230kV. a. Apply fault at the NESET 230kV bus. b. Clear fault after 6 cycles by tripping the faulted transformer.	Stable	Stable	Stable

Cont. #	Contingency Name	Description	2017 Winter Results	2018 Summer Results	2026 Summer Results
104	FLT104-SB	NESET (659138) 230KV Stuck Breaker Scenario a. Apply single line to ground fault at the 659138 230kV bus. b. Run 16 cycles, then clear fault c. Trip NESET (659138) 230kV bus	Stable	Stable	Stable
105	FLT105-SB	JUDSON (659333) 345KV Stuck Breaker Scenario a. Apply single line to ground fault at Judson 345kV bus. b. Run 16 cycles, then clear fault c. Trip JUDSON (659333) 345kV bus	**Un-Stable**	**Un-Stable**	**Un-Stable**
105 A	FLT105A-SB	**Reconfigure Judson 345kV Substation to double breaker double bus, Single Contingency** JUDSON (659333) 345KV Stuck Breaker Scenario a. Apply single line to ground fault at Judson 345kV bus. b. Run 16 cycles, then clear fault c. Trip JUDSON (659333) to TANDE-LNX (659427) to TANDE (659336) 345kV line.	Stable	Stable	Stable
105 B	FLT105B-SB	**Reconfigure Judson 345kV Substation to double breaker double bus, Single Contingency** JUDSON (659333) 345KV Stuck Breaker Scenario a. Apply single line to ground fault at Judson 345kV bus. b. Run 16 cycles, then clear fault c. Trip JUDSON 345/230/13.8kV (659333/659334/659335) transformer, near JUDSON.	Stable	Stable	Stable
105 C	FLT105C-SB	JUDSON (659333) 345KV Stuck Breaker Scenario a. Apply single line to ground fault at Judson 345kV bus. b. Run 16 cycles, then clear fault c. Trip to JUDSON (659333) to PATENTGATE (659390) 345kV line circuit 1	Stable	Stable	Stable
105 D	FLT105D-SB	**Reduced Fault Clearing Time at Judson 345kV** JUDSON (659333) 345KV Stuck Breaker Scenario a. Apply single line to ground fault at Judson 345kV bus. b. Run 10 cycles, then clear fault c. Trip JUDSON (659333) 345kV bus	**Un-Stable**	**Un-Stable**	**Un-Stable**
105 E	FLT105E-SB	**Shifting of GEN-2016-151 POI to TANDE 230kV, and Reduced Fault Clearing Time at Judson 345kV** JUDSON (659333) 345KV Stuck Breaker Scenario a. Apply single line to ground fault at Judson 345kV bus. b. Run 10 cycles, then clear fault c. Trip JUDSON (659333) 345kV bus	Stable	**Un-Stable**	Stable

Cont. #	Contingency Name	Description	2017 Winter Results	2018 Summer Results	2026 Summer Results
105 F	FLT105F-SB	**Shifting of GEN-2016-151 POI to TANDE 230kV, Reduced Fault Clearing Time at Judson 345kV, and 50MVAR SVC at TANDE 230kV** JUDSON (659333) 345KV Stuck Breaker Scenario a. Apply single line to ground fault at Judson 345kV bus. b. Run 10 cycles, then clear fault c. Trip JUDSON (659333) 345kV bus	Stable	Stable	Stable
Some More Scenarios Simulated for summer 2018 to test System response for FLT105-SB contingency (since it was most critical in summer 2018)					
105A1-SB		Addition of DPA-2018-August-918 identified upgrades: Northshore 230 kV Substation, Neset - Northshore 230 kV circuit 1, Northshore 230/115 kV Transformer, Northshore - New Town 115 kV Ckt 1 JUDSON (659333) 345KV Stuck Breaker Scenario a. Apply single line to ground fault at Judson 345kV bus. b. Run 10 cycles, then clear fault c. Trip JUDSON (659333) 345kV bus		**Un-Stable**	
FLT105F1-SB		Reduction in GEN-2016-151request size to **25 MW** (With 50 MW oscillations were observed) JUDSON (659333) 345KV Stuck Breaker Scenario a. Apply single line to ground fault at Judson 345kV bus. b. Run 10 cycles, then clear fault c. Trip JUDSON (659333) 345kV bus		Stable	
FLT105F2-SB		Addition of Judson 345kV/230kV Transformer circuit 2 (identical parameters to circuit 1) JUDSON (659333) 345KV Stuck Breaker Scenario a. Apply single line to ground fault at Judson 345kV bus. b. Run 10 cycles, then clear fault c. Trip JUDSON (659333) to TANDE-LNX (659427) to TANDE (659336) 345kV line		**Un-Stable**	
FLT105F3-SB		Addition of Judson 345kV/230kV Transformer circuit 2 (identical parameters to circuit 1) JUDSON (659333) 345KV Stuck Breaker Scenario a. Apply single line to ground fault at Judson 345kV bus. b. Run 10 cycles, then clear fault c. Trip Judson (659333) to Tande-LNX (659427) to Tande (659336) 345kV line and Judson 345kV/230kV Transformer circuit 1		**Un-Stable**	

Cont. #	Contingency Name	Description	2017 Winter Results	2018 Summer Results	2026 Summer Results
FLT105F3A-SB		Addition of Judson 345kV/230kV Transformer and Judson to Williston 230kV circuit 2 (identical parameters to circuit 1) JUDSON (659333) 345KV Stuck Breaker Scenario a. Apply single line to ground fault at Judson 345kV bus. b. Run 10 cycles, then clear fault c. Trip Judson (659333) to Tande-LNX (659427) to Tande (659336) 345kV line, Judson 345kV/230kV Transformer circuit 1, and Judson to Williston 230kV circuit 1		Stable	
FLT105F4-SB		Addition of Tande 345kV/230kV Transformer circuit 2 (identical parameters to circuit 1) JUDSON (659333) 345KV Stuck Breaker Scenario a. Apply single line to ground fault at Judson 345kV bus. b. Run 10 cycles, then clear fault c. Trip JUDSON (659333) 345kV bus		Stable	
FLT105F5-SB		Addition of **100MVAR SVC** at Tande 230kV JUDSON (659333) 345KV Stuck Breaker Scenario a. Apply single line to ground fault at Judson 345kV bus. b. Run 10 cycles, then clear fault c. Trip JUDSON (659333) 345kV bus		**Un-Stable**	
FLT105F6-SB		Addition of **50MVAR SVC** at Tande 345kV JUDSON (659333) 345KV Stuck Breaker Scenario a. Apply single line to ground fault at Judson 345kV bus. b. Run 10 cycles, then clear fault c. Trip JUDSON (659333) 345kV bus		Stable	
FLT105F7-SB		Addition of DPA-2018-August-918 identified upgrades: Northshore 230 kV Substation, Neset - Northshore 230 kV circuit 1, Northshore 230/115 kV Transformer, Northshore - New Town 115 kV circuit 1 JUDSON (659333) 345KV Stuck Breaker Scenario a. Apply single line to ground fault at Judson 345kV bus. b. Run 10 cycles, then clear fault c. Trip JUDSON (659333) 345kV bus		**Un-Stable**	

Cont. #	Contingency Name	Description	2017 Winter Results	2018 Summer Results	2026 Summer Results
FLT105F8-SB		Addition of DPA-2018-August-918 identified upgrades with a 345kV voltage conversion upgrade: Northshore 345 kV Substation, Neset - Northshore 345 kV circuit 1 (use the per mi characteristics from Judson-Tande 345kV), Northshore 345/115 kV Transformer (use the transformer characteristics from Patent Gate or Kummer Ridge transformers), Northshore - New Town 115 kV circuit 1 JUDSON (659333) 345KV Stuck Breaker Scenario a. Apply single line to ground fault at Judson 345kV bus. b. Run 10 cycles, then clear fault c. Trip JUDSON (659333) 345kV bus		Stable	
FLT105F9-SB		Shifting of GEN-2016-151 POI to TANDE 230kV and addition of DPA-2018-August-918 identified upgrades: Northshore 230 kV Substation, Neset - Northshore 230 kV circuit 1, Northshore 230/115 kV Transformer, Northshore - New Town 115 kV circuit 1 JUDSON (659333) 345KV Stuck Breaker Scenario a. Apply single line to ground fault at Judson 345kV bus. b. Run 10 cycles, then clear fault c. Trip JUDSON (659333) 345kV bus		**Un-Stable**	
FLT105C1-SB		345kV Stuck Breaker for fault on Judson to Patent Gate 345kV circuit at the Judson 345kV bus a. Apply single line to ground fault on the Judson to Patent Gate 345kV circuit at Judson 345kV bus. b. Run 4 cycles, then trip the Judson to Patent Gate 345kV circuitc. Run 6 additional cycles, then clear fault		Stable	
FLT106-SB		345kV Stuck Breaker for fault on Judson to Tande 345kV circuit at the Judson 345kV bus a. Apply single line to ground fault on the Judson to Tande 345kV circuit at Judson 345kV bus. b. Run 4 cycles, then trip the Judson to Tande 345kV circuitc. Run 6 additional cycles, then trip the Judson 345/230kV transformer to clear fault		**Un-Stable**	
FLT107-SB		345kV Stuck Breaker for fault on Judson 345/230kV transformer at the 345kV bus a. Apply single line to ground fault on the Judson 345/230kV transformer at Judson 345kV bus. b. Run 4 cycles, then trip the Judson 345/230kV transformerc. Run 6 additional cycles, then trip the Judson to Tande 345kV circuit to clear fault		**Un-Stable**	

Cont. #	Contingency Name	Description	2017 Winter Results	2018 Summer Results	2026 Summer Results
	FLT108-SB	345kV Stuck Breaker for fault on Judson 345/230kV transformer at the 230kV bus a. Apply single line to ground fault on the Judson 345/230kV transformer at Judson 230kV bus. b. Run 4 cycles, trip the Judson (659334) to Williston (652400) 230kV circuit c. Run 6 additional cycles, then trip the Judson to Tande 345kV circuit and the Judson 345/230kV transformer to clear fault		Un-Stable	
	FLT109-SB	230kV Stuck Breaker for fault on Judson 345/230kV transformer circuit 1 at the 230kV bus a. Apply single line to ground fault on the Judson 345/230kV transformer at Judson 230kV bus. b. Run 4 cycles, trip the Judson 345kV/230kV Transformer circuit 1c. Run 6 additional cycles, then trip the Judson (659334) to Williston (652400) 230kV circuit 1 to clear fault		Stable	
	FLT110-SB	230kV Stuck Breaker for fault on Judson (659334) to Williston (652400) 230kV circuit 1 at the Judson 230kV bus a. Apply single line to ground fault on the Judson (659334) to Williston (652400) 230kV circuit 1 at the 659334 230kV bus. b. Run 4 cycles, trip the Judson (659334) to Williston (652400) 230kV circuit 1c. Run 6 additional cycles, then trip the Judson 345/230kV transformer circuit 1 to clear fault		Stable	
	FLT108A-SB	**Addition of Judson 345kV/230kV Transformer and Judson to Williston 230kV circuit 2** 345kV Stuck Breaker for fault on Judson 345/230kV transformer circuit 1 at the 230kV bus a. Apply single line to ground fault on the Judson 345/230kV transformer circuit 1 at the 230kV bus. b. Run 4 cycles, disconnect the Judson 345kV/230kV Transformer circuit 1 from the Judson 230kV bus, retain the fault at transformer 230kV terminal c. Run 6 additional cycles, then trip the Judson to Tande 345kV circuit and the Judson 345/230kV transformer circuit 1 to clear fault		Un-Stable	

Cont. #	Contingency Name	Description	2017 Winter Results	2018 Summer Results	2026 Summer Results
		Addition of Judson 345kV/230kV Transformer and Judson to Williston 230kV circuit 2			
	FLT108B-SB	345kV Stuck Breaker for fault on Judson 345/230kV transformer circuit 2 at the 230kV bus a. Apply single line to ground fault on the Judson 345/230kV transformer circuit 2 at the 230kV bus. b. Run 4 cycles, disconnect the Judson 345kV/230kV Transformer circuit 2 from the Judson 230kV bus, retain the fault at transformer 230kV terminal c. Run 6 additional cycles, then trip the Judson to Patent Gate 345kV circuit and the Judson 345/230kV transformer circuit 2 to clear fault		Stable	

4.2. Simulation Results for unstable faults

For cluster scenario, there are no impacts on the stability performance of the SPP system for the contingencies tested on the SPP provided base cases, except for the following critical contingencies in each scenario:

- Winter-2017 scenario: FLT18-PO, FLT102-PO, and FLT105-SB.
- Summer-2018 Scenario: FLT16-3PH, FLT18-PO, FLT102-PO, FLT103-PO, and FLT105-SB.
- Summer-2026 Scenario: FLT18-PO, FLT102-PO, and FLT105-SB.
- In general, FLT81-3PH, FLT82-3PH, and FLT83-3PH (during all scenarios) shows unstable response for only two machines i.e., GRE-COAL 41G (615001) and GRE-COAL 41G (615002). However, other system response is stable.

In order to solve these critical contingencies, the following transmission updates/reconfiguration have been proposed:

1. FLT16-3PH, P1 event on the Judson to Tande 345kV circuit, is unstable only in summer-2018 conditions. In the transient run, after the line tripping, adjust GEN-2015-046 machine at bus 584873 auxiliary model VWVAR6 VAR L+1 power factor set point from 0.991 (40 MVar) to 0.98 (60.9 MVAR). This modified fault definition, FLT16A-3PH, shows stable response.
2. FLT81-3PH, FLT82-3PH, and FLT83-3pH, P1 events on circuits terminated at GRE Stanton 230kV, are tested with reduced fault clearing time. However, the machines response for GRE-COAL 41G (615001) and GRE-COAL 41G (615002) are not found satisfactory, loss of synchronism observed. The system response of all other monitored channels were found satisfactory. As further investigation, the governor model for these machines were tested by replacing from IEEEG1 type to the updated WSIEG1 type along-with and remove (switch offline) the withdrawn J511 (buses 85111-85116) request. Even with these changes, the machines responses were not stable. Therefore, it is suggested that SPP should coordinate with GRE to for further investigation on these two machines.
3. For FLT18-PO, FLT102-PO, and FLT103-PO, P6 events with a prior outage of a Tande 345kV circuit, Generation Curtailment (100MW between GEN-2015-046 and GEN-2016-151) was found to mitigate the instability.
4. For FLT105-SB, P4 event with a stuck breaker at Judson 345kV, the issue appeared to be actually power transfer limitation for the simultaneous loss of multiple circuits at Judson 345kV and not the deficiency of reactive power

at Tande 345kV. In order to address this, different scenarios were tested i.e., Reconfigure Judson 345kV substation to double breaker double bus configuration and tripping of One circuit during stuck breaker event, Changing the POI for GEN-2016-151 to Tande 230 kV, Generation Curtailment, Transmission Upgrades (additional transformers and line circuits), DPA-2018-August-918 identified upgrades, DPA-2018-August-918 identified upgrades converted from 230kV to 345kV, Consideration of SVC at 345kV TANDE OR consideration of SVC at 230kV TANDE (with and without shifting of GEN-2016-151 POI to 230kV). It is important to note here that some of the proposals work fine for the satisfactory results for FLT105-SB. Following are among these workable solutions:

- DPA-2018-August-918 identified upgrades converted from 230kV to 345kV (as defined above in scenario FLT105F8-SB)
- Consideration of a 50 MVAR SVC at 345kV Bus (as defined above in scenario FLT105F6-SB)
- Addition of Tande 345kV/230kV Transformer circuit 2 (as defined above in scenario FLT105F4-SB)
- Reduction of GEN-2016-151 from 202MW to 25MW (as defined above in scenario FLT105F1-SB)
- Reconfigure Judson 345kV Substation from ring bus to double breaker double bus (as defined above in scenarios FLT105A-SB, FLT105B-SB, & FLT105C-SB)

Since all the proposed upgrades requiring additional transmission facilities are associated with significant cost, it is recommended that Judson 345kV Substation be reconfigured such that only one circuit should be considered tripped during stuck breaker event i.e., during stuck breaker event only a single circuit; Judson to Tande 345kV, Judson to Patent Gate 345kV, or Judson 345/230kV transformer be considered.

With the above recommendations there are no impacts on the stability performance of the SPP system during cluster scenarios for the contingencies tested on the provided base cases.

For the other contingencies, the study machines stayed on-line and stable for all simulated faults. The project stability simulations specified test disturbances did not show instability problems in the SPP system. Any oscillations were damped out.

5. Conclusions

The findings of the impact study for the proposed interconnection projects under DISIS-2016-002-2 (Group 16) Revise considered 100% of their proposed installed capacity are as follows:

Except for the following contingencies involving circuits connected to Judson 345kV, Tande 345kV, Neset 230kV, GRE Stanton 230kV in each scenario, there are no impacts on the stability performance of the SPP system during cluster scenarios for the contingencies tested on the provided base cases:

- Winter-2017 scenario: FLT18-PO, FLT102-PO, and FLT105-SB.
- Summer-2018 Scenario: FLT16-3PH, FLT18-PO, FLT102-PO, FLT103-PO, and FLT105-SB.
- Summer-2026 Scenario: FLT18-PO, FLT102-PO, and FLT105-SB.
- In general, FLT81-3PH, FLT82-3PH, and FLT83-3PH (during all scenarios) shows unstable response for only two machines i.e., GRE-COAL 41G (615001) and GRE-COAL 41G (615002). However, other system response is stable.

In order to solve these critical contingencies, the following transmission updates/reconfiguration have been proposed:

1. FLT16-3PH is unstable only in summer-2018 conditions, In the transient run, after the line tripping, adjust GEN-2015-046 machine at bus 584873 the auxiliary model VWVAR6 VAR L+1 power factor set point from 0.991 (40 MVar) to 0.98 (60.9 MVAR). This modified fault definition, FLT16A-3PH, shows stable response.
2. FLT81-3PH, FLT82-3PH, and FLT83-3pH are tested with reduced fault clearing time. However, the machines response for GRE-COAL 41G (615001) and GRE-COAL 41G (615002) are not found satisfactory, loss of synchronism observed. As further investigation, the governor model for these machines were tested by replacing from IEEEG1 type to the updated WSIEG1 type along-with and remove (switch offline) the withdrawn J511 (buses 85111-85116) request. Even with these changes, the machines responses were not stable. Therefore, it is suggested that SPP should coordinate with GRE to for further investigation on these two machines.
3. For FLT18-PO, FLT102-PO, and FLT103-PO Generation Curtailment (100MW between GEN-2015-046 and GEN-2016-151) was found to mitigate the instability.
4. For FLT105-SB, the issue appeared to be actually power transfer limitation for the simultaneous loss of multiple circuits at Judson 345kV and not the deficiency of reactive power at Tande 345kV. In order to address this, different scenarios were tested i.e., Reconfigure Judson 345kV substation to double breaker double bus configuration and tripping of One circuit during stuck breaker event, Changing the POI for GEN-2016-151 to Tande 230 kV, Generation Curtailment, Transmission Upgrades (additional transformers and line circuits), DPA-2018-August-918 identified upgrades, DPA-2018-August-918 identified upgrades converted from 230kV to 345kV, Consideration of SVC at 345kV TANDE OR consideration of SVC at 230kV TANDE (with and without shifting of GEN-2016-151 POI to Tande 230kV). It is important to note here that some of the proposals work fine for the satisfactory results for FLT105-SB. Following are among these workable solutions:

- DPA-2018-August-918 identified upgrades converted from 230kV to 345kV (as defined above in scenario FLT105F8-SB)
- Consideration of a 50 MVAR SVC at 345kV Bus (as defined above in scenario FLT105F6-SB)
- Addition of Tande 345kV/230kV Transformer circuit 2 (as defined above in scenario FLT105F4-SB)
- Reduction of GEN-2016-151 from 202MW to 25MW (as defined above in scenario FLT105F1-SB)
- Reconfigure Judson 345kV Substation from ring bus to double breaker double bus (as defined above in scenarios FLT105A-SB, FLT105B-SB, & FLT105C-SB)

Since all the proposed upgrades requiring additional transmission facilities are associated with significant cost, it is recommended that Judson 345kV Substation be reconfigured such that only one circuit should be considered tripped during stuck breaker event i.e., during stuck breaker event only a single circuit; Judson to Tande 345kV, Judson to Patent Gate 345kV, or Judson 345/230kV transformer be considered.

With the above recommendations there are no impacts on the stability performance of the SPP system during cluster scenarios for the contingencies tested on the provided base cases. For all contingencies evaluated, the study machines stayed on-line and stable for all simulated faults. The project stability simulations specified test disturbances did not show instability problems in the SPP system. Any oscillations were damped out.

6. **Appendix A: 2017 winter Peak Case Stability Run Plots – Cluster**

7. **Appendix B: 2018 summer Peak Case Stability Run Plots – Cluster**

8. **Appendix B-Addendum: 2018 Summer Peak Additional Scenarios for FLT105-SB event**

9. **Appendix C: 2026 Summer Peak Case Stability Run Plots – Cluster**

10. **Appendix D: Project Model Data**

(Appendices available from SPP upon request.)

Southwest Power Pool Inc. (SPP)

Definitive Impact Study

DISIS-2016-002 (Group 16) Sensitivity

Report Submitted to
Southwest Power Pool Inc.
June 2020

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1. Executive Summary

The DISIS-2016-002 (Group 16) Sensitivity Impact Study is a generation interconnection study performed by POWER-tek Global Inc. for Southwest Power Pool (SPP). This report presents the results of impact study comprising of short circuit and stability analyses for the proposed interconnection projects under Addendum-2-DISIS16-2 (Group 16) "The Projects" as described in Table 1.1 below:

Table 1.1: Interconnection Request

Request	Size (MW)	Generator Model	Point of Interconnection (POI)
GEN-2016-130	202	GE 2.0MW WTG (588213)	Leland Olds 345kV (659105)
GEN-2016-151	202	GE 2.0MW WTG (588283)	Tande 345kV Sub (659336)

Short circuit analysis up to 5 Buses away from each point of interconnection (POI) and the transient stability simulations were performed for the Projects in service at its full output. SPP provided three base cases for Winter-2017, Summer-2018, and Summer-2026, each comprising of a power flow, sequence data and corresponding dynamics database. The previous queued request projects were already modeled in the base cases. However, prior to technical analysis, some updates were applied on the given base cases as per the instructions and files received from SPP. These updates include:

- The projects "J511 & J593" are removed/turned OFF and used MISO system to offset generation.
- Withdrawal of GEN-2016-052, 3.3MW uprate of GEN-2005-008IS changed to 49.5 MW, and used SPP system to offset generation with updated dynamic models i.e., "GEN-2005-008IS_v33.dyr "change to GE 1.5MW WTG.
- Withdrawal of GEN-2016-053, 3.3MW uprate of GEN-2006-015IS changed to 49.5 MW, and used SPP system to offset generation with updated dynamic models i.e., "GEN-2006-015IS_v33.dyr" change to GE 1.5MW WTG.
- Withdrawal of GEN-2016-155, 1.2 MW uprate of GEN-2007-015IS changed to 102.4 MW, and used SPP system to offset generation with updated dynamic models i.e., "GEN-2007-015IS_V33.dyr" change to GE 1.6MW WTG.
- The project "GEN-2012-012IS" is removed/turned OFF and used SPP system to offset generation.
- GEN-2015-046 changed to 298.8 MW (Vestas V110 2.0MW & Nordex-Acciona 4.8MW), and used SPP system to offset generation with updated dynamic models i.e., "GEN-2015-046.dyr".

Stability analysis results indicate that system remain stable for all the defined contingencies except for FLT102-PO (for all scenarios) involving prior outage of JUDSON (659333) to TANDE-LNX (659427) to TANDE (659336) 345kV line along-with tripping of TIOGA (661084) to NESET (659138) 230kV line.

In order to maintain stability for FLT102-PO contingency, the following mitigations have been proposed for GEN-2015-046 and GEN-2016-151:

1. Without DPA-2018-August-918 identified upgrades (AQ-Study Upgrades: Northshore 230 kV Substation, Neset - Northshore 230 kV circuit 1, Northshore 230/115 kV Transformer, Northshore - New Town 115 kV Ckt 1), following prior outage Curtail Tande 345kV generation to 280 MW i.e., (101MW i.e., 50% for GEN-2016-151, and 179MW i.e., 60% for GEN-2015-046) with main transformer (345/34.5kV) tap settings to unity, and regardless of voltage schedule. The dynamic results are attached as FLT102A-PO.

   In this case, there is thermal limitation on the 188MVA Neset 230/115kV transformer since all power injection at Tande 345kV is directed through this radial transformer. Curtailment for this system condition may require reduction beyond the identified stability limitation.

2. With AQ study upgrades applied, maintaining 1.02 p.u voltage at POI (Tande 345kV), and main transformer (345/34.5kV) tap settings to unity:
   a. following prior outage, Curtail Tande 345kV generation to 375 MW i.e., (151.5MW i.e., 75% for GEN-2016-151, and 224.1 MW i.e., 75% for GEN-2015-046) with generator voltage schedule of GEN-2015-046 to 1.01 p.u and GEN- GEN-2016-151 to 1.03 p.u. The dynamic results are attached as FLT102B-PO.
   b. following prior outage, Curtail Tande 345kV generation to 435 MW i.e., (175.7MW i.e., 87% for GEN-2016-151, and 260 MW i.e., 87% for GEN-2015-046) with generator voltage schedule of GEN-2015-046 to 1.05 p.u and GEN- GEN-2016-151 to 1.05 p.u. The dynamic results are attached as FLT102C-PO.

With the above recommendations there are no impacts on the stability performance of the SPP system during cluster scenarios for the contingencies tested on the provided base cases. For all contingencies evaluated, the study machines stayed on-line and stable for all simulated faults. The project stability simulations specified test disturbances did not show instability problems in the SPP system. Any oscillations were damped out.

2. Introduction

2.1. Project Overview and Assumptions

The DISIS-2016-002 (Group 16) Sensitivity Impact Study is a generation interconnection study performed by POWER-tek Global Inc. for SPP. This report presents the results of impact study comprising of short circuit analysis and stability analyses for the proposed interconnection projects under Addendum-2-DISIS16-2 (Group 16) ("The Projects") as described in Table 2.1.1 below:

Table 2.1.1: Interconnection requests

Request	Size (MW)	Generator Model	Point of Interconnection (POI)
GEN-2016-130	202	GE 2.0MW WTG (588213)	Leland Olds 345kV (659105)
GEN-2016-151	202	GE 2.0MW WTG (588283)	Tande 345kV Sub (659336)

Prior to technical analysis, some updates were applied on the given base cases as per the instructions and files received from SPP. These updates include:

- The projects "J511 & J593" are removed/turned OFF and used MISO system to offset generation.
- Withdrawal of GEN-2016-052, 3.3MW uprate of GEN-2005-008IS changed to 49.5 MW, and used SPP system to offset generation with updated dynamic models i.e., "GEN-2005-008IS_v33.dyr "change to GE 1.5MW WTG.
- Withdrawal of GEN-2016-053, 3.3MW uprate of GEN-2006-015IS changed to 49.5 MW, and used SPP system to offset generation with updated dynamic models i.e., "GEN-2006-015IS_v33.dyr" change to GE 1.5MW WTG.
- Withdrawal of GEN-2016-155, 1.2 MW uprate of GEN-2007-015IS changed to 102.4 MW, and used SPP system to offset generation with updated dynamic models i.e., "GEN-2007-015IS_V33.dyr" change to GE 1.6MW WTG.
- The project "GEN-2012-012IS" is removed/turned OFF and used SPP system to offset generation.
- GEN-2015-046 changed to 298.8 MW (Vestas V110 2.0MW & Nordex-Acciona 4.8MW), and used SPP system to offset generation with updated dynamic models i.e., "GEN-2015-046.dyr".

After applying updates, figure 2.1.1, and 2.1.2, shows the single line diagram for the interconnection of the Projects to present and planned system of SPP. This arrangement was modeled and studied in power flow cases for these projects.

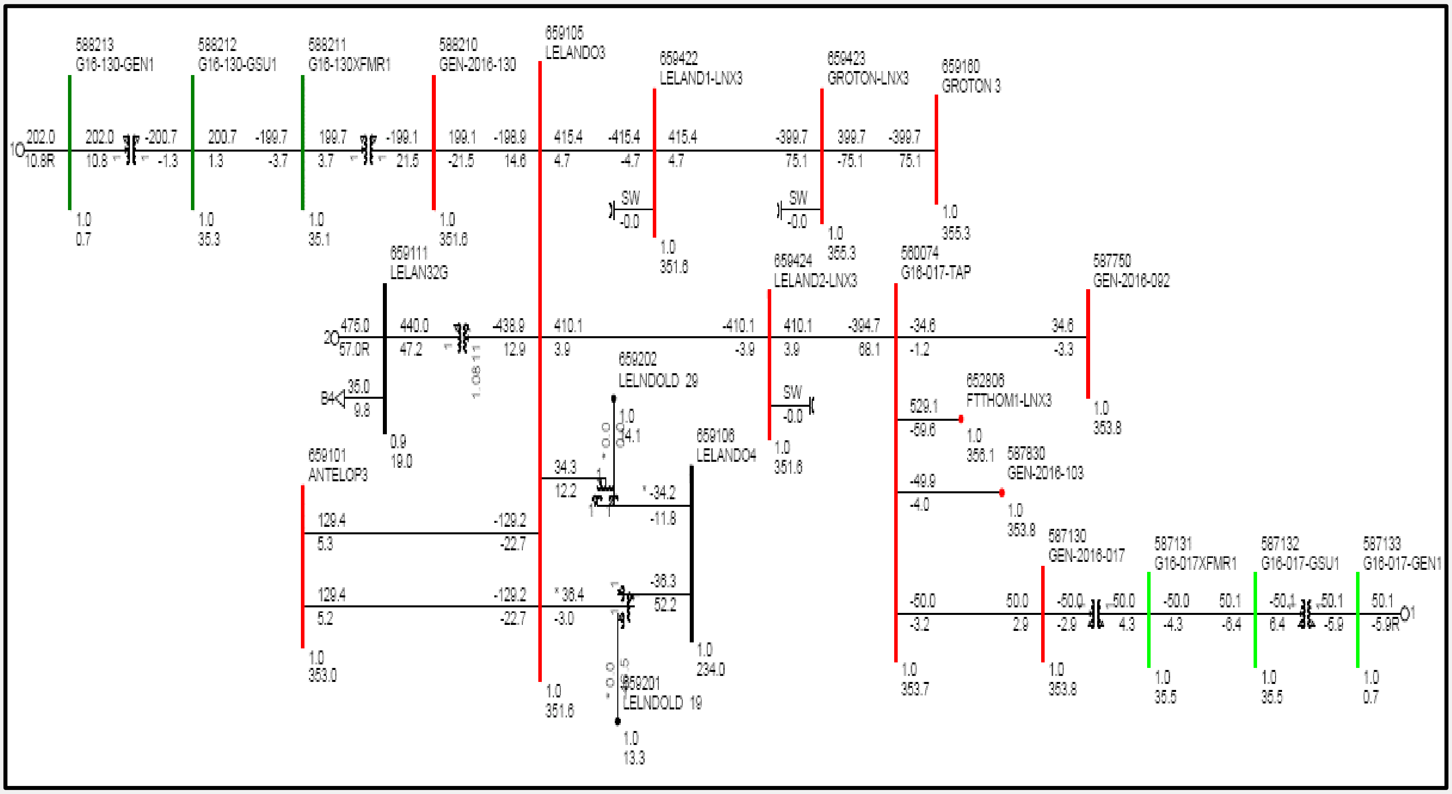

Figure 2.1.1: Power flow single line diagram for GEN-2016-130 and surrounding system components

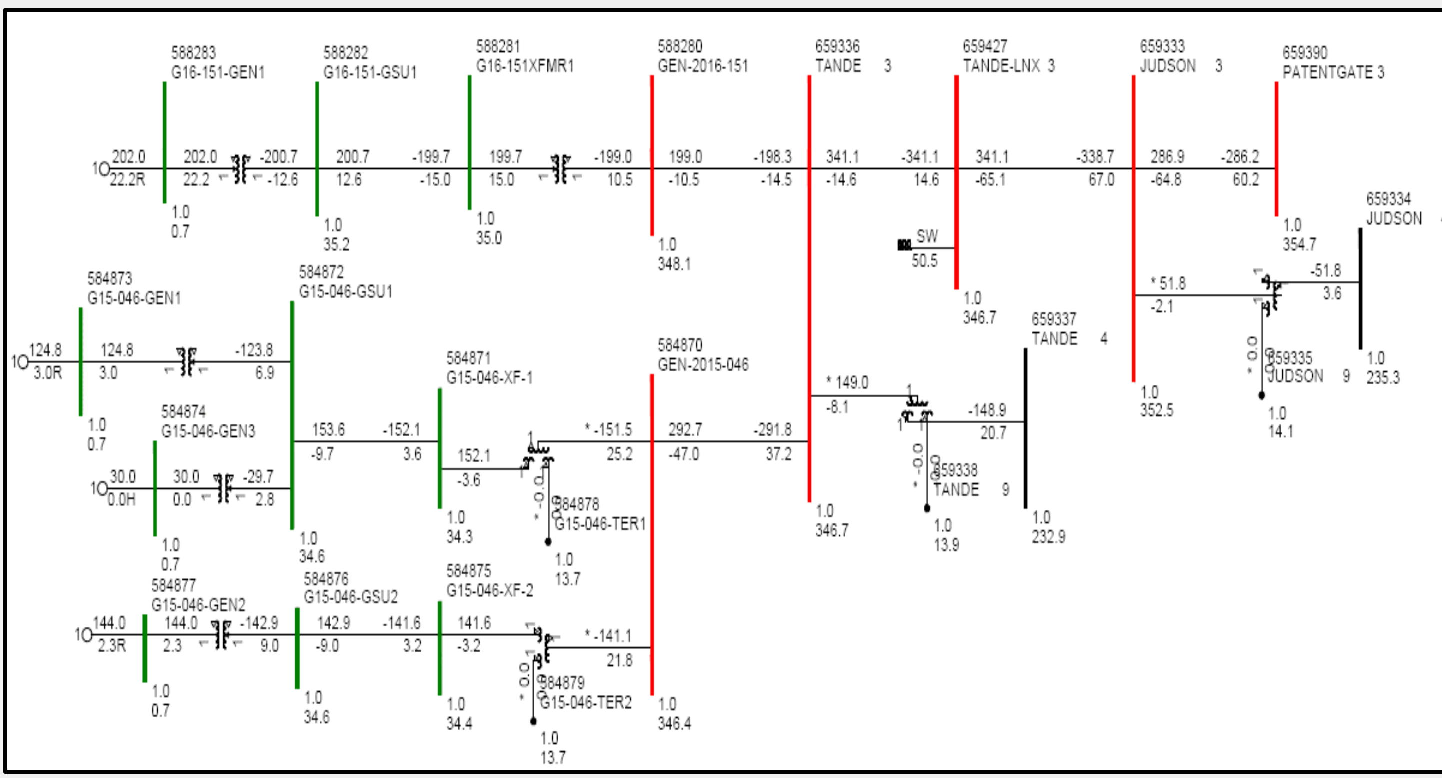

Figure 2.1.2: Power flow single line diagram for GEN-2016-151 and surrounding system components

Appendix-D contains the machines, interconnection, and machines user model parameters.

Table 2.1.2 below shows the list of prior queued projects modeled in the base case.

Table 2.1.2: List of previous queued request projects

Addendum	Request	Size (MW)	Wind Turbine Model	Point of Interconnection
Include	Coyote	453	GENROU	Coyote 345kV (661016)
Include	G380	149.1	Suzlon S88 2.1MW	Rugby 115kV (620379)
Include	G408	11.88	WT1 Generic Wind	Tap McHenry - Souris 115kV (605634)
Include	G502	50.6	W4GUR Wind	Milton Young 230kV (657756)
Include	G645/G788	102.6	GENROU	Ladish 115kV (620270)
Include	G723	7	GENSAL	Heskett 115kV (661043)
Include	G752	150	WT3 Generic Wind	Tap Bison - Hettinger 230kV (661047)
Include	G830	99	GENCLS	GRE McHenry 115kV (615348)
Include	J003	19.5	WT3 Generic Wind	Baker 115kV (661005)
Include	J249	180	WT3 Generic Wind	MDU Tatanka 230kV (661096)
Include	J262/J263	200	Vestas V100 2.0MW	Jamestown 345 (620269)
Include	J290	150	Vestas V100 2.0MW	Tap Glenboro South - Rugby 230kV (602057)
Include	J316	150	GE 1.7045MW	MDU 230 kV Tatanka-Ellendale line (11117)
Exclude	J511	200 (withdrawal not reflected in study)	Vestas V110 2MW	Stanton 230kV (615901)
Exclude	J593	224 (withdrawal not reflected in study)	Vestas V110 2MW	Tioga 4 230kV (661084)
Include	MPC01300	455	GENROU	Square Butte 230kV (657756)
Include	MPC02100	100	GE 2.0MW WTG	Center-Mandan 230kV (657741)

Addendum	Request	Size (MW)	Wind Turbine Model	Point of Interconnection
Include	Young1	274	GENROU	Center 230kV (657751)
Include	GEN-2005-008IS	49.5	GE 1.5MW	Hilken 230kV [Ecklund 230kV] (652466)
Exclude	GEN-2016-052	(withdrawal of GEN-2016-052, 3.3MW uprate of GEN-2005-008IS, not reflected in study)		Hilken 230kV [Ecklund 230kV] (652466)
Include	GEN-2006-015IS	49.5	GE 1.5MW	Hilken 230kV [Ecklund 230kV] (652466)
Exclude	GEN-2016-053	(withdrawal of GEN-2016-053, 3.3MW uprate of GEN-2006-015IS, not reflected in study)	GE 1.6MW	Hilken 230kV [Ecklund 230kV] (652466)
Include	GEN-2007-015IS	102.4	GE 1.6MW WTG (659366)	Hilken 230kV [Ecklund 230kV] (652466)
Include	GEN-2009-026IS	106.5	GENROU	Dickenson-Heskett 230kV (652468)
Include	GEN-2011-005IS/GEN-2012-005IS/GEN-2012-007IS	141	GENROU	Williston 115kV (652421)
Include	GEN-2012-002IS	47	GENROU	Watford City 115/230kV (652408)
Include	GEN-2012-004IS/GEN-2012-008IS	94	GENROU	Williston-Ch. Creek 230kV (652216)
Include	GEN-2012-006IS	141	GENROU	Williston-Ch. Creek 230kV (659391)
Exclude	GEN-2012-012IS	75 (withdrawal not reflected in study)	GE 2.678MW	Wolf Point-Circle 115kV (910007)
Include	GEN-2014-006IS	113.3	GENSAL	Williston 115kV (659430)
Include	GEN-2014-010IS	150	Vestas V110 VCSS 2.0MW	Neset 115kV (659139)

Addendum	Request	Size (MW)	Wind Turbine Model	Point of Interconnection
Include	GEN-2014-014IS	149.73	GE 1.715/1.79MW	Belfield-Rhame 230kV (659448)
Include	GEN-2015-046	298.8	Vestas V110 2.0MW Nordex-Acciona 4.8MW	Tande 345kV (659336)
Include	GEN-2015-096	149.03	GE 2.0MW	Tap Belfied - Rhame 230kV (659448)
Include	GEN-2016-004	201.6	Vestas V110 VCSS 2.0MW, Vestas V136 3.6MW	Leland Olds 230kV (659106)

ATC (Available Transfer Capability) studies were not performed as part of this study. These studies will be required at the time transmission service is actually requested. Additional transmission upgrades may be required based on that analysis.

Study assumptions in general have been based on the specific information and data provided by SPP. The accuracy of the conclusions contained within this study is dependent on the assumptions made with respect to other generation additions and transmission improvements planned by other entities. Changes in the assumptions of the timing of other generation additions or transmission improvements may affect this study's conclusions.

2.2. Objectives

The objectives of the study are to determine the impact on system stability of interconnecting the proposed power plants to SPP's transmission system.

2.3. Models and Simulations Tools Used

Version 33.7 of the Siemens, PSS/E^{TM} power system simulation program was used in this study.

SPP provided its latest stability database cases for Winter-2017, Summer-2018, and Summer-2026 peak seasons. The Project's PSS/E model had been developed prior to this study and was included in the power flow case and the dynamics database. Machines, interconnection and dynamic model data for the Project plants is provided in Appendix D.

Power flow single line diagram of the projects in summer 2018 peak condition is shown in Figure 2.1.1, and 2.1.2 respectively. These figures show that each wind farm model includes representation of the radial transmission line and the substation transformer from transmission voltage (345kV) to the collector system voltage (34.5V), as well as the generation voltage for the wind farms (0.7 kV). The remainder of each wind farm is represented by lumped equivalents including a generator, a step-up transformer, and collector system impedance.

No special modeling is required of line relays in these cases, except for the special modeling related to the wind-turbine tripping.

All generators in Areas 356, 600, 615, 620, 635, 640, 645, 652, and 661 were monitored.

3. Short Circuit Analysis

The short circuit analysis out five buses away was performed for 2018 and 2026 summer peak cases for each interconnection request under project cluster scenario of DISIS-2016-002-2 (Group 16) Revise. No outage was assumed in the system model.

3.1. Short Circuit Result for 2018 Summer Peak Case

The short circuit results for summer-2018 scenario at the POI are tabulated below.

3.1.1. Short Circuit Result for Leland Olds 345kV (659105)

The results of the short circuit analysis for GEN-2016-130 POI i.e., Leland Olds 345kV (659105) and five bus levels away are tabulated below in Table 3.1.1.

Table 3.1.1: Short circuit results for Leland Olds 345kV (659105)

Bus #	Bus Name	Level Away	Short Circuit Value with GEN-2016-130 Project (Amperes)	Short Circuit Value without GEN-2016-130 Project (Amperes)	Net Contribution of GEN-2016-130 Project (Amperes)
			3 PH	3 PH	3 PH
659105	LELANDO3 345.0	0 LEVELS AWAY	17118.6	16731.8	386.8
588210	GEN-2016-130345.0	1 LEVELS AWAY	11884.9	11494.1	390.8
659101	ANTELOP3 345.0	1 LEVELS AWAY	16951.1	16784.9	166.2
659106	LELANDO4 230.0	1 LEVELS AWAY	23821.4	23500.6	320.8
659422	LELAND1-LNX3345.0	1 LEVELS AWAY	17118.6	16731.8	386.8
659424	LELAND2-LNX3345.0	1 LEVELS AWAY	17118.6	16731.8	386.8
560074	G16-017-TAP 345.0	2 LEVELS AWAY	6906.6	6903.5	3.1
587030	GEN-2016-004230.0	2 LEVELS AWAY	7965.3	7932.8	32.5
615901	GRE-STANTON4230.0	2 LEVELS AWAY	16909.8	16899.1	10.7
652441	GARRISN4 230.0	2 LEVELS AWAY	12130.9	12111.9	19
652456	WASHBRN4 230.0	2 LEVELS AWAY	10829.4	10784.4	45
659108	LOGAN 4 230.0	2 LEVELS AWAY	5805.7	5800	5.7
659109	BASIN 7 115.0	2 LEVELS AWAY	5716.5	5707.2	9.3
659183	CHAR.CK3 345.0	2 LEVELS AWAY	10639.9	10612.7	27.2

Bus #	Bus Name	Level Away	Short Circuit Value with GEN-2016-130 Project (Amperes)	Short Circuit Value without GEN-2016-130 Project (Amperes)	Net Contribution of GEN-2016-130 Project (Amperes)
			3 PH	3 PH	3 PH
659212	DGC 3345.0	2 LEVELS AWAY	16212.2	16060.2	152
659218	COTEAU 3345.0	2 LEVELS AWAY	16951.1	16784.9	166.2
659384	ROUNDUP 3345.0	2 LEVELS AWAY	9055.6	9030.3	25.3
659420	ANTELOP-LNX3345.0	2 LEVELS AWAY	16951.1	16784.9	166.2
659423	GROTON-LNX3 345.0	2 LEVELS AWAY	6015.2	6012	3.2
587130	GEN-2016-017345.0	3 LEVELS AWAY	6849.4	6846.3	3.1
587750	GEN-2016-092345.0	3 LEVELS AWAY	6180.8	6178.3	2.5
587830	GEN-2016-103345.0	3 LEVELS AWAY	6850.5	6847.3	3.2
615600	GRE-COAL CR4230.0	3 LEVELS AWAY	16828.6	16822.5	6.1
615900	GRE-COAL TP4230.0	3 LEVELS AWAY	14856.1	14850.4	5.7
652420	NSALEM 7 115.0	3 LEVELS AWAY	1995.5	1994.4	1.1
652424	BELFELD3 345.0	3 LEVELS AWAY	6846.3	6838.8	7.5
652426	BISMARK4 230.0	3 LEVELS AWAY	14827.2	14812.7	14.5
652442	GARRISN7 115.0	3 LEVELS AWAY	13705.9	13700.5	5.4
652444	JAMESTN4 230.0	3 LEVELS AWAY	9202.4	9200.3	2.1
652466	HILKEN 4 230.0	3 LEVELS AWAY	9272.1	9266.3	5.8
652806	FTTHOM1-LNX3345.0	3 LEVELS AWAY	10079.6	10076.8	2.8
657756	SQBUTTE4 230.0	3 LEVELS AWAY	21102.1	21094.7	7.4
659143	BLAISDELL 4230.0	3 LEVELS AWAY	5443	5440.6	2.4
659155	LOGAN 7 115.0	3 LEVELS AWAY	9810.8	9806.3	4.5
659160	GROTON 3 345.0	3 LEVELS AWAY	6015.2	6012	3.2
659182	CHAR.CK7 115.0	3 LEVELS AWAY	14853.3	14837.1	16.2
659233	DGC 4230.0	3 LEVELS AWAY	7455.3	7434	21.3
659302	CHAR.CK4 230.0	3 LEVELS AWAY	11674.4	11654.3	20.1
659385	ROUNDUP 7115.0	3 LEVELS AWAY	13316.9	13300.2	16.7
659390	PATENTGATE 3345.0	3 LEVELS AWAY	7045.9	7040	5.9
659421	BRDLAND-LNX3345.0	3 LEVELS AWAY	4333	4331.2	1.8

Bus #	Bus Name	Level Away	Short Circuit Value with GEN-2016-130 Project (Amperes)	Short Circuit Value without GEN-2016-130 Project (Amperes)	Net Contribution of GEN-2016-130 Project (Amperes)
			3 PH	3 PH	3 PH
603023	MALLARD7 115.0	4 LEVELS AWAY	10002.7	10000.1	2.6
608602	SQBEAST4 230.0	4 LEVELS AWAY	21102.1	21094.7	7.4
615347	GRE-MCHENRY4230.0	4 LEVELS AWAY	6318.3	6317.5	0.8
620381	UNDERWD4 230.0	4 LEVELS AWAY	13790.9	13786.9	4
652175	G09_001IST 345.0	4 LEVELS AWAY	6506.7	6504.5	2.2
652216	WATFORD4 230.0	4 LEVELS AWAY	6543.3	6539.7	3.6
652296	WARD 4 230.0	4 LEVELS AWAY	13029.6	13020.5	9.1
652416	DEVAUL 7 115.0	4 LEVELS AWAY	1454.6	1454	0.6
652419	KILDEER7 115.0	4 LEVELS AWAY	8490.4	8485.4	5
652425	BELFELD4 230.0	4 LEVELS AWAY	9531.8	9524.7	7.1
652427	BISMARK7 115.0	4 LEVELS AWAY	15794.5	15788.4	6.1
652435	FARGO 4 230.0	4 LEVELS AWAY	11479.4	11478.4	1
652445	JAMESTN7 115.0	4 LEVELS AWAY	11041.2	11040	1.2
652449	MAX 7 115.0	4 LEVELS AWAY	6306.5	6305.7	0.8
652499	CAMPBELL 4 230.0	4 LEVELS AWAY	5101.1	5100.7	0.4
652506	FTTHOMP3 345.0	4 LEVELS AWAY	10079.6	10076.8	2.8
652568	GROTONSOUTH 115.0	4 LEVELS AWAY	15093.1	15089	4.1
652590	SNAKECR7 115.0	4 LEVELS AWAY	5678	5677.1	0.9
655643	VOLTAIR -CP7115.0	4 LEVELS AWAY	8606.3	8605.6	0.7
655657	SWMINOT -CP7115.0	4 LEVELS AWAY	6851.1	6849	2.1
655833	GRSYBTTP-MK7115.0	4 LEVELS AWAY	13855	13840.9	14.1
655853	BEARCREK-MK7115.0	4 LEVELS AWAY	10228.7	10219.5	9.2
655893	DUNNCENTRMK7115.0	4 LEVELS AWAY	5382.3	5379.5	2.8
657751	CENTER 4 230.0	4 LEVELS AWAY	19453.6	19447.1	6.5
657759	PICKERT4 230.0	4 LEVELS AWAY	4699.2	4698.9	0.3
657791	CENTER 3 345.0	4 LEVELS AWAY	12325.9	12322.9	3
657848	YNG2 4 230.0	4 LEVELS AWAY	17703.6	17698.9	4.7

Bus #	Bus Name	Level Away	Short Circuit Value with GEN-2016-130 Project (Amperes)	Short Circuit Value without GEN-2016-130 Project (Amperes)	Net Contribution of GEN-2016-130 Project (Amperes)
			3 PH	3 PH	3 PH
659120	BRDLAND3 345.0	4 LEVELS AWAY	4333	4331.2	1.8
659128	WEBER 4 230.0	4 LEVELS AWAY	5310.2	5308.9	1.3
659144	BLAISDELL 7115.0	4 LEVELS AWAY	7396.3	7394.4	1.9
659184	R.RIDER7 115.0	4 LEVELS AWAY	4610.3	4609.1	1.2
659185	FOUREYES 7115.0	4 LEVELS AWAY	3921.3	3920.1	1.2
659333	JUDSON 3345.0	4 LEVELS AWAY	6480.4	6476.4	4
659365	BALDWIN 4230.0	4 LEVELS AWAY	8153.2	8149	4.2
659387	KUMMERRIDGE3345.0	4 LEVELS AWAY	3830.7	3829	1.7
659391	PATENTGATE 7115.0	4 LEVELS AWAY	16152.8	16144.1	8.7
659543	PICKCITY RR7115.0	4 LEVELS AWAY	9733.1	9730.5	2.6
661084	TIOGA4 4 230.0	4 LEVELS AWAY	8457.1	8454	3.1
602006	SHEYNNE4 230.0	5 LEVELS AWAY	12517.7	12516.6	1.1
603280	MAGIC CITY 7115.0	5 LEVELS AWAY	7663	7661.8	1.2
608597	SQBP1DC4 230.0	5 LEVELS AWAY	21102.1	21094.7	7.4
608599	SQBP2DC4 230.0	5 LEVELS AWAY	21102.1	21094.7	7.4
608600	BISONMP4 230.0	5 LEVELS AWAY	6185.3	6184.7	0.6
615348	GRE-MCHENRY7115.0	5 LEVELS AWAY	8660.5	8659.8	0.7
615903	GRE-BALTA 4230.0	5 LEVELS AWAY	7194.4	7193.4	1
620290	HARVEY 4 230.0	5 LEVELS AWAY	5321.2	5320.6	0.6
620369	JAMESTN3 345.0	5 LEVELS AWAY	5850.5	5850.3	0.2
652408	WATFORD7 115.0	5 LEVELS AWAY	7698.8	7696.9	1.9
652413	MEDORA 4 230.0	5 LEVELS AWAY	5295.7	5293.9	1.8
652417	DICKNSN4 230.0	5 LEVELS AWAY	7160	7156.7	3.3
652422	HALIDAY7 115.0	5 LEVELS AWAY	5139.5	5138.2	1.3
652428	CARNGTN7 115.0	5 LEVELS AWAY	2906.7	2906.6	0.1
652432	EDGELEY7 115.0	5 LEVELS AWAY	4397.5	4397.4	0.1
652436	FARGO 7 115.0	5 LEVELS AWAY	11640.8	11640.1	0.7

Bus #	Bus Name	Level Away	Short Circuit Value with GEN-2016-130 Project (Amperes)	Short Circuit Value without GEN-2016-130 Project (Amperes)	Net Contribution of GEN-2016-130 Project (Amperes)
			3 PH	3 PH	3 PH
652437	GRNDFKS4 230.0	5 LEVELS AWAY	7625.7	7625.2	0.5
652440	NELSON 7 115.0	5 LEVELS AWAY	7776.1	7775.2	0.9
652452	RUGBY 7 115.0	5 LEVELS AWAY	8834.7	8832.3	2.4
652454	VALLEYC7 115.0	5 LEVELS AWAY	4859.1	4858.6	0.5
652464	DENBIGH TAP7115.0	5 LEVELS AWAY	4838.7	4838.9	-0.2
652507	FTTHOMP4 230.0	5 LEVELS AWAY	21684.5	21679.8	4.7
652512	GROTON 7 115.0	5 LEVELS AWAY	15092.9	15088.7	4.2
652529	WATERTN3 345.0	5 LEVELS AWAY	11241.3	11238.8	2.5
652534	ORDWAY 7 115.0	5 LEVELS AWAY	9174.8	9173.4	1.4
652535	REDFELD7 115.0	5 LEVELS AWAY	4456.3	4456	0.3
652553	MOORHED4 230.0	5 LEVELS AWAY	7821.5	7821.1	0.4
652807	FTTHOM2-LNX3345.0	5 LEVELS AWAY	10079.6	10076.8	2.8
655419	SW561-ER7 115.0	5 LEVELS AWAY	6852	6851.4	0.6
655641	BTHOLD -CP7115.0	5 LEVELS AWAY	5694.9	5693.8	1.1
655647	BIS WARD-CP7115.0	5 LEVELS AWAY	7994.3	7992.7	1.6
655652	BIS EXPR-CP7115.0	5 LEVELS AWAY	15794.5	15788.4	6.1
655655	RUTHVILL-CP7115.0	5 LEVELS AWAY	5477.5	5477.1	0.4
655661	DGLASCRK-CP7115.0	5 LEVELS AWAY	3980.9	3980.5	0.4
655834	GRASSYBT-MK7115.0	5 LEVELS AWAY	7131.4	7127.7	3.7
655835	LITTLKNF-MK7115.0	5 LEVELS AWAY	7523.9	7519.8	4.1
655836	OAKDALE -MK7115.0	5 LEVELS AWAY	8530.3	8524.5	5.8
655844	TIMBERCK-MK7115.0	5 LEVELS AWAY	9215.4	9212.5	2.9
655850	IDEAL -MK7115.0	5 LEVELS AWAY	11039.3	11035.3	4
655851	NRTHWEST-MK7115.0	5 LEVELS AWAY	11632.8	11628.3	4.5
655856	G8 -MK7115.0	5 LEVELS AWAY	7147	7145.3	1.7
655891	KILLDEER-MK7115.0	5 LEVELS AWAY	8415.5	8410.6	4.9
655916	PALERMO -MW7115.0	5 LEVELS AWAY	5522.4	5521.4	1

Bus #	Bus Name	Level Away	Short Circuit Value with GEN-2016-130 Project (Amperes)	Short Circuit Value without GEN-2016-130 Project (Amperes)	Net Contribution of GEN-2016-130 Project (Amperes)
			3 PH	3 PH	3 PH
655944	PLAZA -MW7115.0	5 LEVELS AWAY	5272.2	5271.3	0.9
657741	ROUGHRIDER 4230.0	5 LEVELS AWAY	15686.7	15681.6	5.1
657951	CNTSHNT3 345.0	5 LEVELS AWAY	12325.9	12322.9	3
659138	NESET 4 230.0	5 LEVELS AWAY	8457.1	8454	3.1
659181	BICNTNL7 115.0	5 LEVELS AWAY	3584.4	3583.9	0.5
659205	BRDLAND4 230.0	5 LEVELS AWAY	10664.2	10660.2	4
659275	GROTONB7 115.0	5 LEVELS AWAY	14474.3	14470.5	3.8
659284	ECKLUND4 230.0	5 LEVELS AWAY	8153.2	8149	4.2
659300	STANTONTAP 7115.0	5 LEVELS AWAY	8011.9	8010.4	1.5
659309	S HEART 4230.0	5 LEVELS AWAY	9531.8	9524.7	7.1
659334	JUDSON 4230.0	5 LEVELS AWAY	8648.8	8645.2	3.6
659349	LSSSWTCHST 7115.0	5 LEVELS AWAY	12194.9	12191.5	3.4
659362	WHEELOCK 4230.0	5 LEVELS AWAY	6687.8	6685.9	1.9
659368	TIMBERCREEK4230.0	5 LEVELS AWAY	6599.2	6596.6	2.6
659388	KUMMERRIDGE7115.0	5 LEVELS AWAY	9049.4	9046.2	3.2
659408	CAMPBLCNTY 4230.0	5 LEVELS AWAY	4631.5	4631.2	0.3
659427	TANDE-LNX 3345.0	5 LEVELS AWAY	5098.5	5096.8	1.7
659448	DAGLUM 4230.0	5 LEVELS AWAY	6646.2	6643.5	2.7
661016	COYOTE 3 345.0	5 LEVELS AWAY	8608.6	8607.4	1.2
661029	ESTBMRK7 115.0	5 LEVELS AWAY	15778.2	15772.2	6
661038	GLENHAM4 230.0	5 LEVELS AWAY	5376.7	5376.3	0.4
661053	MANDAN 4 230.0	5 LEVELS AWAY	15266.5	15258.7	7.8
661085	TIOGA4 7 115.0	5 LEVELS AWAY	9378.9	9377.2	1.7
672603	BDV 4 230.0	5 LEVELS AWAY	4868.4	4868.1	0.3

3.1.2. Short Circuit Result for Tande 345kV (659336)

The results of the short circuit analysis for GEN-2016-151 POI i.e., Tande 345kV (659336) and five bus levels away are tabulated below in Table 3.1.2.

Table 3.1.2: Short circuit results for Tande 345kV (659336)

Bus #	Bus Name	Level Away	Short Circuit Value with GEN-2016-151 Project	Short Circuit Value without GEN-2016-151 Project	Net Contribution of GEN-2016-151 Project
			3 PH	3 PH	3 PH
659336	TANDE 3345.0	0 LEVELS AWAY	5098.5	4724	374.5
584870	GEN-2015-046345.0	1 LEVELS AWAY	4291.5	4039.8	251.7
588280	GEN-2016-151345.0	1 LEVELS AWAY	3562.9	3172.7	390.2
659337	TANDE 4230.0	1 LEVELS AWAY	8139.7	7951.2	188.5
659427	TANDE-LNX 3345.0	1 LEVELS AWAY	5098.5	4724	374.5
659138	NESET 4 230.0	2 LEVELS AWAY	8457.1	8274.3	182.8
659333	JUDSON 3345.0	2 LEVELS AWAY	6480.4	6295.4	185
659139	NESET 7 115.0	3 LEVELS AWAY	9308	9233.9	74.1
659334	JUDSON 4230.0	3 LEVELS AWAY	8648.8	8539.2	109.6
659390	PATENTGATE 3345.0	3 LEVELS AWAY	7045.9	6920.8	125.1
661084	TIOGA4 4 230.0	3 LEVELS AWAY	8457.1	8274.3	182.8
652400	WILISTN4 230.0	4 LEVELS AWAY	8973.1	8860.9	112.2
655909	HESS GAS-MW7115.0	4 LEVELS AWAY	8374.7	8314.8	59.9
655930	WHTEARTH-MW7115.0	4 LEVELS AWAY	8921.2	8853.6	67.6
655947	PWRSLKTP-MW7115.0	4 LEVELS AWAY	6389.7	6358.2	31.5
655952	NTIOGA-MW 7115.0	4 LEVELS AWAY	8374.7	8314.8	59.9
659143	BLAISDELL 4230.0	4 LEVELS AWAY	5443	5406.2	36.8
659183	CHAR.CK3 345.0	4 LEVELS AWAY	10639.9	10569.4	70.5
659362	WHEELOCK 4230.0	4 LEVELS AWAY	6687.8	6605.9	81.9
659387	KUMMERRIDGE3345.0	4 LEVELS AWAY	3830.7	3794.1	36.6
659391	PATENTGATE 7115.0	4 LEVELS AWAY	16152.8	15968.7	184.1
661085	TIOGA4 7 115.0	4 LEVELS AWAY	9378.9	9303	75.9
672603	BDV 4 230.0	4 LEVELS AWAY	4868.4	4868.1	0.3
652391	WILLISTON27 115.0	5 LEVELS AWAY	16356.2	16248	108.2

Bus #	Bus Name	Level Away	Short Circuit Value with GEN-2016-151 Project	Short Circuit Value without GEN-2016-151 Project	Net Contribution of GEN-2016-151 Project
			3 PH	3 PH	3 PH
652421	WILISTN7 115.0	5 LEVELS AWAY	16356.2	16248	108.2
652424	BELFELD3 345.0	5 LEVELS AWAY	6846.3	6827.7	18.6
655844	TIMBERCK-MK7115.0	5 LEVELS AWAY	9215.4	9155.1	60.3
655850	IDEAL -MK7115.0	5 LEVELS AWAY	11039.3	10953.1	86.2
655851	NRTHWEST-MK7115.0	5 LEVELS AWAY	11632.8	11537	95.8
655856	G8 -MK7115.0	5 LEVELS AWAY	7147	7110.7	36.3
655902	PVALLEY -MW7115.0	5 LEVELS AWAY	5709.1	5684.3	24.8
655946	POWERSLK-MW7115.0	5 LEVELS AWAY	4403.6	4388.6	15
655948	LIBERTY -MW7115.0	5 LEVELS AWAY	5927.7	5901.4	26.3
655953	WSTBNKTP-MW7115.0	5 LEVELS AWAY	8374.7	8314.8	59.9
659101	ANTELOP3 345.0	5 LEVELS AWAY	16951.1	16918.7	32.4
659108	LOGAN 4 230.0	5 LEVELS AWAY	5805.7	5792.4	13.3
659144	BLAISDELL 7115.0	5 LEVELS AWAY	7396.3	7371.5	24.8
659182	CHAR.CK7 115.0	5 LEVELS AWAY	14853.3	14812.4	40.9
659302	CHAR.CK4 230.0	5 LEVELS AWAY	11674.4	11612.9	61.5
659349	LSSSWTCHST 7115.0	5 LEVELS AWAY	12194.9	12123.1	71.8
659363	WHEELOCK 7115.0	5 LEVELS AWAY	7084.1	7051.5	32.6
659368	TIMBERCREEK4230.0	5 LEVELS AWAY	6599.2	6552.2	47
659384	ROUNDUP 3345.0	5 LEVELS AWAY	9055.6	9019.5	36.1
659388	KUMMERRIDGE7115.0	5 LEVELS AWAY	9049.4	8982	67.4
661080	STANLEY7 115.0	5 LEVELS AWAY	3775.3	3765.6	9.7
661086	TIOGA7 7 115.0	5 LEVELS AWAY	7997.1	7943.5	53.6
672602	BDX 4 230.0	5 LEVELS AWAY	4210.1	4213	-2.9

3.2. Short Circuit Result for 2026 Summer Peak Case

The short circuit results for summer-2026 scenario at the POI are tabulated below.

3.2.1. Short Circuit Result for Leland Olds 345kV (659105)

The results of the short circuit analysis for GEN-2016-130 POI i.e., Leland Olds 345kV (659105) and five bus levels away are tabulated below in Table 3.2.1.

Table 3.2.1: Short circuit results for Leland Olds 345kV (659105)

Bus #	Bus Name	Level Away	Short Circuit Value with GEN-2016-130 Project (Amperes)	Short Circuit Value without GEN-2016-130 Project (Amperes)	Net Contribution of GEN-2016-130 Project (Amperes)
			3 PH	3 PH	3 PH
659105	LELANDO3 345.0	0 LEVELS AWAY	17268.3	16881.9	386.4
588210	GEN-2016-130345.0	1 LEVELS AWAY	11955.1	11564.6	390.5
659101	ANTELOP3 345.0	1 LEVELS AWAY	17106.2	16941.8	164.4
659106	LELANDO4 230.0	1 LEVELS AWAY	24021.4	23702.8	318.6
659422	LELAND1-LNX3345.0	1 LEVELS AWAY	17268.3	16881.9	386.4
659424	LELAND2-LNX3345.0	1 LEVELS AWAY	17268.3	16881.9	386.4
560074	G16-017-TAP 345.0	2 LEVELS AWAY	6887.8	6884.7	3.1
587030	GEN-2016-004230.0	2 LEVELS AWAY	7984.3	7952.4	31.9
588211	G16-130XFMR134.50	2 LEVELS AWAY	27392.2	22852.1	4540.1
615901	GRE-STANTON4230.0	2 LEVELS AWAY	17285.1	17274.8	10.3
652441	GARRISN4 230.0	2 LEVELS AWAY	12198.8	12180.5	18.3
652456	WASHBRN4 230.0	2 LEVELS AWAY	10909.7	10865.5	44.2
659108	LOGAN 4 230.0	2 LEVELS AWAY	5668.1	5663.3	4.8
659109	BASIN 7 115.0	2 LEVELS AWAY	5736.3	5727.2	9.1
659183	CHAR.CK3 345.0	2 LEVELS AWAY	10855.2	10829.4	25.8
659212	DGC 3345.0	2 LEVELS AWAY	16354	16203.7	150.3
659218	COTEAU 3345.0	2 LEVELS AWAY	17106.2	16941.8	164.4
659384	ROUNDUP 3345.0	2 LEVELS AWAY	9184.1	9159.8	24.3
659420	ANTELOP-LNX3345.0	2 LEVELS AWAY	17106.2	16941.8	164.4
659423	GROTON-LNX3 345.0	2 LEVELS AWAY	6772.6	6769.7	2.9
587130	GEN-2016-017345.0	3 LEVELS AWAY	6830.9	6827.9	3
587750	GEN-2016-092345.0	3 LEVELS AWAY	6165.8	6163.3	2.5
587830	GEN-2016-103345.0	3 LEVELS AWAY	6831.9	6828.9	3
615600	GRE-COAL CR4230.0	3 LEVELS AWAY	17028.1	17022.1	6

Bus #	Bus Name	Level Away	Short Circuit Value with GEN-2016-130 Project (Amperes)	Short Circuit Value without GEN-2016-130 Project (Amperes)	Net Contribution of GEN-2016-130 Project (Amperes)
			3 PH	3 PH	3 PH
615900	GRE-COAL TP4230.0	3 LEVELS AWAY	15053.1	15047.6	5.5
652420	NSALEM 7 115.0	3 LEVELS AWAY	2000.8	1999.7	1.1
652424	BELFELD3 345.0	3 LEVELS AWAY	6947.5	6940.6	6.9
652426	BISMARK4 230.0	3 LEVELS AWAY	15396.3	15382.5	13.8
652442	GARRISN7 115.0	3 LEVELS AWAY	13801	13795.9	5.1
652444	JAMESTN4 230.0	3 LEVELS AWAY	9319.9	9317.8	2.1
652466	HILKEN 4 230.0	3 LEVELS AWAY	9381.2	9375.8	5.4
652806	FTTHOM1-LNX3345.0	3 LEVELS AWAY	10011.7	10009.1	2.6
657756	SQBUTTE4 230.0	3 LEVELS AWAY	23158.2	23151.2	7
659143	BLAISDELL 4230.0	3 LEVELS AWAY	5475.2	5474.8	0.4
659155	LOGAN 7 115.0	3 LEVELS AWAY	9090.8	9087.1	3.7
659160	GROTON 3 345.0	3 LEVELS AWAY	6772.6	6769.7	2.9
659182	CHAR.CK7 115.0	3 LEVELS AWAY	15019.3	15004.3	15
659222	COTEAU1 869.00	3 LEVELS AWAY	10666.5	10654	12.5
659233	DGC 4230.0	3 LEVELS AWAY	7476.1	7455.3	20.8
659302	CHAR.CK4 230.0	3 LEVELS AWAY	11905.4	11886.6	18.8
659385	ROUNDUP 7115.0	3 LEVELS AWAY	13451.7	13435.9	15.8
659390	PATENTGATE 3345.0	3 LEVELS AWAY	7170.3	7165.6	4.7
659421	BRDLAND-LNX3345.0	3 LEVELS AWAY	4349.5	4347.8	1.7
603023	MALLARD7 115.0	4 LEVELS AWAY	8423.8	8421.6	2.2
608602	SQBEAST4 230.0	4 LEVELS AWAY	23158.2	23151.2	7
615347	GRE-MCHENRY4230.0	4 LEVELS AWAY	6443.3	6442.1	1.2
620381	UNDERWD4 230.0	4 LEVELS AWAY	13914.8	13910.7	4.1
652175	G09_001IST 345.0	4 LEVELS AWAY	6986.7	6984.8	1.9
652216	WATFORD4 230.0	4 LEVELS AWAY	6859.3	6856.4	2.9
652296	WARD 4 230.0	4 LEVELS AWAY	13563	13554.5	8.5
652416	DEVAUL 7 115.0	4 LEVELS AWAY	1458.5	1457.9	0.6

Bus #	Bus Name	Level Away	Short Circuit Value with GEN-2016-130 Project (Amperes)	Short Circuit Value without GEN-2016-130 Project (Amperes)	Net Contribution of GEN-2016-130 Project (Amperes)
			3 PH	3 PH	3 PH
652419	KILDEER7 115.0	4 LEVELS AWAY	8575	8570.4	4.6
652425	BELFELD4 230.0	4 LEVELS AWAY	9685.6	9679.2	6.4
652427	BISMARK7 115.0	4 LEVELS AWAY	16645.3	16639.9	5.4
652435	FARGO 4 230.0	4 LEVELS AWAY	11587.2	11586.6	0.6
652445	JAMESTN7 115.0	4 LEVELS AWAY	11132.1	11130.3	1.8
652449	MAX 7 115.0	4 LEVELS AWAY	6257.5	6256.7	0.8
652499	CAMPBELL 4 230.0	4 LEVELS AWAY	5116.1	5115.8	0.3
652506	FTTHOMP3 345.0	4 LEVELS AWAY	10011.7	10009.1	2.6
652568	GROTONSOUTH 115.0	4 LEVELS AWAY	19802.5	19798.6	3.9
652590	SNAKECR7 115.0	4 LEVELS AWAY	5702.3	5701.5	0.8
655643	VOLTAIR -CP7115.0	4 LEVELS AWAY	8327.8	8326.9	0.9
655657	SWMINOT -CP7115.0	4 LEVELS AWAY	6599.4	6597.8	1.6
655833	GRSYBTTP-MK7115.0	4 LEVELS AWAY	13999.5	13986.5	13
655853	BEARCREK-MK7115.0	4 LEVELS AWAY	10335.6	10327	8.6
655893	DUNNCENTRMK7115.0	4 LEVELS AWAY	5410.5	5407.9	2.6
657751	CENTER 4 230.0	4 LEVELS AWAY	21020	21014.1	5.9
657759	PICKERT4 230.0	4 LEVELS AWAY	4795.5	4795.2	0.3
657791	CENTER 3 345.0	4 LEVELS AWAY	13012.2	13009.6	2.6
657848	YNG2 4 230.0	4 LEVEL AWAY	18977.5	18973.3	4.2
659120	BRDLAND3 345.0	4 LEVELS AWAY	4349.5	4347.8	1.7
659128	WEBER 4 230.0	4 LEVELS AWAY	5364.4	5363.2	1.2
659144	BLAISDELL 7115.0	4 LEVELS AWAY	7512.3	7511.8	0.5
659184	R.RIDER7 115.0	4 LEVELS AWAY	4635.5	4634.4	1.1
659185	FOUREYES 7115.0	4 LEVELS AWAY	3938.5	3937.5	1
659226	DGC 3001B 913.80	4 LEVELS AWAY	29150.3	29132.3	18
659333	JUDSON 3345.0	4 LEVELS AWAY	6590.1	6587.5	2.6
659365	BALDWIN 4230.0	4 LEVELS AWAY	8231.2	8227.3	3.9

Bus #	Bus Name	Level Away	Short Circuit Value with GEN-2016-130 Project (Amperes)	Short Circuit Value without GEN-2016-130 Project (Amperes)	Net Contribution of GEN-2016-130 Project (Amperes)
			3 PH	3 PH	3 PH
659387	KUMMERRIDGE3345.0	4 LEVELS AWAY	3876.2	3874.9	1.3
659391	PATENTGATE 7115.0	4 LEVELS AWAY	16393.7	16386.9	6.8
659543	PICKCITY RR7115.0	4 LEVELS AWAY	9779.9	9777.5	2.4
661084	TIOGA4 4 230.0	4 LEVELS AWAY	8665.1	8672.6	-7.5
587720	GEN-2016-087230.0	5 LEVELS AWAY	5116.1	5115.8	0.3
602006	SHEYNNE4 230.0	5 LEVELS AWAY	12626.8	12626.1	0.7
602052	WARD CO 4 230.0	5 LEVELS AWAY	4157.6	4157.1	0.5
608597	SQBP1DC4 230.0	5 LEVELS AWAY	23158.2	23151.2	7
608599	SQBP2DC4 230.0	5 LEVELS AWAY	23158.2	23151.2	7
608600	BISONMP4 230.0	5 LEVELS AWAY	8477.9	8477.3	0.6
615348	GRE-MCHENRY7115.0	5 LEVELS AWAY	8370.4	8369.5	0.9
615903	GRE-BALTA 4230.0	5 LEVELS AWAY	6995.6	6992.9	2.7
620290	HARVEY 4 230.0	5 LEVELS AWAY	5256.2	5255	1.2
620369	JAMESTN3 345.0	5 LEVELS AWAY	5925.3	5925	0.3
652408	WATFORD7 115.0	5 LEVELS AWAY	8421.9	8420.3	1.6
652413	MEDORA 4 230.0	5 LEVELS AWAY	5351.8	5350.3	1.5
652417	DICKNSN4 230.0	5 LEVELS AWAY	7262.4	7259.5	2.9
652422	HALIDAY7 115.0	5 LEVELS AWAY	5171.4	5170.3	1.1
652428	CARNGTN7 115.0	5 LEVELS AWAY	2943.3	2943.2	0.1
652432	EDGELEY7 115.0	5 LEVELS AWAY	4431.6	4431.5	0.1
652436	FARGO 7 115.0	5 LEVELS AWAY	11738.3	11738	0.3
652437	GRNDFKS4 230.0	5 LEVELS AWAY	8165.6	8165	0.6
652440	NELSON 7 115.0	5 LEVELS AWAY	7521.5	7520.5	1
652452	RUGBY 7 115.0	5 LEVELS AWAY	8659	8656.5	2.5
652454	VALLEYC7 115.0	5 LEVELS AWAY	4900.4	4900.4	0
652464	DENBIGH TAP7115.0	5 LEVELS AWAY	4850.1	4849.6	0.5
652507	FTTHOMP4 230.0	5 LEVELS AWAY	21318	21313.8	4.2

Bus #	Bus Name	Level Away	Short Circuit Value with GEN-2016-130 Project (Amperes)	Short Circuit Value without GEN-2016-130 Project (Amperes)	Net Contribution of GEN-2016-130 Project (Amperes)
			3 PH	3 PH	3 PH
652512	GROTON 7 115.0	5 LEVELS AWAY	19802	19798.1	3.9
652529	WATERTN3 345.0	5 LEVELS AWAY	11715.8	11714.3	1.5
652534	ORDWAY 7 115.0	5 LEVELS AWAY	10554.6	10553.5	1.1
652535	REDFELD7 115.0	5 LEVELS AWAY	4548	4547.7	0.3
652553	MOORHED4 230.0	5 LEVELS AWAY	7871.4	7871.2	0.2
652807	FTTHOM2-LNX3345.0	5 LEVELS AWAY	10011.7	10009.1	2.6
655419	SW561-ER7 115.0	5 LEVELS AWAY	7382.6	7382.2	0.4
655641	BTHOLD -CP7115.0	5 LEVELS AWAY	5730.9	5730.4	0.5
655647	BIS WARD-CP7115.0	5 LEVELS AWAY	8130	8128.5	1.5
655652	BIS EXPR-CP7115.0	5 LEVELS AWAY	16645.3	16639.9	5.4
655655	RUTHVILL-CP7115.0	5 LEVELS AWAY	5125.8	5125.1	0.7
655661	DGLASCRK-CP7115.0	5 LEVELS AWAY	4003.9	4003.5	0.4
655834	GRASSYBT-MK7115.0	5 LEVELS AWAY	7170.1	7166.7	3.4
655835	LITTLKNF-MK7115.0	5 LEVELS AWAY	7567.8	7563.9	3.9
655836	OAKDALE -MK7115.0	5 LEVELS AWAY	8631.4	8626	5.4
655844	TIMBERCK-MK7115.0	5 LEVELS AWAY	9322	9319.8	2.2
655850	IDEAL -MK7115.0	5 LEVELS AWAY	11166.1	11162.9	3.2
655851	NRTHWEST-MK7115.0	5 LEVELS AWAY	11767.6	11764.1	3.5
655856	G8 -MK7115.0	5 LEVEL AWAY	7207.4	7206.1	1.3
655891	KILLDEER-MK7115.0	5 LEVELS AWAY	8500.2	8495.6	4.6
655916	PALERMO -MW7115.0	5 LEVELS AWAY	5622.1	5621.9	0.2
655944	PLAZA -MW7115.0	5 LEVELS AWAY	5366	5365.6	0.4
657741	ROUGHRIDER 4230.0	5 LEVELS AWAY	16577.6	16573.2	4.4
657951	CNTSHNT3 345.0	5 LEVELS AWAY	13012.2	13009.6	2.6
659138	NESET 4 230.0	5 LEVELS AWAY	8665.1	8672.6	-7.5
659181	BICNTNL7 115.0	5 LEVELS AWAY	3609	3608.6	0.4
659205	BRDLAND4 230.0	5 LEVELS AWAY	10745	10741.3	3.7

Bus #	Bus Name	Level Away	Short Circuit Value with GEN-2016-130 Project (Amperes)	Short Circuit Value without GEN-2016-130 Project (Amperes)	Net Contribution of GEN-2016-130 Project (Amperes)
			3 PH	3 PH	3 PH
659275	GROTONB7 115.0	5 LEVELS AWAY	19235.2	19231.5	3.7
659284	ECKLUND4 230.0	5 LEVELS AWAY	8231.2	8227.3	3.9
659300	STANTONTAP 7115.0	5 LEVELS AWAY	8045	8043.6	1.4
659309	S HEART 4230.0	5 LEVELS AWAY	9685.6	9679.2	6.4
659334	JUDSON 4230.0	5 LEVELS AWAY	8846	8844.7	1.3
659349	LSSSWTCHST 7115.0	5 LEVELS AWAY	12284	12281.4	2.6
659362	WHEELOCK 4230.0	5 LEVELS AWAY	6807.4	6808.8	-1.4
659368	TIMBERCREEK4230.0	5 LEVELS AWAY	6776.2	6774.6	1.6
659372	LARSON 4230.0	5 LEVELS AWAY	5872.2	5886.6	-14.4
659388	KUMMERRIDGE7115.0	5 LEVELS AWAY	9147	9144.6	2.4
659408	CAMPBLCNTY 4230.0	5 LEVELS AWAY	4643.8	4643.5	0.3
659427	TANDE-LNX 3345.0	5 LEVELS AWAY	5163.1	5163.3	-0.2
659448	DAGLUM 4230.0	5 LEVELS AWAY	6722	6719.7	2.3
661016	COYOTE 3 345.0	5 LEVELS AWAY	8803.2	8802.2	1
661029	ESTBMRK7 115.0	5 LEVELS AWAY	16631.3	16625.8	5.5
661038	GLENHAM4 230.0	5 LEVELS AWAY	5390.8	5390.5	0.3
661053	MANDAN 4 230.0	5 LEVELS AWAY	16248.8	16241.7	7.1
661085	TIOGA4 7 115.0	5 LEVELS AWAY	9544.4	9546.7	-2.3

3.2.2. Short Circuit Result for Tande 345kV (659336)

The results of the short circuit analysis for GEN-2016-151 POI i.e., Tande 345kV (659336) and five bus levels away are tabulated below in Table 3.2.2.

Table 3.2.2: Short circuit results for Tande 345kV (659336)

Bus #	Bus Name	Level Away	Short Circuit Value with GEN-2016-151 Project	Short Circuit Value without GEN-2016-151 Project	Net Contribution of GEN-2016-151 Project
			3 PH	3 PH	3 PH
659336	TANDE 3345.0	0 LEVELS AWAY	5163.1	4795.2	367.9

Bus #	Bus Name	Level Away	Short Circuit Value with GEN-2016-151 Project	Short Circuit Value without GEN-2016-151 Project	Net Contribution of GEN-2016-151 Project
			3 PH	3 PH	3 PH
584870	GEN-2015-046345.0	1 LEVELS AWAY	4333.9	4088	245.9
588280	GEN-2016-151345.0	1 LEVELS AWAY	3591.8	3204.7	387.1
659337	TANDE 4230.0	1 LEVELS AWAY	8326.6	8174.5	152.1
659427	TANDE-LNX 3345.0	1 LEVELS AWAY	5163.1	4795.2	367.9
659138	NESET 4 230.0	2 LEVELS AWAY	8665.1	8523.4	141.7
659333	JUDSON 3345.0	2 LEVELS AWAY	6590.1	6412.6	177.5
659139	NESET 7 115.0	3 LEVELS AWAY	9483.4	9428	55.4
659334	JUDSON 4230.0	3 LEVELS AWAY	8846	8748.1	97.9
659390	PATENTGATE 3345.0	3 LEVELS AWAY	7170.3	7051.8	118.5
661084	TIOGA4 4 230.0	3 LEVELS AWAY	8665.1	8523.4	141.7
652400	WILISTN4 230.0	4 LEVELS AWAY	9190.9	9091.2	99.7
655909	HESS GAS-MW7115.0	4 LEVELS AWAY	8524	8479.4	44.6
655930	WHTEARTH-MW7115.0	4 LEVELS AWAY	9086	9035.5	50.5
655947	PWRSLKTP-MW7115.0	4 LEVELS AWAY	6457	6433.9	23.1
655952	NTIOGA-MW 7115.0	4 LEVELS AWAY	8524	8479.4	44.6
659143	BLAISDELL 4230.0	4 LEVELS AWAY	5475.2	5447.8	27.4
659183	CHAR.CK3 345.0	4 LEVELS AWAY	10855.2	10791.4	63.8
659362	WHEELOCK 4230.0	4 LEVELS AWAY	6807.4	6740.7	66.7
659372	LARSON 4230.0	4 LEVELS AWAY	5872.2	5878.4	-6.2
659387	KUMMERRIDGE3345.0	4 LEVELS AWAY	3876.2	3842.2	34
659391	PATENTGATE 7115.0	4 LEVELS AWAY	16393.7	16221.6	172.1
661085	TIOGA4 7 115.0	4 LEVELS AWAY	9544.4	9487.5	56.9
652391	WILLISTON27 115.0	5 LEVELS AWAY	16712.3	16620.6	91.7
652421	WILISTN7 115.0	5 LEVELS AWAY	16712.3	16620.6	91.7
652424	BELFELD3 345.0	5 LEVELS AWAY	6947.5	6931.1	16.4
655844	TIMBERCK-MK7115.0	5 LEVELS AWAY	9322	9266.2	55.8
655850	IDEAL -MK7115.0	5 LEVELS AWAY	11166.1	11086.2	79.9
655851	NRTHWEST-MK7115.0	5 LEVELS AWAY	11767.6	11678.8	88.8

Bus #	Bus Name	Level Away	Short Circuit Value with GEN-2016-151 Project	Short Circuit Value without GEN-2016-151 Project	Net Contribution of GEN-2016-151 Project
			3 PH	3 PH	3 PH
655856	G8 -MK7115.0	5 LEVELS AWAY	7207.4	7174.1	33.3
655902	PVALLEY -MW7115.0	5 LEVELS AWAY	5804.9	5786.9	18
655946	POWERSLK-MW7115.0	5 LEVELS AWAY	4438.9	4428.1	10.8
655948	LIBERTY -MW7115.0	5 LEVELS AWAY	5980.2	5961	19.2
655953	WSTBNKTP-MW7115.0	5 LEVELS AWAY	8524	8479.4	44.6
659101	ANTELOP3 345.0	5 LEVELS AWAY	17106.2	17078.2	28
659108	LOGAN 4 230.0	5 LEVELS AWAY	5668.1	5658.1	10
659144	BLAISDELL 7115.0	5 LEVELS AWAY	7512.3	7494.3	18
659182	CHAR.CK7 115.0	5 LEVELS AWAY	15019.3	14983.5	35.8
659302	CHAR.CK4 230.0	5 LEVELS AWAY	11905.4	11850.5	54.9
659349	LSSSWTCHST 7115.0	5 LEVELS AWAY	12284	12217.9	66.1
659363	WHEELOCK 7115.0	5 LEVELS AWAY	7171.1	7145.1	26
659368	TIMBERCREEK4230.0	5 LEVELS AWAY	6776.2	6735.1	41.1
659373	LARSON 7115.0	5 LEVELS AWAY	4312.4	4314.4	-2
659384	ROUNDUP 3345.0	5 LEVELS AWAY	9184.1	9152	32.1
659388	KUMMERRIDGE7115.0	5 LEVELS AWAY	9147	9084.7	62.3
661080	STANLEY7 115.0	5 LEVELS AWAY	3830.3	3823.2	7.1
661086	TIOGA7 7 115.0	5 LEVELS AWAY	8109.5	8069.4	40.1
672603	BDV 4 230.0	5 LEVELS AWAY	5183.8	5325.6	-141.8

4. Stability Analysis for Cluster Scenario

4.1. Faults Simulated

Thirty-four (34) faults were considered for the transient stability simulations which included three phase faults, as well as single phase line faults. Single-phase line faults were simulated by applying fault impedance to the positive sequence network at the fault location. As per the SPP current practice to compute the fault levels, the fault impedance was computed to give a positive sequence voltage at the specified fault location of approximately 60% of pre-fault voltage.

Concurrently and previously queued projects as respectively shown in Table-1 and Table-2 of the study request as well as areas number 356, 600, 615, 620, 635, 640, 645, 652, and 661 were monitored during all the simulations. Table 4.1.1 shows the list of simulated contingencies. This Table also shows the fault clearing time and the time delay before re-closing for all the study contingencies.

Simulations were performed with a 0.1-second steady-state run followed by the appropriate disturbance as described in Table 4.1.1. Simulations were run for minimum 20-second duration to confirm proper machine damping.

Table 4.1.1 summarizes the overall results for all faults simulations of cluster scenario. Complete sets of plots for Winter-2017, Summer-2018, and Summer-2026 peak seasons for each fault are included in Appendices A, B and C respectively.

The machines under study as well as the prior queued projects and requested monitored areas produce an exhaustive list for plotting. Therefore, for each contingency description, only five (5) plots sheets are included in the Appendices (i.e. Page-1, Page-2, Page-3, Page-4, and page-5) that respectively represents the machines quantities under this study, prior queued machine quantities, and machine and bus voltages for different areas. Overall, for each season there are 80 channel plots for each of the thirty-four (34) contingency descriptions.

Table 4.1.1: List of simulated faults for cluster scenario stability analysis

Cont. #	Contingency Name	Description	2017 Winter Results	2018 Summer Results	2026 Summer Results
1	FLT01-3PH	3 phase fault on the Antelope Valley Station (659101) to Charlie Creek (659183) 345kV line circuit 1, near Antelope Valley Station. a. Apply fault at the Antelope Valley Station 345kV bus. b. Clear fault after 6 cycles by tripping the faulted line.	Stable	Stable	Stable
2	FLT02-3PH	3 phase fault on the Roundup 345/115/13.8kV (659384/659385/659386) transformer, near Roundup 345kV. a. Apply fault at the Roundup 345kV bus. b. Clear fault after 6 cycles by tripping the faulted transformer.	Stable	Stable	Stable
3	FLT03-3PH	3 phase fault on CHAR.CK (659183) to BELFELD (652424) 345kV line circuit 1, near CHAR.CK. a. Apply fault at the CHAR.CK 345 bus. b. Clear fault after 6 cycles by tripping the faulted line.	Stable	Stable	Stable
4	FLT04-3PH	3 phase fault on CHAR.CK (659183) to ROUNDUP (659384) 345kV line circuit 1, near CHAR.CK. a. Apply fault at the CHAR.CK 345 bus. b. Clear fault after 6 cycles by tripping the faulted line.	Stable	Stable	Stable
5	FLT05-3PH	3 phase fault on CHAR.CK (659183) to PATENTGATE (659390) 345kV line circuit 1, near CHAR.CK. a. Apply fault at the CHAR.CK 345 bus. b. Clear fault after 6 cycles by tripping the faulted line.	Stable	Stable	Stable
6	FLT06-3PH	3 phase fault on the CHAR.CK 345/230/13.8kV (659183/659302/659319) transformer, near CHAR.CK. a. Apply fault at the CHAR.CK 345kV bus. b. Clear fault after 6 cycles by tripping the faulted transformer.	Stable	Stable	Stable
7	FLT07-3PH	3 phase fault on the CHAR.CK 345/115/13.8kV (659183/659182/659211) transformer, near CHAR.CK. a. Apply fault at the CHAR.CK 345kV bus. b. Clear fault after 6 cycles by tripping the faulted transformer.	Stable	Stable	Stable

Cont. #	Contingency Name	Description	2017 Winter Results	2018 Summer Results	2026 Summer Results
8	FLT08-3PH	3 phase fault on Neset (659139) to Tioga (661085) to 115kV line circuit 1, near Neset. a. Apply fault at the Neset 115 bus. b. Clear fault after 6 cycles by tripping the faulted line.	Stable	Stable	Stable
9	FLT09-3PH	3 phase fault on Neset (659139) to Tioga North (655952) to 115kV line circuit 1, near Neset. a. Apply fault at the Neset 115 bus. b. Clear fault after 6 cycles by tripping the faulted line.	Stable	Stable	Stable
10	FLT10-3PH	3 phase fault on Neset (659139) to Powers Lake (655947) to 115kV line circuit 1, near Neset. a. Apply fault at the Neset 115 bus. b. Clear fault after 6 cycles by tripping the faulted line.	Stable	Stable	Stable
11	FLT11-3PH	3 phase fault on Neset (659139) to Whitearth Tap (655930) to 115kV line circuit 1, near Neset. a. Apply fault at the Neset 115 bus. b. Clear fault after 6 cycles by tripping the faulted line.	Stable	Stable	Stable
12	FLT12-3PH	3 phase fault on Neset (659139) to Hess Gas (655909) to 115kV line circuit 1, near Neset. a. Apply fault at the Neset 115 bus. b. Clear fault after 6 cycles by tripping the faulted line.	Stable	Stable	Stable
13	FLT13-3PH	3 phase fault on PATENTGATE (659390) to JUDSON (659333) 345kV line circuit 1, near PATENTGATE. a. Apply fault at the PATENTGATE 345 bus. b. Clear fault after 6 cycles by tripping the faulted line.	Stable	Stable	Stable
14	FLT14-3PH	3 phase fault on PATENTGATE (659390) to KUMMERRIDGE (659387) 345kV line circuit 1, near PATENTGATE. a. Apply fault at the PATENTGATE 345 bus. b. Clear fault after 6 cycles by tripping the faulted line.	Stable	Stable	Stable
15	FLT15-3PH	3 phase fault on the PATENTGATE 345/115/13.8kV (659390/659391/659392) transformer, near PATENTGATE. a. Apply fault at the PATENTGATE 345kV bus. b. Clear fault after 6 cycles by tripping the faulted transformer.	Stable	Stable	Stable

Cont. #	Contingency Name	Description	2017 Winter Results	2018 Summer Results	2026 Summer Results
16	FLT16-3PH	3 phase fault on JUDSON (659333) to TANDE-LNX (659427) to TANDE (659336) 345kV line circuit 1, near JUDSON. a. Apply fault at the JUDSON 345 bus. b. Clear fault after 6 cycles by tripping the faulted line.	Stable	Stable	Stable
17	FLT17-3PH	3 phase fault on the JUDSON 345/230/13.8kV (659333/659334/659335) transformer, near JUDSON. a. Apply fault at the JUDSON345kV bus. b. Clear fault after 6 cycles by tripping the faulted transformer.	Stable	Stable	Stable
18	FLT18-3PH	Prior Outage of TANDE 345/230/13.8kV (659336/659337/659338) transformer CKT 1; 3 phase fault on PATENTGATE (659390) to JUDSON (659333) 345kV line circuit 1, near PATENTGATE. a. Apply fault at the PATENTGATE 345 bus. b. Clear fault after 6 cycles by tripping the faulted line.	Stable	Stable	Stable
19	FLT19-3PH	3 phase fault on the NESET 230/115/13.8kV (659138/659139/659146) transformer, near NESET 230kV. a. Apply fault at the NESET 230kV bus. b. Clear fault after 6 cycles by tripping the faulted transformer.	Stable	Stable	Stable
20	FLT20-3PH	3 phase fault on the TANDE 345/230/13.8kV (659336/659337/659338) transformer, near TANDE. a. Apply fault at the TANDE 345kV bus. b. Clear fault after 6 cycles by tripping the faulted transformer.	Stable	Stable	Stable
21	FLT21-3PH	3 phase fault on TIOGA (661084) to NESET (659138) 230kV line circuit 1, near TIOGA. a. Apply fault at the TIOGA 230kV bus. b. Clear fault after 6 cycles by tripping the faulted line.	Stable	Stable	Stable

Cont. #	Contingency Name	Description	2017 Winter Results	2018 Summer Results	2026 Summer Results
22	FLT22-3PH	3 phase fault on TIOGA (661084) to BLAISDELL (659143) 230kV line circuit 1, near TIOGA. a. Apply fault at the TIOGA 230kV bus. b. Clear fault after 6 cycles by tripping the faulted line.	Stable	Stable	Stable
23	FLT23-3PH	3 phase fault on TIOGA (661084) to WHEELOCK (659362) 230kV line circuit 1, near TIOGA. a. Apply fault at the TIOGA 230kV bus. b. Clear fault after 6 cycles by tripping the faulted line.	Stable	Stable	Stable
24	FLT24-3PH	3 phase fault on TIOGA (661084) to BDV (672603) 230kV line circuit 1, near TIOGA. 3 phase fault on TIOGA (661084) to LARSON (659372) 230kV line circuit 1, near TIOGA (for 2026 Scenario) a. Apply fault at the TIOGA 230kV bus. b. Clear fault after 6 cycles by tripping the faulted line.	Stable	Stable	Stable
25	FLT25-3PH	3 phase fault on the TIOGA 230/115/13.8kV (661084/661085/661900) transformer, near TIOGA. a. Apply fault at the TIOGA 345kV bus. b. Clear fault after 6 cycles by tripping the faulted transformer.	Stable	Stable	Stable
58	FLT58-3PH	3 phase fault on Tioga (661085) to Stanley (661080) 115kV line circuit 1, near Tioga. a. Apply fault at the Tioga 115 bus. b. Clear fault after 6 cycles by tripping the faulted line.	Stable	Stable	Stable
59	FLT59-3PH	3 phase fault on Tioga (661085) to Tioga (661086) 115kV line circuit 1, near Tioga (661085). a. Apply fault at the Tioga (661085) 115 bus. b. Clear fault after 6 cycles by tripping the faulted line.	Stable	Stable	Stable
60	FLT60-3PH	3 phase fault on WILISTN4 (652400) to WHEELOCK (659362) 230kV line circuit 1, near WILISTN4. a. Apply fault at the WILISTN4 230kV bus. b. Clear fault after 6 cycles by tripping the faulted line.	Stable	Stable	Stable

Cont. #	Contingency Name	Description	2017 Winter Results	2018 Summer Results	2026 Summer Results
61	FLT61-3PH	3 phase fault on WILISTN4 (652400) to TIMBERCREEK (659368) 230kV line circuit 1, near WILISTN4. a. Apply fault at the WILISTN4 230kV bus. b. Clear fault after 6 cycles by tripping the faulted line.	Stable	Stable	Stable
62	FLT62-3PH	3 phase fault on the WILISTN4 230/115/13.8kV (652400/652391/652622) transformer, near WILISTN4. a. Apply fault at the WILISTN4 345kV bus. b. Clear fault after 6 cycles by tripping the faulted transformer.	Stable	Stable	Stable
101	FLT101-PO	Prior Outage of TANDE 345/230/13.8kV (659336/659337/659338) transformer CKT 1; 3 phase fault on the JUDSON 345/230/13.8kV (659333/659334/659335) transformer, near JUDSON. a. Apply fault at the JUDSON345kV bus. b. Clear fault after 6 cycles by tripping the faulted transformer.	Stable	Stable	Stable
102	FLT102-PO	Prior Outage of JUDSON (659333) to TANDE-LNX (659427) to TANDE (659336) 345kV line circuit 1; 3 phase fault on TIOGA (661084) to NESET (659138) 230kV line circuit Z, near TIOGA. a. Apply fault at the TIOGA 230kV bus. b. Clear fault after 6 cycles by tripping the faulted line.	**Un-Stable**	**Un-Stable**	**Un-Stable**
102 A	FLT102A-PO	**Without (AQ Upgrades) and regardless of Voltage Schedule (Vsch).** Curtail to **280 MW** (101MW i.e., 50% for GEN-2016-151, and 179MW i.e., 60% for GEN-2015-046). Prior Outage of JUDSON (659333) to TANDE-LNX (659427) to TANDE (659336) 345kV line circuit 1; 3 phase fault on TIOGA (661084) to NESET (659138) 230kV line circuit Z, near TIOGA. a. Apply fault at the TIOGA 230kV bus. b. Clear fault after 6 cycles by tripping the faulted line.	Stable	Stable	Stable

Cont. #	Contingency Name	Description	2017 Winter Results	2018 Summer Results	2026 Summer Results
102 B	FLT102B-PO	**With AQ Upgrades, maintain 1.02 p.u voltage at POI (Tande 345kV), and main transformer (345/34.5kV) tap settings to unity.** **voltage schedule of GEN-2015-046 to 1.01 p.u and GEN-GEN-2016-151 to 1.03 p.u** Curtail Generation to **375MW** (151.5MW i.e., 75% for GEN-2016-151, and 224.1 MW i.e., 75% for GEN-2015-046). Prior Outage of JUDSON (659333) to TANDE-LNX (659427) to TANDE (659336) 345kV line circuit 1; 3 phase fault on TIOGA (661084) to NESET (659138) 230kV line circuit Z, near TIOGA. a. Apply fault at the TIOGA 230kV bus. b. Clear fault after 6 cycles by tripping the faulted line.	Stable	Stable	Stable
102 C	FLT102C-PO	**With AQ Upgrades, maintain 1.02 p.u voltage at POI (Tande 345kV), and main transformer (345/34.5kV) tap settings to unity.** **voltage schedule of GEN-2015-046 to 1.05 p.u and GEN-GEN-2016-151 to 1.05 p.u** Curtail Generation to **435MW** (175.7MW i.e., 87% for GEN-2016-151, and 260 MW i.e., 87% for GEN-2015-046). Prior Outage of JUDSON (659333) to TANDE-LNX (659427) to TANDE (659336) 345kV line circuit 1; 3 phase fault on TIOGA (661084) to NESET (659138) 230kV line circuit Z, near TIOGA. a. Apply fault at the TIOGA 230kV bus. b. Clear fault after 6 cycles by tripping the faulted line.	Stable	Stable	Stable
103	FLT103-PO	Prior Outage of JUDSON (659333) to TANDE-LNX (659427) to TANDE (659336) 345kV line circuit 1; 3 phase fault on the NESET 230/115/13.8kV (659138/659139/659146) transformer, near NESET 230kV. a. Apply fault at the NESET 230kV bus. b. Clear fault after 6 cycles by tripping the faulted transformer.	Stable	Stable	Stable
104	FLT104-SB	NESET (659138) 230KV Stuck Breaker Scenario a. Apply single line to ground fault at the 659138 230kV bus. b. Run 16 cycles, then clear fault c. Trip NESET (659138) 230kV bus	Stable	Stable	Stable

Cont. #	Contingency Name	Description	2017 Winter Results	2018 Summer Results	2026 Summer Results
105	FLT105-SB	JUDSON (659333) 345KV Stuck Breaker Scenario a. Apply single line to ground fault at Judson 345kV bus. b. Run 16 cycles, then clear fault c. Trip JUDSON (659333) 345kV bus	Stable	Stable	Stable

4.2. Simulation Results for unstable faults

For cluster scenario, there are no impacts on the stability performance of the SPP system for the contingencies tested on the SPP provided base cases, except for the FLT102-PO contingency in each scenario:

In order to maintain stability for FLT102-PO contingency, the following mitigations have been proposed for GEN-2015-046 & GEN-2016-151:

1. Without DPA-2018-August-918 identified upgrades (AQ-Study Upgrades: : Northshore 230 kV Substation, Neset - Northshore 230 kV circuit 1, Northshore 230/115 kV Transformer, Northshore - New Town 115 kV Ckt 1), Curtail Tande 345kV generation to 280 MW i.e., (101MW i.e., 50% for GEN-2016-151, and 179MW i.e., 60% for GEN-2015-046) with main transformer (345/34.5kV) tap settings to unity, and regardless of voltage schedule. The dynamic results are attached as FLT102A-PO.

   In this case, there is thermal limitation on the 188MVA Neset 230/115kV transformer since all power injection at Tande 345kV is directed through this radial transformer. Curtailment for this system condition may require reduction beyond the identified stability limitation.
2. With AQ study upgrades applied, maintaining 1.02 p.u voltage at POI (Tande 345kV), and main transformer (345/34.5kV) tap settings to unity:
   a. Curtail to 375 MW i.e., (151.5MW i.e., 75% for GEN-2016-151, and 224.1 MW i.e., 75% for GEN-2015-046) with generator voltage schedule of GEN-2015-046 to 1.01 p.u and GEN- GEN-2016-151 to 1.03 p.u. The dynamic results are attached as FLT102B-PO.
   b. Curtail to 435 MW i.e., (175.7MW i.e., 87% for GEN-2016-151, and 260 MW i.e., 87% for GEN-2015-046) with generator voltage schedule of GEN-2015-046 to 1.05 p.u and GEN- GEN-2016-151 to 1.05 p.u. The dynamic results are attached as FLT102C-PO.

With the above recommendations there are no impacts on the stability performance of the SPP system during cluster scenarios for the contingencies tested on the provided base cases.

For the other contingencies, the study machines stayed on-line and stable for all simulated faults. The project stability simulations specified test disturbances did not show instability problems in the SPP system. Any oscillations were damped out.

5. Conclusions

The findings of the impact study for the proposed interconnection projects under Addendum-2-DISIS16-2 (Group 16) considered 100% of their proposed installed capacity are as follows:

Stability analysis results indicate that system remain stable for all the defined contingencies except for FLT102-PO (for all scenarios) involving prior outage of JUDSON (659333) to TANDE-LNX (659427) to TANDE (659336) 345kV line along-with tripping of TIOGA (661084) to NESET (659138) 230kV line.

In order to maintain stability for FLT102-PO contingency, the following mitigations have been proposed for GEN-2015-046 & GEN-2016-151:

1. Without DPA-2018-August-918 identified upgrades (AQ-Study Upgrades: Northshore 230 kV Substation, Neset - Northshore 230 kV circuit 1, Northshore 230/115 kV Transformer, Northshore - New Town 115 kV Ckt 1), following prior outage Curtail Tande 345kV generation to 280 MW i.e., (101MW i.e., 50% for GEN-2016-151, and 179MW i.e., 60% for GEN-2015-046) with main transformer (345/34.5kV) tap settings to unity, and regardless of voltage schedule. The dynamic results are attached as FLT102A-PO.

   In this case, there is thermal limitation on the 188MVA Neset 230/115kV transformer since all power injection at Tande 345kV is directed through this radial transformer. Curtailment for this system condition may require reduction beyond the identified stability limitation.
2. With AQ study upgrades applied, maintaining 1.02 p.u voltage at POI (Tande 345kV), and main transformer (345/34.5kV) tap settings to unity:
   a. following prior outage, Curtail Tande 345kV generation to 375 MW i.e., (151.5MW i.e., 75% for GEN-2016-151, and 224.1 MW i.e., 75% for GEN-2015-046) with generator voltage schedule of GEN-2015-046 to 1.01 p.u and GEN- GEN-2016-151 to 1.03 p.u. The dynamic results are attached as FLT102B-PO.
   b. following prior outage, Curtail Tande 345kV generation to 435 MW i.e., (175.7MW i.e., 87% for GEN-2016-151, and 260 MW i.e., 87% for GEN-2015-046) with generator voltage schedule of GEN-2015-046 to 1.05 p.u and GEN-GEN-2016-151 to 1.05 p.u. The dynamic results are attached as FLT102C-PO.

With the above recommendations there are no impacts on the stability performance of the SPP system during cluster scenarios for the contingencies tested on the provided base cases. For all contingencies evaluated, the study machines stayed on-line and stable for all simulated faults. The project stability simulations specified test disturbances did not show instability problems in the SPP system. Any oscillations were damped out.

6. **Appendix A:** **2017 winter Peak Case Stability Run Plots – Cluster**

7. **Appendix B:** **2018 summer Peak Case Stability Run Plots – Cluster**

8. **Appendix C:** **2026 Summer Peak Case Stability Run Plots – Cluster**

9. **Appendix D:** **Project Model Data**

(Appendices available from SPP upon request.)

GROUP 17 STABILITY ANALYSIS

Note: a sensitivity dispatch with the Group 15 study cases with GEN-2016-094 at maximum output was performed to further evaluate fault events near the GEN-2016-094 request.

The Group 17 cases included the following system adjustments of dispatching, to maximum output, generation interconnected at the same or adjacent substations to a current study request:

- Big Bend, Fort Randal, & OAHE units: GEN-2016-094

The Group 17 stability analysis for this area was performed by ABB Inc. (ABB).

With the new requests modeled, violations of stability damping criteria and voltage recovery criteria were not observed using both the Group 15 (sensitivity) and Group 17 dispatches. There were no impacts on the stability performance of the SPP system.

With all previously-assigned and currently-assigned Network Upgrades placed in service, no violations were observed, including violations of low-voltage ride-through requirements, for the probable contingencies studied.

Southwest Power Pool
DISIS-2016-002-2 Group 17 Study Report
Final Report

Report No. E00537 17 March 2020

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Prepared for: Southwest Power Pool
Report No.: E00537
Date: 17 March 2020

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EXECUTIVE SUMMARY

Southwest Power Pool (SPP) has commissioned ABB Inc., to perform a System Impact Study for an interconnection request within DISIS-2016-002-2 (Group 17) which includes a single generation interconnection request GEN-2016-094 (200 MW wind farm tapped on the Ft Thompson – Oahe 230 kV transmission line circuit 1).

The objective of this study is to evaluate the impact of the interconnection request on the existing and future planning system. The study is performed on three system scenarios provided by SPP:

- 2017 Winter Peak Case
- 2018 Summer Peak Case
- 2026 Summer Peak Case

Study results show that all online generating units were stable and showed adequate angular damping, and all voltages recovered after fault clearing and met the study criteria for all studied disturbances.

System three-phase short-circuit current levels at up to five buses away from the point of interconnection were calculated and tabulated for SPP's reference.

A sensitivity study was performed to evaluate the impact of this interconnection request when Group 15 requests are also dispatched at full rated capacity. Study results show that all online generating units were stable and showed adequate angular damping, and all voltages recovered after fault clearing and met the study criteria for all studied disturbances. The sensitivity study is documented in Appendix D SPP DISIS-2016-002-2 Group 17 Sensitivity Report.

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.

Contents

1 INTRODUCTION

Southwest Power Pool (SPP) has commissioned ABB Inc., to perform a System Impact Study for interconnection request DISIS-2016-002-2 (Group 17) which includes a single generation interconnection request GEN-2016-094 (200 MW wind farm tapped on the Ft Thompson – Oahe 230 kV transmission line circuit 1) as shown in Table 1-1.

Table 1-1 Generation Interconnection Request Group 17

Request	Size (MW)	Generator Model	Point of Interconnection
GEN-2016-094	200	GE 2.5MW WTG	Tap Ft Thompson – Oahe 230 kV transmission line circuit 1

The objective of this study is to evaluate the impact of GEN-2016-094 on the existing and future planning system. The study is performed on three system scenarios provided by SPP:

- 2017 Winter Peak Case
- 2018 Summer Peak Case
- 2026 Summer Peak Case

SPP provided the study cases for all three system scenarios with study project included. One line diagrams of the local area for all three seasons are show in Figure 1-1, Figure 1-2, and Figure 1-3 respectively. The detailed machine parameters are listed in Appendix A.

Three system scenarios provided by SPP included the following prior queued projects for Group 17.

Table 1-2 Group 17 Prior Queued Projects

Request	Size (MW)	Generator Model	Point of Interconnection
GEN-2006-002IS & GEN-2016-054	54.40 (Withdrawal of GEN-2016-054, 3.4MW uprate to GEN-2006-002IS, not reflected in study)	GE 1.6 MW WTG (662101)	Wessington Springs 230kV (652607)
GEN-2009-020AIS	130 (reduction to 80MW not reflected in study)	GE 1.85 MW WTG (660016)	Tripp Junction 115kV (660005)
GEN-2012-009IS	99.00 (Withdrawal not reflected in study)	Siemens 3.0 MW WTG (952511)	Fort Randall 115kV (652510)
J599 (MISO)	200.00 (Withdrawal not reflected in study)	Vestas 2.0 MW WTG (85994)	Glenham 230kV Substation (661038)

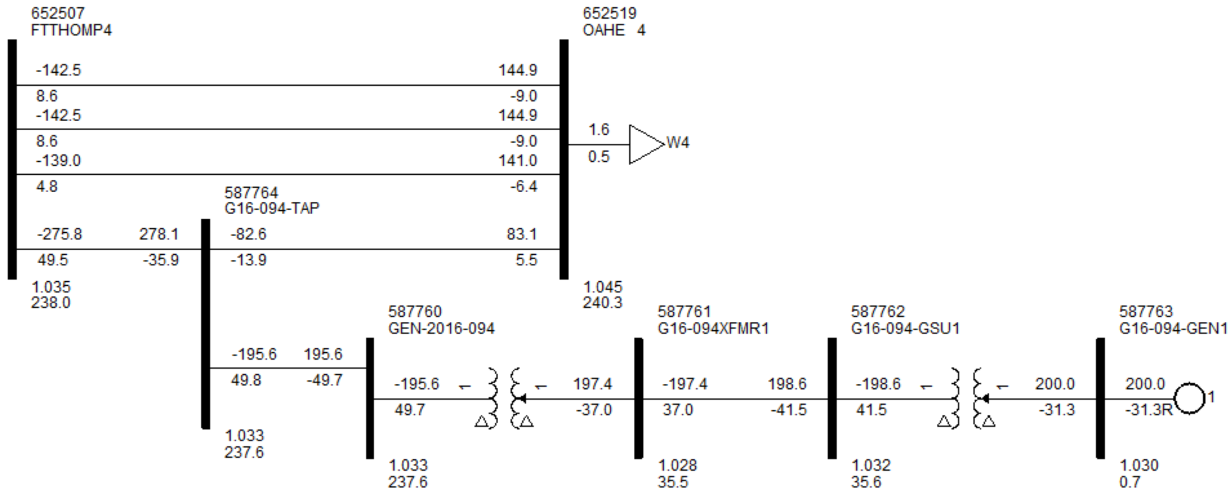

Figure 1-1 One Line Diagram for 2017 Winter Peak Case

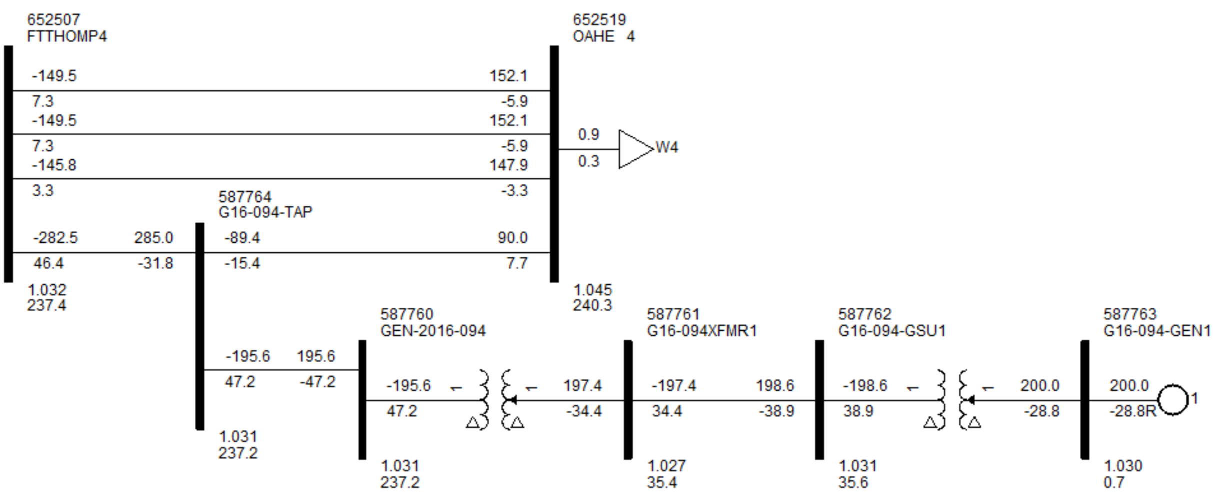

Figure 1-2 One Line Diagram for 2018 Summer Peak Case

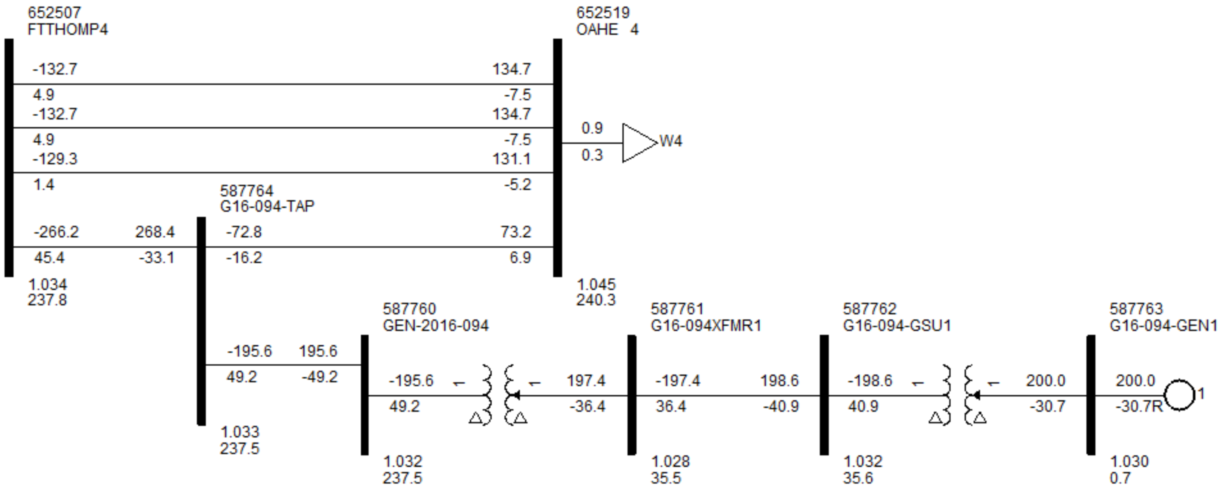

Figure 1-3 One Line Diagram for 2026 Summer Peak Case

A sensitivity study was performed to evaluate the impact of this interconnection request when Group 15 requests are also dispatched at full rated capacity. Study results show that all online generating units were stable and showed adequate angular damping, and all voltages recovered after fault clearing and met the study criteria for all studied disturbances. The sensitivity study is documented in Appendix D SPP DISIS-2016-002-2 Group 17 Sensitivity Report.

2 STABILITY ANALYSIS

In this study, ABB investigated the stability of the system for faults in the vicinity of the study request. The studied faults involve three-phase (3PH) transformer/line faults with normal clearing, and single-line-to-ground (SLG) faults with stuck breaker.

2.1 Contingency (Fault Definitions) Development

Stability analysis was performed to determine whether the electric system would meet stability criteria following the addition of project GEN-2016-094; therefore, faults in the vicinity of the point of interconnection were developed under the approval of SPP.

Three phase faults were developed at point of interconnection and nearby buses with six cycles of duration without reclosing. Prior outage faults were also developed at point of interconnection and nearby buses.

Single-line-to-ground faults with stuck breaker were simulated with the standard method of applying fault impedance to the positive sequence network to represent the effect of the negative and zero sequence networks on the positive sequence network. It simulated potential breaker-failure situations for the substations. The SLG fault impedance was computed by assuming a positive sequence voltage at the fault location at approximately 60% of pre-fault voltage.

The full list and description of developed faults are shown in Table 2-1.

Table 2-1 List of Faults for Stability Analysis

Cont. No.	Cont. Name	Description
1	FLT01-3PH	3 phase fault on G16-094-TAP (587764) to FT THOMPSON 230kV (652507) CKT 1, near G16-094-TAP. a. Apply fault at the G16-094-TAP 230kV bus. b. Clear fault after 6 cycles by tripping the faulted line.
2	FLT02-3PH	3 phase fault on the G16-094-TAP (587764) to OAHE 230kV (652519) CKT 1, near G16-094-TAP. a. Apply fault at the G16-094-TAP 230kV bus. b. Clear fault after 6 cycles by tripping the faulted line.
3	FLT03-3PH	3 phase fault on the OAHE (652519) to FT THOMPSON 230kV (652507) CKT 3, near OAHE 230kV bus. a. Apply fault at the OAHE 230kV bus. b. Clear fault after 6 cycles by tripping the faulted line.
4	FLT04-3PH	3 phase fault on the OAHE (652519) 230/(652520) 115/(652589)13.8kV transformer OA No. 5, near OAHE 230kV bus. a. Apply fault at the OAHE 230kV bus. b. Clear fault after 6 cycles by tripping the faulted transformer.
5	FLT05-3PH	3 phase fault on the OAHE (652519) to SULLY BUTTES 230kV (652521) CKT 1, near OAHE 230kV bus. a. Apply fault at the OAHE 230kV bus. b. Clear fault after 6 cycles by tripping the faulted line.
6	FLT06-3PH	3 phase fault on the FT THOMPSON 230kV (652507) to OAHE (652519) CKT 3, near FT THOMPSON 230kV bus. a. Apply fault at the FT THOMPSON 230kV bus. b. Clear fault after 6 cycles by tripping the faulted line.
7	FLT07-3PH	3 phase fault on the FT THOMPSON (652506) 345/ (652507) 230/ (652273) 13.8kV transformer FT2 KU1A, near FT THOMPSON 230kV bus. a. Apply fault at the FT THOMPSON 230kV bus. b. Clear fault after 6 cycles by tripping the faulted transformer.
8	FLT08-3PH	3 phase fault on the FT THOMPSON 230kV (652507) to WESSINGTON (652607) CKT 1, near FT THOMPSON 230kV bus.

Cont. No.	Cont. Name	Description
		a. Apply fault at the FT THOMPSON 230kV bus. b. Clear fault after 6 cycles by tripping the faulted line.
9	FLT09-3PH	3 phase fault on the FT THOMPSON 230kV (652507) to LETCHER (652606) CKT 1, near FT THOMPSON 230kV bus. a. Apply fault at the FT THOMPSON 230kV bus. b. Clear fault after 6 cycles by tripping the faulted line.
10	FLT10-3PH	3 phase fault on the FT THOMPSON 230kV (652507) to LAKE PLATTE (652516) CKT 1, near FT THOMPSON 230kV bus. a. Apply fault at the FT THOMPSON 230kV bus. b. Clear fault after 6 cycles by tripping the faulted line.
11	FLT11-3PH	3 phase fault on the FT THOMPSON 230kV (652507) to FT RANDALL (652509) CKT 1, near FT THOMPSON 230kV bus. a. Apply fault at the FT THOMPSON 230kV bus. b. Clear fault after 6 cycles by tripping the faulted line.
12	FLT12-3PH	3 phase fault on the FT THOMPSON 230kV (652507) to Huron 230kV (652514) near FT THOMPSON 230kV bus a. Apply fault at the FT. THOMPSON 230kV bus. b. Clear fault after 6 cycles by tripping the faulted line.
13	FLT13-PH	3 phase fault on the FT THOMPSON 345kV (652506) to G16-017-TAP 345kV (560074) line near FT THOMPSON 345kV bus a. Apply fault at the FT THOMPSON 345kV bus. b. Clear fault after 6 cycles by tripping the faulted line (652506-652806-560074)
14	FLT14-3PH	3 phase fault on the FT THOMPSON 345kV (652506) to GRANDE PRAIRIE 345kV (652532) line near FT THOMPSON 345kV bus a. Apply fault at the FT THOMPSON 345kV bus. b. Clear fault after 6 cycles by tripping the faulted line (652506-652807-652833-652532).
15	FLT15-3PH	3 phase fault on the SPLIT ROCK 345kV (601006) to WHITE 345kV (652537) line near SPLIT ROCK 345kV bus a. Apply fault at the SPLIT ROCK 345kV bus. b. Clear fault after 6 cycles by tripping the faulted line.
16	FLT16-3PH	3 phase fault on the SPLIT ROCK 345kV (601006) to NOBLES 345kV (601034) line near SPLIT ROCK 345kV bus a. Apply fault at the SPLIT ROCK 345kV bus. b. Clear fault after 6 cycles by tripping the faulted line.
17	FLT17-3PH	3 phase fault on the SPLIT ROCK 345kV (601006) to SIOUX CITY 345kV (652564) line near SPLIT ROCK 345kV bus a. Apply fault at the SPLIT ROCK 345kV bus. b. Clear fault after 6 cycles by tripping the faulted line (601006-652864-652564).
18	FLT18-PO	**Prior Outage of G16-094-TAP to FT THOMPSON 230kV CKT 1.** 3 phase fault on OAHE – FT THOMPSON 230kV CKT 2, near OAHE 230kV. a. Prior outage G16-094-TAP (587764) to FT THOMPSON (652507) 230kV CKT 1 line (solve network for steady state solution). b. 3 phase fault on OAHE (652519) – FT THOMPSON (652507) 230kV CKT 2, near OAHE 230kV c. Leave fault on for 6 cycles, then trip the faulted line in (b).
19	FLT19-PO	**Prior Outage of G16-094-TAP to OAHE 230kV CKT 1.** 3 phase fault on OAHE – FT THOMPSON 230kV CKT 2, near FT THOMPSON 230kV. a. Prior outage G16-094-TAP (587764) to OAHE (652519) 230kV CKT 1 line (solve network for steady state solution). b. 3 phase fault on OAHE (652519) – FT THOMPSON (652507) 230kV CKT 2, near FT THOMPSON 230kV c. Leave fault on for 6 cycles, then trip the faulted line in (b).
20	FLT20-PO	**Prior Outage of OAHE to FT THOMPSON 230kV CKT 4.** 3 phase fault on OAHE – FT THOMPSON 230kV CKT 3, near OAHE 230kV a. Prior outage OAHE (652519) to FT THOMPSON (652507) 230kV CKT 4 (solve network for steady state solution). b. 3 phase fault on OAHE (652519) – FT THOMPSON (652507) 230kV CKT 3, near OAHE 230kV c. Leave fault on for 6 cycles, then trip the faulted line in (b).
21	FLT21-PO	**Prior Outage of OAHE to FT THOMPSON 230kV CKT 4.** 3 phase fault on G16-094-TAP – OAHE230kV CKT 1, near G16-094-TAP 230kV a. Prior outage OAHE (652519) to FT THOMPSON (652507) 230kV CKT 4 (solve network for steady state solution). b. 3 phase fault on G16-094-TAP (587764) – OAHE (652519)230kV CKT 1, near G16-094-TAP 230kV

Cont. No.	Cont. Name	Description
		c. Leave fault on for 6 cycles, then trip the faulted line in (b).
22	FLT22-PO	**Prior Outage of FT THOMPSON to LAKE PLATTE 230kV CKT 1.** 3 phase fault on FT THOMPSON – FT RANDALL 230kV CKT 1, near FT THMPSON 230kV. a. Prior outage FT THOMPSON (652507) to LAKE PLATTE (652516) 230kV CKT1 (solve network for steady state solution). b. 3 phase fault on FT THMPSON (652507) – FT RANDALL (652509) 230kV CKT 1, near FT THMPSON 230kV. c. Leave fault on for 6 cycles, then trip the faulted line in (b).
23	FLT23-PO	**Prior Outage of FT THOMPSON to LETCHER 230kV CKT 1.** 3 phase fault on FT THOMPSON – WESSINGTON 230kV CKT 1, near FT THMPSON 230kV. a. Prior outage FT THOMPSON (652507) to LETCHER (652606) 230kV CKT1 (solve network for steady state solution). b. 3 phase fault on FT THOMPSON (652507) – WESSINGTON (652607) 230kV CKT 1, near FT THMPSON 230kV c. Leave fault on for 6 cycles, then trip the faulted line in (b).
24	FLT24-PO	**Prior Outage of FT THOMPSON to HURON 230kV CKT 1.** 3 phase fault on FT THOMPSON – HURON 230kV CKT 2, near FT THMPSON 230kV. a. Prior outage FT THOMPSON (652507) to HURON (652514) 230kV CKT1 (solve network for steady state solution). b. 3 phase fault on FT THOMPSON (652507) – HURON (652514) 230kV CKT 2, near FT THMPSON 230kV. c. Leave fault on for 6 cycles, then trip the faulted line in (b).
25	FLT25-PO	**Prior Outage of FT. THOMPSON to HURON 230kV circuit 1.** 3 phase fault on the 345/230/13.8kV FT. THOMPSON Transformer, near FT THMPSON 230kV. a. Prior outage FT. THOMPSON (652507) 230kV to Huron (652514) 230kV (solve network for steady state solution) circuit 1. b. 3 phase fault on the 345/230/13.8kV FT. THOMPSON (652507) transformer #3 (652506) 13.8kV (652274), near FT THMPSON 230kV c. Leave fault on for 6 cycles, then trip the faulted line in (b).
26	FLT26-SB	**G16-094-TAP 230kV Stuck Breaker** a. Apply single phase fault on G16-094-TAP (587764) 230kV to OAHE (652519) 230kV CKT 1, near G16-094-TAP. b. Wait 16 cycles, and then trip the faulted line c. Trip G16-094-TAP (587764) to FT THOMPSON 230kV (652507) CKT 1 and remove the fault. Trip Gen-2016-094 wind farm, including generator (587763) and the collector system (587760, 587761, 587762, 587764).
27	FLT27-SB	**FT. THOMPSON 230kV Stuck Breaker** a. Apply single phase fault on FT THOMPSON (652507) 230kV to G16-094-TAP (587764) 230kV CKT 1, near FT THOMPSON. b. Wait 16 cycles, and then trip the faulted line c. Trip FT THOMPSON (652507) 230kV to HURON 230kV (652514) CKT 1 and remove the fault.
28	FLT28-SB	**FT. THOMPSON 230kV Stuck Breaker** a. Apply single phase fault on FT THOMPSON (652507) 230kV to OAHE (652519) 230kV CKT 3 near FT THOMPSON. b. Wait 16 cycles, and then trip the faulted line c. Trip FT THOMPSON (652507) 230kV to WESSINGTON SPRINGS 230kV (652607) CKT 1 and remove the fault.
29	FLT29-SB	**FT. THOMPSON 230kV Stuck Breaker** a. Apply single phase fault on FT THOMPSON (652507) 230kV to OAHE (652519) 230kV CKT 4 near FT THOMPSON. b. Wait 16 cycles, and then trip the faulted line c. Trip FT THOMPSON (652507) 230kV to LETCHER 230kV (652606) CKT 1 and remove the fault.
30	FLT30-SB	**FT. THOMPSON 230kV Stuck Breaker** a. Apply single phase fault on FT THOMPSON (652507) 230kV to FT RANDALL (652509) 230kV CKT1 near FT THOMPSON. b. Wait 16 cycles, and then trip the faulted line c. Trip BIG BEND GENERATORS G1-G4 (652542, 652543, 652540) and remove the fault.
31	FLT31-SB	**FT. THOMPSON 230kV Stuck Breaker** a. Apply single phase fault on FT THOMPSON (652507) 230kV to LAKE PLATTE (652516) 230kV CKT1 near FT THOMPSON. b. Wait 16 cycles, and then trip the faulted line c. Trip BIG BEND GENERATORS G5-G8 (652544, 652545, 652541) and remove the fault.

Cont. No.	Cont. Name	Description
32	FLT32-SB	**FT. THOMPSON 230kV Stuck Breaker** a. Apply single phase fault on FT THOMPSON (652506) 345kV / (652507) 230kV / (652273) 13.8kV transformer KU1A near FT THOMPSON 230kV (652507). b. Wait 16 cycles, and then trip the faulted transformer c. Trip FT THOMPSON (652506) 345kV / (652507) 230kV / (652274) 13.8kV transformer KU1B and remove the fault.
33	FLT33-SB	**OAHE 230kV Stuck Breaker** a. Apply single phase fault on OAHE (652519) 230kV to FT THOMPSON (652507) 230kV CKT 3 near OAHE. b. Wait 16 cycles, and then trip the faulted line c. Trip OAHE (652519) to FT THOMPSON (652507) 230kV CKT 4, OAHE GENERATORS 6&7, and remove the fault.
34	FLT34-SB	**OAHE 230kV Stuck Breaker** a. Apply single phase fault on OAHE (652519) 230kV to FT THOMPSON (652507) 230kV CKT 2 near OAHE. b. Wait 16 cycles, and then trip the faulted line c. Trip PHILIP TAP (652488) 230kV bus, OAHE (652519) to SULLY BUTTES 230kV (652521), OAHE GENERATORS 4&5, and remove the fault.
35	FLT35-SB	**OAHE 230kV Stuck Breaker** a. Apply single phase fault on OAHE (652519) 230kV to G16-094-TAP (587764) 230kV CKT 1 near OAHE. b. Wait 16 cycles, and then trip the faulted line c. Trip OAHE 230/115 kV transformers OA NO. 5&6, OAHE GENERATORS 2&3, and remove the fault.
36	FLT36-SB	**FT. THOMPSON 345kV Stuck Breaker** a. Apply single phase fault on the 345kV FT. THOMPSON (652506) bus to 345kV G16-017-TAP (560074) bus near FT. THOMPSON. b. Wait 16 cycles, and then trip FT. THOMPSON (652506) – G16-017-TAP (560074) 345kV line (652506-652806-560074 345kV line) c. Trip FT THOMPSON (652506) 345kV / (652507) 230kV / (652273) 13.8kV transformer KU1A and remove the fault.

2.2 Study Methodology

Stability analysis was performed using Siemens-PTI's PSS/E dynamic program V33.7.0. The Southwest Pool Disturbance Performance Criteria Requirements in Reference [1] were used to evaluate the system response during the initial transient period following a disturbance on the system. Generator response and bus voltages (115 kV and above) in Areas 520, 524, 525, 526, 531, 534, 536, 640, 645, 650, and 652 were monitored to ensure the system performance meets criteria requirements. Bus voltage at point of interconnection and nearby 69 kV buses were also monitored to ensure proper transient response. Rotor angles of the nearby synchronous machines were investigated to make sure they maintained synchronism and had adequate damping following system faults.

To maintain system reliability generators must be designed in accordance with Good Utility Practice and comply with all applicable standards including NERC standard PRC-024-2 Generator Frequency and Voltage Protective Relay Settings. Therefore, the generators should be designed to ride through and not be tripped off line for faults on the transmission system, including those at or near the POI, that are cleared within normal clearing times. Generator speed of pre-queued projects was also monitored to ensure they stay online under system contingencies. For contingencies that result in a prior queued project tripping off-line, the contingency shall be re-run with the prior queued project's voltage and frequency tripping disabled.

2.3 Stability Analysis Results

Stability analysis was performed in PSS/E 33.7.0 and all disturbances listed in Table 2-1 were simulated for 20 seconds. Simulation results indicate that all online generating units were stable and showed adequate angular damping, and all voltages recovered after fault clearing and met the study criteria for all studied disturbances. The entire simulation results were summarized in Appendix B Stability Analysis Results.

3 SHORT CIRCUIT ANALYSIS

Short circuit analysis was performed on the 2018 Summer Peak and 2026 Summer Peak power flow cases using ASCC function of PSS/E. Since the provided cases do not have complete sequence data, only three-phase symmetrical fault current levels were calculated at up to five buses away from the point of interconnection. The following simulation settings were used when performing such analysis:

- Use 3 phase fault
- Impose flat condition
- Output option – total fault currents in amps

The detailed analysis results are tabulated in Appendix C Short Circuit Analysis Result for SPP's reference.

4 REFERENCES

[1] Southwest Power Pool Disturbance Performance Requirements, Revision 3.0, July 21, 2016.

Appendix A GEN-2016-094 Machine Parameters

Appendix A.1 Power Flow Model

Power flow model data is in separate file which is listed below:
AppendixA1_Power_Flow_Model.txt

Appendix A.2 Dynamic Model

Dynamic model data is in separate file which is listed below:
AppendixA2_Dynamic_Model.txt

Appendix B Stability Analysis Results

Appendix B.1 Study Result Summary

Index	Fault Name	2017 Winter Peak			2018 Summer Peak			2026 Summer Peak		
		Stable	Volt & Angle Violation	Study Generator Tripped	Stable	Volt & Angle Violation	Study Generator Tripped	Stable	Volt & Angle Violation	Study Generator Tripped
1	FLT01-3PH	Yes	No	No	Yes	No	No	Yes	No	No
2	FLT02-3PH	Yes	No	No	Yes	No	No	Yes	No	No
3	FLT03-3PH	Yes	No	No	Yes	No	No	Yes	No	No
4	FLT04-3PH	Yes	No	No	Yes	No	No	Yes	No	No
5	FLT05-3PH	Yes	No	No	Yes	No	No	Yes	No	No
6	FLT06-3PH	Yes	No	No	Yes	No	No	Yes	No	No
7	FLT07-3PH	Yes	No	No	Yes	No	No	Yes	No	No
8	FLT08-3PH	Yes	No	No	Yes	No	No	Yes	No	No
9	FLT09-3PH	Yes	No	No	Yes	No	No	Yes	No	No
10	FLT10-3PH	Yes	No	No	Yes	No	No	Yes	No	No
11	FLT11-3PH	Yes	No	No	Yes	No	No	Yes	No	No
12	FLT12-3PH	Yes	No	No	Yes	No	No	Yes	No	No
13	FLT13-3PH	Yes	No	No	Yes	No	No	Yes	No	No
14	FLT14-3PH	Yes	No	No	Yes	No	No	Yes	No	No
15	FLT15-3PH	Yes	No	No	Yes	No	No	Yes	No	No
16	FLT16-3PH	Yes	No	No	Yes	No	No	Yes	No	No
17	FLT17-3PH	Yes	No	No	Yes	No	No	Yes	No	No
18	FLT18-PO	Yes	No	No	Yes	No	No	Yes	No	No
19	FLT19-PO	Yes	No	No	Yes	No	No	Yes	No	No
20	FLT20-PO	Yes	No	No	Yes	No	No	Yes	No	No
21	FLT21-PO	Yes	No	No	Yes	No	No	Yes	No	No
22	FLT22-PO	Yes	No	No	Yes	No	No	Yes	No	No
23	FLT23-PO	Yes	No	No	Yes	No	No	Yes	No	No
24	FLT24-PO	Yes	No	No	Yes	No	No	Yes	No	No
25	FLT25-PO	Yes	No	No	Yes	No	No	Yes	No	No
26	FLT26-SB	Yes	No	No	Yes	No	No	Yes	No	No
27	FLT27-SB	Yes	No	No	Yes	No	No	Yes	No	No
28	FLT28-SB	Yes	No	No	Yes	No	No	Yes	No	No
29	FLT29-SB	Yes	No	No	Yes	No	No	Yes	No	No
30	FLT30-SB	Yes	No	No	Yes	No	No	Yes	No	No
31	FLT31-SB	Yes	No	No	Yes	No	No	Yes	No	No
32	FLT32-SB	Yes	No	No	Yes	No	No	Yes	No	No
33	FLT33-SB	Yes	No	No	Yes	No	No	Yes	No	No
34	FLT34-SB	Yes	No	No	Yes	No	No	Yes	No	No
35	FLT35-SB	Yes	No	No	Yes	No	No	Yes	No	No
36	FLT36-SB	Yes	No	No	Yes	No	No	Yes	No	No

Appendix B.2 Study Result Plot

Plots of stability simulations for all three scenarios are available from SPP upon request.

Appendix C Short Circuit Analysis Result

Appendix C.1 2018 Summer Peak Case

Bus Number	Bus Name	3PH (Amp)	Bus Number	Bus Name	3PH (Amp)
560074	G16-017-TAP 345.00	6526.7	652525	TYNDALL7 115.00	3772.8
560347	G10-051-TAP 230.00	7081.8	652526	UTICAJC4 230.00	7846.1
560997	WESSINGTON1C34.500	13530.5	652527	WHITLOK4 230.00	4860.3
563230	GEN-2015-089230.00	5352.4	652528	WOONSKT7 115.00	5257.5
563231	G15-089XFMR134.500	17881.7	652529	WATERTN3 345.00	10272.8
587130	GEN-2016-017345.00	6470.5	652530	WATERTN4 230.00	14170.5
587750	GEN-2016-092345.00	6470.6	652531	WATERTN7 115.00	12434.7
587760	GEN-2016-094230.00	9037.4	652532	GR PRAIRIE 3345.00	6829.5
587761	G16-094XFMR134.500	30437.7	652535	REDFELD7 115.00	4035.2
587762	G16-094-GSU134.500	28724.3	652536	RASMUSN4 230.00	6583.6
587763	G16-094-GEN10.6900	1103402.1	652539	WATERSVC 20.000	23113.9
587764	G16-094-TAP 230.00	9199.5	652540	BIGBND14 230.00	12067.1
587830	GEN-2016-103345.00	6471.5	652541	BIGBND24 230.00	11989.4
602004	SPLT RK4 230.00	12557.2	652542	BGBND12G 13.800	56481.2
603009	GRANT 7 115.00	3948.7	652543	BGBND34G 13.800	56581.5
603012	LAWRENC7 115.00	28883.5	652544	BGBND56G 13.800	56634.9
603016	SPLT RK7 115.00	36570.5	652545	BGBND78G 13.800	56634.9
605725	SPLT RK161 913.800	33991.5	652546	FTRDL12G 13.800	44664.2
620314	BIGSTON4 230.00	16421.4	652547	FTRDL34G 13.800	42320.4
635200	RAUN 3 345.00	25370.2	652548	FTRDL56G 13.800	42320.4
635223	PLYMOTH5 161.00	19711.6	652549	FTRDL78G 13.800	42320.4
640126	E.COL. 4 230.00	9474.9	652550	GRANITF4 230.00	12973.6
640131	COLMB.W4 230.00	9593.7	652556	OAHE2-3G 13.800	89159.5
640133	COLMBUS4 230.00	11129.6	652557	OAHE4-5G 13.800	89159.5
640134	KELLY 7 115.00	17492.4	652558	OAHE6-7G 13.800	89159.5
640135	COLMBS19 13.200	24590.6	652559	OAHE 1G 13.800	47572.7
640305	ONEILL 7 115.00	3892.4	652561	DENISON5 161.00	5230.3
640343	SHELCRK4 230.00	10611.8	652563	SPENCER5 161.00	8848.3
640349	SPENCER7 115.00	4584.2	652564	SIOUXCY3 345.00	14848.7
640350	SPENCER9 34.500	1394.1	652565	SIOUXCY4 230.00	19350.2
640386	TWIN CH4 230.00	8459.3	652566	SIOUXCY5 161.00	20155.3
640387	TWIN CH7 115.00	10554.9	652567	DENISON4 230.00	4272.9
640404	WAYSIDE4 230.00	2738.5	652568	GROTONSOUTH 115.00	13758.3
640405	WAYSIDE7 115.00	3949.8	652574	SIOUXCY8 69.000	17586.3
640406	WAYSIDE9 13.800	14987.7	652578	PAHOJA 4 230.00	7246.6
640540	MEADOWGROVE4230.00	5558	652579	WANBLEE 7 115.00	2369.7
642079	PB_III_SUB 34.500	5418.9	652582	APPLEDORN 4 230.00	7089.4
642080	PB_III_TRT 13.800	10761	652583	DENISON8 69.000	10945.9

Bus Number	Bus Name	3PH (Amp)	Bus Number	Bus Name	3PH (Amp)
643140	SPENCER T1 913.800	2218.5	652588	CLEVELD4 230.00	4741.8
643155	TWIN CH T4 913.800	20810.3	652589	OAHE 9 13.800	6701.6
643156	TWIN CH T6 913.800	21790.4	652591	HANLON 7 115.00	5510.4
648506	PR BRZ 4 230.00	4210.1	652592	HANLON 9 13.800	14556.5
648507	PR BR1X9 34.500	14731.8	652598	OAHE 29 13.800	6232.8
648508	PR BR1Y9 13.800	25510.3	652600	ASH TAP 115.00	8699
648510	PR BR2X9 34.500	14921.1	652601	ASH ST 7 115.00	7252.8
648511	PR BR2Y9 13.800	25820.8	652602	EVANS ST 115.00	7661.4
650102	PR BRZ B9 34.500	9758.5	652604	APPLEDORN 8 69.000	2499.2
650103	PR BRZ Y9 13.800	22620.3	652605	APPLEDORN 9 13.200	5863.5
652001	G13_001IST 115.00	5258.5	652606	LETCHER4 230.00	4728.1
652175	G09_001IST 345.00	5939.1	652607	WESSINGTON 4230.00	6810.1
652223	PIERRE 8 69.000	1592.2	652608	LETCHER9 13.200	16272.8
652224	BLAIR 8 69.000	2536.7	652609	LETCHER7 115.00	6035.6
652232	SIOUXF19 13.200	31418.5	652614	CARPENTER 4 230.00	6805.1
652233	SIOUXF29 13.200	31330.4	652626	UTICAJC7 115.00	8728.1
652235	SIOUXFL8 69.000	3880.6	652627	UTICAJC9 13.200	18055.3
652237	WATERT19 13.800	38163	652630	WATERTNCAP 4230.00	14170.5
652239	WATERT29 13.200	21375.8	652657	DENISON 9 13.800	18464
652240	WATERT39 13.200	21367.1	652806	FTTHOM1-LNX3345.00	9483.9
652242	WATERT18 69.000	3879.2	652807	FTTHOM2-LNX3345.00	9483.9
652243	FAITH 7 115.00	2315.8	652821	SULLYBT-LNX3230.00	6553.8
652246	ARMOUR 9 34.500	2678.1	652829	WATERTN-LNX3345.00	10272.8
652249	ARMOUR 8 69.000	2438.6	652833	GRPRAR2-LNX3345.00	6829.5
652259	EAGLEBE8 69.000	1636.7	652864	SIOUXCY-LNX3345.00	14848.7
652260	EAGLEBW8 69.000	2141.7	652873	STEGALL-LNX3230.00	5263.6
652263	MIDLAND8 69.000	2079.8	652884	NUNDRWD-LNX3230.00	3396.5
652266	NUNDRWD10 13.800	24115.7	655063	SW341-ER8 69.000	3587.4
652267	NUNDRWD9 13.800	20313.4	655066	SW352-ER8 69.000	3625.8
652268	PHILIP 8 69.000	2383.3	655067	SW353-ER8 69.000	3629.6
652273	FTTHMP19 13.800	26014.4	655073	MOS-CRPN-ER869.000	2429.1
652274	FTTHMP29 13.800	26015.2	655079	MOS-KLKP-ER869.000	768.1
652276	FTTHOMP8 69.000	4426.2	655080	MOS-HLTP-ER869.000	1306.4
652277	LAKPLAT8 69.000	4018	655153	MOS-AMES-ER869.000	4365.8
652278	HANLON18 69.000	3017.2	655155	MOS-SLY1-ER869.000	2366.5
652279	HANLON28 69.000	3017.2	655158	MOS-HYDE-ER869.000	3451.6
652281	HURON419 13.328	33805	655250	CHMBRLAN-ER869.000	1581.7
652282	HURON429 13.328	33801.6	655328	BIGBEND-ER8 69.000	3233.9
652284	HURON 8 69.000	3641.2	655329	GANNVALL-ER869.000	862.9
652285	SULLYBT8 69.000	2380.3	655333	ONIDA-ER8 69.000	1515.2
652287	RASMUSN8 69.000	3159.7	655334	OKOBOJO-ER8 69.000	2369.9

Bus Number	Bus Name	3PH (Amp)	Bus Number	Bus Name	3PH (Amp)
652291	REDFELD8 69.000	2784.7	655352	AMES-ER8 69.000	1338.7
652304	SIOUXC19 13.800	26631.8	655355	WOONSKT-ER8 69.000	3565.9
652305	SIOUXC29 13.800	26698.7	655373	MOS-SLY2-ER869.000	2376.6
652308	SIOUXC39 13.800	18552.9	655377	SW1145-ER7 115.00	24323.1
652310	SIOUXC49 13.800	18770.9	655384	NWPS8645-ER869.000	2177.5
652396	VFODNS19 12.500	20765.4	655385	MOS-LKPL-ER869.000	4003.5
652397	VFODNES7 115.00	6282.2	655386	MOS-RVR1-ER869.000	2086.7
652398	VFODNES4 230.00	6985.6	655412	CRPNTR-ER8 69.000	2809.6
652399	VFODNES8 69.000	4198.1	655415	ROSKPS22-ER94.2000	16645.4
652463	WH SWAN7 115.00	12639.2	655417	ROSWELL-ER7 115.00	2603.3
652475	BONESTL7 115.00	3507.8	655418	FREEMAN-ER7 115.00	2557.5
652476	EAGLEBT7 115.00	1946.9	658088	WTREAST7 115.00	9591
652477	ELSWRTH7 115.00	3755.8	658094	WTRPELI7 115.00	8523.5
652478	GREGORY7 115.00	2124.5	658120	GARFLD 7 115.00	7126.7
652480	MAURINE7 115.00	3916.7	659119	STORLA 9 13.200	16148.4
652481	MIDLAND7 115.00	3277.3	659120	BRDLAND3 345.00	3989.8
652484	NUNDRWD4 230.00	3396.5	659122	STORLA 4 230.00	6055.8
652485	NUNDRWD7 115.00	5726.9	659123	STORLA 7 115.00	6608.1
652486	PHILIP 4 230.00	3104.3	659196	CARPENTER 8 69.000	3167.7
652487	PHILIP 7 115.00	5074.8	659204	BROADLAND 913.800	22956.1
652488	PHILTAP4 230.00	3692.1	659205	BRDLAND4 230.00	9740.2
652489	PIERRE 7 115.00	8225.8	659271	RCDC EAST 4230.00	2633.1
652491	IRVSIMM7 115.00	8172.7	659295	SDPRAIRWND 4230.00	5620
652492	WALL 7 115.00	3316.8	659296	WESSINGTON1W0.5750	2253065.5
652493	WICKSVL7 115.00	3890.2	659324	HYDE 934.500	7074.3
652496	RUSHMRE7 115.00	4225.9	659327	SDPRAIRWND 934.500	32108.6
652497	MAURINE4 230.00	2758.2	659376	DRY CREEK 4230.00	2638.6
652498	PHILIP9 13.200	12120.3	659377	DRY CREEK 7115.00	4289.5
652500	ARLNGTN7 115.00	4293	659378	DRY CREEK 913.800	13510.7
652501	ARMOUR 7 115.00	4166.2	659421	BRDLAND-LNX3345.00	3989.8
652502	BERSFRD7 115.00	3177.5	659424	LELAND2-LNX3345.00	16726.5
652503	BLAIR 4 230.00	9842.2	659716	MAPLETAP-LO7115.00	13106.9
652504	BROOKNG7 115.00	7139.8	659900	EAGLE 4 230.00	7094.8
652505	FLANDRU7 115.00	4048.8	659901	EAGLE 8 69.000	13575.5
652506	FTTHOMP3 345.00	9483.9	660002	REDFLD 7 115.00	3953.2
652507	FTTHOMP4 230.00	20503.3	660003	HURONWP7 115.00	9598.5
652509	FTRANDL4 230.00	11028.9	660004	MITCHEL7 115.00	5862.6
652510	FTRANDL7 115.00	12979.8	660005	TRIPP 7 115.00	4233.4
652513	HANLON 4 230.00	5996.7	660007	MENNOJT7 115.00	6554.4
652514	HURON 4 230.00	10735.3	660008	MITCLNW7 115.00	5482.4
652515	HURON 7 115.00	14843.8	660009	BTAP WP7 115.00	14417.6

Bus Number	Bus Name	3PH (Amp)	Bus Number	Bus Name	3PH (Amp)
652516	LAKPLAT4 230.00	5618.2	660012	HURON WP 869.000	5912.4
652518	MTVERN 7 115.00	4301.4	660026	NAPA JCT7 115.00	7837.4
652519	OAHE 4 230.00	14206.4	661038	GLENHAM4 230.00	4864.1
652520	OAHE 7 115.00	11683.4	662100	WESSINGTON 934.500	16621
652521	SULLYBT4 230.00	6553.8	662101	WESSINGTON1W0.6900	420785.1
652523	SIOUXFL4 230.00	12950.9	952509	G12_009IS 115.00	6514.2
652524	SIOUXFL7 115.00	25556	952510	G12_009IS_1 34.500	9099.4

Appendix C.2 2026 Summer Peak Case

Bus Number	Bus Name	3PH (Amp)	Bus Number	Bus Name	3PH (Amp)
560074	G16-017-TAP 345.00	6531.0	652525	TYNDALL7 115.00	3795.4
560347	G10-051-TAP 230.00	7092.0	652526	UTICAJC4 230.00	7893.1
560997	WESSINGTON1C34.500	13534.0	652527	WHITLOK4 230.00	4863.2
563230	GEN-2015-089230.00	5372.7	652528	WOONSKT7 115.00	5263.0
563231	G15-089XFMR134.500	17907.0	652529	WATERTN3 345.00	10697.5
587130	GEN-2016-017345.00	6474.8	652530	WATERTN4 230.00	14508.2
587750	GEN-2016-092345.00	6474.8	652531	WATERTN7 115.00	12584.6
587760	GEN-2016-094230.00	9043.7	652532	GR PRAIRIE 3345.00	6839.8
587761	G16-094XFMR134.500	30446.9	652535	REDFELD7 115.00	4106.8
587762	G16-094-GSU134.500	28732.3	652536	RASMUSN4 230.00	6603.6
587763	G16-094-GEN10.6900	1103607.0	652539	WATERSVC 20.000	23189.7
587764	G16-094-TAP 230.00	9206.1	652540	BIGBND14 230.00	12080.1
587830	GEN-2016-103345.00	6475.8	652541	BIGBND24 230.00	12002.2
602004	SPLT RK4 230.00	12690.9	652542	BGBND12G 13.800	56489.0
603009	GRANT 7 115.00	3953.9	652543	BGBND34G 13.800	56589.3
603012	LAWRENC7 115.00	29287.6	652544	BGBND56G 13.800	56642.7
603016	SPLT RK7 115.00	37046.4	652545	BGBND78G 13.800	56642.7
605725	SPLT RK161 913.800	34038.9	652546	FTRDL12G 13.800	44681.4
620314	BIGSTON4 230.00	16563.7	652547	FTRDL34G 13.800	42330.5
635200	RAUN 3 345.00	25494.2	652548	FTRDL56G 13.800	42330.5
635223	PLYMOTH5 161.00	19893.0	652549	FTRDL78G 13.800	42330.5
640126	E.COL. 4 230.00	9502.5	652550	GRANITF4 230.00	13080.7
640131	COLMB.W4 230.00	9624.7	652556	OAHE2-3G 13.800	89168.5
640133	COLMBUS4 230.00	11167.2	652557	OAHE4-5G 13.800	89168.5
640134	KELLY 7 115.00	17557.9	652558	OAHE6-7G 13.800	89168.5
640135	COLMBS19 13.200	24605.3	652559	OAHE 1G 13.800	47586.5
640305	ONEILL 7 115.00	3893.6	652561	DENISON5 161.00	5242.3
640343	SHELCRK4 230.00	10643.7	652563	SPENCER5 161.00	10147.8
640349	SPENCER7 115.00	4586.4	652564	SIOUXCY3 345.00	14931.6
640350	SPENCER9 34.500	1394.2	652565	SIOUXCY4 230.00	19501.0
640386	TWIN CH4 230.00	8480.5	652566	SIOUXCY5 161.00	20350.0
640387	TWIN CH7 115.00	10574.2	652567	DENISON4 230.00	4283.9
640404	WAYSIDE4 230.00	2739.6	652568	GROTONSOUTH 115.00	18187.0
640405	WAYSIDE7 115.00	3950.7	652574	SIOUXCY8 69.000	17657.0
640406	WAYSIDE9 13.800	14989.2	652578	PAHOJA 4 230.00	7308.4
640540	MEADOWGROVE4230.00	5562.2	652579	WANBLEE 7 115.00	2370.3
642079	PB_III_SUB 34.500	5419.3	652582	APPLEDORN 4 230.00	7128.8
642080	PB_III_TRT 13.800	10761.5	652583	DENISON8 69.000	10977.0
643140	SPENCER T1 913.800	2218.6	652588	CLEVELD4 230.00	4782.6

Bus Number	Bus Name	3PH (Amp)	Bus Number	Bus Name	3PH (Amp)
643155	TWIN CH T4 913.800	20819.5	652589	OAHE 9 13.800	6233.6
643156	TWIN CH T6 913.800	21800.6	652591	HANLON 7 115.00	5520.5
648506	PR BRZ 4 230.00	4211.7	652592	HANLON 9 13.800	14565.0
648507	PR BR1X9 34.500	14733.1	652598	OAHE 29 13.800	6233.6
648508	PR BR1Y9 13.800	25512.8	652600	ASH TAP 115.00	8709.7
648510	PR BR2X9 34.500	14922.4	652601	ASH ST 7 115.00	7260.8
648511	PR BR2Y9 13.800	25823.3	652602	EVANS ST 115.00	7670.1
650102	PR BRZ B9 34.500	9759.6	652604	APPLEDORN 8 69.000	2500.6
650103	PR BRZ Y9 13.800	22622.9	652605	APPLEDORN 9 13.200	5865.0
652001	G13_001IST 115.00	5353.2	652606	LETCHER4 230.00	4737.4
652175	G09_001IST 345.00	6391.5	652607	WESSINGTON 4230.00	6817.0
652223	PIERRE 8 69.000	1592.4	652608	LETCHER9 13.200	16280.1
652224	BLAIR 8 69.000	2538.0	652609	LETCHER7 115.00	6044.2
652232	SIOUXF19 13.200	31492.7	652614	CARPENTER 4 230.00	6845.2
652233	SIOUXF29 13.200	31406.3	652626	UTICAJC7 115.00	8820.2
652235	SIOUXFL8 69.000	3886.2	652627	UTICAJC9 13.200	18106.3
652237	WATERT19 13.800	38411.7	652630	WATERTNCAP 4230.00	14508.2
652239	WATERT29 13.200	21427.4	652657	DENISON 9 13.800	18477.1
652240	WATERT39 13.200	21418.6	652806	FTTHOM1-LNX3345.00	9495.0
652242	WATERT18 69.000	3887.9	652807	FTTHOM2-LNX3345.00	9495.0
652243	FAITH 7 115.00	2316.1	652821	SULLYBT-LNX3230.00	6557.0
652246	ARMOUR 9 34.500	2678.4	652829	WATERTN-LNX3345.00	10697.5
652249	ARMOUR 8 69.000	2439.0	652833	GRPRAR2-LNX3345.00	6839.8
652259	EAGLEBE8 69.000	1636.9	652864	SIOUXCY-LNX3345.00	14931.6
652260	EAGLEBW8 69.000	2141.9	652873	STEGALL-LNX3230.00	5266.3
652263	MIDLAND8 69.000	2080.2	652884	NUNDRWD-LNX3230.00	3400.7
652266	NUNDRWD10 13.800	24663.1	655063	SW341-ER8 69.000	3591.3
652267	NUNDRWD9 13.800	24663.1	655066	SW352-ER8 69.000	3629.7
652268	PHILIP 8 69.000	2384.0	655067	SW353-ER8 69.000	3633.6
652273	FTTHMP19 13.800	26018.8	655073	MOS-CRPN-ER869.000	2430.6
652274	FTTHMP29 13.800	26019.6	655079	MOS-KLKP-ER869.000	768.1
652276	FTTHOMP8 69.000	4426.6	655080	MOS-HLTP-ER869.000	1306.4
652277	LAKPLAT8 69.000	4018.7	655153	MOS-AMES-ER869.000	4366.1
652278	HANLON18 69.000	3018.9	655155	MOS-SLY1-ER869.000	2366.6
652279	HANLON28 69.000	3018.9	655158	MOS-HYDE-ER869.000	3451.7
652281	HURON419 13.328	33875.0	655250	CHMBRLAN-ER869.000	1581.8
652282	HURON429 13.328	33871.5	655328	BIGBEND-ER8 69.000	3234.0
652284	HURON 8 69.000	3645.2	655329	GANNVALL-ER869.000	863.0
652285	SULLYBT8 69.000	2380.4	655333	ONIDA-ER8 69.000	1515.2
652287	RASMUSN8 69.000	3161.1	655334	OKOBOJO-ER8 69.000	2370.1
652291	REDFELD8 69.000	2802.8	655352	AMES-ER8 69.000	1338.8

Bus Number	Bus Name	3PH (Amp)	Bus Number	Bus Name	3PH (Amp)
652304	SIOUXC19 13.800	26650.1	655355	WOONSKT-ER8 69.000	3567.5
652305	SIOUXC29 13.800	26716.9	655373	MOS-SLY2-ER869.000	2376.7
652308	SIOUXC39 13.800	18570.5	655377	SW1145-ER7 115.00	24699.1
652310	SIOUXC49 13.800	18788.9	655384	NWPS8645-ER869.000	2177.5
652396	VFODNS19 12.500	20783.1	655385	MOS-LKPL-ER869.000	4004.1
652397	VFODNES7 115.00	6297.3	655386	MOS-RVR1-ER869.000	2086.9
652398	VFODNES4 230.00	7025.4	655412	CRPNTR-ER8 69.000	2811.7
652399	VFODNES8 69.000	4202.4	655415	ROSKPS22-ER94.2000	16647.8
652463	WH SWAN7 115.00	12660.1	655417	ROSWELL-ER7 115.00	2604.8
652475	BONESTL7 115.00	3509.1	655418	FREEMAN-ER7 115.00	2565.2
652476	EAGLEBT7 115.00	1947.2	658088	WTREAST7 115.00	9679.7
652477	ELSWRTH7 115.00	3806.4	658094	WTRPELI7 115.00	8593.4
652478	GREGORY7 115.00	2124.9	658120	GARFLD 7 115.00	7134.6
652480	MAURINE7 115.00	3917.2	659119	STORLA 9 13.200	16152.6
652481	MIDLAND7 115.00	3278.8	659120	BRDLAND3 345.00	4002.2
652484	NUNDRWD4 230.00	3400.7	659122	STORLA 4 230.00	6063.4
652485	NUNDRWD7 115.00	5939.4	659123	STORLA 7 115.00	6614.0
652486	PHILIP 4 230.00	3105.0	659196	CARPENTER 8 69.000	3170.3
652487	PHILIP 7 115.00	5080.2	659204	BROADLAND 913.800	22977.8
652488	PHILTAP4 230.00	3692.6	659205	BRDLAND4 230.00	9803.4
652489	PIERRE 7 115.00	8235.4	659271	RCDC EAST 4230.00	2633.4
652491	IRVSIMM7 115.00	8181.9	659295	SDPRAIRWND 4230.00	5623.9
652492	WALL 7 115.00	3338.3	659296	WESSINGTON1W0.5750	########
652493	WICKSVL7 115.00	3955.2	659324	HYDE 934.500	7074.5
652496	RUSHMRE7 115.00	4275.4	659327	SDPRAIRWND 934.500	32115.4
652497	MAURINE4 230.00	2758.8	659376	DRY CREEK 4230.00	2638.9
652498	PHILIP9 13.200	12124.6	659377	DRY CREEK 7115.00	4304.7
652500	ARLNGTN7 115.00	4309.0	659378	DRY CREEK 913.800	13535.7
652501	ARMOUR 7 115.00	4168.1	659421	BRDLAND-LNX3345.00	4002.2
652502	BERSFRD7 115.00	3906.5	659424	LELAND2-LNX3345.00	16809.5
652503	BLAIR 4 230.00	9924.3	659716	MAPLETAP-LO7115.00	13213.0
652504	BROOKNG7 115.00	7184.3	659900	EAGLE 4 230.00	7142.6
652505	FLANDRU7 115.00	4058.3	659901	EAGLE 8 69.000	13658.2
652506	FTTHOMP3 345.00	9495.0	660002	REDFLD 7 115.00	3976.7
652507	FTTHOMP4 230.00	20546.6	660003	HURONWP7 115.00	9636.9
652509	FTRANDL4 230.00	11052.8	660004	MITCHEL7 115.00	5872.1
652510	FTRANDL7 115.00	13001.4	660005	TRIPP 7 115.00	4243.6
652513	HANLON 4 230.00	6018.6	660007	MENNOJT7 115.00	6600.3
652514	HURON 4 230.00	10814.2	660008	MITCLNW7 115.00	5490.6
652515	HURON 7 115.00	14954.6	660009	BTAP WP7 115.00	14522.6
652516	LAKPLAT4 230.00	5622.4	660012	HURON WP 869.000	5919.8

Bus Number	Bus Name	3PH (Amp)	Bus Number	Bus Name	3PH (Amp)
652518	MTVERN 7 115.00	4303.6	660026	NAPA JCT7 115.00	8031.4
652519	OAHE 4 230.00	14216.6	661038	GLENHAM4 230.00	4870.7
652520	OAHE 7 115.00	11701.2	662100	WESSINGTON 934.500	16626.7
652521	SULLYBT4 230.00	6557.0	662101	WESSINGTON1W0.6900	420845.5
652523	SIOUXFL4 230.00	13094.4	952509	G12_009IS 115.00	6519.0
652524	SIOUXFL7 115.00	25971.8	952510	G12_009IS_1 34.500	9101.0

Appendix D SPP DISIS-2016-002-2 Group 17 Sensitivity Report

Southwest Power Pool
DISIS-2016-002-2 Group 17 Sensitivity Study Report
Final Report

Report No. E00537

17 March 2020

CONFIDENTIAL

Contains Proprietary Information

DO NOT RELEASE

LEGAL NOTICE

Prepared for: Southwest Power Pool
Report No.: E00537
Date: 17 March 2020

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EXECUTIVE SUMMARY

Southwest Power Pool (SPP) has commissioned ABB Inc., to perform a System Impact Study sensitivity for an interconnection request within DISIS-2016-002-2 (Group 17) using Group 15 dispatch scenarios.

The objective of this study is to evaluate the impact of GEN-2016-094 on the existing and future planning system when Group 15 requests are also dispatched at full rated capacity. The study is performed on three system scenarios provided by SPP:

- 2017 Winter Peak Case
- 2018 Summer Peak Case
- 2026 Summer Peak Case

Study results show that all online generating units were stable and showed adequate angular damping, and all voltages recovered after fault clearing and met the study criteria for all studied disturbances.

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.

Contents

1 INTRODUCTION

Southwest Power Pool (SPP) has commissioned ABB Inc., to perform a System Impact Study sensitivity for an interconnection request within DISIS-2016-002-2 (Group 17) using Group 15 dispatch scenarios. Table 1-1 lists the equally queued Generation Interconnection requests (Generation Interconnection Request Group 15) for this sensitivity.

Table 1-1 Generation Interconnection Requests for this Sensitivity

Request	Size (MW)	Generator Model	Point of Interconnection
GEN-2016-036	44.6	GE 2.3MW & 2.5MW WTG (587713, 587714)	Granite Falls 115kV Sub (652551)
GEN-2016-087	98.9	GE 2.3MW WTG (587723)	Bismarck-Glenham 230kV (Campbell 230kV, 652499)
GEN-2016-092	174.8	GE 2.3MW WTG (587753)	Tap Leland Olds-Ft Thompson 345kV (560074)
GEN-2016-094 (sensitivity)	200	GE 2.5MW WTG(587763)	Tap Ft Thompson-Oahe 230kV circuit 1 (587764)
GEN-2016-164	106.92 (7.92MW uprate to GEN-2009-018IS; withdrawal of uprate not reflected in study)	GE 1.62MW WTG (659289)	Groton 115kV substation (652512)

The objective of this study is to evaluate the impact of GEN-2016-094 on the existing and future planning system when Group 15 requests are also dispatched at full rated capacity. The study is performed on three system scenarios provided by SPP:

- 2017 Winter Peak Case
- 2018 Summer Peak Case
- 2026 Summer Peak Case

SPP provided the study cases for all three system scenarios with study projects included. One line diagrams of the local area of Group 17 request for all three seasons are show in Figure 1-1, Figure 1-2, and Figure 1-3 respectively. The machine parameters are the same as used in DISIS-2016-002-2 Group 17 System Impact Study Report. Three system scenarios provided by SPP included the following prior queued projects for Group 15 listed in Table 1-2.

Table 1-2 Group 15 Prior Queued Projects

Request	Size (MW)	Generator Model	Point of Interconnection
G176	99	WT3 Generic Wind	Yankee 115kV (603191)
G255	100.23	WT3 Generic Wind	Yankee 115kV (603191)
G586	30	WT4 Generic Wind	Yankee 115kV (603191)
G736	200.48	GE 1.79MW WTG	Big Stone South 230kV (620314)
H081	200	Vestas V110 2.0MW WTG	Tap Brookings - Lyons County 345kV (10215)
J414	120 (withdrawal not reflected in study)	Vestas V110 2.0MW WTG	Freeborn 161kV (631180)
J415	200 (withdrawal not reflected in study)	GE 2.3MW & 2.5MW WTG	Emery – Blackhawk 345kV (84151)
J432	98	Gamesa 2.0MW WTG	Brookings 345kV (601031)
J436	150	Vestas V110 VCSS 2.0MW WTG	Big Stone South 345kV (620417)
J437	150	Vestas V110 VCSS 2.0MW WTG	Big Stone South 345kV (620417)
J439	500 (withdrawal not reflected in study)	Vestas V110 2.0MW WTG	Obrien – Kossuth 345 kV line (84390)
J442	200	GE 2.0MW WTG	Big Stone 230 kV (620314)
J455	300	Vestas V110 2.0MW WTG	Kossuth-Obrien 345 kV(55368)
J459	200 (withdrawal not reflected in study)	Vestas V110 2.0MW WTG	Big Stone - Brookings 345kV (84590)
J460	200	Vestas V110 2.0MW WTG	Tap Brookings - Lyons County 345kV (587589)
J485	46.85	GENSAL	West Side Substation (625447)
J488	151.8	GE WTG	Tap Big Stone - Ellendale 345kV (587599)
J489	151.8 (withdrawal not reflected in study)	GE WTG	Tap Big Stone - Ellendale 345kV (587599)
J493	150	Vestas V136 3.45MW WTG	Burr 115kV (620212)
J510	326.9	GENROU	Tap Brookings - Big Stone 345kV (587599)
J512	250.0	Vestas V110 2.0MW & V136 3.6MW WTG	Nobles-Fenton 115kV (85121)

Request	Size (MW)	Generator Model	Point of Interconnection
J523	50.0	REGCAU1 Solar	Adams 161 kV (631122)
J525	50 (withdrawal not reflected in study)	REGCAU1 Solar	Lake Wilson 69kV (618920)
J526	300	GE 2.5MW WTG	Tap Brookings - Big Stone 345kV (587599)
J529	250	Vestas V110 2.0MW WTG	Obrien-Kossuth 345 kV (75368)
J569	100.0	Siemens 2.5MW WTG	Rock County 161kV (602039)
J575	100.0 (withdrawal not reflected in study)	GE 2.5MW WTG	Brookings County 345 kV (601031)
J577	102.8 (withdrawal not reflected in study)	GE 2.5MW WTG	Brookings County 345 kV (601031)
J587	200.0	Vestas V110 2.0MW WTG	Brookings-H081 345kV (61041)
J590	90.0	Vestas V110 2.0MW WTG	Obrien-Kossuth 345 kV (75368)
J594	150.0 (withdrawal not reflected in study)	Vestas V110 2.0MW WTG	Jackson North 161kV (631210)
J596	100.0 (withdrawal not reflected in study)	Vestas V110 2.0MW WTG	Morris-Moro 115kV (85961)
J597	300.0 (withdrawal not reflected in study)	Vestas V110 2.0MW WTG	Brookings County 345kV (601031)
J614	66.0	Vestas V110 2.0MW WTG	Rice 161kV (613330)
J637	98.0 (withdrawal not reflected in study)	Gamesa 2.0MW WTG	Big Stone - Brookings 345 kV (86371)
J638	204.0 (withdrawal not reflected in study)	Gamesa 2.0MW WTG	Big Stone - Brookings 345 kV (86371)
GEN-2002-009IS	40.5	GE 1.5MW WTG	Fort Thompson 69kV (652276)
GEN-2003-016IS	97.4	GENROU	Groton 115kV (652512)
GEN-2006-008IS	97.4	GENROU	Groton 115kV (652512)

Request	Size (MW)	Generator Model	Point of Interconnection
GEN-2007-004IS/GEN-2007-016IS	321	GENROU	White 345kV (652537)
GEN-2007-013IS/GEN-2007-014IS/GEN-2010-003IS	184	GE 1.5MW WTG	Wessington Springs 230kV (652607)
GEN-2009-001IS	200	GE 1.6MW WTG	Groton-Watertown 345kV (652175)
GEN-2009-018IS	99	GE 1.5MW WTG	Groton 115kV (652512)
GEN-2010-001IS	99	GE 1.8MW WTG	Bismarck-Glenham 230kV (652499)
GEN-2012-014IS	100.34 (withdrawal not reflected in study)	GE 1.7MW WTG	Groton 115kV (652512)
GEN-2013-009IS	20.35	GE 1.85MW WTG	Redfield NW 115kV (660015)
GEN-2014-001IS	103.7	GE 1.7MW WTG	Newell-Maurine 115kV (652005)
ASGI-2016-005	20	GE 2.5MW WTG	Tap White Lake - Stickeny 69kV (652252)
ASGI-2016-006	20 (withdrawal not reflected in study)	GE 2.5MW WTG	Mitchall (660008)
ASGI-2016-007	20	GE 2.5MW WTG	Kimball 69kV (652252)
GEN-2016-017	250.7	GE 2.3MW WTG	Tap Fort Thompson (652806) – Leland olds (659105) 345kV, (G16-017-TAP, 560074)

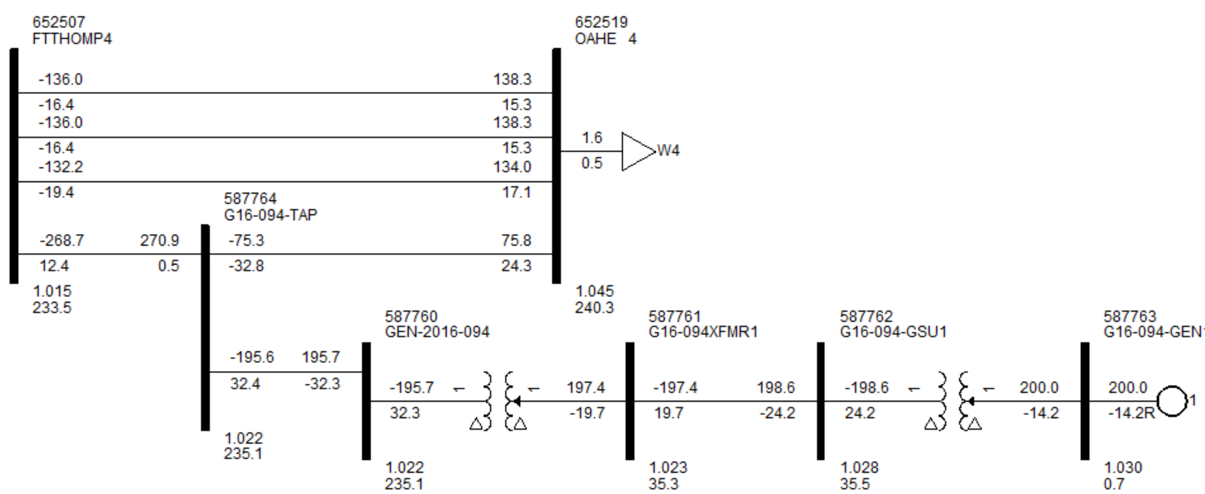

Figure 1-1 One Line Diagram for 2017 Winter Peak Case

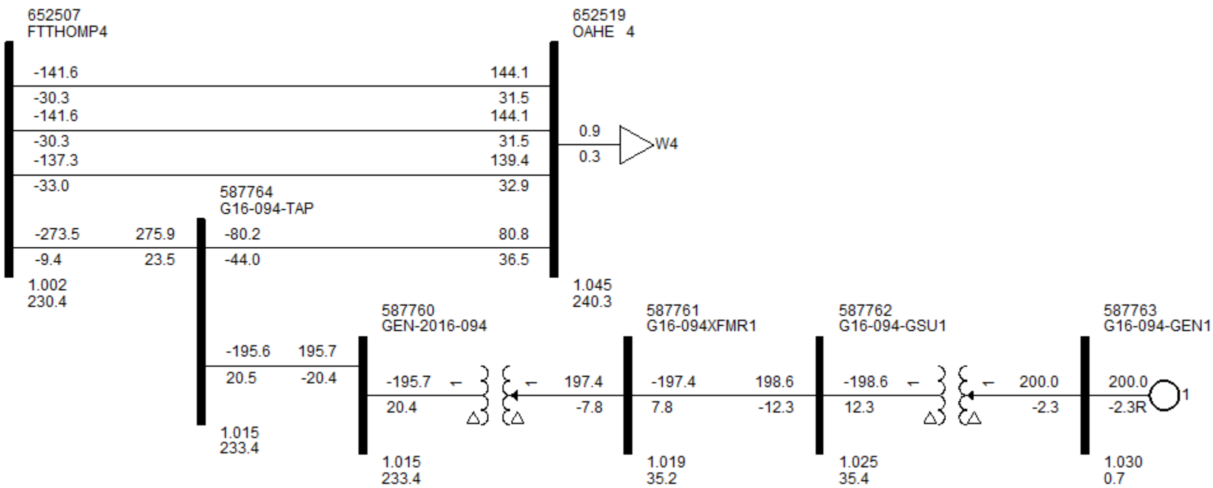

Figure 1-2 One Line Diagram for 2018 Summer Peak Case

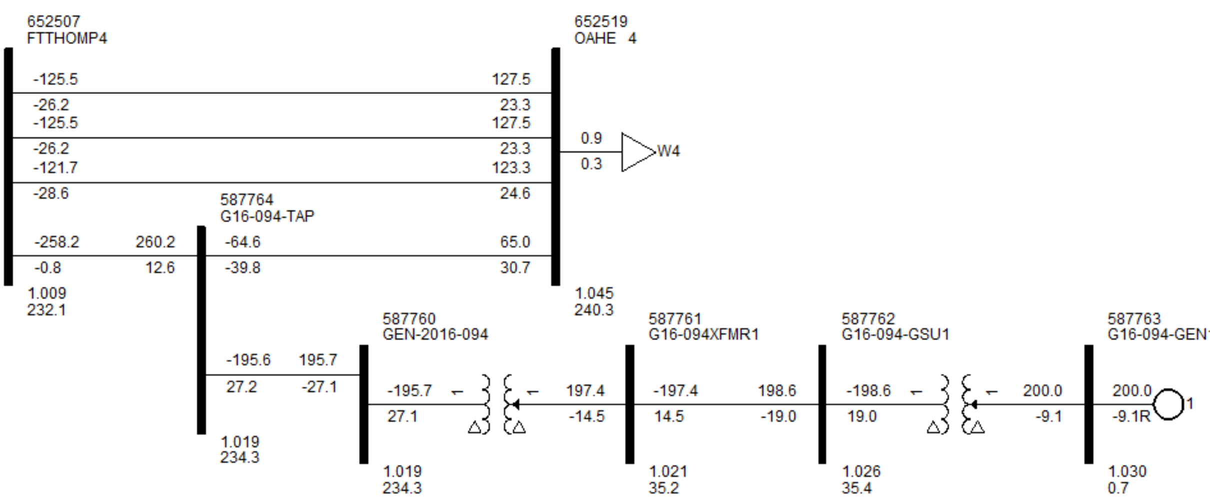

Figure 1-3 One Line Diagram for 2026 Summer Peak Case

2 STABILITY ANALYSIS

In this study, ABB investigated the stability of the system for faults in the vicinity of the Group 17 study request GEN-2016-094. The studied faults involve three-phase (3PH) transformer/line faults with normal clearing, and single-line-to-ground (SLG) faults with stuck breaker.

2.1 Case Development

Group 15 database including the following three (3) power flow scenarios were provided:

- 2017 Winter Peak Case
- 2018 Summer Peak Case
- 2026 Summer Peak Case

The following adjustments/updates were applied to the three scenarios:

- GEN-2016-094 POI was updated to be on only Fort Thompson to Oahe 230kV circuit 1. Fort Thompson to Oahe 230kV circuit 2 was reinstated without a tap.
- Oahe, Big Bend, Fort Randel, GEN-2006-002IS, and GEN-2016-094 generating facilities were dispatched at the full rated capacity.

Issues were observed in the no-fault simulation for 2017 Winter Peak case. The following adjustments were applied:

- 17W case: Fort Randal unit 2 Q-range reduced from [-21.8 34.2] to [-15 20] MVAR
- 17W case: reactive shunt at Bus 652240 was locked to 0 MVAr output

When updating 2018 Summer Peak Case, voltages as low as 0.899 pu were observed on the 345 kV path of Fort Thompson – Grand Prairie – Grand Island due to the increased flow on this important corridor. The following adjustments were made to boost voltages to above 0.95 pu:

- Three nearby reactive shunts were locked to 0 MVAr output: Grand Prairie Line Reactor KU1A (Bus No. 652833), Grand Prairie Line Reactor KU2A (Bus No. 652832), and LO-REA 3 (Bus No. 659201).
- The reactive output of the Grand Prairie wind generators (Bus No. 645065, 645066, 645067, 645068) were adjusted to a +0.98 Power Factor.

The dispatches of Group 15 Prior Queued projects in the developed power flow cases of this sensitivity study are listed in Table 2-1.

Table 2-1 Dispatches of Group 15 Prior Queued Projects in this Sensitivity

Request	Size (MW)	Generator Model	Point of Interconnection	Pmax (MW)	Pgen (MW) 2017 Winter Peak Case	Pgen (MW) 2018 Summer Peak Case	Pgen (MW) 2026 Summer Peak Case
G176	99	WT3 Generic Wind	Yankee 115kV (603191)	99.0	34.7	42.6	48.5
G255	100.23	WT3 Generic Wind	Yankee 115kV (603191)	100.2	0.0	21.9	25.0
G586	30	WT4 Generic Wind	Yankee 115kV (603191)	30.0	10.5	12.9	14.7
G736	200.48	GE 1.79MW WTG	Big Stone South 230kV (620322)	200.5	171.5	29.9	29.9
H081	200	Vestas V110 2.0MW WTG	Tap Brookings - Lyons County 345kV (10215)	200.0	30.1	155.1	155.1
J414	120 (withdrawal not reflected in study)	Vestas V110 2.0MW WTG	Freeborn 161kV (631180)	120	120	120	120
J415	200 (withdrawal not reflected in study)	GE 2.3MW & 2.5MW WTG	Emery – Blackhawk 345kV (84151)	200	200	200	200
J432	98	Gamesa 2.0MW WTG	Brookings 345kV (601031)	98.0	98.0	98.0	98.0
J436	150	Vestas V110 VCSS 2.0MW WTG	Big Stone South - Ellendale 345kV line (50416)	150.0	150.0	150.0	150.0
J437	150	Vestas V110 VCSS 2.0MW WTG	Big Stone South – Ellendale 345kV line (50416)	150.0	150.0	150.0	150.0
J439	500 (withdrawal not reflected in study)	Vestas V110 2.0MW WTG	Obrien – Kossuth 345 kV line (84390)	500	500	500	500
J442	200	GE 2.0MW WTG	Big Stone South 230 kV (620322)	200.0	185.8	30.7	30.7
J455	300	Vestas V110 2.0MW WTG	Kossuth-Obrien 345 kV(55368)	300	300	300	300
J459	200 (withdrawal not reflected in study)	Vestas V110 2.0MW WTG	Big Stone - Brookings 345kV (84590)	200	200	200	200
J460	200	Vestas V110 2.0MW WTG	Tap Brookings - Lyons County 345kV (587589)	200.0	200.0	200.0	200.0
J485	46.85	GENSAL	West Side Substation (625447)	46.85	46.85	46.85	46.85
J488	151.8	GE WTG	Tap Big Stone - Ellendale 345kV (50416)	151.8	151.8	151.8	151.8
J489	151.8 (withdrawal not reflected in study)	GE WTG	Tap Big Stone - Ellendale 345kV (50416)	151.8	151.8	151.8	151.8

Request	Size (MW)	Generator Model	Point of Interconnection	Pmax (MW)	Pgen (MW) 2017 Winter Peak Case	Pgen (MW) 2018 Summer Peak Case	Pgen (MW) 2026 Summer Peak Case
J493	150	Vestas V136 3.45MW WTG	Burr 115kV (620212)	150.0	150.0	150.0	150.0
J510	326.9	GENROU	Tap Brookings - Big Stone 345kV (587599)	284.5	284.5	266.0	266.0
J512	250.0	Vestas V110 2.0MW & V136 3.6MW WTG	Nobles-Fenton 115kV (85121)	250.0	250.0	250.0	250.0
J523	50.0	REGCAU1 Solar	Adams 161 kV (631122)	50.0	50.0	50.0	50.0
J525	50 (withdrawal not reflected in study)	REGCAU1 Solar	Lake Wilson 69kV (618920)	33.0	33.0	33.0	33.0
J526	300	GE 2.5MW WTG	Tap Brookings - Big Stone 345kV (587599)	300.0	300.0	300.0	300.0
J529	250	Vestas V110 2.0MW WTG	Obrien-Kossuth 345 kV (75368)	250	250	250	250
J569	100.0	Siemens 2.5MW WTG	Rock County 161kV (602039)	100.0	100.0	100.0	100.0
J575	100.0 (withdrawal not reflected in study)	GE 2.5MW WTG	Brookings County 345 kV (601031)	100.0	100.0	100.0	100.0
J577	102.8 (withdrawal not reflected in study)	GE 2.5MW WTG	Brookings County 345 kV (601031)	102.8	102.8	102.8	102.8
J587	200.0	Vestas V110 2.0MW WTG	Brookings-H081 345kV (61041)	200.0	200.0	200.0	200.0
J590	90.0	Vestas V110 2.0MW WTG	Obrien-Kossuth 345 kV (75368)	90.0	90.0	90.0	90.0
J594	300.0 (withdrawal not reflected in study)	Vestas V110 2.0MW WTG	Jackson North 161kV (631210)	300.0	300.0	300.0	300.0
J596	100.0 (withdrawal not reflected in study)	Vestas V110 2.0MW WTG	Morris-Moro 115kV (85961)	100.0	100.0	100.0	100.0
J597	300.0 (withdrawal not reflected in study)	Vestas V110 2.0MW WTG	Brookings County 345kV (601031)	300.0	300.0	300.0	300.0
J614	66.0	Vestas V110 2.0MW WTG	Rice 161kV (613330)	66.0	66.0	66.0	66.0
J637	98.0 (withdrawal not	Gamesa 2.0MW WTG	Big Stone - Brookings 345 kV (86371)	98.0	98.0	98.0	98.0

Request	Size (MW)	Generator Model	Point of Interconnection	Pmax (MW)	Pgen (MW) 2017 Winter Peak Case	Pgen (MW) 2018 Summer Peak Case	Pgen (MW) 2026 Summer Peak Case
	reflected in study)						
J638	204.0 (withdrawal not reflected in study)	Gamesa 2.0MW WTG	Big Stone - Brookings 345 kV (86371)	204.0	204.0	204.0	204.0
GEN-2002-009IS	40.5	GE 1.5MW WTG	Fort Thompson 69kV (652276)	40.5	40.5	40.5	40.5
GEN-2003-016IS	97.4	GENROU	Groton 115kV (652512)	97.4	95.7	96.4	96.5
GEN-2006-008IS	97.4	GENROU	Groton 115kV (652512)	97.4	95.7	96.4	96.5
GEN-2007-004IS/GEN-2007-016IS	321	GENROU	White 345kV (652537)	321.0	315.5	317.6	318.1
GEN-2007-013IS/GEN-2007-014IS/GEN-2010-003IS	184	GE 1.5MW WTG	Wessington Springs 230kV (652607)	184.0	184.0	184.0	184.0
GEN-2009-001IS	200	GE 1.6MW WTG	Groton-Watertown 345kV (652175)	200.0	200.0	200.0	200.0
GEN-2009-018IS	99 (withdrawal of GEN-2016-164 7.92MW uprate not reflected in study	GE 1.5MW WTG	Groton 115kV (652512)	106.9	106.9	106.9	106.9
GEN-2010-001IS	99	GE 1.8MW WTG	Bismarck-Glenham 230kV (652499)	99.0	99.0	99.0	99.0
GEN-2012-014IS	100.34 (withdrawal not reflected in study)	GE 1.7MW WTG	Groton 115kV (652512)	100.34	100.34	100.34	100.34
GEN-2013-009IS	20.35	GE 1.85MW WTG	Redfield NW 115kV (660015)	20.4	20.4	20.4	20.4
GEN-2014-001IS	103.7	GE 1.7MW WTG	Newell-Maurine 115kV (652005)	103.7	103.7	103.7	103.7
ASGI-2016-005	20	GE 2.5MW WTG	Tap White Lake - Stickeny 69kV (652252)	20.0	20.0	20.0	20.0
ASGI-2016-006	20 (withdrawal not reflected in study)	GE 2.5MW WTG	Mitchall (660008)	20.0	20.0	20.0	20.0
ASGI-2016-007	20	GE 2.5MW WTG	Kimball 69kV (652252)	20.0	20.0	20.0	20.0
GEN-2016-017	250.7	G.E. 2.3MW WTG	Tap Fort Thompson (652806) – Leland olds (659105) 345kV, (G16-017-TAP, 560074)	250.7	250.7	250.7	250.7

2.2 Contingency (Fault Definitions) Development

Stability analysis was performed to determine whether the electric system would meet stability criteria following the addition of project GEN-2016-094; therefore, faults in the vicinity of the point of interconnection were developed under the approval of SPP.

Three phase faults were developed at point of interconnection and nearby buses with six cycles of duration without reclosing. Prior outage faults were also developed at point of interconnection and nearby buses.

Single-line-to-ground faults with stuck breaker were simulated with the standard method of applying fault impedance to the positive sequence network to represent the effect of the negative and zero sequence networks on the positive sequence network. It simulated potential breaker-failure situations for the substations. The SLG fault impedance was computed by assuming a positive sequence voltage at the fault location at approximately 60% of pre-fault voltage.

The faults that were evaluated in this sensitivity are the same as the ones evaluated in DISIS-2016-002-2 Group 17 System Impact Study. The full list and description of the faults are shown in Table 2-2.

Table 2-2 List of Faults for Stability Analysis

Cont. No.	Cont. Name	Description
1	FLT01-3PH	3 phase fault on G16-094-TAP (587764) to FT THOMPSON 230kV (652507) CKT 1, near G16-094-TAP. a. Apply fault at the G16-094-TAP 230kV bus. b. Clear fault after 6 cycles by tripping the faulted line.
2	FLT02-3PH	3 phase fault on the G16-094-TAP (587764) to OAHE 230kV (652519) CKT 1, near G16-094-TAP. a. Apply fault at the G16-094-TAP 230kV bus. b. Clear fault after 6 cycles by tripping the faulted line.
3	FLT03-3PH	3 phase fault on the OAHE (652519) to FT THOMPSON 230kV (652507) CKT 3, near OAHE 230kV bus. a. Apply fault at the OAHE 230kV bus. b. Clear fault after 6 cycles by tripping the faulted line.
4	FLT04-3PH	3 phase fault on the OAHE (652519) 230/(652520) 115/(652589)13.8kV transformer OA No. 5, near OAHE 230kV bus. a. Apply fault at the OAHE 230kV bus. b. Clear fault after 6 cycles by tripping the faulted transformer.
5	FLT05-3PH	3 phase fault on the OAHE (652519) to SULLY BUTTES 230kV (652521) CKT 1, near OAHE 230kV bus. a. Apply fault at the OAHE 230kV bus. b. Clear fault after 6 cycles by tripping the faulted line.
6	FLT06-3PH	3 phase fault on the FT THOMPSON 230kV (652507) to OAHE (652519) CKT 3, near FT THOMPSON 230kV bus. a. Apply fault at the FT THOMPSON 230kV bus. b. Clear fault after 6 cycles by tripping the faulted line.
7	FLT07-3PH	3 phase fault on the FT THOMPSON (652506) 345/ (652507) 230/ (652273) 13.8kV transformer FT2 KU1A, near FT THOMPSON 230kV bus. a. Apply fault at the FT THOMPSON 230kV bus. b. Clear fault after 6 cycles by tripping the faulted transformer.
8	FLT08-3PH	3 phase fault on the FT THOMPSON 230kV (652507) to WESSINGTON (652607) CKT 1, near FT THOMPSON 230kV bus. a. Apply fault at the FT THOMPSON 230kV bus. b. Clear fault after 6 cycles by tripping the faulted line.
9	FLT09-3PH	3 phase fault on the FT THOMPSON 230kV (652507) to LETCHER (652606) CKT 1, near FT THOMPSON 230kV bus. a. Apply fault at the FT THOMPSON 230kV bus.

Cont. No.	Cont. Name	Description
		b. Clear fault after 6 cycles by tripping the faulted line.
10	FLT10-3PH	3 phase fault on the FT THOMPSON 230kV (652507) to LAKE PLATTE (652516) CKT 1, near FT THOMPSON 230kV bus. a. Apply fault at the FT THOMPSON 230kV bus. b. Clear fault after 6 cycles by tripping the faulted line.
11	FLT11-3PH	3 phase fault on the FT THOMPSON 230kV (652507) to FT RANDALL (652509) CKT 1, near FT THOMPSON 230kV bus. a. Apply fault at the FT THOMPSON 230kV bus. b. Clear fault after 6 cycles by tripping the faulted line.
12	FLT12-3PH	3 phase fault on the FT THOMPSON 230kV (652507) to Huron 230kV (652514) near FT THOMPSON 230kV bus a. Apply fault at the FT. THOMPSON 230kV bus. b. Clear fault after 6 cycles by tripping the faulted line.
13	FLT13-PH	3 phase fault on the FT THOMPSON 345kV (652506) to G16-017-TAP 345kV (560074) line near FT THOMPSON 345kV bus a. Apply fault at the FT THOMPSON 345kV bus. b. Clear fault after 6 cycles by tripping the faulted line (652506-652806-560074)
14	FLT14-3PH	3 phase fault on the FT THOMPSON 345kV (652506) to GRANDE PRAIRIE 345kV (652532) line near FT THOMPSON 345kV bus a. Apply fault at the FT THOMPSON 345kV bus. b. Clear fault after 6 cycles by tripping the faulted line (652506-652807-652833-652532).
15	FLT15-3PH	3 phase fault on the SPLIT ROCK 345kV (601006) to WHITE 345kV (652537) line near SPLIT ROCK 345kV bus a. Apply fault at the SPLIT ROCK 345kV bus. b. Clear fault after 6 cycles by tripping the faulted line.
16	FLT16-3PH	3 phase fault on the SPLIT ROCK 345kV (601006) to NOBLES 345kV (601034) line near SPLIT ROCK 345kV bus a. Apply fault at the SPLIT ROCK 345kV bus. b. Clear fault after 6 cycles by tripping the faulted line.
17	FLT17-3PH	3 phase fault on the SPLIT ROCK 345kV (601006) to SIOUX CITY 345kV (652564) line near SPLIT ROCK 345kV bus a. Apply fault at the SPLIT ROCK 345kV bus. b. Clear fault after 6 cycles by tripping the faulted line (601006-652864-652564).
18	FLT18-PO	**Prior Outage of G16-094-TAP to FT THOMPSON 230kV CKT 1.** 3 phase fault on OAHE – FT THOMPSON 230kV CKT 2, near OAHE 230kV. a. Prior outage G16-094-TAP (587764) to FT THOMPSON (652507) 230kV CKT 1 line (solve network for steady state solution). b. 3 phase fault on OAHE (652519) – FT THOMPSON (652507) 230kV CKT 2, near OAHE 230kV c. Leave fault on for 6 cycles, then trip the faulted line in (b).
19	FLT19-PO	**Prior Outage of G16-094-TAP to OAHE 230kV CKT 1.** 3 phase fault on OAHE – FT THOMPSON 230kV CKT 2, near FT THOMPSON 230kV. a. Prior outage G16-094-TAP (587764) to OAHE (652519) 230kV CKT 1 line (solve network for steady state solution). b. 3 phase fault on OAHE (652519) – FT THOMPSON (652507) 230kV CKT 2, near FT THOMPSON 230kV c. Leave fault on for 6 cycles, then trip the faulted line in (b).
20	FLT20-PO	**Prior Outage of OAHE to FT THOMPSON 230kV CKT 4.** 3 phase fault on OAHE – FT THOMPSON 230kV CKT 3, near OAHE 230kV a. Prior outage OAHE (652519) to FT THOMPSON (652507) 230kV CKT 4 (solve network for steady state solution). b. 3 phase fault on OAHE (652519) – FT THOMPSON (652507) 230kV CKT 3, near OAHE 230kV c. Leave fault on for 6 cycles, then trip the faulted line in (b).
21	FLT21-PO	**Prior Outage of OAHE to FT THOMPSON 230kV CKT 4.** 3 phase fault on G16-094-TAP – OAHE230kV CKT 1, near G16-094-TAP 230kV a. Prior outage OAHE (652519) to FT THOMPSON (652507) 230kV CKT 4 (solve network for steady state solution). b. 3 phase fault on G16-094-TAP (587764) – OAHE (652519)230kV CKT 1, near G16-094-TAP 230kV c. Leave fault on for 6 cycles, then trip the faulted line in (b).
22	FLT22-PO	**Prior Outage of FT THOMPSON to LAKE PLATTE 230kV CKT 1.** 3 phase fault on FT THOMPSON – FT RANDALL 230kV CKT 1, near FT THMPSON 230kV.

Cont. No.	Cont. Name	Description
		a. Prior outage FT THOMPSON (652507) to LAKE PLATTE (652516) 230kV CKT1 (solve network for steady state solution). b. 3 phase fault on FT THMPSON (652507) – FT RANDALL (652509) 230kV CKT 1, near FT THMPSON 230kV. c. Leave fault on for 6 cycles, then trip the faulted line in (b).
23	FLT23-PO	**Prior Outage of FT THOMPSON to LETCHER 230kV CKT 1.** 3 phase fault on FT THOMPSON – WESSINGTON 230kV CKT 1, near FT THMPSON 230kV. a. Prior outage FT THOMPSON (652507) to LETCHER (652606) 230kV CKT1 (solve network for steady state solution). b. 3 phase fault on FT THOMPSON (652507) – WESSINGTON (652607) 230kV CKT 1, near FT THMPSON 230kV c. Leave fault on for 6 cycles, then trip the faulted line in (b).
24	FLT24-PO	**Prior Outage of FT THOMPSON to HURON 230kV CKT 1.** 3 phase fault on FT THOMPSON – HURON 230kV CKT 2, near FT THMPSON 230kV. a. Prior outage FT THOMPSON (652507) to HURON (652514) 230kV CKT1 (solve network for steady state solution). b. 3 phase fault on FT THOMPSON (652507) – HURON (652514) 230kV CKT 2, near FT THMPSON 230kV. c. Leave fault on for 6 cycles, then trip the faulted line in (b).
25	FLT25-PO	**Prior Outage of FT. THOMPSON to HURON 230kV circuit 1.** 3 phase fault on the 345/230/13.8kV FT. THOMPSON Transformer, near FT THMPSON 230kV. a. Prior outage FT. THOMPSON (652507) 230kV to Huron (652514) 230kV (solve network for steady state solution) circuit 1. b. 3 phase fault on the 345/230/13.8kV FT. THOMPSON (652507) transformer #3 (652506) 13.8kV (652274), near FT THMPSON 230kV c. Leave fault on for 6 cycles, then trip the faulted line in (b).
26	FLT26-SB	**G16-094-TAP 230kV Stuck Breaker** a. Apply single phase fault on G16-094-TAP (587764) 230kV to OAHE (652519) 230kV CKT 1, near G16-094-TAP. b. Wait 16 cycles, and then trip the faulted line c. Trip G16-094-TAP (587764) to FT THOMPSON 230kV (652507) CKT 1 and remove the fault. Trip Gen-2016-094 wind farm, including generator (587763) and the collector system (587760, 587761, 587762, 587764).
27	FLT27-SB	**FT. THOMPSON 230kV Stuck Breaker** a. Apply single phase fault on FT THOMPSON (652507) 230kV to G16-094-TAP (587764) 230kV CKT 1, near FT THOMPSON. b. Wait 16 cycles, and then trip the faulted line c. Trip FT THOMPSON (652507) 230kV to HURON 230kV (652514) CKT 1 and remove the fault.
28	FLT28-SB	**FT. THOMPSON 230kV Stuck Breaker** a. Apply single phase fault on FT THOMPSON (652507) 230kV to OAHE (652519) 230kV CKT 3 near FT THOMPSON. b. Wait 16 cycles, and then trip the faulted line c. Trip FT THOMPSON (652507) 230kV to WESSINGTON SPRINGS 230kV (652607) CKT 1 and remove the fault.
29	FLT29-SB	**FT. THOMPSON 230kV Stuck Breaker** a. Apply single phase fault on FT THOMPSON (652507) 230kV to OAHE (652519) 230kV CKT 4 near FT THOMPSON. b. Wait 16 cycles, and then trip the faulted line c. Trip FT THOMPSON (652507) 230kV to LETCHER 230kV (652606) CKT 1 and remove the fault.
30	FLT30-SB	**FT. THOMPSON 230kV Stuck Breaker** a. Apply single phase fault on FT THOMPSON (652507) 230kV to FT RANDALL (652509) 230kV CKT1 near FT THOMPSON. b. Wait 16 cycles, and then trip the faulted line c. Trip BIG BEND GENERATORS G1-G4 (652542, 652543, 652540) and remove the fault.
31	FLT31-SB	**FT. THOMPSON 230kV Stuck Breaker** a. Apply single phase fault on FT THOMPSON (652507) 230kV to LAKE PLATTE (652516) 230kV CKT1 near FT THOMPSON. b. Wait 16 cycles, and then trip the faulted line c. Trip BIG BEND GENERATORS G5-G8 (652544, 652545, 652541) and remove the fault.
32	FLT32-SB	**FT. THOMPSON 230kV Stuck Breaker** a. Apply single phase fault on FT THOMPSON (652506) 345kV / (652507) 230kV / (652273) 13.8kV transformer KU1A near FT THOMPSON 230kV (652507).

Cont. No.	Cont. Name	Description
		b. Wait 16 cycles, and then trip the faulted transformer c. Trip FT THOMPSON (652506) 345kV / (652507) 230kV / (652274) 13.8kV transformer KU1B and remove the fault.
33	FLT33-SB	**OAHE 230kV Stuck Breaker** a. Apply single phase fault on OAHE (652519) 230kV to FT THOMPSON (652507) 230kV CKT 3 near OAHE. b. Wait 16 cycles, and then trip the faulted line c. Trip OAHE (652519) to FT THOMPSON (652507) 230kV CKT 4, OAHE GENERATORS 6&7, and remove the fault.
34	FLT34-SB	**OAHE 230kV Stuck Breaker** a. Apply single phase fault on OAHE (652519) 230kV to FT THOMPSON (652507) 230kV CKT 2 near OAHE. b. Wait 16 cycles, and then trip the faulted line c. Trip PHILIP TAP (652488) 230kV bus, OAHE (652519) to SULLY BUTTES 230kV (652521), OAHE GENERATORS 4&5, and remove the fault.
35	FLT35-SB	**OAHE 230kV Stuck Breaker** a. Apply single phase fault on OAHE (652519) 230kV to G16-094-TAP (587764) 230kV CKT 1 near OAHE. b. Wait 16 cycles, and then trip the faulted line c. Trip OAHE 230/115 kV transformers OA NO. 5&6, OAHE GENERATORS 2&3, and remove the fault.
36	FLT36-SB	**FT. THOMPSON 345kV Stuck Breaker** a. Apply single phase fault on the 345kV FT. THOMPSON (652506) bus to 345kV G16-017-TAP (560074) bus near FT. THOMPSON. b. Wait 16 cycles, and then trip FT. THOMPSON (652506) – G16-017-TAP (560074) 345kV line (652506-652806-560074 345kV line) c. Trip FT THOMPSON (652506) 345kV / (652507) 230kV / (652273) 13.8kV transformer KU1A and remove the fault.

2.3 Study Methodology

Study methodology adopted in this sensitivity is the same as the one documented in the DISIS-2016-002-2 Group 17 System Impact Study. The only difference is that the monitored areas in this sensitivity are for Group 15 instead of Group 17. Areas 600, 608, 613, 615, 620, 640, 645, 650, 652, and 661 are monitored in this sensitivity.

2.4 Stability Analysis Results

Stability analysis was performed in PSS/E 33.7.0 and all disturbances listed in Table 2-2 were simulated for 20 seconds. Simulation results indicate that all online generating units were stable and showed adequate angular damping, and all voltages recovered after fault clearing and met the study criteria for all studied disturbances. The entire simulation results were summarized in Appendix A Stability Analysis Results.

Appendix A Stability Analysis Results

Appendix A.1 Study Result Summary

Index	Fault Name	2017 Winter Peak			2018 Summer Peak			2026 Summer Peak		
		Stable	Volt & Angle Violation	Study Generator Tripped	Stable	Volt & Angle Violation	Study Generator Tripped	Stable	Volt & Angle Violation	Study Generator Tripped
1	FLT01-3PH	Yes	No	No	Yes	No	No	Yes	No	No
2	FLT02-3PH	Yes	No	No	Yes	No	No	Yes	No	No
3	FLT03-3PH	Yes	No	No	Yes	No	No	Yes	No	No
4	FLT04-3PH	Yes	No	No	Yes	No	No	Yes	No	No
5	FLT05-3PH	Yes	No	No	Yes	No	No	Yes	No	No
6	FLT06-3PH	Yes	No	No	Yes	No	No	Yes	No	No
7	FLT07-3PH	Yes	No	No	Yes	No	No	Yes	No	No
8	FLT08-3PH	Yes	No	No	Yes	No	No	Yes	No	No
9	FLT09-3PH	Yes	No	No	Yes	No	No	Yes	No	No
10	FLT10-3PH	Yes	No	No	Yes	No	No	Yes	No	No
11	FLT11-3PH	Yes	No	No	Yes	No	No	Yes	No	No
12	FLT12-3PH	Yes	No	No	Yes	No	No	Yes	No	No
13	FLT13-3PH	Yes	No	No	Yes	No	No	Yes	No	No
14	FLT14-3PH	Yes	No	No	Yes	No	No	Yes	No	No
15	FLT15-3PH	Yes	No	No	Yes	No	No	Yes	No	No
16	FLT16-3PH	Yes	No	No	Yes	No	No	Yes	No	No
17	FLT17-3PH	Yes	No	No	Yes	No	No	Yes	No	No
18	FLT18-PO	Yes	No	No	Yes	No	No	Yes	No	No
19	FLT19-PO	Yes	No	No	Yes	No	No	Yes	No	No
20	FLT20-PO	Yes	No	No	Yes	No	No	Yes	No	No
21	FLT21-PO	Yes	No	No	Yes	No	No	Yes	No	No
22	FLT22-PO	Yes	No	No	Yes	No	No	Yes	No	No
23	FLT23-PO	Yes	No	No	Yes	No	No	Yes	No	No
24	FLT24-PO	Yes	No	No	Yes	No	No	Yes	No	No
25	FLT25-PO	Yes	No	No	Yes	No	No	Yes	No	No
26	FLT26-SB	Yes	No	No	Yes	No	No	Yes	No	No
27	FLT27-SB	Yes	No	No	Yes	No	No	Yes	No	No
28	FLT28-SB	Yes	No	No	Yes	No	No	Yes	No	No
29	FLT29-SB	Yes	No	No	Yes	No	No	Yes	No	No
30	FLT30-SB	Yes	No	No	Yes	No	No	Yes	No	No
31	FLT31-SB	Yes	No	No	Yes	No	No	Yes	No	No
32	FLT32-SB	Yes	No	No	Yes	No	No	Yes	No	No
33	FLT33-SB	Yes	No	No	Yes	No	No	Yes	No	No
34	FLT34-SB	Yes	No	No	Yes	No	No	Yes	No	No
35	FLT35-SB	Yes	No	No	Yes	No	No	Yes	No	No
36	FLT36-SB	Yes	No	No	Yes	No	No	Yes	No	No

Appendix A.2 Study Result Plot

Plots of stability simulations for all three scenarios are available from SPP upon request.

GROUP 18 STABILITY ANALYSIS

The Group 18 stability analysis was not performed. No DISIS-2016-002 interconnection requests were assigned to this group.