# DISIS-2020-002

# Phase 2 Study Report

# 8/26/2021

# Table of Contents

# 1.0 Summary

The Phase 2 of DISIS-2020-002 Definitive Interconnection Study Cluster includes five (5) Generation Interconnection Requests: GI-2020-12, GI-2020-13, GI-2020-14, GI-2020-15 and GI-2020-16.

GI-2020-12 is a 400MW$_{ac}$ net rated wind Generating Facility requesting Energy Resource Interconnection Service (ERIS). The requested Point of Interconnection (POI) is a tap on the Waterton – Midway 345kV line.

GI-2020-13 is a 374MW$_{ac}$ net rated AC-Coupled solar Photovoltaic (PV) plus Battery Energy Storage (BES) Generating Facility requesting ERIS. The requested POI is a tap on the Boone – Midway 230kV line.

GI-2020-14 is a 700MW$_{ac}$ net rated wind Generating Facility requesting ERIS. The requested POI is a tap on the Waterton – Midway 345kV line.

GI-2020-15 is a 250MW$_{ac}$ net rated wind Generating Facility requesting ERIS. The requested POI is a tap on the Fort Lupton – Pawnee 230kV line.

GI-2020-16 is a 199.5MW$_{ac}$ net rated solar PV Generating Facility requesting Network Resource Interconnection Service (NRIS). The requested POI is the Barr Lake 230kV Substation.

The GI-2020-12, GI-2020-13, and GI-2020-14 GIRs were studied under the Southern Colorado study pocket analysis. The GI-2020-15 and GI-2020-16 were studied under the Northern Colorado study pocket analysis.

The Generation Interconnection Service identified in this report in and of itself does not convey any transmission service.

## 1.1 GI-2020-12 Results

The total cost of the required Upgrades for GI-2020-12 to interconnect on the Midway – Waterton 345kV line is $27.527 Million (Tables 15, 19 and 20).

The maximum allowable output of GI-2020-12 before Network Upgrades is 213.8MW.

Energy Resource Interconnection Service of GI-2020-12 is 400MW (after required transmission system improvements in Tables 15, 19 and 20).

GI-2020-12 and GI-2020-14 interconnect at the same POI.

## 1.2 GI-2020-13 Results

The total cost of the required Upgrades for GI-2020-13 to interconnect on the Boone - Midway 230kV line is $26.469 Million (Tables 16, 19 and 21).

The maximum allowable output of GI-2020-13 before Network Upgrades is 303MW.

Energy Resource Interconnection Service of GI-2020-13 is 374MW (after required transmission system improvements in Tables 16, 19 and 21).

TSGT has partial ownership of the Boone – Midway 230kV line and is identified as an impacted Affected System. However, no system improvements are identified, other than ownership impact.

## 1.3 GI-2020-14 Results

The total cost of the required Upgrades for GI-2020-14 to interconnect on the Midway – Waterton 345kV line is $42.567 Million (Tables 15, 19 and 22).

The maximum allowable output of GI-2020-14 before Network Upgrades is 345.6MW.

Energy Resource Interconnection Service of GI-2020-14 is 700MW (after required transmission system improvements in Tables 15, 19 and 22).

## 1.4 GI-2020-15 Results

The total cost of the required Upgrades for GI-2020-15 to interconnect on the Fort Lupton – Pawnee 230kV line is $22.23 Million (Tables 17, 19 and 23).

The maximum allowable output of GI-2020-15 before Network Upgrades is 250MW.

Energy Resource Interconnection Service of GI-2020-15 is 250MW (after required transmission system improvements in Tables 17, 19 and 23).

## 1.5 GI-2020-16 Results

The total cost of the required Upgrades for GI-2020-16 to interconnect at the Barr Lake 230kV Substation is $11.999 Million (Tables 18, 19 and 24).

Network Resource Interconnection Service of GI-2020-16 is 199.5MW (after required transmission system improvements in Tables 18, 19 and 24).

TSGT has been identified as an Affected System to GI-2020-16 as the interconnection may require upgrades to substation termination facilities at the Reunion Substation. The cost of these

Network Upgrades is not included in this study report and are expected to be available in the Phase 4 report.

## 2.0 Introduction

**Public Service Company of Colorado (PSCo) received five (5) Generation Interconnection Request (GIR)s in the DISIS-2020-002 Phase 1, all of which moved to Phase 2. The total Interconnection Service studied in the DISIS is 1724MW of Energy Resource Interconnection Service (ERIS)[1] and 199.5MW of Network Interconnection Service (NRIS)[2]. A summary of the GIRs is given in Table 1– Summary of GIRs in the DISIS-2020-002**

| Generation Interconnection Number | Current Cluster | Date of Valid Request | Capacity (MW) | Maximum MW Output-Summer | Maximum MW Output-Winter | Location (County/State) | Station or Transmission Line POI | Projected In- Service Date | Service Type | Generating Facility Type |
|---|---|---|---|---|---|---|---|---|---|---|
| GI-2020-12 | DISIS-2020-002 | 9/22/2020 | 400 | 400 | 400 | Elbert County, CO | Waterton-Midway 345 kV line | 12/1/2024 | ERIS | Wind |
| GI-2020-13 | DISIS-2020-002 | 9/22/2020 | 374 | 374 | 374 | Pueblo County, CO | Boone-Midway 230 kV line | 12/1/2024 | ERIS | Battery+ Solar |
| GI-2020-14 | DISIS-2020-002 | 9/22/2020 | 700 | 700 | 700 | Cheyenne County, CO | Waterton-Midway 345 kV line | 12/1/2024 | ERIS | Wind |
| GI-2020-15 | DISIS-2020-002 | 10/5/2020 | 250 | 250 | 250 | Morgan County, CO | Ft. Lupton-Pawnee 230kV Line | 12/31/2023 | ERIS | Wind |
| GI-2020-16 | DISIS-2020-002 | 10/6/2020 | 199.5 | 200.64 | 200.64 | Adams County, CO | Barr Lake 230 kV | 10/31/2023 | NRIS | Solar |

.

**Table 1– Summary of GIRs in the DISIS-2020-002**

| Generation Interconnection Number | Current Cluster | Date of Valid Request | Capacity (MW) | Maximum MW Output-Summer | Maximum MW Output-Winter | Location (County/State) | Station or Transmission Line POI | Projected In- Service Date | Service Type | Generating Facility Type |
|---|---|---|---|---|---|---|---|---|---|---|
| GI-2020-12 | DISIS-2020-002 | 9/22/2020 | 400 | 400 | 400 | Elbert County, CO | Waterton-Midway 345 kV line | 12/1/2024 | ERIS | Wind |
| GI-2020-13 | DISIS-2020-002 | 9/22/2020 | 374 | 374 | 374 | Pueblo County, CO | Boone-Midway 230 kV line | 12/1/2024 | ERIS | Battery+ Solar |
| GI-2020-14 | DISIS-2020-002 | 9/22/2020 | 700 | 700 | 700 | Cheyenne County, CO | Waterton-Midway 345 | 12/1/2024 | ERIS | Wind |

[1] Energy Resource Interconnection Service shall mean an Interconnection Service that allows the Interconnection Customer to connect its Generating Facility to the Transmission Provider's Transmission System to be eligible to deliver the Generating Facility's electric output using the existing firm or non-firm capacity of the Transmission Provider's Transmission System on an as available basis. Energy Resource Interconnection Service in and of itself does not convey transmission service.

[2] Network Resource Interconnection Service shall mean an Interconnection Service that allows the Interconnection Customer to integrate its Large Generating Facility with the Transmission Provider's Transmission system (1) in a manner comparable to that in which the Transmission Provider integrates its generating facilities to serve native load customers; or (2) in an RTO or ISO with market based congestion management, in the same manner as all other Network Resources.

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | kV line | | | |
| GI-2020-15 | DISIS-2020-002 | 10/5/2020 | 250 | 250 | 250 | Morgan County, CO | Ft. Lupton-Pawnee 230kV Line | 12/31/2023 | ERIS | Wind |
| GI-2020-16 | DISIS-2020-002 | 10/6/2020 | 199.5 | 200.64 | 200.64 | Adams County, CO | Barr Lake 230 kV | 10/31/2023 | NRIS | Solar |

## 3.0 Description of the GIRs

GI-2020-12, GI-2020-13, GI-2020-14 and GI-2020-16 provided updated modeling data during Phase 2, to correct for the POI MW deficiency identified in Phase1.

## 3.1 Description of GI-2020-12

The new data submitted by GI-2020-12 includes updating the number of wind turbines from 200 to 207 to make up for the MW deficiency at the POI identified in the Phase 1 study.

GI-2020-12 is a 400MW$_{ac}$ net rated Wind Generating Facility located in Elbert County, Colorado. The Generating Facility consists of two hundred-seven (207) Vestas V100 2.0MW MK10D, ±0.95PF wind turbines each with its own 0.69/34.5kV, 2.1MVA fixed Delta/Wye-Grounded, Z=9.5% and X/R = 10.6 pad mounted transformer. The 34.5kV collector will connect to two (2) 131/164/218 MVA, 34.5/345/13.8kV wye-grounded/wye-grounded/delta Z = 10% and X/R = 51 main step-up transformers which will connect to the PSCo transmission system via a 30 mile 345kV generation tie-line. The POI is the Waterton – Midway 345kV line, at approximately 50 miles from the Midway 345kV Substation.

The proposed Commercial Operation Date (COD) of GI-2020-12 is January 12, 2024. For the study purpose, the back-feed date is assumed to be August 12, 2023, approximately six (6) months before the COD.

GI-2020-12 shares the same POI as GI-2020-14 described below. The interconnection at the tap point will require building a new switching station is referred to as “GI-2020-12/GI-2020-14 345kV Switching Station” in this report.

## 3.2 Description of GI-2020-13

The new data submitted by GI-2020-13 includes updating the MVA base.

GI-2020-13 is a 250MW$_{ac}$ solar PV plus 124MW$_{ac}$ Battery Energy Storage (BES) Hybrid Generating Facility located in Pueblo County, Colorado. The hybrid facility will be AC-Coupled

with the net output at the POI limited to 374$MW_{ac}$ using a Power Plant Controller. The Solar PV Generating Facility will consist of seventy-four (74) Sungrow SG3600UD 3.6MVA, ±0.95PF inverters, each with its own 0.63/34.5kV, 3.6 MVA Delta/Wye-grounded, Z=8.5% and X/R=10.8 pad-mount transformer. The BES Generating Facility will consist of thirty-seven (37) Power Electronics FP3510K 3.51MVA, ±0.95PF inverters, each with its own 0.66/34.5kV, 3.5MVA Delta/Wye-grounded, Z=8.5% and X/R=10.8 pad-mount transformer. The 34.5kV Collector system of the solar PV and BES generators will connect to three (3) 99/124/165MVA, 230/34.5/13.8kV Wye-grounded/Wye-grounded/Delta, Z=10% and X/R=51 main step-up transformers which will connect to the PSCo transmission system via a 0.5 mile, 230kV generation tie-line. The POI requested is a tap on the Boone – Midway 230kV line at approximately 26 miles from the Midway 230kV Substation.

The BES inverters have a maximum and minimum state of charge of 100% and 5% respectively.

The interconnection at the tap point will require building a new switching station is referred to as "GI-2020-13 230kV Switching Station" in this report.

The proposed COD of GI-2020-12 is December 1, 2024. For the study purpose, the back-feed date is assumed to be June 1, 2024, approximately six (6) months before the COD.

## 3.3 Description of GI-2020-14

The new data submitted by GI-2020-14 includes updating the number of wind turbines from 377 to 381 to make up for the MW deficiency at the POI identified in Phase1.

GI-2020-14 is a 700$MW_{ac}$ net rated wind Generating Facility located in Cheyenne County, Colorado. The Wind Generation Facility will consist of three-hundred-eighty-one (381) Vestas V100 2.0MW MK10D, 2.1MVA, ±0.95PF wind turbines each with its own 0.69/34.5kV, 2.1MVA, Delta/Wye-grounded Z = 9.5%, X/R = 10.6 pad-mount transformer. The 34.5kV collector system will connect to three (3) 175/218/290MVA, 345/34.5/13.8kV Wye-grounded/Wye-grounded/Delta, Z = 10%, X/R = 51 main step-up transformer which will connect to the PSCo transmission system via a 105 mile, 345kV generation tie-line. The POI is a tap on the Waterton – Midway 345kV line, at approximately 50 miles from the Midway 345kV Substation.

The proposed COD of GI-2020-12 is December 1, 2024. For the study purpose, the back-feed date is assumed to be June 1, 2024, approximately six (6) months before the COD.

GI-2020-14 shares the same POI as GI-2020-12 described above. The interconnection at the tap point will require building a new switching station will be referred to as “GI-2020-12/GI-2020-14 345kV Switching Station” in this report.

## 3.4 Description of GI-2020-15

GI-2020-15 configuration did not change from the Phase 1 study.

GI-2020-15 is a 250MW$_{ac}$ net rated wind Generating Facility located in Morgan County, Colorado. The Generation Facility will consist of one-hundred-seventeen (117) Vestas V120, 2.2MVA, ±0.945PF turbines, each with its own 0.69/34.5kV, 2.3MVA Delta/Wye Z=9.6%, X/R=10.9 pad-mount transformer. The 34.5kV collector system will connect to one (1) 230/34.5/13.8kV, 274/338MVA Wye-grounded/Wye-grounded/Delta Z=9%, X/R=47 main step-up transformer which will connect to the PSCo transmission system via a 0.037mile 230kV generation tie-line. The POI is a tap on the Fort Lupton – Pawnee 230kV line, at approximately 22 miles from the Pawnee Substation.

The proposed COD of GI-2020-15 is December 31, 2023. For the study purpose, the back-feed date is assumed to be July 1, 2023, approximately six (6) months before the COD.

The interconnection at the tap point will require building a new switching station will be referred to as “GI-2020-15 230kV Switching Station” in this report.

## 3.5 Description of GI-2020-16

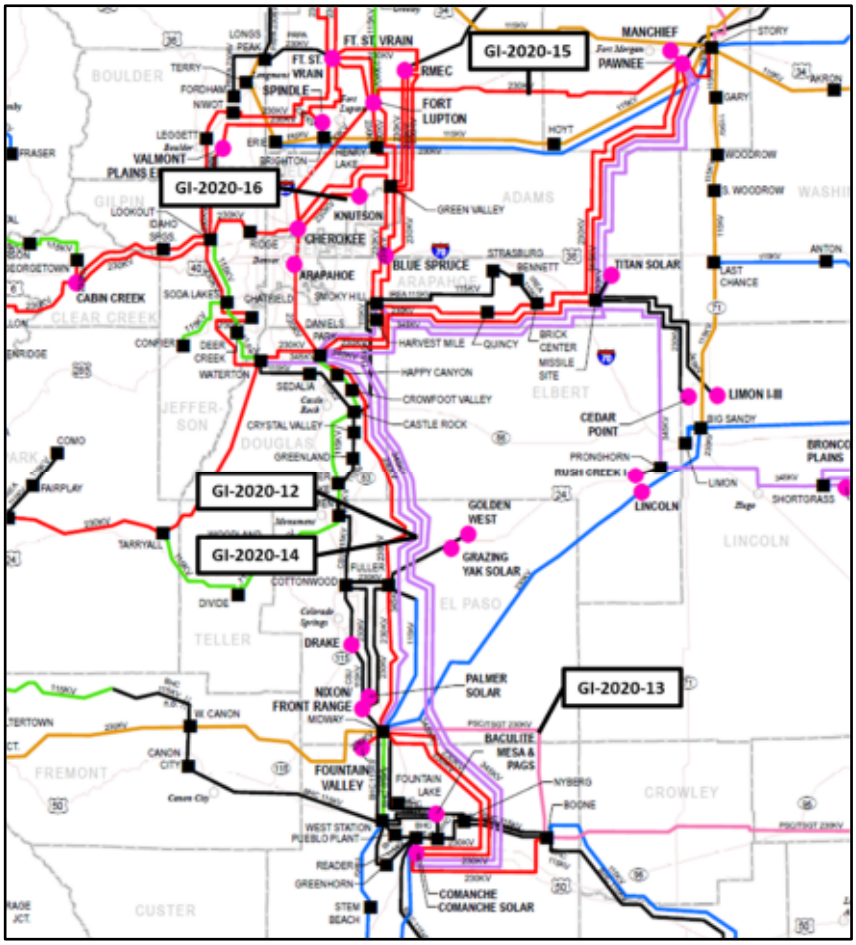
The new data submitted by GI-2020-16 includes updating the number of solar PV inverters from 57 to 59 to make up for the MW deficiency at the POI identified in the Phase 1 report.

GI-2020-16 is a 199.5MW$_{ac}$ net rated solar PV Generating Facility located in Adams County, Colorado. The solar PV Generation Facility will consist of fifty-nine (59) SMA Sunny Central SC4400 UP-US 4.40MVA/3.52MW ±0.80PF inverters, each with its own 0.66/34.5kV, 4.40MVA Wye-Grounded/Delta Z=6.5%, X/R=8.58 pad-mount transformer. The 34.5kV collector system will connect to one (1) 134/178/222MVA, 34.5/230/13.8kV Wye-grounded/Wye-grounded/Delta, Z=11.5%, X/R=34.52 main step-up transformer which will connect to the PSCo transmission system via a 0.13 mile, 230kV generation tie-line. The POI is the Barr Lake 230kV substation.

The proposed COD of GI-2020-16 is October 31, 2023. For the study purpose, the back-feed date is assumed to be June 1, 2023, approximately six (6) months before the COD.

The geographical location of the Transmission System near the POIs is shown in Figure 1 below.

**Figure 1– Approximate Locations of the POIs of the GIRs in the DISIS-2020-002**




## 4.0 Study Scope

The purpose of the study is to determine the system impact of interconnecting all five GIRs in the DISIS-2020-002 for Interconnection Service, as requested in Table 1. The scope of the study which is Phase 2 of the Definitive Interconnection System Impact Study (DISIS) consists of:

a) An updated power flow/voltage analysis (if necessary),
b) stability analysis and short circuit analysis,
c) Non-binding cost estimates for the Transmission Provider's Interconnection Facilities, Station Network Upgrades and Network Upgrades required to reliability interconnect the GIR(s),
d) The report identifies total costs and each Interconnection Customer's assigned costs,
e) The report also identifies the Contingent Facilities applicable to each GIR.

The Phase 1 study identified MW deficiency for GI-2020-12, GI-2020-13, GI-2020-14 and GI-2020-16. Since the reactive power analysis and the power flow analysis in Phase 1 was already performed by increasing the quantity of the generators, the updated modeling data provided for GI-2020-12, GI-2020-13 and GI-2020-14 do not warrant a restudy. The MVA-base modeling data update provided for GI-2020-16 is not considered to be significant enough to require a restudy of the reactive power analysis since the Phase 1 study demonstrated the generator can exceed the power factor requirements and the MVA-base change is not expected to impact the steady state analysis.

Since there were no major system modeling changes from the Phase 1 report and all GIRs in the Phase 1 study moved to Phase 2, the steady state analysis from Phase 1 is accurate and not updated. This report focused on items ‘b’ thru ‘e’ listed above.

Note - This report provides the cost estimates for the improvements identified in both the Phase 1 and the Phase 2 studies.

## 4.1 Study Pocket Determination

As shown in Figure 1, GI-2020-12, GI-2020-13, and GI-2020-14 are in the Southern Colorado study pocket. GI-2020-15 and GI-2020-16 fall under the Northern Colorado study pocket. Each study pocket analysis only modeled the GIRs with POI in that study pocket.

## 4.2 Study Criteria

The following Criteria is used for the reliability analysis of the PSCo system and Affected Systems. The transient voltage stability criteria are as follows:

a. Following fault clearing, voltage shall recover to 80% of the pre-contingency voltage within 20 seconds of the initiating event for all P1 through P7 events for each applicable Bulk Electric System (BES) bus serving load.
b. Following fault clearing and voltage recovery above 80%, voltage at each applicable BES bus serving load shall neither dip below 70% of pre-contingency voltage for more than 30 cycles nor remain below 80% of pre-contingency voltage for more than two seconds, for all P1 through P7 events.
c. For Contingencies without a fault (P2.1 category event), voltage dips at each applicable BES bus serving load shall neither dip below 70% of pre-contingency voltage for more than 30 cycles nor remain below 80% of pre-contingency voltage for more than two seconds.

The transient angular stability criteria are as follows:

a. P1 – No generating unit shall pull out of synchronism. A generator being disconnected from the system by fault clearing action or by a special Protection System is not considered an angular instability.
b. P2-P7 – One or more generators may pull out of synchronism, provided the resulting apparent impedance swings shall not result in the tripping of any other generation facilities.
c. P1-P7 – The relative rotor angle (power) oscillations are characterized by positive damping (i.e., amplitude reduction of successive peaks) > 5% within 30 seconds.

The breaker duty analysis criterion is: Fault Current after GIR(s) addition should not exceed 100% of the Breaker Duty rating.

## 4.3 Study Methodology

All generators in the Study Pocket should meet the Transient stability criteria. If any violations are found, the contributing GIR(s) will be identified for performance violations and mitigations will be attributed to the contributing generator(s).

The stability analysis is performed by running select single and multiple contingencies in the Study Pocket.

PSCo can only perform breaker duty analysis on the PSCo system. Before the GIR goes in-service the Affected Systems may choose to perform a breaker duty analysis to identify breaker duty violations on their system.

## 4.4 Study Area

The Study Area for Southern Colorado study pocket includes WECC designated zones 700, 710, 712, 751, 757, and 785. The Affected Systems included in the analysis include Tri-State Generation and Transmission Inc. (TSGT), Black Hills Energy (BHE), Colorado Spring Utilities (CSU), Intermountain Rural Electric Association (IREA) and Western Area Power Administration (WAPA) transmission systems in the study area.

The Study Area for Northern Colorado study pocket includes WECC designated zones 700, 703 and 706. The Affected Systems included in the analysis include TSGT transmission system in the study area.

# 5.0 Study Analysis

As shown in Figure 1, GI-2020-12, GI-2020-13, and GI-2020-14 are in the Southern Colorado study pocket. GI-2020-15 and GI-2020-16 fall under the Northern Colorado study pocket. Each study pocket analysis only modeled the GIRs with POI in that study pocket.

## 5.1 Southern Colorado

The Phase 2 studies were performed using the same Study Case as the Phase 1 study. The stability analysis is performed using GE PSLF, so a replica model of the Phase 1 PSSE Study Case was created. Since the ERIS steady-state analysis used OPF, the transient  In addition, GI-2014-8 and GI-2014-12 which have been withdrawn are removed from the Study Case models.

The Study Case modeled GI-2020-12 and GI-2020-14 tapping the Waterton-Midway 345kV line. The GI-2020-13 was modeled tapping the Boone-Midway 230kV line. Also, the network upgrades identified in the Phase 1 study are modeled.

### 5.1.1 Steady State Analysis

From the Phase 1 study, the maximum allowable ERIS before Network Upgrades is:

- ERIS of GI-2020-12: 213.8MW
- ERIS of GI-2020-13: 303.0MW
- ERIS of GI-2020-14: 345.6MW

Also, the Phase 1 study identified the following network upgrades:

1. Tap Comanche – Daniels Park 345kV Line at the GI-2020-12/GI-2020-14 Switching Station POI
2. Add a second Waterton 345/230kV Bank
3. Uprate Boone – GI-2020-13 (Midway PS) switching segment from 319 MVA to 374 MVA.

### 5.1.2 Transient Stability Analysis

The results of the transient stability analysis are shown in Table 2. The following results were obtained for the disturbances analysis:

- ✓ No machines lost synchronism with the system
- ✓ No transient voltage drop violations were observed
- ✓ Machine rotor angles displayed positive damping

The following two faults did not result in satisfactory stability performance. It was identified that the stability issue exists in the pre-GI case. DISIS-2020-002 is not considered to contribute to the stability issue based on the inverter settings which demonstrate full control capability for fault ride through and recovery.

- Three-phase fault at Comanche 345kV, P7 loss of Comanche-Daniels Park 345kV and Comanche-Tundra 345kV
- Three-phase fault at Daniels Park 345kV, loss of Daniels Park-Comanche 345kV and Daniels Park-Tundra 345kV

**Table 2 – Southern Colorado Transient Stability Analysis Results**

| Stability Scenarios | | | | | | |
|---|---|---|---|---|---|---|
| # | Fault Location | Fault Type | Facility Tripped | Clearing Time (cycles) | Post-Fault Voltage Recovery | Angular Stability |
| 1 | Boone 230kV | 3ph | Lamar – Boone 230kV line and all generation at Lamar | 5.0 | Stable | Stable |
| 2a | Boone 230kV | 3ph | Boone – GI-2020-3POI - Comanche 230kV | 5.0 | Stable | Stable |
| 2b | GI-2020=3POI | 3ph | GI-2020-3POI – Comanche 230kV | 5.0 | Stable | Stable |
| 3 | Boone 230kV | 3ph | Boone – Midway 230kV | 5.0 | Stable | Stable |
| 4 | Comanche 345 kV | 3ph | Comanche#3 generator | 4.0 | Stable | Stable |
| 5 | Lamar 230kV | 3ph | Lamar – Boone 230kV line and all generation at Lamar | 5.0 | Stable | Stable |
| 6 | MidwayPS 230kV | 3ph | All Fountain Valley gas units | 5.0 | Stable | Stable |
| 7 | MidwayPS 230kV | 3ph | Lose Midway – Fuller 230kV, MidwayBR 230kV Lines | 5.0 | Stable | Stable |
| 8 | MidwayPS 345kV | 3ph | MidwayPS – Waterton 345kV line & Midway 230/345kV xfmr | 4.0 | Stable | Stable |
| 9 | Waterton 345kV | 3ph | Waterton – POI GI-12-14[3] 345kV Line | 4.0 | Stable | Stable |
| 10 | Comanche 345kV | 3ph | Comanche-GI-12-14 345kV Line | 4.0 | Stable | Stable |
| 11 | Daniels Park 345kV | 3ph | Daniels Park-GI-12-14 345kV Line | 4.0 | Stable | Stable |
| 12 | GI-12-14 345kV | 3ph | MidwayPS-GI-2020-12-14 and Comanche-GI-12-14 345kV Lines | 4.0 | Stable | Stable |

| Stability Scenarios | | | | | | |
|---|---|---|---|---|---|---|
| # | Fault Location | Fault Type | Facility Tripped | Clearing Time (cycles) | Post-Fault Voltage Recovery | Angular Stability |
| 13 | GI-12-14 345kV | 3ph | Daniels Park-GI-12-14 and Waterton-GI-1214 345kV Lines | 4.0 | Stable | Stable |
| 14 | Comanche | 3ph | Comanche-GI-12-14 and Comanche-Mirasol 345kV Lines | 4.0 | Stable | Stable |
| 15 | GI-12-14 345kV | 3ph | Loss of all generation at GI-2020-12 and GI-2020-14 | 4.0 | Stable | Stable |
| 16 | Midway PS 345kV | 3ph | Loss of Midway-GI-12-14 and Midway PS 345/230kV Bank | 4.0 | Stable | Stable |
| 17 | Daniels Park | 3ph | Daniels Park-GI-12-14 and Daniels Park-Tundra | 4.0 | Stable | Stable |

The study did not identify any impacts to the Affected Systems.

### 5.1.3 Short Circuit Analysis Results

The short-circuit fault current values and Thevenin equivalent impedances at the POI are shown in Table 3 and Table 4.

**Table 3 – Short Circuit Parameters at GI-2020-12/GI-2020-14 345kV Switching Station POI**

| | Before the Southern Colorado Cluster addition | After the Southern Colorado Cluster addition |
|---|---|---|
| **Three Phase** | | |
| Three Phase Current | 7483A | 21095A |
| Positive Sequence Impedance | 1.67453+j26.7087 ohms | 0.83269+j9.66861 ohms |
| Negative Sequence Impedance | 1.69641+j26.7116 ohms | 0.84982+j9.85131 ohms |
| Zero Sequence Impedance | 7.21074+j44.1360 ohms | 3.52773+j19.3565 ohms |
| **Phase-to-Ground** | | |
| Single Line to Ground Current | 6080A | 15279A |
| Positive Sequence Impedance | 1.67453+j26.7087 ohms | 0.83269+j9.66861 ohms |
| Negative Sequence Impedance | 1.69641+j26.7116 ohms | 0.84982+j9.85131 ohms |
| Zero Sequence Impedance | 7.21074+j44.1360 ohms | 3.52773+j19.3565 ohms |

**Table 4 – Short Circuit Parameters at GI-2020-13 230kV Switching Station POI**

| | Before the Southern Colorado Cluster addition | After the Southern Colorado Cluster addition |
|---|---|---|
| **Three Phase** | | |
| Three Phase Current | 9659A | 9719A |
| Positive Sequence Impedance | 1.58358+j14.1930 ohms | 1.57646+j14.0973 ohms |
| Negative Sequence Impedance | 1.59666+j14.1930 ohms | 1.58911+j14.1021 ohms |
| Zero Sequence Impedance | 7.08079+j29.0876 ohms | 1.90107+j14.3731 ohms |
| **Phase-to-Ground** | | |
| Single Line to Ground Current | 6931A | 10413A |
| Positive Sequence Impedance | 1.58358+j14.1930 ohms | 1.57646+j14.0973 ohms |
| Negative Sequence Impedance | 1.59666+j14.1930 ohms | 1.58911+j14.1021 ohms |
| Zero Sequence Impedance | 7.08079+j29.0876 ohms | 1.90107+j14.3731 ohms |

A breaker duty study for all five (5) GIRs in the Cluster identified several circuit breakers that became over-dutied"[4]. The over-dutied circuit breakers and the impact of each GIR is as shown in Table 5.

**Table 5 – Impact of each GIR on the Overstressed Breakers**

| Substation | Base KV | Breaker Name | GI-2020-12 | GI-2020-13 | GI-2020-14 | GI-2020-15 | GI-2020-16 |
|---|---|---|---|---|---|---|---|
| Cherokee | 230 | 5043 | 20.7% | 0.0% | 24.4% | 13.9% | 41.0% |
| Cherokee | 230 | 5051 | 20.7% | 0.0% | 24.4% | 13.9% | 41.0% |
| Cherokee | 230 | 5057 | 20.7% | 0.0% | 24.4% | 13.9% | 41.0% |
| Cherokee | 230 | 5058 | 20.7% | 0.0% | 24.4% | 13.9% | 41.0% |
| Arapahoe | 230 | 5107 | 28.9% | 0.8% | 33.9% | 8.8% | 27.7% |
| MidwayPS | 230 | 5121 | 20.4% | 53.8% | 24.1% | 0.6% | 1.1% |
| MidwayPS | 230 | 5125 | 20.4% | 53.8% | 24.1% | 0.6% | 1.1% |
| Smoky Hill | 230 | 5164 | 30.8% | 1.4% | 36.2% | 10.9% | 20.7% |
| Smoky Hill | 230 | 5166 | 30.8% | 1.4% | 36.2% | 10.9% | 20.7% |
| Smoky Hill | 230 | 5169 | 30.8% | 1.4% | 36.2% | 10.9% | 20.7% |
| Smoky Hill | 230 | 5170 | 30.2% | 1.7% | 35.4% | 11.0% | 21.8% |
| Smoky Hill | 230 | 5171 | 30.8% | 1.4% | 36.2% | 10.9% | 20.7% |
| Smoky Hill | 230 | 5172 | 30.8% | 1.4% | 36.2% | 10.9% | 20.7% |
| Smoky Hill | 230 | 5175 | 30.8% | 1.4% | 36.2% | 10.9% | 20.7% |
| Smoky Hill | 230 | 5177 | 30.8% | 1.4% | 36.2% | 10.9% | 20.7% |
| Smoky Hill | 230 | 5179 | 30.8% | 1.4% | 36.2% | 10.9% | 20.7% |

[4] "Over-dutied" circuit breaker: A circuit breaker whose short circuit current (SCC) rating is less than the available SCC at the bus.

| Substation | Base KV | Breaker Name | GI-2020-12 | GI-2020-13 | GI-2020-14 | GI-2020-15 | GI-2020-16 |
|---|---|---|---|---|---|---|---|
| Barr Lake | 230 | 5751 | 0.5% | 0.0% | 0.6% | 0.5% | 98.4% |
| Barr Lake | 230 | 5752 | 0.5% | 0.0% | 0.6% | 0.5% | 98.4% |
| Lookout | 115 | 9791 | 28.7% | 0.0% | 33.9% | 8.6% | 28.7% |
| Lookout | 115 | 9792 | 28.7% | 0.0% | 33.9% | 8.6% | 28.7% |
| Lookout | 115 | 9794 | 28.7% | 0.0% | 33.9% | 8.6% | 28.7% |

### 5.1.4 Summary of Southern Colorado Study Pocket Analysis

The transient stability analysis did not identify any Network Upgrades. The Phase 1 study identified the following network upgrades:

1. Tap Comanche – Daniels Park 345kV Line at the GI-2020-12/GI-2020-14 Switching Station POI
2. Add a second Waterton 345/230kV Bank
3. Uprate Boone – GI-2020-13 (Midway PS) switching segment from 319 MVA to 374 MVA.

Based on the analysis performed in the Phase 1 and Phase 2 studies, the results of the GI-2020-12, GI-2020-13 and GI-2020-14 are as follows:

The maximum allowable output of the GIRs before Network Upgrades is:

- GI-2020-12: 213.8MW
- GI-2020-13: 303.0MW
- GI-2020-14: 345.6MW

The ERIS identified after Network Upgrades is:

- ERIS of GI-2020-12: 400MW
- ERIS of GI-2020-13: 374MW
- ERIS of GI-2020-14: 700MW

The studies did not identify any impacts to the Affected Systems.

## 5.2 Northern Colorado Analysis

The GI-2020-15 is modeled by tapping Fort Lupton – Pawnee 230kV line. The GI-2020-16 is modeled at the Barr Lake 230kV Substation. Since the phase 1 power flow study allotted the full ERIS output without upgrades to GI-2020-16, both GI-2020-15 and GI-2020-16 stability analysis is performed using the VERDA dispatch.

### 5.2.1 Steady State Analysis

The Phase 1 report did not identify any single or multiple contingency overloads due to the addition of GI-2020-15 and GI-2020-16.

The maximum ERIS identified for GI-2020-15 is 250 MW.

The maximum NRIS identified for GI-2020-16 is 199.5 MW.

### 5.2.2 Transient Stability Results

The following results were obtained for the disturbances analysis:

- ✓ No machines lost synchronism with the system
- ✓ No transient voltage drop violations were observed
- ✓ Machine rotor angles displayed positive damping

The results of the transient stability analysis are shown in Table 6. The transient stability plots are shown in Section 10 to this report.

**Table 6 - Transient Stability Analysis Results**

| Stability Scenarios | | | | | | |
|---|---|---|---|---|---|---|
| # | Fault Location | Fault Type | Facility Tripped | Clearing Time (cycles) | Post-Fault Voltage Recovery | Angular Stability |
| 1 | St Vrain #2 18kV bus fault | 3ph | Lose St. Vrain #2 and half of St Vrain #1 | 5.0 | Stable | Stable |
| 2 | St Vrain #3 18kV bus fault | 3ph | Lose St. Vrain #3 and half of St Vrain #1 | 5.0 | Stable | Stable |
| 3 | St Vrain 230kV | 3ph | Lose St Vrain #5 and #6 | 5.0 | Stable | Stable |
| 4 | St Vrain 230 kV | 3ph | Lose St Vrain – Fort Lupton #1 and #2 230kV Lines | 5.0 | Stable | Stable |
| 5 | RMEC 230kV | 3ph | Lose all RMEC Generation | 5.0 | Stable | Stable |
| 6 | Pawnee 230kV | 3ph | Lose Pawnee Generation | 5.0 | Stable | Stable |
| 7 | Pawnee 230kV | 3ph | Lose Fort Lupton-Pawnee 230kV Line | 5.0 | Stable | Stable |
| 8 | Barr Lake 230kV | 3ph | Barr Lake – Green Valley 230kV Line | 5.0 | Stable | Stable |
| 9 | Barr Lake 230kV | 3ph | Barr Lake – Reunion 230kV Line | 5.0 | Stable | Stable |

### 5.2.3 Short Circuit Analysis Results

The short-circuit fault current values and Thevenin equivalent impedances at the POI are shown in Tables 7 and 8.

**Table 7 – Short Circuit Parameters at GI-2020-15 POI**

| | Before the Northern Colorado Cluster addition | After Northern Colorado Cluster addition |
|---|---|---|
| **Three Phase** | | |
| Three Phase Current | 9337A | 11489A |
| Positive Sequence Impedance | 1.62276+j14.2011 ohms | 1.19721+j11.5396 ohms |
| Negative Sequence Impedance | 1.66809+j14.2043 ohms | 1.27068+j11.9555 ohms |
| Zero Sequence Impedance | 8.28404+j34.0078 ohms | 1.64990+j14.6036 ohms |
| **Phase-to-Ground** | | |
| Single Line to Ground Current | 6280A | 10401A |
| Positive Sequence Impedance | 1.62276+j14.2011 ohms | 1.19721+j11.5396 ohms |
| Negative Sequence Impedance | 1.66809+j14.2043 ohms | 1.27068+j11.9555 ohms |
| Zero Sequence Impedance | 8.28404+j34.0078 ohms | 1.64990+j14.6036 ohms |

**Table 8 – Short Circuit Parameters at GI-2020-16 POI**

| | Before the Northern Colorado Cluster addition | After Northern Colorado Cluster addition |
|---|---|---|
| **Three Phase** | | |
| Three Phase Current | 17908A | 17999A |
| Positive Sequence Impedance | 0.73335+j7.38761 ohms | 0.73275+j7.34520 ohms |
| Negative Sequence Impedance | 0.76164+j7.34649 ohms | 0.75931+j7.30902 ohms |
| Zero Sequence Impedance | 1.52194+j10.3466 ohms | 0.74330+j5.64129 ohms |
| **Phase-to-Ground** | | |
| Single Line to Ground Current | 15752A | 20144A |
| Positive Sequence Impedance | 0.73335+j7.38761 ohms | 0.73275+j7.34520 ohms |
| Negative Sequence Impedance | 0.76164+j7.34649 ohms | 0.75931+j7.30902 ohms |
| Zero Sequence Impedance | 1.52194+j10.3466 ohms | 0.74330+j5.64129 ohms |

### 5.2.4 Summary of Northern Colorado Analysis

The transient stability analysis did not identify any Network Upgrades. The Phase 1 steady state analysis did not identify any network upgrades.

Based on the analysis performed in the Phase 1 and Phase 2 studies, the results of the GI-2020-15 and GI-2020-16 are as follows:

The maximum allowable output of GI-2020-15 before Network Upgrades is 250 MW.

The ERIS identified for GI-2020-15 is 199.5 MW.

The NRIS identified for GI-2020-16 is 199.5 MW.

TSGT has been identified as an Affected System to GI-2020-16 as the interconnection may require upgrades to substation termination facilities at the Reunion Substation. The cost of these Network Upgrades is not included in this study report and are expected to be available in the Phase 4 report.

There are no other Affected System impacts identified in the Northern study pocket analysis.

## 6.0 Cost Estimates and Assumptions

There are three types of costs identified in the study

- Transmission Provider's Interconnection Facilities which are directly assigned to each GIR
- Station equipment Network Upgrades, which are allocated to each GIR connecting to that station on a per-capita basis per Section 4.2.4(a) of the LGIP
- All other Network Upgrades which are allocated by the proportional impact per Section 4.2.4(b) of the LGIP

The total costs of Network Upgrades assigned under Sections 4.2.4(a) and 4.2.4(b) are given below.

## 6.1 Total Cost of Station Network Upgrades

The estimated total cost of Station Network Upgrades for each POI and the GIRs sharing the POI are given in Table 9.

**Table 9 – Total cost of Station Network Upgrades by POI**

| POI | Total Cost (Million) | GIRs Sharing the POI |
|---|---|---|

| | | |
|---|---|---|
| GI-2020-12/GI-2020-14 345kV Switching Station | $36.699 | GI-2020-12 and GI-2020-14 |
| GI-2020-13 230kV Switching Station | $18.810 | GI-2020-13 |
| GI-2020-15 230kV Switching Station | $19.191 | GI-2020-15 |
| Barr Lake 230kV Substation | $5.224 | GI-2020-16 |

The estimated total cost and details of the Station Network Upgrades required at the GI-2020-12/GI-2020-14 345kV Switching Station, tapping the Midway – Waterton 345kV line are shown in Table 10. These Station Network Upgrade costs are shared by GI-2020-12 and GI-2020-14 on a per-capita basis, as shown in Table 15 below. Construction of the GI-2020-12/GI-2020-14 345kV Switching Station requires a CPCN. It is expected that the CPCN proceedings may take up to 18 months. The construction timeframe following CPCN approval is estimated to take up to 18 months, so the total time required for regulatory activities and, to site, design, procure and construct the switching station is expected to take up to 36 months.

**Table 10 –Station Network Upgrades – GI-2020-12 /GI-2020-14 345kV Switching Station**

| Element | Description | Cost Est. (Millions) |
|---|---|---|
| New PSCo's GI-2020-12/GI-2020-14 345kV Switching Station | Install a new 345kV Switching Station tapping the Waterton - Midway 345kV line. The new equipment includes:<br>• (10) 345kV 3000A circuit breakers<br>• (20) 345kV 3000A disconnect switches<br>• (8) 345kV CCVTs<br>• (12) 345kV Surge Arresters<br>• (4) 345kV deadends<br>• (1) Electrical Equipment Enclosure<br>• (8) Line Traps<br>• Station controls and wiring<br>• Associated foundations and structures | $26.992 |
| New PSCo's GI-2020-12/GI-2020-14 345kV Switching Station | Install required communication in the EEE | $0.558 |
| PSCO's Waterton – Midway 345kV Line | Reconfiguration of lines 7015/7017 and lines 5119/7051to interconnect with the GI-2020-12/GI-2020-14 345kV Switching Station | $7.757 |
| PSCo's Midway Substation | L7051 Midway end termination equipment upgrade | $1.292 |
| | Siting and Land Rights support for substation construction | $0.100 |
| | **Total Cost Estimate for PSCo-Funded, PSCo-Owned Interconnection Facilities** | **$36.699** |
| **Time Frame** | **Site, design, procure and construct** | **36 Months** |

The estimated total cost and details of the Station Network Upgrades required at the GI-2020-13 230kV Switching Station tapping the Boone – Midway 230kV line are shown in Table 11. These

Station Network Upgrade costs are 100% assigned to GI-2020-13, as shown in Table 16. Construction of the GI-2020-13 230kV Switching Station requires a CPCN. It is expected that the CPCN proceedings may take up to 18 months. The construction timeframe following CPCN approval is estimated to take up to 18 months, so the total time required for regulatory activities and, to site, design, procure and construct the switching station is expected to take up to 36 months.

**Table 11 –Station Network Upgrades – GI-2020-13 230kV Switching Station**

| Element | Description | Cost Est. (Millions) |
|---|---|---|
| New PSCo's GI-2020-13 230kV Switching Station | Install a new 230kV Switching Station tapping the Boone – Midway 230kV line. The new equipment includes:<br>• (3) 230kV 3000A circuit breakers<br>• (8) 230kV 3000A disconnect switches<br>• (6) 230kV CCVTs<br>• (6) 230kV Surge Arresters<br>• (1) 230kV Deadends<br>• (1) Electrical Equipment Enclosure<br>• (2) Line Traps<br>• Station controls and wiring<br>• Associated foundations and structures | $13.968 |
| New PSCo's GI-2020-13 230kV Switching Station | Install required communication in the EEE | $0.455 |
| PSCO's Boone- Midway Line 5335 | Line reconfiguration to accommodate Interconnection Customer | $2.216 |
| PSCo's Boone Substation | L5335 Boone end termination equipment upgrade | $1.035 |
| PSCo;s Midway Substation | L5335 Midway end termination equipment upgrade | $1.036 |
| | Siting and Land Rights support for substation construction | $0.100 |
| | **Total Cost Estimate for PSCo-Funded, PSCo-Owned Interconnection Facilities** | **$18.81** |
| **Time Frame** | **Site, design, procure and construct** | **36 Months** |

The estimated total cost and details of the Station Network Upgrades required at the GI-2020-15 230kV Switching Station tapping the Fort Lupton – Pawnee 230kV line are shown in Table 12. These Station Network Upgrade costs are 100% assigned to GI-2020-15, as shown in Table 17. Construction of the GI-2020-15 230kV Switching Station requires a CPCN. It is expected that the CPCN proceedings may take up to 18 months. The construction timeframe following CPCN approval is estimated to take up to 18 months, so the total time required regulatory activities and to site, design, procure and construct the switching station is expected to take up to 36 months.

**Table 12 –Station Network Upgrades – GI-2020-15 230kV Switching Station**

| Element | Description | Cost Est. (Millions) |
|---|---|---|

| | | |
|---|---|---|
| PSCo's GI-2020-15 New 230kV Switchyard | Install a new 230kV substation tapping the Pawnee-Missile 230kV line. The new equipment includes:<br>• (3) 230kV 3000A circuit breakers<br>• (8) 230kV 3000A disconnect switches<br>• (6) 230kV CCVTs<br>• (6) 230kV Surge Arresters<br>• (1) 230kV Deadends<br>• (1) Electrical Equipment Enclosure<br>• (2) Line Traps<br>• Station controls and wiring<br>• Associated foundations and structures | $14.051 |
| PSCo's GI-2020-15 New 230kV Switchyard | Install required communication in the EEE | $0.452 |
| PSCo's Ft. Lupton-Pawnee 5463 Line | Line reconfiguration to accommodate Interconnection Customer | $2.458 |
| PSCo's Fort Lupton Substation | L5463 Fort Lupton end termination equipment upgrade | $1.065 |
| PSCo's Pawnee Substation | L5463 Pawnee end termination equipment upgrade | $1.065 |
| | Siting and Land Rights support for substation construction | $0.100 |
| | **Total Cost Estimate for PSCo-Funded, PSCo-Owned Interconnection Facilities** | **$19.191** |
| **Time Frame** | **Site, design, procure and construct** | **36 Months** |

The estimated total cost and details of the Station Network Upgrades required at the Barr Lake 230kV Substation are shown in Table 13. These Station Network Upgrade costs are shared by GI-2020-16, as shown in Table 18. Since the Barr Lake Substation will be expanded to interconnect GI-2020-16, it is expected that the expansion work may require a CPCN. It is expected that the CPCN proceedings may take up to 18 months. The construction timeframe following CPCN approval is estimated to take up to 18 months, so the total time required for regulatory activities and, to site, design, procure and construct the switching station is expected to take up to 36 months.

**Table 13 –Station Network Upgrades – Barr Lake 230kV Substation**

| Element | Description | Cost Est. (Millions) |
|---|---|---|
| PSCo's Barr Lake 230kV Substation | Expand Barr Lake 230kV substation to accommodate GI-2020-16. The new equipment includes:<br>• (4) 230kV 3000A circuit breakers<br>• (8) 230kV 3000A disconnect switches<br>• (8) 230kV CCVTs<br>• (6) 230kV Surge Arresters<br>• (4) 230kV Deadends<br>• (1) Electrical Equipment Enclosure<br>• (2) Line Traps<br>• Station controls and wiring<br>• Associated foundations and structures | $3.052 |

| | | |
|---|---|---|
| PSCo's Barr Lake 230kV Substation | Install required communication in the EEE | $0.435 |
| PSCo's Reunion-Barr Lake Line 5875 | Line reconfiguration to accommodate Interconnection Customer | $0.871 |
| PSCo'sGreen Valley Substation | L5759 Green Valley end termination upgrade | $0.766 |
| | Siting and Land Rights support for substation construction | $0.100 |
| | **Total Cost Estimate for PSCo-Funded, PSCo-Owned Interconnection Facilities** | **$5.224** |
| **Time Frame** | **Site, design, procure and construct** | **36 Months** |

Note – TSGT's Reunion Substation may require line terminal upgrades. These costs will be included in the Phase 4 report.

## 6.2 Total Cost of Other Network Upgrades

The estimated total cost and details of the other Network Upgrades identified in the Southern Colorado study pocket analysis are shown in Table 14. These Network Upgrade costs are shared by all GIRs in the corresponding Study Pockets based on their proportional impact shown (from Phase 1 report). The Northern Colorado study pocket did not identify any other Network Upgrades.

**Table 14 – Other Southern Colorado Study Pocket Network Upgrades**

| Element | Description | Cost Est. (Millions) | GI-2020-12 Impact | GI-2020-13 Impact | GI-2020-14 Impact | GI-2020-15 Impact | GI-2020-16 Impact |
|---|---|---|---|---|---|---|---|
| Comanche – Daniels Park 345kV line | Terminal Upgrades at Comanche and Daniels Park substations to allow looping of the Comanche – Daniels Park 345kV line into GI-2020-12/GI-2020-14 345kV Switching Station | $2.680 | 32.5% | 15.4% | 52.1% | 0 | 0 |
| PSCo's Waterton Substation | Add second Waterton 345/230kV, 560MVA xfmr | $18.288 | 32.0% | 16.8% | 51.2% | 0 | 0 |
| Boone – GI-2020-13 230kV line | Uprate Boone – GI-2020-13 230kV line to 394MVA | $1.457 | 0 | 100% | 0 | 0 | 0 |
| Cherokee 230kV breakers | Replace the four 230kV Circuit Breakers identified as overstressed due to DISIS-2020-002 addition | $3.520 | 20.7% | 0% | 24.4% | 13.9% | 41.0% |
| Arapahoe 230kV breakers | Replace the one 230kV Circuit Breakers identified as overstressed due to DISIS-2020-002 addition | $0.880 | 28.9% | 0.8% | 33.9% | 8.8% | 27.7% |
| Midway 230kV breakers | Replace the two 230kV Circuit Breakers identified as overstressed due to DISIS-2020-002 addition | $1.760 | 20.4% | 53.8% | 24.1% | 0.6% | 1.1% |
| Smoky Hill 230kV breakers | Replace the nine 230kV Circuit Breakers identified as overstressed due to DISIS-2020-002 addition | $7.920 | 30.8% | 1.4% | 36.2% | 10.9% | 20.7% |
| Barr Lake 230kV breakers | Replace the two 230kV Circuit Breakers identified as overstressed due to DISIS-2020-002 addition | $1.760 | 0.5% | 0% | 0.6% | 0.5% | 98.4% |
| Lookout 115kV breakers | Replace the three 115kV Circuit Breakers identified as overstressed due to DISIS-2020-002 addition | $2.310 | 28.7% | 0% | 33.9% | 8.6% | 28.7% |

## 6.3 Cost of Station and other Network Upgrades by GIR

**Table 15 – Allocation of GI-2020-12/GI-2020-14 345kV Switching Station Cost by GIR**

| GIR | GIR MW | % Share per Section 4.2.4(a) of Attachment N | Costs allocated to GIR (% share x total costs from Table 9) |
|---|---|---|---|
| GI-2020-12 | 400 | 36.37% | $13.347 Million |
| GI-2020-14 | 700 | 63.63% | $23.352 Million |

**Table 16 – Allocation of GI-2020-13 230kV Switching Station Cost by GIR**

| GIR | GIR MW | % Share per Section 4.2.4(a) of Attachment N | Costs allocated to GIR (% share x total costs from Table 9) |
|---|---|---|---|
| GI-2020-13 | 374 | 100% | $18.810 Million |

**Table 17 – Allocation of GI-2020-15 230kV Switching Station Cost by GIR**

| GIR | GIR MW | % Share per Section 4.2.4(a) of Attachment N | Costs allocated to GIR (% share x total costs from Table 9) |
|---|---|---|---|
| GI-2020-15 | 250 | 100% | $19.191 Million |

**Table 18 – Allocation of Barr Lake 230kV Substation POI Cost by GIR**

| GIR | GIR MW | % Share per Section 4.2.4(a) of Attachment N | Costs allocated to GIR (% share x total costs from Table 9) |
|---|---|---|---|
| GI-2020-16 | 199.5 | 100% | $5.224 Million |

**Table 19 – Allocation of Cost of other Network Upgrades**

| Network Upgrade | GIR | % Share per Section 4.2.4(b) of Attachment N | Costs allocated to GIR (% share x total costs from Table 14) |
|---|---|---|---|
| Terminal Upgrades at Comanche and Daniels Park substations to allow looping of the Comanche – Daniels Park 345kV line into GI-2020-12/GI-2020-14 345kV Switching Station | GI-2020-12 | 32.5% | $0.954 Million |
| | GI-2020-13 | 15.4% | $0.452 Million |
| | GI-2020-14 | 52.1% | $1.53 Million |
| Add second Waterton 345/230kV, 560MVA xfmr | GI-2020-12 | 32.0% | $6.271 Million |
| | GI-2020-13 | 16.8% | $3.292 Million |
| | GI-2020-14 | 51.2% | $10.034 Million |
| Uprate Boone – GI-2020-13 230kV line to 394MVA | GI-2020-12 | 0 | 0 |
| | GI-2020-13 | 100% | $1.457 Million |
| | GI-2020-14 | 0 | 0 |
| Cherokee 230kV breakers | GI-2020-12 | 20.7% | $0.729 Million |
| | GI-2020-13 | 0% | 0 |
| | GI-2020-14 | 24.4% | $0.859 Million |
| | GI-2020-15 | 13.9% | $0.489 Million |
| | GI-2020-16 | 41.0% | $1.443 Million |
| Arapahoe 230kV breakers | GI-2020-12 | 28.9% | $0.254 Million |
| | GI-2020-13 | 0.8% | $0.007 Million |

| | | | |
|---|---|---|---|
| | GI-2020-14 | 33.9% | $0.298 Million |
| | GI-2020-15 | 8.8% | $0.077 Million |
| | GI-2020-16 | 27.7% | $0.244 Million |
| Midway 230kV breakers | GI-2020-12 | 20.4% | $0.359 Million |
| | GI-2020-13 | 53.8% | $0.947 Million |
| | GI-2020-14 | 24.1% | $0.424 Million |
| | GI-2020-15 | 0.6% | $0.011 Million |
| | GI-2020-16 | 1.1% | $0.019 Million |
| Smoky Hill 230kV breakers | GI-2020-12 | 30.8% | $2.439 Million |
| | GI-2020-13 | 1.4% | $0.111 Million |
| | GI-2020-14 | 36.2% | $2.867 Million |
| | GI-2020-15 | 10.9% | $0.863 Million |
| | GI-2020-16 | 20.7% | $1.639 Million |
| Barr Lake 230kV breakers | GI-2020-12 | 0.5% | $0.009 Million |
| | GI-2020-13 | 0% | 0 |
| | GI-2020-14 | 0.6% | $0.011 Million |
| | GI-2020-15 | 0.5% | $0.009 Million |
| | GI-2020-16 | 98.4% | $1.732 Million |
| Lookout 115kV breakers | GI-2020-12 | 28.7% | $0.663 Million |
| | GI-2020-13 | 0% | 0 |
| | GI-2020-14 | 33.9% | $0.783 Million |
| | GI-2020-15 | 8.6% | $0.199 Million |
| | GI-2020-16 | 28.7% | $0.663 Million |

## 6.4 Summary of Transmission Provider's Interconnection Facilities and Network Upgrade Costs allocates to GI-2020-12

The total cost of the required Upgrades for GI-2020-12 to interconnect on the Midway – Waterton 345kV line is $27.527 Million.

- The cost of Transmission Provider's Interconnection Facilities is $2.502 Million (Table 20)
- The cost of Station Network Upgrades is $13.347 Million (Table 15)
- The cost of other Network Upgrades is $11.678 Million (Table 19)

Figure 2 is a conceptual one-line of the GI-2020-12 POI at the GI-2020-12/GI-2020-14 345kV Switching Station.

The list of improvements required to accommodate the interconnection of GI-2020-12 are given in Tables 15, 19 and 20. A CPCN will be required to build the GI-2020-12/GI-2020-14 345kV Switching Station. The estimated time frame for regulatory activities and to site, design, procure and construct the interconnection facilities is approximately 36 months after authorization to proceed has been obtained.

System improvements are subject to revision as a more detailed and refined design is produced.

Table 20 – GI-2020-12 Transmission Provider's Interconnection Facilities

| Element | Description | Cost Est. (Millions) |
|---|---|---|
| PSCo's GI-2020-12/14 New 345kV Switching Station | Interconnection GI-2020-12 at the new Switching station tapping the Waterton - Midway 345kV line. The new equipment includes:<br>• (1) 345kV deadend/girder<br>• (3) 345kV Surge Arresters<br>• (1) 345kV 3000A disconnect switch<br>• (1) set (of three) high side metering units<br>• Fiber communication equipment<br>• Station controls<br>• Associated electrical equipment, bus, wiring and grounding<br>• Associated foundations and structures<br>• Associated transmission line communications, fiber, relaying and testing | $2.302 |
| | Transmission line tap into substation. | $0.100 |
| | Siting and Land Rights support for siting studies, land and ROW acquisition and construction | $0.100 |
| | **Total Cost Estimate for Interconnection Customer-Funded, PSCo-Owned Interconnection Facilities** | **$2.502** |
| **Time Frame** | **Site, design, procure and construct** | **36 Months** |

## 6.5 Summary of Transmission Provider's Interconnection Facilities and Network Upgrade Costs allocates to GI-2020-13

The total cost of the required Upgrades for GI-2020-13 to interconnect on the Boone - Midway – 230kV line is $26.469 Million.

- The cost of Transmission Provider's Interconnection Facilities is $1.393 Million (Table 21)
- The cost of Station Network Upgrades is $18.810 Million (Table 16)
- The cost of other Network Upgrades is $6.266 Million (Table 19)

Figure 3 is a conceptual one-line of the GI-2020-13 POI switching station tapping the Boone – Midway 230kV line.

The list of improvements required to accommodate the interconnection of GI-2020-13 are given in Tables 16, 19 and 21. A CPCN will be required to build the GI-2020-13 230kV Switching Station. The estimated time frame for regulatory activities and to site, design, procure and construct the interconnection facilities is approximately 36 months after authorization to proceed has been obtained.

System improvements are subject to revision as a more detailed and refined design is produced.

Table 21 – GI-2020-13 Transmission Provider's Interconnection Facilities

| Element | Description | Cost Est. (Millions) |
|---|---|---|
| PSCo's GI-2020-13 New 230kV Switching Station | Interconnection GI-2020-13 tapping the Boone - Midway 230kV line. The new equipment includes:<br>• (1) 230kV deadend/girder<br>• (3) 230kV Surge Arresters<br>• (1) 230kV 3000A disconnect switch<br>• (1) set (of three) high side metering units<br>• Fiber communication equipment<br>• Station controls<br>• Associated electrical equipment, bus, wiring and grounding<br>• Associated foundations and structures<br>• Associated transmission line communications, fiber, relaying and testing. | $1.193 |
| | Transmission line tap into substation. | $0.100 |
| | Siting and Land Rights support for siting studies, land and ROW acquisition and construction | $0.100 |
| | **Total Cost Estimate for Interconnection Customer-Funded, PSCo-Owned Interconnection Facilities** | **$1.393** |
| **Time Frame** | **Site, design, procure and construct** | **36 Months** |

## 6.6 Summary of Transmission Provider's Interconnection Facilities and Network Upgrade Costs allocates to GI-2020-14

The total cost of the required Upgrades for GI-2020-14 to interconnect on the Midway – Waterton 345kV line is $42.567 Million.

- The cost of Transmission Provider's Interconnection Facilities is $2.409 Million (Table 22)
- The cost of Station Network Upgrades is $23.352 Million (Table 15)
- The cost of other Network Upgrades is $16.806 Million (Table 19)

Figure 2 is a conceptual one-line of the GI-2020-14 POI at the GI-2020-12/GI-2020-14 345kV Switching Station.

The list of improvements required to accommodate the interconnection of GI-2020-14 are given in Tables 15, 19 and 22. A CPCN will be required to build the GI-2020-12/GI-2020-14 345kV Switching Station. The estimated time frame for regulatory activities and to site, design, procure and construct the interconnection facilities is approximately 36 months after authorization to proceed has been obtained.

System improvements are subject to revision as a more detailed and refined design is produced.

Table 22 – GI-2020-14 Transmission Provider's Interconnection Facilities

| Element | Description | Cost Est. (Millions) |
|---|---|---|
| PSCo's GI-2020-12/14 New 345kV Switching Station | Interconnection GI-2020-12 at the new Switching station tapping the Waterton - Midway 345kV line. The new equipment includes:<br>• (1) 345kV deadend/girder<br>• (3) 345kV Surge Arresters<br>• (1) 345kV 3000A disconnect switch<br>• (1) set (of three) high side metering units<br>• Fiber communication equipment<br>• Station controls<br>• Associated electrical equipment, bus, wiring and grounding<br>• Associated foundations and structures<br>• Associated transmission line communications, fiber, relaying and testing. | $2.209 |
| | Transmission line tap into substation. | $0.100 |
| | Siting and Land Rights support for siting studies, land and ROW acquisition and construction | $0.100 |
| | **Total Cost Estimate for Interconnection Customer-Funded, PSCo-Owned Interconnection Facilities** | **$2.409** |
| **Time Frame** | **Site, design, procure and construct** | **36 Months** |

## 6.7 Summary of Transmission Provider's Interconnection Facilities and Network Upgrade Costs allocates to GI-2020-15

The total cost of the required Upgrades for GI-2020-15 to interconnect on the Fort Lupton – Pawnee 230kV line is $22.23 Million.

- The cost of Transmission Provider's Interconnection Facilities is $1.391 Million (Table 23)
- The cost of Station Network Upgrades is $19.191 Million (Table 17)
- The cost of other Network Upgrades is $1.648 Million (Table 19)

Figure 4 is a conceptual one-line of the GI-2020-15 POI switching station tapping the Fort Lupton – Pawnee 230kV line.

The list of improvements required to accommodate the interconnection of GI-2020-15 are given in Tables 17, 19 and 23. A CPCN will be required to build the GI-2020-15 230kV Switching Station. The estimated time frame for regulatory activities and to site, design, procure and construct the interconnection facilities is approximately 36 months after authorization to proceed has been obtained.

System improvements are subject to revision as a more detailed and refined design is produced.

Table 23 – GI-2020-15 Transmission Provider's Interconnection Facilities

| Element | Description | Cost Est. (Millions) |
|---|---|---|
| PSCo's GI-2020-15 New 230kV Switching Station | Interconnection GI-2020-15 on the Fort Lupton-Pawnee 230kV line. The new equipment includes:<br>• (1) 230kV deadend/girder<br>• (3) 230kV Surge Arresters<br>• (1) 230kV 3000A disconnect switch<br>• (1) set (of three) high side metering units<br>• Fiber communication equipment<br>• Station controls<br>• Associated electrical equipment, bus, wiring and grounding<br>• Associated foundations and structures<br>• Associated transmission line communications, fiber, relaying and testing. | $1.191 |
| | Transmission line tap into substation. | $0.100 |
| | Siting and Land Rights support for siting studies, land and ROW acquisition and construction | $0.100 |
| | **Total Cost Estimate for Interconnection Customer-Funded, PSCo-Owned Interconnection Facilities** | **$1.391** |
| **Time Frame** | **Site, design, procure and construct** | **36 Months** |

## 6.8 Summary of Transmission Provider's Interconnection Facilities and Network Upgrade Costs allocates to GI-2020-16

The total cost of the required Upgrades for GI-2020-16 to interconnect at the Barr Lake 230kV Substation is $11.999 Million.

- The cost of Transmission Provider's Interconnection Facilities is $1.035 Million (Table 24)
- The cost of Station Network Upgrades is $5.224 Million (Table 18)
- The cost of other Network Upgrades is $5.74 Million (Table 19)

Figure 5 is a conceptual one-line of the GI-2020-16 POI at the Barr Lake 230kV Substation.

The list of improvements required to accommodate the interconnection of GI-2020-16 are given in Tables 18, 19 and 24. A CPCN will be required to expand the Barr Lake 230kV Substation for the interconnection of GI-2020-16. The estimated time frame for regulatory activities and to site, design, procure and construct the interconnection facilities is approximately 36 months after authorization to proceed has been obtained.

System improvements are subject to revision as a more detailed and refined design is produced.

Table 24 – GI-2020-16 Transmission Provider's Interconnection Facilities

| Element | Description | Cost Est. (Millions) |
|---|---|---|
| PSCo's Barr Lake 230kV Substation | Interconnection GI-2020-16 at the Barr Lake 230kV line. The new equipment includes:<br>• (2) 230kV deadend/girder<br>• (3) 230kV Surge Arresters<br>• (1) 230kV 3000A disconnect switch<br>• (1) set (of three) high side metering units<br>• Fiber communication equipment<br>• Station controls<br>• Associated electrical equipment, bus, wiring and grounding<br>• Associated foundations and structures<br>• Associated transmission line communications, fiber, relaying and testing. | $0.835 |
| | Transmission line tap into substation. | $0.100 |
| | Siting and Land Rights support for siting studies, land and ROW acquisition and construction | $0.100 |
| | **Total Cost Estimate for Interconnection Customer-Funded, PSCo-Owned Interconnection Facilities** | **$1.035** |
| **Time Frame** | **Site, design, procure and construct** | **36 Months** |

## 6.9 Cost Estimate Assumptions

The cost estimates are in 2021 dollars with escalation and contingencies applied. Allowances for Funds Used During Construction (AFUDC) is not included. These estimated costs include all applicable labor and overheads associated with the siting, engineering, design, and construction of these new PSCo facilities. The estimates do not include the cost for any Interconnection Customer owned equipment and associated design and engineering or Affected System impacts. A level of accuracy is not specified for the estimates.

- Labor is estimated for straight time only – no overtime included
- Lead times for materials were considered for the schedule
- A CPCN will be required for the interconnection facilities for all the GIRs
- The estimated time frame for regulatory activities and to site, design, procure and construct the interconnection facilities (entire Project) is approximately 36 months after authorization to proceed has been obtained
- The Customer Generating Facilities are not located in PSCo's retail service territory. Therefore, no costs for retail load metering are included in these estimates
- PSCo (or it's Contractor) crews will perform all construction, wiring, testing and commissioning for PSCo owned and maintained facilities

- Customer will install two (2) redundant fiber optics circuits into the Transmission provider's substation as part of its interconnection facilities construction scope
- Breaker duty study determined that no breaker replacements are needed in neighboring substations
- Line outages will be necessary during the construction period. Outage availability could potentially be problematic and extend requested backfeed date
- Power Quality Metering (PQM) will be required on the Customer's generation tie-line terminating into the POI

The Customer will be required to design, procure, install, own, operate and maintain a Load Frequency/Automated Generation Control (LF/AGC) RTU at their Customer Substation. PSCo / Xcel will need indications, readings and data from the LFAGC RTU

## 7.0 Summary of Generation Interconnection Service

The Customer is required to design and build the Generating Facility to mitigate for any potential inverter interactions with the neighboring inverter based Generating Facility(ies) and/or the inverters of the hybrid Generating Facility.

This report only evaluated Interconnection Service of GIRs in DISIS-2020-002 and Interconnection Service in and itself does not convey transmission service.

### 7.1 GI-2020-12

The total cost of the required Upgrades for GI-2020-12 to interconnect on the Midway – Waterton 345kV line is $27.527 Million (Tables 15, 19 and 20).

The maximum allowable output of GI-2020-12 before Network Upgrades is 213.8MW.

Energy Resource Interconnection Service of GI-2020-12 is 400MW (after required transmission system improvements in Tables 15, 19 and 20).

A CPCN is needed for the construction of the GI-2020-12/GI-2020-14 345kV Switching Station. The estimated time frame for regulatory activities and to site, design, procure and construct the interconnection facilities is approximately 36 months after authorization to proceed has been obtained. Any delays in obtaining the CPCN may delay the COD of GI-2020-12.

## 7.1 GI-2020-13

The total cost of the required Upgrades for GI-2020-13 to interconnect on the Boone - Midway – 230kV line is $26.469 Million (Tables 16, 19 and 21).

The maximum allowable output of GI-2020-13 before Network Upgrades is 303MW.

Energy Resource Interconnection Service of GI-2020-13 is 374MW (after required transmission system improvements in Tables 16, 19 and 21).

A CPCN is needed for the construction of the GI-2020-13 230kV Switching Station. The estimated time frame for regulatory activities and to site, design, procure and construct the interconnection facilities is approximately 36 months after authorization to proceed has been obtained. Any delays in obtaining the CPCN may delay the COD of GI-2020-13.

TSGT has partial ownership of the Boone – Midway 230kV line and is identified as an impacted Affected System. However, no system improvements are identified, other than ownership impact.

The output of the GI-2020-13 hybrid Generating Facility will be limited to 374MW at the POI using centralized power plant controller. The GIR output will also be monitored by PSCo operations. Additional monitoring and control requirements will be added to the LGIA to ensure the Interconnection Service amount is not exceeded.

## 7.2 GI-2020-14

The total cost of the required Upgrades for GI-2020-14 to interconnect on the Midway – Waterton 345kV line is $42.567 Million (Tables 15, 19 and 22).

The maximum allowable output of GI-2020-14 before Network Upgrades is 345.6MW.

Energy Resource Interconnection Service of GI-2020-14 is 700MW (after required transmission system improvements in Tables 15, 19 and 22).

A CPCN is needed for the construction of the GI-2020-12/GI-2020-14 345kV Switching Station. The estimated time frame for regulatory activities and to site, design, procure and construct the interconnection facilities is approximately 36 months after authorization to proceed has been obtained. Any delays in obtaining the CPCN may delay the COD of GI-2020-14.

## 7.3 GI-2020-15

The total cost of the required Upgrades for GI-2020-15 to interconnect on the Fort Lupton – Pawnee 230kV line is $22.23 Million (Tables 17, 19 and 23).

The maximum allowable output of GI-2020-15 before Network Upgrades is 250MW.

Energy Resource Interconnection Service of GI-2020-15 is 250MW (after required transmission system improvements in Tables 17, 19 and 23).

A CPCN is needed for the construction of the GI-2020-15 230kV Switching Station. The estimated time frame for regulatory activities and to site, design, procure and construct the interconnection facilities is approximately 36 months after authorization to proceed has been obtained. Any delays in obtaining the CPCN may delay the COD of GI-2020-15.

## 7.4 GI-2020-16

The total cost of the required Upgrades for GI-2020-16 to interconnect at the Barr Lake 230kV Substation is $11.999 Million (Tables 18, 19 and 24).

Network Resource Interconnection Service of GI-2020-16 is 199.5MW (after required transmission system improvements in Tables 18, 19 and 24).

A CPCN is needed for the expansion of the Barr Lake 230kV Substation to interconnect GI-2020-16. The estimated time frame for regulatory activities and to site, design, procure and construct the interconnection facilities is approximately 36 months after authorization to proceed has been obtained. Any delays in obtaining the CPCN may delay the COD of GI-2020-16.

TSGT has been identified as an Affected System to GI-2020-16 as the interconnection may require upgrades to substation termination facilities at the Reunion Substation. The cost of these Network Upgrades is not included in this study report and are expected to be available in the Phase 4 report.

# 8.0 Contingent Facilities

The following is the list of the unbuilt Interconnection Facilities and Network Upgrades upon which the costs, timing, and study findings of the DISIS-2020-002 are dependent, and if delayed or not built, could cause a need for re-studies of the Interconnection Service or a reassessment of the Interconnection Facilities and/or Network Upgrades and/or costs and timing. The individual GIR's maximum allowable output may be decreased if these Contingent Facilities are not in-service.

**GI-2020-15:** There are no unbuilt facilities modeled in the Northern Colorado study pocket analysis. The Contingent Facilities identified for GI-2020-15 include the Interconnection Facilities, Station Upgrades and Network Upgrades identified in Table 23, Table 17 and Table 19 respectively.

**GI-2020-16:** There are no unbuilt facilities modeled in the Northern Colorado study pocket analysis. The Contingent Facilities identified for GI-2020-16 include the Interconnection Facilities, Station Upgrades and Network Upgrades identified in Table 24, Table 18 and Table 19 respectively.

**GI-2020-12, GI-2020-13 and GI-2020-14:** The Contingent Facilities identified for these GIRs are:

1. The following unbuilt transmission projects modeled in the study were identified as Contingent Facilities for GI-2020-12, GI-2020-13 and GI-2020-14:
    - Monument – Flying Horse 115kV Series Reactor – ISD 2022
    - Greenwood – Arapahoe – Denver Terminal 230kV line – ISD 2022
    - Upgrade Allison – SodaLakes 115kV line to 318MVA – ISD 2021
    - Upgrade Buckley34 – Smokyhill 230kV line to 506MVA – ISD 2021
    - Upgrade Daniels Park – Priarie1 230kV line to 756MVA – ISD under development
    - Upgrade Greenwood – Priarie1 230kV line to 576MVA – ISD 2021
    - Upgrade Daniels Park – Priarie3 230kV line to 576MVA – ISD under development
    - Upgrade Greenwood – Priarie3 230kV line to 576MVA – ISD 2021
    - Upgrade Midway 230kV bus tie to 576MVA – ISD 2023
    - Upgrade Leetsdale – Monaco 230kV line to 560MVA – ISD 2021
    - Upgrade Greenwood – Monaco 230kV line to 560MVA – ISD 2021
    - Fuller – Vollmer – Black Squirrel 115kV line modeled at 173MVA – ISD 2022
    - Fuller 230/115kV, 100MVA #2 transformer – ISD 2023
    - Pueblo West substation – ISD 2021
    - Pueblo Reservoir – Burnt Mill 115kV Rebuild – ISD 2021
    - Boone - South Fowler 115kV Project – ISD 2021
    - North Penrose Substation – ISD 1/2022
    - West Station – Pueblo Res 115kV Rebuild – ISD 1/2022
    - The Cottonwood – Tesla 34.5kV line is modeled open and Kettle Creek – Tesla 34.5kV line is modeled closed on the CSU system – ISD 2023
    - Briargate S 115/230kV transformer project tapping the Cottonwood – Fuller 230kV line – ISD 2023
2. Interconnection Facilities, Station Network Upgrades and Network Upgrades assigned to the respective GIR in this report.
    - Tables 15, 19 and 20 for GI-2020-12
    - Tables 16, 19 and 21 for GI-2020-13
    - Tables 15, 19 and 22 for GI-2020-14

**Figure 2 – Preliminary One-line of the GI-2020-12/GI-2020-14 345kV Switching Station**

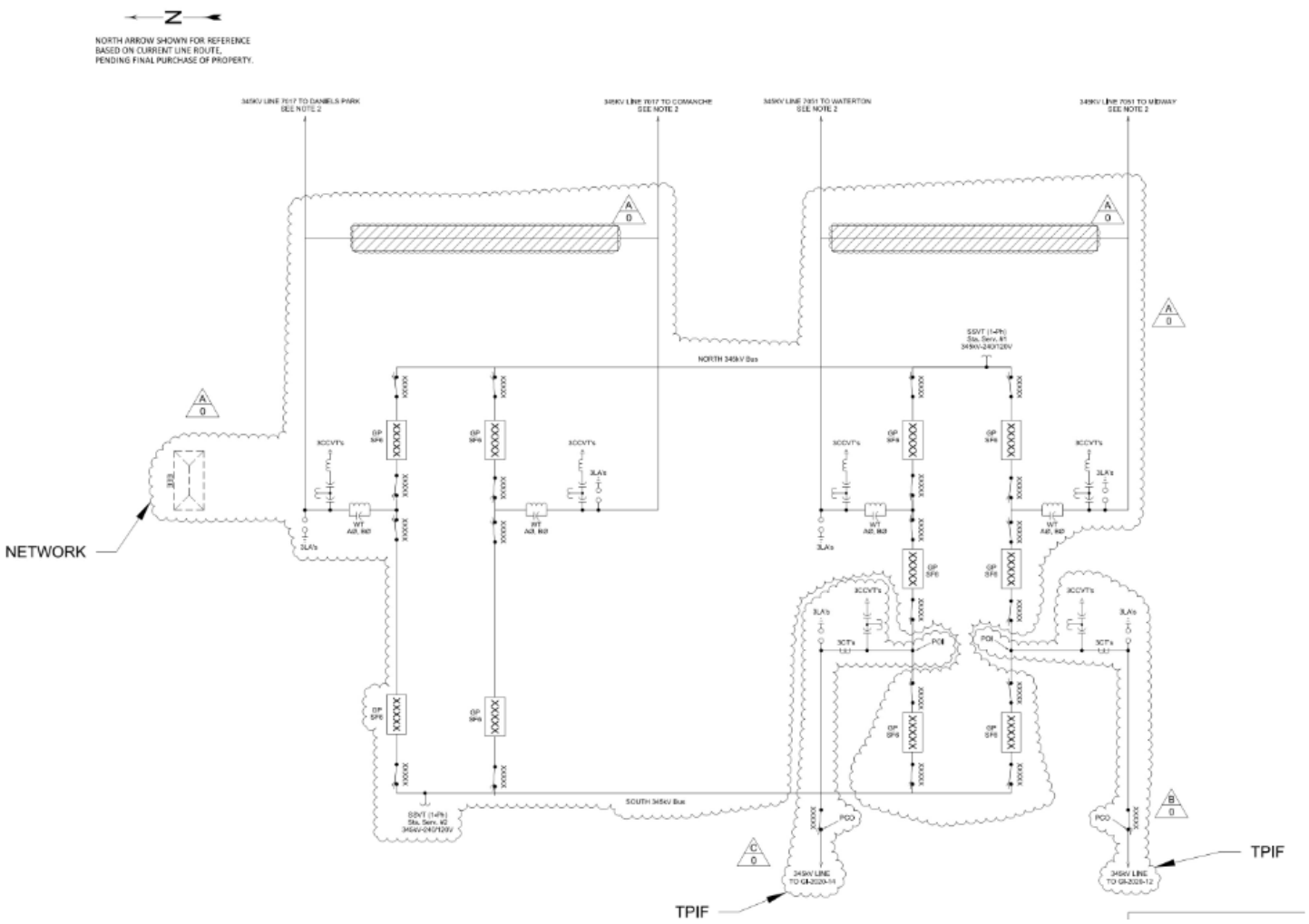


**Figure 3 – Preliminary One-line of GI-2020-13 POI tapping the Boone – Midway 230kV Line**

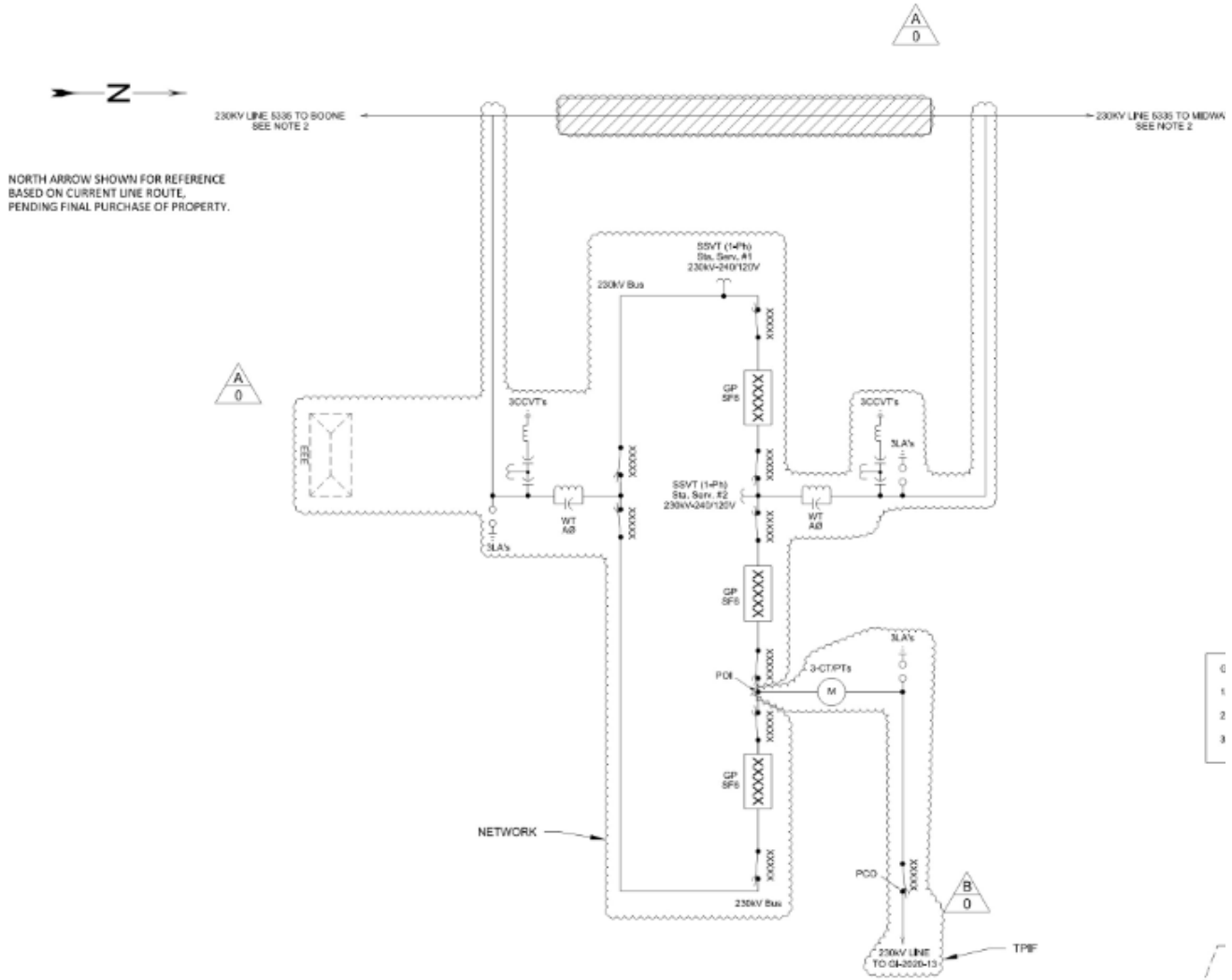


**Figure 4 – Preliminary One-line of the GI-2020-15 230kV Switching Station tapping the Fort Lupton – Pawnee 230kV Line**

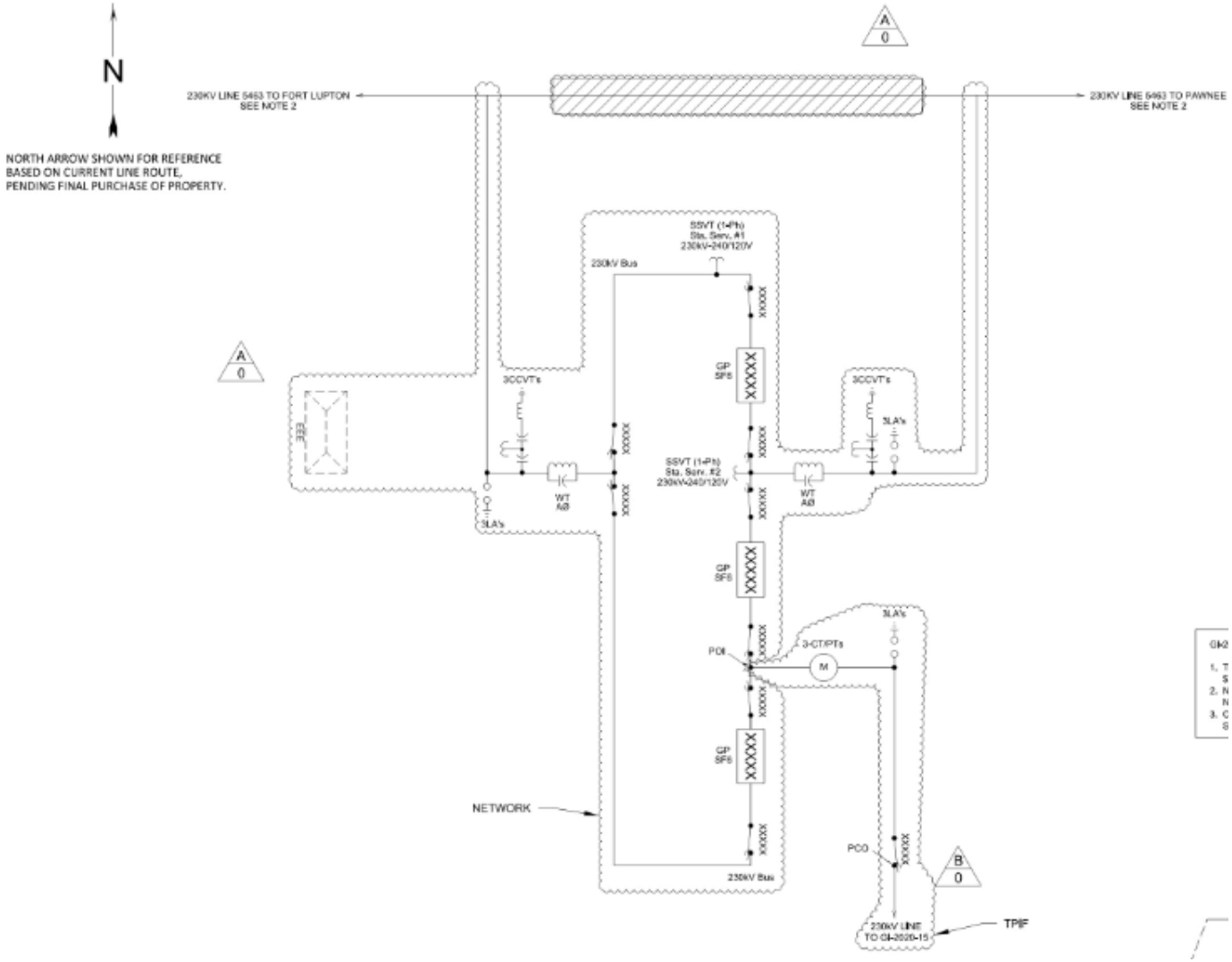
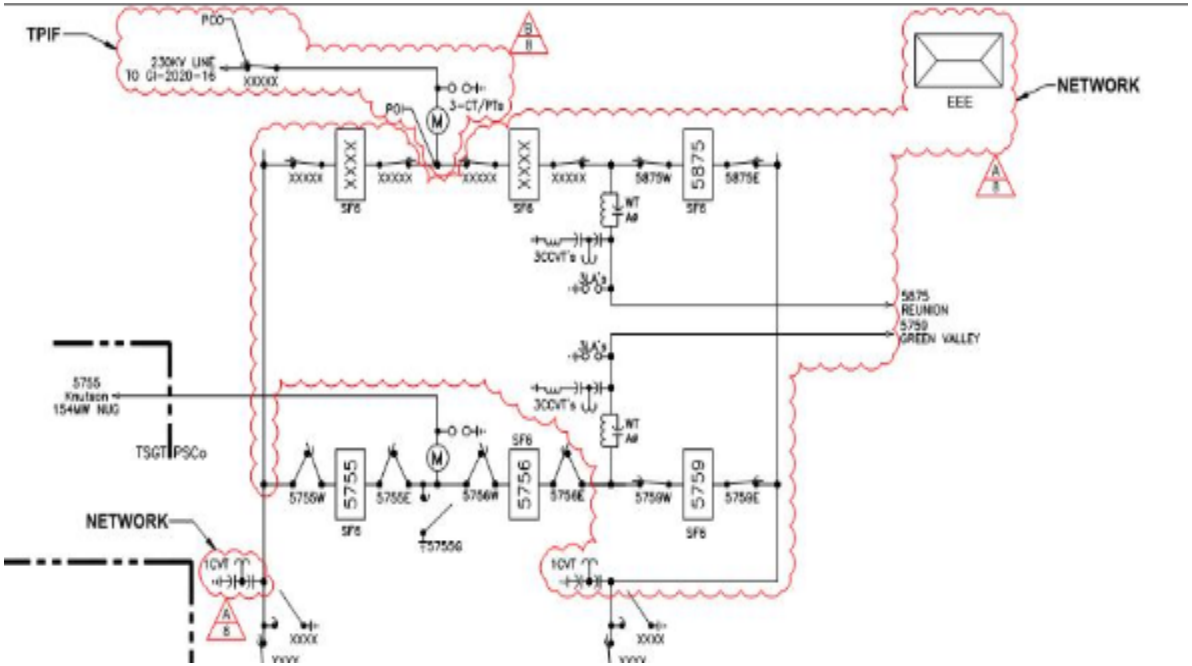
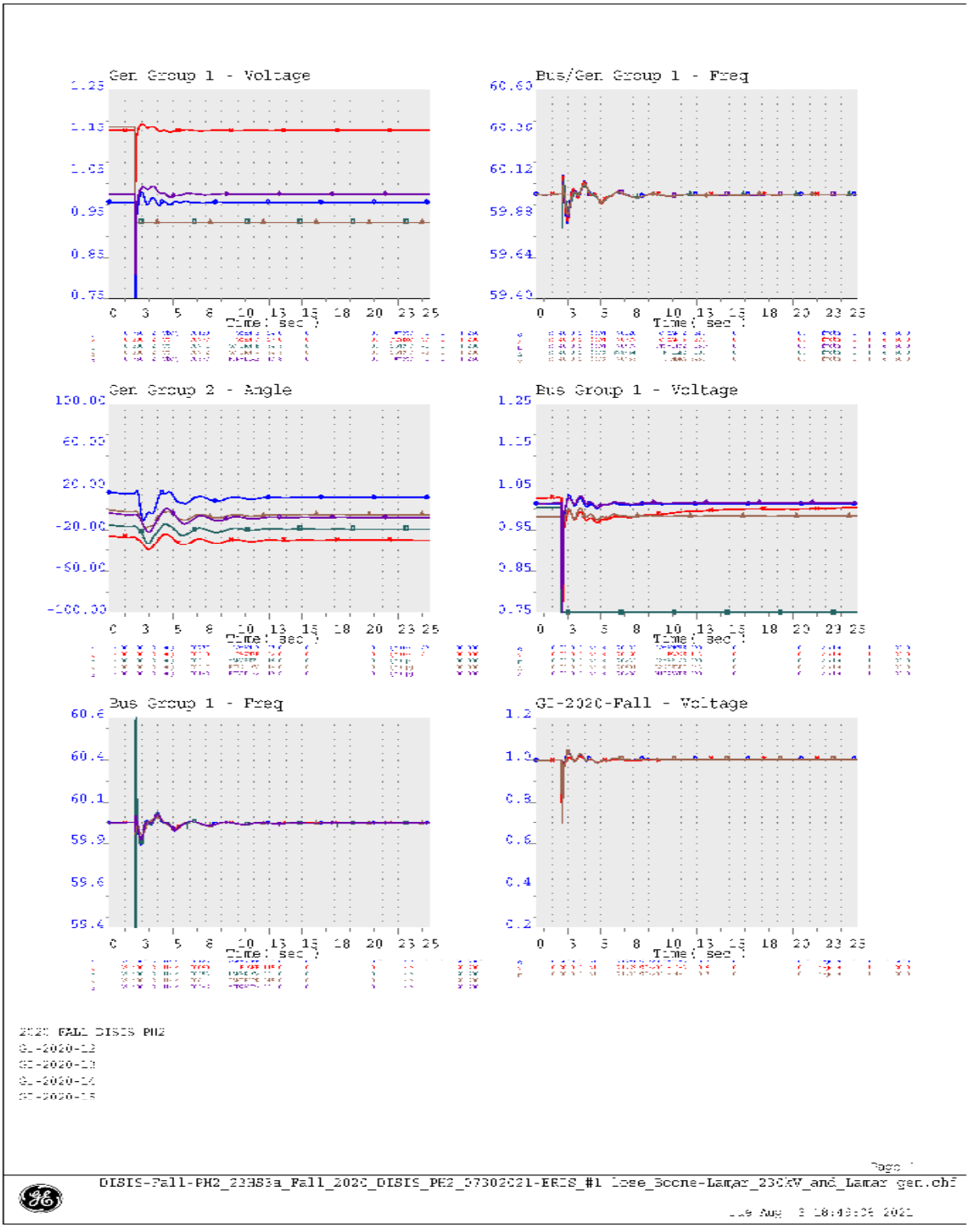


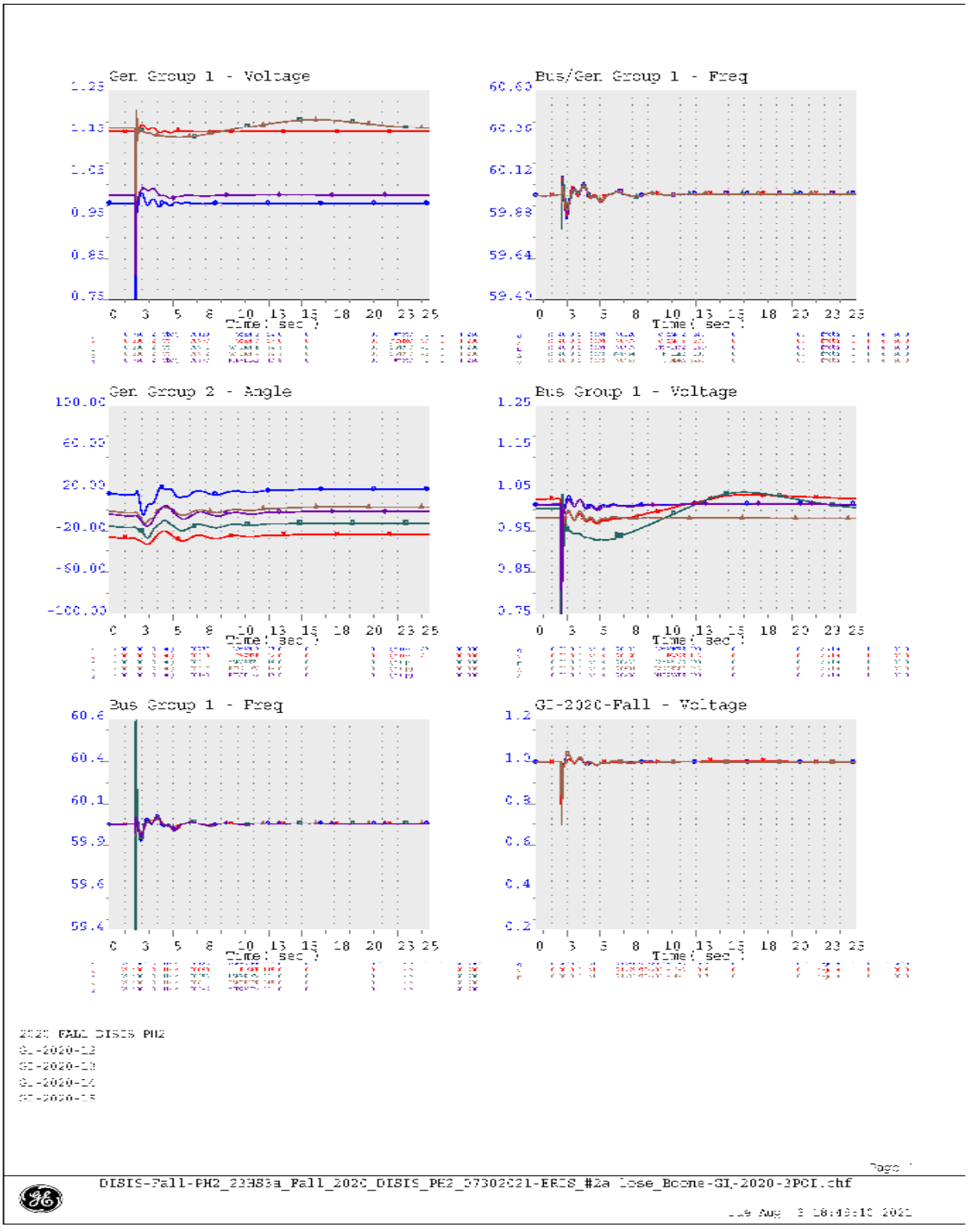
**Figure 5 – Preliminary One-line of the GI-2020-16 at the Barr Lake 230kV Substation**

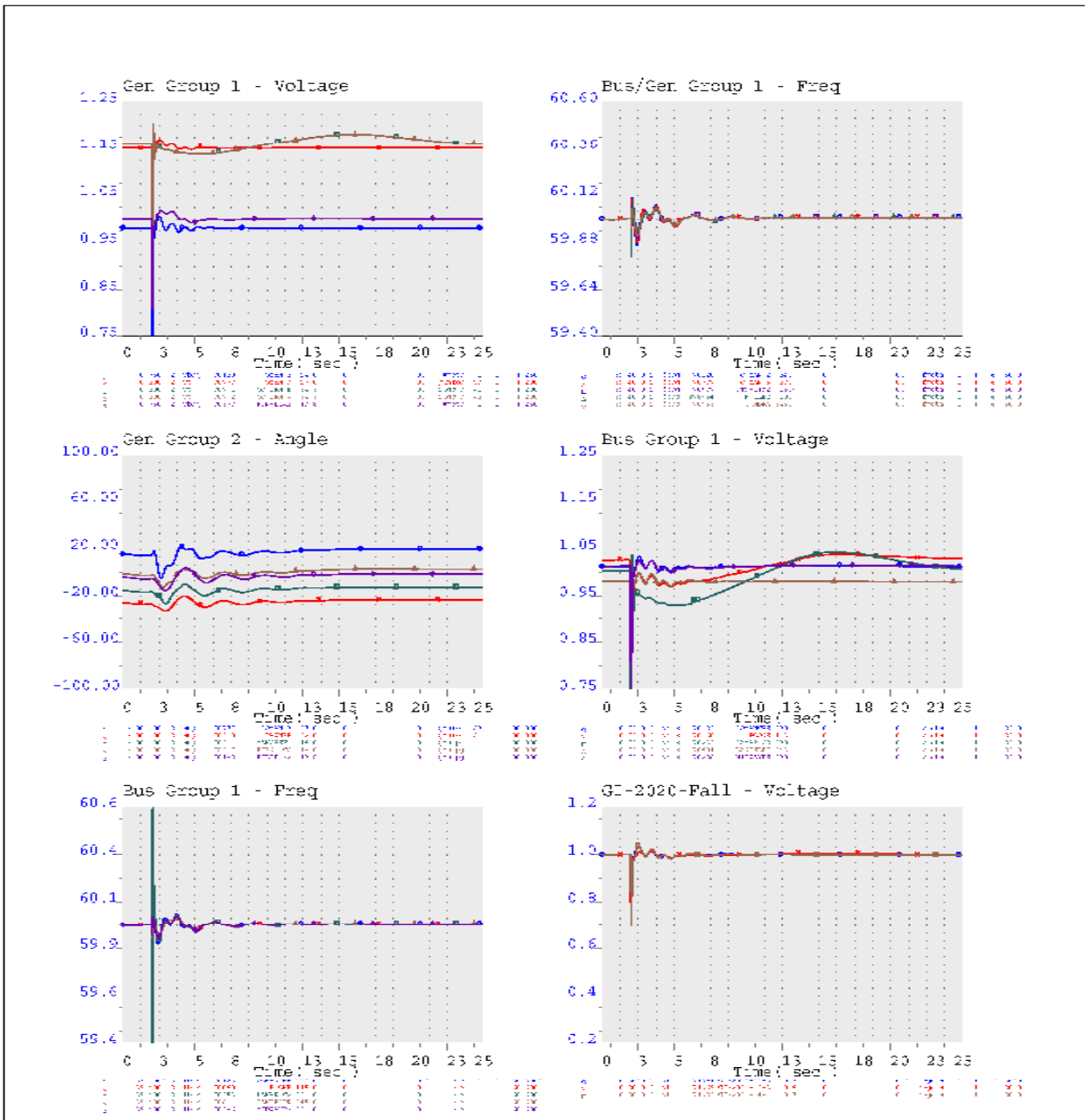


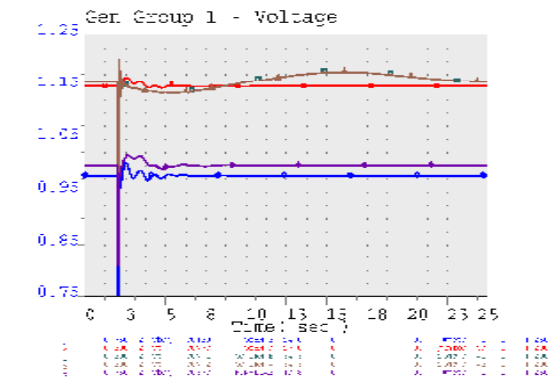
## 9.0 Transient Stability Plots

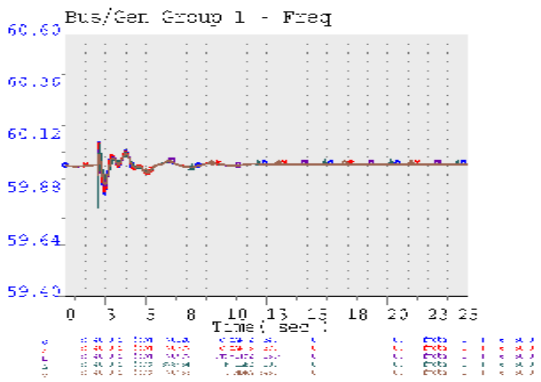
## Southern Pocket (GI-2020-12, GI-2020-13, GI-2020-14)

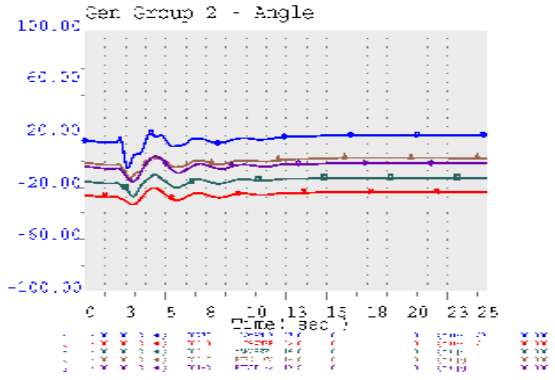


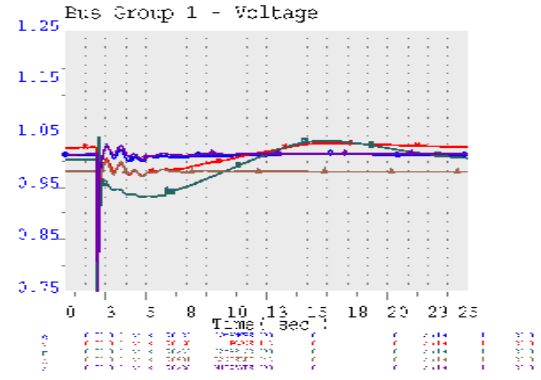

Gen Group 1 - Voltage
Bus/Gen Group 1 - Freq
Gen Group 2 - Angle
Bus Group 1 - Voltage
Bus Group 1 - Freq
GI-2020-Fall - Voltage
Time ( sec )
2020 FALL DISIS PH2
GI-2020-12
GI-2020-13
GI-2020-14
GI-2020-15
DISIS-Fall-PH2_23HS3a_Fall_2020_DISIS_PH2_07302021-ERIS_#2a Lose_Boone-GI-2020-3PCI.chf

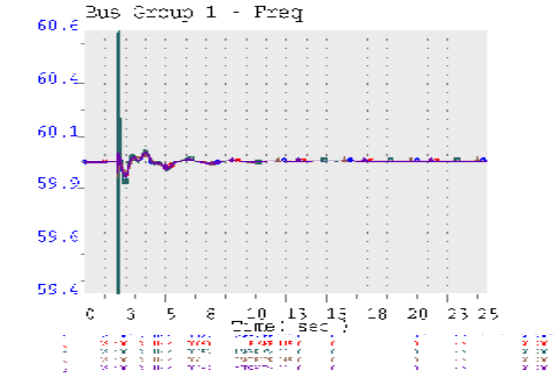

Gen Group 1 - Voltage
Bus/Gen Group 1 - Freq
Gen Group 2 - Angle
Bus Group 1 - Voltage
Bus Group 1 - Freq
GI-2020-Fall - Voltage
Time ( sec )
2020 FALL DISIS PH2
GL-2020-12
GI-2020-13
GL-2020-14
GI-2020-15
DISIS-Fall-PH2_23HS3a_Fall_2020_DISIS_PH2_07302021-ERIS_#28 Lose_GI-2020-3POI-Comanche_230kV.chf
Tue Aug 3 18:43:12 2021

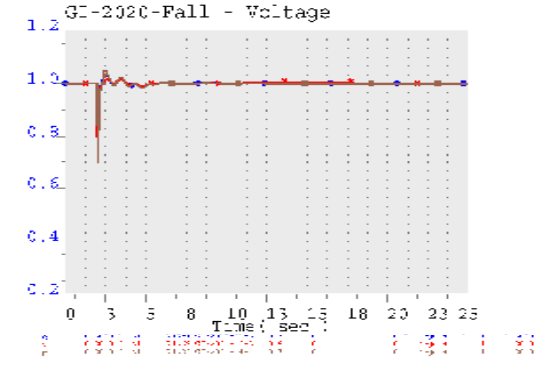


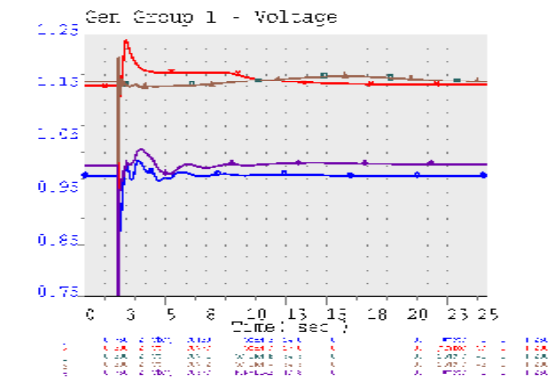



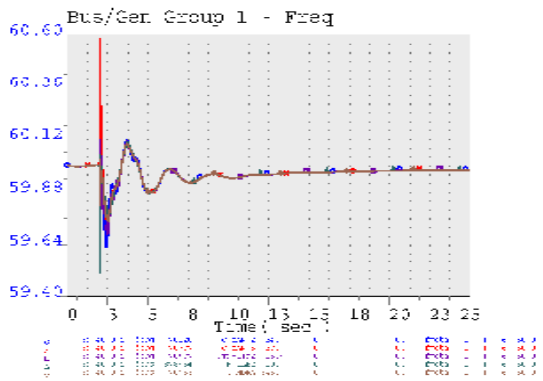

2020 FALL DISIS PH2
GI-2020-12
GI-2020-13
GI-2020-14
GI-2020-15

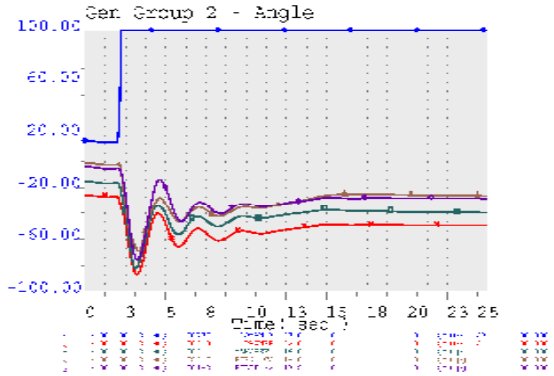
Page 1

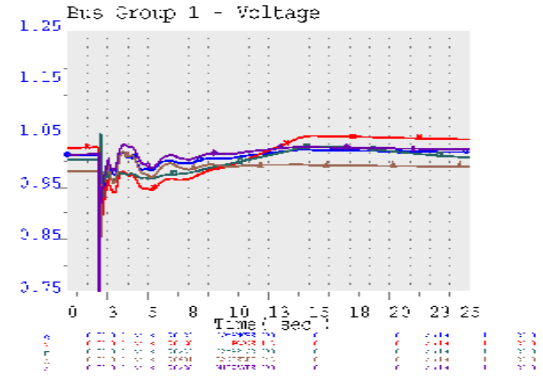
DISIS-Fall-PH2_23HS3a_Fall_2020_DISIS_PH2_07302021-ERIS_#3 Lose_Scene-Midway_230kV.chf

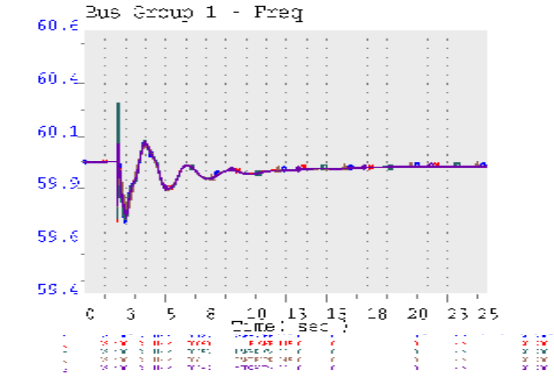
Tue Aug 3 18:43:13 2021

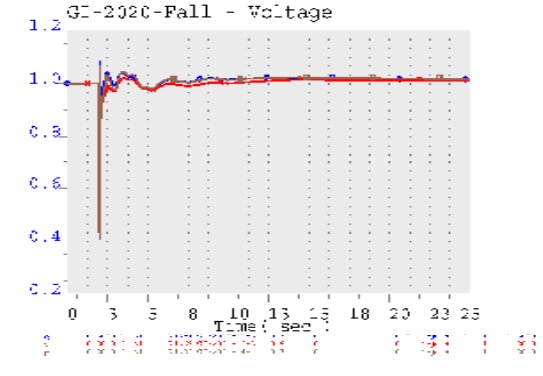


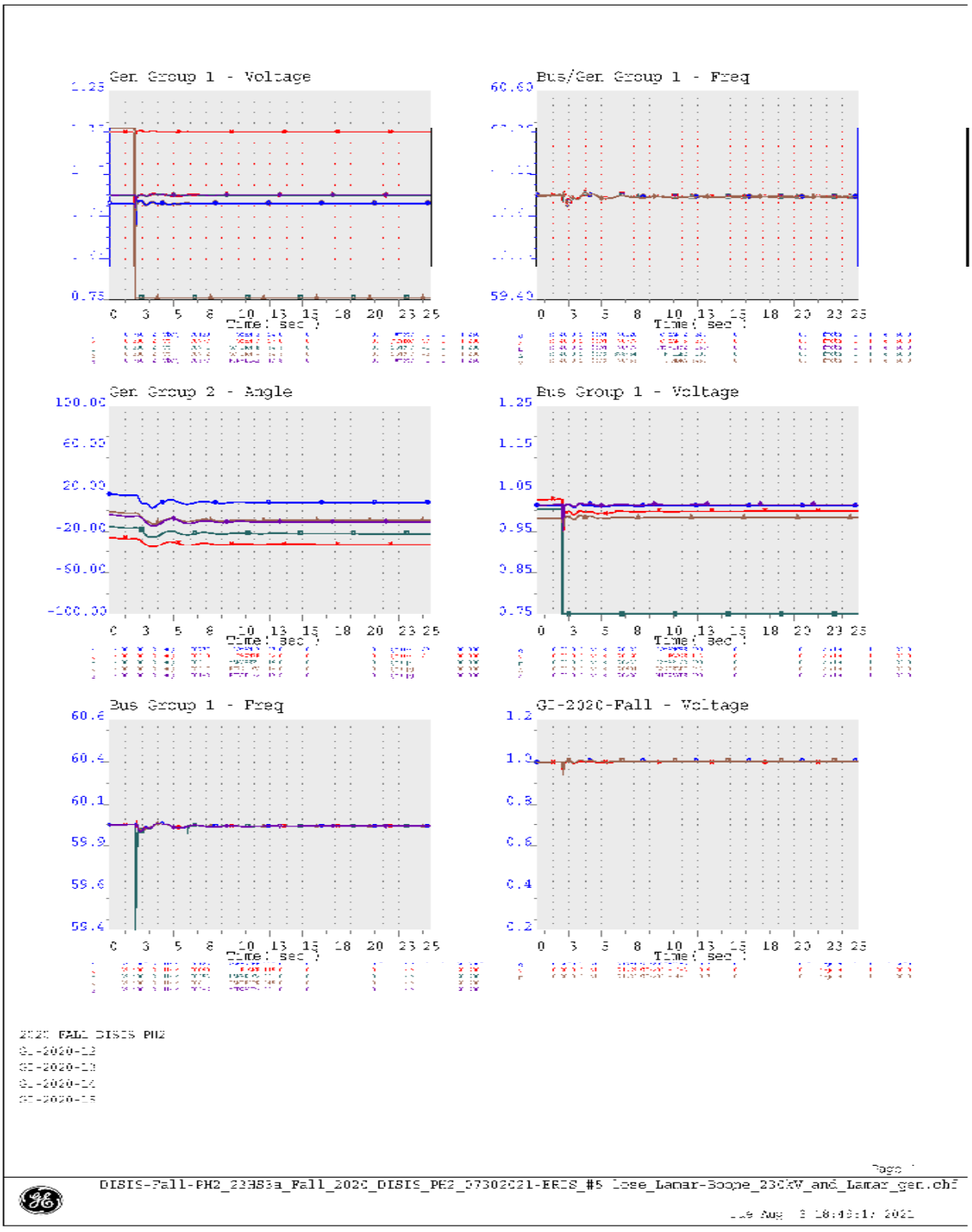



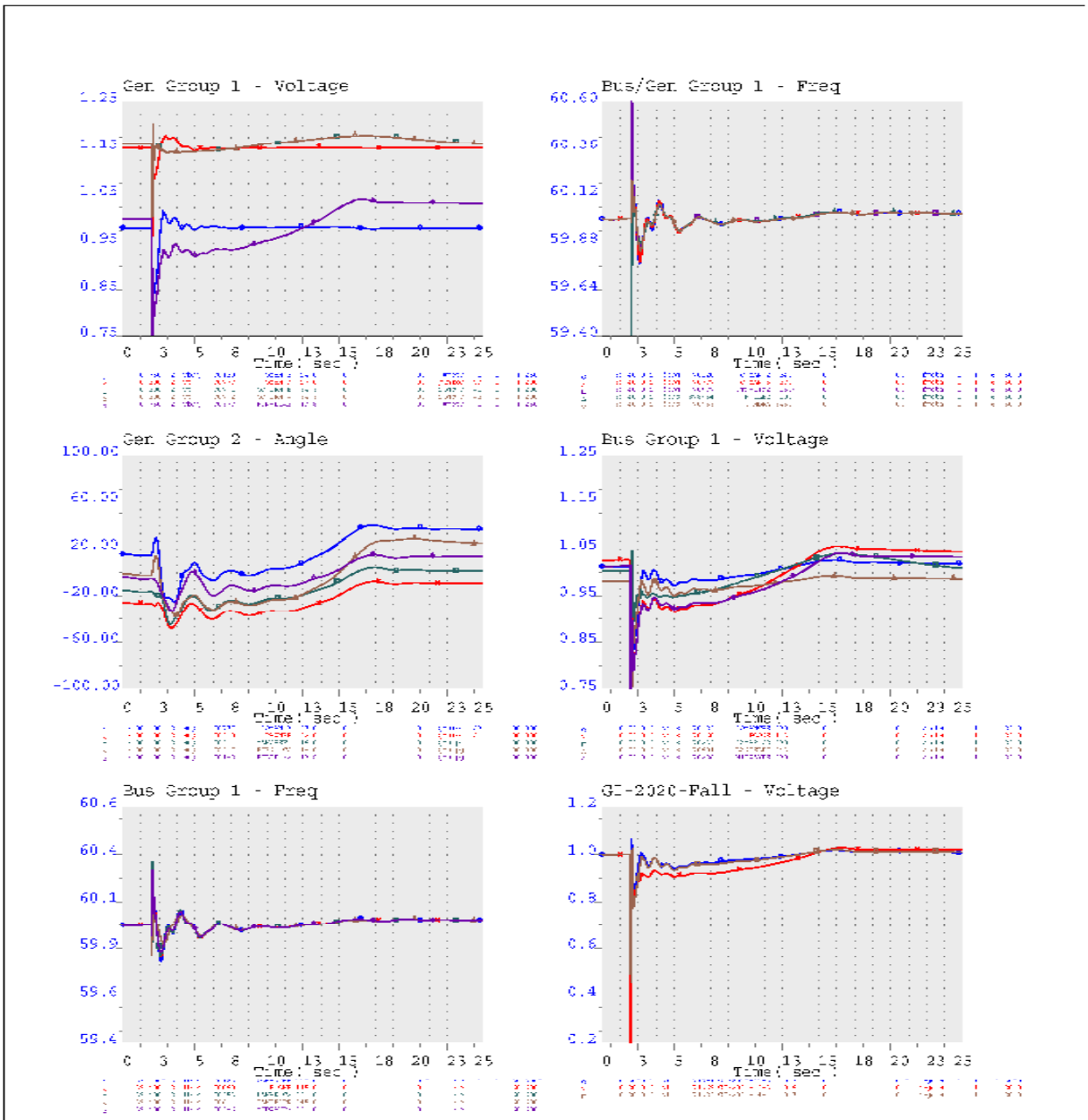



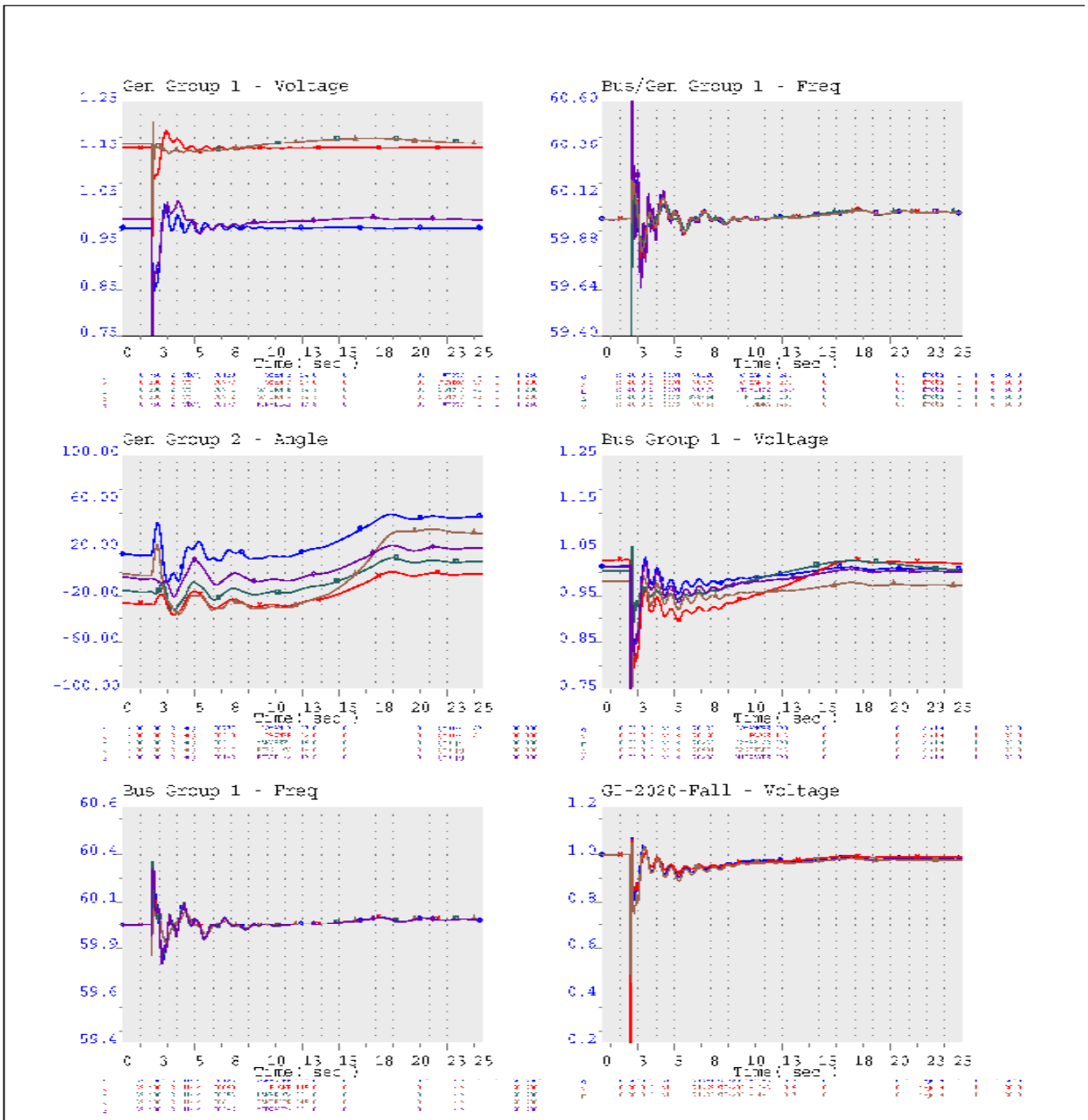



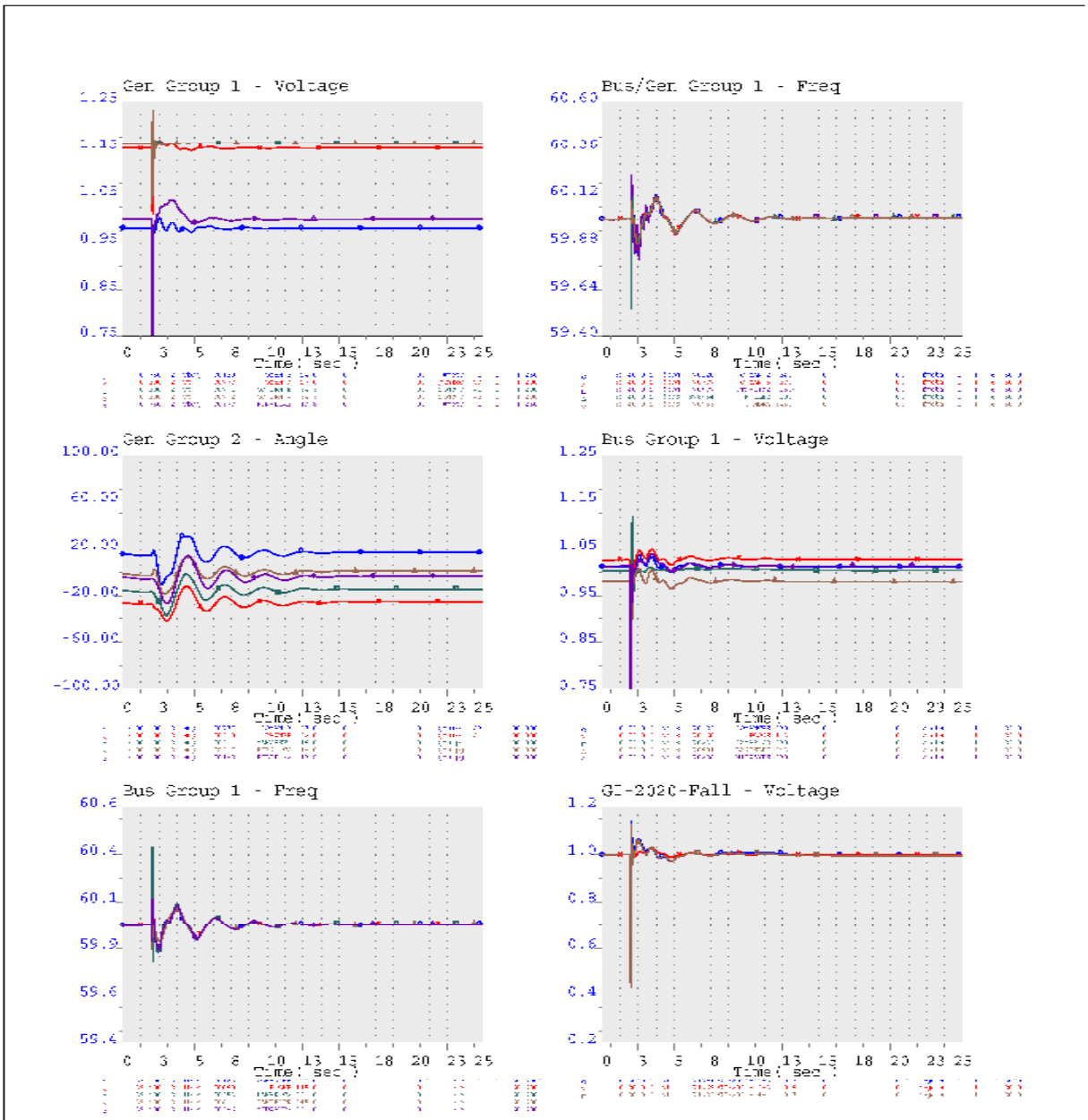

2020 FALL DISIS PH2
GI-2020-12
GI-2020-13
GI-2020-14
GI-2020-15

DISIS-Fall-PH2_2393a_Fall_2020_DISIS_PH2_07302021-ERIS_#4 Comanche_3.chf


Gen Group 1 - Voltage
Bus/Gen Group 1 - Freq
Gen Group 2 - Angle
Bus Group 1 - Voltage
Bus Group 1 - Freq
GI-2020-Fall - Voltage
Time( sec )
DISIS-Fall-PH2_23SS3a_Fall_2020_DISIS_PH2_07302021-ERIS_#5 Lose_Lamar-Boone_230kV_and_Lamar_gen.chf

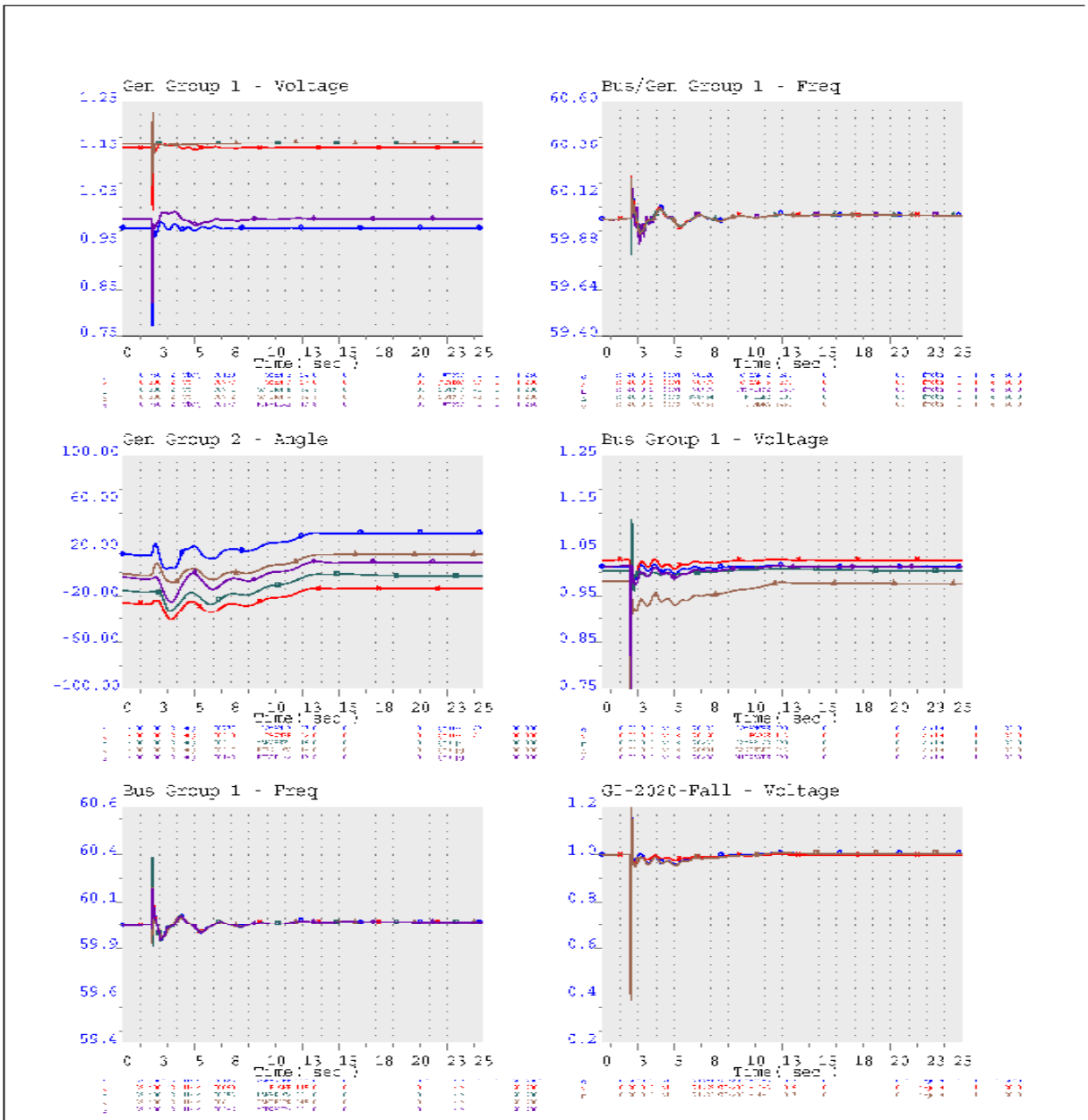

Gen Group 1 - Voltage
Bus/Gen Group 1 - Freq
Gen Group 2 - Angle
Bus Group 1 - Voltage
Bus Group 1 - Freq
GI-2020-Fall - Voltage
Time ( sec )
2020 FALL DISIS PH2
GI-2020-12
GI-2020-13
GI-2020-14
GI-2020-15
DISIS-Fall-PH2_23SS3a_Fall_2020_DISIS_PH2_07302021-ERIS_#8 Lose_Fountain_Valley_geo.chf


Gen Group 1 - Voltage
Bus/Gen Group 1 - Freq
Gen Group 2 - Angle
Bus Group 1 - Voltage
Bus Group 1 - Freq
GI-2020-Fall - Voltage
Time( sec )
DISIS-Fall-PH2_2020a_Fall_2020_DISIS_PH2_07302021-ERIS_#7 Lose_MidwayPS-Fuller_230kV_MidwayBr_lines.c



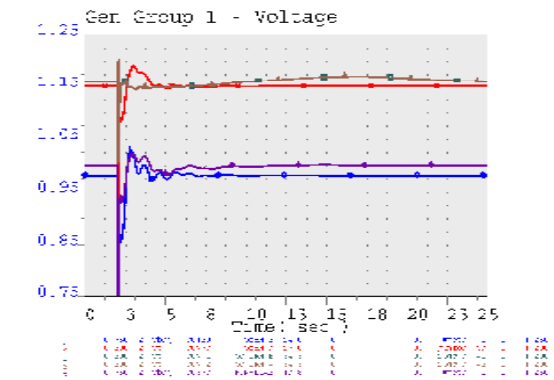

2020 FALL DISIS PH2
GI-2020-12
GI-2020-13
GI-2020-14
GI-2020-15

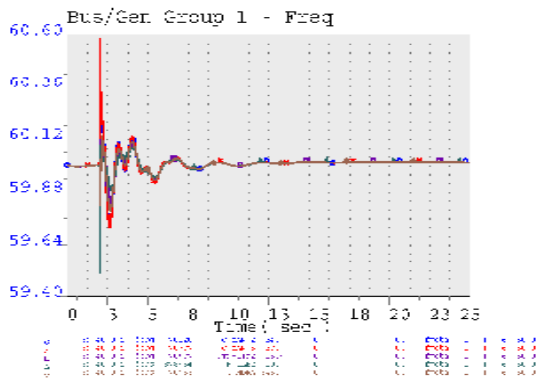
DISIS-Fall-PH2_23B3a_Fall_2020_DISIS_PH2_07302021-ERIS_#8 Lose_MidwayPS-GI-2020-12-14 345kV Line.chf

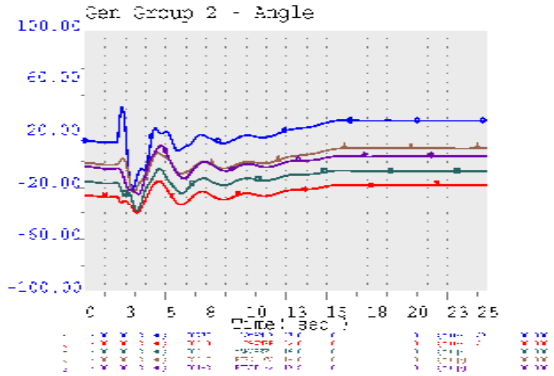


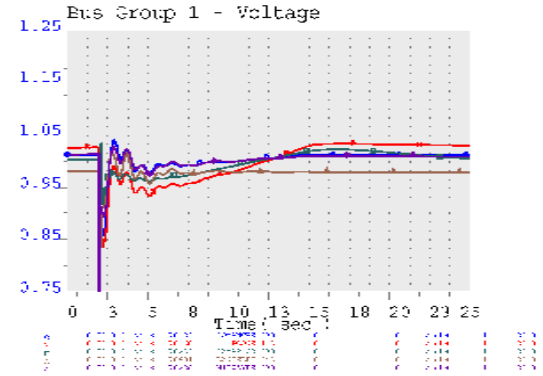

2020 FALL DISIS PH2
GI-2020-12
GI-2020-13
GI-2020-14
GI-2020-15

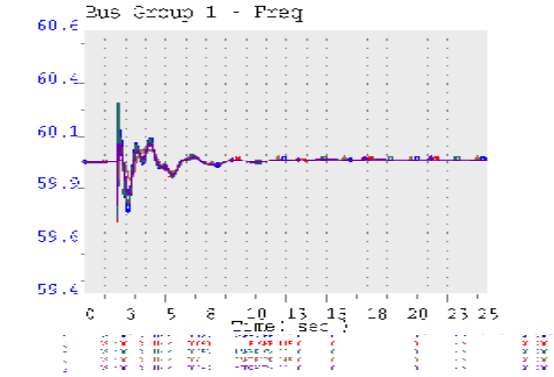
DISIS-Fall-PH2_2345a_Fall_2020_DISIS_PH2_07302021-ERIS_#9 Lose_Waterton-GI-2020-12-14 345kV Line.chf

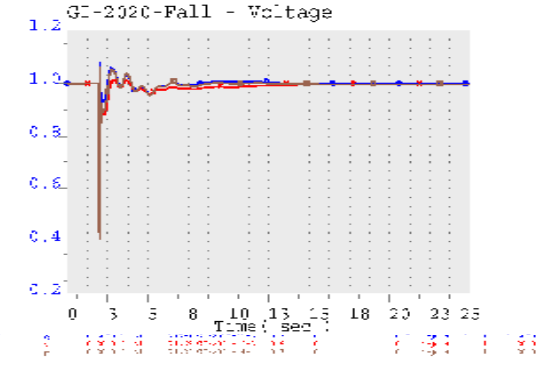


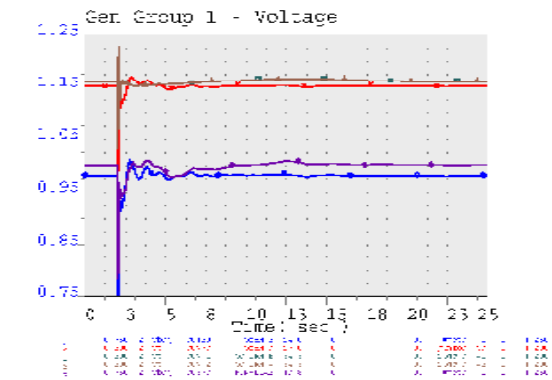



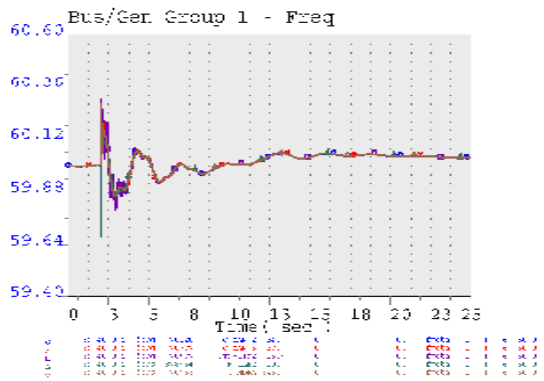



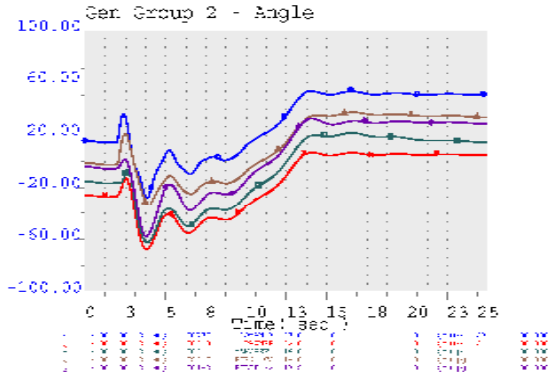



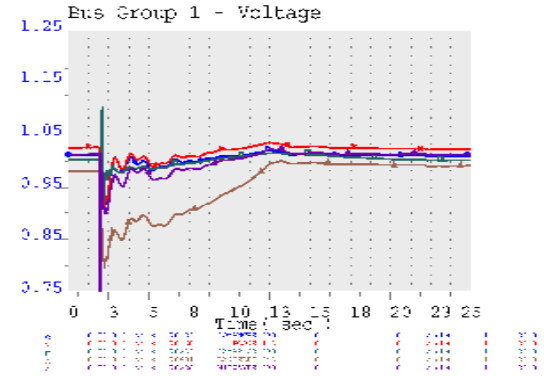



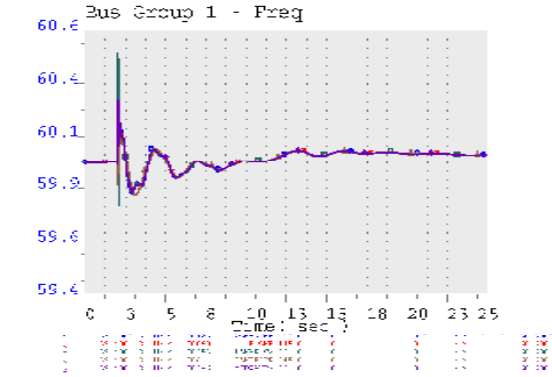

2020 FALL DISIS PH2
GI-2020-12
GI-2020-13
GI-2020-14
GI-2020-15

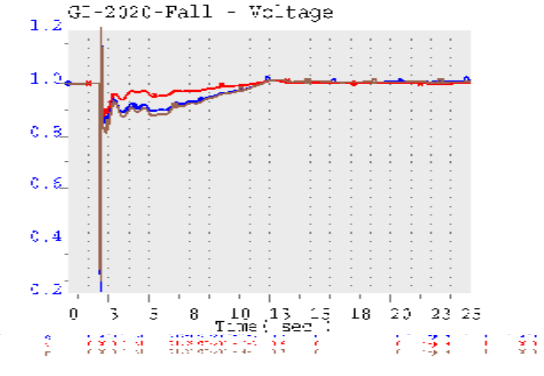


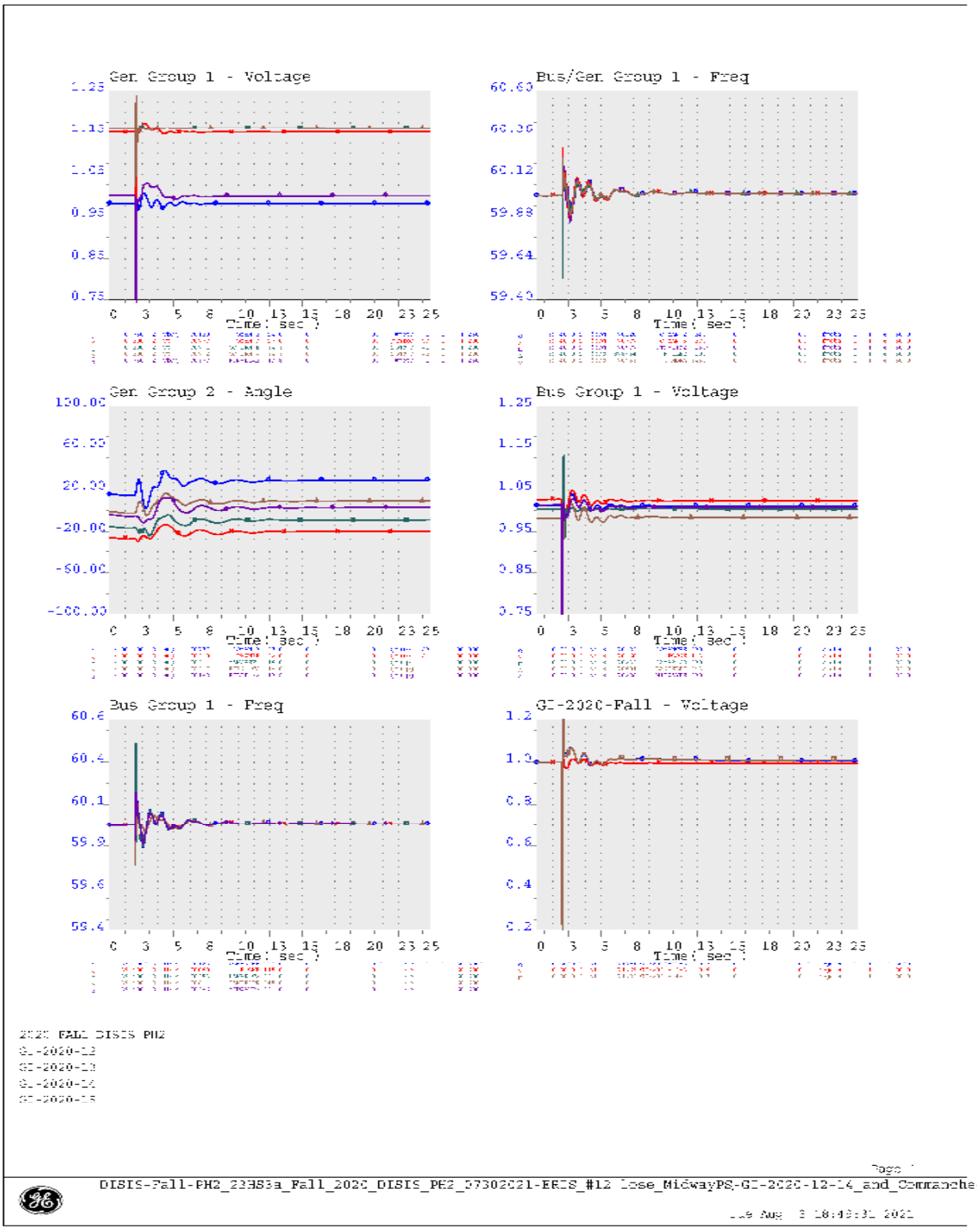



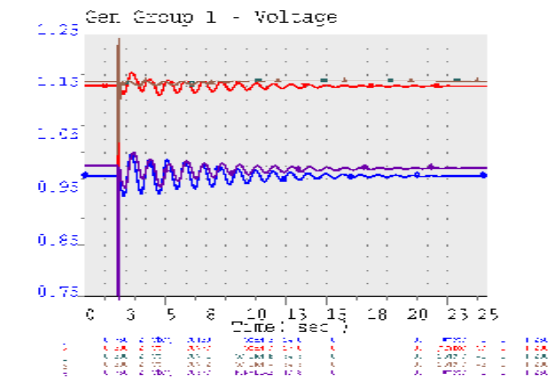

2020 FALL DISIS PH2
GI-2020-12
GI-2020-13
GI-2020-14
GI-2020-15

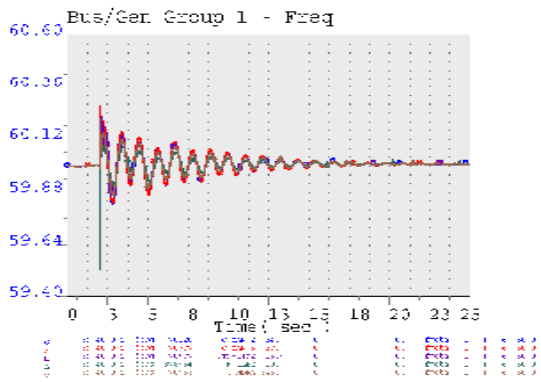
Page 1

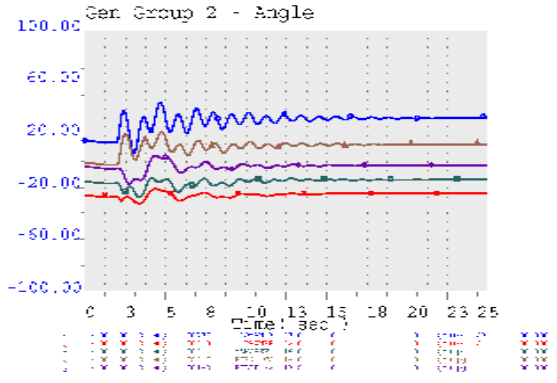
DISIS-Fall-PH2_23HS3a_Fall_2020_DISIS_PH2_07302021-ERIS_#11 Lose_SP-GI-12,14 345kV station.chf

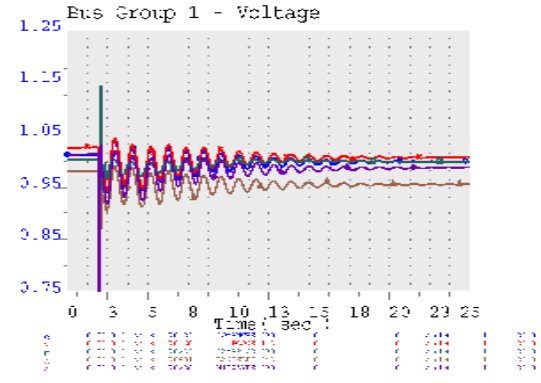
Tue Aug 3 18:43:30 2021

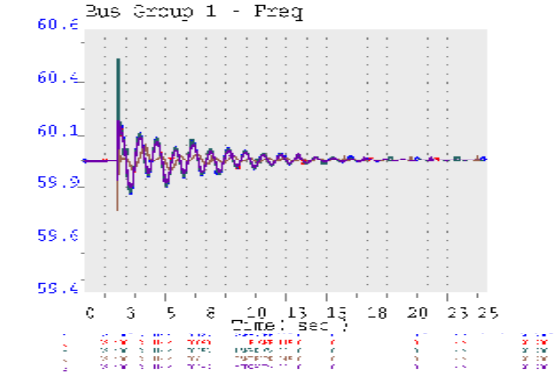

Gen Group 1 - Voltage
Bus/Gen Group 1 - Freq
Gen Group 2 - Angle
Bus Group 1 - Voltage
Bus Group 1 - Freq
GI-2020-Fall - Voltage
Time ( sec )
2020 FALL DISIS PH2
GL-2020-12
GI-2020-13
GL-2020-14
GI-2020-15
DISIS-Fall-PH2_23SS3a_Fall_2020_DISIS_PH2_07302021-ERIS_#12 Lose_MidwayPS-GI-2020-12-14_and_Commanche-
Tue Aug 3 18:43:31 2021

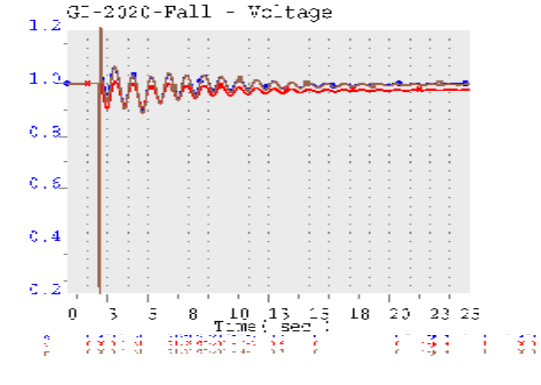


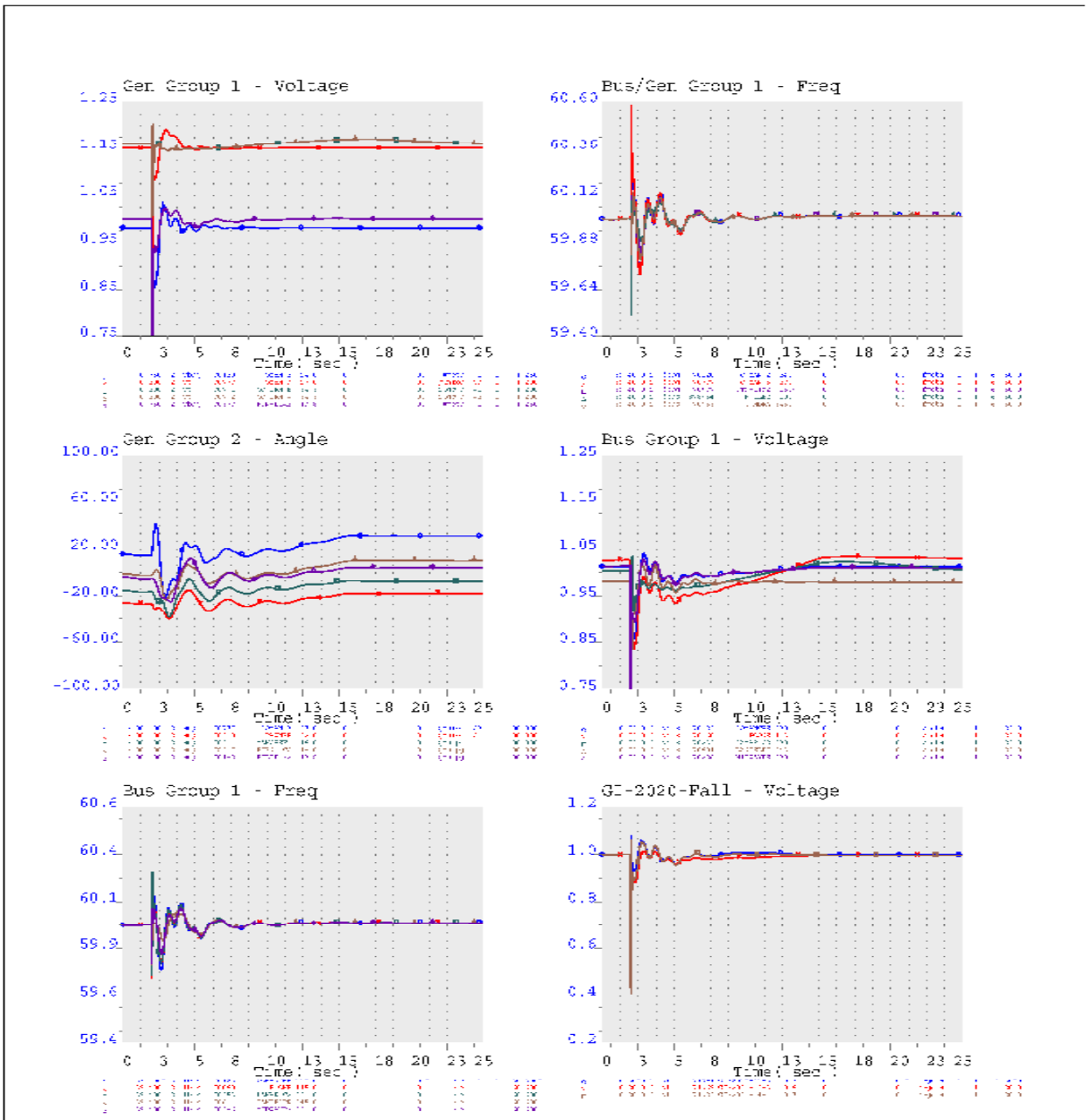



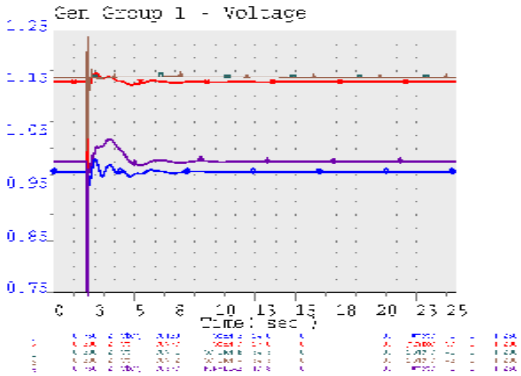



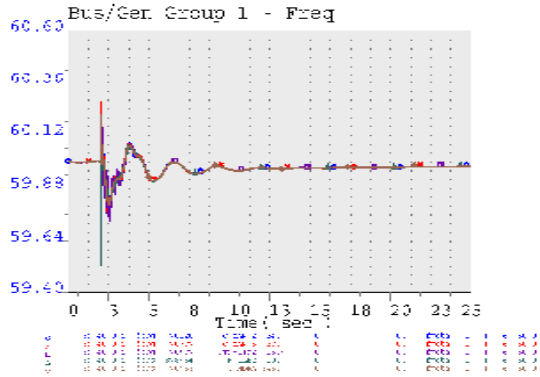



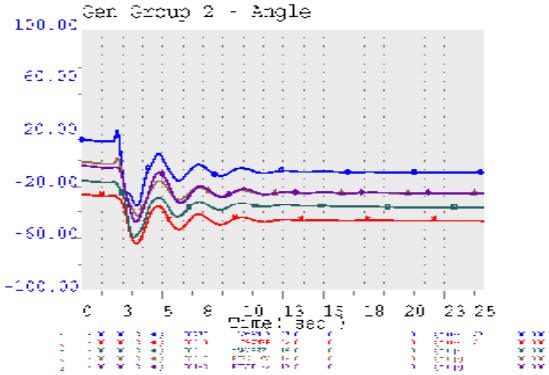

2020 FALL DISIS PH2
GI-2020-12
GI-2020-13
GI-2020-14
GI-2020-15

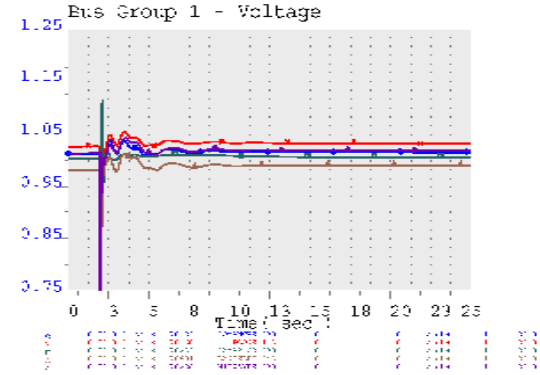


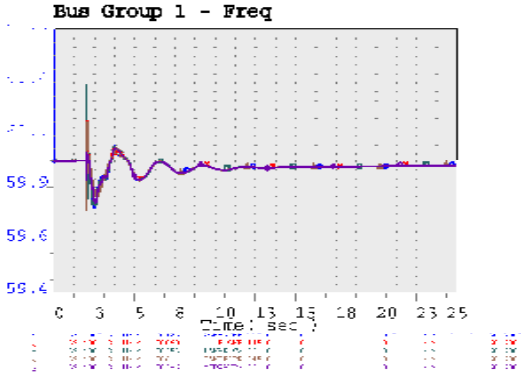

2020 FALL DISIS PH2
GI-2020-12
GI-2020-13
GI-2020-14
GI-2020-15

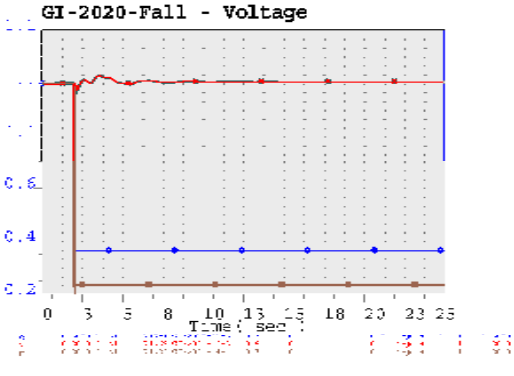


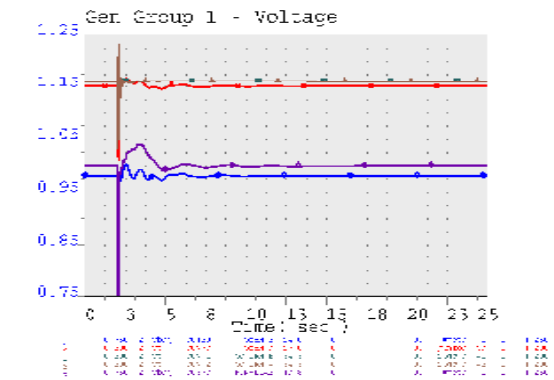



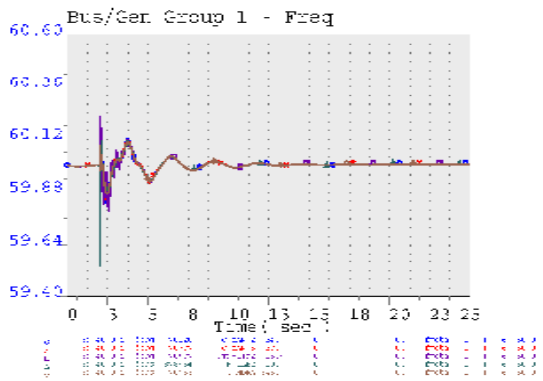



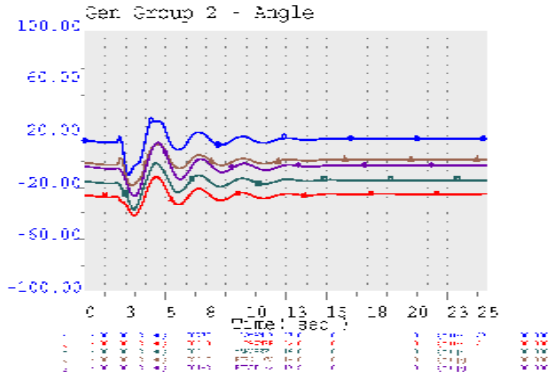



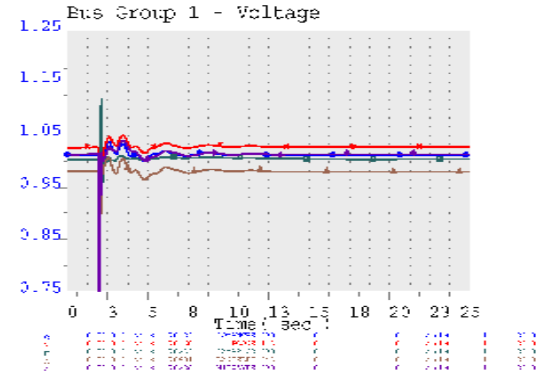



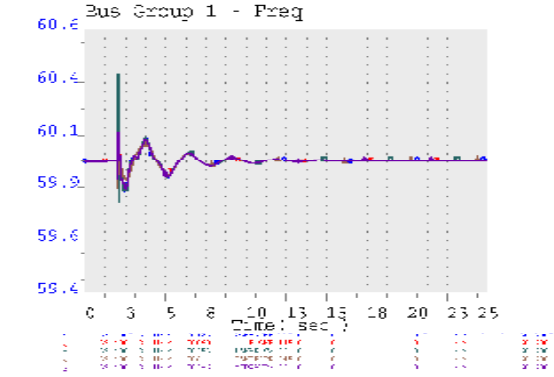

2020 FALL DISIS PH2
GI-2020-12
GI-2020-13
GI-2020-14
GI-2020-15

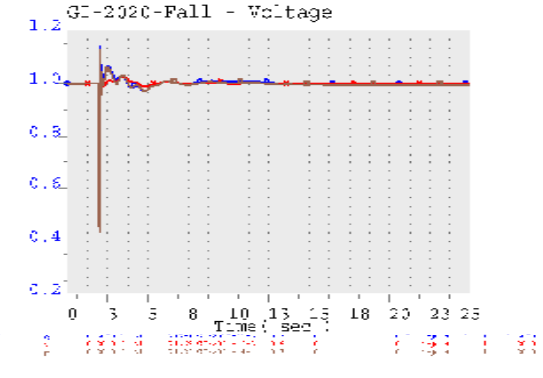


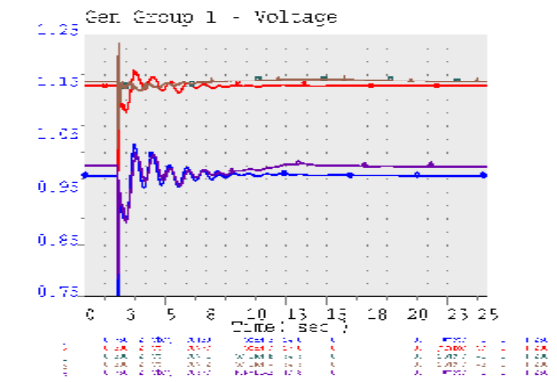



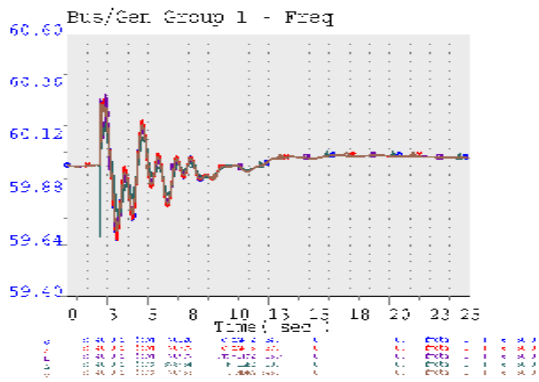



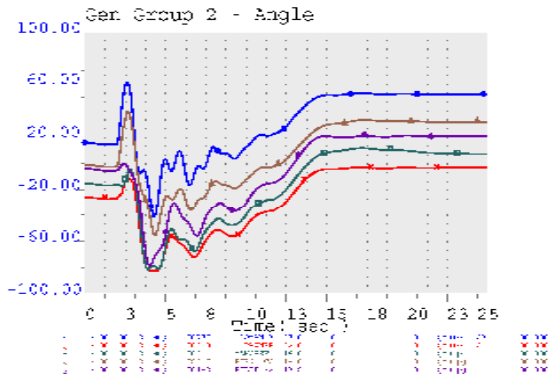



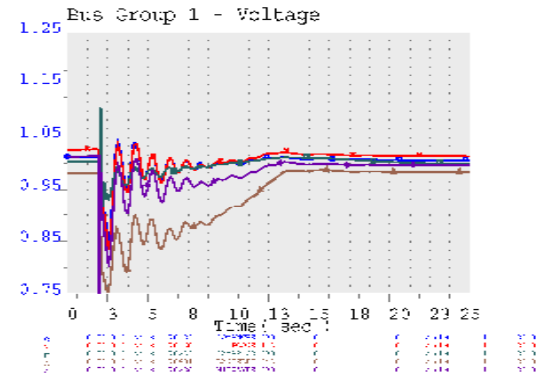



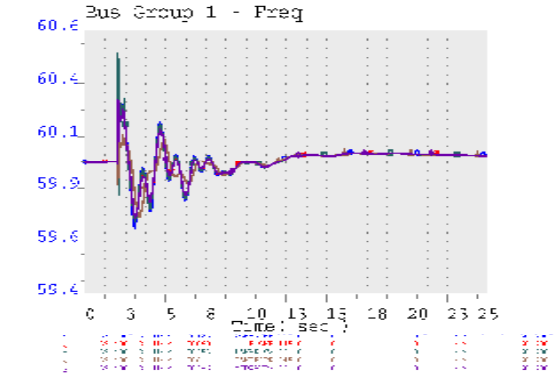

2020 FALL DISIS PH2
GI-2020-12
GI-2020-13
GI-2020-14
GI-2020-15

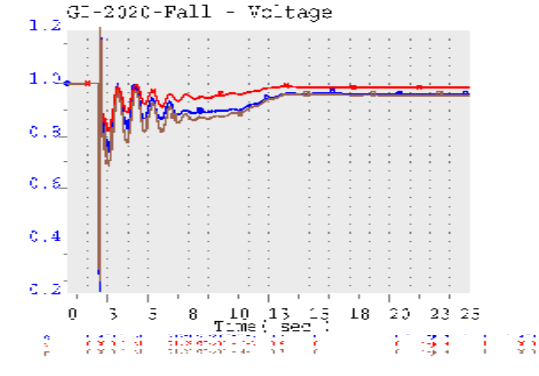


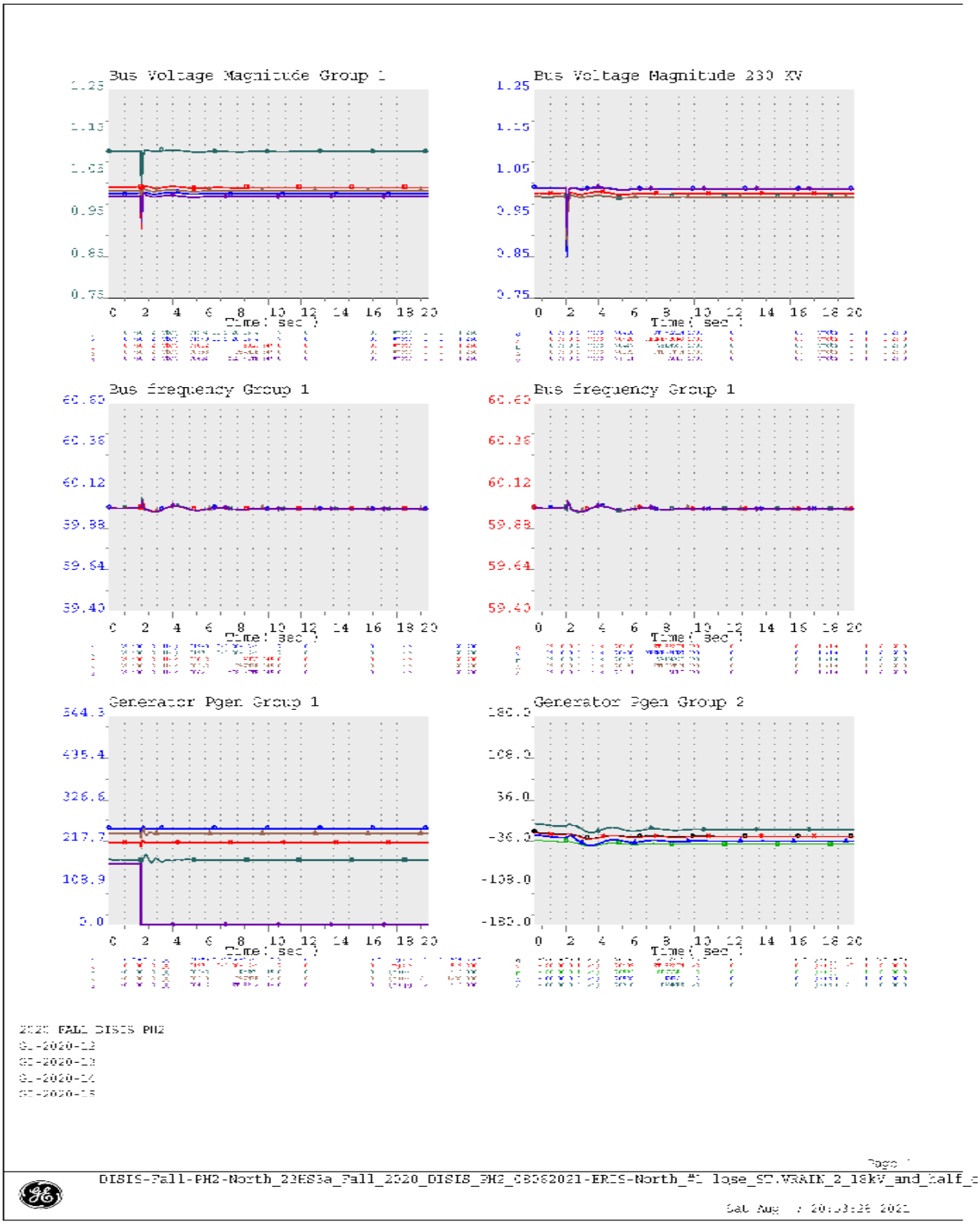



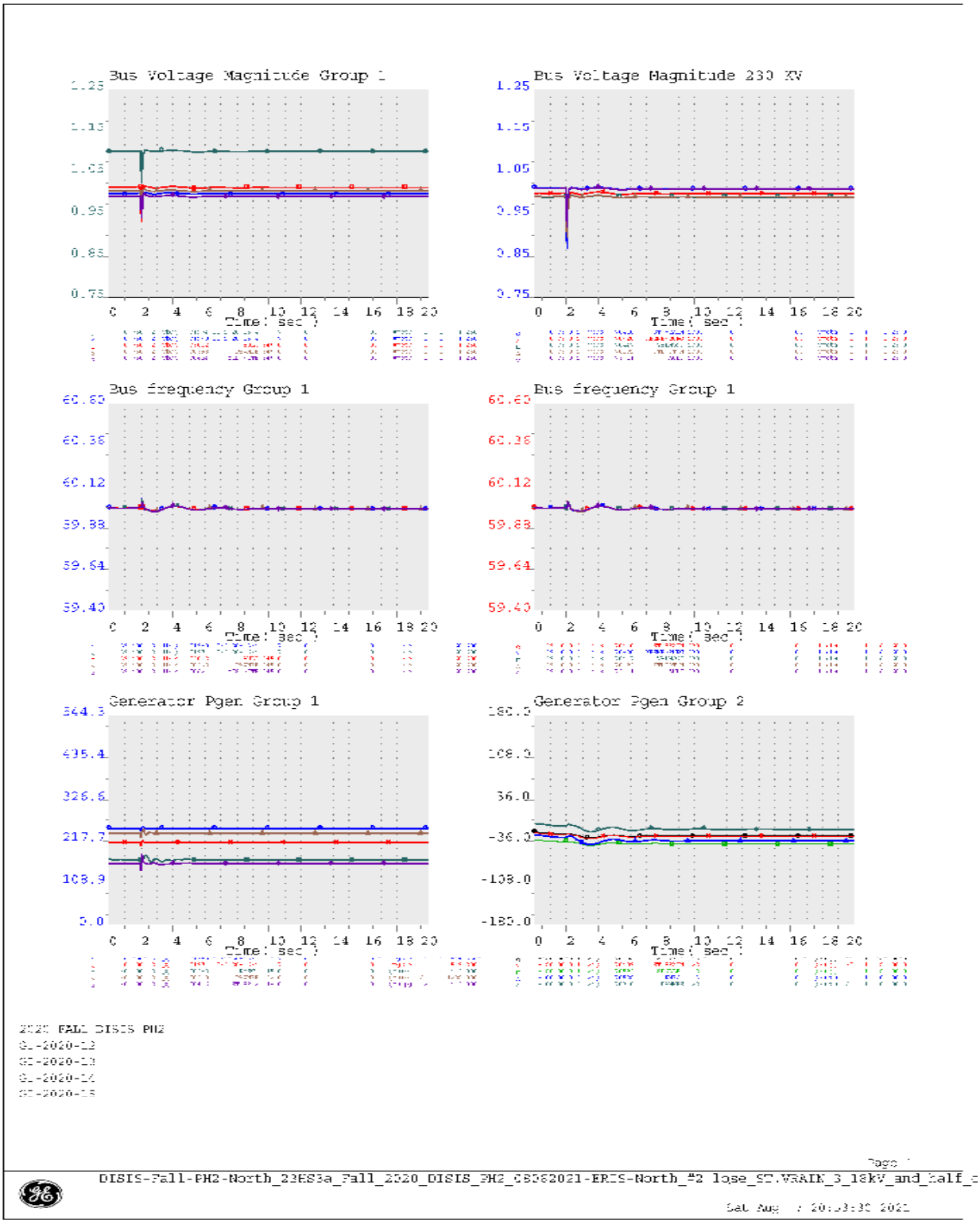



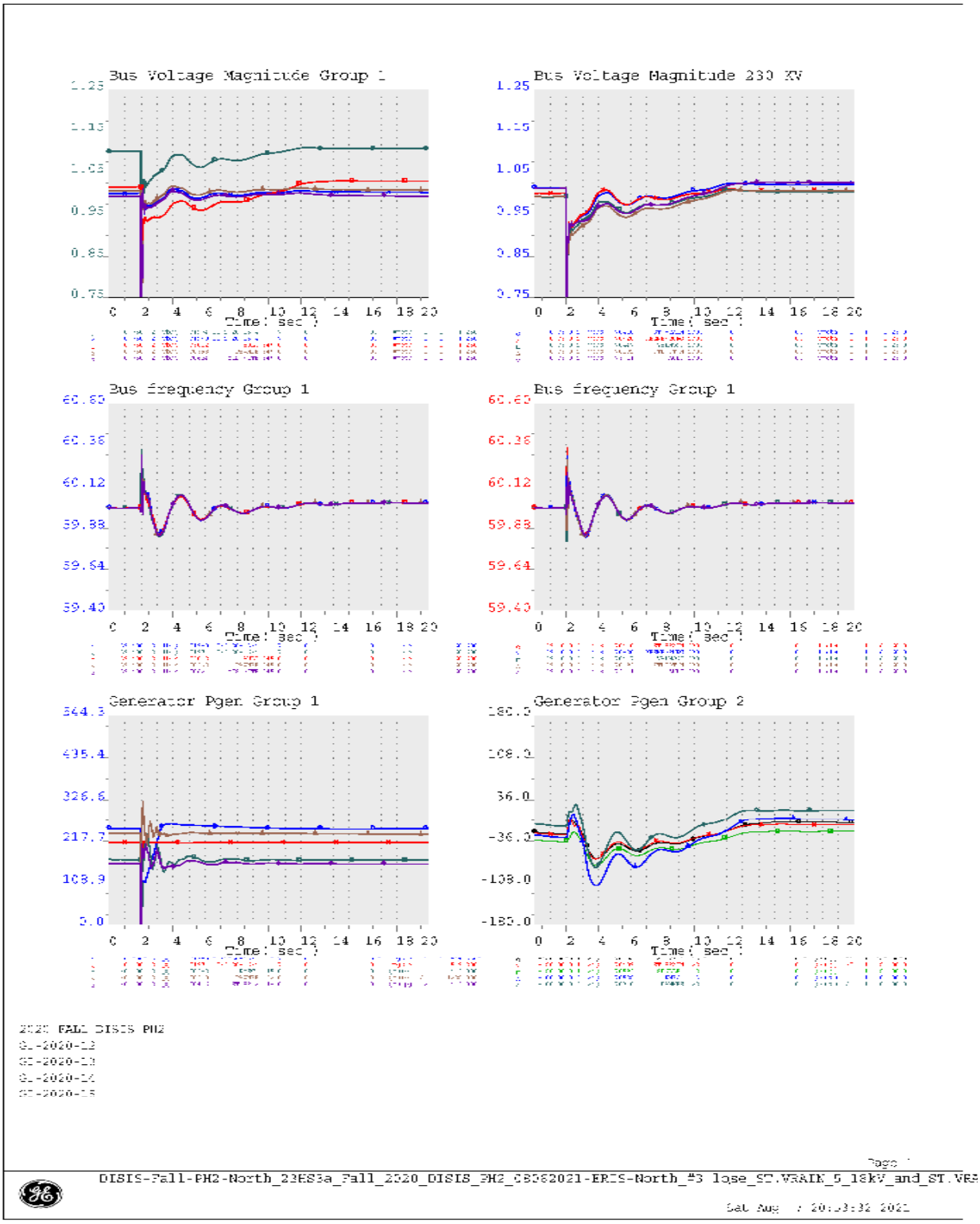



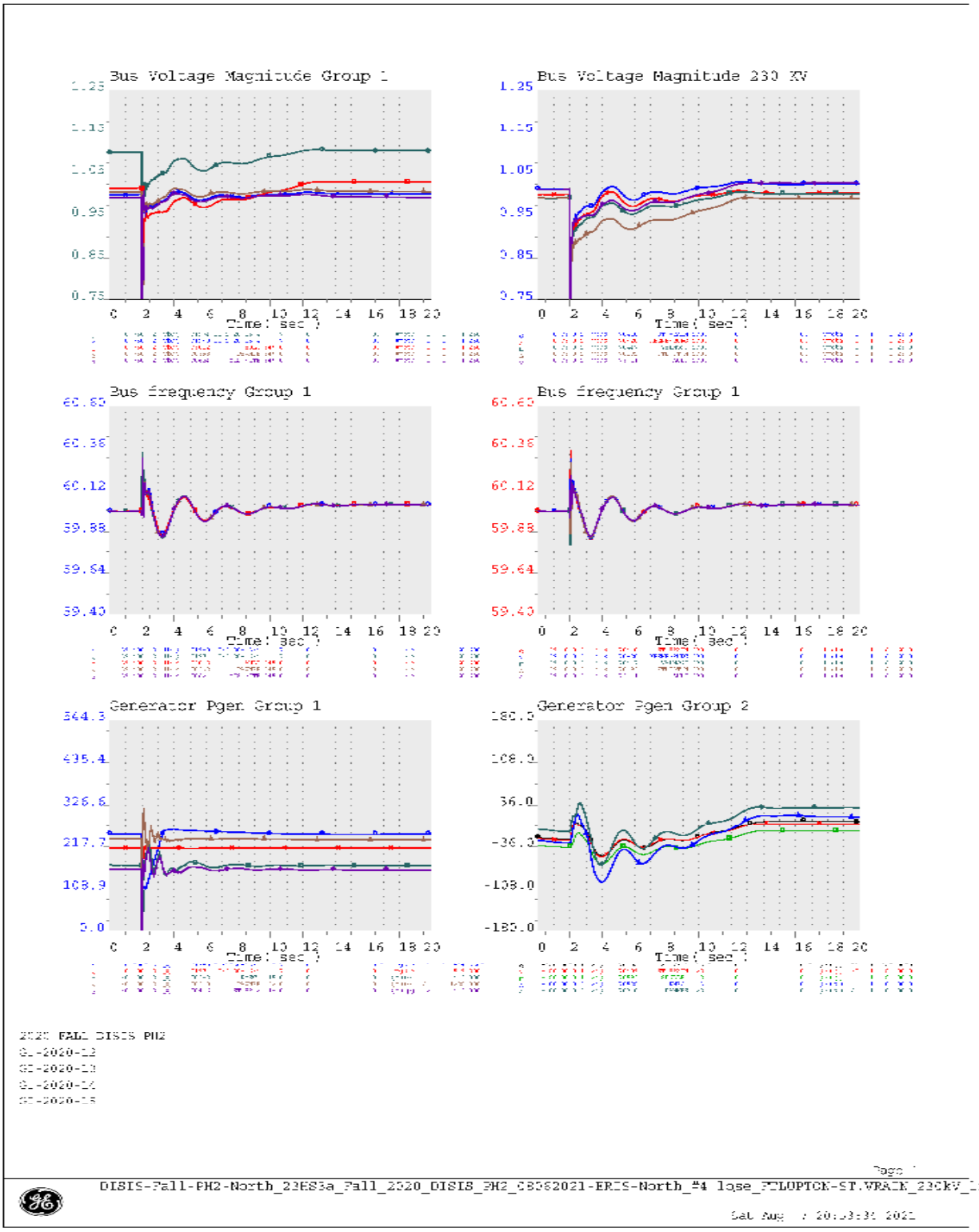

2020 FALL DISIS PH2
GI-2020-12
GI-2020-13
GI-2020-14
GI-2020-15

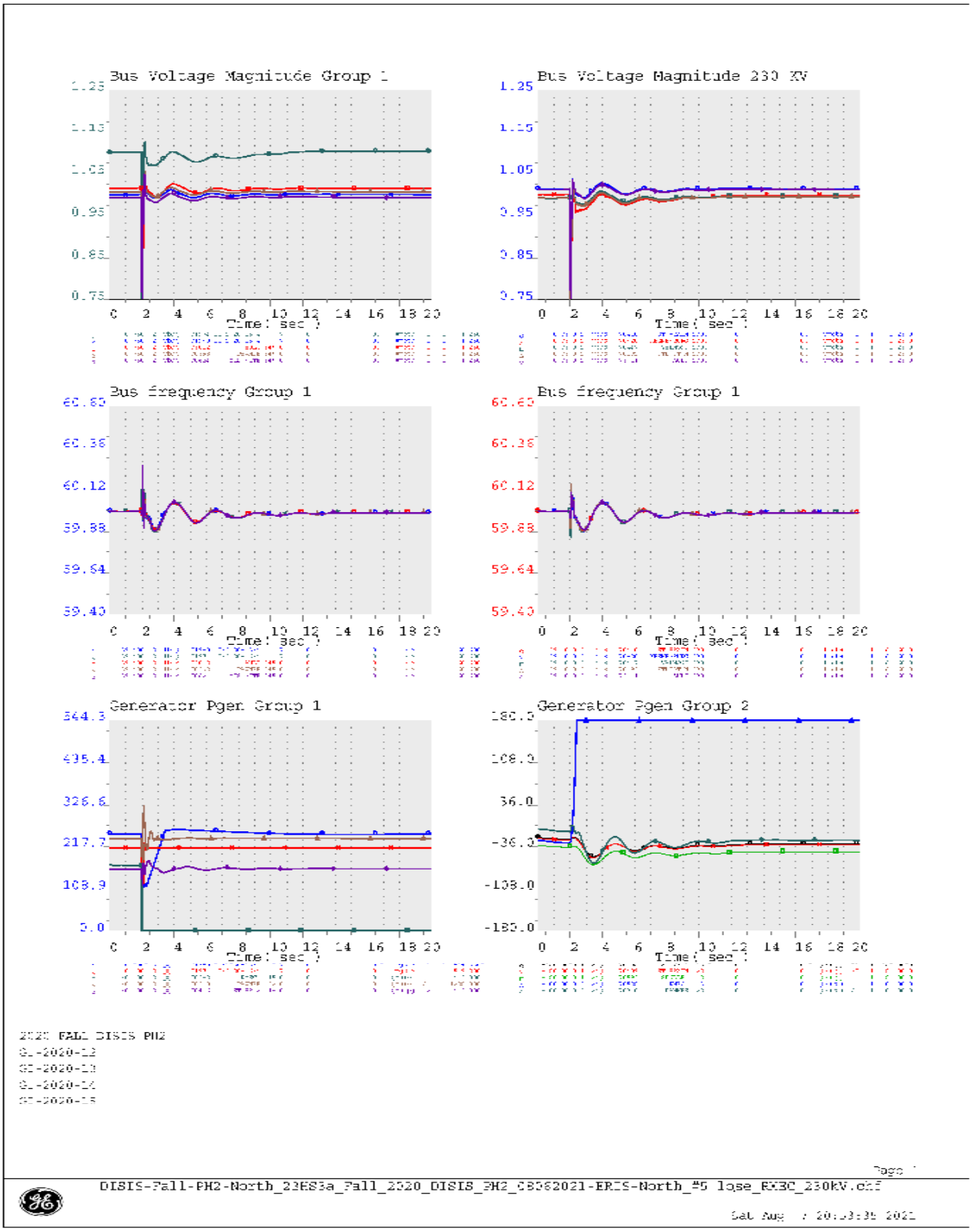
## 9.1 Northern Pocket (GI-2020-15 and GI-2020-16)

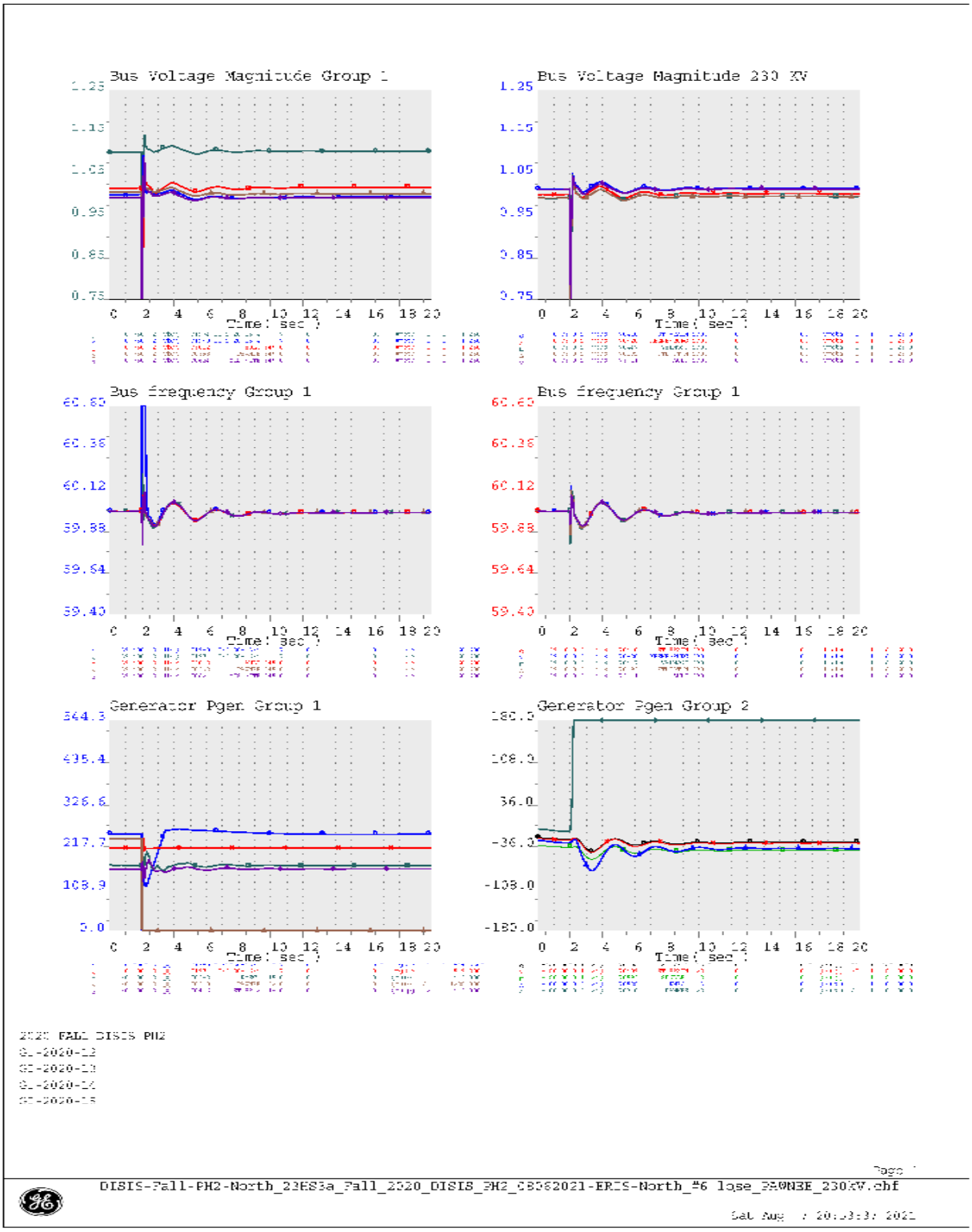


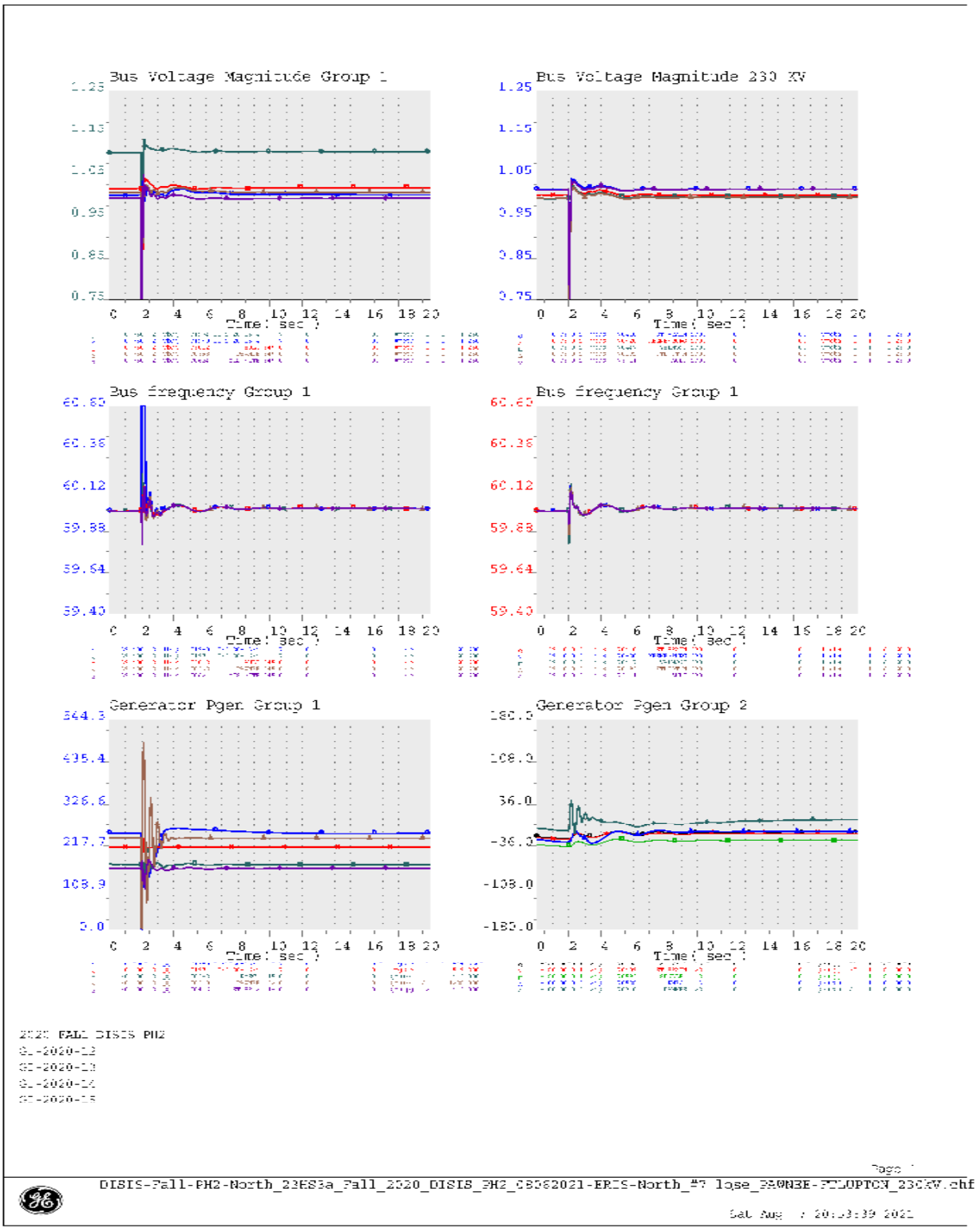

Bus Voltage Magnitude Group 1
Bus Voltage Magnitude 230 KV
Bus Frequency Group 1
Bus Frequency Group 1
Generator Pgen Group 1
Generator Pgen Group 2
Time ( sec )
2020 FALL DISIS PH2
DISIS-Fall-PH2-North_23ES3a_Fall_2020_DISIS_PH2_08062021-ERIS-North_#2 lose_SC.WRAIN_3_18kV_and_half_c

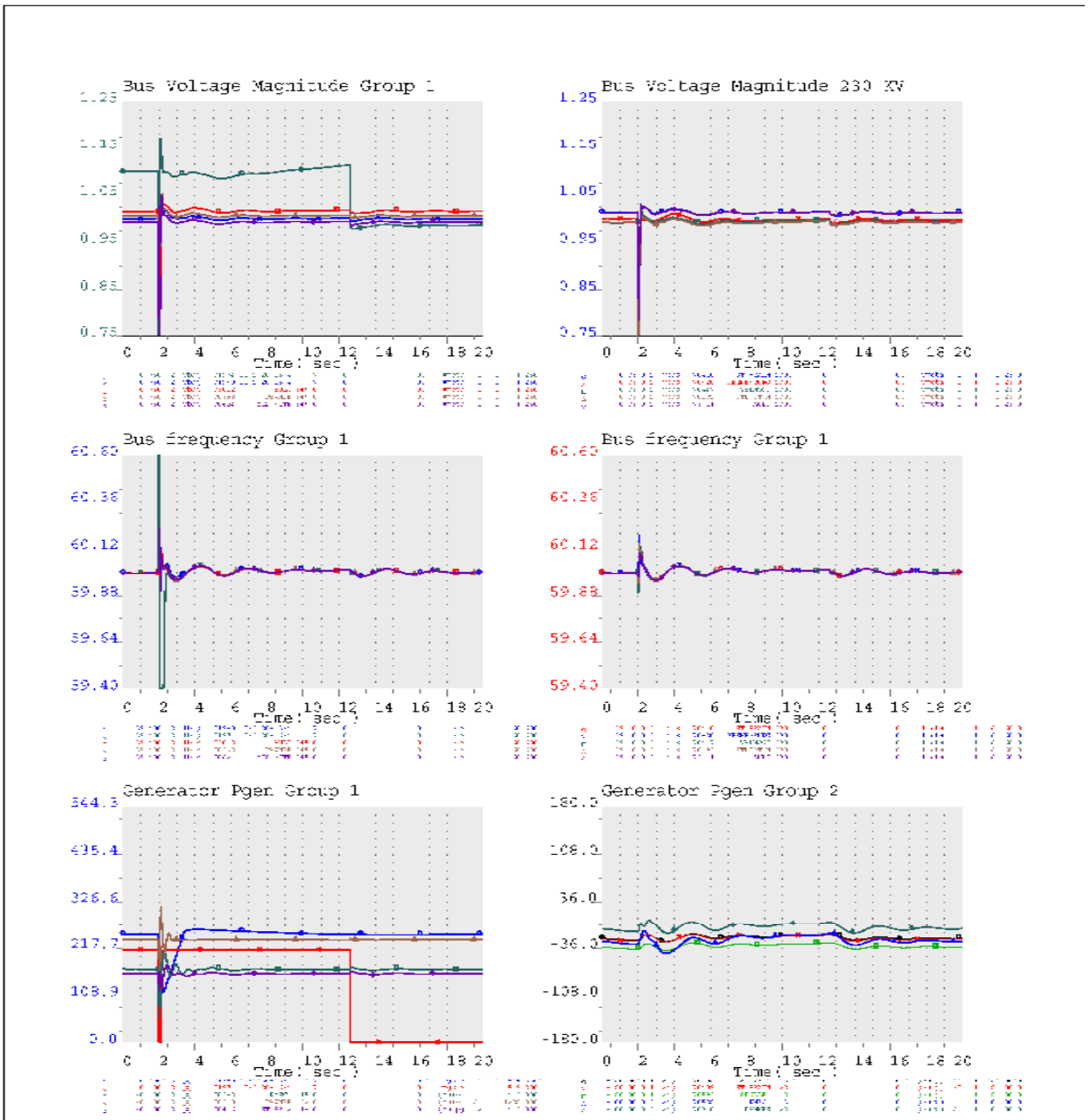

Bus Voltage Magnitude Group 1
Bus Voltage Magnitude 230 KV
Bus Frequency Group 1
Bus Frequency Group 1
Generator Pgen Group 1
Generator Pgen Group 2
Time ( sec )
DISIS-Fall-PH2-North_23ES3a_Fall_2020_DISIS_PH2_08062021-ERIS-North_#3 lose_SC.VRAIK_5_18kV_and_ST.VRA


Bus Voltage Magnitude Group 1
Bus Voltage Magnitude 230 KV
Bus Frequency Group 1
Bus Frequency Group 1
Generator Pgen Group 1
Generator Pgen Group 2
Time ( sec )
DISIS-Fall-PH2-North_23ES3a_Fall_2020_DISIS_PH2_08062021-ERIS-North_#4 lose_FCLOPTCN-ST.WRACK_230kV_1


Bus Voltage Magnitude Group 1
Bus Voltage Magnitude 230 KV
Bus Frequency Group 1
Bus Frequency Group 1
Generator Pgen Group 1
Generator Pgen Group 2
Time ( sec )
DISIS-Fall-PH2-North_23ES3a_Fall_2020_DISIS_PH2_08062021-ERIS-North_#5 lose_RX3C_230kV.chf


Bus Voltage Magnitude Group 1
Bus Voltage Magnitude 230 KV
Bus Frequency Group 1
Bus Frequency Group 1
Generator Pgen Group 1
Generator Pgen Group 2
Time ( sec )
DISIS-Fall-PH2-North_23ES3a_Fall_2020_DISIS_PH2_08062021-ERIS-North_#6 lose_550N3E_230kV.chf


Bus Voltage Magnitude Group 1
Bus Voltage Magnitude 230 KV
Bus Frequency Group 1
Bus Frequency Group 1
Generator Pgen Group 1
Generator Pgen Group 2
Time ( sec )
DISIS-Fall-PH2-North_23ES3a_Fall_2020_DISIS_PH2_08062021-ERIS-North_#7 lose_550N3E-FCLOPTCN_230kV.chf



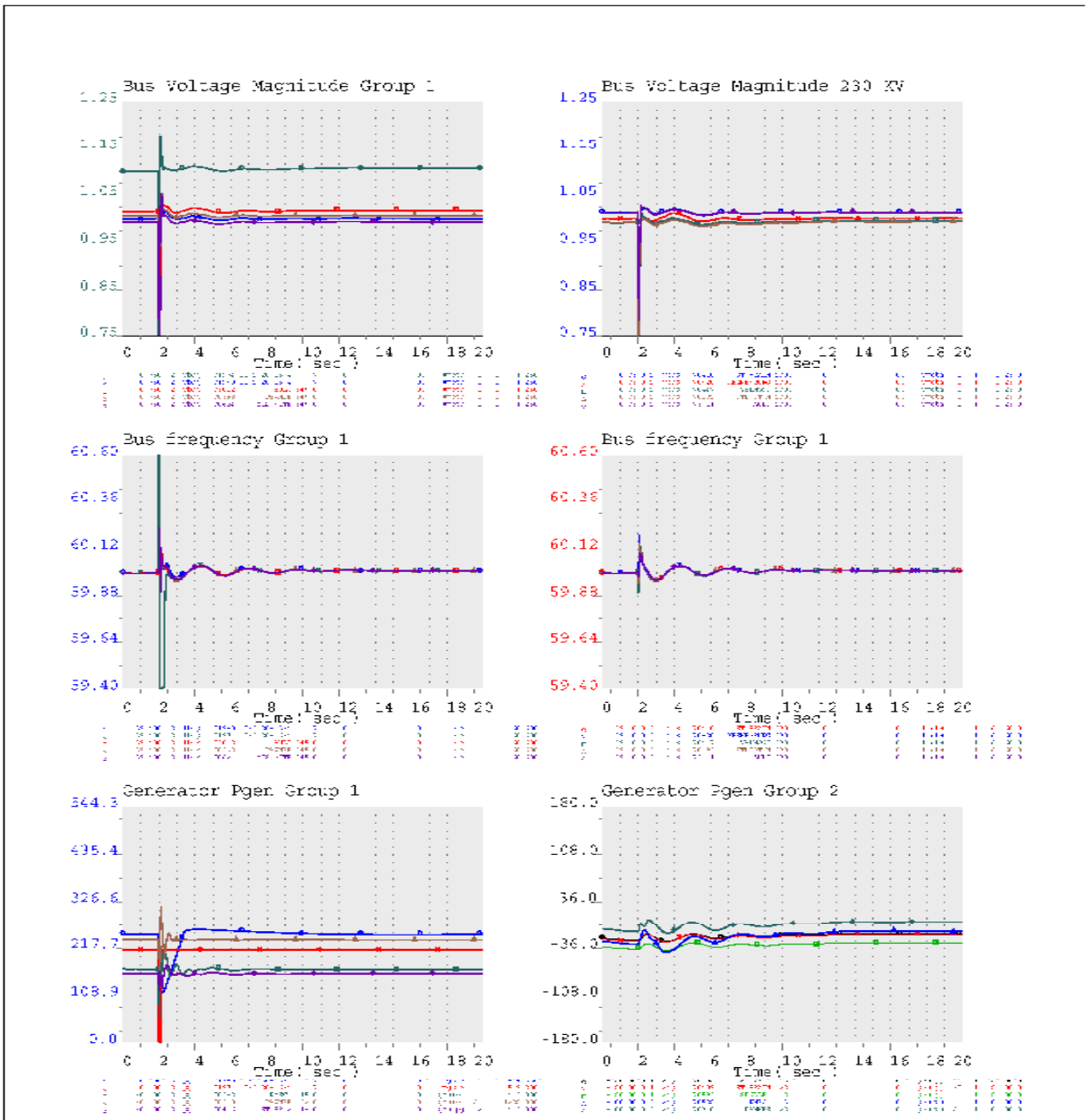

2020 FALL DISIS PH2

G1-2020-12

G1-2020-13

G1-2020-14

G1-2020-15


Bus Voltage Magnitude Group 1
Bus Voltage Magnitude 230 KV
Bus Frequency Group 1
Bus Frequency Group 1
Generator Pgen Group 1
Generator Pgen Group 2
Time ( sec )
DISIS-Fall-PH2-North_23ES3a_Fall_2020_DISIS_PH2_08062021-ERIS-North_#8 lose_BARRLAKE-R3ONICK_230kV.chf