GENERATOR INTERCONNECTION

SYSTEM IMPACT STUDY REPORT

for integration of the proposed

30 MW [redacted] PROJECT

IPC PROJECT QUEUE #556

to the

IDAHO POWER COMPANY TRANSMISSION SYSTEM

for

[redacted]

REPORT v.0

May 28, 2020

Revision History

Date	Revision	Initials	Summary of Changes
5/28/2020	0	MDH	SISR GI #556 – Original issue.

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1.0 Introduction

[redacted] has contracted with Idaho Power Company ("Transmission Provider") to perform a Generator Interconnection System Impact Study for the integration of the proposed 30 MW [redacted] photovoltaic (PV) and battery energy storage system (BESS) Project (the Project). The Project is to be located near [redacted] in Grant County, Oregon (See Figure 1 Location of [redacted] Project in Appendix B). The project latitude and longitude coordinates are approximately [redacted]° N [redacted]° W. The Project is Generation Interconnect queue number 556 (GI #556).

The Project has applied to connect to the Idaho Power Company's (IPC's) transmission system for an injection of 30 MW at a single Point of Interconnection (POI) at 138kV. The POI is on IPC's [redacted] section of the [redacted] 138kV line approximately [redacted] miles from IPC's [redacted] station and approximately [redacted] miles from Oregon Trail Electric Cooperative's (OTEC's)/IPC's [redacted] station.

This report documents the basis for and the results of this System Impact Study for the GI #556 Generation Interconnection Customer. The report describes the proposed project, the determination of project interconnection requirements, and estimated costs for integration of the Project to the Idaho Power System. This report satisfies the system impact study requirements of the Idaho Power Tariff.

2.0 Summary

The interconnection of the 30 MW [redacted] PV/BESS Project to IPC's [redacted] section of the [redacted] 138kV line was evaluated. The 138kV POI evaluated is approximately located at [redacted]° N [redacted]° W.

The GI #556 request is a combined PV and BESS project. It has been assumed the BESS will be charged via the PV output. [redacted] will need to demonstrate the operating procedures and control measures which prevents the BESS from being charged via IPC's transmission system. However, if the intent is also to be able to charge the BESS via IPC's transmission system, [redacted] will need to make an IPC Large Load Service request.

The Project will be required to control voltage in accordance with a voltage schedule as provided by Idaho Power Grid Operations. Therefore, GI #556 will be required to install a plant controller for managing the real and reactive power output of the 30 MW inverter array at the project POI. Also, the installation of phasor measurement unit devices (PMU's) at the POI and the maintenance costs associated with communication circuits needed to stream PMU data will be required to be provided to interconnect GI #556.

It is the generation project's responsibility to provide reactive power capability of the project to have a power factor operating range of at least 0.95 leading (absorbing) to at least 0.95 lagging (supplying) at the POI over the range of real power output (up to maximum output of the project.

The Project's proposed 138/34.5kV GSU transformer does **not** meet Idaho Power's transmission interconnection grounding requirements for system protection which requires a ground source on the high-side of the transformer. This can be typically achieved with an auto-transformer with a delta tertiary which is a source of ground current, (other configurations can and do exist to provide the required ground current source).

After performing the Transient Stability Analysis, the open-ending [redacted] 138kV line at [redacted] without tripping GI_556 generation results in an unacceptable unstable oscillatory state after a few seconds. When the GI #556 Project is left radial on the very weak 138/115kV transmission system with the other BPA's PV plants connected on the Harney-Brasada 115kV line, it eventually finds a state where it oscillates against these other plants. Thus, the [redacted] 103A Open-Breaker Transfer-Trip scheme will now be required to be a fully redundant Remedial Action Scheme (RAS) with redundant communication to securely and reliably trip GI #556 because failure to trip GI #556 results in unacceptable performance. And, ultimately the [redacted] 103A Open-Breaker GI #556 Trip RAS will need to be approved by the WECC Remedial Action Scheme Reliability Subcommittee.

A Network Resource Transmission Service analysis was performed. It was determined the Total East of Brownlee transmission path has enough Available Transmission Capacity (ATC) to accommodate delivering the 30 MW [redacted] Project Network Resource to Network Load in the Treasure Valley. For planned/forced outages on the IPC transmission facilities east of the Quartz 230/138kV station, pre-contingency generation curtailment in the Quartz area, including the GI #556 Project will be required. However, it may be beneficial to expand the scope of the [redacted] 103A Open-Breaker Transfer-Trip RAS for facilities out-of-service to automatically trip GI #556 upon loss of the next facility. The expansion of the [redacted] 103A Open-Breaker Transfer-Trip RAS scope to include facilities out-of-service can be addressed in the Facility Study.

The total preliminary cost estimate to interconnect the 30 MW [redacted] Project to the [redacted]-[redacted] section of the [redacted] 138kV line is $4,512,211, (See Table 1 Conceptual-Level Cost Estimate for GI #556) and includes the following tasks:

- New GI #556 138kV Generation Interconnection Station.
- New [redacted] 138kV Line Terminal.
- [redacted] 103A Open-Breaker GI #556 Trip RAS.

The cost estimate includes direct equipment and installation labor costs, indirect labor costs and general overheads. The estimate does include a contingency allowance. These are cost estimates only and final charges to the customer will be based on the actual construction costs incurred. It should be noted that the preliminary cost estimate of $4,512,211 does not include the cost of the customer's owned equipment to construct the PV/BESS generation site or required communication circuits.

Bonneville Power Administration (BPA) has proposed generation projects prior to the Project which have requested to be interconnected to BPA's Brasada-Harney 115kV line and in the Harney Electric Cooperative (HEC) area. For this system impact study, a minimum of 115 MW of project generation was assumed to be interconnected to the BPA 115kV transmission system prior to the Project. The resolution of BPA's generation requests in this area has not been finalized and any forthcoming material changes may result in the System Impact Study for this project to be re-evaluated and potentially re-studied.

Idaho Power transmission system upgrades might be required for projects ahead in the queue of this project, GI #556. In the scenario that a project(s) in the queue prior to this project withdraws or falls out of the queue, the system impact study for this project will need to be re-evaluated and potentially re-studied. This may result in required additional system upgrades for GI #556.

3.0 Scope of Interconnection System Impact Study

The Interconnection System Impact Study was done and prepared in accordance with Idaho Power Company Standard Generator Interconnection Procedures to provide a preliminary evaluation of the system impact of the interconnection of the proposed generating project to the Idaho Power system. As listed in the Interconnection System Impact Study agreement, the Interconnection System Impact Study report provides the following information:

- preliminary identification of any circuit breaker short circuit capability limits exceeded because of the interconnection;
- preliminary identification of any thermal overload, voltage limit violations, or transient stability issues resulting from the interconnection;
- an analysis to verify adequate transmission capacity is available to accommodate the requested Network Transmission service by Idaho Power's Load Serving Operations (LSO) for the integration of this generation project and if necessary, determine the required Network Upgrades to the transmission system to provide the requested Network Transmission Service.; and
- preliminary description and non-binding estimated cost of facilities required to interconnect the Large Generating Facility to the IPC system and to address the identified short circuit, power flow and transient stability issues, and Network Transmission Service requirements.

All other proposed generation projects prior to the Project in IPC's and Bonneville Power Administration's (BPA's) Generator Interconnect queues were considered in this study. A current list of IPC's projects can be found in the Generation Interconnection folder located on the Idaho Power web site at the link shown below:

http://www.oatioasis.com/ipco/index.html.

BPA's proposed generation projects considered in this study are addressed in the Section 5.0 Contingent Facilities.

4.0 Affected Parties

The Oregon Trail Electric Cooperative (OTEC) and Bonneville Power Administration (BPA) are affected parties to this generation interconnection request and will be provided copies of the System Impact Study report.

5.0 Contingent Projects/Facilities

The ~263-mile transmission system/network which the Project requests to interconnect to consists of the following facilities:

Quartz-West John Day-Hines 138kV line (133.5 miles IPC/OTEC)
Hines-Harney 115kV (3.4 miles IPC)
Hines 138/115kV 48/64/80 MVA auto-transformer (IPC – upgraded spring of 2020)
Brasada-Harney 115kV line (~113 miles BPA)
Redmond-Brasada (~13 miles BPA)

This transmission system/network is jointly owned by IPC, OTEC, and BPA with an interconnection tie-line between IPC and BPA at BPA's Harney 115kV station.

BPA's proposed generation projects prior to the Project which have requested to be interconnected to BPA's Brasada-Harney 115kV line and in the Harney Electric Cooperative (HEC) area that were considered in the Study:

G0520 (20 MW)
G0522 (20 MW)
G0525 (20 MW)
G0536 (20 MW)
G0537 (20 MW)
G0538 (20 MW)
G0592 (40 MW)

The sum of the projects (160 MW) requesting to interconnect with BPA exceeds the thermal capability of the Brasada-Harney 115kV and Redmond-Brasada 115kV lines which will require upgrading ~126 miles of 115kV transmission line which for all practicality makes the G0592 40 MW project unfeasible. The first four projects have proceeded to construction with the first two to be completed by the end of 2019, the third by the end of 2020, and finally the fourth by the of 2021. However, the four projects will be restricted to the 75 MW of firm transmission service acquired/granted by BPA. So, for this System Impact Study, a minimum of 115 MW of project generation was assumed to be interconnected to the BPA 115kV transmission system prior to the Project. The resolution of BPA's generation requests in this area has not been finalized and any forthcoming material changes may result in the System Impact Study for this project to be re-evaluated and potentially re-studied.

BPA's contingent facilities beyond the initial four projects:

- Upgrade the Redmond-Brasada 115kV line to 100° C thermal capability
- For loss of BPA's Redmond-Brasada 115kV line, a generation tripping Remedial Action Scheme (RAS) to protect the Hines 138/115kV transformer from thermal overload, and the IPC/OTEC 138kV transmission system from voltage instability.

Idaho Power transmission system upgrades might be required for projects ahead in the queue of this project, GI #556. The system upgrades assigned to projects ahead of GI #556 will be modeled in this System Impact Study for GI #556. In the scenario that a project(s) in the queue prior to this project withdraws or falls out of the queue, the system impact study for this project will need to be re-evaluated and potentially re-studied. This may result in required additional system upgrades for GI #556.

6.0 Description of Proposed Generating Project

The proposed [redacted] Project, GI #556, consists of a combined 30 MW PV/BESS plant which requested to be connected to IPC's [redacted] section of the [redacted] 138kV line at the approximate coordinate location of [redacted]° N [redacted]° W. The Project's Commercial Operation Date (COD) is November 30, 2021.

The Project's supplied single line drawing shows the project using eleven 3,150 kVA (at 45 deg C) SUNGROW SG3150OU inverters. The eleven inverters will be connected to 3.150 MVA transformers to step-up the voltage from 630 V to 34.5kV. The eleven transformers will be connected to the Transmission Provider's transmission system via a GSU 34.5/138kV transformer with a 24/32/40 MVA capacity.

All generation in voltage regulation (reactive capability used to regulate 138kV bus voltage – supply/absorb reactive).

7.0 Description of Substation Facilities

The interconnection of GI #556, to the [redacted] 138kV line will require the installation of an additional 138kV circuit breaker to alleviate protective relaying issues. The [redacted] 138kV line is already a three-terminal line. It is Idaho Power's policy to not allow another tap on this line and create a four-terminal line due to technical protective relaying issues. From a transmission system perspective, it was determined the best location, for this additional 138kV sectionalizing breaker, would be to install it on the west-side of [redacted] looking toward [redacted]. Thus, breaking the existing [redacted] 138kV line into a [redacted] 138kV line and a [redacted] 138kV line. Loss of the [redacted] 138kV line leaves the [redacted] and GI # 556 stations connected to the Idaho Power's [redacted] station. Corollary, the loss of [redacted] 138kV line including the [redacted] load taps does not strand the [redacted] station on a ~ 200^{+}-mile radial line from Redmond, OR.

At the proposed GI #556 POI, Idaho Power will construct a single 138kV breaker generation integration station tapping the [redacted] line section and creating the previously discussed [redacted] 138kV line.

8.0 Description of Transmission Facilities

The Project's impact on the Idaho-Northwest transmission path (WECC Path #14) and Brownlee East transmission path (WECC Path #55) were evaluated in this Generation System Impact Study. The Idaho-Northwest transmission path was studied at both its West-to-East 1200 MW and East-to-West rated transfer capabilities. The Brownlee East transmission path was studied at its 1915 MW rated West-to-East transfer capability.

The Idaho-Northwest transmission path (WECC Path #14) is defined as the sum of the flows on the following five lines:

- Oxbow-Lolo 230kV
- Hells Canyon-Hurricane 230kV
- North Powder-La Grande 230kV
- Hines-Harney 115kV
- Hemingway-Summer Lake 500kV

The Brownlee East transmission path (WECC Path #55) is defined as the sum of the flows on the following seven lines:

- Brownlee-Boise Bench #1 230kV
- Brownlee-Boise Bench #2 230kV
- Brownlee-Boise Bench #3 230kV
- Brownlee-Horse Flat #4 230kV
- Brownlee-Ontario 230kV
- Oxbow-Starkey 138kV
- Quartz-Ontario 138kV

For this generation interconnection System Impact Study, the flow on the Path 14 Idaho-Northwest transmission path was modeled at 1200 MW West-to-East and the Brownlee East transmission path was modeled at 1915 MW West-to-East. The paths were stressed to these specific levels to determine if the addition of the Project's 30 MW degraded the existing Brownlee East path's transfer capability.

And, a Path 14 Idaho-Northwest study was performed to determine the Project's 30 MW potential impact on Path 14 Idaho-Northwest West-to-East rating of 1200 MW.

In addition to the Path 55 Brownlee East and Path 14 Idaho-Northwest West-to-East transmission paths studies, a Path 14 East-to-West sensitivity study was performed to determine the Project's 30 MW potential impact on Path 14 Idaho-Northwest East-to-West rating of 2400 MW.

9.0 Description of Power Flow Cases

For this Generation Interconnection System Impact Study, four sets of power flow cases (without and with the Project) were used to evaluate the potential impacts due to the 30 MW [redacted] Project, GI #556.

For the Path 14 Idaho-Northwest West-to-East 1200 MW transfer path rating impact study due to the addition of the Project, the WECC 2019 Heavy Summer case was chosen as the power flow base case. These cases were modified to stress the Idaho-Northwest transmission path West-to-East flows to 1200 MW simultaneous with other transmission paths in the Northwest at or near their respective maximum transfer capacity ratings to determine the potential impact due to the addition of the 30 MW Project.

The second set of cases were a modified set of the Path 14 Idaho-Northwest West-to-East transfer path rating impact study. These cases were modified to represent spring (late March to early May) load condition in the local area (between Baker to Redmond) prior to air condition and irrigation load. These cases were used to evaluate the impact of the 30 MW Project in the local area system during minimum load shoulder months conditions (non-summer and non-winter).

For the third set of cases the WECC 2019 Heavy Summer case was again chosen as the power flow base case for the Brownlee East 1915 MW transfer path rating impact study. Path 14 Idaho-Northwest transmission path was modeled at 1200 MW West-to-East and the Brownlee East transmission path was modeled at 1915 MW West-to-East. The paths were stressed to these specific levels to determine if the addition of the Project's 30 MW degraded the existing Brownlee East path's transfer capability.

The fourth and final set of cases used an older Idaho-Northwest East-to-West 2400 MW power flow study case, which was developed from the WECC 2015 Light Summer base case, to determine the Project's 30 MW potential impact on Path 14 Idaho-Northwest East-to-West rating of 2400 MW.

9.1 Power Flow Analysis Results

Results from the Path 14 Idaho-Northwest West-to-East 1200 MW "Spring" transfer path rating impact study case indicate the addition of the GI #556 project will result in potentially unacceptable performance on the BPA's 115kV transmission system.

1. The Quartz 138kV Bus Differential (Open-ends [redacted] 138kV line – NERC TPL-001-4 P2-1)
    a. This contingency results in a post-transient voltage dip of 8.29% (0.918 p.u. absolute voltage) at BPA's Hampton 115kV load bus.

With light spring loads (≤ 20 MW) modeled at the HEC and OTEC load busses, open-ending the [redacted] 138kV line at [redacted] without tripping GI_556 generation is approaching voltage instability in the BPA 115kV transmission system. Even though the condition resulted in a stable operating point when tested with 5% greater generation in the area (Hampton 115kV load bus voltage dip 9.66% (0.9025 p.u. absolute voltage)), it is an operating point which would be unacceptable to operate at for any length of time. Therefore, it is recommended a [redacted] 103A (breaker at [redacted] on the [redacted] 138kV line) Open-Breaker GI #556 Trip RAS be implemented to trip GI #556 (GI #556 Breaker 101A) to move to a more stable operating point in a timely manner.

And, given this result, GI #556 generation may have to be curtailed to 0 MW even if the [redacted] section is restored after the loss of the [redacted] 138kV because of the lack of remaining capacity on the BPA 115kV transmission system to wheel the generation back to the Idaho Power transmission system.

9.2 Transient Stability Analysis Results

For the Generation Interconnection System Impact Study, the Path 14 Idaho-Northwest West-to-East transfer path rating case that was modified to represent spring (late March to early May) load condition in the local area (between Baker to Redmond) prior to air condition and irrigation load with the 30 MW Project was used for the transient stability analysis. This case was used to evaluate the impact of the 30 MW Project in the local area system during minimum load shoulder months conditions (non-summer and non-winter). With the lower loads in conjunction with the local generation at maximum, this load/generation pattern should produce the most meaningful transient stability results.

For the GI #556 30 MW [redacted] Project, the following dynamic data was provided by [redacted] which was modified to match bus number/name in power flow case:

```
#
# [New LGI GI #556 SUNGROW SG3150U 11 X 3.150 MVA]
#
regc_a  60443 "GI_556     "  0.63 "1 ": #9 mva=34.65 "lvplsw" 0.0 "rrpwr" 10.00 /
 "brkpt" 0.900 "zerox" 0.500 "lvpl1" 1.10 "vtmax" 1.100 "lvpnt1" 0.900 "lvpnt0" 0.030 /
 "qmin" -1.00 "accel" 1.0 "tg" 0.020 "tfltr" 0.02 "iqrmax" 99.0 "iqrmin" -99.0 "xe" 0.0
reec_a  60443 "GI_556     "  0.63 "1 ": #9 "mvab" 0.0 "vdip" 0.90 "vup" 1.10 "trv" 0.02 /
 "dbd1" -0.05 "dbd2" 0.05 "kqv" 2.0 "iqh1" 1.00 "iql1" -1.00 "vref0" 1.00 "iqfrz" 0.0 "thld" 0.0 /
 "thld2" 0.0 "tp" 0.02 "qmax" 0.60 "qmin" -0.60 "vmax" 1.10 "vmin" 0.9 "kqp" 1.00 "kqi" 5.00 /
 "kvp" 1.00 "kvi" 3.00 "vref1" 0.0 "tiq" 0.02 "dpmax" 999.0 "dpmin" -999.0 "pmax" 1.0 /
 "pmin" 0.0 "imax" 1.0 "tpord" 0.10 "pfflag" 0.0 "vflag" 1.0 "qflag" 1.0 "pflag" 0.0 /
 "pqflag" 0.0 "vq1" 0.2 "iq1" 1.0 "vq2" 0.4 "iq2" 1.0 "vq3" 0.6 "iq3" 1.0 "vq4" 0.8 "iq4" 1.0 /
 "vp1" 0.2 "ip1" 1.0 "vp2" 0.4 "ip2" 1.0 "vp3" 0.6 "ip3" 1.0 "vp4" 0.8 "ip4" 1.0
repc_a  60443 "GI_556     " 0.63 "1 " 60441 "GI_556     " 34.50 : #9 "mvab" 0.0 "tfltr" 0.05 /
 "kp" 11.00 "ki" 3.00 "tft" 0.00 "tfv" 0.05 "refflg" 1.0 "vfrz" 0.90 "rc" 0.00 "xc" 0.00 "kc" 0.00 /
 "vcmpflg" 1.0 "emax" 0.05 "emin" -0.05 "dbd" 0.00 "qmax" 0.6 "qmin" -0.6 "kpg" 0.50 /
 "kig" 0.25 "tp" 0.25 "fdbd1" -0.0006 "fdbd2" 0.0006 "femax" 999.0 "femin" -999.0 /
 "pmax" 1.00 "pmin" 0.00 "tlag" 0.700 "ddn" 20.00 "dup" 20.00 "frqflg" 0.0 "outflag" 0.0
lhvrt   60443 "GI_556     "  0.63 "1 ": #9 "vref" 1.00 /
"dvtrp1" 0.30 "dvtrp2" 0.20 "dvtrp3" 0.10 "dvtrp4" -0.50 "dvtrp5" -0.30 "dvtrp6" -0.12 /
"dvtrp7" 0.00 "dvtrp8" 0.00 "dvtrp9" 0.00 "dvtrp10" 0.00 /
"dttrp1" 0.05 "dttrp2" 0.15 "dttrp3" 10.0 "dttrp4" 1.00 "dttrp5" 10.0 "dttrp6" 20.0 /
"dttrp7" 0.00 "dttrp8" 0.00 "dttrp9" 0.00 "dttrp10" 0.00 /
"alarm" 0.0
lhfrt   60443 "GI_556     "  0.63 "1 ": #9 "fref" 60.00 /
"dftrp1" 2.0 "dftrp2" 0.70 "dftrp3" -3.0 "dftrp4" -1.7 "dftrp5" 0.0 "dftrp6" 0.0 /
"dftrp7" 0.0 "dftrp8" 0.0 "dftrp9" 0.0 "dftrp10" 0.0 /
"dttrp1" 0.5 "dttrp2" 600.0 "dttrp3" 0.5 "dttrp4" 600.0 "dttrp5" 0.0 "dttrp6" 0.0 /
"dttrp7" 0.0 "dttrp8" 0.0 "dttrp9" 0.0 "dttrp10" 0.0 /
"alarm" 0.0
```

GI #556 [redacted] Dynamic Data

Due to the power flow analysis results which recommended tripping GI #556 for the [redacted] 103A open-breaker outages, the initial transient stability analysis investigated the failure of tripping GI #556 when required. To remove spurious results due to close in faults with renewable dynamic models, which have been observed in other transient stability studies, the transient stability analysis for failure to trip GI #556 for [redacted] 103A open-breaker conditions only modeled opening [redacted] 103A with no fault. As can be seen by the two transient stability plots below, the open-ending [redacted] 138kV line at [redacted] ([redacted] 103A breaker) without/failed tripping GI_556 generation resulted in an unacceptable unstable oscillatory state after a few seconds until GI #556 was tripped. Two additional transient stability studies/runs with reduced voltage/reactive gains in the reec_a and repc_a models were performed and their transient stability results have been included APPENDIX C – Additional Failed to Trip Transient Stability Results. Both studies also resulted in an unacceptable unstable oscillatory state after a few seconds, but slightly delayed due to the reduced voltage/reactive gains, until GI #556 was tripped.

When the GI #556 Project is left radial on the very weak 138/115kV transmission system with the other BPA's PV plants connected on the Harney-Brasada 115kV line, it eventually finds a state where it oscillates against these other plants. Due to these results, the [redacted] 103A Open-Breaker Transfer-Trip scheme will now be required to be a fully redundant Remedial Action Scheme (RAS) with redundant communication to securely and reliably trip GI #556 because failure to trip GI #556 results in unacceptable performance.

Western Electric Coordinating Council (WECC) requires RAS's to have no single point of failure including communication paths. The WECC Remedial Action Scheme Reliability Subcommittee (RASRS) has given preliminary guidance that utilizing multi-phase power line carrier (PLC) equipment on the [redacted] line segment for redundant communication is acceptable because loss of the line along with both communication circuits also results in tripping the GI #556 Project. Thus, eliminating the possibility the GI #556 Project is on-line when both communication circuits are unavailable. The [redacted] 103A Open-Breaker GI #556 Trip RAS cost estimates assumes using multi-phase PLC equipment. And, ultimately the [redacted] 103A Open-Breaker GI #556 Trip RAS will need to be approved by the WECC RASRS.

REDACTED

Original GI #556 Gains:

Reec_a:	kqp= 1.00	kqi= 5.00	kvp= 1.00	kvi= 3.00
Repc_a:	kp= 11.0	ki= 3.00		

REDACTED

Original GI #556 Gains:

Reec_a:	kqp= 1.00	kqi= 5.00	kvp= 1.00	kvi= 3.00
Repc_a:	kp= 11.0	ki= 3.00		

For the Transient Stability Analysis with GI #556 30 MW [redacted] [redacted] Project, the following eleven outages starting in BPA's 115kV transmission system at Redmond, Oregon and ending in IPCo's 138kV transmission system at Ontario, Oregon were simulated/analyzed.

1. Loss of Redmond-Yew Ave-Brasada 115kV w/BPA RAS
2. Loss of Brasada-HBPASOL2 115kV
3. Loss of Harney-HBPASOL2 115kV
4. Loss of Hines-Harney 115kV
5. Hines 138kV Bus Differential
6. Loss of W John Day-Hines 138kV
7. Loss of [redacted] 138kV
8. Quartz 138kV Bus Differential w/GI #556 RAS
9. Loss of Quartz-Nth Powder-Brownlee 230kV
10. Loss of Quartz-Nelson-Hgtn Wind 138kV
11. Loss of Hgtn Wind-Weiser-Ontario 138kV

Outage 4 – Loss of Hines-Harney 115kV when simulated with a Hines 115kV 3-phase fault (3ph) and Outage 5 – Hines 138kV Bus Differential when simulated with a Hines 138kV 3-phase fault had unacceptable voltage recovery in the BPA 115kV transmission system (See Appendix D-4.0 Loss of Hines-Harney 115kV (3ph) and D-5.0 Hines 138kV Bus Differential (3ph) Transient Stability Results). But when simulated with Single-Line-Ground (SLG) faults both outages had acceptable voltage recovery/performance (See Appendix D-4.1 Loss of Hines-Harney 115kV (SLG) and D-5.1 Hines 138kV Bus Differential (SLG) Transient Stability Results). When these two outages were investigated pre-project (without GI # 556 30 MW [redacted] [redacted] Project), the same issue/performance for 3-phase faults was observed and virtually identical performance was observed for SLG faults. The transient stability results for these two outages when simulated with 3-phase faults are skeptical because when they were simulated with SLG faults they had acceptable voltage recovery/performance

From the WECC Solar PV Plant Modeling and Validation Guideline Appendix 6.1 Short-Circuit Ratio Fundamentals, the transient results observed for 3-phase faults in and around the Harney 115kV bus indicate that this weak transmission system may have approached the validity of using the renewable generic models for at least 3-phase faults.

Short-Circuit Ratio (SCR):

$$P_{rated}\,(MW) \stackrel{\text{def}}{=} plant\ max\ MW\ output$$

$$SCR = \frac{SC_{sys}\,(MVA)}{P_{rated}\,(MW)}$$

Voltage on systems with low SCR (<3) are more sensitive to fluctuations in reactive power and tend to experience voltage stability problems including observed high dynamic over-voltage. The WECC renewable generic models are applicable for systems with a short circuit ratio of 3 and higher at the point of interconnection (POI) and are not intended to represent plants with very low short-circuit levels. And, the SCR as defined above cannot be easily applied to a situation when multiple plants are connected electrically close.

Except for the previous discussed two outages (loss of Hine-Harney 115kV and Hines 138kV Bus Differential), all the other outages were simulated with 3-phase faults and when appropriate with their respective RAS's. And, had acceptable transient stability results. When simulated with SLG faults, the other two outages (loss of Hine-Harney 115kV and Hines 138kV Bus Differential) also had acceptable transient stability performance.

10.0 Short Circuit Study Results

The short circuit/fault duty at the approximate GI #556 POI 138kV tap location (with/without GI #556 modeled) is as follows:

Location	SLG (A)	LTL (A)	3PH (A)
@Tap w/o GI #556	1539.4	1533.3	1768.6
@Tap w/ GI #556 Tap	2026.0	1690.1	1689.0

Fault Study (w/o GI #556)			
Location	SLG (A)	LTL (A)	3PH (A)
QUTZ	5666.6	4206.5	5178.6
HINE	1322.8	994.6	1147.8
WJDY	1533.0	1379.9	1590.9

Fault Study (w/ GI #556)			
Location	SLG (A)	LTL (A)	3PH (A)
QUTZ	5688.6	4582.9	5505.4
HINE	1329.8	1106.3	1147.8
WJDY	2108.9	1726.7	1901.9

Studies indicate that there is adequate load and short circuit interrupting capability on the Transmission Provider's existing 138kV breakers after the project is interconnected.

The 138/34.5kV GSU transformer does **not** meet Idaho Power's transmission interconnection grounding requirements for system protection which requires a ground source on the high-side of the transformer. This can be typically achieved with an auto-transformer with a delta tertiary which is a source of ground current, (other configurations can and do exist). Refer to Appendix A, Section 3.0, for additional protection and grounding requirements.

11.0 Network Resource Transmission Service

A Network Resource Transmission Service analysis was performed. It was determined the Total East of Brownlee transmission path has enough Available Transmission Capacity (ATC) to accommodate delivering the 30 MW [redacted] Project Network Resource to Network Load in the Treasure Valley.

Besides the previously mentioned potential Project generation curtailment for the forced/planned outages of the [redacted] 138kV line section, the Project will be subjected to curtailments for planned outages in Idaho Power's transmission system beyond the Quartz 230/138kV station. The Quartz 230/138kV station is sourced/connected to the Idaho Power transmission system via the Brownlee-Quartz-North Powder 230kV line (~80 miles) / Quartz 230/138kV transformer and the Ontario-Huntington Wind-Quartz 138kV line (~70 miles). When a line segment/transformer of one of these facilities is planned/forced out-of-service, the loss of the other facility will strand too much generation toward Redmond, Oregon resulting in voltage/transient instability. Thus, necessitating pre-contingency generation curtailment in the Quartz area, including the GI #556 Project, after forced outages and before planned outages. For planned/forced outages on the IPC transmission facilities east of the Quartz 230/138kV station, it may be beneficial to expand the scope of the [redacted] 103A Open-Breaker Transfer-Trip RAS for facilities out-of-service to automatically trip GI #556 upon loss of the next facility.

12.0 Description of Required Facility Upgrades

The Project will be required to provide a plant controller that will operate the inverter system in Volt/VAr control mode. This is to regulate voltage according to a voltage schedule that will be provided by Idaho Power.

The following upgrades will be required to IPC-owned facilities to facilitate the interconnection of GI #556:

- GI #556 138kV Transmission Line Tap (138kV Line Tap, and two 138kV Air-Break Switches with Interrupters)
- GI #556 Generation Interconnection Station (Single 138kV Breaker/Line Terminal)
- [redacted] 138kV Line Terminals (Additional 138kV Sectionalizing Breaker/Line Terminals and [redacted] Terminal Upgrade)
- [redacted] 103A Open-Breaker GI #556 Trip RAS

See the conceptual-level cost estimate in Table 1.

Table 1 Conceptual-Level Cost Estimate for GI #556

GI #556 [redacted] 30 MW Project Network Resource Generation Interconnection Facilities	
	Cost
GI #556 138kV Transmission Line Tap	$237,800
GI #556 Generation Interconnection Station	$1,409,400

[redacted] 138kV Line Terminals (Including [redacted] Terminal Upgrade)	$1,168,400
[redacted] 103A Open-Breaker GI #556 Trip RAS (Incorporating multi-phase PLC equipment for communications)	$650,000
Subtotal	**$3,465,600**
Contingency (~20.0%) (1)	$693,120
Subtotal	**$4,158,720**
Overheads (~8.5%) (2)	$353,491
Network Resource Generation Interconnection Facilities Total Conceptual-level Cost Estimate in 2020 dollars (3)	**$4,512,211**

(1) Contingency is added to cover the unforeseen costs in the estimate. These costs can include unidentified design components, material cost increases, labor estimate shortfalls, etc.
(2) Overhead costs cover the indirect costs associated with the Project.
(3) This cost estimate includes direct equipment, material, labor, and overheads as shown.

- Note that these estimates do not include the cost of the customer's equipment/facilities or required communication circuits for SCADA, PMU, and metering.
- Note that the overhead rates are subject to change.
- These are estimated costs only and final charges to the customer will be based on the actual construction costs incurred.
- These are non-binding conceptual level cost estimates that will be further refined upon the request and completion of Transmission Facility Study.

The Transmission Provider estimates it will require approximately 36 months to design, procure, and construct the facilities described in this System Impact Report following the execution of Generation Interconnection Agreement. The schedule will be further developed and optimized during the Facility Study should the generation interconnection customer choose to move to that study phase of the interconnection process.

13.0 Description of Operating Requirements

It is the generation project's responsibility to provide reactive power capability of the project to have a power factor operating range of at least 0.95 leading (absorbing) to at least 0.95 lagging (supplying) at the POI over the range of real power output (up to maximum output of the project). Assuming inverters with a power factor operating range of 0.9 lagging (supplying) at maximum output, the 0.95 lagging (supplying) reactive power capability at the POI cannot be achieved without additional shunt reactive support. The 7 MVAr 34.5kV shunt capacitor indicated on the Project's supplied single line drawing will be more than enough to make-up the reactive power deficiency.

Because the Path 14 Idaho-Northwest transmission path is presently not a voltage-stability limited path, a voltage stability/reactive margin study was not performed because the size and location of the Project will have little impact to Path 14 Idaho-Northwest other than the local issues already identified.

The inverter(s) will be required to have the UL 1741SA certification prior to the installation and be approved by Idaho Power cybersecurity group.

The Project will be required to control voltage in accordance with a voltage schedule as provided by Idaho Power Grid Operations. Therefore, GI #556 will be required to install a plant controller for managing the real and reactive power output of the 30 MW inverter array at the project POI.

Voltage flicker at startup and during operation will be limited to less than 5% as measured at the POI. The allowable voltage flicker limit is further reduced during operation due to multiple voltage fluctuations per hour or minute, per Idaho Power's T&D Advisory Information Manual.

The Project is required to comply with the applicable voltage fluctuation limits found in IEEE Standard 1453-2004 *IEEE Recommended Practice for Measurement and Limits of Voltage Fluctuations and Associated Light Flicker on AC Power Systems.*

The project is required to comply with the applicable Voltage and Current Distortion Limits found in IEEE Standard 519-2014 *IEEE Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems.*

Installation of phasor measurement unit devices at the POI and maintenance costs associated with communication circuits needed to stream PMU data will also be required to be provided to interconnect GI #556. The specific costs associated with the IPC requirements for interconnection customers with aggregate facilities larger than 20 MW to provide PMU data to IPC will be identified in the Facility Study should the generation interconnection customer choose to proceed to that phase of the interconnection process.

14.0 Conclusion

The requested interconnection of the [redacted] Project, GI #556, to Idaho Power's [redacted] section of the [redacted] 138kV line was studied.

The results of this study work confirm that it is technically feasible to interconnect the 30 MW [redacted] Project, GI #556, to the Idaho Power transmission system with the identified Network Resource Generation Interconnection Facilities.

A Network Resource Transmission Service analysis was performed. It was determined the Total East of Brownlee transmission path has enough ATC to accommodate delivering the 30 MW [redacted] Project Network Resource to Network Load in the Treasure Valley.

All generation projects in the area ahead of the Project in IPC's/BPA's generation interconnection queue and their associated transmission system improvements were modeled in a power flow analysis to evaluate the technical feasibility of interconnecting GI #556. The results and conclusions of this System Impact Study are based on the realization of these projects in the unique queue/project order.

The estimated cost to interconnect GI #556 to the IPC system at the 138kV point of interconnection considered in this study is approximately $4,512,211.

APPENDIX A

A-1.0 Method of Study

The System Impact Study plan inserts the Project up to the maximum requested injection into the selected Western Electricity Coordinating Council (WECC) power flow case and then, using Power World Simulator or GE's Positive Sequence Load Flow (PSLF) analysis tool, examines the impacts of the new resource on Idaho Power's transmission system (lines, transformers, etc.) within the study area under various operating and outage scenarios. The WECC and Idaho Power reliability criteria and Idaho Power operating procedures were used to determine the acceptability of the configurations considered. The WECC case is a recent case modified to simulate stressed but reasonable pre-contingency energy transfers utilizing the IPC system. For distribution feeder analysis, Idaho Power utilizes DNV·GL's Synergi Electric software and EPRI's OpenDSS software.

A-2.0 Acceptability Criteria

The following acceptability criteria were used in the power flow analysis to determine under which system configuration modifications may be required:

> The continuous rating of equipment is assumed to be the normal thermal rating of the equipment. This rating will be as determined by the manufacturer of the equipment or as determined by Idaho Power. Less than or equal to 100% of continuous rating is acceptable.
>
> Idaho Power's Voltage Operating Guidelines were used to determine voltage requirements on the system. These states, in part, that distribution voltages, under normal operating conditions, are to be maintained within plus or minus 5% (0.05 per unit) of nominal everywhere on the feeder. Therefore, voltages greater than or equal to 0.95 pu voltage and less than or equal to 1.05 pu voltage are acceptable.
>
> Voltage flicker during starting or stopping the generator is limited to 5% as measured at the point of interconnection, per Idaho Power's T&D Advisory Information Manual.
>
> Idaho Power's Reliability Criteria for System Planning was used to determine proper transmission system operation.
>
> All customer generation must meet IEEE 519 and ANSI C84.1 Standards.
>
> All other applicable national and Idaho Power standards and prudent utility practices were used to determine the acceptability of the configurations considered.
>
> The stable operation of the system requires an adequate supply of volt-amperes reactive (VAr or VArs) to maintain a stable voltage profile under both steady-state and dynamic system conditions. An inadequate supply of VArs will result in voltage decay or even collapse under the worst conditions.

Equipment/line/path ratings used will be those that are in use at the time of the study or that are represented by IPC upgrade projects that are either currently under construction or whose budgets have been approved for construction in the near future. All other potential future ratings are outside the scope of this study. Future transmission changes may, however, affect current facility ratings used in the study.

A-3.0 Electrical System Protection Guidance

IPC requires electrical system protection per Facility Connection Requirements found on the Idaho Power Web site,

https://docs.idahopower.com/pdfs/BusinessToBusiness/FacConnReq.pdf

A-4.0 WECC Coordinated Off-Nominal Frequency Load Shedding and Restoration Requirements

IPC requires frequency operational limits to adhere to WECC Under-frequency and Over-frequency Limits per the WECC Coordinated Off-Nominal Frequency Load Shedding and Restoration Requirements available upon request.

APPENDIX B – GI #556 Project Location

B-1.0 GI #556 Project Site Location

REDACTED

Figure 1 Location of [redacted] Project – GI #556

APPENDIX C – Additional GI #556 Failed to Trip Transient Stability Results

REDACTED

Reduced GI #556 Gains:

Reec_a:	kqp= 1.00	kqi= 1.00	kvp= 1.00	kvi= 1.00
Repc_a:	kp= 5.50	ki= 1.50		

REDACTED

Reduced GI #556 Gains:

Reec_a:	kqp= 1.00	kqi= 1.00	kvp= 1.00	kvi= 1.00
Repc_a:	kp= 5.50	ki= 1.50		

C-1.0 Reduced Voltage Gains to ~ Half of Original Gains

REDACTED

Reduced #2 GI #556 Gains:

Reec_a:	kqp= 1.00	kqi= 1.00	kvp= 0.50	kvi= 0.50
Repc_a:	kp= 2.75	ki= 0.75		

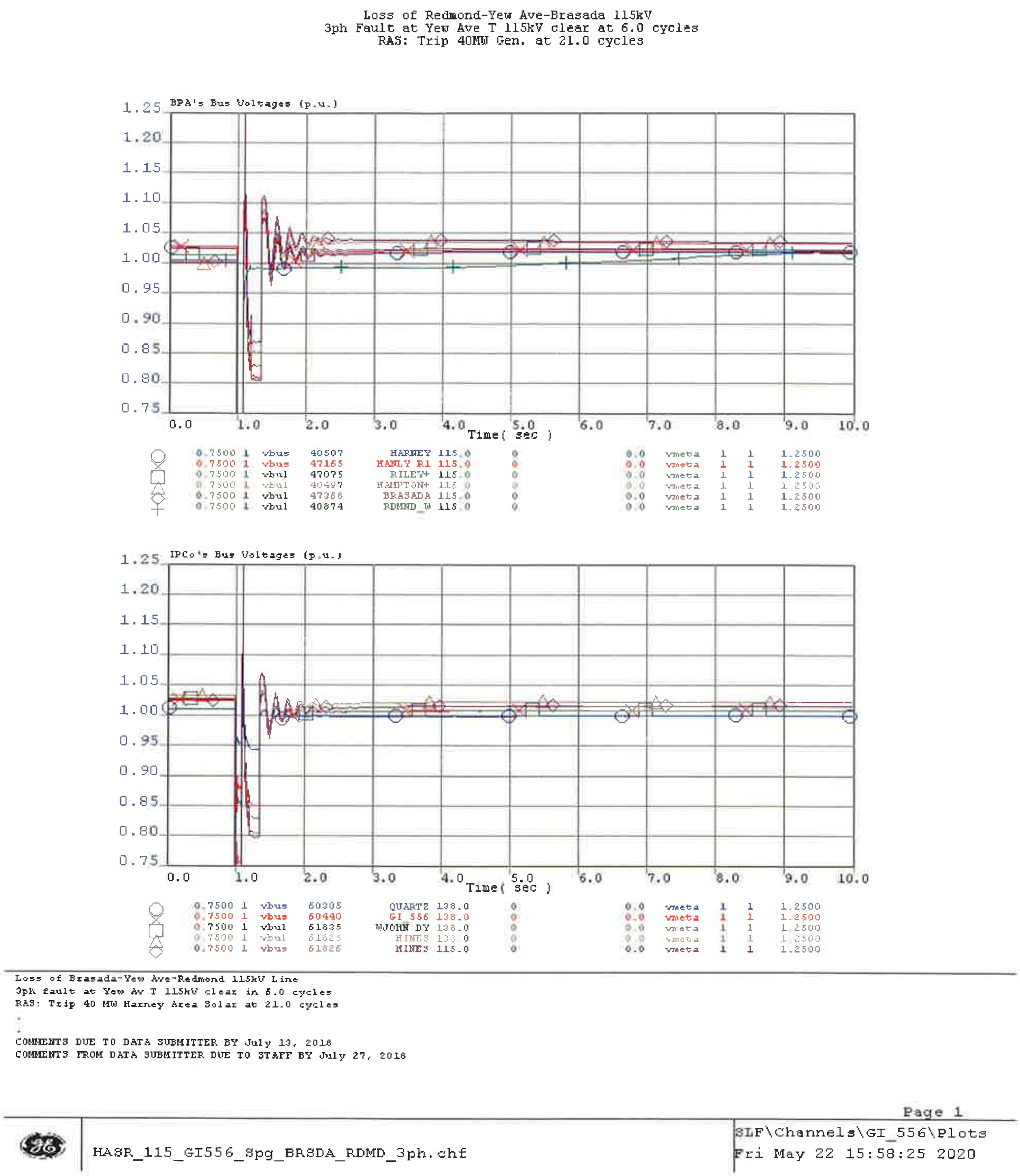
REDACTED

Reduced #2 GI #556 Gains:

Reec_a:	kqp= 1.00	kqi= 1.00	kvp= 0.50	kvi= 0.50
Repc_a:	kp= 2.75	ki= 0.75		

C-2.0 Reduced Voltage Gains to ~ Quarter of Original Gains

APPENDIX D – Transient Stability Results


Loss of Redmond-Yew Ave-Brasada 115kV
3ph Fault at Yew Ave T 115kV clear at 6.0 cycles
RAS: Trip 40MW Gen. at 21.0 cycles
BPA's Bus Voltages (p.u.)
1.25
1.20
1.15
1.10
1.05
1.00
0.95
0.90
0.85
0.80
0.75
0.0 1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0 9.0 10.0
Time(sec)
0.7500 1 vbus 40507 HARNEY 115.0 0 0.0 vmeta 1 1 1.2500
0.7500 1 vbus 47165 HANLY R1 115.0 0 0.0 vmeta 1 1 1.2500
0.7500 1 vbul 47075 RILEY+ 115.0 0 0.0 vmeta 1 1 1.2500
0.7500 1 vbul 40497 HAMPTON+ 115.0 0 0.0 vmeta 1 1 1.2500
0.7500 1 vbul 47366 BRASADA 115.0 0 0.0 vmeta 1 1 1.2500
0.7500 1 vbul 40874 RDMND_W 115.0 0 0.0 vmeta 1 1 1.2500
IPCo's Bus Voltages (p.u.)
1.25
1.20
1.15
1.10
1.05
1.00
0.95
0.90
0.85
0.80
0.75
0.0 1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0 9.0 10.0
Time(sec)
0.7500 1 vbus 60305 QUARTZ 138.0 0 0.0 vmeta 1 1 1.2500
0.7500 1 vbus 60440 GI 556 138.0 0 0.0 vmeta 1 1 1.2500
0.7500 1 vbul 61835 WJOHN DY 138.0 0 0.0 vmeta 1 1 1.2500
0.7500 1 vbul 61825 HINES 138.0 0 0.0 vmeta 1 1 1.2500
0.7500 1 vbus 61826 HINES 115.0 0 0.0 vmeta 1 1 1.2500
Loss of Brasada-Yew Ave-Redmond 115kV Line
3ph fault at Yew Av T 115kV clear in 6.0 cycles
RAS: Trip 40 MW Harney Area Solar at 21.0 cycles
COMMENTS DUE TO DATA SUBMITTER BY July 13, 2018
COMMENTS FROM DATA SUBMITTER DUE TO STAFF BY July 27, 2018
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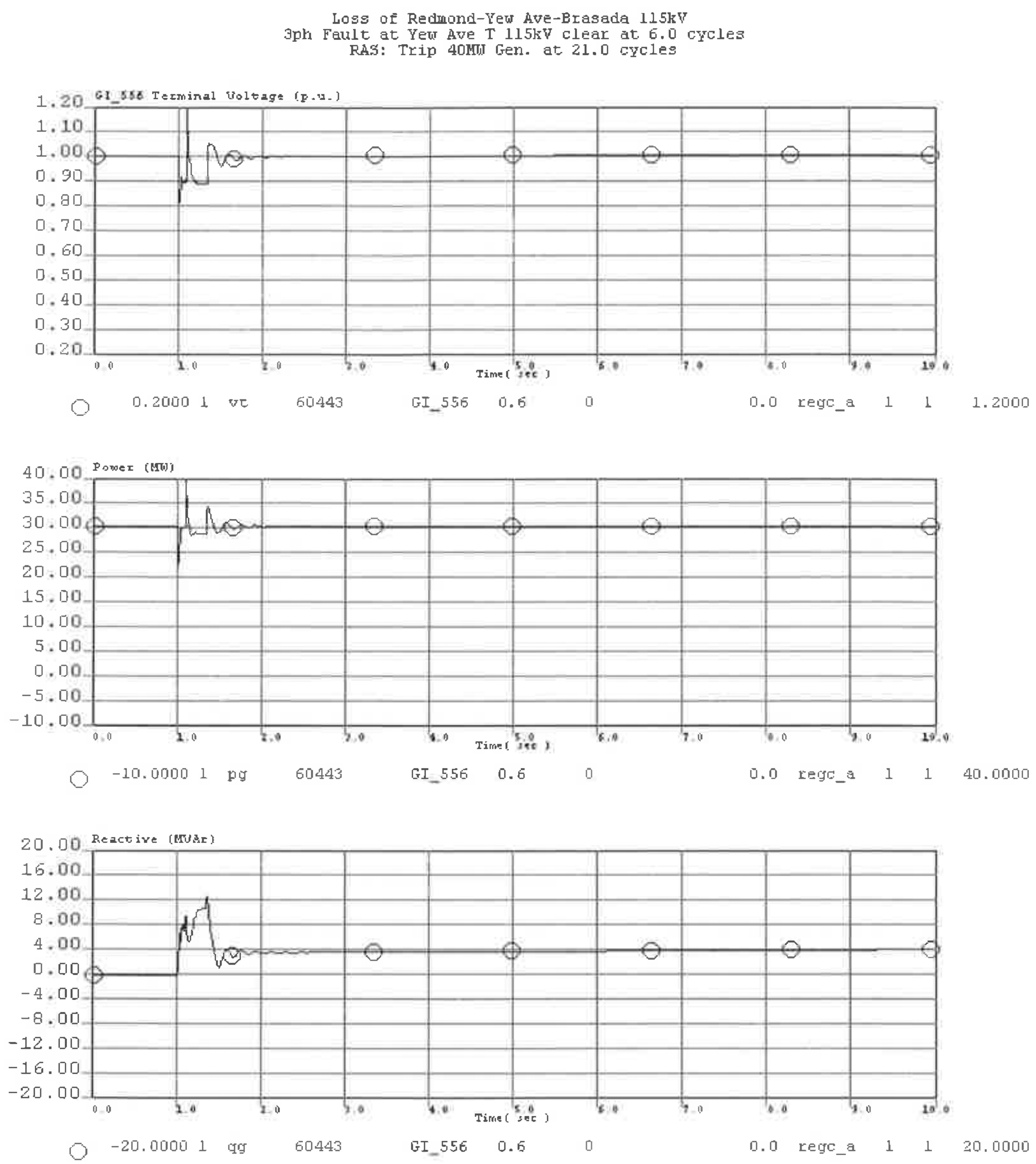

Loss of Brasada-Yew Ave-Redmond 115kV Line
3ph fault at Yew Av T 115kV clear in 6.0 cycles
RAS: Trip 40 MW Harney Area Solar at 21.0 cycles

Page 1

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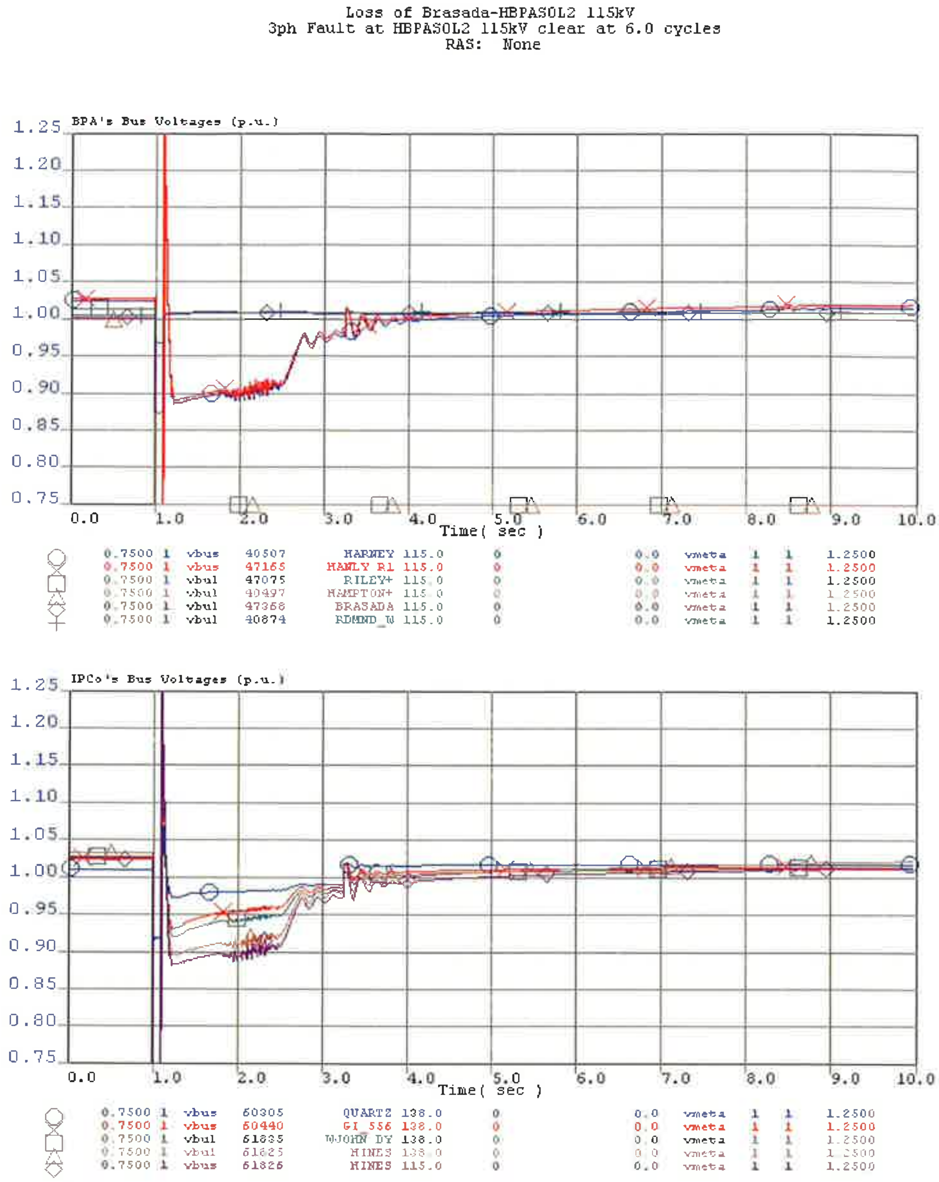
D-1.0 Loss of Redmond-Yew Ave-Brasada 115kV w/BPA RAS



Loss of Brasada-HBPASOL2 115kV Line
3ph fault at HBASOL2 115kV clear in 6.0 cycles
Switched Quartz 138kV Shunt Reactor at 2.25 seconds
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COMMENTS DUE TO DATA SUBMITTER BY July 13, 2018
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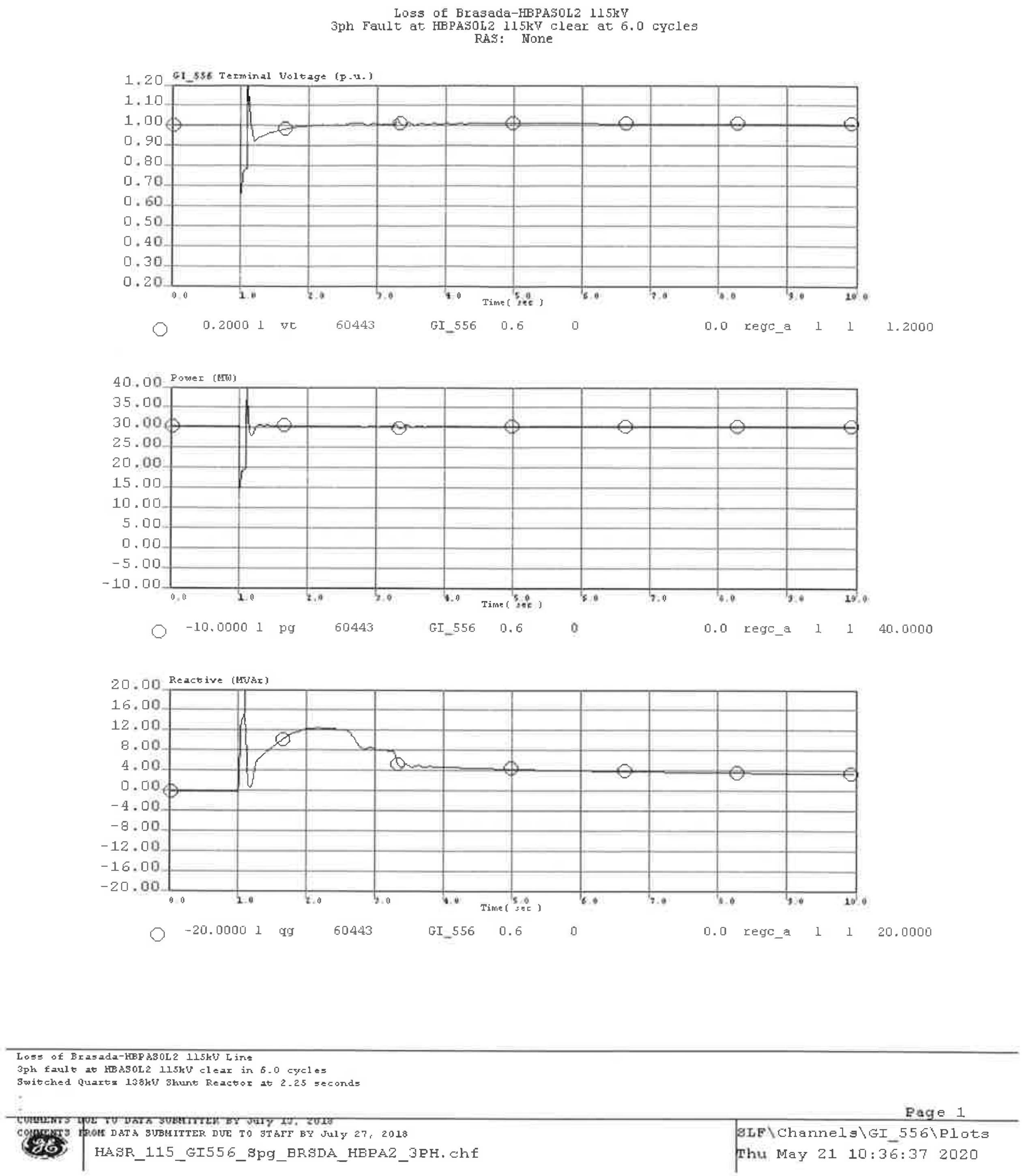
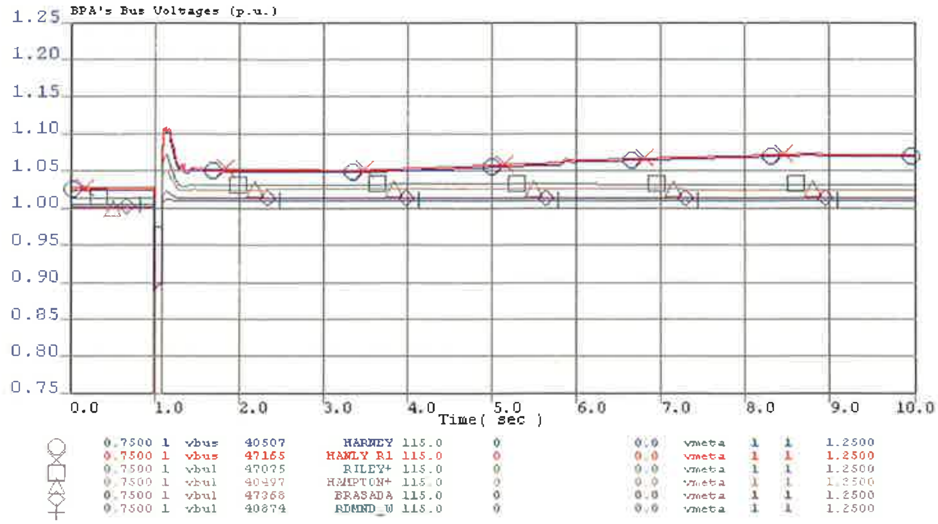
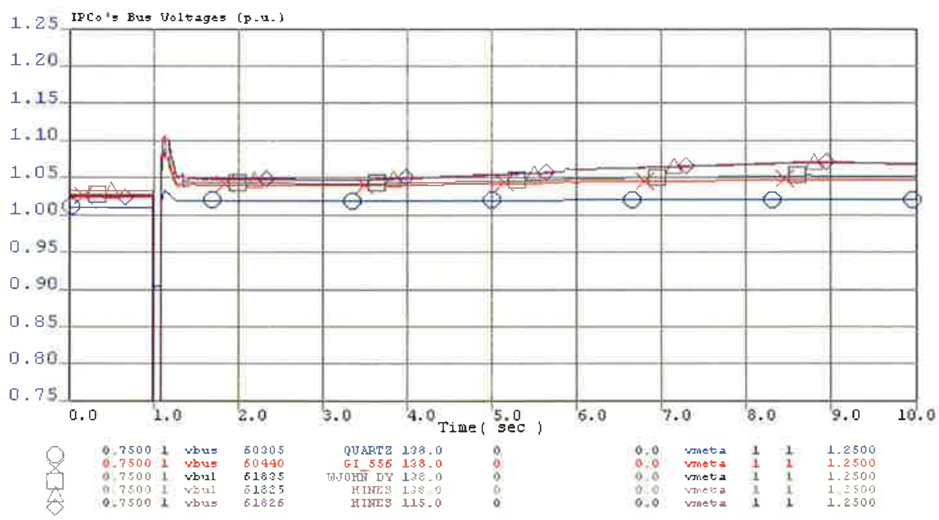


D-2.0 Loss of Brasada-HBPASOL2 115kV

Loss of Harney-HBPASOL2 115kV
3ph Fault at Harney 115kV clear at 6.0 cycles
RAS: None





Loss of Harney-HBPASOL2 115kV Line
3ph fault at Harney 115kV clear in 6.0 cycles
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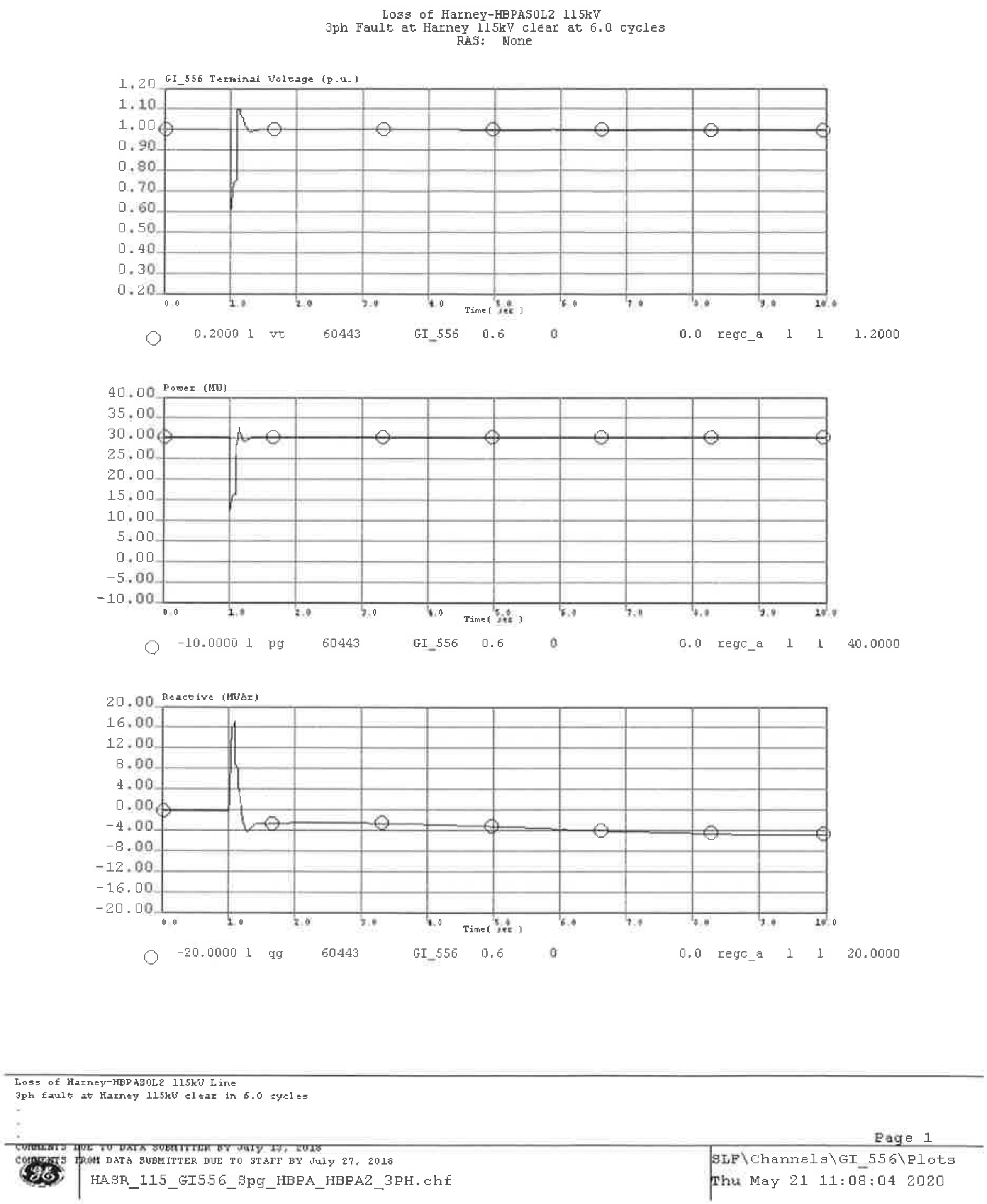
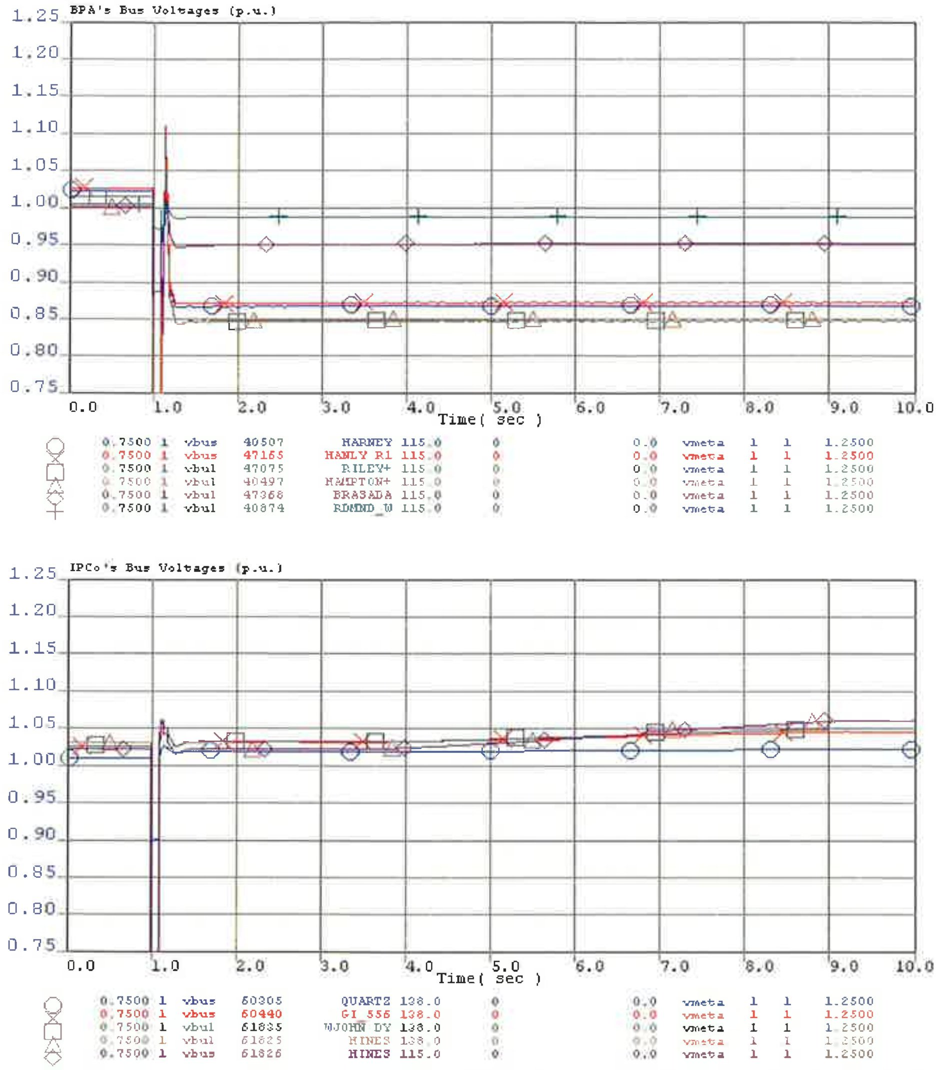


D-3.0 Loss of Harney-HBPASOL2 115kV

Loss of Hines-Harney 115kV
3ph Fault at Hines 115kV clear at 6.0 cycles
RAS: None



Loss of Hines-Harney 115kV Line
3ph fault at Hines 115kV clear in 6.0 cycles
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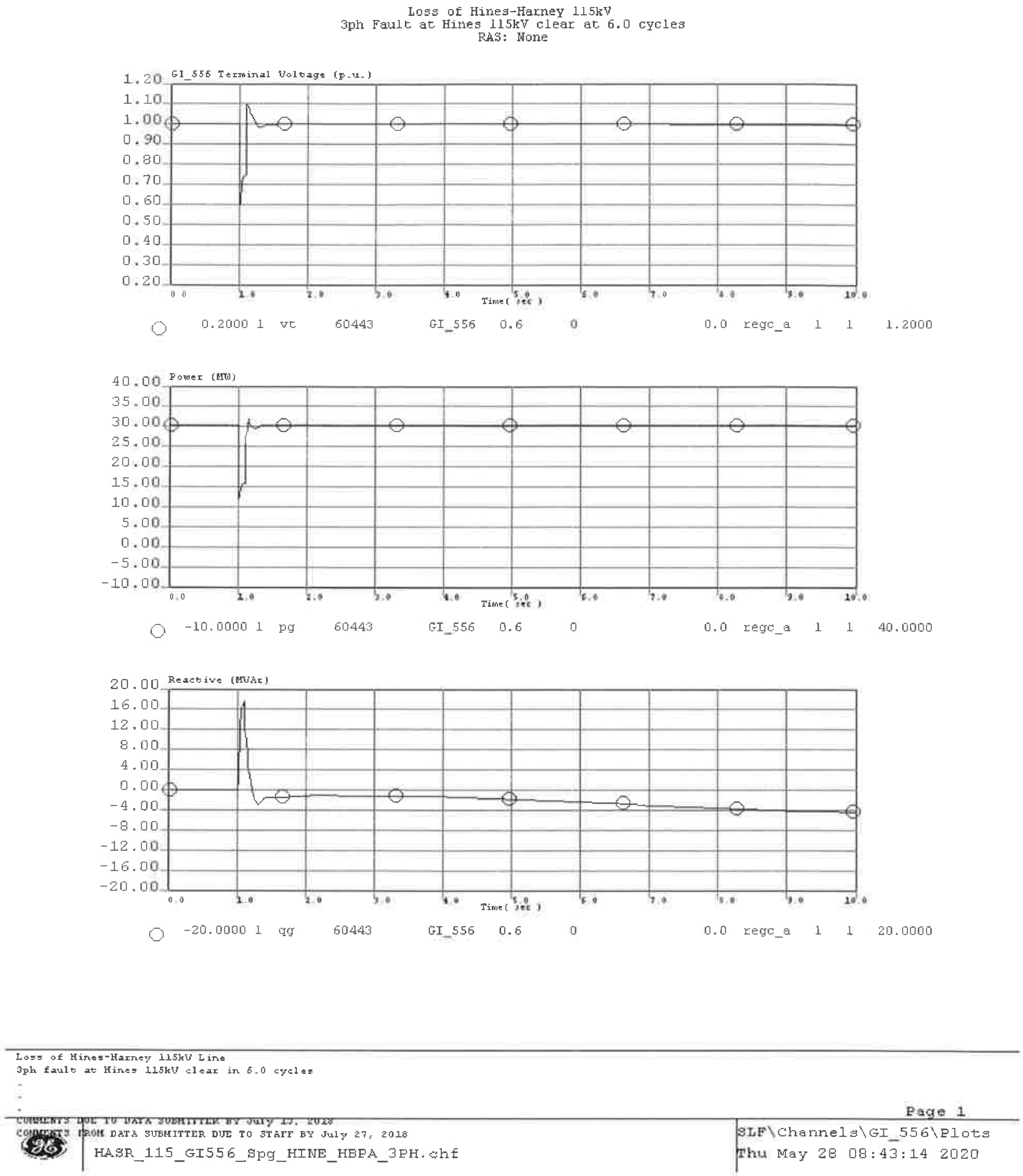
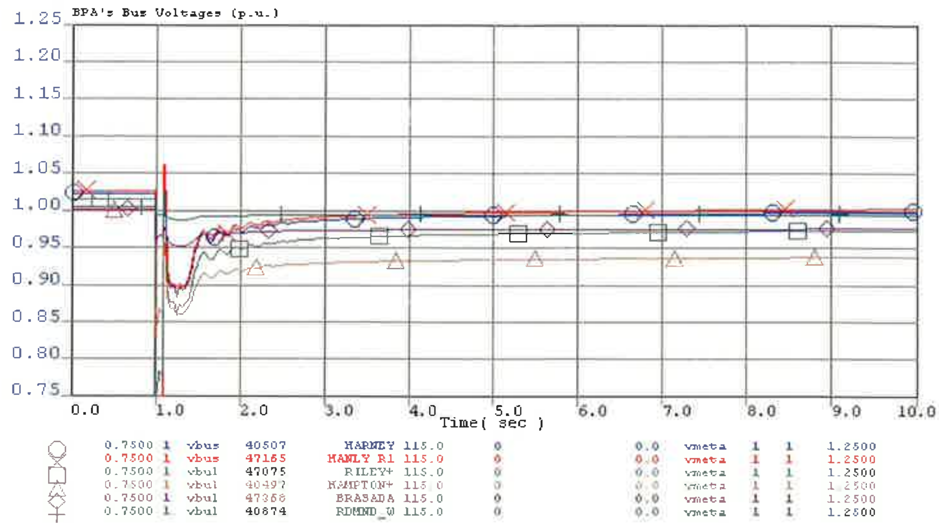
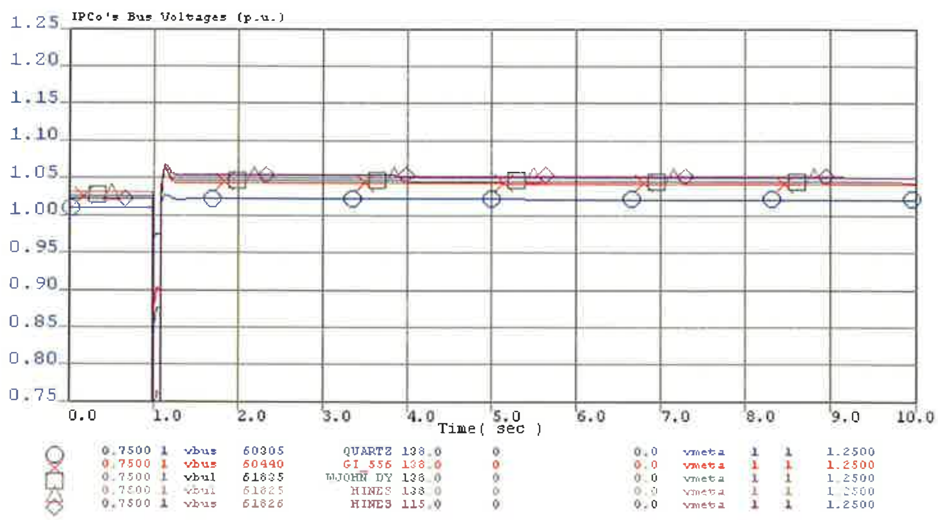


D-4.0 Loss of Hines-Harney 115kV (3ph)

Loss of Hines-Harney 115kV
SLG Fault at Hines 115kV clear at 6.0 cycles
RAS: None





Loss of Hines-Harney 115kV Line
SLG fault at Hines 115kV clear in 6.0 cycles

COMMENTS DUE TO DATA SUBMITTER BY July 13, 2018
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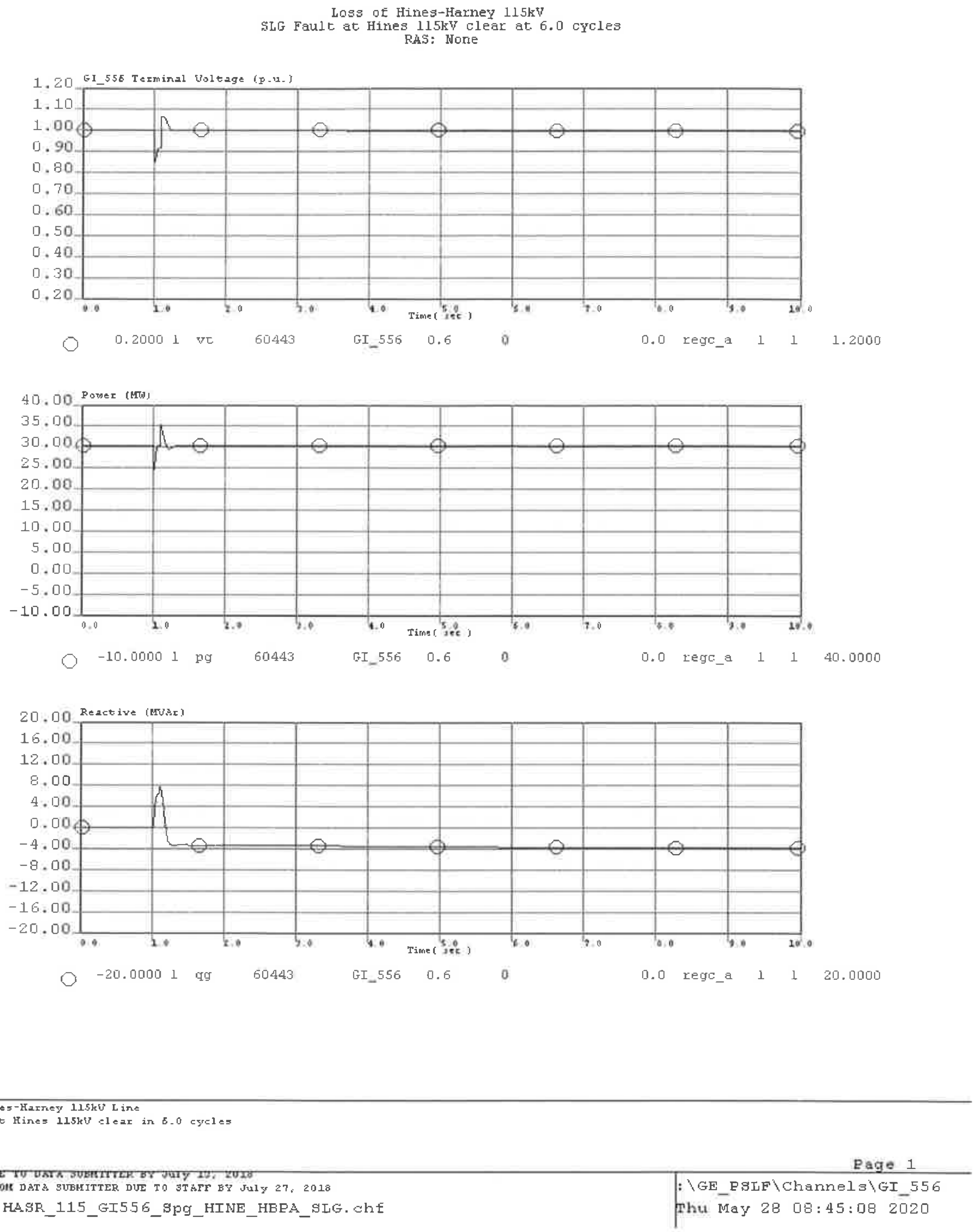
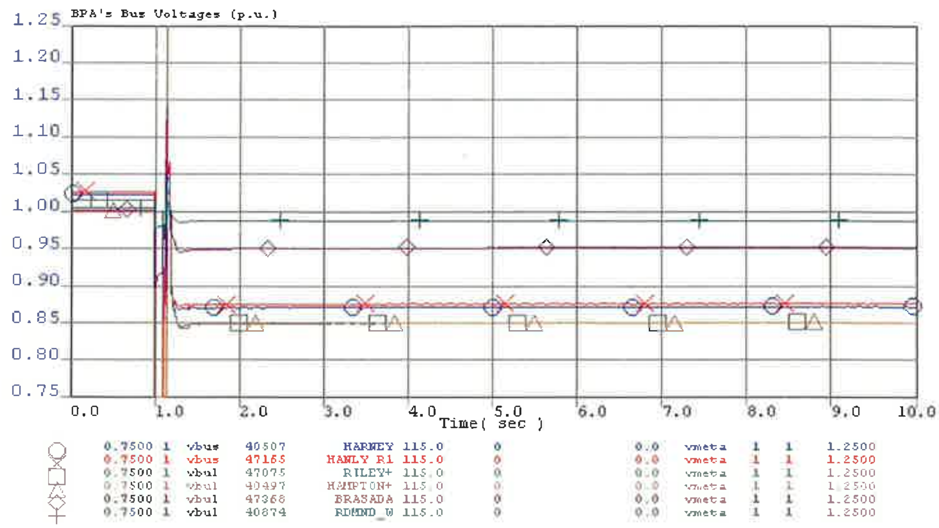
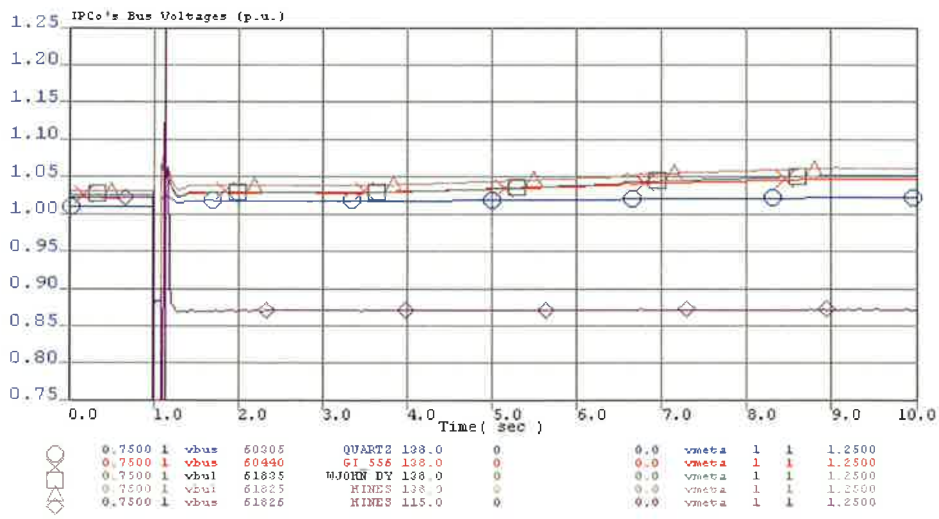


D-4.1 Loss of Hines-Harney 115kV (SLG)

Loss of Hines 138/115kV Station (Bus Differential)
3ph Fault at Hines 138kV clear at 6.0 cycles
RAS: None





Hines 138kV Bus Differential - Clears Station
3ph fault at Hines 138kV clear in 6.0 cycles
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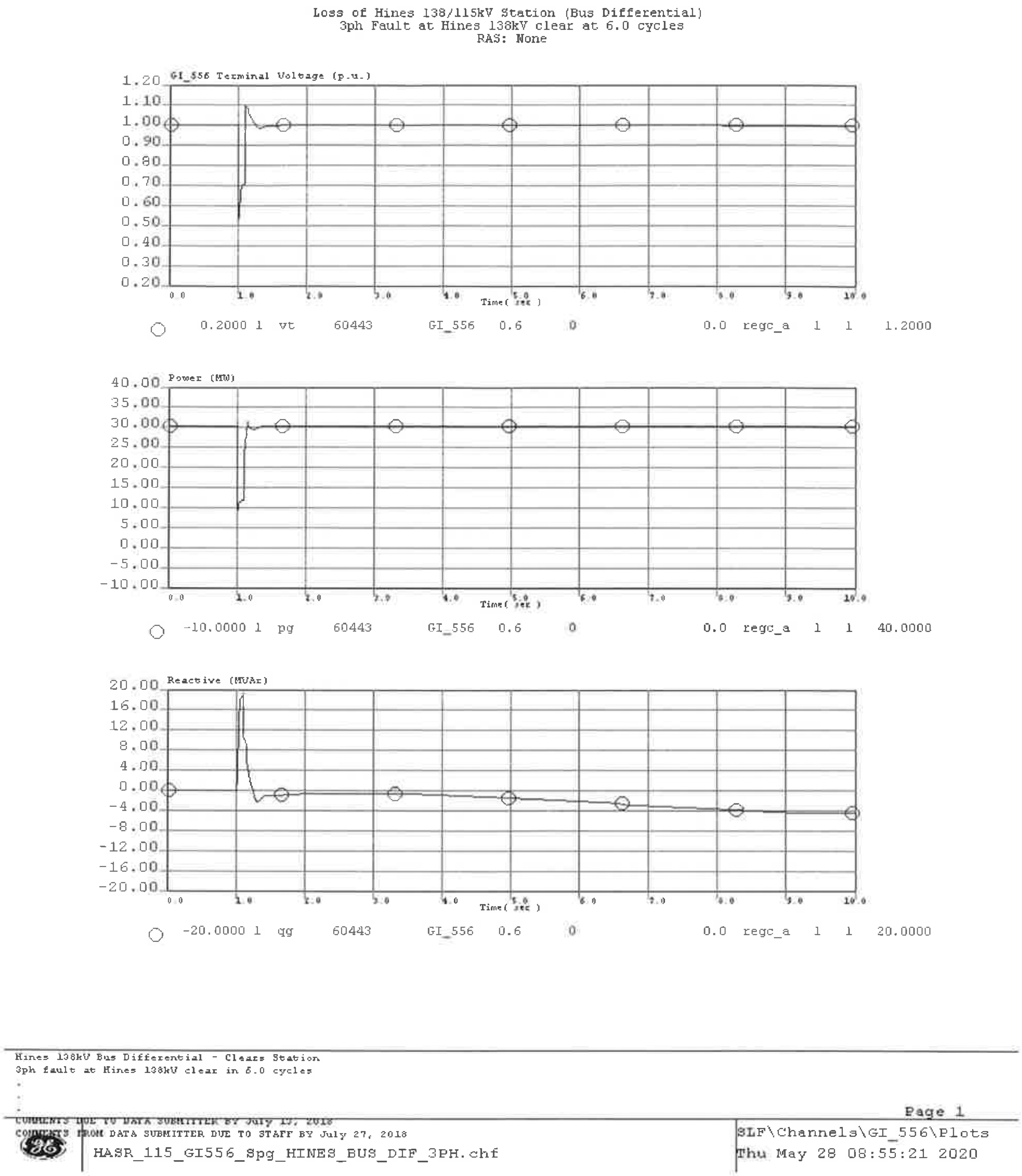
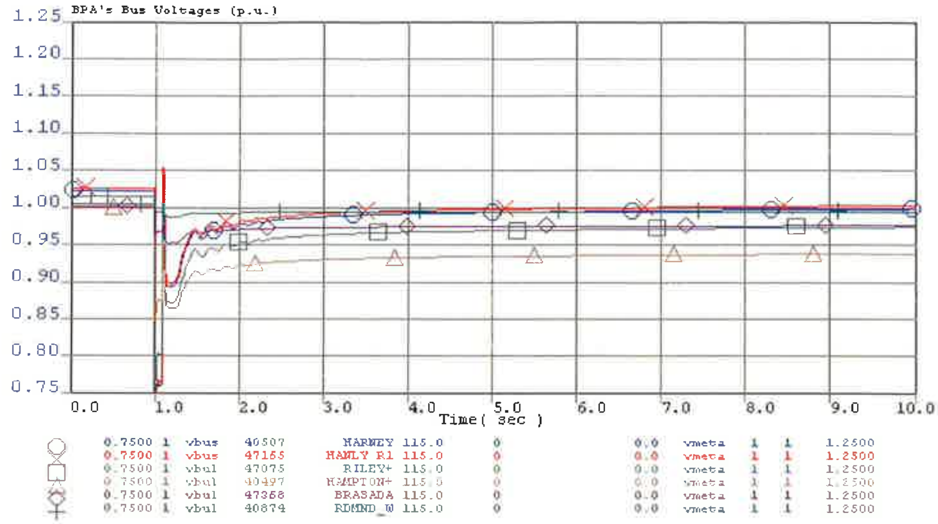
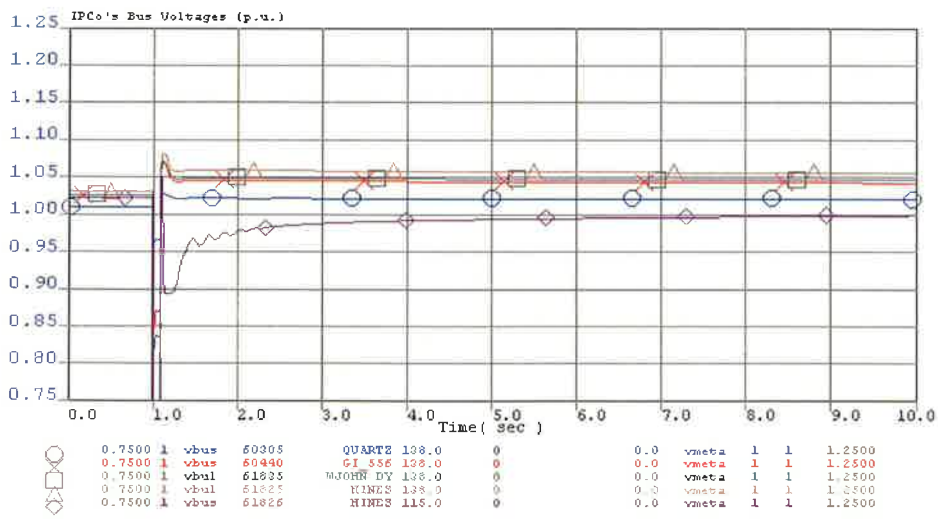


D-5.0 Hines 138kV Bus Differential (3ph)

Loss of Hines 138/115kV Station (Bus Differential)
SLG Fault at Hines 138kV clear at 6.0 cycles
RAS: None





Hines 138kV Bus Differential - Clears Station
SLG fault at Hines 138kV clear in 6.0 cycles
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COMMENTS DUE TO DATA SUBMITTER BY July 13, 2018
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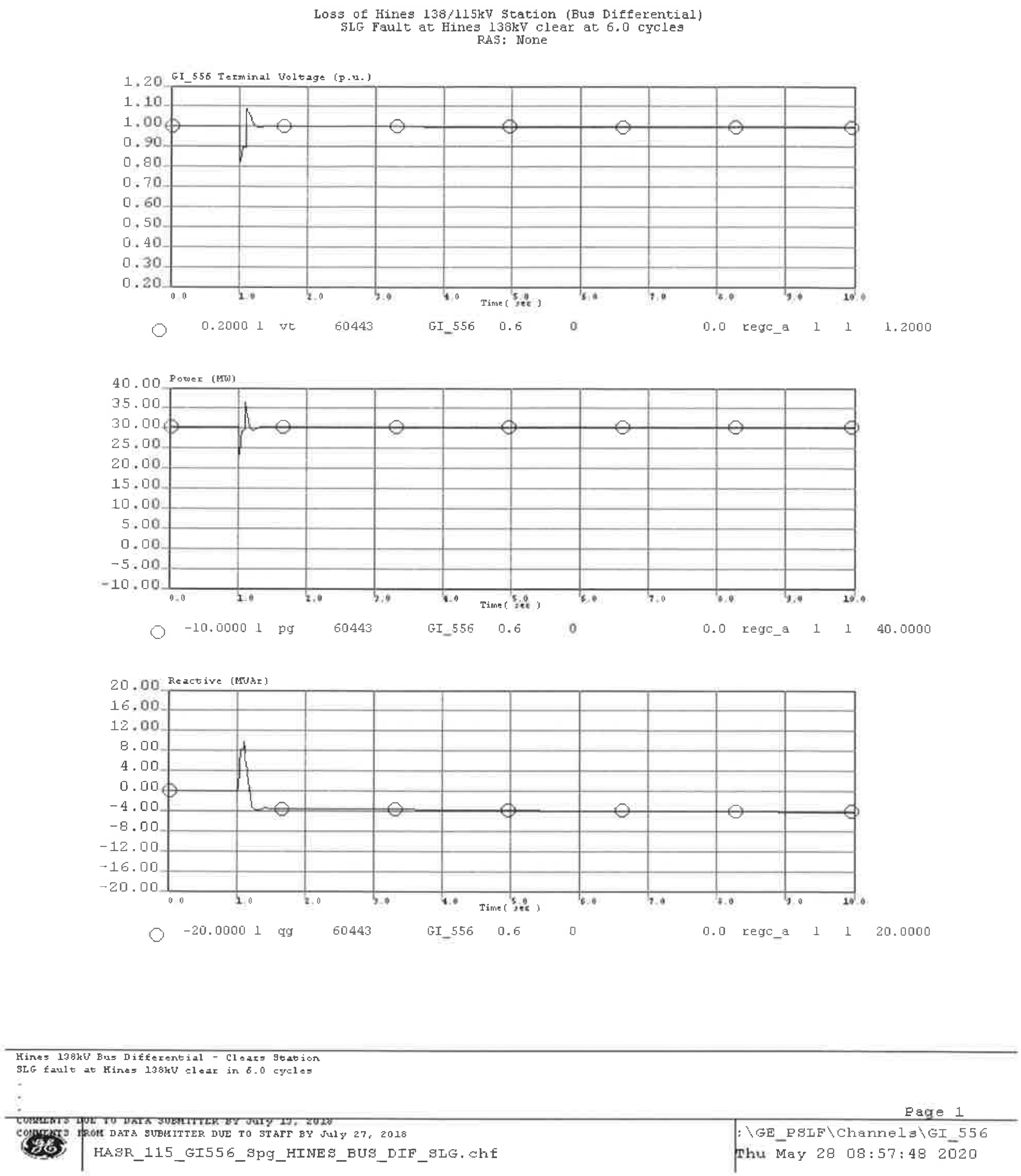
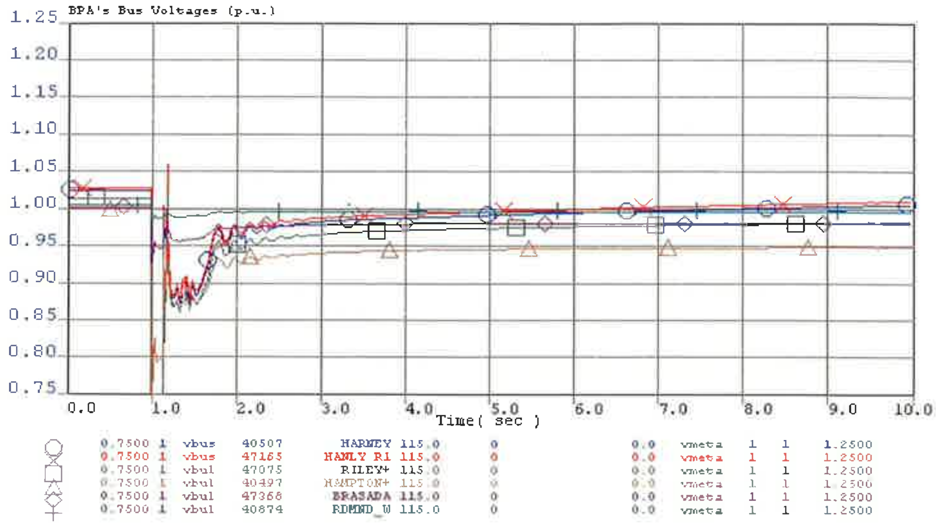
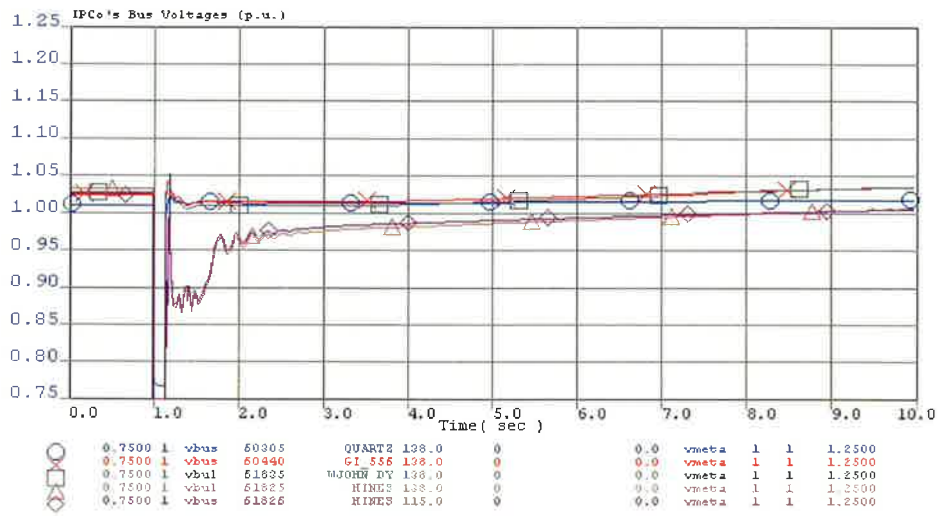


D-5.1 Hines 138kV Bus Differential (SLG)

Loss of W John Day-Hines 138kV
3ph Fault at W John Day 138kV clear at 9.0 cycles
RAS: None





Loss of W John Day-Hines 138kV Line
3ph fault at W John Day 138kV clear in 9.0 cycles
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COMMENTS DUE TO DATA SUBMITTER BY July 13, 2018
COMMENTS FROM DATA SUBMITTER DUE TO STAFF BY July 27, 2018

Page 1

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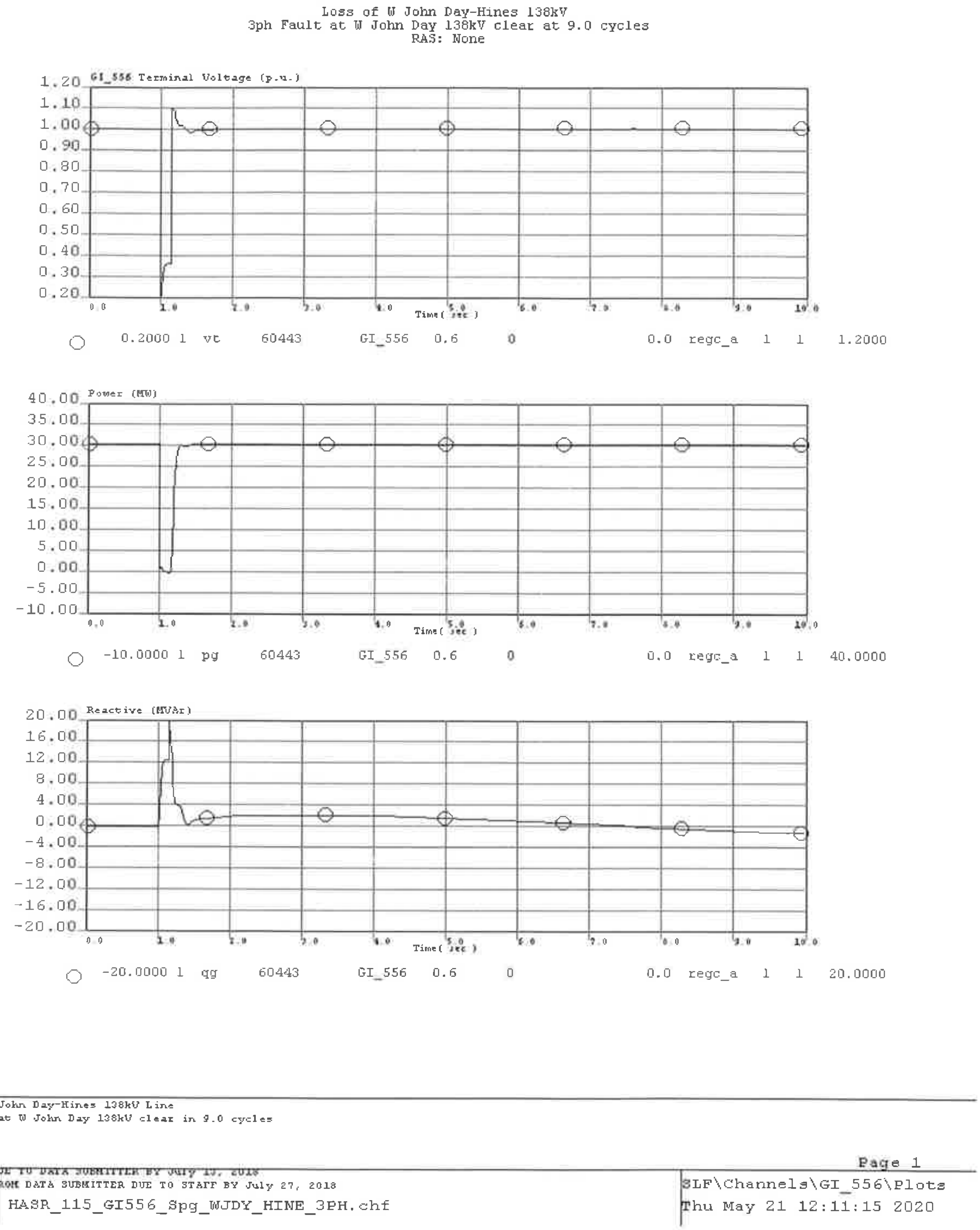


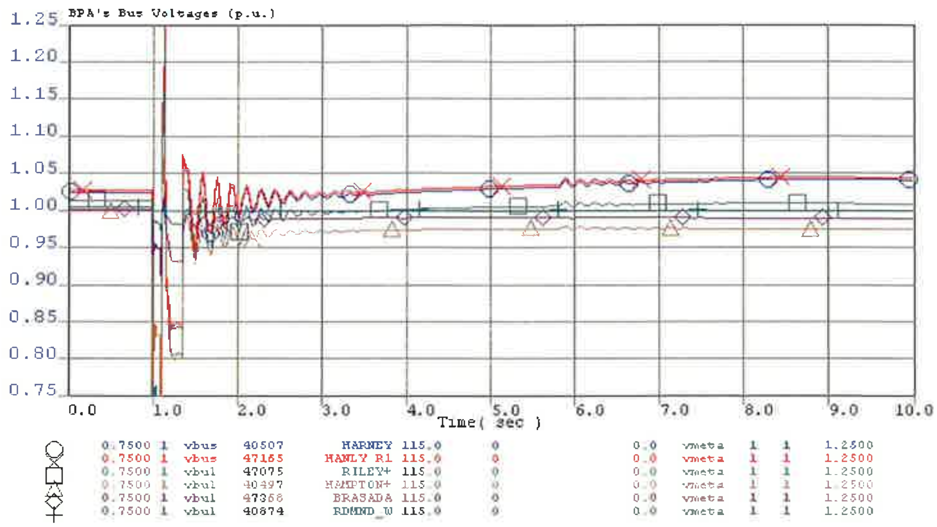
D-6.0 Loss of W John Day-Hines 138kV

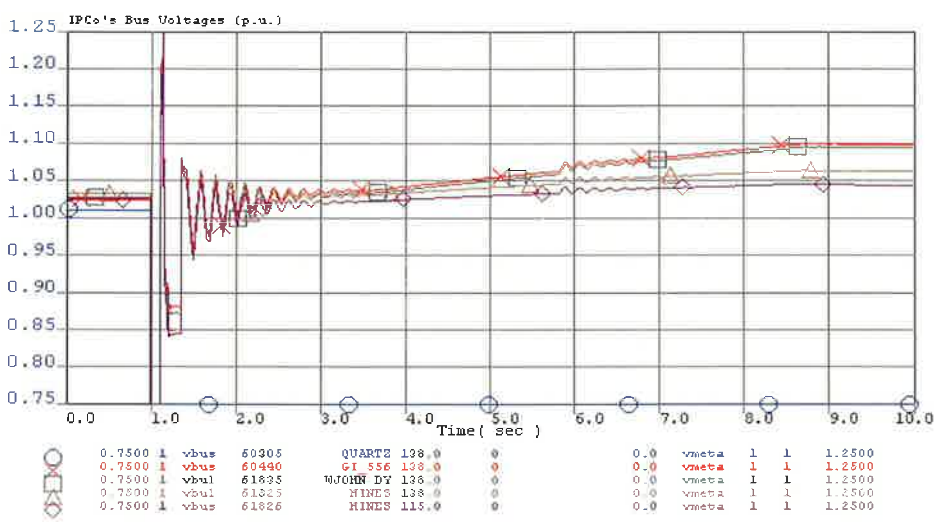
REDACTED

REDACTED

D-7.0 Loss of [redacted] 138kV

Quartz 138kV Bus Differential - Clears Quartz Station
3ph Fault at Quartz 138kV clear at 6.0 cycles
RAS: Trip GI #556 at 21.0 cycles





Quartz 138kV Bus Differential - Clears Station
3ph fault at Quartz 138kV clear in 6.0 cycles
QUTZ 103A Open-breaker RAS - Trip GI_556 at 21.0 cycles
-
-
COMMENTS DUE TO DATA SUBMITTER BY July 13, 2018
COMMENTS FROM DATA SUBMITTER DUE TO STAFF BY July 27, 2018

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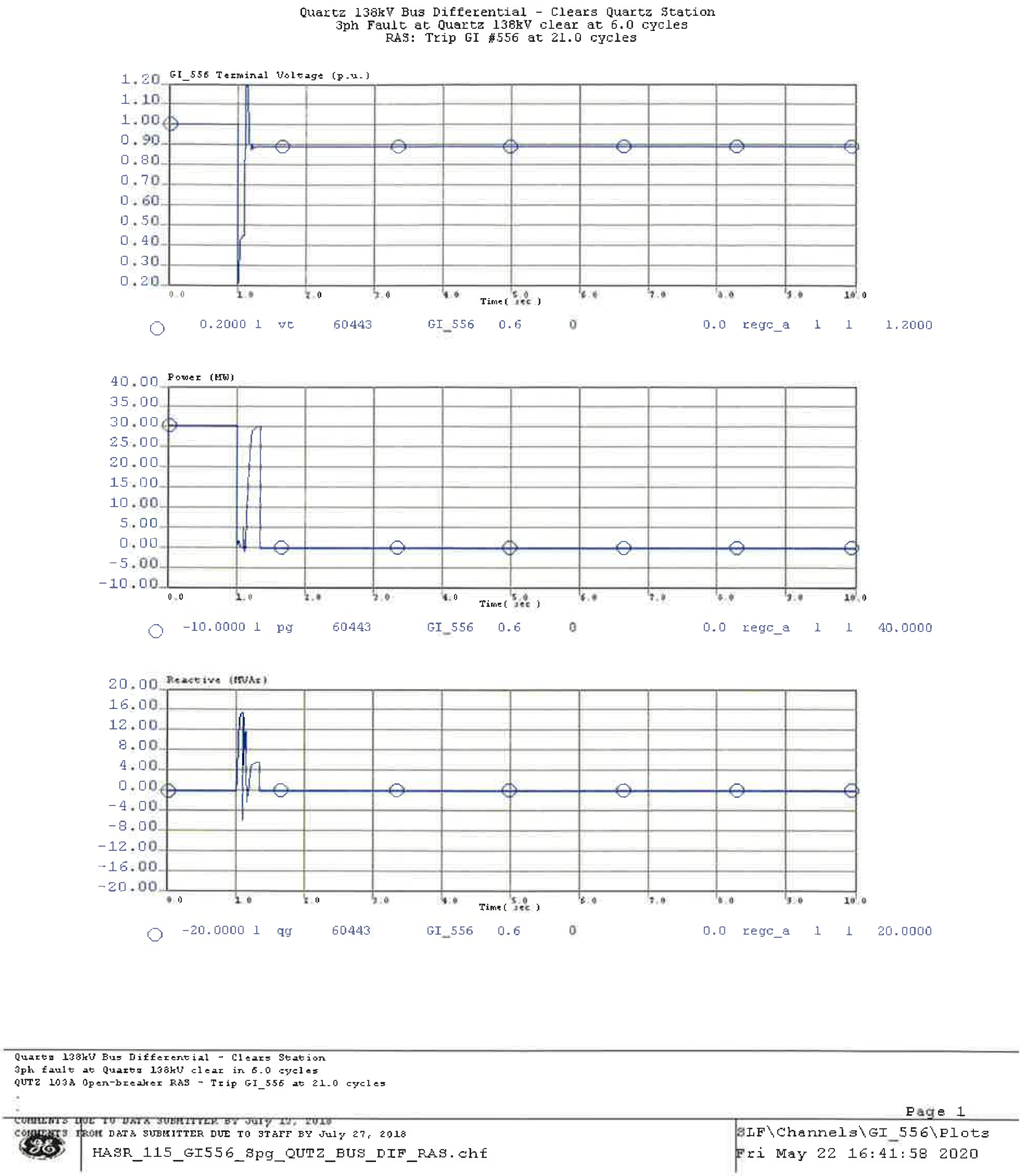
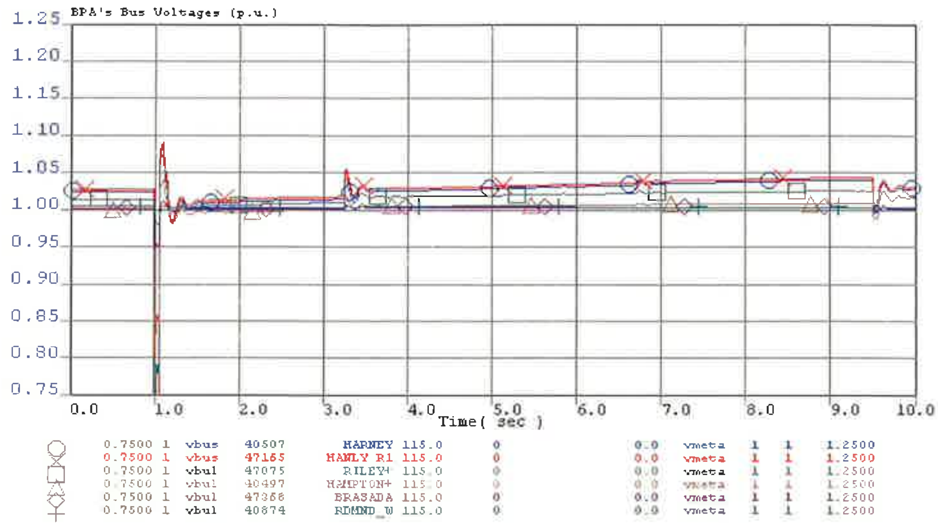
HASR_115_GI556_Spg_QUTZ_BUS_DIF_RAS.chf

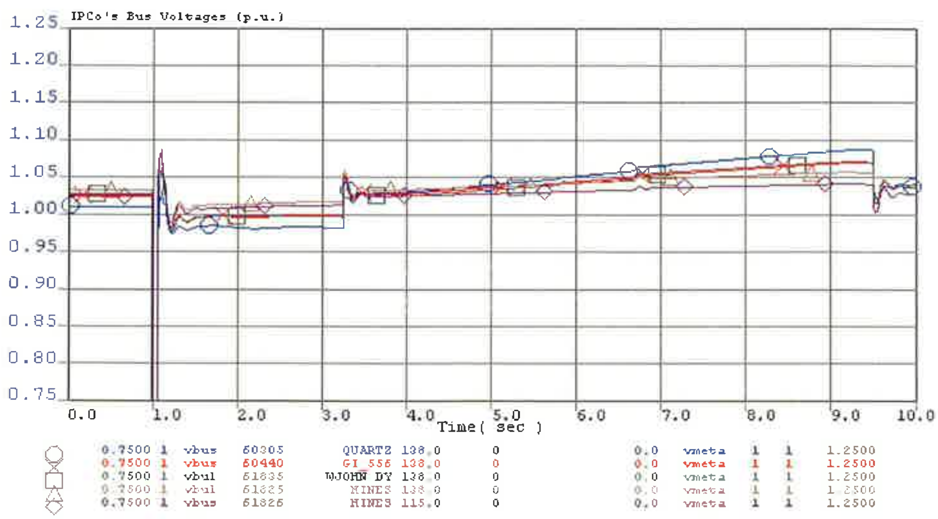
SLF\Channels\GI_556\Plots
Fri May 22 16:14:02 2020



D-8.0 Quartz 138kV Bus Differential w/GI #556 RAS

Loss of Quartz-Nth Powder-Brownlee 230kV
3ph Fault at Quartz 230kV clear at 4.0 cycles
Quartz 138kV Shunt Capacitor Switches In/Out





Loss of Quartz-N Powder-Brownlee 230kV Line
and Quartz T231 230/138kV Transformer
3ph fault at Quartz 230kV clear in 4.0 cycles
Switched Quartz 138kV Shunt Capacitor at 2.25/8.50 seconds
Trip LaGrande 230kV Shunt Capacitor at 5.0 seconds
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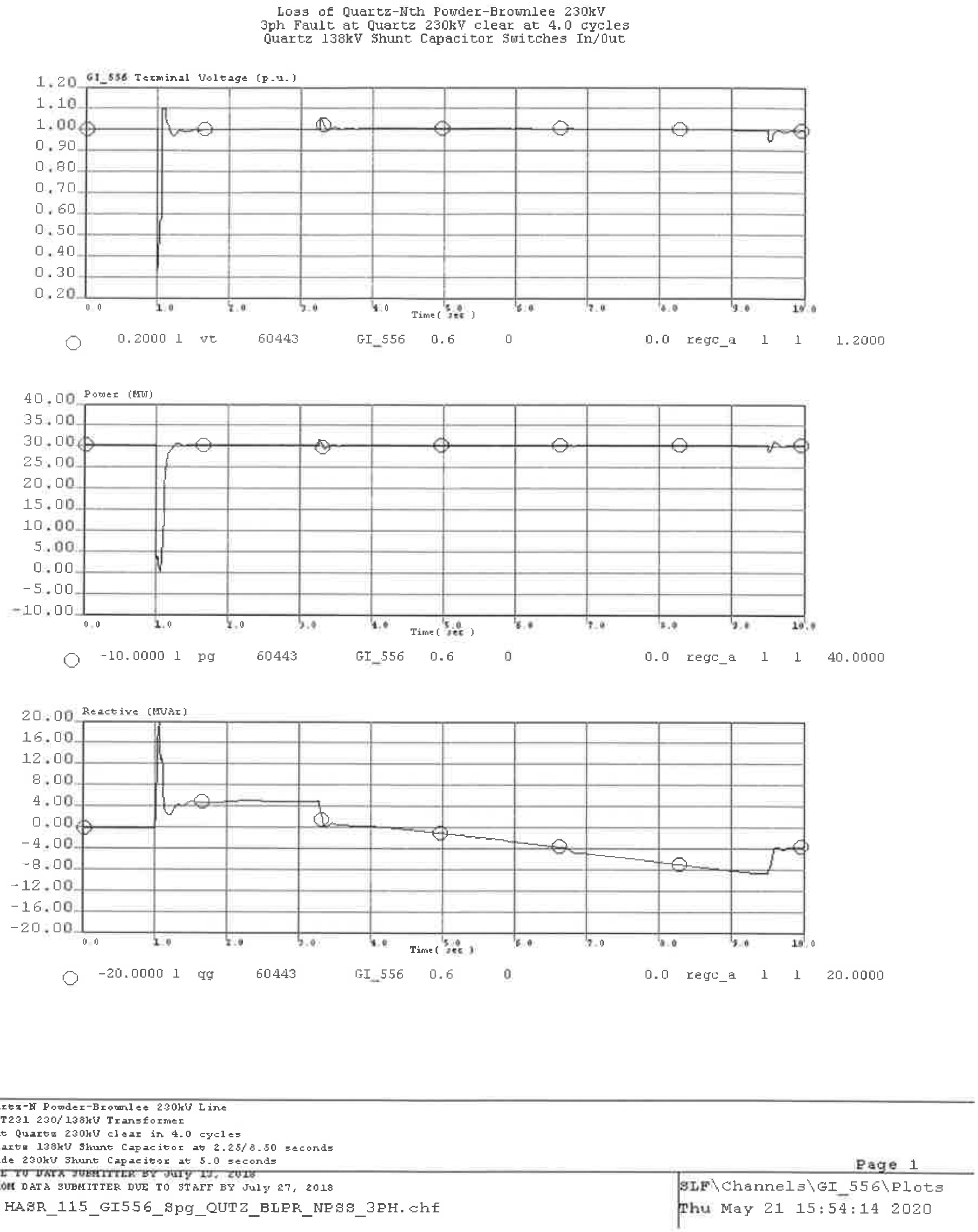
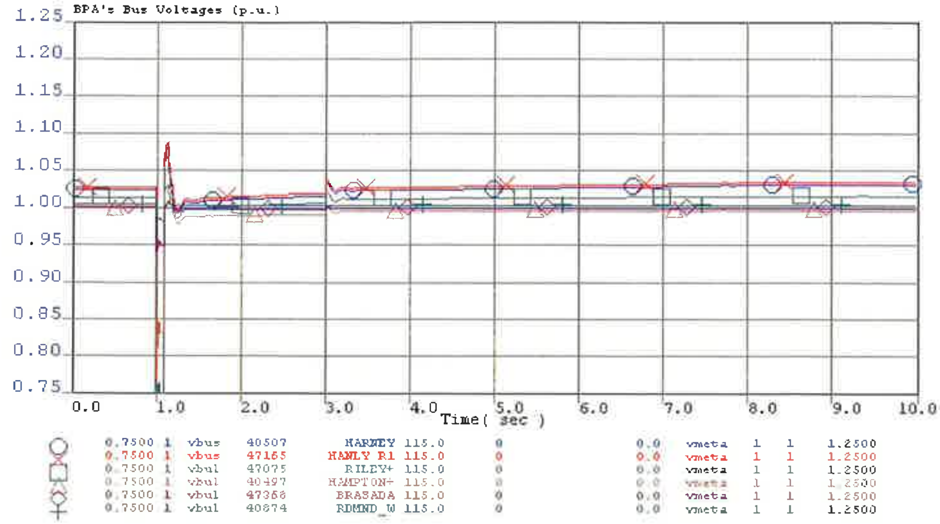
HASR_115_GI556_Spg_QUTZ_BLPR_NPSS_3PH.chf

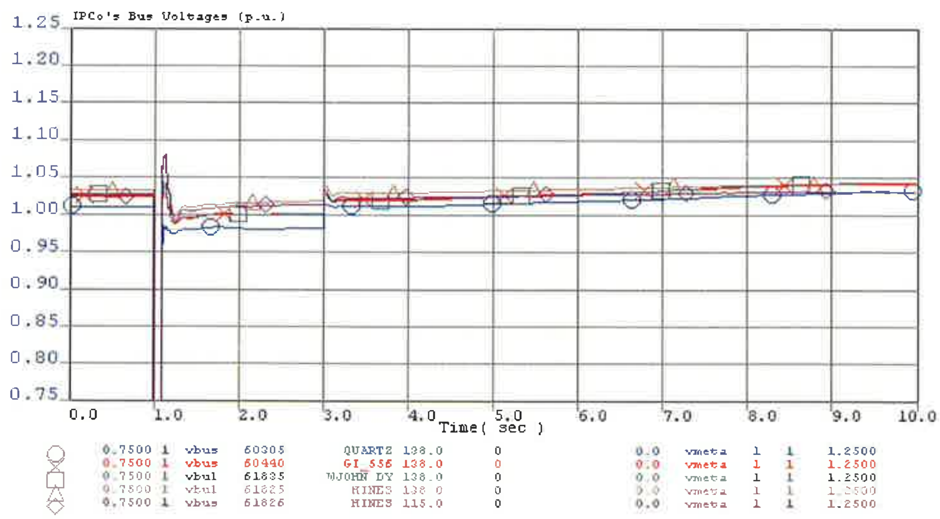
SLF\Channels\GI_556\Plots
Thu May 21 15:56:21 2020



D-9.0 Loss of Quartz-Nth Powder-Brownlee 230kV

Loss of Quartz-Nelson-Hgtn Wind 138kV
3ph Fault at Quartz 138kV clear at 6.0 cycles
Switched Quartz Shunt Reactor at 2.0 seconds





Loss of Quartz-Nelson-Hgtn Wind 138kV Line
3ph fault at Quartz 138kV clear in 6.0 cycles
Switched Quartz 138kV Shunt Reactor at 2.0 seconds

COMMENTS DUE TO DATA SUBMITTER BY July 13, 2018
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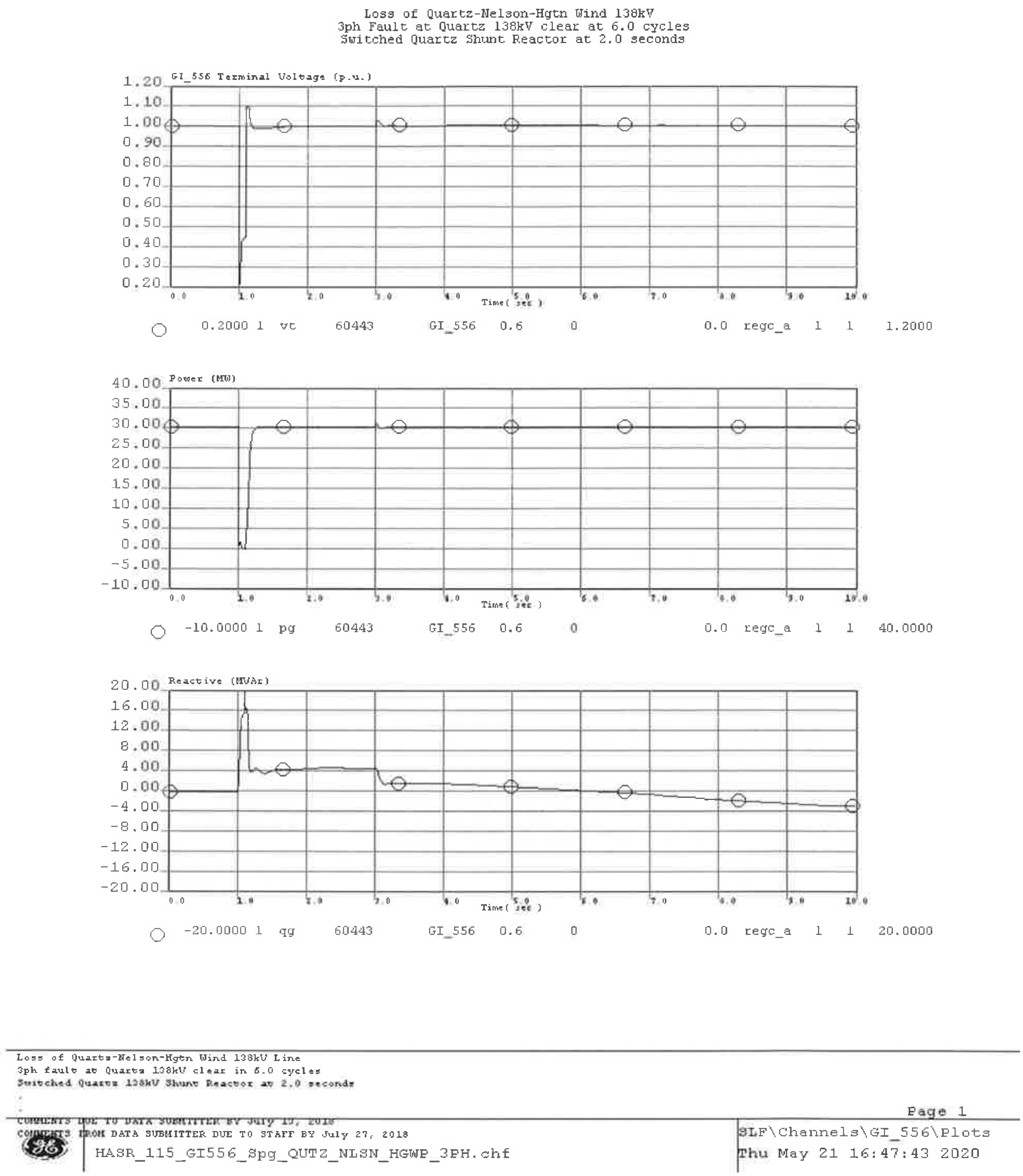
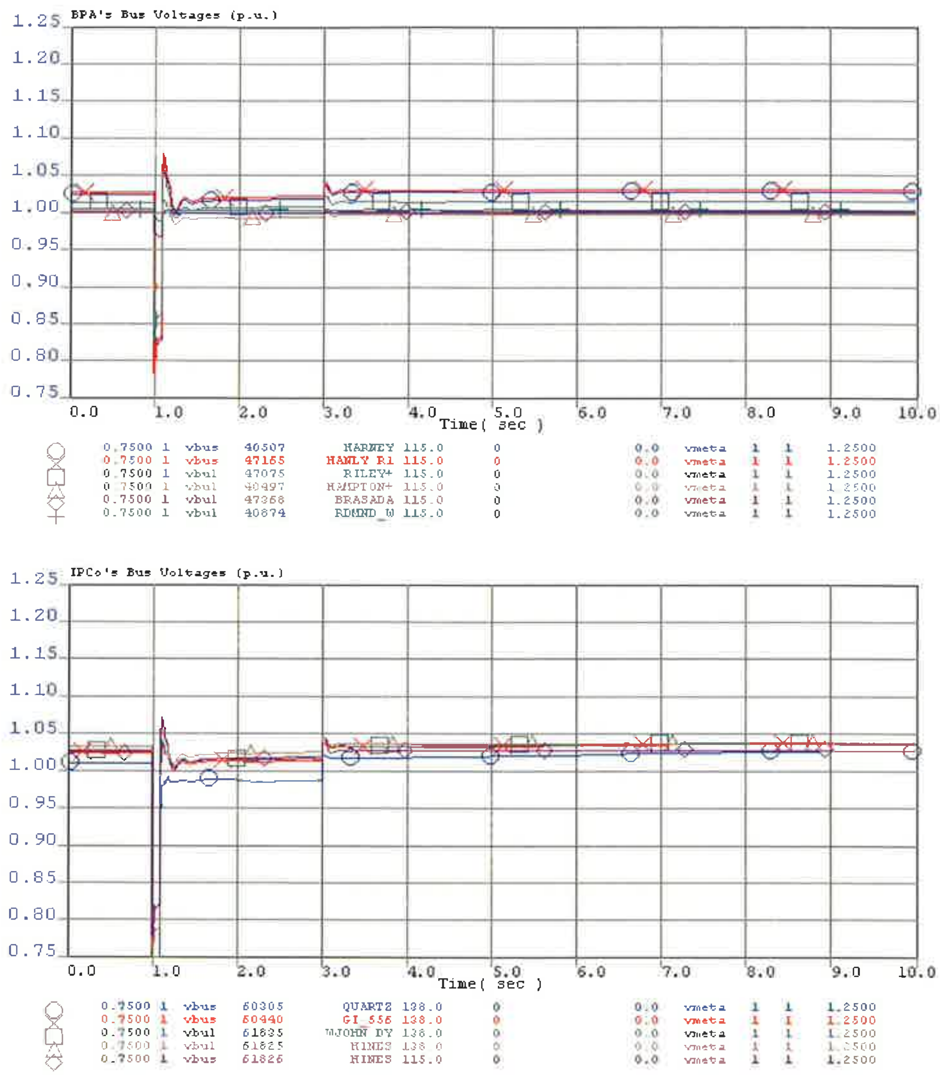
HASR_115_GI556_Spg_QUTZ_NLSN_HGWP_3PH.chf

SLF\Channels\GI_556\Plots
Thu May 21 16:44:01 2020



D-10.0 Loss of Quartz-Nelson-Hgtn Wind 138kV

Loss of Hgtn Wind-Weiser-Ontario 138kV
3ph Fault at Hgtn Wind 138kV clear at 6.0 cycles
Switched Quartz Shunt Reactor at 2.0 seconds



Loss of Hgtn Wind-Weiser-Ontario 138kV Line
3ph fault at Hgtn Wind clear in 6.0 cycles
Switched Quartz 138kV Shunt Reactor at 2.0 seconds
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COMMENTS DUE TO DATA SUBMITTER BY July 13, 2018
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HASR_115_GI556_Spg_HGWP_WESR_ONTO_3PH.chf

SLF\Channels\GI_556\Plots
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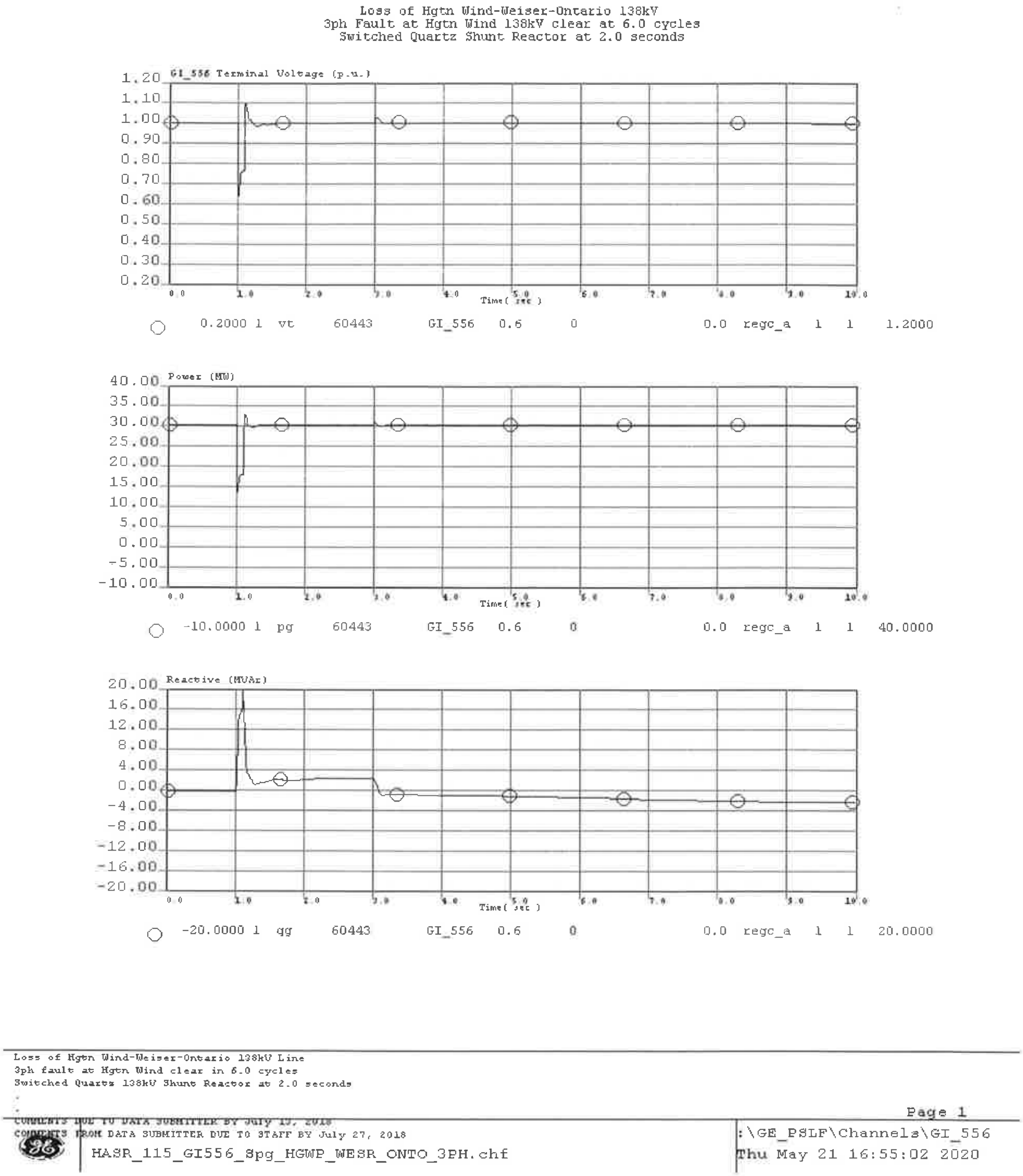

D-11.0 Loss of Hgtn Wind-Weiser-Ontario 138kV