WECC

El Paso Natural Gas Disruption

December 11, 2019

Executive Summary

In 2018 WECC commissioned the Western Interconnection Gas-Electric Interface Study[1] (Interface Study) to identify how the loss of natural gas pipelines would affect electric reliability in the Western Interconnection. The Natural Gas Disruption Task Force (NGDTF) further evaluated the effects of the southern El Paso pipeline outage by investigating when voltage stability and transmission constraints occur. All assumptions about the affected natural gas generators were based on the Interface Study.

The NGDTF focused on three objectives:

1. Identify transmission adequacy or constraints on monitored paths and potential unserved load in the Southern California and Desert Southwest areas using a Production Cost Model (PCM).
2. Identify potential voltage and stability risks in the Southern California and Arizona areas using a power flow (PF) and dynamic program.
3. Identify the range of thresholds for gas-fired capacity that can become unavailable before experiencing unserved load, or voltage or dynamic stability constraints.

NGDTF performed a PCM simulation for August 2028 to find the hour with the highest unserved load resulting from such a disruption: August 24, 7:00 to 8:00 p.m. MT. The task force exported this hour and used it as an input for setting up the PF case.

The following are the PCM results:

- When about 10,700 MW of generation is lost in Arizona in the PCM, we see about 265 MW of unserved load. The unserved load occurs in Arizona on August 24 at 7:00 p.m. Path 15, Midway to Los Banos, exceeds its north-to-south rating of 2,000 MW.[2] Other WECC paths, such as 1 Alberta-British Columbia, 30 TOT 1A, 33 Bonanza West, 51 Southern Navajo, and 83 Montana Alberta Tie Line are at their respective path rating limits.
- The PCM can lose about 2,000 MW of generation more than the PF before unserved load occurs. With 8,300 MW of generation unavailable in the PF case, there were voltage issues.

The following are PF and dynamic results:

When the Western Interconnection has a large event with about 8,300 MW of generation lost, the system becomes vulnerable to voltage issues, path restrictions, and loss of load. In the worst-case scenario, when the system lost 77 generation units in the Southwest, the simulation showed the following system reliability concerns:

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[1] https://www.wecc.org/Administrative/WECC%20Gas-Electric%20Study%20Public%20Report.pdf

[2] For Path 15, the transfer limit ranges from 2,000-3,265 MW for north-to-south. For this study, the limit was 2,000 MW.

- The worst voltage deviation was on the 345-kV system located in the Colorado area, which dropped to 0.858 per unit (pu) from 1.041 pu, a 17.6% change. The voltage drop was caused by power transfer to the Arizona area.
- Over 1,724 buses on the system show changes in voltage of at least 5%, with 362 buses showing changes greater than 10%. Some of these voltage issues could be corrected by the Operator activating shunts or static var devices (SVD) in the system.
- Three paths exceeded the maximum path flow rating:
  - Path 3, Northwest to Canada, exceeded its north-to-south rating of 3,150 MW by 422 MW.
  - Path 15, Midway to Los Banos, exceeded its north-to-south rating of 2,000 MW by 350 MW.
  - Path 83, MATL, exceeded its max rating of 325 MW
- Neither dynamic simulation showed any voltage violations, as seen in the appendices.

If the conditions of this pipeline disruption scenario were to occur, the PF analysis and PCM show that the Western Interconnection is potentially at risk of low voltages and unserved energy, respectively, before the full 24,000 MW of generation shown in the Interface Study become unavailable. The other issue is that the Western Interconnection is vulnerable to potential reliability concerns under transmission contingency conditions.

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1 Introduction and Purpose

In 2018, WECC commissioned the Western Interconnection Gas-Electric Interface Study[3] (Interface Study) to identify how the loss of natural gas pipelines would affect electric reliability in the Western Interconnection. The study showed that the disruption of the southern line of the El Paso Natural Gas Pipeline in the Desert Southwest could potentially affect about 24,000 MW of generation, resulting in the loss of load throughout the Interconnection.

The Reliability Assessment Committee asked the Studies Subcommittee the perform a Production Cost and Power Flow study to evaluate potential reliability risks associated with the Interface Study. The Natural Gas Disruption Task Force Study (Task Force Study) focused on three objectives:

1. Identify transmission adequacy or constraints on monitored paths and potential unserved load in the Southern California and Desert Southwest areas using a PCM.
2. Identify potential voltage and stability risks in the Southern California and Arizona areas using a PF and dynamic program.
3. Identify the range of thresholds for gas-fired capacity that may become unavailable before experiencing unserved load, or voltage or dynamic stability constraints.

The Task Force Study builds on the Interface Study to investigate impacts on the transfer capability in the Desert Southwest and to see which areas indicate more congestion. The assessment focused on stability risks in the Southern California and Arizona areas caused by a complete interruption in gas supply on the southern line of the El Paso Natural Gas Pipeline. The Task Force Study is independent of the Interface Study, but it modeled the generation units that the Interface Study showed were unavailable.

There are two major distinctions between the Task Force Study and the Interface Study:

1. The Task Force Study found transmission constraints by using a PF model and a PCM. This analysis was not performed in the Interface Study.
2. The Task Force Study uses a nodal PCM model, which uses the full system topology limiting the energy flows to the thermal limits on individual lines. This produces results that more accurately reflect actual flow limits throughout the Western Interconnection. The Interface Study used a zonal model, which consists of defined zones allowing power to flow anywhere within the zone, and between zones below aggregated line limits, without considering established transmission limits.

The task force used a PF study to examine voltage and stability issues potentially encountered by the loss of a large amount of generation. The PF study was not meant to solve voltage and transfer

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[3] https://www.wecc.org/Administrative/WECC%20Gas-Electric%20Study%20Public%20Report.pdf

constraints beyond those required to be solved by the model, but to report the level at which these constraints started to cause interconnection-wide reliability concerns. The Natural Gas Disruption Task Force (NGDTF) acknowledges that operating plans and adjustments would likely be made on the real system to mitigate issues. Due to the limited information available to the NGDTF, and because the scenario in the Interface Study was a natural gas disruption of long duration, the task force did not include short-term operating procedures as mitigation steps.

2 Participants

The task force that oversaw and analyzed this assessment included the following people:

Name	Organization
Vijay Satyal—Chair	Western Resource Advocates
Doug Tucker—Staff Liaison	WECC
Tyler Butikofer—Staff Liaison	WECC
Peter Mackin	GridBright
David Frederick	Salt River Project
David Le	California Independent System Operator
Christopher McLean	California Energy Commission
Karen Reedy	Public Service Company of New Mexico
Josh Steiner	Salt River Project
Janice Zewe	Sacramento Municipal Utility District

3 Data and Procedure

3.1 Work Flow

Figure 1—Task Force Study

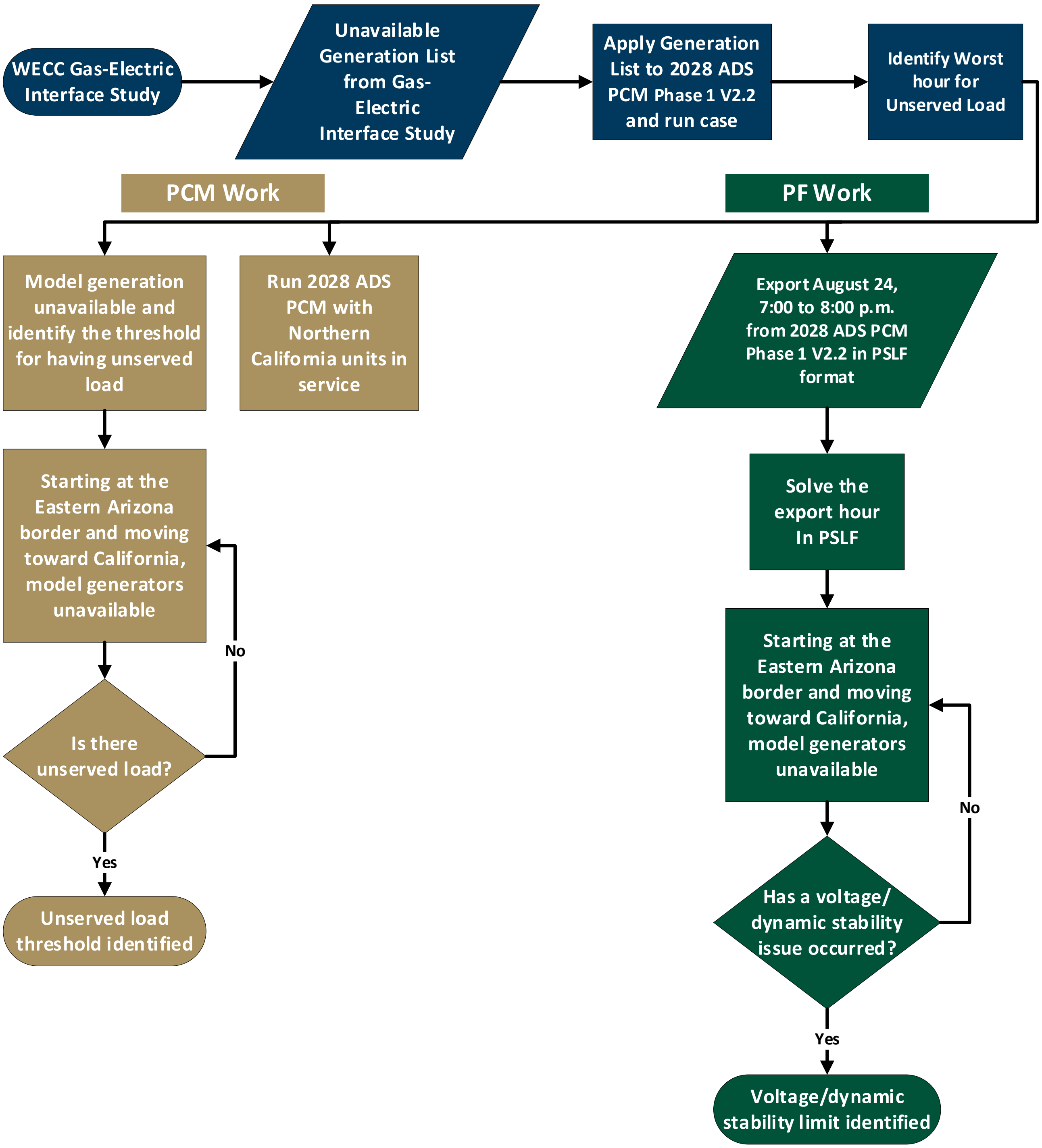

Figure 1 shows how the data flows into the simulations. The simulations are described in greater detail below. The results of the PCM and the PF will differ because the PCM model uses a "DC" network configuration that does not model how bus voltages change with changes in branch loading. All bus voltages are assumed to be unity. The DC model simulates PF in megawatts on the transmission system. A PF model uses a full "AC" network model that accounts for changes in bus voltages as branch flows change, as well as changes in branch power losses. AC network models consider both megawatts and megavars, a measure of units that supports network voltage. The AC network model is more accurate than the DC network model. The DC network solution is faster to run and helps the PCM models finish runs in the simulation more quickly. However, because these two network models treat the bus voltages differently, under severe contingency conditions, like the loss of large blocks of generation or the outage of multiple transmission elements, the model results will be different. Under severe contingency conditions, the DC network model will not recognize all the possible constraints on the system, and it is more likely than the AC model to find system conditions that look feasible. Because of this difference, a PCM model may show a higher load-serving capability than a PF model.

3.2 Data Used

The Phase 1 version of the 2028 Anchor Data Set was used to perform the Task Force Study. This data includes the 2028 Heavy Summer 1 (2028 HS1a) base case and the 2028 Anchor Data Set Production Cost Model (PCM) Phase 1 V2.2 (2028 Phase 1). The Interface Study provided information on the generators affected by the pipeline disruption.

3.3 Procedure

The Interface Study showed August as the month most affected by the disruption of the El Paso pipeline. So, the PCM part of the Task Force Study ran the simulation and found that August 24 from 7:00 to 8:00 p.m. MT was that hour with the greatest amount of unserved load. The task force chose that hour as the focus of the current assessment.

The generation dispatch and load for 7:00 to 8:00 p.m. on August 24 was taken from the PCM and used in the PF part of the assessment. The generation and load dispatch from the PCM model were used to modify the 2028 HS1a PF case, which showed similar scenarios between the two different models.

Another difference between the PF and the PCM cases is the way they treat system losses. The PCM calculated system losses of about 3,167 MW and the PF case calculated about 3,941 MW. The difference in losses calculated is also a result of the differences between the DC and AC models. The PF case accounted for the difference in losses by reducing the total load by about 800 MW, which was spread throughout the case. Table 1 shows the high-level system conditions seen in the PCM and PF.

Table 1—Total Generation and load values between the PCM and the PF

Case Format	Generation (MW)	Load (MW)	System Losses (MW)
PCM	153,964	150,796	3,167
PF	153,963	149,990	3,941

Table 2 compares the PF and PCM flows for several WECC Paths from the Desert Southwest area. Most of the path flows matched well between the two cases, except for Paths 3 and 66. These differences might occur because of how different software handles series compensation on a line, which may have an influence on these path flows. The sign convention on the path flows represents primary or secondary direction. For example, if the flows on Path 3, Northwest to Canada, are positive, then the flows go from the Northwest to Canada. If the flows are negative, they flow from Canada to the Northwest.

Table 2—Path Comparisons between the PCM and PF cases

Path Number and Name	PF Flows (MW)	PCM Flow (MW)	Path Limits (MW)
Path 3 Northwest-Canada	-1,792	-2,083	-3,150
Path 15 Midway-Los Banos	838	861	2,000[4]
Path 22 Southwest of Four Corners	1,038	1,136	2,325
Path 27 IPP DC Line	883	881	2,400
Path 46 West of Co. River	7,098	7,279	11,200
Path 49 East of Co. River	3,200	3,332	10,100
Path 50 Cholla-Pinnacle Peak	529	567	1,200
Path 51 Southern Navajo	70	62	2,800
Path 65 Pacific DC Intertie	913	913	3,220
Path 66 COI	731	1,033	4,800

4 Production Cost Model Assessment Approach

The PCM part of the study was meant to identify:

1. The hour with the highest unserved load; and
2. The amount of generation lost before unserved load, WECC Path transmission constraints, or both occur.

[4] For Path 15, the transfer limit ranges from 2,000-3,265 MW from north-to-south. For the purpose of this study, the limit was set at 2,000 MW.

4.1 Identifying the Hour with the Highest Unserved Load

The task force studied two cases to identify the hour with the highest unserved load. The first case, the Worst-Case scenario, removed all generation that the Interface Study identified as unavailable. The second case, the Northern CA scenario, modeled the same generators being unavailable as in the Worst-Case scenario, but with all generation in Northern California available for dispatch. In other words, all units in Pacific Gas and Electric (PG&E), Balancing Authority of Northern California (BANC), and Turlock Irrigation District (TIDC) were available for dispatch at full capacity in the Northern CA scenario. The task force created the Northern CA scenario because many units in California that would be affected by the disruption may have alternate sources of gas. The NGDTF wanted to see how different the results would be if gas was available. Both cases used August 24, 7:00 to 8:00 p.m. as the hour with the highest unserved load.

The amount of unavailable capacity and unserved load for the two cases is shown in Table 3. The Northern CA scenario has about 10,000 MW of additional capacity available, which reduced the amount of unserved load.

Table 3—Unavailable Capacity and Unserved Load

Scenario	Unavailable Capacity (MW)	Unserved Load (MW)
Worst-Case	31,496	13,698
Northern CA	21,130	7,123

4.2 Identifying the Threshold when Unserved Load Occurs

To see how much gas-fired generation could be lost before load was unserved, the NGDTF used an approach based the generation's location. Generation in the 2028 Phase 1 was simulated as unavailable in phases starting at the Arizona-New Mexico border and moving west toward California. The first instance when load was not served was seen when 10,689 MW of gas-fired capacity was unavailable in Arizona, as Table 4 shows. As a result, the simulation saw 264 MW of unserved load in the Desert Southwest.

Table 4—Generation units and MWs lost during the PCM scenario

Plant	Capacity (MW)
1. Bowie	1,080
2. Apache	1,041
3. H Wilson Sundt	455
4. Valencia	63
5. DeMoss Petrie	75
6. North Loop	94

Plant	Capacity (MW)
7. Saguaro	203
8. Coolidge	562
9. Sundance	440
10. Desert Basin	591
11. Santan	1,247
12. Kyrene	427
13. Ocotillo	648
14. West Phoenix	385
15. Mesquite	601
16. Gila River	2,290
17. Redhawk	487

The PCM is a security-constrained, economic dispatch (SCED) model in which path limits are binding and will not be exceeded. The results of the threshold scenario show that transmission path constraints in the Desert Southwest are not the limiting element in the study. However, several paths outside of the Desert Southwest are constrained, showing that this outage would affect more than just the Desert Southwest and contribute to unserved load in the Desert Southwest region. Table 5 shows some major WECC path flows in the Desert Southwest and constrained paths. The constrained paths are shown in red; these paths are hitting their respective limits.

Table 5—Path flows observed and limits

Path Number and Name	Flow (MW)	Limit (MW)
01 Alberta-British Columbia	1,000	1,000
15 Midway-Los Banos	2,000	2,000
22 Southwest of Four Corners	1,512	2,325
27 Intermountain Power Project DC Line	1,307	2,400
30 TOT 1A	650	650
46 West of Colorado River (WOR)	1,496	11,200
49 East of Colorado River (EOR)	-3,339	-10,100[5]
52 Silver Peak-Control	17	17
65 Pacific DC Intertie (PDCI)	2,457	3,220

[5] Path 49 East of Colorado River is not rated in the west to east direction. In the 2028 ADS PCM Phase 1 V2.2 model, the primary direction is used when the secondary direction is not rated.

66 COI	549	4,800
83 Montana Alberta Tie Line	325	325

5 PF Assessment Approach

5.1 Post Transient Assessment

The PF assessment started with the same list of affected generation from the Interface Study. Since unserved load is not simulated in a PF study, the list had to be phased in a similar approach to what was done in the PCM to identify the first instance of voltage stability risks or path constraints. The El Paso pipeline was ruptured at the Arizona-New Mexico border, so generation was removed from the simulation starting with generation located closest to the Arizona-New Mexico border and moving west toward California.

Because the disruption of the pipeline lasted so long, and because of the speed with which gas travels through the pipes (about 30 miles per hour), the scenario spans many days and impacts a large geographical area in the Desert Southwest. PF is used to study a snapshot of the power system and is not generally used to simulate a scenario that spans multiple hours or days. The Task Force Study is designed to identify voltage stability risk and path constraints into the Arizona and southern California areas, which is a PF simulation. To do this, the Task Force used a post transient simulation, which evaluates the period two to three minutes after the event. Typically, in the two- to three-minute period studied, equipment would not be able to switch on or off. However, for this study, some of the equipment that was modeled with automatic switching was allowed to switch on or off to help mitigate any voltage issues to account for the time frame in which such a gas disruption would take place.

The Task Force Study used a phased-in approach to identify potential voltage and stability risks in the Southern California and Arizona areas. For each progressive post transient simulation, one more plant or unit was taken out of service. Once the system sees the imbalance of generation, the post transient initiates governor responses from the generation that are still connected to the system. This will re-dispatch the shortage of generation to balance the system. Table 6 lists the plants removed from the scenario until a voltage stability risk and path constraints were identified, totaling about 8,513 MW. Table 6 also shows the order in which plants were removed from service. This order is described further in sections 5.1.1 and 5.1.2.

Table 6—Generation plants and MWs lost during PSLF scenario

Plant Name and Removal Order	Capacity (MW)
1. Apache	899.1
2. Bowie	1,012.1
3. H Wilson Sundt	455
4. Valencia	63
5. Saguaro	141
6. Coolidge	561.6
7. Sundance	440
8. Desert Basin	591
9. Santan	1,152.5
10. Kyrene	60
11. Ocotillo	548
12. West Phoenix	285
13. Gila River	2,290

5.1.1 Maximum Level of Affected Generation that Does Not Cause Reliability Concerns

The following section highlights a few key results seen when running the PF model in post transient.

When the system loses about 3,900 MW of generation, it becomes stressed and paths approach their limits. In operation, once a path exceeds its maximum limit, the path Operator has 30 minutes to reduce the flows on the overloaded path(s). In this simulation, Path 83 has increased flows to 325.8 MW, which is above the maximum rating of 325 MW. This is due to generation in Canada increasing output to help alleviate the lost generation in the Desert Southwest. Path 83 contains a phase shifter transformer, which Operators could adjust to the desired flows across this transformer. In this simulation, the series capacitor at Haylake was bypassed to reduce the flows on this path to 290 MW to eliminate the path overflow. These actions were not taken during the post transient simulation.

When voltage drops below 0.90 pu under a no-transmission contingency condition, the system is at risk of a voltage collapse during the next critical transmission contingency. Voltage collapse occurs when there are not enough reactive resources to support the voltage. Due to the phase shifting transformer not regulating and allowing power to flow into Arizona from Colorado, voltage on a 230-kV bus in Colorado dropped by 8.5%, down to .886 pu. Operator intervention would be needed to regulate the flows across this phase shifter. A synchronous condenser was added in Colorado to help control voltage at this bus. In addition, SVDs and shunts in the area were adjusted to correct any voltage issues. In the post transient simulation, the generation in Arizona is being dispatched off-line. As a result, generation elsewhere in the system increased. This increased power transfers into Arizona, and the simulation, show the voltage decreasing for the import paths.

5.1.2 Additional Level of Affected Generation that Causes Reliability Concerns

Following the loss of 4,350 MW of generation, Path 15 (Midway to Los Banos) flows increased to 2,040 MW, exceeding its north-to-south rating of 2,000 MW.[6] To mitigate this, flows on the PDCI increased from 931 MW to 3,100 MW, reducing the Path 15 flows to 1,056 MW, well below the north-to-south limits on that path. Again, this change was made to imitate possible intervention by the Operator.

After the loss of the Santan plant, generation losses then totaled 5,315 MW, three 230/69-kV stepdown transformers at Santan become overloaded, with one transformer exceeding its emergency rating. The Santan load area is a radial network and with the loss of the Santan generation the 69-kV network would no longer be able to supply the load.

Loss of gas supply in the Southwest impacted other regions in the Interconnection as a 345-kV bus in Colorado showed a 5.6% voltage change. In addition, flows on Path 83 (Montana to Alberta Tie Line) increased to 325.8 MW, which is above its path rating limit of 325.

Table 7—Path flows seen when 5,315 MW of generation was lost vs. pre-flows

Path Number and Name	Pre-Flow (0 MW lost)	Post-Flow (~5315 MW lost)	Path Limits
Path 3 Northwest- Canada	-1792	-2827	-3,150
Path 15 Midway-Los Banos	838	1322	2,000
Path 22 Southwest of Four Corners	1038	1070	2,325
Path 27 IPP DC Line	883	883	2,400
Path 46 West of Co. River	7098	3999	11,200
Path 49 East of Co. River	3200	-291	10,100
Path 50 Cholla-Pinnacle Peak	529	409	1,200
Path 51 Southern Navajo	70	1028	2,800
Path 65 Pacific DC Intertie	913	3100	3,220
Path 66 COI	731	1000	4,800

When an additional 1,500 MW of generation was lost (now totaling 6,800 MW), the system became stressed, with Path 3 flows increased to 3,153 MW (north-to-south), exceeding its maximum path rating of 3,150 MW, and Path 83 exceeding its path limit by 29 MW. With Paths 3 and 83 at maximum limits,

[6] For Path 15, the transfer limit ranges from 2,000-3,265 MW for north-to-south direction. For the purpose of this study, the limit was set at 2,000 MW.

the system would no longer be able to use generating resources in Canada to help mitigate this scenario.

Again, the natural gas outage in the Desert Southwest showed impacts throughout the Interconnection. The study showed that a 345-kV bus in Colorado dropped from 1.041 pu to 0.937 pu, a 10% change. In addition, over 465 buses on the system showed changes in voltage of at least 5%, with three buses changing over 10%. In previous scenarios, SVD/shunts were turned on to help with low voltage throughout the system. With 465 buses with at least a 5% change, it was a challenge to identify which SVD/shunts to activate. As a result, no further SVD/shunts were turned on. Some of these voltage issues could be corrected by switching in shunts or SVD devices in the system.

Table 8—Path flows observed when 6,800 MW of generation was lost vs. preflows

Path Number and Name	Pre-Flow (0 MW lost)	Post-Flow (~6800 MW lost)	Path Limits
Path 3 Northwest- Canada	-1,792	-3,153	-3,150
Path 15 Midway-Los Banos	838	1,785	2,000
Path 22 Southwest of Four Corners	1,038	1,183	2,325
Path 27 IPP DC Line	883	883	2,400
Path 46 West of Co. River	7,098	3,188	11,200
Path 49 East of Co. River	3,200	-1,274	10,100
Path 50 Cholla-Pinnacle Peak	529	463	1,200
Path 51 Southern Navajo	70	1,359	2,800
Path 65 Pacific Dc Intertie	913	3,100	3,220
Path 66 COI	731	1,585	4,800

Table 9—Number of buses with at least 5% voltage change by kV level when 6,800 MW of generation was lost

Buses (kV)	Number of buses with at least 5% voltage change
500	2
345	22
230	21
115	117
Below 115	305

In the final simulation, when the system saw the loss of 8,513 MW, Path 3 exceeded its maximum rating by 422 MW (-3,572 MW) and Path 15 exceeded its north-to-south rating by 350 MW (2,350 MW). Selected paths are listed in Table 9 with the flows that were seen after losing a total of 8,513 MW comprising 77 generation units. Path 3, 15, and 83 exceeded the maximum path rating, the system becomes limited on what it can do to get power into the Arizona area. About 800 MW needs to be re-dispatched in order to get these three paths under their maximum limits, which may cause other paths to hit their limits. At this point, path constraints have become an issue. Identifying path constraints was one of the goals of this study, as seen in Table 9.

One of the Interconnection-wide impacts of this pipeline disruption is that the largest deviation, a 17.6% change in voltage, was seen at a 345-kV bus in Colorado (not in the Desert Southwest). In total 1,724 buses had change in voltage of 5% or greater, with 362 having a change of more than 10%. In previous scenarios, SVD/shunts were turned on to help with low voltage in the system. With 1,724 buses having at least a 5% change, it was a challenge to identify which SVD/shunts to activate to help with voltage issues. As a result, no further SVD/shunts were turned on. Some of these voltage issues could be corrected by activating any shunts or SVD devices in the area, as seen in Table 10. The change in voltage throughout the system shows that voltage stability risks can occur throughout the Western Interconnection.

Table 10—Path flows observed when 8,513 MW of generation was lost vs preflows

Path Number and Name	Pre-Flow (0 MW lost)	Post-Flow (~8513 MW lost)	Path Limits (MW)
Path 3 Northwest- Canada	-1,792	-3,572	-3,150
Path 15 Midway-Los Banos	838	2,350	2,000
Path 22 Southwest of Four Corners	1,038	1,288	2,325
Path 27 IPP DC Line	883	883	2,400
Path 46 West of Co. River	7,098	2,226	11,200
Path 49 East of Co. River	3,200	-2,436	10,100
Path 50 Cholla-Pinnacle Peak	529	485	1,200
Path 51 Southern Navajo	70	1,718	2,800
Path 65 Pacific DC Intertie	913	3,100	3,220
Path 66 COI	731	2,327	4,800

Table 11—Number of buses with at least 5% voltage change by kV level when 8,513 MW of generation was lost

Buses (kV)	Number of buses with at least 5% voltage change
500	56
345	34

230	231
115	317
Below 115	1,086

5.2 Dynamic Simulation

The NGDTF explored voltage criteria violations while the system was in the stressed state of 5,315 MW of gas generation not being available since this is the scenario before we saw path constraints and large numbers of voltage deviations. The criteria states, "voltage shall recover to 80 percent of the pre-contingency voltage level within 20 seconds of the initiating event … for all BES elements."[7] The task force used two dynamic simulations to explore whether the criteria were met, and to make sure no voltage violations were identified. The two outages used for dynamic simulations were the loss of the PDCI (bi-pole outage), and the loss of a single unit at Palo Verde. The simulation results are found in Appendix A for the bi-pole PDCI contingency and Appendix B for the loss of the one Palo Verde unit. Neither dynamic simulation showed any voltage violations.

6 Observations and Conclusions

PCM results:

- When about 10,700 MW of generation is lost in Arizona in the PCM, about 265 MW of unserved load is seen. The unserved load occurs in Arizona on August 24 at 7:00 p.m. Path 15, Midway to Los Banos, exceeds its north-to-south rating of 2,000 MW. Other WECC paths, such as paths 1 Alberta-British Columbia, 30 TOT 1A, 33 Bonanza West, 51 Southern Navajo, and 83 Montana Alberta Tie Line are at their path rating limits.
- The PCM can lose about 2,000 MW more generation than the PF before unserved load occurs. With 8,300 MW of generation that is unavailable in the PF case, voltage issues occurred.

PF and dynamic stability results:

When the Western Interconnection has a large event with a loss of about 8,300 MW of generation, the system becomes vulnerable to voltage issues, path restrictions, and loss of load. In the worst-case scenario, when the system lost 77 generation units in the Southwest, the following system reliability concerns occurred:

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[7] https://www.wecc.org/Reliability/TPL-001-WECC-CRT-3.2.pdf

- The worst voltage deviation was on the 345-kV system located in the Colorado area. The deviation was a drop from 1.041 to 0.858 pu, a 17.6% change. The voltage drop was caused by power transfer to the Arizona area.
- Over 1,724 buses on the system show changes in voltage of at least 5%, with 362 buses showing changes over 10%. It is expected some of these voltage issues could be corrected by the Operator activating shunts or SVD devices in the system.
- Three paths exceeded the maximum path flow rating:
  - Path 3, Northwest to Canada, exceeded its north-to-south rating of 3,150 MW by 422 MW (3,572 MW);
  - Path 15, Midway to Los Banos, exceeded its north-to-south rating of 2000 MW[8] by 350 MW (2,350 MW); and
  - Path 83, MATL, exceeded its max rating of 325 MW.
- Neither dynamic simulation showed any voltage violations, as seen in the appendices.

If the conditions of this pipeline disruption scenario were to occur, the PF analysis and PCM show that the Western Interconnection is potentially at risk of low voltages and unserved energy, respectively, before the full 24,000 MW of generation shown in the Interface Study become unavailable. The Western Interconnection is also vulnerable to other potential reliability concerns under transmission contingency conditions.

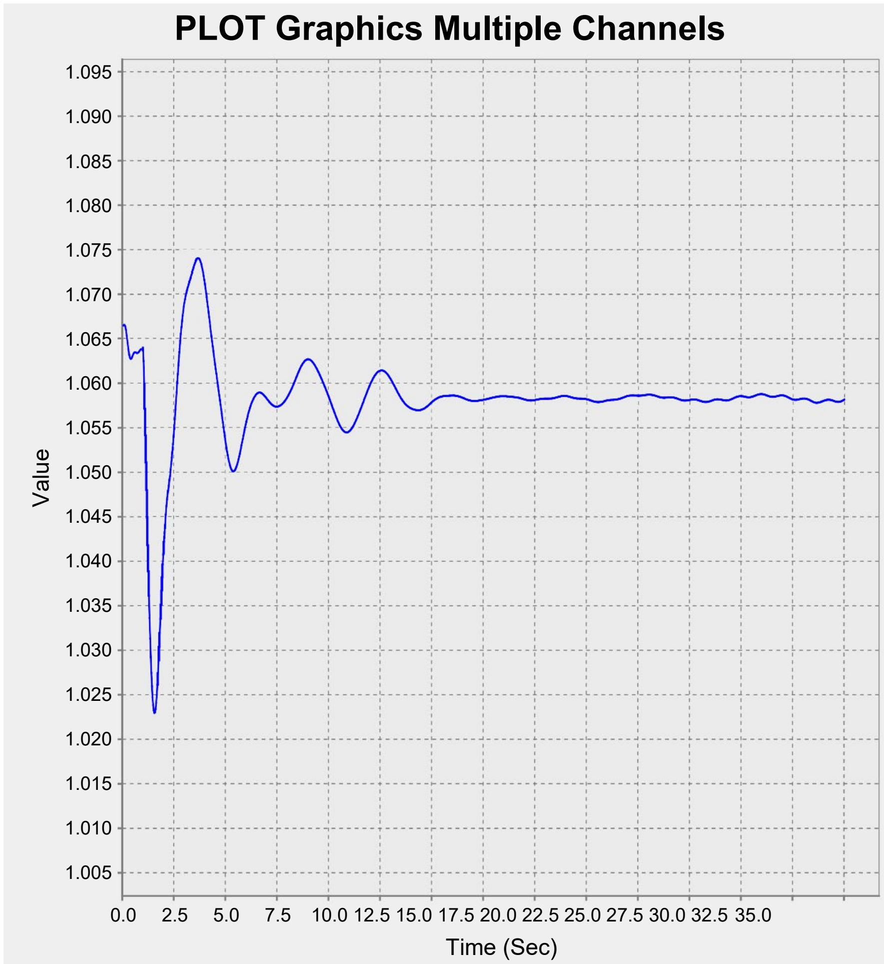
7 Recommendations

Natural gas, and fuel availability in general, should be considered when planning the bulk power system. This study illustrates an extreme scenario, but it does highlight the risks associated with fuel availability.

[8] For Path 15, the transfer limit ranges from 2,000-3,265 MW from north-to-south. For this study, the limit was 2,000 MW.

8 Appendix A: Dynamic results for the bi-pole PDCI contingency

Figure 8-1—Voltage at a 500-kV bus in Sothern California



WESTERN ELECTRICITY COORDINATING COUNCIL
2028 HS1 ADS PLANNING CASE
DECEMBER 20, 2017
Loss of Southern Line Simulation
August 26, 2019
ALL COMMENTS FROM DS REVIEW ARE INCLUDED

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Figure 8-2— Voltage at a 500-kV bus in Arizona

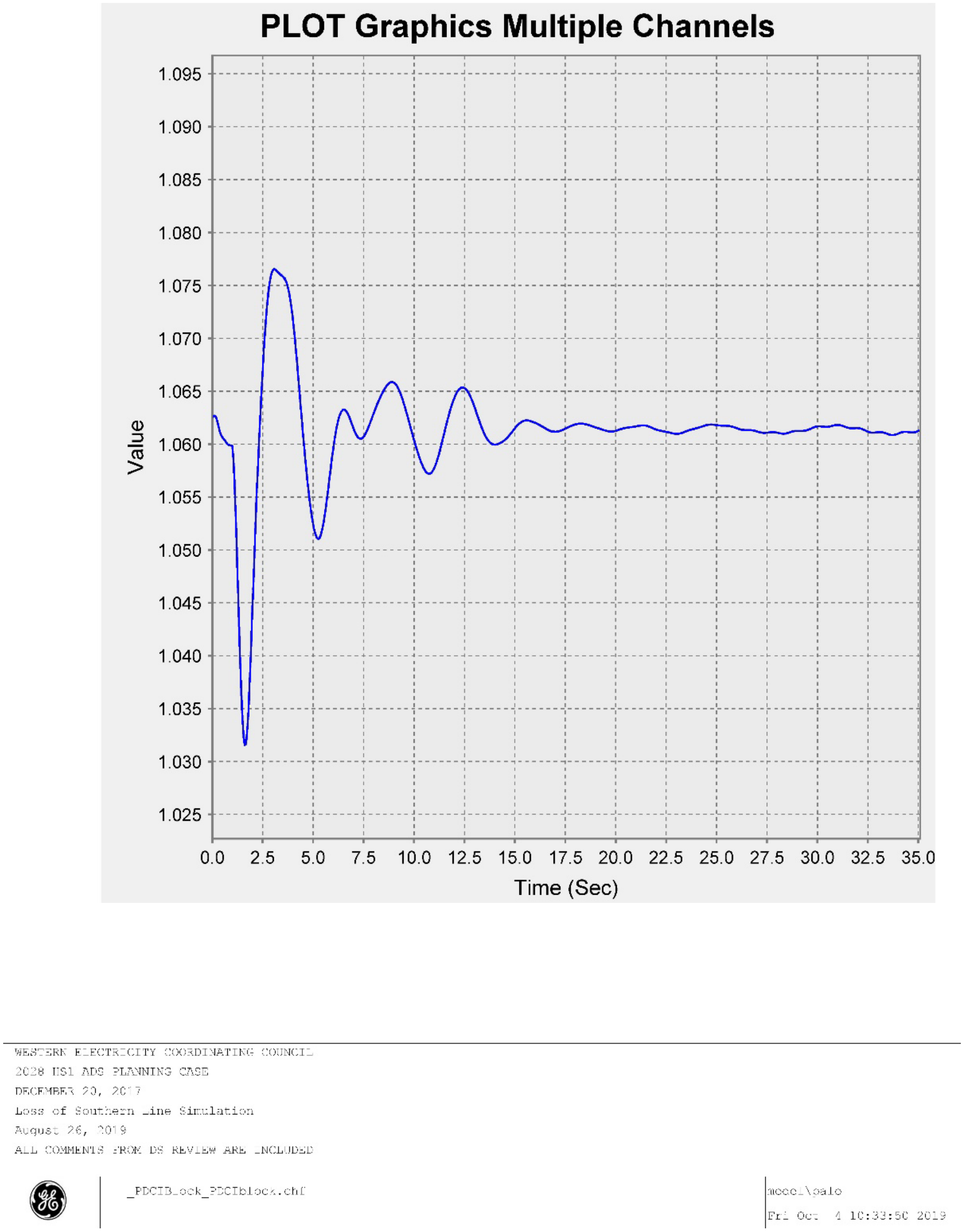

Figure 8-3— Voltage at a 500-kV bus in Northwest

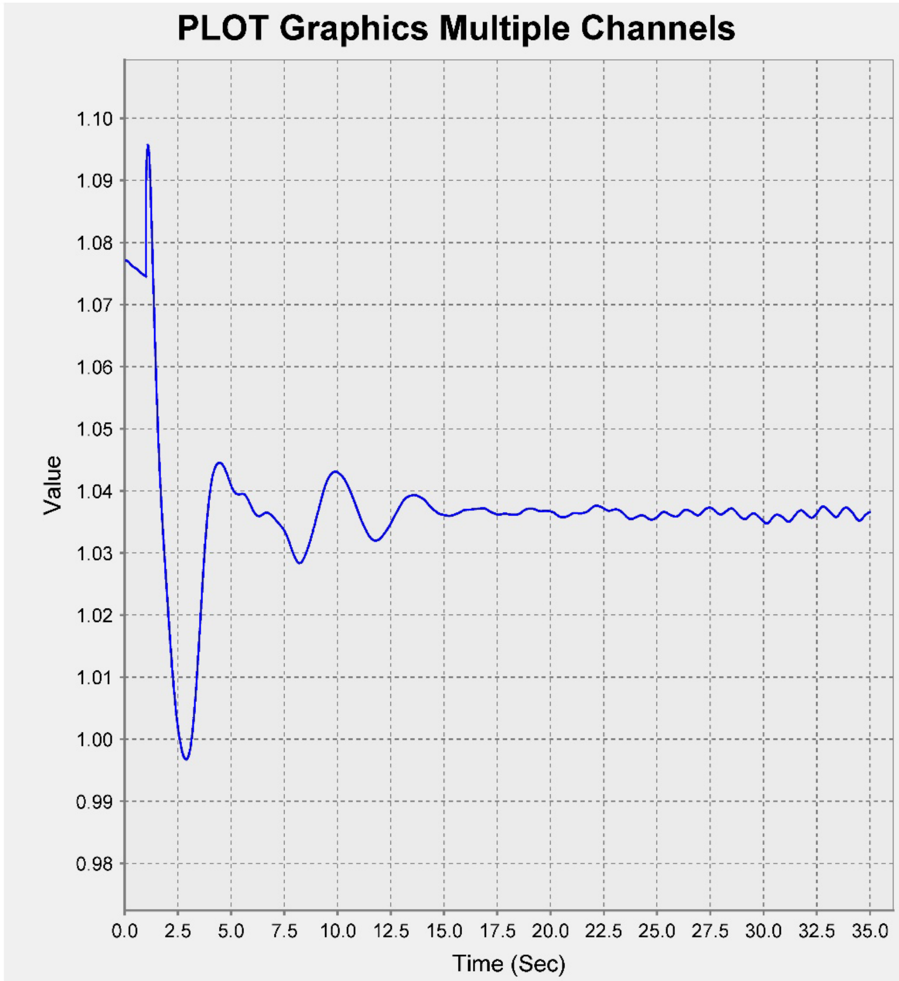

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Figure 8-4— Voltage at a 500-kV bus in Nevada

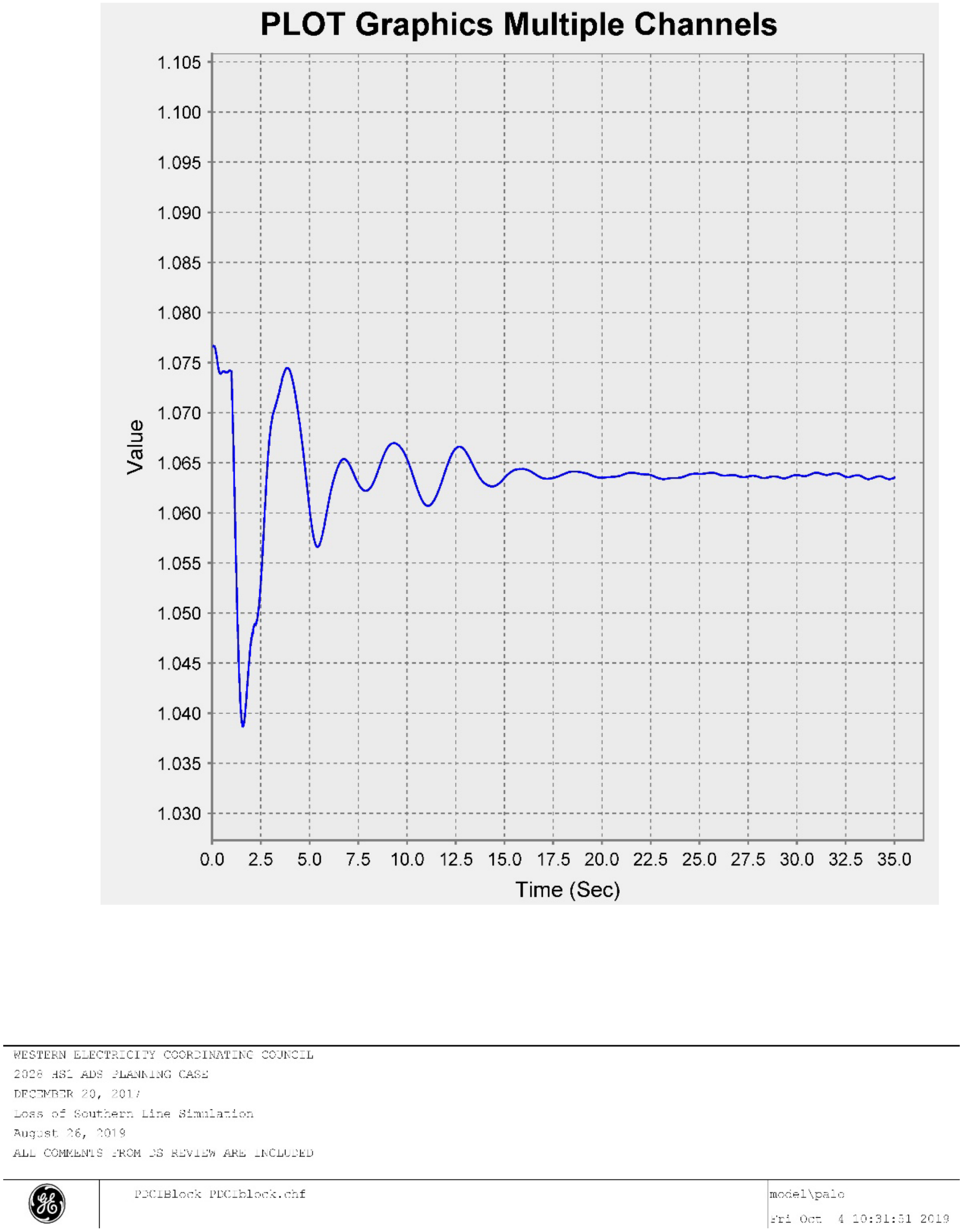

Figure 8-5— Voltage at a 345-kV bus in Colorado

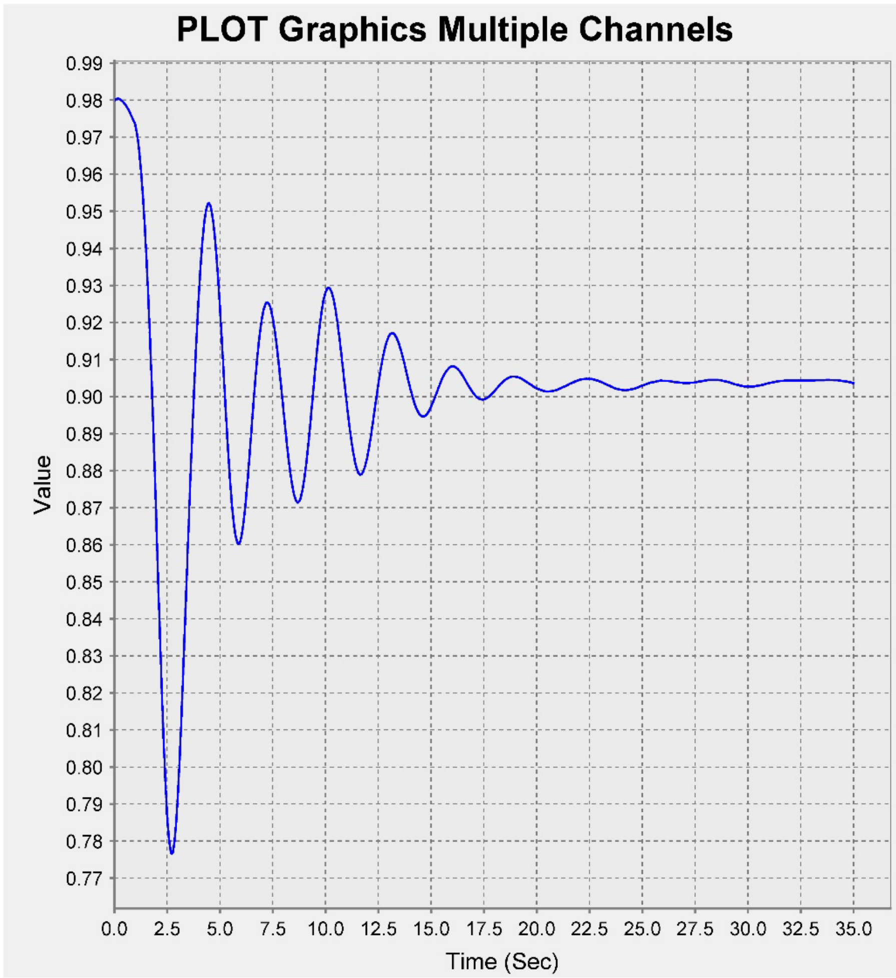

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Figure 8-6— Voltage at a 345-kV bus in Utah

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Figure 8-7—Path 3 Northwest to British Columbia

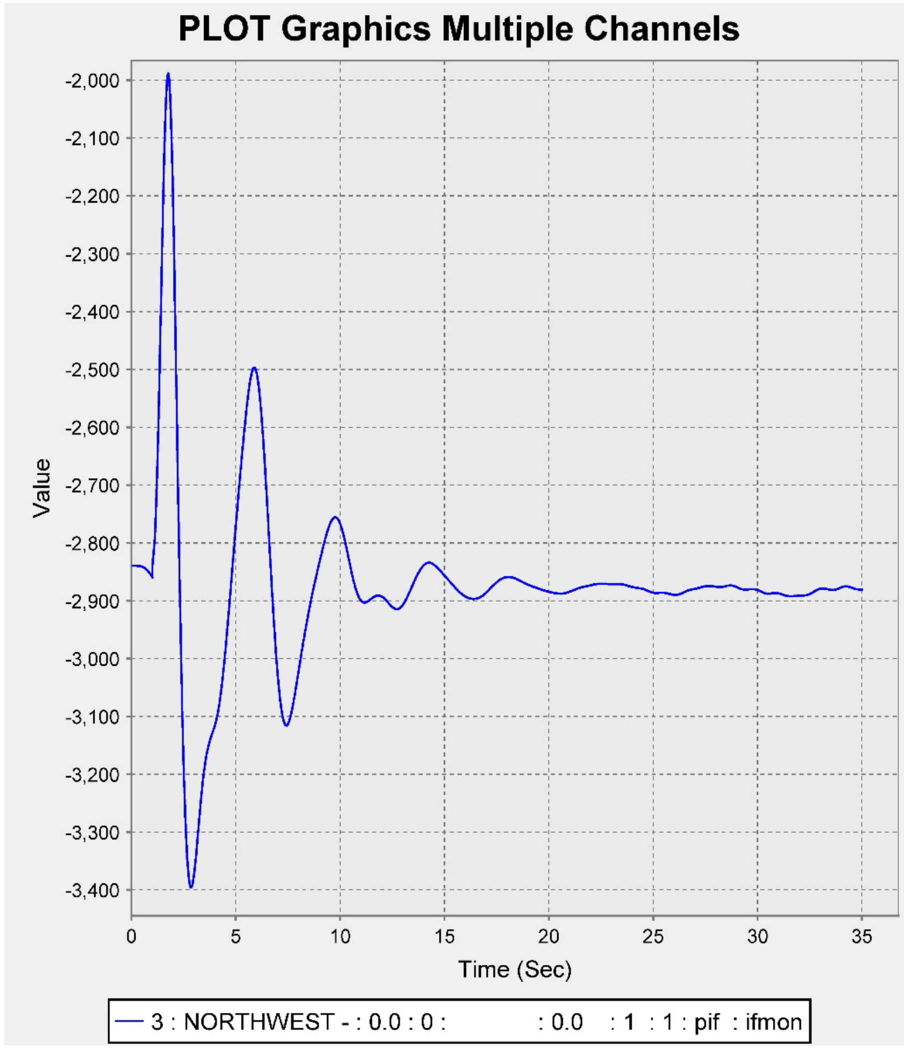

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Figure 8-8—Path 15 Midway to Los Banos

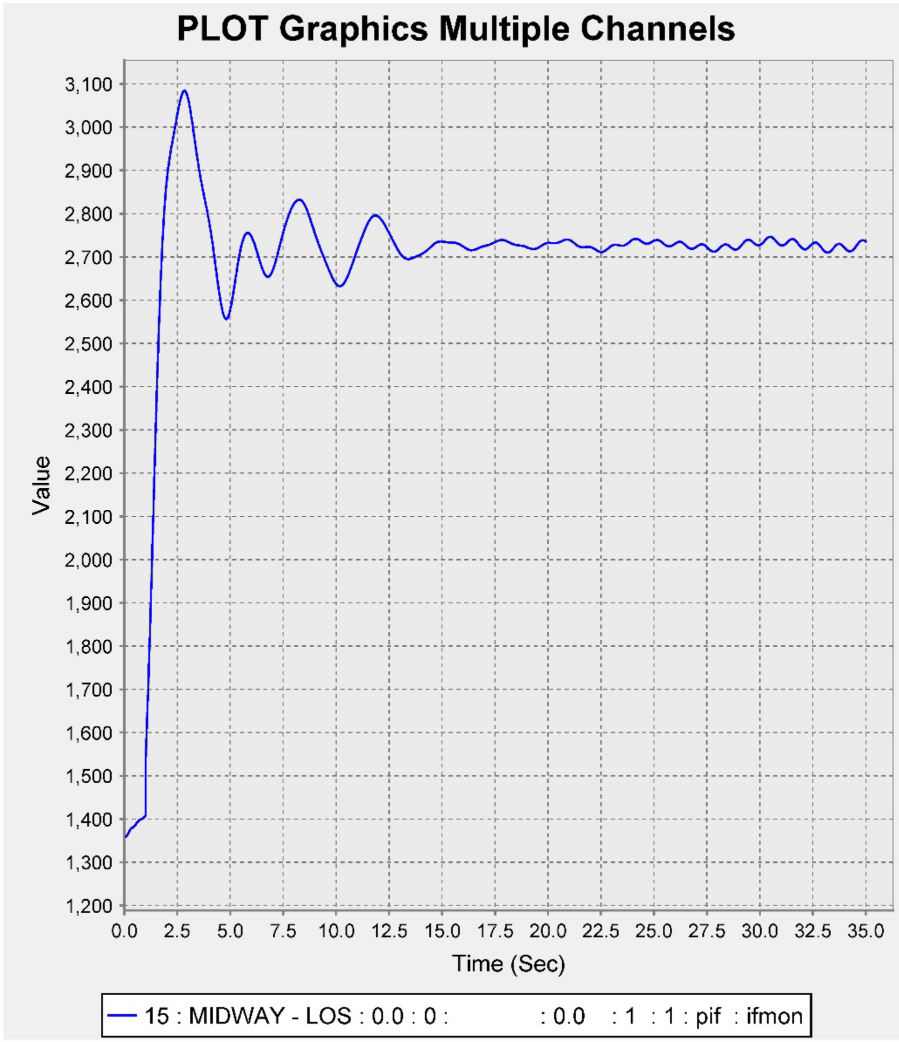

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Figure 8-9—Path 26 Norther to Southern California

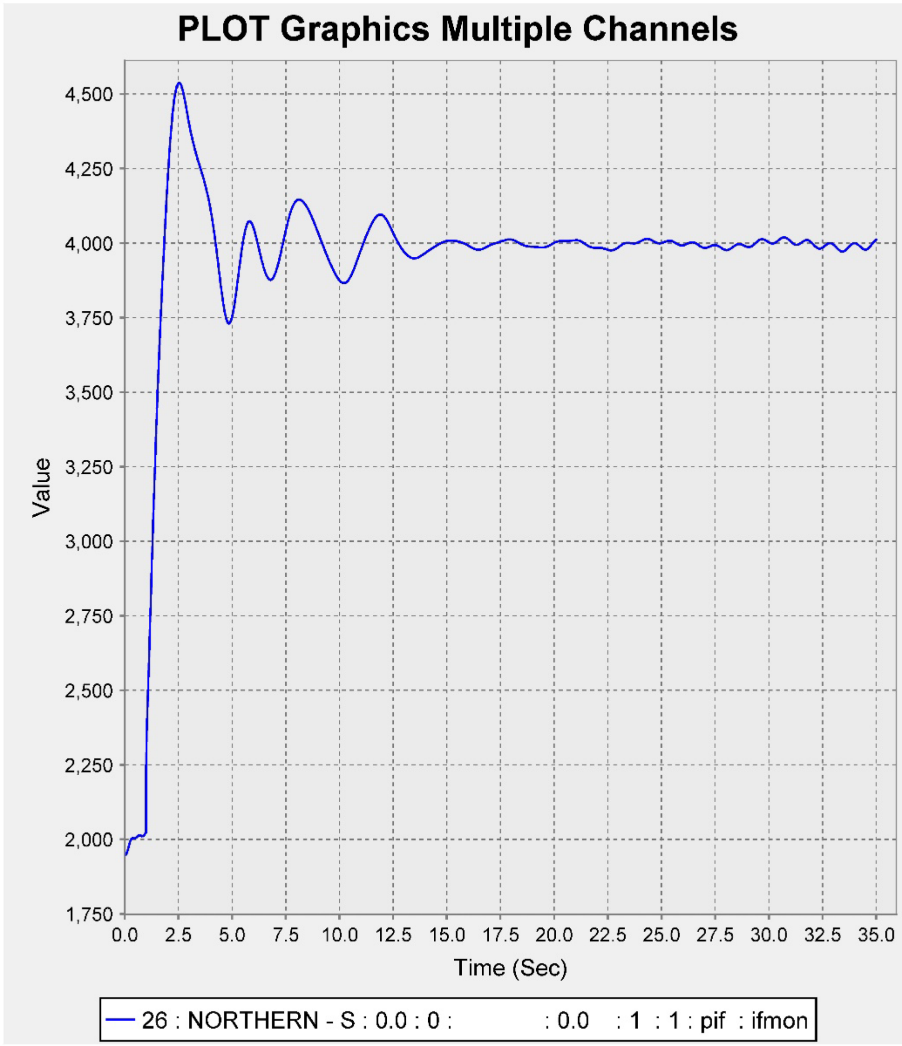

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Figure 8-10—Path 46 West of Colorado River

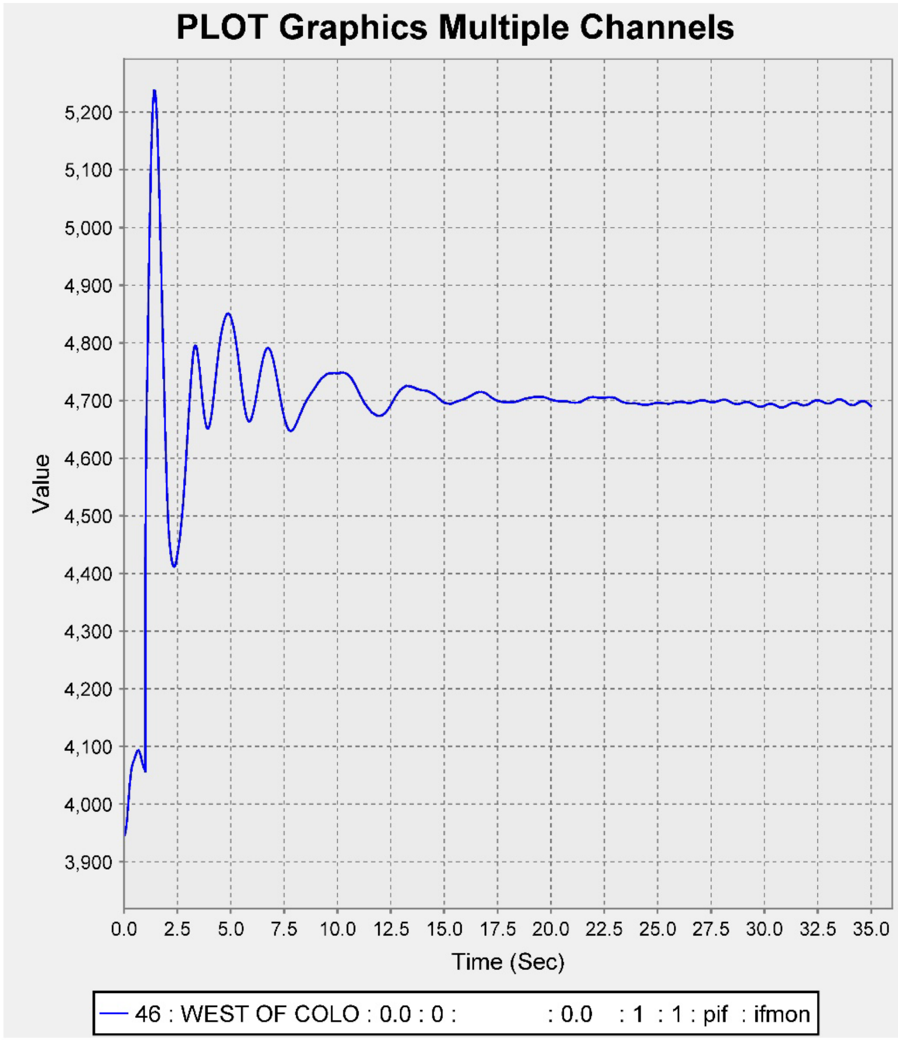

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Figure 8-11—Path 49 East of Colorado River

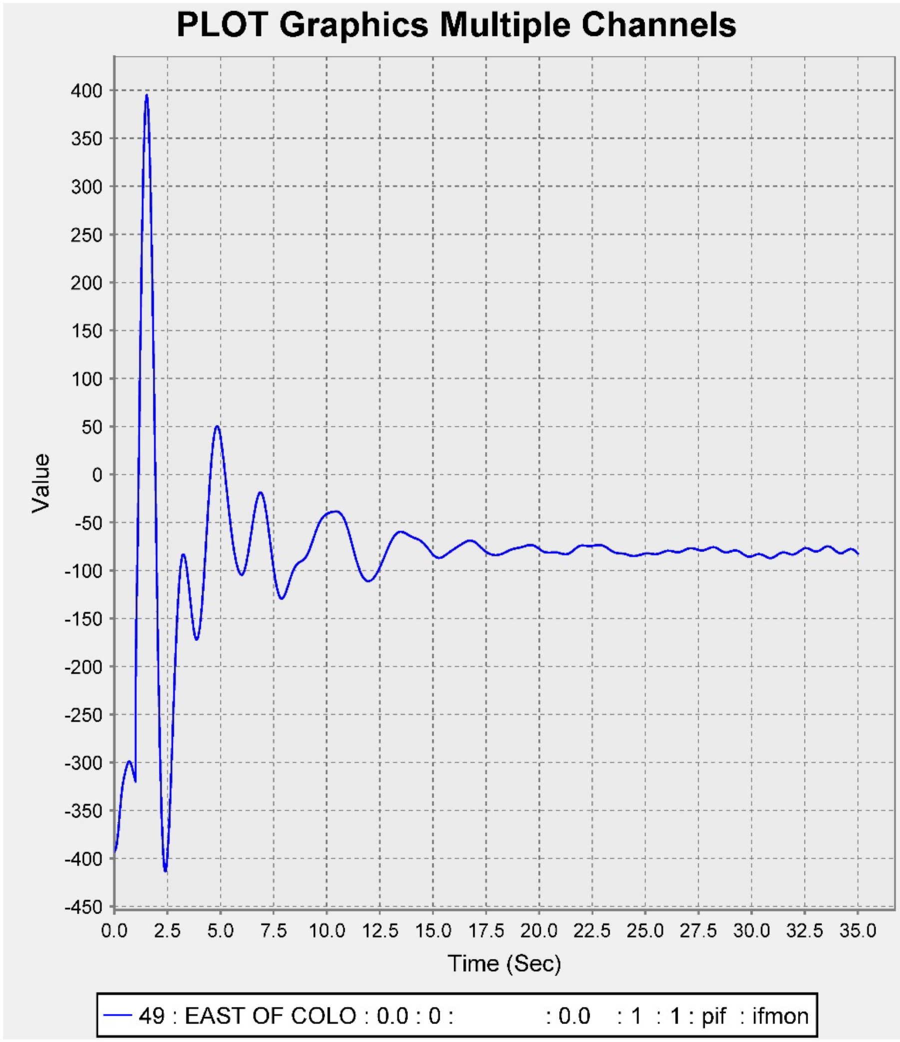

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Figure 8-12—Path 66 California Oregon Intertie

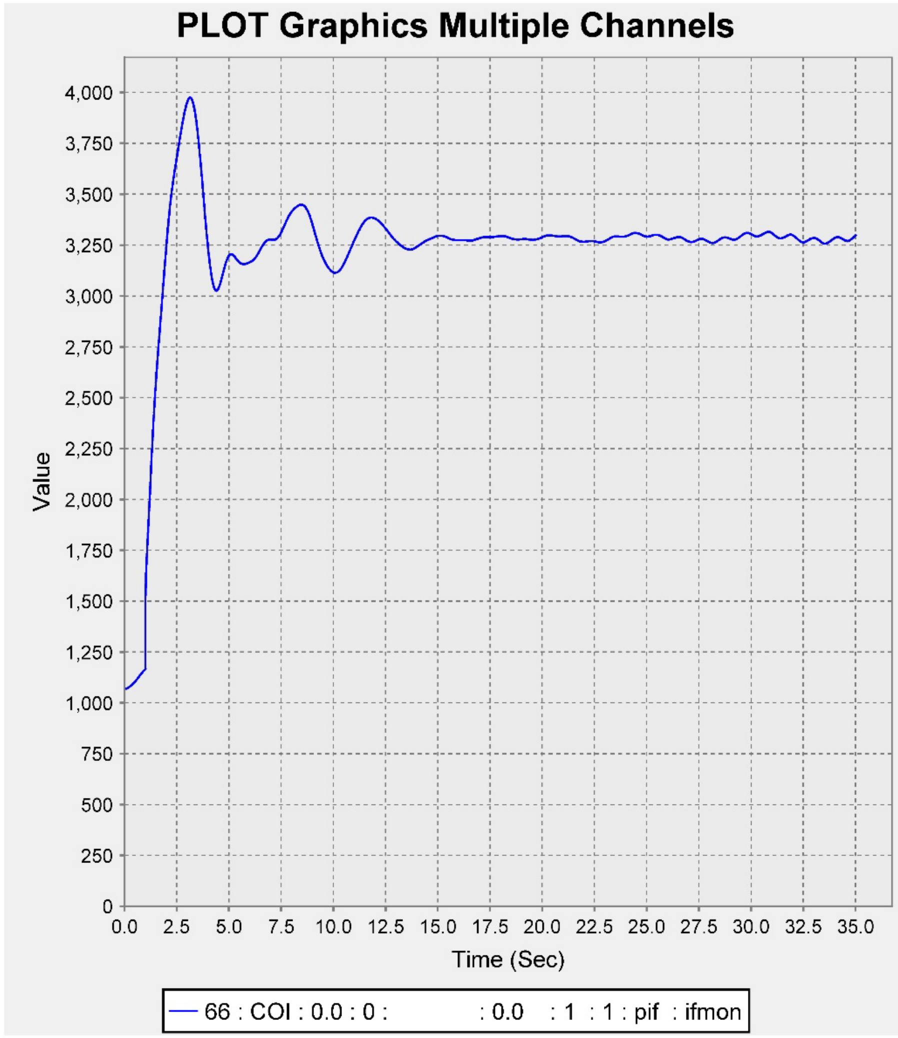

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Figure 8-13—Southern California Gas Generator response

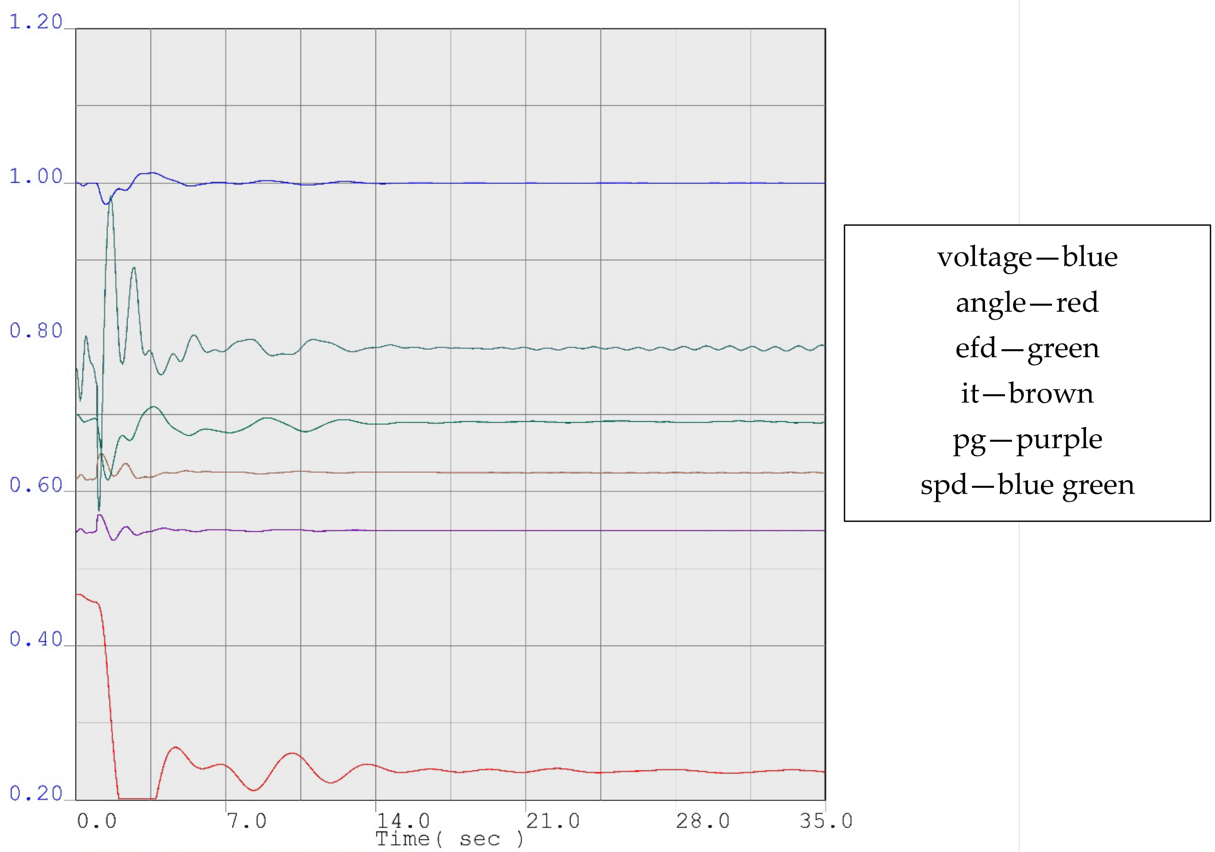

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Figure 8-14—Colorado Gas Generator response

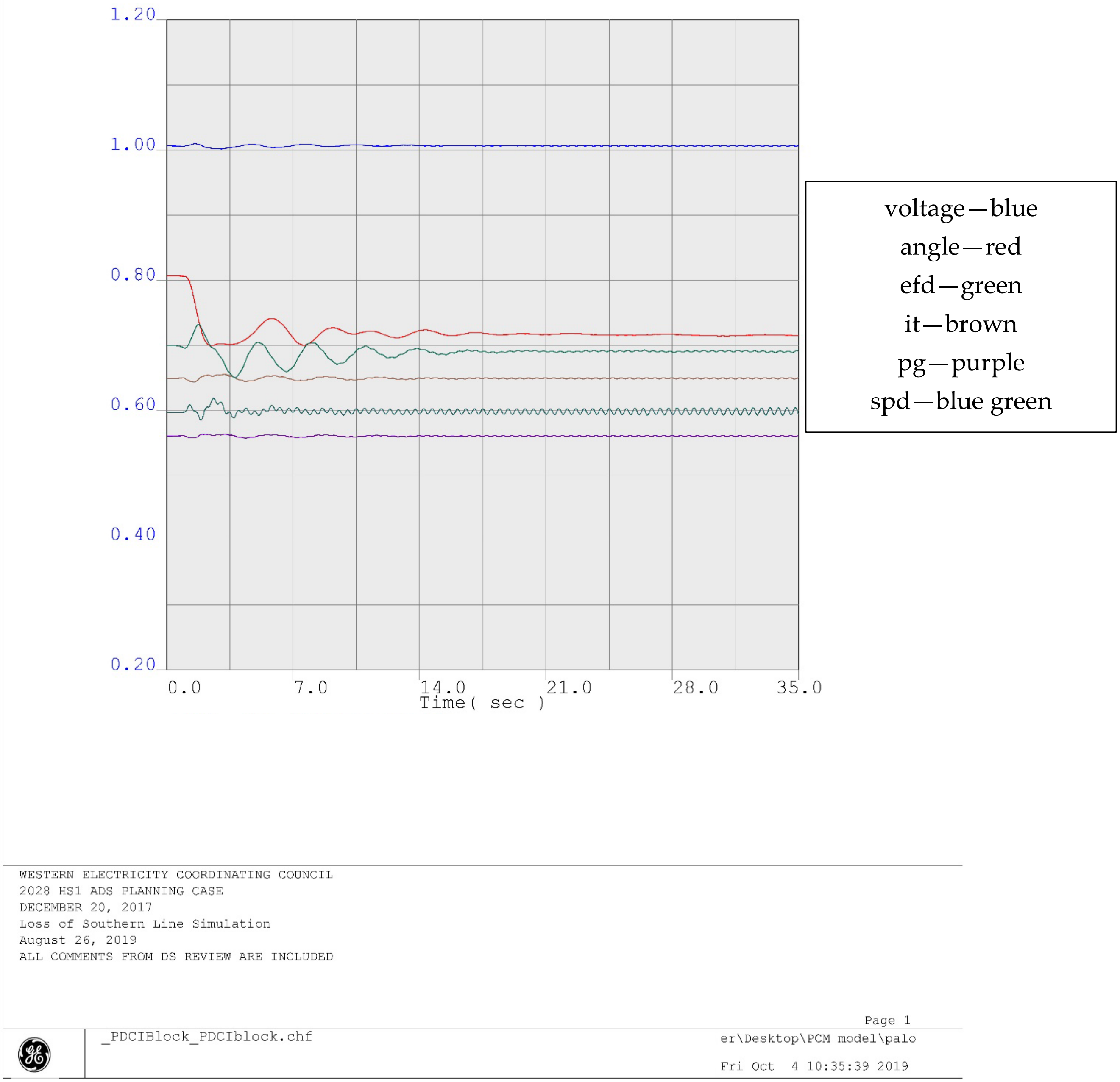


Figure 8-15—Utah Gas Generator response

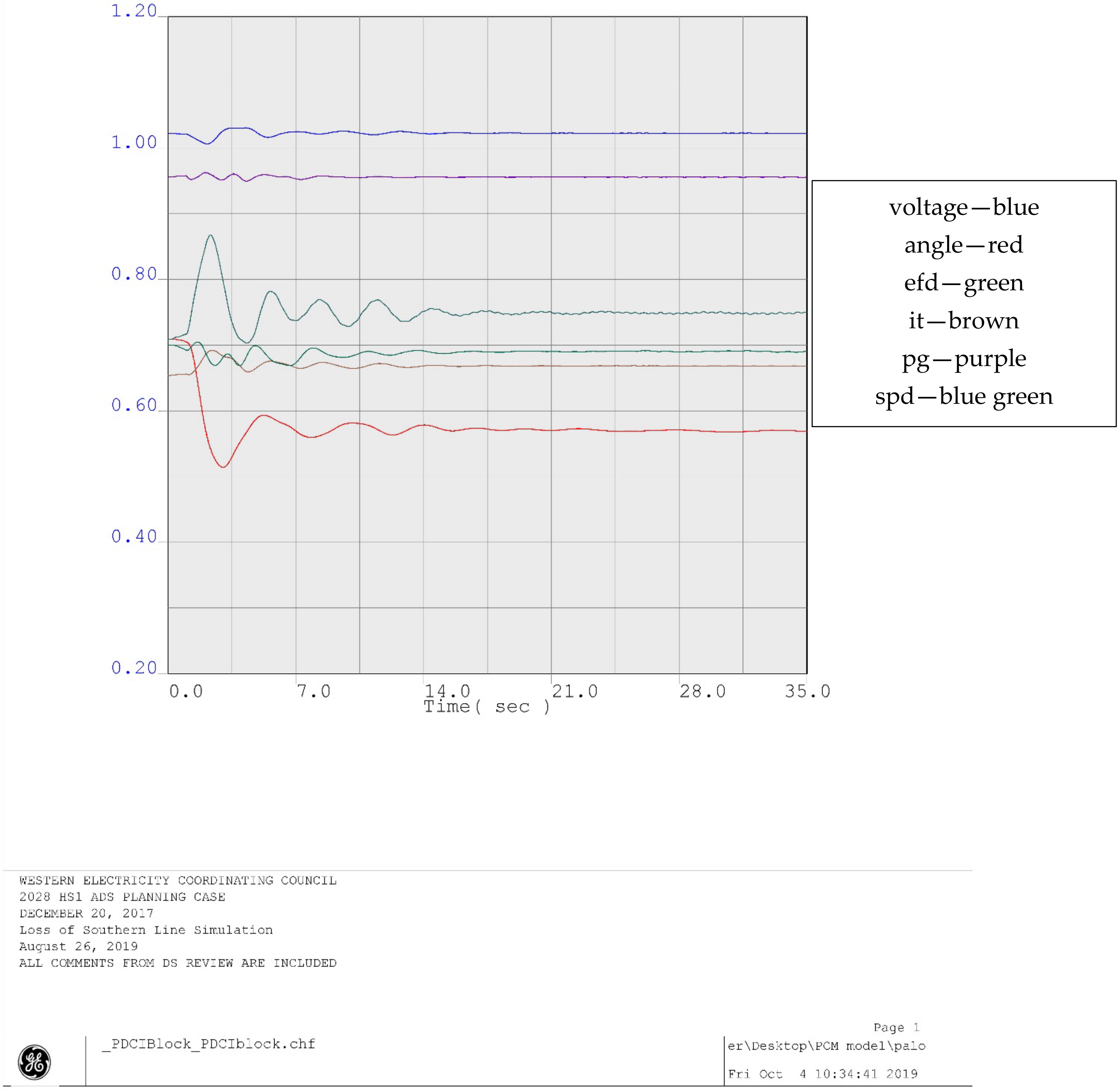


Figure 8-16—Northwest Gas Generator response

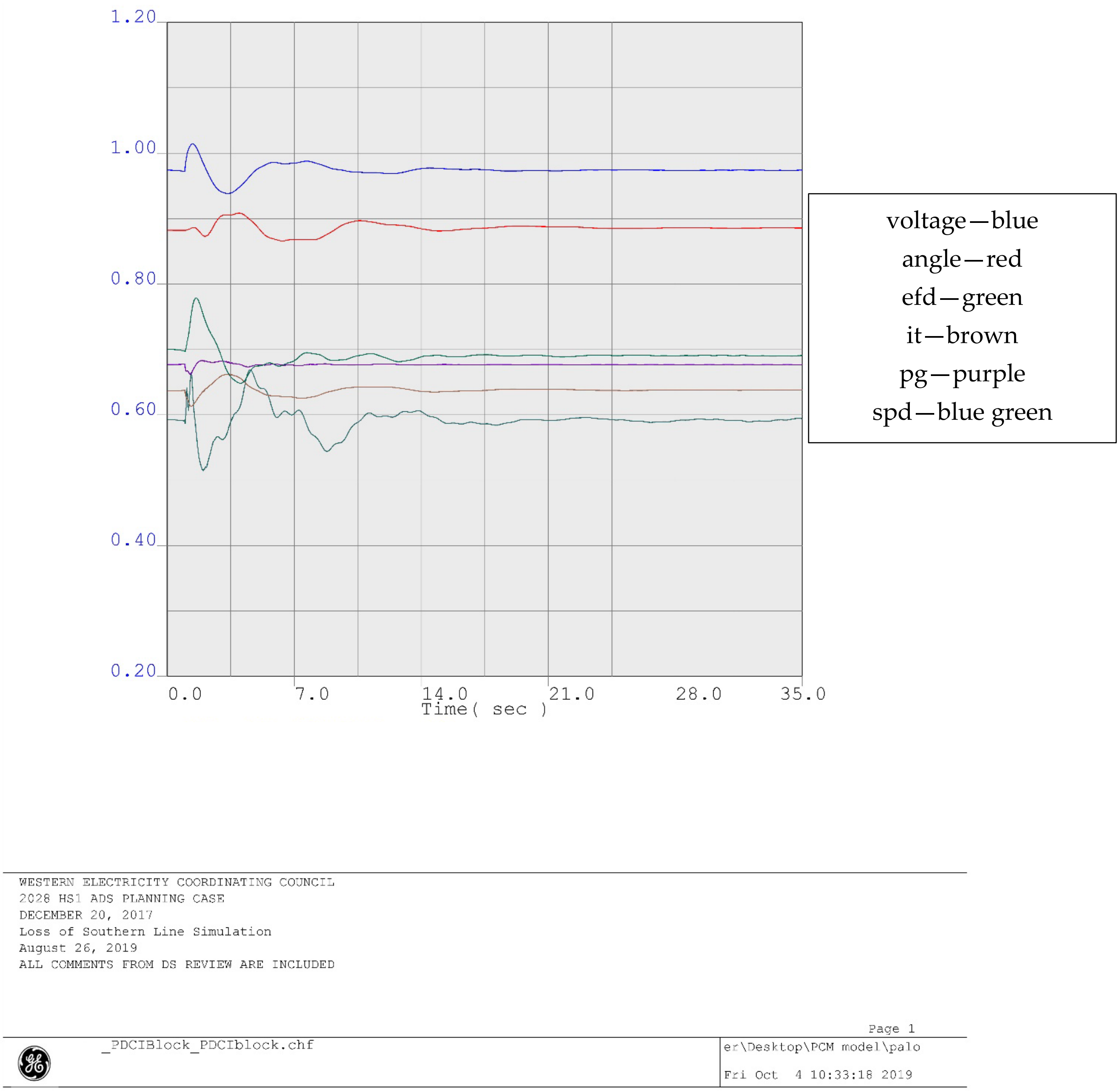


Figure 8-17—Southern California Gas Generator response

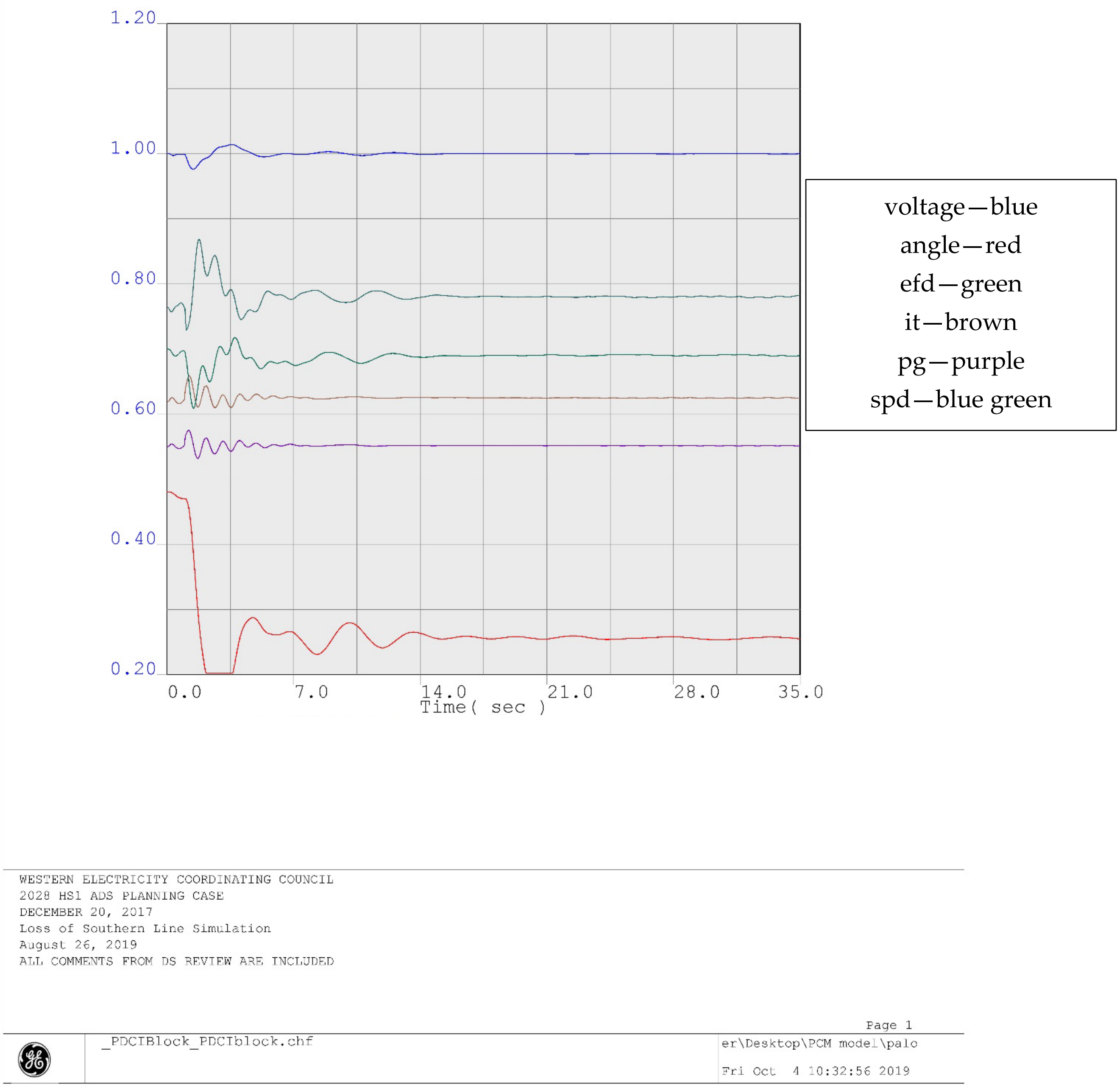
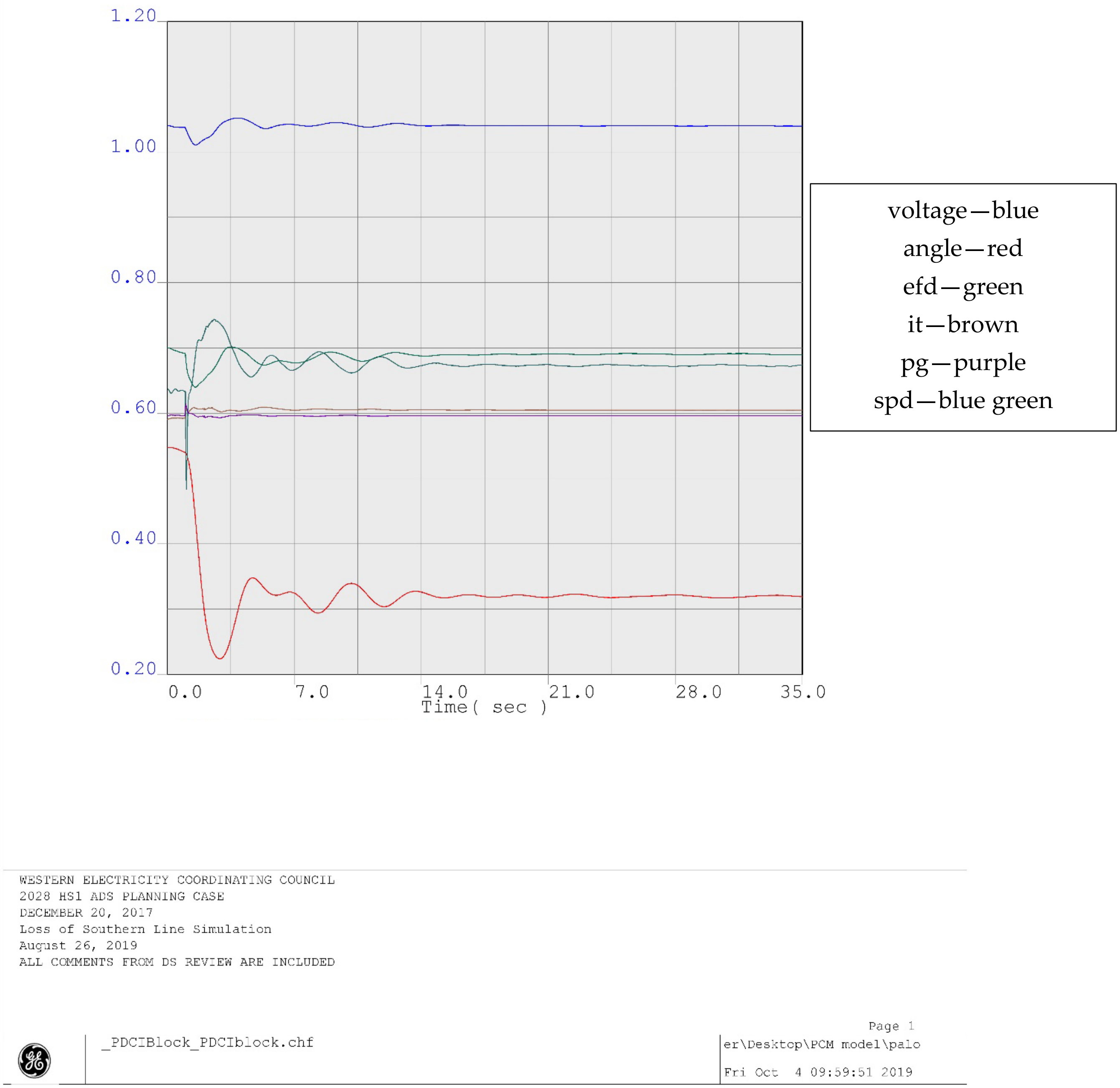


Figure 8-18—Nevada Gas Generator response



9 Appendix B: Dynamics results for the loss of a single Palo Verde unit

Figure 9-1— Voltage at a 500-kV bus in Sothern California

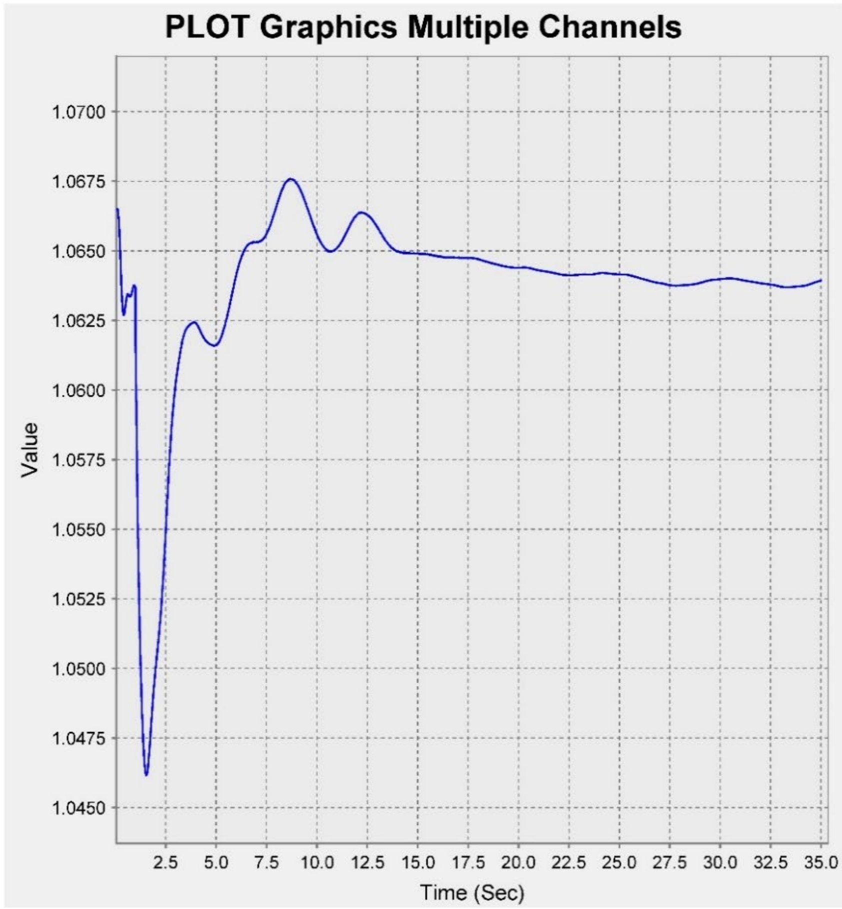


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Figure 9-2— Voltage at a 500-kV bus in Arizona

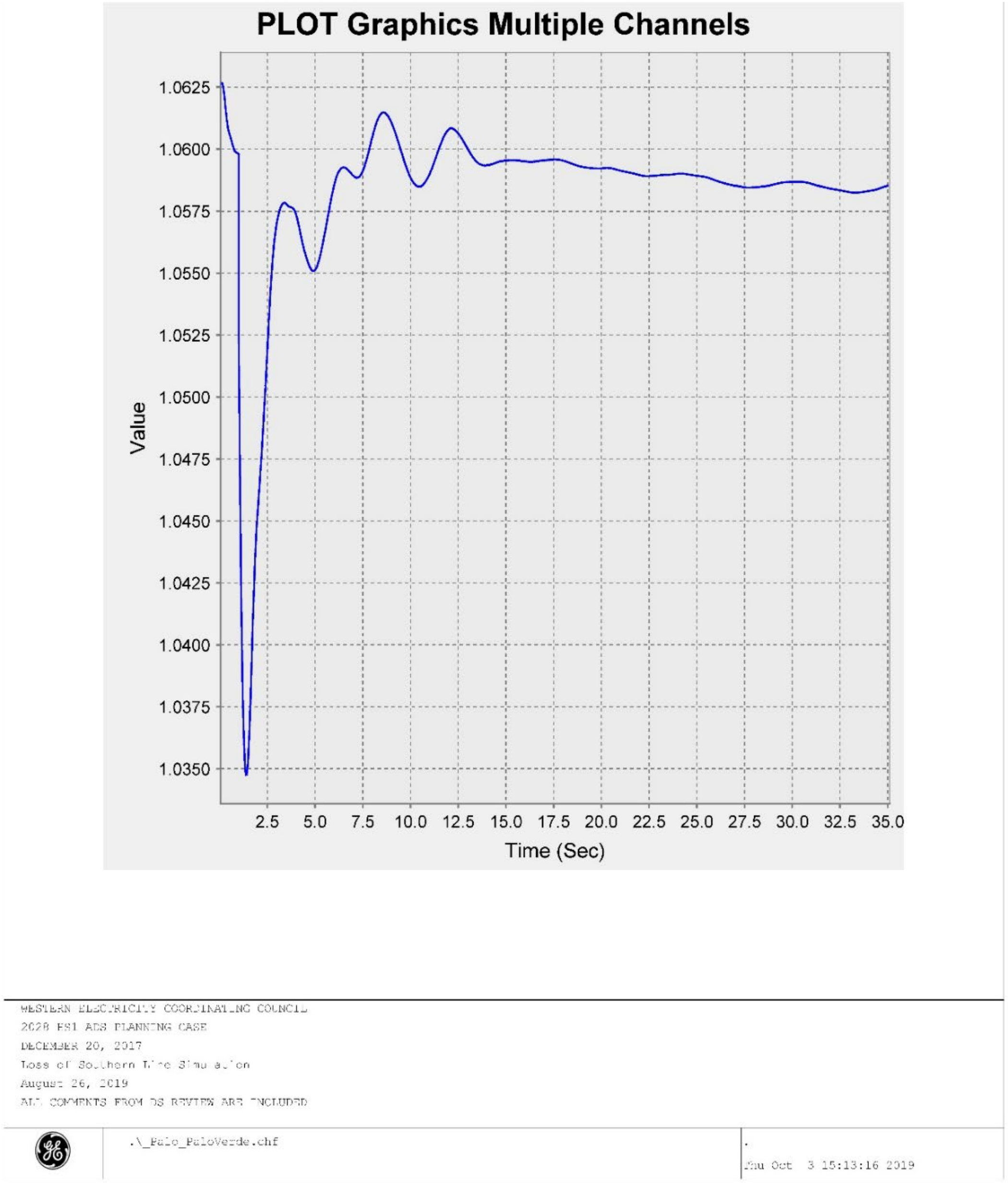

Figure 9-3— Voltage at a 500-kV bus in Northwest

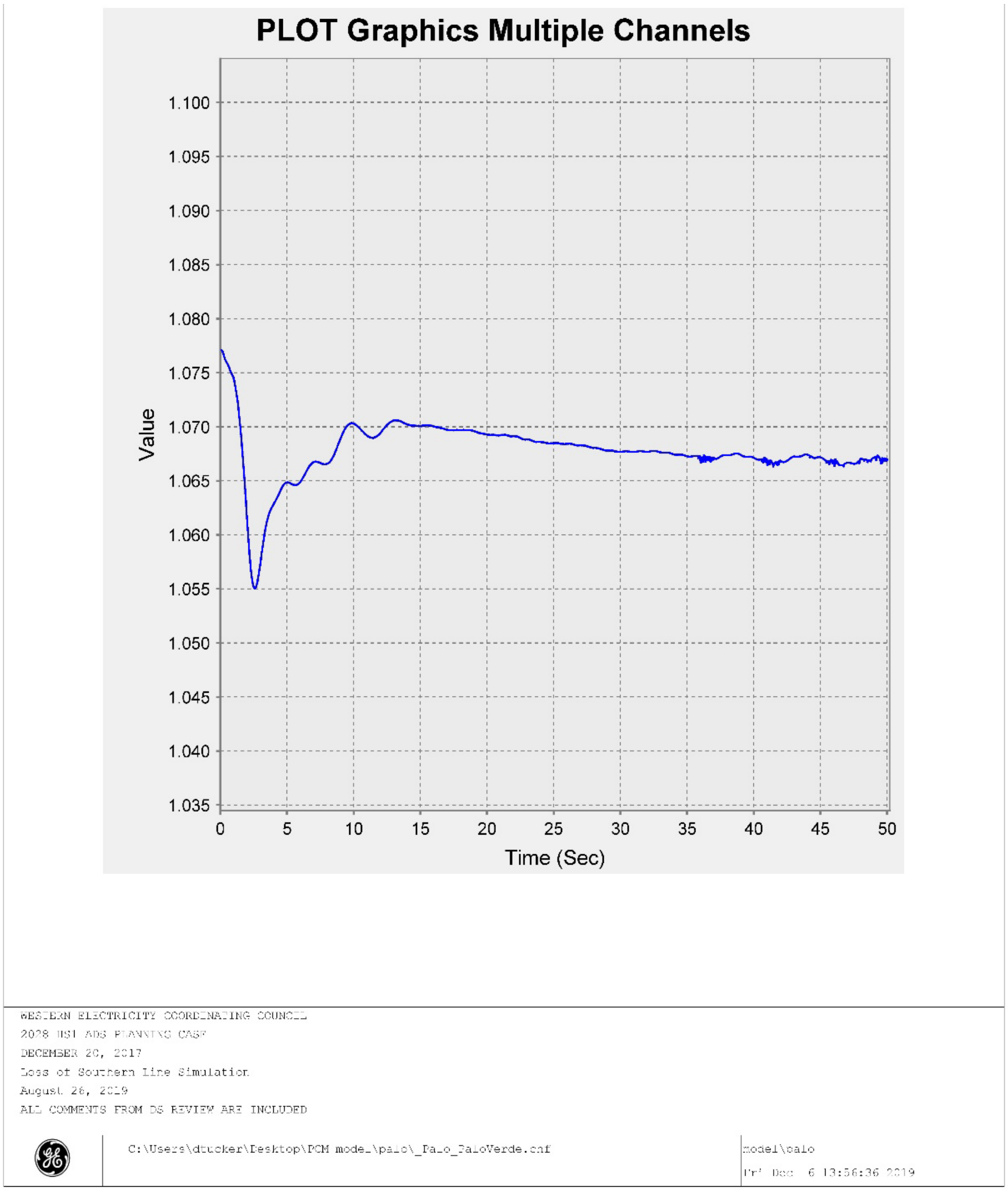

Figure 9-4— Voltage at a 500-kV bus in Nevada

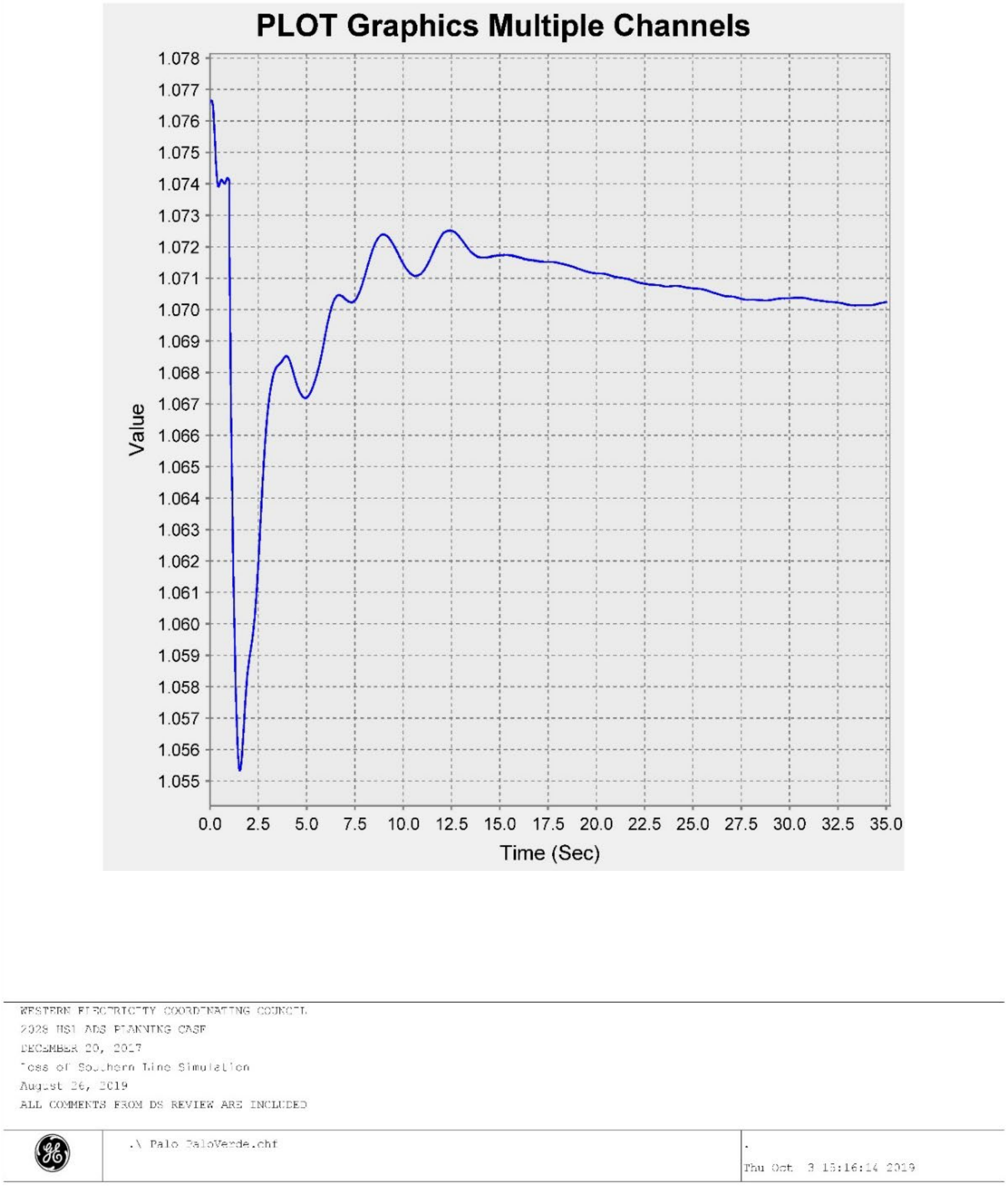

Figure 9-5— Voltage at a 345-kV bus in Colorado

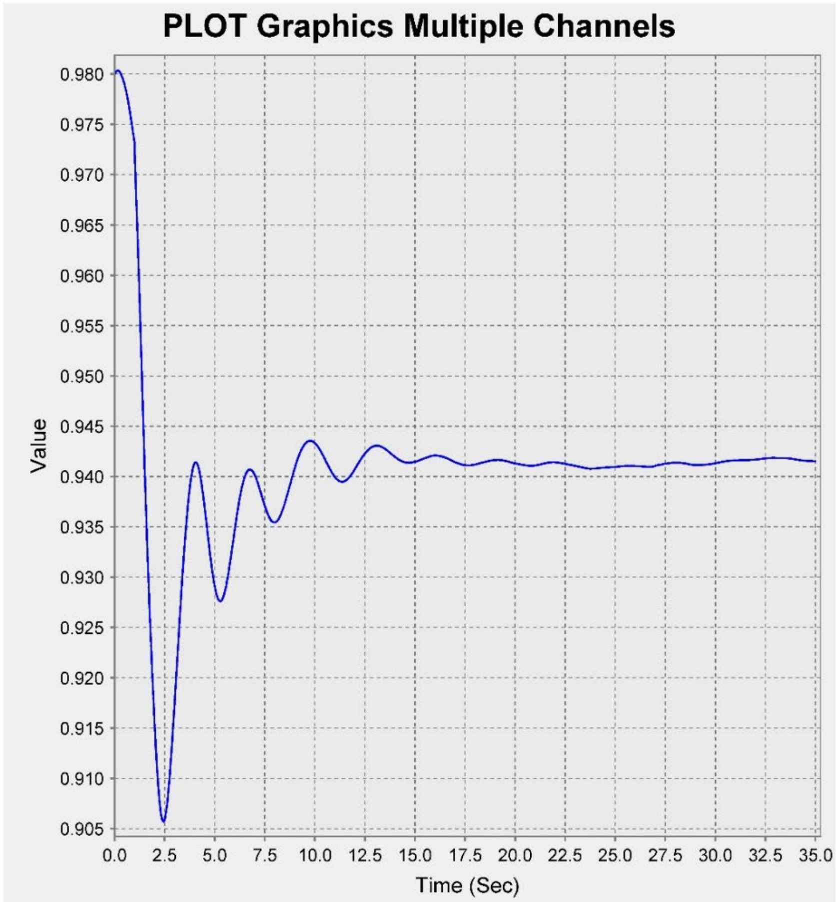

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Figure 9-6— Voltage at a 345-kV bus in Utah

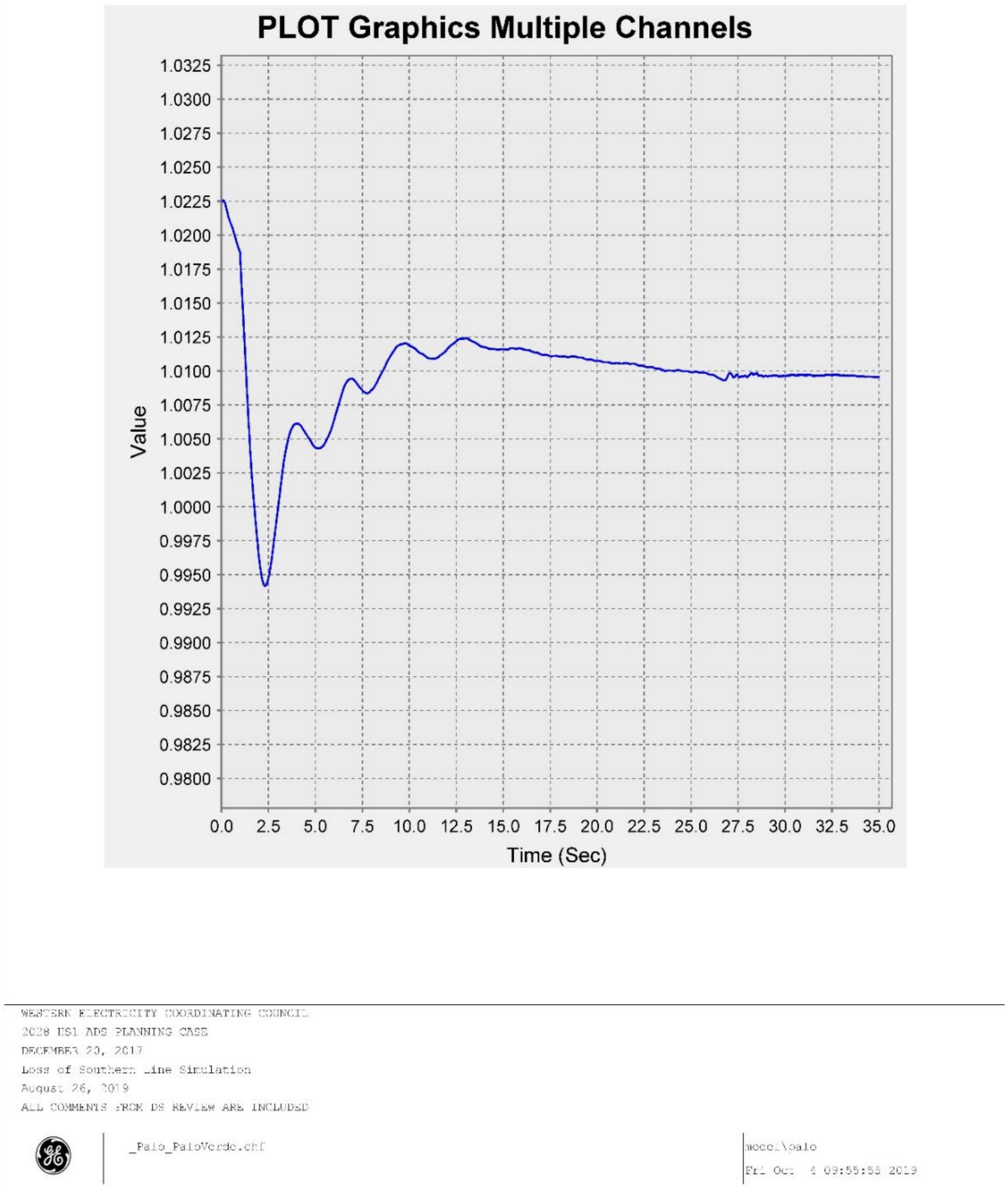


Figure 9-7—Frequency at a 500-kV bus in the Northwest

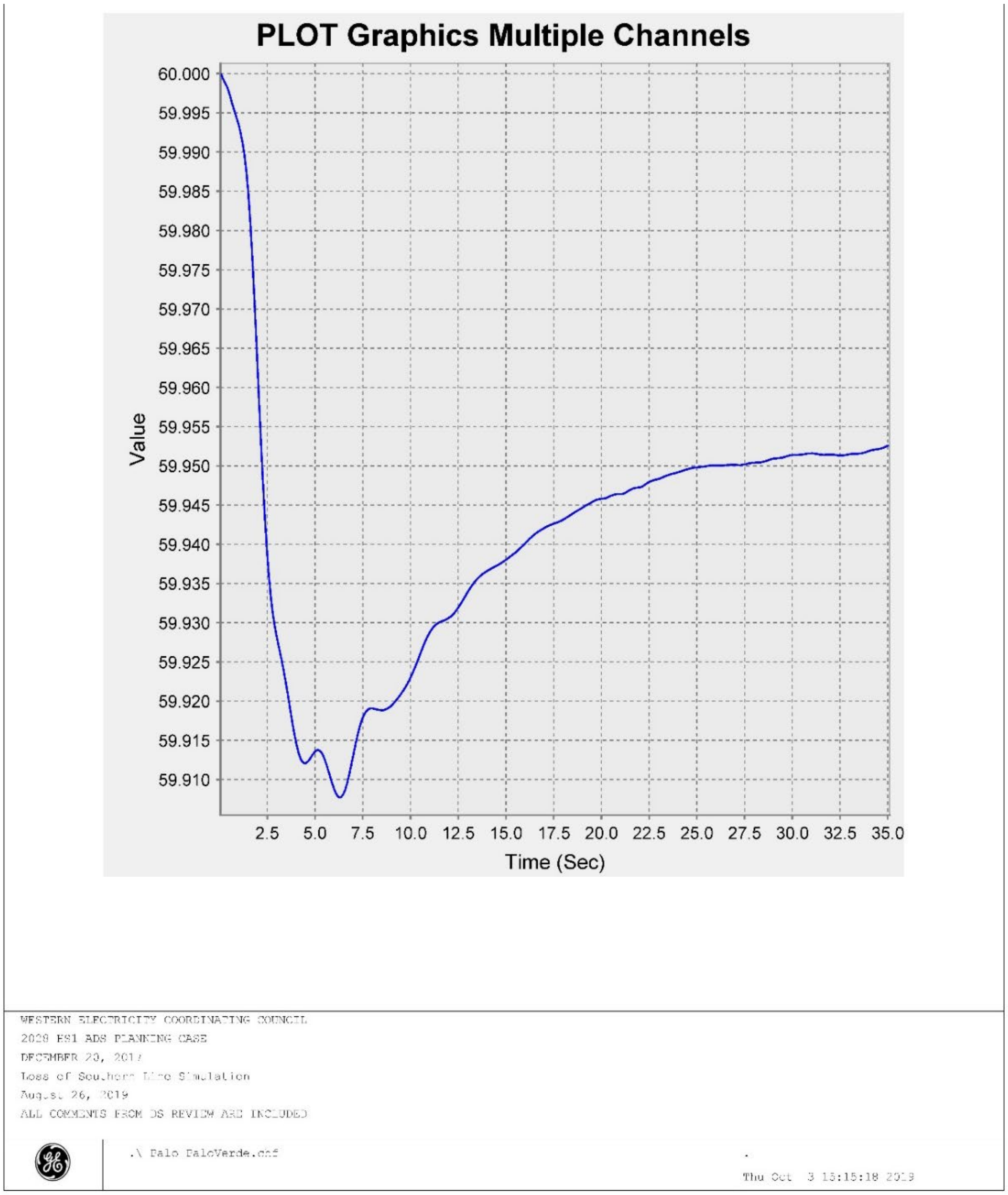


Figure 9-8—Path 3 Northwest to British Columbia

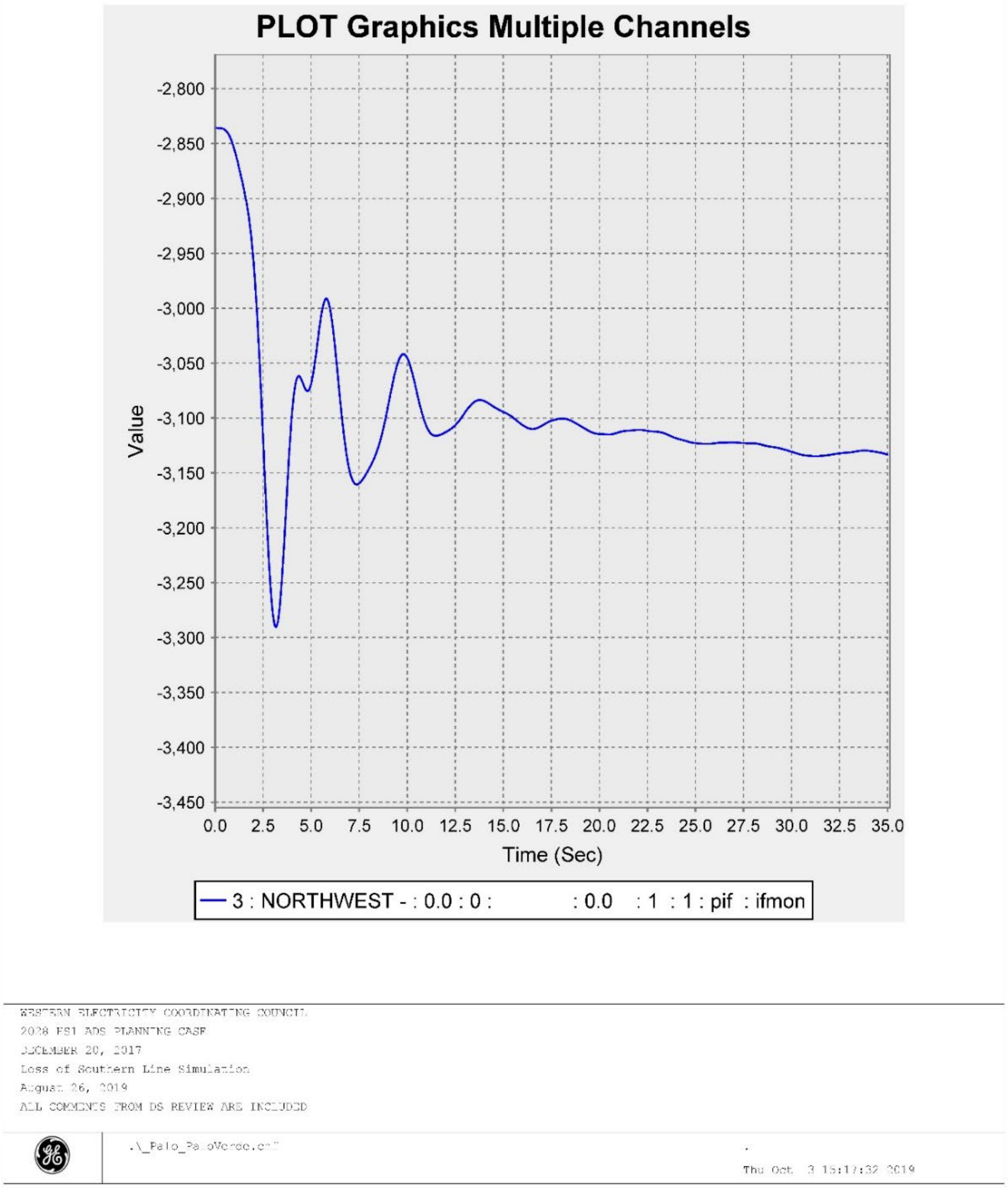


Figure 9-9—Path 15 Midway to Los Banos

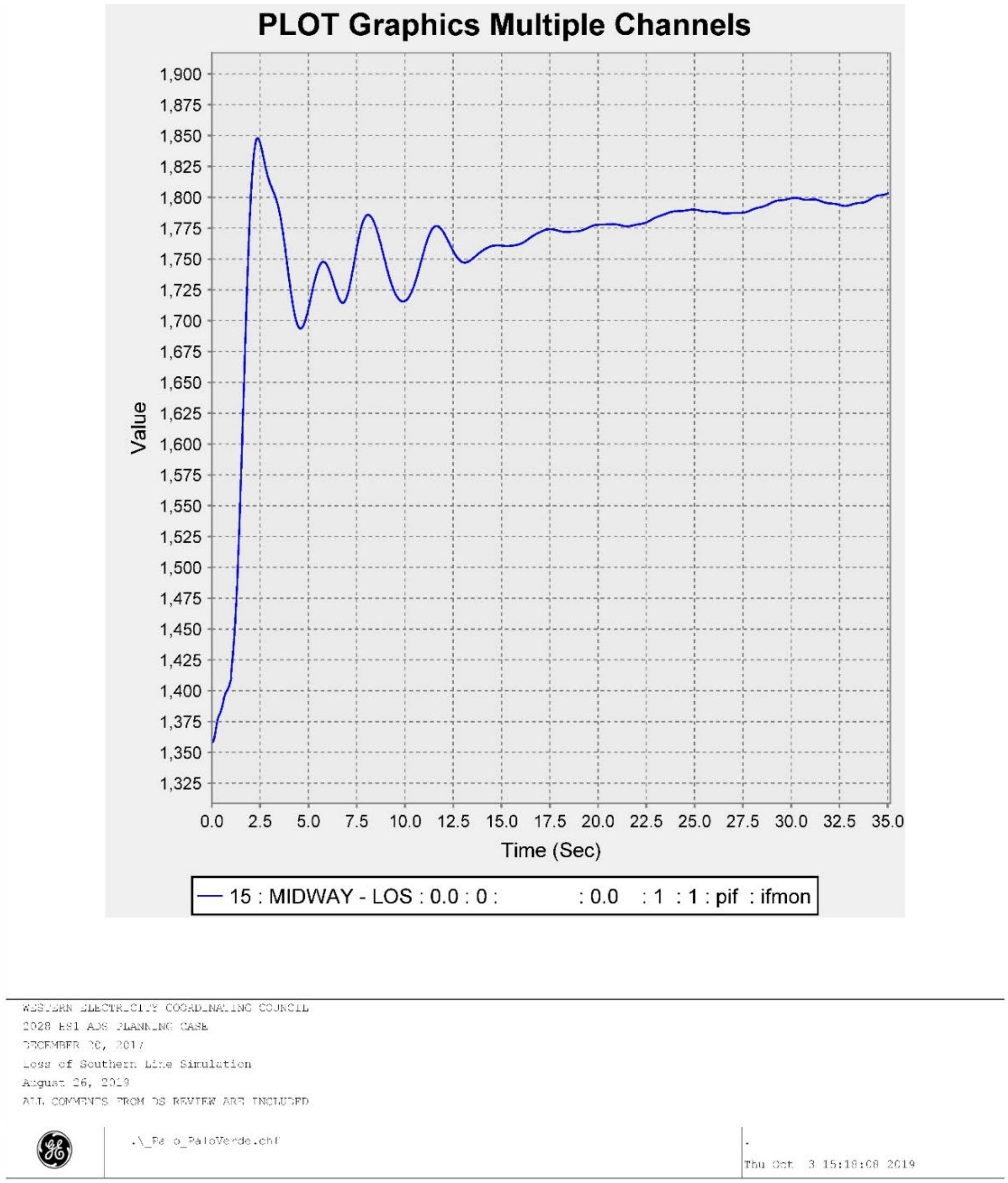


Figure 9-10—Path 26 Northern to Southern California

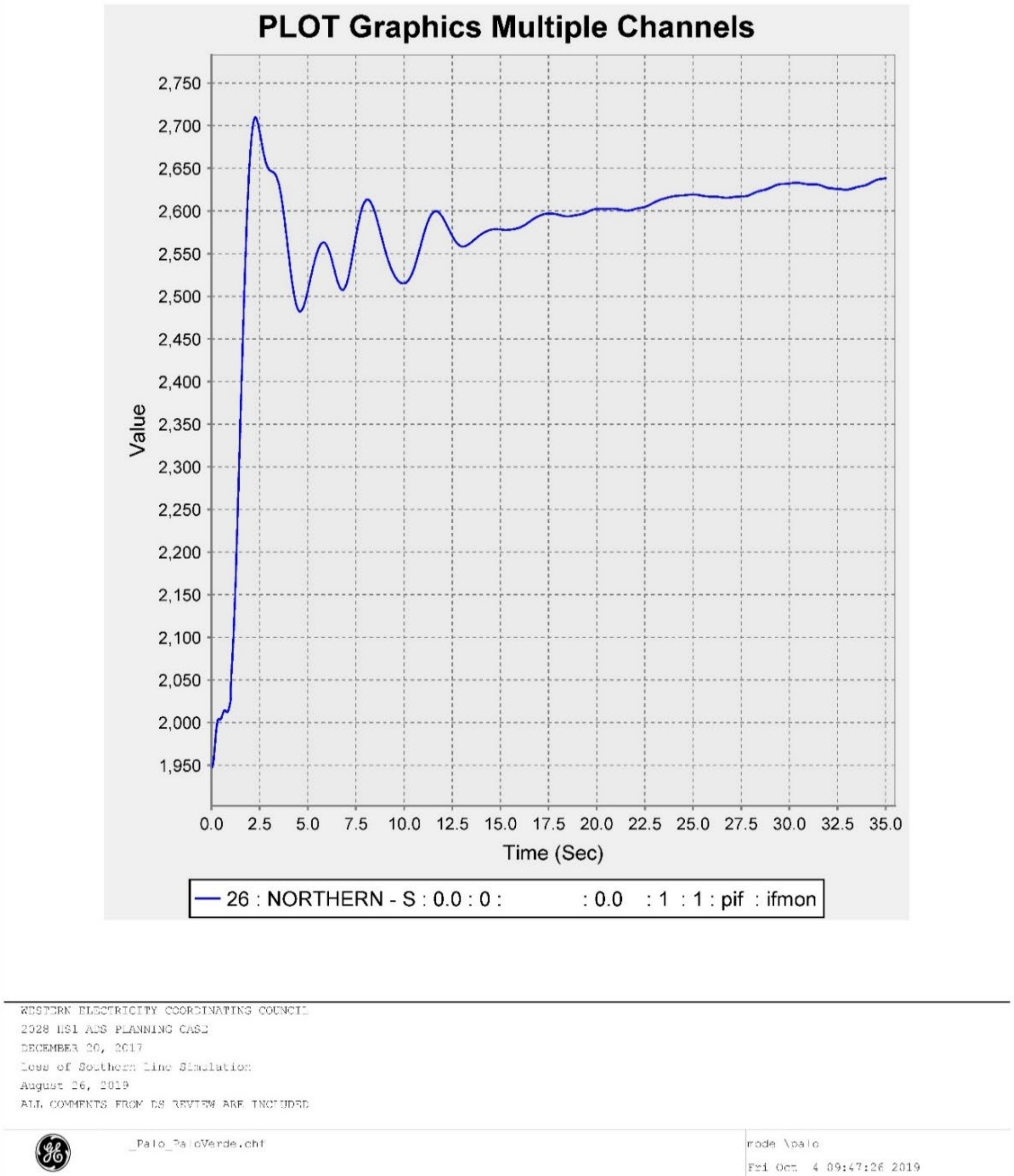


Figure 9-11—Path 46 West of Colorado River

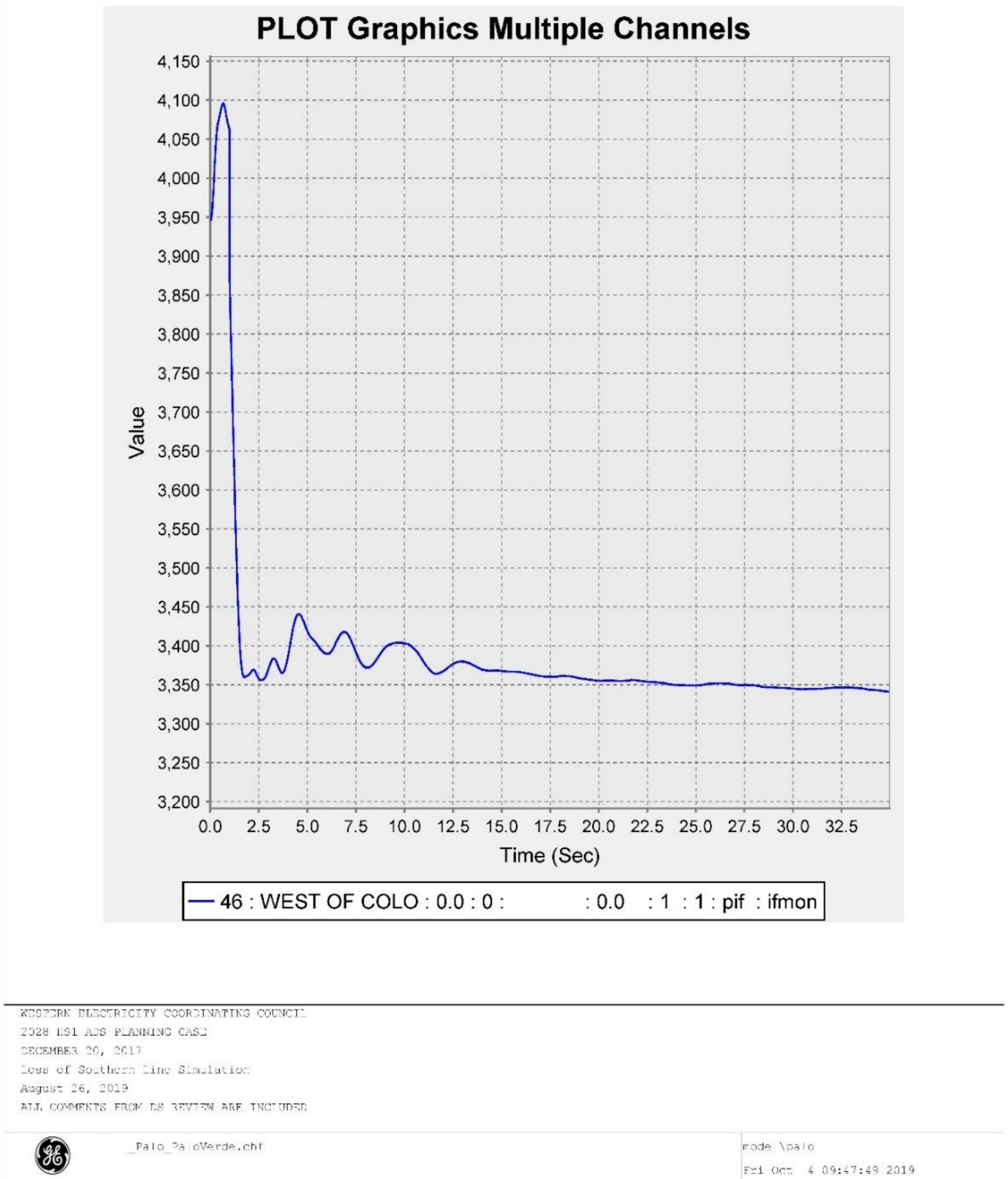


Figure 9-12—Path 49 East of Colorado River

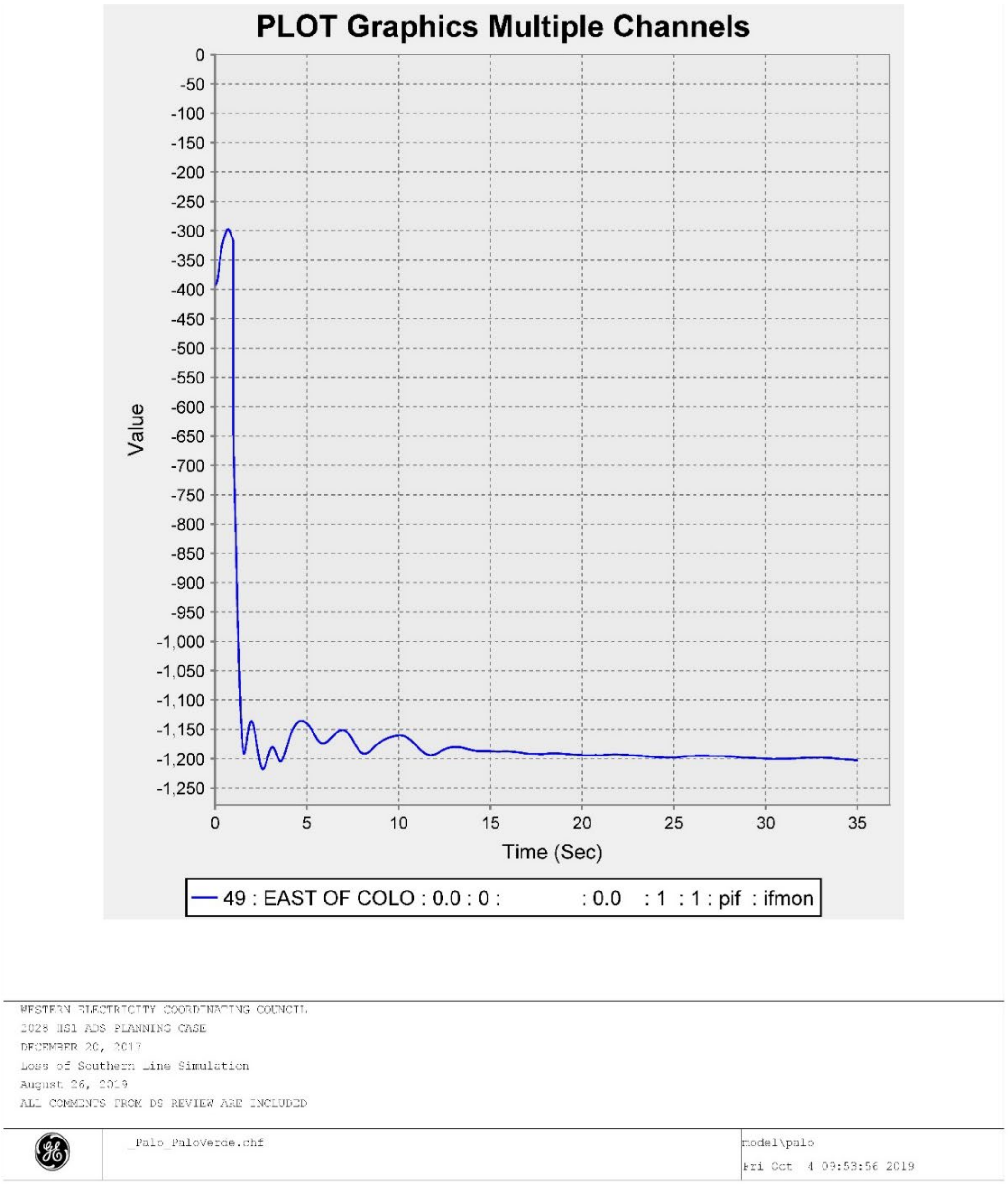


Figure 9-13—Path 66 California Oregon Intertie

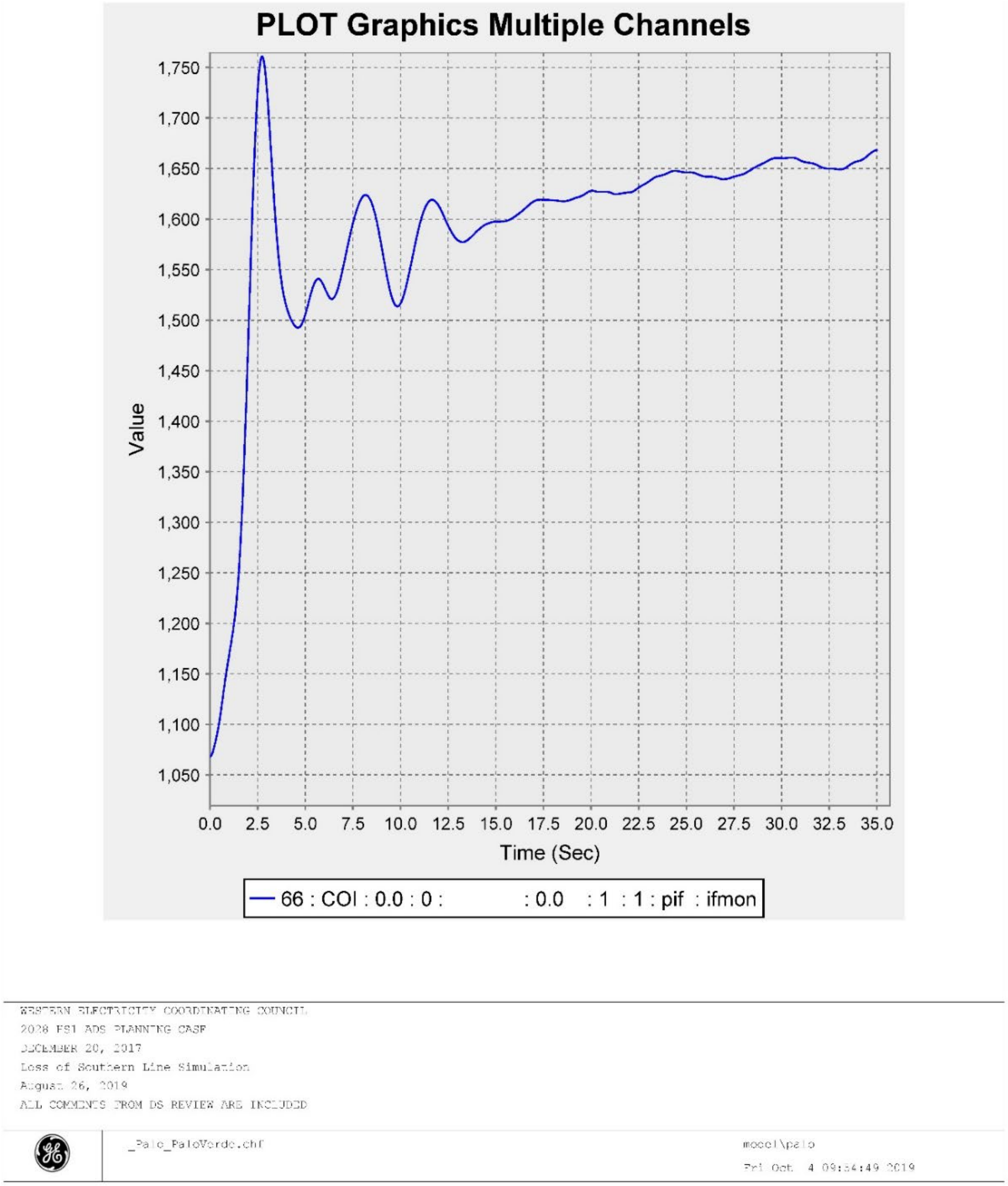


Figure 9-14— Southern California Gas Generator response

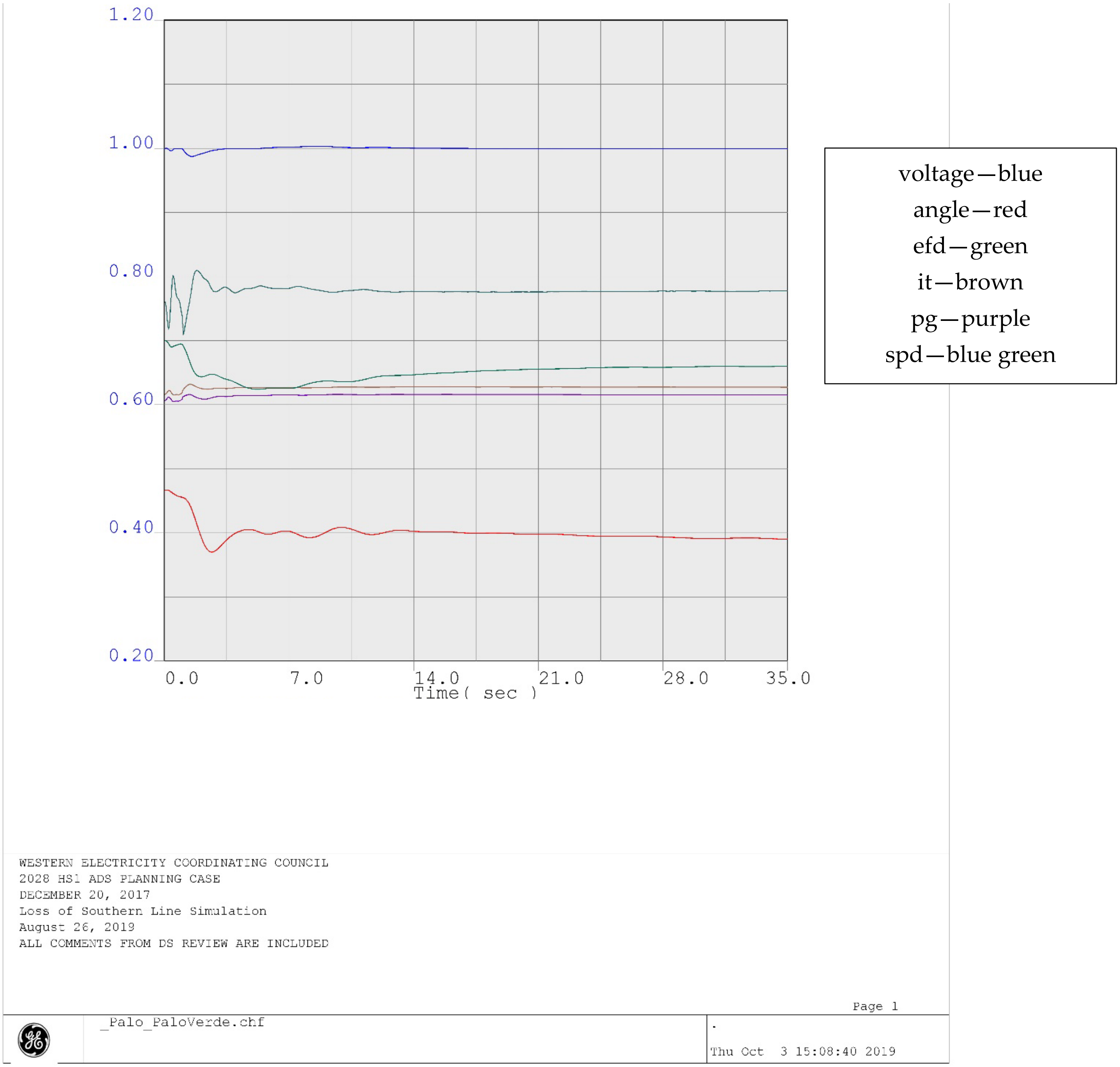
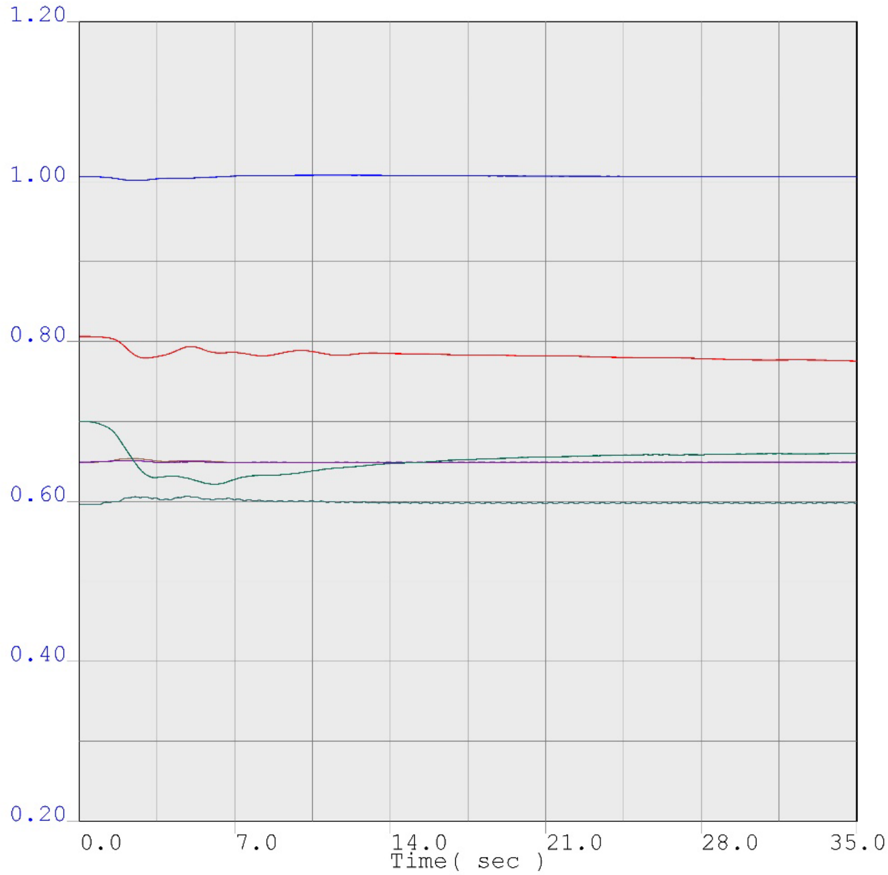


Figure 9-15—Colorado Gas Generator response



voltage—blue
angle—red
efd—green
it—brown
pg—purple
spd—blue green

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Figure 9-16—Utah Gas Generator response

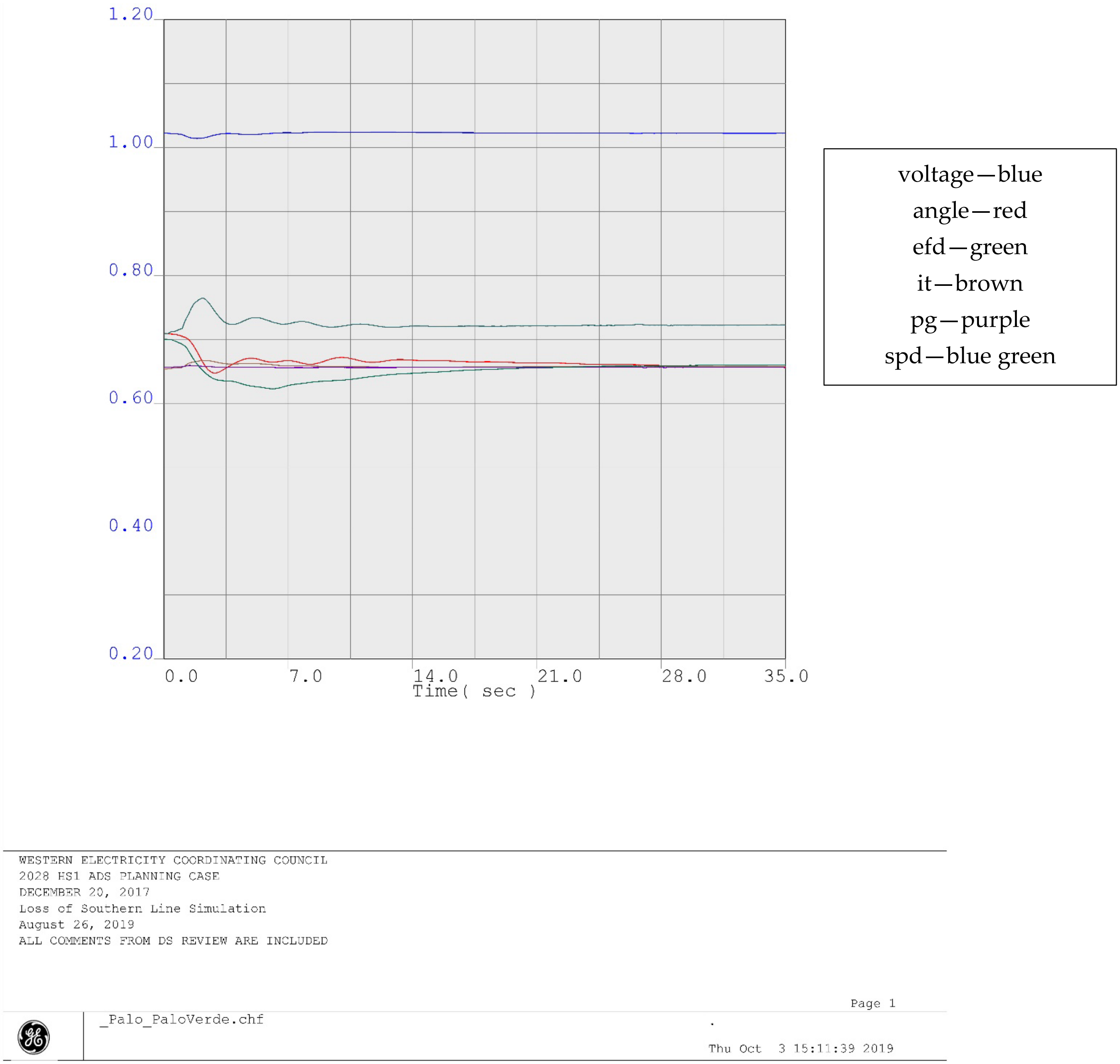

Figure 9-17—Northwest Gas Generator response

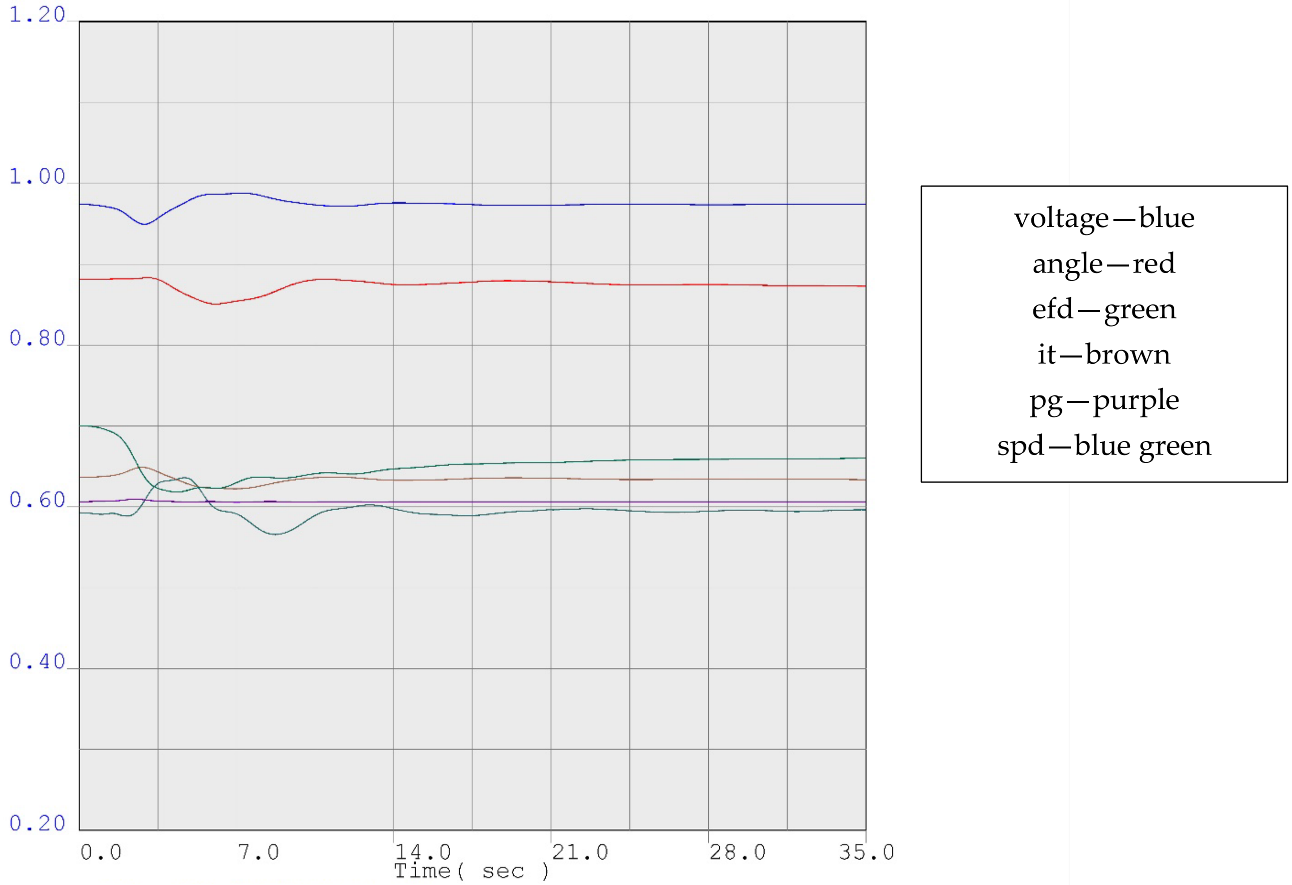

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Figure 9-18—Southern California Gas Generator response

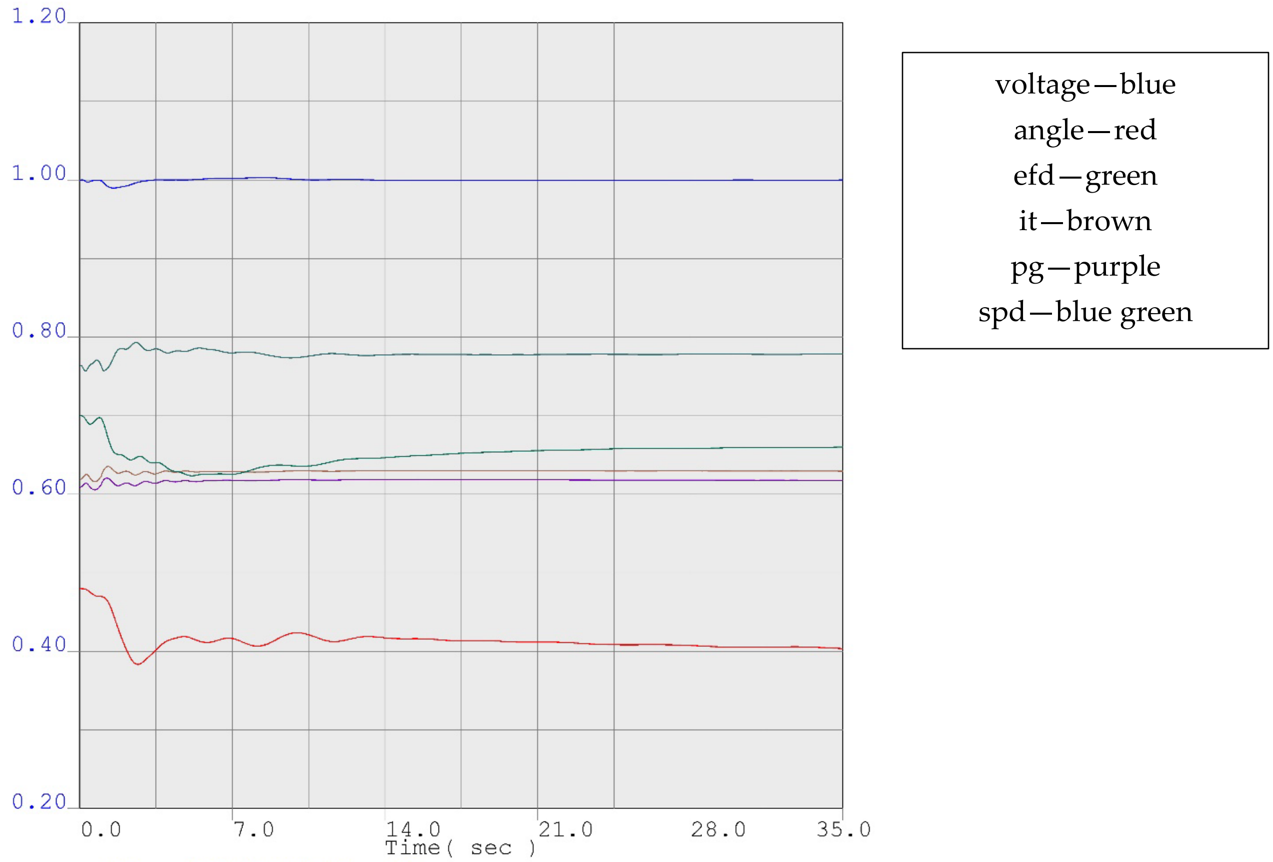

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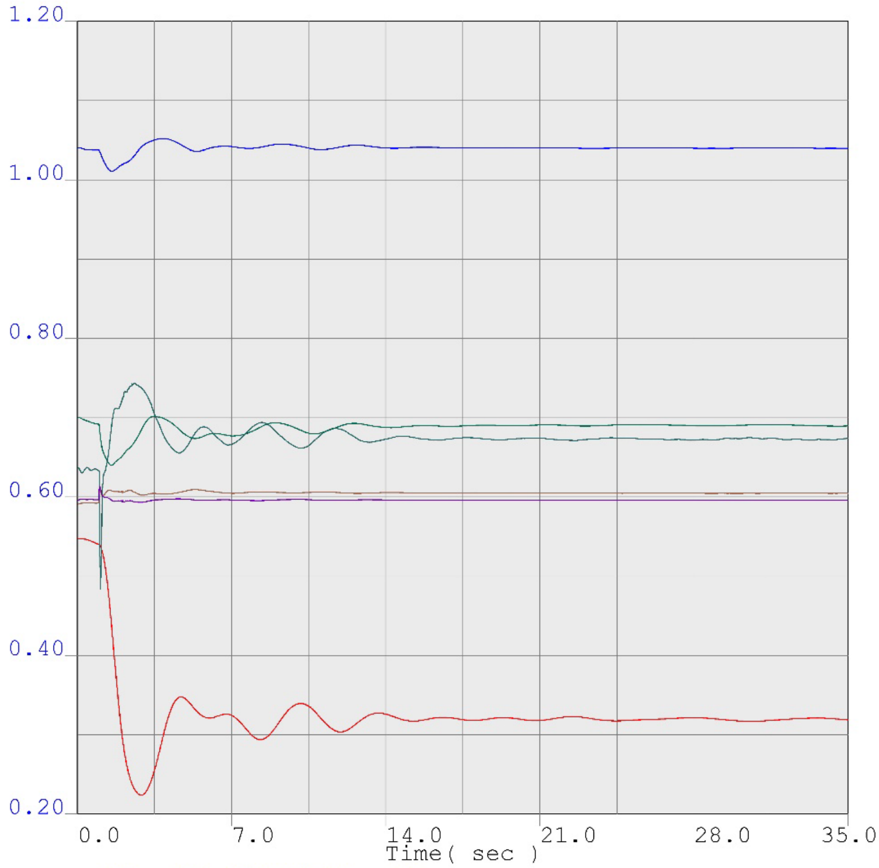
Figure 9-19—Nevada Gas Generator response



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angle—red
efd—green
it—brown
pg—purple
spd—blue green

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