OHIO VALLEY ELECTRIC CORPORATION

2017 TRANSMISSION PLAN

Prepared On OVEC's behalf by:
East Transmission Planning
American Electric Power

December, 2017

Foreword

American Electric Power (AEP) completed this Transmission Performance Appraisal on behalf of the Ohio Valley Electric Corporation (OVEC)

Questions and comments regarding this document should be referred to:

Mary B. Scherer
Engineer Assc
East Transmission Planning
American Electric Power
8500 Smiths Mill Rd
New Albany, Ohio 43054

Phone: (614) 933-2209
Fax: (614) 883-7234
E-mail: mbscherer@aep.com

Or to Scott R. Cunningham
Electrical Operations Director
Ohio Valley Electric Corporation
3932 US Route 23
Piketon, Ohio
(740) 289-7217
Fax: (740) 289-7285
E-mail: scunning@ovec.com

Table of Contents

Executive Summary 1

Introduction 2

System Description 2
- Review of Recent Operating Conditions and System Changes 4
- New Facilities 4
- Abnormal Conditions 4

Study Base Cases
- Assumptions 5
  - 2018 Summer Peak Load 5
  - 2022 Summer Peak Load 6
  - 2022 Spring Light Load 6
  - 2027 Summer Peak Load 6

  Sensitivity Studies
    - 2018 Summer Peak w/postulated generation retirements 6
    - 2022 Summer Peak w/postulated generation retirements 6

Steady State Analysis Results 7

Short Circuit Assessment 7

Stability Studies and Results 7

Operating Procedures/Special Protection Systems 8

Appendices
- Appendix A– Performance Testing Criteria
- Appendix B – Special Procedures & Contingencies
- Appendix C – Steady State Simulation Outputs
- Appendix D – Short Circuit Assessment
- Appendix E – Stability Assessment Template
- Appendix F – Kyger Creek Stability Assessment
- Appendix G – Clifty Creek Stability Assessment

Executive Summary

The Ohio Valley Electric Corporation (OVEC) system in the near-term planning horizon is projected to meet the requirements of both OVEC planning criteria and the applicable NERC Transmission Planning Standards.

Steady State studies examined performance of the planned OVEC system at the projected summer peak load levels and planned systems of 2018 and 2022, and 2022 Spring Light Load conditions. A sensitivity analysis examined 2018 and 2022 summer peak load performance assuming that several generators in the area were retired or otherwise unavailable. Because there were no major topology changes between the 2022 and 2027 cases, the 2022 steady state study results were considered valid for the long term 2027 case. Results of these studies identified outage conditions which could overload elements of several OVEC tielines to neighboring systems and one OVEC facility. For all tieline overloads, the limiting elements are owned by the other systems. OVEC will communicate these results to the facility owners for their consideration. For the overload on the OVEC facility, OVEC plans to perform a sag study on the line, which is expected to increase the ratings beyond the contingency flow.

Short Circuit studies were carried out by PJM in 2017 as part of the OVEC integration studies, reflecting known changes in the vicinity of the OVEC system. It was determined that the highest anticipated breaker duties are approximately 80% of capability. The results of the studies are provided for reference in Appendix D. Replacement of the last antiquated bulk oil breaker at Kyger Creek was completed in 2016. Replacement of four older Air Blast breakers at Clifty Creek with modern SF6 breakers of similar interrupting capabilities was completed this year with two more planned in 2018 and all breaker replacements expected to be completed within 7 years.

Previous studies of the stability performance of the Clifty Creek and Kyger Creek plants have been determined to still be valid. These studies indicated that performance meets the requirements of the NERC TPL standards. The previous assessments are provided for reference in Appendix F for Kyger Creek and Appendix G for Clifty Creek.

In light of the results documented in this 2017 assessment, the existing and planned OVEC system is expected to meet the NERC TPL standards without any additional transmission reinforcements or upgrades through 2027. A Corrective Action Plan is in place to mitigate the possibility of an OVEC overload in the second half of 2018.

Introduction

This report provides an assessment of the OVEC transmission system as required by the NERC Transmission Planning Standards. This assessment, and the studies it documents, is also an integral part of the open planning process instituted in response to FERC Order 890.

System Description

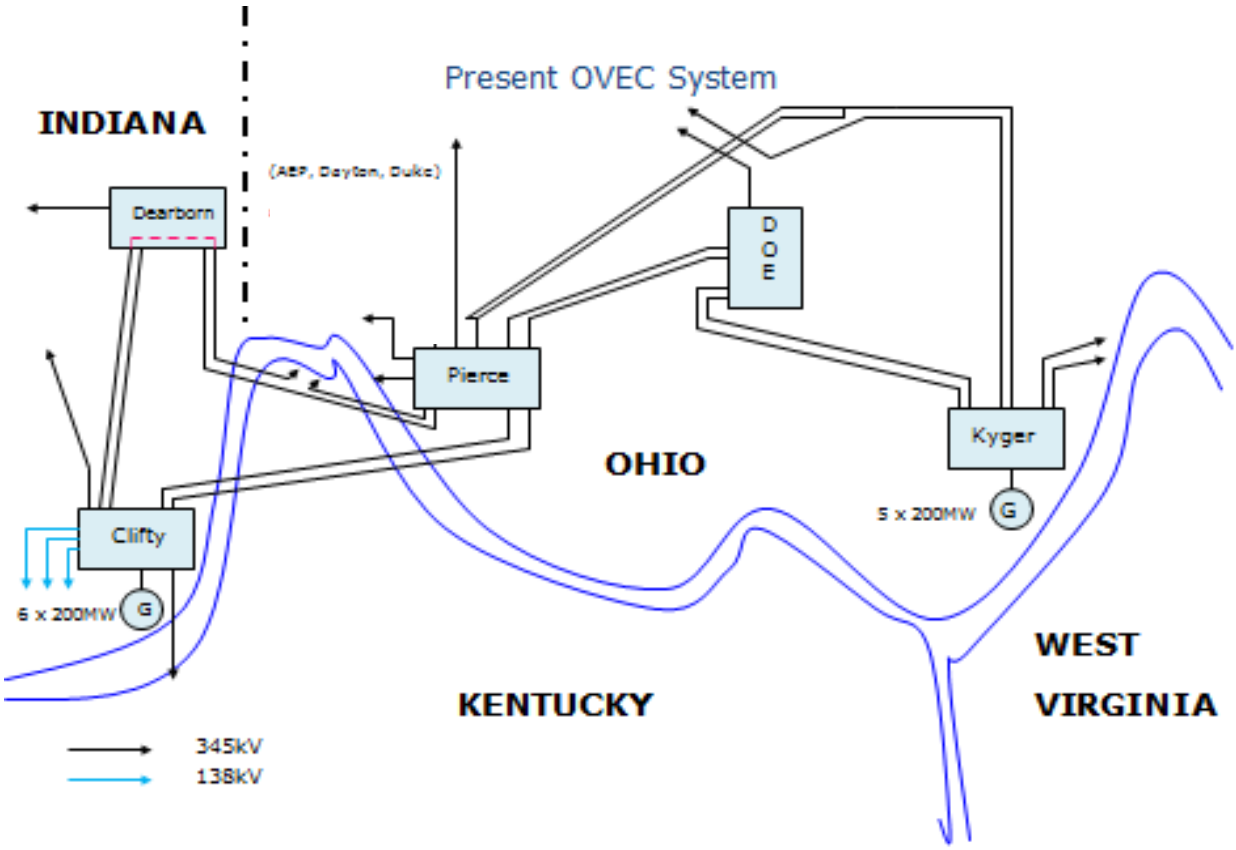
The Ohio Valley Electric Corporation (OVEC) and its subsidiary, Indiana-Kentucky Electric Corporation (IKEC), were organized and their transmission systems constructed in the years 1952-1956. OVEC/IKEC was formed by 15 investor-owned electric utility companies (Sponsors) for the express purpose of supplying the electric power requirements of a single retail customer, the U.S. Department of Energy's (DOE) uranium enrichment project (Project) located near Portsmouth, Ohio. Due to the highly critical nature of the DOE load, stringent design criteria were adopted for planning and constructing the OVEC/IKEC System.

The entire OVEC/IKEC System is considered to be part of the bulk electric system, as it is primarily an EHV network. The system map, showing the configuration as presently planned to exist through the end of the 10 year planning horizon, appears below. The only non-EHV transmission facilities are 138 kV facilities associated with interconnections to the systems of several Sponsors. The OVEC system is highly interconnected. Interconnecting facilities consist of eight 345 kV lines, the high-side connections to four neighboring system 345/138 kV transformers, and three 138 kV lines. The strong internal EHV network and number of interconnections relative to the size of the system precludes a need to analyze sub areas within OVEC, or to use more detailed models than are used in regional studies.

The minimal DOE load today is served from the remaining DOE-owned 345 kV station (DOE X530) within the Project's boundaries. Two double-circuit tower 345kV lines and one single-circuit 345 kV line from OVEC/IKEC and Sponsors' stations supply this station. A second, similar station (DOE X533) was removed from service in November 2008. Reconnection of the lines (bypassing the former station site) was completed in December 2010. A request to terminate service to the DOE load and have the load transferred as a retail customer to AEP Ohio (PUCO, Case No. 15-0892-EL-AEC) was filed by OVEC in 2015 and is currently pending. Hearings are in progress regarding the case, but no conclusions have been reached as of 2017. A decision on this case is predicted to have an impact on the system in 2022 at the earliest.

The OVEC/IKEC System has eleven generating units located at two plants with a total capacity of about 2200 MW. Prior to September 2001, a portion of the OVEC generation was delivered to the DOE load based on the demand established in OVEC/IKEC's contract with DOE, and any remaining generation was sold to the Sponsors on an ownership participation basis. Since September 2001, all generation, with the exception of required operating reserves, has been made available to the Sponsors. Considering the

strength of the generation and transmission system compared with the total load served and the transfers incurred in real time, it is reasonable to assume that OVEC does not require additional reactive compensation.



Review of Recent Operating Conditions and System Changes

As outlined in Attachment M of the OVEC Tariff, the following factors are to be addressed in developing the OVEC transmission plan:

- Review of recent operating conditions, such as NERC Transmission Loading Relief events or MISO and PJM LMP binding constraints that may indicate developing reliability concerns on the OVEC system
  - *Recent congestion has generally been associated with multiple prior outages of other facilities*

- Requests for connection to OVEC facilities
  - *None*

- Requests for service into, out of, or through the OVEC Transmission system
  - *Pending decision on PUCO, Case No. 15-0892-EL-AEC*

- Projections of future load or generation changes within OVEC
  - *Pending decision on PUCO, Case No. 15-0892-EL-AEC*

- Equipment Upgrades in Progress
  – *The Clifty Creek 345 kV station is the only station containing OVEC/IKEC-owned BES circuit breakers other than modern SF6 "puffer" designs. IKEC-owned equipment at this station as of 11/16/2017 included 13 high pressure Air Blast circuit breakers. Although this equipment has adequate interrupting capability, the age, design and operating characteristics pose increasing concerns about O&M costs, availability of parts, and associated declining availability of the breakers for service. Replacement of these breakers is in progress and will take place over the next 6 to 7 years, with priority based on individual breaker condition and in coordination with unit outage schedules.*

New Facilities

Replacement of antiquated circuit breakers and associated relays and controls at Kyger Creek was completed in 2016. In addition, four 345 kV air blast circuit breakers were replaced at Clifty Creek in 2016 and 2017.

Abnormal Conditions

No extended periods of abnormal conditions are expected on the OVEC system.

Study Base Cases

Assumptions

The primary analyses for this assessment were based on power flow models derived from the ERAG/MMWG 2017 library models of projected conditions for 2022 Summer near term peak load and 2022 Spring light load conditions. These models represent Eastern Interconnection systems, particularly those of RF members, including OVEC and adjacent transmission systems, as planned for the 2022 Summer period in early to mid-2017. This represents the latter portion of the near term (Years 1-6) planning horizon.

Analysis of system performance with neighboring system plans not yet finalized at the time the OVEC analysis is performed will be an ongoing process as plans in adjacent systems continue to evolve.

Additional analyses were performed to provide context and provide a basis for assessing other load levels, time periods and generation dispatch. Studies based on the 2018 Summer peak load model provide a reference point based on year-one conditions. These studies also reviewed the effect of the retirement of the Stuart and Killen generators in summer 2018. As the known system improvements and generator retirements affecting the OVEC area are represented in the 2022 Summer model, and no emerging issues involving OVEC-owned facilities appeared in the 2022 near term analyses, previous studies of the long term planning period were deemed to still be valid. Based on the system plans known at this time, performance for the longer term (6-10 year) planning horizon is anticipated to be similar to that identified in the 2022 analysis.

2018 Summer Peak model:

- The initial base case model for the 2018 peak load studies was derived from the 2018 summer peak model contained in the 2017 series ERAG-MMWG library. The model used for the OVEC studies is the base case used in ReliabilityFirst 2018 Summer studies conducted in 2017, with the exception of updates to the ratings for the Clifty–Dearborn #1 345 kV line and the Pierce–Foster 345 kV line prior to finalizing the OVEC studies. A second study was done on the 2018 Summer Peak model with Stuart and Killen generators turned off, due to their retirement in summer 2018. The generation removals were balanced by scaling generation up throughout the PJM market.

2022 Summer Peak Planning horizon models:

- The initial base case models for the 2022 peak load studies were derived from the 2022 summer peak model contained in the 2017 series ERAG-MMWG library with the same ratings corrections as in the 2018 case. Because the OVEC Transmission system consists entirely of 345 kV and 138 kV facilities, the OVEC system is fully represented in the MMWG power flow models. There are no additional OVEC transmission facilities expected to be in service for the planning horizon that were not represented in the ERAG/MMWG models. For OVEC, key

assumptions for all peak load models consist of an area load of 35 MW and a total generation of 2,000 MW delivered to the OVEC owners. In determining the level of OVEC interchange to be modeled, it is assumed that the equivalent of one of the eleven OVEC generators is not available. Because the OVEC generation units are all of similar size, age, and operating history, the assumption is made that they will all be dispatched at similar levels.

2022 Spring Light Load Condition:

- The 2022 ERAG/MMWG Light Load model was reviewed and compared to the 2022 Summer peak model. No major topology differences were identified in the vicinity of OVEC. RF member systems had the opportunity to review and update this model in the first half of 2016 in preparation for the Transmission System Performance Subcommittee study of this period.

2027 Summer Peak Load:

- The 2027 ERAG/MMWG Summer peak load model was reviewed and compared to the 2022 Summer peak model. Since no major topology differences were identified in the vicinity of OVEC, no further analysis was performed.

Sensitivity Studies

2018 and 2022 Summer Peak with retirement of additional nearby generators

Due to the uncertainties introduced by various proposals to implement further reductions in allowable power plant emissions, a sensitivity scenario was developed based on postulated retirement of additional coal-fired units in several neighboring systems in the PJM RTO. The units selected, while generally newer than units retired in 2010-2016, are among the older coal units remaining in these systems, but were primarily selected based on proximity to OVEC. The generation removals were balanced by scaling generation up throughout the PJM market.

Removed Generation:

Unit	MW dispatched in 2018 SP model	MW dispatched in 2022 SP model
Cardinal 1	585	585
Conesville	1580	1580
Zimmer	1171.62	1191.07

Steady State Analysis Results

Results of the studies performed for the 2017 Assessment are documented in Appendix C. To summarize, the following base cases were used to simulate single and double contingencies corresponding to the NERC Planning Event categories P1 – P7:

- 2018 Summer Peak, Stuart and Killen on
- 2018 Summer Peak, Stuart and Killen off
- 2022 Spring Light Load
- 2022 Summer Peak
- 2018 Summer Peak, additional generation retirements
- 2022 Summer Peak, additional generation retirements

The results shown identify potential overloads on 4 OVEC tielines to neighboring systems and one OVEC facility. In each instance involving a tieline, the identified loading levels remain below the capability of the OVEC-owned facilities associated with the circuit. Therefore, OVEC will communicate these results to the facility owners, but is not responsible for any upgrades of those facilities at this time.

The Corrective Action Plan in place for the one overloaded OVEC facility is to perform a sag study in 2018. It is expected that the results of this study will increase the ratings beyond the contingency flow. In the interim before the study is performed, a generation redispatch involving Trimble County generators was identified to be effective to resolve the issue should the contingencies occur during a period of peak flow.

Short Circuit Assessment

Short circuit analysis performed by PJM in 2017 as part of the OVEC integration studies evaluated the expected short circuit interrupting duties relative to the capability of OVEC circuit breakers. The studies showed that no OVEC circuit breakers are expected to be called upon to interrupt fault currents in excess of their capability. Six breakers were found to have interrupting duties above 80% of their capability, with the highest at 80.4% of capability. The detailed studies are documented in Appendix D.

Stability Studies and Results

Studies were performed in late 2011 to evaluate the stability performance of the Clifty Creek plant during the outages needed to retire the Dearborn CBs DA and DD and applying the requirements of the proposed TPL-001-2. The plant performance was found to meet the requirements of both the OVEC Transmission Testing Criteria and NERC Reliability Standards. Analysis of the stability performance of the Kyger Creek plant was completed in 2010. As there have been no major topology changes affecting stability since then, both studies remain valid. They are provided for reference as Appendix G and F, respectively.

Operating Procedures/Special Protection Systems

OVEC has no Special Protection Systems. Operating procedures exist to reduce flows through the Clifty Creek-Carrollton 138 kV tieline between OVEC and KU. They are described in Part 5 of the OVEC response to FERC Form 715, and reproduced in Appendix B of this report. This operating procedure was reevaluated in 2017 and confirmed to be a viable resolution for the overload.

Appendices

Appendix A – Performance Testing Criteria

(Excerpt from the OVEC response to FERC FORM 715 - ANNUAL TRANSMISSION PLANNING AND EVALUATION REPORT)

4. TRANSMISSION TESTING CRITERIA

4.1 Steady State Testing Criteria

The planning process for OVEC/IKEC's transmission network embraces conditions with all facilities in service (NERC Category P0) as well as two major sets of contingency testing criteria to ensure reliability. The first set includes single and multiple contingencies contained in NERC Categories P1 through P7. The second set includes more severe multiple contingencies (NERC Extreme Events) and is primarily intended to test the potential for system cascading.

For OVEC/IKEC transmission planning, the testing criteria are deterministic in nature; these outages serve as surrogates for a broad range of possible operating conditions that the power system will have to withstand in a reliable fashion. In the OVEC/IKEC transmission system, thermal and voltage performance standards are usually the most constraining measures of reliable system performance. Each type of performance requirement is described in the following discussion. Table 1 below documents the performance criteria for all transmission facilities under normal and contingency conditions.

4.1.1 Planning Contingencies

Planning Contingencies include those defined in NERC Reliability Standard TPL-001-4. A single event is defined based on the arrangement of automatic protective devices.

4.1.2 Extreme Events

The more severe reliability assessment criteria required in NERC Reliability Standard TPL-001-4 are primarily intended to prevent uncontrolled area-wide cascading outages under adverse but credible conditions. OVEC/IKEC, as a member of ReliabilityFirst, plans and operates its transmission system to meet the criteria. However, new facilities would not be committed based on local overloads or voltage depressions following the more severe multiple contingencies unless those resultant conditions were expected to lead to widespread, uncontrolled outages.

In operational planning studies, the purpose of studying multiple contingencies and/or high levels of power transfers is to evaluate the strength of the system. Where conditions are identified that could result in significant equipment damage, uncontrolled area-wide power interruptions, or danger to human life, IROL operating procedures will be

developed, if possible, to mitigate the adverse effects. It is accepted that the defined performance limits could be exceeded on a localized basis during the Extreme Events, and that there could be resultant minor equipment damage, increased loss of equipment life, or limited loss of customer load.

4.2 Stability Testing Criteria

OVEC/IKEC transmission systems stability testing is performed in accordance with the contingency scenarios defined in NERC TPL-001-4. An exception is that P7 Planning Events are simulated with three-phase faults instead of phase-to-ground faults because three-phase is more conservative for common tower structure outages.

Appendix B – Special Procedures & Contingencies

(Excerpt from the OVEC response to FERC FORM 715 - ANNUAL TRANSMISSION PLANNING AND EVALUATION REPORT)

A. SPECIAL PROCEDURES

This section describes operating procedures that have been developed to mitigate problems identified on the transmission system and special modeling techniques used in the assessment of OVEC/IKEC system performance. Unless otherwise stated, these operating procedures are anticipated to be applicable indefinitely. As a result, they should be modeled in screening studies that evaluate future system performance. The procedures described herein generally are implemented to reduce facility loadings to within equipment thermal capabilities or to insure that adequate voltage levels or steady state stability margins are maintained.

Clifty Creek-Carrollton 138 kV (OVEC-KU)

Past operating experience indicates that the Clifty Creek – Carrollton 138 kV tieline between OVEC and KU may become heavily loaded anticipating loss of either Ghent Unit 1 (KU) or Spurlock-N. Clark 345 kV (EKPC). Loading concerns would likely occur during periods of high north-to-south transactions, especially if these transfers coincide with high output at Trimble County (KU) and reduced output at other LGE or KU plants. If necessary, OVEC has agreed to open the Clifty Creek 345/138 kV transformer T-100A at the request of the MISO Reliability Coordinator to relieve the loading concerns.

The areas of concern described above are those identified in the most recent performance appraisals conducted, based on the best available knowledge of interconnected system development, and expected operating conditions. The results of appraisals assuming different system conditions can be considerably different.

B. CONTINGENCY LIST

The following is a description of the contingencies that have been simulated in recent appraisals of the OVEC/IKEC system performance, to meet the requirements of the NERC Reliability Standards. This list is not exhaustive, but is designed to screen OVEC/IKEC system performance to verify that reliability criteria are being met and that OVEC system performance will not cause widespread cascading of the interconnected network.

Single Contingencies

Each 300 kV or higher branch within OVEC or the systems of OVEC's immediate neighbors (AEP, Duke Energy Ohio & Kentucky, Dayton, and LGEE).
For those neighbors connected to Clifty Creek 138 kV, each 100 kV or higher branch in the zones connected to Clifty Creek.
Each tieline from the portion of the system comprised of the areas and zones described above

The OVEC stations (and DOE-owned stations within the OVEC Balancing Authority area) are primarily of the "breaker and a half" configuration. Therefore, single contingencies can generally be represented by individually removing each branch or generator represented in the powerflow model. Exceptions from this statement include the following:

- Clifty Creek 345/138 kV transformation – Clifty Creek transformer T-100A does not have automatic switching between the transformer and the 138 kV bus. Forced outages of this transformer also de-energize the Clifty Creek 138 kV bus, opening the ties to Carrollton(KU), Northside(LGE) and Miami Fort(DEO&K) until the transformer low-side disconnect can be manually opened and the bus restored.

- Dearborn(OVEC) – Tanners Creek(AEP) 345 kV bus extension – The 345 kV tie between these adjacent OVEC and AEP stations is protected as a bus extension rather than a transmission line. Normal clearing of a fault on the tie or the #1 Tanners Creek bus will also trip the Tanners Creek (AEP) – East Bend (DEO&K) tie, as well as the Dearborn-Clifty Creek #1 and

Dearborn – Pierce circuits.

The OVEC/IKEC generators are cross-compound machines. Future modeling refinements to increase compatibility between steady state and dynamics models will have each shaft represented individually. Representing a change in dispatch or status of a single unit will require changes to both HP and LP machines in the model.

One additional outage scenario that does not directly correspond to any of the contingencies required by the NERC TPL Reliability Standards should be included in contingency simulations testing the OVEC/IKEC transmission system:

- FGD systems at both Clifty Creek and Kyger Creek plants create the possibility that some common-mode FGD equipment trips could remove up to 3 units at either plant. This exposure does not match any of the contingencies required by the NERC TPL Standards, therefore OVEC does not consider that issues identified for these outages would require mitigation. However, performance for such outages should be evaluated for risks and consequences.

Multiple Contingencies

All combinations of branches connected to any OVEC bus, or two layers out from any OVEC bus, augmented by any branches identified in the Single Contingency analysis above. Similar to the discussion in the Single contingency section, the "breaker and a half" configuration present at most OVEC stations means that power flow analysis simulating NERC Category P2 contingencies removes no additional facilities than an associated P1 contingency. Similarly, (neglecting, for screening purposes, the manual system adjustments allowed between the individual "Category P1" contingencies contained in NERC Category P3 or P6 contingencies) powerflow simulation of most types of NERC Category P3-P7 contingencies on the OVEC system can be simulated by simply removing individual branches two at a time. NERC Extreme Event contingencies resulting in complete station outages are also regularly tested. Most common power system analysis tools provide options to easily simulate these outages.

Appendix C – Steady State Simulation Outputs

The PowerGEM Transmission Adequacy & Reliability Assessment (TARA) tool was used for the steady-state analysis in the studies conducted for the 2017 OVEC Transmission Assessment. TARA has the capability to perform system adjustments between N-1 and the second step in an N-1-1 simulation. This feature was used for the N-1-1 simulations documented here. Results are shown for facilities where the "Final AC Loading" is equal to or greater than 100% of the applicable rating.

As discussed in the Contingency List portion of Appendix B steady-state simulation of most NERC Category P3-P7 contingencies on the OVEC system can be simulated by simply removing individual branches two at a time. This N-2 analysis was performed, so that the results apply to the more severe contingency categories, including parts of the Extreme Events portion of TPL-001-4 Table 1. Extreme Events applicable to the OVEC system that are not addressed by the N-2 analysis include Types 2c (Loss of a switching station or substation) and 2d (Loss of all generating units at a generating station). Type 2c is deemed to be more severe for the OVEC system, since the loss of a substation at a power plant would include the loss of the generation as well as weakening the remaining system. Results of simulations of Extreme Event Type 2c contingencies are tabulated separately from the Planning Event results.

Using current OVEC rating methodology, flows for N-1 contingencies were assessed based on Rate B (Summer/Winter Emergency rating). For N-1-1 analysis, Rate A (Summer/Winter Normal rating) was used to obtain a secured N-1 case and then Rate B was used for flows following the second contingency. For the N-2 analysis, Rate B was used for both iterations, with no system correction allowed between contingencies.

Contingencies analyzed in each of the N-1-1 and N-2 steady-state studies include initial loss of the Clifty Creek 345/138 kV transformer, which satisfies the need to study loss of long lead time equipment. No overloads were seen for contingencies following the loss of this equipment. The operating procedure for reducing flows on Clifty – Carrollton was revalidated, also showing no issue operating the system without this transformer.

The results show overloads on 4 tielines with other systems, specifically LGEE and Duke, limited by non-OVEC equipment. The 2018 Summer analysis revealed an overload on an OVEC facility after the retirement of Stuart and Killen. The Corrective Action Plan in place for the overload is to perform a sag study in 2018. It is expected that the results of this study will increase the ratings beyond the contingency flow. In the interim before the study is completed, a generation redispatch involving Trimble generators can be utilized to resolve the issue should the contingencies occur during a period of peak flow. No formal Corrective Action Plan is required for overloads identified in sensitivity studies, but the only new overload from the sensitivity is on a tieline limited by LGEE equipment.

2018 Summer Peak

N-1 – Thermal, VMag, VDev: No violations

N-1-1 – VMag, VDev: No violations

N-1-1 – Thermal:

AEP N-1-1 AC Iterative SCD Thermal Result[TARA Ver 1702 64-bit - Wed Nov 8 11:23:23 2017]

Loadflow Case: H:\Internal\PWS\OVEC Analysis\2018 Summer\N-1-1\MMWG_2018SUM_2016Series_Final_secure.raw
Study Data File: H:\Internal\PWS\OVEC Analysis\2018 Summer\N-1-1\ovec_16compl_inertia_kvrange_modified.sub
Contingency File: H:\Internal\PWS\OVEC Analysis\2018 Summer\N-1-1\18S_OVEC_N-1-1_COMBINED.con (total 1827 contingencies)/ First-Level Contingency File: H:\Internal\PWS\OVEC Analysis\2018 Summer\N-1-1\18S_OVEC_N-1-
Monitor File: H:\Internal\PWS\OVEC Analysis\2018 Summer\N-1-1\OVEC combo 2016.mon (90.0% loading cutoff)
Exclude File: H:\Internal\PWS\OVEC Analysis\2018 Summer\N-1-1\OVEC_N-1-1.exc
Pre/Post Contingency PAR Adjustment: Adjusted/Fixed ***** SCD Advanced Penalties: Reduce Existing Branch Overloads[1500.000000] Aggravate Existing Branch Overloads[10000.000000] Create New Branch Overloads[10000.(

Filtered to Facilities > 100% (Single Entry)

First Level Scenario Index	First Level Scenario	Monitored Facility	Areas	Rate Base (MVA)	Rate Cont (MVA)	Cont Name	Cont ID	SCD Base Flow (Signed MVA)	SCD Cont Flow (Signed MVA)	SE SCD AC %Loading	Cont MW Flow	Cont MVAR Flow	Fr Cont Volt	To Cont Volt
1130	324105 7GHENT 345 324109 7NAS 345 1	248009 06CLIFTY 138 324227 4CARROLLTON 138 1	206/363	166	210	324253 4GHENT 138 324287 4NAS TAP 138 1	1252	30.2	226.4	107.8	194.5	109	0.9875	0.8855

Notes:

Clifty-Trimble Co 345 kV was Excluded because this is overloaded in N-1 with Summer Normal Rating.

2018 Summer Peak - Station/Bus Outage (NERC Extreme Event type 2.c.)

N-1 – Thermal, VMag, VDev: No violations

2018 Summer Peak - Stuart & Killen Off

N-1 – VMag, VDev: No violations

N-1 – Thermal:

AEP N-1 AC Monitored Facility Loadings[TARA Ver 1702 64-bit - Wed Nov 8 07:40:02 2017]

Loadflow Case: H:\Internal\PWS\OVEC Analysis\2018 Summer\MMWG_2018SUM_2016Series_Final_stuart_killen_off.raw
Study Data File: H:\Internal\PWS\OVEC Analysis\2018 Summer\ovec_16compl_inertia_kvrange_modified.sub
Contingency File: H:\Internal\PWS\OVEC Analysis\2018 Summer\18S_OVEC_N-1_COMBINED.con (total 2845 contingencies)
Monitor File: H:\Internal\PWS\OVEC Analysis\2018 Summer\OVEC combo 2016.mon (95.0% loading cutoff)
Exclude File: not provided
Solution Options (Pre/Post Contingency): Shunts[All Enabled/Continuous Only] PAR[Adjusted/Fixed] XFMR Tap[Adjusted/Fixed] Area Interchange [Disabled/Disabled]

Filtered to Facilities > 100%

Monitored Facility	Areas	Rate Base (MVA)	Rate Cont (MVA)	Cont Name	Cont ID	Base Flow (MVA)	Cont Flow (MVA)	SE Final AC %Loading	Cont MW Flow	Cont MVAR Flow
248000 06CLIFTY 345 248001 06DEARB1 345 1	206	972	972	AEP_P4_#1760_05JEFRSO 765_A	987	627.7	990.8	101.93	1006.7	26.1
248000 06CLIFTY 345 324114 7TRIMBLE CO 345 1	206/363	1134	1451	AEP_P4_#3002_05ROCKPT 765_C2	1201	1033	1519.8	104.74	-1534.8	210.3
248000 06CLIFTY 345 324114 7TRIMBLE CO 345 1	206/363	1134	1451	AEP_P4_#363_05JEFRSO 765_B1	991	1033	1519.8	104.74	-1534.8	210.3
248000 06CLIFTY 345 324114 7TRIMBLE CO 345 1	206/363	1134	1451	AEP_P1-2_#363	362	1033	1519.8	104.74	-1534.8	210.3
248000 06CLIFTY 345 324114 7TRIMBLE CO 345 1	206/363	1134	1451	AEP_P4_#9336_05ROCKPT 765_C	1199	1033	1519.8	104.74	-1534.8	210.3
248000 06CLIFTY 345 324114 7TRIMBLE CO 345 1	206/363	1134	1451	AEP_P1-2_#10136	258	1033	1499.9	103.37	-1514.8	206.5

N-1-1 – VMag, VDev: No violations

N-1-1 – Thermal:

AEP N-1-1 AC Iterative SCD Thermal Result[TARA Ver 1702 64-bit - Wed Nov 8 12:31:51 2017]

Loadflow Case: H:\Internal\PWS\OVEC Analysis\2018 Summer\N-1-1\MMWG_2018SUM_2016Series_Final_stuart_killen_off_secure.raw

Study Data File: H:\Internal\PWS\OVEC Analysis\2018 Summer\N-1-1\ovec_16compl_inertia_kvrange_modified.sub

Contingency File: H:\Internal\PWS\OVEC Analysis\2018 Summer\N-1-1\18S_OVEC_N-1-1_COMBINED.con (total 1827 contingencies)/ First-Level Contingency File: H:\Internal\PWS\OVEC Analysis\2018 Summer\N-1-1\18S_OVEC_N-1-1_COMBI

Monitor File: H:\Internal\PWS\OVEC Analysis\2018 Summer\N-1-1\OVEC combo 2016.mon (90.0% loading cutoff)

Exclude File: H:\Internal\PWS\OVEC Analysis\2018 Summer\N-1-1\OVEC_N-1-1.exc

Pre/Post Contingency PAR Adjustment: Adjusted/Fixed ***** SCD Advanced Penalties: Reduce Existing Branch Overloads[1500.000000] Aggravate Existing Branch Overloads[10000.000000] Create New Branch Overloads[10000.000000]

Filtered to Facilities > 100% (Single Entry)

First Level Scenario Index	First Level Scenario	Monitored Facility	Areas	Rate Base (MVA)	Rate Cont (MVA)	Rate A (MVA)	Cont Name	Cont ID	SCD Cont Flow (Signed MVA)	SE SCD AC %Loading	Cont MW Flow	Cont MVAR Flow	Fr Cont Volt	To Cont Volt
304	AEP_P1-2_#144	248009 06CLIFTY 138 250057 08M.FORT 138 1	206/212	129	129	129	249754 08HEHIDN 138 249877 08WILM J 138 1	809	129.4	100.28	132.5	-3.8	1.0243	0.9803
580	248831 07HUBBL8 138 249691 08BATESV 138 1	248009 06CLIFTY 138 250057 08M.FORT 138 1	206/212	129	129	129	AEP_P1-2_#144	304	129.1	100.05	132.1	-3.9	1.0239	0.9802
581	248831 07HUBBL8 138 249914 08WEISBG 138 1	248009 06CLIFTY 138 250057 08M.FORT 138 1	206/212	129	129	129	AEP_P1-2_#144	304	129	100.04	132.1	-3.5	1.0238	0.9793
920	249877 08WILM J 138 249914 08WEISBG 138 1	248009 06CLIFTY 138 250057 08M.FORT 138 1	206/212	129	129	129	AEP_P1-2_#144	304	129	100.03	132.1	-3.4	1.0238	0.9789
631	249577 08ZIMER 345 249580 08ZIMERG 345 Z1	248009 06CLIFTY 138 250057 08M.FORT 138 1	206/212	129	129	129	AEP_P1-2_#144	304	129	100.01	132	-3	1.0237	0.978
789	249736 08GRDALE 138 249754 08HEHIDN 138 1	248009 06CLIFTY 138 250057 08M.FORT 138 1	206/212	129	129	129	AEP_P1-2_#144	304	129	100.01	132.1	-3.9	1.0244	0.9807
790	249736 08GRDALE 138 250057 08M.FORT 138 1	248009 06CLIFTY 138 250057 08M.FORT 138 1	206/212	129	129	129	AEP_P1-2_#144	304	129	100.01	132.1	-4.8	1.0245	0.9826
1130	324105 7GHENT 345 324109 7NAS 345 1	248009 06CLIFTY 138 324227 4CARROLLTON 138 1	206/363	166	210	166	324253 4GHENT 138 324287 4NAS TAP 138 1	1252	227.8	108.47	196.2	107.9	0.9862	0.8845

Notes:

Clifty-Trimble Co 345 kV was Excluded because this is overloaded in N-1 with Summer Normal Rating.

<u>2018 Summer Peak - Stuart & Killen Off - Station/Bus Outage (NERC Extreme Event type 2.c.)</u>

N-1 – Thermal, VMag, VDev: No violations

2018 Summer Peak – postulated additional generation retirements

N-1 – VMag, VDev: No violations

N-1 – Thermal:

AEP N-1 AC Monitored Facility Loadings[TARA Ver 1702 64-bit - Tue Nov 14 08:47:53 2017]

Loadflow Case: H:\Internal\PWS\OVEC Analysis\2018 Summer\MMWG_2018SUM_2016Series_Final_Zimmer_Cardinal_Conesville_Off.raw
Study Data File: H:\Internal\PWS\OVEC Analysis\2018 Summer\ovec_16compl_inertia_kvrange_modified.sub
Contingency File: H:\Internal\PWS\OVEC Analysis\2018 Summer\18S_OVEC_N-1_COMBINED.con (total 2843 contingencies)
Monitor File: H:\Internal\PWS\OVEC Analysis\2018 Summer\OVEC combo 2016.mon (90.0% loading cutoff)
Exclude File: not provided
Solution Options (Pre/Post Contingency): Shunts[All Enabled/Disabled] PAR[Adjusted/Fixed] XFMR Tap[Adjusted/Fixed] Area Interchange [Disabled/Disabled]

Filtered to Facilities > 100%

Monitored Facility	Areas	Rate Base (MVA)	Rate Cont (MVA)	Cont Name	Cont ID	Base Flow (MVA)	Cont Flow (MVA)	Final AC %Loading	Cont MW Flow	Cont MVAR Flow
248000 06CLIFTY 345 324114 7TRIMBLE CO 345 1	206/363	1134	1451	AEP_P4_#3002_05ROCKPT 765_C2	1201	1101.6	1595.6	109.96	-1610.8	225
248000 06CLIFTY 345 324114 7TRIMBLE CO 345 1	206/363	1134	1451	AEP_P1-2_#363	362	1101.6	1595.6	109.96	-1610.8	225
248000 06CLIFTY 345 324114 7TRIMBLE CO 345 1	206/363	1134	1451	AEP_P4_#9336_05ROCKPT 765_C	1199	1101.6	1595.6	109.96	-1610.8	225
248000 06CLIFTY 345 324114 7TRIMBLE CO 345 1	206/363	1134	1451	AEP_P4_#363_05JEFRSO 765_B1	991	1101.6	1595.6	109.96	-1610.8	225
248000 06CLIFTY 345 324114 7TRIMBLE CO 345 1	206/363	1134	1451	AEP_P1-2_#10136	258	1101.6	1574.7	108.53	-1589.9	220.9
248000 06CLIFTY 345 248001 06DEARB1 345 1	206	972	972	AEP_P4_#1760_05JEFRSO 765_A	987	638.9	1018.4	104.77	1033.9	28.2
248009 06CLIFTY 138 250057 08M.FORT 138 1	206/212	129	129	AEP_P7-1_#632_Dup1	1513	99.3	130.6	101.25	133.8	-3.5
248009 06CLIFTY 138 250057 08M.FORT 138 1	206/212	129	129	AEP_P7-1_#632	97	99.3	130.6	101.25	133.8	-3.5

N-1-1 – VMag, VDev: No violations

N-1-1 – Thermal:

AEP N-1-1 AC Iterative SCD Thermal Result[TARA Ver 1702 64-bit - Tue Nov 14 16:57:39 2017]

Loadflow Case: H:\Internal\PWS\OVEC Analysis\2018 Summer\N-1-1\MMWG_2018SUM_2016Series_Final_sensitivity_secure.raw
Study Data File: H:\Internal\PWS\OVEC Analysis\2018 Summer\N-1-1\ovec_16compl_inertia_kvrange_modified.sub
Contingency File: H:\Internal\PWS\OVEC Analysis\2018 Summer\N-1-1\18S_OVEC_N-1-1_COMBINED.con (total 1825 contingencies)/ First-Level Contingency File: H:\Internal\PWS\OVEC Analysis\2018 Summer\N-1-1\
Monitor File: H:\Internal\PWS\OVEC Analysis\2018 Summer\N-1-1\OVEC combo 2016.mon (90.0% loading cutoff)
Exclude File: H:\Internal\PWS\OVEC Analysis\2018 Summer\N-1-1\OVEC_N-1-1_sensitivity.exc
Pre/Post Contingency PAR Adjustment: Adjusted/Fixed ***** SCD Advanced Penalties: Reduce Existing Branch Overloads[1500.000000] Aggravate Existing Branch Overloads[10000.000000] Create New Branch Over

Filtered to Facilities > 100% (Single Entry)

First Level Scenario Index	First Level Scenario	Monitored Facility	Areas	Rate Base (MVA)	Rate Cont (MVA)	Cont Name	Cont ID	SCD Base Flow (Signed MVA)	SCD Cont Flow (Signed MVA)	SE SCD AC %Loading	Cont MW Flow	Cont MVAR Flow	Fr Cont Volt	To Cont Volt
192	AEP_P1-2_#10136	248009 06CLIFTY 138 324289 4NORTHSIDE 138 1	206/363	120	120	AEP_P1-2_#1027	16	-20.9	-120	100	-111	45.3	1.0068	1.0097
192	AEP_P1-2_#10136	248009 06CLIFTY 138 324289 4NORTHSIDE 138 1	206/363	120	120	AEP_P1-2_#1027	234	-20.9	-120	100	-111	45.3	1.0068	1.0097
193	AEP_P1-2_#10135	248009 06CLIFTY 138 324289 4NORTHSIDE 138 1	206/363	120	120	AEP_P1-2_#1027	16	-20.9	-120	100	-111	45.3	1.0068	1.0097
193	AEP_P1-2_#10135	248009 06CLIFTY 138 324289 4NORTHSIDE 138 1	206/363	120	120	AEP_P1-2_#1027	234	-20.9	-120	100	-111	45.3	1.0068	1.0097
520	08TRIMBL 345 - 7GHENT 345 - 1	248009 06CLIFTY 138 324289 4NORTHSIDE 138 1	206/363	120	120	AEP_P1-2_#1027	16	-14.8	-120	100	-109.8	50	1.0143	1.0098
520	08TRIMBL 345 - 7GHENT 345 - 1	248009 06CLIFTY 138 324289 4NORTHSIDE 138 1	206/363	120	120	AEP_P1-2_#1027	234	-14.8	-120	100	-109.8	50	1.0143	1.0098
618	249532 08TRIMBL 345 324114 7TRIMBLE CO 345 1	248009 06CLIFTY 138 324289 4NORTHSIDE 138 1	206/363	120	120	AEP_P1-2_#1027	16	-14.8	-120	100	-109.8	50	1.0143	1.0098
618	249532 08TRIMBL 345 324114 7TRIMBLE CO 345 1	248009 06CLIFTY 138 324289 4NORTHSIDE 138 1	206/363	120	120	AEP_P1-2_#1027	234	-14.8	-120	100	-109.8	50	1.0143	1.0098

Notes:

Clifty-Trimble Co 345 kV, Clifty-Carrollton 138 kV, Clifty-Dearborn 1 345 kV, Clifty-Miami Fort 138 kV, and Pierce 345/138 kV were Excluded because they are overloaded in N-1 with Summer Normal Rating.

2022 Summer Peak

N-1 – Thermal, VMag, VDev: No violations

N-1-1 – Thermal, VMag, VDev: No violations

N-2 – VMag, VDev: No violations

N-2 – Thermal:

AEP N-1-1 AC Monitored Facility Loadings[TARA Ver 1702 64-bit - Fri Nov 17 12:44:37 2017]

Loadflow Case: H:\Internal\PWS\OVEC Analysis\2022 Summer\n-2\MMWG_2022SUM_2017Series_Final.raw

Study Data File: H:\Internal\PWS\OVEC Analysis\2022 Summer\n-2\ovec_16compl_inertia_kvrange_modified.sub

Contingency File: H:\Internal\PWS\OVEC Analysis\2022 Summer\n-2\22S_OVEC_N-1-1_COMBINED.con (total 1421 contingencies)/ First-Level Contingency File: H:\Internal\PWS\OVEC Analysis\2022 Summer\n-2\22S_OVEC_N-1-1

Monitor File: H:\Internal\PWS\OVEC Analysis\2022 Summer\n-2\OVEC combo 2016.mon (90.0% loading cutoff)

Exclude File: not provided

Solution Options (Pre/Post Contingency): Shunts[All Enabled/All Enabled] PAR[Adjusted/Fixed] XFMR Tap[Adjusted/Adjusted] Area Interchange [Disabled/Disabled]

Filtered to Facilities >100% (Single Entry)

First Level Scenario Index	First Level Scenario	Monitored Facility	Areas	Rate Base (MVA)	Rate Cont (MVA)	Cont Name	Cont ID	Base Flow (MVA)	Cont Flow (MVA)	Final AC %Loading	Cont MW Flow	Cont MVAR Flow
720	324105 7GHENT 345 324109 7NAS 345 1	248009 06CLIFTY 138 324227 4CARROLLTON 138 1	206/363	210	210	324253 4GHENT 138 324287 4NAS TAP 138 1	841	79.4	251.4	119.72	233.4	86.1
62	AEP_P1-2_#363	248009 06CLIFTY 138 324289 4NORTHSIDE 138 1	206/363	120	120	AEP_P1-2_#1027	16	39.6	131.3	109.44	-117.2	58.4
62	AEP_P1-2_#363	248000 06CLIFTY 345 324114 7TRIMBLE CO 345 1	206/363	1451	1451	AEP_P1-2_#16	63	1392.5	1557	107.3	-1572.1	217.5
62	AEP_P1-2_#363	248000 06CLIFTY 345 324114 7TRIMBLE CO 345 1	206/363	1451	1451	249532 08TRIMBL 345 324114 7TRIMBLE CO 345 1	198	1392.5	1554.4	107.13	-1569.5	217
62	AEP_P1-2_#363	248000 06CLIFTY 345 324114 7TRIMBLE CO 345 1	206/363	1451	1451	08TRIMBL 345 - 7GHENT 345 - 1	92	1392.5	1554.4	107.13	-1569.5	217
62	AEP_P1-2_#363	248000 06CLIFTY 345 324114 7TRIMBLE CO 345 1	206/363	1451	1451	AEP_P1-2_#6188	65	1392.5	1520.7	104.81	-1535.8	210.5
62	AEP_P1-2_#363	248000 06CLIFTY 345 324114 7TRIMBLE CO 345 1	206/363	1451	1451	AEP_P1-1_#4959	38	1392.5	1512.8	104.26	-1527.8	208.9
64	AEP_P1-2_#144	248009 06CLIFTY 138 250057 08M.FORT 138 1	206/212	129	129	249754 08HEHIDN 138 249877 08WILM J 138 1	389	111.3	132	102.29	134.8	-4.4
902	249501 08BATESV 345 249691 08BATESV 138 1	248000 06CLIFTY 345 324114 7TRIMBLE CO 345 1	206/363	1451	1451	AEP_P1-2_#363	62	993.2	1481.1	102.07	-1496	202.9
166	249501 08BATESV 345 324105 7GHENT 345 1	248000 06CLIFTY 345 324114 7TRIMBLE CO 345 1	206/363	1451	1451	AEP_P1-2_#363	62	993.2	1481.1	102.07	-1496	202.9
713	324102 7BROWN NORTH 345 324106 7HARDIN CO 345 1	248000 06CLIFTY 345 324114 7TRIMBLE CO 345 1	206/363	1451	1451	AEP_P1-2_#363	62	953.2	1479.7	101.97	-1494.5	202.6
165	249500 08AMO 345 249530 08EDWDSP 345 1	248000 06CLIFTY 345 324114 7TRIMBLE CO 345 1	206/363	1451	1451	AEP_P1-2_#363	62	955.2	1479.5	101.96	-1494.4	202.6
64	AEP_P1-2_#144	248009 06CLIFTY 138 250057 08M.FORT 138 1	206/212	129	129	249736 08GRDALE 138 249754 08HEHIDN 138 1	370	111.3	131.3	101.79	134.2	-4.6
106	09STUART 345 - 20SPURLCK 345 - 1	248000 06CLIFTY 345 324114 7TRIMBLE CO 345 1	206/363	1451	1451	AEP_P1-2_#363	62	960	1466.5	101.07	-1481.3	200.1
389	249754 08HEHIDN 138 249877 08WILM J 138 1	248000 06CLIFTY 345 324114 7TRIMBLE CO 345 1	206/363	1451	1451	AEP_P1-2_#363	62	955.8	1465.3	100.99	-1480.1	199.9
39	AEP_P1-1_#4838	248000 06CLIFTY 345 324114 7TRIMBLE CO 345 1	206/363	1451	1451	AEP_P1-2_#363	62	949.1	1465.3	100.99	-1480.2	199.9
370	249736 08GRDALE 138 249754 08HEHIDN 138 1	248000 06CLIFTY 345 324114 7TRIMBLE CO 345 1	206/363	1451	1451	AEP_P1-2_#363	62	953.3	1462.6	100.8	-1477.5	199.4
211	249577 08ZIMER 345 249580 08ZIMERG 345 Z1	248000 06CLIFTY 345 324114 7TRIMBLE CO 345 1	206/363	1451	1451	AEP_P1-2_#363	62	947.7	1455.9	100.34	-1470.7	198.1
80	u|08ZIMMER 1	248000 06CLIFTY 345 324114 7TRIMBLE CO 345 1	206/363	1451	1451	AEP_P1-2_#363	62	947.4	1455.5	100.31	-1470.3	198.1
164	249500 08AMO 345 249518 08QUALTC 345 1	248000 06CLIFTY 345 324114 7TRIMBLE CO 345 1	206/363	1451	1451	AEP_P1-2_#363	62	939.4	1454.9	100.27	-1469.7	197.9

2022 Summer Peak - Station/Bus Outage (NERC Extreme Event type 2.c.)

N-1 – Thermal, VMag, VDev: No violations

2022 Spring Light Load

N-1 – Thermal, VMag, VDev: No violations

N-1-1 – Thermal, VMag, VDev: No violations

2022 Summer Peak – postulated additional generation retirements

N-1 – VMag, VDev: No violations

N-1 – Thermal:

AEP N-1 AC Monitored Facility Loadings[TARA Ver 1702 64-bit - Tue Nov 14 09:52:24 2017]

Loadflow Case: H:\Internal\PWS\OVEC Analysis\2022 Summer\MMWG_2022SUM_2017Series_Final_Zimmer_Cardinal_Conesville_Off.raw
Study Data File: H:\Internal\PWS\OVEC Analysis\2022 Summer\ovec_16compl_inertia_kvrange_modified.sub
Contingency File: H:\Internal\PWS\OVEC Analysis\2022 Summer\22S_OVEC_N-1_COMBINED.con (total 2821 contingencies)
Monitor File: H:\Internal\PWS\OVEC Analysis\2022 Summer\OVEC combo 2016.mon (90.0% loading cutoff)
Exclude File: not provided
Solution Options (Pre/Post Contingency): Shunts[All Enabled/Disabled] PAR[Adjusted/Fixed] XFMR Tap[Adjusted/Fixed] Area Interchange [Disabled/Disabled]
Filtered to Facilities > 100%

Monitored Facility	Areas	Rate Base (MVA)	Rate Cont (MVA)	Cont Name	Cont ID	Base Flow (MVA)	Cont Flow (MVA)	SE Final AC %Loading	Cont MW Flow	Cont MVAR Flow
248009 06CLIFTY 138 250057 08M.FORT 138 1	206/212	129	129	AEP_P7-1_#632	1373	107	140.3	108.74	143.4	-3.3
248009 06CLIFTY 138 250057 08M.FORT 138 1	206/212	129	129	AEP_P7-1_#632_Dup1	1476	107	140.3	108.74	143.4	-3.3
248000 06CLIFTY 345 324114 7TRIMBLE CO 345 1	206/363	1134	1451	AEP_P1-2_#363	263	1020.4	1558.2	107.39	-1573.4	217.7
248000 06CLIFTY 345 324114 7TRIMBLE CO 345 1	206/363	1134	1451	AEP_P4_#363_05JEFRSO 765_B1	872	1020.4	1558.2	107.39	-1573.4	217.7
248000 06CLIFTY 345 324114 7TRIMBLE CO 345 1	206/363	1134	1451	AEP_P4_#3002_05ROCKPT 765_C2	1074	1020.4	1558.2	107.39	-1573.4	217.7
248000 06CLIFTY 345 324114 7TRIMBLE CO 345 1	206/363	1134	1451	AEP_P4_#9336_05ROCKPT 765_C	1072	1020.4	1540.6	106.17	-1555.7	214.3
248009 06CLIFTY 138 250057 08M.FORT 138 1	206/212	129	129	AEP_P4_#3022_05TANNER 345_S1	1180	107	134.6	104.32	137.5	-3.5
248009 06CLIFTY 138 250057 08M.FORT 138 1	206/212	129	129	AEP_P4_#3022_05TANNER 345_S1_Dup1	1433	107	134.6	104.32	137.5	-3.5
248009 06CLIFTY 138 250057 08M.FORT 138 1	206/212	129	129	AEP_P4_#3026_05TANNER 345_S2	1181	107	133.6	103.54	136.4	-3.5
248009 06CLIFTY 138 250057 08M.FORT 138 1	206/212	129	129	AEP_P4_#3027_05TANNER 345_R2	1178	107	132.1	102.44	135	-3.5
248009 06CLIFTY 138 250057 08M.FORT 138 1	206/212	129	129	AEP_P2-2_#2812_05TANNER 345_2	561	107	132.1	102.41	134.9	-3.5
248009 06CLIFTY 138 250057 08M.FORT 138 1	206/212	129	129	AEP_P4_#9392_05TANNER 345_M2	1173	107	132.1	102.41	134.9	-3.5
248009 06CLIFTY 138 250057 08M.FORT 138 1	206/212	129	129	AEP_P1-2_#144	271	107	131.5	101.9	134.3	-3.5
248009 06CLIFTY 138 250057 08M.FORT 138 1	206/212	129	129	AEP_P4_#3023_05TANNER 345_R1_Dup1	1432	107	129.4	100.33	132.3	-3.7

N-1-1 – VMag, VDev: No violations

N-1-1 – Thermal:

AEP N-1-1 AC Iterative SCD Thermal Result[TARA Ver 1702 64-bit - Wed Nov 15 12:12:36 2017]

Loadflow Case: H:\Internal\PWS\OVEC Analysis\2022 Summer\MMWG_2022SUM_2016Series_Final_sensitivity_secure.raw
Study Data File: H:\Internal\PWS\OVEC Analysis\2022 Summer\ovec_16compl_inertia_kvrange_modified.sub
Contingency File: H:\Internal\PWS\OVEC Analysis\2022 Summer\22S_OVEC_N-1-1_COMBINED.con (total 1840 contingencies)/ First-Level Contingency File: H:\Internal\PWS\OVEC Analysis\2022 Summer\22S_OVEC_N-1-1_COMBINED.con (total
Monitor File: H:\Internal\PWS\OVEC Analysis\2022 Summer\OVEC combo 2016.mon (90.0% loading cutoff)
Exclude File: H:\Internal\PWS\OVEC Analysis\2022 Summer\N-1-1\OVEC_N-1-1_sensitivity.exc
Pre/Post Contingency PAR Adjustment: Adjusted/Fixed ***** SCD Advanced Penalties: Reduce Existing Branch Overloads[1500.000000] Aggravate Existing Branch Overloads[10000.000000] Create New Branch Overloads[10000.000000] En
Filtered to Facilities > 100% (Single Entry)

First Level Scenario Index	First Level Scenario	Monitored Facility	Areas	Rate Base (MVA)	Rate Cont (MVA)	Cont Name	Cont ID	SCD Base Flow (Signed MVA)	SCD Cont Flow (Signed MVA)	SE SCD AC %Loading	Cont MW Flow	Cont MVAR Flow	Fr Cont Volt	To Cont Volt
16	AEP_P1-2_#1027	248009 06CLIFTY 138 324289 4NORTHSIDE 138 1	206/363	120	120	AEP_P1-2_#363	301	-51.6	-120	100.01	-106.6	54.4	1.0073	0.9948
195	AEP_P1-2_#10136	248009 06CLIFTY 138 324289 4NORTHSIDE 138 1	206/363	120	120	AEP_P1-2_#1027	16	-35.2	-120	100	-107.1	53.6	1.0079	0.9968
195	AEP_P1-2_#10136	248009 06CLIFTY 138 324289 4NORTHSIDE 138 1	206/363	120	120	AEP_P1-2_#1027	238	-35.2	-120	100	-107.1	53.6	1.0079	0.9968
196	AEP_P1-2_#10135	248009 06CLIFTY 138 324289 4NORTHSIDE 138 1	206/363	120	120	AEP_P1-2_#1027	16	-35.2	-120	100	-107.1	53.6	1.0079	0.9968
196	AEP_P1-2_#10135	248009 06CLIFTY 138 324289 4NORTHSIDE 138 1	206/363	120	120	AEP_P1-2_#1027	238	-35.2	-120	100	-107.1	53.6	1.0079	0.9968
238	AEP_P1-2_#1027_238	248009 06CLIFTY 138 324289 4NORTHSIDE 138 1	206/363	120	120	AEP_P1-2_#363	301	-51.6	-120	100.01	-106.6	54.4	1.0073	0.9948
301	AEP_P1-2_#363	248009 06CLIFTY 138 324289 4NORTHSIDE 138 1	206/363	120	120	AEP_P1-2_#1027	16	-35.5	-120	100	-106.6	54.4	1.0074	0.9948
301	AEP_P1-2_#363	248009 06CLIFTY 138 324289 4NORTHSIDE 138 1	206/363	120	120	AEP_P1-2_#1027	238	-35.5	-120	100	-106.6	54.4	1.0074	0.9948
519	08TRIMBL 345 - 7GHENT 345 - 1	248009 06CLIFTY 138 324289 4NORTHSIDE 138 1	206/363	120	120	AEP_P1-2_#1027	16	-30.4	-120.3	100.24	-106.1	57.4	1.0138	0.9967
519	08TRIMBL 345 - 7GHENT 345 - 1	248009 06CLIFTY 138 324289 4NORTHSIDE 138 1	206/363	120	120	AEP_P1-2_#1027	238	-30.4	-120.3	100.24	-106.1	57.4	1.0138	0.9967
619	249532 08TRIMBL 345 324114 7TRIMBLE CO 345 1	248009 06CLIFTY 138 324289 4NORTHSIDE 138 1	206/363	120	120	AEP_P1-2_#1027	16	-30.4	-120.3	100.24	-106.1	57.4	1.0138	0.9967
619	249532 08TRIMBL 345 324114 7TRIMBLE CO 345 1	248009 06CLIFTY 138 324289 4NORTHSIDE 138 1	206/363	120	120	AEP_P1-2_#1027	238	-30.4	-120.3	100.24	-106.1	57.4	1.0138	0.9967
1141	324105 7GHENT 345 324109 7NAS 345 1	248009 06CLIFTY 138 324227 4CARROLLTON 138 1	206/363	166	210	324253 4GHENT 138 324287 4NAS TAP 138 1	1262	72.9	245.2	116.75	226.7	85.4	0.9901	0.9033
1262	324253 4GHENT 138 324287 4NAS TAP 138 1	248009 06CLIFTY 138 324227 4CARROLLTON 138 1	206/363	166	210	324105 7GHENT 345 324109 7NAS 345 1	1141	55.4	245.2	116.75	226.7	85.4	0.9901	0.9033

Notes:
Clifty-Trimble Co 345 kV, Clifty-Miami Fort 138 kV, Pierce-Foster 345 kV, and Pierce 345/138 kV were Excluded because they are overloaded in N-1 with Summer Normal Rating.

Appendix D

Ohio Valley Electric Corporation

2017 Short Circuit Assessment

(based on studies conducted by PJM in 2017)

East Transmission Planning
November 2017

AEP AMERICAN ELECTRIC POWER

AEP: America's Energy Partner SM

The 2017 OVEC Short Circuit Assessment

The OVEC short circuit assessment is based on the OVEC integration studies conducted by PJM in 2017. Those studies were performed using v14.5 of the Aspen OneLiner™ program including the ASPEN Breaker Rating Module™. The study was based on the latest available AEP/PJM model for 2018 and 2022 at the time the study was conducted with the OVEC circuit breaker data* added.

The results of the study are summarized in the tables included as **Attachment A**. Those studies show that no OVEC circuit breakers are expected to be called upon to interrupt fault currents in excess of their capability. Six breakers were found to have interrupting duties above 80% of their capability, with the highest at 80.4% of capability. The lowest margins were found at Clifty.

Note that these results are expected to be somewhat conservative (i.e., overstate the actual fault currents to be reasonably expected.) This is because some of the generating units already retired or expected to be retired in neighboring systems may still be modeled as in service. Under the terms of the applicable tariff, the owner of a unit that has requested deactivation has up to one year from the actual date of deactivation to apply to reuse their connection rights. To prevent "overselling" connection rights, the impact of the retiring units needs to be included until those rights have expired.

*Breaker characteristics utilized for Circuit Breakers located within the OVEC Balancing Authority Area, but owned by others, reflect the best information available at the time of this study. Results documented here are provided for the benefit of the equipment owner to make their own determination as to the adequacy of the breaker interrupting capabilities. The equipment owner bears ultimate responsibility to ensure that the equipment continues to be suitable for the application, including any applicable NERC Reliability Standard Compliance requirements.

Base 2018 results

BUS	BREAKER	DUTY %	DUTY MPS	BREAKER CAPABILITY	MOMENTARY DUTY %	MOMENTARY DUTY AMPS	MOMENTARY BREAKER CAPABILITY	ISC	X/R
06CLIFTY 345.kV	DL	80.3	50559.9	63000	64.3	81315.1	126400	50559.9	27.1
06CLIFTY 345.kV	DL1	80.3	50559.9	63000	49.6	81315.1	163800	50559.9	27.1
06CLIFTY 345.kV	DL2	80.3	50559.9	63000	64.3	81315.1	126400	50559.9	27.1
06CLIFTY 345.kV	R	80.3	50559.9	63000	49.6	81315.1	163800	50559.9	27.1
06CLIFTY 345.kV	S	80.3	50559.9	63000	49.6	81315.1	163800	50559.9	27.1
06CLIFTY 345.kV	T	80.3	50559.9	63000	49.6	81315.1	163800	50559.9	27.1
06DEARBN 345.kV	DB	78.4	39196.6	50000	46.9	61016.4	130000	39196.6	18.5
06DEARBN 345.kV	DC	78.4	39196.6	50000	46.9	61016.4	130000	39196.6	18.5
06KYGER 345.kV	D	78.4	39202.8	50000	47	61122.4	130000	36656.2	24.7
06KYGER 345.kV	E	78.4	39202.8	50000	45.3	58884.1	130000	36656.2	24.7
06KYGER 345.kV	G	78.4	39202.8	50000	47	61122.4	130000	36656.2	24.7
06KYGER 345.kV	H	78.4	39202.8	50000	45.2	58801.4	130000	36656.2	24.7
06KYGER 345.kV	M	77.3	38626.8	50000	47	61122.4	130000	35924.3	25.5
06KYGER 345.kV	N	77.3	38626.8	50000	45.3	58841	130000	35924.3	25.5
06KYGER 345.kV	A	76.5	38268.9	50000	47	61122.4	130000	38268.9	24.7
06KYGER 345.kV	AA	76.5	38268.9	50000	47	61122.4	130000	38268.9	24.7
06KYGER 345.kV	C	76.5	38268.9	50000	47	61122.4	130000	38268.9	24.7
06KYGER 345.kV	F	76.5	38268.9	50000	47	61122.4	130000	38268.9	24.7
06KYGER 345.kV	I	76.5	38268.9	50000	47	61122.4	130000	38268.9	24.7
06KYGER 345.kV	J	76.5	38268.9	50000	47	61122.4	130000	38268.9	24.7
06KYGER 345.kV	L	76.5	38268.9	50000	47	61122.4	130000	38268.9	24.7
06KYGER 345.kV	O	76.5	38268.9	50000	47	61122.4	130000	38268.9	24.7
06KYGER 345.kV	P	76.5	38269.1	50000	37.3	61122.8	163800	38269.1	24.7
06KYGER 345.kV	Q	76.5	38269.1	50000	37.3	61122.8	163800	38269.1	24.7
06KYGER 345.kV	K	76.2	38118.5	50000	45.3	58872.8	130000	35452.6	25.5
06DOE530 345.kV	212	76	25071.5	33000	44.3	38136.6	86164	23379	33.8
06DOE530 345.kV	215	76	25071.7	33000	44.3	38137	86164	23379.3	33.8

06DOE530 345.kV	218	76	25071.7	33000	44.3	38137	86164	23379.3	33.8
06DOE530 345.kV	222	76	25071.5	33000	44.3	38136.6	86164	23379	33.8
06DOE530 345.kV	225	76	25071.7	33000	44.3	38137	86164	23379.3	33.8
06DOE530 345.kV	228	76	25071.7	33000	44.3	38137	86164	23379.3	33.8
06DOE530 345.kV	242	76	25071.5	33000	44.3	38136.6	86164	23379	33.8
06DOE530 345.kV	245	76	25071.5	33000	44.3	38136.6	86164	23379	33.8
06DOE530 345.kV	248	76	25071.5	33000	44.3	38136.6	86164	23379	33.8
06DOE530 345.kV	252	76	25071.5	33000	44.3	38136.6	86164	23379	33.8
06DOE530 345.kV	255	76	25071.7	33000	44.3	38137	86164	23379.3	33.8
06DOE530 345.kV	258	76	25071.7	33000	44.3	38137	86164	23379.3	33.8
06DOE530 345.kV	262	76	25071.5	33000	44.3	38136.6	86164	23379	33.8
06DOE530 345.kV	268	76	25071.5	33000	44.3	38136.6	86164	23379	33.8
06CLIFTY 345.kV	A	75.8	53033	70000	58	81315.1	140100	48597.7	27.7
06CLIFTY 345.kV	B	75.8	53033	70000	56.4	79002.3	140100	48597.7	27.7
06CLIFTY 345.kV	D	75.8	53033	70000	58	81315.1	140100	48597.7	27.7
06CLIFTY 345.kV	E	75.8	53033	70000	56.4	78999.4	140100	48597.7	27.7
06CLIFTY 345.kV	G	75.6	52900.4	70000	58	81315.1	140100	48464.6	27.7
06CLIFTY 345.kV	H	75.6	52900.4	70000	56.3	78841	140100	48464.6	27.7
06KYGER 345.kV	BB	74.4	37201.1	50000	45.7	59417.1	130000	37201.1	24.7
06PIERCE 345.kV	A	74.3	37148.3	50000	43.2	56130.6	130000	37148.3	14.2
06PIERCE 345.kV	C	74.3	37148.3	50000	43.2	56130.6	130000	37148.3	14.2
06PIERCE 345.kV	D	74.3	37148.3	50000	43.2	56130.6	130000	37148.3	14.2
06PIERCE 345.kV	E	74.3	37148.3	50000	43.2	56130.6	130000	37148.3	14.2
06PIERCE 345.kV	G	74.3	37148.3	50000	43.2	56130.6	130000	37148.3	14.2
06PIERCE 345.kV	H	74.3	37148.3	50000	43.2	56130.6	130000	37148.3	14.2
06PIERCE 345.kV	J	74.3	37148.3	50000	43.2	56130.6	130000	37148.3	14.2
06PIERCE 345.kV	P	74.3	37148.3	50000	43.2	56130.6	130000	37148.3	14.2
06PIERCE 345.kV	K	73.6	36819.9	50000	42.8	55634.4	130000	36819.9	14.2
06PIERCE 345.kV	M	73.6	36819.9	50000	42.8	55634.4	130000	36819.9	14.2
06PIERCE 345.kV	Q	73.6	36819.9	50000	42.8	55634.4	130000	36819.9	14.2
06PIERCE 345.kV	R	73.6	36819.9	50000	42.8	55634.4	130000	36819.9	14.2
06KYGER 345.kV	B	73.3	36634	50000	45	58511.2	130000	36634	24.7

06CLIFTY 345.kV	J	72.3	50579.1	70000	58	81315.1	140100	46142.8	28.4
06CLIFTY 345.kV	K	72.3	50579.1	70000	56.4	78982.9	140100	46142.8	28.4
06CLIFTY 345.kV	C	72.2	50559.9	70000	58	81315.1	140100	50559.9	27.1
06CLIFTY 345.kV	F	72.2	50559.9	70000	58	81315.1	140100	50559.9	27.1
06CLIFTY 345.kV	I	72.2	50559.9	70000	58	81315.1	140100	50559.9	27.1
06CLIFTY 345.kV	L	72.2	50559.9	70000	58	81315.1	140100	50559.9	27.1
06CLIFTY 345.kV	M	72.2	50559.9	70000	58	81315.1	140100	50559.9	27.1
06CLIFTY 345.kV	O	72.2	50559.9	70000	58	81315.1	140100	50559.9	27.1
06CLIFTY 345.kV	P	72.2	50559.9	70000	58	81315.1	140100	50559.9	27.1
06CLIFTY 345.kV	Q	72.2	50559.9	70000	58	81315.1	140100	50559.9	27.1
06PIERCE 345.kV	I	70.6	35290.5	50000	40.9	53208.3	130000	35290.5	13.9
06CLIFTY 345.kV	N	70.4	49311	70000	56.7	79395.2	140100	49311	27.6
06PIERCE 345.kV	L	70	34978.5	50000	40.6	52738	130000	34978.5	13.9
06PIERCE 345.kV	F	69.6	34776.2	50000	40.4	52547	130000	34776.2	14.2
06DOE530 345.kV	272	60.2	24060.6	40000	36.7	38136.6	104000	23379	33.8
06DOE530 345.kV	275	60.2	24060.6	40000	36.7	38137	104000	23379	33.8
06DOE530 345.kV	278	60.2	24060.6	40000	36.7	38137	104000	23379	33.8
06DOE530 345.kV	282	60.2	24060.6	40000	36.7	38136.6	104000	23379	33.8
06DOE530 345.kV	285	60.2	24060.6	40000	36.7	38136.6	104000	23379	33.8
06DOE530 345.kV	265	48	15845.8	33000	25.8	22205.2	86164	13612.6	33.8
06CLIFTY 138.kV	AE	47	18801.8	40000	24.8	25829.3	104000	15691.9	40
06CLIFTY 138.kV	AC	45.3	18110.4	40000	23.8	24761.6	104000	15012	41.8
06CLIFTY 138.kV	AD	41.4	16542	40000	21.6	22429.4	104000	13549.7	45.2

Base 2022 Results

BUS	BREAKER	DUTY %	DUTY MPS	BREAKER CAPABILITY	MOMENTARY DUTY %	MOMENTARY DUTY AMPS	MOMENTARY BREAKER CAPABILITY	ISC	X/R
06CLIFTY 345.kV	DL	80.4	50668.5	63000	64.5	81492.5	126400	50668.5	27.1
06CLIFTY 345.kV	DL1	80.4	50668.5	63000	49.8	81492.5	163800	50668.5	27.1
06CLIFTY 345.kV	DL2	80.4	50668.5	63000	64.5	81492.5	126400	50668.5	27.1
06CLIFTY 345.kV	R	80.4	50668.5	63000	49.8	81492.5	163800	50668.5	27.1
06CLIFTY 345.kV	S	80.4	50668.5	63000	49.8	81492.5	163800	50668.5	27.1
06CLIFTY 345.kV	T	80.4	50668.5	63000	49.8	81492.5	163800	50668.5	27.1
06KYGER 345.kV	D	78.3	39151.2	50000	47	61096.5	130000	36660.1	24.5
06KYGER 345.kV	E	78.3	39151.2	50000	45.3	58859.5	130000	36660.1	24.5
06KYGER 345.kV	G	78.3	39151.2	50000	47	61096.5	130000	36660.1	24.5
06KYGER 345.kV	H	78.3	39151.2	50000	45.2	58776.8	130000	36660.1	24.5
06DEARBN 345.kV	DB	77.9	38962.1	50000	46.7	60689.2	130000	38962.1	18.6
06DEARBN 345.kV	DC	77.9	38962.1	50000	46.7	60689.2	130000	38962.1	18.6
06KYGER 345.kV	M	77.2	38577.3	50000	47	61096.5	130000	35928	25.3
06KYGER 345.kV	N	77.2	38577.3	50000	45.2	58816.4	130000	35928	25.3
06KYGER 345.kV	AA	76.5	38274.6	50000	47	61096.5	130000	38274.6	24.5
06KYGER 345.kV	B	76.5	38274.6	50000	47	61096.5	130000	38274.6	24.5
06KYGER 345.kV	C	76.5	38274.6	50000	47	61096.5	130000	38274.6	24.5
06KYGER 345.kV	F	76.5	38274.6	50000	47	61096.5	130000	38274.6	24.5
06KYGER 345.kV	I	76.5	38274.6	50000	47	61096.5	130000	38274.6	24.5
06KYGER 345.kV	J	76.5	38274.6	50000	47	61096.5	130000	38274.6	24.5
06KYGER 345.kV	L	76.5	38274.6	50000	47	61096.5	130000	38274.6	24.5
06KYGER 345.kV	O	76.5	38274.6	50000	47	61096.5	130000	38274.6	24.5
06KYGER 345.kV	P	76.5	38274.8	50000	37.3	61096.8	163800	38274.8	24.5
06KYGER 345.kV	Q	76.5	38274.8	50000	37.3	61096.8	163800	38274.8	24.5
06KYGER 345.kV	K	76.1	38067.7	50000	45.3	58848.2	130000	35454.9	25.3
06DOE530 345.kV	212	76	25078.7	33000	44.3	38146.6	86164	23385	33.8
06DOE530 345.kV	215	76	25078.9	33000	44.3	38146.9	86164	23385.2	33.8
06DOE530 345.kV	218	76	25078.9	33000	44.3	38146.9	86164	23385.2	33.8

06DOE530 345.kV	222	76	25078.7	33000	44.3	38146.6	86164	23385	33.8
06DOE530 345.kV	225	76	25078.9	33000	44.3	38146.9	86164	23385.2	33.8
06DOE530 345.kV	228	76	25078.9	33000	44.3	38146.9	86164	23385.2	33.8
06DOE530 345.kV	242	76	25078.7	33000	44.3	38146.6	86164	23385	33.8
06DOE530 345.kV	245	76	25078.7	33000	44.3	38146.6	86164	23385	33.8
06DOE530 345.kV	248	76	25078.7	33000	44.3	38146.6	86164	23385	33.8
06DOE530 345.kV	252	76	25078.7	33000	44.3	38146.6	86164	23385	33.8
06DOE530 345.kV	255	76	25078.9	33000	44.3	38146.9	86164	23385.2	33.8
06DOE530 345.kV	258	76	25078.9	33000	44.3	38146.9	86164	23385.2	33.8
06DOE530 345.kV	262	76	25078.7	33000	44.3	38146.6	86164	23385	33.8
06DOE530 345.kV	268	76	25078.7	33000	44.3	38146.6	86164	23385	33.8
06CLIFTY 345.kV	A	75.9	53150.3	70000	58.2	81492.5	140100	48701.3	27.7
06CLIFTY 345.kV	B	75.9	53150.3	70000	56.5	79179.5	140100	48701.3	27.7
06CLIFTY 345.kV	D	75.9	53150.3	70000	58.2	81492.5	140100	48701.3	27.7
06CLIFTY 345.kV	E	75.9	53150.3	70000	56.5	79176.7	140100	48701.3	27.7
06CLIFTY 345.kV	G	75.7	53015.4	70000	58.2	81492.5	140100	48565.6	27.7
06CLIFTY 345.kV	H	75.7	53015.4	70000	56.4	79018.2	140100	48565.6	27.7
06KYGER 345.kV	BB	74.4	37206.7	50000	45.7	59391.8	130000	37206.7	24.5
06PIERCE 345.kV	A	74.4	37216.3	50000	43.3	56254.2	130000	37216.3	14.2
06PIERCE 345.kV	C	74.4	37216.3	50000	43.3	56254.2	130000	37216.3	14.2
06PIERCE 345.kV	D	74.4	37216.3	50000	43.3	56254.2	130000	37216.3	14.2
06PIERCE 345.kV	E	74.4	37216.3	50000	43.3	56254.2	130000	37216.3	14.2
06PIERCE 345.kV	G	74.4	37216.3	50000	43.3	56254.2	130000	37216.3	14.2
06PIERCE 345.kV	H	74.4	37216.3	50000	43.3	56254.2	130000	37216.3	14.2
06PIERCE 345.kV	J	74.4	37216.3	50000	43.3	56254.2	130000	37216.3	14.2
06PIERCE 345.kV	P	74.4	37216.3	50000	43.3	56254.2	130000	37216.3	14.2
06PIERCE 345.kV	K	73.8	36887.3	50000	42.9	55757	130000	36887.3	14.2
06PIERCE 345.kV	M	73.8	36887.3	50000	42.9	55757	130000	36887.3	14.2
06PIERCE 345.kV	Q	73.8	36887.3	50000	42.9	55757	130000	36887.3	14.2
06PIERCE 345.kV	R	73.8	36887.3	50000	42.9	55757	130000	36887.3	14.2
06CLIFTY 345.kV	C	72.4	50668.5	70000	58.2	81492.5	140100	50668.5	27.1

06CLIFTY 345.kV	F	72.4	50668.5	70000	58.2	81492.5	140100	50668.5	27.1
06CLIFTY 345.kV	I	72.4	50668.5	70000	58.2	81492.5	140100	50668.5	27.1
06CLIFTY 345.kV	J	72.4	50700.8	70000	58.2	81492.5	140100	46251	28.4
06CLIFTY 345.kV	K	72.4	50700.8	70000	56.5	79160.1	140100	46251	28.4
06CLIFTY 345.kV	L	72.4	50668.5	70000	58.2	81492.5	140100	50668.5	27.1
06CLIFTY 345.kV	M	72.4	50668.5	70000	58.2	81492.5	140100	50668.5	27.1
06CLIFTY 345.kV	O	72.4	50668.5	70000	58.2	81492.5	140100	50668.5	27.1
06CLIFTY 345.kV	P	72.4	50668.5	70000	58.2	81492.5	140100	50668.5	27.1
06CLIFTY 345.kV	Q	72.4	50668.5	70000	58.2	81492.5	140100	50668.5	27.1
06PIERCE 345.kV	I	70.7	35358.7	50000	41	53332.9	130000	35358.7	14
06CLIFTY 345.kV	N	70.6	49437.9	70000	56.8	79599.6	140100	49437.9	27.6
06PIERCE 345.kV	L	70.1	35046.1	50000	40.7	52861.4	130000	35046.1	14
06PIERCE 345.kV	F	69.7	34843.8	50000	40.5	52670.4	130000	34843.8	14.2
06DOE530 345.kV	272	60.2	24067.4	40000	36.7	38146.6	104000	23385	33.8
06DOE530 345.kV	275	60.2	24067.4	40000	36.7	38146.9	104000	23385	33.8
06DOE530 345.kV	278	60.2	24067.4	40000	36.7	38146.9	104000	23385	33.8
06DOE530 345.kV	282	60.2	24067.4	40000	36.7	38146.6	104000	23385	33.8
06DOE530 345.kV	285	60.2	24067.4	40000	36.7	38146.6	104000	23385	33.8
06DOE530 345.kV	265	48	15851.1	33000	25.8	22212.2	86164	13616.7	33.8
06CLIFTY 138.kV	AE	47	18810.1	40000	24.8	25840.7	104000	15698.8	40
06CLIFTY 138.kV	AC	44.6	17828.1	40000	23.4	24314	104000	14724.6	42.7
06CLIFTY 138.kV	AD	40.6	16246.7	40000	21.1	21970.1	104000	13257.2	46.3

Appendix E

Ohio Valley Electric Corporation

Stability Assessment Template

Indiana-Kentucky Electric Corporation TPL-001-0.1, TPL-002-0, TPL-003-0, TPL-004-0

Electrical Operations – Record

A stability study of an existing generating plant connected to the OVEC system is not needed unless the answer to at least one of the following statements is "YES":

1. The impedance or configuration of the transmission network in the vicinity of a generating plant connected to the OVEC system has been modified by addition, removal, or other change so as to weaken the transmission system in the vicinity of the generating plant.
YES ____ NO __X__

2. Changes have been made to the steady-state or stability modeling or MW capability of any generating unit(s) so as to decrease the stability of the unit(s).
YES ____ NO __X__

Is a stability study needed based on 1 or 2 above?
YES ____ NO __X__

This assessment was completed for the period listed and completed the individual named below.

2017 – 2022
Dates covering this assessment

Robert J. O'Keefe
Name

November 14, 2017
Date of assessment

Stability Assessment Template

TPL-001-0.1, TPL-002-0, TPL-003-0, TPL-004-0

Version History

REVISION	DATE	REVISED/REVIEWED BY	PURPOSE
1.0	08/30/10	JHR, GWB, RJM, SRC, JAD	Original Issue
1.1	11/25/15	RJO, JHR, SRC	Clarifying text added to items 1&2

Appendix F

Ohio Valley Electric Corporation

Kyger Creek Plant

Stability Performance Study

Of Final DOE Station Configurations

Advanced Transmission Studies and Technologies
September 2010

1. INTRODUCTION

This study was undertaken to evaluate the stability performance of Ohio Valley Electric Corporation's (OVEC) Kyger Creek Plant following permanent changes to transmission interconnections at the Department of Energy's (DOE) X530 and X533 345 kV Stations. These changes are expected to be placed in service during the 4th quarter of 2010.

2. OVERVIEW OF GENERATION/TRANSMISSION FACILITIES

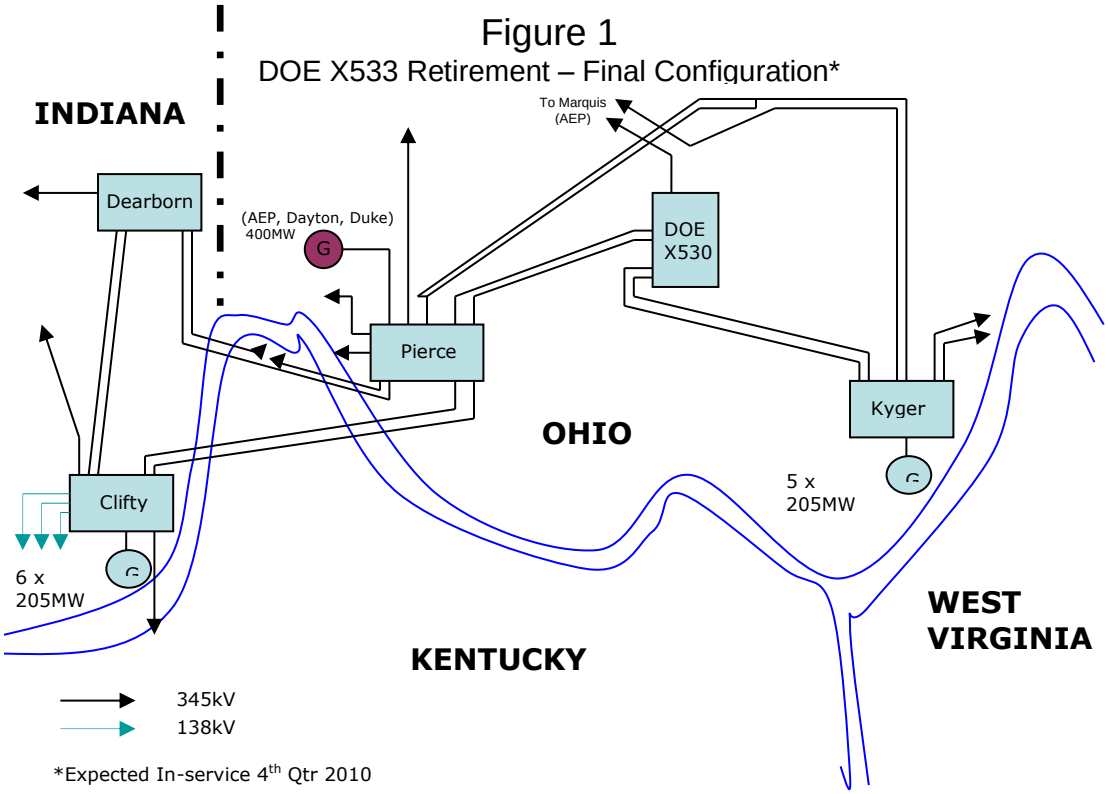
The generation capability at the Kyger Creek Plant is 1,025 MW winter net and is the sum of five similar units each rated at 205 MW winter net.

The final transmission configuration in the vicinity of DOE's X530 and X533 345 kV stations that was the subject of this study is as follows: Kyger Creek – X533 circuit 1 of the 345 kV double circuit tower (DCT) line is now routed directly to Marquis 345 kV from the X533 site (also utilizing the former X533-Marquis line, but without the series reactor) and Kyger Creek – X533 circuit 2 now connects to X533 – Pierce DCT line as a 6-wire DCT line from the X533 site to Pierce 345 kV Station. The X530 345 kV Station has been returned to the configuration that existed prior to the start of construction at Marquis and the 2008 interim reconfigurations.

The final configuration is also shown in Figure 1. The X533 Station no longer exists as a station and the entire DOE load of approximately 35 MW is now served from the X530 Station.

Figure 1

DOE X533 Retirement – Final Configuration*



3. TESTING CRITERIA

AEP / OVEC transient stability criteria for 345 kV connected generation facilities shown in Table 1 below specify the conditions and events for which stable operation is required (see OVEC FERC Form 715 filing, Part 4). In addition, satisfactory damping of generator post-disturbance power oscillations is required.

These testing criteria are applied in time domain simulations to evaluate the stability performance of a generation facility. For each disturbance, the resulting transmission system response is simulated and then analyzed to assess the impact of the disturbance scenarios on the proposed generators and the surrounding system. A one cycle margin to instability is present in the stability results designated as acceptable reported in this study.

Although beyond the scope of the AEP / OVEC stability testing criteria, a double circuit tower (DCT) line outage was considered in this study as a valid and credible fault disturbance scenario.

TABLE 1

AEP / OVEC Stability Testing Criteria for 345 kV Connected Generation

Prefault System Condition		Fault Disturbance Scenario
All Transmission Facilities in Service	2A	Permanent single phase to ground fault with breaker failure. Fault clearing by backup breakers.
	2B	Permanent three phase to ground fault with unsuccessful HSR if applicable. Fault cleared by primary breakers.
	2C	Three phase line opening without fault.
One Transmission Facility Out	2D	Permanent three phase to ground fault with unsuccessful HSR, if applicable. Fault cleared by primary breakers.
	2E	Three phase line opening without fault.
Two Transmission Facilities Out	2F	Temporary three phase to ground fault with successful HSR, if applicable.
	2G	Three phase line opening without fault.

Where, Criteria 2A = NERC TPL Table 1 Category C6-9
Criteria 2B = NERC TPL Table 1 Category B1-3
Criteria 2C = NERC TPL Table 1 Category B1-3
Criteria 2D = NERC TPL Table 1 Category C3
Criteria 2E = NERC TPL Table 1 Category C3

The DCT line outages simulated in this study may be considered as a combination of NERC Category C3 and C5 contingencies. In this study, a prior outage of a DCT line is followed by another DCT line outage. The other NERC TPL category contingencies are either not applicable or would be less severe.

4. STUDY SCOPE and DATA

With reference to the above stability testing criteria, and in consideration of double circuit tower (DCT) faults and outages, the cases to be simulated were determined and are listed in Table 2 below. These cases all involved three-phase primary cleared faults or non-fault initiated tripping. Phase-to-ground delayed clearing faults were not simulated due to the station configuration at Kyger Creek 345 kV which is such that outage of further transmission elements does not occur, thus making these disturbance scenarios less severe.

Unsuccessful high speed reclosing (HSR) of faulted transmission lines was simulated in all three-phase fault cases. All primary fault clearing was assumed to be 3.5 cycles from fault initiation. The Kyger Creek Plant was dispatched at its winter net capacity of 1,025 MW unless otherwise indicated. The AEP 2009 series BCD 2015 Summer ERAG / MMWG base case was used in this study.

5. STUDY RESULTS

The study results for each stability simulation case are indicated in Table 2 below.

Each case consists of a prior double circuit tower (DCT) outage out of the Kyger Creek 345 kV Station followed by three-phase fault and trip, or non-fault initiated trip, of a second DCT. The Kyger Creek Plant is thus connected by one remaining DCT post-contingency in each case. Each of these cases is beyond the severity of the stated stability criteria in Section 3 above. The acceptable stability results from these cases indicate that less severe cases consistent with the criteria would also have acceptable stability.

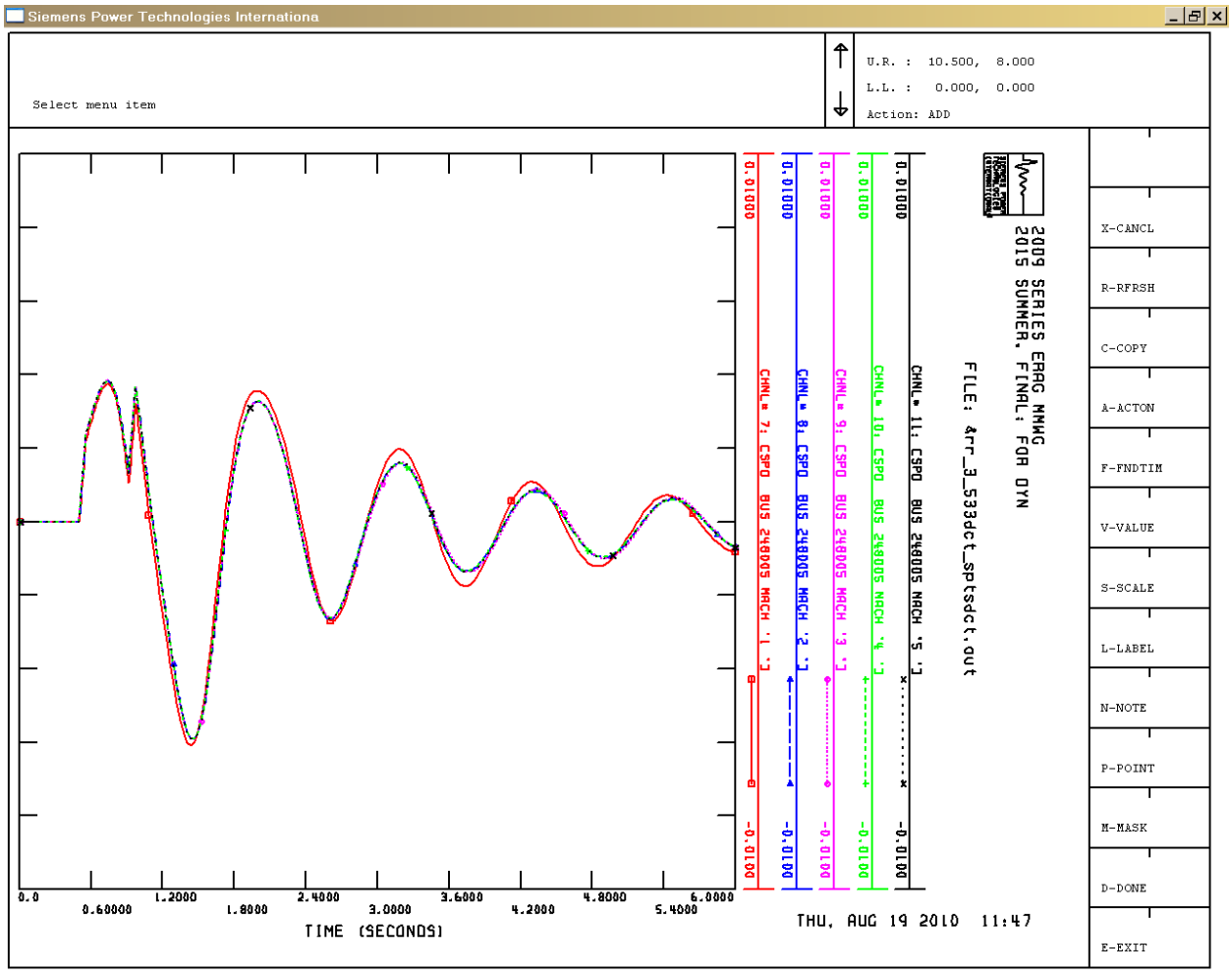
Plots of the dynamic simulation cases with three-phase faults are attached below.

6. CONCLUSION

The Kyger Creek Plant exhibits acceptable stability with the final configuration at DOE's X530 and X533 345 kV stations for Criteria 2A through 2E without a need for curtailment.

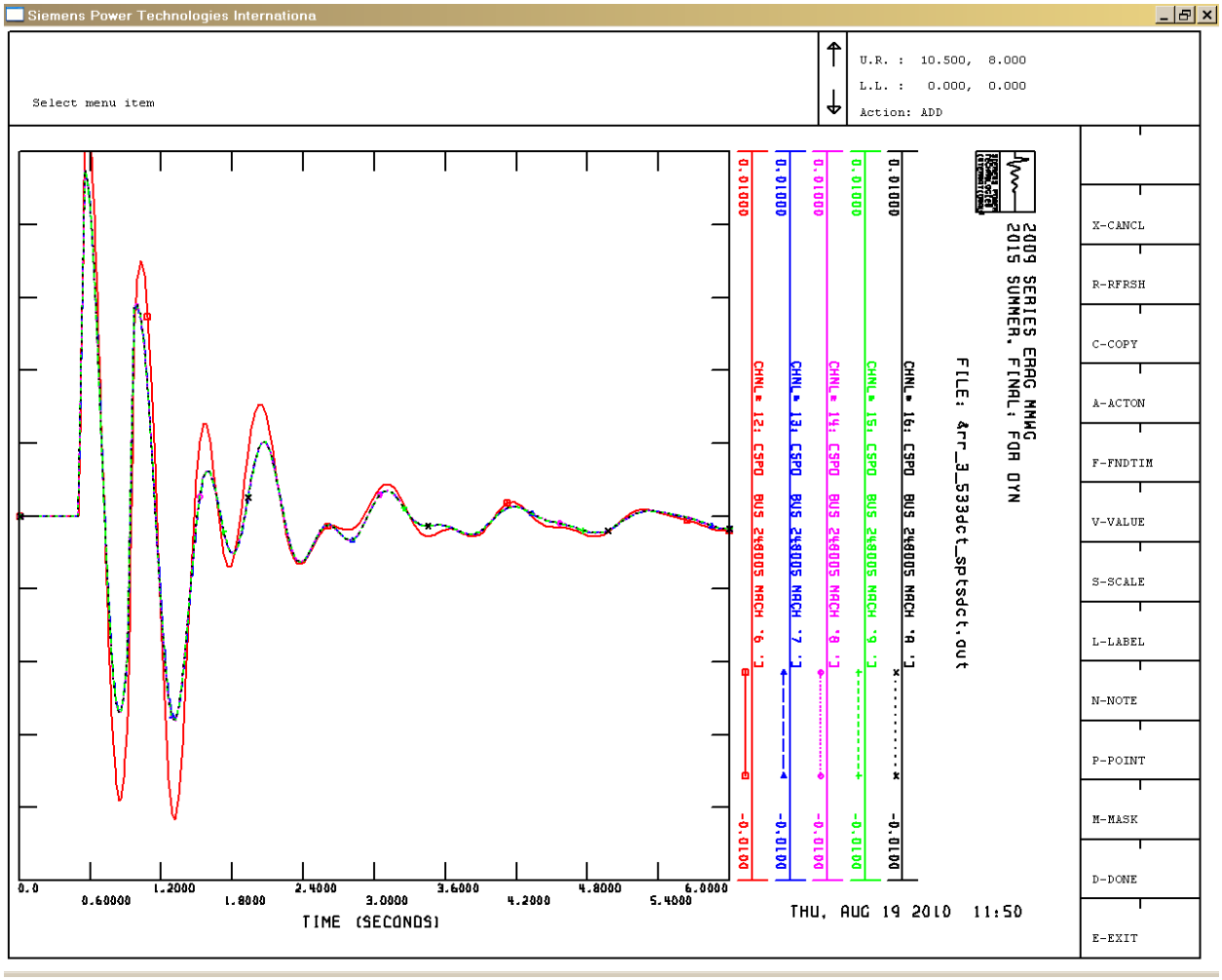
TABLE 2

Case Number	Prior Outage	Outaged Line	MW	Fault Type	Result
Case 1	Kyger Ck – X533 345 kV DCT	Kyger Ck – Sporn / Tristate 345 kV DCT	1025	3 Phase w/ HSR	Stable
Case 2	Kyger Ck – X533 345 kV DCT	Kyger Ck – Sporn / Tristate 345 kV DCT	1025	No Fault	Stable
Case 3	Kyger Ck – X530 345 kV DCT	Kyger Ck – Sporn / Tristate 345 kV DCT	1025	3 Phase w/ HSR	Stable
Case 4	Kyger Ck – X530 345 kV DCT	Kyger Ck – Sporn / Tristate 345 kV DCT	1025	No Fault	Stable
Case 5	Kyger Ck – X530 345 kV DCT	Kyger Ck – X533 345 kV DCT	1025	3 Phase w/ HSR	Stable
Case 6	Kyger Ck – X530 345 kV DCT	Kyger Ck – X533 345 kV DCT	1025	No Fault	Stable



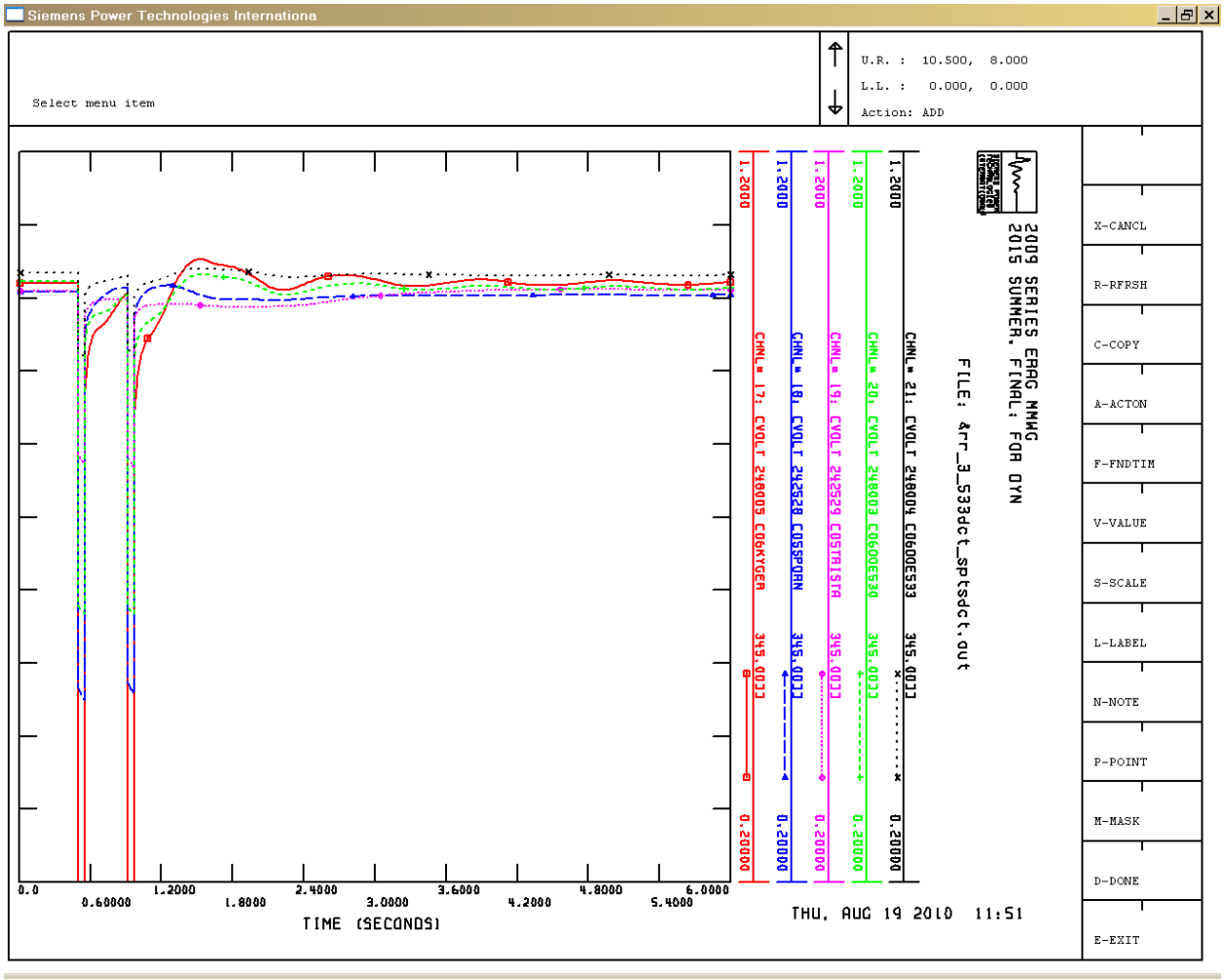
Kyger Creek Plant Per Unit Speeds

Case 1 – Prior outage of Kyger Creek – X533 345 kV DCT. Fault and trip Kyger Creek – Sporn/Tristate 345 kV DCT with unsuccessful HSR.



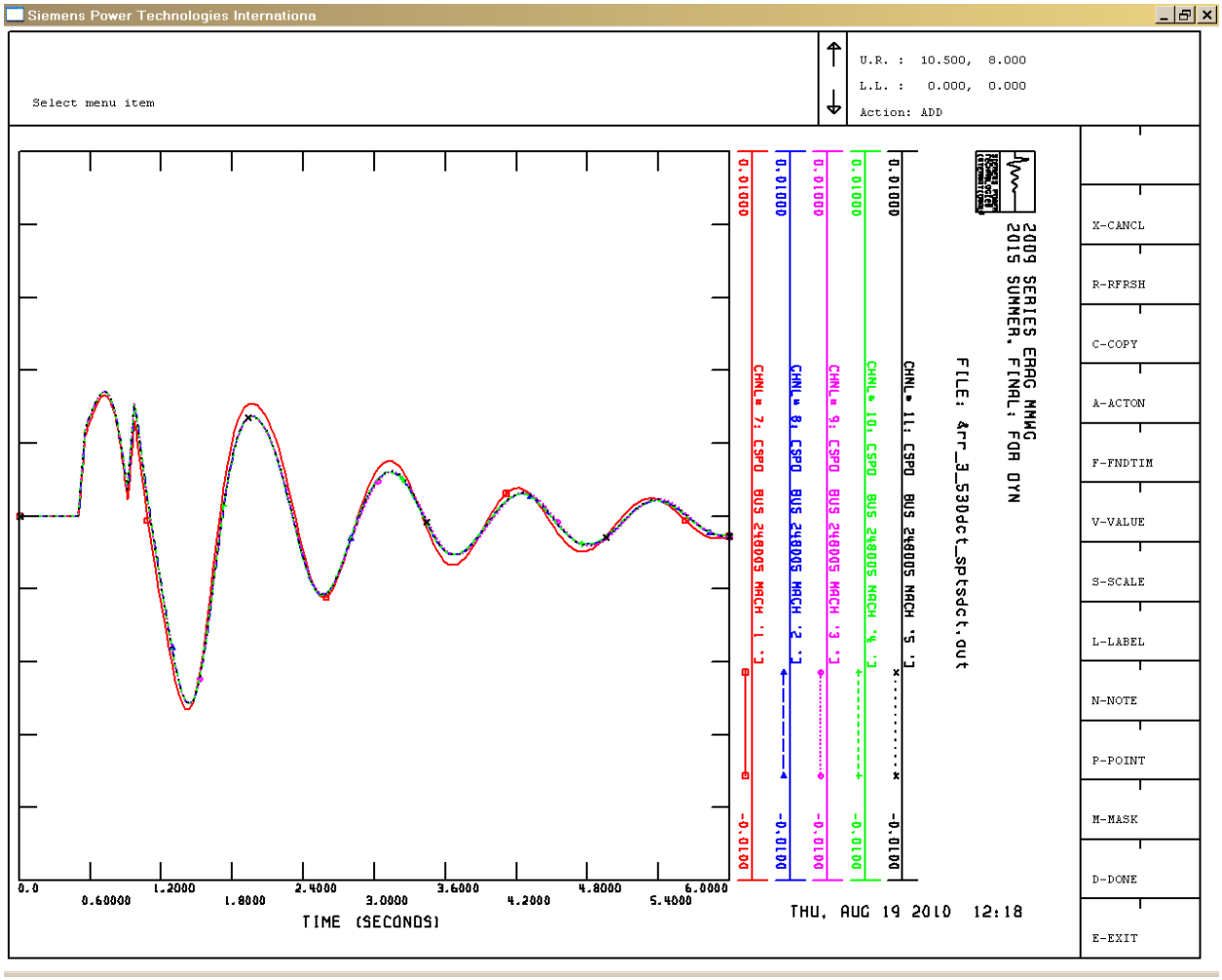
Kyger Creek Plant Per Unit Speeds

Case 1 – Prior outage of Kyger Creek – X533 345 kV DCT. Fault and trip Kyger Creek – Sporn/Tristate 345 kV DCT with unsuccessful HSR.



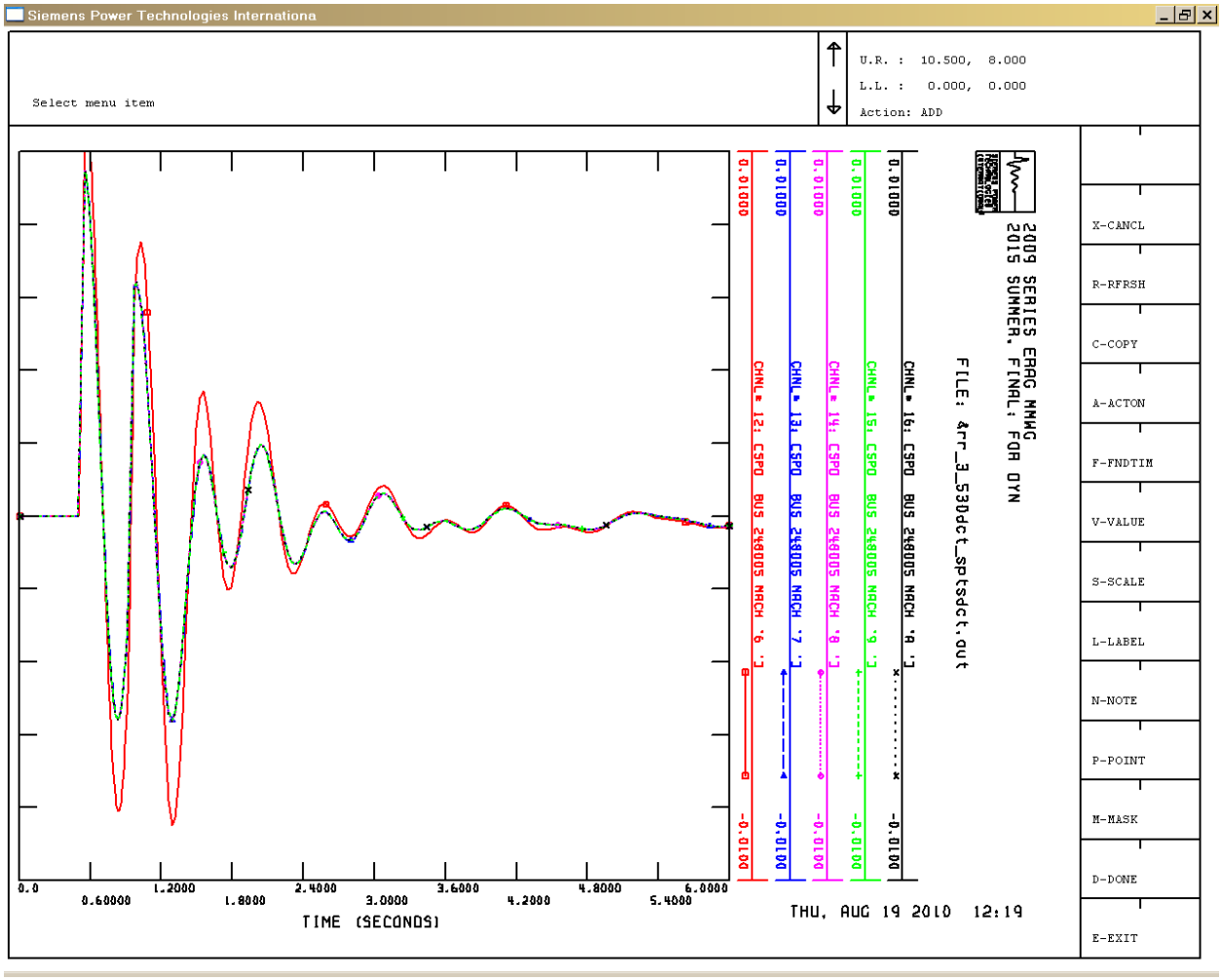
Per Unit Station Voltages

Case 1 – Prior outage of Kyger Creek – X533 345 kV DCT. Fault and trip Kyger Creek – Sporn/Tristate 345 kV DCT with unsuccessful HSR.



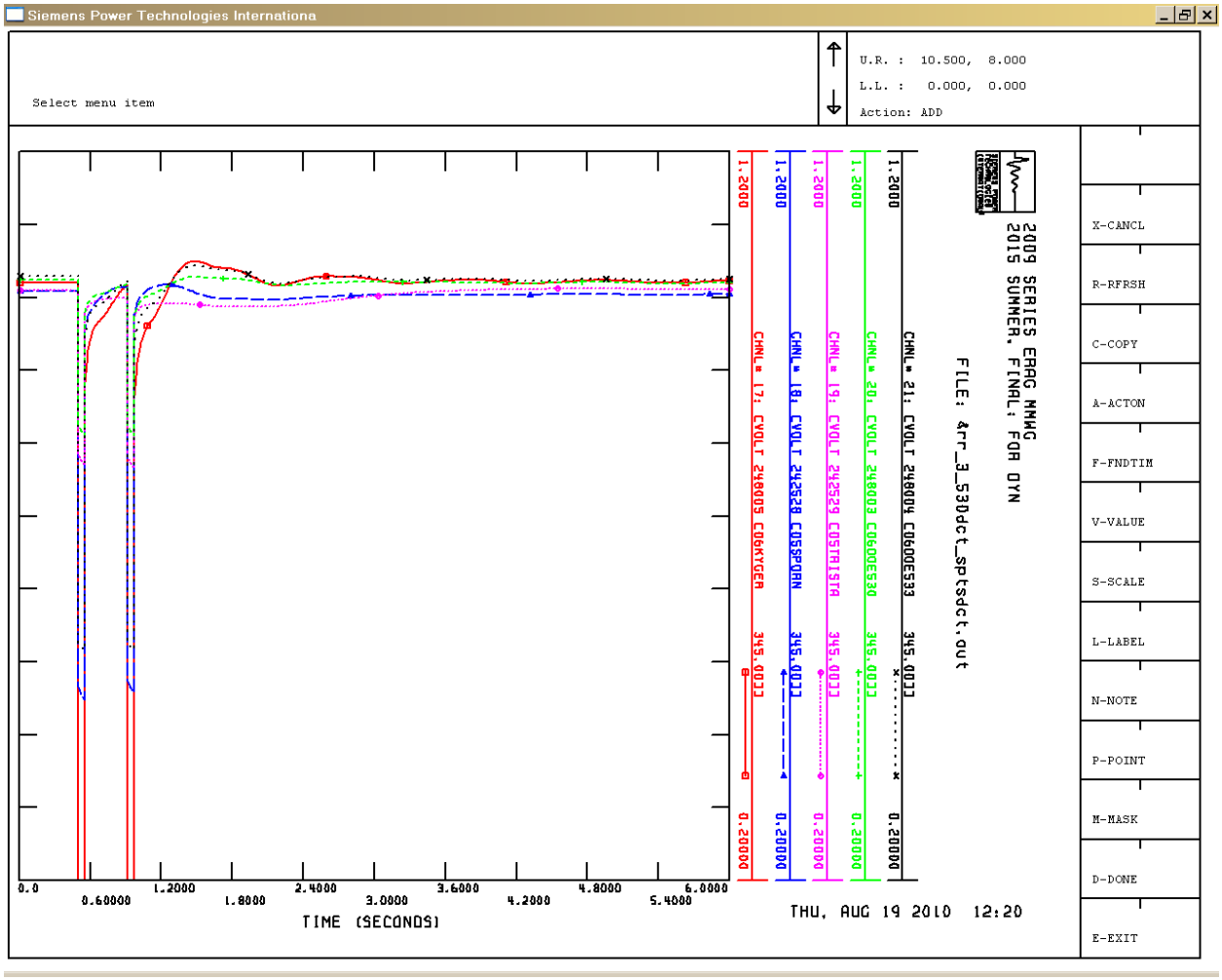
Kyger Creek Plant Per Unit Speeds

Case 3 – Prior outage of Kyger Creek – X530 345 kV DCT. Fault and trip Kyger Creek – Sporn/Tristate 345 kV DCT with unsuccessful HSR.



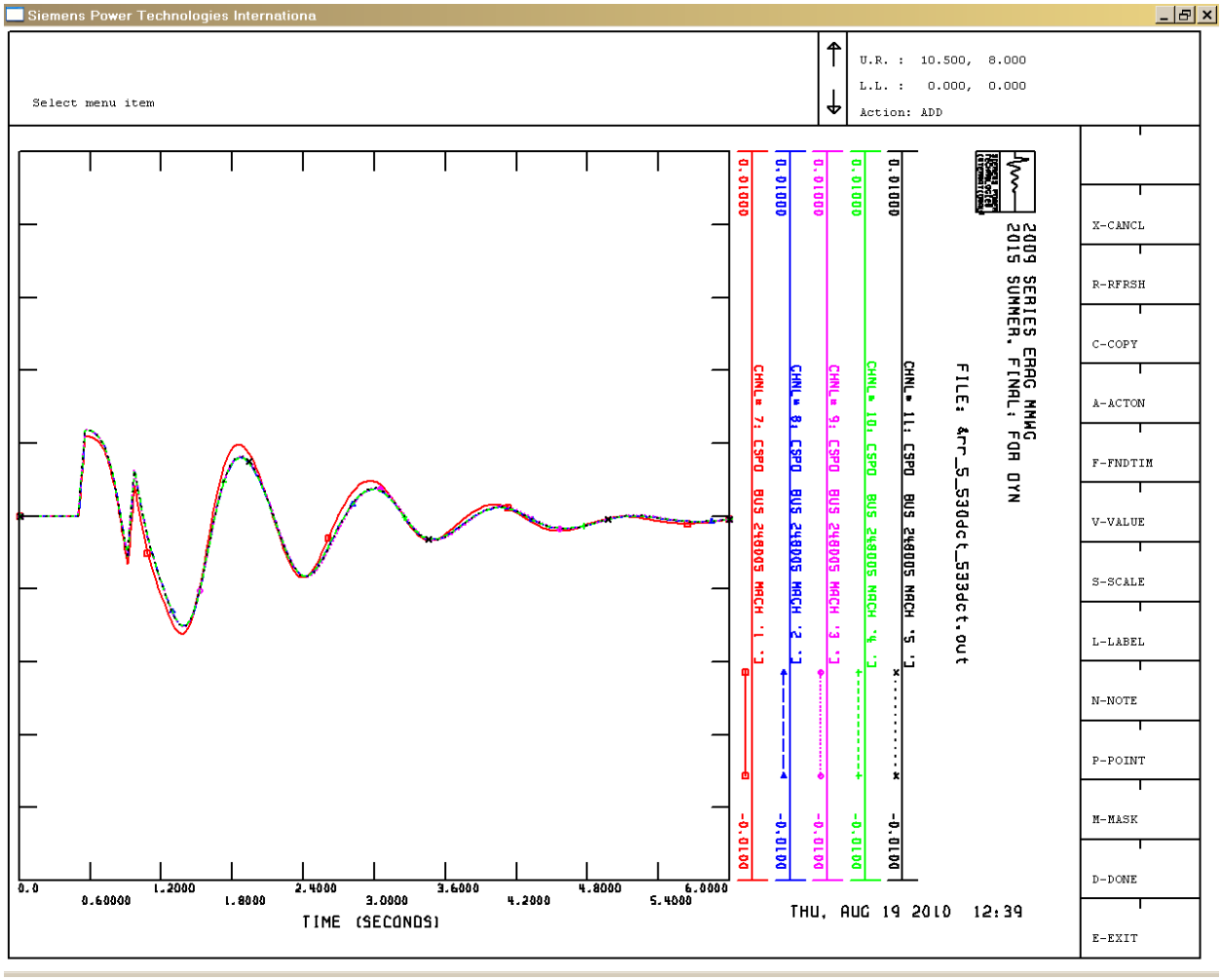
Kyger Creek Plant Per Unit Speeds

Case 3 – Prior outage of Kyger Creek – X530 345 kV DCT. Fault and trip Kyger Creek – Sporn/Tristate 345 kV DCT with unsuccessful HSR.



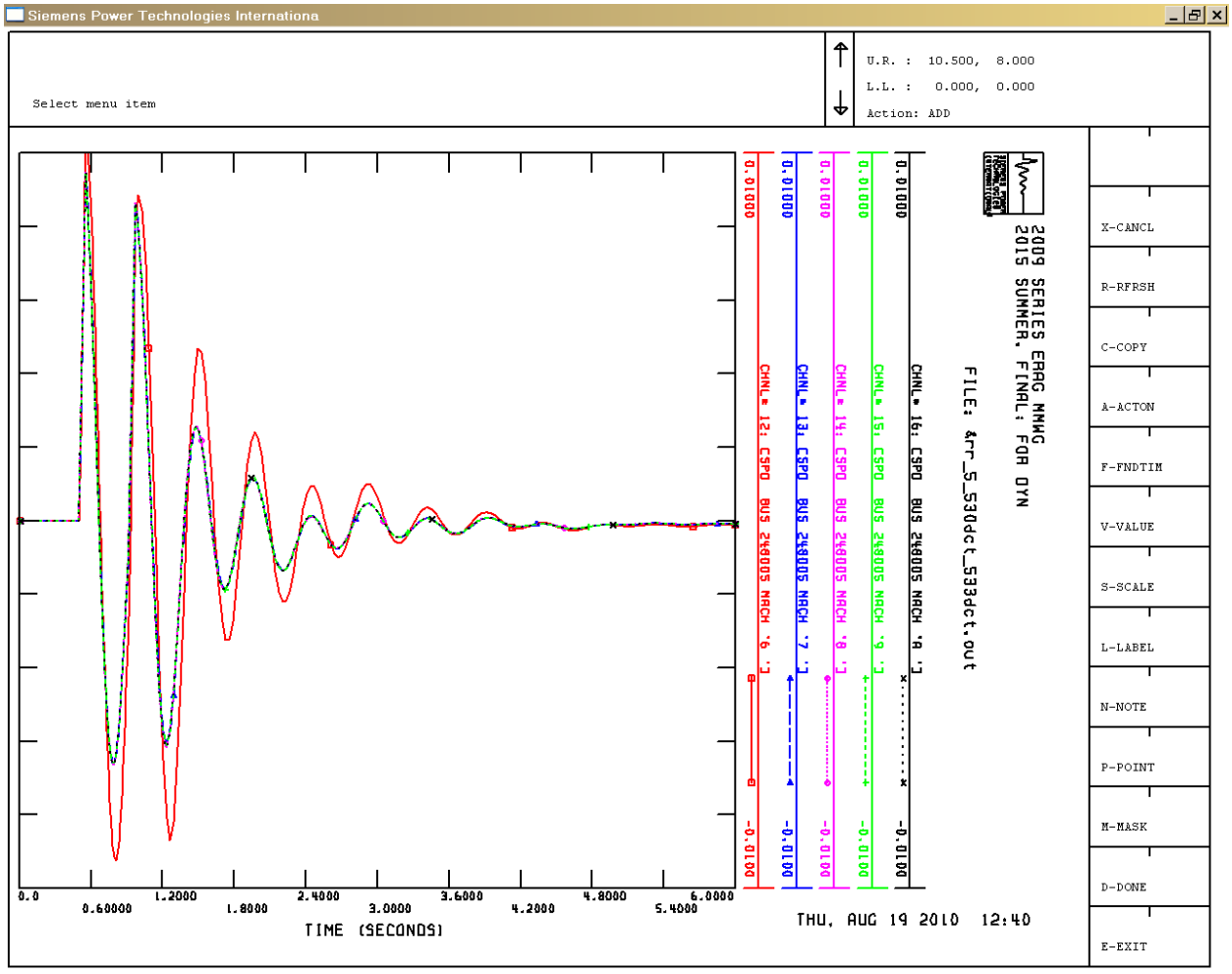
Per Unit Station Voltages

Case 3 – Prior outage of Kyger Creek – X530 345 kV DCT. Fault and trip Kyger Creek – Sporn/Tristate 345 kV DCT with unsuccessful HSR.



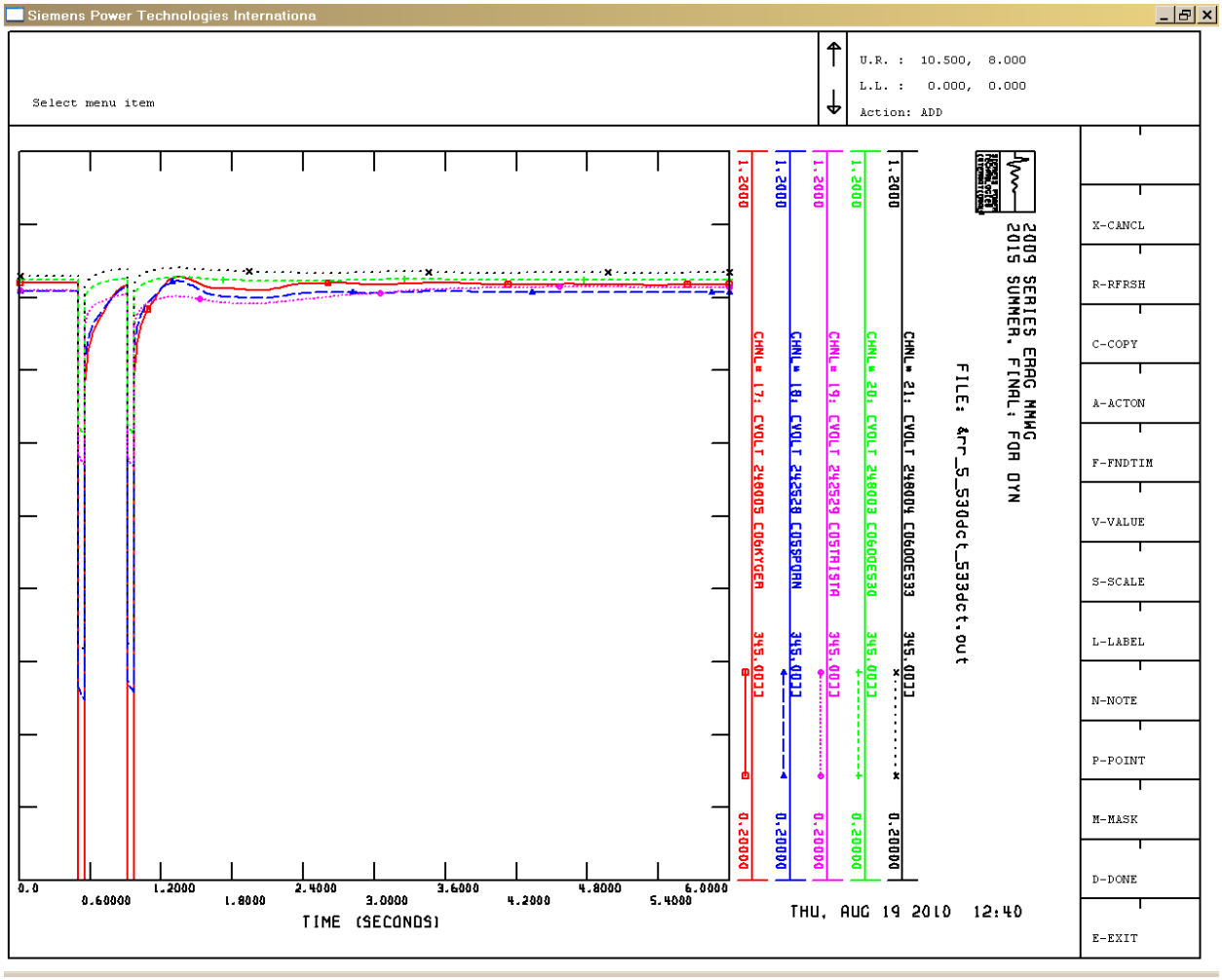
Kyger Creek Plant Per Unit Speeds

Case 5 – Prior outage of Kyger Creek – X530 345 kV DCT. Fault and trip Kyger Creek – X533 345 kV DCT with unsuccessful HSR.



Kyger Creek Plant Per Unit Speeds

Case 5 – Prior outage of Kyger Creek – X530 345 kV DCT. Fault and trip Kyger Creek – X533 345 kV DCT with unsuccessful HSR.



Per Unit Station Voltages

Case 5 – Prior outage of Kyger Creek – X530 345 kV DCT. Fault and trip Kyger Creek – X533 345 kV DCT with unsuccessful HSR.

Appendix G

Ohio Valley Electric Corporation

Clifty Creek Plant

Stability Performance Study

Advanced Transmission Studies and Technologies

December 2011

AEP AMERICAN® ELECTRIC POWER

AEP: America's Energy Partner℠

7. INTRODUCTION

This study was undertaken to evaluate the stability performance of Ohio Valley Electric Corporation's (OVEC) Clifty Creek Plant. The study was conducted in accordance with the August 2011 NERC Board approved NERC TPL-001-2 standard.

8. OVERVIEW OF GENERATION/TRANSMISSION FACILITIES

The generation capability at the Clifty Creek Plant is 1,230 MW winter net and is the sum of six similar units each rated at 205 MW winter net. This study considered the planned temporary outages of Clifty Creek – Dearborn – Buffington 345 kV line sections in late 2011 through early 2012 that were necessary for removal of Dearborn circuit breakers DA and DD, though this outage is not within the planning horizon.

9. TESTING CRITERIA

NERC TPL-001-2 Table 1 specifies the system conditions and disturbance events for which stable operation is required. In addition, satisfactory damping of generator post-disturbance power oscillations is required.

The Table 1 testing criteria are applied in time domain simulations to evaluate the stability performance of a generation facility. For each disturbance, the resulting transmission system response is simulated and then analyzed to assess the impact of the disturbance scenario on the proposed generators and the surrounding system. A minimum one cycle margin to instability is present in the stability results designated as acceptable reported in this study.

Some of the NERC TPL-001-2 Table 1 category contingencies are either not applicable or would be less severe and are omitted from this study. Specifically, P1 contingencies are less severe than P6 contingencies (P6 is the same as P1 under a prior outage condition) which, if stable, demonstrate compliance with P1. Due to the configuration of Clifty Creek 345 kV Station, P2 bus section and circuit breaker faults are equivalent in severity to line faults because these disturbance scenarios would not remove any more transmission facilities than would P1 contingencies and may remove a generating unit. P3 prior generation outages would be less severe due to the fact that stability studies test the ability of the transmission system under contingency outages to absorb generation and a condition of less generation would be more stable. P4 stuck breaker contingencies with backup fault clearing are less severe than P6 three-phase fault cases under a prior outage condition because, also due to the configuration of Clifty Creek 345 kV Station, these disturbance scenarios would result only in the removal of one transmission facility.

P6 and P7 criteria are combined in this study by simulating the three-phase fault and tripping of double circuit tower lines on top of the prior outage of another transmission facility. These are the type of disturbance scenarios that produce the most severe stability tests on the Clifty Creek Plant due to the most severe fault type (3-phase) and the most transmission facilities removed. The prior outage cases are not followed by any system adjustments and so also qualify as Type 1 stability extreme disturbances in TPL-001-2 Table 1.

For the purposes of post-fault transient voltage criteria required by TPL-001-2 R5, this study assumes that transient voltage dips at the transmission station above 40 percent voltage for 2.5 seconds are acceptable. The magnitude and duration of post-fault transient voltage dips is closely associated with proximity to instability of conventional generation and transient voltage dips that do not lead to instability are acceptable for conventional generating plants and should not otherwise result in tripping of the generator or plant auxiliary load. Therefore, where instability of the subject generating plant is approached in any of the cases included in this study, either a clearing time margin or a MW dispatch margin is applied instead.

10. STUDY SCOPE and DATA

With reference to the above stability testing criteria, and in consideration of double circuit tower (DCT) faults and outages, the cases to be simulated were determined and are listed in Table 1 below. These cases involved three-phase primary cleared faults or non-fault initiated tripping. Phase-to-ground delayed clearing faults at Clifty Creek 345 kV Station were not simulated due to the station configuration that is such that outage of further transmission elements does not occur, thus making these disturbance scenarios less severe. Phase-to-ground delayed clearing faults were considered at remote ends of lines emanating from Clifty Creek Station.

Base cases applied in this study were the 2010 series ERAG / MMWG 2012 Summer Peak Load and 2016 Light Load cases in accordance with TPL-001-2 R2.4.1 and R2.4.2, respectively. All ERAG / MMWG dynamic base cases include modeling of automatic dynamic control devices relevant to the Clifty Creek area in accordance with TPL-001-2 R4.3.2. The 2012 Summer Peak Load case was studied with Clifty Creek – Dearborn #2 – Buffington 345 kV line sections out of service due to the Dearborn Bus 2 bypass project, though this is not a planning horizon condition for TPL purposes.

Dynamic load representation, in accordance with TPL-001-2 R2.4.1, was applied as a sensitivity variable in the 2012 Summer Peak case. The PSS/E CLODAR model was applied to the study area (OVEC, AEP, LGEE, HE, DEM areas) with the following percentages:

Large motor	20 percent
Small motor	40
Transformer exciting current	3
Discharge lighting	5
Constant power	2
Constant current	30
Distribution equivalent R + jX	4 percent on load MW per unit base

The Clifty Creek Plant was dispatched at its winter net capacity of 1,230 MW unless otherwise indicated. Other nearby generating plants at Trimble County (LGEE) and Buckner (IPP) were also dispatched at their winter net MW capacities.

Unsuccessful high speed reclosing (HSR) of faulted transmission lines was simulated in three-phase fault cases inclusive to the OVEC system in accordance with TPL-001-2 R4.3.1.1. All primary fault clearing was assumed to be 3.5 cycles from fault initiation and backup or delayed clearing was assumed to be 15.0 cycles from fault initiation. Failure of a primary protection system(s) may cause up to a 30-cycle delayed fault clearing at the remote end of a line.

In all stability simulations in this study, the PSS/E simulation option "Scan circuits against generic relay zones" was turned on in accordance with TPL-001-2 R4.3.1.3.

Sensitivity conditions as required by TPL-001-2 R2.4.3 for both peak load and light load base cases considered the redispatch of generation on or in the vicinity of the OVEC system. Specifically, the Kyger Creek and Sporn generating plants were turned off and Tanners Creek and Lawrenceburg generating plants (one station away from Dearborn) were turned on and dispatched to their winter net MW capability.

11. STUDY RESULTS

The study results for each stability simulation case are indicated in Table 1 below. The results of cases simulated on peak load and light load conditions, as well as the sensitivity variable cases and non-fault initiated outage cases, are all the same as far as the their stability is concerned. The acceptable stability results from these cases in recognition of TPL-001-2 R4.1.1, 4.1.2, and 4.1.3 indicate that less severe cases consistent with TPL-001-2 criteria would also have acceptable stability.

No generic relay scan alarms were observed on any non-faulted lines in any of the cases included in this study (TPL-001-2 R 4.3.1.3). No generators are expected to trip during faults due to lack of low voltage ride-through capability (TPL-001-2 R4.3.1.2).

Plots of a representative sample of the dynamic simulation cases involving three-phase and phase-to-ground faults are attached below.

12. CONCLUSION

The Clifty Creek Plant exhibits acceptable stability performance under all credible contingencies consistent with NERC TPL-001-2 without a need for generation curtailment.

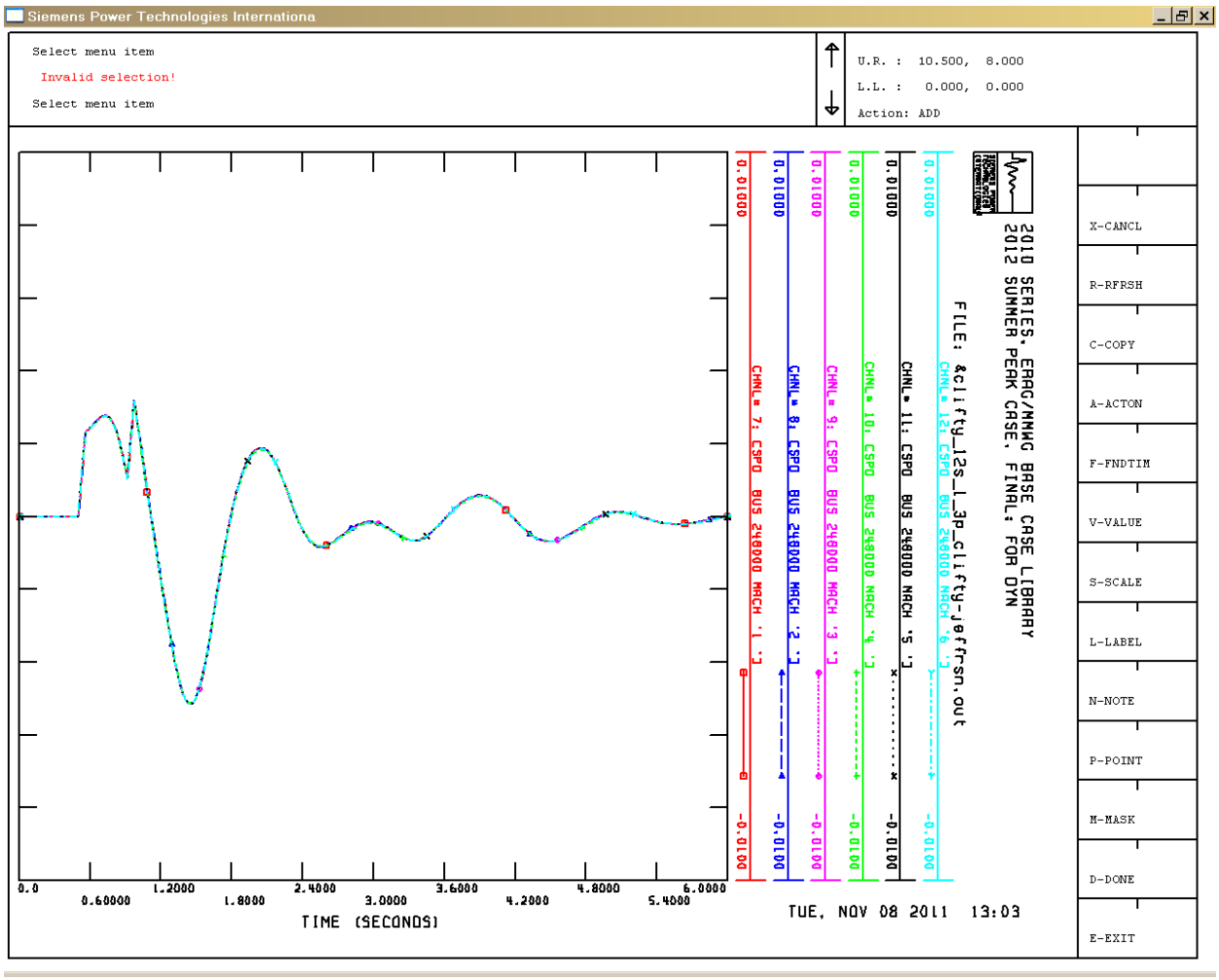
Table 1 – Clifty Creek Plant Stability Study Cases

	Prior Outage *	Outaged Facility	NERC Category	Fault Type **	Result
Case 1	Clifty Creek – Jefferson 345 kV	Clifty Creek – Pierce 345 kV DCT	P6-P7	3 Phase w/ unsuccessful HSR	Stable
Case 2	Clifty Creek – Jefferson 345 kV	Clifty Creek – Dearborn 345 kV DCT	P6-P7	3 Phase w/ unsuccessful HSR	Stable
Case 3	Clifty Creek – Jefferson 345 kV	Clifty Creek – Trimble Co 345 kV	P6	3 Phase No HSR	Stable
Case 4	Clifty Creek – Jefferson 345 kV	Buckner – Middletown 345 kV DCT	P6-P7	3 Phase No HSR	Stable
Case 5	Clifty Creek – Trimble Co 345 kV	Clifty Creek – Pierce 345 kV DCT	P6-P7	3 Phase w/ unsuccessful HSR	Stable
Case 6	Buckner – Middleton 345 kV	Clifty Creek – Pierce 345 kV DCT	P6-P7	3 Phase w/ unsuccessful HSR	Stable
Case 7	None	Dearborn – Clifty Creek 345 kV #1 Remote End Fault @ Dearborn	P5	1 Phase-to-ground w/ relay failure	Stable

Case 8	None	Clifty Creek 345 kV Station Bus 1 or 2	Extreme Event	3 Phase w/ 3 Phase delayed	Unstable, No Cascading

* The prior outage cases listed above (1 through 6) are not followed by any system adjustments and so also qualify as Type 1 stability extreme disturbances in TPL-001-2 Table 1.

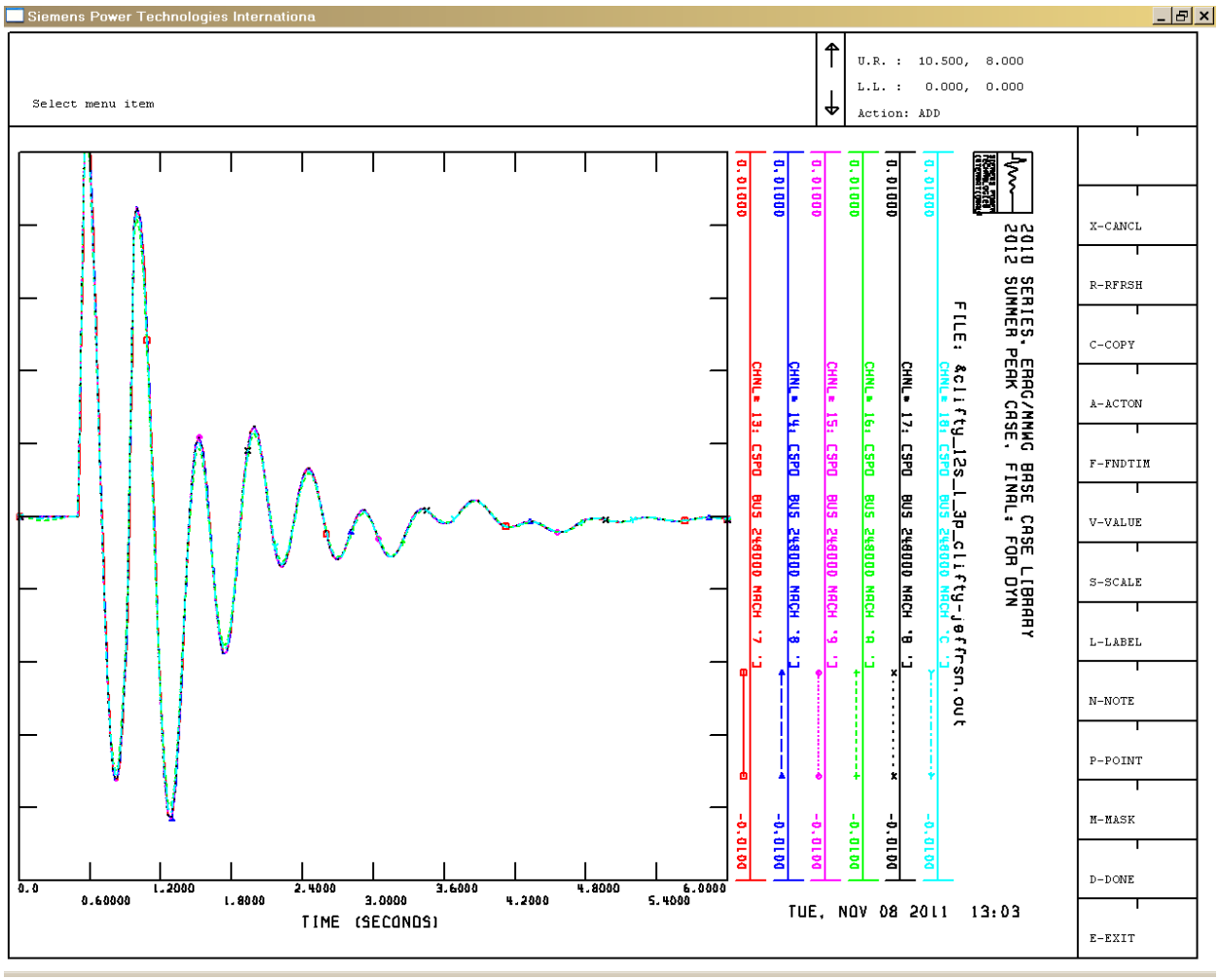
** A representative sample of non-fault initiated outages was also considered per TPL-001-2 P2.1.



Clifty Creek Plant LP Generator Speeds

Case 1: Prior outage of Clifty Creek – Jefferson 345 kV. Fault and trip Clifty Creek – Pierce 345 kV DCT with unsuccessful HSR.

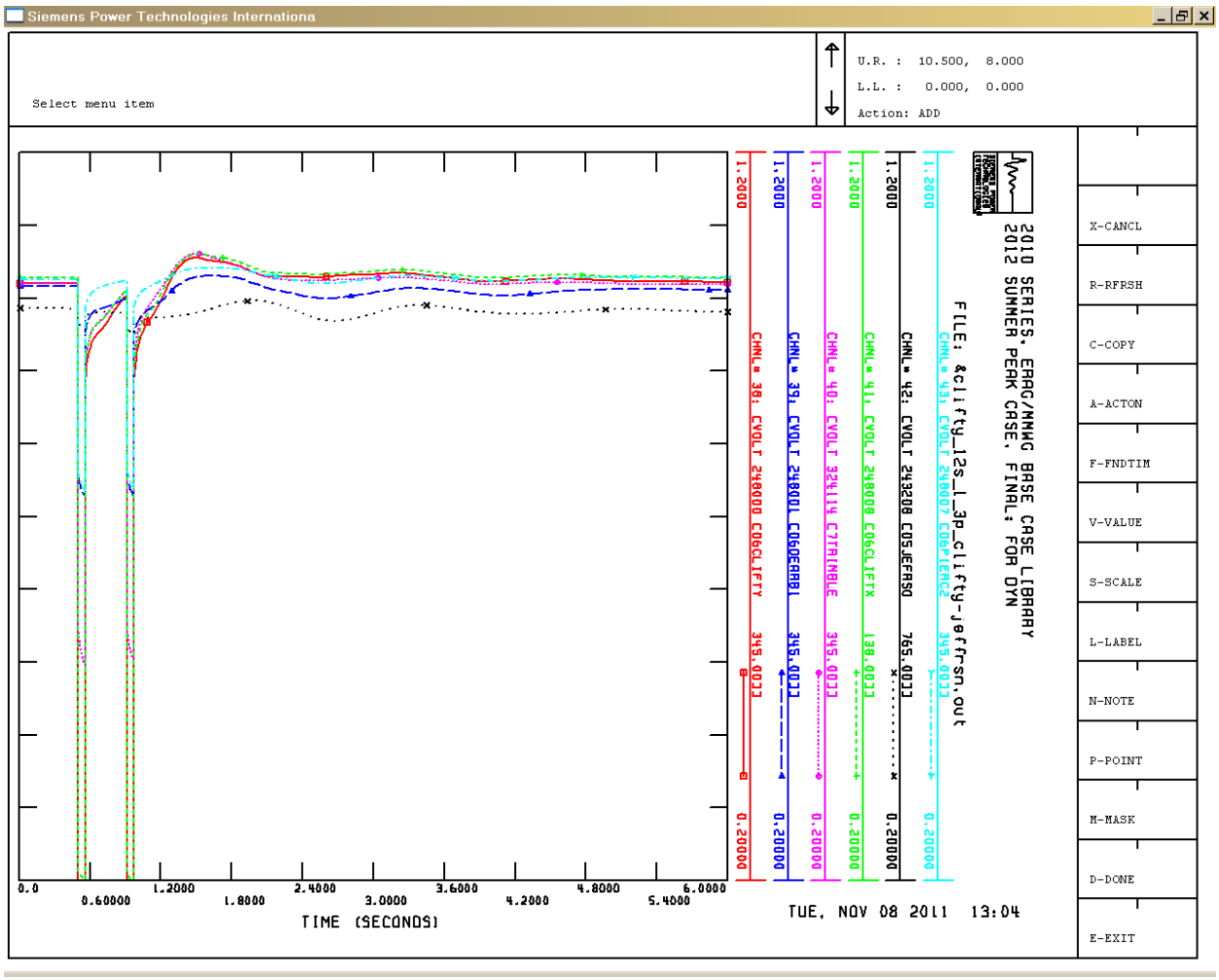
2012S Base Case



Clifty Creek Plant HP Generator Speeds

Case 1: Prior outage of Clifty Creek – Jefferson 345 kV. Fault and trip Clifty Creek – Pierce 345 kV DCT with unsuccessful HSR.

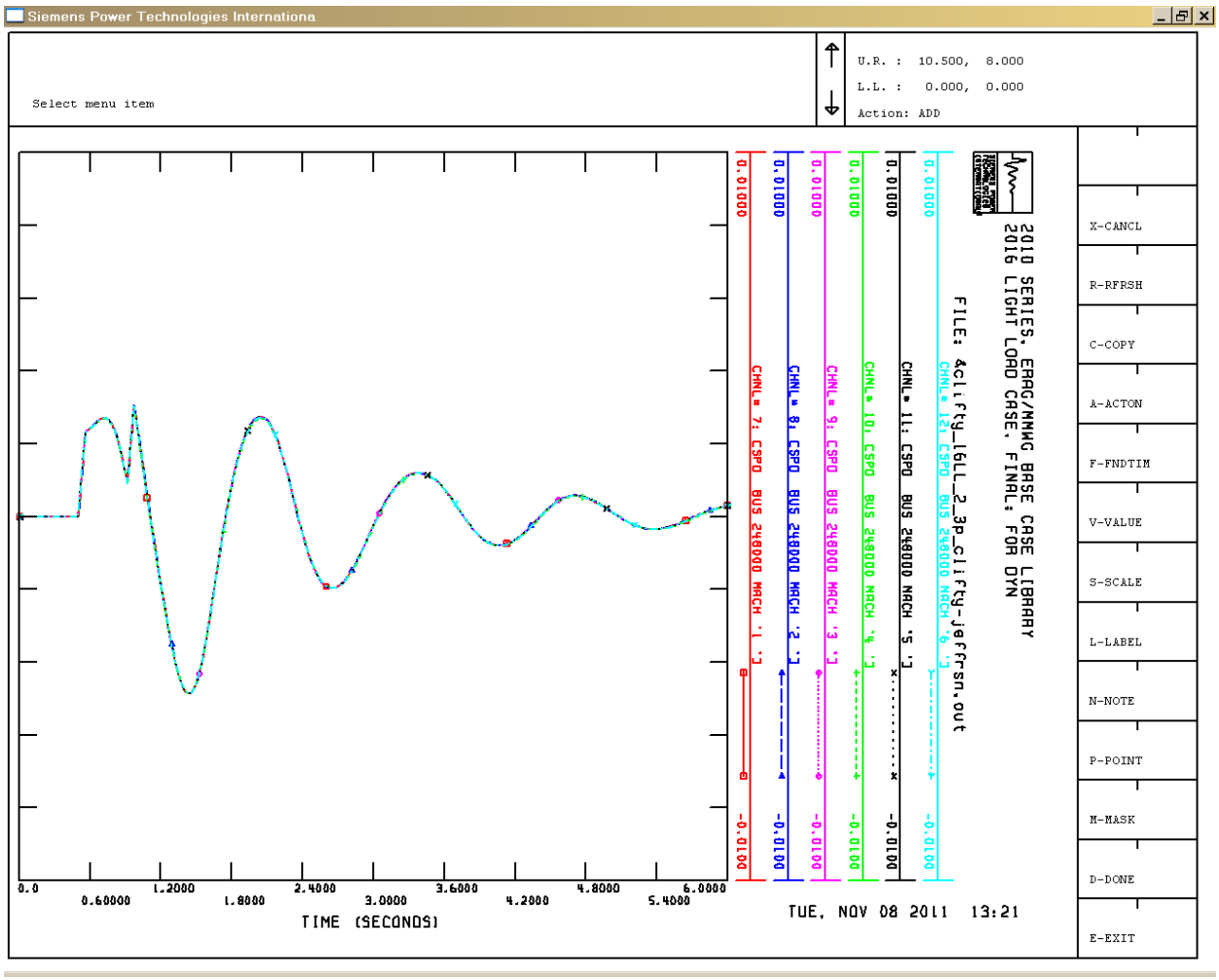
2012S Base Case



Clifty Creek, Dearborn, Trimble County, Jefferson, Pierce Station Voltages

Case 1: Prior outage of Clifty Creek – Jefferson 345 kV. Fault and trip Clifty Creek – Pierce 345 kV DCT with unsuccessful HSR.

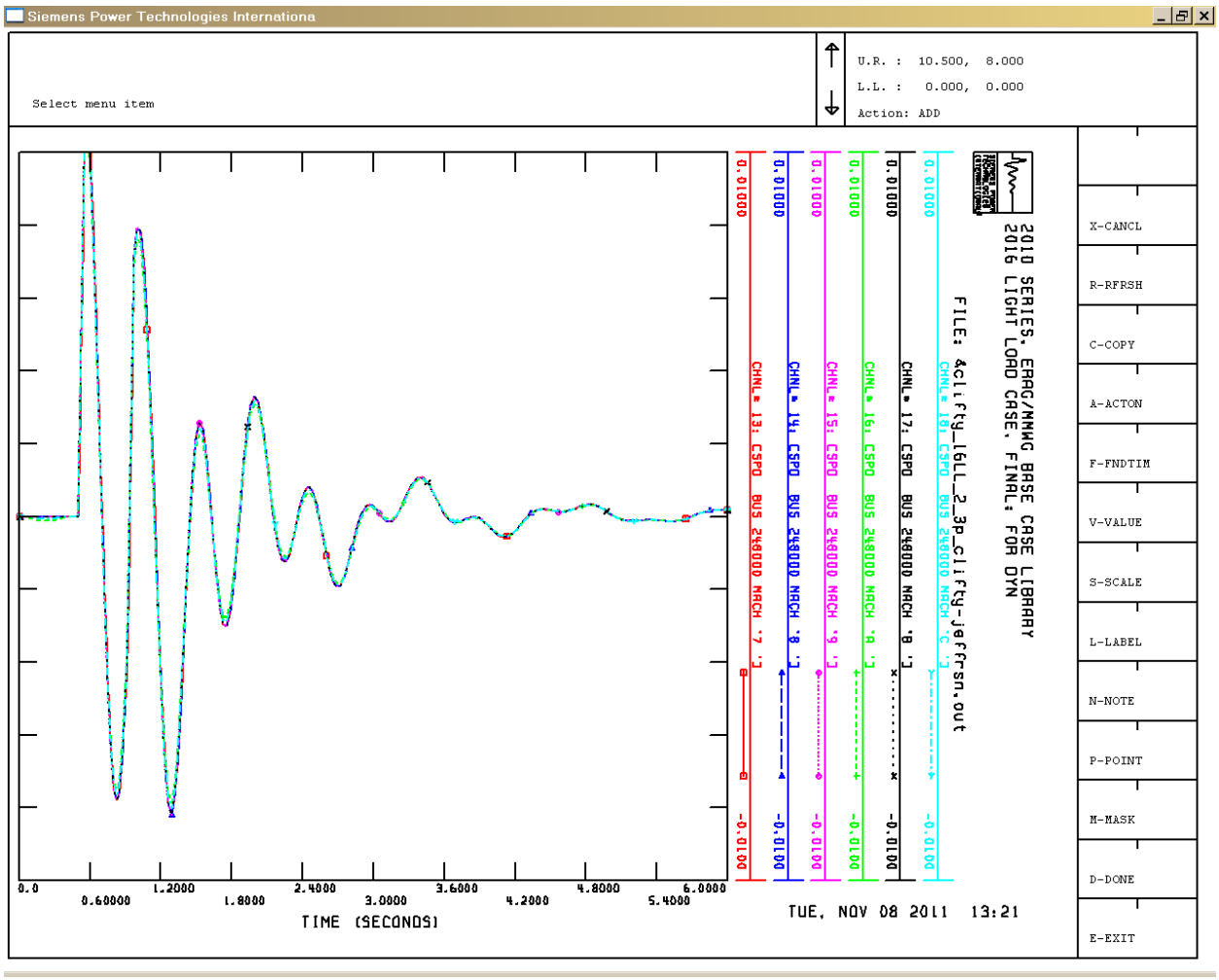
2012S Base Case



Clifty Creek Plant LP Generator Speeds

Case 2: Prior outage of Clifty Creek – Jefferson 345 kV. Fault and trip Clifty Creek – Dearborn 345 kV DCT with unsuccessful HSR.

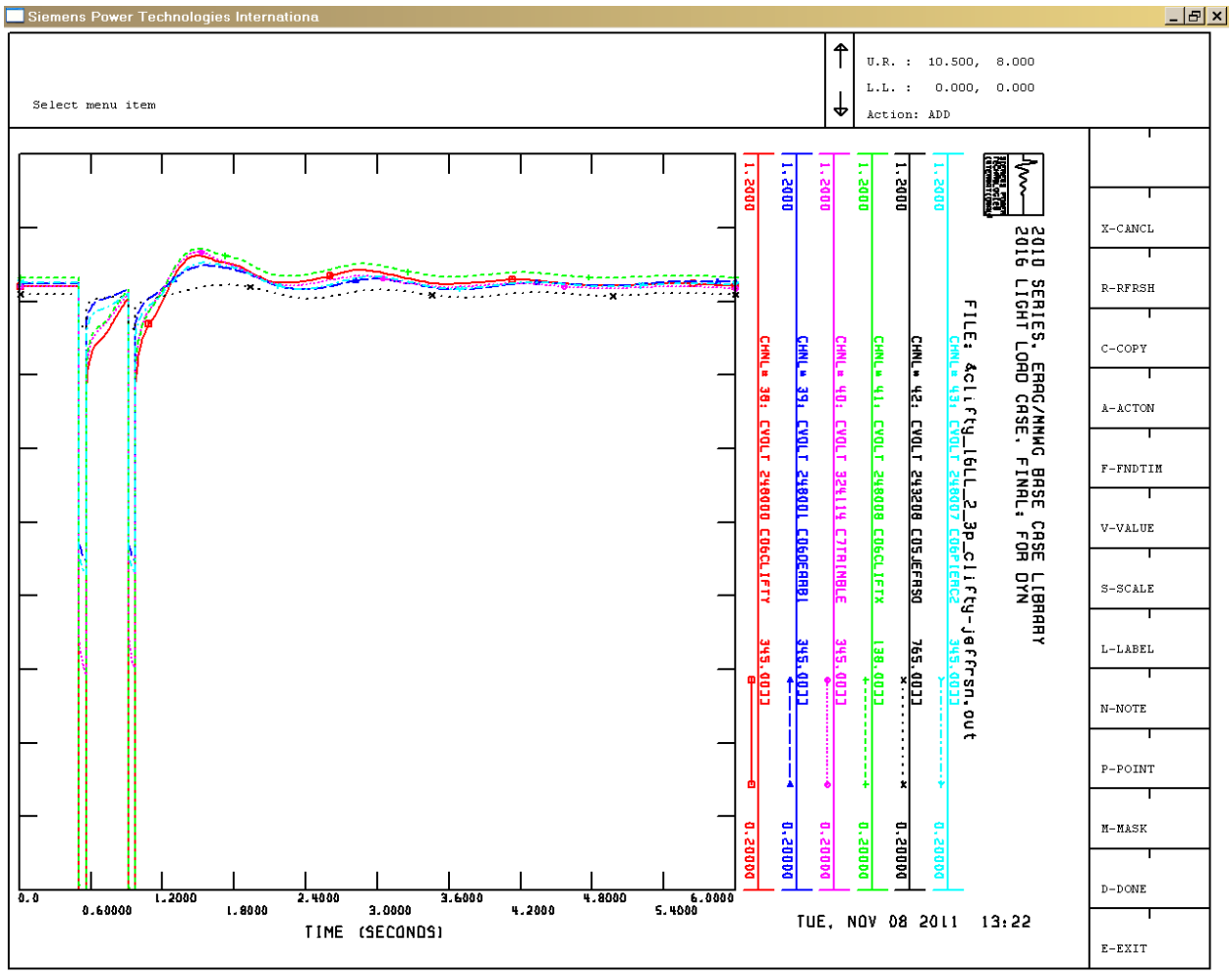
2016LL Base Case



Clifty Creek Plant HP Generator Speeds

Case 2: Prior outage of Clifty Creek – Jefferson 345 kV. Fault and trip Clifty Creek – Dearborn 345 kV DCT with unsuccessful HSR.

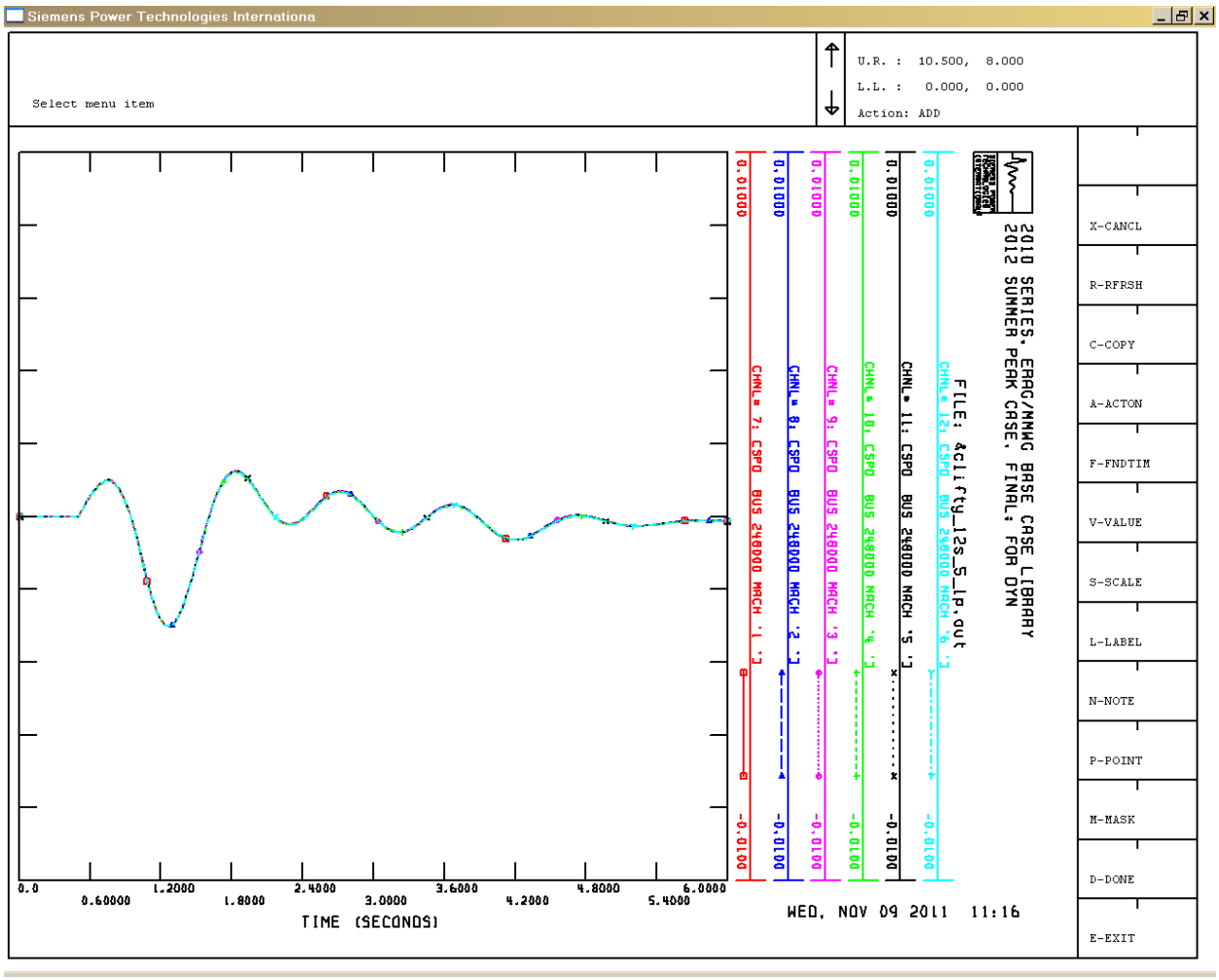
2016LL Base Case



Clifty Creek, Dearborn, Trimble County, Jefferson, Pierce Station Voltages

Case 2: Prior outage of Clifty Creek – Jefferson 345 kV. Fault and trip Clifty Creek – Dearborn 345 kV DCT with unsuccessful HSR.

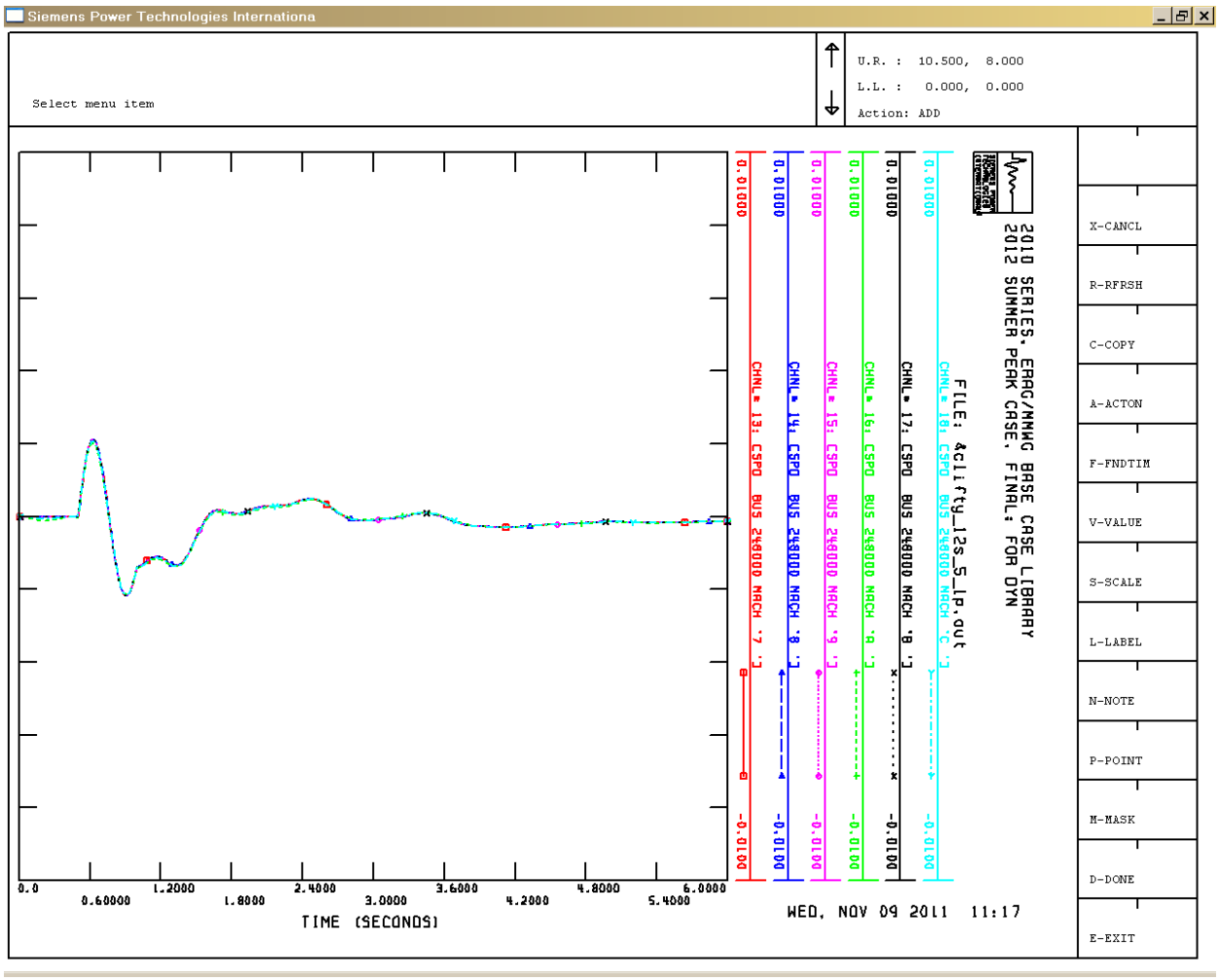
2016LL Base Case



Clifty Creek Plant LP Generator Speeds

Case 7: No prior outage. Remote end phase-to-ground fault, relay failure, and delayed trip of Clifty Creek – Dearborn 345 kV #1.

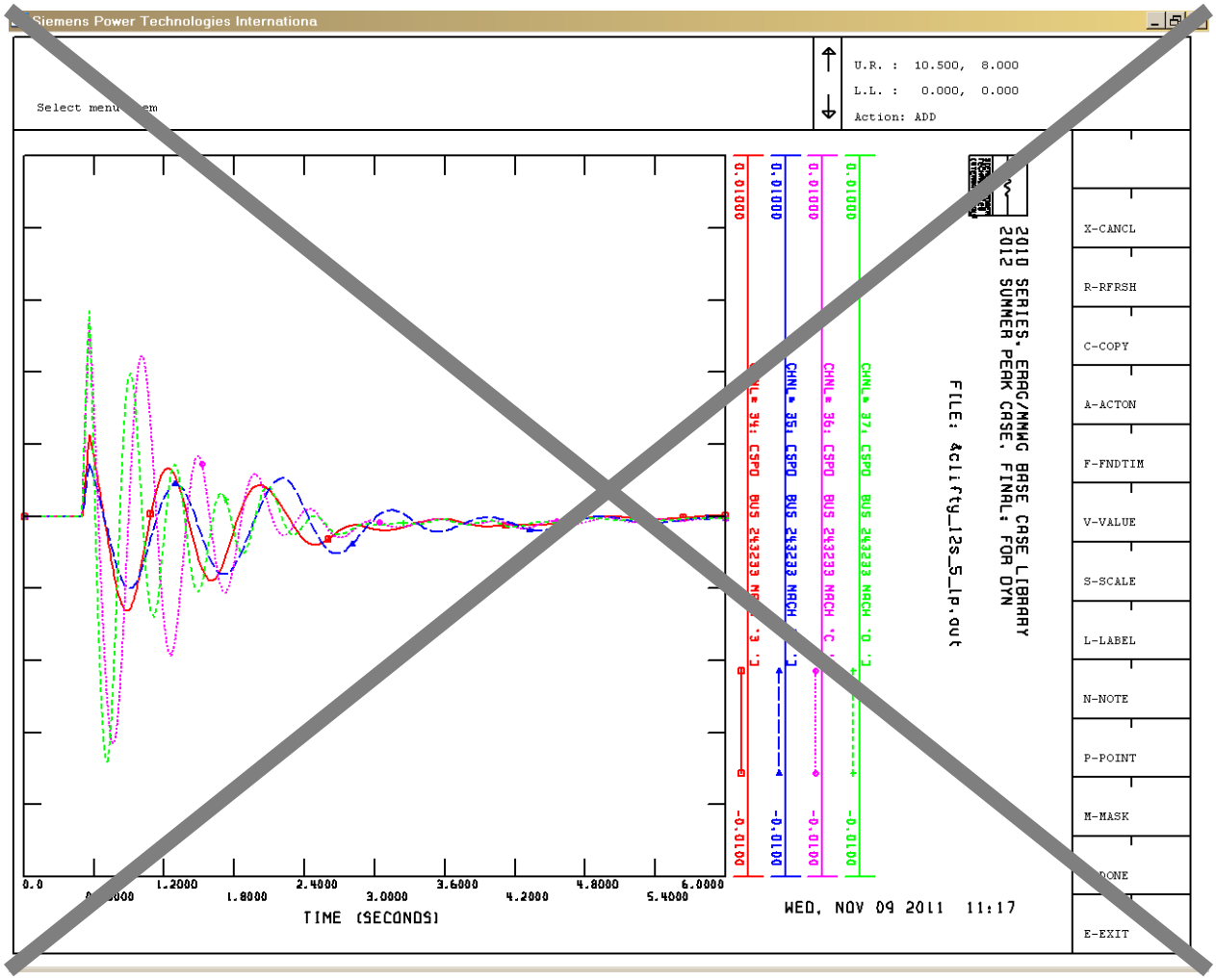
2012S Base Case



Clifty Creek Plant HP Generator Speeds

Case 7: No prior outage. Remote end phase-to-ground fault, relay failure, and delayed trip of Clifty Creek – Dearborn 345 kV #1.

2012S Base Case

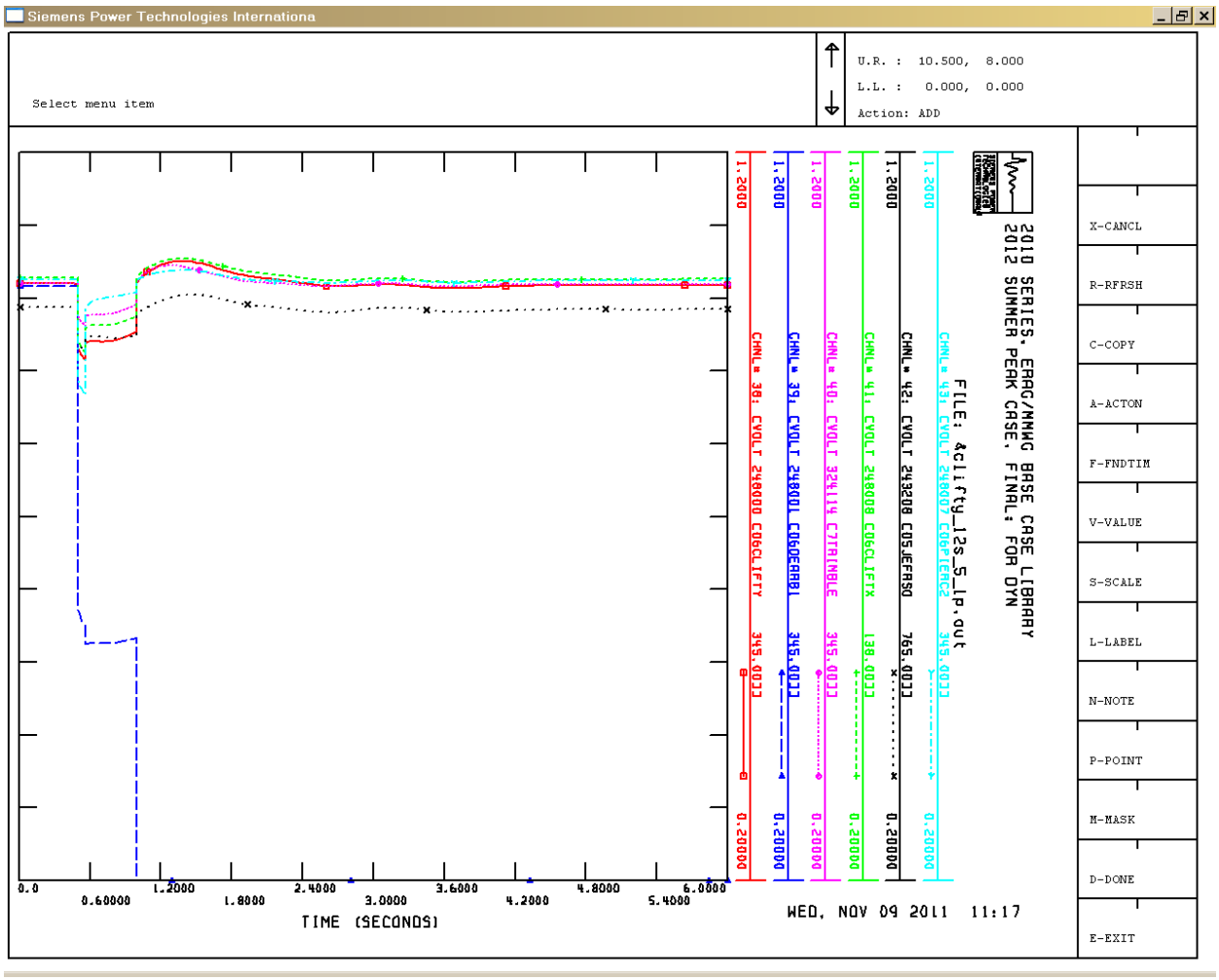


~~Tanners Creek 3 and 4 Generator Speeds~~

~~Case 7: No prior outage. Remote end phase-to-ground fault, relay failure, and delayed trip of Clifty Creek – Dearborn 345 kV #1.~~

~~2012S Base Case~~

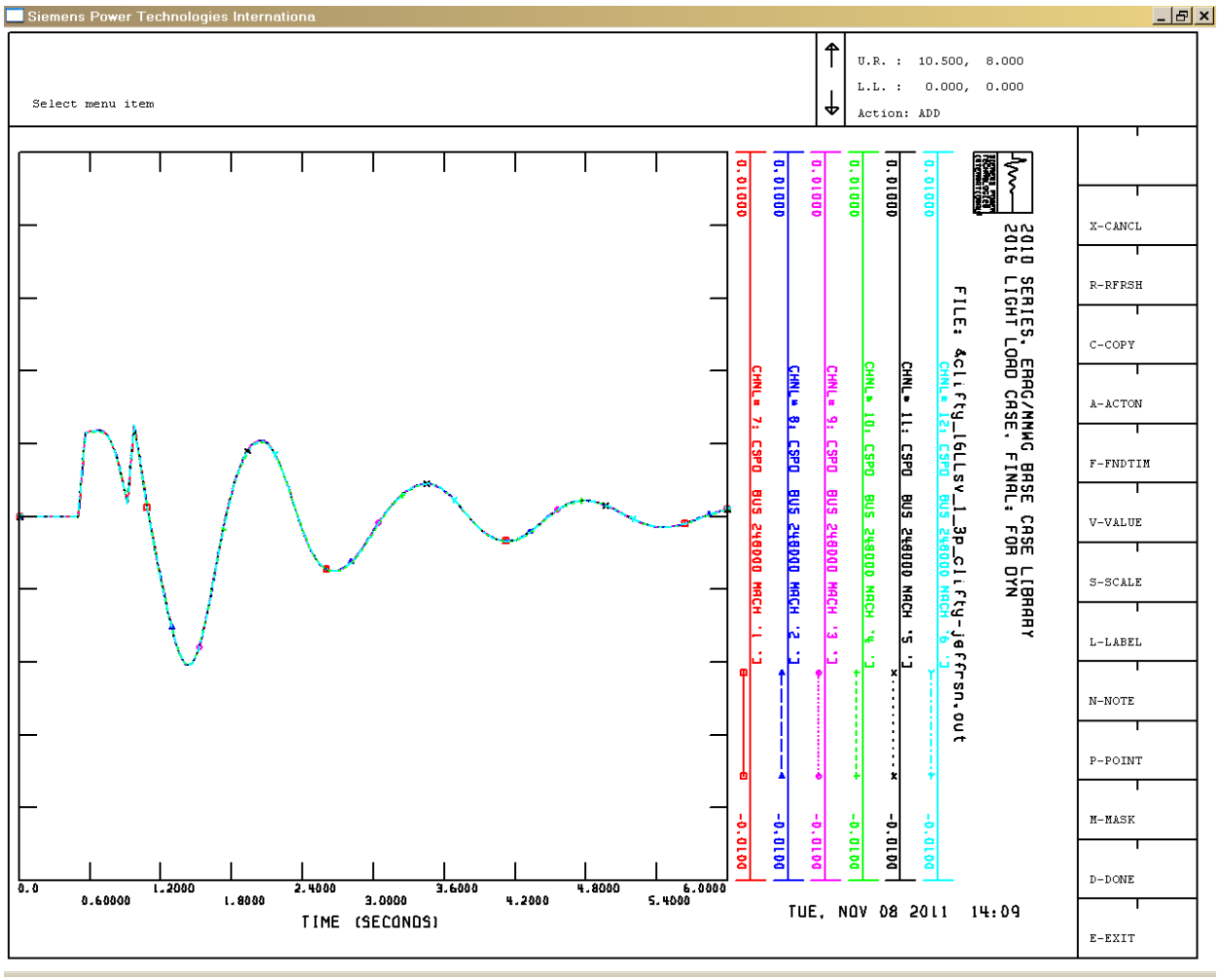
Tanners Creek Generators have since been retired.



Clifty Creek, Dearborn, Trimble County, Jefferson, Pierce Station Voltages

Case 7: No prior outage. Remote end phase-to-ground fault, relay failure, and delayed trip of Clifty Creek – Dearborn 345 kV #1.

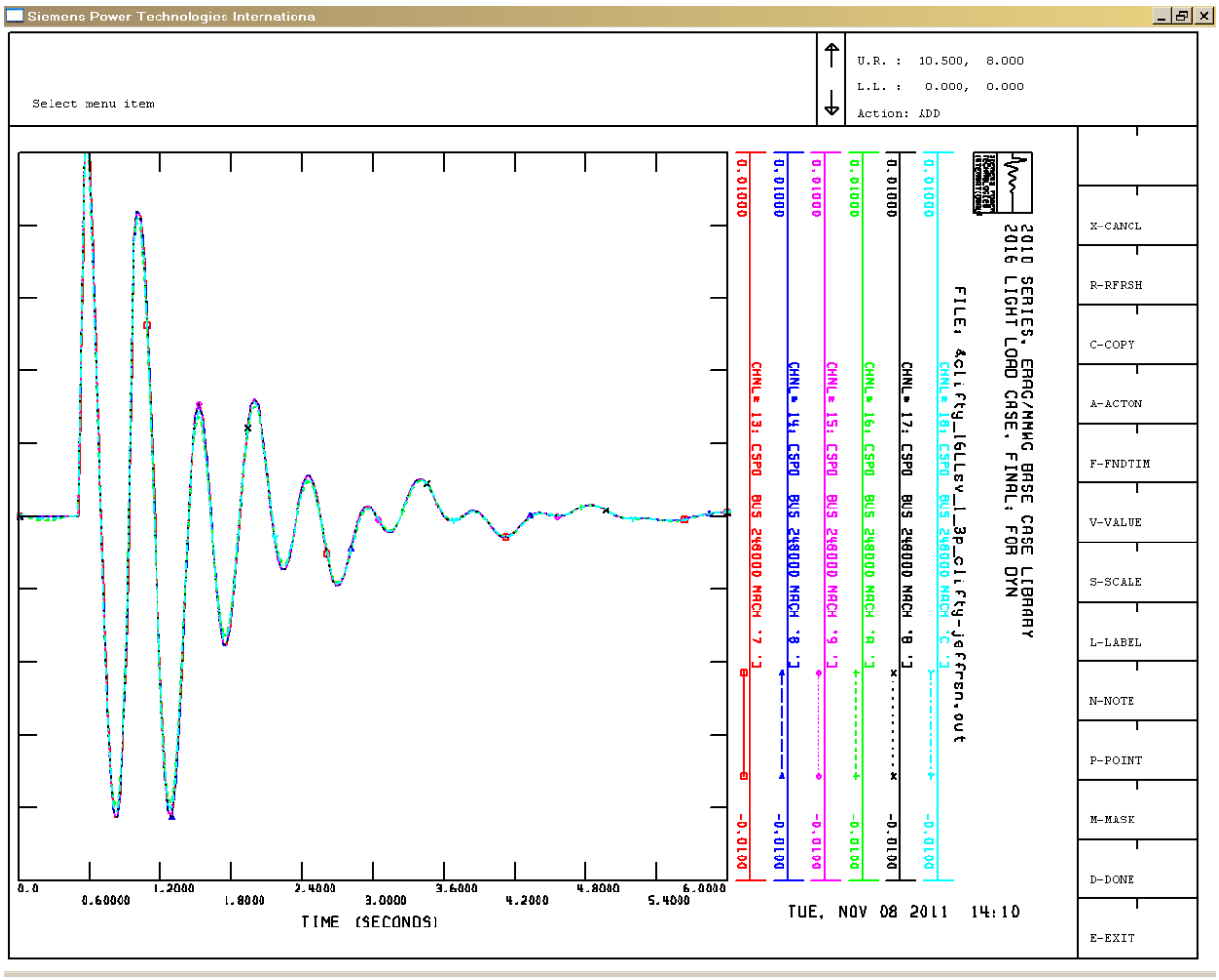
2012S Base Case



Clifty Creek Plant LP Generator Speeds

Case 1: Prior outage of Clifty Creek – Jefferson 345 kV. Fault and trip Clifty Creek – Pierce 345 kV DCT with unsuccessful HSR.

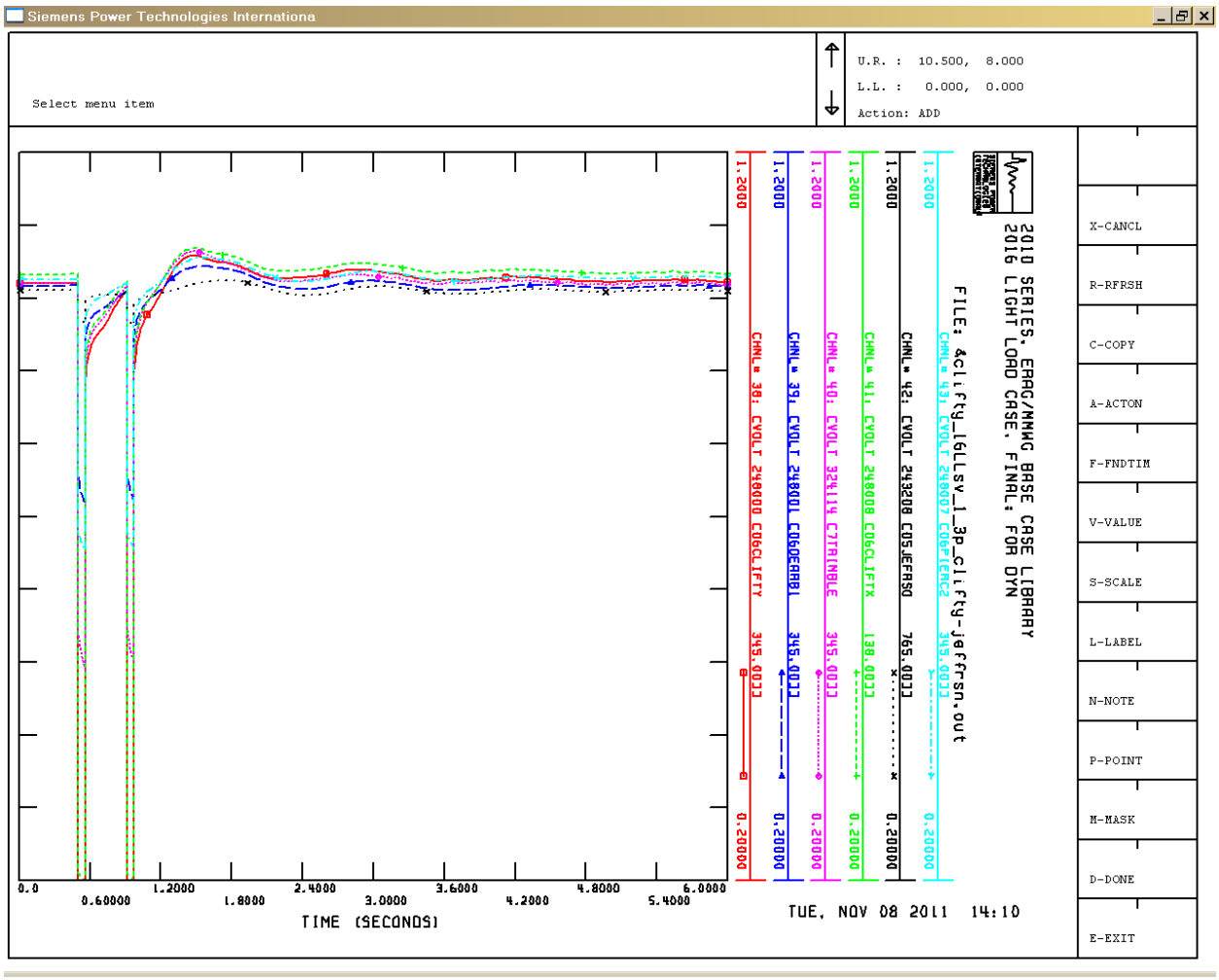
2016LL Base Case with generation dispatch sensitivity



Clifty Creek Plant HP Generator Speeds

Case 1: Prior outage of Clifty Creek – Jefferson 345 kV. Fault and trip Clifty Creek – Pierce 345 kV DCT with unsuccessful HSR.

2016LL Base Case with generation dispatch sensitivity



Clifty Creek, Dearborn, Trimble County, Jefferson, Pierce Station Voltages

Case 1: Prior outage of Clifty Creek – Jefferson 345 kV. Fault and trip Clifty Creek – Pierce 345 kV DCT with unsuccessful HSR.

2016LL Base Case with generation dispatch sensitivity