OHIO VALLEY ELECTRIC CORPORATION

2018 TRANSMISSION PLAN

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

November, 2018

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:

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Table of Contents

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 the performance of the planned OVEC system at the projected summer peak load levels of 2019 and 2023, and 2023 Spring Light Load conditions. A sensitivity analysis examined 2019 and 2023 summer peak load performance assuming that the Zimmer Power Plant in Moscow, Ohio retired or was otherwise unavailable. Because there are no major topology changes between the 2023 and 2028 cases, the 2023 steady state study results were considered valid for the long term 2028 case. Results of these studies identified outage conditions which could overload elements of three 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. The overload on the OVEC facility appears only in the sensitivity case, so no formal Corrective Action Plan is necessary. OVEC will put a plan in place should the retirement studied in the sensitivity case be announced.

Short Circuit studies were carried out, reflecting known changes in the vicinity of the OVEC system. It was determined that the highest anticipated breaker duties are approximately 94% 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 eight older Air Blast breakers at Clifty Creek with modern SF6 breakers of similar interrupting capabilities has been completed, and all breaker replacements are expected to be completed within 6 years.

The stability performance of the Clifty Creek and Kyger Creek plants was restudied considering upcoming topology changes in the OVEC footprint. These studies indicate that performance meets the requirements of the NERC TPL standards. The 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 2018 assessment, the existing and planned OVEC system is expected to meet the NERC TPL standards without any additional transmission reinforcements or upgrades through 2028.

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.

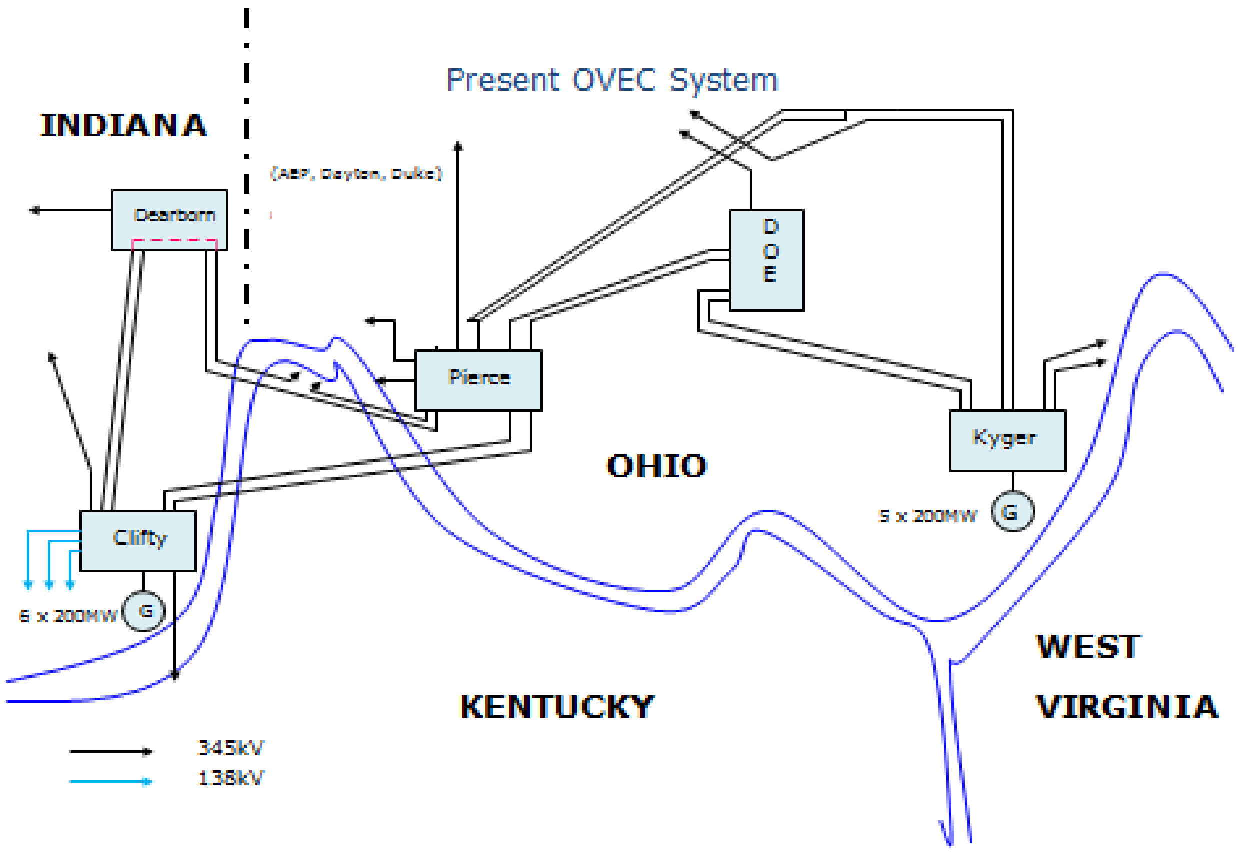
System Description

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 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 approved on August 22, 2018.

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.


Present OVEC System
INDIANA
(AEP, Dayton, Duke)
Dearborn
D
O
E
Pierce
OHIO
Kyger
5 x 200MW
G
Clifty
6 x 200MW
G
WEST
VIRGINIA
KENTUCKY
345kV
138kV

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
    - *Case No. 15-0892-EL-AEC was approved by PUCO on August 22, 2018. The Department of Energy plans to retire the 345 kV X-530 substation and has requested to terminate their 345 kV service from OVEC. AEP will serve their 36 MW load from the new Arboles 138 kV station fed from Waverly, South Lucasville, and Don Marquis. The two OVEC lines from X-530 to Kyger Creek will be six wired and connected at Don Marquis 345 kV station. Similarly, the two lines from X-530 to Pierce will be six wired and connected at Don Marquis 345 kV station.*

- Projections of future load or generation changes within OVEC
    - *Case No. 15-0892-EL-AEC was approved by PUCO on August 22, 2018. OVEC will transfer the 36 MW DOE load to AEP by 2023.*

- 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 2018 included 11 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.*

- Other projects within or bordering OVEC
    - *A LIDAR study has been performed on the Clifty Creek – Dearborn 345 kV line to increase the summer emergency rating. Results of this study are expected January 31, 2019.*

- *The terminal equipment at Tanners Creek 345 kV station on the Tanners Creek – Dearborn line will be upgraded by AEP, including the bus and risers, with an expected in service date of June 1, 2021.*
- *DEO&K will be installing a new 345 kV breaker so Pierce 345/138 kV transformer 18 will be fed in a double breaker, double bus configuration. The Buffington – Pierce 345 kV feeder will be relocated and a new tower installed. Additionally, breaker B will be replaced at Pierce and breaker A will be removed so the 345/138 kV transformer 17 can be relocated. Lastly, breaker 822 at Beckjord 138 kV station will be replaced to increase the rating of the Pierce – Beckjord 138 kV line.*
- *AEP will six-wire the Kyger Creek – Sporn 345 kV circuits 1 and 2 with an in-service date of June 1, 2019.*
- *LGE/KU will install a 0.66% reactor on the Clifty – Trimble 345 kV line with an in-service date of May 1, 2019.*

New Facilities

Replacement of antiquated circuit breakers and associated relays and controls at Kyger Creek was completed in 2016. In addition, eight 345 kV air blast circuit breakers were replaced at Clifty Creek by 2018.

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 MMWG 2018 library models of projected conditions for 2023 summer near term peak load and 2023 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 2023 summer period in early to mid-2018. 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 2019 summer peak load model provide a reference point based on year-one conditions. These studies also reviewed the effect of the retirement of the Zimmer Power Plant in 2019. As the known system improvements and firm generator retirements affecting the OVEC area are represented in the 2023 summer model, and no emerging issues involving OVEC-owned facilities appeared in the 2023 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 2023 analysis.

2019 Summer Peak model:

- The initial base case model for the 2019 peak load studies was derived from the 2019 summer peak model contained in the 2018 series MMWG library. The model used for the OVEC studies is the base case used in Reliability First 2019 summer studies conducted in 2018. A second study was done on the 2019 summer Peak model with the Zimmer plant turned off, considering the possibility of its future retirement. The generation removal was balanced by scaling generation up throughout OVEC and neighboring Generation Owners.

2023 Summer Peak Planning horizon models:

- The initial base case models for the 2023 peak load studies were derived from the 2023 summer peak model contained in the 2018 series MMWG library with recently approved projects modeled. 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. For OVEC, key assumptions for the 2019 peak load models consist of an area load of 41 MW and 0 MW for 2023 peak models. A total generation of 2,000 MW delivered to the OVEC owners is assumed for all peak models. 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.

2023 Spring Light Load Condition:

- The 2023 MMWG Light Load model was reviewed and compared to the 2023 summer peak model. All major topology changes in the vicinity of OVEC were reflected. RF member systems had the opportunity to review and update this model in the first half of 2017 in preparation for the Transmission System Performance Subcommittee study of this period.

2028 Summer Peak Load:

- The 2028 MMWG summer peak load model was reviewed and compared to the 2023 summer peak model. Since no major topology differences were identified in the vicinity of OVEC, no further analysis was performed.

Sensitivity Studies

2019 and 2023 Summer Peak with retirement of the Zimmer Power Plant

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 Zimmer Power Plant is among the older coal units remaining in these systems but is primarily selected based on proximity to OVEC. The generation removal was balanced by scaling generation up throughout OVEC and neighboring Generation Owners.

Removed Generation:

Unit	MW dispatched in 2019 SP model	MW dispatched in 2023 SP model
Zimmer	1266.8	1270.8

Steady State Analysis Results

Results of the studies performed for the 2018 Assessment are documented in Appendix C. To summarize, the following base cases were used to simulate single contingencies corresponding to the NERC Planning Event category P1:

- 2019 Summer Peak
- 2019 Summer Peak, Zimmer off
- 2023 Spring Light Load
- 2023 Summer Peak
- 2023 Spring Light Load, Zimmer off
- 2023 Summer Peak, Zimmer off

The results shown identify potential overloads on 3 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. No formal Corrective Action Plan is required for overloads identified in sensitivity studies.

Short Circuit Assessment

Short circuit analysis was performed on the PJM 2023 short circuit case with all project related changes applied to evaluate the expected 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. Two breakers were found to have interrupting duties above 90% of their capability, with the highest at 94.2% of capability. In the case that these breakers are projected to exceed their capability, OVEC can install TRV capacitors to raise their breaker capabilities to 63 kA. The detailed studies are documented in Appendix D.

Stability Studies and Results

Stability studies were performed for both Clifty Creek and Kyger Creek because the impedance or configuration of the transmission network in the vicinity of a generating plant connected to the OVEC system was modified by addition, removal, or other change so as to weaken the transmission system in the vicinity of the generating plant. The most notable topology change is the Kyger-Sporn six-wire project which affects the number of outlets at Kyger Creek. The plants' performance was found to meet the requirements of both the OVEC Transmission Testing Criteria and NERC Reliability Standards. 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 2018 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.

<u>Clifty Creek-Carrollton 138 kV (OVEC-KU)</u>
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 2018 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.

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.

Contingencies analyzed in each of the N-1-1 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 results show overloads on 3 tielines with Duke Energy, limited by non-OVEC equipment. The 2023 Sensitivity analyses revealed an overload on an OVEC facility after the retirement of Zimmer, however no formal Corrective Action Plan is required for overloads identified in sensitivity studies.

2019 Summer Peak
N-1 – Thermal, VMag, VDev: No violations
N-1-1 – VMag, VDev: No violations
N-1-1 – Thermal: No violations

2019 Summer Peak - Zimmer Off
N-1 – VMag, VDev: No violations
N-1 – Thermal: No Violations
N-1-1 – VMag, VDev: No violations
N-1-1 – Thermal:

AEP N-1-1 AC Iterative SCD Thermal Result[TARA Ver 1802 64-bit - Thu Nov 29 10:23:32 2018]

Loadflow Case: M:\OVEC\2018 Annual Assessment\Supporting Files\Starting Cases\MMWG_2019SUM_2018Series_Final\MMWG_2019SUM_2018Series_Final_wo_Zimmer_SCD.raw
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Contin AEP DEOK Dayton and LGEEK AEP DEOK Daytcingencies)
Monitor File: M:\OVEC\2018 Annual Assessment\Supporting Files\Contingencies and TARA Files\.sub and .mon files\OVEC combo 2018 for 2019 Studies.mon (95.0% loading cutoff)
Exclude File: not provided
Pre/Post Contingency PAR Adjustment: Adjusted/Fixed ***** SCD Advanced Penalties: Reduce Existing Branch Overloads[1500.000000] Aggravate Existing Branch Overloads[100000.000000] Create New Branch Overloads[100000.000000]

First Level Scenario	First Level Scenario	Monitored Facility	Fr Bus	Fr Name	To Bus	To Name	CKT	kVs	Areas	Rate Base (MVA)	Rate Cont (MVA)	Cont Name	Cont ID	Initial Base Flow (Signed	Initial Cont Flow (Signed MVA)	SCD Base Flow (Signed MVA)	SCD Cont Flow (Si	Flow Change (MVA)	Orig Case Cont AC %Loadi	Initial AC %Loading	SCD AC %Loading
691	AEP_P1-2_#1357	248009 06CLIFTY	248009	06CLIFTY	250057	08M.FORT	1	138	206/212	129	129	AEP_P1-2_#144	876	106.6	129.3	106.3	129	-0.3	91.41	100.21	100
691	AEP_P1-2_#1357	248009 06CLIFTY	248009	06CLIFTY	250057	08M.FORT	1	138	206/212	129	129	AEP_P1-2_#144	1125	106.6	129.3	106.3	129	-0.3	91.41	100.21	100
709	AEP_P1-2_#2811	248009 06CLIFTY	248009	06CLIFTY	250057	08M.FORT	1	138	206/212	129	129	AEP_P1-2_#144	876	110.3	132.8	106.7	129	-3.8	91.41	102.97	100
709	AEP_P1-2_#2811	248009 06CLIFTY	248009	06CLIFTY	250057	08M.FORT	1	138	206/212	129	129	AEP_P1-2_#144	1125	110.3	132.8	106.7	129	-3.8	91.41	102.97	100
894	AEP_P1-2_#2811_89	248009 06CLIFTY	248009	06CLIFTY	250057	08M.FORT	1	138	206/212	129	129	AEP_P1-2_#144	876	110.3	132.8	106.7	129	-3.8	91.41	102.97	100
714	AEP_P1-3_#6322_06	248013 06PIERCE	248013	06PIERCE	250143	08PRCE18	18	345/138	206/212	480	501	AEP_P1-2_#876	702	405.3	501.9	404.7	501	-0.9	82.04	100.19	100
714	AEP_P1-3_#6322_06	248013 06PIERCE	248013	06PIERCE	250143	08PRCE18	18	345/138	206/212	480	501	AEP_P1-2_#876	1123	405.3	501.9	404.7	501	-0.9	82.04	100.19	100
1129	AEP_P1-3_#6322_06	248013 06PIERCE	248013	06PIERCE	250143	08PRCE18	18	345/138	206/212	480	501	AEP_P1-2_#876	702	405.3	501.9	404.7	501	-0.9	82.04	100.19	100
1129	AEP_P1-3_#6322_06	248013 06PIERCE	248013	06PIERCE	250143	08PRCE18	18	345/138	206/212	480	501	AEP_P1-2_#876	1123	405.3	501.9	404.7	501	-0.9	82.04	100.19	100
1139	DEOK_P1-3_B3 WCB	248013 06PIERCE	248013	06PIERCE	250143	08PRCE18	18	345/138	206/212	480	501	AEP_P1-2_#876	702	405.3	501.9	404.7	501	-0.9	82.04	100.19	100

2023 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 1802 64-bit - Wed Nov 28 16:54:00 2018]

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1398	DEOK_P1_C2 P_PIERCE	248013 06PIEI	248013	06PIERCE	250086	08PIERCE	17	345/138	206/212	515	537	DEOK_P1_C2 1447_Zimm	1410	471.7	598.3	400.9	537.6	-60.7	77.58	111.42	100.11	
1398	DEOK_P1_C2 P_PIERCE	248013 06PIEI	248013	06PIERCE	250086	08PIERCE	17	345/138	206/212	515	537	DEOK_P1_C2 1449_Zimm	1411	471.7	605.8	400.9	537.1	-68.7	75.69	112.81	100.01	
1347	DEOK_P1_C2 1487_RED BANK	248013 06PIEI	248013	06PIERCE	250086	08PIERCE	17	345/138	206/212	515	537	DEOK_P1_C2 P_PIERCE	1398	423.1	581.2	406.5	548.7	-32.5	87.84	108.23	102.17	
1350	DEOK_P1_C2 1493_RED BANK	248013 06PIEI	248013	06PIERCE	250086	08PIERCE	17	345/138	206/212	515	537	DEOK_P1_C2 P_PIERCE	1398	412.3	579.4	389.6	537.1	-42.3	87.84	107.9	100.01	
1353	DEOK_P1_C2 1301_TERMINAL	248013 06PIEI	248013	06PIERCE	250086	08PIERCE	17	345/138	206/212	515	537	DEOK_P1_C2 P_PIERCE	1398	373.6	586.2	350.4	537	-49.2	87.84	109.16	100	
268	AEP_P1-2_#144	248013 06PIEI	248013	06PIERCE	250143	08PRCE18	18	345/138	206/212	480	501	DEOK_P1_C2 R_PIERCE	1399	356.6	557.4	340.6	522.2	-35.2	93.33	111.25	104.22	
283	AEP_P1-2_#2811	248013 06PIEI	248013	06PIERCE	250143	08PRCE18	18	345/138	206/212	480	501	DEOK_P1_C2 R_PIERCE	1399	330.6	539.5	313.1	501.1	-38.4	93.33	107.68	100.02	
739	DEOK_P1_B2 Red Bank-SG-Zir	248013 06PIEI	248013	06PIERCE	250143	08PRCE18	18	345/138	206/212	480	501	DEOK_P1_C2 R_PIERCE	1399	358.1	520.7	348.4	501.1	-19.6	93.33	103.94	100.03	
750	DEOK_P1_B2 Miami Fort-Terr	248013 06PIEI	248013	06PIERCE	250143	08PRCE18	18	345/138	206/212	480	501	DEOK_P1_C2 R_PIERCE	1399	338.6	502.6	337.7	501	-1.6	93.33	100.32	100	
752	DEOK_P1_B3 Zimmer 345 TB1	248013 06PIEI	248013	06PIERCE	250143	08PRCE18	18	345/138	206/212	480	501	DEOK_P1_C2 R_PIERCE	1399	362.2	537.3	346.6	506.1	-31.2	93.33	107.25	101.02	

<u>2023 Spring Light Load</u>
N-1 – Thermal, VMag, VDev: No violations
N-1-1 – Thermal, VMag, VDev: No violations

<u>2023 Spring Light Load – Zimmer Off</u>
N-1 – Thermal, VMag, VDev: No violations
N-1-1 – VMag, VDev: No violation
N-1-1 – Thermal

AEP N-1-1 AC Iterative SCD Thermal Result[TARA Ver 1802 64-bit - Wed Nov 28 11:17:31 2018]

Loadflow Case: C:\Users\s269325\Desktop\OVEC 2018 N-1-1 2023SLL Sensitivity\MMWG_2023SLL_2018Series_Final_wo_Zimmer_SCD.raw
Study Data File: C:\Users\s269325\Desktop\OVEC 2018 N-1-1 2023SLL Sensitivity\ovec_compl_inertia_kvrange_modified_2018 for 2023 Studies.sub
Contingency File: C:\Users\s269325\Desktop\OVEC 2018 N-1-1 2023SLL Sensitivity\2018 OVEC Annual Assesment 2023S.con (total 1891 contingencies)/ First-Level Contingency File: C:\Users\s269325\Desktop\OVEC 2018 N-1-1 2023SLL Sen
Monitor File: C:\Users\s269325\Desktop\OVEC 2018 N-1-1 2023SLL Sensitivity\OVEC combo 2018 for 2023 Studies.mon (95.0% loading cutoff)
Exclude File: not provided
Pre/Post Contingency PAR Adjustment: Adjusted/Fixed ***** SCD Advanced Penalties: Reduce Existing Branch Overloads[1500.000000] Aggravate Existing Branch Overloads[100000.000000] Create New Branch Overloads[100000.000000] Ener

First Level Scenario	First Level Scenario	Monitored Facility	Fr Bus	Fr Name	To Bus	To Name	CKT	kVs	Areas	Rate Base (MVA)	Rate Cont (MVA)	Cont Name	Cont ID	Initial Base Flow	Initial Cont Flow (Signe	SCD Base Flow (Signe	SCD Cont Flow (Signed MVA)	Flow Change (MVA)	Orig Case Cont AC %Loading	Initial AC %Loading	SCD AC %Loading
1451	DEOK_P1_D7 5783_3886_4	248001 06DEARB1	248001	06DEARB1	248013	06PIERCE	1	345	206	972	972	DEOK_P1_D7 4514_4516_6864_1783_1782_9787	1471	501.1	1010.4	479.9	972	-38.4	59.65	103.95	100
1471	DEOK_P1_D7 4514_4516_6	248001 06DEARB1	248001	06DEARB1	248013	06PIERCE	1	345	206	972	972	DEOK_P1_D7 5783_3886_4591_4592	1451	579.8	1010.4	553.7	972	-38.4	51.55	103.95	100
1450	DEOK_P1_D7 4591_4592_1	248001 06DEARB1	248001	06DEARB1	248013	06PIERCE	1	345	206	972	972	DEOK_P1_D7 4514_4516_6864_1783_1782_9787	1471	497.8	974.6	496.9	972	-2.7	59.65	100.27	100

<u>2023 Summer Peak – Zimmer Off</u>
N-1 – VMag, VDev: No violations
N-1 – Thermal:

AEP N-1 AC Monitored Facility Loadings[TARA Ver 1802 64-bit - Mon Nov 19 10:54:01 2018]

Loadflow Case: M:\OVEC\2018 Annual Assessment\Supporting Files\Starting Cases\MMWG_2023SUM_2018Series_Final\MMWG_2023SUM_2018Series_Final_wo_Zimmer.raw
Study Data File: M:\OVEC\2018 Annual Assessment\Supporting Files\Contingencies and TARA Files\.sub and .mon files\ovec_compl_inertia_kvrange_modified_2018 for 2023 Studies.sub
Contingency Fil AEP DEOK Dayton and LGEEKU Contingencies\2018 OVEC Annual Assesment 2023S.con (total 1916 contingencies)
Monitor File: M:\OVEC\2018 Annual Assessment\Supporting Files\Contingencies and TARA Files\.sub and .mon files\OVEC combo 2018 for 2023 Studies.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]

Monitored Facility	Fr Bus	Fr Name	To Bus	To Name	CK T	kVs	Areas	Rate Base (MVA)	Rate Cont (MVA)	Cont Name	Cont I	Base Flow (MVA)	Cont Flow (MVA)	Final DC %Loading	Final AC %Loading	Severity Rank	Radial Index	Base MW Flow	Cont MW Flow	Base MVAR Flow	Cont MVAR Flow
248013 06PIERCE	248013	06PIERCE	250143	08PRCE18	18	345/138	206/212	480	501	DEOK_P1_	1399	361.6	535.5	107.59	106.89	1	0.49467	360.6	531.4	26.1	66.6
248013 06PIERCE	248013	06PIERCE	250086	08PIERCE	17	345/138	206/212	515	537	DEOK_P1_	1398	371.5	556.9	104.56	103.7	1	0.46889	370.9	553.9	11.6	57.5

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

AEP N-1-1 AC Iterative SCD Thermal Result[TARA Ver 1802 64-bit - Wed Nov 28 11:17:31 2018]

Loadflow Case: C:\Users\s269325\Desktop\OVEC 2018 N-1-1 2023SLL Sensitivity\MMWG_2023SLL_2018Series_Final_wo_Zimmer_SCD.raw
Study Data File: C:\Users\s269325\Desktop\OVEC 2018 N-1-1 2023SLL Sensitivity\ovec_compl_inertia_kvrange_modified_2018 for 2023 Studies.sub
Contingency File: C:\Users\s269325\Desktop\OVEC 2018 N-1-1 2023SLL Sensitivity\2018 OVEC Annual Assesment 2023S.con (total 1891 contingencies)/ First-Level Contingency File: C:\Users\s269325\Desktop\OVEC 2018 N-1
Monitor File: C:\Users\s269325\Desktop\OVEC 2018 N-1-1 2023SLL Sensitivity\OVEC combo 2018 for 2023 Studies.mon (95.0% loading cutoff)
Exclude File: not provided
Pre/Post Contingency PAR Adjustment: Adjusted/Fixed ***** SCD Advanced Penalties: Reduce Existing Branch Overloads[1500.000000] Aggravate Existing Branch Overloads[100000.000000] Create New Branch Overloads[10000

First Level Scenario	First Level Scenario	Monitored Facility	Fr Bu	Fr Name	To Bu	To Name	CK	kVs	Area	Rate Base (MVA)	Rate Cont (MVA)	Cont Name	Cont ID	Initial Base Flow	Initial Cont Flow (Sign	SCD Base Flow (Sig	SCD Cont Flow (Si	Flow Change (MVA	Orig Case Cont AC	Initial AC %Loading	SCD AC %Loading
1451	DEOK_P1_D7 5783_3886_4	248001 06DEARB1	248001	06DEARB1	248013	06PIERCE	1	345	206	972	972	DEOK_P1_D7 4514_4516_6864_1783_1782_9787	1471	501.1	1010.4	479.9	972	-38.4	59.65	103.95	100
1471	DEOK_P1_D7 4514_4516_6	248001 06DEARB1	248001	06DEARB1	248013	06PIERCE	1	345	206	972	972	DEOK_P1_D7 5783_3886_4591_4592	1451	579.8	1010.4	553.7	972	-38.4	51.55	103.95	100
1450	DEOK_P1_D7 4591_4592_1	248001 06DEARB1	248001	06DEARB1	248013	06PIERCE	1	345	206	972	972	DEOK_P1_D7 4514_4516_6864_1783_1782_9787	1471	497.8	974.6	496.9	972	-2.7	59.65	100.27	100

Appendix D

Ohio Valley Electric Corporation

2018 Short Circuit Assessment

East Transmission Planning
November, 2018

AEP AMERICAN® ELECTRIC POWER

AEP: America's Energy Partner SM

The 2018 OVEC Short Circuit Assessment

The OVEC short circuit assessment is based on the latest available AEP/PJM model for 2023 with the OVEC circuit breaker data* added. These studies were performed using v14.5 of the Aspen OneLiner™ program including the ASPEN Breaker Rating Module™.

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. Two breakers were found to have interrupting duties above 90% of their capability, both at Dearborn 345 kV. In the case that these breakers are projected to exceed their capability, OVEC can install TRV capacitors to raise their breaker capabilities to 63 kA. The lowest margins were found at Dearborn 345 kV.

*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

2023 Results

BUS	BREAKER	% DUTY	DUTY MPS	BREAKER CAPABILITY	% MOMENTARY DUTY	MOMENTARY DUTY AMPS	MOMENTARY BREAKER CAPABILITY	ISC	X/R
06DEARBN 345.kV	DC	94.2	47106.2	50000	55.8	72479.1	130000	47106.2	16.5
06DEARBN 345.kV	DB	92.9	46472.6	50000	55.1	71619.4	130000	46472.6	16.8
06CLIFTY 345.kV	H	88.6	55827.9	63000	50.6	82818.8	163800	51604.1	26.3
06CLIFTY 345.kV	A	85.5	53868.7	63000	50.6	82818.1	163800	49620.4	26.9
06CLIFTY 345.kV	B	85.5	53868.7	63000	49.2	80510.3	163800	49620.4	26.9
06CLIFTY 345.kV	D	85.5	53868.7	63000	50.6	82818.1	163800	49620.4	26.9
06CLIFTY 345.kV	E	85.5	53868.7	63000	49.1	80507.5	163800	49620.4	26.9
06CLIFTY 345.kV	C	81.9	51603.7	63000	50.6	82818.1	163800	51603.7	26.3
06CLIFTY 345.kV	DL	81.9	51603.7	63000	65.5	82818.1	126400	51603.7	26.3
06CLIFTY 345.kV	DL1	81.9	51603.7	63000	50.6	82818.1	163800	51603.7	26.3
06CLIFTY 345.kV	DL2	81.9	51603.7	63000	65.5	82818.1	126400	51603.7	26.3
06CLIFTY 345.kV	F	81.9	51603.7	63000	50.6	82818.1	163800	51603.7	26.3
06CLIFTY 345.kV	I	81.9	51603.7	63000	50.6	82818.1	163800	51603.7	26.3
06CLIFTY 345.kV	L	81.9	51603.7	63000	50.6	82818.1	163800	51603.7	26.3
06CLIFTY 345.kV	O	81.9	51603.7	63000	50.6	82818.1	163800	51603.7	26.3
06CLIFTY 345.kV	Q	81.9	51603.7	63000	50.6	82818.1	163800	51603.7	26.3
06CLIFTY 345.kV	R	81.9	51603.7	63000	50.6	82818.1	163800	51603.7	26.3
06CLIFTY 345.kV	S	81.9	51603.7	63000	50.6	82818.1	163800	51603.7	26.3
06CLIFTY 345.kV	T	81.9	51603.7	63000	50.6	82818.1	163800	51603.7	26.3

06CLIFTY 345.kV	K	81.2	51138.1	63000	49.1	80491	163800	46858.2	27.7
06CLIFTY 345.kV	G	79.8	55827.9	70000	59.1	82818.8	140100	51604.1	26.3
06CLIFTY 345.kV	N	79.8	50287.9	63000	49.3	80802.8	163800	50287.9	26.8
06KYGER 345.kV	D	78.4	39201.7	50000	47.1	61181.3	130000	36710.6	24.5
06KYGER 345.kV	E	78.4	39201.7	50000	45.3	58944.5	130000	36710.6	24.5
06KYGER 345.kV	G	78.4	39201.7	50000	47.1	61181.3	130000	36710.6	24.5
06KYGER 345.kV	H	78.4	39201.7	50000	45.3	58861.8	130000	36710.6	24.5
06KYGER 345.kV	M	77.3	38627.3	50000	47.1	61181.3	130000	35979.8	25.2
06KYGER 345.kV	N	77.3	38627.3	50000	45.3	58901.5	130000	35979.8	25.2
06KYGER 345.kV	A	76.7	38330.7	50000	47.1	61181.3	130000	38330.7	24.5
06KYGER 345.kV	AA	76.7	38330.7	50000	47.1	61181.3	130000	38330.7	24.5
06KYGER 345.kV	C	76.7	38330.7	50000	47.1	61181.3	130000	38330.7	24.5
06KYGER 345.kV	F	76.7	38330.7	50000	47.1	61181.3	130000	38330.7	24.5
06KYGER 345.kV	I	76.7	38330.7	50000	47.1	61181.3	130000	38330.7	24.5
06KYGER 345.kV	J	76.7	38330.7	50000	47.1	61181.3	130000	38330.7	24.5
06KYGER 345.kV	L	76.7	38330.7	50000	47.1	61181.3	130000	38330.7	24.5
06KYGER 345.kV	O	76.7	38330.7	50000	47.1	61181.3	130000	38330.7	24.5
06KYGER 345.kV	P	76.7	38330.9	50000	37.4	61181.7	163800	38330.9	24.5
06KYGER 345.kV	Q	76.7	38330.9	50000	37.4	61181.7	163800	38330.9	24.5
06KYGER 345.kV	K	76.2	38115.1	50000	45.3	58933.2	130000	35501.4	25.2
06DOE530 345.kV	212	75.8	25023.1	33000	44.3	38184.9	86164	23435.6	33.2

06DOE530 345.kV	215	75.8	25023.3	33000	44.3	38185.3	86164	23435.8	33.2
06DOE530 345.kV	218	75.8	25023.3	33000	44.3	38185.3	86164	23435.8	33.2
06DOE530 345.kV	222	75.8	25023.1	33000	44.3	38184.9	86164	23435.6	33.2
06DOE530 345.kV	225	75.8	25023.3	33000	44.3	38185.3	86164	23435.8	33.2
06DOE530 345.kV	228	75.8	25023.3	33000	44.3	38185.3	86164	23435.8	33.2
06DOE530 345.kV	242	75.8	25023.1	33000	44.3	38184.9	86164	23435.6	33.2
06DOE530 345.kV	245	75.8	25023.1	33000	44.3	38184.9	86164	23435.6	33.2
06DOE530 345.kV	248	75.8	25023.1	33000	44.3	38184.9	86164	23435.6	33.2
06DOE530 345.kV	252	75.8	25023.1	33000	44.3	38184.9	86164	23435.6	33.2
06DOE530 345.kV	255	75.8	25023.3	33000	44.3	38185.3	86164	23435.8	33.2
06DOE530 345.kV	258	75.8	25023.3	33000	44.3	38185.3	86164	23435.8	33.2
06DOE530 345.kV	262	75.8	25023.1	33000	44.3	38184.9	86164	23435.6	33.2
06DOE530 345.kV	265	75.8	25023.1	33000	44.3	38184.9	86164	23435.6	33.2
06DOE530 345.kV	268	75.8	25023.1	33000	44.3	38184.9	86164	23435.6	33.2
06PIERCE 345.kV	A	74.8	37392.2	50000	43.4	56431.7	130000	37392.2	14
06PIERCE 345.kV	C	74.8	37392.2	50000	43.4	56431.7	130000	37392.2	14
06PIERCE 345.kV	D	74.8	37392.2	50000	43.4	56431.7	130000	37392.2	14
06PIERCE 345.kV	E	74.8	37392.2	50000	43.4	56431.7	130000	37392.2	14
06PIERCE 345.kV	G	74.8	37392.2	50000	43.4	56431.7	130000	37392.2	14
06PIERCE 345.kV	H	74.8	37392.2	50000	43.4	56431.7	130000	37392.2	14
06PIERCE 345.kV	J	74.8	37392.2	50000	43.4	56431.7	130000	37392.2	14

06PIERCE 345.kV	K	74.8	37392.2	50000	43.4	56431.7	130000	37392.2	14
06PIERCE 345.kV	M	74.8	37392.2	50000	43.4	56431.7	130000	37392.2	14
06PIERCE 345.kV	P	74.8	37392.2	50000	43.4	56431.7	130000	37392.2	14
06KYGER 345.kV	BB	74.5	37261.2	50000	45.7	59474.3	130000	37261.2	24.5
06PIERCE 345.kV	Q	74.1	37061.7	50000	43	55932.8	130000	37061.7	14
06PIERCE 345.kV	R	74.1	37061.7	50000	43	55932.8	130000	37061.7	14
06CLIFTY 345.kV	J	73.7	51603.7	70000	59.1	82818.1	140100	51603.7	26.3
06CLIFTY 345.kV	M	73.7	51603.7	70000	59.1	82818.1	140100	51603.7	26.3
06CLIFTY 345.kV	P	73.7	51603.7	70000	59.1	82818.1	140100	51603.7	26.3
06KYGER 345.kV	B	73.4	36695.9	50000	45.1	58571.9	130000	36695.9	24.5
06PIERCE 345.kV	I	71.1	35531.9	50000	41.2	53506.7	130000	35531.9	13.8
06PIERCE 345.kV	L	71.1	35531.9	50000	41.2	53506.7	130000	35531.9	13.8
06PIERCE 345.kV	F	70	35018.4	50000	40.7	52846.6	130000	35018.4	14
06DOE530 345.kV	272	60.1	24021.5	40000	36.7	38184.9	104000	23435.6	33.2
06DOE530 345.kV	275	60.1	24021.5	40000	36.7	38185.3	104000	23435.6	33.2
06DOE530 345.kV	278	60.1	24021.5	40000	36.7	38185.3	104000	23435.6	33.2
06DOE530 345.kV	282	60.1	24021.5	40000	36.7	38184.9	104000	23435.6	33.2
06DOE530 345.kV	285	60.1	24021.5	40000	36.7	38184.9	104000	23435.6	33.2
06CLIFTY 138.kV	AE	47.3	18908.2	40000	25	26003.3	104000	15805	39.6
06CLIFTY 138.kV	AC	45.3	18120.9	40000	23.8	24777.5	104000	15022.1	41.7
06CLIFTY 138.kV	AD	41.4	16559.2	40000	21.6	22459.1	104000	13569.2	45

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 _X___ NO ____

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 _X___ NO ____

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

2018 – 2023
Dates covering this assessment

Eric J. Swanger
Name

November 29, 2018
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

Advanced Transmission Studies and Technologies
November 2018

AEP: America's Energy Partner℠

1. INTRODUCTION

This study was undertaken to evaluate the stability performance of Ohio Valley Electric Corporation's (OVEC) Kyger Creek Plant. The study was conducted in accordance with the NERC TPL-001-4 standard.

2. OVERVIEW OF GENERATION/TRANSMISSION FACILITIES

The generation capability at the Kyger Creek Plant is approximately 981 MW (referenced in the 2017 series MMWG cases for the 2022 year) and is the sum of five similar units each providing approximately 196 MW.

This study is utilizing the MMWG dynamic cases for the 2022 year. Therefore the PJM baseline project b2832 (six-wiring of the Kyger Creek – Sporn 345kV circuits #1 and #2, converting into a single circuit) is already modeled and taken into account. All other OVEC transmission facilities remain unchanged regarding configuration.

3. TESTING CRITERIA

NERC TPL-001-4 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-001-4 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 Kyger 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 Kyger 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 Kyger 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-001-4 Table 1.

P5 criteria is only applicable for non-redundant bus differential relays at 345kV OVEC facilities. All other 345kV protection at OVEC facilities have redundant relaying in place. Dearborn 345kV does have redundant bus differential relaying and can therefore also be excluded. A P5 bus fault involving the failure of non-redundant relaying at Kyger Creek or Clifty Creek stations results in the loss of all generating units at the respective station, so those scenarios were also excluded from the study. Delayed clearing for this situation is assumed to be 60.0 cycles from fault initiation.

A Type 2 stability extreme disturbance example at Kyger Creek is provided in the form a three phase fault on a Transmission circuit with a stuck breaker resulting in a delayed fault clearing. Delayed clearing for this situation is assumed to be 15.0 cycles from fault initiation.

For the purposes of post-fault transient voltage criteria required by TPL-001-4 R5, this study assumes that transient voltage dips at the transmission station above 70 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.

Uncontrolled islanding (system separation) is obvious when occurring in dynamic simulations. Facility loadings exceeding emergency ratings persisting after one stage of tripping of such facilities, or voltages persisting below emergency limits or UVLS set points following one stage of generator under-voltage tripping (per criterion above) or UVLS load removal (where applicable) are indicative of cascading or voltage instability, respectively.

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 1 below. These cases all involved three-phase primary cleared faults or non-fault initiated tripping. Phase-to-ground delayed clearing faults at Kyger Creek 345 kV Station were not simulated due to the station configuration which is such that outage of further transmission elements does not occur, thus making these disturbance scenarios less severe.

Base cases applied in this study were the 2017 series ERAG / MMWG 2022 Summer Peak Load and 2022 Spring Light Load cases in accordance with TPL-001-4 R2.4.1 and R2.4.2, respectively. A sensitivity case involving the Zimmer plant being out-of-service was studied for TPL-001-4 R2.4.3. The ERAG / MMWG dynamic base cases are developed based on coordinated topology amongst all members of Reliability First and all contingency events considered for analysis are therefore based on this topology in accordance with TPL-001-4 R4.4.1. All ERAG / MMWG dynamic base cases include modeling of automatic dynamic control devices relevant to the Kyger Creek area in accordance with TPL-001-4 R4.3.2. Dynamic modeling data for the Kyger Creek units can be found in the appendix. Updates were made to the Kyger Creek Units 2-5 governor model data including the addition of a load controller model per a NERC MOD-027 report issued March 2018. There are no proposed material generation additions or changes in the long-term transmission planning horizon in accordance with TPL-001-4 R2.5.

The Kyger Creek Plant was dispatched at its net capacity of 981 MW unless otherwise indicated. The dispatch at nearby generating plants were reviewed to ensure their dispatch was at net capacity. The Amos Unit 1 dispatch was modified to be at its net MW capacity.

Unsuccessful high speed reclosing (HSR) of faulted transmission lines was simulated in three-phase fault cases in accordance with TPL-001-4 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 60-cycle delayed fault clearing at the remote end of a line.

5. 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 are all the same as far as their stability is concerned. The acceptable stability results from these cases in recognition of TPL-001-4 R4.1.1 and R4.1.2 indicate that less severe cases consistent with TPL-001-4 criteria would also have acceptable stability. Per R4.1.3, all simulations conducted indicate that power swing damping is within the established 3 percent damping ratio criterion.

For TPL-001-4 R4.3.1.2, the assumed generator low voltage ride through capability threshold is 85 percent. Post disturbance generator voltage remained above this threshold for all simulations. Also for R4.3.1.3, no generic or actual relay operations were caused by transient power swings during the simulations.

With respect to the previously mentioned transient voltage criteria for TPL-001-4 R5, all simulations show that voltage recovery is to at least 70 percent within the 2.5 seconds following a fault clearing event.

Plots of the light load dynamic simulation cases involving three-phase faults are attached below.

6. CONCLUSION

The Kyger Creek Plant exhibits acceptable stability performance under all credible contingencies consistent with NERC TPL-001-4 without a need for generation curtailment.

Table 1 – Kyger Creek Plant Stability Study Cases

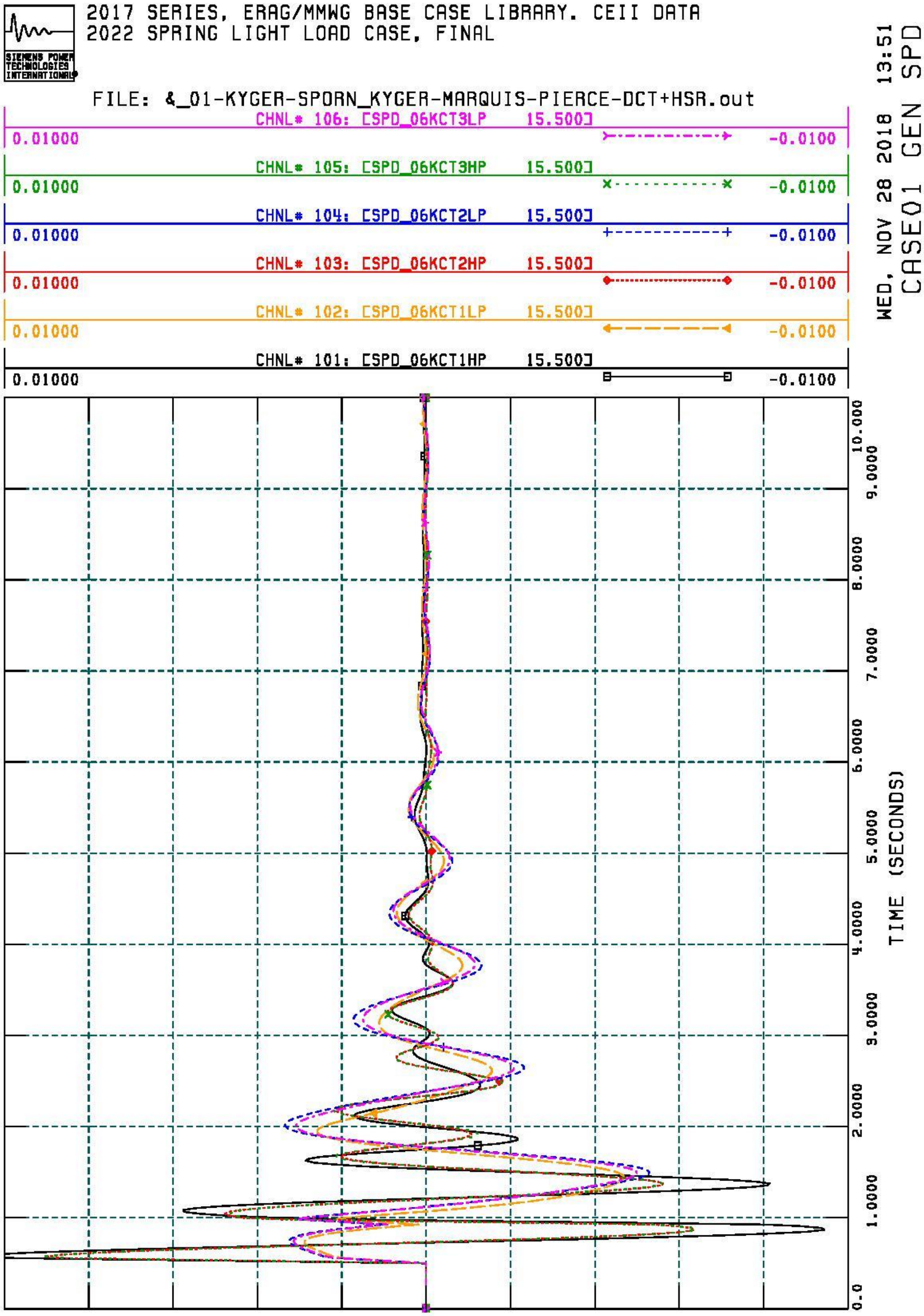
	Prior Outage	Outaged Facility	NERC Category	Fault Type	Result
***Case 1**	Kyger Creek – Sporn 345 kV	Kyger Creek – Don Marquis / Pierce 345 kV DCT	P6/P7/ Extreme Type1	3 Phase w/ unsuccessful HSR	Stable
***Case 2**	Kyger Creek – Sporn 345 kV	Kyger Creek – Don Marquis / Pierce 345 kV DCT	P6/P7/ Extreme Type1	No Fault	Stable
***Case 3**	Kyger Creek – Sporn 345 kV	Kyger Creek – X530 345kV DCT	P6/P7/ Extreme Type1	3 Phase w/ unsuccessful HSR	Stable
***Case 4**	Kyger Creek – Sporn 345 kV	Kyger Creek – X530 345kV DCT	P6/P7/ Extreme Type1	No Fault	Stable
***Case 5**	Kyger Creek – X530 345kV DCT	Kyger Creek – Don Marquis / Pierce 345 kV DCT	P6/P7/ Extreme Type1	3 Phase w/ unsuccessful HSR	Stable
***Case 6**	Kyger Creek – X530 345kV DCT	Kyger Creek – Don Marquis / Pierce 345 kV DCT	P6/P7/ Extreme Type1	No Fault	Stable
****Case 7**	None	Pierce 345kV Bus #1 Pierce 345/138kV Trf 17 Pierce – Buffington 345kV	P5	Single Phase	Stable

		Dearborn – Pierce 345kV Clifty Creek – Pierce 345kV #1 and #2			
****Case 8**	None	Pierce 345kV Bus #2 Pierce 345/138kV Trf 18 Kyger Creek – Pierce 345kV Pierce – X530 345kV #1 and #2	P5	Single Phase	Stable
****Case 9**	None	X530 345kV Bus #21 Don Marquis – X530 345kV Pierce – X530 345kV #1 and #2 Kyger Creek – X530 345kV #1 and #2	P5	Single Phase	Stable
*****Case 10**	None	Kyger Creek – Sporn 345 kV	Extreme Type 2	3 Phase w/ Delay	Stable

* All of the prior outage cases listed above are not followed by any system adjustments and so also qualify as Type 1 stability extreme disturbances in TPL-001-4 Table 1.

** Cases 7-9 refer to non-redundant bus differential relay failures during a bus fault at Pierce and X530 stations. Bus differential relays at Kyger Creek and Clifty Creek are also non-redundant, but a similar P5 would result in loss of all units at those stations.

*** Case 10; To test an Extreme Type 2 scenario, a three phase fault on the Kyger Creek – Sporn 345 kV plus a stuck breaker at Kyger Creek 345kV CB 'A' was studied. Under this scenario the high pressure turbines at Kyger Creek become unstable and as result all Kyger Creek units were tripped offline. The system becomes stable after the tripping of the Kyger Creek units.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2017 SERIES, ERAG/MMWG BASE CASE LIBRARY. CEII DATA
2022 SPRING LIGHT LOAD CASE, FINAL

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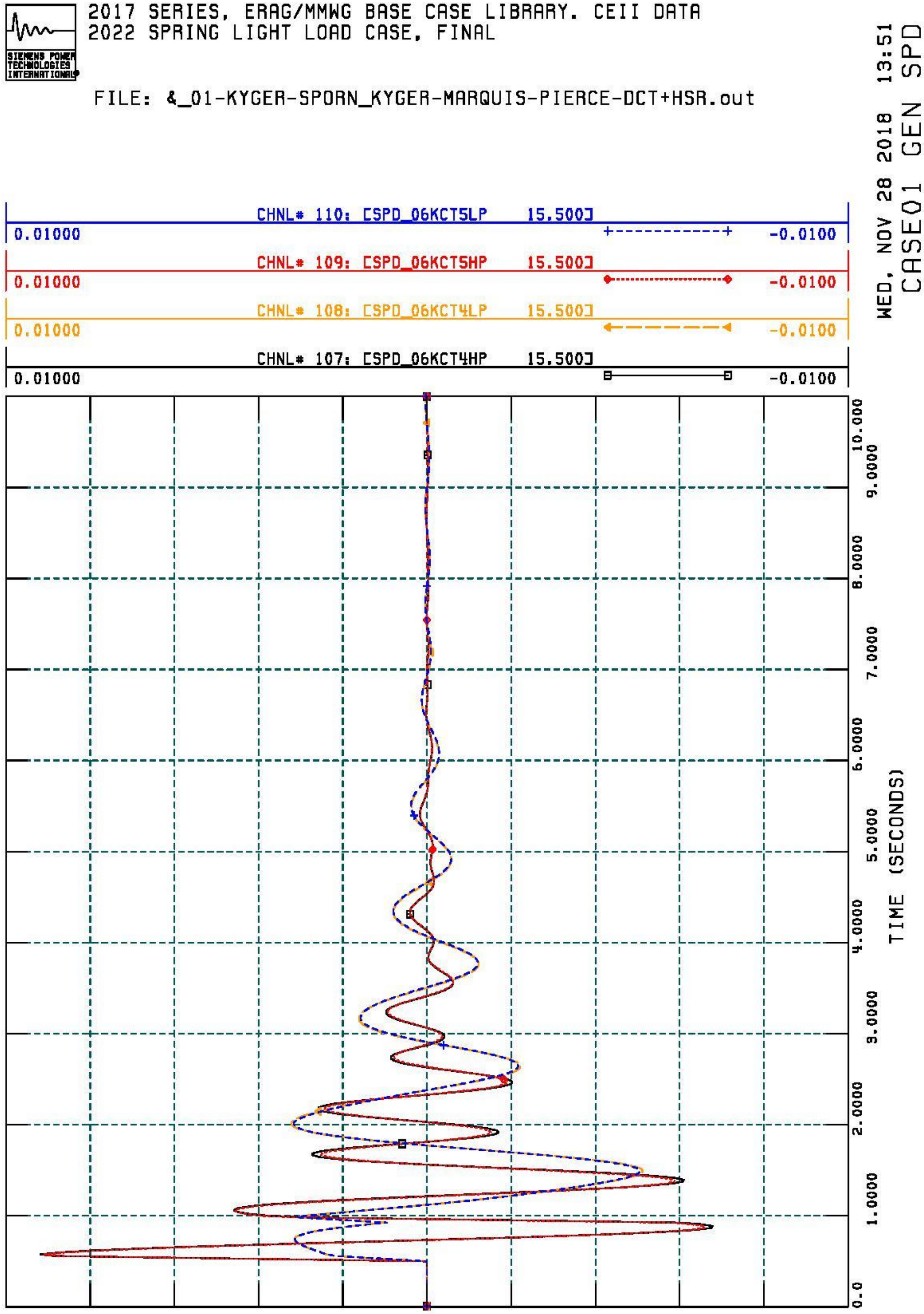

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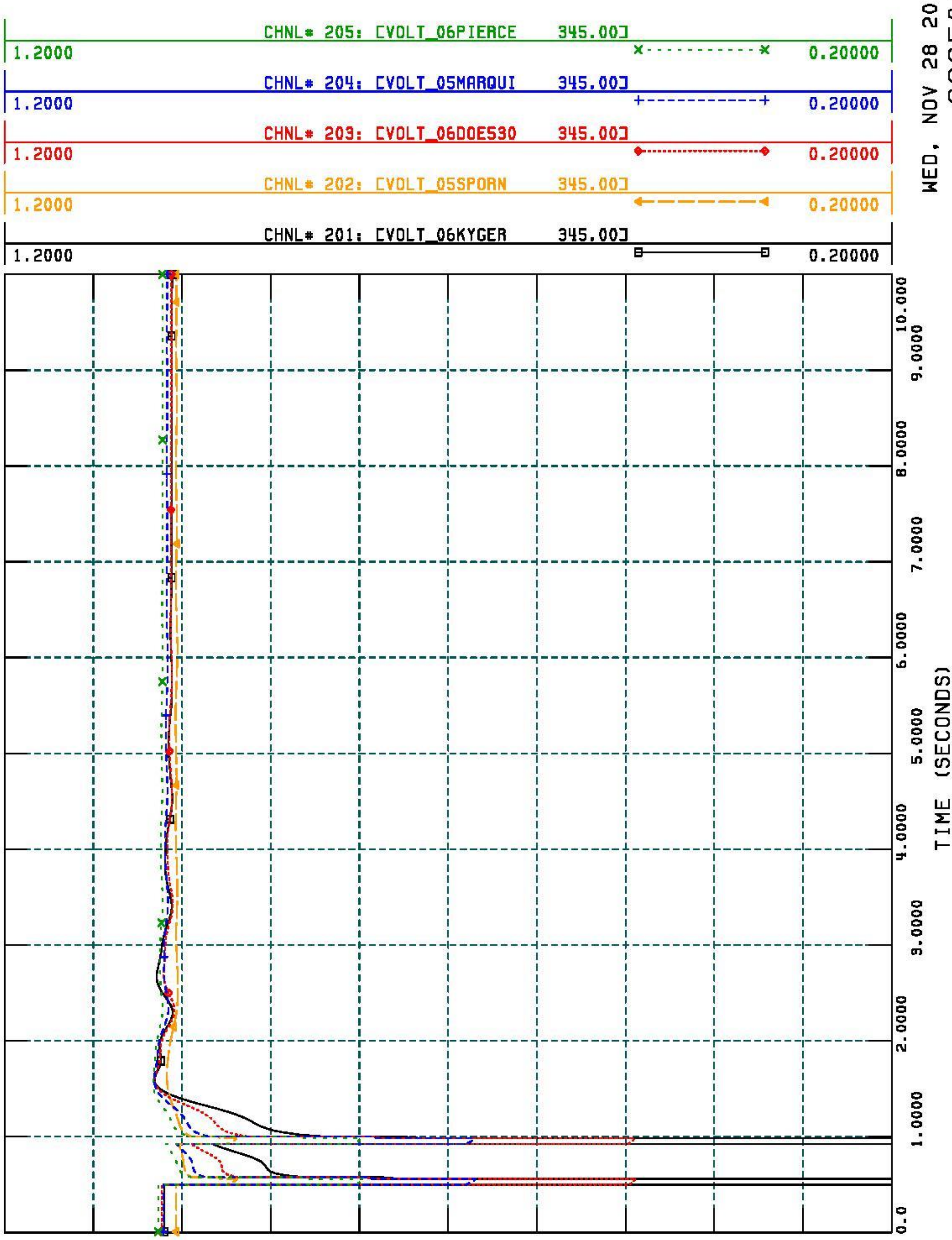

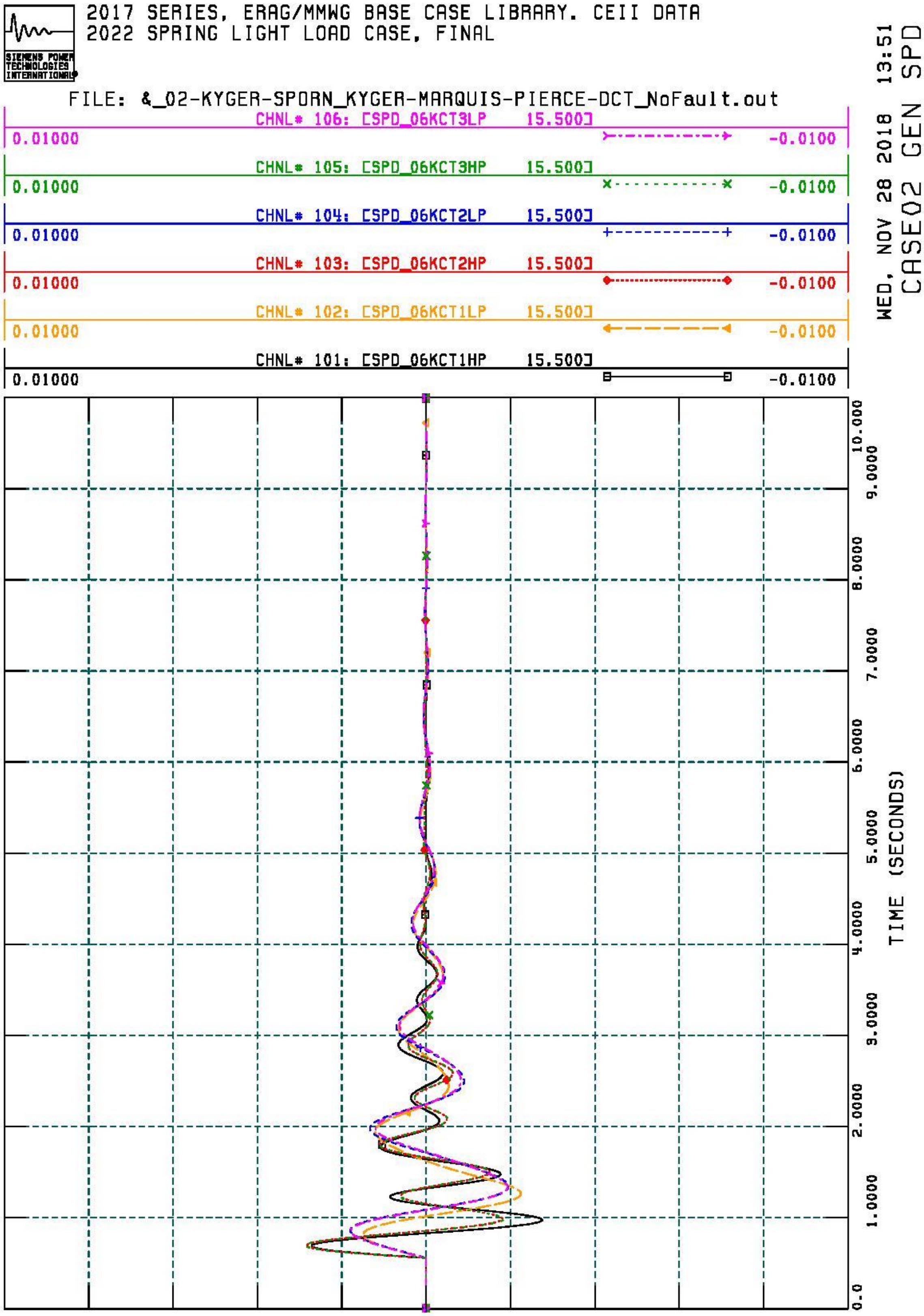

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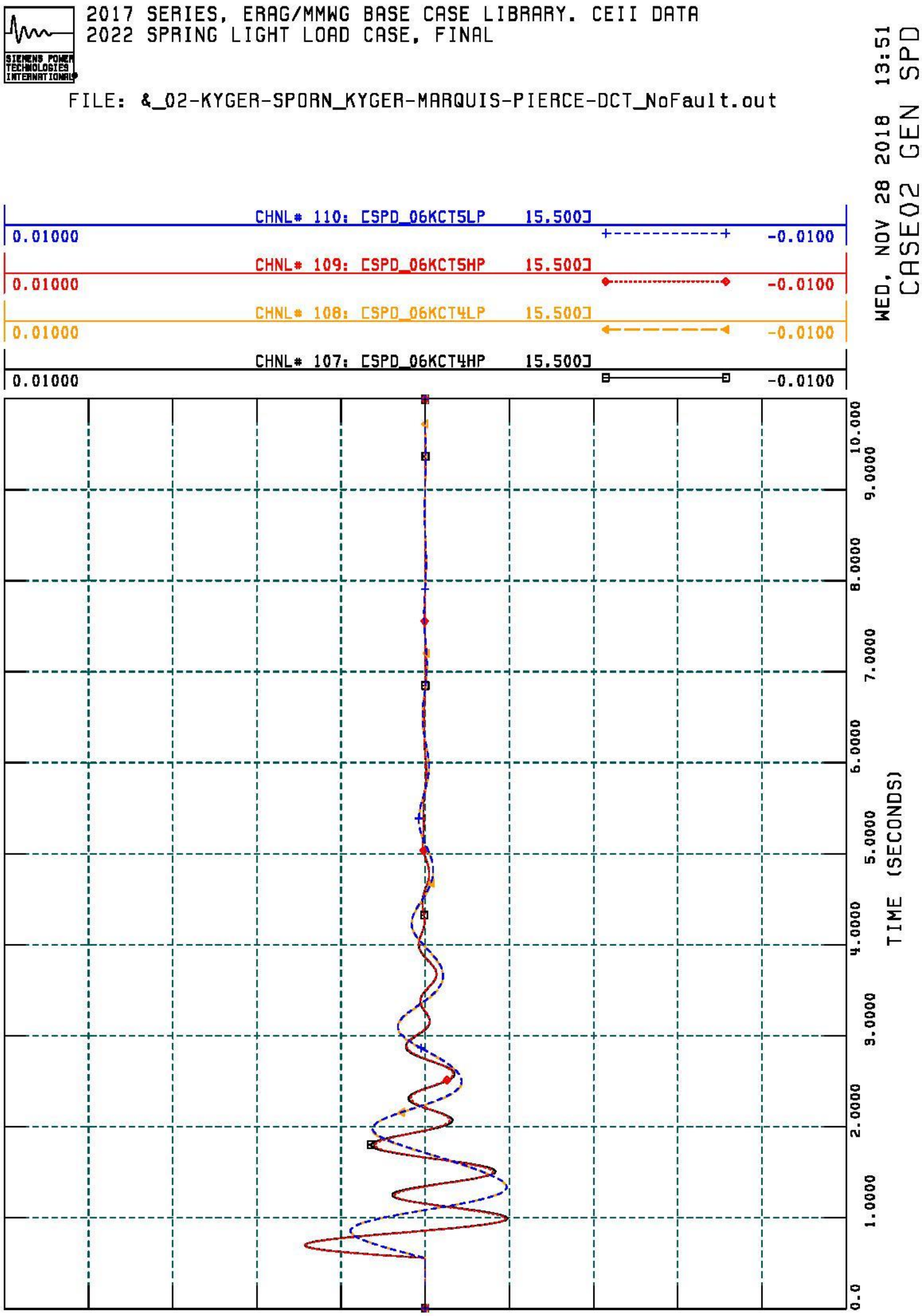
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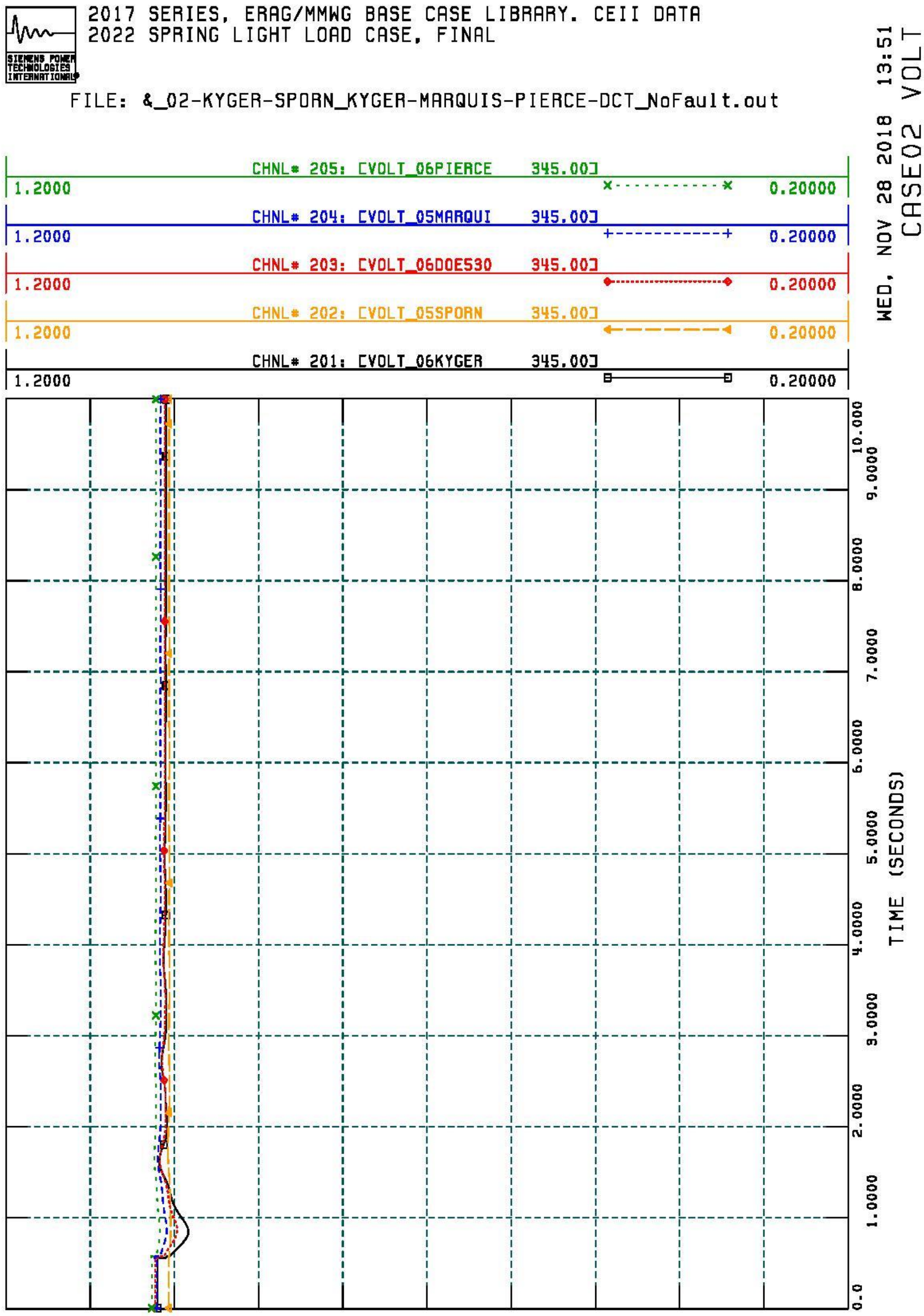

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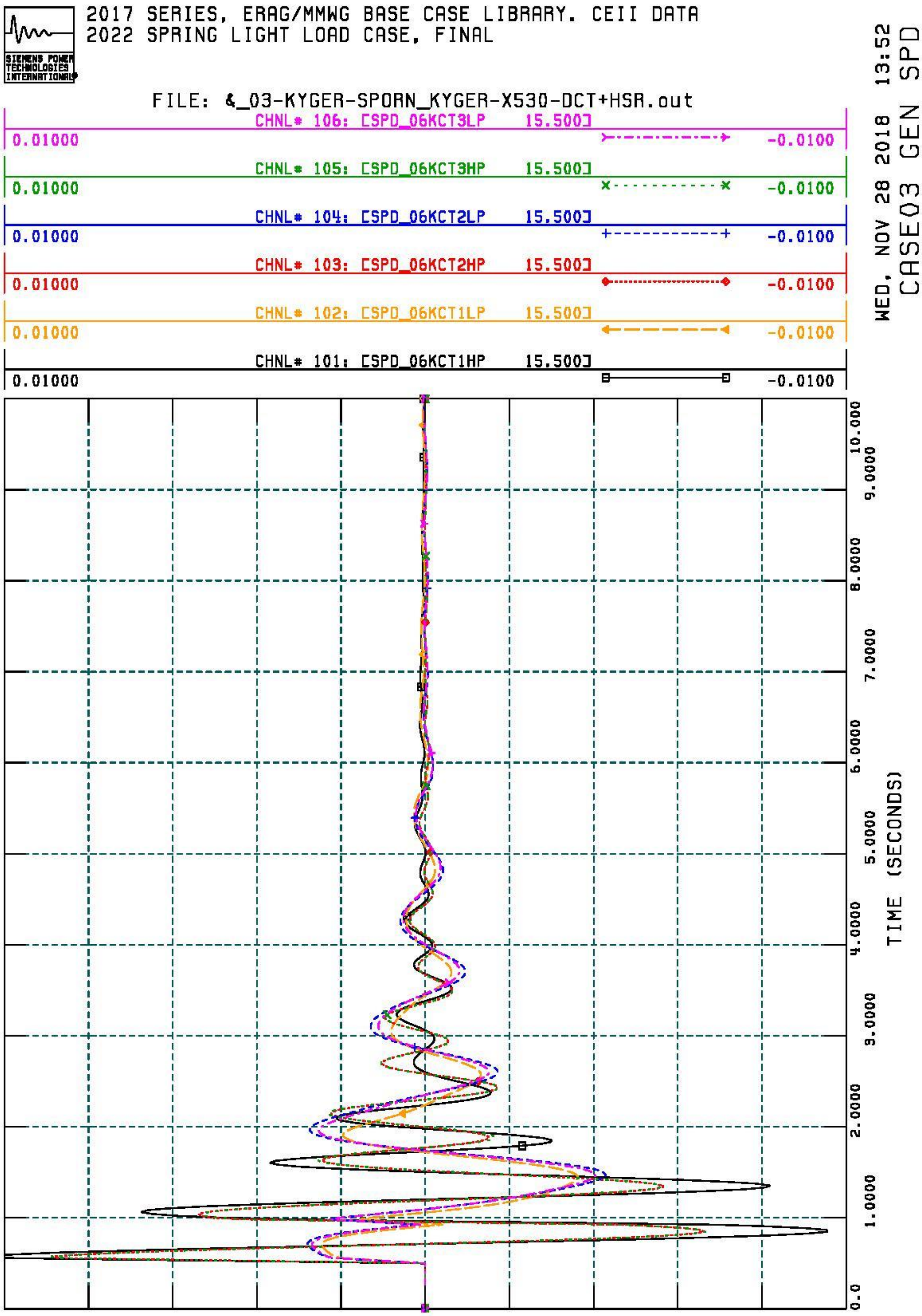
CASE02 VOLT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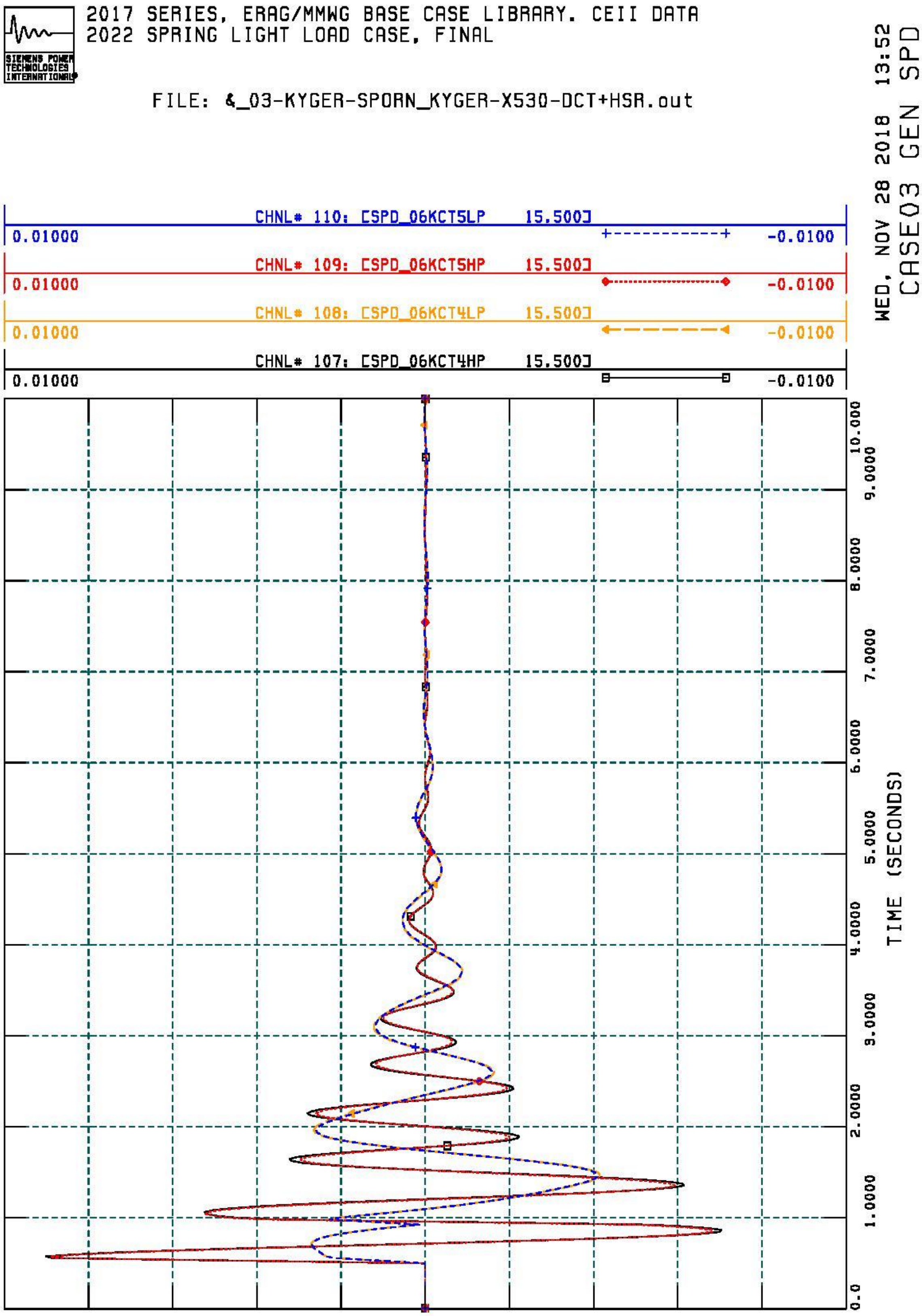
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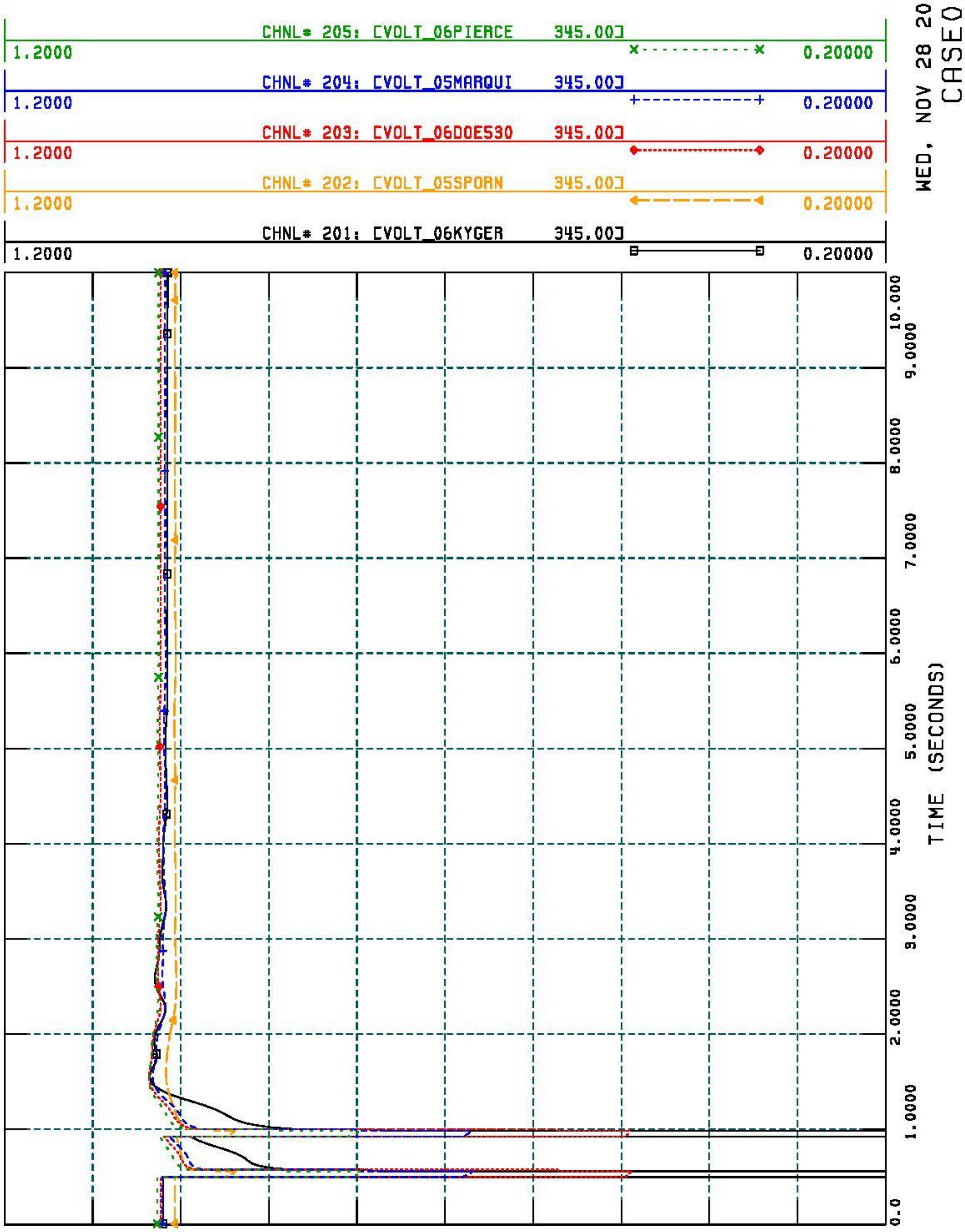

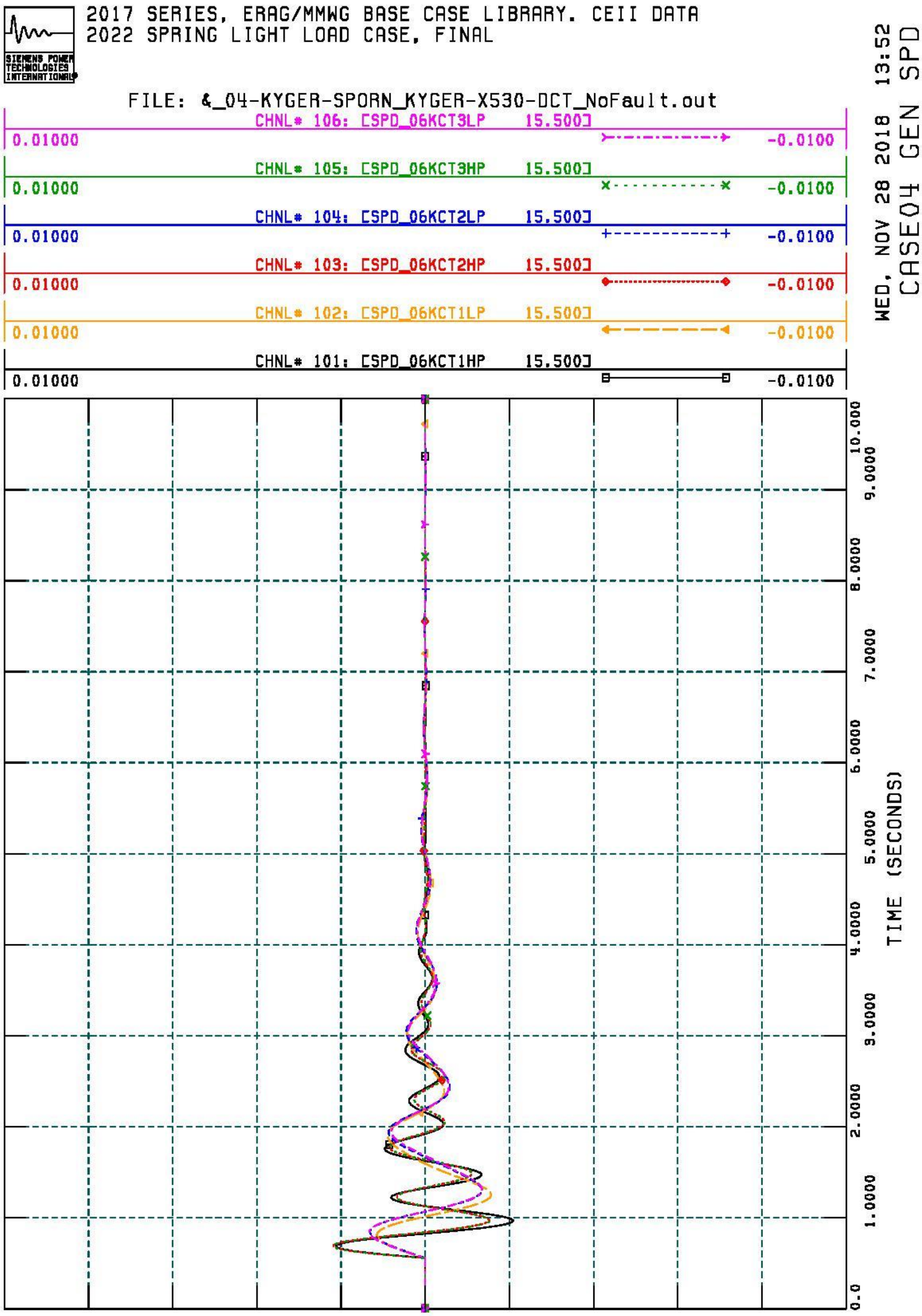
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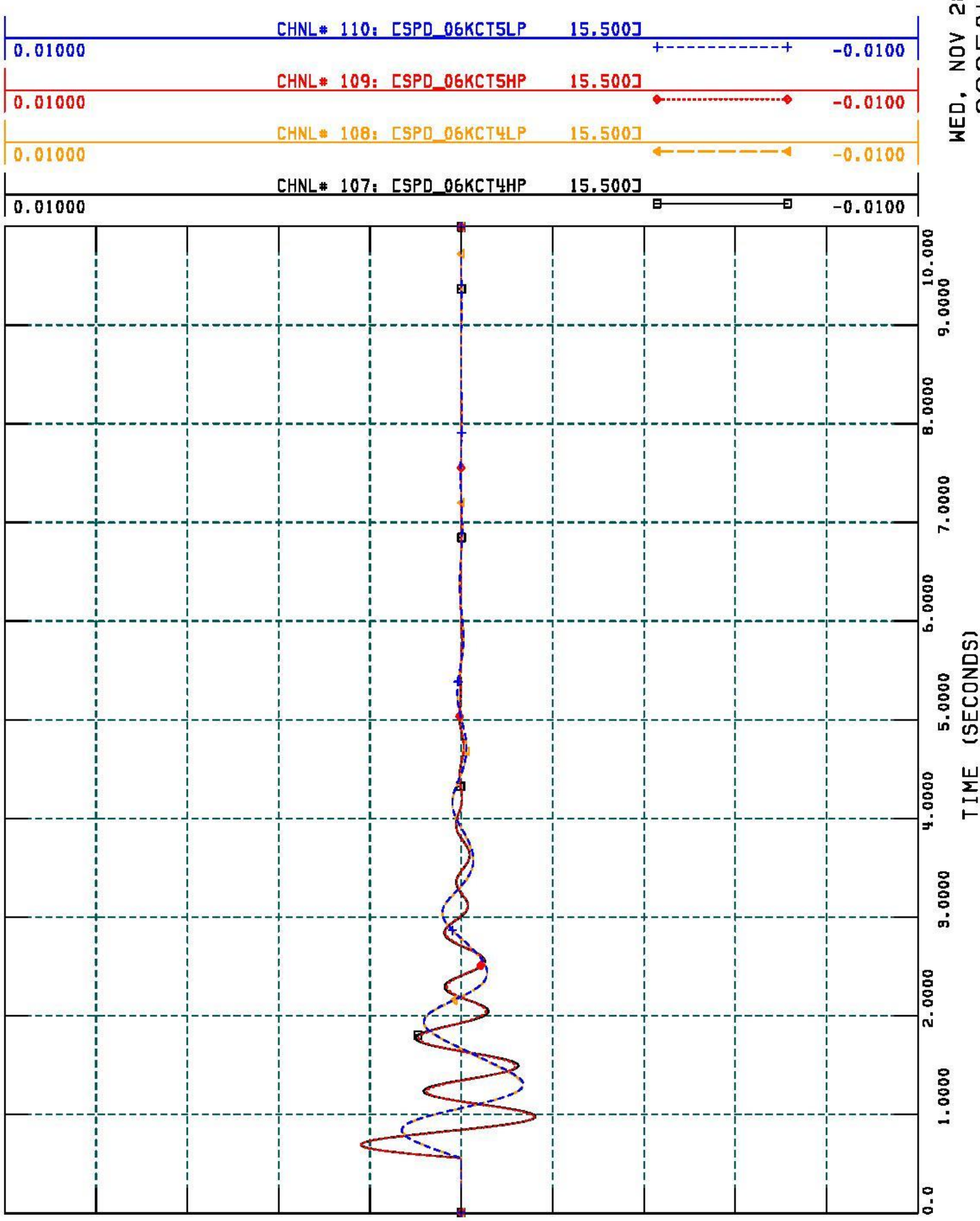

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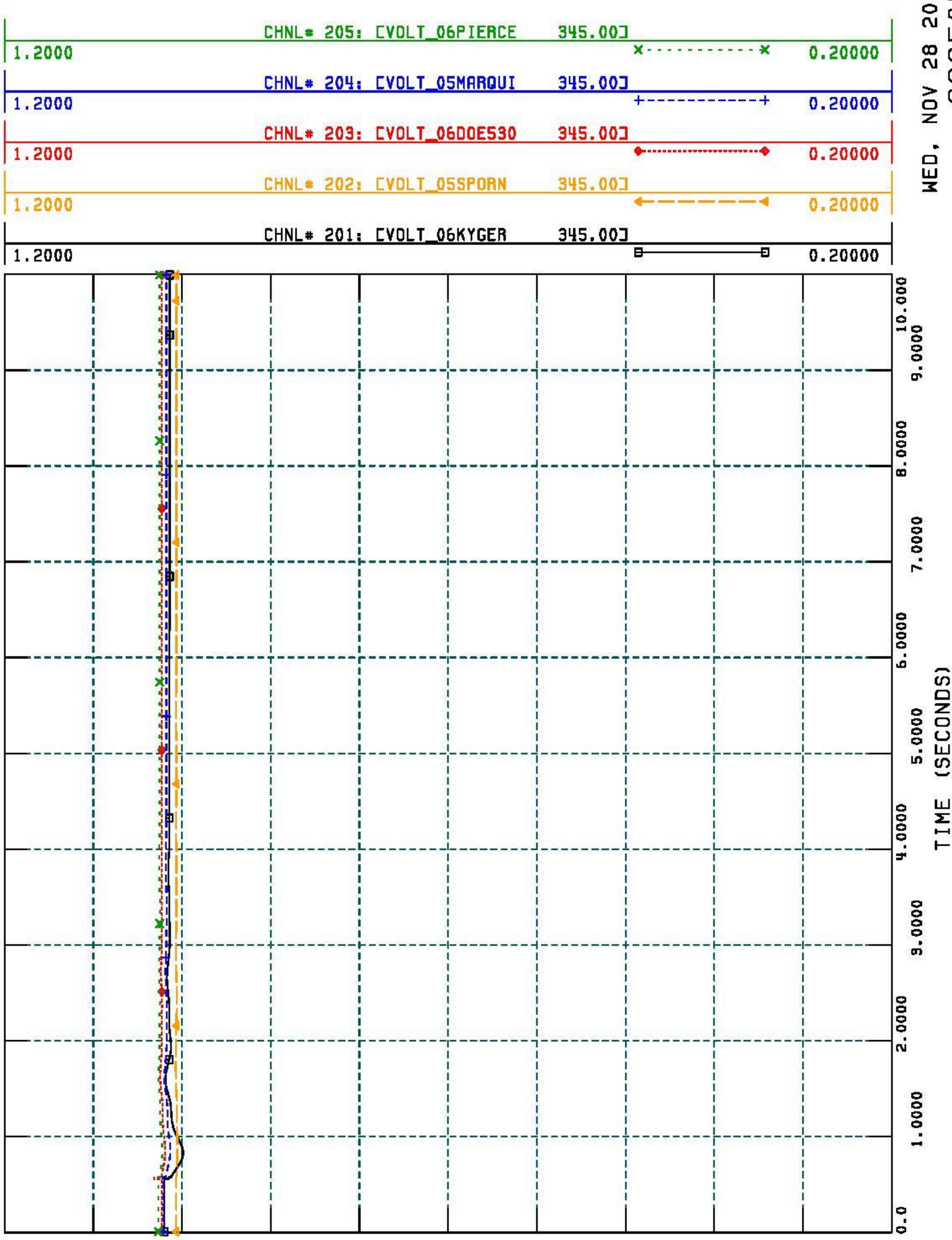

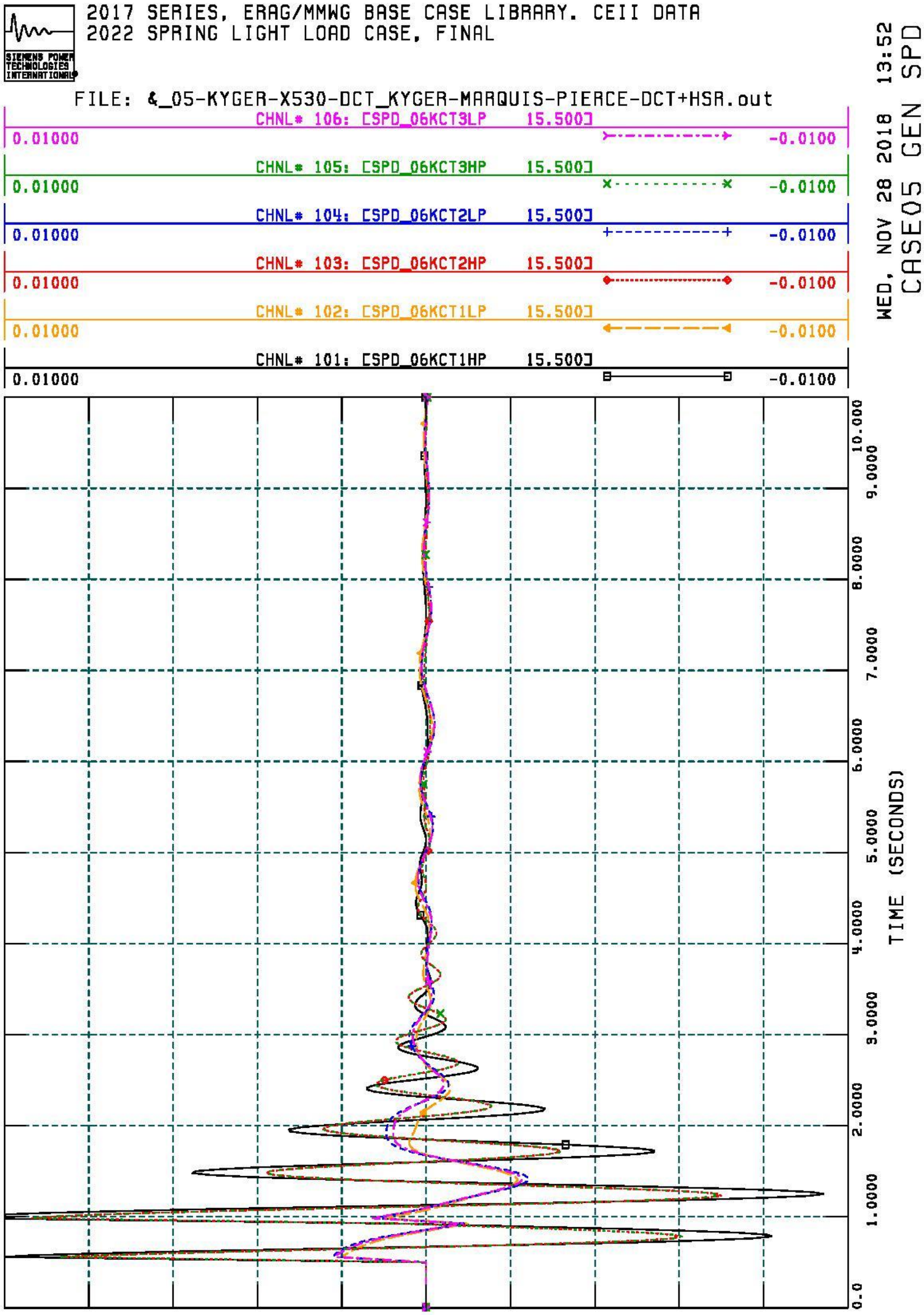
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2017 SERIES, ERAG/MMWG BASE CASE LIBRARY. CEII DATA
2022 SPRING LIGHT LOAD CASE, FINAL

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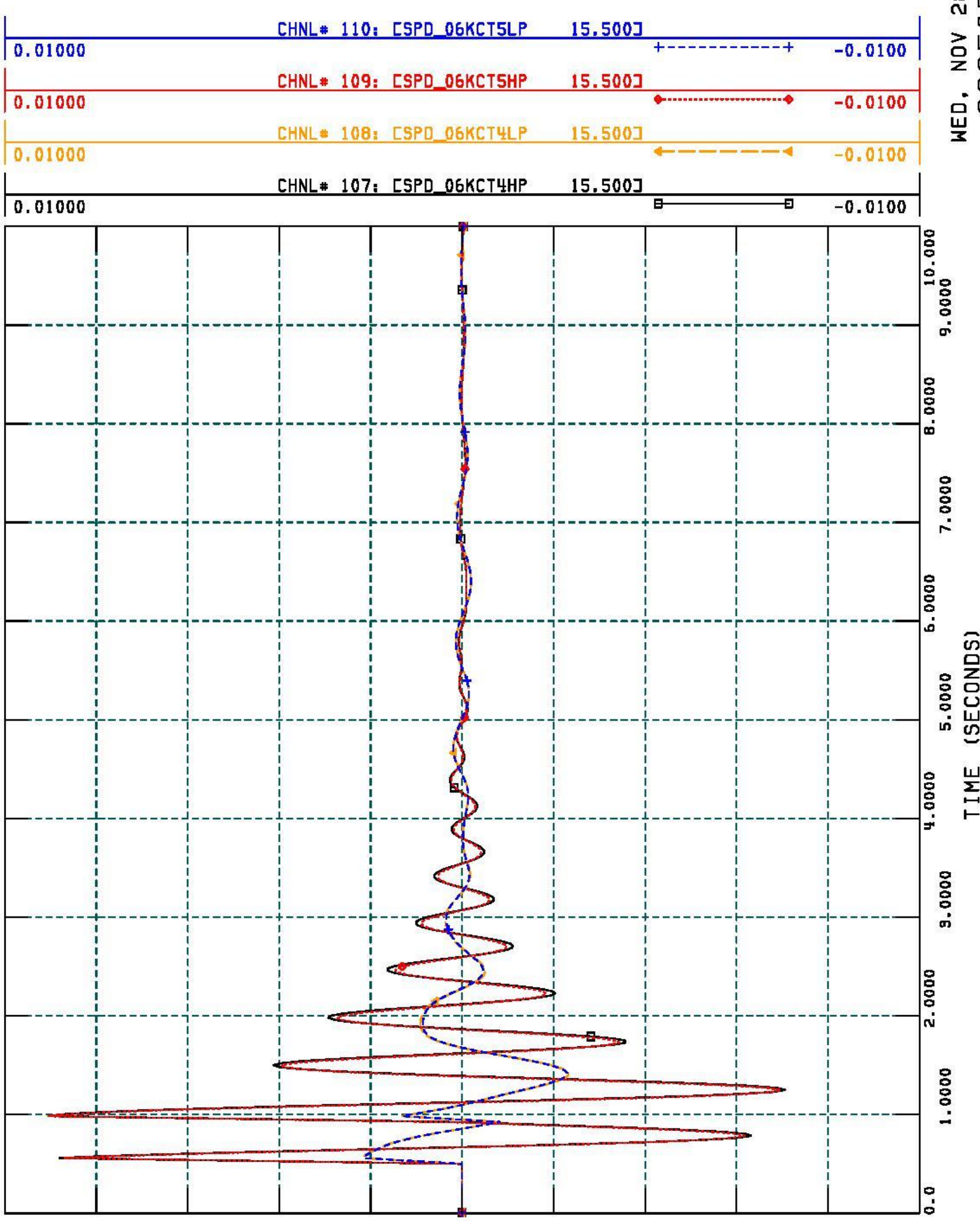

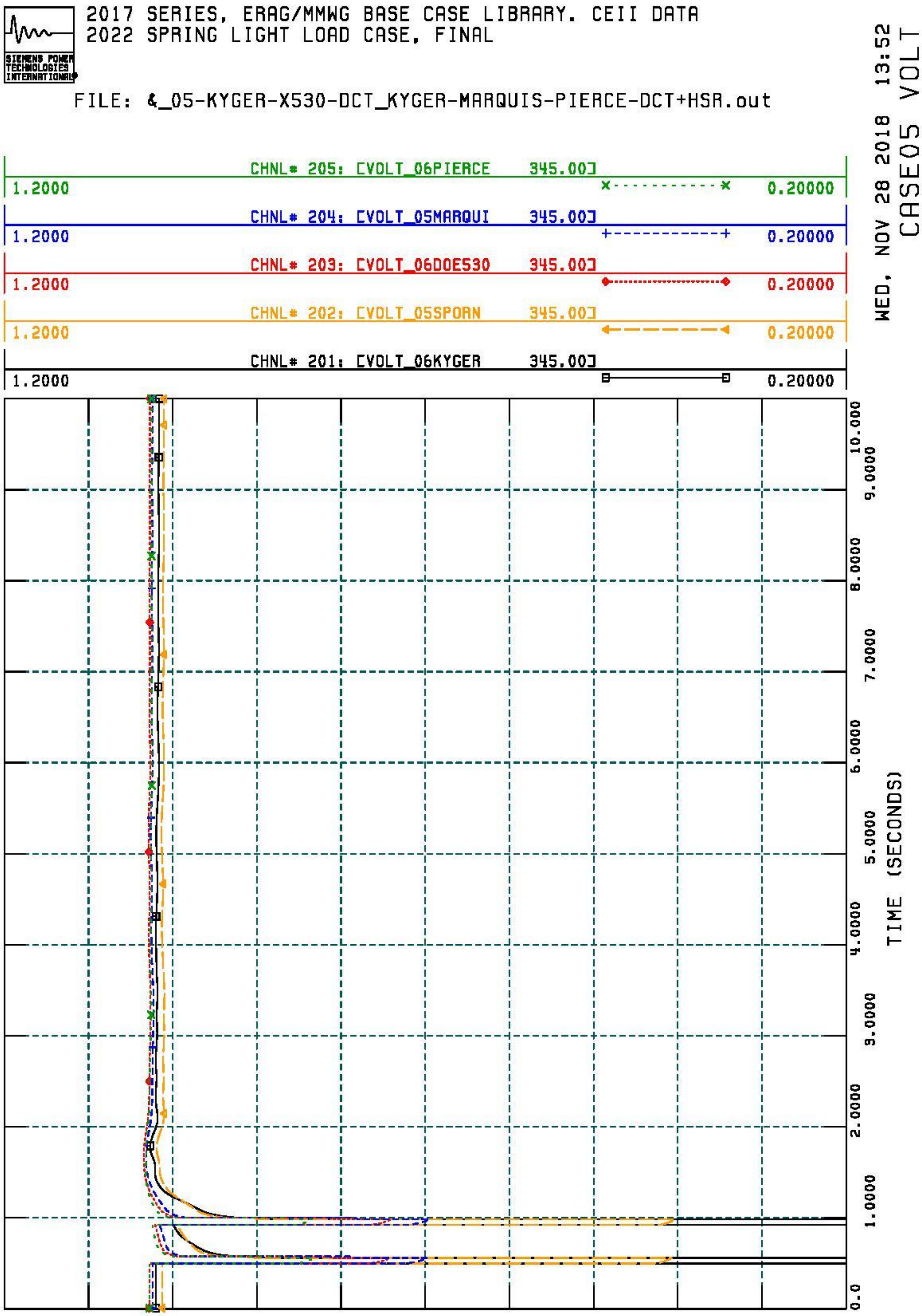

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SIEMENS POWER TECHNOLOGIES INTERNATIONAL
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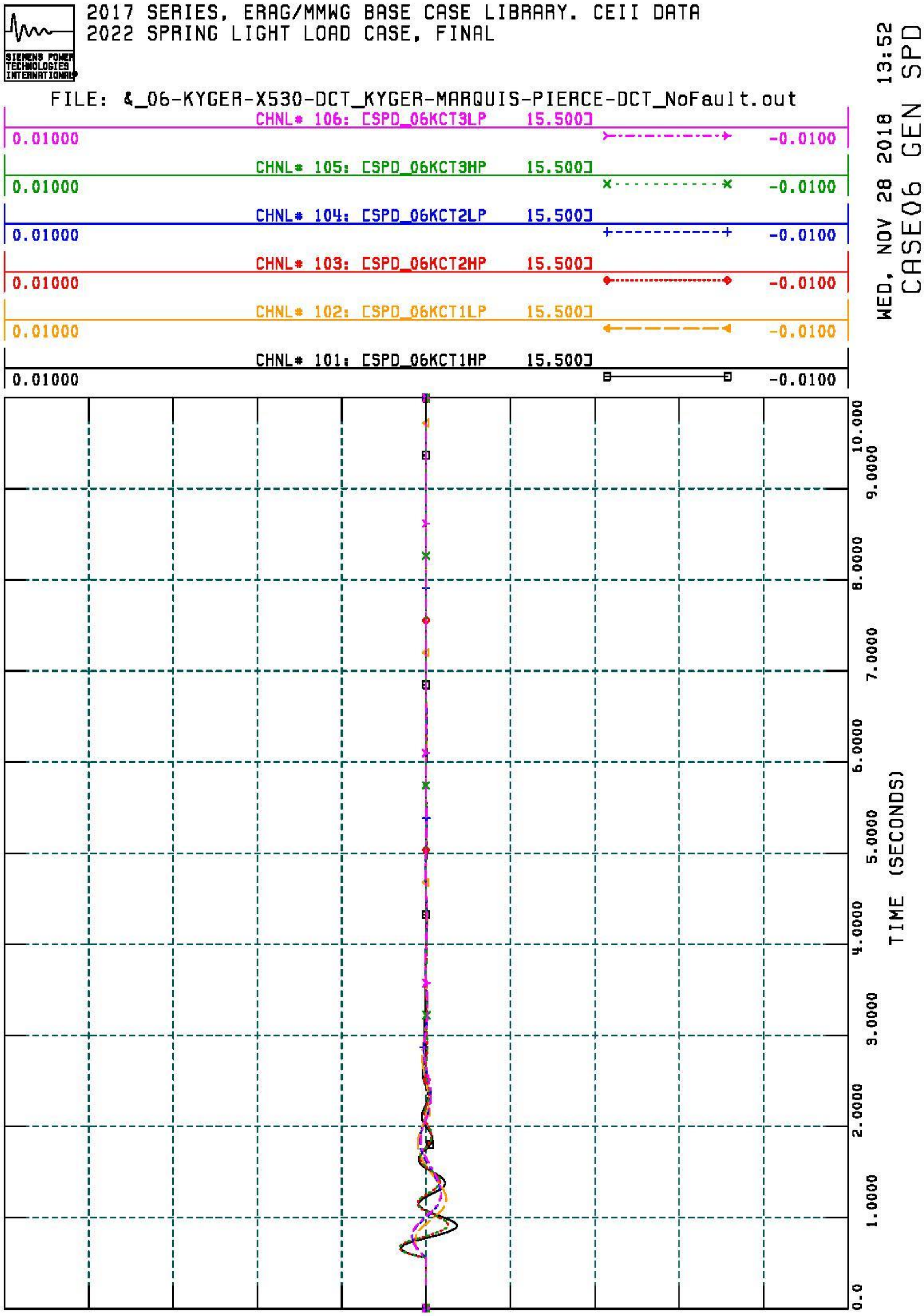

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2017 SERIES, ERAG/MMWG BASE CASE LIBRARY. CEII DATA
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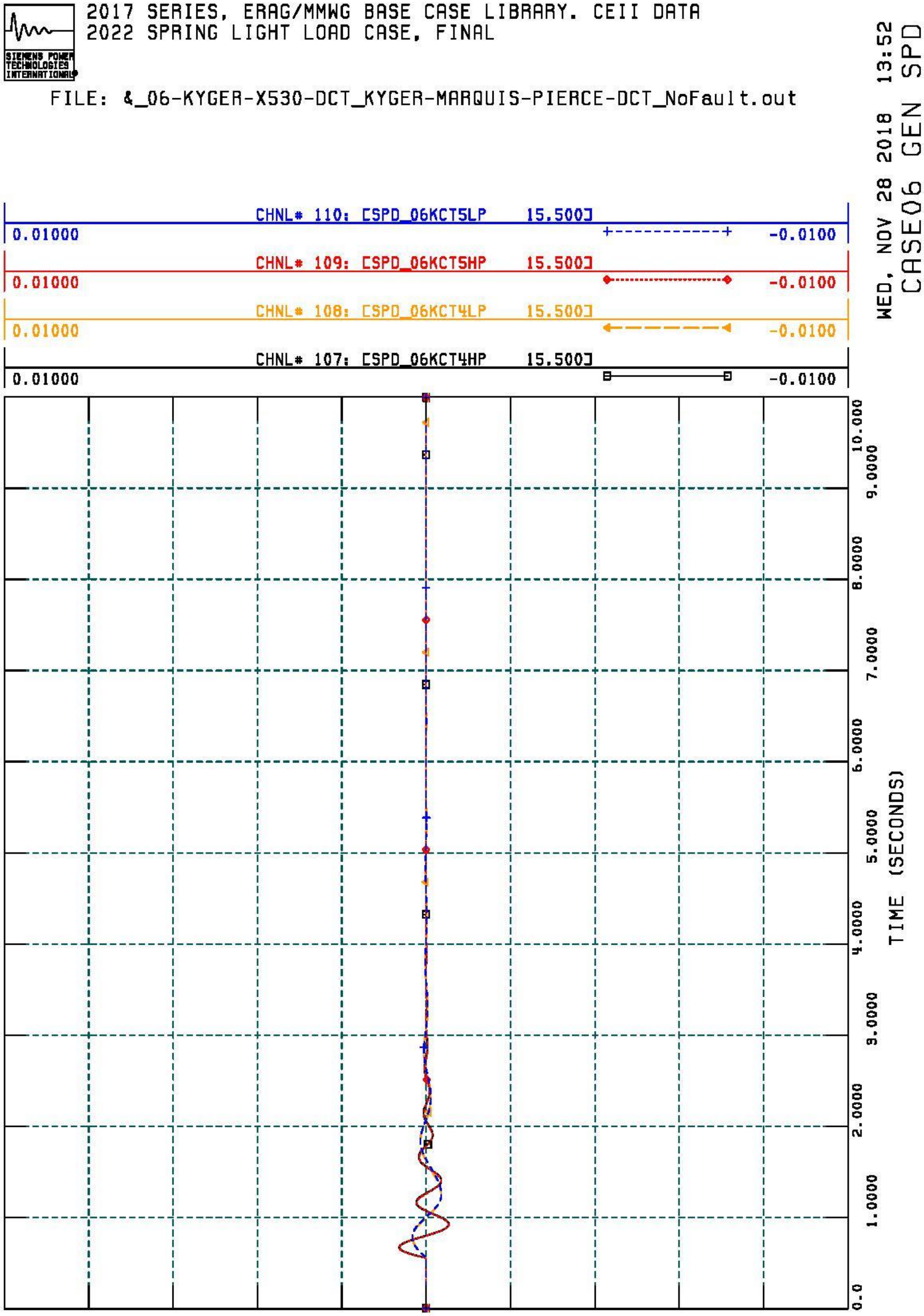

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2022 SPRING LIGHT LOAD CASE, FINAL

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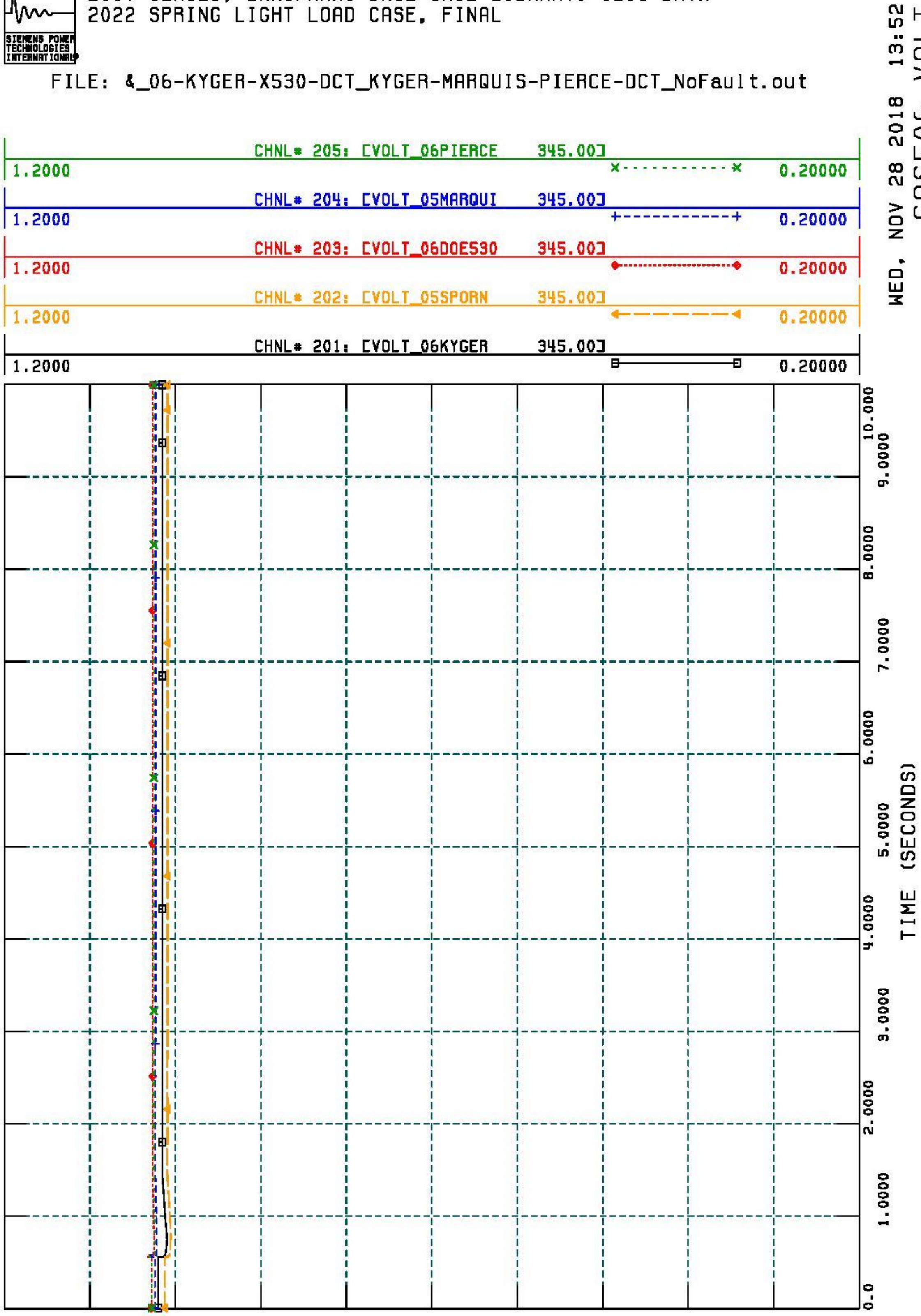

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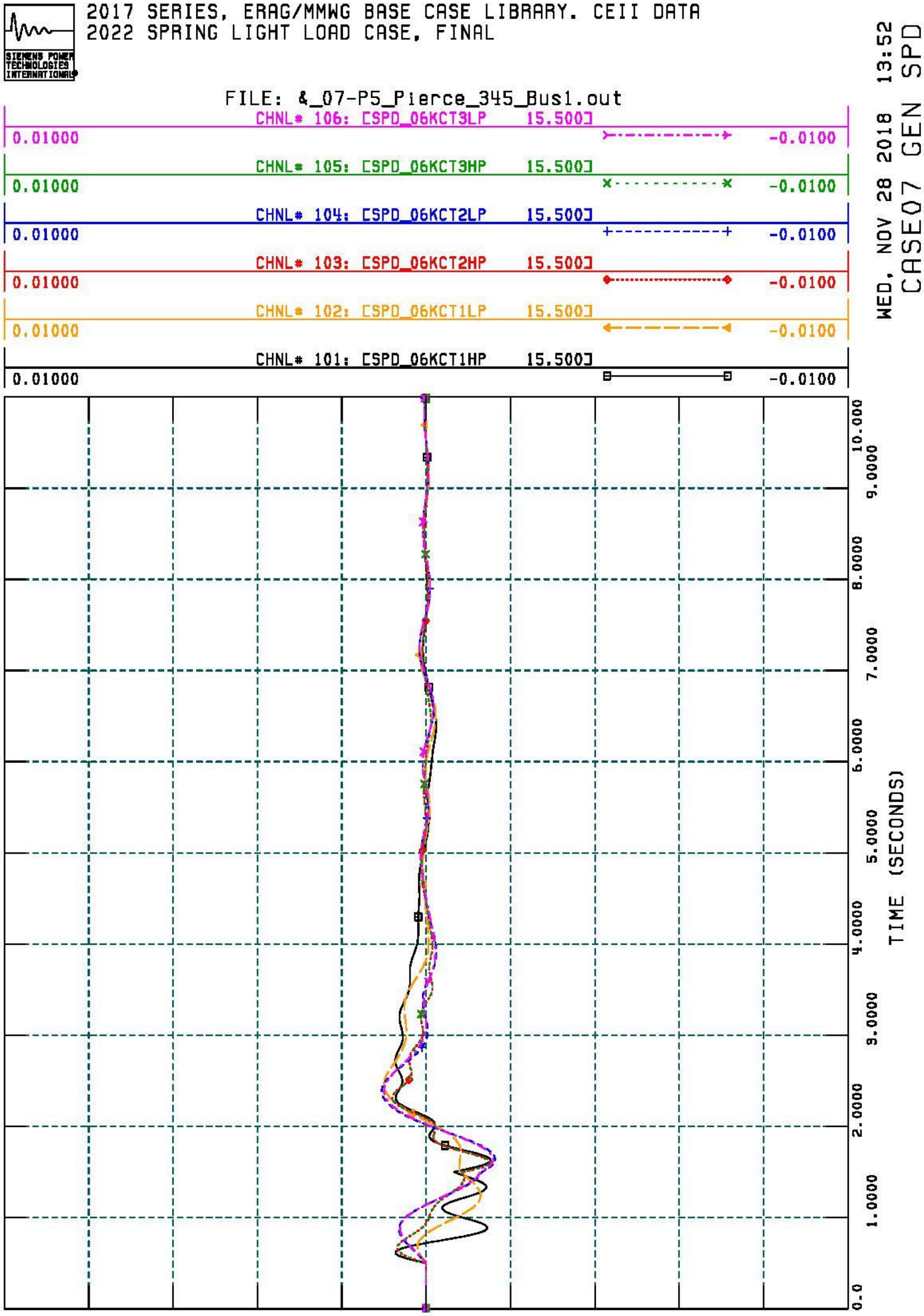

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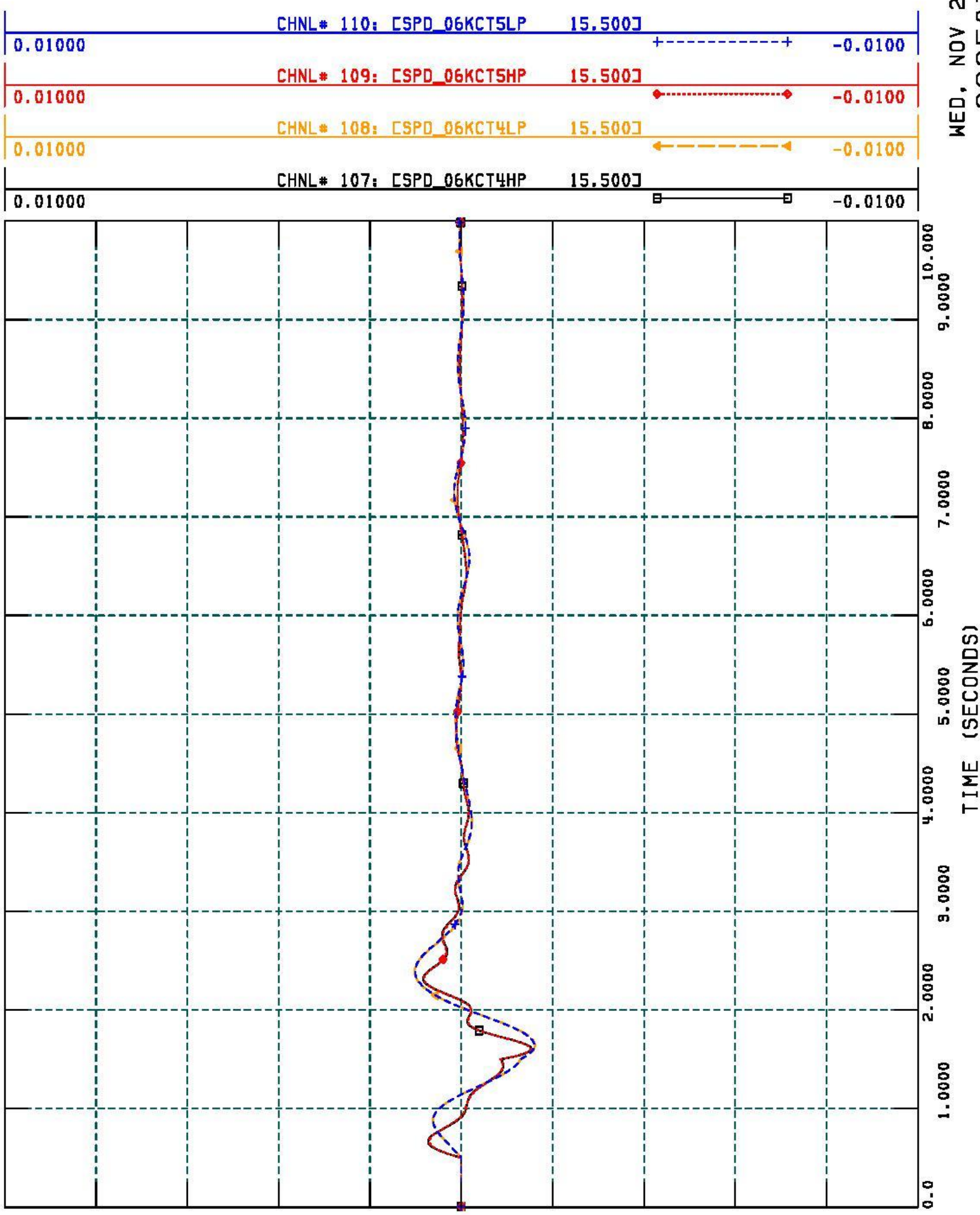

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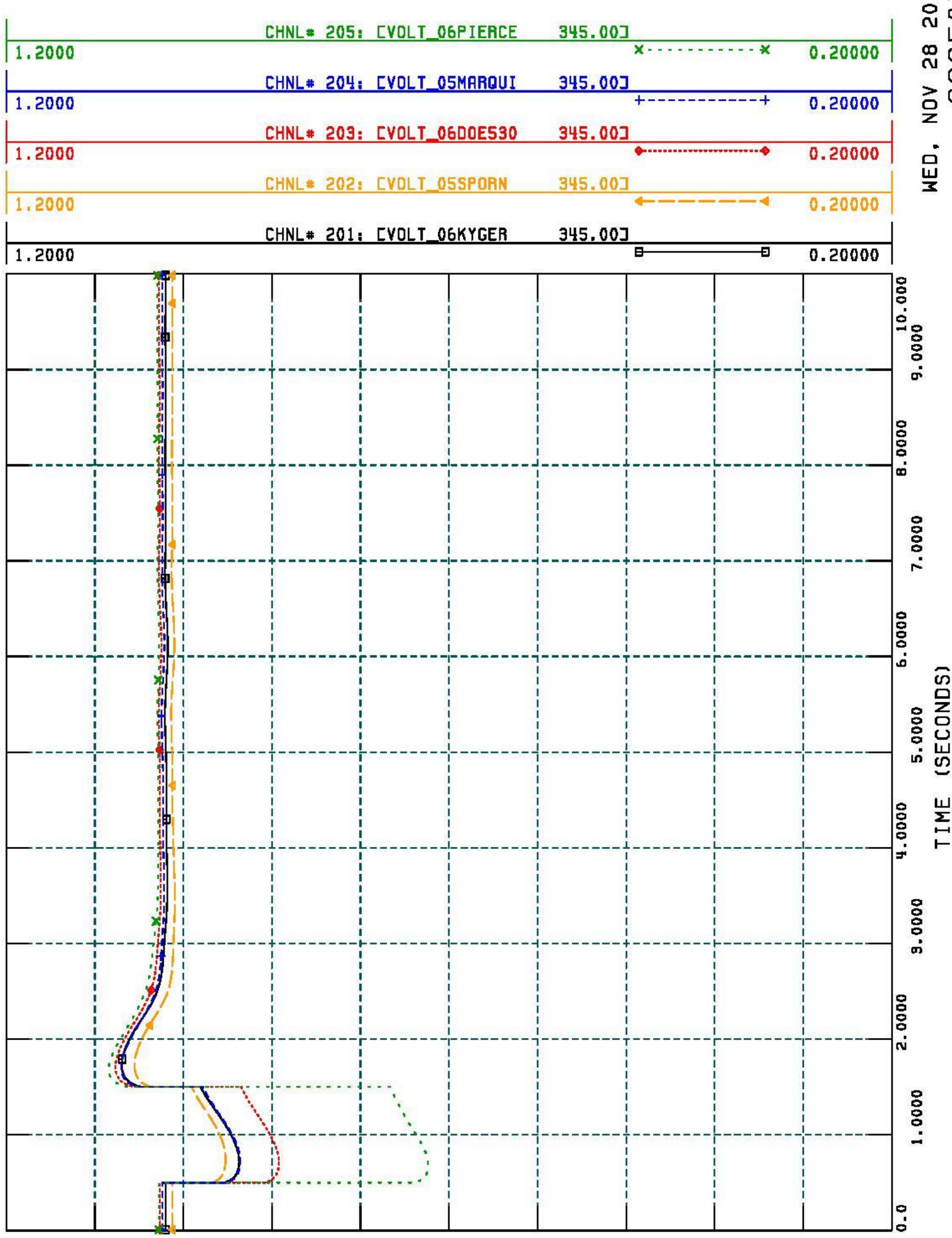

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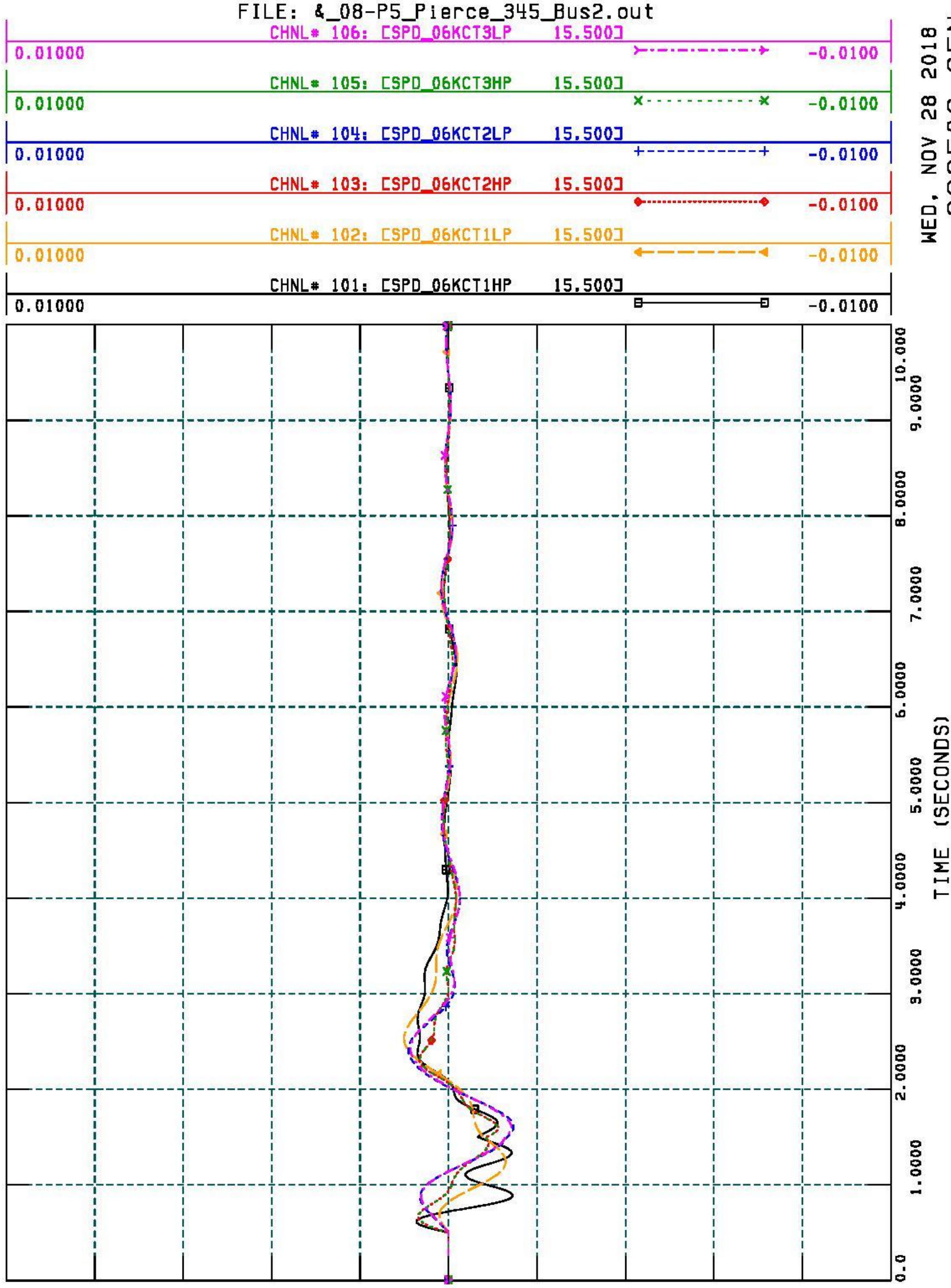

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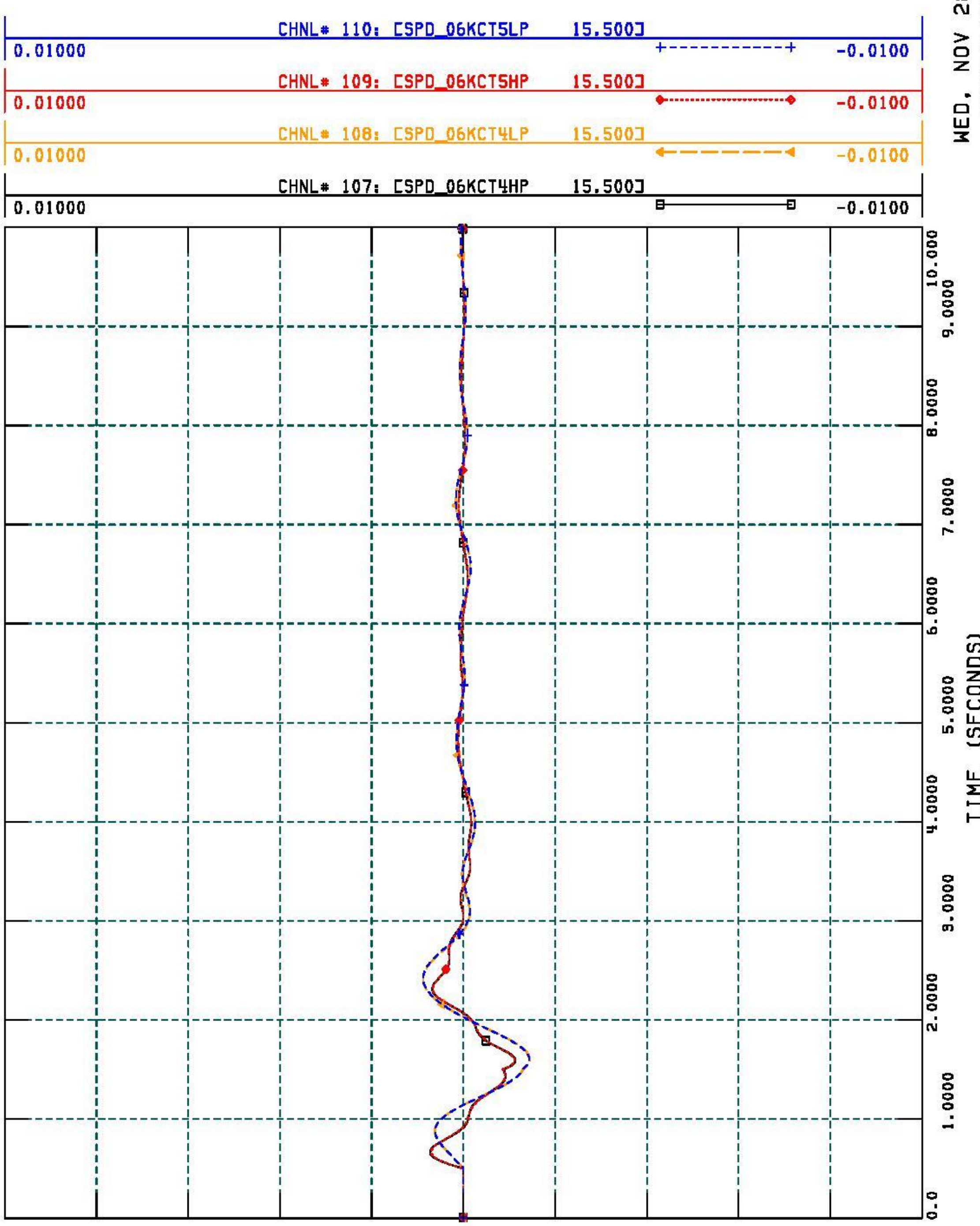

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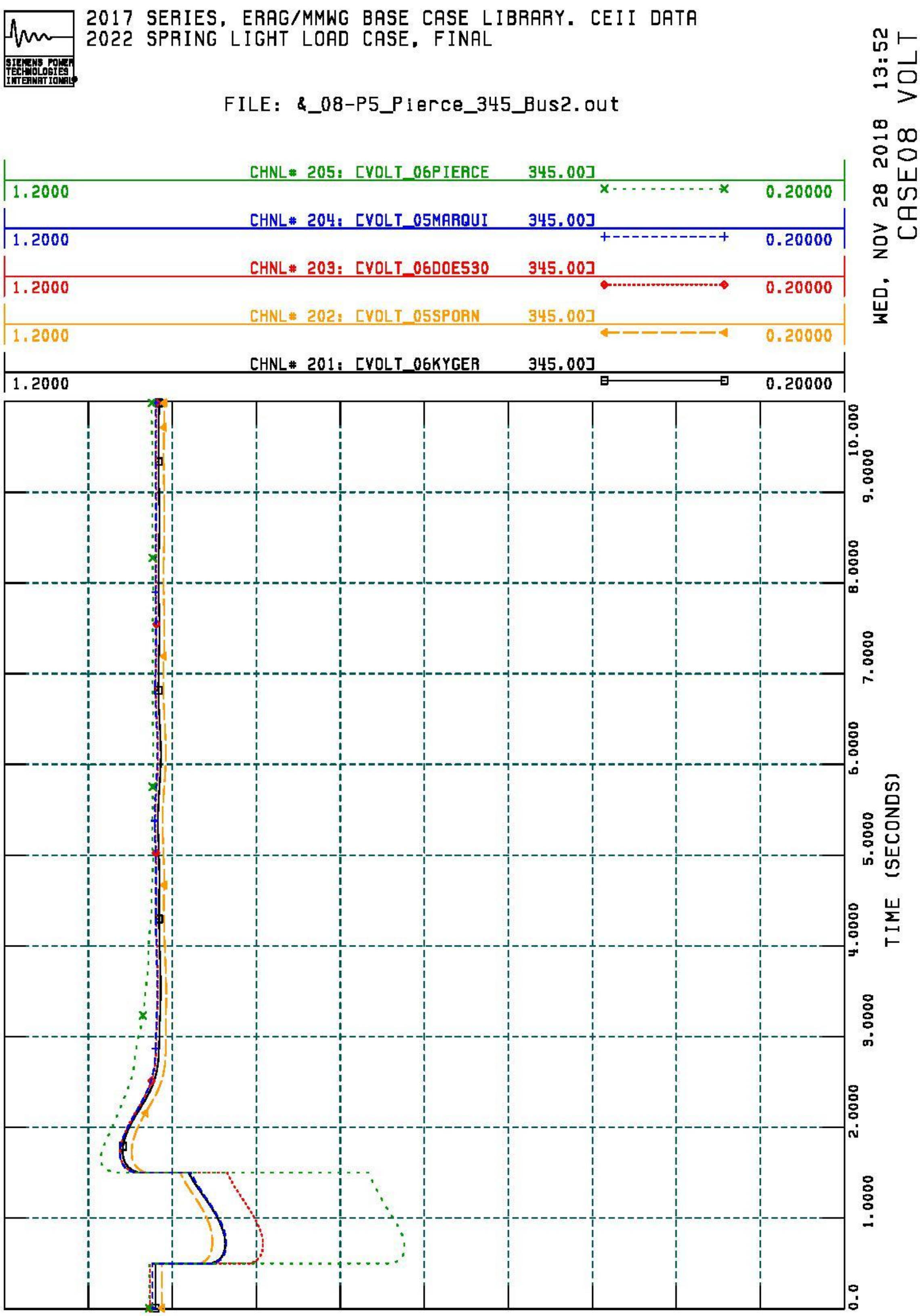

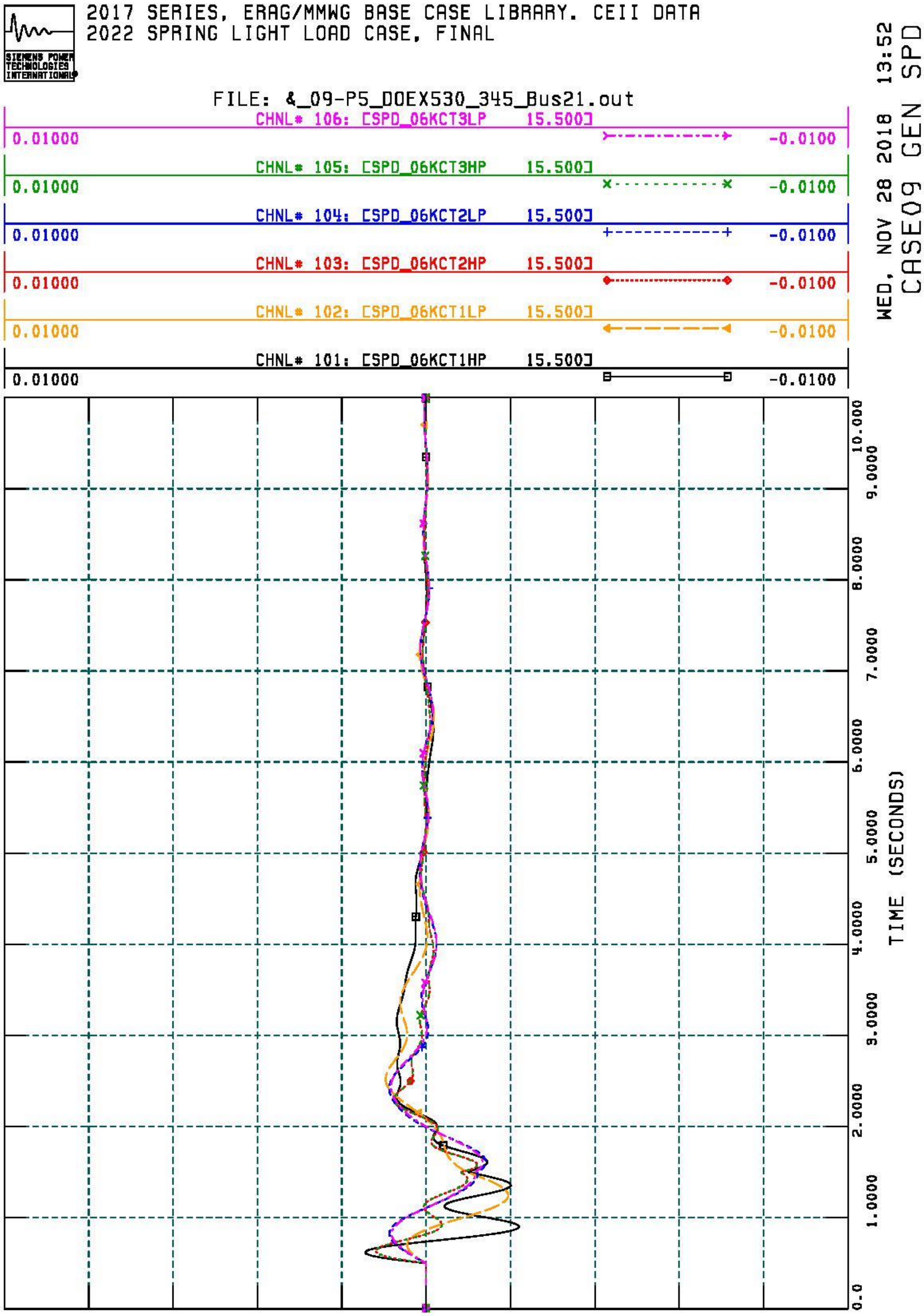

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SIEMENS POWER TECHNOLOGIES INTERNATIONAL

2017 SERIES, ERAG/MMWG BASE CASE LIBRARY. CEII DATA
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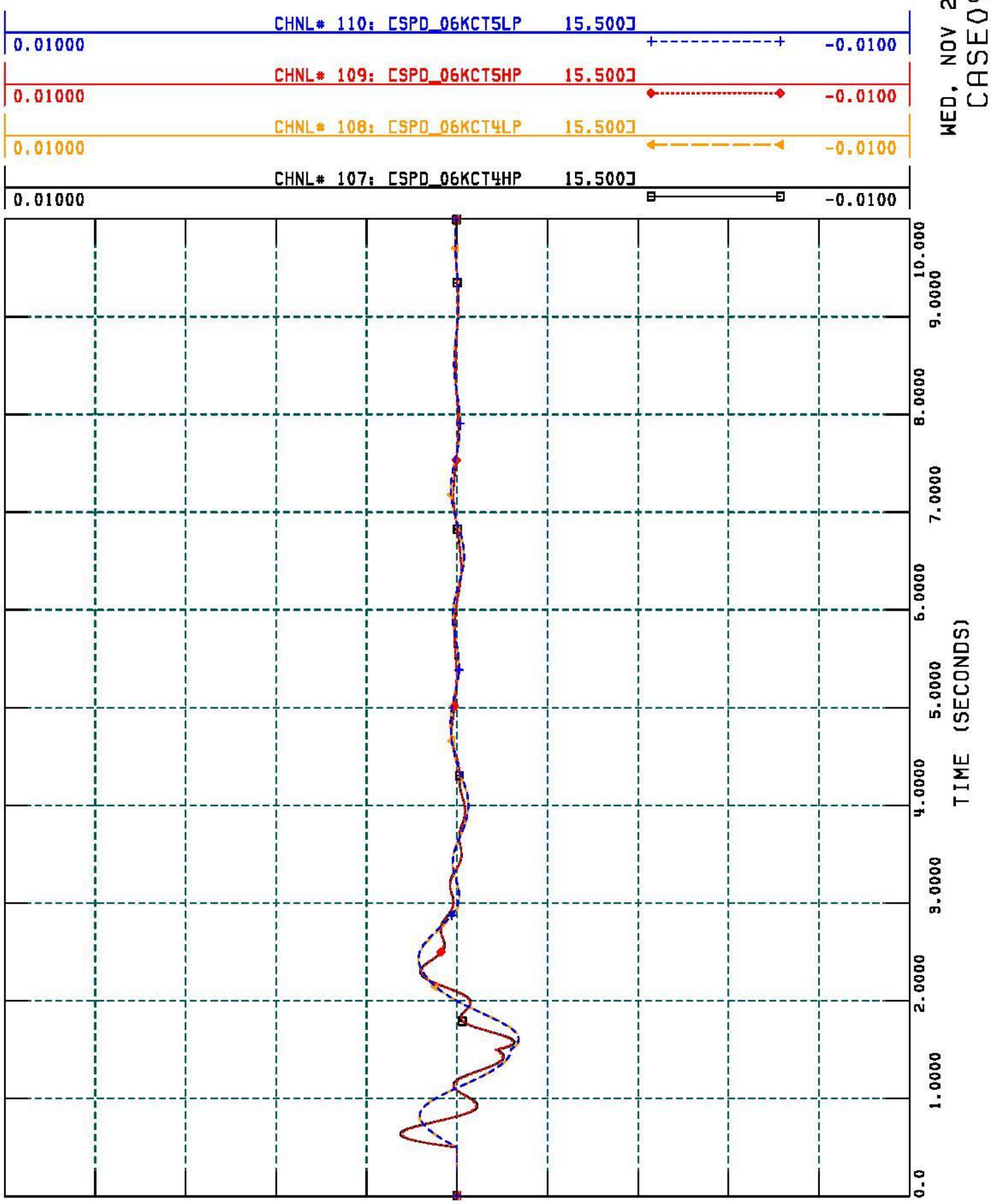

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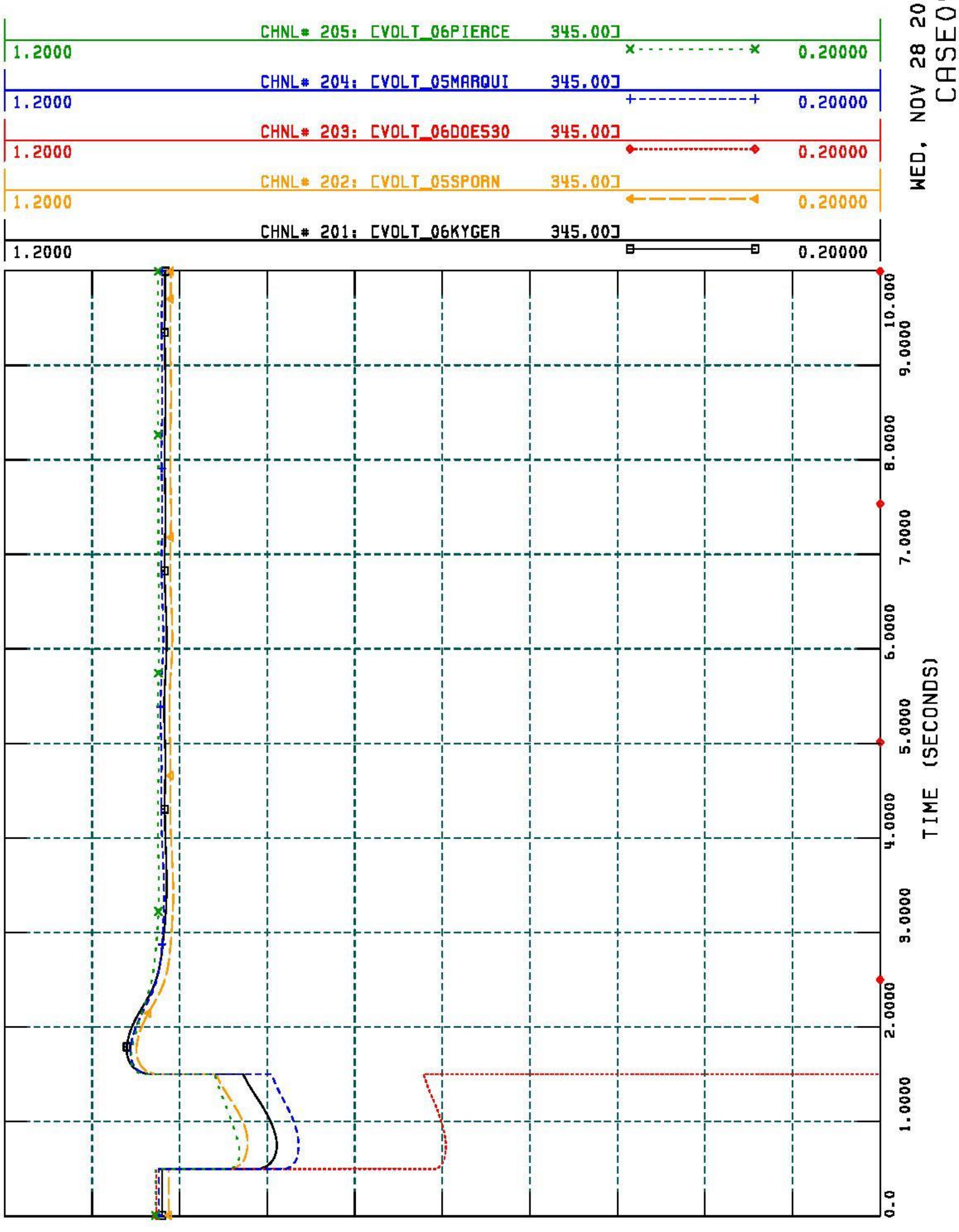

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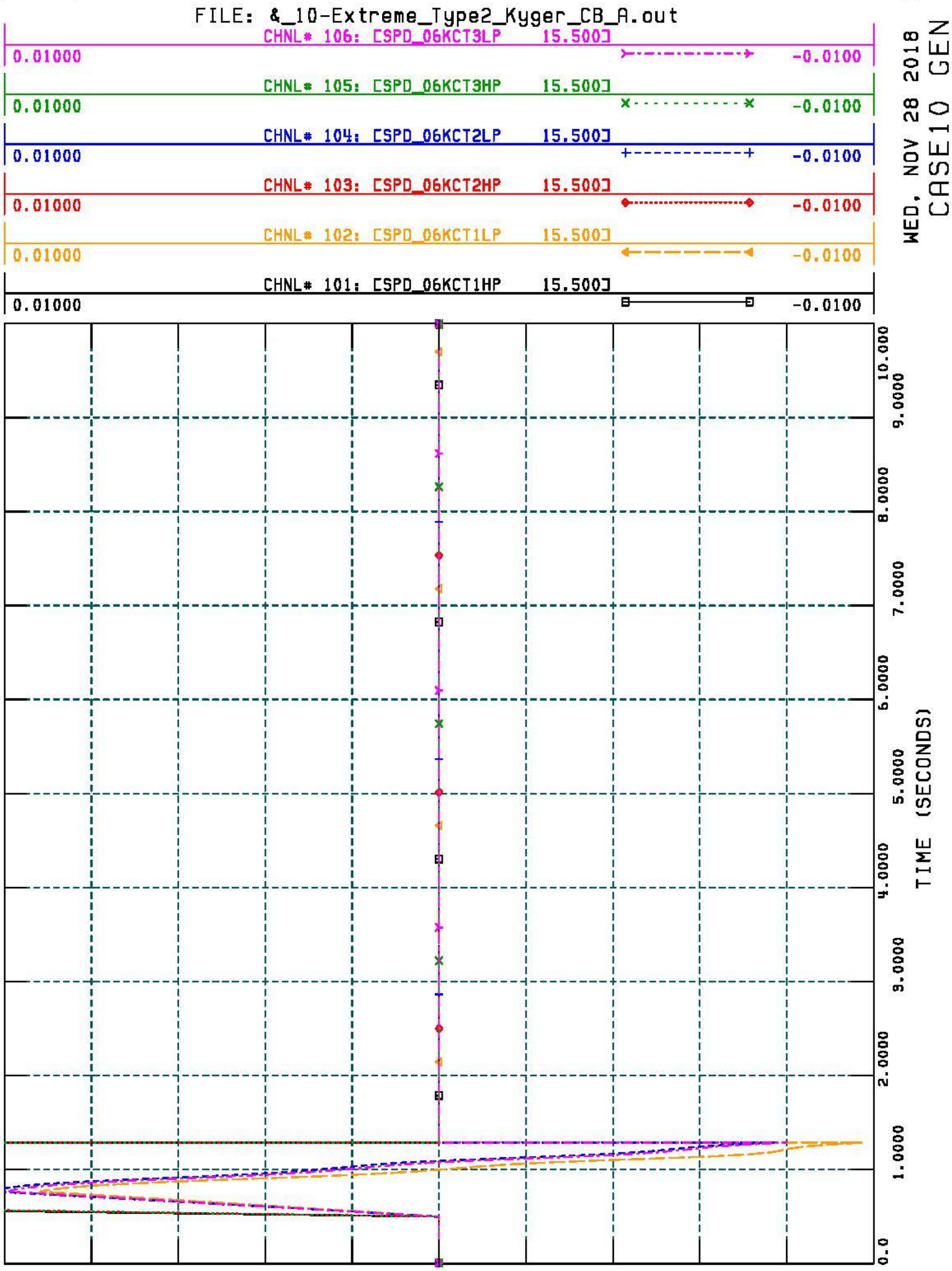

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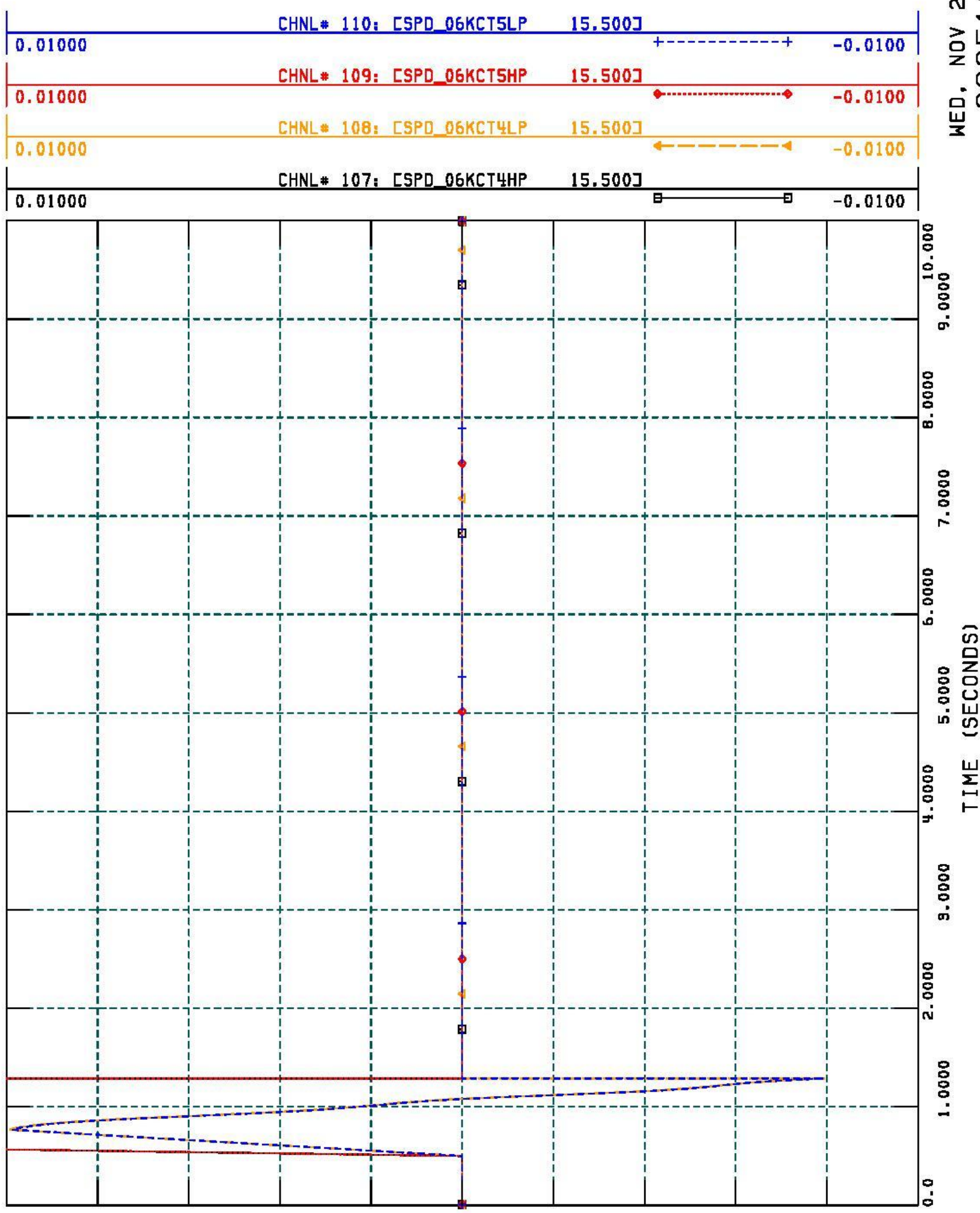

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2022 SPRING LIGHT LOAD CASE, FINAL

FILE: &_10-Extreme_Type2_Kyger_CB_A.out

WED, NOV 28 2018 13:52
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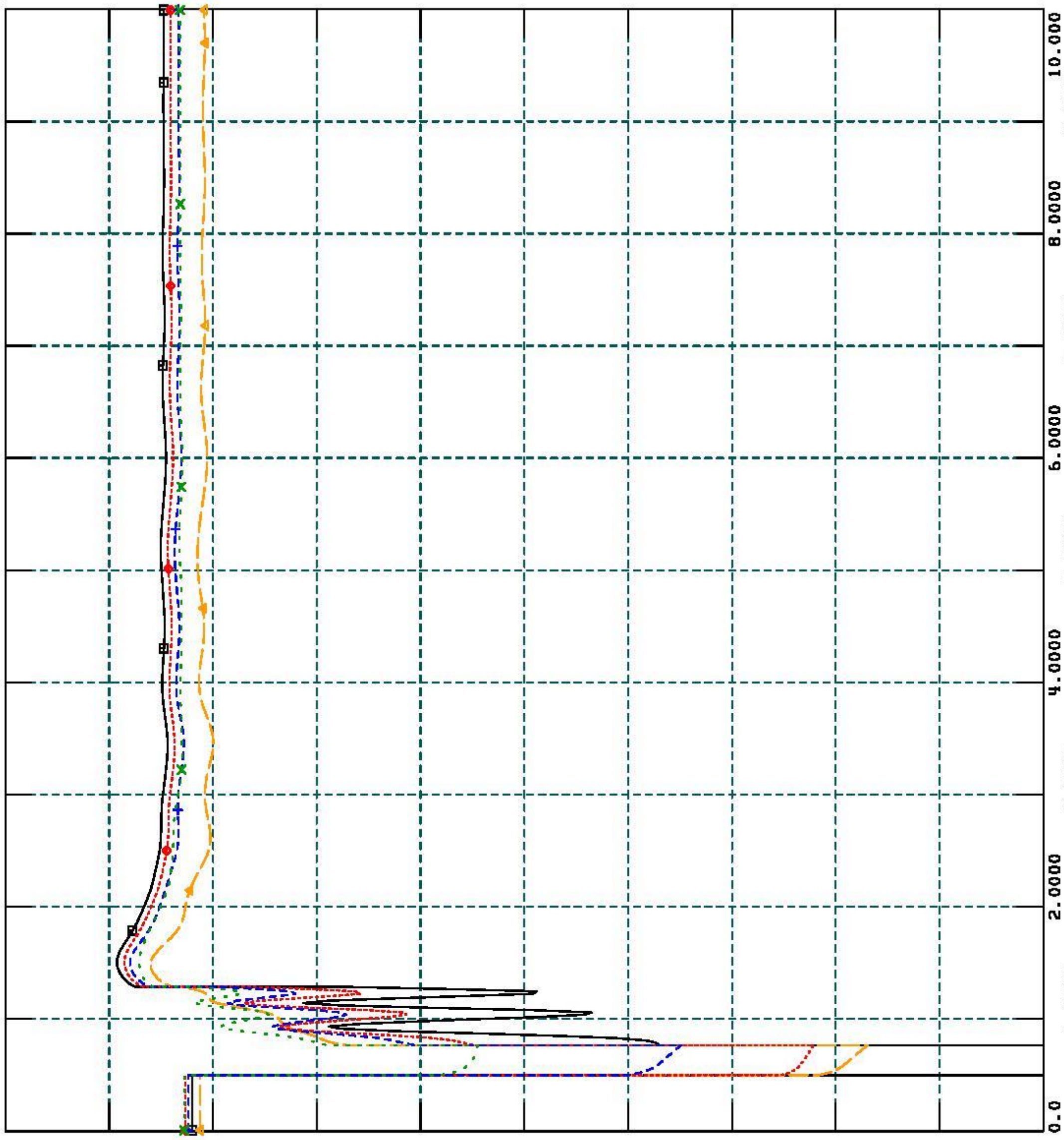


Appendix – Kyger Creek Dynamic Model Data

Generator Model - GENROU				
Kyger Creek	Unit 1		Unit 2 - 5	
	LP	HP	LP	HP
MVA base	100	117.7	95	123.4
T’d0	6	5.6	7.39	8.14
T”d0	0.04	0.033	0.041	0.033
T’q0	0.3	0.48	0.3	0.48
T”q0	0.08	0.079	0.082	0.079
H	9.9	2.86	10	3.17
D	0	0	0	0
Xd	1.16	1.34	1.36	1.293
Xq	1.11	1.29	1.11	1.29
X’d	0.25	0.19	0.263	0.138
X’q	0.41	0.322	0.406	0.322
X”d, X”q	0.17	0.145	0.184	0.09
Xl	0.09	0.085	0.085	0.085
S1.0	0.09	0.05	0.138	0.141
S1.2	0.58	0.45	0.514	0.579

Exciter Model												
Kyger Creek	Unit 1 – ESAC8B			Kyger Creek	Unit 2 – EXDC2		Unit 3 – EXDC2		Unit 4 – EXDC2		Unit 5 – EXDC2	
	LP	HP			LP	HP	LP	HP	LP	HP	LP	HP
TR (sec)	0	0		TR (sec)	0	0	0	0	0	0	0	0
KP	120	120		KA	706	706	242	505	807	807	404	656
KI	30	30		TA (sec)	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022
KD	30	30		TB (sec)	0	0	0	0	0	0	0	0
TD (sec)	0.01	0.01		TC (sec)	0	0	0	0	0	0	0	0
KA	1.2	0.973		VR MAX or zero	2.756	2.756	2.756	2.756	2.756	2.756	2.756	2.756
TA	0	0		VR MIN	-2.76	-2.76	-2.76	-2.76	-2.76	-2.76	-2.76	-2.76
VR MAX or zero	11.2	9.1		KE or zero	0	0	0	0	0	0	0	0
VR MIN	0	0		TE (>0)(sec)	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
TE > 0 (sec)	0.656	0.65		KF	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027
KE or zero	0	0		TF1 (>0)(sec)	1.19	1.19	1.19	1.19	1.19	1.19	1.19	1.19
E1	2.574	2.597		Switch, value = 0	0	0	0	0	0	0	0	0
SE(E1)	0.09	0.089		E1	2.657	2.657	2.657	2.657	2.657	2.657	2.657	2.657
E2	3.432	3.462		SE (E1)	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22
SE(E2)	0.35	0.347		E2	3.543	3.543	3.543	3.543	3.543	3.543	3.543	3.543
				SE (E2)	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95

Turbine Governor Model - IEEEG1		
Kyger Creek	Unit 1	Unit 2 - 5
K	19.9	20.393
T1	0	0
T2	0	0
T3 (> 0)	0.3	0.1
Uo	0.1	0.1
Uc (< 0.)	-0.1	-0.1
PMAX	1.79	1.82
PMIN	0	0
T4	0.53	0.1
K1	0.27	0.27
K2	0	0
T5	3.6	3.6
K3	0.36	0.36
K4	0.37	0.37
T6	0	0
K5	0	0
K6	0	0
T7	0	0
K7	0	0
K8	0	0

Compensator Model - COMP				
Kyger Creek	Unit 1		Units 2 - 5	
	LP	HP	LP	HP
Xe	0.063	0.083	0.058	0.073

Turbine Load Controller Model - LCFB1		
Kyger Creek	Unit 1	Units 2 - 5
Fb, Frequency bias gain(pu/pu)	n/a	0
Tpelec, Electrical power transducer time constant(sec)	n/a	0
db, Controller dead band(pu)	n/a	0.0006
emax, Maximum control error(pu)	n/a	0
Kp, Proportional gain	n/a	0
Ki, Integral gain	n/a	0
Irmax, Maximum turbine speed/load reference bias(pu)	n/a	0
fbf, Frequency bias flag	n/a	1
pbf, Power Controller flag	n/a	1

Appendix G

Ohio Valley Electric Corporation

Clifty Creek Plant

Stability Performance Study

Advanced Transmission Studies and Technologies

November 2018

AEP AMERICAN ELECTRIC POWER

AEP: America's Energy Partner℠

1. 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 NERC TPL-001-4 standard.

2. OVERVIEW OF GENERATION/TRANSMISSION FACILITIES

The generation capability at the Clifty Creek Plant is approximately 1188 MW (referenced in the 2017 series MMWG cases for the 2022 year) and is the sum of six similar units each providing approximately 198 MW.

This study is utilizing the MMWG dynamic cases for the 2022 year. Therefore the PJM baseline project b2832 (six-wiring of the Kyger Creek – Sporn 345kV circuits #1 and #2, converting into a single circuit) is already modeled and taken into account. All other OVEC transmission facilities remain unchanged regarding configuration.

3. TESTING CRITERIA

NERC TPL-001-4 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-001-4 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-001-4 Table 1.

P5 criteria is only applicable for non-redundant bus differential relays at 345kV OVEC facilities. All other 345kV protection at OVEC facilities have redundant relaying in place. Dearborn 345kV does have redundant bus differential relaying and can therefore also be excluded. A P5 bus fault involving the failure of non-redundant relaying at Kyger Creek or Clifty Creek stations results in the loss of all generating units at the respective station, so those scenarios were also excluded from the study. Delayed clearing for this situation is assumed to be 60.0 cycles from fault initiation.

A Type 2 stability extreme disturbance example at Clifty Creek is provided in the form a three phase fault on a Transmission circuit with a stuck breaker resulting in a delayed fault clearing. Delayed clearing for this situation is assumed to be 15.0 cycles from fault initiation.

For the purposes of post-fault transient voltage criteria required by TPL-001-4 R5, this study assumes that transient voltage dips at the transmission station above 70 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.

Uncontrolled islanding (system separation) is obvious when occurring in dynamic simulations. Facility loadings exceeding emergency ratings persisting after one stage of tripping of such facilities, or voltages persisting below emergency limits or UVLS set points following one stage of generator under-voltage tripping (per criterion above) or UVLS load removal (where applicable) are indicative of cascading or voltage instability, respectively.

4. <u>STUDY SCOPE and DATA</u>

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 which is such that outage of further transmission elements does not occur, thus making these disturbance scenarios less severe.

Base cases applied in this study were the 2017 series ERAG / MMWG 2022 Summer Peak Load and 2022 Spring Light Load cases in accordance with TPL-001-4 R2.4.1 and R2.4.2, respectively. A sensitivity case involving the Zimmer plant being out-of-service was studied for TPL-001-4 R2.4.3. The ERAG / MMWG dynamic base cases are developed based on coordinated topology amongst all members of Reliability First and all contingency events considered for analysis are therefore based on this topology in accordance with TPL-001-4 R4.4.1. All ERAG / MMWG dynamic base cases include modeling of automatic dynamic control devices relevant to the Clifty Creek area in accordance with TPL-001-4 R4.3.2. Dynamic modeling data for the Clifty Creek units can be found in the appendix. Updates were made to the Clifty Creek Units 1-6 governor model data including the addition of a load controller model per a NERC MOD-027 report issued March 2018. There are no proposed material generation additions or changes in the long-term transmission planning horizon in accordance with TPL-001-4 R2.5.

The Clifty Creek Plant was dispatched at its net capacity of 1188 MW unless otherwise indicated. The dispatch at nearby generating plants such as Trimble County (LGEE) were reviewed to ensure their dispatch was at net capacity. The Buckner (IPP) dispatch was modified to be at its net MW capacity.

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-001-4 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 60-cycle delayed fault clearing at the remote end of a line.

5. <u>STUDY RESULTS</u>

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 are all the same as far as their stability is concerned. The acceptable stability results from these cases in recognition of TPL-001-4 R4.1.1 and R4.1.2 indicate that less severe cases consistent with TPL-001-4 criteria would also have acceptable stability. Per R4.1.3, all simulations conducted indicate that power swing damping is within the established 3 percent damping ratio criterion.

For TPL-001-4 R4.3.1.2, the assumed generator low voltage ride through capability threshold is 85 percent. Post disturbance generator voltage remained above this threshold for all simulations. Also for R4.3.1.3, no generic or actual relay operations were caused by transient power swings during the simulations.

With respect to the previously mentioned transient voltage criteria for TPL-001-4 R5, all simulations show that voltage recovery is to at least 70 percent within the 2.5 seconds following a fault clearing event.

Plots of the light load dynamic simulation cases involving three-phase faults are attached below.

6. CONCLUSION

The Clifty Creek Plant exhibits acceptable stability performance under all credible contingencies consistent with NERC TPL-001-4 without a need for generation curtailment.

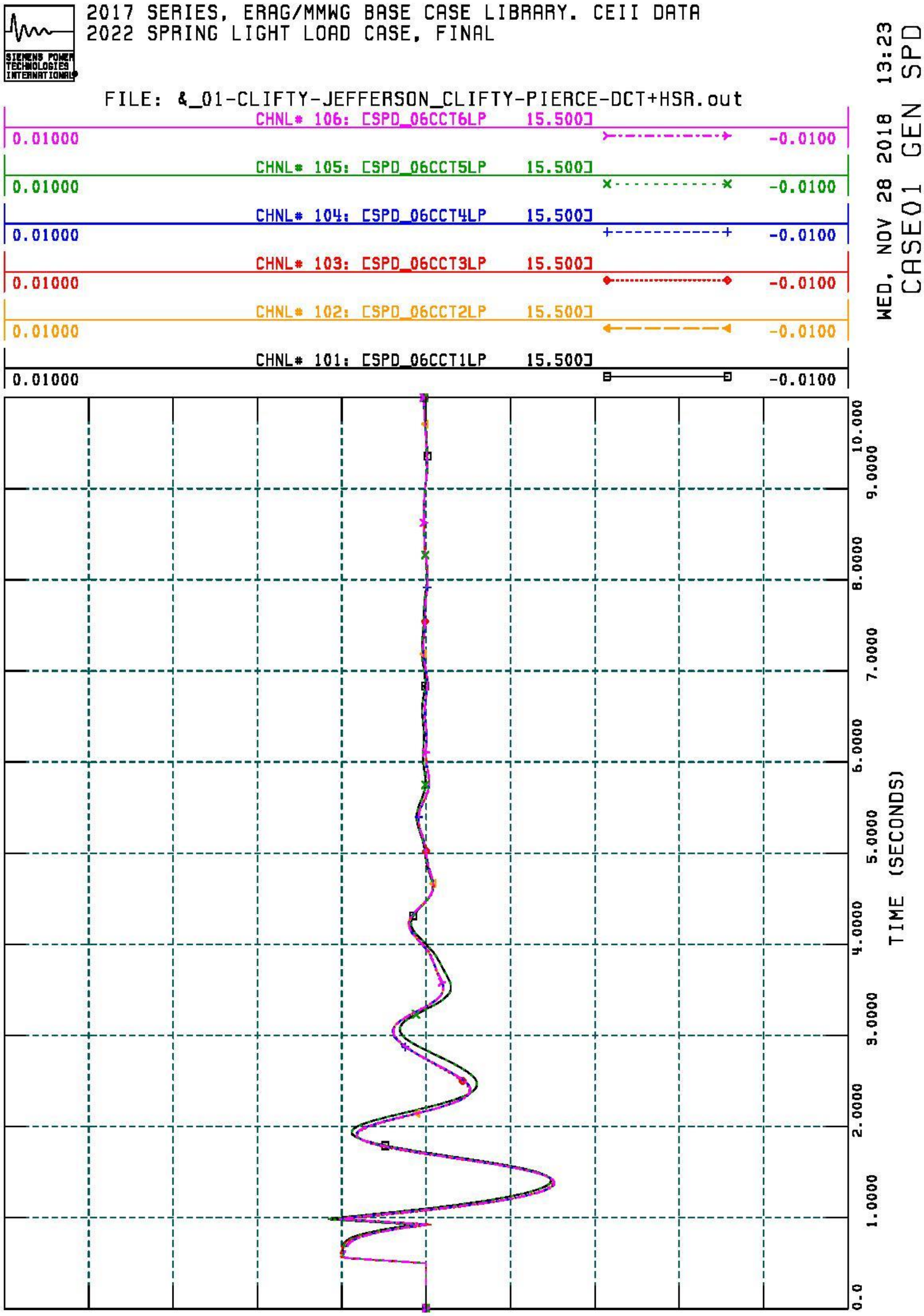
Table 1 – Clifty Creek Plant Stability Study Cases

	Prior Outage	**Outaged Facility**	**NERC Category**	**Fault Type**	**Result**
***Case 1**	Clifty Creek – Jefferson 345 kV	Clifty Creek – Pierce 345 kV DCT	P6/P7/ Extreme Type1	3 Phase w/ unsuccessful HSR	Stable
***Case 2**	Clifty Creek – Jefferson 345 kV	Clifty Creek – Dearborn 345 kV DCT	P6/P7/ Extreme Type1	3 Phase w/ unsuccessful HSR	Stable
***Case 3**	Clifty Creek – Jefferson 345 kV	Clifty Creek 345/138kV TRF	P6/ Extreme Type1	3 Phase w/ unsuccessful HSR	Stable
***Case 4**	Clifty Creek – Jefferson 345 kV	Clifty Creek – Trimble Co 345 kV	P6/ Extreme Type1	3 Phase No HSR	Stable
***Case 5**	Clifty Creek – Jefferson 345 kV	Buckner – Middletown 345 kV DCT	P6/P7/ Extreme Type1	3 Phase No HSR	Stable
***Case 6**	Clifty Creek – Trimble Co 345 kV	Clifty Creek – Pierce 345 kV DCT	P6/P7/ Extreme Type1	3 Phase w/ unsuccessful HSR	Stable
***Case 7**	Clifty Creek – Trimble Co 345 kV	Clifty Creek – Dearborn 345 kV DCT	P6/P7/ Extreme Type1	3 Phase w/ unsuccessful HSR	Stable

***Case 8**	Clifty Creek – Trimble Co 345 kV	Clifty Creek 345/138kV TRF	P6/ Extreme Type1	3 Phase w/ unsuccessful HSR	Stable
***Case 9**	Clifty Creek – Dearborn 345 kV DCT	Clifty Creek – Pierce 345 kV DCT	P6/P7/ Extreme Type1	3 Phase w/ unsuccessful HSR	Stable
***Case 10**	Clifty Creek 345/138kV TRF	Clifty Creek – Dearborn 345 kV DCT	P6/P7/ Extreme Type1	3 Phase w/ unsuccessful HSR	Stable
***Case 11**	Clifty Creek 345/138kV TRF	Clifty Creek – Pierce 345 kV DCT	P6/P7/ Extreme Type1	3 Phase w/ unsuccessful HSR	Stable
***Case 12**	Buckner – Middleton 345 kV	Clifty Creek – Pierce 345 kV DCT	P6/P7/ Extreme Type1	3 Phase w/ unsuccessful HSR	Stable
****Case 13**	None	Pierce 345kV Bus #1 Pierce 345/138kV Trf 17 Pierce – Buffington 345kV Dearborn – Pierce 345kV Clifty Creek – Pierce 345kV #1 and #2	P5	Single Phase	Stable
****Case 14**	None	Pierce 345kV Bus #2 Pierce 345/138kV Trf 18 Kyger Creek – Pierce 345kV Pierce – X530 345kV #1 and #2	P5	Single Phase	Stable

****Case 15**	None	X530 345kV Bus #21 Don Marquis – X530 345kV Pierce – X530 345kV #1 and #2 Kyger Creek – X530 345kV #1 and #2	P5	Single Phase	Stable
*****Case 16**	None	Clifty Creek – Buffington 345 kV	Extreme Type 2	3 Phase w/ Delay	Stable

* All of the prior outage cases listed above are not followed by any system adjustments and so also qualify as Type 1 stability extreme disturbances in TPL-001-4 Table 1.
** Cases 13-15 refer to non-redundant bus differential relay failures during a bus fault at Pierce and X530 stations. Bus differential relays at Kyger Creek and Clifty Creek are also non-redundant, but a similar P5 would result in loss of all units at those stations.
*** Case 16; To test an Extreme Type 2 scenario, a three phase fault on the Clifty Creek – Buffington 345 kV plus a stuck breaker at Clifty Creek 345kV CB ‘G’ was studied. Under this scenario the high pressure turbines at Clifty Creek become unstable and as result all Clifty Creek units were tripped offline. The system becomes stable after the tripping of the Clifty Creek units.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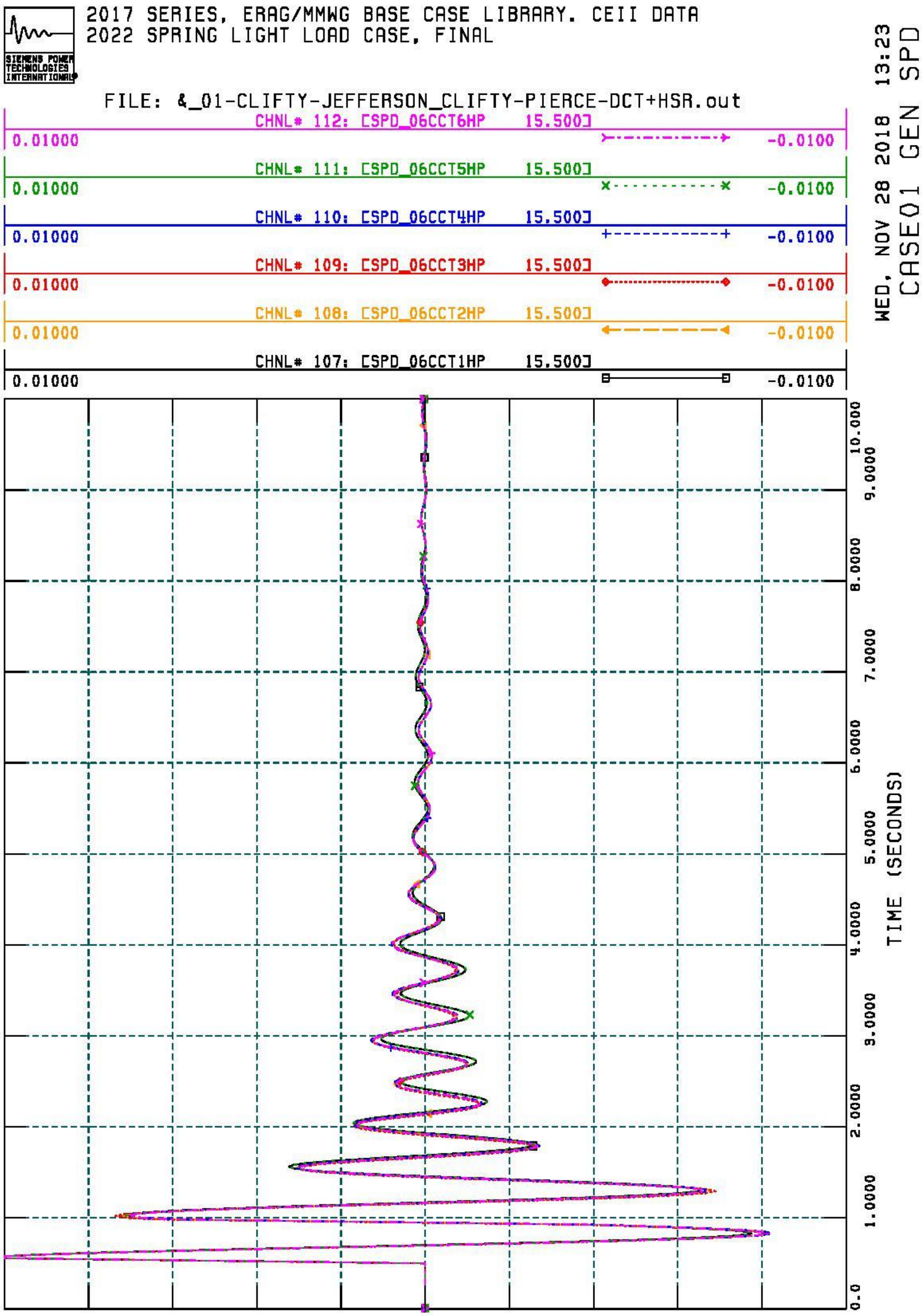
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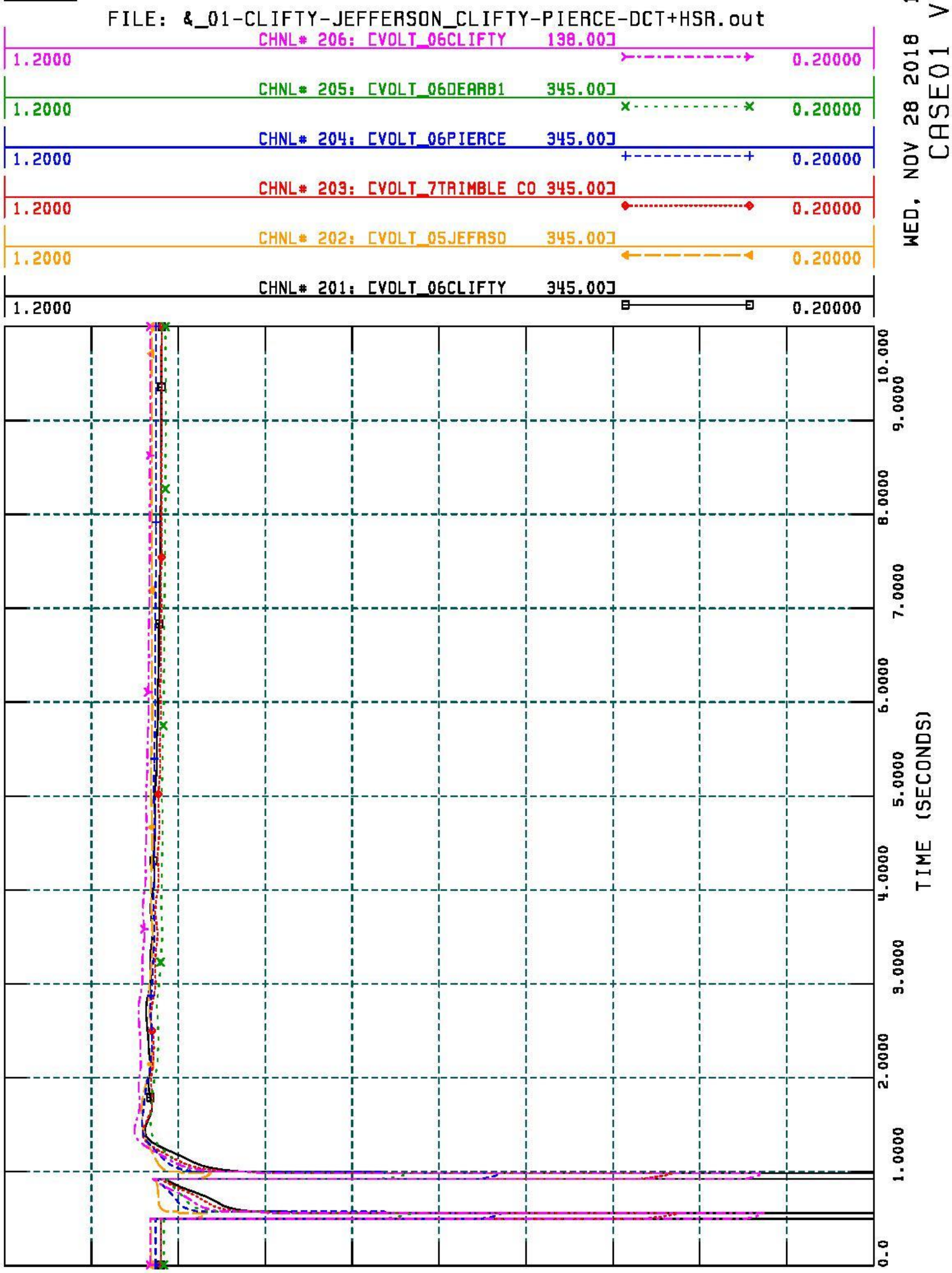
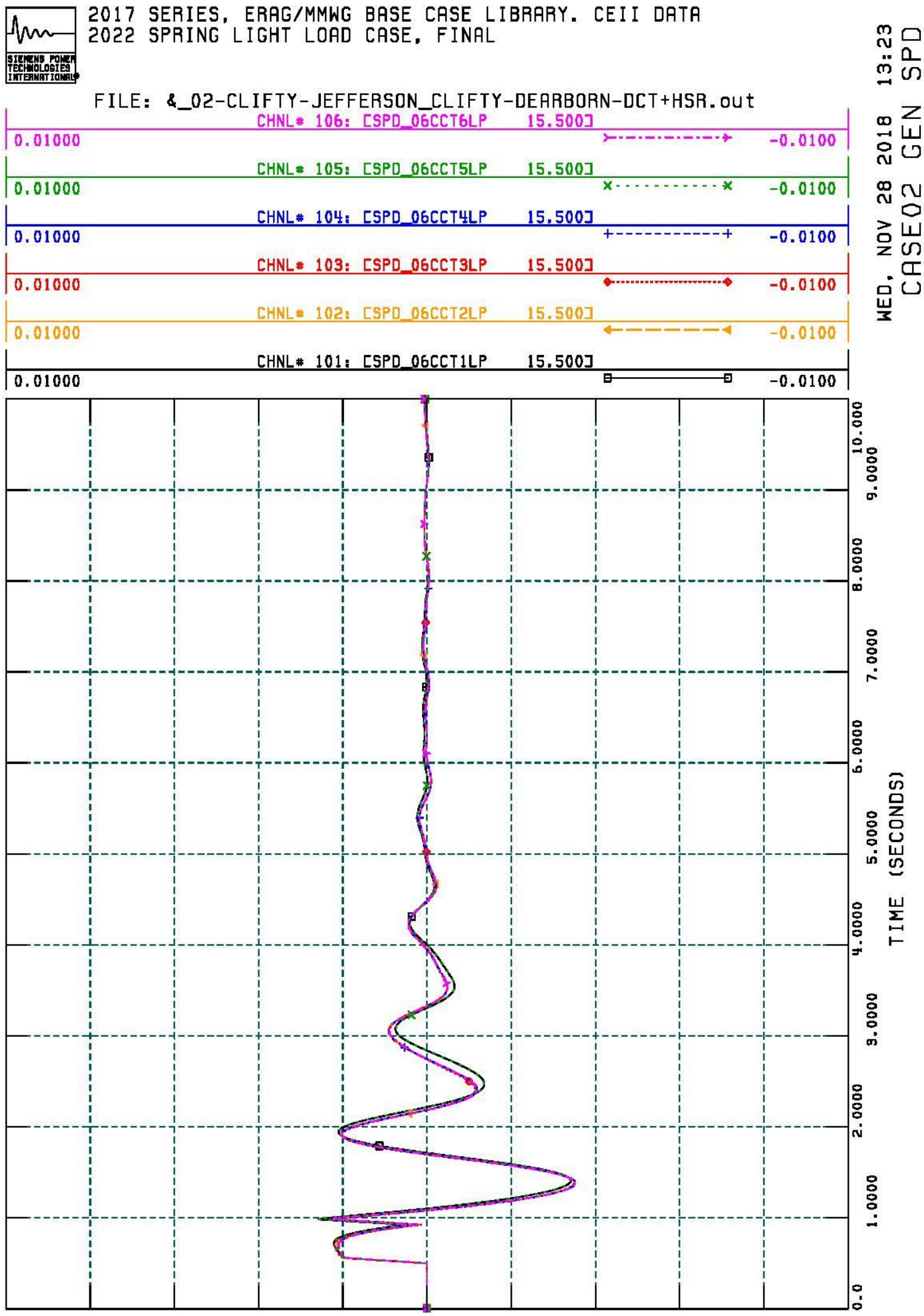
CASE01 GEN SPD

2017 SERIES, ERAG/MMWG BASE CASE LIBRARY. CEII DATA
2022 SPRING LIGHT LOAD CASE, FINAL

FILE: &_01-CLIFTY-JEFFERSON_CLIFTY-PIERCE-DCT+HSR.out




2017 SERIES, ERAG/MMWG BASE CASE LIBRARY. CEII DATA
2022 SPRING LIGHT LOAD CASE, FINAL
SIEMENS POWER TECHNOLOGIES INTERNATIONAL
FILE: &_02-CLIFTY-JEFFERSON_CLIFTY-DEARBORN-DCT+HSR.out
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-0.0100
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-0.0100
CHNL# 103: [SPD_06CCT3LP 15.500]
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CHNL# 102: [SPD_06CCT2LP 15.500]
0.01000
-0.0100
CHNL# 101: [SPD_06CCT1LP 15.500]
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-0.0100
WED, NOV 28 2018 13:23
CASE02 GEN SPD
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5.0000
6.0000
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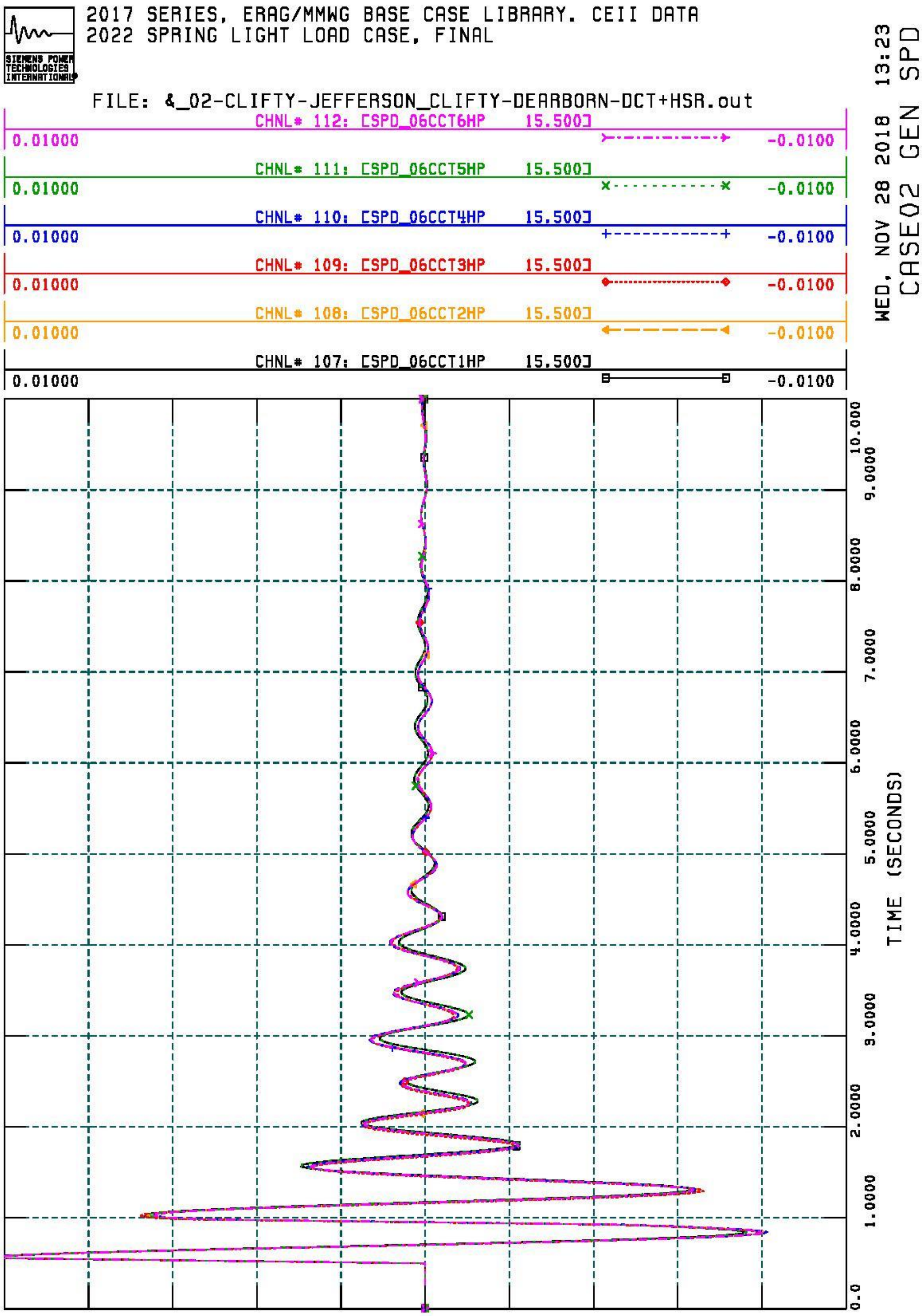
8.0000
9.0000
10.000
TIME (SECONDS)


2017 SERIES, ERAG/MMWG BASE CASE LIBRARY. CEII DATA
2022 SPRING LIGHT LOAD CASE, FINAL
SIEMENS POWER TECHNOLOGIES INTERNATIONAL
FILE: &_02-CLIFTY-JEFFERSON_CLIFTY-DEARBORN-DCT+HSR.out
CHNL# 112: [SPD_06CCT6HP 15.500]
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0.01000
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CHNL# 107: [SPD_06CCT1HP 15.500]
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-0.0100
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1.0000
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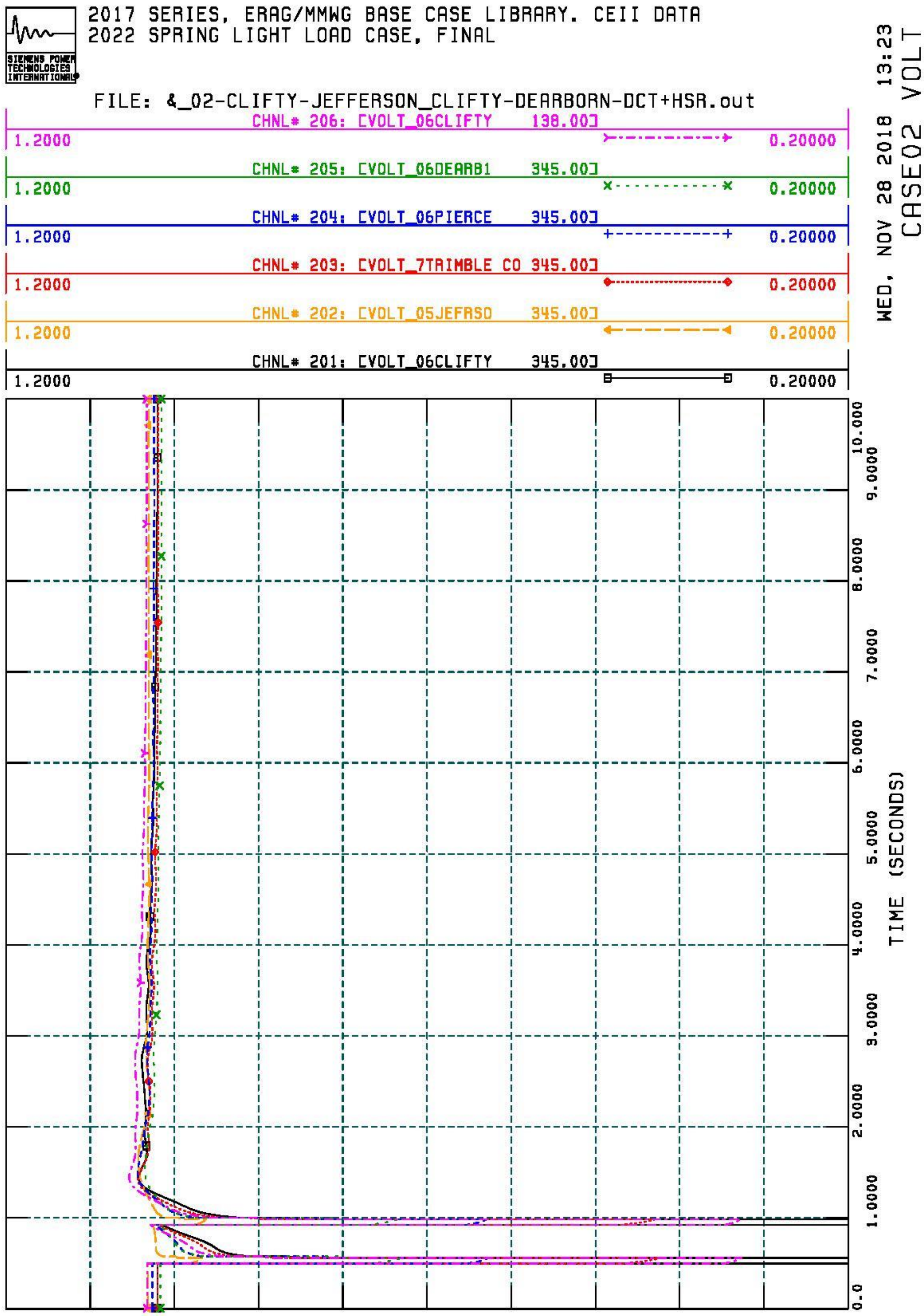
TIME (SECONDS)
WED, NOV 28 2018 13:23
CASE02 GEN SPD



2017 SERIES, ERAG/MMWG BASE CASE LIBRARY. CEII DATA
2022 SPRING LIGHT LOAD CASE, FINAL
SIEMENS POWER TECHNOLOGIES INTERNATIONAL
FILE: &_02-CLIFTY-JEFFERSON_CLIFTY-DEARBORN-DCT+HSR.out
CHNL# 206: [VOLT_06CLIFTY 138.00]
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1.2000
0.20000
CHNL# 204: [VOLT_06PIERCE 345.00]
1.2000
0.20000
CHNL# 203: [VOLT_7TRIMBLE CO 345.00]
1.2000
0.20000
CHNL# 202: [VOLT_05JEFRSD 345.00]
1.2000
0.20000
CHNL# 201: [VOLT_06CLIFTY 345.00]
1.2000
0.20000
WED, NOV 28 2018 13:23
CASE02 VOLT
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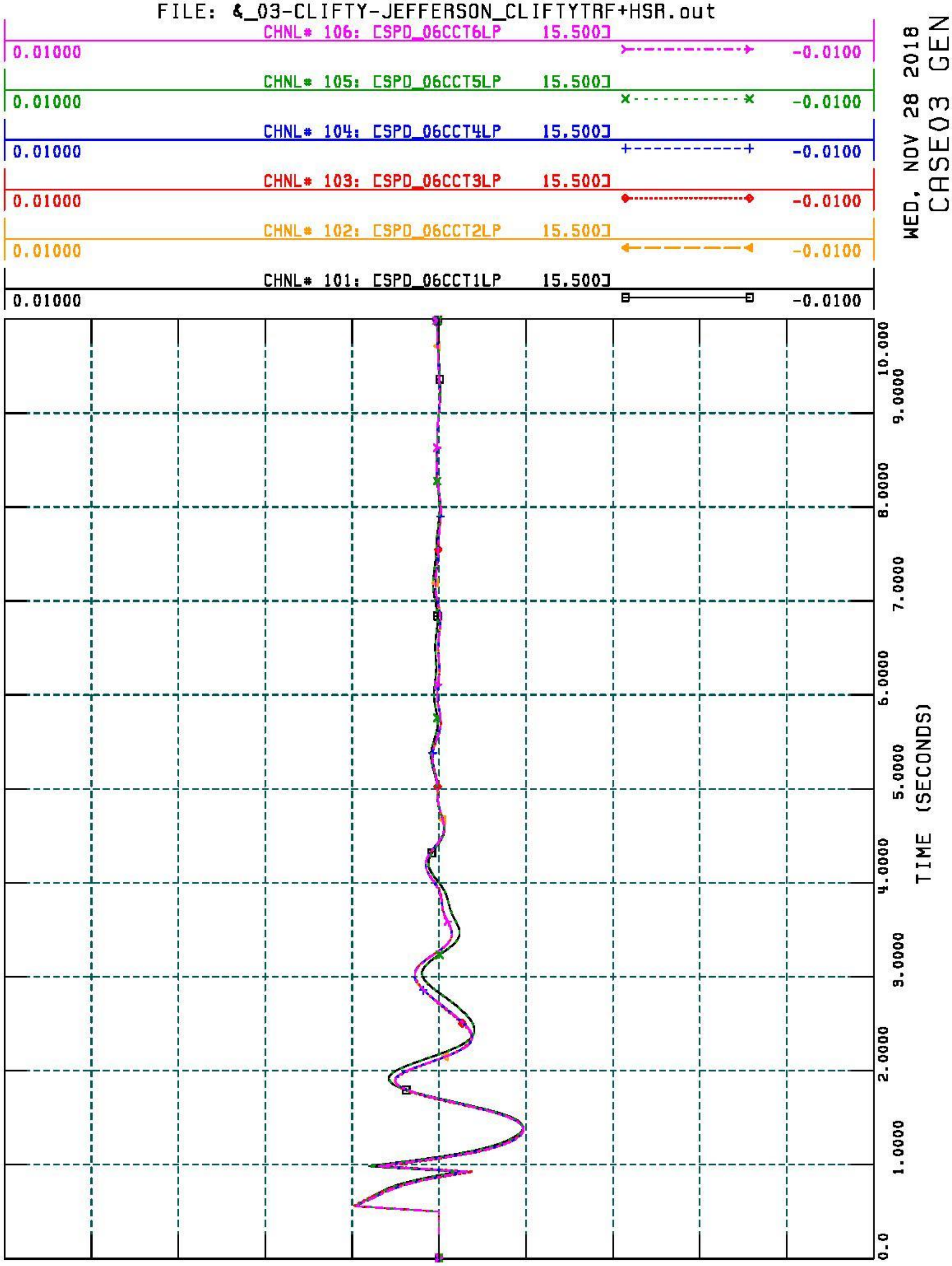
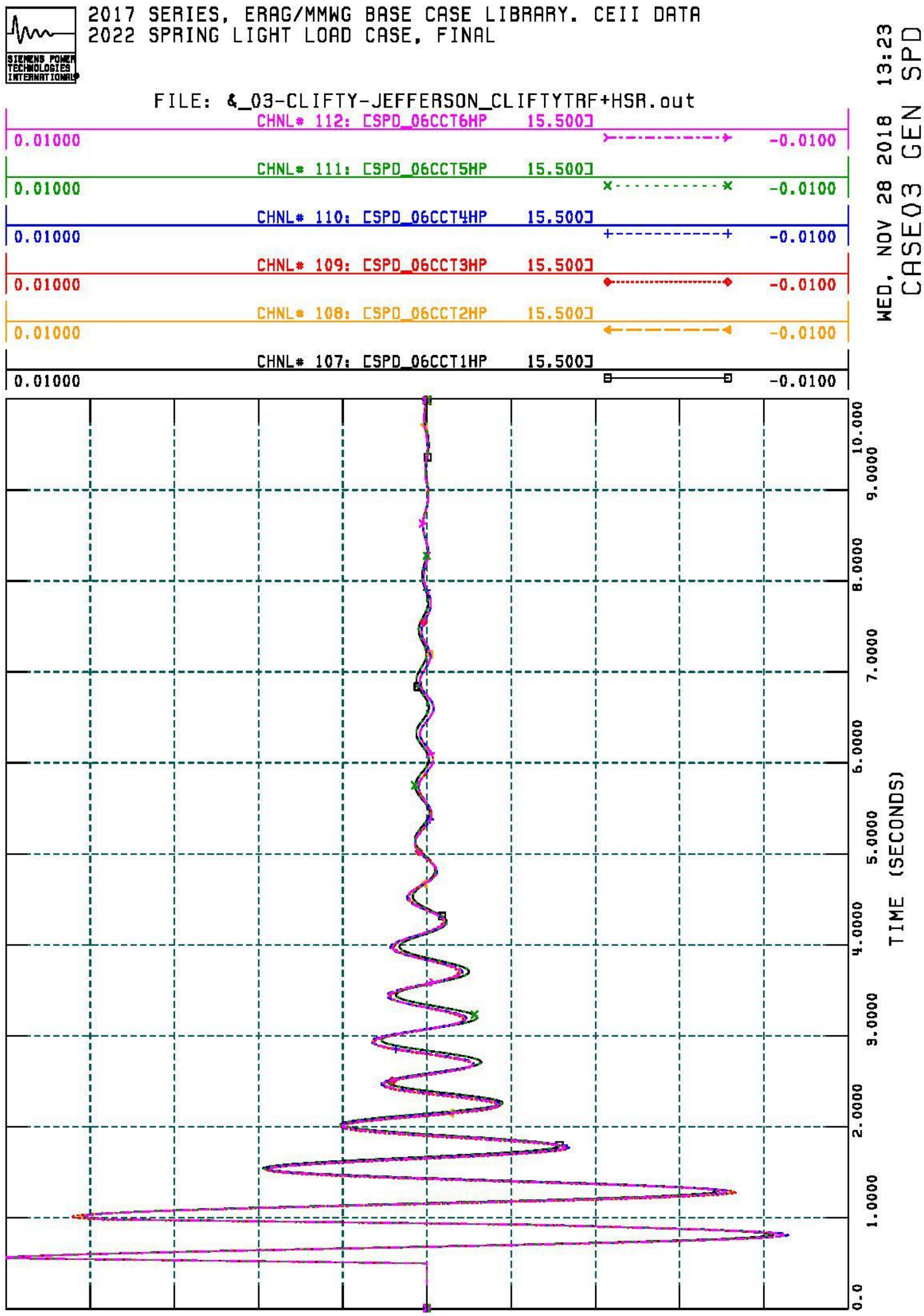
2.0000
3.0000
4.0000
5.0000
6.0000
7.0000
8.0000
9.0000
10.000
TIME (SECONDS)

2017 SERIES, ERAG/MMWG BASE CASE LIBRARY. CEII DATA
2022 SPRING LIGHT LOAD CASE, FINAL

WED, NOV 28 2018 13:23
CASE03 GEN SPD

FILE: &_03-CLIFTY-JEFFERSON_CLIFTYTRF+HSR.out




2017 SERIES, ERAG/MMWG BASE CASE LIBRARY. CEII DATA
2022 SPRING LIGHT LOAD CASE, FINAL
SIEMENS POWER TECHNOLOGIES INTERNATIONAL
FILE: &_03-CLIFTY-JEFFERSON_CLIFTYTRF+HSR.out
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CHNL# 108: [SPD_06CCT2HP 15.500]
0.01000
-0.0100
CHNL# 107: [SPD_06CCT1HP 15.500]
0.01000
-0.0100
WED, NOV 28 2018 13:23
CASE03 GEN SPD
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4.0000
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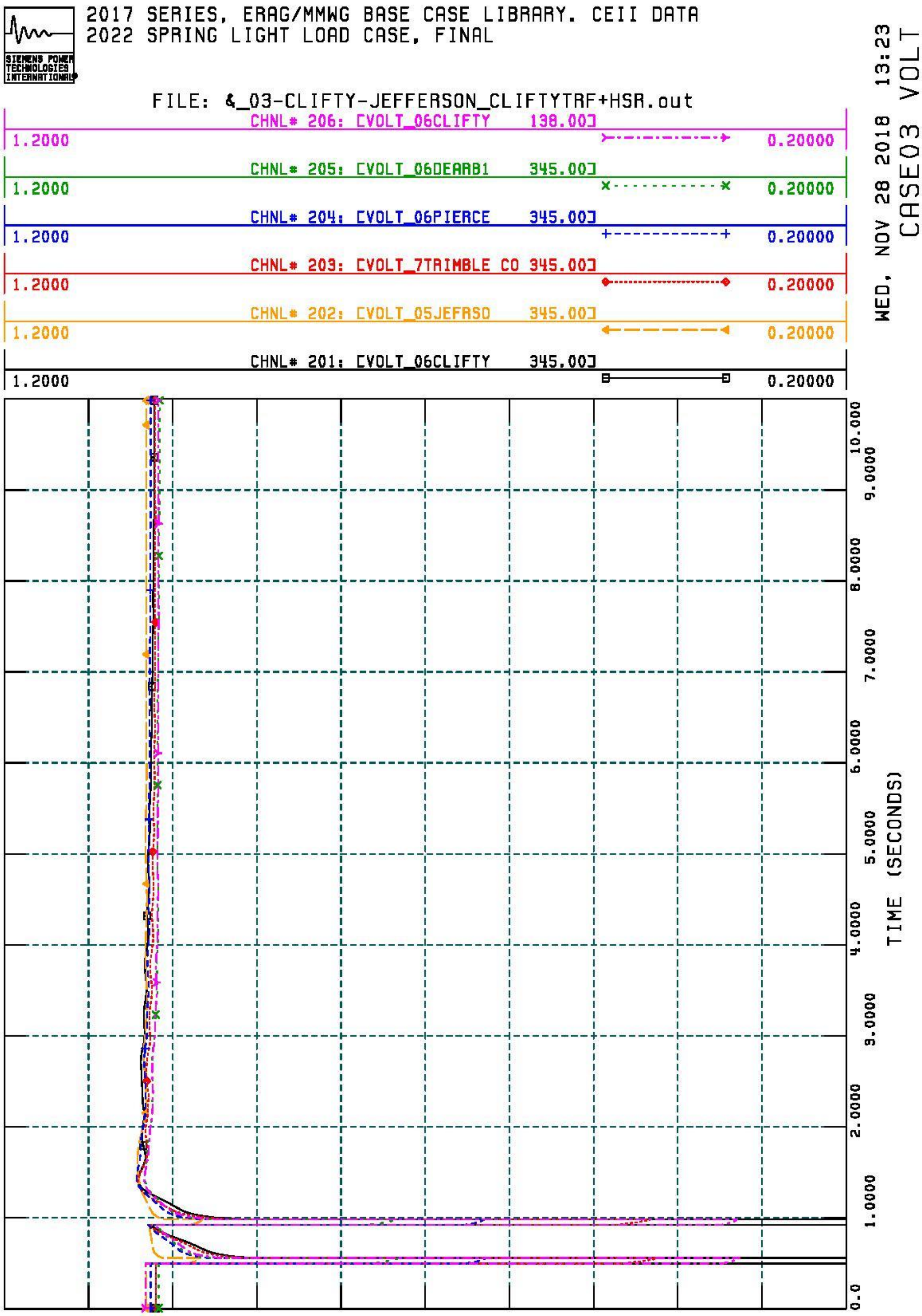
10.000
TIME (SECONDS)


2017 SERIES, ERAG/MMWG BASE CASE LIBRARY. CEII DATA
2022 SPRING LIGHT LOAD CASE, FINAL
SIEMENS POWER TECHNOLOGIES INTERNATIONAL
FILE: &_03-CLIFTY-JEFFERSON_CLIFTYTRF+HSR.out
CHNL# 206: [VOLT_06CLIFTY 138.00]
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CHNL# 205: [VOLT_06DEARB1 345.00]
1.2000
0.20000
CHNL# 204: [VOLT_06PIERCE 345.00]
1.2000
0.20000
CHNL# 203: [VOLT_7TRIMBLE CO 345.00]
1.2000
0.20000
CHNL# 202: [VOLT_05JEFRSD 345.00]
1.2000
0.20000
CHNL# 201: [VOLT_06CLIFTY 345.00]
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WED, NOV 28 2018 13:23
CASE03 VOLT
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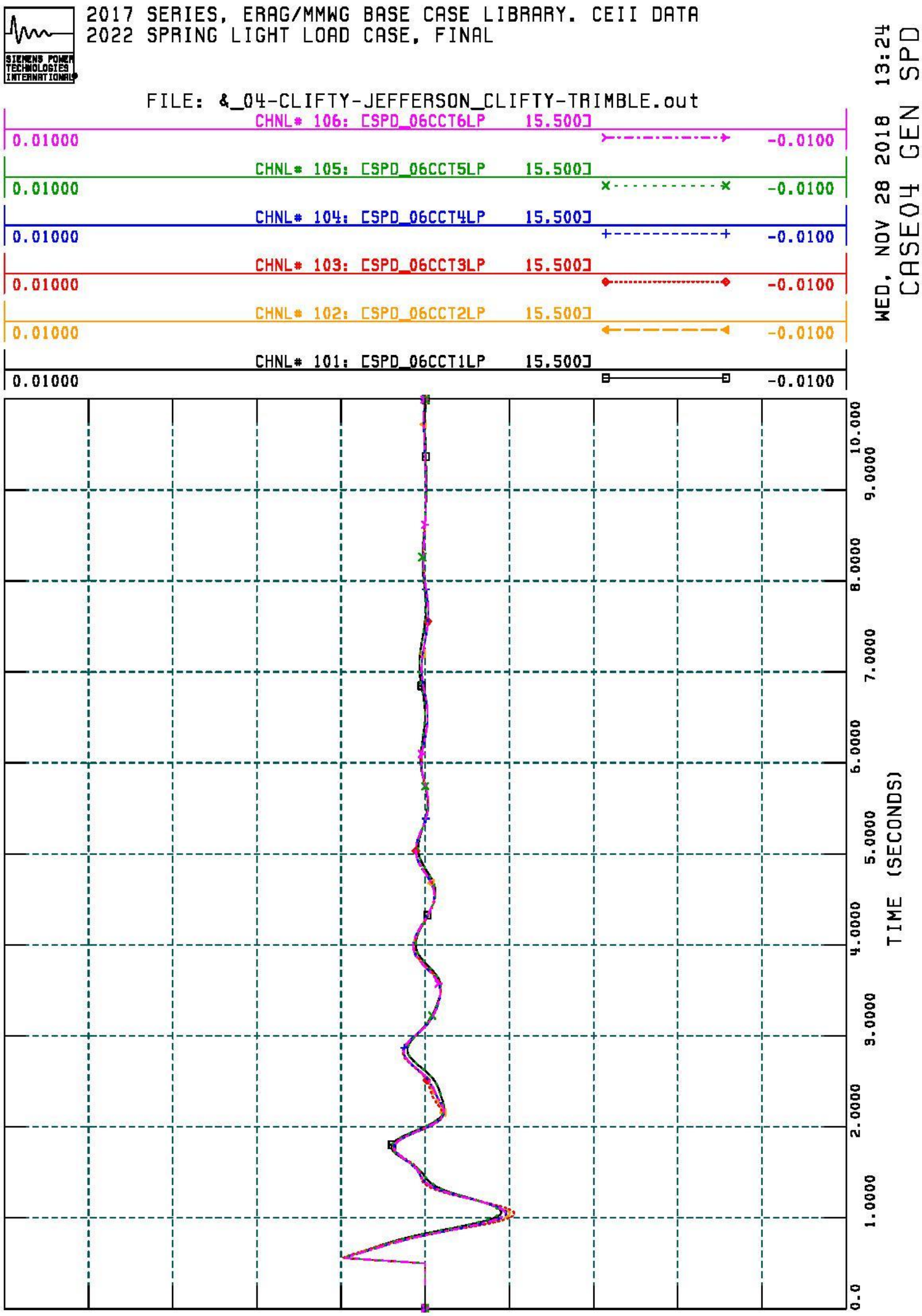
10.000
TIME (SECONDS)



2017 SERIES, ERAG/MMWG BASE CASE LIBRARY. CEII DATA
2022 SPRING LIGHT LOAD CASE, FINAL
SIEMENS POWER TECHNOLOGIES INTERNATIONAL
FILE: &_04-CLIFTY-JEFFERSON_CLIFTY-TRIMBLE.out
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CHNL# 104: [SPD_06CCT4LP 15.500]
0.01000 -0.0100
CHNL# 103: [SPD_06CCT3LP 15.500]
0.01000 -0.0100
CHNL# 102: [SPD_06CCT2LP 15.500]
0.01000 -0.0100
CHNL# 101: [SPD_06CCT1LP 15.500]
0.01000 -0.0100
WED, NOV 28 2018 13:24
CASE04 GEN SPD
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4.0000
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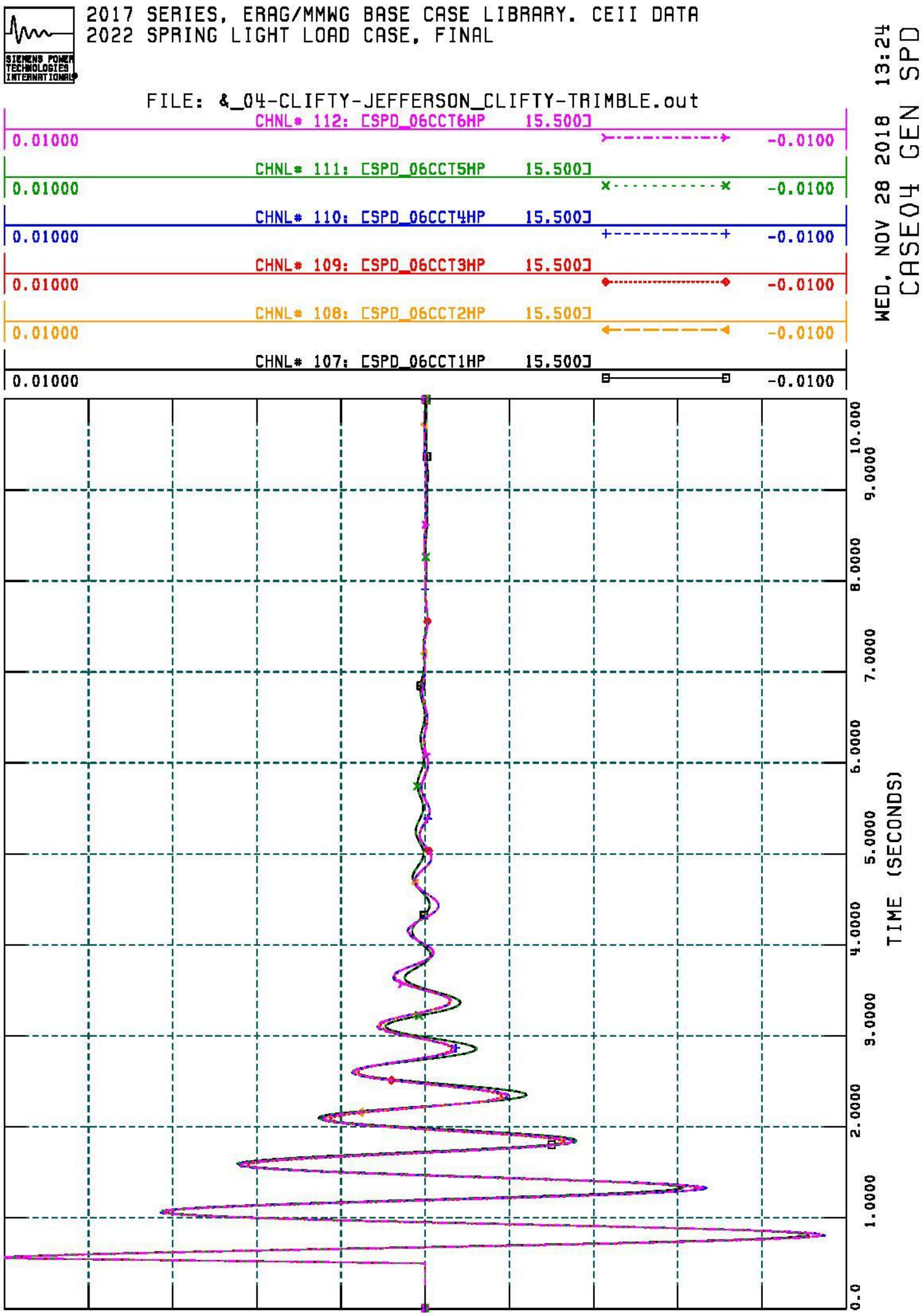
10.000
TIME (SECONDS)


2017 SERIES, ERAG/MMWG BASE CASE LIBRARY. CEII DATA
2022 SPRING LIGHT LOAD CASE, FINAL
SIEMENS POWER TECHNOLOGIES INTERNATIONAL
FILE: &_04-CLIFTY-JEFFERSON_CLIFTY-TRIMBLE.out
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CHNL# 110: [SPD_06CCT4HP 15.500]
0.01000 -0.0100
CHNL# 109: [SPD_06CCT3HP 15.500]
0.01000 -0.0100
CHNL# 108: [SPD_06CCT2HP 15.500]
0.01000 -0.0100
CHNL# 107: [SPD_06CCT1HP 15.500]
0.01000 -0.0100
WED, NOV 28 2018 13:24
CASE04 GEN SPD
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3.0000
4.0000
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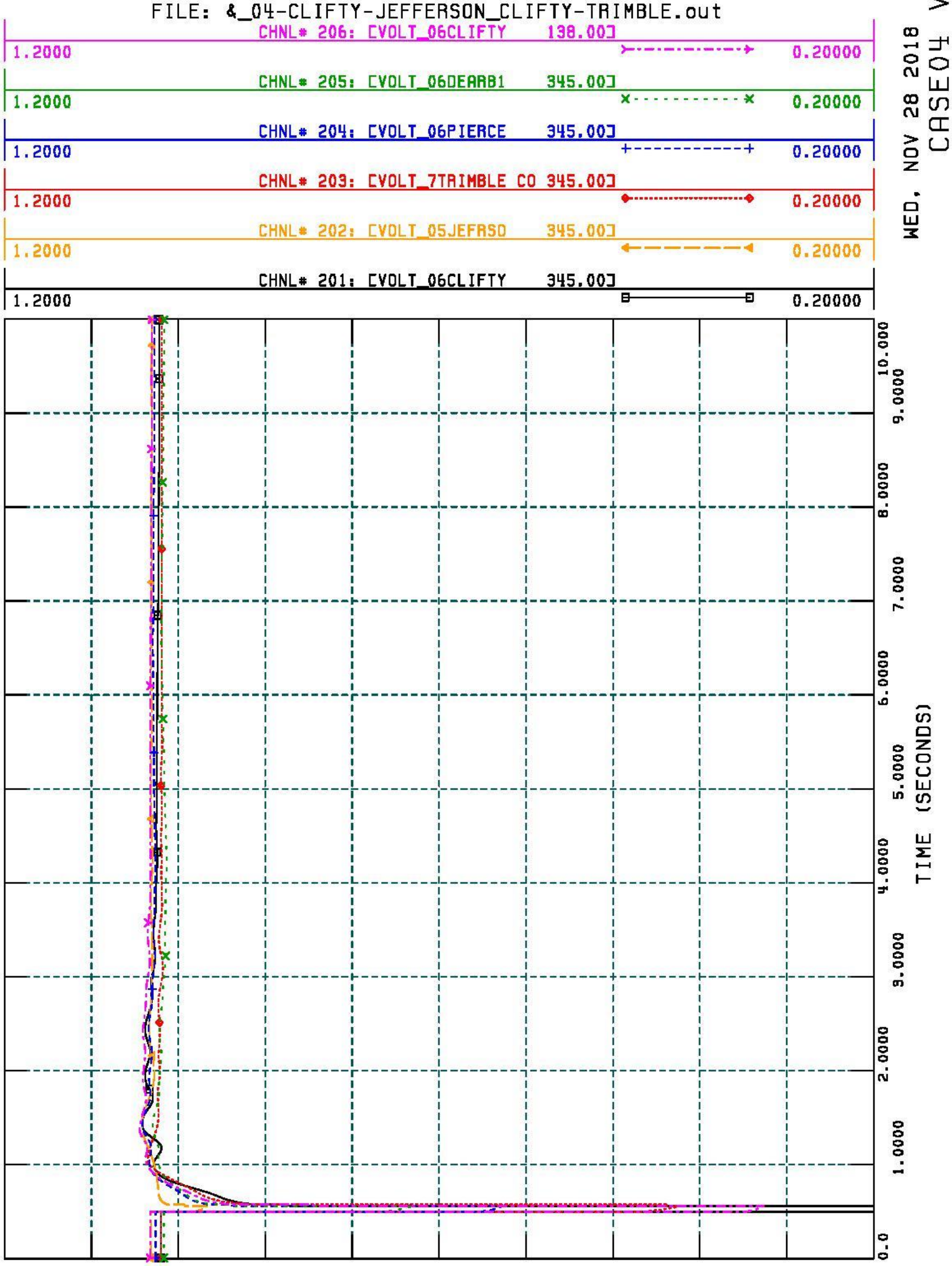
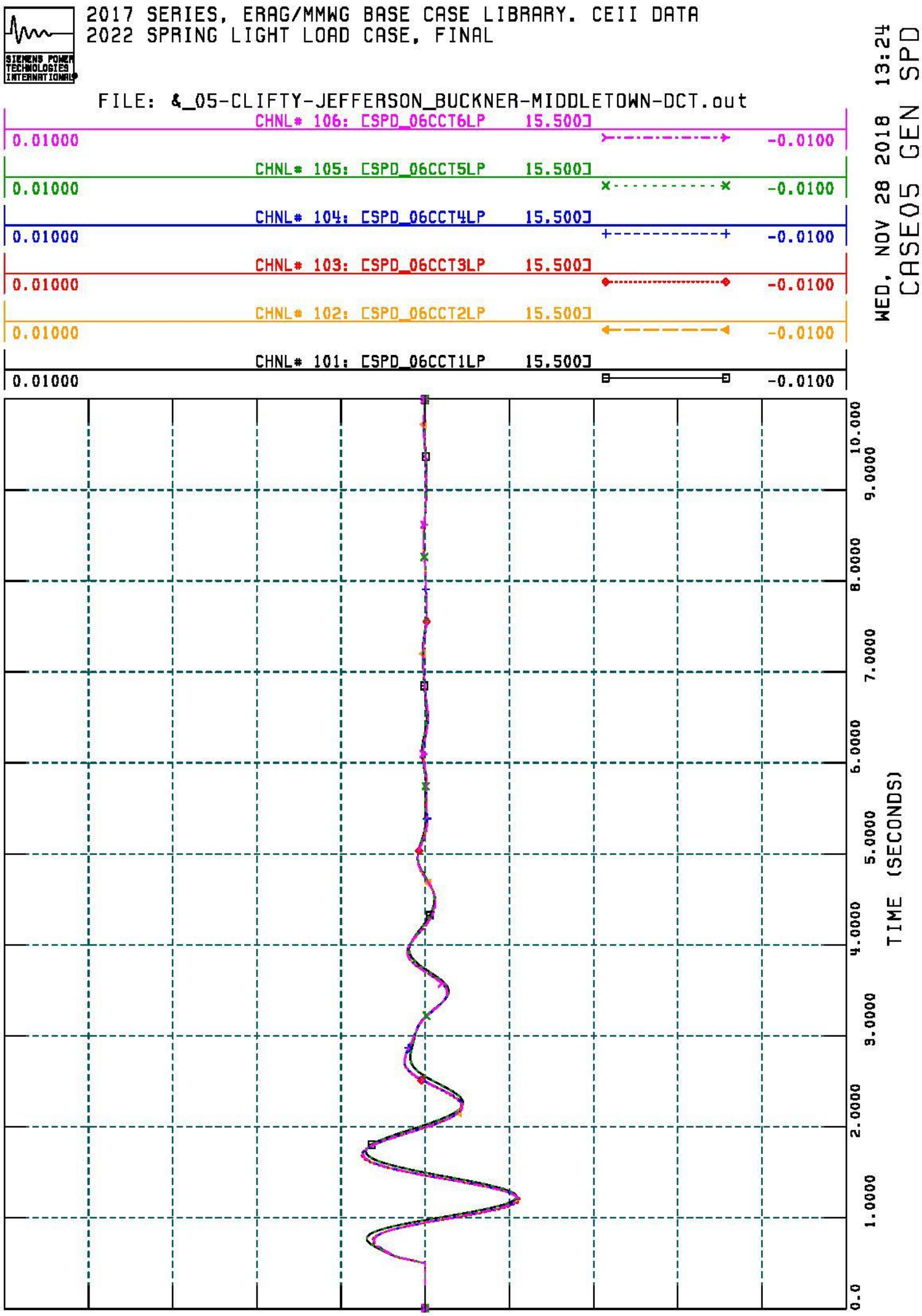
TIME (SECONDS)

2017 SERIES, ERAG/MMWG BASE CASE LIBRARY. CEII DATA
2022 SPRING LIGHT LOAD CASE, FINAL

FILE: &_04-CLIFTY-JEFFERSON_CLIFTY-TRIMBLE.out




SIEMENS POWER TECHNOLOGIES INTERNATIONAL
2017 SERIES, ERAG/MMWG BASE CASE LIBRARY. CEII DATA
2022 SPRING LIGHT LOAD CASE, FINAL
FILE: &_05-CLIFTY-JEFFERSON_BUCKNER-MIDDLETOWN-DCT.out
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CHNL# 104: [SPD_06CCT4LP 15.500]
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-0.0100
CHNL# 103: [SPD_06CCT3LP 15.500]
0.01000
-0.0100
CHNL# 102: [SPD_06CCT2LP 15.500]
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-0.0100
CHNL# 101: [SPD_06CCT1LP 15.500]
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-0.0100
WED, NOV 28 2018 13:24
CASE05 GEN SPD
TIME (SECONDS)
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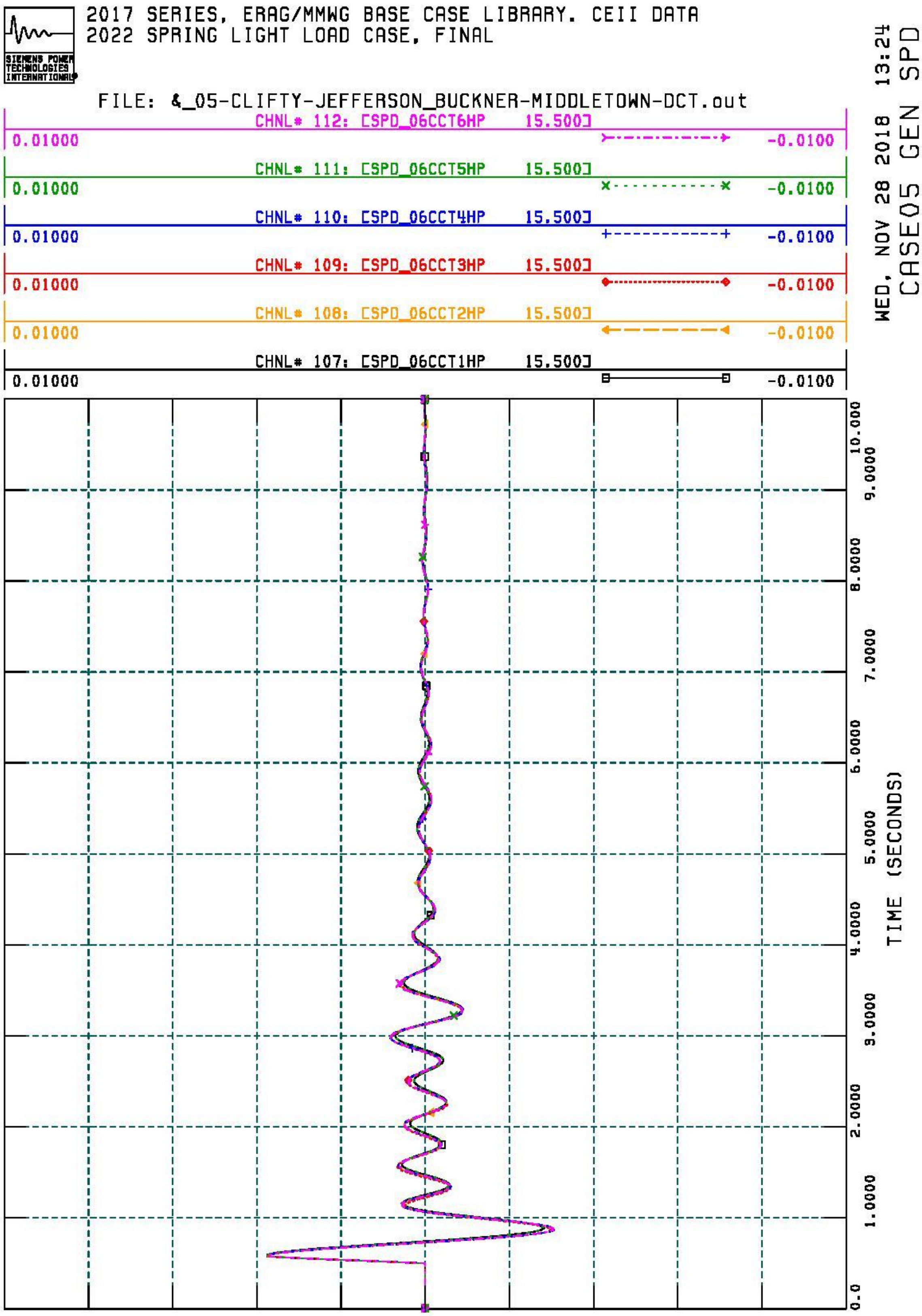
SIEMENS POWER TECHNOLOGIES INTERNATIONAL
2017 SERIES, ERAG/MMWG BASE CASE LIBRARY. CEII DATA
2022 SPRING LIGHT LOAD CASE, FINAL
FILE: &_05-CLIFTY-JEFFERSON_BUCKNER-MIDDLETOWN-DCT.out
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CHNL# 110: [SPD_06CCT4HP 15.500]
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CHNL# 109: [SPD_06CCT3HP 15.500]
0.01000
-0.0100
CHNL# 108: [SPD_06CCT2HP 15.500]
0.01000
-0.0100
CHNL# 107: [SPD_06CCT1HP 15.500]
0.01000
-0.0100
WED, NOV 28 2018 13:24
CASE05 GEN SPD
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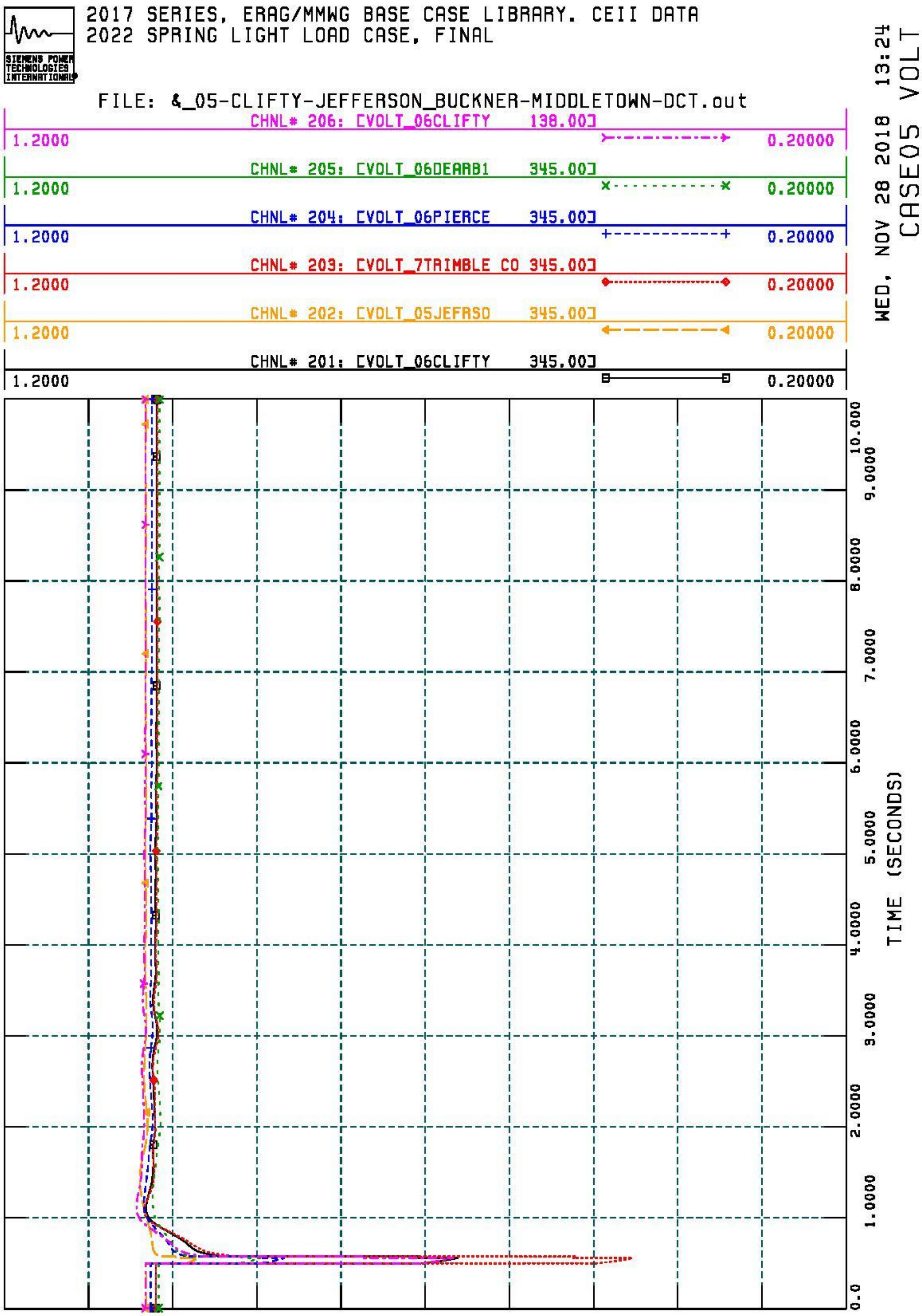
TIME (SECONDS)



2017 SERIES, ERAG/MMWG BASE CASE LIBRARY. CEII DATA
2022 SPRING LIGHT LOAD CASE, FINAL
SIEMENS POWER TECHNOLOGIES INTERNATIONAL
FILE: &_05-CLIFTY-JEFFERSON_BUCKNER-MIDDLETOWN-DCT.out
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CHNL# 205: [VOLT_06DEARB1 345.00]
1.2000
0.20000
CHNL# 204: [VOLT_06PIERCE 345.00]
1.2000
0.20000
CHNL# 203: [VOLT_7TRIMBLE CO 345.00]
1.2000
0.20000
CHNL# 202: [VOLT_05JEFRSO 345.00]
1.2000
0.20000
CHNL# 201: [VOLT_06CLIFTY 345.00]
1.2000
0.20000
WED, NOV 28 2018 13:24
CASE05 VOLT
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8.0000
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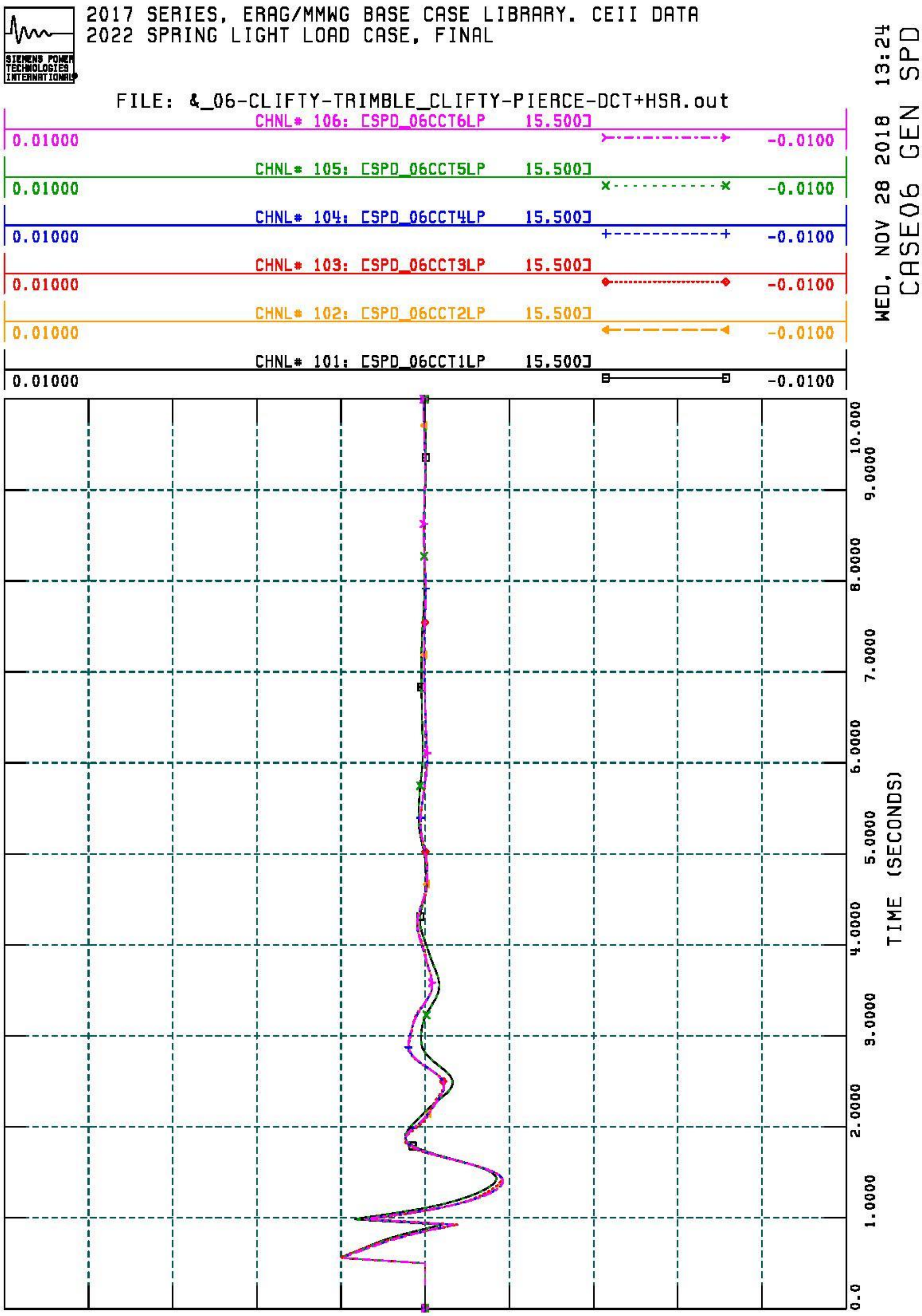
TIME (SECONDS)



2017 SERIES, ERAG/MMWG BASE CASE LIBRARY. CEII DATA
2022 SPRING LIGHT LOAD CASE, FINAL
SIEMENS POWER TECHNOLOGIES INTERNATIONAL
FILE: &_06-CLIFTY-TRIMBLE_CLIFTY-PIERCE-DCT+HSR.out
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CHNL# 104: [SPD_06CCT4LP 15.500]
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-0.0100
CHNL# 103: [SPD_06CCT3LP 15.500]
0.01000
-0.0100
CHNL# 102: [SPD_06CCT2LP 15.500]
0.01000
-0.0100
CHNL# 101: [SPD_06CCT1LP 15.500]
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-0.0100
WED, NOV 28 2018 13:24
CASE06 GEN SPD
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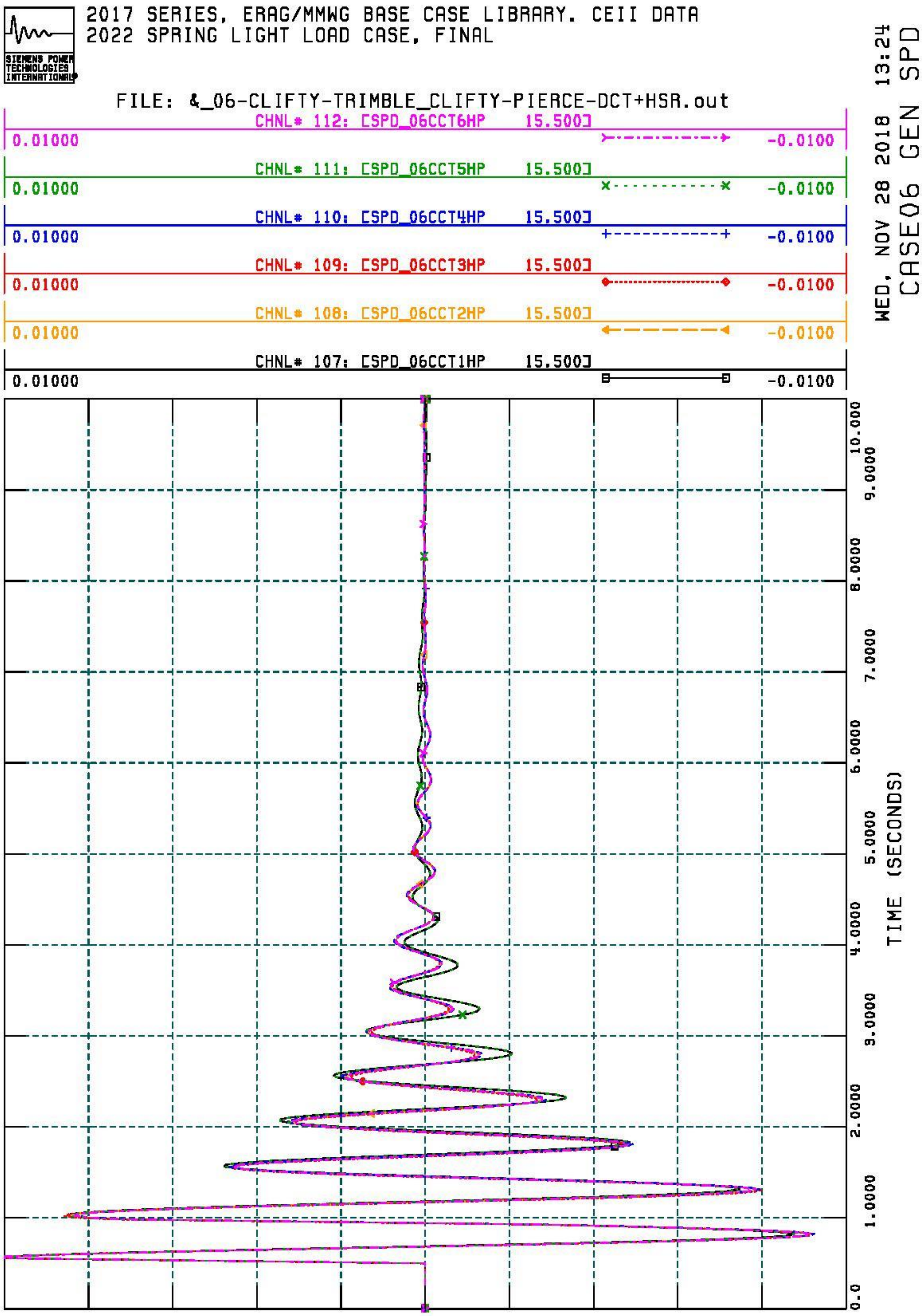
TIME (SECONDS)


2017 SERIES, ERAG/MMWG BASE CASE LIBRARY. CEII DATA
2022 SPRING LIGHT LOAD CASE, FINAL
SIEMENS POWER TECHNOLOGIES INTERNATIONAL
FILE: &_06-CLIFTY-TRIMBLE_CLIFTY-PIERCE-DCT+HSR.out
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CHNL# 110: [SPD_06CCT4HP 15.500]
0.01000
-0.0100
CHNL# 109: [SPD_06CCT3HP 15.500]
0.01000
-0.0100
CHNL# 108: [SPD_06CCT2HP 15.500]
0.01000
-0.0100
CHNL# 107: [SPD_06CCT1HP 15.500]
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-0.0100
WED, NOV 28 2018 13:24
CASE06 GEN SPD
TIME (SECONDS)
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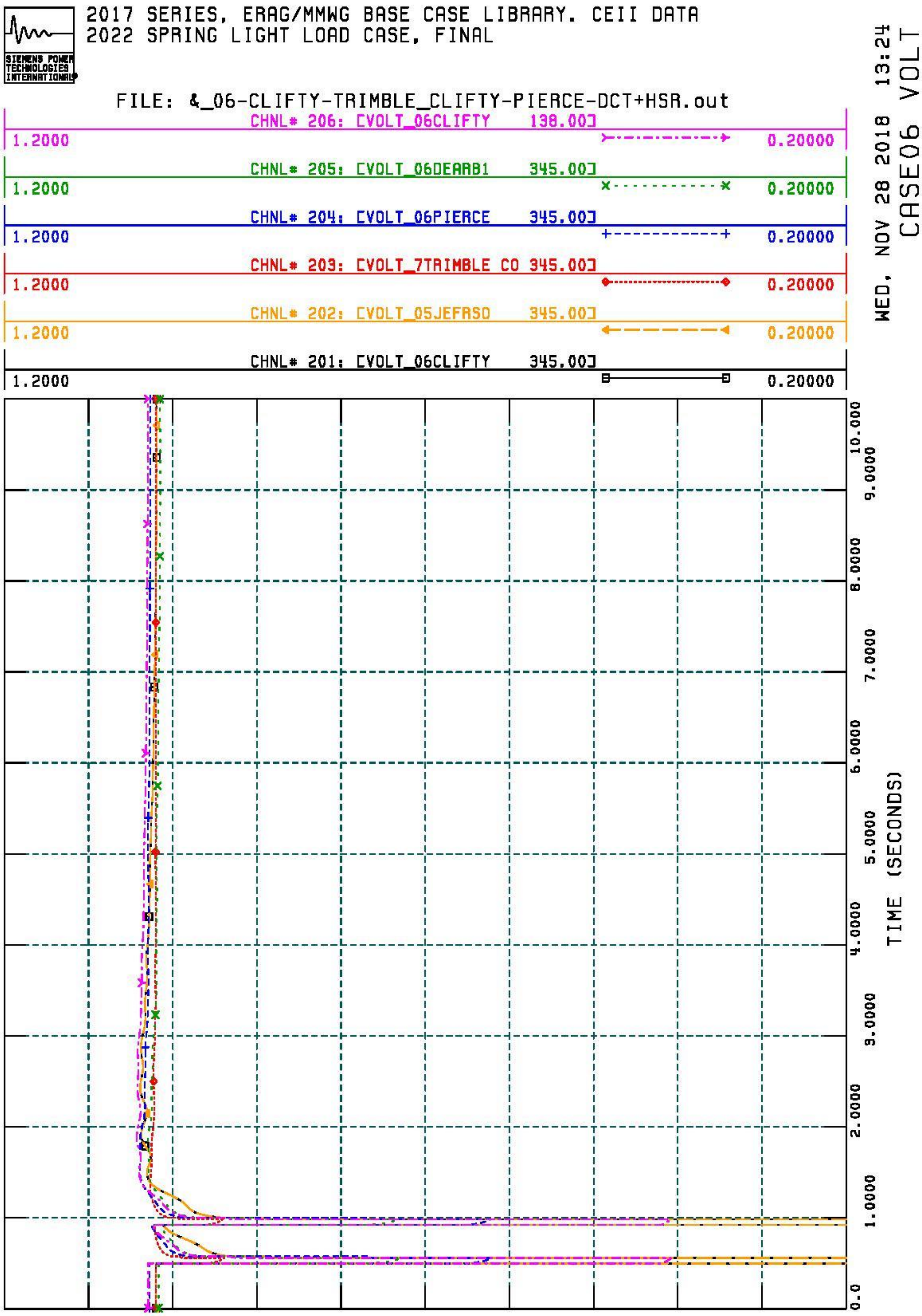
2017 SERIES, ERAG/MMWG BASE CASE LIBRARY. CEII DATA
2022 SPRING LIGHT LOAD CASE, FINAL
SIEMENS POWER TECHNOLOGIES INTERNATIONAL
FILE: &_06-CLIFTY-TRIMBLE_CLIFTY-PIERCE-DCT+HSR.out
CHNL# 206: [VOLT_06CLIFTY 138.00]
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CHNL# 205: [VOLT_06DEARB1 345.00]
1.2000
0.20000
CHNL# 204: [VOLT_06PIERCE 345.00]
1.2000
0.20000
CHNL# 203: [VOLT_7TRIMBLE CO 345.00]
1.2000
0.20000
CHNL# 202: [VOLT_05JEFRSD 345.00]
1.2000
0.20000
CHNL# 201: [VOLT_06CLIFTY 345.00]
1.2000
0.20000
0.0
1.0000
2.0000
3.0000
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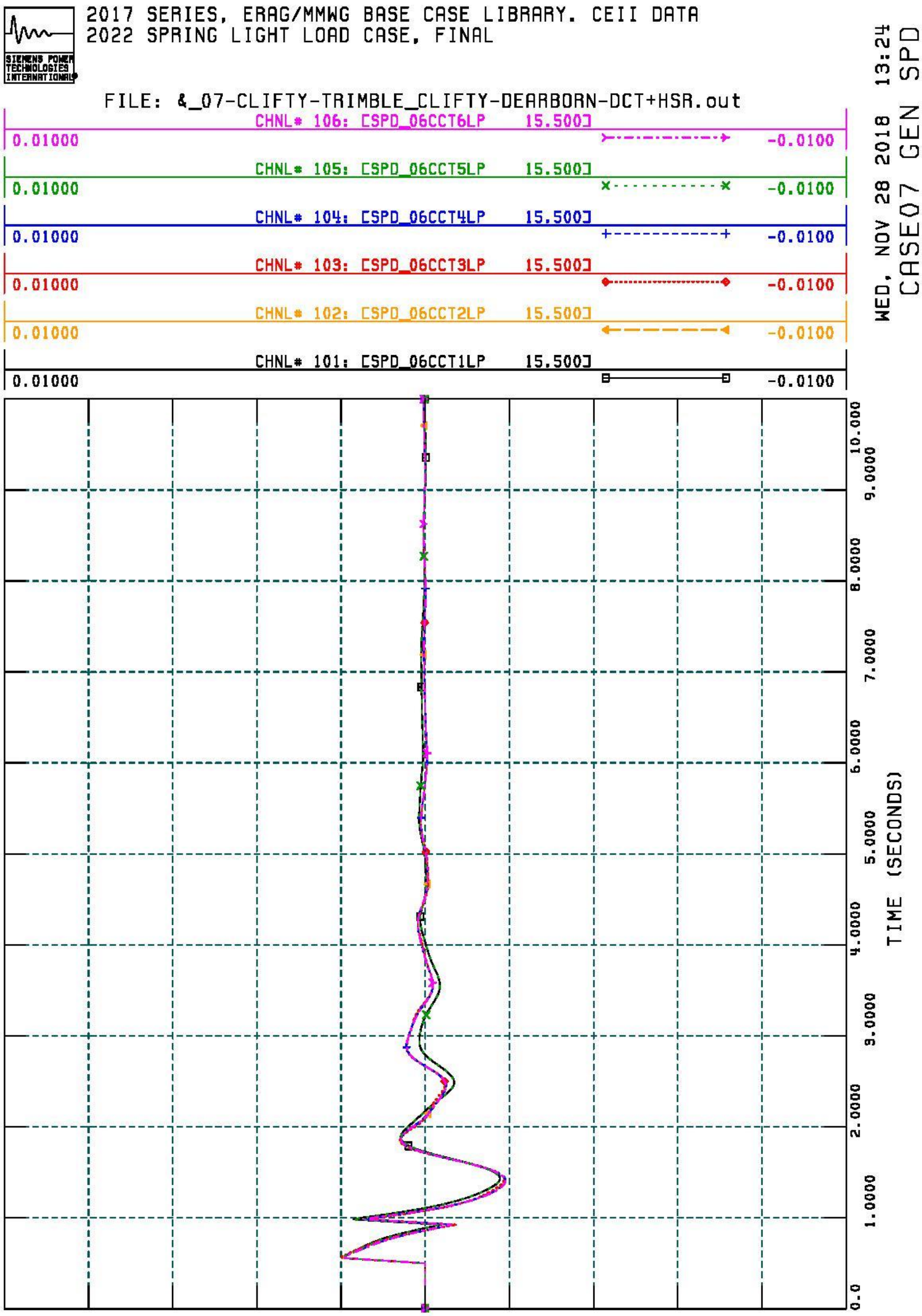
TIME (SECONDS)
WED, NOV 28 2018 13:24
CASE06 VOLT


2017 SERIES, ERAG/MMWG BASE CASE LIBRARY. CEII DATA
2022 SPRING LIGHT LOAD CASE, FINAL
SIEMENS POWER TECHNOLOGIES INTERNATIONAL
FILE: &_07-CLIFTY-TRIMBLE_CLIFTY-DEARBORN-DCT+HSR.out
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CHNL# 104: [SPD_06CCT4LP 15.500]
0.01000 -0.0100
CHNL# 103: [SPD_06CCT3LP 15.500]
0.01000 -0.0100
CHNL# 102: [SPD_06CCT2LP 15.500]
0.01000 -0.0100
CHNL# 101: [SPD_06CCT1LP 15.500]
0.01000 -0.0100
WED, NOV 28 2018 13:24
CASE07 GEN SPD
TIME (SECONDS)
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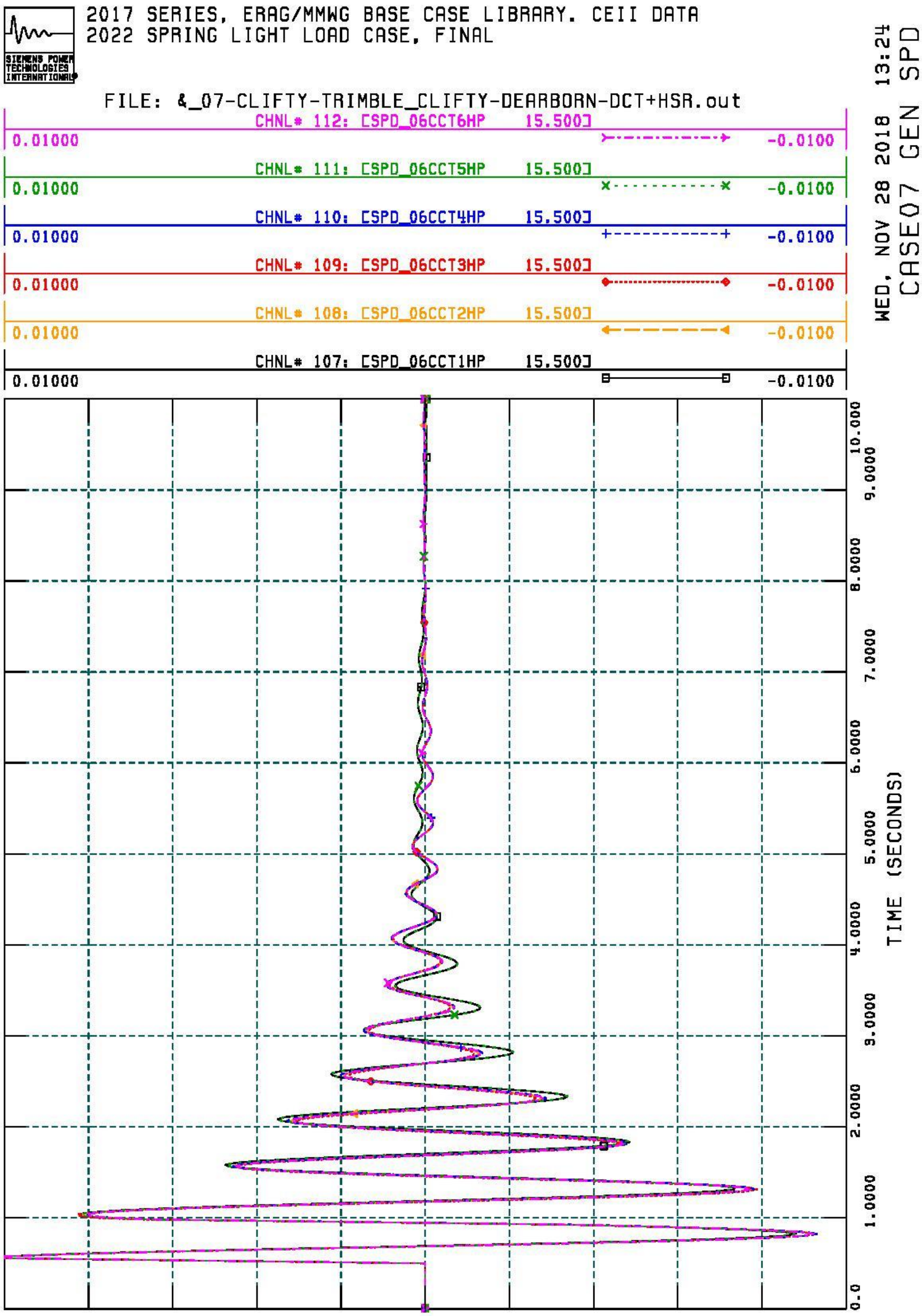
SIEMENS POWER TECHNOLOGIES INTERNATIONAL
2017 SERIES, ERAG/MMWG BASE CASE LIBRARY. CEII DATA
2022 SPRING LIGHT LOAD CASE, FINAL
FILE: &_07-CLIFTY-TRIMBLE_CLIFTY-DEARBORN-DCT+HSR.out
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CHNL# 110: [SPD_06CCT4HP 15.500]
0.01000 -0.0100
CHNL# 109: [SPD_06CCT3HP 15.500]
0.01000 -0.0100
CHNL# 108: [SPD_06CCT2HP 15.500]
0.01000 -0.0100
CHNL# 107: [SPD_06CCT1HP 15.500]
0.01000 -0.0100
WED, NOV 28 2018 13:24
CASE07 GEN SPD
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2.0000
3.0000
4.0000
5.0000
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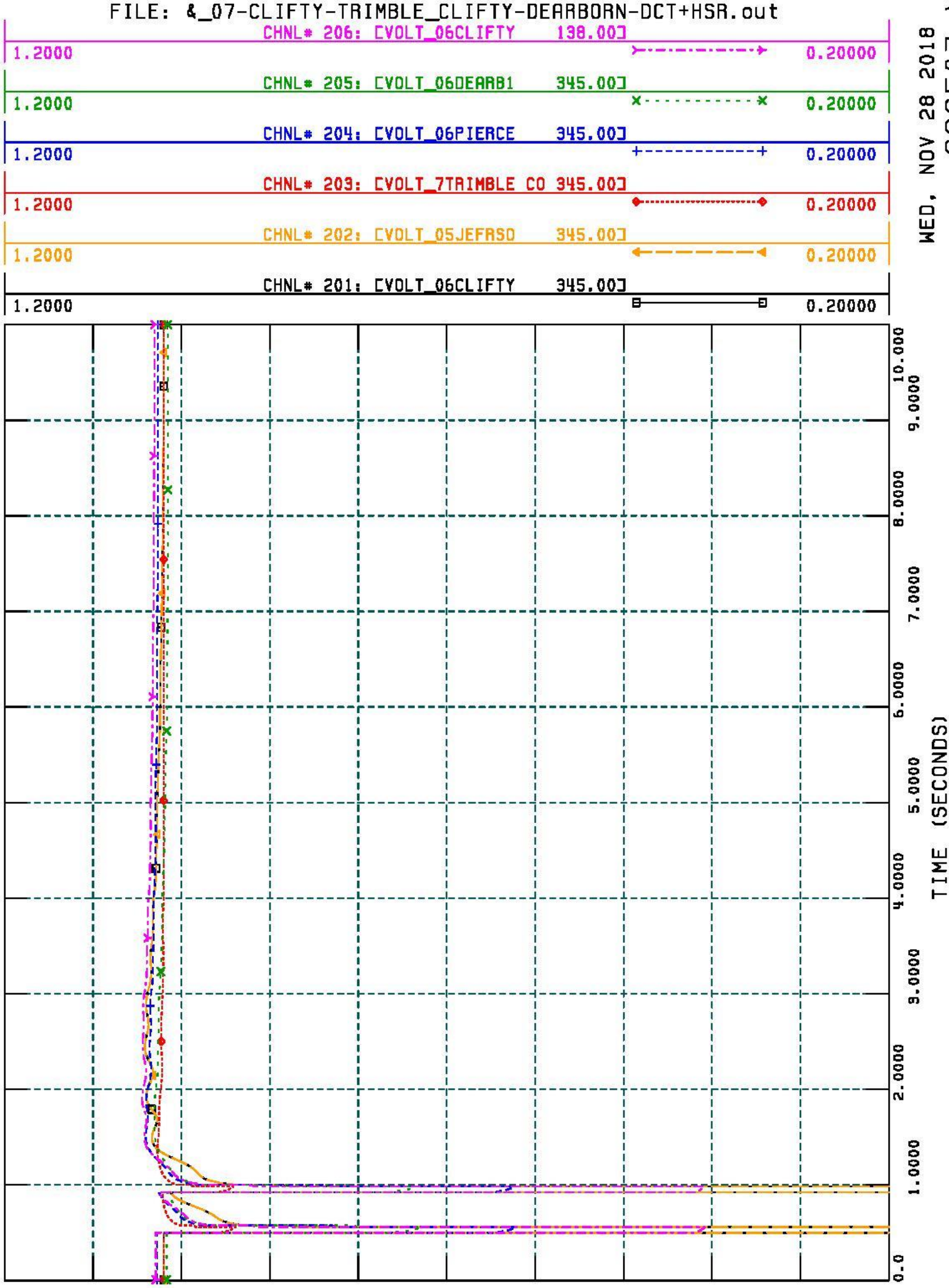
8.0000
9.0000
10.000
TIME (SECONDS)

2017 SERIES, ERAG/MMWG BASE CASE LIBRARY. CEII DATA
2022 SPRING LIGHT LOAD CASE, FINAL

WED, NOV 28 2018 13:24
CASE07 VOLT

FILE: &_07-CLIFTY-TRIMBLE_CLIFTY-DEARBORN-DCT+HSR.out



2017 SERIES, ERAG/MMWG BASE CASE LIBRARY. CEII DATA
2022 SPRING LIGHT LOAD CASE, FINAL

WED, NOV 28 2018 13:24
CASE08 GEN SPD

FILE: &_08-CLIFTY-TRIMBLE_CLIFTYTRF+HSR.out

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CHNL# 104: [SPD_06CCT4LP 15.500]		
0.01000		-0.0100
CHNL# 103: [SPD_06CCT3LP 15.500]		
0.01000		-0.0100
CHNL# 102: [SPD_06CCT2LP 15.500]		
0.01000		-0.0100
CHNL# 101: [SPD_06CCT1LP 15.500]		
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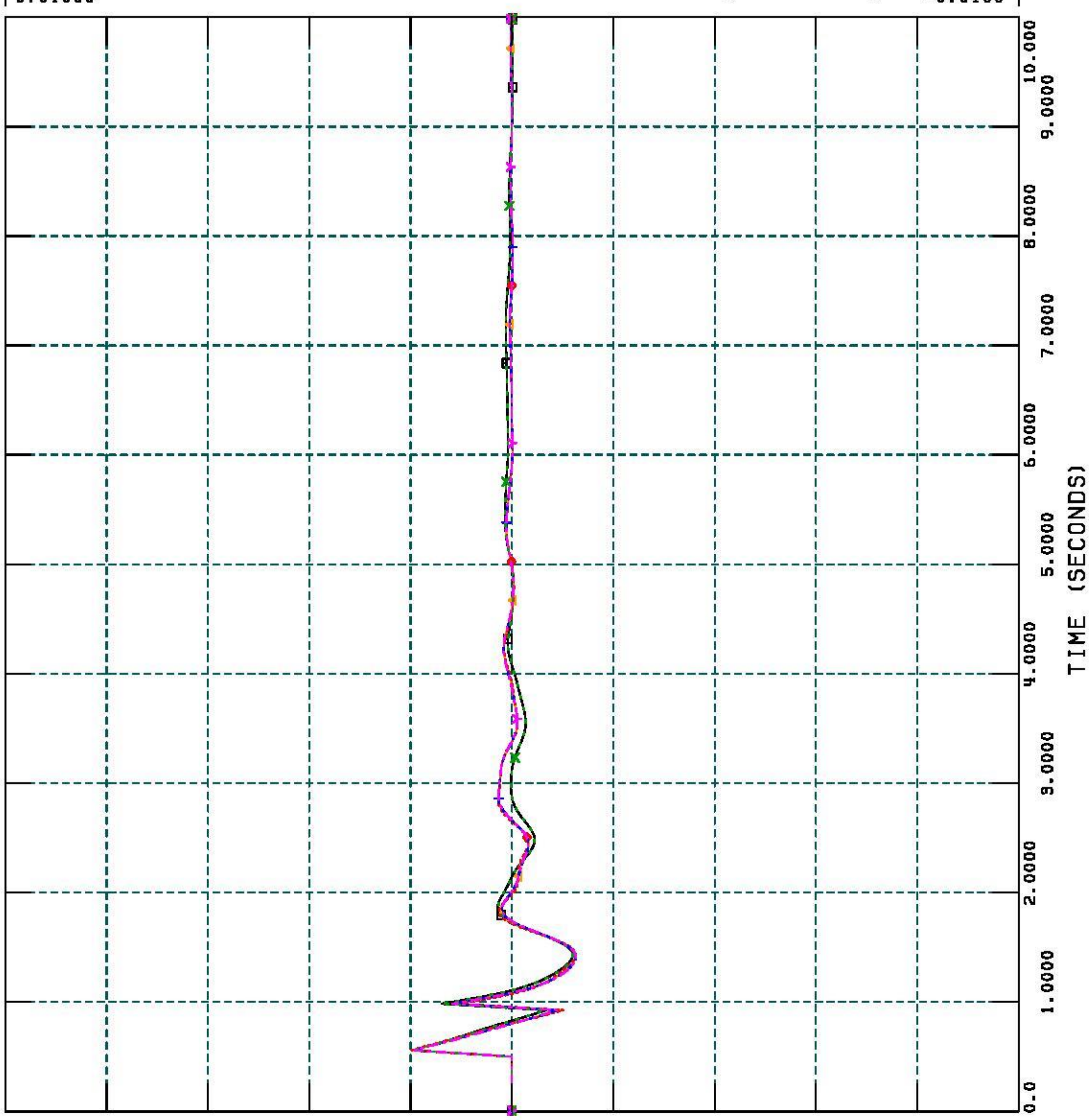

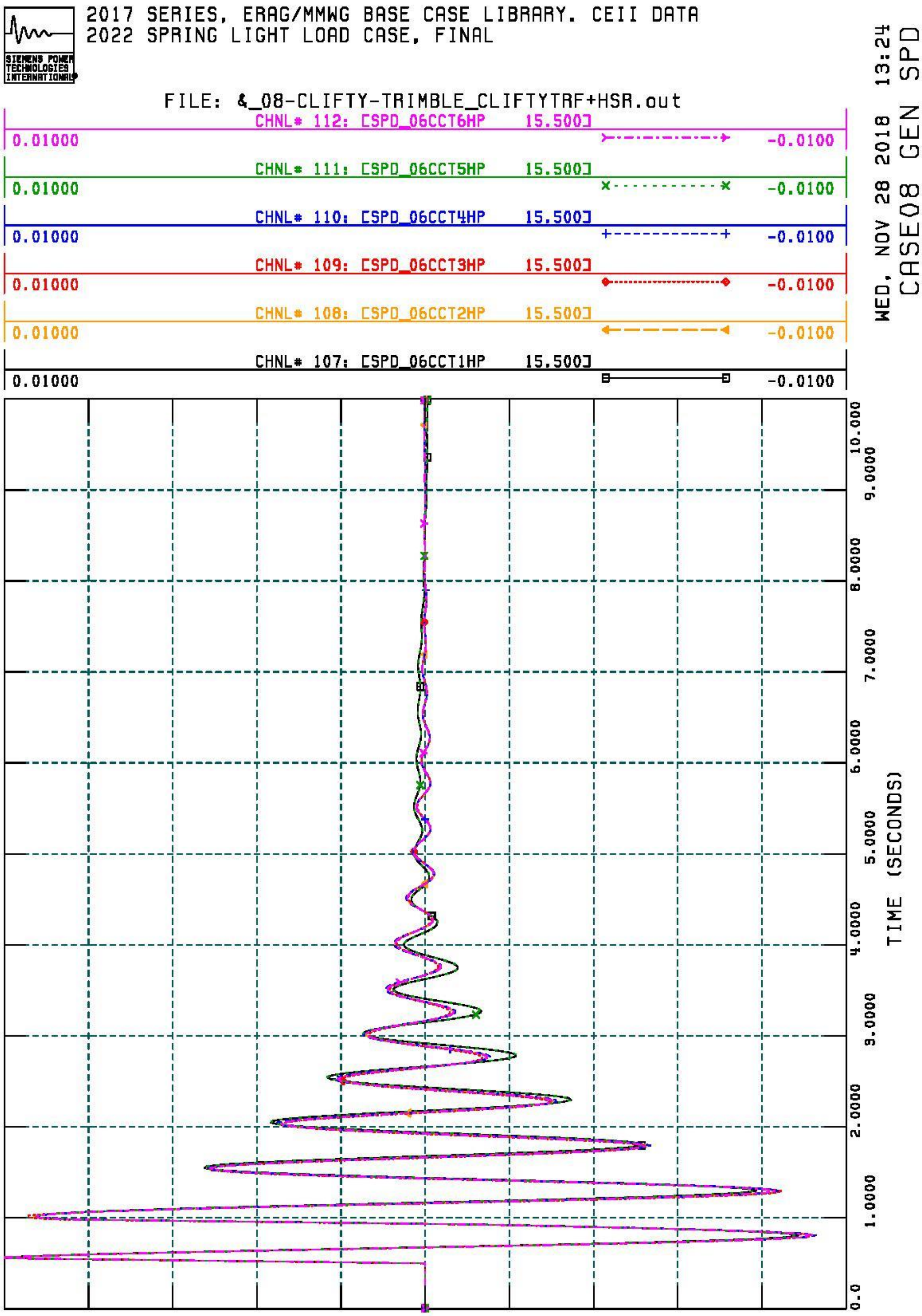

2017 SERIES, ERAG/MMWG BASE CASE LIBRARY. CEII DATA
2022 SPRING LIGHT LOAD CASE, FINAL
SIEMENS POWER TECHNOLOGIES INTERNATIONAL
WED, NOV 28 2018 13:24
CASE08 GEN SPD
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CHNL# 110: [SPD_06CCT4HP 15.500]
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CHNL# 109: [SPD_06CCT3HP 15.500]
0.01000 -0.0100
CHNL# 108: [SPD_06CCT2HP 15.500]
0.01000 -0.0100
CHNL# 107: [SPD_06CCT1HP 15.500]
0.01000 -0.0100
0.0
1.0000
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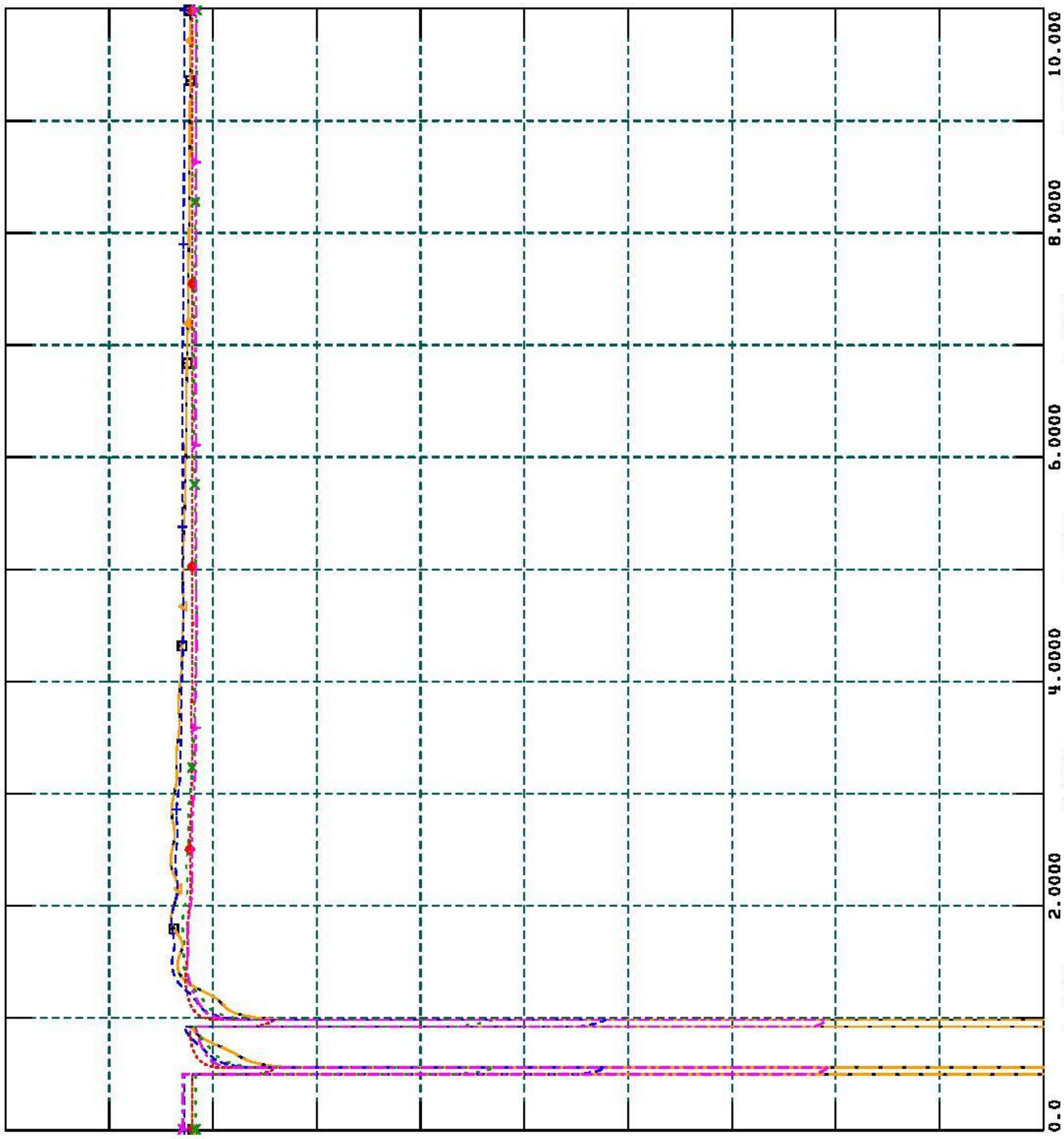
10.000
TIME (SECONDS)

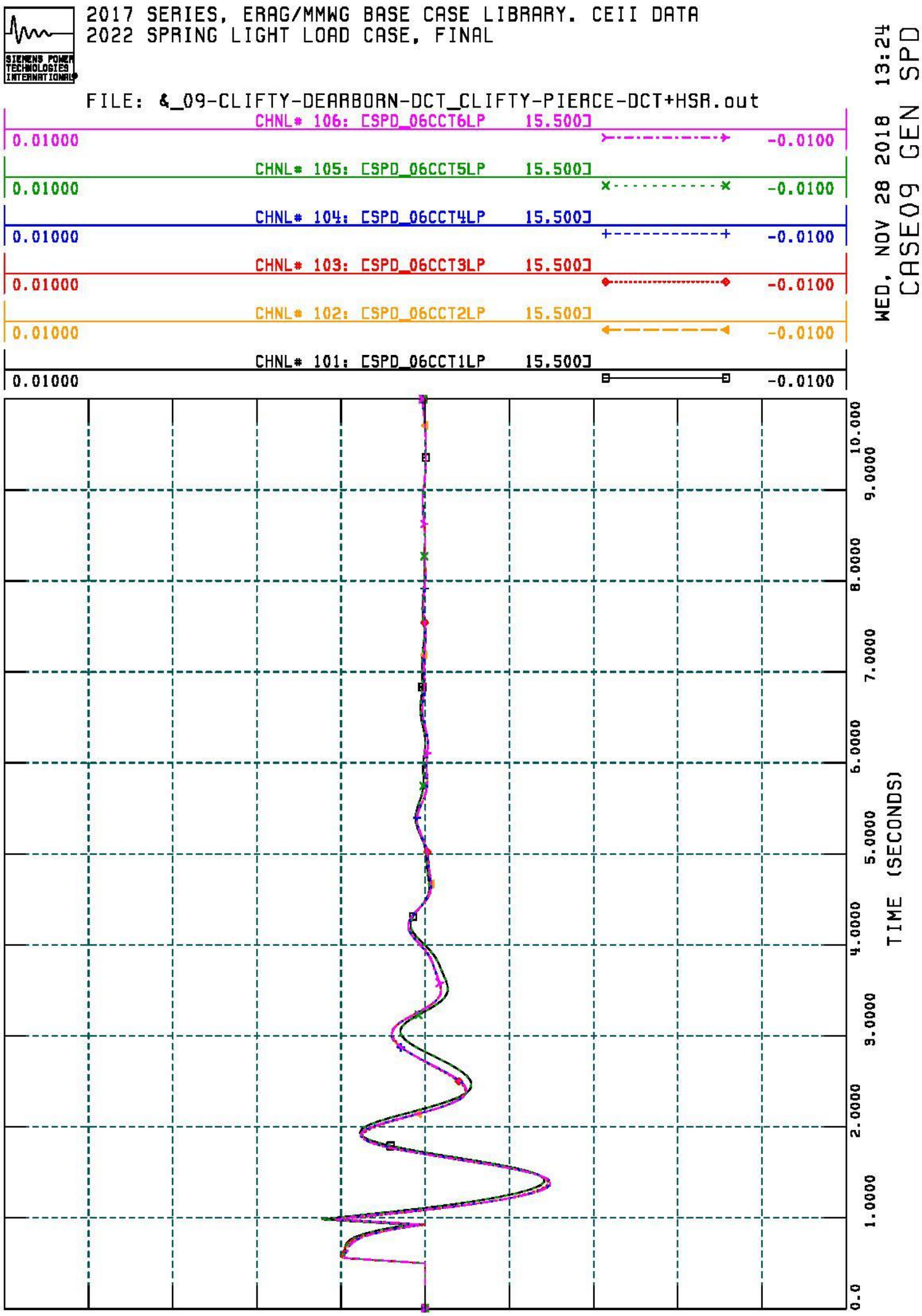
2017 SERIES, ERAG/MMWG BASE CASE LIBRARY. CEII DATA
2022 SPRING LIGHT LOAD CASE, FINAL

WED, NOV 28 2018 13:24
CASE08 VOLT

FILE: &_08-CLIFTY-TRIMBLE_CLIFTYTRF+HSR.out

CHNL# 206: [VOLT_06CLIFTY 138.00]	1.2000	0.20000
CHNL# 205: [VOLT_06DEARB1 345.00]	1.2000	0.20000
CHNL# 204: [VOLT_06PIERCE 345.00]	1.2000	0.20000
CHNL# 203: [VOLT_7TRIMBLE CO 345.00]	1.2000	0.20000
CHNL# 202: [VOLT_05JEFRSD 345.00]	1.2000	0.20000
CHNL# 201: [VOLT_06CLIFTY 345.00]	1.2000	0.20000




2017 SERIES, ERAG/MMWG BASE CASE LIBRARY. CEII DATA
2022 SPRING LIGHT LOAD CASE, FINAL
SIEMENS POWER TECHNOLOGIES INTERNATIONAL
FILE: &_09-CLIFTY-DEARBORN-DCT_CLIFTY-PIERCE-DCT+HSR.out
CHNL# 106: [SPD_06CCT6LP 15.500]
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CHNL# 105: [SPD_06CCT5LP 15.500]
0.01000
-0.0100
CHNL# 104: [SPD_06CCT4LP 15.500]
0.01000
-0.0100
CHNL# 103: [SPD_06CCT3LP 15.500]
0.01000
-0.0100
CHNL# 102: [SPD_06CCT2LP 15.500]
0.01000
-0.0100
CHNL# 101: [SPD_06CCT1LP 15.500]
0.01000
-0.0100
0.0
1.0000
2.0000
3.0000
4.0000
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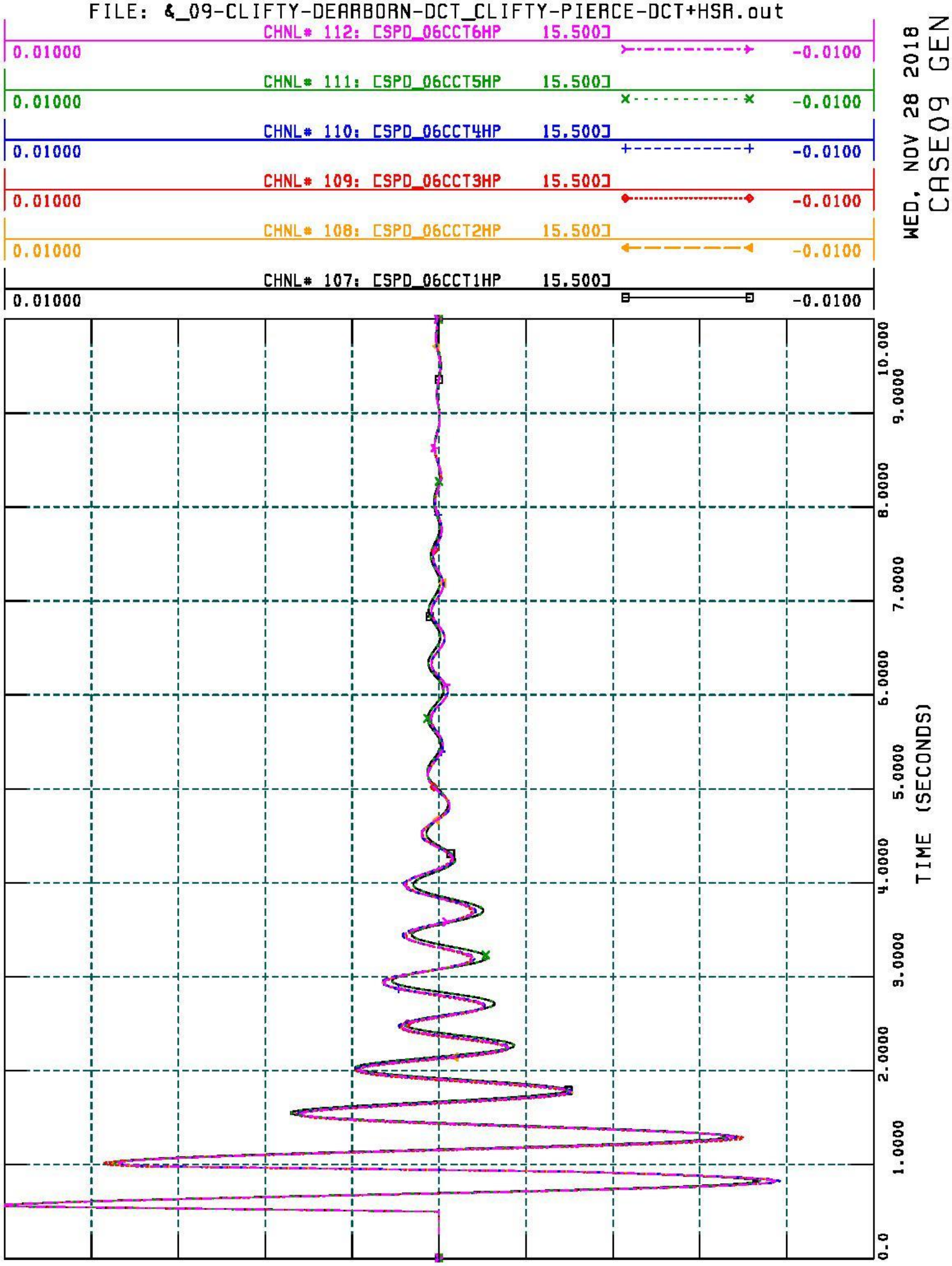
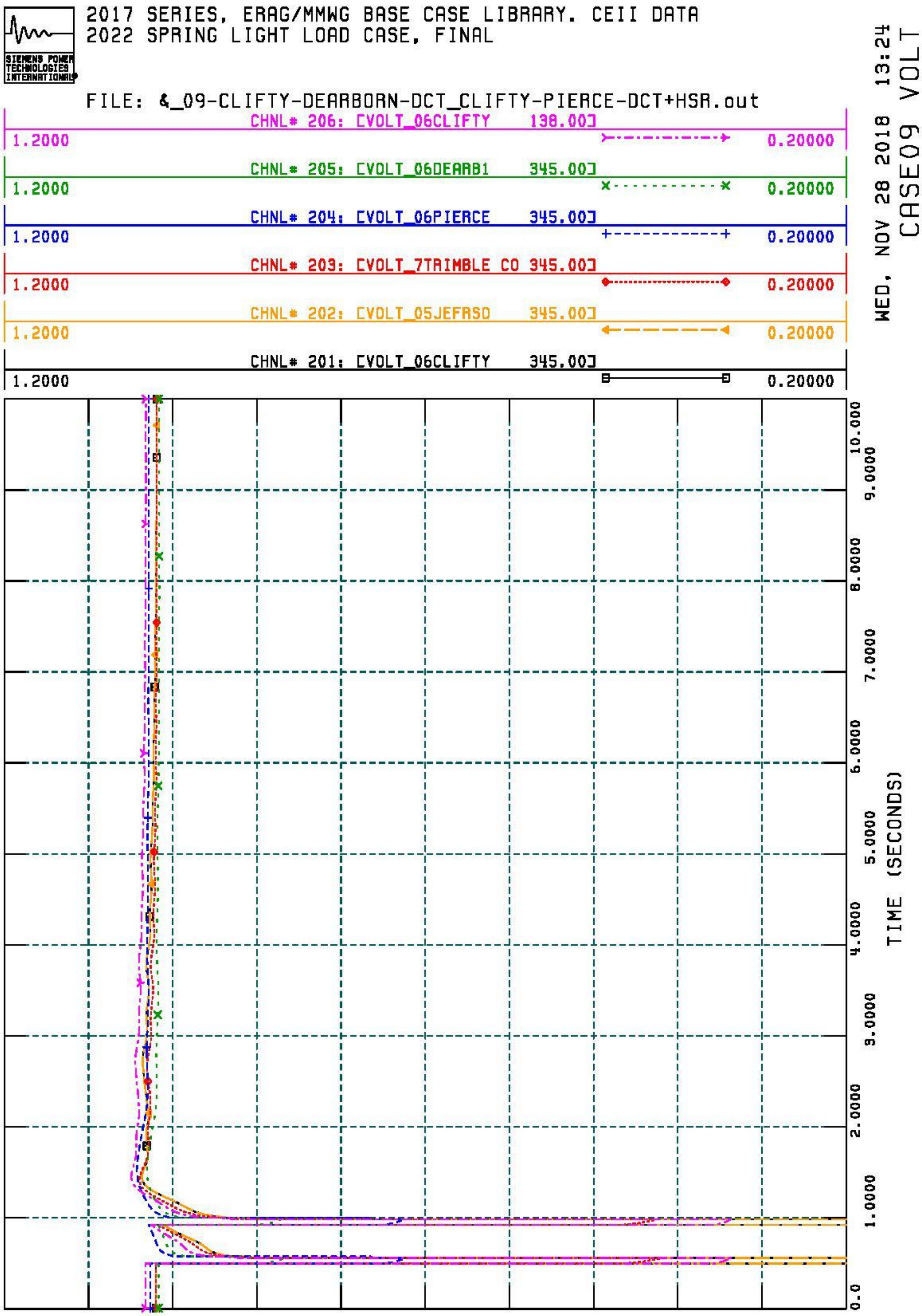
6.0000
7.0000
8.0000
9.0000
10.000
TIME (SECONDS)
WED, NOV 28 2018 13:24
CASE09 GEN SPD

2017 SERIES, ERAG/MMWG BASE CASE LIBRARY. CEII DATA
2022 SPRING LIGHT LOAD CASE, FINAL

FILE: &_09-CLIFTY-DEARBORN-DCT_CLIFTY-PIERCE-DCT+HSR.out




2017 SERIES, ERAG/MMWG BASE CASE LIBRARY. CEII DATA
2022 SPRING LIGHT LOAD CASE, FINAL
SIEMENS POWER TECHNOLOGIES INTERNATIONAL
FILE: &_09-CLIFTY-DEARBORN-DCT_CLIFTY-PIERCE-DCT+HSR.out
CHNL# 206: [VOLT_06CLIFTY 138.00]
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0.20000
CHNL# 205: [VOLT_06DEARB1 345.00]
1.2000
0.20000
CHNL# 204: [VOLT_06PIERCE 345.00]
1.2000
0.20000
CHNL# 203: [VOLT_7TRIMBLE CO 345.00]
1.2000
0.20000
CHNL# 202: [VOLT_05JEFRSD 345.00]
1.2000
0.20000
CHNL# 201: [VOLT_06CLIFTY 345.00]
1.2000
0.20000
WED, NOV 28 2018 13:24
CASE09 VOLT
0.0
1.0000
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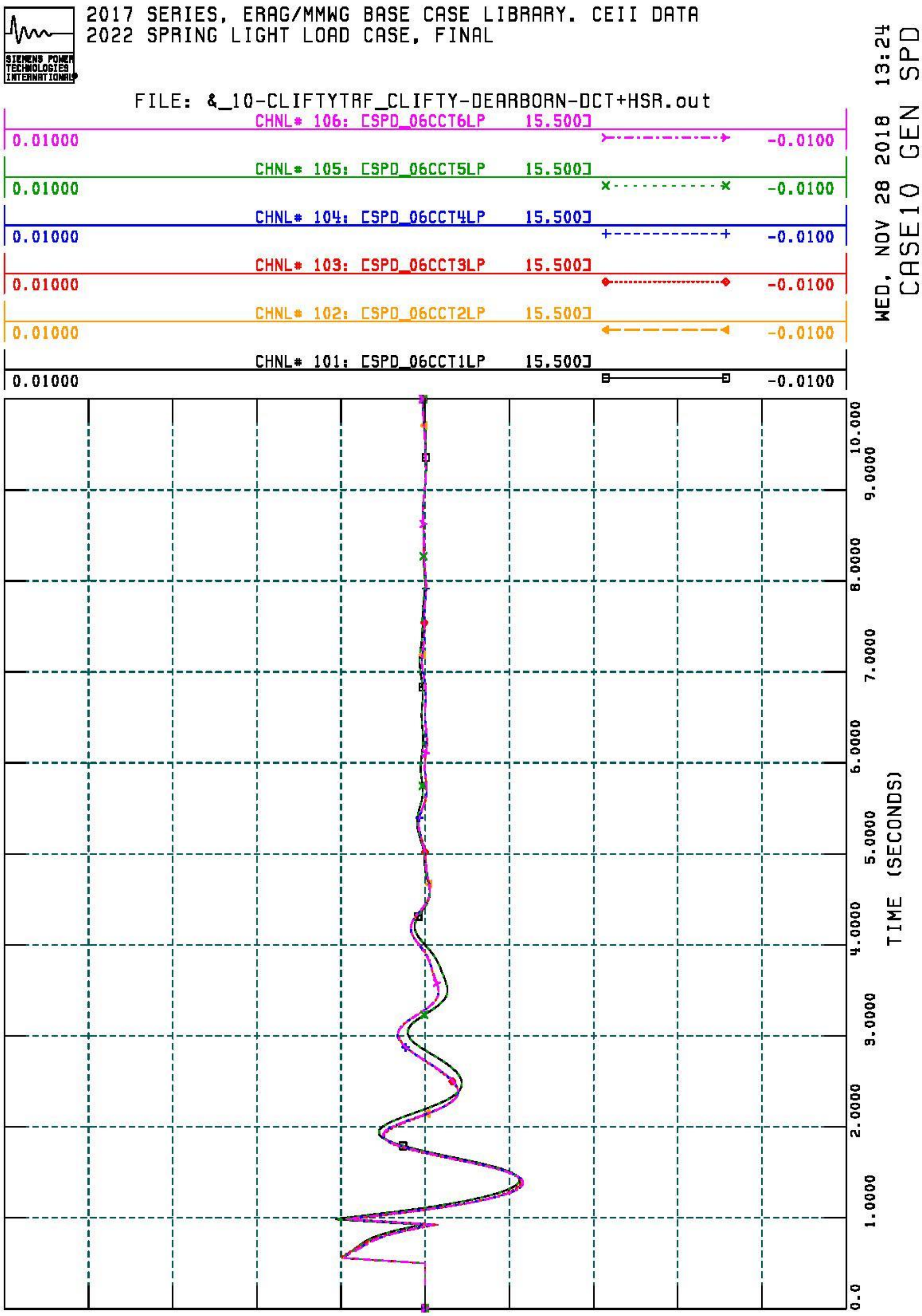
10.000
TIME (SECONDS)



SIEMENS POWER TECHNOLOGIES INTERNATIONAL
2017 SERIES, ERAG/MMWG BASE CASE LIBRARY. CEII DATA
2022 SPRING LIGHT LOAD CASE, FINAL
FILE: &_10-CLIFTYTRF_CLIFTY-DEARBORN-DCT+HSR.out
CHNL# 106: [SPD_06CCT6LP 15.500]
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CHNL# 105: [SPD_06CCT5LP 15.500]
0.01000
-0.0100
CHNL# 104: [SPD_06CCT4LP 15.500]
0.01000
-0.0100
CHNL# 103: [SPD_06CCT3LP 15.500]
0.01000
-0.0100
CHNL# 102: [SPD_06CCT2LP 15.500]
0.01000
-0.0100
CHNL# 101: [SPD_06CCT1LP 15.500]
0.01000
-0.0100
WED, NOV 28 2018 13:24
CASE10 GEN SPD
TIME (SECONDS)
0.0
1.0000
2.0000
3.0000
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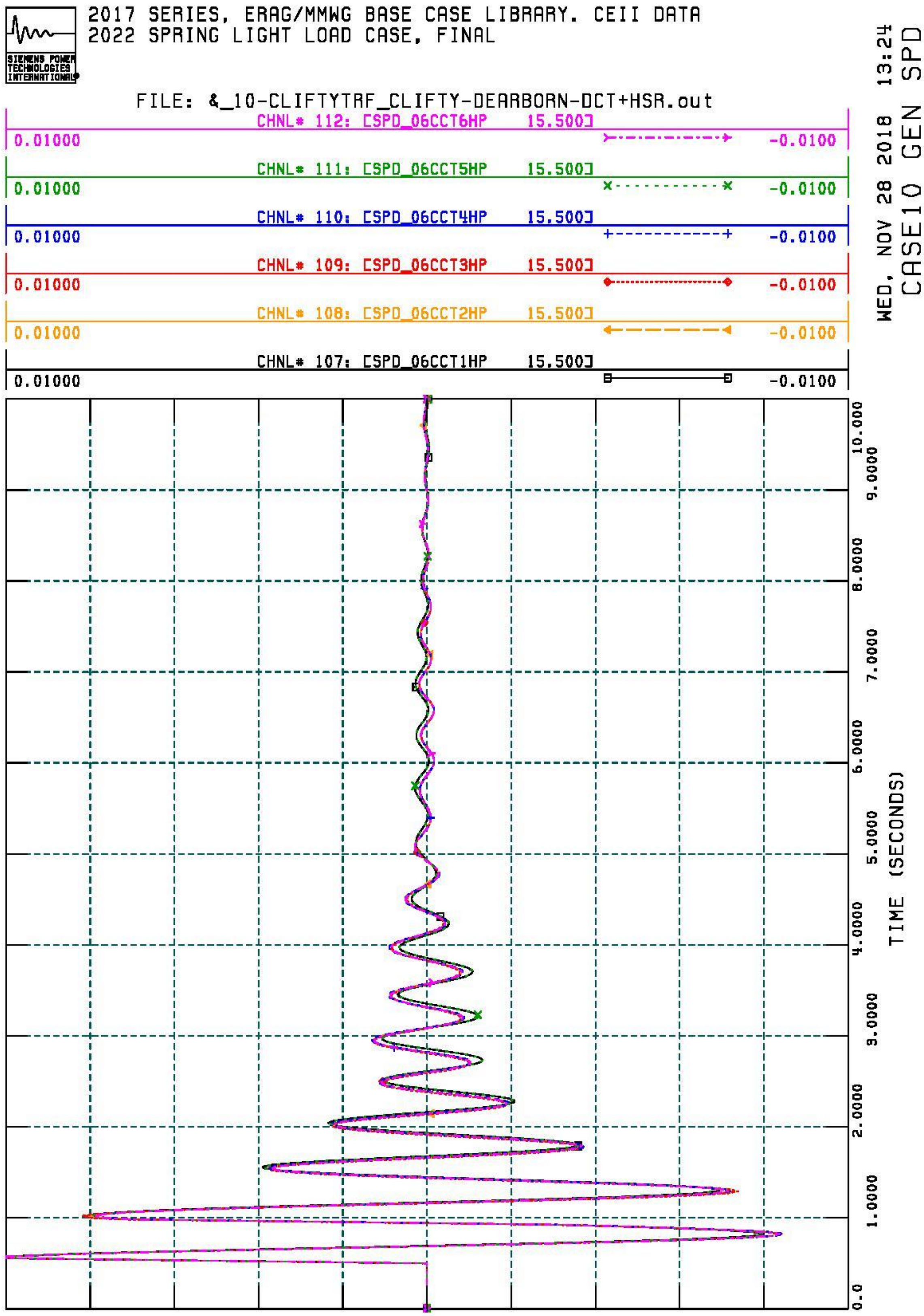
10.000


2017 SERIES, ERAG/MMWG BASE CASE LIBRARY. CEII DATA
2022 SPRING LIGHT LOAD CASE, FINAL
SIEMENS POWER TECHNOLOGIES INTERNATIONAL
FILE: &_10-CLIFTYTRF_CLIFTY-DEARBORN-DCT+HSR.out
CHNL# 112: [SPD_06CCT6HP 15.500]
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CHNL# 111: [SPD_06CCT5HP 15.500]
0.01000 -0.0100
CHNL# 110: [SPD_06CCT4HP 15.500]
0.01000 -0.0100
CHNL# 109: [SPD_06CCT3HP 15.500]
0.01000 -0.0100
CHNL# 108: [SPD_06CCT2HP 15.500]
0.01000 -0.0100
CHNL# 107: [SPD_06CCT1HP 15.500]
0.01000 -0.0100
WED, NOV 28 2018 13:24
CASE10 GEN SPD
TIME (SECONDS)
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1.0000
2.0000
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4.0000
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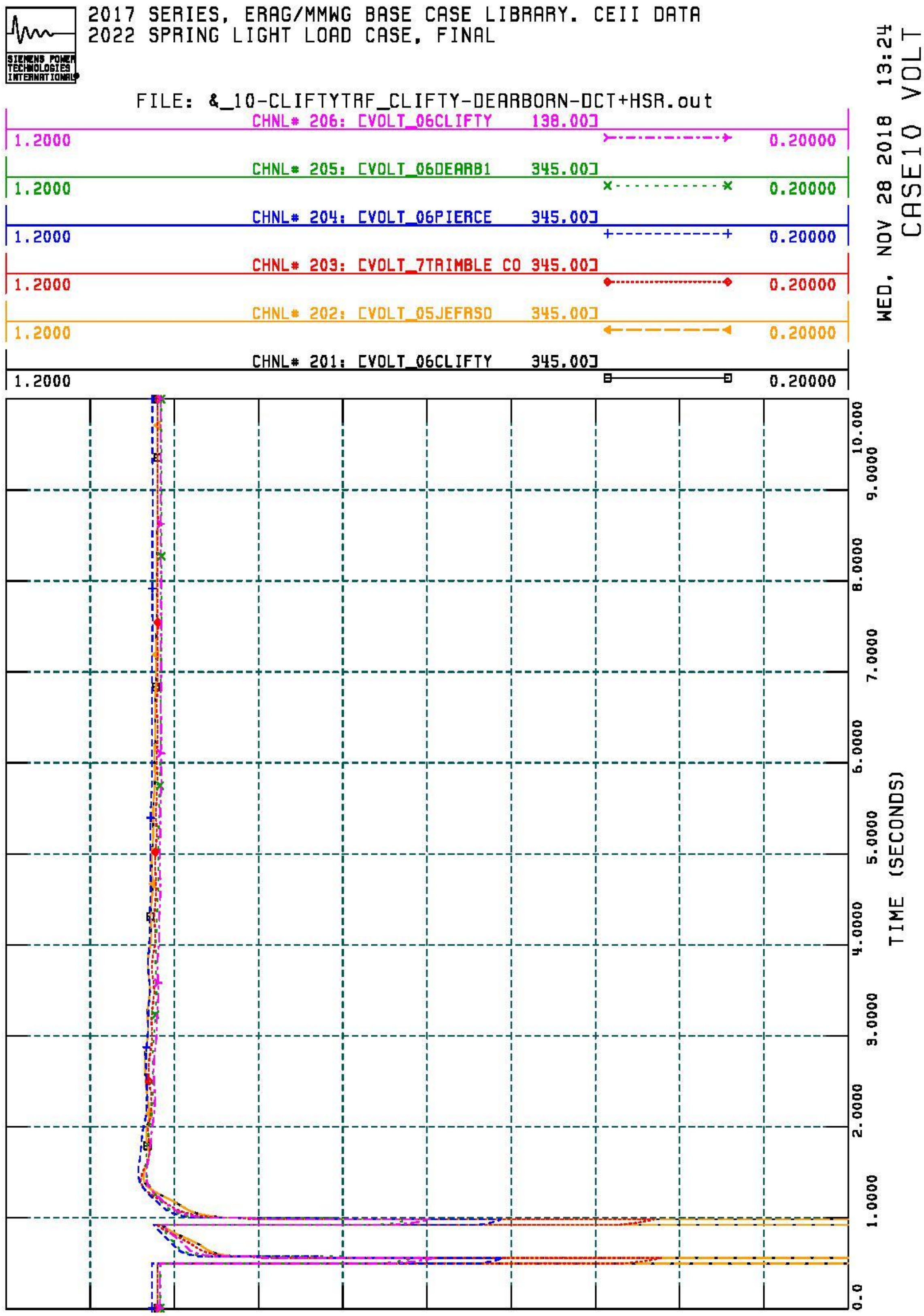
2017 SERIES, ERAG/MMWG BASE CASE LIBRARY. CEII DATA
2022 SPRING LIGHT LOAD CASE, FINAL
SIEMENS POWER TECHNOLOGIES INTERNATIONAL
FILE: &_10-CLIFTYTRF_CLIFTY-DEARBORN-DCT+HSR.out
CHNL# 206: [VOLT_06CLIFTY 138.00]
1.2000
0.20000
CHNL# 205: [VOLT_06DEARB1 345.00]
1.2000
0.20000
CHNL# 204: [VOLT_06PIERCE 345.00]
1.2000
0.20000
CHNL# 203: [VOLT_7TRIMBLE CO 345.00]
1.2000
0.20000
CHNL# 202: [VOLT_05JEFRSD 345.00]
1.2000
0.20000
CHNL# 201: [VOLT_06CLIFTY 345.00]
1.2000
0.20000
WED, NOV 28 2018 13:24
CASE10 VOLT
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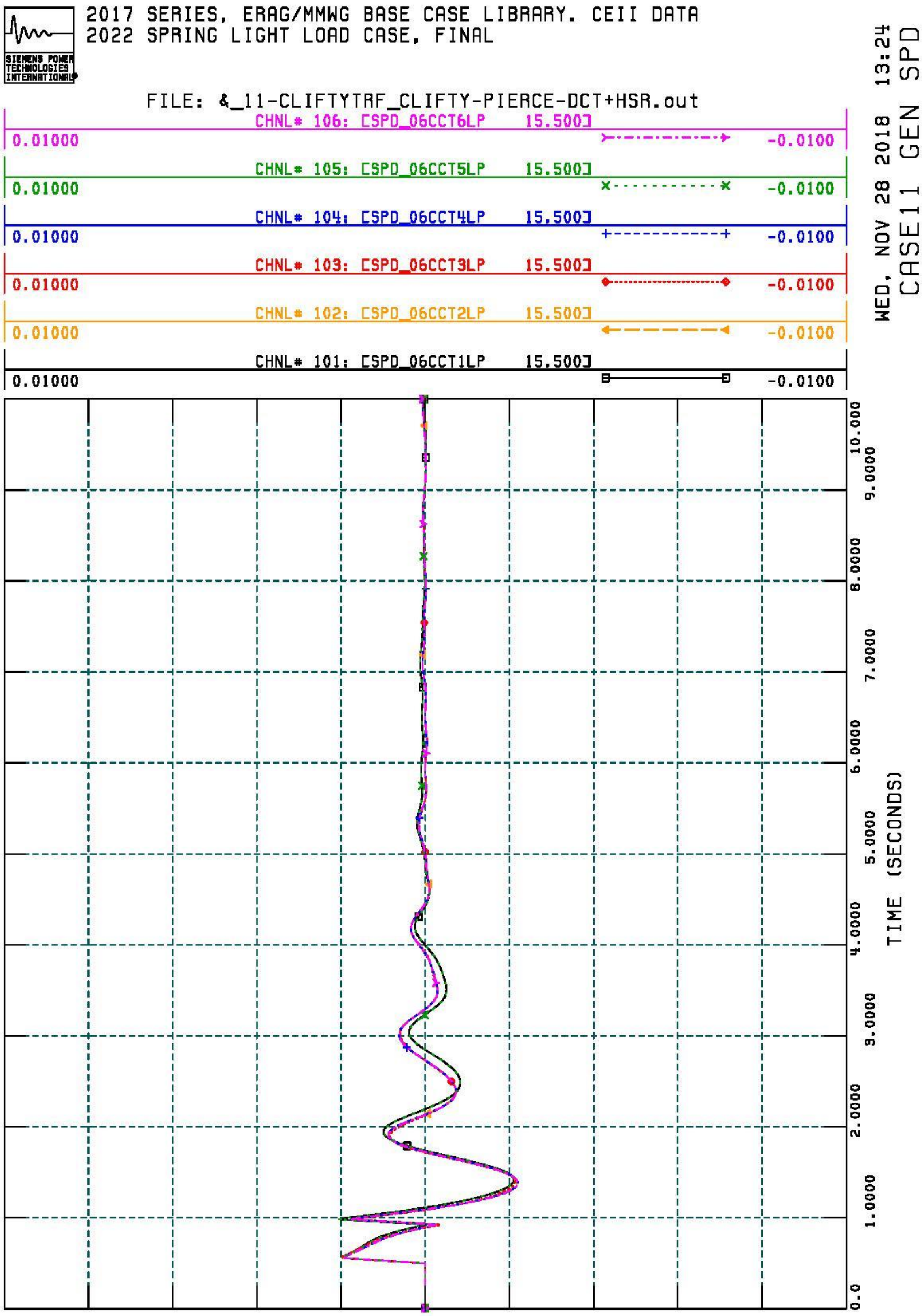
10.000
TIME (SECONDS)



2017 SERIES, ERAG/MMWG BASE CASE LIBRARY. CEII DATA
2022 SPRING LIGHT LOAD CASE, FINAL
SIEMENS POWER TECHNOLOGIES INTERNATIONAL
FILE: &_11-CLIFTYTRF_CLIFTY-PIERCE-DCT+HSR.out
CHNL# 106: [SPD_06CCT6LP 15.500]
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-0.0100
CHNL# 105: [SPD_06CCT5LP 15.500]
0.01000
-0.0100
CHNL# 104: [SPD_06CCT4LP 15.500]
0.01000
-0.0100
CHNL# 103: [SPD_06CCT3LP 15.500]
0.01000
-0.0100
CHNL# 102: [SPD_06CCT2LP 15.500]
0.01000
-0.0100
CHNL# 101: [SPD_06CCT1LP 15.500]
0.01000
-0.0100
WED, NOV 28 2018 13:24
CASE11 GEN SPD
0.0
1.0000
2.0000
3.0000
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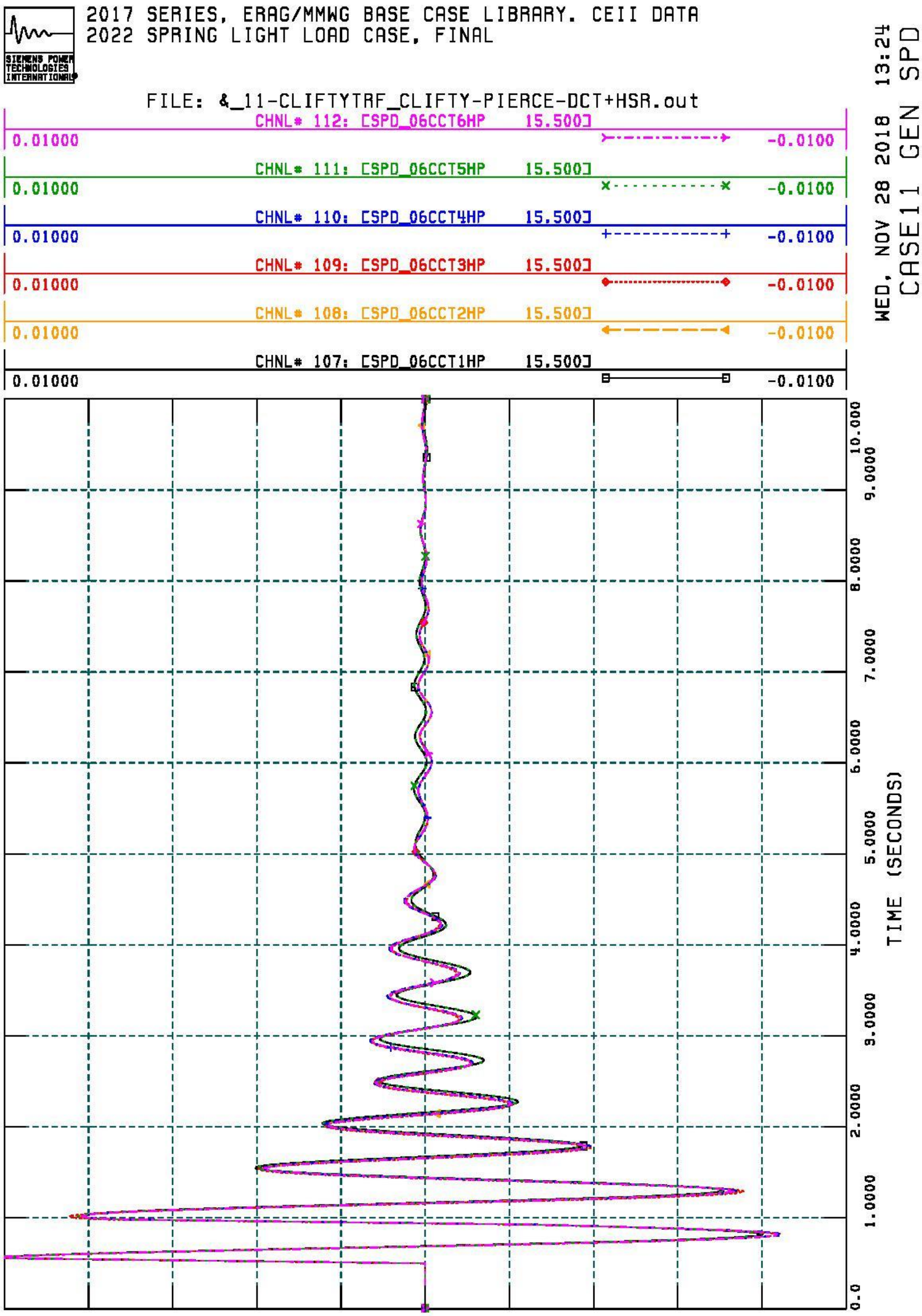
TIME (SECONDS)


2017 SERIES, ERAG/MMWG BASE CASE LIBRARY. CEII DATA
2022 SPRING LIGHT LOAD CASE, FINAL
SIEMENS POWER TECHNOLOGIES INTERNATIONAL
FILE: &_11-CLIFTYTRF_CLIFTY-PIERCE-DCT+HSR.out
CHNL# 112: [SPD_06CCT6HP 15.500]
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CHNL# 111: [SPD_06CCT5HP 15.500]
0.01000 -0.0100
CHNL# 110: [SPD_06CCT4HP 15.500]
0.01000 -0.0100
CHNL# 109: [SPD_06CCT3HP 15.500]
0.01000 -0.0100
CHNL# 108: [SPD_06CCT2HP 15.500]
0.01000 -0.0100
CHNL# 107: [SPD_06CCT1HP 15.500]
0.01000 -0.0100
WED, NOV 28 2018 13:24
CASE11 GEN SPD
TIME (SECONDS)
0.0
1.0000
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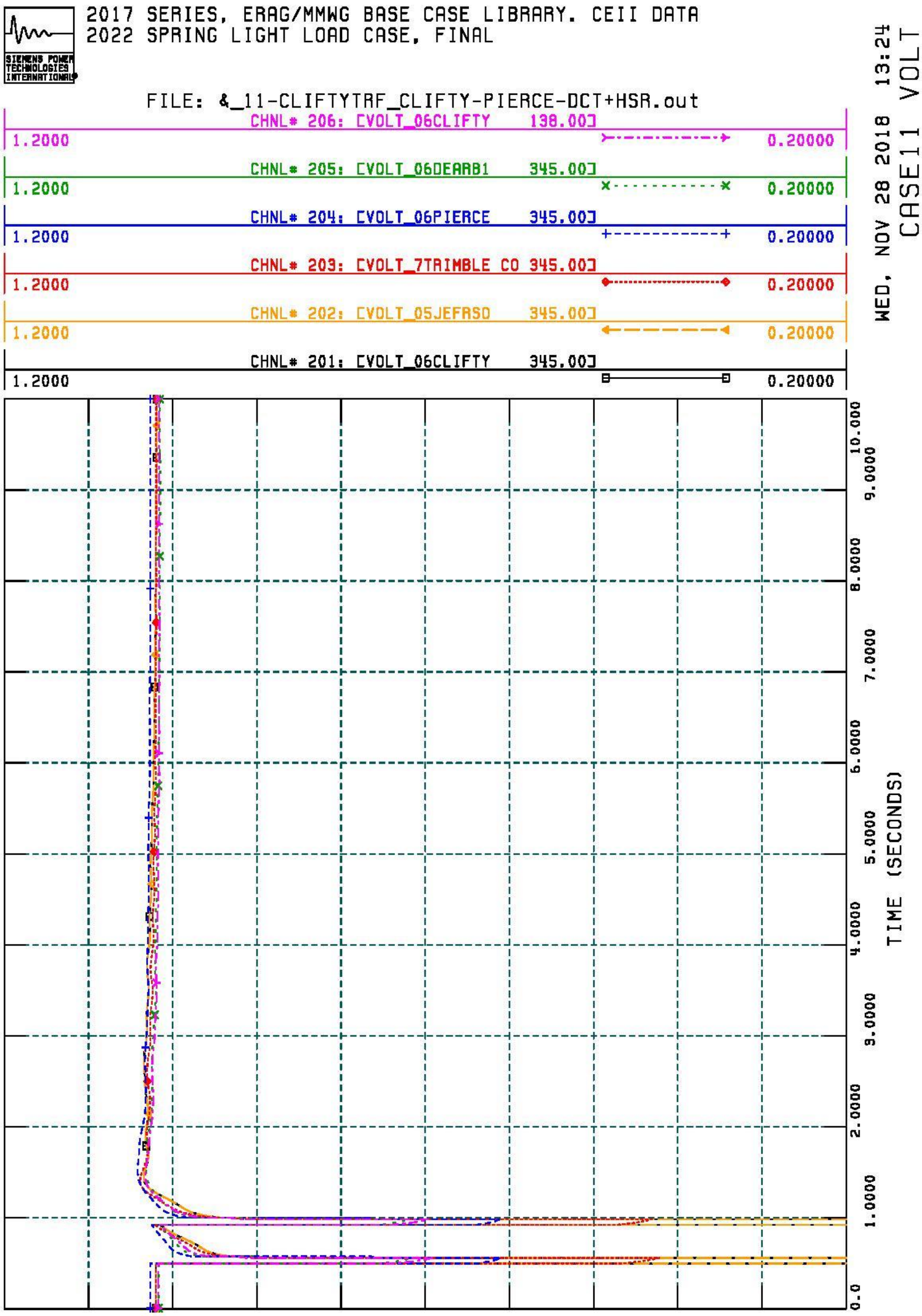
2017 SERIES, ERAG/MMWG BASE CASE LIBRARY. CEII DATA
2022 SPRING LIGHT LOAD CASE, FINAL

FILE: &_11-CLIFTYTRF_CLIFTY-PIERCE-DCT+HSR.out



2017 SERIES, ERAG/MMWG BASE CASE LIBRARY. CEII DATA
2022 SPRING LIGHT LOAD CASE, FINAL

WED, NOV 28 2018 13:24
CASE12 GEN SPD

FILE: &_12-BUCKNER-MIDDLETOWN_CLIFTY-PIERCE-DCT+HSR.out

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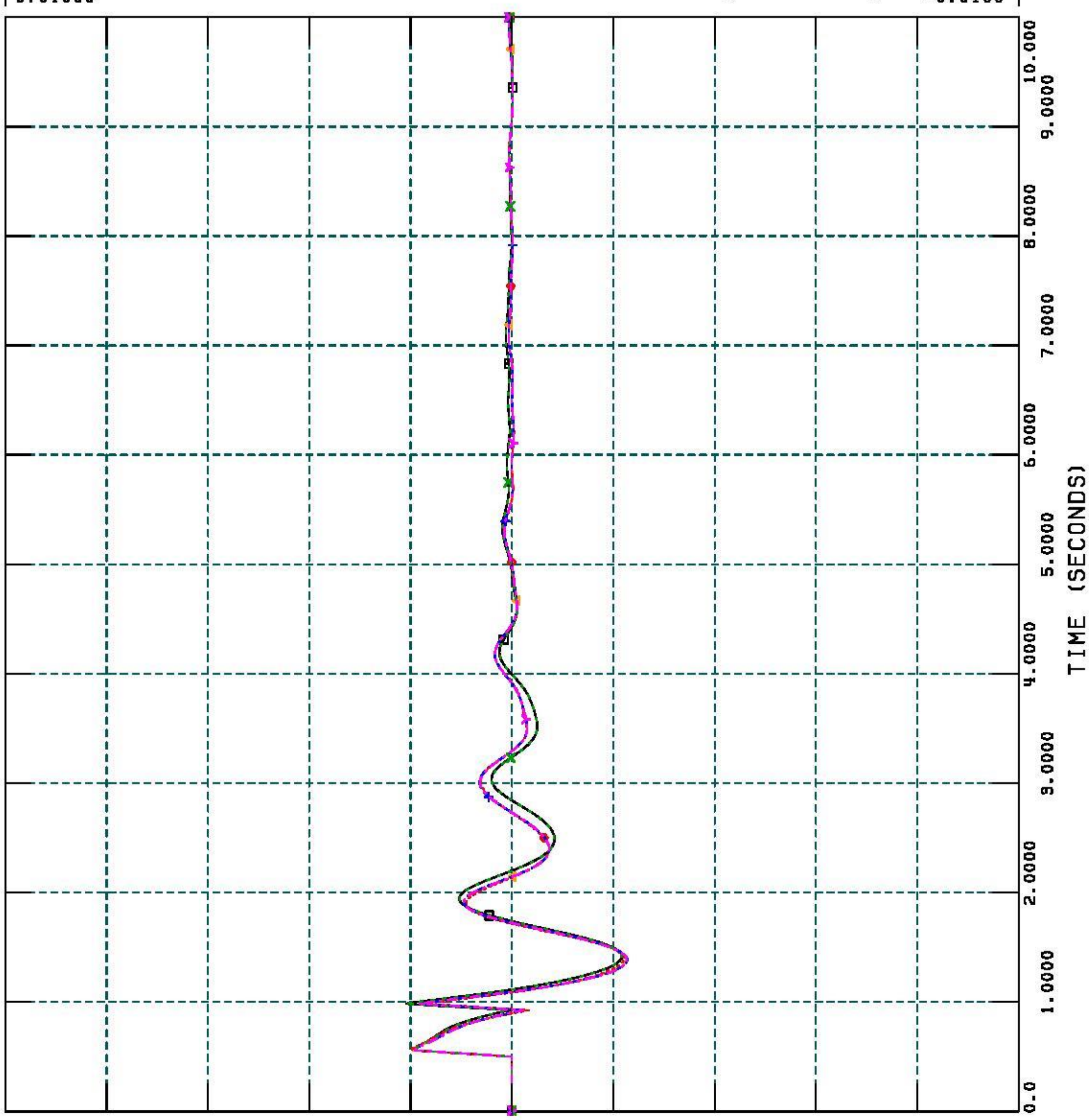
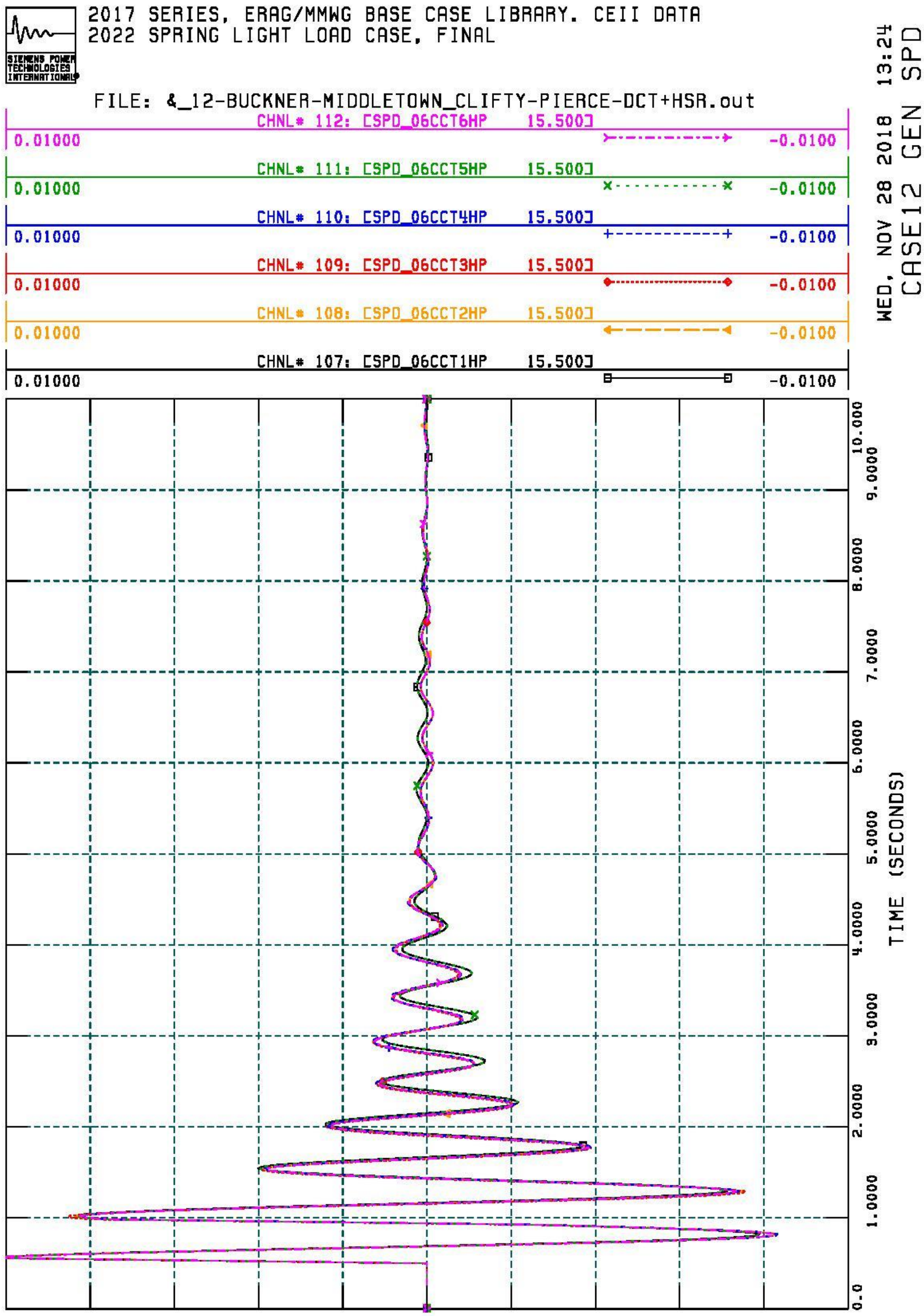
0.01000	CHNL# 105: [SPD_06CCT5LP	15.500]	-0.0100
0.01000	CHNL# 104: [SPD_06CCT4LP	15.500]	-0.0100
0.01000	CHNL# 103: [SPD_06CCT3LP	15.500]	-0.0100
0.01000	CHNL# 102: [SPD_06CCT2LP	15.500]	-0.0100
0.01000	CHNL# 101: [SPD_06CCT1LP	15.500]	-0.0100




2017 SERIES, ERAG/MMWG BASE CASE LIBRARY. CEII DATA
2022 SPRING LIGHT LOAD CASE, FINAL
SIEMENS POWER TECHNOLOGIES INTERNATIONAL
FILE: &_12-BUCKNER-MIDDLETOWN_CLIFTY-PIERCE-DCT+HSR.out
CHNL# 112: [SPD_06CCT6HP 15.500]
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CHNL# 111: [SPD_06CCT5HP 15.500]
0.01000 -0.0100
CHNL# 110: [SPD_06CCT4HP 15.500]
0.01000 -0.0100
CHNL# 109: [SPD_06CCT3HP 15.500]
0.01000 -0.0100
CHNL# 108: [SPD_06CCT2HP 15.500]
0.01000 -0.0100
CHNL# 107: [SPD_06CCT1HP 15.500]
0.01000 -0.0100
WED, NOV 28 2018 13:24
CASE12 GEN SPD
TIME (SECONDS)
0.0
1.0000
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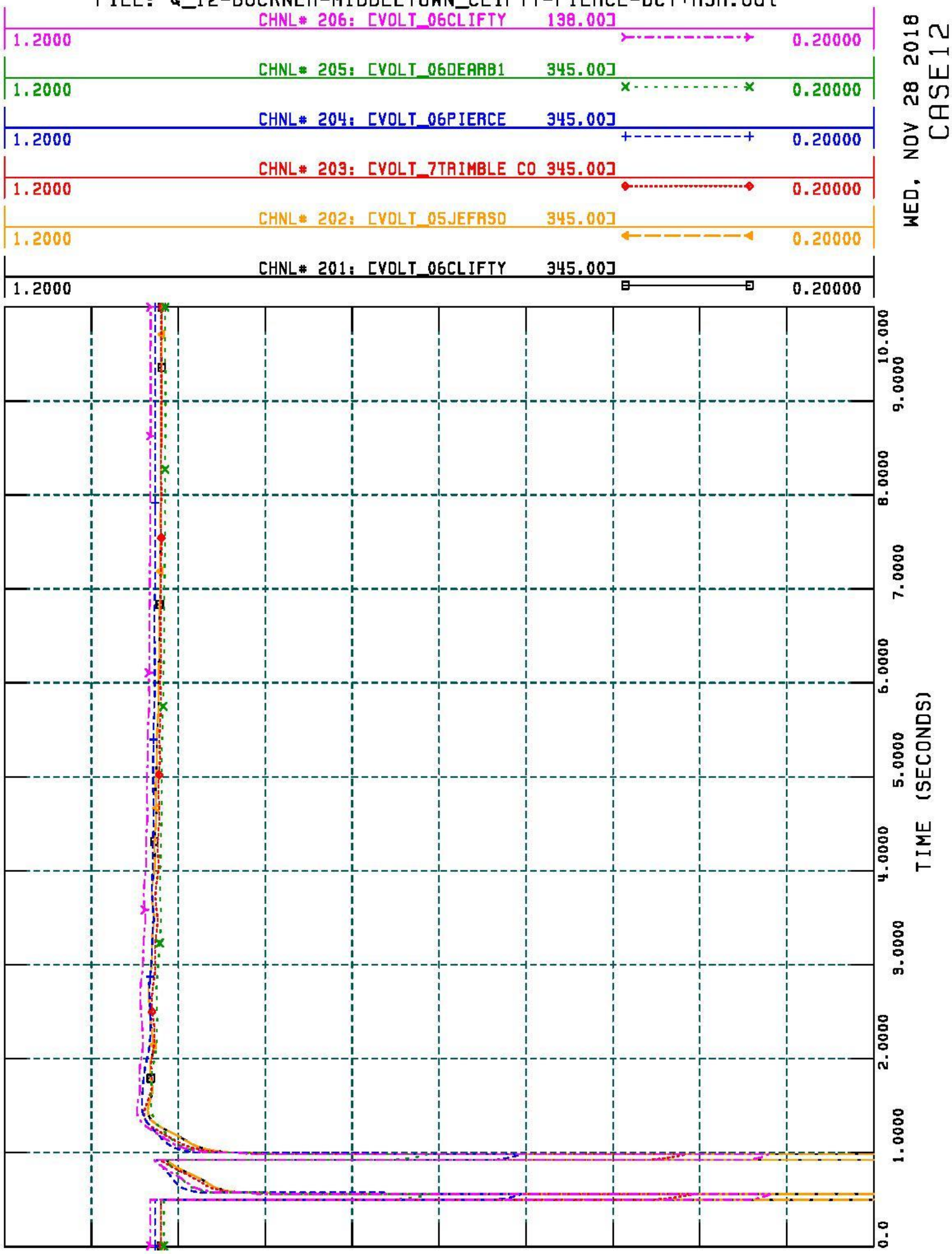
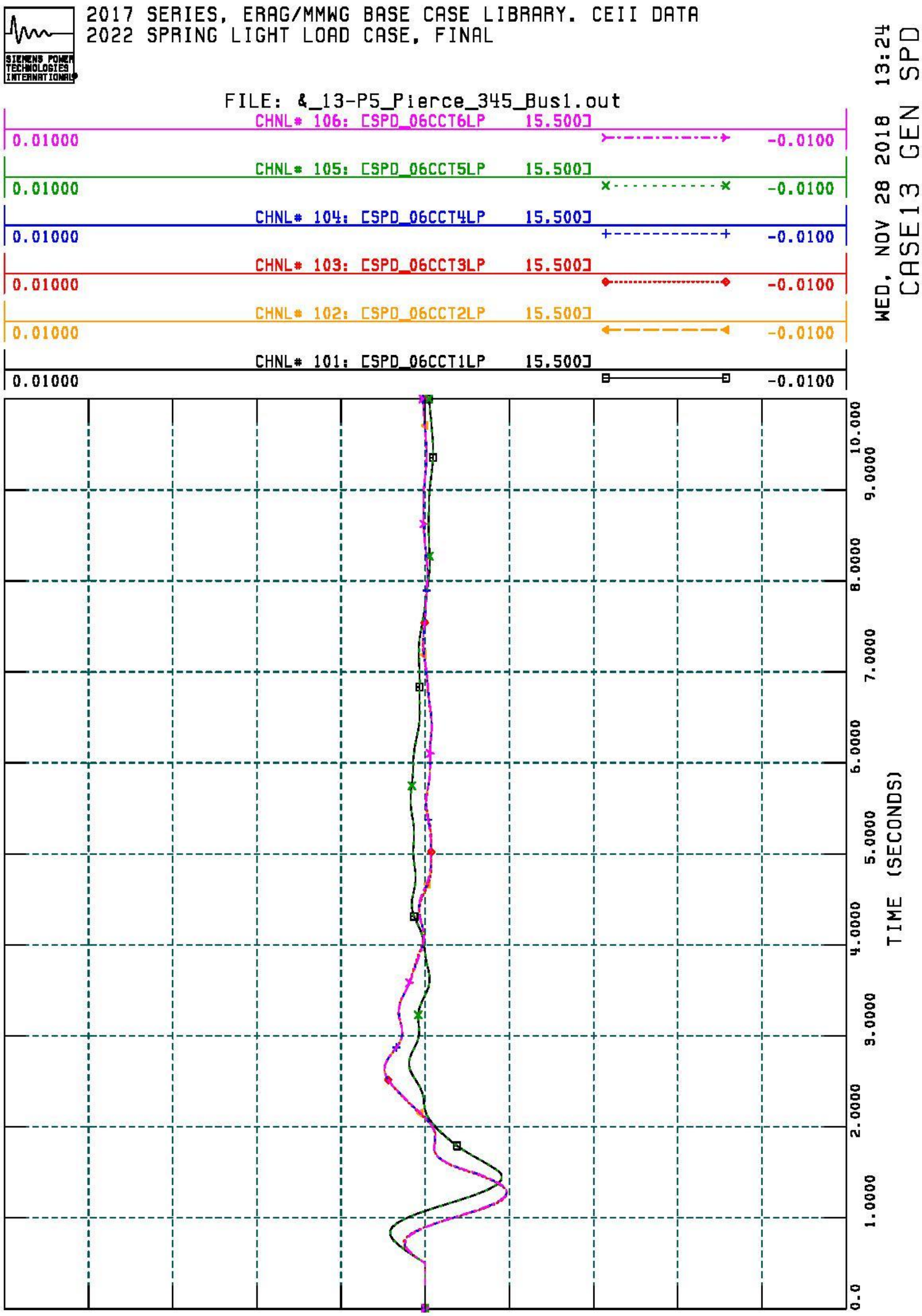
2017 SERIES, ERAG/MMWG BASE CASE LIBRARY. CEII DATA
2022 SPRING LIGHT LOAD CASE, FINAL

FILE: &_12-BUCKNER-MIDDLETOWN_CLIFTY-PIERCE-DCT+HSR.out




2017 SERIES, ERAG/MMWG BASE CASE LIBRARY. CEII DATA
2022 SPRING LIGHT LOAD CASE, FINAL
SIEMENS POWER TECHNOLOGIES INTERNATIONAL
FILE: &_13-P5_Pierce_345_Bus1.out
CHNL# 106: [SPD_06CCT6LP 15.500]
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-0.0100
CHNL# 105: [SPD_06CCT5LP 15.500]
0.01000
-0.0100
CHNL# 104: [SPD_06CCT4LP 15.500]
0.01000
-0.0100
CHNL# 103: [SPD_06CCT3LP 15.500]
0.01000
-0.0100
CHNL# 102: [SPD_06CCT2LP 15.500]
0.01000
-0.0100
CHNL# 101: [SPD_06CCT1LP 15.500]
0.01000
-0.0100
WED, NOV 28 2018 13:24
CASE13 GEN SPD
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3.0000
4.0000
5.0000
6.0000
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8.0000
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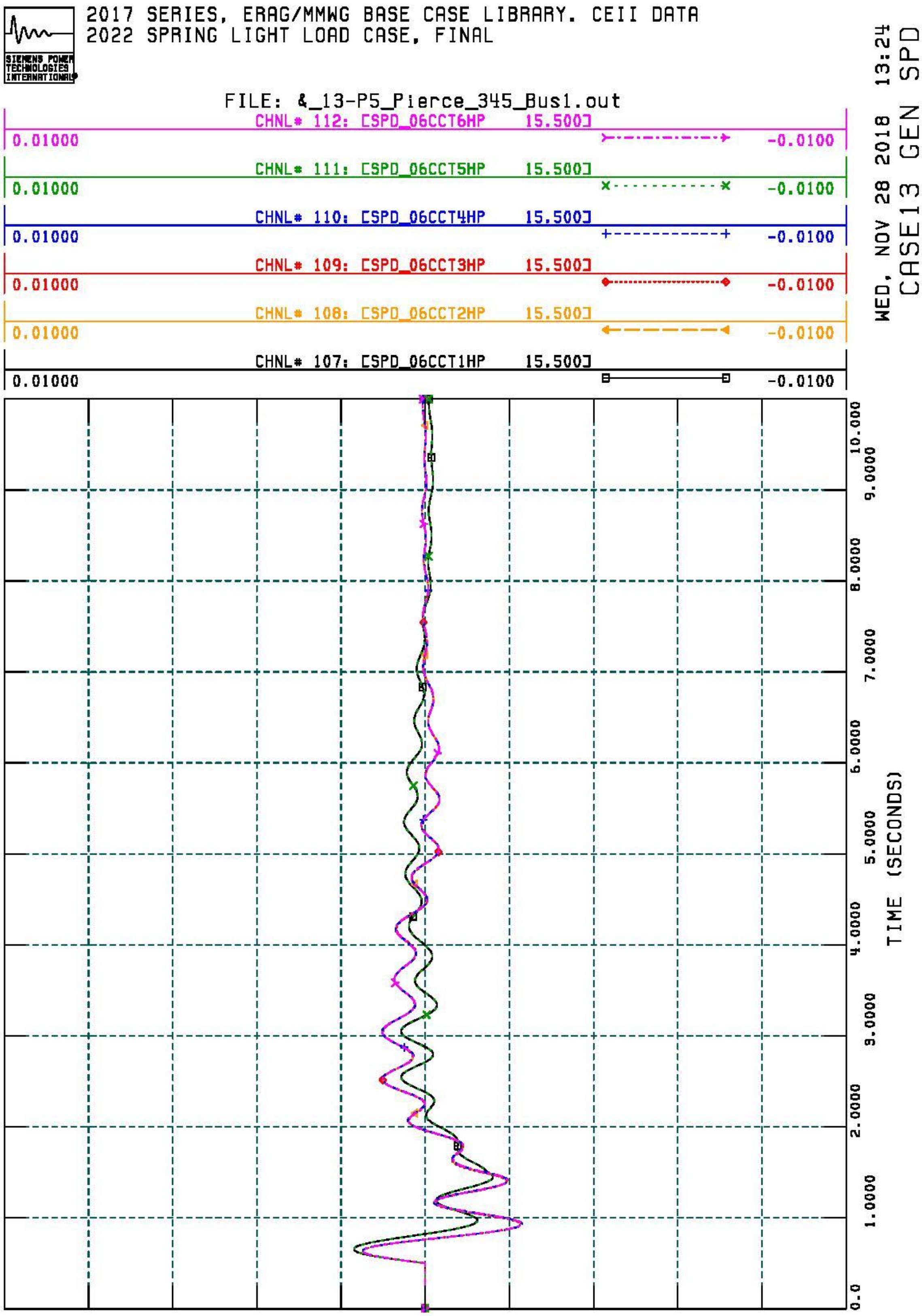
10.000
TIME (SECONDS)


2017 SERIES, ERAG/MMWG BASE CASE LIBRARY. CEII DATA
2022 SPRING LIGHT LOAD CASE, FINAL
SIEMENS POWER TECHNOLOGIES INTERNATIONAL
FILE: &_13-P5_Pierce_345_Bus1.out
CHNL# 112: [SPD_06CCT6HP 15.500]
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CHNL# 111: [SPD_06CCT5HP 15.500]
0.01000 -0.0100
CHNL# 110: [SPD_06CCT4HP 15.500]
0.01000 -0.0100
CHNL# 109: [SPD_06CCT3HP 15.500]
0.01000 -0.0100
CHNL# 108: [SPD_06CCT2HP 15.500]
0.01000 -0.0100
CHNL# 107: [SPD_06CCT1HP 15.500]
0.01000 -0.0100
WED, NOV 28 2018 13:24
CASE13 GEN SPD
0.0
1.0000
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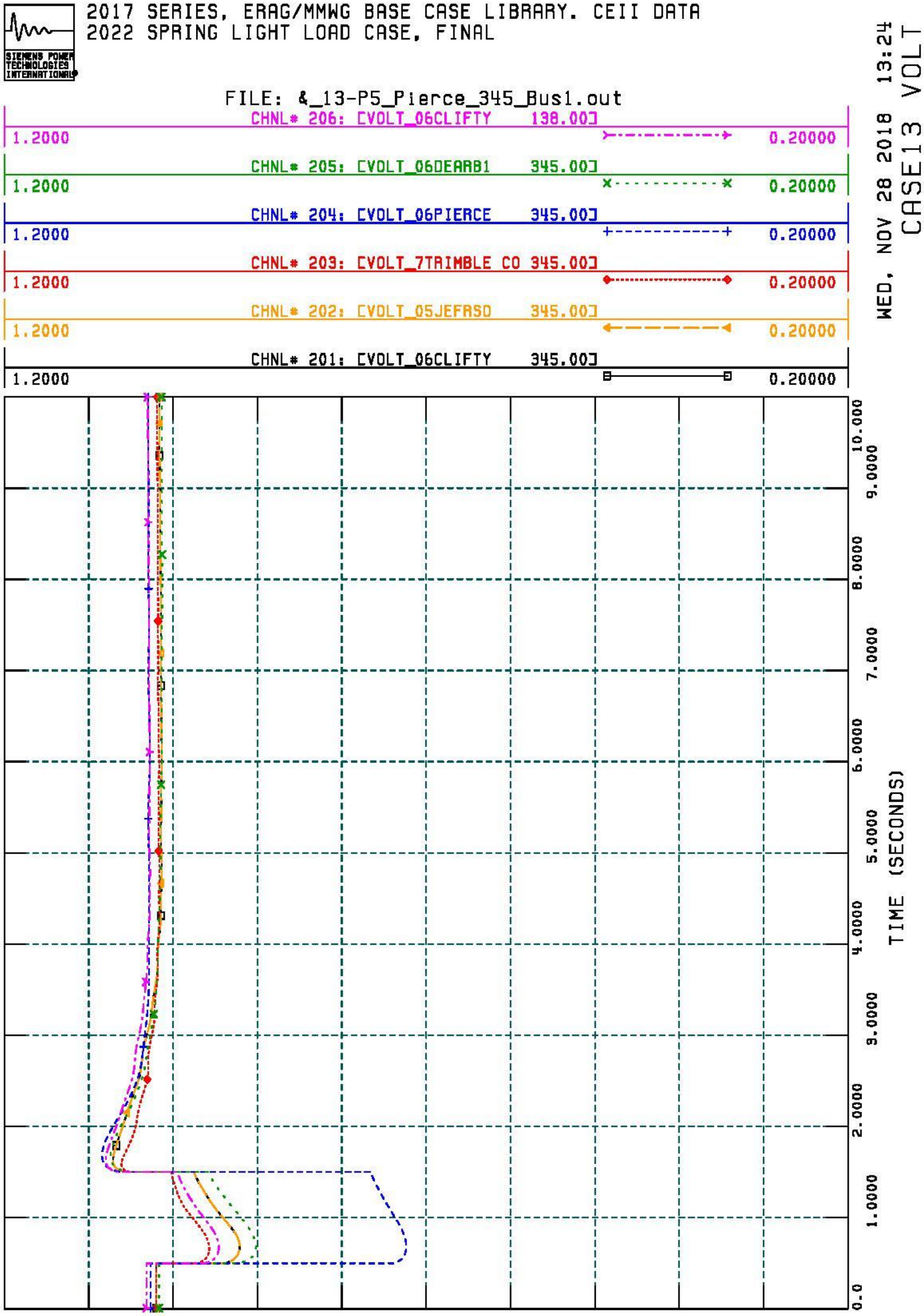
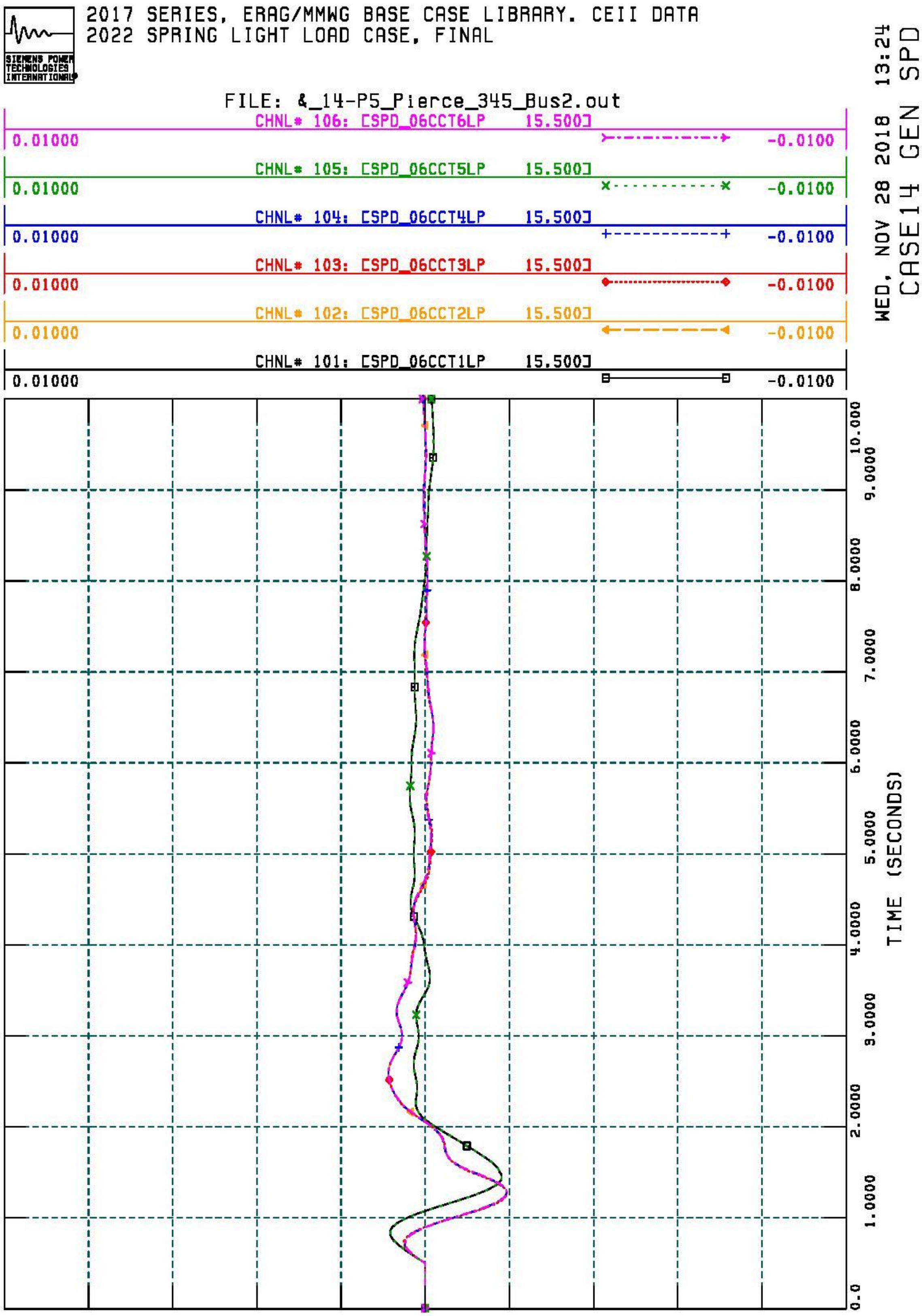
TIME (SECONDS)

2017 SERIES, ERAG/MMWG BASE CASE LIBRARY. CEII DATA
2022 SPRING LIGHT LOAD CASE, FINAL




2017 SERIES, ERAG/MMWG BASE CASE LIBRARY. CEII DATA
2022 SPRING LIGHT LOAD CASE, FINAL
SIEMENS POWER TECHNOLOGIES INTERNATIONAL
FILE: &_14-P5_Pierce_345_Bus2.out
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-0.0100
CHNL# 104: [SPD_06CCT4LP 15.500]
0.01000
-0.0100
CHNL# 103: [SPD_06CCT3LP 15.500]
0.01000
-0.0100
CHNL# 102: [SPD_06CCT2LP 15.500]
0.01000
-0.0100
CHNL# 101: [SPD_06CCT1LP 15.500]
0.01000
-0.0100
WED, NOV 28 2018 13:24
CASE14 GEN SPD
TIME (SECONDS)
0.0
1.0000
2.0000
3.0000
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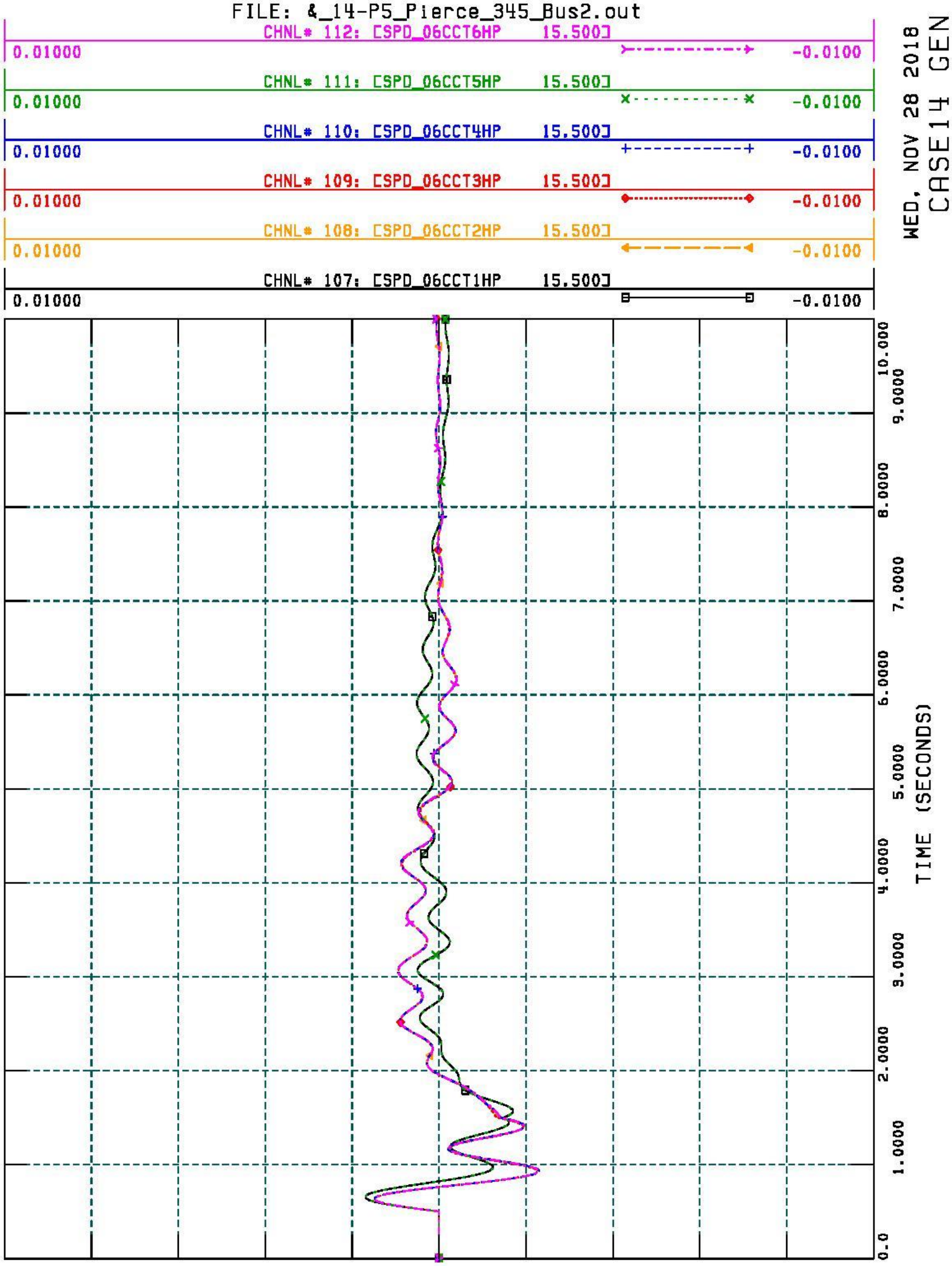
10.000

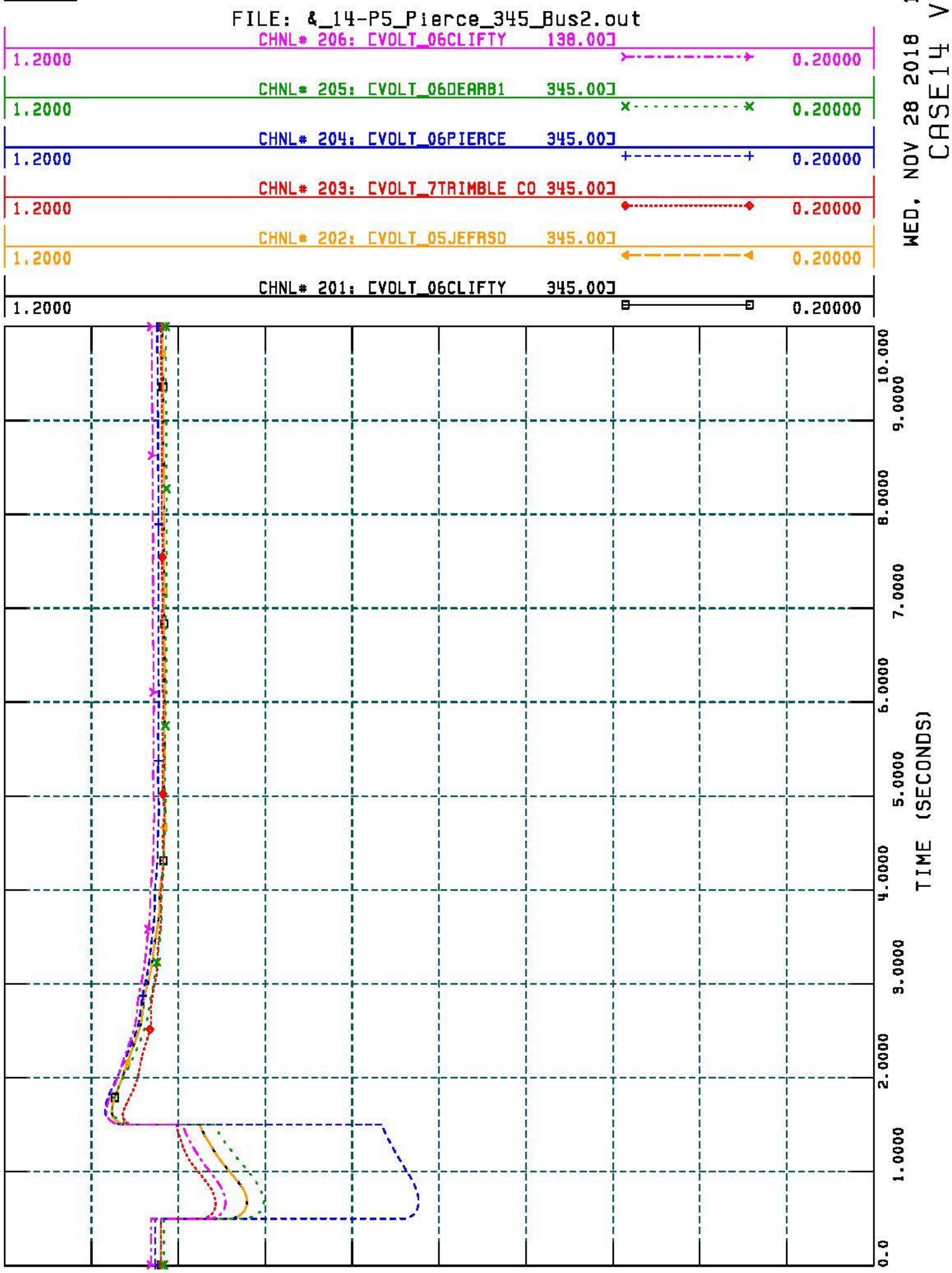
2017 SERIES, ERAG/MMWG BASE CASE LIBRARY. CEII DATA
2022 SPRING LIGHT LOAD CASE, FINAL

WED, NOV 28 2018 13:24
CASE14 GEN SPD

FILE: &_14-P5_Pierce_345_Bus2.out



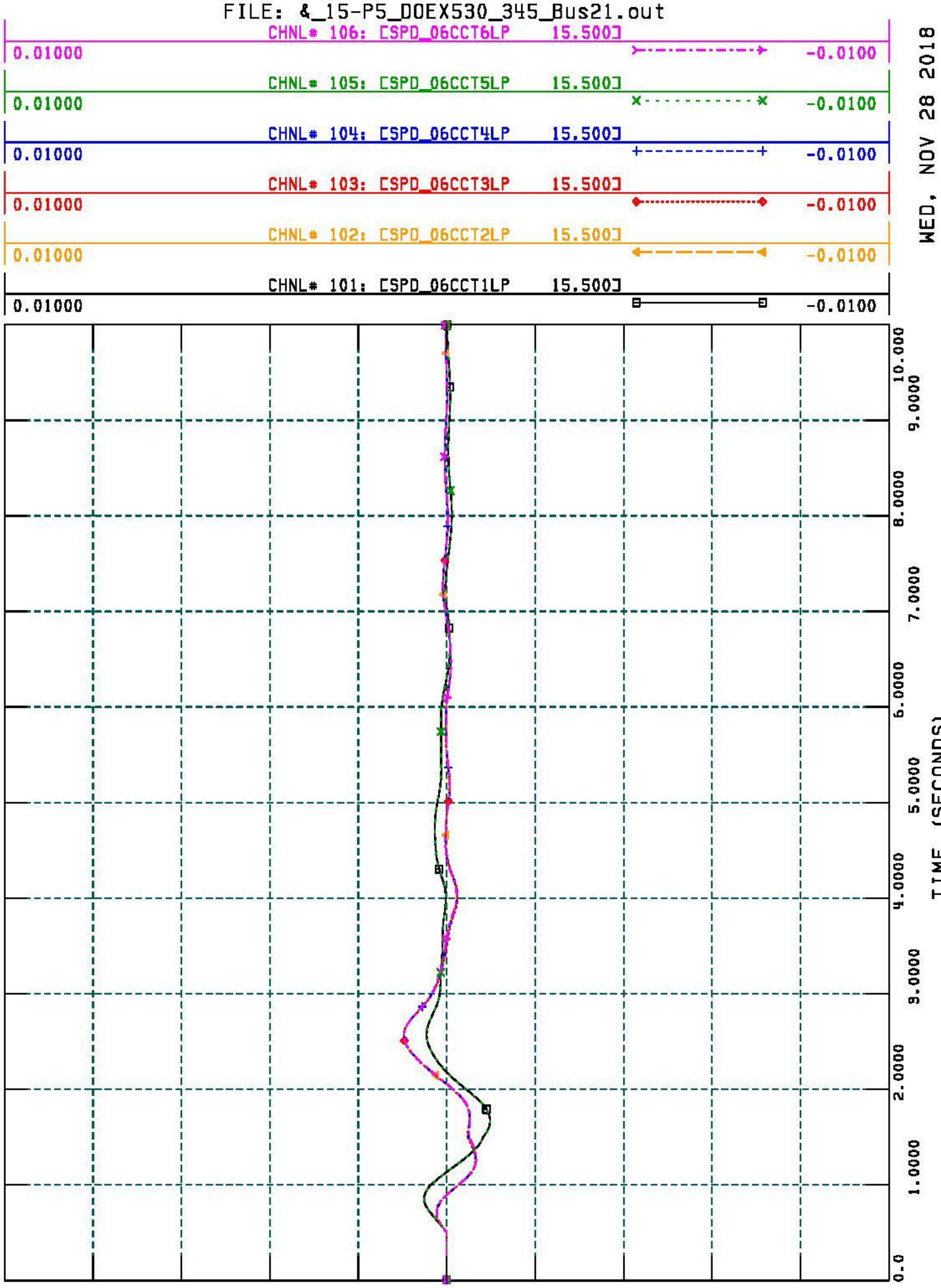
2017 SERIES, ERAG/MMWG BASE CASE LIBRARY. CEII DATA
2022 SPRING LIGHT LOAD CASE, FINAL

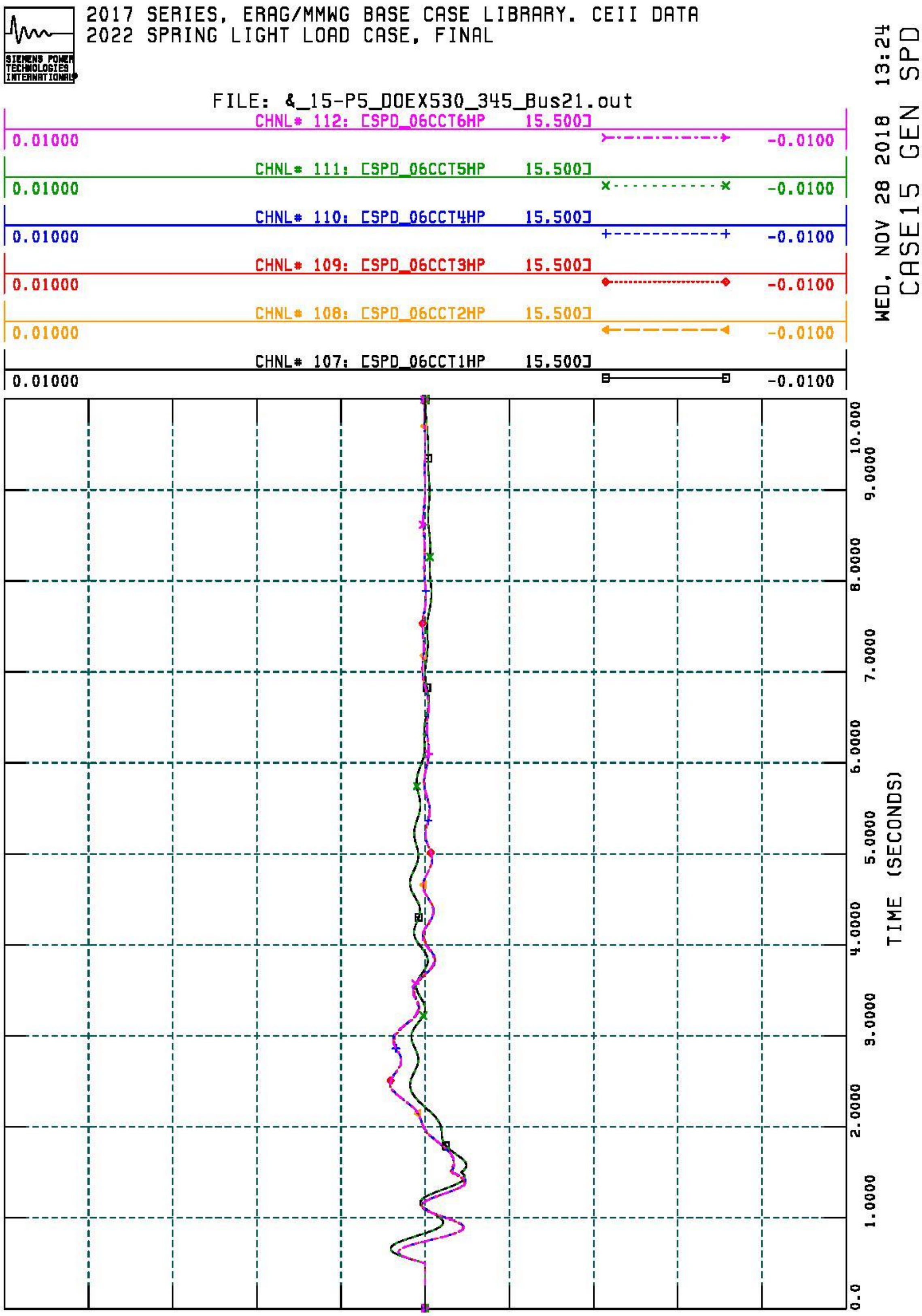


2017 SERIES, ERAG/MMWG BASE CASE LIBRARY. CEII DATA
2022 SPRING LIGHT LOAD CASE, FINAL

WED, NOV 28 2018 13:24
CASE15 GEN SPD

FILE: &_15-P5_DOEX530_345_Bus21.out




2017 SERIES, ERAG/MMWG BASE CASE LIBRARY. CEII DATA
2022 SPRING LIGHT LOAD CASE, FINAL
SIEMENS POWER TECHNOLOGIES INTERNATIONAL
FILE: &_15-P5_DOEX530_345_Bus21.out
CHNL# 112: [SPD_06CCT6HP 15.500]
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-0.0100
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0.01000
-0.0100
CHNL# 110: [SPD_06CCT4HP 15.500]
0.01000
-0.0100
CHNL# 109: [SPD_06CCT3HP 15.500]
0.01000
-0.0100
CHNL# 108: [SPD_06CCT2HP 15.500]
0.01000
-0.0100
CHNL# 107: [SPD_06CCT1HP 15.500]
0.01000
-0.0100
WED, NOV 28 2018 13:24
CASE15 GEN SPD
0.0
1.0000
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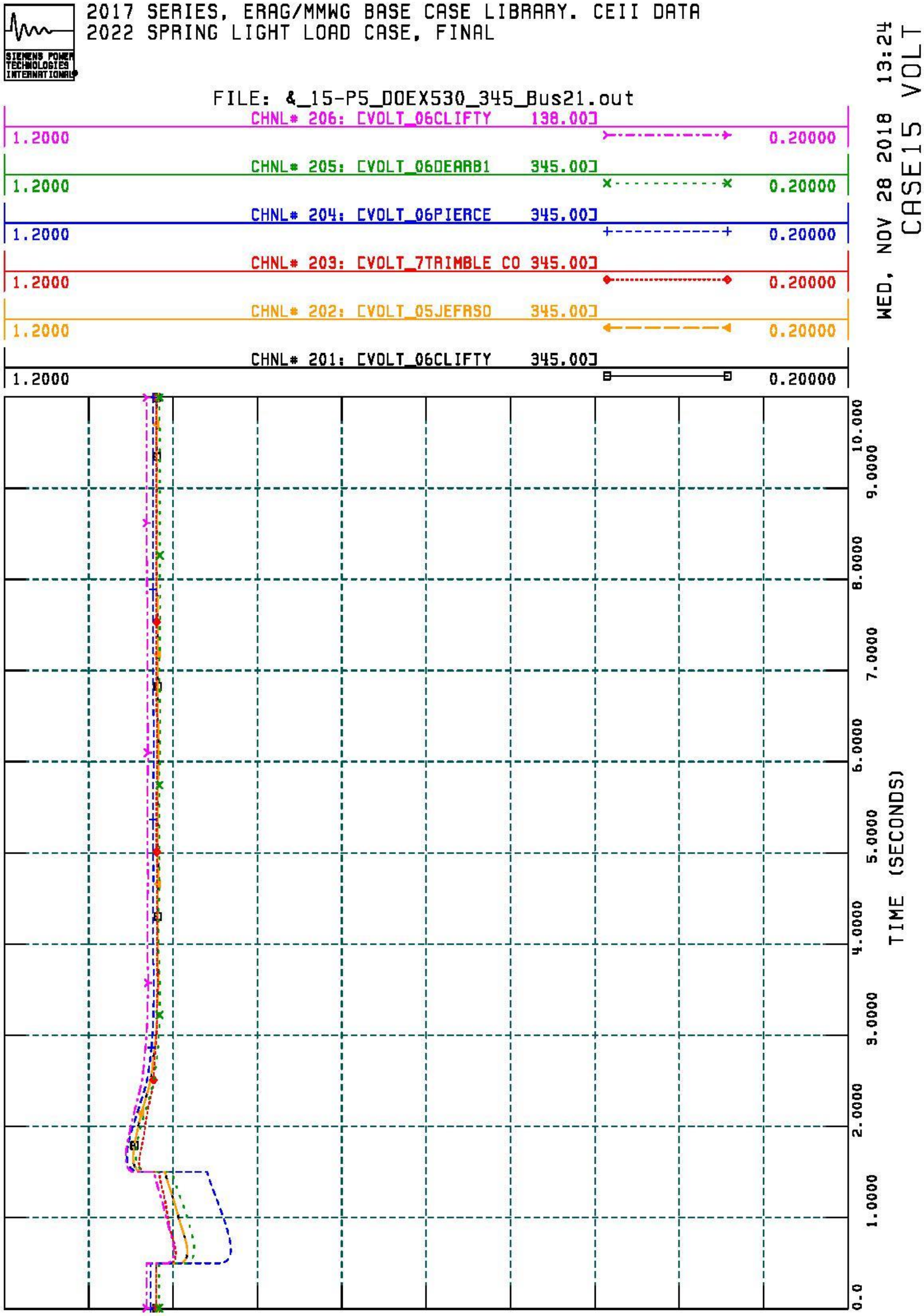
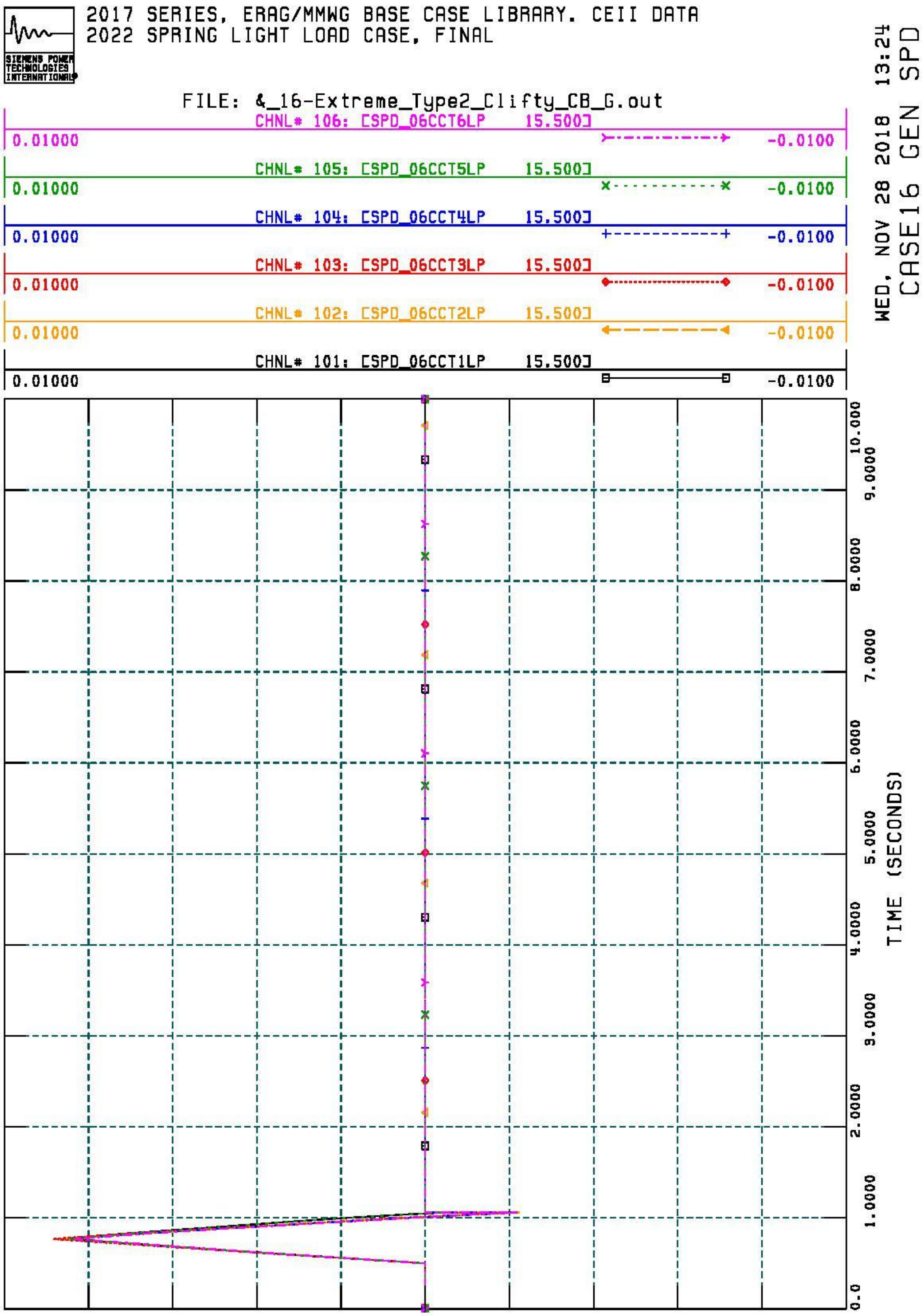
TIME (SECONDS)

2017 SERIES, ERAG/MMWG BASE CASE LIBRARY. CEII DATA
2022 SPRING LIGHT LOAD CASE, FINAL




2017 SERIES, ERAG/MMWG BASE CASE LIBRARY. CEII DATA
2022 SPRING LIGHT LOAD CASE, FINAL
SIEMENS POWER TECHNOLOGIES INTERNATIONAL
FILE: &_16-Extreme_Type2_Clifty_CB_G.out
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-0.0100
CHNL# 105: [SPD_06CCT5LP 15.500]
0.01000
-0.0100
CHNL# 104: [SPD_06CCT4LP 15.500]
0.01000
-0.0100
CHNL# 103: [SPD_06CCT3LP 15.500]
0.01000
-0.0100
CHNL# 102: [SPD_06CCT2LP 15.500]
0.01000
-0.0100
CHNL# 101: [SPD_06CCT1LP 15.500]
0.01000
-0.0100
WED, NOV 28 2018 13:24
CASE16 GEN SPD
0.0
1.0000
2.0000
3.0000
4.0000
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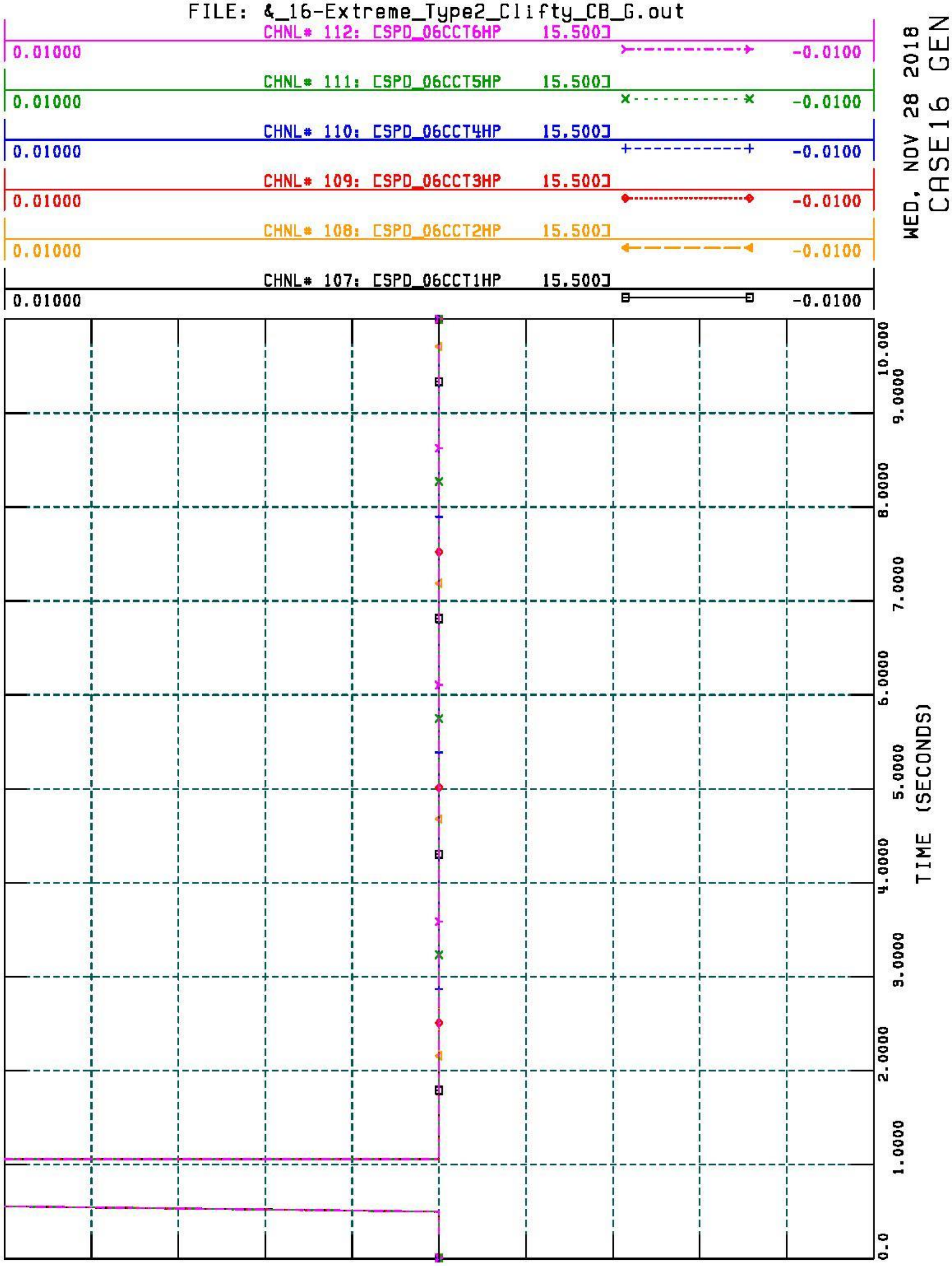
8.0000
9.0000
10.000
TIME (SECONDS)

SIEMENS POWER TECHNOLOGIES INTERNATIONAL

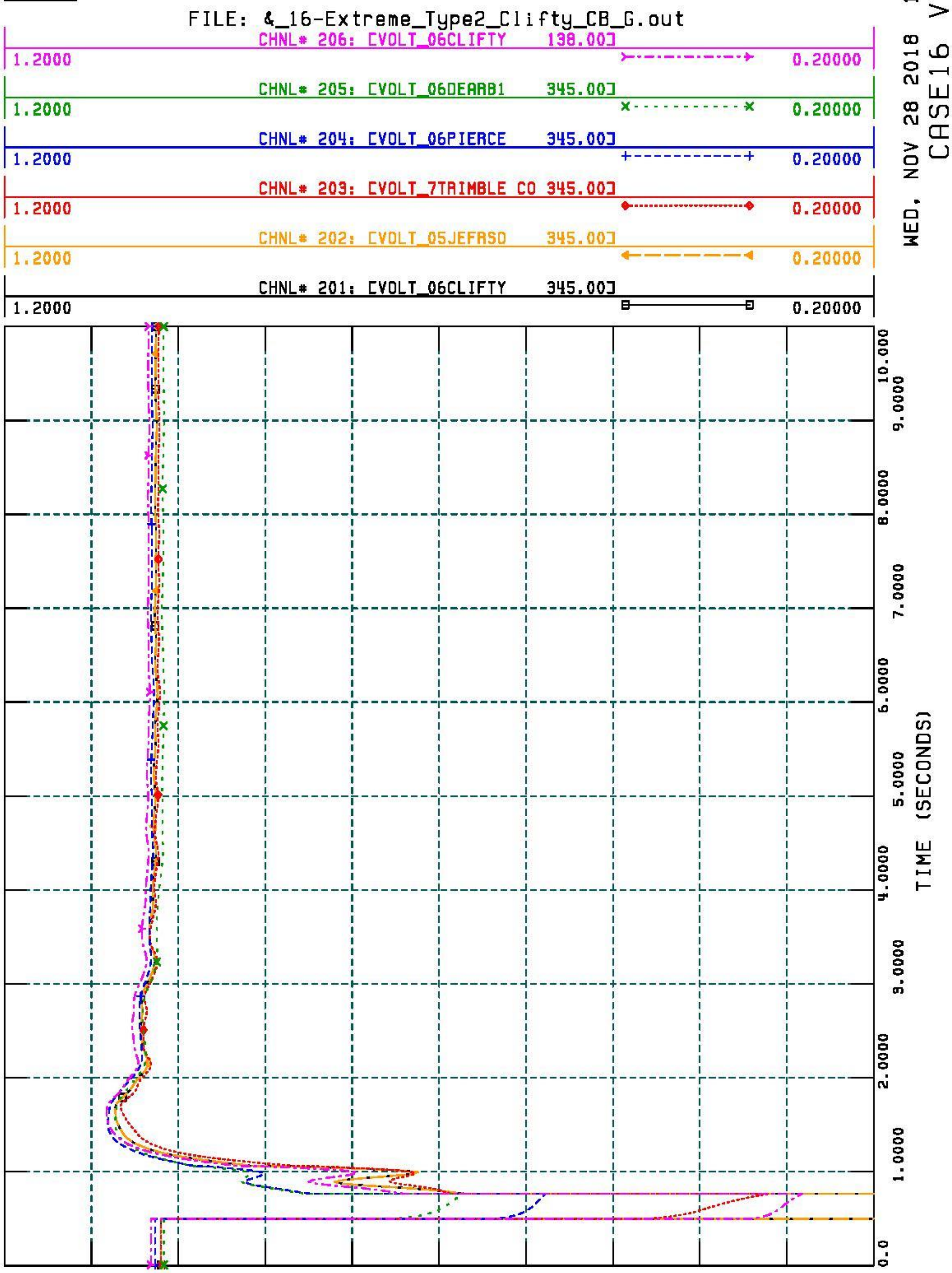
2017 SERIES, ERAG/MMWG BASE CASE LIBRARY. CEII DATA
2022 SPRING LIGHT LOAD CASE, FINAL

WED, NOV 28 2018 13:24
CASE16 GEN SPD

FILE: &_16-Extreme_Type2_Clifty_CB_G.out



2017 SERIES, ERAG/MMWG BASE CASE LIBRARY. CEII DATA
2022 SPRING LIGHT LOAD CASE, FINAL



<u>Appendix</u> – Clifty Creek Dynamic Model Data

Generator Model - GENROU		
Clifty Creek	Units 1 - 6	
	LP	HP
MVA base	100	117.65
T'd0	6	5.6
T"d0	0.041	0.033
T'q0	0.3	0.48
T"q0	0.082	0.079
H	9.9	2.86
D	0	0
Xd	1.16	1.34
Xq	1.11	1.29
X'd	0.25	0.19
X'q	0.406	0.322
X"d, X"q	0.165	0.145
Xl	0.085	0.085
S1.0	0.09	0.05
S1.2	0.58	0.45

Exciter Model - ESAC8B												
Clifty Creek	Unit 1		Unit 2		Unit 3		Unit 4		Unit 5		Unit 6	
	LP	HP	LP	HP	LP	HP	LP	HP	LP	HP	LP	HP
TR (sec)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
KP	120	120	120	120	120	120	120	120	120	120	120	120
KI	30	30	30	30	30	30	30	30	30	30	30	30
KD	30	30	30	30	30	30	30	30	30	30	30	30
TD (sec)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
KA	0.265	0.262	1.2	0.973	1.2	0.973	1.2	0.973	0.265	0.262	1.2	0.973
TA	0	0	0	0	0	0	0	0	0	0	0	0
VR MAX or zero	2.5	2.4	11.2	9.1	11.2	9.1	11.2	9.1	2.5	2.4	11.2	9.1
VR MIN	0	0	0	0	0	0	0	0	0	0	0	0
TE > 0 (sec)	0.6556	0.6556	0.6499	0.6556	0.6499	0.6556	0.6499	0.6556	0.6556	0.6556	0.6499	0.6556
KE or zero	0	0	0	0	0	0	0	0	0	0	0	0
E1	2.574	2.574	2.5965	2.574	2.5965	2.574	2.5965	2.574	2.574	2.574	2.5965	2.574
SE(E1)	0.0897	0.0897	0.0889	0.0897	0.0889	0.0897	0.0889	0.0897	0.0897	0.0897	0.0889	0.0897
E2	3.432	3.432	3.462	3.432	3.462	3.432	3.462	3.432	3.432	3.432	3.462	3.432
SE(E2)	0.3497	0.3497	0.3467	0.3497	0.3467	0.3497	0.3467	0.3497	0.3497	0.3497	0.3467	0.3497

Turbine Governor Model - IEEEG1	
Clifty Creek	Units 1 - 6
K	24.582
T1	0
T2	0
T3 (> 0)	0.1
Uo	0.1
Uc (< 0.)	-0.1
PMAX	1.87
PMIN	0
T4	0.1
K1	0.27
K2	0
T5	15.741
K3	0.36
K4	0.37
T6	0.3
K5	0
K6	0
T7	0
K7	0
K8	0

Compensator Model - COMP		
Clifty Creek	Units 1 - 6	
	LP	HP
Xe	0.071	0.093

Turbine Load Controller Model - LCFB1	
Clifty Creek	Units 1 - 6
Fb, Frequency bias gain(pu/pu)	0
Tpelec, Electrical power transducer time constant(sec)	0
db, Controller dead band(pu)	0.0001
emax, Maximum control error(pu)	0
Kp, Proportional gain	0
Ki, Integral gain	0
lrmax, Maximum turbine speed/load reference bias(pu)	0
fbf, Frequency bias flag	1
pbf, Power Controller flag	1