New York ISO
Independent System Operator

# TOTAL EAST STABILITY LIMITS ANALYSIS FOR ALL LINES I/S AND OUTAGE CONDITIONS (TE-23)

A Report by the
New York Independent System Operator

**April 2023**

## Executive Summary

This study was conducted to examine the stability limits for the Total East interface and determine the impact of construction of the Princetown 345 kV substation and associated equipment built as part of the Segment A and Segment B projects, as well as the Leeds-Hurley smart wire project. The study covers the impact of transmission upgrades from the Segment A and Segment B projects up to and including the Princetown – New Scotland (361 and 362) 345 kV lines, the Knickerbocker 345 kV substation, the Knickerbocker series compensation path to Pleasant Valley 345 kV, and the Van Wagner 345 kV substation. A future analysis will be conducted for the full completion of the Segment A&B project, accounting for the Edic-Princetown (351 and 352) 345 kV lines and the Dover PAR.

The Total East Interface is a closed interface linking central NY to eastern NY. For more details refer to Table 2 and Fig 1. The study provides updates to the all-lines-in-service limit as well as the two equipment outage limits associated with Total East. The transfer limits developed in this analysis increase by 150 to 200 MW as shown on Table 1.

The limits recommended in this report are all based on stable system response at the highest transfer level tested. There were no instances of any system or unit instability observed in this analysis.

On an informational basis, this study examined the system responses for contingencies involving three-phase faults, line-to-line-to-ground faults as well as the normal criteria single-phase line-to-ground faults. The new all-lines-in-service stability limits for Total East is valid for either form of contingency at the levels tested.

It is recommended that the Total East stability transfer limits be updated as reported on Table 1.

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## Introduction

The purpose of this study was to determine the impact of transmission upgrades from the Segment A and Segment B projects on the Total East interface stability limits, up to and including the Princetown – New Scotland (361 and 362) 345 kV lines, the Knickerbocker 345 kV substation, the Knickerbocker series compensation path to Pleasant Valley 345 kV, and the Van Wagner 345 kV substation.

The study evaluated the all lines in-service condition, an outage on the 5018 line and the outage of an SVC/STATCOM. The Marcy South Series Capacitors (MSSC) were studied in the bypassed configuration, and changes in their status showed negligible impact on Total East limits. Sensitivities were also performed on the Segment B series compensation and the Leeds – Hurley SDU and the status of each was determined to have negligible impact on the Total East stability limit. The dynamic response of the system was gauged by examining the voltage response at Edic and Pleasant Valley, and the generator angles at Athens, Gilboa, Niagara and Moses.

## Summary of Proposed Limits

Table 1 shows the new proposed limits and the existing limits for Total East. The new proposed limits would have an All Lines In value of 6150 MW with a 750 MW reduction for outages on the 5018 Ramapo- Hotpatcong 500 kV Line and a further 100 MW reduction for the outage of any SVC/STATCOM.

**Table 1**

**Proposed and Existing Total East Stability Limits**

| | Scenario | Proposed Limit (MW) | | Existing Limit (MW) | | Diff (MW) |
|---|---|---|---|---|---|---|
| 1 | All Lines In | 6150 | | 6000 | | +150 |
| 2 | 5018 Ramapo-Hotpatcong 500 kV O/S | 5400 | | 5200 | | +200 |
| 3 | 5018 Ramapo-Hopatcong 500 kV & (SVC or Statcom O/S) | 5300 | | 5100 | | +200 |

## System Operating Limit Methodology

"NYSRC Reliability Rules for Planning and Operating the New York State Power System" (NYSRC Rules) provides the methodology for developing System Operating Limits (SOLs) within the NYISO Reliability Coordinator Area. Rule C of the NYSRC Rules sets forth the contingencies to be evaluated and the performance requirements to be applied in developing SOLs. Rule C also incorporates NYISO Transmission Planning Guideline #3-1, "Guideline for Stability Analysis and Determination of Stability-Based Transfer Limits" set forth in Attachment H to the NYISO "Transmission Expansion and Interconnection Manual."

## Interface Summary

The Total East interface definition is given in Table 2 and illustrated in Figure 1.

**Table 2**

**Total East Interface Definition**

| Name | Line ID | (kV) | | Name | Line ID | (kV) |
|---|---|---|---|---|---|---|
| Edic-Gordon Rd* | 14 | 345 | | Hudson-Farragut* | C3403 | 345 |
| Marcy-New Scotland* | 18 | 345 | | Hudson-Farragut* | B3402 | 345 |
| *Fraser-Gilboa | GF5-35 | 345 | | Linden-Goethals* | A2253 | 230 |
| East Springfield - Inghams* | 7 | 115 | | *Cresskill – Sparkill | 751 | 69 |
| Inghams PAR | PAR | 115 | | *Harings Corners – W. Nyack | 701 | 69 |
| Inghams Bus Tie | R81 | 115 | | *Harings Corners – Corporate Drive | 703 | 138 |
| Middletown-Rock Tavern* | CCRT34 | 345 | | *Montvale – Bluehill | 44 | 69 |
| Coopers Corners- Dolson Ave* | CCDA42 | 345 | | *Montvale – Bluehill | 43 | 69 |
| Middletown 345*/138 | BK114 | 345/138 | | *Montvale – Pearl River | 491 | 69 |
| West Woodbourne 115/69* | BK1 | 115/69 | | *Harings Corners – Pearl River | 45 | 34 |
| *Plattsburgh-Sand Bar | PV20 | 115 | | *S. Mahwah – Ramapo | 51 | 138 |
| Hopatcong-Ramapo* | 5018 | 500 | | *S. Mahwah - Hilburn | 65 | 69 |
| *Waldwick- S. Mahwah | J3410 | 345 | | S. Mahwah 138/345* | BK258 | 138/345 |
| *Waldwick-S. Mahwah | K3411 | 345 | | | | |

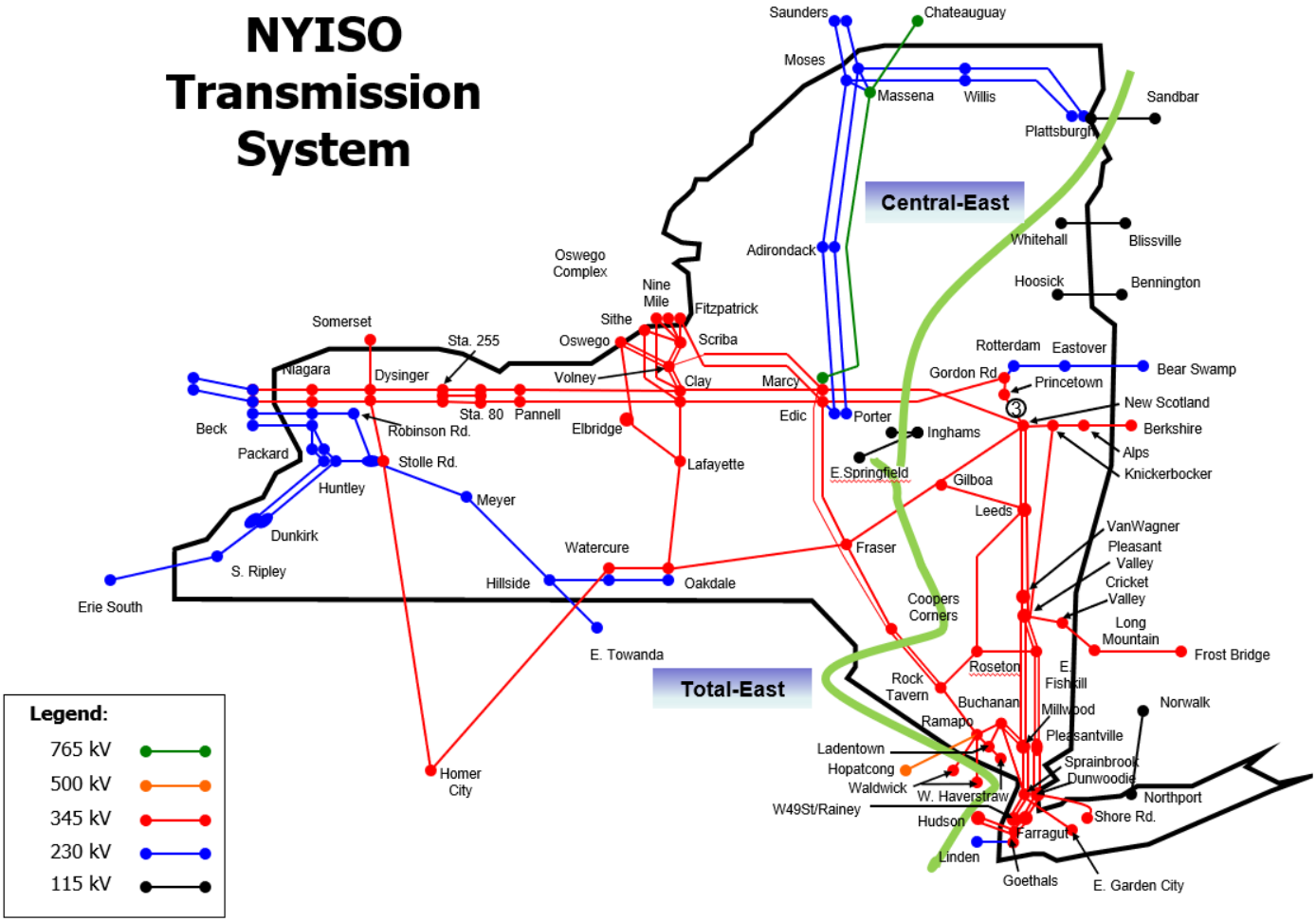


Figure 1. NYCA Transmission System Interface (Total East inset)

## System Representation and Transfer Case Development

The analysis was based on the 2022 NYISO Dynamics Base Case that was developed from the 2021 MMWG Dynamics Base Case with the NYISO representation updated to reflect the results of the NYISO 2022 Summer Operating Study.

The base case model includes the following:

- the NYISO Transmission Operator area;
- all Transmission Operator areas contiguous with NYISO;
- all system elements modeled as in-service;
- all generation represented;
- phase shifters in the regulating mode;
- the NYISO Load Forecast;
- transmission facility additions and retirements;
- generation facility additions and retirements;
- Remedial Action Scheme (RAS) models currently existing or projected for implementation within the studied time horizon;
- series compensation for each line at the expected operating level; and
- facility Ratings as provided by the Transmission Owner and Generator Owner.

Three transfer cases were developed as shown on Table 3. The capacitor banks at Oakdale and Edic were producing maximum VAR output of 135MVAR and 200MVAR respectively. The 7040 tie line between Hydro-Quebec and the NYCA was importing 1312 MW (all AC) with the DC lines put out of service.

Table 3
Transfer Cases

| | |
|---|---|
| A | TE 6845, Marcy Statcom I/S, Leeds I/S, Fraser I/S, 5018 I/S |
| B | TE 6015, Marcy Statcom I/S, Leeds I/S, Fraser I/S, 5018 O/S |
| C | TE 5915, Any SVC/Statcom O/S, 5018 O/S |

## Tested Contingencies

Fifty seven (57) contingencies were tested for each developed Total East transfer case scenario. Table 4 provides the identification and description of these contingencies.

Table 4.

Contingencies applied for evaluating Total East stability transfer limits.

| # | ID | Description |
|---|---|---|
| 1 | TE02(LLG) | LLG@FISHKILL-L/O TOWER(2-1938)FISHKILL*PLEASANTVILLE |
| 2 | TE03(LLG) | LLG@SPRAIN BK-L/O TOWER(2-1956)MILLWOOD*SPRAIN BROOK |
| 3 | TE10 | SLG-STK@RAMAPO (BKR T77-94-2) – L/O RAMAPO-ROCK TAVERN (77) / BKUP CLR Y94 |
| 4 | TE12 | SLG-STK@RAMAPO500 (BRK T1500-W72-2) – L/O RAMAPO-HOPATCONG (5018) / BKUP CLR#W72 |
| 5 | TE14 | SLG/STK@LEEDS*GILBOA / STK R391 / CLR#91 PL.VALLEY |
| 6 | TE15 | SLG-STK LEEDS BKRR9293 L/O LEEDS-VW59BKUPCLR93N.SCOT |
| 7 | TE16 | SLG/STK @ ROSETON/ROSETON*ROCK TAVERN#311/STK 31151 |
| 8 | TE18(LLG) | LLG@LADENTOWN-L/O TOWER Y88/Y94 DOUBLE CIRCUIT |
| 9 | TE20(LLG) | LLG@DUNWOODIE-L/O TOWER(2-1938)PLEASANTVILLE*DUNWO. |
| 10 | TE21 | 3PH@PLEAS.VAL-L/O TOWER(2-1961)PV*MILLWOOD DBL CKT |
| 11 | TE27 | SLG/STK@ROCK TAVERN*COOPERS/CLR ROCK TAVN*RAMAPO |
| 12 | TE29 | 3PH@N.SCOT / N.SCOT-LEEDS#93 W/HS RCL |
| 13 | TE30 | 3PH@LEEDS / GILBOA * LEEDS GL-3 |
| 14 | TE31 | 3PH@GILBOA – L/O GILBOA - NEW SCOTLAND (GNS-1) |
| 15 | TE32 | 3PH@NEW SCOTLAND - 77 BUS |
| 16 | TE33 | 3PH@NEW SCOTLAND - 99 BUS |
| 17 | TE34 | SLG-STK@GILBOA/GILBOA*NSCOT / STUCK 3208 |
| 18 | TE35 | 3PH-NC@LEEDS – L/O LEEDS-ATHENS#95 W/HS RCL |
| 19 | TE36 | 3PH @ LEEDS / LEEDS - HURLEY AVENUE |
| 20 | TE38 | 3PH/NC @ ROCK TAVERN / ROSETON * ROCK TAVERN #311 |
| 21 | TE39 | STORM-L/O 69/J3410 W/OUT FAULT & 1.1SEC LATER LLG@LADENTOWN – L/O Y88/Y94 DCT W/RCL |
| 22 | TE40 (LLG) | LLG@RAMAPO - L/O 69/J3410+70/K3411 DCT |
| 23 | TE41 | SLG-STK@GILBOA (BKR 3208) – L/O GILBOA - LEEDS (GL-3) / BKUP CLR GILBOA#1, 2 |

| | | |
|---|---|---|
| 24 | TE42 | 3PH-NC@RAMAPO500 – L/O RAMAPO-HOPATCONG |
| 25 | TE43 | 3PH-NC@VANWGNR - LO-VANWGNR-PLTVLLEYY59WHSRCL |
| 26 | TE44(LLG) | LLG@RAMAPO - L/O RAMAPO - ROCK-TAVERN 77 & 76 / DCT |
| 27 | TE45 | 3PH-NCLEEDS/LO LEEDS-VANWGNR59WHSRCL |
| 28 | TE46 | SLG-STK/VANWGNR BKRR12/LO PLTVLLEY-VANWGNRY58BKUPCLR91 |
| 29 | TE47 | SLG-STK/VANWGNR BKRR12/LO ATHENS-VANWGNR91 BKUP CLR Y58 |
| 30 | CE03 | SLG-STK@EDIC345 (BKR R935) – L/O EDIC-GORDON ROAD #14 / BKUP CLR FE1 |
| 31 | CE06 | 3PH-NC@MARCY345 – L/O EDIC-MARCY (UE1-7) |
| 32 | CE07(LLG) | LLG@MARCY/EDIC - L/O MARCY-COOPERS (UCC2-41) & EDIC-FRASER (EF24-40) DCT |
| 33 | CE07AR(LLG) | LLG@MARCY/EDIC - L/O MARCY-COOPERS (UCC2-41) & EDIC-FRASER (EF24-40) DCT W/RCL |
| 34 | CE09 | SLG-STK@EDIC345kV – L/O FITZ-EDIC #FE-1/BKUP CLR#14 |
| 35 | CE15 | SLG-STK@MARCY345(BKR 3108) – L/O VOLNEY-MARCY (VU-19) / BKUP CLR#UE1-7 |
| 36 | CE36 | SLG--STK@SCRIBA345 (BKR R100)/SCRIBA-FITZ #10/ BKUP CLR SCRIBA 345-SCRIBA 115 XFMR |
| 37 | CE99 | SLG-STK@SCRIBA345 (BKR R935) – L/O SCRIBA-VOLNEY 21 / BKUP CLR FITZ-SCRIBA #10 |
| 38 | SA01_Q556 | SLG-STK@EDIC345 (BKR R915) – L/O EDIC-FRASER EF24-40 / BKUP CLR 2-15 |
| 39 | P1-2-F14 | 3PH@KNICKERBOCKER – L/O KNICKERBOCKER – ALPS (6) |
| 40 | P1-2-F15 | 3PH@ALPS – L/O ALPS – KNICKERBOCKER (6) |
| 41 | P1-2-F20 | 3PH@KNICKERBOCKER – L/O KNICKERBOCKER – PLEASANT VALLEY (Y57) |
| 42 | P1-2-F21 | 3PH@PLEASANT VALLEY – L/O PLEASANT VALLEY – KNICKERBOCKER (Y57) |
| 43 | P1-2-F31 | 3PH@NEW SCOTLAND – 66 BUS – L/O NEW SCOTLAND – KNICKERBOCKER (2) |
| 44 | P1-2-F32 | 3PH@KNICKERBOCKER – L/O NEW SCOTLAND – KNICKERBOCKER (2) |
| 45 | P4-2-F13_#4 | SLG-STK@KNICKERBOCKER (BKR 4) – L/O KNICKERBOCKER – NEW SCOTLAND (2) |
| 46 | P4-2-F13_#7 | SLG-STK@KNICKERBOCKER (BKR 7) – L/O KNICKERBOCKER – NEW SCOTLAND (2) |
| 47 | P4-2-F14_#5 | SLG-STK@KNICKERBOCKER (BKR 5) – L/O KNICKERBOCKER – ALPS (6) |
| 48 | P4-2-F14_#7 | SLG-STK@KNICKERBOCKER (BKR 7) – L/O KNICKERBOCKER – ALPS (6) |
| 49 | P4-2-F15 | SLG-STK@ALPS (BKR R2) – L/O ALPS – KNICKERBOCKER (6) |
| 50 | P4-2-F20_#4 | SLG-STK@KNICKERBOCKER (BKR 4) – L/O KNICKERBOCKER – PLEASANT VALLEY (Y57) |
| 51 | P4-2-F20_#5 | SLG-STK@KNICKERBOCKER (BKR 5) – L/O KNICKERBOCKER – PLEASANT VALLEY (Y57) |
| 52 | P4-2-F21 | SLG-STK@PLEASANT VALLEY (BKR RNS3) – L/O PLEASANT VALLEY – KNICKERBOCKER (Y57) |
| 53 | P4-2-F31 | SLG-STK@NEW SCOTLAND – 66 BUS (BKR R2) – L/O NEW SCOTLAND – KNICKERBOCKER (2) |

| | | |
|---|---|---|
| 54 | P7_F1 | L/O TOWER KNICKERBOCKER – PLEASANT VALLEY 345 & FORT ORANGE – VALKIN 115 DBL CKT |
| 55 | P7_F5 | L/O TOWER KNICKERBOCKER – PLEASANT VALLEY 345 & ADM MILLING – CHURCHTOWN 115 DBL CKT |
| 56 | P7_F6 | L/O TOWER KNICKERBOCKER – PLEASANT VALLEY 345 & CHURCHTOWN – BLUE STORES 115 DBL CKT |
| 57 | P7_F8 | L/O TOWER KNICKERBOCKER – PLEASANT VALLEY 345 & MILAN – PLEASANT VALLEY 115 DBL CKT |

Contingencies 1, 2, 8, 9 and 10 are tower three-phase faults, which are beyond NYSRC criteria for the determination of NYISO System Operating Limits. Those contingencies were only examined on an informational basis.

# Monitored Parameters

In order to assess system stability response for the Total East power transfer scenarios considering contingencies, the following parameters were monitored and analyzed:

- Generators' angles, power outputs, terminal voltages in the following areas/zones (West, North, Mohawk, Capital, representative generators from West, Central, Hudson and Capital);
- Bus voltages around Total East, Western NY and Central East especially at Edic and Pleasant Valley.

# Discussion

## Angle, Voltage, and Frequency Monitoring

Machine angle, voltage and frequency were employed in this analysis as the key indicators of system stability. Machine angles at Niagara and Athens, voltages at Edic and Pleasant Valley stations and frequency at New Scotland station were plotted for the CE-99 contingency on the all equipment in-service scenario, as shown in Figure 2. The CE99 contingency is a single line to ground fault at Scriba 345 kV which results in the loss of Scriba – Volney (21) 345 kV and the back-up clearing of the Fitzpatrick – Scriba (FS-10) 345 kV line.

Edic voltage was selected as the representative indicator of system performance for the CE-99 contingency in the discussions that follow. Similar plots for all the Total East contingencies simulated are included in the appendices.

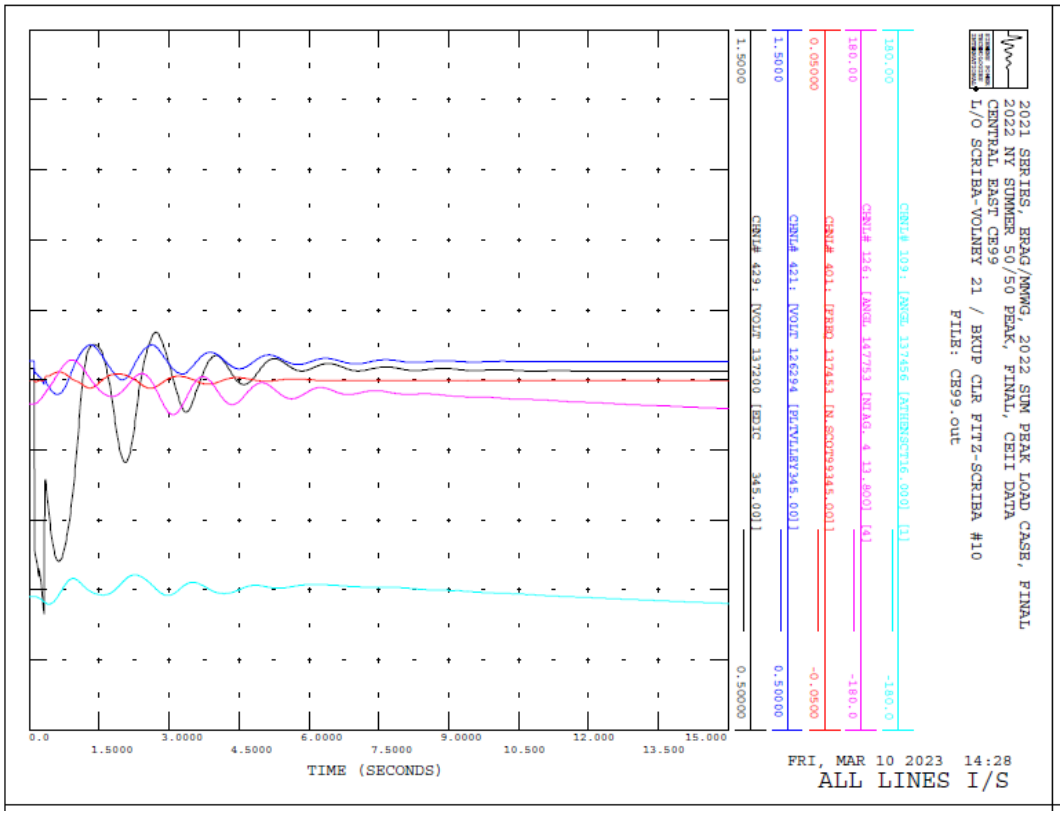


Figure 2. Voltage Angle and Frequency for scenario with all equipment in-service

## Most Severe Contingency

Edic voltages were plotted for all the Total East contingencies as shown in Figure 3. It can be seen from Figure 3 that the voltage response at Edic 345 kV is most severe for CE-99 contingency compared to all other Total East contingencies. The magnitude of the post contingency voltage swings was found to be the largest when the CE-99 contingency was applied. The CE-99 contingency was selected as the most severe contingency in the discussions that follow. Similar plots for all the Total East contingencies simulated are included in the appendices.

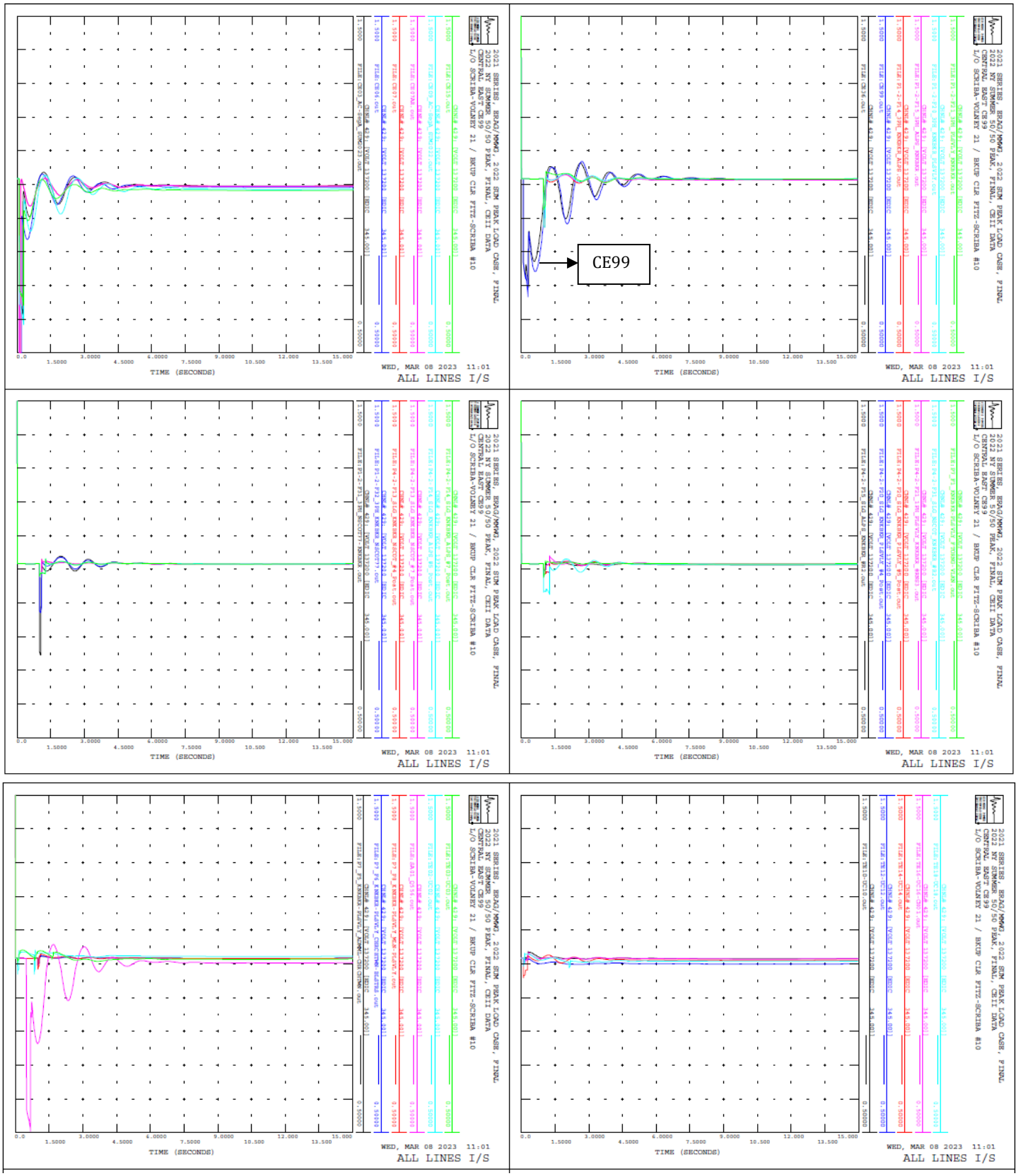


Figure 3. Edic Voltage response for all contingencies for all equipment in-service

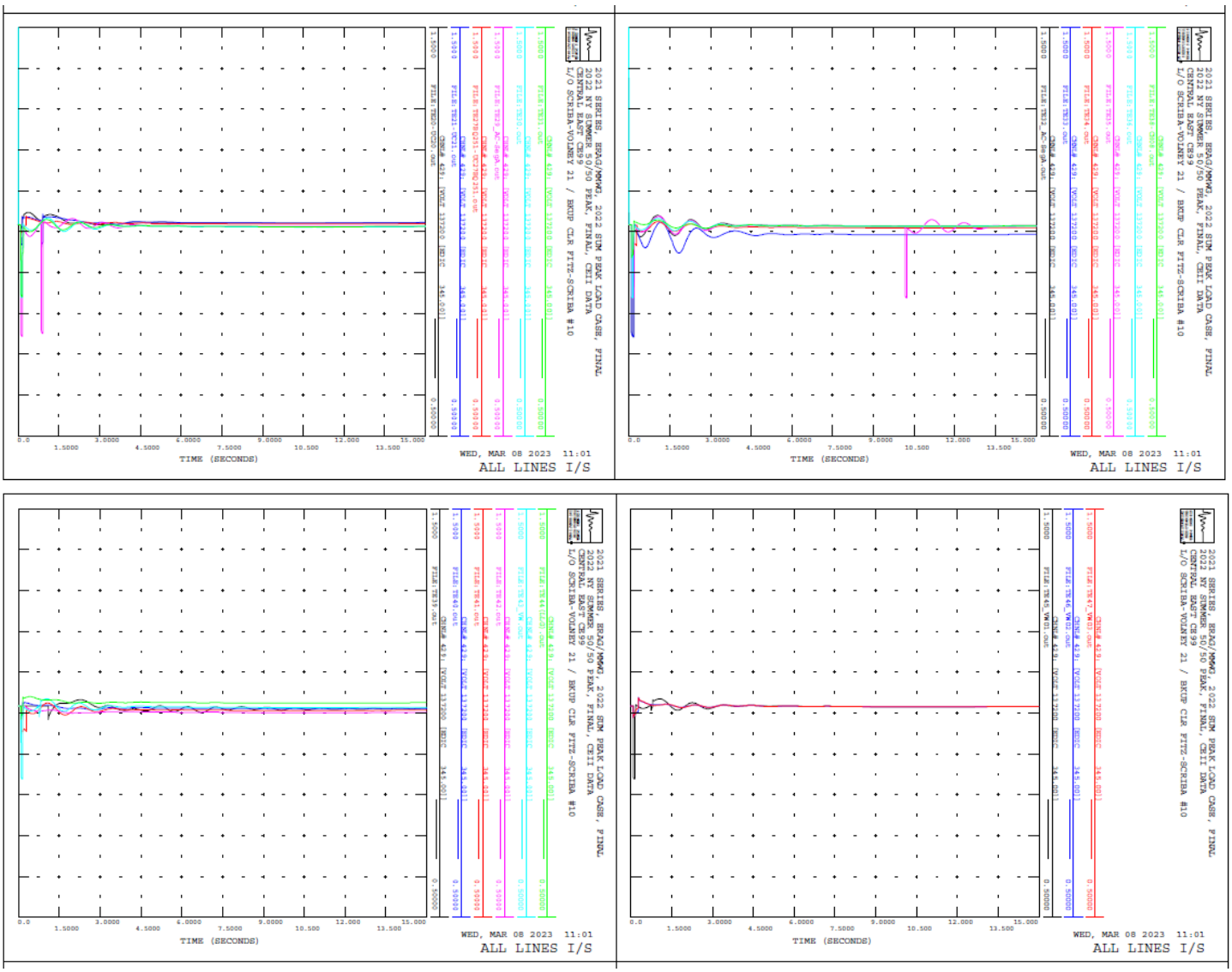


Figure 3 (Continued). Edic Voltage response for all contingencies for all equipment in-service

## 5018 Out of Service

Machine angle, voltage and frequency were employed in this analysis as the key indicators of system stability and the dynamic response of the system under this outage condition is shown in Fig 4. All dynamic responses were clearly stable for this configuration at a test level of 6015 MW. The Edic voltage response for all 57 contingencies with 5018 Line out of service is found in Appendix B.

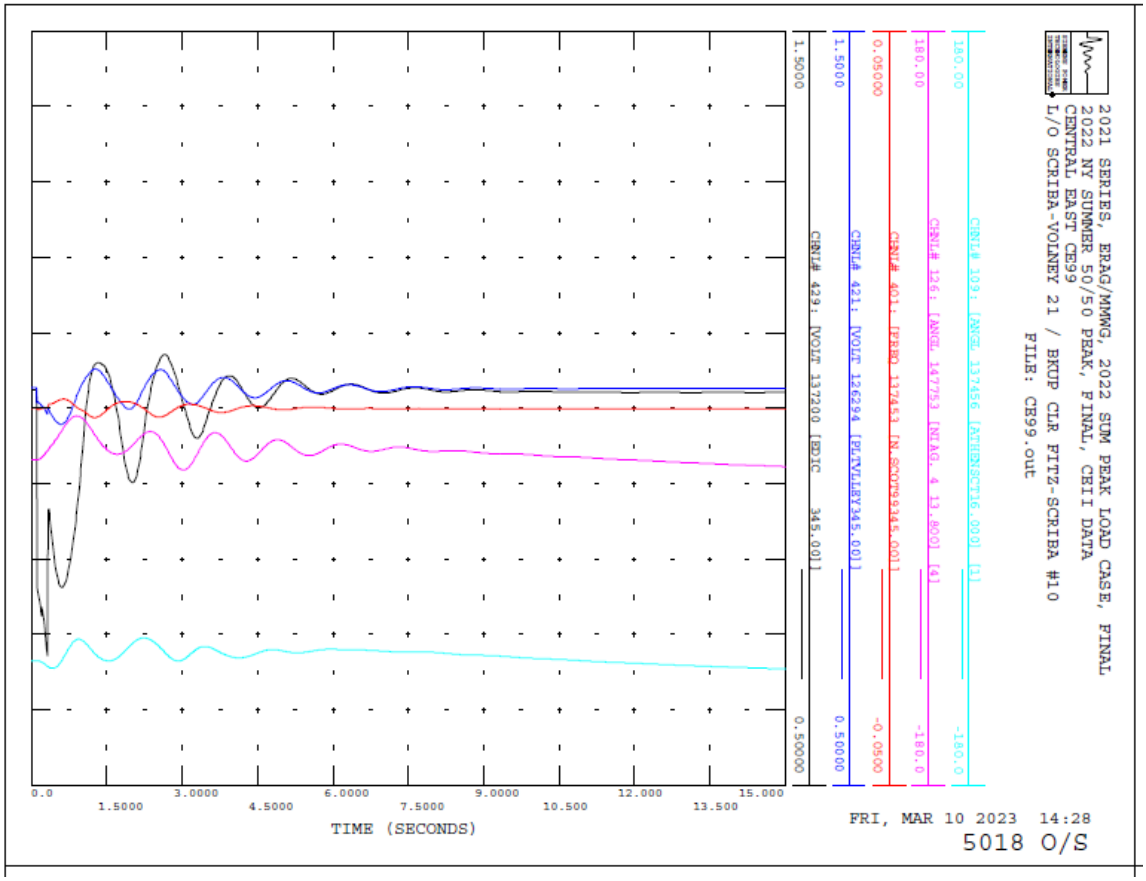


Figure 4. Voltage Angle and Frequency for scenario with 5018 O/S

## 5018 Out of Service and SVCs and STATCOM's Out of Service

Machine angle, voltage and frequency were employed in this analysis as the key indicators of system stability and the dynamic response of the system under this outage condition is shown in Fig 5, 6, 7. All responses were clearly stable for this configuration at a test level of 5915 MW.

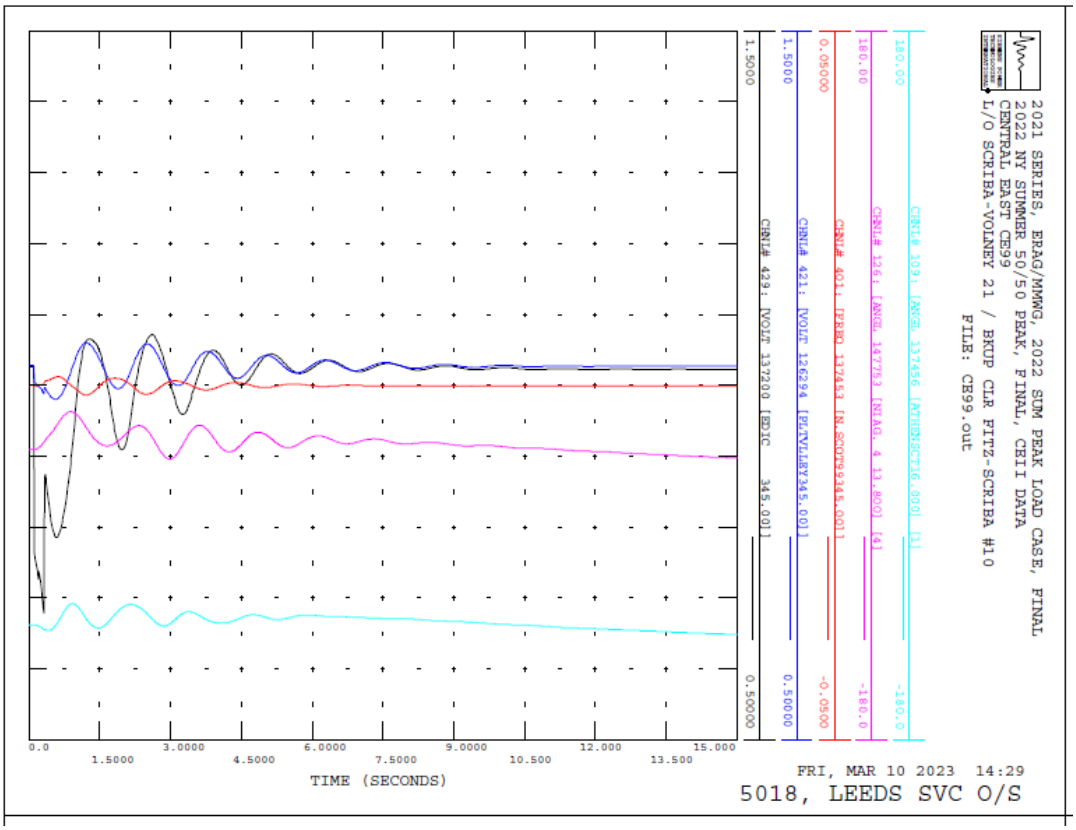


Figure 5. Voltage Angle and Frequency for scenario with 5018 O/S and Leeds SVC O/S

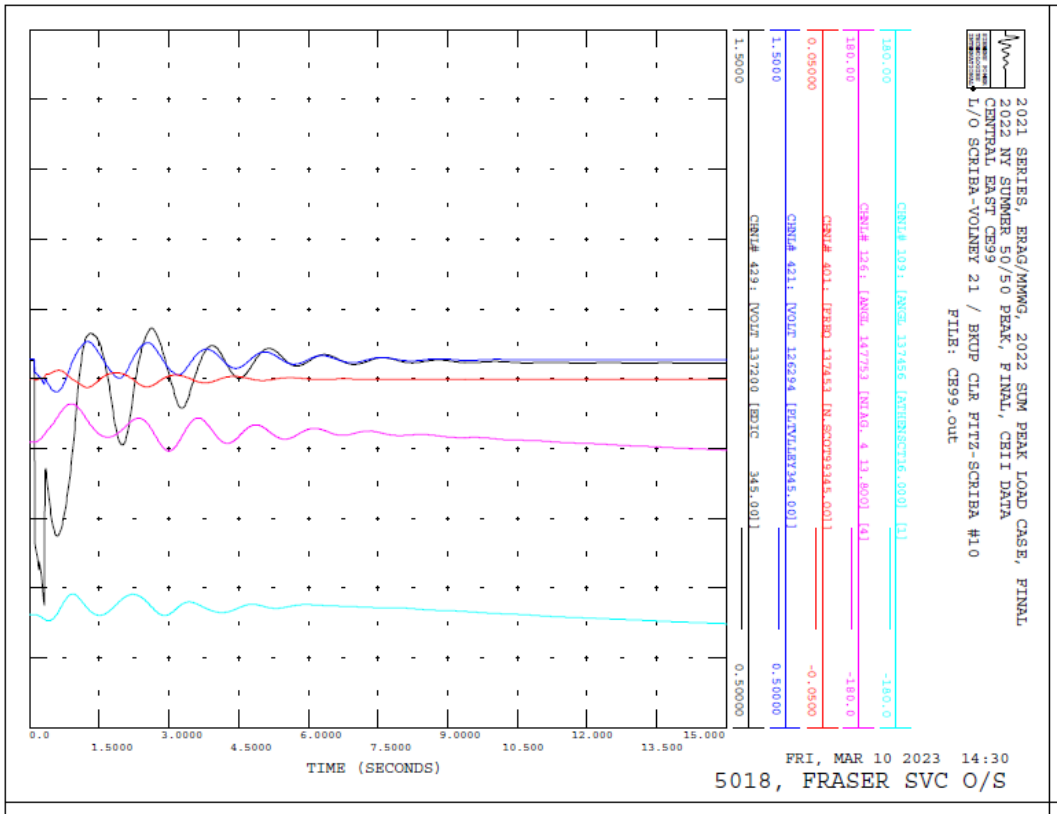


Figure 6. Voltage Angle and Frequency for scenario with 5018 O/S and Fraser SVC O/S

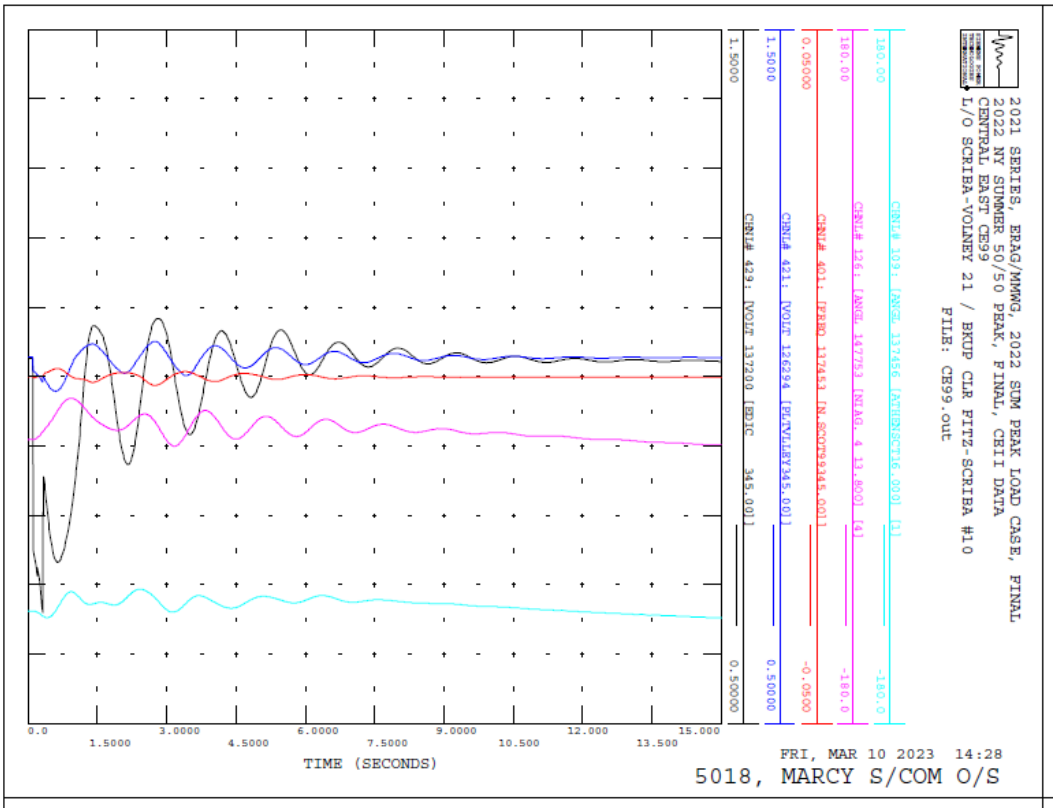


Figure 7. Voltage Angle and Frequency for scenario with 5018 O/S and Marcy STATCOM O/S

## Recommendations

This report has been reviewed and recommended for NYISO Operating Committee approval by the NYISO Operating Studies Task Force (OSTF) and the System Operations Advisory Subcommittee (SOAS).

It is recommended that the stability limit of Total East be increased. The transfer case was set up for a transfer level of 6845MW and a stability limit of 6150MW across Total East. Table 5 outlines the proposed stability limits for Total East and also the stability limit under outage conditions.

| # | Scenario | 2023 | | 2022 | | Difference of Proposed limit from the existing Total East Stability Limit (MW) |
|---|---|---|---|---|---|---|
| | | Total East Stability Limit(MW) | Total East Tested Transfer Level(MW) | Total East Stability Limit (MW) | Total East Tested Transfer Level (MW) | |
| 1 | All Lines In | 6150 | 6845 | 6000 | 6675 | +150 |
| 2 | 5018 Ramapo-Hopatcong 500 kV O/S | 5400 | 6015 | 5200 | 5780 | +200 |
| 3 | 5018 Ramapo-Hopatcong 500 kV & Any SVC/STATCOM O/S | 5300 | 5915 | 5100 | 5670 | +200 |

Table 5: Summary of proposed Total East Stability Transfer Limits