Simulation Study of the Northeast Wisconsin/Upper Peninsula Separation Event of November 14, 2001

A Report Prepared for
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Exhibits

E Excerpt from MAIN Guide 1B

F Characteristics of Generating Units within Island Area

G Characteristics of Existing Underfrequency Load Shedding in Island Area

H PSS/E Command Files used to create the Base Case Power Flow

I PSS/E Command Files used to set up and run the simulations
(Note: these files invoke certain IDEV files distributed with the NERC System Dynamics Database, which are not included in this report but may be obtained by persons authorized to receive it.)

Simulation Study of the Northeast Wisconsin/Upper
Peninsula Separation Event of November 14, 2001

Summary

American Transmission Company (ATC) commissioned a study to investigate a system separation event that occurred on November 14, 2001 and involved the power systems in Northeast Wisconsin and the Upper Peninsula of Michigan. During this event the affected area was isolated from the Eastern Interconnection, and sustained frequencies of 58 Hz were observed due to an imbalance of load and generation. ATC's assessment of the event indicated that the performance of the system was less than desirable even though the separated area did not experience a complete power shutdown. Some industrial loads, primarily motors, tripped during the event; it is not known definitively whether this was due to low frequency, low voltage, or both. The objectives of the study were to reproduce the event by computer simulation to better understand the factors that contributed to the performance, and then develop recommendations to improve the performance should a similar event occur in the future.

A computer simulation that reasonably duplicated the actual event has been completed. The results indicated that the amount of load shed automatically by underfrequency load shedding (UFLS) relays was inadequate and this was the major cause of the marginal system response. Voltage levels during and after the transient period did not contribute significantly to the system performance. The simulation study included the effect of the industrial load trips, and a comparison case included in the analysis demonstrated that without such motor tripping system response would have been worse. In effect, beneficial but unplanned and uncontrolled load shedding occurred due to the response of customer equipment.

A second simulation was also run, with the same system conditions but with the UFLS enhanced to trip up to 30% of the load in the area in three stages: at least 10% of load at 59.3 Hz, another 10% at 59.0 Hz, and a final 10% at 58.7 Hz. These are the levels of UFLS required for each control area under MAIN Guide 1B. The results showed that the system response was significantly improved even without the uncontrolled tripping of the motor load. It should be noted that this requirement currently applies to entire control areas, not to operating districts or other subsidiary areas within one or more control areas.

The principal recommendation reached during this study is that the UFLS protection system in the area affected by this disturbance should be upgraded to meet the level specified in MAIN Guide 1B for control areas.

Overview of the Disturbance

The principal events leading up to the islanding incident were as follows.

0600: 138 kV Line 6851, North Appleton-White Clay, was taken out of service for scheduled work.

0604 Hiawatha- Indian Lake 69 kV lines 6912 and 6913 were closed, a routine operation dictated by the operation of the Ludington Pumped Storage Plant, completing a through path to the lower peninsula of Michigan via the Straits of Mackinac.

0636 138 kV line 64441, Pulliam-Stiles, tripped due to tree contact. At this time the West Marinette Units M31 and M32 were ordered to start.

0638 Line 64441 was successfully reclosed and the startup of the West Marinette units was canceled.

0645 Line 64441 tripped again. However, since the West Marinette units were still coasting down to standstill, they could not be restarted.

0645 138 kV line 64451, the second Pulliam-Stiles circuit, sagged into a distribution feeder and tripped. Almost simultaneously 6912 and 6913 opened automatically at Hiawatha, islanding the area north of, and including, 138 kV substations at Stiles and White Clay in Oconto County, Wisconsin, and west of a 69 kV substation at Hiawatha in Mackinac County, Michigan.

System Model

The NERC MMWG base case power flow model representing 2002 light load conditions was used as a starting point. The NERC power flow model was modified in the area of interest to replicate actual conditions at the time of the event. Loads in the area that became islanded were iteratively incremented until flows into the islanded area reasonably matched EMS values. A transfer of 60 MW from WPS to UPP was added to further tune the power flow model. The industrial loads were converted to motor loads so that they could be represented as dynamic models.

The NERC System Dynamics Data Base (SDDB) was the source for dynamic data for generating plants. It is notable that many of the small hydro plants in the area have no voltage regulator and exciter models, and some have no governors. Such modeling simplification would tend to bias the study results in a conservative or pessimistic direction. See Exhibit F for details.

Locations and settings of existing underfrequency relays were obtained from a 2001 MAIN UFLS study. This data was reviewed by ATC and updated. (See Exhibit G for details.) The UFLS relays in this area have a 15 cycle time delay rather than the 6 cycle delay specified in MAIN Guide 1B.

Relay data for Indian Lake- Hiawatha 69 kV lines 6912 and 6913, which tripped to form the island, was also provided by ATC. ATC provided dynamic data for the induction and synchronous motor loads at two large industrial sites in the island. During the dynamic time period all other loads were modeled as constant current for the MW component and constant reactance for the Mvar component.

The simulations were conducted using the PSS/E computer code marketed by Power Technologies, Inc., of Schenectady, NY.

Sequence of Island Formation

The initial power flows on the ties into the island prior to any switching operations are shown on Exhibit A-1. The flows following switching the North Appleton-White Clay 138 kV Line out of service are shown on Exhibit A-2. Exhibit A-3 shows flows following switching which closed Hiawatha –Indian Lake 69 kV lines 6912 and 6913. This power flow was used as the steady state operating condition prior to island formation.

Exhibit B-1 shows the MVA flows on the ties into the island as the island formed illustrating the sequence of tripping. Pulliam-Stiles 138 kV Line 64441 was tripped at time equal to 0.5 seconds. (The 0.5 second delay was used to insure that the system remained in the steady state for a period time after the dynamic routine was called.) 138 kV Line 64451 was tripped 0.5 seconds later. Both of these line trips are known to be the result of heavy loading levels, during which the lines sagged into a tree and an underbuilt distribution line, respectively. The 0.5 second interval between the trips was intended to allow machine swings from the first switching event to damp out before a second perturbation was imposed; the actual time interval is believed to be at least several seconds and possibly a minute or two. The tripping of 69 kV Lines 6912 and 6913 occurred almost simultaneously by distance relay operation, which was modeled. Exhibits B-2.1 and B-2.2 show that the impedance trajectories entered the zone 1 relay settings at Hiawatha, resulting in instantaneous relay operation and line tripping after a 5 cycle breaker operating time.

Analysis of the Simulated Actual Event

Exhibits C-1 through C-6 give the time domain plots of variables in the islanded area after island formation. These exhibits represent the simulation of the actual event and include the effects of the existing UFLS relays and the tripping of some of the industrial motor load. This motor tripping was implemented by underfrequency load shedding models available in the PSS/E program, with settings in the neighborhood of 58 Hz.

Exhibit C-1 shows selected 138 and 69 kV bus voltages. Following an initial transient voltage depression, voltages recover to somewhat higher levels than their initial values due to load shedding. Reactive power support is adequate to allow the island to recover to acceptable voltages. It is of interest to note that pronounced 69 kV voltage oscillations occur at the High Falls plant. Voltages on lightly loaded radial lines commonly jump up following underfrequency load shedding and this indicates that this happened. No voltage regulator models were included in the SDDB for the small hydro units in the southern part of the island area, and if there is no provision for automatic regulation of generators, significant voltage swings on the 69 kV system are to be expected following a disturbance. Manually controlled excitation of these units is likely to result in unsatisfactory extreme voltages following disturbances, to which tap changers and switched capacitors will only slowly respond.

Exhibit C-2 shows generator speeds expressed as frequency at various plants. Frequency drops to about 58.2 Hz and recovers to about 59.2 Hz after 10 seconds. This result is more favorable than the reported frequency response of 58 Hz as a low with recovery to 59 Hz in one minute. The tripping of motor loads was included in the simulation. The cause of the motor trips, the amount tripped, and the time that they tripped is unknown.

In the simulation it was assumed that the motors tripped when frequency reached slightly above 58 Hz. Exhibit C-6 compares the frequency trajectory shown on Exhibit C-2 with that for an identical scenario without motor tripping. For this case frequency drops to nearly 58 Hz and recovers to about 58.25 Hz after 10 seconds. The actual frequency trajectory would then be somewhere between these two, and cannot be further determined because of uncertainty in the motor trips.

Exhibit C-3 shows generator mechanical power and load in the island. The increase in prime mover output is attributed to governor action. The load shown on Exhibit C-3 includes all substation loads and synchronous motor load, totaling 730 MW initially. The induction motor load is 115 MW giving a total island load of 845 MW. Due to a limitation in the PSS/E software it was not possible to add the induction motors to the other load in Exhibit C-3. Exhibit C-3A was developed to show the details of the various load components. From this data it is seen that about 63 MW, or 7.5% of the total island load was shed by underfrequency relays. The frequency was low enough that all three steps of UFLS should operate. The unintentional tripping of motor load assisted in recovery, but being uncontrolled, it can be concluded that the amount of load included in the automatic UFLS program in this area of the system is inadequate.

Exhibits C-4.1 through C-5.2 show motor speeds and 13.8 kV voltages at the Empire and Tilden mines, the largest industrial customers in the island area. These plots show that some motors did trip due to frequency. The 13.8 kV voltages did not drop below 85% indicating that motor tripping due to contactor dropout was unlikely.

Analysis of a Simulation with Enhanced UFLS

A second simulation was run with UFLS in accordance with MAIN Guide 1B, with 10% of the initial island load shed at each frequency set point of 59.3, 59.0, and 58.7 Hz. The relays were modeled with a 6 cycle time delay rather than a 15 cycle delay. The results of this simulation are shown in Exhibits D-1 to D-7. The tripping of motor loads was not included in this case.

Exhibit D-1 shows substantially the same voltage response as the first simulation. The frequency response shown on Exhibit D-2 shows a marked improvement, with frequency dropping to about 58.7 Hz and recovering to about 59.75 Hz in 10 seconds. This frequency level is above the generally accepted minimum level for safe continuous operation of steam turbines, 59.5 Hz. (see IEEE Std. C37.106, *Guide for Abnormal Frequency Protection for Power Generating Plants*, currently under revision).

Exhibits D-3 and D-3A show island load and generation. It is likely that all of the UFLS relays set at 58.7 Hz did not operate. Analysis of the plots shows that about 195 MW or 23% of the total island load was shed by UFLS relay operation.

Exhibits D-4.1 to D-5.2 show motor speeds and the 13.8 kV voltages at the supply buses. As in the previous case, there is no indication of motors stalling or excessive low voltage to cause contactor dropout. However, it cannot be concluded that motor trips will not occur since the cause has not been established. It is reasonable to conclude that motor trips are less likely to occur since the shock to the system is reduced.

Exhibits D-6 and D-7 are presented to compare the frequency response and island load for the three conditions analyzed: the existing UFLS with and without motor tripping and the UFLS modified to apply MAIN Guide 1B to this zone without motor tripping.

<u>Conclusions and Recommendations</u>

The study has demonstrated that the current UFLS in the area does not provide a satisfactory system response to separation disturbances. Frequency levels are low enough and of sufficient duration to cause possible damage to steam turbines. Relying on unpredictable and uncontrolled tripping of customer motor load does not constitute a robust protection plan to prevent power outages over a wide area of the system. An enhanced UFLS program has been shown to provide considerable improvement.

It is recommended that ATC and load serving entities and generating unit owners within its transmission service area consider the following.

- Upgrade the UFLS protection system in the area affected by this disturbance to:
    - Trip at least 10% of connected load at 59.3 Hz,
    - Another 10% at 59.0 Hz,
    - And a final 10% at 58.7 Hz.

  To minimize costs while achieving maximum protection, existing UFLS electromechanical relays that cannot be set to trip within 6 cycles should be utilized in the third, 58.7 Hz, step of this UFLS program.

  Note: MAIN Guide 1B does not require uniform distribution of UFLS across all load in a control area. This study found that relatively uniform distribution of UFLS in the amounts and at the settings specified in MAIN Guide 1B would have stabilized frequency within the island area at an acceptable level.

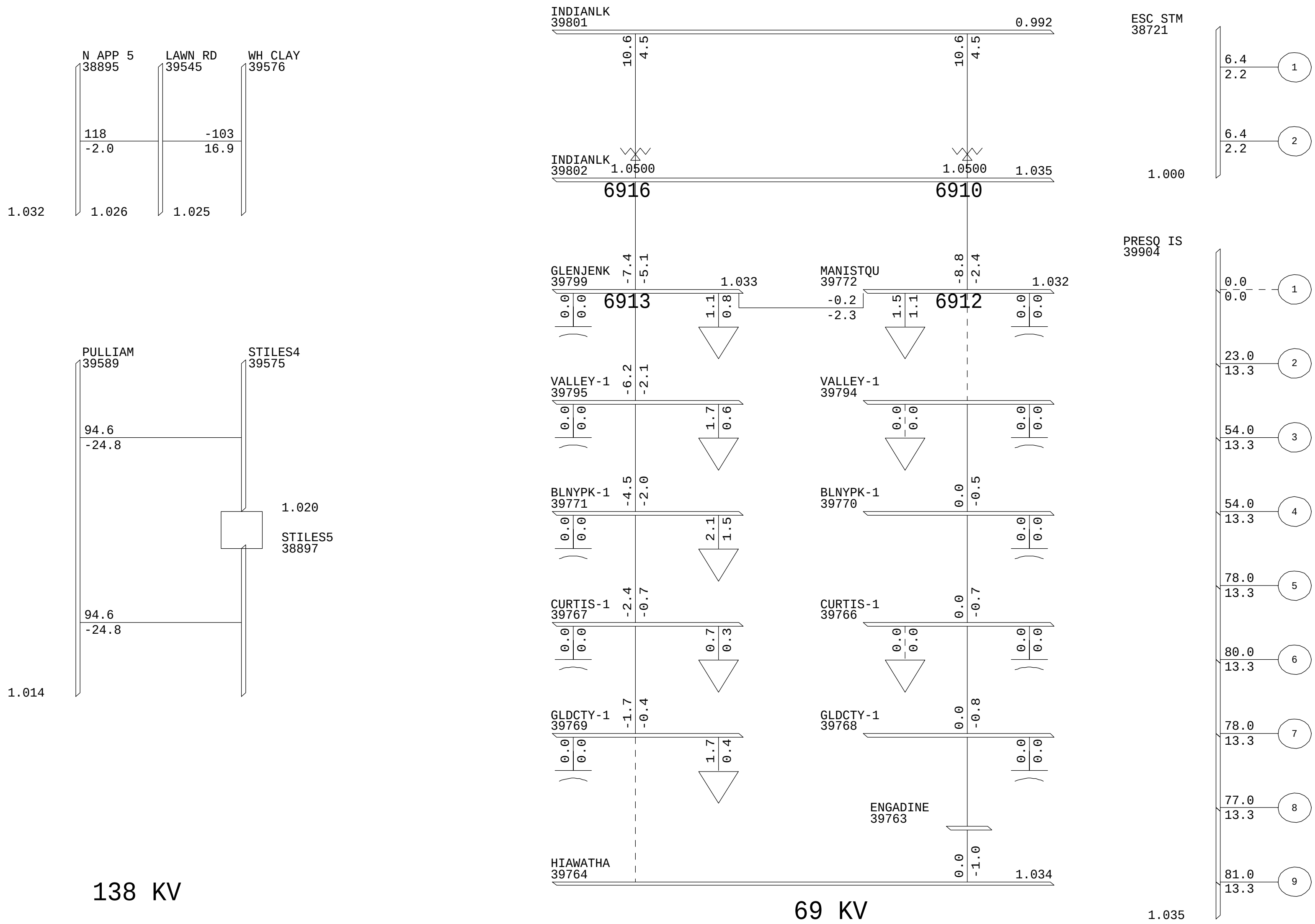
- Review UFLS practices to uncover deficiencies, particularly in areas more prone to separation disturbances.

- Submit voltage regulator models to the SDDB for hydro units if so equipped. These will increase the realism of studies in the area.

- Consider equipping hydro units with automatic voltage regulators if they are not so equipped.

Exhibit A

ONE LINE DIAGRAMS OF
STEADY STATE POWER FLOWS INTO ISLAND



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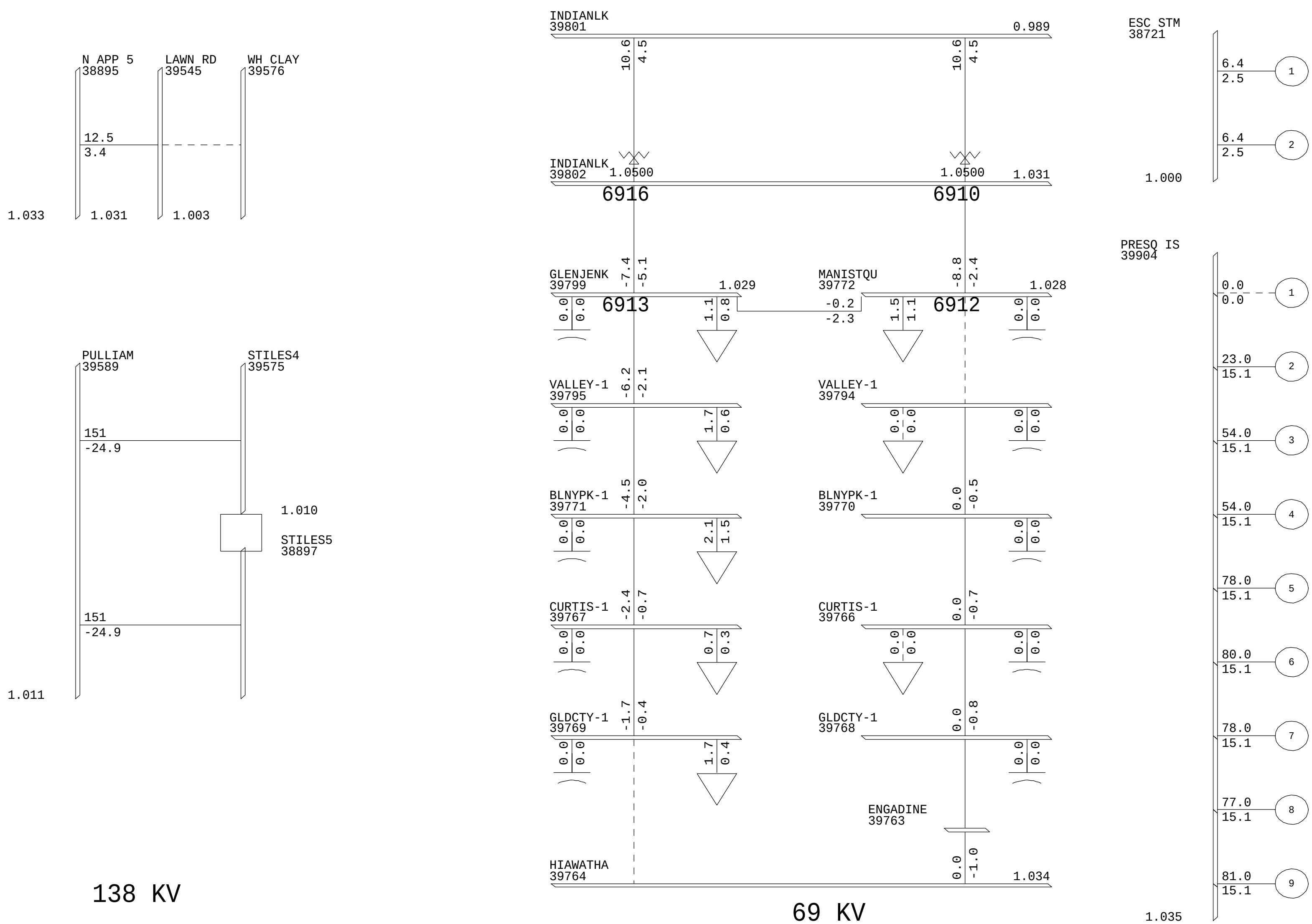
2001 SERIES, NERC/MMWG BASE CASE LIBRARY
INITIAL CASE - LOAD INCR 60 PCT, INTER OF 60 FROM WPS TO UPP
FIG. A-1 TSM. TIES INTO ISLAND FRI, NOV 08 2002 18:51

BUS - VOLTAGE(PU)
BRANCH - MW/MVAR
EQUIPMENT - MW/MVAR



2001 SERIES, NERC/MMWG BASE CASE LIBRARY
LINE 6851 (WHITE CLAY-LAWN ROAD) OUT
FIG. A-2 TSM. TIES INTO ISLAND FRI, NOV 08 2002 18:52

BUS - VOLTAGE(PU)
BRANCH - MW/MVAR
EQUIPMENT - MW/MVAR

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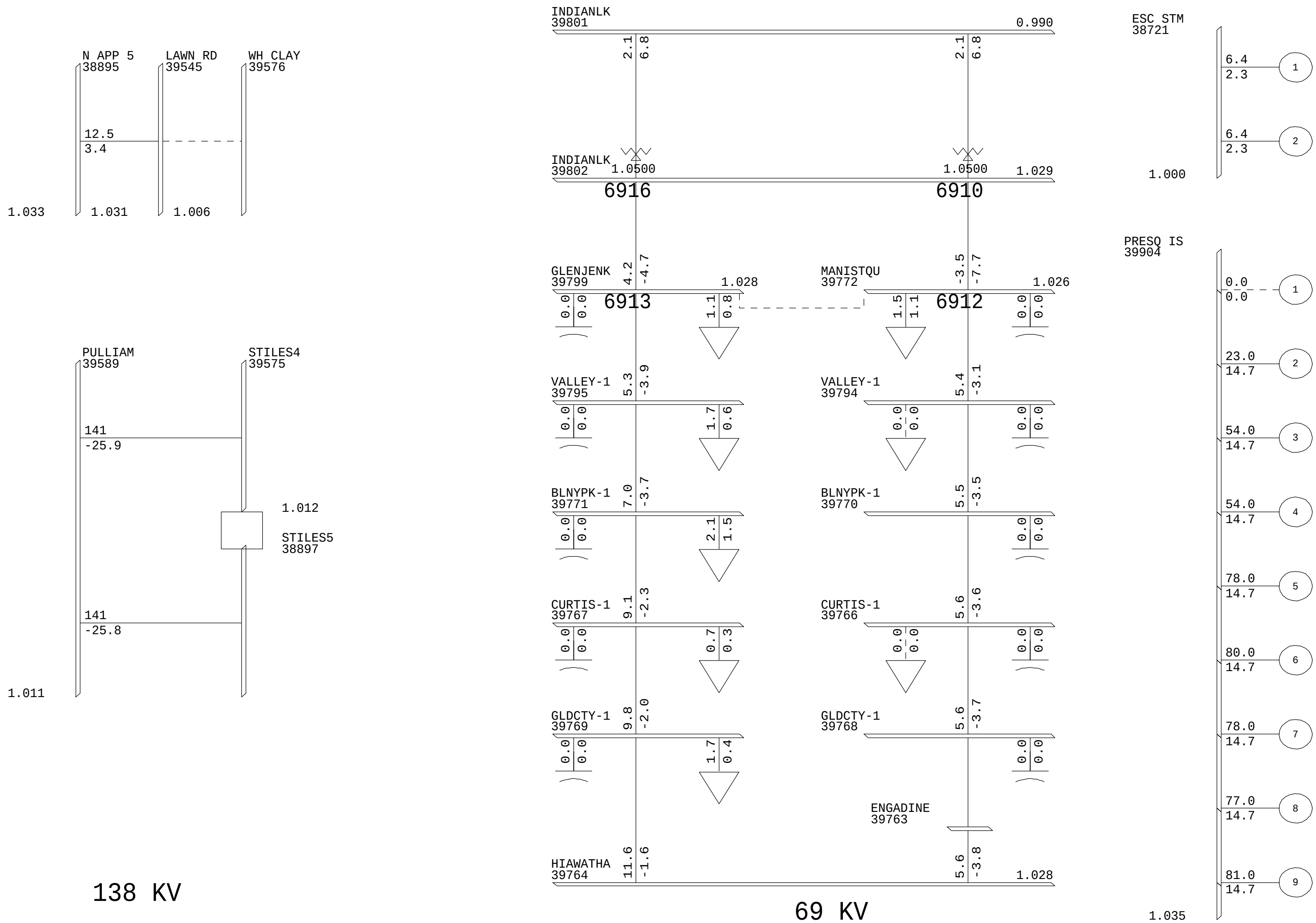

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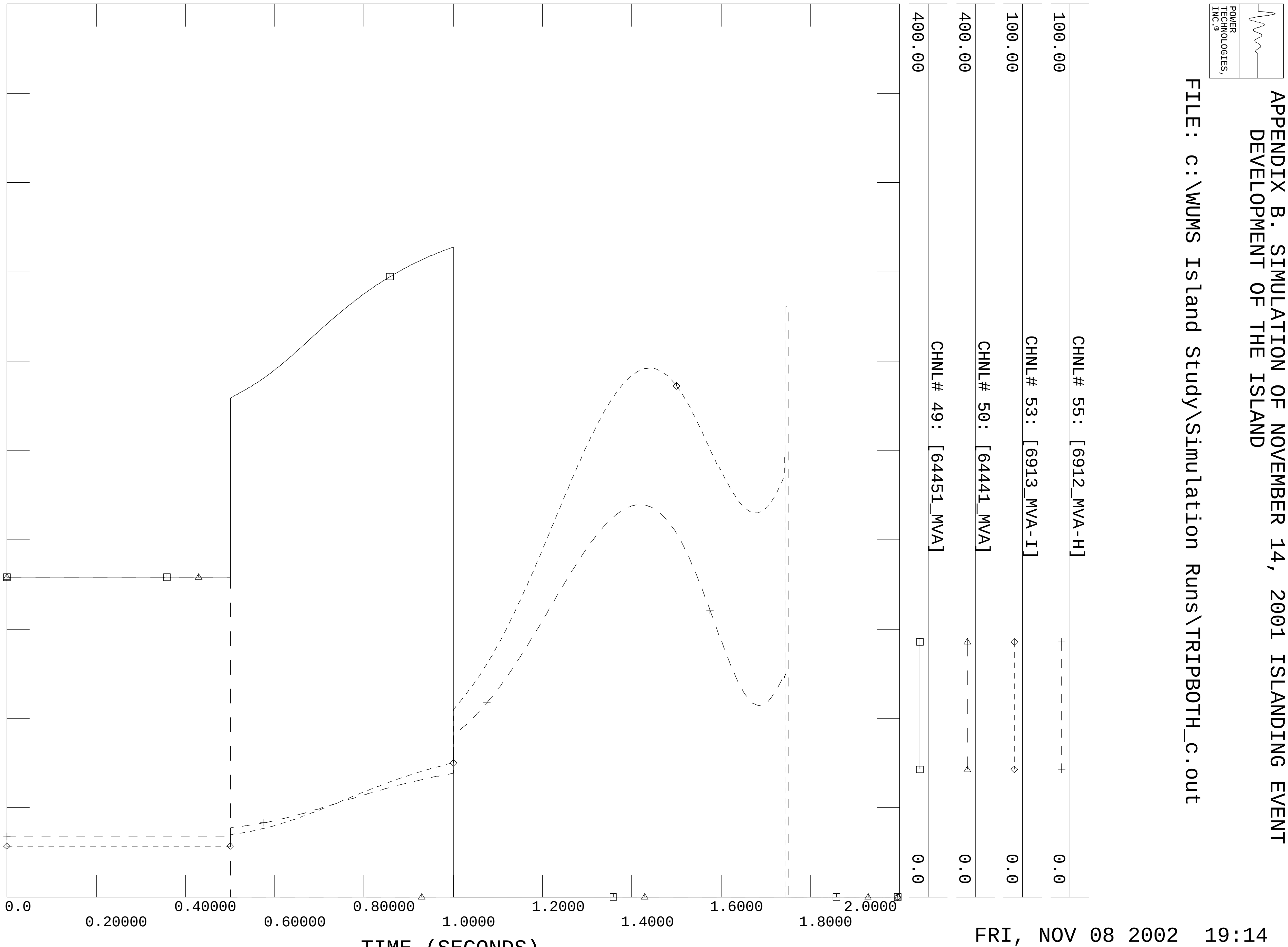
2001 SERIES, NERC/MMWG BASE CASE LIBRARY
INDIAN LAKE - HIAWATHA CLOSED
FIG. A-3 TSM. TIES INTO ISLAND FRI, NOV 08 2002 18:52

BUS - VOLTAGE(PU)
BRANCH - MW/MVAR
EQUIPMENT - MW/MVAR

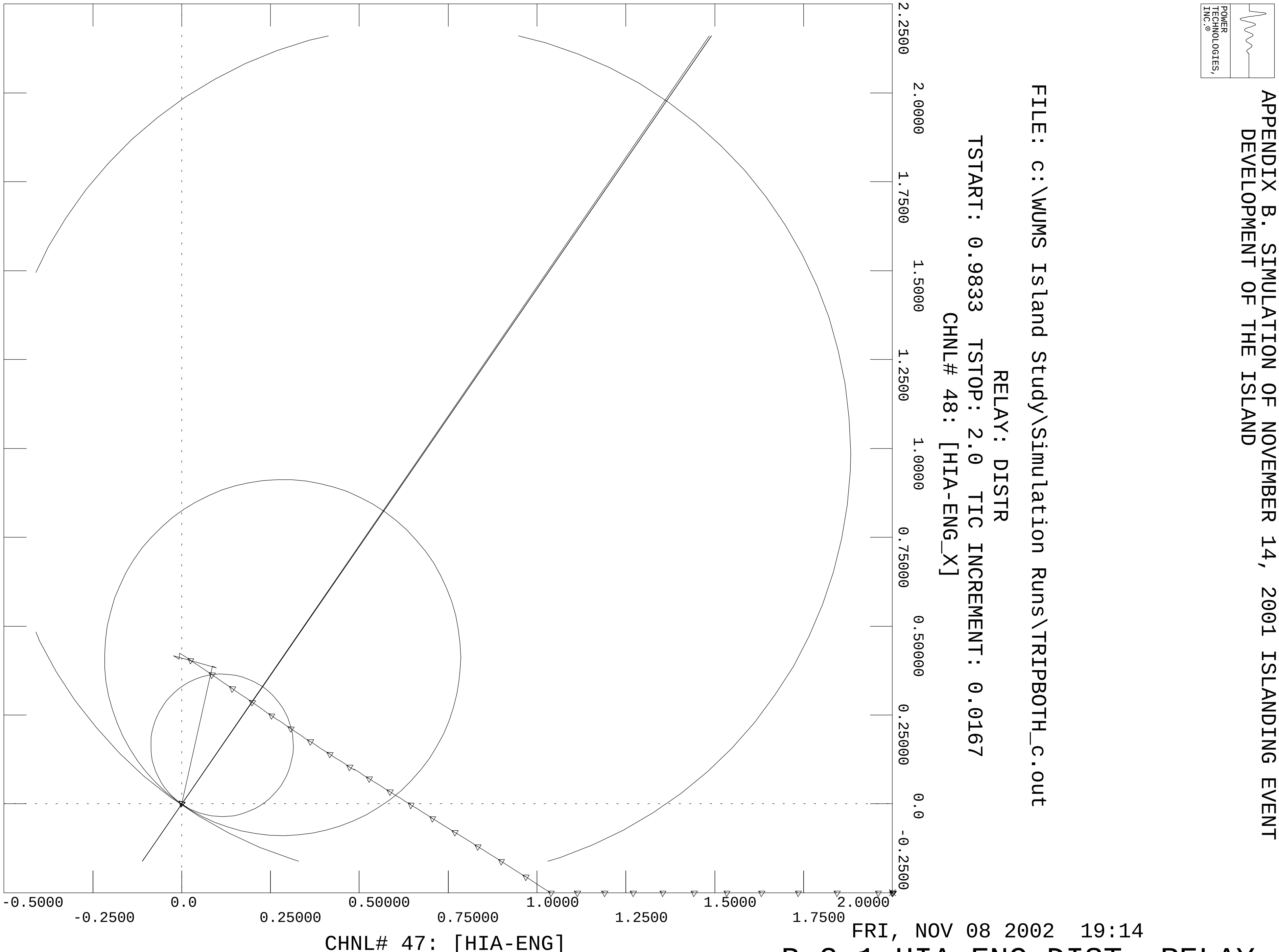
Exhibit B

DEVELOPMENT OF ISLAND

(Dynamic Simulation)



B-1 MVA FLOWS INTO ISLAND



B-2.1 HIA-ENG DIST. RELAY

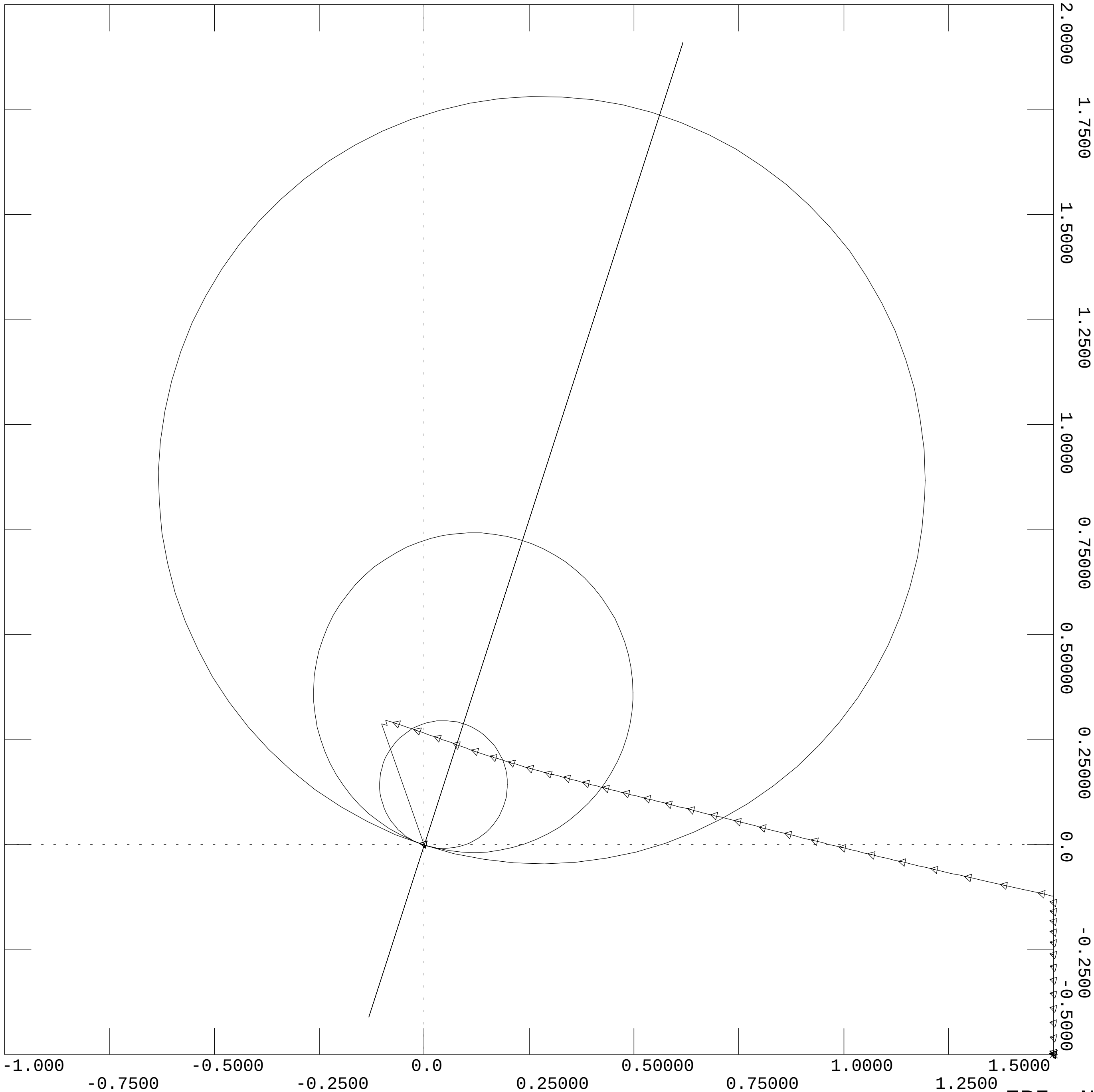
APPENDIX B. SIMULATION OF NOVEMBER 14, 2001 ISLANDING EVENT
DEVELOPMENT OF THE ISLAND

FILE: c:\WUMS Island Study\Simulation Runs\TRIPBOTH_c.out

RELAY: DISTR

TSTART: 0.9833 TSTOP: 2.0 TIC INCREMENT: 0.0167

CHNL# 46: [HIA-GLD_X]



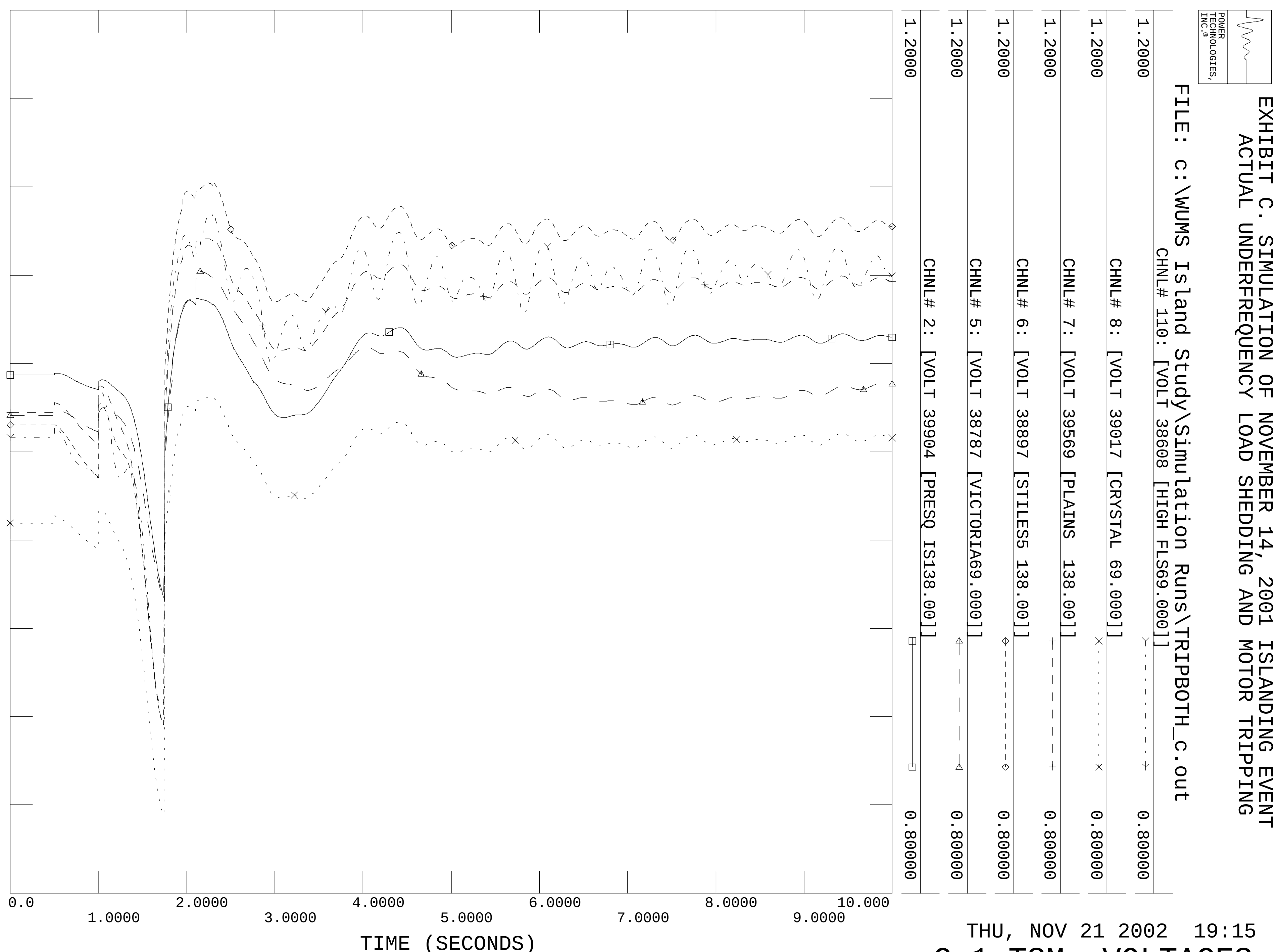
CHNL# 45: [HIA-GLD]

FRI, NOV 08 2002 19:14

B-2.2 HIA-GLD DIST. RELAY

Exhibit C

SIMULATION OF THE ACTUAL EVENT



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C-1 TSM. VOLTAGES

EXHIBIT C. SIMULATION OF NOVEMBER 14, 2001 ISLANDING EVENT
ACTUAL UNDERFREQUENCY LOAD SHEDDING AND MOTOR TRIPPING

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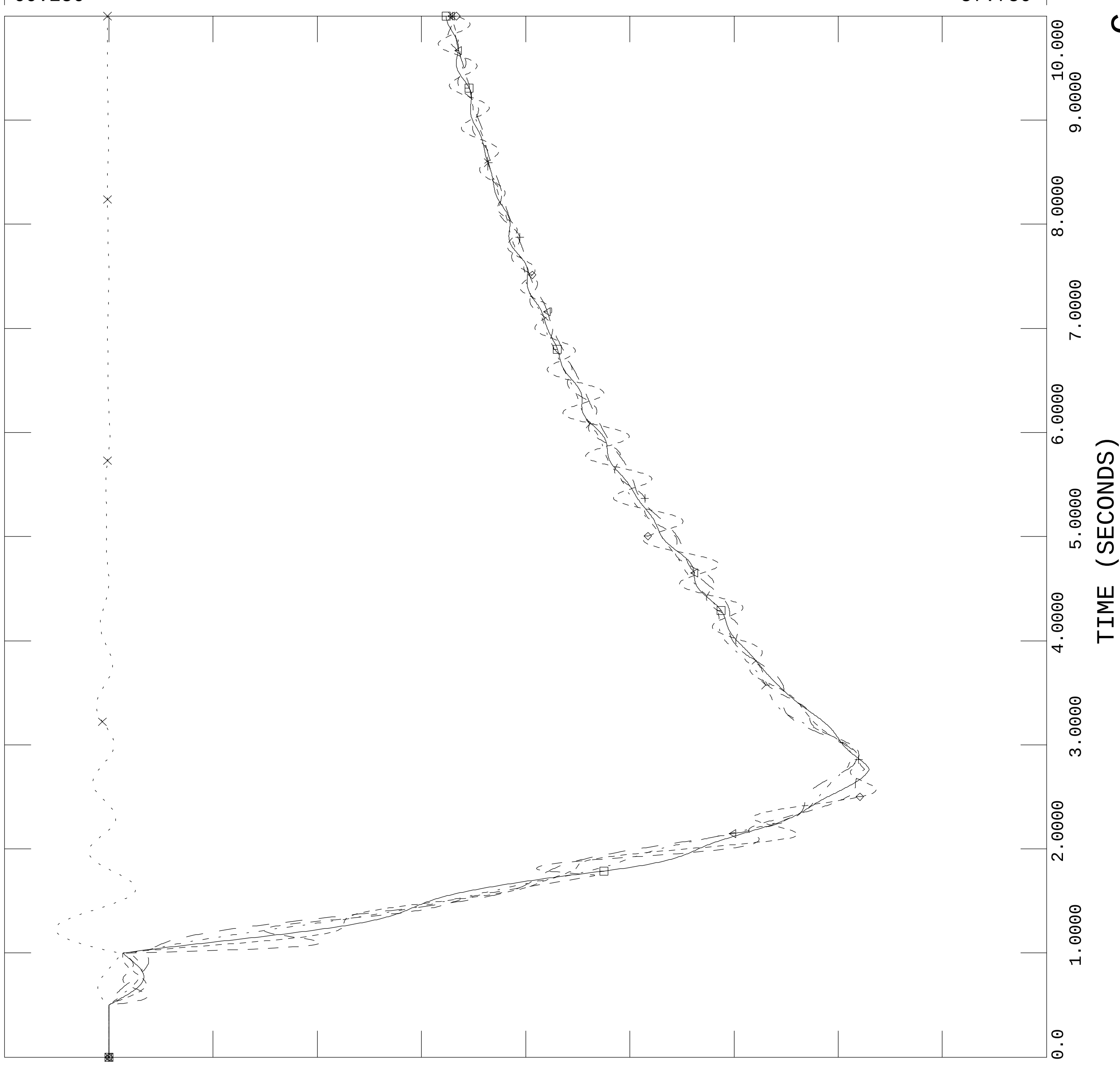
FILE: c:\WUMS Island Study\Simulation Runs\TRIPBOTH_c.out

Channel	Min	Max
CHNL# 20: 60*(1+[SPD 38721 [ESC STM 12.500] [1]])	60.250	57.750
CHNL# 18: 60*(1+[SPD 39594 [PUL G8 16.000] [8]])	60.250	57.750
CHNL# 17: 60*(1+[SPD 39102 [BRUL HG 6.6000] [1]])	60.250	57.750
CHNL# 16: 60*(1+[SPD 38807 [VIC 1 1111.500] [1]])	60.250	57.750
CHNL# 15: 60*(1+[SPD 39895 [MQT STM 69.000] [3]])	60.250	57.750
CHNL# 14: 60*(1+[SPD 38774 [PSQI G9 13.800] [9]])	60.250	57.750



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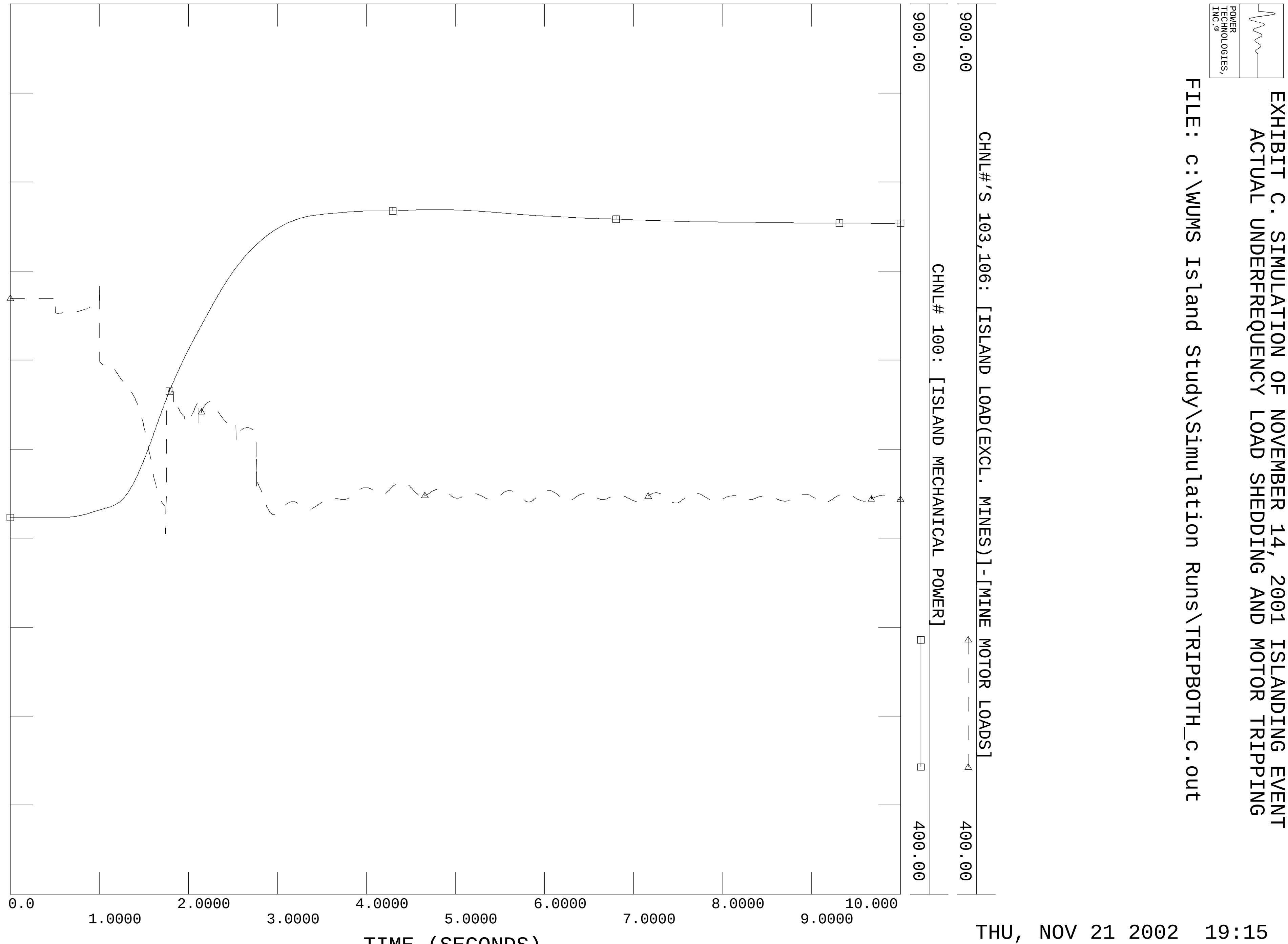
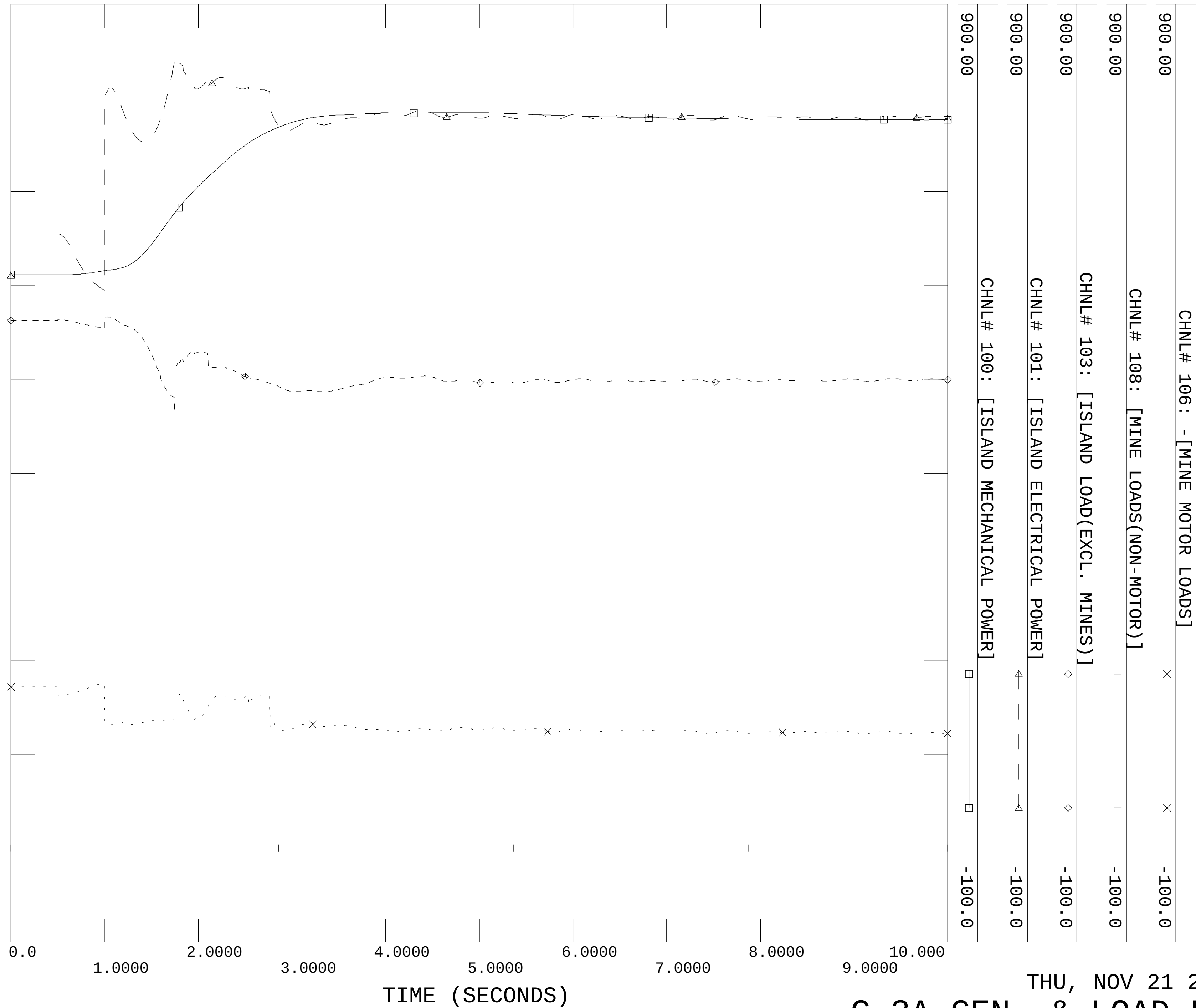
C-2 GEN. SPEEDS (HZ)



C-3 ISLAND GEN. & LOAD

EXHIBIT C. SIMULATION OF NOVEMBER 14, 2001 ISLANDING EVENT
ACTUAL UNDERFREQUENCY LOAD SHEDDING AND MOTOR TRIPPING

FILE: c:\WUMS Island Study\Simulation Runs\TRIPBOTH_c.out



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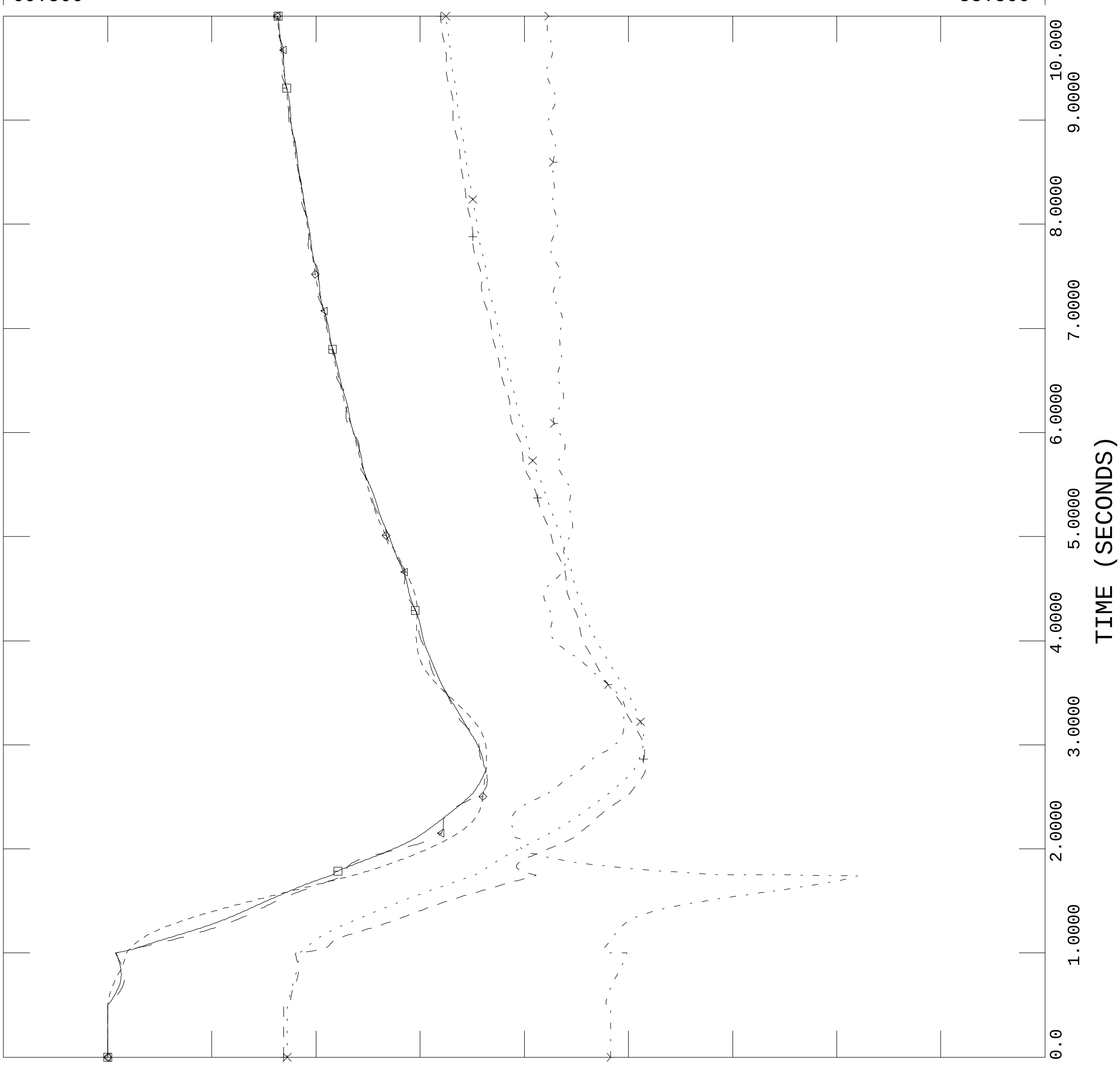
C-3A GEN. & LOAD DETAILS

EXHIBIT C. SIMULATION OF NOVEMBER 14, 2001 ISLANDING EVENT
ACTUAL UNDERFREQUENCY LOAD SHEDDING AND MOTOR TRIPPING

FILE: c:\WUMS Island Study\Simulation Runs\TRIPBOTH_c.out

Channel	Min	Max
CHNL# 62: [VOLT 38908 [EMPIRE 113.800]]	1.2000	0.80000
CHNL# 71: 60*(1+[SPD 38908 [EMPIRE 113.800] [P]])	60.500	55.500
CHNL# 70: 60*(1+[SPD 38908 [EMPIRE 113.800] [M]])	60.500	55.500
CHNL# 69: 60*(1+[SPD 38908 [EMPIRE 113.800] [2]])	60.500	55.500
CHNL# 68: 60*(1+[SPD 38908 [EMPIRE 113.800] [1]])	60.500	55.500
CHNL# 1: 60*(1+[FREQ 39904 [PRESQ IS138.00]])	60.500	55.500



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C-4.1 EMPIRE 1

EXHIBIT C. SIMULATION OF NOVEMBER 14, 2001 ISLANDING EVENT
ACTUAL UNDERFREQUENCY LOAD SHEDDING AND MOTOR TRIPPING

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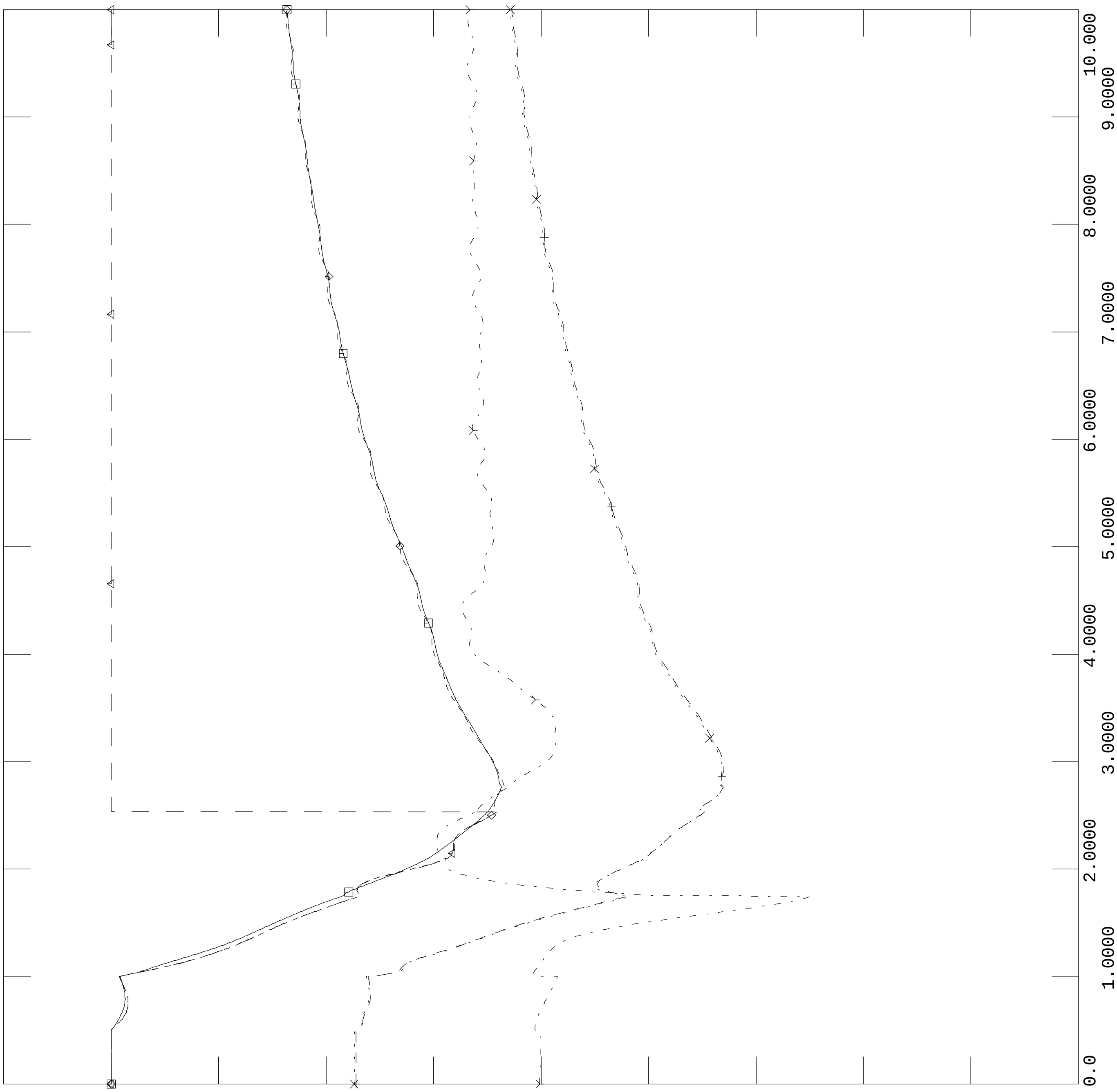
FILE: c:\WUMS Island Study\Simulation Runs\TRIPBOTH_c.out

Channel	Min	Max
CHNL# 63: [VOLT 38909 [EMPIRE 213.800]]	1.2000	0.80000
CHNL# 76: 60*(1+[SPD 38909 [EMPIRE 213.800] [N]])	60.500	55.500
CHNL# 75: 60*(1+[SPD 38909 [EMPIRE 213.800] [M]])	60.500	55.500
CHNL# 73: 60*(1+[SPD 38909 [EMPIRE 213.800] [2]])	60.500	55.500
CHNL# 72: 60*(1+[SPD 38909 [EMPIRE 213.800] [1]])	60.500	55.500
CHNL# 1: 60*(1+[FREQ 39904 [PRESQ IS138.00]])	60.500	55.500



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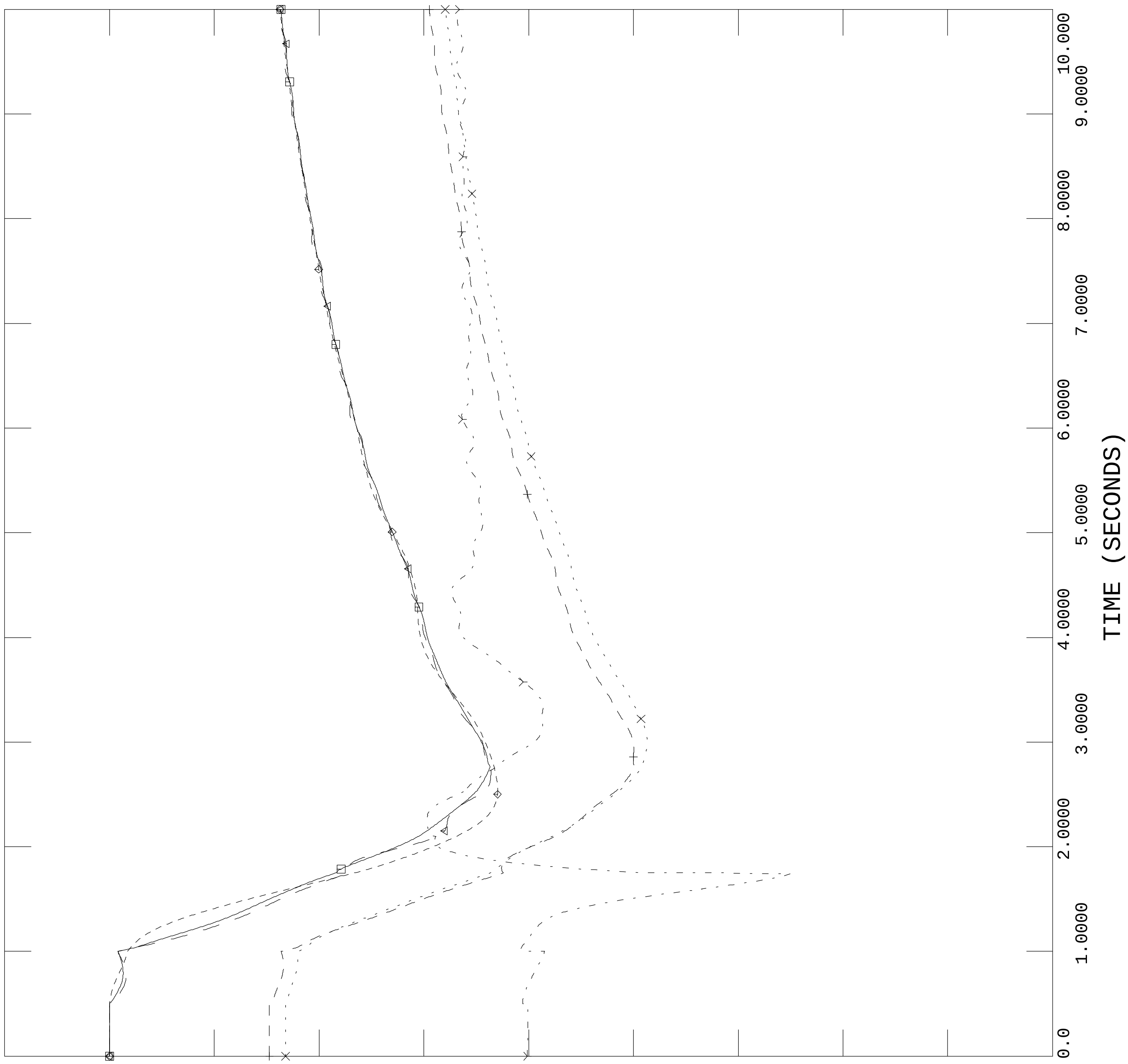
C-4.2 EMPIRE 2

EXHIBIT C. SIMULATION OF NOVEMBER 14, 2001 ISLANDING EVENT
ACTUAL UNDERFREQUENCY LOAD SHEDDING AND MOTOR TRIPPING

POWER TECHNOLOGIES, INC.®

FILE: c:\WUMS Island Study\Simulation Runs\TRIPBOTH_c.out

Channel	Min	Max
CHNL# 63: [VOLT 38909 [EMPIRE 213.800]]	1.2000	0.80000
CHNL# 81: 60*(1+[SPD 38910 [EMPIRE 313.800] [P]])	60.500	55.500
CHNL# 80: 60*(1+[SPD 38910 [EMPIRE 313.800] [M]])	60.500	55.500
CHNL# 79: 60*(1+[SPD 38910 [EMPIRE 313.800] [2]])	60.500	55.500
CHNL# 78: 60*(1+[SPD 38910 [EMPIRE 313.800] [1]])	60.500	55.500
CHNL# 1: 60*(1+[FREQ 39904 [PRESQ IS138.00]])	60.500	55.500



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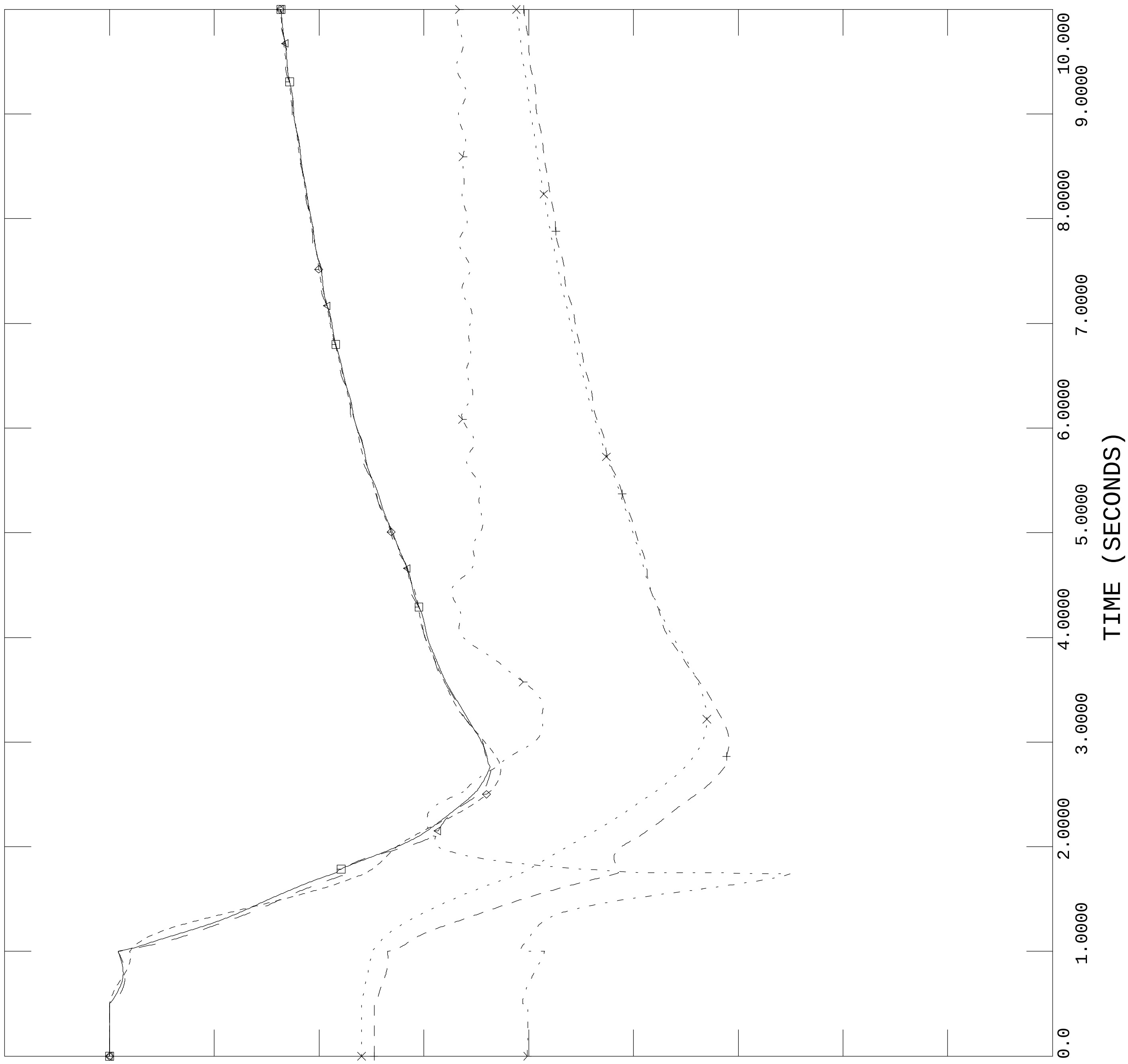
C-4.3 EMPIRE 3

EXHIBIT C. SIMULATION OF NOVEMBER 14, 2001 ISLANDING EVENT
ACTUAL UNDERFREQUENCY LOAD SHEDDING AND MOTOR TRIPPING

POWER TECHNOLOGIES, INC.®

FILE: c:\WUMS Island Study\Simulation Runs\TRIPBOTH_c.out

Channel	Min	Max
CHNL# 63: [VOLT 38909 [EMPIRE 213.800]]	1.2000	0.80000
CHNL# 85: 60*(1+[SPD 38911 [EMPIRE 413.800] [P]])	60.500	55.500
CHNL# 84: 60*(1+[SPD 38911 [EMPIRE 413.800] [M]])	60.500	55.500
CHNL# 83: 60*(1+[SPD 38911 [EMPIRE 413.800] [2]])	60.500	55.500
CHNL# 82: 60*(1+[SPD 38911 [EMPIRE 413.800] [1]])	60.500	55.500
CHNL# 1: 60*(1+[FREQ 39904 [PRESQ IS138.00]])	60.500	55.500



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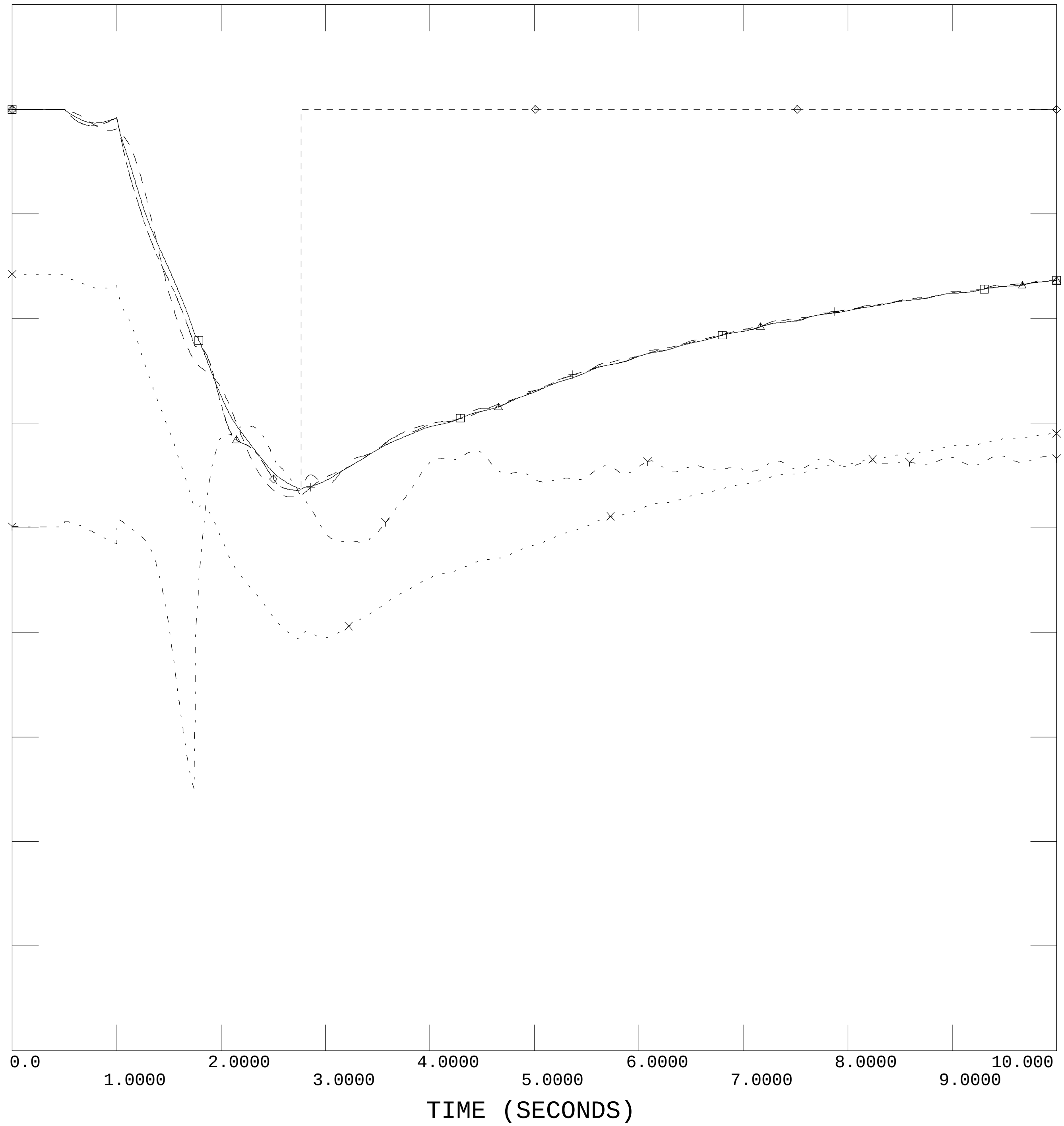
C-4.4 EMPIRE 4

EXHIBIT C. SIMULATION OF NOVEMBER 14, 2001 ISLANDING EVENT
ACTUAL UNDERFREQUENCY LOAD SHEDDING AND MOTOR TRIPPING

FILE: c:\WUMS Island Study\Simulation Runs\TRIPBOTH_c.out

Channel	Min	Max
CHNL# 63: [VOLT 38909 [EMPIRE 213.800]]	0.80000	1.2000
CHNL# 89: 60*(1+[SPD 38920 [TILDEN 113.800] [M]])	55.500	60.500
CHNL# 88: 60*(1+[SPD 38920 [TILDEN 113.800] [3]])	55.500	60.500
CHNL# 87: 60*(1+[SPD 38920 [TILDEN 113.800] [2]])	55.500	60.500
CHNL# 86: 60*(1+[SPD 38920 [TILDEN 113.800] [1]])	55.500	60.500
CHNL# 1: 60*(1+[FREQ 39904 [PRESQ IS138.00]])	55.500	60.500



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C-5.1 TILDEN 1

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EXHIBIT C. SIMULATION OF NOVEMBER 14, 2001 ISLANDING EVENT
ACTUAL UNDERFREQUENCY LOAD SHEDDING AND MOTOR TRIPPING

FILE: c:\WUMS Island Study\Simulation Runs\TRIPBOTH_c.out

CHNL# 63: [VOLT 38909 [EMPIRE 213.800]]
1.2000 — 0.80000

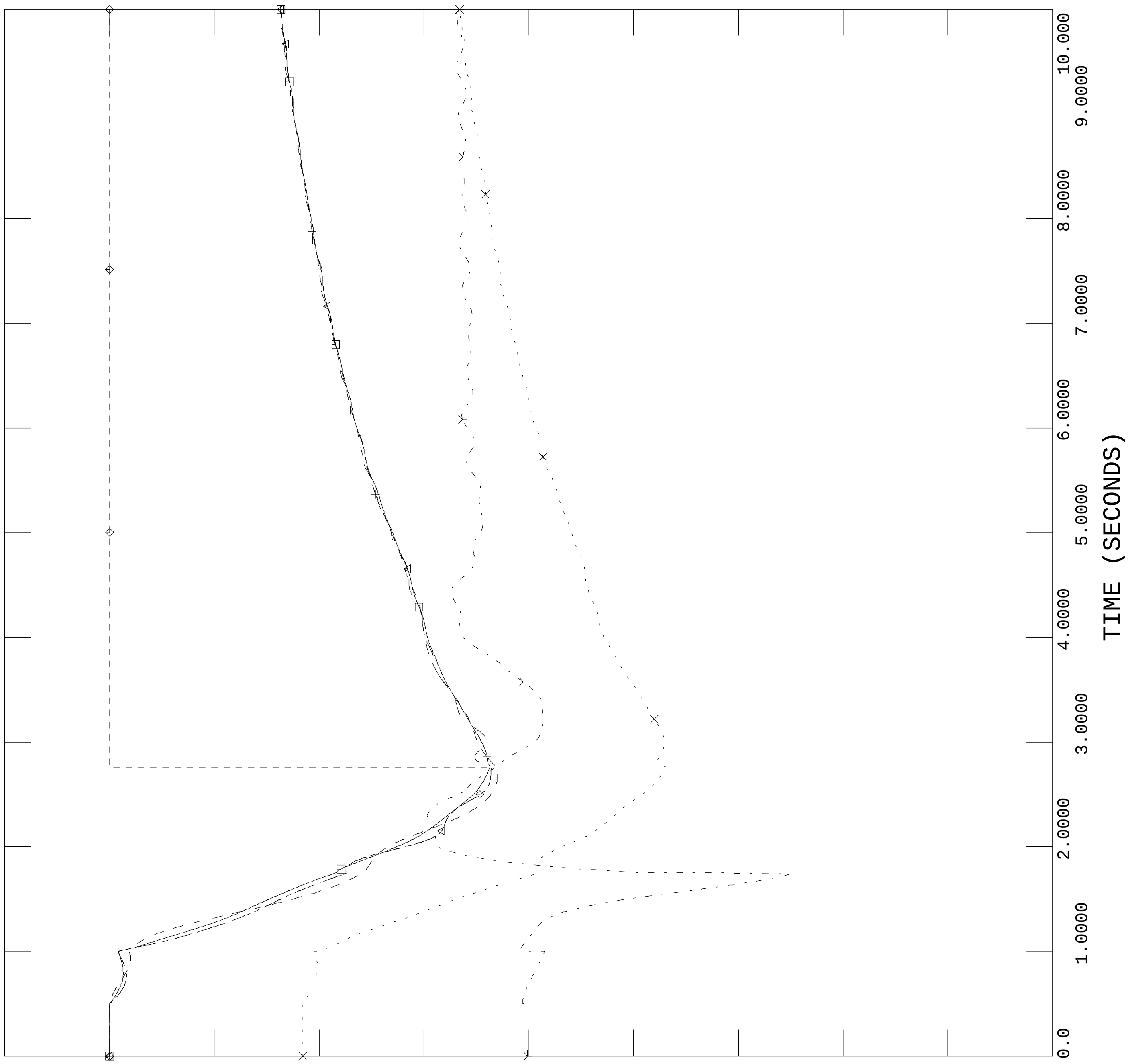
CHNL# 95: 60*(1+[SPD 38921 [TILDEN 213.800] [M]])
60.500 — 55.500

CHNL# 94: 60*(1+[SPD 38921 [TILDEN 213.800] [3]])
60.500 — 55.500

CHNL# 93: 60*(1+[SPD 38921 [TILDEN 213.800] [2]])
60.500 — 55.500

CHNL# 92: 60*(1+[SPD 38921 [TILDEN 213.800] [1]])
60.500 — 55.500

CHNL# 1: 60*(1+[FREQ 39904 [PRESQ IS138.00]])
60.500 — 55.500



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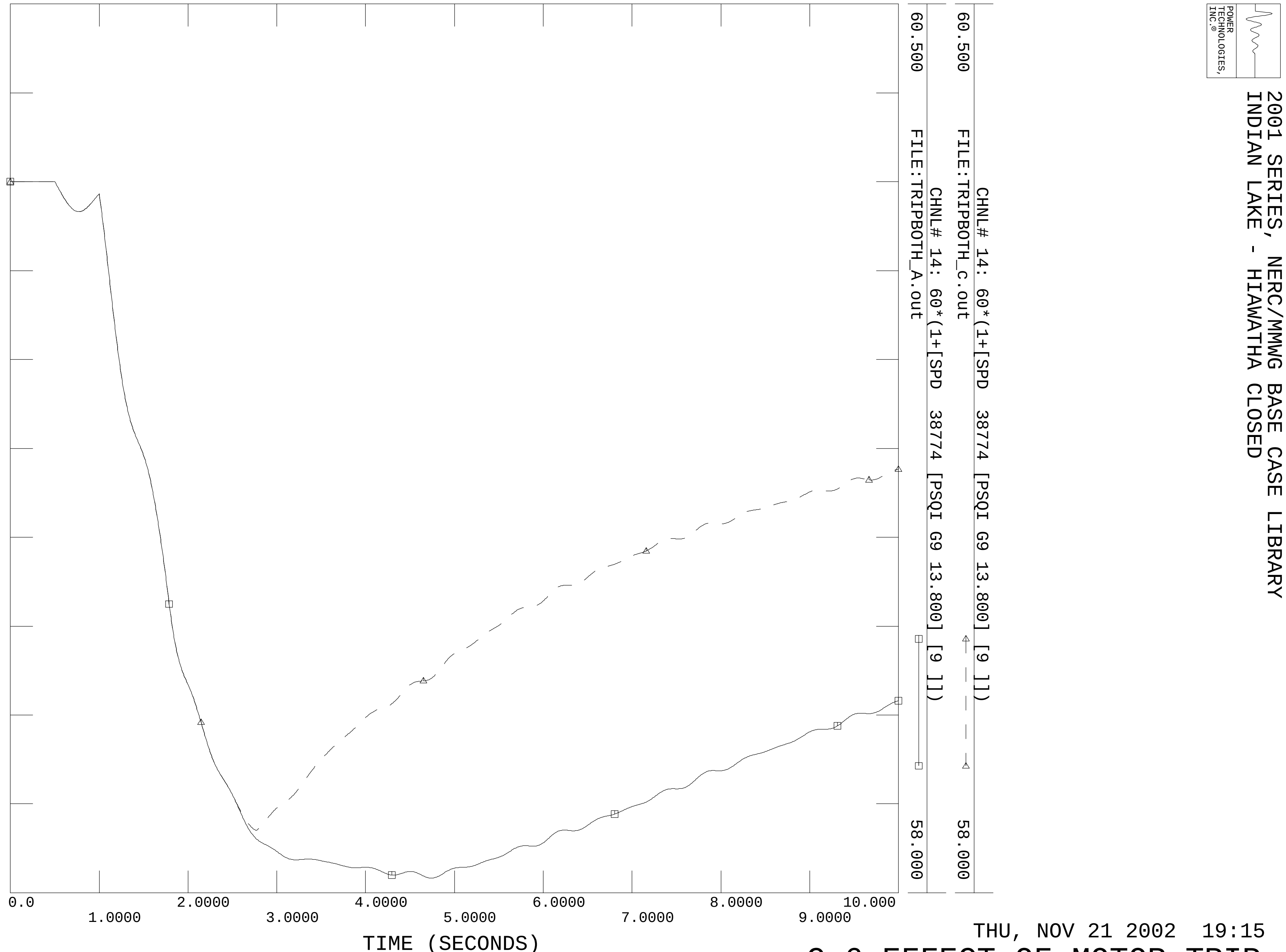
C-5.2 TILDEN 2



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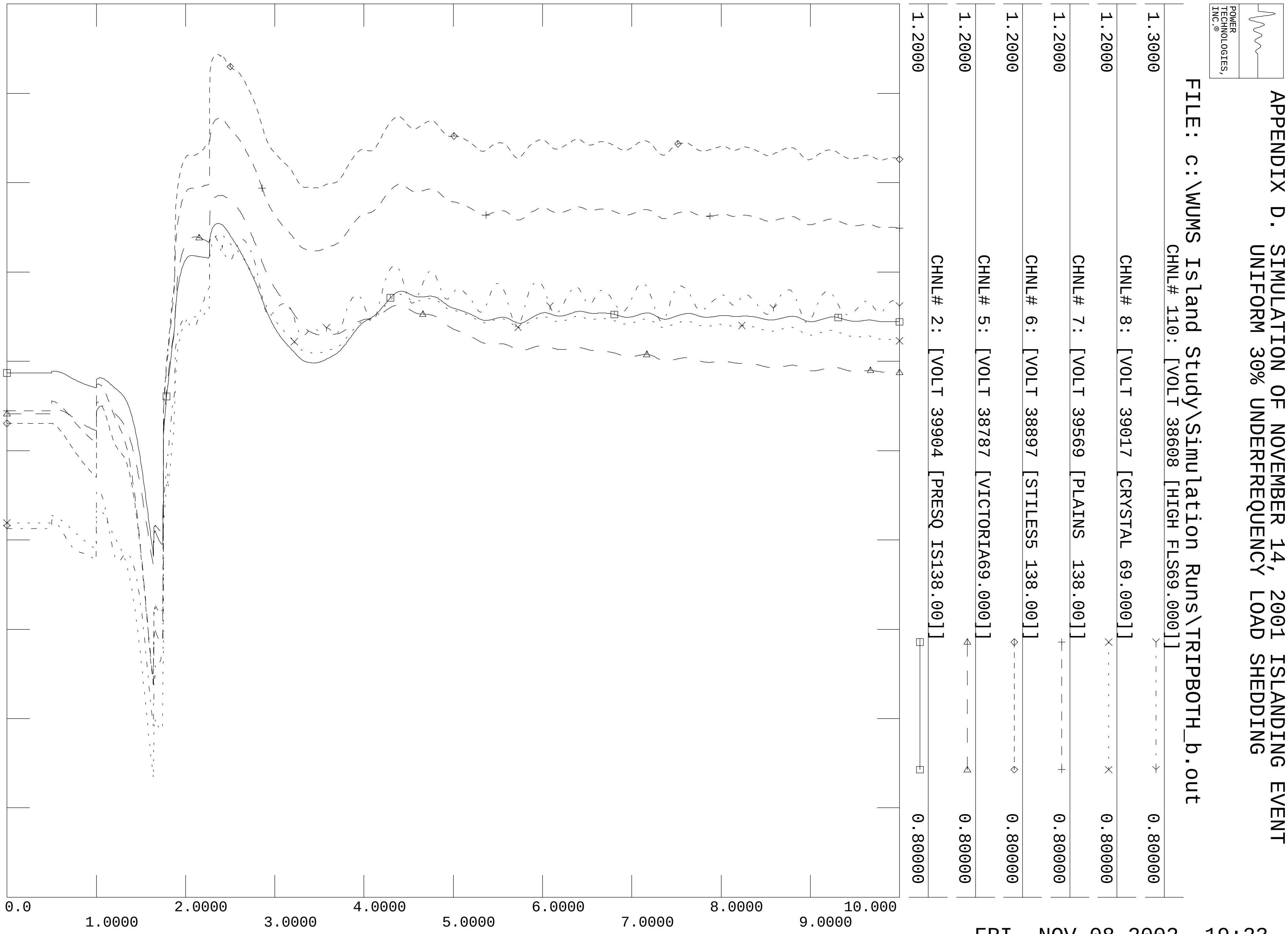
C-6 EFFECT OF MOTOR TRIP

Exhibit D

SIMULATION OF AN EVENT WITH ENHANCED UFLS



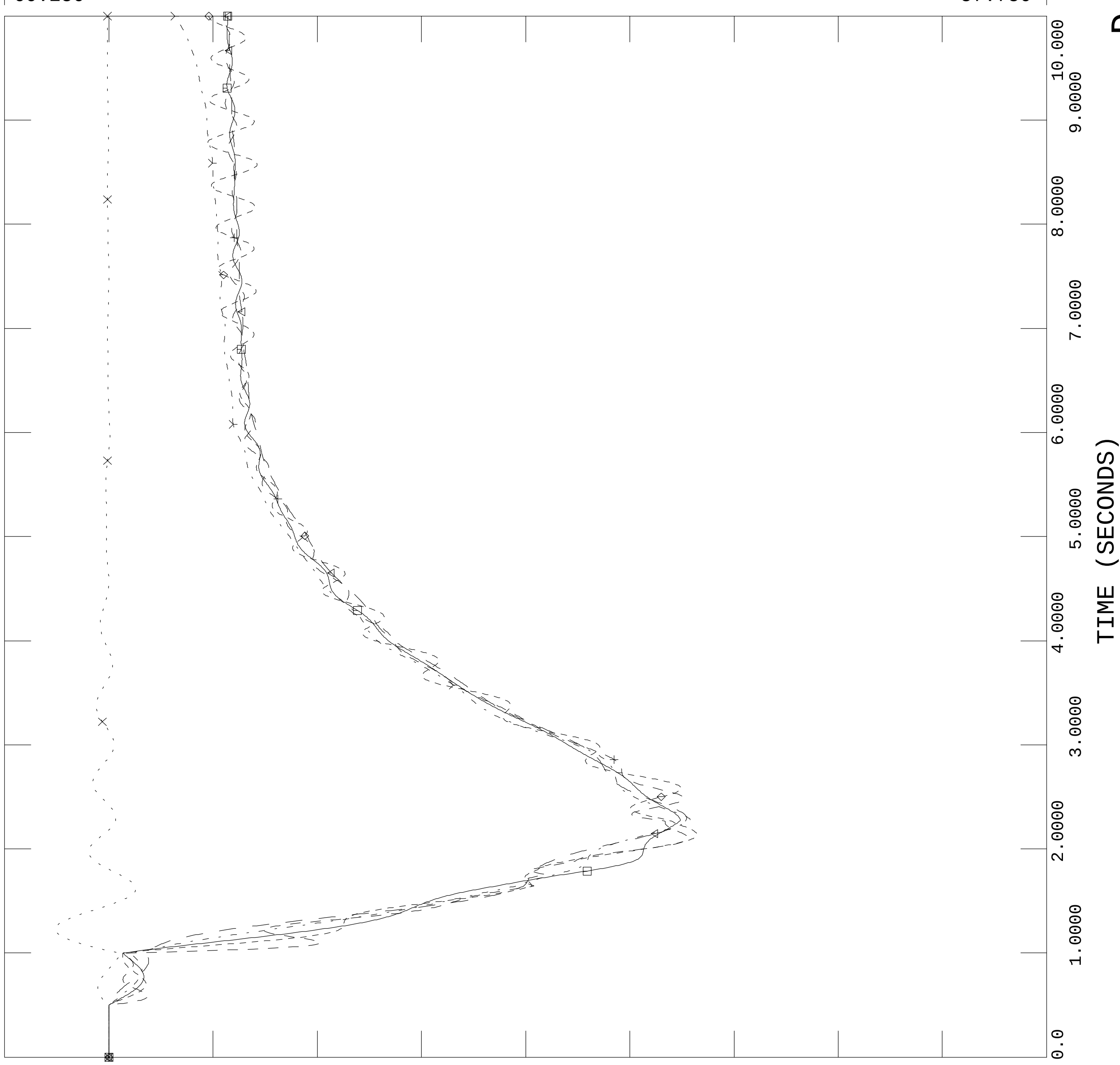
D-1 TSM. VOLTAGES

APPENDIX D. SIMULATION OF NOVEMBER 14, 2001 ISLANDING EVENT
UNIFORM 30% UNDERFREQUENCY LOAD SHEDDING

POWER TECHNOLOGIES, INC.®

FILE: c:\WUMS Island Study\Simulation Runs\TRIPBOTH_b.out

Channel	Min	Max
CHNL# 20: 60*(1+[SPD 38721 [ESC STM 12.500] [1]])	60.250	57.750
CHNL# 18: 60*(1+[SPD 39594 [PUL G8 16.000] [8]])	60.250	57.750
CHNL# 17: 60*(1+[SPD 39102 [BRUL HG 6.6000] [1]])	60.250	57.750
CHNL# 16: 60*(1+[SPD 38807 [VIC 1 1111.500] [1]])	60.250	57.750
CHNL# 15: 60*(1+[SPD 39895 [MQT STM 69.000] [3]])	60.250	57.750
CHNL# 14: 60*(1+[SPD 38774 [PSQI G9 13.800] [9]])	60.250	57.750



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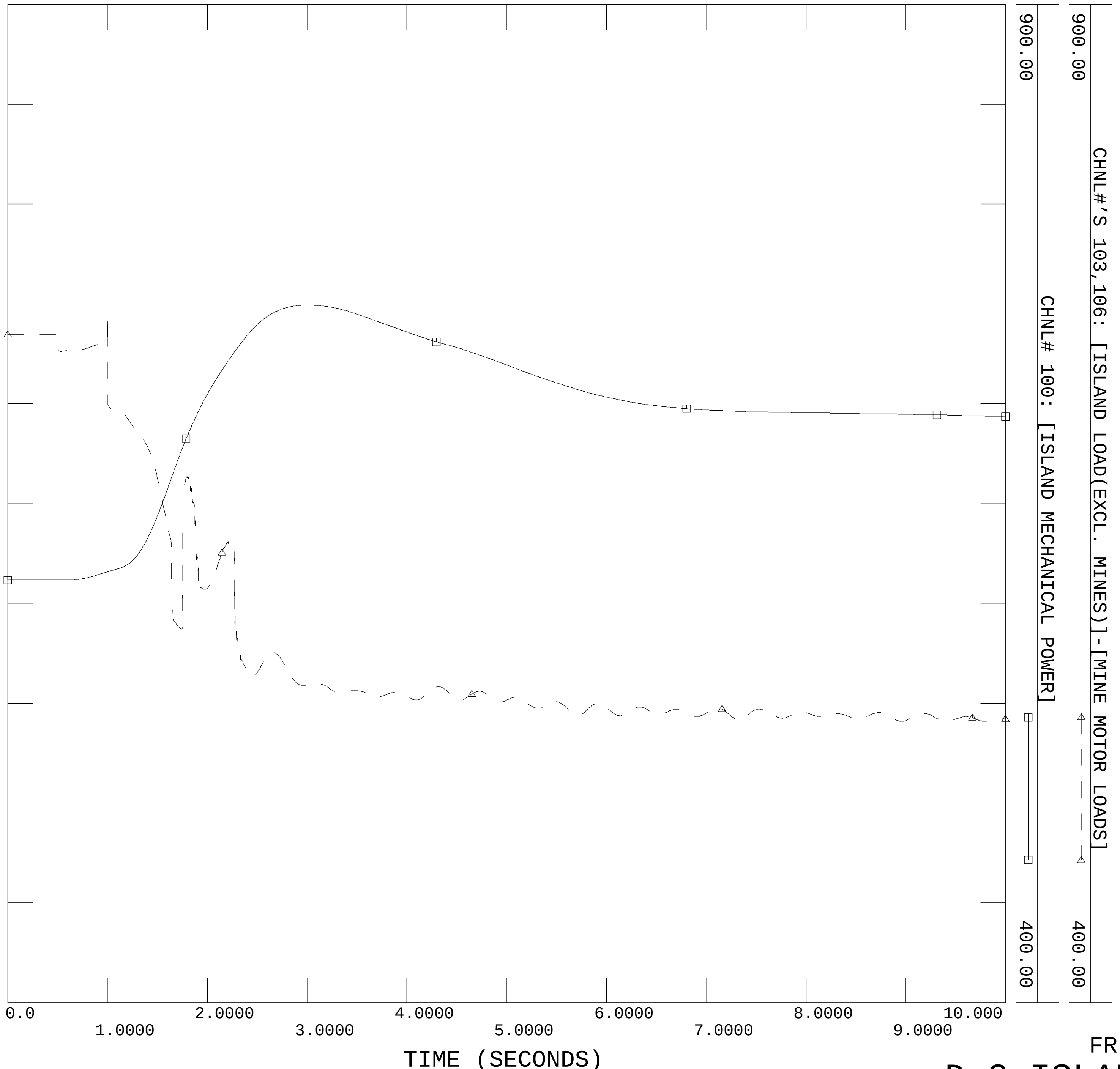
D-2 GEN. SPEEDS (HZ)

APPENDIX D. SIMULATION OF NOVEMBER 14, 2001 ISLANDING EVENT
UNIFORM 30% UNDERFREQUENCY LOAD SHEDDING

FILE: c:\WUMS Island Study\Simulation Runs\TRIPBOTH_b.out

POWER TECHNOLOGIES, INC.®



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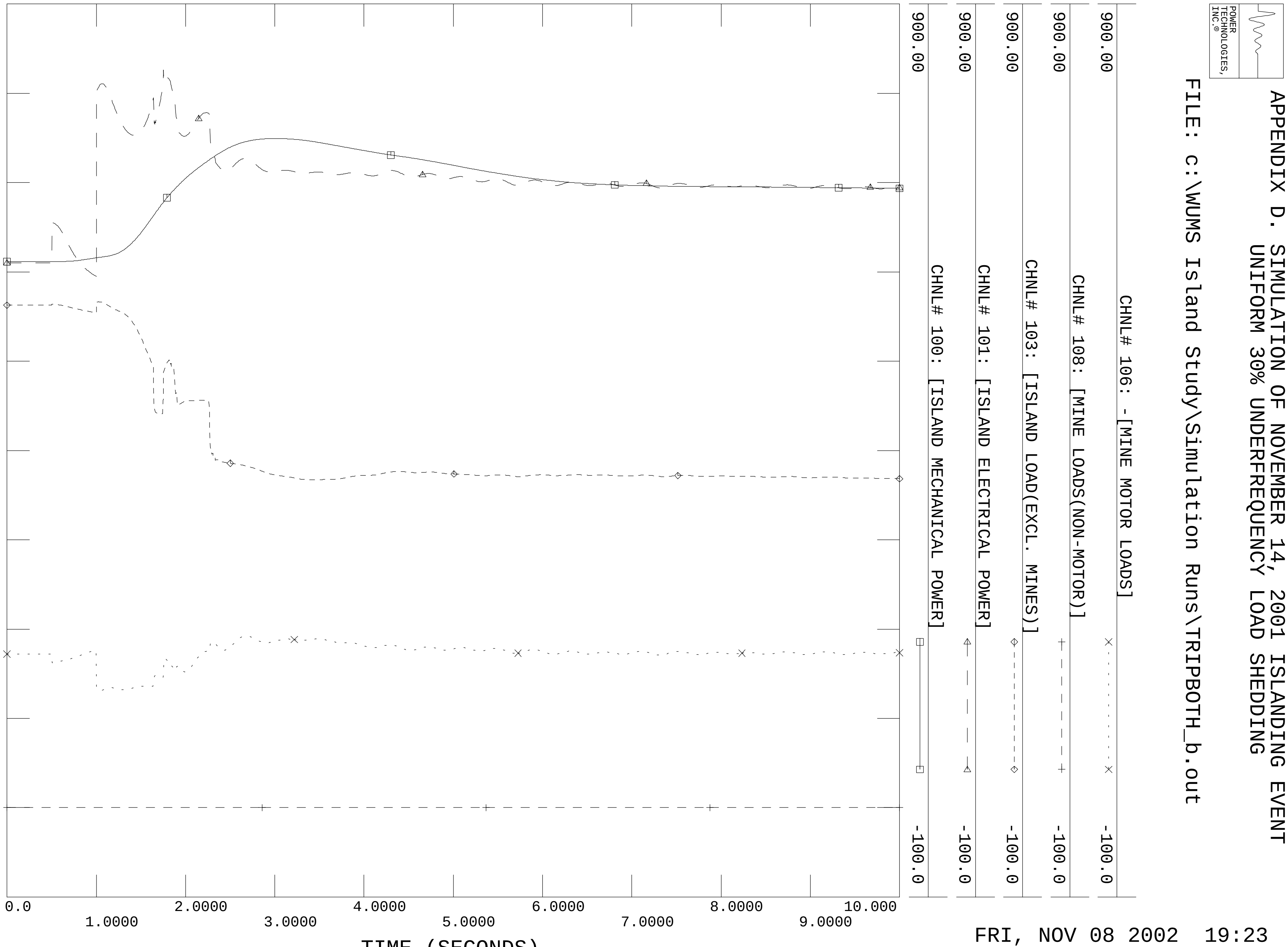
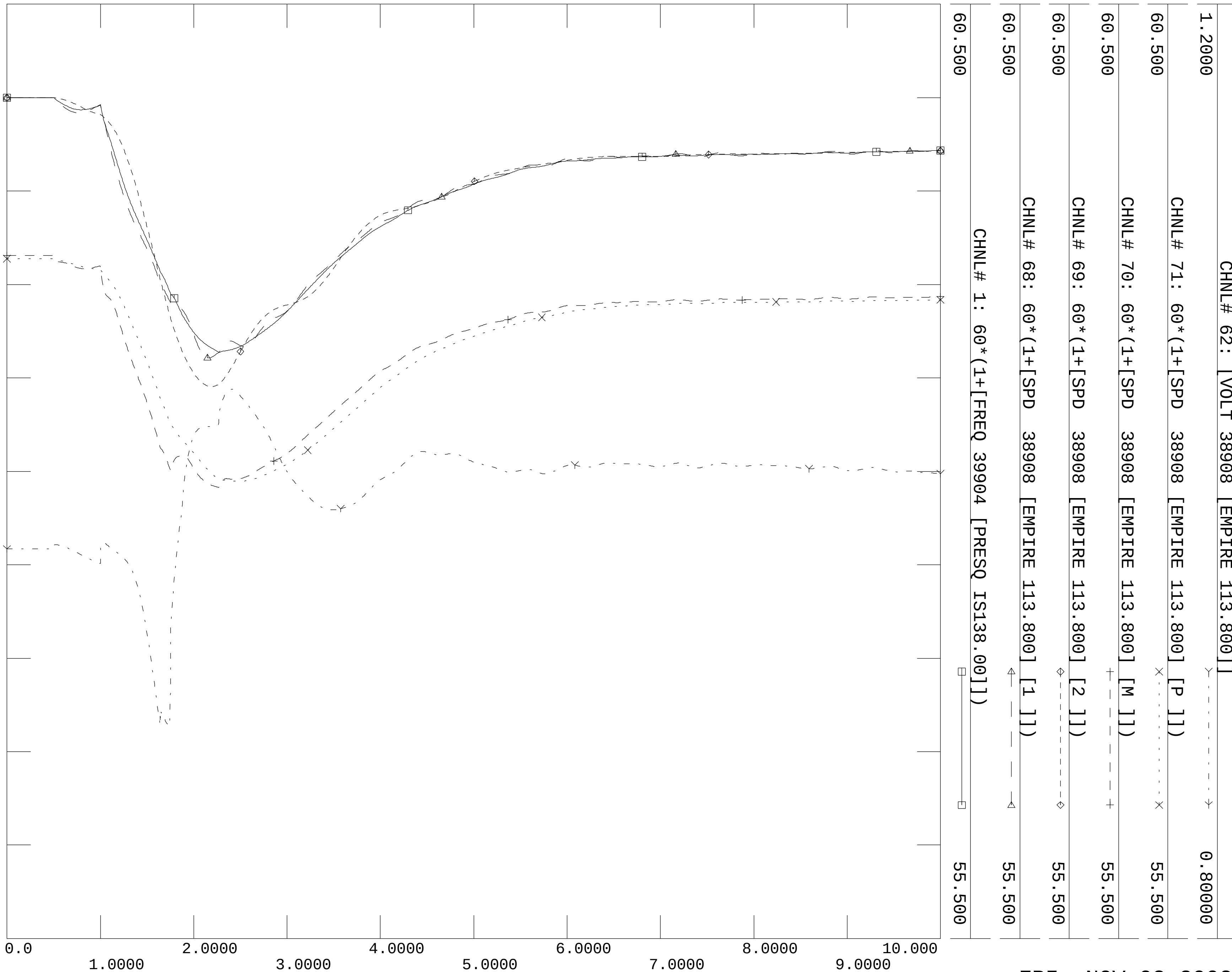
D-3 ISLAND GEN. & LOAD



D-3A GEN. & LOAD DETAILS

APPENDIX D. SIMULATION OF NOVEMBER 14, 2001 ISLANDING EVENT
UNIFORM 30% UNDERFREQUENCY LOAD SHEDDING

FILE: c:\WUMS Island Study\Simulation Runs\TRIPBOTH_b.out



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D-4.1 EMPIRE 1

APPENDIX D. SIMULATION OF NOVEMBER 14, 2001 ISLANDING EVENT
UNIFORM 30% UNDERFREQUENCY LOAD SHEDDING

FILE: c:\WUMS Island Study\Simulation Runs\TRIPBOTH_b.out

CHNL# 63: [VOLT 38909 [EMPIRE 213.800]] 1.2000 – 0.80000

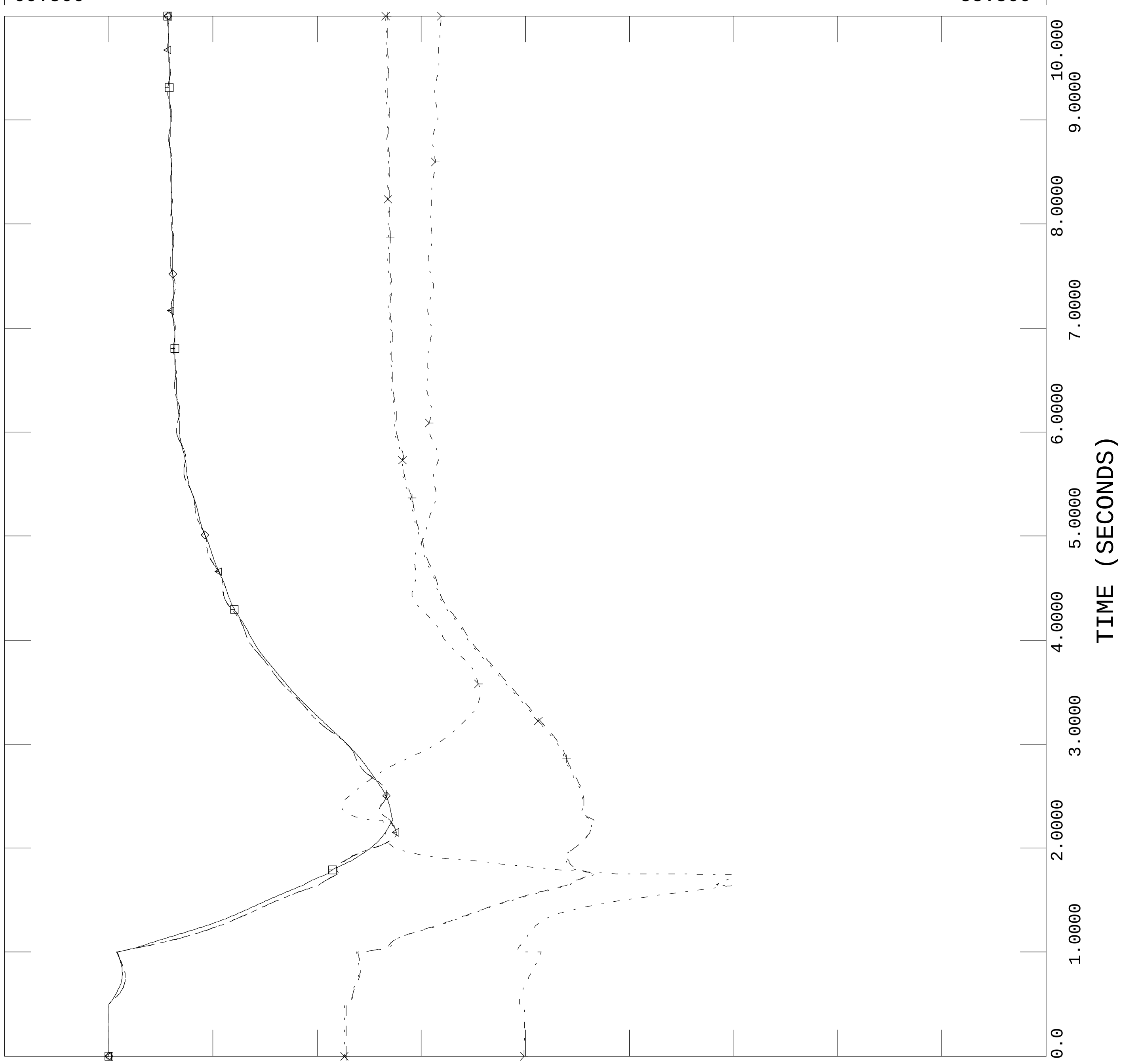
CHNL# 76: 60*(1+[SPD 38909 [EMPIRE 213.800] [N]]) 60.500 – 55.500

CHNL# 75: 60*(1+[SPD 38909 [EMPIRE 213.800] [M]]) 60.500 – 55.500

CHNL# 73: 60*(1+[SPD 38909 [EMPIRE 213.800] [2]]) 60.500 – 55.500

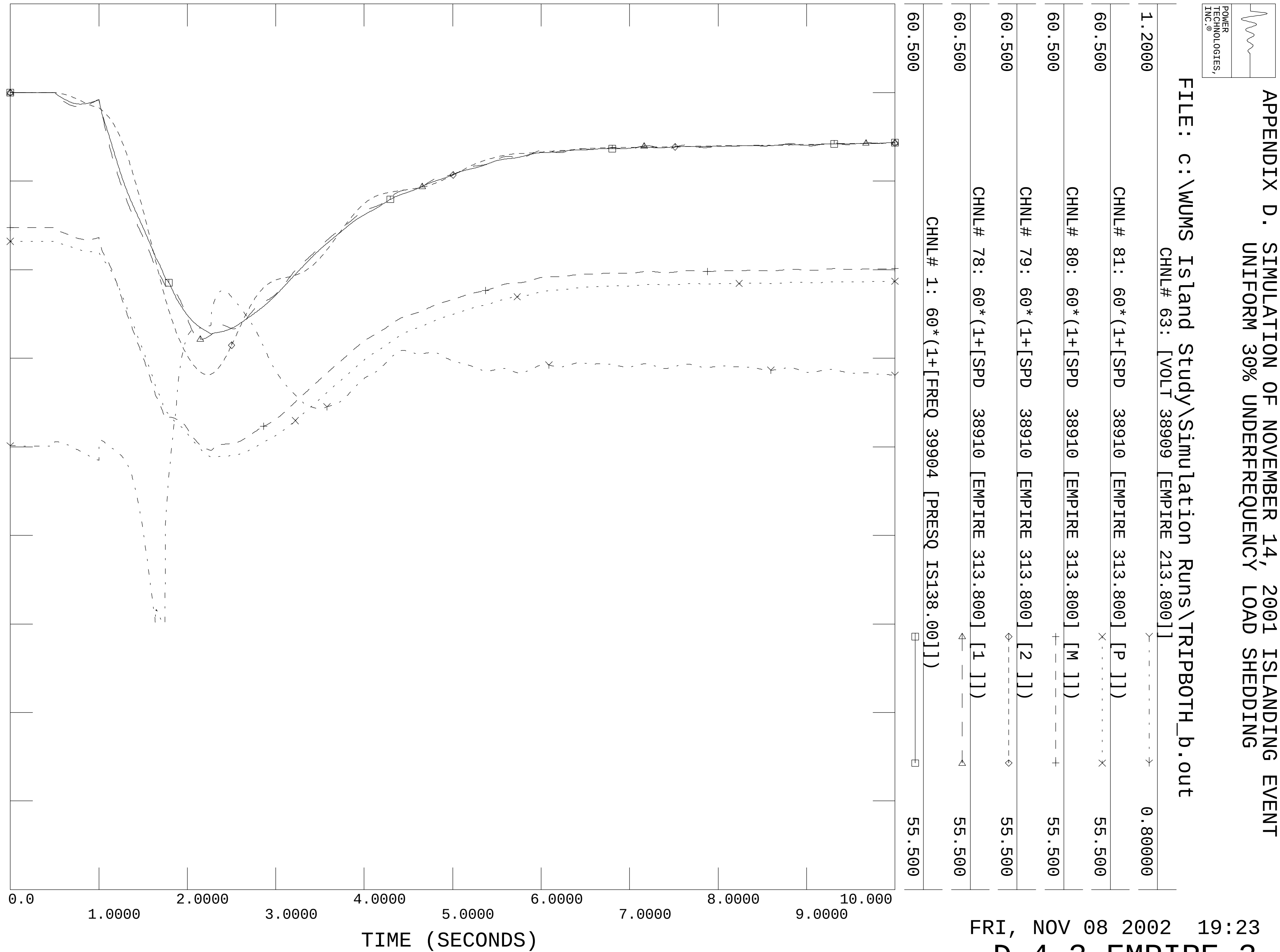
CHNL# 72: 60*(1+[SPD 38909 [EMPIRE 213.800] [1]]) 60.500 – 55.500

CHNL# 1: 60*(1+[FREQ 39904 [PRESQ IS138.00]]) 60.500 – 55.500



FRI, NOV 08 2002 19:23

D-4.2 EMPIRE 2



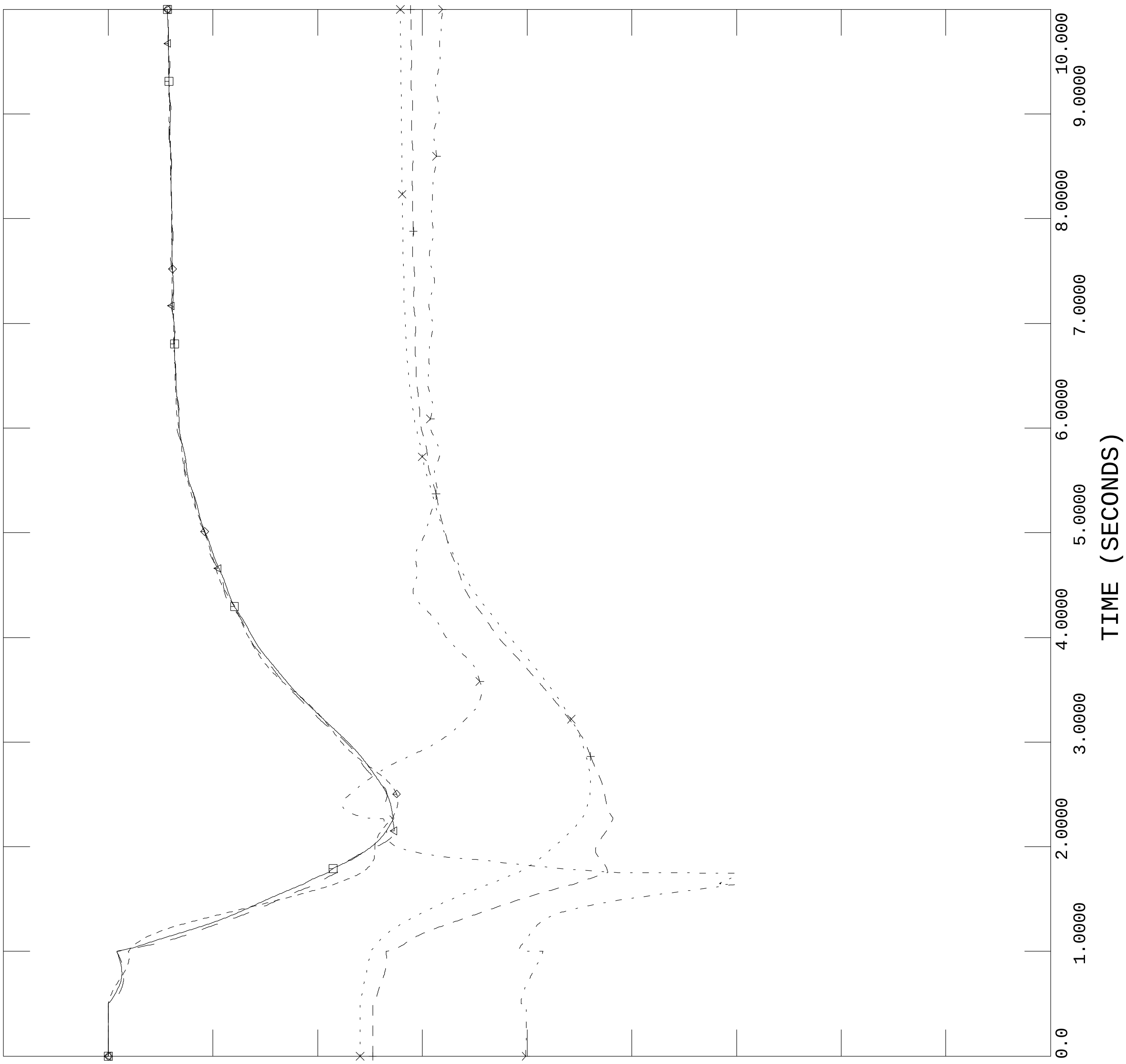
APPENDIX D. SIMULATION OF NOVEMBER 14, 2001 ISLANDING EVENT
UNIFORM 30% UNDERFREQUENCY LOAD SHEDDING
FILE: c:\WUMS Island Study\Simulation Runs\TRIPBOTH_b.out
POWER TECHNOLOGIES, INC.®
CHNL# 63: [VOLT 38909 [EMPIRE 213.800]]
1.2000
0.80000
CHNL# 81: 60*(1+[SPD 38910 [EMPIRE 313.800] [P]])
60.500
55.500
CHNL# 80: 60*(1+[SPD 38910 [EMPIRE 313.800] [M]])
60.500
55.500
CHNL# 79: 60*(1+[SPD 38910 [EMPIRE 313.800] [2]])
60.500
55.500
CHNL# 78: 60*(1+[SPD 38910 [EMPIRE 313.800] [1]])
60.500
55.500
CHNL# 1: 60*(1+[FREQ 39904 [PRESQ IS138.00]])
60.500
55.500
0.0
1.0000
2.0000
3.0000
4.0000
5.0000
6.0000
7.0000
8.0000
9.0000
10.000
TIME (SECONDS)
FRI, NOV 08 2002 19:23
D-4.3 EMPIRE 3

APPENDIX D. SIMULATION OF NOVEMBER 14, 2001 ISLANDING EVENT
UNIFORM 30% UNDERFREQUENCY LOAD SHEDDING

POWER TECHNOLOGIES, INC.®

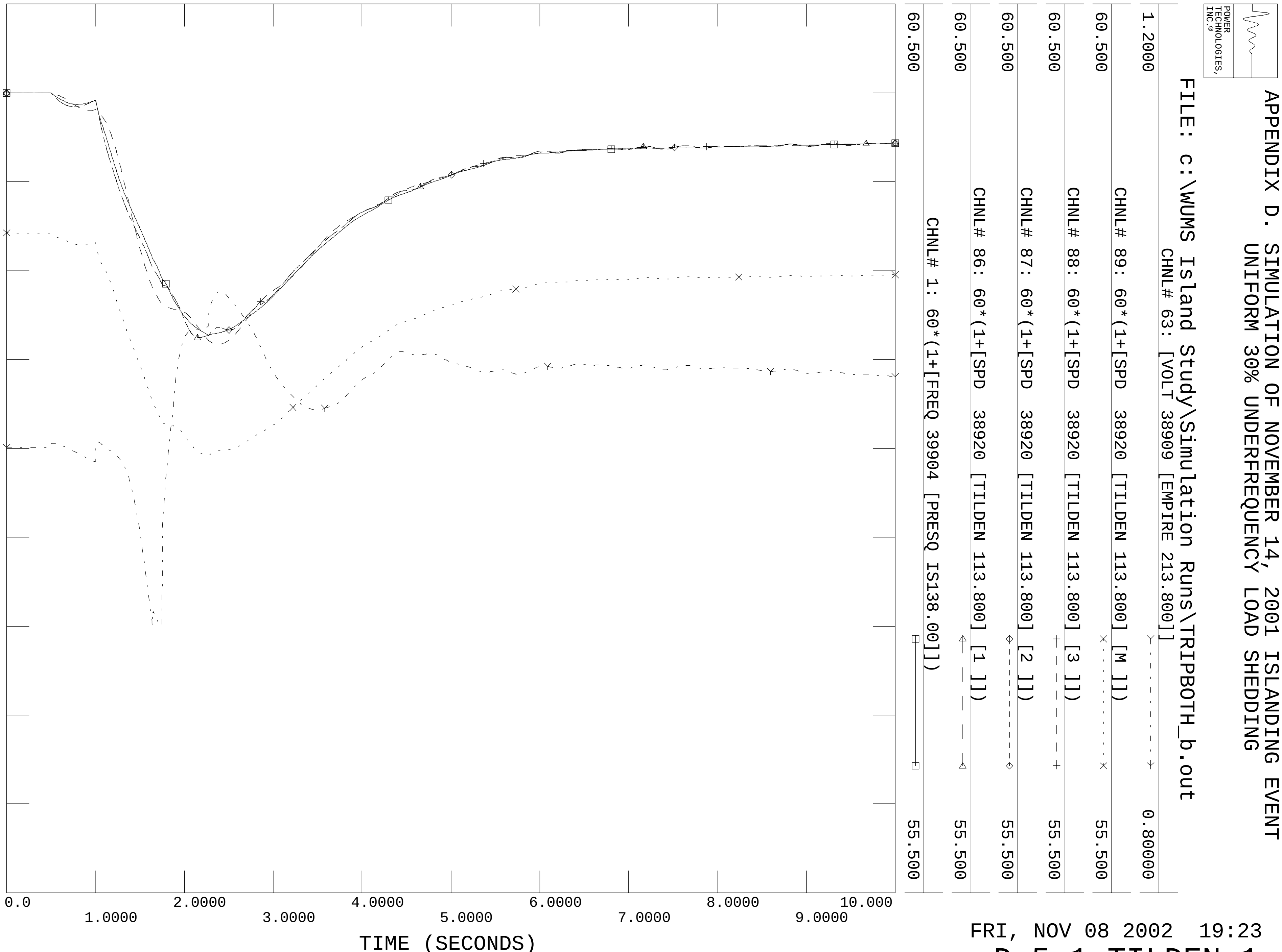
FILE: c:\WUMS Island Study\Simulation Runs\TRIPBOTH_b.out

Channel	Max	Min
CHNL# 63: [VOLT 38909 [EMPIRE 213.800]]	1.2000	0.80000
CHNL# 85: 60*(1+[SPD 38911 [EMPIRE 413.800] [P]])	60.500	55.500
CHNL# 84: 60*(1+[SPD 38911 [EMPIRE 413.800] [M]])	60.500	55.500
CHNL# 83: 60*(1+[SPD 38911 [EMPIRE 413.800] [2]])	60.500	55.500
CHNL# 82: 60*(1+[SPD 38911 [EMPIRE 413.800] [1]])	60.500	55.500
CHNL# 1: 60*(1+[FREQ 39904 [PRESQ IS138.00]])	60.500	55.500



FRI, NOV 08 2002 19:23

D-4.4 EMPIRE 4



FRI, NOV 08 2002 19:23

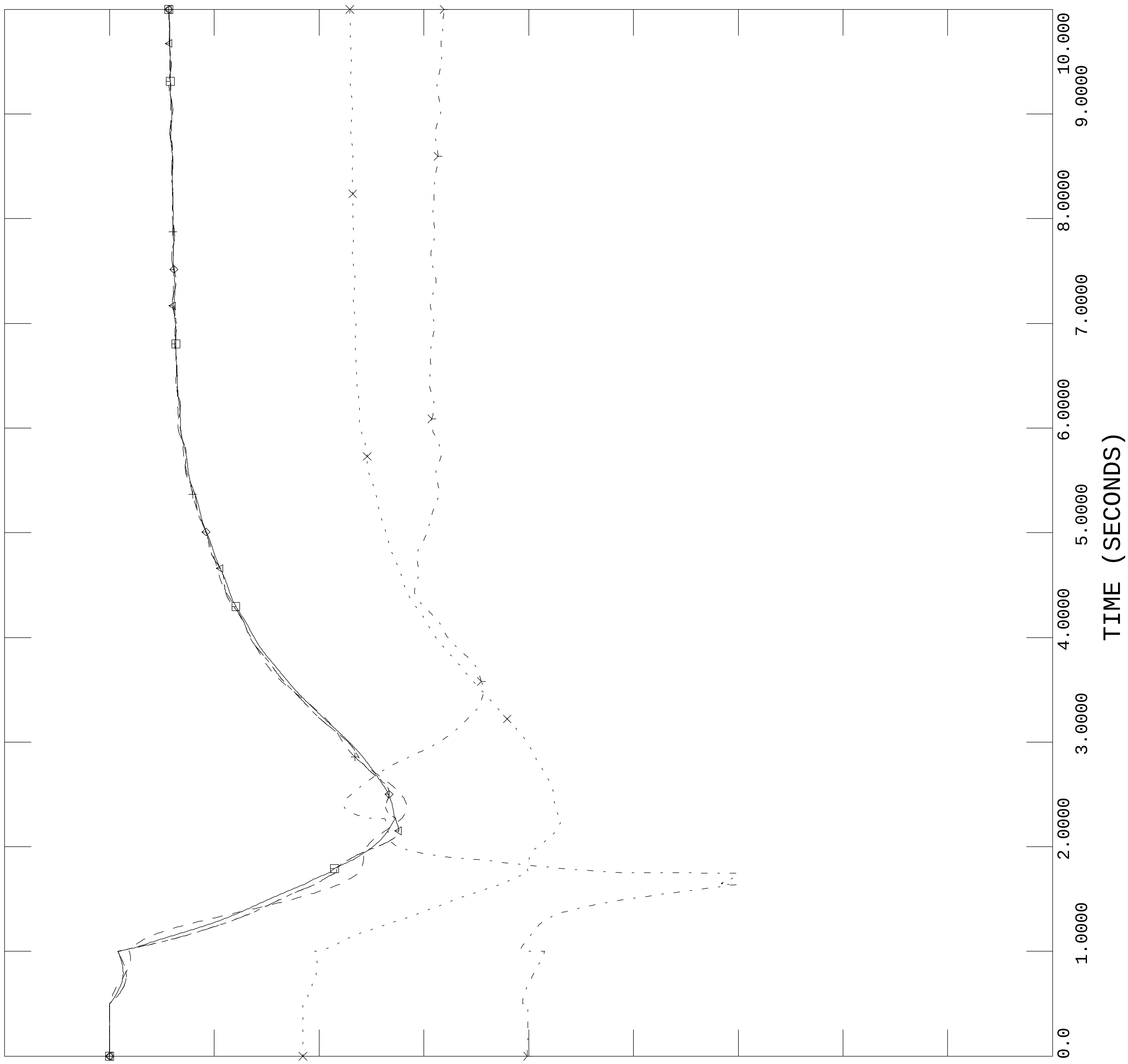
D-5.1 TILDEN 1

APPENDIX D. SIMULATION OF NOVEMBER 14, 2001 ISLANDING EVENT
UNIFORM 30% UNDERFREQUENCY LOAD SHEDDING

POWER TECHNOLOGIES, INC.®

FILE: c:\WUMS Island Study\Simulation Runs\TRIPBOTH_b.out

Channel	Min	Max
CHNL# 63: [VOLT 38909 [EMPIRE 213.800]]	1.2000	0.80000
CHNL# 95: 60*(1+[SPD 38921 [TILDEN 213.800] [M]])	60.500	55.500
CHNL# 94: 60*(1+[SPD 38921 [TILDEN 213.800] [3]])	60.500	55.500
CHNL# 93: 60*(1+[SPD 38921 [TILDEN 213.800] [2]])	60.500	55.500
CHNL# 92: 60*(1+[SPD 38921 [TILDEN 213.800] [1]])	60.500	55.500
CHNL# 1: 60*(1+[FREQ 39904 [PRESQ IS138.00]])	60.500	55.500



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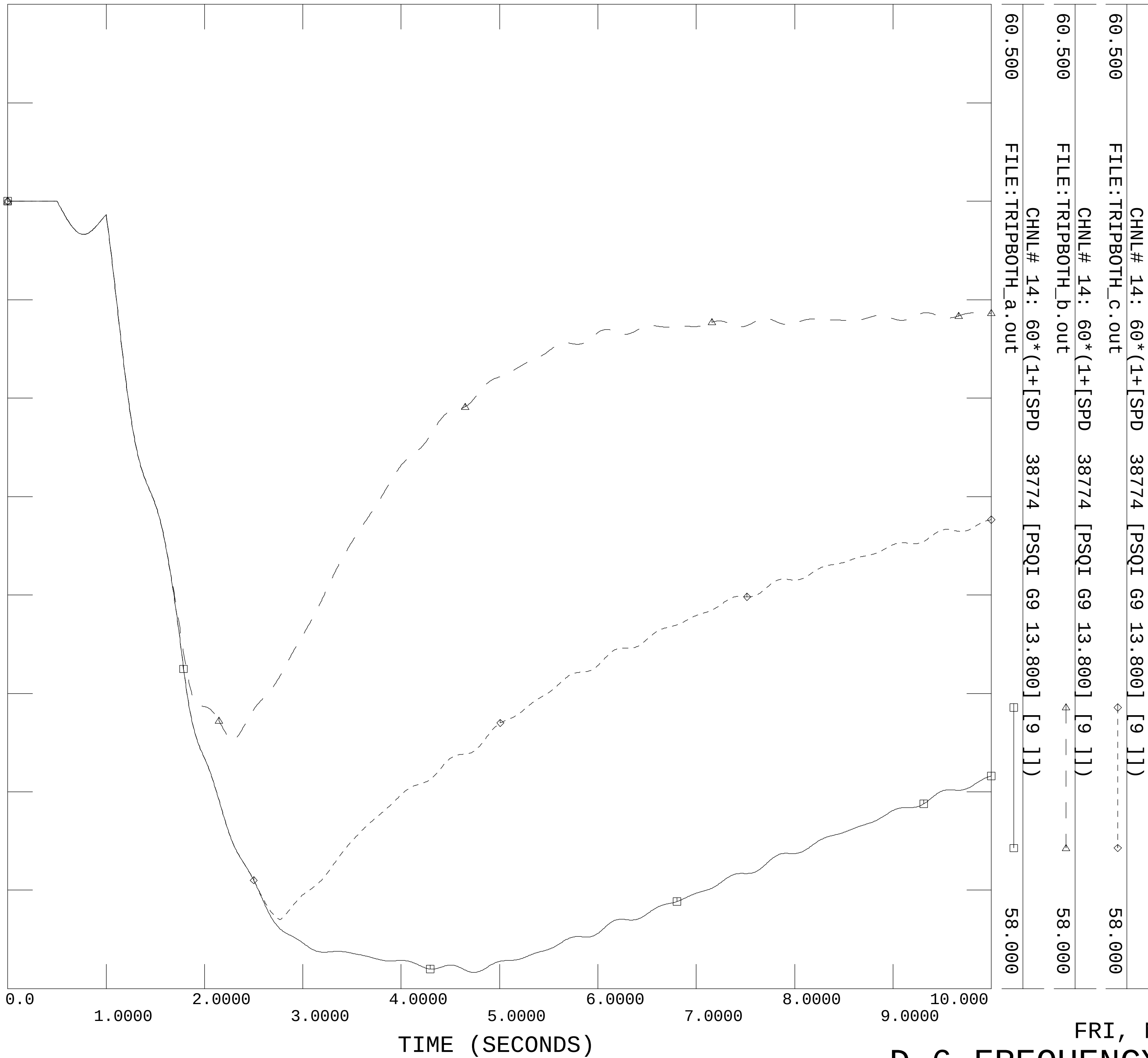
D-5.2 TILDEN 2

2001 SERIES, NERC/MMWG BASE CASE LIBRARY
INDIAN LAKE - HIAWATHA CLOSED



POWER TECHNOLOGIES, INC.®

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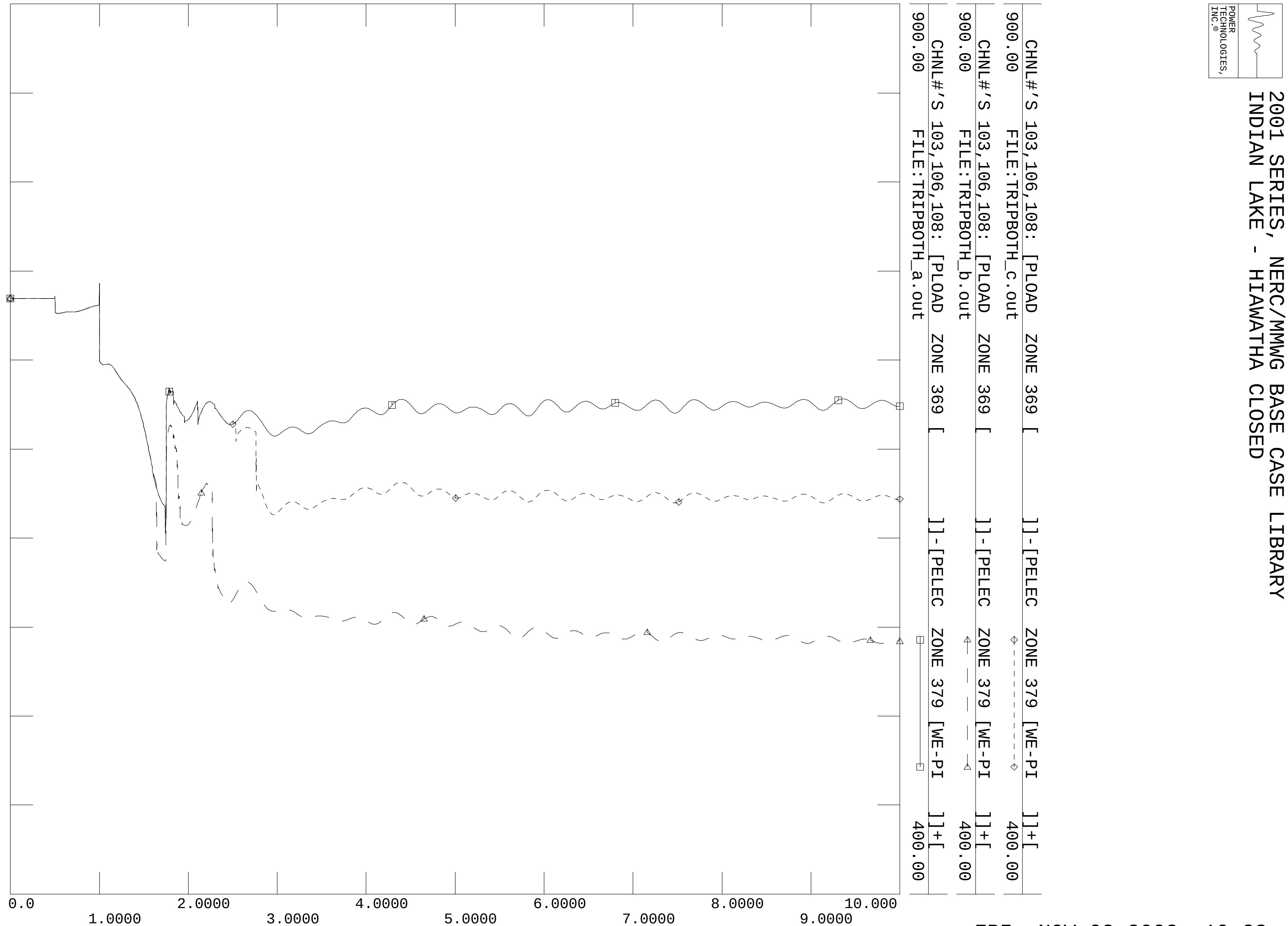
D-6 FREQUENCY COMPARISON



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D-7 LOAD COMPARISON

Exhibit E

EXCERPT FROM
MAIN GUIDE 1B: PROCEDURES DURING
GENERATING CAPACITY DEFICIENCIES CAUSING
DECLINING SYSTEM FREQUENCY OR SEPARATION

Note: the complete and current text of MAIN Guide 1B is available on the MAIN Web site, www.maininc.org to authorized users.

I. SYSTEM EMERGENCY CONDITION

C. Frequency Declining: **59.3** to **58.7** Hz

All MAIN load serving entities shall utilize automatic load shedding devices to arrest declining frequency. The frequency settings shall be as follows:

Step 1 — At **59.3** Hz, shed not less than 10% of system load.

Step 2 — At **59.0** Hz, shed additional load so that the total amount shed from Steps 1 and 2 is not less than 20% of system load prior to Step 1.

Step 3 — At **58.7** Hz, shed additional load so that the total amount shed from Steps 1, 2 and 3 is not less than 30% of system load prior to Step 1.

To enhance the effectiveness of automatic load shedding, all MAIN load serving entities shall comply with the following:

1. Use solid state underfrequency relays for all new installations and relay replacements. These relays should be applied on the first step of load shedding, where practical, to take advantage of their improved stability over electromechanical relays and their constant response time which is not significantly affected by voltage magnitude or frequency decay rate.
2. Set time delays for each of the three automatic load-shedding steps at 6 cycles. For large motor loads that may be isolated, the time delay may be increased to 15 cycles. If this is not adequate to avoid operation on isolation, a high-dropout overcurrent relay should be applied to supervise underfrequency relay tripping having a 6 cycle time delay.
3. Trip bulk power capacitor banks along with loads, unless specific studies show this to be a problem or of negligible benefit.

4. Set the voltage setting on automatic load shedding relays which are equipped with undervoltage inhibit as low as possible within the security constraints of the relay.

Exhibit F

CHARACTERISTICS OF GENERATING UNITS WITHIN ISLAND AREA

BUS#	NAME	KV	ID	Status	PGEN	QGEN	PMAX	MBASE	RSORCE	XSORCE	Generator	Exciter	Stabilizer	Governor
38556	WHR HG	2.4	1	On	2.3	-1.2	8.0	10.0	0.0030	0.2200	Salient			Hydro
38608	HIGH FLS	69	1	On	1.7	3.0	7.0	8.8	0.0000	0.2800	Classical			
								Trans:	0.0064	0.7802				
38611	CAF G	2.4	1	On	1.3	4.0	6.4	8.0	0.0000	0.3900	Classical			
38617	JOF G	2.4	1	On	1.3	1.5	3.5	4.4	0.0000	0.3400	Classical			
38618	SANDSTON	69	1	On	1.2	2.5	3.8	4.8	0.0000	0.3800	Classical			
								Trans:	0.0058	0.0542				
38628	GR RAPID	69	1	On	3.5	2.0	6.5	7.8	0.0000	0.2500	Salient			Hydro
								Trans:	0.0085	0.0696				
38721	ESC STM	12.5	1	On	6.4	2.3	7.2	13.5	0.0020	0.1904	Round	IEEET1		Steam
38721	ESC STM	12.5	2	On	6.4	2.3	7.2	13.5	0.0020	0.1904	Round	IEEET2		Steam
38724	GLADSTN	12.5	1	Off	0.0	1.3	27.0	24.1	0.0020	0.1140	Round	IEEET1		Gas Turbine
38763	PORT 12.	12.5	1	Off	0.0	0.0	23.8	24.1	0.0020	0.1140	Round	IEEET1		Gas Turbine
38766	PSQI G1	13.8	1	Off	0.0	3.2	25.0	29.4	0.0020	0.2090	Round	IEEET4		Steam
38767	PSQI G2	13.8	2	On	23.0	14.7	37.0	44.1	0.0020	0.1940	Round	IEEET1		Steam
38768	PSQI G3	13.8	3	On	54.0	14.7	58.0	68.0	0.0020	0.2120	Round	IEEET3		Steam
38769	PSQI G4	13.8	4	On	54.0	14.7	58.0	68.0	0.0020	0.2120	Round	IEEET4		Steam
38770	PSQI G5	13.8	5	On	78.0	14.7	88.0	100.0	0.0030	0.1700	Round	EXST2A	PTIST1	Steam
38771	PSQI G6	13.8	6	On	80.0	14.7	90.0	100.0	0.0030	0.1700	Round	EXST2A	PTIST1	Steam
38772	PSQI G7	13.8	7	On	78.0	14.7	85.0	100.0	0.0030	0.1700	Round	EXST2A	PTIST1	Steam
38773	PSQI G8	13.8	8	On	77.0	14.7	88.0	100.0	0.0030	0.1700	Round	EXST2A	PTIST1	Steam
38774	PSQI G9	13.8	9	On	81.0	14.7	88.0	100.0	0.0030	0.1700	Round	IEEET3		Steam
38790	WARDEN 1	13.8	1	Off	0.0	0.0	17.7	22.1	0.0020	0.1490	Classical			
38798	WPINE M	13.8	1	On	6.0	0.0	14.8	17.5	0.0020	0.1470	Round	IEEET1		Gas Turbine
38798	WPINE M	13.8	2	Off	0.0	0.0	14.8	17.5	0.0020	0.1470	Round	IEEET1		Gas Turbine

BUS#	NAME	KV	ID	Status	PGEN	QGEN	PMAX	MBASE	RSORCE	XSORCE	Generator	Exciter	Stabilizer	Governor
38798	WPINE M	13.8	3	Off	0.0	0.0	14.8	17.5	0.0020	0.1470	Round	IEEET1		Gas Turbine
38807	VIC 1 11	11.5	1	On	5.0	0.7	6.0	7.5	0.0030	0.3800	Classical			
38808	VIC A 11	11.5	1	On	5.0	0.0	6.0	7.5	0.0030	0.3800	Classical			
39022	WAY HG1	4.16	1	Off	0.0	0.0	1.8	2.2	0.0030	0.2200	Classical			
39024	HEM HG1	4.16	1	Off	0.0	-0.5	2.8	3.1	0.0000	0.3500	Salient			Hydro
39071	NEQ HG1	6.9	1	On	7.9	3.4	8.0	8.9	0.0030	0.3250	Salient			Hydro
39072	NEQ HG2	6.9	2	On	7.9	3.4	8.0	8.9	0.0030	0.3250	Salient			Hydro
39099	PVY HG1	6.9	1	Off	0.0	4.0	6.0	7.5	0.0030	0.3400	Salient			Hydro
39101	PVY HG2	6.9	2	Off	0.0	4.0	6.0	7.5	0.0030	0.3400	Salient			Hydro
39102	BRUL HG	6.6	1	On	1.1	2.3	5.3	6.7	0.0030	0.2840	Salient			Hydro
39105	MCH HG1	4.16	1	Off	0.0	1.9	4.8	5.3	0.0030	0.4000	Salient			Hydro
39106	MCH HG2	4.16	2	Off	0.0	1.9	4.8	5.3	0.0030	0.4000	Salient			Hydro
39107	TWF HG	6.6	1	On	2.1	2.9	6.1	6.4	0.0030	0.1460	Salient			Hydro
39108	PIN HG	2.3	1	On	1.1	2.3	3.6	4.0	0.0030	0.2500	Salient			Hydro
39109	KIN HG	13.8	1	On	2.1	1.5	7.2	9.0	0.0030	0.2830	Salient			Hydro
39111	OLQ HG1	2.3	1	Off	0.0	0.0	1.8	2.2	0.0030	0.1700	Salient			Hydro
39112	OLQ HG2	2.3	2	Off	0.0	0.0	1.8	2.2	0.0030	0.1700	Salient			Hydro
39124	CKH HG	2.4	1	On	2.0	1.5	7.8	9.8	0.0030	0.4300	Salient			Hydro
39655	WEM G31	13.8	1	Off	0.0	8.2	41.0	47.0	0.0000	0.1150	Round	IEEET2		Gas Turbine
39660	WEM G32	13.8	2	Off	0.0	1.1	39.0	47.0	0.0000	0.1150	Round	IEEET2		Gas Turbine
39661	WEM G33	13.8	3	Off	0.0	0.0	75.0	112.9	0.0000	0.2000	Round	IEEET1		Gas Turbine
39824	WEM 34	13.8	1	Off	0.0	0.0	79.5	112.9	0.0000	0.2000	Round	IEEET1		Gas Turbine
39895	MQT STM	69	1	On	2.7	0.0	6.0	14.7	0.0020	0.1036	Round	IEEET1		Steam
								Trans:	0.0110	0.1100				
39895	MQT STM	69	2	On	4.2	0.0	9.4	22.9	0.0020	0.1434	Round	IEEET1		Steam
								Trans:	0.0110	0.1100				
39895	MQT STM	69	3	On	9.6	0.0	21.2	52.0	0.0020	0.2110	Round	IEEET1		Steam
								Trans:	0.0110	0.1100				
39895	MQT STM	69	4	On	4.5	0.0	9.9	24.1	0.0020	0.1140	Round	IEEET1		Gas Turbine
								Trans:	0.0110	0.1100				

Exhibit G

CHARACTERISTICS OF EXISTING UNDERFREQUENCY LOAD SHEDDING

IN ISLAND AREA

Owner	Name	KV	Fraction Shed
WPS	WELLS ST	69	100%
WPS	30TH AVE	69	50%
UPP	DELTA 69	69	100%
UPP	ELEV 69	69	100%
UPP	HENRY 69	69	100%
UPP	SAWYER 6	69	100%
UPP	ELEV TP2	69	100%
WE	WCL	34.5	40%
WPS	W.MARNET	138	100%

Exhibit H

PSS/E COMMAND FILES USED TO CREATE THE BASE CASE POWER FLOW

INITIAL.IDV

```
MENU,OFF      /* FORCE MENU TO CORRECT STATUS
TEXT PARAMETER 1 = %1% IS PERCENTAGE INCREASE IN LOAD FOR ISLAND AREA
TEXT PARAMETER 2 = %2% IS MW INTERCHANGE FROM AREA 366 TO AREA 368 TO SUPPLY LOAD
TEXT            ORIGINAL LOAD IS 94 MW
ODEV
2
INITIAL.LOG
PDEV
2
INITIAL.LOG
TEXT PARAMETER 1 = %1% IS PERCENTAGE INCREASE IN LOAD FOR ISLAND AREA
TEXT PARAMETER 2 = %2% IS MW INTERCHANGE FROM AREA 366 TO AREA 368 TO SUPPLY LOAD
CASE
C:\WUMS Island Study\Power Flow Cases\INITIAL_1.SAV
OPTN
16 / TURN ON PHASE SHIFT ADJUSTMENT
1
21 / NEWTON TOLERANCE
0.250000
0
rdch
1
0 / bus data
0 / load data
0 / gen data
39799,39772,1,.01438,.04379,.00084,76,76,76,,,,,,,0 / man-glen jk (open)
0  / line data
Q
@INPUT,"C:\WUMS Island Study\Power Flow Cases\initial_lines.idv"
TEXT Change Presque Isle and Pulliam controlled voltages and MW to 6:30 values
TEXT Change PSQI to control 138 kV bus
TEXT Change area 366 and 368 control buses to Weston 3 and Escanaba
chng
2 / gen
38766 / PSQI 1
1
1.0348,39904
1
1
0 / off
-1 / next
38767/ PSQI 2
1
1.0348,39904
1
2
1
1 23 / on, new MW
-1 / next
38768 / PSQI 3
1
1.0348,39904
3
1
```

1,54
-1 / next
38769 / PSQI 4
1
1.0348,39904
4
1
1 54
-1 / next
38770 / PSQI 5
1
1.0348,39904
5
1
1,78
-1 / next
38771 / PSQI 6
1
1.0348,39904
6
1
1,80
-1 / next
38772 / PSQI 7
1
1.0348,39904
7
1
1,78
-1 / next
38773 / PSQI 8
1
1.0348,39904
8
1
1,77
-1 / next
38774 / PSQI 9
1
1.0348,39904
9
1
1,81
-1 / next
39590 / Pulliam G7
1
1.0188
7
1
0 / off
-1
39591 / Pulliam 5
1
1.0188
5
1

, 44, 9
-1
39592 / Pulliam G4
1
1.0188
4
1
,21.3,6.5
-1
39593 / Pulliam G3
1
1.0188
3
1
,18.9,4.3
-1
39594 / Pulliam G8
1
1.0109
8
1
1,125.5,31.2
-1
39595 / Pulliam G6
1
1.0109
6
1
1,61.3,9.0
-1
0 / NEW CHANGE CODE
9 / SWITCHED SHUNT
39589 / PULLIAM 138
1
,1.025,1.01,25.2 / NEW VALUES

0 / NEW CHANGE CODE
5 / AREA INTERCHANGE
366 / WPS
1 / CHANGE
39678 / WESTON 3
368 / UPP
1 / CHANGE
38721 / ESC STM
-1 / EXIT
TEXT FOLLOWING MODELED AS 1 UNIT IN POWER FLOW EXCEPT AS NOTED
RDCH
1
0 / bus data
0 / load data
38556,1,2.3,,,,,,,,,,,1 /WHR HG 2.40
38608,1,1.7,,,,,,,,,,,1 /HIGH FLS69.0
38611,1,1.3,,,,,,,,,,,1 /CAF G   2.40
38617,1,1.3,,,,,,,,,,,1 /JOF G   2.40
38618,1,1.2,,,,,,,,,,,1 /SANDSTON69.0
38628,1,3.5,,,,,,,,,,,1 /GR RAPID69.0

```
38721,1,7.0,,,,,,,,,,,1  /ESC STM
38721,2,7.0,,,,,,,,,,,1  /ESC STM
38763,1,10.,,,,,,,,,,,0  /PORT 12.12.5
38790,1,3.7,,,,,,,,,,,0  /WARDEN  12.5
39022,1,0.0,,,,,,,,,,,0  /WAY HG1 4.16
39024,1,0.0,,,,,,,,,,,0  /HEM HG1 4.16
39071,1,7.9,,,,,,,,,,,1  /NEQ HG1 6.90
39072,2,7.9,,,,,,,,,,,1  /NEQ HG2 6.90
39099,1,0.0,,,,,,,,,,,0  /PVY HG1 6.90 -- EMS VALUES NEGATIVE
39101,2,0.0,,,,,,,,,,,0  /PVY HG2 6.90
39102,1,1.1,,,,,,,,,,,1  /BRUL HG 6.60
39105,1,0.0,,,,,,,,,,,0  /MCH HG1 4.16
39106,2,0.0,,,,,,,,,,,0  /MCH HG2 4.16
39107,1,2.1,,,,,,,,,,,1  /TWF HG1 6.60
39108,1,1.1,,,,,,,,,,,1  /PIN HG  2.30
39109,1,2.1,,,,,,,,,,,1  /KIN HG  13.8
39111,1,0.0,,,,,,,,,,,0  /OLQ HG1 2.30
39112,2,0.0,,,,,,,,,,,0  /OLQ HG2 2.30
39124,1,2.0,,,,,,,,,,,1  /CKH HG  2.40
39678,3,319.,,,,,,,,,,,1 /WESTON 3
39679,1,41.5,,,,,,,,,,,1 /WESTON 1
39680,2,80.5,,,,,,,,,,,1 /WESTON 2
39737,1,2.3,,,,,,,,,,,1  /ESHYDR-14.20
39738,1,2.3,,,,,,,,,,,1  /ESHYDR-24.20
39739,1,2.2,,,,,,,,,,,1  /ESHYDR-34.20
39740,1,2.1,,,,,,,,,,,1  /ESHYDR-44.20
39745,1,16.3,,,,,,,,,,,1  /US HYDRO13.8
0 / generator data
Q
TEXT TAP CODE CHANGED TO DIRECT
FDNS,OPT
1,2,1,0,0,0
0
@INPUT,"C:\WUMS Island Study\Power Flow Cases\changeemptld.idv"
TEXT REGULATE EMPIRE AND TILDEN 138 kV BUS AT 6:30 AM VALUES
CHNG
2
38908
1
0.9986,39886,,11.5
-1
38909
1
0.9986,39886,,8.0
-1
38910
1
.9986,39886,,29.4
-1
38911
1
.9986,39886,,51.0
-1
38920
1
1.0022,39915,,50.0
```

```
-1
38921
1
1.0022,39915,,50.0
-1
-1   / EXIT
TEXT SCALE EMPIRE AND TILDEN MOTOR LOADS TO 6:30 VALUES
scal
38908
1  / SPECIFY NEW TOTAL POWERS
,,,,-23.3
1  / ENFORCE POWER LIMITS
0  / NO CHANGE IN LOAD MVAR
38909
1
,,,,-47.1
1
0
38910
1
,,,,-21.9
1
0
38911
1
,,,,-56
1
0
38920
1
,,,,-62.8
1
0
38921
1
,,,,-71.6
1
0

CHNG
8
0
1
BASE LOAD and INTERCHANGE, 6:00 Configuration
0
FDNS,OPT
1,2,1,0,0,0
0
SAVE
INITIAL_BASE
text @INPUT,"C:\WUMS Island Study\Power Flow Cases\draw_case.idv"
rdch
island_loads_in_zone369.rdc
TEXT FOLLOWING REMOVED BY CHANGEMPTLD.IDV FILE
TEXT 38718,1,,365,369
TEXT 38785,1,,365,369
```

```
TEXT 38912,1,,365,369
TEXT 38922,1,,365,369
rdch
island_buses_in_zone369.rdc
TEXT FOLLOWING REMOVED BY CHANGEMPTLD.IDV FILE
TEXT 38718,,13.8,,,,365,369
TEXT 38785,,13.8,,,,365,369
TEXT 38912,,13.8,,,,365,369
TEXT 38922,,13.8,,,,365,369
TEXT
TEXT FOLLOWING REMOVED TO ALLOW A CHSB MODEL TO SUM AREA 379
TEXT 38908,,13.8,,,,365,369
TEXT 38909,,13.8,,,,365,369
TEXT 38910,,13.8,,,,365,369
TEXT 38911,,13.8,,,,365,369
TEXT
@INPUT,"C:\WUMS Island Study\Power Flow Cases\scale_zone.idv" %1%
TEXT @INPUT,"C:\WUMS Island Study\Power Flow Cases\scale_wps.idv" %1%
TEXT SCALE PAPER MILLS (NIAGARA OF WIS, CHAMPION) TO MEASURED VALUES -- ADDED
        9/29/02
scal
38554
1
26.2
1
1
38546
1
62
1
1


FDNS,OPT
1,2,1,0,0,0
0
@INPUT,"C:\WUMS Island Study\Power Flow Cases\CHNG_366_TO_368.idv" %2%
CHNG
8
0
1
INITIAL CASE - LOAD INCR %1% PCT, INTER OF %2% FROM WPS TO UPP
0
FDNS,OPT
1,2,1,0,0,0
0
SAVE
INITIAL_%1%
@INPUT,"C:\WUMS Island Study\Power Flow Cases\draw_case.idv"
@INPUT,"C:\WUMS Island Study\Power Flow Cases\LIST_FLOWS.idv" %1%_pct
LIST,AR
2 / FILE
WUMS_GENS
365 366 368
4 / PLANT DATA
5 / UNITS
```

```
11 / AREA INTERCHANGE
0
chng
3 / branch
39576 39545 1 / 6851 -- White Clay - Lawn Road
1 / change first line
0 / status off
-1
0
0
CHNG
8
0
1
Line 6851 (White Clay-Lawn Road) Out
0
FDNS,OPT
1,2,1,0,0,0
0
@INPUT,"C:\WUMS Island Study\Power Flow Cases\draw_case.idv"
save
trip_6851
chng
3 / branch
39764 39769 1 / 6913 -- Hiawatha - Gould City
1
1
-1
39772 39794 1 / 6912 -- Manistique - Valley
1
1
-1
39772 39799 1 / 6913 -- Manistique - Glen Jenks
1
0
-1
0
8
0
1
Indian Lake - Hiawatha Closed
0
FDNS,OPT
1,2,1,0,0,0
0
save
close69
@INPUT,"C:\WUMS Island Study\Power Flow Cases\draw_case.idv"
@INPUT,"C:\WUMS Island Study\Power Flow Cases\convertlf_wums.idv" close69
ODEV
1
PDEV
1
TEXT SOLUTION COMPLETED
```

@end

INITIAL_LINES.IDV

```
MENU,OFF      /* FORCE MENU TO CORRECT STATUS
chng
3
38895 39545 1 / 6851  N App - Lawn Rd
1
1
-1
39589 38897 2 / 64451 Pulliam - Stiles 5
1
1
-1
39589 39575 1 / 64441 Pulliam - Stiles 4
1
1
-1
39764 39769 1 / 6913 HIA - GLD
1
0
-1
39772 39799 1 / 6913 MTQ - GLJ (N.O.)
1
1
-1
39802 39799 1 / 6916 ILK - GLJ
1
1
-1
39764 39763 1 / 6912 HIA - ENG
1
1
-1
39772 39794 1 / 6912 MTQ - VLE
1
0
-1
-1
fnsl
0
save inital_config
IDEV,"C:\WUMS Island Study\Power Flow Cases\list_flows.IDV" Initial

@end
```

CHANGEEMPTLD.IDV

```
EXTR,SI
YES
0
0
38718 38785 38908 38909 38910 38911 38912 38920 38921 38922
0
RDCH
1
38908,'EMPIRE 1',13.8,2,,5.0,365,379   /EMP GEN BUS
38909,'EMPIRE 2',13.8,2,,15.0,365,379  /EMP GEN BUS
38910,'EMPIRE 3',13.8,2,,,365,379      /EMP GEN BUS
38911,'EMPIRE 4',13.8,2,,,365,379      /EMP GEN BUS
38920,'TILDEN 1',13.8,2,,,365,379      /TLD GEN BUS
38921,'TILDEN 2',13.8,2,,,365,379      /TLD GEN BUS
0  / BUS DATA
0  / LOAD DATA (NONE)
38908,'1 ',-15.100,  2.268,  4.8, -4.8,0.98,0,17.6,0.00,0.16,0.0,0.08000,1.0,1,100.0,0.0,-17.000,1,1.0
38908,'2 ', -2.600,  0.390,  1.0, -0.9,0.98,0, 3.0,0.00,0.16,0.0,0.04000,1.0,1,100.0,0.0, -2.800,1,1.0
38908,'M ', -9.200, -6.800, -6.8, -6.8,0.98,0,13.1,0.02,0.16,0.0,0.04000,1.0,1,100.0,0.0,-10.900,1,1.0
38908,'P ', -1.100, -0.700, -0.7, -0.7,0.98,0, 1.5,0.02,0.16,0.0,0.02000,1.0,1,100.0,0.0, -1.200,1,1.0
38909,'1 ',-10.400,  3.464,  8.7, -4.4,0.98,0,14.6,0.00,0.17,0.0,0.07000,1.0,1,100.0,0.0,-11.700,1,1.0
38909,'2 ',-12.600,  4.196, 11.4, -5.7,0.98,0,18.9,0.00,0.16,0.0,0.08400,1.0,1,100.0,0.0,-15.100,1,1.0
38909,'3 ', -3.100,  1.032,  1.4, -1.1,0.98,0, 3.6,0.00,0.15,0.0,0.04800,1.0,1,100.0,0.0, -3.300,1,1.0
38909,'M ', -6.200, -4.100, -4.1, -4.1,0.98,0, 7.9,0.02,0.16,0.0,0.03700,1.0,1,100.0,0.0, -6.600,1,1.0
38909,'N ', -7.600, -5.800, -5.8, -5.8,0.98,0,11.1,0.02,0.16,0.0,0.04000,1.0,1,100.0,0.0, -9.200,1,1.0
38909,'P ', -1.100, -0.700, -0.7, -0.7,0.98,0, 1.5,0.02,0.16,0.0,0.02000,1.0,1,100.0,0.0, -1.200,1,1.0
38910,'1 ',-19.800,  5.203, 10.2, -7.4,0.98,0,24.6,0.00,0.12,0.0,0.06500,1.0,1,100.0,0.0,-22.300,1,1.0
38910,'2 ', -2.400,  0.631,  2.0, -1.0,0.98,0, 3.4,0.00,0.17,0.0,0.04500,1.0,1,100.0,0.0, -2.700,1,1.0
38910,'M ', -6.700, -4.900, -4.9, -4.9,0.98,0, 9.4,0.02,0.16,0.0,0.02200,1.0,1,100.0,0.0, -7.800,1,1.0
38910,'P ', -1.100, -0.700, -0.7, -0.7,0.98,0, 1.4,0.02,0.16,0.0,0.01900,1.0,1,100.0,0.0, -1.200,1,1.0
38911,'1 ',-10.000,  7.306,  8.8, -4.4,0.98,0,14.7,0.00,0.13,0.0,0.02000,1.0,1,100.0,0.0,-11.800,1,1.0
38911,'2 ', -4.600,  3.361,  3.8, -1.9,0.98,0, 6.3,0.00,0.21,0.0,0.02500,1.0,1,100.0,0.0, -5.100,1,1.0
38911,'M ',-34.000,-24.100,-24.1,-24.1,0.98,0,46.2,0.02,0.16,0.0,0.04100,1.0,1,100.0,0.0,-38.400,1,1.0
38911,'P ', -2.400, -1.700, -1.7, -1.7,0.98,0, 3.3,0.02,0.16,0.0,0.01300,1.0,1,100.0,0.0, -2.700,1,1.0
38920,'1 ',-22.600,  7.680, 16.0, -9.0,0.98,0,30.6,0.00,0.14,0.0,0.03400,1.0,1,100.0,0.0,-26.100,1,1.0
38920,'2 ',-22.500,  7.646, 16.0, -9.0,0.98,0,30.8,0.00,0.14,0.0,0.03400,1.0,1,100.0,0.0,-26.300,1,1.0
38920,'3 ', -8.200,  2.786,  7.8, -4.0,0.98,0,12.9,0.00,0.21,0.0,0.02100,1.0,1,100.0,0.0,-10.300,1,1.0
38920,'M ',-13.300,-10.700,-10.7,-10.7,0.98,0,19.2,0.02,0.16,0.0,0.04700,1.0,1,100.0,0.0,-15.900,1,1.0
38920,'N ', -5.700, -4.900, -4.9, -4.9,0.98,0, 8.8,0.02,0.16,0.0,0.04800,1.0,1,100.0,0.0, -7.300,1,1.0
38920,'P ', -5.200, -4.500, -4.5, -4.5,0.98,0, 8.1,0.02,0.16,0.0,0.02700,1.0,1,100.0,0.0, -6.700,1,1.0
38921,'1 ',-22.500,  6.539, 17.5,-10.0,0.98,0,33.1,0.00,0.14,0.0,0.03680,1.0,1,100.0,0.0,-28.100,1,1.0
38921,'2 ',-22.200,  6.452, 17.4,-10.0,0.98,0,32.9,0.00,0.14,0.0,0.03680,1.0,1,100.0,0.0,-27.900,1,1.0
38921,'3 ', -7.600,  2.209,  7.8, -4.0,0.98,0,12.9,0.00,0.21,0.0,0.02150,1.0,1,100.0,0.0,-10.300,1,1.0
38921,'M ',-11.100, -9.400, -9.4, -9.4,0.98,0,16.8,0.02,0.16,0.0,0.04600,1.0,1,100.0,0.0,-13.900,1,1.0
38921,'N ', -4.500, -4.200, -4.2, -4.2,0.98,0, 7.5,0.02,0.16,0.0,0.04100,1.0,1,100.0,0.0, -6.200,1,1.0
38921,'P ', -4.600, -4.300, -4.3, -4.3,0.98,0, 7.8,0.02,0.16,0.0,0.02600,1.0,1,100.0,0.0, -6.500,1,1.0
0 / GENERATOR (MOTOR) DATA
39886,38908,'1 ',0.01400,0.29430,0.0,50.00,50.0,50.0,1.0,0.0,0.0,0.0,0.0,0.0,0.0,1,0.0,1,1.0
38903,38909,'1 ',0.01400,0.29430,0.0,50.00,50.0,50.0,1.0,0.0,0.0,0.0,0.0,0.0,0.0,1,0.0,1,1.0
38904,38909,'1 ',0.01400,0.29430,0.0,50.00,50.0,50.0,1.0,0.0,0.0,0.0,0.0,0.0,0.0,1,0.0,1,1.0
38905,38910,'1 ',0.01400,0.29430,0.0,50.00,50.0,50.0,1.0,0.0,0.0,0.0,0.0,0.0,0.0,1,0.0,1,1.0
38906,38911,'1 ',0.01400,0.29430,0.0,50.00,50.0,50.0,1.0,0.0,0.0,0.0,0.0,0.0,0.0,1,0.0,1,1.0
38907,38911,'1 ',0.01400,0.29430,0.0,50.00,50.0,50.0,1.0,0.0,0.0,0.0,0.0,0.0,0.0,1,0.0,1,1.0
39915,38920,'1 ',0.01280,0.16000,0.0,50.00,50.0,50.0,1.0,0.0,0.0,0.0,0.0,0.0,0.0,1,0.0,1,1.0
```

```
38917,38920,'1 ',0.01280,0.16000,0.0,50.00,50.0,50.0,1.0,0.0,0.0,0.0,0.0,0.0,1,0.0,1,1.0
38918,38921,'1 ',0.01280,0.16000,0.0,50.00,50.0,50.0,1.0,0.0,0.0,0.0,0.0,0.0,1,0.0,1,1.0
38919,38921,'1 ',0.01280,0.16000,0.0,50.00,50.0,50.0,1.0,0.0,0.0,0.0,0.0,0.0,1,0.0,1,1.0
0 / BRANCH DATA
0
0
0
0
0
0
0
0
0
0

RDCH
1
0
0
0
0
0
218,,-1223  /CONS  nc FROM -1223
363,,572    /NI    nc FROM +572
364,,671    /ALTE  nc FROM +671
365,,-623   /WEC   nc FROM -623
366,,-194   /WPS   nc FROM -194
367,,-278   /MGE   nc FROM -278
368,,-75    /UPPC  nc FROM - 75
0
0
0
0
0
0
0
0
0

@END
```

SCALE_ZONE.IDV

```
MENU,OFF      /* FORCE MENU TO CORRECT STATUS
TEXT Was zones 368 378 379
scal,zone
369
2
%1%

1  / constant p/q

@END
```

SCALE_WPS.COM

```
MENU,OFF      /* FORCE MENU TO CORRECT STATUS
scal
38604 -38630 39633 39647 39648 39658
2  / percent change
%1%

1 / constant P/Q
39895
2
,%1%

1
0
@end
```

CHNE_366_TO_368.IDV

```
MENU,OFF      /* FORCE MENU TO CORRECT STATUS
RDCH
1
0 / BUS
0 / LOAD
0 / GENERATOR
0 / BRANCH
0 / TR ADJ
0 / AREA INT
0 / 2 TERM DC
0 / SW SHUNT
0 / TR Z CORR
0 / MULT TERM DC
0 / MULTISECTION LINE GROUP
0 / ZONE
366 368 1 0.1
0 / INTERAREA TRANSFER
Q
chng
13 / inter area transfer
1  / change affected net interchange values
366 368 1
1
%1%
0
0
-1
@END
```

FIX_CONFLICTS.IDV

```
MENU,OFF      /* FORCE MENU TO CORRECT STATUS
cntb
0
1
16371
1.0174
68630 68330 -68333
1.07
70836 70837
1.017

@END
```

DRAWCASE.IDV

```
MENU,OFF      /* FORCE MENU TO CORRECT STATUS
TEXT OUTPUT DEVICE CHANGED FROM 29 (PRINTER) TO 41 (POSTSCRIPT) WITH 1 COPY 9/29/02
DRAW
C:\WUMS Island Study\Power Flow Cases\ilk-hia.drw
1
0
0,SIGN
2
2
0
0
3
0
0
0
138 and 69 kV Ties Into Island
29
4
41
1,Acrobat PDFWriter
0    / No more
@END
```

ZERO_LOADS_OFF.IDV

```
MENU,OFF      /* FORCE MENU TO CORRECT STATUS
chng
1/ bus data
38555


1
1
0
-1
38741


1
1
0
-1
38753


1
1
0
-1
38792


1
1
0
-1
38848


1
1
0
-1
39025


1
1
0
-1
-1
@END
```

LIST_FLOWS.IDV

```
MENU,OFF      /* FORCE MENU TO CORRECT STATUS
pout
2
%1% flows
39589 39575 38897 39576 39545
39590 -39595
39588 38605
39802 39772 39799 39764
39904 38765 -38768 38721
38769 -38774 38808
38903 -38911 39886
38917 -38921 39915
39678 -39680
28273 39753

exam
2
%1% config
39589 39575
38897 39576 39545
39590 39591
39592 39593
39594 39595
39588 38605
39802 39772
39799 39764
39904 38808
38765 -38768 38721
38769
38903 -38911 39886
38917 -38921 39915
28273 39753

@END
```

CONVERTLF_WUMS.IDV

```
MENU,OFF      /* FORCE MENU TO CORRECT STATUS
TEXT Parameter 1 =%1% is percent increase in island load
case %1%.sav
@input PLI2002LLXsorce.rdc
@input PliNpcc74942.rsp
@input mainMerge2Gens.idv
@input solveLf.idv
conl,all
100 0
0 100
1
@input 02LL_gnet.rsp
rawd,all
2
%1%.raw
1,1
cong
ordr
fact,dp
tysl
save %1%_conv
@end
```

```
HD,  ,  10.000   8.00   0.050   0.000  R
CO,  ,   0   0   0   0   1   2   3   4
VO,  ,   69.0  115.00  230.00

BU,  , 38895   2.000   6.750   2.000   5.750   0  -4 /* NAP 138
BU,  , 39545   2.500   6.750   2.500   5.750   0  -4 /* WCL 138
BU,  , 39576   3.000   6.750   3.000   5.750   0  -4 /* WCL 138
LI,F , 38895   39545 1 2.000   6.250   2.500   6.250 R  0.125 L  0.125
LI,T , 39545   39576 1 2.500   6.250   3.000   6.250 R  0.125 L  0.125

BU,  , 39589   2.000   4.750   2.000   2.500   0  -4 /* PUL 138
BU,  , 39575   3.000   4.750   3.000   3.750   0   4 /* STL 4 138
BU,N , 38897   3.000   3.500   3.000   2.500   4   0 /* STL 5 138

BU,  , 39801   4.875   7.000   7.875   7.000   0  -4 /* ILK 138
BU,  , 39802   4.875   6.000   7.875   6.000   0  -4 /* ILK 69

BU,  , 39799   4.875   5.250   6.000   5.250   0  -2 /* GLJ
BU,  , 39772   6.750   5.250   7.875   5.250  -5  -2 /* MTQ
BU,N , 39794   6.750   4.500   7.875   4.500  -5  -2 /* VLE
BU,N , 39795   4.875   4.500   6.000   4.500   0  -2
BU,N , 39770   6.750   3.750   7.875   3.750  -5  -2 /* BPK
BU,N , 39771   4.875   3.750   6.000   3.750   0  -2
BU,N , 39766   6.750   3.000   7.875   3.000  -5  -2 /* CUR
BU,N , 39767   4.875   3.000   6.000   3.000   0  -2
BU,N , 39768   6.750   2.250   7.875   2.250  -5  -2 /* GLD
BU,N , 39769   4.875   2.250   6.000   2.250   0  -2
BU,N , 39763   7.250   1.625   7.500   1.625  -9  -2 /* ENG (FUT)
BU,  , 39764   4.875   1.250   7.875   1.250   0  -4 /* HIA

BU,  , 38721   8.875   7.000   8.875   6.000  -4  -4 /* ESC STM 12.5

GE, 1, 38721   8.875   6.750   9.250   6.750        /* ESC STM
GE, 2, 38721   8.875   6.250   9.250   6.250        /* ESC STM

BU,  , 39904   8.875   5.500   8.875   1.000  -4  -4 /* PRESQUE IS

GE, 1, 38766   8.875   5.250   9.250   5.250        /* PRESQUE IS
GE, 2, 38767   8.875   4.750   9.250   4.750        /* PRESQUE IS
GE, 3, 38768   8.875   4.250   9.250   4.250        /* PRESQUE IS
GE, 4, 38769   8.875   3.750   9.250   3.750        /* PRESQUE IS
GE, 5, 38770   8.875   3.250   9.250   3.250        /* PRESQUE IS
GE, 6, 38771   8.875   2.750   9.250   2.750        /* PRESQUE IS
GE, 7, 38772   8.875   2.250   9.250   2.250        /* PRESQUE IS
GE, 8, 38773   8.875   1.750   9.250   1.750        /* PRESQUE IS
GE, 9, 38774   8.875   1.250   9.250   1.250        /* PRESQUE IS

BU, S, 38766   8.875   5.250   8.875   5.250        /* PRESQUE IS
BU, S, 38767   8.875   4.750   8.875   4.750        /* PRESQUE IS
BU, S, 38768   8.875   4.250   8.875   4.250        /* PRESQUE IS
BU, S, 38769   8.875   3.750   8.875   3.750        /* PRESQUE IS
BU, S, 38770   8.875   3.250   8.875   3.250        /* PRESQUE IS
BU, S, 38771   8.875   2.750   8.875   2.750        /* PRESQUE IS
```

```
BU, S, 38772   8.875   2.250   8.875   2.250         /* PRESQUE IS
BU, S, 38773   8.875   1.750   8.875   1.750         /* PRESQUE IS
BU, S, 38774   8.875   1.250   8.875   1.250         /* PRESQUE IS

TX, 1,   6.350   1.000  0.100    0.0 '69 kV'

LI,F , 39589   39575 1    2.000   4.250   3.000   4.250 R  0.125 L  0.125
LI,F , 39589   38897 2    2.000   3.000   3.000   3.000 R  0.125 L  0.125
/* LI,SP, 39575   38897 1    3.000   3.750   3.000   3.500 D  0.125 U  0.125
SY,  , 133,       3.000   3.625      0.250   0.000

TX, 1,   2.125   1.125  0.100    0.0 '138 kV'

TR,F , 39801   39802 1    5.375   7.000   5.375   6.000 D  0.125 U  0.250
TR,F , 39801   39802 2    7.375   7.000   7.375   6.000 D  0.125 U  0.250

LI,T , 39802   39799 1    5.375   6.000   5.375   5.250 D  0.125 U  0.125
LI,T , 39802   39772 1    7.375   6.000   7.375   5.250 D  0.125 U  0.125

LI,T , 39799   39772 1    6.000   5.250   6.750   5.250 D  0.125 D  0.125

LI,T , 39799   39795 1    5.375   5.250   5.375   4.500 D  0.125 U  0.125
LI,T , 39772   39794 1    7.375   5.250   7.375   4.500 D  0.125 U  0.125

LI,T , 39795   39771 1    5.375   4.500   5.375   3.750 D  0.125 U  0.125
LI,T , 39794   39770 1    7.375   4.500   7.375   3.750 D  0.125 U  0.125

LI,T , 39771   39767 1    5.375   3.750   5.375   3.000 D  0.125 U  0.125
LI,T , 39770   39766 1    7.375   3.750   7.375   3.000 D  0.125 U  0.125

LI,T , 39767   39769 1    5.375   3.000   5.375   2.250 D  0.125 U  0.125
LI,T , 39766   39768 1    7.375   3.000   7.375   2.250 D  0.125 U  0.125

LI,T , 39769   39764 1    5.375   2.250   5.375   1.250 D  0.125 U  0.125
LI,SP, 39768   39763 1    7.375   2.250   7.375   1.625 D  0.125 U  0.125

LI,T , 39763   39764 1    7.375   1.625   7.375   1.250 D  0.125 U  0.125

LO,  , 39799   5.875   5.250   5.875   5.000   0  -2 /* GLJ
LO,  , 39772   7.000   5.250   7.000   5.000   0  -2 /* MTQ

LO,  , 39794   7.000   4.500   7.000   4.250   0  -2 /* VLE
LO,  , 39795   5.875   4.500   5.875   4.250   0  -2

LO,  , 39771   5.875   3.750   5.875   3.500   0  -2 /* BPK

LO,  , 39766   7.000   3.000   7.000   2.750   0  -2 /* CUR
LO,  , 39767   5.875   3.000   5.875   2.750   0  -2

LO,  , 39769   5.875   2.250   5.875   2.000   0  -2 /* GLD

SH,  , 39799   5.000   5.250   5.000   5.000   0  -2 /* GLJ
SH,  , 39772   7.750   5.250   7.750   5.000   0  -2 /* MTQ
SH,  , 39794   7.750   4.500   7.750   4.250   0  -2 /* VLE
SH,  , 39795   5.000   4.500   5.000   4.250   0  -2
SH,  , 39770   7.750   3.750   7.750   3.500   0  -2 /* BPK
```

```
SH,  , 39771   5.000   3.750   5.000   3.500   0  -2
SH,  , 39766   7.750   3.000   7.750   2.750   0  -2 /* CUR
SH,  , 39767   5.000   3.000   5.000   2.750   0  -2
SH,  , 39768   7.750   2.250   7.750   2.000   0  -2 /* GLD
SH,  , 39769   5.000   2.250   5.000   2.000   0  -2
TX, 1,   5.200   5.875  0.080    0.0 '6916'
TX, 1,   7.200   5.875  0.080    0.0 '6910'
TX, 1,   5.200   5.125  0.080    0.0 '6913'
TX, 1,   7.200   5.125  0.080    0.0 '6912'
EN
```

Exhibit I

PSS/E COMMAND FILES USED TO SET UP AND RUN THE SIMULATIONS

<u>CRTSNAP_WUMS.IDV</u>

```
.MENU,OFF       /* FORCE MENU TO CORRECT STATUS
ODEV
2
CRTSNAP.LOG
PDEV
2
CRTSNAP.LOG
lofl
read
C:\WUMS Island Study\Power Flow Cases\close69.raw
fdns,opt
1,2,1,0,0,0
0
cong
ordr
fact,dp
tysl
save close69_conv.sav

rtrn
dyre
wums.dyr
conec.flx
conet.flx
wums_relays
101,101,101,101
MyCompile.bat
snap INITIAL.snp

STOP
```

STRTDS_MOD.IDV

```
odev
2
strtds_mod.log
pdev
2
strtds_mod.log
rstr initial.snp
lofl
case C:\WUMS Island Study\Power Flow Cases\close69_conv.sav
fact,dp
tysl
rtrn
@INPUT CHANNEL_SEL
@input dynadcfx25.idv
@input tstep.rsp
@input audrain.idv
@input removeModels2002LL.rsp
@input chngPrm2002LL.rsp
@input PLIConfirm2002LL.rsp
@input PLIModelsOff2002LL.rsp
@input PliChngPrm2002LL.rsp
TEXT @input AddSysChan.rsp
@input Big_Bend.idv
text @input zone_total.idv

TEXT OPEN GRAPHICS WINDOW
OPTN
10
26

dyre,add
ufls.dyr




text dyre,add
text minetrip.dyr




strt
nodist_wums
wums_started

run
0.5,100,1,5
stop
```

CHANNEL_SEL.IDV

```
MENU,OFF
TEXT 12 =FREQUENCY (CHANNEL 1 -- PRESQUE ISLE)
TEXT 13 = VOLTAGE (CHANNELS 2-9)
TEXT 1 = ANGLE (CHANNELS 10-13)
TEXT 7 = SPEED (CHANNELS 14-20)
TEXT 16 = FLOW (CHANNELS 21-36)(2 PER LINE)
TEXT 18 = APPARENT IMPEDANCE (CHANNELS 37-48)(2 PER LINE)
TEXT 17 = MVA (CHANNELS 49-56)
chan

12
39904

13
39904
38903
38919
38787
38897
39569
39017
38630

1
38774,9
39895,3
38807,1
39678,3

7
38774,9
39895,3
38807,1
39102,1
39594,8
39678,3
38721,1

16
39589 38897 2 '64451_W'
'64451_R'
39589 39575 1 '64441_W'
'64441_R'
39802 39772 1 '6910_W'
'6910_R'
39802 39799 1 '6916_W'
'6916_R'
39764 39769 1 'HIA-GLD_W'
'HIA-GLD_R'
39764 39763 1 'HIA-ENGD_W'
'HIA-ENGD_R'
28273 39753 1 'Straits_W'
'Straits_R'
38765 39895 1 'MQT-W'
'MQT_R'
```

```
18
39589 38897 2 '64451'
'64451_X'
39589 39575 1 '64441'
'64451_X'
39802 39772 1 '6910'
'6910_X'
39802 39799 1 '6916'
'6916_X'
39764 39769 1 'HIA-GLD'
'HIA-GLD_X'
39764 39763 1 'HIA-ENG'
'HIA-ENG_X'

17
39589 38897 2 '64451_MVA'
39589 39575 1 '64441_MVA'
39802 39772 1 '6910_MVA'
39772 39794 1 '6912_MVA-M'
39802 39799 1 '6913_MVA-I'
39764 39720 1 '6913_MVA_H'
39764 39763 1 '6912_MVA-H'

0
@input AddSysChan.rsp
TEXT EMPIRE AND TILDEN VALUES
TEXT 13 = VOLTAGE
TEXT  7 = SPEED
chan

13
38908
38909
38910
38911
38920
38921

7
38908,1
38908,2
38908,M
38908,P
38909,1
38909,2
38909,3
38909,M
38909,N
38909,P
38910,1
38910,2
38910,M
38910,P
38911,1
38911,2
38911,M
```

```
38911,P
38920,1
38920,2
38920,3
38920,M
38920,N
38920,P
38921,1
38921,2
38921,3
38921,M
38921,N
38921,P

18
38995 38997 1 '3810'
'3810_X'

0
@input zone_total.idv
chan

13
38608
38628

0
TEXT SELECT CHANNELS TO MONITOR IN GRAPHICS WINDOW
TEXT 1 -- #1  -- FREQUENCY -- PRESQUE ISLE
TEXT 2 -- #2  -- VOLTAGE   -- PRESQUE ISLE (WAS #49 -- MVA -- LINE 64451)
TEXT 3 -- #111 -- VOLTAGE  -- GR RAPID69
TEXT 4 -- #53 -- MVA       -- LINE 6913 @ INDIAN LK
TEXT 5 -- #103-- MW        -- ISLAND LOAD (ZONE 369)
TEXT 6 -- #55 -- MVA       -- LINE 6912 @ HIAWATHA
ALTR
4
1
Y
1
Y
Y
-.045,0.005
2
Y
2
Y
Y
0.875,1.125
3
Y
111
Y
Y
0.85,1.20
4
Y
53
```

```
Y
y
0,50
5
Y
103
Y
Y
0,600
6
Y
55
Y
y
0,50
-1
0

@end
```

```
MENU,OFF      /* FORCE MENU TO CORRECT STATUS
ODEV
2
tripBOTH.LOG
PDEV
2
tripBOTH.LOG
rstr wums_started.snp
lofl
CASE
C:\WUMS Island Study\Power Flow Cases\close69_conv.SAV
TEXT @input aep_fix
ordr
fact
tysl
rtrn
ALTR
6


Y
TRIPBOTH_A.out


0
TEXT SELECT CHANNELS TO MONITOR IN GRAPHICS WINDOW
TEXT 1 -- #1  -- FREQUENCY -- PRESQUE ISLE
TEXT 2 -- #2  -- VOLTAGE   -- PRESQUE ISLE (WAS #49 -- MVA -- LINE 64451)
TEXT 3 -- #111 -- VOLTAGE  -- GR RAPID69
TEXT 4 -- #53 -- MVA       -- LINE 6913 @ INDIAN LK
TEXT 5 -- #103-- MW        -- ISLAND LOAD (ZONE 369)
TEXT 6 -- #55 -- MVA       -- LINE 6912 @ HIAWATHA
ALTR
4
1
Y
1
Y
Y
-.045,0.005
2
Y
2
Y
Y
0.875,1.125
3
Y
111
Y
Y
0.85,1.20
4
Y
53
```

```
Y
y
0,50
5
Y
103
Y
Y
0,600
6
Y
55
Y
y
0,50
-1
0
TEXT OPEN GRAPHICS WINDOW
OPTN
10
26

run
0.5,20,1,5
lofl
chng
3 / branch
39576 39545 1 / 6851 -- White Clay - Lawn Road
1 / change first line
0 / status off
-1
39575 39589 1 / 64441 -- Stiles 4 - Pulliam
1
0
0
-1

ORDR
FACT,DP
rtrn
run
1,120,1,5
lofl
chng
3 / branch
38897 39589 2 / 64441 -- Stiles 5 - Pulliam
1
0
0
-1

ORDR
FACT,DP
rtrn
run,CM
1.80,120,1,5
lofl
```

```
chng
3 / branch
38995 38997 1 / 6530 -- MASS
1
0
0
-1

ORDR
FACT,DP
rtrn
run,cm
10,120,1,5
stop
```

PLOT_FIG_C.IDV

```
MENU,OFF      /* FORCE MENU TO CORRECT STATUS
odev
2
plotcase.log
pdev
2
plotcase.log
chnf c:\WUMS Island Study\Simulation Runs\TRIPBOTH_c.out
LFTI
1
APPENDIX c. SIMULATION OF NOVEMBER 14, 2001 ISLANDING EVENT
1
     UNIFORM 30% UNDERFREQUENCY LOAD SHEDDING -- No MOTOR TRIPPING
RELY
C:\WUMS Island Study\Simulation Runs\wums_relays.DAT
TINT
0.000000 10.000000
SLCT
2
0.85 1.15
5
0.85 1.15
6
0.85 1.15
7
0.85 1.15
8
0.85 1.15
9
0.75 1.25
PLOT
C-1 TSM. VOLTAGES
41
FUNC
2
60*(1+A)
SLCT
14
57.75 60.25
15
57.75 60.25
16
57.75 60.25
17
57.75 60.25
18
57.75 60.25
20
57.75 60.25
PLOT
C-2 GEN. SPEEDS (Hz)
FUNC
1
TINT
0.000000 2.000000
```

```
SLCT
49
0.0000 400.0000
50
0.0000 400.0000
53
0.0000 100.0000
55
0.0000 100.0000
0
PLOT
C-3 mva flows into island
TINT
0.000000 10.000000
SLCT
62
400. 900.
0
FUNC
2
A-B
SLCT
65 68
400. 900.
0
PLOT
C-4 Island Gen. & Load
FUNC
2
60*(1+A)
SLCT
1
57.75 60.25
78
57.75 60.25
79
57.75 60.25
80
55 60
81
55 60
0
FUNC
1
SLCT
72
0.8750 1.1250
PLOT
C-5.1 Empire 1
FUNC
2
60*(1+A)
SLCT
1
57.75 60.25
82
57.75 60.25
```

```
83
57.75 60.25
85
55 60
86
55 60
0
FUNC
1
SLCT
73
0.8750 1.1250
PLOT
C-5.2 Empire 2
FUNC
2
60*(1+A)
SLCT
1
57.75 60.25
88
57.75 60.25
89
57.75 60.25
90
55 60
91
55 60
0
FUNC
1
SLCT
73
0.8750 1.1250
PLOT
C-5.3 Empire 3
FUNC
2
60*(1+A)
SLCT
1
57.75 60.25
92
57.75 60.25
93
57.75 60.25
94
55 60
95
55 60
0
FUNC
1
SLCT
73
0.8750 1.1250
PLOT
```

```
C-5.4 Empire 4
FUNC
2
60*(1+A)
SLCT
1
57.75 60.25
96
57.75 60.25
97
57.75 60.25
98
57.75 60.25
99
55 60
0
FUNC
1
SLCT
73
0.8750 1.1250
PLOT
C-6.1 Tilden 1
FUNC
2
60*(1+A)
SLCT
1
57.75 60.25
102
57.75 60.25
103
57.75 60.25
104
57.75 60.25
105
55 60
0
FUNC
1
SLCT
73
0.8750 1.1250
PLOT
C-6.2 Tilden 2
POPT
6
0.01667
0
TINT
0.9833 2.0
PTYP,XY
SLCT
47
-.5000 2.0000
48
-.2500 2.2500
```

```
39764-39763- DISTR
PLOT
C-7.1 hiC-eng DIST. relay
SLCT
45
-1.0000 1.5000
46
-.5000 2.0000
39764-39769- DISTR
PLOT
C-7.2 hiC-gld DIST. relay
ODEV
1
PDEV
1
TEXT ENTER 0
stop
```

PLOT_FIG_D.IDV

```
MENU,OFF      /* FORCE MENU TO CORRECT STATUS
odev
2
plotcase.log
pdev
2
plotcase.log
chnf c:\WUMS Island Study\Simulation Runs\TRIPBOTH_b.out
RANG
1
5
1
VOLT*,1,99,0.80,1.20
SPD*,1,999,55.5,60.5
FREQ*,1,999,55.5,60.5

0
LFTI
1
EHHIBIT D. SIMULATION OF NOVEMBER 14, 2001 ISLANDING EVENT
1
            UNIFORM 30% UNDERFREQUENCY LOAD SHEDDING
RELY
C:\WUMS Island Study\Simulation Runs\wums_relays.DAT
TINT
0.0 10.0
SLCT
2

5

6

7

8

110

PLOT
D-1 TSM. VOLTAGES
41
FUNC
2
60*(1+A)
SLCT
14
57.75 60.25
15
57.75 60.25
16
57.75 60.25
17
57.75 60.25
18
```

```
57.75 60.25
20
57.75 60.25
PLOT
D-2 GEN. SPEEDS (Hz)
FUNC
1
CHID
100
1
ISLAND MECHANICAL POWER
101
1
ISLAND ELECTRICAL POWER
103
1
ISLAND LOAD(EXCL. MINES)
108
1
MINE LOADS(NON-MOTOR)
106
1
MINE MOTOR LOADS
0
SLCT
100
400. 900.
0
FUNC
2
A-B
SLCT
103 106
400. 900.
0
PLOT
D-3 Island Gen. & Load
FUNC
1
SLCT
100
-100. 900
101
-100. 900
103
-100. 900
108
-100. 900.
0
FUNC
2
-A
SLCT
106
-100. 900.
0
CHID
```

```
100
1
ISLAND MECHANICAL POWER
101
1
ISLAND ELECTRICAL POWER
103
1
ISLAND LOAD(EXCL. MINES)
108
1
MINE LOADS(NON-MOTOR)
106
1
MINE MOTOR LOADS
0
PLOT
D-3A Gen. & Load Details
FUNC
2
60*(1+A)
SLCT
1
55.5,60.5
68
55.5,60.5
69
55.5,60.5
70
55.5,60.5
71
55.5,60.5
0
FUNC
1
SLCT
62

PLOT
D-4.1 Empire 1
FUNC
2
60*(1+A)
SLCT
1
55.5,60.5
72
55.5,60.5
73
55.5,60.5
75
55.5,60.5
76
55.5,60.5
0
FUNC
1
```

```
SLCT
63

PLOT
D-4.2 Empire 2
FUNC
2
60*(1+A)
SLCT
1
55.5,60.5
78
55.5,60.5
79
55.5,60.5
80
55.5,60.5
81
55.5,60.5
0
FUNC
1
SLCT
63

PLOT
D-4.3 Empire 3
FUNC
2
60*(1+A)
SLCT
1
55.5,60.5
82
55.5,60.5
83
55.5,60.5
84
55.5,60.5
85
55.5,60.5
0
FUNC
1
SLCT
63

PLOT
D-4.4 Empire 4
FUNC
2
60*(1+A)
SLCT
1
55.5,60.5
86
55.5,60.5
```

```
87
55.5,60.5
88
55.5,60.5
89
55.5,60.5
0
FUNC
1
SLCT
63

PLOT
D-5.1 Tilden 1
FUNC
2
60*(1+A)
SLCT
1
55.5,60.5
92
55.5,60.5
93
55.5,60.5
94
55.5,60.5
95
55.5,60.5
0
FUNC
1
SLCT
63

PLOT
D-5.2 Tilden 2
MCHN
TRIPBOTH_a.out
TRIPBOTH_b.out
TRIPBOTH_c.out
-1
FUNC
2
60*(1+A)
SLCT
14
58.0,60.5
0
LFTI
1
EHHIBIT D. SIMULATION OF NOVEMBER 14, 2001 ISLANDING EVENT
1
COMPARE EXISTING AND ENHANCED UNDERFREQUENCY LOAD SHEDDING
PLOT
D-6 Frequency comparison
FUNC
2
```

```
A-B+C
SLCT
103 106 108
400. 900.
0
PLOT
D-7 Load comparison
ODEV
1
PDEV
1
TEXT ENTER 0
stop
```