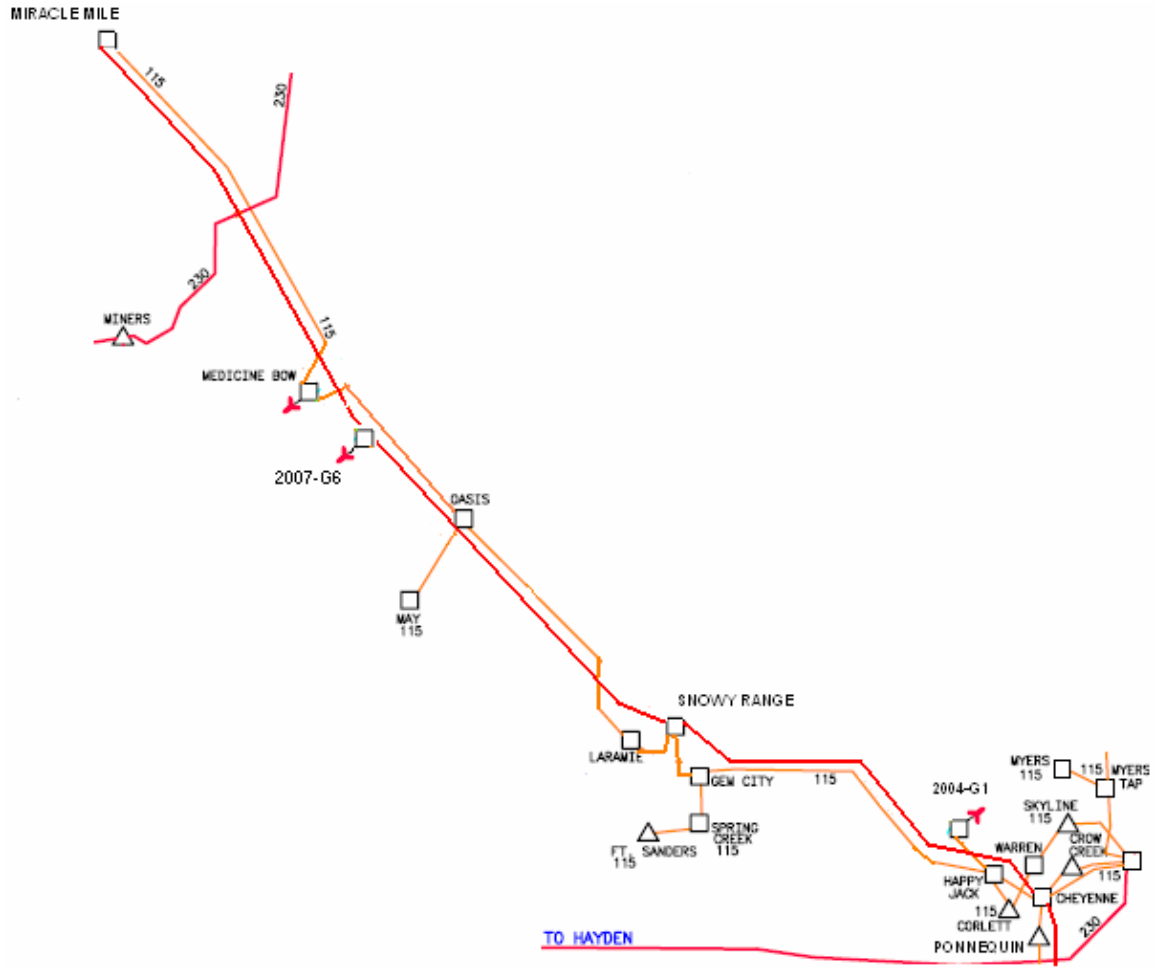
System Impact Study
2007-G6

Studies Conducted By: Jared Griffiths
November 9, 2007

I. Introduction

The purpose of this study is to determine system impacts incurred by the addition of a 240 MW wind farm on Western Area Power Administration's (Western) new 230 kV transmission line from Miracle Mile to Snowy Range. The location of the proposed interconnection is near Rock River, Wyoming. The proposed interconnection currently holds queue positions 2007-G6 and 2007-T7 which are interconnection and transmission service (TSR) requests respectively. A single line drawing of the proposed interconnection follows:



II. Methodology

Western's Large Generator Interconnection Procedure (LGIA) requires this request to be studied with all higher ceded requests in the queue. As this interconnection request does have an associated request for transmission it takes precedence over several of the higher ceded interconnection requests that do not have transmission requests associated with them. In an effort to expedite the study effort, only interconnection and transmission requests thought to impact the results of this interconnection and transmission request

were studied. The following list contains the interconnection and transmission requests included in the study of requests 2007-G6 and 2007-T7:

2004-T1 – 75 MW Miracle Mile-Ault
2004-G1 – 30 MW Near Happy Jack (2006-T4 associated TSR)
2005-T2 – 170 MW Wyodak-Cheyenne
2006-T1 – 28 MW South of Ponnequin
2007-T6 – 11 MW at Kodak
70373324 – 200 MW Dave Johnson-Ault (TSR)

III. Criteria

A. System Intact

Bus voltages shall remain between 0.95 and 1.05 p.u. Transmission lines and transformers shall not exceed their thermal rating.

B. Single Contingency

Bus voltages shall remain between 0.90 and 1.10 p.u. Transmission lines and transformers shall not exceed their thermal rating or an established emergency rating.

C. Dynamic

First swing bus voltage deviations shall not exceed 30 percent. First swing bus voltages shall not cause bus voltages to be less than 0.70 p.u. Bus frequency shall not be less than 59.5 Hz for all faults studied. All faults shall not result in unit instability or cascading outages (damped response).

IV. Base Case

The WECC 2011 HS1BP base case was used for this study. This case contains required dynamics data to perform the dynamic portion of the system impact study. Interconnection and transmission requests as mentioned in section II of this report were also included in the base case.

V. Findings

A. Benchmark Case

Several overloads were found in the base case. The following ratings were changed in the benchmark case as they are required by higher ceded requests in the interconnection and transmission queues or are known system problems for which projects are currently underway to fix.

Laramie River Station – Archer 345 kV Transmission Line 1200 MVA
Laramie River Station – Ault 345 kV Transmission Line 1200 MVA
Ault – Weld 230 kV Transmission Lines 513 MVA (621 MVA 30 Minute)
Weld 230/115 kV Transformers 350 MVA
Snowy Range – Gem City Tap 115 kV Transmission Line 180 MVA

Projects to fix the next list of overloads have not been initiated. These overloads are thought to be due to higher ceded transmission or interconnection requests. As projects have not been identified to fix these overloads, they will remain in the overload spreadsheet. This spreadsheet will show contingency loading on these lines both prior to and after the addition of interconnection request 2007-G6.

Sidney – Peetz 115 kV Transmission Line 180 MVA
Peetz – Sterling 115 kV Transmission Line 180 MVA
Sidney 230/115 kV Transfomer 250 MVA

The only remaining valid overload in the base case is that of the Archer 345/230 kV 560 MVA transformer. This transformer is not yet installed as it is part of a higher ceded transmission request. A larger transformer is recommended at this location.

Two other overloads that appear in the spreadsheet which are not considered valid are the Happy Jack-Corlett and Archer-Skyline 115 kV transmission lines. The contingencies that cause these overloads are the Archer-Skyline 115-kV and Happy Jack Corlett 115-kV transmission lines respectively. These are not breaker to breaker contingencies and would thus only occur as planned outages. These outages are scheduled during times of off-peak loading to prevent the possibility of overloads as observed in the overload spreadsheet.

The limiting element in this case is the Ault-Cheyenne 230 kV transmission line. This line loads to 100% of its 453 MVA thermal rating during the Laramie River Station (LRS)-Ault 345 kV contingency. An overload spreadsheet for all of the different cases studied can be found in Appendix A. Overloads found in the benchmark case can be found in the first column.

B. Network Resource 2007-G6

The generation associated with 2007-G6 was scheduled to the Dave Johnston 230 kV substation by reducing the output of generation located at this bus. Doing this was seen to increase TOT 3 transfers from 1842 MW in the base case to 1865 MW. With this level of TOT 3 transfers the Cheyenne-Ault 230 kV transmission line was seen to exceed its 453 MVA

limit for the LRS-Ault 345 kV contingency. Other overloads observed were that of the Snowy Range-Gem City Tap and Gem City Tap-Happy Jack 115 kV transmission lines. In addition, the Fort Lupton-Fort St. Vrain 230 kV lines were seen to load to their limit due to the slight increase in TOT 3 transfers. Overloads for this analysis can be found in the second column of the overload spreadsheet in Appendix A.

An increase in TOT 3 transfers from 1842 to 1865 show that approximately 10% of the proposed generation will inadvertently flow across TOT 3 even when generation from the proposed interconnection is scheduled directly to Dave Johnson power plant.

TOT 3 transfers were reduced to 1842 MW as in the base case by increasing generation at Lamar DC and decreasing generation at Yellowtail. With generation at the proposed point of interconnection and TOT 3 at 1842 MW, the loading on the Cheyenne-Ault 230 kV transmission line increased from 100% in the base case (limiting element) to 104%. Also, the Snowy Range-Gem City Tap 115 kV transmission line was seen to load to 109% of its 180 MVA rating. Finally, the Gem City Tap-Happy Jack 115 kV transmission line was seen to overload to 110% of its 133 MVA rating. Overloads observed in this portion of the analysis can be found in the third column of the spreadsheet found in Appendix A. Diagrams of the overloads observed can be found in Appendix C.

To correct overloads observed on the Cheyenne-Ault 230 kV transmission line, the parallel Cheyenne-Ault 115 kV transmission line was converted to 230 kV operation. This 115 kV transmission line will be built for 230 kV operation but initially operated at 115 kV. In order to operate this line at 230 kV all terminal work will have to be changed out at both ends of the transmission line as well as at the various taps and substations along this line. Column four of the overload spreadsheet found in Appendix A shows the Cheyenne-Ault 230 kV overload to be fixed by converting the Cheyenne-Ault 115 kV transmission line to 230 kV. However, this fix caused the Black Hollow-Ault 115 kV transmission line to overload. Also, the Snowy Range-Happy Jack 115 kV transmission line was still seen to overload.

The last column in the overload spreadsheet in Appendix A is represents overloads in the case with thermal upgrades to the Snowy Range-Happy Jack and Ault-Black Hollow 115 kV transmission lines. Overloads on the Snowy Range-Happy Jack 115 kV line necessitated this line to be rebuilt with 1272 ACSR conductor. The Ault-Black Hollow line upgrade was modeled with 954 ACSR conductor to match the conductor on other sections of this line.

C. Energy Resource

The difference between studies for an energy resource and a network resource is the energy resource determines how much generation can be interconnected without requiring upgrades to the transmission system in place at the time of the proposed interconnection.

Any additional generation added at the proposed interconnection was seen to increase flows on the Cheyenne-Ault 230 kV transmission line which is at its limit in the benchmark case. Thus no available capacity exists at the proposed point of interconnection for 2007-G6.

D. Cost Estimates

The following projects are required to integrate interconnection request 2007-G6:

Convert the Cheyenne-Ault 115 kV Transmission Line to 230 kV Operation.

As previously discussed, the conversion of the Cheyenne-Ault 115 kV transmission line to 230 kV operation would require terminal work at both ends of this transmission line. The Cheyenne end would require a line bay addition which requires one power circuit breaker and associated equipment. The Ault terminal of this transmission line would require both a line and a transformer bay. As the Ault 230 kV substation is a breaker and a half configuration this terminal would require three breakers and a 230/115 kV, 150 MVA transformer. Cost estimates for additions at Ault comes to $5 million whereas the addition to Cheyenne is estimated at $800,000.

In addition to the terminal ends, the 115 kV taps and substations at Ponnequin, Owl Creek, Rockport, and Nunn would need to be upgraded to 230 kV. Of these four locations, only Owl Creek is spaced to be able to operate at 230 kV. Ponnequin, Rockport, and Nunn would need to be completely rebuilt as three breaker ring buses with 230/115/13.8 kV transformers at each location. Cost estimates for a three breaker 230 kV ring bus and a 230/115 kV 30 MVA transformer is approximately $3 million. Estimates to replace the transformers at Owl Creek come to $1.25 million. One proposal to reduce these 230-kV conversion costs would be to potentially consolidate Rockport loads into Owl Creek. Any reduction in cost due to this consolidation would have to be determined through a Facilities Study involving impacted utilities.

The total cost of converting the Cheyenne-Ault 230 kV transmission line to 230 kV operation is approximately $16 million.

Ault-Black Hollow 115 kV Transmission Line Rebuild

This transmission line was seen to load to 101% for the Ault-Timberline 230 kV contingency. This loading is increased from the benchmark case where it was seen to load only to 73% of its capacity for this same contingency.

The Ault-Black Hollow 115 kV transmission line is approximately 6 miles long. This line would have to be built with a minimum of 477 ACSR conductor which would increase its rating to 121 MVA. Cost estimates will use this conductor as opposed to the 954 ACSR studied as this is the minimum conductor required to meet the thermal requirements of this project. Costs to rebuild this transmission line are estimated at $672,000.

Snowy Range-Happy Jack 115 kV Transmission Line Rebuild

The minimum conductor required for this section of line to be rebuilt is 1272 ACSR conductor. At 115 kV, this conductor has a thermal rating of approximately 220 MVA. This line is approximately 41 miles long. Cost estimates to rebuild this portion of transmission line are approximately $12.3 million. Cost estimates included are for a complete rebuild of this transmission line as this transmission line was built in 1960 and most likely is not a good candidate to be re-condutored. A facility study would be required to determine if installing new conductor as opposed to new conductor and towers is possible.

Generation Interconnection Costs

Western, at a minimum would require a three breaker ring bus to interconnect the proposed generation. Estimates for this come to $2.4 million for the breakers and an additional $1.6 million for the transformer bringing the total cost to $4.0 million.

Total Costs

Convert Cheyenne-Ault 115 kV to 230 kV - $16,000,000
Rebuild Ault-Black Hollow 115 kV - $672,000
Snowy Range-Happy Jack 115 kV - $12,300,000
Generation Interconnection - $4,000,000
TOTAL - $32,972,00

E. Stability

Stability analysis will be conducted using PSS/E version 30.2. Historically, the fault that has been known to cause low voltages in the area is that of the Laramie River Station-Ault 345-kV fault. A list of all of the faults studied as well as fault type and duration follows:

Laramie River Station-Ault 345-kV fault – 3 phase 4 cycles
Laramie River Station-Archer 345-kV fault – 3 phase 4 cycles
Archer-Story 345-kV fault – 3 phase 4 cycles
Dave Johnston-Miracle Mile 230-kV 3 phase 5 cycles
Miracle Mile-2007-G6 230-kV 3 phase 5 cycles
2007-G6-Snowy Range 3 phase 5 cycles

Results of dynamic analyses showed compliance with all criteria. Several plots of dynamic simulations can be found in Appendix B. The first four plots show phase angle deviations at the point of interconnection, Laramie River Station, Rawhide, and Dave Johnston respectively for each of the faults listed above. The next three plots show the voltage deviations expected at Laramie 115-kV, Black Hollow Tap 115-kV, and the point of interconnection (230-kV) respectively for each of the faults listed above. The final plot shows the resulting frequency deviation to the system should a fault cause the proposed interconnection to trip off-line. Results of the last plot show that the frequency response of the system is sufficient to integrate the proposed wind farm.

In all plots except the last, the following colors and labels represent the fault studied:

Purple – LAU_3p4c - Laramie River Station-Ault 345-kV fault
Green – LARH_3p4c - Laramie River Station-Archer 345-kV fault
Light Blue – ARHSTY_3p4c - Archer-Story 345-kV fault
Black – DJMM_3p5c - Dave Johnston-Miracle Mile 230-kV
Magenta – MMWND_3p5c- Miracle Mile-2007-G6 230-kV
Yellow –WNDSNG_3p4c- 2007-G6-Snowy Range

VI. Conclusions

The results of this study are based on two major projects that precede this request in the transmission queue. These transmission requests are 70373324 and 2005-T2. If either of these requests drop out of the queue or are modified, a restudy will be required to determine the impacts of the proposed interconnection (2007-G6). A restudy of this interconnection request may also be required if any of the other interconnection or transmission requests listed in section II above are dropped or modified.

The cost estimate to implement the full output of the proposed interconnection is $32,972,000. These estimates are preliminary and should be confirmed through a facilities study. Due to the location of the generation it was observed that ten percent of this generation flows across TOT 3 even if generation at Dave Johnston is reduced to accommodate the new generation.

Appendix A
Overload Spreadsheet

X--- MONITORED ELEMENT ----X	X---LABEL--X	BENCHOUT _RXB.acc	GEN1865_ RXB_OUT. acc	GEN1842_ RXB_OUT. acc	GENFIX1_ 1842_RXB _OUT.acc	GENFIX2_ 1842_RXB _OUT.acc
70192 FTLUPTON 230.00 70410 ST.VRAIN 230.00 1	SINGL1 10		100.1% 440MVA (1x)			
70192 FTLUPTON 230.00 70410 ST.VRAIN 230.00 2	SINGL1 9		100.1% 440MVA (1x)			
70410 ST.VRAIN 230.00 70471 WELD PS 230.00 1	SINGL1 35	100.1% 507MVA (1x)	101.6% 514MVA (1x)		100.1% 507MVA (1x)	100.2% 508MVA (1x)
70471 WELD PS 230.00 73212 WELD LM 230.00 1	SINGL1 35	100.6% 649MVA (1x)	101.8% 655MVA (1x)	100.1% 645MVA (1x)	100.6% 649MVA (1x)	100.6% 650MVA (1x)
73008 ARCHER 115.00 73183 SKYLINE 115.00 1	SINGL1 195	106.4% 127MVA (1x)	106.8% 127MVA (1x)	106.7% 127MVA (1x)	106.5% 127MVA (1x)	106.4% 127MVA (1x)
73009 ARCHER 230.00 77910 ARCHTAP3 345.00 1	LRS_AULT	106.4% 596MVA (1x)			104.0% 582MVA (1x)	103.9% 582MVA (1x)
73011 AULT 230.00 73536 CHEYENNE 230.00 1	LRS_AULT	100.0% 442MVA (1x)	105.4% 466MVA (1x)	104.0% 460MVA (1x)		
73024 BLKHLWTP 115.00 73552 AULT 115.00 1	SINGL1 260				101.0% 114MVA (1x)	
73066 GEMCTYTP 115.00 73077 HAPPYJCK 115.00 1	CH_SNG230		109.7% 175MVA (1x)	107.9% 172MVA (1x)	107.2% 171MVA (1x)	
73066 GEMCTYTP 115.00 73570 SNOWYRNG 115.00 1	CH_SNG230		110.9% 199MVA (1x)	109.2% 197MVA (1x)	108.7% 196MVA (1x)	
73077 HAPPYJCK 115.00 73348 CORLETT 115.00 1	SINGL1 169	105.4% 126MVA (1x)	106.0% 126MVA (1x)	105.9% 126MVA (1x)	105.7% 126MVA (1x)	105.5% 126MVA (1x)
73137 MIRACLEM 115.00 73362 MEDBOWTP 115.00 1	SINGL1 245		100.1% 122MVA (1x)			
73150 PEETZ 115.00 73179 SIDNEY 115.00 1	SID_SPCN	117.7% 132MVA (2x)		114.4% 128MVA (2x)	112.4% 126MVA (2x)	112.4% 126MVA (2x)

73150 PEETZ 115.00 73179 SIDNEY 115.00 1	NYU_SPCN		116.0% 130MVA (2x)			
73150 PEETZ 115.00 73191 STERLING 115.00 1	NYU_SPCN	119.7% 129MVA (2x)	117.9% 127MVA (2x)	116.4% 125MVA (2x)	114.4% 123MVA (2x)	114.4% 124MVA (2x)
73179 SIDNEY 115.00 73180 SIDNEY 230.00 1	SID_SPCN	129.0% 215MVA (2x)	126.4% 211MVA (2x)	125.4% 209MVA (2x)		124.5% 208MVA (2x)
73179 SIDNEY 115.00 73180 SIDNEY 230.00 1	NYU_SPCN				124.6% 208MVA (2x)	

CONTINGENCY LEGEND:

X--LABEL---X	EVENTS
LRS_AULT	: TRIP LINE FROM BUS 73108 [LAR.RIVR 345.00] TO BUS 73012 [AULT 345.00]
SID_SPCN	: TRIP LINE FROM BUS 73180 [SIDNEY 230.00] TO BUS 73579 [SPRNGCAN 230.00]
NYU_SPCN	: TRIP LINE FROM BUS 73143 [N.YUMA 230.00] TO BUS 73579 [SPRNGCAN 230.00]
CH_SNG230	: TRIP LINE FROM BUS 73536 [CHEYENNE 230.00] TO BUS 73571 [SNOWYRNG 230.00]
SINGL1 9	: OPEN LINE FROM BUS 70192 [FTLUPTON 230.00] TO BUS 70410 [ST.VRAIN 230.00] CKT 1
SINGL1 10	: OPEN LINE FROM BUS 70192 [FTLUPTON 230.00] TO BUS 70410 [ST.VRAIN 230.00] CKT 2
SINGL1 35	: OPEN LINE FROM BUS 70410 [ST.VRAIN 230.00] TO BUS 70474 [WINDSOR 230.00] CKT 1
SINGL1 169	: OPEN LINE FROM BUS 73008 [ARCHER 115.00] TO BUS 73183 [SKYLINE 115.00] CKT 1
SINGL1 195	: OPEN LINE FROM BUS 73077 [HAPPYJCK 115.00] TO BUS 73348 [CORLETT 115.00] CKT 1
SINGL1 245	: OPEN LINE FROM BUS 73571 [SNOWYRNG 230.00] TO BUS 93000 [2007G6 230.00] CKT 1
SINGL1 260	: OPEN LINE FROM BUS 73011 [AULT 230.00] TO BUS 73199 [TIMBERLN 230.00] CKT 1

Appendix B
Dynamic Simulation Plots

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2011 HS1B APPROVED BASE CASE

WED, NOV 07 2007 7:36

INT. ANGLE MULT. FAULTS

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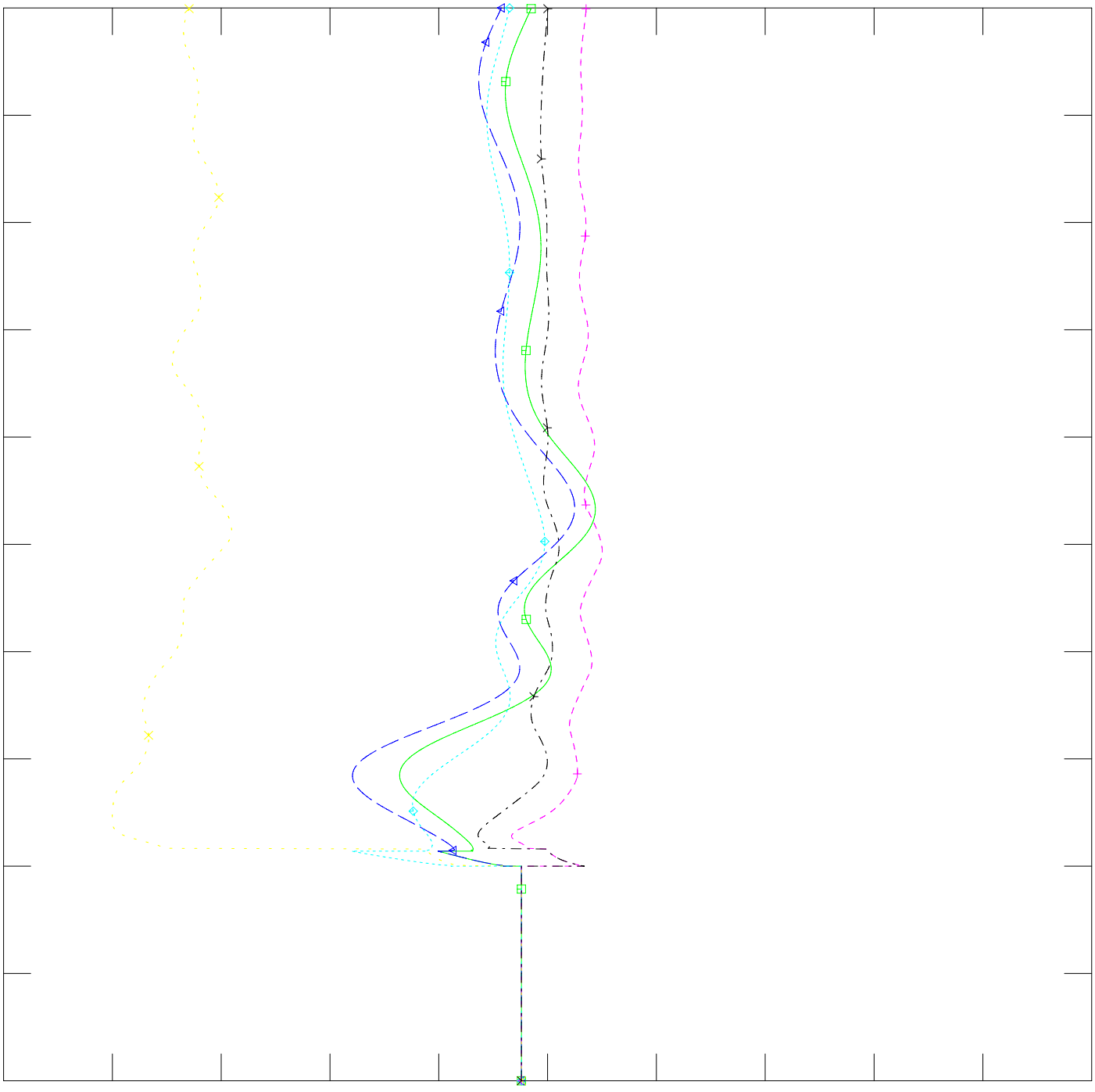

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WESTERN ELECTRICITY COORDINATING COUNCIL
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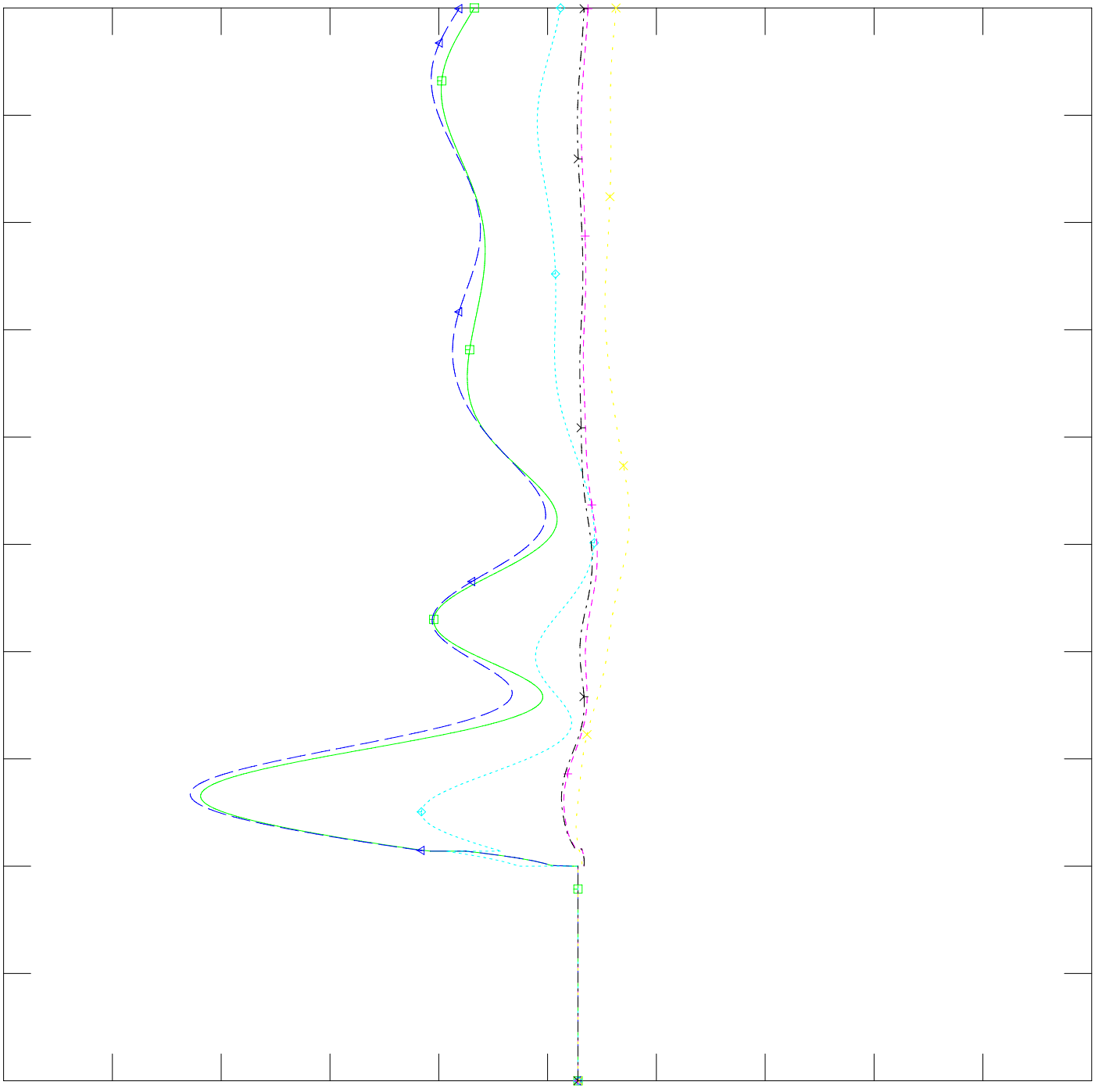

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WED, NOV 07 2007 7:54

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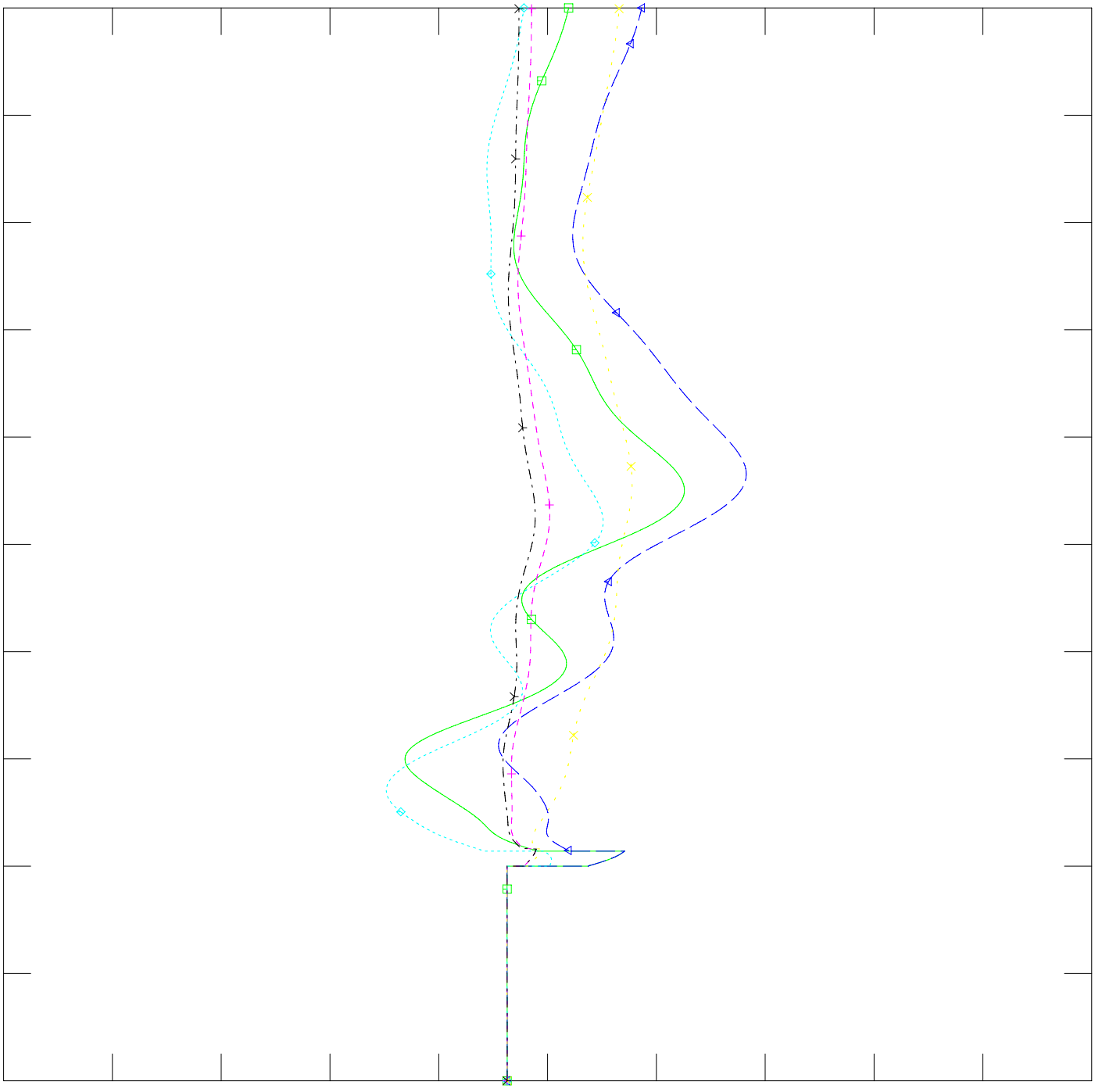

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WED, NOV 07 2007 7:57

DJ ANG. MULT. FAULTS

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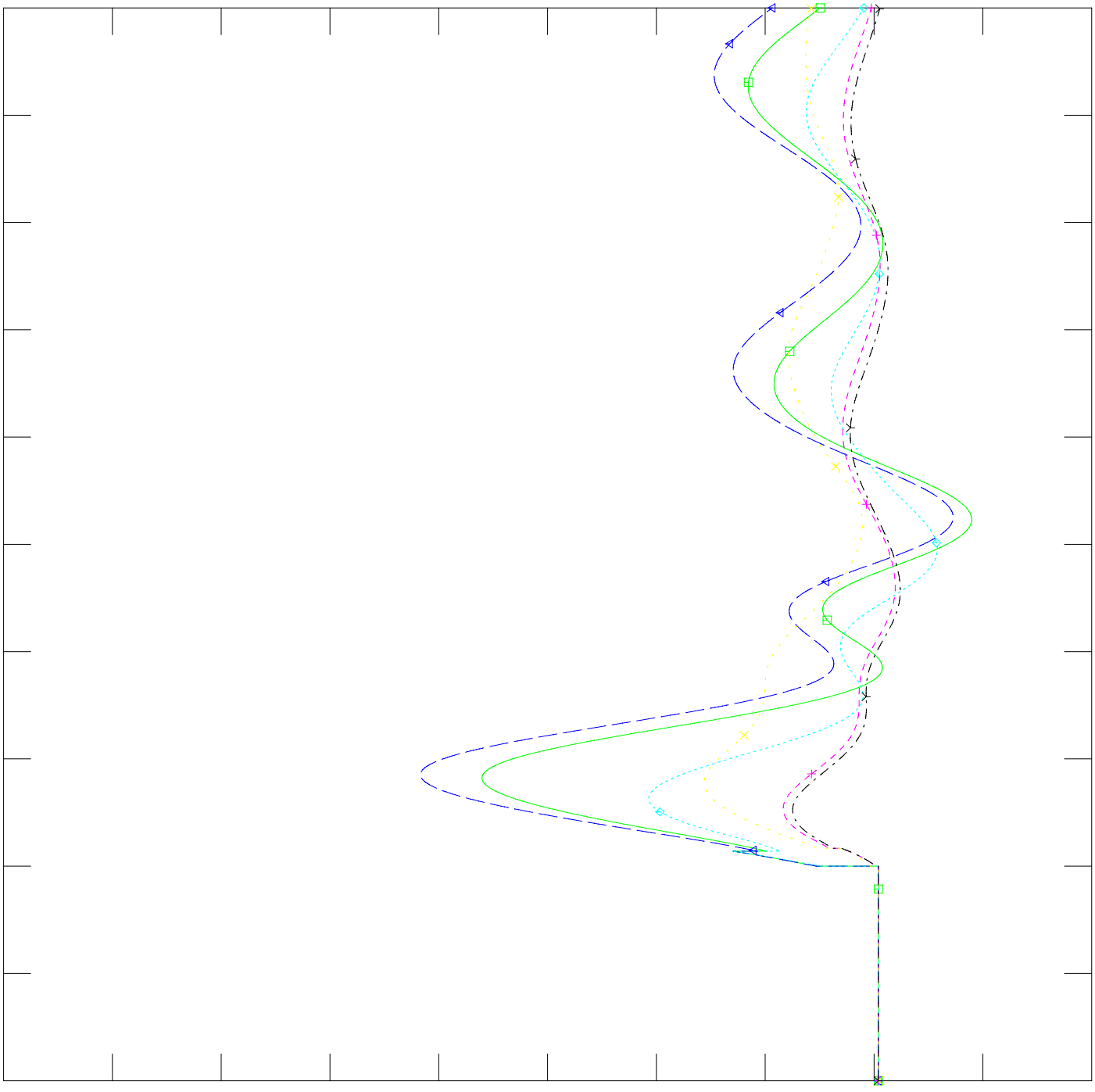

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WED, NOV 07 2007 8:00

LAM VOLT MULT. FAULTS

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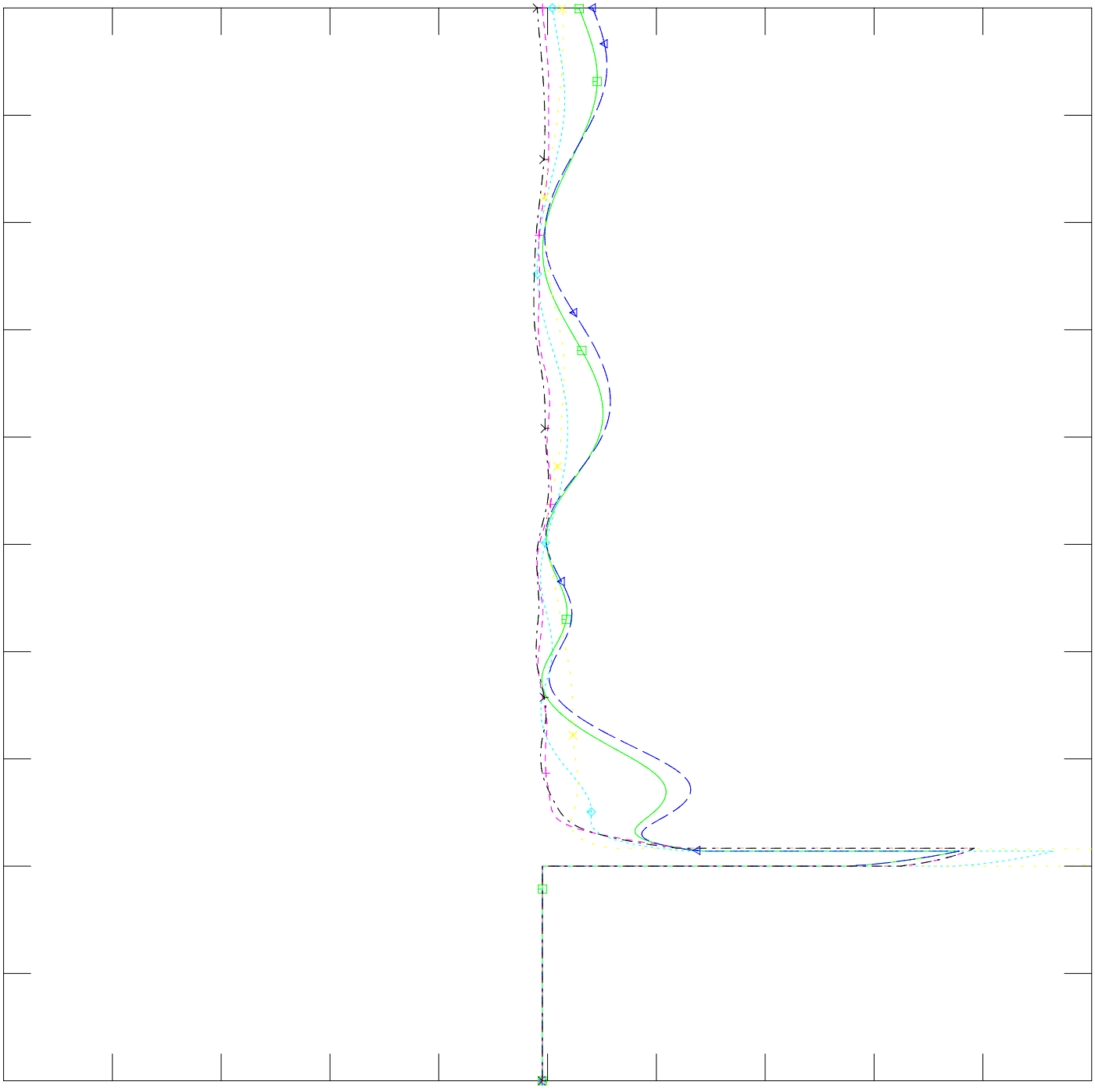

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WESTERN ELECTRICITY COORDINATING COUNCIL
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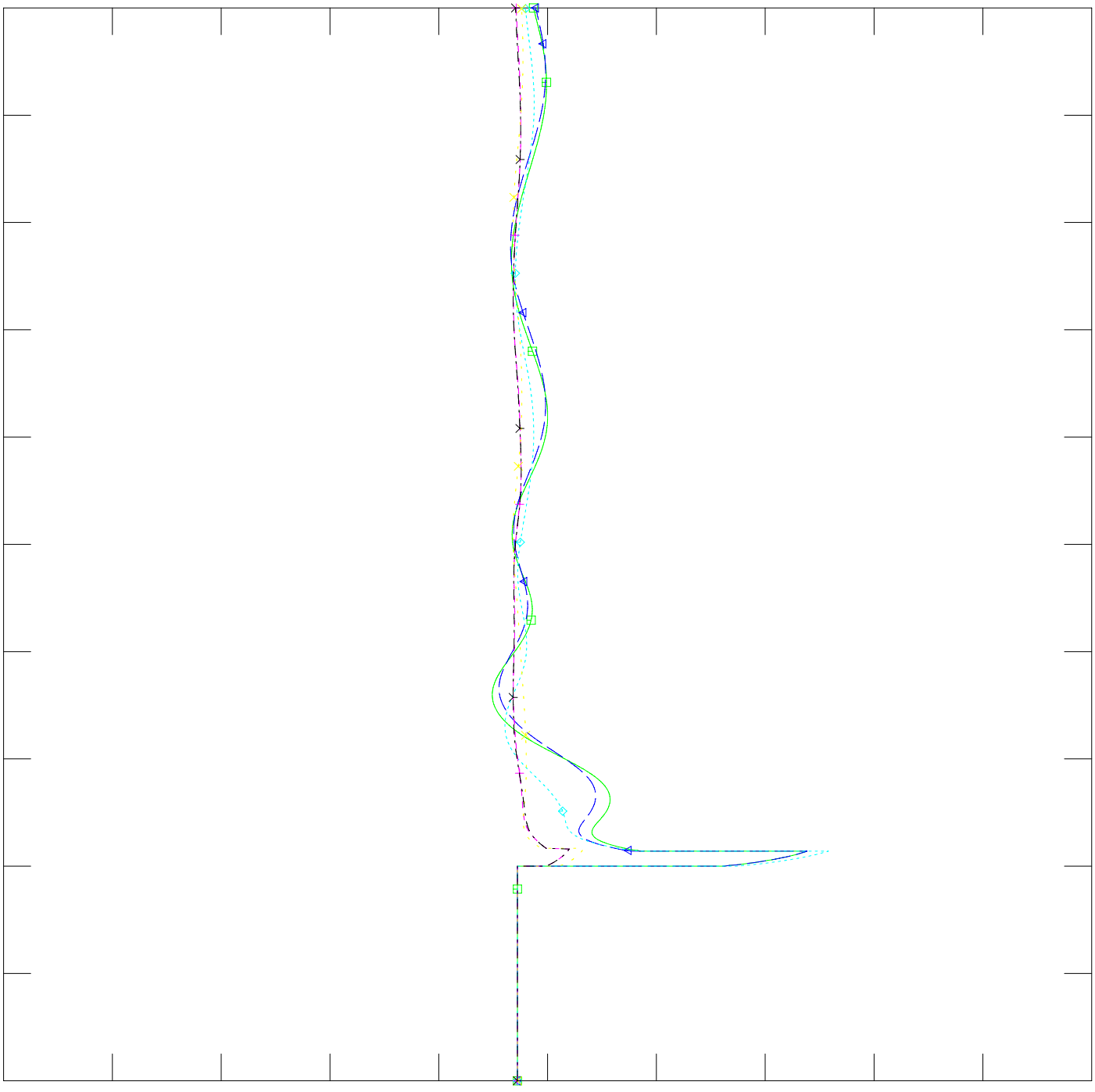

SIEMENS POWER TECHNOLOGIES INTERNATIONAL

WESTERN ELECTRICITY COORDINATING COUNCIL
2011 HS1B APPROVED BASE CASE

WED, NOV 07 2007 8:02

INTERCONNECTION VOLTAGE

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CHNL# 33: [VOLT 93000 [2007G6 230.00]]
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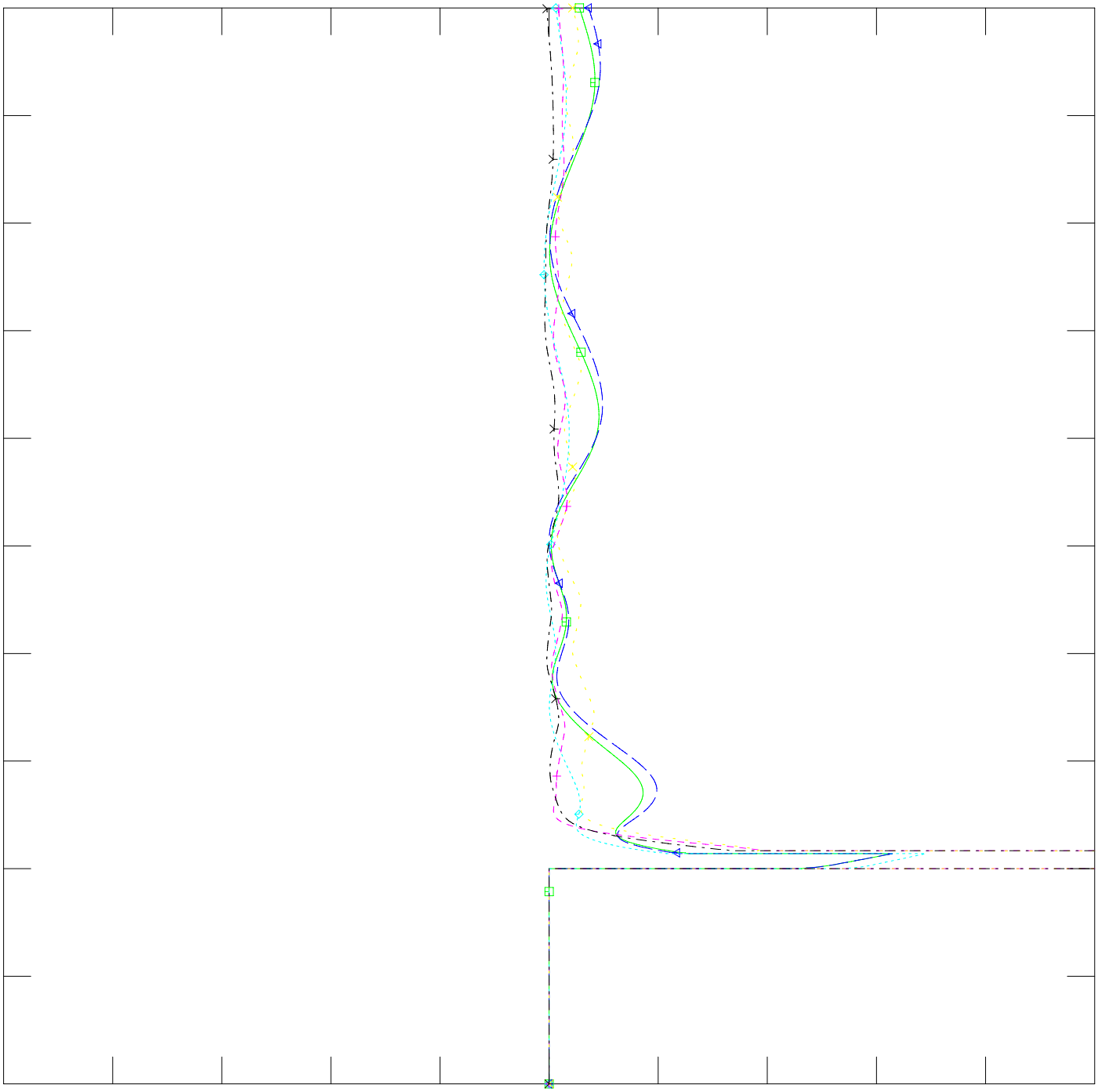

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2011 HS1B APPROVED BASE CASE

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WED, NOV 07 2007 14:52

GEN TRIP 2007G6 HZ

CHNL# 75: [FREQ 65420 [DAVEJOHN 230.00]]
0.01000 -0.0100

CHNL# 76: [FREQ 66730 [WYODAK 1 22.000]]
0.01000 -0.0100

CHNL# 77: [FREQ 70311 [PAWNEE 230.00]]
0.01000 -0.0100

CHNL# 78: [FREQ 73108 [LAR.RIVR 345.00]]
0.01000 -0.0100

CHNL# 79: [FREQ 73165 [RAWHIDE 230.00]]
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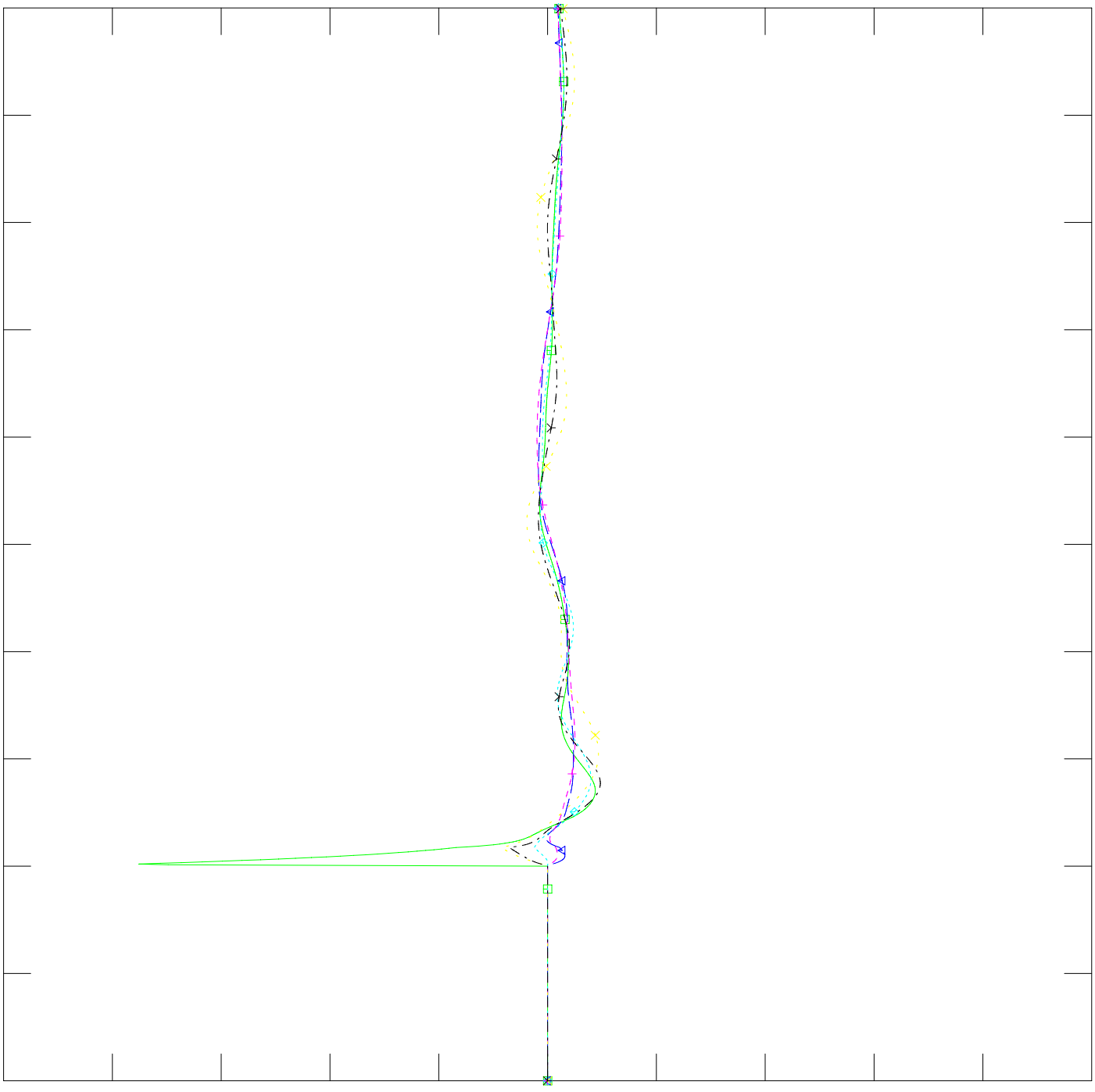
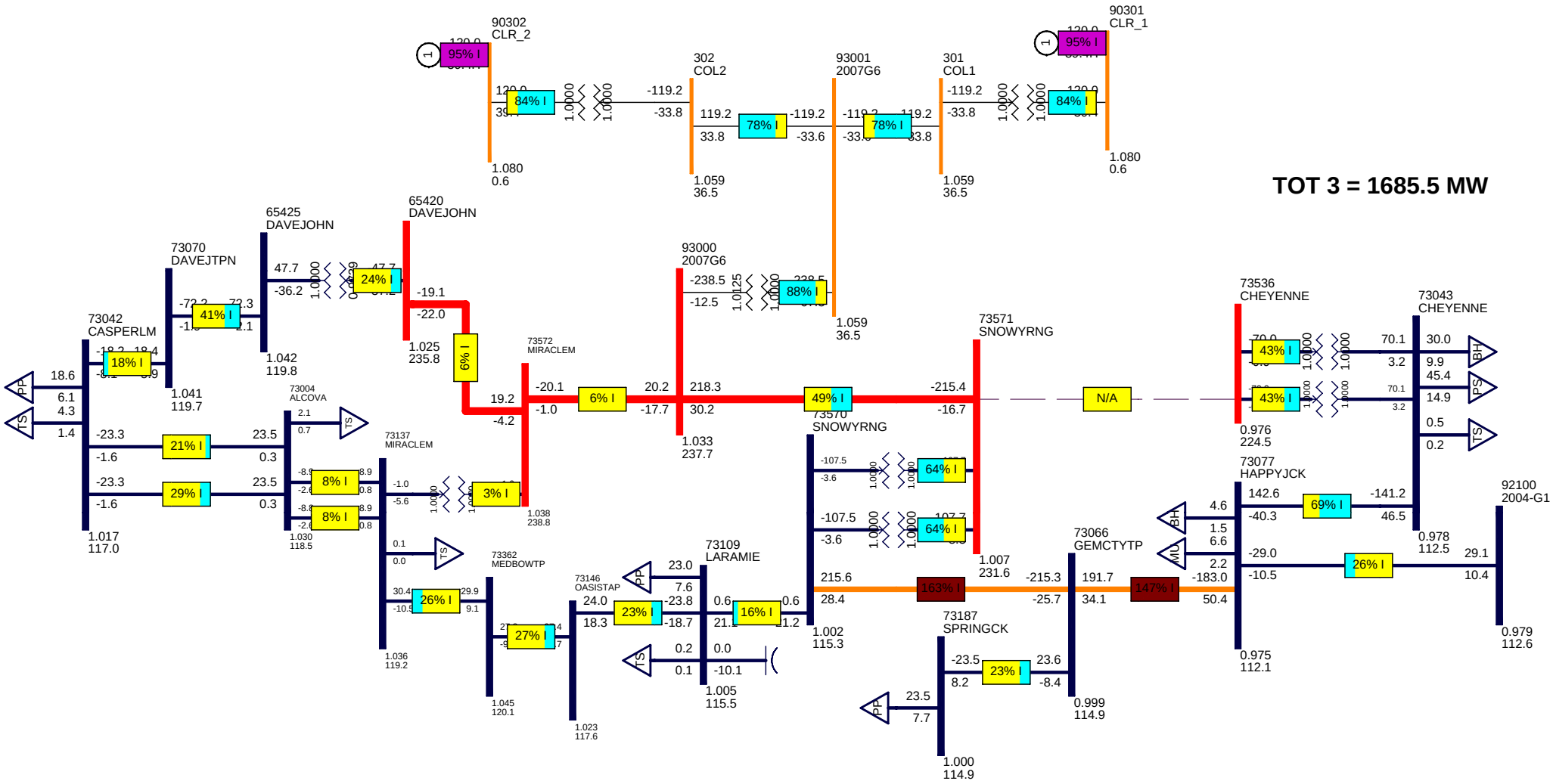
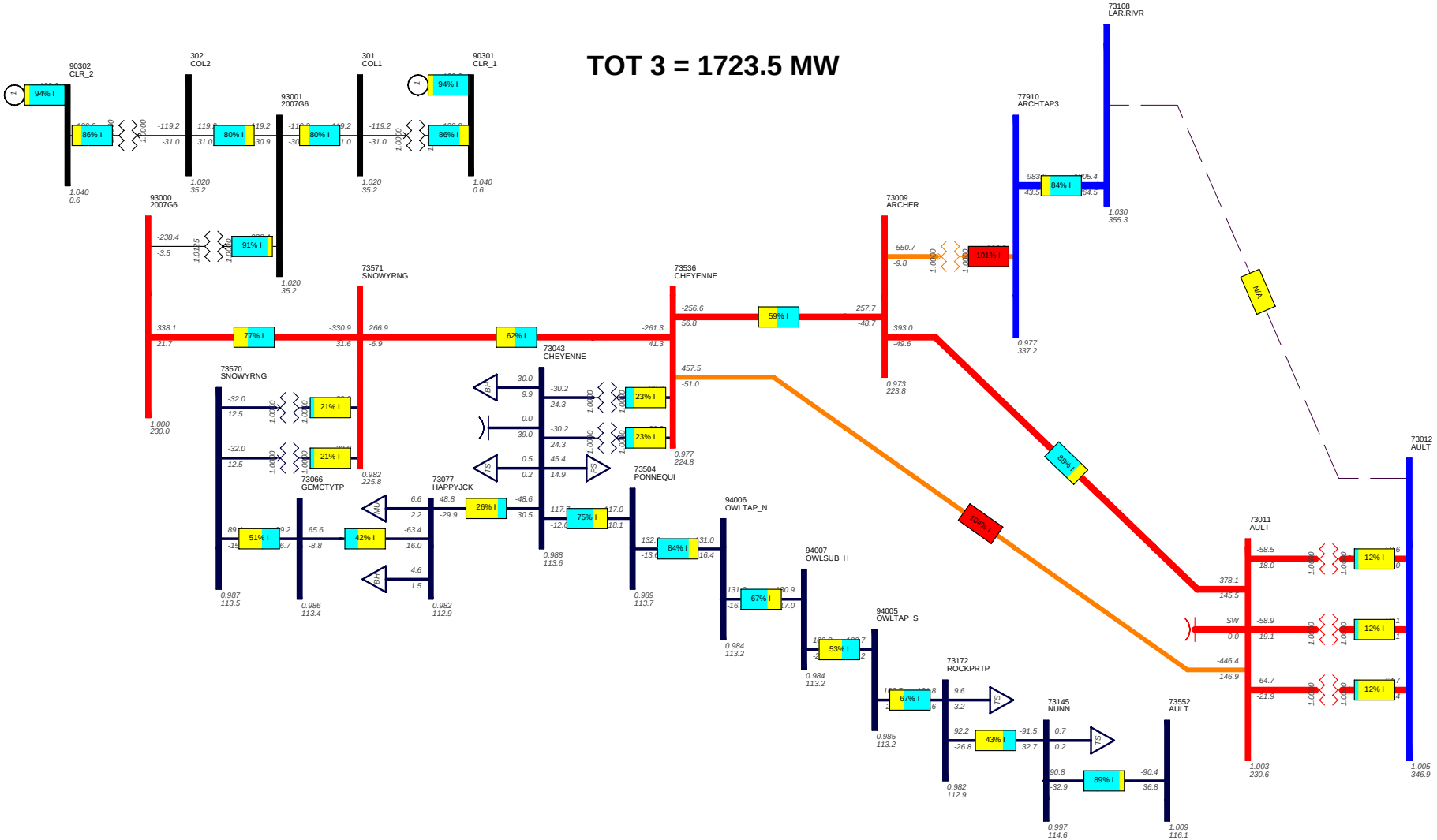
CHNL# 80: [FREQ 93000 [2007G6 230.00]]
0.01000 -0.0100



Appendix C
Single Line Diagrams


TOT 3 = 1685.5 MW
90302
CLR_2
95% I
84% I
1.080
0.6
302
COL2
-119.2
-33.8
119.2
33.8
78% I
1.059
36.5
93001
2007G6
-119.2
-33.6
78% I
1.059
36.5
301
COL1
-119.2
-33.8
84% I
90301
CLR_1
95% I
1.080
0.6
1.0000
65425
DAVEJOHN
47.7
-36.2
1.042
119.8
73070
DAVEJTPN
41% I
1.041
119.7
73042
CASPERLM
18% I
18.6
6.1
4.3
1.4
-23.3
-1.6
21% I
23.5
0.3
29% I
1.017
117.0
65420
DAVEJOHN
24% I
-19.1
-22.0
1.025
235.8
6% I
19.2
-4.2
73572
MIRACLEM
-20.1
-1.0
6% I
20.2
-17.7
3% I
1.038
238.8
93000
2007G6
-238.5
-12.5
88% I
1.059
36.5
218.3
30.2
1.033
237.7
49% I
73571
SNOWYRNG
-215.4
-16.7
N/A
73004
ALCOVA
2.1
0.7
8% I
8% I
1.030
118.5
73137
MIRACLEM
-1.0
-5.6
0.1
0.0
30.4
-10.5
26% I
29.9
9.1
1.036
119.2
73362
MEDBOWTP
27% I
1.045
120.1
73146
OASISTAP
24.0
18.3
23% I
1.023
117.6
73109
LARAMIE
23.0
7.6
-23.8
-18.7
16% I
0.6
21.2
0.2
0.1
0.0
-10.1
1.005
115.5
73570
SNOWYRNG
-107.5
-3.6
64% I
-107.5
-3.6
64% I
215.6
28.4
163% I
1.002
115.3
1.007
231.6
73066
GEMCTYTP
-215.3
-25.7
191.7
34.1
147% I
73187
SPRINGCK
23.5
7.7
-23.5
8.2
23% I
23.6
-8.4
1.000
114.9
0.999
114.9
73536
CHEYENNE
43% I
43% I
0.976
224.5
73043
CHEYENNE
70.1
3.2
30.0
9.9
45.4
14.9
0.5
0.2
0.978
112.5
73077
HAPPYJCK
4.6
1.5
6.6
2.2
-183.0
50.4
142.6
-40.3
69% I
-141.2
46.5
-29.0
-10.5
26% I
29.1
10.4
0.975
112.1
92100
2004-G1
0.979
112.6
PP
TS
BH
PS
MU


TOT 3 = 1723.5 MW
90302
CLR_2
302
COL2
301
COL1
90301
CLR_1
93001
2007G6
93000
2007G6
73571
SNOWYRNG
73536
CHEYENNE
73043
CHEYENNE
73570
SNOWYRNG
73066
GEMCTYTP
73077
HAPPYJCK
73504
PONNEQUI
94006
OWLTAP_N
94007
OWLSUB_H
94005
OWLTAP_S
73172
ROCKPRTP
73145
NUNN
73552
AULT
73009
ARCHER
77910
ARCHTAP3
73108
LAR.RIVR
73011
AULT
73012
AULT
N/A
SW
94% I
86% I
80% I
80% I
86% I
91% I
77% I
62% I
59% I
101% I
84% I
88% I
104% I
23% I
23% I
21% I
21% I
51% I
42% I
26% I
75% I
84% I
67% I
53% I
67% I
43% I
89% I
12% I
12% I
12% I