CATEGORY 1

REGULATORY INFORMATION DISTRIBUTION SYSTEM (RIDS)

ACCESSION NBR:9701060083 DOC.DATE: 96/12/27 NOTARIZED: YES DOCKET #
FACIL:STN-50-528 Palo Verde Nuclear Station, Unit 1, Arizona Publi 05000528
STN-50-529 Palo Verde Nuclear Station, Unit 2, Arizona Publi 05000529
STN-50-530 Palo Verde Nuclear Station, Unit 3, Arizona Publi 05000530

AUTH.NAME AUTHOR AFFILIATION
* Arizona Public Service Co. (formerly Arizona Nuclear Power

RECIP.NAME RECIPIENT AFFILIATION
Document Control Branch (Document Control Desk)

SUBJECT: Requests NRC review & approval of change to PVNGS grid stability analyses due to construction of new high voltage transmission line over two of five transmission lines which serve station.

DISTRIBUTION CODE: A001D COPIES RECEIVED:LTR 1 ENCL 1 SIZE: 40
TITLE: OR Submittal: General Distribution

NOTES:STANDARDIZED PLANT 05000528
Standardized plant. 05000529
Standardized plant. 05000530

	RECIPIENT ID CODE/NAME	COPIES LTTR	COPIES ENCL	RECIPIENT ID CODE/NAME	COPIES LTTR	COPIES ENCL
	PD4-2 LA	1	1	PD4-2 PD	1	1
	CLIFFORD,J	1	1	THOMAS,C	1	1
INTERNAL:	ACRS	1	1	FILE CENTER 01	1	1
	NRR/DE/ECGB/A	1	1	NRR/DE/EMCB	1	1
	NRR/DRCH/HICB	1	1	NRR/DSSA/SPLB	1	1
	NRR/DSSA/SRXB	1	1	NUDOCS-ABSTRACT	1	1
	OGC/HDS2	1	0			
EXTERNAL:	NOAC	1	1	NRC PDR	1	1

CATEGORY 1 DOCUMENT

NOTE TO ALL "RIDS" RECIPIENTS:
PLEASE HELP US TO REDUCE WASTE! CONTACT THE DOCUMENT CONTROL DESK, ROOM OWFN 5D-5(EXT. 415-2083) TO ELIMINATE YOUR NAME FROM DISTRIBUTION LISTS FOR DOCUMENTS YOU DON'T NEED!

TOTAL NUMBER OF COPIES REQUIRED: LTTR 15 ENCL 14

MAH

APS
Commitment. Innovation. Energy.

Palo Verde Nuclear
Generating Station

James M. Levine
Senior Vice President
Nuclear

TEL (602)393-5300
FAX (602)393-6077

Mail Station 7602
P.O. Box 52034
Phoenix, AZ 85072-2034

10 CFR 50.90

102-03832-JML/AKK/DRL
December 27, 1996

U. S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Mail Station P1-37
Washington, D.C. 20555-0001

Dear Sirs:

Subject: Palo Verde Nuclear Generating Station (PVNGS)
Units 1, 2, and 3
Docket Nos. STN 50-528/529/530
Request for NRC Review of Revised Grid Stability Analyses

Arizona Public Service Company (APS) is requesting NRC review and approval of a change to the Palo Verde Nuclear Generating Station (PVNGS) grid stability analyses due to the construction of a new high voltage transmission line over two of the five transmission lines which serve PVNGS. Please note that grid stability remains within design requirements and remains capable of performing its function in accordance General Design Criterion 17 of Appendix A to 10 CFR Part 50. This condition has been reviewed in accordance with 10 CFR 50.59 with the conclusion that this change involves an unreviewed safety question and requires NRC review.

Provided in Enclosure 1 to this letter are the following sections which support the proposed change to the grid stability analyses:

A. Description of the Proposed Change and Reason for Change
B. Safety Analysis for the Change
C. No Significant Hazards Consideration Determination
D. Environmental Impact Determination
E. Affected Updated Final Safety Analysis Report Pages.

In order to comply with the requirements of General Design Criterion 17,

9701060083 961227
PDR ADOCK 05000528
P PDR

A001 1/1

"Electric Power Systems" of Appendix A to 10 CFR Part 50, NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants," Section 8.2.III.1(f), and Combustion Engineering Standardized Safety Analysis Report (CESSAR) Section 8.3.1.7, studies were performed modeling the loss of two transmission lines (Westwing I and Westwing II). Both a maximum boost case (providing MVARs during the heavily loaded summer conditions to maintain the area's voltage) and a maximum buck case (absorbing MVARs during the lightly loaded autumn conditions to reduce the area's high voltage tendency) were run. These studies show that the grid remains stable within the parameters of the above requirements. The revised grid stability analyses (USFAR Section 8B) and revised UFSAR pages are provided in Enclosure 2.

In accordance with Technical Specification 6.5, the Plant Review Board and the Offsite Safety Review Committee have reviewed and concurred with this request. Pursuant to 10 CFR 50.91(b)(1), a copy of this request has been forwarded to the Arizona Radiation Regulatory Agency.

Should you have any questions, please contact Scott A. Bauer, Licensing Section Leader, at (602) 393-5978.

Sincerely,

Gregg R. Overbeck
for: JML

JML/AKK/DRL/rh

Enclosures

cc: L. J. Callan
K. E. Perkins
J. W. Clifford
K. E. Johnston
A. V. Godwin ARRA

STATE OF ARIZONA)
) ss.
COUNTY OF MARICOPA)

I, G. R. Overbeck, represent that I am Vice President - Nuclear Production, that the foregoing document has been signed by me on behalf of Arizona Public Service Company with full authority to do so, and that to the best of my knowledge and belief, the statements made therein are true and correct.

Gregg R. Overbeck

G. R. Overbeck

Sworn To Before Me This 27 Day Of December, 1996.

A. Krainik

Notary Public

My Commission Expires

"OFFICIAL SEAL"
A. K. Krainik
Notary Public-Arizona
Maricopa County
My Commission Expires 5/6/2000

ENCLOSURE 1

CHANGES TO THE PVNGS

GRID STABILITY STUDIES

ENCLOSURE 1

A. Description of the Proposed Change and Reason for Change

Recently, the Salt River Project installed a 525 kV transmission line between their Mead and Perkins substations. This new line crosses over two of the five transmissions lines that serve the Palo Verde Nuclear Generating Station (PVNGS); i.e., the Westwing I and Westwing II lines. Due to the installation of this new Salt River Project transmission line, an unreviewed safety question (USQ) was introduced in that a malfunction of a different type was created and an increase in the probability of a malfunction of equipment important to safety exists.

The current PVNGS Updated Final Safety Analysis Report (UFSAR), Section 8.2.1.1 states, in part, that "There are no crossings of the five 525 kV lines associated with PVNGS and none of the lines cross under any existing lines." In addition, "the five lines associated with the PVNGS switchyard... are designed so as to eliminate line proximity's that could result in simultaneous failure of more than one circuit."

Based on the introduction of the Mead - Perkins line, a malfunction of a different type was introduced, (i.e., a transmission line can now fall on transmission lines which serve PVNGS) and the probability of a malfunction of equipment important to safety is increased (although a small increase) since the probability of failure is increased by the probability of the Mead - Perkins line falling on the Westwing I and Westwing II lines. Therefore, this condition constitutes an unreviewed safety question.

NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants," Section 8.2.III.1(f) provides requirements for grid stability analysis in order to meet the intent of General Design Criterion 17 of Appendix A to 10 CFR Part 50. In addition, the Combustion Engineering Standardized Safety Analysis Report (CESSAR), Section 8.3.1.7, requires a maximum frequency decay rate of 3 Hz/sec. Previous analysis to meet this requirement is contained in UFSAR Appendix 8B and shows that the grid is stable for a loss of the single most critical transmission line; i.e., the Palo Verde - Devers line.

However, with the introduction of the Mead - Perkins line, an airplane crash induced mechanical failure of the Mead - Perkins line could short circuit both the Westwing I and Westwing II lines simultaneously. This condition was ,therefore, recently analyzed and that analysis is provide in Enclosure 2. This analysis shows that the grid remains stable within the requirements of NUREG-0800, Section 8.2.III.1(f) and CESSAR Section 8.3.1.7, however, the simultaneous loss

of the Westwing I and Westwing II lines now constitutes the most critical transmission line loss.

B. Safety Analysis for the Change

NUREG-0800, Section 8.2 requires that the preferred power system arrangement be reviewed to determine the adequacy of the system, and to determine the independence of the two (or more) circuits, through a review of the electrical and physical independence, to minimize the chance of simultaneous failure. This includes, in part, the review of assignment of power sources from the grid, the location of right-of-ways, and transmission lines and towers. In addition, NUREG-0800, Section 8.2 requires grid stability analyses be performed that ensures, in part, that the loss, through a single event, of the most critical transmission line does not result in the complete loss of preferred offsite power.

Since Salt River Project's new Mead - Perkins transmission line runs over both the Westwing I and the Westwing II lines, APS has reanalyzed grid stability assuming the simultaneous loss of both Westwing lines due to a short circuit (single phase to ground) caused by an airplane crash induced dropping of the Mead - Perkins line onto the Westwing I and Westwing II lines.

The analyses performed were chosen to bracket the conditions under which PVNGS operates. Both a maximum boost case (providing MVARs during the heavily loaded summer conditions to maintain the area's voltage) and a maximum buck case (absorbing MVARs during the lightly loaded autumn conditions to reduce the area's high voltage tendency) were run with all three units and all five lines in service. These new analyses demonstrate that the simultaneous loss of both Westwing lines is the most critical loss of a transmission line, rather than the loss of the Palo Verde - Devers analysis that is currently in the PVNGS UFSAR Appendix 8B. These analyses demonstrate that the grid remains stable, and that the CESSAR Section 8.3.1.7 interface requirement of a sustained frequency decay of less than 3 Hz/second is satisfied. This interface requirement ensures that the Reactor Coolant Pumps will not be slowed due to frequency decay more rapidly than during a loss of offsite power (LOP); i.e., the LOP analysis will remain the bounding analysis.

APS transmission planning, in cooperation with Salt River Project, has reviewed the specific line crossing configuration to determine the potential failure mechanisms and resultant failure rate. Based on actual operating experience, only three types of incidents have caused 525kV lines to fall within the APS system: 1) splice failures, 2) insulator failures, and 3) airplane crashes. APS has confirmed with Salt River Project that the Mead - Perkins line segment crossing Westwing I and Westwing II does not contain a splice. In addition, the particular

line crossing was constructed using dead end towers which have three insulator strings per conductor phase. The insulator strings are designed such that only one is required to hold up a conductor phase. Normal 525kV construction uses only one or two insulators per conductor phase.

For the above reasons, the first two failure mechanisms were eliminated. The third failure mechanism (airplane crashes) has occurred twice to the APS 525kV system. APS has approximately 1230 mile of 525kV lines. These lines have been in service between twelve and twenty-seven years. The product of the line lengths and years of service is 27345.16 mile-years. The distance between the towers where the Mead - Perkins line crosses the Westwing I and Westwing II lines is 781 feet (0.148 miles). The resultant probability of the subject span falling in any given year is:

$$p = (2 \text{ events}/27345.16 \text{ mile-years}) \times 0.148 \text{ miles} = 1.1\times10^{-5} \text{ events/year}$$

A search of abstracts of Licensee Event Reports (LER) from 1980 through the second quarter of 1996 also suggested sagging as a potential failure mechanism. Normal constructions standards for crossings of 525kV A.C. lines requires a minimum of 20 feet between the upper line and the lower lines when the upper is at its maximum electrical loading and the lower is at its minimum electrical loading. The Mead - Perkins crossing has a minimum of 31 feet of space under these circumstances and, therefore, sagging is ruled out as a potential failure mechanism.

Regulatory Guide 1.70, "Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants (LWR Edition)," Revision 3, Section 2.2.3.1 requires analysis of events, external to the nuclear power plant, that have a probability of occurrence on the order of about 10^{-7} per year or greater and have potential consequences serious enough to effect safety of the plant to the extent that 10 CFR Part 100 guidelines could be exceeded.

Operational history for the years 1994 and 1995 were queried to determine outage rates (both planned and forced) on the Devers, North Gila, and Kyrene lines. It was found that for the two years, the three lines were out of service a total of seventy-nine hours. Therefore, the combined probability of the simultaneous loss of Westwing I and Westwing II while one of the remaining three lines is out of service is approximately 4.5×10^{-8} per year, which is below the threshold for required analysis. If the combined output of PVNGS is greater than 3657 MW, and simultaneously the two West Wing lines are lost, with the Kyrene line out of service, one or more of the units could become unstable, however, grid stability is maintained. Plant trips are analyzed events in UFSAR Chapter 15. The consequences, therefore, do not effect the safety of the plant nor approach 10 CFR Part 100 guidelines. Such an instability does not exist if either the Devers or North Gila lines are out of service as an initial condition.

Therefore, since neither the probability nor consequences tests of RG 1.70, section 2.2.3.1 are met when one line is out of service, only the studies utilizing all five lines in service as an initial condition will be incorporated in the UFSAR.

Previous studies of the impact of the loss of the most critical PVNGS transmission line on the stability of the Arizona grid have assumed three phase bolted faults at the Palo Verde switchyard end of the respective transmission lines. Such faults are rare and are generally caused by catastrophic failure of equipment at the substation. As the previous probability discussion shows, the simultaneous failure of the two Westwing lines is also an unlikely event. (i.e., an airplane crash causing the Mead - Perkins line to drop on top of the two Westwing lines). APS Engineering evaluated the various failure modes and determined that the correct fault to impose on the two Westwing lines is single phase to ground faults. The electrical protection on the Westwing lines can detect and clear a fault in a maximum of 4 cycles (4/60 of a second). Objects falling (transmission lines or planes) would have to impact all three phases within 4 cycles in order to produce a three phase fault. In performing this failure mode evaluation, the geometry of the crossing was taken into account. The Mead - Perkins line and the Westwing lines cross at an acute angle and are not near the mid span of their respective towers when they cross. This produces a center of gravity of the Mead - Perkins line that is not over the top of the Westwing lines. This also results in the crossing being at a point in the catenary of the lines which is approaching its maximum slope. Therefore, a falling line will impact one of the phases in sufficient time for the electrical protection to clear the fault before the conductor has enough time to travel the distance to the next phase (The Westwing lines have 32 feet horizontally between phases.). Therefore, single phase to ground faults are considered to be the appropriate failure to impose based on the speed of the protection and the geometry of the crossing.

The conclusion of the grid stability analyses is that the preferred, offsite power system remains capable of performing its function in accordance with General Design Criterion 17 of Appendix A to 10 CFR Part 50.

C. <u>No Significant Hazards Consideration Determination</u>

The Commission has provided standards for determining whether a significant hazards consideration exists as stated in 10 CFR Part 50.92. A proposed amendment to an operating license for a facility involves no significant hazards consideration if operation of the facility, in accordance with a proposed amendment, would not:

1. involve a significant increase in the probability or consequences of an accident previously evaluated;

2. create the possibility of a new or different kind of accident from any accident previously evaluated; or

3. involve a significant reduction in a margin of safety.

A discussion of these standards, as they relate to this amendment request, follows.

Standard 1: Does the proposed change involve a significant increase in the probability or consequences of an accident previously evaluated?

Analysis of grid stability is performed to assure the reliability and capability of offsite power. Grid instabilities could result in a loss of offsite power. The loss of offsite power is an analyzed event in UFSAR Chapter 15. Previous grid stability analyses documented in UFSAR Section 8B have demonstrated that the loss of the most critical transmission element will not create a grid instability and, therefore, does not result in an accident.

However, Regulatory Guide 1.70, "Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants (LWR Edition)," Revision 3, Section 2.2.3.1 requires analysis of events, external to the nuclear power plant, that have a probability of occurrence on the order of 10^{-7} per year or greater and have potential consequences serious enough to effect safety of the plant to the extent that 10 CFR Part 100 guidelines could be exceeded.

The probability of the simultaneous loss of both the Westwing I and Westwing II lines due to the mechanical failure of the Mead - Perkins line while all five lines serving PVNGS are in service is 1.1×10^{-5} events per year. Analysis has been performed (Enclosure 2) that shows that the grid and the PVNGS turbine generators remain stable within the design requirements of NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants," Section 8.2.III.1(f) and the Combustion Engineering Standardized Safety Analysis Report (CESSAR) Section 8.3.1.7. Since grid stability is assured (i.e., a loss of offsite power is not created by the new event), the probability of an accident previously evaluated is not affected.

The consequences of a loss of offsite power are analyzed in UFSAR Chapter 15. The simultaneous loss of the Westwing I and Westwing II lines has been demonstrated to not cause a loss of offsite power. Therefore, the proposed change does not affect the consequences of accidents previously analyzed.

Standard 2: Does the proposed change create the possibility of a new or different kind of accident from any accident previously evaluated?

The revised grid stability analyses, performed in accordance with NUREG-0800, Section 8.2.III.1(f) and CESSAR, Section 8.3.1.7 interface requirements, shows that the simultaneous loss of both the Westwing I and Westwing II transmission lines satisfies grid stability and interface requirements; i.e., General Design Criterion 17, "Electric Power Systems" of Appendix A to 10 CFR Part 50 is met.

Additional analysis has been performed demonstrating that the simultaneous loss of Westwing I and Westwing II lines, while the most critical of the remaining three lines is out of service and net station output is at or above 3657 MW, will not cause grid instability, but could cause the loss of one or more PVNGS turbine generators. The loss of a PVNGS turbine is analyzed in UFSAR Chapter 15.

Therefore, the addition of a new transmission line over two of the five transmission lines serving PVNGS does not create the possibility of a new or different kind of accident from any accident previously evaluated.

Standard 3: Does the proposed change involve a significant reduction in a margin of safety?

Both the previous grid stability studies and the current studies increased PVNGS output by 7% for stability margin. The studies presently in the UFSAR used a nominal 1270 MW net power output per unit. This output was a design estimate and never actually reached. The recent power uprate of 2% now produces a nominal net output of 1270 MW, therefore both the current UFSAR studies and the revised studies use the same 7% margin. The revised grid stability analyses, performed in accordance with NUREG-0800, Section 8.2.III.1(f) and CESSAR, Section 8.3.1.7 interface requirements, demonstrates that the simultaneous loss of both the Westwing I and Westwing II transmission lines would not cause an unstable grid.

Therefore, the addition of a transmission line over two of the five transmission lines serving PVNGS does not involve a significant reduction in a margin of safety.

D. Environmental Impact Determination

APS has determined that the proposed amendment involves no change in the amount or type of effluent that may be released offsite, and that there is no increase in individual or cumulative occupational radiation exposure. As such, operation of PVNGS Units 1, 2, and 3 in accordance with the proposed amendment, does not involve an unreviewed environmental safety question.

E. <u>Affected Updated Final Safety Analysis Report Pages</u>

Figure 8.1-1

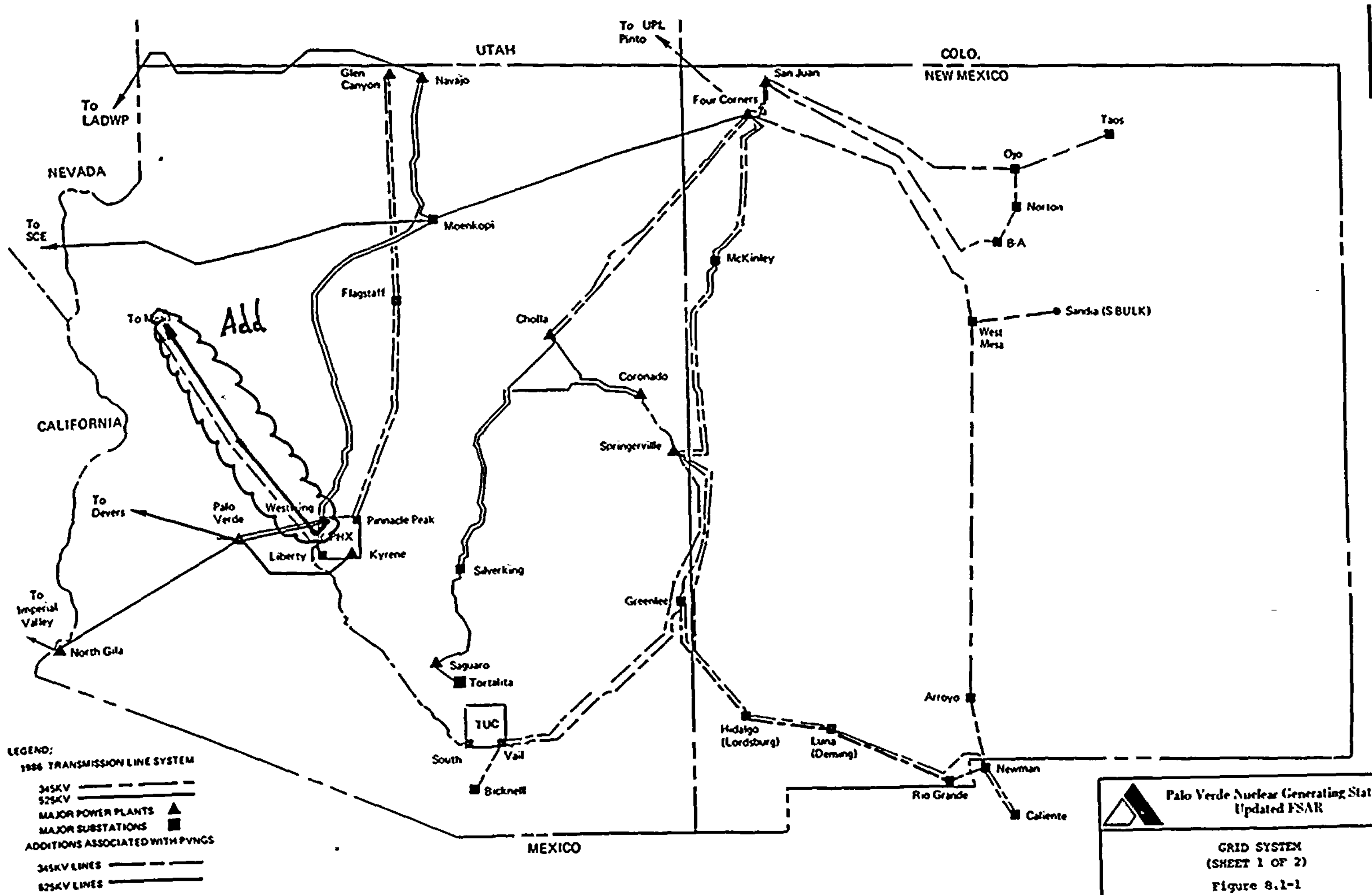
8.2-1
8.2-2
8.2-7

8B-1

8B.1-1	8B.1.13 (added)
8B.1-2	8B.1-14 (added)
8B.1-3	8B.1-15 (added)
8B.1-4	8B.1-16 (added)
8B.1-5	8B.1-17 (added)
8B.1-6	8B.1-18 (added)
8B.1-7	8B.1-19 (added)
8B.1-8	8B.1-20 (added)
8B.1-9	8B.1-21 (added)
8B.1-10	8B.1-22 (added)
8B.1-11	8B.1.23 (added)
8B.1-12 (added)	8B.1-24 (added)

ENCLOSURE 2

REVISED GRID STABILITY ANALYSIS (UFSAR SECTION 8B) AND REVISED UFSAR PAGES



Palo Verde Nuclear Generating Station
Updated FSAR

GRID SYSTEM
(SHEET 1 OF 2)

Figure 8.1-1

8.2 OFFSITE POWER SYSTEM

8.2.1 DESCRIPTION

The offsite power system consists of five physically independent circuits from the Arizona-New Mexico-California-Southern Nevada power grid to the PVNGS switchyard. Offsite power from the switchyard through three startup transformers and six intermediate buses is provided to supply two physically independent preferred power circuits to the ac power distribution system of each unit. The offsite power system is described in this section and is depicted in figures 8.1-1 and 8.2-1.

8.2.1.1 Transmission Network

The transmission system associated with PVNGS supplies offsite ac power at 525 kV for startup, normal operation, and safe shutdown of Units 1, 2, and 3. The five 525 kV lines of this system, PVNGS to Westwing I, PVNGS to Westwing II, PVNGS to Kyrene, PVNGS to North Gila, and PVNGS to Devers, cover distances of approximately 44, 44, 74, 114, and 235 miles, respectively.

All five transmission lines associated with PVNGS traverse relatively flat terrain and their design meets grade B requirements specified by the National Electrical Safety Code, sixth edition.

The Code specifies loading areas, wind loads for towers and conductors, and safety factors to be used. The conductors and the overhead ground wires are dampened to maintain acceptable levels of vibration. ~~There are no crossings of the five 525 kV lines associated with PVNGS and none of the lines cross under any existing lines.~~ None of the 525 kV lines associated with PVNGS cross one another. There is a crossing of the Westwing I and Westwing II lines by a 525 kV line not associated with PVNGS, approximately 43 miles from PVNGS. 3

3 The five transmission lines associated with the PVNGS ~~switch-~~ REVISE yard, and their rights-of-way, are designed so as to ~~eliminate~~ MINIMIZE line proximities that could result in simultaneous failure of more than one circuit. ADD The grid stability analyses of Section 8.2.2 were performed utilizing the simultaneous loss of Westwing 1 and Westwing 2 lines in lieu of a failure of a single line.

8.2.1.2 Switchyard and Connections to the Onsite Power System

Prior to the construction of PVNGS there were no transmission lines to, or transmission switchyards in the vicinity of, the site.

Construction of PVNGS includes construction of a 525 kV switchyard of the breaker-and-a-half design in which three breakers are provided for every two terminations, either line
3 or transformers. The switchyard is connected to the five 525 kV transmission lines associated with PVNGS, the 525/24 kV turbine-generator main transformers, and the 525/13.8 kV startup transformers, as shown in figure 8.2-2. These figures reflect the development of the switchyard as each unit is added.

Each turbine-generator connects to the switchyard through a main transformer, a 525 kV tie line, and two 525 kV switchyard breakers, as shown in figure 8.2-2. Physical connections between the units and the 525 kV switchyard are shown in figure 8.2-1.

The three startup transformers connect to the switchyard through two 525 kV switchyard breakers each, and feed six 13.8 kV intermediate buses. These buses are arranged in three pairs, each pair feeding only one unit.

The intermediate buses for Units 1, 2, and 3 are interconnected to the startup transformers so that each unit's buses can access all three startup transformers when all startup transformers are connected to the switchyard.

Power flow studies conducted for the described system indicate that the system can reliably deliver power to all project participants using the above planning criteria. Dynamic stability studies have shown that the system can withstand the following disturbances without loss of system stability or loss of load:

A. A permanent ~~three~~ SINGLE-phase fault on the ~~switchyard 525 kV bus with subsequent loss of the critical 525 kV line.~~ Palo Verde - Westwing I and Palo Verde - Westwing II 525 kV transmission lines. ~~The study of this disturbance incorporates the reinsertion characteristics of the metal oxide series capacitor protection used in the Palo Verde-Devers and the Palo Verde-North Gila-Miguel 525 kV transmission lines.~~

B. A sudden loss of one of the three PVNGS units with no underfrequency load shedding measures in effect.

C. The sudden loss of the largest single load on the 1988 Arizona-New Mexico-California-Southern Nevada system.

In withstanding these disturbances, which are used as design criteria, the system exhibits a very stable response, with significant positive damping achieved and with system frequency deviation held within acceptable limits. This stability is substantiated by voltage and frequency curves in appendix 8B. In addition, generator angle curves are included for representative units throughout the system. These constitute an important indication of the system damping and stability response. These results represent the response of the system associated with PVNGS with 7% generation stability margin.

Grid availability data on EHV systems in the area indicate an
outage rate of 2.27 total outages per year per 100 line miles.
Of these, 1.2 are due to planned outages and 1.07 are due to 0
forced outages. Due to all causes, the outage ratio for 500 kV
lines in the area is 0.00213.

Replace with Insert A

APPENDIX 8B

DYNAMIC STABILITY CASES

~~POWER FLOW BASE CASE~~

~~1988 heavy summer base case with Palo Verde generator output increased 7% (4077 MW) for stability margin and western flow of 4857.8 MW.~~

~~STABILITY CASES~~

~~1. Loss of most critical line - 88 STBANPP2~~ 3

~~t=0~~	~~Three-phase fault on Palo Verde 500 kV bus. Flash series capacitors in Palo Verde-Devers, Palo Verde-North Gila-Imperial Valley-Miguel, Westwing-Moenkopi, and Westwing-Navajo.~~
~~t=4 cycles~~	~~Clear fault by removal of Palo Verde-Devers line. Reinsert series capacitors in Palo Verde-North Gila-Imperial Valley-Miguel line.~~
~~t=8 cycles~~	~~Reinsert series capacitors in Westwing-Moenkopi and Westwing-Navajo lines.~~
~~t=9 seconds~~	~~End of calculations.~~

2. Loss of a Palo Verde unit - 88 STBANPP3

t=0	Palo Verde Unit 1 dropped. No capacitor flashing or line switching.
t=9 seconds	End of calculations.

Replace with
Insert A

Insert A

POWER FLOW BASE CASE

2003 heavy summer base case with Palo Verde generator output increased 7% (4077 MW) for stability margin, net MVARs equal to 1500 MVARs boosting, and western flow of 7783 MW is used for maximum boosting cases 1a. 1995 light autumn base case with Palo Verde output increased 7% (4077 MW) for stability margin, net MVARs equal to 822 MVARs bucking, and western flow of 5138 MW is used for maximum bucking cases 1b.

STABILITY CASES

1a. Single line to ground fault applied to the Westwing 525 kV bus with loss of the Perkins-Mead 525 kV and both Palo Verde-Westwing 525 kV lines.

t=0	Single line to ground fault on Westwing 525 kV bus. Flash series capacitors in Navajo-Westwing, Moenkopi-Yavapai-Westwing and the Westwing-Mead lines.
t=4 cycles	Clear Westwing fault by removing the Westwing-Mead and both Palo Verde-Westwing lines. Reinsert series capacitors in the Westwing-Mead line.
t=8 cycles	Reinsert series capacitors in Navajo-Westwing and Moenkopi-Westwing 525 kV lines.
t=9 seconds	End of calculations

Results: Stable and well damped.

1b. Single line to ground fault applied to the Westwing 525 kV bus with loss of the Perkins-Mead 525 kV and both Palo Verde-Westwing 525 kV lines.

t=0	Single line to ground fault on Westwing 525 kV bus. Flash series capacitors in Navajo-Westwing, Moenkopi-Yavapai-Westwing and the Westwing-Mead lines.
t=4 cycles	Clear Westwing fault by removing the Westwing-Mead and both Palo Verde-Westwing lines. Reinsert series capacitors in the Westwing-Mead line.
t=8 cycles	Reinsert series capacitors in Navajo-Westwing and Moenkopi-Westwing 525 kV lines.
t=9 seconds	End of calculations

Results: Stable and well damped.

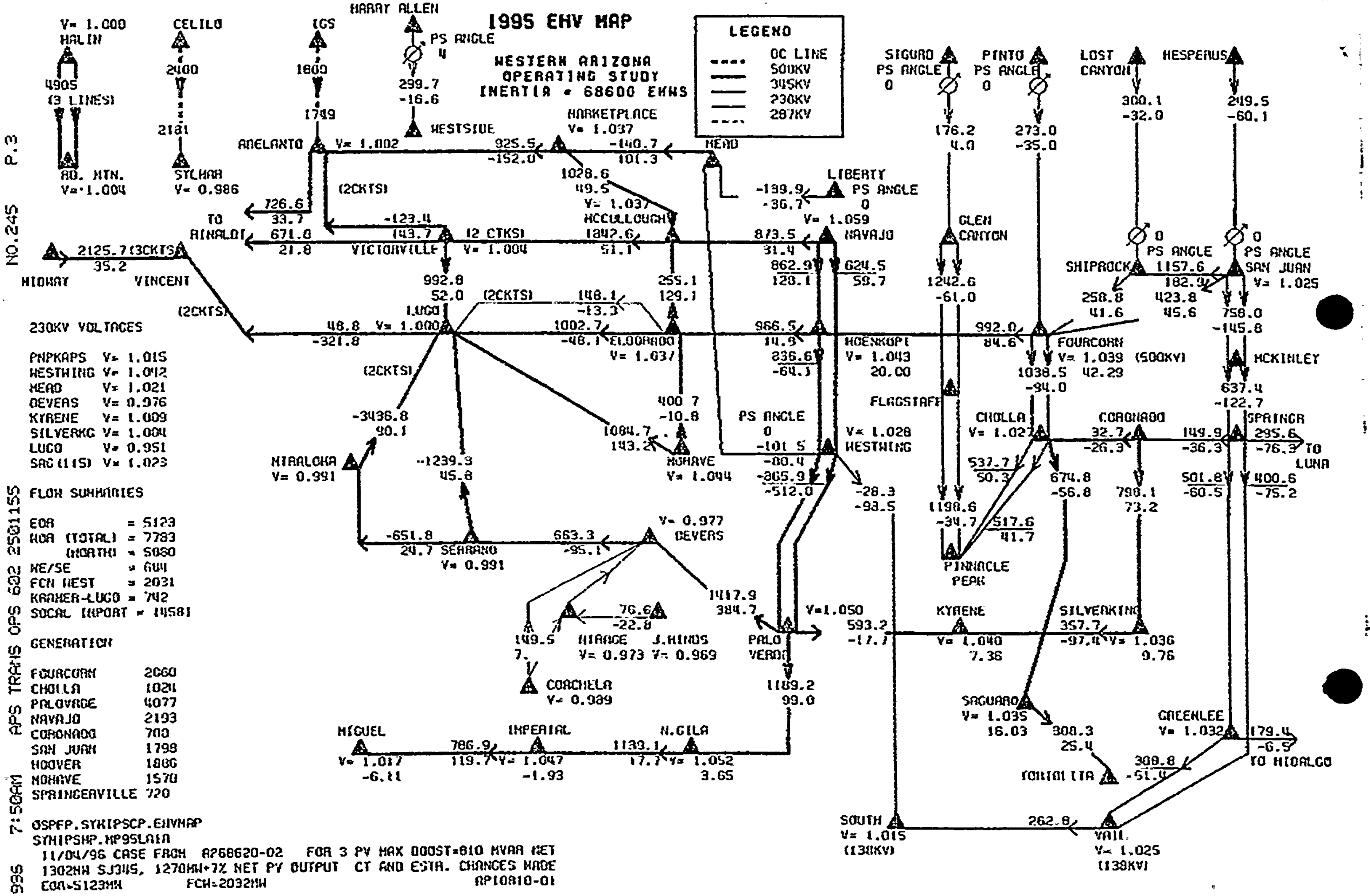

1995 EHV MAP
WESTERN ARIZONA
OPERATING STUDY
INERTIA = 68600 EMWS
LEGEND
DC LINE
500KV
345KV
230KV
287KV
V= 1.000
MALIN
4905
(3 LINES)
RD. MTN.
V= 1.004
CELILO
2400
2181
SYLMAR
V= 0.986
IGS
1800
1749
HARRY ALLEN
PS ANGLE
4
299.7
-16.6
WESTSIDE
ADELANTO
V= 1.002
925.5
-152.0
MARKETPLACE
V= 1.037
-140.7
101.3
MEAD
1028.6
49.5
V= 1.037
MCCULLOUGH
1842.6
51.1
726.6
33.7
TO
RINALDI
671.0
21.8
(2CKTS)
-123.4
143.7
VICTORVILLE
(2 CTKS)
V= 1.004
992.8
52.0
LUGO
V= 1.000
48.8
-321.8
MIDWAY
2125.7 (3CKTS)
35.2
VINCENT
(2CKTS)
(2CKTS)
146.1
-13.3
1002.7
-48.1
ELDORADO
V= 1.037
255.1
129.1
400.7
-10.8
MOHAVE
V= 1.044
1084.7
143.2
-3436.8
90.1
MIRALOMA
V= 0.991
-1239.3
45.8
-651.8
24.7
SERRANO
V= 0.991
663.3
-95.1
V= 0.977
DEVERS
1417.9
384.7
149.5
7.
MIRAGE
V= 0.973
76.6
-22.8
J.HINDS
V= 0.969
COACHELA
V= 0.989
-139.9
-36.7
LIBERTY
PS ANGLE
0
V= 1.059
NAVAJO
873.5
31.4
862.9
128.1
624.5
58.7
966.5
14.9
MOENKOPI
V= 1.043
20.00
836.6
-64.1
PS ANGLE
0
-101.5
V= 1.028
WESTWING
-80.4
-865.9
-512.0
-28.3
-93.5
V=1.050
PALO
VERDE
1189.2
99.0
MIGUEL
V= 1.017
-6.11
786.9
119.7
IMPERIAL
V= 1.047
-1.93
1139.1
17.7
N.GILA
V= 1.052
3.65
SIGURD
PS ANGLE
0
176.2
4.0
PINTO
PS ANGLE
0
273.0
-35.0
GLEN
CANYON
1242.6
-61.0
FLAGSTAFF
1198.6
-34.7
517.6
41.7
PINNACLE
PEAK
LOST
CANYON
300.1
-32.0
HESPERUS
249.5
-60.1
PS ANGLE
0
PS ANGLE
0
SHIPROCK
1157.6
182.9
SAN JUAN
V= 1.025
258.8
41.6
423.8
45.6
758.0
-145.8
992.0
84.6
FOURCORN
V= 1.039 (500KV)
1038.5
-94.0
42.29
MCKINLEY
637.4
-122.7
CHOLLA
V= 1.027
537.7
50.3
674.8
-56.8
CORONADO
32.7
-26.3
798.1
73.2
149.9
-36.3
SPRINGR
295.6
-76.3
TO
LUNA
501.8
-60.5
400.6
-75.2
593.2
-17.7
KYRENE
V= 1.040
7.36
SILVERKING
357.7
-97.4
V= 1.036
9.76
SAGUARO
V= 1.035
16.03
308.3
25.4
TORTOLITA
GREENLEE
V= 1.032
179.4
-6.5
TO HIDALGO
308.8
-51.4
SOUTH
V= 1.015
(138KV)
262.8
VAIL
V= 1.025
(138KV)
230KV VOLTAGES
PNPKAPS V= 1.015
WESTWING V= 1.042
MEAD V= 1.021
DEVERS V= 0.976
KYRENE V= 1.009
SILVERKG V= 1.004
LUGO V= 0.951
SAG(115) V= 1.023
FLOW SUMMARIES
EOR = 5123
WOR (TOTAL) = 7783
(NORTH) = 5080
NE/SE = 604
FCN WEST = 2031
KRAMER-LUGO = 742
SOCAL IMPORT = 14581
GENERATION
FOURCORN 2060
CHOLLA 1024
PALOVRDE 4077
NAVAJO 2193
CORONADO 700
SAN JUAN 1798
HOOVER 1806
MOHAVE 1570
SPRINGERVILLE 720
OSPFP.SYKIPSCP.EHVMAP
SYKIPSHP.MP95LAIA
11/04/96 CASE FROM AP68620-02 FOR 3 PV MAX BOOST=810 MVAR NET
1302MW SJ345, 1270MW+7% NET PV OUTPUT CT AND ESTR. CHANGES MADE
EOR=5123MW FCW=2032MW AP10810-01

Figure 8B.1-1

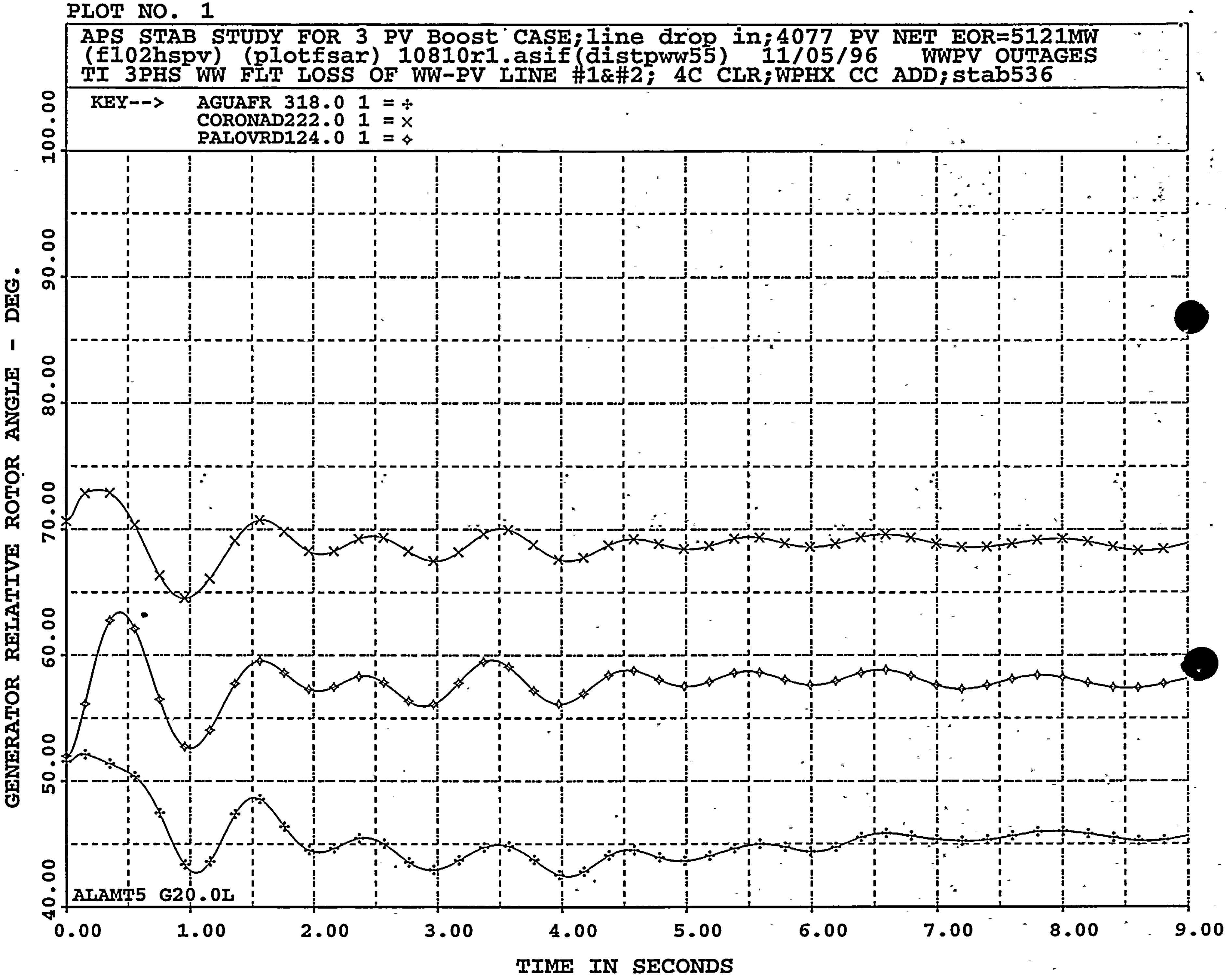
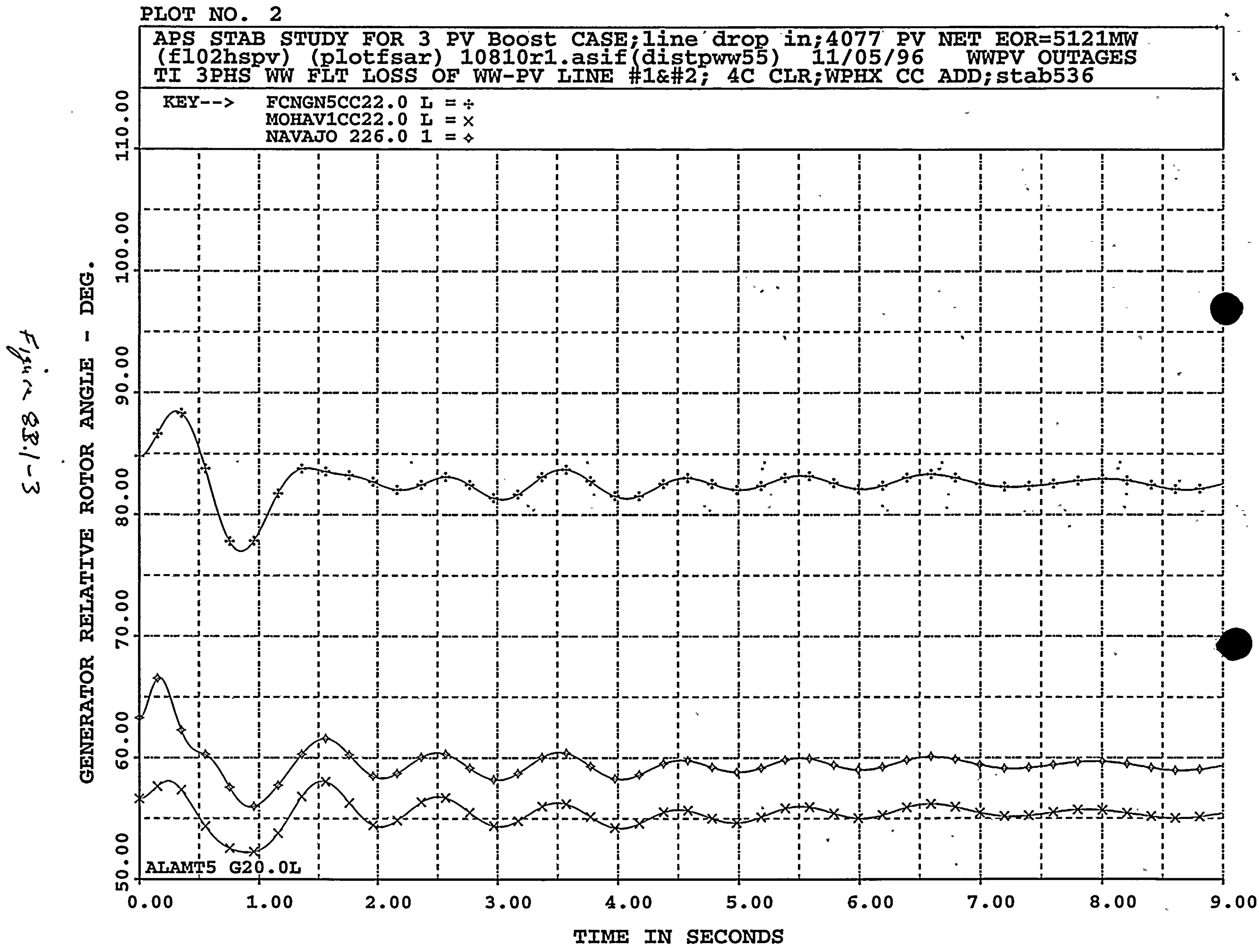

PLOT NO. 1
APS STAB STUDY FOR 3 PV Boost CASE;line drop in;4077 PV NET EOR=5121MW
(f102hspv) (plotfsar) 10810r1.asif(distpww55) 11/05/96 WWPV OUTAGES
TI 3PHS WW FLT LOSS OF WW-PV LINE #1&#2; 4C CLR;WPHX CC ADD;stab536
KEY--> AGUAFR 318.0 1 = +
CORONAD222.0 1 = ×
PALOVRD124.0 1 = ◇
GENERATOR RELATIVE ROTOR ANGLE - DEG.
100.00
90.00
80.00
70.00
60.00
50.00
40.00
ALAMT5 G20.0L
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
TIME IN SECONDS

Figure 8B.1-2



PLOT NO. 2
APS STAB STUDY FOR 3 PV Boost CASE;line drop in;4077 PV NET EOR=5121MW
(f102hspv) (plotfsar) 10810r1.asif(distpww55) 11/05/96 WWPV OUTAGES
TI 3PHS WW FLT LOSS OF WW-PV LINE #1&#2; 4C CLR;WPHX CC ADD;stab536
KEY--> FCNGN5CC22.0 L = +
MOHAV1CC22.0 L = ×
NAVAJO 226.0 1 = ◇
GENERATOR RELATIVE ROTOR ANGLE - DEG.
110.00
100.00
90.00
80.00
70.00
60.00
50.00
ALAMT5 G20.0L
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
TIME IN SECONDS
Figure 8.1-3

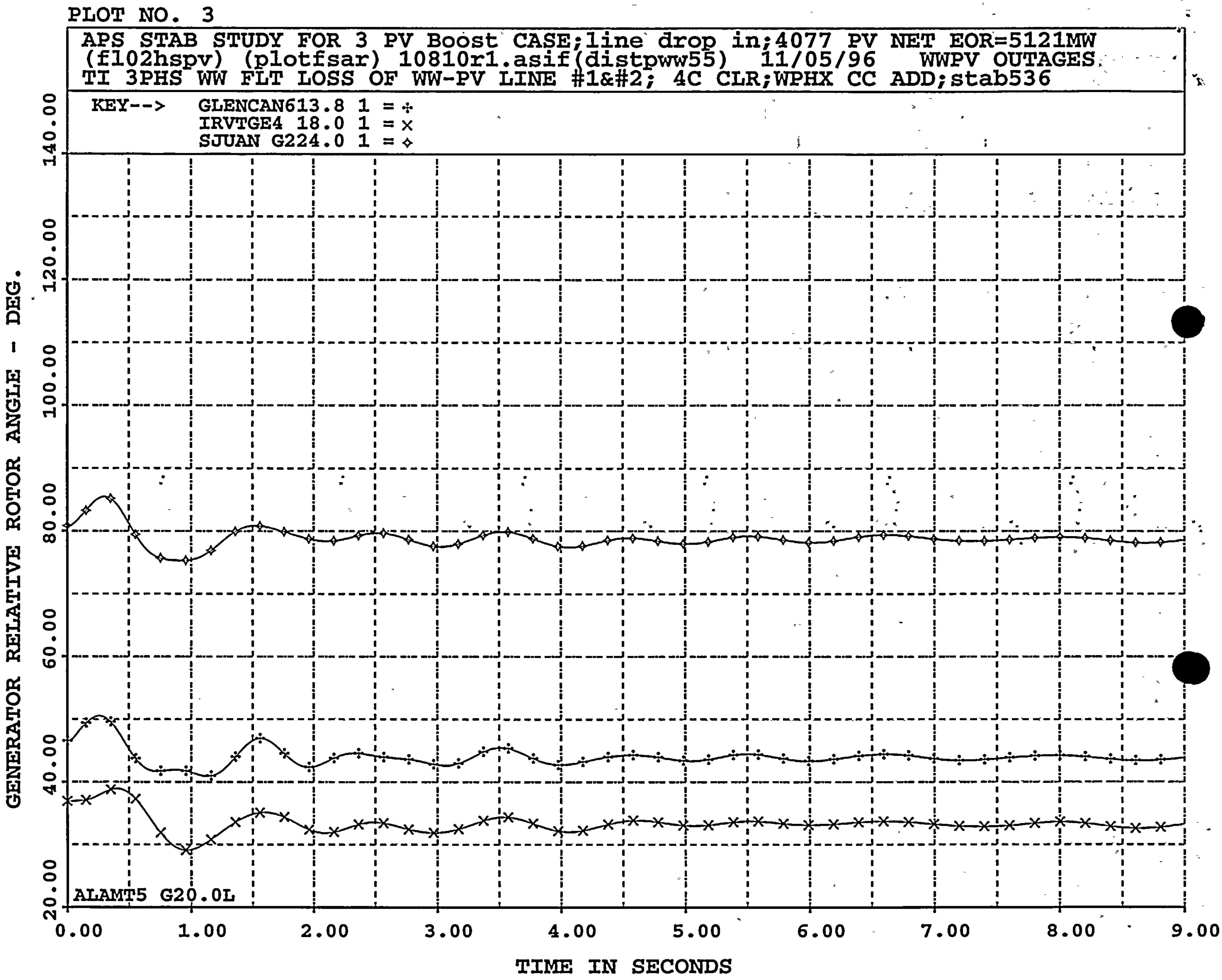

PLOT NO. 3
APS STAB STUDY FOR 3 PV Boost CASE;line drop in;4077 PV NET EOR=5121MW
(f102hspv) (plotfsar) 10810r1.asif(distpww55) 11/05/96 WWPV OUTAGES
TI 3PHS WW FLT LOSS OF WW-PV LINE #1&#2; 4C CLR;WPHX CC ADD;stab536
KEY--> GLENCAN613.8 1 = +
IRVTGE4 18.0 1 = ×
SJUAN G224.0 1 = ◇
GENERATOR RELATIVE ROTOR ANGLE - DEG.
140.00
120.00
100.00
80.00
60.00
40.00
20.00
ALAMT5 G20.0L
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
TIME IN SECONDS

Figure 8B.1-4

PLOT NO. 4

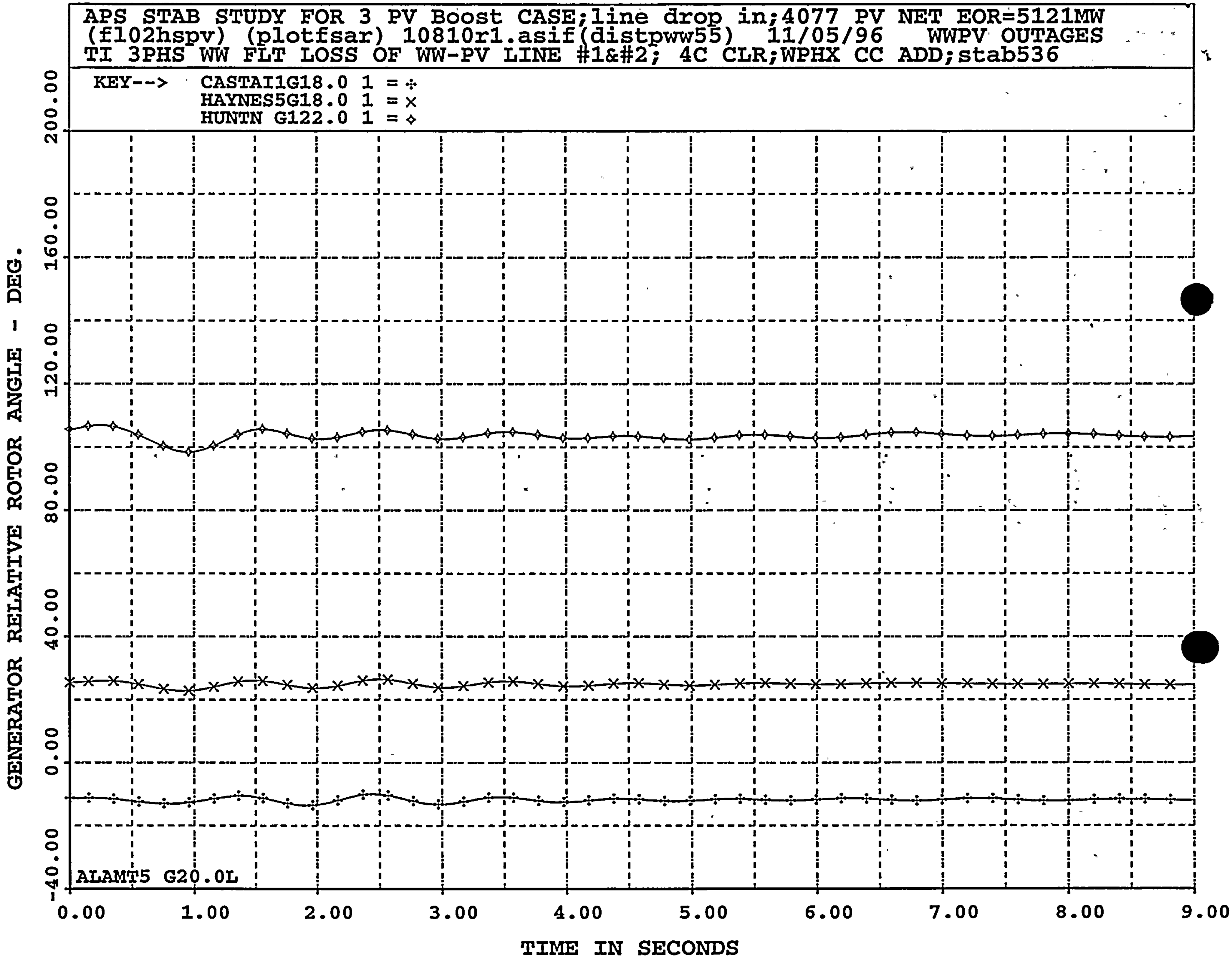


Figure 8B.1-5

PLOT NO. 5

APS STAB STUDY FOR 3 PV Boost CASE;line drop in;4077 PV NET EOR=5121MW
(f102hspv) (plotfsar) 10810r1.asif(distpww55) 11/05/96 WWPV OUTAGES
TI 3PHS WW FLT LOSS OF WW-PV LINE #1&#2; 4C CLR;WPHX CC ADD;stab536

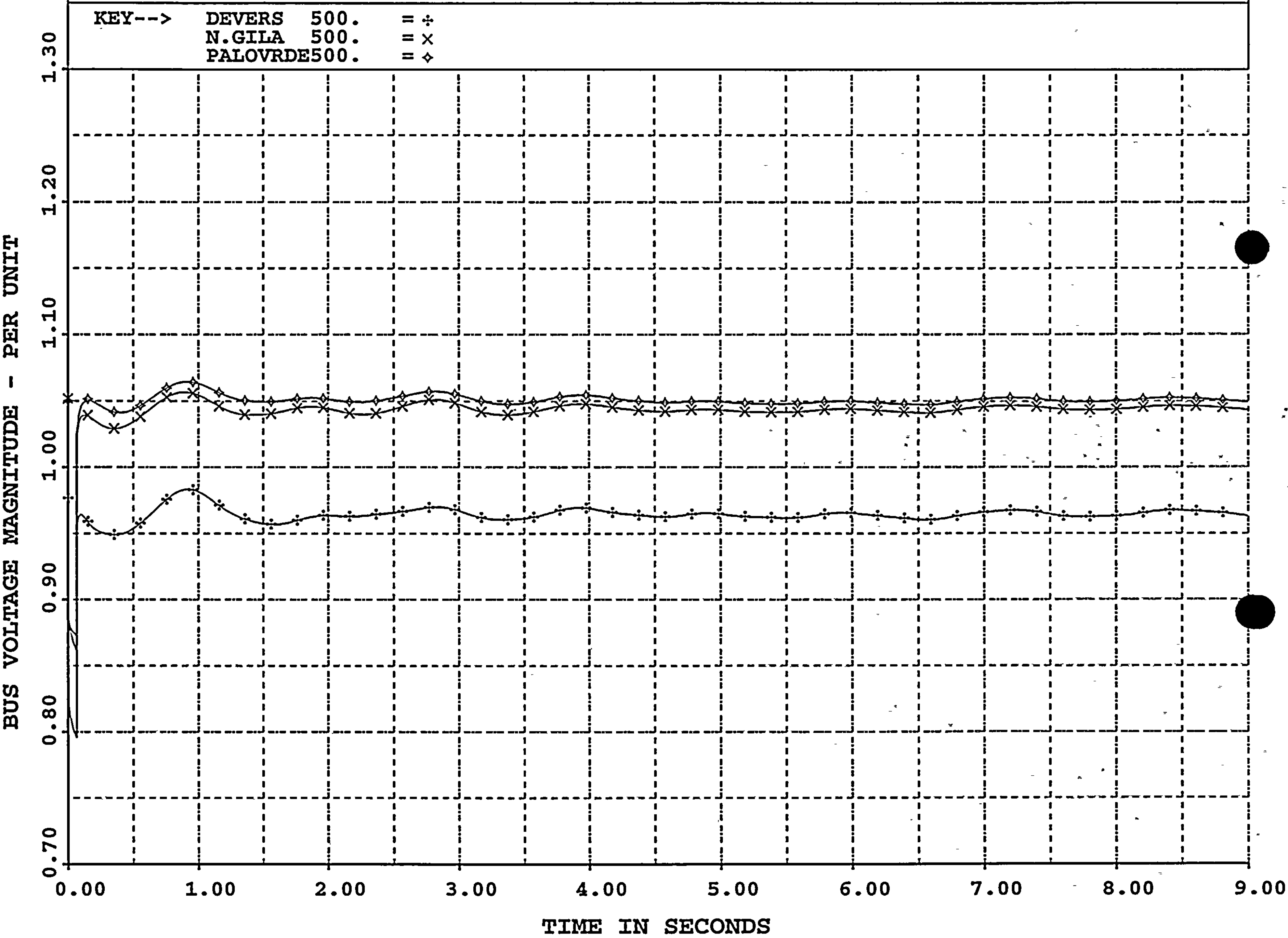


Figure 8B.1-6

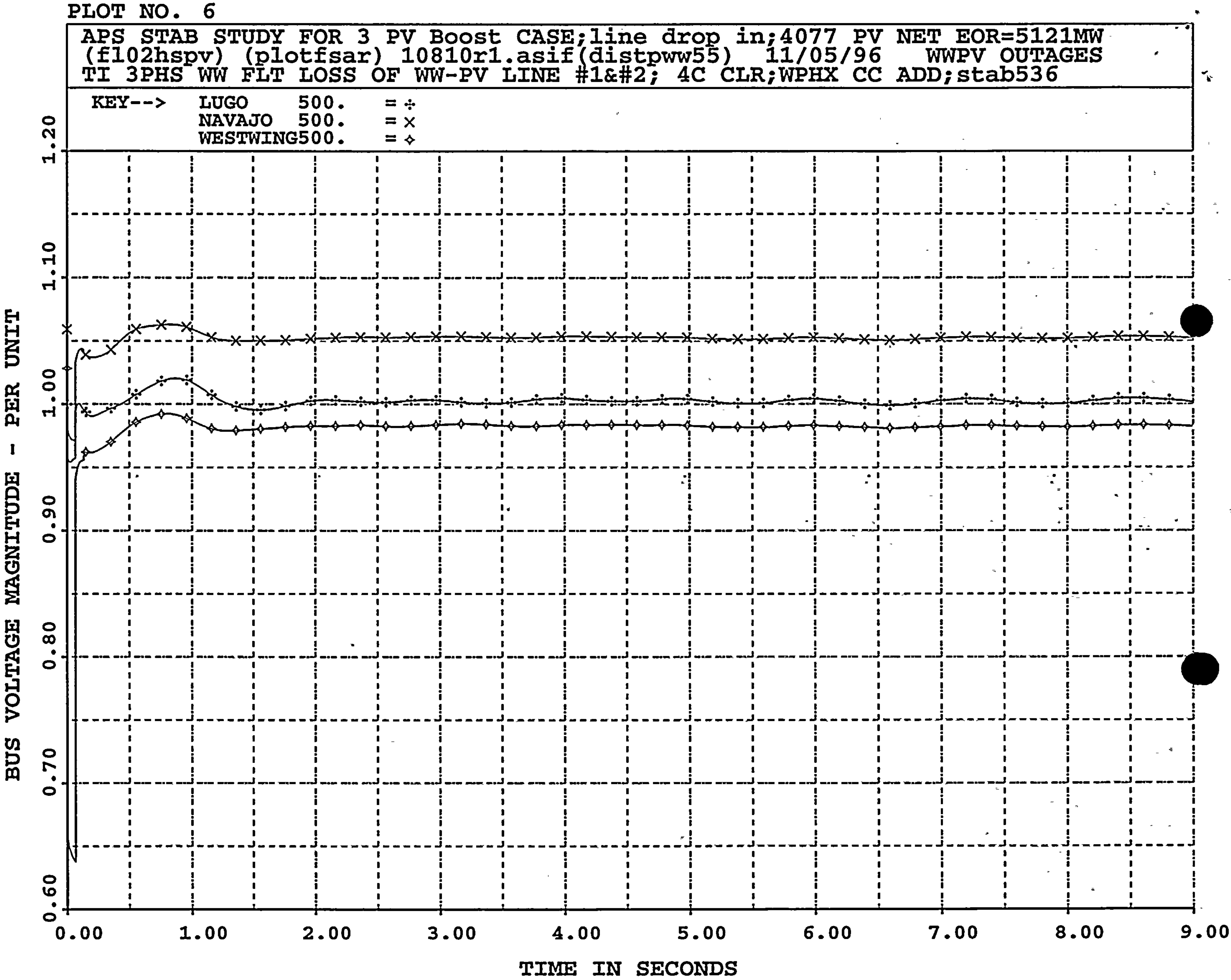

PLOT NO. 6
APS STAB STUDY FOR 3 PV Boost CASE;line drop in;4077 PV NET EOR=5121MW
(f102hspv) (plotfsar) 10810r1.asif(distpww55) 11/05/96 WWPV OUTAGES
TI 3PHS WW FLT LOSS OF WW-PV LINE #1&#2; 4C CLR;WPHX CC ADD;stab536
KEY--> LUGO 500. = +
NAVAJO 500. = ×
WESTWING500. = ◇
BUS VOLTAGE MAGNITUDE - PER UNIT
1.20
1.10
1.00
0.90
0.80
0.70
0.60
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
TIME IN SECONDS

Figure 8B.1-7

PLOT NO. 7

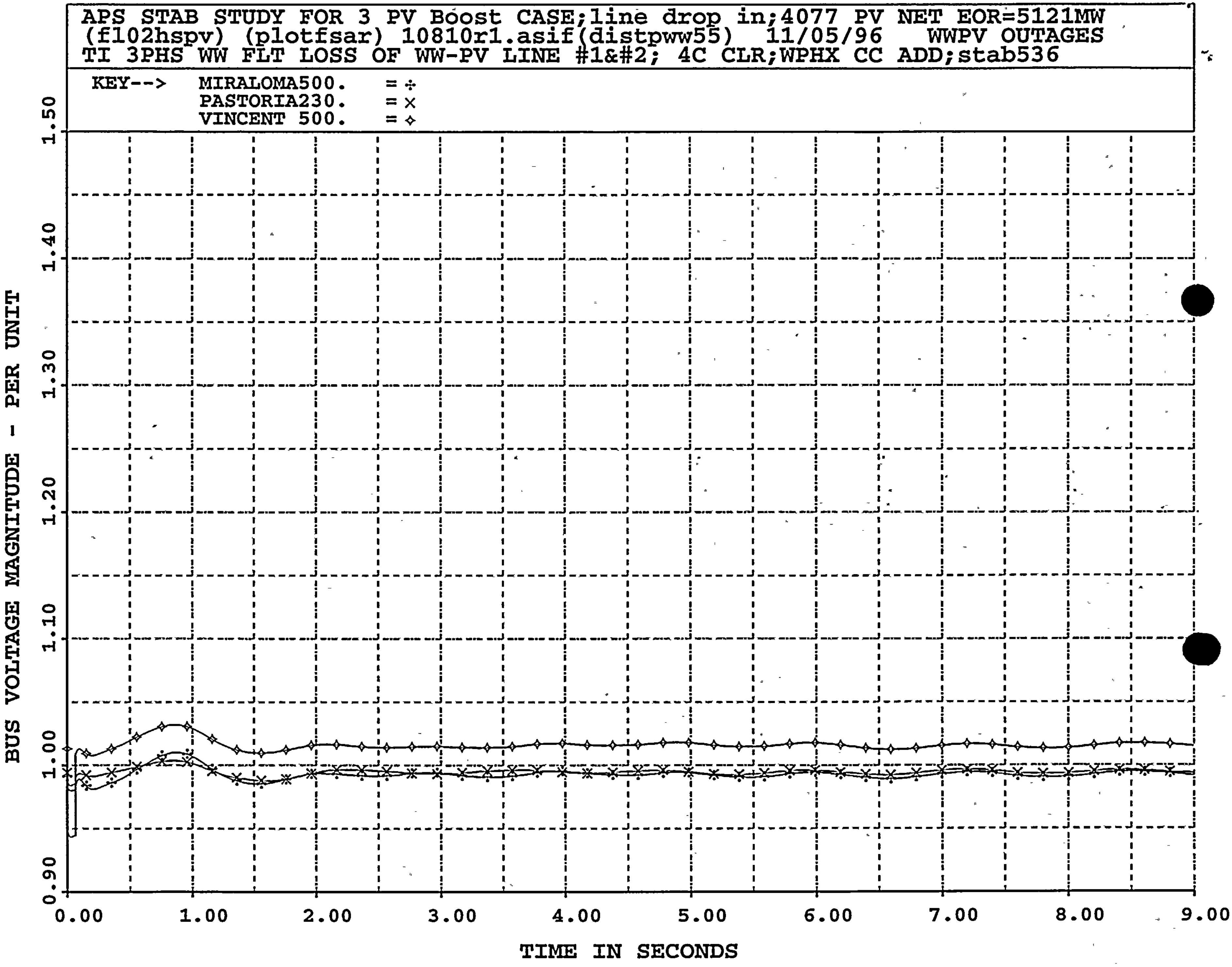


Figure 8B.1-8

PLOT NO. 8

APS STAB STUDY FOR 3 PV Boost CASE;line drop in;4077 PV NET EOR=5121MW
(f102hspv) (plotfsar) 10810r1.asif(distpww55) 11/05/96 WWPV OUTAGES
TI 3PHS WW FLT LOSS OF WW-PV LINE #1&#2; 4C CLR;WPHX CC ADD;stab536

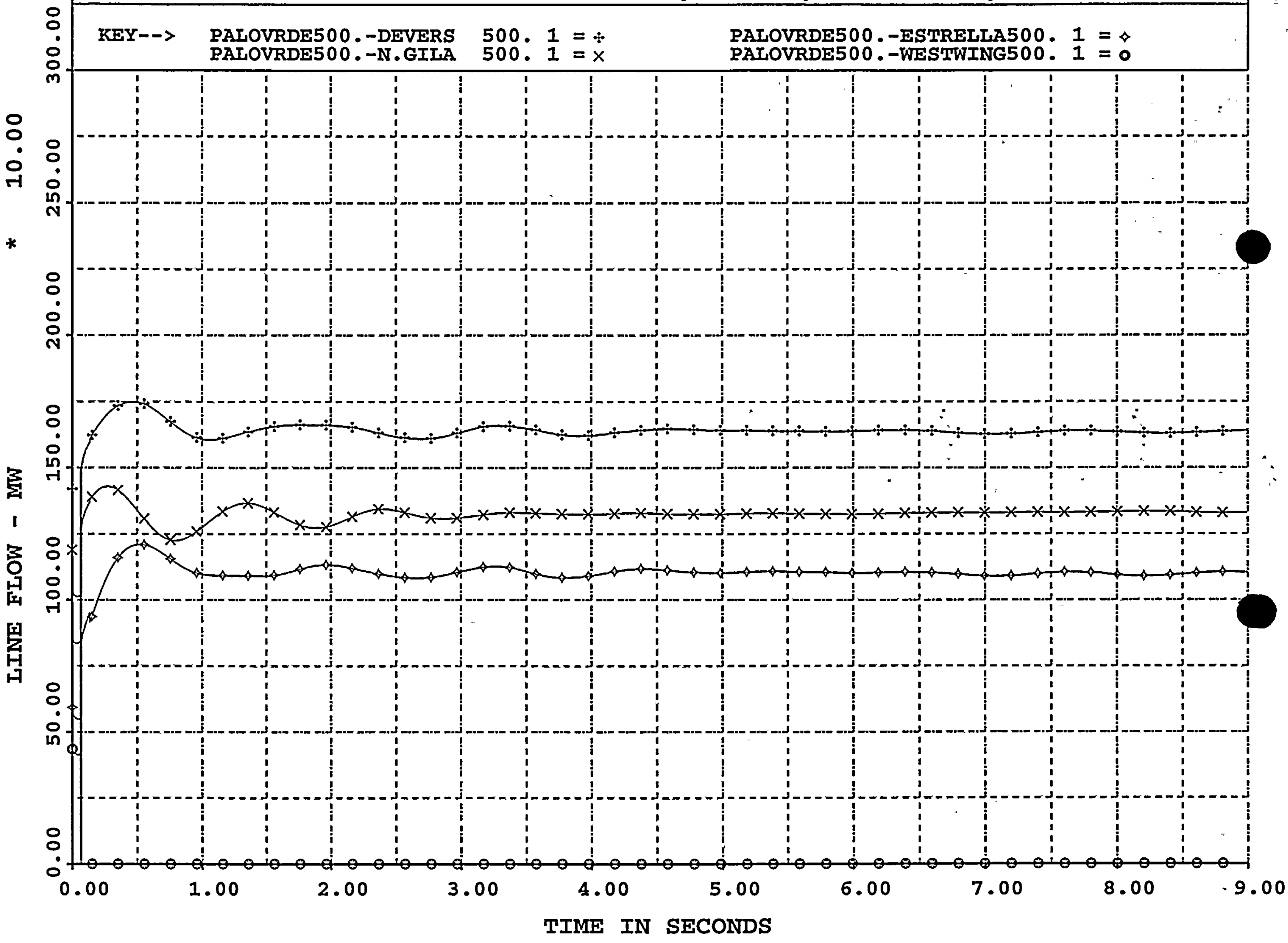


Figure 8B.1-9

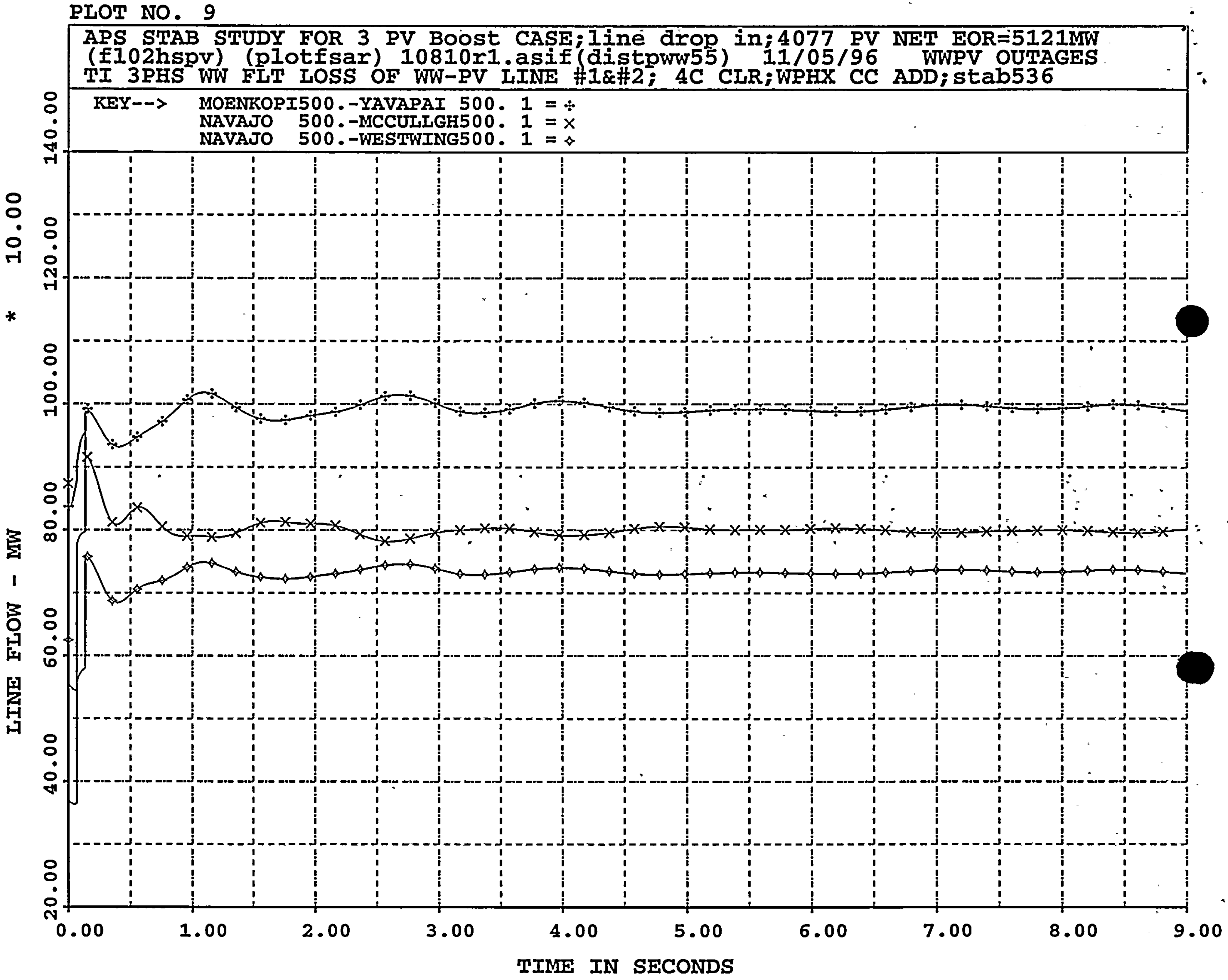


Figure 8B1-10

PLOT NO. 10

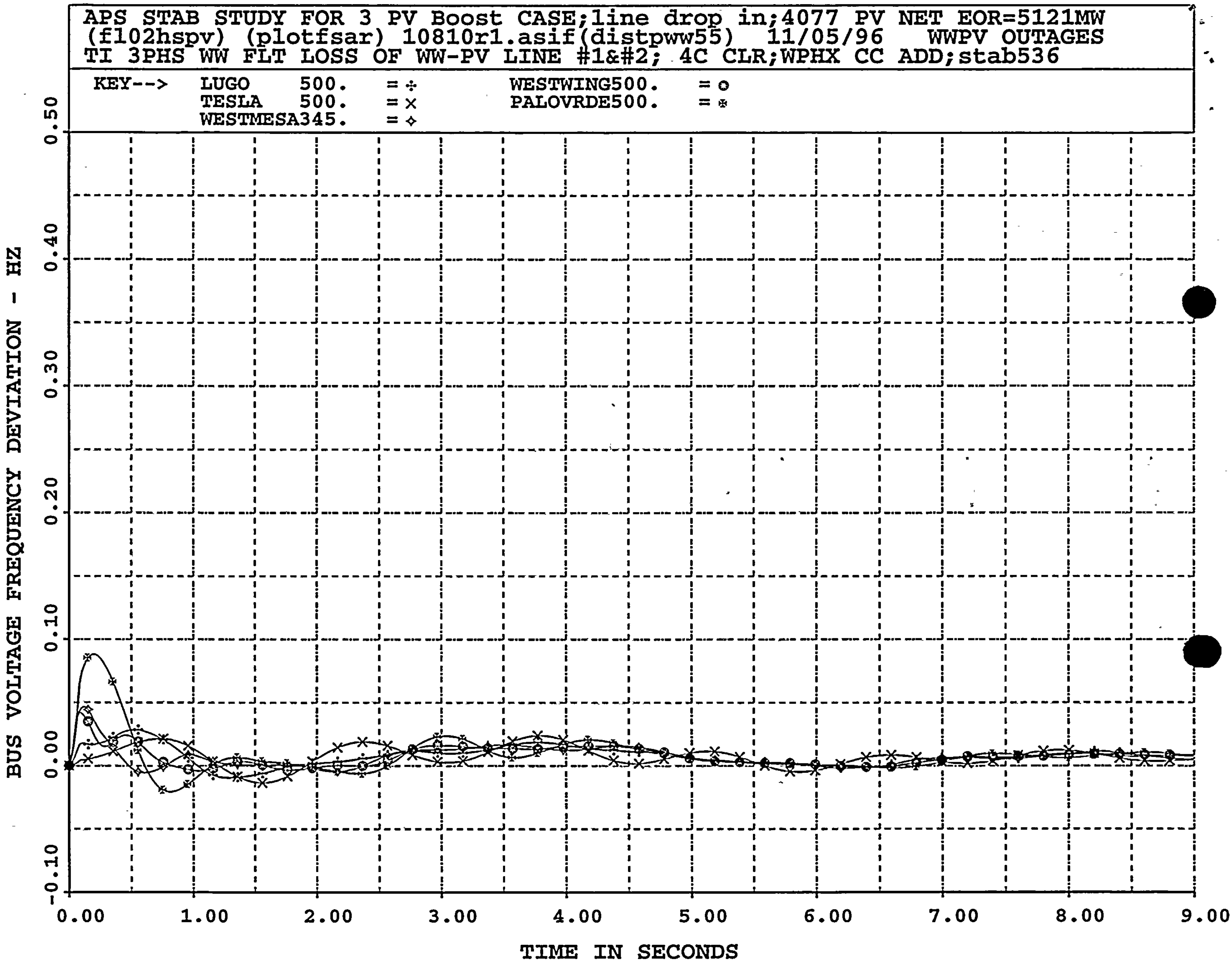
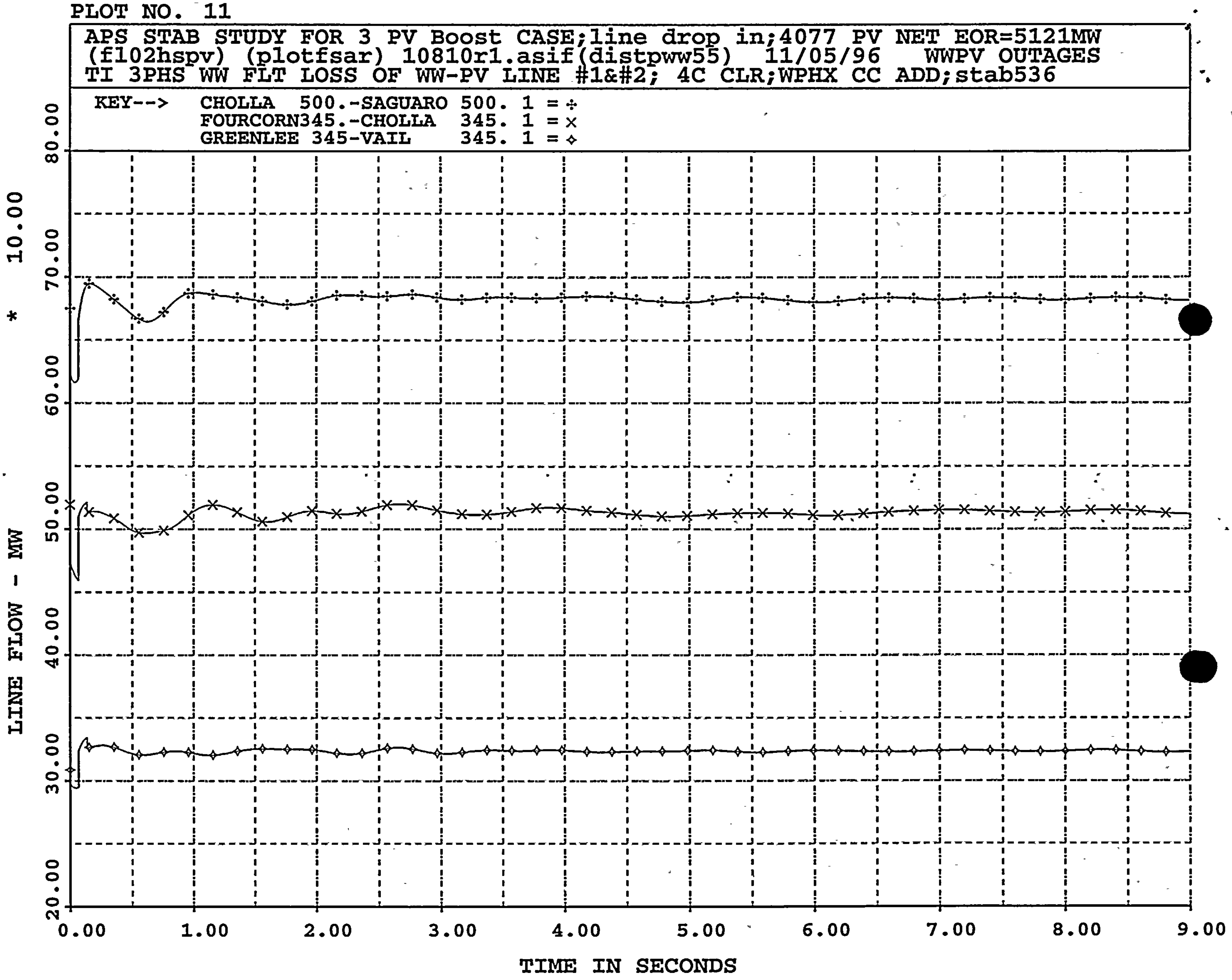


Figure 8B.1-11


PLOT NO. 11
APS STAB STUDY FOR 3 PV Boost CASE;line drop in;4077 PV NET EOR=5121MW
(f102hspv) (plotfsar) 10810r1.asif(distpww55) 11/05/96 WWPV OUTAGES
TI 3PHS WW FLT LOSS OF WW-PV LINE #1&#2; 4C CLR;WPHX CC ADD;stab536
KEY--> CHOLLA 500.-SAGUARO 500. 1 = ÷
FOURCORN345.-CHOLLA 345. 1 = ×
GREENLEE 345-VAIL 345. 1 = ◇
LINE FLOW - MW * 10.00
80.00
70.00
60.00
50.00
40.00
30.00
20.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
TIME IN SECONDS
Figure 8.1-12

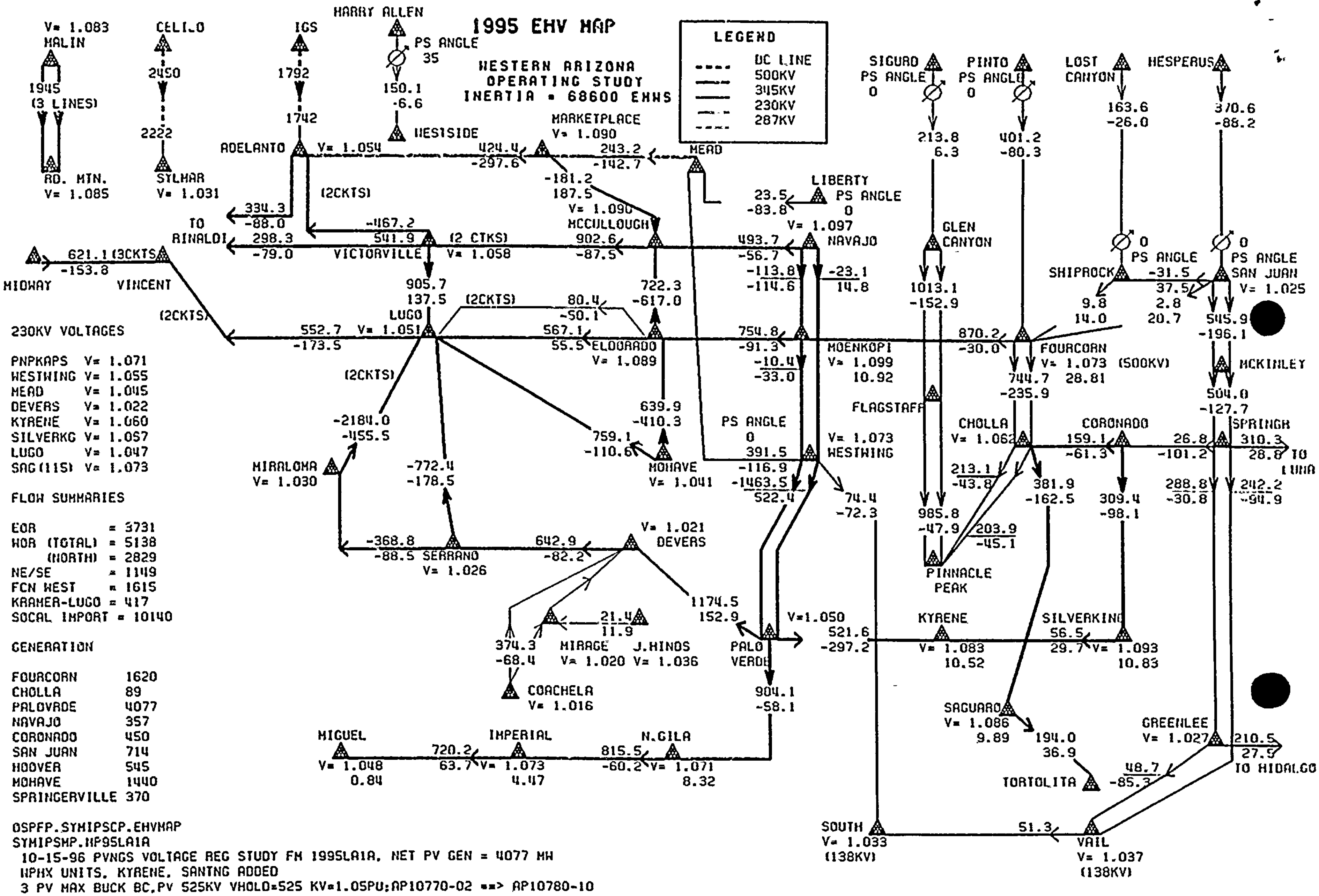


Figure 8B.1-13

PLOT NO. 1

APS STAB STUDY FOR 3 PV BUCK CASE;line drop in;4077 PV NET EOR=3731MW
(f195last) (plotfsar) 10780r10.asif(distpww54) 11/12/96 WWPV OUTAGES
TI SLG WW FLT LOSS OF WW-PV LINE #1&#2; 4C CLR;WPHX CC ADD;stab535

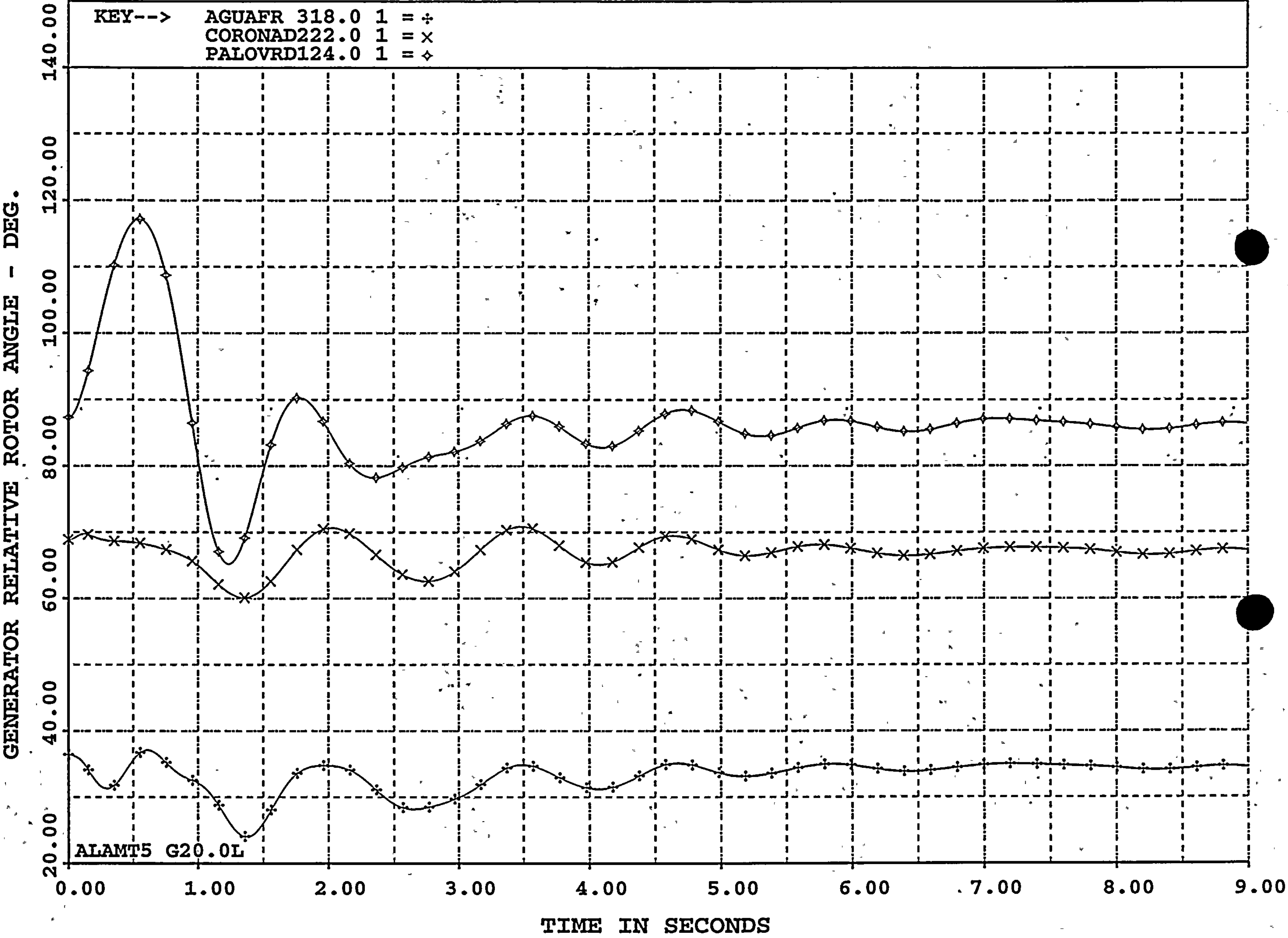
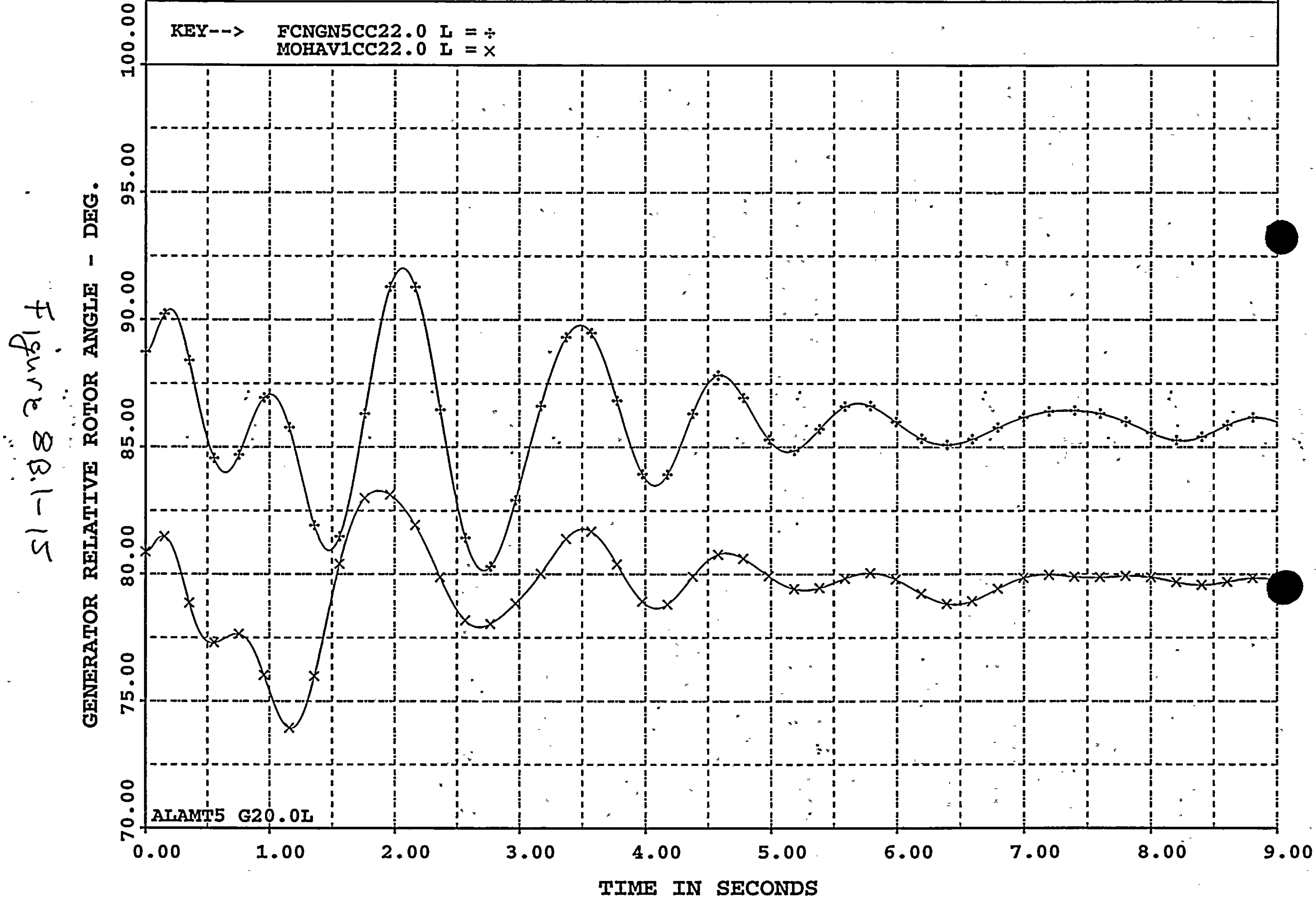
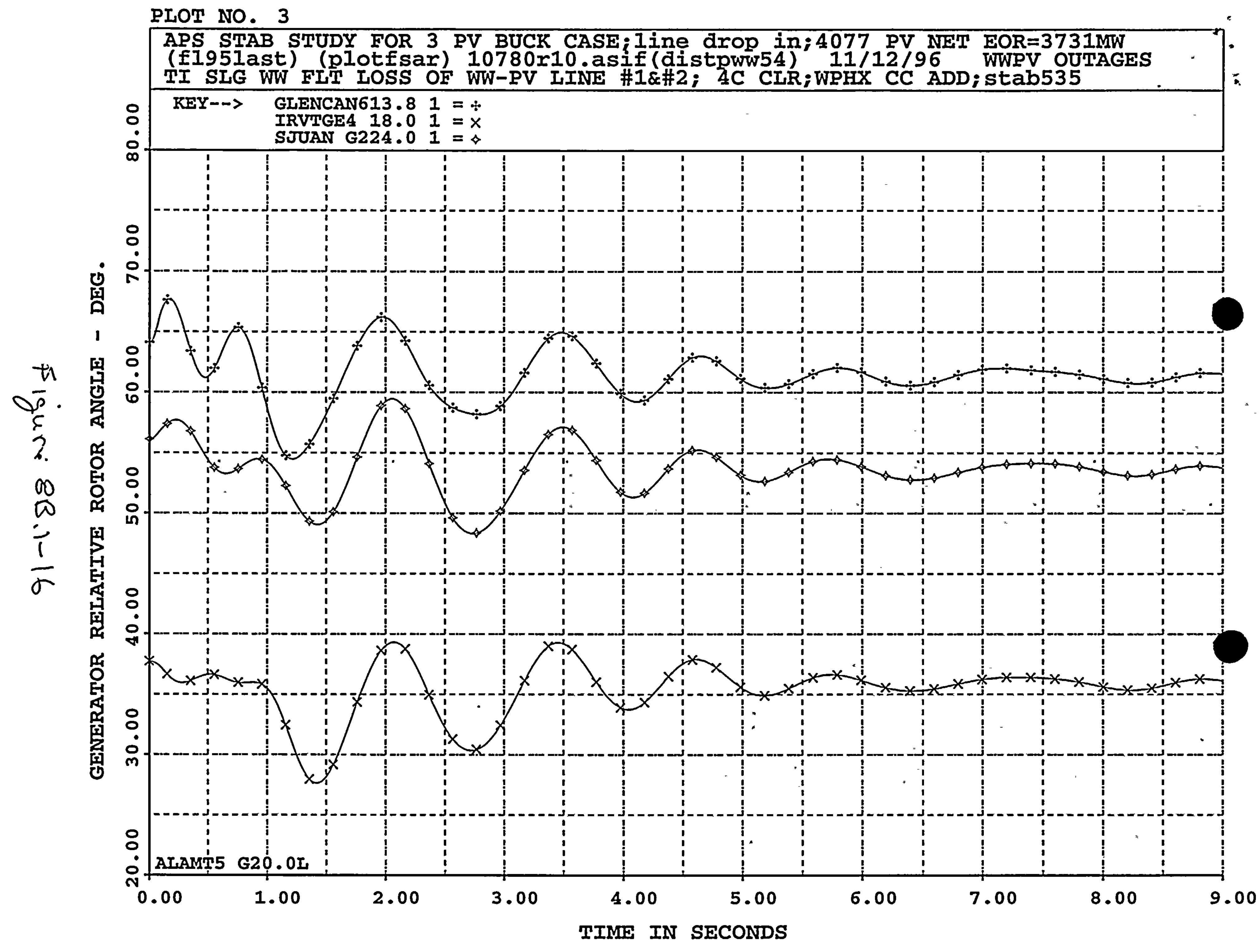


Figure 8B.1-14

PLOT NO. 2

APS STAB STUDY FOR 3 PV BUCK CASE;line drop in;4077 PV NET EOR=3731MW
(fl95last) (plotfsar) 10780r10.asif(distpww54) 11/12/96 WWPV OUTAGES
TI SLG WW FLT LOSS OF WW-PV LINE #1&#2; 4C CLR;WPHX CC ADD;stab535




PLOT NO. 3
APS STAB STUDY FOR 3 PV BUCK CASE;line drop in;4077 PV NET EOR=3731MW
(f195last) (plotfsar) 10780r10.asif(distpww54) 11/12/96 WWPV OUTAGES
TI SLG WW FLT LOSS OF WW-PV LINE #1&#2; 4C CLR;WPHX CC ADD;stab535
KEY--> GLENCAN613.8 1 =
IRVTGE4 18.0 1 = ×
SJUAN G224.0 1 =
GENERATOR RELATIVE ROTOR ANGLE - DEG.
20.00
30.00
40.00
50.00
60.00
70.00
80.00
ALAMT5 G20.0L
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
TIME IN SECONDS
Figure 8B.1-16

PLOT NO. 4

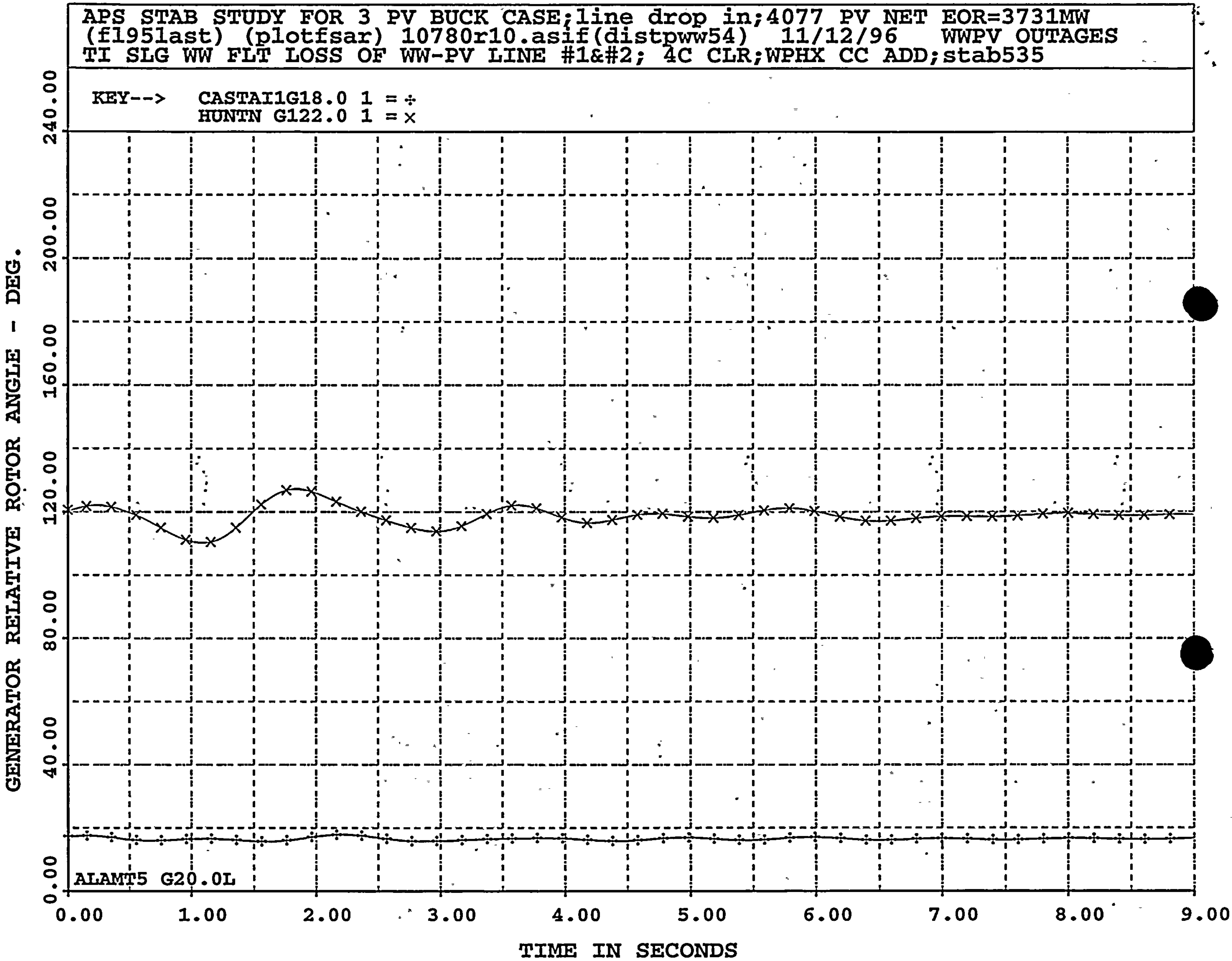


Figure 8B.1-17

PLOT NO. 5

APS STAB STUDY FOR 3 PV BUCK CASE;line drop in;4077 PV NET EOR=3731MW
(f195last) (plotfsar) 10780r10.asif(distpww54) 11/12/96 WWPV OUTAGES
TI SLG WW FLT LOSS OF WW-PV LINE #1&#2; 4C CLR;WPHX CC ADD;stab535

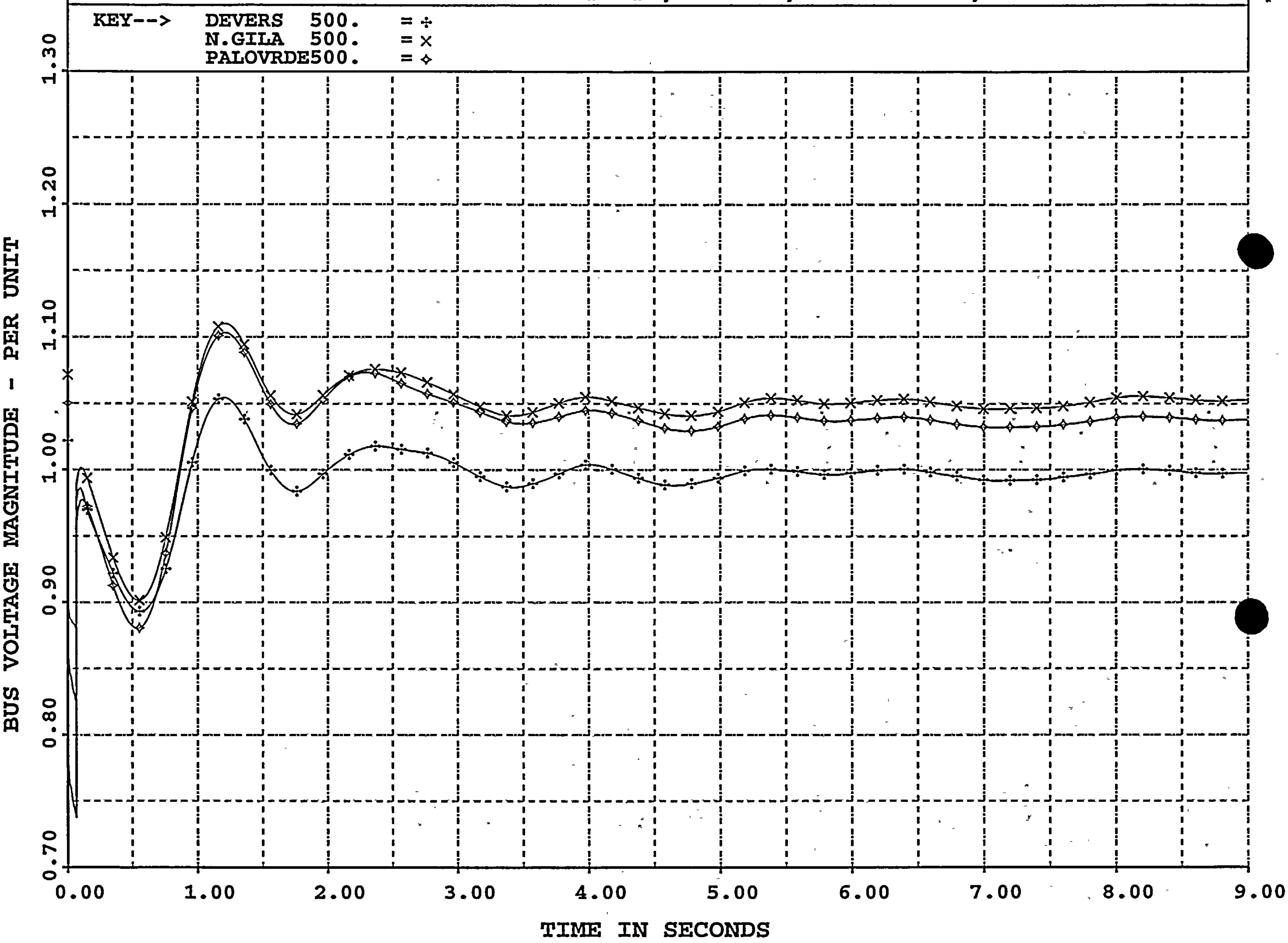


Figure 8B.1-18

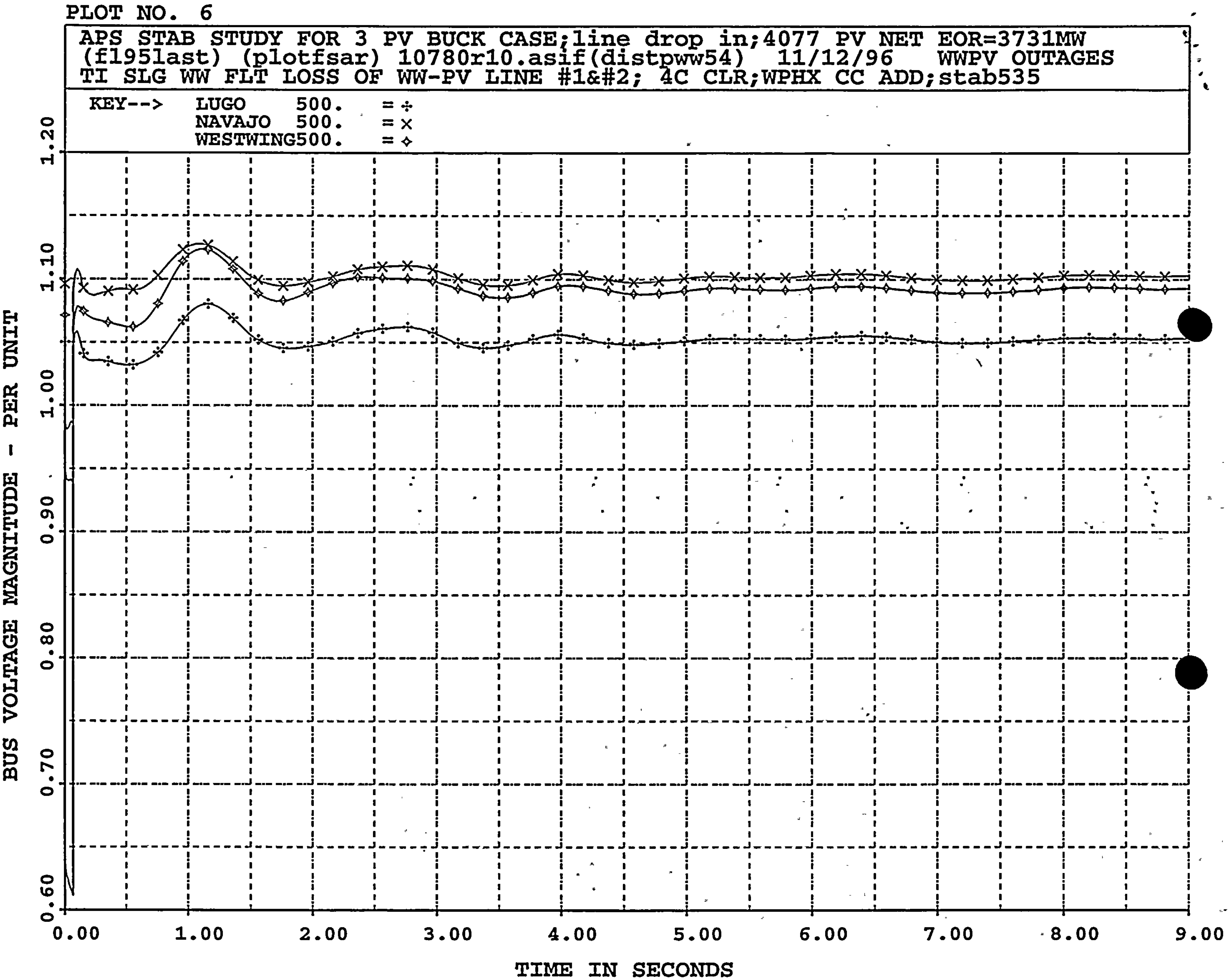
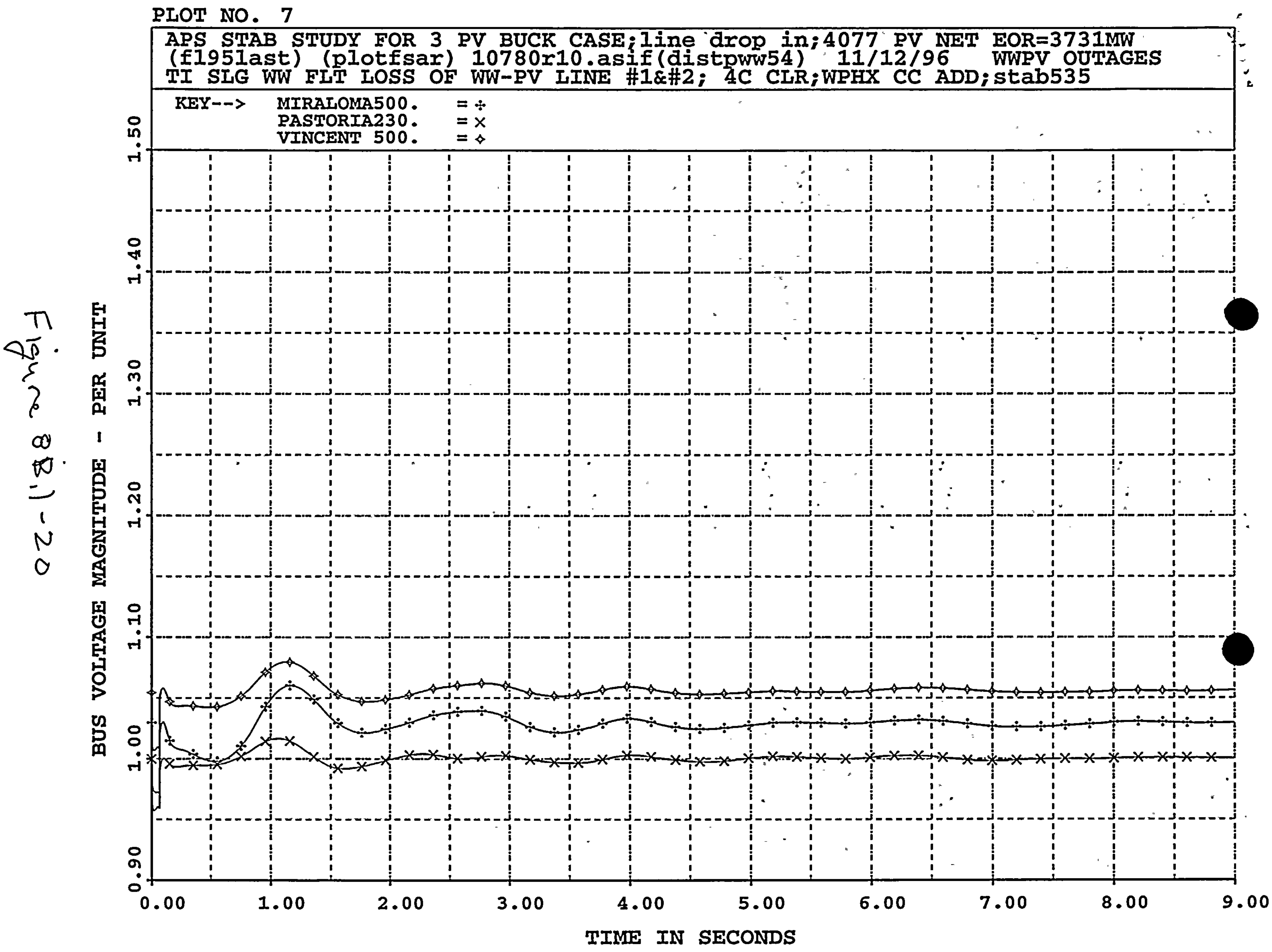


Figure 8B.1-19


PLOT NO. 7
APS STAB STUDY FOR 3 PV BUCK CASE;line drop in;4077 PV NET EOR=3731MW
(f195last) (plotfsar) 10780r10.asif(distpww54) 11/12/96 WWPV OUTAGES
TI SLG WW FLT LOSS OF WW-PV LINE #1&#2; 4C CLR;WPHX CC ADD;stab535
KEY--> MIRALOMA500. = +
PASTORIA230. = ×
VINCENT 500. = ◇
BUS VOLTAGE MAGNITUDE - PER UNIT
0.90
1.00
1.10
1.20
1.30
1.40
1.50
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
TIME IN SECONDS
Figure 8B.1-20

PLOT NO. 8

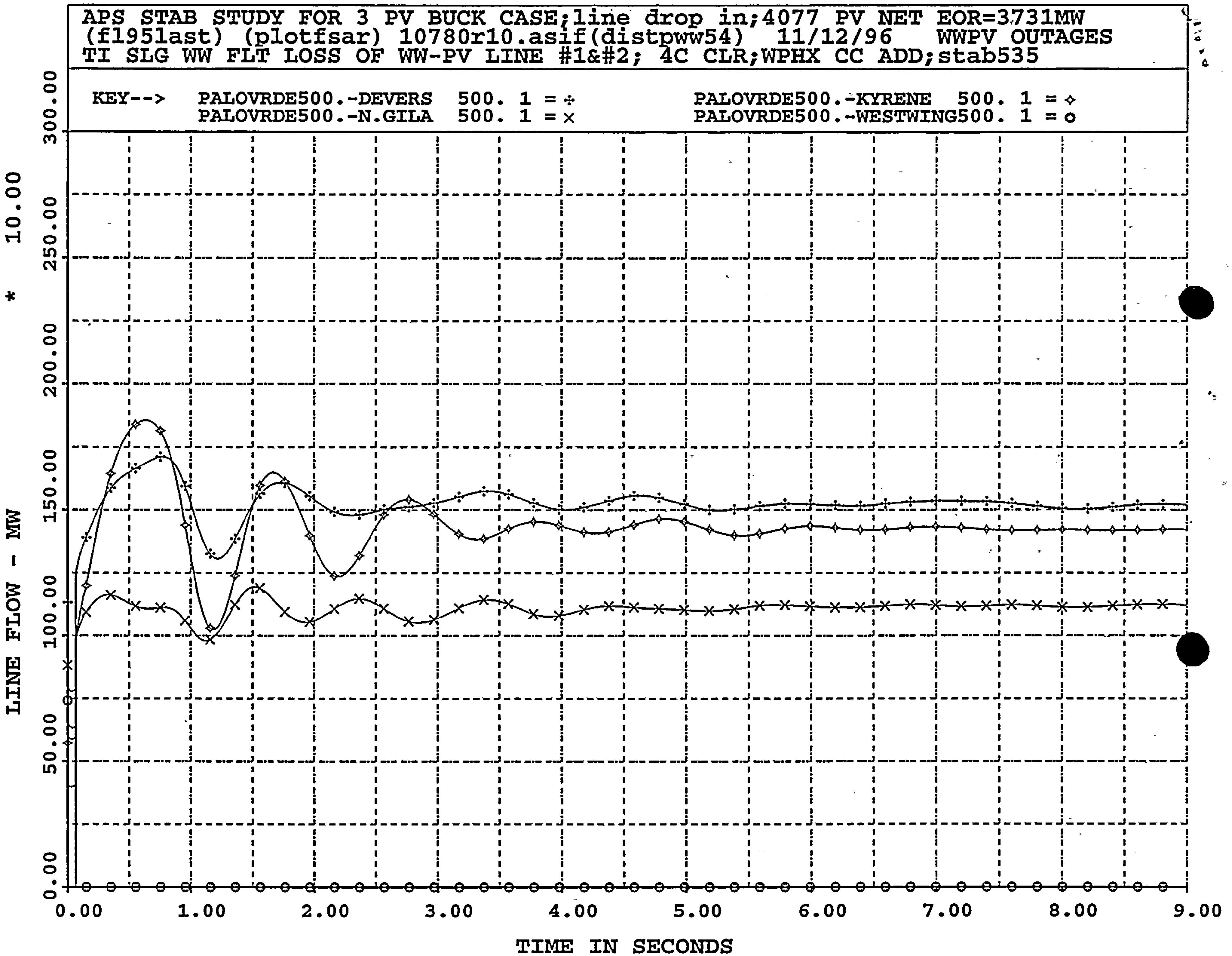
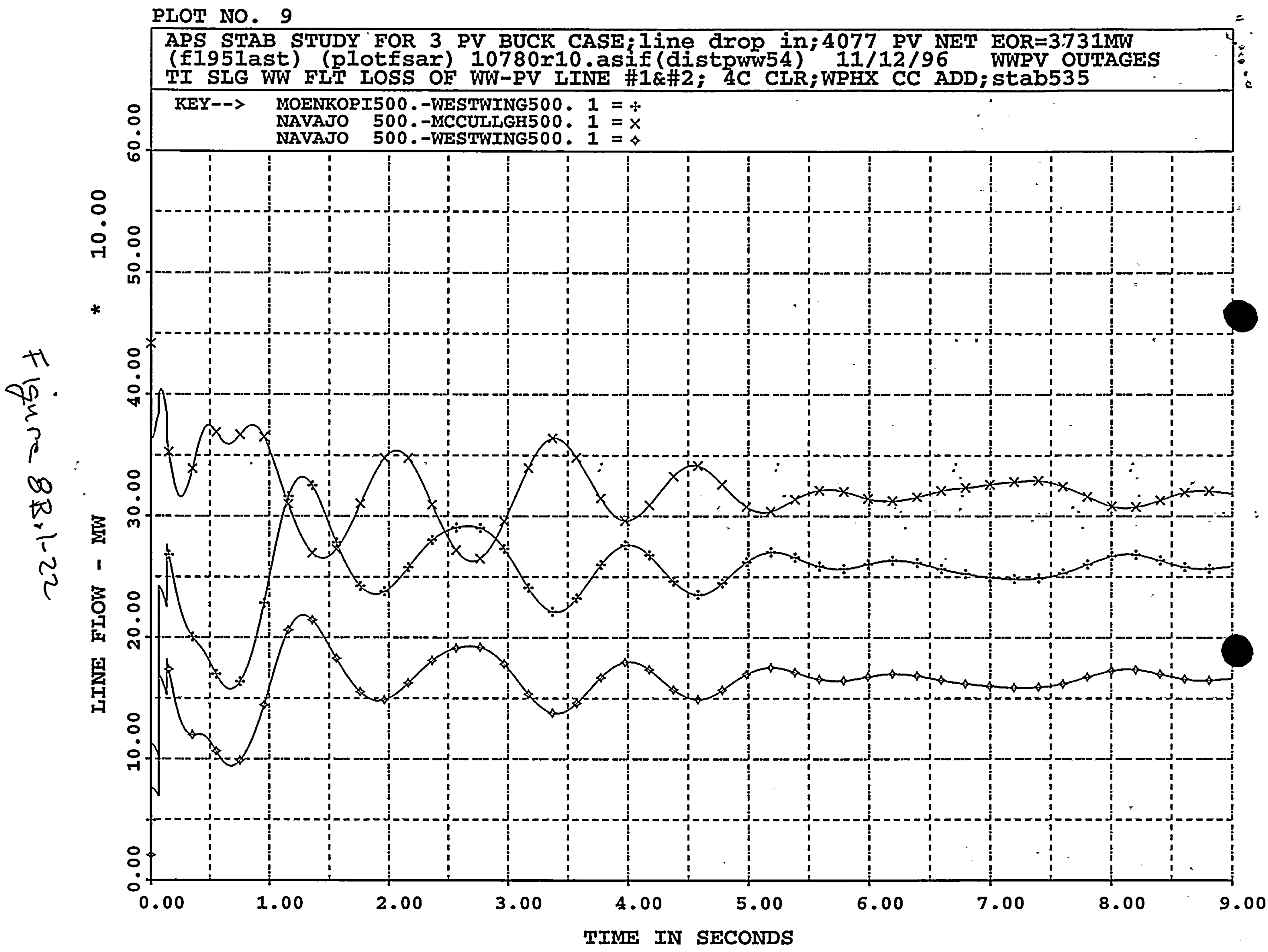
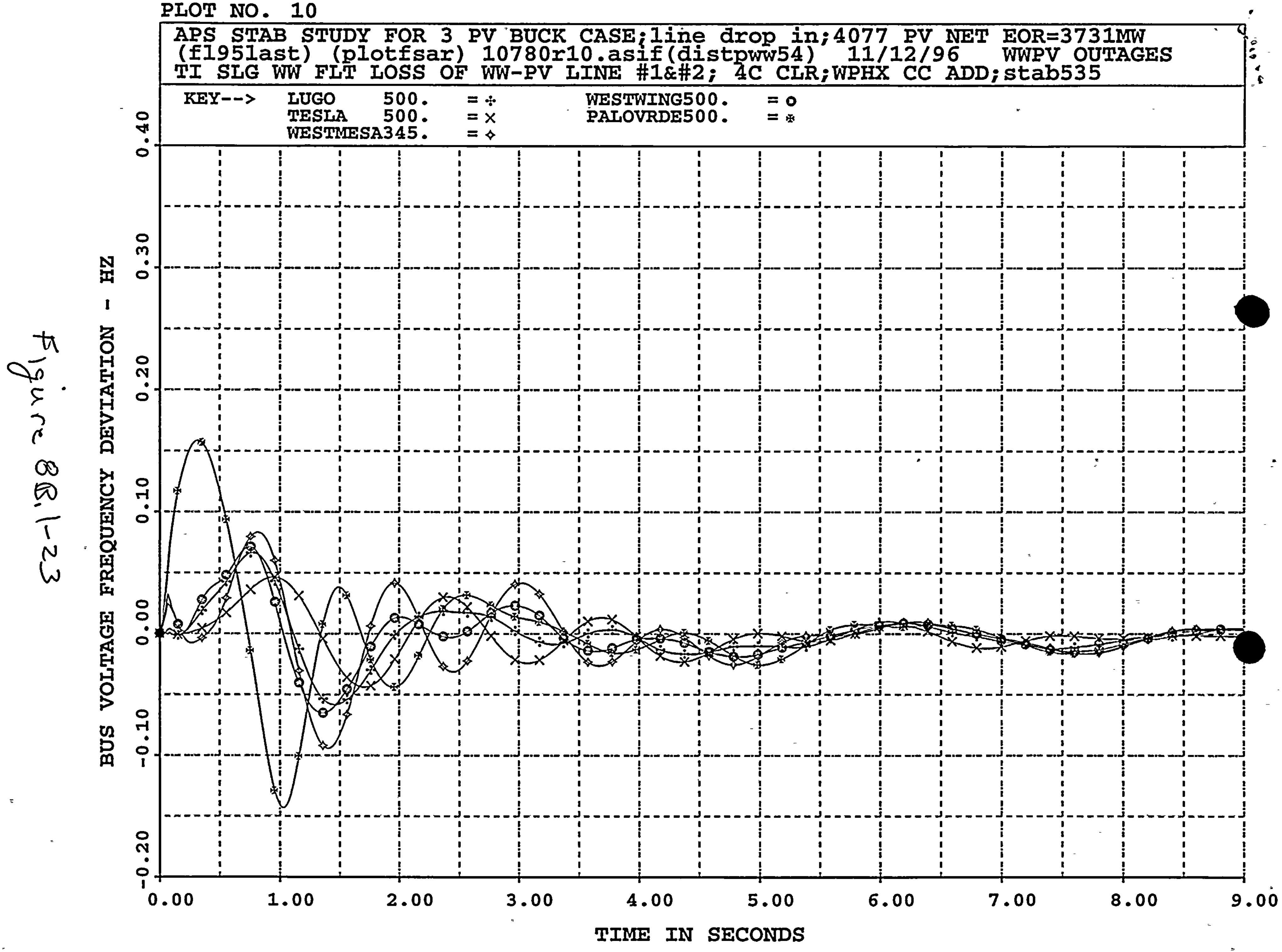


Figure 8.1-21


PLOT NO. 9
APS STAB STUDY FOR 3 PV BUCK CASE;line drop in;4077 PV NET EOR=3731MW
(f195last) (plotfsar) 10780r10.asif(distpww54) 11/12/96 WWPV OUTAGES
TI SLG WW FLT LOSS OF WW-PV LINE #1&#2; 4C CLR;WPHX CC ADD;stab535
KEY--> MOENKOPI500.-WESTWING500. 1 = +
NAVAJO 500.-MCCULLGH500. 1 = ×
NAVAJO 500.-WESTWING500. 1 = ◇
LINE FLOW - MW
* 10.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
TIME IN SECONDS
Figure 8B.1-22



PLOT NO. 10
APS STAB STUDY FOR 3 PV BUCK CASE;line drop in;4077 PV NET EOR=3731MW
(fl95last) (plotfsar) 10780r10.asif(distpww54) 11/12/96 WWPV OUTAGES
TI SLG WW FLT LOSS OF WW-PV LINE #1&#2; 4C CLR;WPHX CC ADD;stab535
KEY--> LUGO 500. = +
TESLA 500. = ×
WESTMESA345. = ◇
WESTWING500. = o
PALOVRDE500. = *
BUS VOLTAGE FREQUENCY DEVIATION - HZ
0.40
0.30
0.20
0.10
0.00
-0.10
-0.20
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
TIME IN SECONDS
Figure 8B,1-23

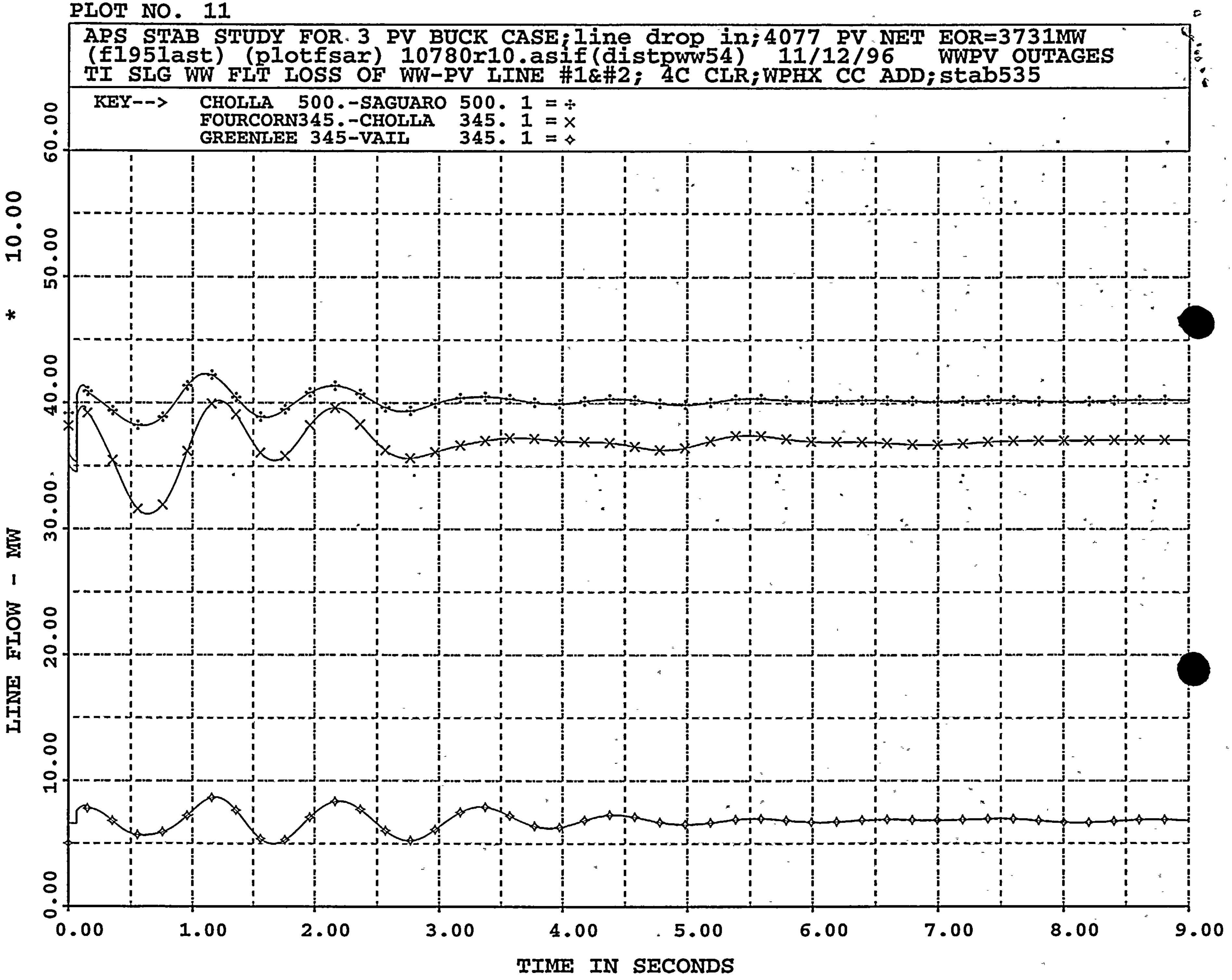
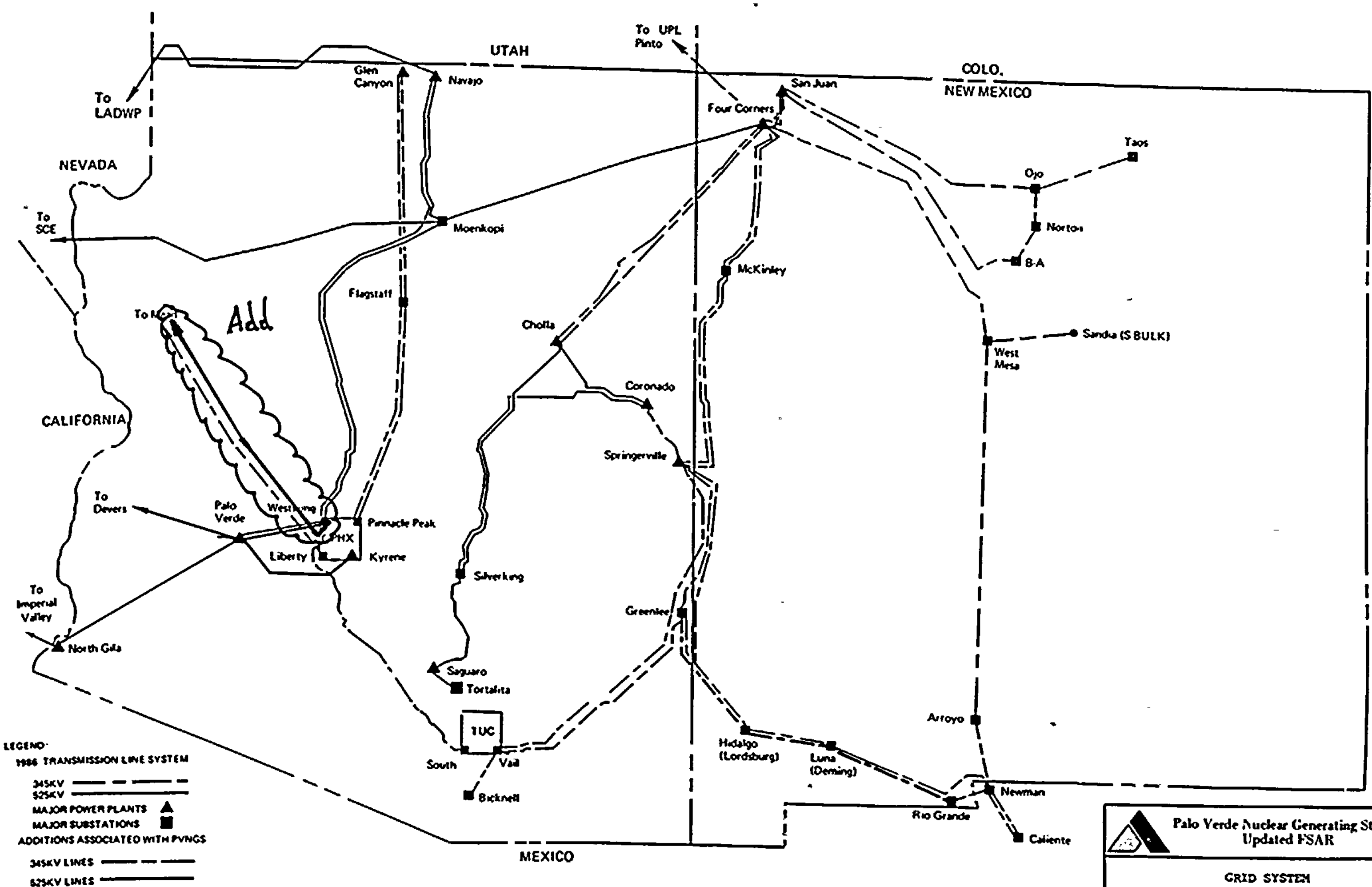


Figure 8B.1-24

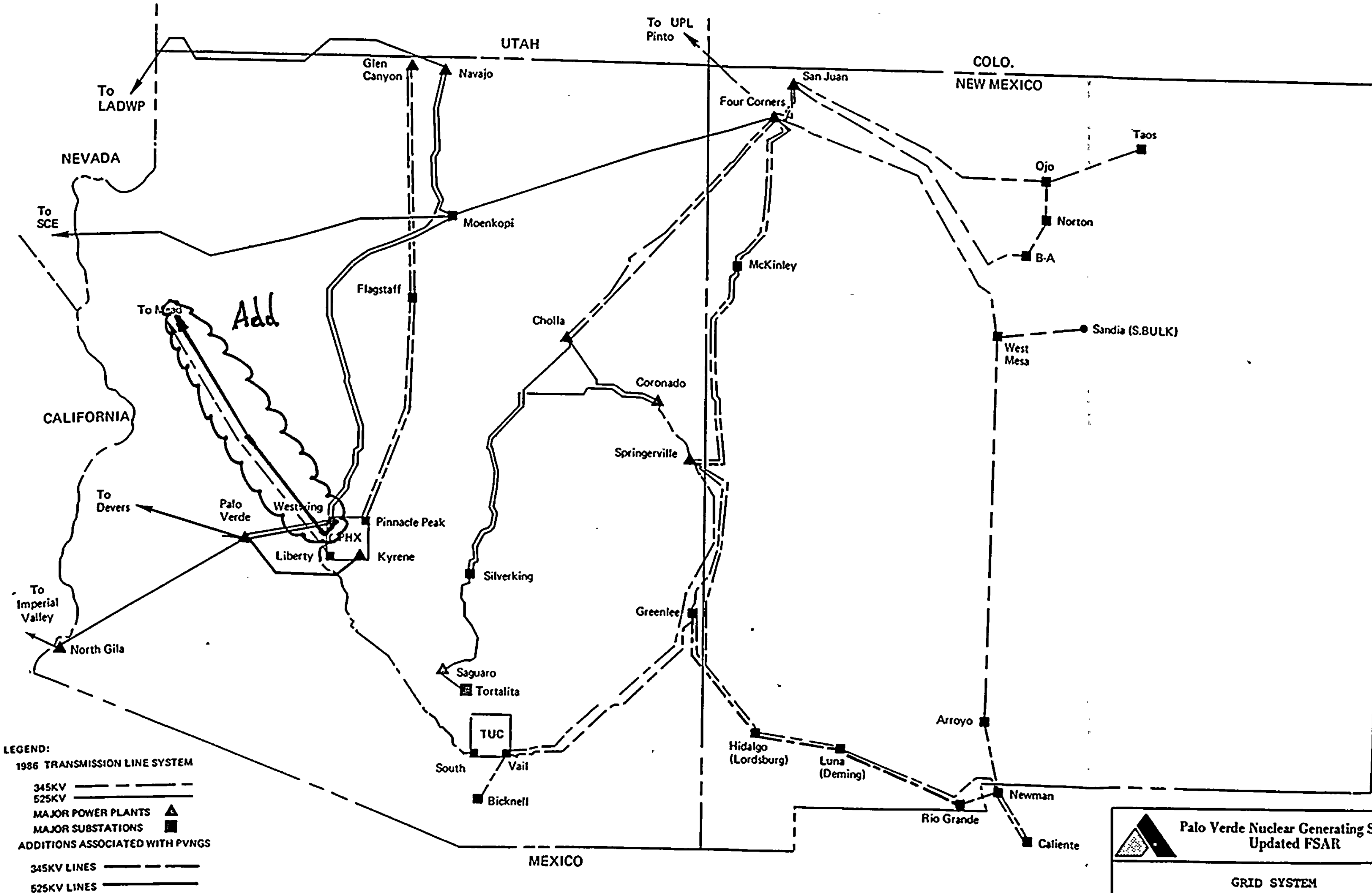


Palo Verde Nuclear Generating Station
Updated FSAR

GRID SYSTEM
(SHEET 1 OF 2)

Figure 8.1-1

[illegible]



Palo Verde Nuclear Generating Station
Updated FSAR

GRID SYSTEM
(SHEET 1 OF 2)

Figure 8.1-1