Southern California Edison Company	CALC. NO. E4C-098	ICCN NO./ PRELIM. CCN NO. C-7		PAGE 1	TOTAL NO. OF PAGES 16
INTERIM CALCULATION CHANGE NOTICE (ICCN)/ CALCULATION CHANGE NOTICE (CCN) COVER PAGE	BASE CALC. REV. 0	UNIT 2	CCN CONVERSION : CCN NO. CCN-		CALC. REV.
	CALCULATION SUBJECT : 4KV SWGR PROTECTIVE RELAY SETTING CALCULATION				
CALCULATION CROSS-INDEX ☒ New/Updated index included ☐ Existing index is complete	ENGINEERING SYSTEM NUMBER / PRIMARY STATION SYSTEM DESIGNATOR 1804 / PBA/PBB				Q-CLASS II
1. BRIEF DESCRIPTION OF ICCN / CCN:	CONTROLLED PROGRAM OR DATABASE ACCORDING TO SO123-XXIV-5.1 ☐ PROGRAM ☐ DATA BASE	PROGRAM / DATABASE NAME (S) ☐ ALSO, LISTED BELOW		VERSION/RELEASE NO.(S)	

UNIT 2 ONLY

THIS ICCN VOIDS PREVIOUSLY ISSUED ICCN C-5

Agastat models E7012PKL (162D), E7012PB (162T), and E7012PC (162A) are used in the SDVS and DGVSS protection schemes. This ICCN adds a design margin to the manufacturers specification of 10% for accuracy/repeatability tolerance. The design margin establishes circuit operability.

INITIATING DOCUMENT (DCP, FCN, OTHER) MMP 2/3-2060.00SE REV. 0

2. OTHER AFFECTED DOCUMENTS (CHECK AS APPLICABLE FOR CCN ONLY):

○ YES ○ NO OTHER AFFECTED DOCUMENTS EXIST AND ARE IDENTIFIED ON ATTACHED FORM 26-503.

3. APPROVAL : DISCIPLINE / ESC : ELECTRICAL

K. MOSLEY KM 1/12/95	[signature] 1-12-95	[signature] 1/12/95
ORIGINATOR (Print name/initial/date)	GS (Signature/date)	OTHER (Signature/date)
J.KIM / JK / 1-12-95	[signature] 1/13/95	
IRE (Print name/initial/date)	DM (Signature/date)	OTHER (Signature/date)

4. ASSIGNED SUPPLEMENT ALPHA DESIGNATOR : ________

CONVERSION TO CCN DATE ______

9501300172 950118
PDR ADOCK 05000361
P PDR

SCE CDM - SONGS

CALCULATION CROSS-INDEX

ICCN NO./
PRELIM. CCN NO. C-7

CCN CONVERSION:
CCN NO. CCN-

Calculation No. E4C-098 Sheet No. ______ of ______

Calc. rev. number and responsible supervisor initials and date	INPUTS These interfacing calculations and/or documents provide input to the subject calculation and if revised may require revision of the subject calculation.		OUTPUTS Results and conclusions of the subject calculation are used in these interfacing calculations and/or documents.		Does the output interface calc/ document require revision?	Identify output interface calc/document CCN, DCN, TCN/Rev., FIDCN, or tracking number.
	Calc / Document No.	Rev. No.	Calc / Document No.	Rev. No.	YES / NO	
0 [initials] 1/12/95	MMP 2/3-2060.00SE ASC#1	0	TECHNICAL SPECIFICATIONS MMP 2/3-2060.00SE ASC # 2	- 0	YES	KJ-94-196

SCE 26-434 REV. 1 8/94 [REFERENCE: SO123-XXIV-7.18]

T:\JETFORM\FORMS\NEDO_GEN\424_01.MDF Ver. 00.00.00 8/24/94
C:\JETDATA\424.DAT DevID: -1.0000 Printed: 11/18/94

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE
	J. Kim / B. Bosu	08/13/93	R. Cabling	08/13/93					

* THIS 'BEFORE' IS THE "AFTER" OF ICCN C-1, Pg 9

BEFORE

2.1.2.2 Timing relays 162D-1, 162D-2, 162D-3, & 162D-4 (refer to para.8.5.3)

Time delay setting: 120 seconds ± 10% (12 seconds)

Since the Sustained Degraded Voltage Signal (SDVS) will be used for protection of the permanently connected Class 1E loads from sustained degraded voltage, this timing relay may be set to operate after the automatic load sequencing operations are completed.

A time delay of 120 seconds is chosen since the automatic load sequencing operations will take 114 seconds (reference 6.18) to complete. The 27N relay in conjunction with this timing relay will generate a sustained degraded voltage signal in 120 seconds after a degraded voltage condition occurs. The 27N relay may not protect the motors from this short time degraded voltage conditions.

However, the existing CV-2 relays will protect motors from a degraded voltage as shown in paragraph 8.5.3.2. Therefore, this time delay meets acceptance criterion 1.3.1.3.

2.1.2.3 Timing Relays 162T-1, 162T-2, 162T-3, & 162T-4 (refer to para. 5.6)

Time delay setting: 1.5 seconds ± 10% (0.15 second)

A time delay of 1.5 seconds is chosen to disable the degraded voltage detection circuit before the start of the second automatic load sequencing, since the DGVSS should be generated during the first automatic load sequencing, and to provide a window of sufficient duration so that if the voltage at the bus drops below the 127D relay setpoint up to 1 second prior to the start of the voltage detection window (4.11 seconds) as 2.0 seconds delay is provided for 127D relay to establish a degraded voltage condition before voltage detection window closes (refer to paragraph 5.6).

2.1.2.4 Alarm Relays 162A

Time delay setting: 5 seconds ± 10% (0.5 second)

Timing of 5 seconds was selected to provide alarm within a total of approximately 7 seconds (5 seconds for 162A + 2 seconds for 127D-1,2,3, & 4).

2.1.3 CV-2 Relays 127F-1, 127F-2, 127F-3, & 127F-4 (refer to para. 8.4)

Voltage setting: 105 V ± 3.3%

Time dial: # 1 with operating time tolerance of ± 5%

CV-2 relay with 105 V tap and time dial # 1 will operate within 5 seconds at 75% of 4.16 KV

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AFTER

2.1.2.2 Timing relays 162D-1, 162D-2, 162D-3, & 162D-4 (refer to para.8.5.3)

Time delay setting: 110 seconds ± 10%* (11 seconds)
***Note: The allowable design limit for circuit operability is 110 sec ± 20% (22 sec)**

Since the Sustained Degraded Voltage Signal (SDVS) will be used for protection of the permanently connected Class 1E loads from sustained degraded voltage, this timing relay may be set to operate after critical automatic load sequencing operations are completed.

A time delay of 110 seconds is chosen since the automatic load sequencing operations will take 40 seconds (references 6.18 and 6.28) to complete and the setting is within the established upper limit of 140 seconds(see 8.5.3.2). As stated in section 8.5.3.2, the 27N relay in conjunction with this timing relay may generate a sustained degraded voltage signal at a maximum time of 134.2 seconds after a degraded voltage condition occurs. The 27N relay may not protect the motors from this short time degraded voltage condition.

However, the existing CV-2 relays will protect motors from a degraded voltage as shown in paragraph 8.5.3.2. Therefore, this time delay meets acceptance criterion 1.3.1.3.

2.1.2.3 Timing Relays 162T-1, 162T-2, 162T-3, & 162T-4 (refer to para. 5.6)

Time delay setting: 1.25 seconds ± 10%* (0.125 second)
***Note: The allowable design limit for circuit operability is 1.25 sec ± 30% (0.40 sec)**

A time delay of 1.25 seconds is chosen to close the degraded voltage detection circuit before the start of the second automatic load sequencing. The earliest the window will close is 4.96 seconds and the latest the window will close is 6.14 seconds. A 2.0 second delay is provided for the 127D relay to establish a degraded voltage condition before the voltage detection window closes (refer to paragraph 5.6).

2.1.2.4 Alarm Relays 162A (refer to para. 4.10)

Time delay setting: 5 seconds ± 10%* (0.5 second)
***Note: The allowable design limit for circuit operability is 5 sec ± 20% (1 sec)**

Timing of 5 seconds was selected to provide alarm within a total of approximately 7 seconds (5 seconds for 162A + 2 seconds for 127D-1,2,3, & 4).

2.1.3 CV-2 Relays 127F-1, 127F-2, 127F-3, & 127F-4 (refer to para. 8.4)

Voltage setting: 105 V ± 3.3%
Time dial: # 1 with operating time tolerance of ± 5%

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	J. Kim / B. Basu	08/13/93	R. Cabilling	08/13/93			—		

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BEFORE

motor rated voltage at 4.16 KV bus and at a voltage corresponding to 75% of 460 V rated motor voltage at 480 V bus. The relay operating time of 5 second at 75% of rated motor voltage meets acceptance criterion 1.3.2.1.

This relay with 105 V tap and time dial # 1 will operate in 1 second following total loss of voltage. This relay operating time of 1 second meets acceptance criterion 1.3.2.2.

2.2 Recommendations

2.2.1 The following relay settings are recommended:

Relay	Setting	Tolerance	Remarks
27N relay (127D-1,127D-2, 127D-3, & 127D-4)	Reset (pickup) - 121.40V	± 1.11% (1.35 V)	Relay with harmonic filter
	Dropout - 120.80 V (99.5% of reset)	± 1.11% (1.35 V)	
	Time delay - 2 seconds	± 10% (0.2 sec.)	
CV-2 relay (127F-1,127F-2, 127F-3, & 127F-4)	Voltage tap - 105 V	± 3.3% (3.465 V)	
	Time dial - # 1	± 5%	
Timing relay (162S-1, 162S-2, 162S-3, & 162S-4)	Time delay - 4.3 seconds	± 4.5% (0.19 second)	
Timing relay (162D-1, 162D-2, 162D-3, & 162D-4)	Time delay - 120 seconds	± 10% (12 seconds)	
Timing relay (162T-1, 162T-2, 162T-3, & 162T-4)	Time delay - 1.5 seconds	± 10% (0.15 second)	
Timing relay 162A	Time delay - 5 seconds	± 10% (0.5 second)	

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motor rated voltage at 4.16 KV bus and at a voltage corresponding to 75% of 460 V rated motor voltage at 480 V bus. The relay operating time of 5 second at 75% of rated motor voltage meets acceptance criterion 1.3.2.1.

This relay with 105 V tap and time dial # 1 will operate in 1 second following a total loss of voltage. This relay operating time of 1 second meets acceptance criterion 1.3.2.2.

2.2 Recommendations

2.2.1 The following relay settings are recommended:

Relay	Setting	Tolerance	Remarks
27N relay (127D-1,127D-2, 127D-3, & 127D-4)	Reset (pickup) - 121.40V	± 1.11% (1.35 V)	Relay with harmonic filter
	Dropout - 120.80 V (99.5% of reset)	± 1.11% (1.35 V)	
	Time delay - 2 seconds	± 10% (0.2 sec.)	
CV-2 relay (127F-1,127F-2, 127F-3, & 127F-4)	Voltage tap - 105 V	± 3.3% (3.465 V)	
	Time dial - # 1	± 5%	
Timing relay (162S-1, 162S-2, 162S-3, & 162S-4)	Time delay - 4.3 seconds	± 4.5% (0.19 second)	
Timing relay (162D-1, 162D-2, 162D-3, & 162D-4)	Time delay - 110 seconds	± 10% (11 seconds)	
Timing relay (162T-1, 162T-2, 162T-3, & 162T-4)	Time delay - 1.25 seconds	± 10% (0.125 second)	
Timing relay 162A	Time delay - 5 seconds	± 10% (0.5 second)	

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The time delay settings of the DGVSS timing relays 162S-1, 162S-2, 162S-3, 162S-4, 162T-1, 162T-2, 162T-3, 162T-4 are selected to comply with the above consideration due to the tolerances associated with these timers, sequencing timing relays, and the response time of the 127D-1, 127D-2, 127D-3, 127D-4 relays.

- Timing relays 162S-1, 162S-2, 162S-3, & 162S-4

BEFORE

Load group 2 starts at 5 seconds. Sequencing uses agastat relays with ± 0.5 seconds tolerance. As such 162S timing should not exceed 4.5 seconds. The ABB 62T relay has a ± 4.5% tolerance as such use a relay setting of 4.3 seconds. With this setting a DGVSS window could open earliest at 4.11 seconds and latest at 4.49 seconds to allow generation of DGVSS if 127D relay permits. This time delay satisfies PSB-1 paragraph B.1(b)(1) as discussed in paragraph 4.12.

- Timing relays 162T-1, 162T-2, 162T-3, & 162T-4

The purpose of this timer is to disable this voltage detection circuit before the start of the load group 2. However this must also provide a window of sufficient duration so that if the voltage at the bus drops below the 127D relay setpoint up to 1 second prior to the start of the voltage detection window (4.11 seconds) as 2.0 seconds ± 10% delay is provided for 127D relay to establish a degraded voltage condition before voltage detection window closes. A delay setting of 1.5 seconds is chosen for the closure of this window so that it is not affected by the second load group load starting transients. The time delay tolerance is ± 0.15 second. With this delay in opening the earliest the window could close in 5.46 seconds (4.11 seconds + 1.5 seconds - 0.15 seconds = 5.46 seconds) and the latest the window could close in 6.14 seconds (4.49 seconds + 1.5 seconds + 0.15 seconds = 6.14 seconds).
This setting of the DGVSS window from 4.11 seconds to 6.14 seconds will detect degraded voltage in the first load group sequence and will not be affected by the subsequent load group ESF load starting transients.

- Alarm Relays 162A

Timing of 5 seconds was selected to provide alarm within a total of approximately 7 seconds (5 seconds for 162A + 2 seconds for 127D-1,2,3, & 4).

NOTE: DGVSS trips 4.16kV Class 1E source breakers. Since the latest a DGVSS bus trip may be initiated at 6.14 seconds from the initiation of an SIAS all ESF loads shall be analyzed for operation with a degraded voltage condition upto 6.14 seconds.

5.7 Calculation E4C-082 ICCN C-7 (reference 6.3) identified that due to the time delays of timing relays and 27N relays, generation of the DGVSS could be delayed for up to 6.14 seconds, therefore, the minimum post trip transient SWYD voltage of 200 KV could supply power to the 4.16 KV Class 1E buses following a major disturbance in the grid (refer to paragraph 4.1). Motors in first (t=0 second) and the second (t=5 seconds) load groups may start with this minimum post trip

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The time delay settings of the DGVSS timing relays 162S-1 , 162S-2, 162S-3, 162S-4, 162T-1 , 162T-2, 162T-3, 162T-4 are selected to comply with the above consideration due to the tolerances associated with these timers, sequencing timing relays, and the response time of the 127D-1, 127D-2, 127D-3, 127D-4 relays.

- Timing relays 162S-1 , 162S-2, 162S-3, & 162S-4

  Load group 2 starts at 5 seconds. Sequencing uses agastat relays with ± 0.5 seconds tolerance. As such 162S timing should not exceed 4.5 seconds. The ABB 62T relay has a ± 4.5% tolerance as such use a relay setting of 4.3 seconds. With this setting a DGVSS window could open earliest at 4.11 seconds and latest at 4.49 seconds to allow generation of DGVSS if 127D relay permits. This time delay satisfies PSB-1 paragraph B.1(b)(1) as discussed in paragraph 4.12.

- Timing relays 162T-1 , 162T-2, 162T-3, & 162T-4

  The purpose of this timer is to disable this voltage detection circuit before the start of group 2 load sequencing and close the DGVSS window. However, this must also provide a window of sufficient duration so that if the voltage at the bus drops below the 127D relay setpoint up to 1 second prior to the start of the voltage detection window (4.11 seconds) a 2.0 seconds ± 10% delay will be provided for the 127D relay to establish a degraded voltage condition before the voltage detection window closes. A delay setting of 1.25 seconds is chosen for the closure of this window so that it is not affected by the second load group load starting transients which could generate a spurious DGVSS. The time delay tolerance is ± 0.40 second which conservatively establishes the design limits. With this delay in opening the earliest the window could close due to an early SIAS is 4.96 seconds (4.11 seconds + 1.25 seconds - 0.40 seconds = 4.96 seconds) and the latest the window could close is 6.14 seconds (4.49 seconds + 1.25 seconds + 0.40 seconds = 6.14 seconds).

  This setting of the DGVSS window from 4.11 seconds to 6.14 seconds will detect degraded voltage in the first load group sequence and will not be affected by the subsequent load group ESF load starting transients.

- Alarm Relays 162A

  Timing of 5 seconds was selected to provide alarm within a total of approximately 7 seconds (5 seconds for 162A + 2 seconds for 127D-1,2,3, & 4).

NOTE: DGVSS trips 4.16kV Class 1E source breakers. Since the latest a DGVSS bus trip may be initiated at 6.14 seconds from the initiation of an SIAS all ESF loads shall be analyzed for operation with a degraded voltage condition upto 6.14 seconds.

5.7 Calculation E4C-082 ICCN C-7 (reference 6.3) identified that due to the time delays of timing relays and 27N relays, generation of the DGVSS could be delayed for up to 6.14 seconds, therefore,

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Project or DCP/MMP UNITS 2 & 3 Calc No. E4C-098, REV. 0

Subject 4KV SWITCHGEAR PROTECTIVE RELAY SETTING CALCULATION Sheet No. ______

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE
	J. Kim / B. Basu	08/13/93	R. Cabilling	08/13/93					

* THIS 'BEFORE' IS THE 'AFTER' OF ICCN C-1, Pg 29

6.22 NEMA Standard MG1 - Motor and Generator

6.23 ANSI Standard C37.96-1988 - AC Motor Protection

6.24 Calculation E4C-098 Rev. 0 - 4 KV SWGR Protective Relay Setting Calculation

6.25 Calculation E4C-099 Rev. 0 - SR 480 V Power Circuit breaker Setting

6.26 Document C930813S6057, dated 8-13-93 - SONGS Grid Stability and Voltage Study prepared by W. D. Conner of System Planning and Operation Department

BEFORE

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE
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AFTER

6.22 NEMA Standard MG1 - Motor and Generator

6.23 ANSI Standard C37.96-1988 - AC Motor Protection

6.24 Calculation E4C-098 Rev. 0 - 4 KV SWGR Protective Relay Setting Calculation

6.25 Calculation E4C-099 Rev. 0 - SR 480 V Power Circuit breaker Setting

6.26 Document C930813S6057, dated 8-13-93 - SONGS Grid Stability and Voltage Study prepared by W. D. Conner of System Planning and Operation Department

6.27 SO23-3-3.12 rev 0, Integrated ESF System Refueling Test.

6.28 Memo/Evaluation, dated 12-22-94, Subject: Component Cooling Water System/Emergency Chilled Water System Interaction, SONGS Units 2 and 3.

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE
	J. Kim / B. Basu	08/13/93	R. Cabiling	08/13/93					

* THIS "BEFORE" IS THE "AFTER" OF ICCN C-1, Pg 63

BEFORE

- * A voltage drop of 3% in the motor feeder cable was considered.
- ** The voltage drop across the loadcenter transformer was considered per the voltage ratio shown in paragraph 8.3.2.

Considering Relay circuit inaccuracy:

$$V_{relay\ min.} = 93.2\ V \times 0.967 = 90.12\ V$$

$$V_{relay\ max.} = 93.2\ V \times 1.033 = 96.27\ V$$

These voltages correspond to 85.8% and 91.68% of the existing relay tap setting (105 V), respectively. The existing relay (with 105 V tap and time dial #1) will operate within 8 seconds at these voltages (Attachment 9.7).

8.4.3 Attachment 9.7 shows that the existing relay (with 105 V tap and time dial # 1) will operate in 1 second following a total loss of voltage.

8.5 Time Delay Setpoints

8.5.1 27N Relay

Set the minimum time delay of 2 seconds to avoid a nuisance tripping due to a transient voltage dip.

8.5.2 Timing Relays 162S-1, 162S-2, 162S-3, & 162S-4

Since the DGVSS should be generated during the first automatic load sequencing cycle (refer to paragraph 1.2.4) and the motor starting transient voltages are stabilized within 4 seconds (Attachment 9.8), a time delay of 4.3 seconds selected is adequate.

8.5.3 Timing Relays 162D-1, 162D-2, 162D-3, & 162D-4

8.5.3.1 Since SDVS will be used for protection of the permanently connected Class 1E loads from sustained degraded voltage, this timing relay may be set to operate after the automatic load sequencing operations are completed.

The automatic load sequencing operations will take 117 seconds to complete since emergency chillers E335 and E336 could start between 40 to 117 seconds (reference 6.18). Therefore, set the timing relay at 120 seconds. The undervoltage relay, in conjunction with this timing relay, will generate a sustained degraded voltage signal at 120 seconds after a degraded voltage condition occurs.

It should be verified that this time delay of 120 seconds will not damage Class 1E loads as required by PSB-1 paragraph B.1.(b)(2).

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AFTER

Considering Relay circuit inaccuracy:

$V_{relay\ min.} = 93.2\ V \times 0.967 = 90.12\ V$

$V_{relay\ max.} = 93.2\ V \times 1.033 = 96.27\ V$

These voltages correspond to 85.8% and 91.68% of the existing relay tap setting (105 V), respectively. The existing relay (with 105 V tap and time dial #1) will operate within 8 seconds at these voltages (Attachment 9.7).

8.4.3 Attachment 9.7 shows that the existing relay (with 105 V tap and time dial # 1) will operate in 1 second following a total loss of voltage.

8.5 Time Delay Setpoints

8.5.1 27N Relay

Set the minimum time delay of 2 seconds to avoid a nuisance tripping due to a transient voltage dip.

8.5.2 Timing Relays 162S-1, 162S-2, 162S-3, & 162S-4

Since the DGVSS should be generated during the first automatic load sequencing cycle (refer to paragraph 1.2.4) and the motor starting transient voltages are stabilized within 4 seconds (Attachment 9.8), a time delay of 4.3 seconds selected is adequate.

8.5.3 Timing Relays 162D-1, 162D-2, 162D-3, & 162D-4

8.5.3.1 Since SDVS will be used for protection of the permanently connected Class 1E loads from sustained degraded voltage, this timing relay may be set to operate after the automatic load sequencing operations are completed.

The automatic load sequencing operations may take 117 seconds to complete since emergency chillers E335 and E336 could start between 40 to 117 seconds (reference 6.18). However, the interuption of the automatic load sequencing for these chillers will not have an adverse impact on accident mitigation operations because analysis has shown that the chillers may be unavailable for a period of 2 hrs without grave consequences (reference 6.28). The more critical Aux. Feedwater Pumps P141 and P504 are required to start at t=40 seconds from initiation of an event. The maximum time allowed for class 1E motors to be subjected to degraded voltage conditions without damage is 140 seconds (see 8.5.3.2). Therefore, set the timing relay at 110 seconds. This will allow some time for operators to establish a sustained undervoltage condition and not challenge the diesel generators unnecessarily. The undervoltage relay, in conjunction with this timing relay, will generate a sustained degraded voltage signal at a maximum time of 134.2 (110 + 22 + 2.2s delay for 27N) seconds after a degraded voltage condition occurs.

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Subject 4KV SWITCHGEAR PROTECTIVE RELAY SETTING CALCULATION Sheet No. ____

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE
	J. Kim JK	09/02/93	R. Cabiling	09/02/93					

* THIS "BEFORE" IS THE "AFTER" OF ICCN C-3, pg 4

BEFORE

8.5.3.2 Impact on Class 1E motor loads due to the time delay of 120 seconds

8.5.3.2.1 It is considered that the detrimental effects of low bus voltage is more critical on motors because they will draw excessive currents under low voltage condition.

For 134.2 seconds (2.2 seconds of time delay for 27N relay and 120+12 seconds of time delay for 162D relay) after a degraded voltage condition without SIAS, the new 27 N relay may not be able to protect motors from the short time degraded voltage condition. However, the existing CV-2 relays will provide motor protection under these circumstances.

8.5.3.2.2 NEMA Standard MG1 (Reference 6.22) recommends that the thermal protector be specified to limit the combination of motor and protector to an ultimate trip current not exceeding 170%, 156%, and 140% of motor full load current rating where full load current is not exceeding 9 A, between 9.1 to 20 A, and above 20 A, respectively. Motors are manufactured per NEMA Standard MG1.

SONGS Units 2&3 QC II motors have been procured to operate at ±10% rated voltage continuously and are able to withstand voltage drops as low as 75% of rated voltage for up to 15 seconds (reference 6.19).

ANSI Standard C37.96 (reference 6.23) recommends that the time-overcurrent pickup be set at 125% of full load current.

Calculations E4C-098 (reference 6.24) and E4C-099 (reference 6.25) show that time-overcurrent relays for motors are set at 125 to 140 % of motor full load current.

The 125% of full load current is equivalent to a motor current at 80% of rated voltage. This means that the motor can be operated at 80% of rated voltage for ~~140~~ seconds, which is operating time range of Westinghouse CO-5 relay, without damage.

Based on data above, if the CV-2 relay can provide motor protection at 75% to 80% of rated motor voltage, the nominal time delay of 120 seconds for the timing relay 162D-1, 162D-2, 162D-3 & 162D-4 is considered adequate.

8.5.3.2.3 4.16 KV motor

As shown in paragraph 8.4.1, the CV-2 relay (with 105 V tap and time dial #1) will operate within 5 seconds at 75% of the rated motor voltage.

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	Kim Mosley								

AFTER

It should be verified that this maximum time delay of 134.2 seconds will not damage Class 1E loads as required by PSB-1 paragraph B.1.(b)(2).

8.5.3.2 Impact on Class 1E motor loads due to the time delay of 110 seconds

8.5.3.2.1 It is considered that the detrimental effects of low bus voltage is more critical on motors because they will draw excessive currents under low voltage condition.

For 134.2 seconds (2.2 seconds of time delay for 27N relay and 110+22 seconds of time delay for 162D relay) after a degraded voltage condition without SIAS, the new 27 N relay may not be able to protect motors from the short time degraded voltage condition. However, the existing CV-2 relays will provide motor protection under these circumstances.

8.5.3.2.2 NEMA Standard MG1 (Reference 6.22) recommends that the thermal protector be specified to limit the combination of motor and protector to an ultimate trip current not exceeding 170%, 156%, and 140% of motor full load current rating where full load current is not exceeding 9 A, between 9.1 to 20 A, and above 20 A, respectively. Motors are manufactured per NEMA Standard MG1.

SONGS Units 2&3 QC II motors have been procured to operate at ±10% rated voltage continuously and are able to withstand voltage drops as low as 75% of rated voltage for up to 15 seconds (reference 6.19).

ANSI Standard C37.96 (reference 6.23) recommends that the time-overcurrent pickup be set at 125% of full load current.

Calculations E4C-098 (reference 6.24) and E4C-099 (reference 6.25) show that time-overcurrent relays for motors are set at 125 to 140 % of motor full load current.

The 125% of full load current is equivalent to a motor current at 80% of rated voltage. This means that the motor can be operated at 80% of rated voltage for 140 seconds, which is the operating time range of Westinghouse CO-5 relay, without damage.

Based on data above, if the CV-2 relay can provide motor protection at 75% to 80% of rated motor voltage, the nominal time delay of 110 seconds for the timing relay 162D-1, 162D-2, 162D-3 & 162D-4 is considered adequate.

8.5.3.2.3 4.16 KV motor

As shown in paragraph 8.4.1, the CV-2 relay (with 105 V tap and time

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	CCN CONVERSION CCN NO CCN -

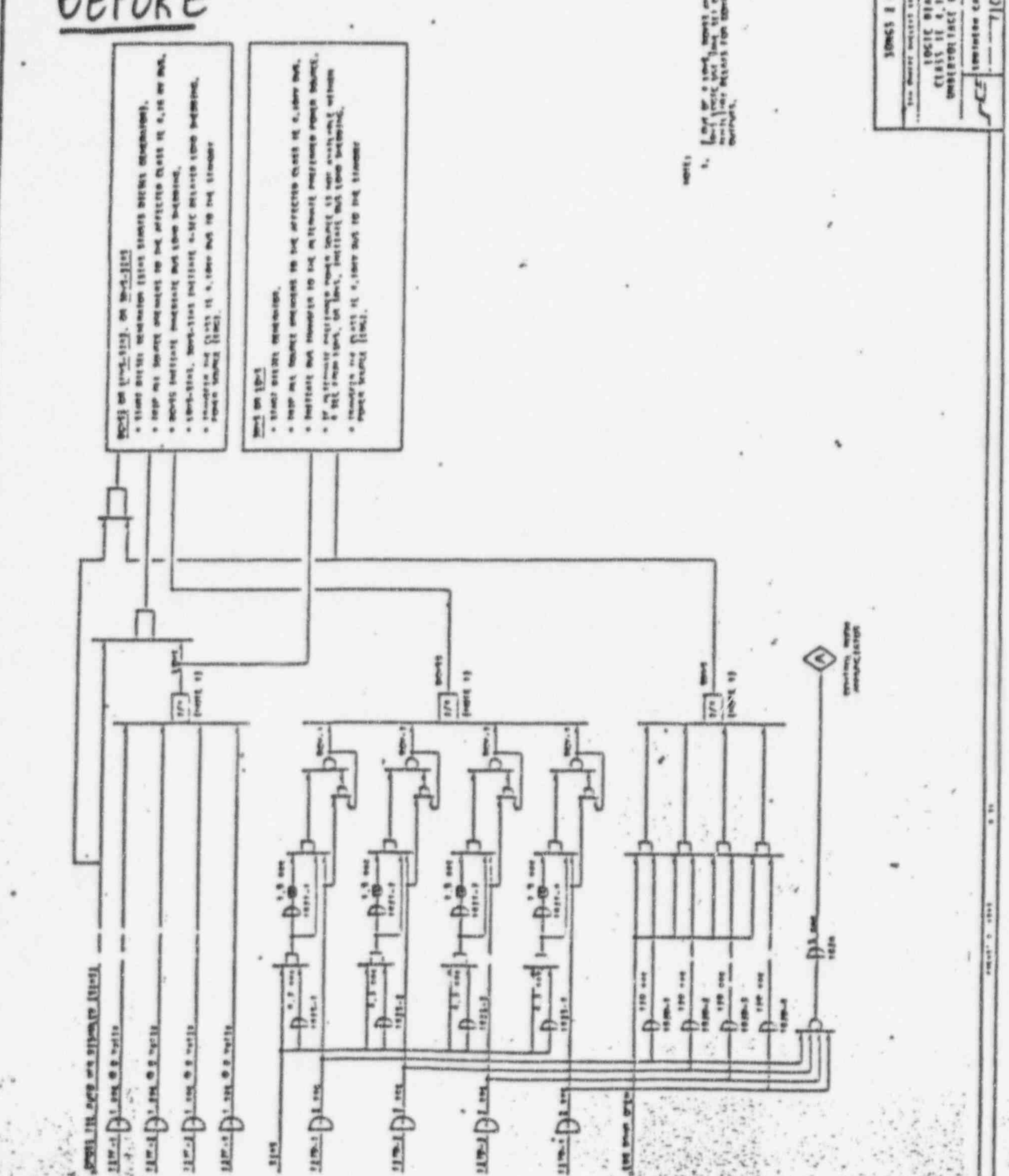
ATTACHMENT 9.5

Sheet______

CALCULATION NO. E4C-098 REV. 0 ICCN C-1

* THIS 'BEFORE' IS THE 'AFTER' OF ICCN C-1, pg 53

BEFORE



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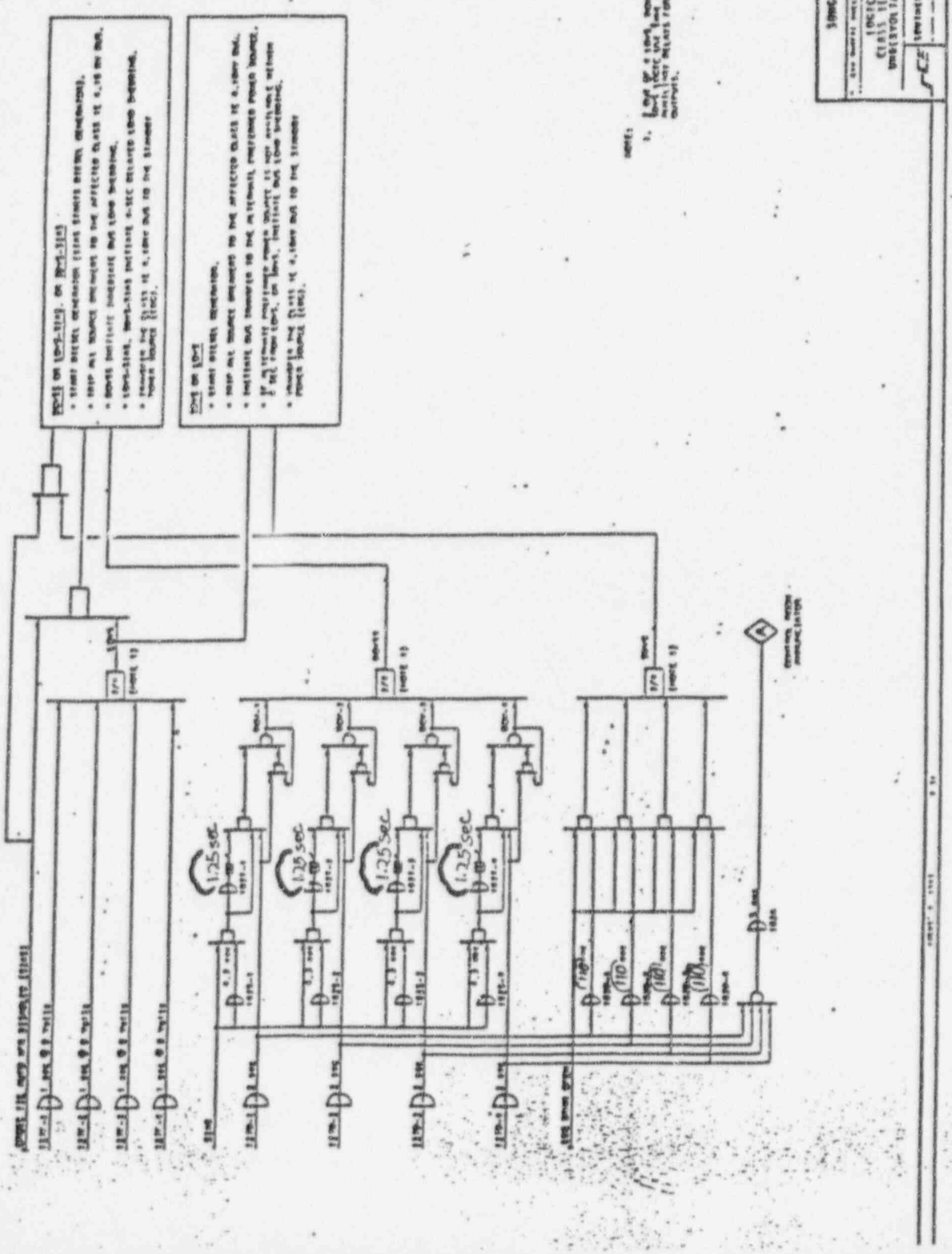
	CCN CONVERSION CCN NO CCN -

ATTACHMENT 9.5

Sheet______

CALCULATION NO. E4C-098 REV. 0 ICCN C-5

AFTER



Southern California Edison Company	CALC. NO. E4C-098	ICCN NO./ PRELIM. CCN NO. C-8		PAGE 1	TOTAL NO. OF PAGES 16
INTERIM CALCULATION CHANGE NOTICE (ICCN)/ CALCULATION CHANGE NOTICE (CCN) COVER PAGE	BASE CALC. REV. 0	UNIT 3	CCN CONVERSION : CCN NO. CCN-		CALC. REV.
	CALCULATION SUBJECT : 4KV SWGR PROTECTIVE RELAY SETTING CALCULATION				
CALCULATION CROSS-INDEX ☒ New/Updated index included ☐ Existing index is complete	ENGINEERING SYSTEM NUMBER / PRIMARY STATION SYSTEM DESIGNATOR 1804 / PBA/PBB				Q-CLASS II
1. BRIEF DESCRIPTION OF ICCN / CCN:	CONTROLLED PROGRAM OR DATABASE ACCORDING TO SO123-XXIV-5.1 ☐ PROGRAM ☐ DATA BASE	PROGRAM / DATABASE NAME (S) ☐ ALSO, LISTED BELOW		VERSION/RELEASE NO.(S)	

UNIT 3 ONLY

THIS ICCN VOIDS PREVIOUSLY ISSUED ICCN C-8

Agastat models E7012PKL (162D), E7012PB (162T), and E7012PC (162A) are used in the SDVS and DGVSS protection schemes. This ICCN adds a design margin to the manufacturers specification of 10% for accuracy/repeatability tolerance. The design margin establishes circuit operability.

INITIATING DOCUMENT (DCP, FCN, OTHER) MMP 2/3-2060.00SE REV. 0

2. OTHER AFFECTED DOCUMENTS (CHECK AS APPLICABLE FOR CCN ONLY):

○ YES ○ NO OTHER AFFECTED DOCUMENTS EXIST AND ARE IDENTIFIED ON ATTACHED FORM 26-503.

3. APPROVAL : DISCIPLINE / ESC : ELECTRICAL

K. MOSLEY KM 1/12/95 — ORIGINATOR (Print name/initial/date)

[signature] 1-12-95 — GS (Signature/date)

[signature] 1/12/95 — OTHER (Signature/date)

J.KIM / JK / 1-12-95 — IRE (Print name/initial/date)

K.L.Johnson 1/13/95 — DM (Signature/date)

OTHER (Signature/date)

4. ASSIGNED SUPPLEMENT ALPHA DESIGNATOR : ______

CONVERSION TO CCN DATE ______

SCE CDM - SONGS

CALCULATION CROSS-INDEX

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CCN CONVERSION: CCN NO. CCN-

Calculation No. E4C-098 Sheet No. ____ of ____

Calc. rev. number and responsible supervisor initials and date	INPUTS These interfacing calculations and/or documents provide input to the subject calculation and if revised may require revision of the subject calculation.		OUTPUTS Results and conclusions of the subject calculation are used in these interfacing calculations and/or documents.		Does the output interface calc/ document require revision?	Identify output interface calc/document CCN, DCN, TCN/Rev., FIDCN, or tracking number.
	Calc / Document No.	Rev. No.	Calc / Document No.	Rev. No.	YES / NO	
0 [initials] 1/12/95	NMP 2/3-2000.00SE ASC#1	0	- TECHNICAL SPECIFICATIONS MMP 2/3-2060.005E ASC#2	0	YES	KJ-94-196

SCE 26-424 REV. 1 9/94 [REFERENCE: SO123-XXIV-7.10]

T:\JETFORM\FORMS\HEDO_GEN424_01.MDF Ver. 00.00.00 8/24/94 C:\JETDATA\Q~.DAT Dev.Q -1.0000 Printed: 11/16/94

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE
	J. Kim / B. Basu	08/13/93	R. Tailling	08/13/93					

* THIS 'BEFORE' IS THE "AFTER" OF ICCN C-2, Pg 9

BEFORE

2.1.2.2 Timing relays 162D-1, 162D-2, 162D-3, & 162D-4 (refer to para.8.5.3)

Time delay setting: 120 seconds ± 10% (12 seconds)

Since the Sustained Degraded Voltage Signal (SDVS) will be used for protection of the permanently connected Class 1E loads from sustained degraded voltage, this timing relay may be set to operate after the automatic load sequencing operations are completed.

A time delay of 120 seconds is chosen since the automatic load sequencing operations will take 114 seconds (reference 6.18) to complete. The 27N relay in conjunction with this timing relay will generate a sustained degraded voltage signal in 120 seconds after a degraded voltage condition occurs. The 27N relay may not protect the motors from this short time degraded voltage conditions.

However, the existing CV-2 relays will protect motors from a degraded voltage as shown in paragraph 8.5.3.2. Therefore, this time delay meets acceptance criterion 1.3.1.3.

2.1.2.3 Timing Relays 162T-1, 162T-2, 162T-3, & 162T-4 (refer to para. 5.6)

Time delay setting: 1.5 seconds ± 10% (0.15 second)

A time delay of 1.5 seconds is chosen to disable the degraded voltage detection circuit before the start of the second automatic load sequencing, since the DGVSS should be generated during the first automatic load sequencing, and to provide a window of sufficient duration so that if the voltage at the bus drops below the 127D relay setpoint up to 1 second prior to the start of the voltage detection window (4.11 seconds) as 2.0 seconds delay is provided for 127D relay to establish a degraded voltage condition before voltage detection window closes (refer to paragraph 5.6).

2.1.2.4 Alarm Relays 162A

Time delay setting: 5 seconds ± 10% (0.5 second)

Timing of 5 seconds was selected to provide alarm within a total of approximately 7 seconds (5 seconds for 162A + 2 seconds for 127D-1,2,3, & 4).

2.1.3 CV-2 Relays 127F-1, 127F-2, 127F-3, & 127F-4 (refer to para. 8.4)

Voltage setting: 105 V ± 3.3%

Time dial: # 1 with operating time tolerance of ± 5%

CV-2 relay with 105 V tap and time dial # 1 will operate within 5 seconds at 75% of 4.16 KV

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	Kim Mosley								

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2.1.2.2 Timing relays 162D-1, 162D-2, 162D-3, & 162D-4 (refer to para.8.5.3)

Time delay setting: 110 seconds ± 10%* (11 seconds)
***Note: The allowable design limit for circuit operability is 110 sec ± 20% (22 sec)**

Since the Sustained Degraded Voltage Signal (SDVS) will be used for protection of the permanently connected Class 1E loads from sustained degraded voltage, this timing relay may be set to operate after critical automatic load sequencing operations are completed.

A time delay of 110 seconds is chosen since the automatic load sequencing operations will take 40 seconds (references 6.18 and 6.28) to complete and the setting is within the established upper limit of 140 seconds(see 8.5.3.2). As stated in section 8.5.3.2, the 27N relay in conjunction with this timing relay may generate a sustained degraded voltage signal at a maximum time of 134.2 seconds after a degraded voltage condition occurs. The 27N relay may not protect the motors from this short time degraded voltage condition.

However, the existing CV-2 relays will protect motors from a degraded voltage as shown in paragraph 8.5.3.2. Therefore, this time delay meets acceptance criterion 1.3.1.3.

2.1.2.3 Timing Relays 162T-1, 162T-2, 162T-3, & 162T-4 (refer to para. 5.6)

Time delay setting: 1.25 seconds ± 10%* (0.125 second)
***Note: The allowable design limit for circuit operability is 1.25 sec ± 30% (0.40 sec)**

A time delay of 1.25 seconds is chosen to close the degraded voltage detection circuit before the start of the second automatic load sequencing. The earliest the window will close is 4.96 seconds and the latest the window will close is 6.14 seconds. A 2.0 second delay is provided for the 127D relay to establish a degraded voltage condition before the voltage detection window closes (refer to paragraph 5.6).

2.1.2.4 Alarm Relays 162A (refer to para. 4.10)

Time delay setting: 5 seconds ± 10%* (0.5 second)
***Note: The allowable design limit for circuit operability is 5 sec ± 20% (1 sec)**

Timing of 5 seconds was selected to provide alarm within a total of approximately 7 seconds (5 seconds for 162A + 2 seconds for 127D-1,2,3, & 4).

2.1.3 CV-2 Relays 127F-1, 127F-2, 127F-3, & 127F-4 (refer to para. 8.4)

Voltage setting: 105 V ± 3.3%
Time dial: # 1 with operating time tolerance of ± 5%

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CCN CONVERSION
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Project or DCR/MMP UNITS 2 & 3 Calc No. E4C-098, REV. 0

Subject 4KV SWITCHGEAR PROTECTIVE RELAY SETTING CALCULATION Sheet No. ____

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE
	JC J. Kim / B. Basu	08/13/93	R. Cabiling	08/13/93			–		

*, THIS 'BEFORE' IS THE 'AFTER' OF ICCN C-2, pg 10

BEFORE

motor rated voltage at 4.16 KV bus and at a voltage corresponding to 75% of 460 V rated motor voltage at 480 V bus. The relay operating time of 5 second at 75% of rated motor voltage meets acceptance criterion 1.3.2.1.

This relay with 105 V tap and time dial # 1 will operate in 1 second following a total loss of voltage. This relay operating time of 1 second meets acceptance criterion 1.3.2.2.

2.2 Recommendations

2.2.1 The following relay settings are recommended:

Relay	Setting	Tolerance	Remarks
27N relay (127D-1, 127D-2, 127D-3, & 127D-4)	Reset (pickup) - 121.40V	± 1.11% (1.35 V)	Relay with harmonic filter
	Dropout - 120.80 V (99.5% of reset)	± 1.11% (1.35 V)	
	Time delay - 2 seconds	± 10% (0.2 sec.)	
CV-2 relay (127F-1, 127F-2, 127F-3, & 127F-4)	Voltage tap - 105 V	± 3.3% (3.465 V)	
	Time dial - # 1	± 5%	
Timing relay (162S-1, 162S-2, 162S-3, & 162S-4)	Time delay - 4.3 seconds	± 4.5% (0.19 second)	
Timing relay (162D-1, 162D-2, 162D-3, & 162D-4)	Time delay - 120 seconds	± 10% (12 seconds)	
Timing relay (162T-1, 162T-2, 162T-3, & 162T-4)	Time delay - 1.5 seconds	± 10% (0.15 second)	
Timing relay 162A	Time delay - 5 seconds	± 10% (0.5 second)	

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE
	Kim Mosley								

AFTER

motor rated voltage at 4.16 KV bus and at a voltage corresponding to 75% of 460 V rated motor voltage at 480 V bus. The relay operating time of 5 second at 75% of rated motor voltage meets acceptance criterion 1.3.2.1.

This relay with 105 V tap and time dial # 1 will operate in 1 second following a total loss of voltage. This relay operating time of 1 second meets acceptance criterion 1.3.2.2.

2.2 Recommendations

2.2.1 The following relay settings are recommended:

Relay	Setting	Tolerance	Remarks
27N relay (127D-1,127D-2, 127D-3, & 127D-4)	Reset (pickup) - 121.40V	± 1.11% (1.35 V)	Relay with harmonic filter
	Dropout - 120.80 V (99.5% of reset)	± 1.11% (1.35 V)	
	Time delay - 2 seconds	± 10% (0.2 sec.)	
CV-2 relay (127F-1,127F-2, 127F-3, & 127F-4)	Voltage tap - 105 V	± 3.3% (3.465 V)	
	Time dial - # 1	± 5%	
Timing relay (162S-1, 162S-2, 162S-3, & 162S-4)	Time delay - 4.3 seconds	± 4.5% (0.19 second)	
Timing relay (162D-1, 162D-2, 162D-3, & 162D-4)	Time delay - 110 seconds	± 10% (11 seconds)	
Timing relay (162T-1, 162T-2, 162T-3, & 162T-4)	Time delay - 1.25 seconds	± 10% (0.125 second)	
Timing relay 162A	Time delay - 5 seconds	± 10% (0.5 second)	

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE
	J. Kim / B. Basu	08/13/93	R. Castling	08/13/93					

* THIS 'BEFORE' IS THE 'AFTER' OF ICCN C-2, Pg 25

The time delay settings of the DGVSS timing relays 162S-1, 162S-2, 162S-3, 162S-4, 162T-1, 162T-2, 162T-3, 162T-4 are selected to comply with the above consideration due to the tolerances associated with these timers, sequencing timing relays, and the response time of the 127D-1, 127D-2, 127D-3, 127D-4 relays.

BEFORE

- Timing relays 162S-1, 162S-2, 162S-3, & 162S-4

  Load group 2 starts at 5 seconds. Sequencing uses agastat relays with ± 0.5 seconds tolerance. As such 162S timing should not exceed 4.5 seconds. The ABB 62T relay has a ± 4.5% tolerance as such use a relay setting of 4.3 seconds. With this setting a DGVSS window could open earliest at 4.11 seconds and latest at 4.49 seconds to allow generation of DGVSS if 127D relay permits. This time delay satisfies PSB-1 paragraph B.1(b)(1) as discussed in paragraph 4.12.

- Timing relays 162T-1, 162T-2, 162T-3, & 162T-4

  The purpose of this timer is to disable this voltage detection circuit before the start of the load group 2. However this must also provide a window of sufficient duration so that if the voltage at the bus drops below the 127D relay setpoint up to 1 second prior to the start of the voltage detection window (4.11 seconds) a 2.0 seconds ± 10% delay is provided for 127D relay to establish a degraded voltage condition before voltage detection window closes. A delay setting of 1.5 seconds is chosen for the closure of this window so that it is not affected by the second load group load starting transients. The time delay tolerance is ± 0.15 second. With this delay in opening the earliest the window could close in 5.46 seconds (4.11 seconds + 1.5 seconds - 0.15 seconds = 5.46 seconds) and the latest the window could close in 6.14 seconds (4.49 seconds + 1.5 seconds + 0.15 seconds = 6.14 seconds).
  This setting of the DGVSS window from 4.11 seconds to 6.14 seconds will detect degraded voltage in the first load group sequence and will not be affected by the subsequent load group ESF load starting transients.

- Alarm Relays 162A

  Timing of 5 seconds was selected to provide alarm within a total of approximately 7 seconds (5 seconds for 162A + 2 seconds for 127D-1,2,3, & 4).

NOTE: DGVSS trips 4.16kV Class 1E source breakers. Since the latest a DGVSS bus trip may be initiated at 6.14 seconds from the initiation of an SIAS all ESF loads shall be analyzed for operation with a degraded voltage condition upto 6.14 seconds.

5.7 Calculation E4C-082 ICCN C-7 (reference 6.3) identified that due to the time delays of timing relays and 27N relays, generation of the DGVSS could be delayed for up to 6.14 seconds, therefore, the minimum post trip transient SWYD voltage of 200 KV could supply power to the 4.16 KV Class 1E buses following a major disturbance in the grid (refer to paragraph 4.1). Motors in first (t=0 second) and the second (t=5 seconds) load groups may start with this minimum post trip

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	Kim Mosley								

AFTER

The time delay settings of the DGVSS timing relays 162S-1, 162S-2, 162S-3, 162S-4, 162T-1, 162T-2, 162T-3, 162T-4 are selected to comply with the above consideration due to the tolerances associated with these timers, sequencing timing relays, and the response time of the 127D-1, 127D-2, 127D-3, 127D-4 relays.

- Timing relays 162S-1, 162S-2, 162S-3, & 162S-4

  Load group 2 starts at 5 seconds. Sequencing uses agastat relays with ± 0.5 seconds tolerance. As such 162S timing should not exceed 4.5 seconds. The ABB 62T relay has a ± 4.5% tolerance as such use a relay setting of 4.3 seconds. With this setting a DGVSS window could open earliest at 4.11 seconds and latest at 4.49 seconds to allow generation of DGVSS if 127D relay permits. This time delay satisfies PSB-1 paragraph B.1(b)(1) as discussed in paragraph 4.12.

- Timing relays 162T-1, 162T-2, 162T-3, & 162T-4

  The purpose of this timer is to disable this voltage detection circuit before the start of group 2 load sequencing and close the DGVSS window. However, this must also provide a window of sufficient duration so that if the voltage at the bus drops below the 127D relay setpoint up to 1 second prior to the start of the voltage detection window (4.11 seconds) a 2.0 seconds ± 10% delay will be provided for the 127D relay to establish a degraded voltage condition before the voltage detection window closes. A delay setting of 1.25 seconds is chosen for the closure of this window so that it is not affected by the second load group load starting transients which could generate a spurious DGVSS. The time delay tolerance is ± 0.40 second which conservatively establishes the design limits. With this delay in opening the earliest the window could close due to an early SIAS is 4.96 seconds (4.11 seconds + 1.25 seconds - 0.40 seconds = 4.96 seconds) and the latest the window could close is 6.14 seconds (4.49 seconds + 1.25 seconds + 0.40 seconds = 6.14 seconds).

  This setting of the DGVSS window from 4.11 seconds to 6.14 seconds will detect degraded voltage in the first load group sequence and will not be affected by the subsequent load group ESF load starting transients.

- Alarm Relays 162A

  Timing of 5 seconds was selected to provide alarm within a total of approximately 7 seconds (5 seconds for 162A + 2 seconds for 127D-1,2,3, & 4).

NOTE: DGVSS trips 4.16kV Class 1E source breakers. Since the latest a DGVSS bus trip may be initiated at 6.14 seconds from the initiation of an SIAS all ESF loads shall be analyzed for operation with a degraded voltage condition upto 6.14 seconds.

5.7 Calculation E4C-082 ICCN C-7 (reference 6.3) identified that due to the time delays of timing relays and 27N relays, generation of the DGVSS could be delayed for up to 6.14 seconds, therefore,

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	J. Kim / B. Basu	08/13/93	R. Cabilling	08/13/93					

* THIS 'BEFORE' IS THE 'AFTER' OF ICCN C-2, Pg 29

6.22 NEMA Standard MG1 - Motor and Generator

6.23 ANSI Standard C37.96-1988 - AC Motor Protection

6.24 Calculation E4C-098 Rev. 0 - 4 KV SWGR Protective Relay Setting Calculation

6.25 Calculation E4C-099 Rev. 0 - SR 480 V Power Circuit breaker Setting

6.26 Document C930813S6057, dated 8-13-93 - SONGS Grid Stability and Voltage Study prepared by W. D. Conner of System Planning and Operation Department

BEFORE

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Subject 4KV SWITCHGEAR PROTECTIVE RELAY SETTING CALCULATION Sheet No. ____________

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE
	Kim Mosley								

AFTER

6.22 NEMA Standard MG1 - Motor and Generator

6.23 ANSI Standard C37.96-1988 - AC Motor Protection

6.24 Calculation E4C-098 Rev. 0 - 4 KV SWGR Protective Relay Setting Calculation

6.25 Calculation E4C-099 Rev. 0 - SR 480 V Power Circuit breaker Setting

6.26 Document C930813S6057, dated 8-13-93 - SONGS Grid Stability and Voltage Study prepared by W. D. Conner of System Planning and Operation Department

6.27 SO23-3-3.12 rev 0, Integrated ESF System Refueling Test.

6.28 Memo/Evaluation, dated 12-22-94, Subject: Component Cooling Water System/Emergency Chilled Water System Interaction, SONGS Units 2 and 3.

NES&L DEPARTMENT
CALCULATION SHEET

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REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE
	J. Kim / B. Basu	08/13/93	R. Cabiling	08/13/93					

* THIS "BEFORE" IS THE "AFTER" OF ICCN C-2, Pg 37

BEFORE

- * A voltage drop of 3% in the motor feeder cable was considered.
- ** The voltage drop across the loadcenter transformer was considered per the voltage ratio shown in paragraph 8.3.2.

Considering Relay circuit inaccuracy:

$V_{relay\ min.} = 93.2\ V \times 0.967 = 90.12\ V$

$V_{relay\ max.} = 93.2\ V \times 1.033 = 96.27\ V$

These voltages correspond to 85.8% and 91.68% of the existing relay tap setting (105 V), respectively. The existing relay (with 105 V tap and time dial #1) will operate within 8 seconds at these voltages (Attachment 9.7).

8.4.3 Attachment 9.7 shows that the existing relay (with 105 V tap and time dial #1) will operate in 1 second following a total loss of voltage.

8.5 Time Delay Setpoints

8.5.1 27N Relay

Set the minimum time delay of 2 seconds to avoid a nuisance tripping due to a transient voltage dip.

8.5.2 Timing Relays 162S-1, 162S-2, 162S-3, & 162S-4

Since the DGVSS should be generated during the first automatic load sequencing cycle (refer to paragraph 1.2.4) and the motor starting transient voltages are stabilized within 4 seconds (Attachment 9.8), a time delay of 4.3 seconds selected is adequate.

8.5.3 Timing Relays 162D-1, 162D-2, 162D-3, & 162D-4

8.5.3.1 Since SDVS will be used for protection of the permanently connected Class 1E loads from sustained degraded voltage, this timing relay may be set to operate after the automatic load sequencing operations are completed.

The automatic load sequencing operations will take 117 seconds to complete since emergency chillers E335 and E336 could start between 40 to 117 seconds (reference 6.18). Therefore, set the timing relay at 120 seconds. The undervoltage relay, in conjunction with this timing relay, will generate a sustained degraded voltage signal at 120 seconds after a degraded voltage condition occurs.

It should be verified that this time delay of 120 seconds will not damage Class 1E loads as required by PSB-1 paragraph B.1.(b)(2).

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE
	Kim Mosley								

AFTER

Considering Relay circuit inaccuracy:

$V_{relay\ min.} = 93.2\text{ V} \times 0.967 = 90.12\text{ V}$

$V_{relay\ max.} = 93.2\text{ V} \times 1.033 = 96.27\text{ V}$

These voltages correspond to 85.8% and 91.68% of the existing relay tap setting (105 V), respectively. The existing relay (with 105 V tap and time dial #1) will operate within 8 seconds at these voltages (Attachment 9.7).

8.4.3 Attachment 9.7 shows that the existing relay (with 105 V tap and time dial # 1) will operate in 1 second following a total loss of voltage.

8.5 Time Delay Setpoints

8.5.1 27N Relay

Set the minimum time delay of 2 seconds to avoid a nuisance tripping due to a transient voltage dip.

8.5.2 Timing Relays 162S-1, 162S-2, 162S-3, & 162S-4

Since the DGVSS should be generated during the first automatic load sequencing cycle (refer to paragraph 1.2.4) and the motor starting transient voltages are stabilized within 4 seconds (Attachment 9.8), a time delay of 4.3 seconds selected is adequate.

8.5.3 Timing Relays 162D-1, 162D-2, 162D-3, & 162D-4

8.5.3.1 Since SDVS will be used for protection of the permanently connected Class 1E loads from sustained degraded voltage, this timing relay may be set to operate after the automatic load sequencing operations are completed.

The automatic load sequencing operations may take 117 seconds to complete since emergency chillers E335 and E336 could start between 40 to 117 seconds (reference 6.18). However, the interuption of the automatic load sequencing for these chillers will not have an adverse impact on accident mitigation operations because analysis has shown that the chillers may be unavailable for a period of 2 hrs without grave consequences (reference 6.28). The more critical Aux. Feedwater Pumps P141 and P504 are required to start at t=40 seconds from initiation of an event. The maximum time allowed for class 1E motors to be subjected to degraded voltage conditions without damage is 140 seconds (see 8.5.3.2). Therefore, set the timing relay at 110 seconds. This will allow some time for operators to establish a sustained undervoltage condition and not challenge the diesel generators unnecessarily. The undervoltage relay, in conjunction with this timing relay, will generate a sustained degraded voltage signal at a maximum time of 134.2 (110 + 22 + 2.2s delay for 27N) seconds after a degraded voltage condition occurs.

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Subject 4KV SWITCHGEAR PROTECTIVE RELAY SETTING CALCULATION Sheet No. ______

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE
	J. Kim JK	09/02/93	R. Cabilling	09/02/93					

* THIS "BEFORE" IS THE "AFTER" OF ICCN C-4, Pg 4

BEFORE

8.5.3.2 Impact on Class 1E motor loads due to the time delay of 120 seconds

8.5.3.2.1 It is considered that the detrimental effects of low bus voltage is more critical on motors because they will draw excessive currents under low voltage condition.

For 134.2 seconds (2.2 seconds of time delay for 27N relay and 120+12 seconds of time delay for 162D relay) after a degraded voltage condition without SIAS, the new 27 N relay may not be able to protect motors from the short time degraded voltage condition. However, the existing CV-2 relays will provide motor protection under these circumstances.

8.5.3.2.2 NEMA Standard MG1 (Reference 6.22) recommends that the thermal protector be specified to limit the combination of motor and protector to an ultimate trip current not exceeding 170%, 156%, and 140% of motor full load current rating where full load current is not exceeding 9 A, between 9.1 to 20 A, and above 20 A, respectively. Motors are manufactured per NEMA Standard MG1.

SONGS Units 2&3 QC II motors have been procured to operate at ±10% rated voltage continuously and are able to withstand voltage drops as low as 75% of rated voltage for up to 15 seconds (reference 6.19).

ANSI Standard C37.96 (reference 6.23) recommends that the time-overcurrent pickup be set at 125% of full load current.

Calculations E4C-098 (reference 6.24) and E4C-099 (reference 6.25) show that time-overcurrent relays for motors are set at 125 to 140 % of motor full load current.

The 125% of full load current is equivalent to a motor current at 80% of rated voltage. This means that the motor can be operated at 80% of rated voltage for ~~140 seconds~~, which is operating time range of Westinghouse CO-5 relay, without damage.

Based on data above, if the CV-2 relay can provide motor protection at 75% to 80% of rated motor voltage, the nominal time delay of 120 seconds for the timing relay 162D-1, 162D-2, 162D-3 & 162D-4 is considered adequate.

8.5.3.2.3 4.16 KV motor

As shown in paragraph 8.4.1, the CV-2 relay (with 105 V tap and time dial #1) will operate within 5 seconds at 75% of the rated motor voltage.

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE
	Kim Mosley								

AFTER

It should be verified that this maximum time delay of 134.2 seconds will not damage Class 1E loads as required by PSB-1 paragraph B.1.(b)(2).

8.5.3.2 Impact on Class 1E motor loads due to the time delay of 110 seconds

8.5.3.2.1 It is considered that the detrimental effects of low bus voltage is more critical on motors because they will draw excessive currents under low voltage condition.

For 134.2 seconds (2.2 seconds of time delay for 27N relay and 110+22 seconds of time delay for 162D relay) after a degraded voltage condition without SIAS, the new 27 N relay may not be able to protect motors from the short time degraded voltage condition. However, the existing CV-2 relays will provide motor protection under these circumstances.

8.5.3.2.2 NEMA Standard MG1 (Reference 6.22) recommends that the thermal protector be specified to limit the combination of motor and protector to an ultimate trip current not exceeding 170%, 156%, and 140% of motor full load current rating where full load current is not exceeding 9 A, between 9.1 to 20 A, and above 20 A, respectively. Motors are manufactured per NEMA Standard MG1.

SONGS Units 2&3 QC II motors have been procured to operate at ±10% rated voltage continuously and are able to withstand voltage drops as low as 75% of rated voltage for up to 15 seconds (reference 6.19).

ANSI Standard C37.96 (reference 6.23) recommends that the time-overcurrent pickup be set at 125% of full load current.

Calculations E4C-098 (reference 6.24) and E4C-099 (reference 6.25) show that time-overcurrent relays for motors are set at 125 to 140 % of motor full load current.

The 125% of full load current is equivalent to a motor current at 80% of rated voltage. This means that the motor can be operated at 80% of rated voltage for 140 seconds, which is the operating time range of Westinghouse CO-5 relay, without damage.

Based on data above, if the CV-2 relay can provide motor protection at 75% to 80% of rated motor voltage, the nominal time delay of 110 seconds for the timing relay 162D-1, 162D-2, 162D-3 & 162D-4 is considered adequate.

8.5.3.2.3 4.16 KV motor

As shown in paragraph 8.4.1, the CV-2 relay (with 105 V tap and time

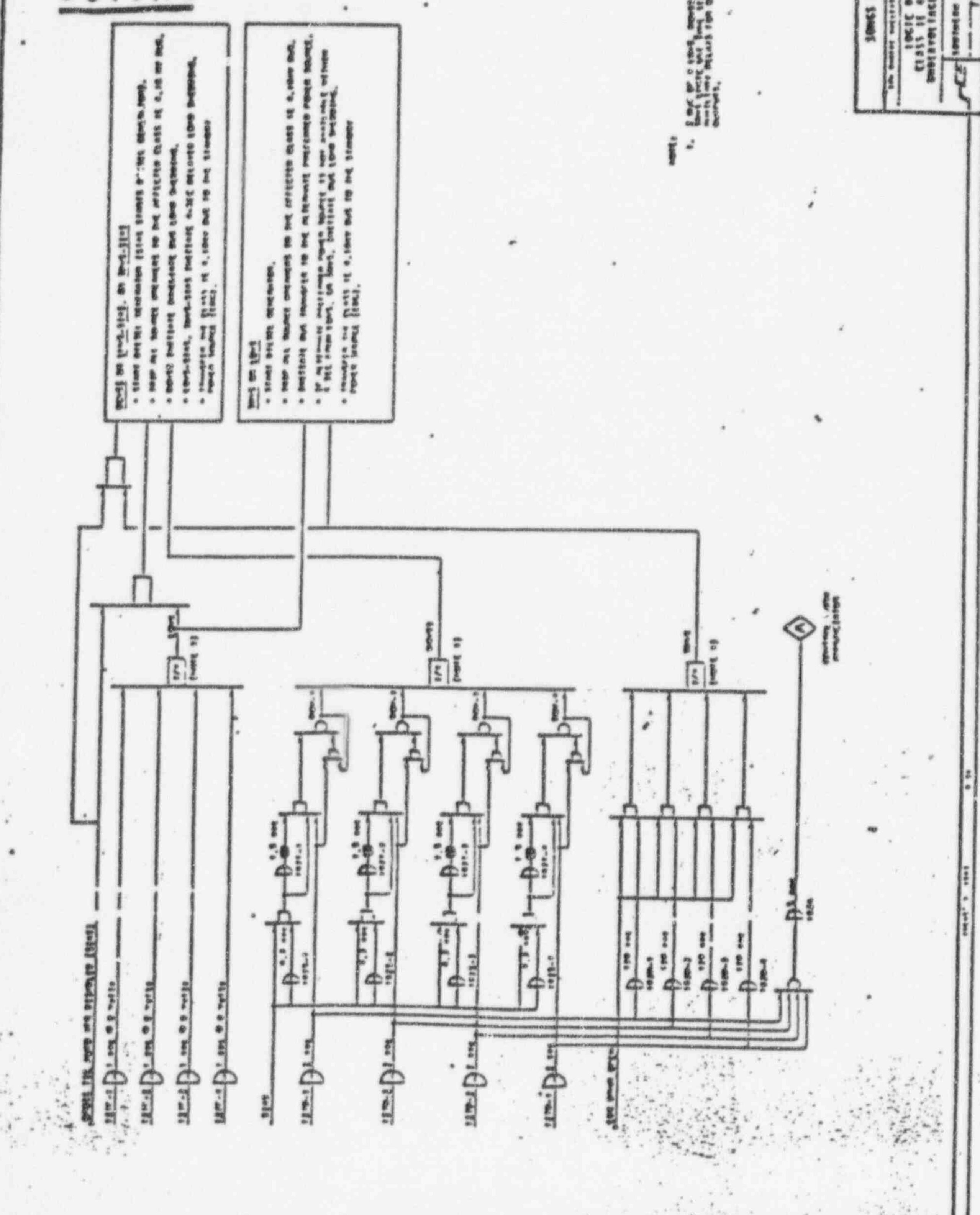
ATTACHMENT 9.5

Sheet______

CALCULATION NO. E4C-098 REV. 0 ICCN C-1

* THIS 'BEFORE' IS THE 'AFTER' OF ICCN C-1, pg 53

BEFORE



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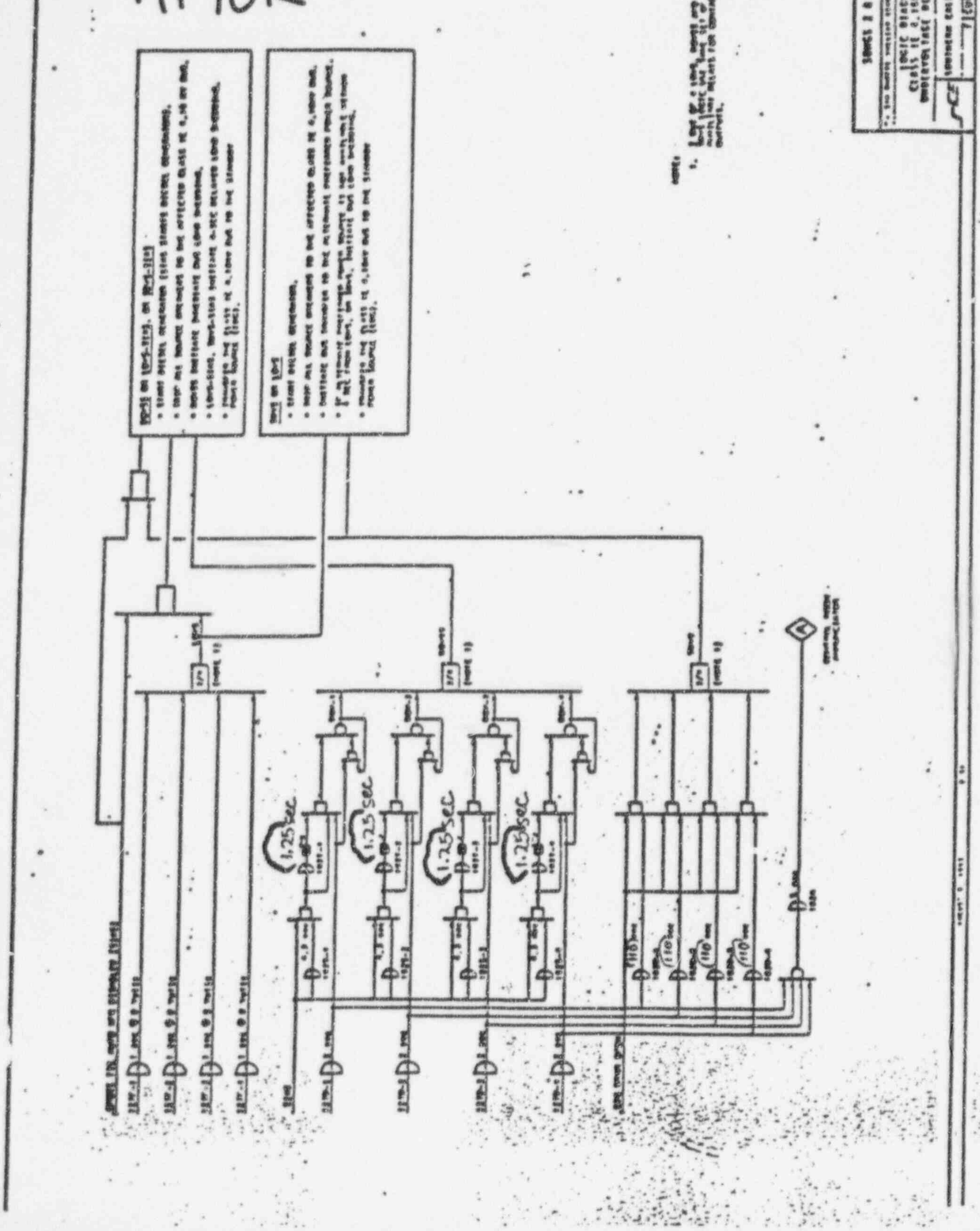
	CCN CONVERSION CCN NO. CCN -

ATTACHMENT 9.5

Sheet______

CALCULATION NO. E4C-098 REV. 0 ICCN C-5

AFTER



Southern California Edison Company	CALC NO E4C-098	ICCN NO./ C-3 PRELIM. CCN NO.	PAGE 1	TOTAL NO. OF PAGES 7
INTERIM CALCULATION CHANGE NOTICE (ICCN)/ CALCULATION CHANGE NOTICE(CCN)	BASE CALC. REV 0 / UNITS 2	CCN CONVERSION: CCN NO. CCN-		CALC. REV
	CALCULATION SUBJECT: 4 KV SWGR PROTECTIVE RELAY SETTING CALCULATION			
CALCULATION CROSS-INDEX [ ] New/Updated Index Included [X] Existing Index is Complete	ENGINEERING SYSTEM NUMBER/PRIMARY STATION SYSTEM DESIGNATOR 1804 / PBA/PBB		Q-CLASS II	
	CONTROLLED PROGRAM OR DATABASE IN ACCORDANCE WITH NESAL 41-5-1 [ ] PROGRAM [ ] DATABASE	PROGRAM/DATABASE NAME(S) [ ] ALSO LISTED BELOW	VERSION/RELEASE NO.S	

1. BRIEF DESCRIPTION OF ICCN/CCN:

UNIT 2 ONLY

THIS ICCN WAS PREPARED TO REVISE ICCN C-1 TO REFLECT THE FOLLOWING CHANGES:

- DELETION OF TRANSDUCER TDV FROM VOLTAGE TRANSFORMER BURDEN CALCULATION. TRANSDUCERS TDV FOR CONTROL ROOM VOLTMETER 2EI-1662 AND TDV1 FOR CFMS INPUT ARE CURRENTLY CONNECTED TO THE SAME SET OF VOLTAGE TRANSFORMERS. THIS DESIGN COULD CAUSE NO CLASS 1E 4.16 KV BUS VOLTAGE INDICATION AT THE CONTROL ROOM DURING A FAILURE OF THE VOLTAGE TRANSFORMER. THEREFORE, TRANSDUCER TDV WILL BE MOVED TO OTHER SET OF VOLTAGE TRANSFORMERS.
- ADDITION OF THE JUSTIFICATIONS FOR THE TIME DELAY OF 135 SECONDS WHICH WILL BE LISTED IN THE TECHNICAL SPECIFICATION FOR SUSTAINED DEGRADED VOLTAGE SIGNAL WITHOUT SIAS.

THIS ICCN REPLACES PAGES 33, 34, 38, 39, 40, AND 52 OF ICCN C-1 AS FOLLOW:

ICCN C-1 PAGE NO	CORRESPONDING ICCN C-3 PAGE NO
33	2
34	3
38	4
39	5
40	6
52	7

INITIATING DOCUMENT (NCR, SPR, OTHER) MMP # 2&3 2060.00SE Rev. 0

2. OTHER AFFECTED DOCUMENTS (CHECK AS APPLICABLE FOR CCN ONLY):

[ ] YES [X] NO OTHER AFFECTED DOCUMENTS EXIST AND ARE IDENTIFIED ON ATTACHED FORM 26-503.

3. APPROVAL: DISCIPLINE/ESC: NEDO / ELECTRICAL

J. KIM/JK 51207 — ORIGINATOR(Print name/initial)PAX — ashating — GS(Signature) — OTHER(Signature)

R. CABILING / RC 51148 — IRE(Print name/initial)PAX — 9/13/93 — NES&L DM(Signature)

4. ASSIGNED SUPPLEMENT ALPHA DESIGNATOR:
CONVERSION TO CCN DATE

SCE CDM-SONGS

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE
	J. Kim JC	09/02/93	R. Cabiling	09/02/93					

$B_{CA} = 0$ since there are no loads connected across this phase. The total burden is then the sum of the burdens across the other two phases B_{AB} and B_{BC} (refer to reference 6.5 & Attachment 9.4)

$$B_{AB} = B_{TDV1} + B_{DFR} + B_{127D1} + B_{127F1} + B_{127R1+EXT\ RES}$$

where:

$B_{TDV1} = 2\ VA\ \angle 0°$ (refer to para. 3.3)
$B_{DFR} = 0.288\ VA\ \angle 0°$ (reference 6.7)
$B_{127D1} = 0.5\ VA\ \angle 0°$ (reference 6.8)
$B_{127F1} = 2.4\ VA\ \angle 73°$ lagging (reference 6.9)
$B_{127R1} = 17\ VA\ \angle 27°$ lagging (reference 6.10)

$B_{127R1\text{-}IMPEDANCE} = (120V^2 / (17\ VA))\ \angle 27° = 754.7\Omega + j384.5\Omega$ @ 120V
$B_{127R1+EXT\ RES} = 754.7\Omega + j384.5\Omega + 106\Omega = 860.7\Omega + j384.5\Omega$ (see note below)
$B_{127R1+EXT\ RES} = (120\ V)^2 / (860 + j384.5)\Omega = 15.3\ \angle 24.1°$ @ 120V

$$B_{AB} = 2+0.288+0.5+(0.7+j2.29)+(13.96+j6.25) = 17.448+j8.54$$

Note: The 106Ω external resistor in series with the 127R residual relays has been included in the calculation of overall burden (refer to ref. 6.17). In addition, the cable impedance of the Data Acquisition Unit is conservatively considered negligible since adding the cable impedance would reduce the overall burden.

$$B_{BC} = B_{127D2} + B_{127F2} + B_{127R2+EXT\ RES} + B_{SYNCH}$$

where:

$B_{127D2} = 0.5\ VA\ \angle 0°$ (reference 6.8)
$B_{127F2} = 2.4\ VA\ \angle 73°$ lagging (reference 6.9)
$B_{127R2} = 17\ VA\ \angle 27°$ lagging (reference 6.10)
$B_{127R2+EXT\ RES} = 15.3\ VA\ \angle 24.1°$

The burden caused by the synchroscope circuit, B_{SYNCH}, comes from voltage transducers, frequency transducers, and the synchroscopes. The synchroscope circuit is broken into two parts, the incoming channel and the running channel. Since the PTs, on the undervoltage circuit, can be connected to either of the channels, incoming or running, it is necessary to determine the channel with the largest burden.

There is an equivalent number of transducers on either channel. However, the synchroscopes create more burden on the incoming channel than the running channel. The incoming channel is, therefore, conservatively used as the limiting case for greatest circuit burden.

The following instruments are fed on the incoming channel (Ref. 6.11 and 6.12):

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE
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Instrument ID	Function	Manufacturer	Model
2EY-1627B	Voltage Transducer	Scientific Columbus	VT110A2
2/3 EY-1627B	Voltage Transducer	Scientific Columbus	VT110A2
3EY-1627B	Voltage Transducer	Scientific Columbus	VT110A2
2SY-1627B	Freq Transducer	Scientific Columbus	6284A
2/3 SY-1627B	Freq Transducer	Scientific Columbus	6284A
3SY-1627B	Freq Transducer	Scientific Columbus	6284A
2SI-1627C	Synchroscope	General Electric	AB-16 50-120-452
2/3 SI-1627A	Synchroscope	General Electric	AB-16 50-120-452
2/3 SI-1627B	Synchroscope	General Electric	AB-16 50-120-452
3SI-1627C	Synchroscope	General Electric	AB-16 50-120-452

Therefore:

$B_{SYNCH} = (3 \times B_{VOLT\ TRANS}) + (3 \times B_{FREQ\ TRANS}) + (4 \times B_{SYNCHS})$

where:

$B_{VOLT.\ TRANS.} = 2.5\ VA\ \angle 0°$ (Attachment 9.3)
$B_{FREQ.\ TRANS.} = 4\ VA\ \angle 0°$ (Attachment 9.3)
$B_{SYNCHS} = 4.2\ VA\ \angle 33.9$ (Attachment 9.3)

$B_{SYNCH} = 3x2.5\ VA + 3x4\ VA + 4x4.2\ VA\ \angle 33.9 = 33.44 + j9.37\ VA$

$B_{BC} = 0.5 + 2.4\ \angle 73° + 15.3\ \angle 24.1° + 33.44 + j9.37\ VA = 48.11 + j17.912\ VA$

$B_T = B_{AB} + B_{BC}$
$= 17.448 + j8.54 + 48.11 + j17.912 = 65.558 + j26.452 = 70.69\ \angle 21.97°$

Since the burden is less than 129.9 VA, the PT inaccuracy of ±0.3% is adequate for use in this calculation.

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE
	J. Kim JC	09/02/93	R. Cabiling	09/02/93					

critical on motors because they will draw excessive currents under low voltage condition.

For 134.2 seconds (2.2 seconds of time delay for 27N relay and 120+12 seconds of time delay for 162D relay) after a degraded voltage condition without SIAS, the new 27 N relay may not be able to protect motors from the short time degraded voltage condition. However, the existing CV-2 relays will provide motor protection under these circumstances.

8.5.3.2.2 NEMA Standard MG1 (Reference 6.22) recommends that the thermal protector be specified to limit the combination of motor and protector to an ultimate trip current not exceeding 170%, 156%, and 140% of motor full load current rating where full load current is not exceeding 9 A, between 9.1 to 20 A, and above 20 A, respectively. Motors are manufactured per NEMA Standard MG1.

SONGS Units 2&3 QC II motors have been procured to operate at ±10% rated voltage continuously and are able to withstand voltage drops as low as 75% of rated voltage for up to 15 seconds (reference 6.19).

ANSI Standard C37.96 (reference 6.23) recommends that the time-overcurrent pickup be set at 125% of full load current.

Calculations E4C-098 (reference 6.24) and E4C-099 (reference 6.25) show that time-overcurrent relays for motors are set at 125 to 140 % of motor full load current.

The 125% of full load current is equivalent to a motor current at 80% of rated voltage. This means that the motor can be operated at 80% of rated voltage for 140 seconds, which is operating time range of Westinghouse CO-5 relay, without damage.

Based on data above, if the CV-2 relay can provide motor protection at 75% to 80% of rated motor voltage, the nominal time delay of 120 seconds for the timing relay 162D-1, 162D-2, 162D-3 & 162D-4 is considered adequate.

8.5.3.2.3 4.16 KV motor

As shown in paragraph 8.4.1, the CV-2 relay (with 105 V tap and time dial #1) will operate within 5 seconds at 75% of the rated motor voltage.

The voltage at the CV-2 relay corresponding to 80% of 4.16 KV motor voltage:

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	J. Kim JK	09/02/93	R. Cabiling	09/02/93					

V_{relay} = (0.80 x rated motor voltage) / PT ratio

= (0.80 x 4160 V) / 35

= 95.09 V

The voltage drop between 4.16 KV bus and a motor is considered negligible.

Considering Relay circuit inaccuracy:

$V_{relay\ min.}$ = 95.09 V x 0.967 = 91.95 V

$V_{relay\ max.}$ = 95.09 V x 1.033 = 98.23 V

These voltages correspond to 87.5% and 93.35% of the existing CV-2 relay tap setting (105 V), respectively. The existing relay (with 105 V tap and time dial #1) will operate within 8 seconds at these voltages (refer to Attachment 9.7).

Therefore, the CV-2 relay will provide protection to 4.16 KV motors at 75% to 80% of rated motor voltage and the time delay of 134.2 seconds after a degraded voltage condition without SIAS is considered acceptable.

8.5.3.2.4 460 V motor

As shown in paragraph 8.4.2, the CV-2 relay (with 105 V tap and time dial #1) will operate within 8 seconds at 75% of the rated motor voltage.

The voltage at the CV-2 relay corresponding to 80% of 460 V motor voltage:

V_{relay} = [0.80x460 V x 1.03x(4160V/480V)X(1.00124/0.94523)]/35

= 99.41 V

* A voltage drop of 3% in the motor feeder cable was considered.

** The voltage drop across the loadcenter transformer was considered per the voltage ratio shown in paragraph 8.3.2.

Considering Relay circuit inaccuracy:

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE
	J. Kim JC	09/02/93	R. Cabiling	09/02/93					

$V_{relay\ min.} = 99.41\ V \times 0.967 = 96.13\ V$

$V_{relay\ max.} = 99.41\ V \times 1.033 = 102.69\ V$

These voltages correspond to 91.55% and 97.8% of the existing CV-2 relay tap setting (105 V), respectively. The existing relay (with 105 V tap and time dial #1) will operate in approximately 15 seconds at these voltages (refer to Attachment 9.7).

Therefore, the CV-2 relay will provide protection to 460 V motors at 75% to 80% of rated motor voltage and the time delay of 134.2 seconds after a degraded voltage condition without SIAS is considered acceptable.

8.6 Impact on the first and second load group motors due to the minimum post trip transient of 200 KV in the switchyard

8.6.1 Since motor starting impedance is constant impedance, motor starting current is proportional to motor terminal voltage. Therefore, the starting current of the motor with the minimum post trip transient of 200 KV in the switchyard must be less than its rated starting current. However, the motor starting time with the minimum post trip transient of 200 KV in the switchyard is longer than the motor starting time with the rated voltage as shown in paragraph 4.1.2.

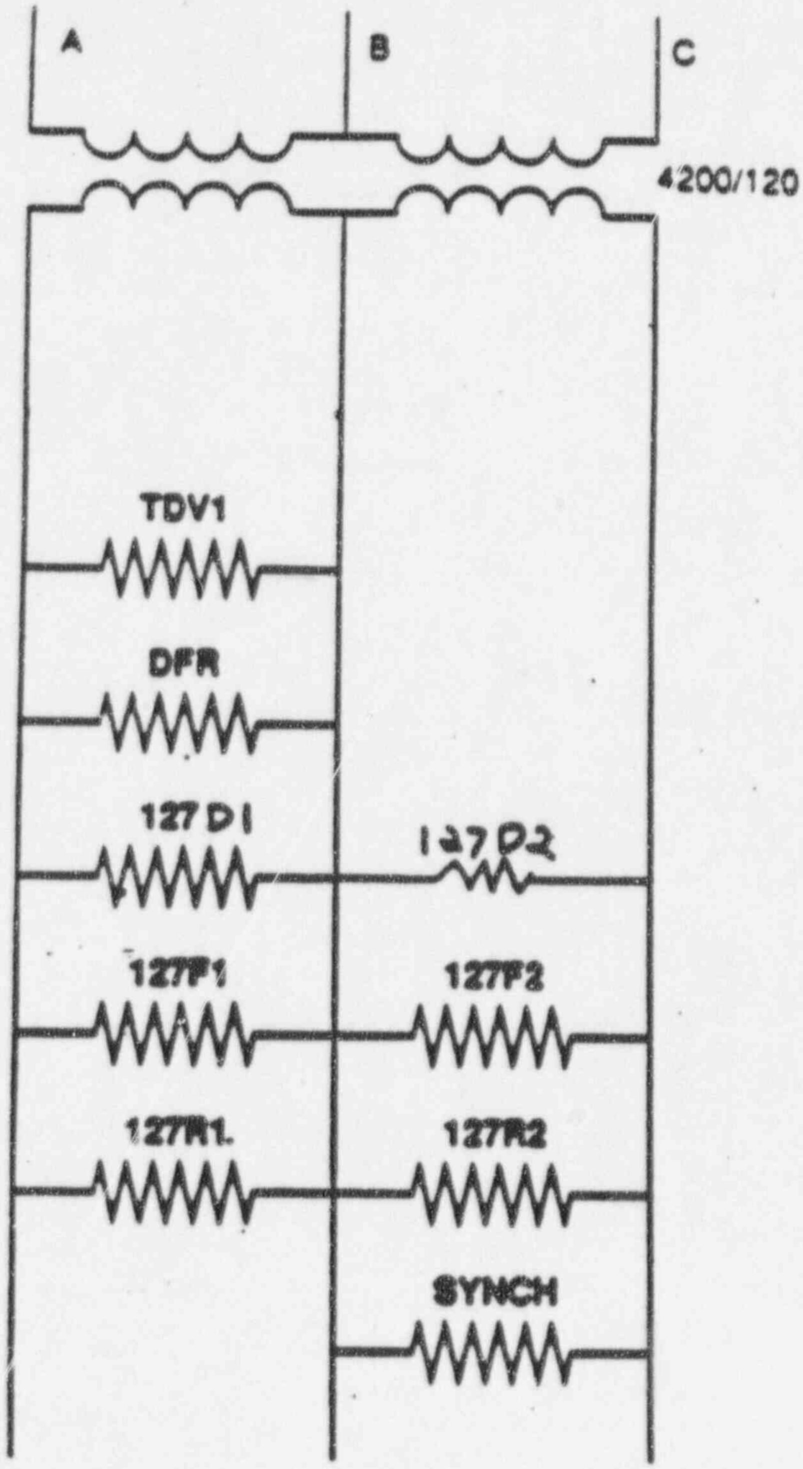
If the trip times of the relays or circuit breakers at the rated locked rotor currents of the associated motors are less than the motor starting times listed in paragraph 4.1.2, it is conservatively considered that the motor starting current with the minimum post trip transient SWYD voltage of 200 KV will not cause the lockout of the associated feeder breakers of the first and second load group motors.

ATTACHMENT 9.4

Sheet______

CALCULATION NO. E4C-098 REV. 0 ~~ICCN C-2~~ FC 7/13/93

Potential Transformer Burden



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INTERIM CALCULATION CHANGE NOTICE (ICCN)/ ~~CALCULATION CHANGE NOTICE (CCN)~~	BASE CALC. REV. 0	UNITS 2	CCN CONVERSION: CCN NO. CCN-		CALC. REV.
	CALCULATION SUBJECT: 4 KV SWGR PROTECTIVE RELAY SETTING CALCULATION				
CALCULATION CROSS-INDEX [X] New/Updated Index Included [ ] Existing Index is Complete	ENGINEERING SYSTEM NUMBER/PRIMARY STATION SYSTEM DESIGNATOR 1804 / PBA/PBB			Q-CLASS II	
1. BRIEF DESCRIPTION OF ICCN/CCN:	CONTROLLED PROGRAM OR DATABASE IN ACCORDANCE WITH NESAL 43-6-1 [ ] PROGRAM [ ] DATABASE		PROGRAM/DATABASE NAME(S) [ ] ALSO LISTED BELOW	VERSION/RELEASE NO.S	

UNIT 2 ONLY

THIS ICCN PROVIDES THE BASIS FOR THE TECHNICAL SPECIFICATION SURVEILLANCE SETPOINTS AND THE RELAY SETTINGS SPECIFIED IN ESL DOCUMENT 90042 IDCN S-15 PREPARED IN SUPPORT OF MMP 2 & 3-2060.00SE.

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INITIATING DOCUMENT (NCR, SPR, OTHER) MMP # 2&3-2060.00SE Rev. 0

2. OTHER AFFECTED DOCUMENTS (CHECK AS APPLICABLE FOR CCN ONLY):

[ ] YES [X] NO OTHER AFFECTED DOCUMENTS EXIST AND ARE IDENTIFIED ON ATTACHED FORM 26-503.

3. APPROVAL: DISCIPLINE/ESC: NEDO / ELECTRICAL

J. KIM/JK 51207 — [signature]
ORIGINATOR(Print name/initial)PAX — GS(Signature)

R. CABILING/[initials] 51148 — [signature] 8/26/93
IRE(Print name/initial)PAX — NESAL GM(Signature) — OTHER(Signature)

4. ASSIGNED SUPPLEMENT ALPHA DESIGNATOR:
CONVERSION TO CCN DATE

SCE CDM-SONGS

SCE 26-122-1 REV. 9/91

CALCULATION CROSS-INDEX

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	CCN CONVERSION: CCN NO. CCN--

Calculation No. E4C-098 Rev. 0 **Sheet No.**

Calc. rev. number and responsible supervisor initials and date	INPUTS These interfacing calculations and/or documents provide input to the subject calculation, and if revised may require revision of the subject calculation		OUTPUTS Results and conclusions of the subject calculation are used in these interfacing calculations and/or documents.		Does the output interface calc/document require revision? YES/NO?	Identify output interface calc/document CCN or DCN TCN/Rev. or FIDCN
	Calc/Document No.	Rev. No.	Calc/Document No.	Rev. No.		
0 /	CALC. E4C-017	11	CALC. E4C-082	1	YES	ICCN C-7
	CALC. E4C-050	12	CALC. E4C-090	1	YES	ICCN C-7
	CALC. E4C-082 ICCN C-7	1	TECHNICAL SPECIFICATION	-	YES	MMP 2&3 2060.00SE
	CALC. E4C-090 ICCN C-7	1	DOCUMENT 90042	3	YES	IDCN S-15
	Drawing 30220	8				
	Drawing 30229	10				
	Drawing 31468	4				
	DBD-SO23-120	0				
	SPECIFICATION S023-302-3-12	1				
	DOCUMENT 90042	3				
	SCE STD JS-123-103C	0				
	V/P SO23-302-2-84	4				
	V/P SO23-302-2-85	3				
	V/P SO23-306-6-16	1				
	V/P SO23-503-13	0				

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE
	J. Kim / B. Basu	08/13/93	R. Cabiling	08/13/93					

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	J. Kim / B. Bask	08/13/93	R. Cabiling	08/13/93					

1 PURPOSE

1.1 Purpose

The purpose of this calculation is to determine the optimum voltage and time delay setpoints for the degraded undervoltage protection scheme which will detect a degraded voltage condition in the 4.16 KV Class 1E buses corresponding to the grid voltage below the currently analyzed value of 218 KV.

In support of MMP # 2 & 3-2060.00SE, this calculation will:

- Determine ABB 27N undervoltage relay and time delay relay setpoints in conjunction with the degraded voltage protection scheme.
- Provide the bases for the Technical Specifications trip setpoints with minimum and maximum limits and allowable values for the second level undervoltage protection sensors.
- Verify the adequacy of the existing CV-2 undervoltage relay setting.

1.2 Background

1.2.1 With the permanent shutdown of Unit 1, a SONGS grid stability and voltage study (reference 6.26) performed by SCE System Planning and Operations Department concluded that the voltage in the switchyard may fall below the acceptable level of 218 KV under the following conditions:

a. Either SONGS Unit 2 or 3 is in an outage situation,

b. SCE system load exceeds specified thresholds (typical of heavy system loading during hot summer day afternoon),

c. Loss of a certain critical transmission line or lines due to a single event (e.g. loss of a transmission tower),

d. and a design basis accident or unit trip.

The 218 KV is the minimum switchyard voltage that is required to provide adequate voltages to the accident mitigation loads (refer to reference 6.4).

Under the above scenario following a Safety Injection Actuation Signal (SIAS), the turbine-generator trip can cause voltage degradation at the SONGS switchyard (reference 6.26). With the existing design, the unit experiencing a trip under this event scenario will attempt to transfer its 4.16 KV Class 1E buses to the companion unit via the bus-tie breaker. However, because the switchyard voltage for both units would be in a degraded condition, the alternate preferred power source would be unavailable and the unit would need to transfer its 4.16 KV Class 1E buses to the standby power source, which has started on receipt upon the SIAS.

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If the 4.16 KV Class 1E buses do not go directly to the standby power source during a SIAS with degraded voltage scenario, it is likely that the approximately 10 seconds allowed by the Updated Final Safety Analysis Report (UFSAR) Chapter 15 safety analyses will be exceeded before standby power becomes available to the safety related loads.

1.2.2 MMP 2&3-2060.00SE will install a set of new undervoltage relays to provide a scheme which will ensure that adequate voltage is maintained at the Class 1E buses under the conditions stated above. This new scheme will have the capability to transfer each 4.16 KV Class 1E bus directly to the standby power source following a SIAS. In addition, a Loss Of Voltage Signal (LOVS) following a SIAS will also transfer each 4.16 KV Class 1E bus directly to the standby power source instead of initially seeking the alternate preferred power source from the companion Unit as in the existing design.

1.2.3 The existing LOVS trip function without SIAS will be unaffected by this change. With no SIAS present the existing CV-2 undervoltage relays 127F-1, 127F-2, 127F-3, and 127F-4 will still provide the LOVS trip upon a complete loss of voltage. This signal will still connect the affected unit to the alternate preferred power source if it is available, and then to the standby power if the alternate preferred power source is unavailable.

1.2.4 The degraded voltage condition will be detected by new ABB 27N undervoltage relays 127D-1, 127D-2, 127D-3, and 127D-4. These relays in conjunction with timing relays (see Attachment 9.5) will initiate a degraded grid voltage signal with SIAS (DGVSS), which will immediately transfer the 4.16 KV Class 1E buses to the standby power source, during the first automatic load sequencing cycle only. If no degraded voltage is detected during the first automatic load sequencing cycle, timing relays will ensure that during subsequent load sequencing cycles no DGVSS will be generated. Chapter 15 of the Updated Final Safety Analysis Report (UFSAR) analyzed 10 seconds allowable limit from a design basis accident before standby power is available to the safety related loads.

In addition, the same undervoltage relays 127D-1, 127D-2, 127D-3, and 127D-4 will also be used for sustained degraded voltage protection without SIAS, and annunciation of sustained degraded voltage condition.

This application will comply with the intent of the NRC Branch Technical Position PSB-1 paragraph B1.

1.3 Acceptance Criteria

1.3.1 Degraded Voltage Protection (refer to paragraph 4.12)

1.3.1.1 The selection of undervoltage 127D relay setpoint shall be determined from an analysis of the voltage requirements of the Class 1E loads at all onsite system distribution levels.

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1.3.1.2 The first time delay should be of a duration that established the existence of a sustained degraded voltage condition (i.e., longer than a motor starting transient).

1.3.1.3 The second time delay should be of a limited duration such that the permanently connected Class 1E loads will not be damaged. Bases and justification must be provided in support of the actual delay chosen.

1.3.2 Loss of Voltage Protection (refer to paragraph 5.4)

In order to protect motors from short time voltage dips but avoid a nuisance operation of the relay, the relay should be set as follows:

1.3.2.1 Relays shall operate at a voltage dip for a short time period such that relay operation occurs within 15 seconds at 75% of rated motor voltage.

1.3.2.2 The relay should operate in 1 second to initiate automatic bus transfer following a total loss of voltage.

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	J. Kim / B. Basu	08/13/93	R. Cabilling	08/13/93					

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REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE
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2 RESULTS/CONCLUSIONS and RECOMMENDATIONS

2.1 Results/Conclusions

2.1.1 27N relays 127D-1, 127D-2, 127D-3, & 127D-4 (refer to paragraphs 8.3 & 8.5)

Relay with harmonic filter

Voltage settings: Reset (pickup) - 121.40 V
Dropout - 120.80 V (99.5% of reset)

Time delay setting: 2 seconds ± 10% (0.2 second)

The relay settings are based on the System Dynamic Voltage Analysis (reference 6.3) and System Steady State Voltage Analysis (reference 6.4). Therefore, these setpoints meet acceptance criterion 1.3.1.1. Time delay setting of 2 seconds will ensure that the relay will not cycle unnecessarily due to system transient.

The relay, considering relay circuit tolerance, will operate within the following voltage ranges:

Relay with harmonic filter (tolerance ±1.11%)

	Relay Setting(V)	4160 V bus voltage volts	P. U.
Maximum reset	122.75	4296.25	1.033
Maximum dropout	122.14	4274.90	1.028
Nominal reset	121.40	4249.00	1.021
Nominal dropout	120.80	4228.00	1.016
Minimum reset	120.05	4201.75	1.010
Minimum dropout	119.45	4180.75	1.005

2.1.2 Timing relay settings

2.1.2.1 Timing relays 162S-1, 162S-2, 162S-3, & 162S-4 (refer to para. 8.5.2)

Time delay setting: 4.3 seconds ± 4.5% (0.19 second)

Since the Degraded Grid Voltage Signal with a SIAS (DGVSS) should be generated during the first automatic load sequencing cycle (refer to paragraph 1.2.4) and the motor starting transient voltages are stabilized within 4 seconds, a time delay of 4.3 seconds meets acceptance criterion 1.3.1.2.

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2.1.2.2 Timing relays 162D-1, 162D-2, 162D-3, & 162D-4 (refer to para.8.5.3)

Time delay setting: 120 seconds ± 10% (12 seconds)

Since the Sustained Degraded Voltage Signal (SDVS) will be used for protection of the permanently connected Class 1E loads from sustained degraded voltage, this timing relay may be set to operate after the automatic load sequencing operations are completed.

A time delay of 120 seconds is chosen since the automatic load sequencing operations will take 114 seconds (reference 6.18) to complete. The 27N relay in conjunction with this timing relay will generate a sustained degraded voltage signal in 120 seconds after a degraded voltage condition occurs. The 27N relay may not protect the motors from this short time degraded voltage conditions.

However, the existing CV-2 relays will protect motors from a degraded voltage as shown in paragraph 8.5.3.2. Therefore, this time delay meets acceptance criterion 1.3.1.3.

2.1.2.3 Timing Relays 162T-1, 162T-2, 162T-3, & 162T-4 (refer to para. 5.6)

Time delay setting: 1.5 seconds ± 10% (0.15 second)

A time delay of 1.5 seconds is chosen to disable the degraded voltage detection circuit before the start of the second automatic load sequencing, since the DGVSS should be generated during the first automatic load sequencing, and to provide a window of sufficient duration so that if the voltage at the bus drops below the 127D relay setpoint up to 1 second prior to the start of the voltage detection window (4.11 seconds) as 2.0 seconds delay is provided for 127D relay to establish a degraded voltage condition before voltage detection window closes (refer to paragraph 5.6).

2.1.2.4 Alarm Relays 162A

Time delay setting: 5 seconds ± 10% (0.5 second)

Timing of 5 seconds was selected to provide alarm within a total of approximately 7 seconds (5 seconds for 162A + 2 seconds for 127D-1,2,3, & 4).

2.1.3 CV-2 Relays 127F-1, 127F-2, 127F-3, & 127F-4 (refer to para. 8.4)

Voltage setting: 105 V ± 3.3%

Time dial: # 1 with operating time tolerance of ± 5%

CV-2 relay with 105 V tap and time dial # 1 will operate within 5 seconds at 75% of 4.16 KV

motor rated voltage at 4.16 KV bus and at a voltage corresponding to 75% of 460 V rated motor voltage at 480 V bus. The relay operating time of 5 second at 75% of rated motor voltage meets acceptance criterion 1.3.2.1.

This relay with 105 V tap and time dial # 1 will operate in 1 second following a total loss of voltage. This relay operating time of 1 second meets acceptance criterion 1.3.2.2.

2.2 Recommendations

2.2.1 The following relay settings are recommended:

Relay	Setting	Tolerance	Remarks
27N relay (127D-1,127D-2, 127D-3, & 127D-4)	Reset (pickup) - 121.40V	± 1.11% (1.35 V)	Relay with harmonic filter
	Dropout - 120.80 V (99.5% of reset)	± 1.11% (1.35 V)	
	Time delay - 2 seconds	± 10% (0.2 sec.)	
CV-2 relay (127F-1,127F-2, 127F-3, & 127F-4)	Voltage tap - 105 V	± 3.3% (3.465 V)	
	Time dial - # 1	± 5%	
Timing relay (162S-1, 162S-2, 162S-3, & 162S-4)	Time delay - 4.3 seconds	± 4.5% (0.19 second)	
Timing relay (162D-1, 162D-2, 162D-3, & 162D-4)	Time delay - 120 seconds	± 10% (12 seconds)	
- Timing relay (162T-1, 162T-2, 162T-3, & 162T-4)	Time delay - 1.5 seconds	± 10% (0.15 second)	
Timing relay 162A	Time delay - 5 seconds	± 10% (0.5 second)	

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2.2.2 In order to limit 27N relay tolerance within 1.11%, the relay calibration tolerances should be limited as follows:

2.2.2.1 Instrument

The voltmeter used for calibration of the relay shall be a Fluke 45 Digital Multimeter or equal

Reference accuracy:	±0.2% + 10 digits
Full scale:	300 VAC, 5 digits
Minimum gradation	0.01 V

2.2.2.2 Calibration procedure

The setting tolerance when setting relay trip unit voltage shall not exceed ± 0.1 V.

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3 ASSUMPTIONS

3.1 A 3% voltage drop in the motor feeder cables is assumed for determining the minimum voltage limits at the 480 V MCC buses that would ensure 90% voltage at the motor terminals (Ref. 6.4). Consistent with the assumptions used in calculation E4C-090, the minimum voltage at the MCC bus is thus 93% (460 V x 0.93 = 427.8 V) of the motor rated voltage.

3.2 The voltage drops in the 4160 V motor feeder cables are assumed to be negligible since calculation E4C-090 (reference 6.4) shows that the voltage drops in the motor feeder cables is 2 to 7 volts which is less than 2% of motor rated voltage.

3.3 The burden of voltage transducers TDV and TDV1 which are Westinghouse Type VE2-841, Style 606B299A09 (references 6.14 & 6.15) was assumed to be 2 VA based on Westinghouse Description Bulletin 43-251 for Edgewise Switchboard Instrument.

3.4 The setting tolerance used for setting the trip unit voltage is assumed to be ±0.1 V.

3.5 The voltmeter used for calibration of the relay is assumed to be a Fluke 45 Digital Multimeter. It is also assumed that this voltmeter has been set to a user selected reading rate of 5 (medium) reading per second.

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4 DESIGN INPUT

4.1 Calculation E4C-082 ICCN C-7 (reference 6.3)

4.1.1 Case IA of this calculation determines the following 4160 V and 480 V bus voltages during the automatic sequencing of ESF loads immediately following an accident:

Voltages based on 218 KV SWYD voltage

Bus	Voltage (PU) @4.3 Sec	Voltage (PU) post accident steady state
2A04	1.01	1.00
2A06	1.01	1.00
2B04	0.96	0.93
2B06	0.96	0.94

Voltages based on 200 KV SWYD voltage

Bus	Time (Sec)	Voltage (PU)
2A04	0.00	0.832
	1.50	0.870
	5.00	0.862
	6.14	0.875
2A06	0.00	0.841
	1.50	0.881
	5.00	0.871
	6.14	0.884
2B04	0.00	0.614
	1.54	0.693
	5.00	0.762
	5.00	0.696
	6.14	0.724
2B06	0.00	0.633
	1.54	0.715
	5.00	0.776
	5.00	0.703
	6.14	0.732

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4.1.2 This calculation states that the minimum post trip transient SWYD voltage of 200 KV could supply power to 4.16 KV Class 1E buses for up to 6.14 seconds following a major disturbance in the grid due to the delays of the timing relays and 27N relay (refer to Attachment 9.5), therefore, motors in first (t=0 second) and the second (t=5 seconds) load groups may start with this minimum post trip transient voltage before the degraded voltage scheme transfers the ESF buses to their corresponding standby power source.

Case IA of this calculation includes a dynamic simulation for the first and second load groups with a switchyard voltage of 200 KV. The dynamic simulation provides the following motor starting times of the first and second load groups with switchyard voltages of 200 KV and 218 KV:

First load group (t=0 second)

Bus	Load	Approx. time(sec) w/218 KV	Approx. time(sec) w/200 KV
2A04	2P025-A	0.67	0.93
	2P017	1.0	1.67
	2P307	0.67	0.83
2A06	2P025-B	0.67	0.93
	2P019	1.0	1.67
	2P114	0.67	0.83
2B04	2P191-A	0.67	1.33
	2A071	6	8.67
	2E399	3	5.33
	2E401	3	5.33
	2P190	0.67	1.33
	2A074	6	8.67
	2P009	0.67	1.33
	2P162	0.67	1.33
2B06	2P191-B	0.67	1.33
	2A072	6	8.33
	2E400	3	5
	2E402	3.33	5.66
	2P192	0.67	1.33
	2A073	6	8.33
	2P010	0.67	1.33
	2P160	0.67	1

Second load group (t=5 seconds)

Bus	Load	Approx. time(sec) w/218 KV	Approx. time(sec) w/200 KV	Remarks
2A04	2P015	0.67	1	
2A06	2P016	0.67	1	
2B04	2E418	5	6.67	See Note
2B06	2E419	5	6.67	See Note

Note: The switchyard voltage of 200 KV will last only 1.14 seconds because the degraded voltage scheme will transfer the ESF bus to the corresponding standby power source.

4.2 Calculation E4C-090 ICCN C-7 (reference 6.4)

Case A14 of this calculation shows the following 4160 V and 480 V bus steady state post accident voltages:

Voltages based on 218 KV SWYD voltage

Bus	Voltage (PU)
2A04	1.00124
2A06	1.00140
2B04	0.94523
2B06	0.94630

4.3 Voltage transformer at 4.16 KV Class 1E SWGRs (reference 6.14)

MFR:	GE
Model:	JVM-3
Style:	643X94
Voltage ratio:	4200-120 V, 35/1
Frequency:	60 Hz
Accuracy class:	±0.3 W, X, M, Y, 1.2 Z @ 120 V

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4.4 Undervoltage Relay (reference 6.8)

Device No.:	127D-1, 2, 3, 4
Manufacturer:	ABB
Type:	27N
Catalog #:	411T5375
Pickup range:	70-120 V
Dropout:	70-99% of pickup
Dropout delay:	2-20 seconds
Reset time:	Less than 2 cycles
Control voltage:	100-140 V DC
Temperature range:	-30 to +70° C
Burden:	0.5 VA at 120 V

Repeatability tolerance: Without harmonic filter

a. @ constant temperature & control voltage - ±0.1%
b. For allowable dc control power range (100-140V) - ±0.1%
c. Temp. range
   -20 to +55° C - ±0.4%
   0 to +40° C - ±0.2%
   -20 to +70° C - ±0.7%

With harmonic filter

a. @ constant temperature & control voltage - ±0.1%
b. For allowable dc control power range (100-140V) - ±0.1%
c. Temp. range
   0 to +55° C - ±0.75%
   +10 to +40° C - ±0.4%
   -20 to +70° C - ±1.5%

Notes:

1. Difference between pickup and dropout can be set as low as 0.5 %
2. The three repeatability tolerances are cumulative. The repeatability at constant temperature and constant control voltage is random tolerance. The repeatability over allowable dc control power range and over temperature range are non-random tolerances (refer to Attachment 9.2)

4.5 Existing undervoltage relay at 4.16 KV Class 1E SWGR (references 6.9 & 6.20)

Device No:	127F-1, 2, 3, & 4
MFR:	Westinghouse
Type:	CV-2
Style No:	1875516
Volt Range:	55-140V

Setting: 105 V tap, 1 second at 120 V to 0 V
Burden: 3.64 VA & 0.34 PF at 105 V tap
4.66 VA & 0.35 PF at 93 V tap
Accuracy: Voltage tap - ±3%
Time curve - ±5%

4.6 Voltmeter calibration data (Attachment 9.1)

Voltmeter: Fluke 45 digital multimeter
Accuracy: ±0.2% + 10 digits
Full scale: 300 V AC
Resolution: 0.01 V

4.7 Time delay relay (Attachment 9.6)

Device No.: 162S-1, 2, 3, & 4
Manufacturer: ABB
Catalog No.: 417T2170
Time delay range: 0.01 - 9.99 seconds

Accuracy: Repeatability - ±0.5 or ±15ms whichever is greater.
Variation of timing with change in ambient temp. - ±2% or ±20ms whichever is greater for -20°C to +70°C

Variation of timing with change in control voltage - ±2% or ±20ms whichever is greater for -20% to +10% voltage variation.

4.8 Time delay relay (Attachment 9.6)

Device No.: 162T-1, 2, 3, & 4
Manufacturer: Amerace Corp.
Catalog No.: Agastat E7012PB
Time delay range: 0.5 - 5 seconds
Accuracy: ±10%

4.9 Time delay relay (Attachment 9.6)

Device No.: 162D-1, 2, 3, & 4
Manufacturer: Amerace Corp.
Catalog No.: Agastat E7012PKL
Time delay range: 1-300 seconds
Accuracy: ±10%

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4.10 Time delay relay (Attachment 9.6)

Device No.:	162A
Manufacturer:	Amerace Corp.
Catalog No.:	Agastat E7012PC
Time delay range:	1.5-15 seconds
Accuracy:	±10%

4.11 Voltage requirements for motors

SONGS Units 2&3 QC II motors have been procured to operate at ±10% rated voltage continuously and are able to withstand voltage drops as low as 75% of rated voltage for up to 15 seconds (reference 6.19).

4.16 KV motor

Continuous:	4160 V ±10%
15 seconds:	3120 V (75% of 4160 V)

460 V motor

Continuous:	460 V ±10%
15 seconds:	345 V (75% of 460 V)

4.12 The NRC Branch Technical Position PSB-1 paragraph B.1 states:

In addition to the undervoltage scheme provided to detect loss of offsite power at the Class 1E buses, a second level of undervoltage protection with a time delay should also be provided to protect the Class 1E equipment; this second level of undervoltage protection shall satisfy the following criteria:

a) The selection of undervoltage and time delay setpoints shall be determined from an analysis of the voltage requirements of the Class 1E loads at all onsite system distribution levels.

b) Two separate time delays shall be selected for the second level of undervoltage protection based on the following conditions:

1) The first time delay should be of a duration that established the existence of a sustained degraded voltage condition (i.e., longer than a motor starting transient). Following this delay, an alarm in the control room should alert the operator to the degraded condition. The subsequent occurrence of a safety injection actuation signal (SIAS) should immediately separate the Class 1E distribution system from the offsite power system.

2) The second time delay should be of a limited duration such that the permanently connected Class 1E loads will not be damaged. Following this delay, if the operator has failed to restore adequate voltages, the Class 1E distribution system should be *automatically separated from the offsite power system. Bases and justification must be provided in support of the actual delay chosen.*

c. *The voltage sensors shall be designed to satisfy the applicable requirements derived from IEEE Std 279-1971, "Criteria for Protection Systems for Nuclear Power Generating Stations":*

1) *Class 1E equipment shall be utilized and shall be physically located at the electrically connected to the Class 1E switchgear.*

2) *An independent scheme shall be provided for each division.*

3) *The voltage protection shall include coincidence logic on a per bus basis to preclude spurious trips of the offsite power source.*

4) *The voltage sensors shall automatically initiate the disconnection of offsite power sources whenever the voltage setpoint and time delay limits (cited in item 1.2.2.b above) have been exceeded.*

4 5) *Capability for test and calibration during power operation shall be provided.*

6) *Annunciation must be provided in the control room for any bypasses incorporated in the design.*

d) *The Technical Specifications shall include limiting conditions for operations, surveillance requirements, trip setpoints with minimum and maximum limits, and allowable values for the second level voltage protection sensors and associated time delay devices.*

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5 METHODOLOGY

5.1 General

Based on the results of the dynamic voltage (E4C-082, ICCN C-8) and steady state voltage (E4C-090, ICCN C-8) calculations, in conjunction with the sustained degraded voltage protection scheme,

a. Calculate the total relay circuit tolerance.

b. Determine the pickup and dropout voltage setpoints for the undervoltage relays, considering the relay circuit tolerance.

c. Determine the setpoints for the time delay relays.

5.2 Relay Circuit Tolerance

5.2.1 Analytical methodology

A combination of the Straight Sum and Square Root Sum of the Squares (RSS) methodologies will be utilized per SCE Standard JS-123-103C (reference 6.13) and ANSI S67.04-1988 (reference 6.2). The random elements of uncertainty are combined under the RSS methodology, and any non-random uncertainties are added algebraically (straight-sum) to the RSS result as shown below:

a. Random, independent elements are combined by RSS methodology:

$$U = \pm (W^2 + X^2 + Y^2 + Z^2)^{1/2}$$

Where: W, X, Y, & Z are random, independent elements of uncertainty and U is the total uncertainty.

b. Random, dependent elements are first combined algebraically according to their dependency to form new independent elements. Then, as independent elements, they are combined with other independent elements by RSS methodology as follows:

$$U = \pm [W^2 + X^2 + (Y + Z)^2]^{1/2}$$

Where: Y & Z are random, dependent elements of uncertainty, W, X, and (Y + Z) are random, independent elements of uncertainty, and U is the total uncertainty.

c. Non-random element should be combined algebraically (straight sum) with the results of the RSS computation for random, independent elements.

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$$U = \pm (W^2 + X^2 + Y^2)^{1/2} + Z$$

Where: W, X, & Y are random, independent elements of uncertainty, Z is non-random, and U is the total uncertainty.

5.2.2 Relay circuit tolerance

Calculate the total relay circuit tolerance, considering tolerances of relay, voltage transformer (PT), voltmeter to be used for setting the relay, and voltage setting tolerance used for setting the trip unit voltage.

5.3 27N Relay Voltage Setpoints

5.3.1 Degraded grid voltage signal with SIAS (DGVSS)

Calculations E4C-082 (reference 6.3) and E4C-090 (reference 6.4) determined that the 218 KV switchyard voltage is the voltage required to provide adequate voltage to the accident mitigation loads only if the 4.16 KV Class 1E bus is powered from its own normal preferred power source.

Since the DGVSS should be generated during the first automatic load sequencing cycle (refer to paragraph 1.2.4), obtain voltages of 4.16 KV Class 1E buses 2A04 & 2A06 from calculation E4C-082 System Dynamic Voltages During Design Basis Accident, at 4.3 seconds (refer to Attachment 9.5) during the first automatic load sequencing cycle, based on 218 KV switchyard voltage and normal bus alignment.

The 4.16 KV Class 1E bus voltages corresponding to 218 KV switchyard voltage are considered adequate, therefore, select the relay tap such that the minimum reset (nominal setting - relay tolerance) of the relay is equivalent to highest of the four 4.16 KV bus voltages at 4.3 seconds.

Choose 99.5% of the reset (pickup) voltage as the minimum dropout voltage (nominal dropout voltage - relay tolerance). Verify that this minimum dropout voltage is equal or greater than the post accident steady state voltages.

5.3.2 Sustained degraded voltage signal without SIAS (SDVS)

The same relay used for DGVSS functions, in conjunction with the other timing relay (i.e. 162D1), will generate sustained degraded voltage signal (SDVS). This signal will be utilized for protection of the permanently connected Class 1E loads from sustained degraded voltage in accordance with PSB-1 paragraph B.1.(b)(2).

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5.4 CV-2 Relay Setpoints

In order to protect motors from short time voltage dips but avoid a nuisance operation of the relay, the relay should be set as follows:

5.4.1 The relay should operate at 75% of 4.16 kV bus voltage within 15 seconds to protect motors from short time voltage dips (refer to paragraph 4.11).

5.4.2 The relay should operate at a voltage corresponding to 75% of 460 V at 460 V motor terminals within 15 seconds to protect motors from short time voltage dips (refer to paragraph 4.11).

5.4.3 The relay should operate in 1 second to initiate automatic bus transfer following a total loss of voltage (see references 6.5 & 6.6)

5.5 Time Delay Setpoints

5.5.1 First time delay - Timing relays 162S-1, 162S-2, 162S-3, & 162S-4

Time delay of this relay should be of a duration that established the existence of a sustained degraded voltage condition (i.e., longer than motor starting transient) to satisfy the NRC Branch Technical Position PSB-1 paragraph B.1(b)(1), as discussed in paragraph 4.12.

5.5.2 Second time delay - Timing relay 162D-1, 162D-2, 162D-3, & 162D-4

Since SDVS signal will be used for protection of the permanently connected Class 1E loads from sustained degraded voltage, this timing relay may be set to operate after the automatic load sequencing operations are completed.

However, it should be verified that this time delay will not damage Class 1E loads to satisfy the requirements of PSB-1 paragraph B.1.(b)(2), as discussed in paragraph 4.12.

5.6 DGVSS Timing Relays Setpoints

Attachment 9.5, " Logic Diagram, Class 1E 4.16 kV Bus Undervoltage Detection", shows the enhanced undervoltage detection scheme that will be in place once MMP# 2&3 -2060.00SE is installed. Purpose of this scheme was briefly described in paragraph 1.2.

Degraded voltage protection requires that a DGVSS shall be initiated within first load group sequencing time of 5 seconds only. This DGVSS detection scheme is disarmed during subsequent cycles. If the voltage is above the 127D relay setpoint before the start of the second load group all the ESF loads will be sequenced onto the bus irrespective of the bus voltage during the subsequent cycles thus assuring no interruption in the middle of load sequencing. The dynamic voltage calculation shows that if the bus voltage is maintained above 4180V (relay minimum dropout voltage is selected 4180.75 V) all ESF loads will be sequenced as per design.

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The time delay settings of the DGVSS timing relays 162S-1, 162S-2, 162S-3, 162S-4, 162T-1, 162T-2, 162T-3, 162T-4 are selected to comply with the above consideration due to the tolerances associated with these timers, sequencing timing relays, and the response time of the 127D-1, 127D-2, 127D-3, 127D-4 relays.

- Timing relays 162S-1, 162S-2, 162S-3, & 162S-4

  Load group 2 starts at 5 seconds. Sequencing uses agastat relays with ± 0.5 seconds tolerance. As such 162S timing should not exceed 4.5 seconds. The ABB 62T relay has a ± 4.5% tolerance as such use a relay setting of 4.3 seconds. With this setting a DGVSS window could open earliest at 4.11 seconds and latest at 4.49 seconds to allow generation of DGVSS if 127D relay permits. This time delay satisfies PSB-1 paragraph B.1(b)(1) as discussed in paragraph 4.12.

- Timing relays 162T-1, 162T-2, 162T-3, & 162T-4

  The purpose of this timer is to disable this voltage detection circuit before the start of the load group 2. However this must also provide a window of sufficient duration so that if the voltage at the bus drops below the 127D relay setpoint up to 1 second prior to the start of the voltage detection window (4.11 seconds) as 2.0 seconds ± 10% delay is provided for 127D relay to establish a degraded voltage condition before voltage detection window closes. A delay setting of 1.5 seconds is chosen for the closure of this window so that it is not affected by the second load group load starting transients. The time delay tolerance is ± 0.15 second. With this delay in opening the earliest the window could close in 5.46 seconds (4.11 seconds + 1.5 seconds - 0.15 seconds = 5.46 seconds) and the latest the window could close in 6.14 seconds (4.49 seconds + 1.5 seconds + 0.15 seconds = 6.14 seconds).
  This setting of the DGVSS window from 4.11 seconds to 6.14 seconds will detect degraded voltage in the first load group sequence and will not be affected by the subsequent load group ESF load starting transients.

- Alarm Relays 162A

  Timing of 5 seconds was selected to provide alarm within a total of approximately 7 seconds (5 seconds for 162A + 2 seconds for 127D-1,2,3, & 4).

NOTE: DGVSS trips 4.16kV Class 1E source breakers. Since the latest a DGVSS bus trip may be initiated at 6.14 seconds from the initiation of an SIAS all ESF loads shall be analyzed for operation with a degraded voltage condition upto 6.14 seconds.

5.7 Calculation E4C-082 ICCN C-7 (reference 6.3) identified that due to the time delays of timing relays and 27N relays, generation of the DGVSS could be delayed for up to 6.14 seconds, therefore, the minimum post trip transient SWYD voltage of 200 KV could supply power to the 4.16 KV Class 1E buses following a major disturbance in the grid (refer to paragraph 4.1). Motors in first (t=0 second) and the second (t=5 seconds) load groups may start with this minimum post trip

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transient SWYD voltage before the degraded voltage scheme transfers the ESF buses to their corresponding standby power source. Calculation E4C-082 demonstrated the operability of the first and second group motors with the minimum post trip transient of 200 KV in the switchyard.

However, the motor starting with the voltage corresponding to the minimum post trip transient SWYD voltage takes longer time as shown in paragraph 4.1.2. This starting current could trip associated feeder breaker and lock out the breaker before the degraded voltage scheme transfers the ESF buses to their corresponding standby power source.

Verify that the minimum post trip transient SWYD voltage of 200 KV in the switchyard will not cause the lockout of the associated feeder breakers of the first and second load group motors.

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6 REFERENCES

6.1 NRC Branch Technical Position PSB-1, Adequacy of Station Electric Distribution System Voltages

6.2 ANSI S67.04-1988, Setpoint for Nuclear Safety-Related Instrumentation

6.3 E4C-082 Rev. 1, ICCN Nos. C-7 - System Dynamic Voltages During Design Basis Accident.

6.4 E4C-090 Rev. 1, ICCN Nos. C-7 - Auxiliary System Voltage Regulation

6.5 Drawing 30220 Rev. 8, Electrical Auxiliary - 4.16KV Bus

6.6 Drawing 30299 Rev. 10, Electrical Auxiliary - 4.16KV Bus

6.7 SO23-306-6-16, Volume I Digital Fault Recorder System Manual, Section 1.5.5

6.8 Asea Brown Boveri Information Bulletin, IB 7.4.1.7-7 Issue D

6.9 Instruction Manual 41-201.4C, Type CV Voltage Relay, Westinghouse

6.10 Instruction Manual 41-766.4B, Types SVF, SVF-1, SVF-3, SVF-31 Relays, Westinghouse

6.11 SO23-505-13, Bill of Materials - Control Panel Instruments

6.12 Drawing 31468 Rev.4, Synchronizing Potentials

6.13 SCE Standard Number JS-123-103C, Rev. 0 - Instrument Setpoint/Loop Accuracy Calculation Methodology

6.14 SO23-302-2-84-4, Bill of Material - 4 KV SWGR 2A04

6.15 SO23-302-2-85-3, Bill of Material - 4 KV SWGR 2A06

6.16 DBD-SO23-120, Rev.0 - 6.9 KV, 4.16 KV, & 480 V Electrical systems

6.17 Calculation E4C-050, Rev. 12 - Low Voltage Power Circuit Breaker Settings

6.18 Calculation E4C-017 Rev. 11 - 125 V battery DC system sizing.

6.19 Specification SO23-403-12 Rev. 1 - Diesel Driven Electrical Generating sets

6.20 Document 90042 Rev.3 - Q.C. II Electrical St Point List (ESL): Units 2 and 3

6.21 MMP 2&3-2060.00SE - Class 1E Degraded Voltage Protection Scheme Enhancement

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6.22 NEMA Standard MG1 - Motor and Generator

6.23 ANSI Standard C37.96-1988 - AC Motor Protection

6.24 Calculation E4C-098 Rev. 0 - 4 KV SWGR Protective Relay Setting Calculation

6.25 Calculation E4C-099 Rev. 0 - SR 480 V Power Circuit breaker Setting

6.26 Document C930813S6057, dated 8-13-93 - SONGS Grid Stability and Voltage Study prepared by W. D. Conner of System Planning and Operation Department

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7 NOMENCLATURES

DGVSS	Degraded Grid Voltage Signal with SIAS
LOVS	Loss of Voltage Signal
LPSI	Low Pressure Safety Injection
PT	Potential Transformer/Voltage Transformer
SDVS	Sustained Degraded Voltage Signal
SIAS	Safety Injection Actuation Signal
SWYD	Switchyard
TS	Technical Specifications
NRC	Nuclear Regulatory Commission

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8 EVALUATION / COMPUTATIONS

8.1 Relay Circuit Tolerance

8.1.1 27N Relay Circuit Tolerance

27N Relay Tolerance (refer to Attachment 9.2)

Random : Pickup and dropout settings, repeatability at constant temperature and constant control voltage = ± 0.1%

Non-random: Pickup and dropout settings, repeatability over allowable dc control power range = ± 0.1%

Pickup and dropout settings, repeatability over temperature range = ±0.4% for a relay with Harmonic Filter (HF). The ESF SWGR room temperature will be maintained between 50° F and 95° F during normal and emergency operations (reference 6.16).

Voltage transformer tolerance (refer to para. 4.3)

± 0.3% non-random tolerance up to Y burden (75 VA). The PT burden should be verified.

Voltmeter (refer to para. 4.6)

Fluke 45 multimeter random accuracy is ± 0.2% + 10 digits

Since the resolution at medium sampling rate on the 300 V range is 10 mV, the reference accuracy is ±(0.2% +10x0.001V) = ±(0.2% + 0.1V)

If the relay is set near 121 V, then 0.1 V is equivalent to about 0.083%. Therefore, the random accuracy of Fluke 45 multimeter is ±0.283%.

Voltage setting tolerance (refer to para. 3.4)

Random accuracy ±0.1 V

If the relay is set near 121 V, then 0.1 V is equivalent to about 0.083%.

Non-random tolerance (refer to para. 5.2.2)

a. 27N Relay pickup and dropout setting, repeatability over allowable dc control power = ± 0.1%

b. 27N Relay pickup and dropout setting, repeatability overtemperature range = ±0.2% without HF and ±0.4% with HF

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c. Voltage transformer tolerance = ±0.3%

Total non-random tolerance with HF = ±(0.1 + 0.4 + 0.3)% = ±0.8%

Random tolerance (refer to para. 5.2.2)

a. 27N Relay pickup and dropout setting, repeatability at constant temperature and constant control voltage = ±0.1%

b. Fluke 45 voltmeter = ±0.283%

c. Voltage setting tolerance = ±0.083%

Total random tolerance = $\pm(0.1^2 + 0.283^2 + 0.083^2)^{1/2}$ = ±0.31%

Total relay circuit tolerance

Total tolerance with HF = random tolerance + non-random tolerance = ±1.11%

8.1.2 CV-2 Relay (4.16 KV and 480 V SWGR) Circuit Tolerance

CV-2 relay tolerance (refer to para. 4.5)

Random: ±3%

Voltage transformer tolerance (refer to para. 4.3)

± 0.3% non-random tolerance up to Y burden (75 VA). The PT burden should be verified.

Total relay circuit tolerance

Total tolerance = random + non-random = ±(3 + 0.3) = ±3.3%

8.2 Voltage Transformer (PT) Burden

The accuracy of GE JVM-3 voltage transformer is ±0.3% up to 75 VA burden (refer to 4.3). The configuration of the potential transformers yield a total burden capacity of 129.9 VA (75 VA x 2 x 0.866).

The total burden on a PT is the sum of the burdens across the individual phases:

$B_T = B_{AB} + B_{BC} + B_{CA}$

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$B_{CA} = 0$ since there are no loads connected across this phase. The total burden is then the sum of the burdens across the other two phases B_{AB} and B_{BC} (refer to reference 6.5 & Attachment 9.4)

$$B_{AB} = B_{TDV} + B_{TDV1} + B_{DFR} + B_{127D} + B_{127F1} + B_{127R1+EXT\ RES}$$

where:

$B_{TDV} = 2$ VA $\angle 0°$	(refer to para. 3.3)
$B_{TDV1} = 2$ VA $\angle 0°$	(refer to para. 3.3)
$B_{DFR} = 0.288$ VA $\angle 0°$	(reference 6.7)
$B_{127D} = 0.5$ VA $\angle 0°$	(reference 6.8)
$B_{127F1} = 2.4$ VA $\angle 73°$ lagging	(reference 6.9)
$B_{127R1} = 17$ VA $\angle 27°$ lagging	(reference 6.10)

$$B_{127R1\text{-}IMPEDANCE} = (120V^2 / (17\ VA))\ \angle 27° = 754.7\Omega + j384.5\Omega \text{ @ } 120V$$
$$B_{127R1+EXT\ RES} = 754.7\Omega + j384.5\Omega + 106\Omega = 860.7\Omega + j384.5\Omega \text{ (see note below)}$$
$$B_{127R1+EXT\ RES} = (120\ V)^2 / (860 + j384.5)\Omega = 15.3\ \angle 24.1° \text{ @ } 120V$$

$$B_{AB} = 2+2+0.288+0.5+(0.7+j2.29)+(13.96+j6.25) = 19.448+j8.54$$

Note: The 106Ω external resistor in series with the 127R residual relays has been included in the calculation of overall burden (refer to ref. 6.17). In addition, the cable impedance of the Data Acquisition Unit is conservatively considered negligible since adding the cable impedance would reduce the overall burden.

$$B_{BC} = B_{127F2} + B_{127R2+EXT\ RES} + B_{SYNCH}$$

where:

$B_{127F1} = 2.4$ VA $\angle 73°$ lagging	(reference 6.9)
$B_{127R1} = 17$ VA $\angle 27°$ lagging	(reference 6.10)
$B_{127R2+EXT\ RES} = 15.3$ VA $\angle 24.1°$	

The burden caused by the synchroscope circuit, B_{SYNCH}, comes from voltage transducers, frequency transducers, and the synchroscopes. The synchroscope circuit is broken into two parts, the incoming channel and the running channel. Since the PTs, on the undervoltage circuit, can be connected to either of the channels, incoming or running, it is necessary to determine the channel with the largest burden.

There is an equivalent number of transducers on either channel. However, the synchroscopes create more burden on the incoming channel than the running channel. The incoming channel is, therefore, conservatively used as the limiting case for greatest circuit burden.

The following instruments are fed on the incoming channel (Ref. 6.11 and 6.12):

Instrument ID	Function	Manufacturer	Model
2EY-1627B	Voltage Transducer	Scientific Columbus	VT110A2
2/3 EY-1627B	Voltage Transducer	Scientific Columbus	VT110A2
3EY-1627B	Voltage Transducer	Scientific Columbus	VT110A2
2SY-1627B	Freq Transducer	Scientific Columbus	6284A
2/3 SY-1627B	Freq Transducer	Scientific Columbus	6284A
3SY-1627B	Freq Transducer	Scientific Columbus	6284A
2SI-1627C	Synchroscope	General Electric	AB-16 50-120-452
2/3 SI-1627A	Synchroscope	General Electric	AB-16 50-120-452
2/3 SI-1627B	Synchroscope	General Electric	AB-16 50-120-452
3SI-1627C	Synchroscope	General Electric	AB-16 50-120-452

Therefore:

$$B_{SYNCH} = (3 \times B_{VOLT\ TRANS}) + (3 \times B_{FREQ\ TRANS}) + (4 \times B_{SYNCHS})$$

where:

$B_{VOLT.\ TRANS.} = 2.5\ VA\ \angle 0°$ (Attachment 9.3)
$B_{FREQ.\ TRANS.} = 4\ VA\ \angle 0°$ (Attachment 9.3)
$B_{SYNCHS} = 4.2\ VA\ \angle 33.9$ (Attachment 9.3)

$$B_{SYNCH} = 3x2.5\ VA + 3x4\ VA + 4.2\ VA\ \angle 33.9 = 22.986 + j2.3425\ VA$$

$$B_{BC} = 2.4\ \angle 73° + 15.3\ \angle 24.1° + 22.986 + j2.3425\ VA = 37.654 + j10.885\ VA$$

$$B_T = B_{AB} + B_{BC}$$
$$= 19.448 + j8.54 + 37.654 + j10.885 = 57.102 + j19.424 = 60.32\ \angle 18.9°$$

Since the burden is less than 129.9 VA, the PT inaccuracy of ±0.3% is adequate for used in this calculation.

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8.3 27N Relay Voltage Setpoints (refer to para. 5.3)

8.3.1 System voltage dynamic analyses (refer to para.s 4.1 & 4.2)

Calculation E4C-082 (reference 6.3) determines the following 4160V voltages, based on 218 KV switchyard voltage, during the automatic sequencing of ESF loads immediately following a design basis accident:

Bus	Voltage (PU) @4.3 Sec.	Voltage (PU) Post accident steady state
2A04	1.01	1.0
2A06	1.01	1.0

Calculation E4C-082 also demonstrates that system voltages, based on 218 KV switchyard voltage, are adequate for accelerating motors.

8.3.2 Calculation E4C-090 (reference 6.4) show the following 4160 V and 480 V bus steady state post accident voltages based on 218 KV switchyard voltage:

Bus	Voltage (PU)
2A04	1.00124
2A06	1.00140

8.3.3 27N Relay with a Harmonic Filter

Given: Min. undervoltage reset (pickup) voltage at 4.16 KV - 1.010 p.u. or 4201.75 V
Relay circuit tolerance - ±1.11% (refer to para. 8.1.1)
PT ratio - 4200-120 V (refer to para. 4.3)

PT secondary voltage = 4201.75 V / 35 = 120.05 V

Minimum relay reset (pickup) voltage = 120.05 V (refer to paragraph 5.3)

Minimum relay dropout voltage = 120.05 V x 0.995 = 119.45 V

Nominal relay reset (pickup) voltage = 120.05 V / (1-0.0111) = 121.40 V

nominal relay dropout voltage = 121.40 V x 0.995 = 120.80 V

Maximum relay reset (pickup) voltage = 121.40 V x 1.0111 = 122.75 V

Maximum relay dropout voltage = 122.75 V x 0.995 = 122.14 V

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The min. relay dropout voltage at 4.16 KV bus is 119.45 V x 35 = 4180.75 V or 1.005 p.u. which exceeds the post accident steady state voltages of 4.16 KV Class 1E buses shown in paragraph 8.3.2.

8.4 CV-2 Relay Voltage Setpoint (refer to paragraph 5.4)

8.4.1 4.16 KV motor

In order to protect the 4.16 kV motors during a short time voltage dip, the CV-2 relay should operate within 15 seconds at 75% of rated motor voltage (refer to paragraph 4.11).

The voltage at the CV-2 relay corresponding to 75% of rated motor voltage:

V_{relay} = (0.75 x rated motor voltage) / PT ratio

= (0.75 x 4160 V) / 35

= 89.1 V

The voltage drop between 4.16 KV bus and a motor is considered negligible.

Considering Relay circuit inaccuracy:

$V_{relay\ min.}$ = 89.1 V x 0.967 = 86.16 V

$V_{relay\ max.}$ = 89.1 V x 1.033 = 92.04 V

These voltages correspond to 82% and 87.65% of the existing relay tap setting (105 V), respectively. The existing relay (with 105 V tap and time dial #1) will operate within 5 seconds at these voltages (refer to Attachment 9.7).

8.4.2 460 V motor

In order to protect the 460 V motors during a short time voltage dip, the CV-2 relay should operate within 15 seconds at a voltage corresponding to 75% of the rated motor voltage (refer to paragraph 4.11).

The voltage at the CV-2 relay corresponding to 75% of rated motor voltage of 460 V:

V_{relay} = [0.75x460 Vx1.03* x(4160 V/480 V)x(1.00124/0.94523)**] / 35

= 93.2 V

* A voltage drop of 3% in the motor feeder cable was considered.

** The voltage drop across the loadcenter transformer was considered per

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the voltage ratio shown in paragraph 8.3.2.

Considering Relay circuit inaccuracy:

$V_{relay\ min.} = 93.2\ V \times 0.967 = 90.12\ V$

$V_{relay\ max.} = 93.2\ V \times 1.033 = 96.27\ V$

These voltages correspond to 85.8% and 91.68% of the existing relay tap setting (105 V), respectively. The existing relay (with 105 V tap and time dial #1) will operate within 8 seconds at these voltages (Attachment 9.7).

8.4.3 Attachment 9.7 shows that the existing relay (with 105 V tap and time dial # 1) will operate in 1 second following a total loss of voltage.

8.5 Time Delay Setpoints

8.5.1 27N Relay

Set the minimum time delay of 2 seconds to avoid a nuisance tripping due to a transient voltage dip.

8.5.2 Timing Relays 162S-1, 162S-2, 162S-3, & 162S-4

Since the DGVSS should be generated during the first automatic load sequencing cycle (refer to paragraph 1.2.4) and the motor starting transient voltages are stabilized within 4 seconds (Attachment 9.8), a time delay of 4.3 seconds selected is adequate.

8.5.3 Timing Relays 162D-1, 162D-2, 162D-3, & 162D-4

8.5.3.1 Since SDVS will be used for protection of the permanently connected Class 1E loads from sustained degraded voltage, this timing relay may be set to operate after the automatic load sequencing operations are completed.

The automatic load sequencing operations will take 117 seconds to complete since emergency chillers E335 and E336 could start between 40 to 117 seconds (reference 6.18). Therefore, set the timing relay at 120 seconds. The undervoltage relay, in conjunction with this timing relay, will generate a sustained degraded voltage signal at 120 seconds after a degraded voltage condition occurs.

It should be verified that this time delay of 120 seconds will not damage Class 1E loads as required by PSB-1 paragraph B.1.(b)(2).

8.5.3.2 Impact on Class 1E motor loads due to the time delay of 120 seconds

8.5.3.2.1 It is considered that the detrimental effects of low bus voltage is more

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critical on motors because they will draw excessive currents under low voltage condition.

For 120 seconds after a degraded voltage condition without SIAS, the new 27 N relay may not be able to protect motors from the short time degraded voltage condition. However, the existing CV-2 relays will provide motor protection under these circumstances.

8.5.3.2.2 NEMA Standard MG1 (Reference 6.22) recommends that the thermal protector be specified to limit the combination of motor and protector to an ultimate trip current not exceeding 170%, 156%, and 140% of motor full load current rating where full load current is not exceeding 9 A,between 9.1 to 20 A, and above 20 A, respectively. Motors are manufactured per NEMA Standard MG1.

SONGS Units 2&3 QC II motors have been procured to operate at ±10% rated voltage continuously and are able to withstand voltage drops as low as 75% of rated voltage for up to 15 seconds (reference 6.19).

ANSI Standard C37.96 (reference 6.23) recommends that the time-overcurrent pickup be set at 125% of full load current.

Calculations E4C-098 (reference 6.24) and E4C-099 (reference 6.25) show that time-overcurrent relays for motors are set at 125 to 140 % of motor full load current.

The 125% of full load current is equivalent to a motor current at 80% of rated voltage. This means that the motor can be operated at 80% of rated voltage.

Based on data above, if the CV-2 relay can provide motor protection at 75% to 80% of rated motor voltage, the time delay of 120 seconds is considered adequate.

8.5.3.2.3 4.16 KV motor

As shown in paragraph 8.4.1, the CV-2 relay (with 105 V tap and time dial #1) will operate within 5 seconds at 75% of the rated motor voltage.

The voltage at the CV-2 relay corresponding to 80% of 4.16 KV motor voltage:

V_{relay} = (0.80 x rated motor voltage) / PT ratio

= (0.80 x 4160 V) / 35

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= 95.09 V

The voltage drop between 4.16 KV bus and a motor is considered negligible.

Considering Relay circuit inaccuracy:

$V_{relay\ min.}$ = 95.09 V x 0.967 = 91.95 V

$V_{relay\ max.}$ = 95.09 V x 1.033 = 98.23 V

These voltages correspond to 87.5% and 93.35% of the existing CV-2 relay tap setting (105 V), respectively. The existing relay (with 105 V tap and time dial #1) will operate within 8 seconds at these voltages (refer to Attachment 9.7).

Therefore, the CV-2 relay will provide protection to 4.16 KV motors at 75% to 80% of rated motor voltage.

8.5.3.2.4 460 V motor

As shown in paragraph 8.4.2, the CV-2 relay (with 105 V tap and time dial #1) will operate within 8 seconds at 75% of the rated motor voltage.

The voltage at the CV-2 relay corresponding to 80% of 460 V motor voltage:

V_{relay} = [0.80x460 V x 1.03x(4160V/480V)X(1.00124/0.94523)]/35

= 99.41 V

* A voltage drop of 3% in the motor feeder cable was considered.

** The voltage drop across the loadcenter transformer was considered per the voltage ratio shown in paragraph 8.3.2.

Considering Relay circuit inaccuracy:

$V_{relay\ min.}$ = 93.86 V x 0.967 = 90.76 V

$V_{relay\ max.}$ = 93.86 V x 1.033 = 96.96 V

These voltages correspond to 86.43% and 92.34% of the existing CV-2 relay tap setting (105 V), respectively. The existing relay (with 105 V

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tap and time dial #1) will operate within 8 seconds at these voltages (refer to Attachment 9.7).

Therefore, the CV-2 relay will provide protection to 460 V motors at 75% to 80% of rated motor voltage.

8.6 Impact on the first and second load group motors due to the minimum post trip transient of 200 KV in the switchyard

8.6.1 Since motor starting impedance is constant impedance, motor starting current is proportional to motor terminal voltage. Therefore, the starting current of the motor with the minimum post trip transient of 200 KV in the switchyard must be less than its rated starting current. However, the motor starting time with the minimum post trip transient of 200 KV in the switchyard is longer than the motor starting time with the rated voltage as shown in paragraph 4.1.2.

If the trip times of the relays or circuit breakers at the rated locked rotor currents of the associated motors are less than the motor starting times listed in paragraph 4.1.2, it is conservatively considered that the motor starting current with the minimum post trip transient SWYD voltage of 200 KV will not cause the lockout of the associated feeder breakers of the first and second load group motors.

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8.6.2 Relay or circuit breaker trip time and motor starting time

Train A

Bus	load	Approx. motor starting time w/200 KV (second)	Approx. Relay / BKR trip time @ rated LRA (second)	Reference
2A04	2P025-A	0.93	9.0	Fig. 8.6.3 of ref. 6.24 and para. 4.1.2.
	2P017	1.67	4.0	Fig. 8.6.5 of ref. 6.24 and para. 4.1.2.
	2P307	0.83	14.0	Fig. 8.6.6 of ref. 6.24 and para. 4.1.2.
	2P015	1.0	5.0	Fig. 8.6.4 of ref. 6.24 and para. 4.1.2.
2B04	2P191-A	1.33	3.3	Fig. 8.1.9.5 of ref. 6.25 and para. 4.1.2.
	2A071	8.67	15.0	Fig. 8.1.9.6 of ref. 6.25 and para. 4.1.2.
	2E399	5.33	5.6	Fig. 8.1.9.7 of ref 6.25 and para. 4.1.2.
	2E401	5.33	5.6	Fig. 8.1.9.7 of ref. 6.25 and para. 4.1.2.
	2P190	1.33	3.3	Fig. 8.1.9.5 of ref. 6.25 and para. 4.1.2.
	2A074	8.67	15	Fig. 8.1.9.6 of ref. 6.25 and para. 4.1.2.
	2P009	1.33	17	Attachment 9.9
	2P162	1.33	22	Attachment 9.9
	2E418	6.67	5.4 (see note)	Fig. 8.1.9.8 of ref. 6.25 and para. 4.1.2.

Note: The motor starting time with the minimum post trip transient of 200 KV in the switchyard is longer than the associated circuit breaker trip time at the rated locked rotor current. However, the minimum post trip transient SWYD voltage of 200 KV will not cause the lockout of the associated feeder breaker because of the following reasons:

- Voltage at 480 V bus 2B04 corresponding to the minimum post trip transient of 200 KV is 0.614 p.u. of 480 V (refer to paragraph 4.1).

- Since motor starting current is proportional to motor terminal voltage, the motor starting current with this voltage will be:

  LRA = 1,340 A (reference 6.25)

  I = 1340 A x 0.614 x (1-0.03) = 798 A, considering a voltage drop of 3% on the motor feeder cable.

- The circuit breaker trip time at the motor starting current of 798 A is approximately 16 seconds (Figure 8.1.9.8 of reference 6.25) which is much longer than the motor starting time of 6.67 seconds.

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8.6.3 As shown in paragraph 4.1.2, motor starting times of the first and second group motors for Train B are very similar to the motor starting times for Train A. Calculations E4C-098 (reference 6.24) and E4C-099 (reference 6.25) show that the relay breaker settings of Train B are the same as those of Train A for the same type of loads.

Therefore, it is concluded that the motor starting current with the minimum post trip transient SWYD voltage of 200 KV will not cause the lockout of the associated feeder breakers of the first and second load group motors without analyses for Train B.

ATTACHMENT 9.1

Sheet_______

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Appendix A
Specifications

INTRODUCTION

Appendix A contains the specifications of the Fluke 45 Dual Display Multimeter.

These specifications assume:

- A 1-year calibration cycle
- An operating temperature of 18 to 28° C (64.4 to 82.4° F)
- Relative humidity not exceeding 90% (non-condensing) (70% for 1,000 kΩ range and above)

Accuracy is expressed as ±(percentage of reading + digits).

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE
	J. Kim / B. Basu	08/13/93	R. Cabiling	08/13/93					

9 ATTACHMENTS

9.1 Appendix A Specifications - Fluke 45 Dual Display Multimeter.

9.2 Telephone Note between J. Kim of SCE and C. Downs of ABB, dated July 9, 1993.

9.3 Data sheets for Scientific Columbus Transducer and General Electric Synchroscope.

9.4 PT loading configuration

9.5 SONGS 2 & 3 Logic Diagram Class 1E 4.16 KV bus undervoltage Detection

9.6 Time delay relays - Agastat E7000 and ABB type 62T

9.7 CV-2 Undervoltage Relay, Typical Time Curve

9.8 SONGS 2&3 System Dynamic Voltage During Design Basis Accident

9.9 MCC Breaker Trip Curves.

ATTACHMENT 9.1

Sheet_______

CALCULATION NO. E4C-098 REV. 0 ICCN C-1

SPECIFICATIONS — DC VOLTAGE

DISPLAY COUNTS AND READING RATES

Rate	Readings per Second	Full Range Display Counts
Slow	2.5	99,999*
Medium	5	30,000
Fast	20	3,000

* Ohms full range will typically be 98,000 counts

RS-232 AND IEEE-488 READING TRANSFER RATES

Rate	Reading Per Second		
	Internal Trigger Operation (TRIGGER 1)	Internal Trigger Operation (TRIGGER 4)	Print Mode Operation (Print set at 1)
Slow	2.5	1.5	2.5
Medium	4.5	2.4	5.0
Fast	4.5	3.8	13.5

Response Times

Refer to Section 4 for detailed information.

DC VOLTAGE

Range	Resolution			Accuracy	
	Slow	Medium	Fast	(6 Months)	(1 Year)
300 mV	—	10 µV	100 µV	0.02% + 2	0.025% + 2
3V	—	100 µV	1 mV	0.02% + 2	0.025% + 2
30V	—	1 mV	10 mV	0.02% + 2	0.025% + 2
300V	—	10 mV	100 mV	0.02% + 2	0.025% + 2
1000V	—	100 mV	1V	0.02% + 2	0.025% + 2
100 mV	1 µV	—	—	0.02% + 6	0.025% + 6
1000 mV	10 µV	—	—	0.02% + 6	0.025% + 6
10V	100 µV	—	—	0.02% + 6	0.025% + 6
100V	1 mV	—	—	0.02% + 6	0.025% + 6
1000V	10 mV	—	—	0.02% + 6	0.025% + 6

ATTACHMENT 9. 3

Sheet_______

CALCULATION NO. E4C-098 REV. 0 ICCN C-1

EXCELTRONIC™ CURRENT and VOLTAGE TRANSDUCERS

- Average Sensing
- True RMS
- 3 in 1 Packaging

Accuracy 0.1%-0.25% Patent No 3971979

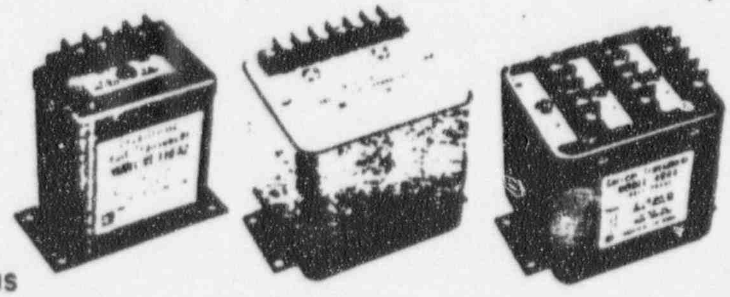
DESCRIPTION

Exceltronic current and voltage transducers are manufactured to the same high standards of the watt and var series. In addition to their high accuracies (± 0.25% and ± 0.1%), they have features such as minimal space requirements, 3 in 1 packaging, and adjustable gain potentiometers.

Scientific Columbus' Current and Voltage Transducers are available as average sensing devices calibrated in rms or as true rms units, either with a dc current output proportional to the input.

The dc output is a constant current of 0 - 1 mA which will work into any load from 0 - 10,000 ohms. These outputs are also filtered. Resistance variations in the signal loop, over the range of 0 to 10,000 ohms, do not cause any deviation from stated accuracy.

STYLE III PACKAGE
CT510A2
CT510A4
VT110A2
VT110A4



STYLE II PACKAGE
4044 (3 in 1 Current)
4074 - RMS
3567 - RMS
3588 (3 in 1 Voltage)

SPECIFICATIONS

Model	4044 CT510A2	CT510A4	RMS 4074
Full Scale Current	5 a	*	*
Burden	0.25 VA	*	*
Overload	10a continuous 250A for 1 sec.	*	6.25A cont 250A for 1 sec
Frequency Range (Specify nominal)	50-500 Hz	*	60 Hz ± 5 Hz fundamental & thru 9th Harmonics
Temperature Range	- 20°C to + 60°C	*	*
Maximum Temperature Effects on Accuracy	± 0.5%	*	*
Accuracy @ 25°C (% RO at nominal frequency)	± 0.25%	± 0.1%	± 0.25%
Output at Rated Input (d.c.)	1mA	*	*
Output Load Required	0-1[illegible] ohm	*	*
Ripple (Peak)	[illegible]		≤ 1.0%
Response Time	400 ms	*	2.0 sec.
Calibration Adjustment	± 10%	*	± 5%
Dielectric Test	1500 rms	*	*
Packaging Style Page 47	4044 - II CT510A2 - III	III	II
Connection Page 49	4044 49B CT510A2 49A	49A	49C

Model	3588 VT110A2	VT110A4	RMS 3567
Full Scale Voltage	150 v	*	*
Nominal Voltage	120 v	*	*
Overload	180v	*	*
Burden @ 120 v	2.5 va	*	1.0va
Frequency Range (Specify nominal)	50-500 Hz	*	60 ± 5 Hz fundamental & thru Harmonics
Temperature Range	- 20°C to + 60°C	*	*
Maximum Temperature Effects on Accuracy	± 0.5%	*	*
Accuracy (% RO @ 25°C 10 to 150 V at nominal frequency)	± 0.25%	± 0.1%	± 0.25%
Output at Rated Input (d.c.)	1 mA	*	*
Output Load Required	0-10K ohm	*	*
Ripple (Peak)	≤ 0.25%	*	≤ 1.0%
Response Time	400 ms	*	2.0 sec
Calibration Adjustment	± 10%	*	± 5%
Dielectric Test	1500 vrms	*	*
Packaging Style Page 47	3588 - II VT110A2 - III	III	II
Connection Page 49	3588 49B VT110A2 49A	49A	49C

* Specification shown in first column is the same for all models in this series.

ATTACHMENT 9.1

Sheet ______

CALCULATION NO. E4C-098 REV. 0 ICCN C-1

SPECIFICATIONS — DC VOLTAGE

Input Impedance

10 MΩ in parallel with <100 pF

NOTE

In the dual display mode, when the volts ac and volts dc functions are selected, the 10 MΩ dc input divider is in parallel with the 1 MΩ ac divider.

Normal Mode Rejection Ratio

>60 dB at 50 or 60 Hz, slow and medium rates
>54 dB for frequencies between 50-440 Hz, slow and medium rates
>60 dB at 50 Hz, fast rate (Note: Fast rate has no filtering)

Maximum Allowable AC Voltage While Measuring DC Voltage

Range		Max Allowable Peak AC Voltage	Peak Normal Mode Signal	
			NMRR* >60 dB†	NMRR >60 dB†
300 mV	100 mV	20V	15V	15V
3V	1000 mV	20V	15V	15V
30V	10V	1000V	50V	300V
300V	100V	1000V	50V	300V
1000V	1000V	1000V	200V	1000V

* NMRR is the Normal Mode Rejection Ratio

† Normal Mode Rejection Ratio at 50 or 60 Hz ± 0.1%

Common Mode Rejection Ratio

>60 dB at dc, 50 or 60 Hz, (1 kΩ unbalanced, medium and slow rates)

Maximum Input

1000V dc or peak ac on any range

ATTACHMENT 9. 2

Sheet_______

CALCULATION NO. E4C-098 REV. 0 ICCN C-1

TELEPHONE NOTES

BY Joon Kim OF SCE

TELEPHONE NO. (714) 587-5507

WITH Clifford Downs OF ABB

TELEPHONE NO. (215) 395-7333

DATE: July 9, 1993

SUBJECT: ABB 27N Relay Tolerance

REFERENCE: ABB Instructions IB 7.4.1.7-7

DISCUSSION AND AGREEMENTS REACHED:

Mr. Downs was asked to clarify which tolerance is random element for the pickup and dropout setting repeatability tolerances listed in ABB instructions IB 7.4.1.7-7.

Mr. Downs stated as follows:

Random : Pickup and dropout settings, repeatability at constant temperature and constant control voltage

Non-random: 1. Pickup and dropout settings, repeatability over allowable dc control power range

2. Pickup and dropout settings, repeatability over temperature range.

ATTACHMENT 9.1

Sheet_______

CALCULATION NO. E4C-098 REV. 0 ICCN C-1

SPECIFICATIONS — TRUE RMS AC VOLTAGE

TRUE RMS AC VOLTAGE, AC-COUPLED

Range	Resolution		
	Slow	Medium	Fast
300 mV	—	10 µV	100 µV
3V	—	100 µV	1 mV
30V	—	1 mV	10 mV
300V	—	10 mV	100 mV
750V	—	100 mV	1V
100 mV	1 µV	—	—
1000 mV	10 µV	—	—
10V	100 µV	—	—
100V	1 mV	—	—
750V	10 mV	—	—

Accuracy

Frequency	Linear Accuracy			dB Accuracy		Power*	Max Input at Upper Freq
	Slow	Medium	Fast	Slow/Med	Fast		
20-50 Hz	1% + 100	1% + 10	7% + 2	0.15	0.72	2% + 10	750 V
50 Hz -10 kHz	0.2% + 100	0.2% + 10	0.5% + 2	0.06	0.17	0.4% + 10	750 V
10-20 kHz	0.5% + 100	0.5% + 10	0.5% + 2	0.11	0.17	1% + 10	750 V
20-50 kHz	2% + 200	2% + 20	2% + 3	0.28	0.34	4% + 20	400 V
50-100 kHz	5% + 500	5% + 50	5% + 5	0.70	0.78	10% + 50	200 V

* Error in power mode will not exceed twice the linear accuracy specification

Accuracy specifications apply within the following limits, based on reading rate:

Slow Reading Rate: Between 15,000 and 99,999 counts (full range)
Medium Reading Rate: Between 1,500 and 30,000 counts (full range)
Fast Reading Rate: Between 150 and 3,000 counts (full range)

Decibel Resolution

Resolution	
Slow & Medium	Fast
0.01 dB	0.1 dB

ATTACHMENT 9. 3

Sheet_______

CALCULATION NO. E4C-098 REV. 0 ICCN C-1

EXCELTRONIC™

FREQUENCY TRANSDUCERS

Models 6281B, 6283B, 6284B

DESCRIPTION

Scientific Columbus Frequency Transducers develop a DC output signal which is proportional to input frequency.

These transducers have an expanded scale output. A variety of calibrations may be ordered or the user may calibrate the transducer at the installation site to meet specific requirements.

These transducers feature the exceptional Scientific Columbus constant current output. This means, for a given input, no adjustment is necessary to compensate for various output signal loop characteristics.

Series components and devices such as indicators, recorders, resistors for alarms and analog-to-digital pick-off points can be added to the output signal circuit without recalibrating these transducers. Filtering is also included, which simplifies matching these units to fast response devices.

SPECIFICATIONS

	6281B	6283B	6284B
Input Voltage	120 V	120 V	120 V
Overload	150 V	150 V	150 V
Frequency Range	45-55 Hz	375-425 Hz	55-65 Hz
Output	0-1 ma into 0-10K ohms	0-1 ma into 0-10K ohms	0-1 ma into 0-10K ohms
Accuracy	± 0.02% of Center frequency at 25° C	± 0.02% of Center frequency at 25° C	± 0.02% of Center frequency at 25° C
Ambient Temperature Effect on Accuracy	± 0.0025% / C Max	± 0.0025% / C Max.	± 0.0025% / C Max.
Adjustments	Zero, Span	Zero, Span	Zero, Span
Burden	4VA	4VA	4VA
Ripple	1% maximum output peak	1% maximum output peak	1% maximum output peak
Temperature Range	− 20° C to + 50° C	− 20° C to + 60° C	− 20° C to + 60° C
Response	0.4 sec. to 99% of final value	0.4 sec. to 99% of final value	0.4 sec. to 99% of final value

Connections see page 49. Connection 49E   Packaging see page 47   Style II Case

SHUNT/ISOLATION/ AMPLIFIER

Model 6271A

DESCRIPTION

The Model 6271A Shunt Amplifier is a linear amplifier designed to amplify DC shunt millivolt signals or D.C. voltages from 50 MV to 1000 V D.C., and provides *complete isolation* of the input signal. A magnetic amplifier is used in the input circuit to isolate the input from all other circuits and grounds. The input is tested at *4000 volts D.C.* for one minute to insure that no breakdown will occur when connected to shunts operating at high voltage levels above ground. The output circuit is a hybrid amplifier operating in the transconductance mode to provide a constant current output. Load resistance variations from 0-10K have less than 0.1% effect on the output current. This makes the amplifier an ideal device for telemetering, scaling, recording applications or matching to tone transmitters or A to D converters. The output is also filtered, thus making expensive filtering unnecessary.

A 20 turn zero and gain adjustment is provided and is accessible through the top cover. Large gain changes can be accomplished by changing the auxiliary gain resistor across terminals 3 and 4.

SPECIFICATIONS

Power Requirements	120V 60 Hz ± 10% 10VA (Max.)
Signal Input (nominal)	0 to ± 100 Millivolts
Signal Input Range Options	50 MV to 1000 V D.C.
Input Impedance	5000 ohms/Volt
Output D.C.	0 to ± 1 ma
Load Impedance	Any Load between 0-10K
Accuracy	± 0.5% RO @ 25° C
Temperature Range	− 10° C to + 70° C
Temperature Coefficient	± 0.04% °C
Size	3" x 4⅝" x 4⁷/₁₆" High
Packaging	Style II Metal Case

Connections see page 49
Connection 49D
Dimensions see page 47
Style II Case

D.C. AMPLIFIER

Model 6181A

SPECIFICATIONS

Amplifier Type and Model	DC Instrument Amplifier/6181A
DC Input Limits Max	Current 10 µa to 5 ma Voltage 10 mv to 8 Volts
DC Output Limits	Current 10 ma Voltage 8 Volts
Effective Input Impedance	Less than 10 ohms for current input, more than 10 megohms for voltage input
Gain Stability	± 0.5% maximum output*
DC Linearity	± 0.5% of maximum output*
Zero Stability	20 µv/° C maximum (5 µv/° C typical) referred to input
Response Time	0.1 second or better to reach 99% of final value
Ambient Temperature Range	− 10° C to + 50° C
Duty Cycle	Continuous*
Weight	Approximately 2-1/2 lbs.
Power Requirements	100-130 V, 50-400 Hz, single phase, 5 VA

See Unit Instruction Manual for 4 modes of operation

* Within specified ambient temperature range

* Must fall within input, output and feedback resistance limits listed.

ATTACHMENT 9.3

Sheet________

CALCULATION NO. E4C-098 REV. 0 ICCN C-1

INSTRUMENT TRANSFORMER BURDEN DATA

BURDENS IMPOSED ON POTENTIAL TRANSFORMERS

(Data are for one element and based on 120 volts at rated frequency; where no specific frequency rating is assigned, data are for 60 cycles.)

G-E Type*	Coil	Rating: Volts	Rating: Cycles	Impedance (Ohms)	Effective Resistance (Ohms)	Inductance (Henrys)	Volt-amperes	Watts	Vars	Power Factor
POWER-FACTOR METERS										
AB-10-12-15		115	25-125	3800	3800	0	3.8	3.8	0	1.00
AB-15-16-18-30		120	60	3940	3940	0	3.66	3.66	0	1.00
AD-6, -7		115	25-60	3160	3160	0.01	4.6	4.6	0	1.00
ADB (Polyphase)		115	25-60	4900	4900	0	2.9	2.9	0	1.00
SH-12 (Polyphase)	A, B	115	25-60	2050	2050	0	7.0	7.0	0	1.00
	C, D	115	25-60	2320	2320	0	6.2	6.2	0	1.00
AB, AB-2 (Polyphase)	A, B	110	Up to 125	1900	1900	0	7.6	7.6	0	1.00
	C, D	110	Up to 125	2650	2650	0	5.5	5.5	0	1.00
C-4-6-7, CP (Polyphase)	A, B	110	Up to 125	135	135	0	107.0	107.0	0	1.00
	C, D	110	Up to 125	218	218	0	65.0	65.0	0	1.00
C-20-2- (Polyphase)		110	Up to 125	618	618	0.12	23.3	23.3	1.7	1.00
CD-3-4-7-8, CD-27-28		110	Up to 125	1100	1100	0.33	13.1	13.1	1.5	0.99
CDP-3-4, CP-4-5 (Polyphase)										
H, H-2, H-3 (Polyphase)	A, B	110	Up to 125	2030	2030	0	7.1	7.1	0	1.00
	C, D	110	Up to 125	2320	2320	0	6.2	6.2	0	1.00
P-3 (Polyphase)	A, B	110	Up to 125	6480	6480	0.01	2.2	2.2	0	1.00
	C, D	110	Up to 125	2570	2570	0.01	5.6	5.6	0	1.00
P-3 (Single Phase)		115	25-60	2390	1970	3.60	6.0	4.9	3.4	0.82
FREQUENCY METERS†										
AB-10-12-13		115	60	2800	1960	5.3	5.1	3.6	3.7	0.70
AB-15-16-18		120	60	2700	2677	1.0	5.3	5.3	0.76	0.99
DB-30		120	60	8000	7900	3.84	1.8	1.78	0.26	0.99
AD-6, AD-7		115	25	3270	3270	0	4.4	4.4	0	1.00
		115	60	1800	1770	1.06	8.1	8.0	1.4	0.96
ADB		115	25	3270	3290	0	4.4	4.4	0	1.00
		115	60	1800	1770	0.56	8.1	8.0	1.4	0.98
SH-12		115	25-60	1900	1900	0	7.6	7.6	0	1.00
			25	3160	3160	0	4.6	4.6	0	1.00
AB-4		115	60	2050	2050	0	7.5	7.0	0	1.00
CD-3-4-7-8		115	25	740	740	0	19.5	19.5	0	1.00
CD-27-28		115	60	1100	1100	0	13.1	13.1	0	1.00
AB, AB-2		110	25	795	291	4.70	18.1	6.6	16.9	0.37
AB, AB-2		110	60	706	286	1.71	20.5	8.3	18.7	0.40
AB-3		110	60	635	510	1.01	22.6	18.2	13.3	0.80
C-4-6-7		110	25	205	205	0.05	70.0	70.0	2.7	1.00
CP		110	60	248	244	0.13	58.0	56.8	11.3	0.98
H-2		110	25	772	250	4.64	18.6	6.2	17.5	0.33
H-3		110	60	769	764	0.24	18.7	18.1	2.2	0.99
H-4		110	60	863	267	2.16	16.2	5.2	15.9	0.31
H-5		110	25	796	282	4.70	18.1	6.4	16.9	0.36
H-5		110	60	868	307	2.14	16.5	5.9	15.6	0.36
H-6		110	25	1090	1070	1.36	13.2	12.8	2.6	0.98
H-6		110	60	840	809	0.62	17.1	16.4	4.8	0.96
P-3 (60-72 cyc)		110	60	733	733	0	19.6	19.6	0	1.00
P-3 (55-65 cyc)		110	60	2290	2290	0	6.3	6.3	0	1.00
SYNCHROSCOPES										
AB-10-12-13 (with ext. reactor) (Running)	A, B	115	60	6900	5070	12.80	2.1	1.5	1.4	0.72
(Incoming)	C, D	115	60	2100	1170	4.60	6.9	3.8	5.7	0.55
AB-12-13-15-16-12 (Self-contained) (Running)		115	60	7200	6035	10.3	2.0	1.7	1.1	0.84
(Incoming)		115	60	3420	2040	(A)	4.2	3.5	2.3	0.83
AB-13-14 (Running)	A, B	115	60	6900	5070	12.80	2.1	1.5	1.4	0.73
(Incoming)	C, D	115	60	2100	1170	4.60	6.9	3.8	5.7	0.51
AB-16-17-18-19-20 (Self-contained) (Running)		115	60	7200	6035	10.3	2.0	1.7	1.1	0.84
(Incoming)		115	60	3420	2040	(A)	4.2	3.5	2.3	0.83

* For explanation of Reference Marks, see page 3.

Table continued on page 8

ATTACHMENT 9.6

Sheet_______

CALCULATION NO. E4C-098 REV. 0 ICCN C-1

series
E7000

seismic and radiation-tested timing relays

SPECIFICATIONS [illegible]

Environmental Conditions [illegible]

PARAMETER	MIN	NORMAL	MAX
Temperature (°F)	40	70-104	50
Humidity (% RH)	10	40-60	95
Pressure	—	Atmospheric	—
Radiation (rads)	—	—	2 × 10[illegible] Gamma

Operating Conditions [illegible]

NORMAL OPERATING SPECIFICATIONS	WITH DC COILS	WITH AC COILS
Coil Operating Voltage (Nominal Rated)	As Spec	As Spec
Pick-up (% of rated value)	80% Max	85% Max
Drop-out (% of rated value)	10% Approx	50% Approx
Power (watts at rated value)	6 Approx	6 Approx
Relay Operate Time		
Model E7012	N/A	N/A
Model E7022	50 ms Max	50 ms Max
Relay Release (Reset) Time		
Model E7012	50 ms Max	50 ms Max
Model E7022	N/A	N/A
Contact Ratings, Continuous		
Resistive at 125 VDC	1.0 amp	1.0 amp
Resistive at 120 VAC, 60 Hz	10.0 amp	10.0 amp
Insulation Resistance		
in megohms at 500 VDC	500 Min	500 Min
Dielectric (VRMS 60 Hz)		
Between Terminals and Ground	1500	1500
Between Non-connected Terminals	1000	1000
Repeat Accuracy	± 10%	± 10%
Approximate Weight	Model E7012 and E7022 2.25 lbs; Model E7014 and E7024 2.57 lbs	Model E7012 and E7022 2.13 lbs; Model E7014 and E7024 2.43 lbs

(Weight may vary slightly with particular coil voltage.)

Operating Conditions [illegible] Environment

ADVERSE OPERATING SPECIFICATIONS	NORMAL	DBE "A"	DBE "B"	DBE "C"	DBE "D"
Temperature (°F)	70-104	40	120	145	158
Humidity (% RH)	40-60	10-95	10-95	10-95	10-95
Coil Operating Voltage (% of Rated)					
Model E7012 (AC)	85-110	85-110	85-110	85-110	85-110
(DC)	80-110	80-110	80-115	80-110	80-110
Model E7022 (AC)	85-110	85-110	85-110	85-110	85-110
(DC)	80-110	80-110	80-110	80-110	80-110

(All coils may be operated on intermittent duty cycles at voltages 10% above rated maximums. Intermittent Duty = Maximum 50% duty cycle and 30 minutes "ON" time.)

ORDERING INFORMATION

Catalog Number Code

Nuclear Safety Related	Model Series: AGASTAT Series 7000 Timing Relay	Operation: 1 = On-Delay; 2 = Off-Delay	Contact Arrangement: 2 = Double Pole Double Throw; 4 = Four Pole Double Throw	Coil Voltage	Time Range	Configuration Code

Coil Voltage

AC:
A = 120V 60Hz
110V 50Hz
B = 240V 60Hz
220V 50Hz
C = 480V 60Hz
D = 208V 60Hz
E = 24V 60Hz
F = 127V 50Hz
G = 240V 50Hz
H = 12V 60Hz
I = 6V 60Hz
J = 208V 60Hz

DC:
[illegible] = 28 VDC
N = 48 VDC
O = 24 VDC
P = 125 VDC
Q = 6 VDC
R = 60 VDC
S = 250 VDC
T = 125 VDC
U = 12 VDC
V = 28 VDC
W = 48 VDC
Y = 6 VDC
Z = 250 VDC

Time Range
E7012, E7022, E7024

A = 1 to 1 sec.
B = 2 to 6 sec.
C = 1.5 to 15 sec.
D = 5 to 50 sec.
E = 20 to 200 sec.
F = 1 to 10 min.
H = 3 to 30 min.
I = 6 to 60 min.
K = 1 to 100 min.

†E7014

A = .2 to 2 sec.
B = .7 to 7 sec.
C = 2 to 20 sec.
D = 10 to 100 sec.
E = 30 to 300 sec.
F = 1.5 to 15 min.
H = 3 to 30 min.

† Model E7014 is available with [illegible] dials only. The upper end of the time ranges in this [illegible] may be [illegible] the values shown.

** CONFIGURATION CODE

The Configuration Code is a suffix to the Model Number which provides a means of identification. When a significant product change is introduced, the Configuration Code and specification sheets will be revised (001 to 002, etc.).

Replacement Schedule

The qualified life of this unit is 25,000 operations or 10 years from the date of manufacture, whichever occurs first.

The date of manufacture can be found in the first four (4) digits of the serial number on the nameplate. XX XX

First two digits indicate the year ______________

Second two digits indicate the week. ______________

Example: Date code 8014: 80 indicates 1980; 14 indicates the week of April 2 through 8.

MODEL E7012PC002
COIL 125VDC Serial 8014 —
TIME 1.5 TO 15 SEC
[illegible]

Mounting Instructions

The Series E7000 relay MUST BE MOUNTED IN THE VERTICAL POSITION; all performance specifications are valid only when they are mounted in this manner.

A mounting bracket and screws and lockwashers required to attach it to the relay are supplied with each unit. Four 8-32 tapped [illegible] holes are provided in the rear of the relay for attaching the mounting bracket, or for mounting the relay directly to a panel from the rear.

WARRANTY

This product is warranted against mechanical and electrical defects for a period of two years from date of shipment from factory if it has been installed and used in accordance with factory recommendations. Any field repairs or modifications to the original unit will void this warranty. Amerace Corporation's liability is limited to replacement of parts proved defective in workmanship or materials. (W-AB2)

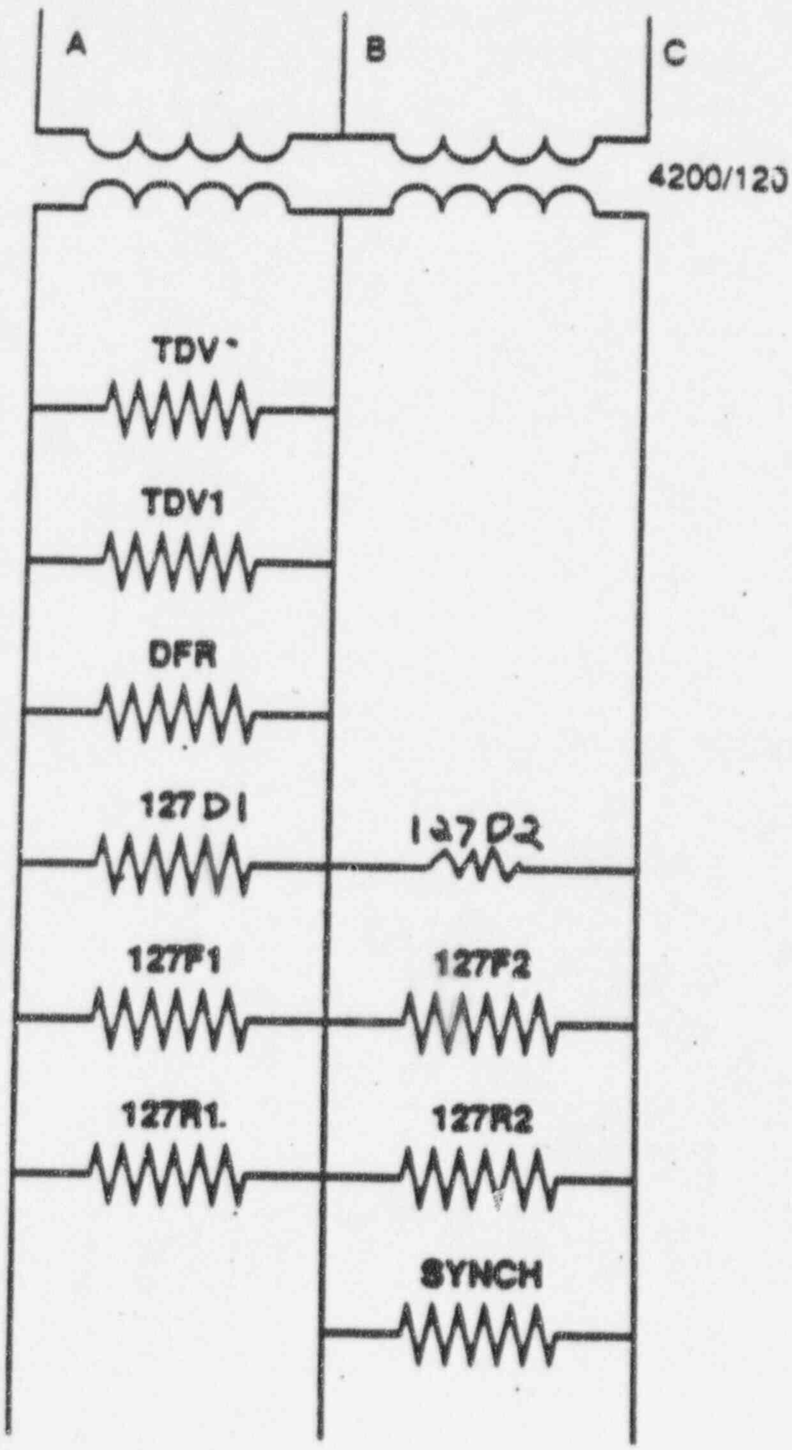
NOTE: THE BASIC UNIT IS SUBJECTED TO IEEE STD 323-1974 AND IEEE STD 344-1975 QUALIFICATION TESTS. PERFORMANCE WITH FACTORY INSTALLED AND/OR CUSTOMER SPECIAL OPTIONS HAS NOT BEEN TESTED.

ATTACHMENT 9.4

Sheet________

CALCULATION NO. E4C-098 REV. 0 ICCN C-1

Potential Transformer Burden



ATTACHMENT 9.6

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CALCULATION NO. E4C-098 REV. 0 ICCN C-1

ABB
ASEA BROWN BOVERI

ABB Power T&D Company Inc.
Relay Division
Coral Springs, FL
Allentown, PA
Hamilton, Ontario, Canada

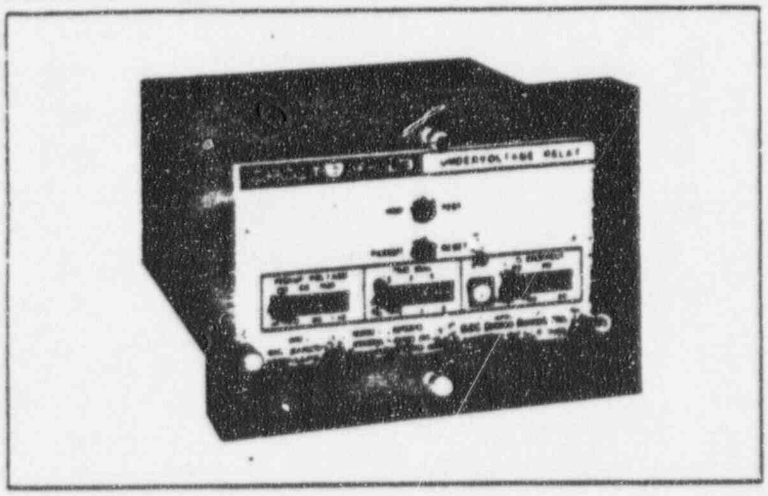
Descriptive Bulletin
41-233S
Page 1

September, 1990
Supersedes Bulletin 7.4.9-1C,
pages 1-2, dated June, 1989
Mailed to: E, D, C 41-200B

Highly Accurate
Device Number: 27 Undervoltage
Device Number: 59 Overvoltage

CIRCUIT SHIELD ©

Type 27N and 59N Undervoltage and Overvoltage Relay



Application

The Type 27N and Type 59N Voltage Relays provide a wide range of protective functions, including undervoltage protection of motors, overvoltage protection, and automatic bus transfer. The Type 27N and Type 59N relays are primarily designed for those applications where exceptional accuracy, exceptional repeatability, and long term stability are important. In addition, inherently high seismic and transient immunity allow the use of these relays in generating stations or substations where the performance of electromechanical or other types of static relays is marginal.

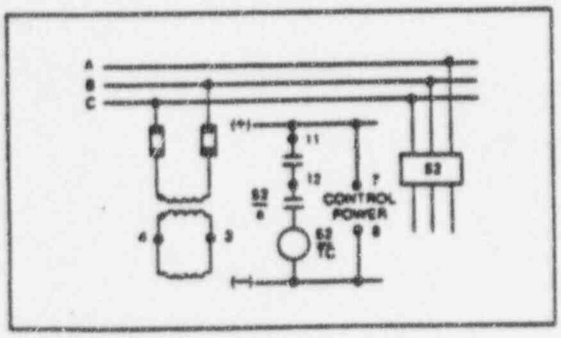
Both types have a dual nominal frequency rating of 50 or 60 Hz.

The unique design of the output circuit does not require seal-in contacts, allowing simplification of bus-transfer schemes. Operation indicators, however, are provided as standard features on all types.

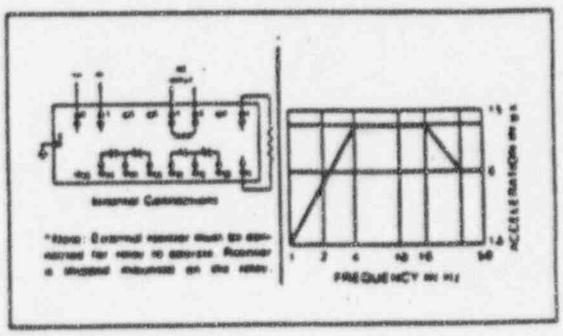
Harmonic distortion in the AC waveform can have a noticeable effect on the relay operating point and on measuring instruments used to set the relay. An internal harmonic filter module is available for those applications where waveform distortion is a factor.

Features

- Definite time or high speed
- Highly stable, accurate and repeatable characteristics
- Low burden
- Seismic capability to 6g ZPA
- Transient immunity
- Drawout construction
- 2 year warranty



Typical Circuit Shield Voltage Relay Application



Typical Seismic Test Results

ATTACHMENT 9. 5

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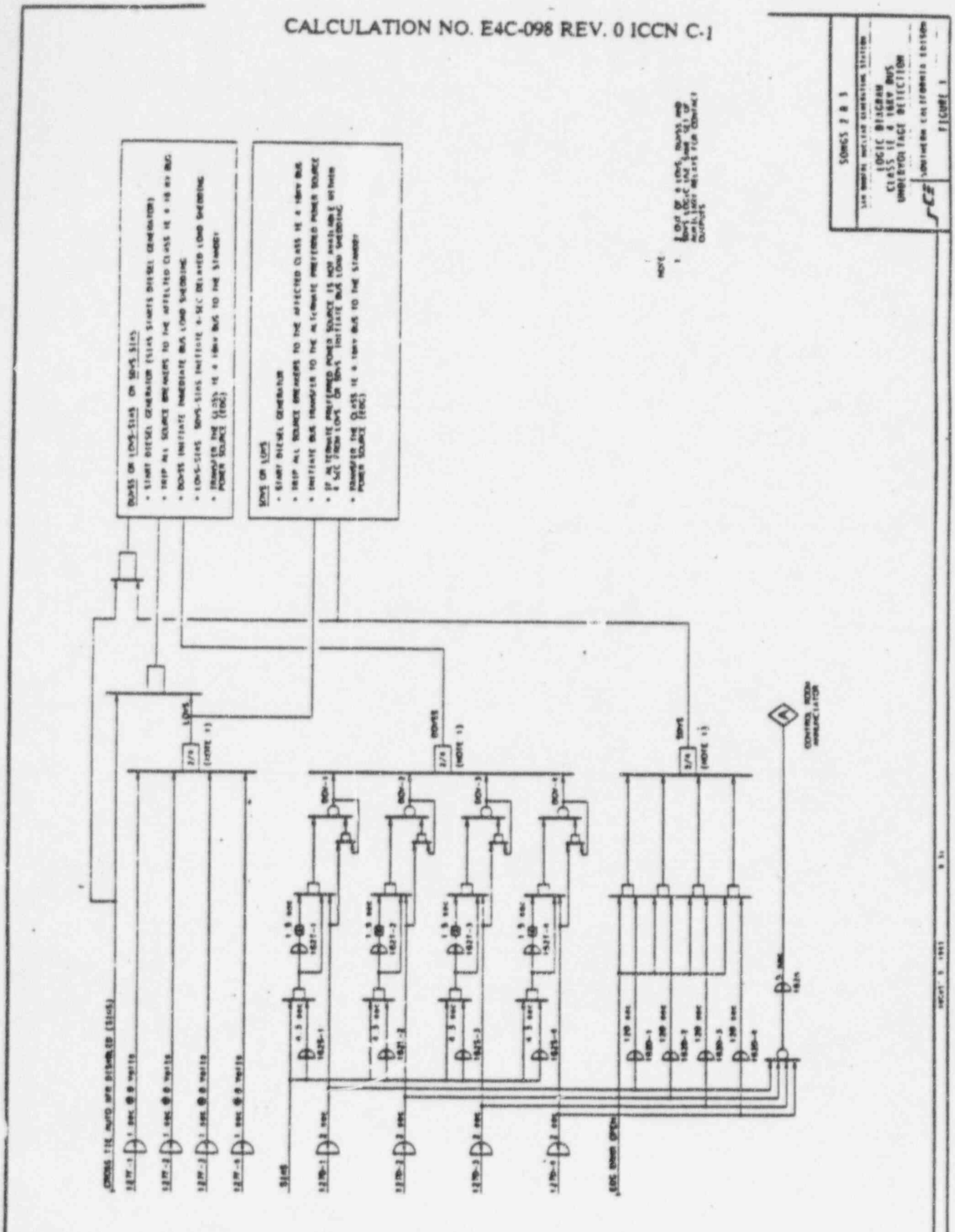
CALCULATION NO. E4C-098 REV. 0 ICCN C-1



ATTACHMENT 9.6

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CALCULATION NO. E4C-098 REV. 0 ICCN C-1

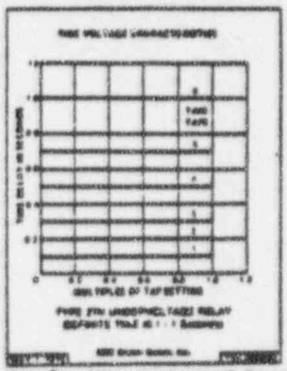
ABB
ASEA BROWN BOVERI

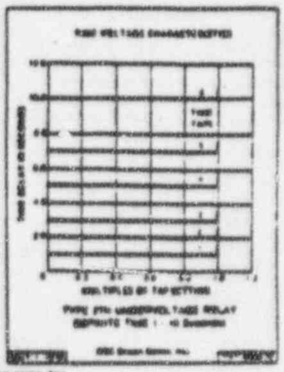
Specifications

Input Circuit Rating:	Type 27N 150 Vac Maximum Continuous Type 59N 160 Vac Maximum Continuous
Burden:	Less than 0.5 VA at 120 Vac
Frequency:	50/60 Hz.
Output Circuit:	Each contact at 125 Vdc: 30A Tripping Duty 5A Continuous 1A Break, Resistive 0.3A Break, Inductive.
Control Power:	Rated at 48/125, 250 Vdc at 0.05 ampere maximum.
Temperature:	ANSI range −20°C to +55°C Must operate −30°C to +70°C
Tolerances: (Without harmonic filter module, after 10 minute warm-up.)	Pickup and dropout settings with respect to printed dial markings (factory calibration) = ±2%. Pickup and dropout settings, repeatability at constant temperature and constant control voltage = ±0.1%. (See Note) Pickup and dropout settings, repeatability over DC control power range of 100-140 volts = ±0.1%. (See Note) Pickup and dropout settings, repeatability over temperature range: (See Note) −20°C to +55°C ±0.4% −27°C to +70°C ±0.7% 0°C to +40°C ±0.2% Note: The three tolerances shown should be considered independent and may be cumulative. Tolerances assume pure sine wave input signal. Time Delay Instantaneous model: 3 cycles or less operating time. Definite Time models (see appropriate curve). ±10% or ±20 milliseconds, whichever is greater.
Tolerances: (With harmonic filter module)	All ratings are the same except: Pickup and dropout settings, repeatability over temperature range: 0°C to +55°C ±0.75% +10°C to +40°C ±0.40% −20°C to +70°C ±1.50%
Reset Time:	Less than 2 cycles (Type 27N). Less than 3 cycles (Type 59N). (The relay resets when the input voltage goes above the pickup setting − 27N, below the dropout setting − 59N.)
Seismic Capability:	More than 6g ZPA either AXIS biaxial broadband multifrequency vibration without damage or malfunction ANSI/IEEE C37.98.
Transient Immunity:	More than 2500V, 1MHz bursts at 400 Hz repetition rate, continuous (ANSI C37.90.1 SWC). Fast transient test. EMI test.
Dielectric:	2000 Vac RMS 60 seconds all circuits to ground.

How To Specify

Voltage Relay shall be Asea Brown Boveri Type 27N, Type 59N or approved equal, draw-out case, capable of withstanding up to 6g ZPA seismic stress without damage or malfunction, at minimum voltage and time settings. A magnetic operation indicator shall be provided which retains position on loss of control power. Built-in means shall be provided to allow operational tests without additional equipment.





Note: Time delays associated with the time taps for the Type 59N Overvoltage Relay are identical to those of the Type 27N Undervoltage Relay, except the delay occurs on pickup; i.e., when voltage increases to above the pickup tap setting.

How To Order

For a complete listing of available versions of single and three phase voltage relays see TD 41-025.

Models are available for 48 to 250 Vdc control power, and 120 Vac potential transformers. For other control voltages contact the nearest District Office.

To place an order, or for further information, contact the nearest District Office.

Further Information

List Prices: PL 41-020
Technical Data: TD 41-025
Instruction Book: IB 7.4.1.7-7①
Other Protective Relays:
Application Selector Guide, TD 41-016
① Available upon request, only from Allentown Plant.

ABB Power T&D Company Inc.
Relay Division
4300 Coral Ridge Drive
Coral Springs, FL 33065
305-752-6700

ABB Power T&D Company Inc.
Relay Division
35 N. Snowdrift Road
Allentown, PA 18106
215-395-7333

ABB Power T&D Company Inc.
Relay & Relay Systems Division
826 Aberdeen Avenue
Hamilton, Ontario L8P 2T1 Canada
416-528-8811

September, 1990

ICCN NO PRELIM CCN NO C-1	PAGE 57 OF 63
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ATTACHMENT 9.7

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CALCULATION NO. E4C-098 REV. 0 ICCN C-1

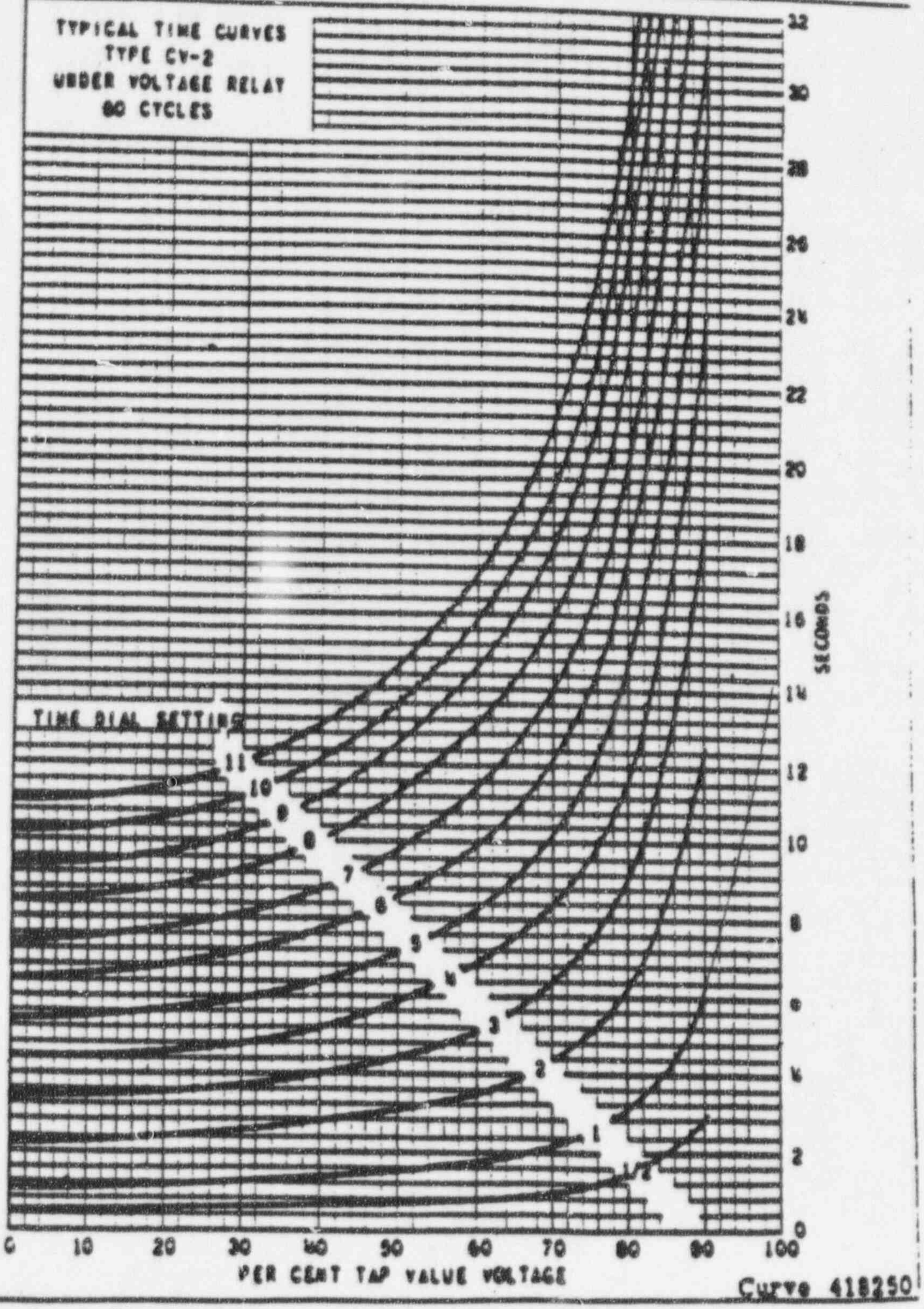

Fig. 12. Typical 60-cycle Time curves of the type CV2 Short Time Undervoltage Relay.

ATTACHMENT 9.B

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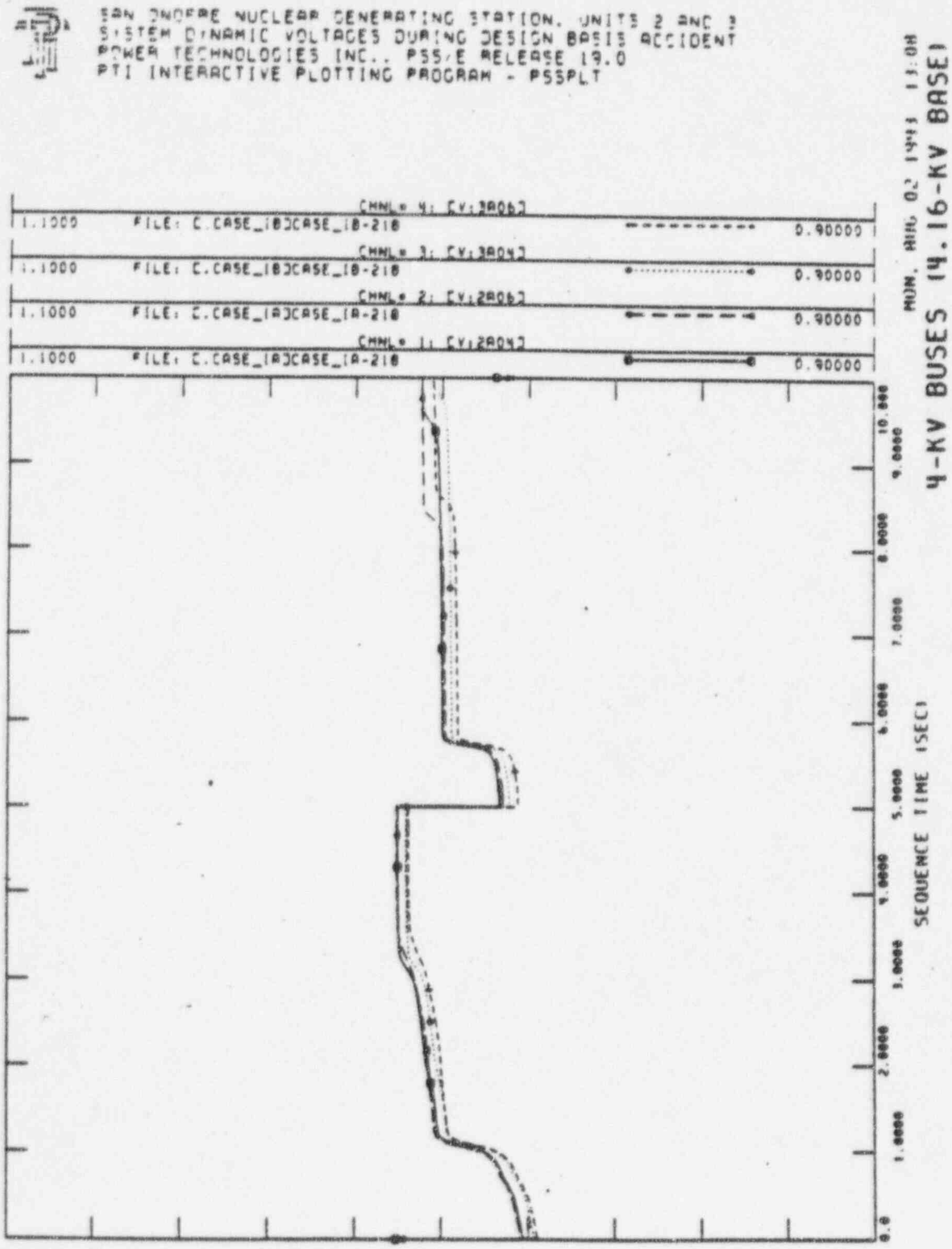

ATTACHMENT 9.8

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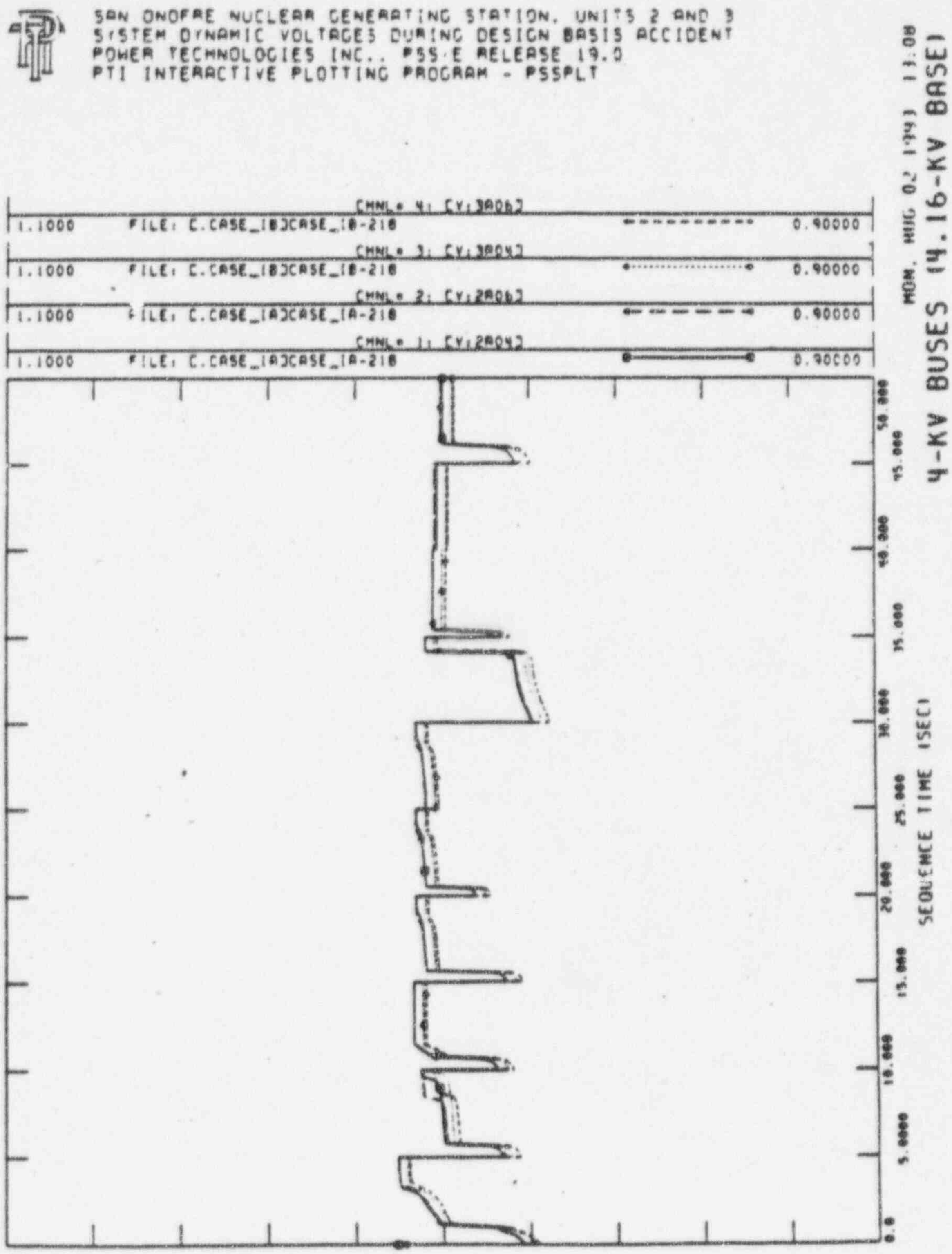
CALCULATION NO. E4C-098 REV. 0 ICCN C-1

Page 2 of 4



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	CCN CONVERSION CCN NO CCN -

ATTACHMENT 9.8

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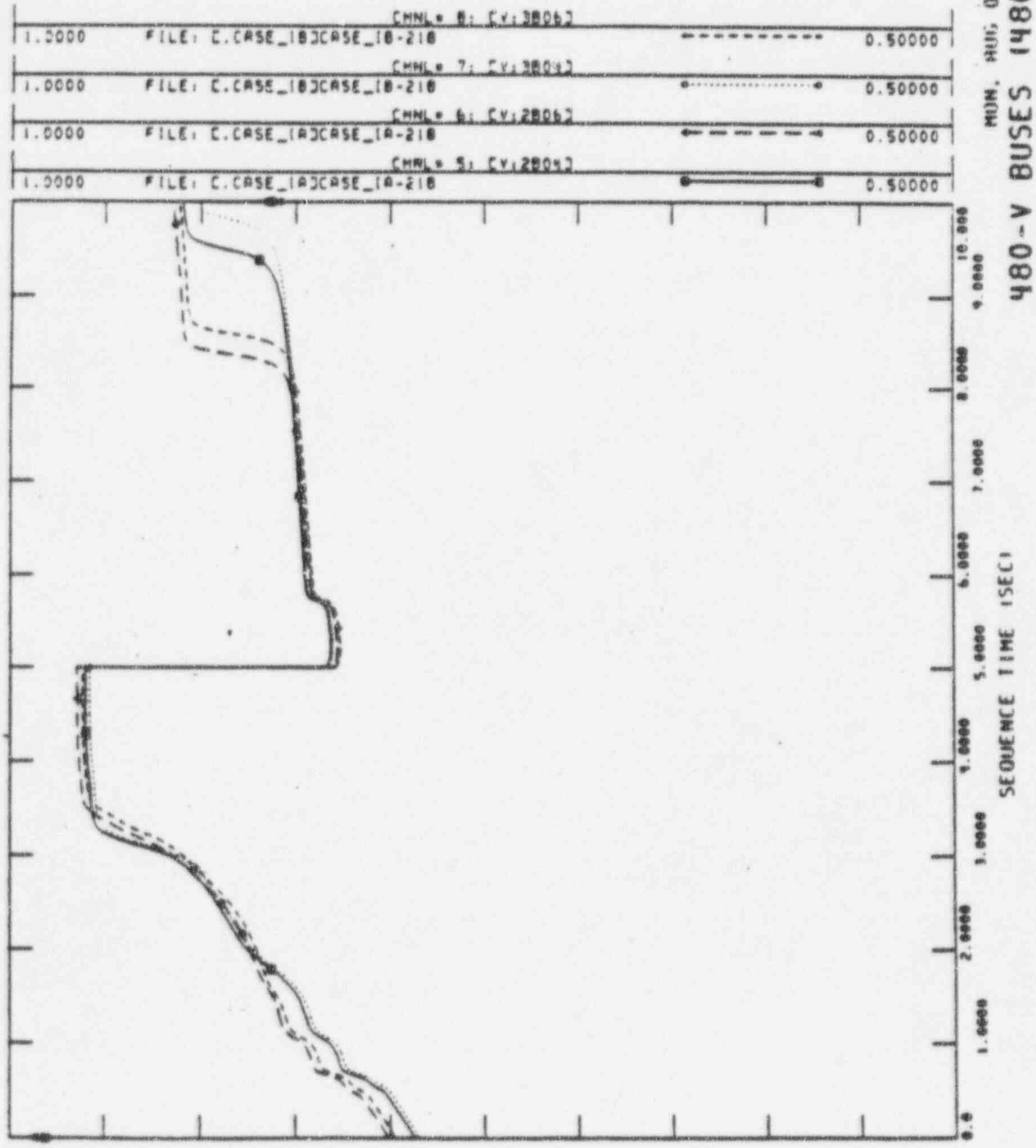
CALCULATION NO. E4C-098 REV. 0 ICCN C-1

SAN ONOFRE NUCLEAR GENERATING STATION, UNITS 2 AND 3
SYSTEM DYNAMIC VOLTAGES DURING DESIGN BASIS ACCIDENT
POWER TECHNOLOGIES INC., PSS E RELEASE 19.0
PTI INTERACTIVE PLOTTING PROGRAM - PSSPLT



ATTACHMENT 9.8

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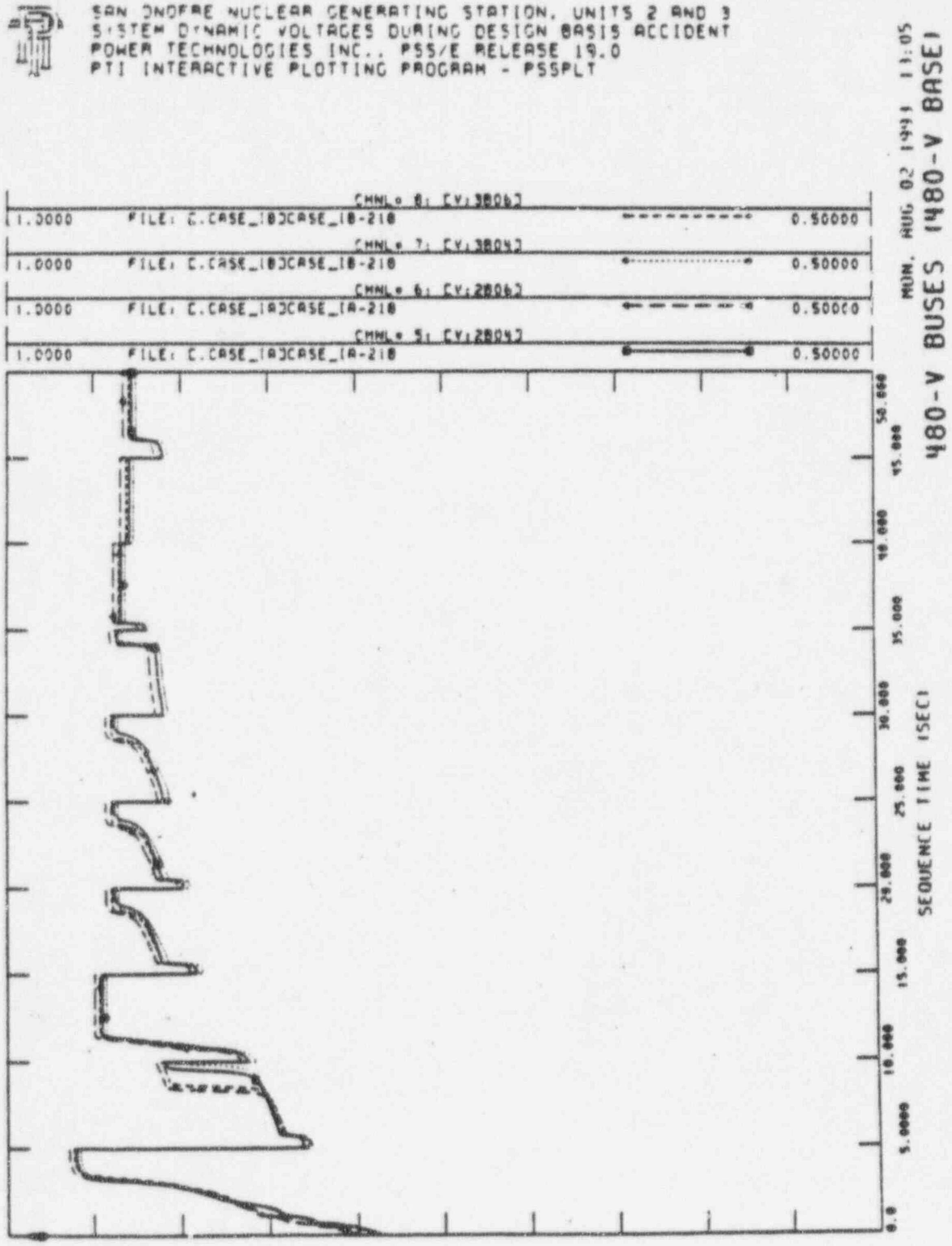
CALCULATION NO. E4C-098 REV. 0 ICCN C-1

SAN ONOFRE NUCLEAR GENERATING STATION, UNITS 2 AND 3
SYSTEM DYNAMIC VOLTAGES DURING DESIGN BASIS ACCIDENT
POWER TECHNOLOGIES INC., PSS/E RELEASE 19.0
PTI INTERACTIVE PLOTTING PROGRAM - PSSPLT



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PRELIM CCN NO C-1	PAGE 62 OF 63
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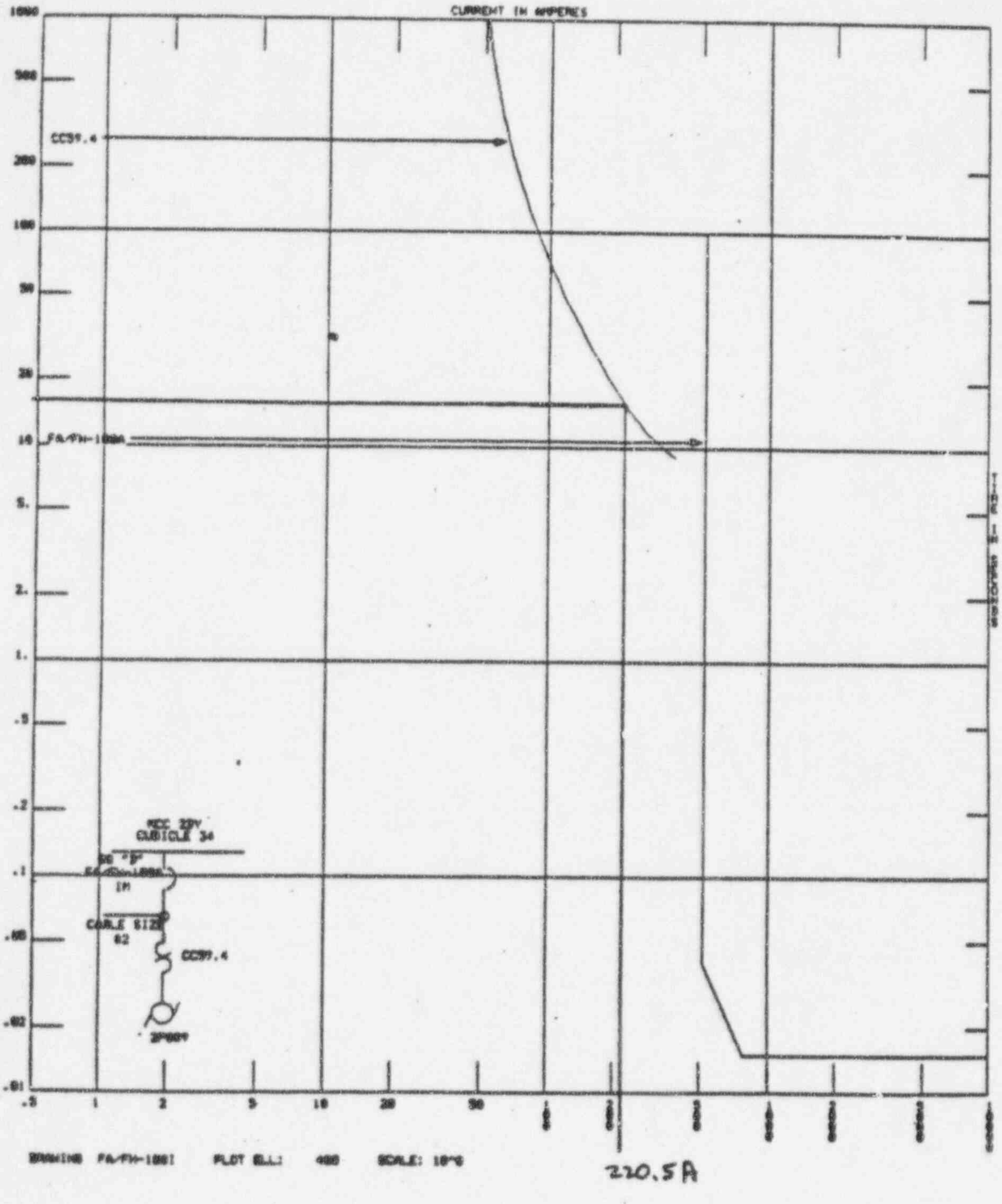
CALCULATION NO. E4C-098 REV. 0 ICCN C-1

Page 1 of 2



ATTACHMENT 9.9

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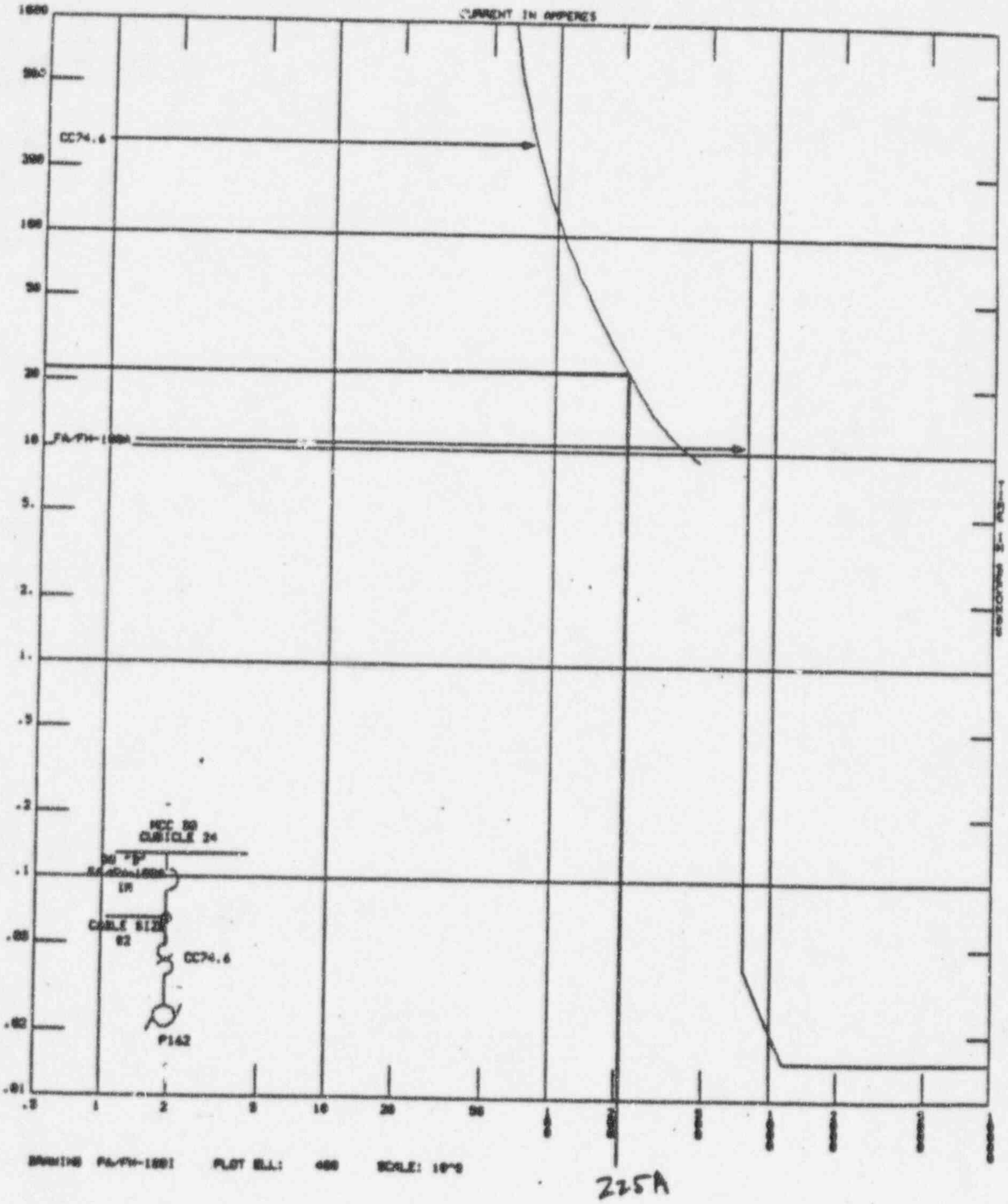
CALCULATION NO. E4C-098 REV. 0 ICCN C-1



CDM FILE # C930813S6056

SONGS GRID STABILITY AND VOLTAGE STUDY

LETTER FROM ROMULO F. BARRENO TO B. CARLISLE
DATED AUGUST 9, 1993

August 9, 1993

B. CARLISLE

SUBJECT: *SONGS Grid Voltage Study*

In your letter of November 25, 1993, you requested, on behalf of Nuclear Engineering Design Organization (NEDO), that System Operation perform an operating study to determine if voltage at the San Onofre Nuclear Generating Station (SONGS) 230kV bus can be maintained at the minimum 218kV level, under conditions specified by your organization, in the absence of SONGS Unit No. 1 (which was taken permanently out of service).

Don Conner of System Operation has completed the requested study and prepared a report, which is attached for your information. As you know, the results of this study have been reviewed in several meetings between System Operation, NEDO and System Planning. The report includes comments received from the different parties involved in the review process.

The study was performed under guidelines prepared jointly by System Operation and NEDO. The following four scenarios were investigated:

1. Scenario 1 is the case when one SONGS unit is off-line, and the remaining SONGS unit trips.
2. Scenario 2 is the case where both SONGS units are on-line, and both units trip following a fault.
3. Scenario 3 is the case where one SONGS unit is off-line, one SONGS unit remains on-line, and critical 230/500kV line(s)/bus is lost.
4. Scenario 4 is the case where one SONGS unit is off-line, and the remaining SONGS unit trips after the loss of critical 230/500kV line(s)/bus.

Scenario 1 resulted in marginally adequate voltage at SONGS. An operating procedure to curtail transmission service to SDG&E under certain conditions was implemented (SDG&E is a part owner of SONGS) to achieve adequate voltage at SONGS.

Scenario 2 resulted in inadequate voltage at SONGS.

Scenario 3 resulted in adequate voltage conditions at SONGS.

Scenario 4 resulted in inadequate voltage conditions at SONGS for several unlikely events studied under this scenario (please refer to the report for detailed description of the events studied). System Operation, with the agreement of the review parties, has implemented an operating procedure to monitor system conditions so that Nuclear Engineering is informed of conditions leading to inadequate voltage at SONGS.

I understand NEDO is developing a relay scheme to protect SONGS for the undervoltages resulting from unlikely conti...cies studied in Scenarios 2 and 4. Monitoring of operating conditions and the corresponding operating procedure will remain in place until this relay scheme is implemented or until facilities to prevent low voltage at SONGS are added to the system, whichever occurs first.

This report completes our response to your request. If you have any questions, please do not hesitate to call Don Conner at PAX 21671 or me at PAX 29588.

ROMULO F. BARRENO

Attachment

cc: J. W. Ballance
W. H. Borgardt
W. D. Conner
J. D. Dyer
Q. S. Hendricks
A. T. Kaneko
M. Kondragunta
J. G. Kritikson
M. D. Lopez
T. S. Ning
A. J. Perez
D. G. Stickney
G. S. Tarplee

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RFB0729 O11/gw

CDM FILE # C930813S6057

SONGS GRID STABILITY AND VOLTAGE STUDY

BY
W.D. CONNER
DATED JULY 30, 1993

WITH

SUPPLEMENT - ECC OPERATING PROCEDURE: MIRA LOMA 500KV NORTH BUS OUTAGE (SCENARIO 4E)

BY
W.D. CONNER
DATED NOVEMBER 2, 1993

SONGS GRID STABILITY AND VOLTAGE STUDY

July 30, 1993

Prepared by

W. D. Conner

System Operation

for

Nuclear Engineering

I. EXECUTIVE SUMMARY

INTRODUCTION

At the request of the Nuclear Engineering Design Organization (NEDO), a grid stability and voltage study was performed for the SONGS units. The purpose of the study was to determine the impact each of four pre-defined Scenarios (see Attachment 1) would have on the stability and on the SONGS 230kV switchyard voltage (minimum analyzed SONGS switchyard voltage = 218kV). This study considers worst case contingencies on both the SCE and SDG&E systems within the guidelines established by NEDO (Attachment 1). This report documents the results of this study.

SUMMARY OF SCENARIOS

- Scenario 1 is the case when one SONGS unit is off-line, and the remaining SONGS unit trips due to a design basis accident.
- Scenario 2 is the case where both SONGS units are on-line, and both units trip under non-accident conditions following a fault on the grid.
- Scenario 3 is the case where one SONGS unit is off-line, one SONGS unit remains on-line, and critical 230/500kV line(s)/bus is lost.
- Scenario 4 is the case where one SONGS unit is off-line, and the remaining SONGS unit trips due to a design basis accident after the loss of critical 230/500kV line(s)/bus.

The station load for each SONGS unit used in this study is assumed to be 80 MW, 45 MVARS. These maximum values were provided by NEDO-Electrical and represent bounding conditions for either a normal or post-accident shutdown condition.

FINDINGS

A. Under Scenario 1, the SONGS voltage did not recover to 218kV when the remaining SONGS unit trips while under heavy SCE Area Load conditions. If 200 MW of firm transmission service to SDG&E is curtailed, the voltage recovers to 218kV.

B. Under Scenario 2, the SONGS voltage does not recover to 218kV when both units trip simultaneously under heavy load conditions.

C. Scenario 3 does not pose a problem to the SONGS 230kV switchyard voltage, as the voltage recovers to 218kV and above for all contingencies. No corrective action is needed.

D. Under Scenario 4, six contingencies were identified in which the SONGS voltage did not recover to 218kV.

An ECC operating procedure has been established to deal with the potential low SONGS voltage conditions found in Scenario 4. The procedure is designed to monitor system operating conditions which can lead to inadequate voltage at SONGS (less than 218kV). Whenever a SONGS unit is off-line and a critical line is lost while the SCE Area Load is above pre-determined threshold level, the ECC will notify SONGS of the inoperable status of the SONGS off-site power source (defined by NEDO as that condition under which the system is unable to support SONGS voltage at 218kV if the remaining unit trips). SONGS will then enter the appropriate Technical Specification action statement and take any necessary action.

CONCLUSIONS

Dependable voltage is sustained at SONGS under Scenario 1 with an ECC operating procedure which curtails up to 200 MW of SDG&E imports under predetermined operating condition.

Under Scenario 2, the SONGS voltage does not recover to 218kV when both units trip simultaneously. NEDO is designing a relay scheme for SONGS which will compensate for the undervoltage condition found in Scenario 2.

Under Scenario 3, the SONGS switchyard voltage recovers to 218kV and above following system disturbances. No corrective action is required.

Under Scenario 4, the SONGS switchyard voltage does not recover to 218kV. Though studies show that 218kV voltage can be attained following disturbances by tripping various amounts of load, this alternative is not being considered due to the very low probability of such events happening. As a more desirable alternative, NEDO is presently developing a relay scheme for SONGS which will protect SONGS for the undervoltages found in the contingencies studied in Scenario 4, as well as Scenario 2 (WR 2060).

In the meantime, an ECC operating procedure has been developed to monitor system conditions which can lead to inadequate voltage at SONGS. Under the procedure, whenever a SONGS unit is off-line and a critical line is lost while the SCE Area Load is above the threshold level, the ECC will notify SONGS of the inoperable status of the SONGS off-site power source (unable to support SONGS voltage at 218kV if the remaining unit trips). SONGS will then enter the appropriate technical specification action statement and take any required action. The Scenario 4 procedure will remain in effect until NEDO and System Operation decide it is no longer necessary to monitor system conditions because either new facilities are added as long-term solutions or automatic tripping/relay schemes are implemented to protect against inadequate voltages at the SONGS switchyard.

II. OUTLINE FOR SONGS GRID STABILITY AND VOLTAGE STUDIES

INTRODUCTION

These studies, completed at the request of NEDO, were performed to ensure that voltage conditions at the SONGS switchyard are adequate at all times to respond to an accident scenario such as a Loss of Coolant Accident (LOCA). Critical system conditions studied were jointly determined with NEDO. Once results of power flow and stability analysis became known, an operating procedure was developed by System Operation and approved in joint meetings with NEDO and System Planning. This procedure, described in this report, is now in place.

A corrective measure, involving a tripping scheme at SONGS, is presently being developed by NEDO. This scheme will protect SONGS against potential low voltages that could be caused by certain events identified in [illegible] report.

Based on guidelines prepared by NEDO (see Attachment 1) System Operation prepared an outline for the SONGS Grid Stability and Voltage Study. This outline, shown below, was the basis for the study and describes the assumptions, scenarios, system representation and study procedure used in the study.

GENERAL ASSUMPTIONS

1. SONGS Unit 1 is permanently shut down.
2. Peak summer loads are modeled in system representation. (See Tables 2-3 for a description of the area interchange and MW/MVAR ratios modeled in the system representation.)
3. Each on-line SONGS unit is capable of generating a maximum of 1160 MW and 550 MVAR.
4. A total auxiliary load of 160 MW and 90 MVAR at SONGS (80 MW and 45 MVAR at each of Units 2 and 3 -- bounding values for all modes of normal and post-accident operation.

STUDY SCENARIOS

The four study scenarios to be evaluated are described in Attachment 1.

SYSTEM REPRESENTATION

The basis for the system representation is the WSCC 1991 HS3 case. The Area Interchange Sheets for the SCE/MWD and SDG&E areas in this case are shown in Table 2.

The WSCC 1991 HS3 base case was modified to represent SONGS 1 off-line and approximate load levels of 18,300 MW and 3,300 MW for the Southern California and San Diego control areas, respectively, which represent the estimated 1993 peak conditions. Additional load levels for the Southern California and San Diego control areas will be evaluated as required.

For the load level shown above, the following base case will be developed:

Case A: SONGS 2 and 3 On-Line

- Seven percent spinning reserve in both areas.
- MW:MVAR ratios for SCE area as shown in Table 3.
- No cold stand-by units or peakers on-line in SCE area.
- QF generation in SCE area equivalent to generation on-line at time of 1992 system peak.

Case B: SONGS 3 On-Line

- Adjust Case A by removing generation output of SONGS 2 and re-adjusting generation in both Southern California and San Diego control areas for loss of SONGS 2 to achieve spinning reserve levels between five and seven percent in each of these areas.
- Utilize oil and gas units before peakers.
- Do not utilize cold standby units.
- Convert economy purchases to short-term firm imports if required to achieve spinning reserve objectives once all available oil and gas units and peakers have been brought on-line.

STUDY PROCEDURE

At heavy load levels, perform evaluation of conditions outlined in Attachment 1 by utilizing the following power flow and stability set-ups:

Scenario 1

1. Power Flow

   - Modify Case B by removing generation output from SONGS 3.
   - Adjust generation in Southern California and San Diego control areas by "leaning" on interties proportionately according to area load.

2. Stability

   - Use Case B as a history file.
   - At time=0, trip SONGS 3 (no fault).
   - Run program for 10 seconds.

3. Re-run power flow with SONGS 1 on-line for maximum load level condition.

Scenario 2

1. Power Flow

   - Modify Case A by removing generation output from both SONGS 2 and 3.
   - Adjust generation in Southern California and San Diego control areas by "leaning" on interties proportionately according to area load.

2. Stability

   - Use Case A as a history file.
   - At time=0+, apply three-phase fault near the San Onofre 230kV bus.
   - Clear this fault in five cycles and trip SONGS 2 and 3 concurrently.
   - Run program for 10 seconds.

3. Re-run power flow with SONGS 1 on-line for maximum load condition.

Scenario 3

1. Power Flow

   - Study Case B with the following contingencies (taken one at a time):

     a. Loss of Mira Loma-Serrano and Lugo-Serrano 500kV lines.

     b. Loss of Lugo-Mira Loma Nos. 2 and 3 500kV lines.

     c. Loss of Ellis-Johanna and Ellis-Santiago 230kV lines.

     d. Loss of Imperial Valley-Miguel 500kV line and Imperial Valley-La Rosita 230kV line.

     e. Loss of 500kV bus at Mira Loma Substation.

     f. Loss of Palo Verde-Devers 500kV line.

2. Stability

   - Use Case B as a history file.
   - For each contingency listed above, apply a three-phase fault at the common bus or bus nearest San Onofre if a common bus is not shared. Clear this fault in five cycles and four cycles for the 230kV and 500kV lines, respectively, and open the lines involved in the contingency.
   - Run program for 10 seconds.

Scenario 4

1. Power Flow

   - Modify Case B by modeling each contingency listed in Scenario 3 separately and removing the generation output from SONGS 3.
   - Adjust generation in Southern California and San Diego control areas by "leaning" on interties proportionately according to area load.

2. Stability

   - Use Case B as a history file.
   - For each contingency listed in Scenario 3, apply a three-phase fault at the common bus or bus nearest San Onofre if a common bus is not shared. Clear this fault in five cycles and four cycles for the 230kV and 500kV lines, respectively, and open the lines involved in the contingency. One cycle later, trip SONGS 3 (no fault).
   - Run program for 10 seconds.

3. Re-run power flow with SONGS 1 on-line for maximum load level condition.

III. STUDY RESULTS

The SONGS Grid Stability and Voltage Study Results are shown in Table 1. Shown below is a description of the study results for each Scenario (stability plots are shown in Attachment 2):

Scenario 1

Under Scenario 1, one SONGS unit is out of service and in Mode 3 (80 MW, 45 MVAR), and the remaining SONGS unit in Mode 1 (80 MW, 45 MVAR) trips.

The SCE grid is stable. The minimum post trip transient voltage at the SONGS switchyard is 208kV, and the steady state voltage recovers to 217.2kV in about 2.5 seconds. In order for the voltage to recover to 218kV, the maximum allowable SCE load (threshold) should be 17,900 MW. If SONGS Unit 1 were on-line in this scenario, the SONGS steady state voltage would be 223kV.

Curtailing up to 200 MW of SDG&E power imports will insure that 218kV is maintained at SONGS for loss of the remaining SONGS generating unit.

Scenario 2

Under Scenario 2, both SONGS units are in service in Mode 1 (80 MW, 45 MVAR), a 3-phase fault is applied external to the SONGS 230kV switchyard, and both SONGS 2 and 3 trip concurrently.

The SCE grid remains stable. The minimum post-trip transient voltage at the SONGS switchyard is 191kV, and the steady state voltage recovers to 214.7kV in about 2 seconds. In order for the voltage to recover to 218kV, the maximum allowable SCE load (threshold) should be 15,600 MW. If SONGS Unit 1 were on-line in this scenario, the SONGS steady state voltage would be 221kV. In order to maintain 218kV for loss of both SONGS units simultaneously without SONGS 1, about 540 MW of load needs to be shed at Santiago for Scenario 2.

Scenario 3

Under Scenario 3, one SONGS unit is off-line in Mode 3 (80 MW, 45 MVAR), the remaining SONGS unit is on-line in Mode 1 (80 MW, 45 MVAR), and a critical 230/500kV line(s)/bus trips as shown below:

Case A
The Mira Loma-Serrano and Lugo-Serrano 500kV lines trip for Case A.

The SCE grid remains stable. The minimum post-trip transient voltage at the SONG switchyard is 217.6kV, and the steady-state voltage recovers to 218kV in about 2 seconds. The steady state voltage at the SONGS switchyard is 228kV.

Case B
The Lugo-Mira Loma 2 and 3 500kV lines trip for Case B.

The SCE grid remains stable. The minimum post-trip transient voltage at the SONGS switchyard is 210.5kV and recovers to 218kV in about 2 seconds. The steady state voltage at the SONGS switchyard is 226.7kV.

Case C
The Ellis-Johanna and Ellis-Santiago 230kV lines trip for Case C.

The SCE grid remains stable. The minimum post-trip transient voltage at the SONGS switchyard is 217.5kV, and the steady state voltage recovers to 218kV in about 2 seconds. The steady state voltage at the SONGS switchyard is 227.3kV.

Case D
The Imperial Valley-Miguel 500kV line and Imperial Valley-Rosita 230kV line trips for Case D.

The SCE grid remains stable. The minimum post-trip transient voltage at the SONGS switchyard is 217.6kV, and the steady state voltage recovers to 218kV in about 3 seconds. The steady state voltage at the SONGS switchyard is 224.8kV.

Case E
The Mira Loma 500kV North bus and No. 2AA transformer trip for Case E.

The SCE grid remains stable. The minimum post-trip transient voltage at the SONGS switchyard is 215.7kV and recovers to 218kV in about 2 seconds. The steady state voltage at the SONGS switchyard is 229.1kV.

Case F
The Palo Verde-Devers 500kV line trips for Case F.

The SCE grid remains stable. The minimum post-trip transient voltage at the SONGS switchyard is 221kV, and the steady state voltage is 227.2kV.

Since the SONGS voltage was greater than 218kV for Cases A-F of Scenario 3, no operating solutions are necessary.

Scenario 4

Under Scenario 4, one SONGS unit is off-line in either Mode 3 (80 MW, 45 MVAR) or Mode 5 (25 MW, 15 MVAR), and the remaining SONGS unit in Mode 1 (80 MW, 45 MVAR) trips following loss of a critical 230/500kV line(s)/bus as shown below:

Note: *Numbers shown below in parenthesis represent the case where the SONGS off-line unit is in Mode 5. Numbers not shown in parenthesis represent the case where the SONGS off-line unit is in Mode 3. The same lines trip in Scenario 4 as shown in Scenario 3 and are followed by the tripping of the remaining SONGS unit.*

Case A
The SCE grid remains stable. The minimum post-trip transient voltage is 201 (202.3) kV at the SONGS switchyard, and the steady state voltage is 211.6 (212.9) kV. The SCE system threshold load is 13,600 (14,600) MW in order for the SONGS switchyard voltage to recover to 218kV under Case A.

When the SCE Area Load is above the threshold, shedding 960 (540) MW of load at Johanna and Santiago when the remaining SONGS unit trips will allow the SONGS switchyard voltage to recover to 219kV.

Case B
The SCE grid remains stable. The minimum post-trip transient voltage is 187.5 (188.5) kV at the SONGS switchyard, and the steady state voltage is 205 (206) kV. The SCE system threshold load is 13,600 (14,100) MW in order for the SONGS switchyard voltage to recover to 218kV under Case B.

When the SCE Area Load is above the threshold level, tripping of 1530 (1530) MW of load at Ellis, Johanna and Santiago when the remaining SONGS unit trips would allow the SCE switchyard voltage to recover to 218.5 (218.6) kV.

Case C
The SCE grid remains stable. The minimum post-trip transient voltage is 180 (182) kV at the SONGS switchyard, and the steady state voltage is 190 (192) kV. The SCE system threshold load is 11,600 (12,600) MW in order for the SONGS switchyard voltage to recover to 218kV under Case C.

When the SCE Area Load is above the threshold level, tripping of 960 (960) MW of load at Johanna and Santiago when the remaining SONGS unit trips would allow the SONGS switchyard voltage to recover to 220 (222) kV.

Case D
The SCE grid is unstable for Case D under base case conditions (SCE load at 18,300 MW and Arizona-California flows at 5000 MW). Sensitivity analysis indicates that if either the Arizona-California flow is reduced to 4500 MW or SCE load is reduced to 17,000 MW, system stability is attained. In order to attain 218kV voltage at SONGS, the SCE system load is 12,600 (13,600) MW or lower.

When the SCE Area Load is above the threshold level, opening the SCE/SDG&E tie and tripping 200 MW of Santiago load would allow the SONGS switchyard voltage to recover to 218 (219) kV when the remaining SONGS unit trips. If the SCE/SDG&E tie lines are not opened, tripping of about 3500 MW of SCE/SDG&E load would be necessary when the remaining SONGS unit trips to allow the SONGS switchyard to recover to 218 (219) kV.

Case E
The SCE grid is stable. The minimum post-trip transient voltage is 205 (206) kV at the SONGS switchyard, and the steady state voltage is 216.6 (217.8) kV. The SCE system threshold load is 16,600 (17,400) MW in order for the SONGS switchyard voltage to recover to 218kV under Case E.

When the SCE Area Load is above the threshold level, tripping of 540 (540) MW of load at Santiago when the remaining SONGS unit trips would allow the SONGS switchyard voltage to recover to 220 (221) kV.

Case F
The SCE grid remains stable. The minimum post-trip transient voltage is 197 (199) kV at the SONGS switchyard, and the steady state voltage is 206.4 (208.4) kV. The SCE system threshold load is 13,600 (14,600) MW in order for the SONGS switchyard voltage to recover to 218kV under Case F.

When the SCE Area Load is above the threshold level, tripping of 1530 (1530) MW of load at Ellis, Johanna, and Santiago when the remaining SONGS unit trips would allow the SONGS switchyard voltage to recover to 218.4 (219.8) kV.

For all contingency cases studied under Scenario 4: 1) The SONGS voltage is greater than 218kV prior to tripping the remaining SONGS unit, and 2) The SONGS voltage would be greater than 218kV following loss of lines and the remaining SONGS unit if SONGS Unit 1 were on-line.

IV. CONCLUSIONS

Under Scenario 1, the SONGS voltage is marginally below the required 218kV. An ECC operating procedure is now in place to insure that the SONGS switchyard voltage does not fall below 218kV when the remaining SONGS unit trips. This procedure restricts SDG&E by up to 200 MW of import power under certain operating conditions.

Under Scenario 2, the SONGS voltage does not recover to 218kV when both units trip simultaneously. NEDO is designing a relay scheme for SONGS which will compensate for the undervoltage condition found in Scenario 2.

Under Scenario 3, the SONGS switchyard voltage recovers to 218kV and above. No corrective action is required.

Under Scenario 4, the SONGS switchyard voltage does not recover to 218kV. Though studies show that 218kV voltage can be attained following disturbances by tripping various amounts of load, this alternative is not being considered due to the very low probability of such events happening. As a more desirable alternative, NEDO is presently developing a relay scheme for SONGS which will protect SONGS for the undervoltages found in the contingencies studied in Scenario 4, as well as Scenario 2 (WR 2060).

In the meantime, an ECC operating procedure has been developed to monitor system conditions which can lead to inadequate voltage at SONGS. Under the procedure, whenever a SONGS unit is off-line and a critical line is lost while the SCE Area Load is above the threshold level, the ECC will notify SONGS of the inoperable status of the SONGS off-site power source (unable to support SONGS voltage at 218kV if the remaining unit trips). SONGS will then enter the appropriate technical specification action statement and take any required action. The Scenario 4 procedure will remain in effect until NEDO and System Operation decide it is no longer necessary to monitor system conditions because either new facilities are added as long-term solutions or automatic tripping/relay schemes are implemented to protect against inadequate voltages at the SONGS switchyard.

Table 1

SONGS GRID STABILITY AND VOLTAGE STUDY RESULTS: 1993

Case	System Condition *	1993 Voltage/Stability Conditions **	Operating Solutions
Base Case	Base Case: SONGS 2 & 3 Units in service & in Mode 1	No Problem: Base Case or Line(s) Outage Condition	None
Scenario 1	One SONGS unit out of service & in Mode 3 (80 MW, 45 MVAR) & remaining SONGS unit in Mode 1 (80 MW, 45 MVAR).	Remaining SONGS unit trips; grid remains stable. Minimum Post-trip Transient Voltage = 208kV; Steady State Voltage = 217.2kV. If Unit 1 were on-line, the steady state voltage would be 223kV.	Curtail up to 200 MW of SDG&E power imports. Steady State Voltage = 218.2kV.
Scenario 2	Both SONGS units in service & in Mode 1 (80 MW, 45 MVAR).	Apply a 3-phase fault at the San Onofre 230kV bus & trip SONGS 2 & 3 concurrently; grid remains stable. Minimum Post-trip Transient Voltage = 191kV. Steady State Voltage = 214.7kV. If Unit 1 were on line, steady state voltage would be 221kV.	Trip 540 MW of load at Santiago. Steady State Voltage at 218.9kV. Load Threshold = 15,600 MW.
Scenario 3	One SONGS unit off-line & in Mode 3 (80 MW, 45 MVAR) & remaining SONGS unit in Mode 1 (80 MW, 45 MVAR).	A. Outage of Double Circuit Tower: Mira Loma-Serrano & Lugo-Serrano 500kV lines out; grid remains stable. Minimum Post-trip Transient Voltage = 217.6kV & recovers to 218kV in about 2 sec.; Steady State Voltage = 228.0kV.	None Needed
		B. Outage of Double Circuit Tower: Lugo-Mira Loma 2,3 500kV lines out; grid remains stable. Minimum Post-trip Transient Voltage = 210.5kV & recovers to 218kV in about 2 sec.; Steady State Voltage = 226.7kV.	None Needed
		C. Outage of Double Circuit Tower: Ellis-Johanna & Ellis-Santiago 230kV lines out; grid remains stable. Minimum Post-trip Transient Voltage = 217.5kV & recovers to 218kV in about 2 sec.; Steady State Voltage = 227.3kV.	None Needed
		D. Outage of Imperial Valley-Miguel 500kV line & Imperial Valley-Rosita 230kV line; grid remains stable. Minimum Post-trip Transient Voltage = 217.6kV & recovers to 218kV in about 3 sec.; Steady State Voltage = 224.8kV.	None Needed
		E. Outage of the Mira Loma 500kV North Bus & No. 2AA Transformer; grid remains stable. Minimum Post-trip Transient Voltage = 215.7kV & recovers to 218kV in about 2 sec.; Steady State Voltage = 229.1kV.	None Needed
		F. Outage of the Palo Verde-Devers 500kV line; grid remains stable. Minimum Post-trip Transient Voltage = 221kV; Steady State Voltage = 227.2kV.	None Needed
Scenario 4	One SONGS unit off-line & in Mode 3 (80 MW, 45 MVAR) & remaining SONGS unit in Mode 1 (80 MW, 45 MVAR) _NOTE: For all line outage cases under Scenario 4: 1) Prior to tripping SONGS 3, SONGS voltage >> 218kV, and 2) If SONGS Unit 1 were on-line, SONGS voltage >> 218kV following loss of lines & remaining SONGS unit_	**_Remaining SONGS unit trips following loss of each of the following lines:_** A. **Outage of the Lugo-Serrano & Mira Loma-Serrano 500kV Lines** Grid remains stable. Minimum Post-trip Transient Voltage = 201kV; Steady State Voltage = 211.6kV.	Trip 960 MW of load at Johanna & Santiago. Steady State Voltage at 219.1kV; Load Threshold = 13,600 MW
		B. **Outage of the Lugo-Mira Loma 2 & 3 500kV Lines** Grid remains stable. Minimum Post-trip Transient Voltage = 187.5kV; Steady State Voltage = 205kV.	Trip 1530 MW of load: Ellis, Johanna & Santiago. Steady State Voltage at 218.5kV; Load Threshold = 13,600 MW.
		C. **Outage of the Ellis-Johanna & Ellis-Santiago 230kV Lines** Grid remains stable. Minimum Post-trip Transient Voltage = 180kV; Steady State Voltage = 190kV	Trip 960 MW of load at Johanna & Santiago. Steady State Voltage at 220.2kV; Load Threshold = 11,600 MW

SONGS GRID STABILITY AND VOLTAGE STUDY RESULTS: 1993 (Cont'd.)

Case	System Condition *	1993 Voltage/Stability Conditions **	Operating Solutions
Scenario 4 *(Continued)*		**D. Outage of the Imperial Valley-Miguel 500kV line & the Imperial Valley-Rosita 230kV Line** Grid is unstable. Minimum Post-Trip Transient Voltage = N/A; Steady State Voltage = N/A.	Trip 3500 MW of load in SCE/SDG&E's system with SCE/SDG&E tie lines in place. Steady State Voltage at 218.0kV; Load Threshold = 12,600 MW. EOR = 4700 MW. Open SCE/SDG&E tie lines and trip only 200 MW of SCE load.
		E. Outage of the Mira Loma 500kV North Bus & No. 2AA Bank Grid remains stable. Minimum Post-trip Transient Voltage = 205kV; Steady State Voltage = 216.6kV.	Trip 540 MW at Santiago. Steady State Voltage at 220.1kV; Load Threshold = 16,600 MW.
		F. Outage of the Palo Verde-Devers 500kV line Grid remains stable. Minimum Post-trip Transient Voltage = 197kV; Steady State Voltage = 206.4kV.	Trip 1530 MW of load at Ellis, Johanna & Santiago. Steady State Voltage at 218.4kV; Load Threshold = 13,600 MW.
Scenario 4	One SONGS unit out of service & in Mode 5 (25 MW, 15 MVAR) & remaining SONGS unit in Mode 1 (80 MW, 45 MVAR).	***Remaining SONGS unit trips following loss of each of the following lines:***	
		A. Outage of the Lugo-Serrano & Mira Loma-Serrano 500kV Lines Steady State Voltage = 212.9kV	Trip 540 MW of load at Santiago. Steady State Voltage at 218.2kV; Load Threshold = 14,500 MW.
		B. Outage of the Lugo-Mira Loma 2 & 3 500kV Lines Steady State Voltage = 206kV	Trip 1530 MW of load at Ellis, Johanna & Santiago. Steady State Voltage at 218.6kV; Load Threshold = 14,100 MW.
		C. Outage of the Ellis-Johanna & Ellis-Santiago 230kV Lines Steady State Voltage = 192kV	Trip 960 MW of load at Santiago & Johanna. Steady State Voltage at 222kV; Load Threshold = 12,600 MW.
		D. Outage of the Imperial Valley-Miguel 500kV Line & the Imperial Valley-Rosita 230kV Line Grid is unstable.	Trip 3500 MW of load in SCE/SDG&E's system with SCE/SDG&E tie lines in place. Steady State Voltage at 219.2kV; Load Threshold = 13,600 MW. EOR = 4700 MW. Open SCE/SDG&E tie lines and trip only 200 MW of SCE load.
		E. Outage of the Mira Loma 500 North Bus & No. 2AA Bank Steady State Voltage = 217.8kV	Trip 540 MW at Santiago. Steady State Voltage at 221kV; Load Threshold = 17,400 MW.
		F. Outage of the Palo Verde-Devers 500kV Line Steady State Voltage = 208.4kV	Trip 1530 MW of load at Ellis, Johanna, Santiago. Steady State Voltage at 219.8kV; Load Threshold = 14,600 MW.

* ***All cases shown in this Table with SCE load at 18,300 MW and EOR at 5100 MW.***

** ***Minimum Required Voltage at SONGS = 218kV.***

Table 2

Southern California Edison and Metropolitan Water District Area

1991 Heavy Summer 3 Loading - 1991 HS3

AREA INTERCHANGE SHEET

RESOURCE	METERED AT	MW +OUT -IN	
(4 Corners)	Eldorado	-688.1	
(UP&L)	Eldorado	0.0	
(Navaho)	Eldorado	0.0	
(Palo Verde 1,2,3)	PV	-602.0	
(MSR)	PV	-38.5	
(PV-D fr LADWP)	PV	-217.2	
(PV-D fr DWP/SCPPA)	PV	-150.8	
(SRP Excess)	PV	-100.0	
(APS)	PV	-500.0	
(TEP)	Eldorado	-300.0	
( )	PV	0.0	
	NET with ARIZONA		-2596.0
(SCE Geothermal)	Mirage	-470.0	
	NET with IMPERIALCA		-470.0
(Pacific AC for LADWP)	Sylmar	294.4	
(PV for LADWP Firm)	Sylmar	359.2	
(Mohave)	Eldorado	316.0	
(CDWR - Reid Gardner)	Eldorado	0.0	
(CPP DC Line)	Sylmar	-1813.5	
(DC Line Pasadena)	Sylmar	-62.5	
(Hoover Pasadena)	Sylmar	-19.0	
(CDWR Castaic - State)	Sylmar	-71.0	
(SCPPA - Pasadena)	Sylmar	-9.4	
(IPP - Pasadena)	Sylmar	-96.0	
(IPP - Ana/Riv)	Victorville	-333.5	
(SCPPA - Riverside)	Victorville	-11.6	
(SCPPA - Munies)	Victorville	-16.9	
(Deseret - Ana/Riv)	Victorville	-127.0	
(LADWP-SCE)Vernon	Sylmar	-15.0	
(Resale Cities)	Victorville	0.0	
	NET with LADWP		-1605.8

Southern California Edison and Metropolitan Water District Area

1991 Heavy Summer 3 Loading - 1991 HS3

AREA INTERCHANGE SHEET (Cont'd.)

RESOURCE	METERED AT	MW +OUT -IN	
(NPC Laughlin Load)	Mohave	65.0	
	NET with NPC		65.0
(Northwest DC)	Midway	689.5	
(Northwest AC)	Midway	-1081.0	
(Hyatt)	Midway	-490.4	
(Thermalito)	Midway	-84.6	
(MSR)	Midway	38.5	
(CDWR)	Midway	71.0	
(Economy Purchase)	Midway	-1143.0	
	NET with PG&E		-2000.0
(San Onofre 1,2,&3)	San Onofre	410.0	
(Northwest AC)	San Onofre	149.1	
(Northwest DC)	San Onofre	96.5	
(CFE) Firm	San Onofre	-68.0	
(Economy)	San Onofre	0.0	
(QF)	San Onofre	0.0	
	NET with SDG&E		587.6
(Hoover SCE/MWD)	Mead	-525.0	
(Hoover-Munies)	Mead	-80.7	
(Parker/Davis-Grge./Nrtn.)	Blythe	-4.5	
(Parker/Davis - FAFB)	Blythe	-18.3	
(Parker/Davis - MWD)	Gene	-50.0	
(Mohave - SRP)	Mead	158.0	
(Mohave - NPC)	Mead	155.0	
(Economy Fm SRP)	Mead	0.0	
(Appa - Anza Sale)	Mead	-4.3	
(For MSR fm SRP)	Mead	0.0	
	NET with WAPA LC		-369.8
	Total Area Interchange		-6389.0
	Firm Import		3750.0

San Diego Gas & Electric
1991 Heavy Summer - 1991 HS3

AREA INTERCHANGE SUMMARY

AREA	RESOURCE	METER PT.	MW (+OUT,-IN)	
SOCALIF	(SAN ONOFRE #1,2,3)	SAN ONOFRE	-410.0	
SOCALIF	(NORTHWEST)	SAN ONFORE	-245.6	
SOCALIF	(MEXICO-CFE)	SAN ONOFRE	68.0	
		NET with SOCALIF		-587.6
ARIZONA	(APS)	NORTH GILA	-230.0	
ARIZONA	(SRP ECONOMY)	NORTH GILA	-150.0	
ARIZONA	(PNM)	NORTH GILA	-99.0	
ARIZONA	(TEP)	NORTH GILA	-215.0	
ARIZONA	(PALO VERDE-IID)	NORTH GILA	-14.5	
ARIZONA	(EPE-IID)	NORTH GILA	-99.0	
		NET with ARIZONA		807.5
IID	(PALO VERDE-IID)	IMPERIAL VLY.	14.5	
IID	(EPE-IID)	IMPERIAL VLY.	98.0	
		NET with IID		112.5
MEXICO-CFE	(CFE)	MIGUEL, IMPERIAL VLY.	-220.0	
		NET with CFE		-220.0
	TOTAL AREA INTERCHANGE			-1502.6

Table 3

Heavy Summer
*MW:MVAR Ratios**
1993 Operating Studies

230 kV Bus	MW:MVAR	230 kV Bus	MW:MVAR
Alamitos	6:1	Moorpark	12:1
Antelope	20:1	Olinda	20:1
Bailey	20:1	Padua	20:1
Barre	20:1	Rector	20:1
Center	20:1	Rio Hondo	20:1
Chino	20:1	San Bernardino	20:1
Del Amo	20:1	Santa Clara	10:1
Devers	20:1	Santiago	13:1
Eagle Mountain	20:1	Saugus	20:1
Eagle Rock	20:1	Springville	20:1
Ellis	20:1	Valley (500kV)	20:1
El Nido	14:1	Vestal	20:1
Etiwanda	20:1	Victor (115 kV)	10:1
Goleta	13:1	Villa Park	20:1
Gould	9:1	Vista	20:1
Hinson	20:1	Walnut	20:1
Johanna	20:1		
Kramer (115 kV)	10:1		
La Cienega	9:1		
La Fresa	15:1		
Laguna Bell	20:1		
Lewis	6:1		
Lighthipe	20:1		
Mesa	10:1		
Mirage	7:1		

* ***Based on evaluation of actual MW:MVAR ratios at 1500 HRS on August 17, 1992. All available subtransmission capacitors and condensers are considered to be in-service to the extent that the substation MW:MVAR ratio is not greater than 20:1 at any location for conservative purposes.***

Attachment 1

GUIDELINES for

SONGS Grid Stability Studies

SCENARIO 1

Initial Conditions and Sequence of Events

Unit 2: Offline, mode 3.

Unit 3: Mode 1, 100% power; design basis accident occurs followed by a unit trip.

Evaluation[1]

1) Does the grid remain stable?

2) What is the minimum post trip *transient* voltage at the SONGS switchyard?

3) What is the post trip *steady state* voltage at the SONGS switchyard?

4) If the *transient* voltage dips below 218 kV at the SONGS switchyard:

   a) does it recover to ≥ 218 kV?
   b) how long does it take?
   c) what is the maximum allowable offsite system load (threshold), prior to the SONGS 3 trip, that will ensure that the SONGS switchyard voltage will recover to ≥ 218 kV?

5) If Unit 1 were online at 100% power in this scenario, would the SONGS switchyard voltage remain stable at ≥ 218 kV? If not, what offsite system load threshold would be required to achieve this?

Note 1: Voltage and frequency profiles should be provided for each scenario.

SCENARIO 2

Initial Conditions and Sequence of Events

Units 2 and 3 both operating at 100% power. A system fault occurs (external to SONGS) which results in a simultaneous trip of both SONGS units.

Evaluation

1) Does the grid remain stable?

2) What is the minimum post trip *transient* voltage at the SONGS switchyard?

3) What is the post trip *steady state* voltage at the SONGS switchyard?

4) If the *transient* voltage dips below 218 kV at the SONGS switchyard:

   a) does it recover to ≥ 218 kV?
   b) how long does it take?
   c) what is the maximum allowable offsite system load (threshold), prior to the unit trips, that will ensure that the SONGS switchyard voltage will recover to ≥ 218 kV?

5) If Unit 1 were online at 100% power in this scenario, would the SONGS switchyard voltage remain stable at ≥ 218 kV? If not, what offsite system load threshold would be required to achieve this?

SCENARIO 3

Initial Conditions and Sequence of Events

Unit 2: Offline, mode 3.

Unit 3: Mode 1, 100% power.

System: Loss of largest generation source due to a single event. This may be the loss of the largest station or transmission line on the grid, or possibly several large stations or transmission lines if they share a common tower. A subsequent loss of generation that could occur due to interlocks or cascading effects should be considered. Events on both the SCE system and SDG&E system should be considered.

Evaluation

1) Does the grid remain stable?

2) What is the minimum *transient* voltage at the SONGS switchyard?

3) What is the final *steady state* voltage at the SONGS switchyard?

SCENARIO 4

Initial Conditions and Sequence of Events

Unit 2: Offline, mode 3.

System: Loss of largest generation source due to a single event followed by (not concurrent with) a Unit 3 trip (this scenario is a continuation of Scenario 3 above). Events on both the SCE system and SDG&E system should be considered.

Unit 3: Mode 1, 100% power; a design basis accident occurs followed by a unit trip.

Evaluation

1) Does the grid remain stable?

2) What is the minimum post trip *transient* voltage at the SONGS switchyard?

3) What is the post trip *steady state* voltage at the SONGS switchyard?

4) If the *transient* voltage dips below 218 kV at the SONGS switchyard:

    a) does it recover to ≥ 218 kV?
    b) how long does it take?
    c) what is the maximum allowable offsite system load (threshold), prior to the SONGS 3 trip, that will ensure that the SONGS switchyard voltage will recover to ≥ 218 kV?

5) Following the generation loss on the grid, but prior to the SONGS 3 trip:

    a) can the offsite system "Operability" be restored (i.e. can loads and generation sources be adjusted such that the grid will remain stable at ≥ 218 kV when SONGS 3 trips)?

    b) how is restoration of the offsite source Operability accomplished, and how long does it take?

6) If offsite system Operability cannot be restored per [5] above, what other methods, such as system load shedding, can be used to ensure SONGS switchyard voltage remains stable at ≥ 218 kV?

7) If Unit 1 were online at 100% power in this scenario, would the SONGS switchyard voltage remain stable at ≥ 218 kV? If not, what actions could be taken or what offsite system load threshold would be required to achieve this?

Attachment 2

Stability Plots

Scenarios 1 - 4

Stability Plots

Scenario 1

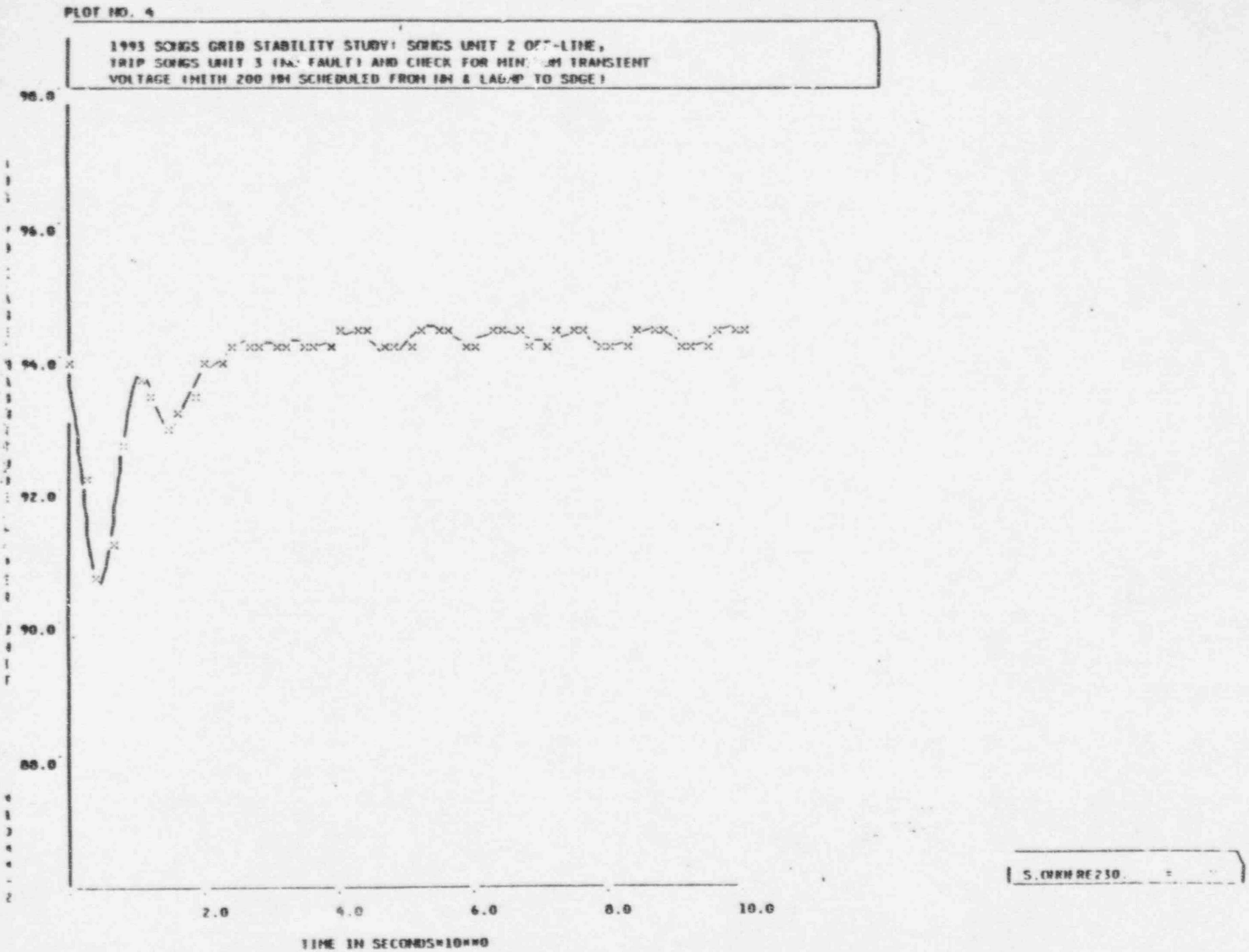
One SONGS unit out of service and in Mode 3 (80 MW, 45 MVAR), and the remaining SONGS unit on-line in Mode 1 (80 MW, 45 MVAR) trips.

Stability Plots

Scenario 1

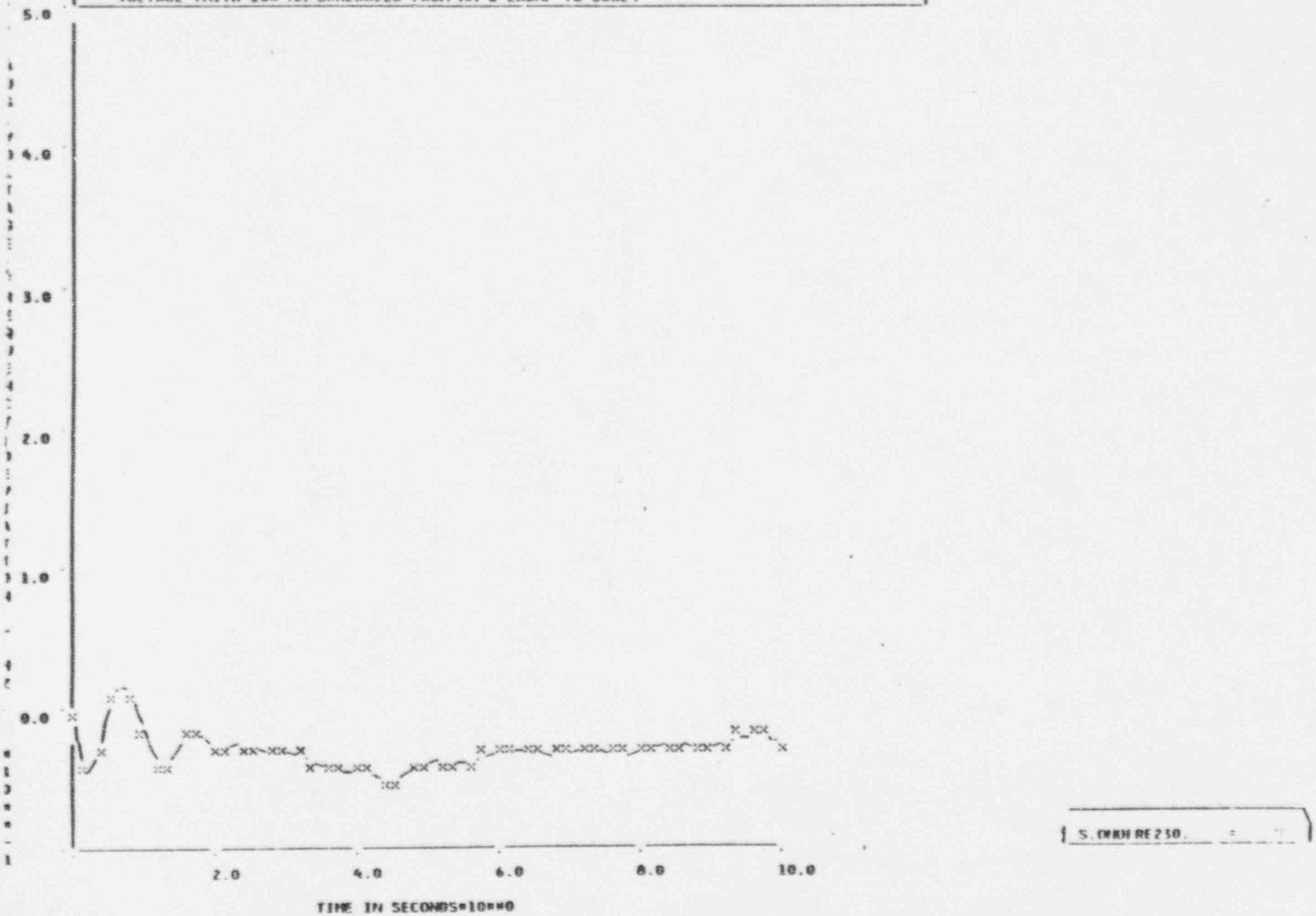
Case A:

With additional 200 MW of transmission service scheduled from Northwest and LADWP to SDG&E.


PLOT NO. 4
1993 SONGS GRID STABILITY STUDY: SONGS UNIT 2 OFF-LINE,
TRIP SONGS UNIT 3 (NO FAULT) AND CHECK FOR MIN. UM TRANSIENT
VOLTAGE (WITH 200 MW SCHEDULED FROM MW & LAG/P TO SDGE)
98.0
96.0
94.0
92.0
90.0
88.0
2.0
4.0
6.0
8.0
10.0
TIME IN SECONDS*10**0
S.ONNHRE230.

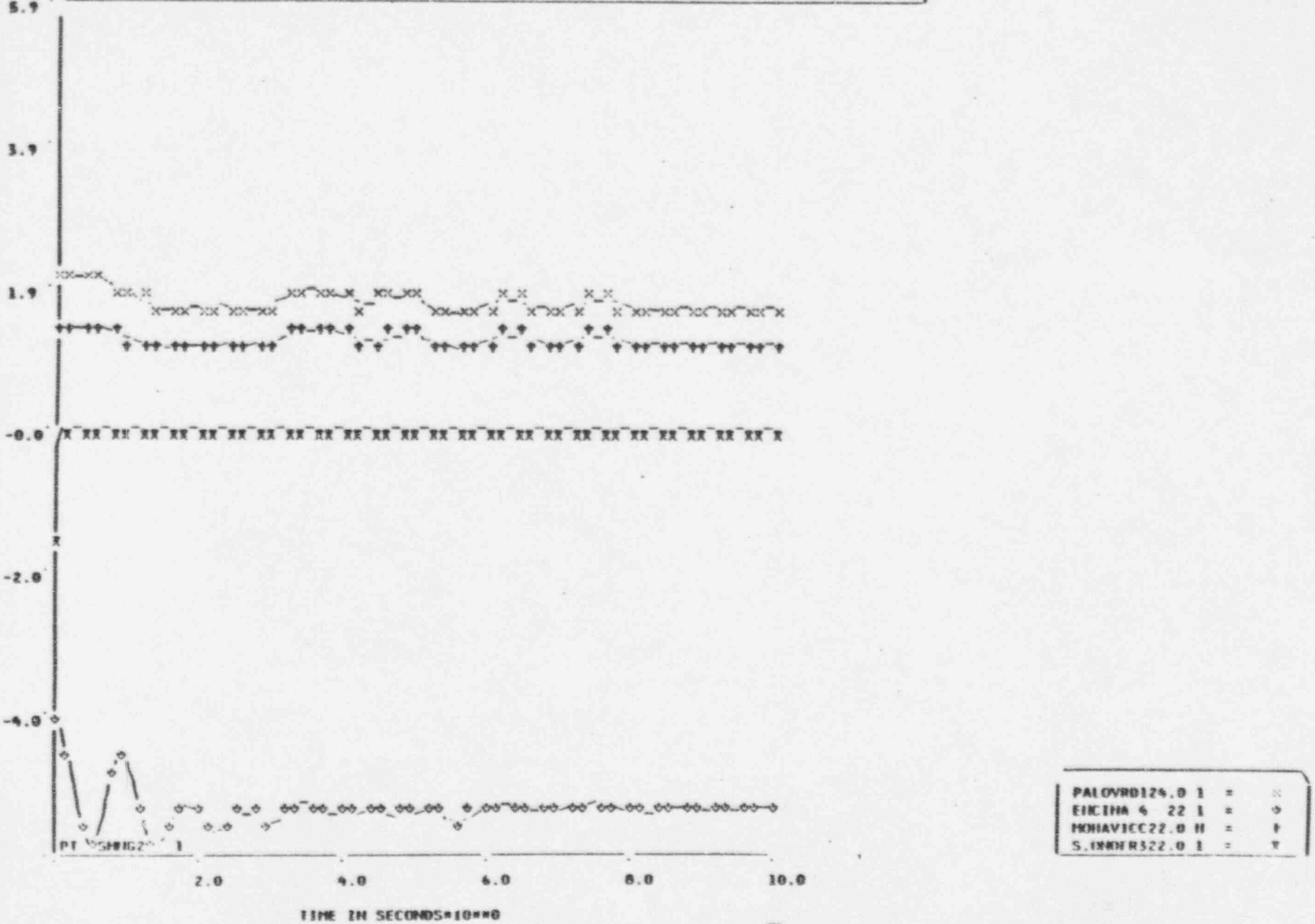
PLOT NO. 13

1993 SONGS GRID STABILITY STUDY: SONGS UNIT 2 OFF-LINE,
TRIP SONGS UNIT 3 (NO FAULT) AND CHECK FOR MINIMUM TRANSIENT
VOLTAGE (WITH 200 MW SCHEDULED FROM NM & LADWP TO SDGE)



PLOT NO. 47

1993 SONGS GRID STABILITY STUDY: SONGS UNIT 2 OFF-LINE,
TRIP SONGS UNIT 3 (NO FAULT) AND CHECK FOR MINIMUM TRANSIENT
VOLTAGE (WITH 200 MW SCHEDULED FROM IM & LADWP TO SDGE)

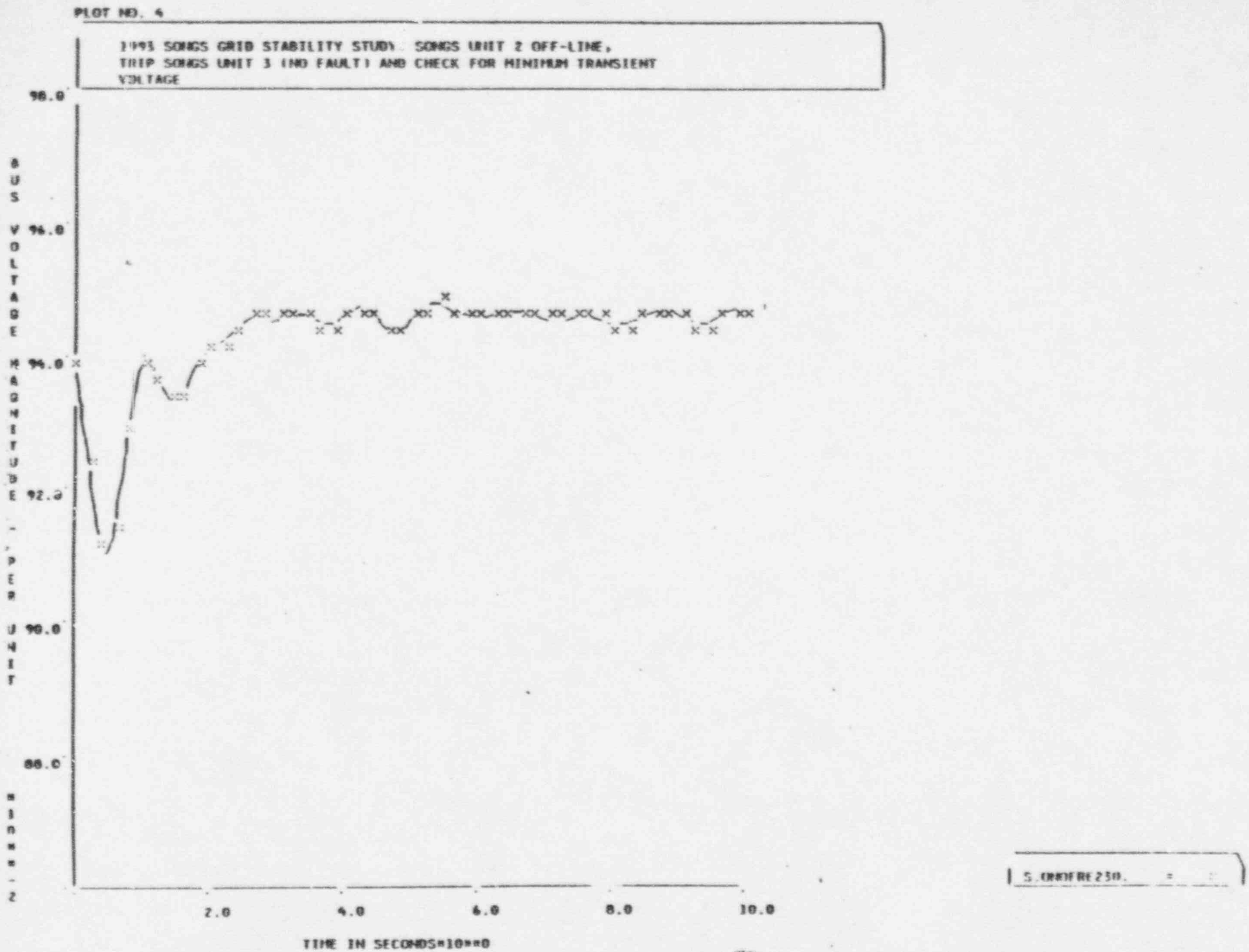


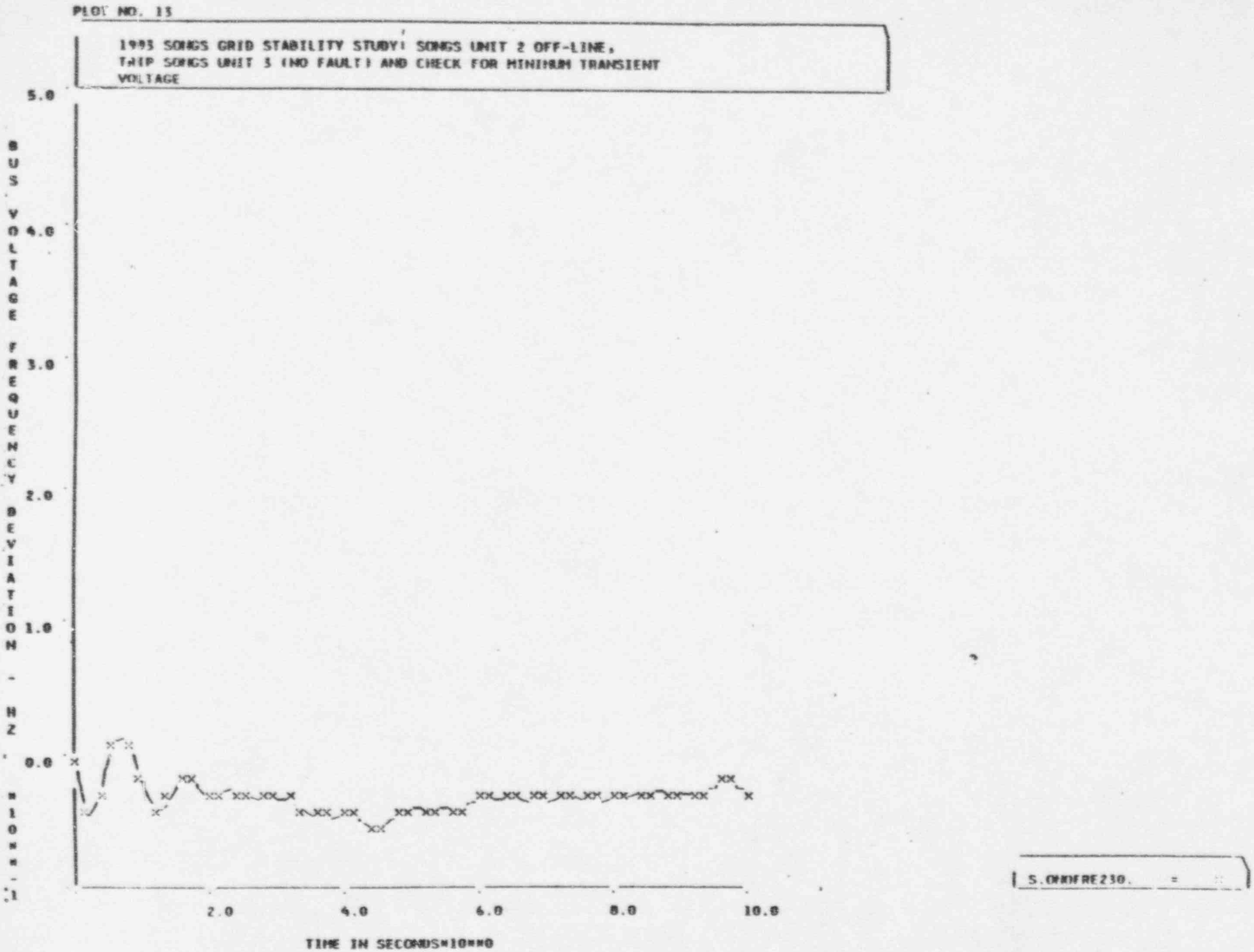
Stability Plots

Scenario 1

Case B:

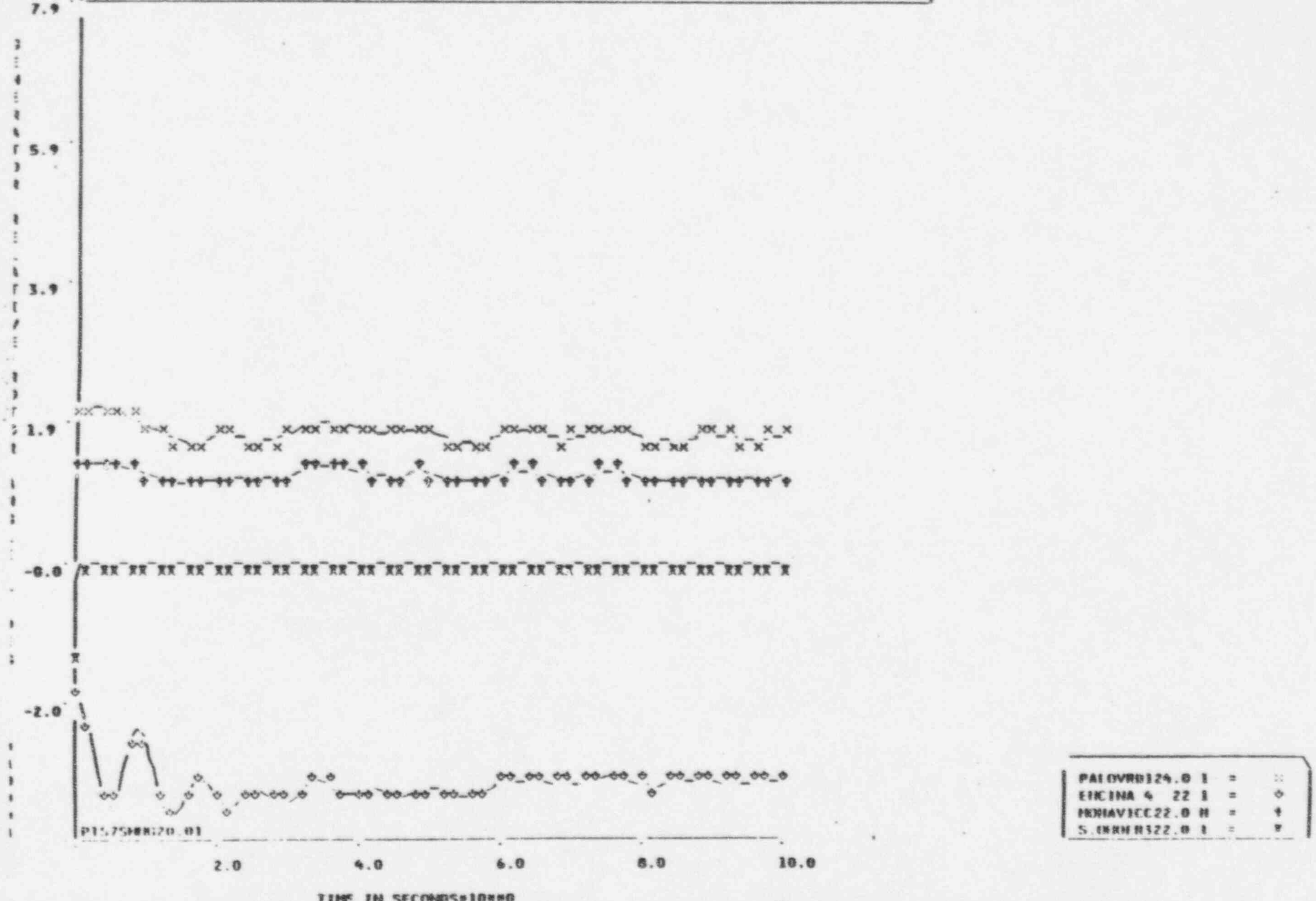
Without additional 200 MW of transmission service scheduled from Northwest and LADWP to SDG&E.


PLOT NO. 4
1993 SONGS GRID STABILITY STUDY SONGS UNIT 2 OFF-LINE,
TRIP SONGS UNIT 3 (NO FAULT) AND CHECK FOR MINIMUM TRANSIENT
VOLTAGE
BUS VOLTAGE MAGNITUDE , PER UNIT
98.0
96.0
94.0
92.0
90.0
88.0
2.0
4.0
6.0
8.0
10.0
TIME IN SECONDS*10**0
S.ONOFRE230. =


PLOT NO. 13
1993 SONGS GRID STABILITY STUDY: SONGS UNIT 2 OFF-LINE,
TRIP SONGS UNIT 3 (NO FAULT) AND CHECK FOR MINIMUM TRANSIENT
VOLTAGE
BUS VOLTAGE FREQUENCY DEVIATION - HZ *10**-1
5.0
4.0
3.0
2.0
1.0
0.0
2.0
4.0
6.0
8.0
10.0
TIME IN SECONDS*10**0
S.ONOFRE230.

PLOT NO. 47

1993 SONGS GRID STABILITY STUDY: SONGS UNIT 2 OFF-LINE,
TRIP SONGS UNIT 3 (NO FAULT) AND CHECK FOR MINIMUM TRANSIENT
VOLTAGE



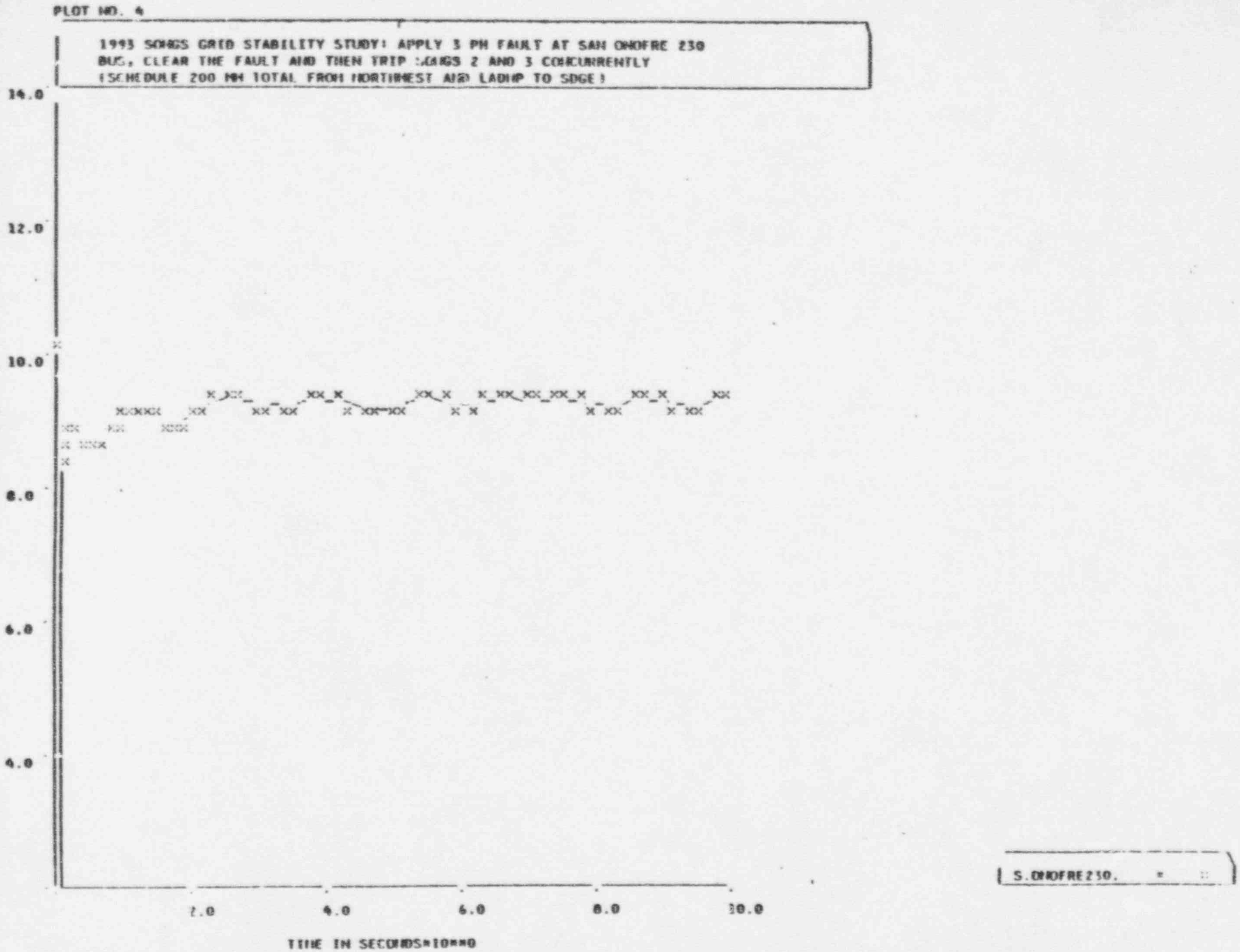
A2-9

Stability Plots

Scenario 2

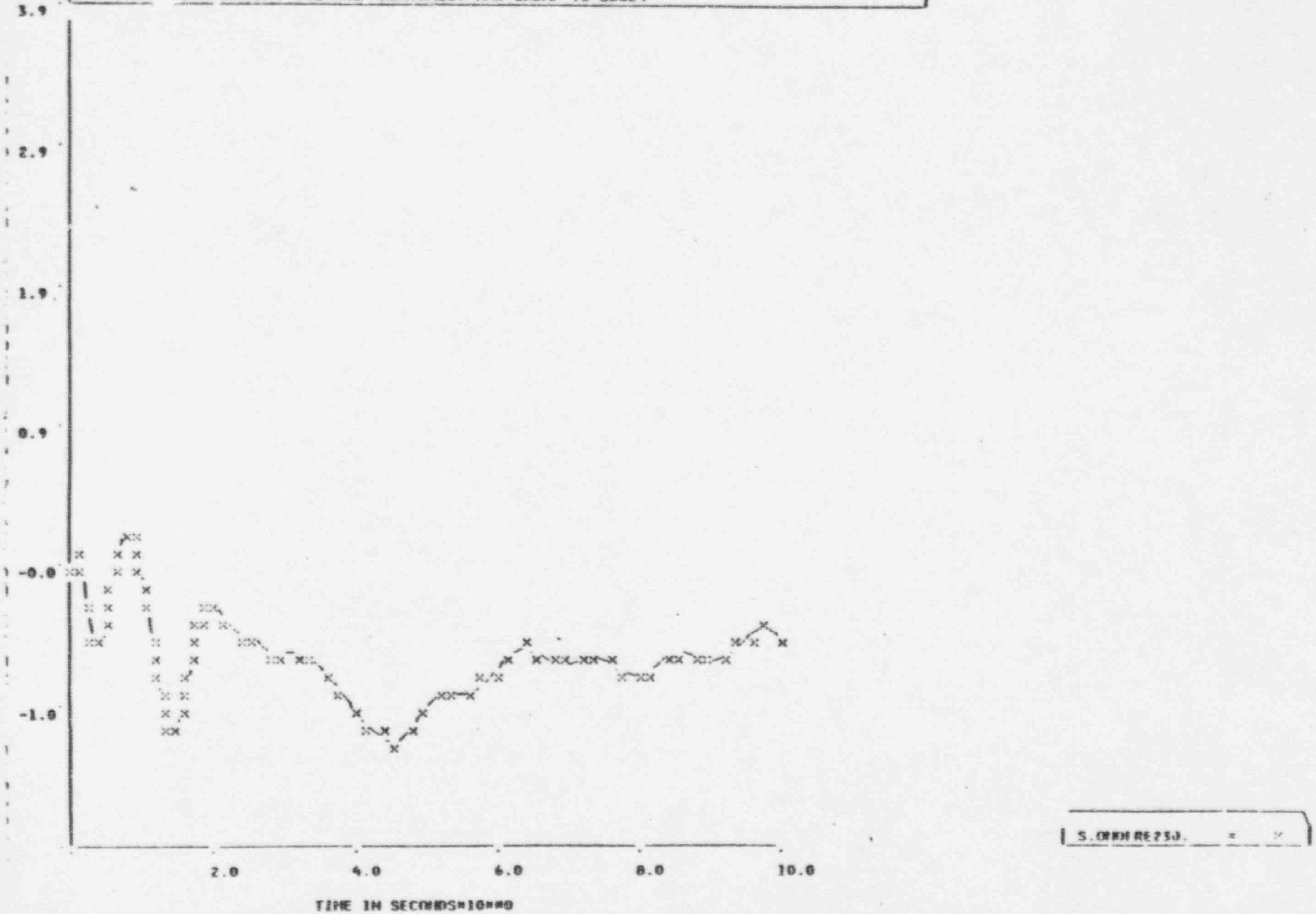
Both SONGS units in service and in Mode 1 (80 MW, 45 MVAR).

Both units trip concurrently.


PLOT NO. 4
1993 SONGS GRID STABILITY STUDY: APPLY 3 PH FAULT AT SAN ONOFRE 230
BUS, CLEAR THE FAULT AND THEN TRIP SONGS 2 AND 3 CONCURRENTLY
(SCHEDULE 200 MW TOTAL FROM NORTHWEST AND LADWP TO SDGE)
14.0
12.0
10.0
8.0
6.0
4.0
2.0
4.0
6.0
8.0
10.0
TIME IN SECONDS*10**0
S.ONOFRE230.

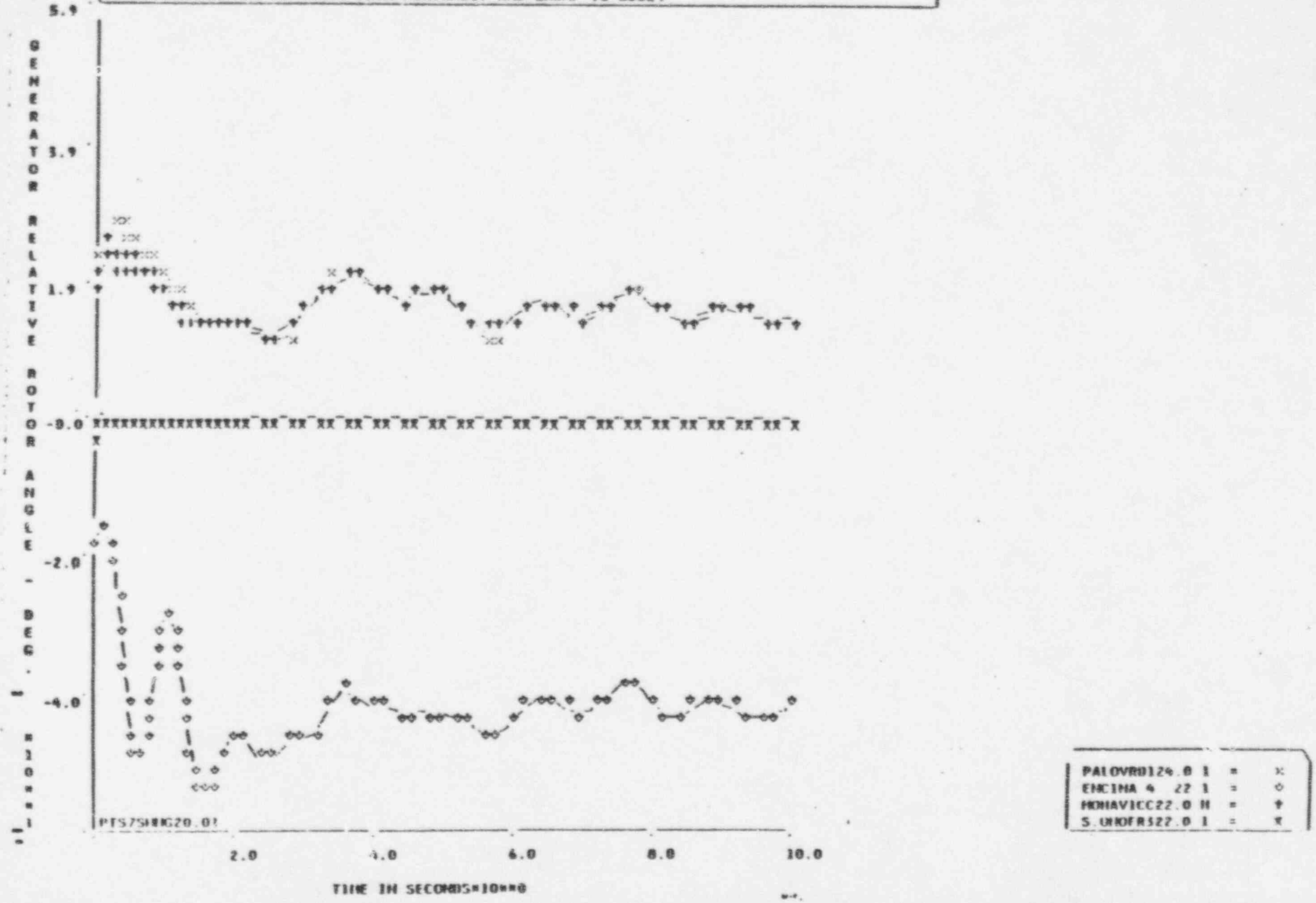
PLOT NO. 13

1993 SONGS GRID STABILITY STUDY: APPLY 3 PH FAULT AT SAN ONOFRE 230
BUS, CLEAR THE FAULT AND THEN TRIP SONGS 2 AND 3 CONCURRENTLY
(SCI[illegible]ULE 700 MW TOTAL FROM NORTHWEST AND LADWP TO SDGE)



PLOT NO. 47

1993 SONGS GRID STABILITY STUDY: APPLY 3 PH FAULT AT SAN ONOFRE 230 BUS, CLEAR THE FAULT AND THEN TRIP SONGS 2 AND 3 CONCURRENTLY (SCHEDULE 200 MW TOTAL FROM NORTHWEST AND LADWP TO SDGE)



Stability Plots

Scenario 3

One SONGS unit off-line and in Mode 3 (80 MW, 45 MVAR), remaining SONGS unit on-line in Mode 1 (80 MW, 45 MVAR), and a critical line trips.

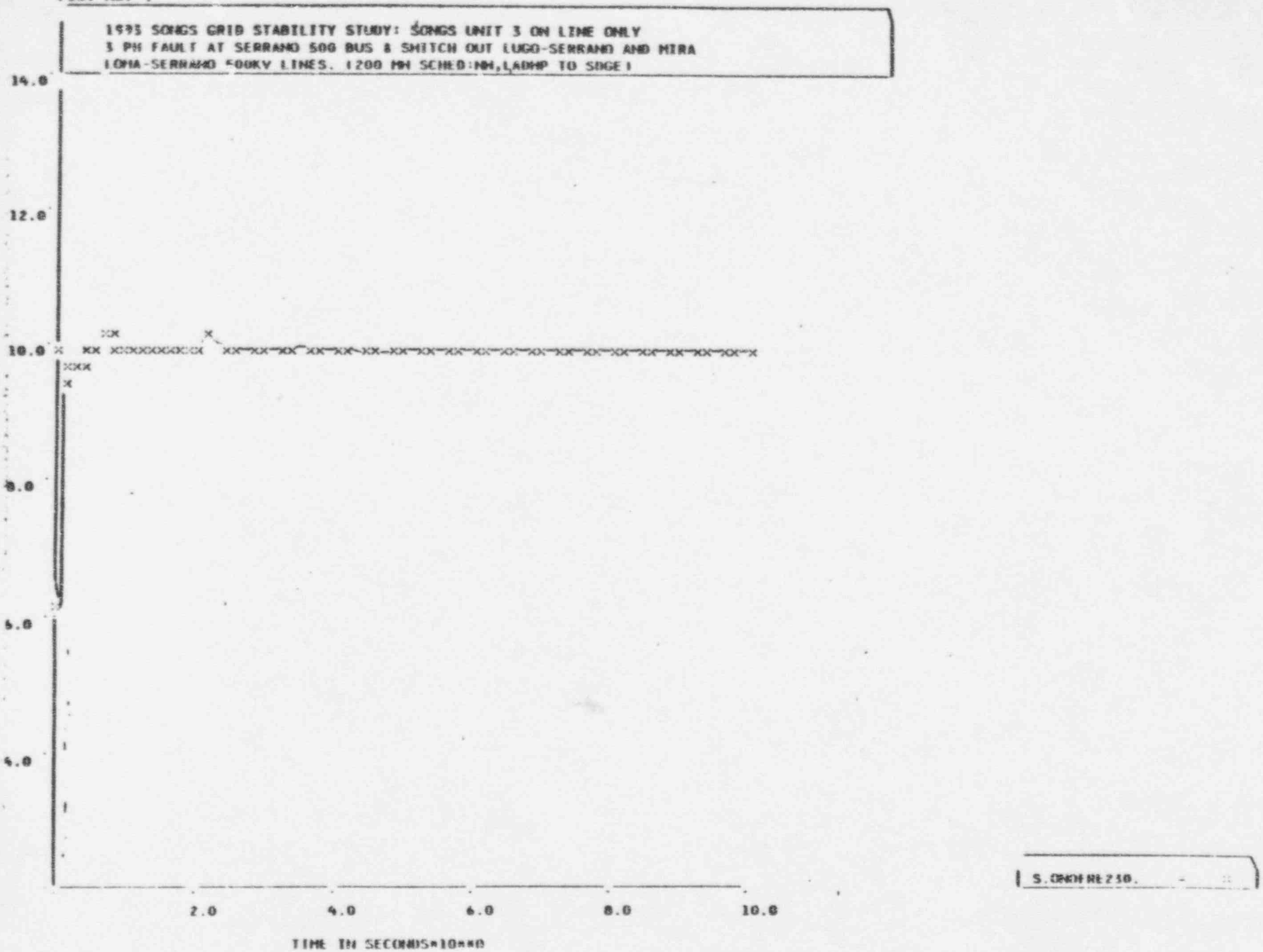
Stability Plots

Scenario 3

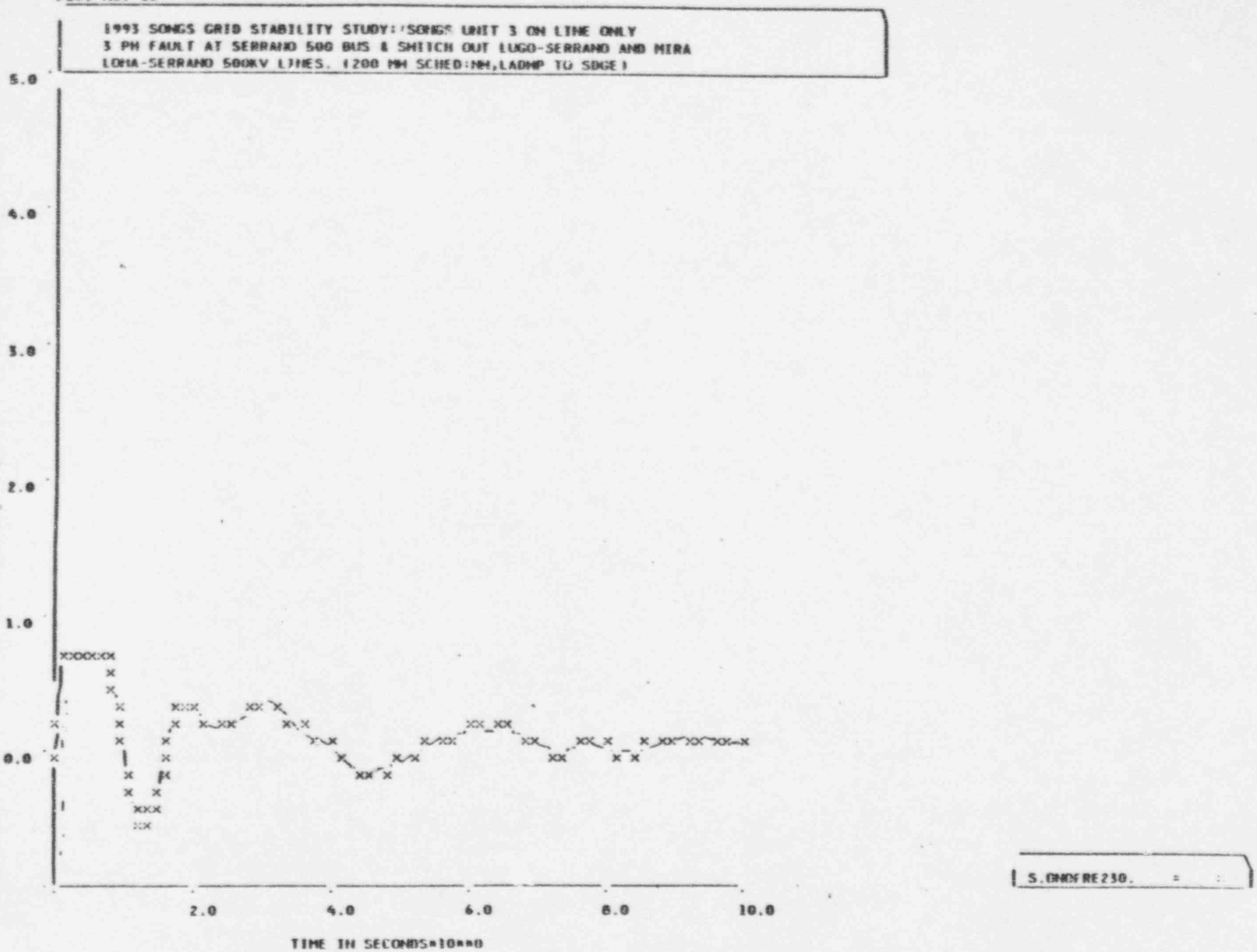
Case A:

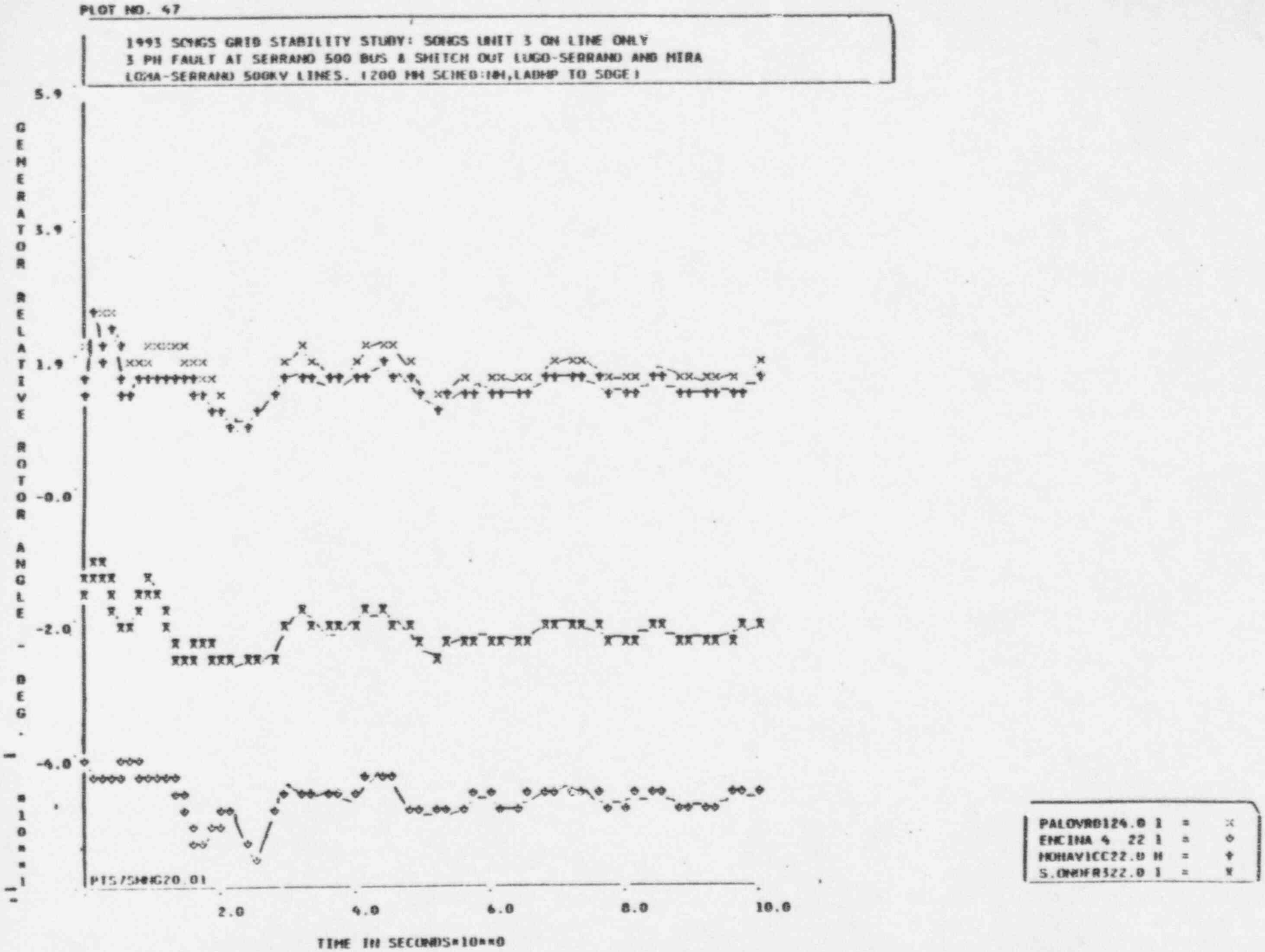
Outage of Mira Loma-Serrano and Lugo-Serrano 500kV lines (double circuit tower).

PLOT NO. 4


1995 SONGS GRID STABILITY STUDY: SONGS UNIT 3 ON LINE ONLY
3 PH FAULT AT SERRANO 500 BUS & SWITCH OUT LUGO-SERRANO AND MIRA
LOMA-SERRANO 500KV LINES. (200 MW SCHED:NW,LADWP TO SDGE)
14.0
12.0
10.0
8.0
6.0
4.0
2.0
4.0
6.0
8.0
10.0
TIME IN SECONDS*10**0
S.ONOFRE230.

PLOT NO. 13


1993 SONGS GRID STABILITY STUDY:/SONGS UNIT 3 ON LINE ONLY
3 PH FAULT AT SERRANO 500 BUS & SWITCH OUT LUGO-SERRANO AND MIRA
LOMA-SERRANO 500KV LINES. (200 MW SCHED:NM,LADWP TO SDGE)
5.0
4.0
3.0
2.0
1.0
0.0
2.0
4.0
6.0
8.0
10.0
TIME IN SECONDS*10**0
S.ONOFRE230.

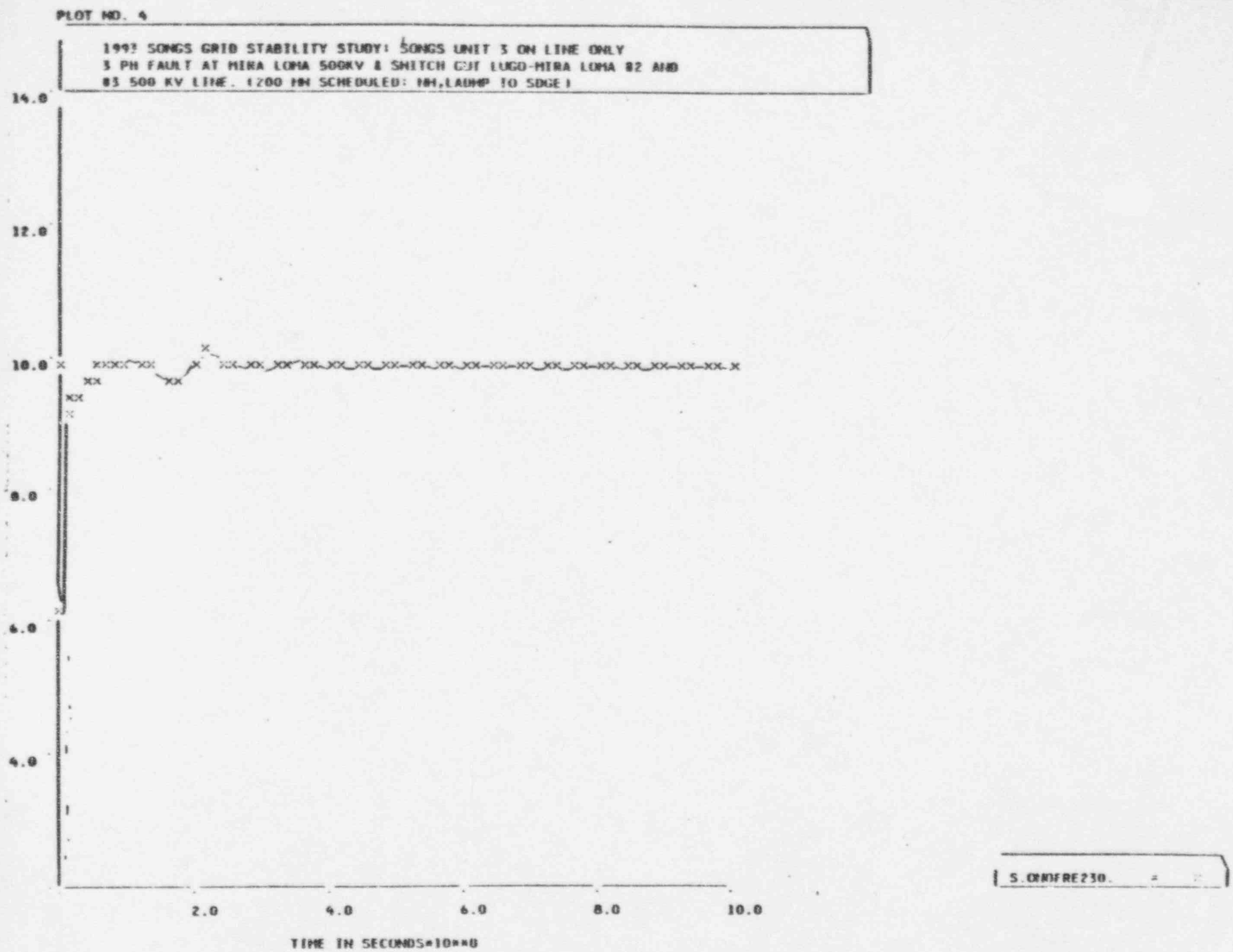

PLOT NO. 47
1993 SONGS GRID STABILITY STUDY: SONGS UNIT 3 ON LINE ONLY
3 PH FAULT AT SERRANO 500 BUS & SWITCH OUT LUGO-SERRANO AND MIRA
LOMA-SERRANO 500KV LINES. (200 MW SCHED:MH,LADWP TO SDGE)
GENERATOR RELATIVE ROTOR ANGLE - DEG. * 10**-1
5.9
3.9
1.9
-0.0
-2.0
-4.0
PTS7SWG20.01
2.0
4.0
6.0
8.0
10.0
TIME IN SECONDS*10**0
PALOVRD124.0 1 = x
ENCINA 4 22 1 = ◇
MOHAVICC22.0 H = +
S.ONOFR322.0 1 = ¥

Stability Plots

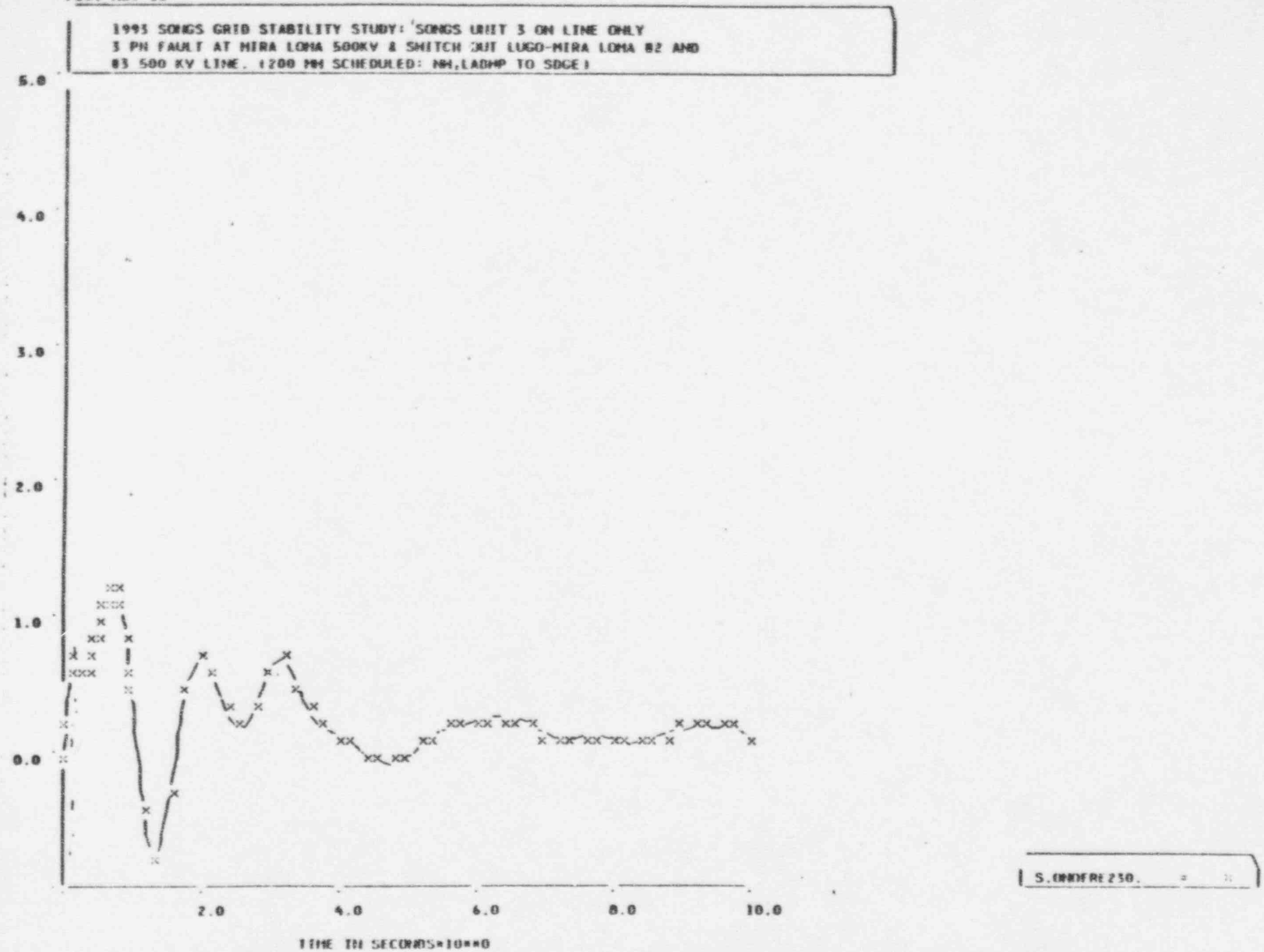
<u>Scenario 3</u>

Case B:

Outage of Lugo-Mira Loma 2 and 3 500kV lines (double circuit tower).

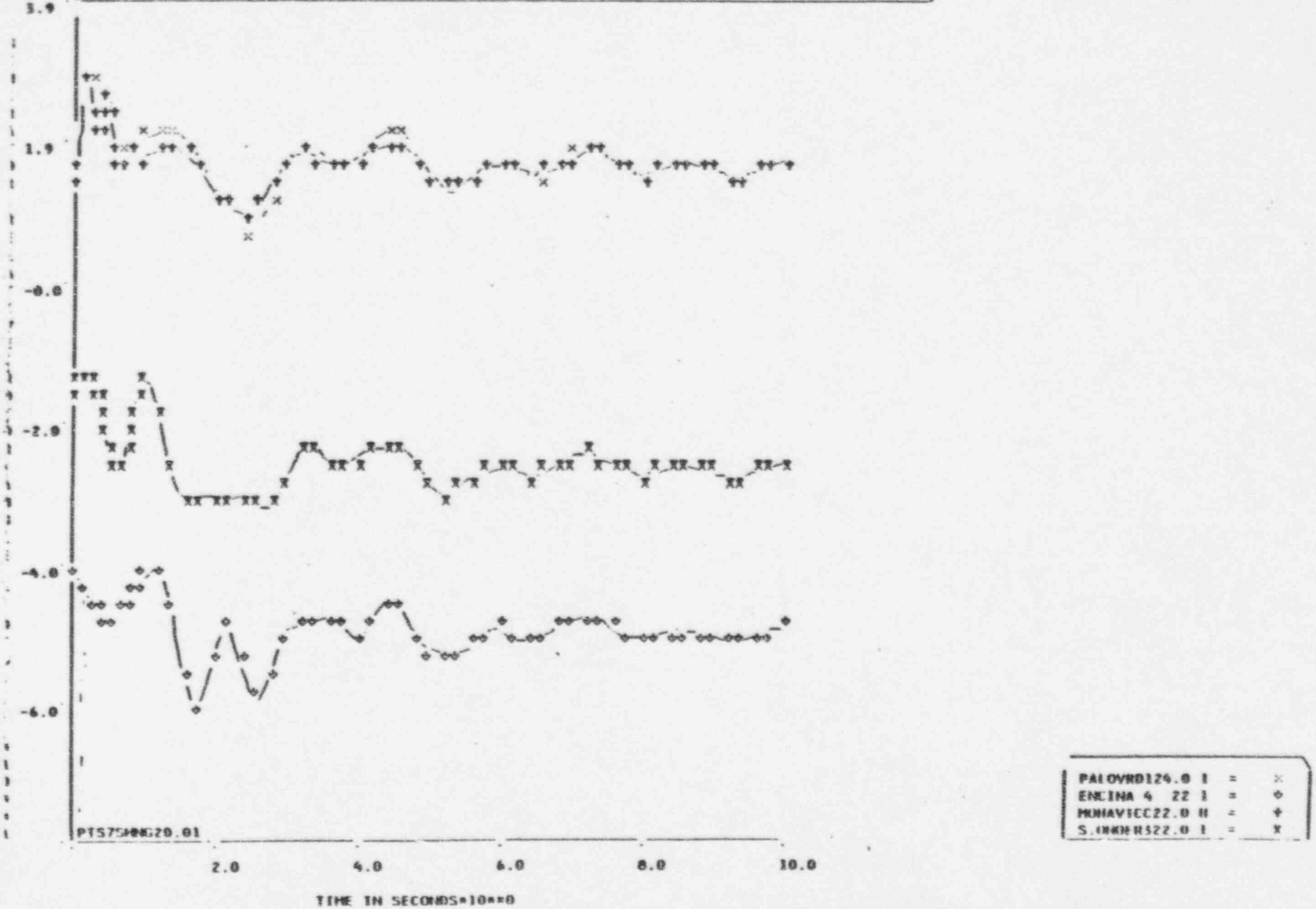

PLOT NO. 4
199? SONGS GRID STABILITY STUDY: SONGS UNIT 3 ON LINE ONLY
3 PH FAULT AT MIRA LOMA 500KV & SWITCH OUT LUGO-MIRA LOMA #2 AND
#3 500 KV LINE. (200 MW SCHEDULED: NM,LADWP TO SDGE)
14.0
12.0
10.0
8.0
6.0
4.0
2.0
4.0
6.0
8.0
10.0
TIME IN SECONDS*10**0
S.ONOFRE230.

PLOT NO. 13


1993 SONGS GRID STABILITY STUDY: SONGS UNIT 3 ON LINE ONLY
3 PH FAULT AT MIRA LOMA 500KV & SWITCH OUT LUGO-MIRA LOMA #2 AND
#3 500 KV LINE. (200 MW SCHEDULED: NW,LADWP TO SDGE)
5.0
4.0
3.0
2.0
1.0
0.0
2.0
4.0
6.0
8.0
10.0
TIME IN SECONDS*10**0
S.ONOFRE230.

PLOT NO. 47

1993 SONGS GRID STABILITY STUDY: SONGS UNIT 3 ON LINE ONLY
3 PH FAULT AT MIRA LOMA 500KV & SWITCH OUT LUGO-MIRA LOMA #2 AND
#3 500 KV LINE. (200 MW SCHEDULED: NM,LADWP TO SDGE)



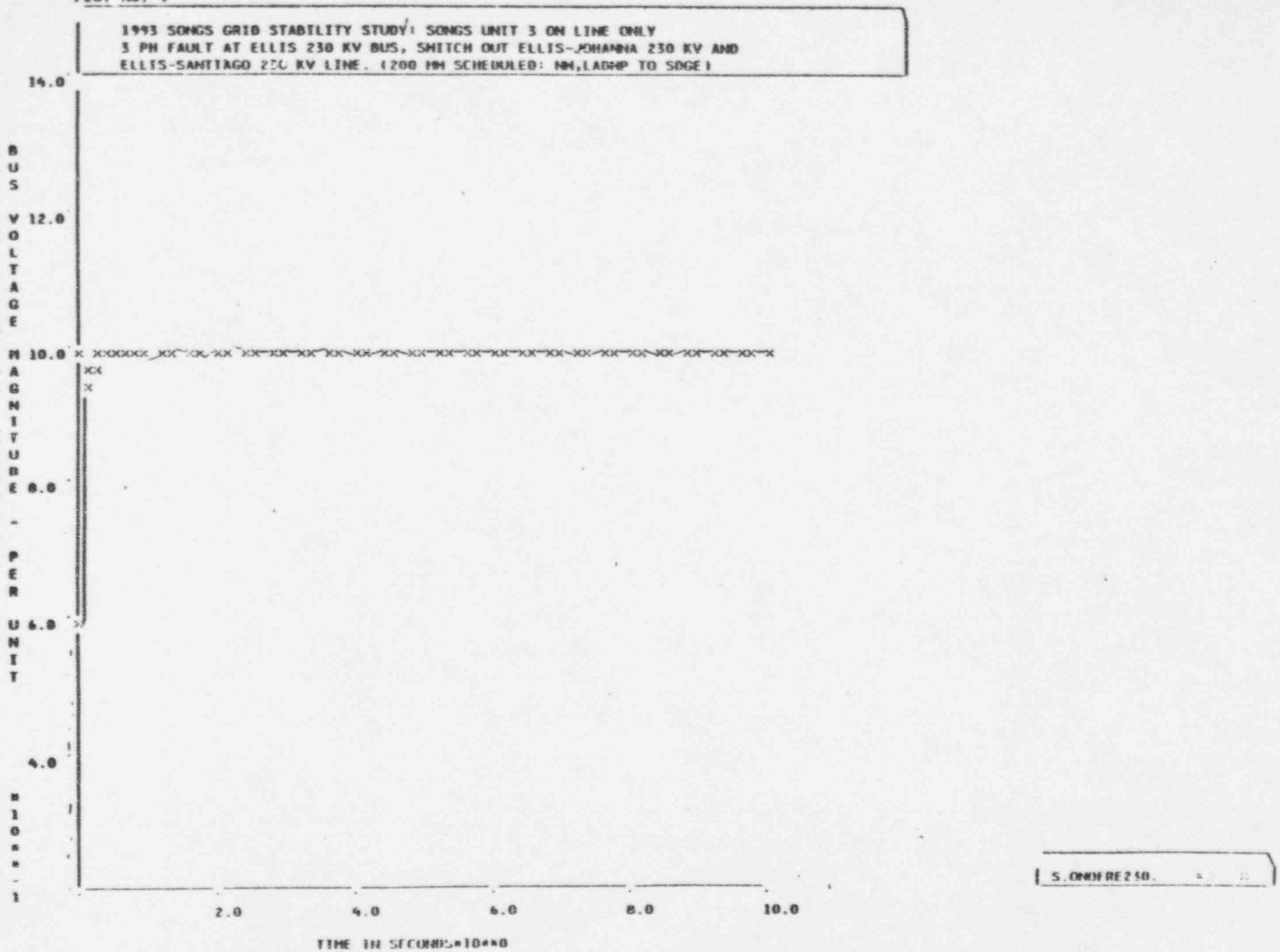
Stability Plots

Scenario 3

Case C:

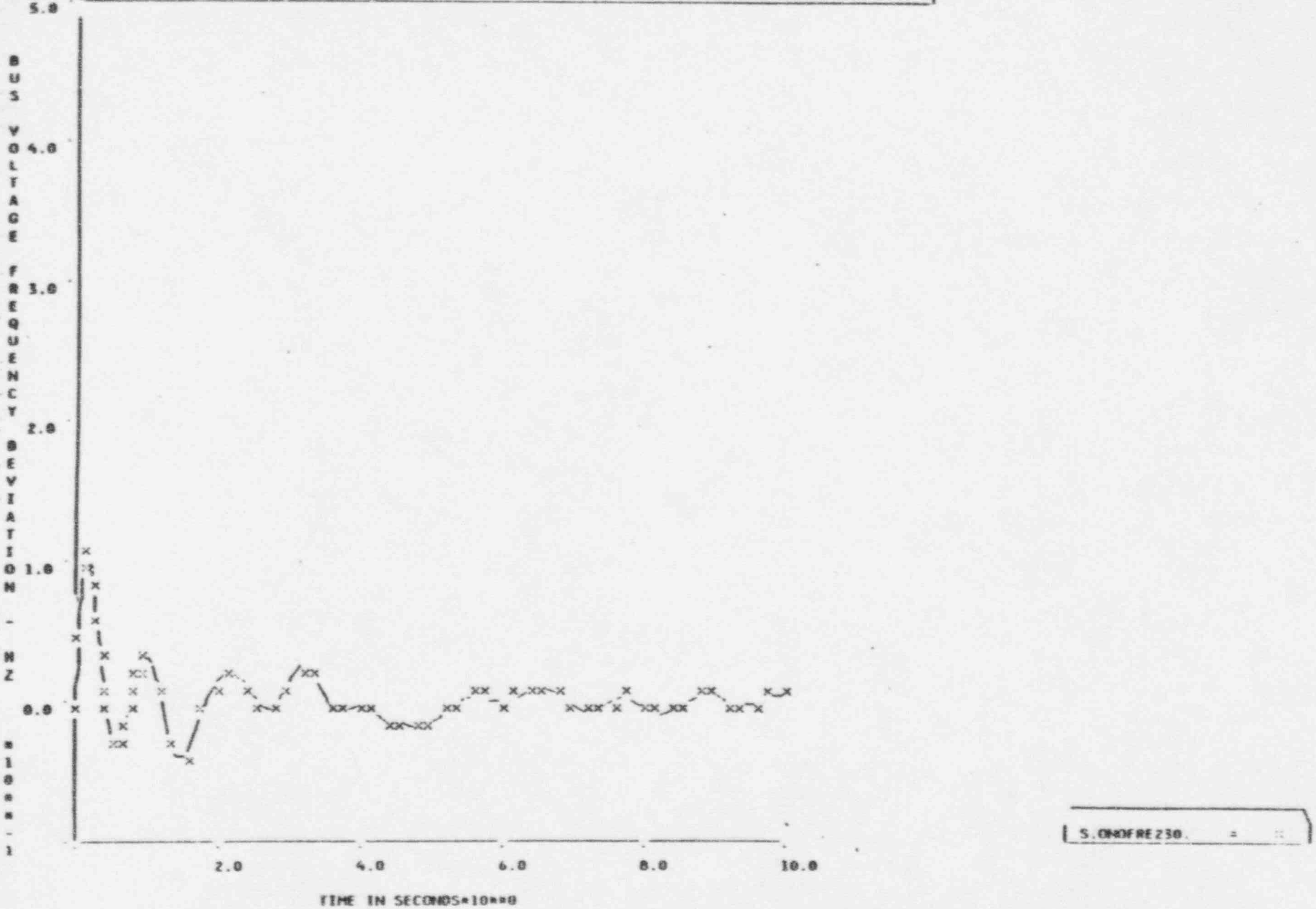
Outage of Ellis-Johanna and Ellis-Santiago 230kV lines (double circuit tower).

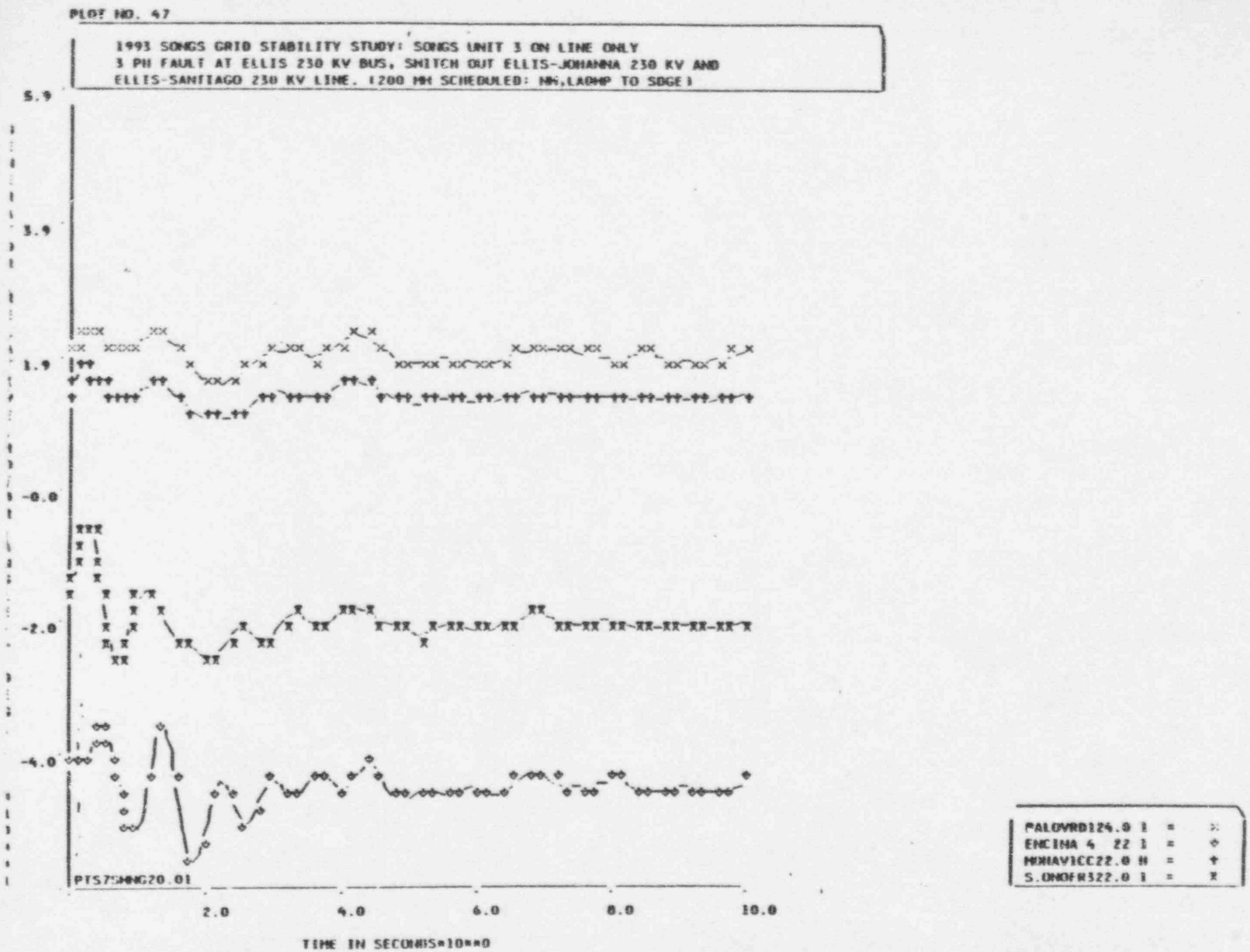
PLOT NO. 4


1993 SONGS GRID STABILITY STUDY: SONGS UNIT 3 ON LINE ONLY
3 PH FAULT AT ELLIS 230 KV BUS, SWITCH OUT ELLIS-JOHANNA 230 KV AND
ELLIS-SANTIAGO 230 KV LINE. (200 MW SCHEDULED: NM,LADWP TO SDGE)
BUS VOLTAGE MAGNITUDE - PER UNIT *10**-1
14.0
12.0
10.0
8.0
6.0
4.0
2.0
4.0
6.0
8.0
10.0
TIME IN SECONDS*10**0
S.ONOFRE230.

PLOT NO. 13

1993 SONGS GRID STABILITY STUDY: SONGS UNIT 3 ON LINE ONLY
3 PH FAULT AT ELLIS 230 KV BUS, SWITCH OUT ELLIS-JOHANNA 230 KV AND
ELLIS-SANTIAGO 230 KV LINE. (200 MW SCHEDULED: NM,LADWP TO SDGE)



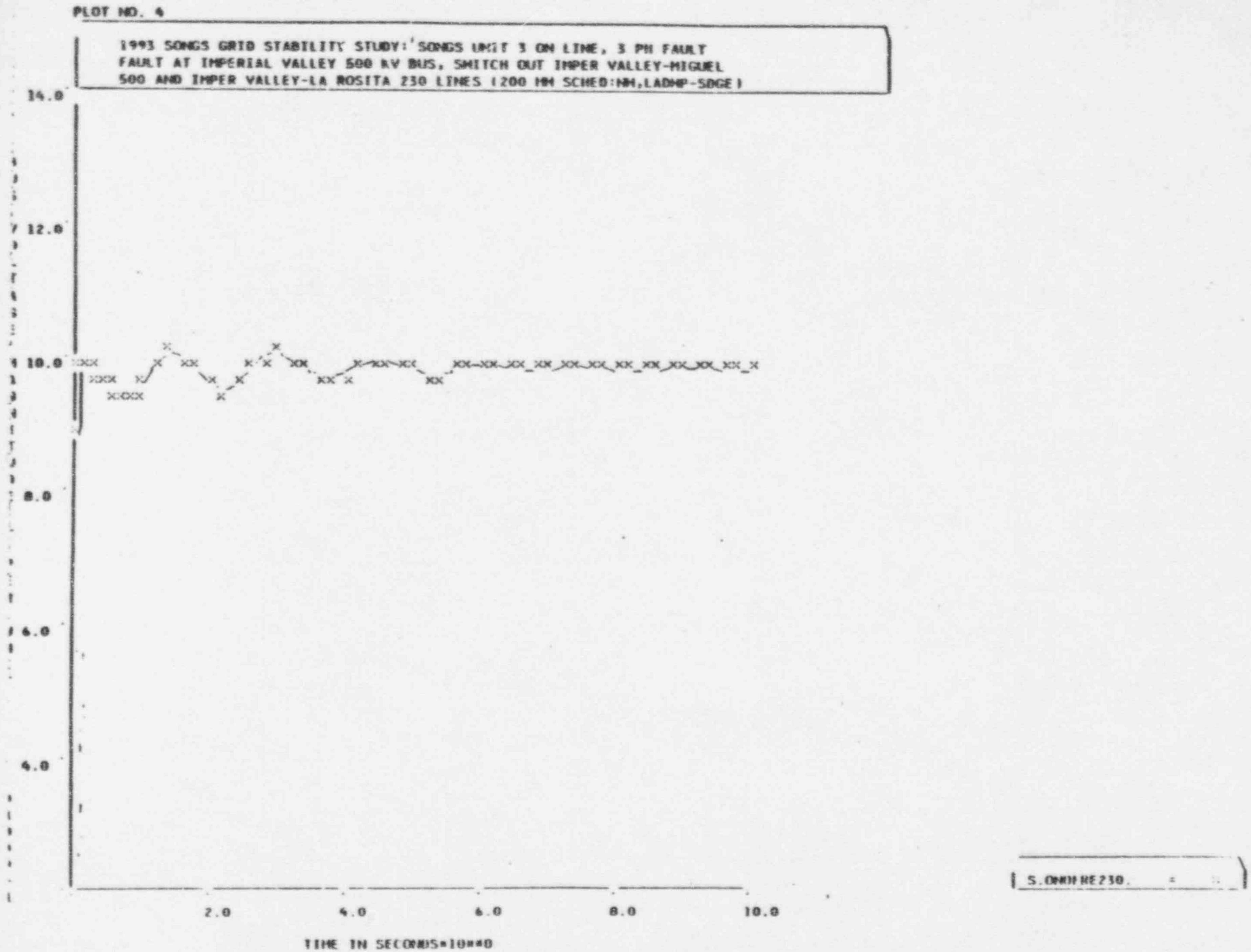

PLOT NO. 47
1993 SONGS GRID STABILITY STUDY: SONGS UNIT 3 ON LINE ONLY
3 PH FAULT AT ELLIS 230 KV BUS, SWITCH OUT ELLIS-JOHANNA 230 KV AND
ELLIS-SANTIAGO 230 KV LINE. (200 MW SCHEDULED: NW,LADWP TO SDGE)
5.9
3.9
1.9
-0.0
-2.0
-4.0
PTS7SWNG20.01
2.0
4.0
6.0
8.0
10.0
TIME IN SECONDS*10**0
PALOVRDI24.0 1 = X
ENCINA 4 22 1 = ◇
MOHAVICC22.0 H = +
S.ONOFR322.0 1 = X

Stability Plots

Scenario 3

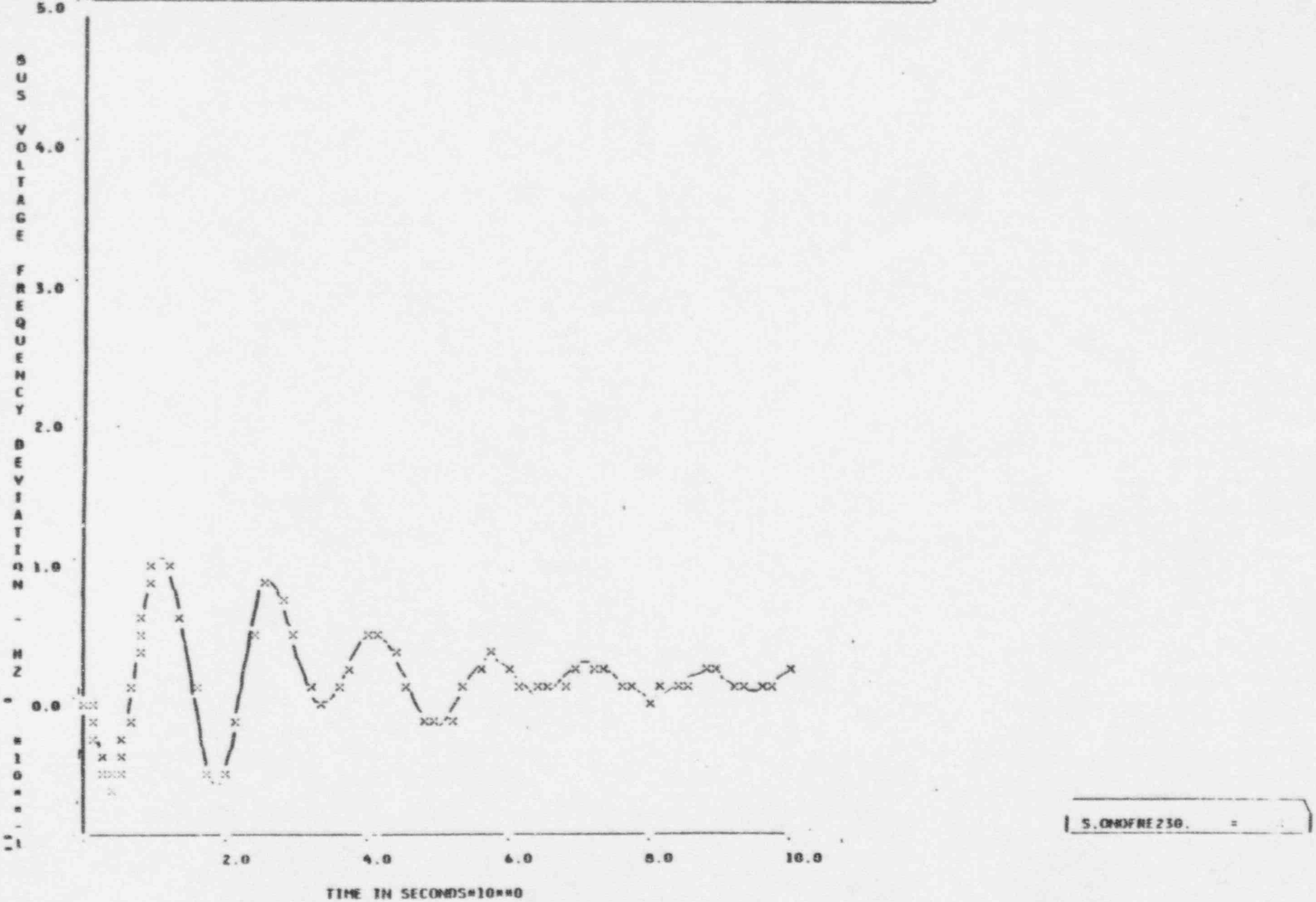
Case D:

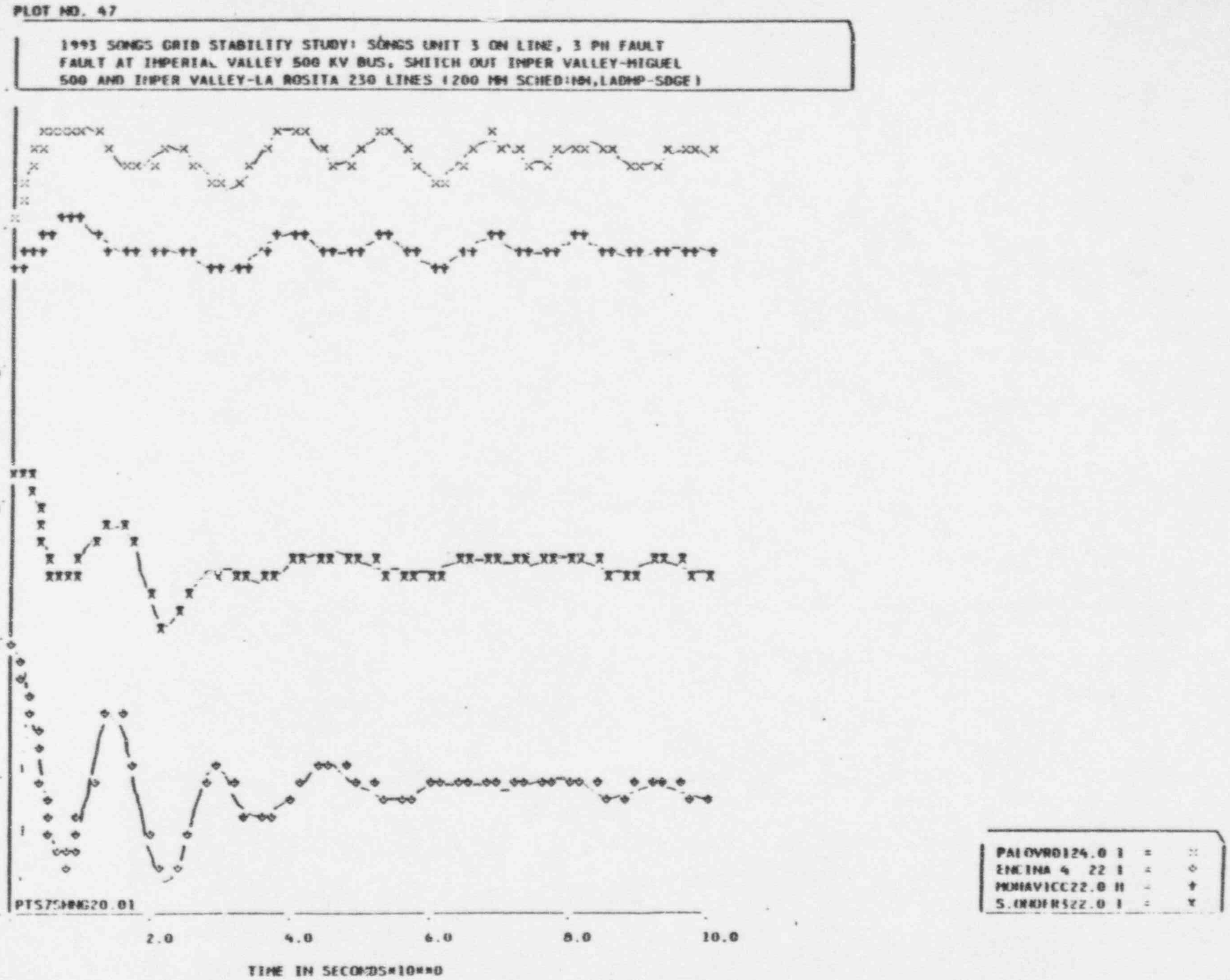
Outage of the Imperial Valley-Miguel 500kV line and Imperial Valley-Rosita 230kV line.


PLOT NO. 4
1993 SONGS GRID STABILITY STUDY: SONGS UNIT 3 ON LINE, 3 PH FAULT
FAULT AT IMPERIAL VALLEY 500 KV BUS, SWITCH OUT IMPER VALLEY-MIGUEL
500 AND IMPER VALLEY-LA ROSITA 230 LINES (200 MM SCHED:NM,LADWP-SDGE)
14.0
12.0
10.0
8.0
6.0
4.0
2.0
4.0
6.0
8.0
10.0
TIME IN SECONDS*10**0
S.ONOFRE230.

PLOT NO. 13

1993 SONGS GRID STABILITY STUDY: SONGS UNIT 3 ON LINE, 3 PH FAULT
FAULT AT IMPERIAL VALLEY 500 KV BUS, SWITCH OUT IMPER VALLEY-MIGUEL
500 AND IMPER VALLEY-LA ROSITA 230 LINES (200 MW SCHED:NM,LADWP-SDGE)



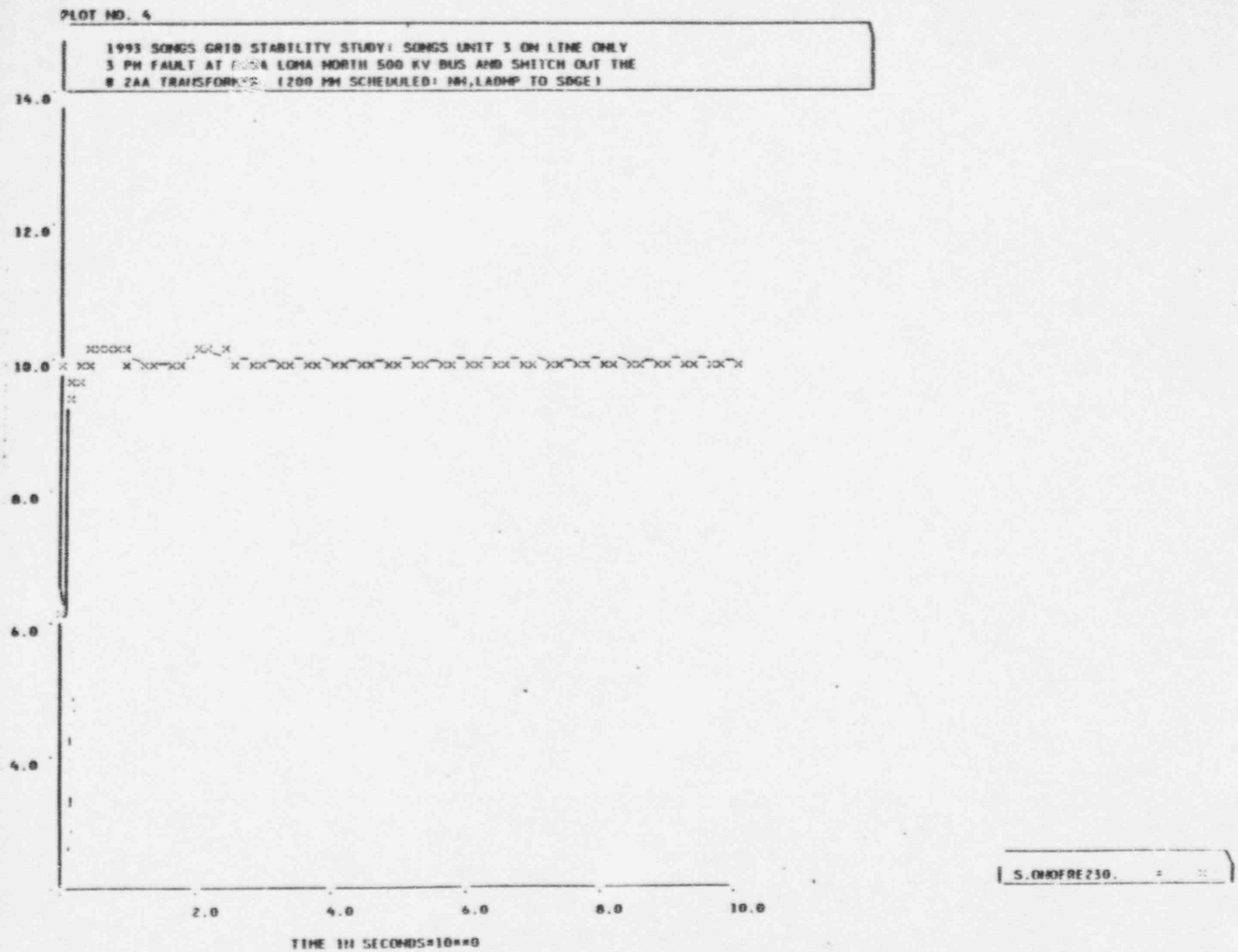

PLOT NO. 47
1993 SONGS GRID STABILITY STUDY: SONGS UNIT 3 ON LINE, 3 PH FAULT
FAULT AT IMPERIAL VALLEY 500 KV BUS, SWITCH OUT IMPER VALLEY-MIGUEL
500 AND IMPER VALLEY-LA ROSITA 230 LINES (200 MW SCHED:NM,LADWP-SDGE)
3.9
1.9
-0.0
-2.0
-4.0
-6.0
PTS75MNG20.01
2.0
4.0
6.0
8.0
10.0
TIME IN SECONDS*10**0
PALOVRD124.0 1 = x
ENCINA 4 22 1 = ◊
MOHAVICC22.0 N = +
S.ONOFRS22.0 1 = Y

Stability Plots

Scenario 3

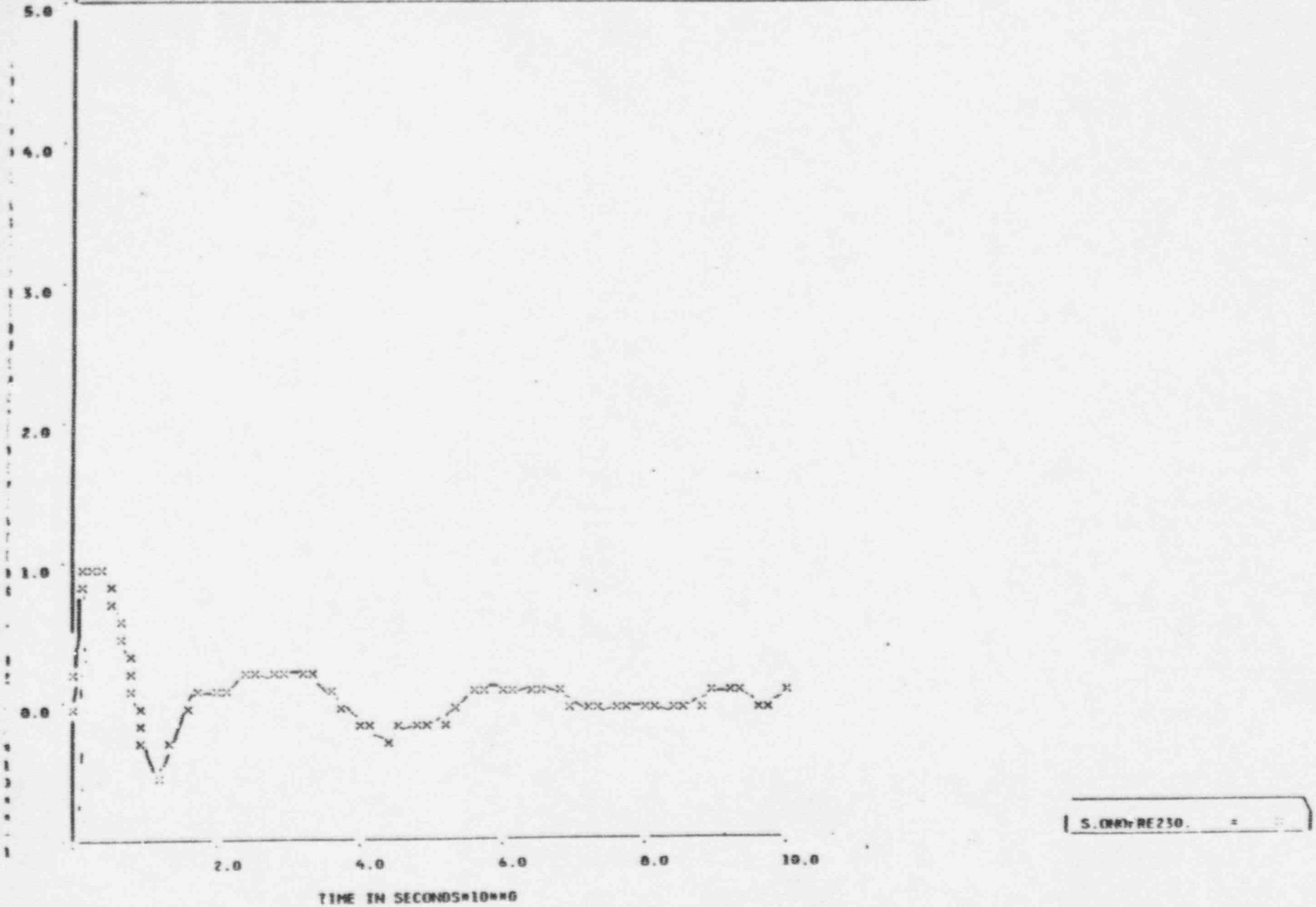
Case E:

Outage of the Mira Loma 500kV north bus and No. 2AA transformer.


PLOT NO. 4
1993 SONGS GRID STABILITY STUDY: SONGS UNIT 3 ON LINE ONLY
3 PH FAULT AT LOMA NORTH 500 KV BUS AND SWITCH OUT THE
2AA TRANSFORMERS (200 MW SCHEDULED: NM,LADWP TO SDGE)
14.0
12.0
10.0
8.0
6.0
4.0
2.0
4.0
6.0
8.0
10.0
TIME IN SECONDS*10**0
S.ONOFRE230.

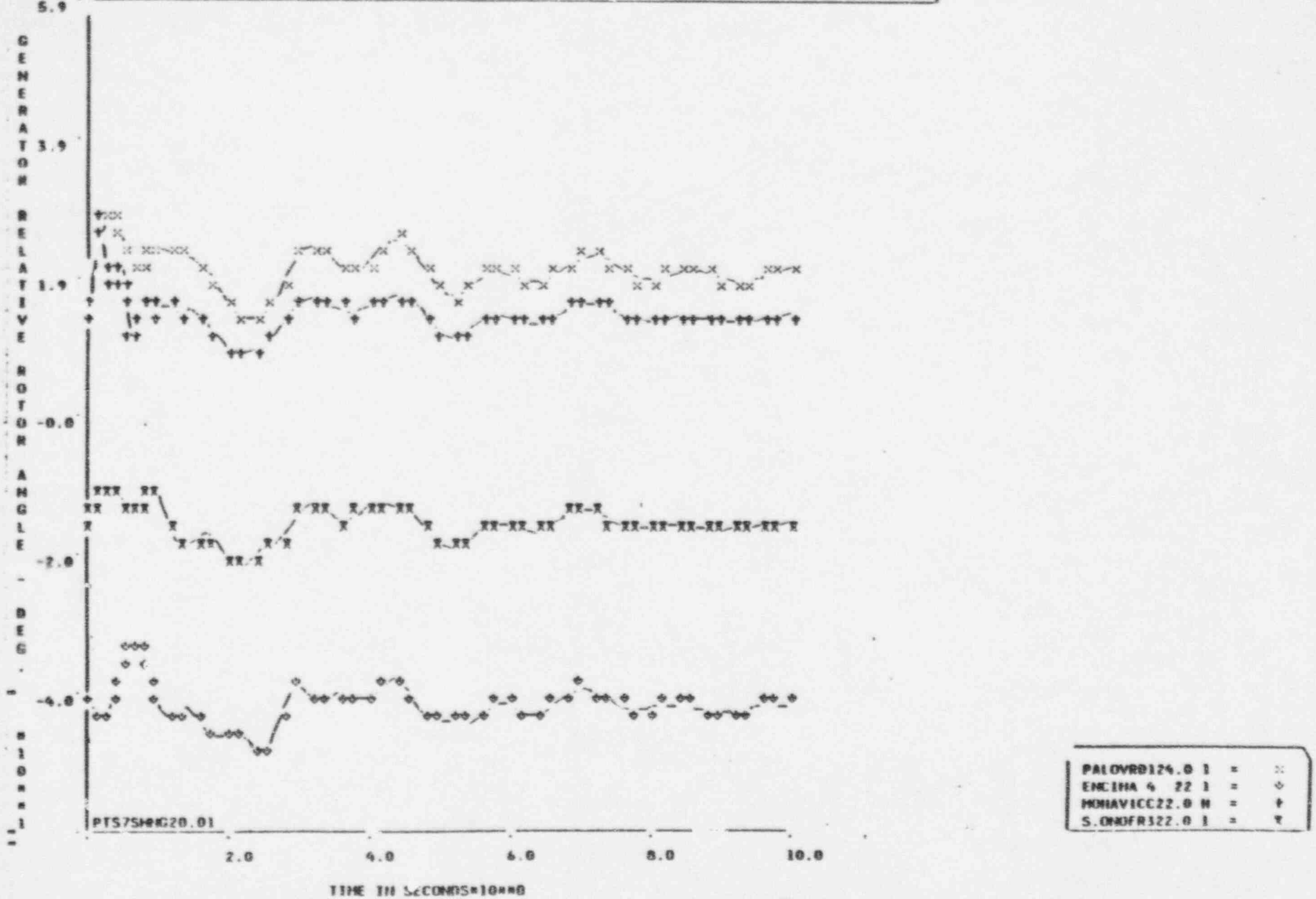
PLOT NO. 13

1993 SONGS GRID STABILITY STUDY: SONGS UNIT 3 ON LINE ONLY
3 PH FAULT AT MIRA LOMA NORTH 500 KV BUS AND SWITCH OUT THE
2AA TRANSFORMER. (200 MW SCHEDULED: NM,LADWP TO SDGE)



PLOT NO. 47

1993 SONGS GRID STABILITY STUDY: SONGS UNIT 3 ON LINE ONLY
3 PH FAULT AT MIRA LOMA NORTH 500 KV BUS AND SWITCH OUT THE
2AA TRANSFORMER. (200 MW SCHEDULED: NM,LADWP TO SDGE)



Stability Plots

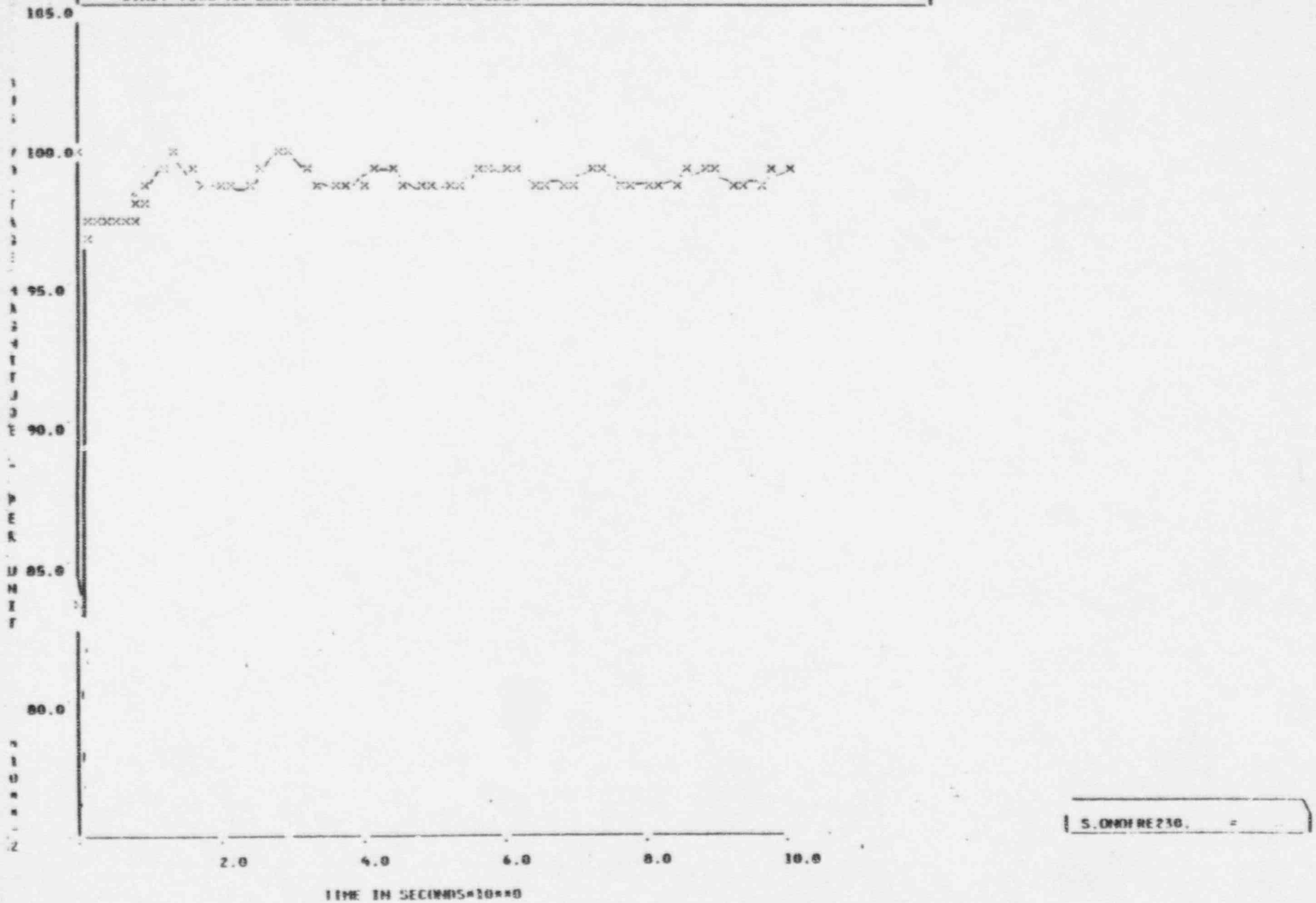
Scenario 3

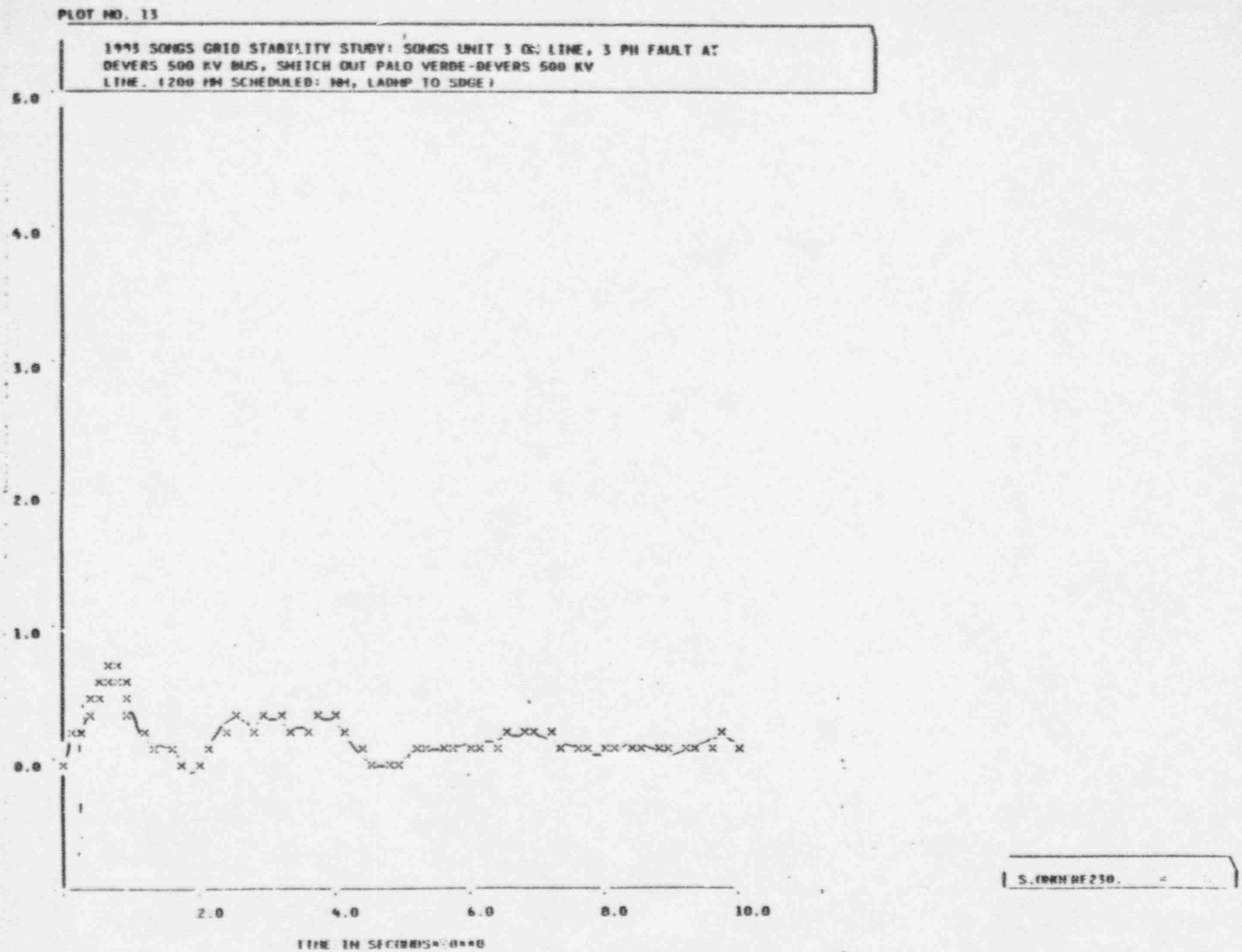
Case F:

Outage of the Palo Verde-Devers 500kV line.

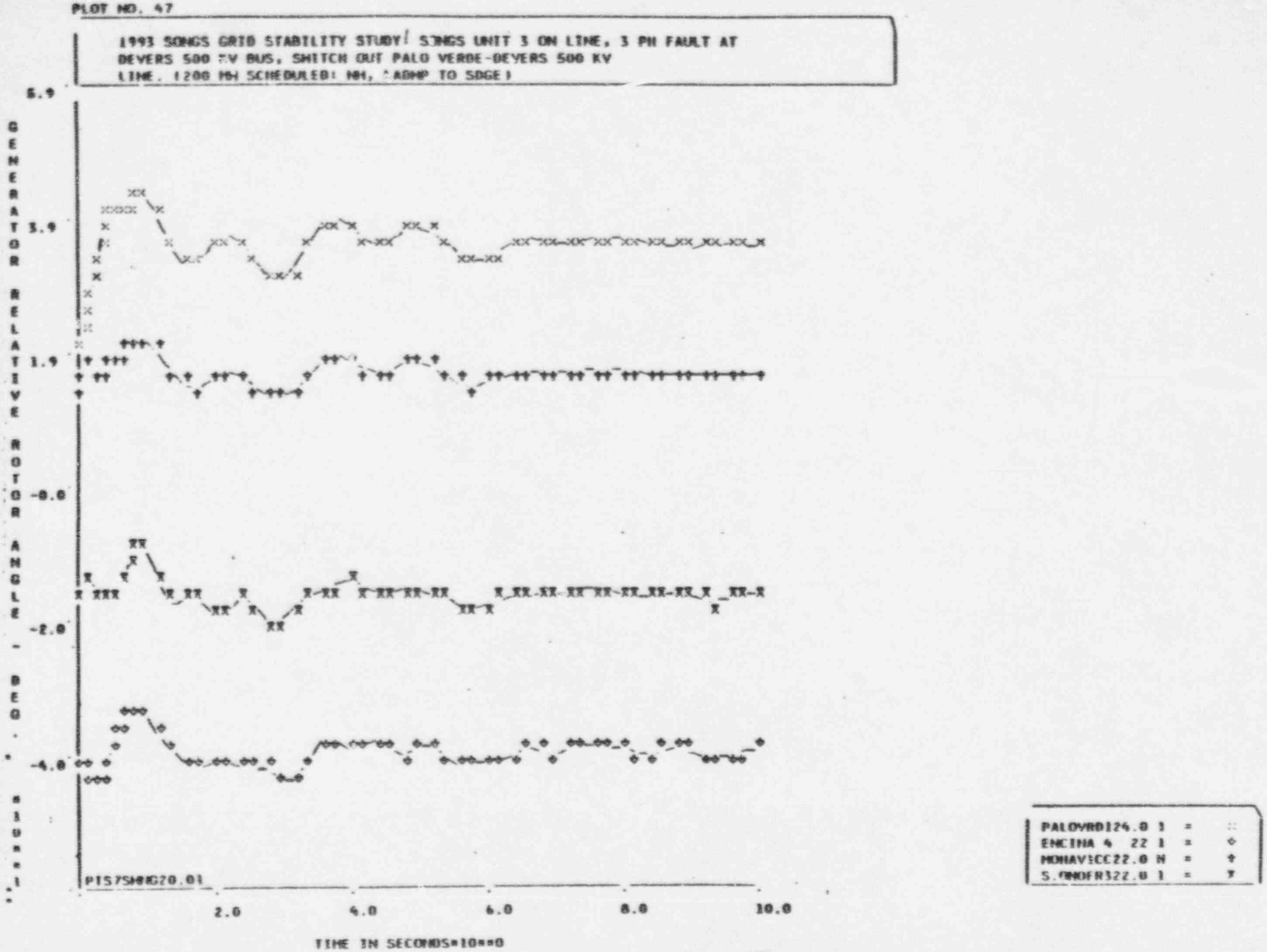
PLOT NO. 4

1993 SONGS GRID STABILITY STUDY: SONGS UNIT 3 ON LINE, 3 PH FAULT AT DEVERS 500 KV BUS, SWITCH OUT PALO VERDE-DEVERS 500 KV LINE. (200 MW SCHEDULED: 1M, LADWP TO SDGE)




PLOT NO. 13
1993 SONGS GRID STABILITY STUDY: SONGS UNIT 3 ON LINE, 3 PH FAULT AT
DEVERS 500 KV BUS, SWITCH OUT PALO VERDE-DEVERS 500 KV
LINE. (200 MW SCHEDULED: NM, LADWP TO SDGE)
5.0
4.0
3.0
2.0
1.0
0.0
2.0
4.0
6.0
8.0
10.0
TIME IN SECONDS
S.ONHRF230.

PLOT NO. 47



1993 SONGS GRID STABILITY STUDY! SONGS UNIT 3 ON LINE, 3 PH FAULT AT
DEVERS 500 KV BUS, SWITCH OUT PALO VERDE-DEVERS 500 KV
LINE. (200 MW SCHEDULED: NW, ADMP TO SDGE)
5.9
3.9
1.9
-0.0
-2.0
-4.0
GENERATOR RELATIVE ROTOR ANGLE - DEG.
PTS7SWNG20.01
2.0
4.0
6.0
8.0
10.0
TIME IN SECONDS*10**0
PALOVRD124.0 1 =
ENCINA 4 22 1 =
MOHAVICC22.0 H =
S.ONOFR322.0 1 =

Stability Plots

Scenario 4

One SONGS unit off-line and in Mode 3 (80 MW, 45 MVAR), remaining SONGS unit on-line in Mode 1 (80 MW, 45 MVAR).

The remaining SONGS unit trips following loss of a critical line.

Stability Plots

Scenario 4

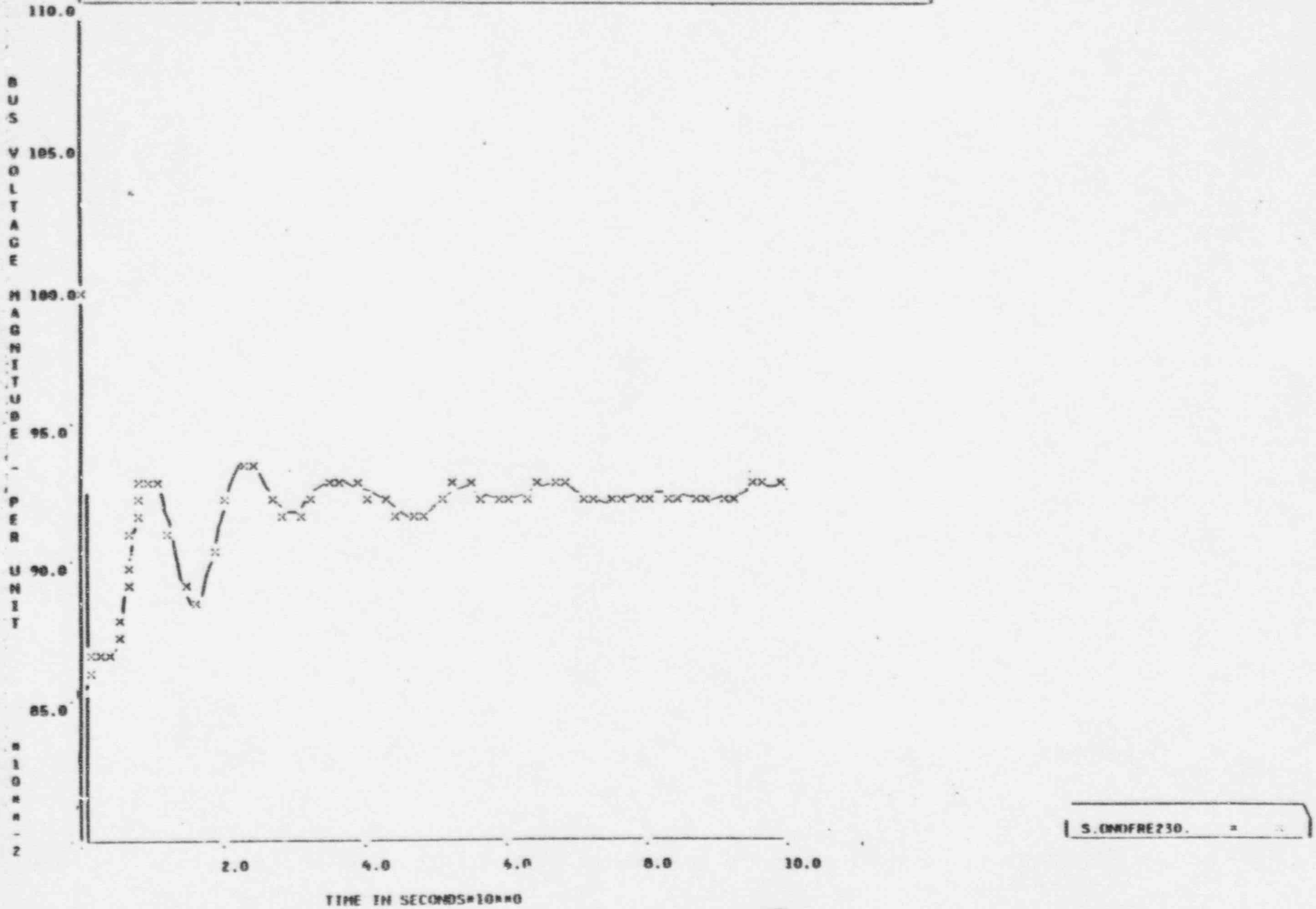
Case A:

Outage of the Mira Loma-Serrano and Lugo-Serrano 500kV lines (double circuit tower), and then the remaining SONGS unit trips.

Shed zero load.

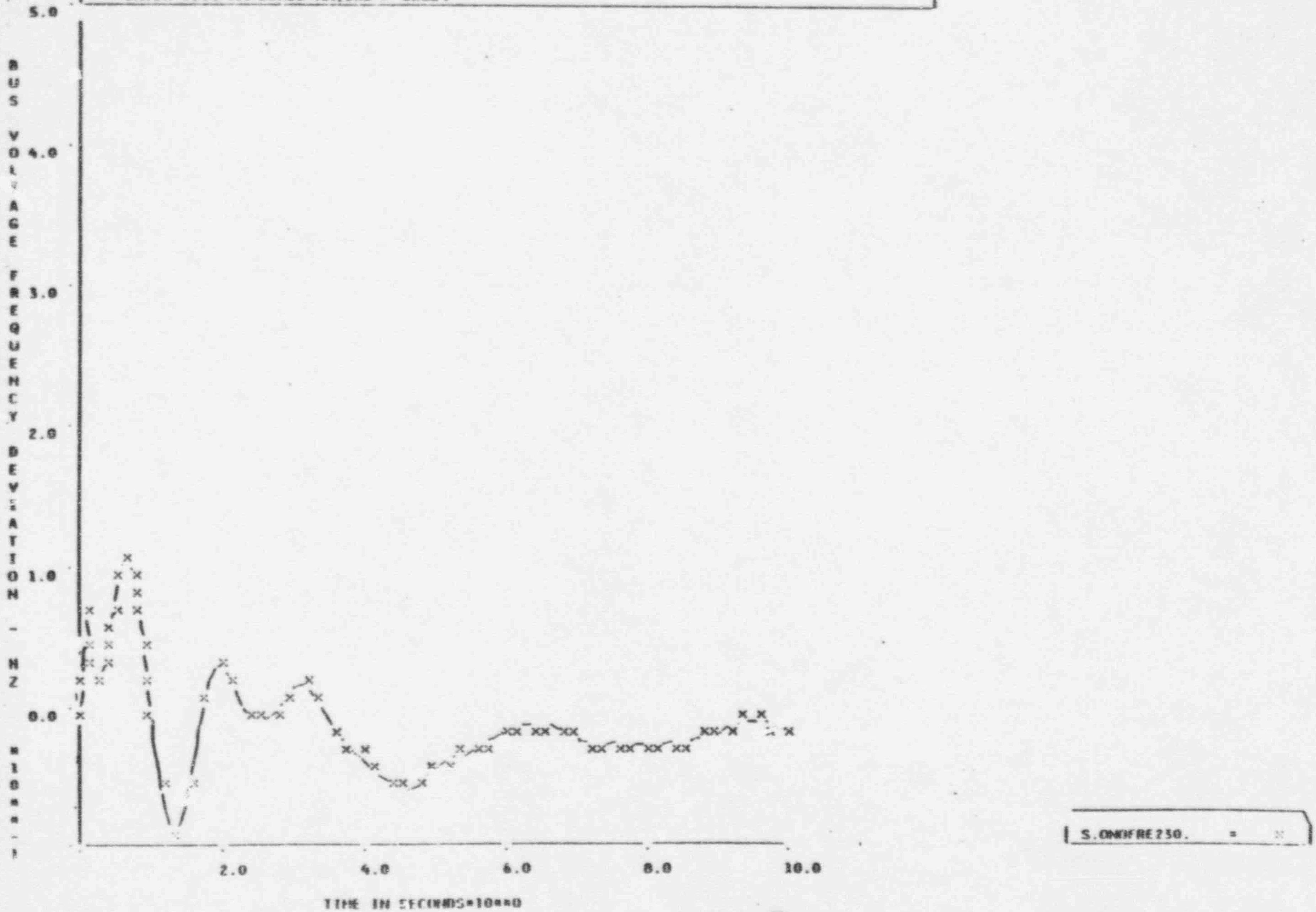
PLOT NO. 4

1993 SONGS GRID STABILITY STUDY: 3 PH FAULT AT SERRANO 500 BUS,
TRIP LUGO-SERRANO AND MIRA LOMA-SERRANO LINES, TRIP SONGS 3 SLIGHTLY
LATER (200 MW SCHED:184,LADWP-SDGE)

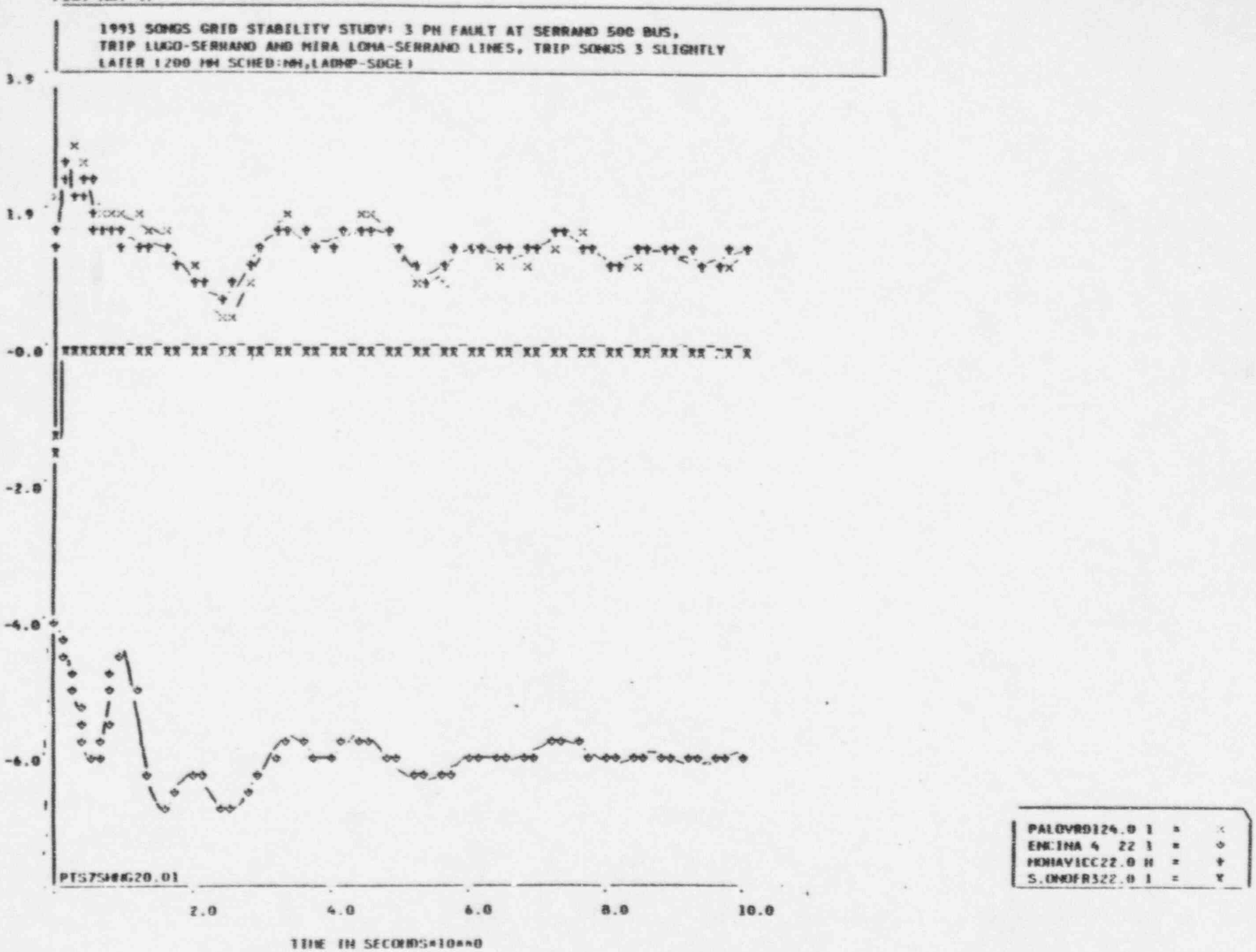


PLOT NO. 13

1993 SONGS GRID STABILITY STUDY: 3 PH FAULT AT SERRANO 500 BUS,
TRIP LUGO-SERRANO AND MIRA LOMA-SERRANO LINES, TRIP SONGS 3 SLIGHTLY
LATER (200 MM SCHED:MM,LADMP-SDGE)



PLOT NO. 47



1993 SONGS GRID STABILITY STUDY: 3 PH FAULT AT SERRANO 500 BUS,
TRIP LUGO-SERRANO AND MIRA LOMA-SERRANO LINES, TRIP SONGS 3 SLIGHTLY
LATER (200 MW SCHED:NW,LADWP-SDGE)
GENERATOR RELATIVE ROTOR ANGLE - DEG *10**1
3.9
1.9
-0.0
-2.0
-4.0
-6.0
PTS7SWNG20.01
2.0
4.0
6.0
8.0
10.0
TIME IN SECONDS*10**0
PALOVRD124.0 1 = x
ENCINA 4 22 1 = ◊
MOHAVICC22.0 H = +
S.ONOFR322.0 1 = Y

Stability Plots

Scenario 4

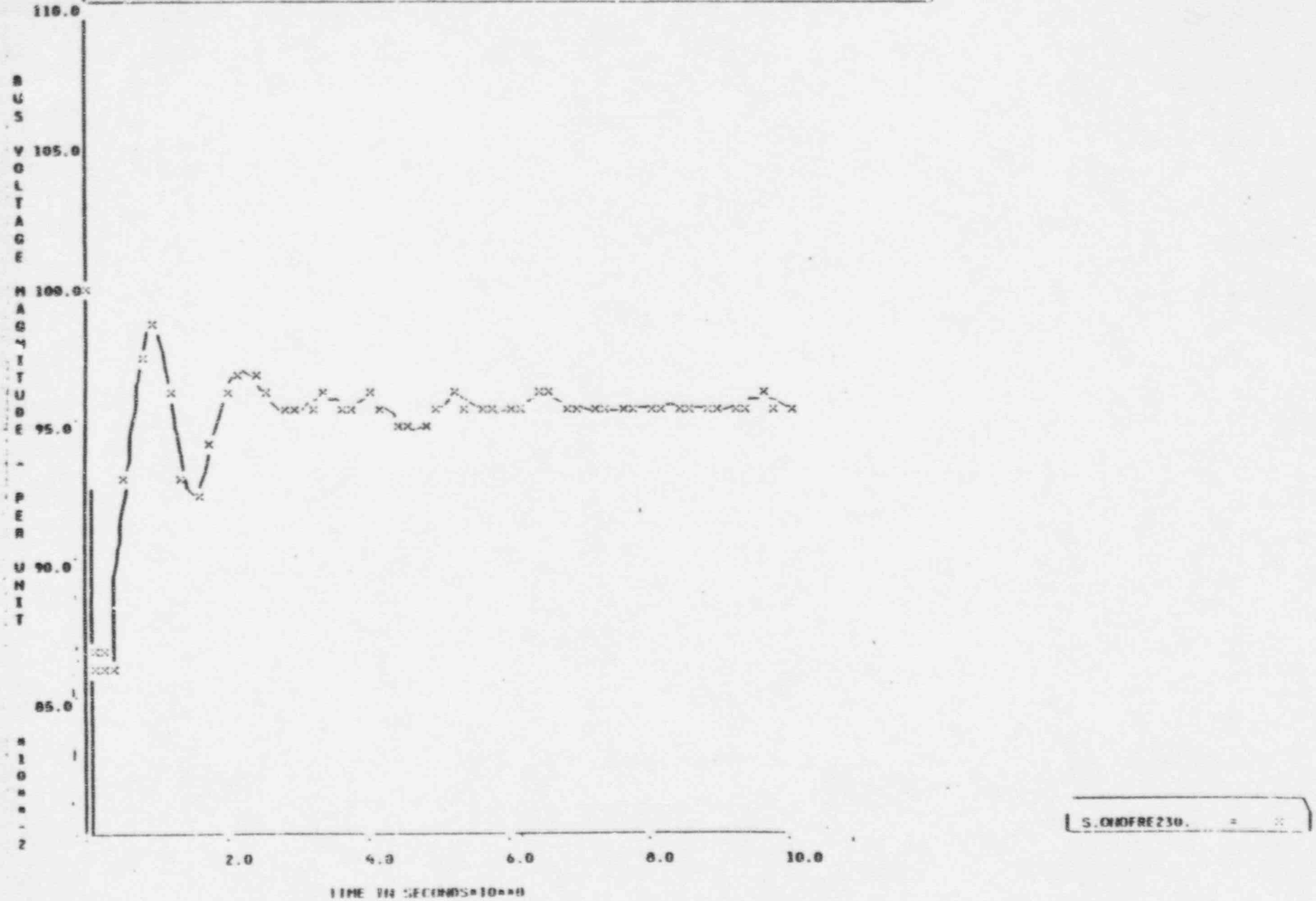
Case A:

Outage of the Mira Loma-Serrano and Lugo-Serrano 500kV lines (double circuit tower), and then the remaining SONGS unit trips.

Shed Santiago and Johanna loads (960 MW).

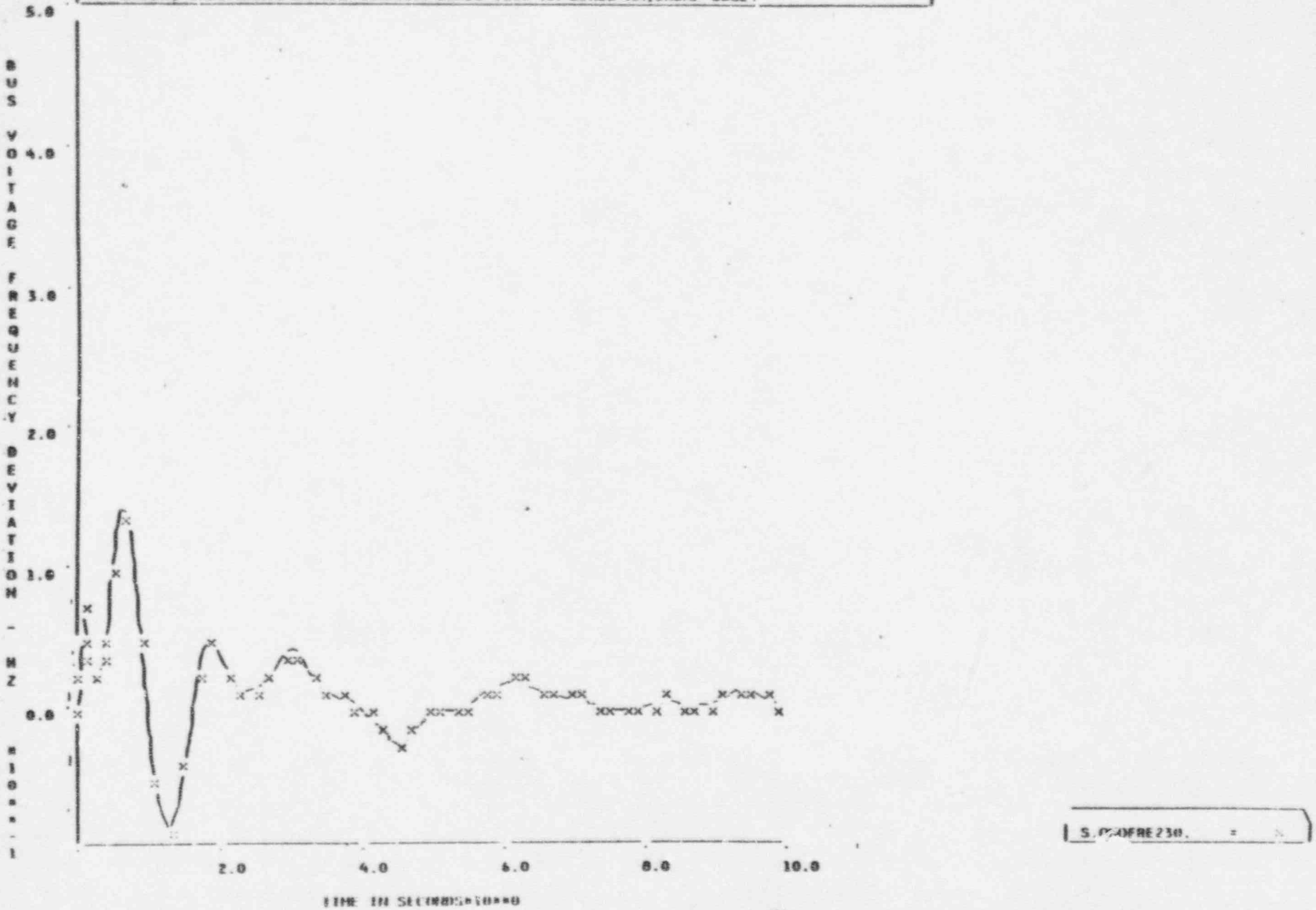
PLOT NO. 4

1991 SONGS GRID STABILITY STUDY: 3 PH FAULT AT SERRANO 500 BUS,
TRIP LUGO-SERRANO AND MIRA LOMA-SERRANO LINES, TRIP SONGS 3 SLIGHTLY
LATER, SHED SANTIAGO AND JOHANNA LOADS (200 MW SCHEF:NH,LADWP-SDGE)



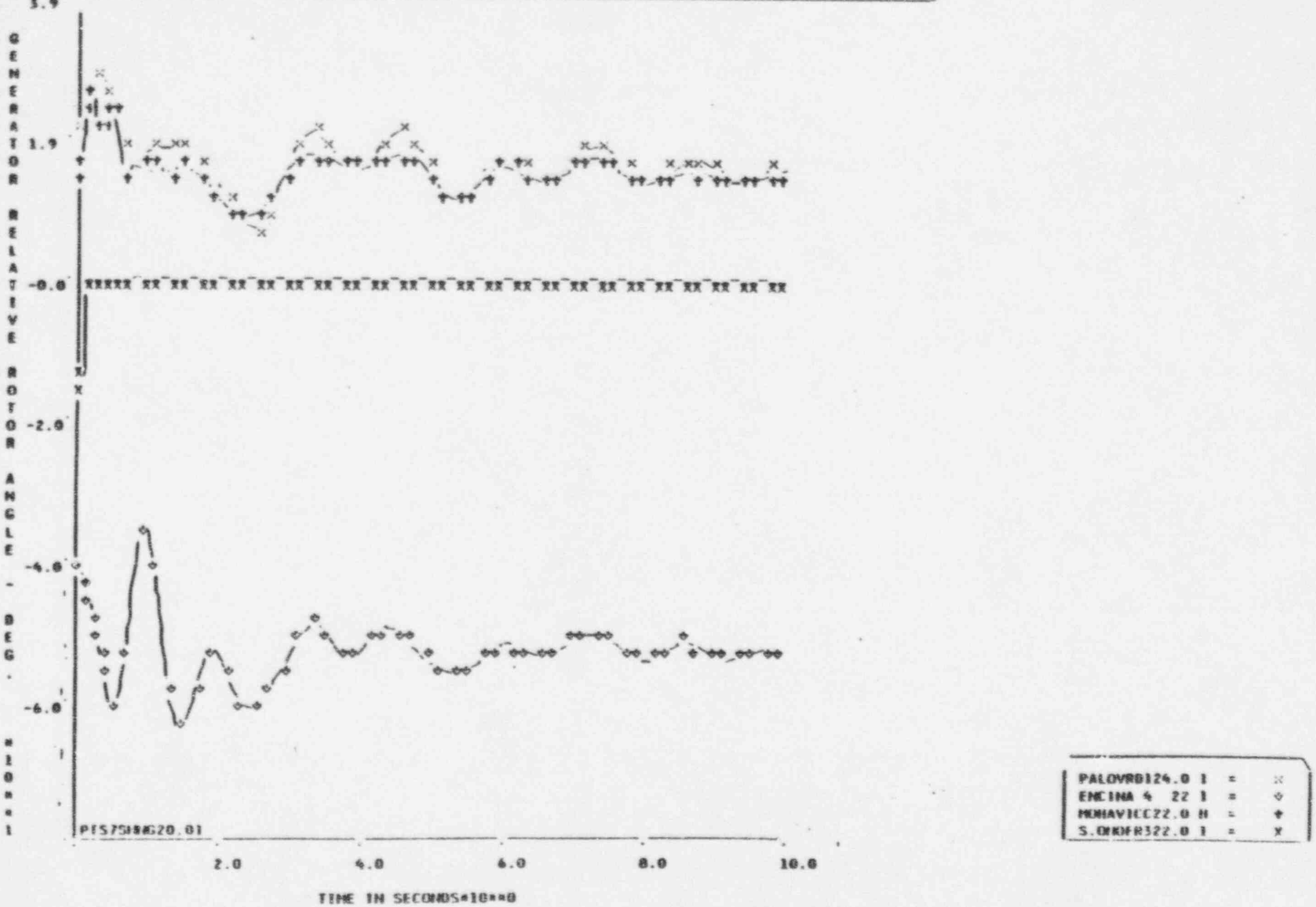
PLOT NO. 13

1993 SONGS GRID STABILITY STUDY: 3 PH FAULT AT SERRANO 500 BUS,
TRIP LUGO-SERRANO AND MIRA LOMA-SERRANO LINES, TRIP SONGS 3 SLIGHTLY
LATER, SHED SANTIAGO AND JOHANNA LOADS (200 MW SCHED:1M,LADMP-SDGE)



PLOT NO. 47

1993 SONGS GRID STABILITY STUDY: 3 PH FAULT AT SERRANO 500 BUS,
TRIP LUGO-SERRANO AND MIRA LOMA-SERRANO LINES, TRIP SONGS 3 SLIGHTLY
LATER, SHED SANTIAGO AND JOHANNA LOADS (200 MW SCHED:NM,LADWP-SDGE)



Stability Plots

Scenario 4

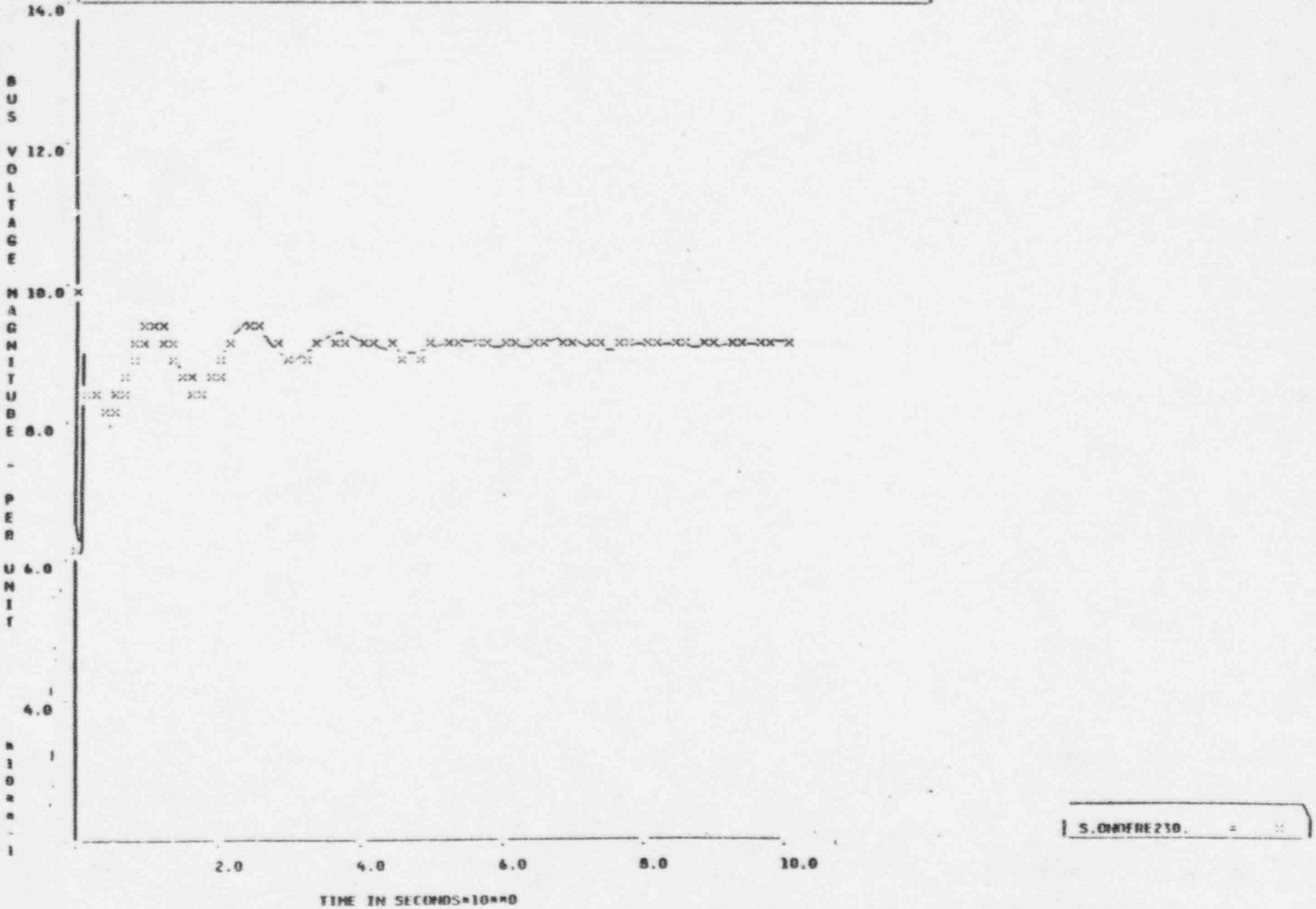
Case B:

Outage of the Lugo-Mira Loma 2 and 3 500kV lines (double circuit tower), and then the remaining SONGS unit trips.

Shed zero load.

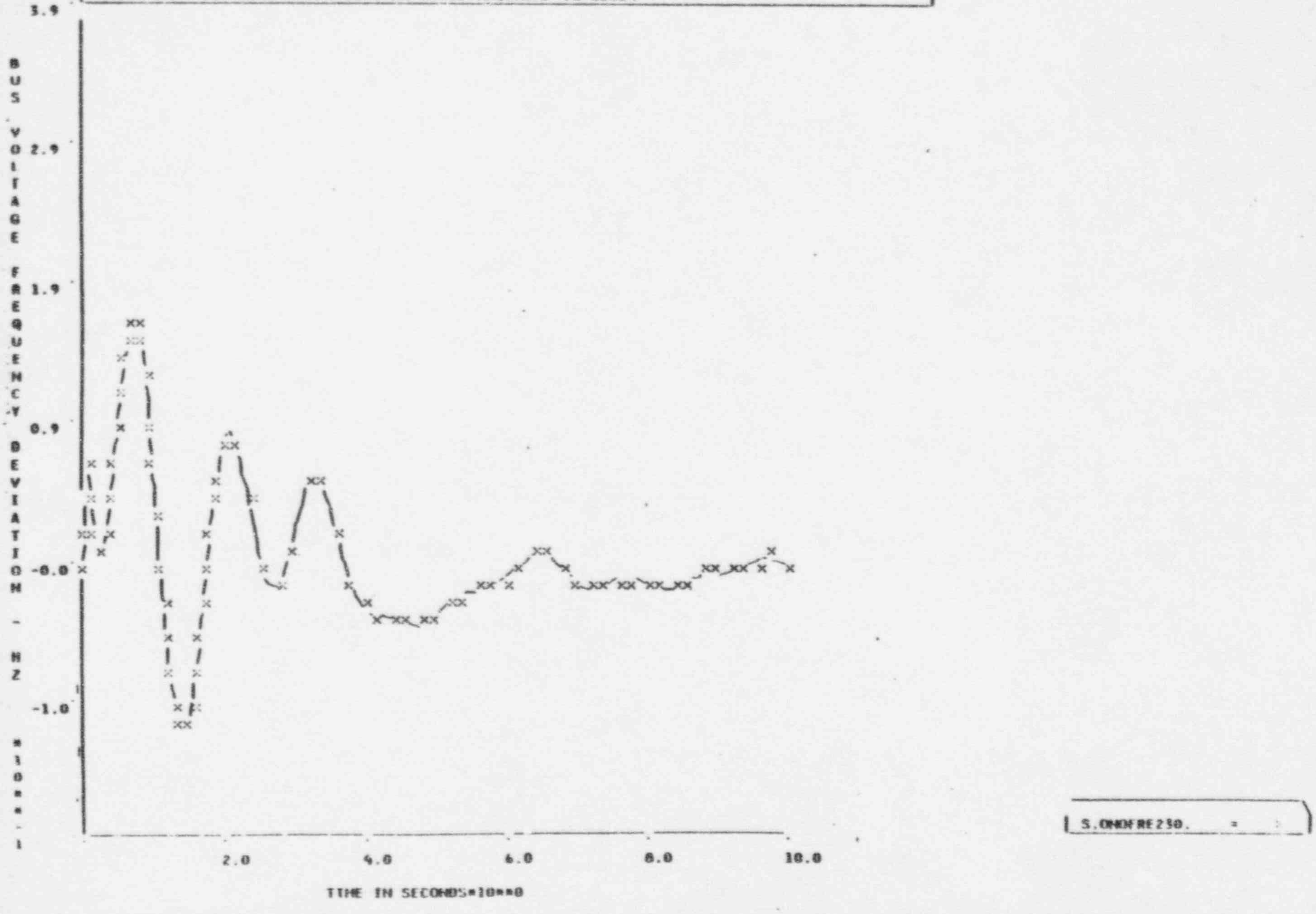
PLOT NO. 4

1993 SONGS GRID STABILITY STUDY: 3 PH FAULT AT MIRA LOMA 500 KV,
SWITCH OUT LUGO-MIRA LOMA #2 AND #3 500 KV LINES AND THEN TRIP
SONGS 3 SLIGHTLY LATER (200 MW SCHED:NM,LADWP TO SDGE)



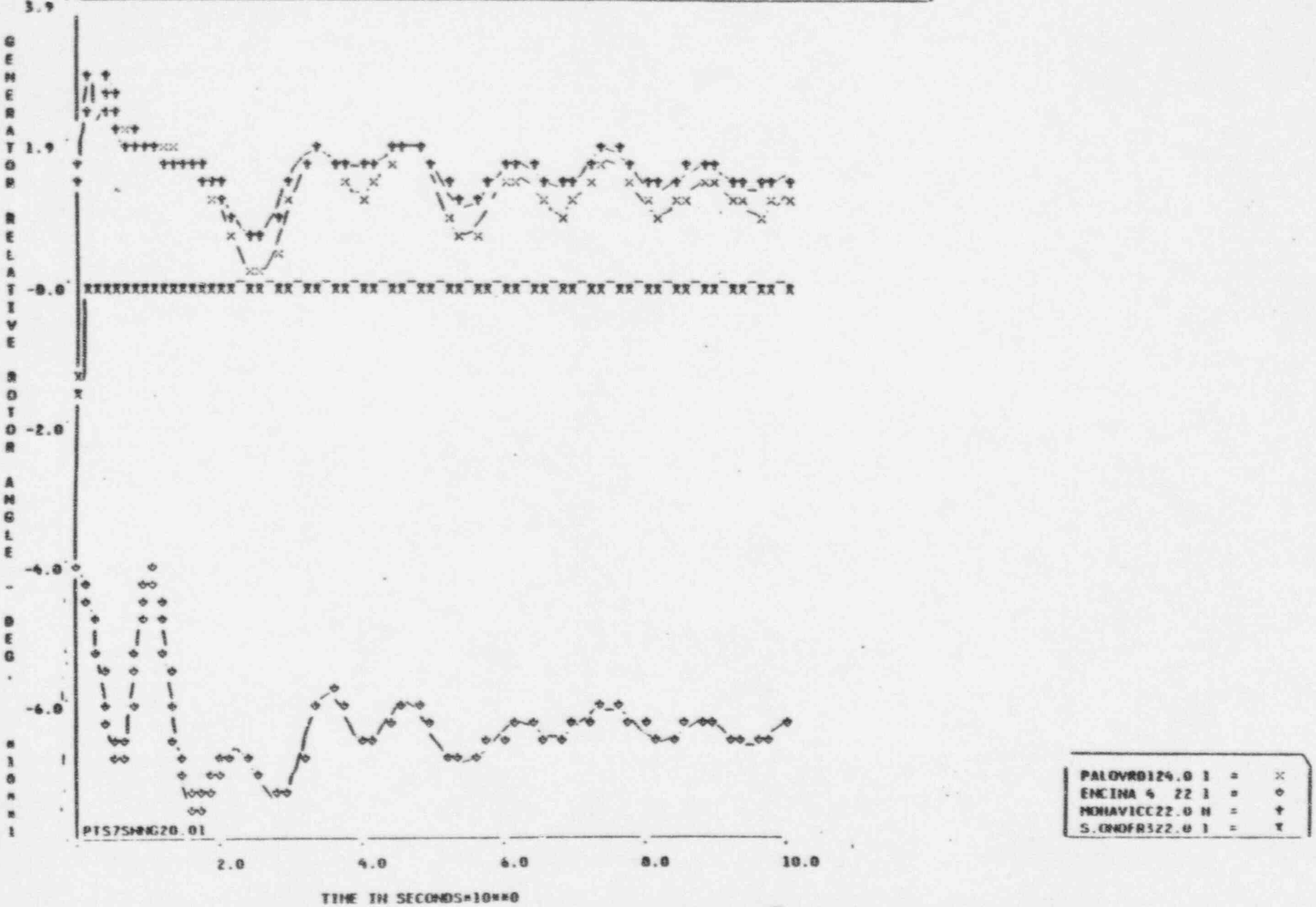
PLOT NO. 13

1993 SONGS GRID STABILITY STUDY: 3 PH FAULT AT MIRA LOMA 500 KV,
SWITCH OUT LUGO-MIRA LOMA #2 AND #3 500 KV LINES AND THEN TRIP
SONGS 3 SLIGHTLY LATER (200 MW SCHED:NW,LADWP TO SDGE)



PLOT NO. 47

1993 SONGS GRID STABILITY STUDY: 3 PH FAULT AT MIRA LOMA 500 KV,
SWITCH OUT LUGO-MIRA LOMA 82 AND 83 500 KV LINES AND THEN TRIP
SONGS 3 SLIGHTLY LATER (200 MW SCHED:NW,LADWP ,0 SDGE)



Stability Plots

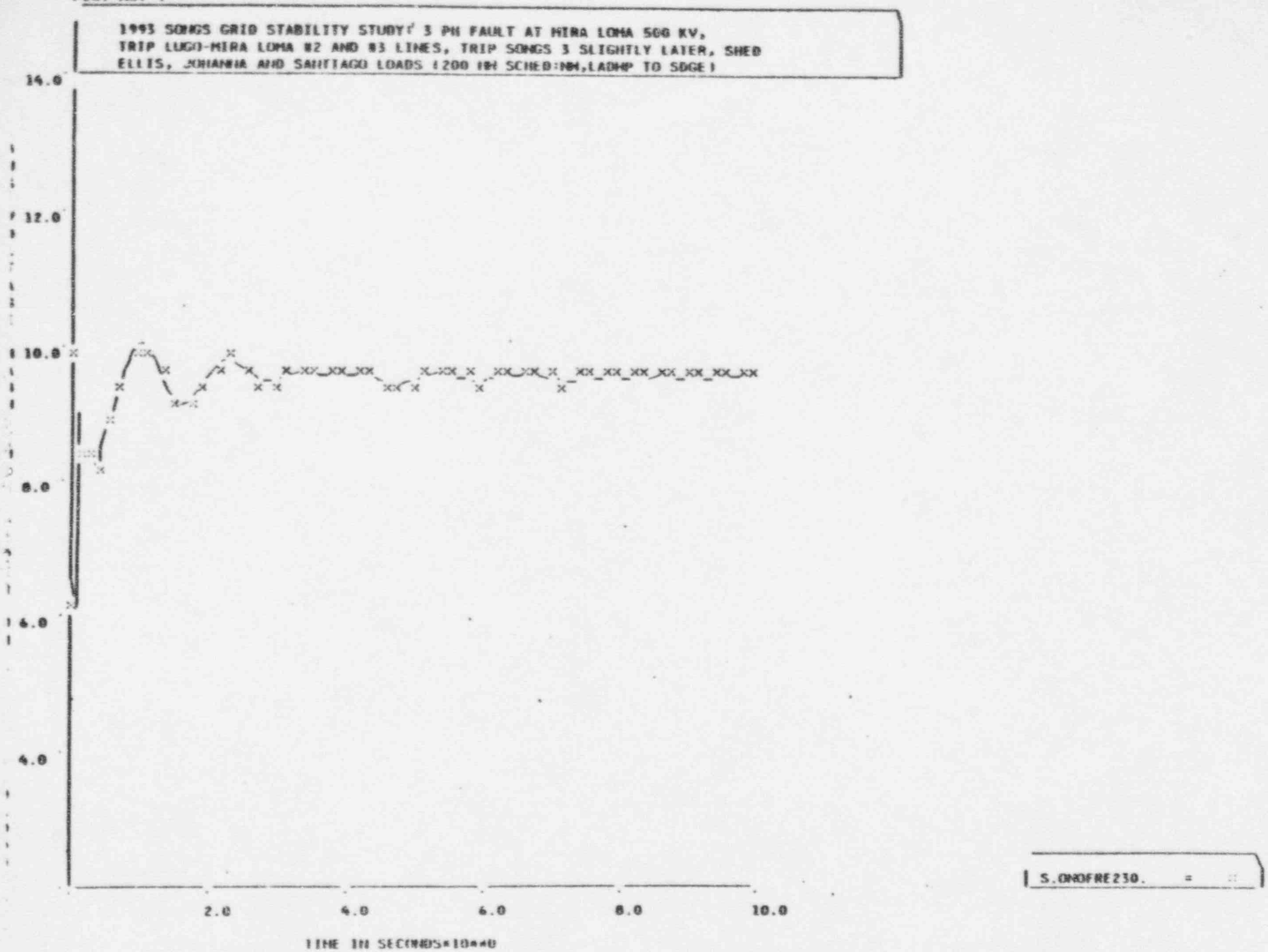
<u>Scenario 4</u>

Case B:

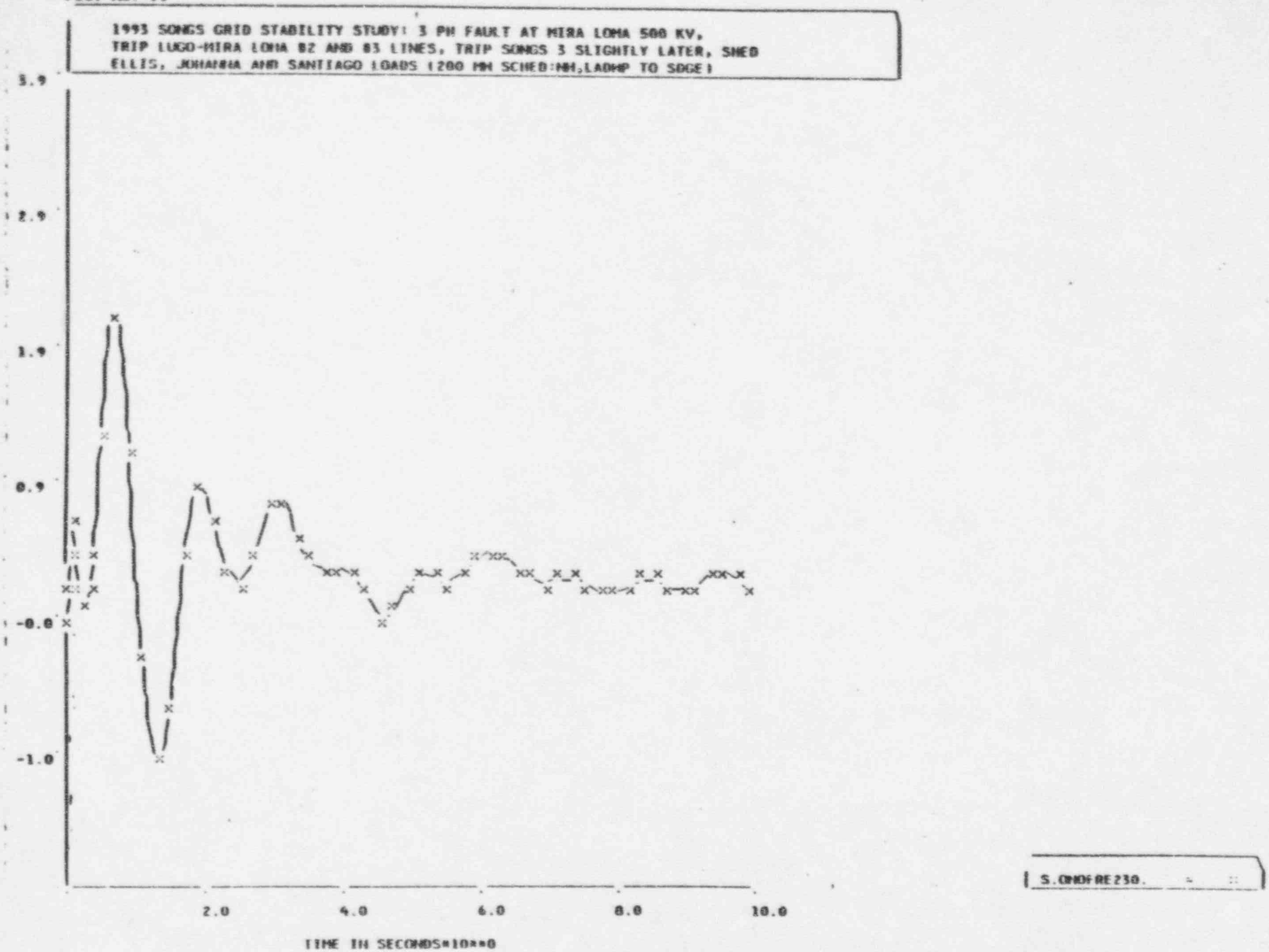
Outage of the Lugo-Mira Loma 2 and 3 500kV lines (double circuit tower), and then the remaining SONGS unit trips.

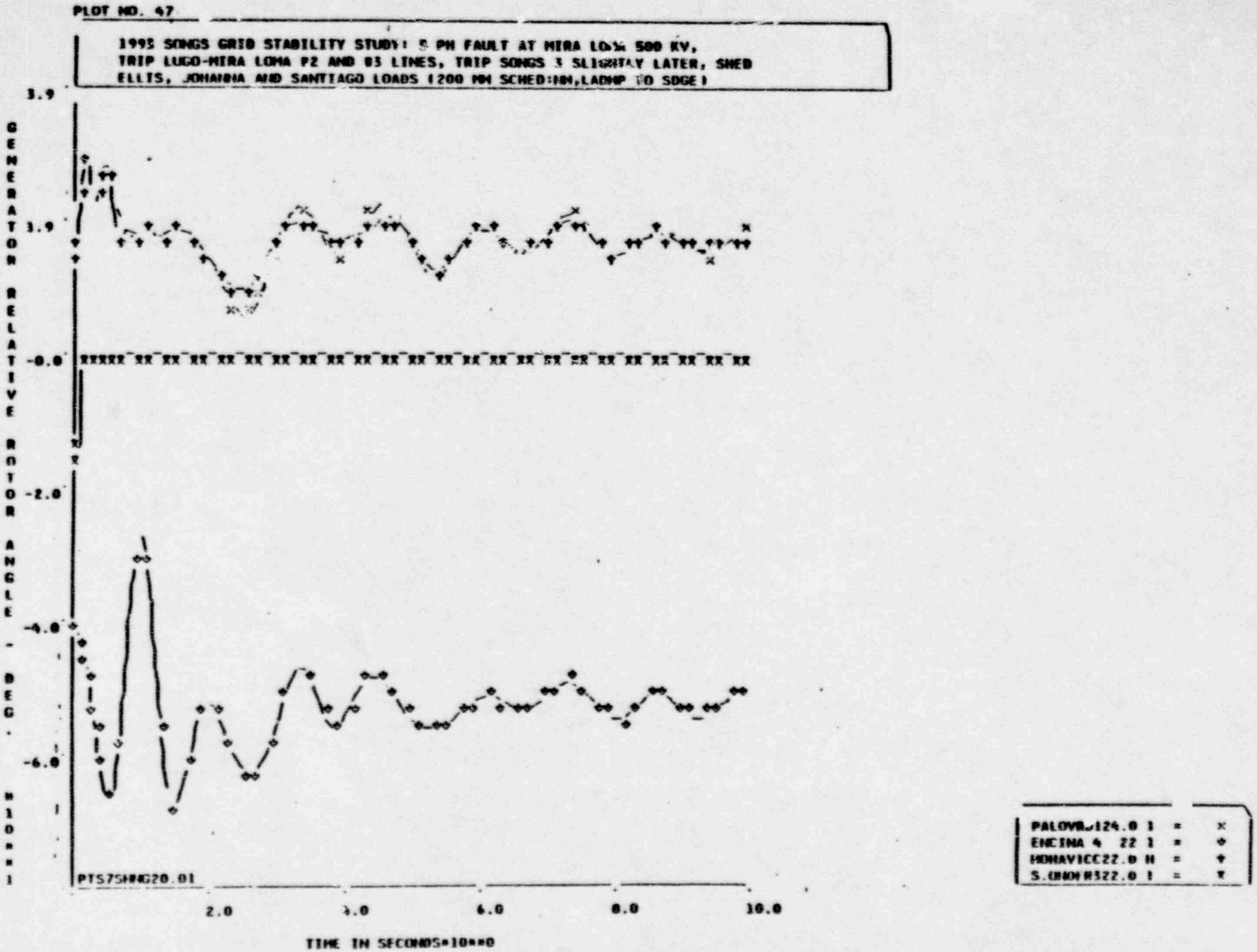
Shed Ellis, Johanna and Santiago loads (1530 MW).

PLOT NO. 4


1993 SONGS GRID STABILITY STUDY: 3 PH FAULT AT MIRA LOMA 500 KV,
TRIP LUGO-MIRA LOMA #2 AND #3 LINES, TRIP SONGS 3 SLIGHTLY LATER, SHED
ELLIS, JOHANNA AND SANTIAGO LOADS (200 MW SCHED:NM,LADWP TO SDGE)
14.0
12.0
10.0
8.0
6.0
4.0
2.0
4.0
6.0
8.0
10.0
TIME IN SECONDS*10**0
S.ONOFRE230. = ::

PLOT NO. 13


1993 SONGS GRID STABILITY STUDY: 3 PH FAULT AT MIRA LOMA 500 KV,
TRIP LUGO-MIRA LOMA 82 AND 83 LINES, TRIP SONGS 3 SLIGHTLY LATER, SHED
ELLIS, JOHANNA AND SANTIAGO LOADS (200 MW SCHED:NW,LADWP TO SDGE)
3.9
2.9
1.9
0.9
-0.0
-1.0
2.0
4.0
6.0
8.0
10.0
TIME IN SECONDS*10**0
S.ONOFRE230.


PLOT NO. 47
1995 SONGS GRID STABILITY STUDY: 5 PH FAULT AT MIRA LOMA 500 KV,
TRIP LUGO-MIRA LOMA #2 AND #3 LINES, TRIP SONGS 3 SLIGHTLY LATER, SHED
ELLIS, JOHANNA AND SANTIAGO LOADS (200 MW SCHED:MW,LADWP TO SDGE)
GENERATOR RELATIVE ROTOR ANGLE - DEG. * 10**1
3.9
1.9
-0.0
-2.0
-4.0
-6.0
2.0
4.0
6.0
8.0
10.0
TIME IN SECONDS*10**0
PTS7SNG20.01
PALOVRD124.0 1 = X
ENCINA 4 22 1 = ◊
MOHAVICC22.0 H = +
S.ONOFR322.0 1 = Y

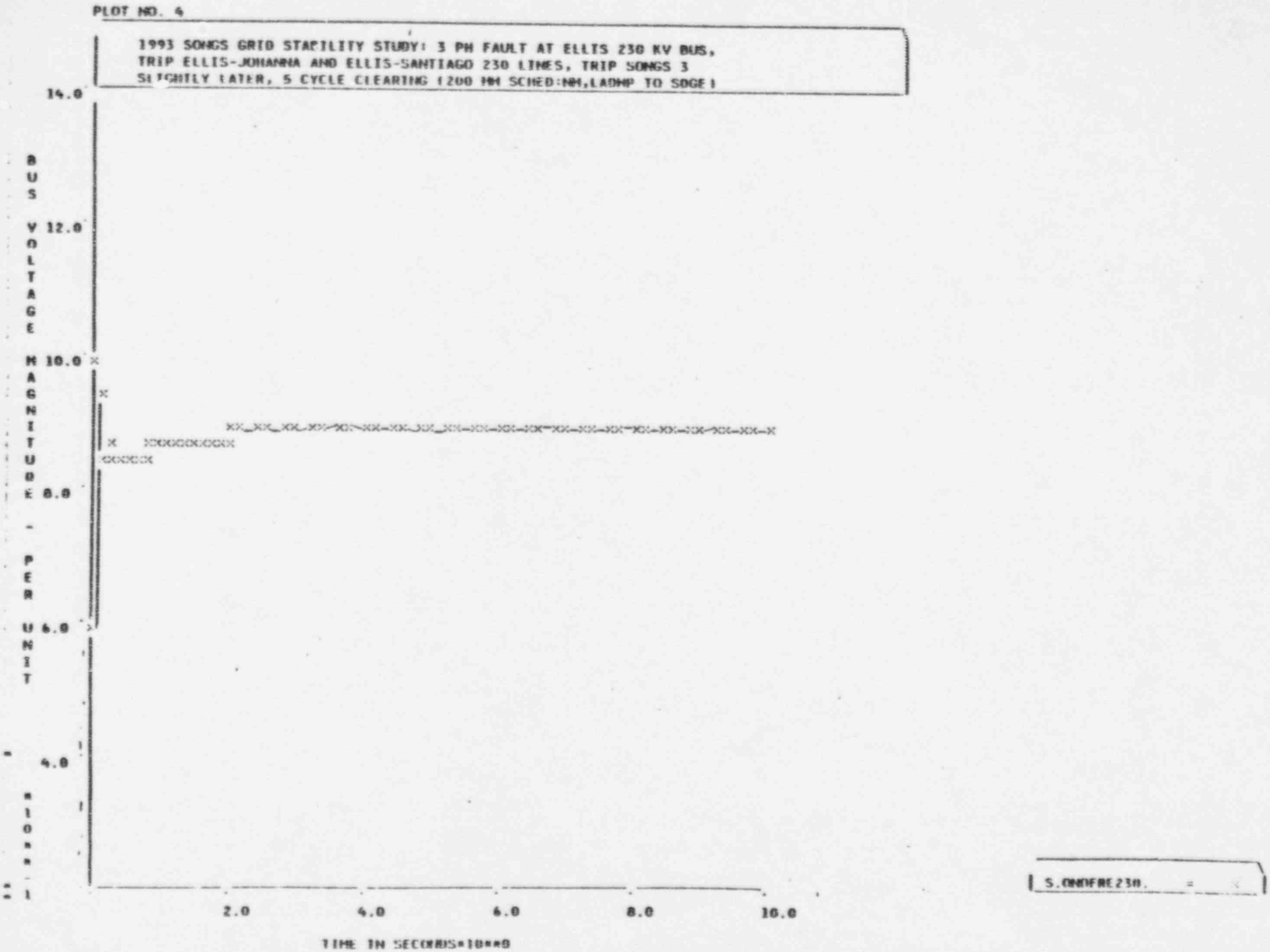
Stability Plots

Scenario 4

Case C:

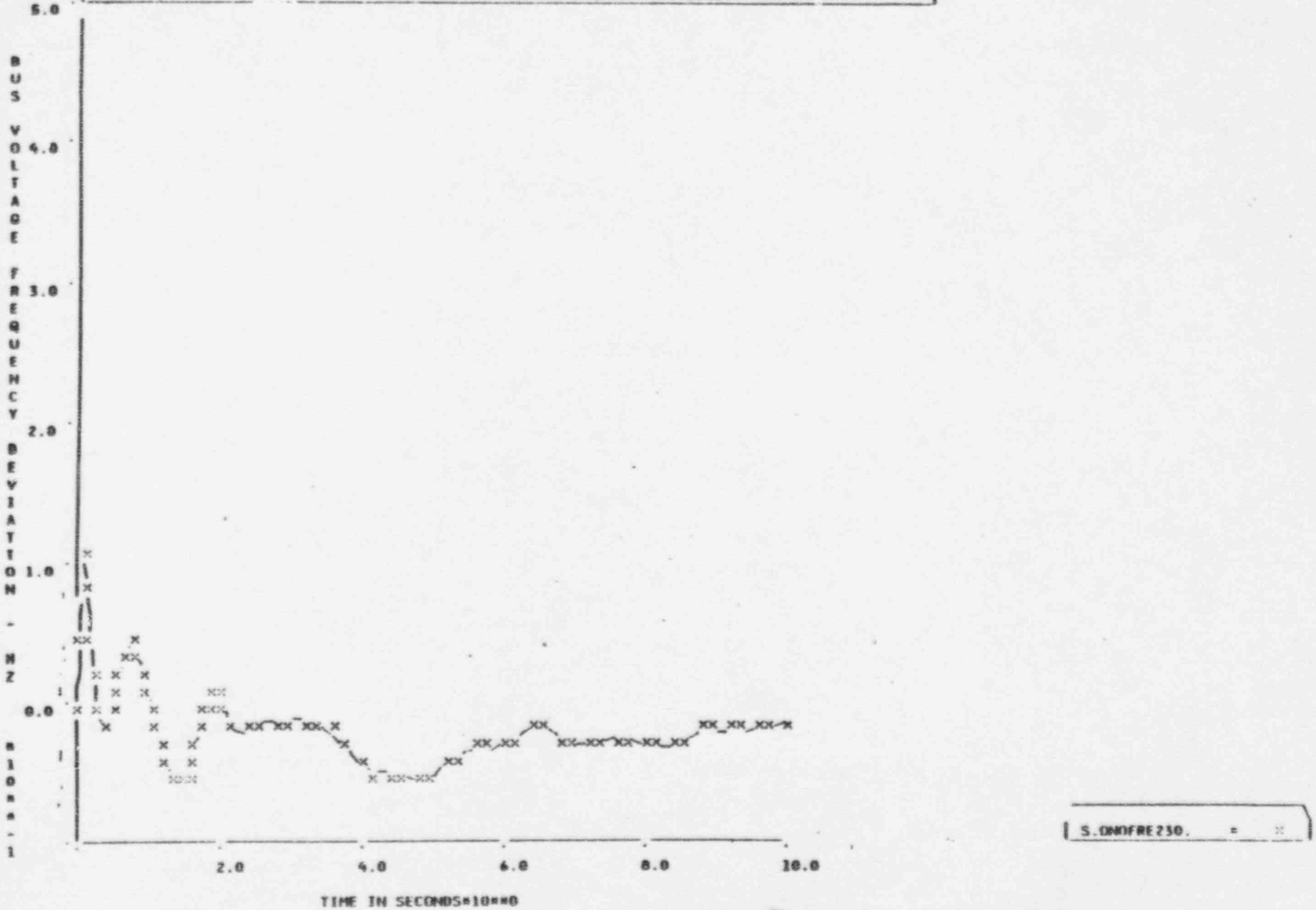
Outage of the Ellis-Johanna and Ellis-Santiago 230kV lines (double circuit tower), and then the remaining SONGS unit trips.

Shed zero load.


PLOT NO. 4
1993 SONGS GRID STABILITY STUDY: 3 PH FAULT AT ELLIS 230 KV BUS,
TRIP ELLIS-JOHANNA AND ELLIS-SANTIAGO 230 LINES, TRIP SONGS 3
SLIGHTLY LATER, 5 CYCLE CLEARING (200 MW SCHED:NM,LADWP TO SDGE)
14.0
12.0
10.0
8.0
6.0
4.0
BUS VOLTAGE MAGNITUDE - PER UNIT
2.0
4.0
6.0
8.0
10.0
TIME IN SECONDS*10**0
S.ONOFRE230. = X

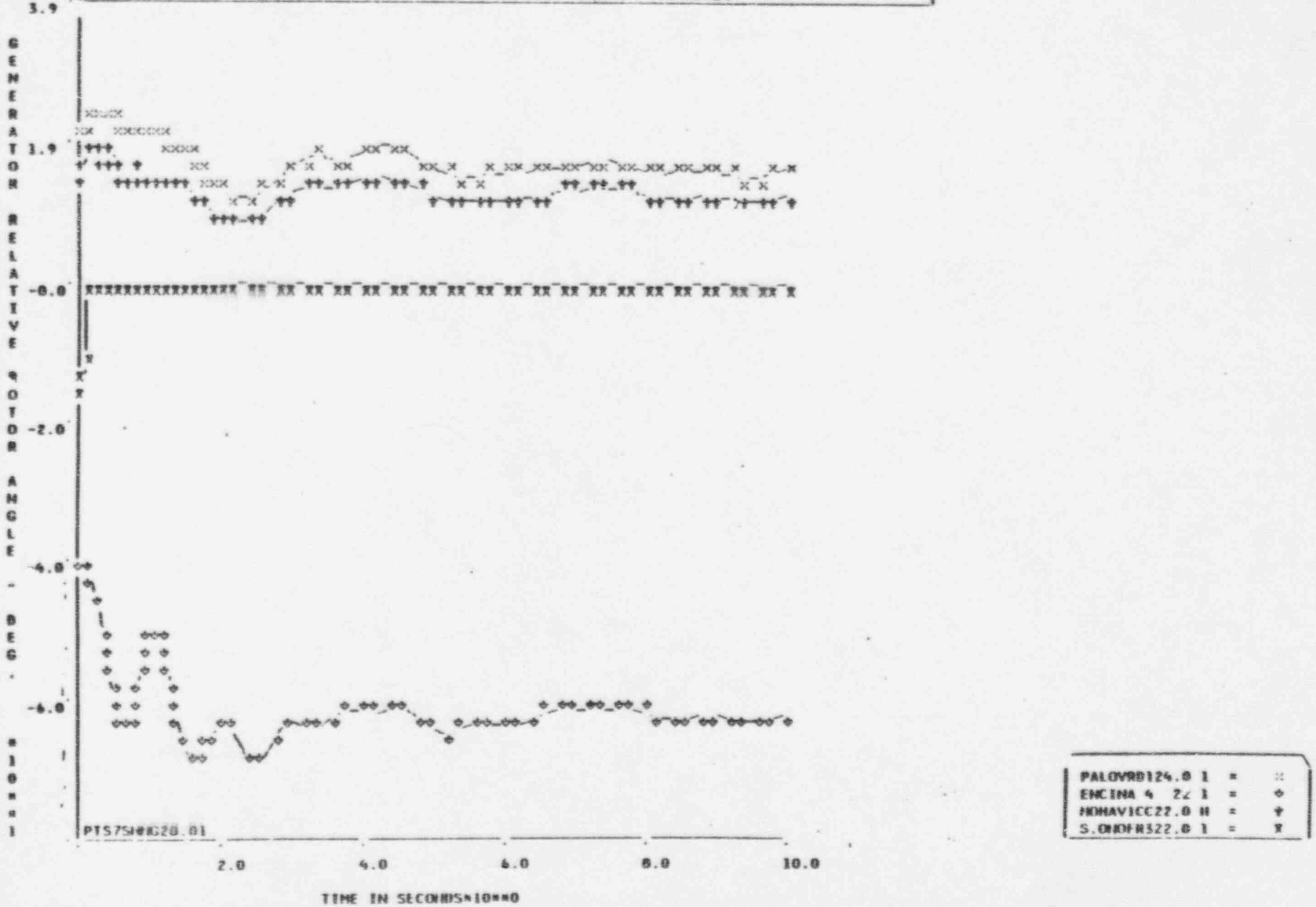
PLOT NO. 13

1993 SONGS GRID STABILITY STUDY: 3 PH FAULT AT ELLIS 230 KV BUS,
TRIP ELLIS-JOHA[illegible] AND ELLIS-SANTIAGO 230 LINES, TRIP SONGS 3
SLIGHTLY LATER [illegible] CYCLE CLEARING (200 MW SCHED:MW,LADWP TO SDGE)



PLOT NO. 47

1993 SONGS GRID STABILITY STUDY: 3 PH FAULT AT ELLIS 230 KV BUS,
TRIP ELLIS-JOHANNA AND ELLIS-SANTIAGO 230 LINES, TRIP SONGS 3
SLIGHTLY LATER, 5 CYCLE CLEARING (200 MW SCHED:MH,LADWP TO SDGE)



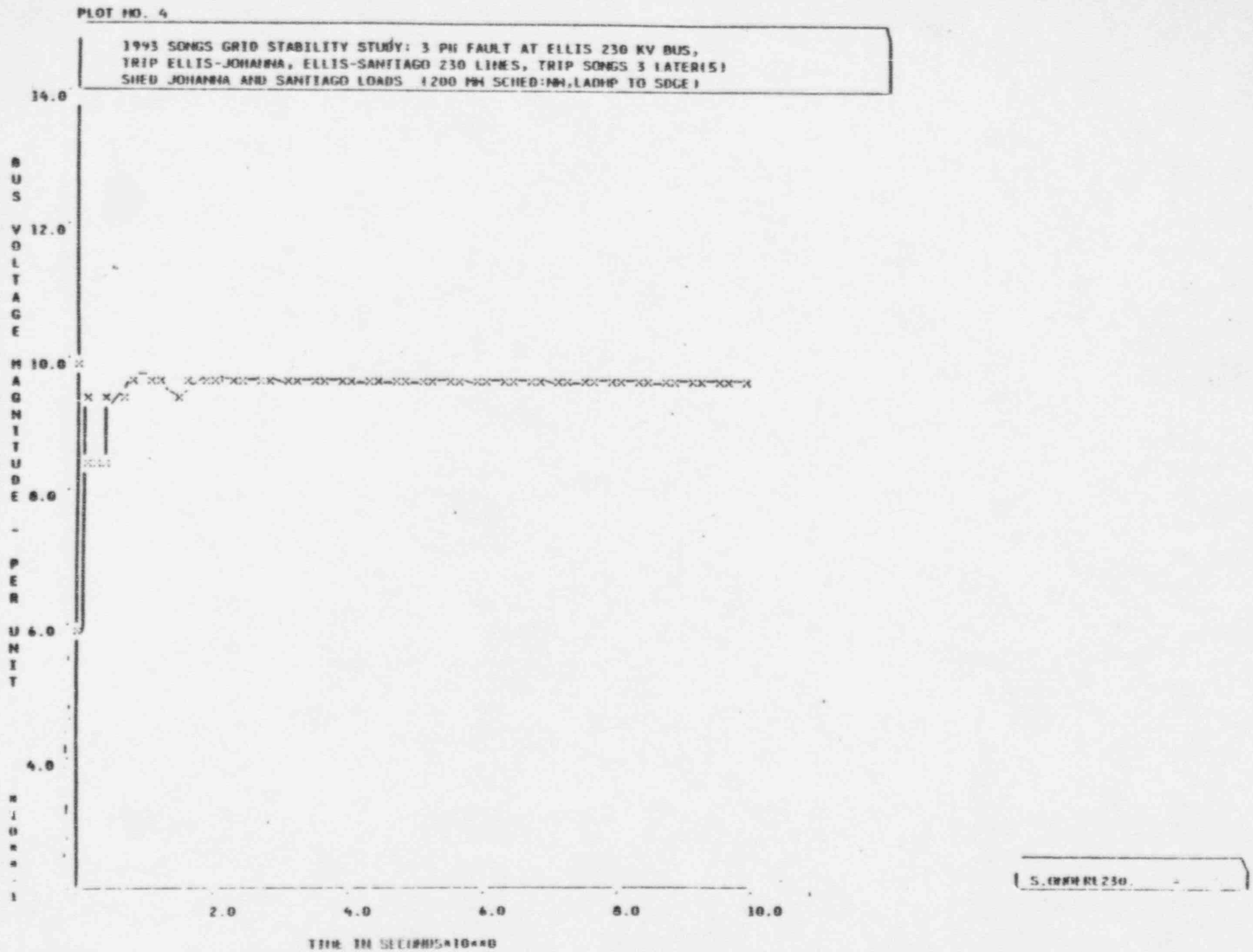
Stability Plots

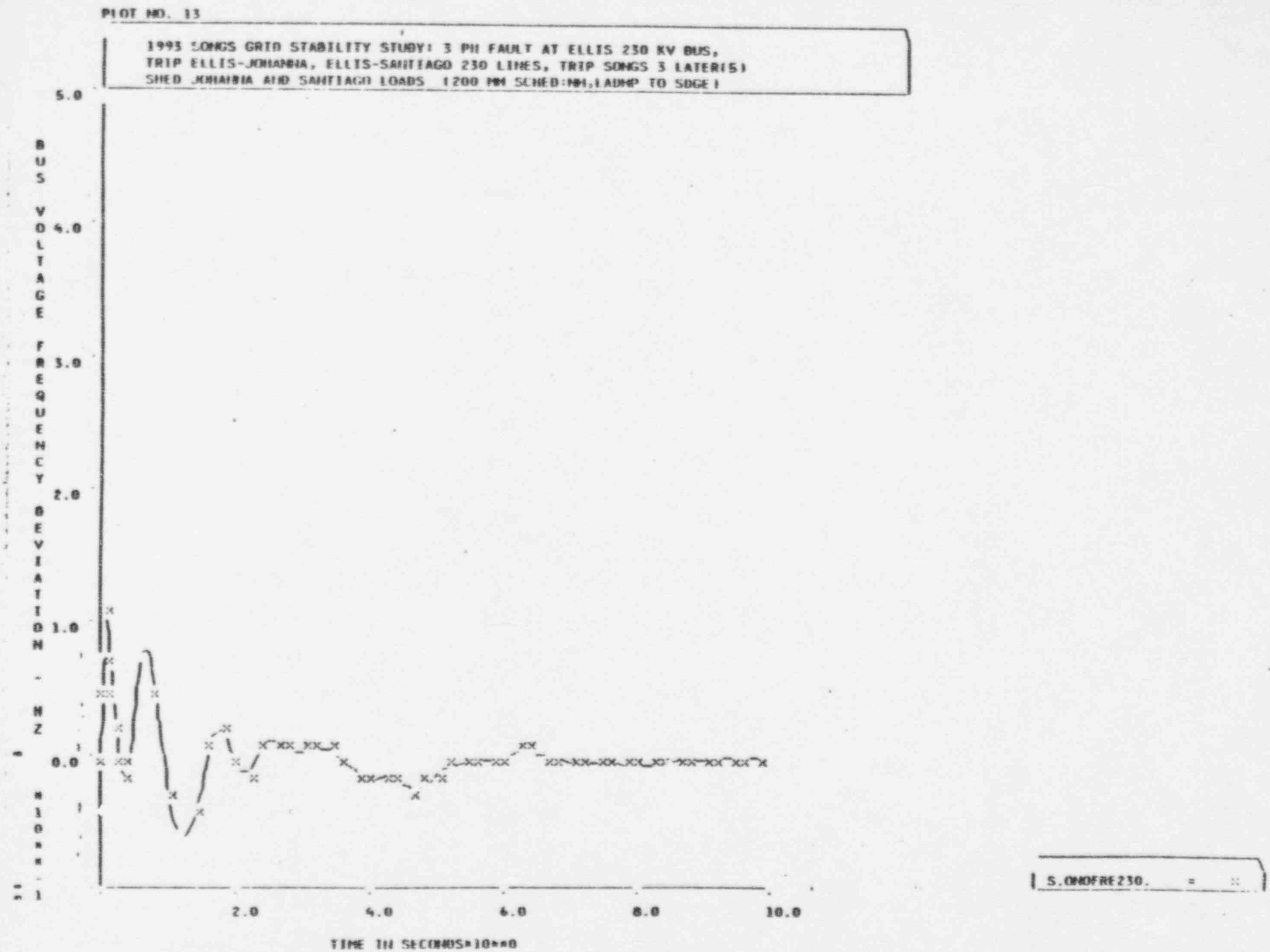
Scenario 4

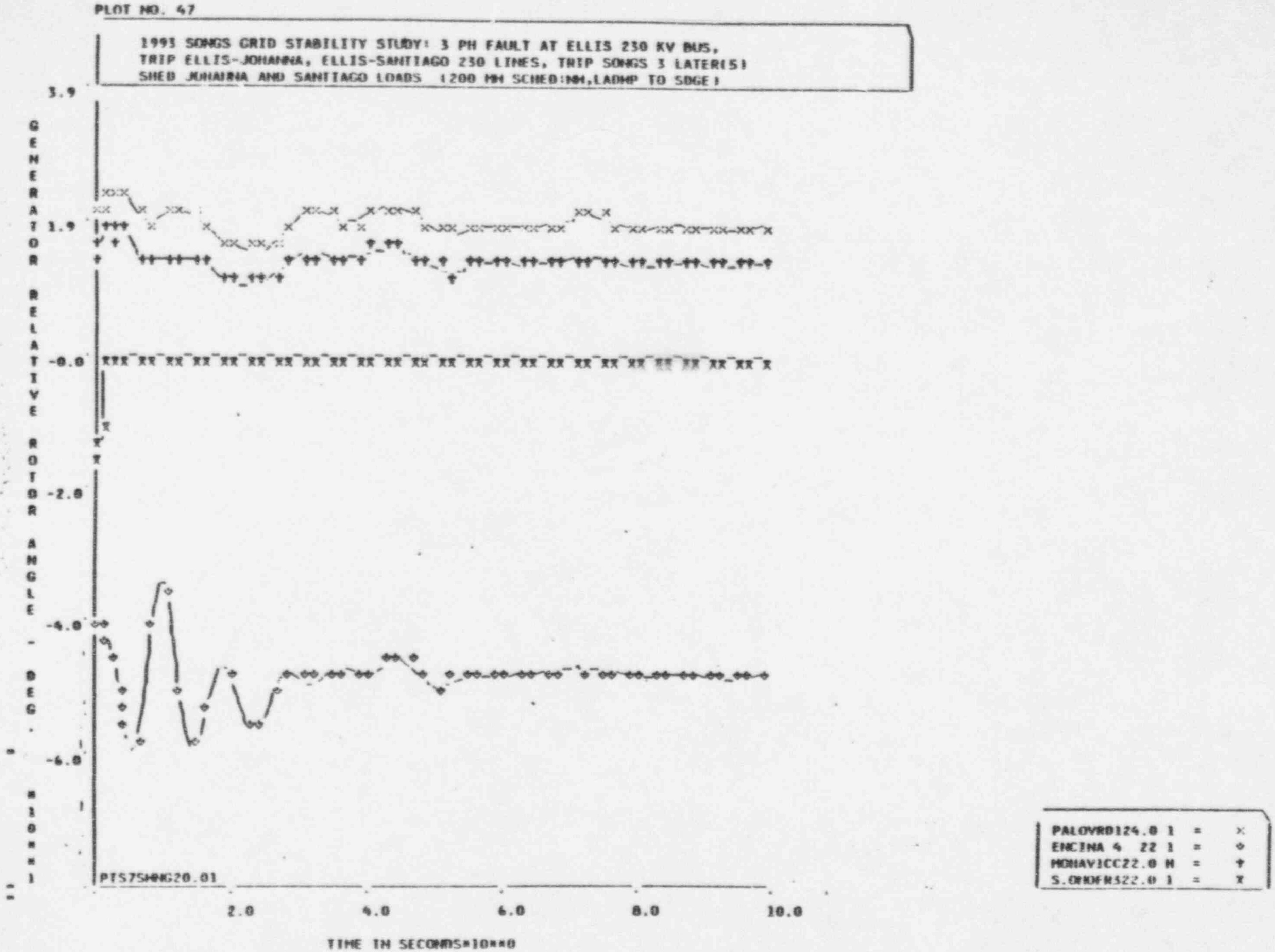
Case C:

Outage of the Ellis-Johanna and Ellis-Santiago 230kV lines (double circuit tower), and then the remaining SONGS unit trips.

Shed Santiago and Johanna loads (960 MW).


PLOT NO. 4
1993 SONGS GRID STABILITY STUDY: 3 PH FAULT AT ELLIS 230 KV BUS,
TRIP ELLIS-JOHANNA, ELLIS-SANTIAGO 230 LINES, TRIP SONGS 3 LATER(S)
SHED JOHANNA AND SANTIAGO LOADS (200 MW SCHED:NW,LADWP TO SDGE)
BUS VOLTAGE MAGNITUDE - PER UNIT *10**-1
14.0
12.0
10.0
8.0
6.0
4.0
2.0
4.0
6.0
8.0
10.0
TIME IN SECONDS*10**0
S.###RL230.


PLOT NO. 13
1993 SONGS GRID STABILITY STUDY: 3 PH FAULT AT ELLIS 230 KV BUS,
TRIP ELLIS-JOHANNA, ELLIS-SANTIAGO 230 LINES, TRIP SONGS 3 LATER(5)
SHED JOHANNA AND SANTIAGO LOADS (200 MM SCHED:MM,LADMP TO SDGE)
BUS VOLTAGE FREQUENCY DEVIATION - HZ
5.0
4.0
3.0
2.0
1.0
0.0
2.0
4.0
6.0
8.0
10.0
TIME IN SECONDS*10**0
S.ONOFRE230. = X


PLOT NO. 47
1993 SONGS GRID STABILITY STUDY: 3 PH FAULT AT ELLIS 230 KV BUS,
TRIP ELLIS-JOHANNA, ELLIS-SANTIAGO 230 LINES, TRIP SONGS 3 LATER(5)
SHED JOHANNA AND SANTIAGO LOADS (200 MW SCHED:NM,LADWP TO SDGE)
GENERATOR RELATIVE ROTOR ANGLE - DEG. * 10**1
3.9
1.9
-0.0
-2.0
-4.0
-6.0
PTS7SWNG20.01
2.0
4.0
6.0
8.0
10.0
TIME IN SECONDS*10**0
PALOVRD124.0 1 = x
ENCINA 4 22 1 = ◇
MOHAVICC22.0 M = †
S.ONOFR322.0 1 = x

Stability Plots

Scenario 4

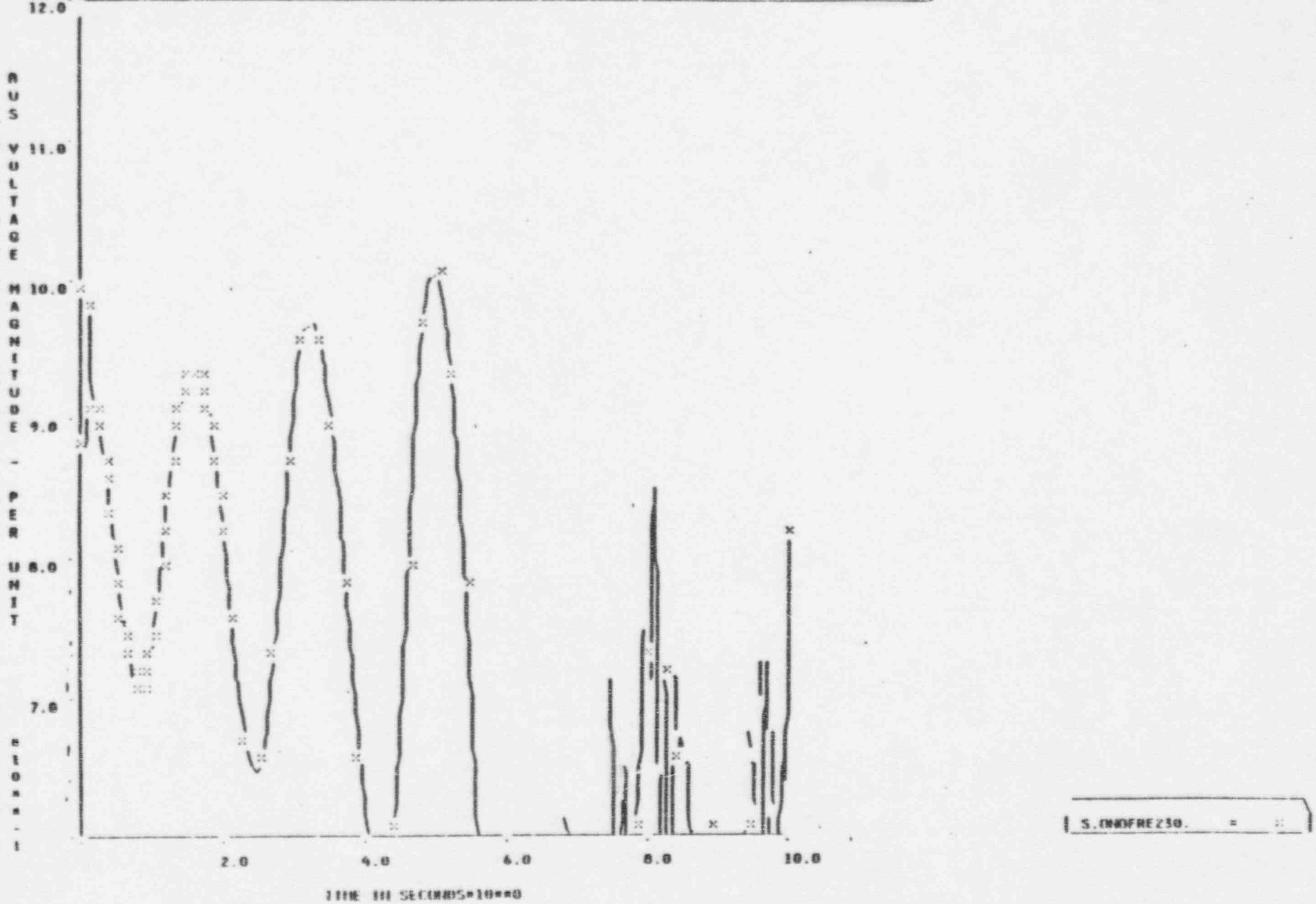
Case D:

Outage of the Imperial Valley-Miguel 500kV line, Imperial Valley-Rosita 230kV line, and then the remaining SONGS unit trips.

Shed zero load.
EOR Flow = 5000 MW
SCE Load = 18,000 MW

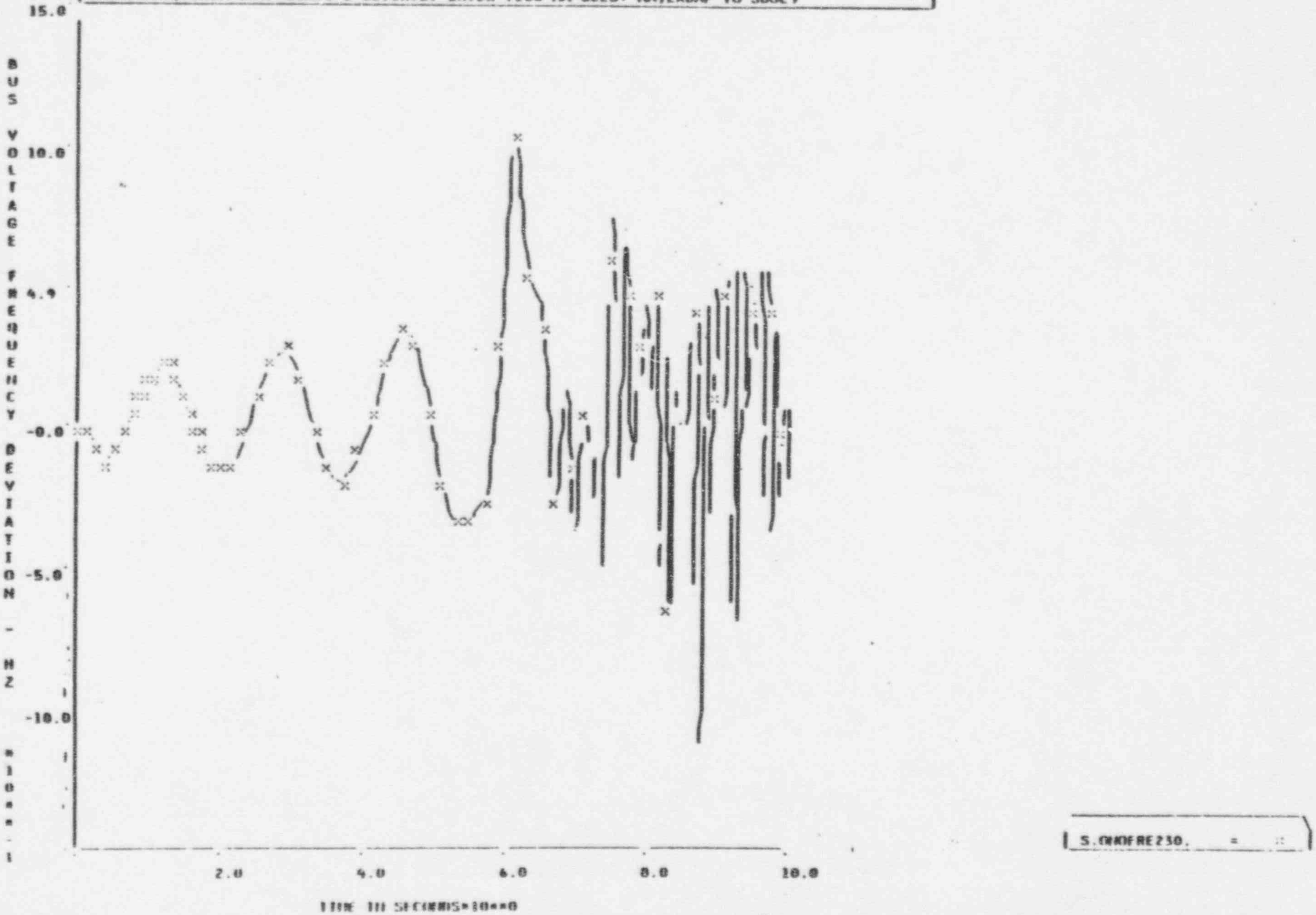
PLOT NO. 4

1993 SONGS GRID STABILITY STUDY: 3 PH FAULT AT IMPERIAL-VALLEY 500 KV BUS, TRIP IMPERIAL VALLEY-MIGUEL 500 KV, IMPERIAL VALLEY- LA ROSITA LINES, THEN TRIP SONGS 3 SLIGHTLY LATER (200 MW SCED: MH,LADWP TO SDGE)



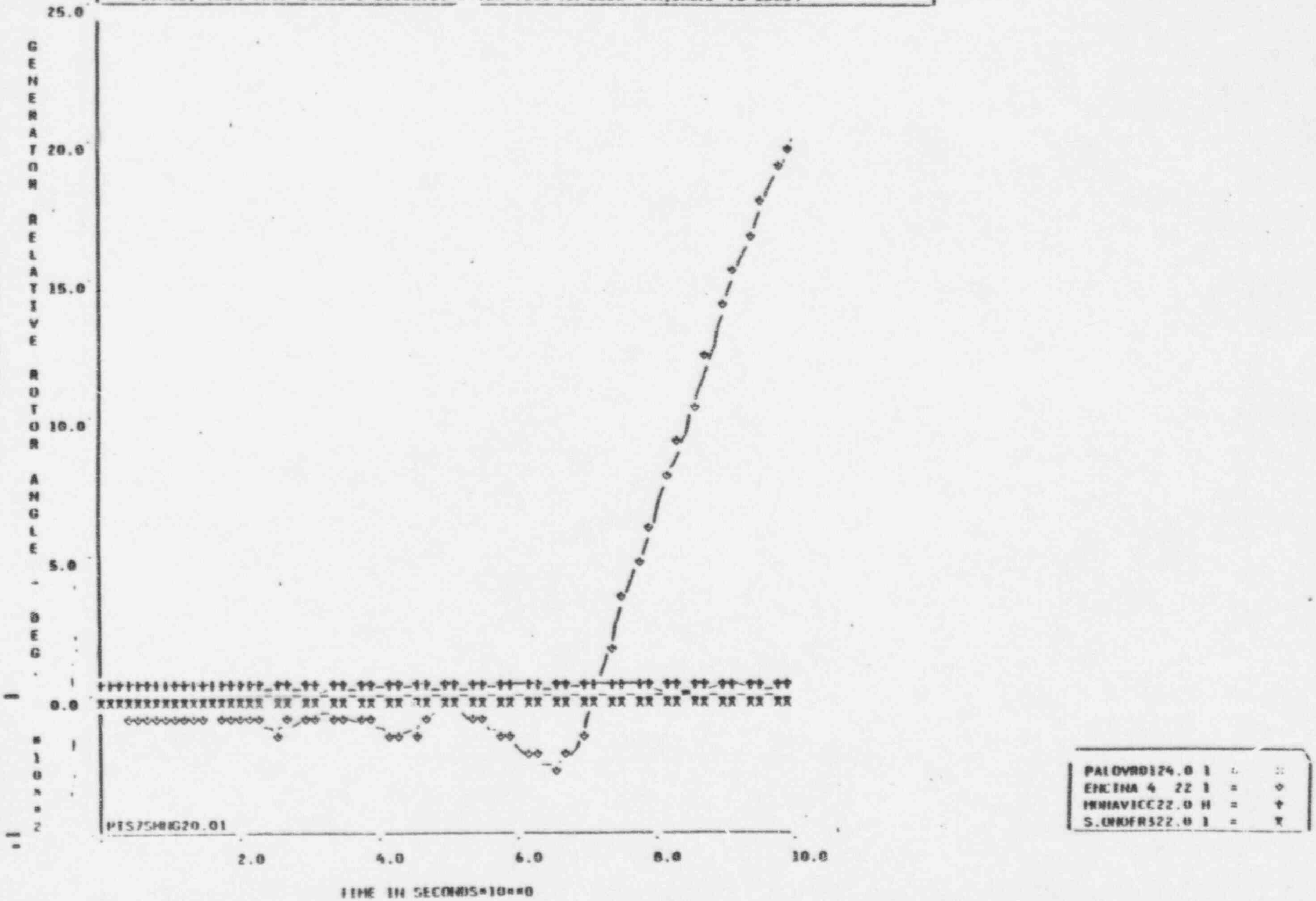
PLOT NO. 13

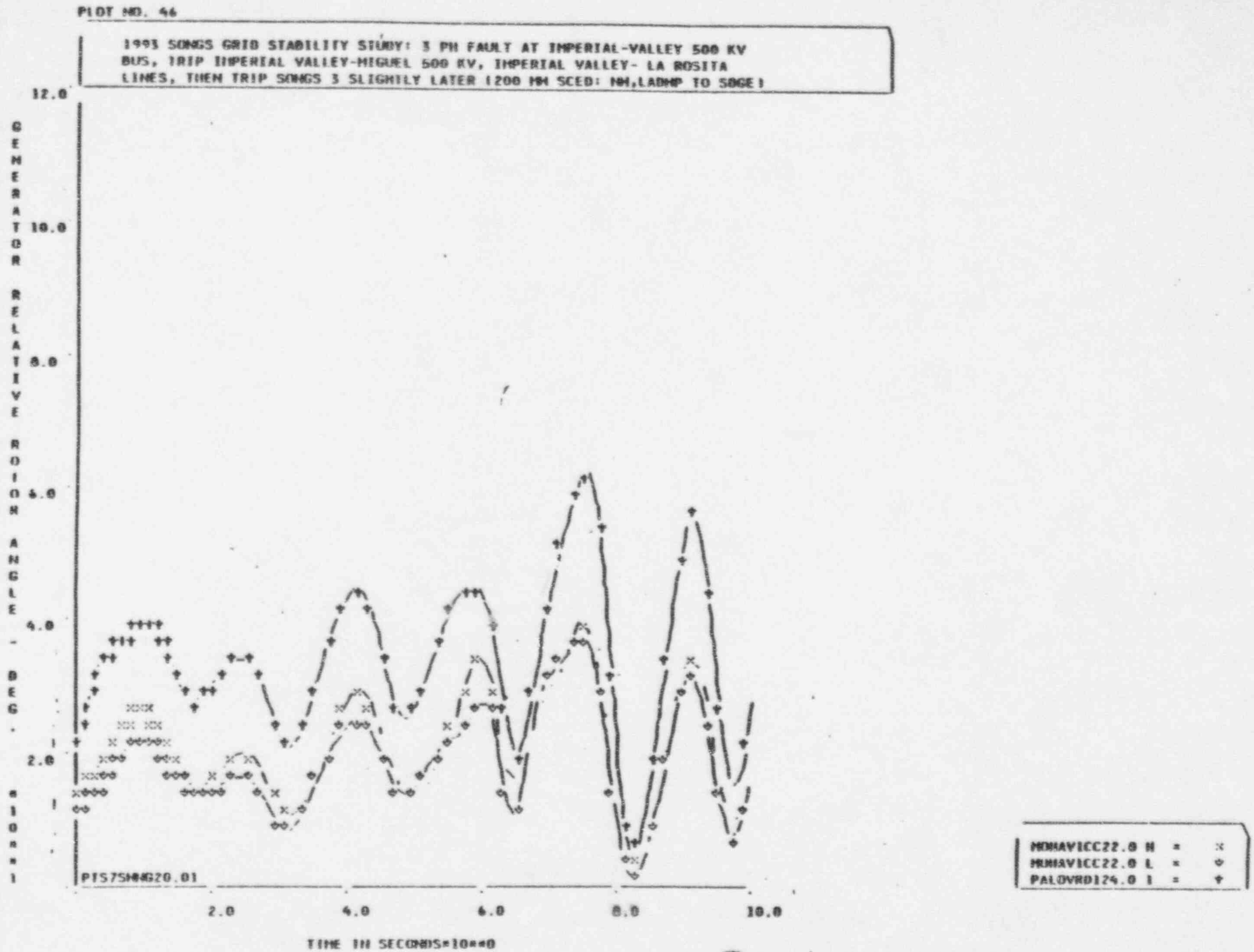
1993 SONGS GRID STABILITY STUDY: 3 PH FAULT AT IMPERIAL-VALLEY 500 KV BUS, TRIP IMPERIAL VALLEY-MIGUEL 500 KV, IMPERIAL VALLEY- LA ROSITA LINES, THEN TRIP SONGS 3 SLIGHTLY LATER (200 MW SCED: NM,LADWP TO SDGE)



PLOT NO. 47

1993 SONGS GRID STABILITY STUDY: 3 PH FAULT AT IMPERIAL-VALLEY 500 KV BUS, TRIP IMPERIAL VALLEY-MIGUEL 500 KV, IMPERIAL VALLEY- LA ROSITA LINES, THEN TRIP SONGS 3 SLIGHTLY LATER (200 MW SCED: NM,LADWP TO SDGE)




PLOT NO. 46
1993 SONGS GRID STABILITY STUDY: 3 PH FAULT AT IMPERIAL-VALLEY 500 KV
BUS, TRIP IMPERIAL VALLEY-MIGUEL 500 KV, IMPERIAL VALLEY- LA ROSITA
LINES, THEN TRIP SONGS 3 SLIGHTLY LATER (200 MW SCED: NM,LADWP TO SDGE)
GENERATOR RELATIVE ROTOR ANGLE - DEG.
12.0
10.0
8.0
6.0
4.0
2.0
PTS7SNNG20.01
2.0
4.0
6.0
8.0
10.0
TIME IN SECONDS*10**0
MOHAVICC22.0 H = x
MOHAVICC22.0 L = ◊
PALOVRD124.0 1 = +

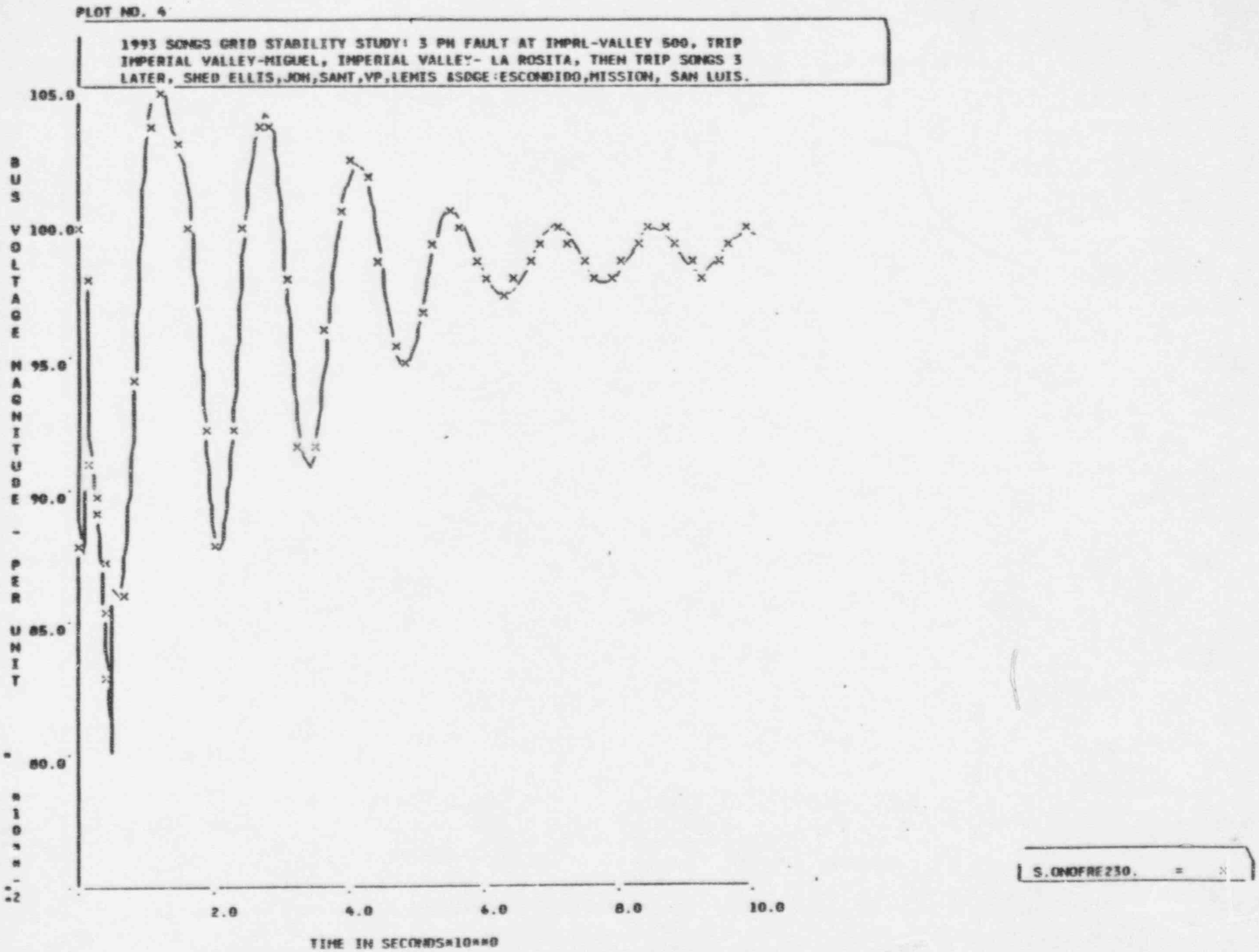
Stability Plots

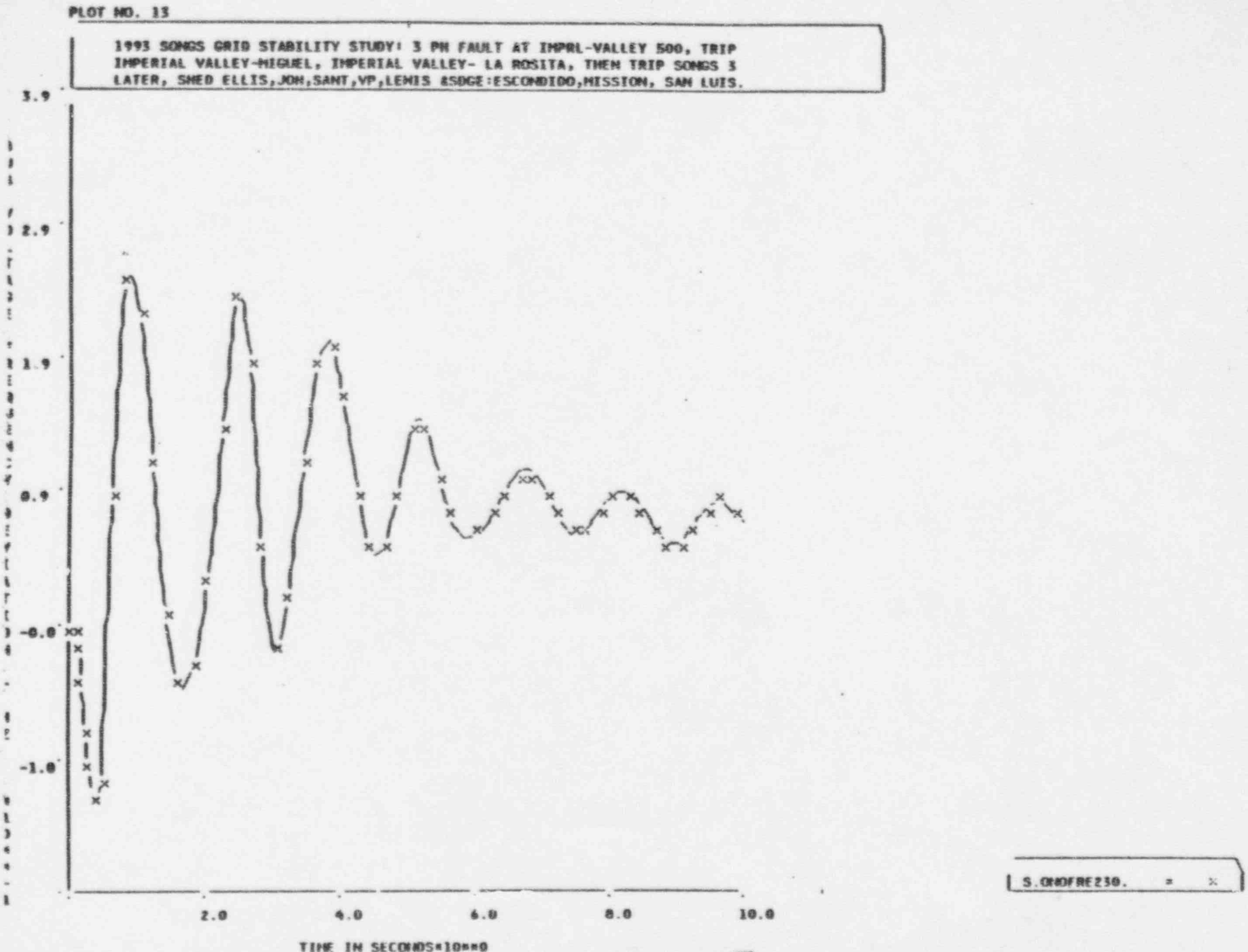
Scenario 4

Case D:

Outage of the Imperial Valley-Miguel 500kV line, Imperial Valley-Rosita 230kV line, and then the remaining SONGS unit trips.

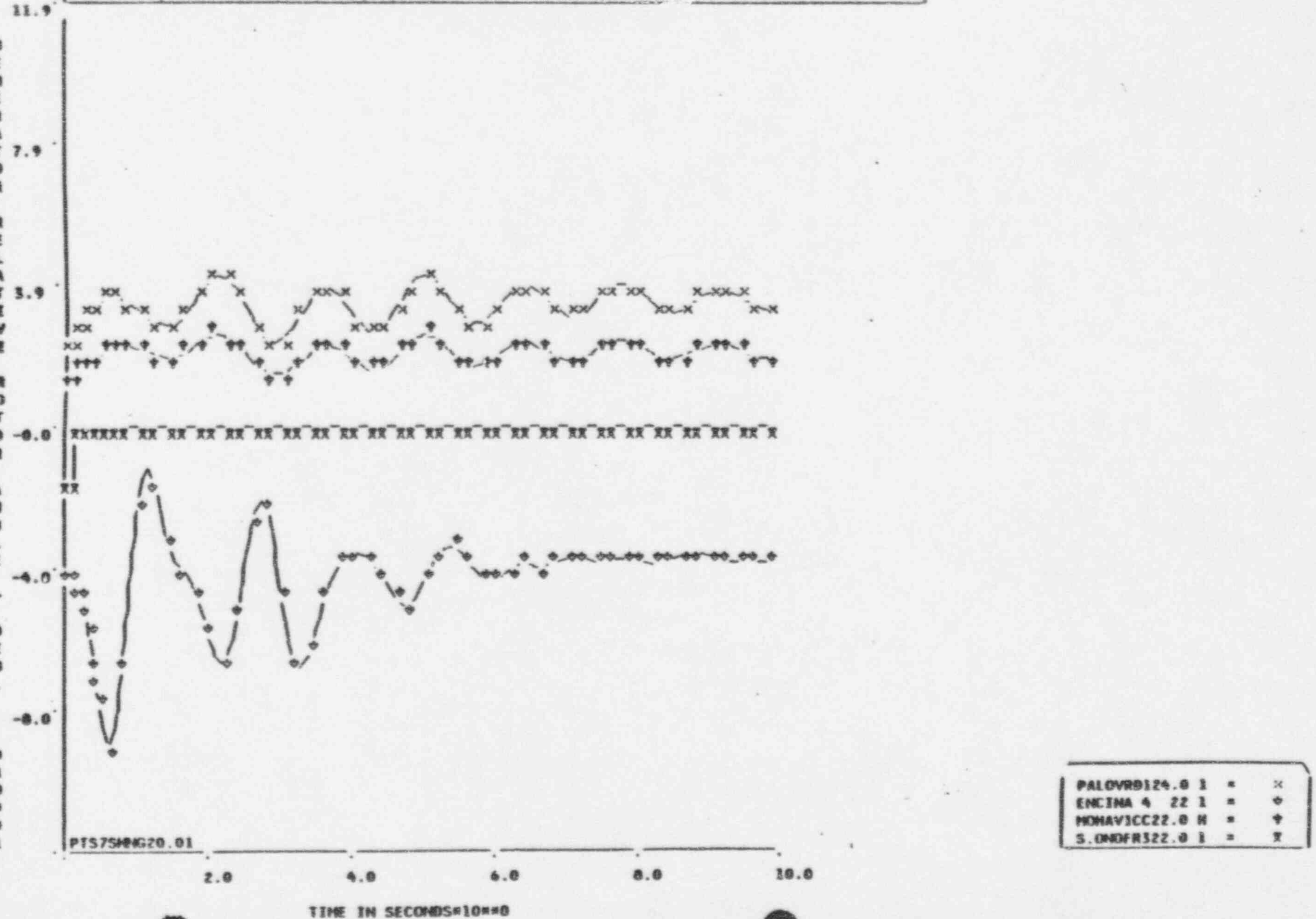
Shed SCE Loads: Ellis, Johanna, Santiago, Villa Park and Lewis *and SDG&E Loads*: Escondido, Mission, San Luis Rey (3500 MW).


PLOT NO. 4
1993 SONGS GRID STABILITY STUDY: 3 PH FAULT AT IMPRL-VALLEY 500, TRIP
IMPERIAL VALLEY-MIGUEL, IMPERIAL VALLEY- LA ROSITA, THEN TRIP SONGS 3
LATER, SHED ELLIS,JOH,SANT,VP,LEWIS &SDGE:ESCONDIDO,MISSION, SAN LUIS.
105.0
100.0
95.0
90.0
85.0
80.0
BUS VOLTAGE MAGNITUDE - PER UNIT
2.0
4.0
6.0
8.0
10.0
TIME IN SECONDS*10**0
S.ONOFRE230. = ×


PLOT NO. 13
1993 SONGS GRID STABILITY STUDY: 3 PH FAULT AT IMPRL-VALLEY 500, TRIP
IMPERIAL VALLEY-MIGUEL, IMPERIAL VALLEY- LA ROSITA, THEN TRIP SONGS 3
LATER, SHED ELLIS,JOH,SANT,VP,LEWIS &SDGE:ESCONDIDO,MISSION, SAN LUIS.
3.9
2.9
1.9
0.9
-0.0
-1.0
2.0
4.0
6.0
8.0
10.0
TIME IN SECONDS*10**0
S.ONOFRE230. = X

PLOT NO. 47

1993 SONGS GRID STABILITY STUDY: 3 PH FAULT AT IMPRL-VALLEY 500, TRIP IMPERIAL VALLEY-MIGUEL, IMPERIAL VALLEY- LA ROSITA, THEN TRIP SONGS 3 LATER, SHED ELLIS,JOH,SANT,VP,LEWIS &SDGE:ESCONDIDO,MISSION- SAN LUIS.



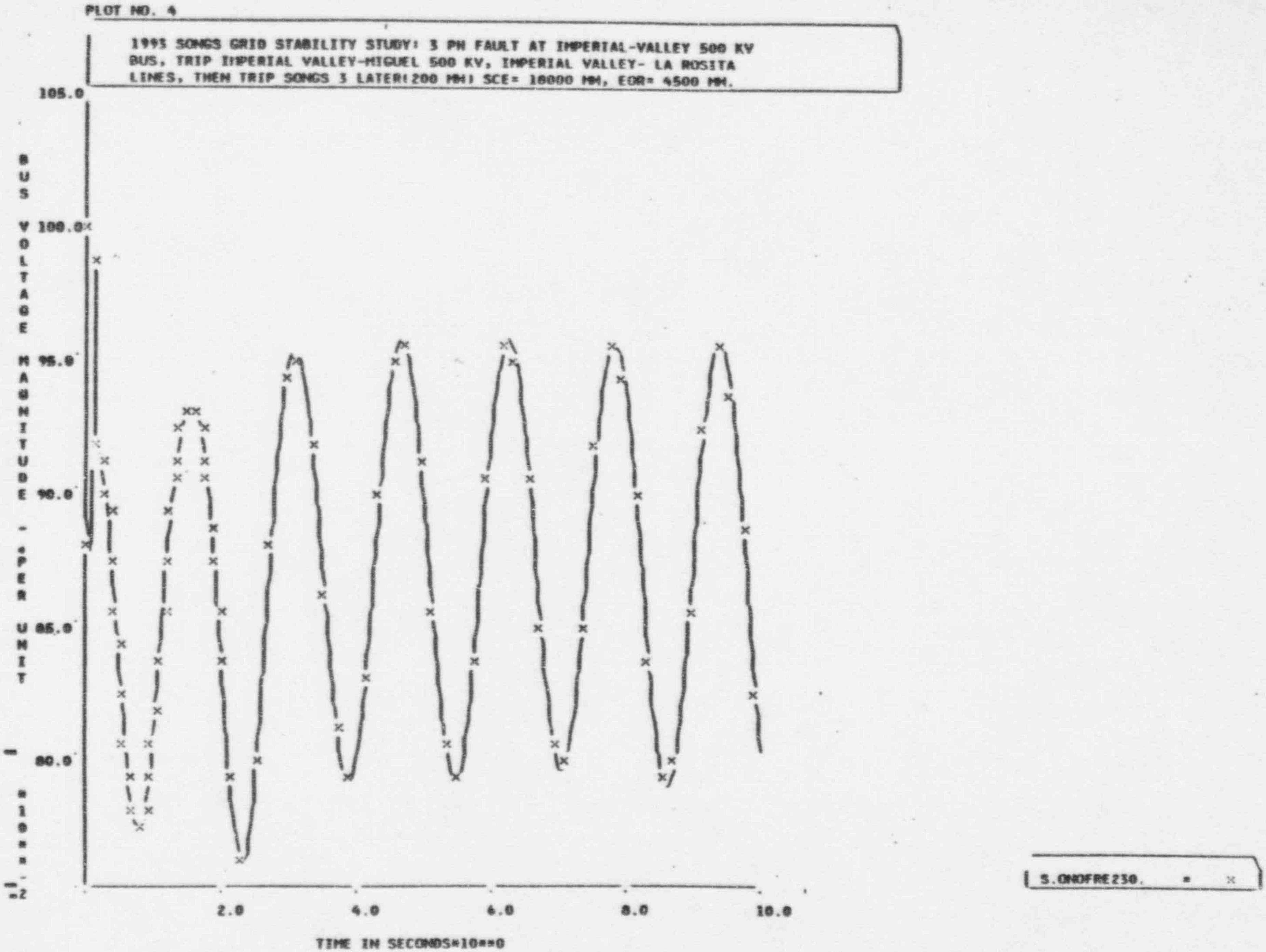
Stability Plots

<u>Scenario 4</u>

Case D:

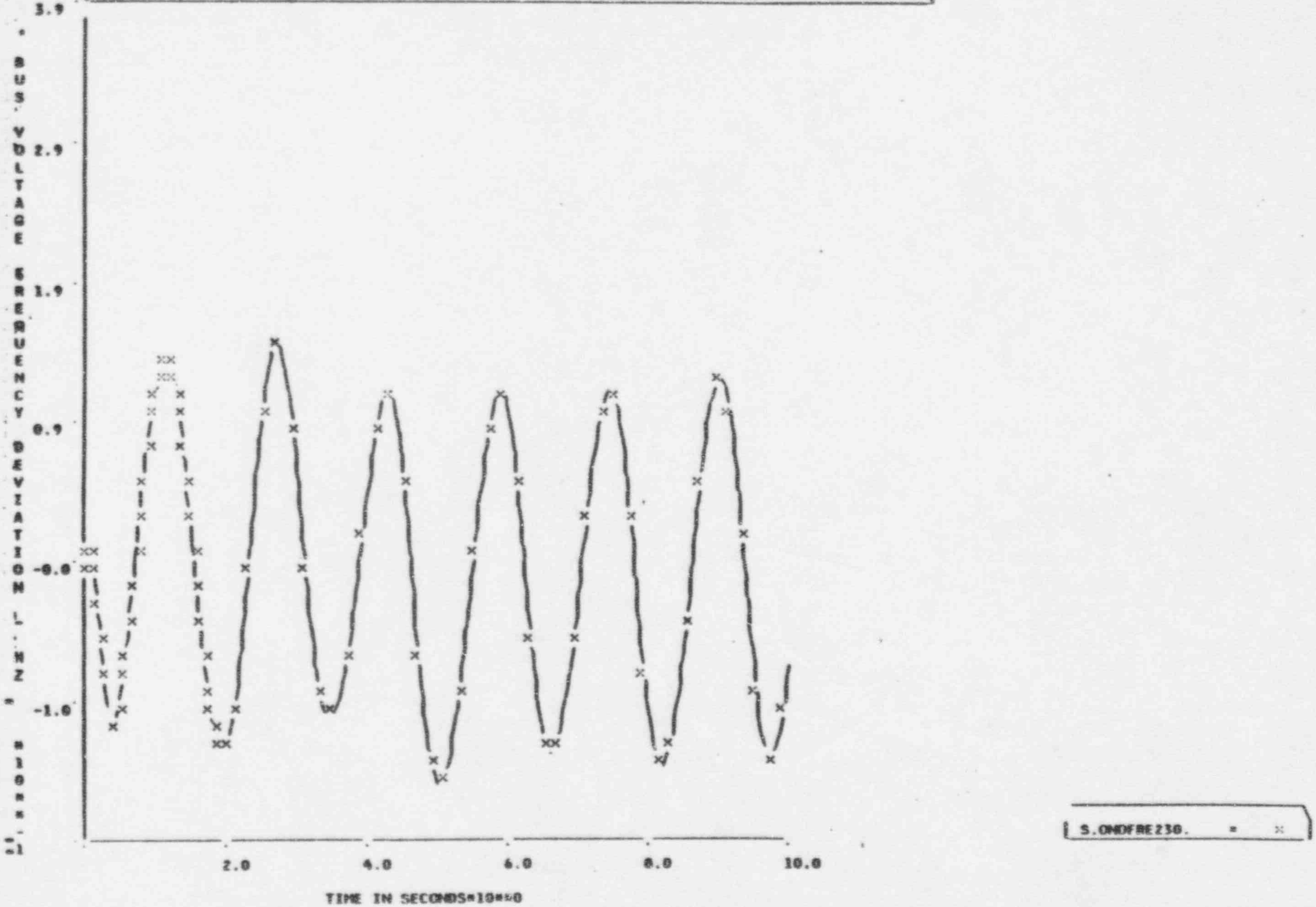
Outage of the Imperial Valley-Miguel 500kV line, Imperial Valley-Rosita 230kV line, and then the remaining SONGS unit trips.

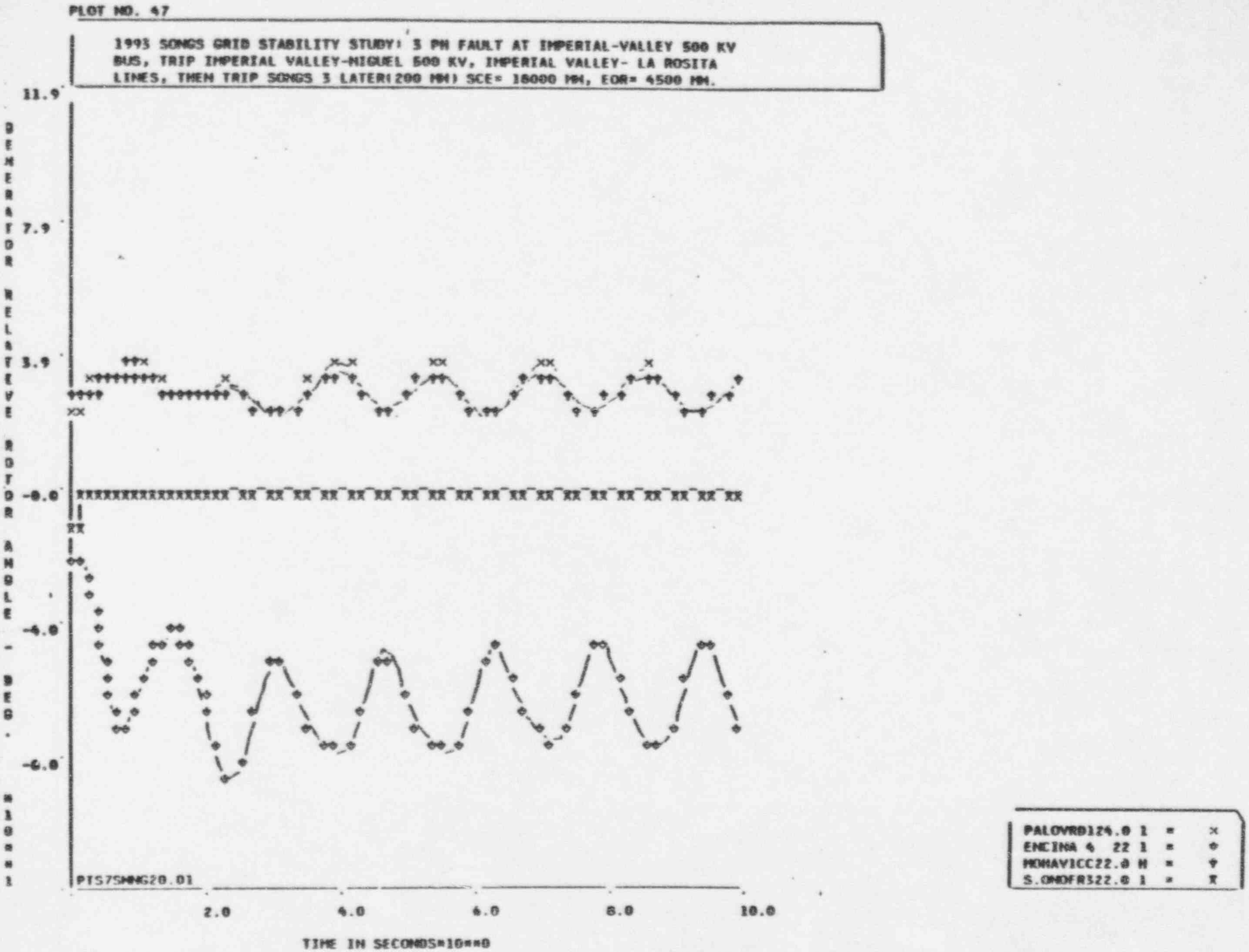
Shed zero load.
EOR Flow = 4500 MW
SCE Load = 18,000 MW


PLOT NO. 4
1995 SONGS GRID STABILITY STUDY: 3 PH FAULT AT IMPERIAL-VALLEY 500 KV
BUS, TRIP IMPERIAL VALLEY-MIGUEL 500 KV, IMPERIAL VALLEY- LA ROSITA
LINES, THEN TRIP SONGS 3 LATER(200 MW) SCE= 10000 MW, EOR= 4500 MW.
105.0
100.0
95.0
90.0
85.0
80.0
BUS VOLTAGE MAGNITUDE - PER UNIT
*10**-2
2.0
4.0
6.0
8.0
10.0
TIME IN SECONDS*10**0
S.ONOFRE230. = x

PLOT NO. 13

1993 SONGS GRID STABILITY STUDY: 3 PH FAULT AT IMPERIAL-VALLEY 500 KV BUS, TRIP IMPERIAL VALLEY-MIGUEL 500 KV, IMPERIAL VALLEY- LA ROSITA LINES, THEN TRIP SONGS 3 LATER(200 MW) SCE= 18000 MW, EOR= 4500 MW.




PLOT NO. 47
1993 SONGS GRID STABILITY STUDY: 3 PH FAULT AT IMPERIAL-VALLEY 500 KV BUS, TRIP IMPERIAL VALLEY-MIGUEL 500 KV, IMPERIAL VALLEY- LA ROSITA LINES, THEN TRIP SONGS 3 LATER(200 MW) SCE= 18000 MW, EOR= 4500 MW.
GENERATOR RELATIVE ROTOR ANGLE - DEG. *10**1
11.9
7.9
3.9
-0.0
-4.0
-6.0
PTS7SWNG20.01
2.0
4.0
6.0
8.0
10.0
TIME IN SECONDS*10**0
PALOVRD124.0 1 = ×
ENCINA 4 22 1 = ◆
MOHAVICC22.0 H = ✝
S.ONOFR322.0 1 = X

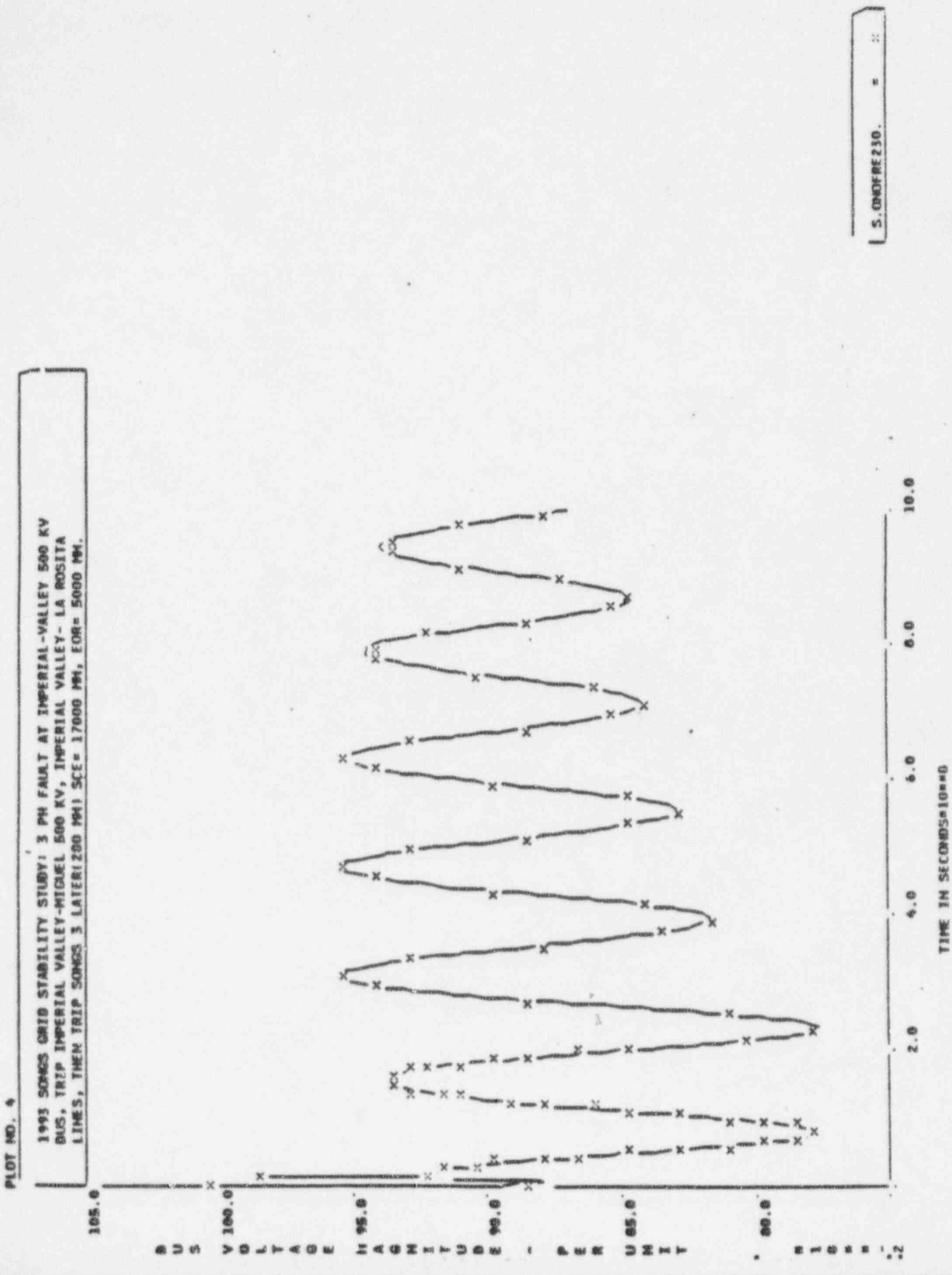
Stability Plots

Scenario 4

Case D:

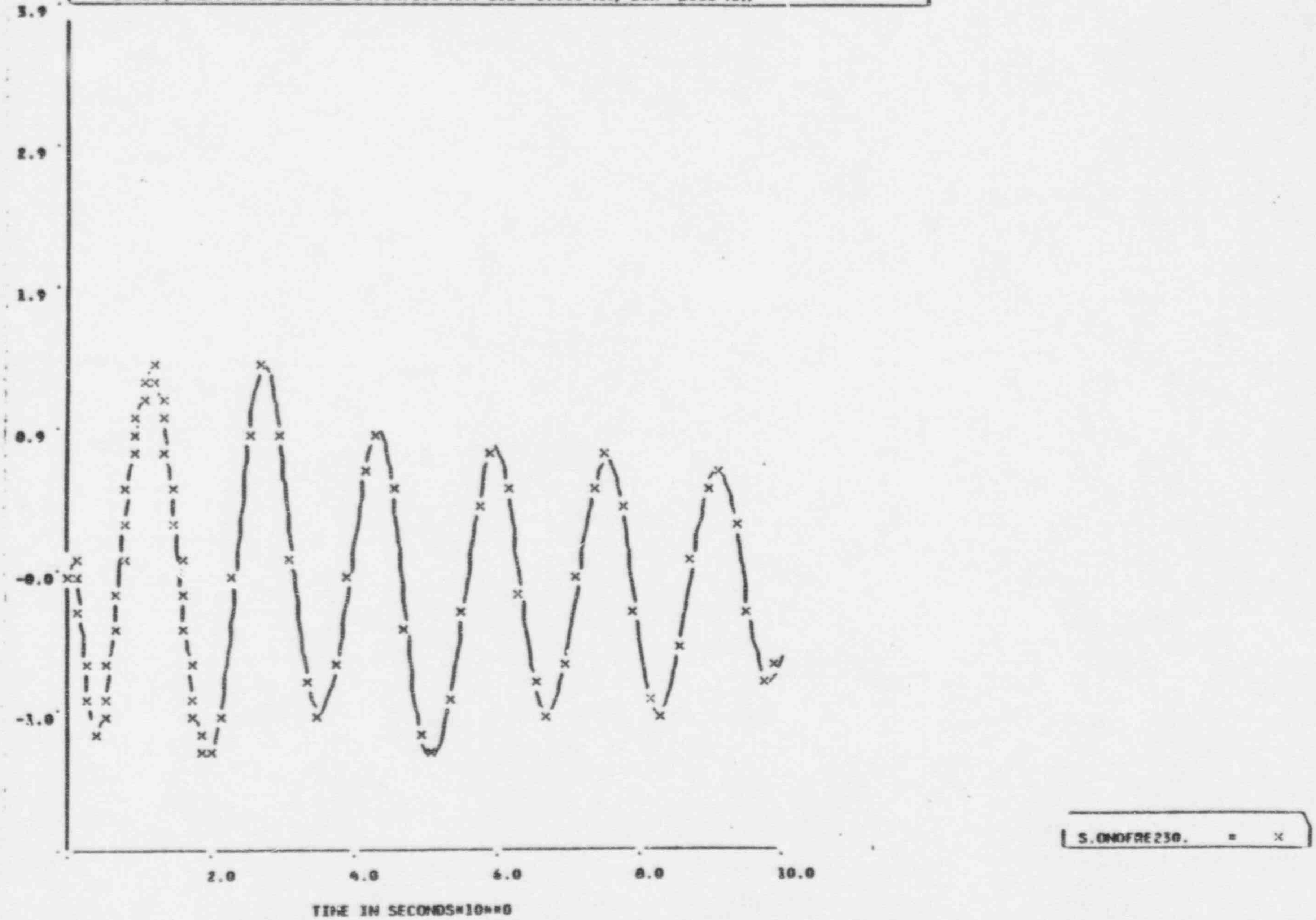
Outage of the Imperial Valley-Miguel 500kV line, Imperial Valley-Rosita 230kV line, and then the remaining SONGS unit trips.

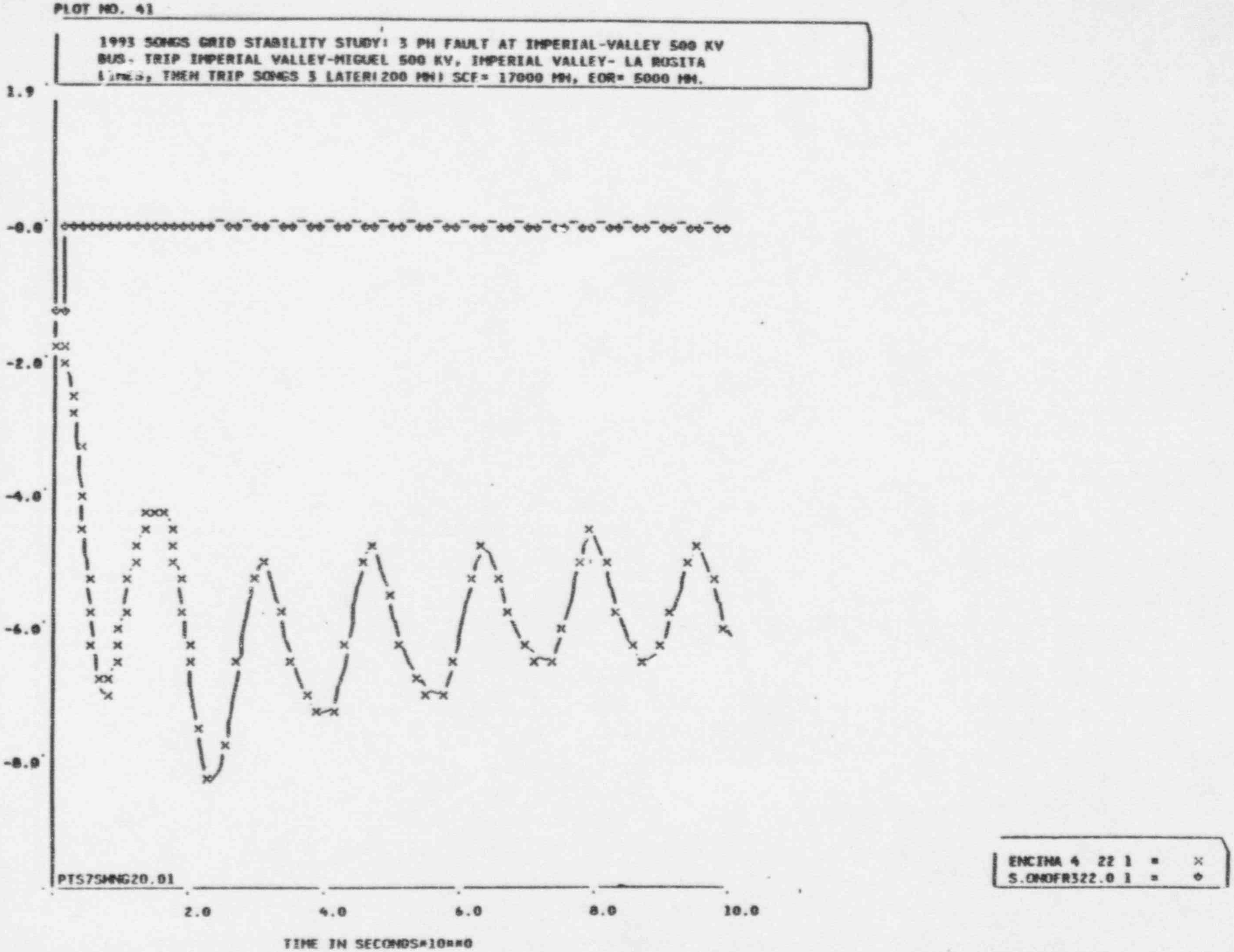
Shed zero load.
EOR Flow = 5000 MW
SCE Load = 17,000 MW


PLOT NO. 4
1993 SONGS GRID STABILITY STUDY: 3 PH FAULT AT IMPERIAL-VALLEY 500 KV
BUS, TRIP IMPERIAL VALLEY-MIGUEL 500 KV, IMPERIAL VALLEY- LA ROSITA
LINES, THEN TRIP SONGS 3 LATER(280 MW) SCE= 17000 MW, EOR= 5000 MW.
S.ONOFRE230. = X
105.0
100.0
95.0
90.0
85.0
80.0
BUS VOLTAGE MAGNITUDE - PER UNIT
2.0
4.0
6.0
8.0
10.0
TIME IN SECONDS*10**0

PLOT NO. 13

1993 SONGS GRID STABILITY STUDY: 3 PH FAULT AT IMPERIAL-VALLEY 500 KV BUS, TRIP IMPERIAL VALLEY-MIGUEL 500 KV, IMPERIAL VALLEY- LA ROSITA LINES, THEN TRIP SONGS 3 LATER(200 MW) SCE= 17000 MW, EOR= 8000 MW.




PLOT NO. 41
1993 SONGS GRID STABILITY STUDY: 3 PH FAULT AT IMPERIAL-VALLEY 500 KV
BUS. TRIP IMPERIAL VALLEY-MIGUEL 500 KV, IMPERIAL VALLEY- LA ROSITA
LINES, THEN TRIP SONGS 3 LATER(200 MW) SCF= 17000 MW, EOR= 5000 MW.
1.9
-0.0
-2.0
-4.0
-6.0
-8.0
GENERATOR RELATIVE ROTOR ANGLE - DEG.
PTS7SWNG20.01
2.0
4.0
6.0
8.0
10.0
TIME IN SECONDS*10**0
ENCINA 4 22 1 = x
S.ONOFR322.0 1 = ◊

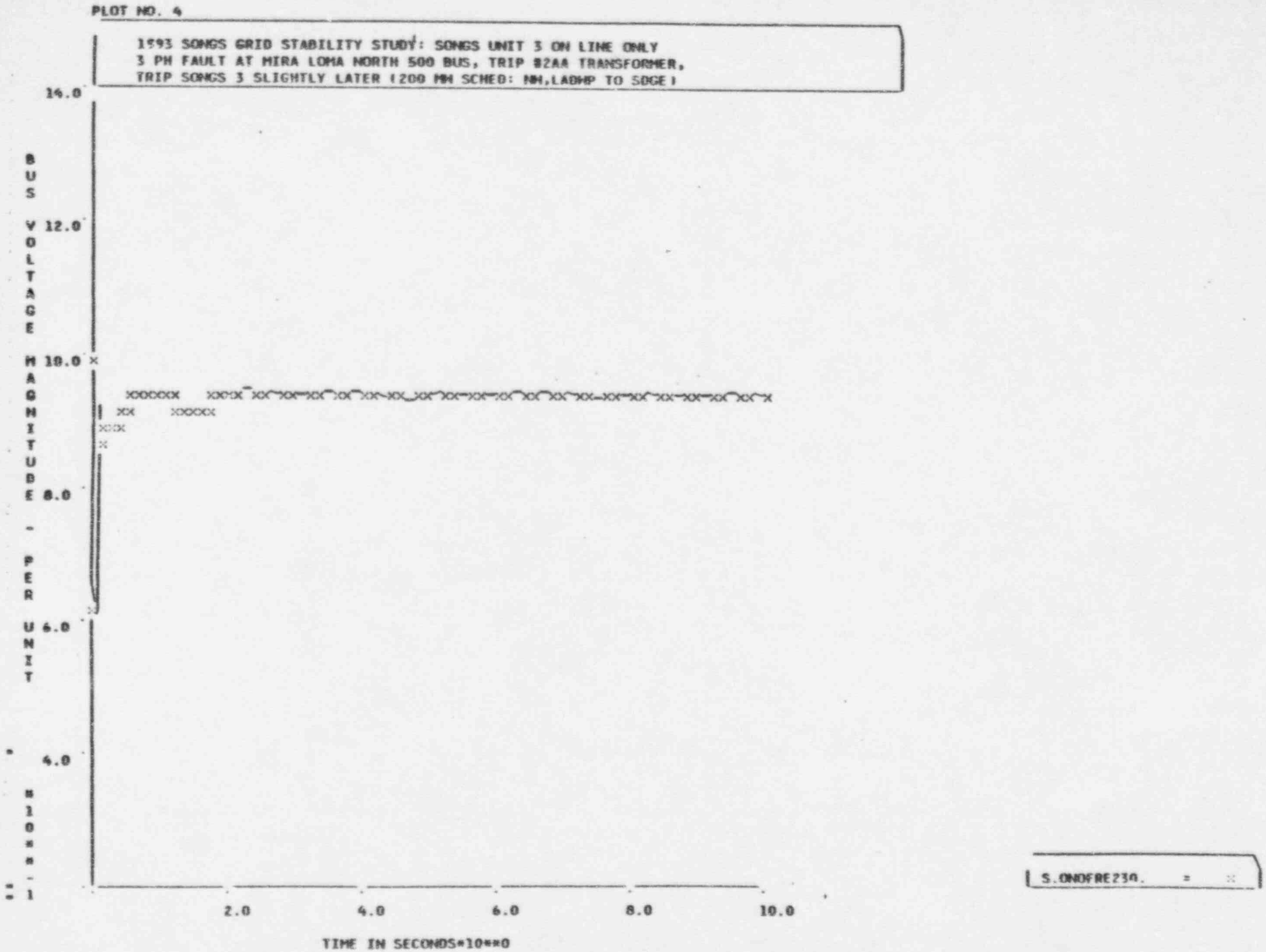
Stability Plots

Scenario 4

Case E:

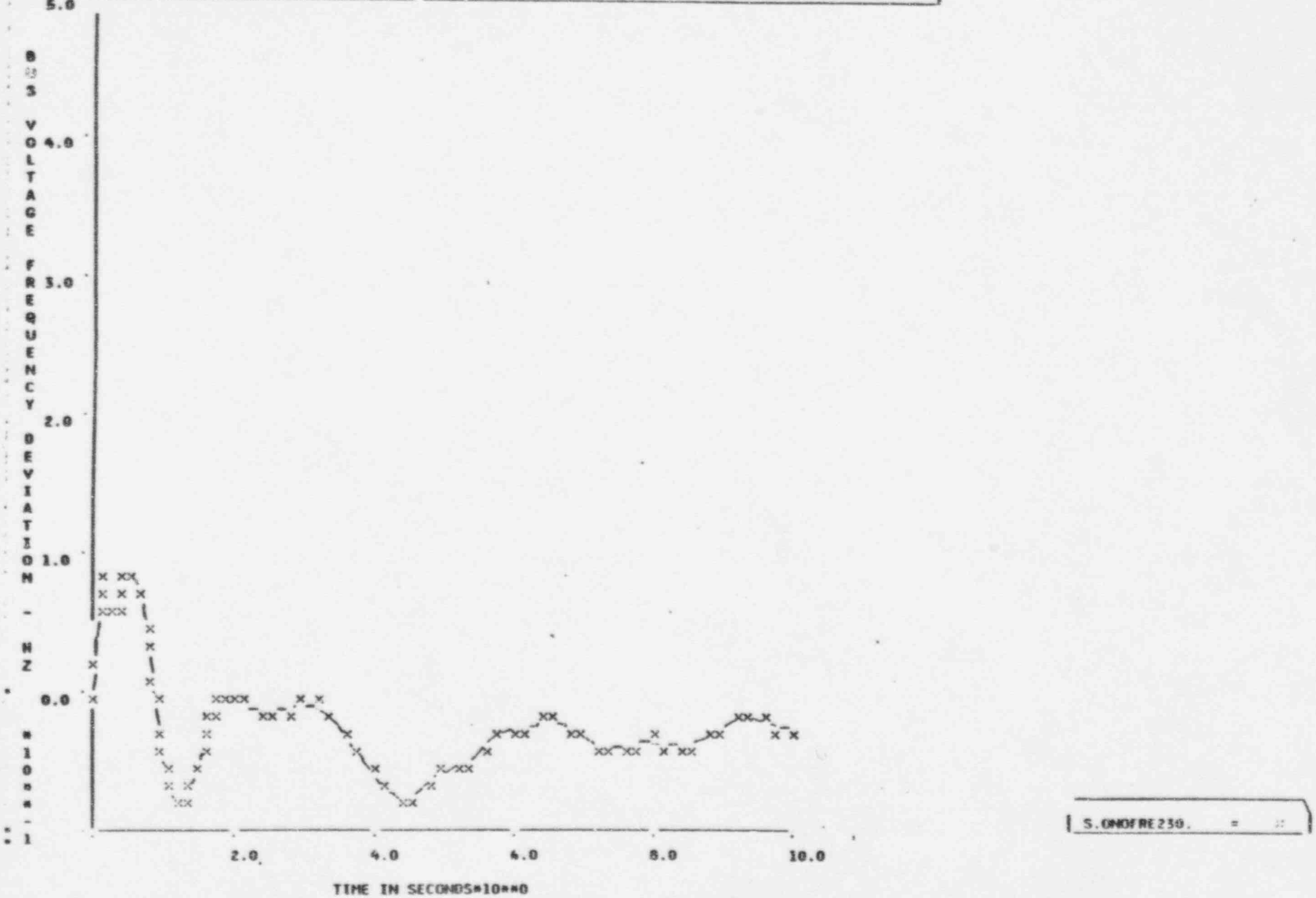
Outage of the Mira Loma 500kV north bus, No. 2AA transformer, and then the remaining SONGS unit trips.

Shed Zero load.


PLOT NO. 4
1593 SONGS GRID STABILITY STUDY: SONGS UNIT 3 ON LINE ONLY
3 PH FAULT AT MIRA LOMA NORTH 500 BUS, TRIP #2AA TRANSFORMER,
TRIP SONGS 3 SLIGHTLY LATER (200 MW SCHED: NW,LADWP TO SDGE)
BUS VOLTAGE MAGNITUDE - PER UNIT * 10**-1
14.0
12.0
10.0
8.0
6.0
4.0
2.0
4.0
6.0
8.0
10.0
TIME IN SECONDS*10**0
S.ONOFRE230. = x

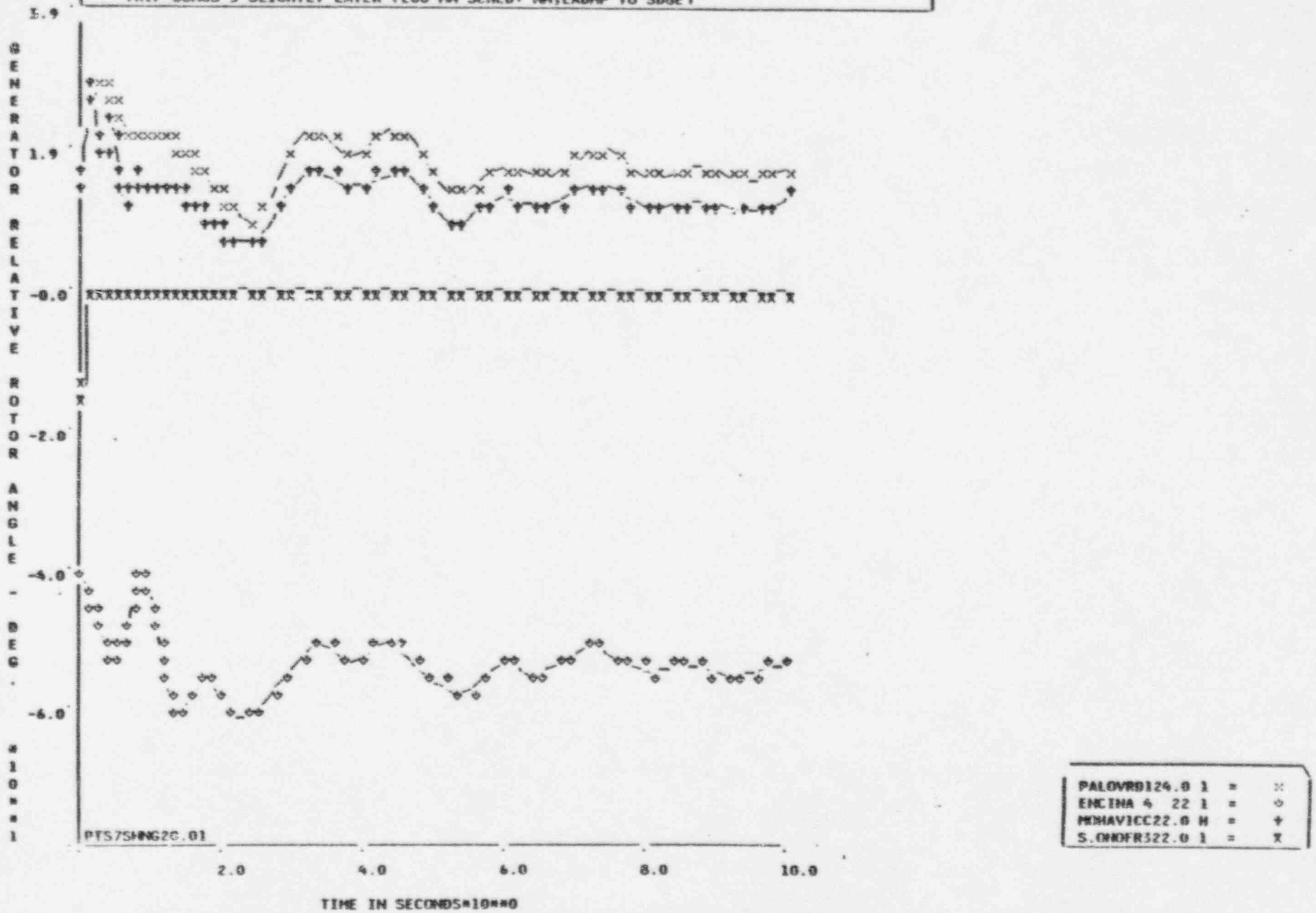
PLOT NO. 13

1993 SONGS GRID STABILITY STUDY: SONGS UNIT 3 ON LINE ONLY
3 PH FAULT AT MIRA LOMA NORTH 500 BUS, TRIP #2AA TRANSFORMER,
TRIP SONGS 3 SLIGHTLY LATER (200 MW SCHED: NM,LADWP TO SDGE)



PLOT NO. 47

1993 SONGS GRID STABILITY STUDY: SONGS UNIT 3 ON LINE ONLY
3 PH FAULT AT MIRA LOMA NORTH 500 BUS, TRIP 82AA TRANSFORMER,
TRIP SONGS 3 SLIGHTLY LATER (200 MW SCHED: NW,LADWP TO SDGE)



Stability Plots

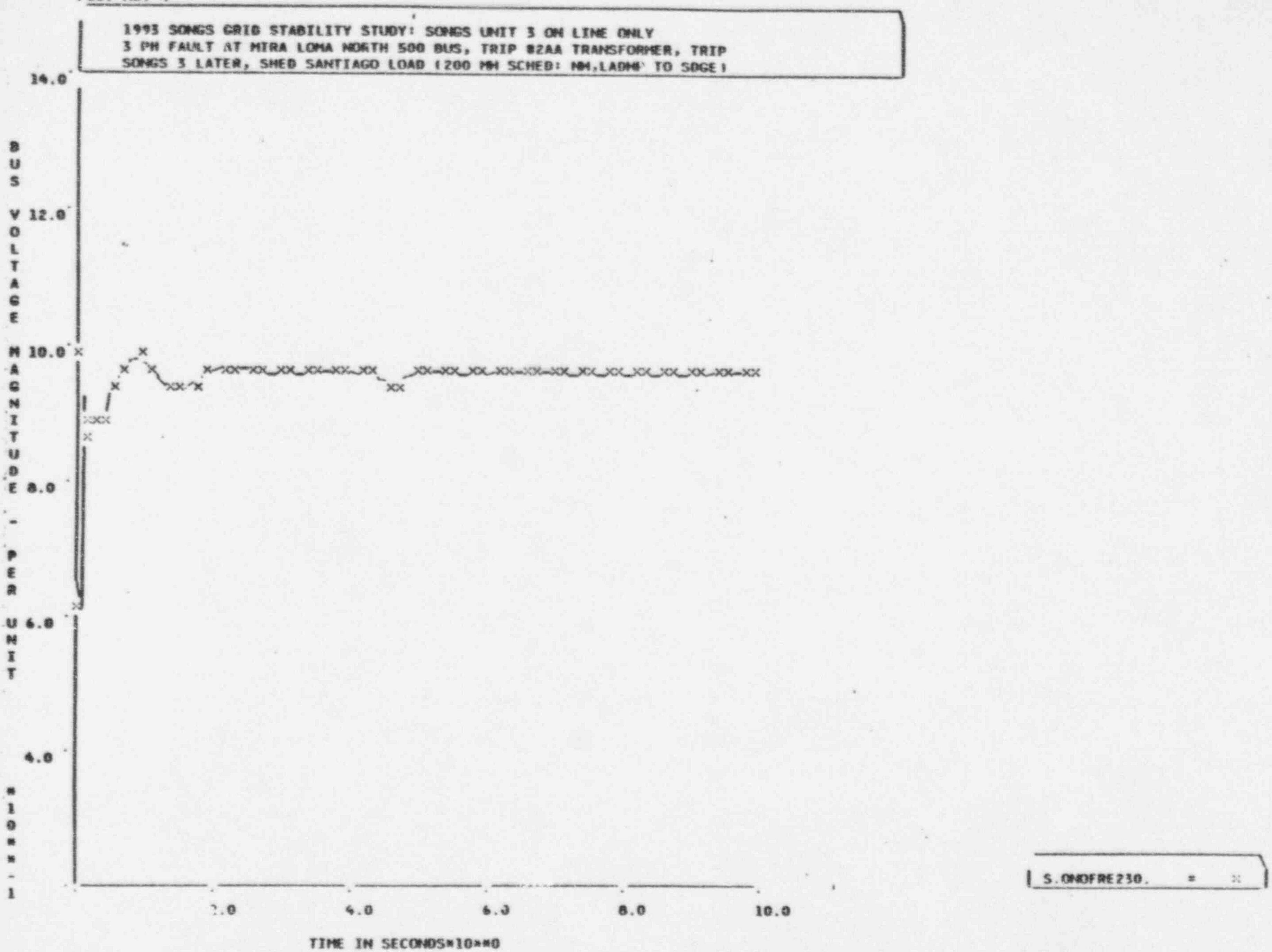
Scenario 4

Case E:

Outage of the Mira Loma 500kV north bus, No. 2AA transformer, and then the remaining SONGS unit trips.

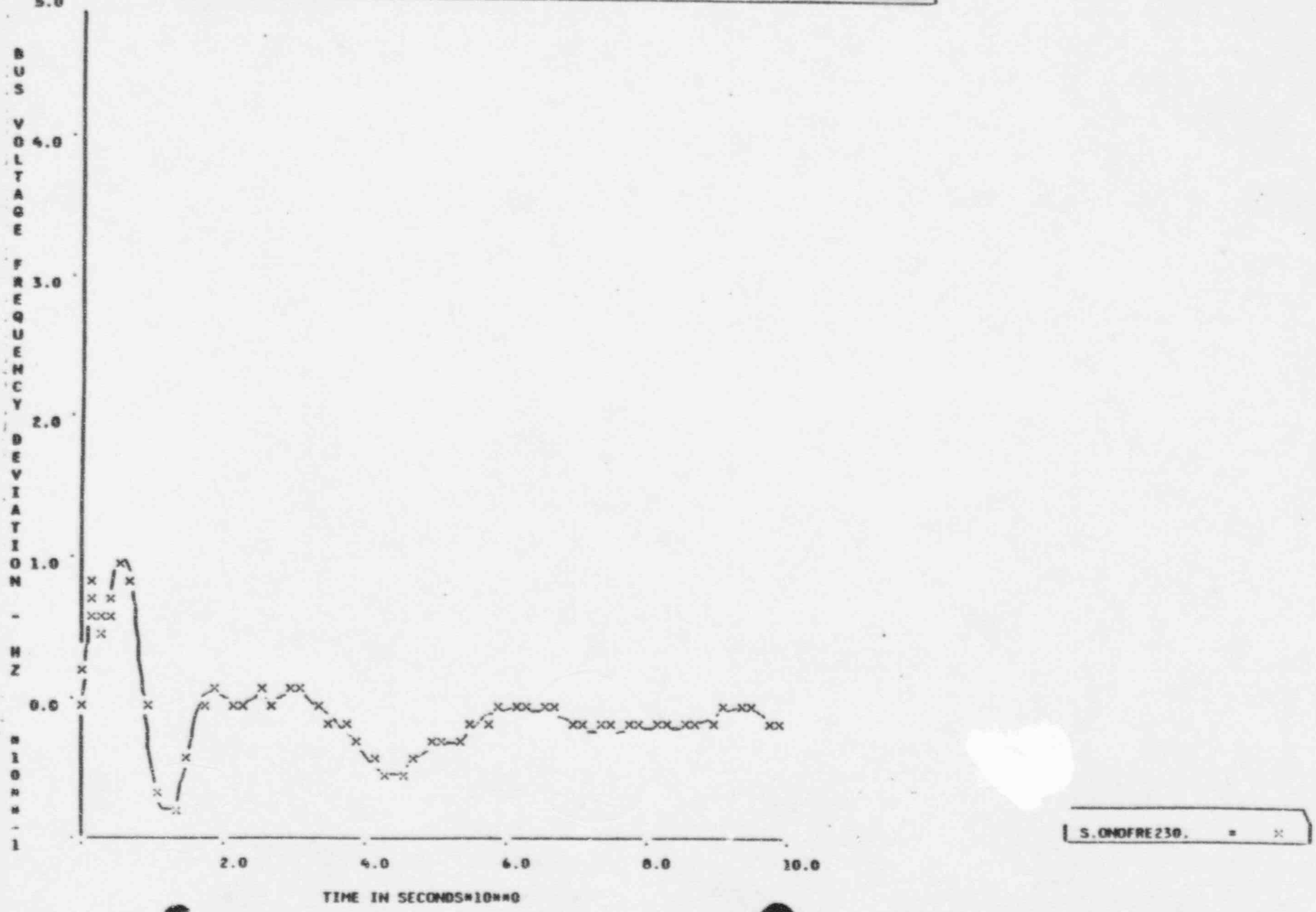
Shed Santiago load (540 MW).

PLOT NO. 4

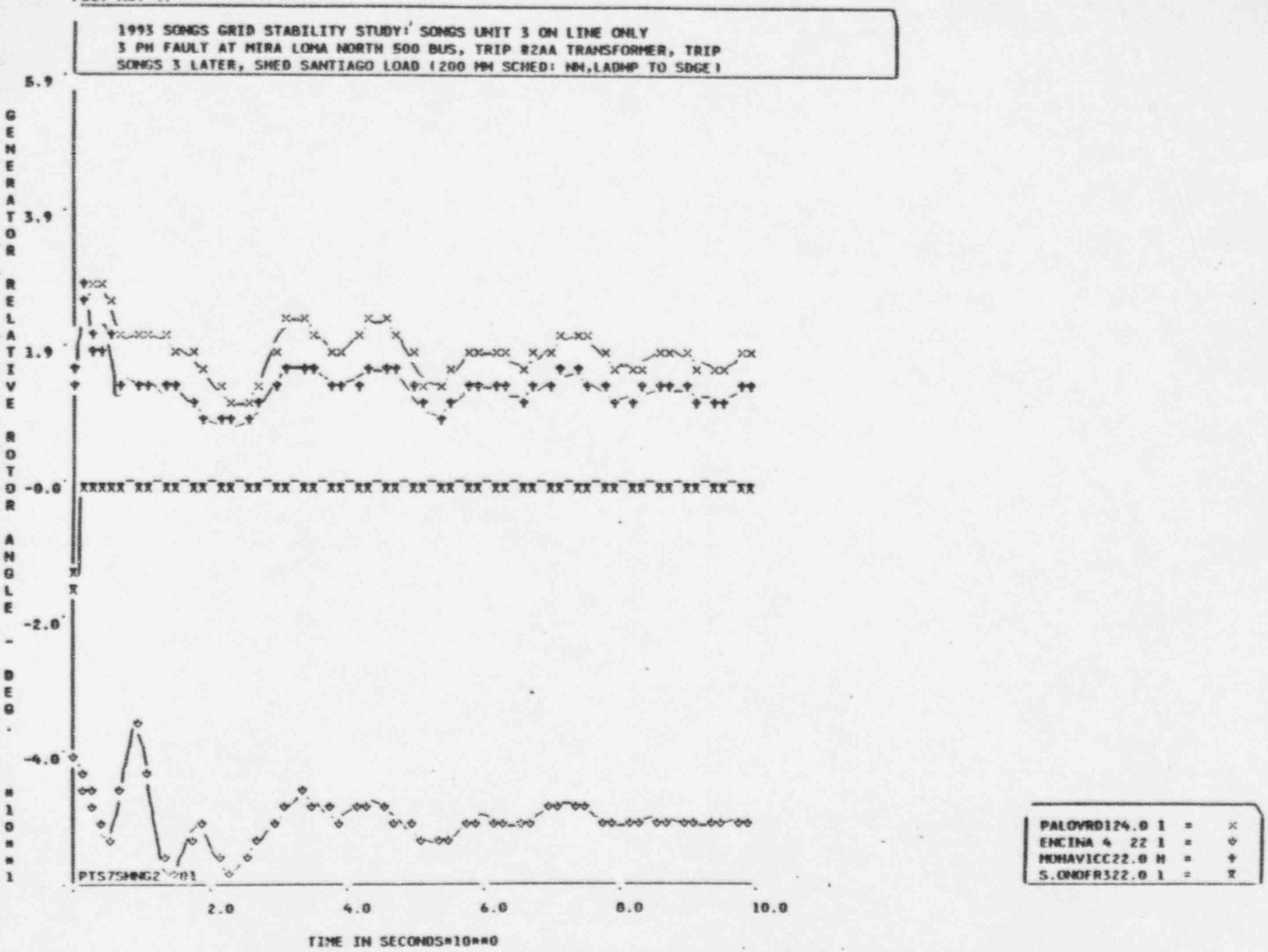

1993 SONGS GRID STABILITY STUDY: SONGS UNIT 3 ON LINE ONLY
3 PH FAULT AT MIRA LOMA NORTH 500 BUS, TRIP #2AA TRANSFORMER, TRIP
SONGS 3 LATER, SHED SANTIAGO LOAD (200 MW SCHED: NW,LADWP TO SDGE)
BUS VOLTAGE MAGNITUDE - PER UNIT *10**-1
14.0
12.0
10.0
8.0
6.0
4.0
2.0
4.0
6.0
8.0
10.0
TIME IN SECONDS*10**0
S.ONOFRE230. = x

PLOT NO. 13

1993 SONGS GRID STABILITY STUDY: SONGS UNIT 3 ON LINE ONLY
3 PH FAULT AT MIRA LOMA NORTH 500 BUS, TRIP 82AA TRANSFORMER, TRIP
SONGS 3 LATER, SHED SANTIAGO LOAD (200 MW SCHED: NM,LADWP TO SDGE)



PLOT NO. 47



1993 SONGS GRID STABILITY STUDY: SONGS UNIT 3 ON LINE ONLY
3 PH FAULT AT MIRA LOMA NORTH 500 BUS, TRIP #2AA TRANSFORMER, TRIP
SONGS 3 LATER, SHED SANTIAGO LOAD (200 MW SCHED: NM,LADWP TO SDGE)
5.9
3.9
1.9
-0.0
-2.0
-4.0
GENERATOR RELATIVE ROTOR ANGLE - DEG. *10**1
PTS7SHNG2 201
2.0
4.0
6.0
8.0
10.0
TIME IN SECONDS*10**0
PALOVRD124.0 1 = X
ENCINA 4 22 1 = ◇
MOHAVICC22.0 H = +
S.ONOFR322.0 1 = Ж

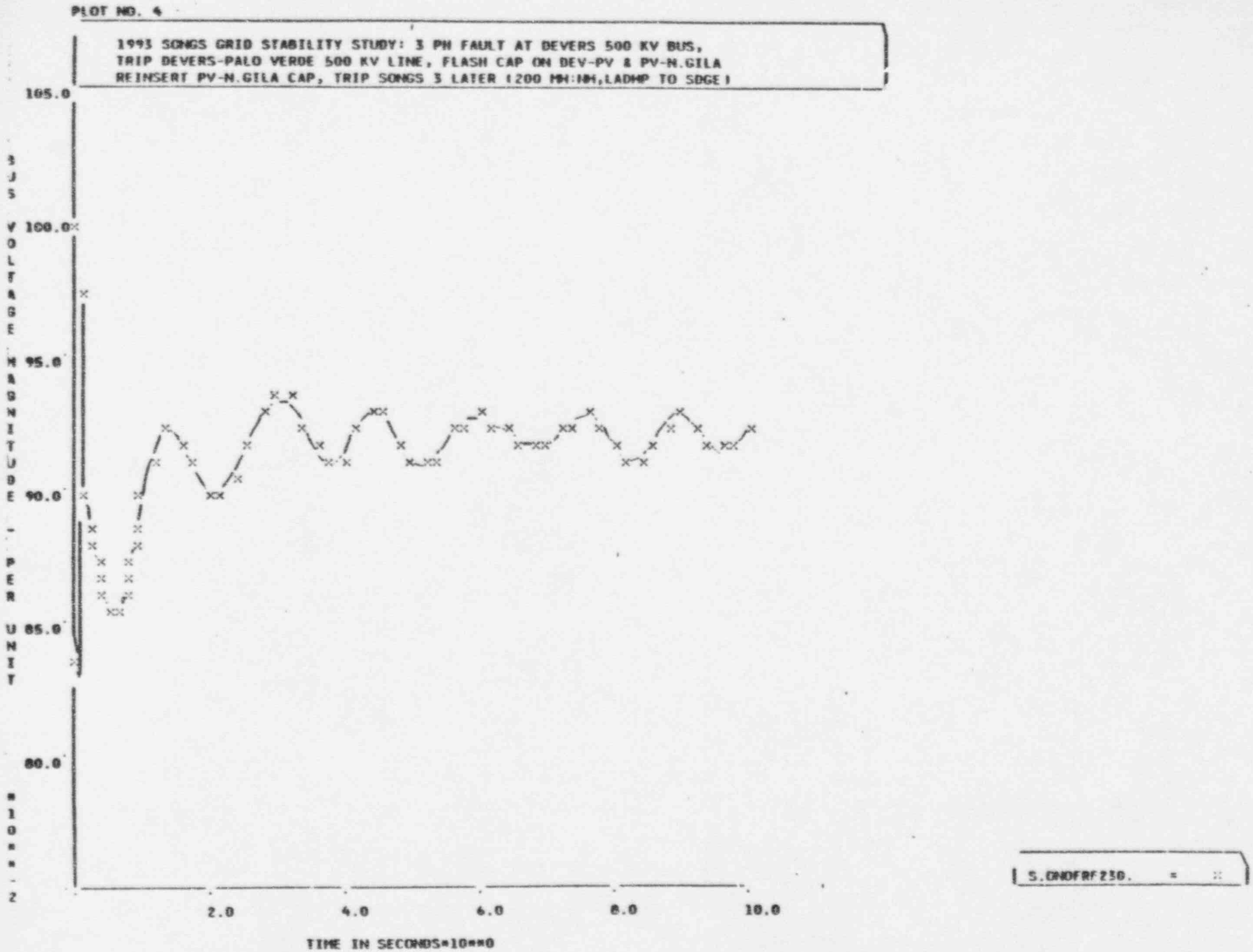
Stability Plots

<u>Scenario 4</u>

***Case F*:**

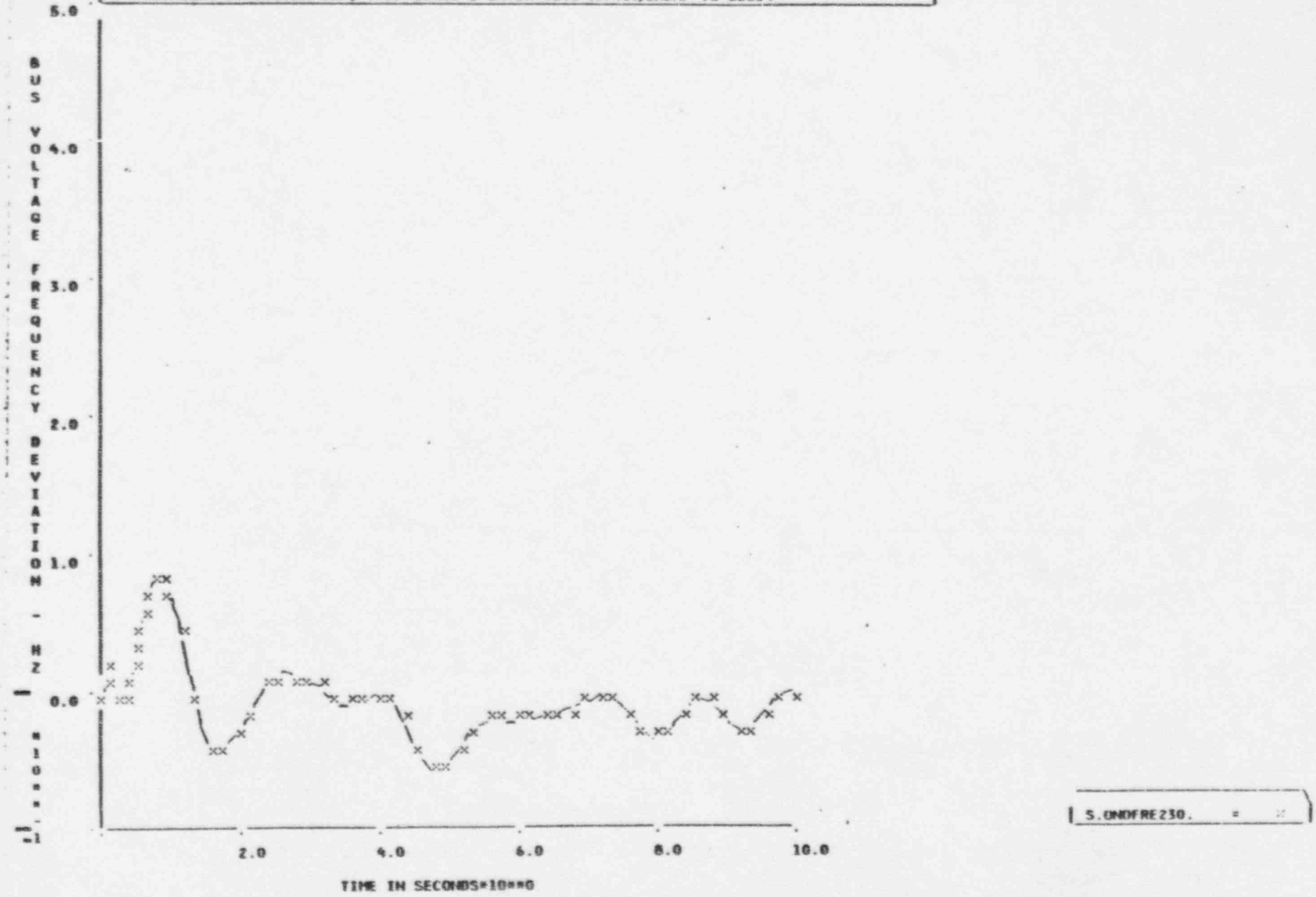
Outage of the Palo Verde-Devers 500kV line, and then the remaining SONGS unit trips.

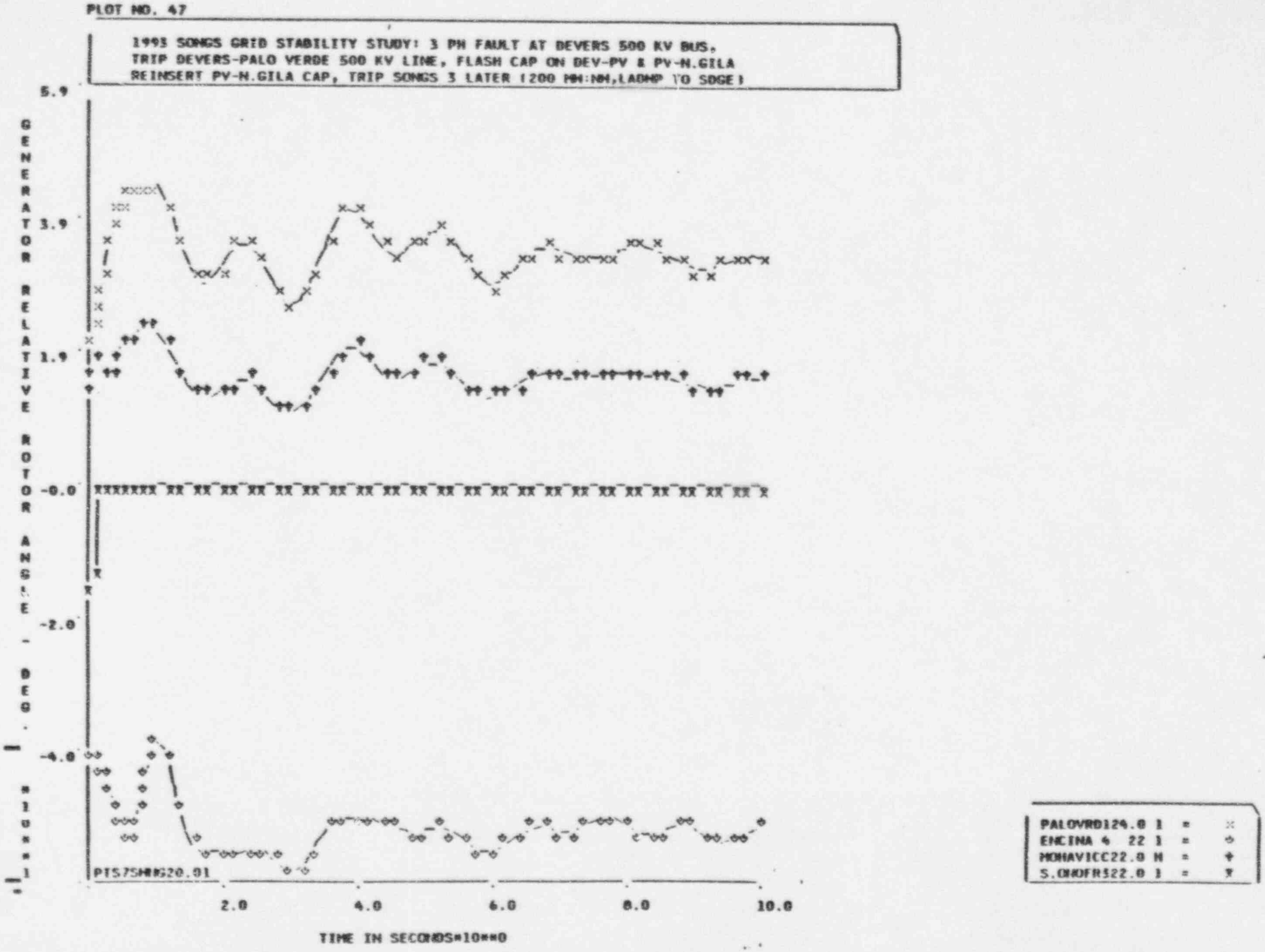
Shed zero load.


PLOT NO. 4
1993 SONGS GRID STABILITY STUDY: 3 PH FAULT AT DEVERS 500 KV BUS,
TRIP DEVERS-PALO VERDE 500 KV LINE, FLASH CAP ON DEV-PV & PV-N.GILA
REINSERT PV-N.GILA CAP, TRIP SONGS 3 LATER (200 MH:MH,LADWP TO SDGE)
105.0
100.0
95.0
90.0
85.0
80.0
BUS VOLTAGE MAGNITUDE - PER UNIT *10** -2
2.0
4.0
6.0
8.0
10.0
TIME IN SECONDS*10**0
S.ONOFRF230. = ×

PLOT NO. 13

1993 SONGS GRID STABILITY STUDY: 3 PH FAULT AT DEVERS 500 KV BUS,
TRIP DEVERS-PALO VERDE 500 KV LINE, FLASH CAP ON DEV-PV & PV-N.GILA
REINSERT PV-N.GILA CAP, TRIP SONGS 3 LATER (200 MW:MW,LADWP TO SDGE)




PLOT NO. 47
1993 SONGS GRID STABILITY STUDY: 3 PH FAULT AT DEVERS 500 KV BUS,
TRIP DEVERS-PALO VERDE 500 KV LINE, FLASH CAP ON DEV-PV & PV-N.GILA
REINSERT PV-N.GILA CAP, TRIP SONGS 3 LATER (200 MW:MH,LADWP TO SDGE)
GENERATOR RELATIVE ROTOR ANGLE - DEG.
5.9
3.9
1.9
-0.0
-2.0
-4.0
PTS7SMHG20.01
2.0
4.0
6.0
8.0
10.0
TIME IN SECONDS*10**0
PALOVRD124.0 1 = x
ENCINA 4 22 1 = ◊
MOHAVICC22.0 M = +
S.ONOFR322.0 3 = ¥

Stability Plots

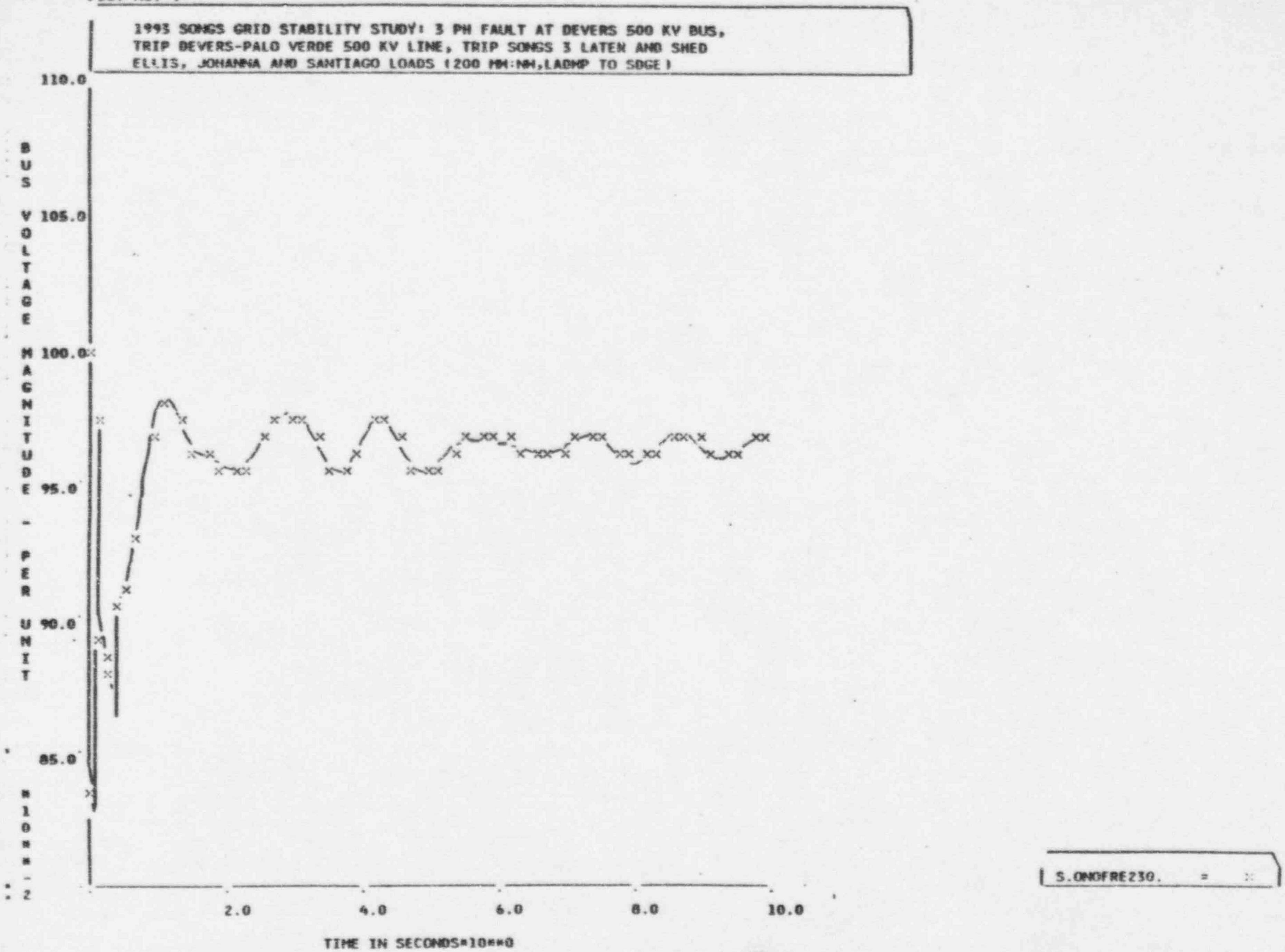
<u>Scenario 4</u>

Case F:

Outage of the Palo Verde-Devers 500kV line, and then the remaining SONGS unit trips.

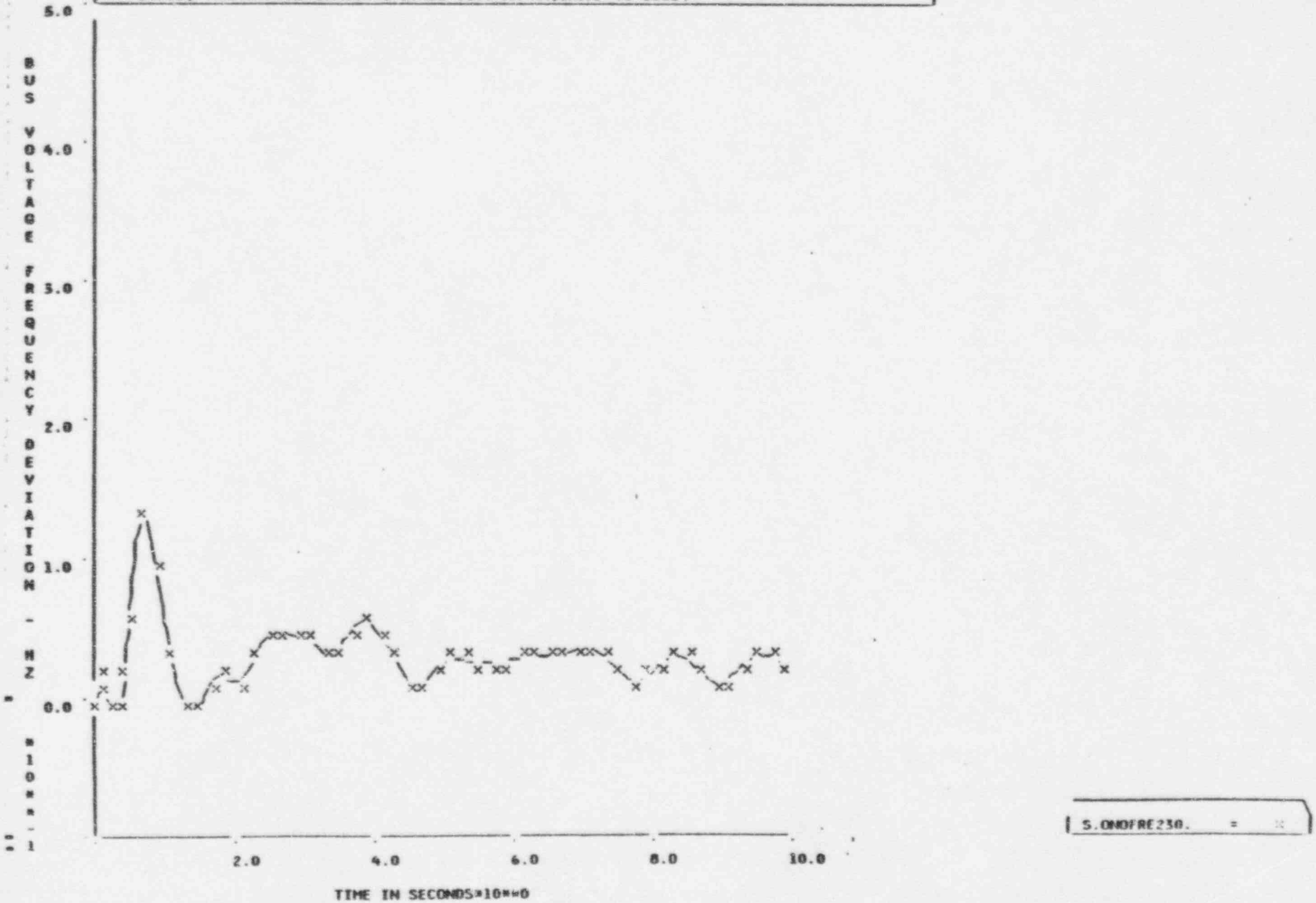
Shed Ellis, Johanna and Santiago loads (1530 MW).

PLOT NO. 4


1993 SONGS GRID STABILITY STUDY: 3 PH FAULT AT DEVERS 500 KV BUS,
TRIP DEVERS-PALO VERDE 500 KV LINE, TRIP SONGS 3 LATER AND SHED
ELLIS, JOHANNA AND SANTIAGO LOADS (200 MW:NW,LADWP TO SDGE)
110.0
105.0
100.0
95.0
90.0
85.0
BUS VOLTAGE MAGNITUDE - PER UNIT
*10**-2
2.0
4.0
6.0
8.0
10.0
TIME IN SECONDS*10**0
S.ONOFRE230. = x

PLOT NO. 13

1993 SONGS GRID STABILITY STUDY: 3 PH FAULT AT DEVERS 500 KV BUS,
TRIP DEVERS-PALO VERDE 500 KV LINE, TRIP SONGS 3 LATER AND SHED
ELLIS, JOHANNA AND SANTIAGO LOADS (200 MW:MW,LADWP TO SDGE)



November 2, 1993

B. CARLISLE

SUBJECT: ***ECC Operating Procedure: Mira Loma 500kV North Bus Outage (Scenario 4E)***

This letter is in response to your recent inquiry concerning the absence of the Mira Loma 500kV North Bus outage in the ECC operating procedure.

A SONGS Grid Stability and Voltage Study was issued on August 9, 1993 which covered the study results of several SONGS scenarios (Scenarios 1-4) which could lead to inadequate voltage at SONGS. Using these study results, an ECC operating procedure was issued on June 15, 1993 and was designed to monitor system conditions which could lead to inadequate voltage at SONGS. The ECC procedure did not include the Mira Loma 500kV North Bus outage. This outage would result in 216.6kV bus voltage at SONGS only if the SCE area load exceeds 16,600 MW. It was felt that the probability of reaching this high SCE area threshold (probability of load exceeding 16,600 MW = .005) was very low. (The 1993 annual peak load was 16,475 MW.) Furthermore, historical data showed no records of forced outages of 500kV buses other than those due to severe earthquakes.

Since that study, both System Operation and Planning have agreed to adopt a 25/1 watt/var ratio for <u>all</u> SCE substations modeled in load flows. A sensitivity study with a 25/1 watt/var ratio was made of the Mira Loma 500kV North Bus outage, and the SONGS voltage improved to 218.1kV. The earlier study used a 20/1 watt/var ratio for most substations, with some substations as low as 6/1. Due to the latest studies, there is no need to include the Mira Loma 500kV bus outage in the ECC procedure.

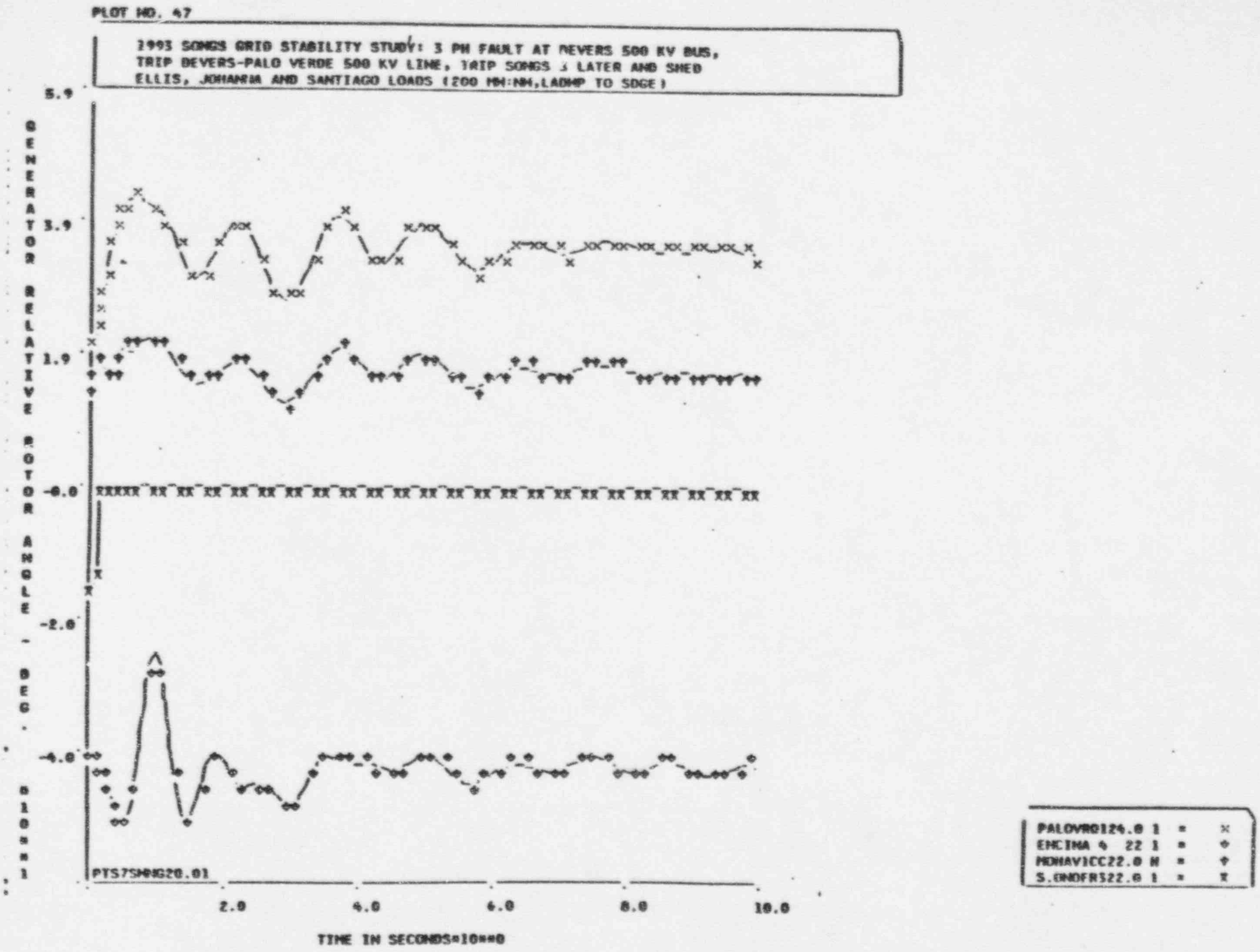
If you have any further questions concerning this matter, please call me at PAX 2-1671.

W. D. Conner

W. D. CONNER

cc: R. F. Barreno
M. D. Lopez
D. Stickney

WDC1101.DOC/pw


PLOT NO. 47
1993 SONGS GRID STABILITY STUDY: 3 PH FAULT AT DEVERS 500 KV BUS,
TRIP DEVERS-PALO VERDE 500 KV LINE, TRIP SONGS 3 LATER AND SHED
ELLIS, JOHANNA AND SANTIAGO LOADS (200 MW:MW,LADWP TO SDGE)
GENERATOR RELATIVE ROTOR ANGLE - DEG.
5.9
3.9
1.9
-0.0
-2.0
-4.0
PTS7SMNG20.01
2.0
4.0
6.0
8.0
10.0
TIME IN SECONDS*10**0
PALOVRD124.0 1 = X
ENCINA 4 22 1 = ◆
MOHAVICC22.0 N = ✝
S.ONOFRS22.0 1 = ⌘