



CALIFORNIA ISO

California Independent
System Operator

STEP Dynamic Stability Study Results

Presentation for STEP Group 12/10/2003

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Grid Planning

California ISO

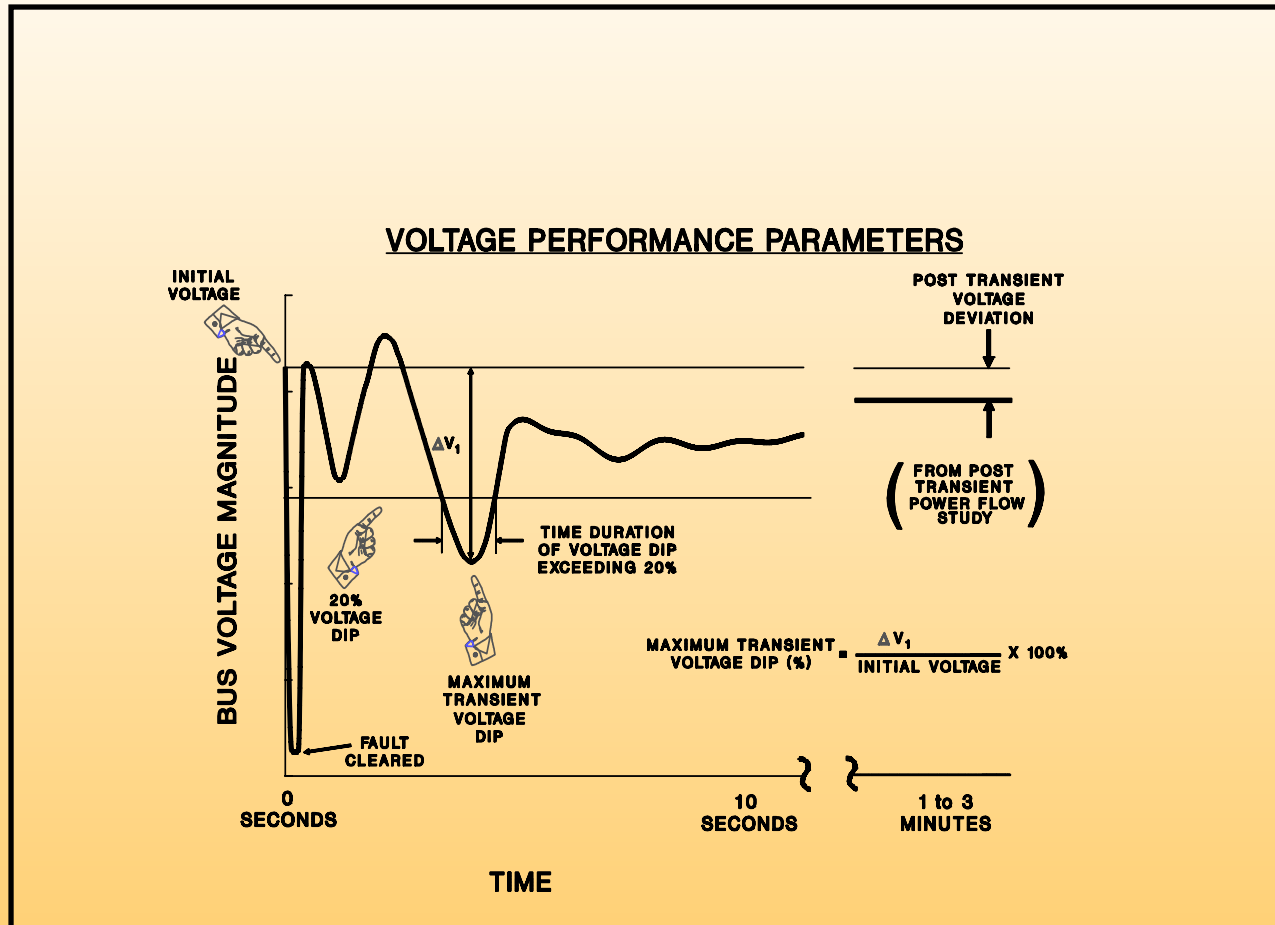


WECC TRANSIENT STABILITY STANDARDS PERFORMANCE TABLE

NERC and WECC Categories	Outage Frequency Associated with the Performance Category (outage/year)	Transient Voltage Dip Standard	Minimum Transient Frequency Standard	Post Transient Voltage Deviation Standard
A	Not Applicable	Nothing in addition to NERC		
B	≥ 0.33	<p>Not to exceed 25% at load buses or 30% at non-load buses.</p> <p>Not to exceed 20% for more than 20 cycles at load buses.</p>	Not below 59.6 Hz for 6 cycles or more at a load bus.	Not to exceed 5% at a bus.
C	0.033 – 0.33	<p>Not to exceed 30% at any bus.</p> <p>Not to exceed 20% for more than 40 cycles at load buses.</p>	Not below 59.0 Hz for 6 cycles or more at a load bus.	Not to exceed 10% at a bus.
D	< 0.033	Nothing in addition to NERC		



WECC TRANSIENT STABILITY STANDARDS VOLTAGE PERFORMANCE PARAMETERS





DYNAMIC STABILITY STUDIES

- **TO IDENTIFY CRITERIA VIOLATIONS AND DETERMINE ADDITIONAL VOLTAGE SUPPORT**
- **BASE CASES**
 - PEAK
 - OFF-PEAK
- **OUTAGES**
 - 3-PHASE FAULTS AND SINGLE OR DOUBLE CONTINGENCIES
 - ALL 500 KV OUTAGES IN THE SOUTHWEST
- **GE COMPUTER PROGRAM FOR DYNAMIC STABILITY ANALYSIS AND A PROGRAM TO IDENTIFY CRITERIA VIOLATIONS AND BUSES WITH HIGHEST VOLTAGE DIPS AND LOWEST FREQUENCIES WAS USED**



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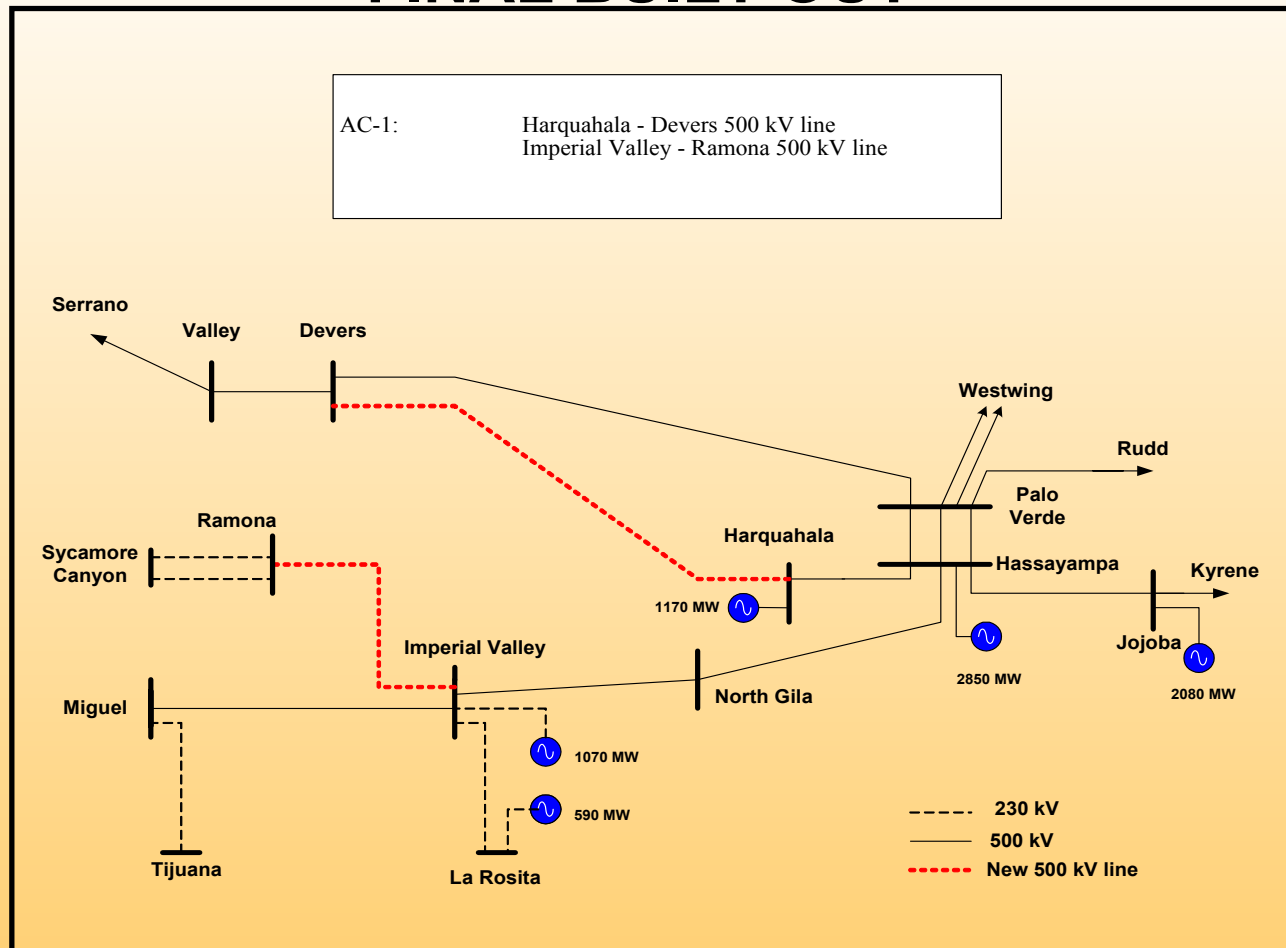
INITIAL STUDIES

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- 6 SELECTED ALTERNATIVES
- NO ADDITIONAL REACTIVE SUPPORT
- MOST CRITICAL SINGLE OUTAGE: HASSYAMPA-NORTH GILA
- BEST PERFORMANCE - ALTERNATIVE AC 2
- WORST PERFORMANCE – ALTERNATIVES AC 4 AND DC 2



DETAILED STUDIES:ALTERNATIVE AC-1 FINAL BUILT OUT





UPGRADES FOR THERMAL AND POST-TRANSIENT VIOLATIONS

- 500 kV Series Capacitor Rating Upgrade:
SWPL Navajo – Crystal Palo Verde – Devers
- 230 kV Upgrades West of Devers, Miguel, Sycamore Canyon
- Voltage support

Shunts (static support):

2X43 MVAR S. BAY 138 KV

1X79 MVAR SN BERNARDINO 230 KV

2X79 MVAR BARRE 230 KV

2X79 MVAR VISTA 230 KV

1X79 MVAR MIRA LOMA 230 KV

1X79 MVAR COACHELLA VLY 230 KV

3X79 MVAR DEVERS 230 KV

Dynamic Support:

400 MVAR STATCON or SVC (SYNCHR.COND) ON DEVERS 500 KV

200 MVAR SVC (SYNCHR.COND) ON VALLEY 500 KV



STABILITY STUDY RESULTS. ALTERNATIVE AC- 1. PEAK CASE

MOST CRITICAL SINGLE-LINE OUTAGE
HASSYAMPA-NORTH GILA

CAUSES NUMEROUS VOLTAGE VIOLATIONS IN THE GILA
AND DEVERS AREAS

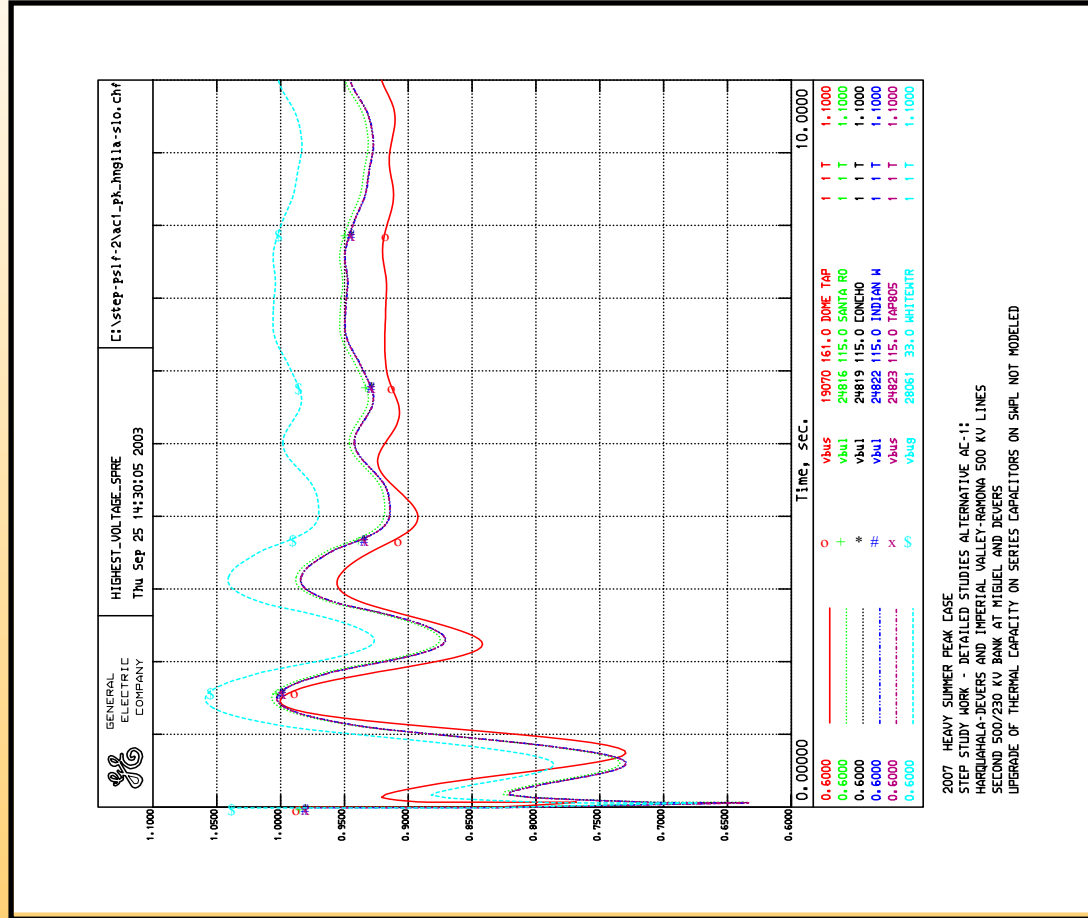
HIGHEST VOLTAGE DIP

AREA	BUS NAME	BUS KV	TYPE	Initial	MaxDip	Prct	@time
24	HI DESER	115	vbul	0.956	0.706	26.2	0.588
14	DOME TAP	161	vbus	0.988	0.73	26.2	0.738
24	CAPWIND	115	vbug	0.989	0.743	24.8	0.588

THE STUDIES WERE PERFORMED TO IDENTIFY REACTIVE
SUPPORT REQUIRED TO ELIMINATE VIOLATIONS WITH
THIS OUTAGE

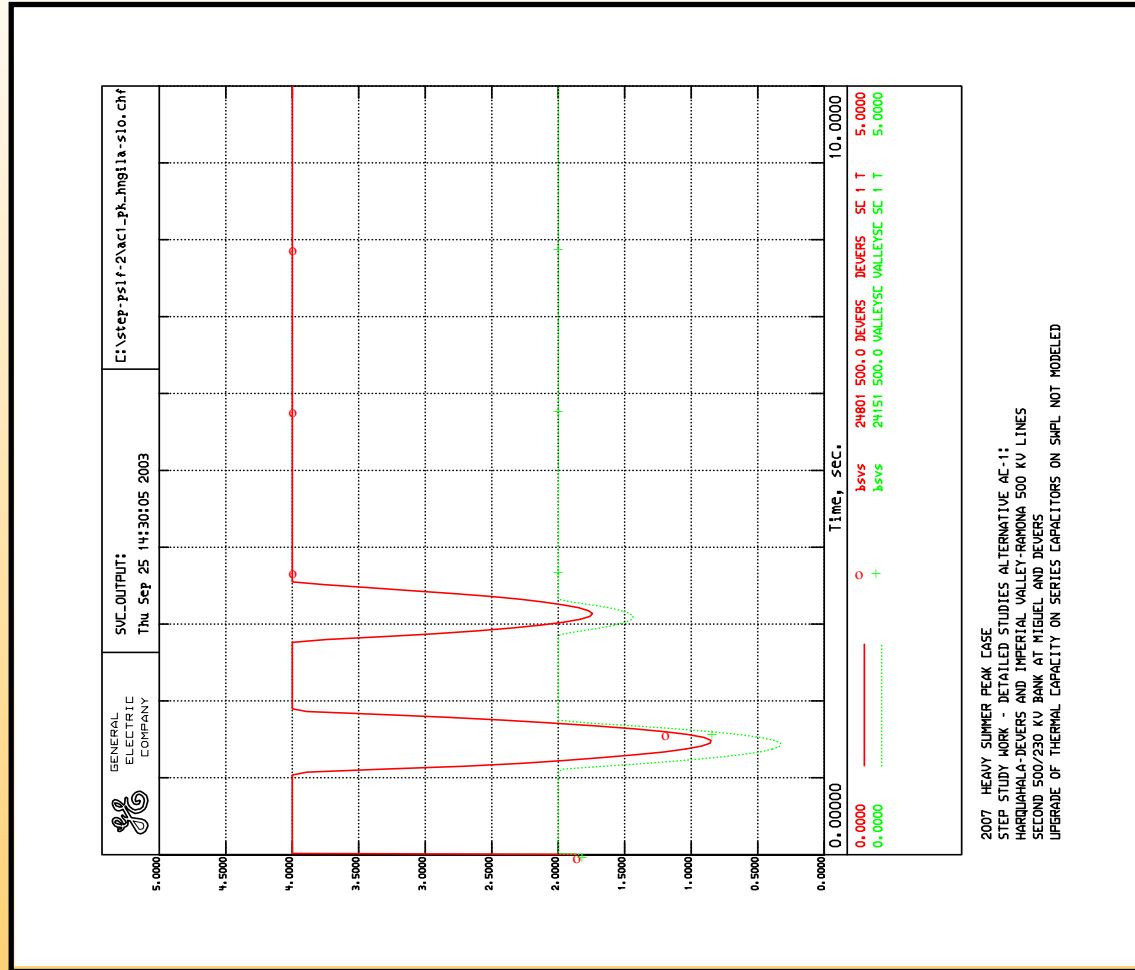


OUTAGE HASSYAMPA-NORTH GILA. BUSES WITH LARGEST VOLTAGE DIP





OUTAGE HASSYAMPA-NORTH GILA. SVC OUTPUT





ADDITIONAL VOLTAGE SUPPORT

- SEVERAL ALTERNATIVES STUDIED, INCLUDING SVC OR STATCON AT DEVERS 230 KV AND 115 KV BUSES, AND SVC IN THE GILA AREA
- DIFFERENT SIZES OF COMPENSATING DEVICES WERE CONSIDERED

REQUIRED DYNAMIC REACTIVE SUPPORT

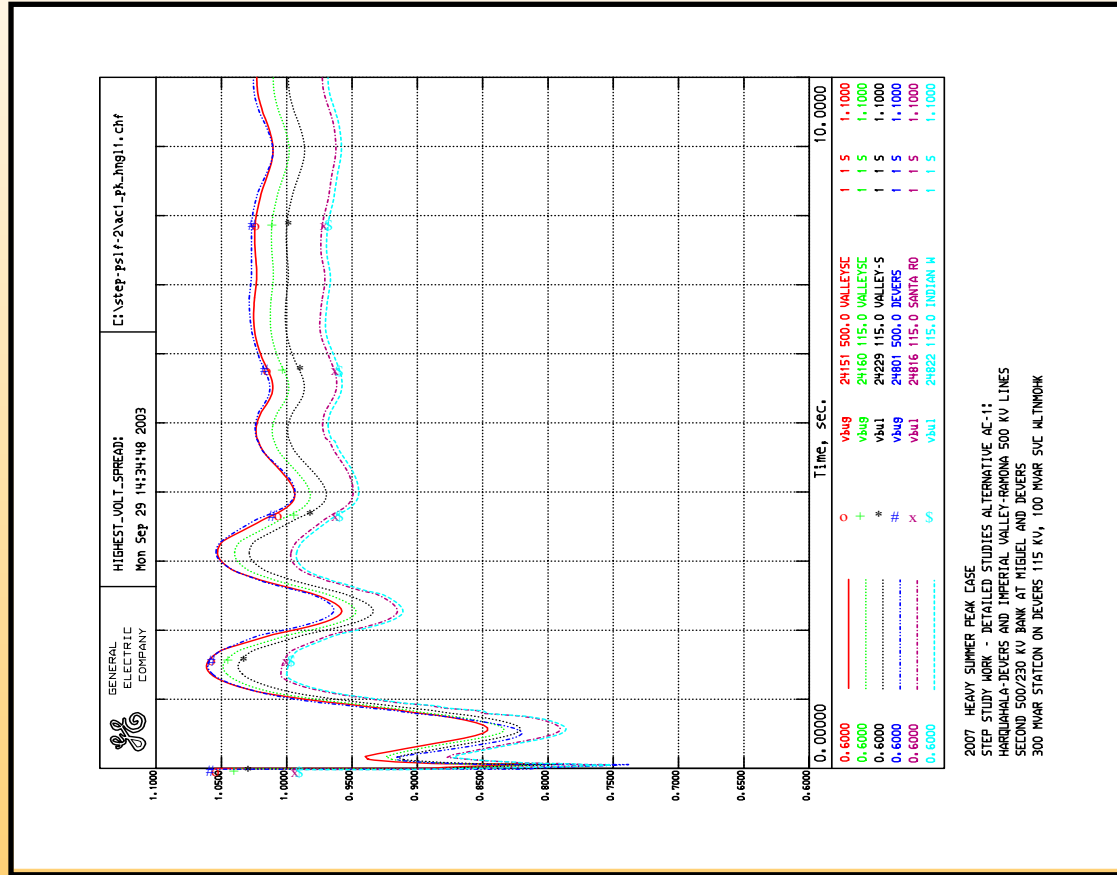
- 400 MVAR SVC AT DEVERS 500 KV
- 200 MVAR SVC AT VALLEY 500 KV
- 300 MVAR STATCON AT DEVERS 115 KV
- 100 MVAR SVC AT WLTMONHR 161 KV

HIGHEST VOLTAGE DIP

AREA	BUS NAME	BUS KV	TYPE		Initial	MaxDip	Prct	@time
24	HI DESER	115	vbul		0.966	0.764	20.9	0.588
24	TAP805	115	vbus		0.992	0.787	20.7	0.588
24	DEVERS	500	vbug		1.059	0.82	22.5	0.513

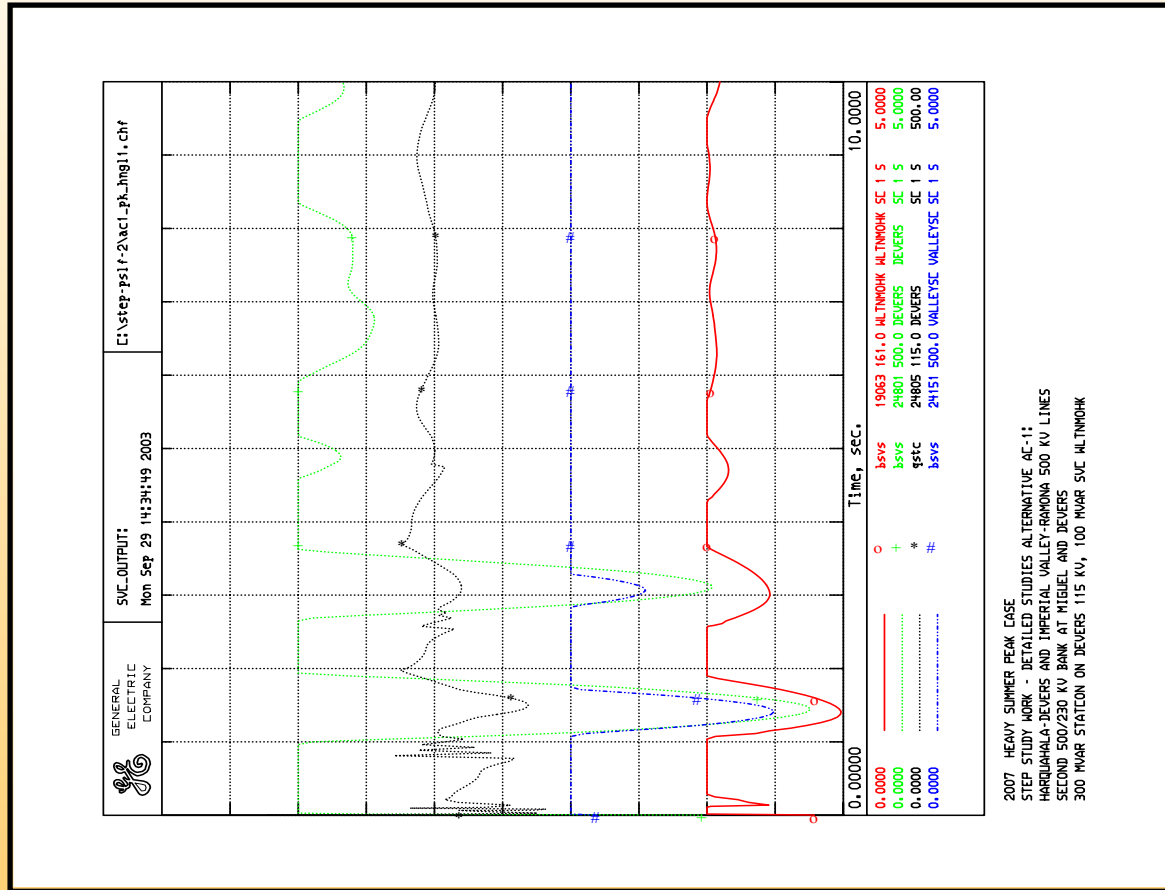


OUTAGE HASSYAMPA-NORTH GILA. ADDITIONAL REACTIVE SUPPORT. BUSES WITH LARGEST VOLTAGE DIP.





OUTAGE HASSYAMPA-NORTH GILA. ADDITIONAL REACTIVE SUPPORT. MVAR OUTPUT FROM DYNAMIC COMPENSATION DEVICES.





STABILITY STUDY RESULTS PEAK CASE WITH ADDITIONAL VOLTAGE SUPPORT

FREQUENCY VIOLATIONS IN SEARLES AREA (SCE) WITH
FAULTS AT LUGO

Example:

3-PHASE 4-CYCLE FAULT AT LUGO 500 KV, LUGO-MOHAVE
OUTAGE

FREQUENCY LESS THAN 59.6

AREA	BUS NAME	BUS KV	TYPE	Cycles	From	To
24	KERRGEN	12.5	fbug	15.8	0.85	1.113
24	KERRGEN	12.5	fbug	11.3	1.863	2.05
24	KERRMGEE	13.8	fbug	11.3	0.85	1.038

APPEARED TO BE CAUSED BY MODELING ERRORS
NO VIOLATIONS AFTER THE ERRORS WERE CORRECTED



STABILITY STUDY RESULTS. ALTERNATIVE AC- 1. OFF-PEAK CASE. 10,000 MW EOR FLOW. 1000 MVAR DYNAMIC SUPPORT.

- MOST CRITICAL OUTAGE HASSYAMPA-NORTH GILA, UNSTABLE
- OTHER OUTAGES WITH CRITERIA VIOLATIONS

PALOVERDE-DEVERS VOLTAGE CRITERIA VIOLATIONS

AREA	BUS NAME	BUS KV	TYPE	Initial	MaxDip	Prct	@time	Cycles	From	To
26	HALLDALE	138	vbul	1.015				20.2	0.438	0.775
26	WLMNTNLD	138	vbul	1.013				22.5	0.438	0.813
26	HARBOR	138	vbul	1.012				20.2	0.438	0.775

SERRANO-VALLEY, FAULT ON VALLEY

FREQUENCY LESS THAN 59.6

AREA	BUS NAME	BUS KV	TYPE	Cycles	From	To
24	VALLEY-S	115	fbul	10	0.017	0.183

DOUBLE OUTAGE PALOVEDE-DEVERS, HARQUAHALA-DEVERS, UNSTABLE



ALTERNATIVE AC-1 OFF PEAK. OUTAGE HASSYAMPA-NORTH GILA

DYNAMIC VOLTAGE SUPPORT REQUIRED TO AVOID VOLTAGE CRITERIA VIOLATIONS

- 1000 MVAR STATCON ON DEVERS 500 KV
- 500 MVAR STATCON ON VALLEY 500 KV
- 400 MVAR STATCON ON ADELANTO 500 KV
- 200 MVAR STATCON ON VICTORVILLE 287 KV
- 300 MVAR STATCON ON DEVERS 115 KV
- 100 MVAR SVC ON WLTMOHR 161 KV

TOTAL 2500 MVAR

OTHER SOLUTIONS: DROP SCE PUMPS OR SOME
HASSYAMPA GENERATION WITH THIS OUTAGE



OFF-PEAK CASE WITH REDUCED EOR FLOW. HASSYAMPA-NORTH GILA OUTAGE

- EOR FLOW 9500 MW, ADDITIONAL GENERATION AT MTN VISTA
- DYNAMIC REACTIVE SUPPORT
 - 1000 MVAR STATCON ON DEVERS 500 KV
 - 200 MVAR STATCON ON VALLEY 500 KV
 - 300 MVAR STATCON ON DEVERS 115 KV

TOTAL 1500 MVAR

HIGHEST VOLTAGE DIP

AREA	BUS NAME	BUS KV	TYPE		Initial	MaxDip	Prct	@time
26	WLMNTNLD	138	vbul		1.036	0.799	22.9	0.7
26	HARB	138	vbus		1.037	0.799	22.9	0.7
26	VICTORVL	287	vbug		1.051	0.811	22.8	0.688

HIGHER REACTIVE SUPPORT IS REQUIRED WITHOUT ADDITIONAL SCE GENERATION: 1700 MVAR WITH 9500 MW EOR FLOW WITHOUT MTN VISTA



PHASE I UPGRADES. EOR FLOW 8300 MW

- MIGUEL AND DEVERS 500/230 KV TRANSFORMERS
- MIGUEL-MISSION #2 230 KV LINE
- 500 KV SERIES CAPACITORS THERMAL UPGRADE
- REACTIVE SUPORT: 400 MVAR SVC ON DEVERS 500 KV

DYNAMIC STABILITY CRITERIA VIOLATIONS

OUTAGE PALOVERDE-DEVERS

FREQUENCY LESS THAN 59.6

AREA	BUS NAME	BUS KV	TYPE		Cycles	From	To
21	DELRANCH	14.4	fbug		11.3	1.638	1.825
21	JJELMORE	14.4	fbug		11.3	1.638	1.825
21	LEATHERS	14.4	fbug		9	1.675	1.825

OUTAGE VALLEY-SERRANO, FAULT ON VALLEY

FREQUENCY LESS THAN 59.6

AREA	BUS NAME	BUS KV	TYPE		Cycles	From	To
24	VALLEY-S	115	fbul		10	0.017	0.183



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PHASE I UPGRADES. EOR FLOW 8300 MW.

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OUTAGE HASSYAMPA-NORTH GILA

VOLTAGE CRITERIA VIOLATIONS ON 49 BUSES

HIGHEST VOLTAGE DIP

AREA	BUS NAME	BUS KV	TYPE		Initial	MaxDip	Prct	@time
26	WLMNTNLD	138	vbul		1.037	0.756	27.1	0.763
26	HARB	138	vbus		1.037	0.756	27.1	0.763
24	DEVERS	500	vbug		1.05	0.764	27.3	0.688



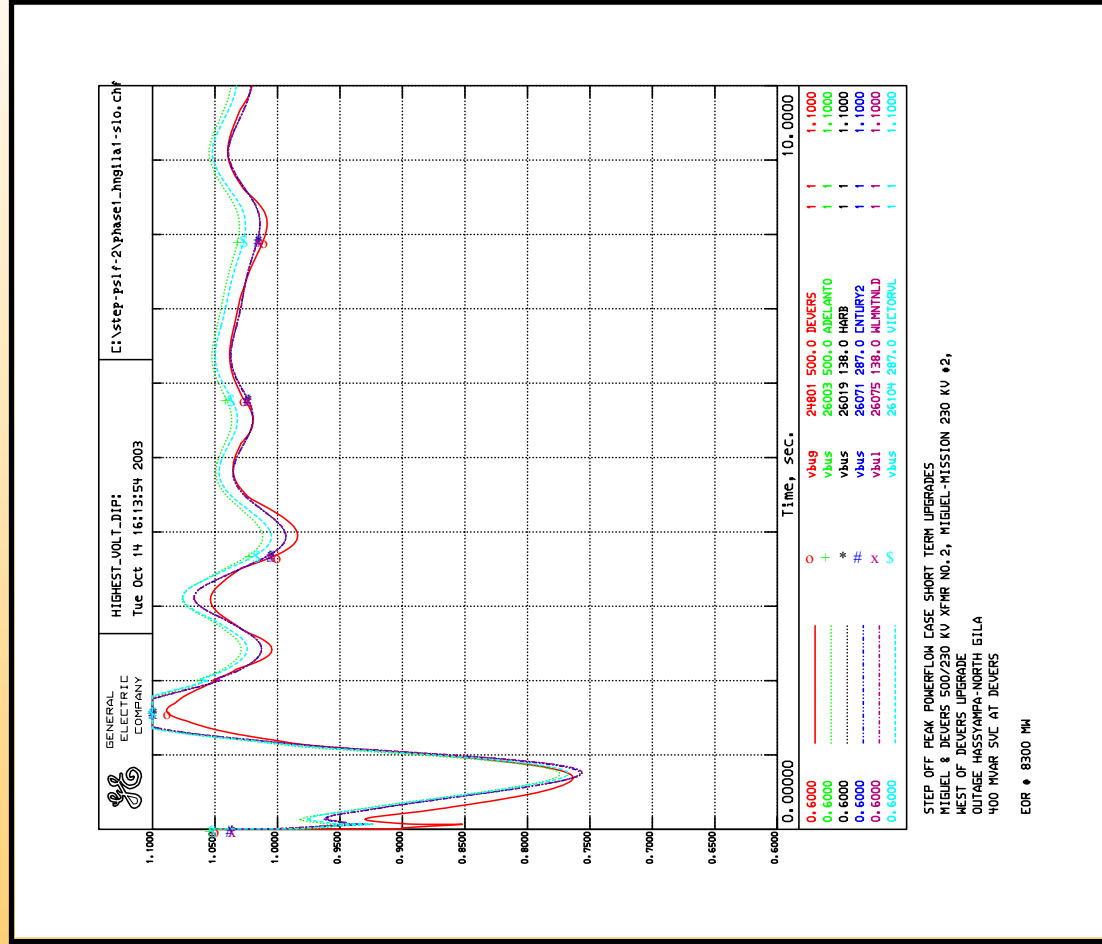


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PHASE I UPGRADES. EOR FLOW 8300 MW.

OUTAGE HASSYAMPA-NORTH GILA

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PHASE I UPGRADES. EOR FLOW 8300 MW

ADDITIONAL DYNAMIC VOLTAGE SUPPORT TO MITIGATE VOLTAGE VIOLATIONS WITH HASSYAMPA-NORTH GILA OUTAGE

IN ADDITION TO THE DEVERS 500 KV 400 MVAR SVC, 300 MVAR STATCON ON THE DEVERS 115 KV BUS – VIOLATIONS IN THE LADWP AREA

VOLTAGE CRITERIA VIOLATIONS

AREA	BUS NAME	BUS KV	TYPE	Initial	MaxDip	Prct	@time	Cycles	From	To
24	VALLEY-S	115	vbul	1.024				21	0.5	0.85
26	HALLDALE	138	vbul	1.038				21	0.538	0.888
26	WLMNTNLD	138	vbul	1.037				21	0.538	0.888
26	HARBOR	138	vbul	1.036				21	0.538	0.888

NO VIOLATIONS IF SVC AT DEVERS 500 KV IS REPLACED BY THE SAME SIZE STATCON. 300 MVAR STATCON AT DEVERS 115 KV MAY BE REPLACED BY 400 MVAR SVC (OR STATCON IF NO MONTA VISTA) AT VALLEY 500 KV
SAME FREQUENCY VIOLATIONS WITH PALOVERDE-DEVERS OUTAGE REMAIN



PHASE I UPGRADES. EOR FLOW LIMIT AND REACTIVE SUPPORT. VOLTAGE VIOLATIONS MITIGATED

PERKINS AND LIBERTY PH. SHIFTERS	OTAY MESA, PALOMAR, MNT VIEW GENERATION	DYNAMIC REACTIVE SUPPORT	FREQUENCY VIOLATIONS IN IID	EOB FLOW
IN SERVICE	NO	400 MVAR STATCON DEVERS AND VALLEY 500 KV	YES	8300 MW
IN SERVICE	NO	400 MVAR STATCON DEVERS AND VALLEY 500 KV	NO	8170 MW
IN SERVICE	YES	400 MVAR STATCON DEVERS AND VALLEY 500 KV	NO	7860 MW
IN SERVICE	YES	400 MVAR STATCON DEVERS	YES	8210 MW
IN SERVICE	YES	400 MVAR STATCON VALLEY	YES	8300 MW
BYPASSED	NO	400 MVAR STATCON DEVERS AND VALLEY 500 KV	YES	8150 MW
BYPASSED	NO	400 MVAR STATCON DEVERS AND VALLEY 500 KV	NO	7860 MW
BYPASSED	YES	400 MVAR STATCON DEVERS AND VALLEY 500 KV	YES	8200 MW
BYPASSED	YES	400 MVAR STATCON DEVERS AND VALLEY 500 KV	NO	7650 MW

NEW GENERATION AT OTAY MESA, PALOMAR AND MTN VIEW REPLACED ENCINA, SOUTH BAY, HUNT.BCH, ALAMITOS, REDONDO, EL SEGUNDO



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7% EOR FLOW MARGIN CRITERIA.

EOR FLOW 8880 MW

PROPOSED REACTIVE SUPPORT IS NOT SUFFICIENT: VOLTAGE AND FREQUENCY VIOLATIONS WITH PALOVERDE-DEVERS OUTAGE, OUTAGE HASSYAMPA-NORTH GILA IS UNSTABLE.

1000 MVAR STATCON at Devers 500 kV
300 MVAR STATCON at Devers 115 kV
500 MVAR STATCON at Valley 500 kV
400 MVAR STATCON at Adelanto 500 kV
200 MVAR STATCON at Victorville 287 kV
Total 2400 MVAR



VOLTAGE AND FREQUENCY VIOLATIONS WITH PALOVERDE-DEVERS OUTAGE REMAIN

ANOTHER 200 MVAR STATCON AT NEEDLES ELIMINATES VOLTAGE, BUT NOT FREQUENCY VIOLATIONS



REQUIRED DYNAMIC REACTIVE
SUPPORT (2500 MVAR) IS TOO HIGH,
BOTH IN PHASE I AND WITH FINAL
BUILT-OUT.

ASSUME LOWER EOR FLOW?





EOR FLOW LIMIT DEPENDS ON
GENERATION DISPATCH AND ON
LOCATIONS AND AMOUNT OF REACTIVE
SUPPORT





- **QUESTIONS?**
- **NEXT STEPS?**

