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Notice of Filing

E-00000M-08-0170

PART 1 OF 2
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Arizona Corporation Commission
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APR 28 2014
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Arizona Corporation Commission
DOCKETED
APR 28 2014
DOCKETED BY

IN THE MATTER OF THE GENERIC DOCKET FOR THE 90-DAY PRE-APPLICATION PLANS FOR POWER PLANTS FILED PURSUANT TO A.R.S. § 40-360-02.B.	Docket No. E-00000M-08-0170 **NOTICE OF FILING PLAN PURSUANT TO A.R.S. § 40-360-02.B**

Arizona Public Service Company ("APS") submits the attached Plan for the APS Ocotillo Modernization Project pursuant to A.R.S. § 40-360-02.B.

. . .

. . .

. . .

RESPECTFULLY SUBMITTED this 28th day of April 2014.

By: Linda Benally
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By: Linda Benally for
Thomas H. Campbell

Attorneys for Arizona Public Service Company

ORIGINAL and thirteen (13) copies of the foregoing filed this 28th day of April 2014, with:

The Arizona Corporation Commission
Hearing Division – Docket Control
1200 West Washington Street
Phoenix, Arizona 85007

COPY of the foregoing hand-delivered this 28th day of April 2014, to:

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PLAN FOR THE OCOTILLO MODERNIZATION PROJECT

SUBMITTED BY ARIZONA PUBLIC SERVICE COMPANY
APRIL 2014

Arizona Public Service Company (APS) submits this plan (Plan) for the proposed Ocotillo Modernization Project pursuant to A.R.S § 40-360.2.

The proposed modernization of the Ocotillo Power Plant (Power Plant) in Tempe, Arizona will maintain and enhance the Power Plant's contribution to system reliability, provide highly flexible generating capacity to help integrate renewable energy resources, optimize existing natural gas and transmission infrastructure, and optimize environmental benefits through retiring the aging steam units. The modernization of the Power Plant consists of retiring two 1960's-era steam generators and replacing them with five (5) quick-start natural Gas Turbines (GTs), and the associated 230kV Generation Interconnections (Project). The GTs, with capacities of 102 megawatts (MW) each, will support grid and operational reliability at the heart of APS's load center, and complement increases in solar generation capacity. After adding the five GTs and retiring the aging steam units, plant output will increase from 330 MW to 620 MW (290 MW net output increase).

As depicted in APS's recently filed Integrated Resource Plan, APS anticipates needing over 3,800 MW of new peak resources by 2021 to replace expiring purchase contracts and meet projected customer demand growth. The proposed Ocotillo Modernization Project would represent 290 MW of the approximately 3,800 MW needed. APS expects significant contributions from other sources of energy to help fill this remaining need, such as wholesale energy markets, energy efficiency, and renewable energy.

This submittal covers the Plan to modernize the Power Plant, and the specific items required by A.R.S § 40-360.2 are set forth below:

1) **The size and proposed route of any transmission lines or location of each plant proposed to be constructed.**

   The five new GTs and associated 230kV Generation Interconnections would be entirely located within the existing Power Plant site (Ocotillo Site), which is located at 1500 East University Drive in Tempe, Arizona. Attached as Figure 1 is a map showing the location of the Ocotillo Site. The Power Plant is located on approximately 125 acres within the southeast ¼ of Section 14, Township 1 North, Range 4 East, of the Gila and Salt River Baseline and Meridian, Maricopa County, Arizona.

   The proposed 102 MW GTs (summer conditions) installed at the Power Plant will be fueled by natural gas.

APS proposes to construct two 230kV Generation Interconnections to connect the GTs to the existing onsite substation (Ocotillo 230kV Substation, located near the northeast corner of the Ocotillo Site). To the extent possible, the Generation Interconnections will be double-circuited on shared structures, generally routed around the western and northern boundaries of the Ocotillo Site.

2) The purpose to be served by each proposed transmission line or plant.

As with many utilities across the U.S., portions of APS's fleet are aging beyond their useful life. Given the Power Plant's key location on the transmission system, having reliable, and flexible, generation at that location is critical. One way APS is addressing this issue is the modernization of the Power Plant in Tempe. The need to upgrade the Power Plant stems from the key balancing role the Power Plant plays within APS's transmission system and Phoenix area load-pocket.

Having played a significant role in bringing power to the Phoenix area over the past 54 years, the existing steam generating units are relatively inefficient and less flexible than other alternatives. All of this, coupled with the evolving landscape of integrating renewable energy into the grid, makes the need to modernize the Power Plant with fast-starting, fast-ramping technology compelling on many levels.

- Enhances flexibility of APS portfolio: The state-of-the-art gas turbine technology proposed for this Project will provide APS added flexibility to quickly respond to the intermittency of renewable energy and system contingencies. The new gas turbine technology will add operational flexibility to manage the increase in solar energy because they can be on line and sending power to the grid in less than six minutes.

- Use of existing infrastructure: The Power Plant has the available land as well as capability through existing 230kV transmission line and natural gas pipeline infrastructure to support the additional generation, thus optimizing plant capability.

- Uniquely situated: Valley load-serving capability is maintained and enhanced by the Power Plant due to its location on the transmission system and proximity to the Metro Phoenix area. This proximity affords dynamic voltage support, reduced system energy losses, and reduces impacts from transmission line outages.

3) The estimated date by which each transmission line or plant will be in operation.

If approved, the Project's five GT units will be constructed and put into service consecutively. With the first unit's and transmission line's commercial operation expected in the Fall of 2017, all new GT units are anticipated to be in operation before Summer 2018.

APS proposes to commence decommissioning of the two (2) aging steam generators at the Power Plant beginning in the Fall of 2018.

4) **The average and maximum power output measured in megawatts of each plant to be installed.**

The average power output is challenging to define for a peaking unit due to the variability in run-time with this type of generation. However, the majority of the operating hours are expected in the summer when the output is expected to be 102 MW per unit. The maximum estimated output will occur during winter conditions with a power output of approximately 104 MW per unit. Using the summer expected output of 102 MW for each unit, the new units will total 510 MW for the five (5) new units.

5) **The expected capacity factor for each proposed unit.**

The annual capacity factors of the new units are expected to vary year-by-year depending on natural gas prices, system operating conditions and renewable energy penetration, but are not expected to exceed 33 percent in any year.

6) **The type of fuel to be used for each proposed plant.**

Natural gas will continue to be used as the fuel at the Power Plant. The existing Kinder Morgan (formerly El Paso Natural Gas) system will continue to provide natural gas to the Power Plant site.

7) **The plans for any new facilities shall include a power flow and stability analysis report showing the effect on the current Arizona electric transmission system. Transmission owners shall provide the technical reports, analysis or basis for projects that are included for serving customer load growth in their service territories.**

Attached as Exhibit A is APS's power flow and stability analysis report (Report) for the Project showing the effect on the current Arizona electric transmission system.

FIGURE 1

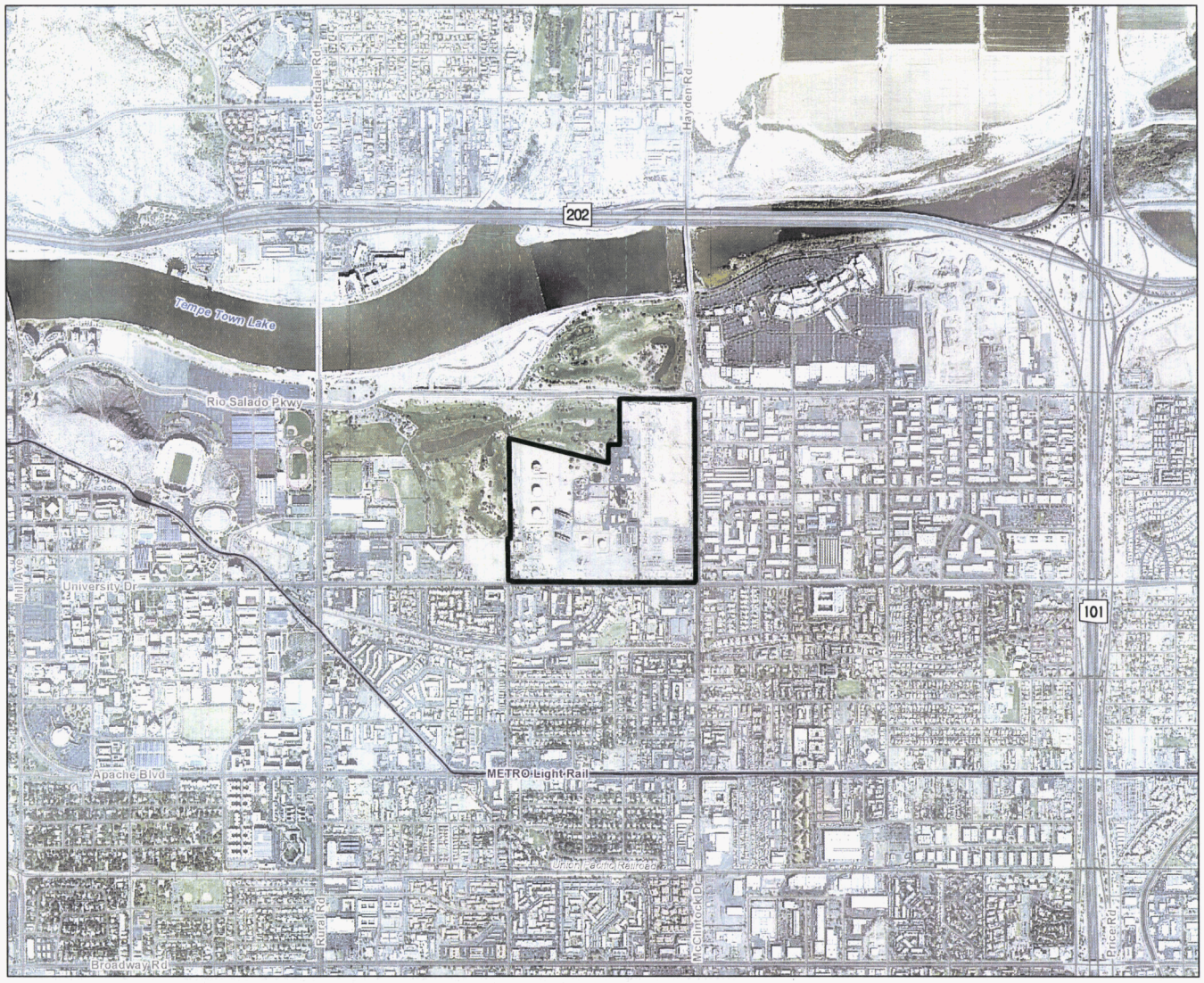

Figure 1

Project Location

Ocotillo Modernization Project

Legend

- Ocotillo Power Plant
- Road
- Railroad

Source:
Base Map: ALRIS 1997 - 2014, ADOT 2014, Valley Metro 2014, BTS 2013
Imagery: FCDMC 2012

N

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aps

EXHIBIT A

April 11, 2014

ARIZONA PUBLIC SERVICE

Ocotillo Modernization Project Load Flow, Transient Stability, Post-Transient, Short Circuit, and MLSC Analysis

Revision B

PROJECT NUMBER:
133887

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OCOTILLO MODERNIZATION PROJECT

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REVISION HISTORY

REV.	ISSUE DATE	ISSUED FOR	PREP BY	CHKD BY	APPD BY	NOTES
A	04/07/14	Appvl	JWS	TMM	DJ	Issued for client review
B	04/11/14	Appvl	JWS	TMM	DJ	Issued for client review

"Issued For" Definitions:

- "Prelim" means this document is issued for preliminary review, not for implementation
- "Appvl" means this document is issued for review and approval, not for implementation
- "Impl" means this document is issued for implementation
- "Record" means this document is issued after project completion for project file

TABLE OF CONTENTS

EXECUTIVE SUMMARY **1**

STUDY OVERVIEW **3**

STUDY METHODOLOGY AND EVALUATED CRITERIA **5**

POWER FLOW ANALYSIS 5
TRANSIENT STABILITY ANALYSIS 5
POST TRANSIENT ANALYSIS 8
SHORT CIRCUIT ANALYSIS 8
MAXIMUM LOAD SERVING CAPABILITY ANALYSIS 8

STUDY BASE CASE DESCRIPTION AND ASSUMPTIONS **10**

BASE CASE ASSUMPTIONS 10
BASE CASES STUDIED 10
MLSC CASES STUDIED 11
DYNAMIC MODELS 12
SHORT CIRCUIT MODELS 12

STUDY RESULTS **14**

POWER FLOW ANALYSIS FINDINGS 14
2018 Power Flow Study: Normal (N-0) Operating Conditions 14
2018 Power Flow Study: Single Element Outage (N-1) Conditions 14
2018 Power Flow Study: Multiple Element Outage (N-2+) Conditions 15
2023 Power Flow Study: Normal (N-0) Operating Conditions 15
2023 Power Flow Study: Single Element Outage (N-1) Conditions 15
2023 Power Flow Study: Multiple Element Outage (N-2+) Conditions 16
TRANSIENT STABILITY ANALYSIS FINDINGS 16
POST-TRANSIENT ANALYSIS FINDINGS 17
SHORT CIRCUIT ANALYSIS FINDINGS 18
MAXIMUM LOAD SERVING CAPABILITY (MLSC) ANALYSIS FINDINGS 18

CONCLUSIONS **21**

APPENDIX A: POWER FLOW MAPS: OCOTILLO MODERNIZATION PROJECT STUDY **22**

APPENDIX B: MLSC - POWER FLOW MAPS: OCOTILLO MODERNIZATION PROJECT STUDY **27**

APPENDIX C: OCOTILLO #3-7 PSLF TRANSIENT STABILITYSIMULATION MODEL **46**

APPENDIX D: LIST OF MULTIPULE ELEMENT CONTINGENCES **49**

LIST OF TABLES

TABLE 1: BASE CASE SELECTION FOR OCOTILLO MODERNIZATION PROJECT 4
TABLE 2: TRANSIENT STABILITY AND POST-TRANSIENT ANALYSIS EVALUATION CRITERIA 7
TABLE 3: STUDY BASE CASES 11
TABLE 4: MLSC STUDY BASE CASES 11
TABLE 5: 2018 – N-0 FLOWS 14
TABLE 6: 2018 – N-1 FLOWS 14
TABLE 7: 2018 – MULTIPLE CONTINGENCY FLOW 15
TABLE 8: 2023 – N-0 FLOWS 15
TABLE 9: 2023 – N-1 FLOWS 16
TABLE 10: 2023 – MULTIPLE CONTINGENCY FLOW 16
TABLE 11: 2018 POST-TRANSIENT ANALYSIS RESULTS (VAR MARGIN) 17
TABLE 12: 2023 POST-TRANSIENT ANALYSIS RESULTS (VAR MARGIN) 18
TABLE 13: SUMMARY OF SHORT CIRCUIT ANALYSIS RESULTS 18
TABLE 14: 2018 MLSC STUDY RESULTS 19
TABLE 15: 2023 MLSC STUDY RESULTS 20
TABLE D.1: MULTIPLE ELEMENT CONTINGENCY LIST 50

LIST OF FIGURES

FIGURE 1: PROPOSED 2018 OCOTILLO 230 KV SYSTEM AND GENERATION 1
FIGURE 2: CURRENT OCOTILLO 230 KV SYSTEM AND GENERATION 3
FIGURE 3: PROPOSED 2018 OCOTILLO 230 KV SYSTEM AND GENERATION 4
FIGURE 4: GRAPHICAL REPRESENTATION OF TRANSIENT STABILITY ANALYSIS EVALUATION CRITERIA 7
FIGURE 5: POST PROJECT OCOTILLO AREA MODEL 10
FIGURE 6: APS OCOTILLO MODERNIZATION PROJECT ASPEN MODEL 13
FIGURE A-1: POWER FLOW MAP-2018 HEAVY SUMMER OCOTILLO 330MW BASE CASE 23
FIGURE A-2: POWER FLOW MAP-2018 HEAVY SUMMER OCOTILLO 620MW BASE CASE 24
FIGURE A-3: POWER FLOW MAP-2023 HEAVY SUMMER OCOTILLO 330MW BASE CASE 25

FIGURE A-4: POWER FLOW MAP-2023 HEAVY SUMMER OCOTILLO 620MW BASE CASE 26

FIGURE B-1: POWER FLOW MAP-2018 OCOTILLO 0MW ALIS 28

FIGURE B-2: POWER FLOW MAP-2018 OCOTILLO 330MW ALIS 29

FIGURE B-3: POWER FLOW MAP-2018 OCOTILLO 620MW ALIS 30

FIGURE B-4: POWER FLOW MAP-2018 OCOTILLO 0MW JOJOBA-KYRENE 500KV IOS 31

FIGURE B-5: POWER FLOW MAP-2018 OCOTILLO 330MW JOJOBA-KYRENE 500KV IOS 32

FIGURE B-6: POWER FLOW MAP-2018 OCOTILLO 620MW JOJOBA-KYRENE 500KV IOS 33

FIGURE B-7: POWER FLOW MAP-2018 OCOTILLO 0MW PALO VERDE- RUDD 500KV IOS 34

FIGURE B-8: POWER FLOW MAP-2018 OCOTILLO 330MW PALO VERDE- RUDD 500KV IOS 35

FIGURE B-9: POWER FLOW MAP-2018 OCOTILLO 620MW PALO VERDE- RUDD 500KV IOS 36

FIGURE B-10: POWER FLOW MAP-2023 OCOTILLO 0MW ALIS 37

FIGURE B-11: POWER FLOW MAP-2023 OCOTILLO 330MW ALIS 38

FIGURE B-12: POWER FLOW MAP-2023 OCOTILLO 620MW ALIS 39

FIGURE B-13: POWER FLOW MAP-2023 OCOTILLO 0MW JOJOBA-KYRENE 500KV IOS 40

FIGURE B-14: POWER FLOW MAP-2023 OCOTILLO 330MW JOJOBA-KYRENE 500KV IOS 41

FIGURE B-15: POWER FLOW MAP-2023 OCOTILLO 620MW JOJOBA-KYRENE 500KV IOS 42

FIGURE B-16: POWER FLOW MAP-2023 OCOTILLO 0MW PALO VERDE- RUDD 500KV IOS 43

FIGURE B-17: POWER FLOW MAP-2023 OCOTILLO 330MW PALO VERDE- RUDD 500KV IOS 44

FIGURE B-18: POWER FLOW MAP-2023 OCOTILLO 620MW PALO VERDE- RUDD 500KV IOS 45

EXECUTIVE SUMMARY

Arizona Public Service (APS) is investigating the retirement and subsequent addition of generation at their Ocotillo generating facility, located in Tempe, AZ. The existing Ocotillo generating facility is comprised of two steam generators (110 MW net each) and two gas generators (55 MW net each) which have a total net output of 330 MW. The proposed project would retire the two steam generators and be replaced with five new gas turbines, with a net increase of 290 MW of capacity. The proposed project evaluated in this report is based on the following changes at the Ocotillo generating facility in 2018:

- Retire two existing steam generators (reduction of 220 MW net generation capacity)
- Install five new gas generators (LMS100) with a capacity of 102 MW net each (addition of 510 MW of new generation)
- Proposed total Ocotillo generating facility capacity of 620 MW net (an increase of 290 MW net generation from the existing configuration)

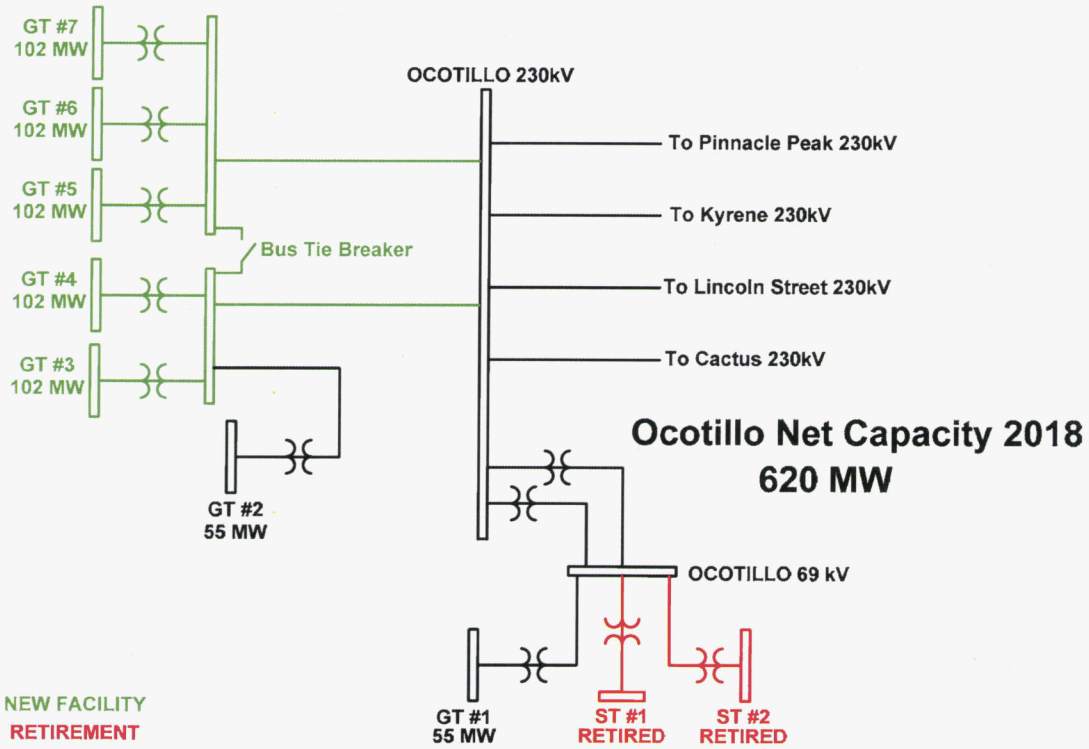


Figure 1: Proposed 2018 Ocotillo 230 kV System and Generation

Based on the power flow, transient stability, post-transient stability, short circuit and maximum load serving capability (MLSC) studies, mitigation plans are not necessary for the Ocotillo Modernization Project. The study results for all studied contingencies and scenarios result in no violations of any WECC/NERC and APS reliability criteria.

The MLSC studies show that under the all lines in service (ALIS) scenario, addition of the Ocotillo Modernization Project results in MLSC values above the forecasted peak load (plus 800 MW margin) of the Phoenix Metro load pocket, which illustrates the continued ability of the Arizona transmission system to reliably serve the forecasted Phoenix load in future years. In addition, the Ocotillo Modernization Project provides an added benefit to the transmission system with additional MLSC capability under the studied IOS conditions. This allows operators at APS and SRP additional flexibility to make system adjustments in the event of a long term outage of one of the major 500kV circuits that serves the Phoenix Metro load pocket.

STUDY OVERVIEW

Arizona Public Service (APS) is investigating the retirement and subsequent addition of generation at their Ocotillo generating facility, located in Tempe, AZ. The existing Ocotillo generating facility is comprised of two steam generators (110 MW net each) and two gas generators (55 MW net each) which have a total net output of 330 MW. The proposed project would retire the two steam generators and be replaced with five new gas turbines, with a net increase of 290 MW of capacity. The proposed project evaluated in this report is based on the following changes at the Ocotillo generating facility in 2018:

- Retire two existing steam generators (reduction of 220 MW net generation capacity)
- Install five new gas generators (LMS100) with a capacity of 102 MW net each (addition of 510 MW of new generation)
- Proposed total Ocotillo generating facility capacity of 620 MW net (an increase of 290 MW net generation from the existing configuration)

Figures 2 and 3 illustrate the change in the Ocotillo system due to the generation retirement and addition. Figure 2 depicts the current system with the existing gas and steam generators interconnected. In Figure 3, the retirement of the steam units is shown, as well as the system configuration and addition of the five new gas generators.

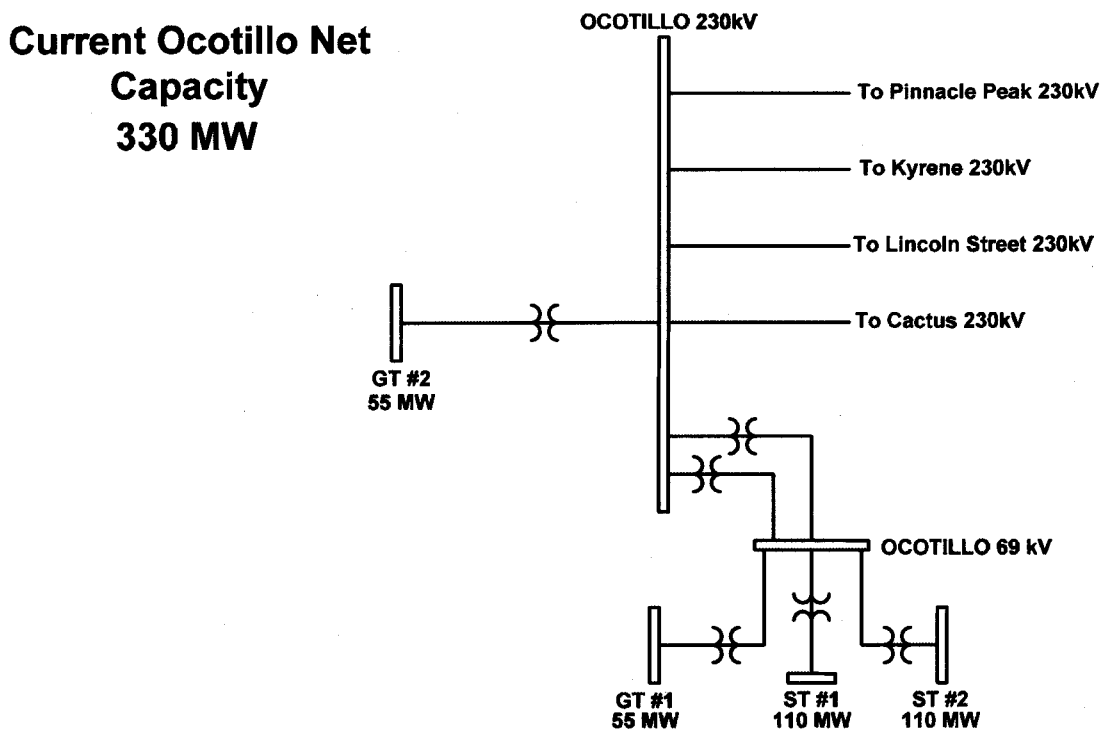


Figure 2: Current Ocotillo 230 kV System and Generation

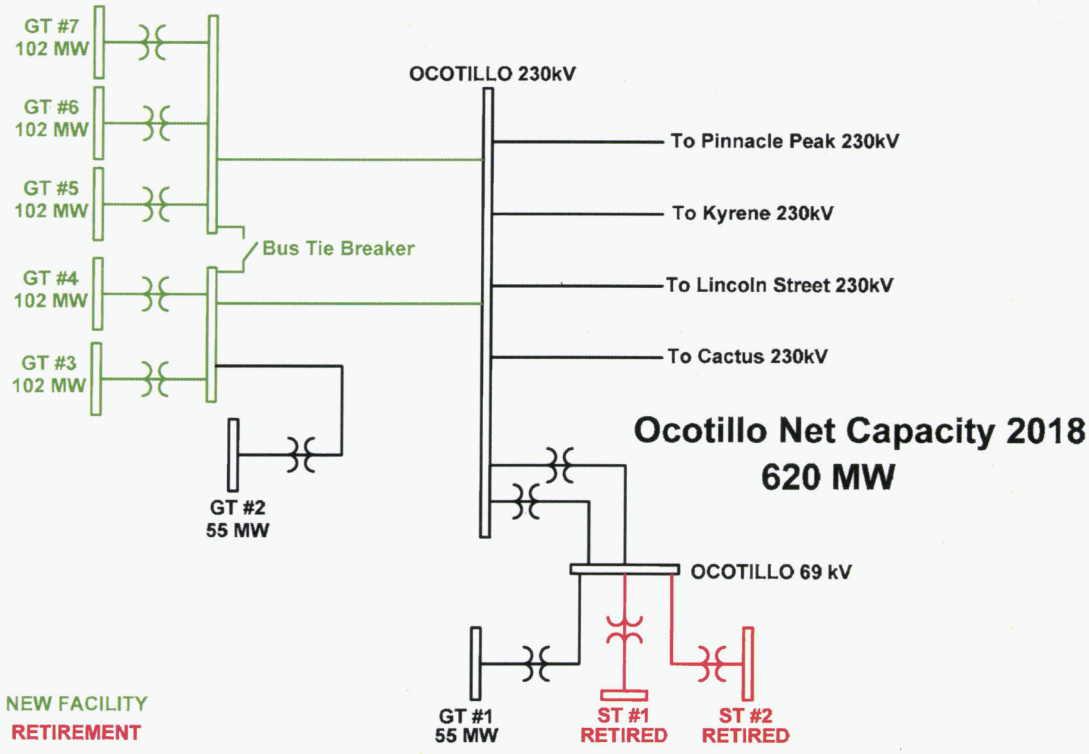


Figure 3: Proposed 2018 Ocotillo 230 kV System and Generation

To determine the impact of the proposed project on the APS Transmission System and the neighboring transmission systems, APS contracted with POWER Engineers to perform technical analysis on these changes at the Ocotillo generating facility. The study was conducted using Western Electricity Coordination Council's (WECC) approved heavy summer models with detailed Arizona transmission system representation incorporated. Studies performed included power flow, transient stability, post-transient, short circuit, and Maximum Load Serving Capability (MLSC) analyses. POWER performed all studies documented in this report.

The proposed project was studied according to the project in-service date of 2018 for the years 2018 and 2023. Table 1 depicts the projects and the WECC base models used for studying the project.

TABLE 1: BASE CASE SELECTION FOR OCOTILLO MODERNIZATION PROJECT

BASE MODEL
2018 Heavy Summer Arizona coordinated base case
2023 Heavy Summer Arizona coordinated base case

The output from the generation project was dispatched and delivered to APS via a reduction of resources from the Palo Verde Hub. The adequacy of the study results were evaluated using WECC/NERC reliability and the APS planning standards. Impacts of the generation project to the transmission system were determined.

STUDY METHODOLOGY AND EVALUATED CRITERIA

The analyses performed in this study included power flow, transient stability, post-transient stability, short circuit, and MLSC analysis. This section provides a summary of the methods and the evaluation criteria used for analyzing the results of the studies.

Power Flow Analysis

Power flow analysis was conducted on all the pre- and post-project base cases developed for the Ocotillo Modernization Project study. Power flow analysis considers a snapshot in time where tap changing transformers, Static VAR Devices (SVD) and phase-shifters have had time to adjust. In addition, a swing generator balances generation and load (plus losses) on the system during each contingency scenario. The power flow analysis was conducted with version 18 of General Electric's PSLF software. Power flow results were monitored and reported for the APS and the neighboring control areas.

Thermal and voltage performance of the system was evaluated under normal (N-0), single element outage (N-1) and select multiple element outage (N-2+) conditions. The contingencies selected are summarized as:

- All single element outages above 100 kV in the Arizona Transmission System
- N-2+ contingencies in the Arizona Transmission System. The contingency list of studied N-2+ contingencies is provided in Appendix D.

Thermal loadings were reported when a modeled transmission component is loaded to 100% or more of its emergency MVA rating (as provided in the power flow database).

Transmission voltage deviation violations between the pre- and post-contingency conditions were recorded whenever these deviations were greater than 5% for single contingencies and 10% for double contingencies.

In summary, the following WECC/NERC reliability criteria were used to assess the adequacy of the power flow study results:

- Allowable voltage deviation of five (5) percent for N-1 contingencies (deviation from pre-disturbance voltage).
- Allowable voltage deviation of ten (10) percent for N-2+ contingencies (deviation from pre-disturbance voltage).
- Pre- and post-disturbance loading to remain within the emergency ratings of all equipment and line conductors. The emergency ratings are determined by the owner/operator of each equipment item.

As applied in the analysis, all tables and results for loading criteria were based on the normal or continuous rating (Rating 1) for all lines in service conditions and the emergency rating (Rating 2) for outage conditions.

Transient Stability Analysis

Transient stability analysis is a time-based simulation that assesses the performance of the power system shortly before, during, and after a contingency. Transient stability studies were performed on

both the pre- and post-project base cases to verify the stability of the system following a system fault. Transient stability analysis was performed based on WECC Disturbance-Performance Criteria for selected system contingencies using version 18 of General Electric's PSLF software. Transient stability contingencies were simulated for 10 seconds, excluding one (1) second of pre-disturbance data. All simulated faults, unless specified, were assumed to be three-phase with a 4 cycle breaker clearing time. Delayed clearing events where assumed to be three-phase with a 16 cycle breaker clearing time. System damping was assessed visually with the aid of stability plots.
Selected critical contingencies were simulated. The simulated outages included select N-1 and N-2+ contingencies.

The following WECC transient voltage dip and transient frequency criteria were used to evaluate the impact of the project. A summary of the transient stability analysis evaluation criteria is provided in Table 2 and depicted graphically in Figure 4.

- WECC transient voltage dip criteria: The transient voltage dip must not exceed 25% at load buses or 30% at non-load buses for N-1 contingency. For N-2+ contingency, the transient voltage dip must not exceed 30% at any bus. The maximum duration of the voltage dip of 20% at load buses must not exceed 20 cycles for N-1 contingency or 40 cycles for N-2+ contingency.
- WECC transient frequency criteria: The minimum transient frequency for N-1 contingency is 59.6 Hz; if below 59.6 Hz, the duration must not exceed 6 cycles at load bus. For N-2+ contingencies, the minimum transient frequency is 59.0 Hz; if below 59.0 Hz, the duration should not exceed 6 cycles at load bus.

The following parameters were plotted on the stability plots:

- **Bus Voltage**
  Bus voltage plots provide a means of detecting out-of-step conditions and are useful to assess the magnitude and duration of post disturbance voltage dips and peak-to-peak voltage oscillations. The voltage plots also indicate system damping response and the expected bus voltage following the disturbance.

- **Bus Frequency**
  Bus frequency plots provide expected magnitude and duration of post-disturbance frequency swings as well as indicating possible over-frequency or under-frequency conditions.

TABLE 2: TRANSIENT STABILITY AND POST-TRANSIENT ANALYSIS EVALUATION CRITERIA

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 System Normal	Not Applicable	Nothing in addition to NERC		
B One element out-of-service	≥ 0.33	Not to exceed 25% at load buses or 30% at non-load buses. Not to exceed 20% for more than 20 cycles at load buses.	Not below 59.6Hz for 6 cycles or more at a load bus.	Not to exceed 5% at any bus.
C Two or more elements out-of-service	0.033-0.33	Not to exceed 30% at any bus. Not to exceed 20% for more than 40 cycles at load buses.	Not below 59.0Hz for 6 cycles or more at a load bus.	Not to exceed 10% at any bus.
D Extreme multiple-element outages	< 0.033	Nothing in addition to NERC		

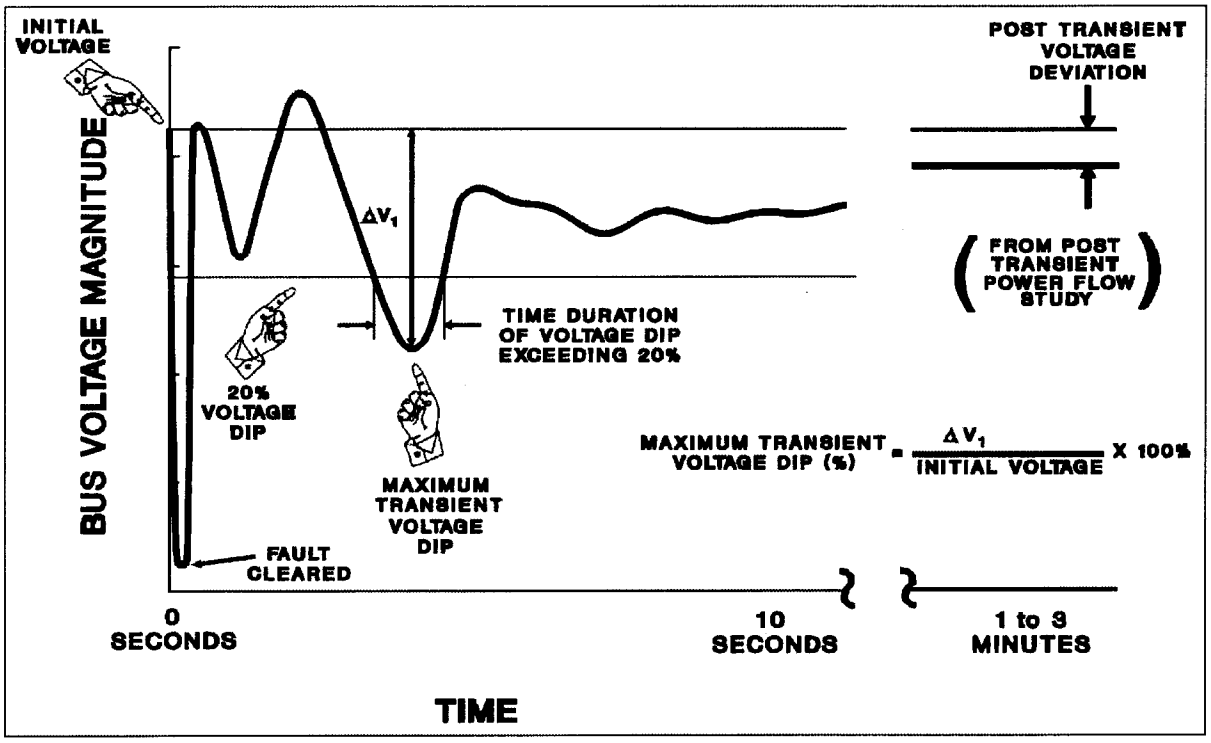


Figure 4: Graphical Representation of Transient Stability Analysis Evaluation Criteria

Post Transient Analysis

Post-transient analysis was performed on selected buses in the APS transmission system following selected critical outages. Governor power flow tools were used for the analysis. For each bus assessed, a synchronous condenser was modeled to extract reactive power till voltage collapse occurs. The maximum reactive power consumed prior to the voltage collapse is determined.

The post-transient analysis related assumptions made are:

- Loads were modeled as constant MVA during the post-transient time frame
- Reactive power output of the system swing generator was limited to its maximum capability.
- No manual operator intervention was allowed to increase generator MVAR flow.
- Remedial actions such as generator dropping, load shedding or blocking of automatic generator control were not considered for single outages.

The list of outages simulated is provided below:

- Palo Verde – Rudd 500 kV line outage
- Jojoba – Kyrene 500 kV line outage

The monitored buses include:

- Brandow 230 kV
- Browning 230 kV
- Corbell 230 kV
- Kyrene 230 kV
- Pinnacle Peak Center 230 kV
- Pinnacle Peak East 230 kV
- Pinnacle Peak North 230 kV
- Pinnacle Peak West 230 kV
- Rudd 230 kV
- Westwing East 230 kV
- Westwing West 230 kV

For post-transient study, positive reactive margin must be achieved at all buses.

Short Circuit Analysis

Short circuit analysis was performed to determine the impact to the interconnected system of the addition of the project to the APS system. The analysis was performed using the ASPEN One-Liner (V11.10) program and the respective machine data and associated facilities contained in the project's interconnection application.

Fault duties were calculated for both single-phase -to- ground and three-phase faults at the selected substation buses prior to and after the interconnection of the project. The fault contributions from the project were compared to the pre project to determine the incremental impact.

Maximum Load Serving Capability Analysis

Maximum Load Serving Capability (MLSC) analysis was performed for the Phoenix Metro "load pocket". The MLSC analysis is an iterative process which determines the maximum load that can be served reliably for the Phoenix Metro area (combined APS and SRP loads). The MLSC analysis assumes that generation included inside the Phoenix Metro load pocket is online and at maximum

output. The load inside the Phoenix Metro load pocket is increased until a reliability limit is observed, either under N-0 or N-1 conditions. Once the reliability limit is observed, a cutplane of transmission lines which monitors flow into the load pocket is used to determine the MLSC value of the load pocket. The summation of the real power flow on the cutplane elements and online internal load pocket generation is the resulting MLSC value.

STUDY BASE CASE DESCRIPTION AND ASSUMPTIONS

Base Case Assumptions

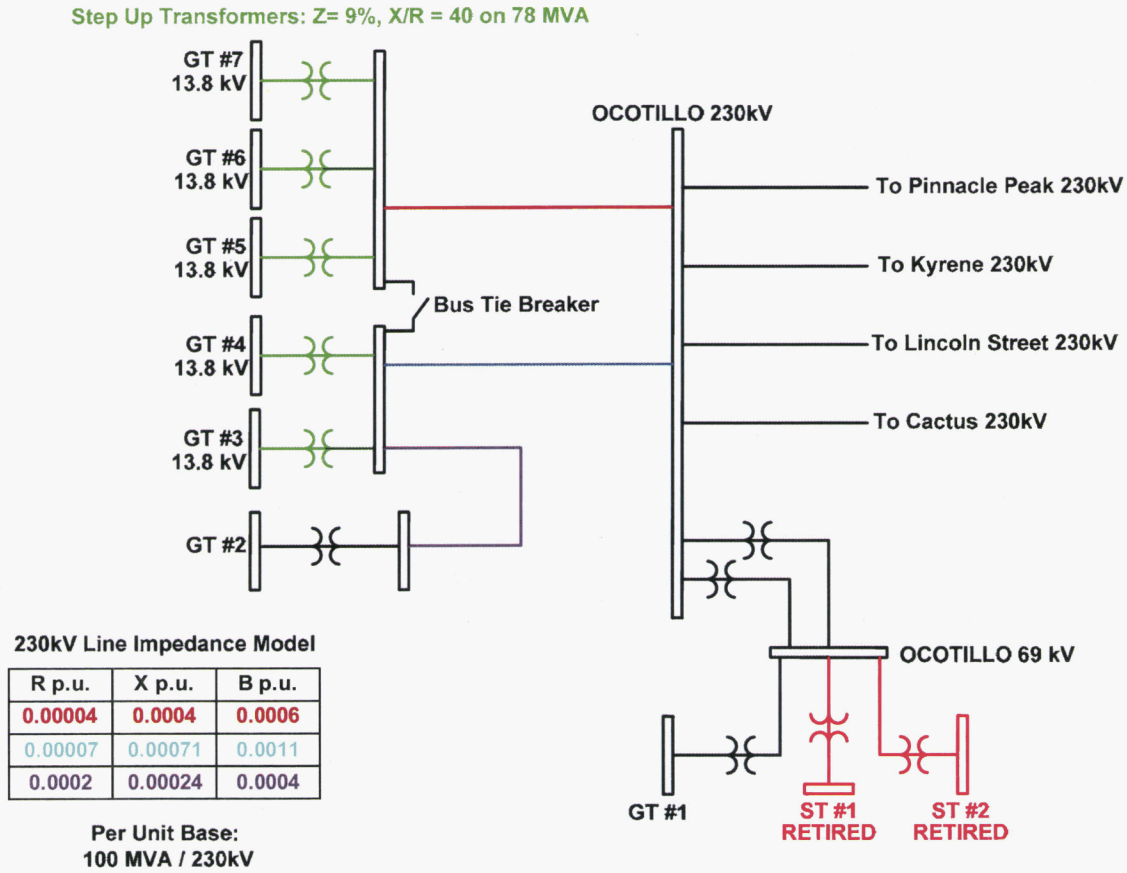
The study was performed using the following power flow model as the starting base cases:

- Heavy summer . . . .sm18#13b.sav .....APS HS 2018 Planning Case
- Heavy summer . . . .sm23#07.sav .....APS HS 2023 Planning Case

The power flow base cases were selected and provided to POWER by APS. The base case was the most recently developed case which represents the system conditions in the year the Ocotillo Modernization Project is expected to take place (2018) and the 2023 future year. Post project base cases were developed based on the proposed system configuration of the new generation at Ocotillo.

Base Cases Studied

Four (4) base cases were developed for the power flow, stability, and post transient stability studies. These base cases include both pre- and post- Ocotillo Modernization Project scenarios for the 2018 and 2023 planning years. The net Ocotillo dispatch for the pre- cases is 330 MW, and 620 MW in the post- cases. The post-project base cases initially include the following changes from the pre-project base case as shown in Figure 5.



R p.u.	X p.u.	B p.u.
0.00004	0.0004	0.0006
0.00007	0.00071	0.0011
0.0002	0.00024	0.0004

Figure 5: Post Project Ocotillo Area Model

The base cases developed and used for the power flow, post transient stability, and stability analysis are summarized in Table 3.

TABLE 3: STUDY BASE CASES

STUDY YEAR	OCOTILLO DISPATCH	PSLF CASE NAME	DESCRIPTION
2018	330 MW	Sm18#13b_330.sav	Planned APS heavy summer configuration without the Ocotillo Modernization Project
2018	620 MW	Sm18#13b_620.sav	Planned APS heavy summer configuration with the Ocotillo Modernization Project
2023	330 MW	Sm23#07_330.sav	Planned APS heavy summer configuration without the Ocotillo Modernization Project
2023	620 MW	Sm23#07_620.sav	Planned APS heavy summer configuration with the Ocotillo Modernization Project

MLSC Cases Studied

For the MLSC analysis, additional base cases are created to evaluate the load serving capability of the Phoenix Metro load pocket. The base cases include the following dispatch scenarios of the Ocotillo generating facility:

- 0 MW
- 330 MW
- 620 MW

Additionally, three system configurations are studied for the Ocotillo generation dispatch scenarios. These system configurations include:

- All lines in service (ALIS) – no base case outages
- Jojoba – Kyrene 500kV Initially out of service (IOS)
- Palo Verde – Rudd 500kV IOS

The base cases developed for the MLSC analysis is summarized in Table 4.

TABLE 4: MLSC STUDY BASE CASES

STUDY YEAR	OCOTILLO DISPATCH	PSLF CASE NAME	DESCRIPTION
2018	0 MW	Sm18#13b_ALIS_OCO_OFF.sav	All lines in service
2018	330 MW	Sm18#13b_ALIS_OCO_330.sav	All lines in service
2018	620 MW	Sm18#13b_ALIS_OCO_620.sav	All lines in service
2018	0 MW	Sm18#13b_JJKY_OCO_OFF.sav	Jojoba – Kyrene 500kV IOS
2018	330 MW	Sm18#13b_JJKY_OCO_330.sav	Jojoba – Kyrene 500kV IOS
2018	620 MW	Sm18#13b_JJKY_OCO_620.sav	Jojoba – Kyrene 500kV IOS
2018	0 MW	Sm18#13b_PVRD_OCO_OFF.sav	Palo Verde - Rudd 500kV IOS
2018	330 MW	Sm18#13b_PVRD_OCO_330.sav	Palo Verde - Rudd 500kV IOS

TABLE 4: MLSC STUDY BASE CASES			
2018	620 MW	Sm18#13b_PVRD_OCO_620.sav	Palo Verde - Rudd 500kV IOS
2023	0 MW	Sm23#07_ALIS_OCO_OFF.sav	All lines in service
2023	330 MW	Sm23#07_ALIS_OCO_330.sav	All lines in service
2023	620 MW	Sm23#07_ALIS_OCO_620.sav	All lines in service
2023	0 MW	Sm23#07_JJKY_OCO_OFF.sav	Jojoba – Kyrene 500kV IOS
2023	330 MW	Sm23#07_JJKY_OCO_330.sav	Jojoba – Kyrene 500kV IOS
2023	620 MW	Sm23#07_JJKY_OCO_620.sav	Jojoba – Kyrene 500kV IOS
2023	0 MW	Sm23#07_PVRD_OCO_OFF.sav	Palo Verde - Rudd 500kV IOS
2023	330 MW	Sm23#07_PVRD_OCO_330.sav	Palo Verde - Rudd 500kV IOS
2023	620 MW	Sm23#07_PVRD_OCO_620.sav	Palo Verde - Rudd 500kV IOS

Dynamic Models

Dynamic data files "18hs21_OCO.dyd" and "23hs11_OCO.dyd" developed for use with the base cases and used for the transient stability analysis. The stability model used for the project was supplied and implemented in the study. The dynamic models used for the new Ocotillo generation units are shown in Appendix C.

Dynamic model parameters for the generator model and exciter model were supplied by APS. The following assumptions were used:

- For the generator model, the gentpf PSLF model is utilized.
  - The supplied data from APS only included saturated reactance values, and the model requires unsaturated values. For this analysis, the supplied saturated values were modeled.
  - The only inertia value submitted was the generator inertia which was 0.88 sec. No turbine or compressor inertia values were submitted. Therefore, the inertia constant used for the analysis is approximated to be 4 sec, which is in the standard range for this type of generator.
- For the exciter model, the esac8b PSLF model is utilized. The parameters are taken directly from the supplied data.
- Governor (ieeeg1) and power system stabilizer (pss2a) model parameters are utilized in the study. Typical model parameters are used for both of these models.

Dynamic data developed and studied in this report includes typical modeling and parameters of the new Ocotillo generation units. Study results will not be significantly different when the generator parameters of the real units are determined in the generator testing process.

Short Circuit Models

The model for the APS Project was developed to accommodate the development of the Project as five GE LMS 100 gas turbines and related facilities. The detailed assumptions of the short circuit model for the Project are listed below.

Generator Step-Up Transformer (each – five total):
13.8/230kV, Delta-Wye-solid grounded
78/97/130 MVA (55 deg C)
X = 9%, X0 = 9% (78 MVA base)
X/R = 50

Generator Data (each – five total, G3 – G7)
Terminal Voltage: 13.8kV
MVA Rating: 190.47 MVA
Subtransient Reactance = X"d = 0.174 p.u. (190.47 MVA base)

G5 – G7 230kV Transmission Line (North): (100MVA base, 0.6 miles in length, 2-954ACSR per phase)
R: 0.00004 X: 0.00040
R0: 0.00032 X0: 0.00134
G2 – G4 230kV Transmission Line (South): (100MVA base, 0.34 miles in length, 2-954ACSR per phase)
R: 0.00007 X: 0.00071
R0: 0.00057 X0: 0.00238

The existing G2 facilities were modified to be directly connected to the new G2-G4 230kV switching station (versus connected to the existing Ocotillo 230kV station). The following is the tie line assumptions to tie to the new station:

G2 230kV Transmission Line (NEW): (100MVA base, 0.2 miles in length, 2-954ACSR per phase)
R: 0.00002 X: 0.00024
R0: 0.0002 X0: 0.00082

The above models were added to the ASPEN base case based on the assumptions stated above; Figure 6 illustrates the model that was developed in the ASPEN One-Liner post-project case.

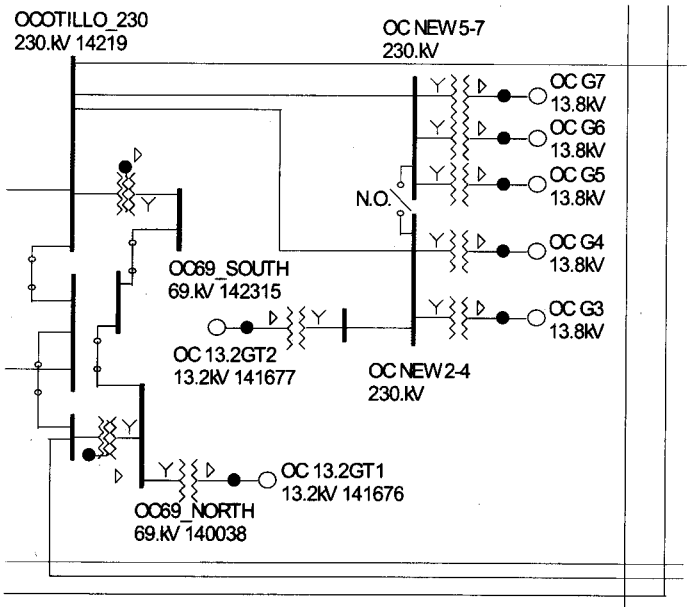


Figure 6: APS Ocotillo Modernization Project ASPEN Model

STUDY RESULTS

This section provides the results obtained by applying the stated study assumptions and the general study methodology. It illustrates the findings associated with the power flow, transient stability, post-transient stability, short circuit and MLSC analyses for study base cases.

Power Flow Analysis Findings

This section details the findings of the power flow analysis. WECC/NERC reliability criteria were used to assess the adequacy of the study results.

2018 Power Flow Study: Normal (N-0) Operating Conditions

For both the 330 MW and 620 MW Ocotillo dispatch scenarios, there are no N-0 thermal overloads observed attributable to the Ocotillo Generation dispatch difference. Flow increases on notable facilities are outlined in Table 5. With the increase of Ocotillo generation, flow on the Country Club-Lincoln Street 230 kV line increases by approximately 16%.

TABLE 5: 2018 – N-0 FLOWS

FACILITY	RATING (MVA)	FLOW (% RATING - CONTINUOUS)	
		OCOTILLO 330 MW	OCOTILLO 620 MW
Lincoln Street-Country Club 230kV	458 MVA	79.7%	96.0%

2018 Power Flow Study: Single Element Outage (N-1) Conditions

No thermal violations are observed under N-1 contingency conditions per WECC/NERC criteria and APS Planning practices. The most critical single element outage for both study cases are listed in Table 6, with the highest flows observed for those contingencies.

No voltage deviation violations are observed under N-1 per WECC/NERC criteria and APS Planning practices.

TABLE 6: 2018 – N-1 FLOWS

OUTAGE	FACILITY	RATING (MVA)	FLOW (% RATING - 30 MIN EMERGENCY)	
			OCOTILLO 330 MW	OCOTILLO 620 MW
Pinnacle Peak – Rogers 230kV #1	Pinnacle Peak – Rogers 230kV #2	411 MVA	94.9%	96.6%
Pinnacle Peak-Cactus 230kV	Cactus – Ocotillo 230kV	412 MVA	69.3%	77.6%
Cactus – Ocotillo 230kV	Pinnacle Peak-Cactus 230kV	463 MVA	96.7%	98.7%
Palo Verde – Rudd 500kV	Kyrene – Anderson 230kV	868 MVA	58.9%	60.5%

2018 Power Flow Study: Multiple Element Outage (N-2+) Conditions

No thermal violations are observed under credible multiple contingency conditions per WECC/NERC criteria and APS Planning practices. The most critical multiple element outages for both study cases are listed in Table 7 with the highest flows observed for those contingencies.

No voltage deviation violations are observed under multiple contingency conditions per WECC/NERC criteria and APS Planning practices.

TABLE 7: 2018 – MULTIPLE CONTINGENCY FLOW

OUTAGE	FACILITY	RATING (MVA)	FLOW (% RATING - 30 MIN EMERGENCY)	
			OCOTILLO 330 MW	OCOTILLO 620 MW
Jojoba – Kyrene 500kV & Palo Verde – Rudd 500kV	Gila River – TS4 230kV	545 MVA	97.91%	95.7%
	Sun Valley 500/230kV	598 MVA	97.3%	94.9%
	PPK WAPA – Rogers 230kV	411 MVA	88.6%	99.0%
Coronado – Silverking 500kV & Cholla – Saguaro 500kV	Vail 345/138kV	806 MVA	99.9%	100%

2023 Power Flow Study: Normal (N-0) Operating Conditions

For both the 330 MW and 620 MW Ocotillo dispatch scenarios, there are no N-0 thermal overloads observed attributable to the Ocotillo Generation dispatch difference. Flows on notable facilities are outlined in Table 8. With the increase of Ocotillo generation, flow on the Country Club- Lincoln Street 230kV line increases to near its thermal capability.

TABLE 8: 2023 – N-0 FLOWS

STUDY YEAR	FACILITY	RATING (MVA)	FLOW (% RATING - CONTINUOUS)	
			OCOTILLO 330 MW	OCOTILLO 620 MW
2023	Lincoln Street – Country Club 230kV	458 MVA	85%	99.8%
2023	Cactus – Ocotillo 230kV	373 MVA	31.3%	43.5%
2023	Pinnacle Peak - Cactus 230kV	373 MVA	93.4 %	82.4%

2023 Power Flow Study: Single Element Outage (N-1) Conditions

No thermal violations are observed under N-1 contingency conditions per WECC/NERC criteria and APS Planning practices. The most critical single element outage for both study cases are listed in Table 9 with the highest flows observed for those contingencies.

No voltage deviation violations are observed under N-1 per WECC/NERC criteria and APS Planning practices.

TABLE 9: 2023 – N-1 FLOWS

OUTAGE	FACILITY	RATING (MVA)	FLOW (% RATING - 30 MIN EMERGENCY)	
			OCOTILLO 330 MW	OCOTILLO 620 MW
Pinnacle Peak - Cactus 230kV	Cactus – Ocotillo 230kV	412 MVA	81.6%	90.2%
Palo Verde – Rudd 500kV	Kyrene - Anderson 230kV	661 MVA	94.4%	96.6%
Cactus – Ocotillo 230kV	Pinnacle Peak - Cactus 230kV	463 MVA	91.2%	93.0%
Pinnacle Peak – Rogers 230kV #1	Pinnacle Peak – Rogers 230kV #2	411 MVA	55.7%	57.3%

2023 Power Flow Study: Multiple Element Outage (N-2+) Conditions

Thermal violations are observed under credible multiple contingency conditions per WECC/NERC criteria and APS Planning practices. The observed thermal violations are pre-existing and the impact of the Ocotillo Modernization Project impact is documented in Table 10. In addition, the most critical multiple element outage for both study cases are listed in Table 10.

No voltage deviation violations are observed under multiple contingency conditions per WECC/NERC criteria and APS Planning practices.

TABLE 10: 2023 – MULTIPLE CONTINGENCY FLOW

OUTAGE	FACILITY	RATING (MVA)	FLOW (% RATING - 30 MIN EMERGENCY)	
			OCOTILLO 330 MW	OCOTILLO 620 MW
Jojoba – Kyrene 500kV & Palo Verde – Rudd 500kV	Gila River – TS4 230kV	545 MVA	103.1%	100.1%
Coronado – Silverking 500kV & Cholla – Saguaro 500kV	Vail 345/138kV	806 MVA	97.1%	97.3%
	TechPark – Vail 138kV	287 MVA	110.8%	110.8%
Westwing – Palo Verde 500kV & Palo Verde – Rudd 500kV	Kyrene-Anderson 230kV	661 MVA	102.2%	104.1%

Transient Stability Analysis Findings

Stable and adequately damped transient stability performances were achieved following all of the outages simulated. No transient voltage dip violation or transient frequency violation was observed following any of the outages. Key findings from the transient stability analysis using both the heavy summer pre- and post-project base cases are:

- No transient voltage dip violations were observed per WECC/NERC transient voltage dip for all the outages simulated.
- No transient frequency criteria violations were observed for all the outages simulated.

Transient plots at selected critical buses following each of the simulated outages can be found in Attachment A.

Post-Transient Analysis Findings

For both the 2018 and 2023 study years, the post transient analysis findings resulted in adequate positive reactive margin on all monitored busses. The reactive power margin results are shown in Tables 11 and 12. The Ocotillo Modernization Project results in increased VAR margin at all monitored busses.

TABLE 11: 2018 POST-TRANSIENT ANALYSIS RESULTS (VAR MARGIN)

MONITORED BUS	JOJOBA – KYRENE 500KV OUTAGE (2018)		PALO VERDE - RUDD 500KV OUTAGE (2018)	
	OCOTILLO 330 MW	OCOTILLO 620 MW	OCOTILLO 330 MW	OCOTILLO 620 MW
BRANDOW 230	1441.0	1520.4	1684.3	1755.4
BROWNING 230	1291.1	1322.0	1585.9	1610.1
CORBELL 230	1275.4	1285.2	1503.5	1610.4
KYR-WEST 230	1558.1	1668.0	1836.9	2003.1
RUDD 230	1972.1	2130.2	1667.1	1801.9
WESTWNGE 230	2022.6	2139.8	2065.2	2155.6
WESTWNGW 230	2253.3	2433.6	2264.3	2456.5
PPAPS_C 230	1228.0	1244.5	1228.6	1240.0
PPAPS_E 230	1454.3	1502.0	1462.3	1505.4
PPAPS_N 230	1789.3	1982.0	1918.1	2129.5
PPAPS_W 230	1798.4	1971.4	1930.9	2125.7

TABLE 12: 2023 POST-TRANSIENT ANALYSIS RESULTS (VAR MARGIN)

MONITORED BUS	JOJOBA – KYRENE 500KV OUTAGE (2023)		PALO VERDE - RUDD 500KV OUTAGE (2023)	
	OCOTILLO 330 MW	OCOTILLO 620 MW	OCOTILLO 330 MW	OCOTILLO 620 MW
BRANDOW 230	1293.0	1429.3	1367.4	1533.4
BROWNING 230	1359.0	1448.6	1547.6	1652.5
CORBELL 230	1286.6	1409.0	1424.1	1527.3
KYR-WEST 230	1402.3	1606.7	1460.4	1695.1
RUDD 230	1558.3	1668.6	1131.4	1204.4
WESTWNGE 230	1590.7	1729.3	1491.2	1621.8
WESTWNGW 230	1769.9	1926.4	1605.4	1757.3
PPAPS_C 230	1031.8	1047.0	977.0	1030.8
PPAPS_E 230	1217.0	1324.7	1137.1	1265.8
PPAPS_N 230	1458.0	1667.4	1402.7	1589.2
PPAPS_W 230	1469.0	1637.4	1416.3	1581.4

Short Circuit Analysis Findings

The incremental fault duty results from the short circuit study are show in Table 13.

TABLE 13: SUMMARY OF SHORT CIRCUIT ANALYSIS RESULTS

SUBSTATION LOCATION	KV	MINIMUM BREAKER CAPABILITY (kA)	PRE-PROJECT BASE CASE		POST-PROJECT CASE		INCREMENTAL	
			3LG Phase (A)	1LG Ground (A)	3LG Phase (A)	1LG Ground (A)	3LG Phase (A)	1LG Ground (A)
Ocotillo (POI)	230	50 kA	26323	23558	31048	30223	4724	6665
Ocotillo	69	50 kA	24154	30164	17821	21849	-6333	-8314
Ward	230		30121	26739	30412	27024	290	285
Ward	69		24637	27721	24695	27788	57	67
Brandow	230		33888	31059	34257	31455	368	395
Brandow	69		36836	29054	36964	29133	128	79.9

Maximum Load Serving Capability (MLSC) Analysis Findings

The MSLC analysis is conducted by scaling load in APS (power flow case zones 142-148) and SRP (power flow case zones 801-817) areas of the Phoenix Metropolitan area with all available generation online in the Phoenix Metropolitan area. The load is scaled by applying a total increment of load

allocated by 42% to the APS zones and 58% to the SRP zones. Once the load is scaled, the increase (or decrease) of load is made up by generation resources outside of the Phoenix Metropolitan area. For this study, available generation at the Palo Verde hub is utilized.

Results of the MLSC study are shown in Tables 14 and 15. For both study years, the all lines in service (ALIS) study resulted in MLSC values above the forecasted peak load plus margin for the Phoenix-Metro Load Pocket. With regard to the initially out of service (IOS) cases, increased generation at Ocotillo reduces the impact of the MLSC reduction due to the IOS condition. Power flow maps of the MLSC readings are provided in Appendix B.

TABLE 14: 2018 MLSC STUDY RESULTS

PEAK LOAD + MARGIN	13,900 MW			
SCENARIO	**OCOTILLO DISPATCH**	**MLSC**	**OUTAGE**	**LIMITING ELEMENT**
ALIS	0 MW	14,792 MW	N-0	Pinnacle Peak-Cactus 230kV
	330 MW	16,259 MW	West Phoenix - Lincoln Street 230kV	Agua Fria- Glendale 230kV
	620 MW	16,256 MW	Agua Fria- Glendale 230kV	Lincoln Street - Country Club 230kV
JOJOBA – KYRENE 500KV IOS	0 MW	12,815 MW	Pinal C - Duke 500kV	Test Track - Santa Rosa 230kV
	330 MW	13,005 MW	Pinal C - Duke 500kV	Test Track - Santa Rosa 230kV
	620 MW	13,255 MW	Pinal C - Duke 500kV	Test Track - Santa Rosa 230kV
PV-RUDD 500KV IOS	0 MW	13,781 MW	N-0	Pinnacle Peak-Cactus 230kV
	330 MW	15,156 MW	N-0	Pinnacle Peak-Cactus 230kV
	620 MW	15,353 MW	Palm Valley - Rudd 230kV	Liberty - Rudd 230kV

TABLE 15: 2023 MLSC STUDY RESULTS

PEAK LOAD + MARGIN	14,850 MW			
SCENARIO	**OCOTILLO DISPATCH**	**MLSC**	**OUTAGE**	**LIMITING ELEMENT**
ALIS	0 MW	14,901 MW	West Phoenix - Lincoln Street 230kV	Agua Fria - Glendale 230kV
	330 MW	16,058 MW	Cactus - Ocotillo 230kV	Pinnacle Peak - Cactus 230kV
	620 MW	15,572 MW	N-0	Lincoln Street - Country Club 230kV
JOJOBA – KYRENE 500KV IOS	0 MW	12,703 MW	Pinal C - Duke 500kV	Test Track - Santa Rosa - 230kV
	330 MW	12,906 MW	Pinal C - Duke 500kV	Test Track - Santa Rosa - 230kV
	620 MW	13,131 MW	Pinal C - Duke 500kV	Test Track - Santa Rosa - 230kV
PV-RUDD 500KV IOS	0 MW	14,122 MW	N-0	Pinnacle Peak - Cactus 230kV
	330 MW	15,287 MW	N-0	Pinnacle Peak - Cactus 230kV
	620 MW	15,470 MW	Palm Valley - Rudd 230kV	Liberty - Rudd 230kV

CONCLUSIONS

Based on the power flow, transient stability, post-transient, and short circuit studies, mitigation plans are not necessary for the Ocotillo Modernization Project. The MLSC studies show that under the all lines in service (ALIS) scenario, addition of the Ocotillo Modernization Project results in MLSC values above the forecasted peak load (plus 800 MW margin) of the Phoenix Metro load pocket, which illustrates the continued ability of the Arizona transmission system to reliably serve the forecasted Phoenix load in future years. In addition, the Ocotillo Modernization Project provides an added benefit to the transmission system with additional MLSC capability under the studied IOS conditions. This allows operators at APS and SRP additional flexibility to make system adjustments in the event of a long term outage of one of the major 500kV circuits that serves the Phoenix Metro load pocket.

APPENDIX A: POWER FLOW MAPS: OCOTILLO MODERNIZATION PROJECT STUDY

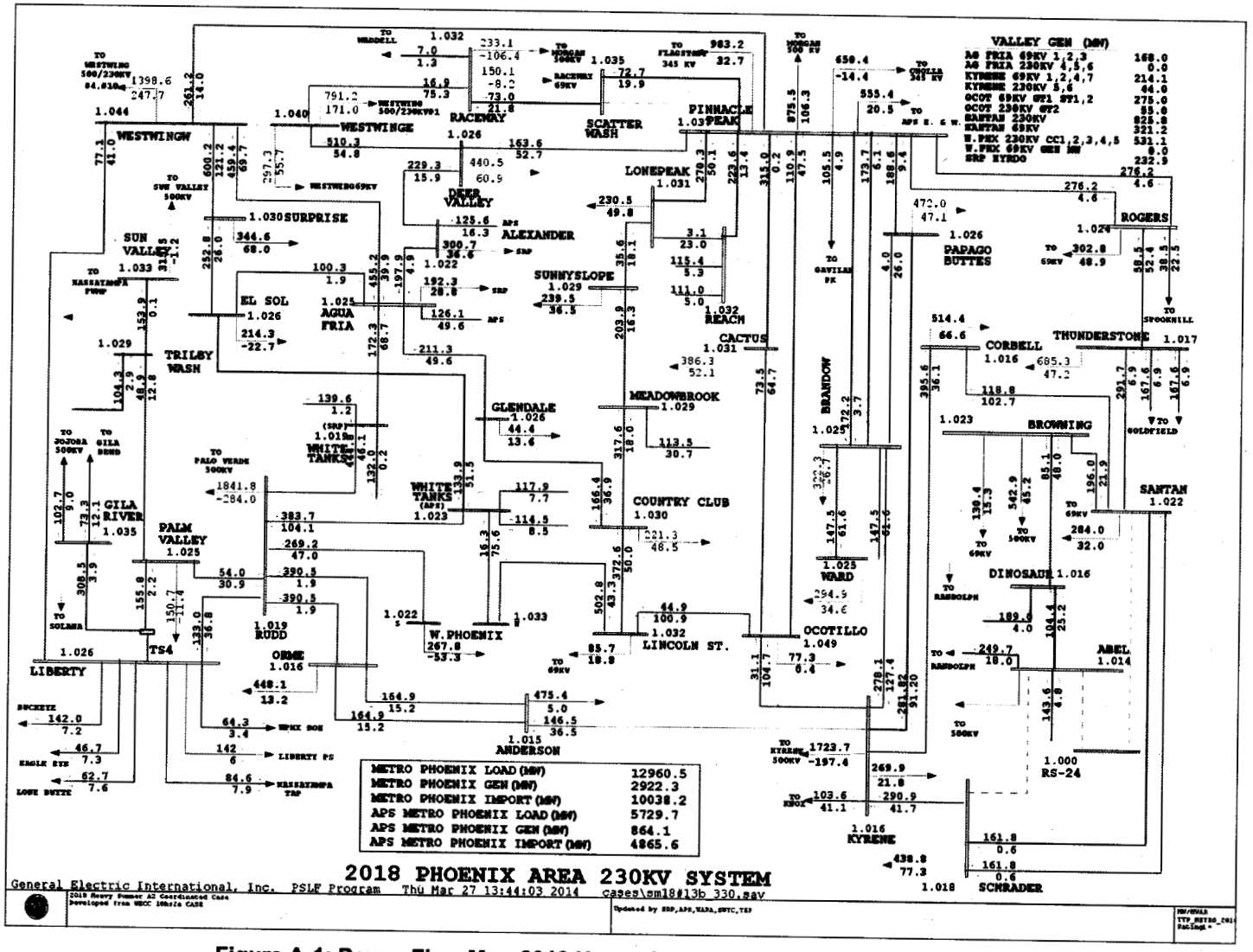


Figure A-1: Power Flow Map-2018 Heavy Summer Ocotillo 330MW Base Case

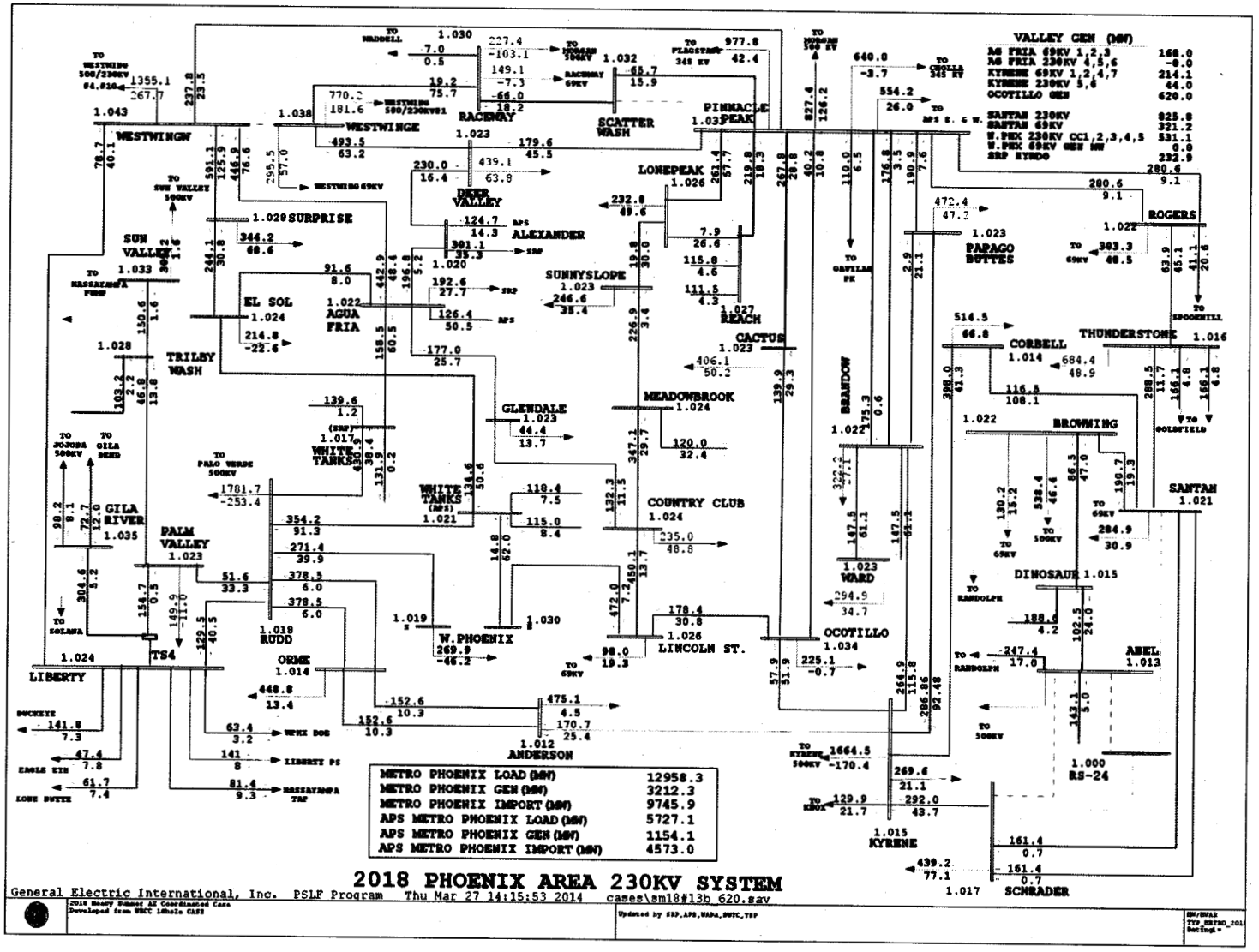


Figure A-2: Power Flow Map-2018 Heavy Summer Ocotillo 620MW Base Case

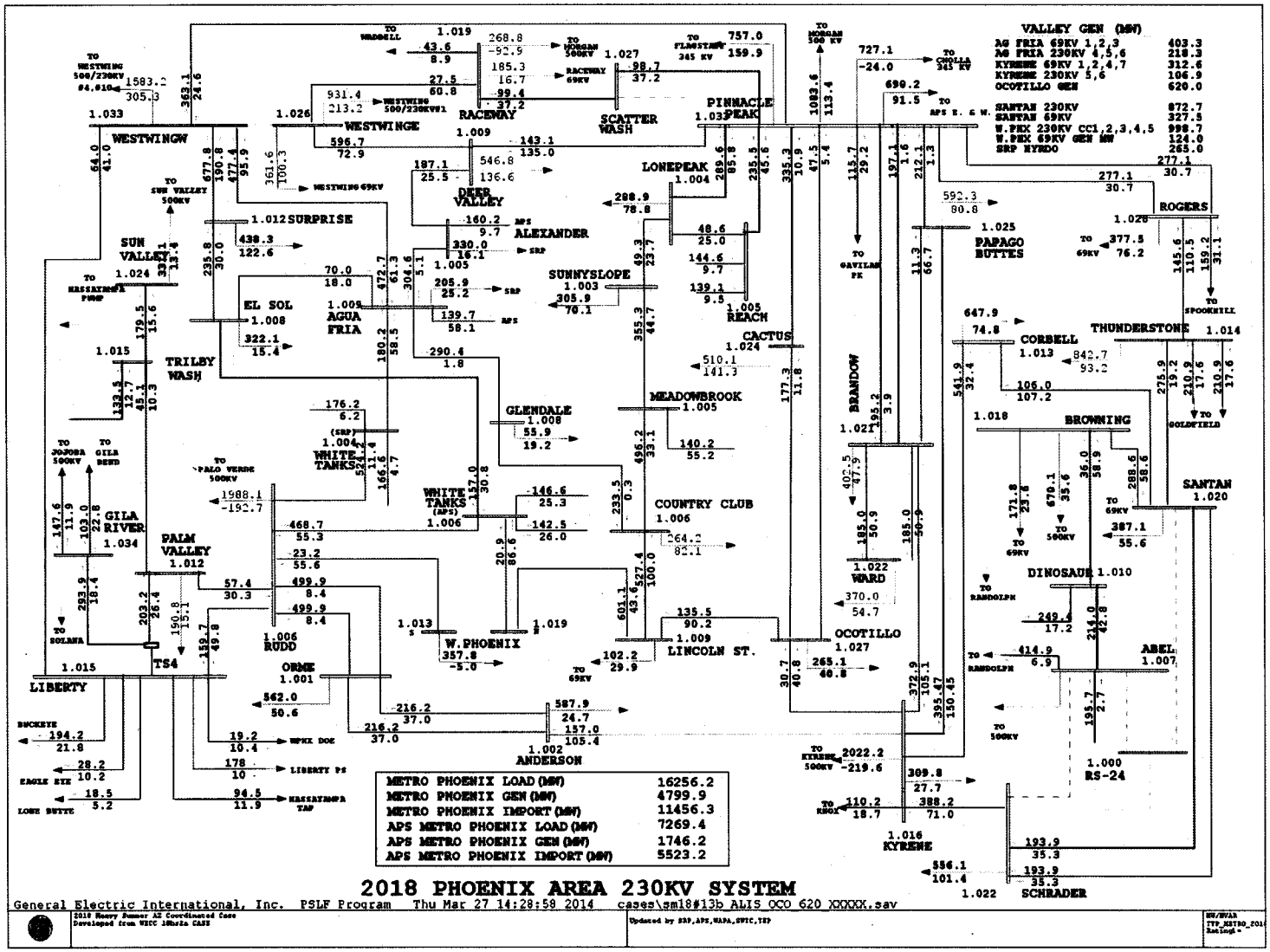


Figure A-3: Power Flow Map-2023 Heavy Summer Ocotillo 330MW Base Case

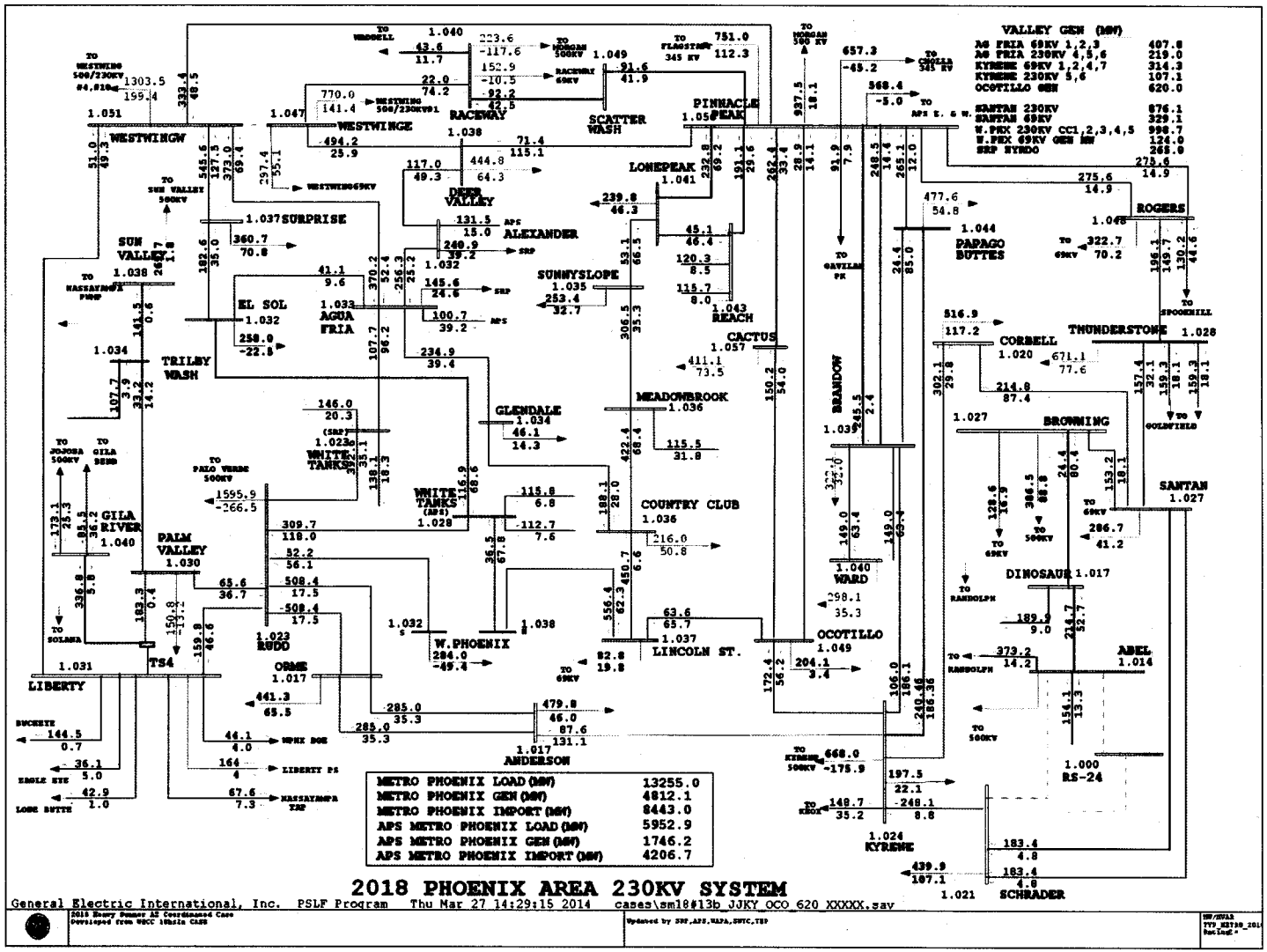


Figure A-4: Power Flow Map-2023 Heavy Summer Ocotillo 620MW Base Case

APPENDIX B: MLSC - POWER FLOW MAPS: OCOTILLO MODERNIZATION PROJECT STUDY

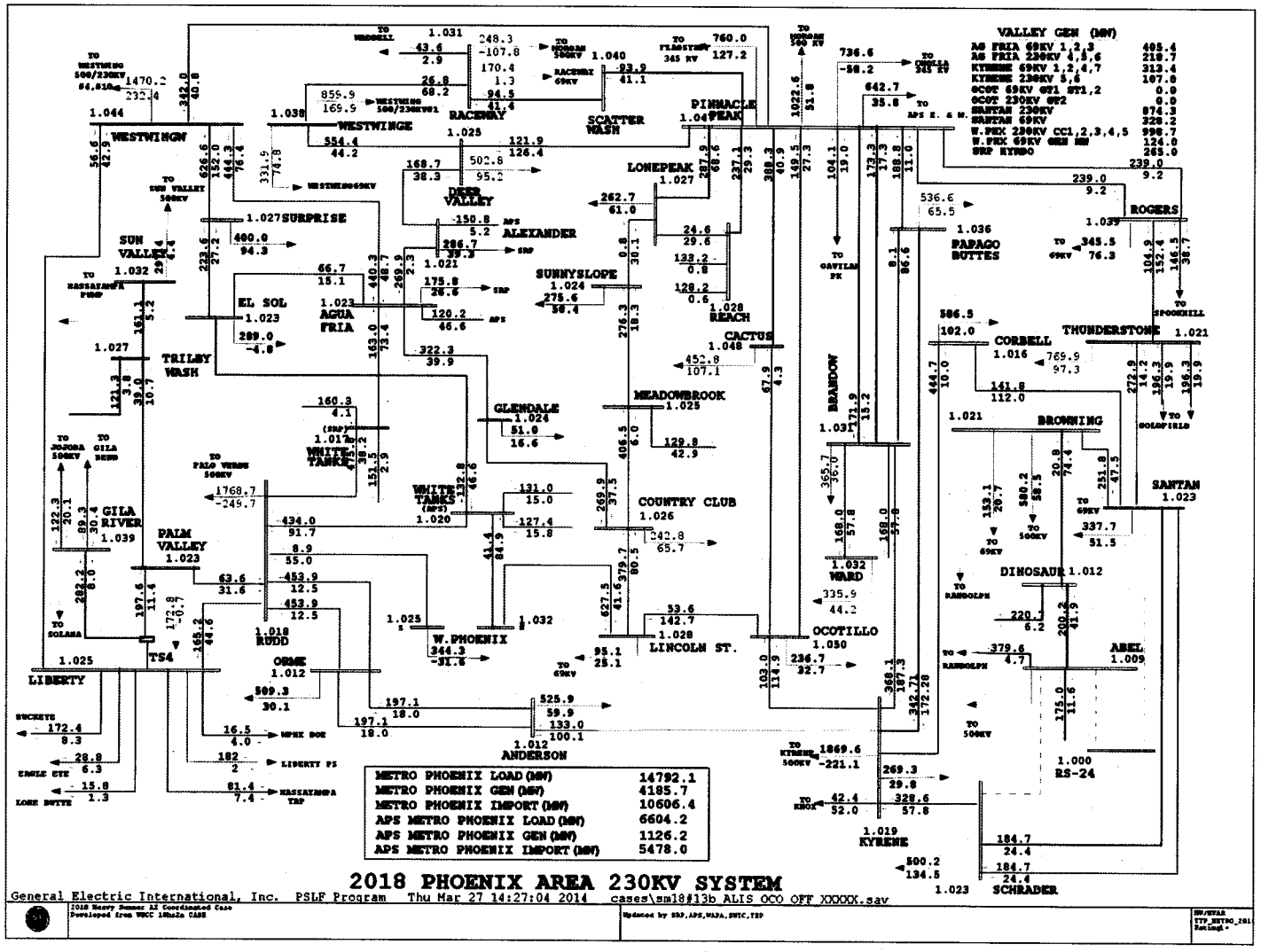


Figure B-1: Power Flow Map-2018 Ocotillo 0MW ALIS

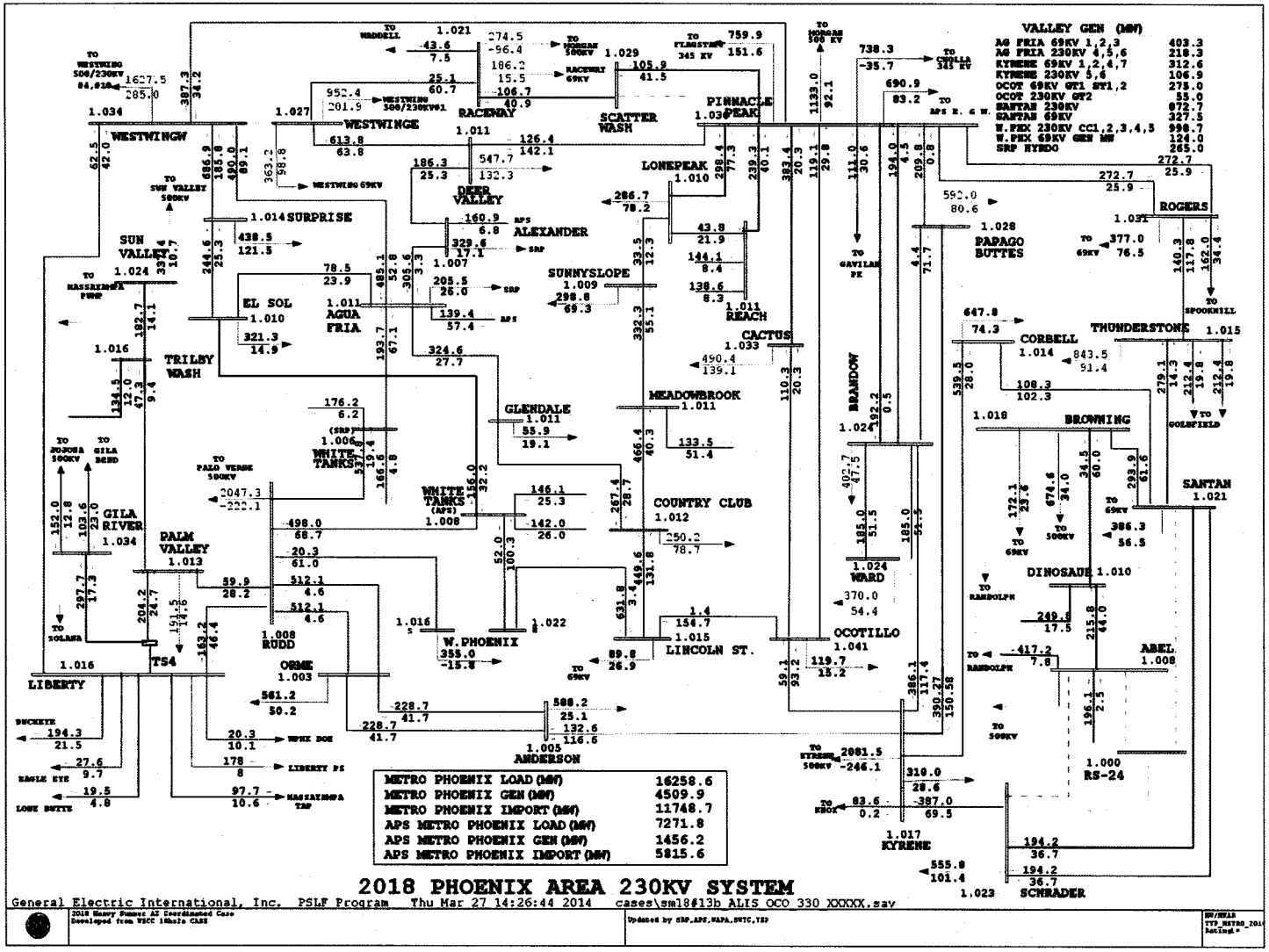


Figure B-2: Power Flow Map-2018 Ocotillo 330MW ALIS

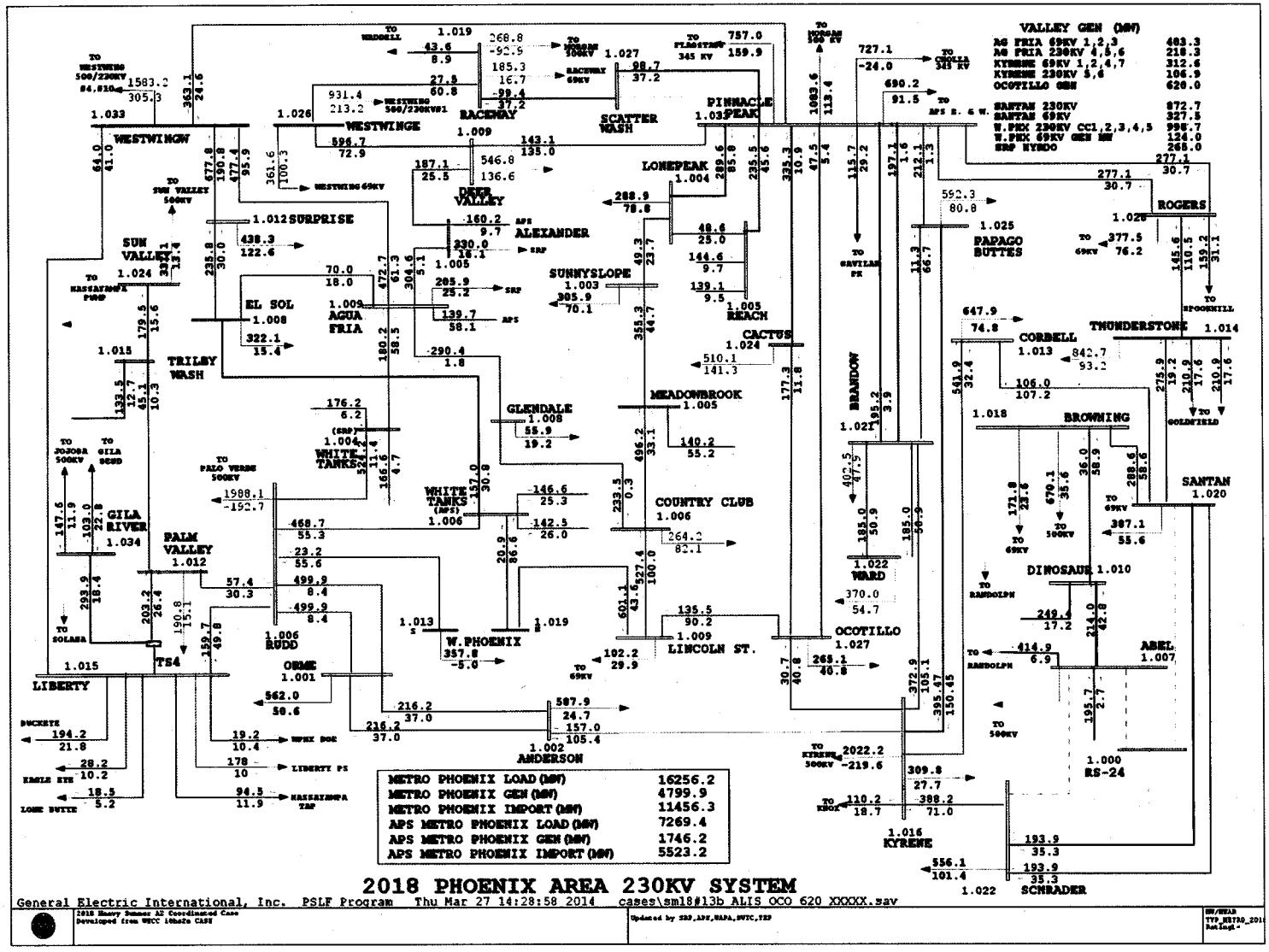


Figure B-3: Power Flow Map-2018 Ocotillo 620MW ALIS

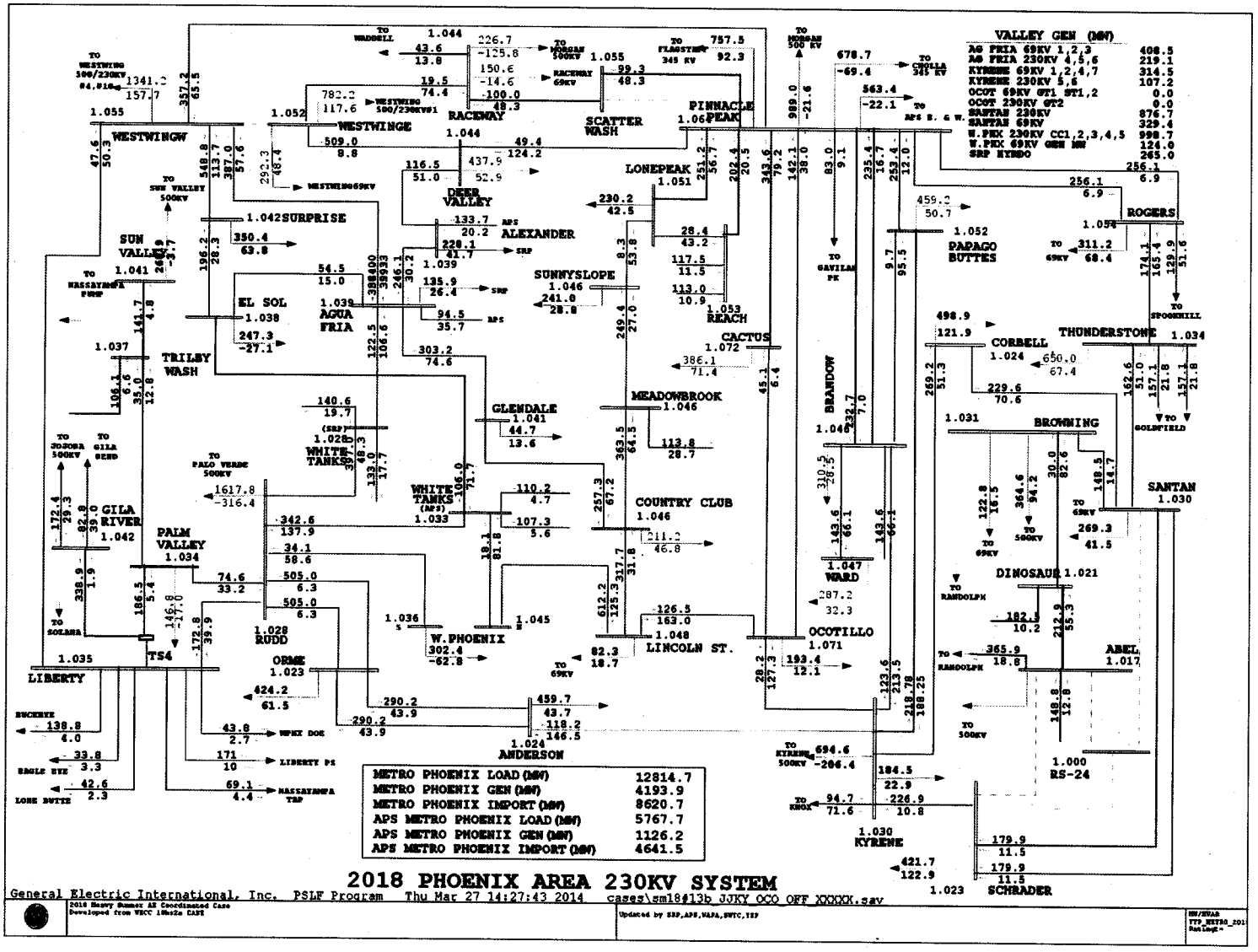


Figure B-4: Power Flow Map-2018 Ocotillo 0MW Jojoba-Kyrene 500kV IOS

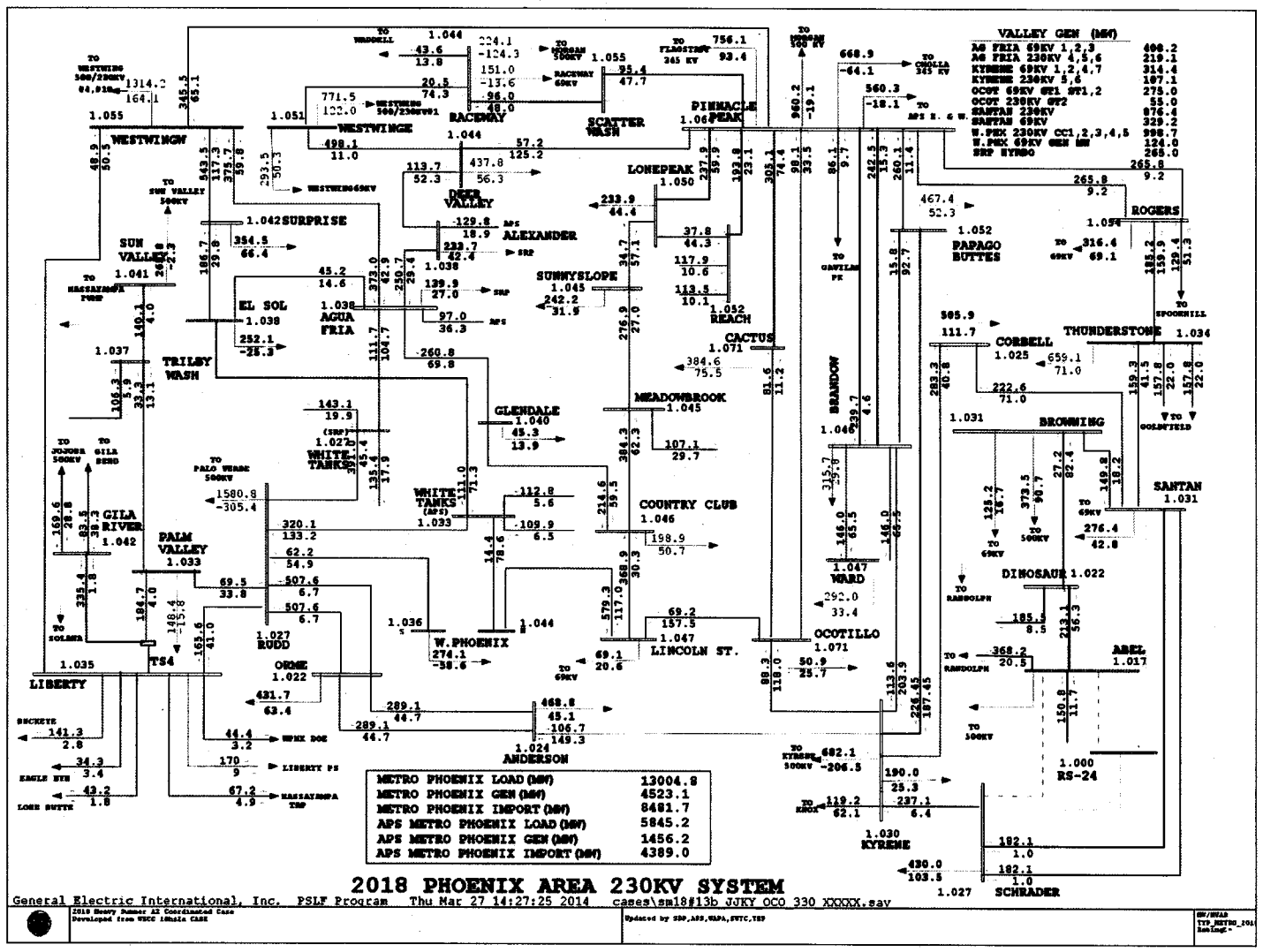


Figure B-5: Power Flow Map-2018 Ocotillo 330MW Jojoba-Kyrene 500kV IOS

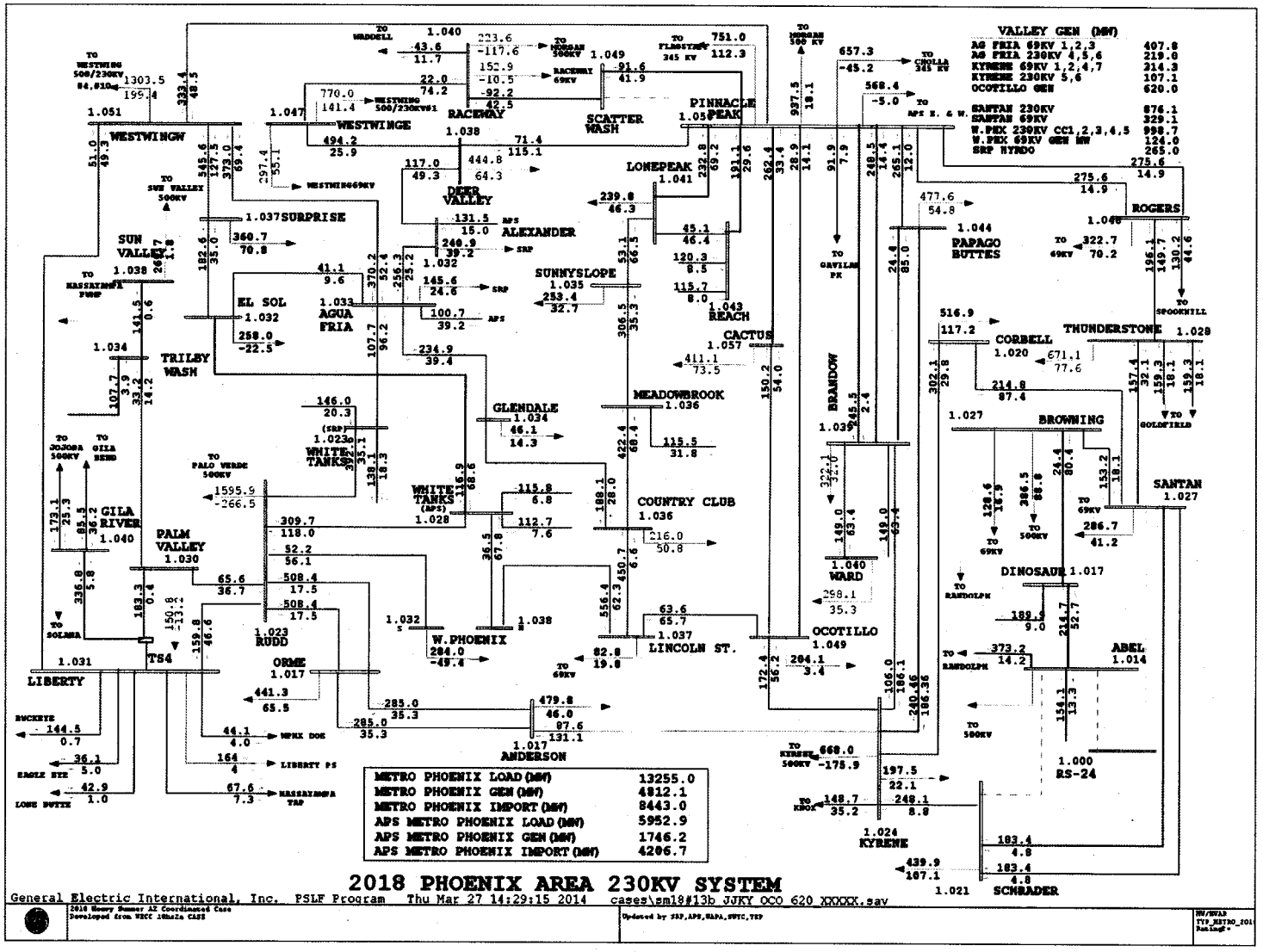


Figure B-6: Power Flow Map-2018 Ocotillo 620MW Jojoba-Kyrene 500kV IOS

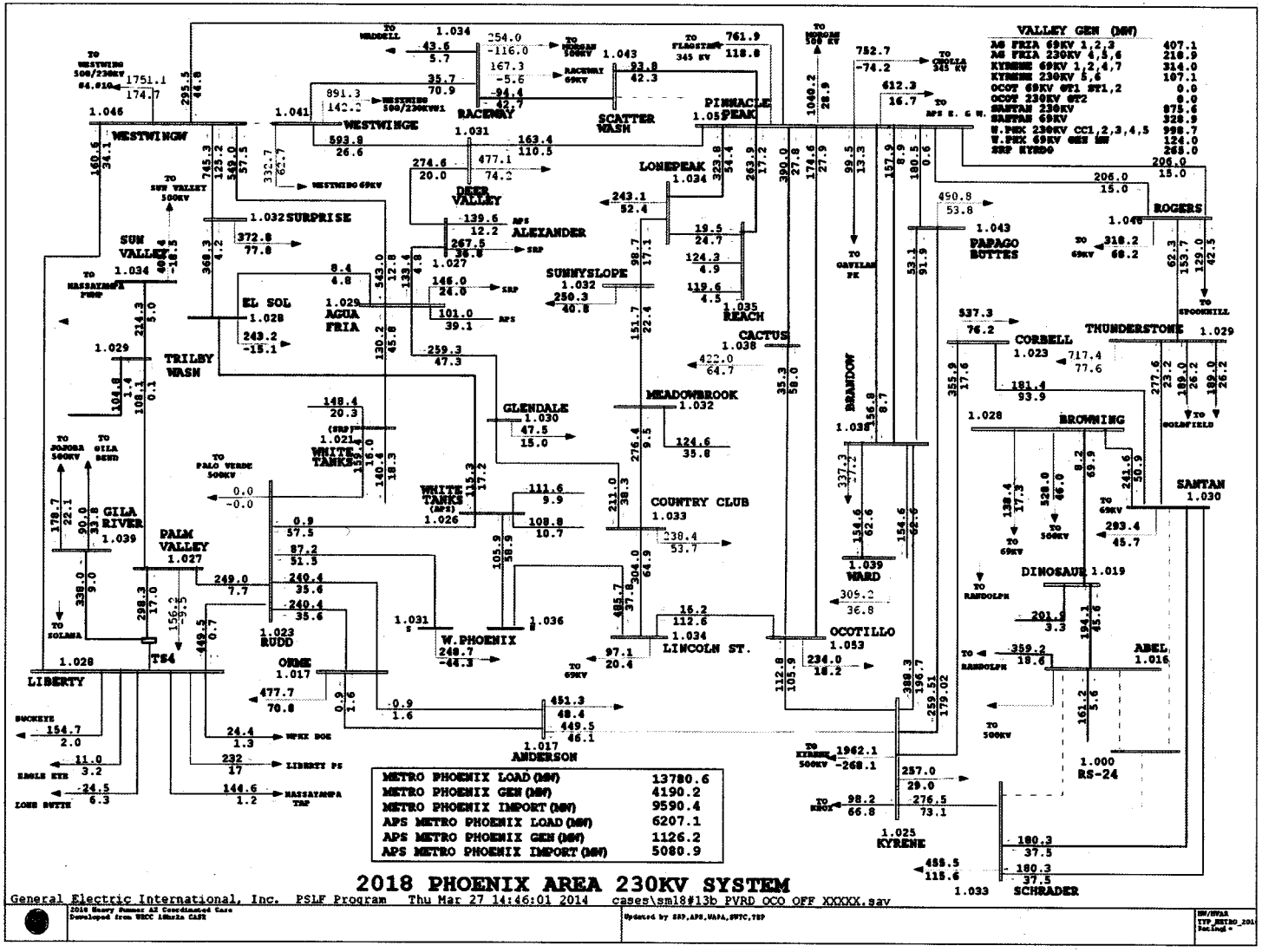


Figure B-7: Power Flow Map-2018 Ocotillo 0MW Palo Verde- Rudd 500kV IOS

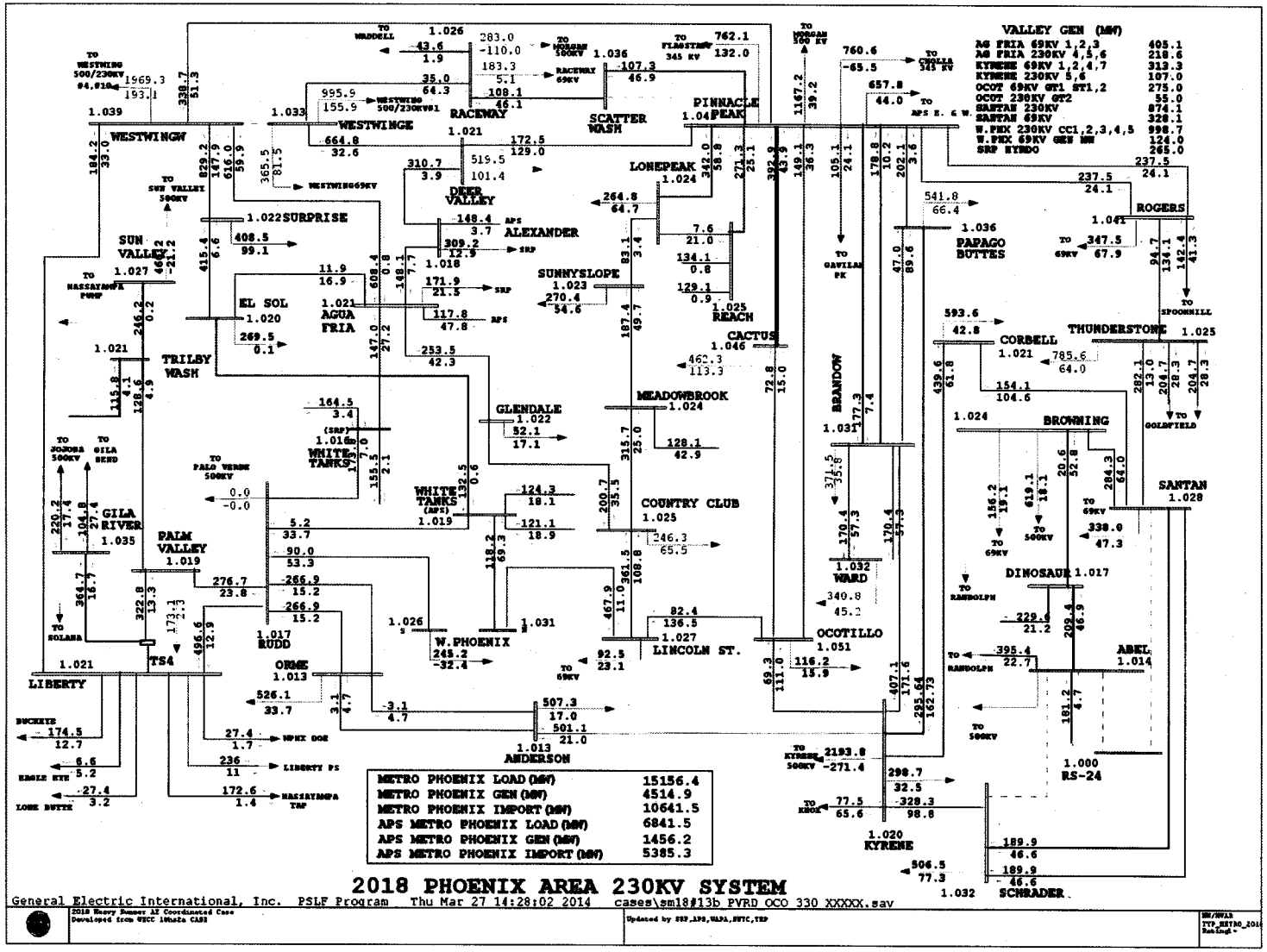


Figure B-8: Power Flow Map-2018 Ocotillo 330MW Palo Verde- Rudd 500kV IOS

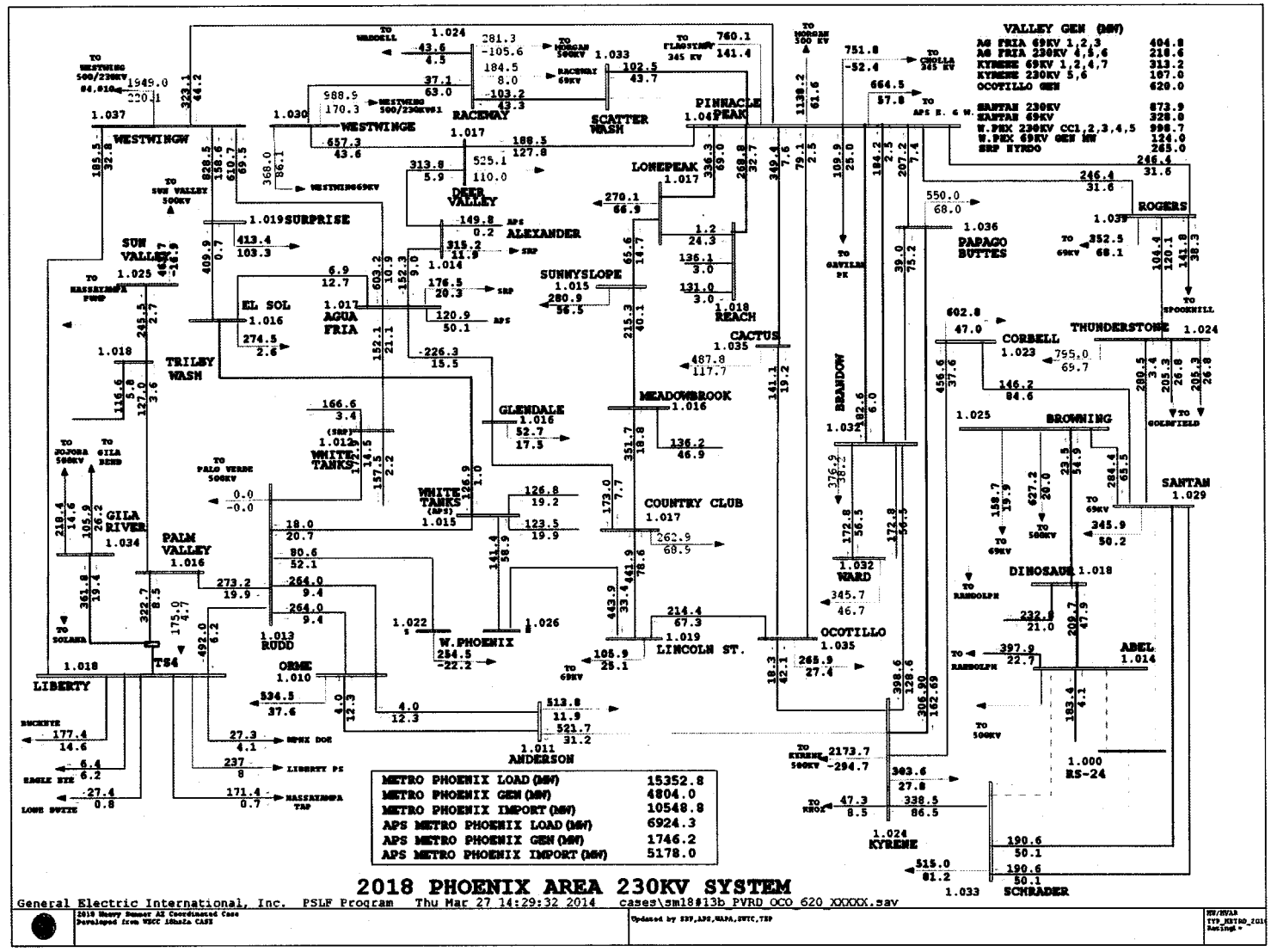


Figure B-9: Power Flow Map-2018 Ocotillo 620MW Palo Verde- Rudd 500kV IOS

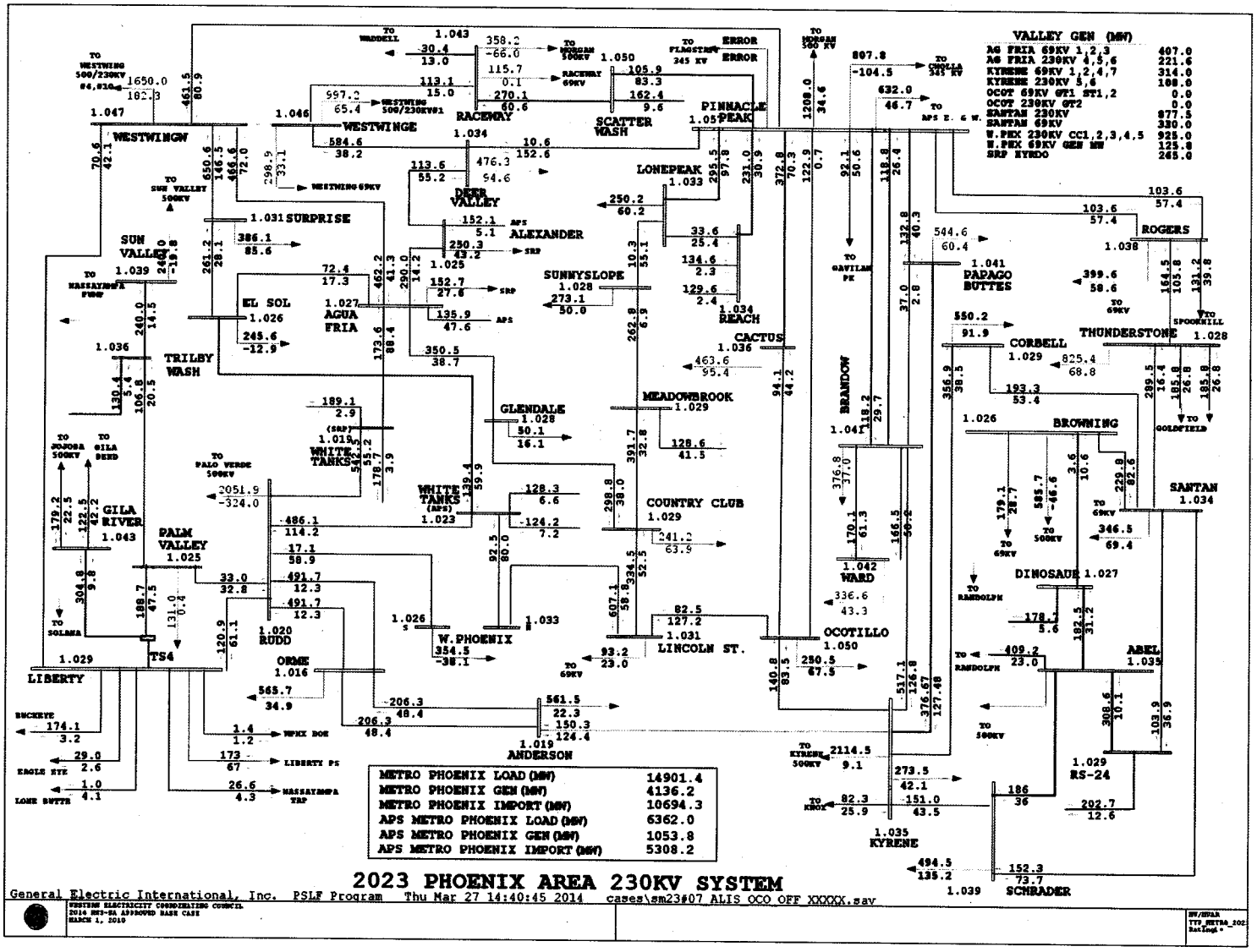


Figure B-10: Power Flow Map-2023 Ocotillo 0MW ALIS

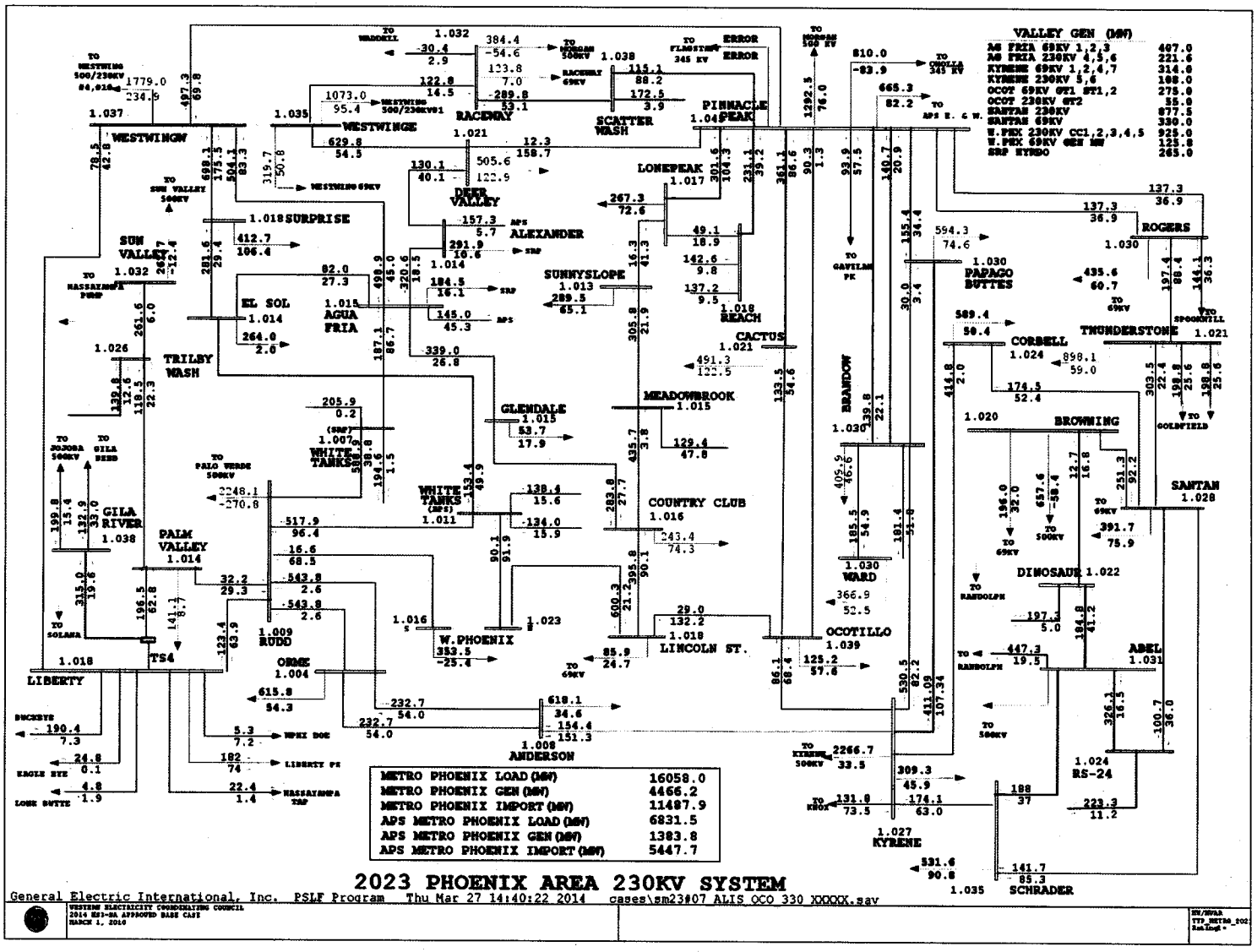


Figure B-11: Power Flow Map-2023 Ocotillo 330MW ALIS

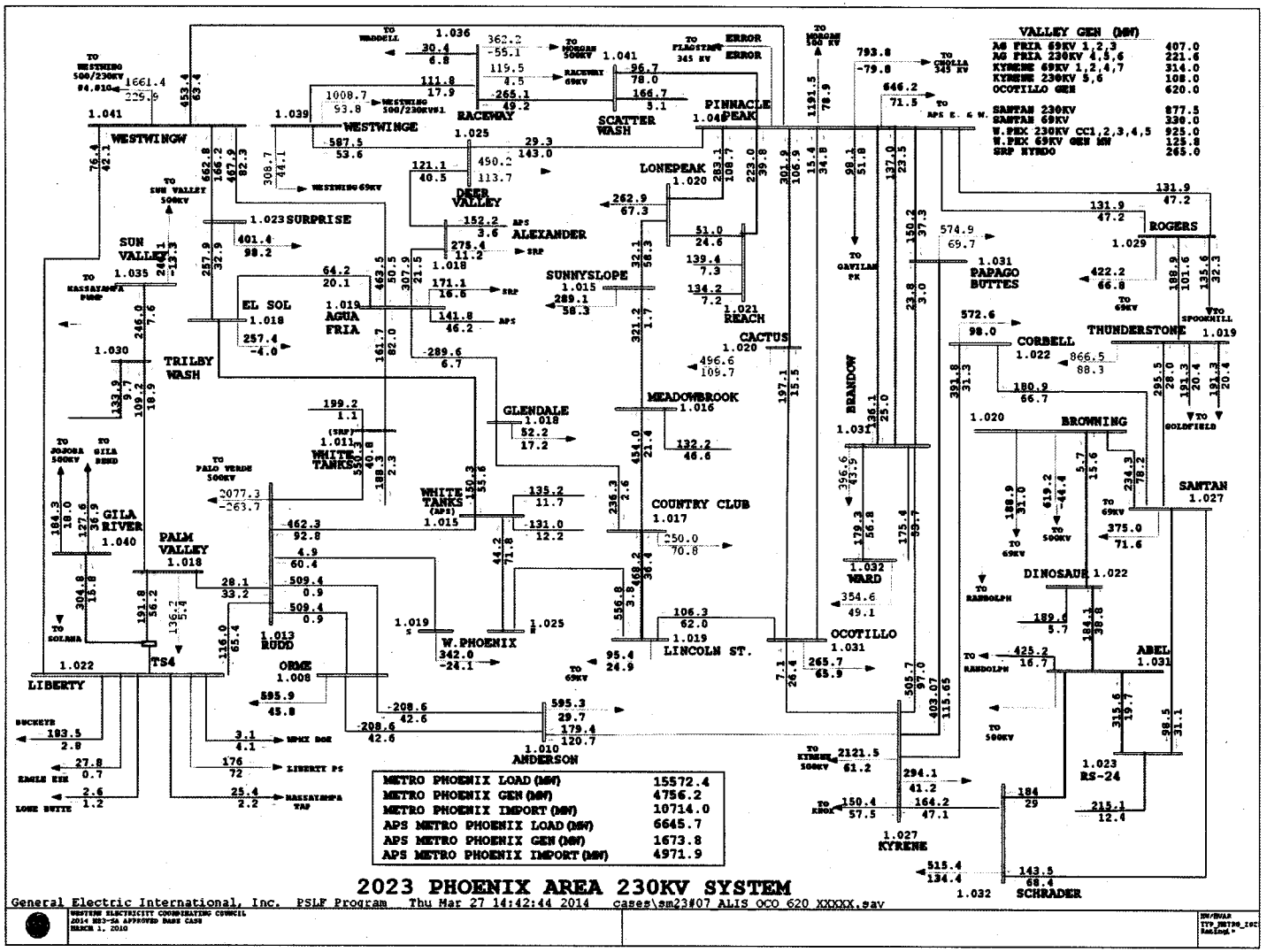


Figure B-12: Power Flow Map-2023 Ocotillo 620MW ALIS

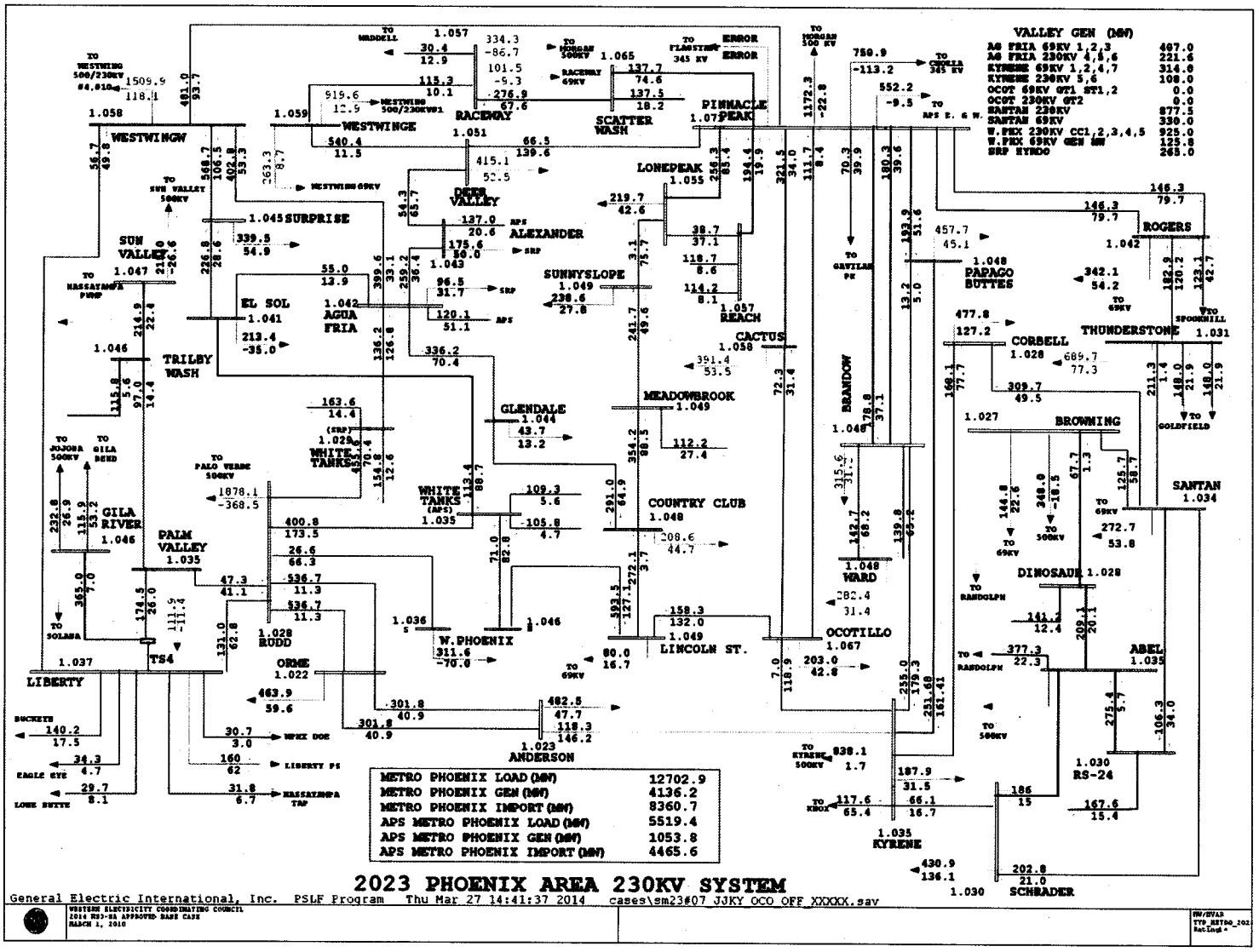


Figure B-13: Power Flow Map-2023 Ocotillo 0MW Jojoba-Kyrene 500kV IOS

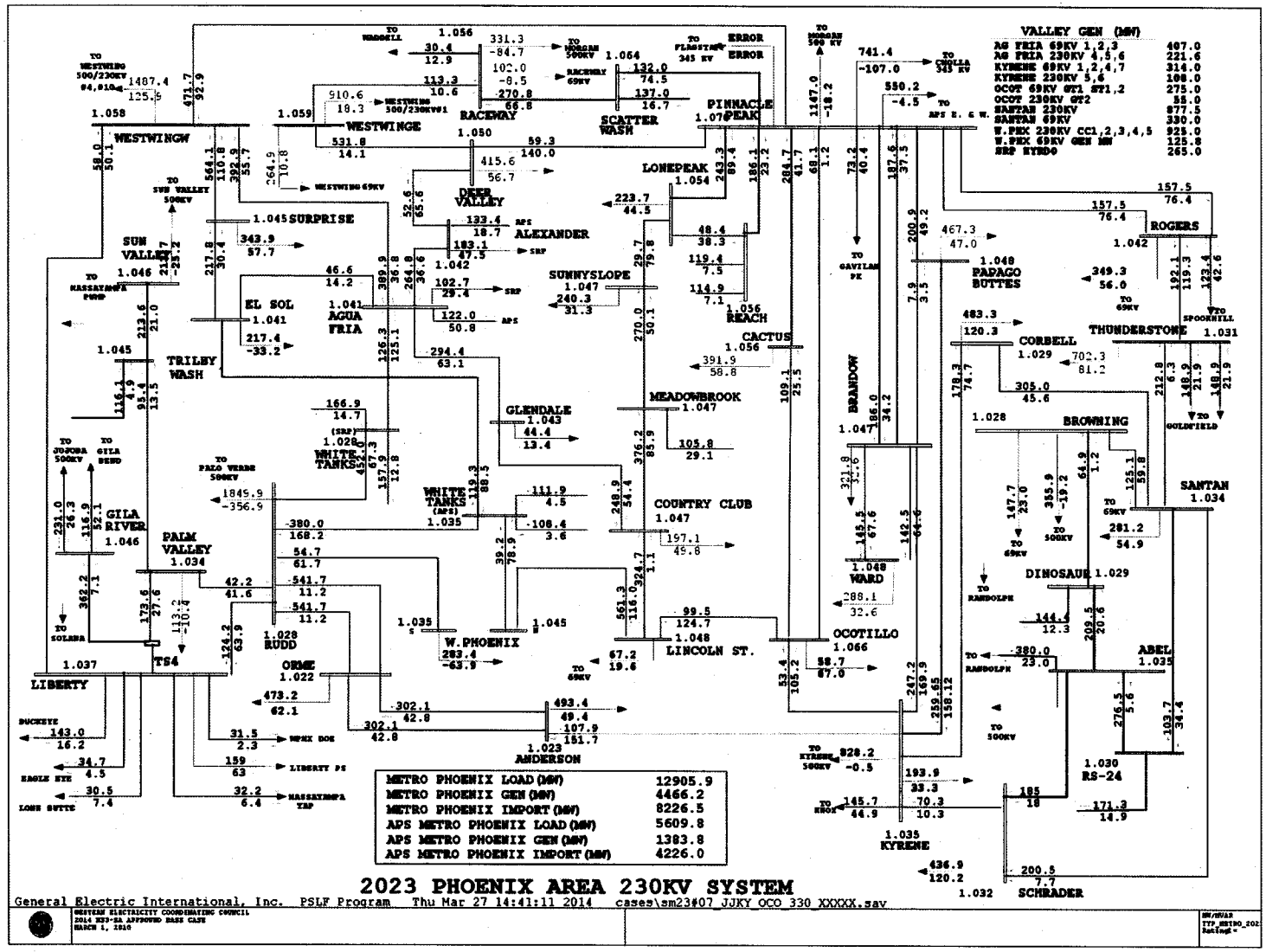


Figure B-14: Power Flow Map-2023 Ocotillo 330MW Jojoba-Kyrene 500kV IOS

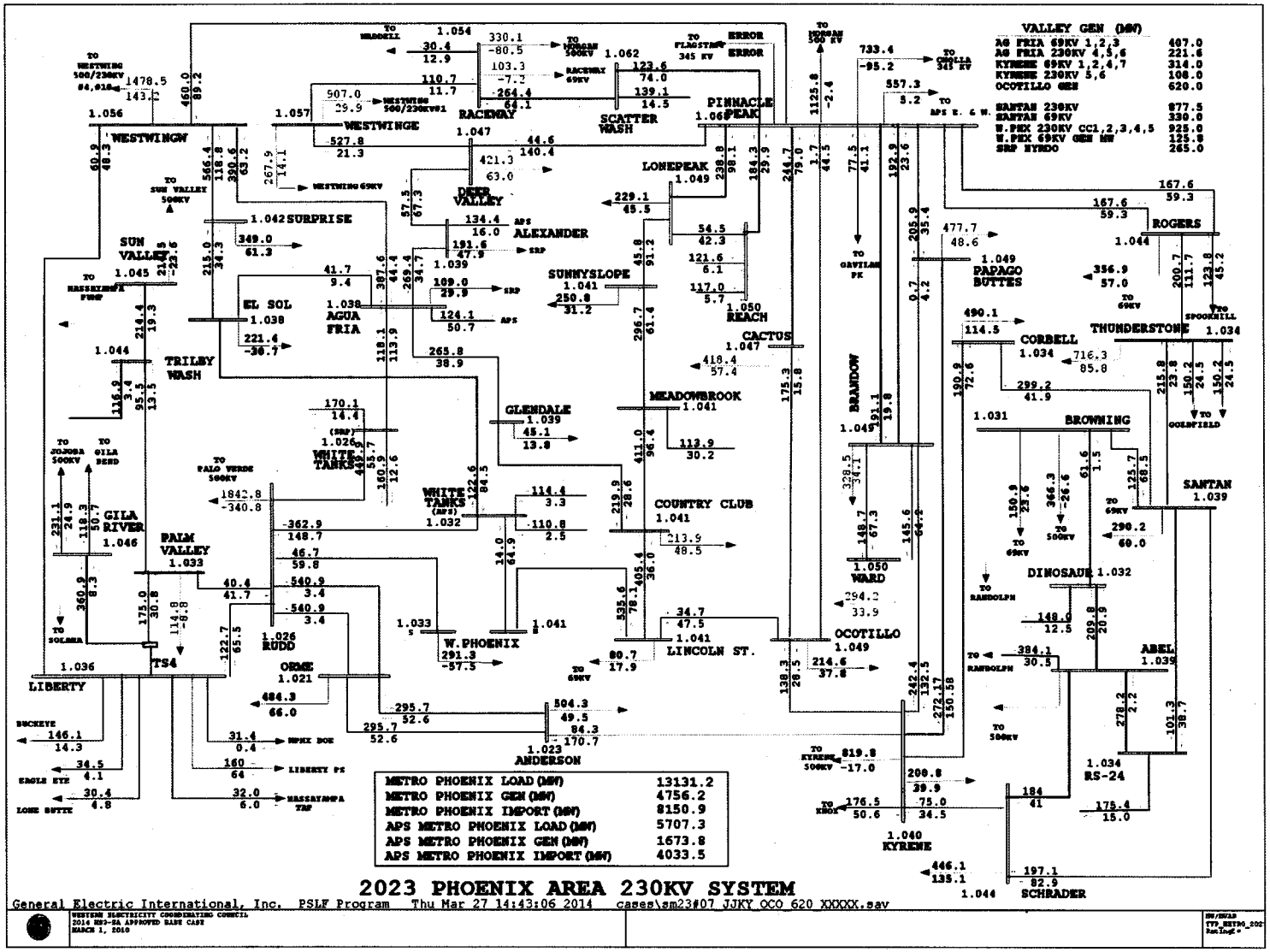


Figure B-15: Power Flow Map-2023 Ocotillo 620MW Jojoba-Kyrene 500kV IOS

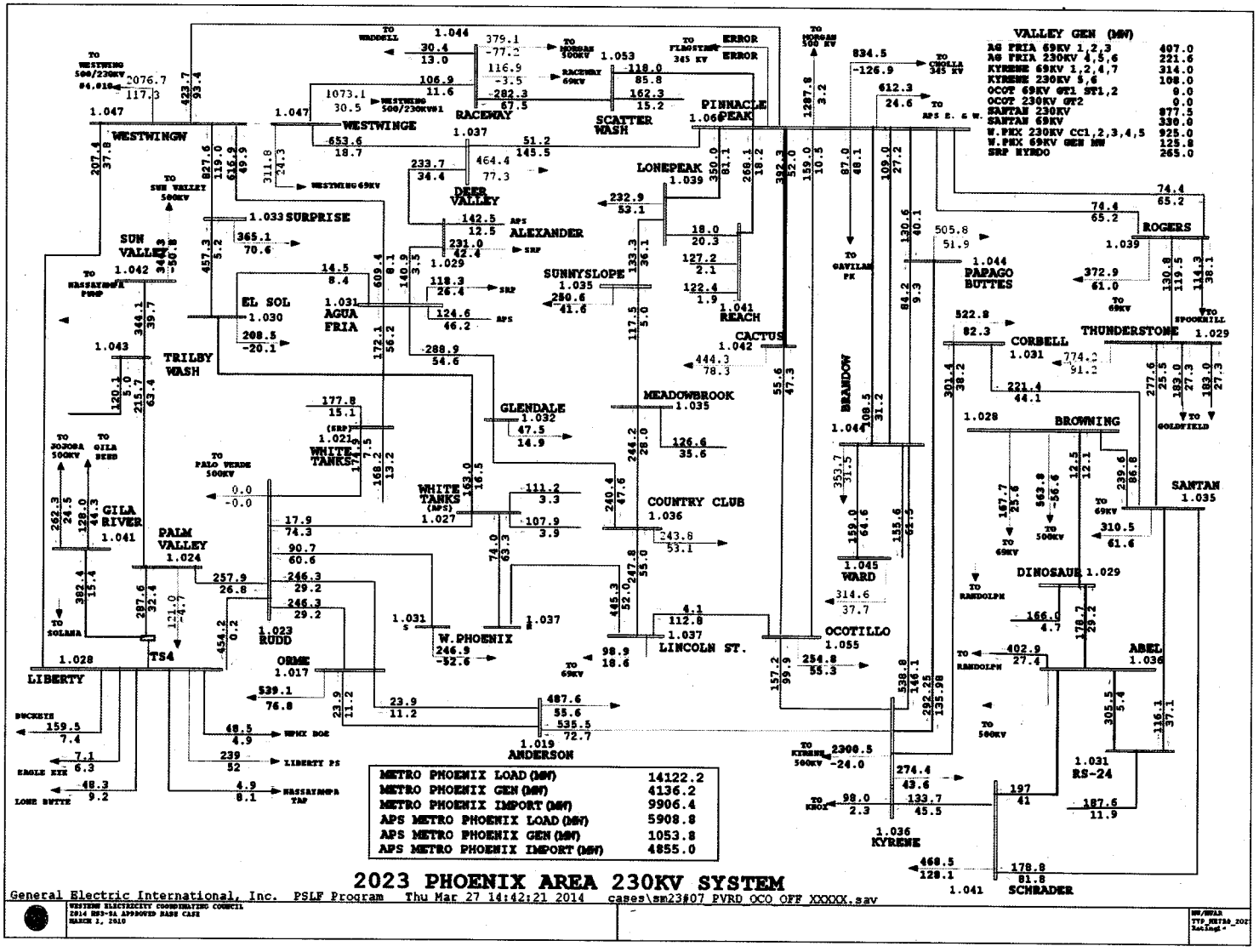


Figure B-16: Power Flow Map-2023 Ocotillo 0MW Palo Verde- Rudd 500kV IOS

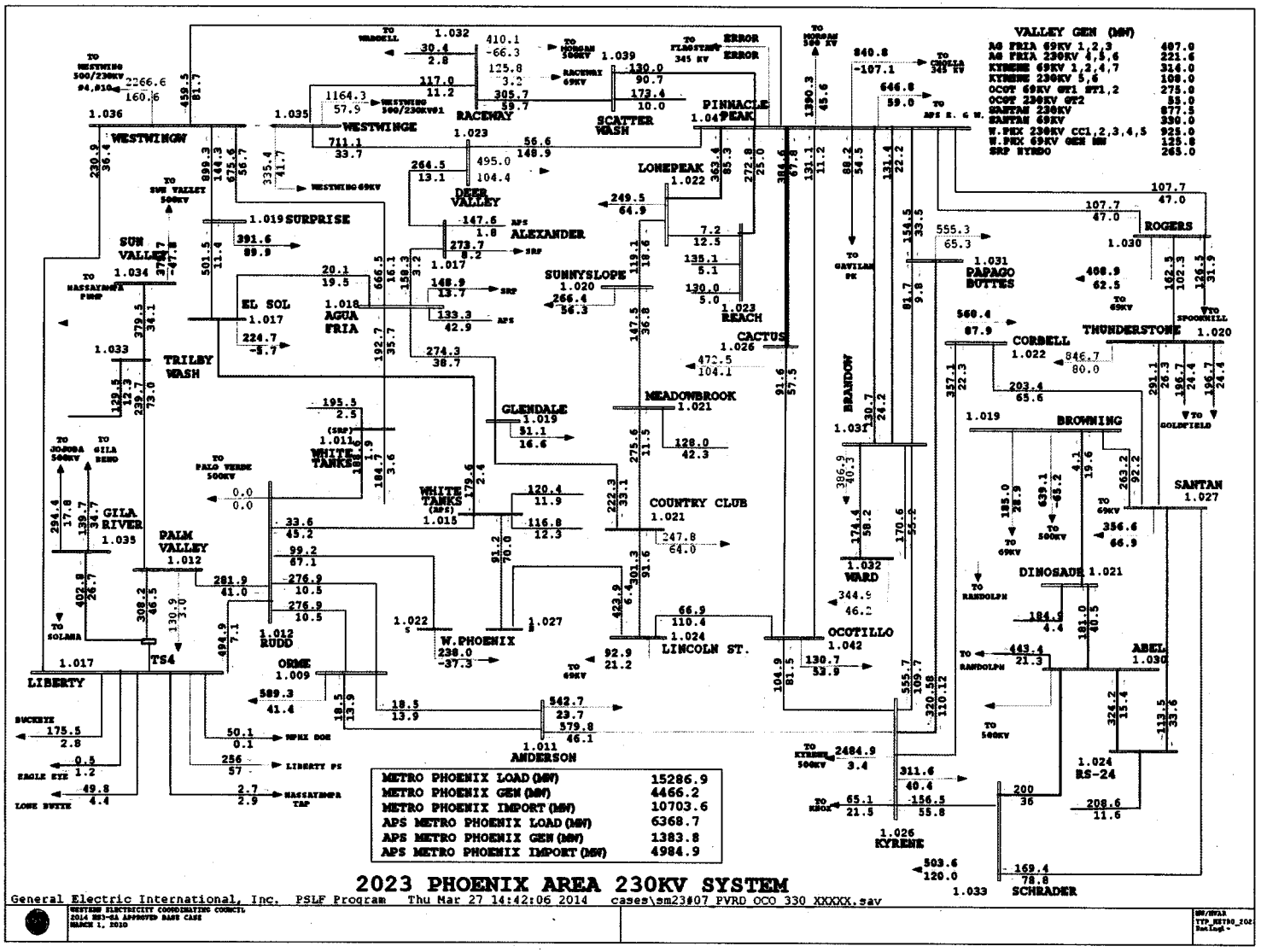


Figure B-17: Power Flow Map-2023 Ocotillo 330MW Palo Verde- Rudd 500kV IOS

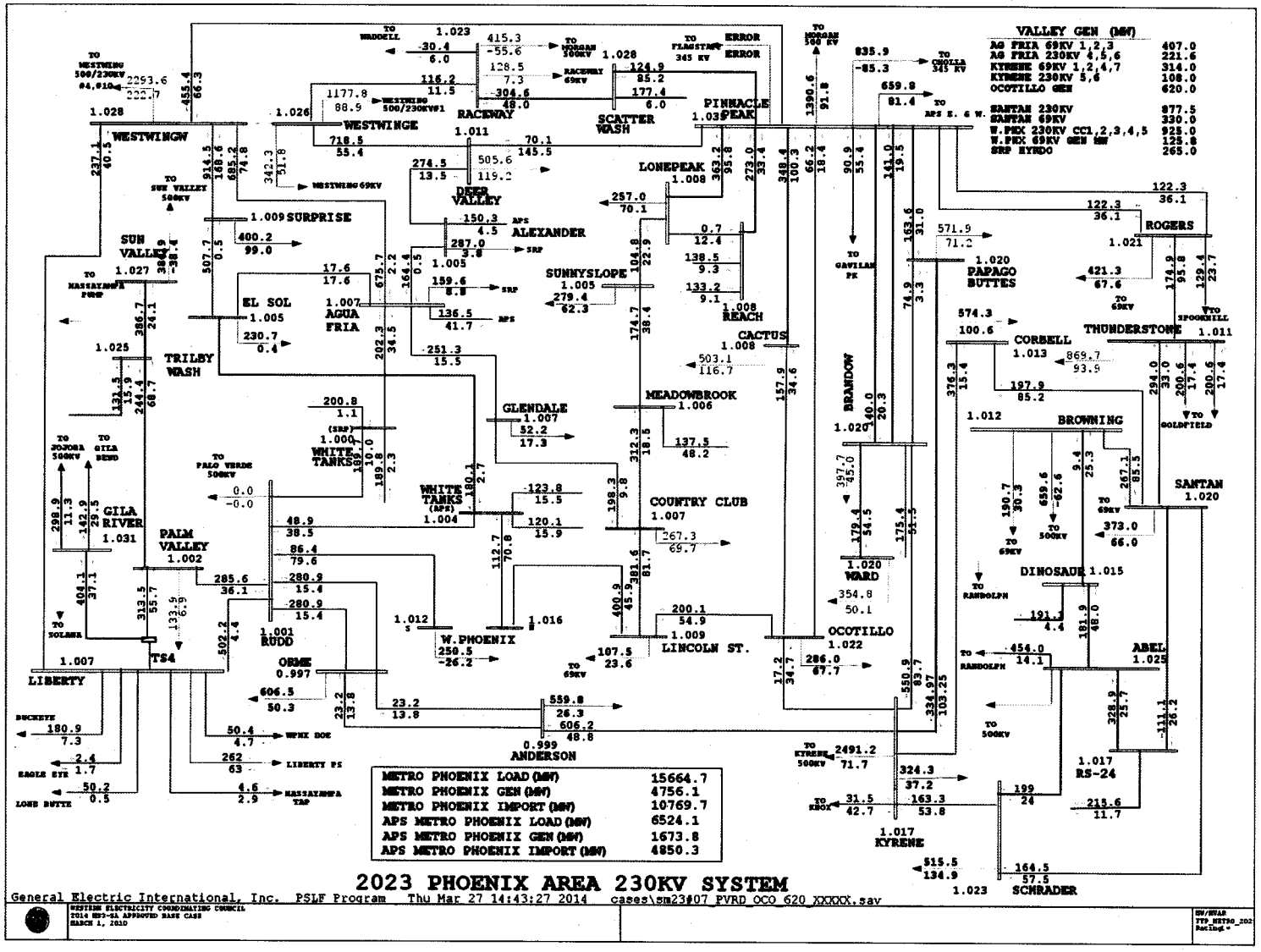


Figure B-18: Power Flow Map-2023 Ocotillo 620MW Palo Verde- Rudd 500kV IOS

APPENDIX C: OCOTILLO #3-7 PSLF TRANSIENT STABILITYSIMULATION MODEL

#OCOTILLO Units 3-7

gentpf 9003 "OCOGT3" 13.80 "1 " : #9 mva=190.47 "Tpdo" 12.4 "Tppdo" 0.05 "Tpqo" 12.4 "Tppqo" 0.05 "h" 4.00 "d" .0 "Ld" 2.83 "Lq" 2.59 "Lpd" .241 "Lpq" .290 "Lppd" .174 "Lppq" .210 "L1" .240 "S1" .0500 "S1.2" .300 "ra" .0009 "Rcomp" 0 "Xcomp" 0 "accel" 0.5gentpf 9004 "OCOGT4" 13.80 "1 " : #9 mva=190.47 "Tpdo" 12.4 "Tppdo" 0.05 "Tpqo" 12.4 "Tppqo" 0.05 "h" 0.88 "d" .0 "Ld" 2.83 "Lq" 2.59"Lpd" .241"Lpq" .290 "Lppd" .174"Lppq" .210"L1" .240"S1" .0500"S1.2" .300 "ra" .0009 "Rcomp" 0 "Xcomp" 0"accel" 0.5

esac8b 9003 "OCOGT3" 13.80 "1 " : #9 "Tr" 0.0 "Kpr" 84 "Kir" 5 "Kdr" 10 "Tdr" 0.1 "Vrmax" 28.15 "Vrmin" 0 "Ka" 1"Ta" 0 "Te" 1.4 "Vfemax" 22.4 "Vemin" 0 "Ke" 1 "Kc" 0.47 "Kd" 0.97 "E1" 6.9 "SE1" 0.15 "E2" 9.2"SE2" 2.07 "vtmult" 0.0 "spdmlt" 0.0

pss2a 9003 "OCOGT3" 13.80 "1 " : #9 "j1" 1 "k1" 0 "j2" 3 "k2" 0"tw1" 2 "tw2" 2 "tw3" 2 "tw4" 0 "t6" 0 "t7" 2 "ks2" 0.2 "ks3" 1 "ks4" 1 "t8" .5 "t9" .1 "n" 1 "m" 5 "ks1" 10. "t1".25 "t2" .04 "t3" .20 "t4" .03"vstmax" .10 "vstmin" -.10

ieeeg1 9003 "OCOGT3" 13.80 "1 " : #9 mwcap=190 "k" 25 "t1" 0.0 "t2" 0.00 "t3" 0.1 "uo" 1.0 "uc" -10 "pmax" 1 "pmin" 0.00 "t4" .0 "k1" 1.0 "k2" 1.0 "t5" 0.0 "k3" 0.0 "k4" 0.0 "t6" 0.0 "k5" 0.0 "k6" 0.0 "t7" 0.0 "k7" 0.0 "k8" 0.0 "db1" .0 "eps" 0.0 "db2" .0 "gv1" 0.0 "pgv1" 0.0 "gv2" 0.0 "pgv2" 0.0 "gv3" 0.0 "pgv3" 0.0 "gv4" 0.0 "pgv4" 0.0 "gv5" 0.0 "pgv5" 0.0 "gv6" 0.0 "pgv6" 0.0

gentpf 9004 "OCOGT4" 13.80 "1 " : #9 mva=190.47 "Tpdo" 12.4 "Tppdo" 0.05 "Tpqo" 12.4 "Tppqo" 0.05 "h" 4.00 "d" .0 "Ld" 2.83 "Lq" 2.59 "Lpd" .241 "Lpq" .290 "Lppd" .174 "Lppq" .210 "L1" .240 "S1" .0500 "S1.2" .300 "ra" .0009 "Rcomp" 0 "Xcomp" 0 "accel" 0.5gentpf 9004 "OCOGT4" 13.80 "1 " : #9 mva=190.47 "Tpdo" 12.4 "Tppdo" 0.05 "Tpqo" 12.4 "Tppqo" 0.05 "h" 0.88 "d" .0 "Ld" 2.83 "Lq" 2.59"Lpd" .241"Lpq" .290 "Lppd" .174"Lppq" .210"L1" .240"S1" .0500"S1.2" .300 "ra" .0009 "Rcomp" 0 "Xcomp" 0"accel" 0.5

esac8b 9004 "OCOGT4" 13.80 "1 " : #9 "Tr" 0.0 "Kpr" 84 "Kir" 5 "Kdr" 10 "Tdr" 0.1 "Vrmax" 28.15 "Vrmin" 0 "Ka" 1"Ta" 0 "Te" 1.4 "Vfemax" 22.4 "Vemin" 0 "Ke" 1 "Kc" 0.47 "Kd" 0.97 "E1" 6.9 "SE1" 0.15 "E2" 9.2"SE2" 2.07 "vtmult" 0.0 "spdmlt" 0.0

pss2a 9004 "OCOGT4" 13.80 "1 " : #9 "j1" 1 "k1" 0 "j2" 3 "k2" 0"tw1" 2 "tw2" 2 "tw3" 2 "tw4" 0 "t6" 0 "t7" 2 "ks2" 0.2 "ks3" 1 "ks4" 1 "t8" .5 "t9" .1 "n" 1 "m" 5 "ks1" 10. "t1".25 "t2" .04 "t3" .20 "t4" .03"vstmax" .10 "vstmin" -.10

ieeeg1 9004 "OCOGT4" 13.80 "1 " : #9 mwcap=190 "k" 25 "t1" 0.0 "t2" 0.00 "t3" 0.1 "uo" 1.0 "uc" -10 "pmax" 1 "pmin" 0.00 "t4" .0 "k1" 1.0 "k2" 1.0 "t5" 0.0 "k3" 0.0 "k4" 0.0 "t6" 0.0 "k5" 0.0 "k6" 0.0 "t7" 0.0 "k7" 0.0 "k8" 0.0 "db1" .0 "eps" 0.0 "db2" .0 "gv1" 0.0 "pgv1" 0.0 "gv2" 0.0 "pgv2" 0.0 "gv3" 0.0 "pgv3" 0.0 "gv4" 0.0 "pgv4" 0.0 "gv5" 0.0 "pgv5" 0.0 "gv6" 0.0 "pgv6" 0.0

gentpf 9005 "OCOGT5" 13.80 "1 " : #9 mva=190.47 "Tpdo" 12.4 "Tppdo" 0.05 "Tpqo" 12.4 "Tppqo" 0.05 "h" 4.00 "d" .0 "Ld" 2.83 "Lq" 2.59 "Lpd" .241 "Lpq" .290 "Lppd" .174 "Lppq" .210 "L1" .240 "S1" .0500 "S1.2" .300 "ra" .0009 "Rcomp" 0 "Xcomp" 0 "accel" 0.5gentpf 9004 "OCOGT4" 13.80 "1 " : #9 mva=190.47 "Tpdo" 12.4 "Tppdo" 0.05 "Tpqo" 12.4 "Tppqo" 0.05 "h" 0.88 "d" .0 "Ld" 2.83 "Lq" 2.59"Lpd" .241"Lpq" .290 "Lppd" .174"Lppq" .210"L1" .240"S1" .0500"S1.2" .300 "ra" .0009 "Rcomp" 0 "Xcomp" 0"accel" 0.5

esac8b 9005 "OCOGT5" 13.80 "1 " : #9 "Tr" 0.0 "Kpr" 84 "Kir" 5 "Kdr" 10 "Tdr" 0.1 "Vrmax" 28.15 "Vrmin" 0 "Ka" 1"Ta" 0 "Te" 1.4 "Vfemax" 22.4 "Vemin" 0 "Ke" 1 "Kc" 0.47 "Kd" 0.97 "E1" 6.9 "SE1" 0.15 "E2" 9.2"SE2" 2.07 "vtmult" 0.0 "spdmlt" 0.0

pss2a 9005 "OCOGT5" 13.80 "1 " : #9 "j1" 1 "k1" 0 "j2" 3 "k2" 0"tw1" 2 "tw2" 2 "tw3" 2 "tw4" 0 "t6" 0 "t7" 2 "ks2" 0.2 "ks3" 1 "ks4" 1 "t8" .5 "t9" .1 "n" 1 "m" 5 "ks1" 10. "t1".25 "t2" .04 "t3" .20 "t4" .03"vstmax" .10 "vstmin" -.10

ieeeg1 9005 "OCOGT5" 13.80 "1 " : #9 mwcap=190 "k" 25 "t1" 0.0 "t2" 0.00 "t3" 0.1 "uo" 1.0 "uc" -10 "pmax" 1 "pmin" 0.00 "t4" .0 "k1" 1.0 "k2" 1.0 "t5" 0.0 "k3" 0.0 "k4" 0.0 "t6" 0.0 "k5" 0.0 "k6" 0.0 "t7" 0.0 "k7" 0.0 "k8" 0.0 "db1" .0 "eps" 0.0 "db2" .0 "gv1" 0.0 "pgv1" 0.0 "gv2" 0.0 "pgv2" 0.0 "gv3" 0.0 "pgv3" 0.0 "gv4" 0.0 "pgv4" 0.0 "gv5" 0.0 "pgv5" 0.0 "gv6" 0.0 "pgv6" 0.0

gentpf 9006 "OCOGT6" 13.80 "1 " : #9 mva=190.47 "Tpdo" 12.4 "Tppdo" 0.05 "Tpqo" 12.4 "Tppqo" 0.05 "h" 4.00 "d" .0 "Ld" 2.83 "Lq" 2.59 "Lpd" .241 "Lpq" .290 "Lppd" .174 "Lppq" .210 "L1" .240 "S1" .0500 "S1.2" .300 "ra" .0009 "Rcomp" 0 "Xcomp" 0 "accel" 0.5gentpf 9004 "OCOGT4" 13.80 "1 " : #9 mva=190.47 "Tpdo" 12.4 "Tppdo" 0.05 "Tpqo" 12.4 "Tppqo" 0.05 "h" 0.88 "d" .0 "Ld" 2.83 "Lq" 2.59"Lpd" .241"Lpq" .290 "Lppd" .174"Lppq" .210"L1" .240"S1" .0500"S1.2" .300 "ra" .0009 "Rcomp" 0 "Xcomp" 0"accel" 0.5

esac8b 9006 "OCOGT6" 13.80 "1 " : #9 "Tr" 0.0 "Kpr" 84 "Kir" 5 "Kdr" 10 "Tdr" 0.1 "Vrmax" 28.15 "Vrmin" 0 "Ka" 1"Ta" 0 "Te" 1.4 "Vfemax" 22.4 "Vemin" 0 "Ke" 1 "Kc" 0.47 "Kd" 0.97 "E1" 6.9 "SE1" 0.15 "E2" 9.2"SE2" 2.07 "vtmult" 0.0 "spdmlt" 0.0

pss2a 9006 "OCOGT6" 13.80 "1 " : #9 "j1" 1 "k1" 0 "j2" 3 "k2" 0"tw1" 2 "tw2" 2 "tw3" 2 "tw4" 0 "t6" 0 "t7" 2 "ks2" 0.2 "ks3" 1 "ks4" 1 "t8" .5 "t9" .1 "n" 1 "m" 5 "ks1" 10. "t1".25 "t2" .04 "t3" .20 "t4" .03"vstmax" .10 "vstmin" -.10

ieeeg1 9006 "OCOGT6" 13.80 "1 " : #9 mwcap=190 "k" 25 "t1" 0.0 "t2" 0.00 "t3" 0.1 "uo" 1.0 "uc" -10 "pmax" 1 "pmin" 0.00 "t4" .0 "k1" 1.0 "k2" 1.0 "t5" 0.0 "k3" 0.0 "k4" 0.0 "t6" 0.0 "k5" 0.0 "k6" 0.0 "t7" 0.0 "k7" 0.0 "k8" 0.0 "db1" .0 "eps" 0.0 "db2" .0 "gv1" 0.0 "pgv1" 0.0 "gv2" 0.0 "pgv2" 0.0 "gv3" 0.0 "pgv3" 0.0 "gv4" 0.0 "pgv4" 0.0 "gv5" 0.0 "pgv5" 0.0 "gv6" 0.0 "pgv6" 0.0

gentpf 9007 "OCOGT7" 13.80 "1 " : #9 mva=190.47 "Tpdo" 12.4 "Tppdo" 0.05 "Tpqo" 12.4 "Tppqo" 0.05 "h" 4.00 "d" .0 "Ld" 2.83 "Lq" 2.59 "Lpd" .241 "Lpq" .290 "Lppd" .174 "Lppq" .210 "L1" .240 "S1" .0500 "S1.2" .300 "ra" .0009 "Rcomp" 0 "Xcomp" 0 "accel" 0.5gentpf 9004 "OCOGT4" 13.80 "1 " : #9 mva=190.47 "Tpdo" 12.4 "Tppdo" 0.05 "Tpqo" 12.4 "Tppqo" 0.05 "h" 0.88 "d" .0 "Ld" 2.83 "Lq" 2.59"Lpd" .241"Lpq" .290 "Lppd" .174"Lppq" .210"L1" .240"S1" .0500"S1.2" .300 "ra" .0009 "Rcomp" 0 "Xcomp" 0"accel" 0.5

esac8b 9007 "OCOGT7" 13.80 "1 " : #9 "Tr" 0.0 "Kpr" 84 "Kir" 5 "Kdr" 10 "Tdr" 0.1 "Vrmax" 28.15 "Vrmin" 0 "Ka" 1"Ta" 0 "Te" 1.4 "Vfemax" 22.4 "Vemin" 0 "Ke" 1 "Kc" 0.47 "Kd" 0.97 "E1" 6.9 "SE1" 0.15 "E2" 9.2"SE2" 2.07 "vtmult" 0.0 "spdmlt" 0.0

pss2a 9007 "OCOGT7" 13.80 "1 " : #9 "j1" 1 "k1" 0 "j2" 3 "k2" 0"tw1" 2 "tw2" 2 "tw3" 2 "tw4" 0 "t6" 0 "t7" 2 "ks2" 0.2 "ks3" 1 "ks4" 1 "t8" .5 "t9" .1 "n" 1 "m" 5 "ks1" 10. "t1".25 "t2" .04 "t3" .20 "t4" .03"vstmax" .10 "vstmin" -.10

ieeeg1 9007 "OCOGT7" 13.80 "1 " : #9 mwcap=190 "k" 25 "t1" 0.0 "t2" 0.00 "t3" 0.1 "uo" 1.0 "uc" -10 "pmax" 1 "pmin" 0.00 "t4" .0 "k1" 1.0 "k2" 1.0 "t5" 0.0 "k3" 0.0 "k4" 0.0 "t6" 0.0 "k5" 0.0 "k6" 0.0 "t7" 0.0 "k7" 0.0 "k8" 0.0 "db1" .0 "eps" 0.0 "db2" .0 "gv1" 0.0 "pgv1" 0.0 "gv2" 0.0 "pgv2" 0.0 "gv3" 0.0 "pgv3" 0.0 "gv4" 0.0 "pgv4" 0.0 "gv5" 0.0 "pgv5" 0.0 "gv6" 0.0 "pgv6" 0.

APPENDIX D: LIST OF MULTIPULE ELEMENT CONTINGENCES

TABLE D.1: MULTIPLE ELEMENT CONTINGENCY LIST

OUTAGE #	OUTAGE
1	Cholla – Saguaro 500kV and Cholla Sugarloaf 500kV
2	Cholla – Pinnacle Peak 345kV 1 and 2
3	Cholla – Saguaro 500kV and Cholla 500/345kV
4	Cholla – Saguaro 500kV and Coronado – Silverking 500kV
5	Cholla – Sugarloaf 500kV and Cholla 500/345kV
6	Four Corners – Moenkopi – Eldorado 500kV
7	Four Corners – Cholla 345kV 1 and 2
8	Gila River – Jojoba 500kV 1 and 2
9	Jojoba – Hassayampa 500kV and Jojoba – Kyrene 500kV
10	Jojoba – Kyrene 500kV and Palo Verde – Rudd 500kV
11	Navajo – Dugas 500kV and Navajo – Crystal 500kV
12	Navajo – Moenkopi 500kV and Navajo Crystal 500kV
13	Navajo – Dugas – Yavapai 500kV
14	Navajo – Moenkopi 500kV and Navajo – Dugas 500kV
15	Palo Verde – Colorado River 500kV and Palo Verde – Hassayampa 500kV
16	Palo Verde – Colorado River 500kV and Palo Verde – Rudd 500kV
17	Palo Verde – Colorado River 500kV and Palo Verde – Westwing 500kV
18	Palo Verde – Rudd 500kV and Palo Verde – Hassayampa 500kV

TABLE D.1: MULTIPLE ELEMENT CONTINGENCY LIST

OUTAGE #	OUTAGE
19	Palo Verde – Westwing 500kV and Palo Verde – Rudd 500kV
20	Hassayampa – North Gila 500kV and Hassayampa – Hoodoo Wash 500kV
21	Morgan – Pinnacle Peak 500kV and Raceway to Pinnacle Peak 230kV
22	Navajo – Dugas 500kV and Moenkopi – Cedar Mountain 500kV
23	Navajo – Dugas 500kV and Yavapai – Westwing 500kV
24	Navajo – Moenkopi 500kV and Navajo – Dugas 500kV
25	Palo Verde – Hassayampa 500kV 1 and 2
26	Palo Verde – Westwing 500kV 1 and 2
27	Yavapai – Westwing 500kV and Morgan – Westwing 500kV
28	Cholla – Saguaro 500kV and Saguaro – San Manuel 115kV
29	Single line to ground (SLG) Cholla Unit 2 and Cholla 500/345kV
30	SLG Navajo Unit 1 and Navajo – Dugas 500kV
31	SLG Palo Verde Unit 1 and Palo Verde – Westwing 500kV
32	SLG Cholla – Sugarloaf 500kV and Cholla 500/345kV
33	SLG Stuck Breaker Pinnacle Peak North 230kV Bus
34	SLG Stuck Breaker Pinnacle Peak West 230kV Bus
35	Stuck Breaker Pinnacle Peak Center 230kV Bus
36	Stuck Breaker Pinnacle Peak East 230kV Bus

TABLE D.1: MULTIPLE ELEMENT CONTINGENCY LIST

OUTAGE #	OUTAGE
37	Stuck Breaker – Pinnacle Peak – Mazatzal 345kV, PP/PP East 345/230kV, and PP/PP Center 345/230kV
38	Stuck Breaker Pinnacle Peak 345kV Bus
39	Stuck Breaker Westwing – Morgan 500kV and Westwing 500/230kV
40	Stuck Breaker Palo Verde – Westwing 500kV and Westwing 500/230kV
41	Stuck Breaker Yavapai – Westwing 500kV and Westwing 500/345kV

Attachment A

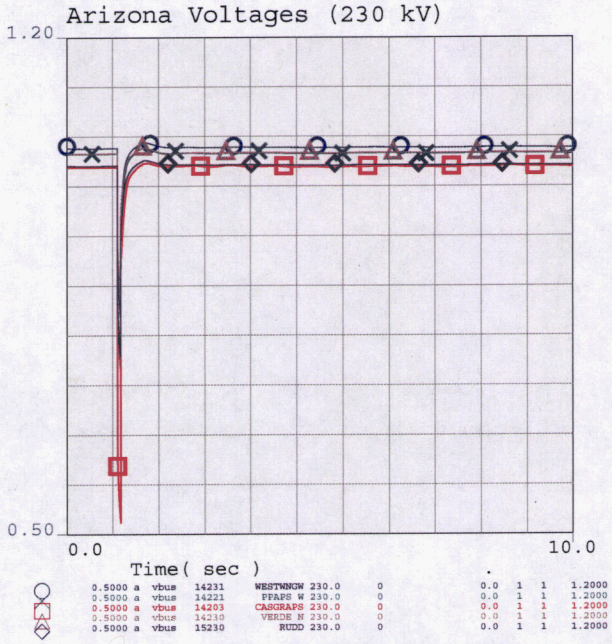
Transient Stability Analysis Results

2018 HS – Ocotillo 330 MW Dispatch

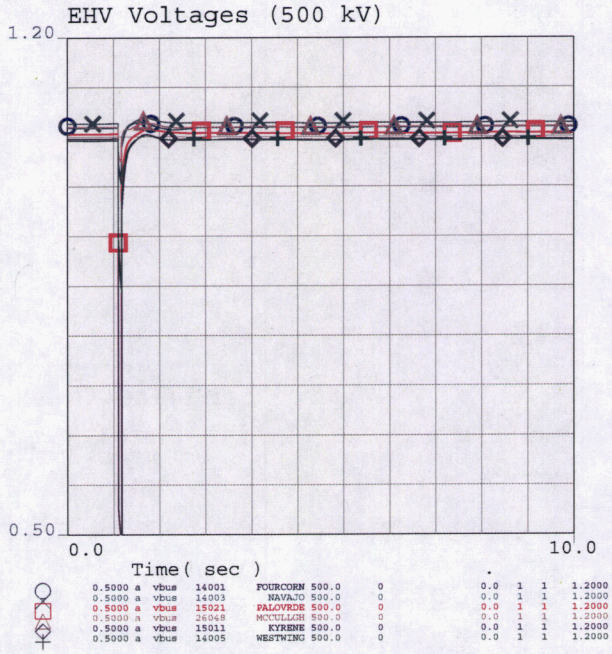
N-1 Contingencies

2018 Heavy Summer Detailed Planning Case

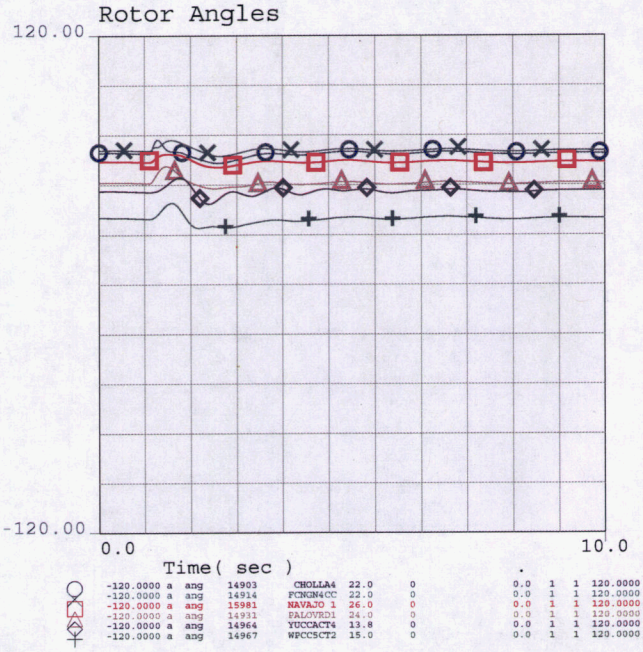
Arizona Voltages (230 kV)



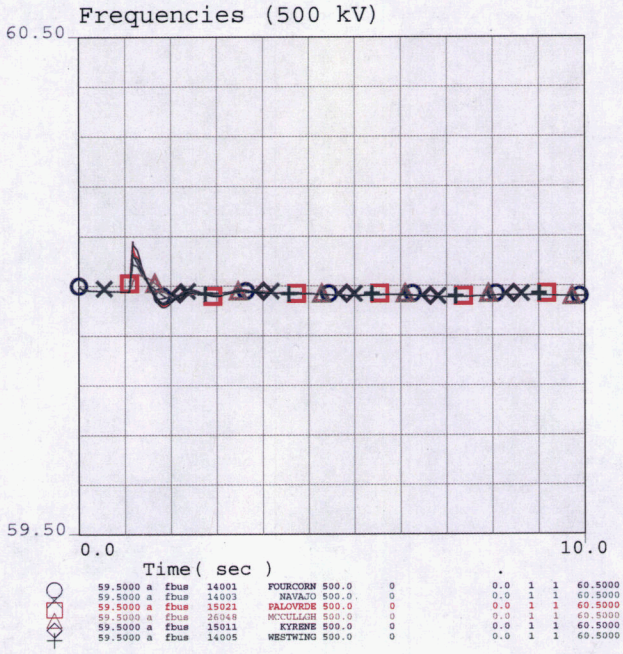
EHV Voltages (500 kV)



Rotor Angles

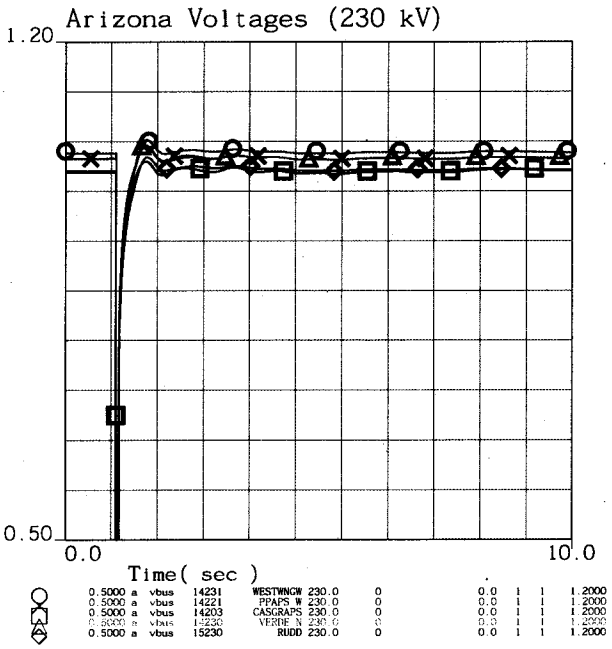


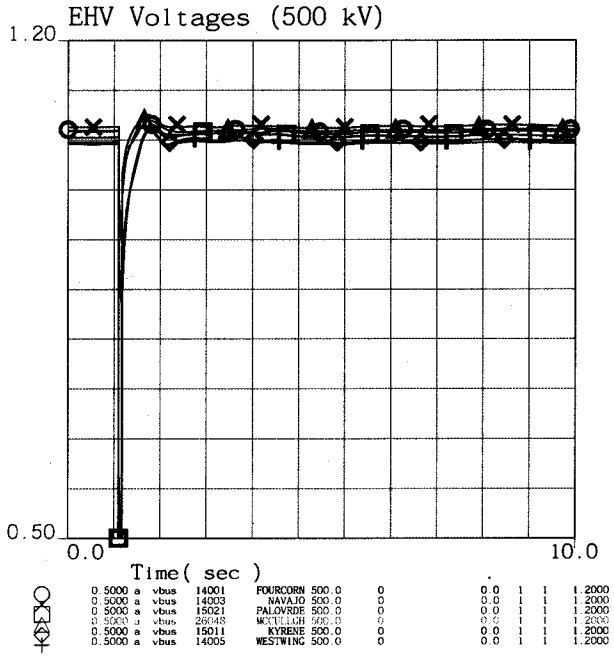
Frequencies (500 kV)

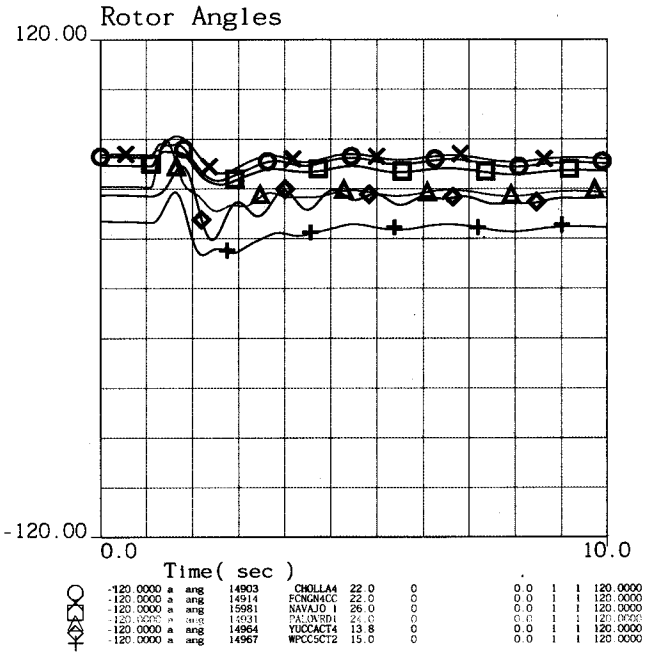


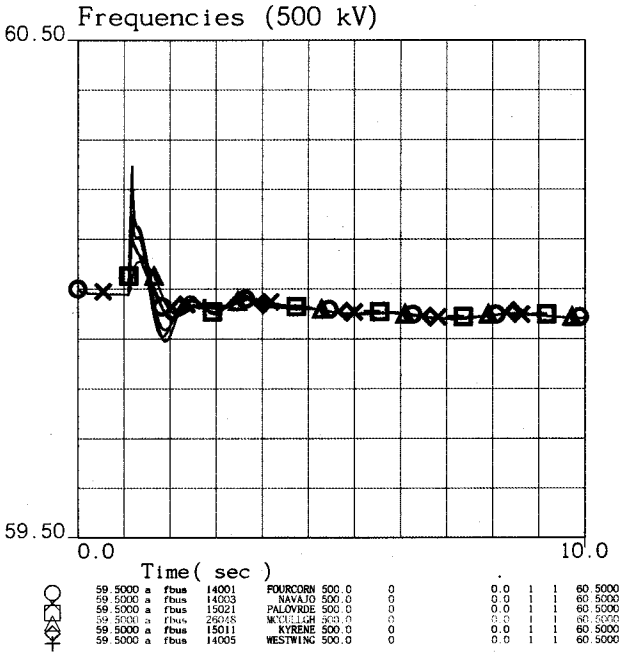
2018 Heavy Summer AZ Coordinated Case
Developed from WECC 18hs2a CASE
Updated by SRP,APS,WAPA,SWTC,TEP

2018 Heavy Summer Detailed Planning Case









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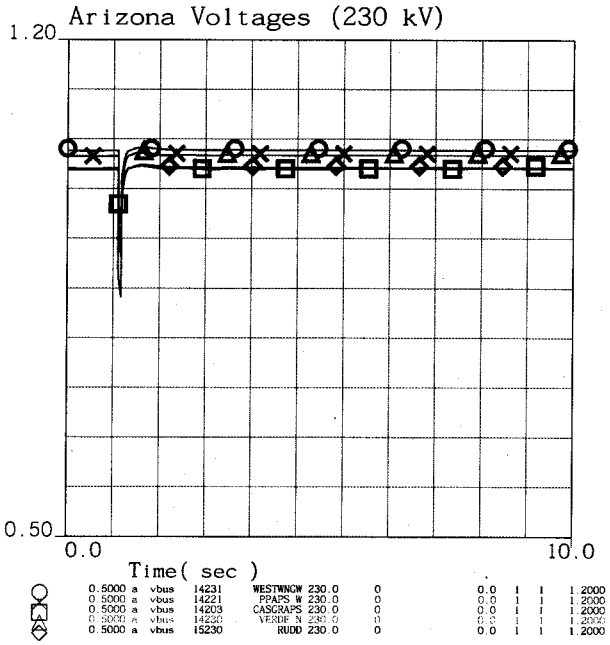

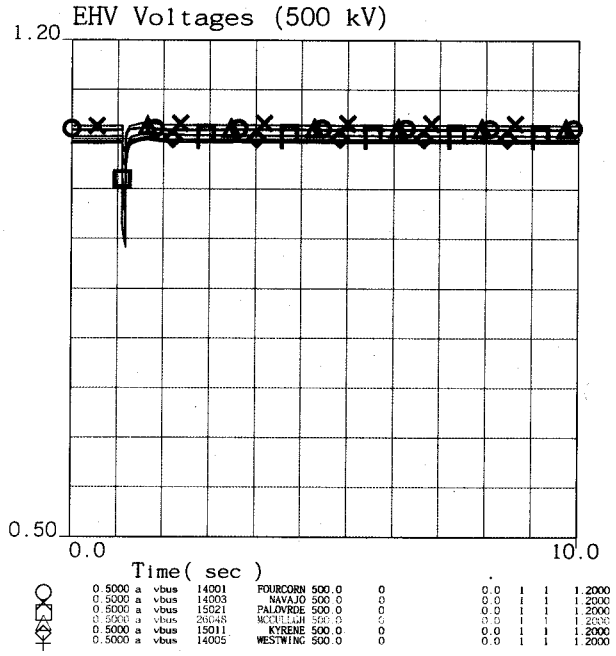

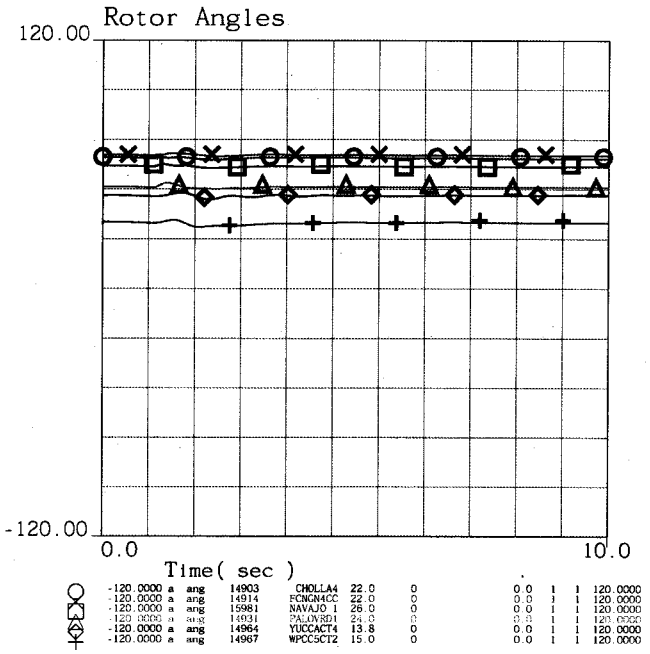

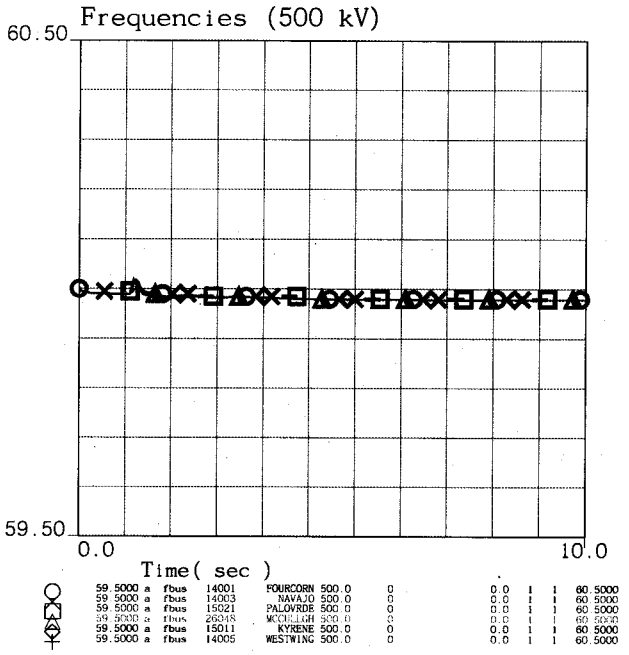

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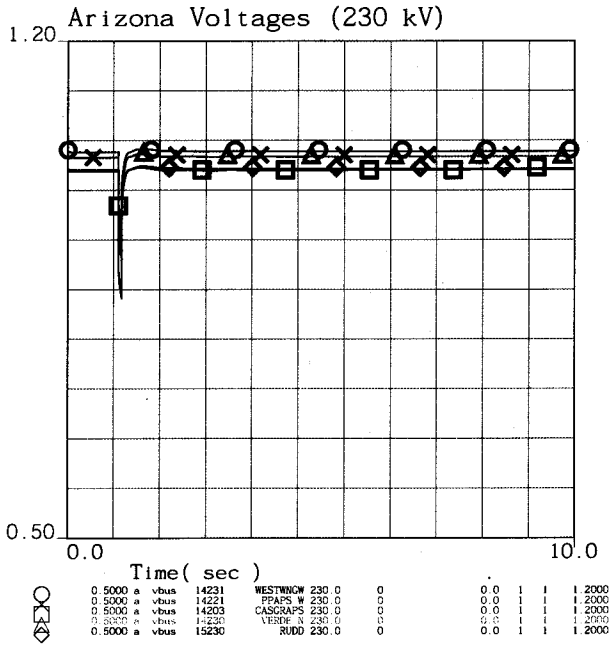

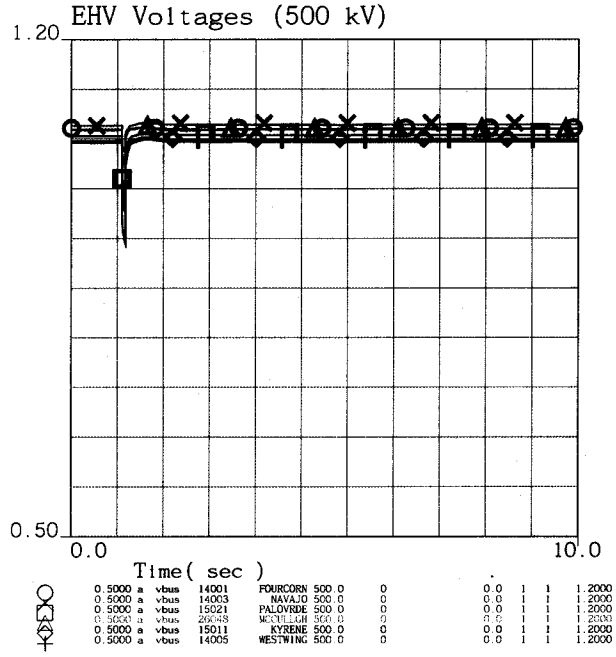

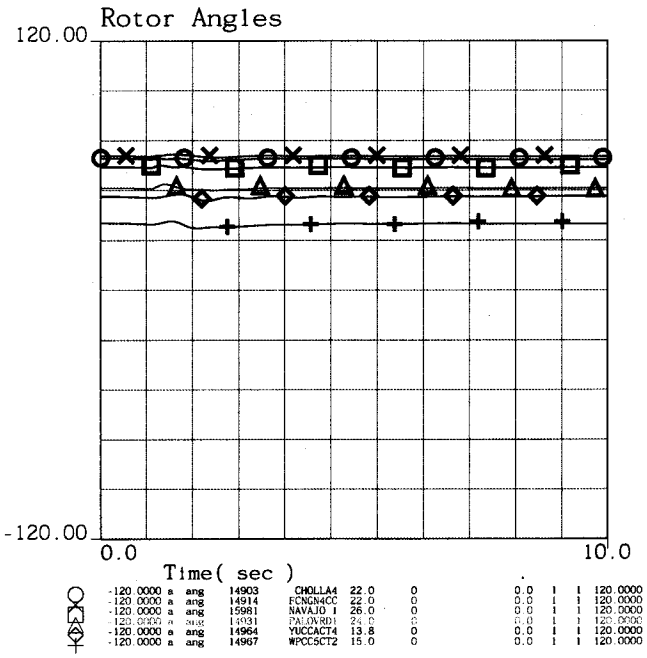

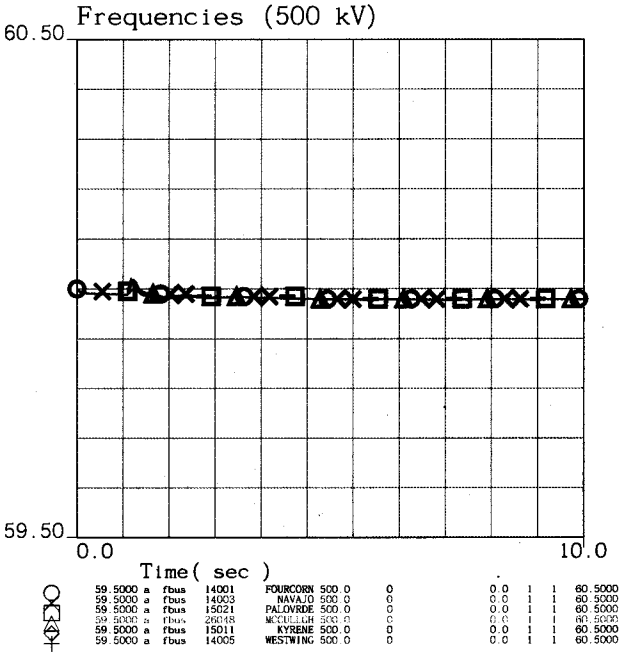

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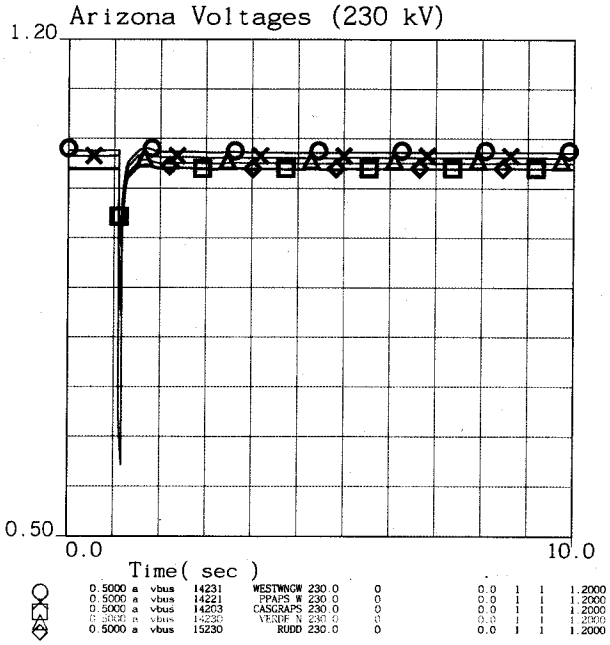

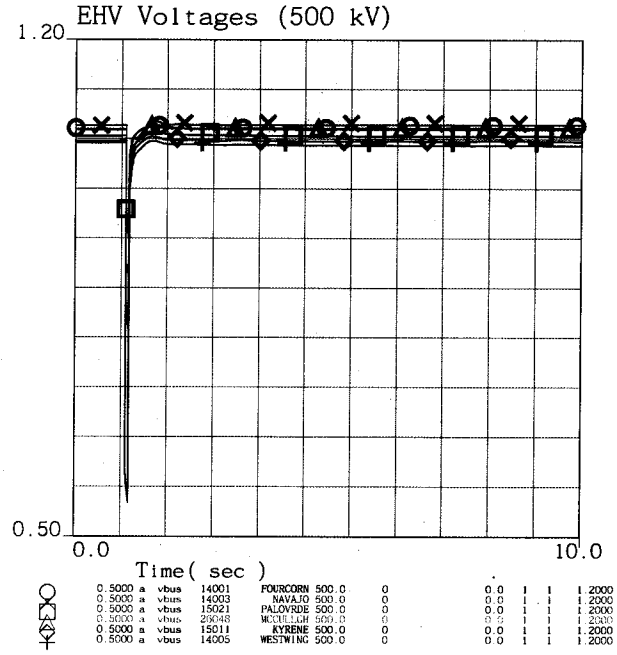

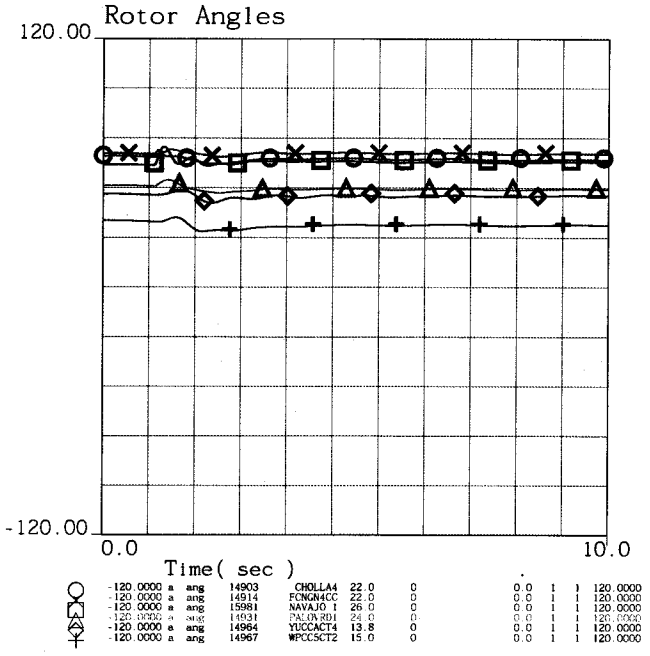

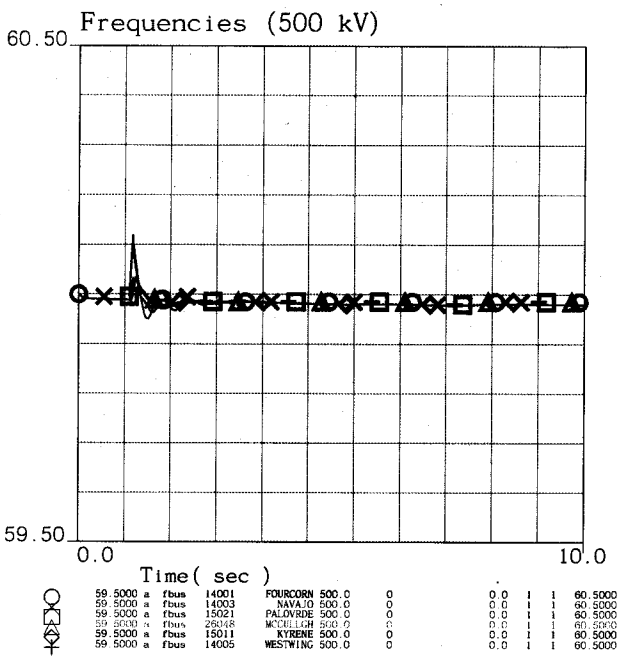

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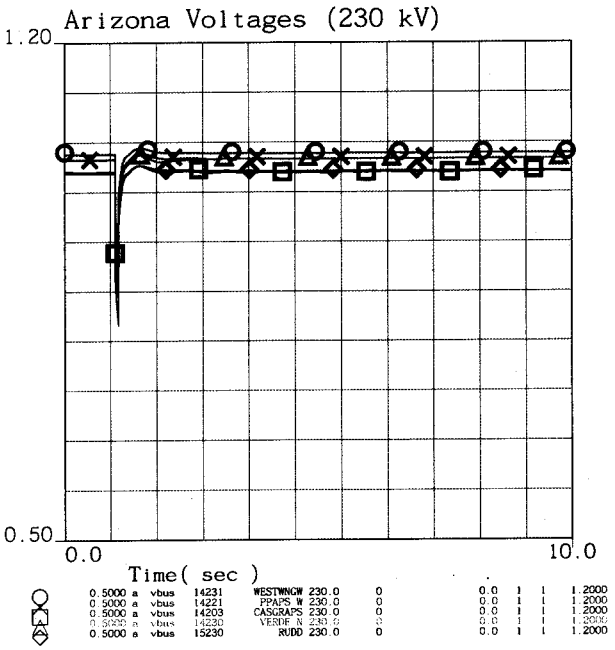

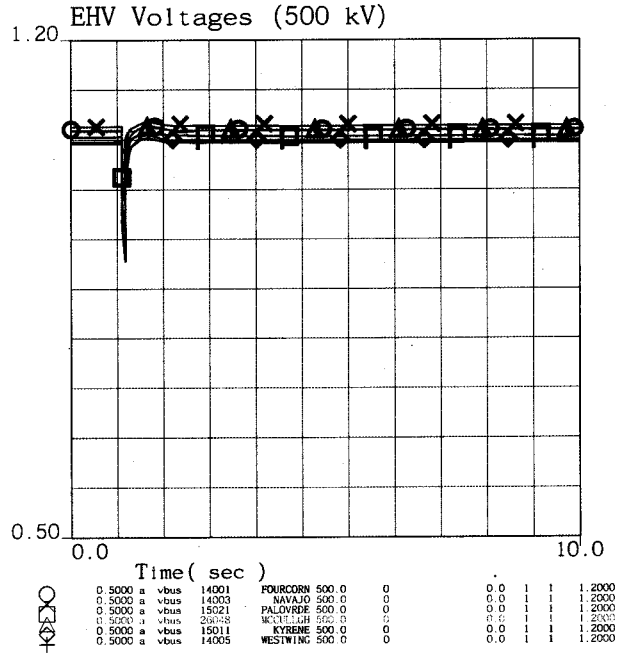

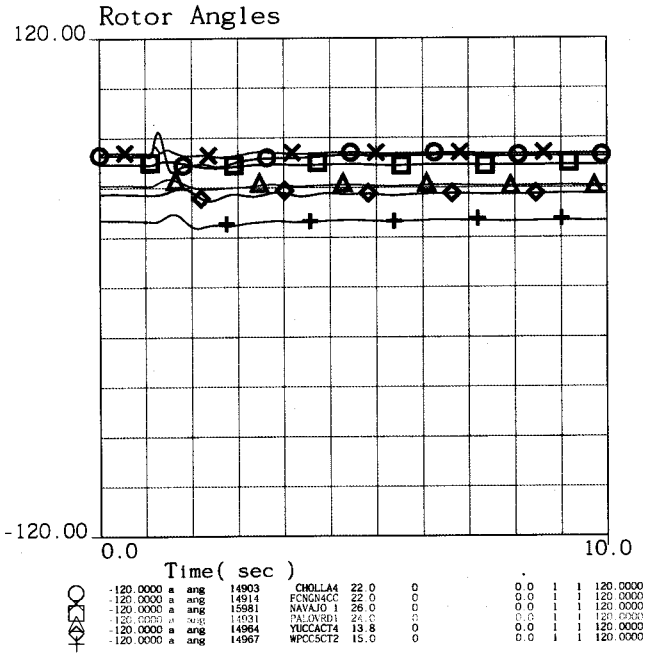

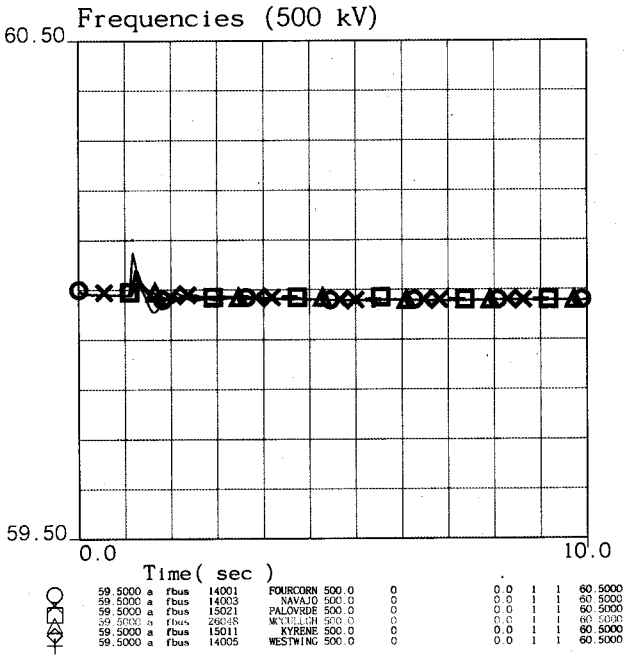

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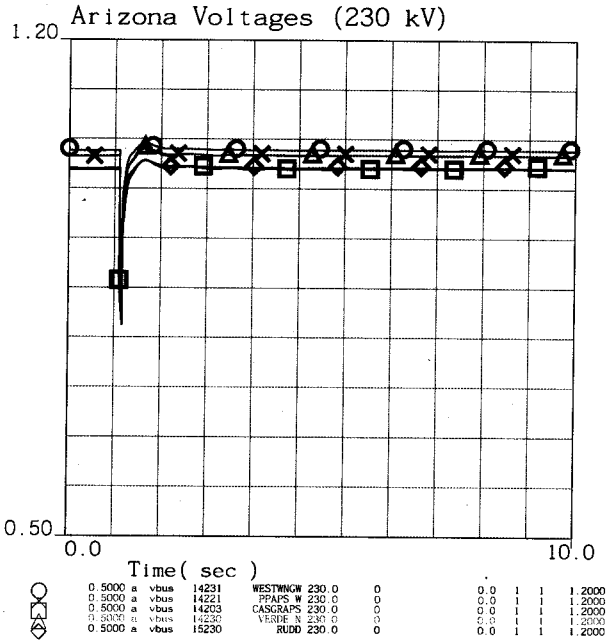

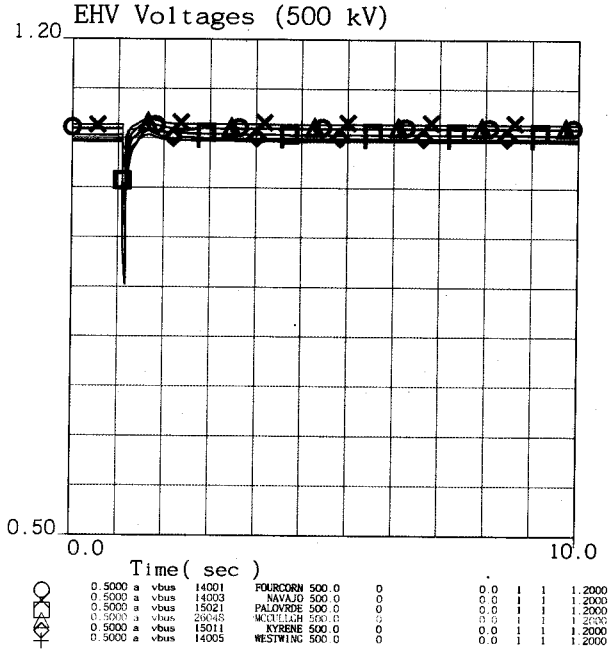

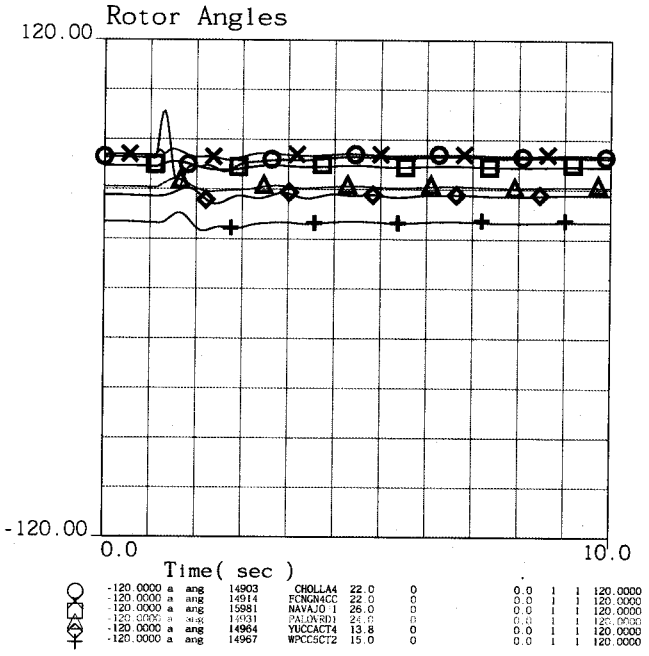

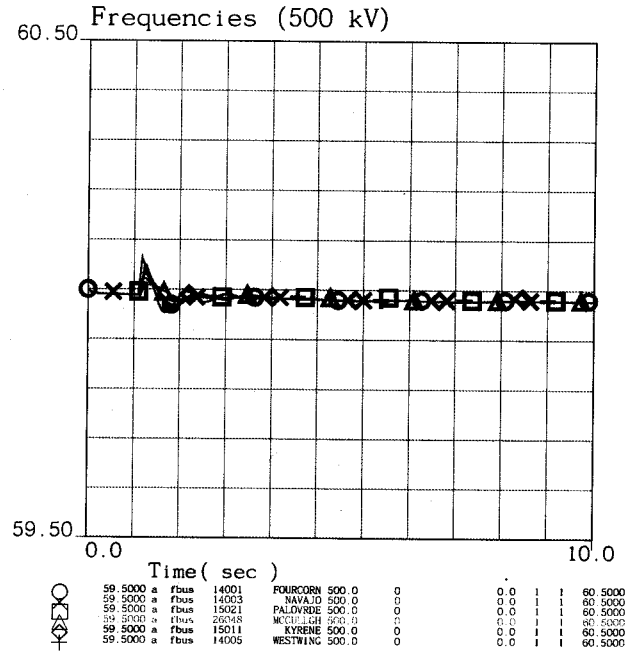

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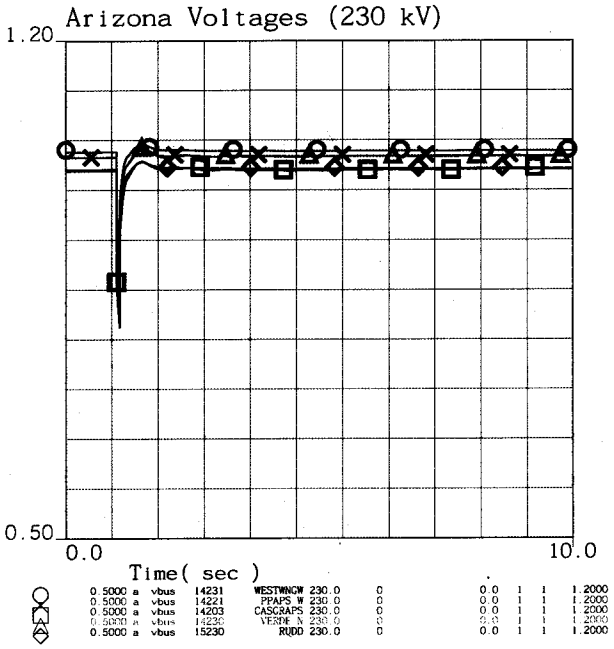

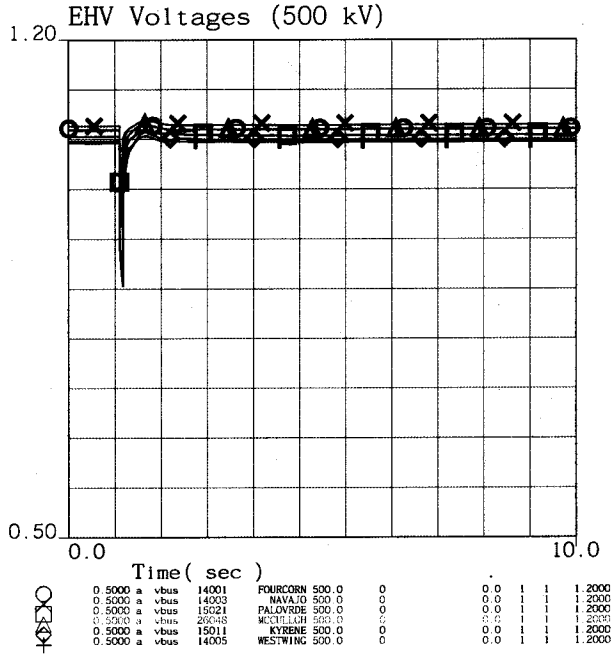

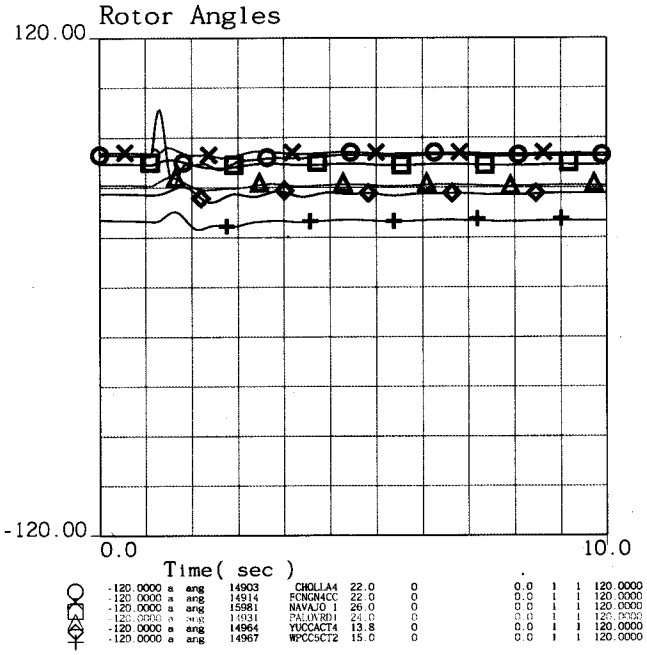

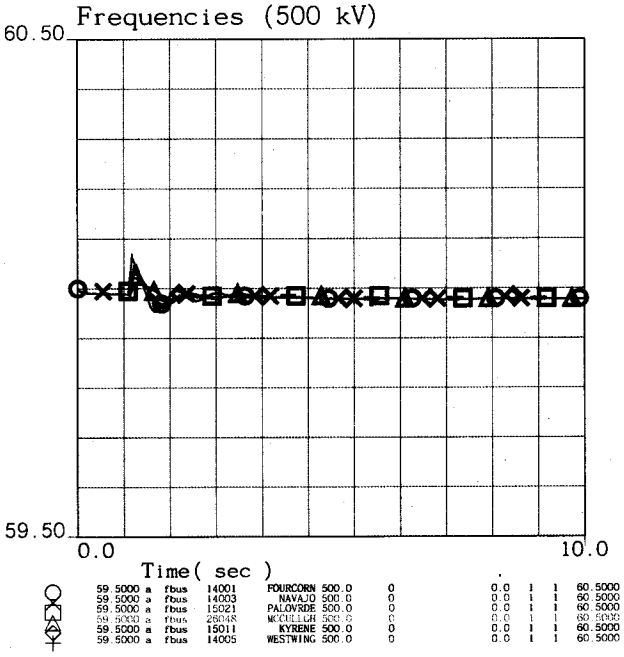

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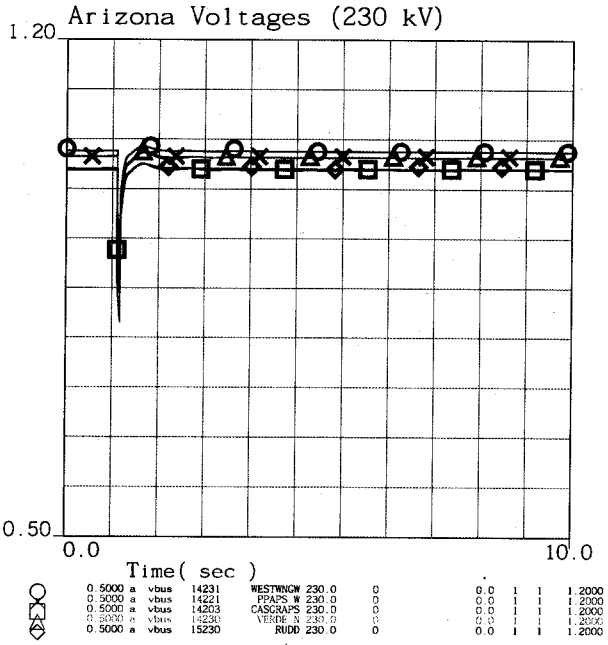

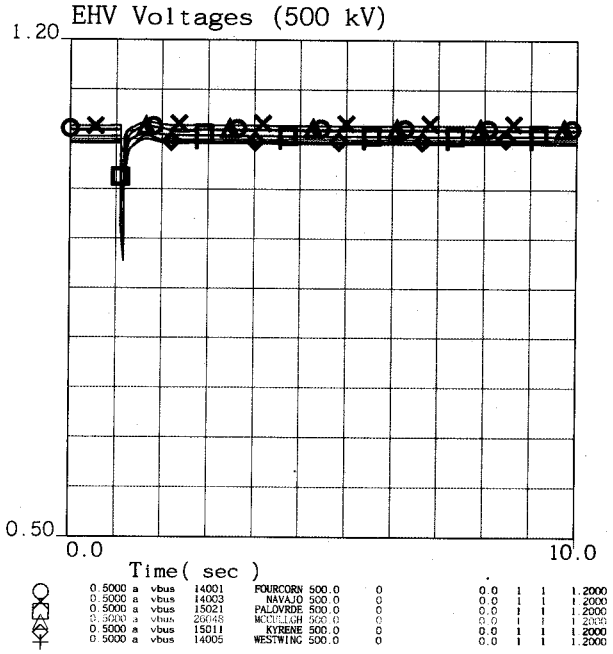

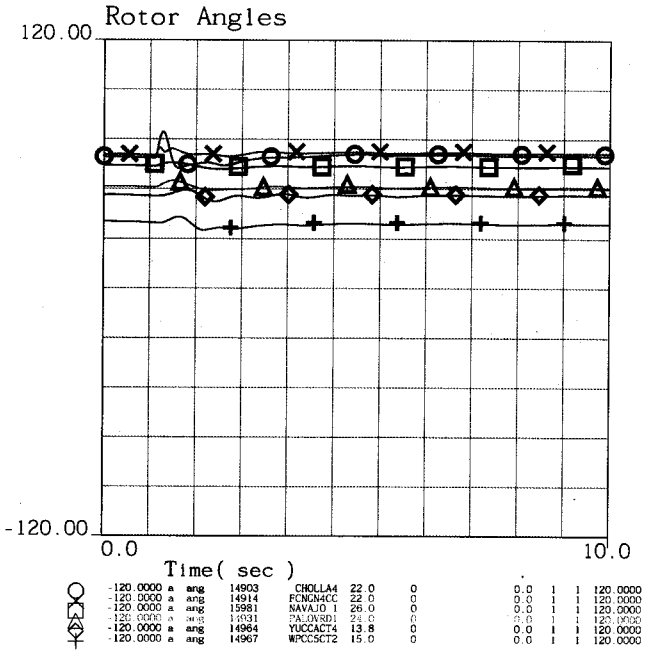

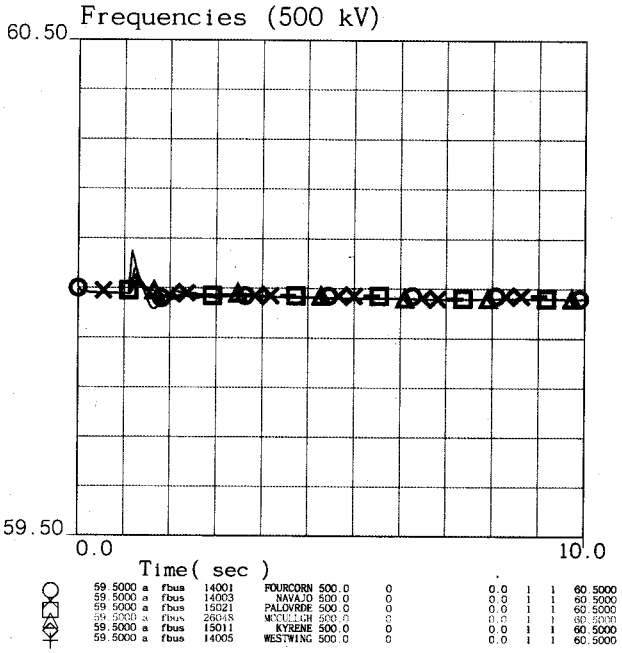

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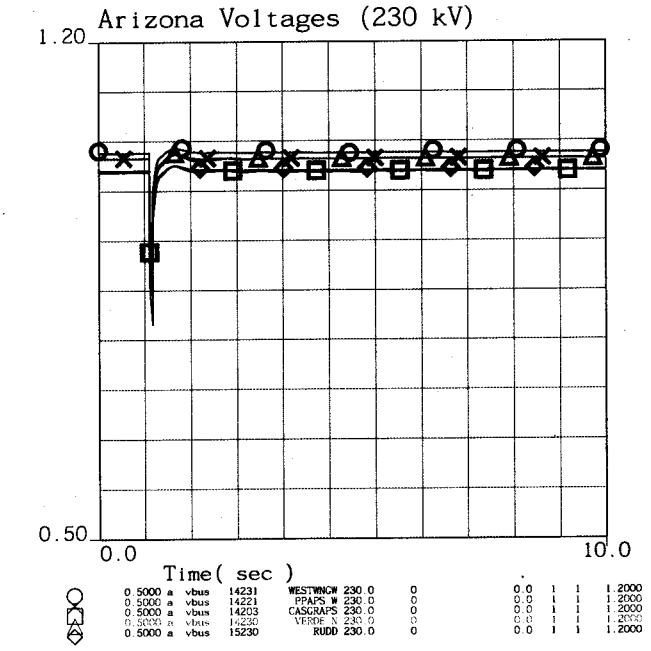

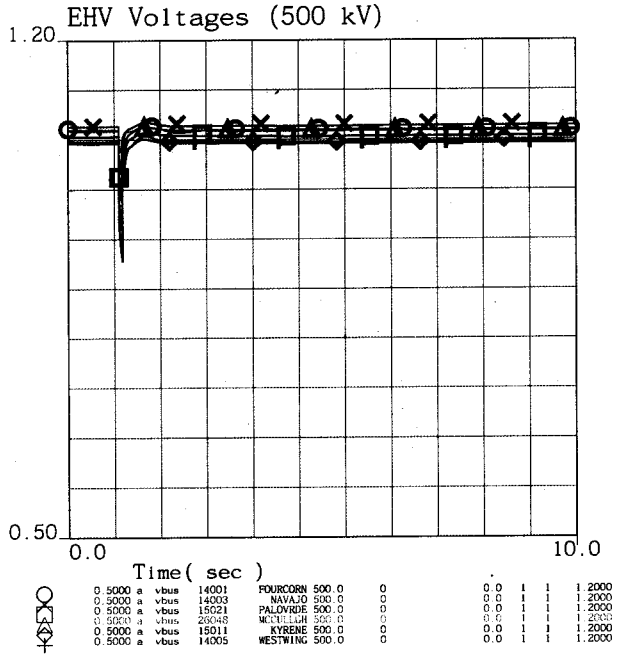

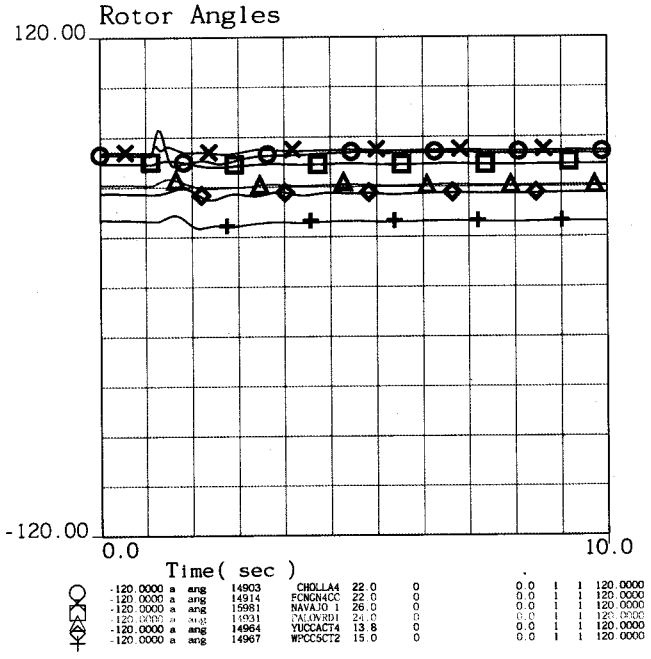

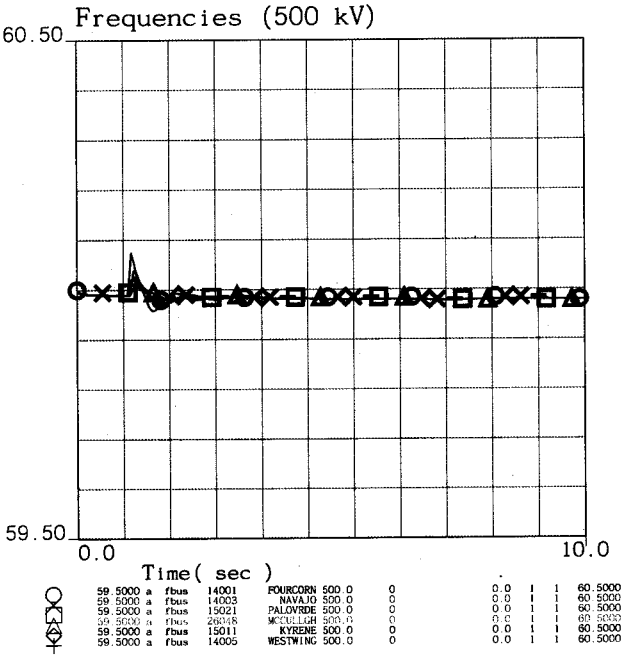

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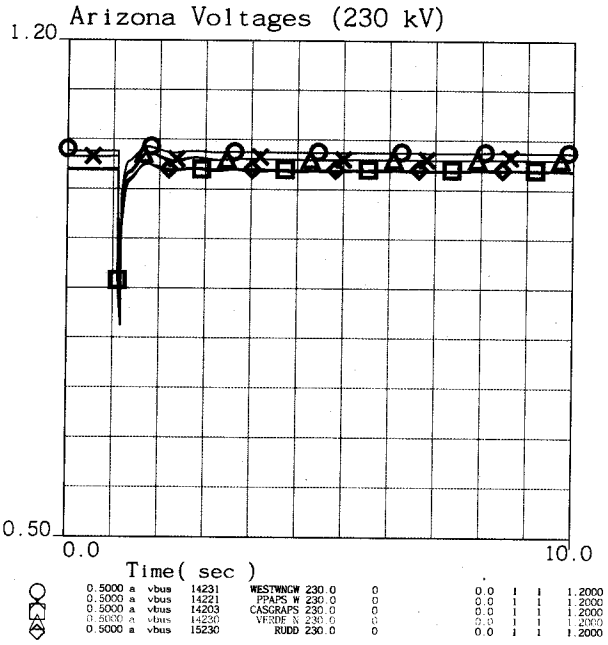

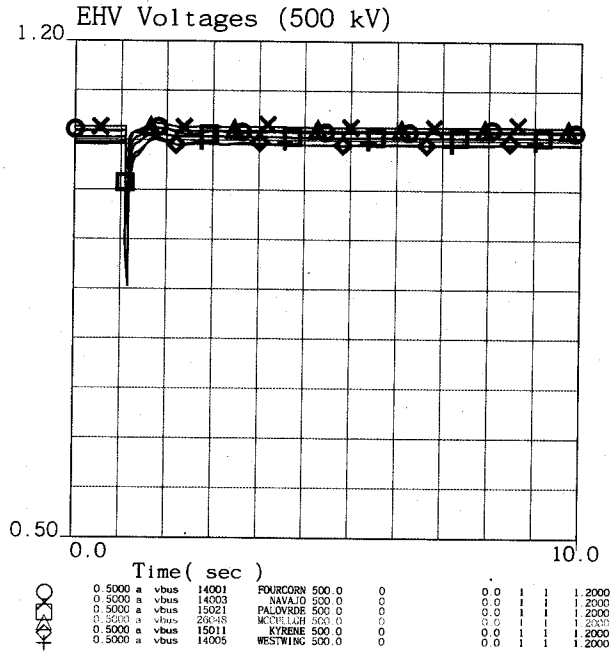

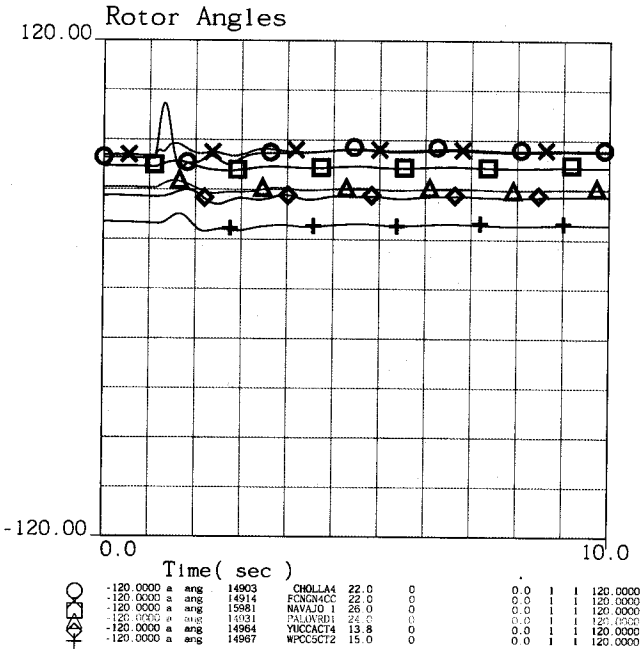

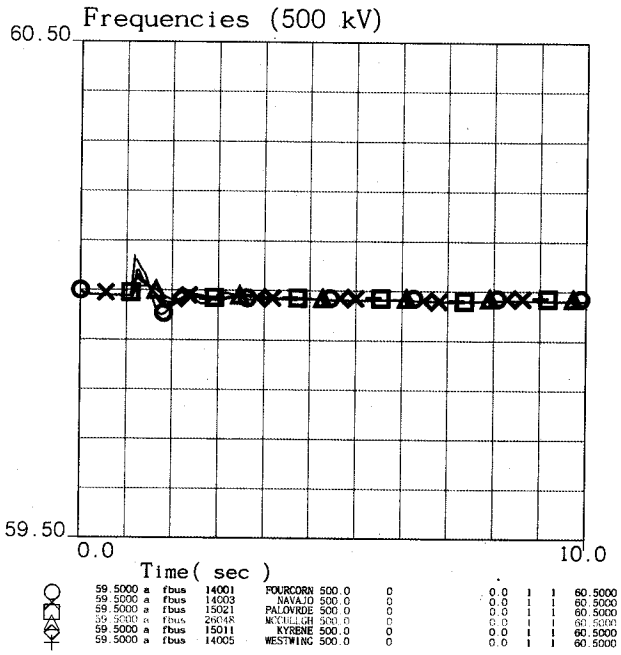

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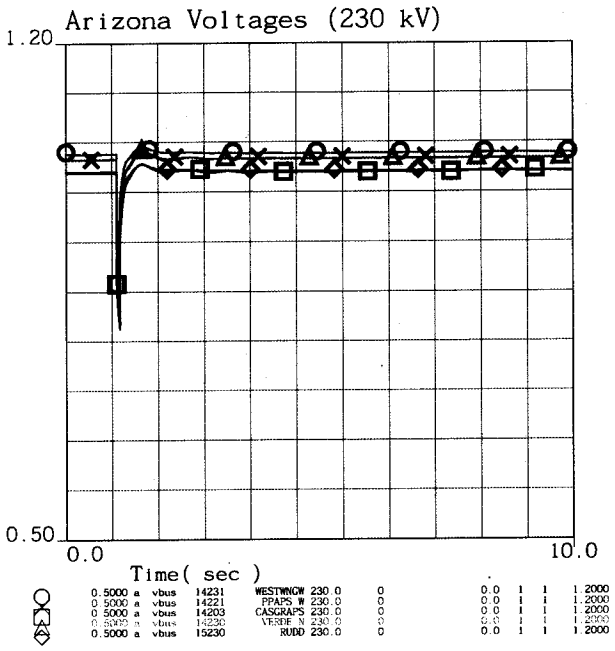

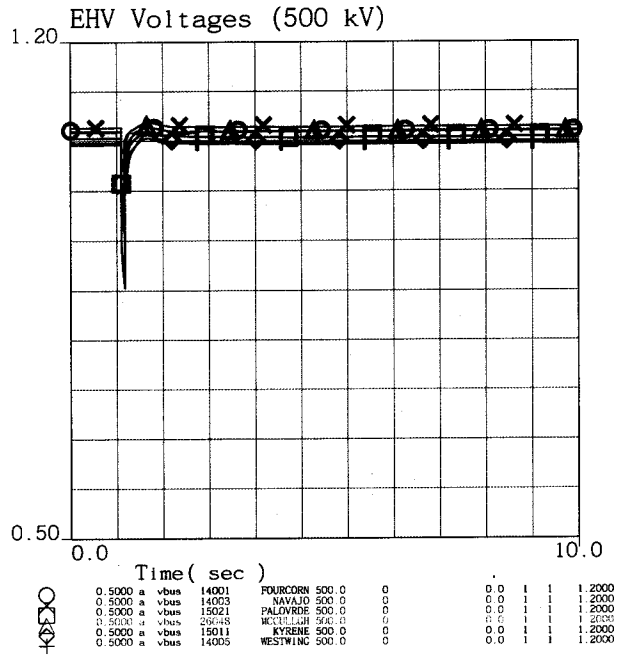

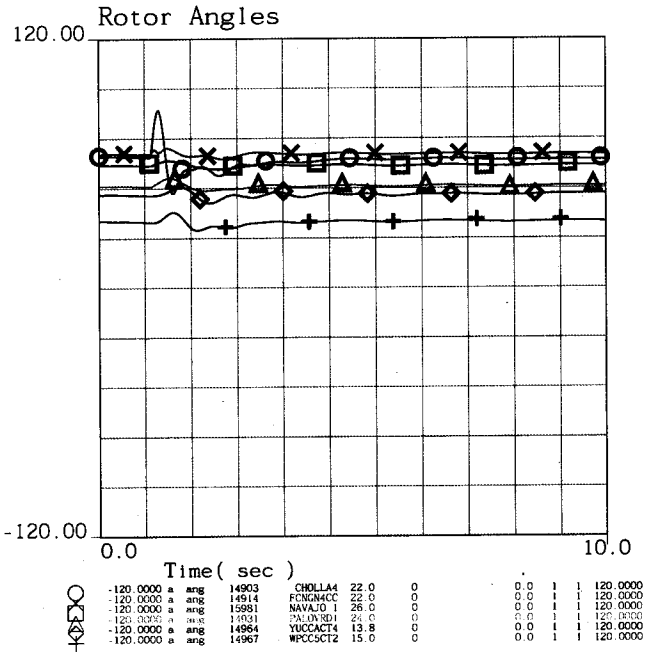

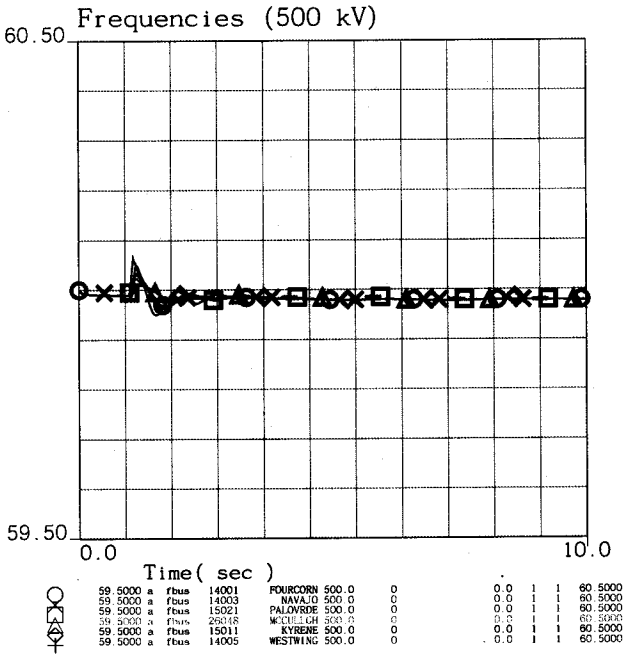

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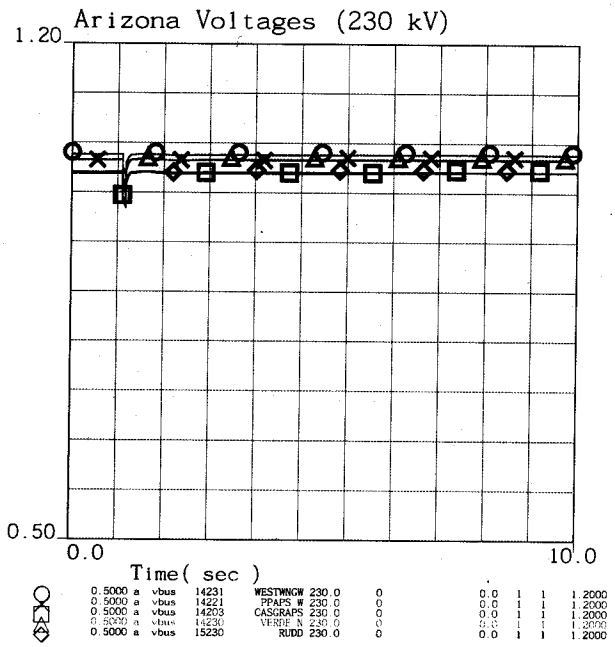

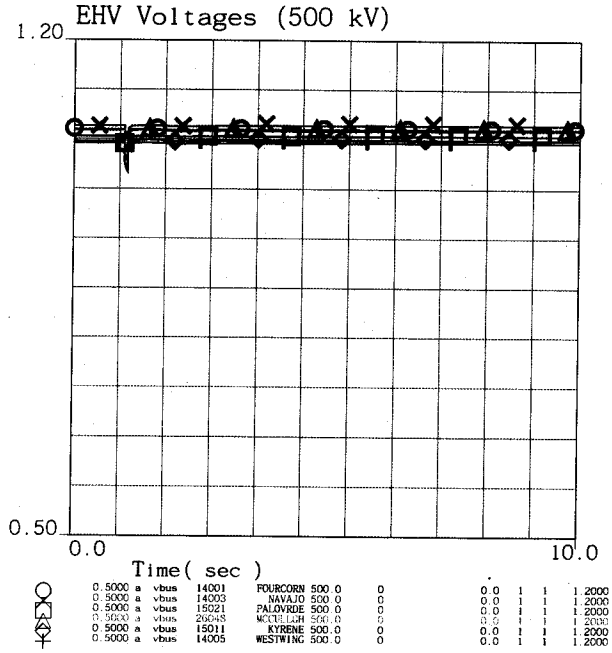

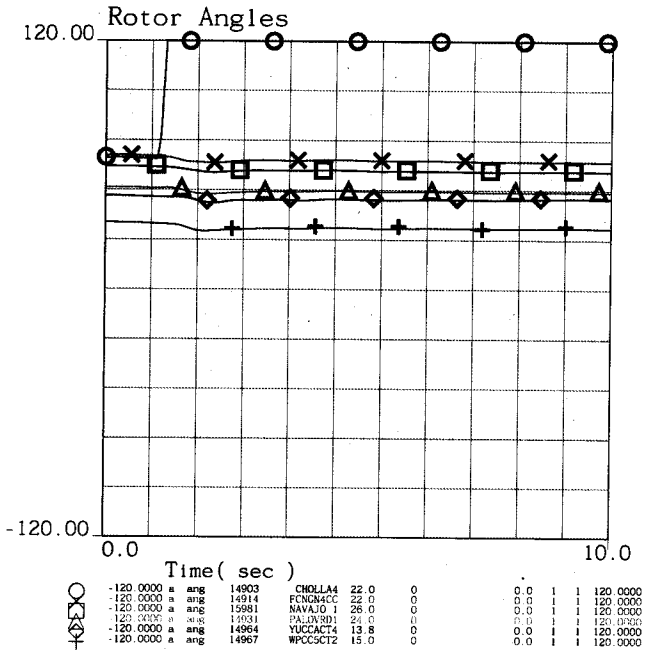

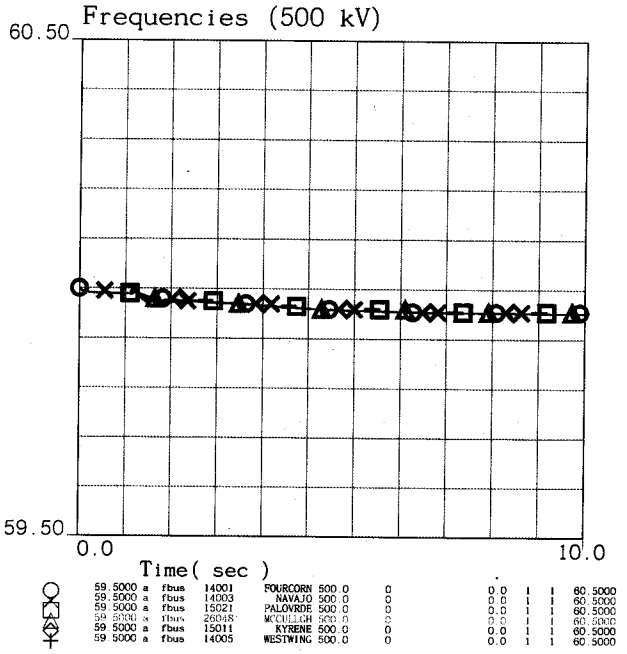

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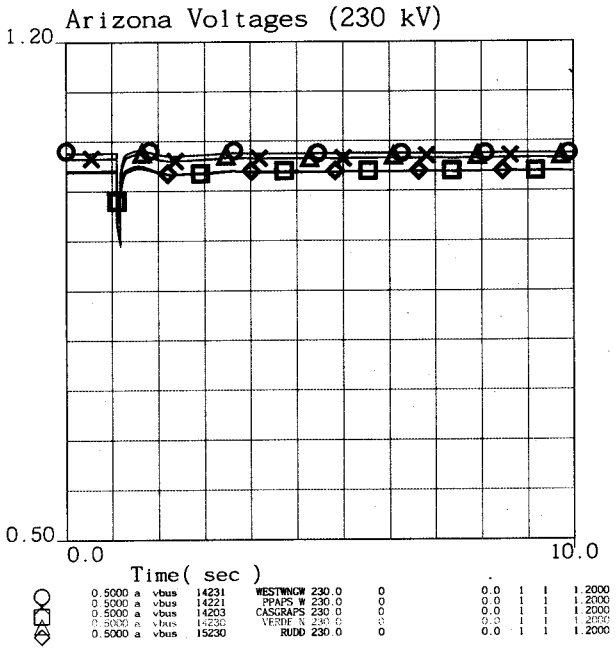

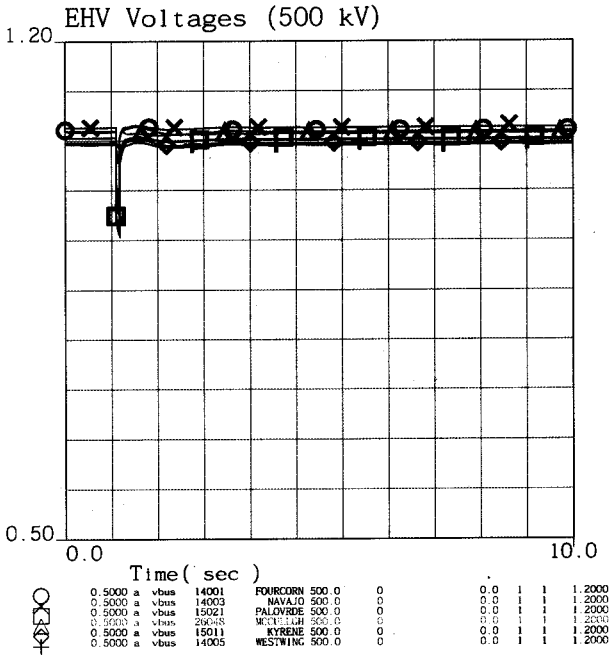

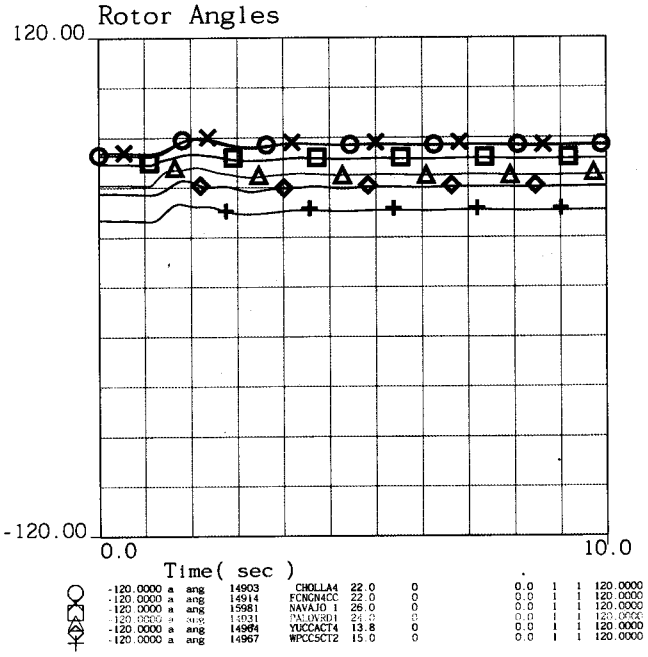

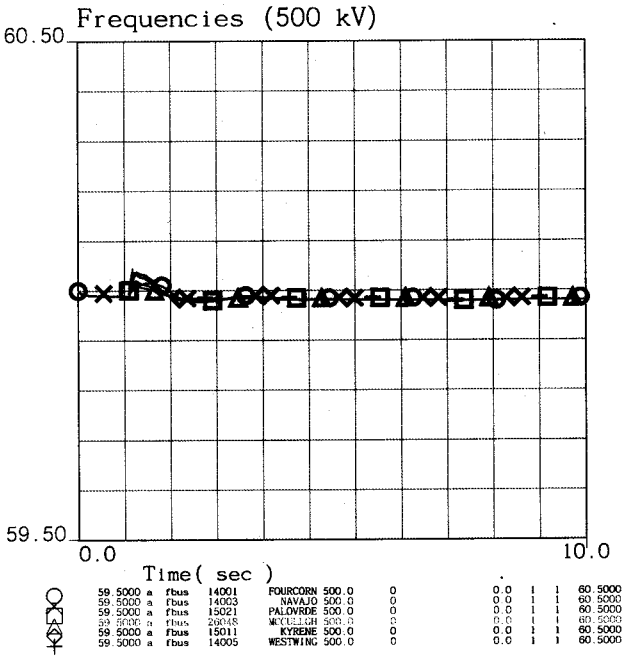

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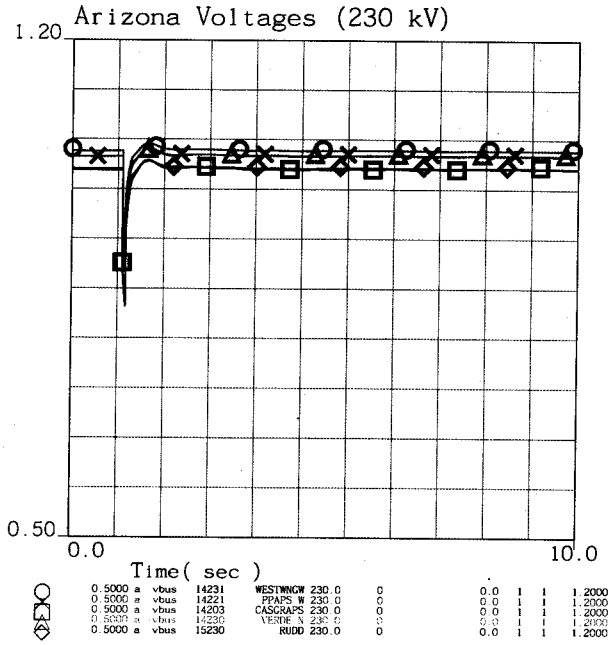

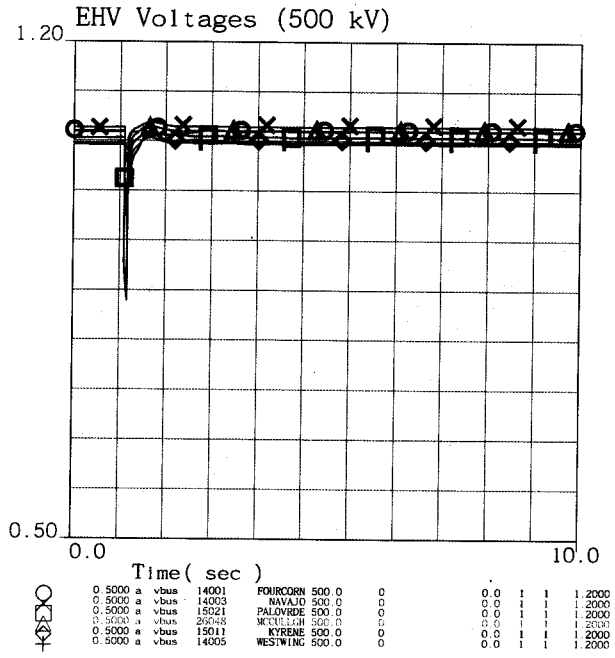

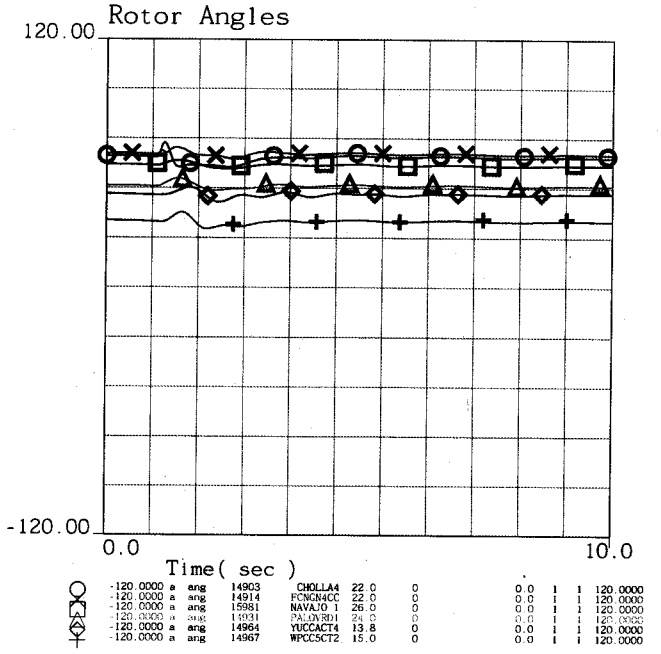

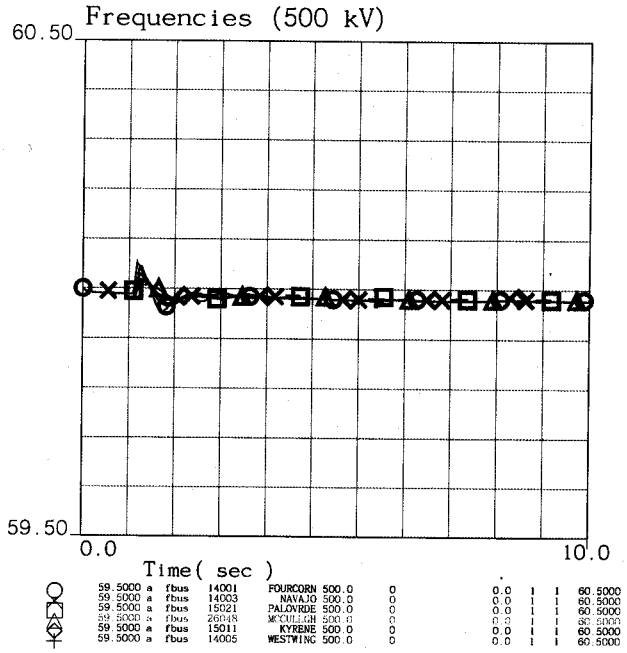

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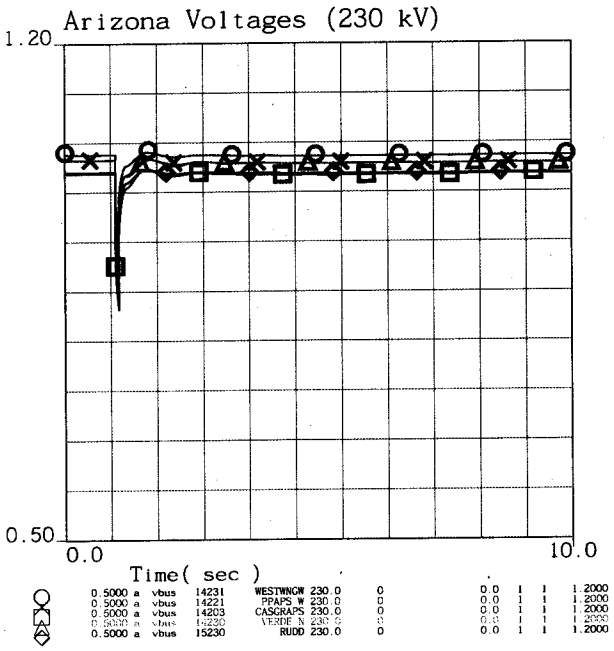

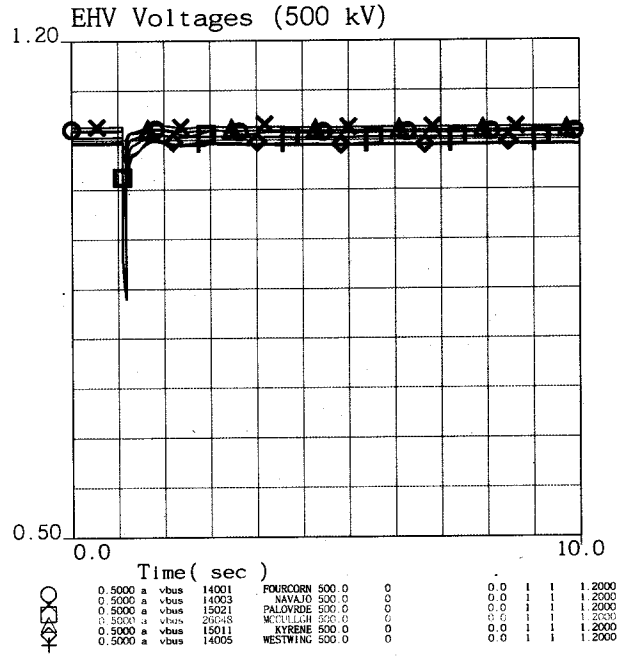

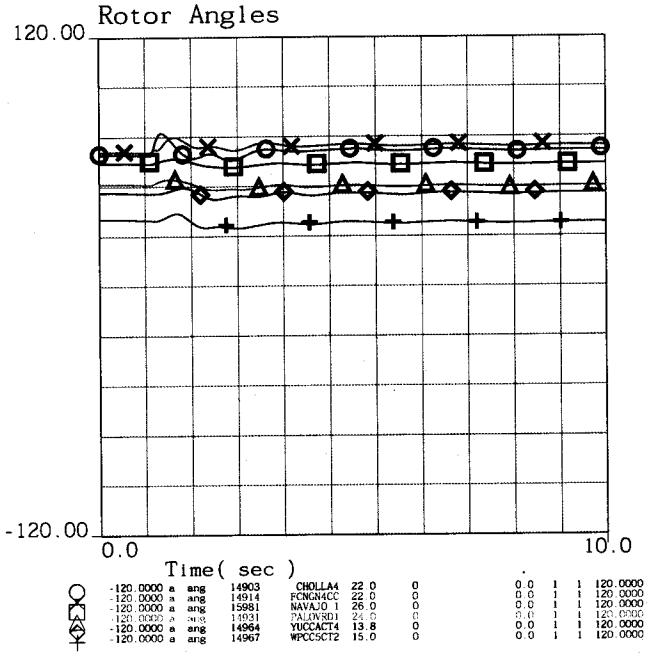

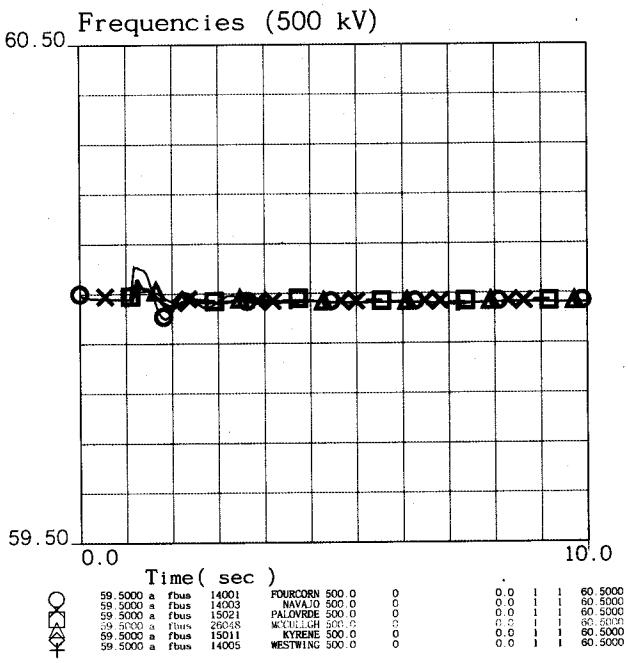

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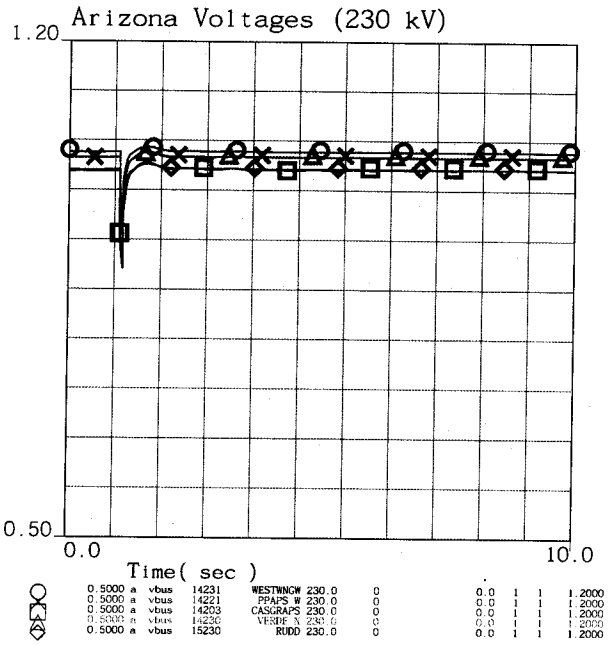
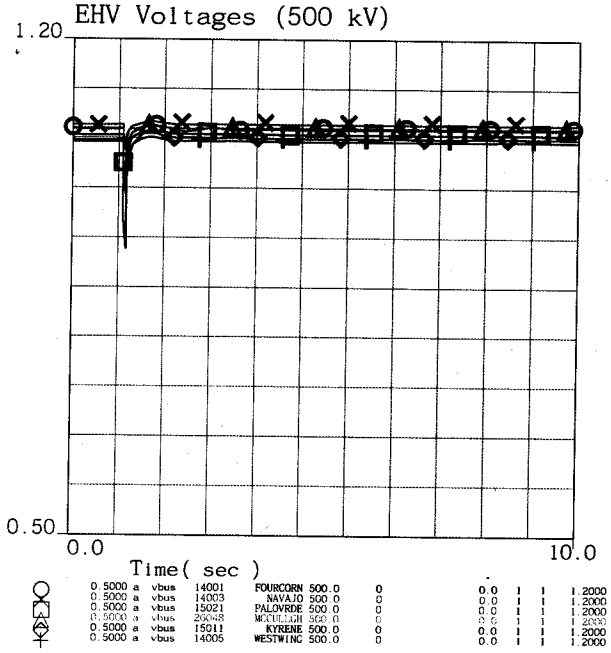
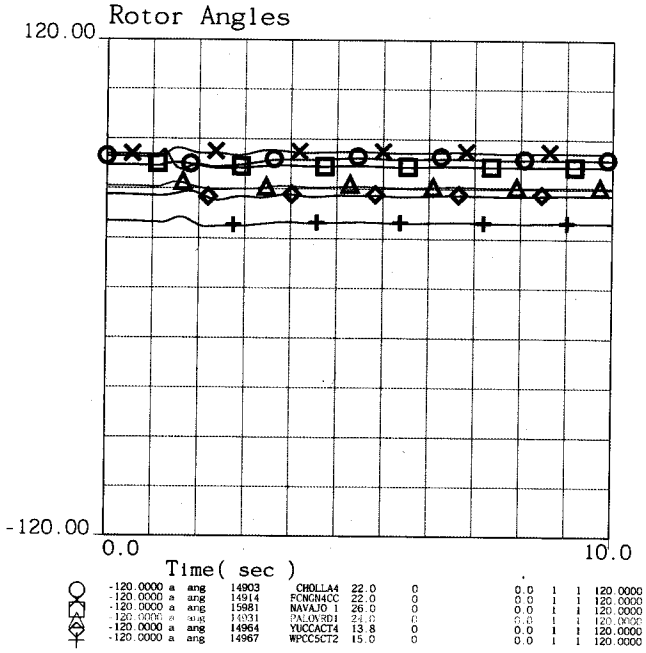
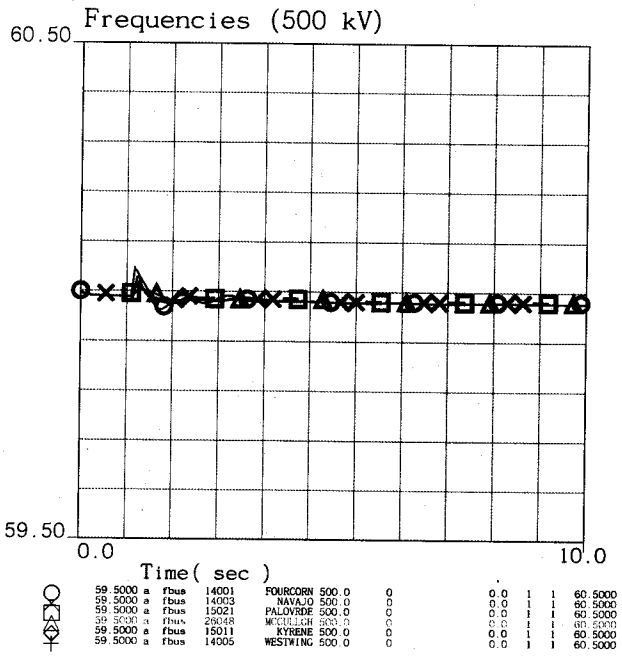
2018 Heavy Summer Detailed Planning Case









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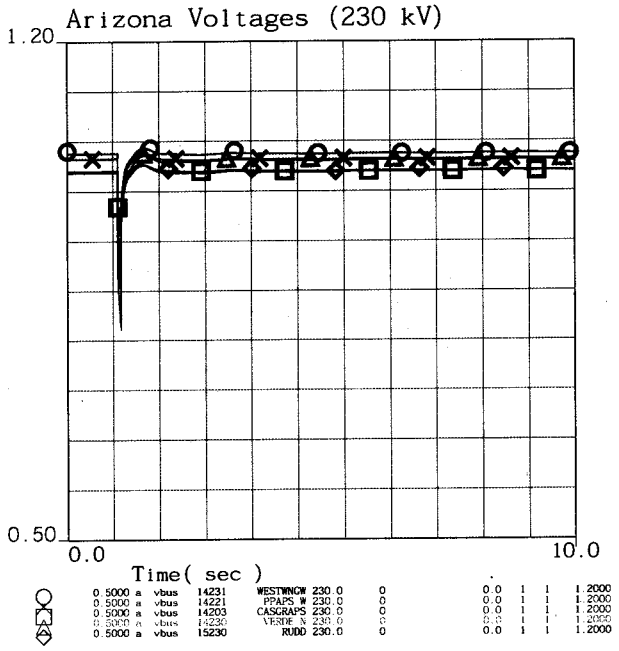

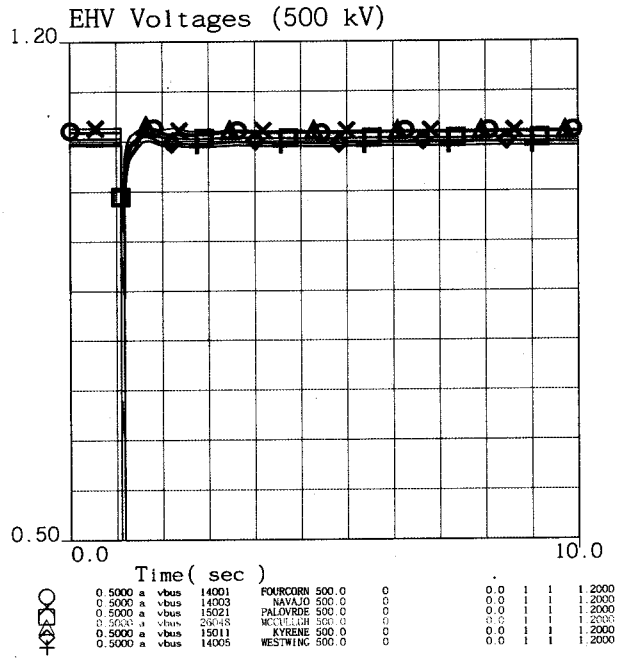

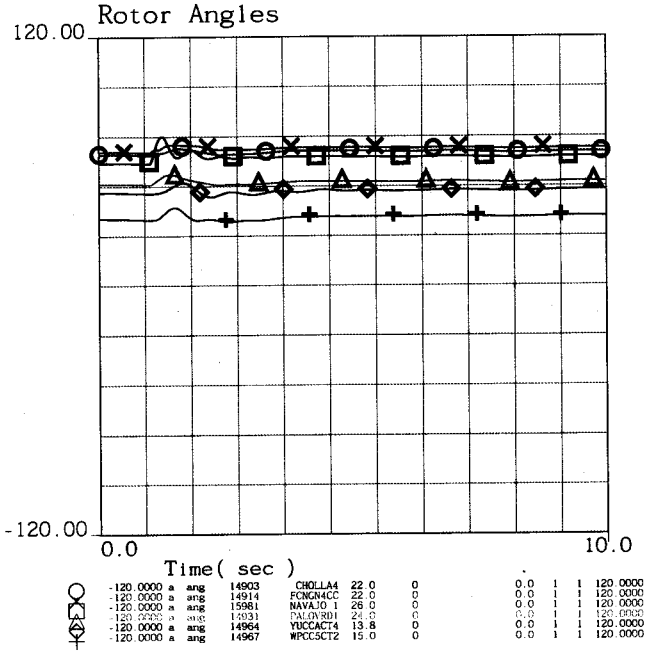

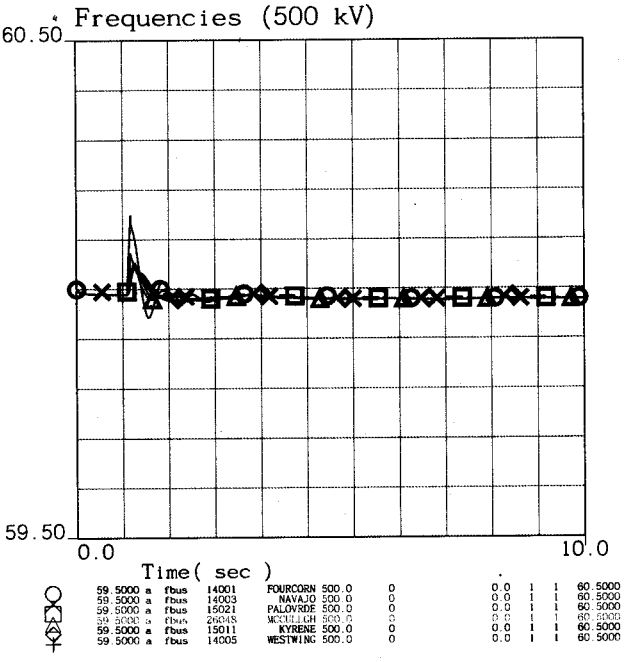

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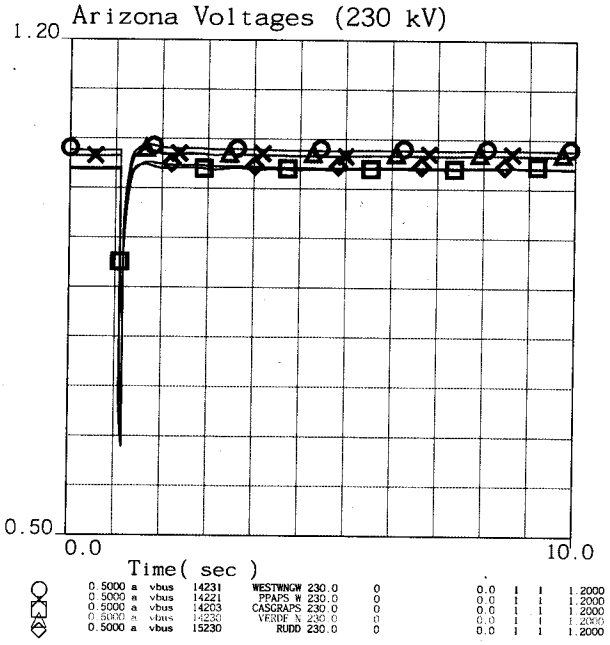

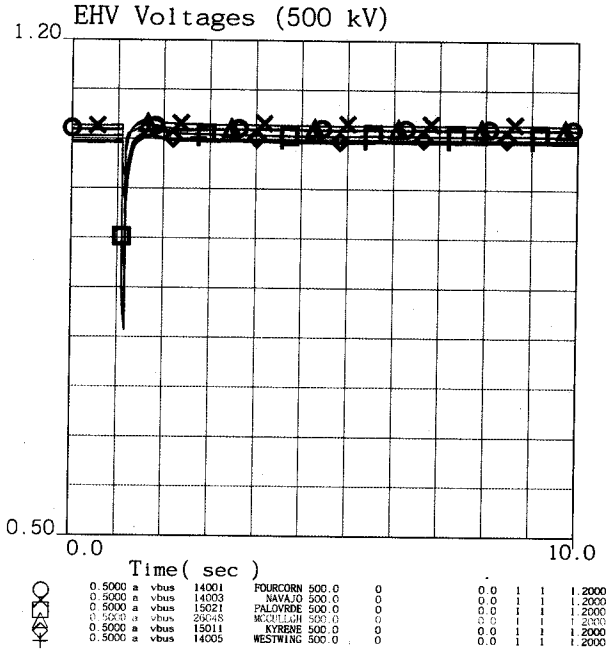

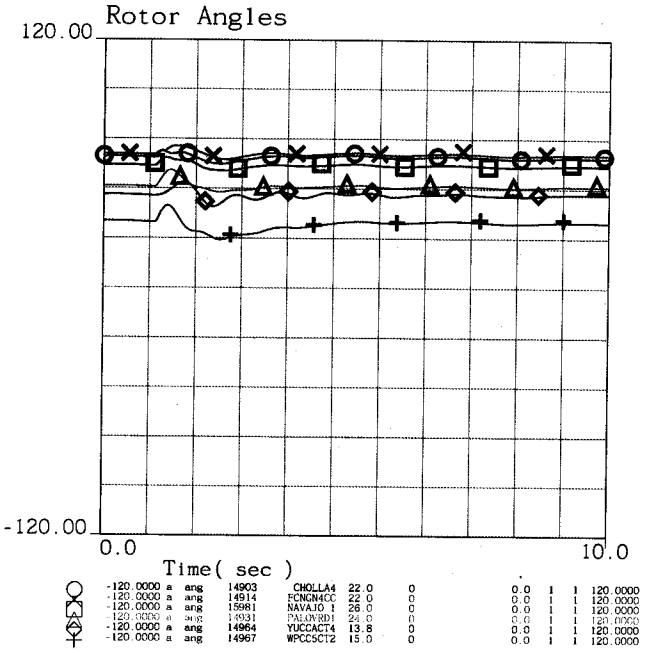

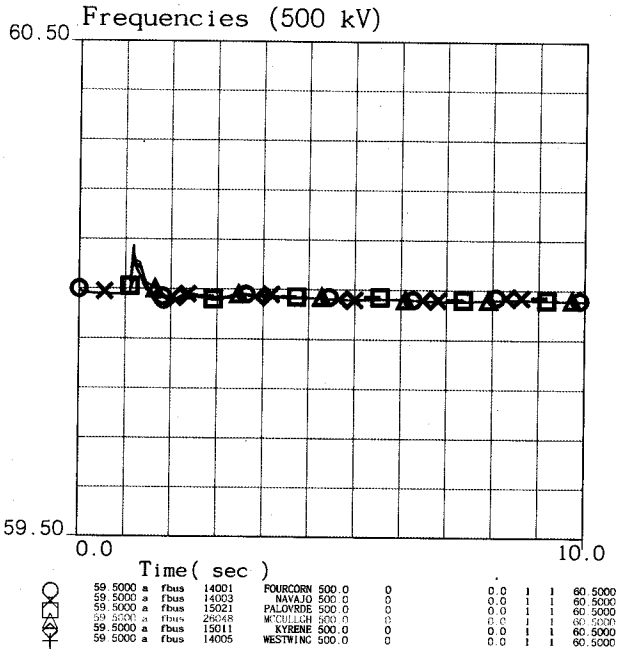

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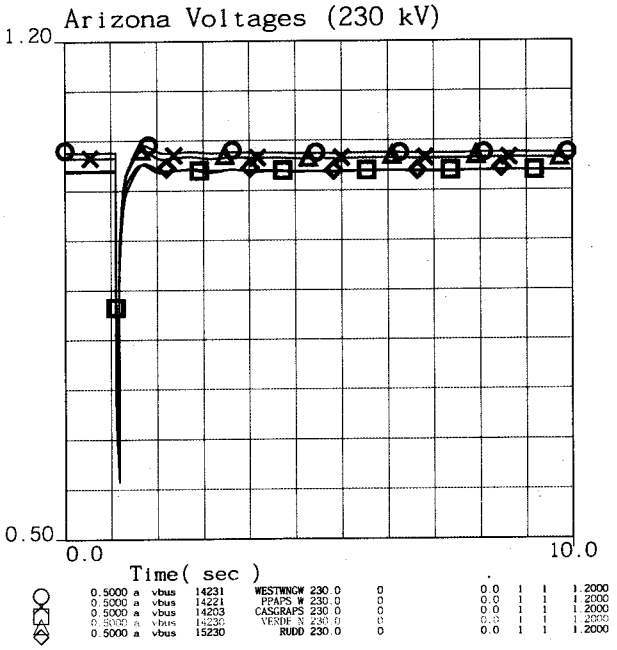

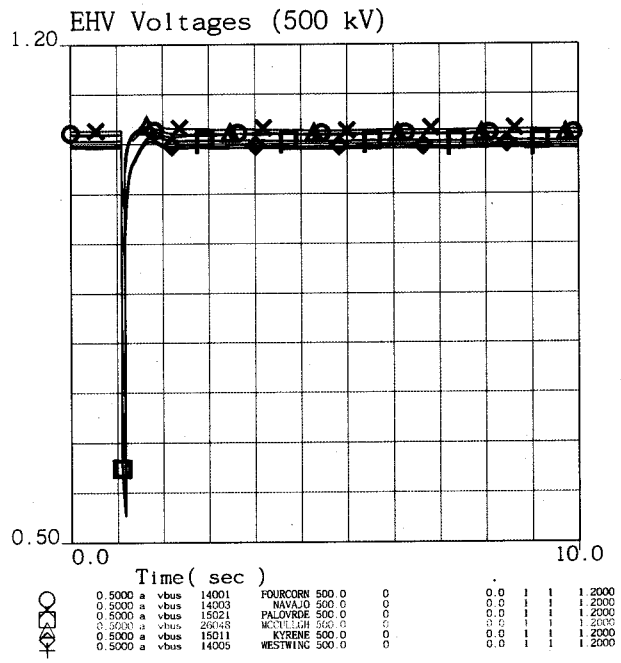

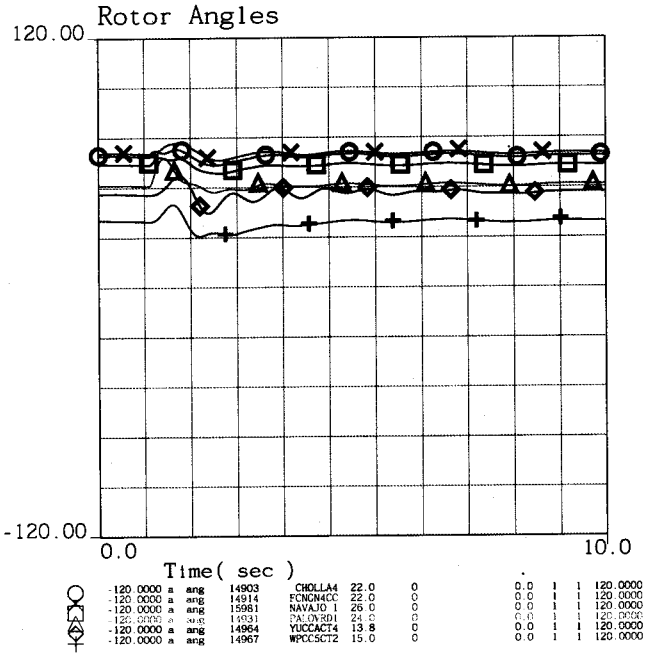

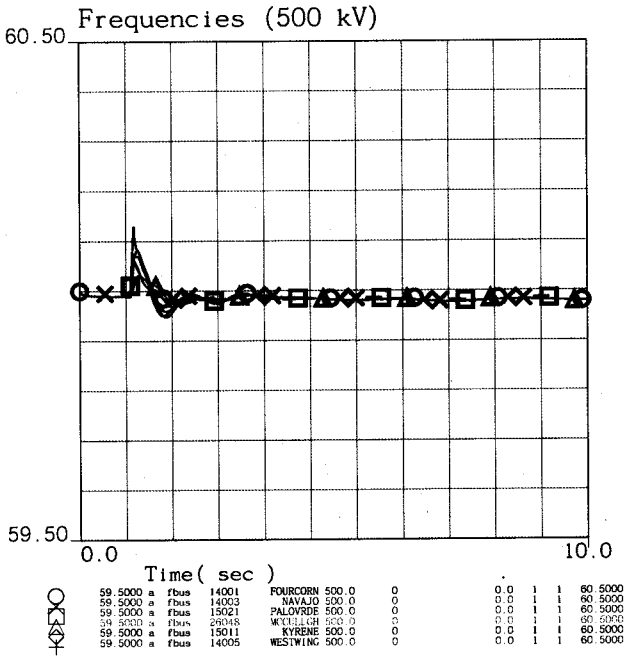

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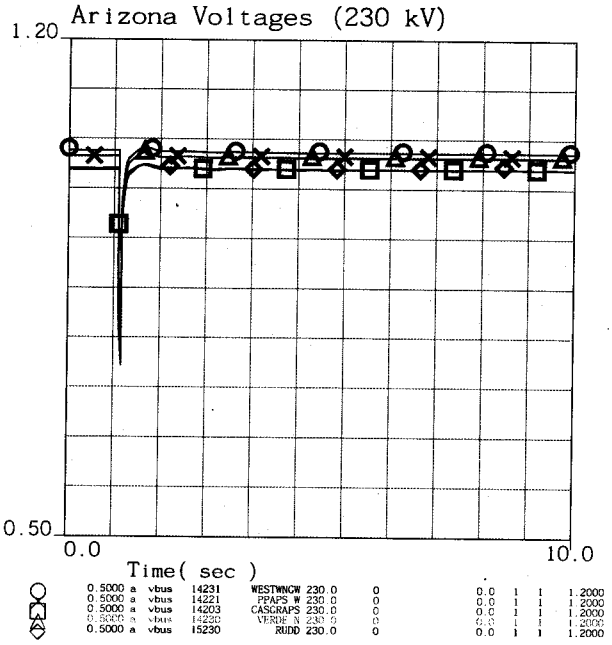

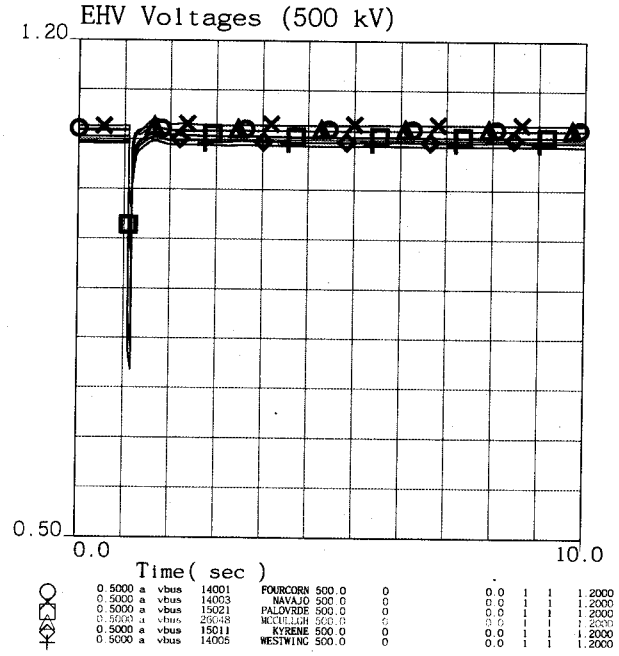

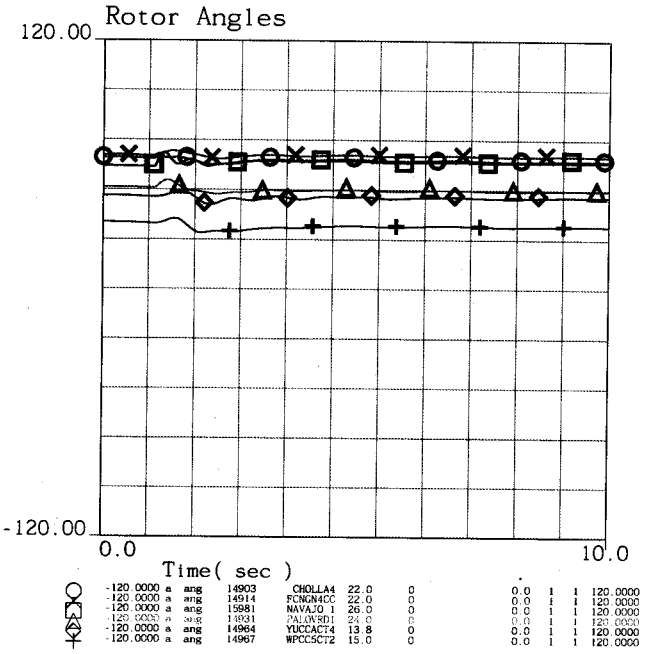

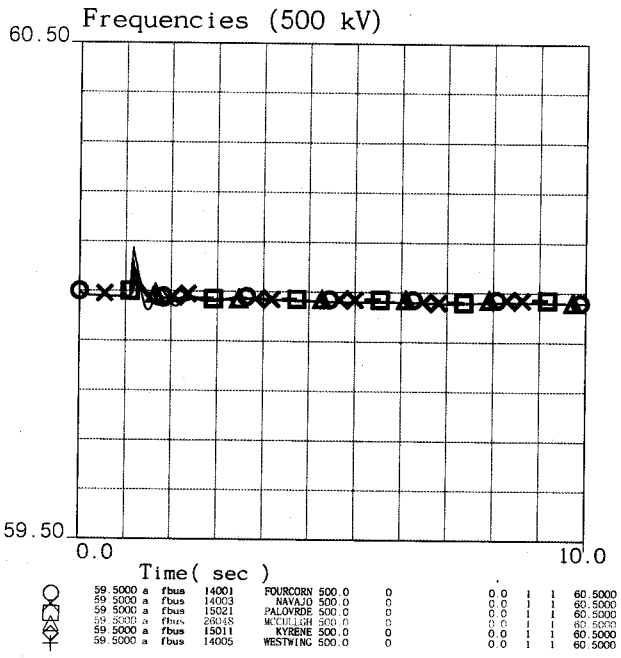

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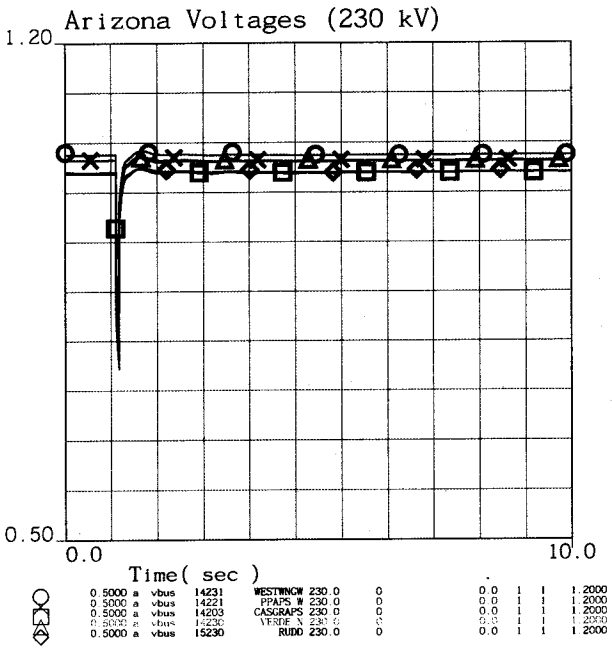

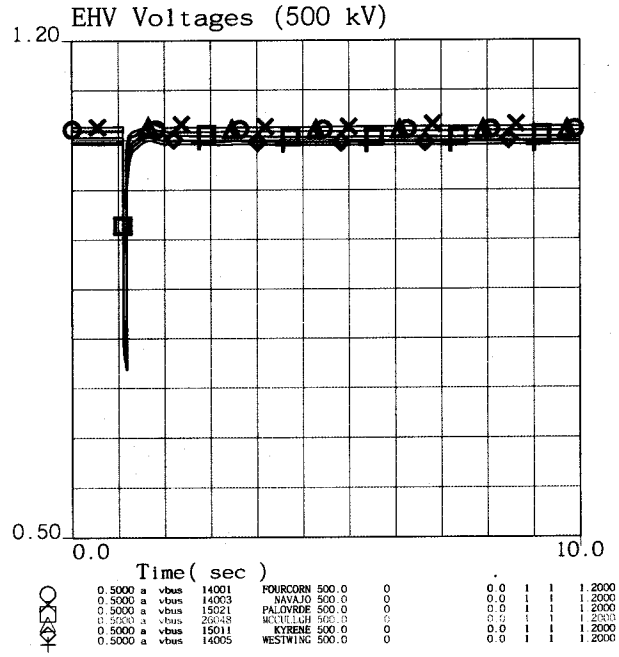

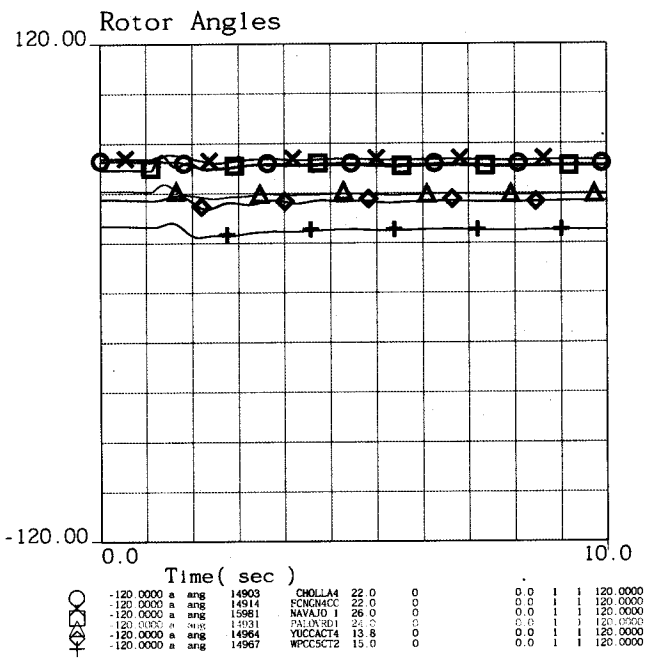

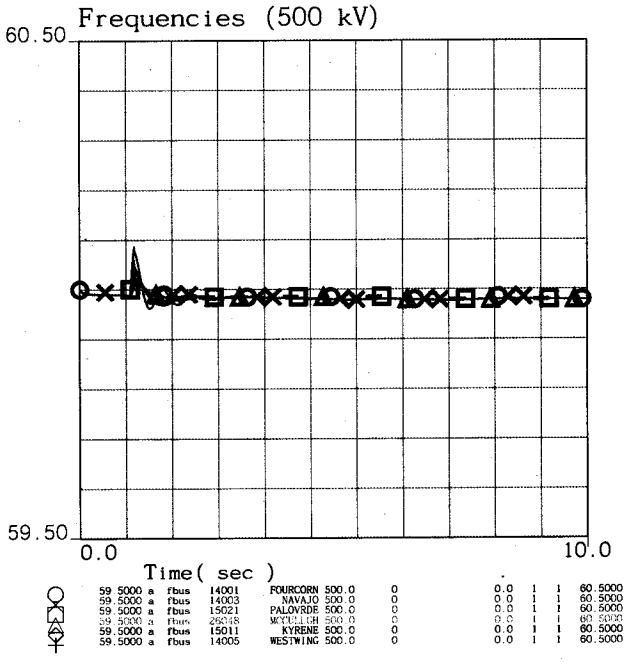

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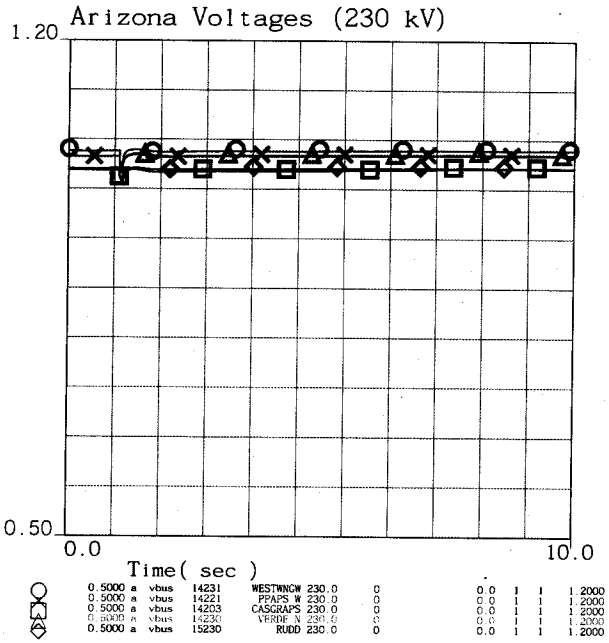

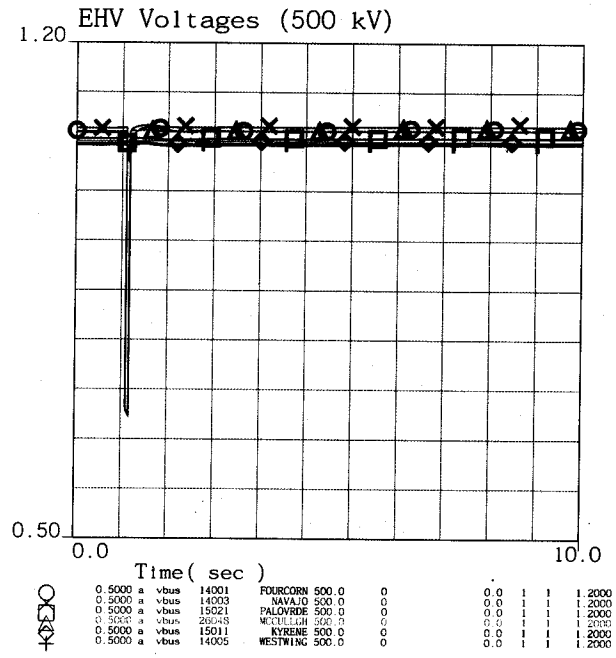

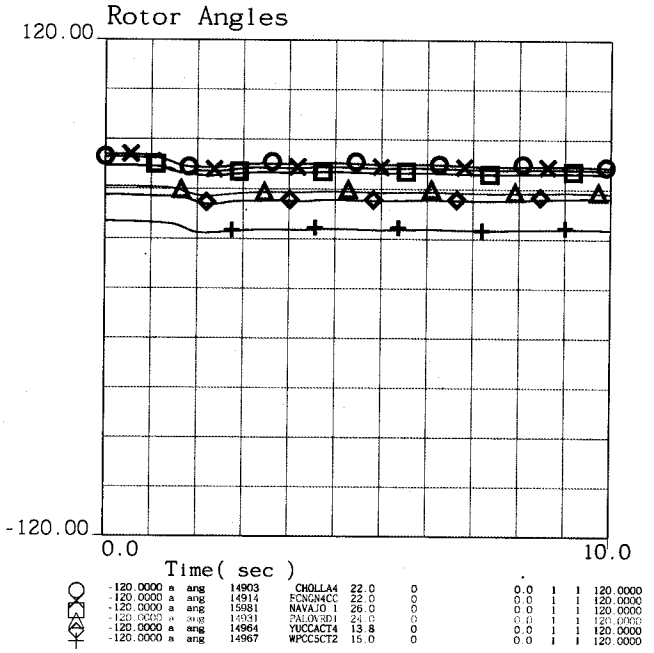

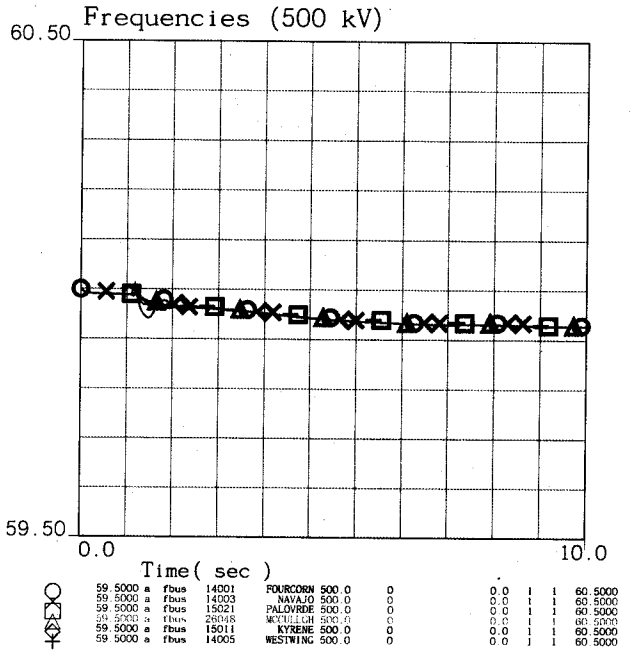

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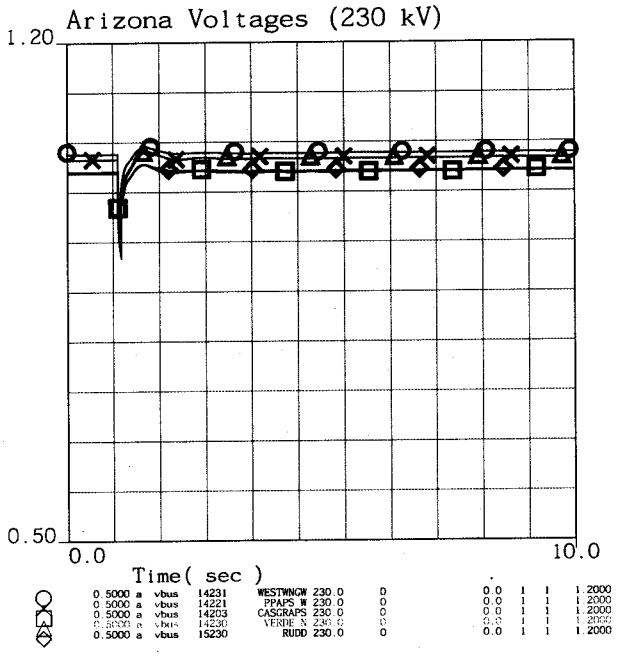

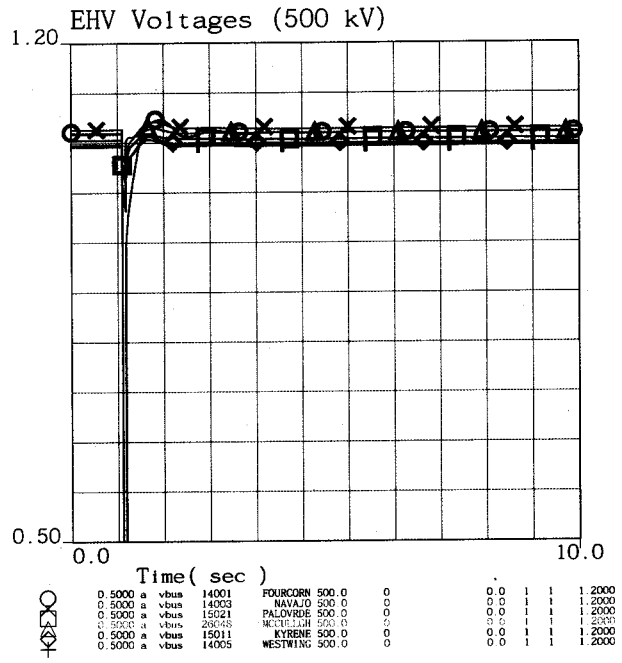

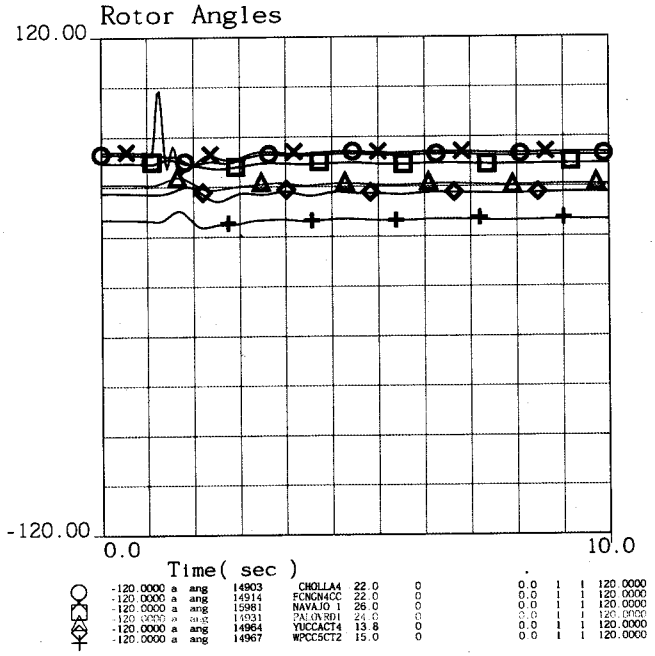

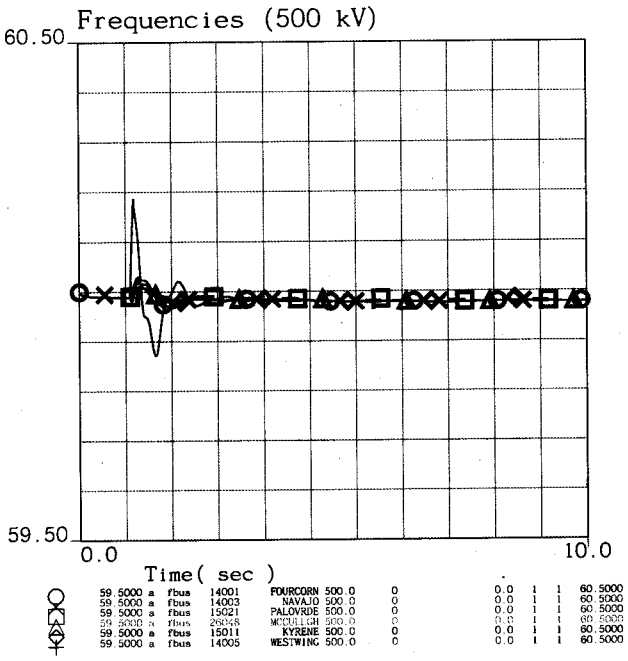

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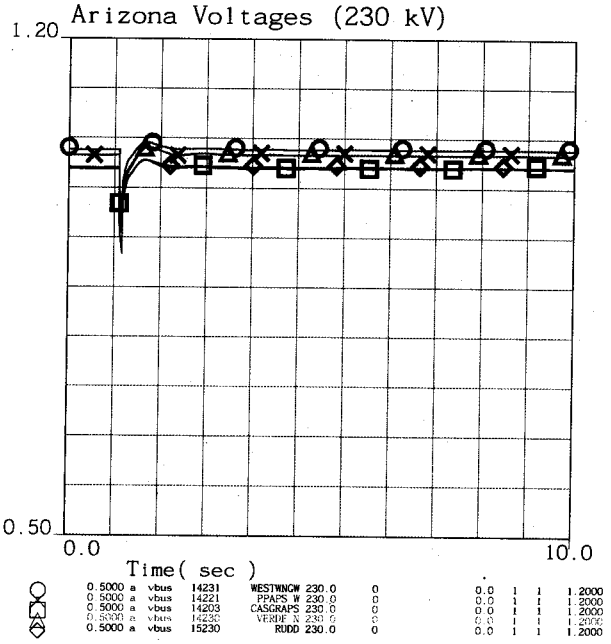

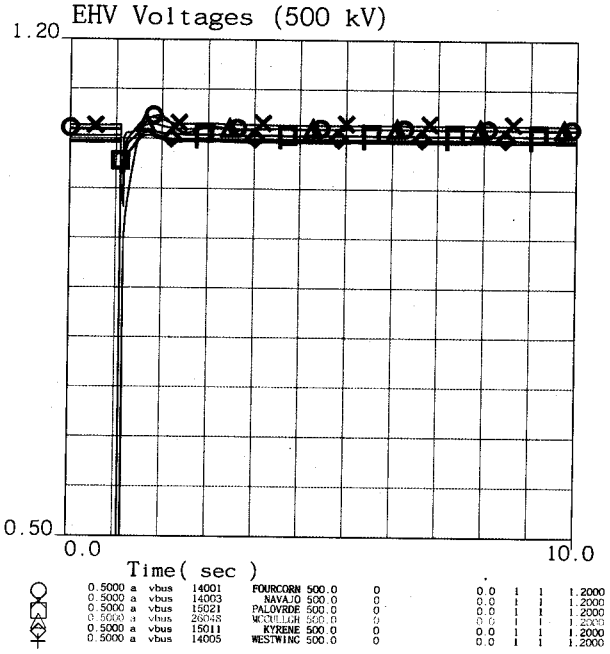

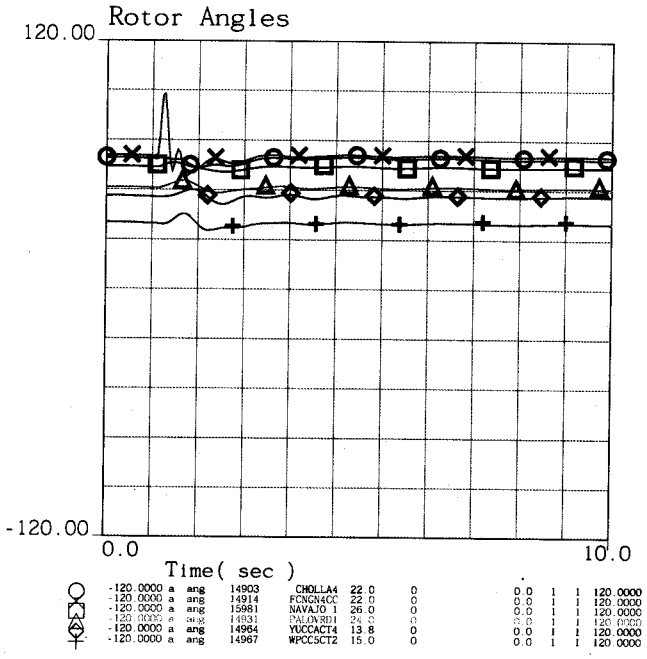

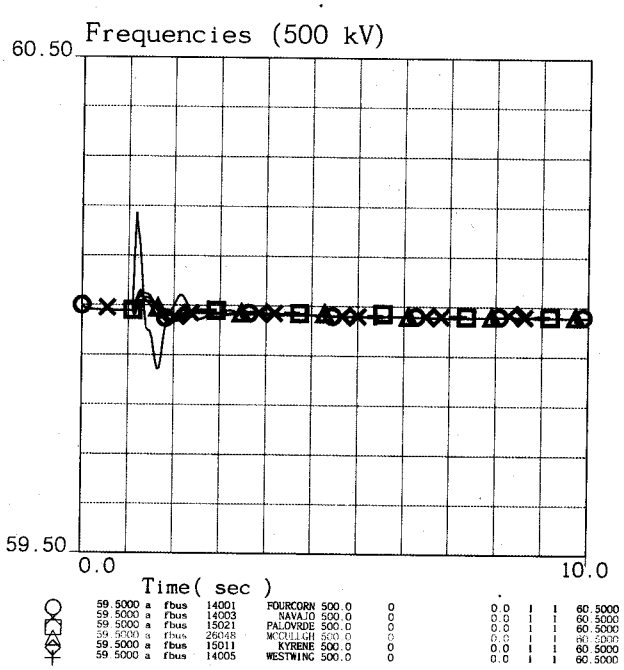

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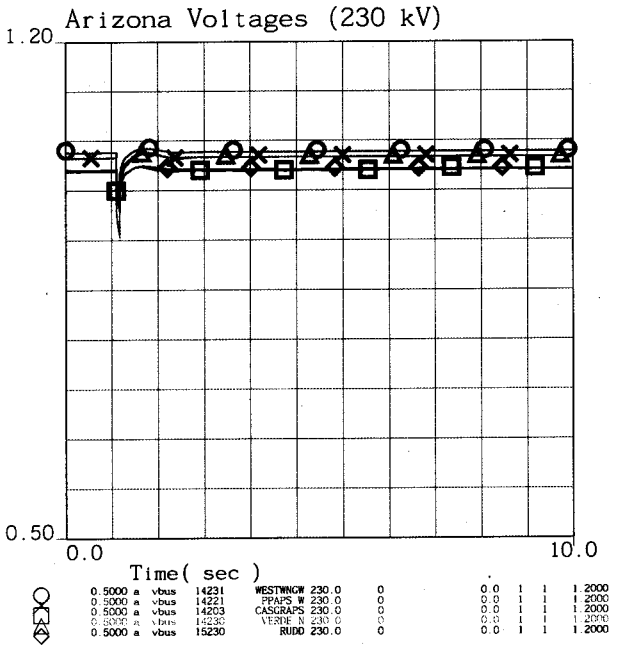

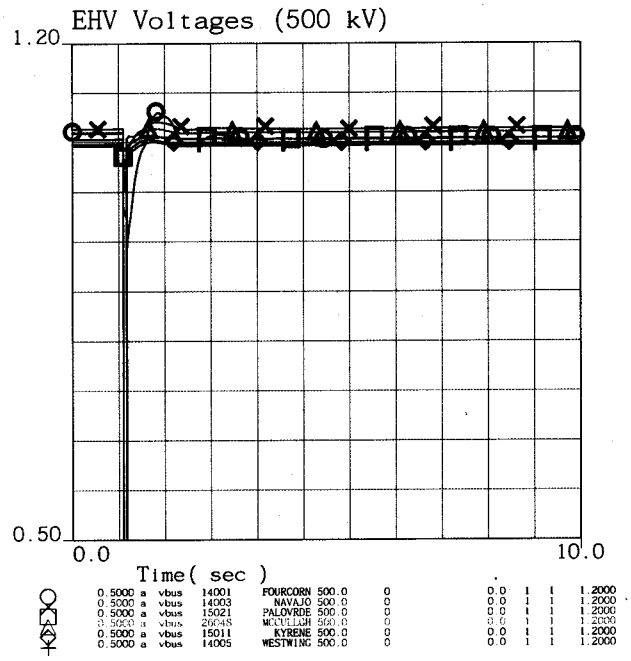

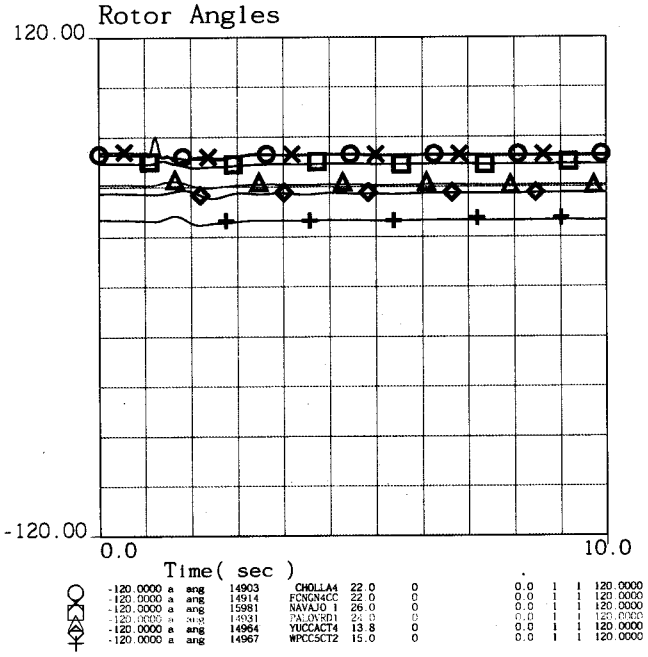

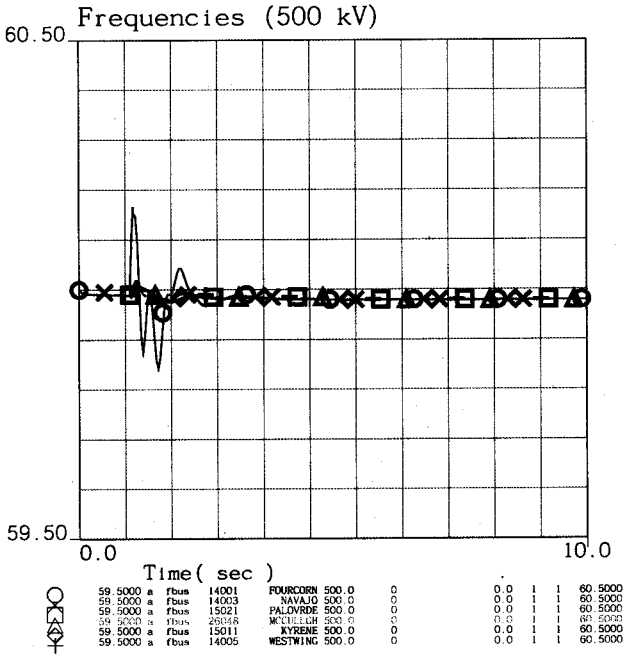

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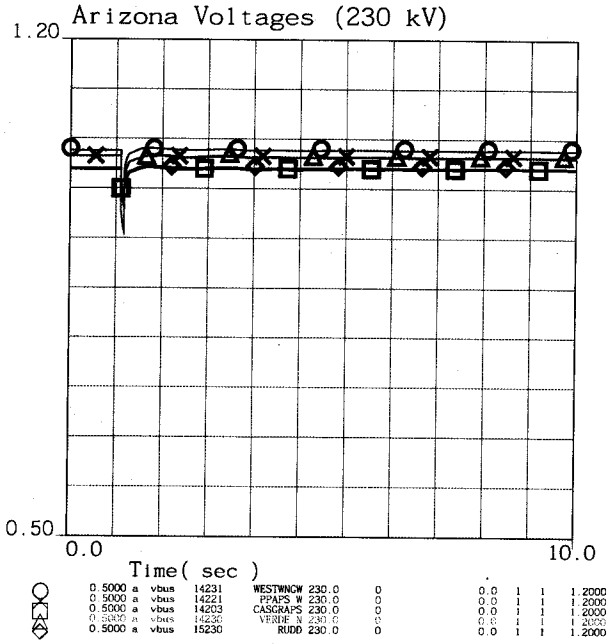

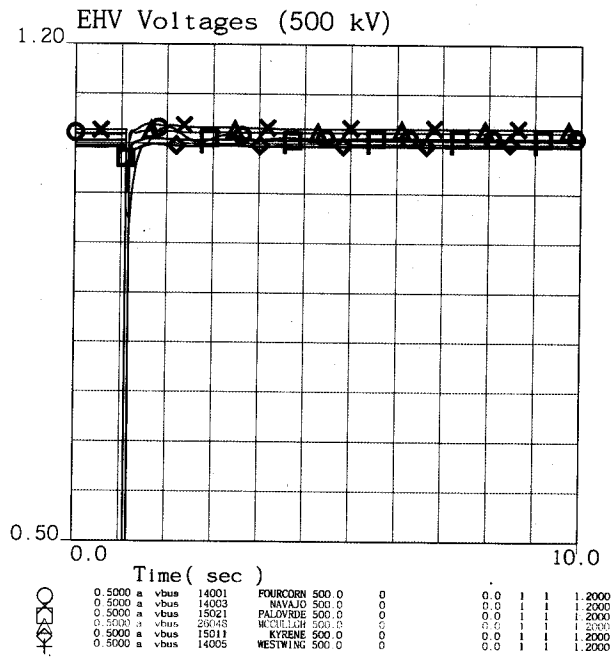

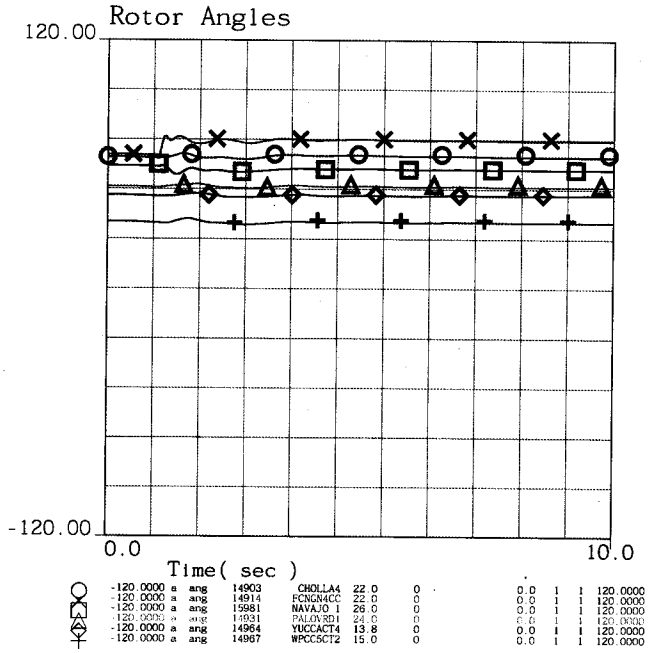

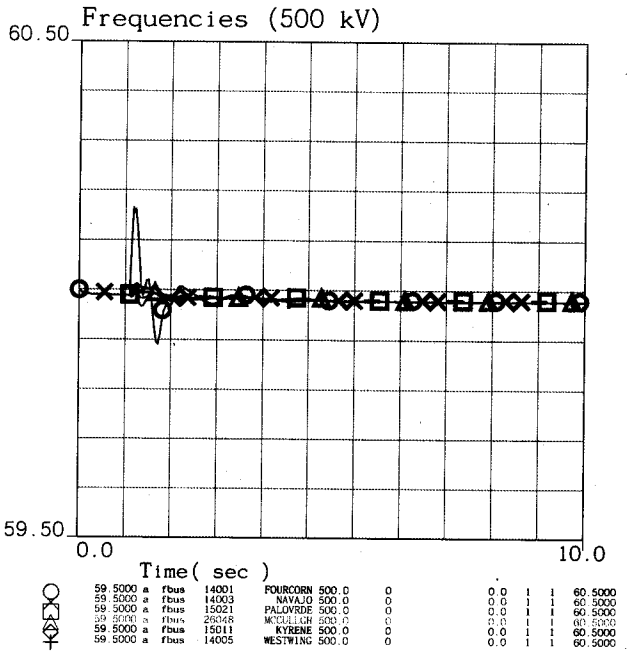

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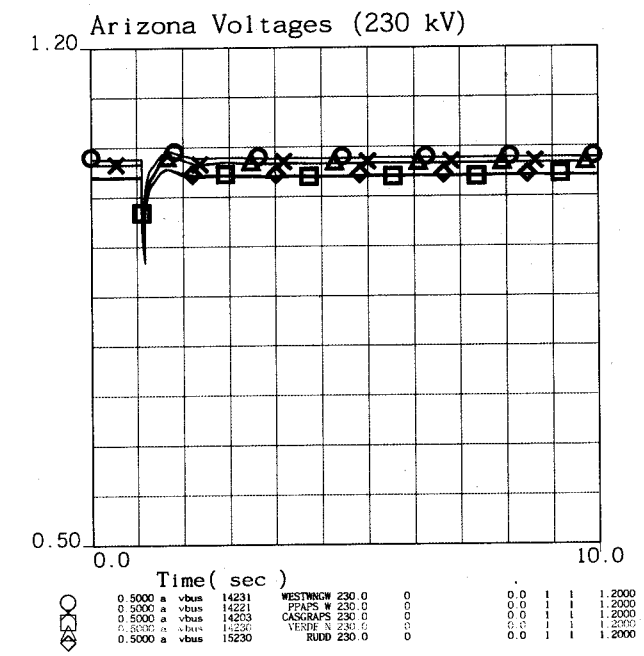

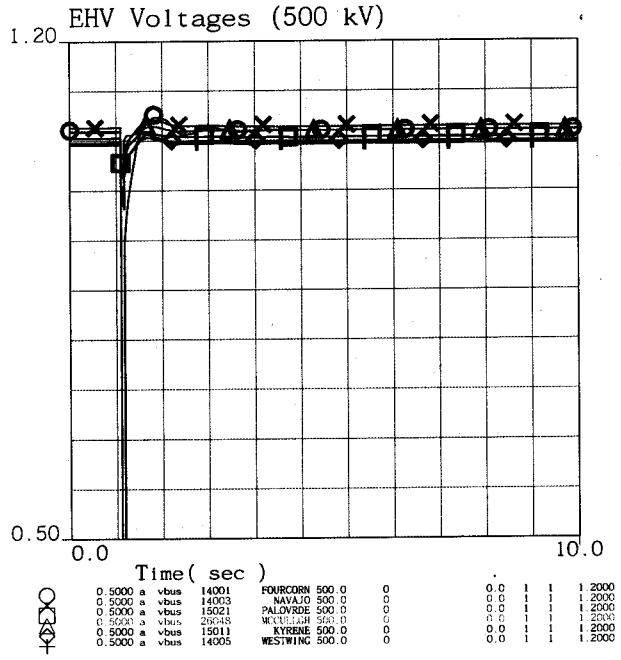

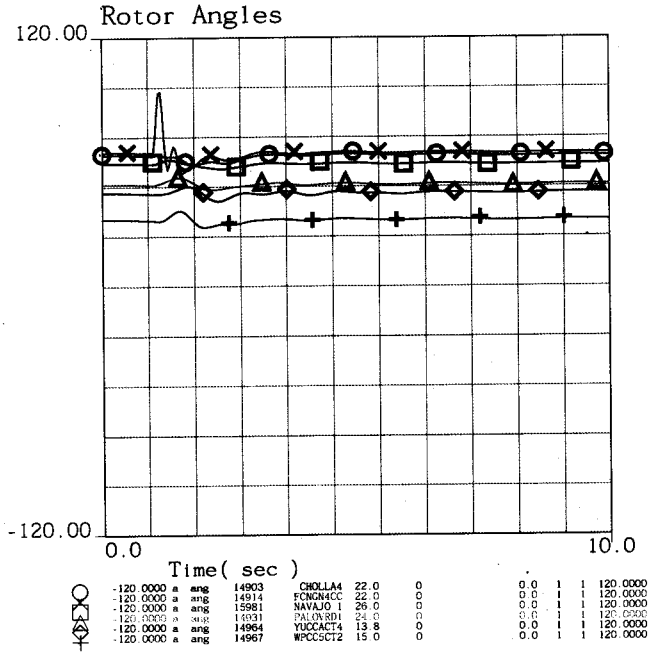

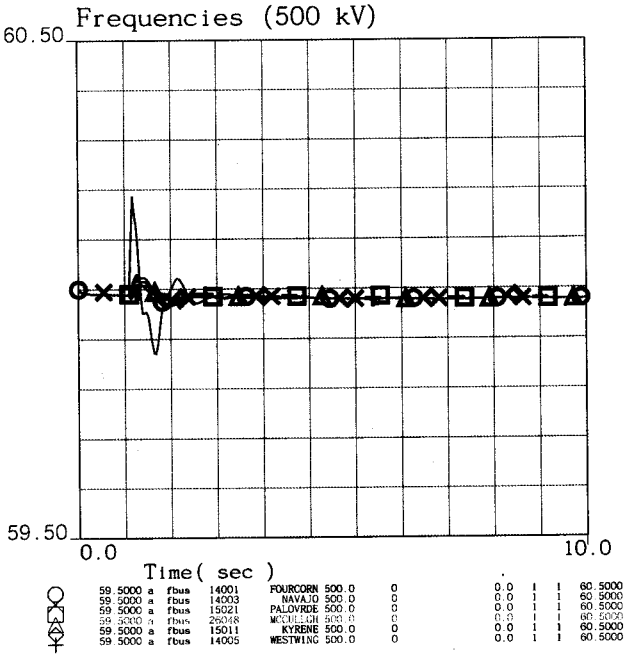

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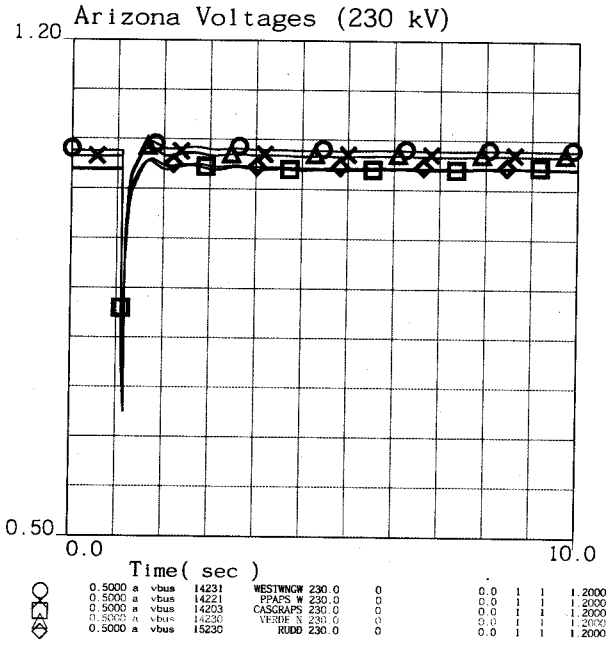

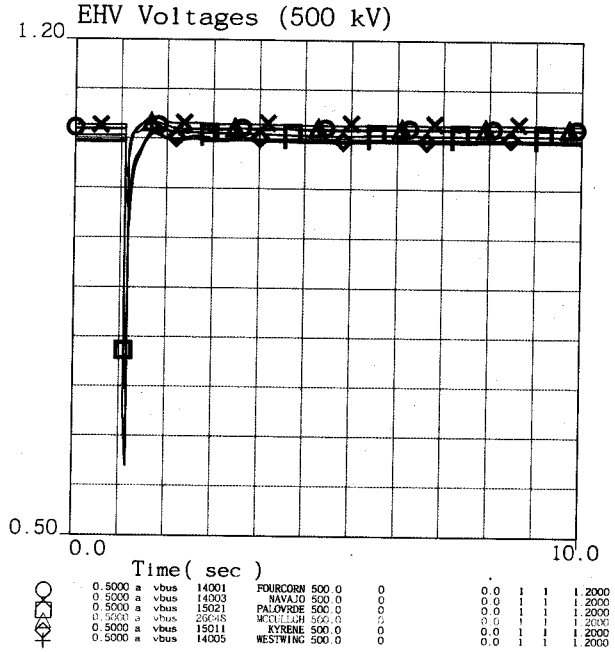

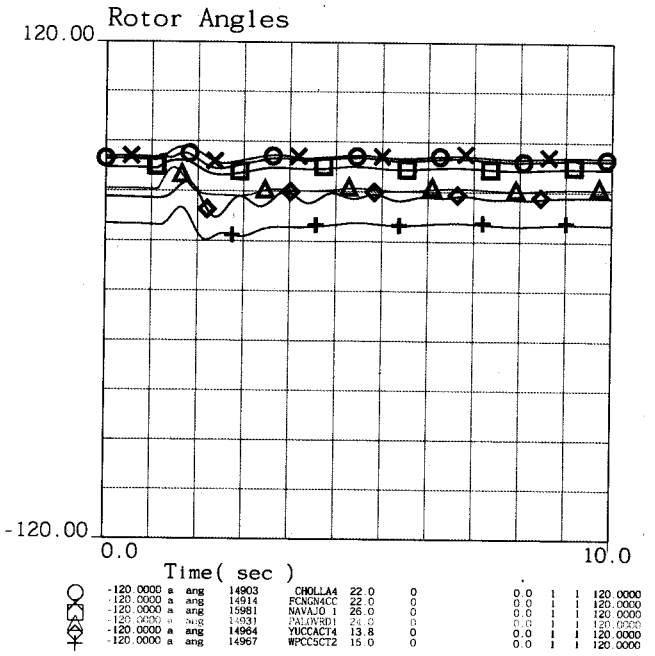

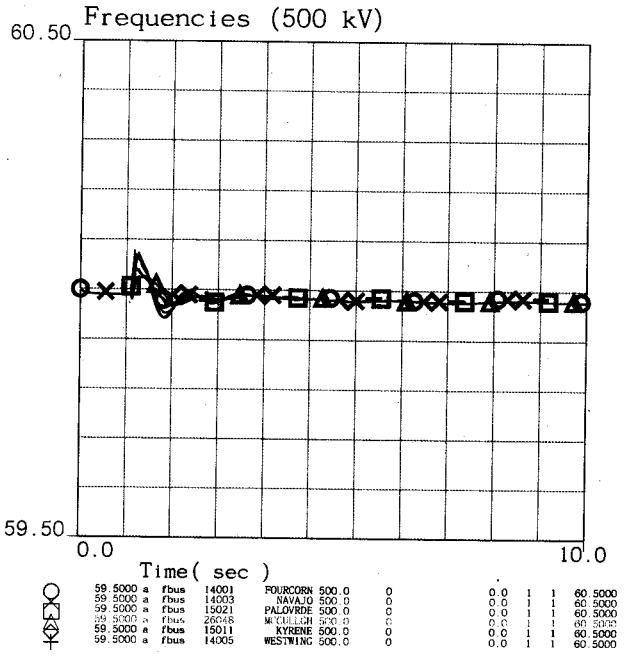

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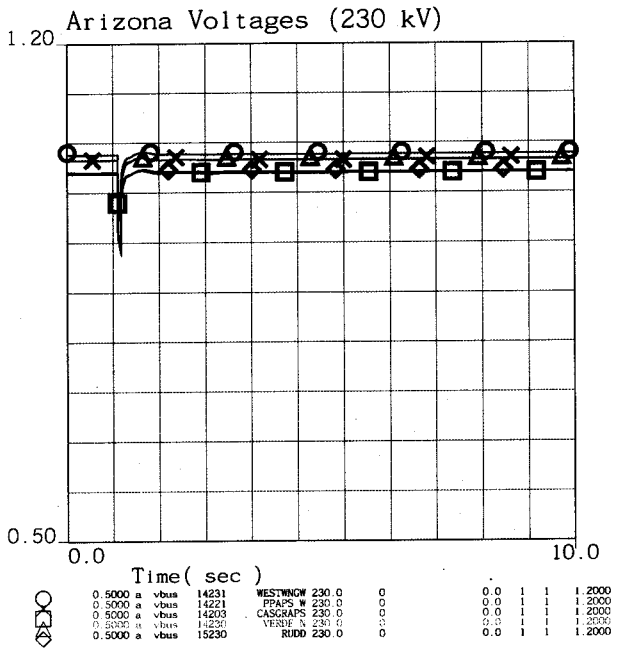

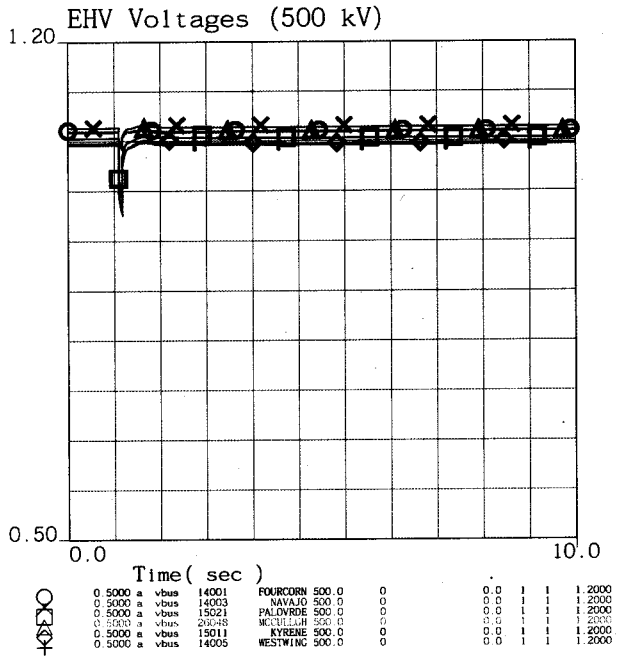

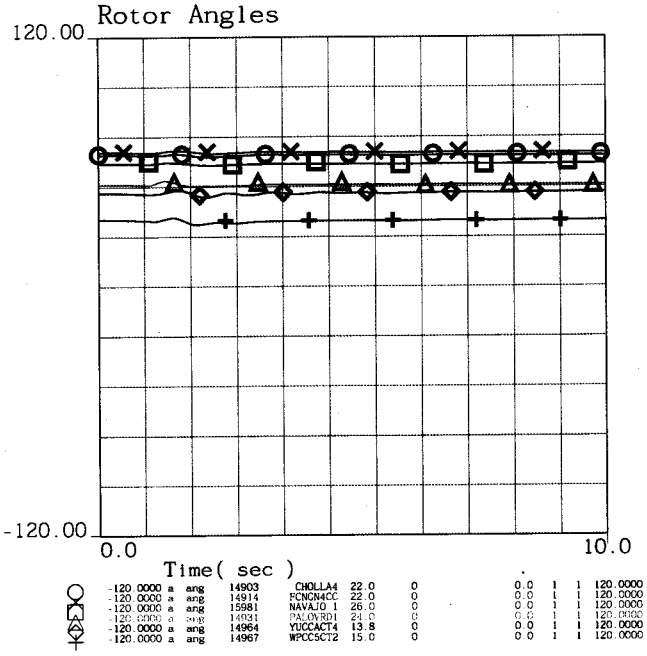

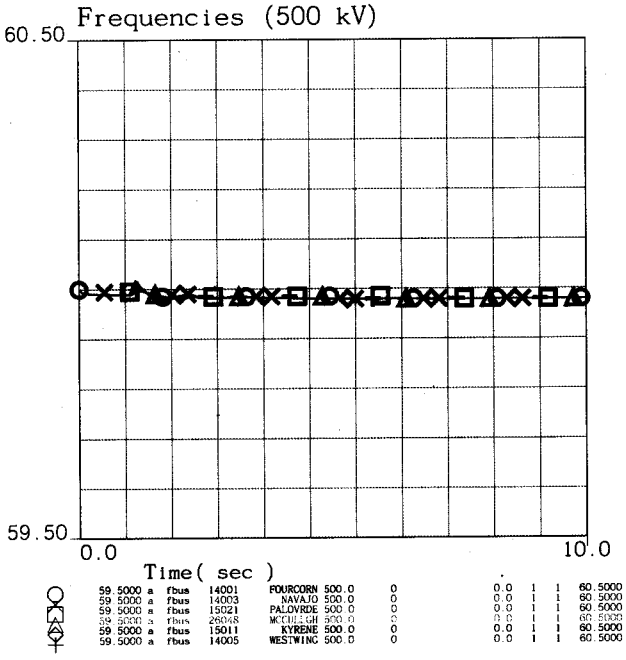

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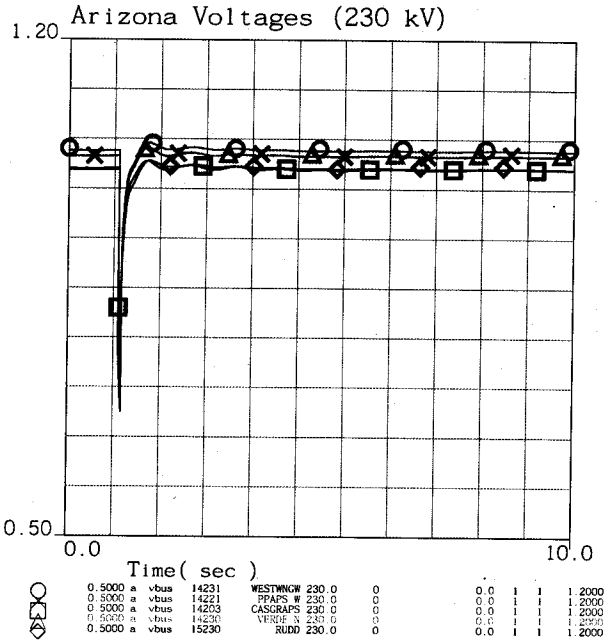
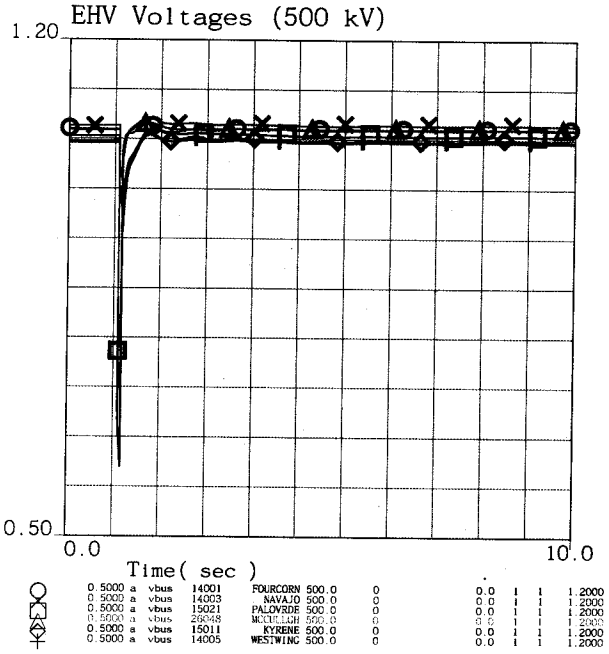
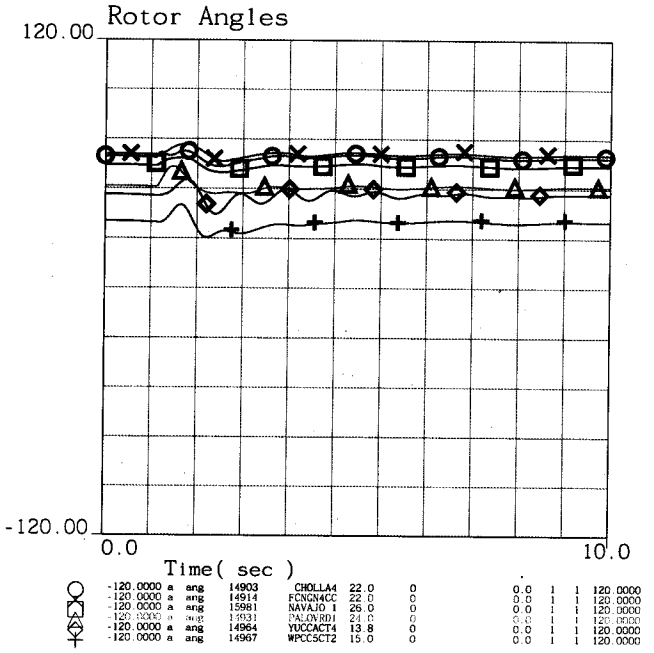
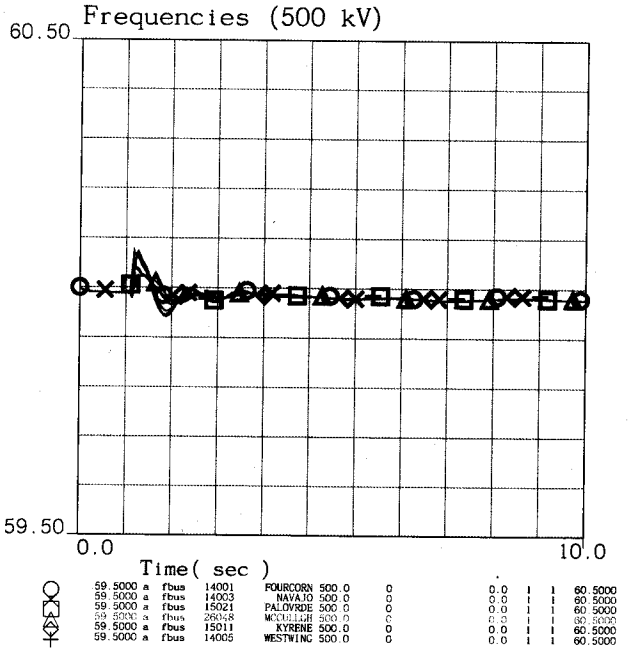
2018 Heavy Summer Detailed Planning Case









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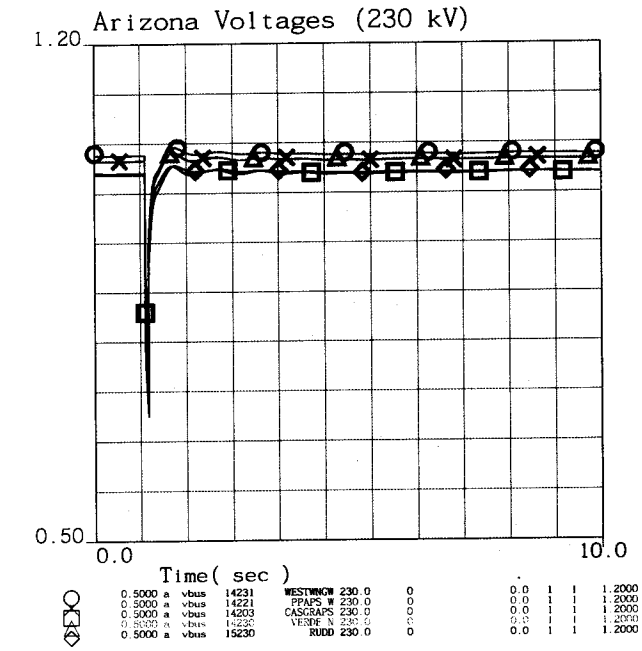

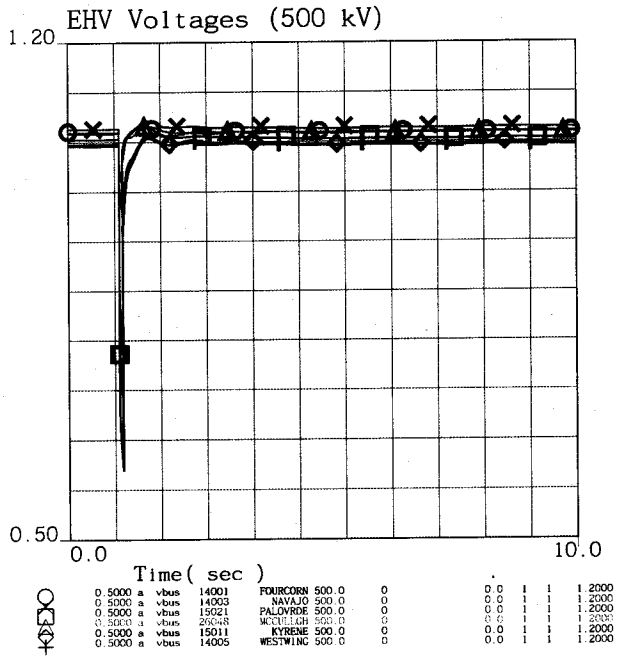

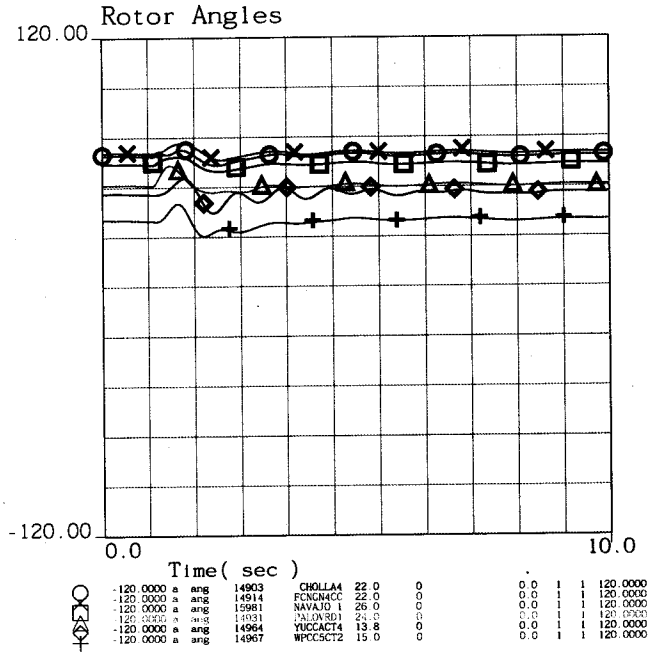

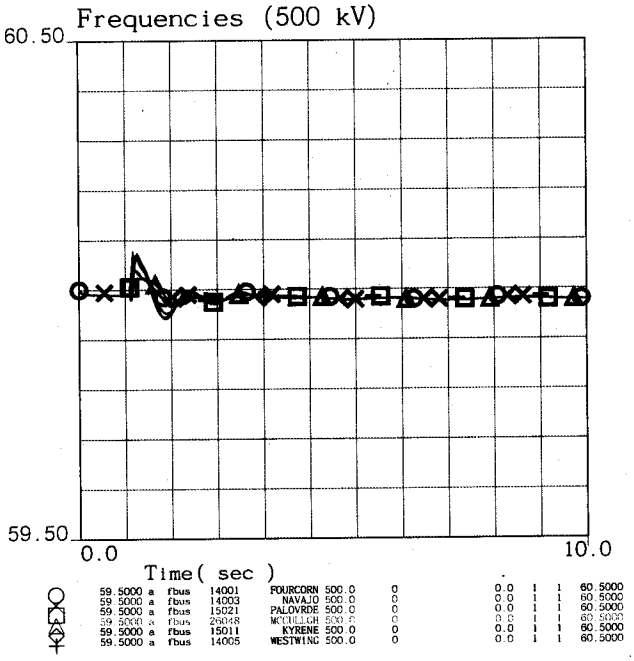

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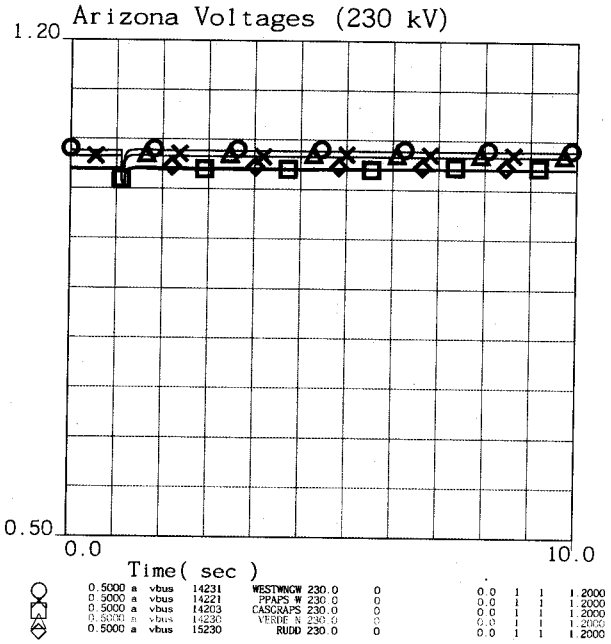

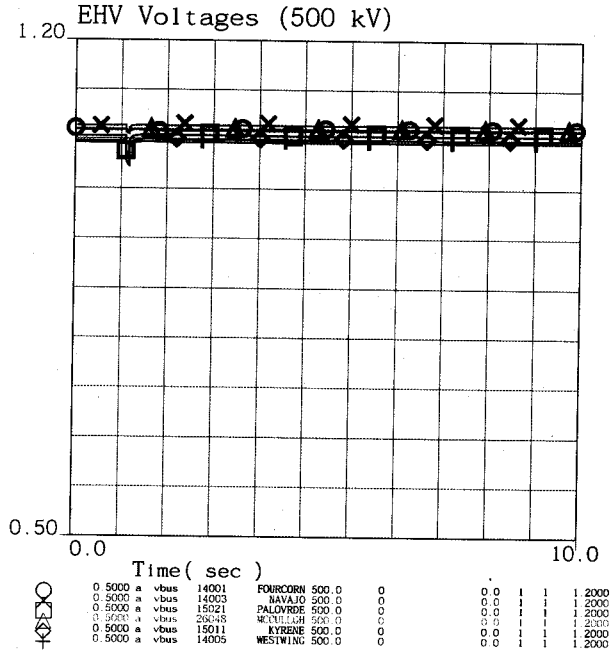

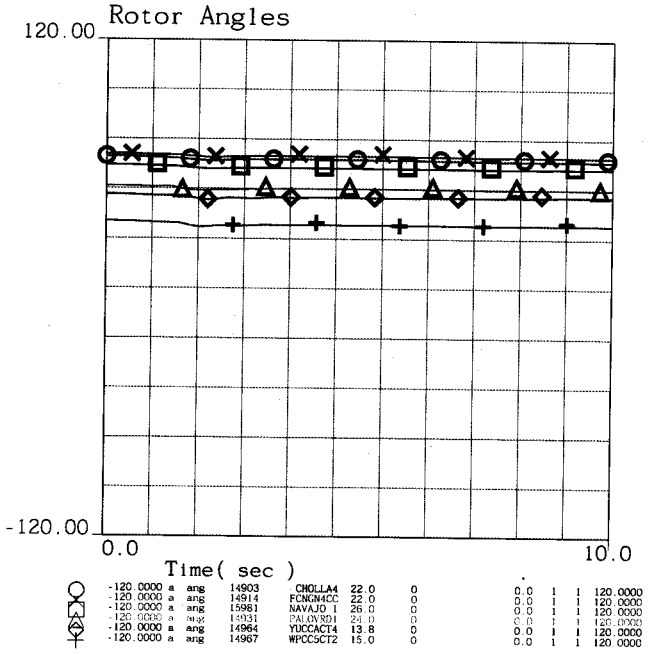

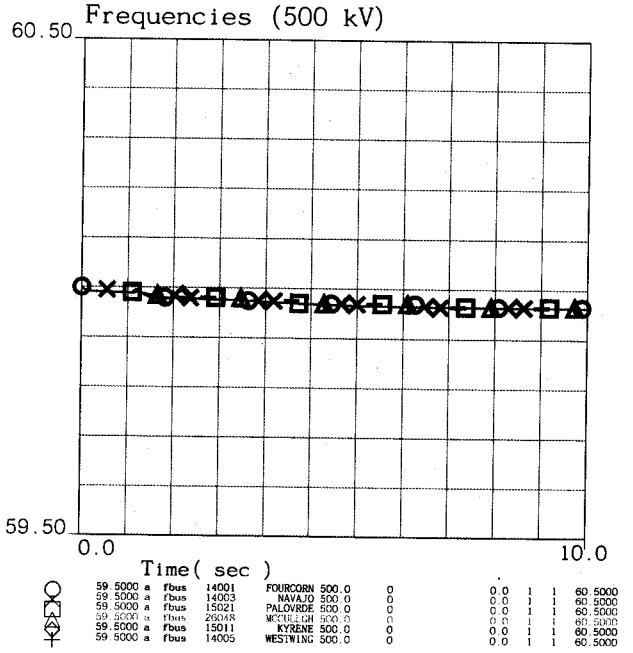

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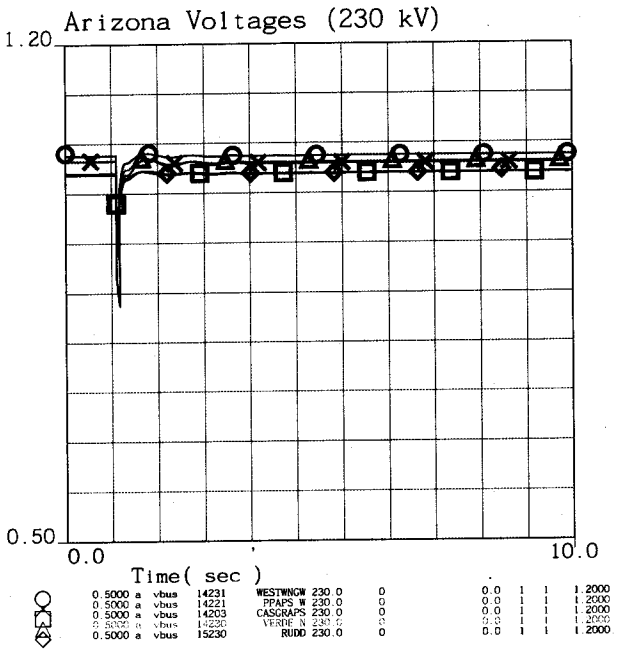

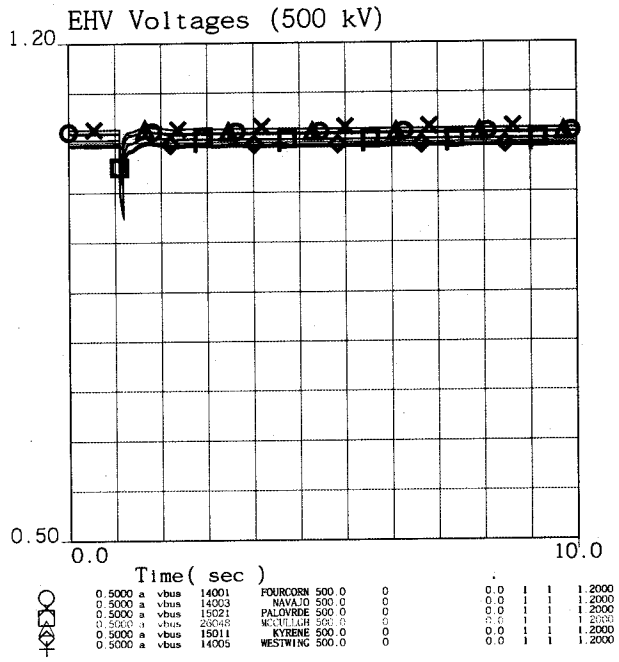

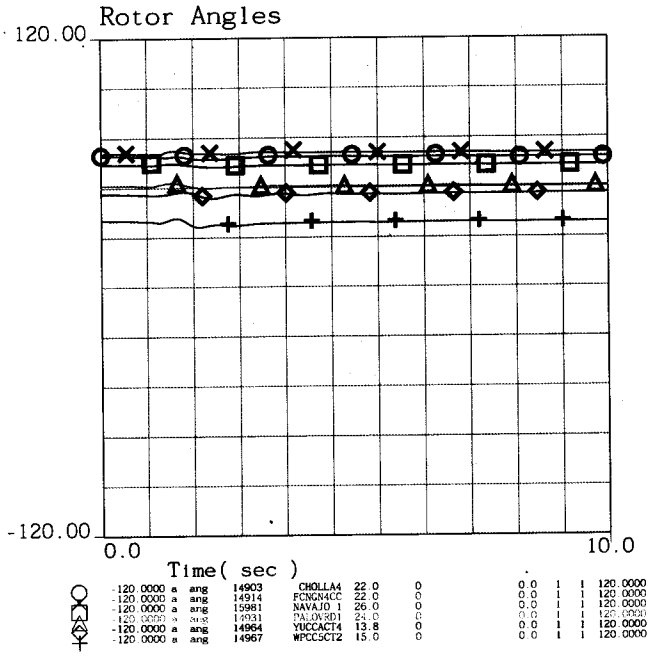

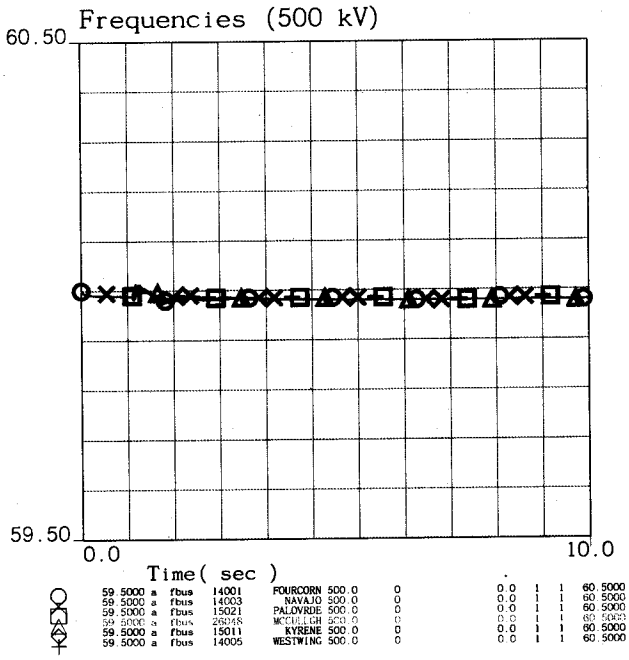

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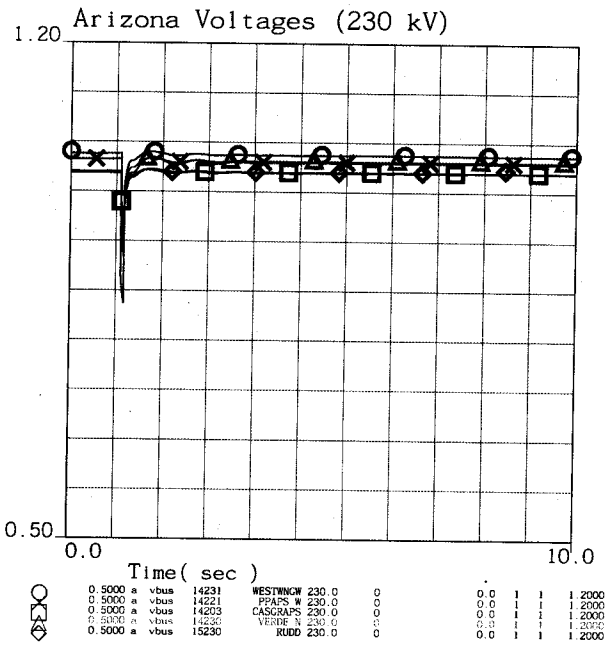

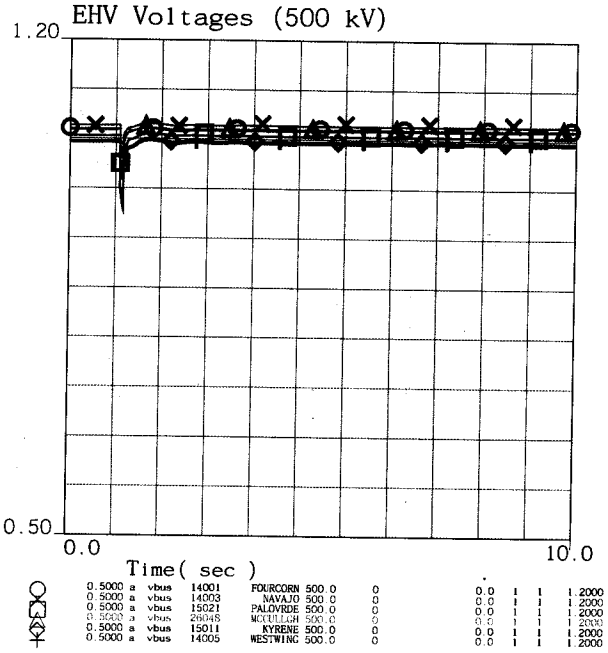

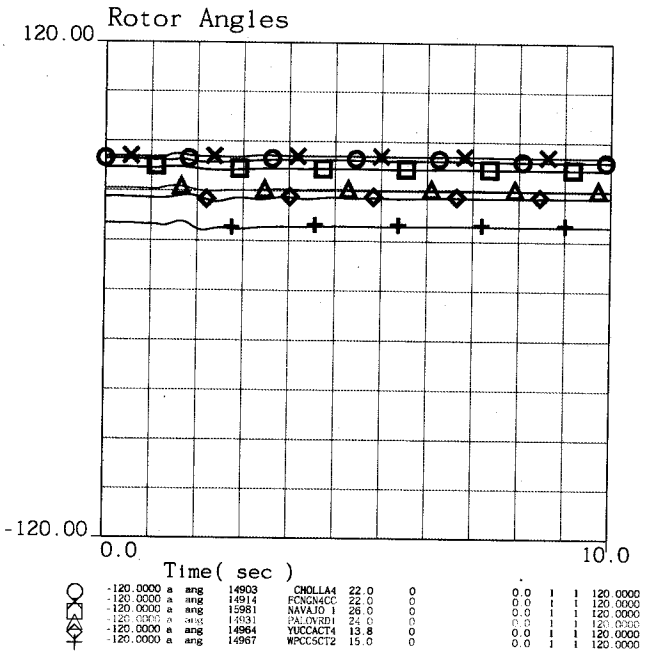

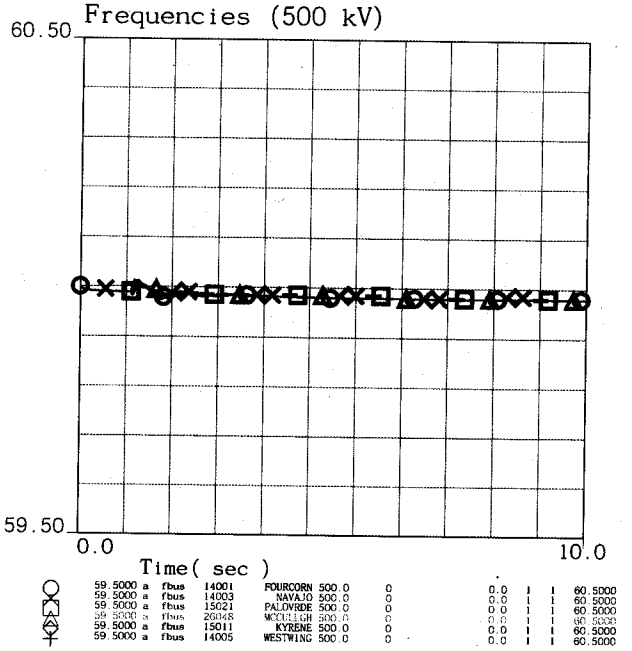

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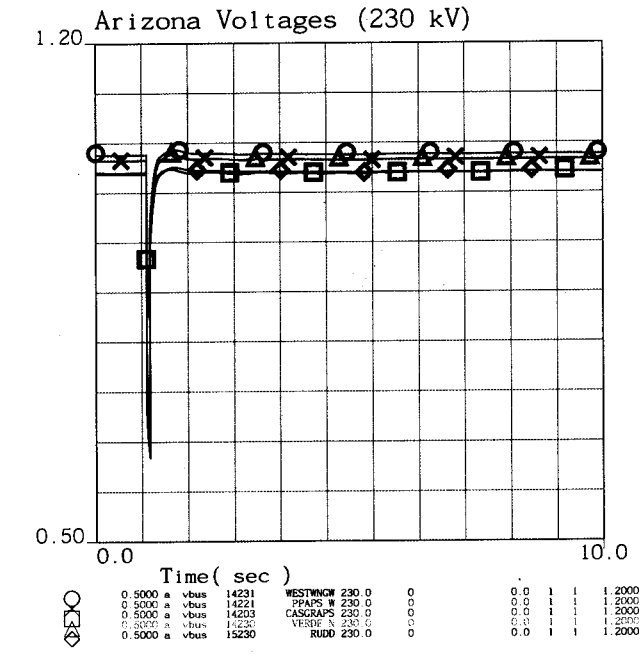

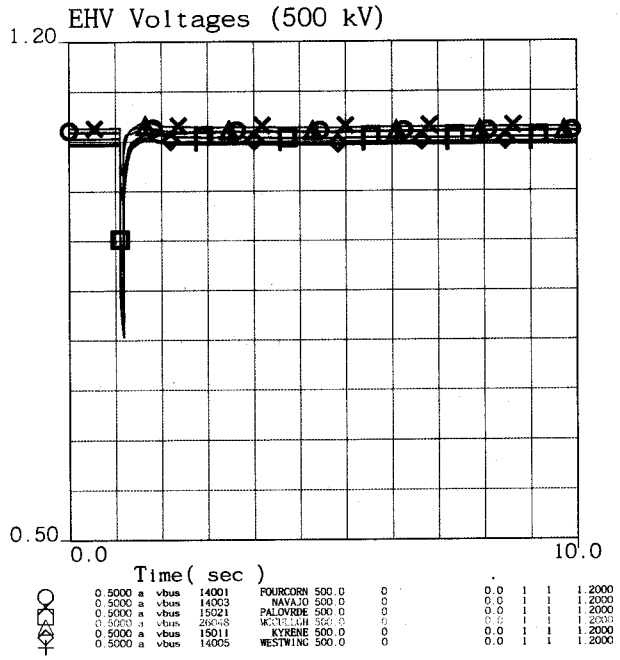

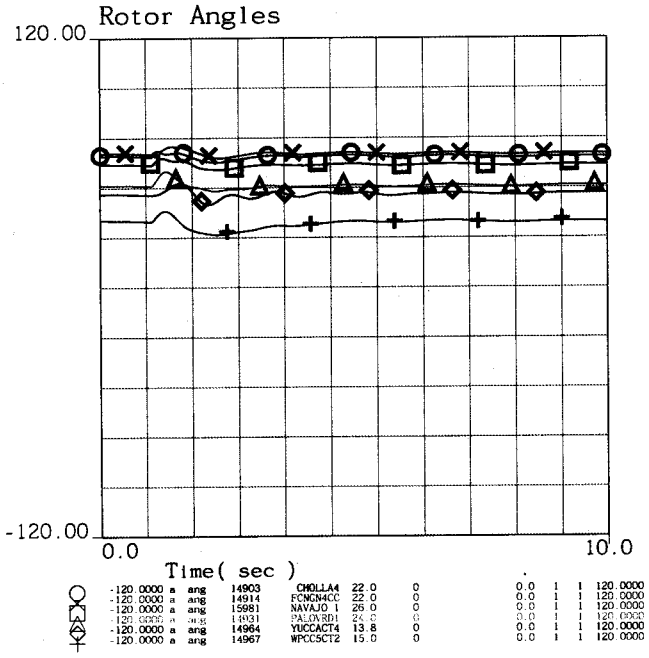

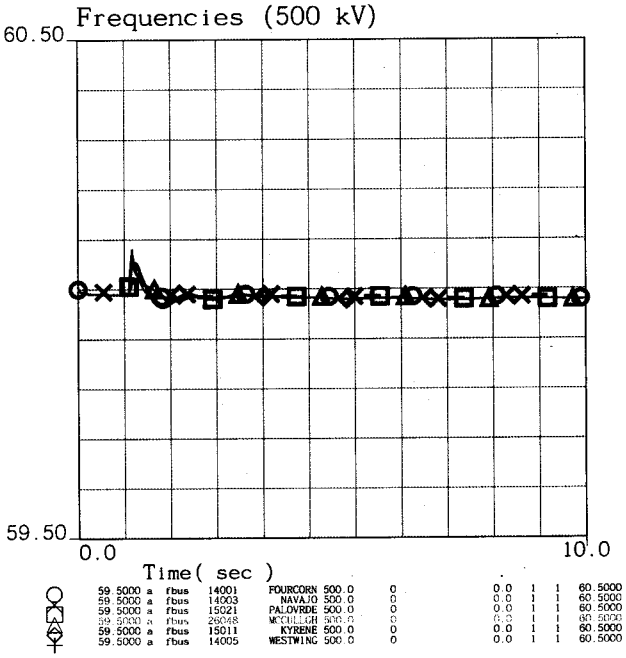

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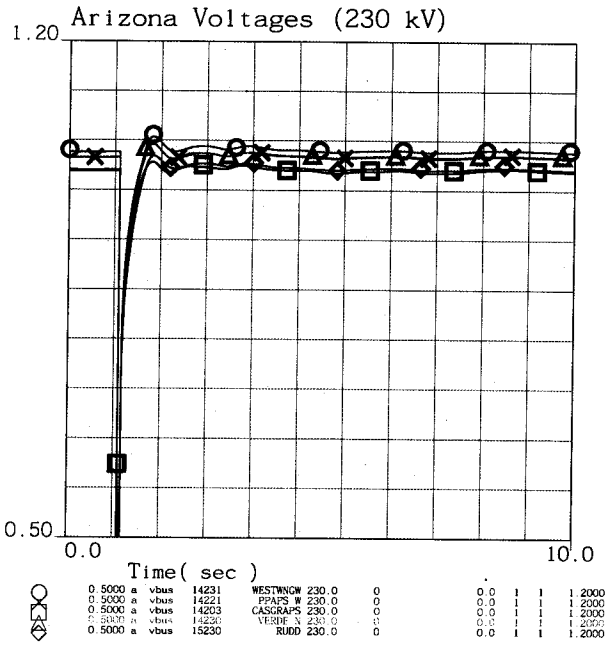

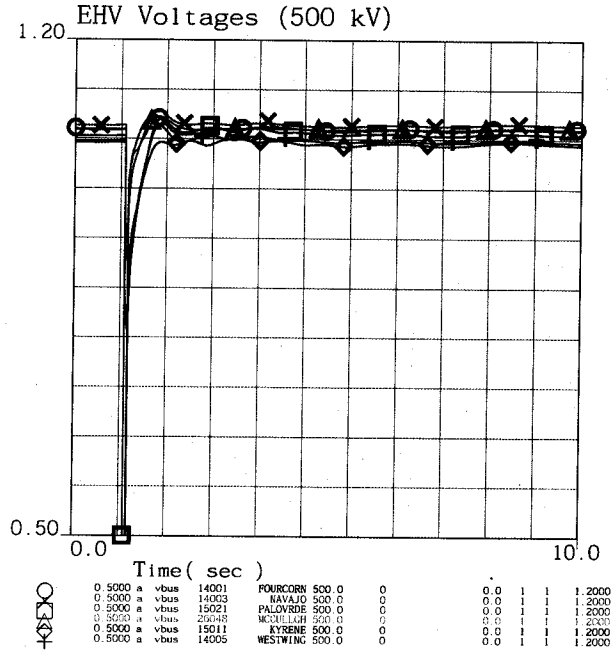

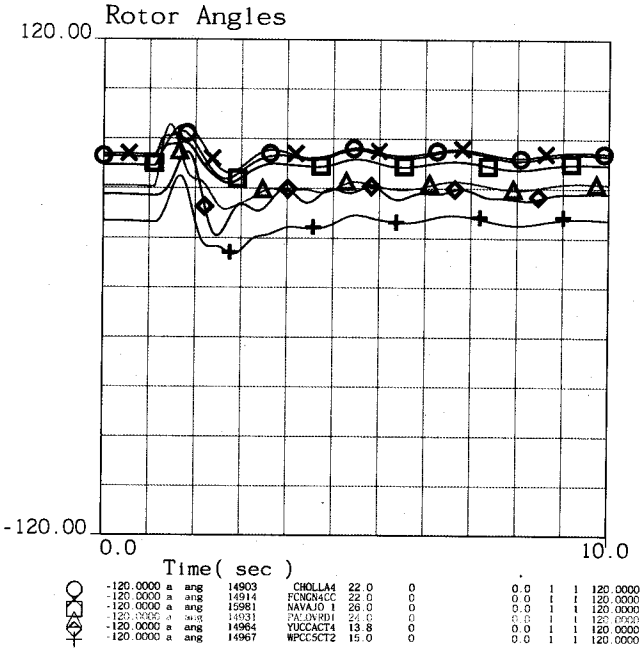

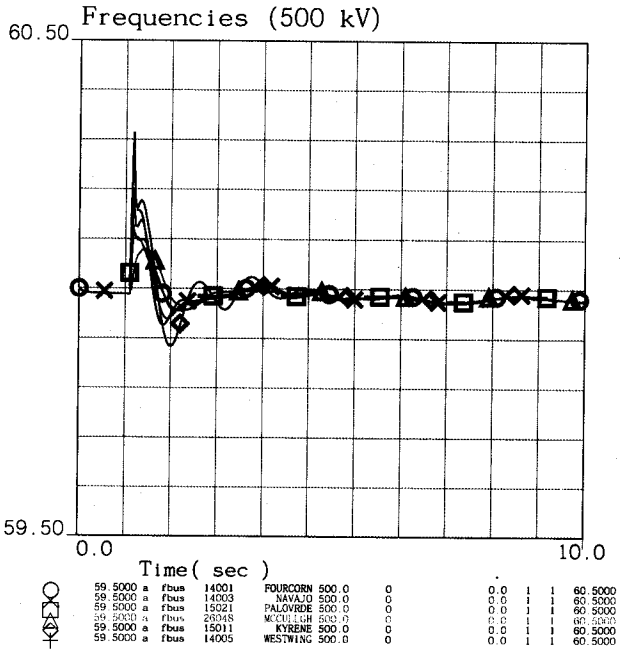

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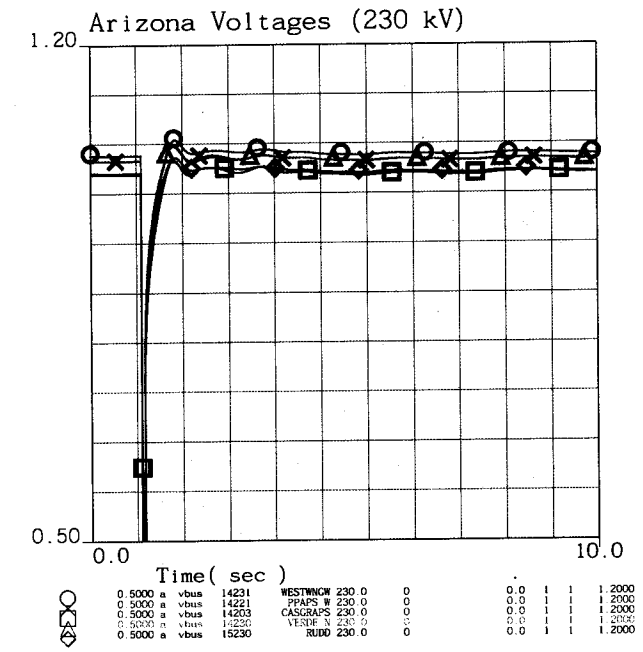

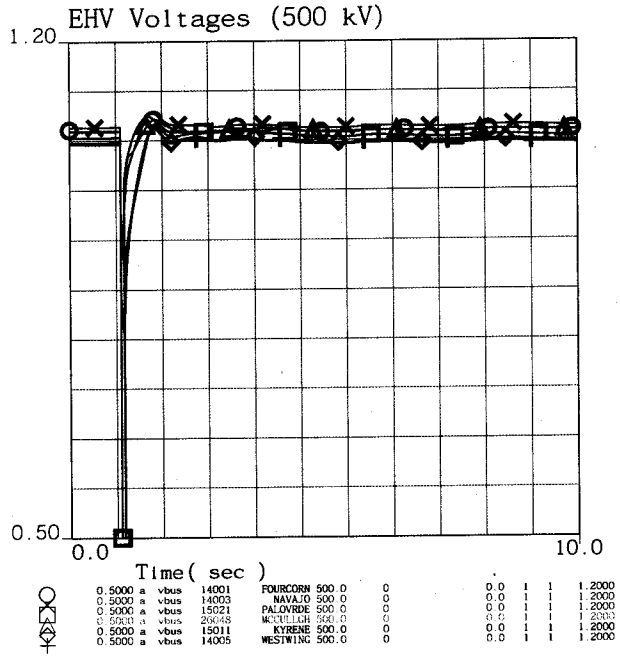

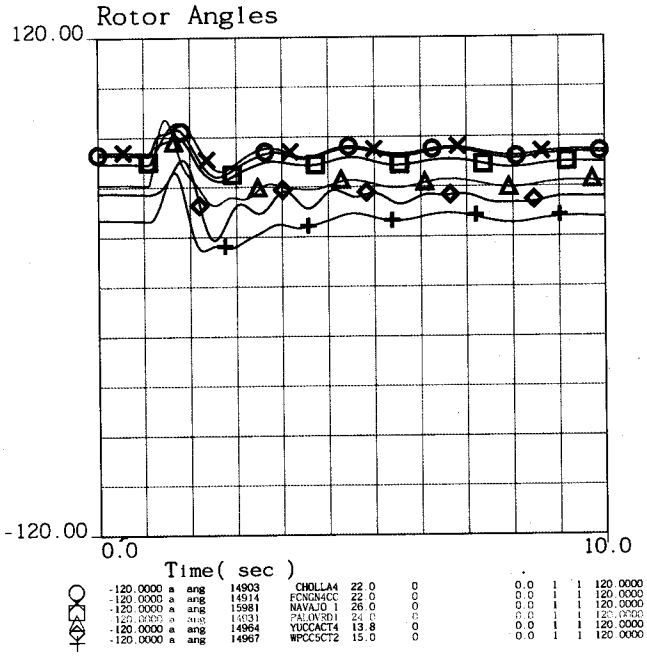

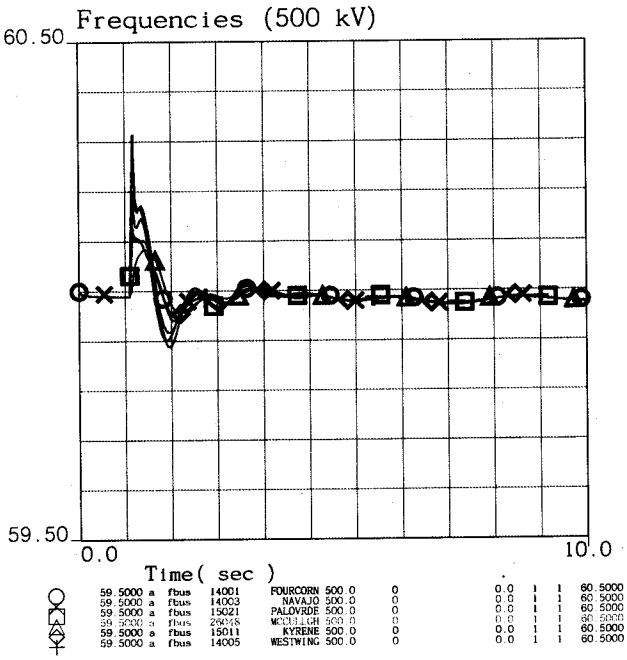

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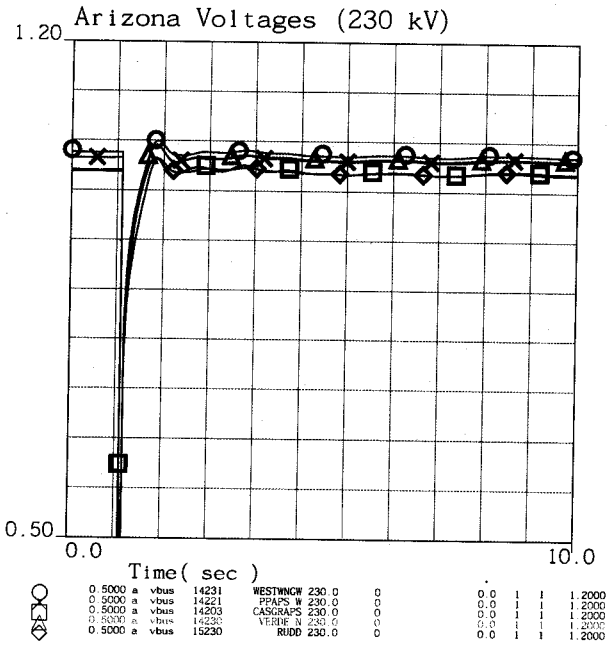

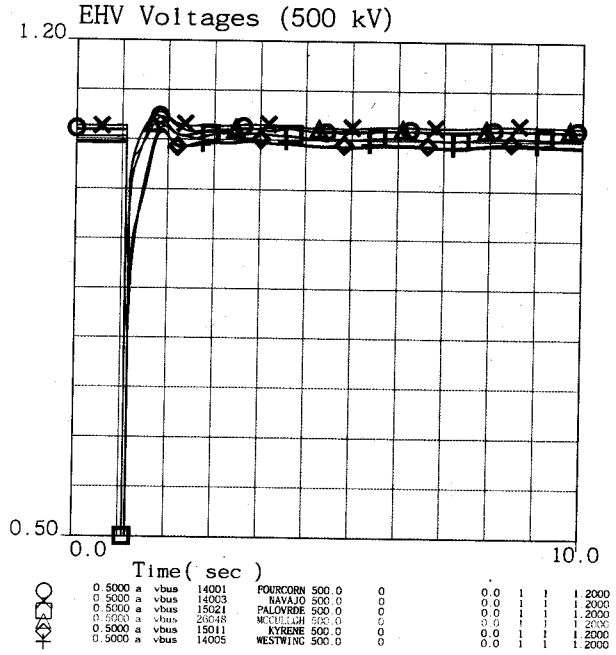

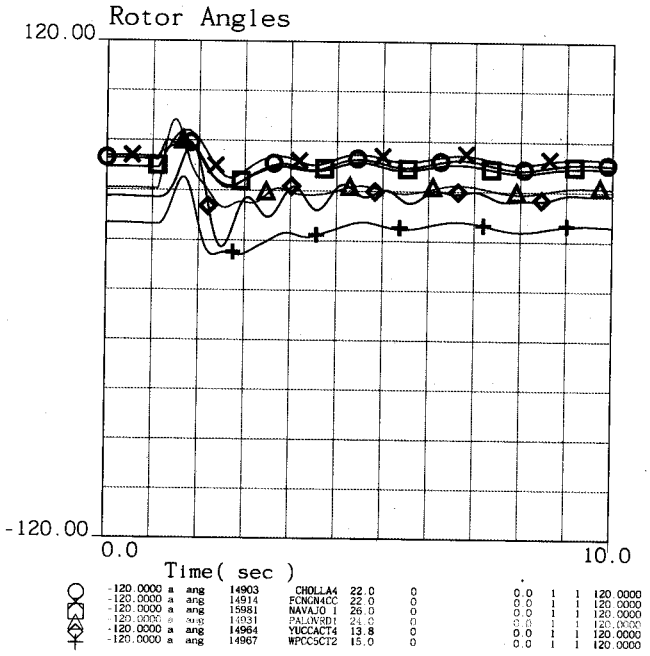

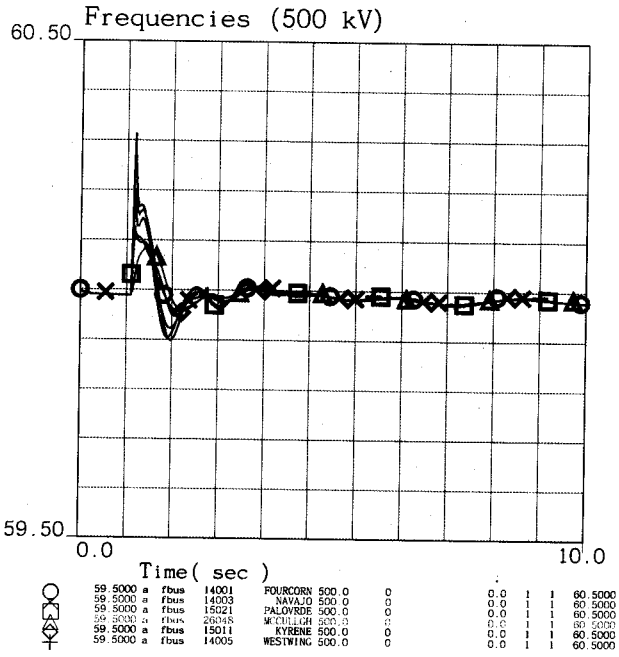

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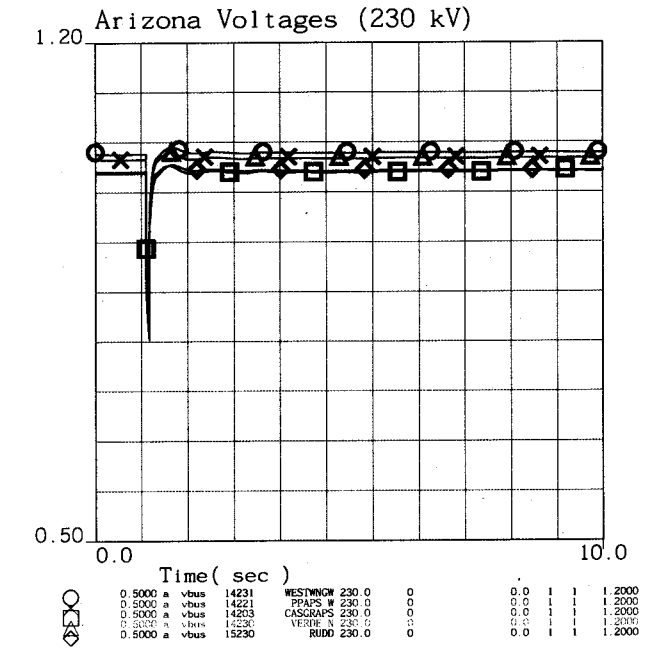

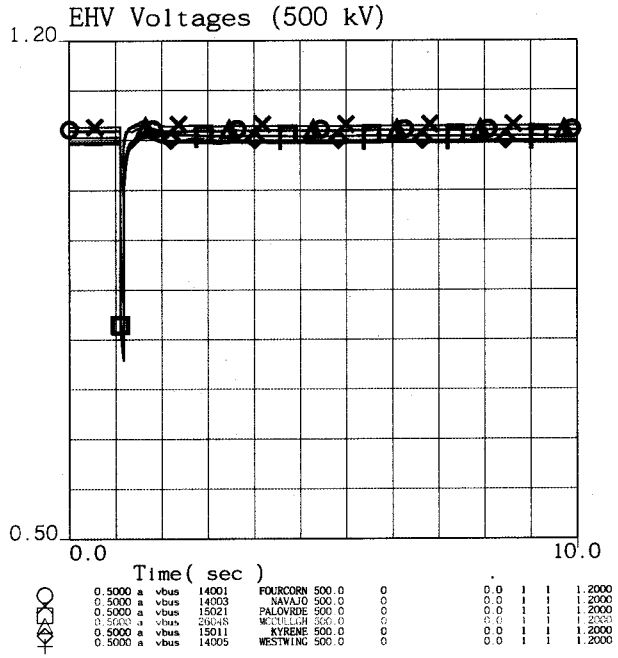

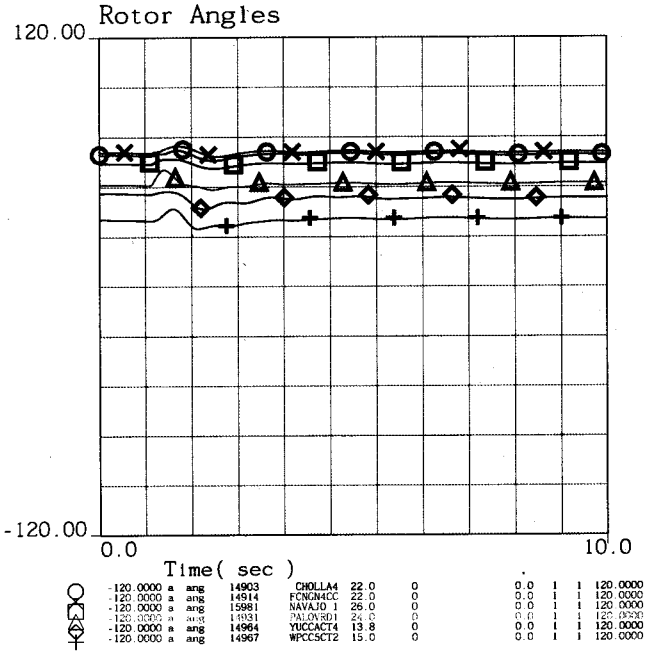

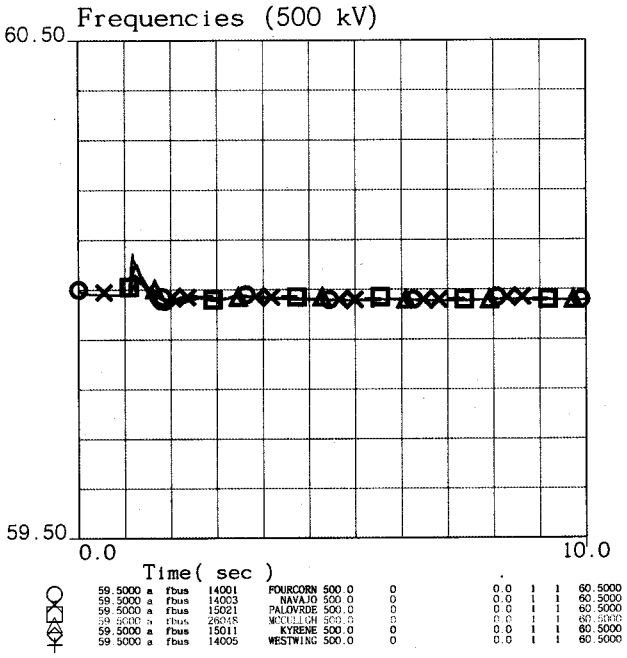

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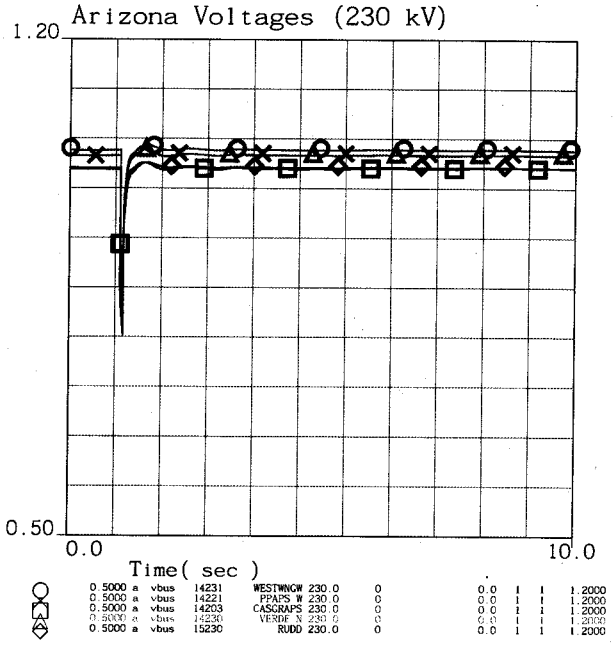

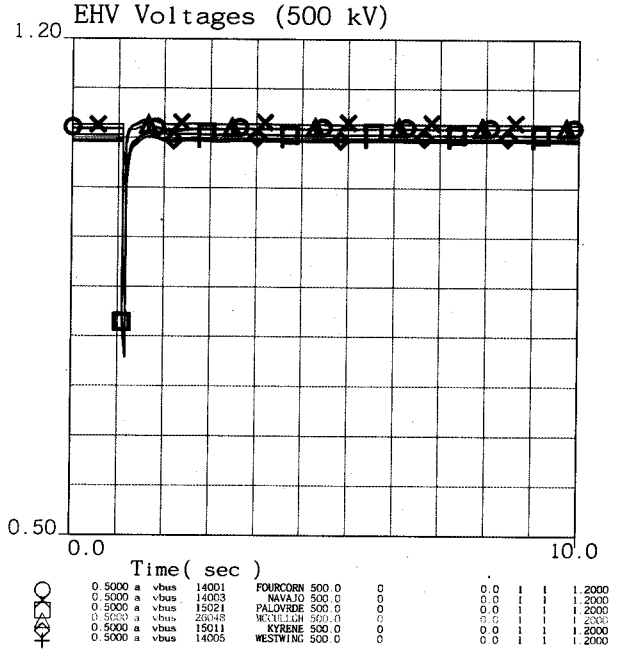

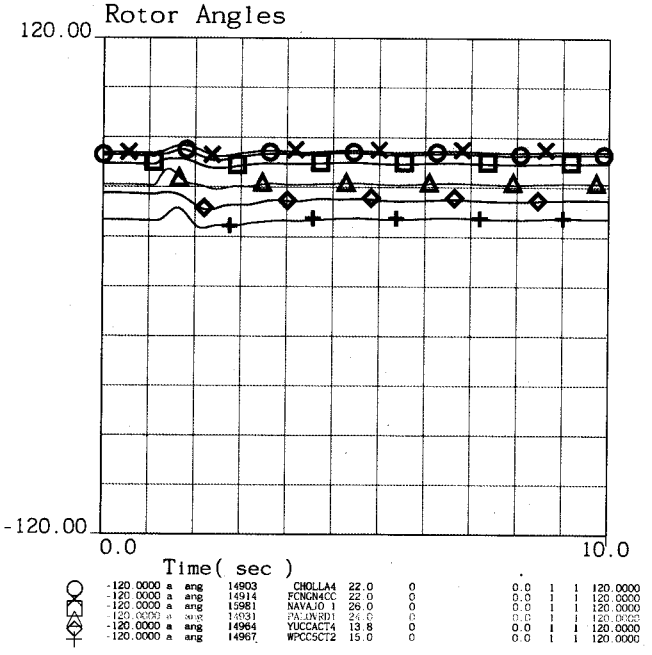

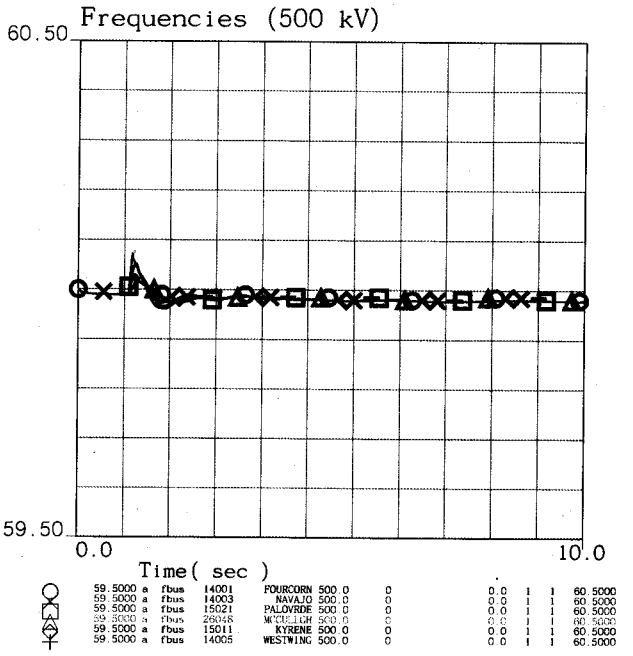

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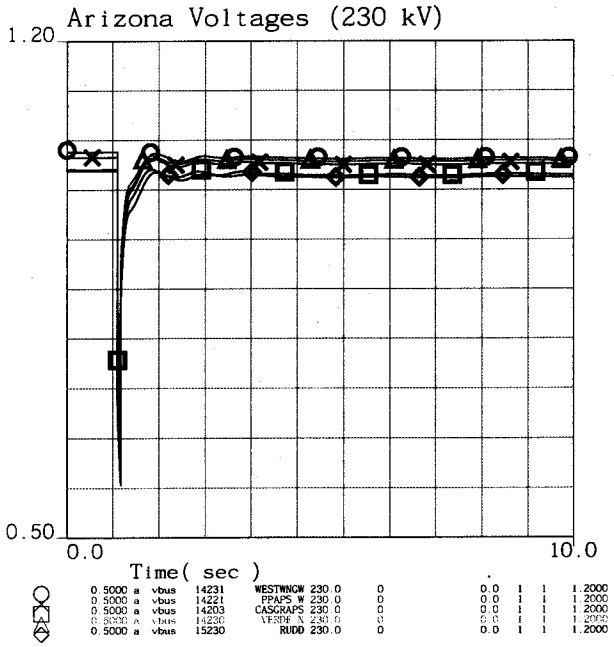

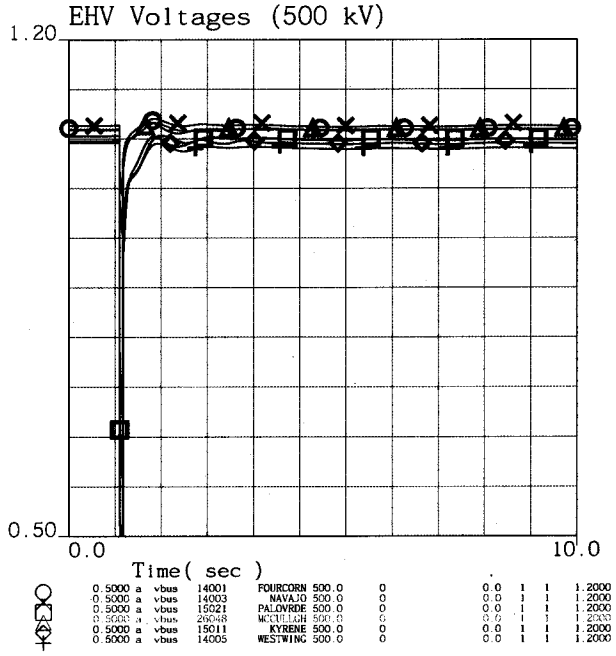

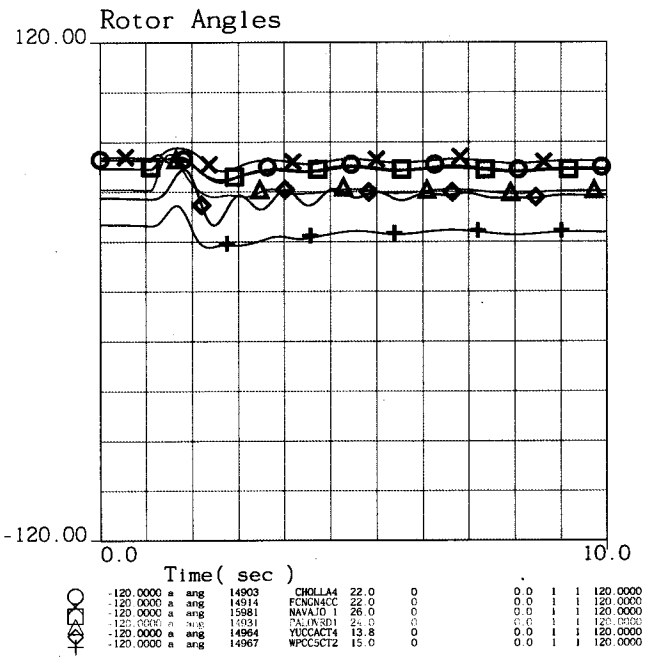

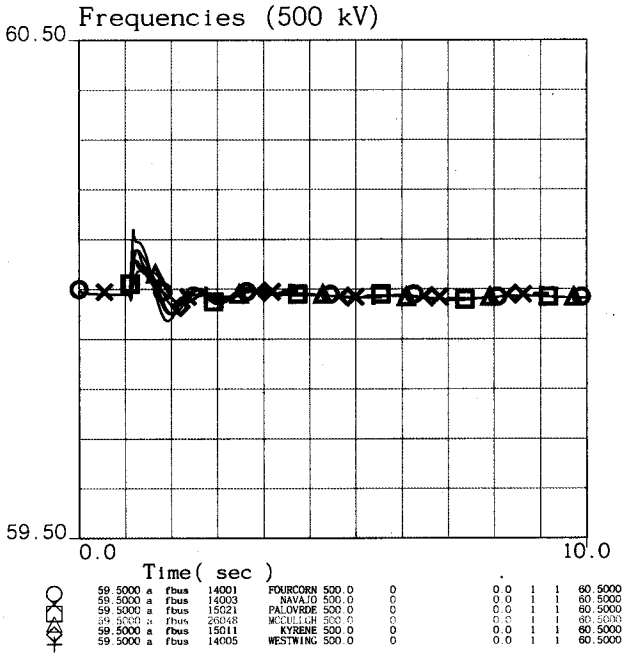

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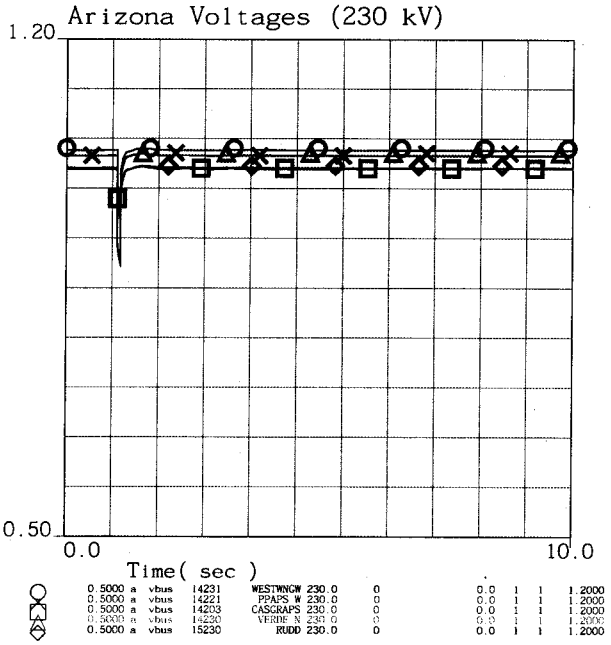

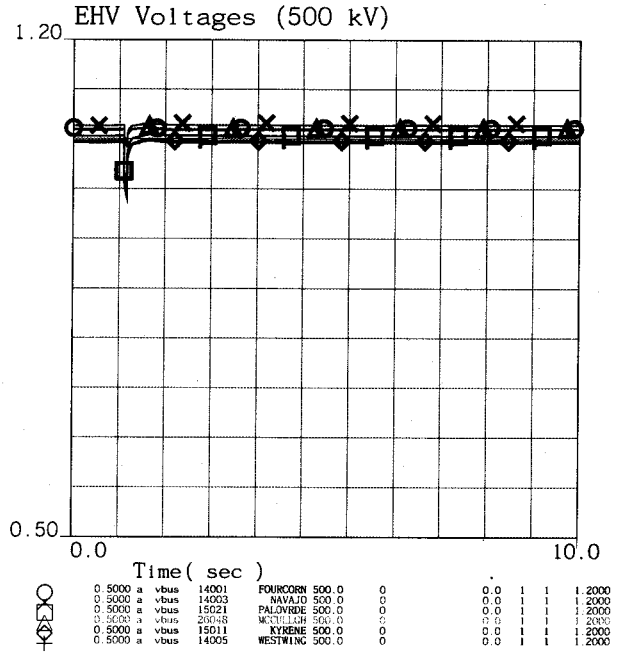

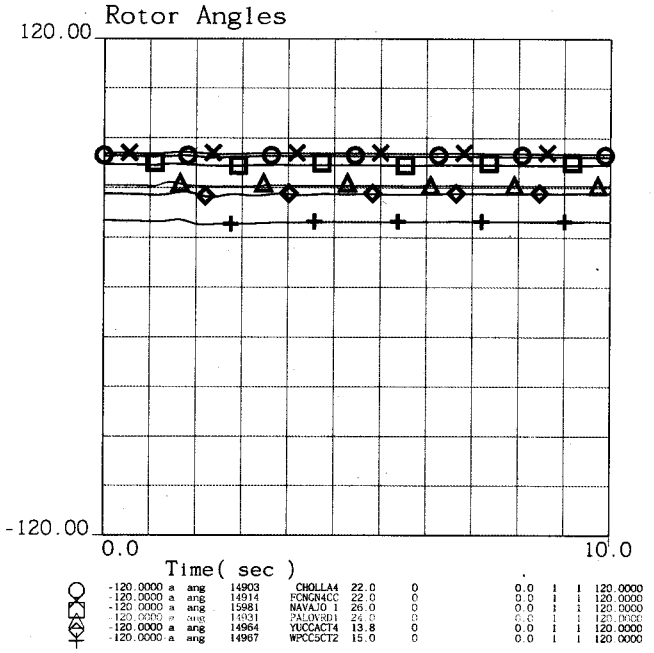

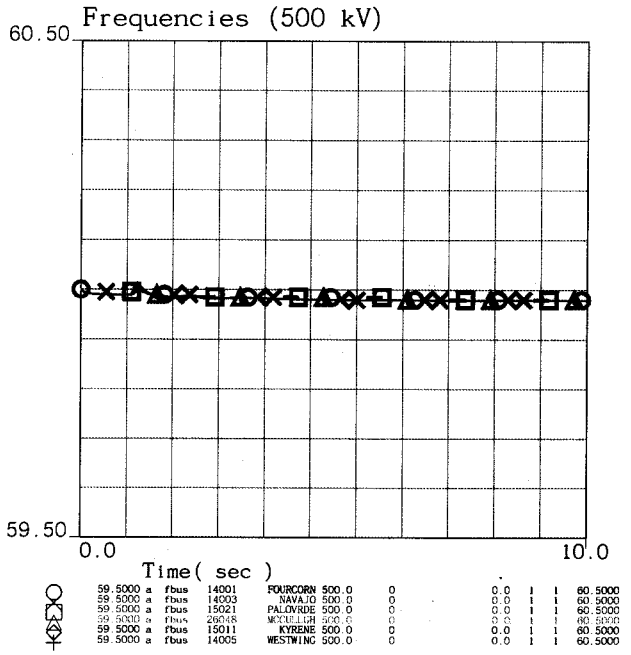

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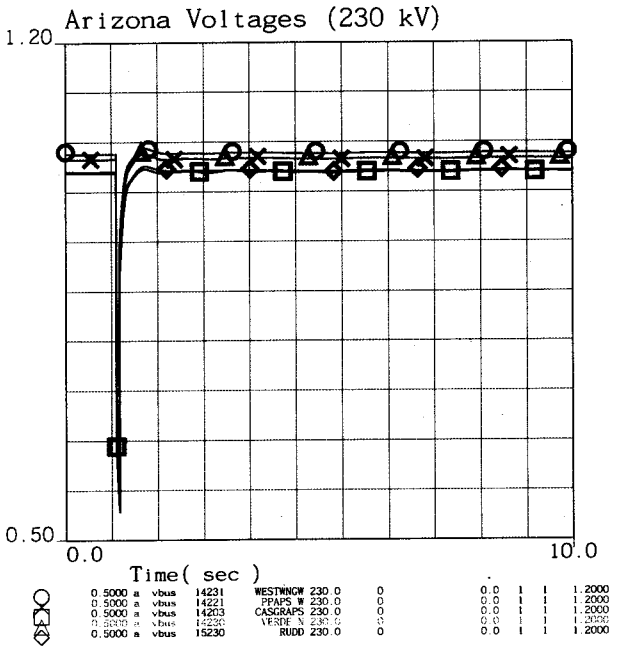

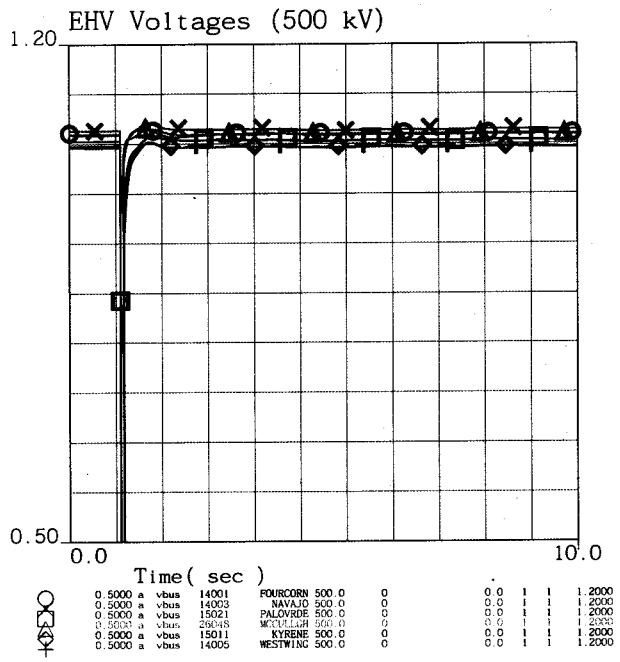

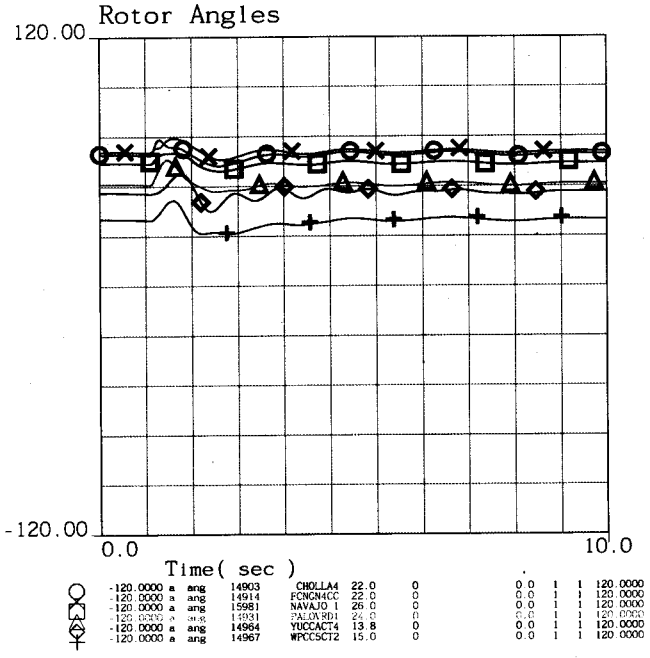

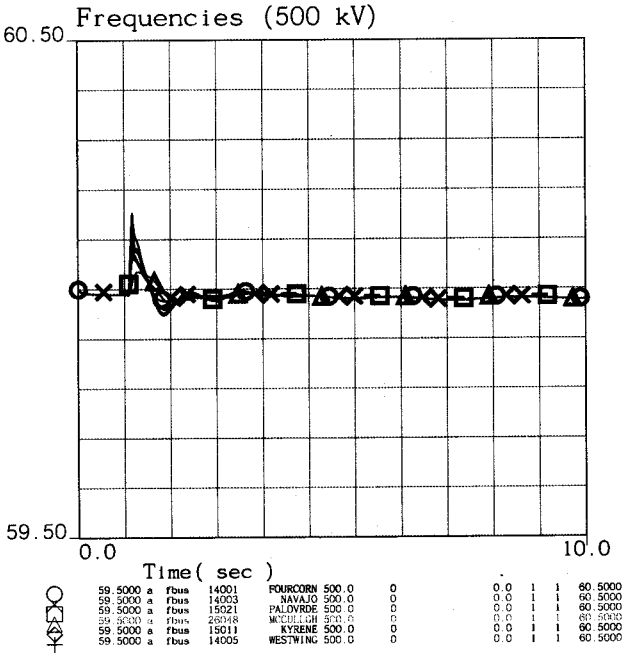

2018 Heavy Summer AZ Coordinated Case
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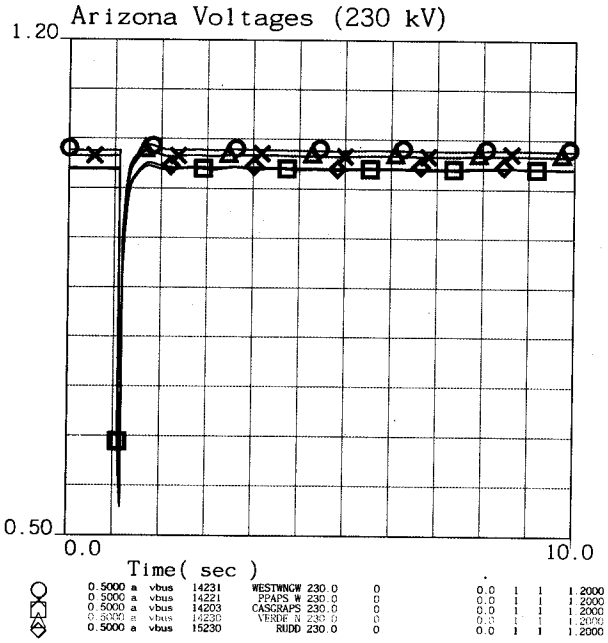
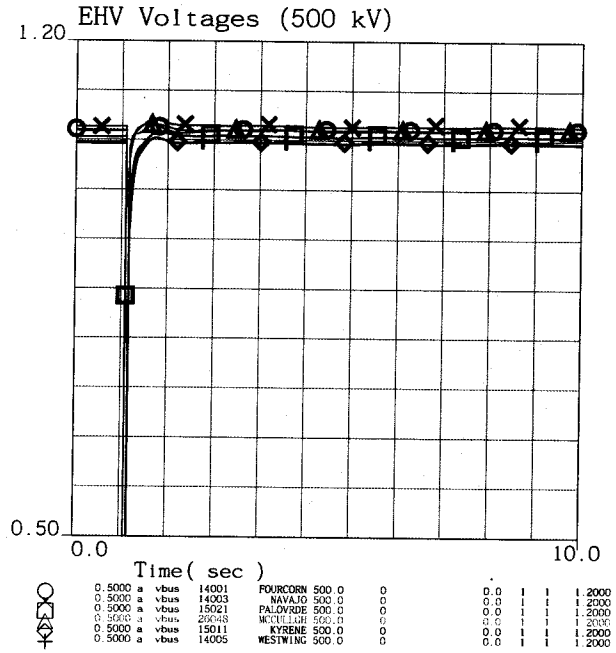
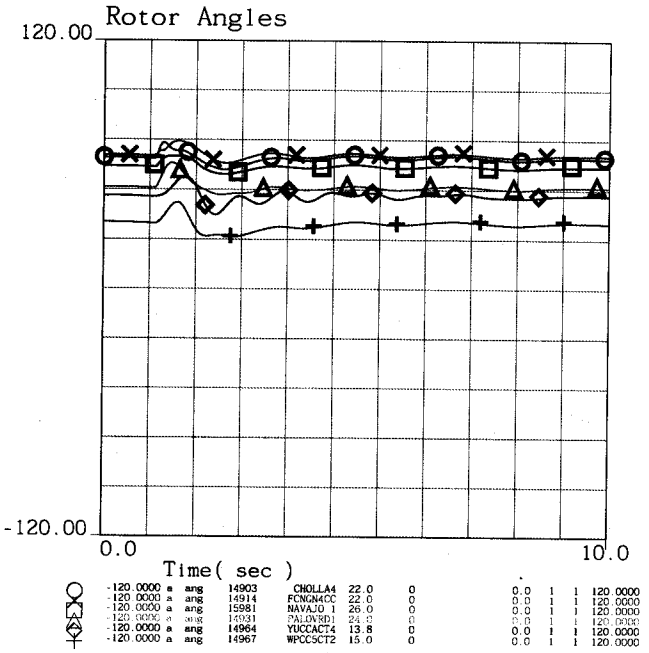
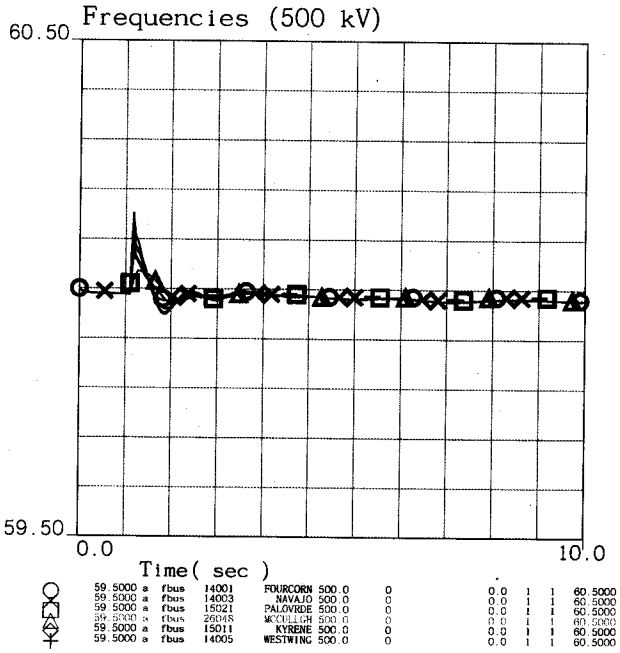
2018 Heavy Summer Detailed Planning Case









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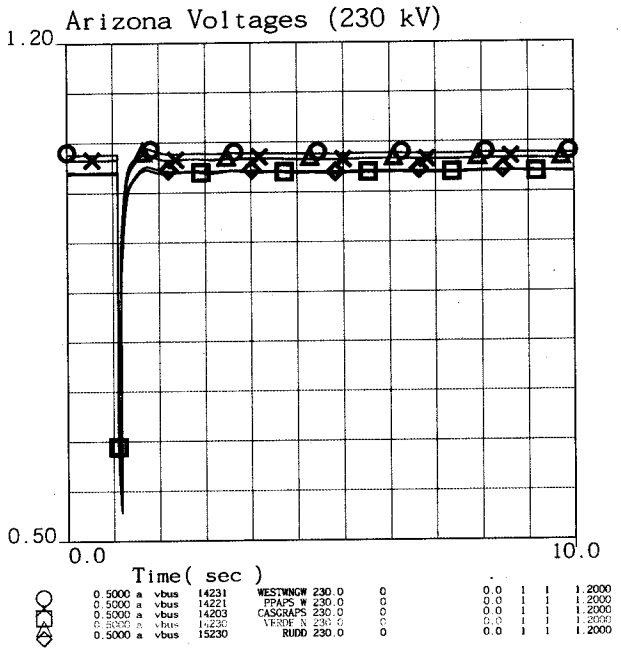

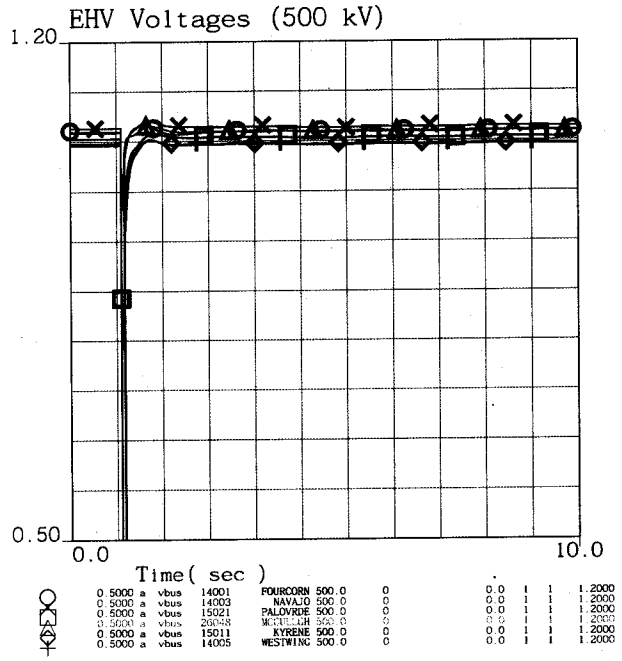

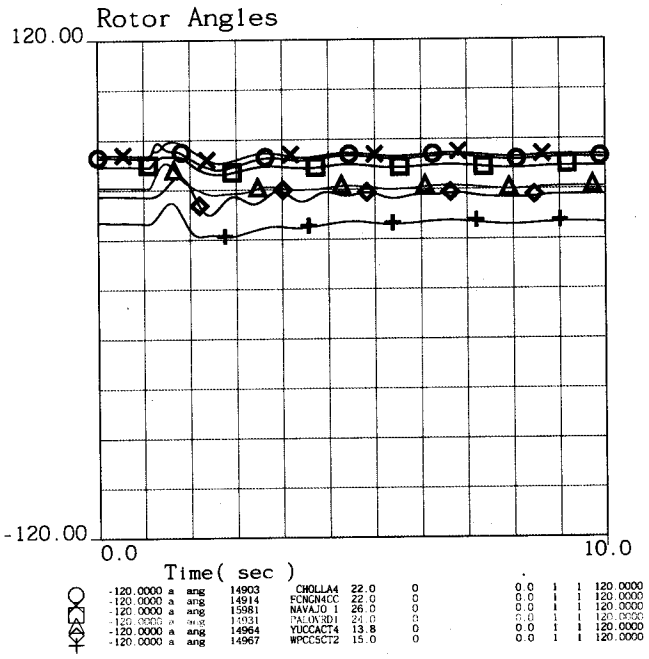

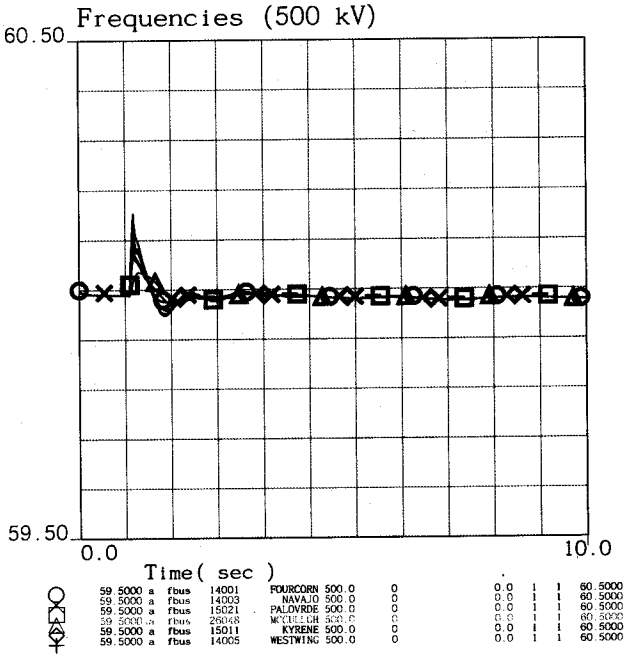

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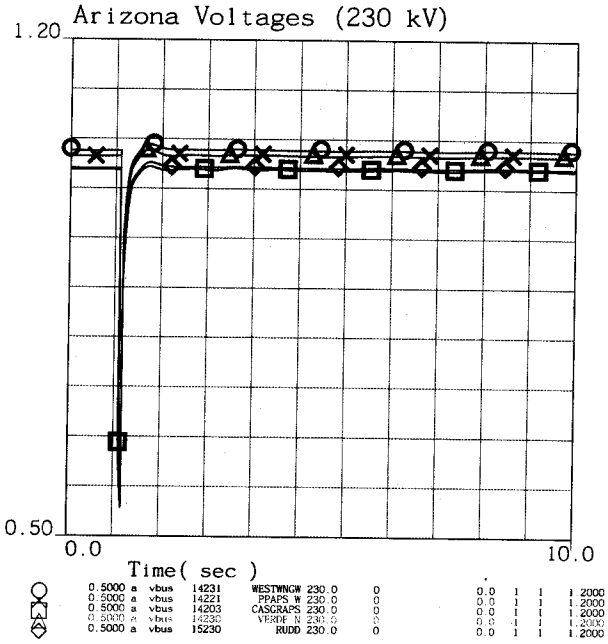

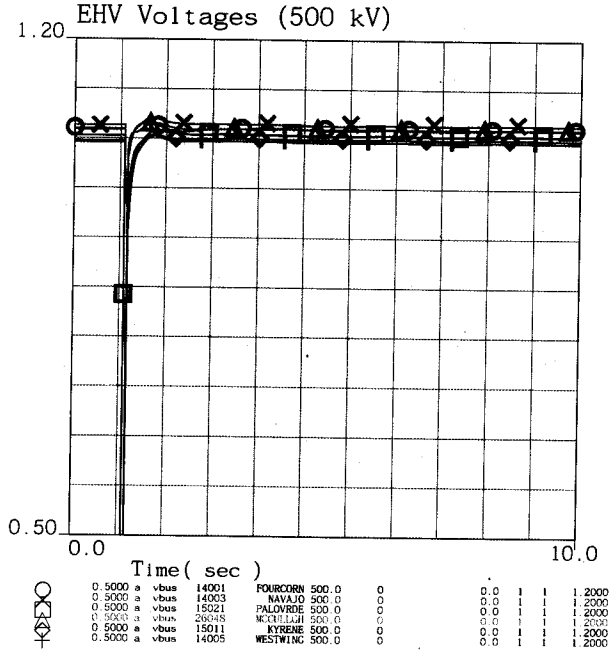

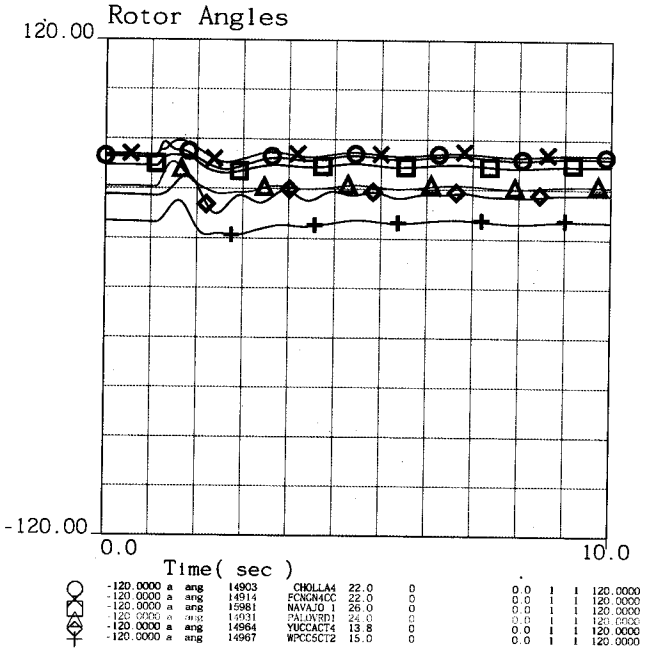

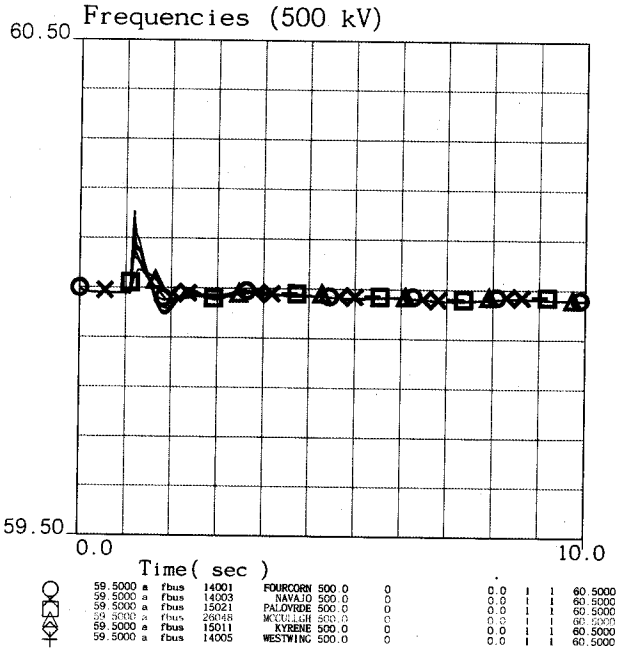

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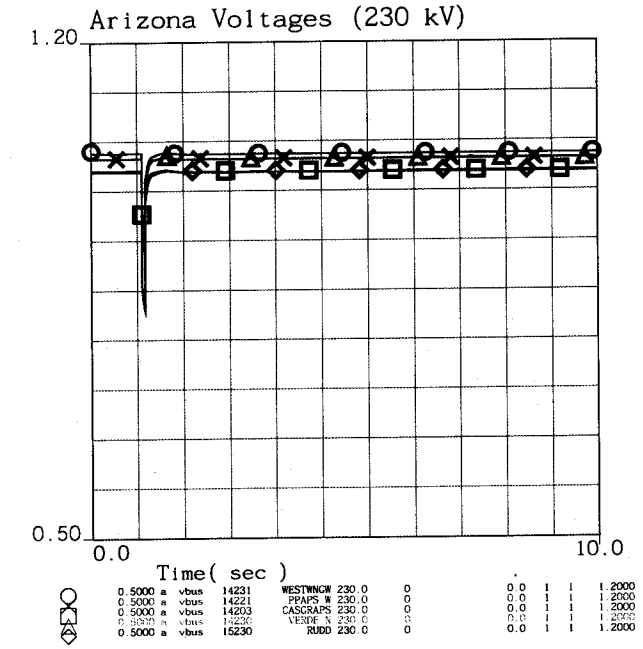

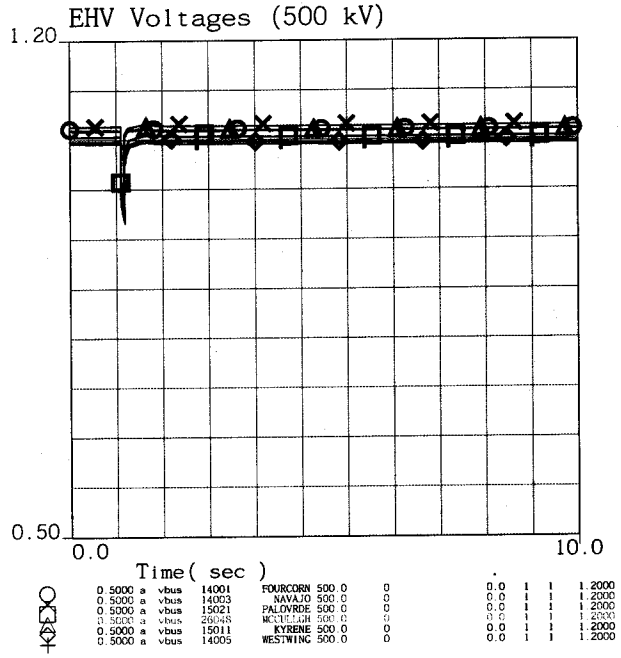

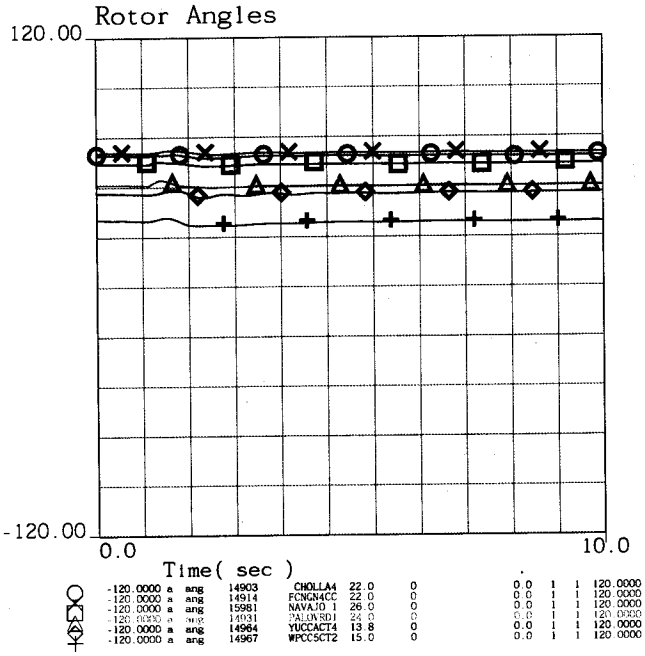

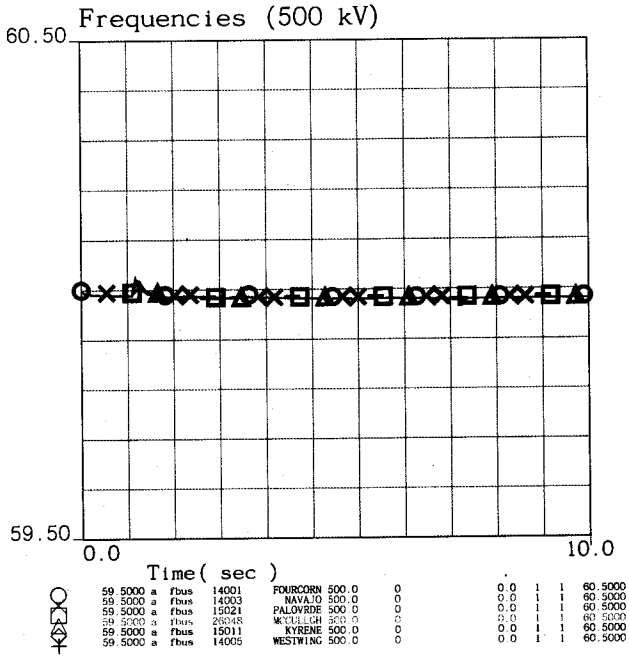

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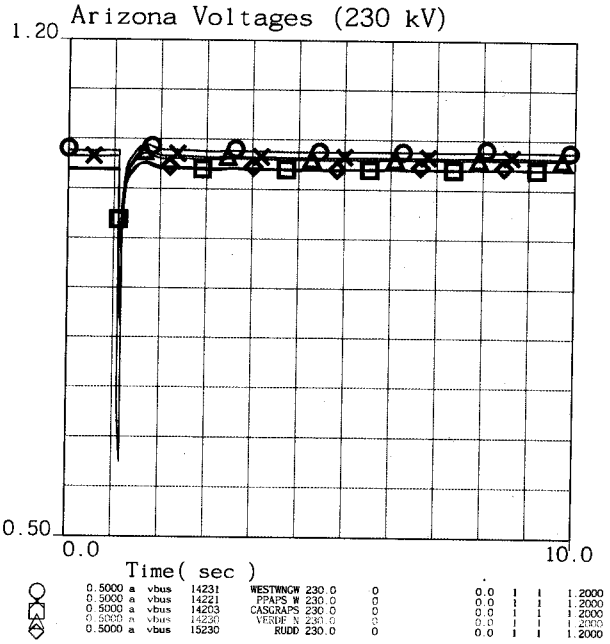

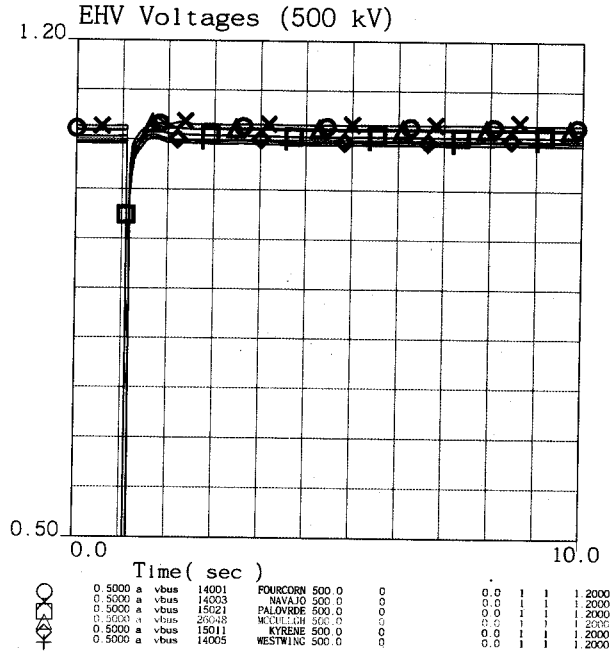

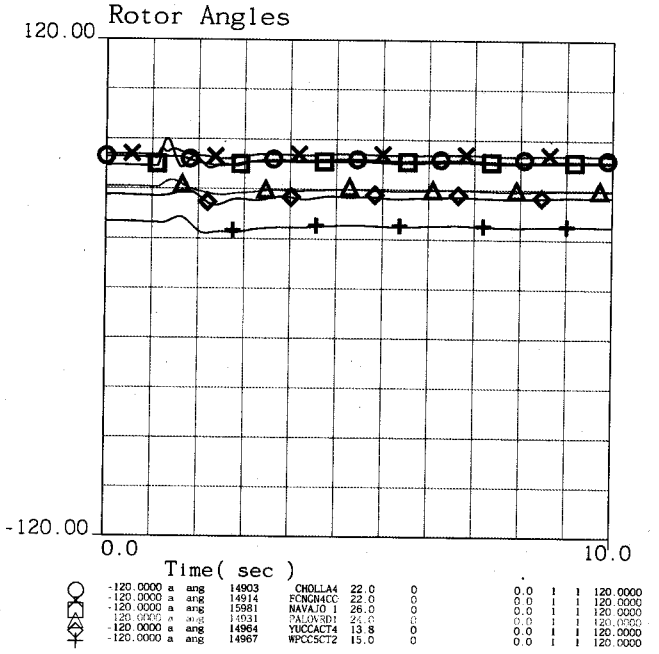

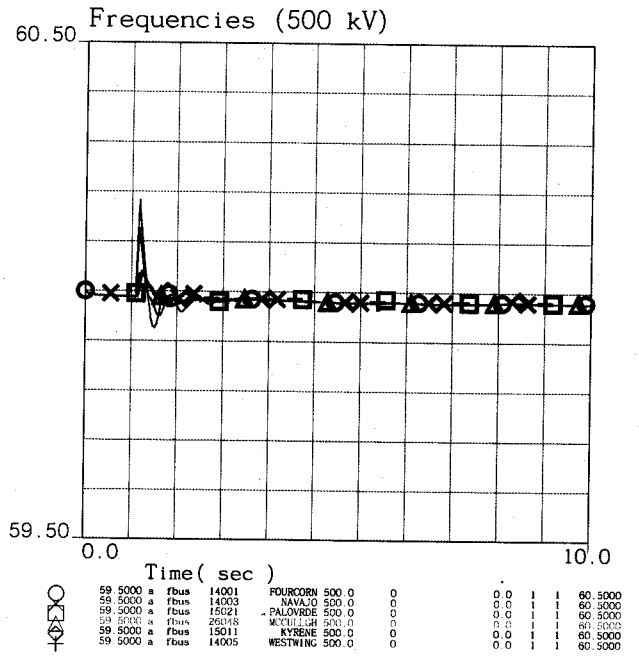

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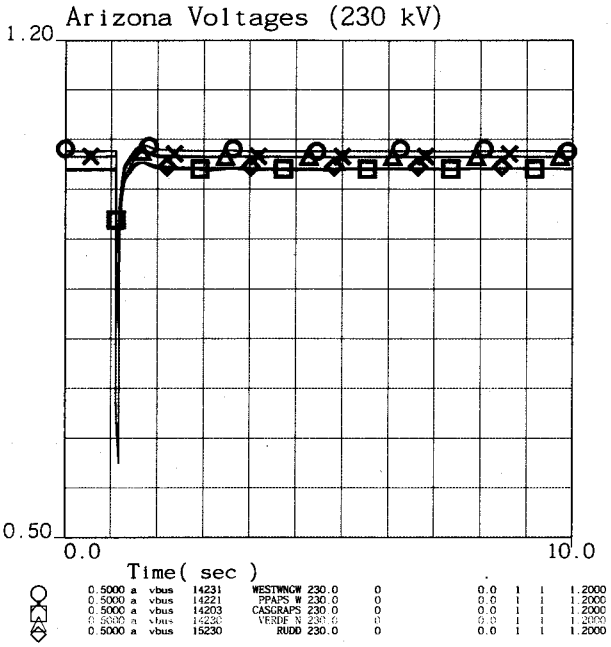

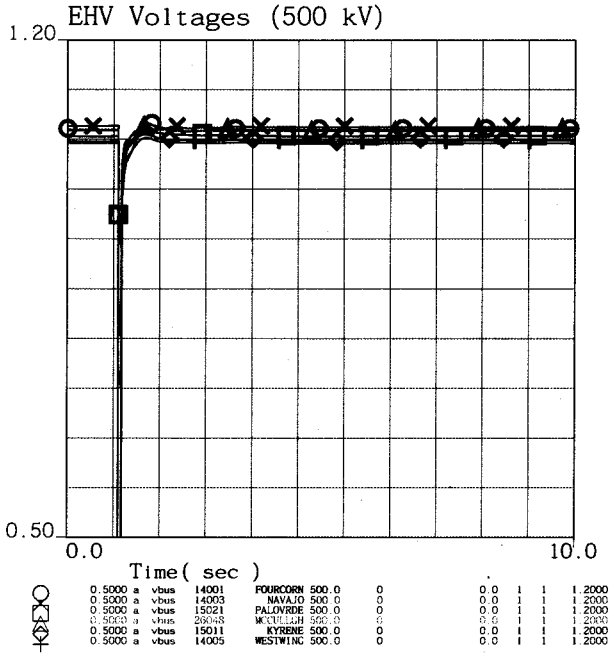

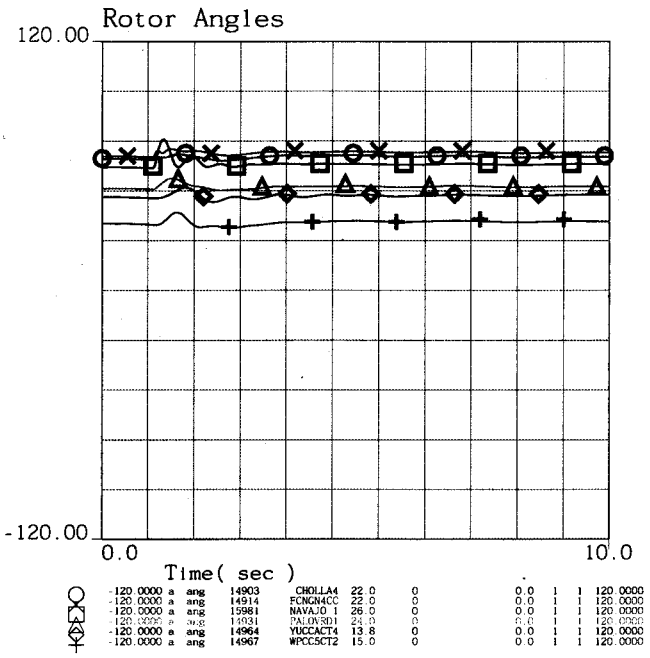

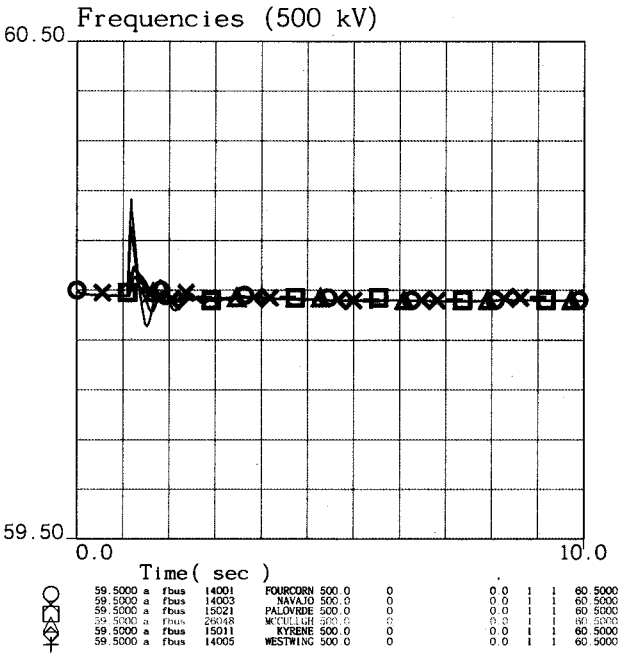

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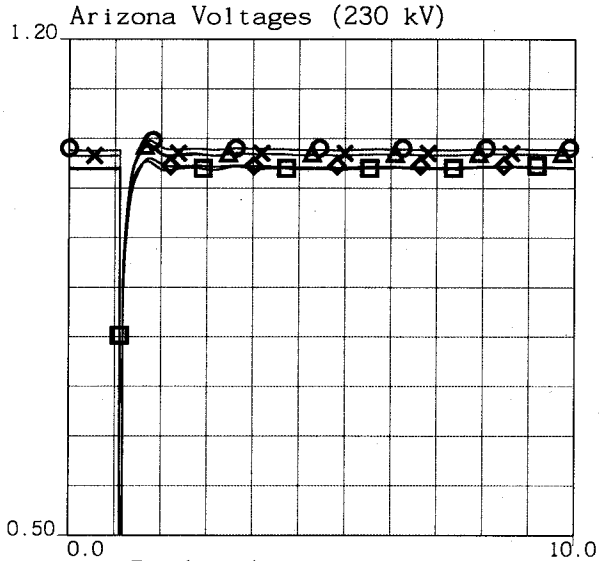

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0.5000	a	vbus	14236	VERDE N 230.0	0	0.0	1	1	1.2000
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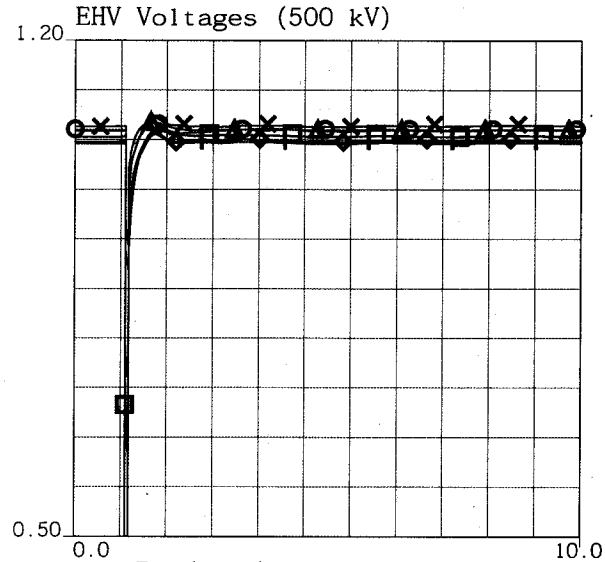

0.5000	a	vbus	14001	FOURCORN 500.0	0	0.0	1	1	1.2000
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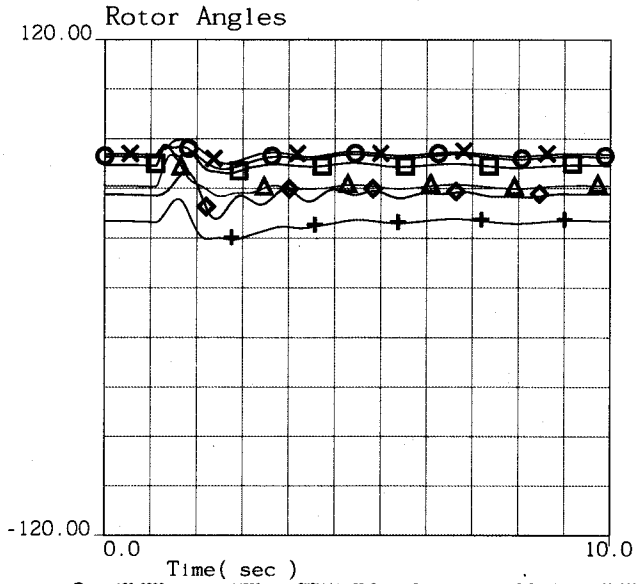
0.5000	a	vbus	15021	PALOVRDE 500.0	0	0.0	1	1	1.2000
0.5000	a	vbus	26048	MCCULLGH 500.0	0	0.0	1	1	1.2000
0.5000	a	vbus	15011	KYRENE 500.0	0	0.0	1	1	1.2000
0.5000	a	vbus	14005	WESTWING 500.0	0	0.0	1	1	1.2000



-120.0000	a	ang	14903	CHOLLA4 22.0	0	0.0	1	1	120.0000
-120.0000	a	ang	14914	FCNGN4CC 22.0	0	0.0	1	1	120.0000
-120.0000	a	ang	15981	NAVAJO 1 26.0	0	0.0	1	1	120.0000
-120.0000	a	ang	14931	PALOVRD1 26.0	0	0.0	1	1	120.0000
-120.0000	a	ang	14964	YUCCACT4 13.8	0	0.0	1	1	120.0000
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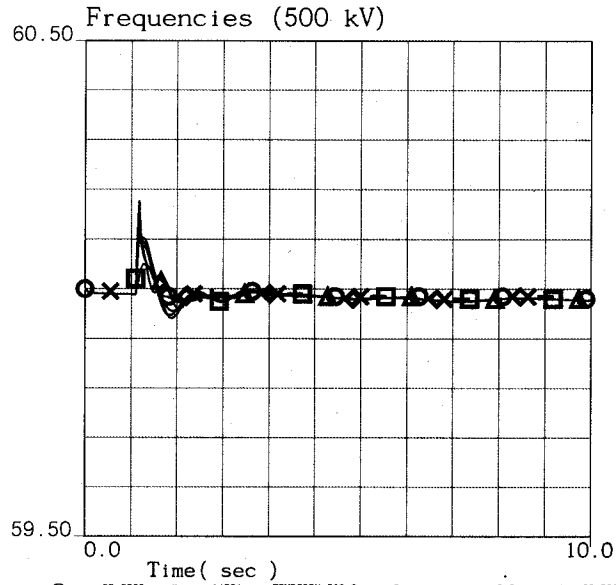

59.5000	a	fbus	14001	FOURCORN 500.0	0	0.0	1	1	60.5000
59.5000	a	fbus	14003	NAVAJO 500.0	0	0.0	1	1	60.5000
59.5000	a	fbus	15021	PALOVRDE 500.0	0	0.0	1	1	60.5000
59.5000	a	fbus	26048	MCCULLGH 500.0	0	0.0	1	1	60.5000
59.5000	a	fbus	15011	KYRENE 500.0	0	0.0	1	1	60.5000
59.5000	a	fbus	14005	WESTWING 500.0	0	0.0	1	1	60.5000

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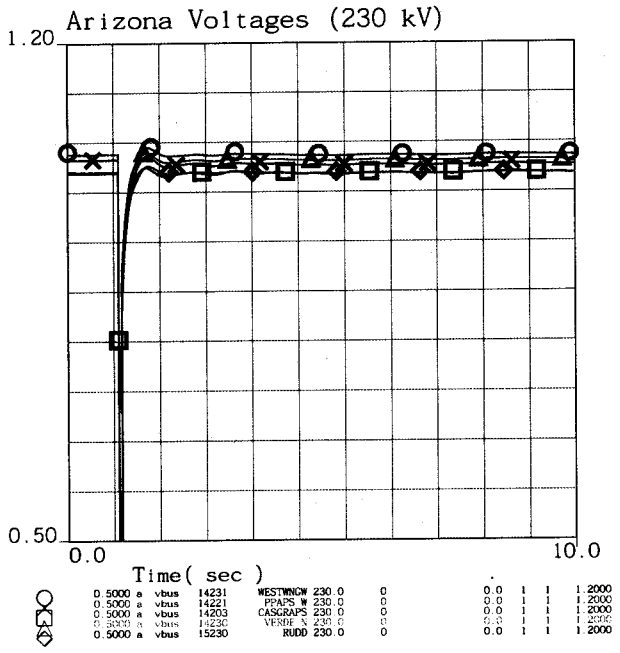
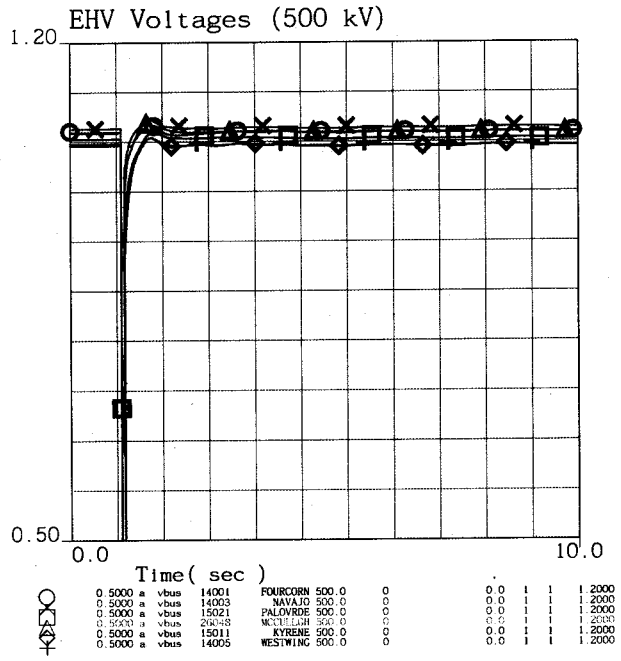
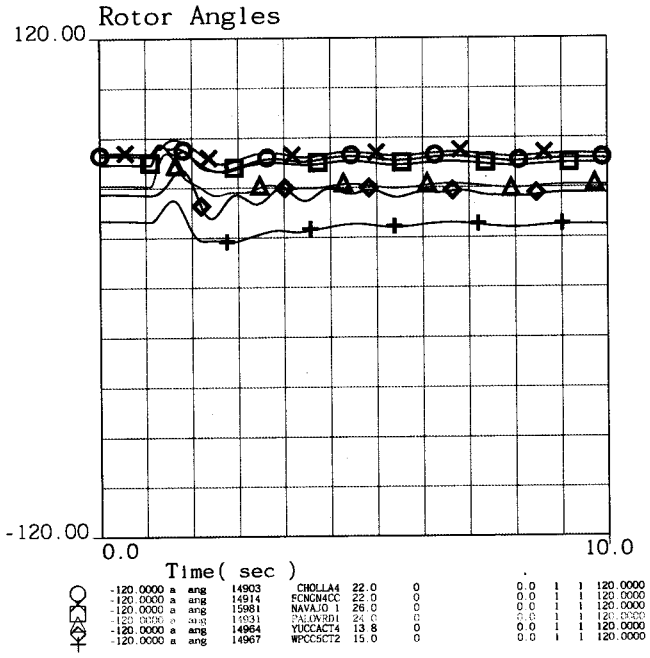
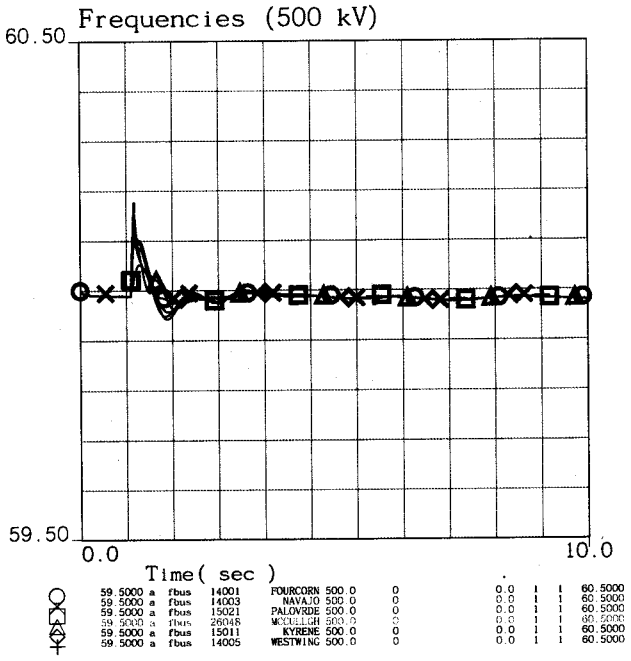
2018 Heavy Summer Detailed Planning Case









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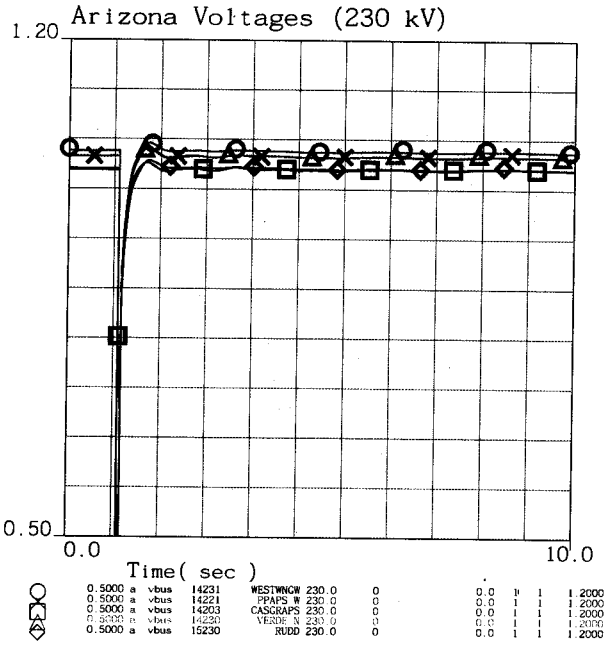

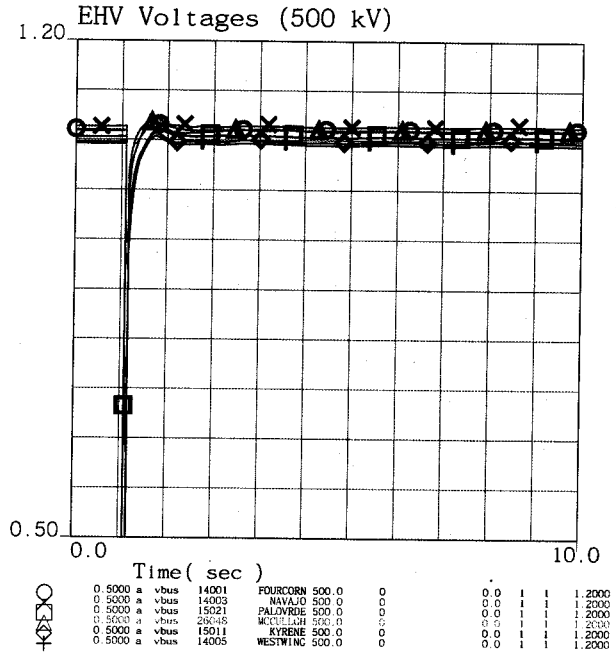

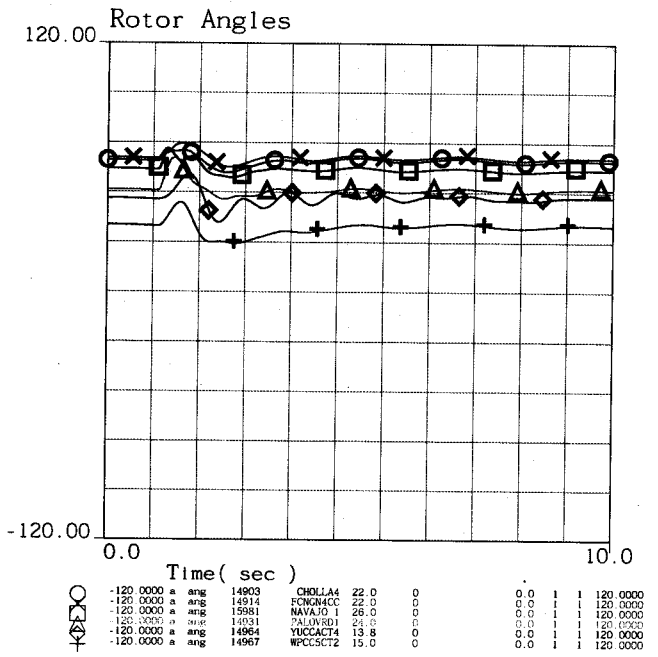

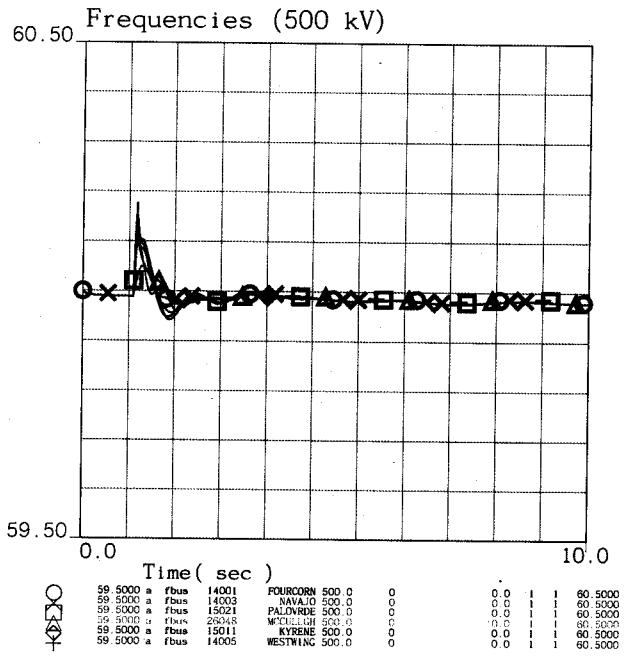

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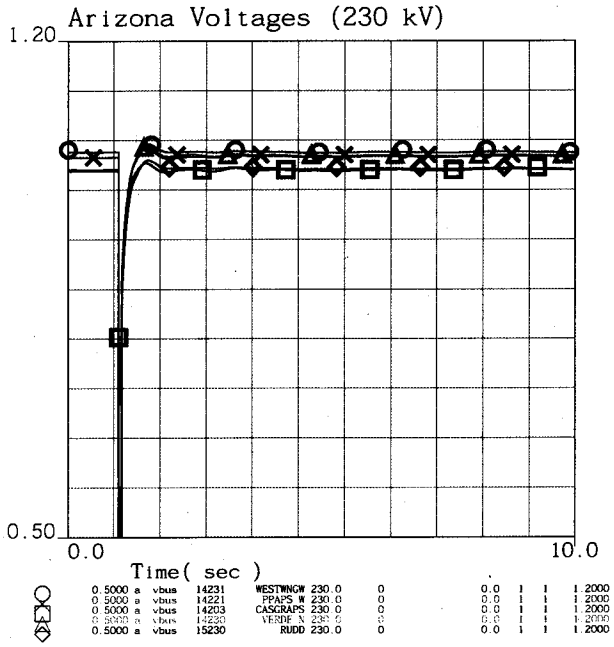

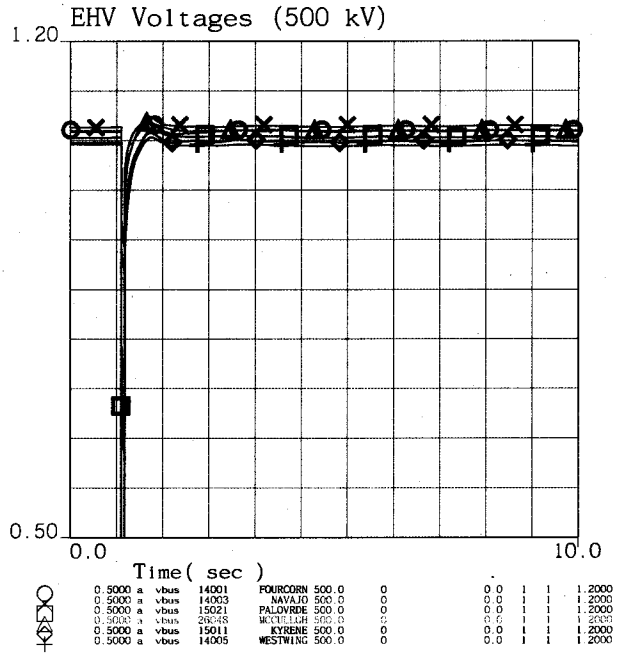

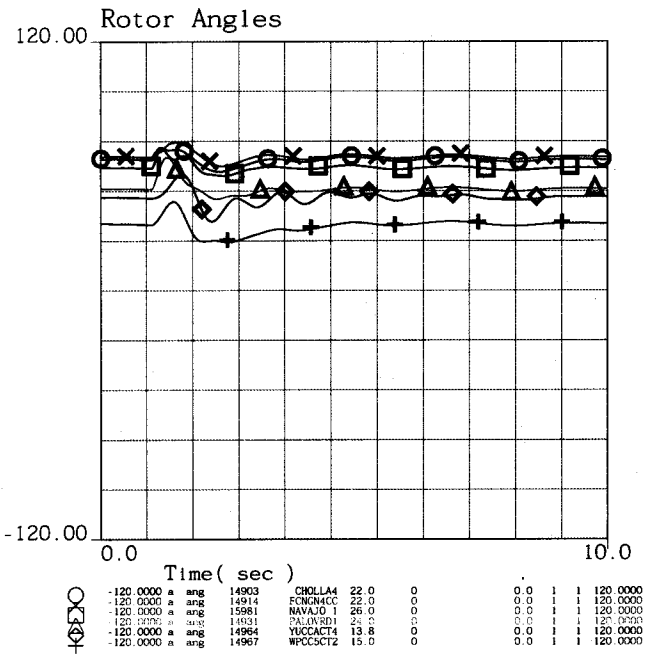

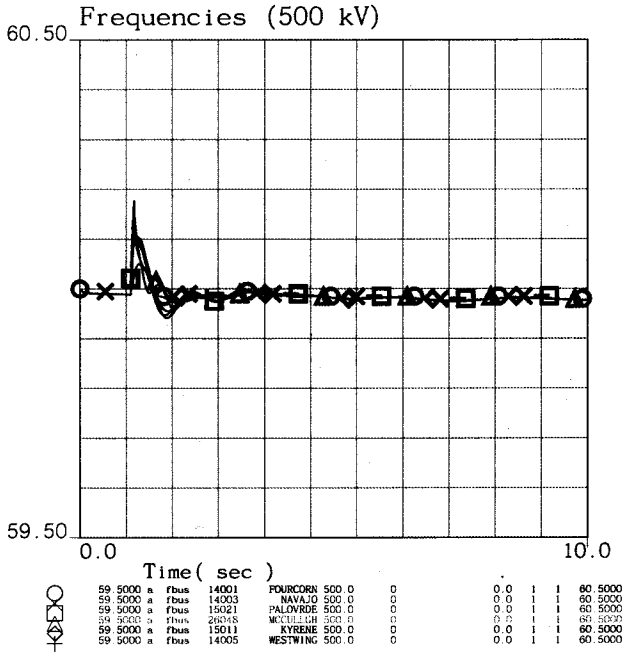

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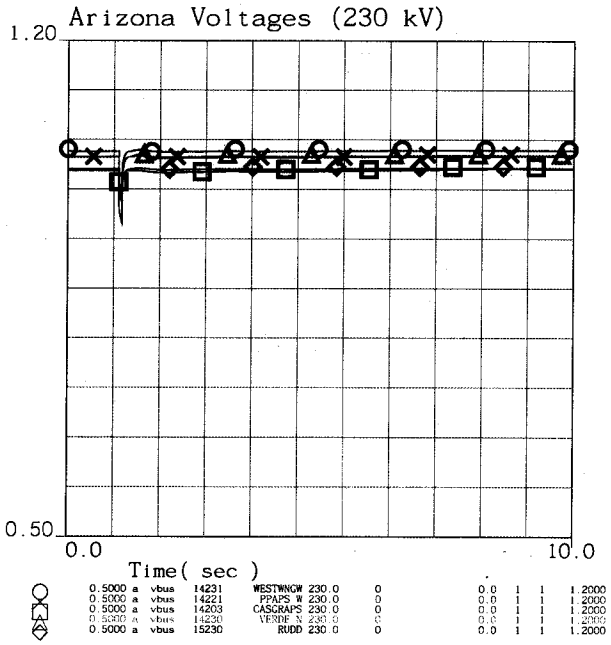

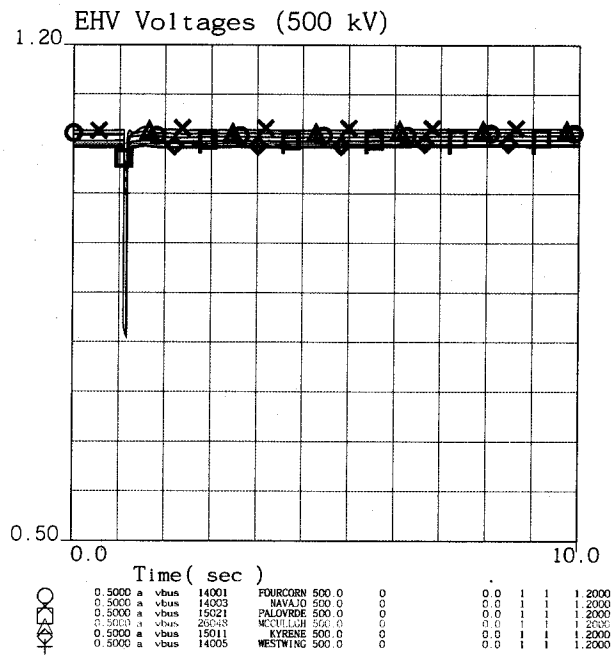

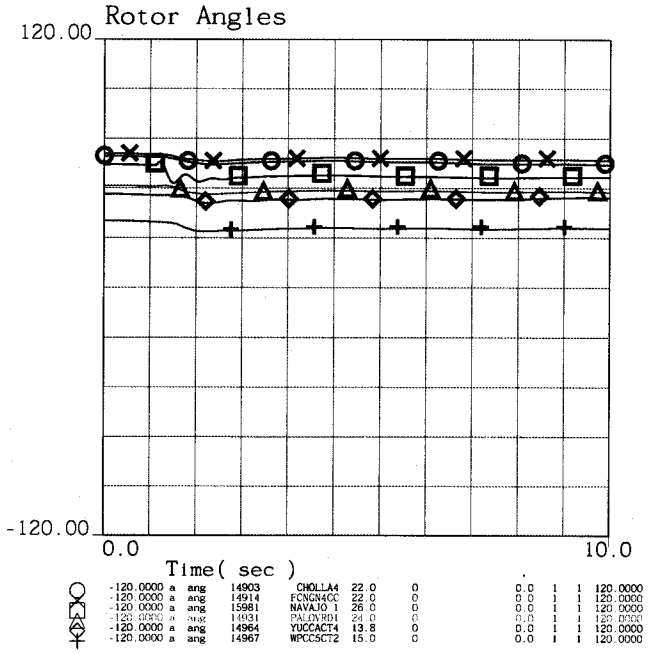

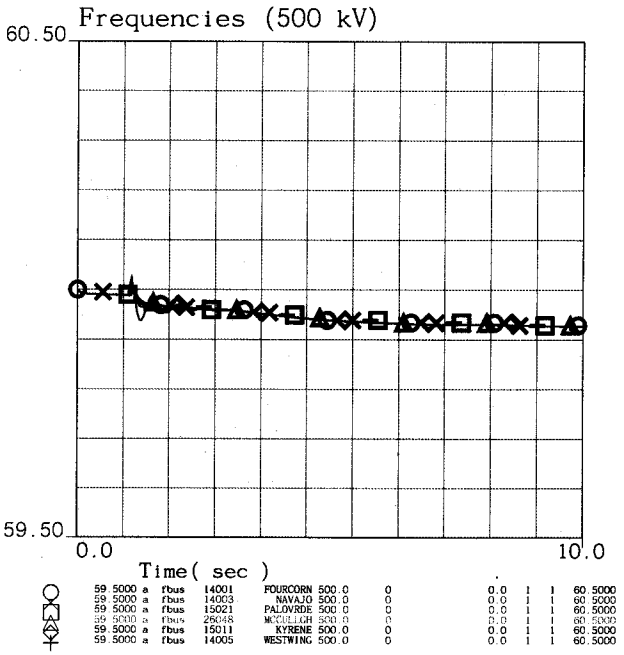

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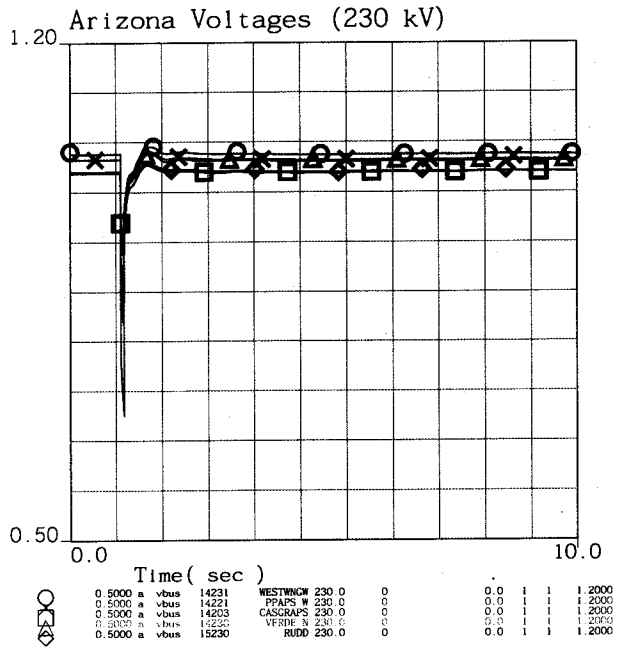

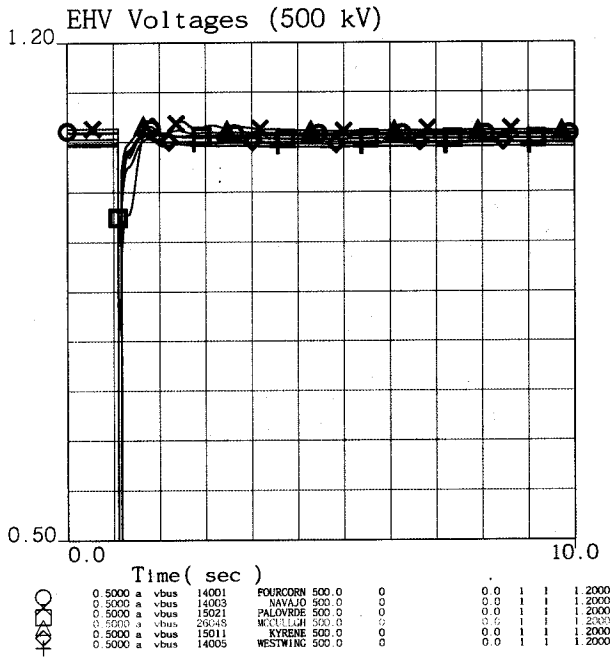

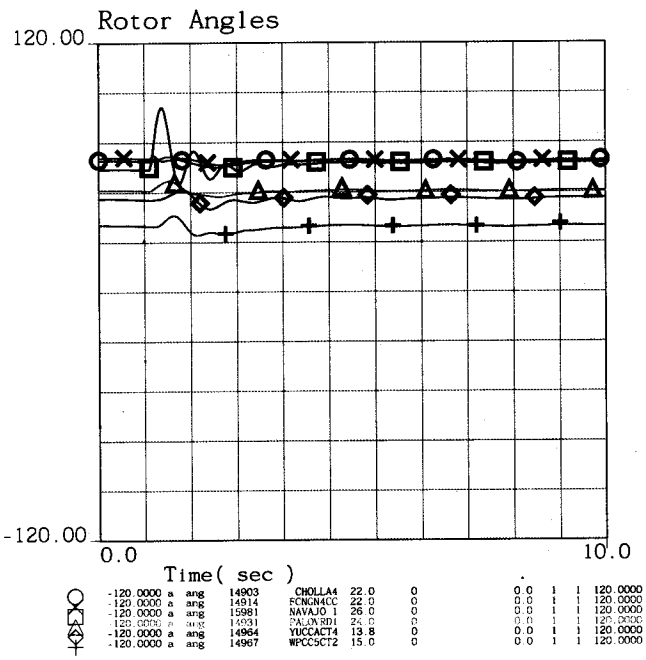

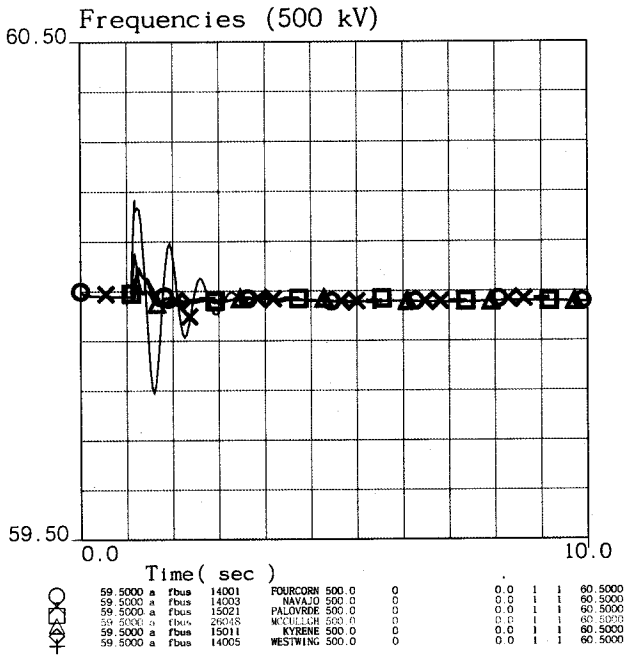

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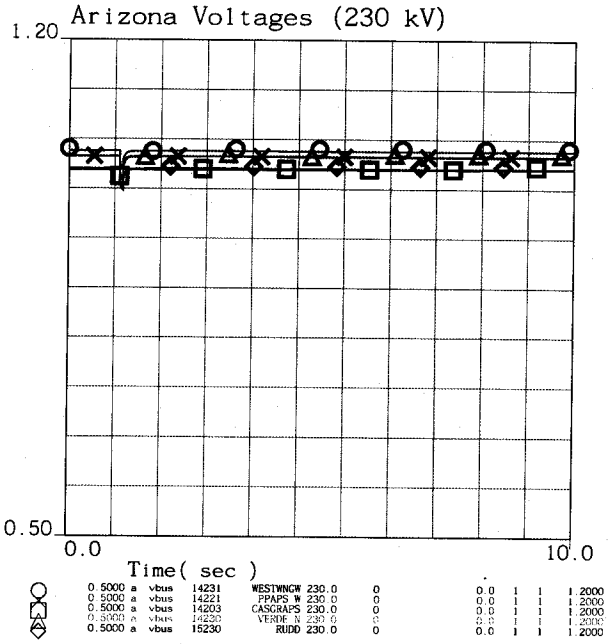
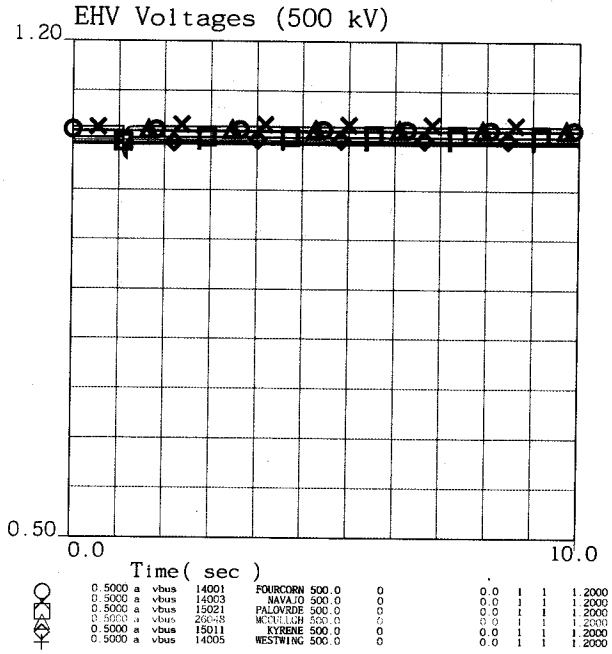
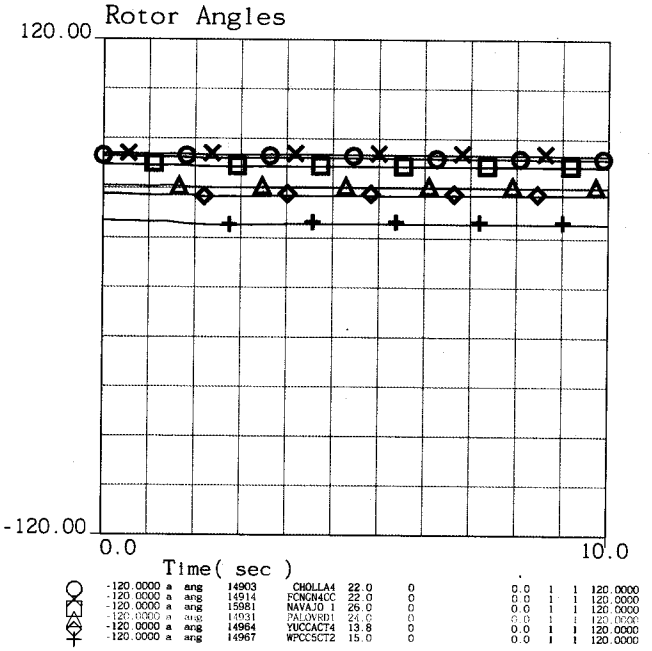
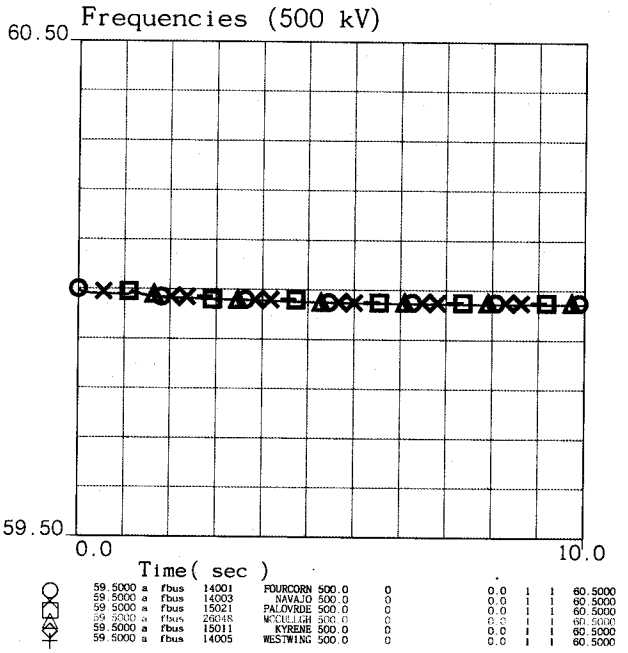
2018 Heavy Summer Detailed Planning Case









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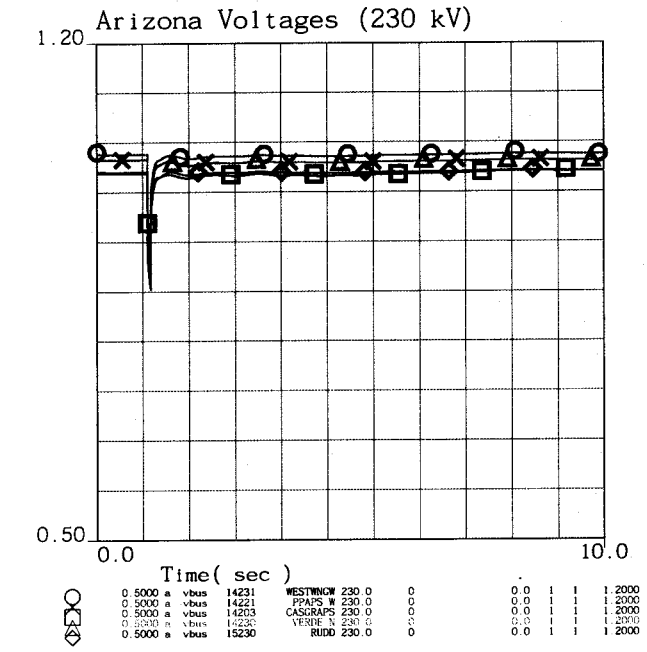

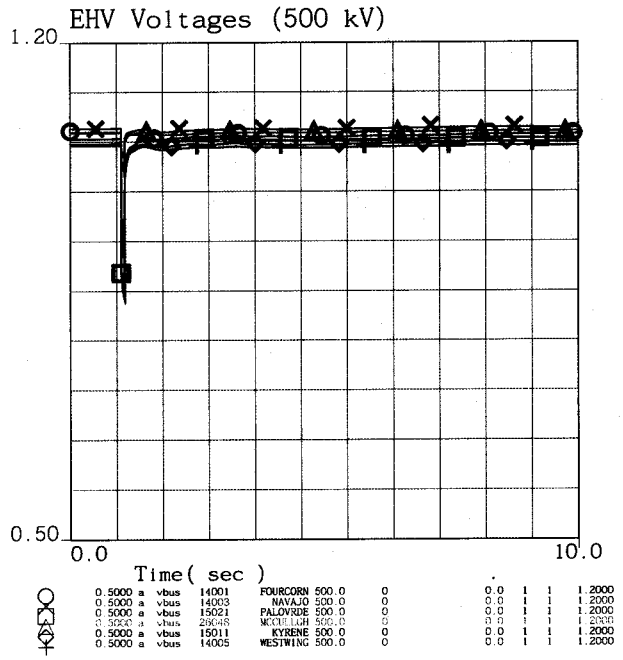

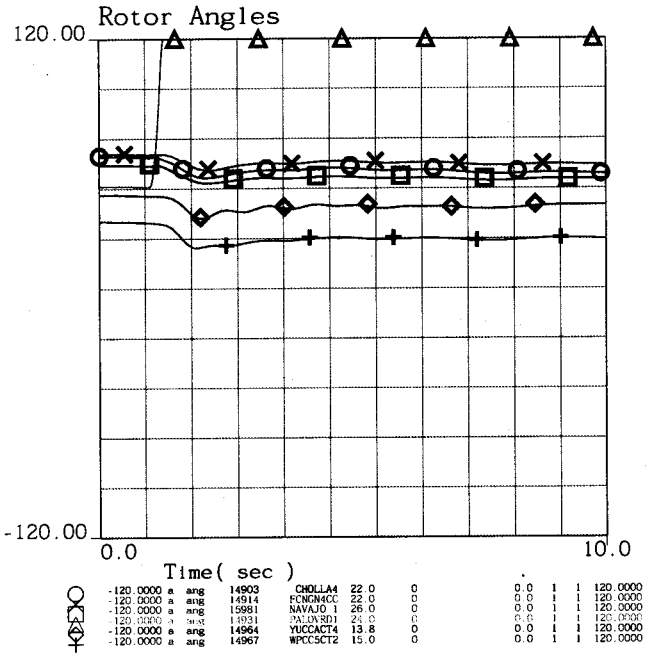

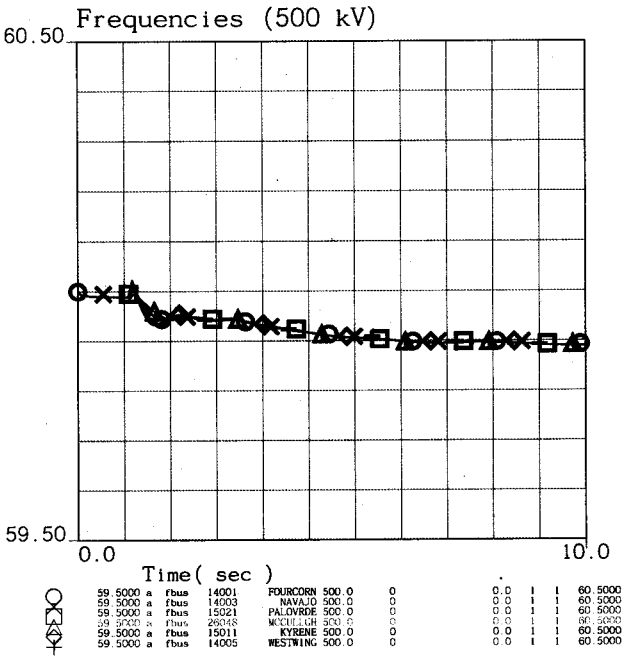

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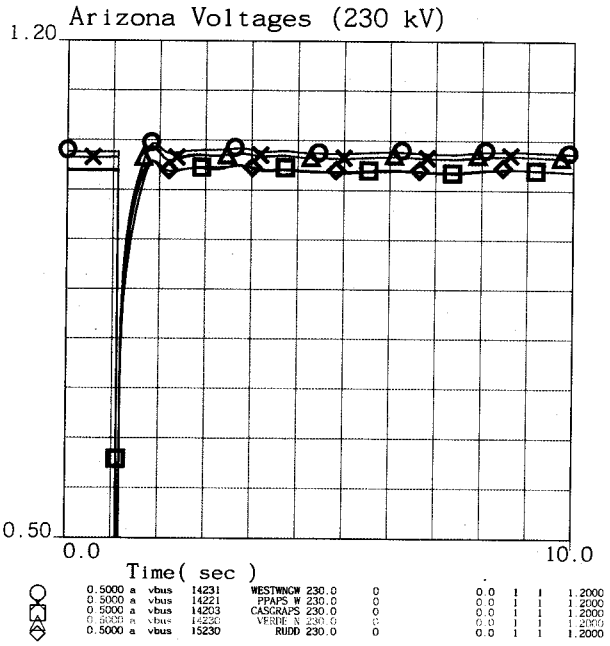

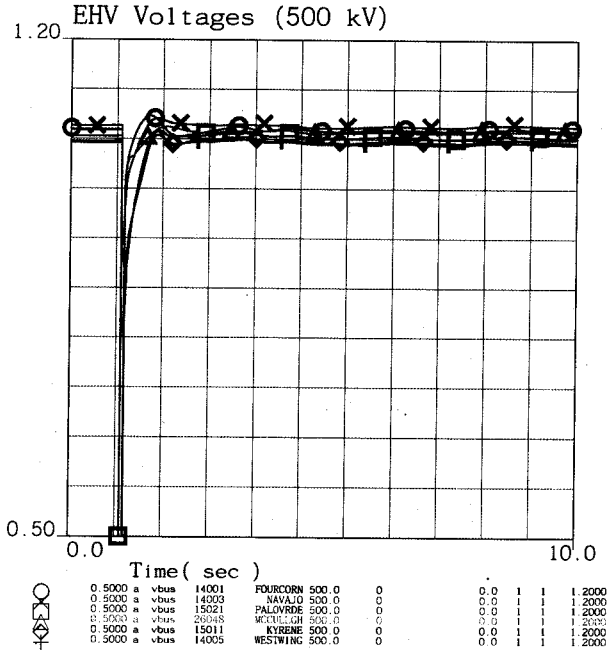

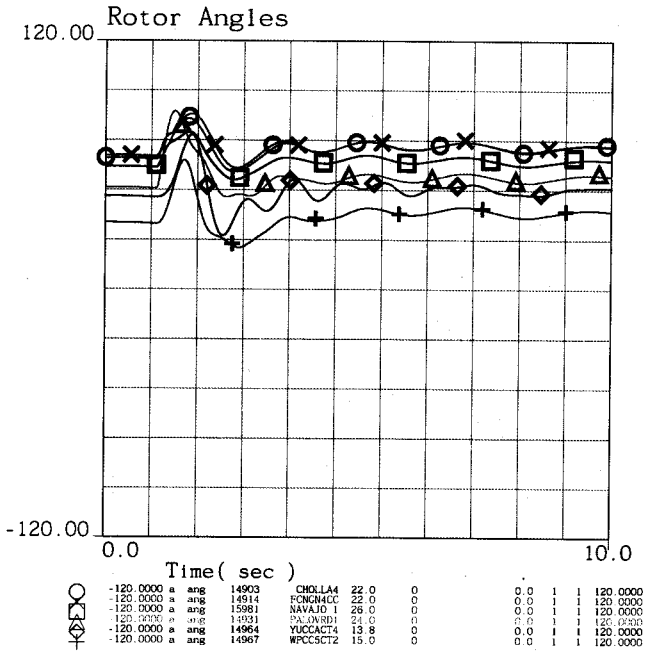

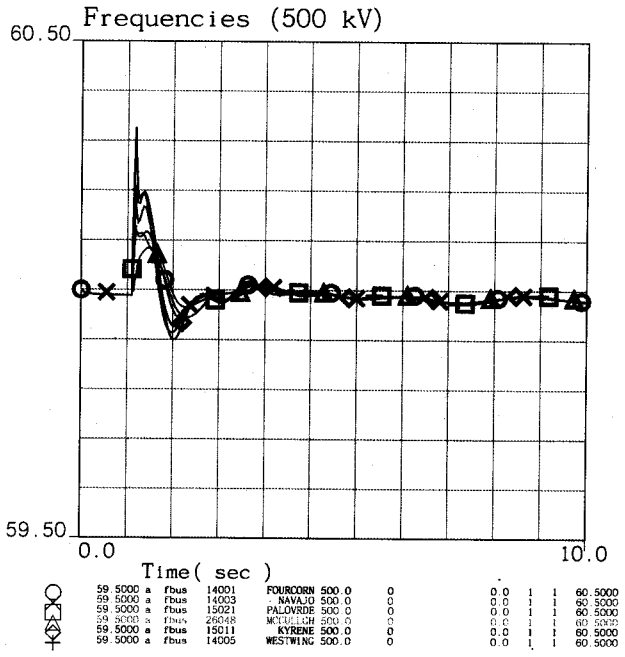

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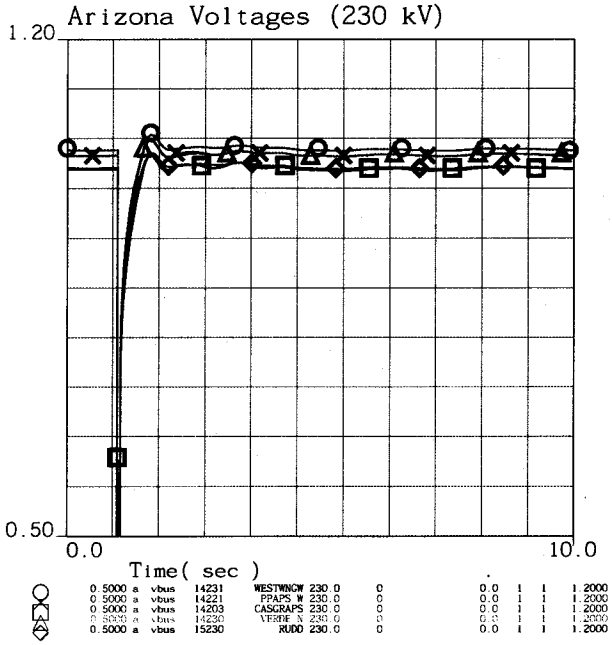

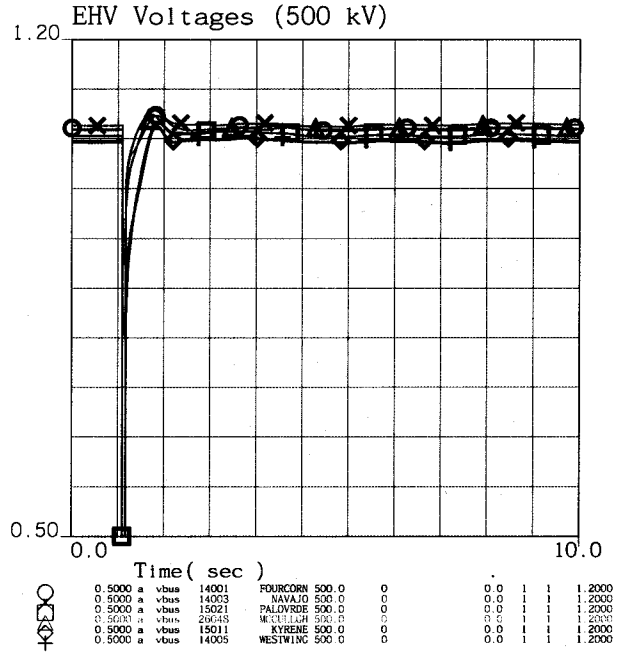

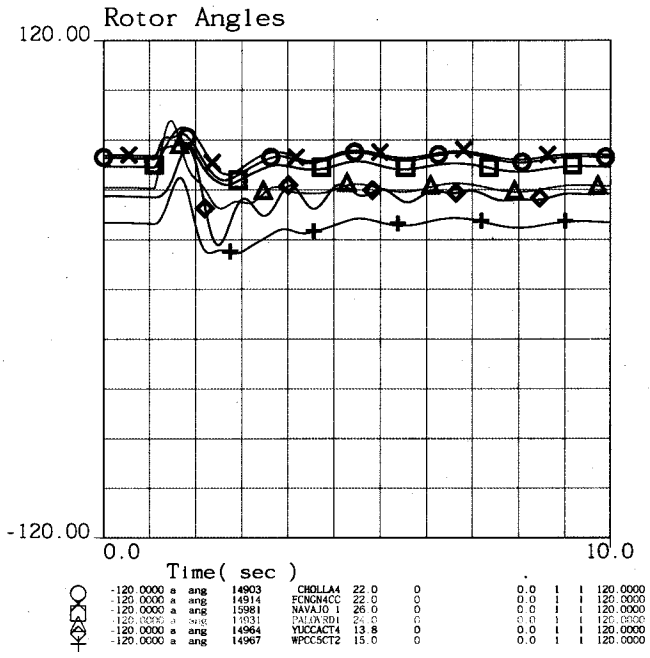

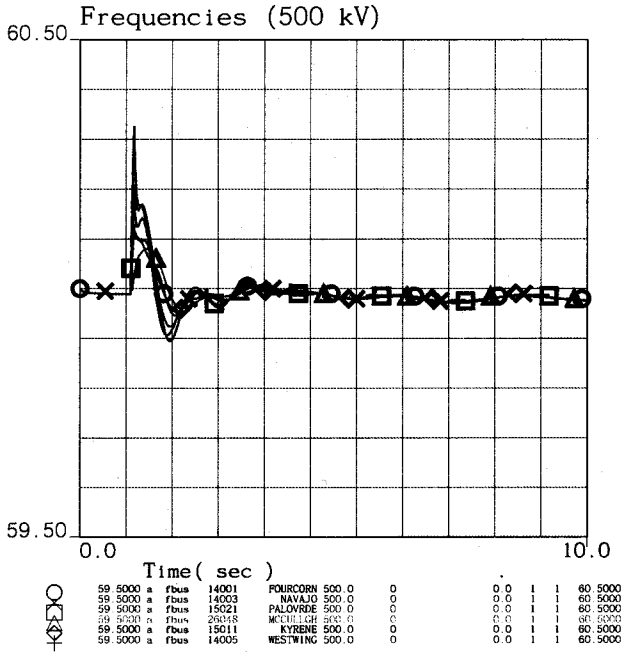

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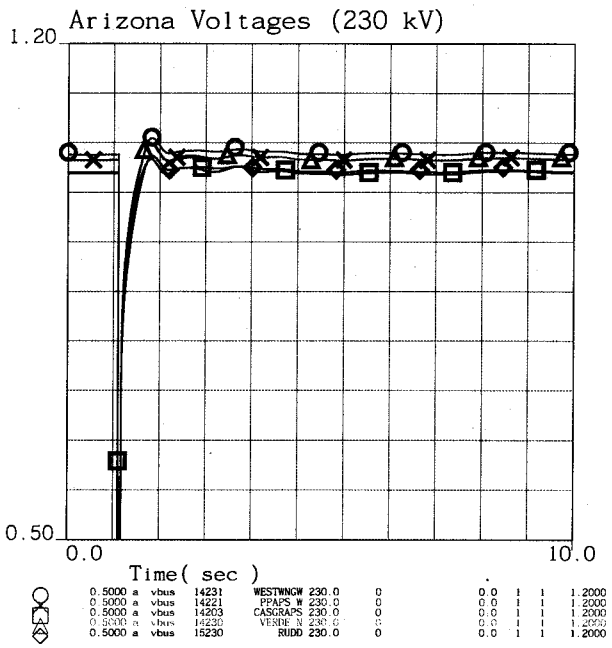

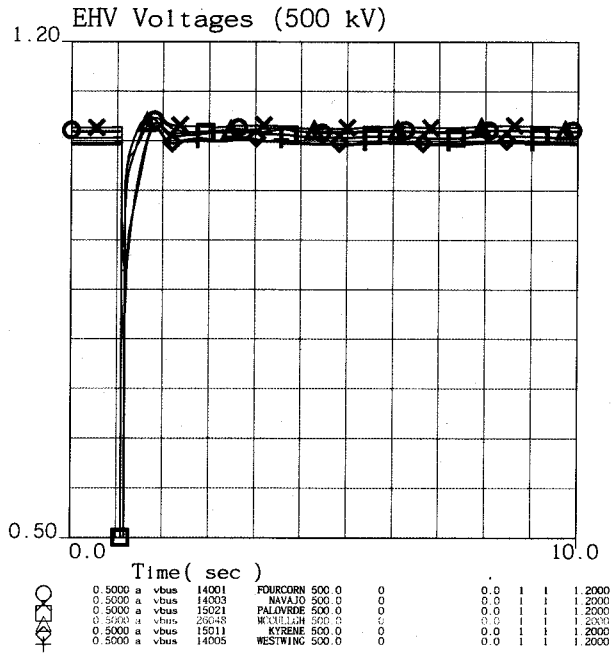

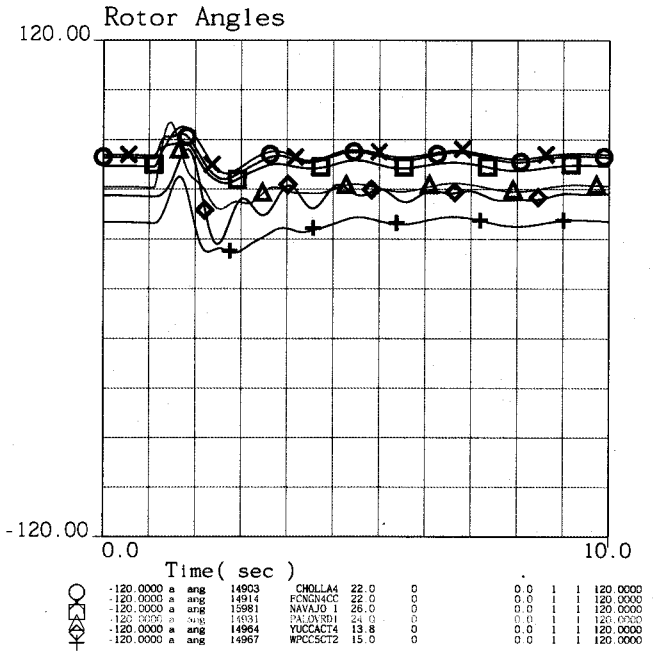

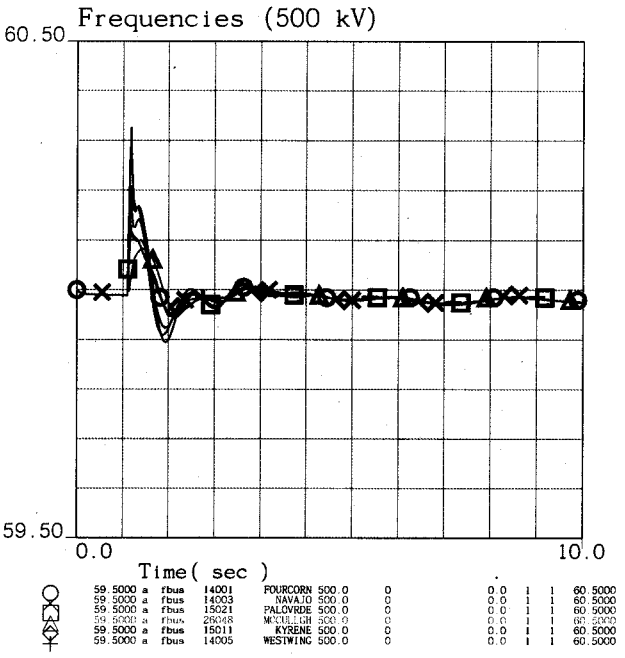

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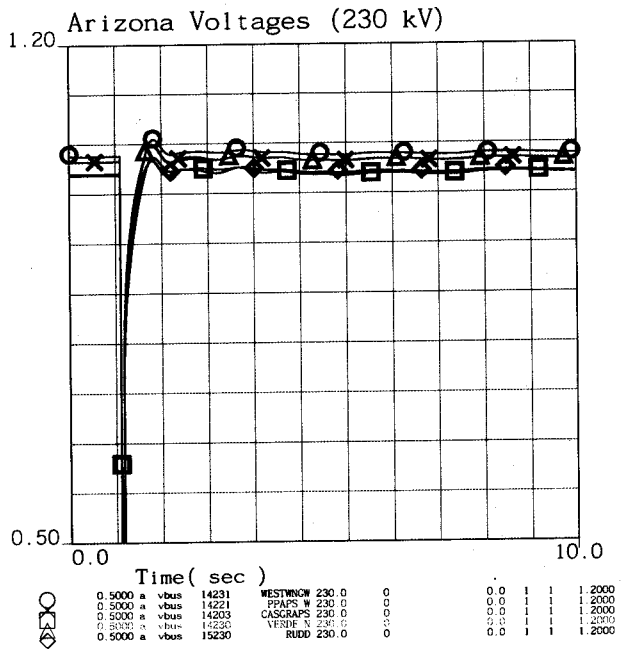

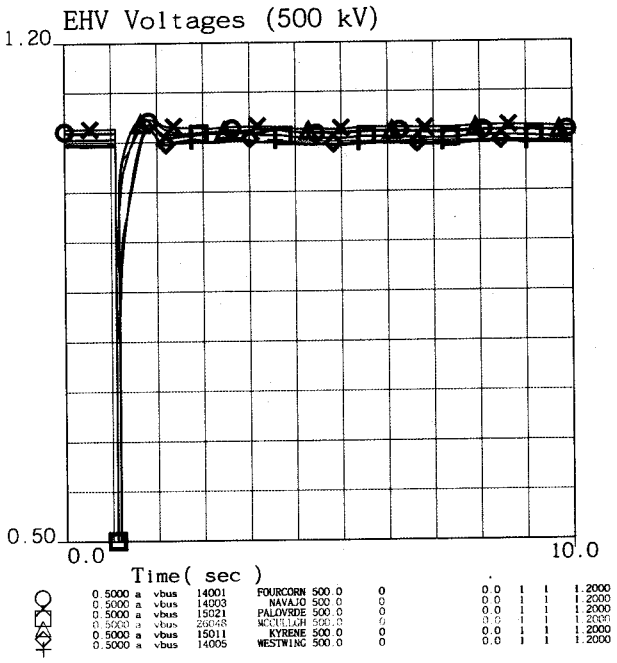

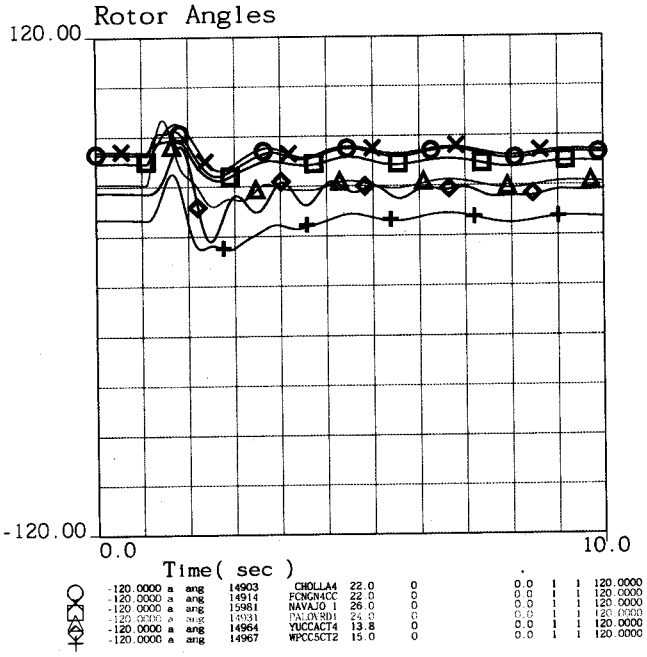

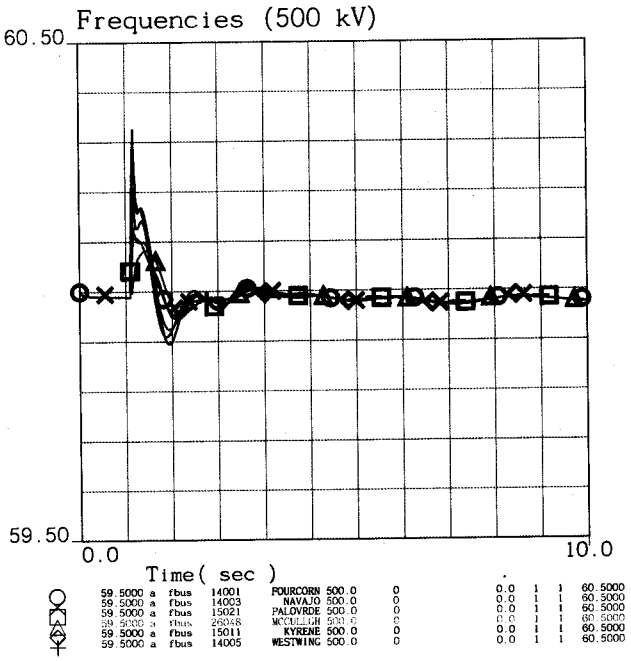

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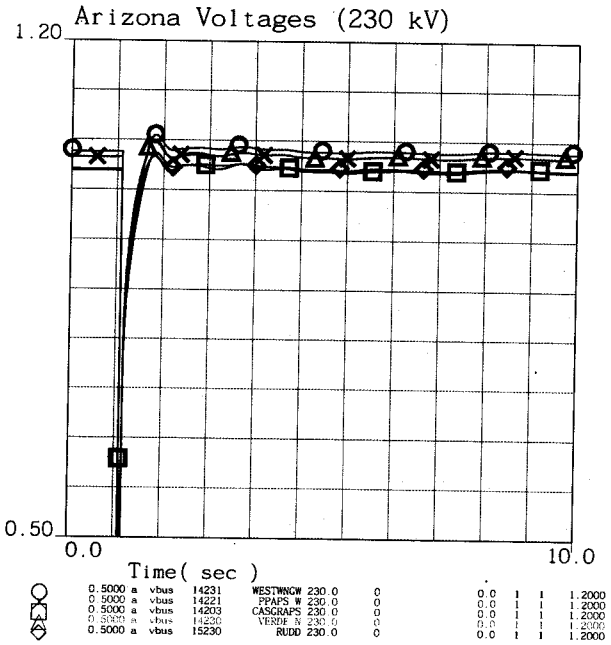

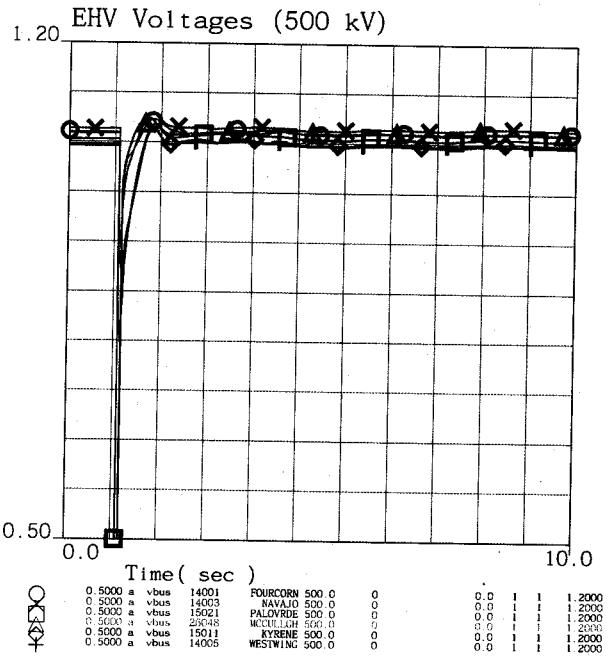

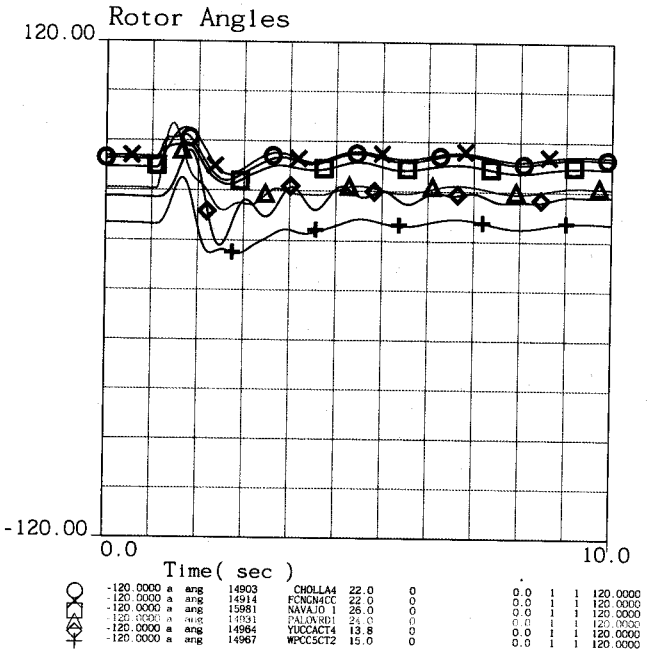

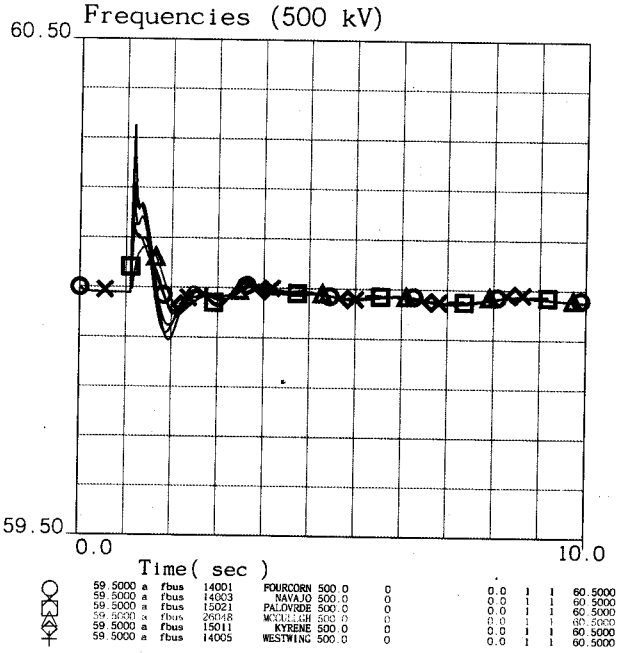

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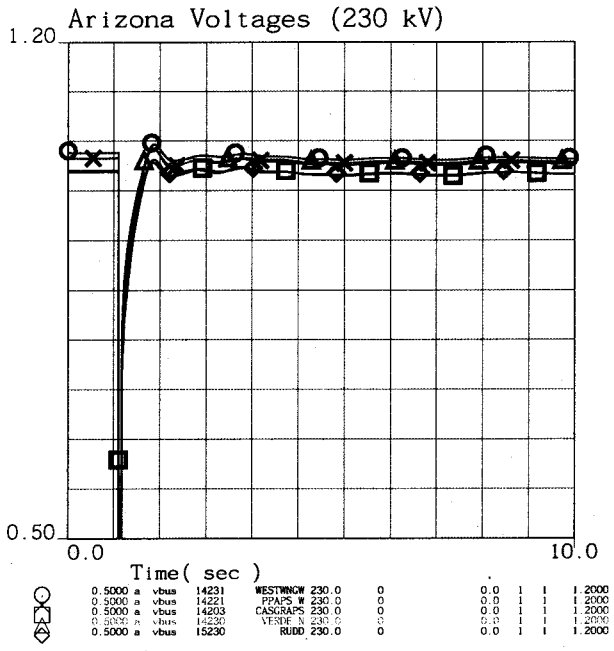

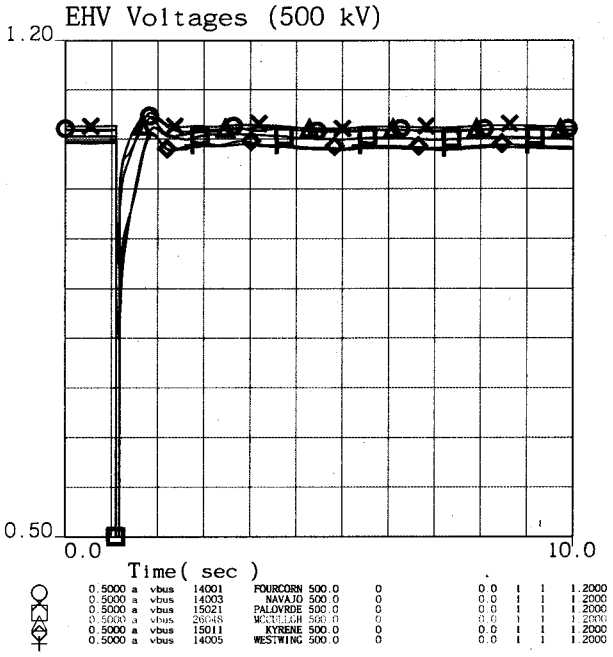

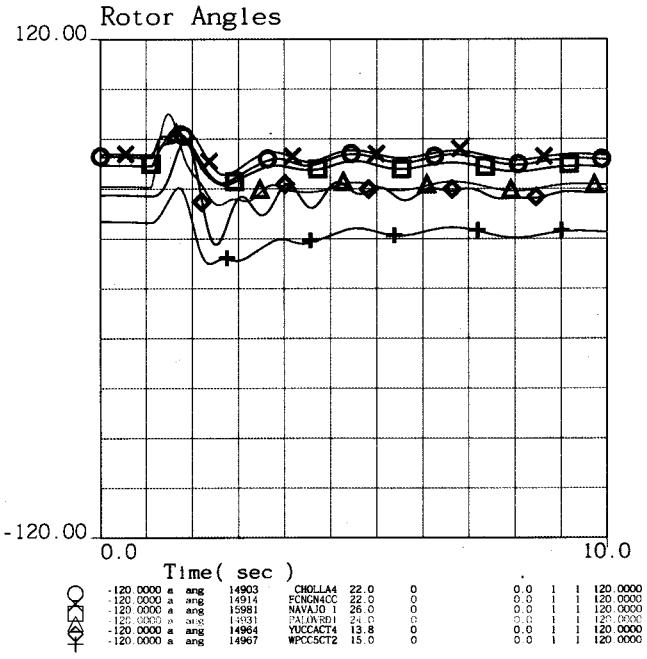

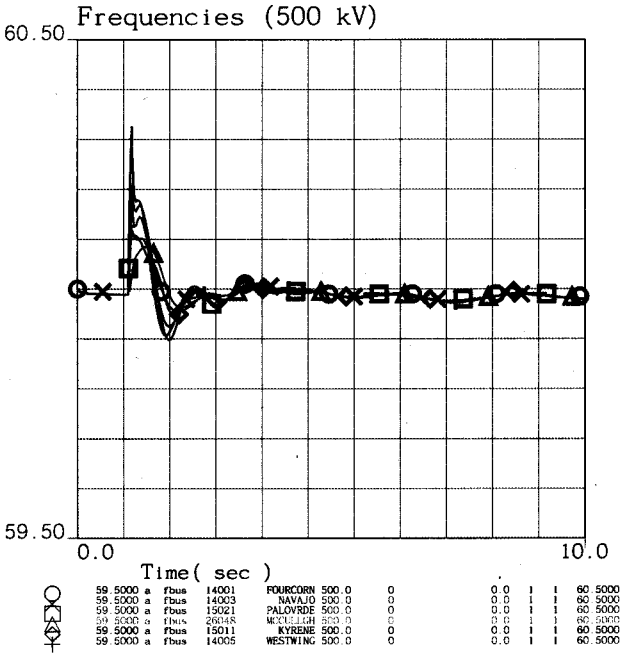

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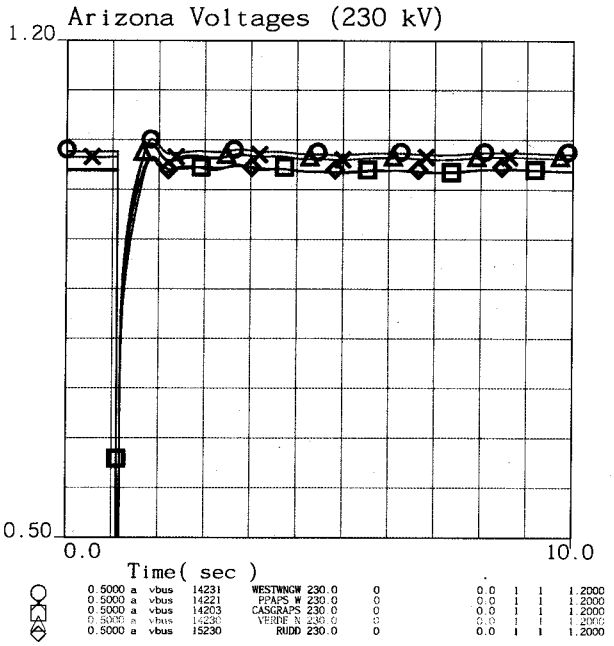

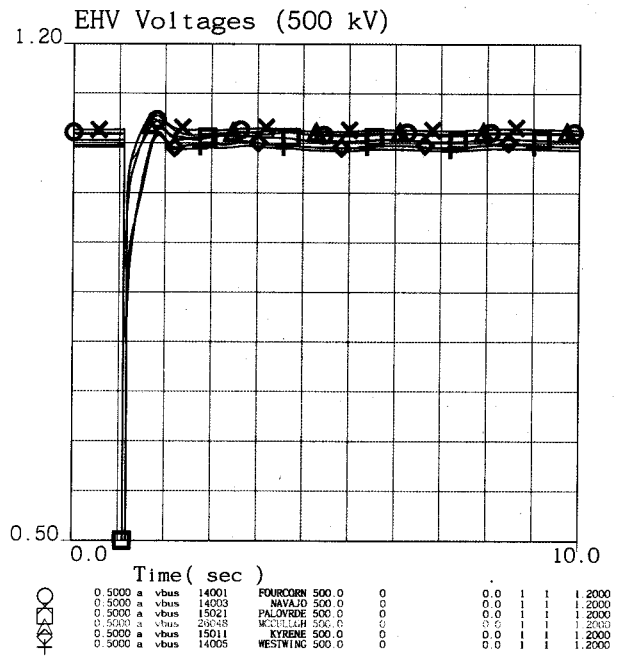

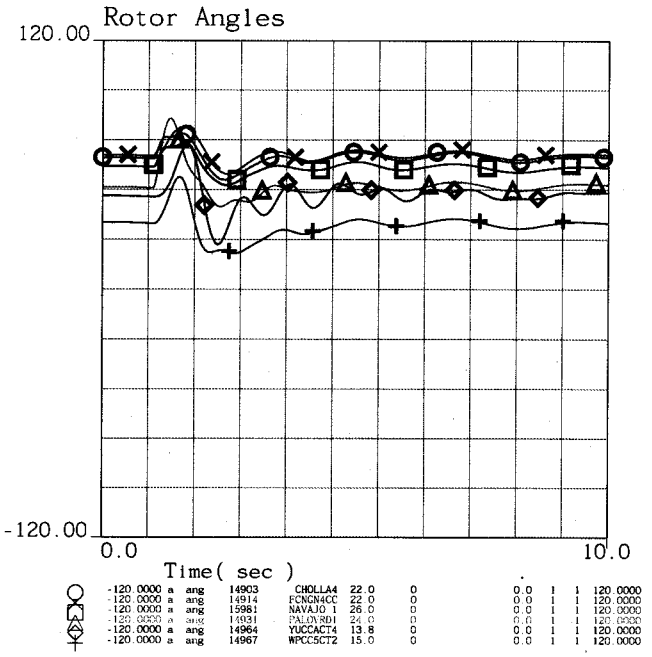

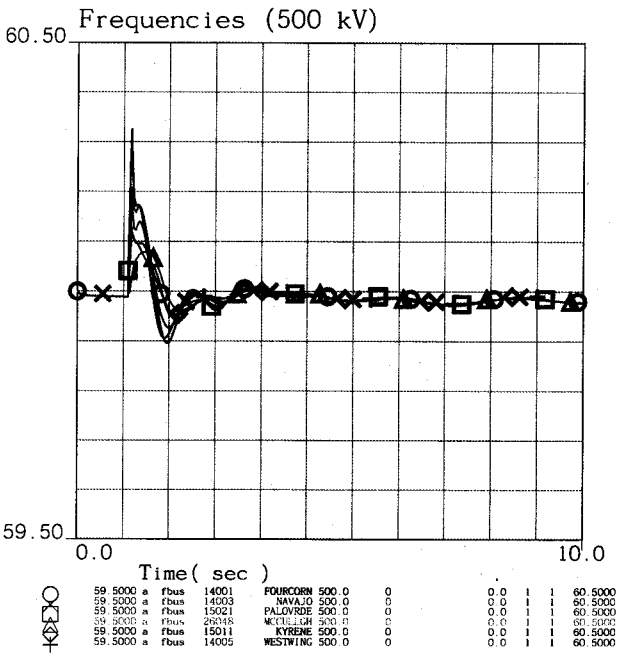

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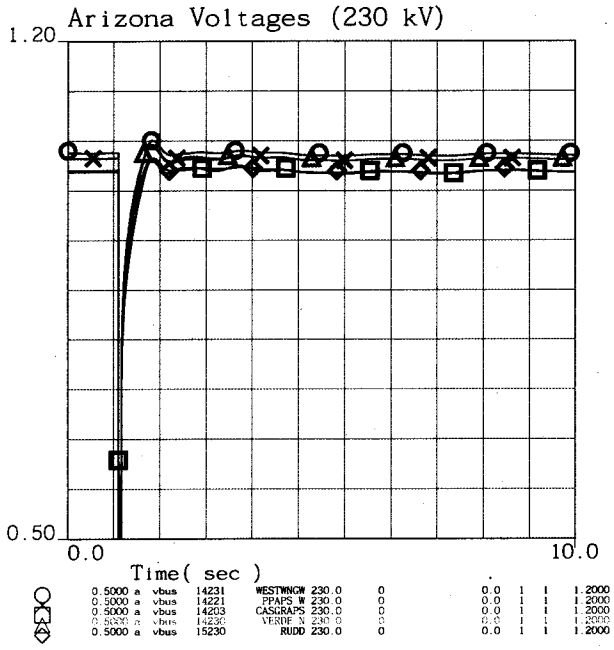

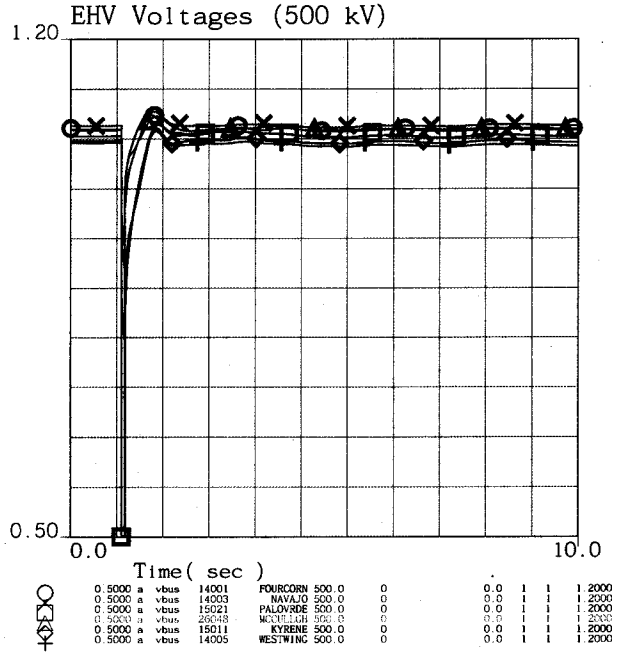

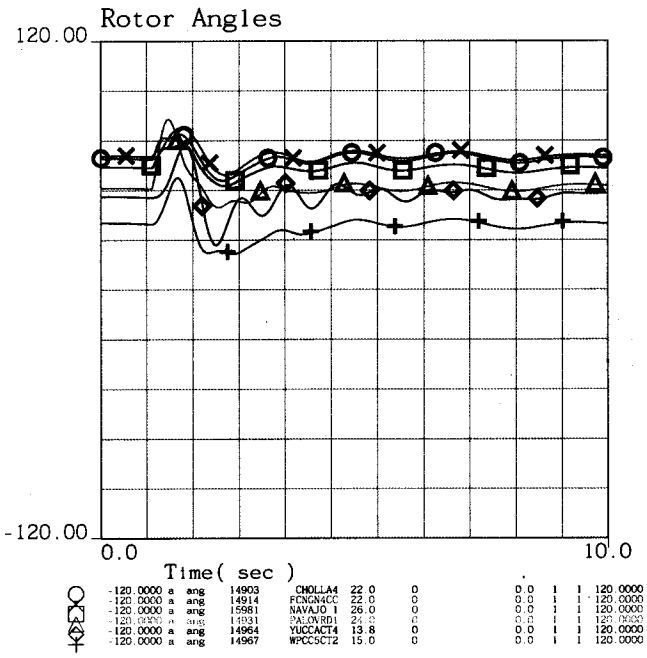

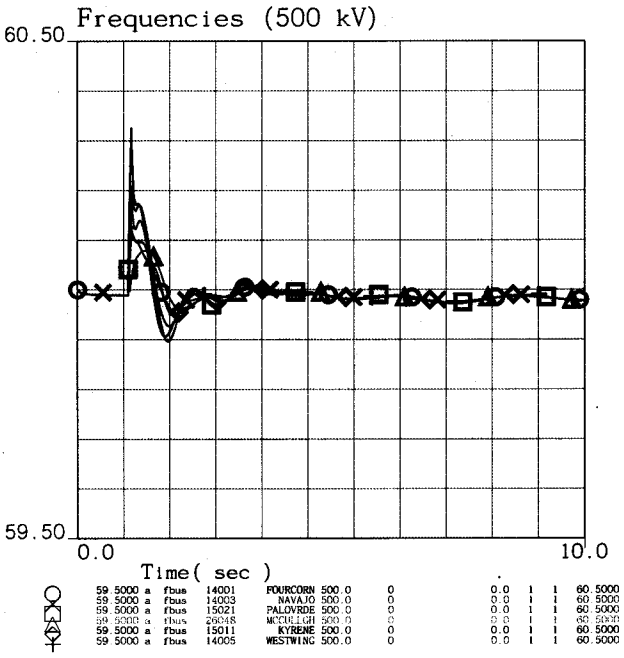

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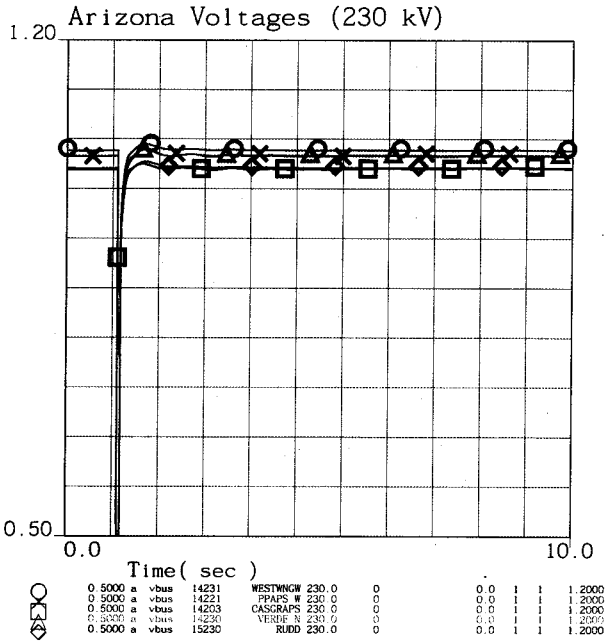

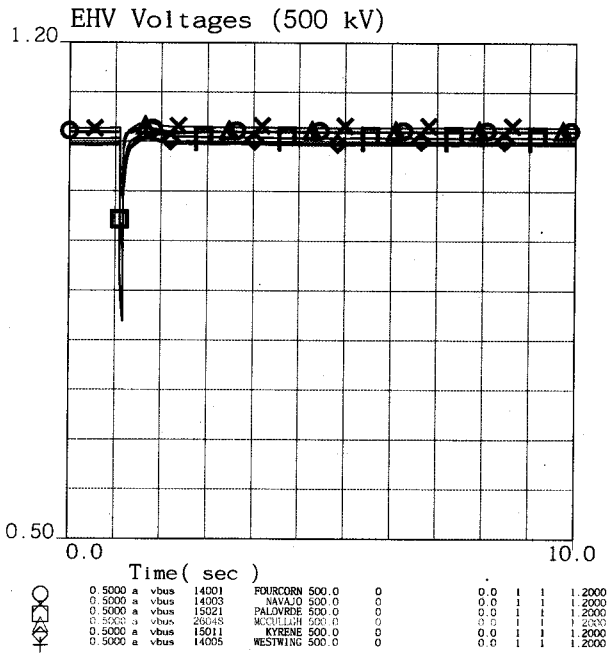

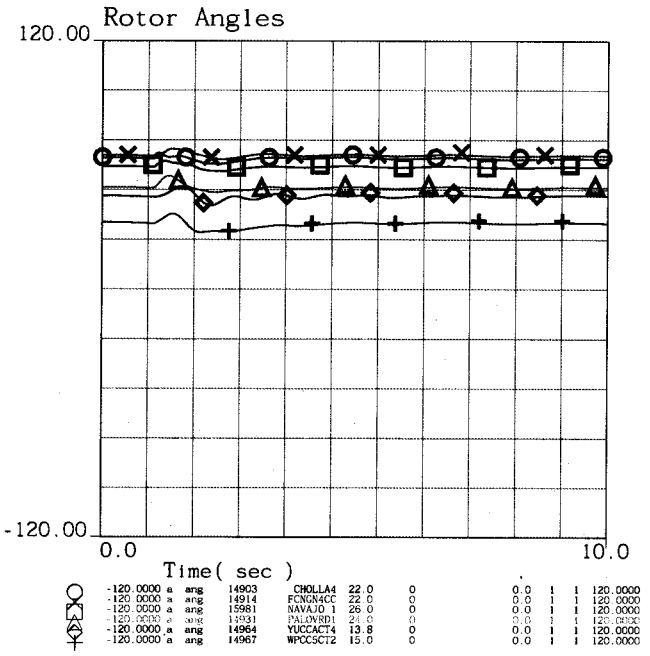

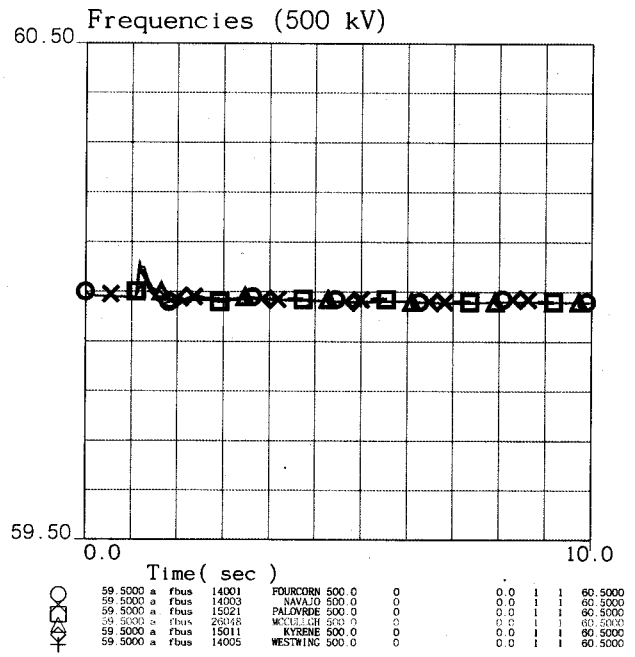

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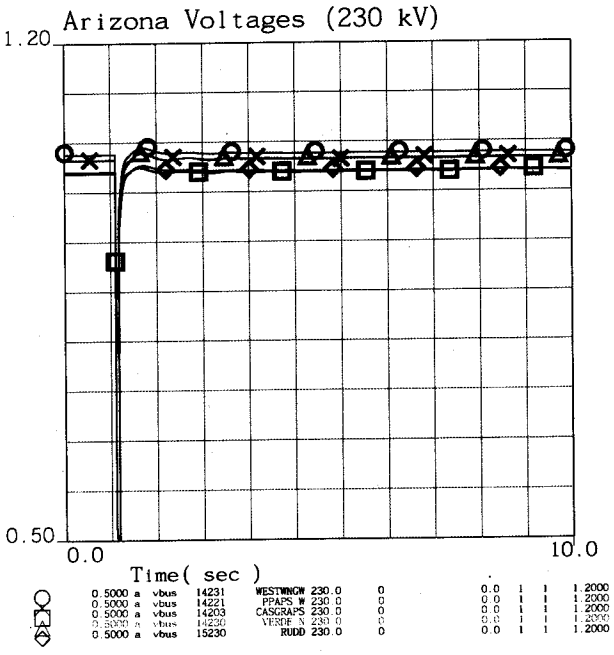

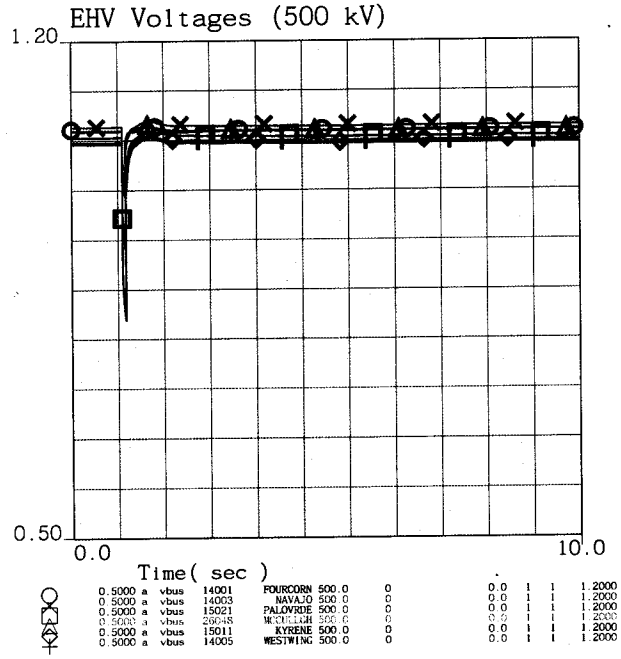

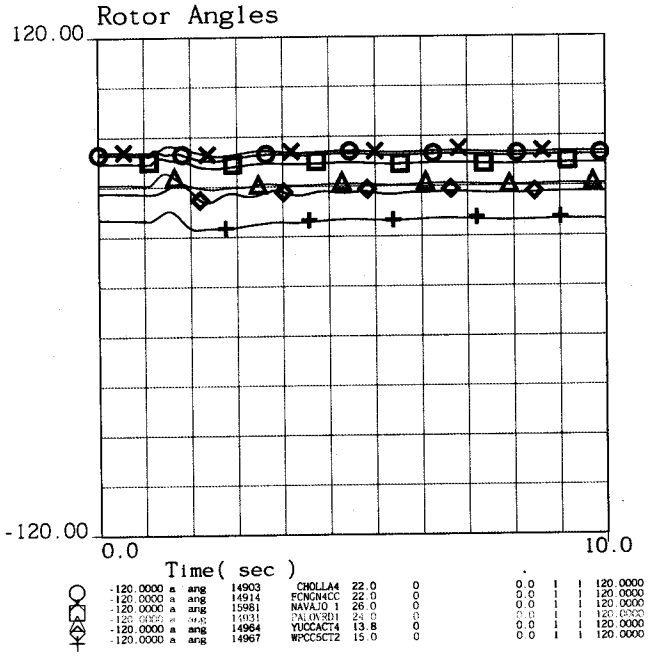

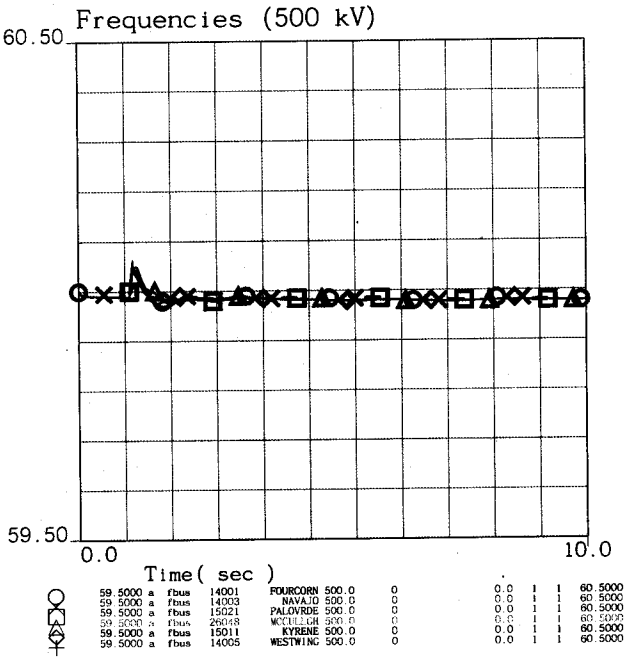

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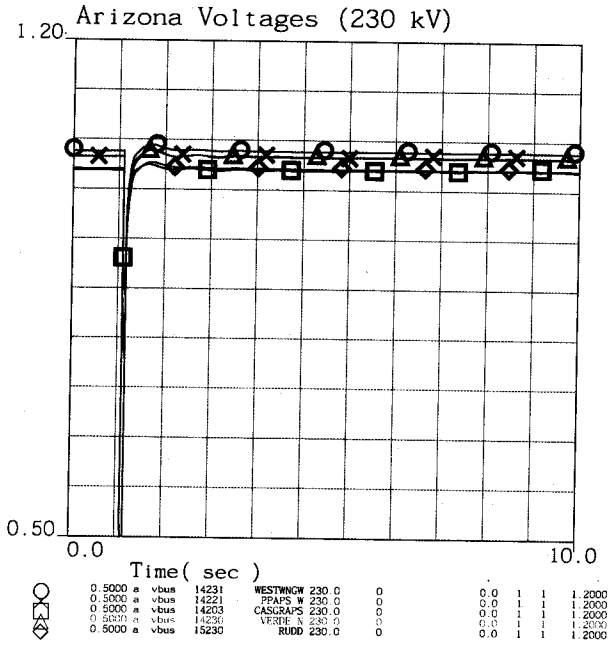

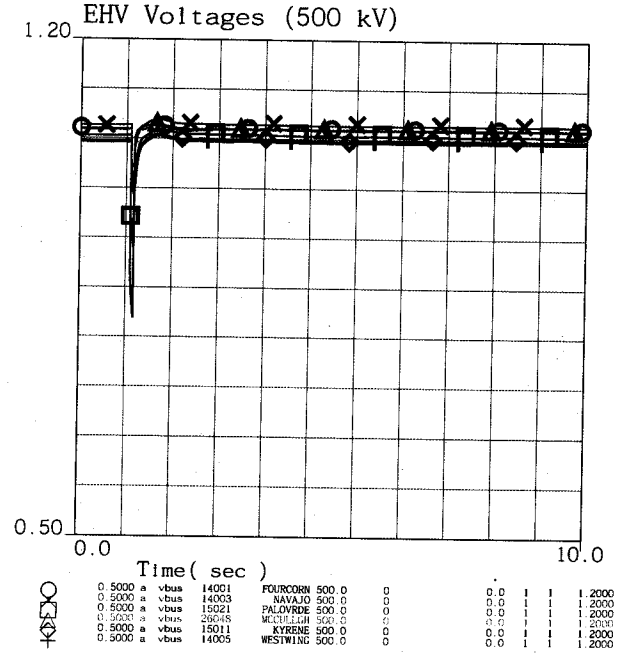

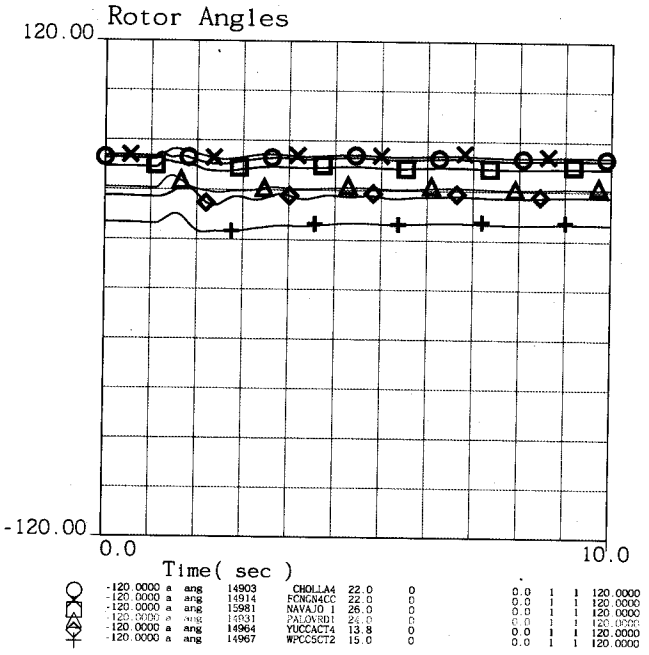

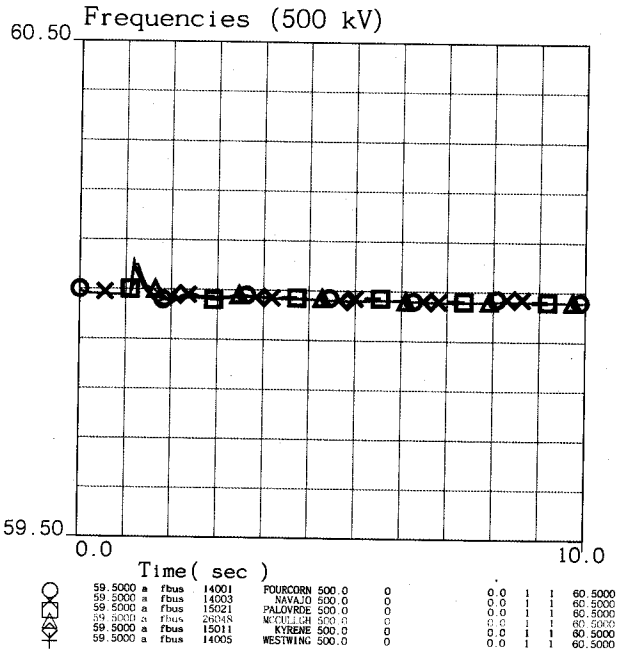

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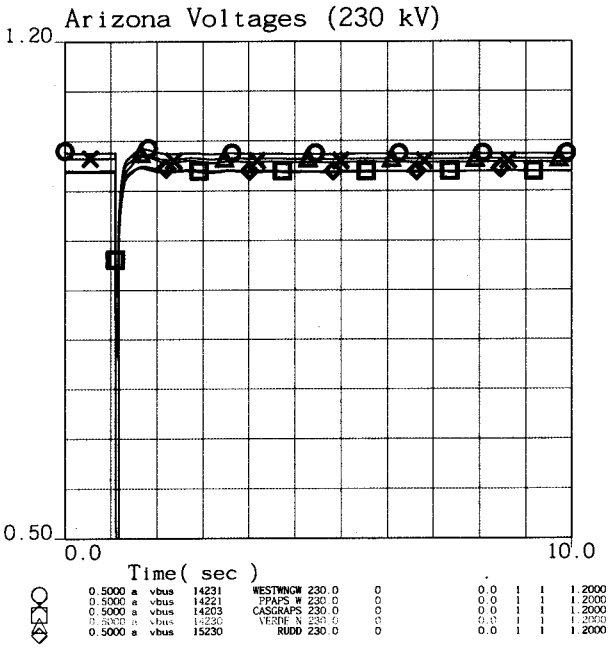

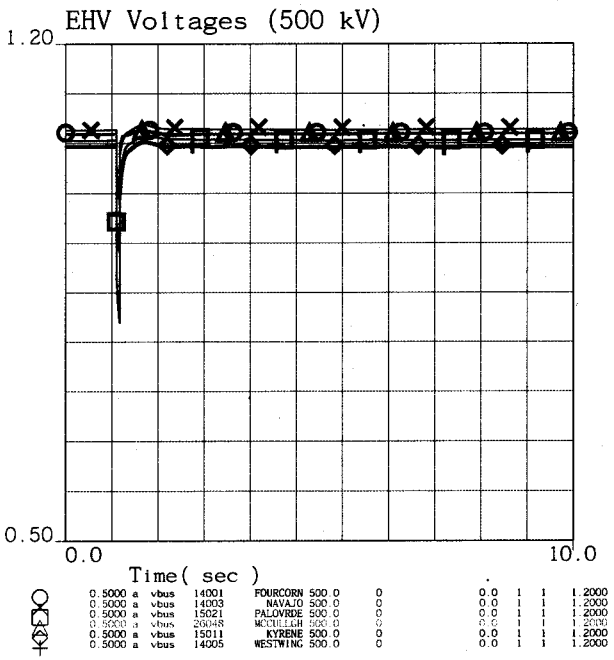

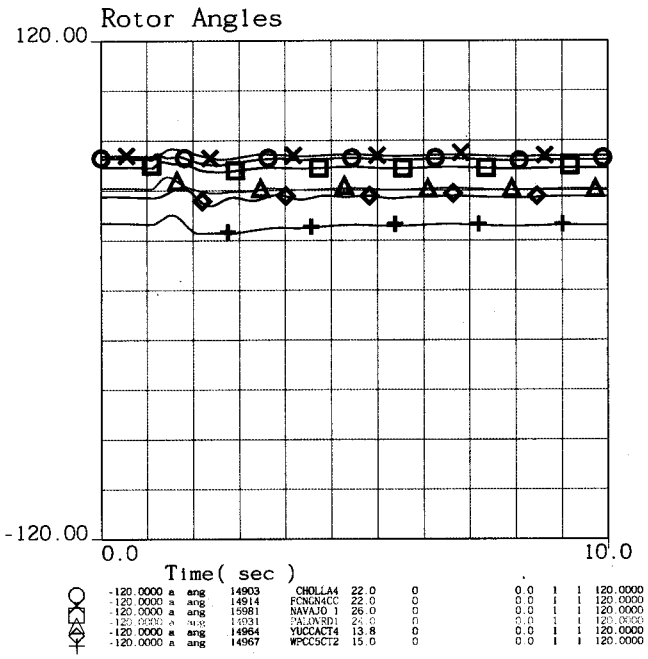

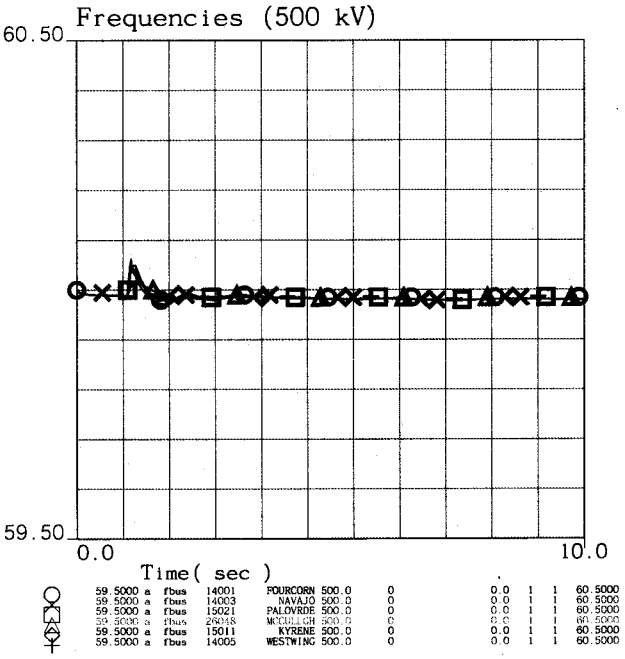

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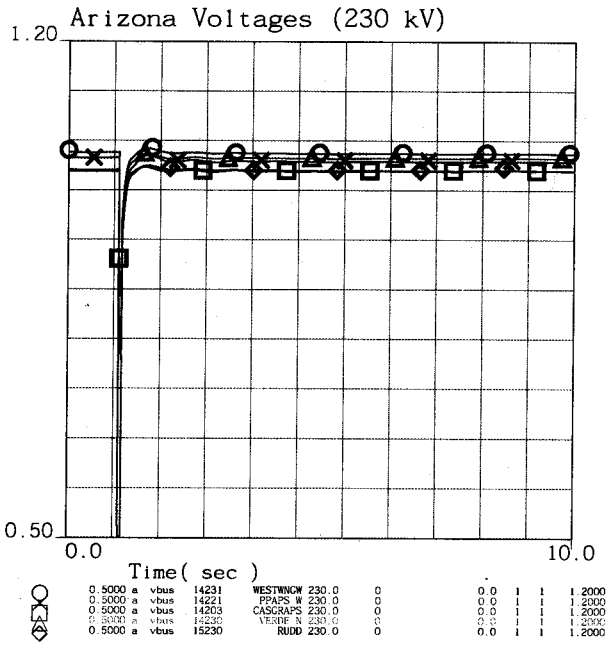

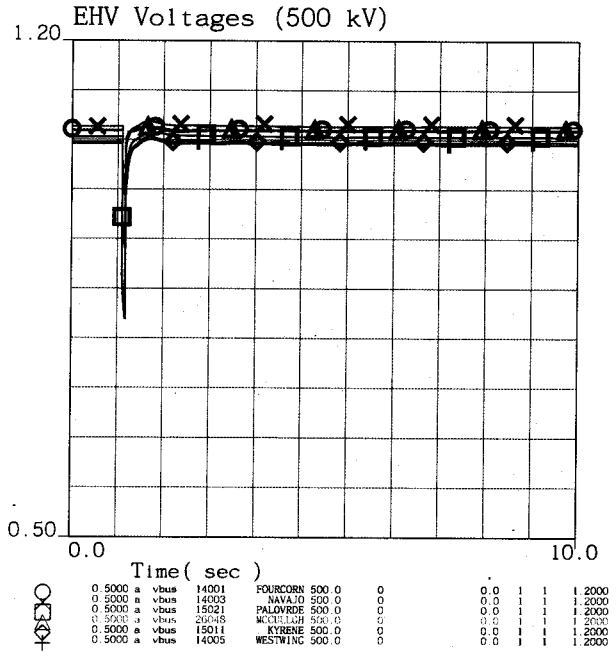

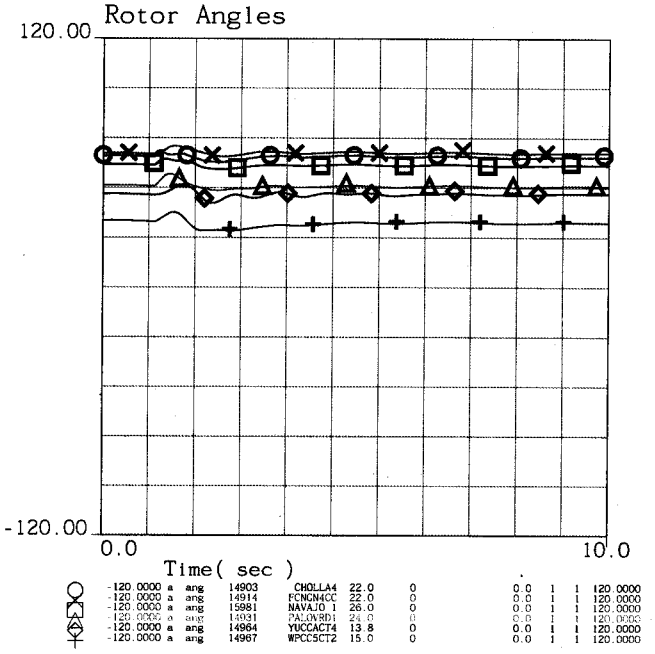

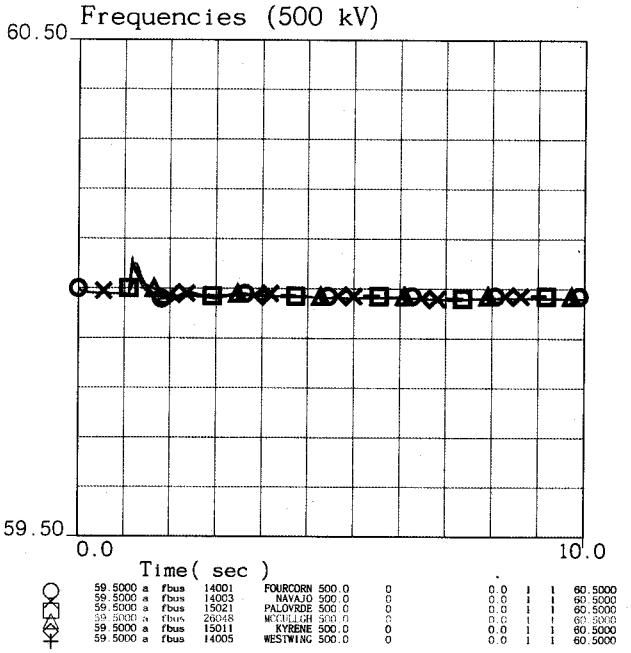

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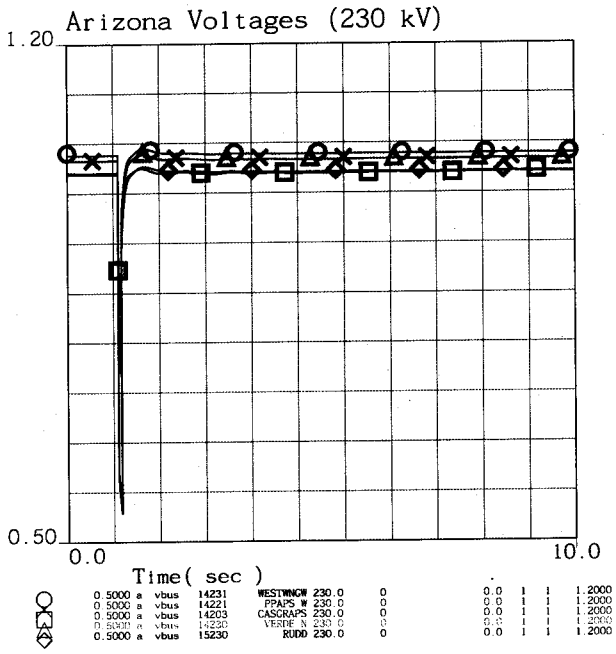
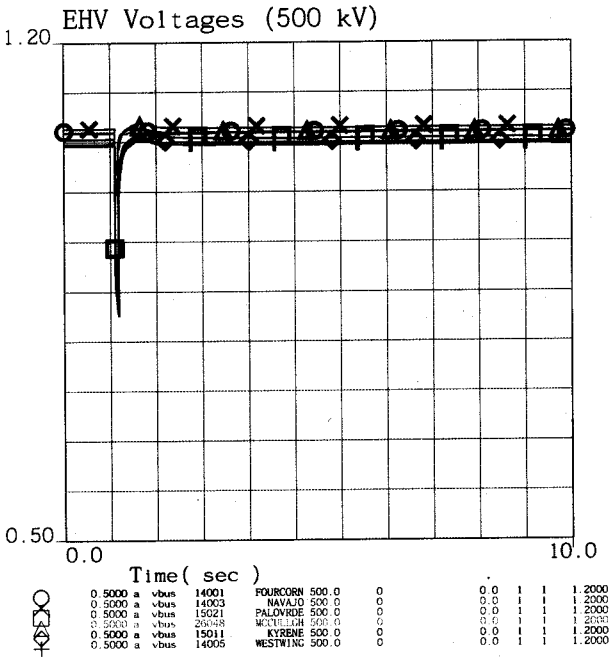
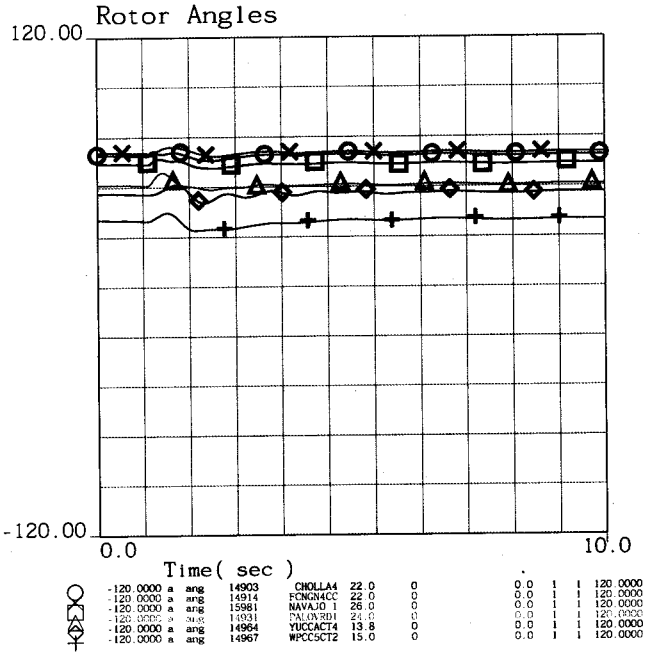
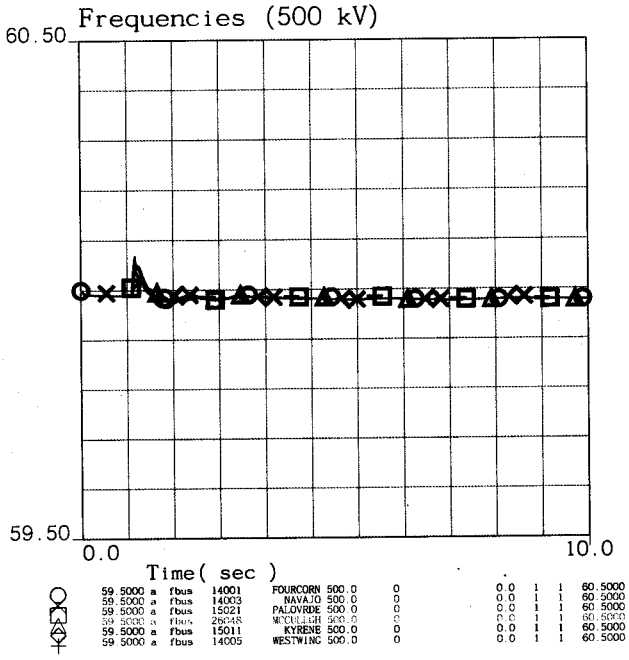
2018 Heavy Summer Detailed Planning Case









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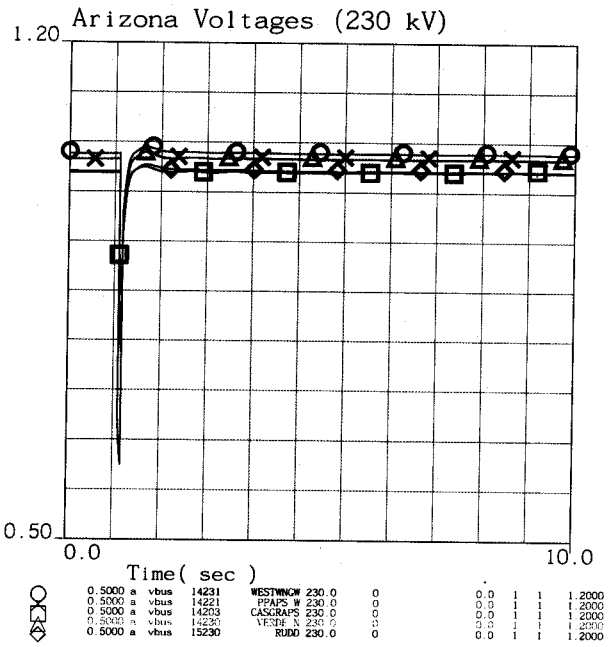

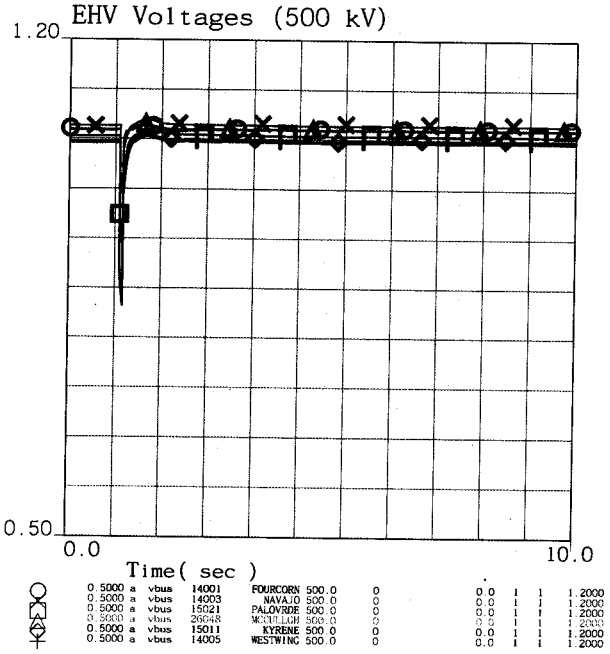

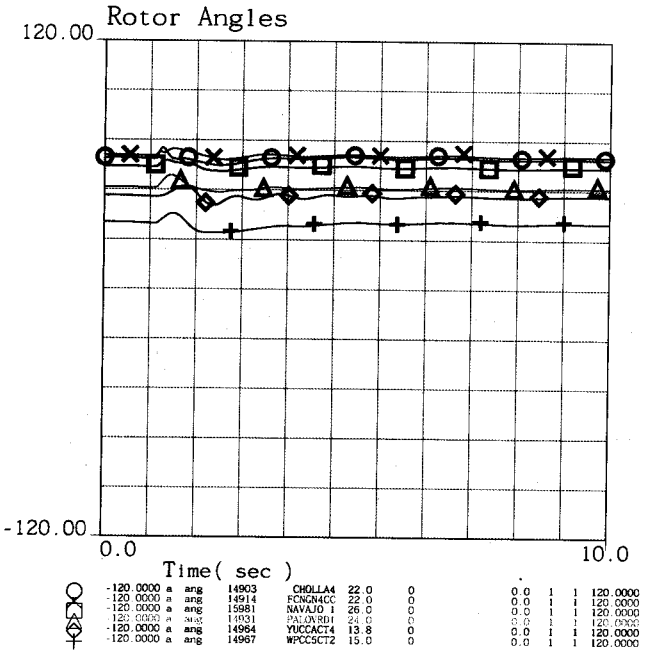

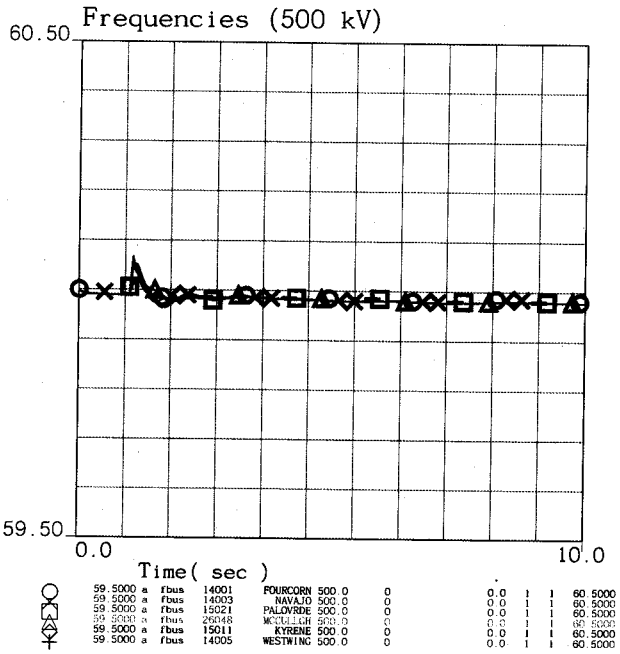

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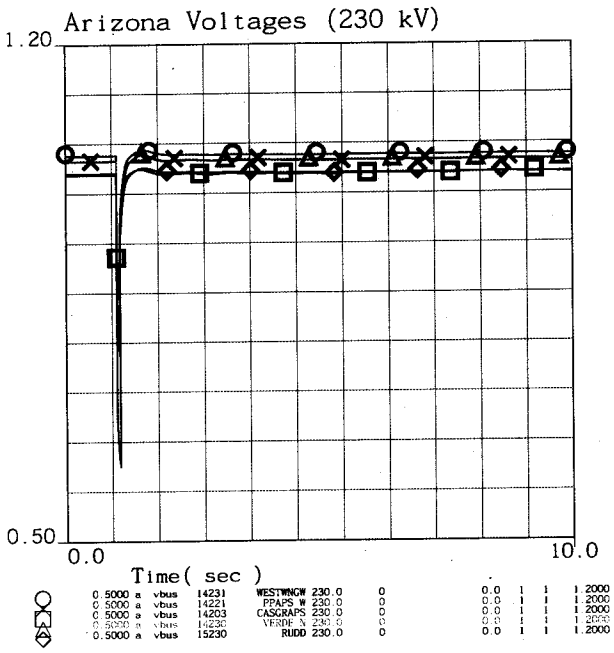

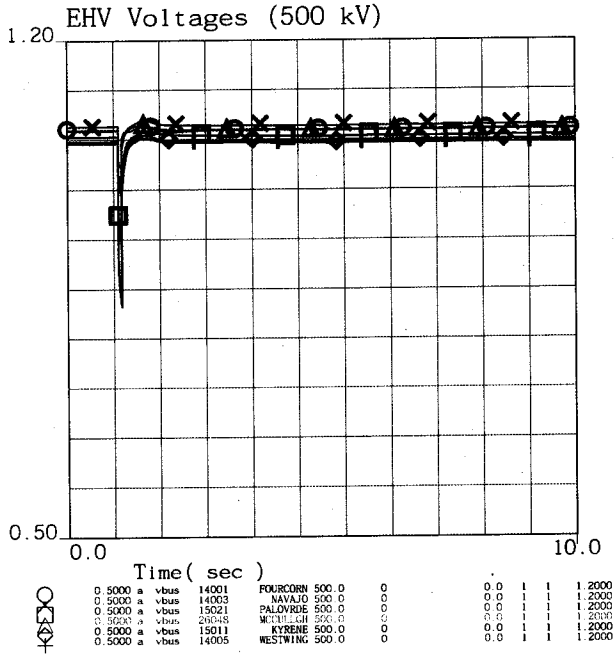

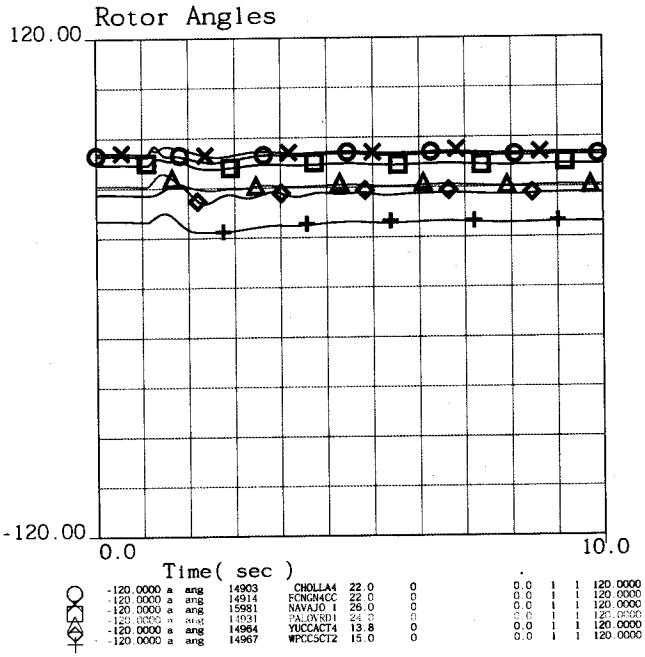

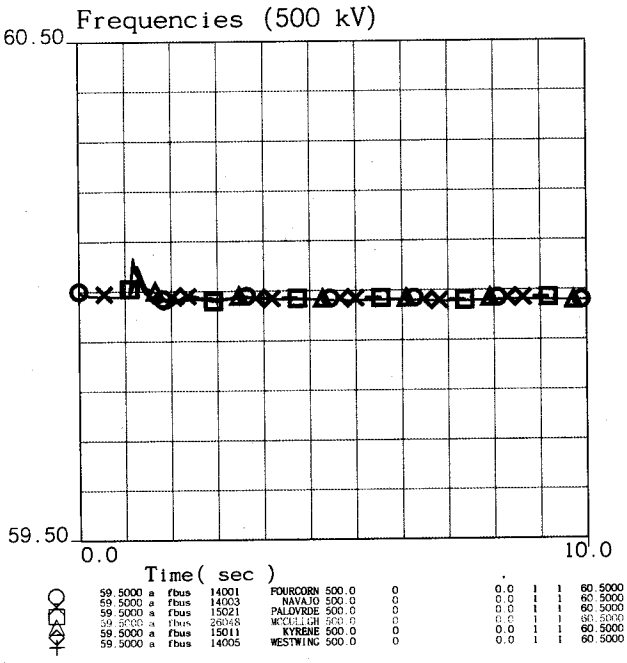

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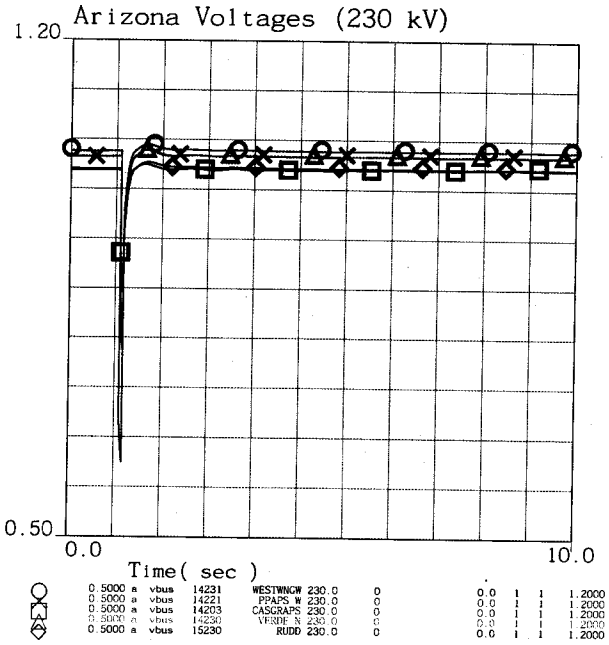

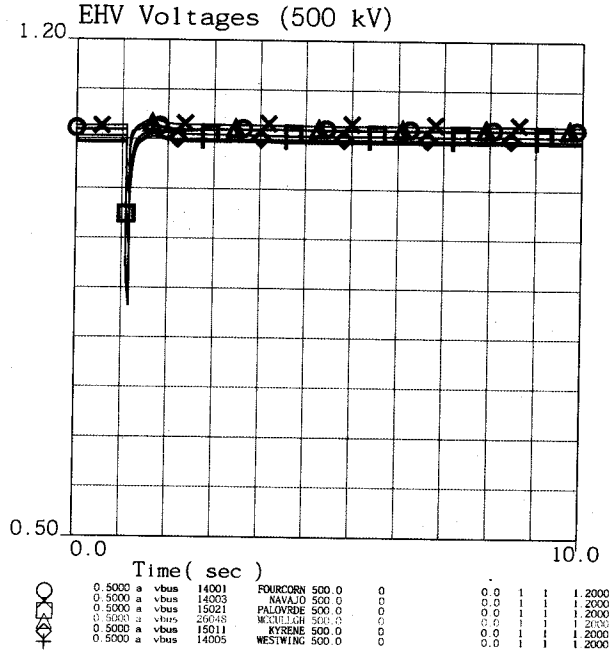

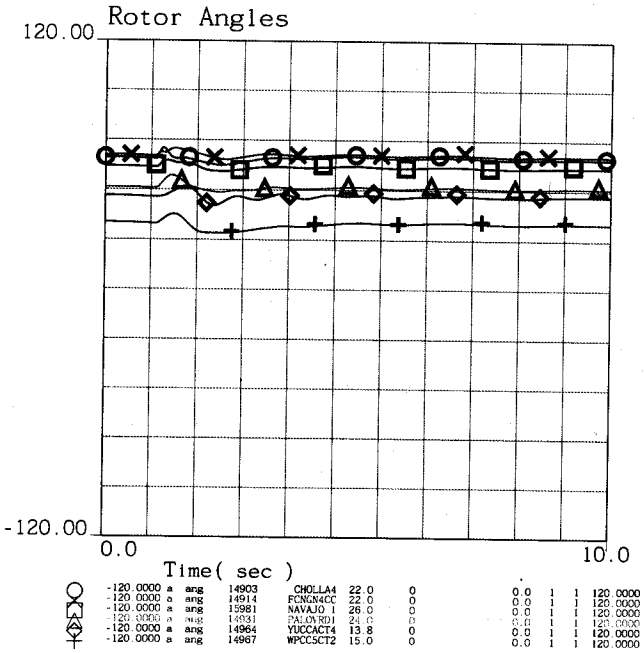

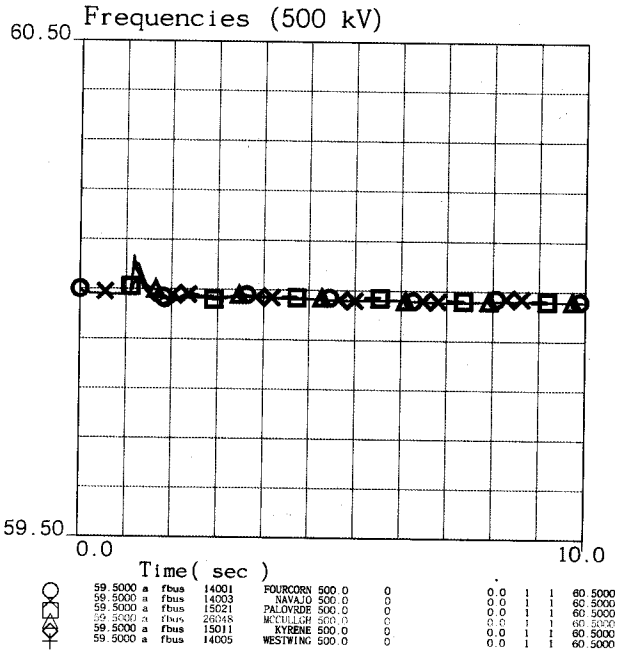

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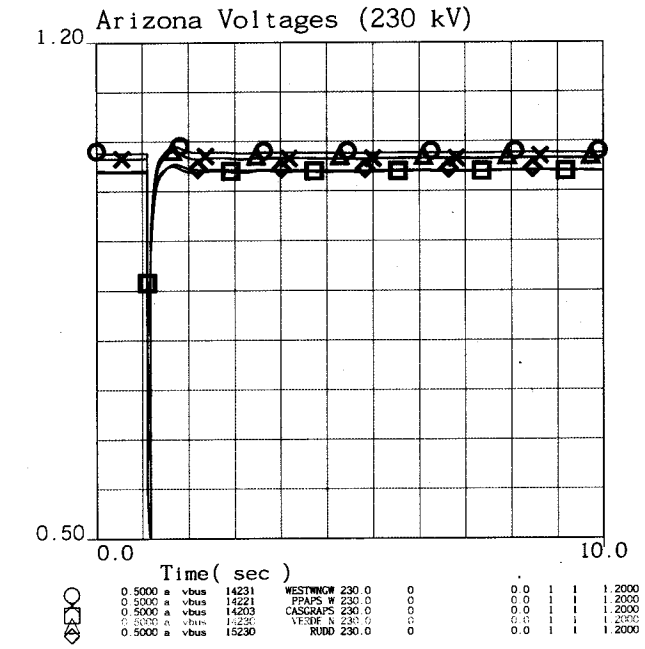

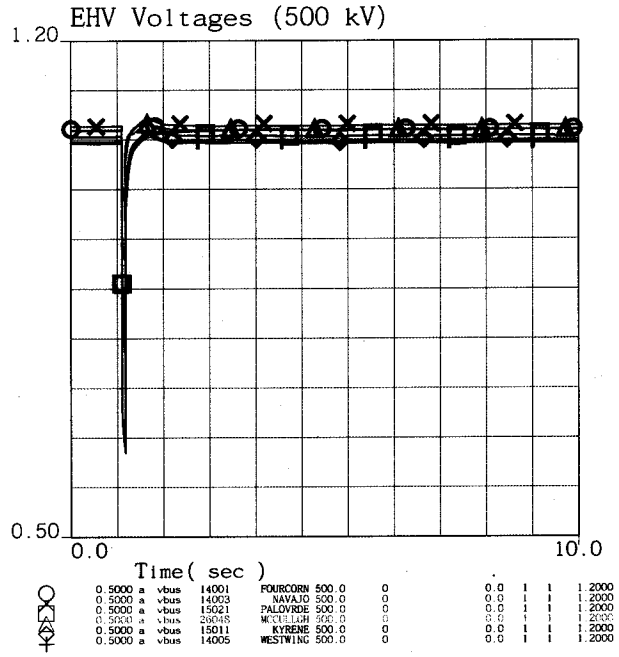

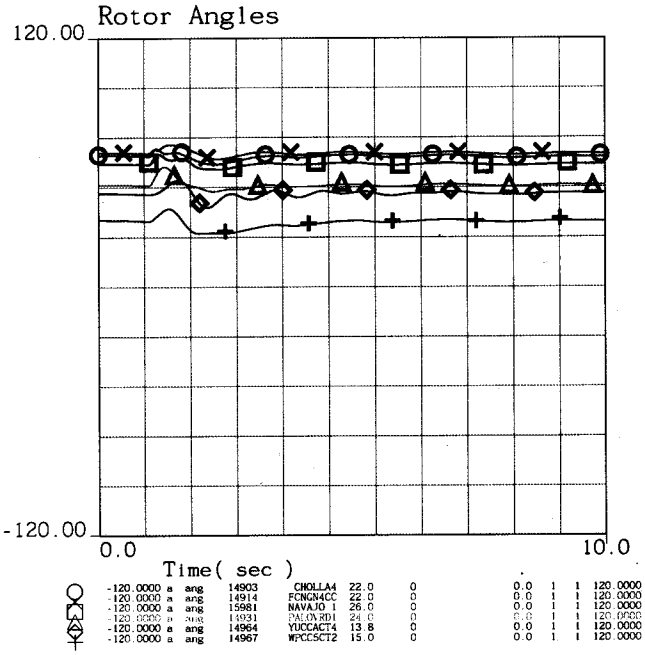

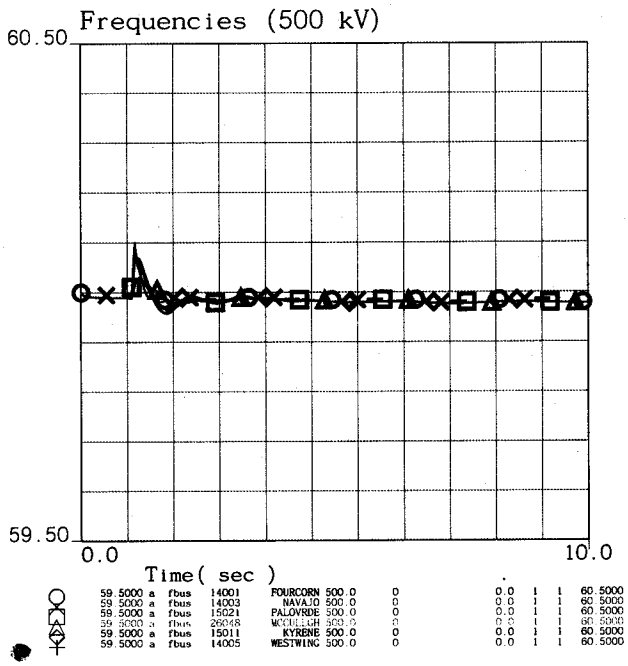

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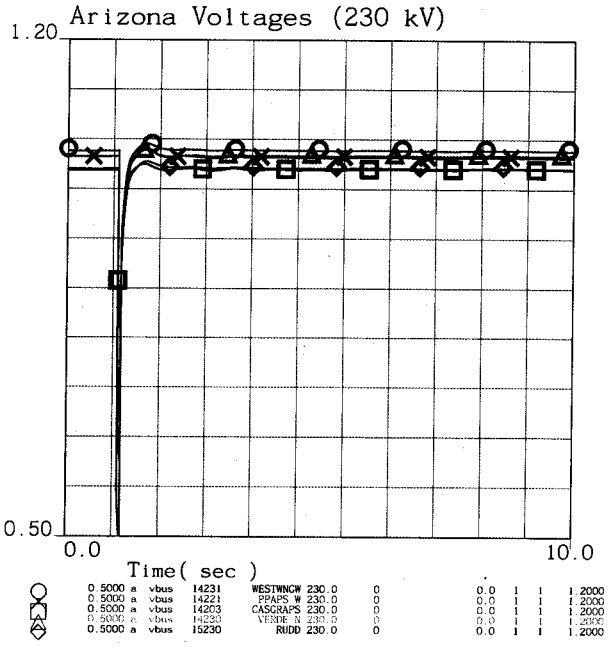

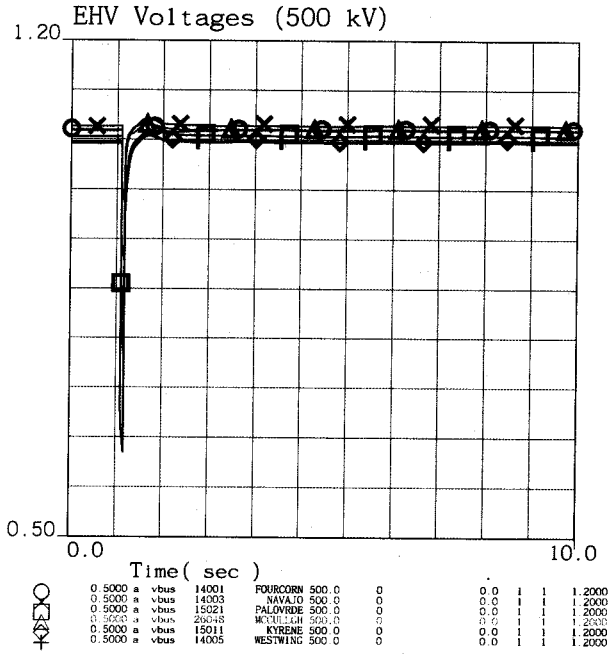

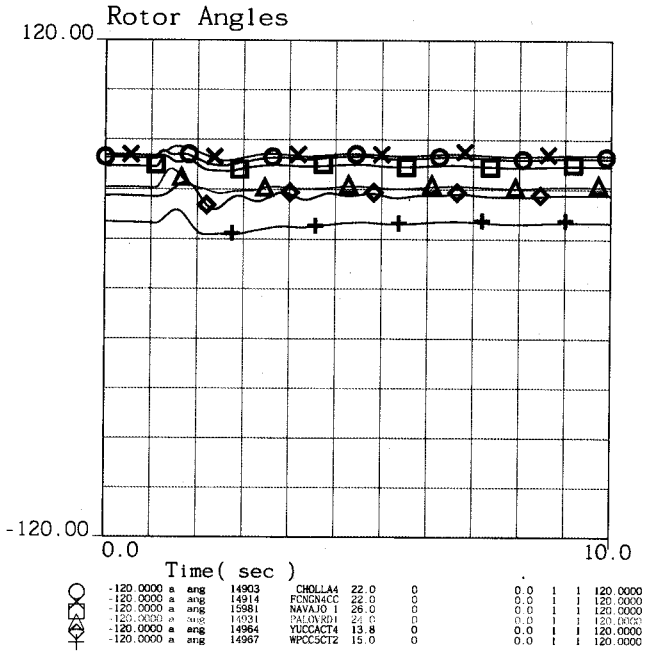

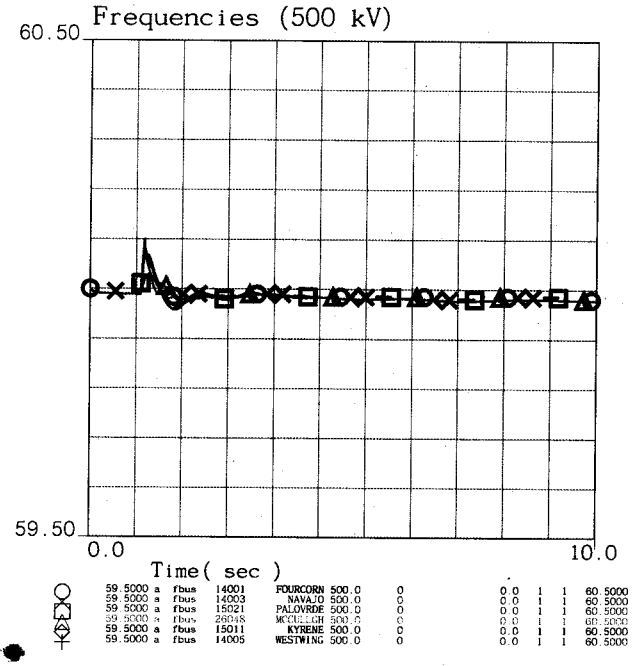

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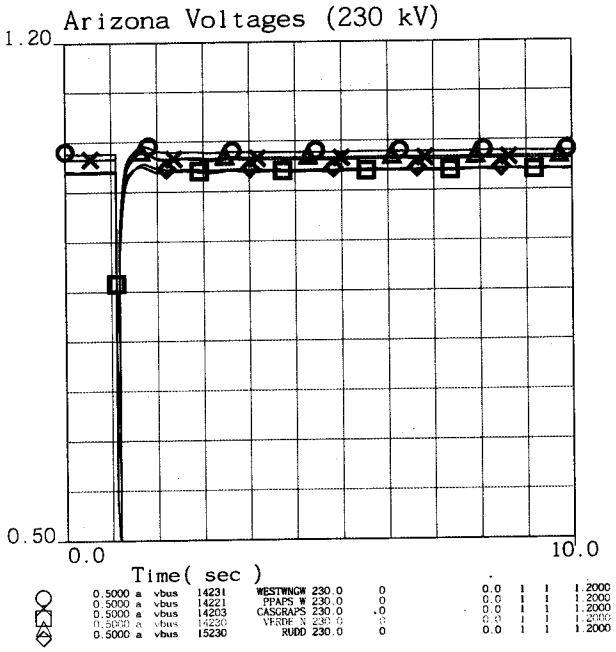

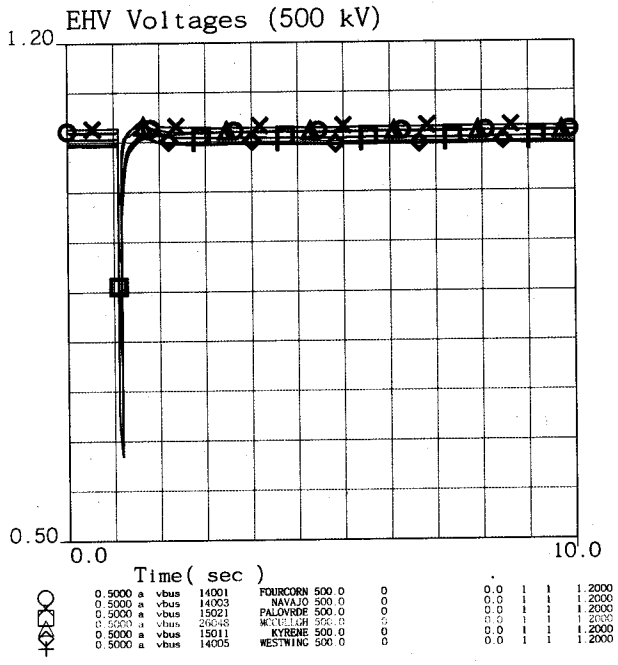

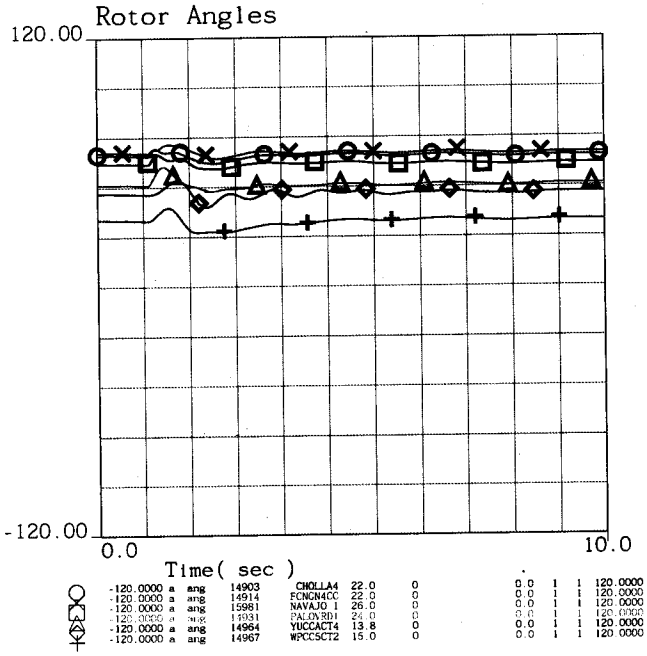

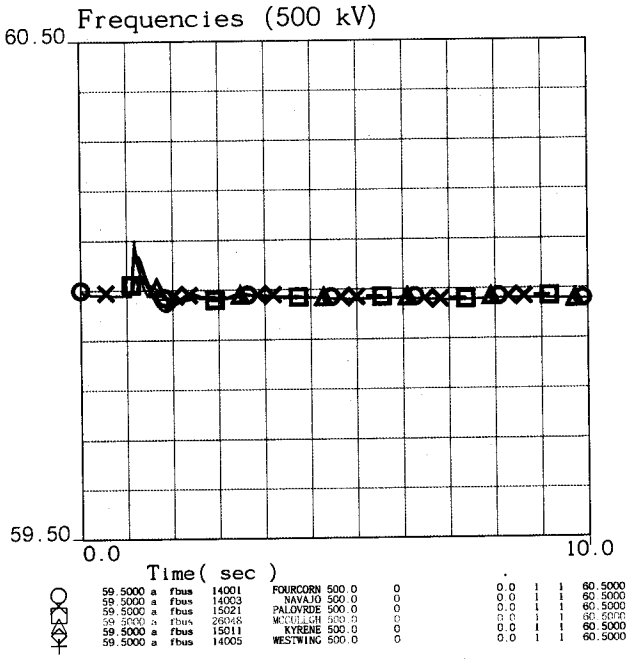

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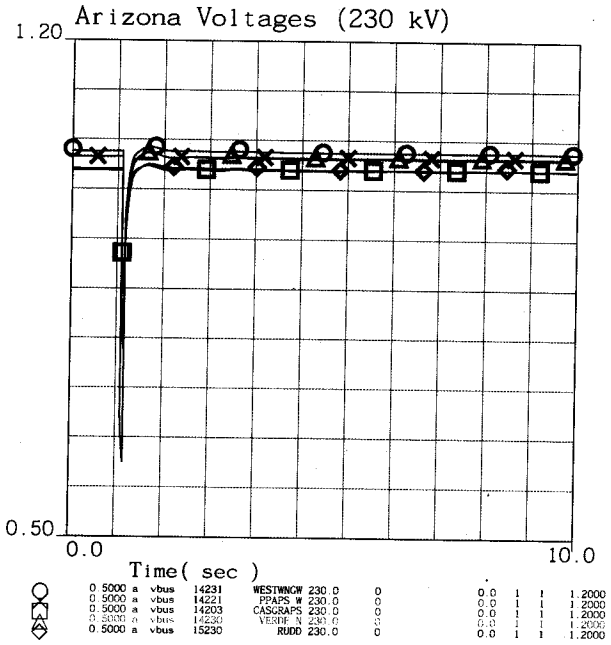

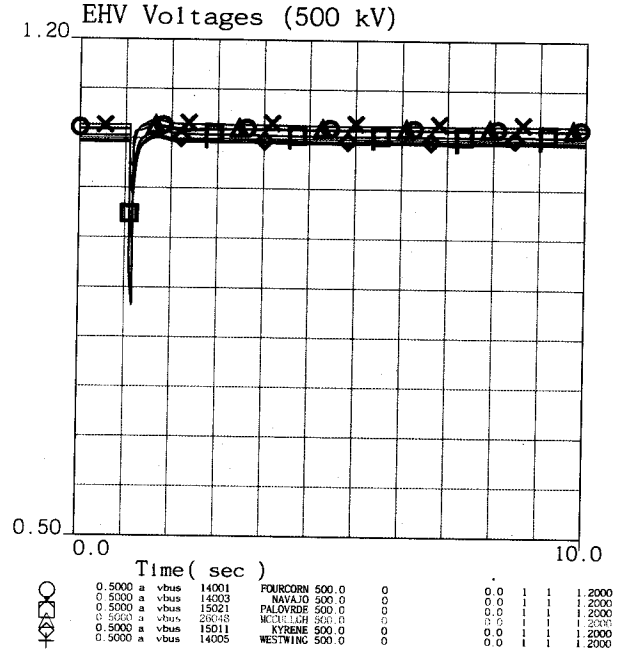

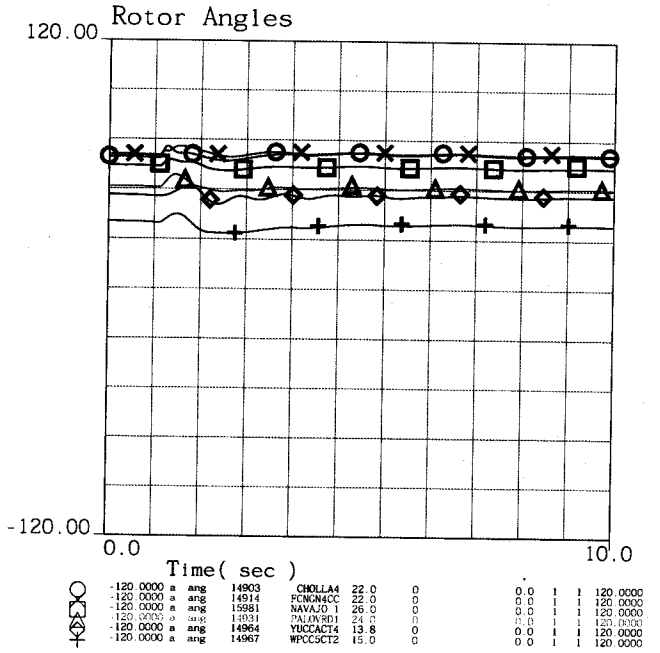

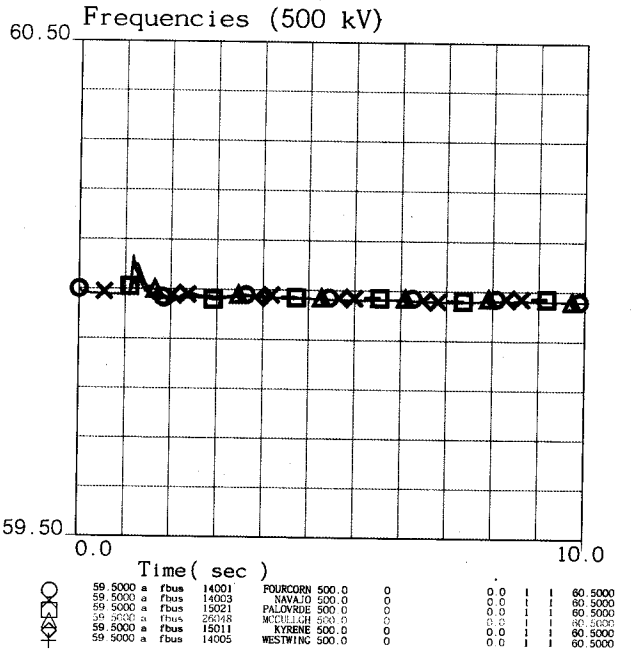

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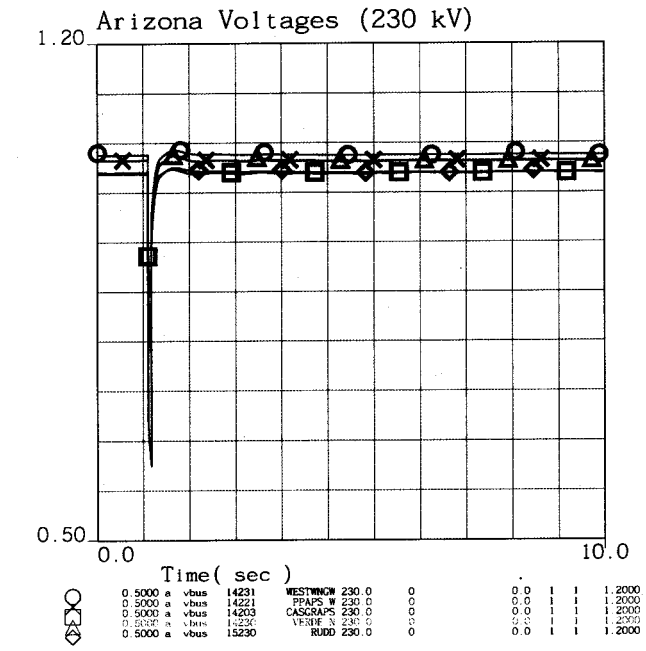

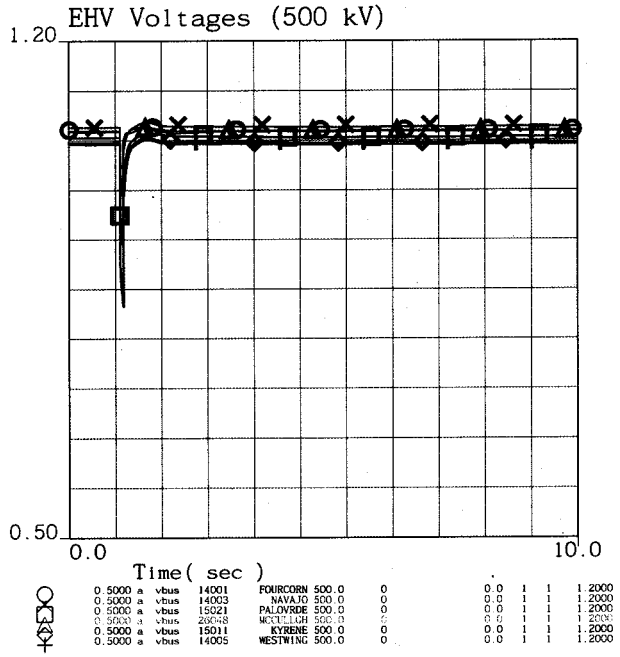

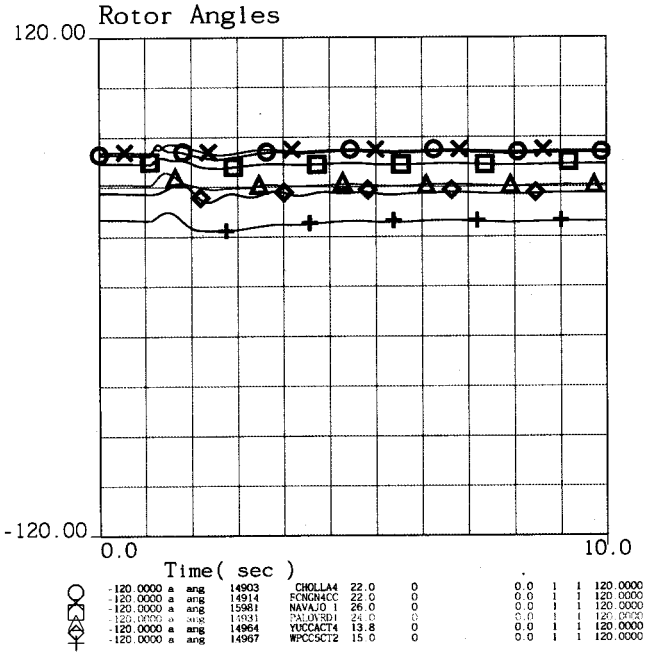

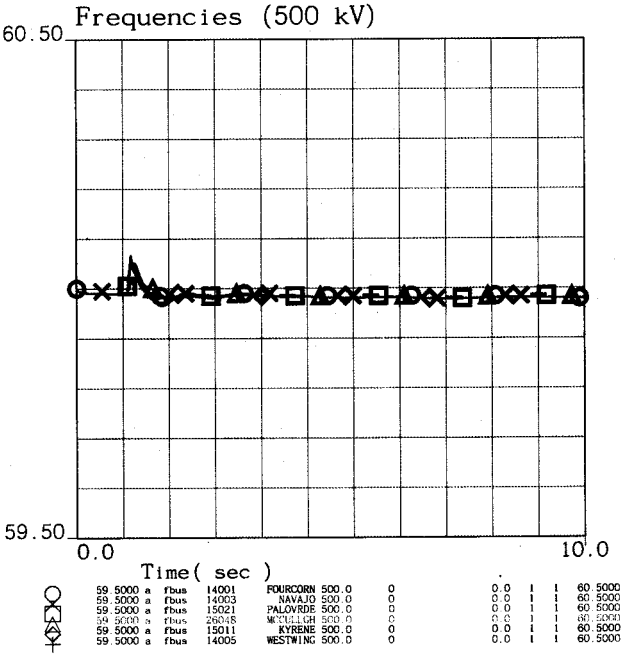

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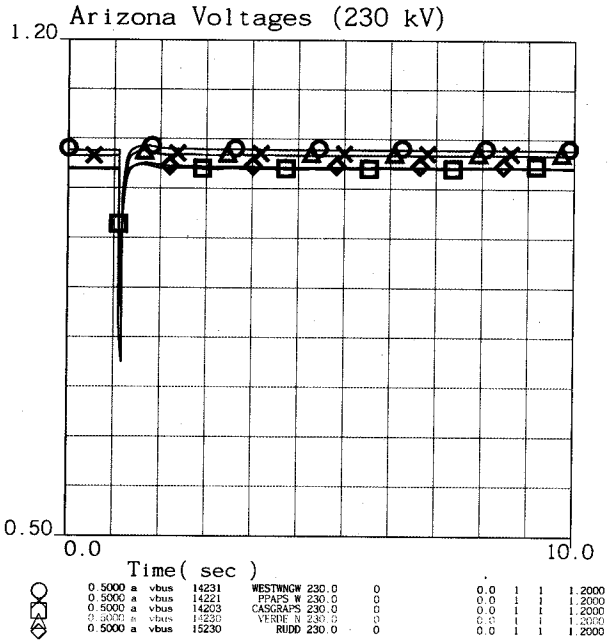

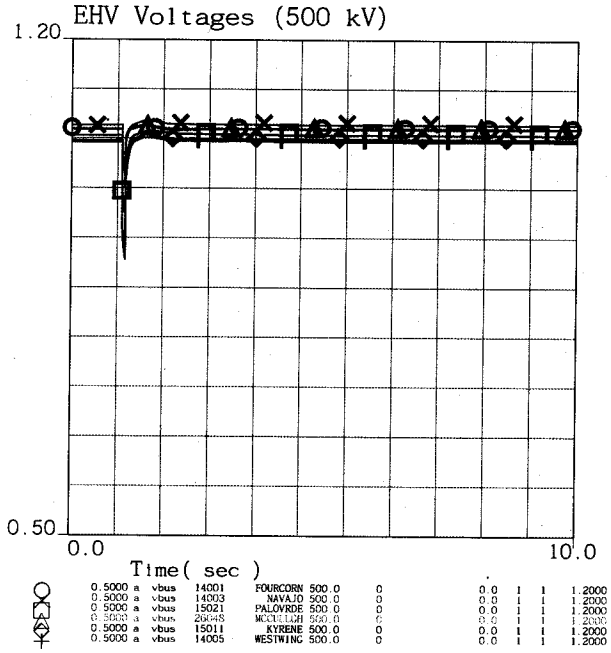

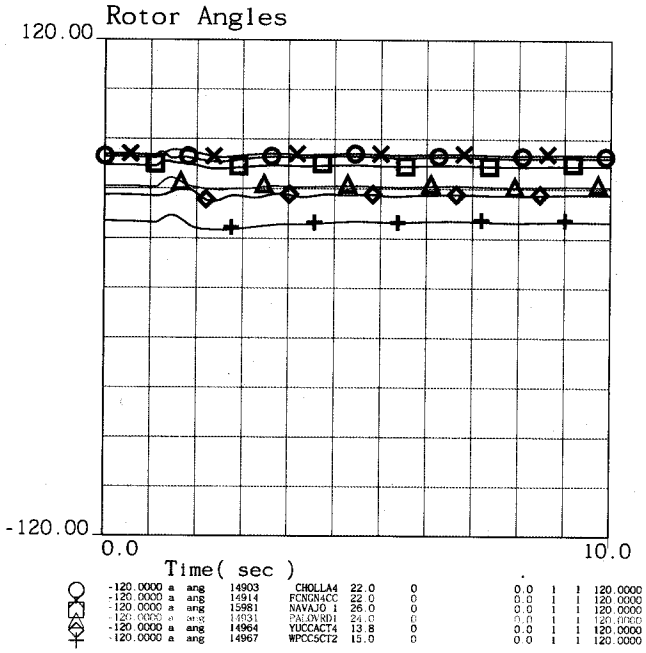

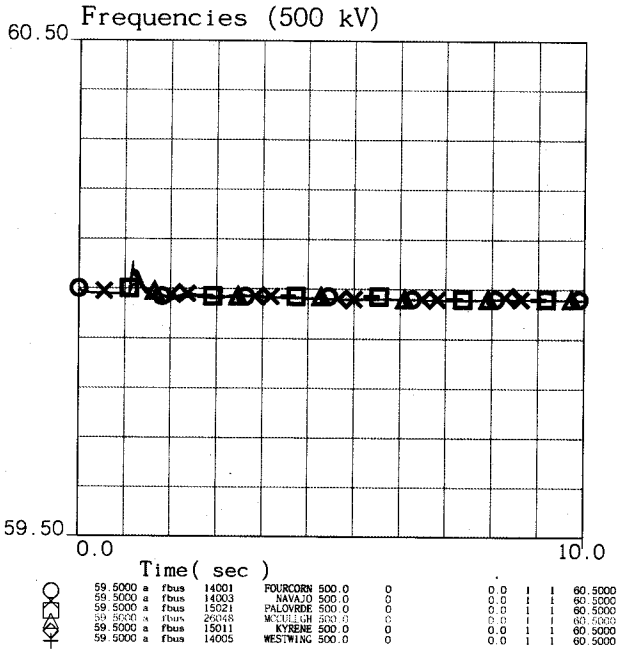

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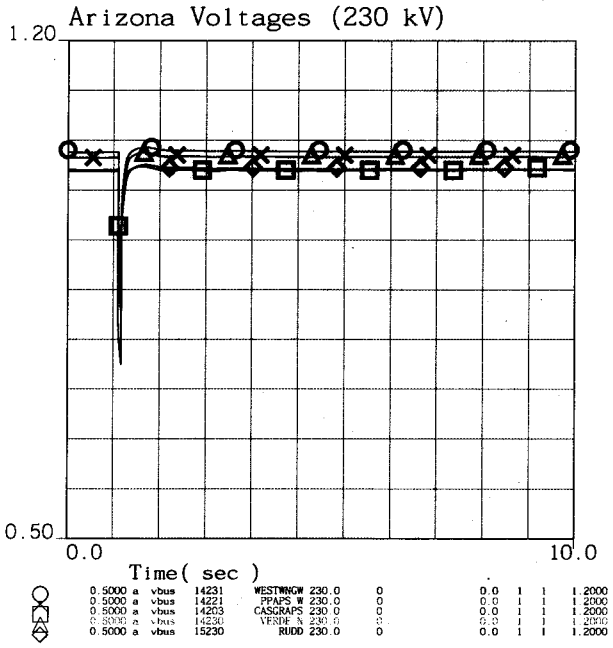

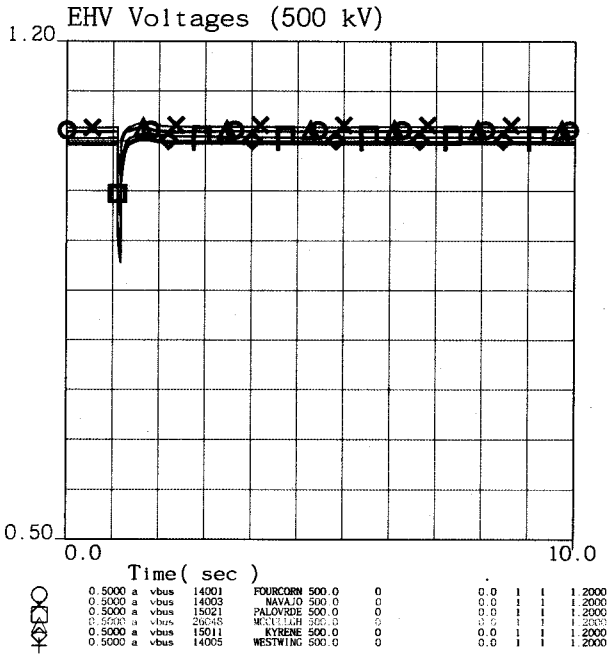

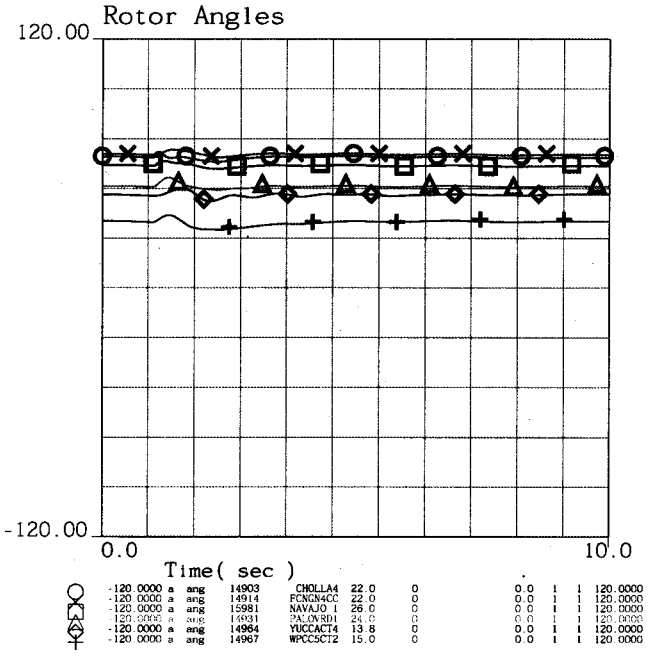

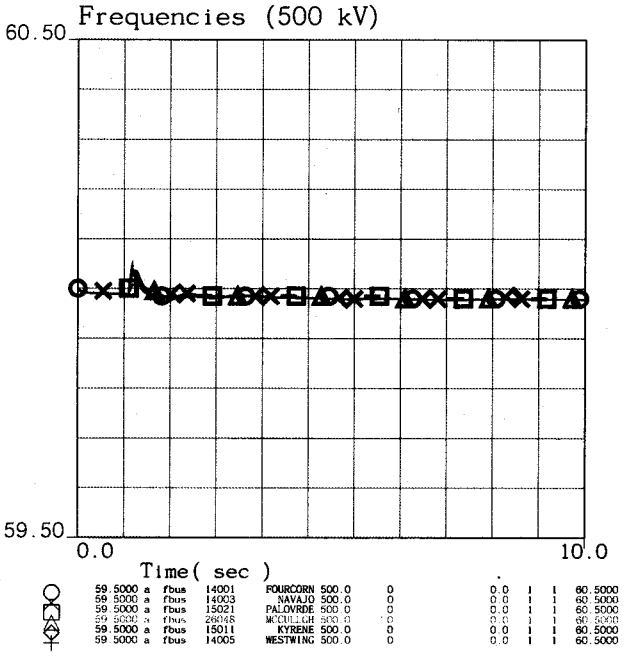

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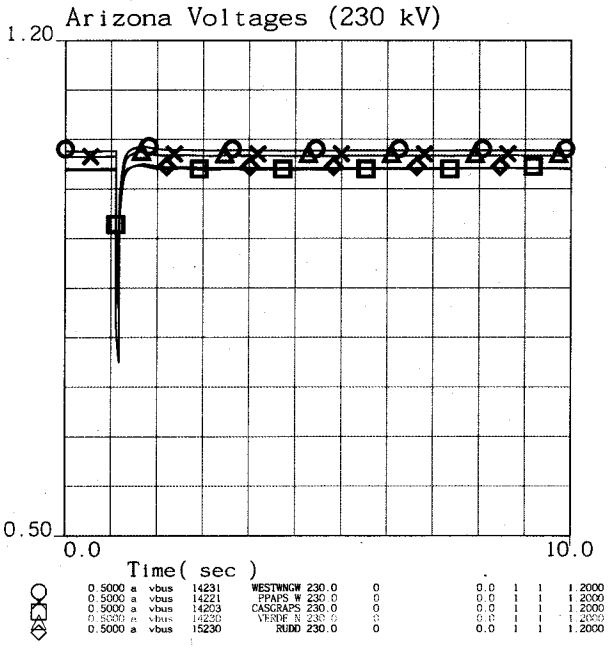

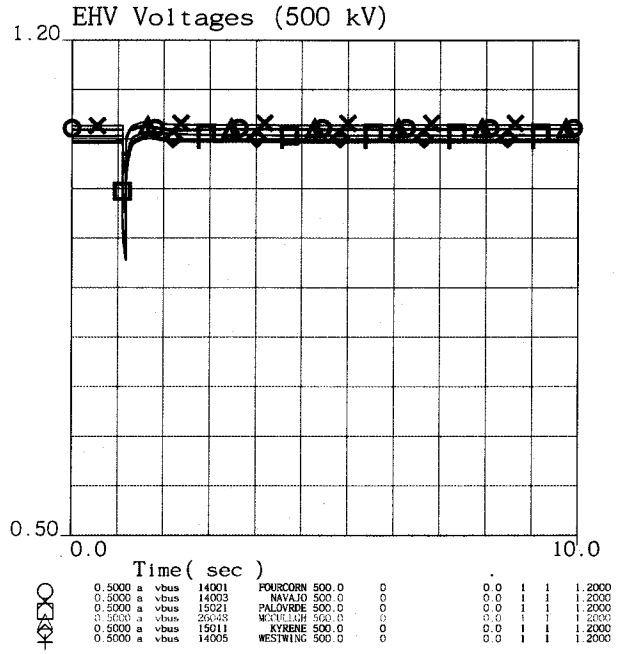

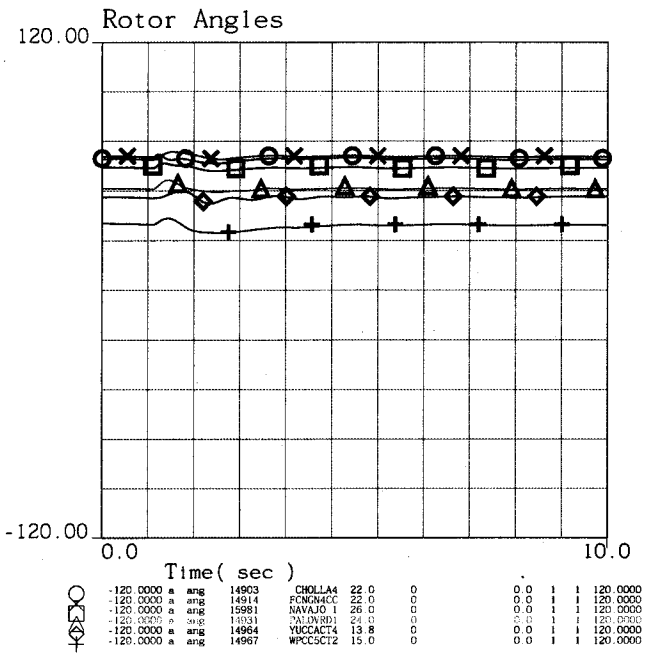

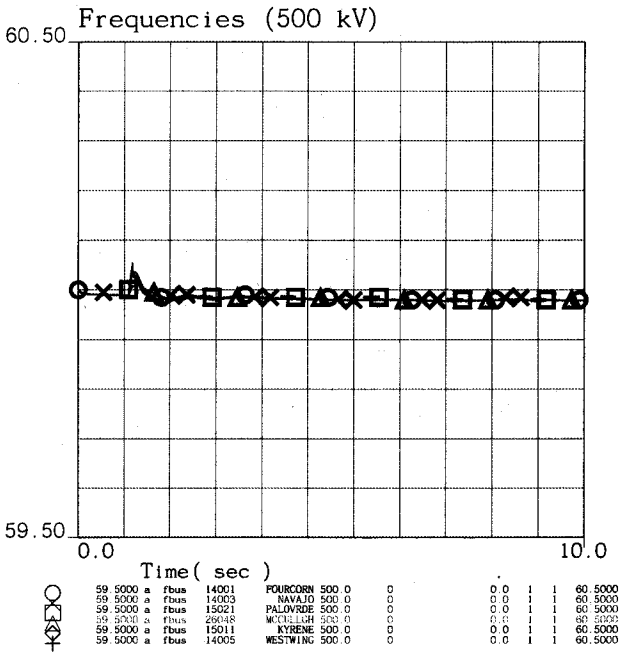

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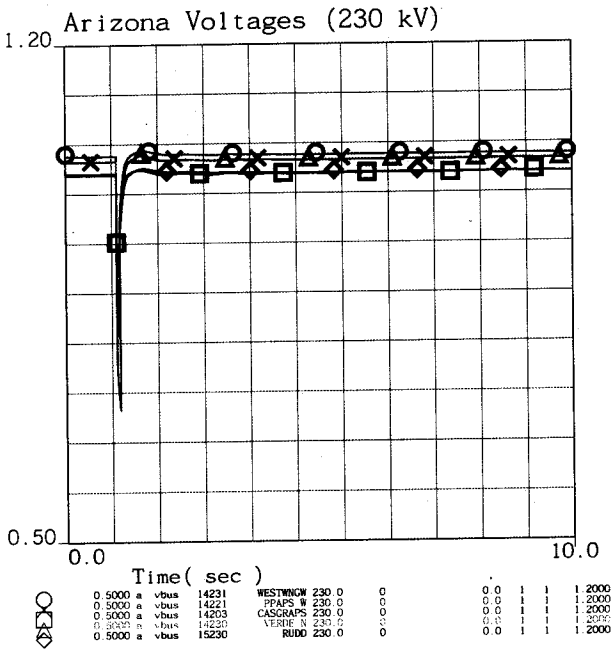

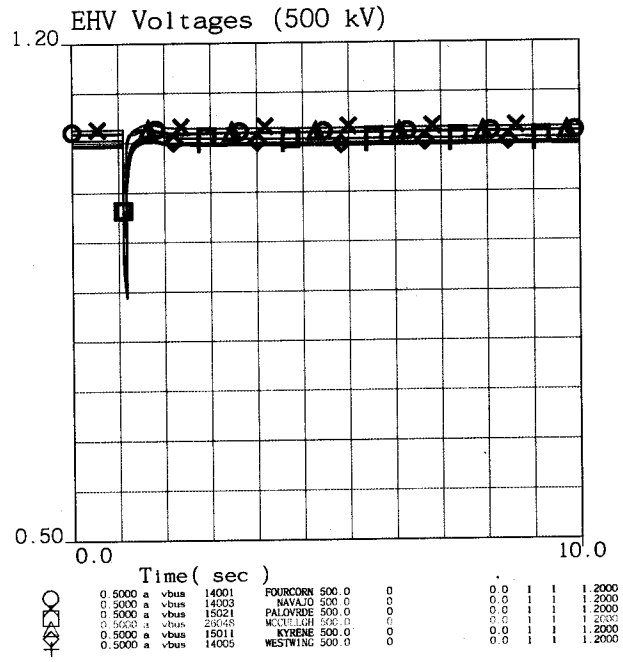

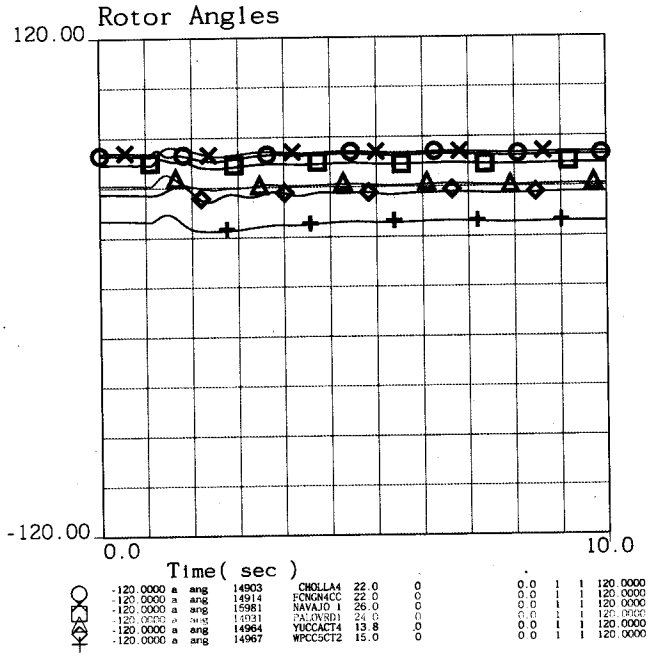

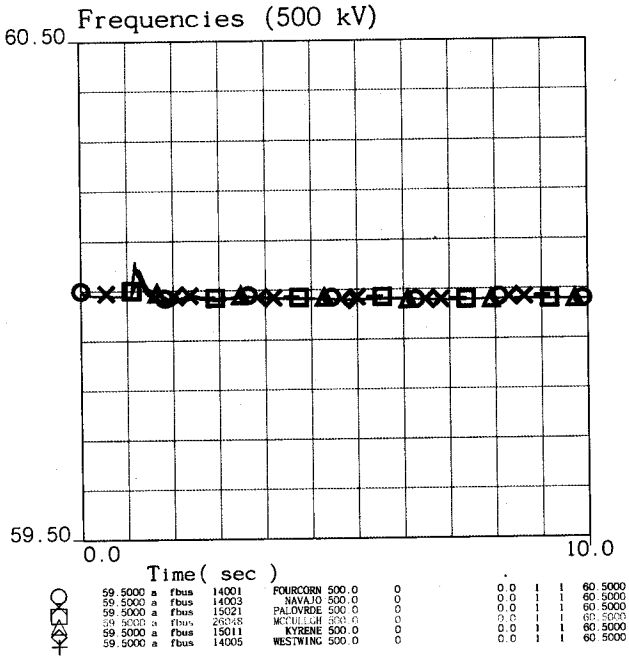

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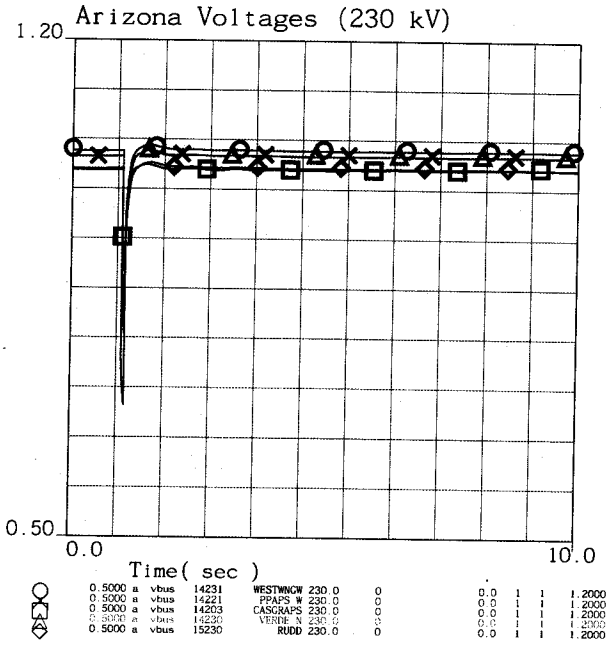

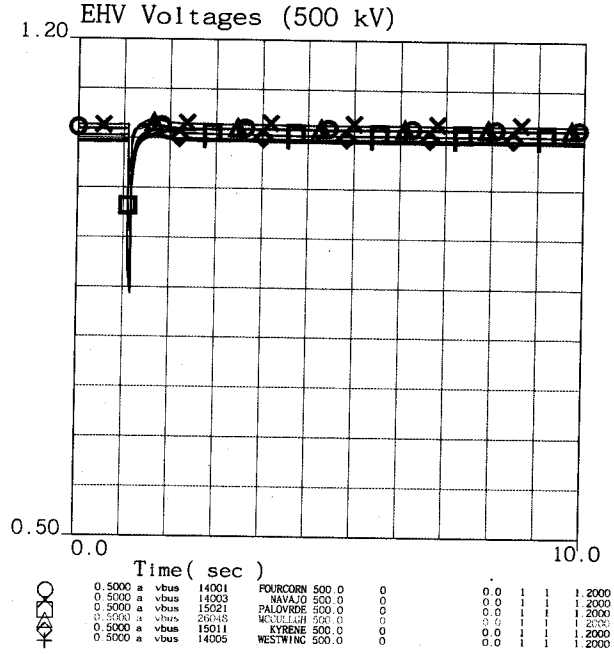

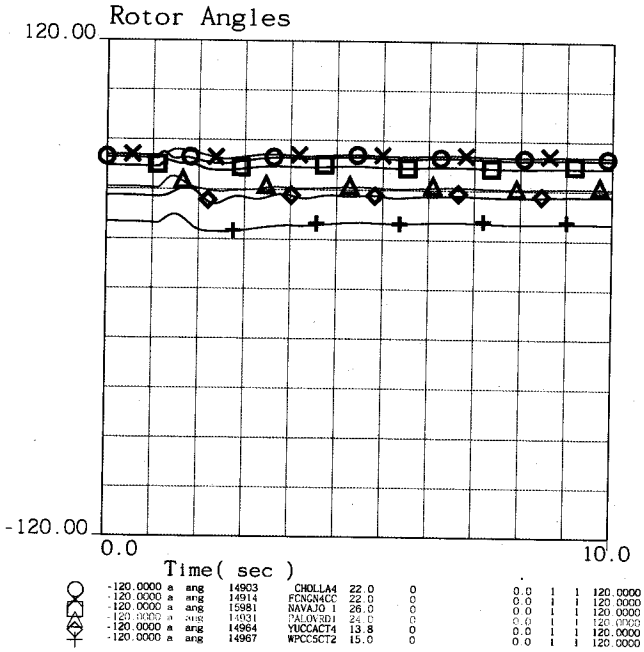

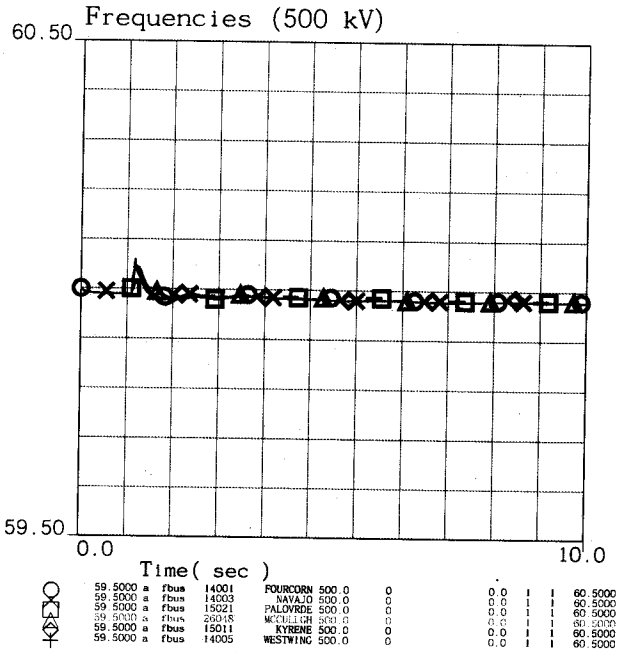

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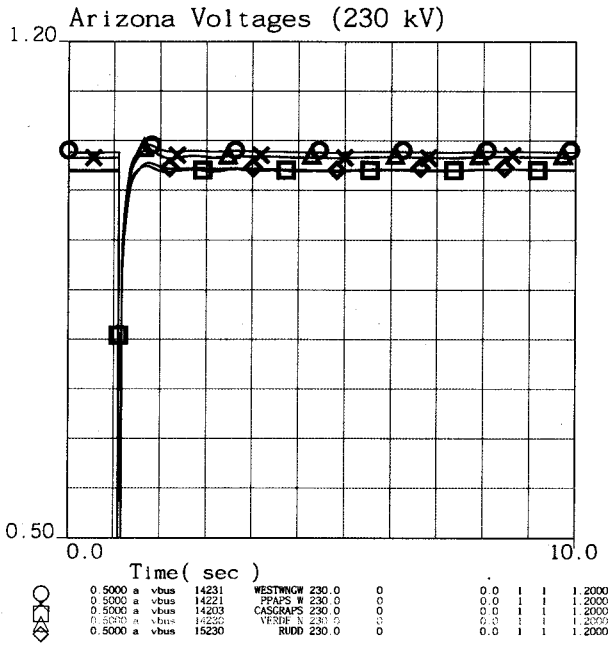
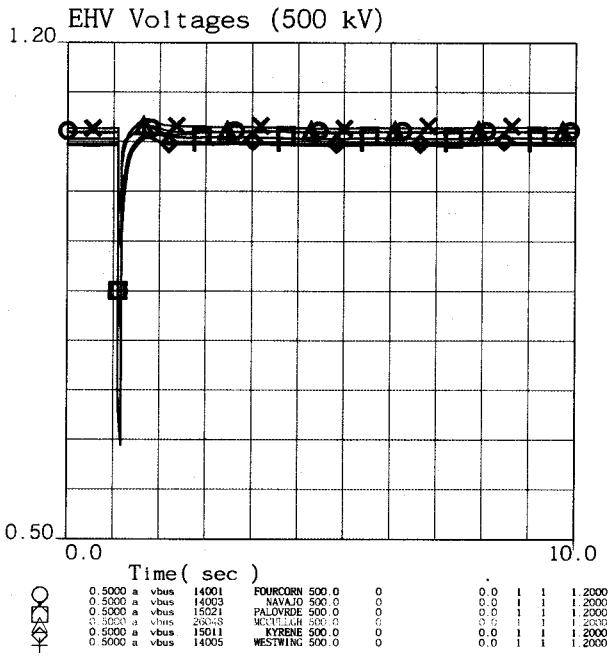
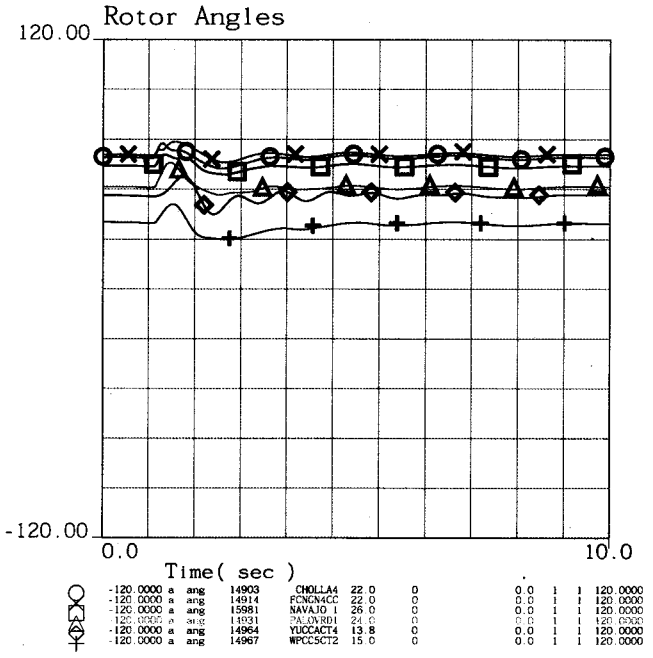
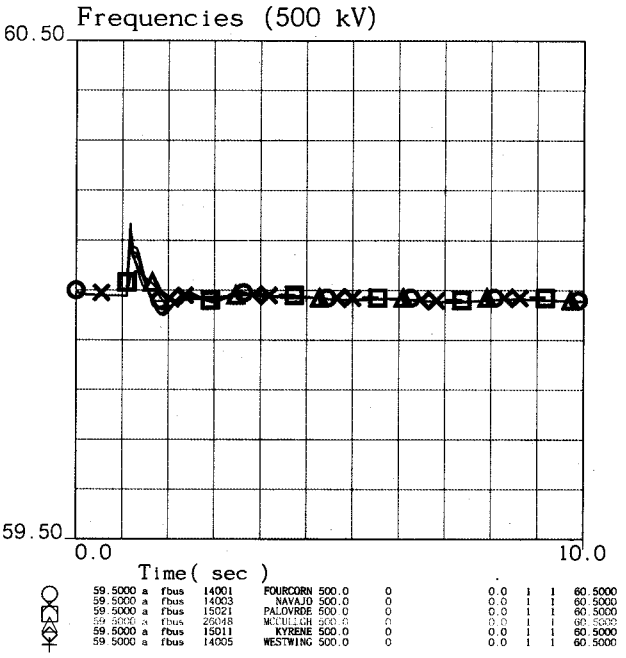
2018 Heavy Summer Detailed Planning Case









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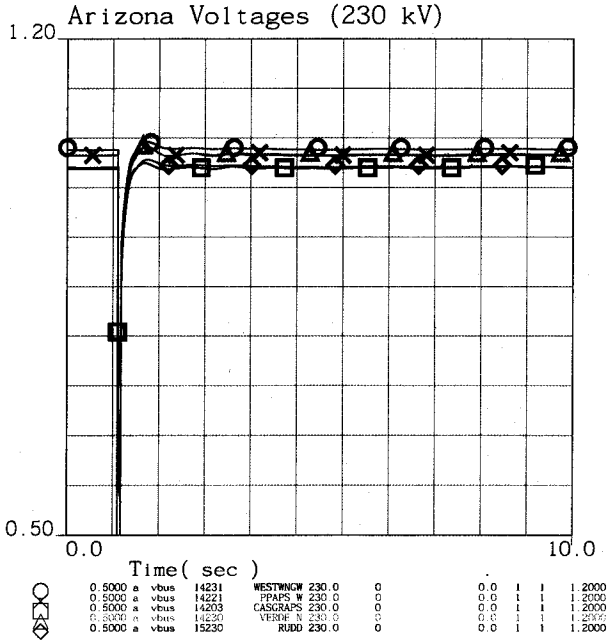

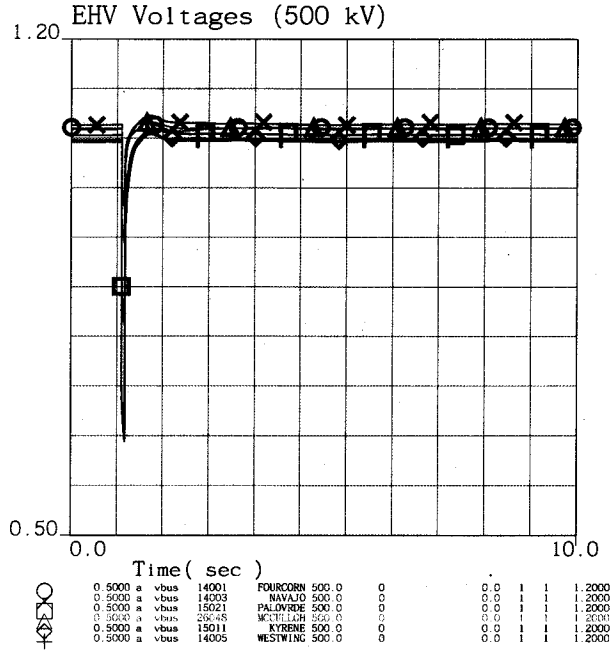

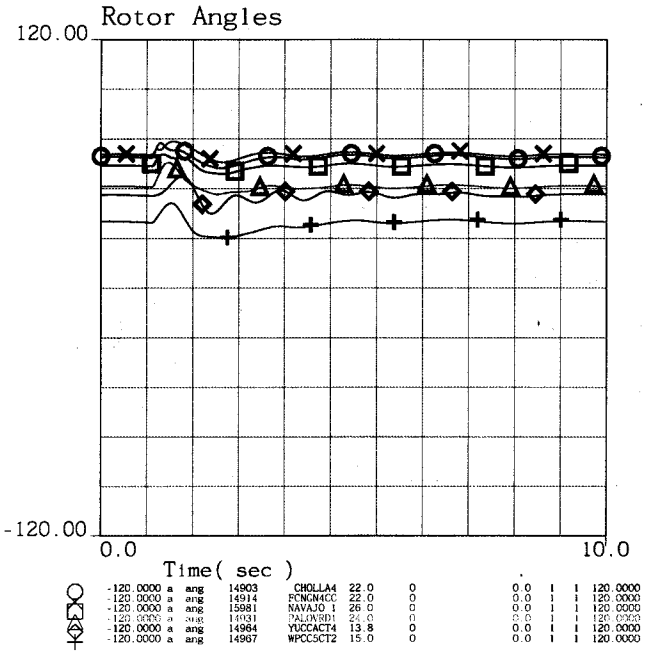

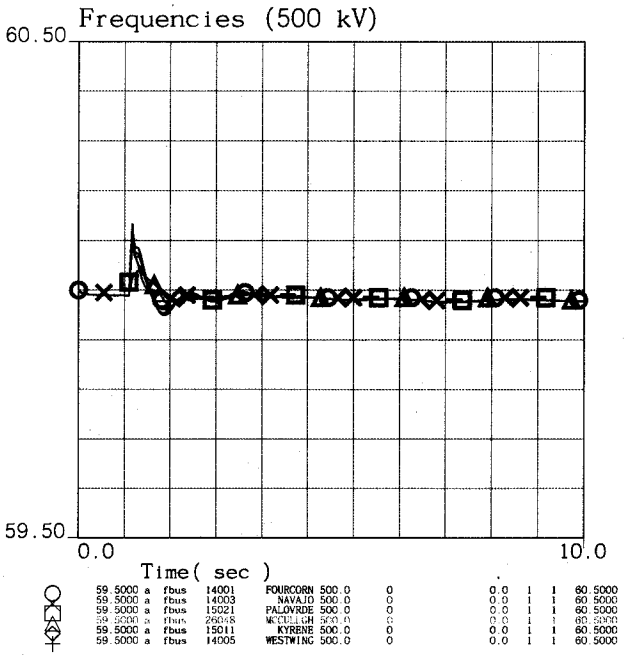

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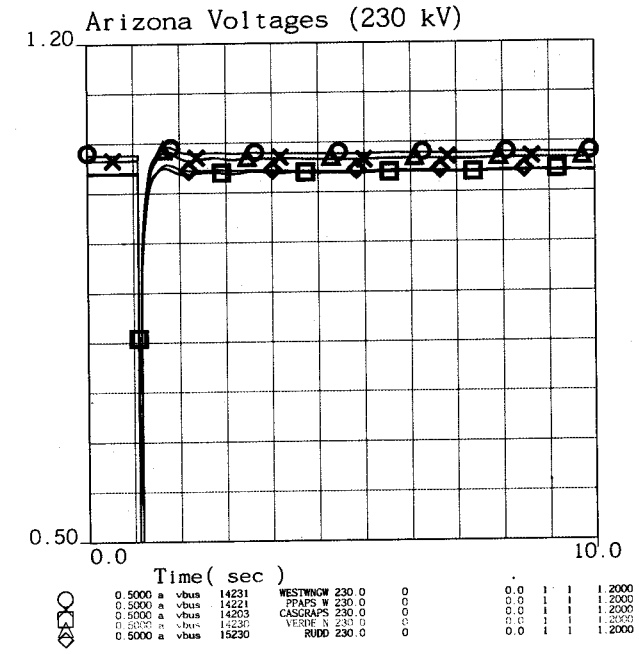

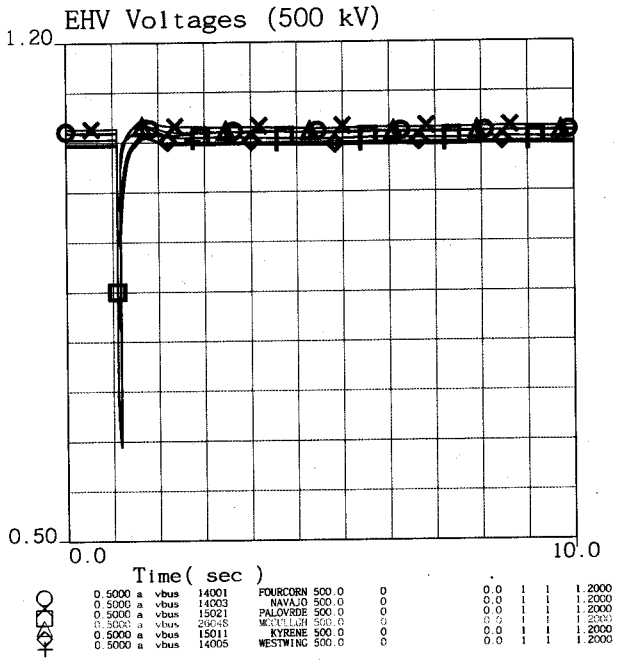

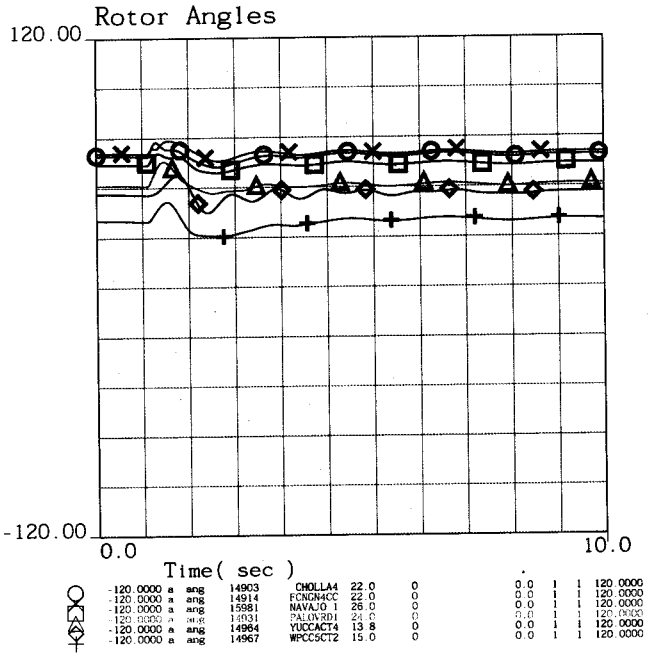

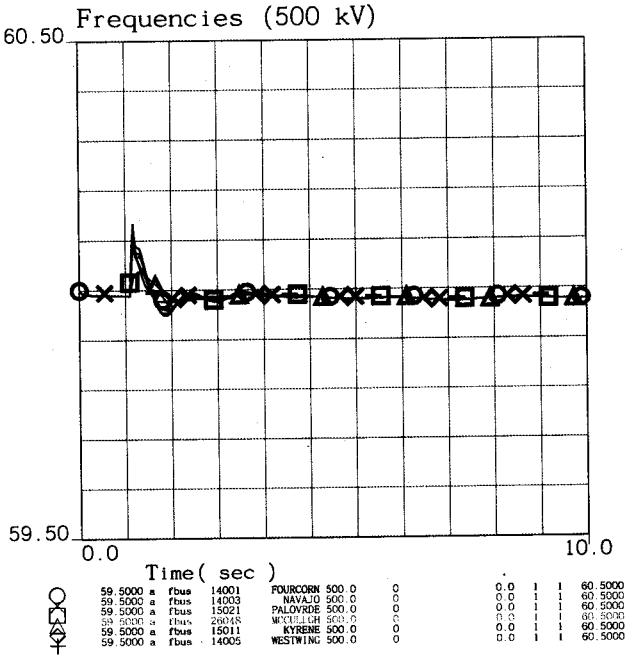

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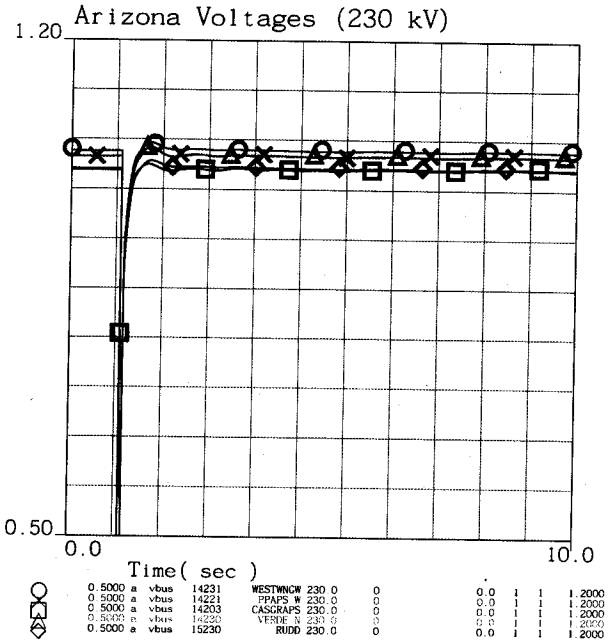

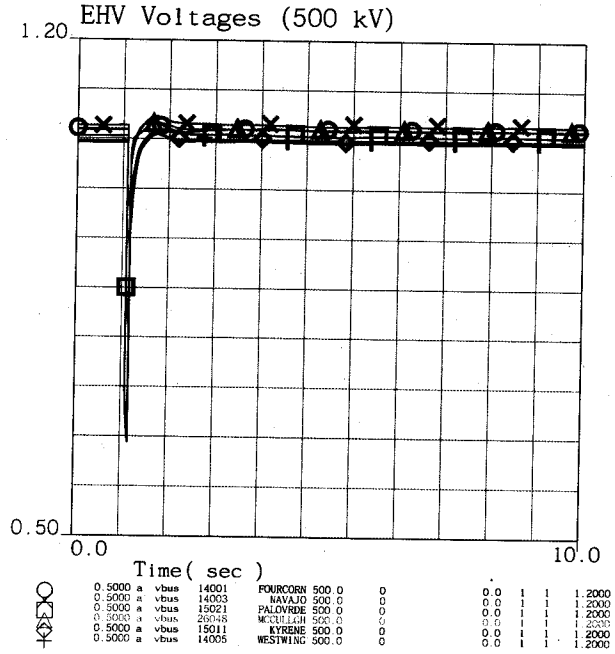

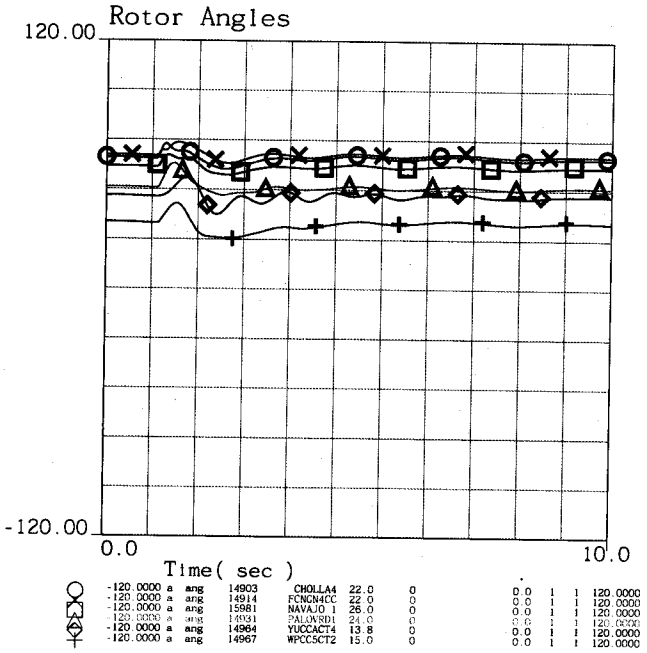

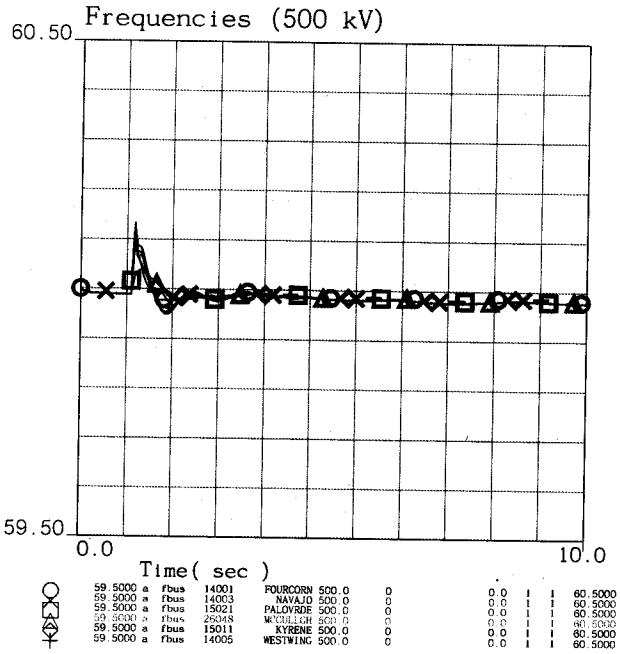

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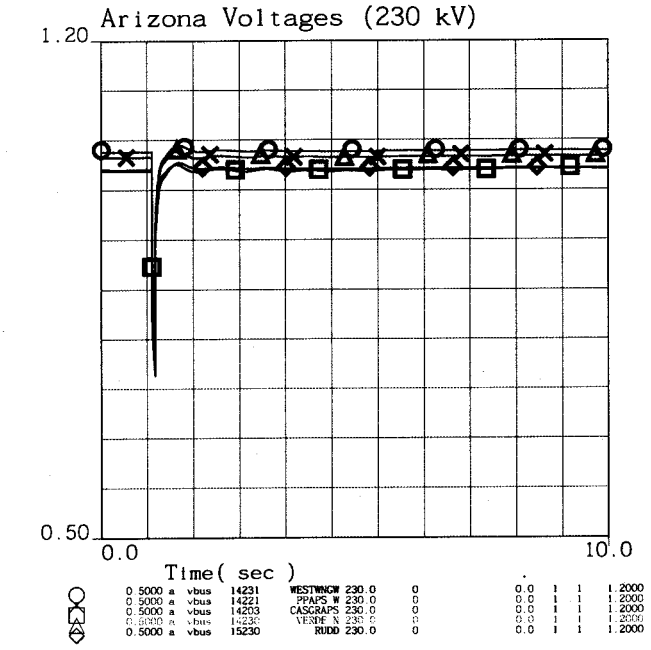

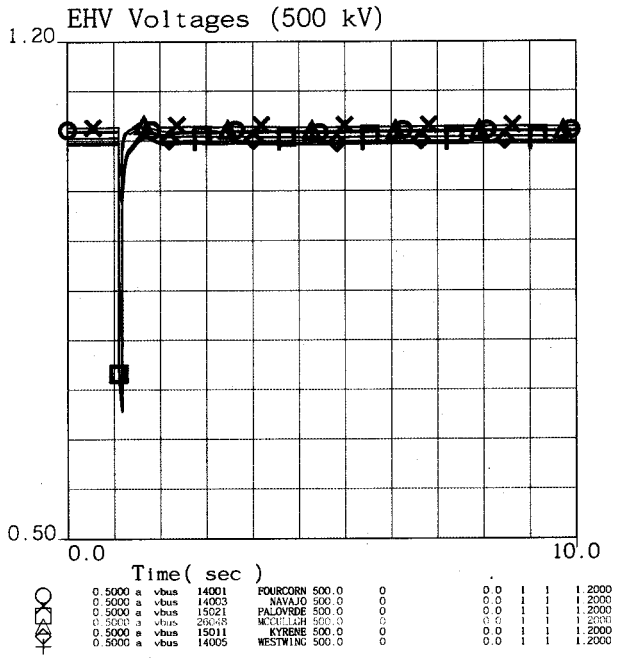

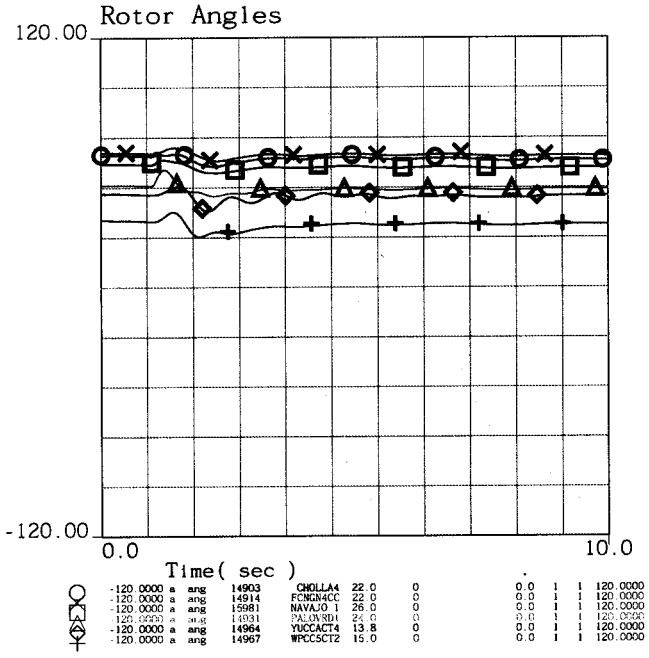

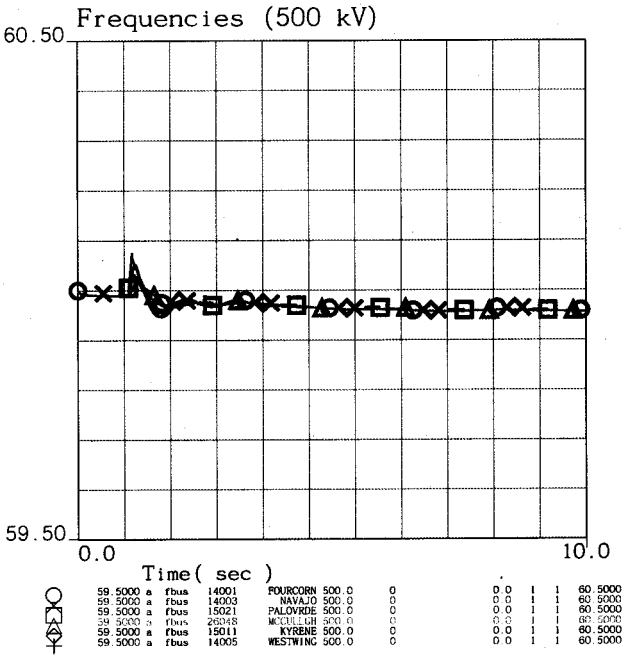

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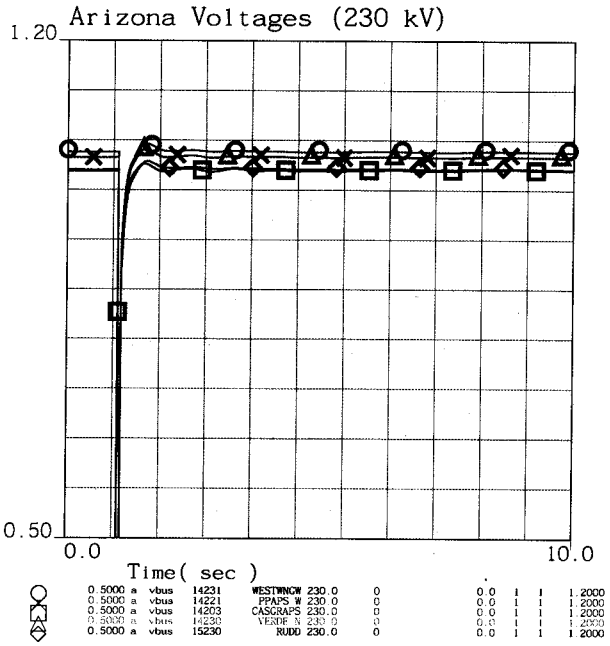

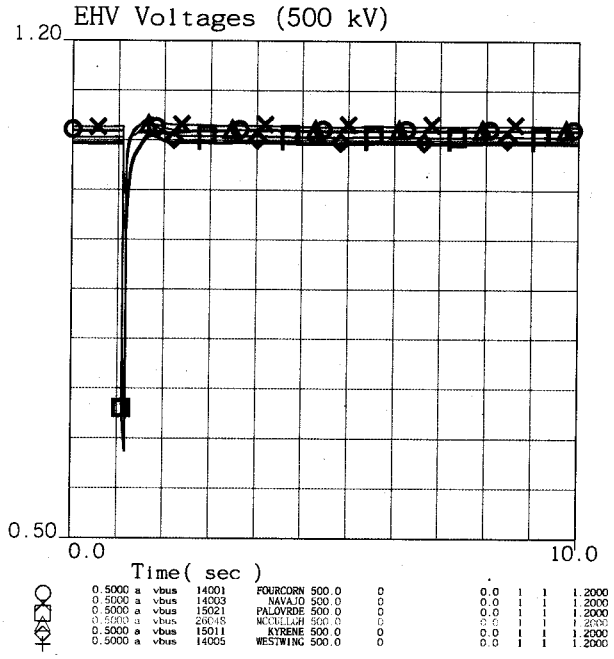

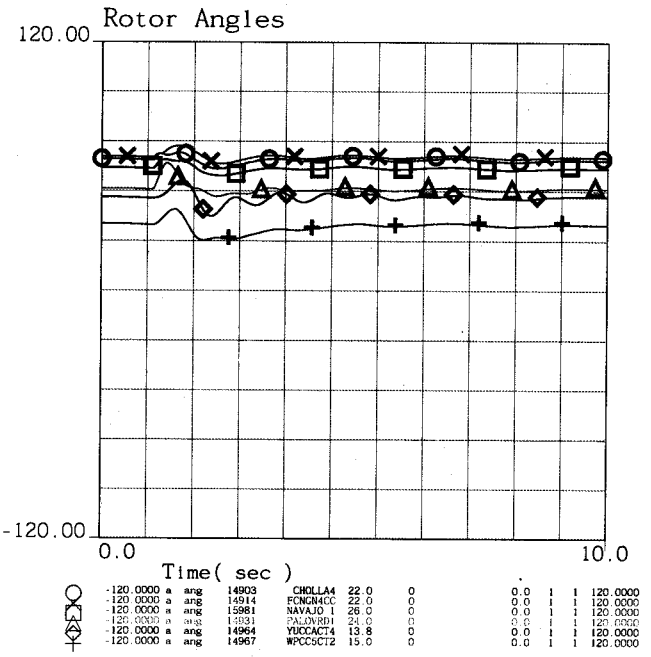

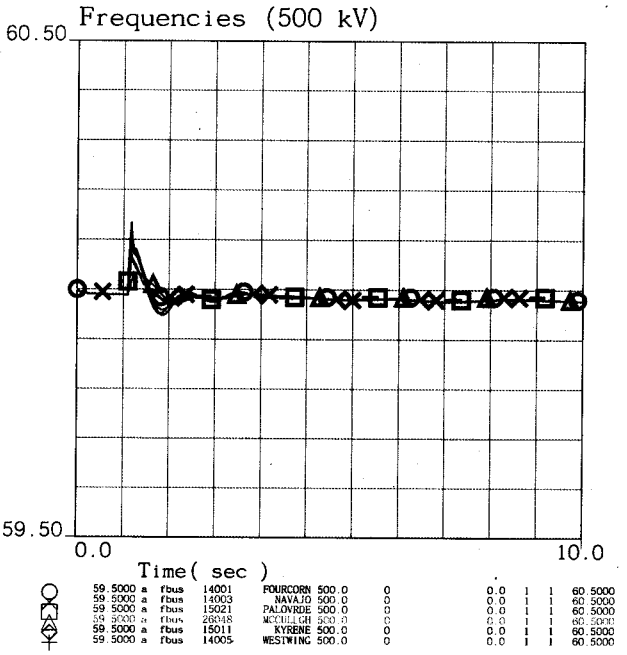

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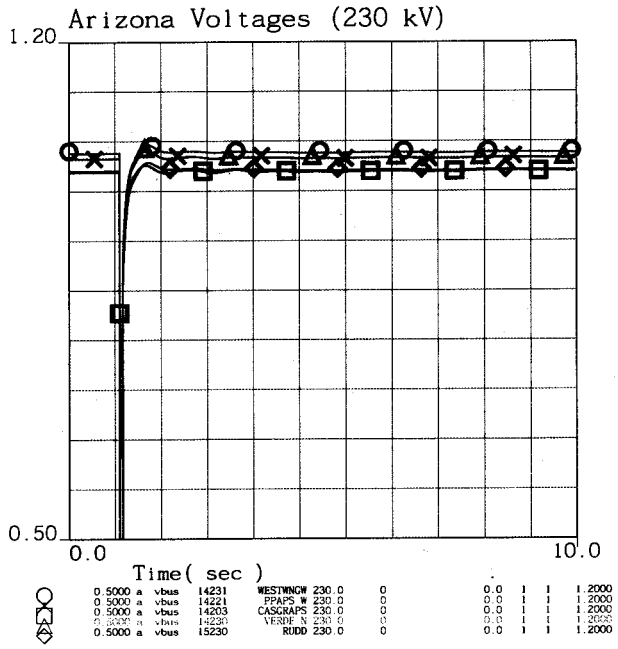

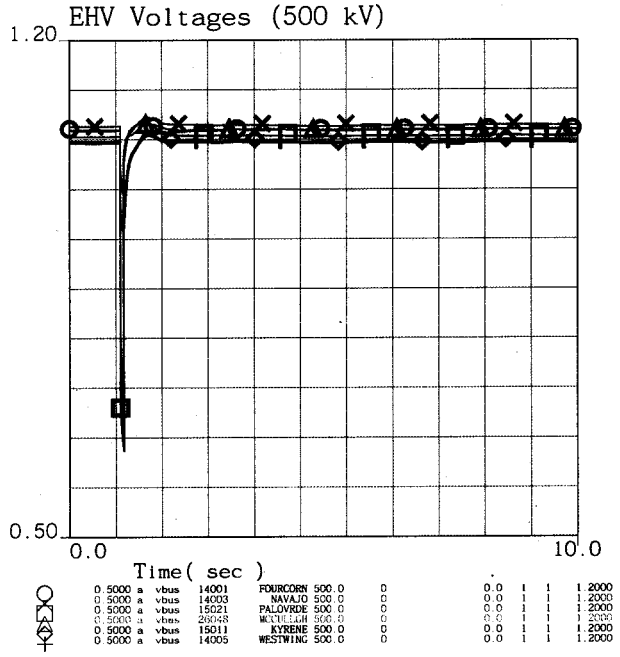

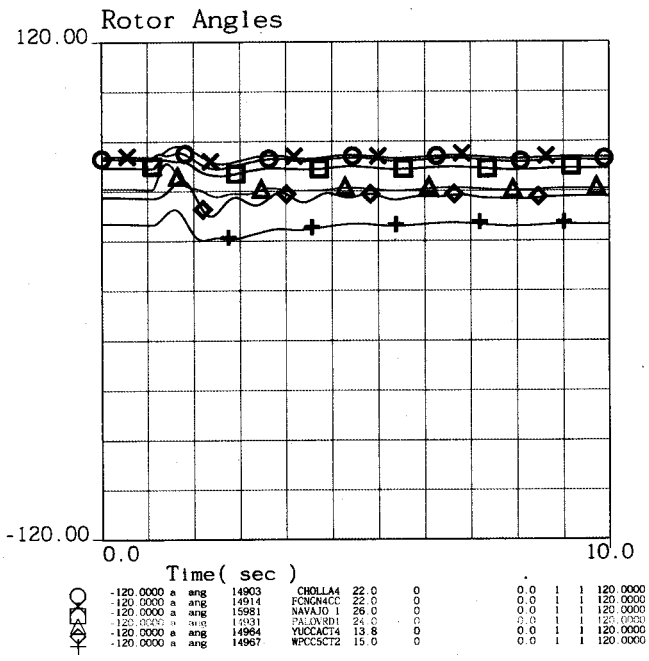

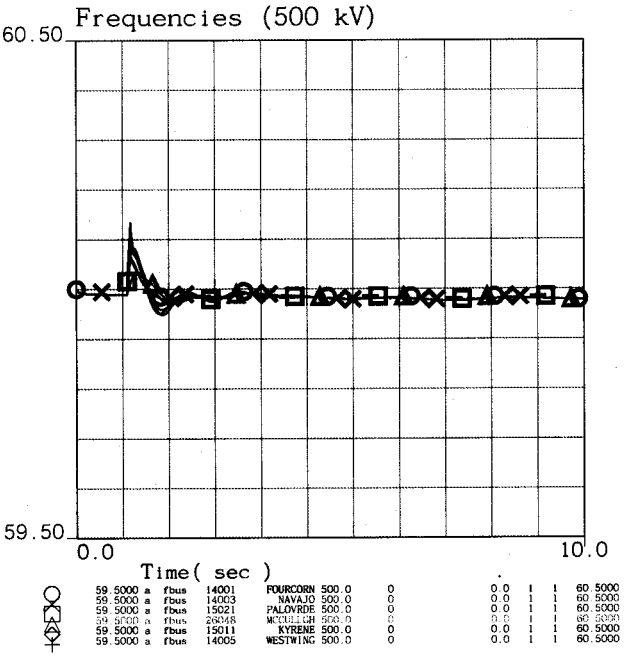

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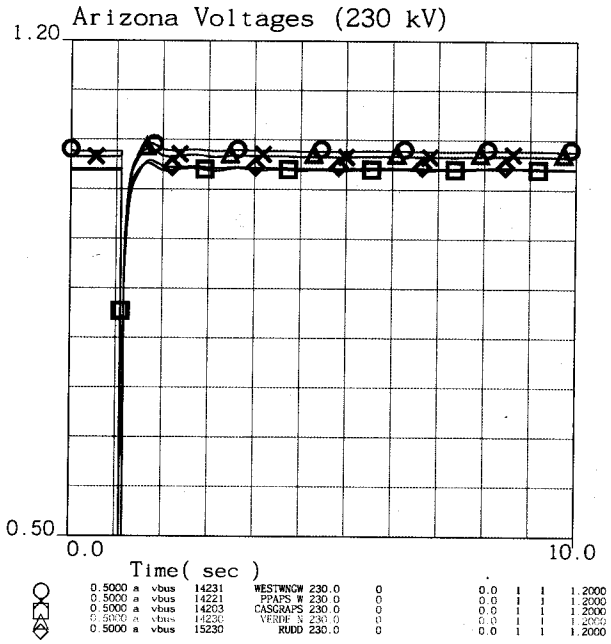

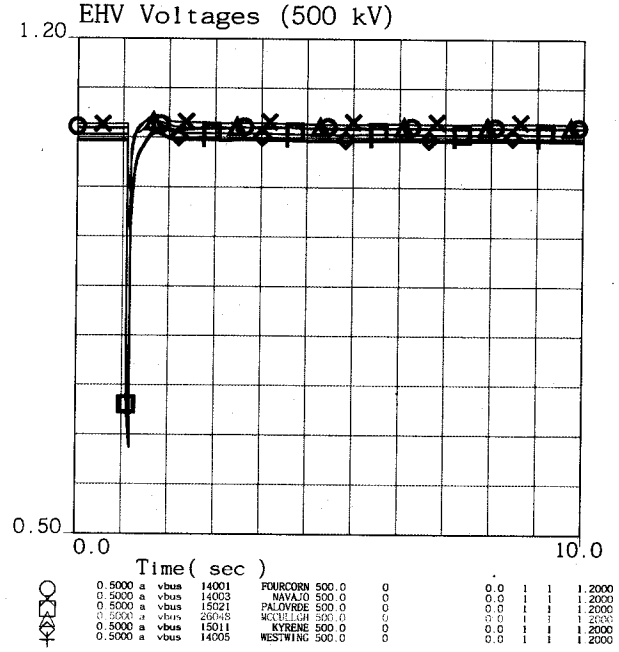

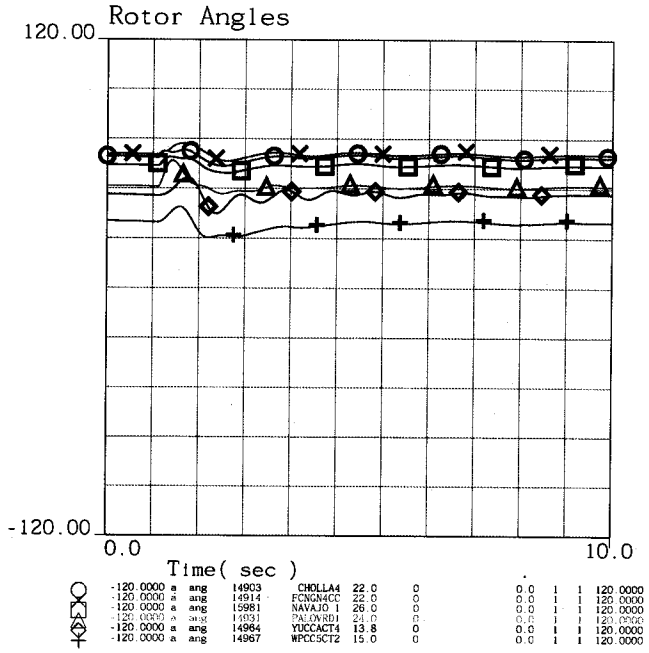

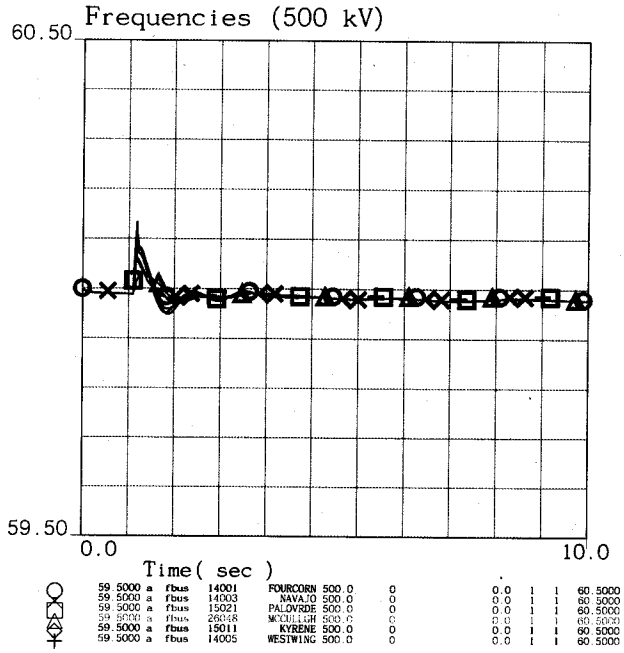

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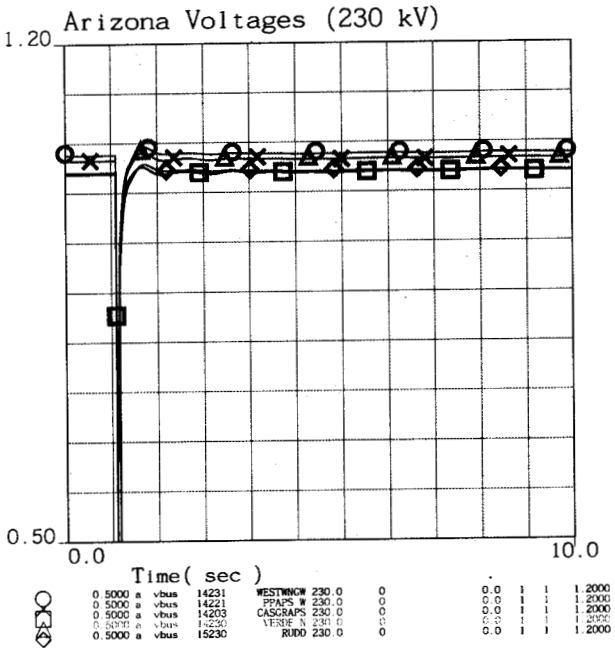

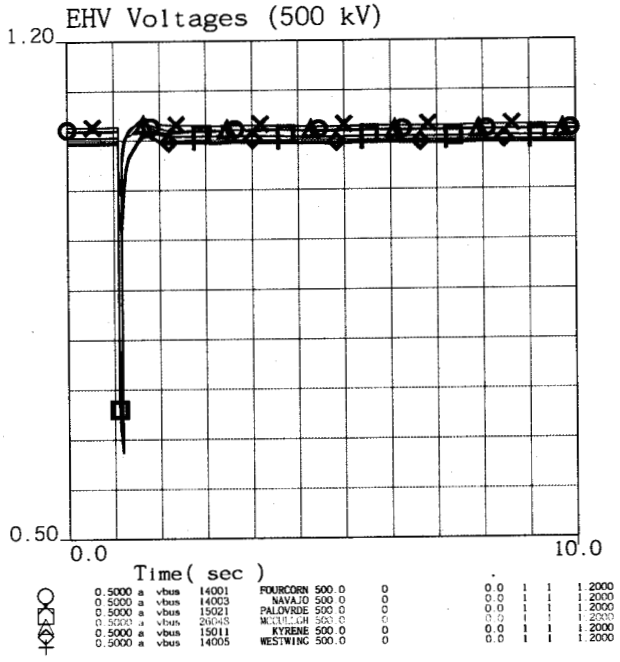

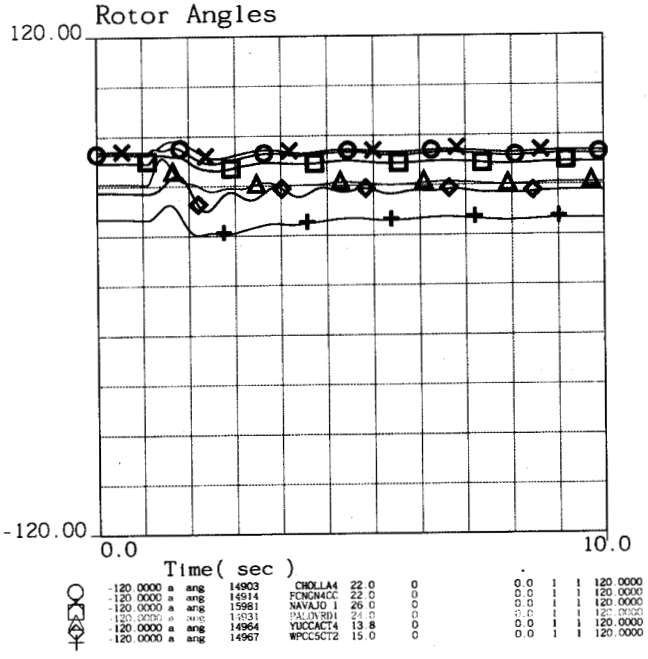

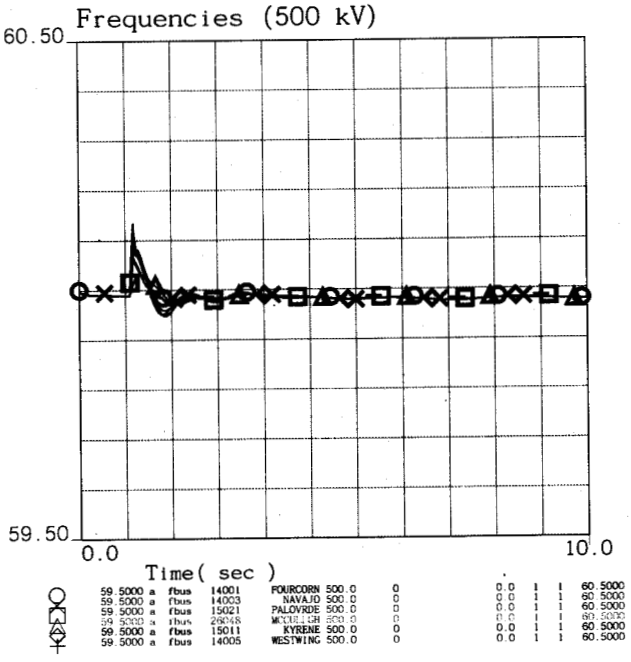

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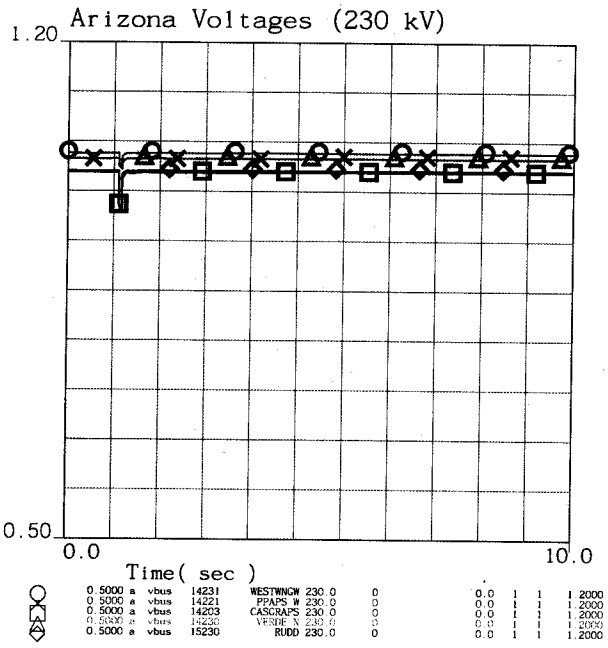

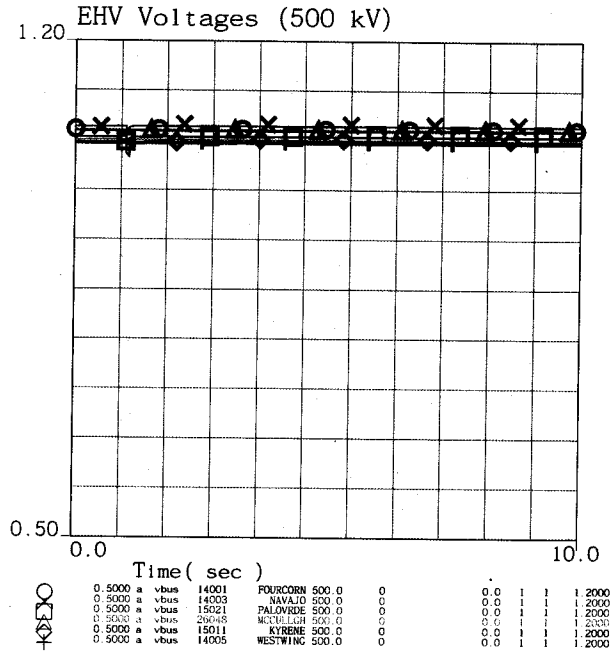

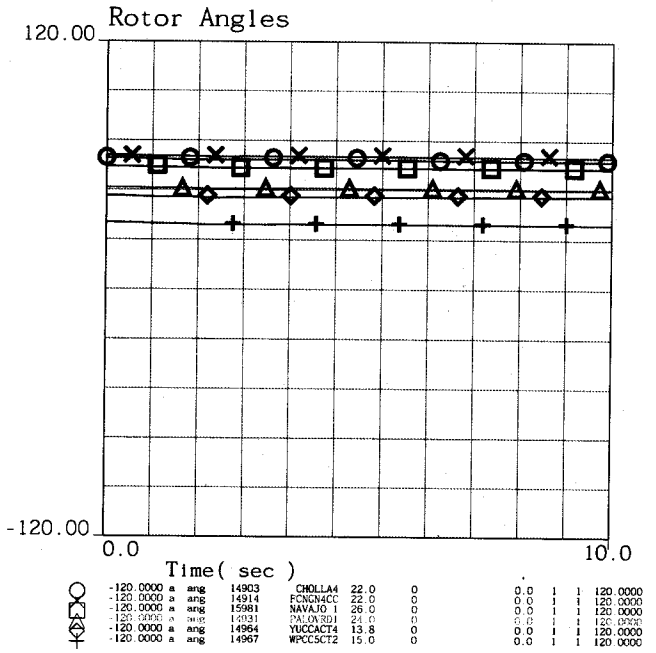

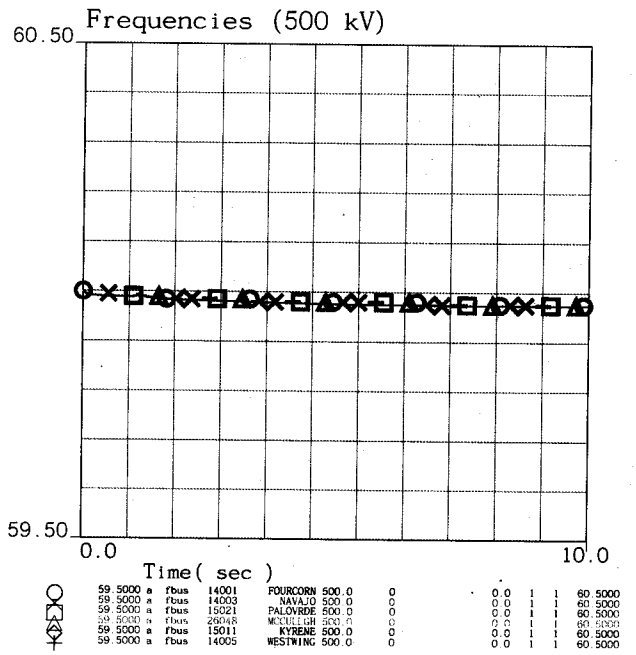

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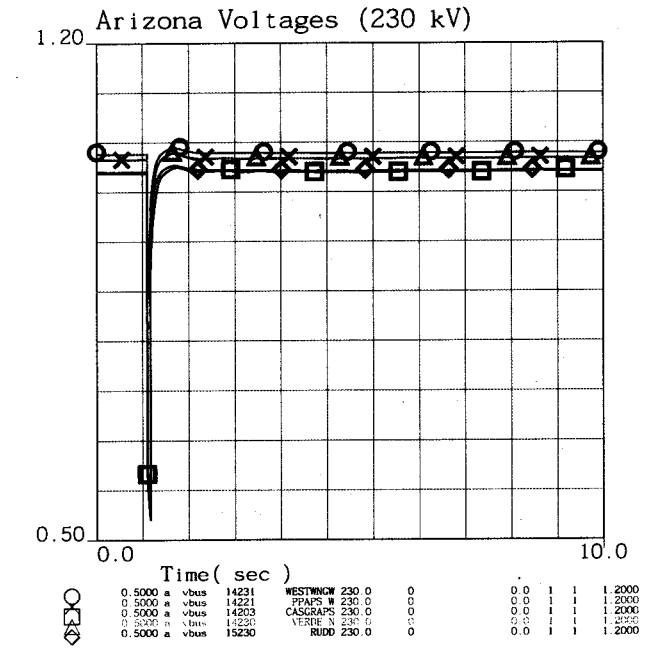

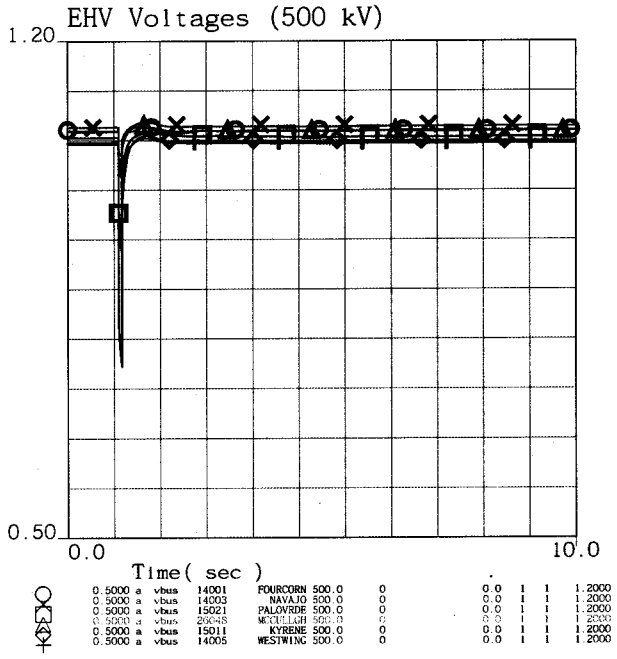

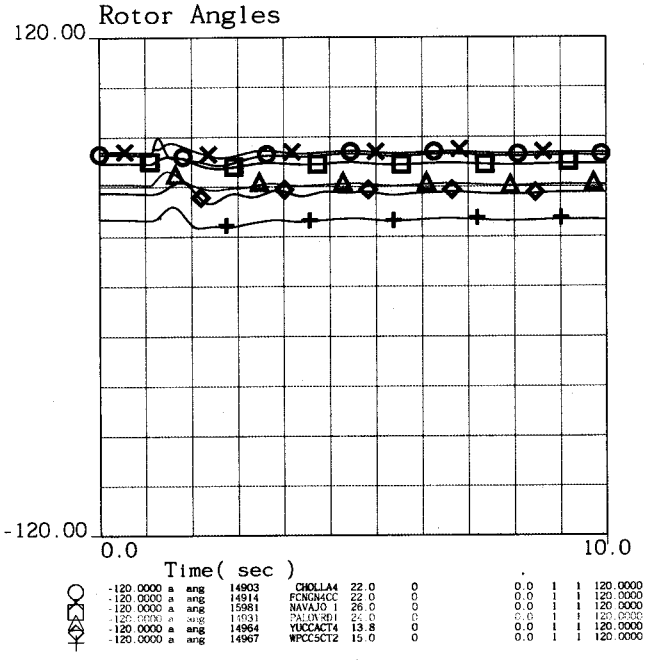

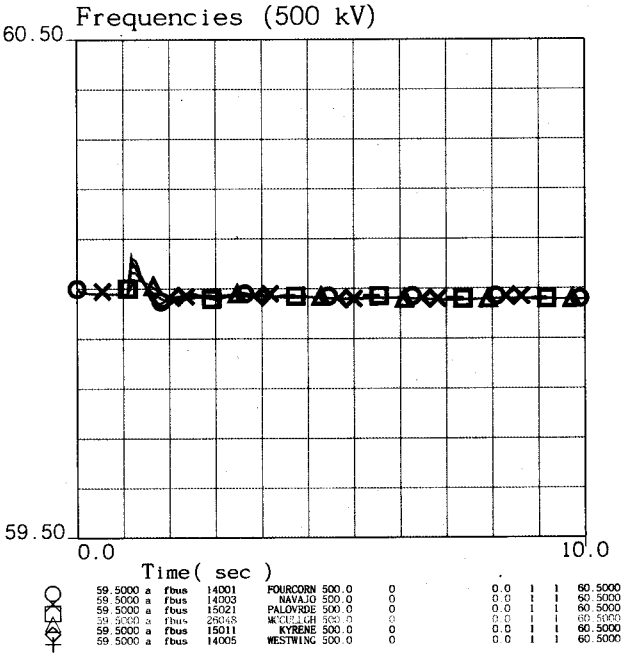

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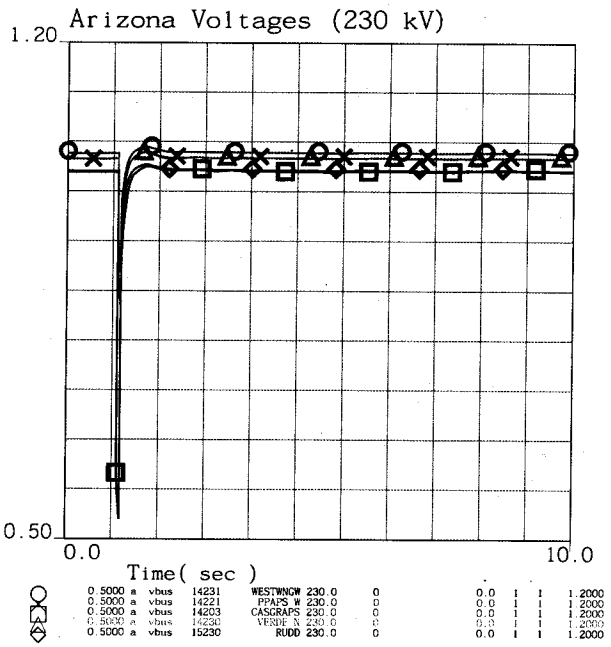

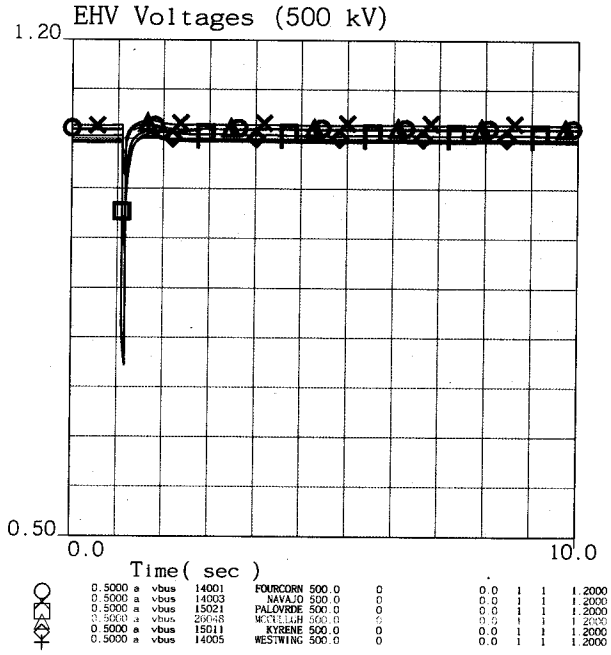

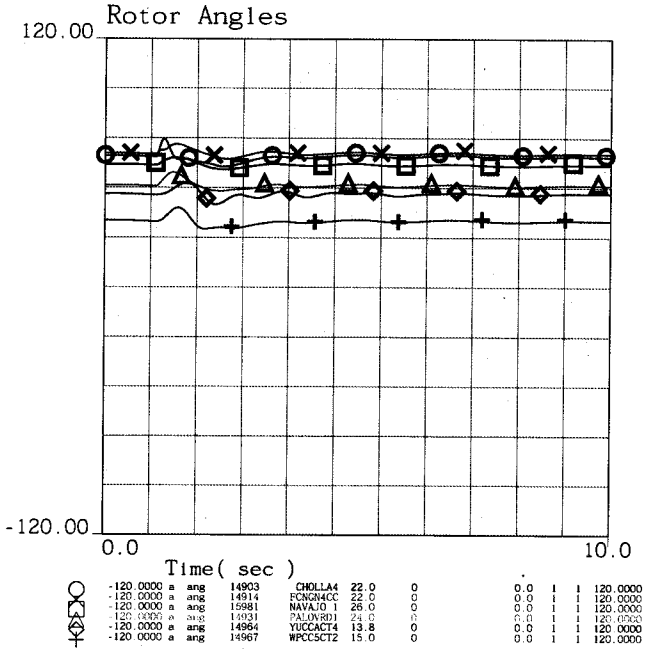

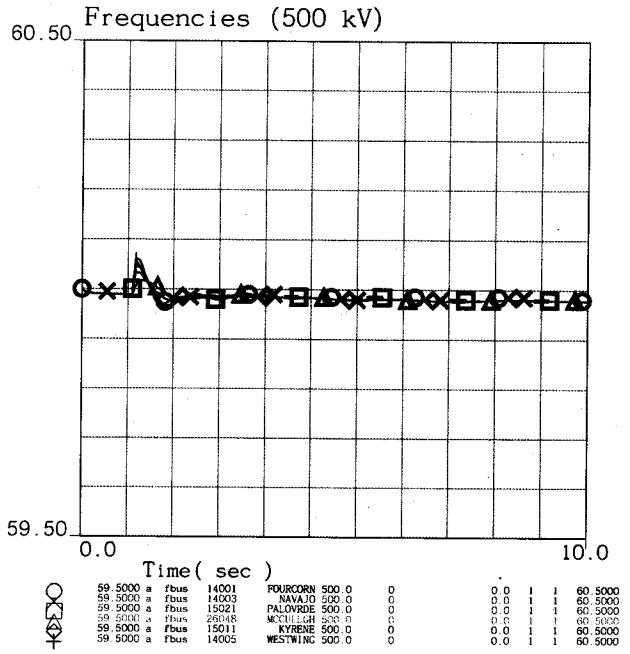

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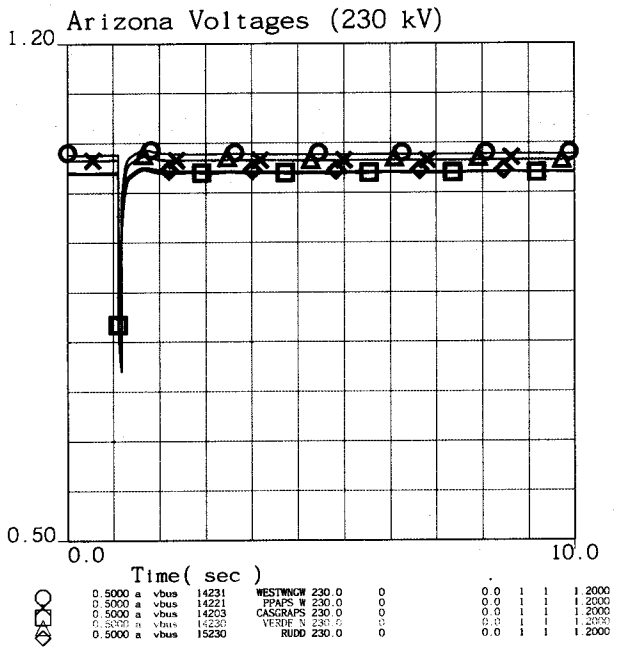

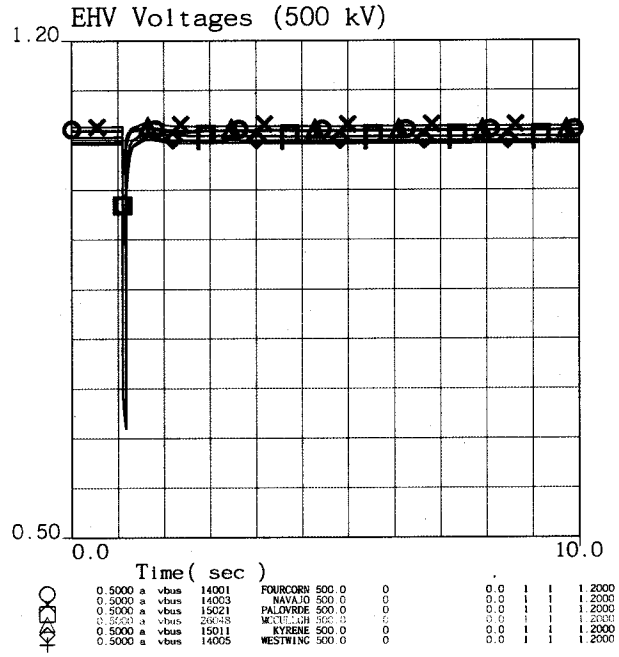

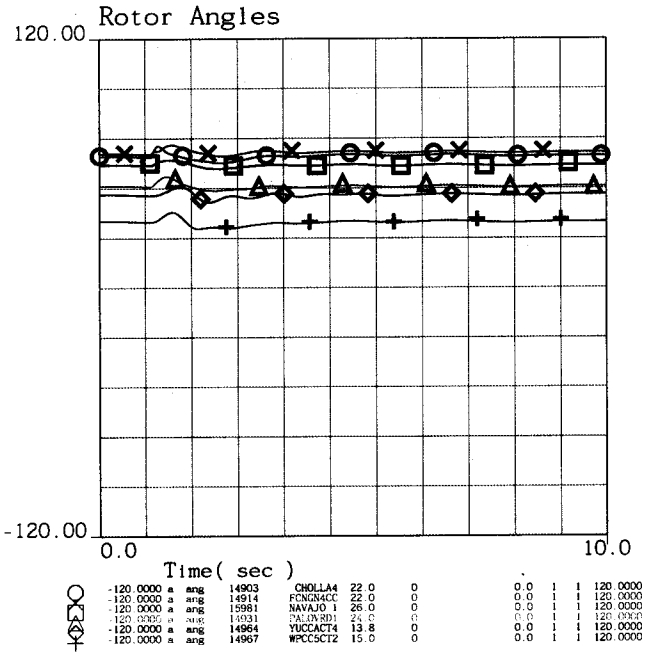

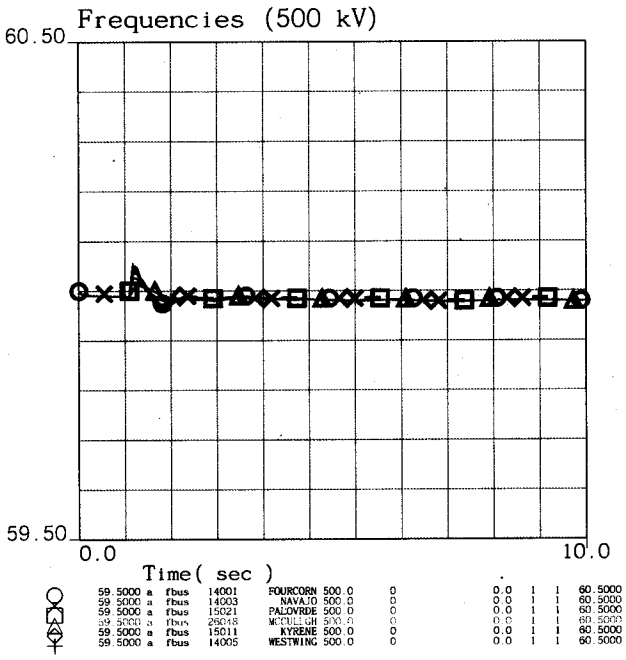

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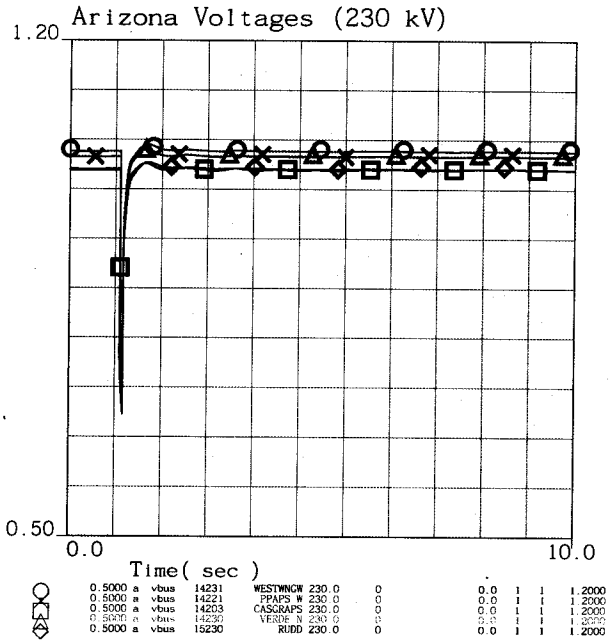

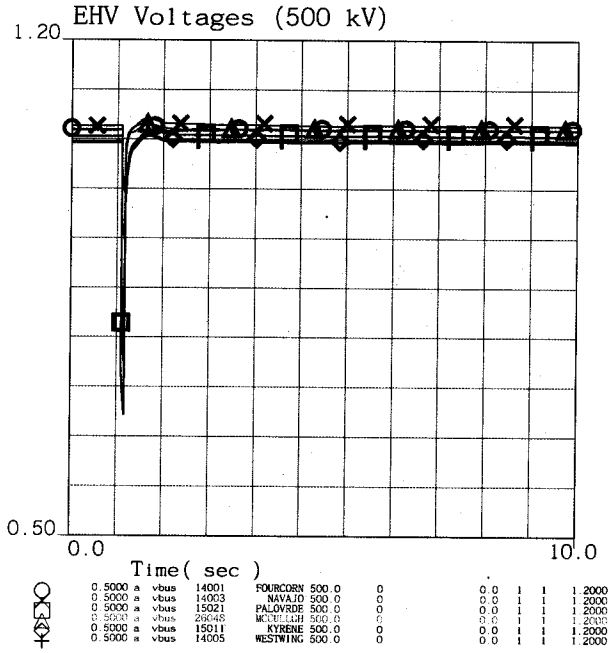

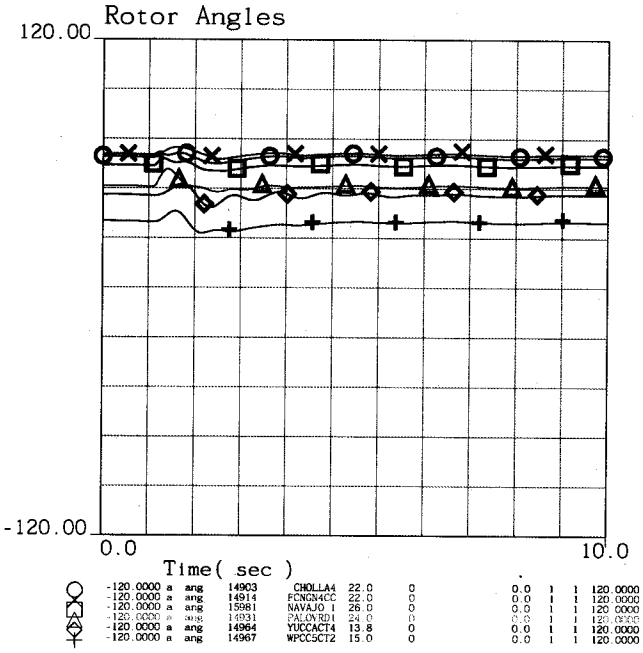

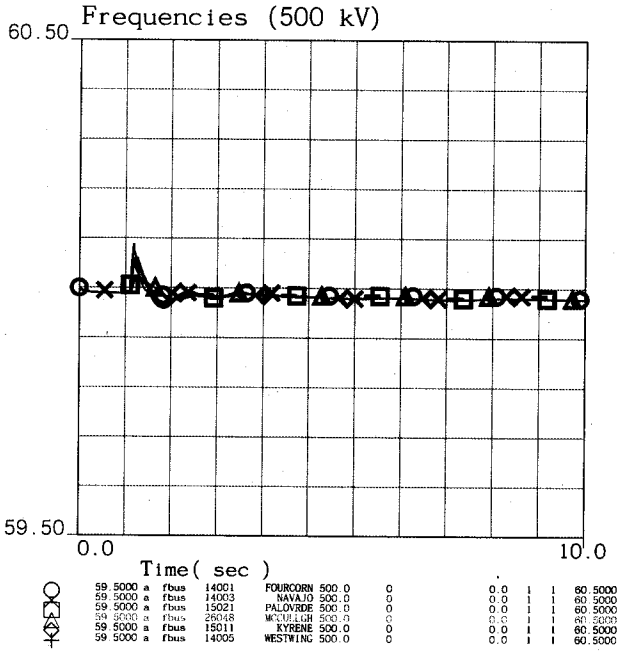

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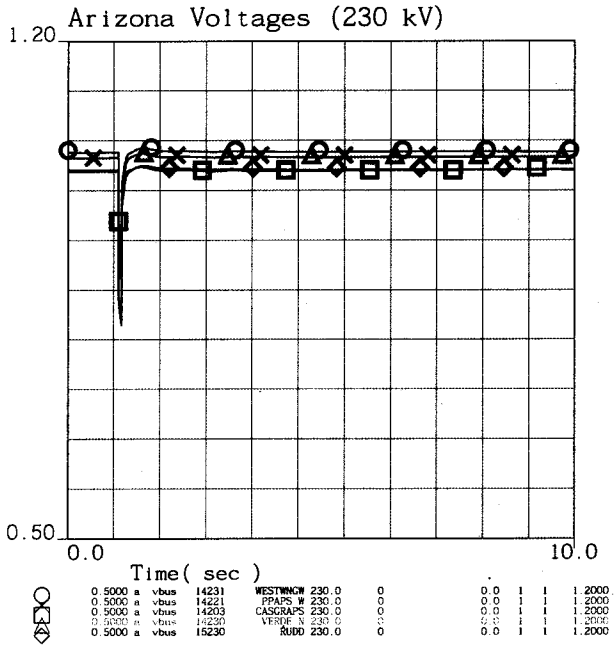
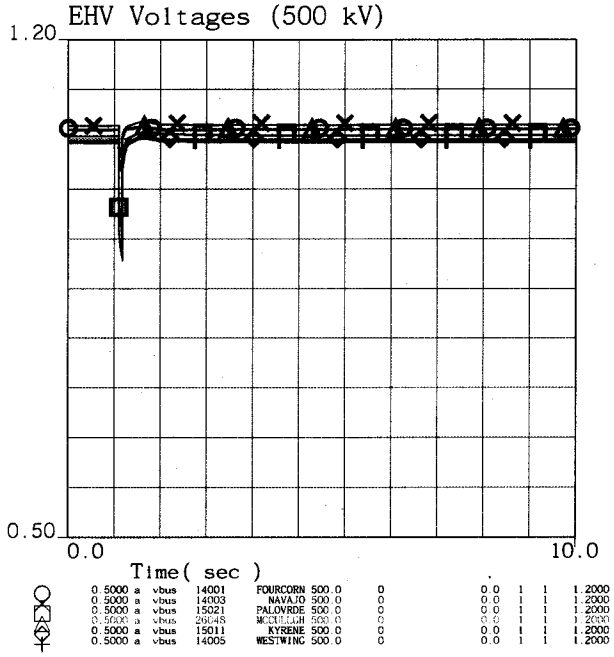
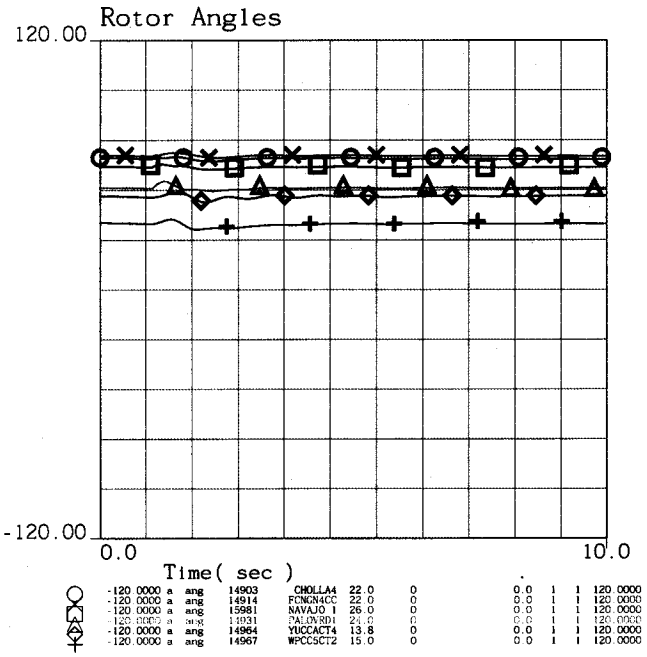
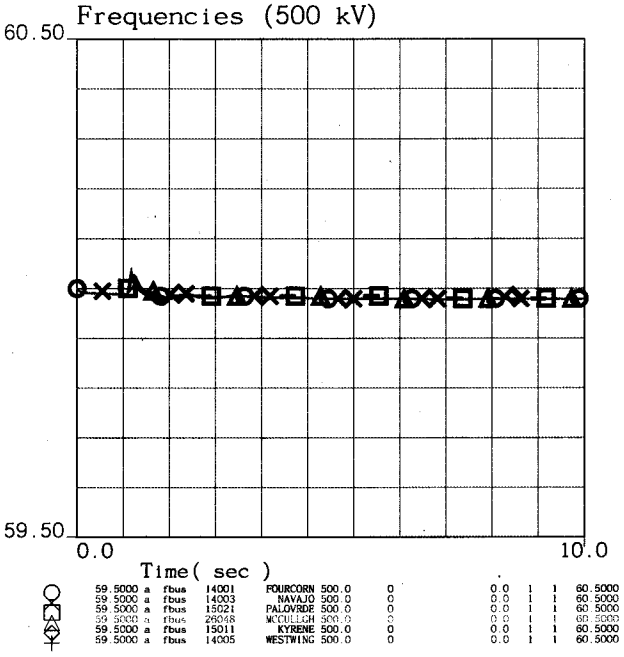
2018 Heavy Summer Detailed Planning Case









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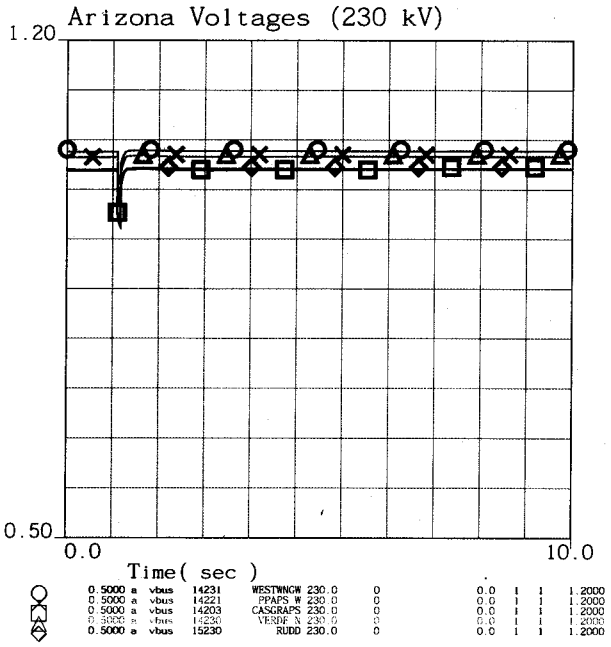

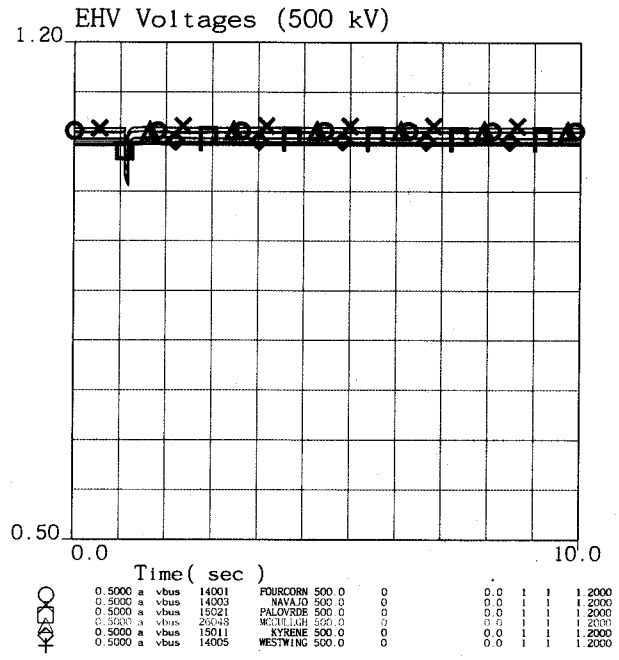

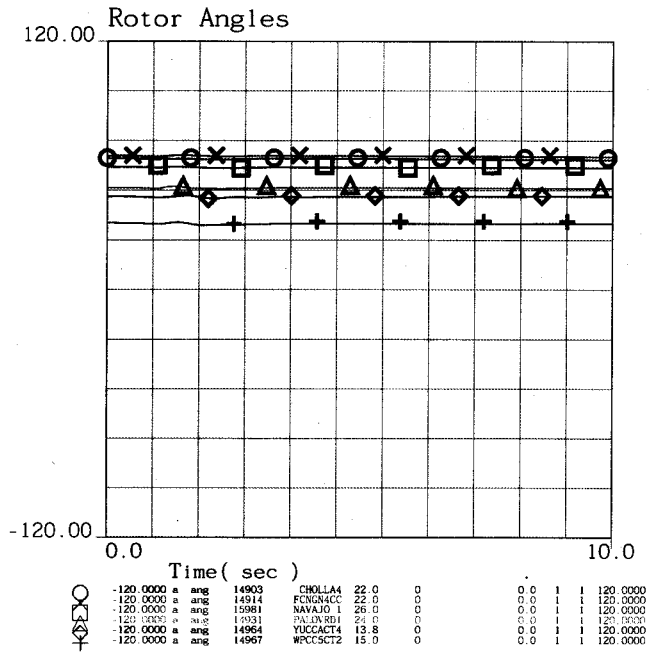

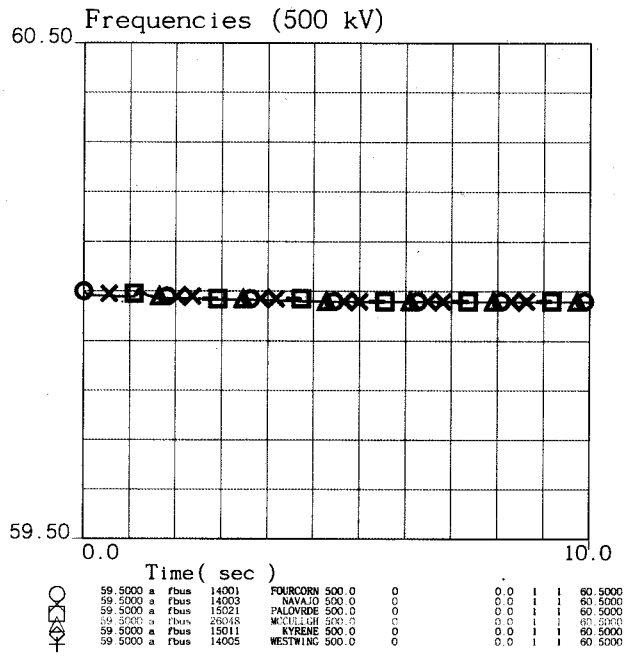

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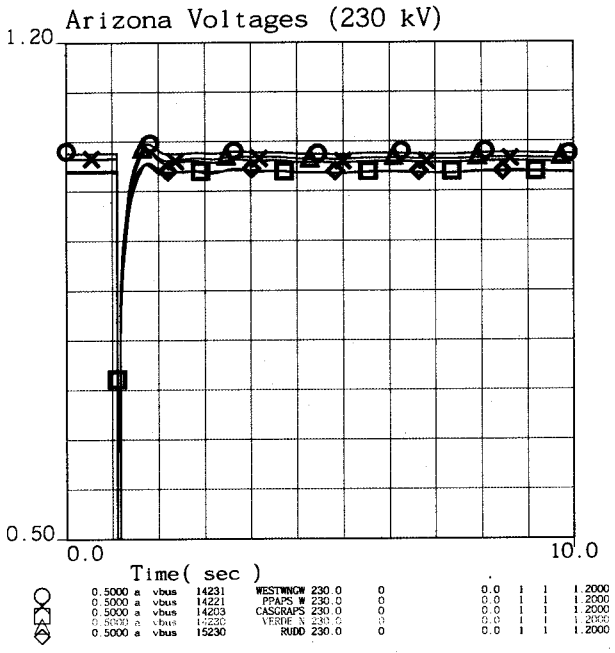

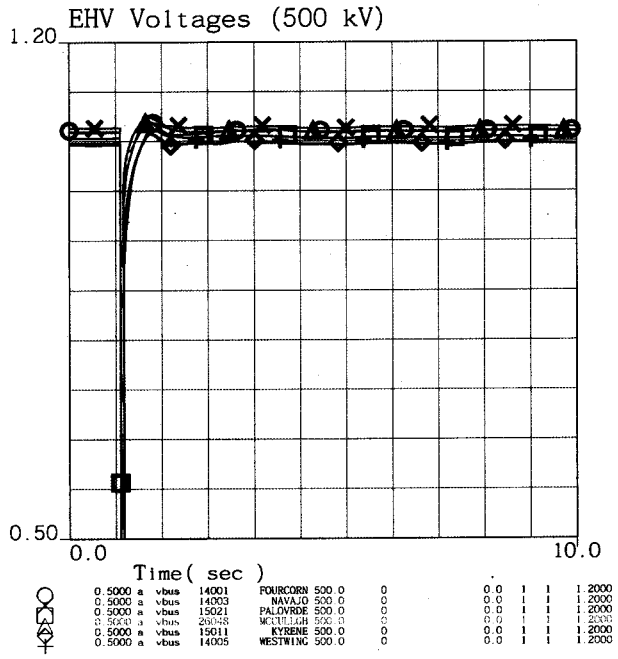

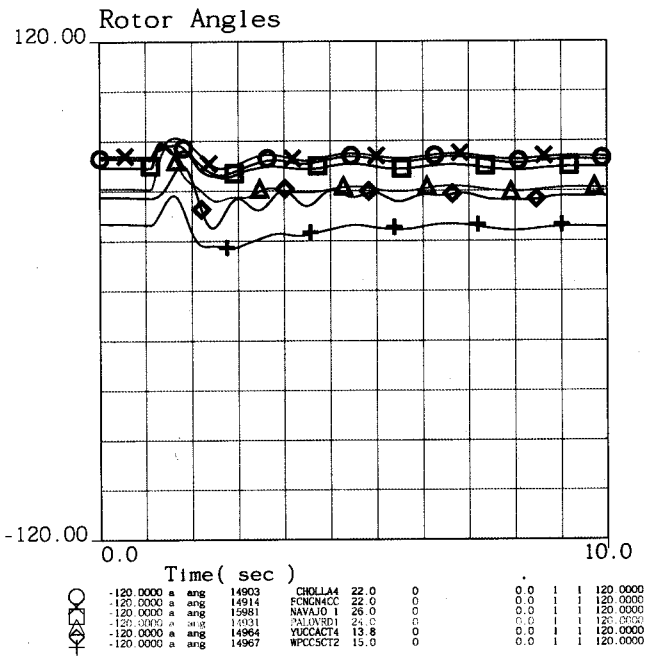

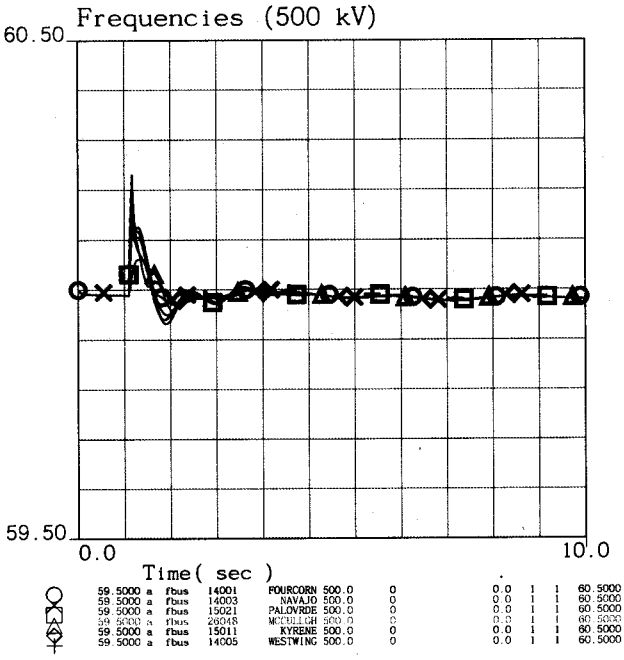

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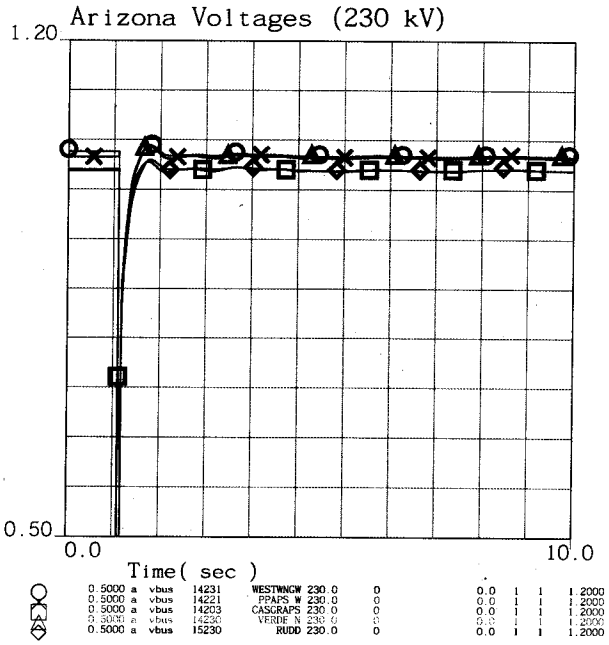

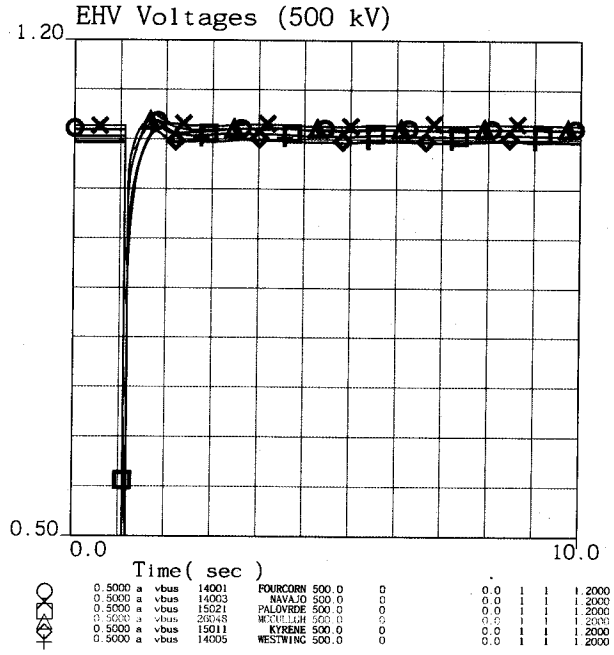

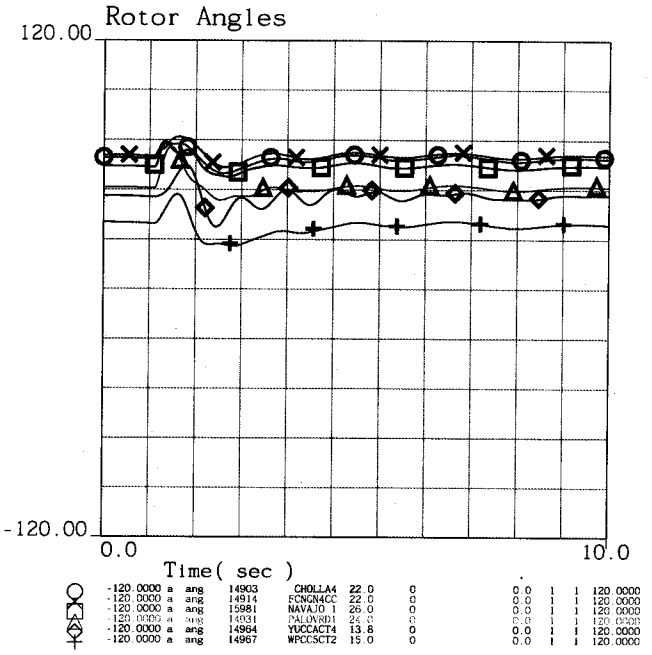

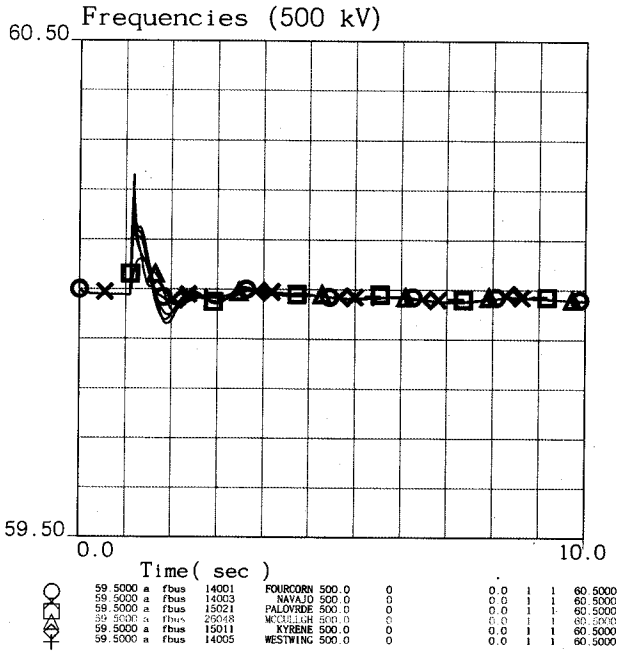

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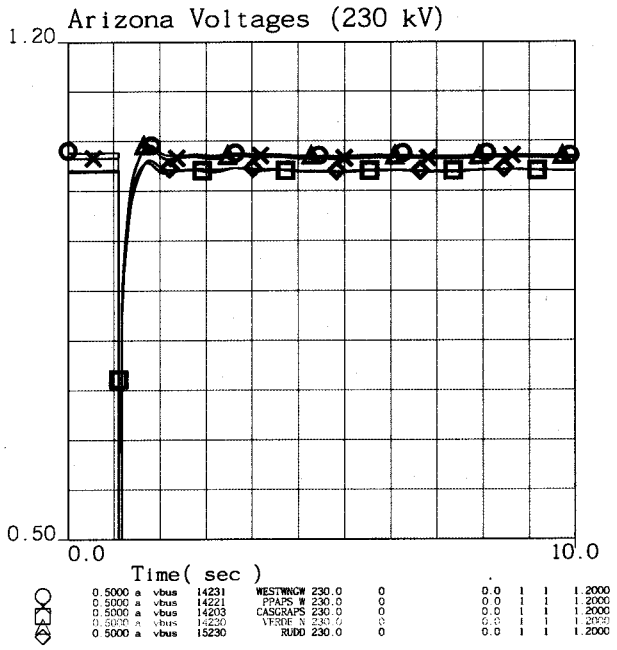

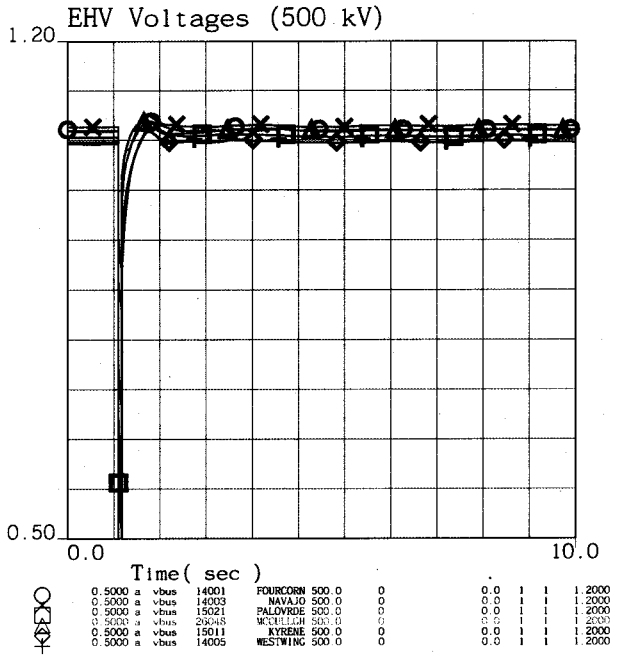

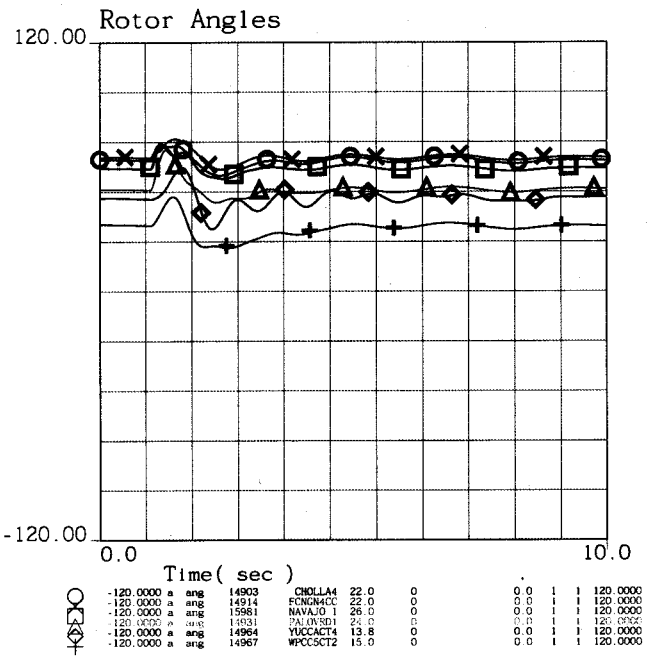

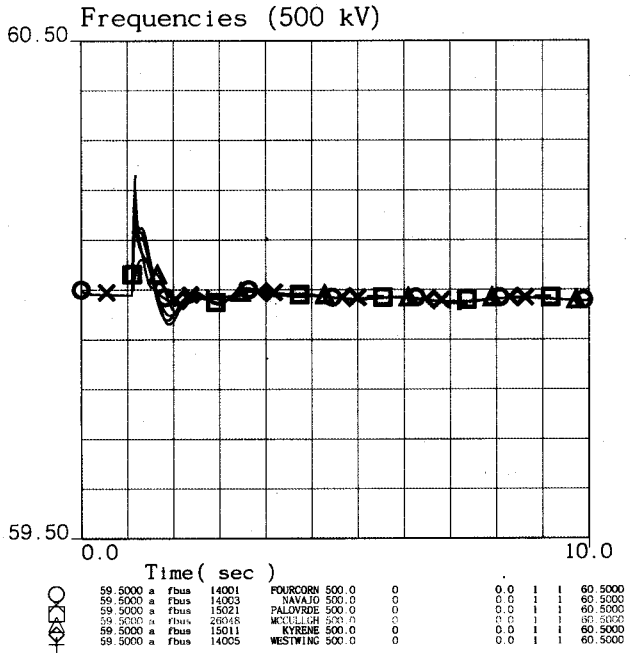

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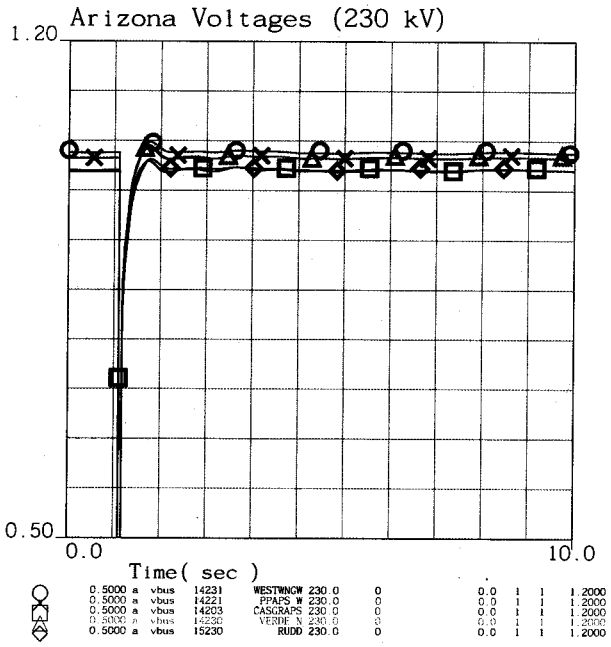

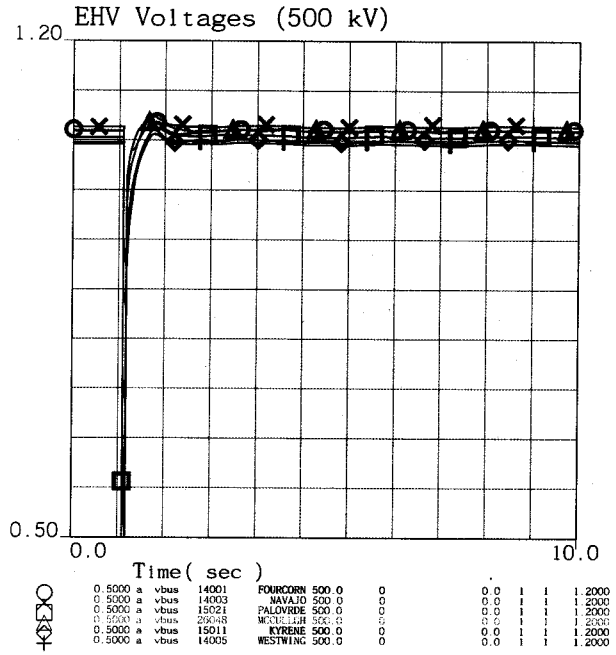

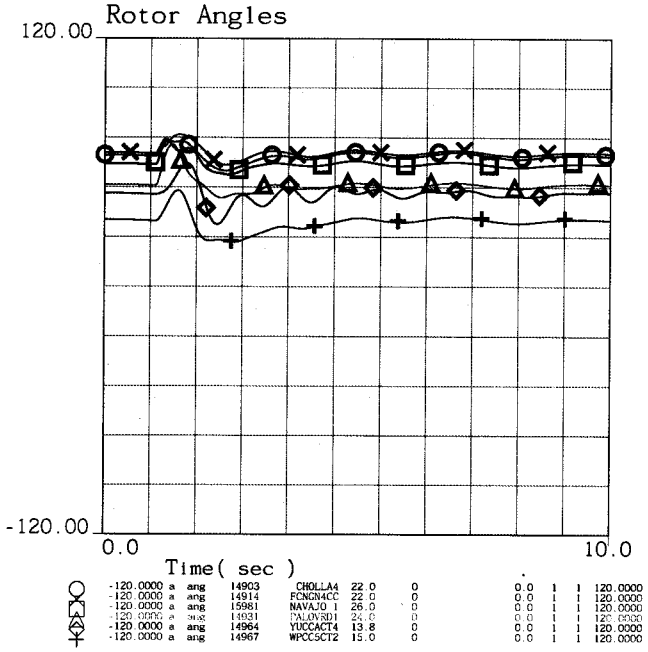

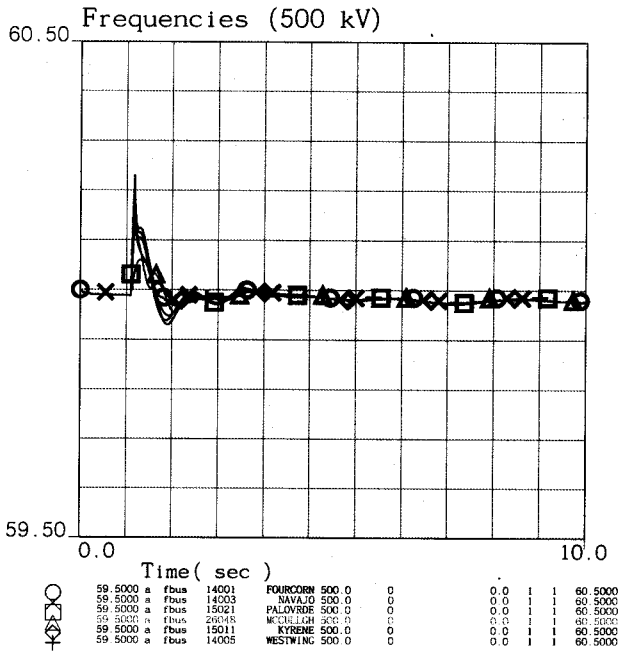

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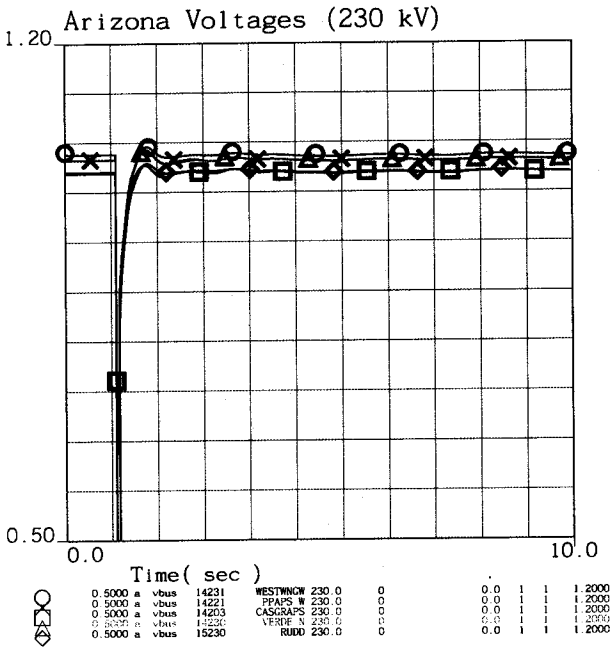

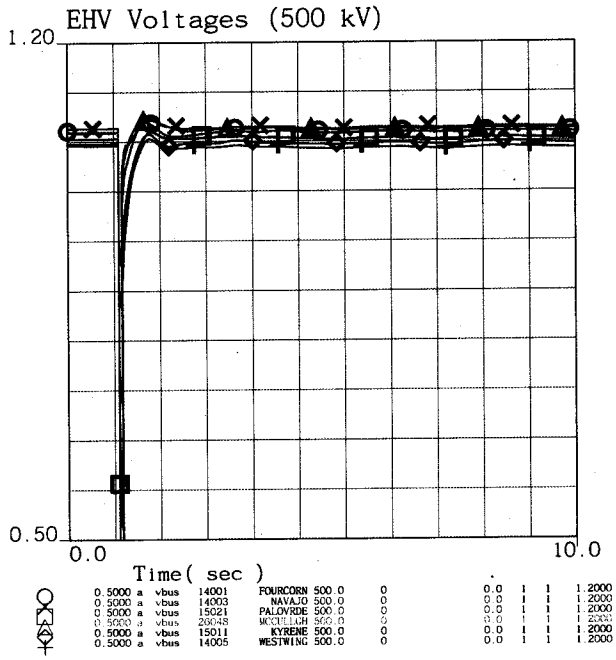

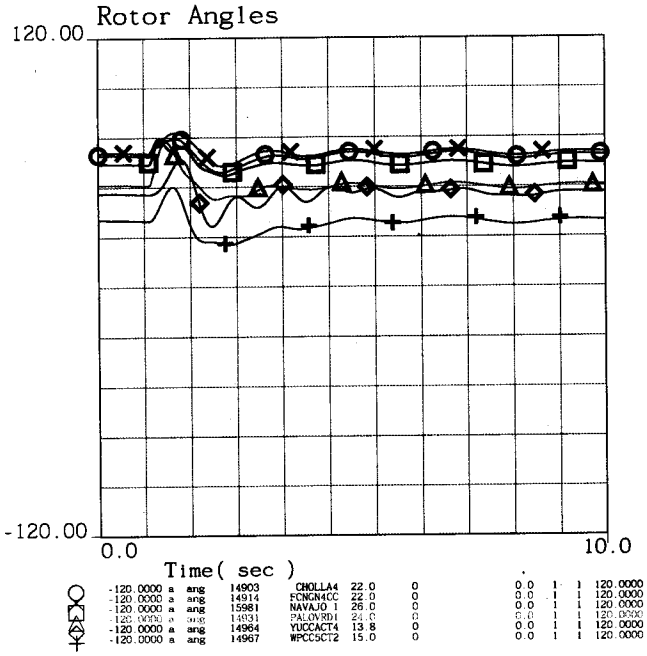

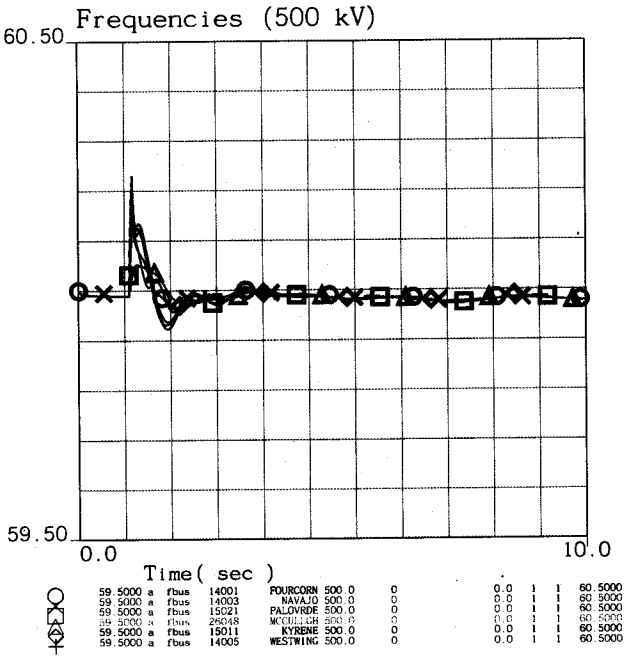

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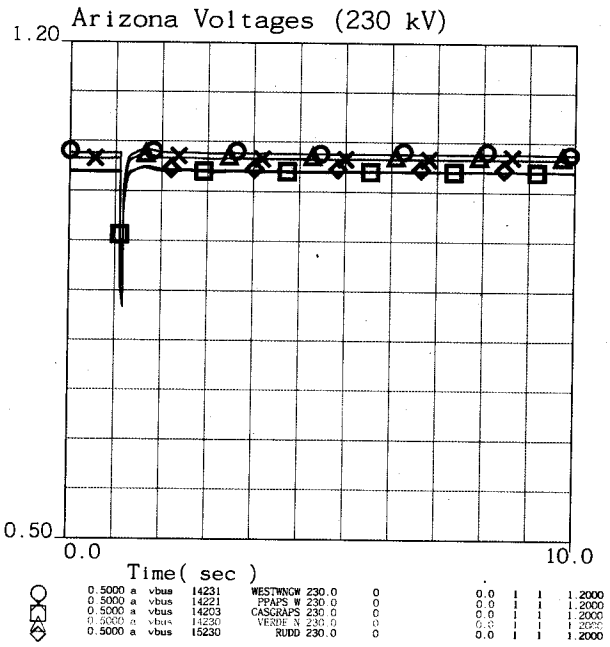

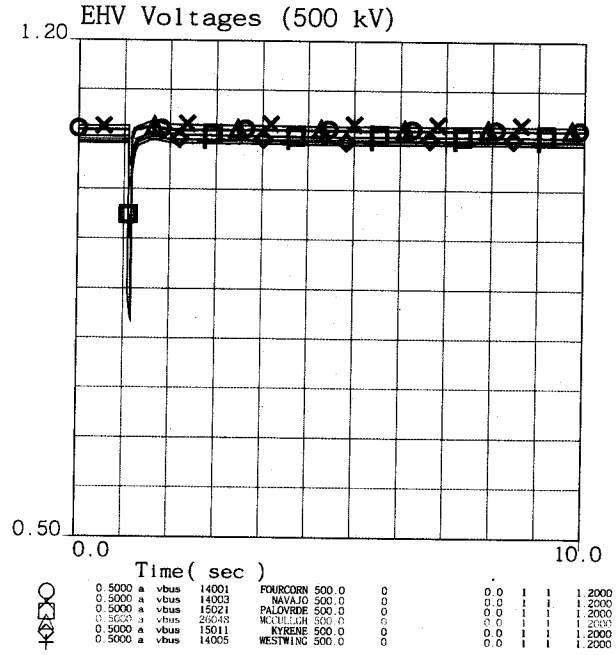

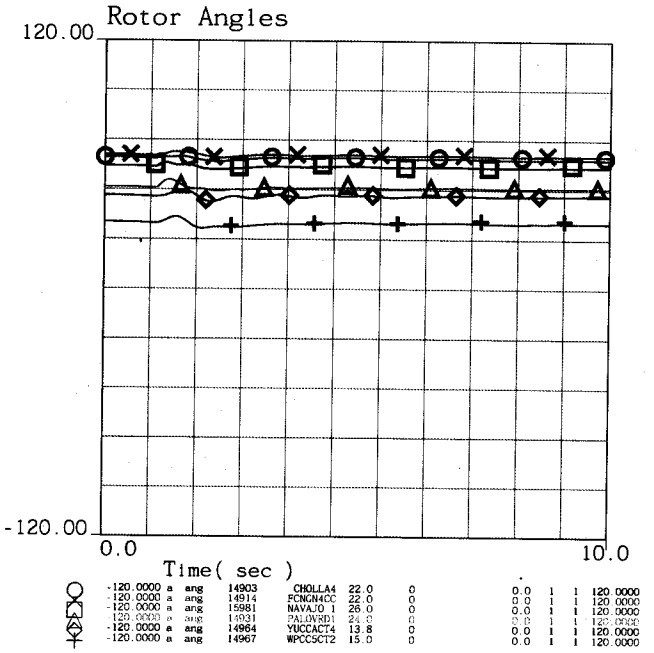

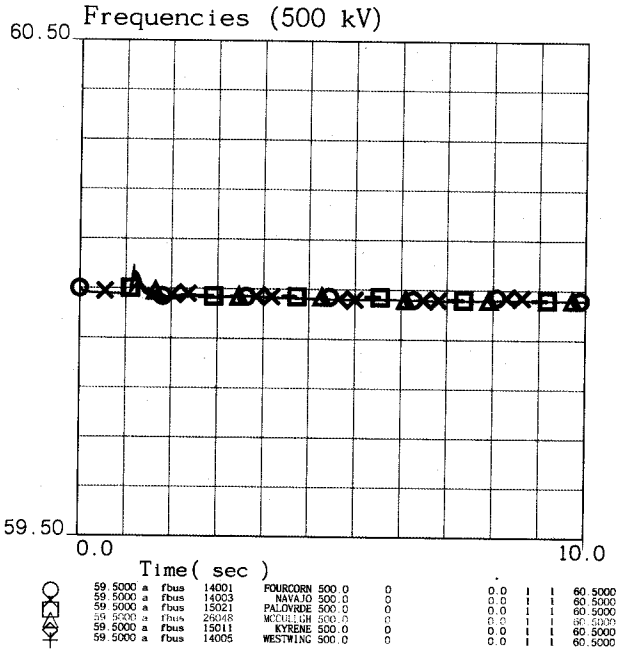

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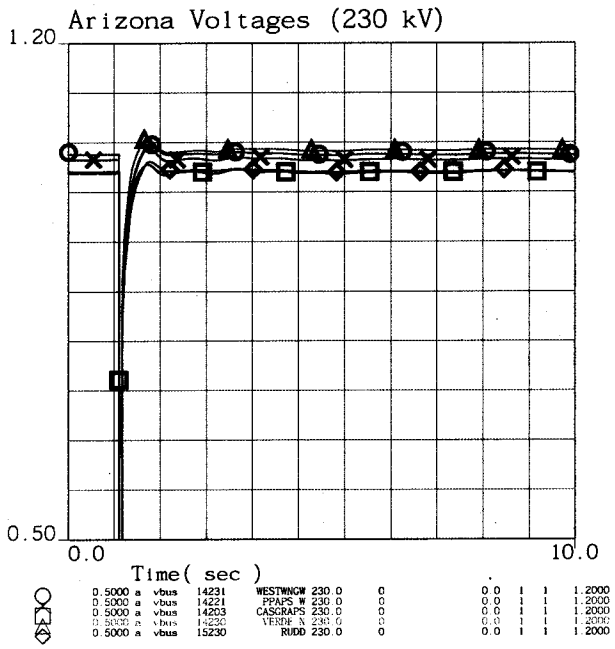

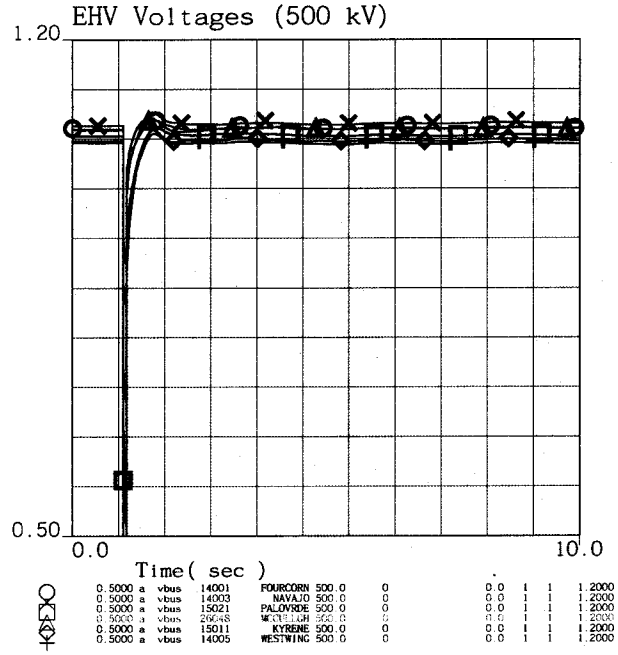

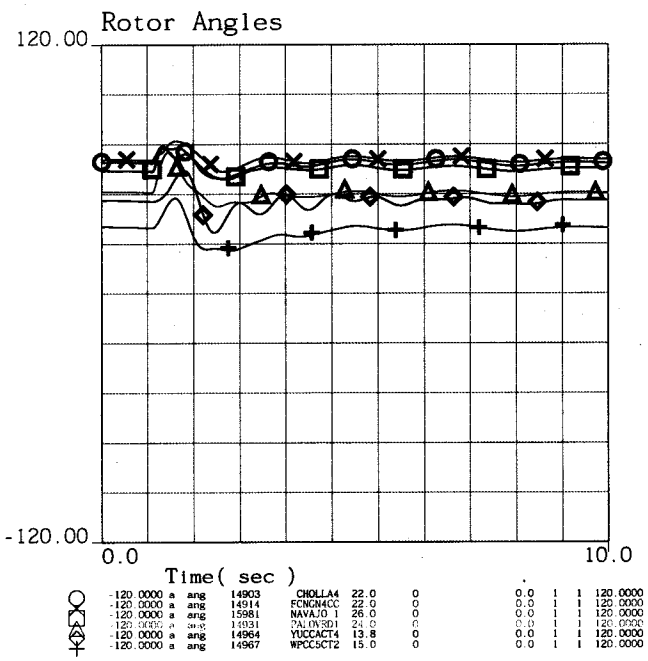

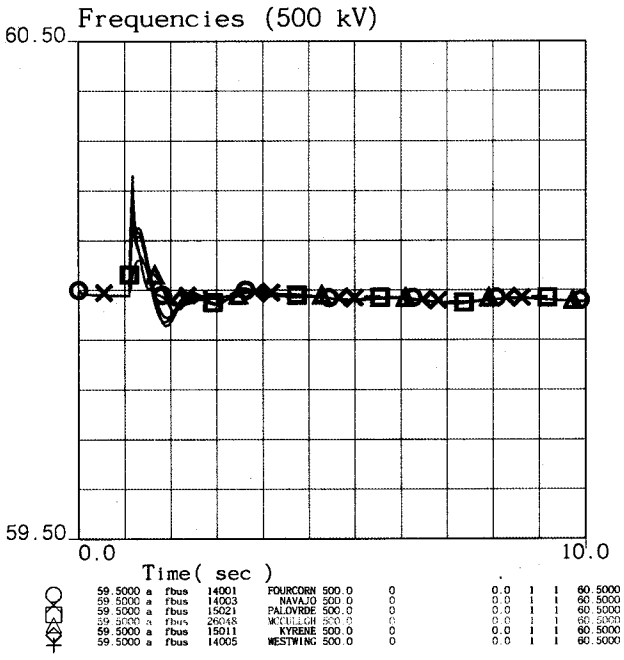

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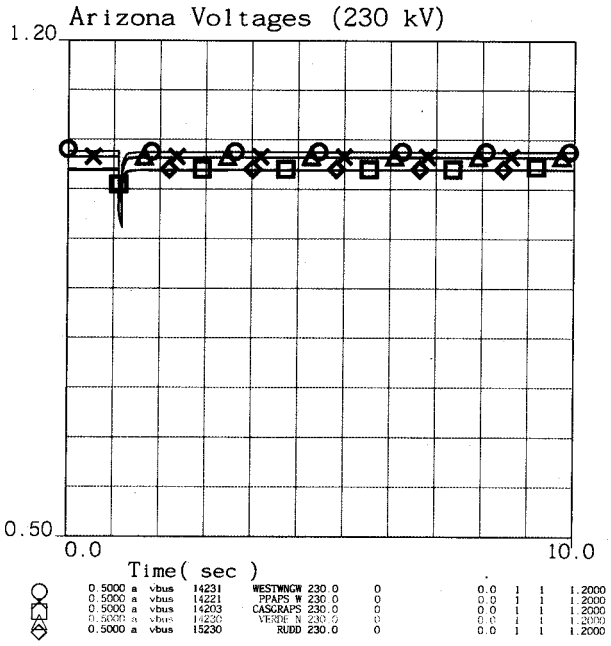

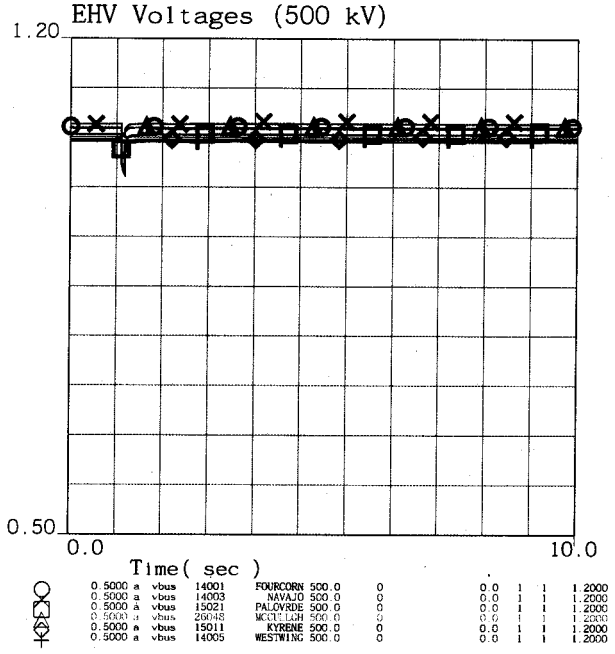

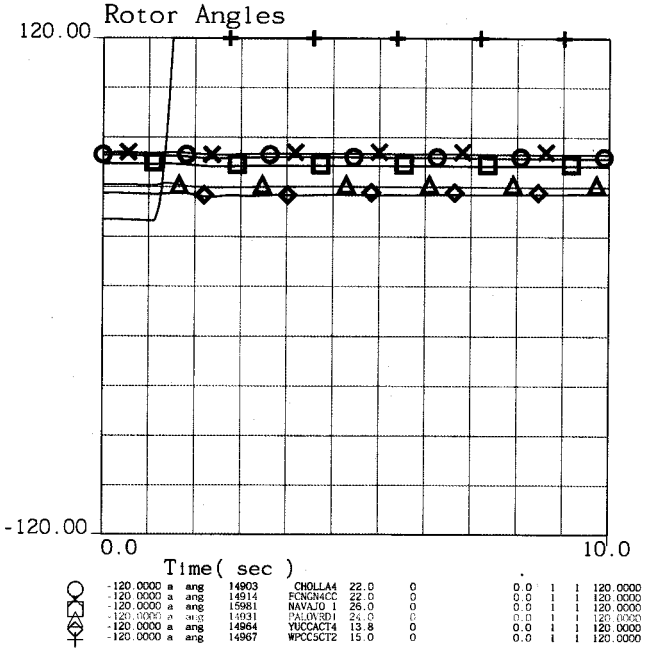

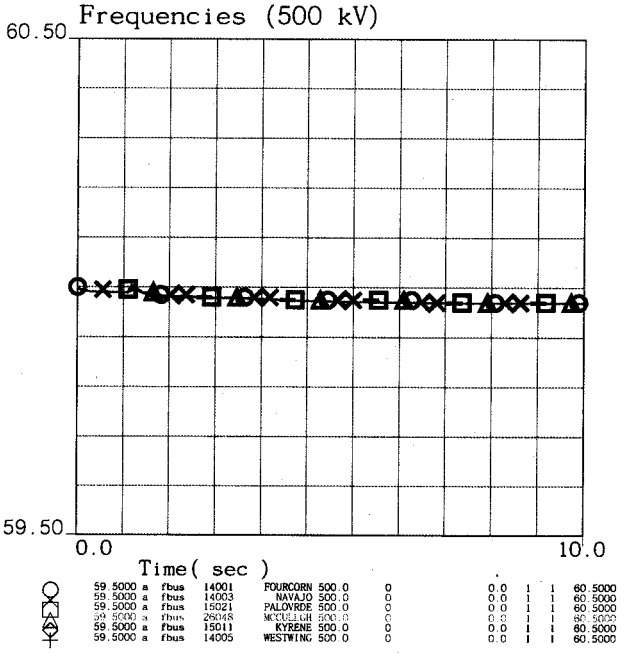

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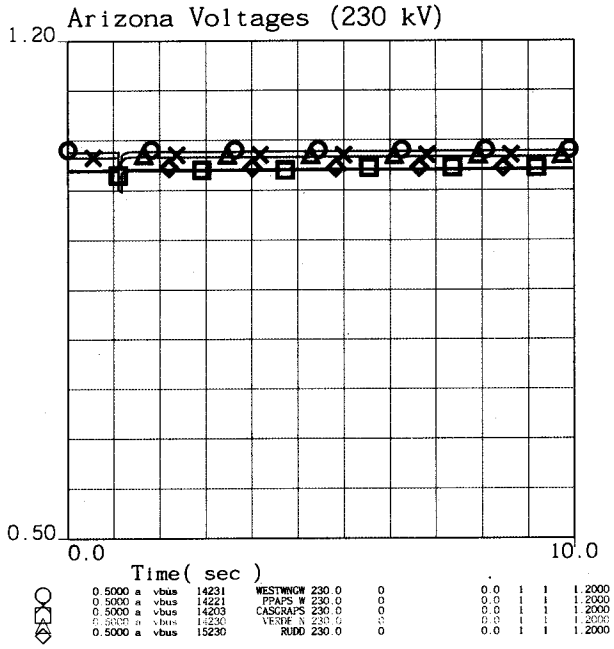

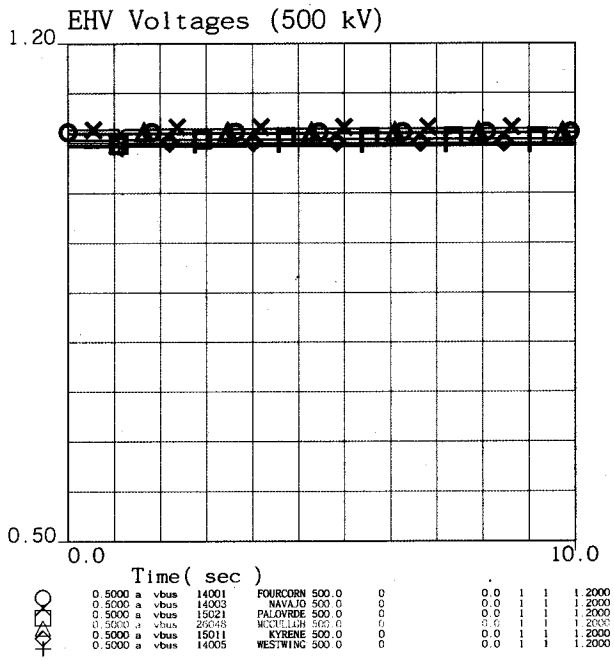

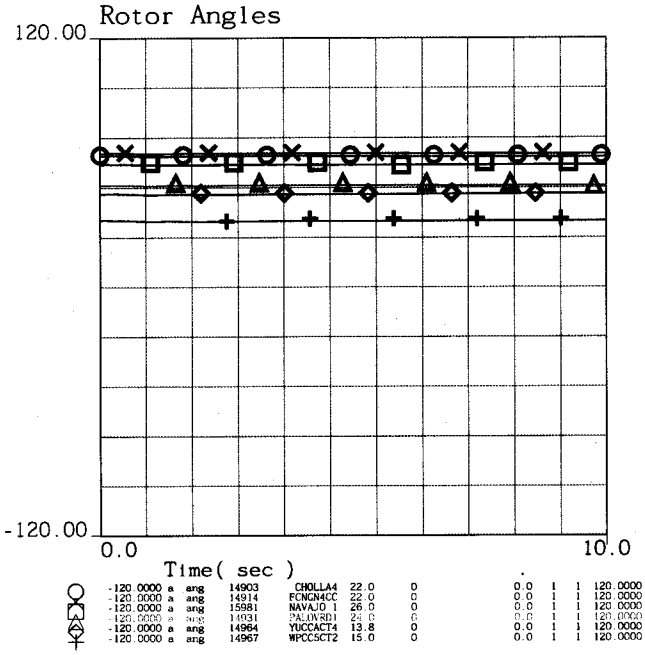

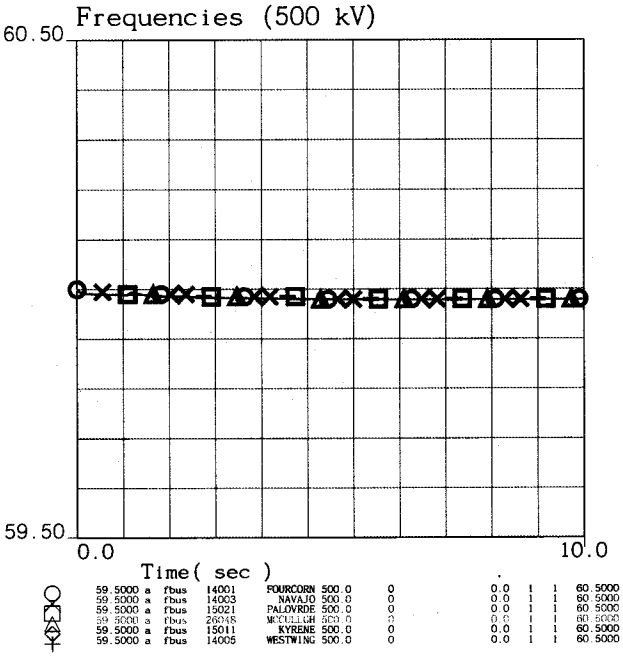

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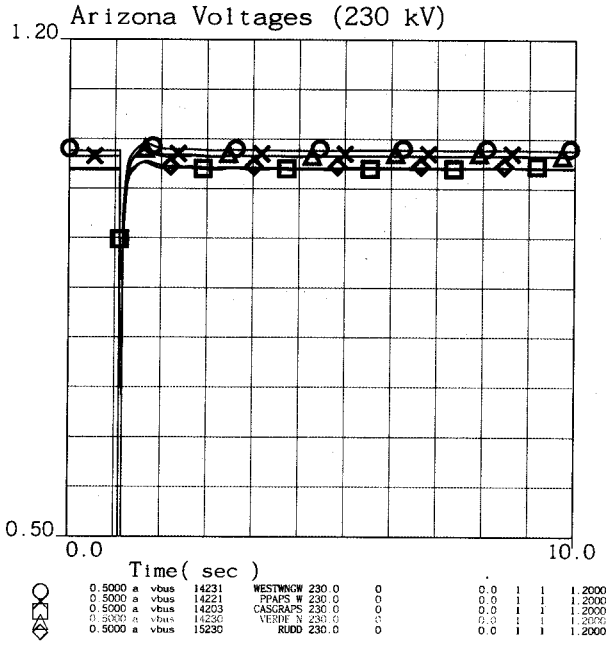

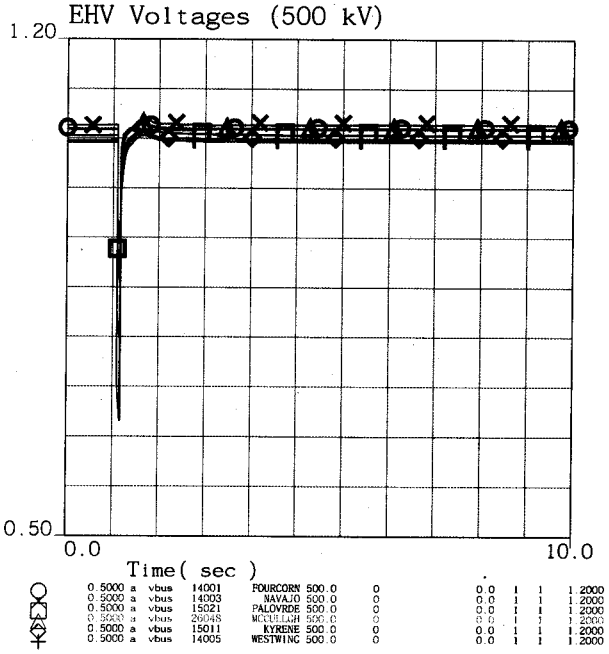

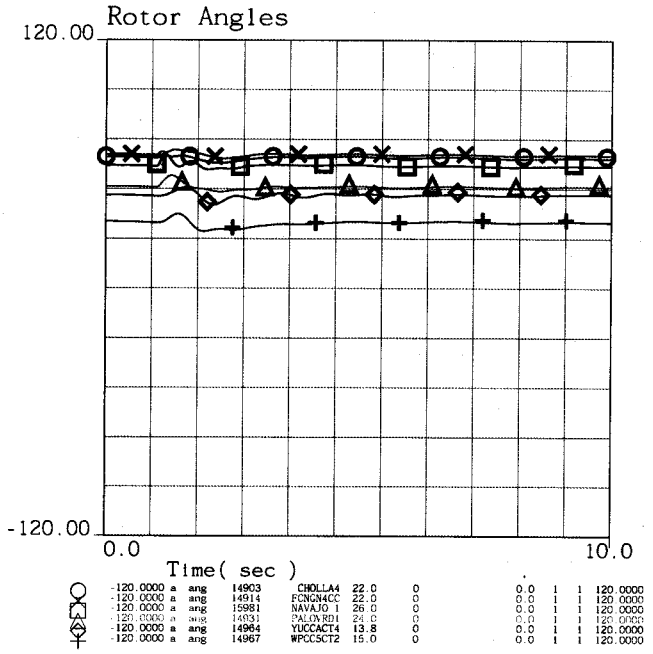

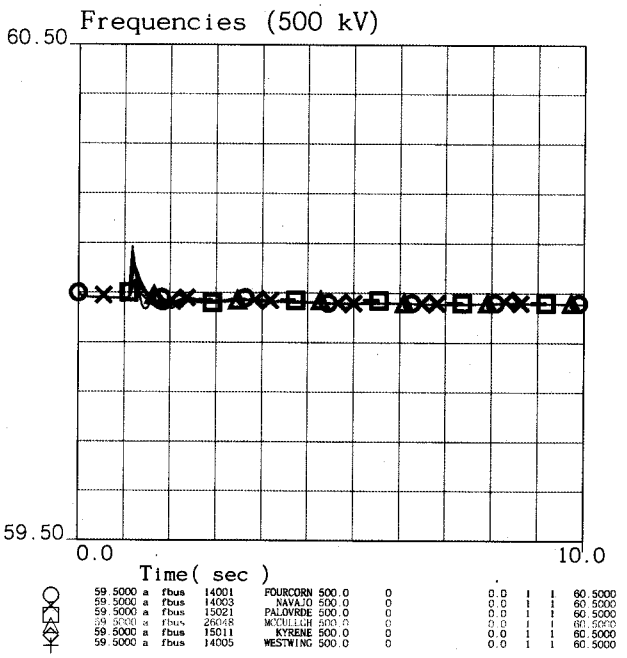

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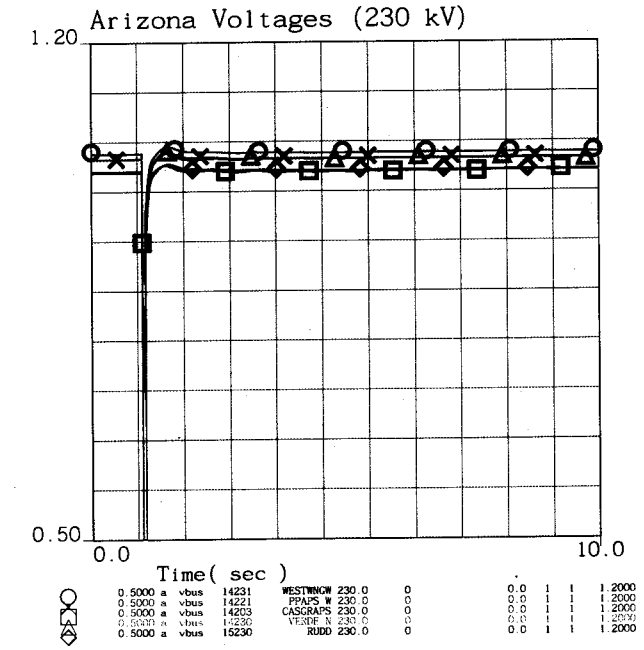

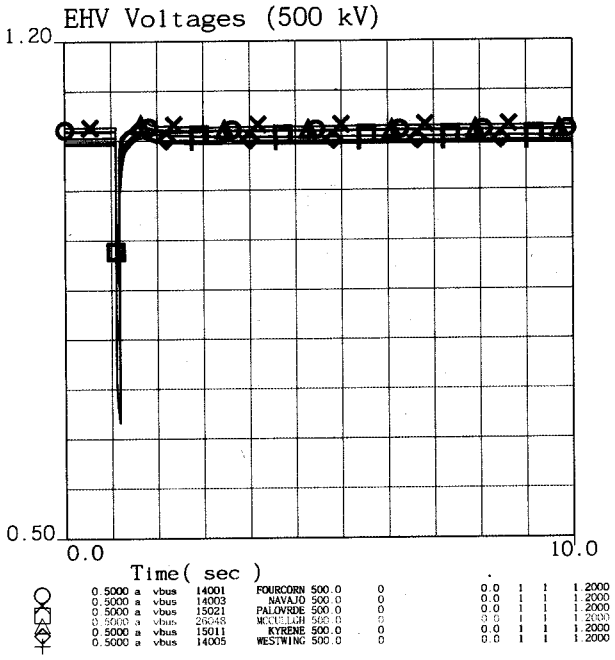

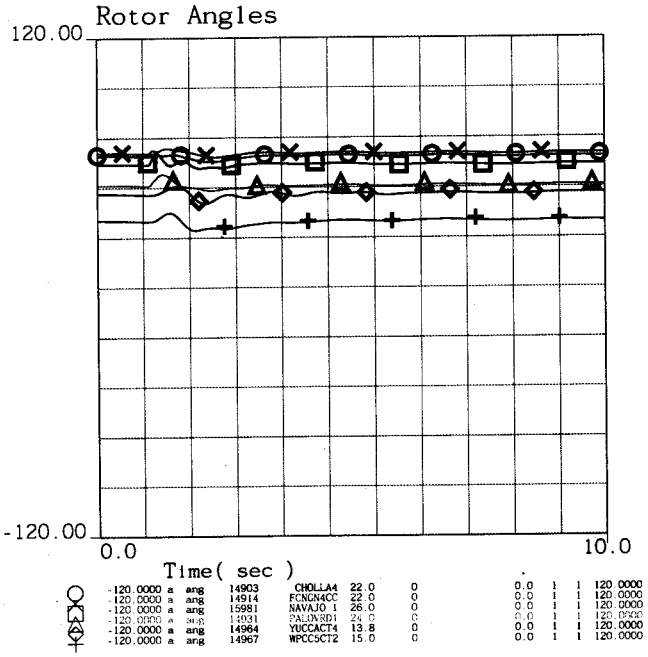

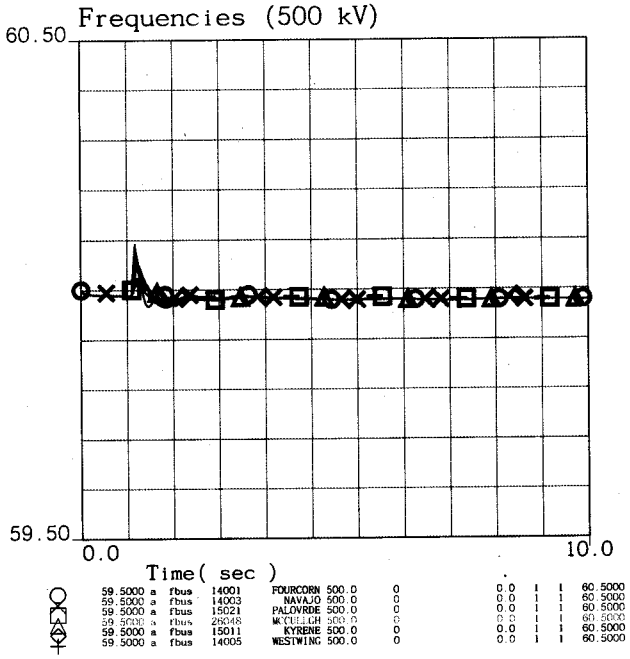

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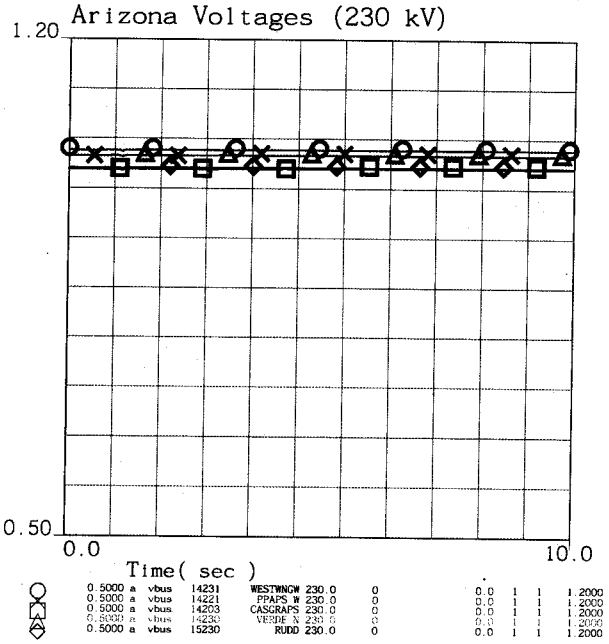

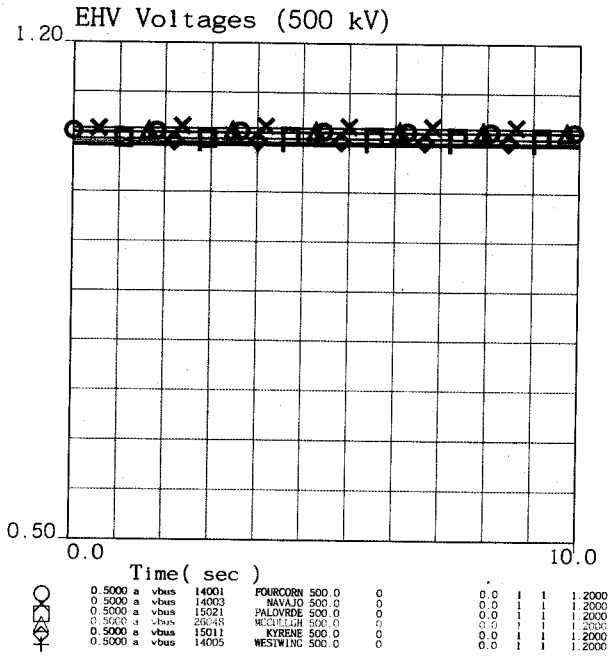

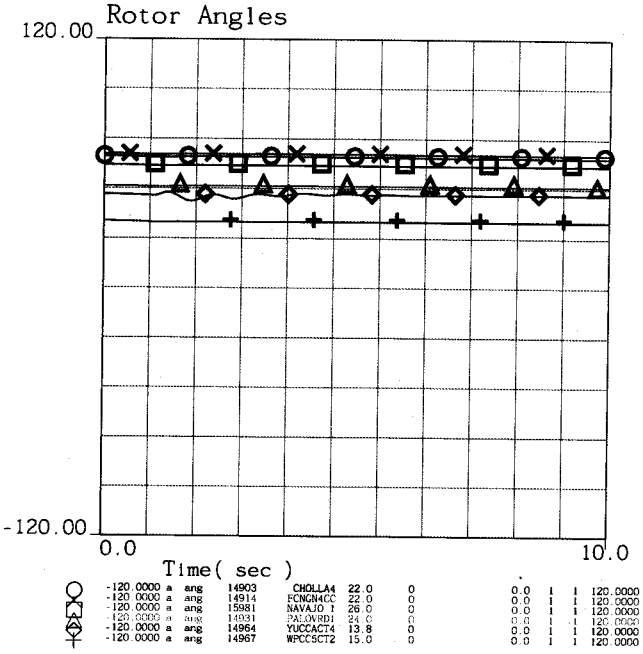

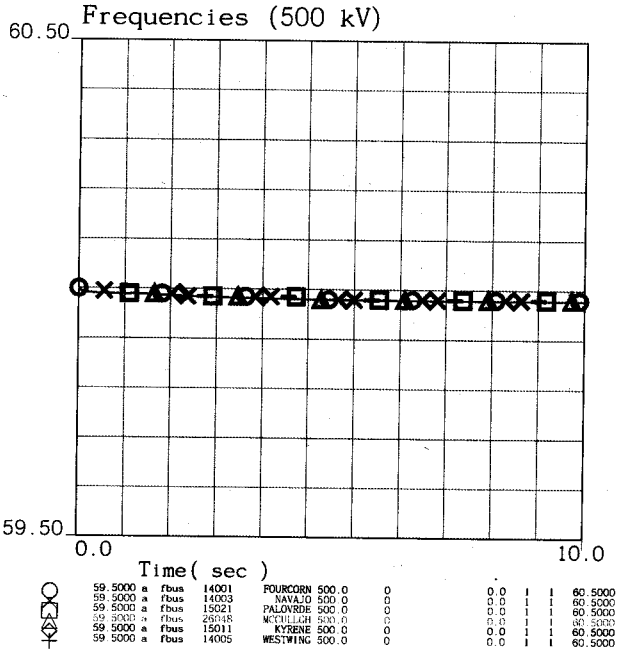

2018 Heavy Summer AZ Coordinated Case
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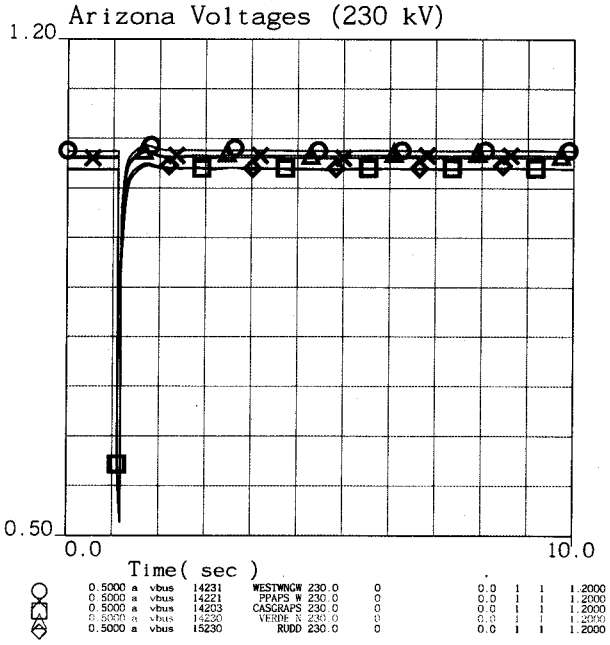
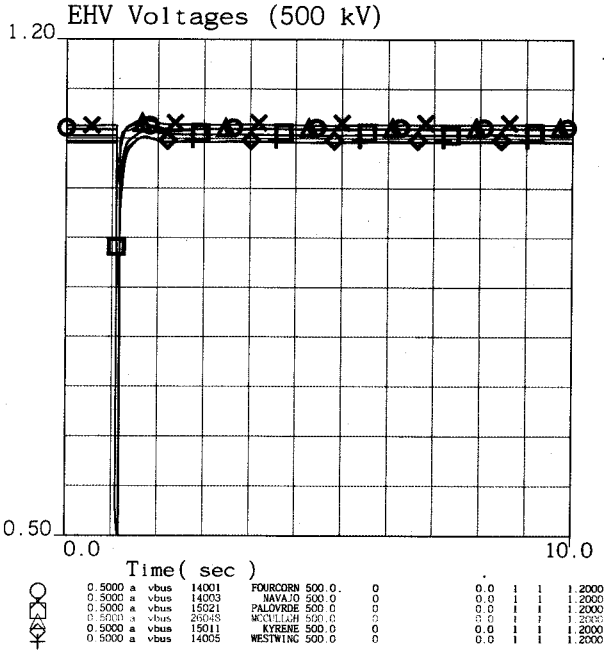
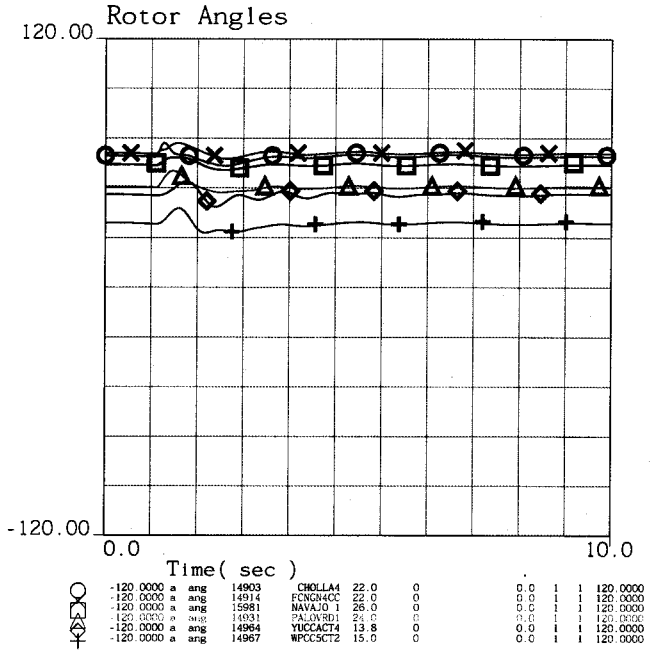
2018 HS – Ocotillo 620 MW Dispatch

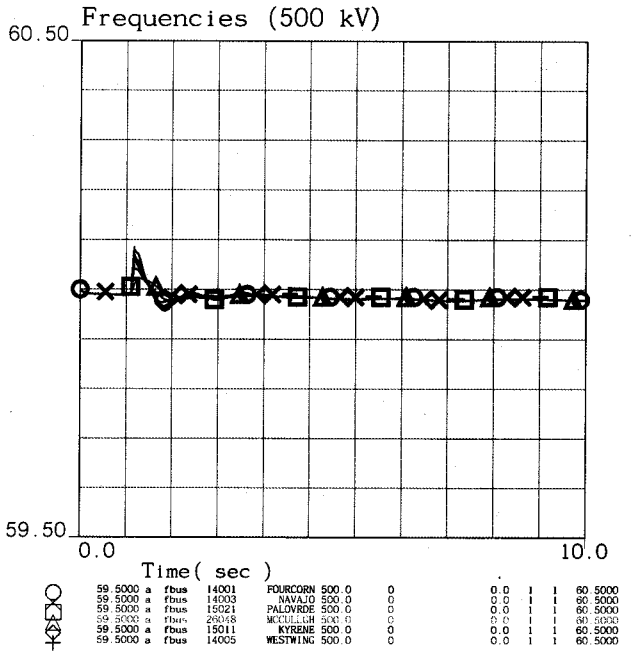
N-1 Contingencies

2018 Heavy Summer Detailed Planning Case









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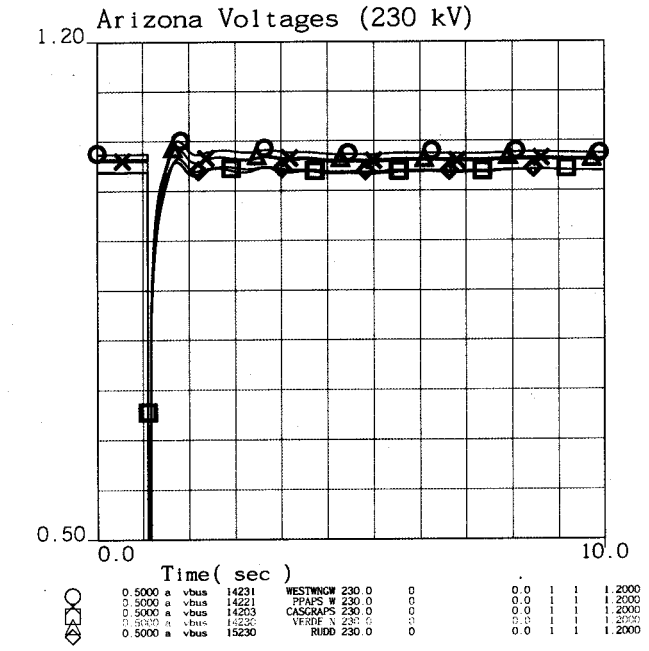
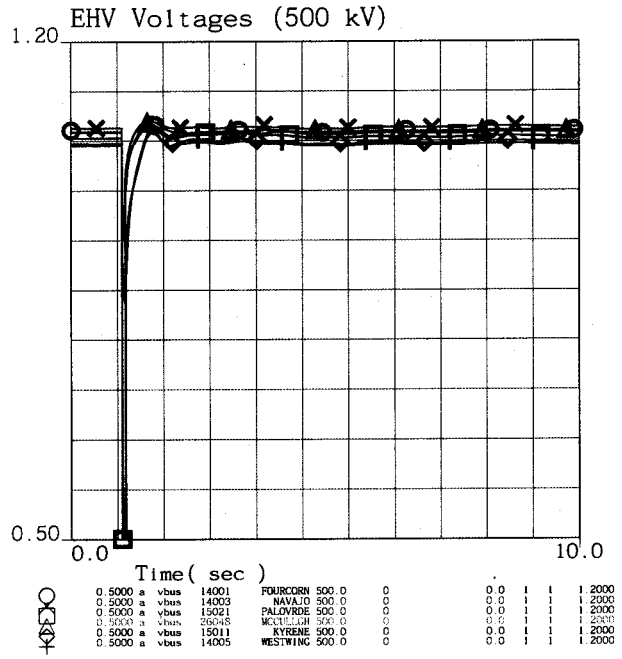
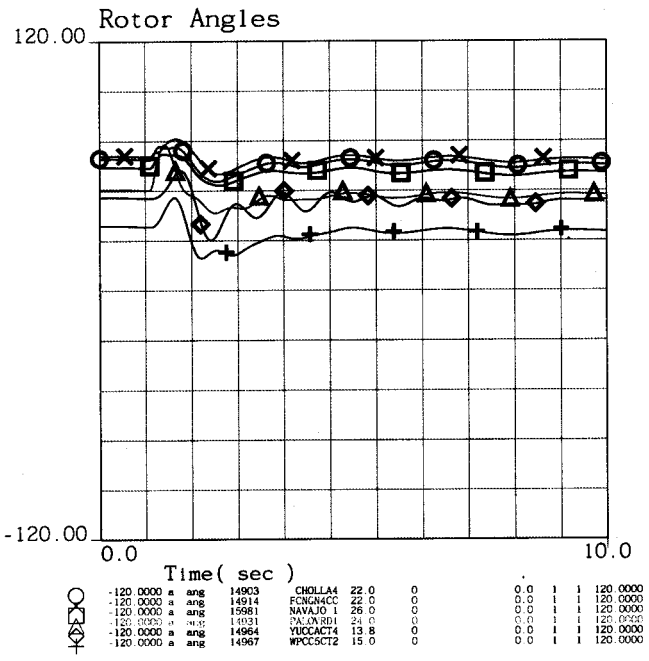
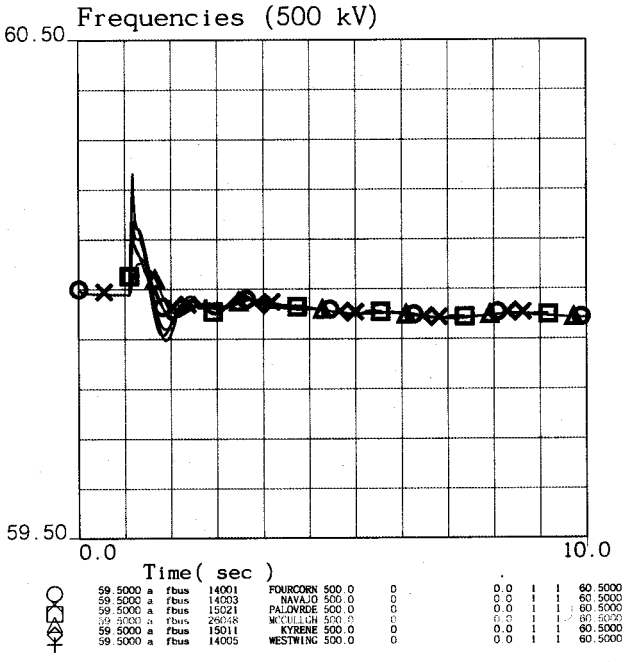
2018 Heavy Summer Detailed Planning Case









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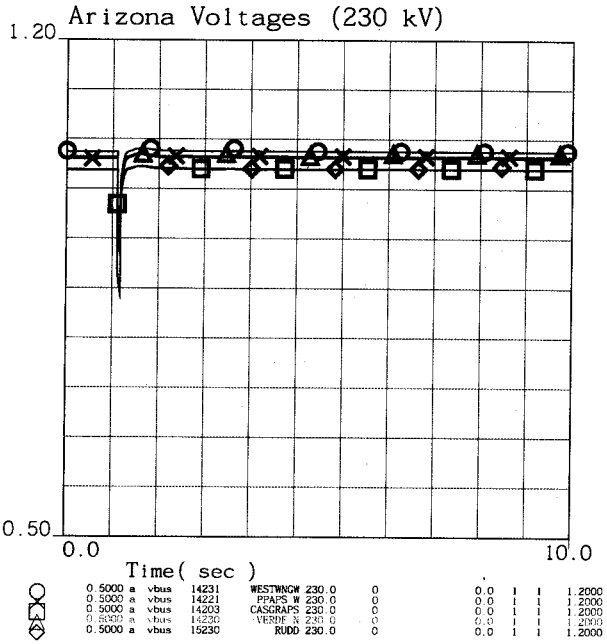
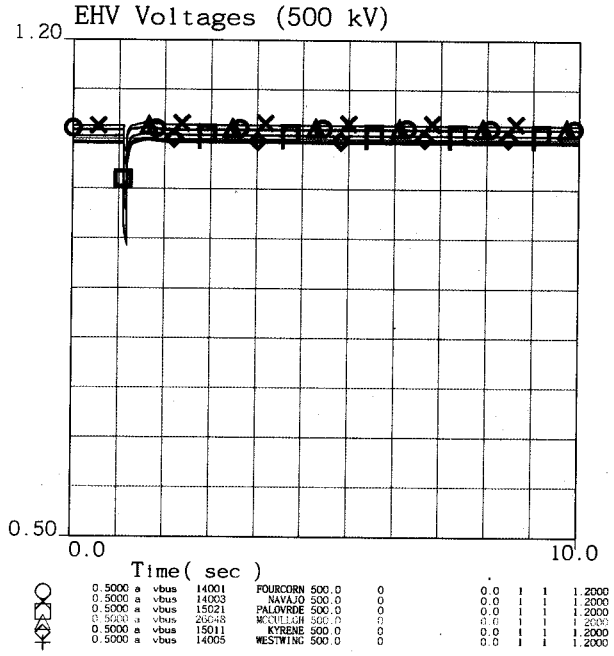
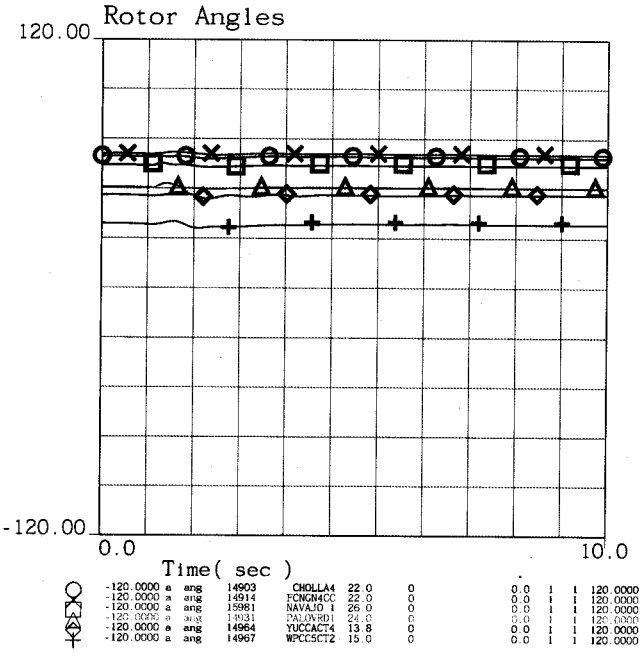
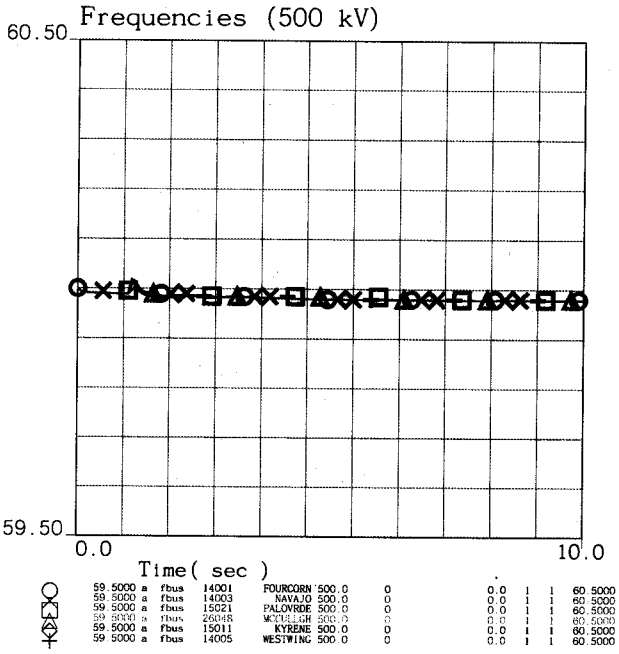
2018 Heavy Summer Detailed Planning Case









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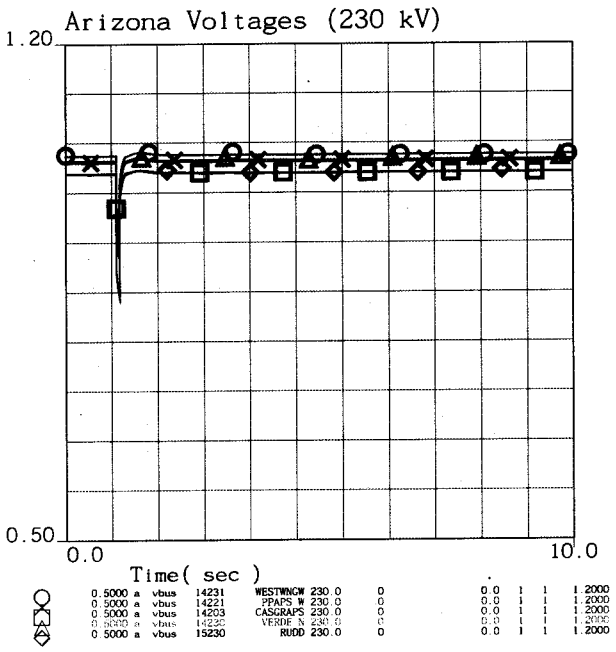
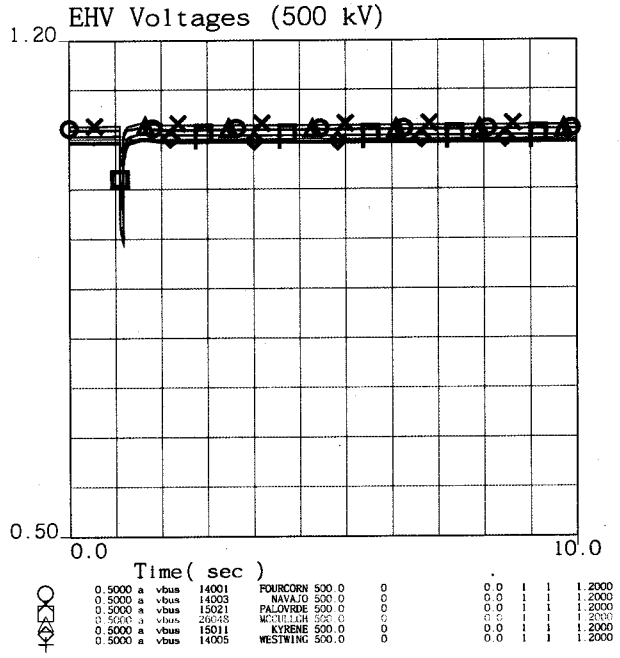
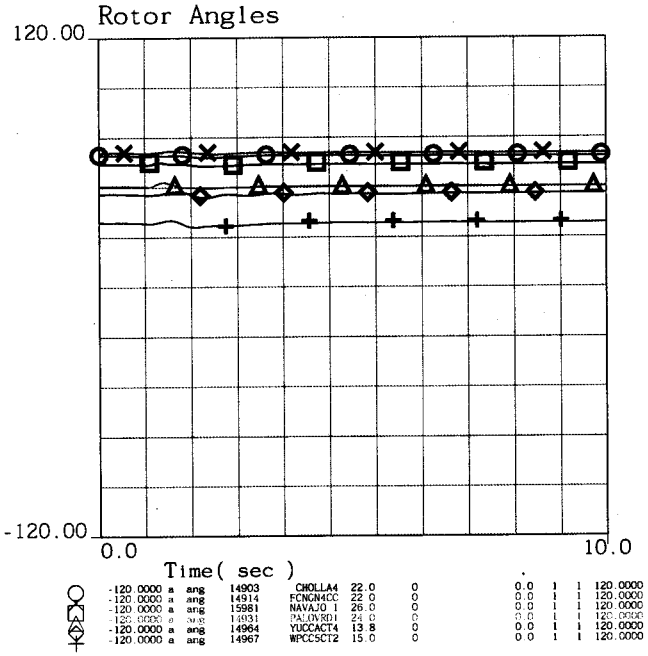
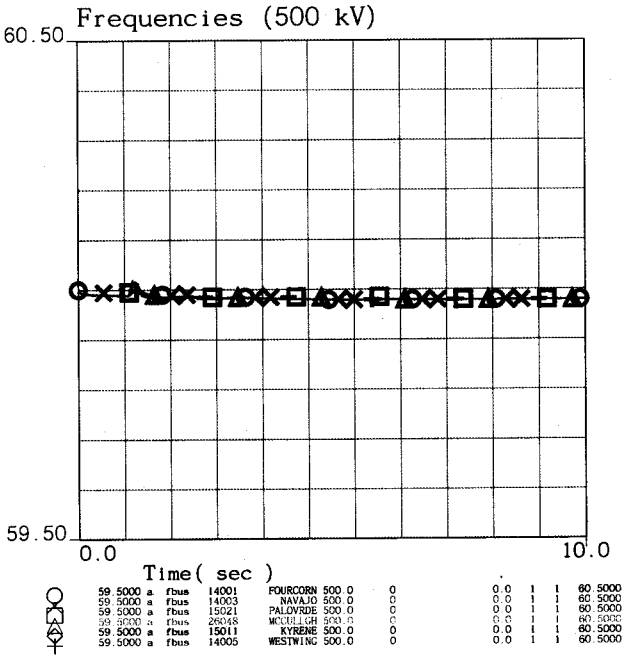
2018 Heavy Summer Detailed Planning Case









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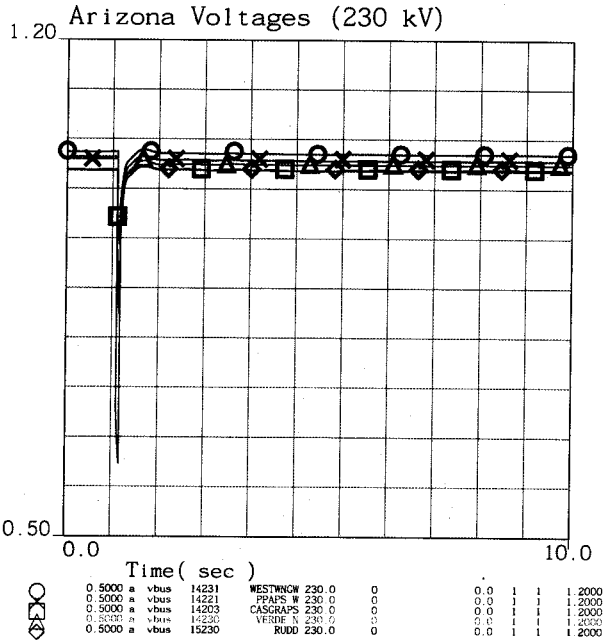
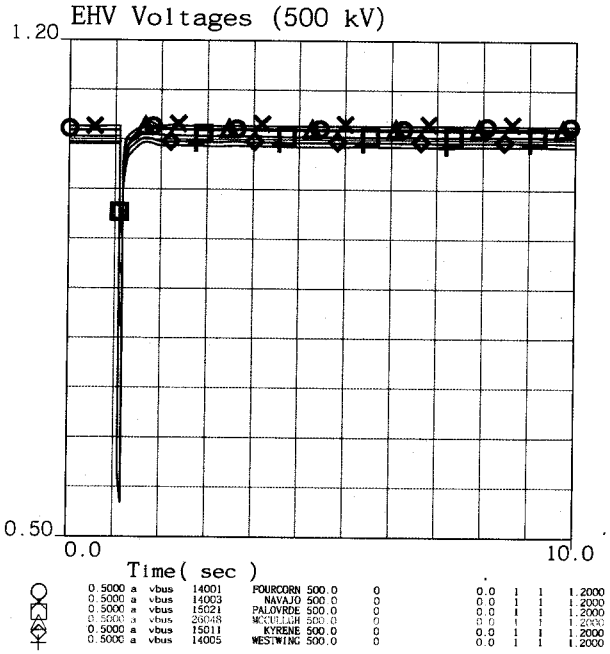
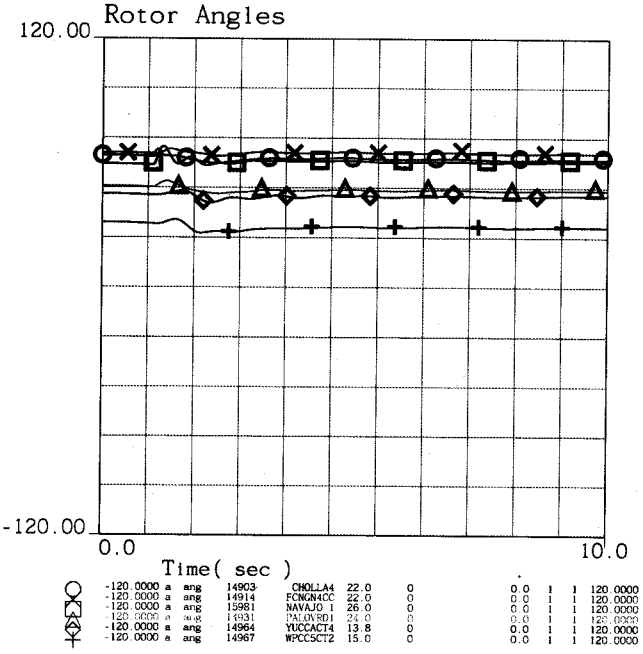
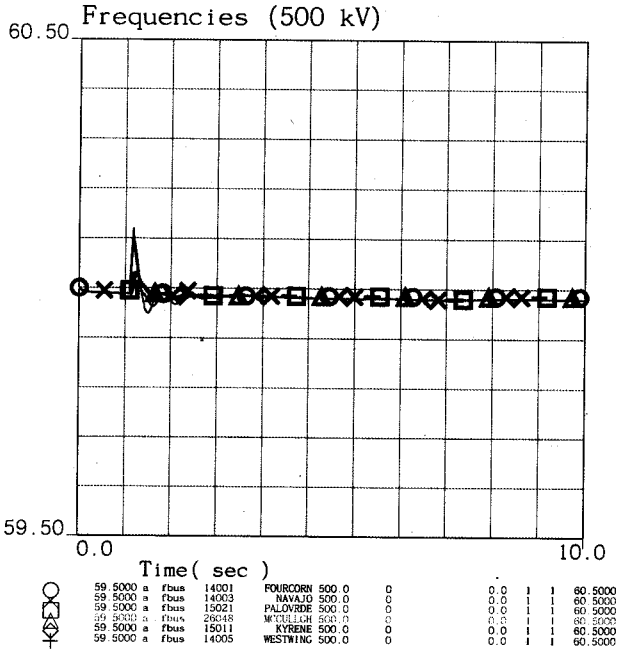
2018 Heavy Summer Detailed Planning Case









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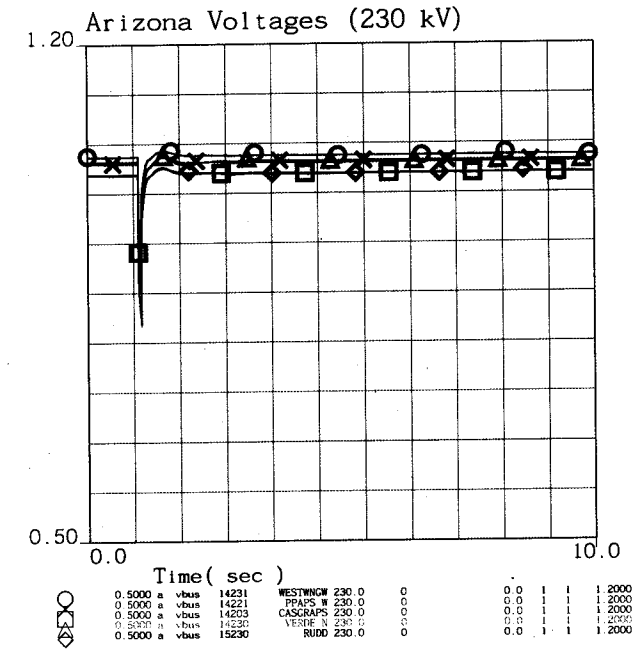
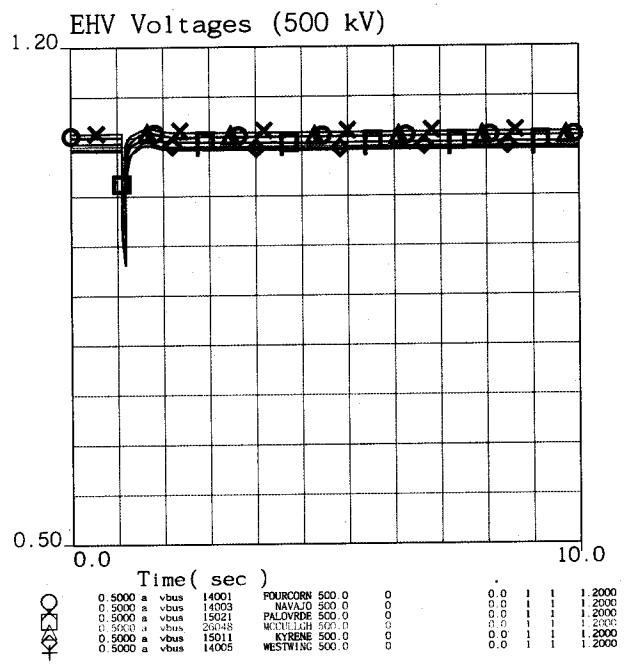
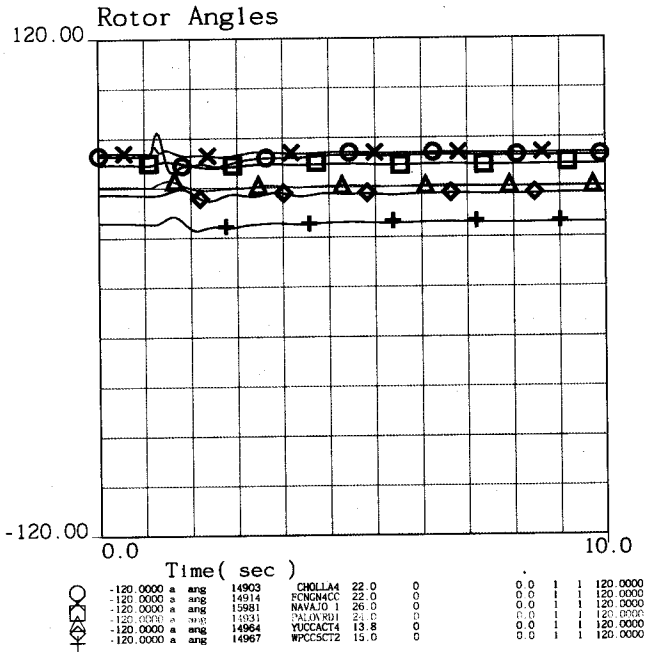
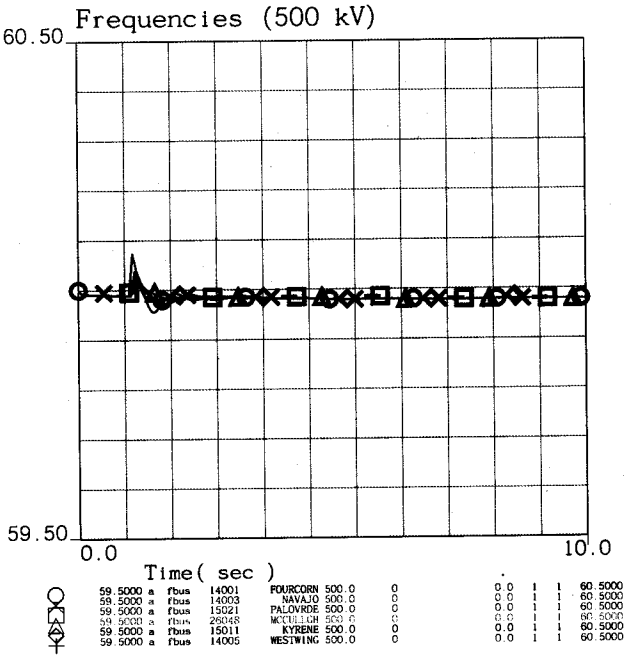
2018 Heavy Summer Detailed Planning Case









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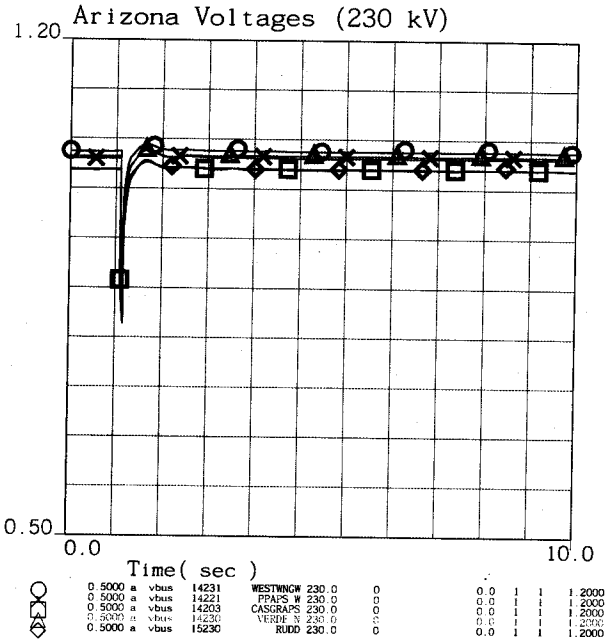
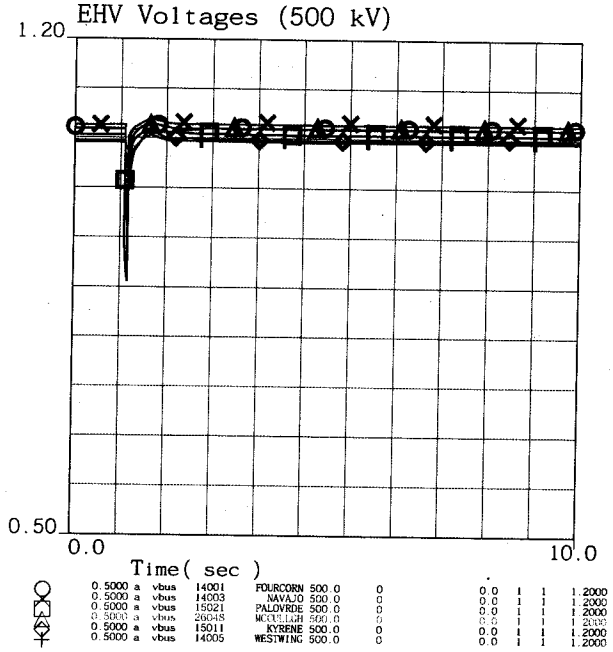
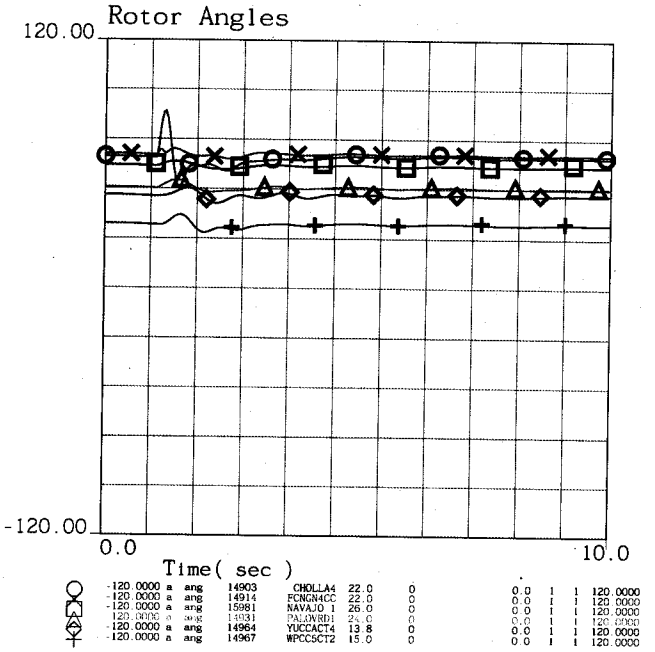
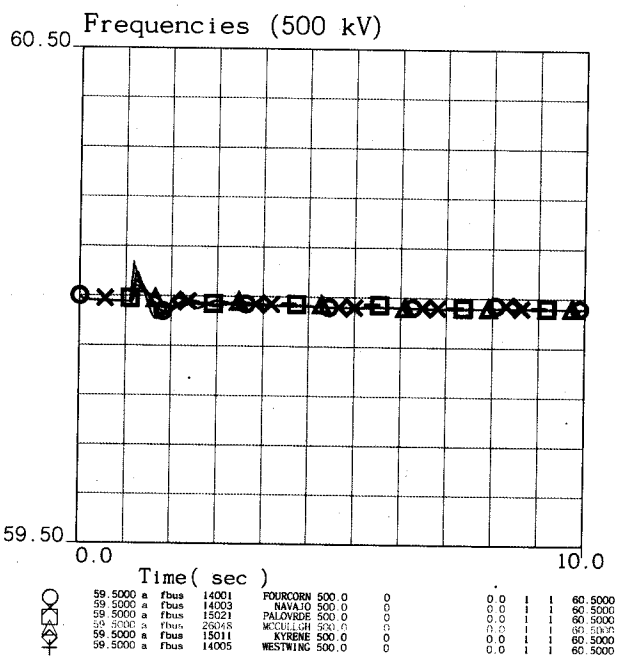
2018 Heavy Summer Detailed Planning Case









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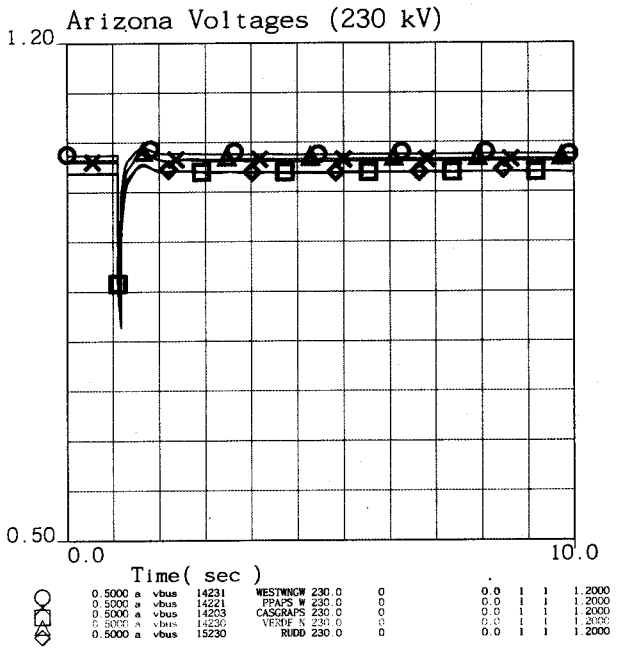

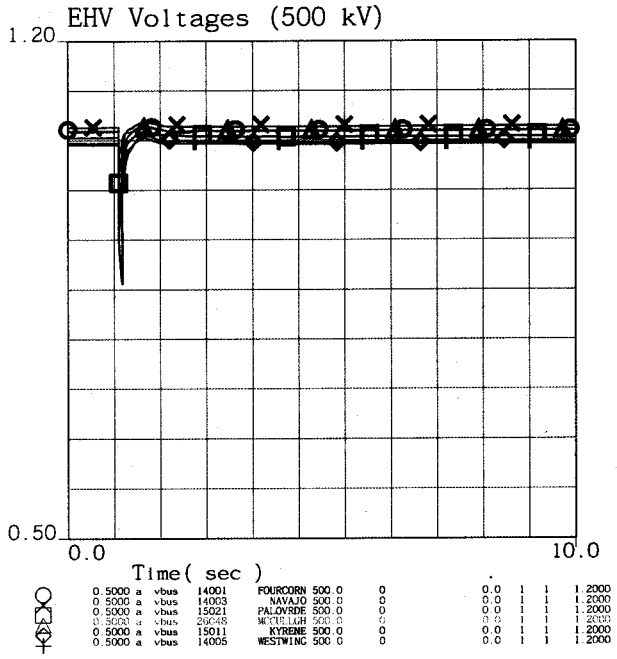

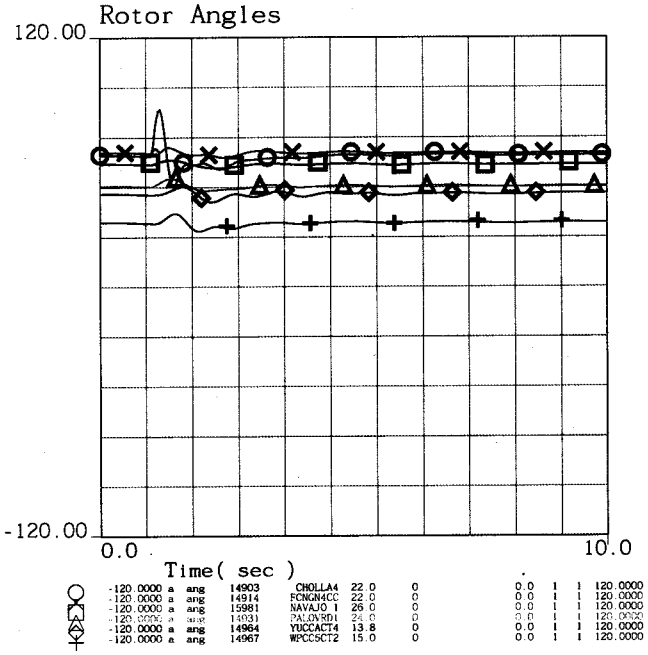

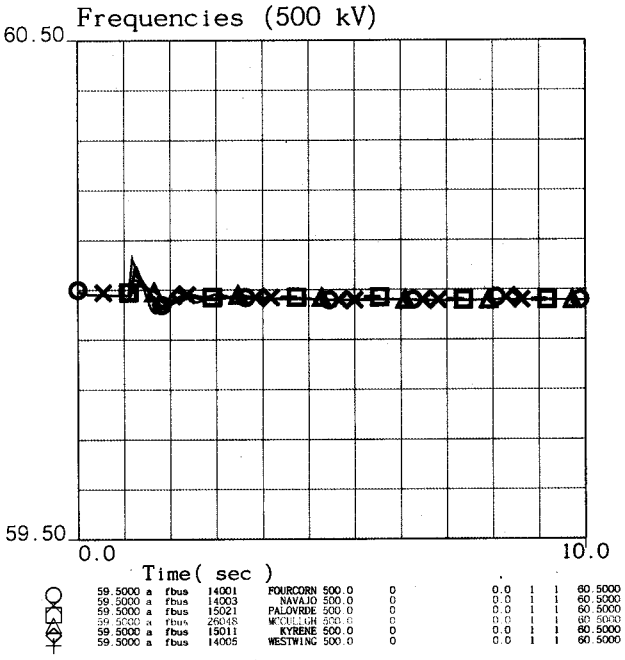

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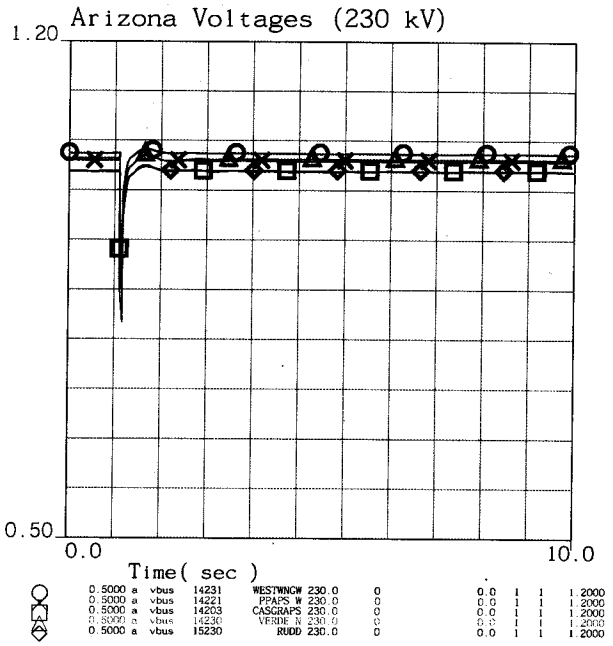
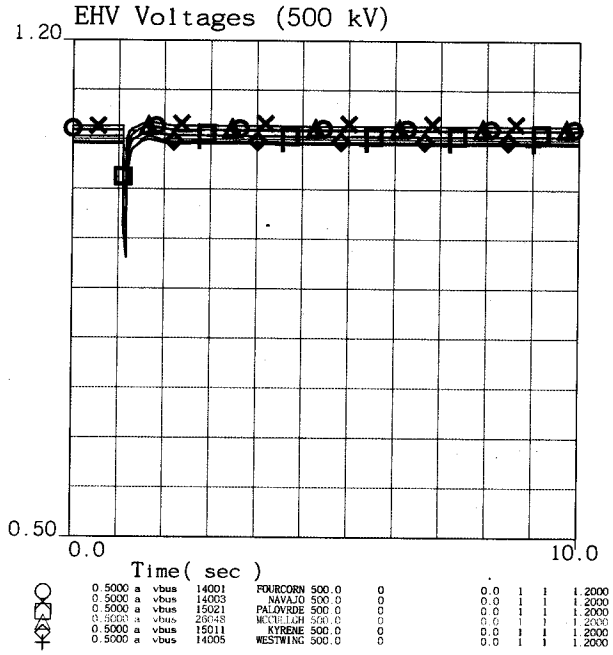
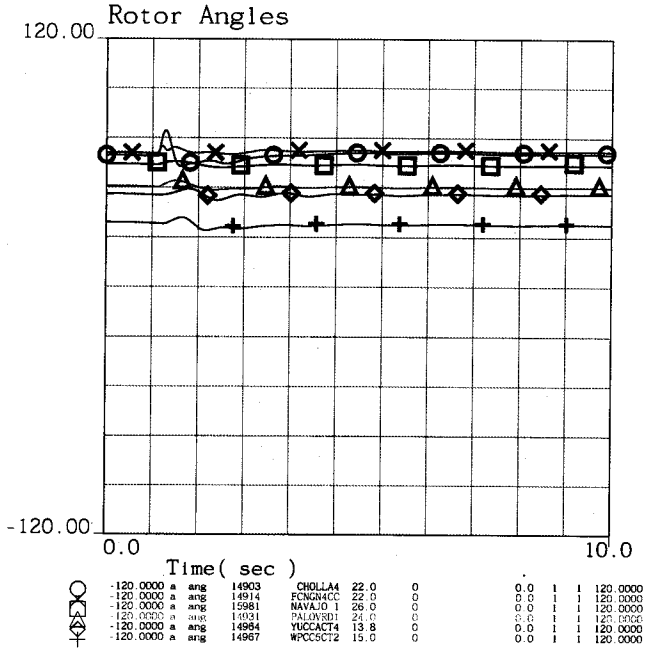
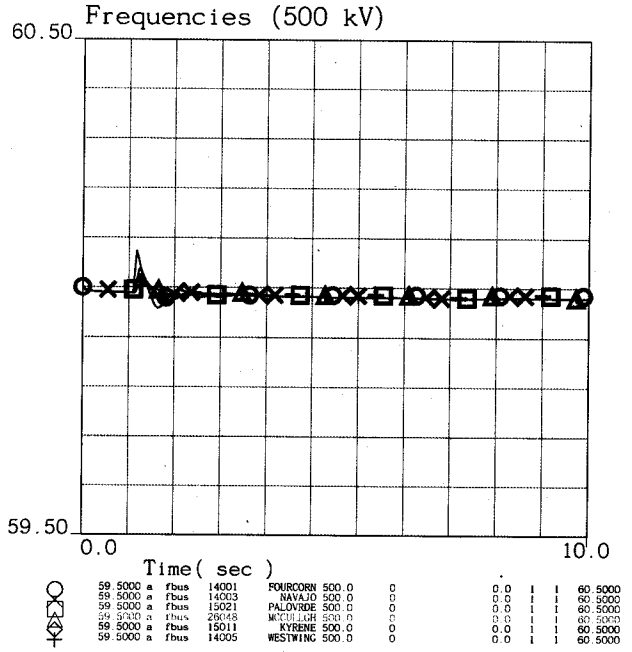
2018 Heavy Summer Detailed Planning Case









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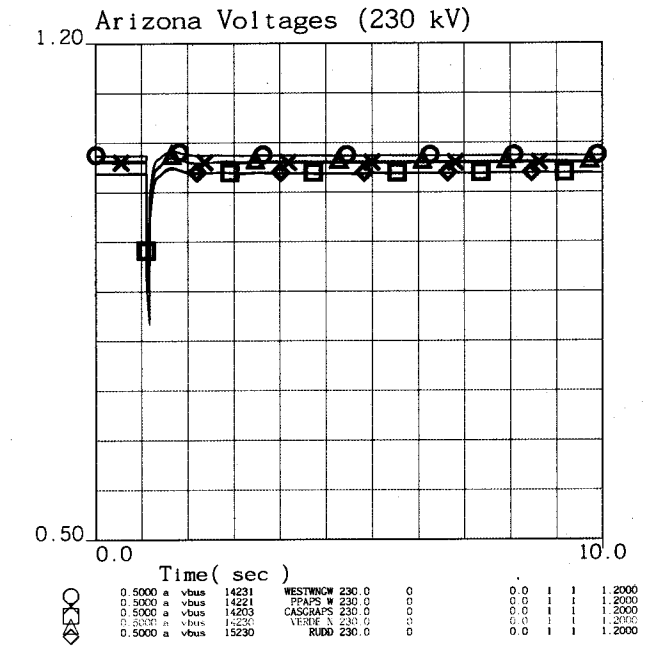
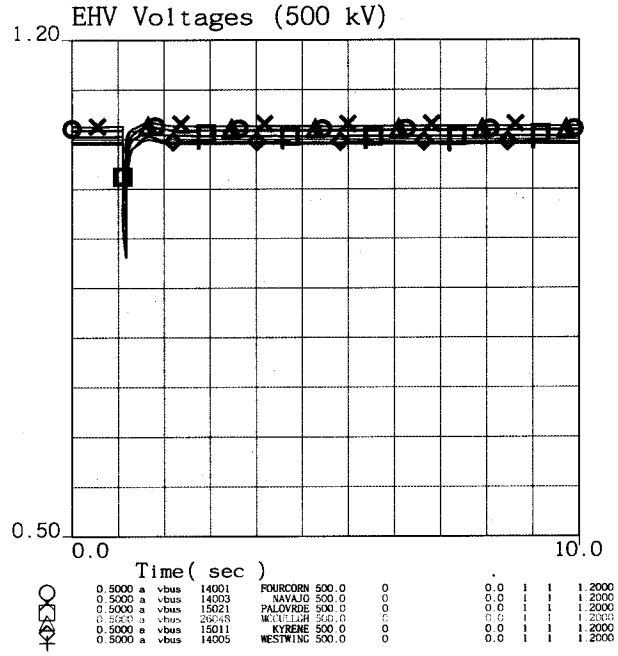
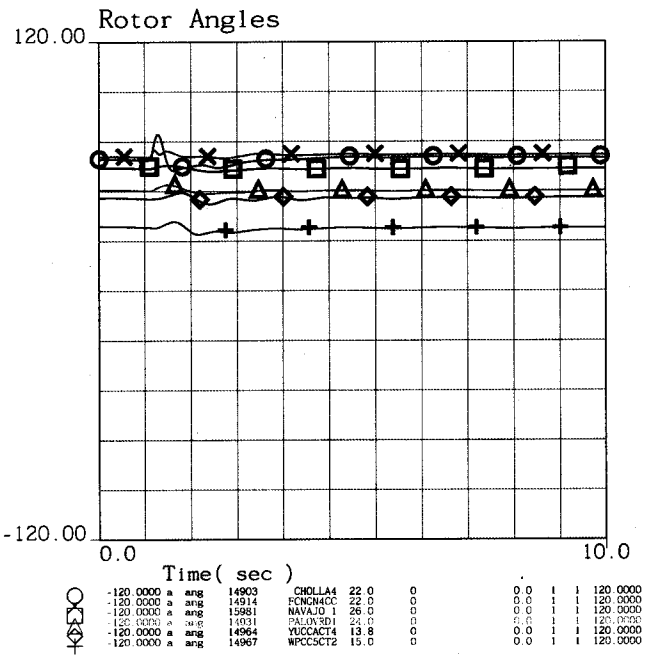
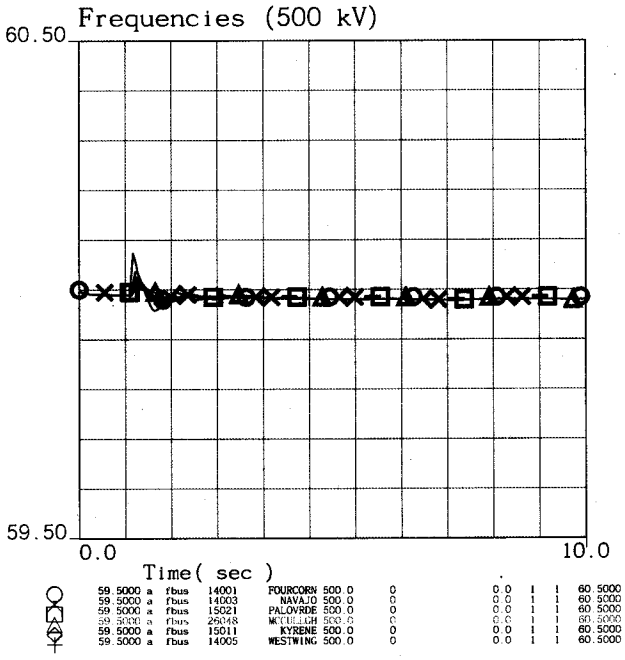
2018 Heavy Summer Detailed Planning Case









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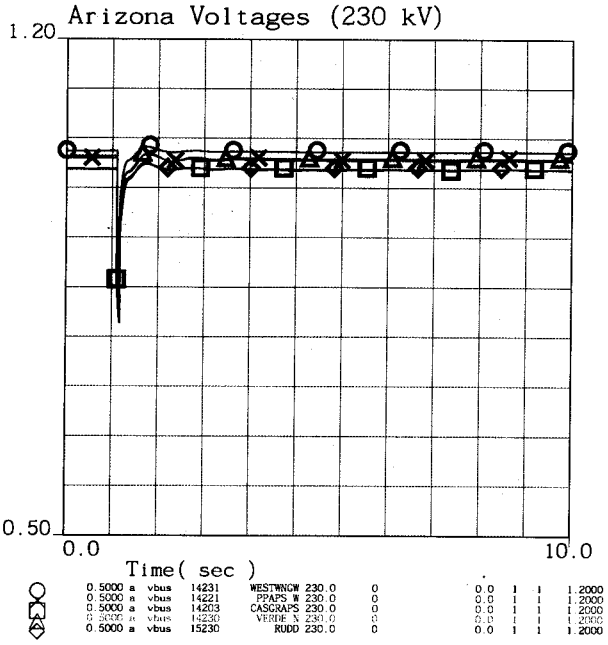

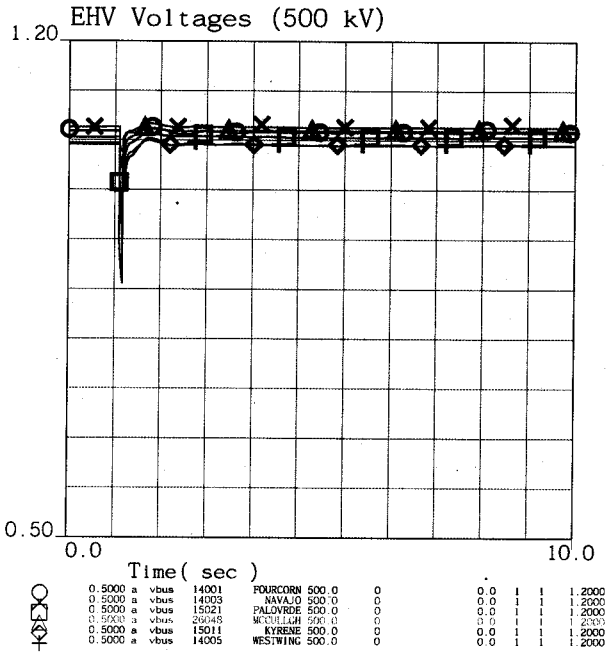

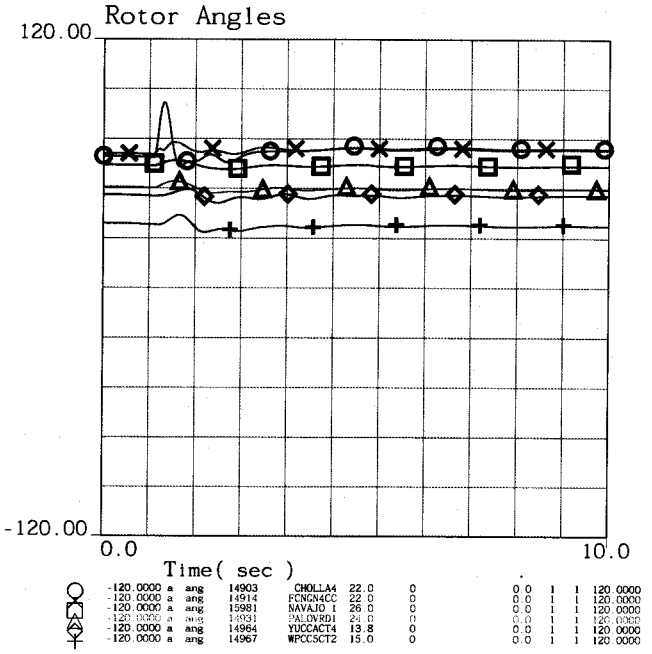

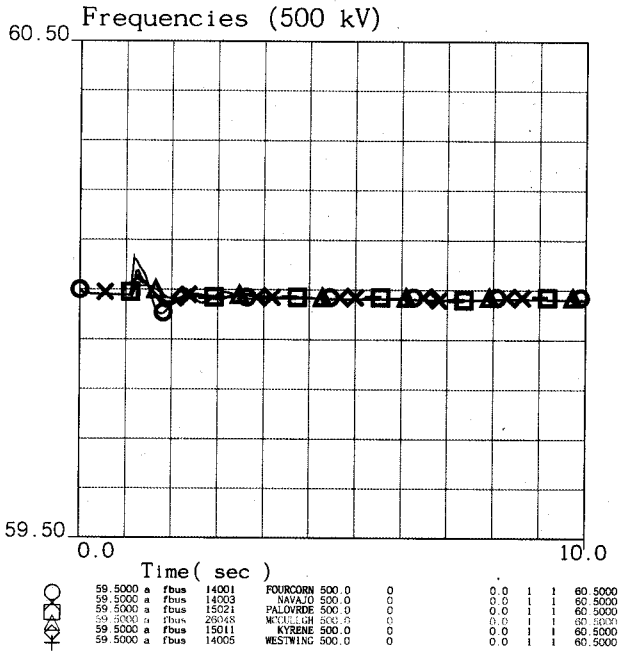

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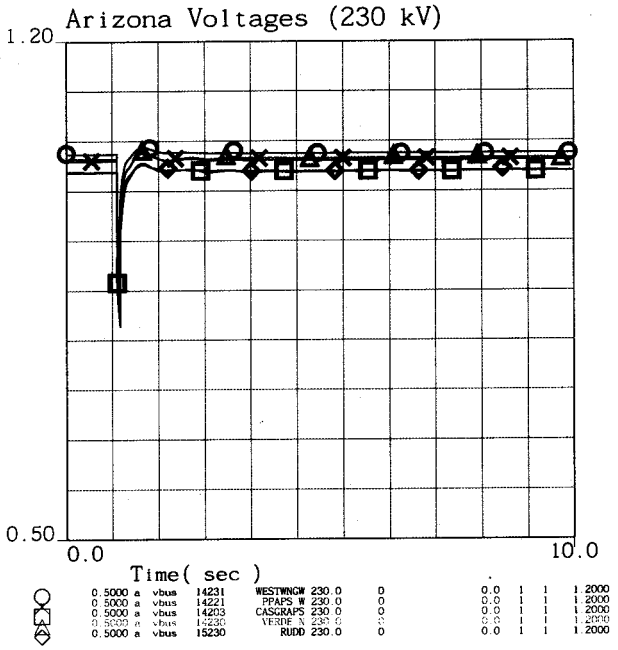

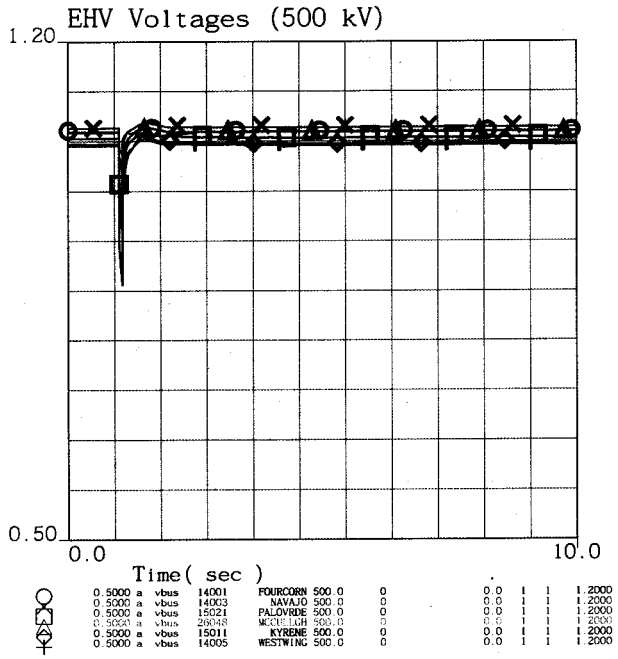

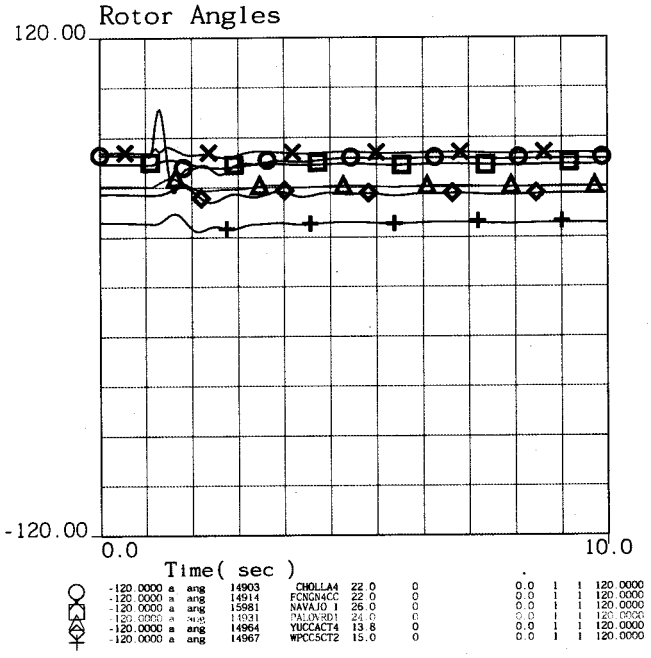

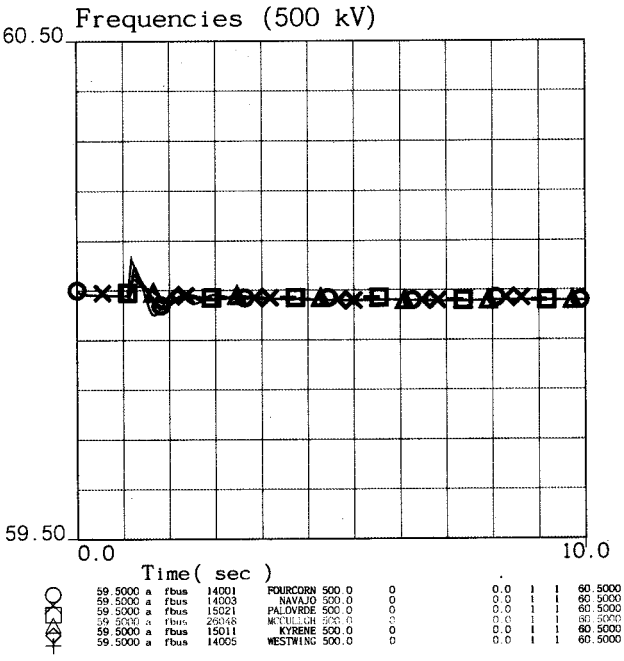

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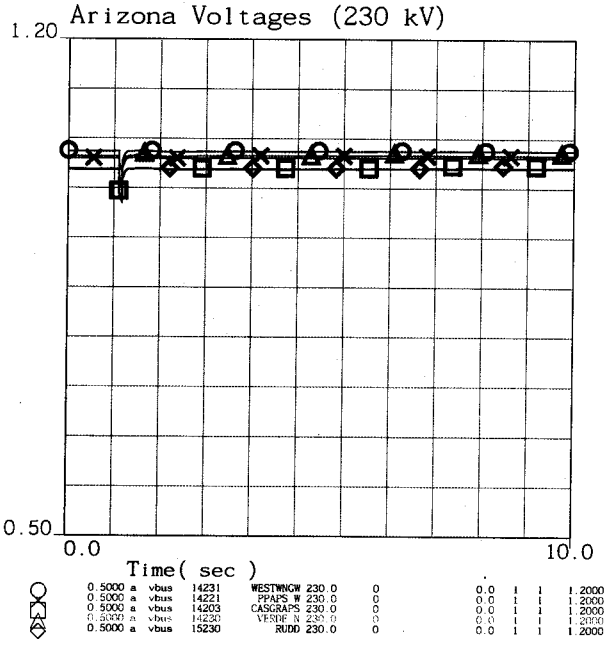

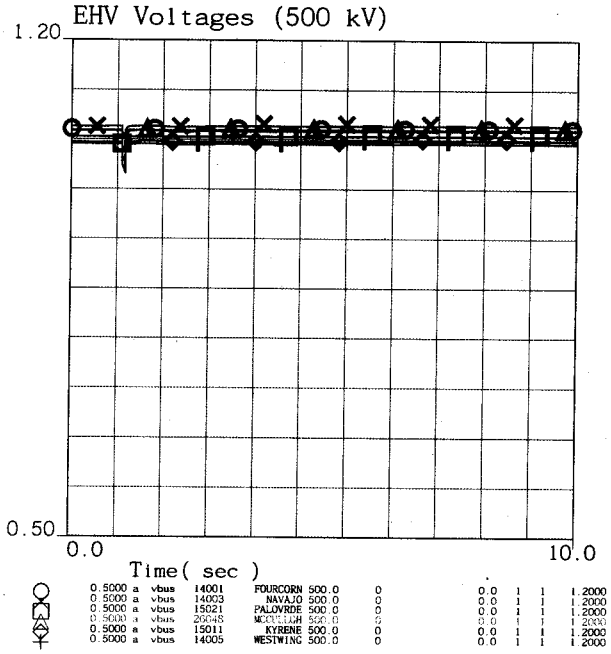

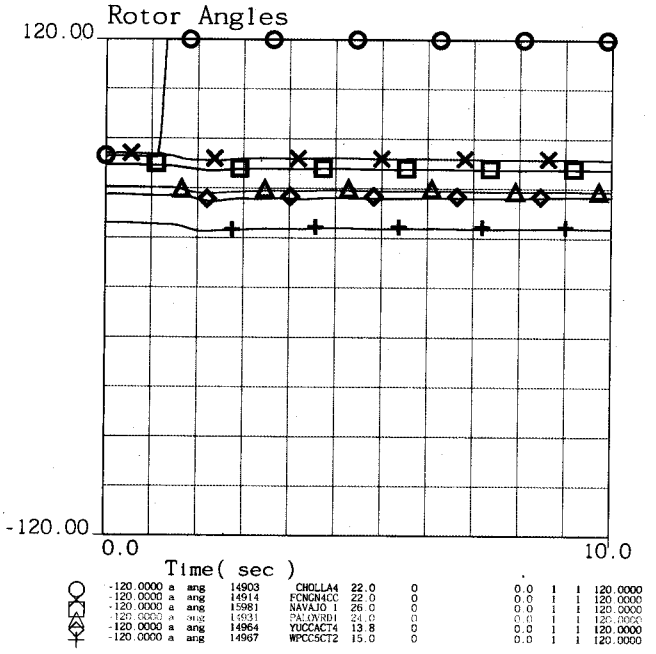

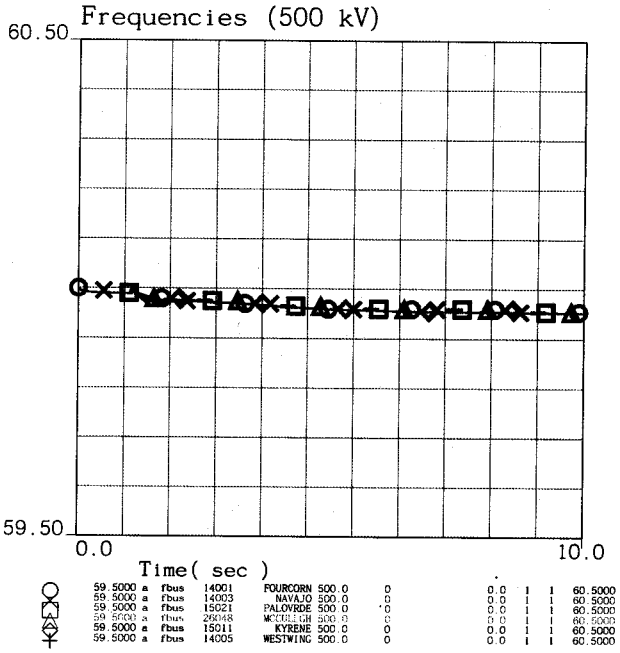

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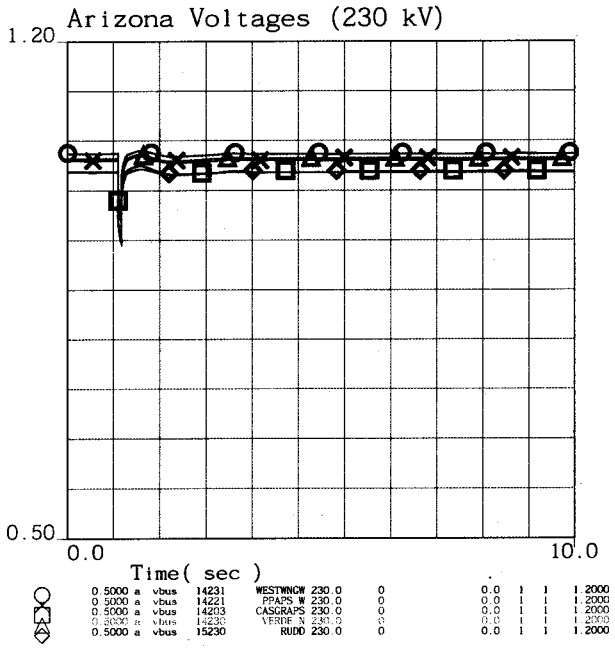

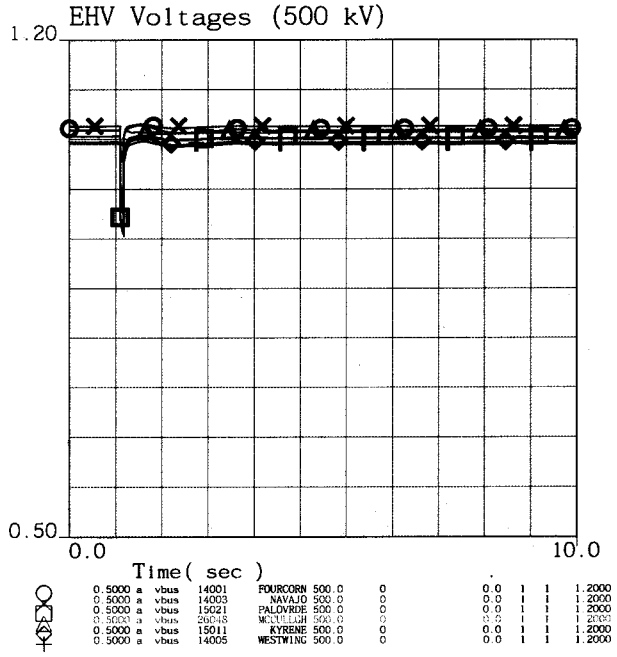

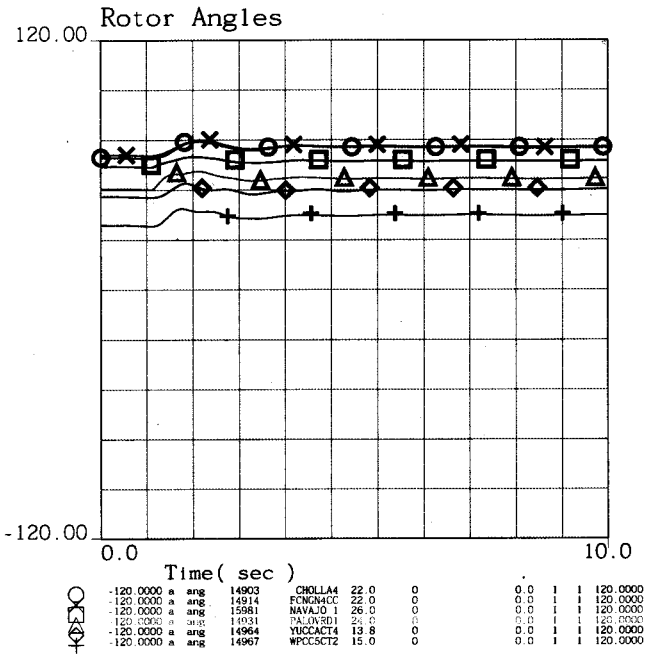

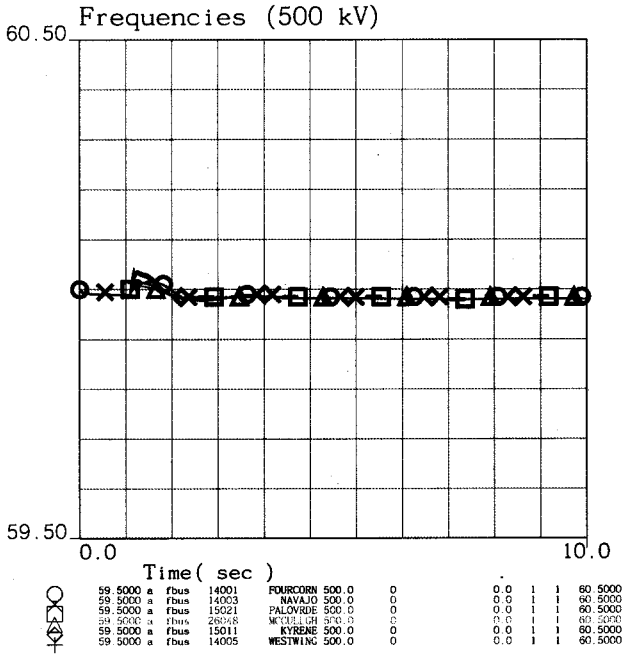

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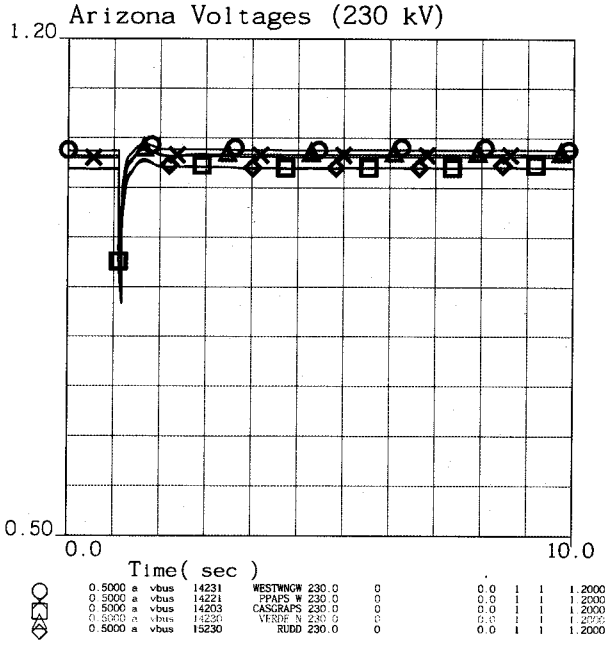
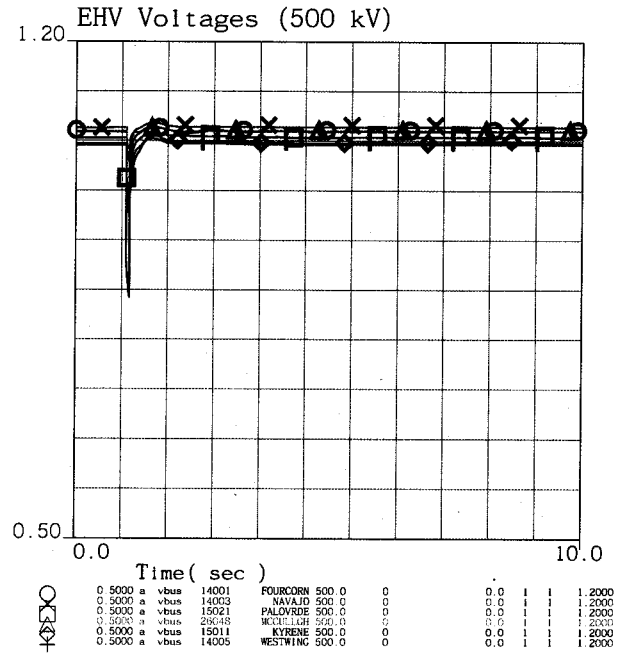
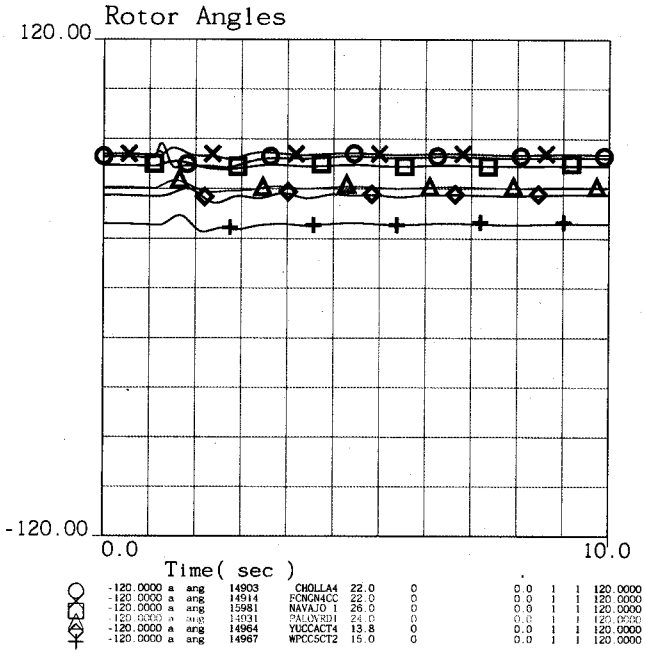
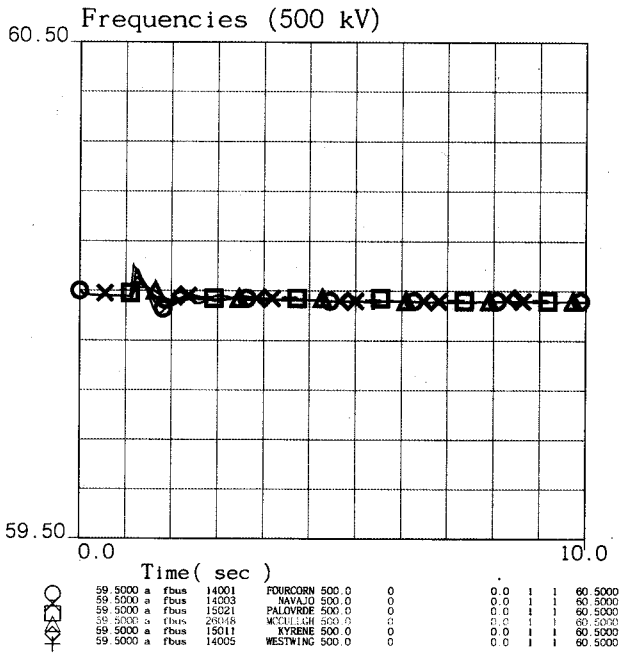
2018 Heavy Summer Detailed Planning Case









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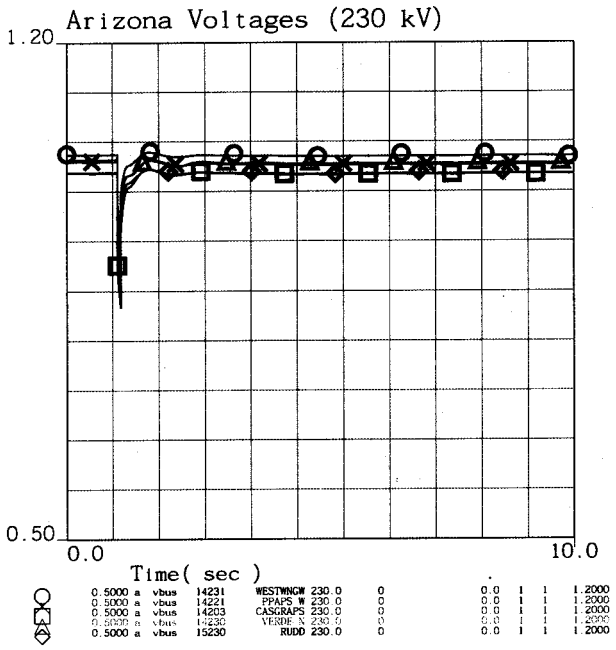

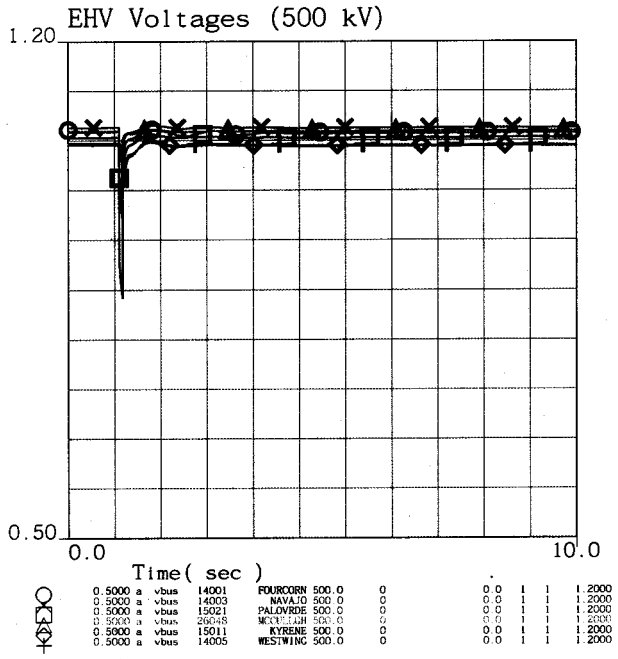

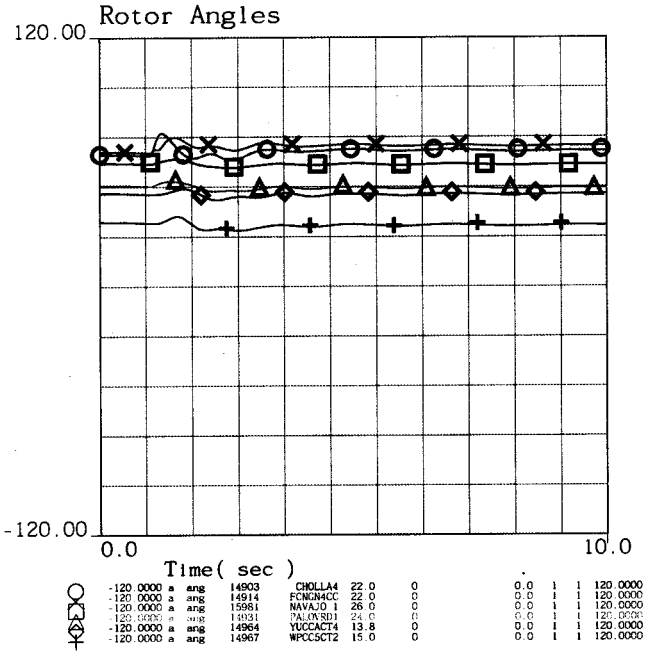

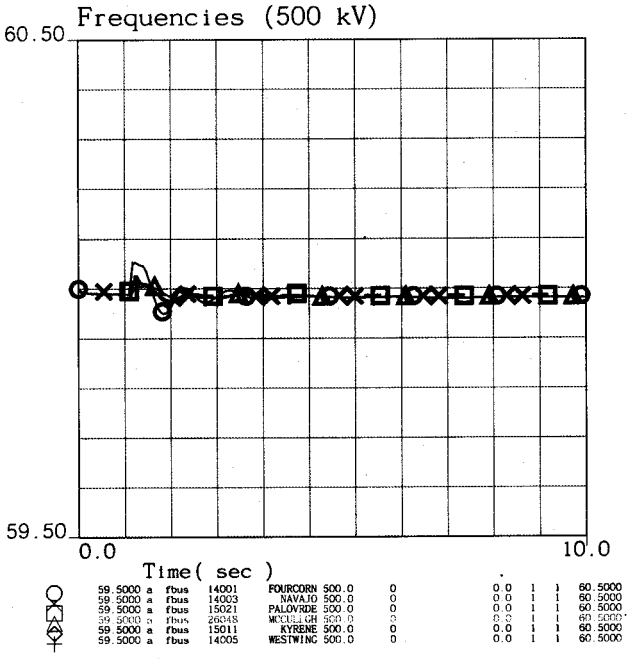

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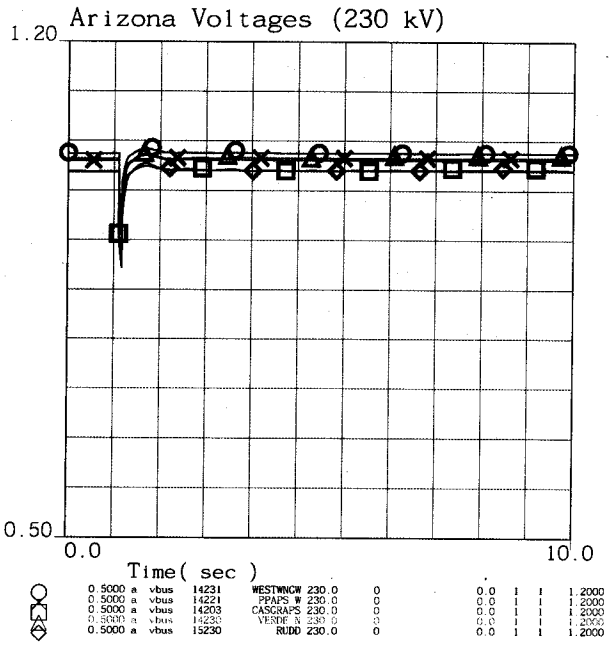

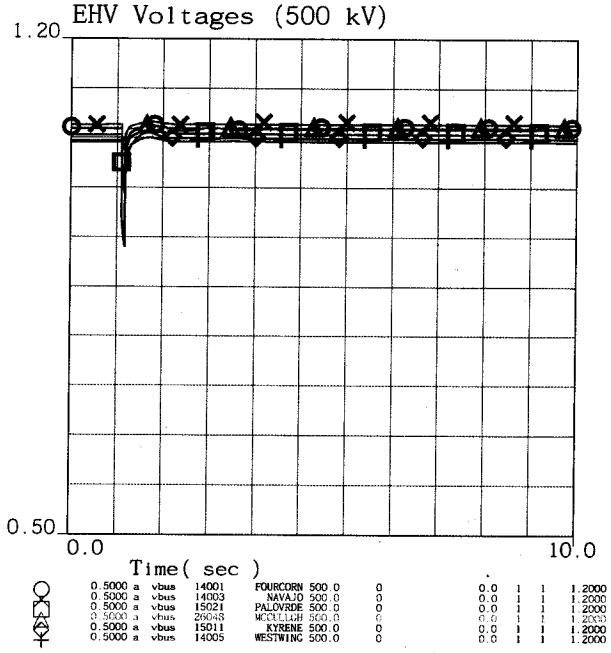

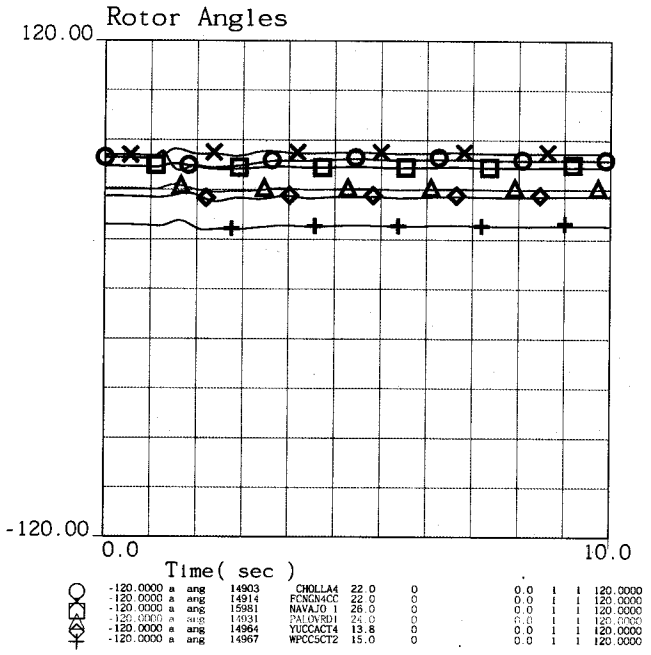

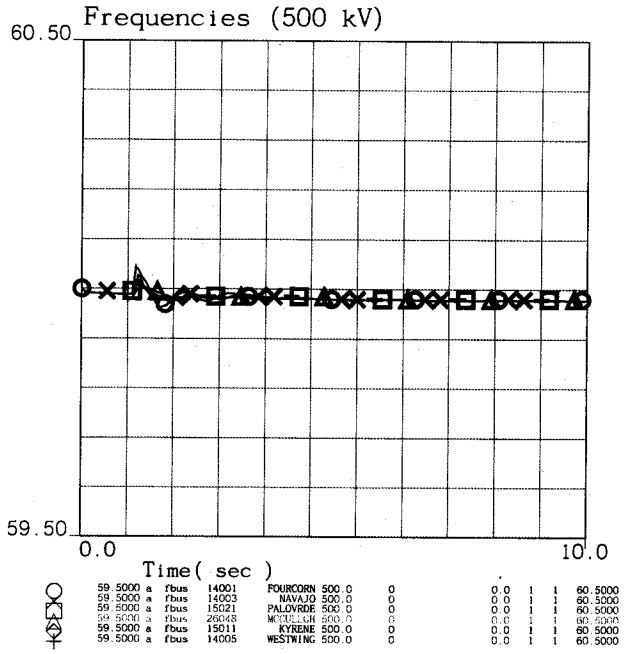

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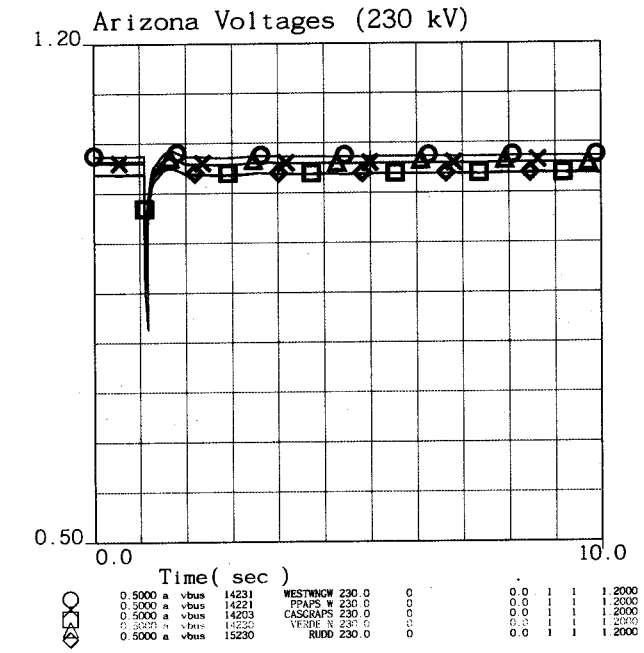

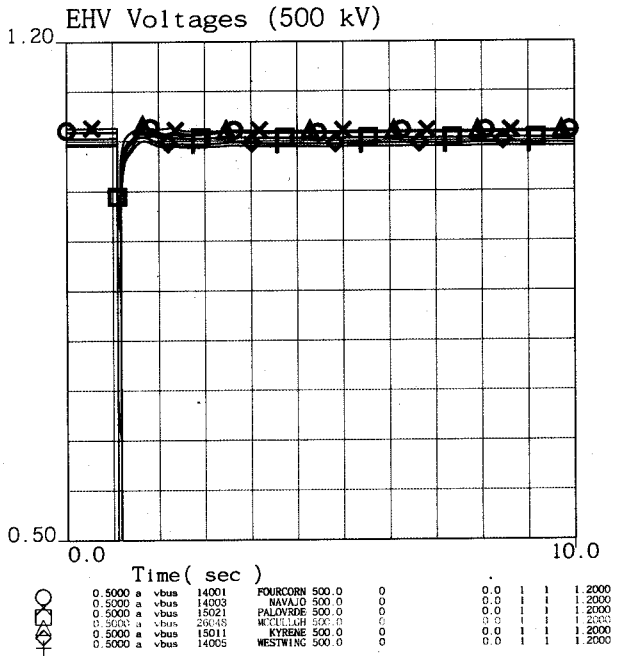

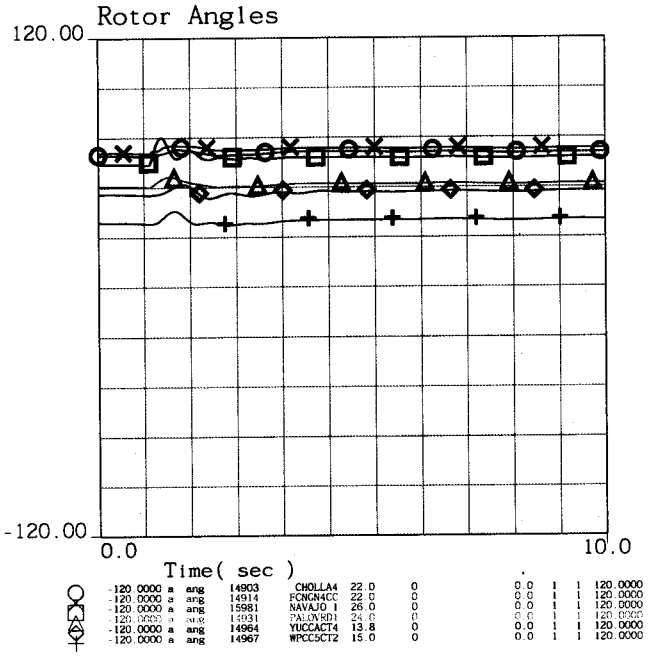

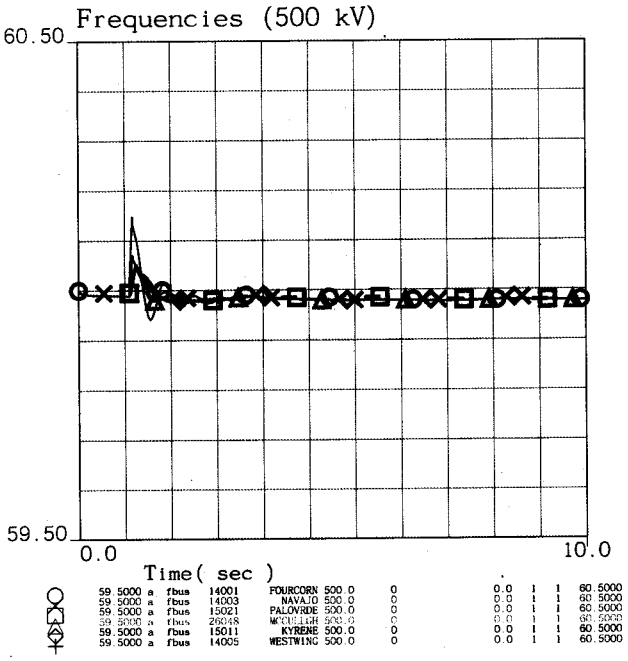

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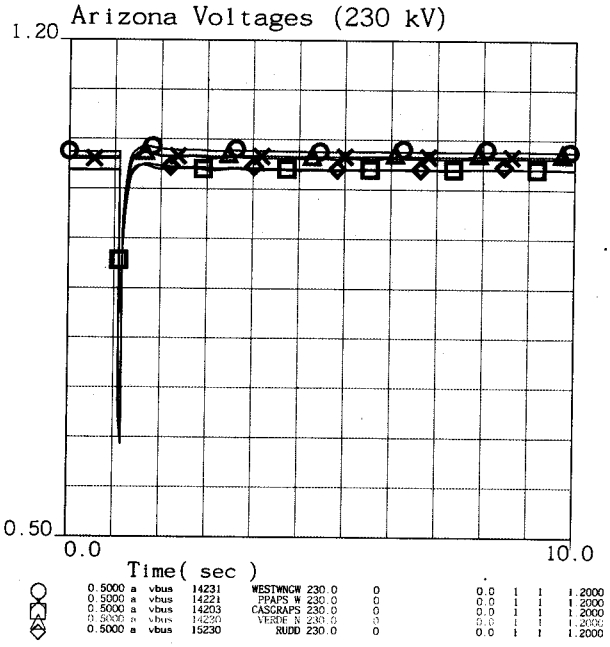

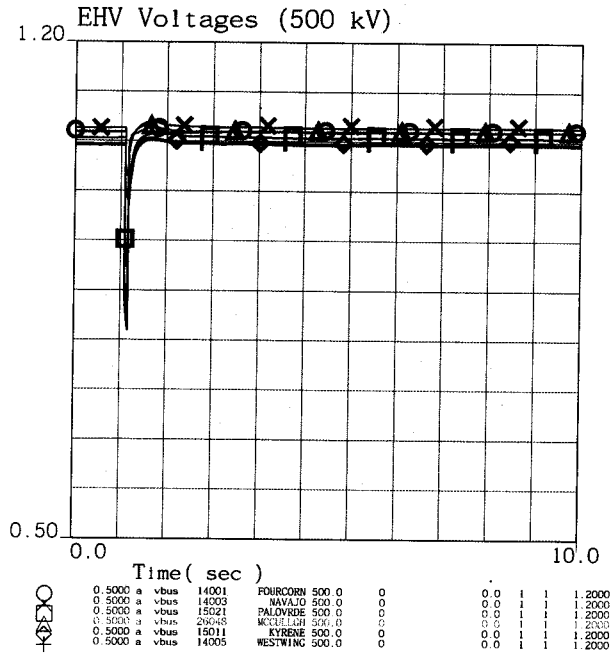

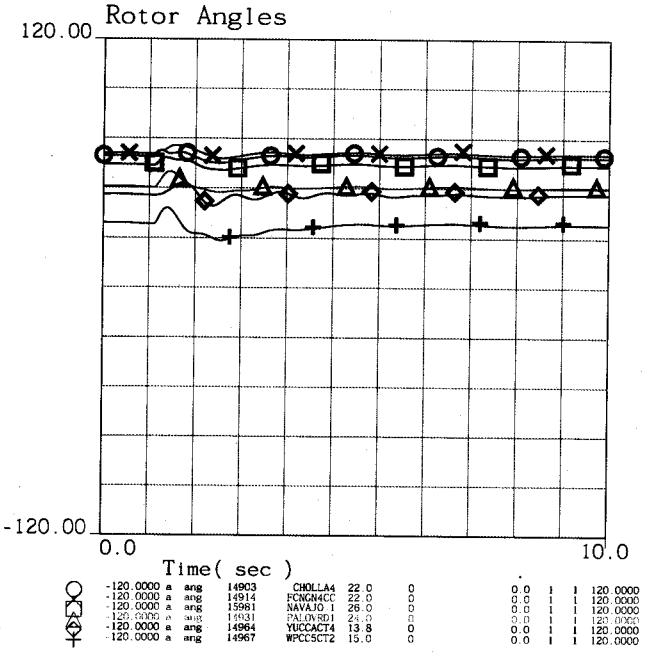

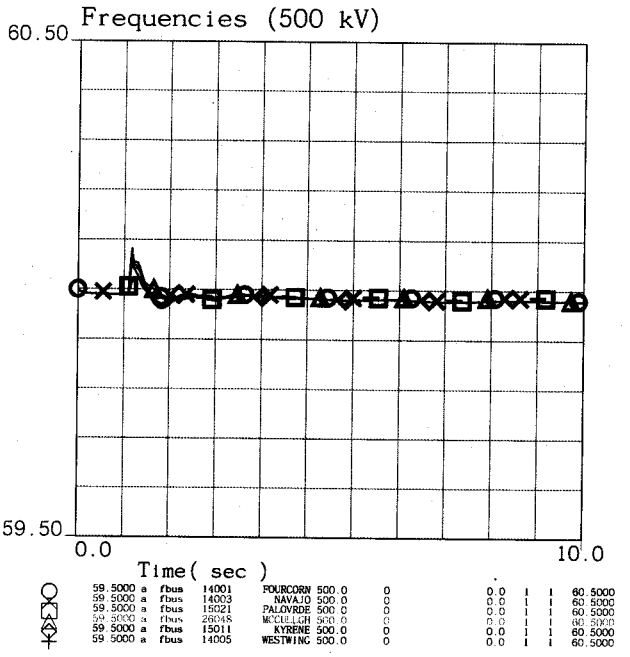

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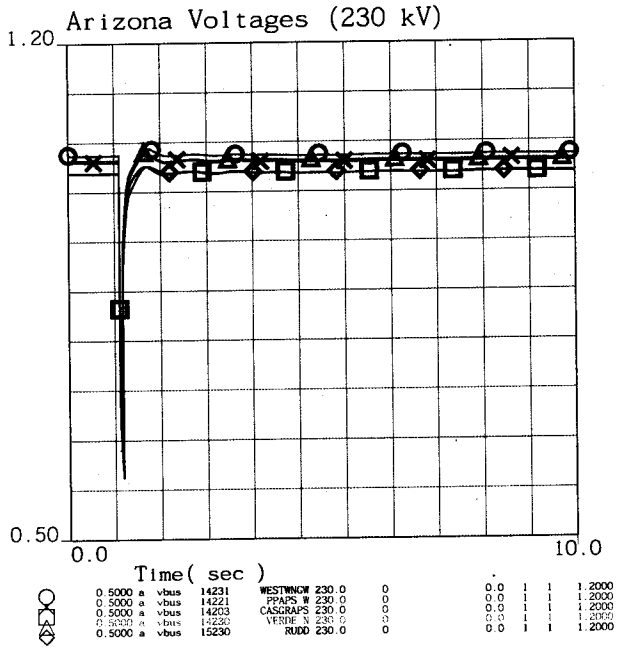

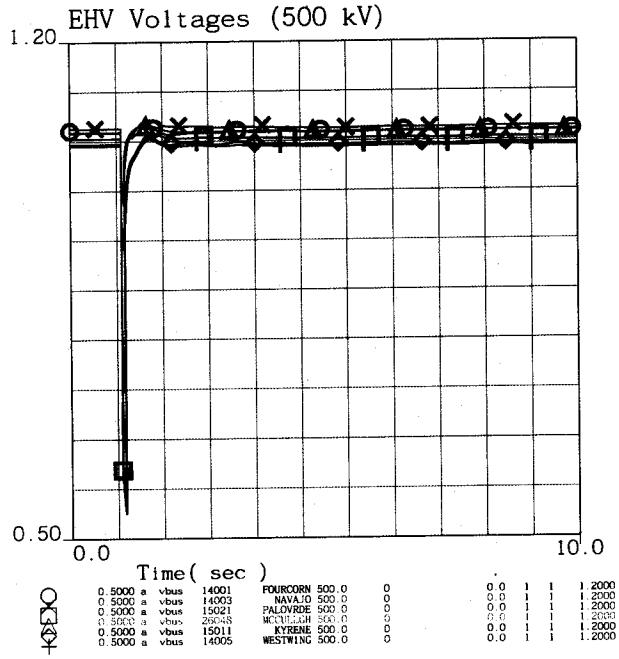

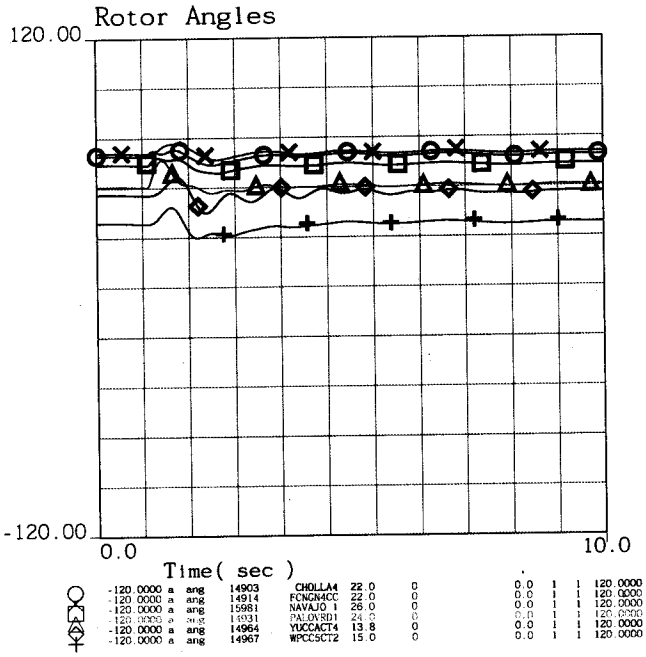

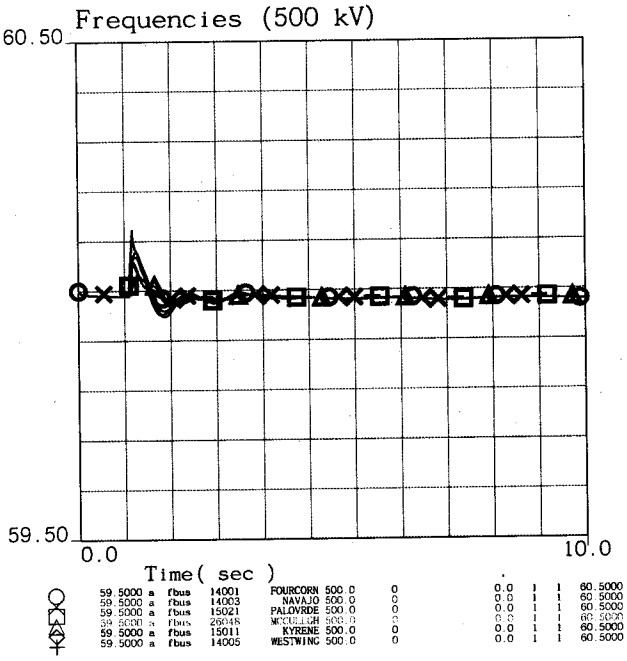

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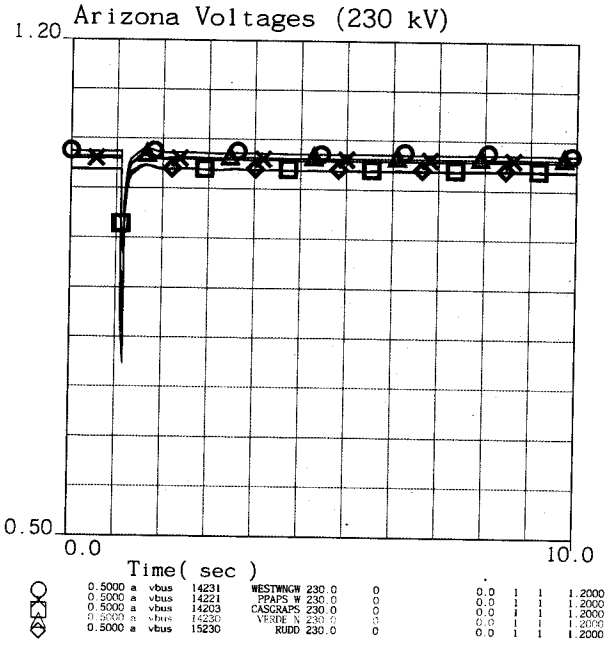

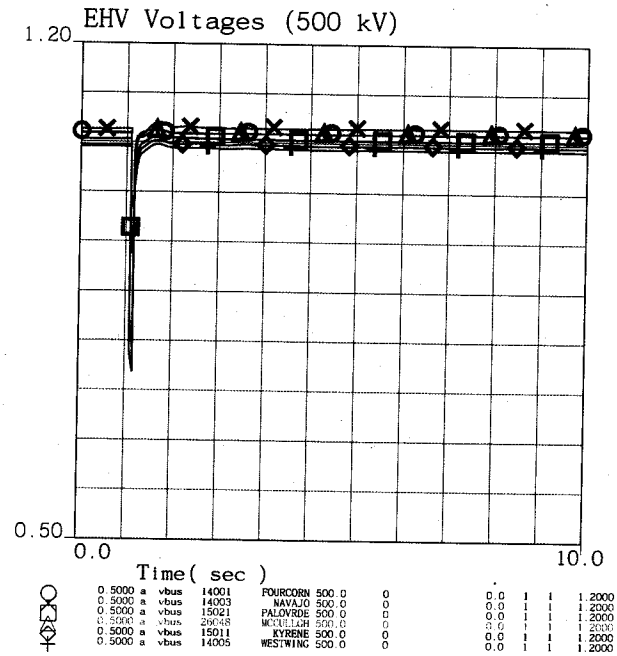

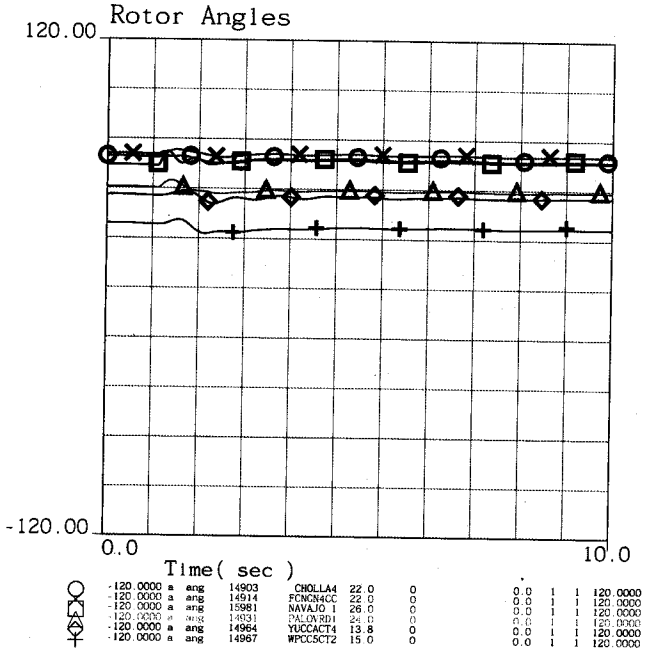

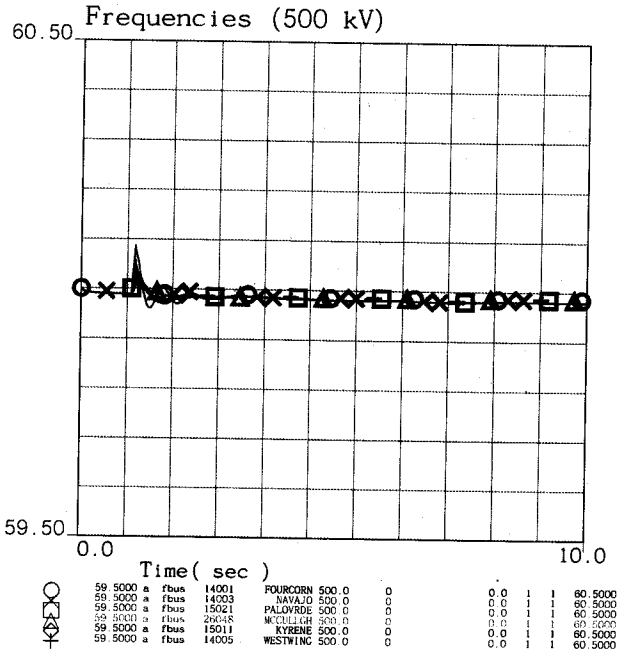

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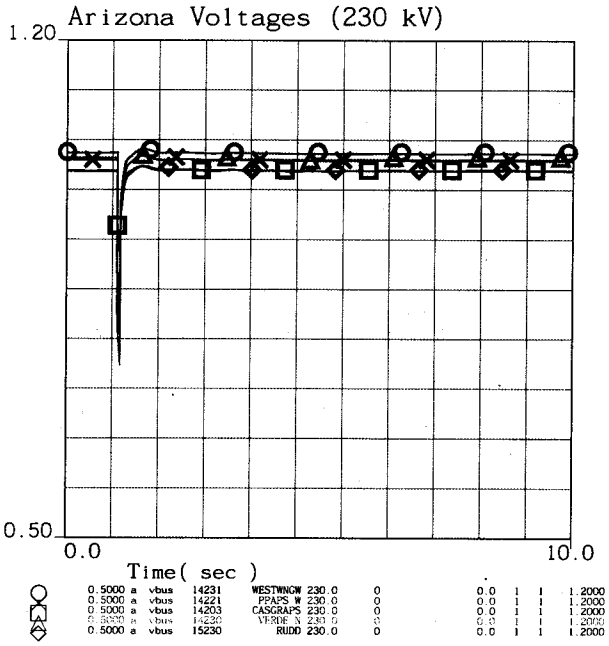

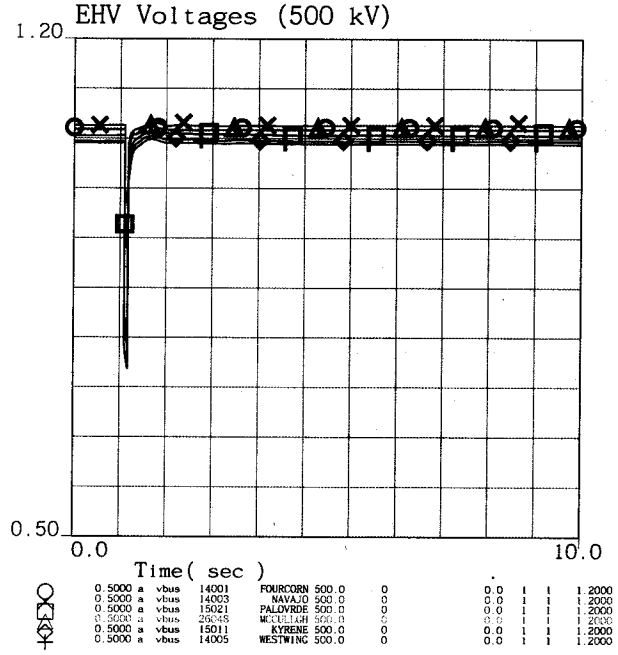

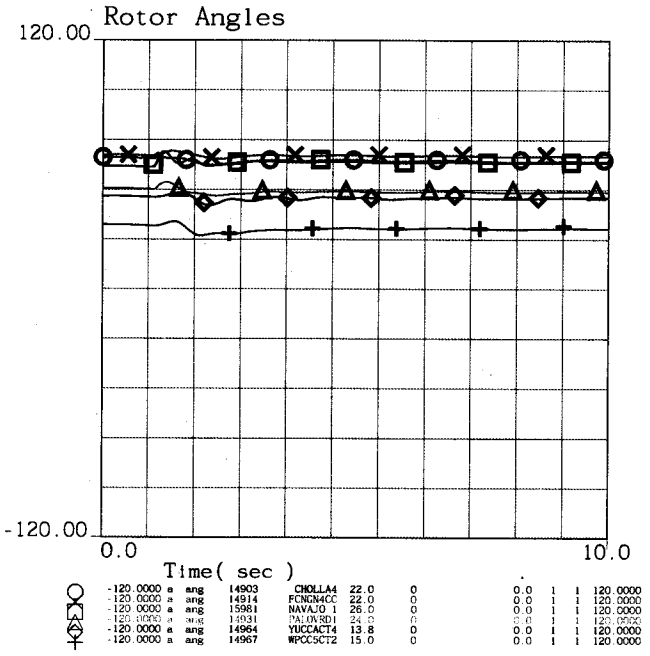

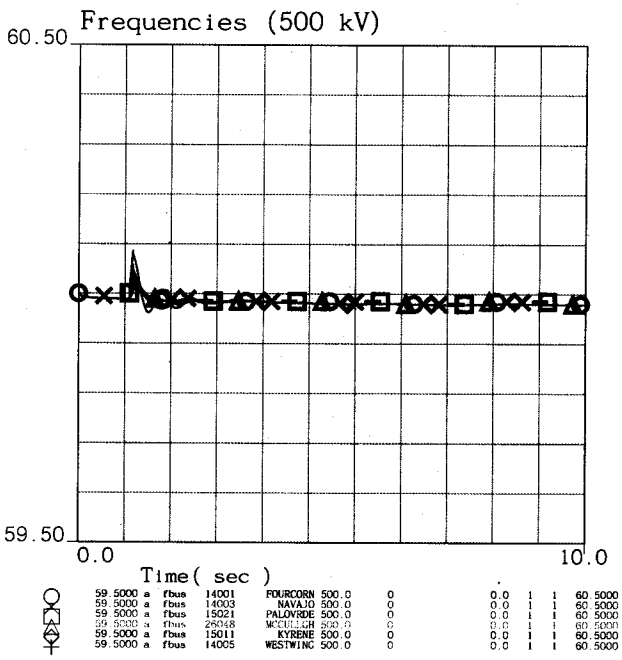

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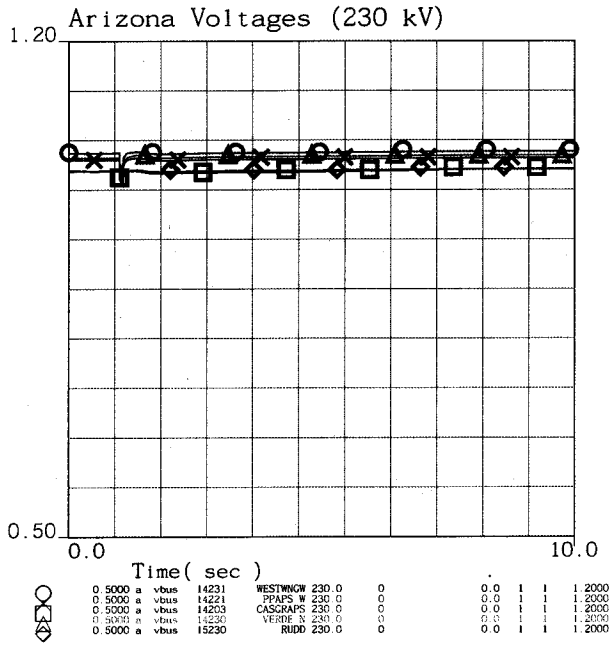

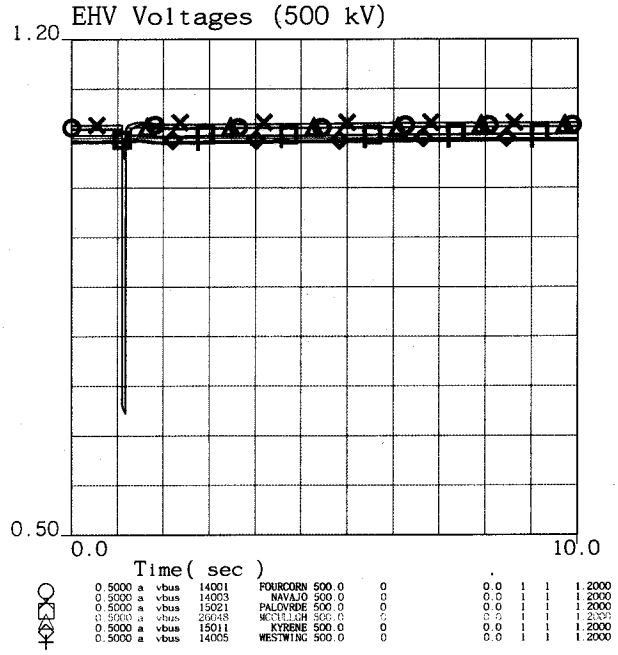

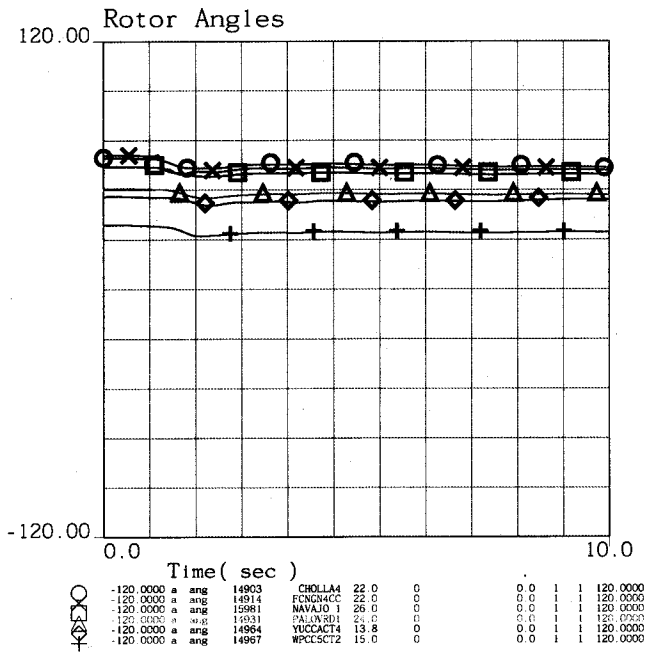

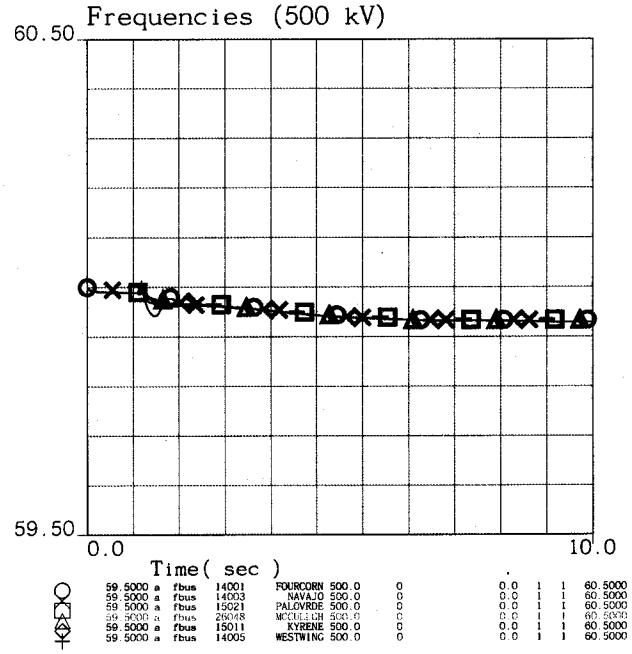

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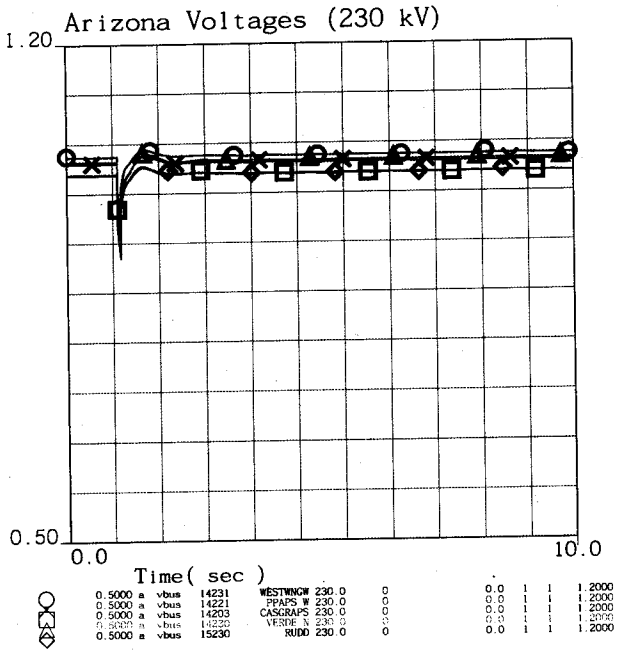

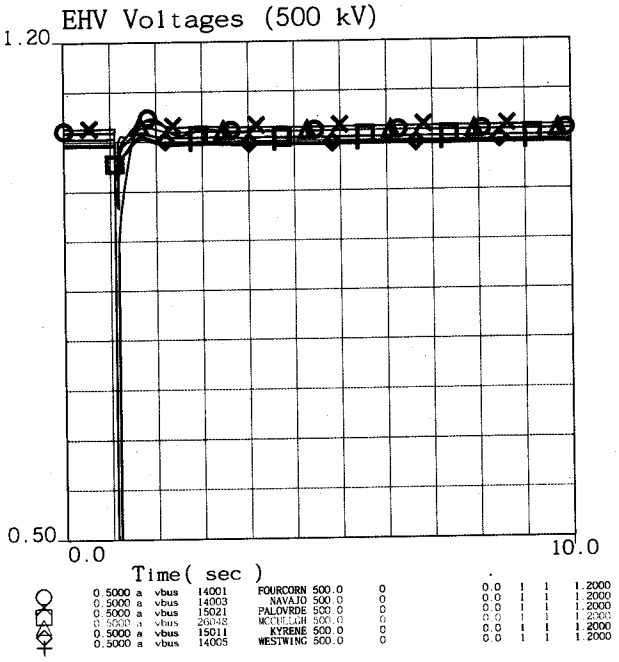

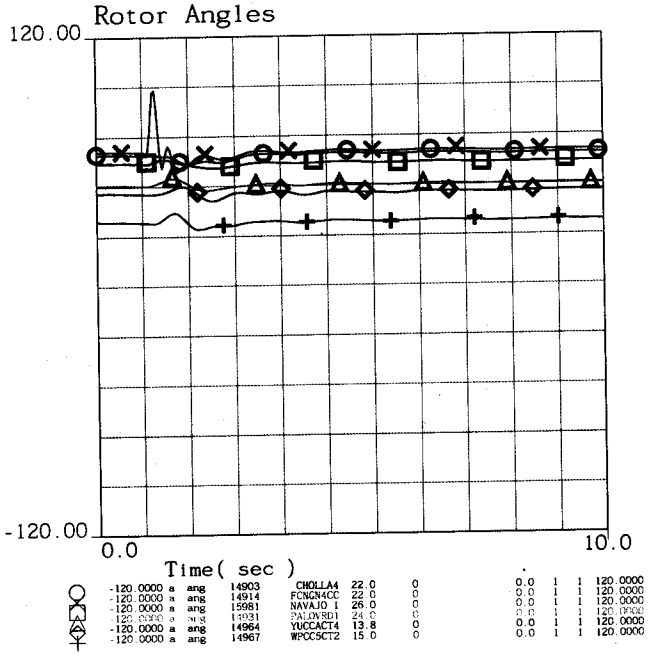

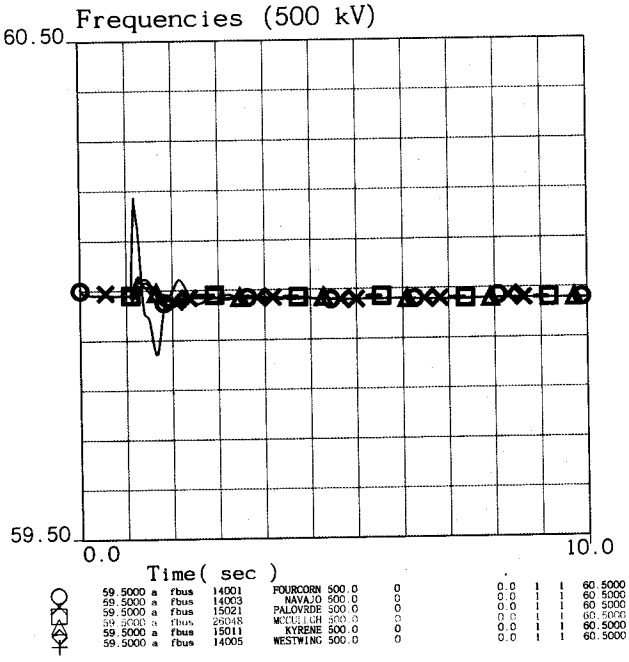

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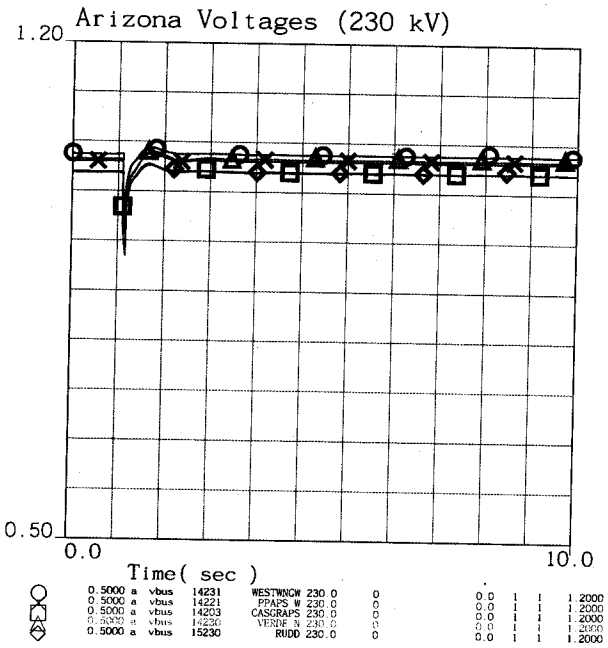

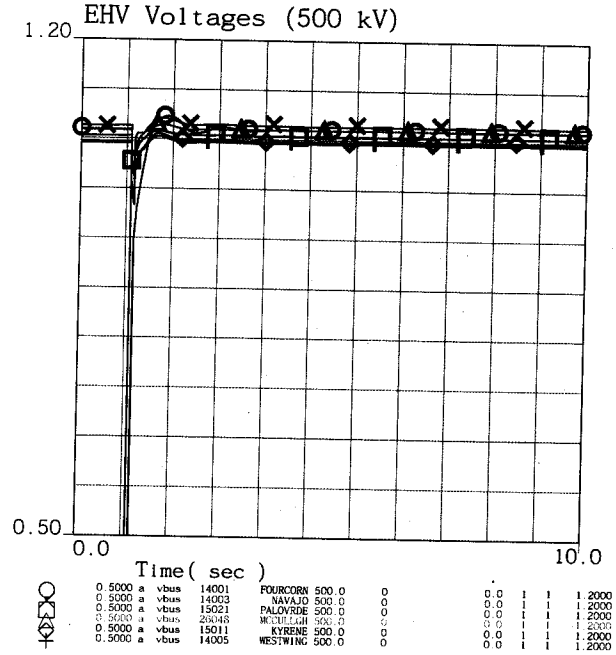

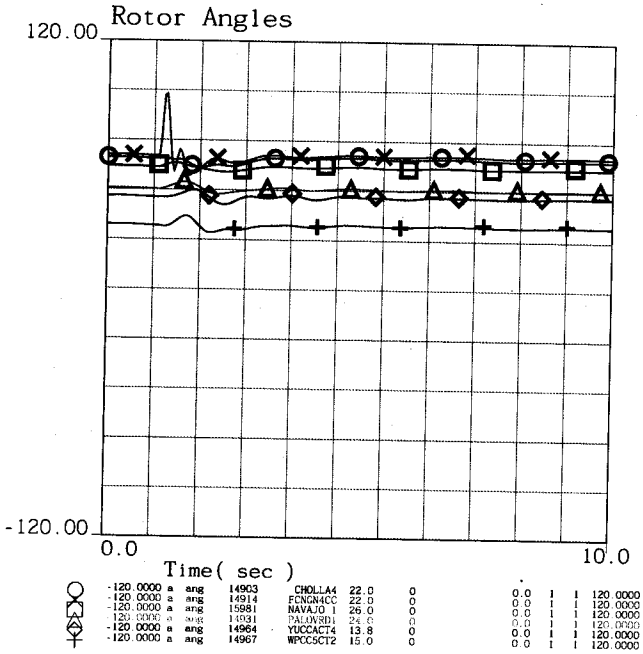

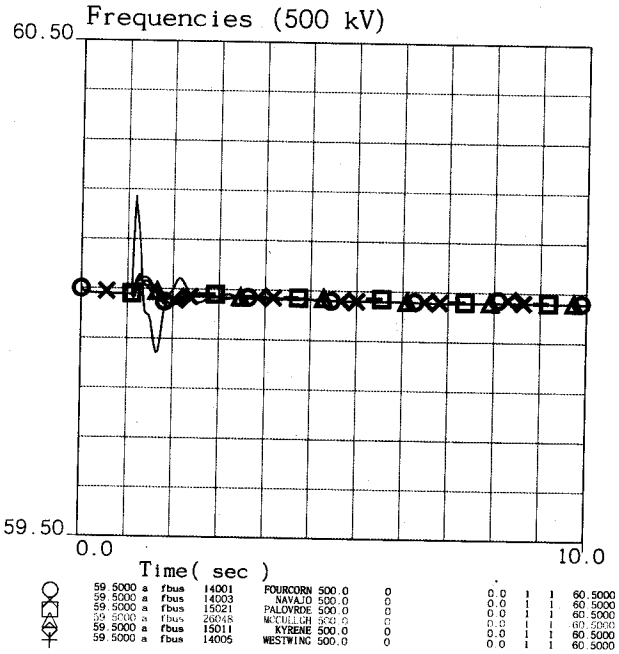

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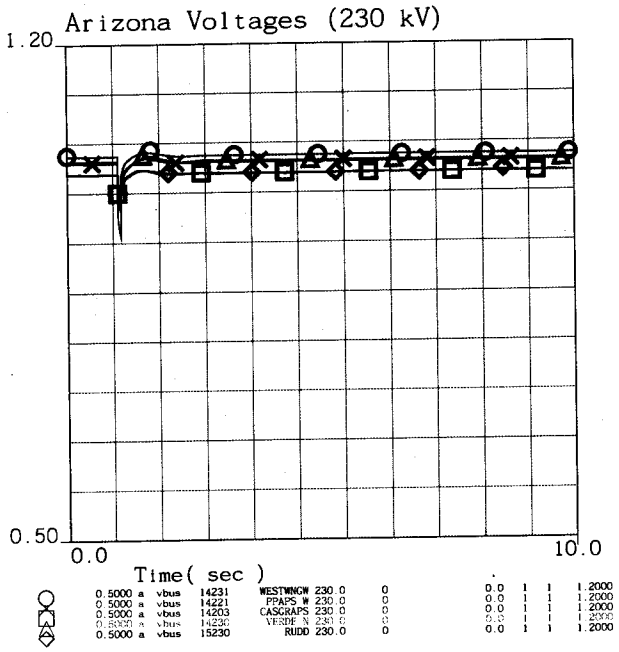

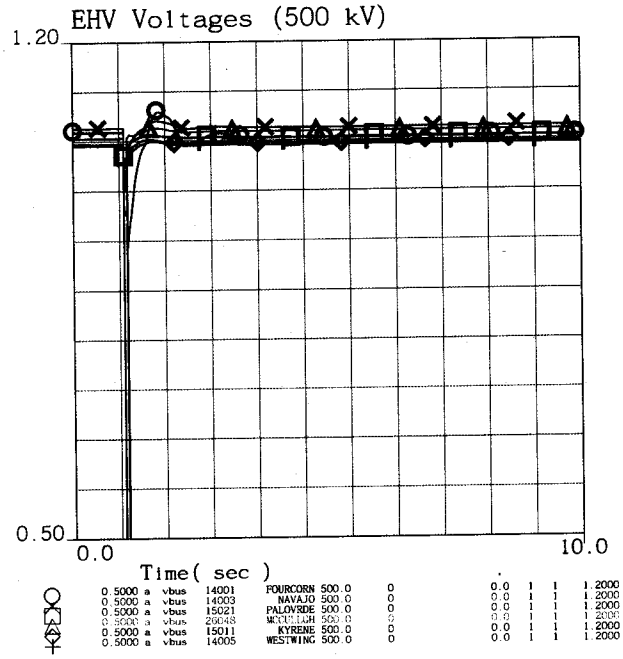

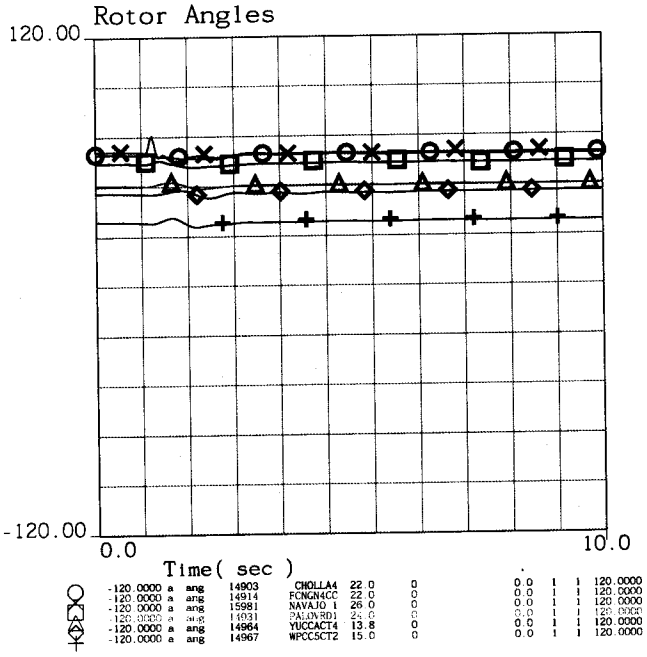

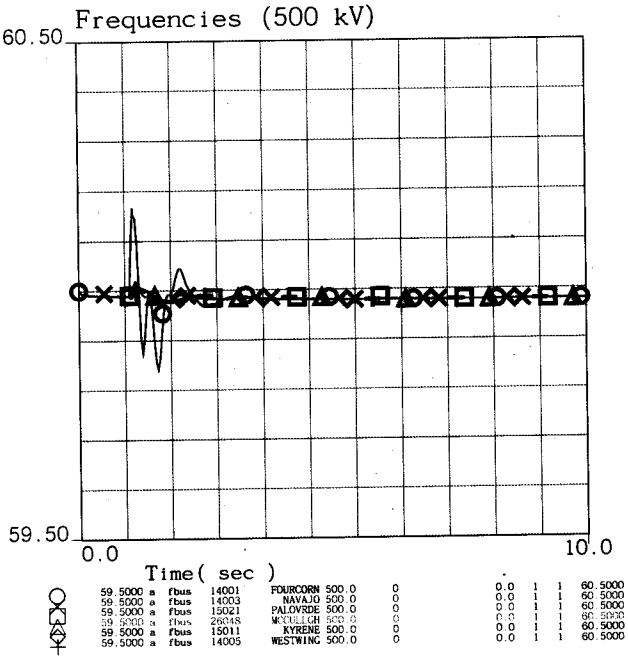

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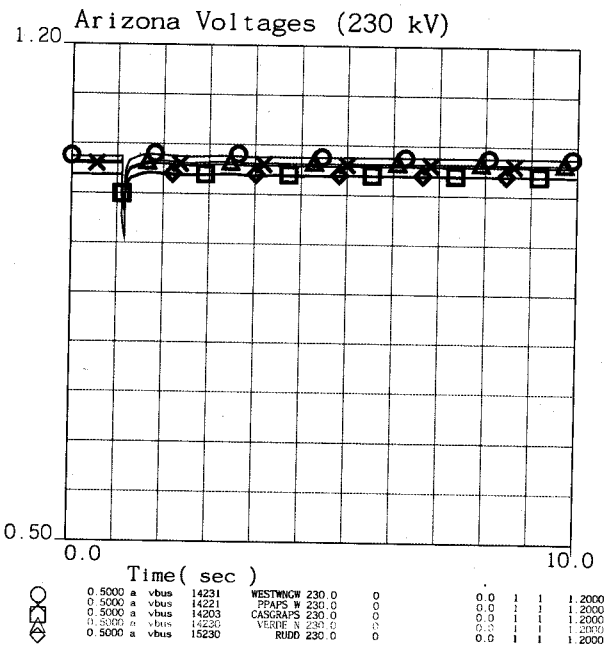

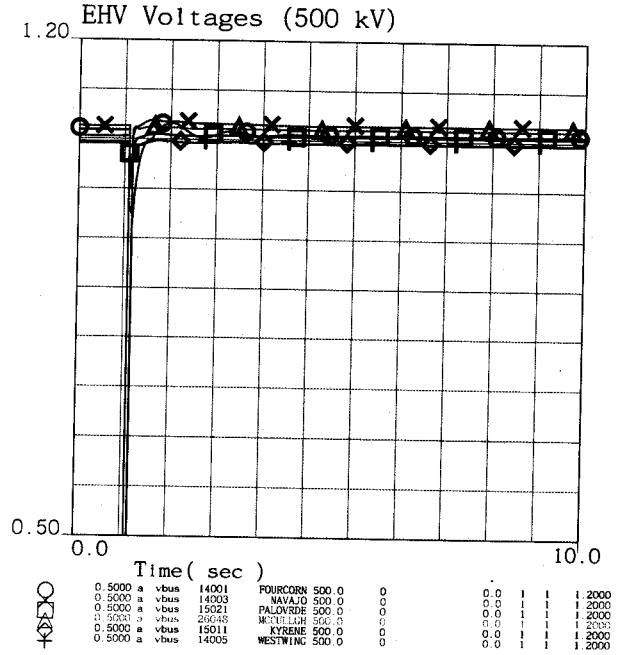

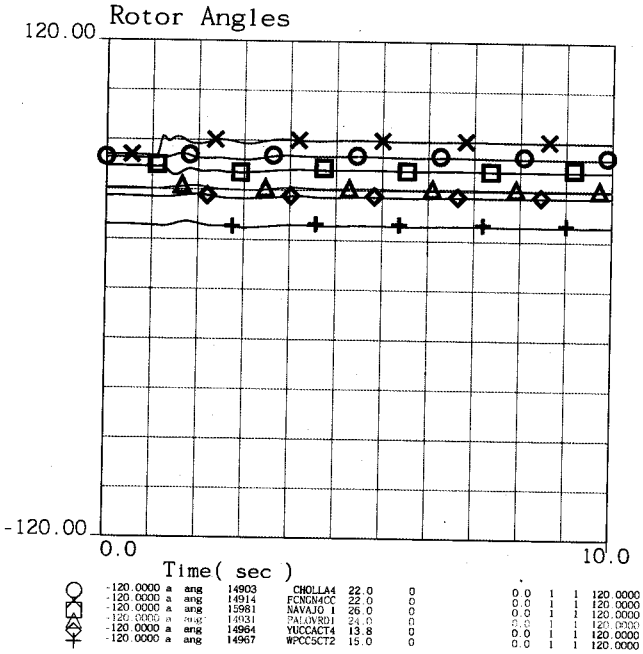

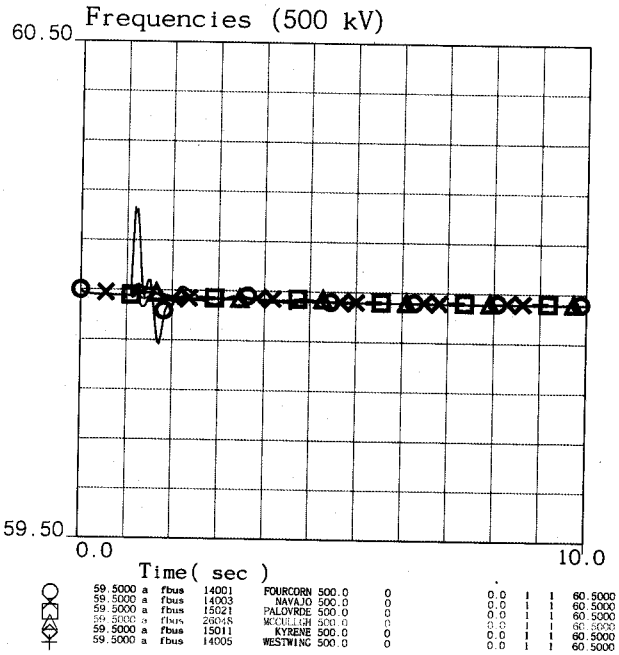

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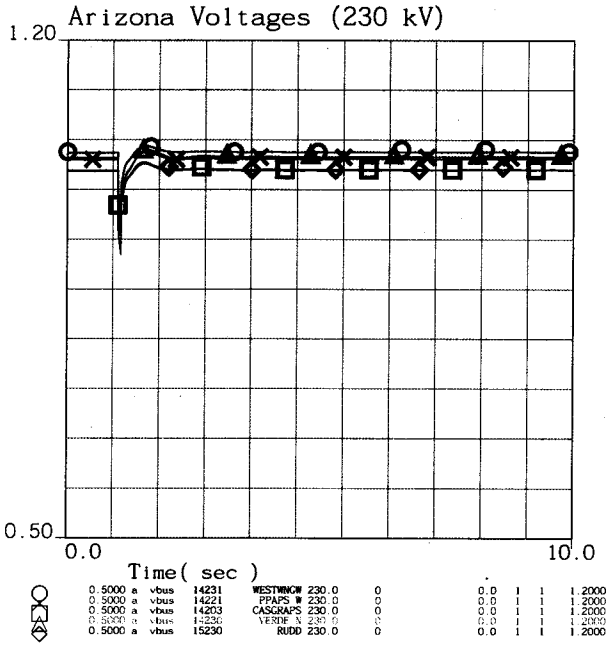

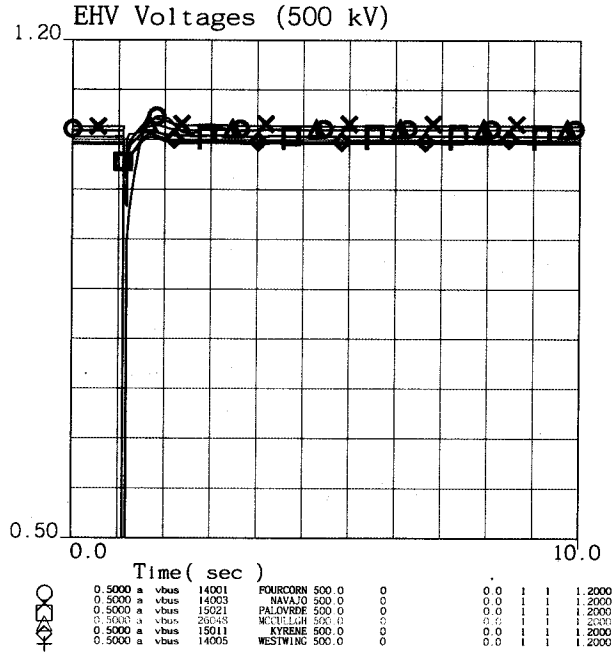

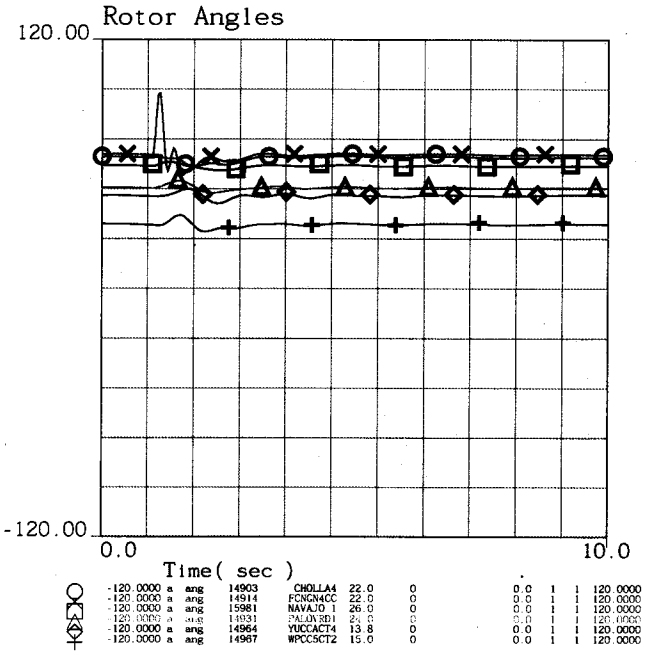

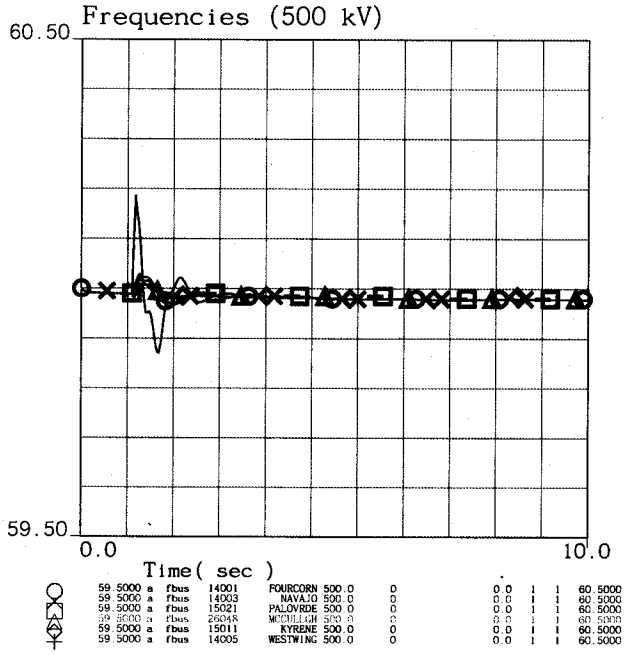

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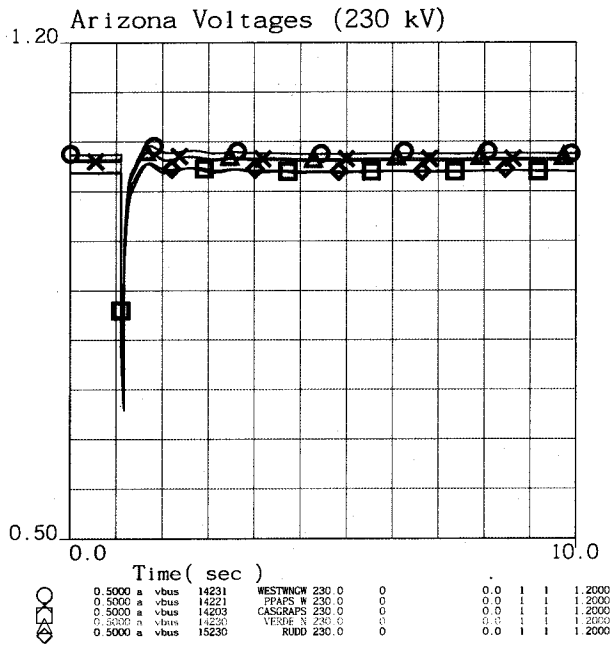
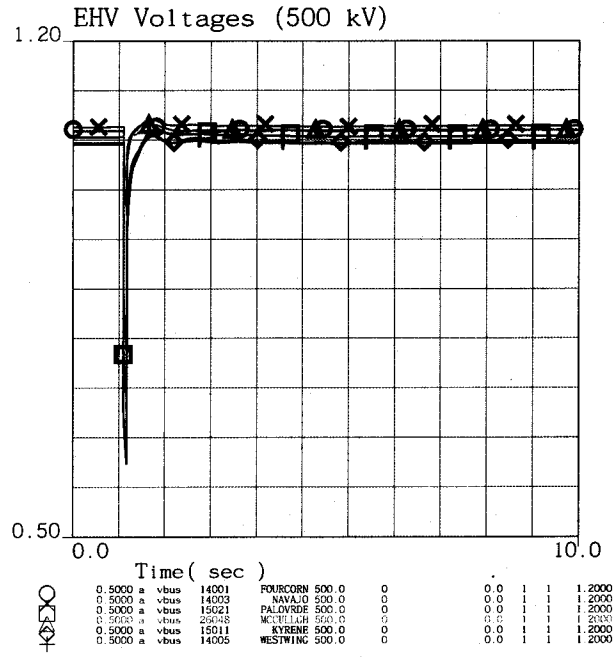
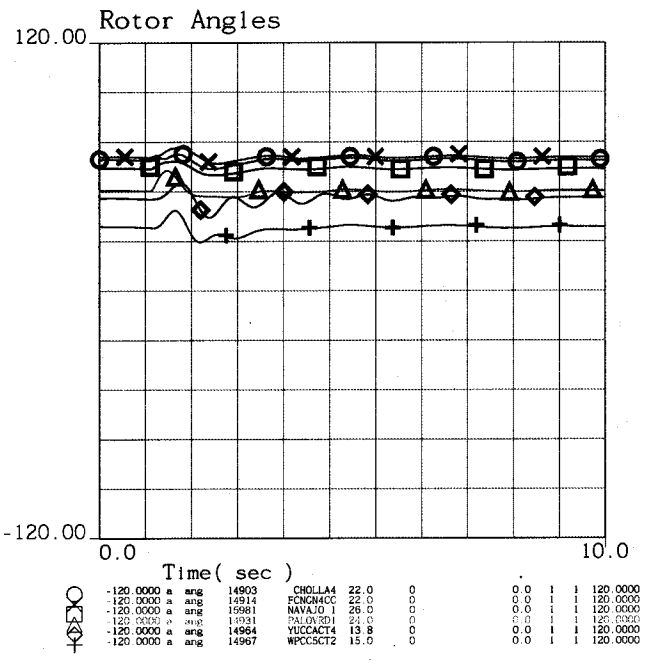
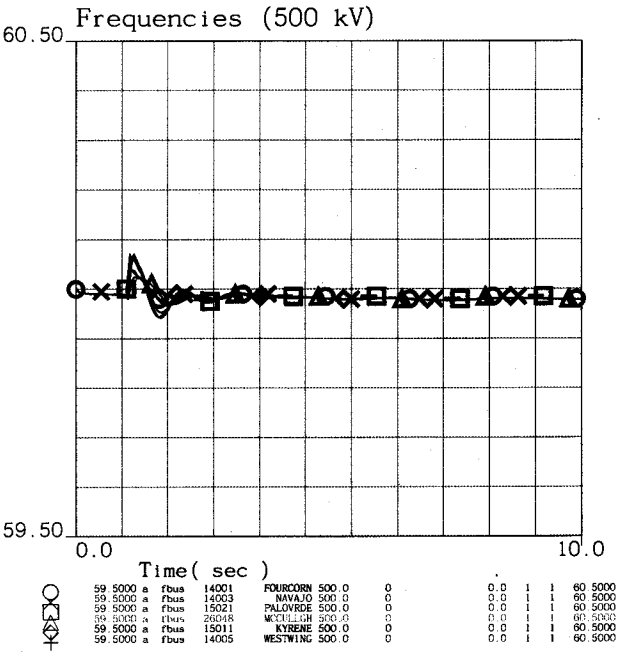
2018 Heavy Summer Detailed Planning Case









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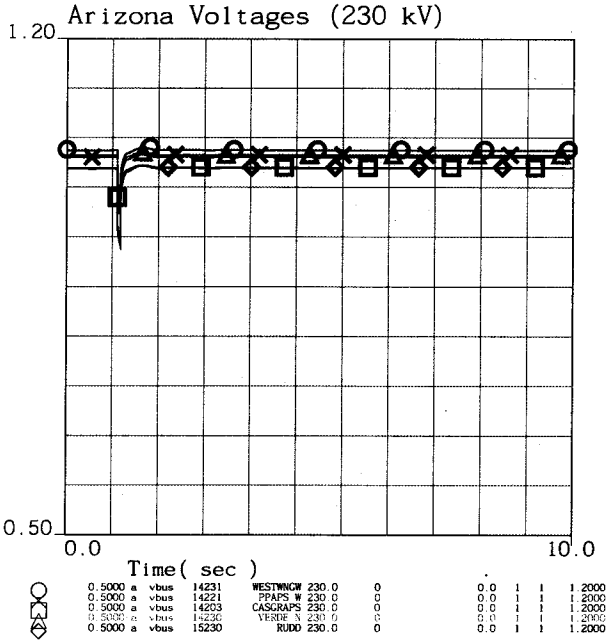

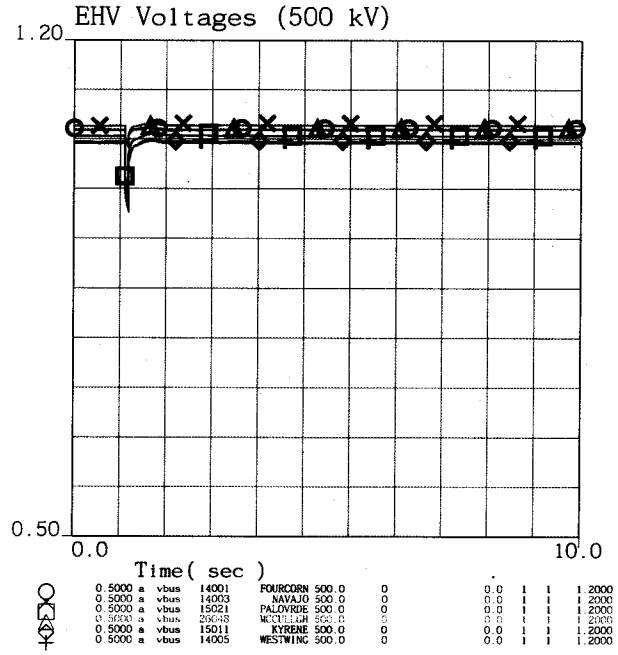

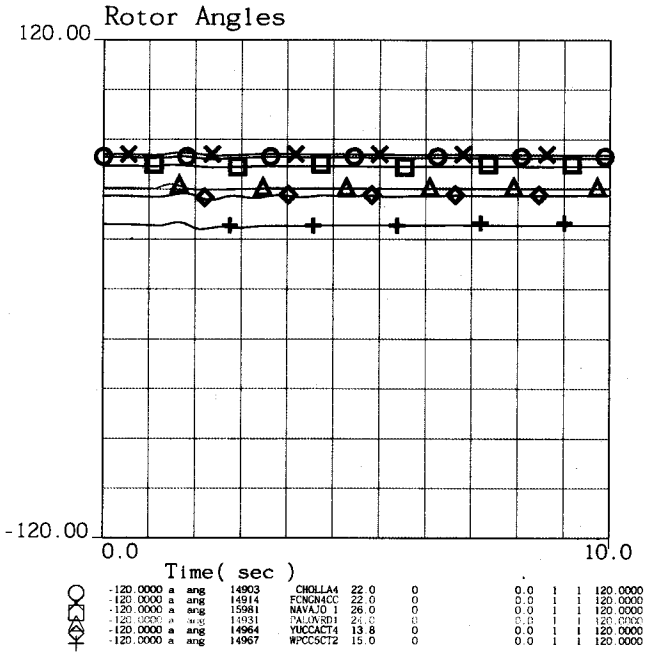

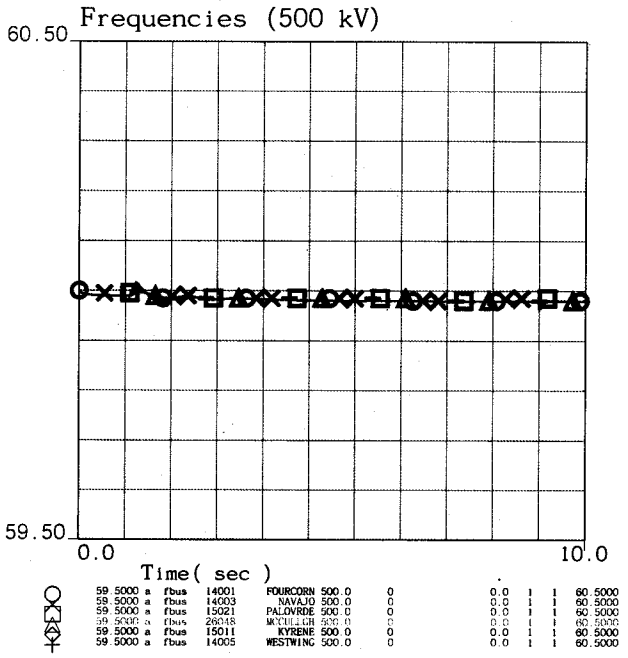

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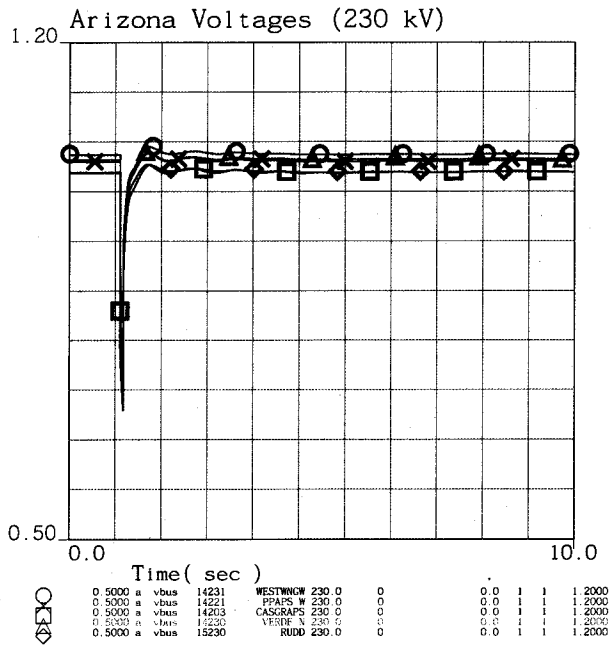

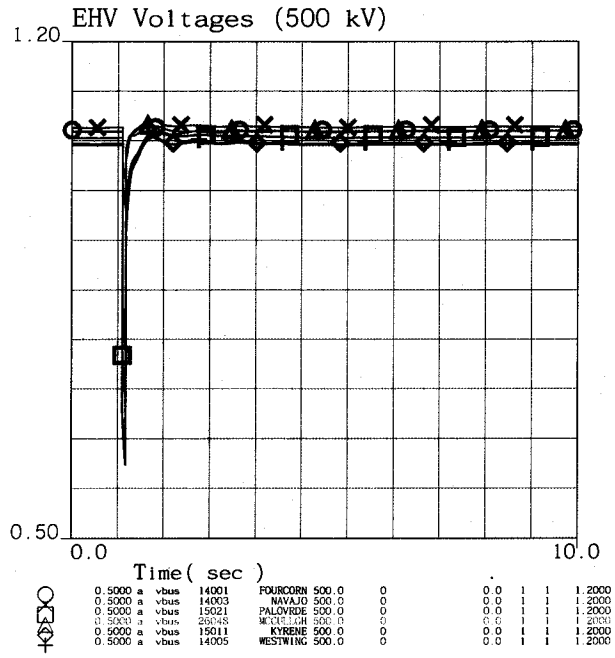

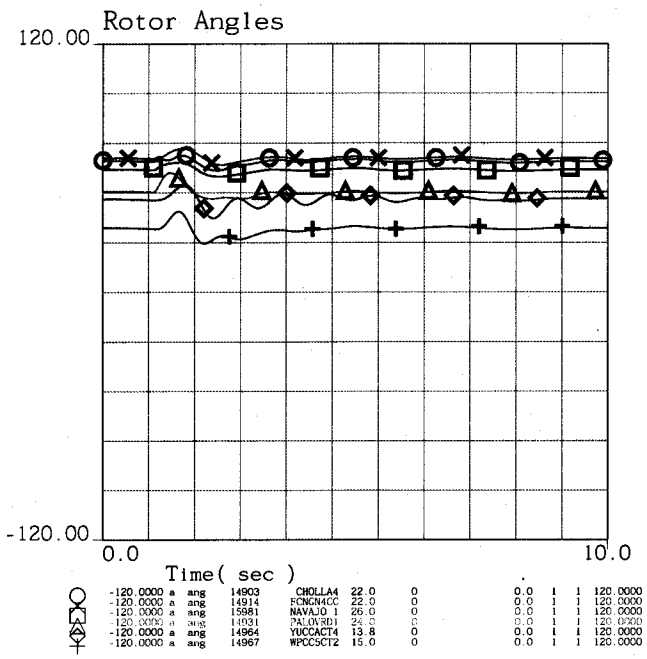

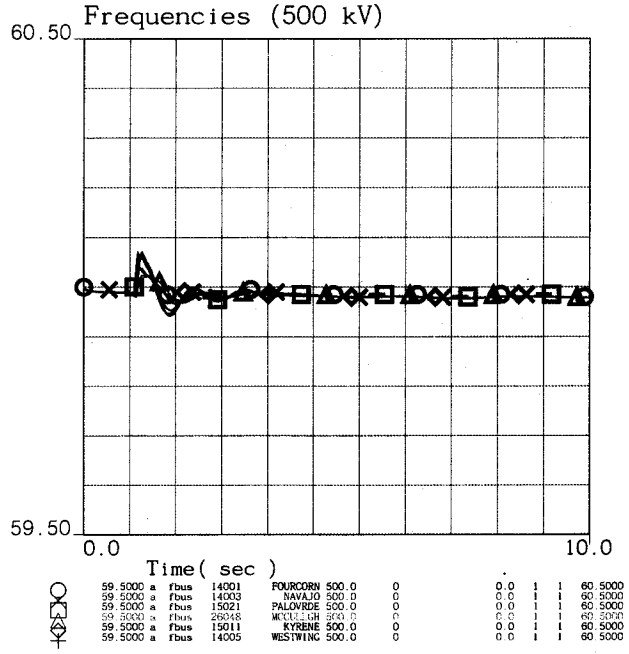

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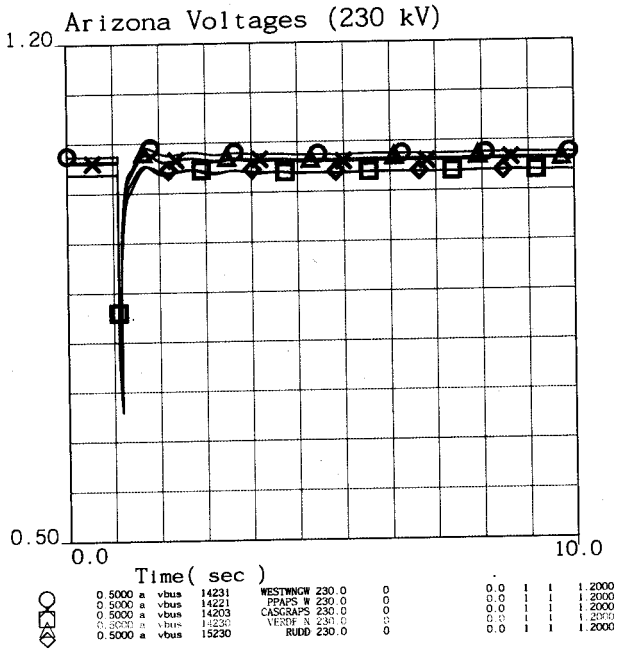

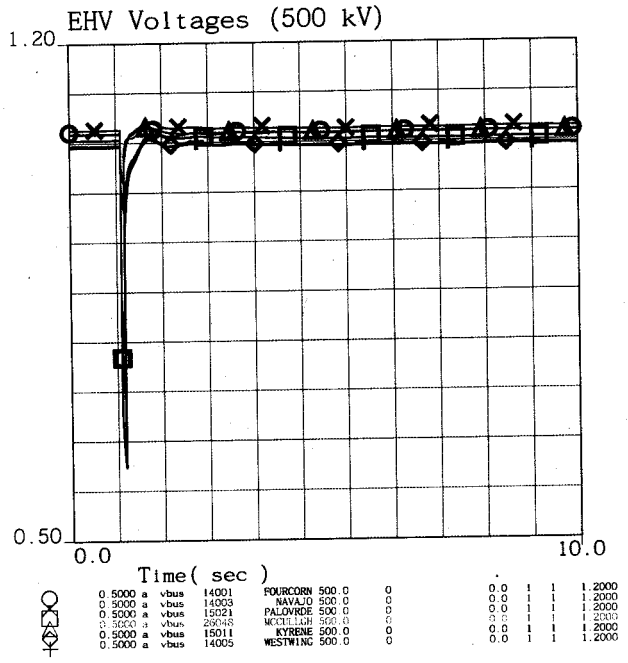

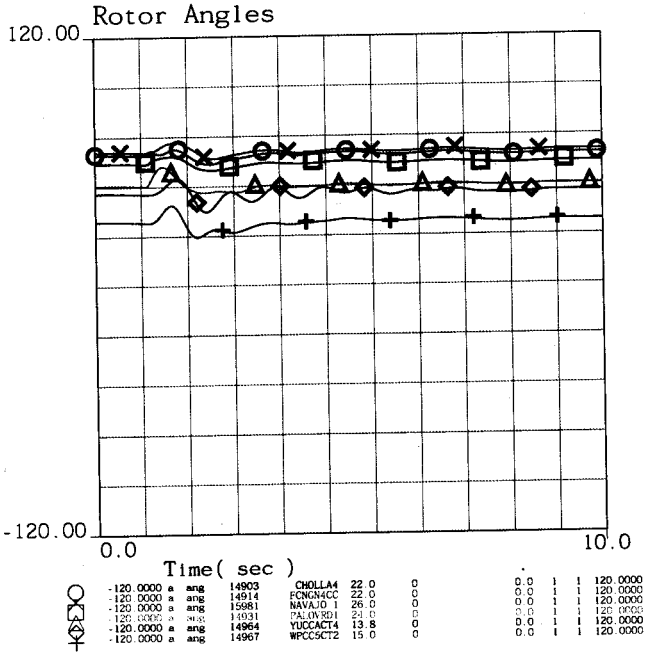

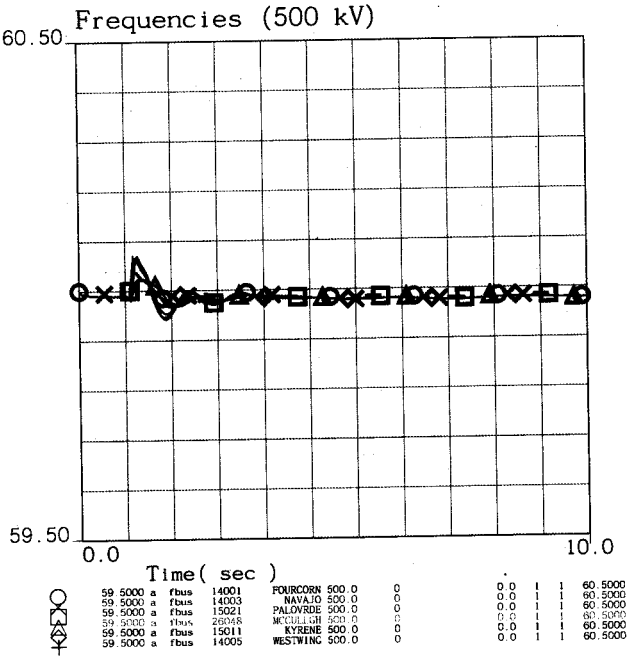

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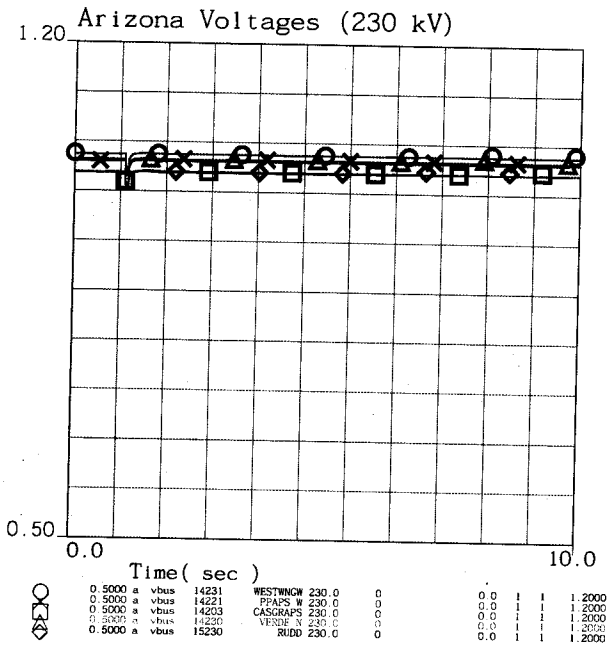

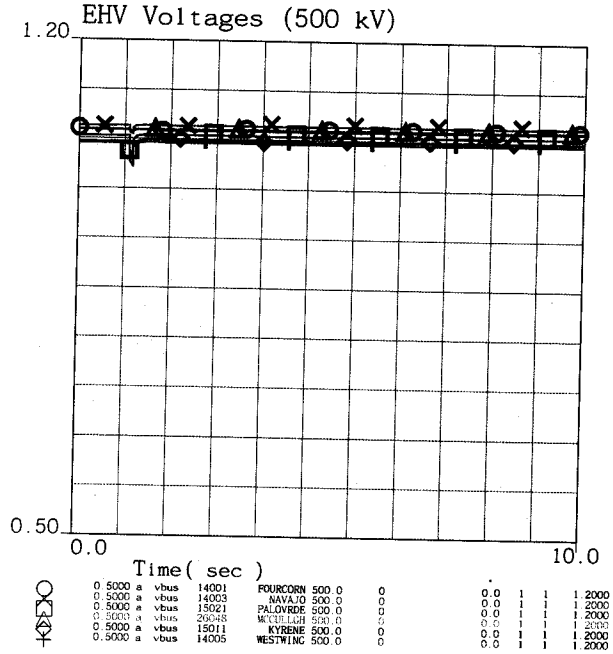

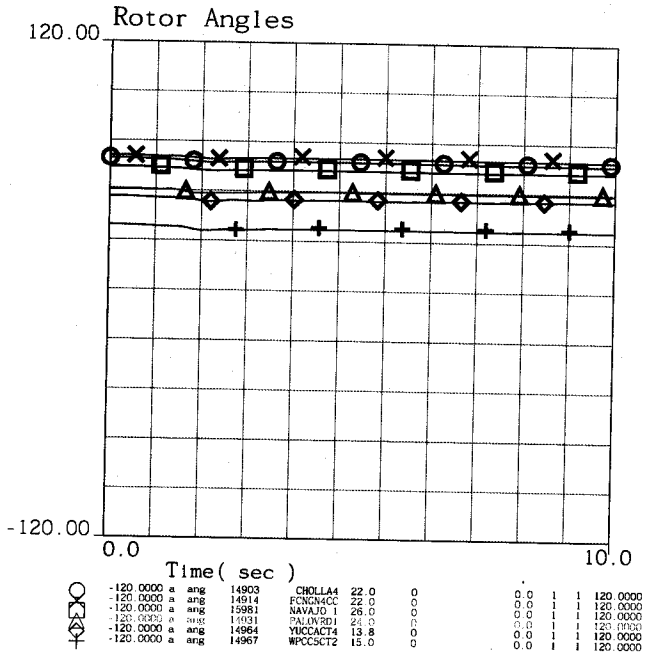

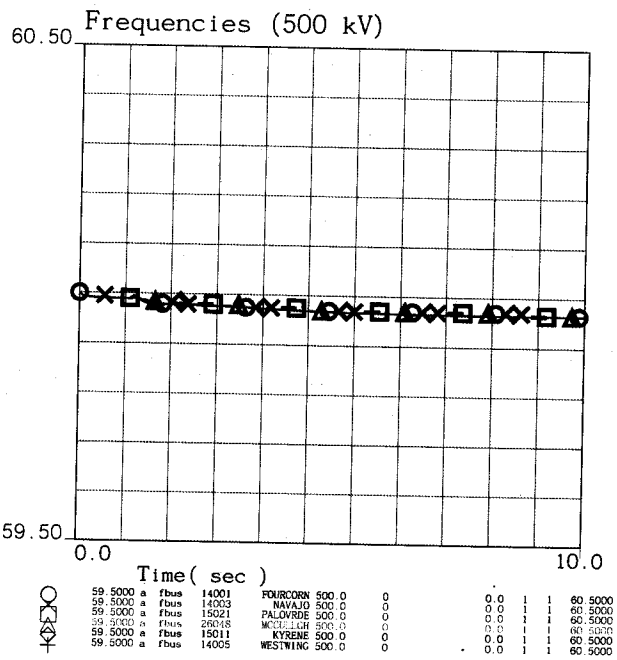

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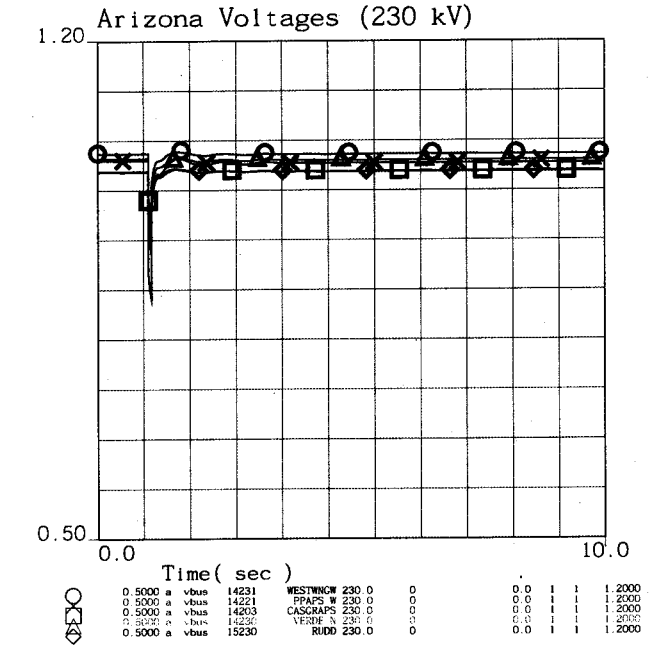

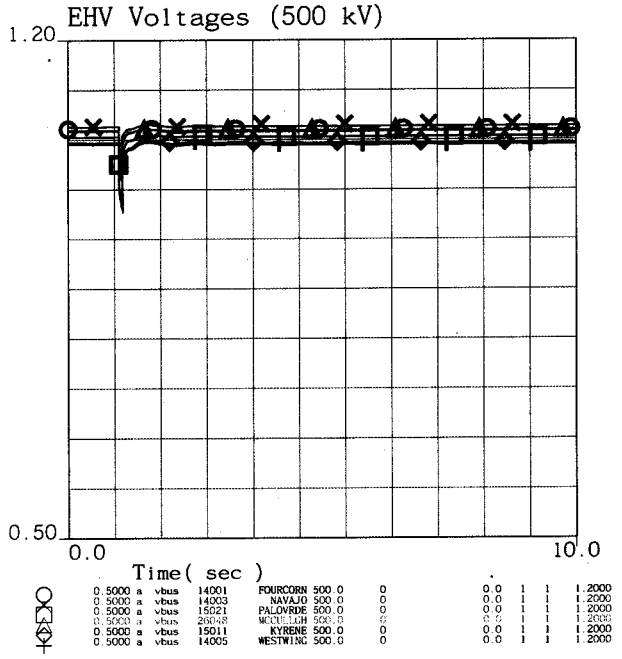

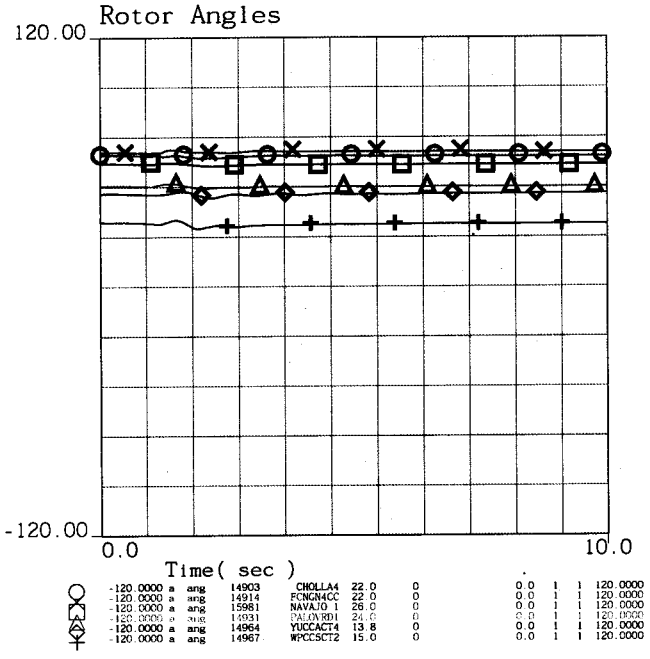

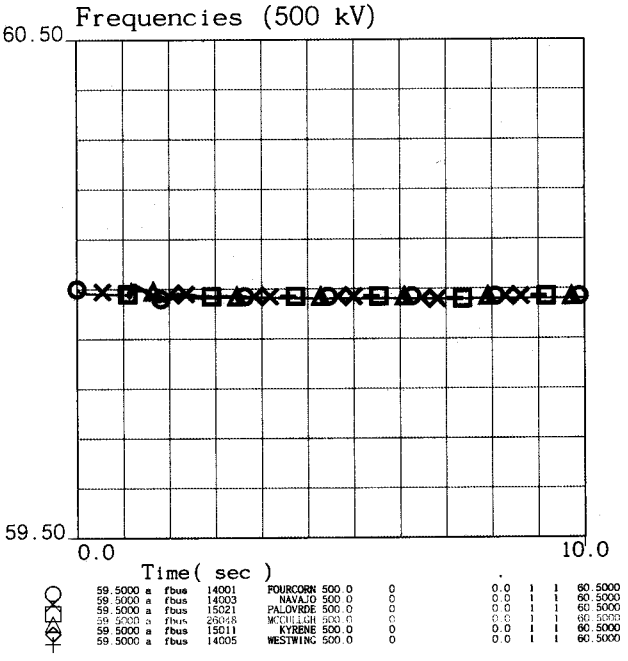

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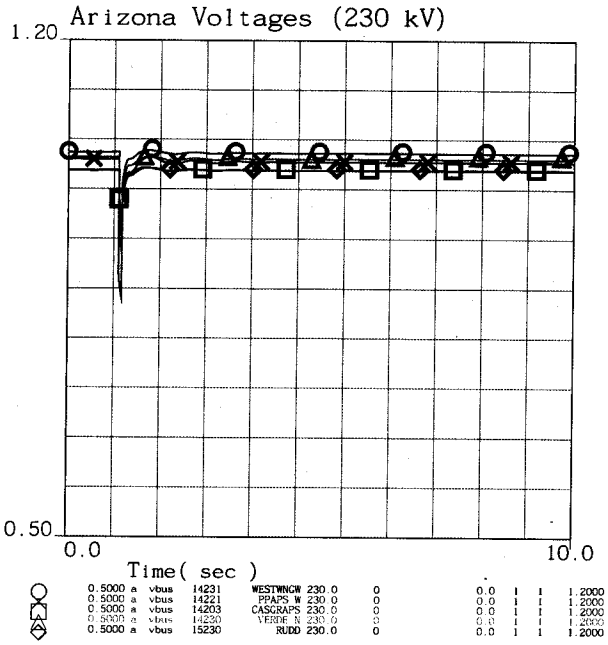

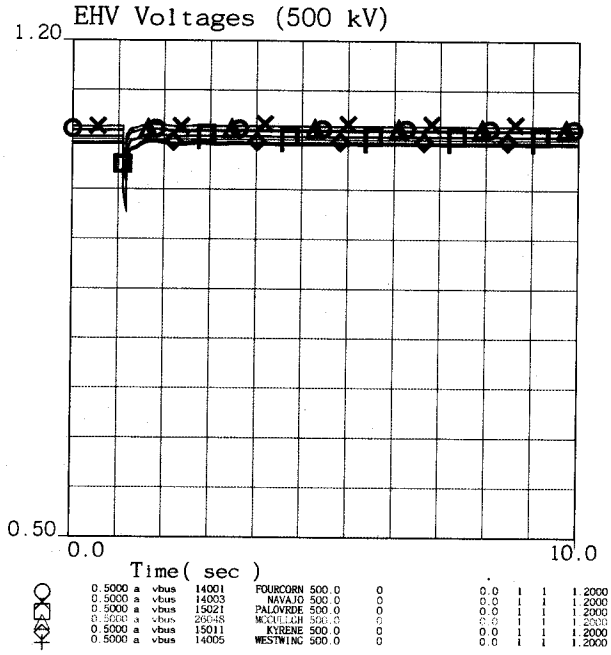

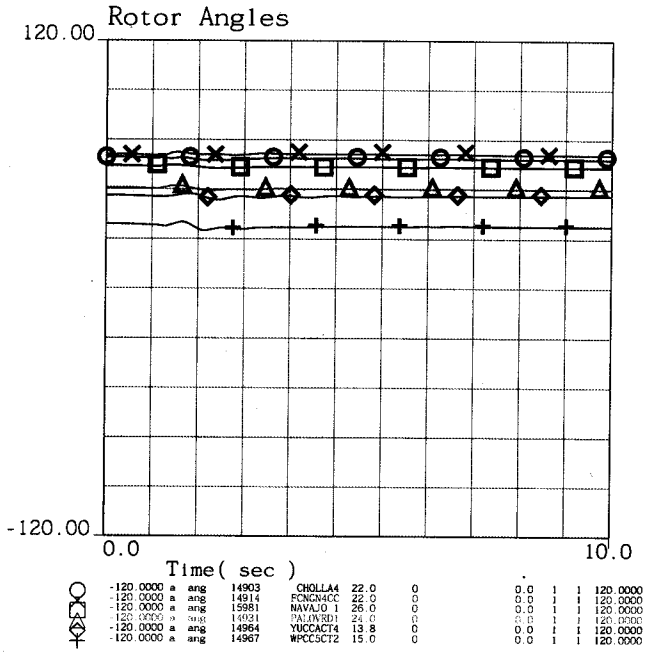

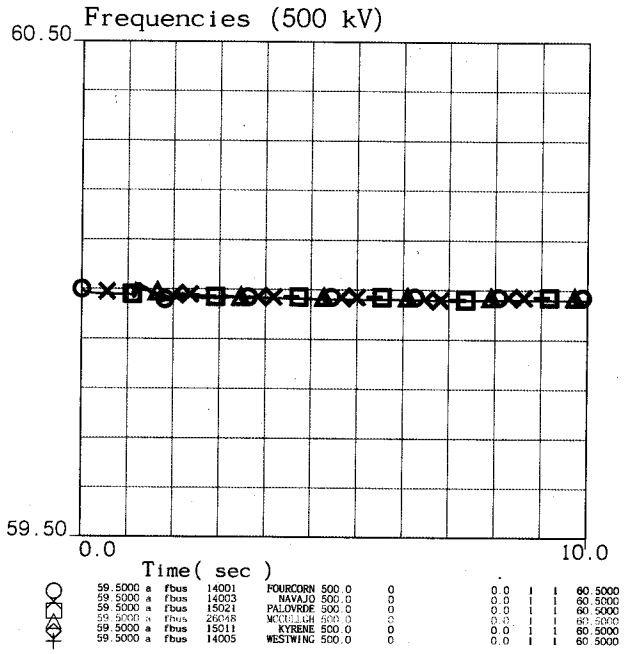

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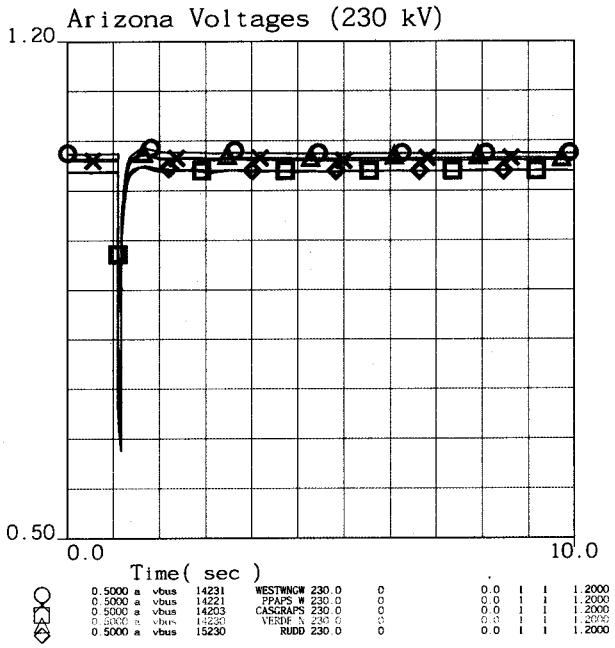

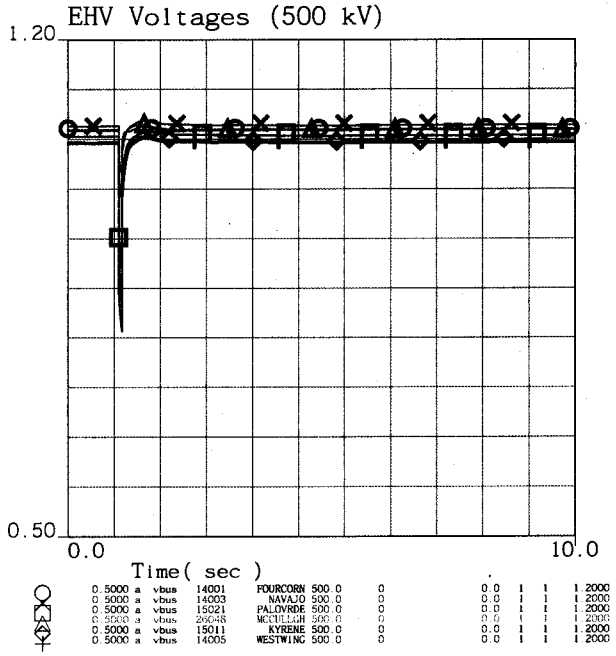

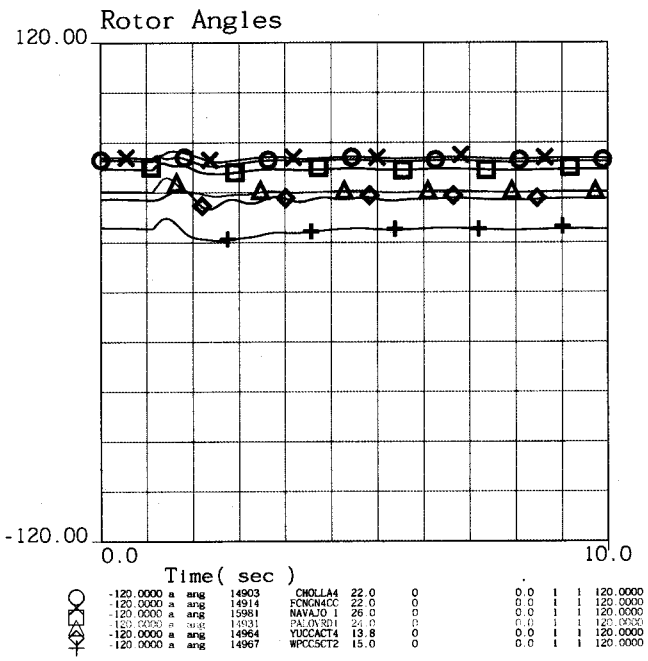

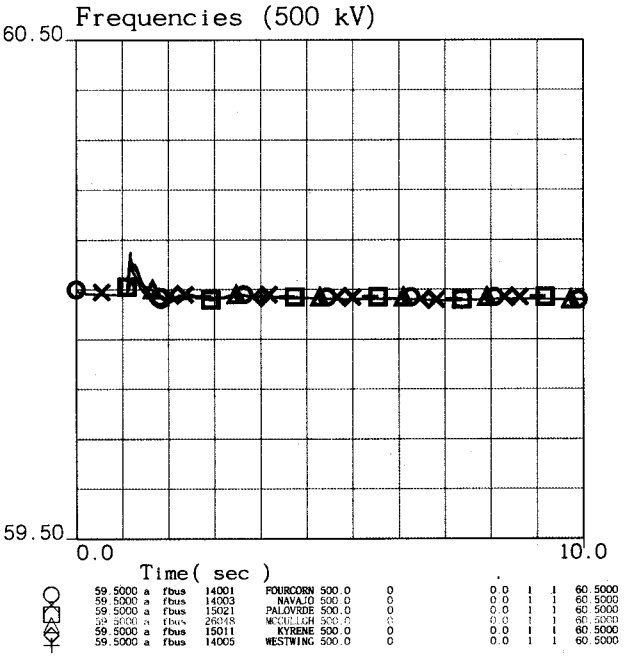

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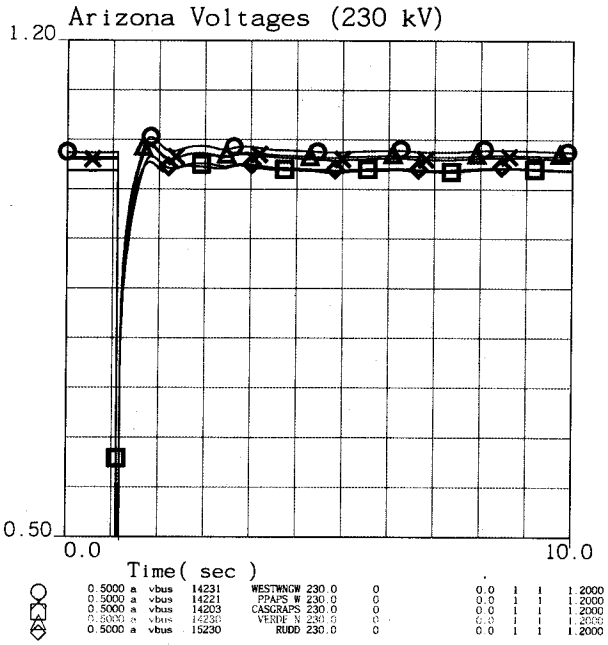

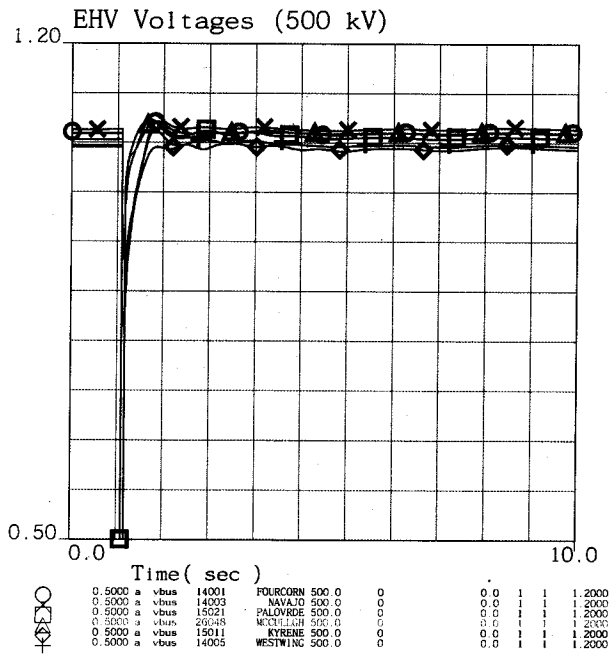

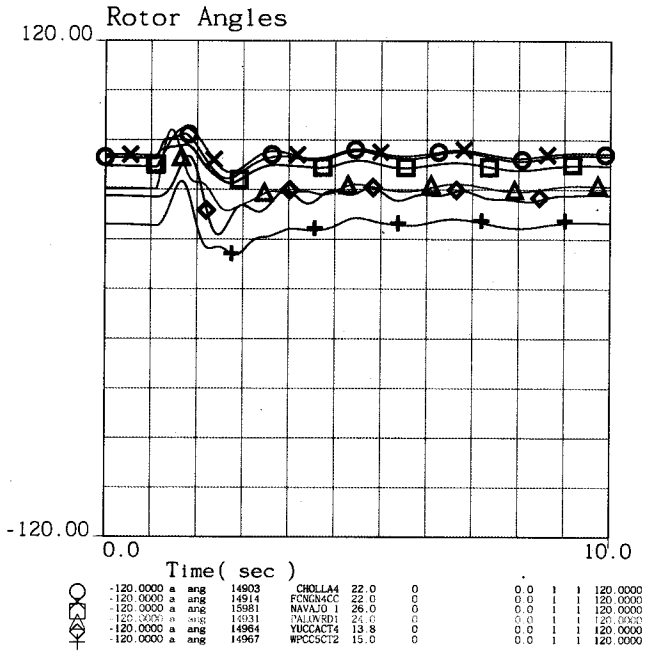

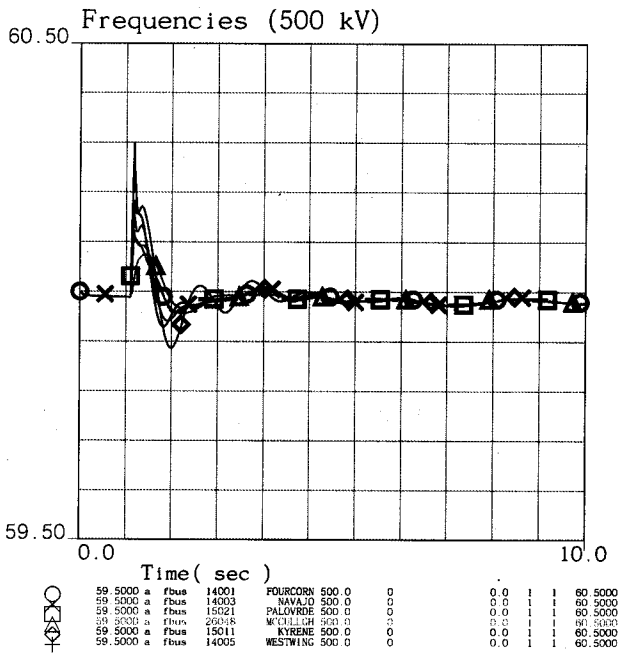

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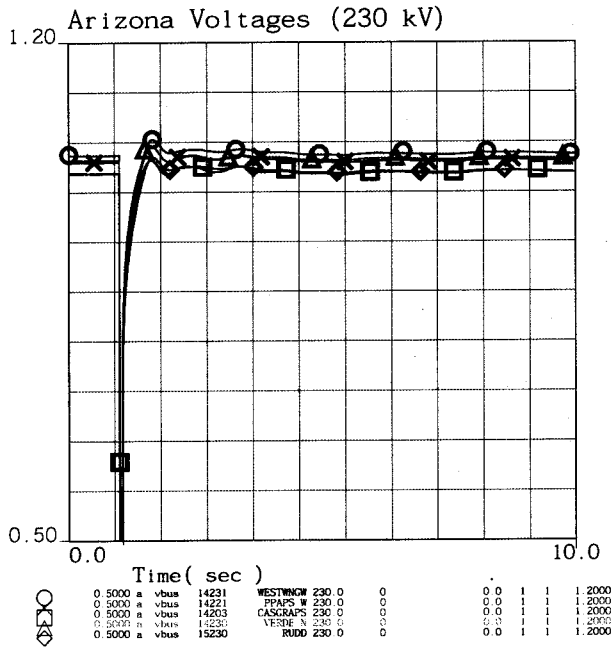

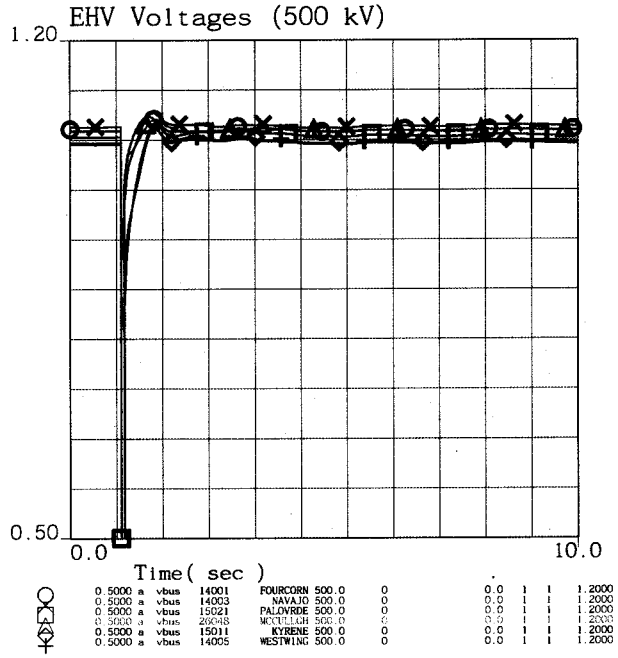

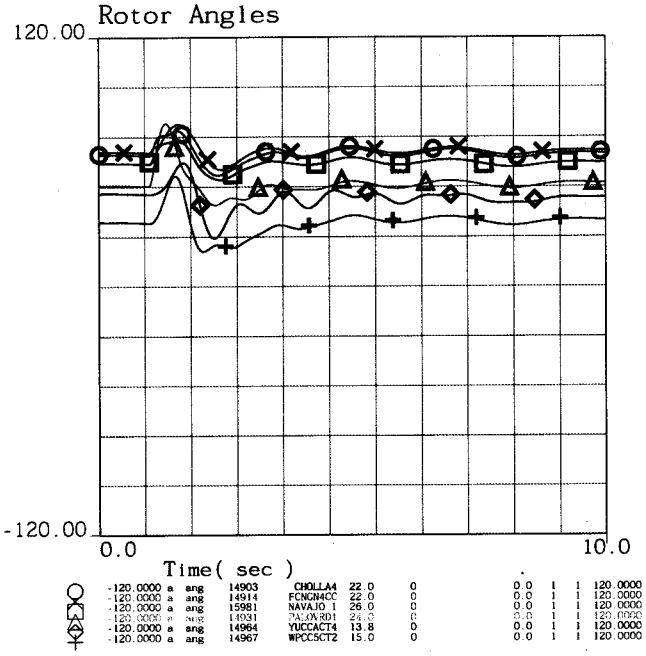

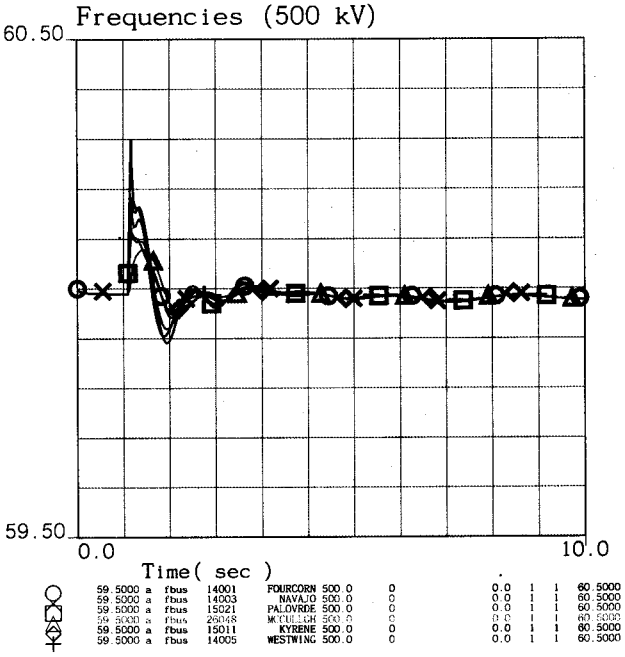

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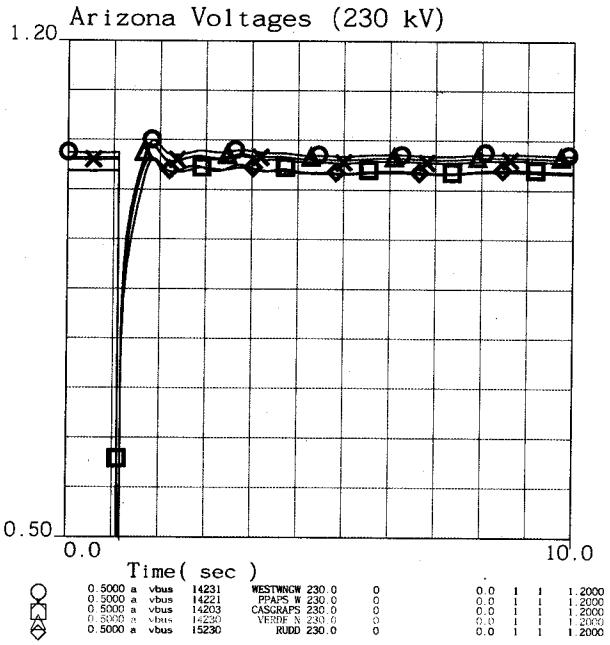

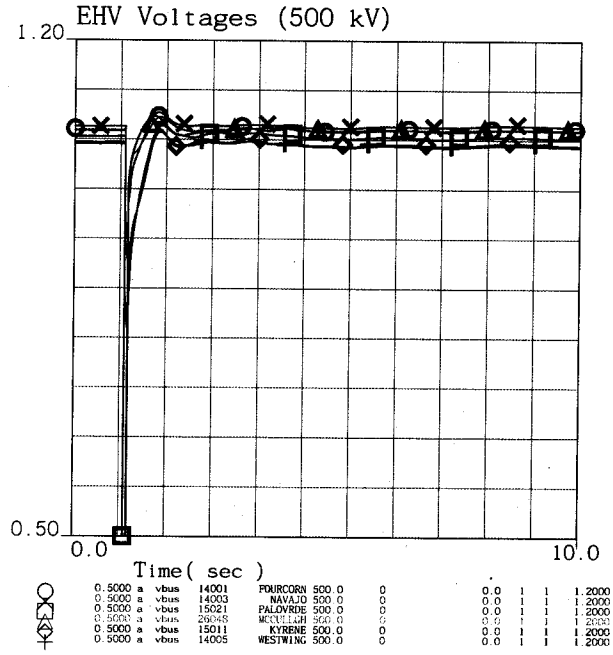

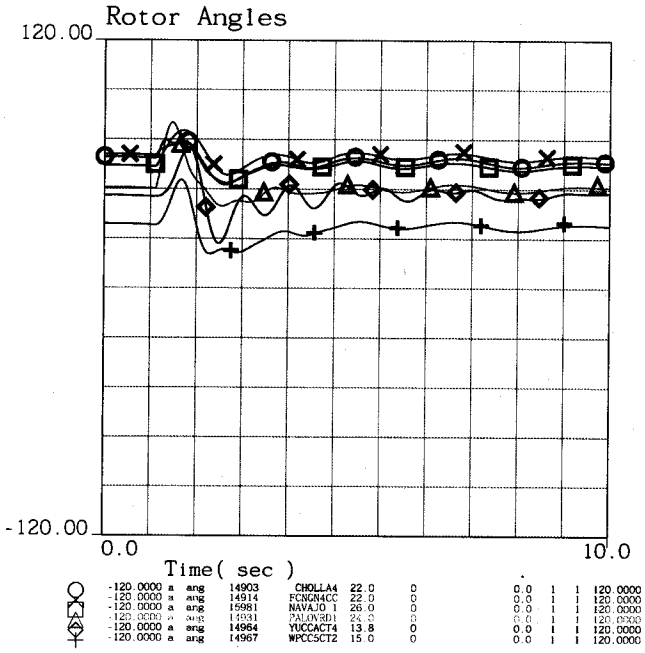

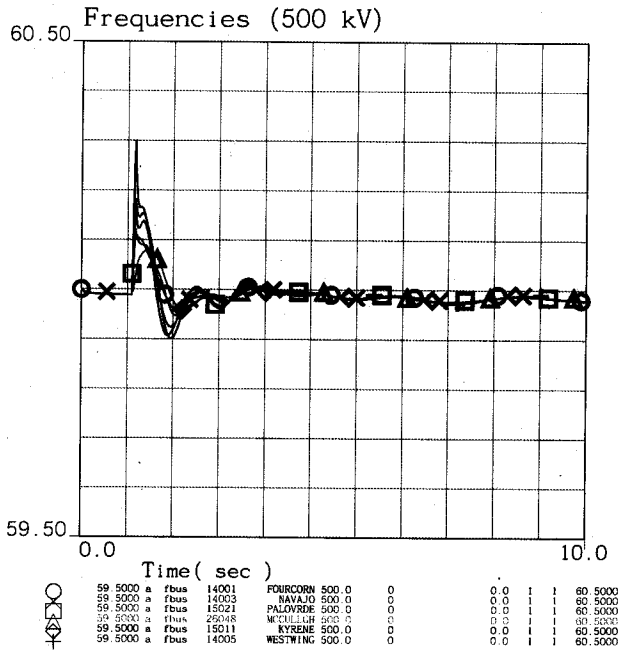

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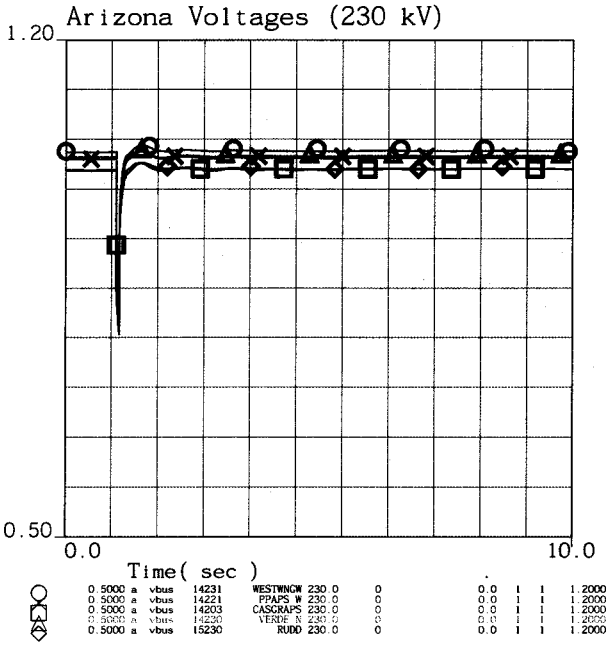

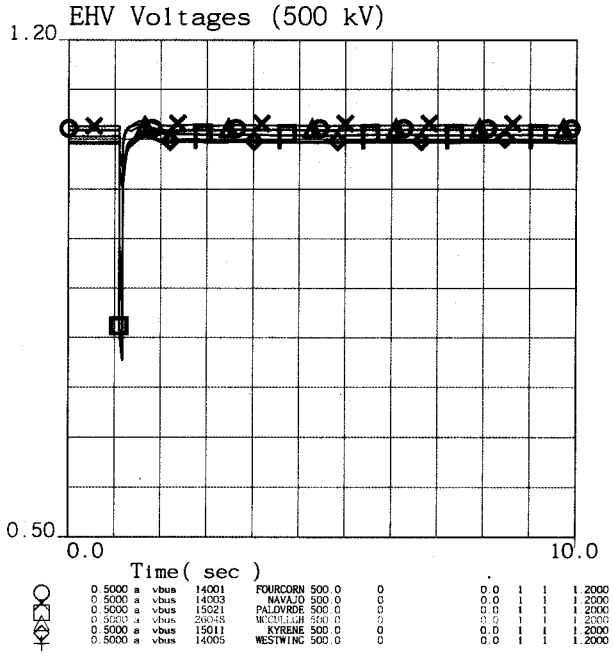

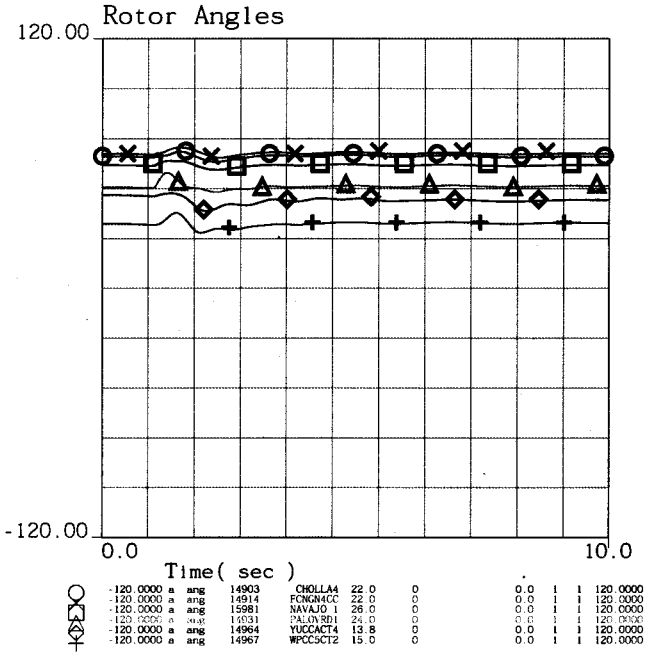

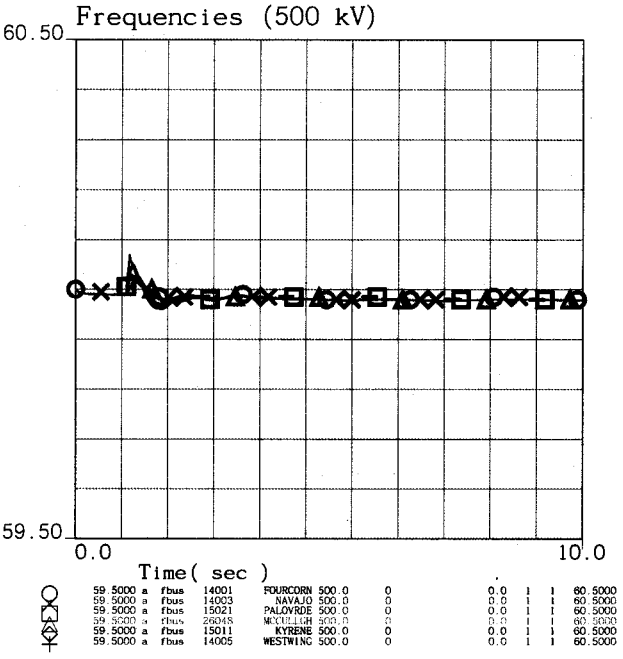

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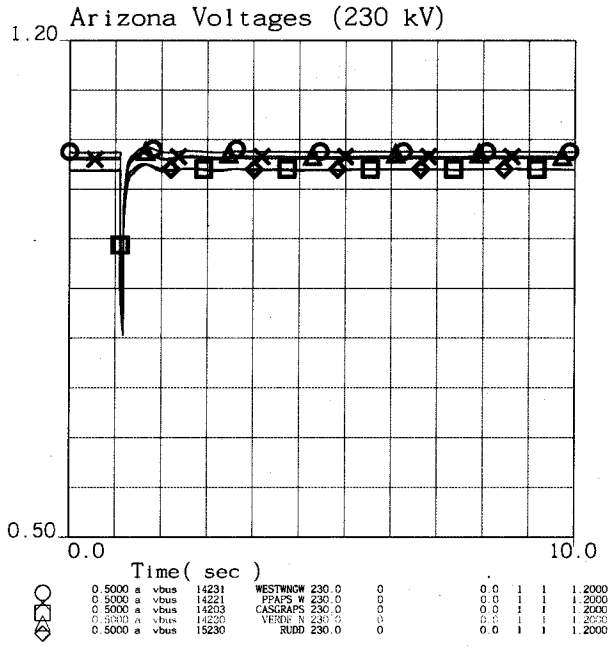

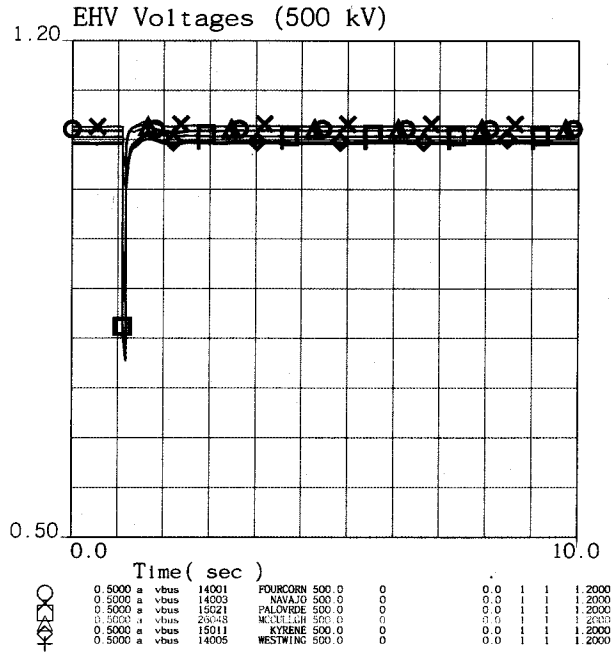

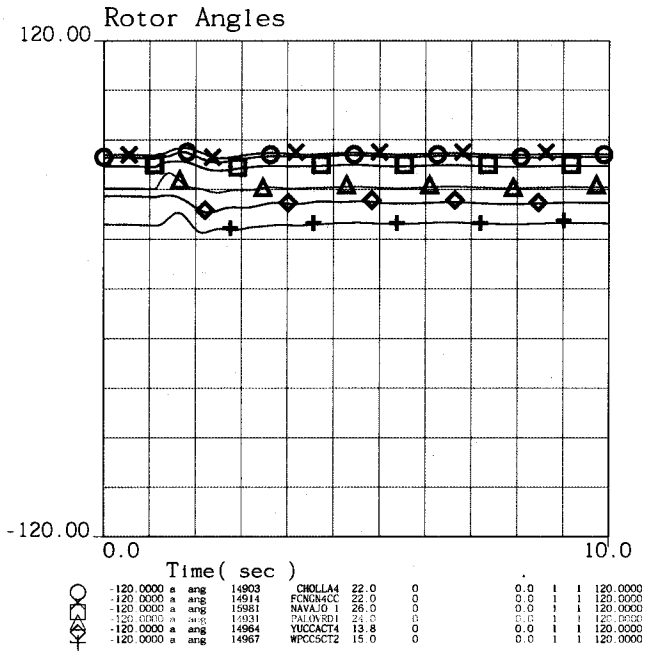

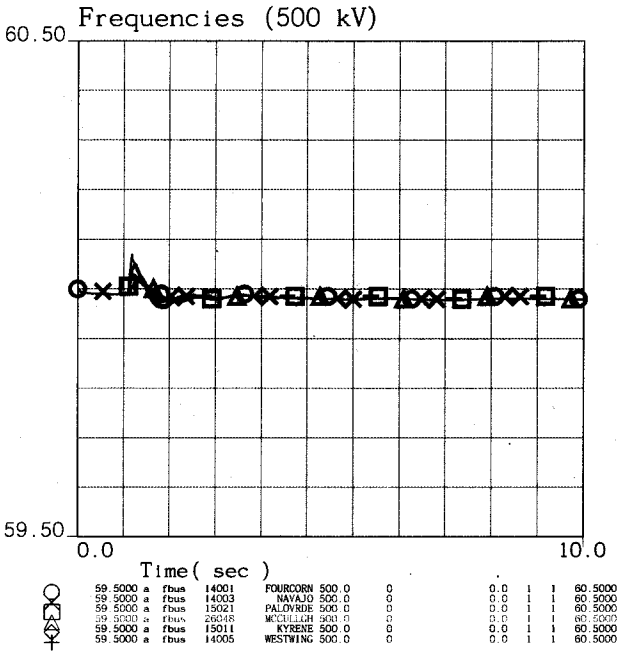

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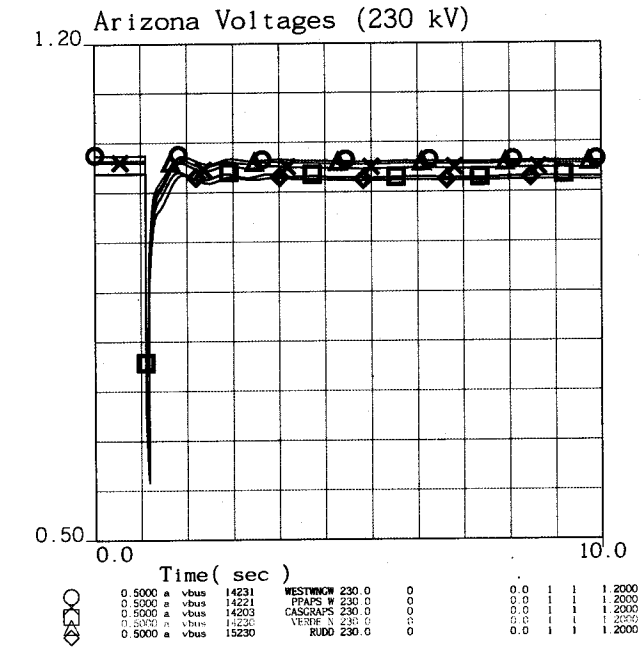

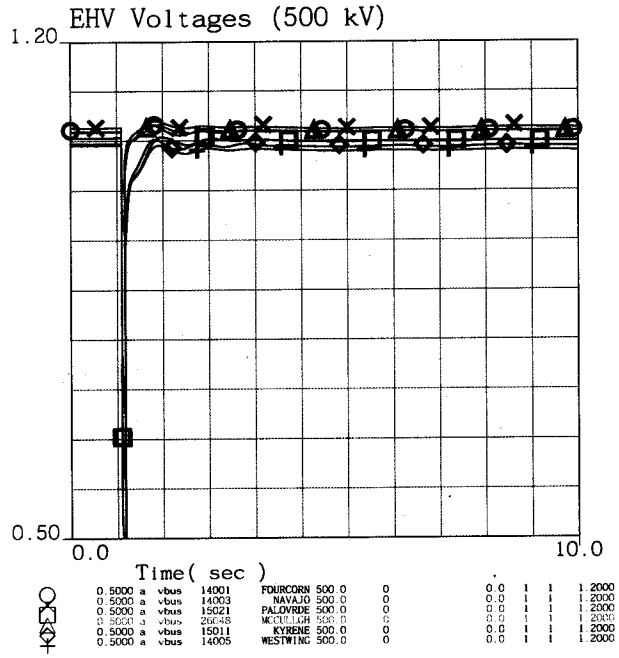

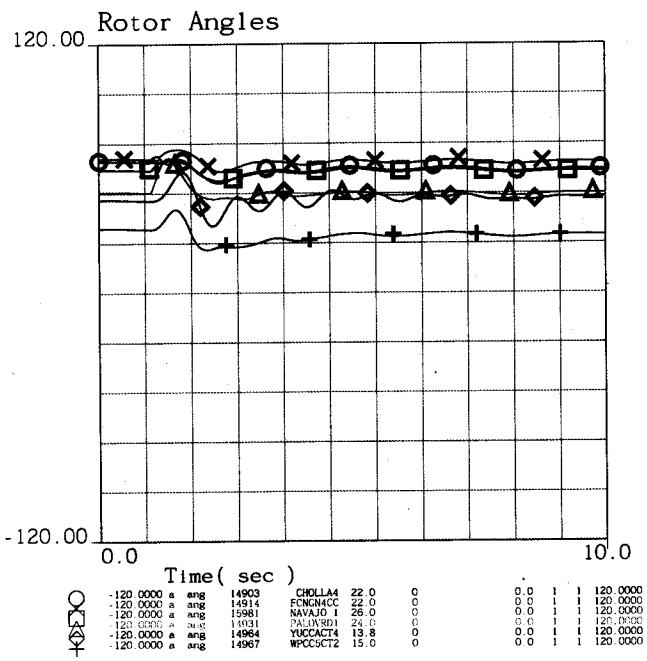

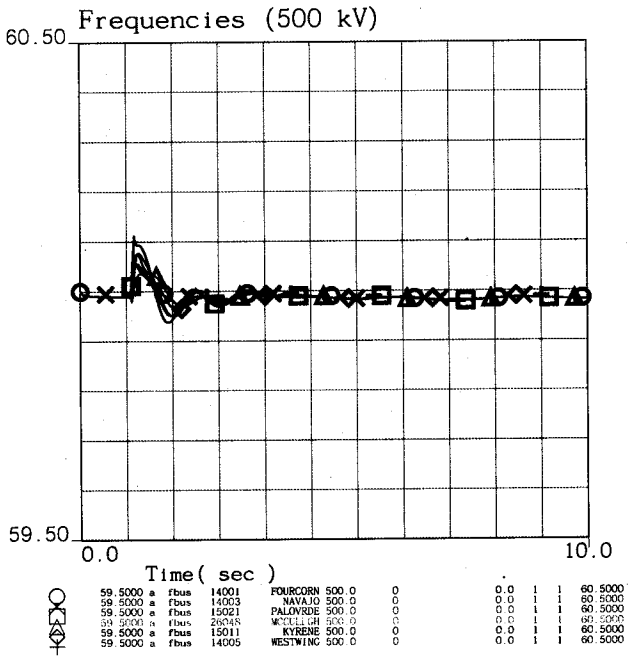

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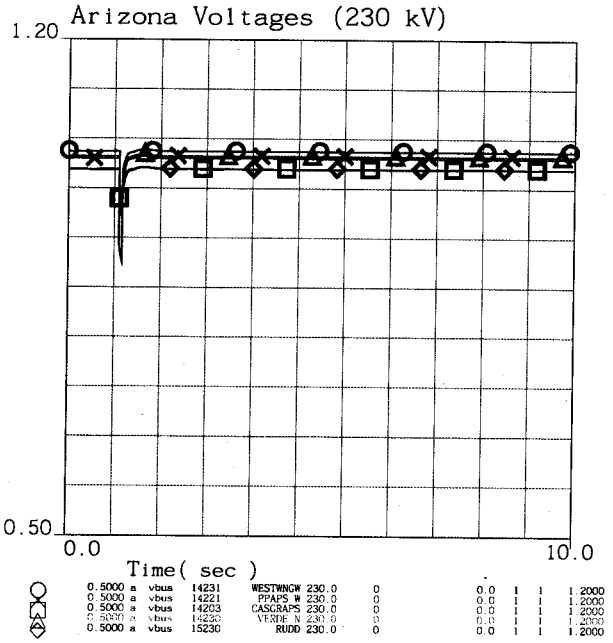
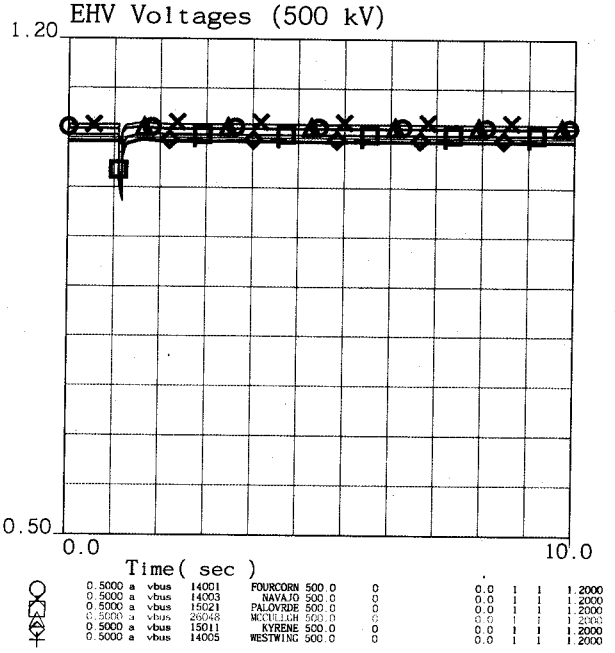
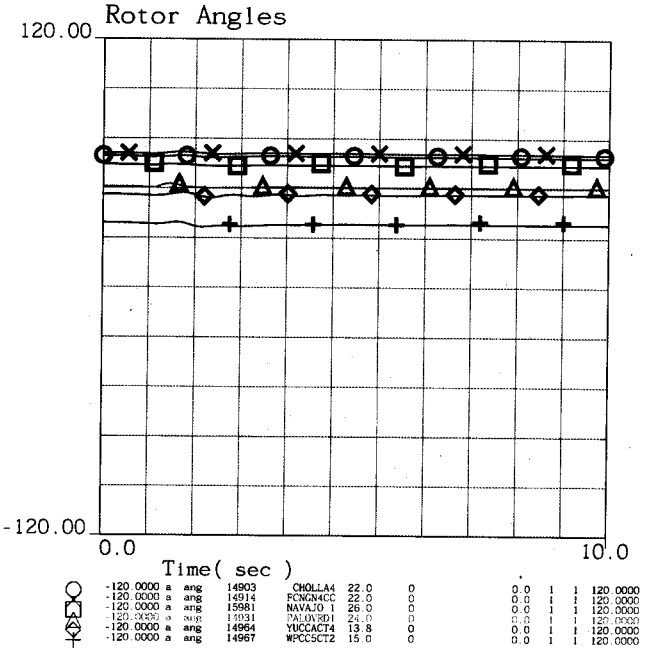
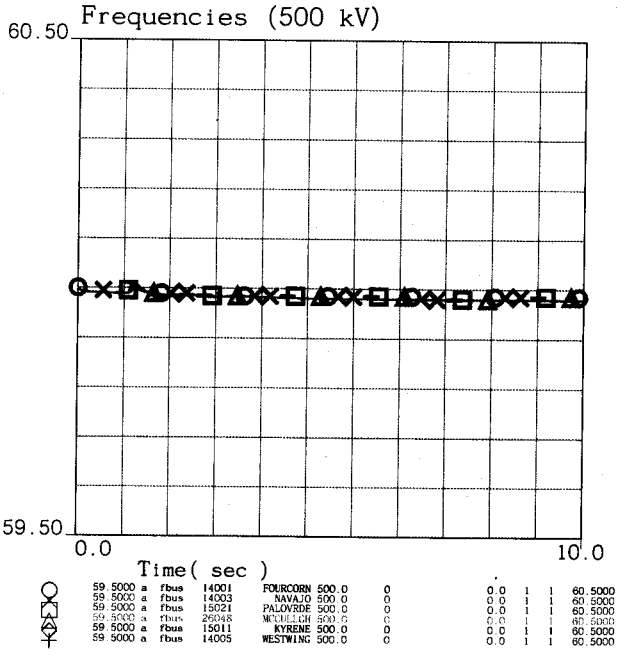
2018 Heavy Summer Detailed Planning Case









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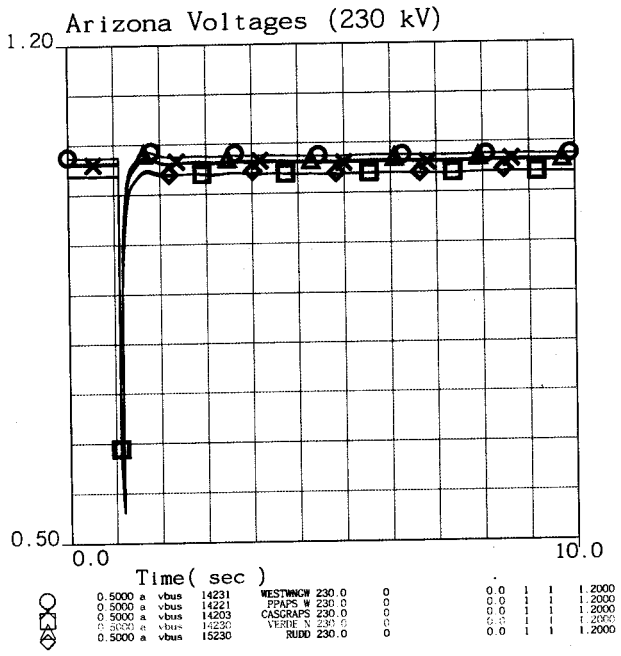

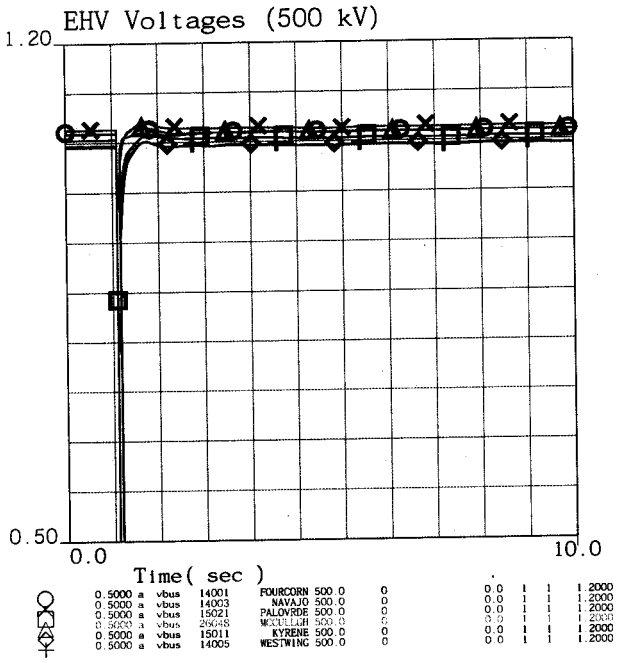

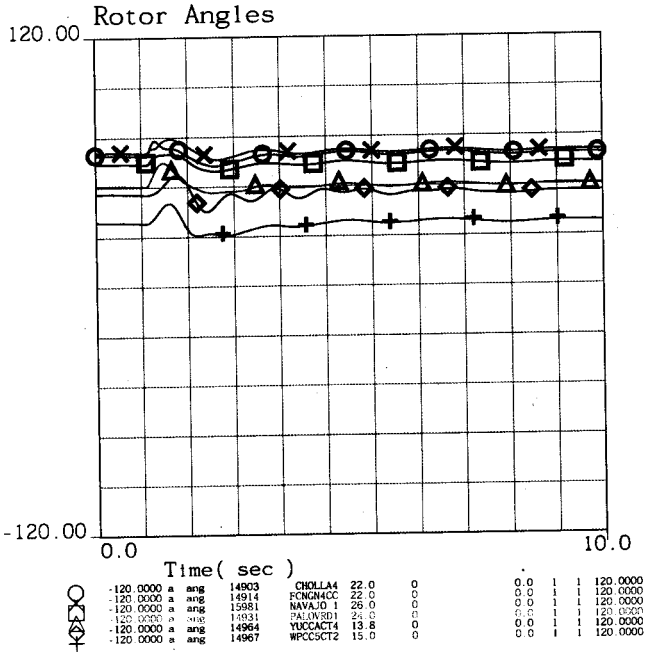

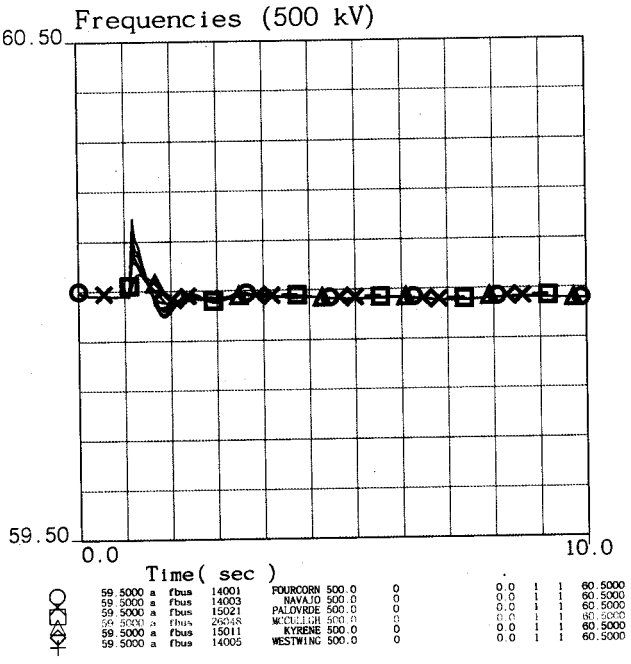

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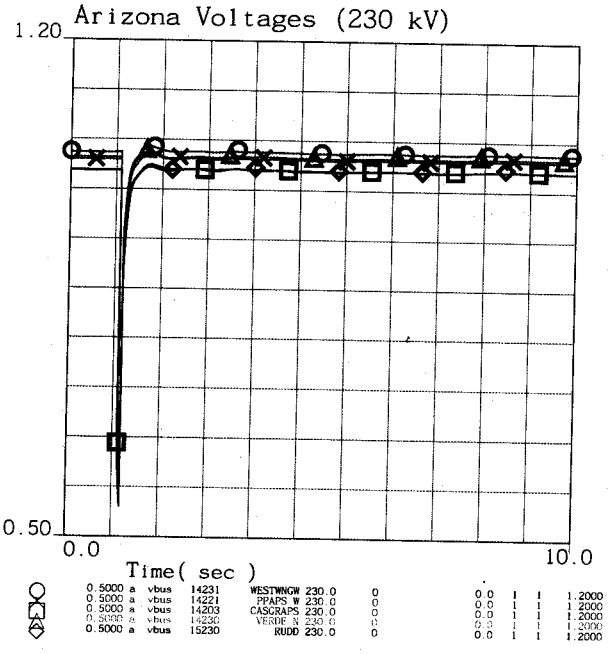

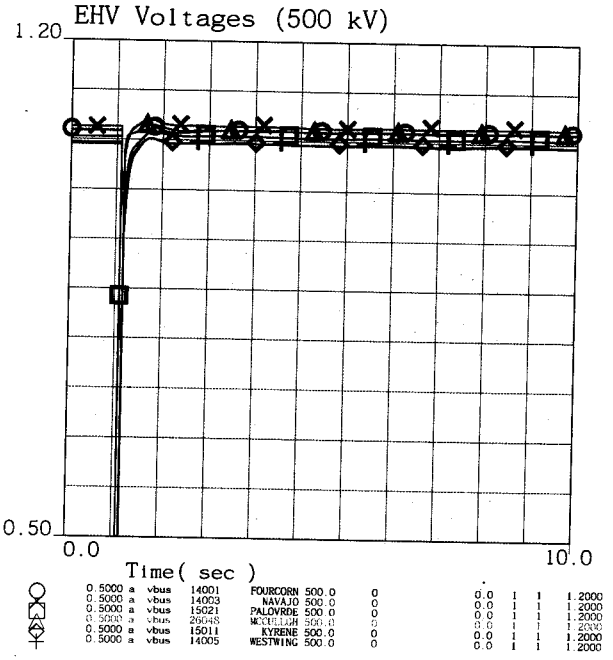

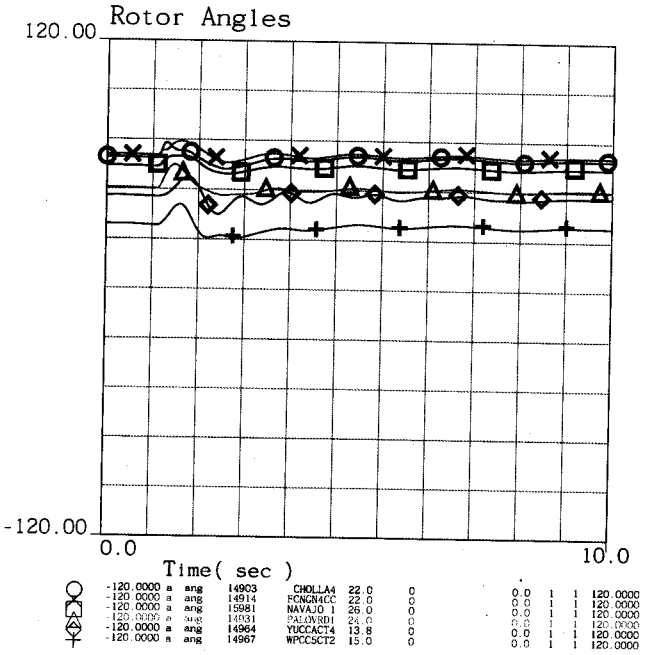

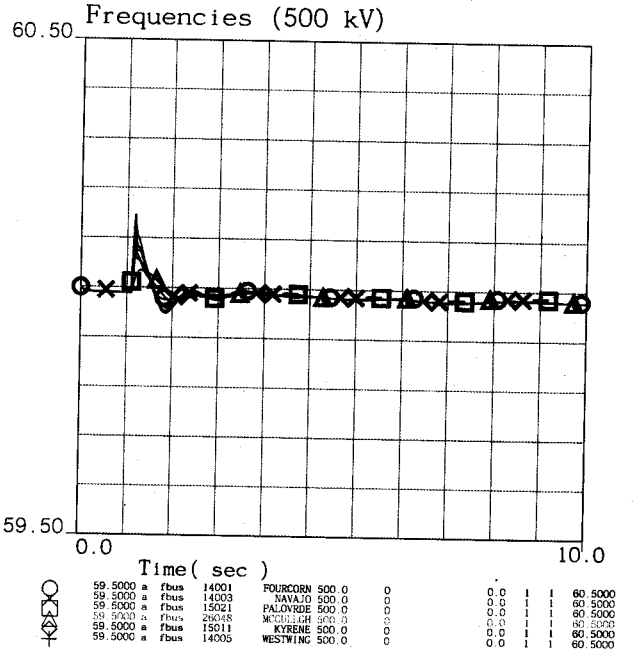

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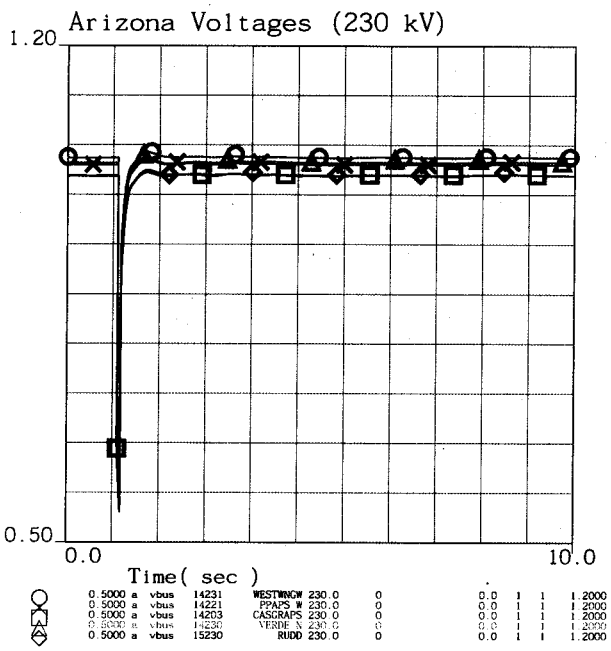

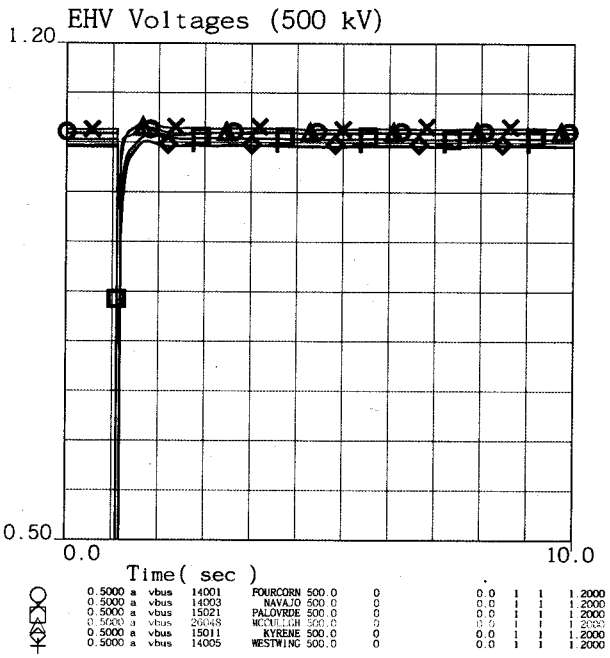

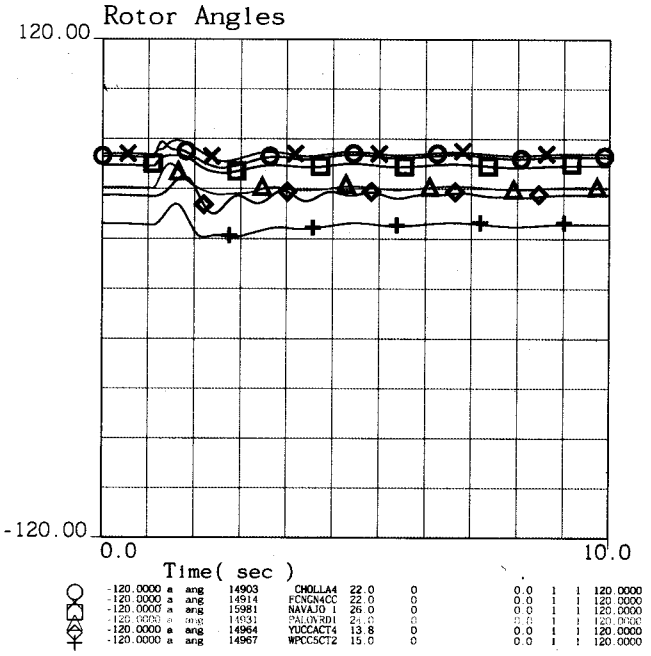

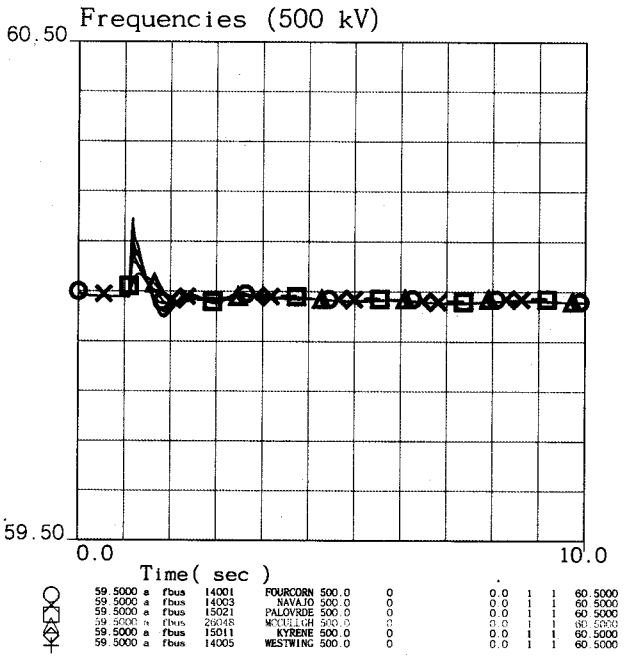

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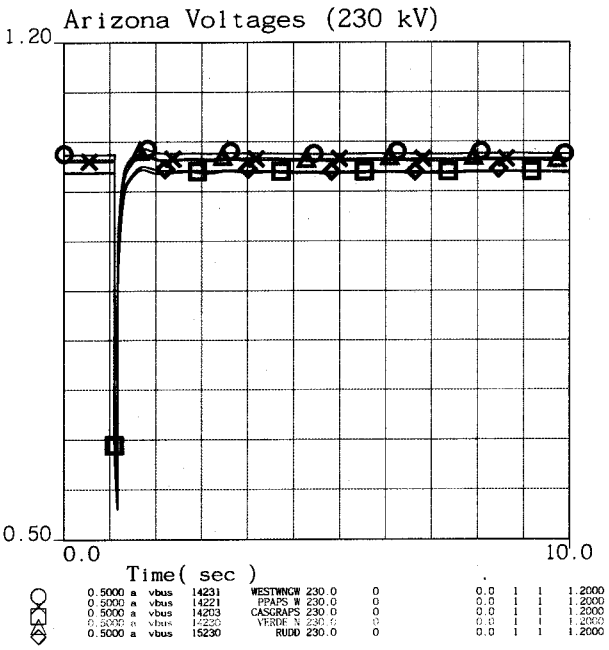

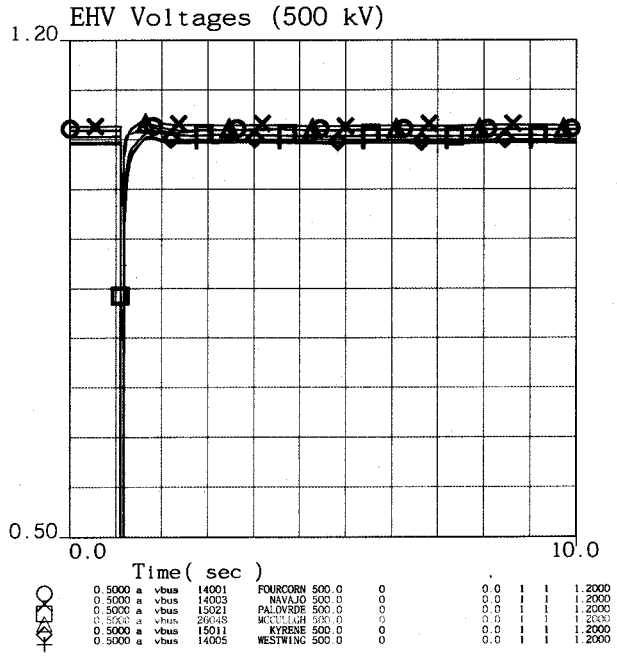

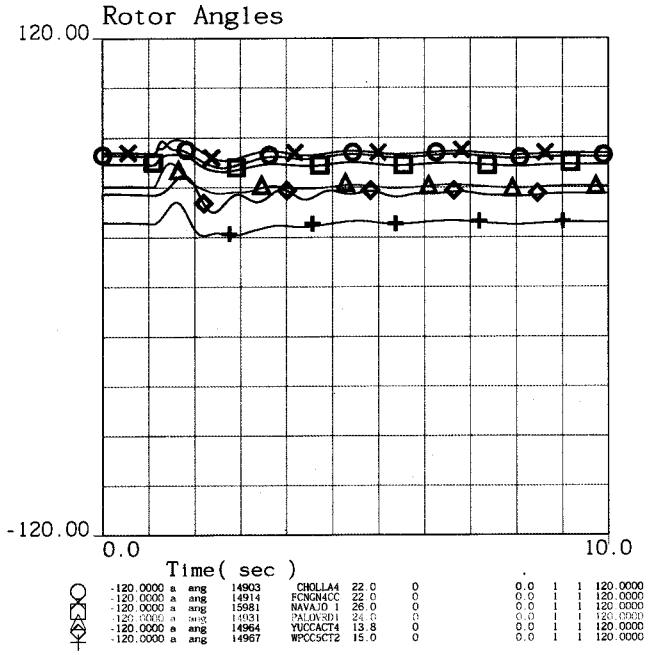

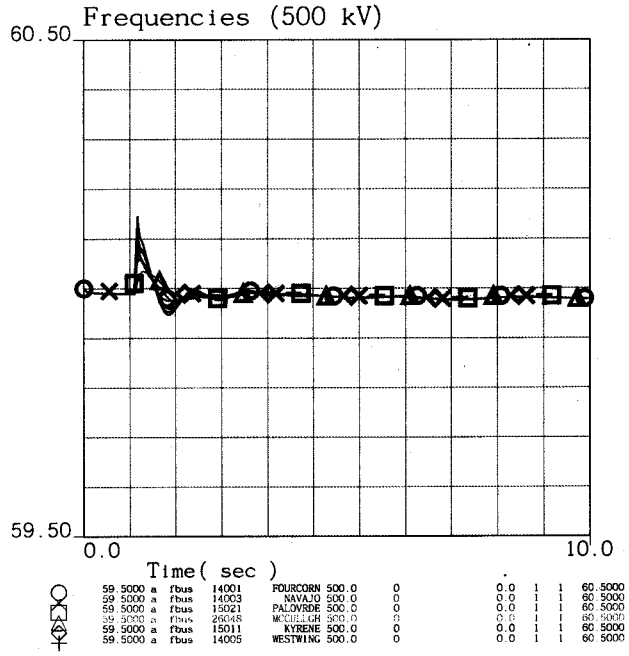

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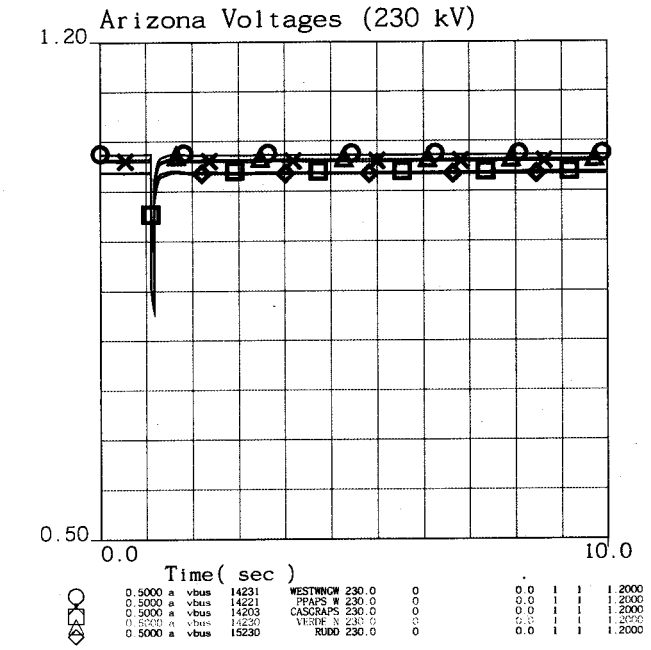

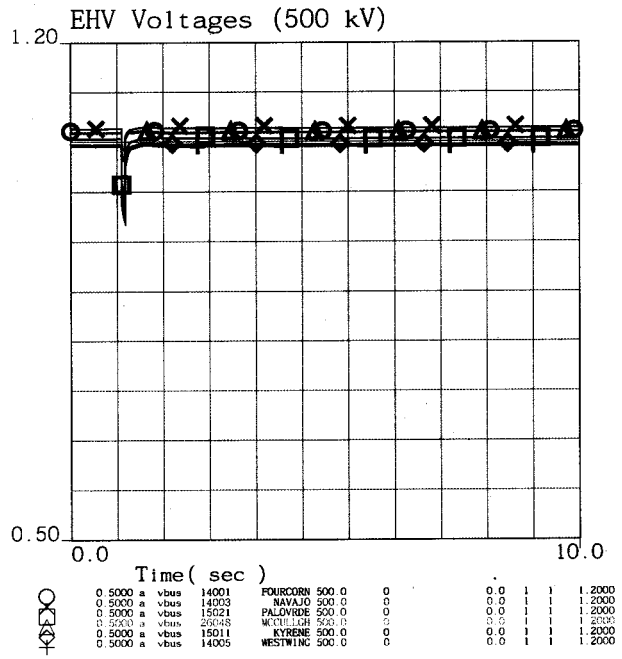

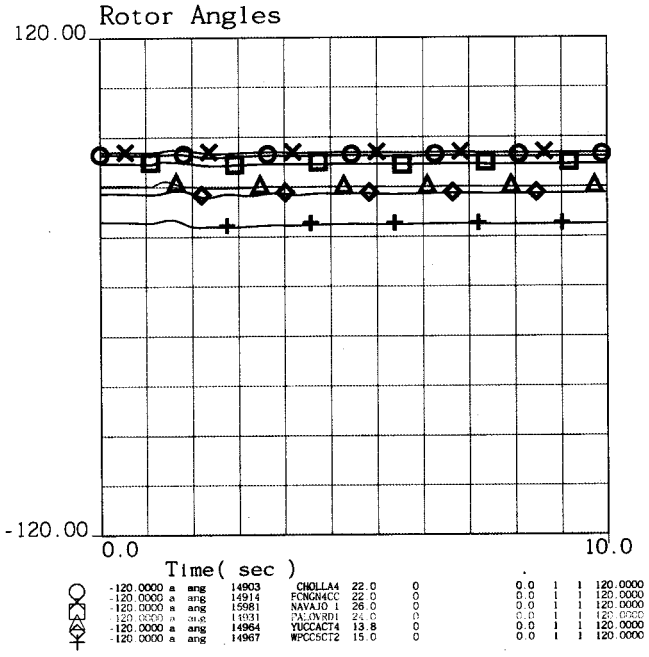

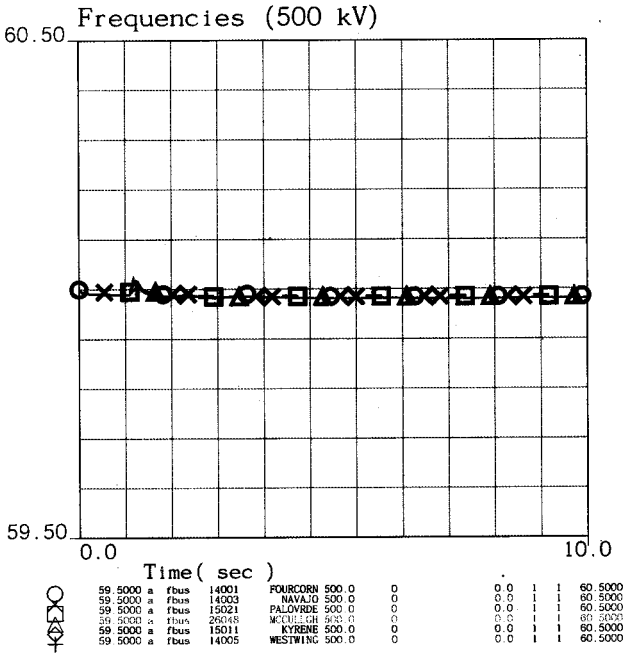

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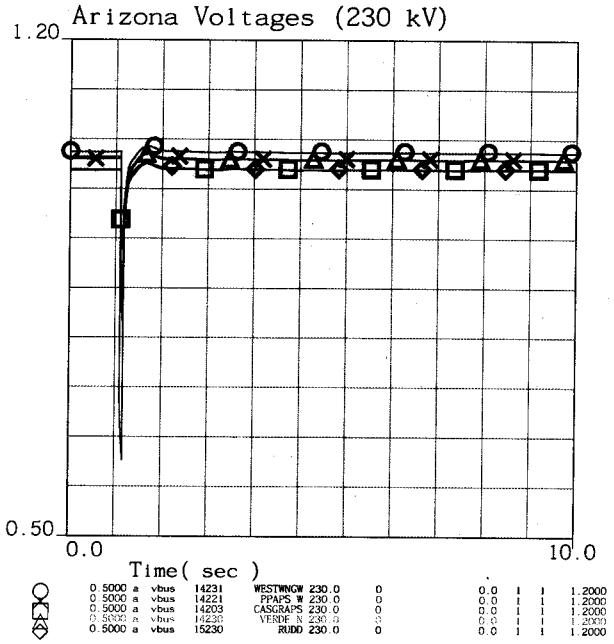

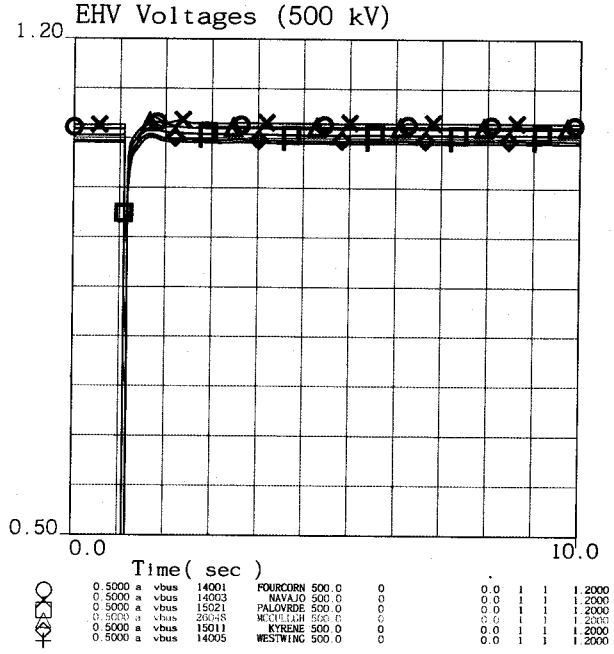

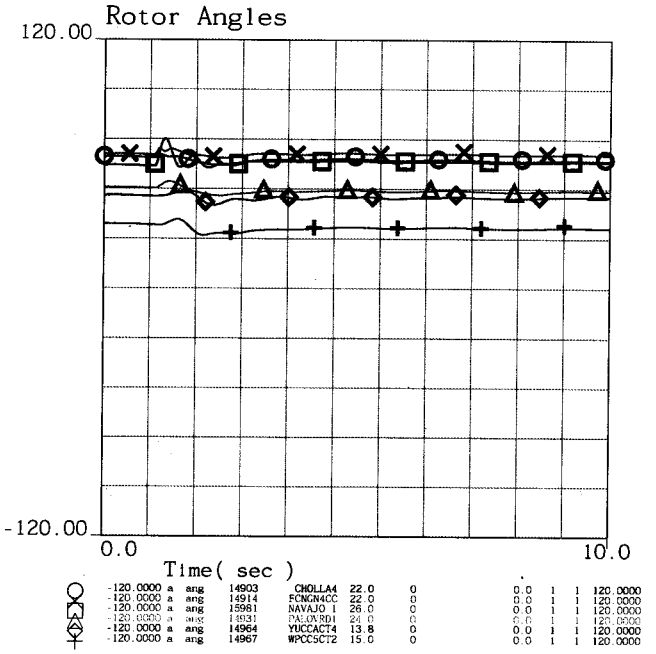

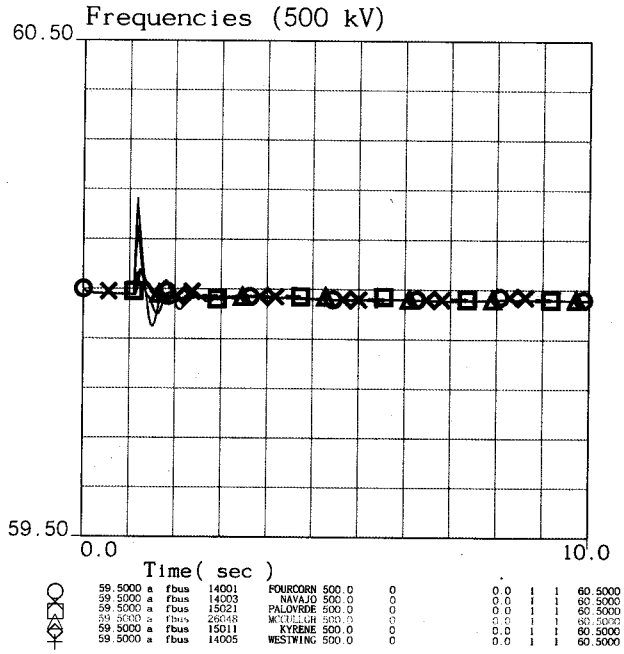

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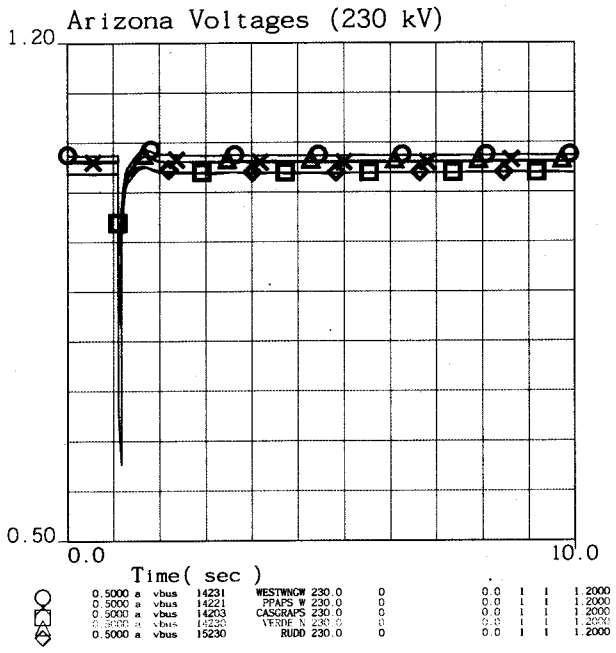

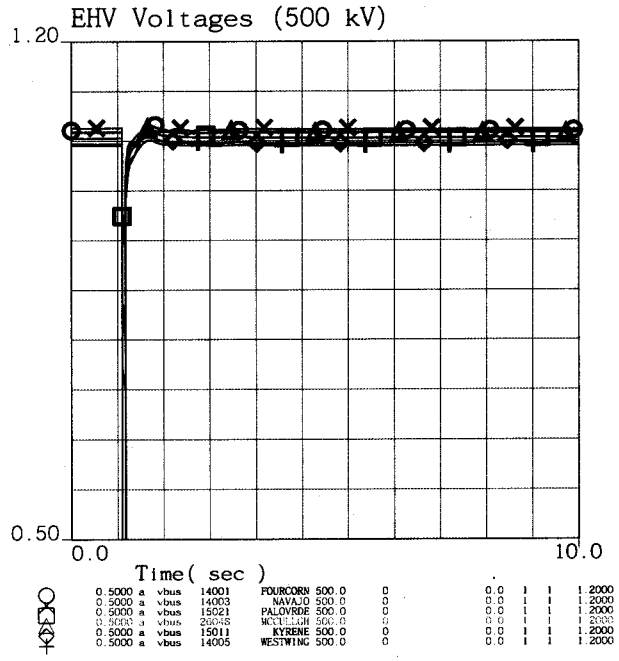

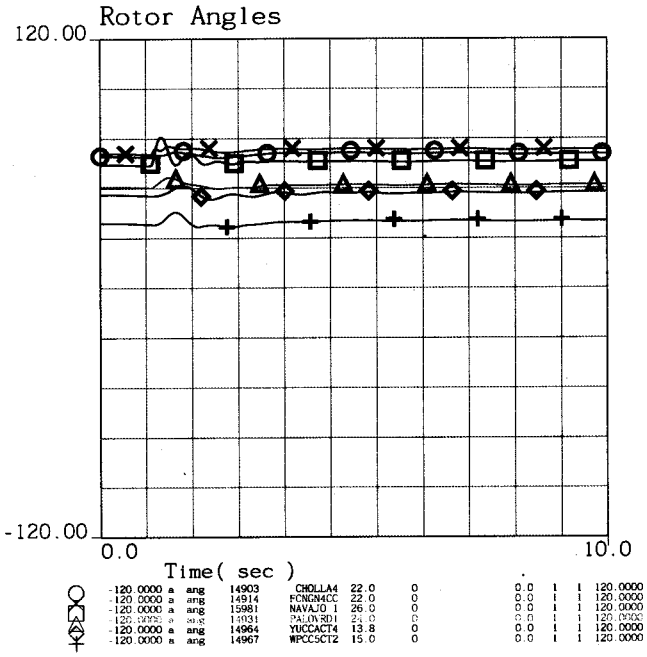

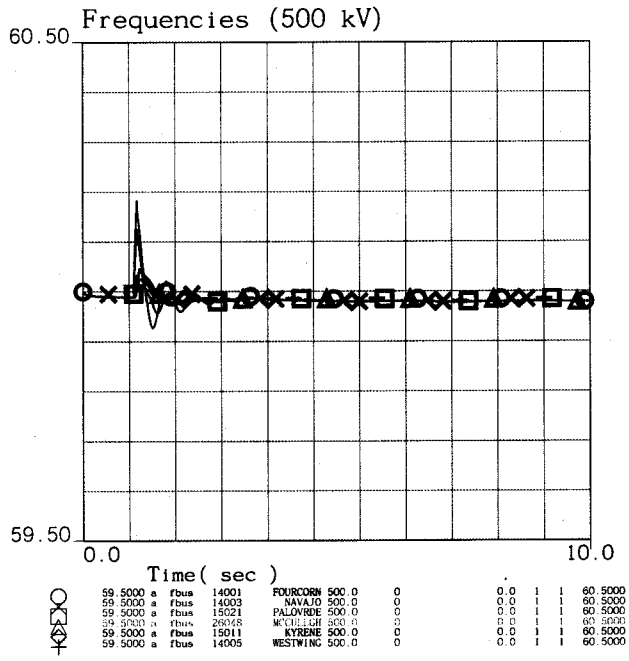

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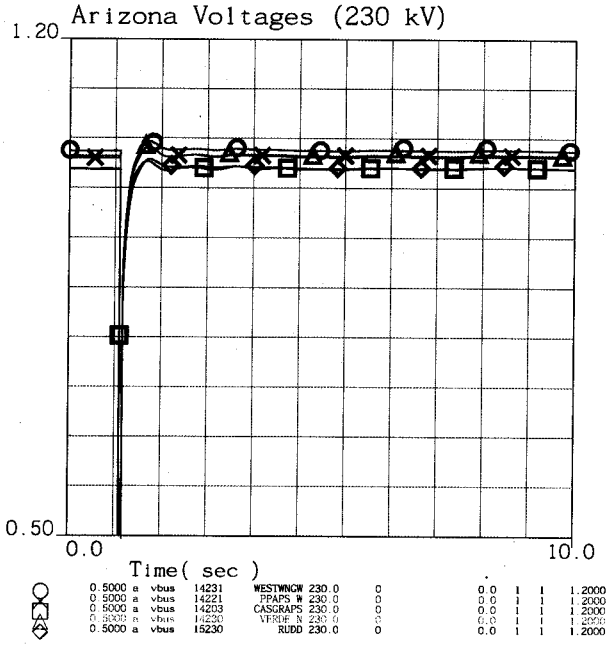

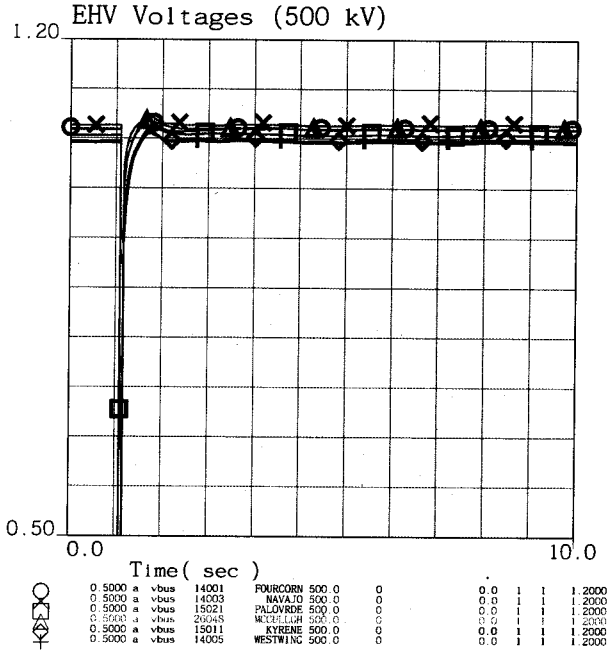

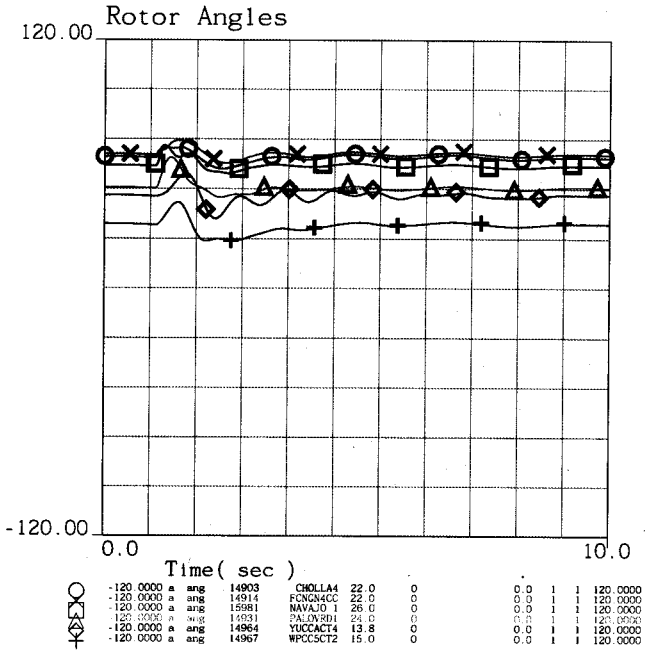

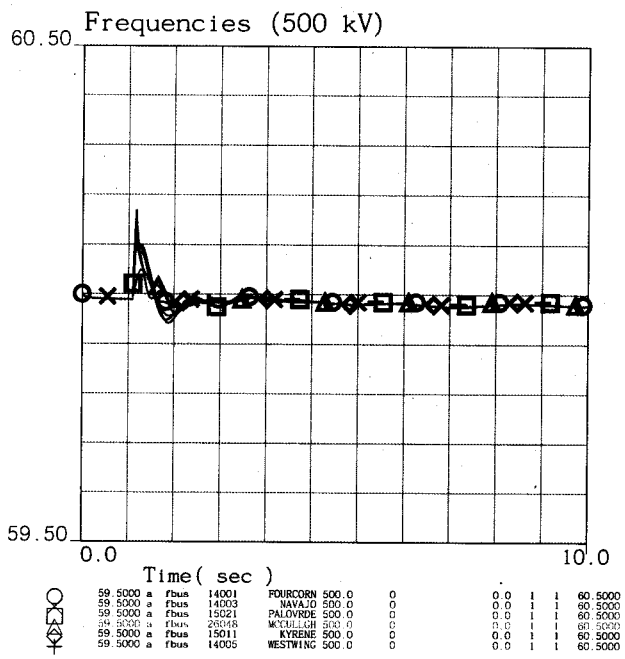

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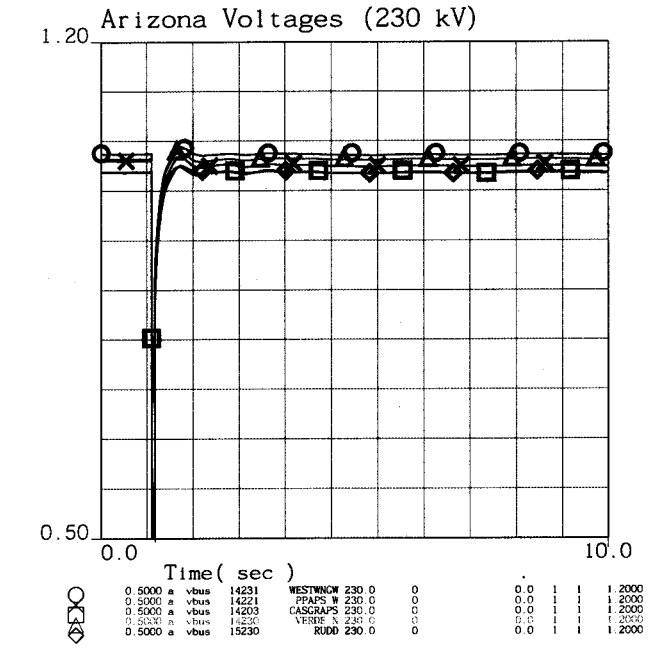

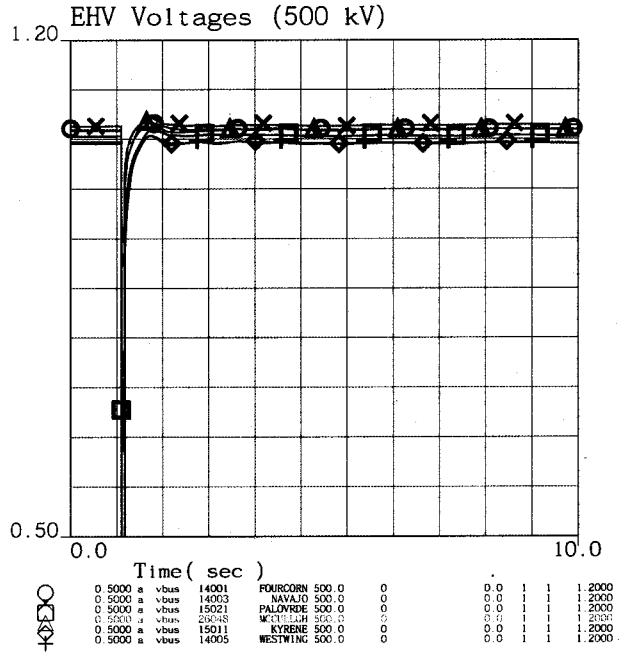

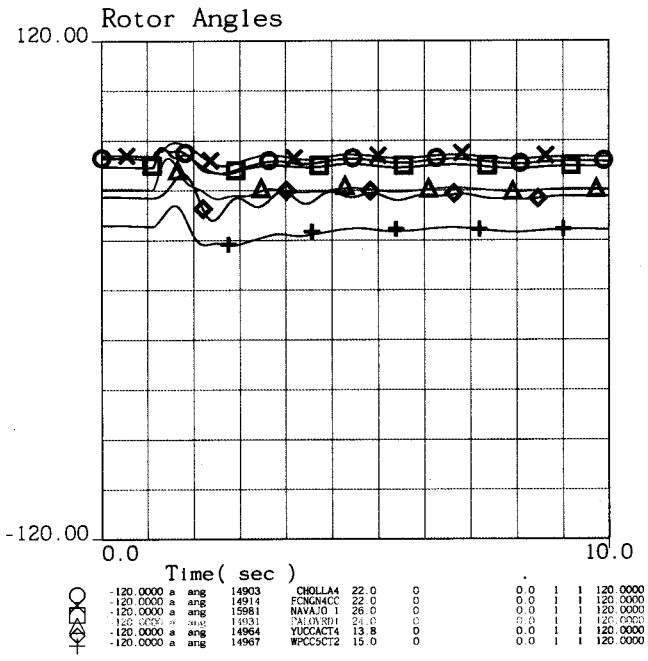

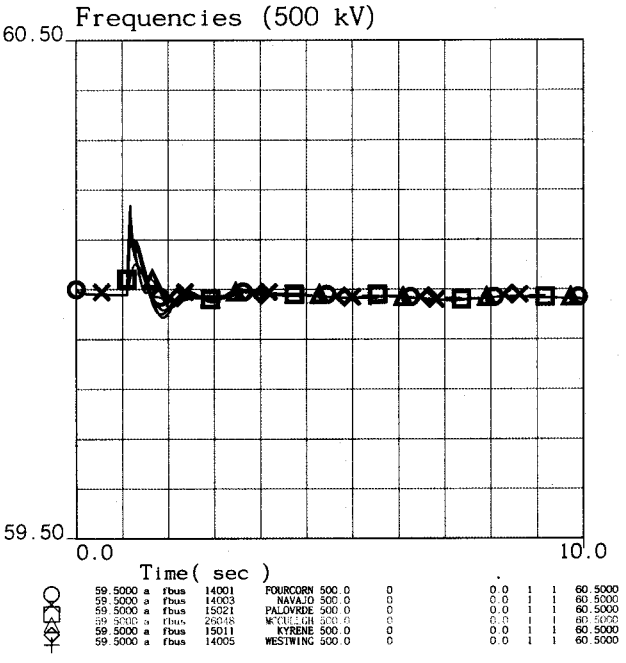

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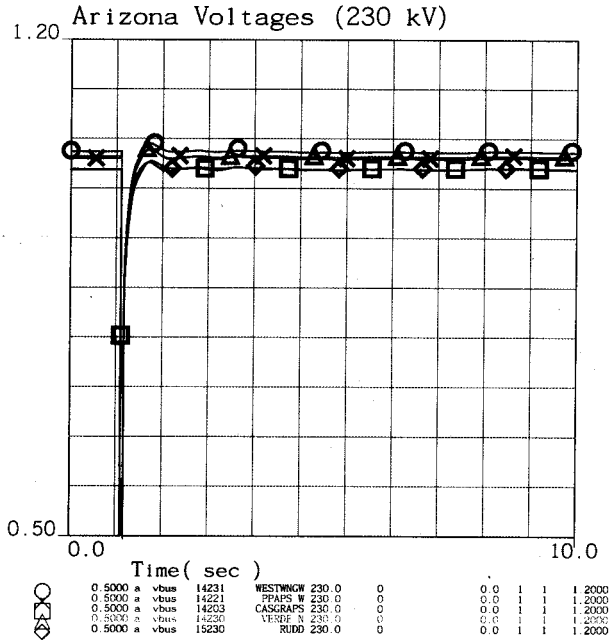

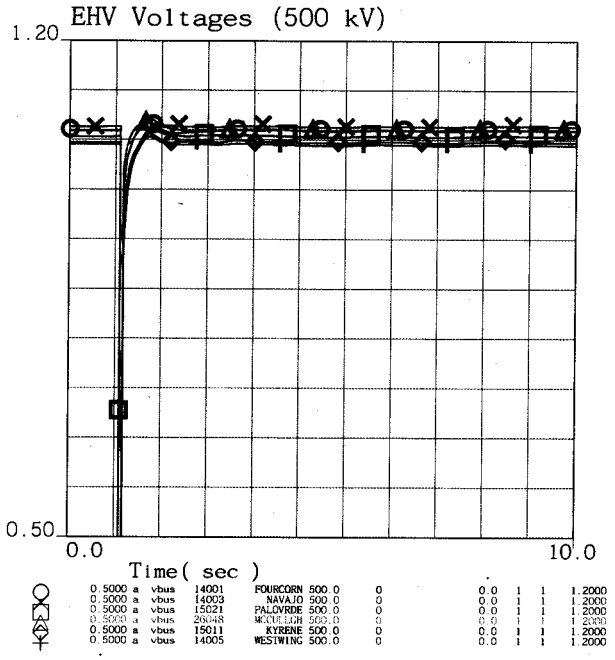

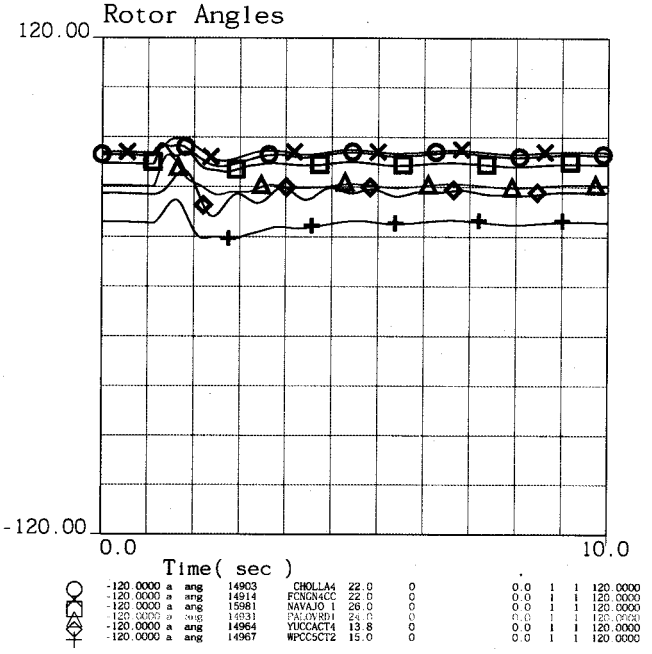

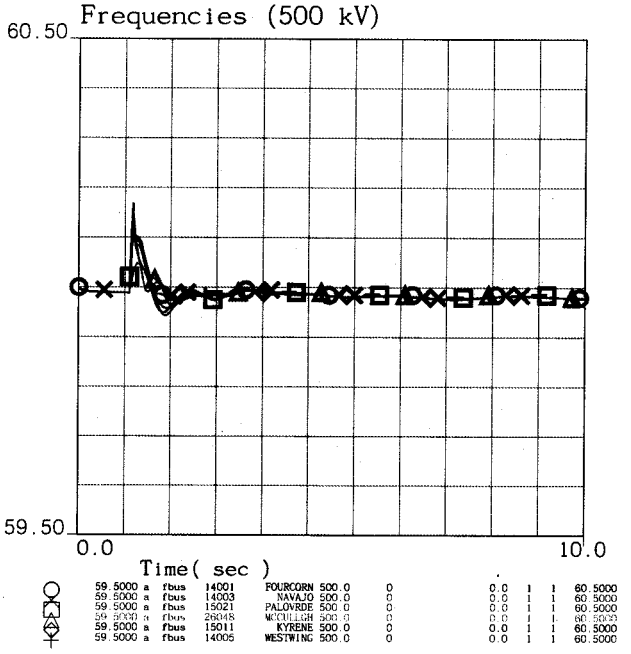

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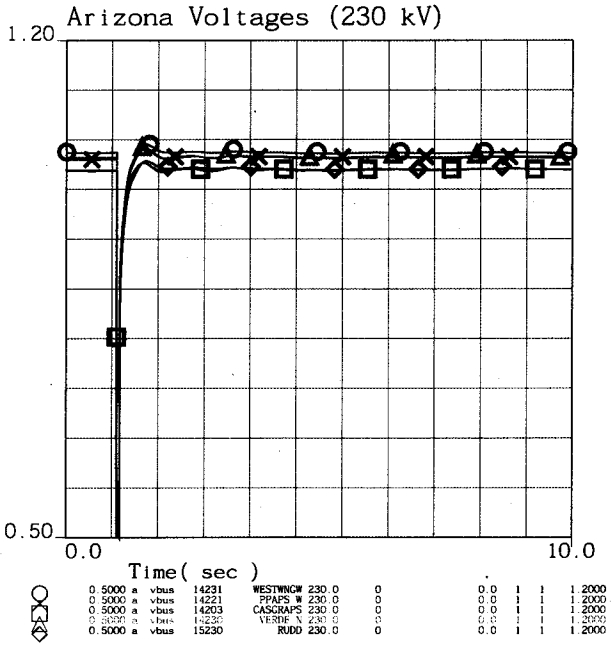

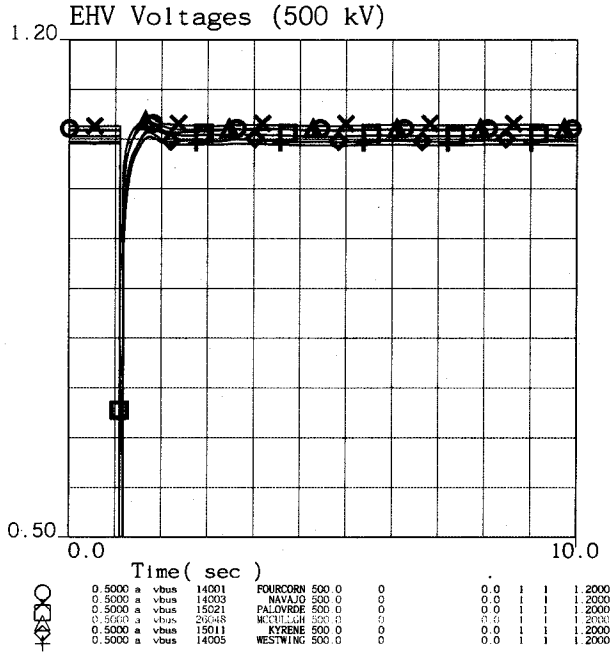

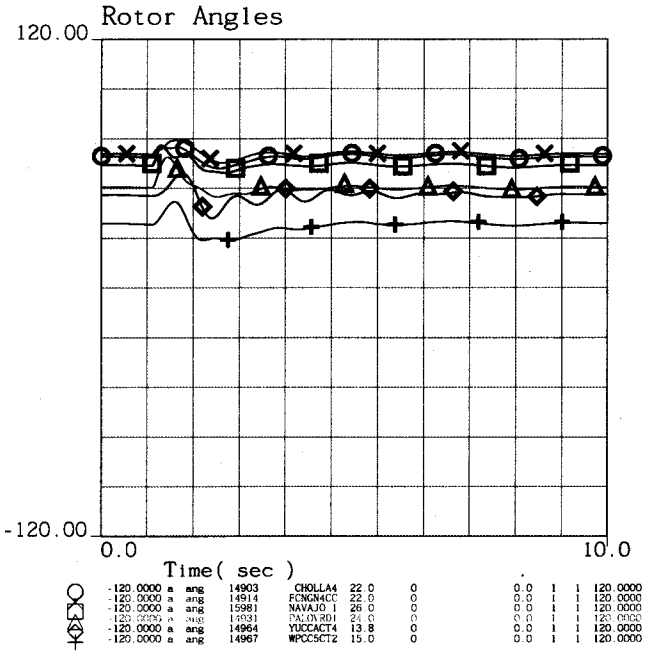

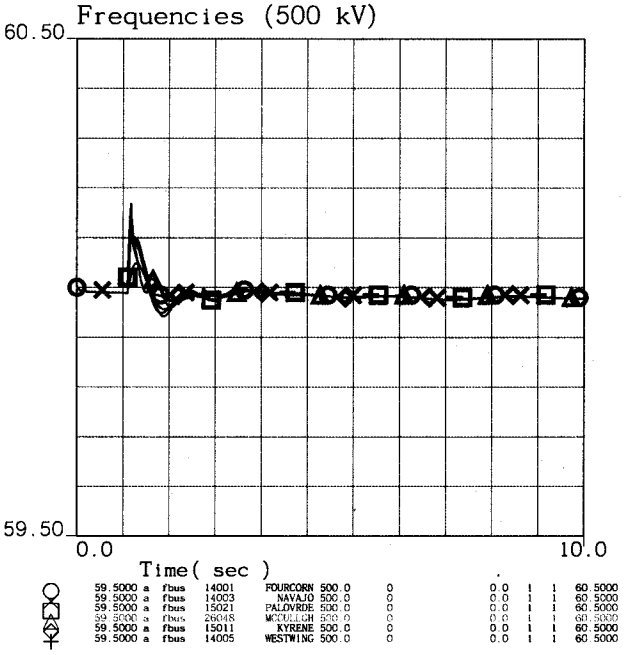

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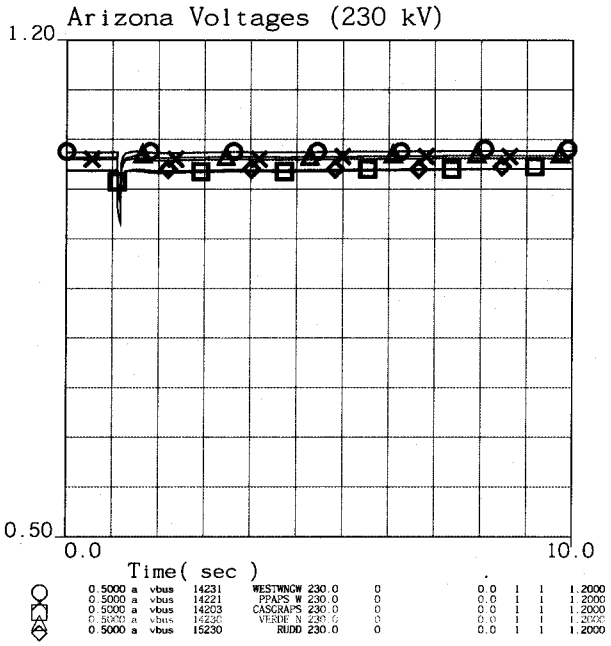

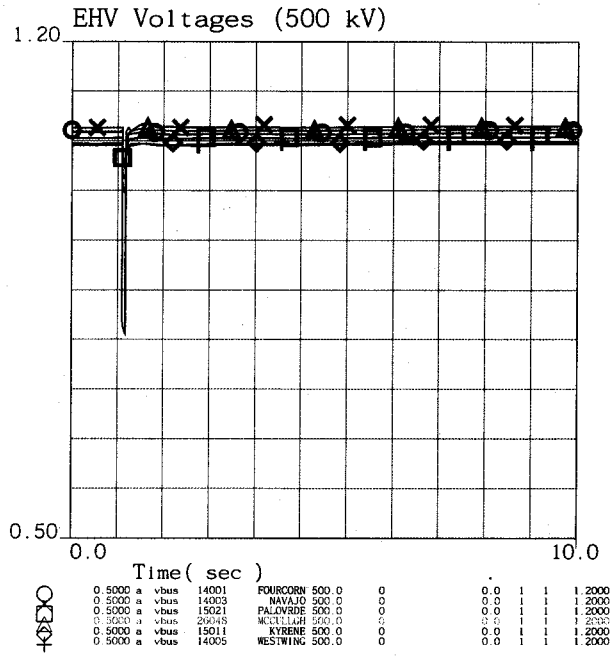

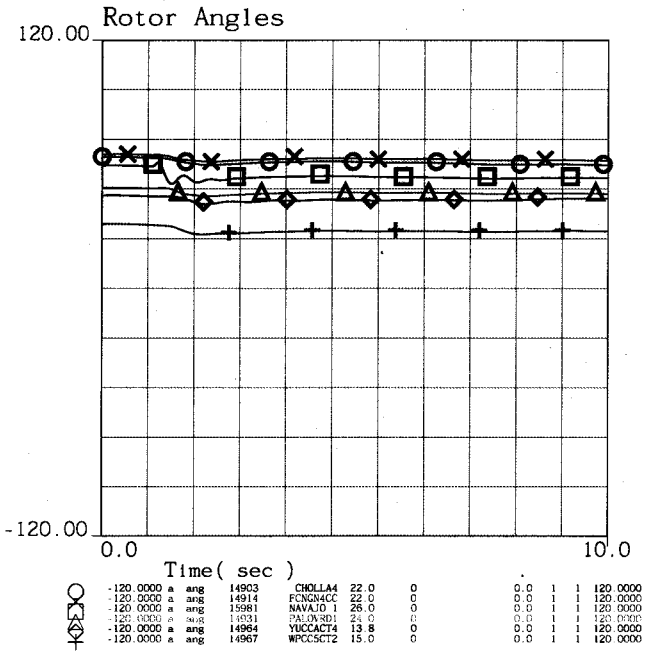

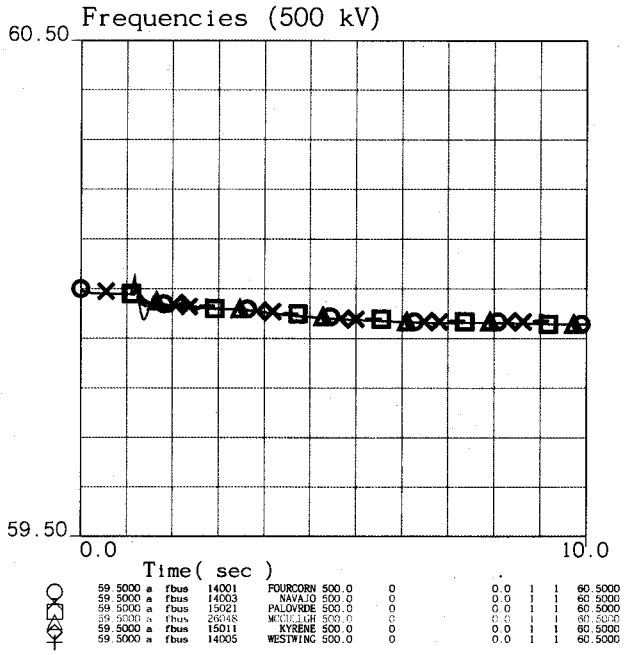

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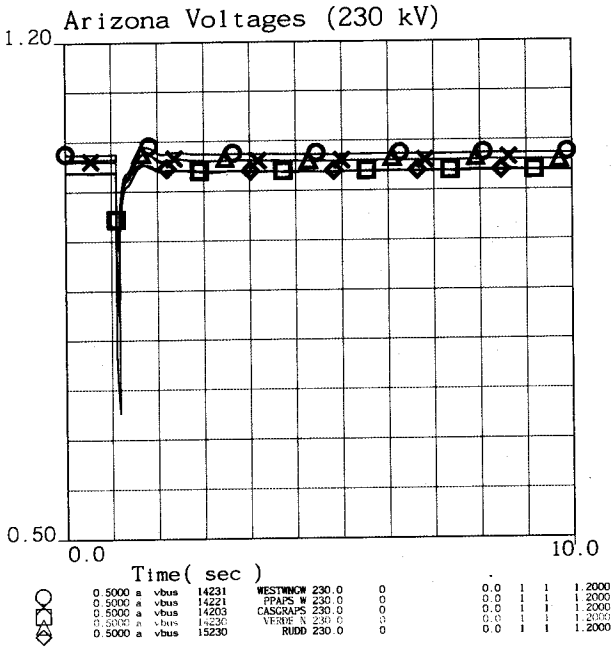

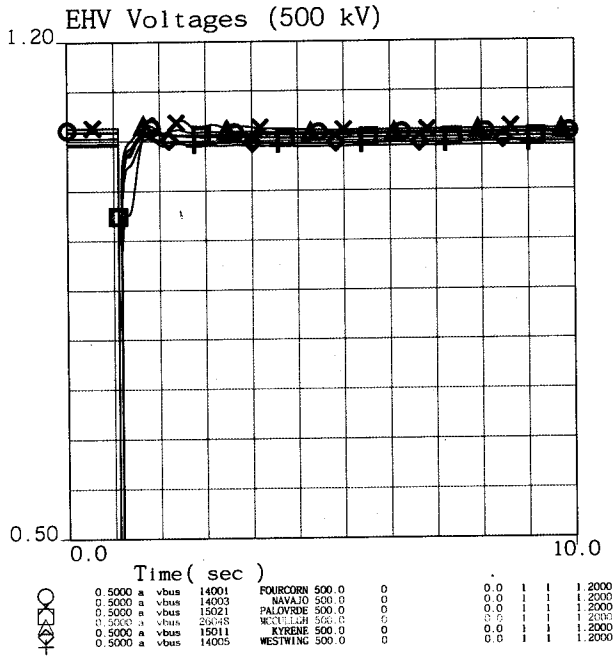

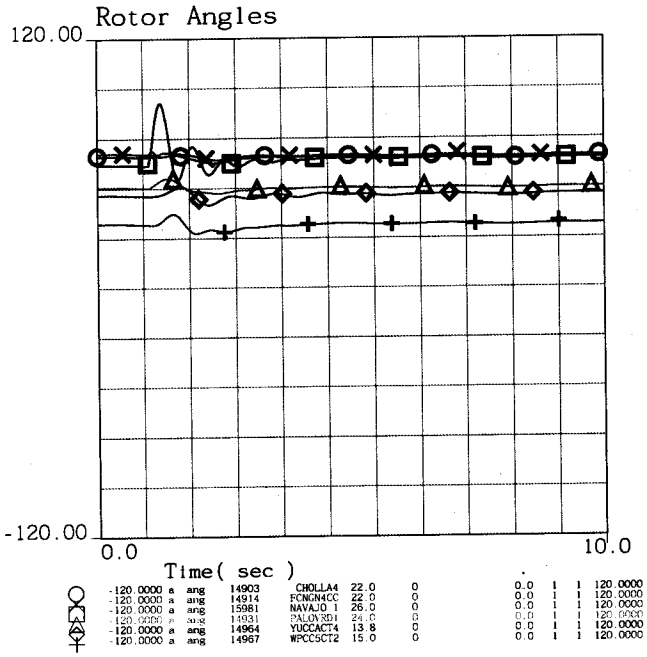

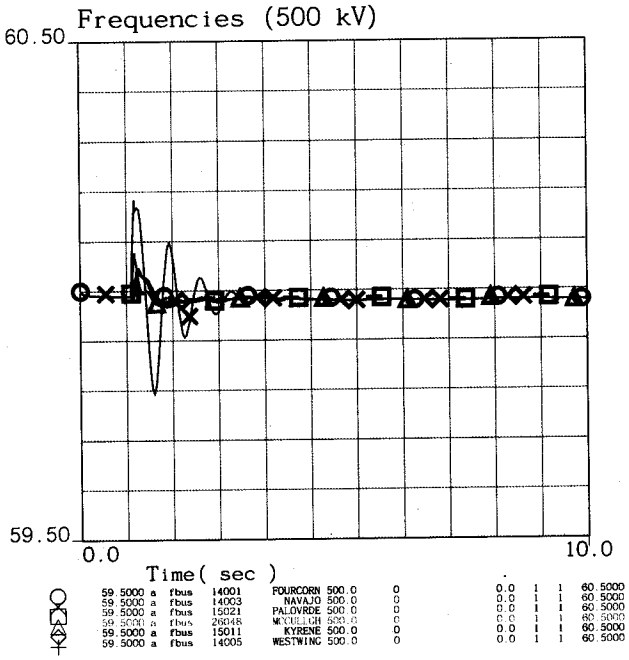

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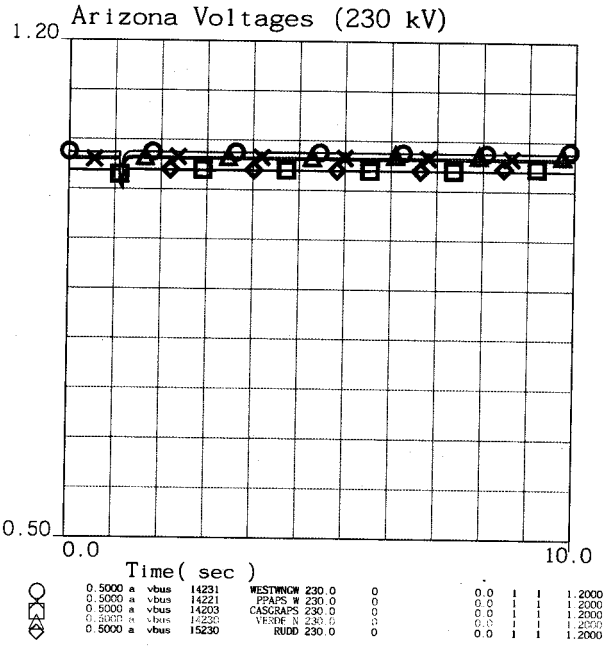
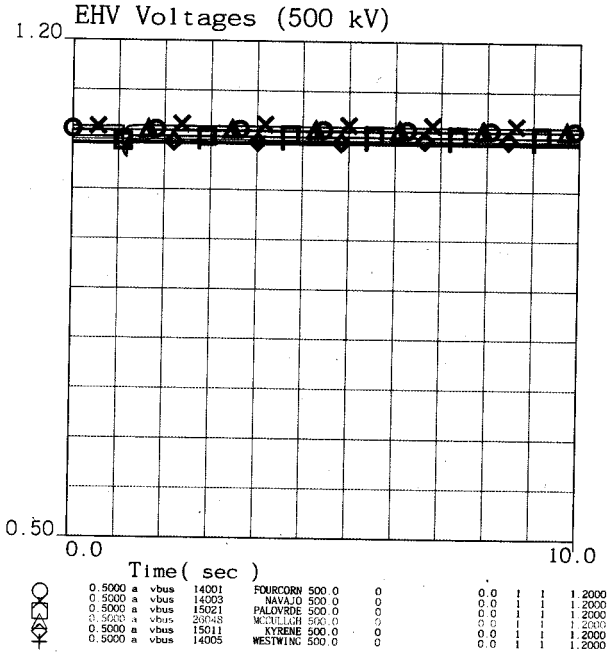
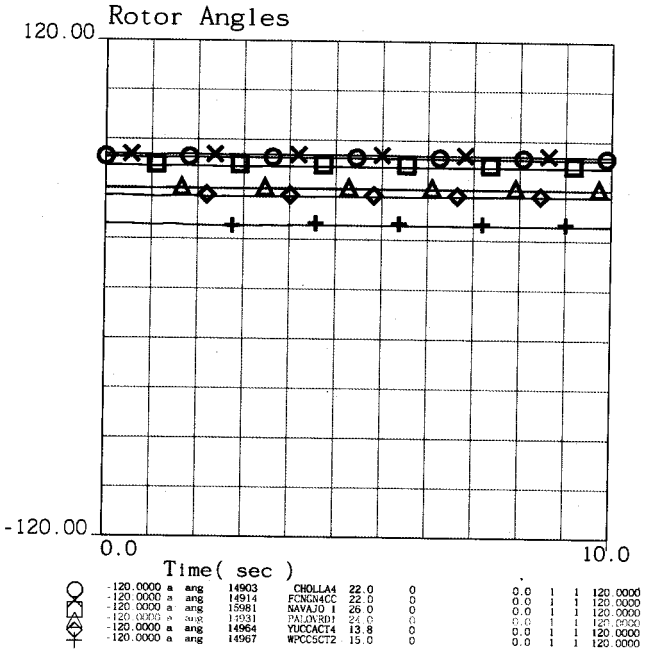
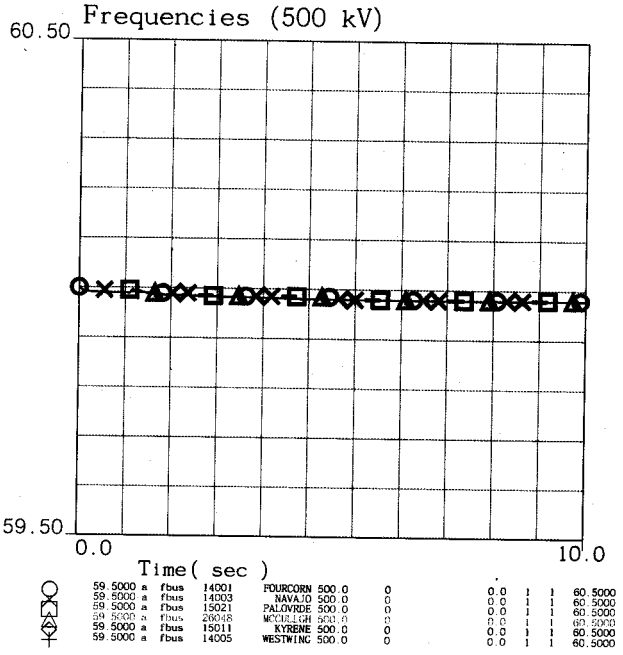
2018 Heavy Summer Detailed Planning Case









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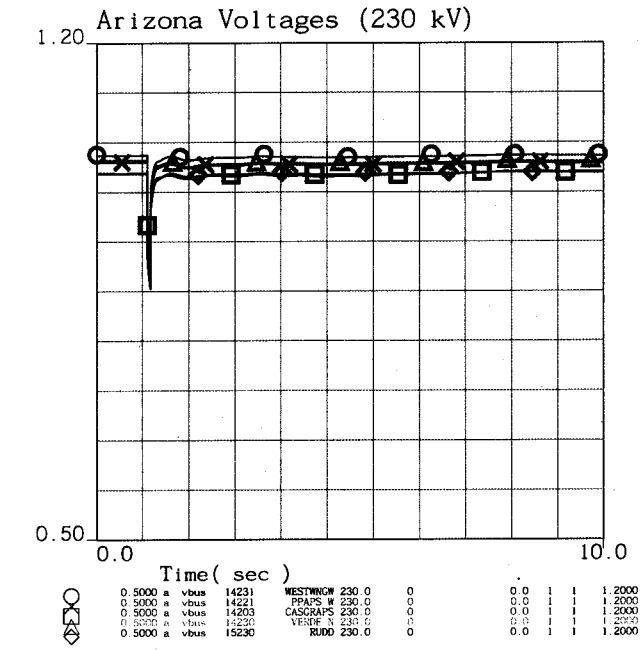

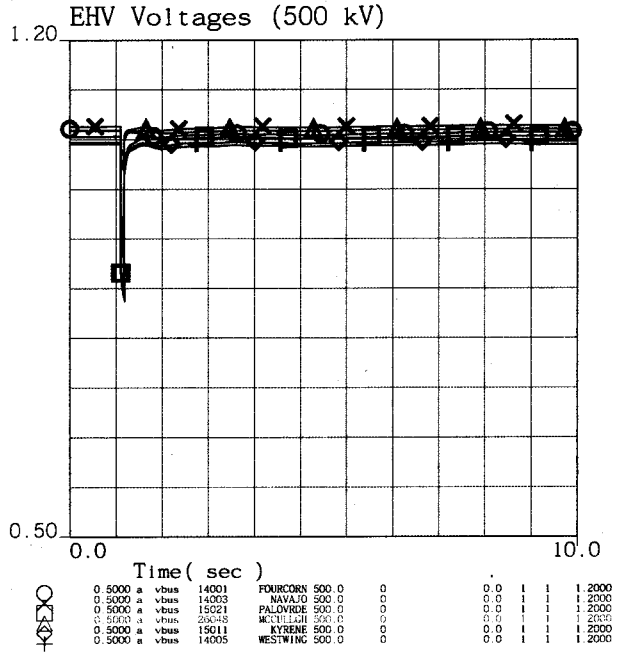

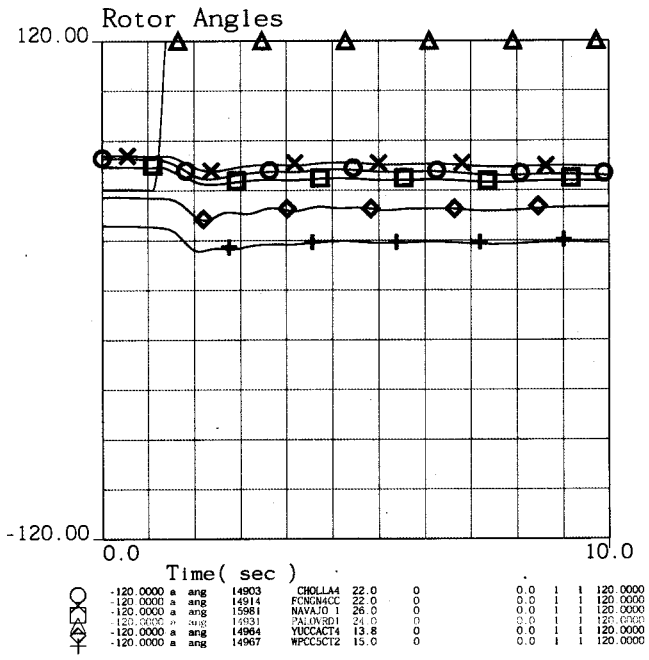

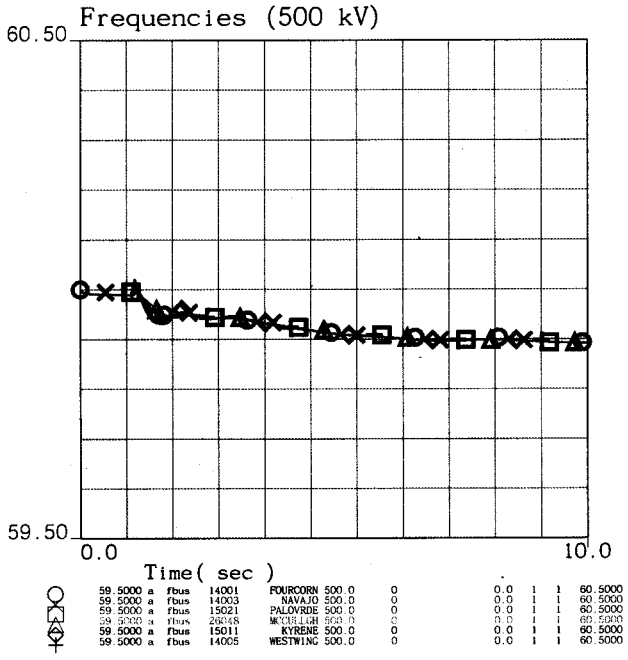

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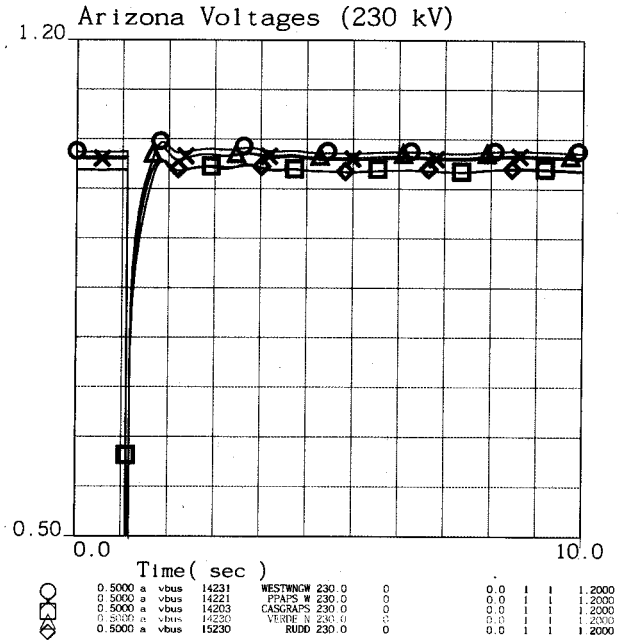

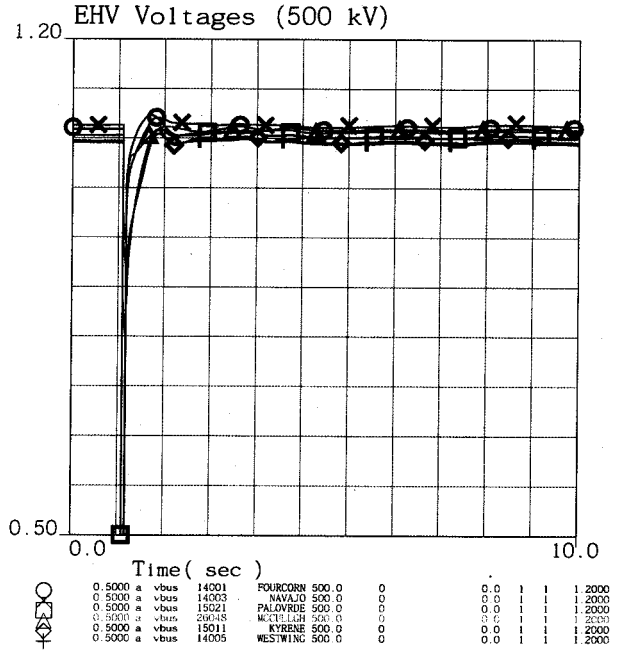

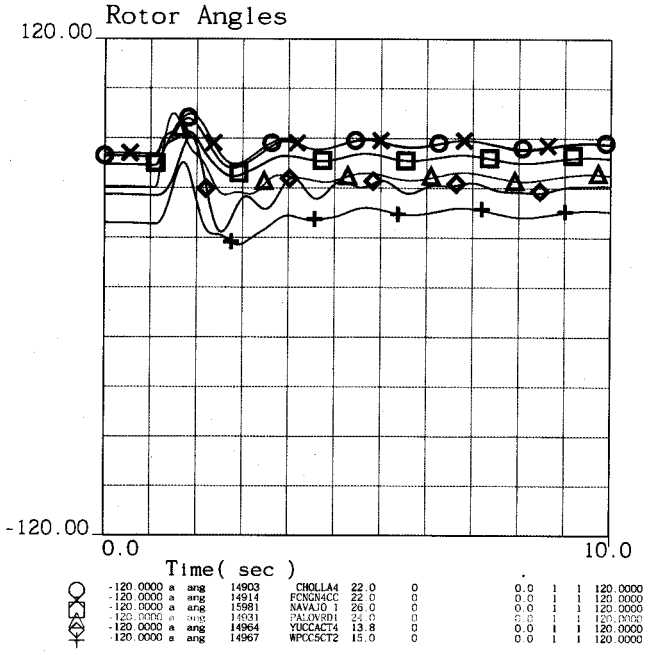

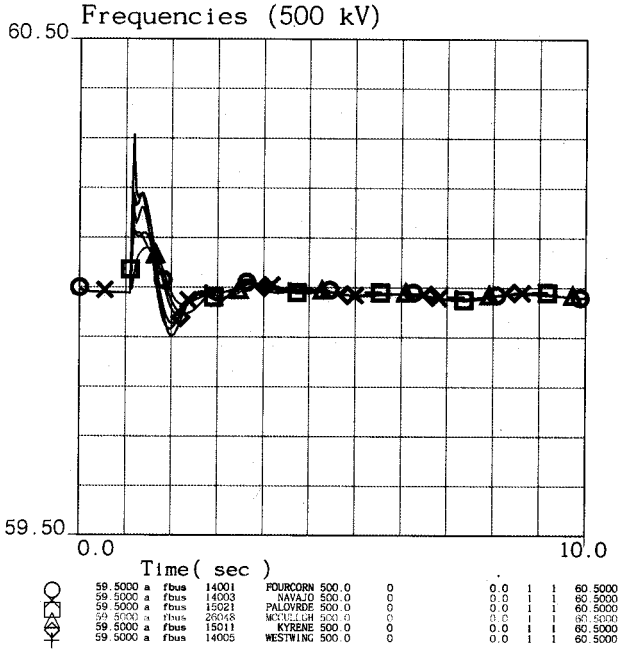

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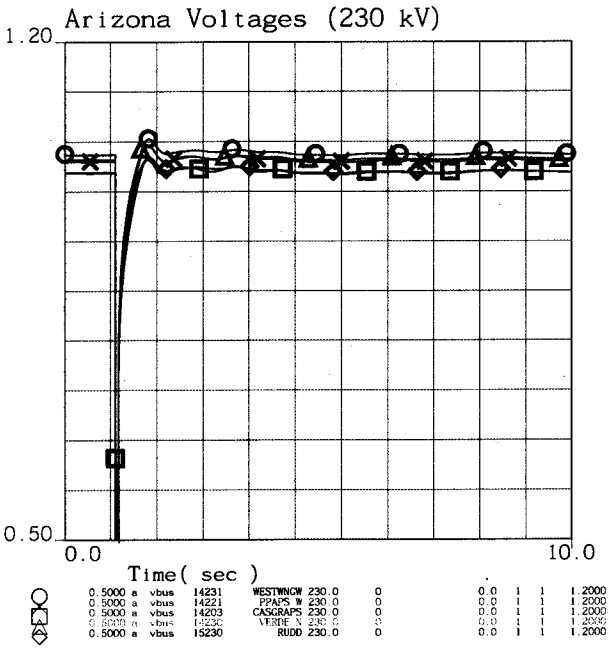

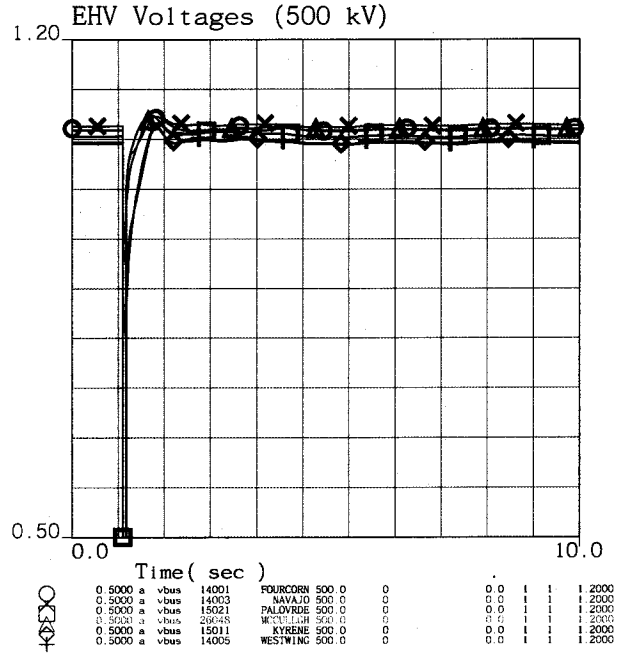

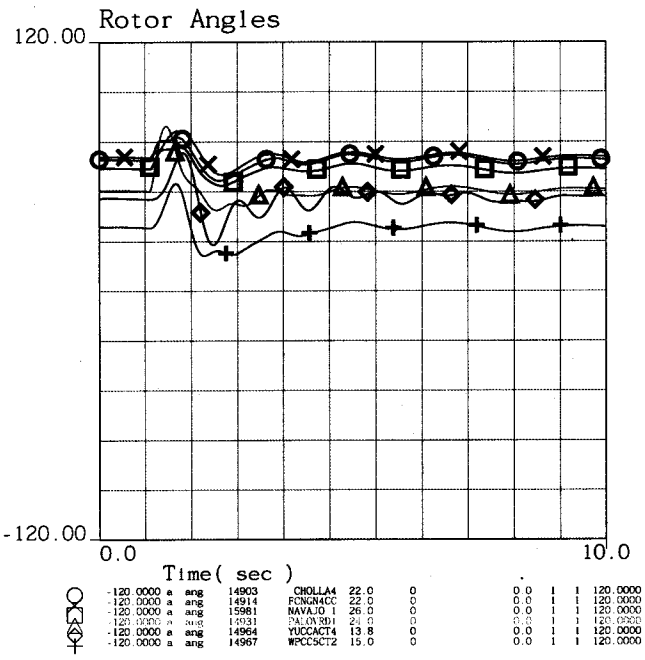

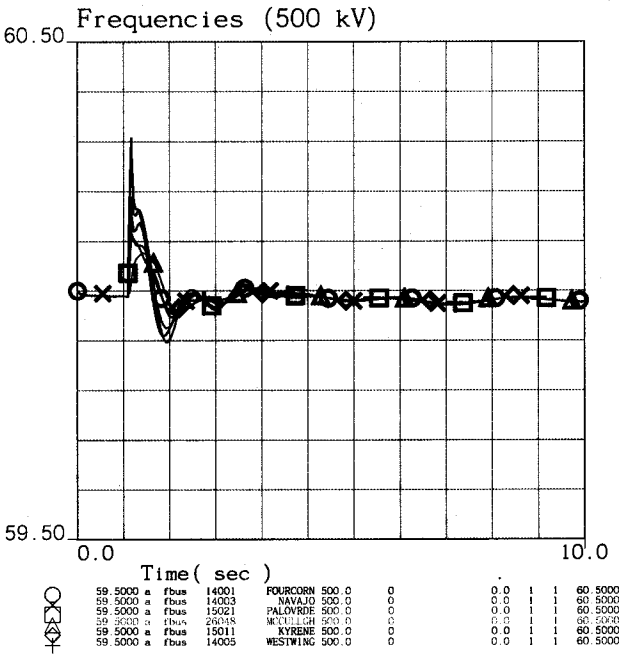

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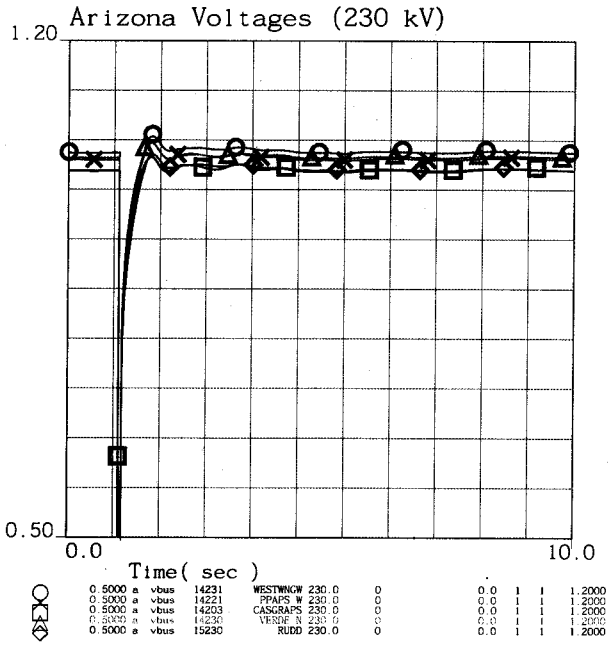

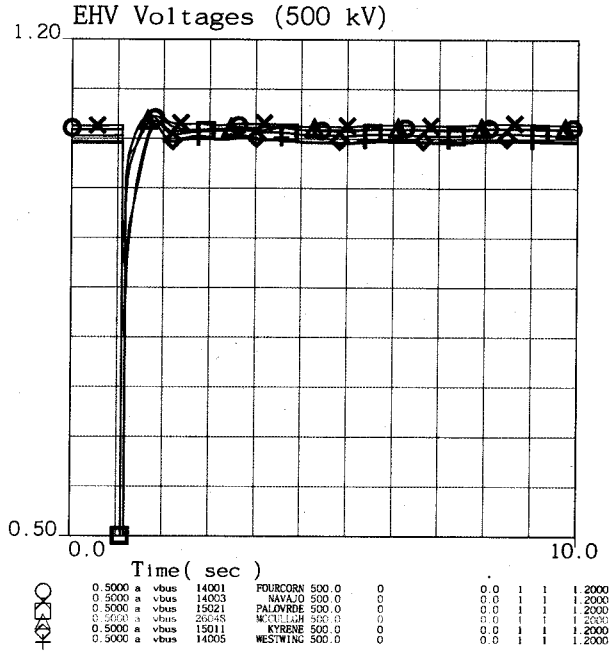

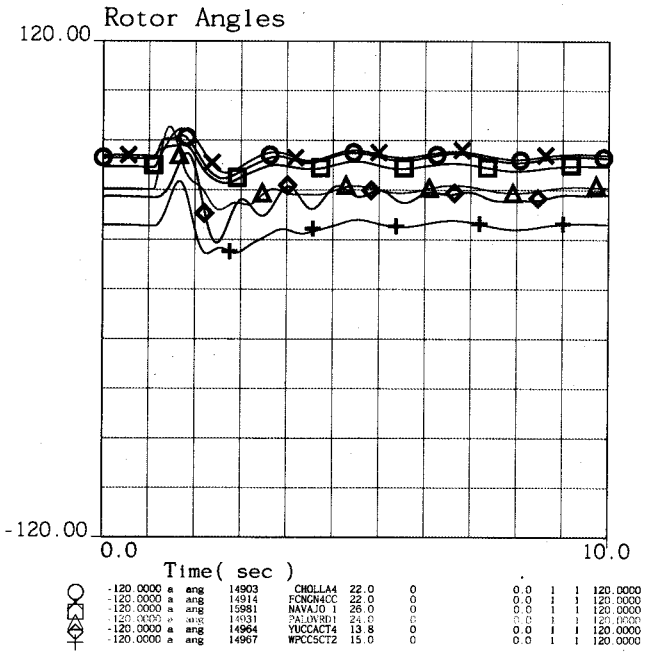

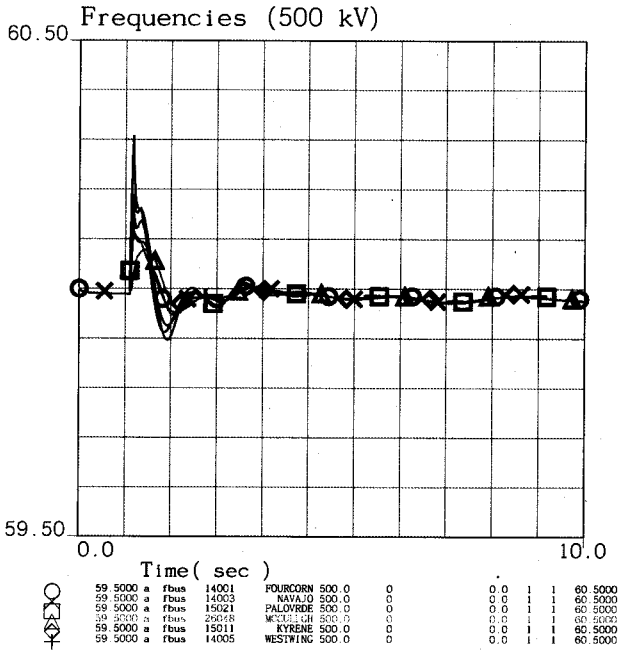

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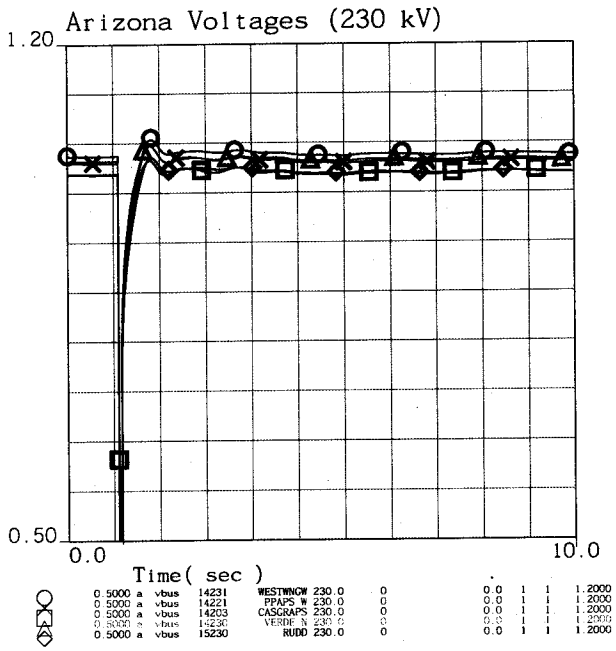

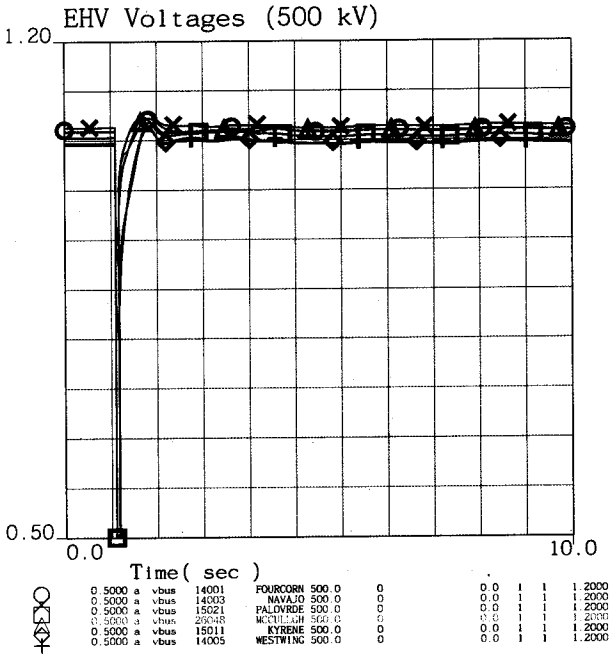

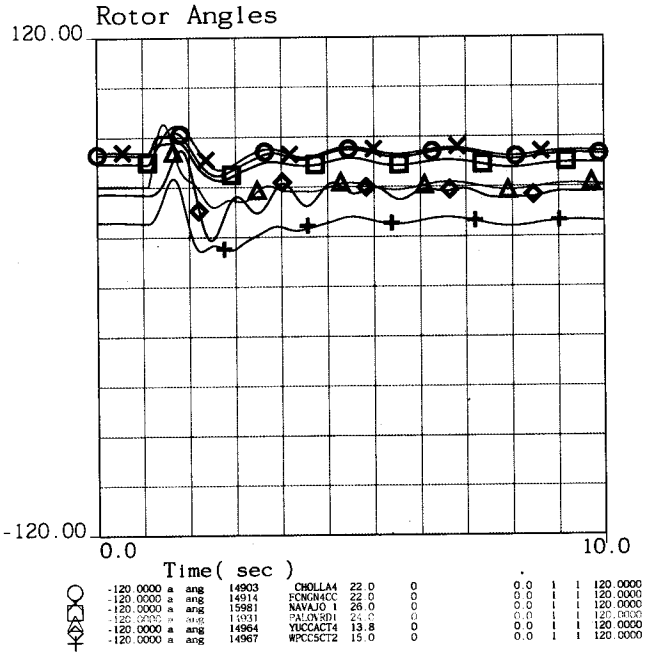

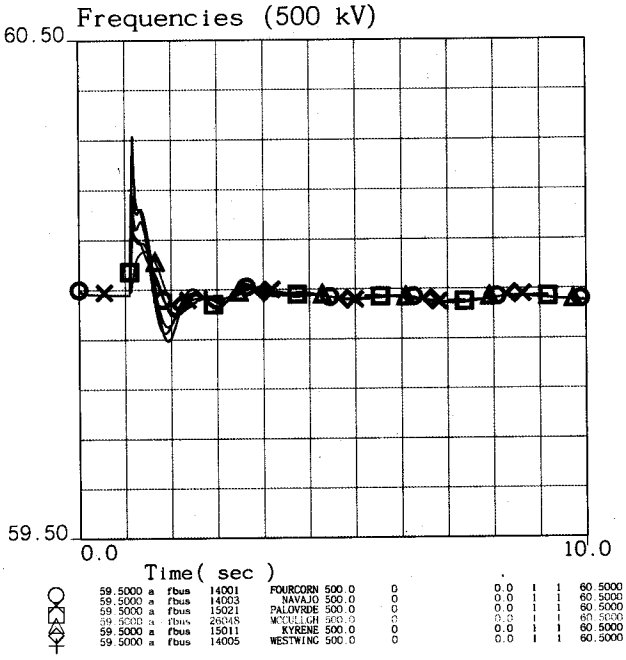

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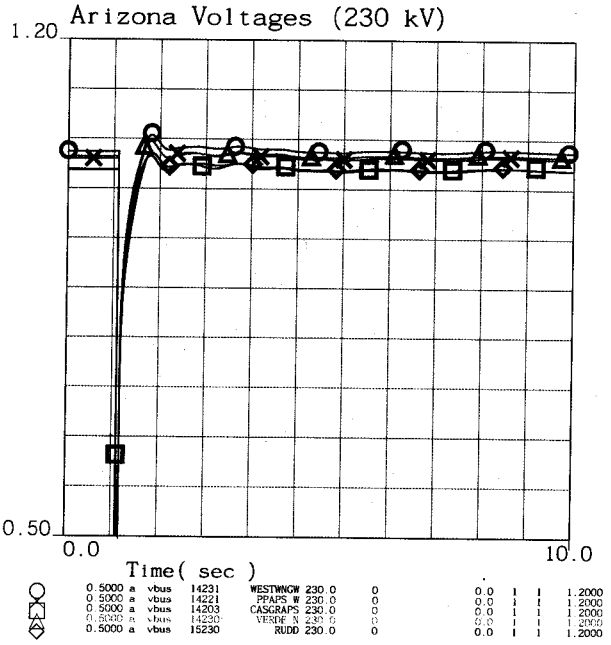

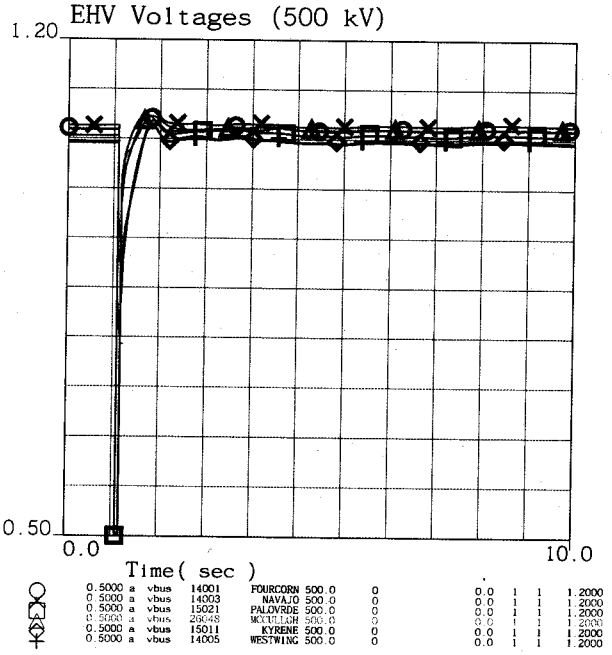

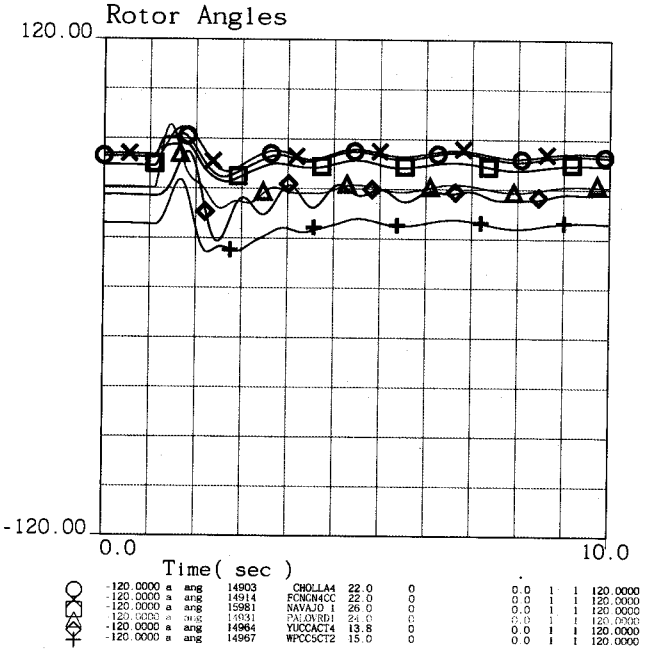

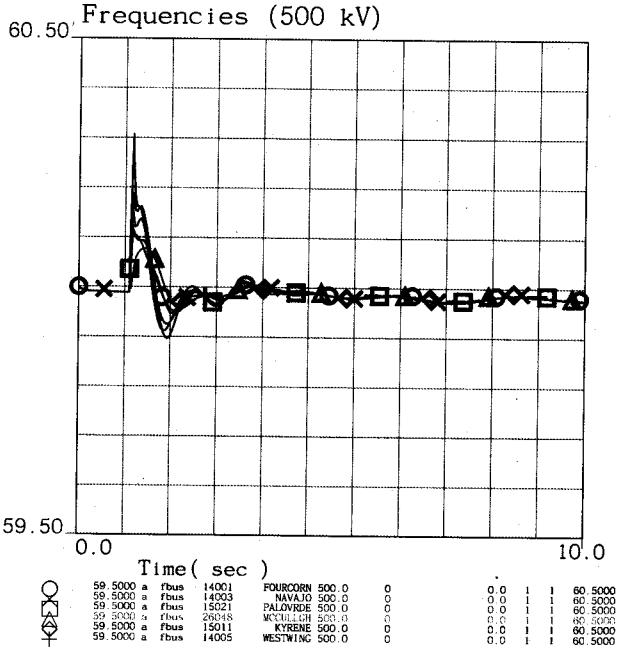

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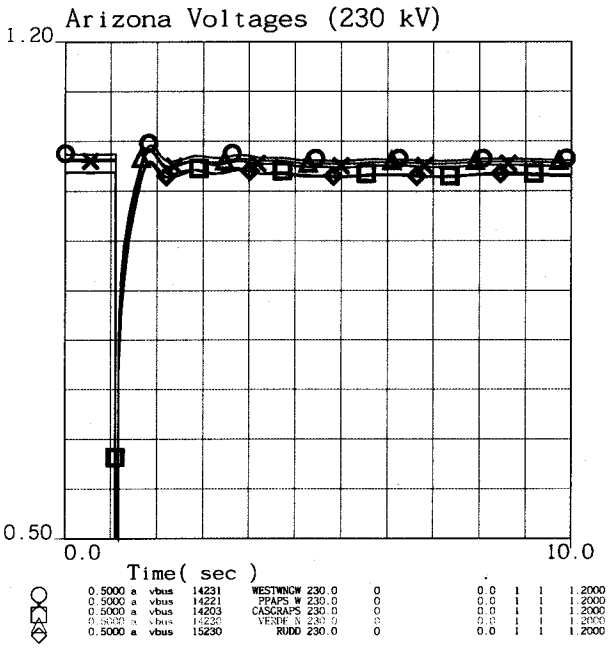

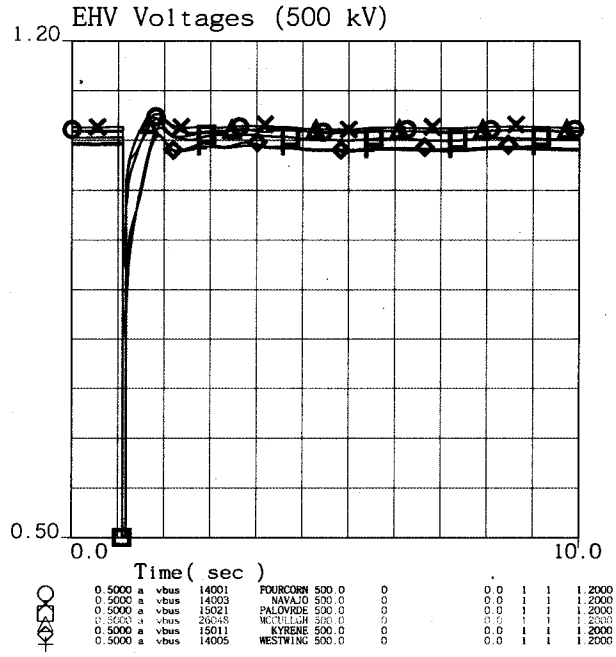

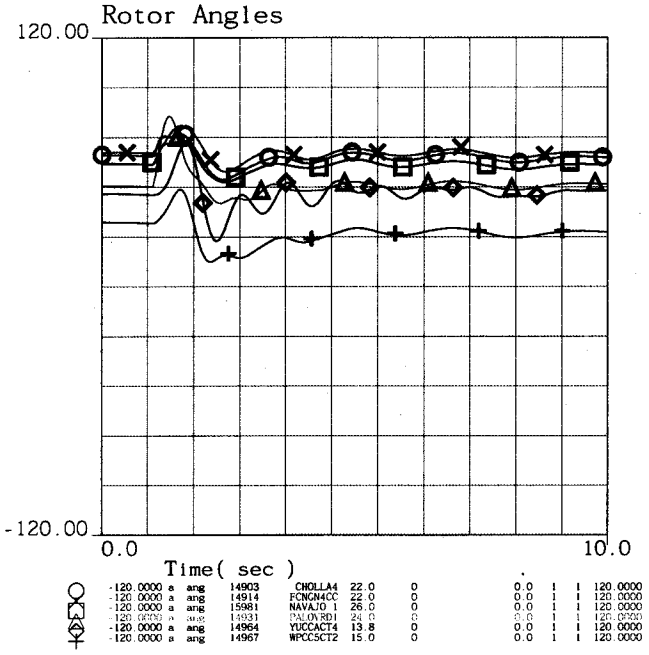

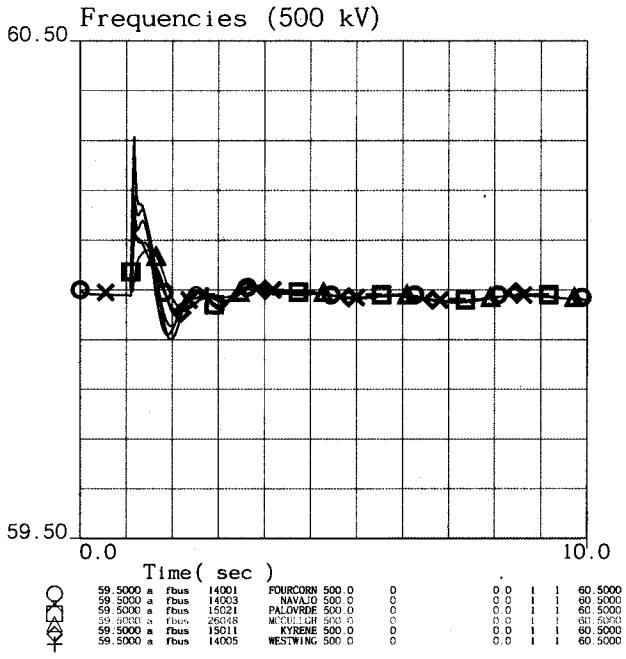

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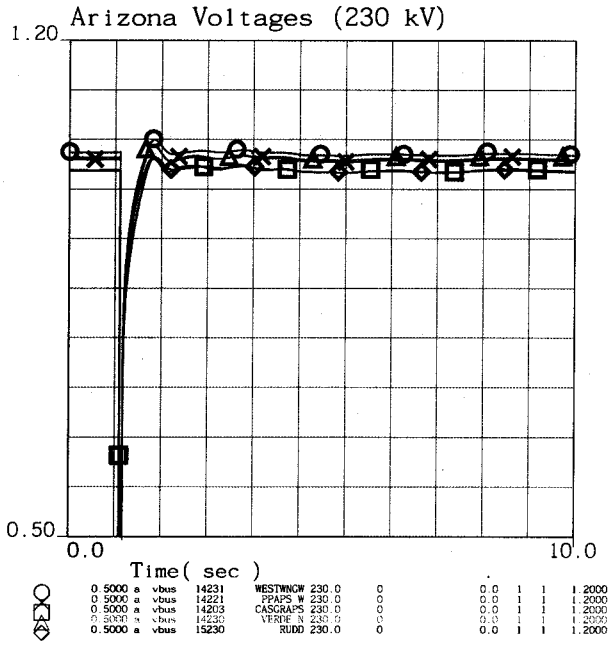

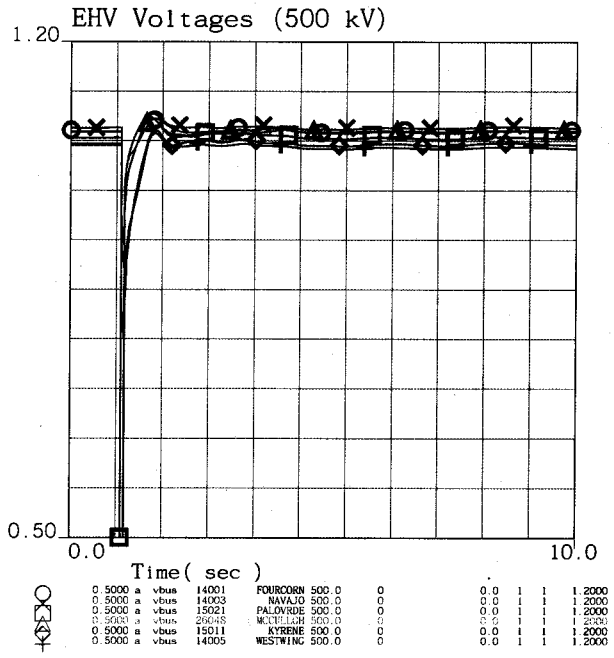

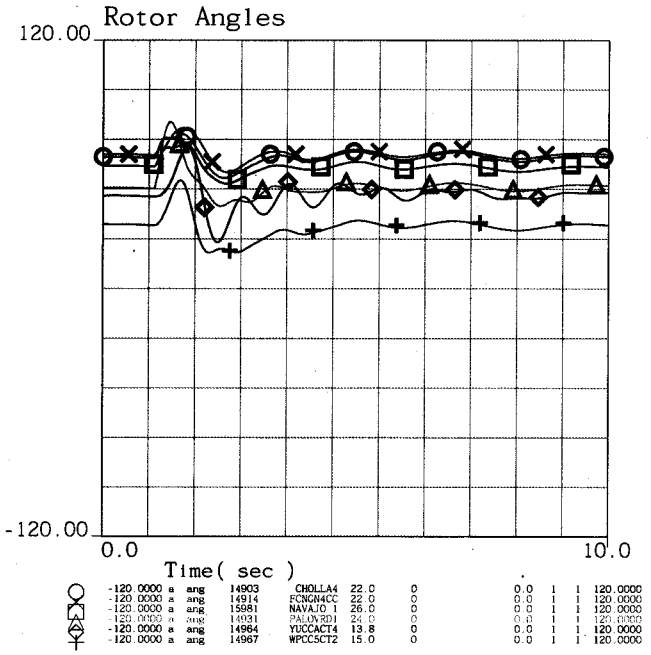

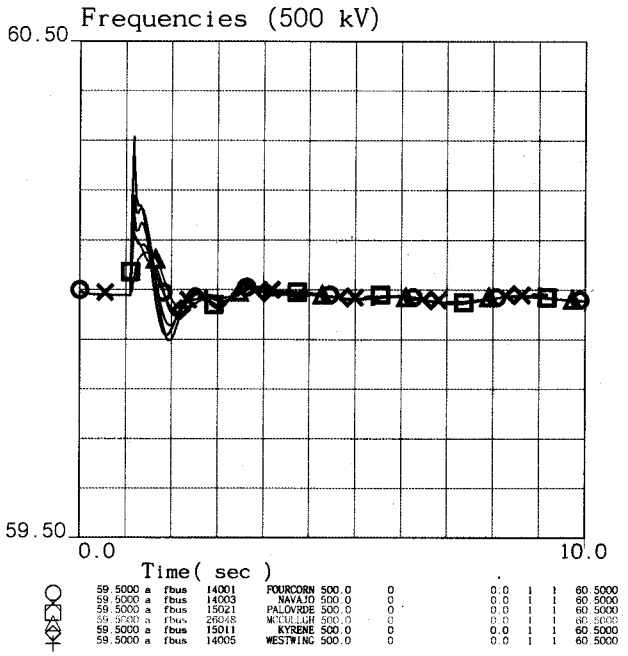

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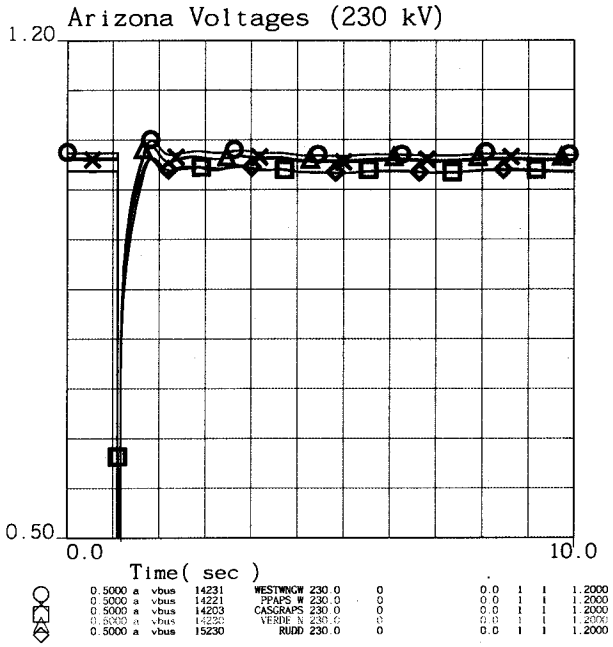

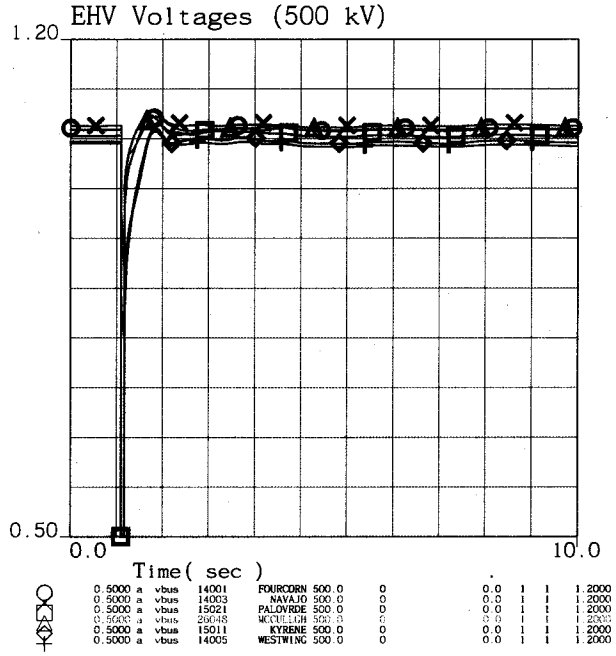

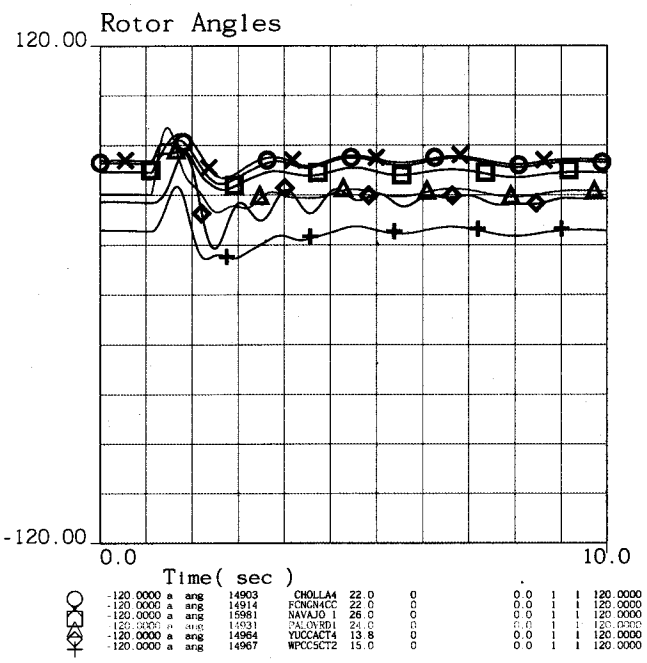

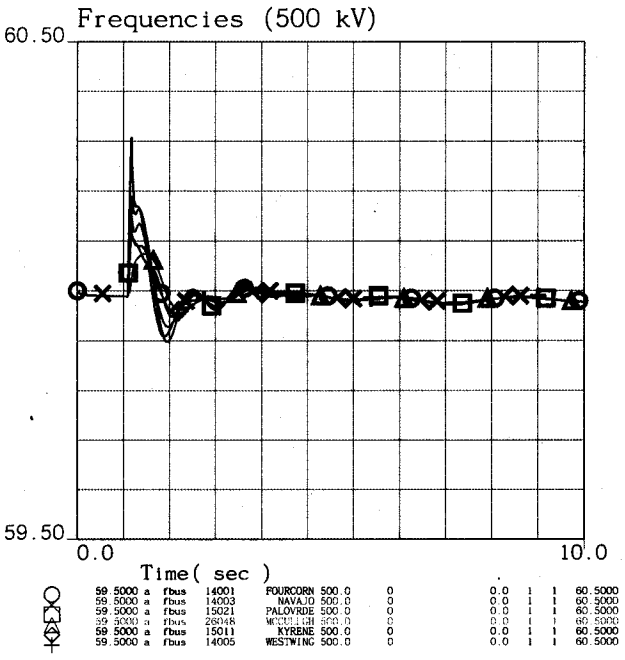

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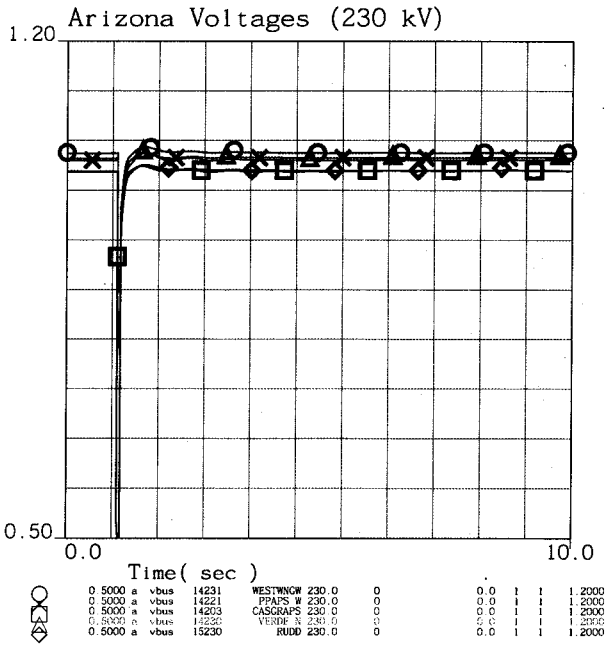

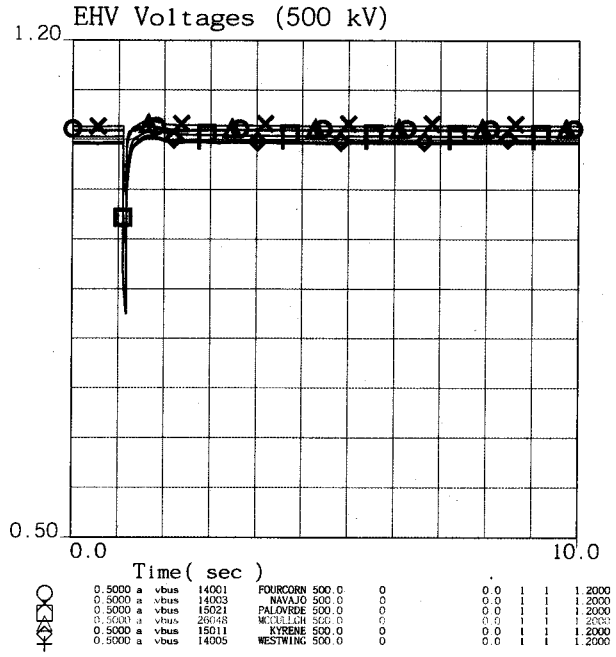

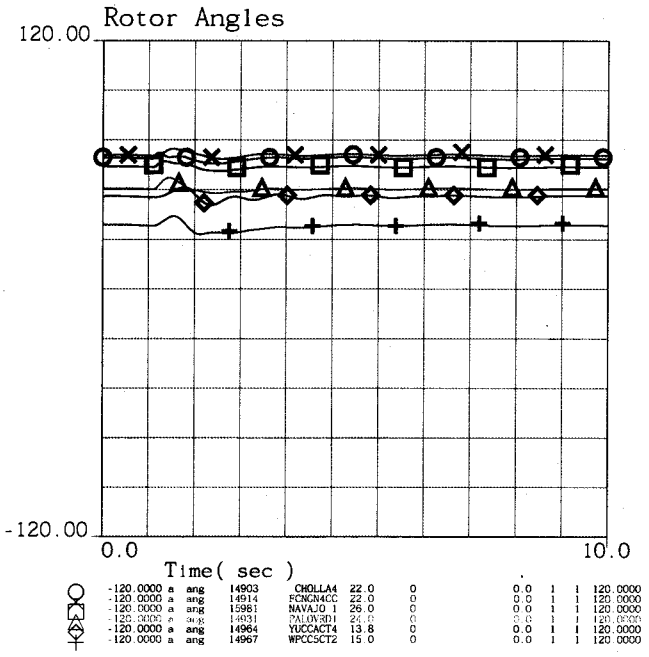

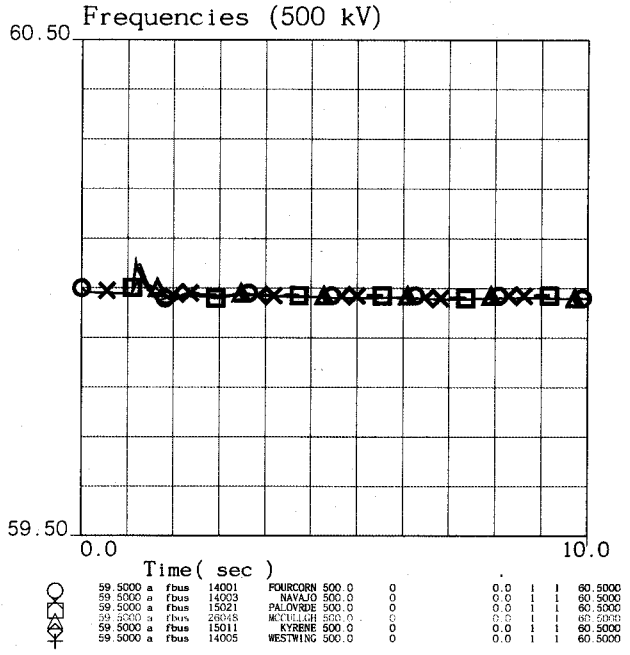

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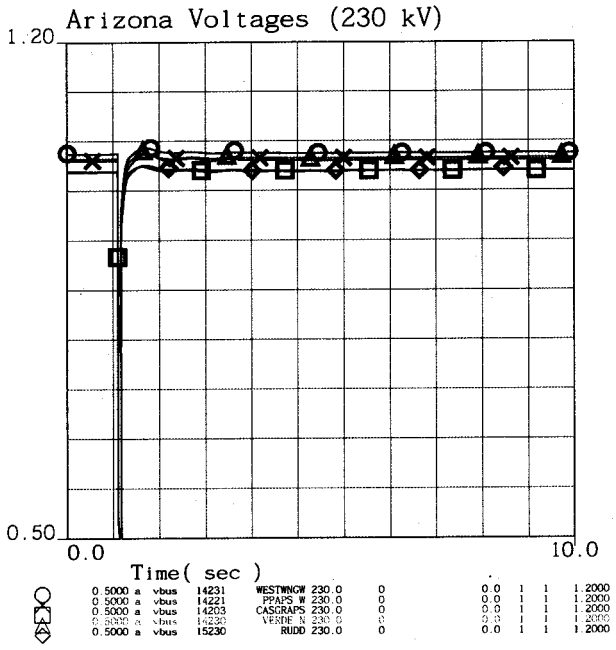

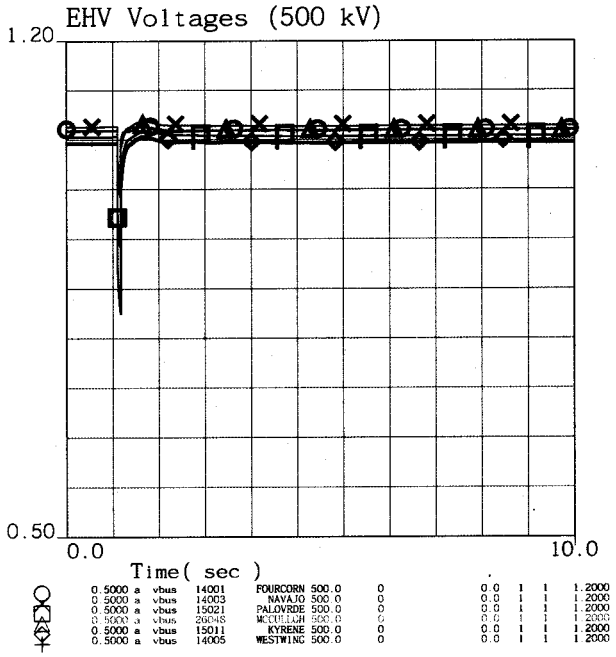

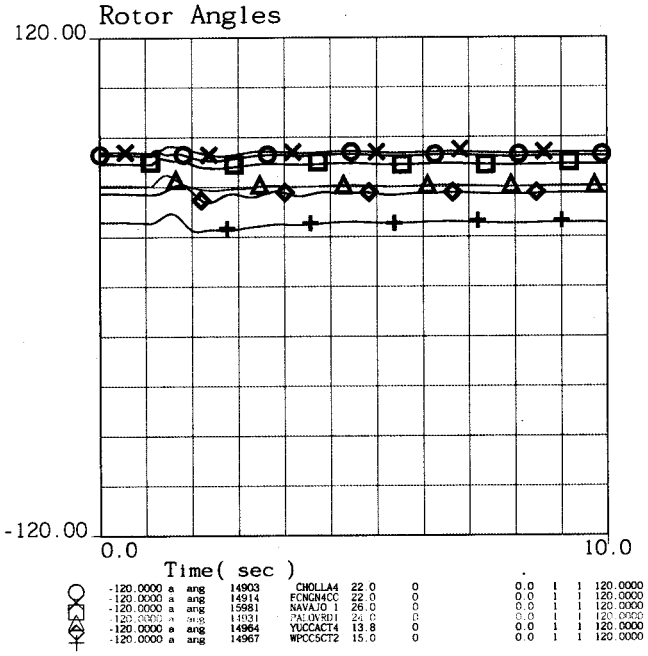

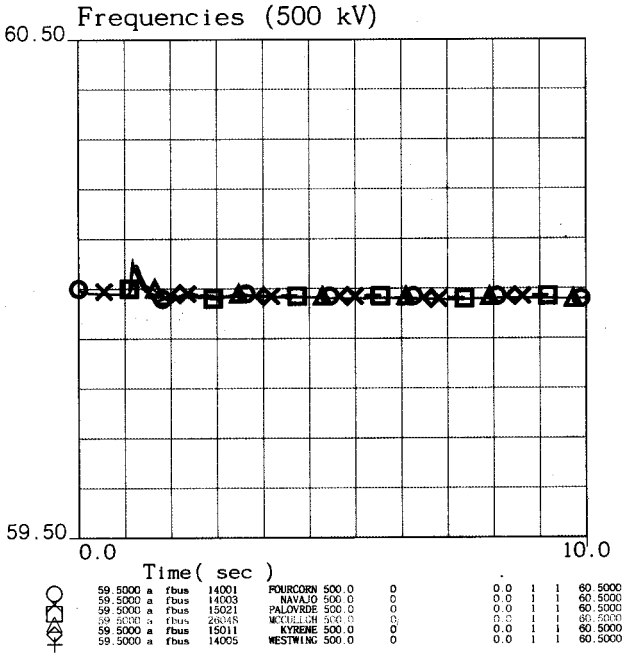

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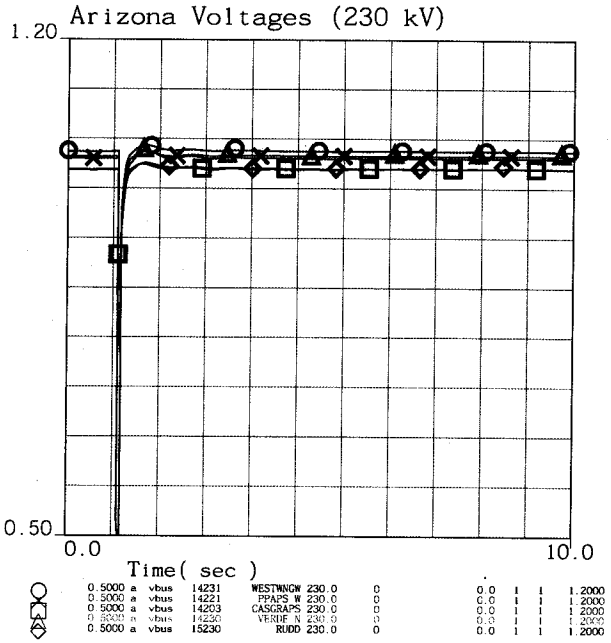

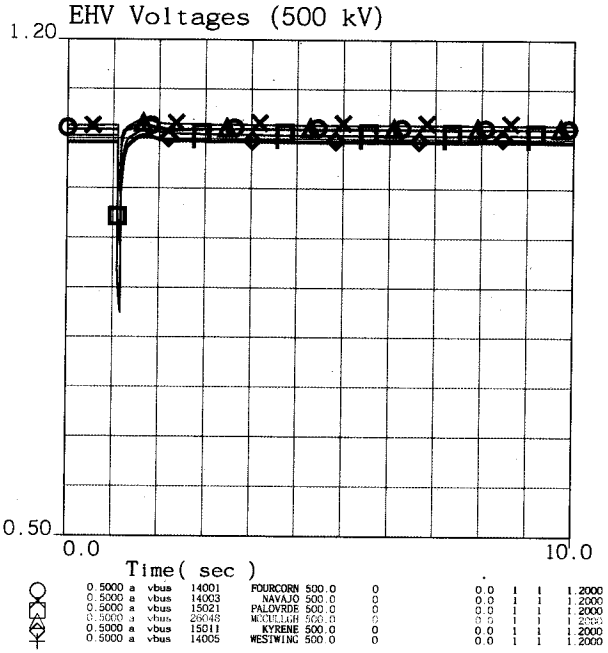

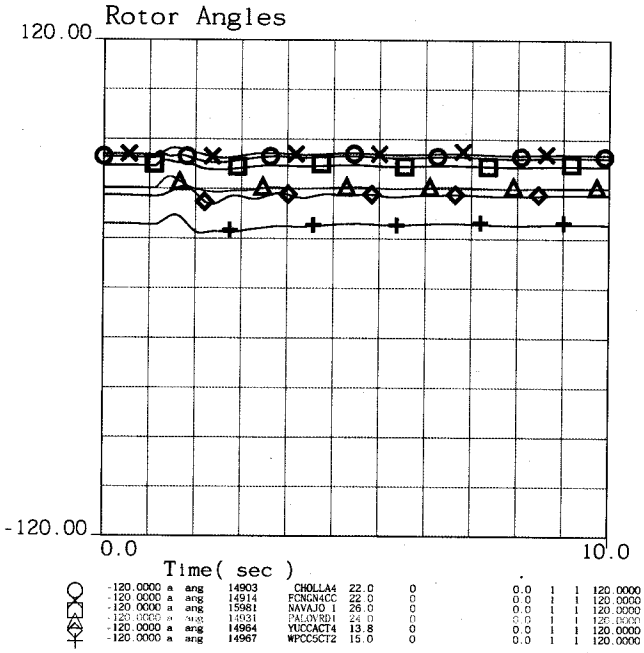

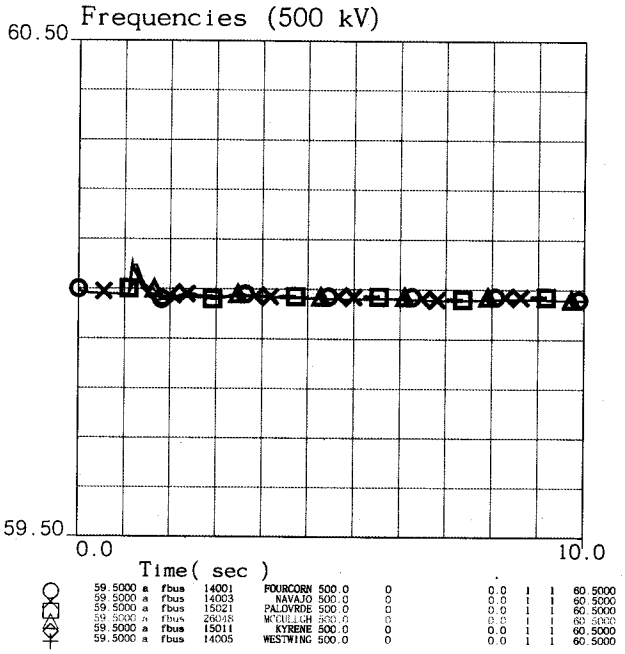

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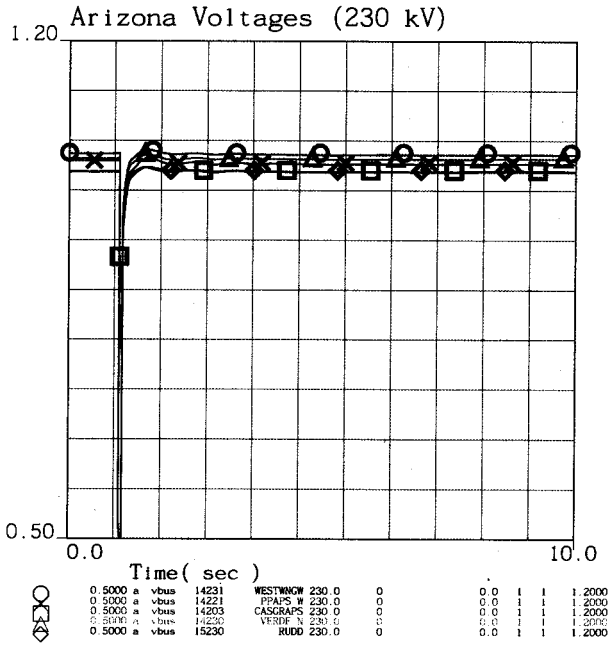

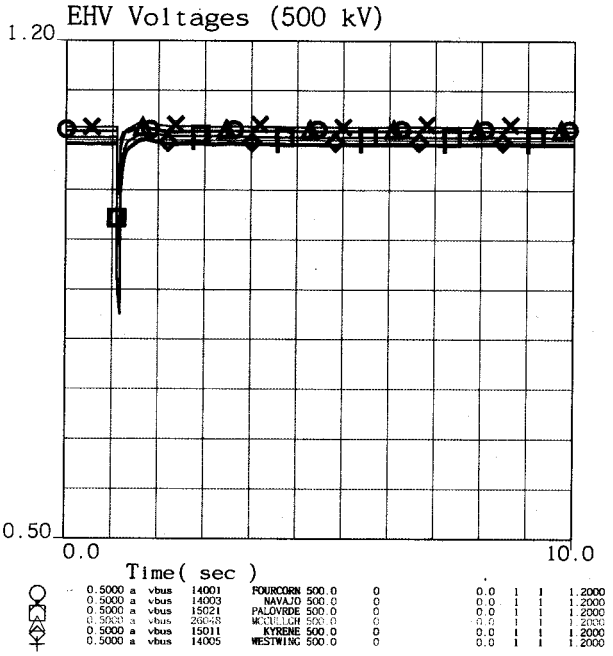

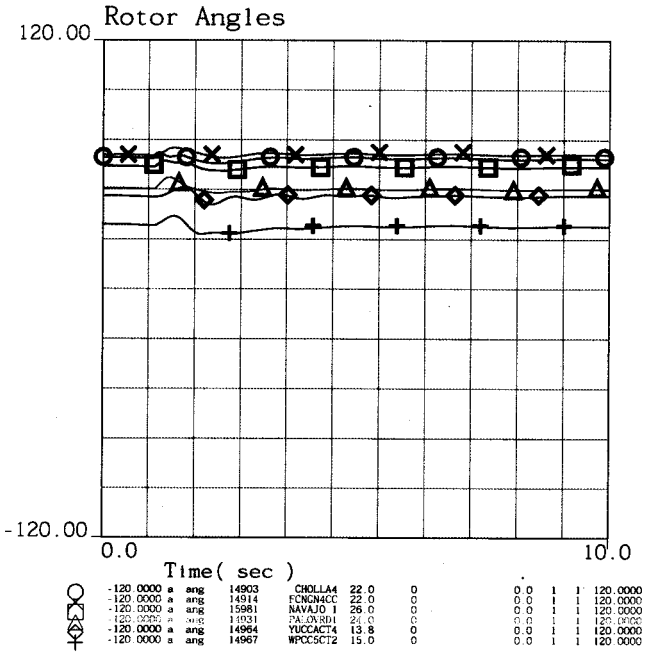

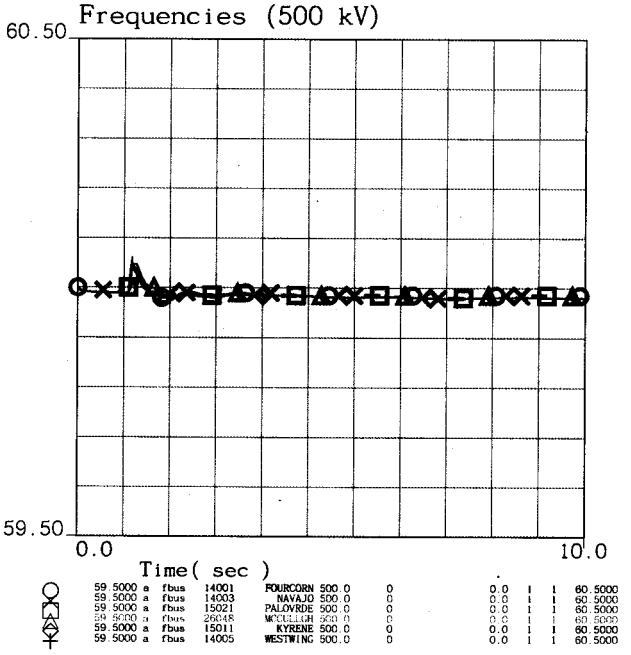

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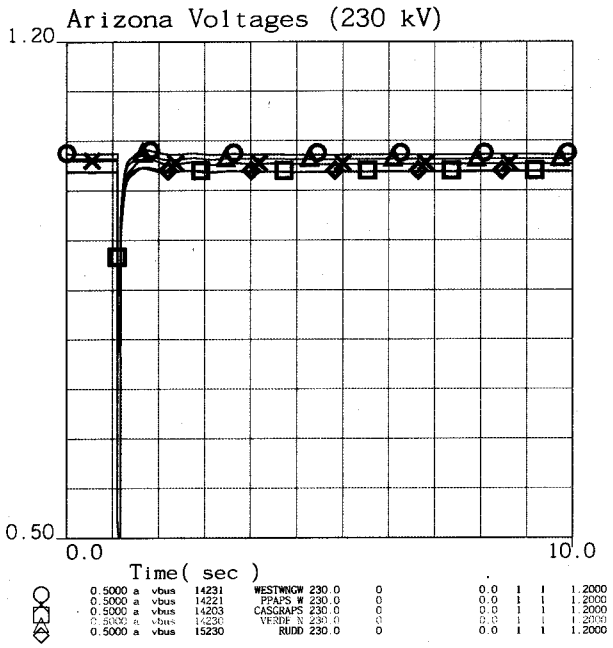
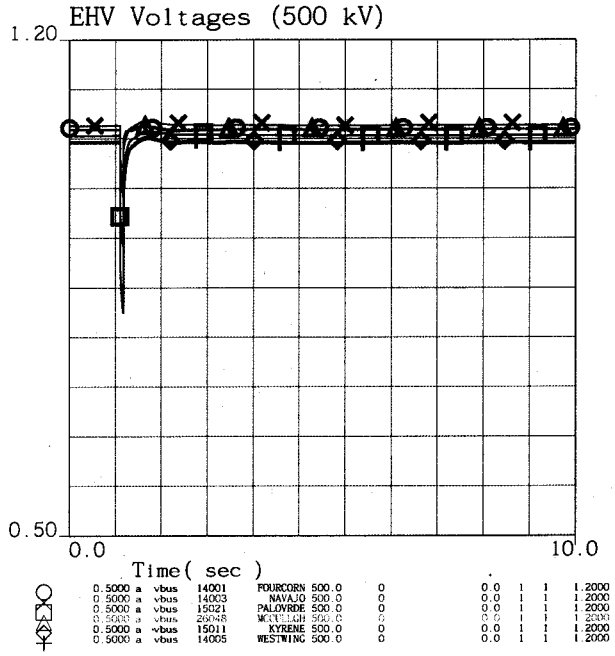
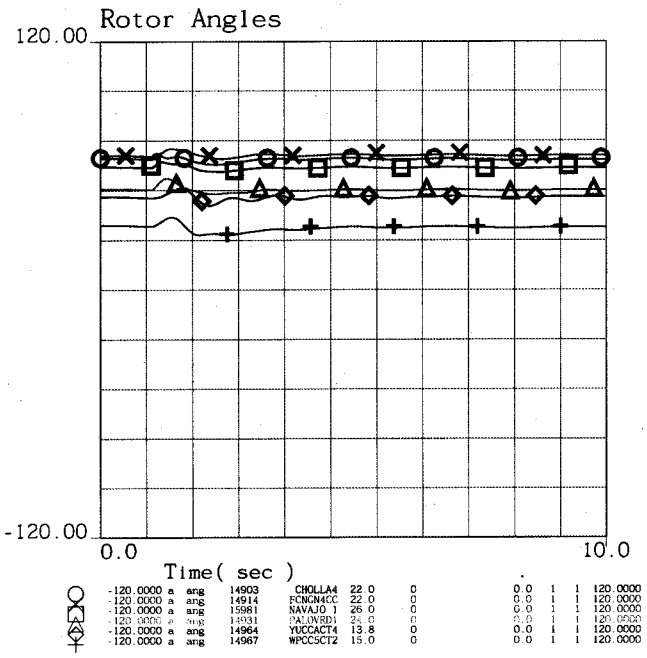
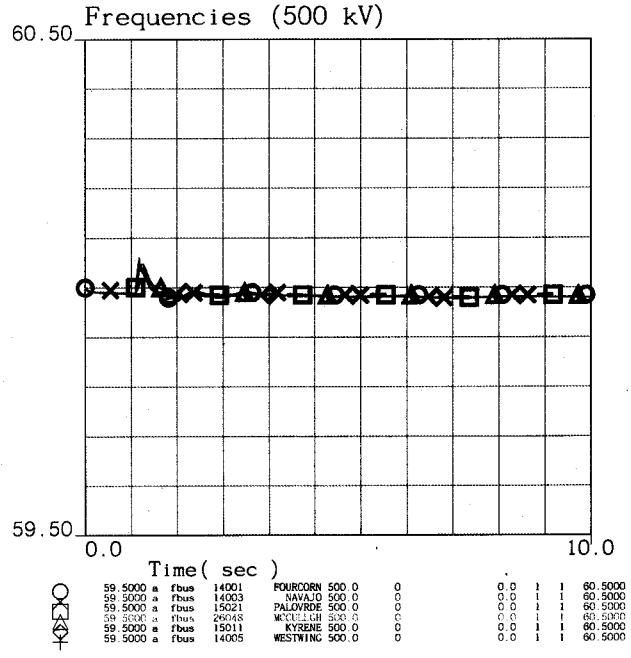
2018 Heavy Summer Detailed Planning Case









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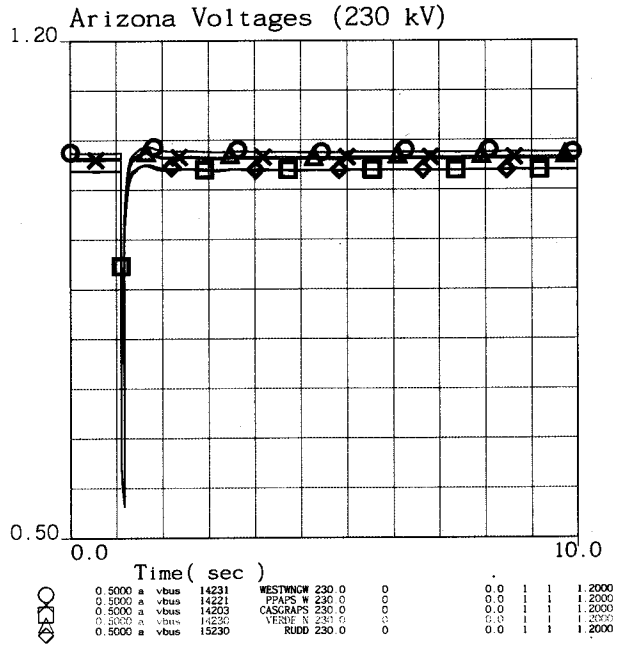

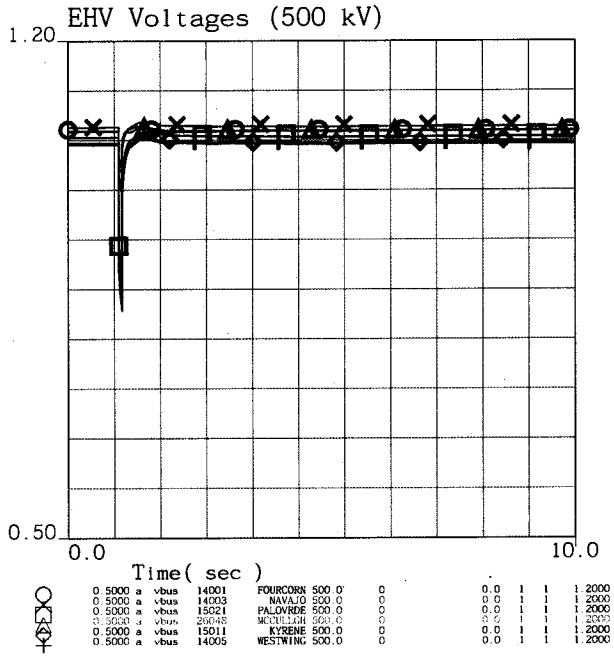

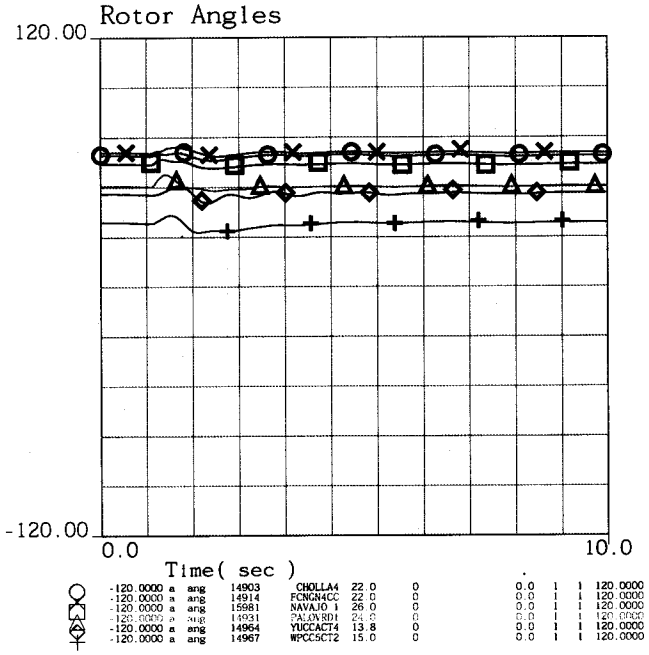

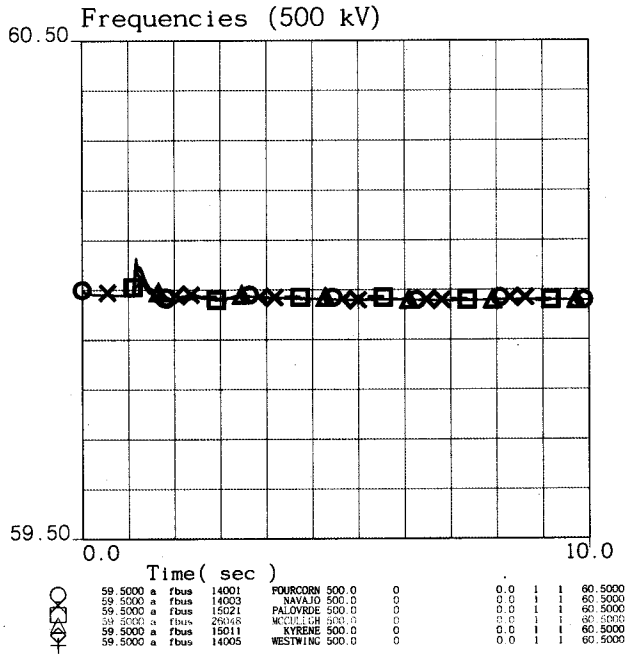

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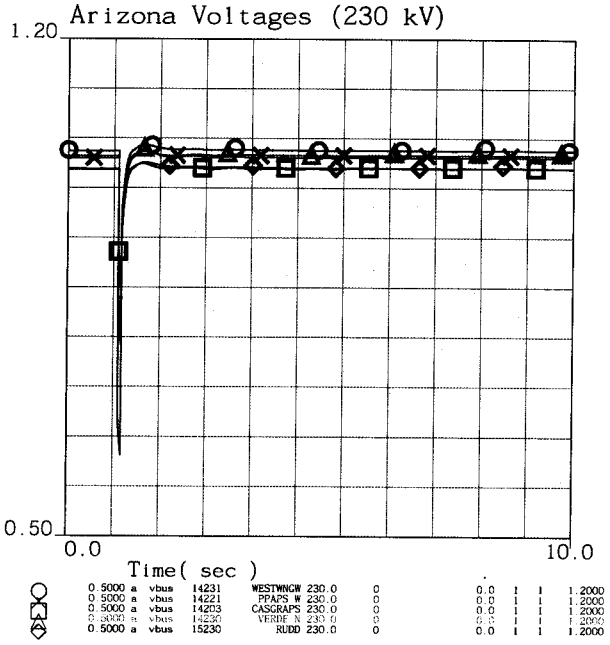

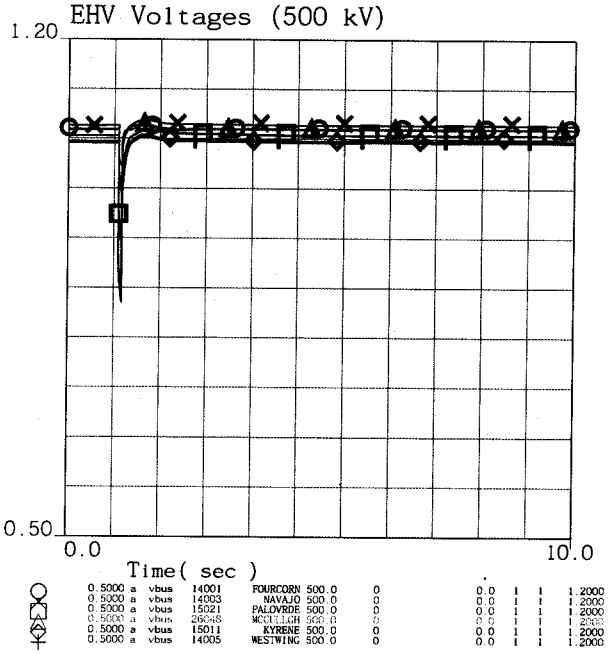

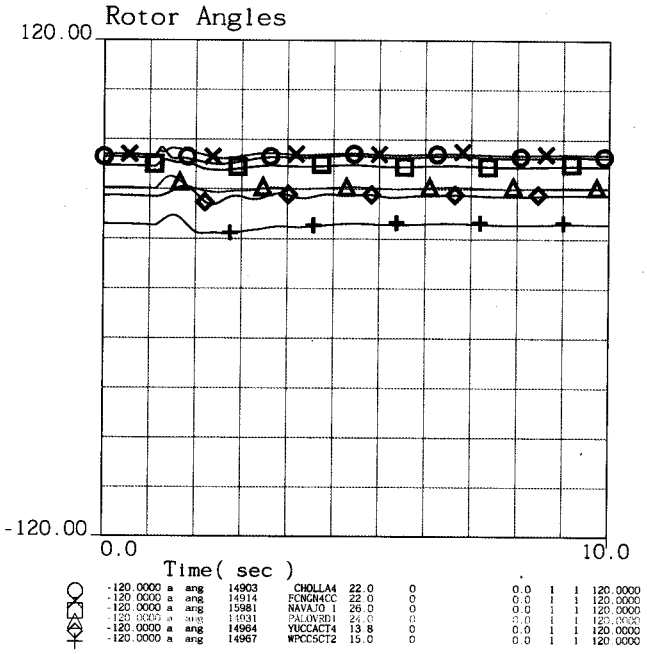

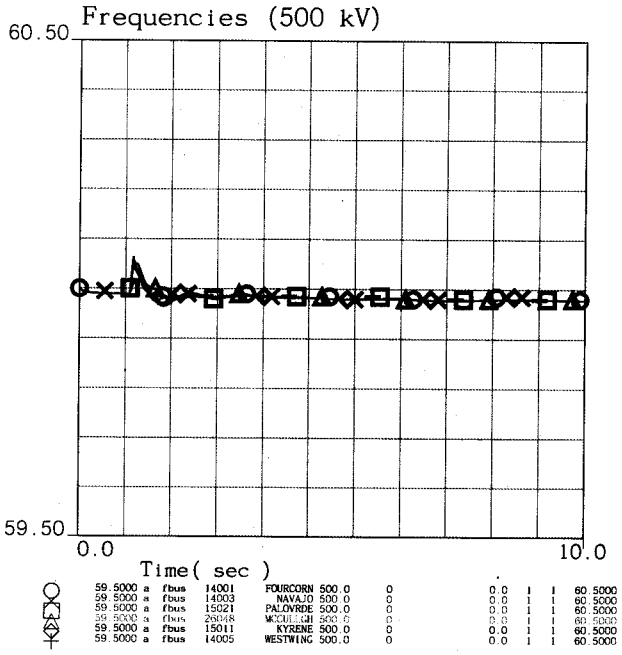

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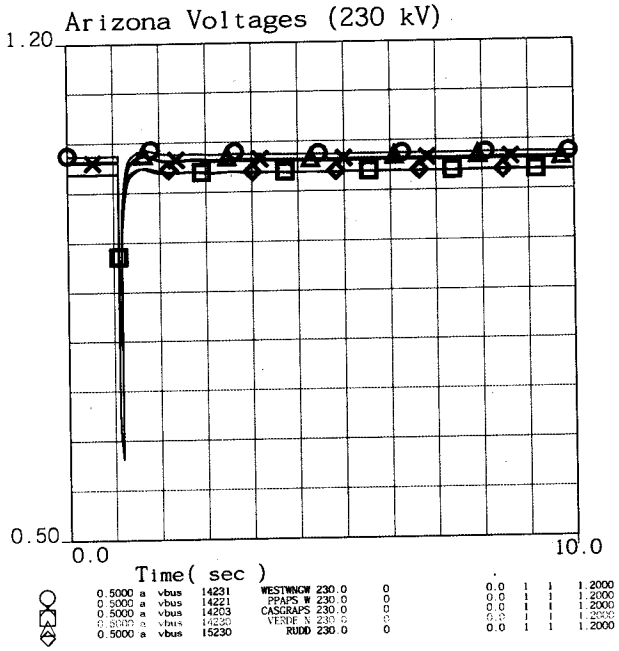

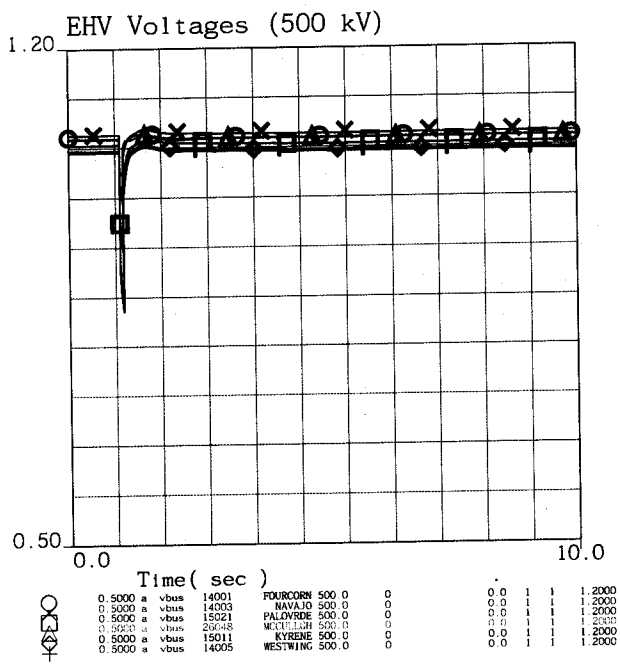

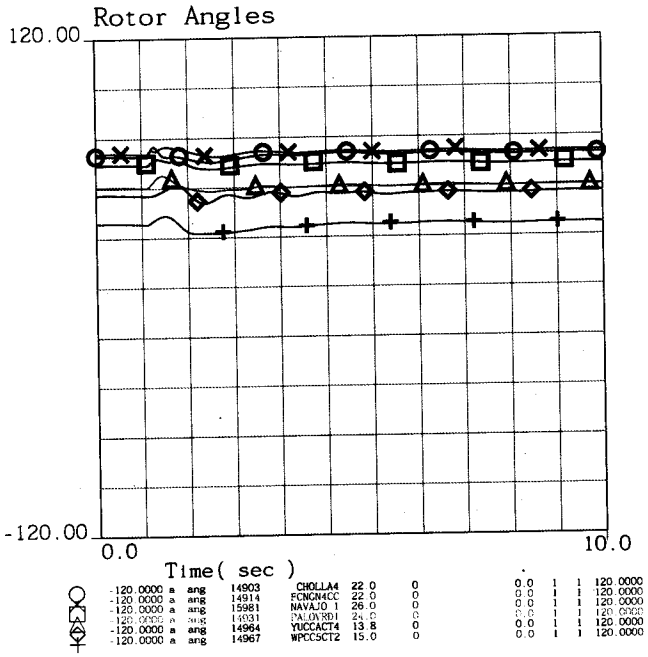

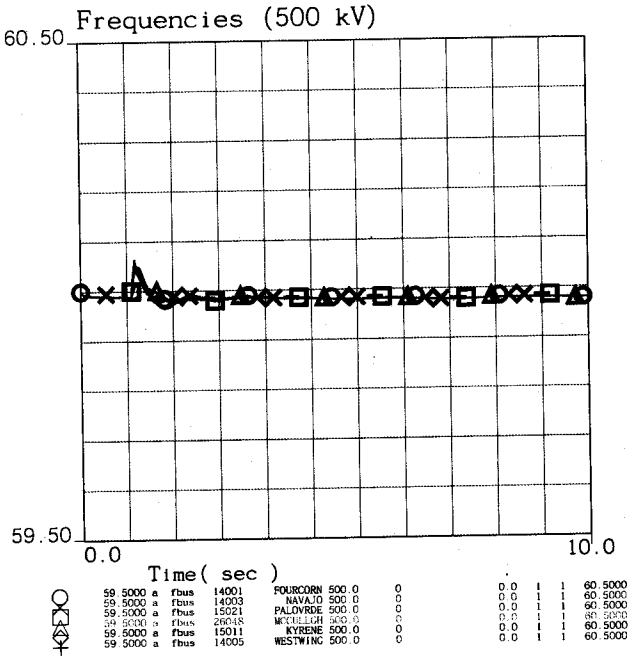

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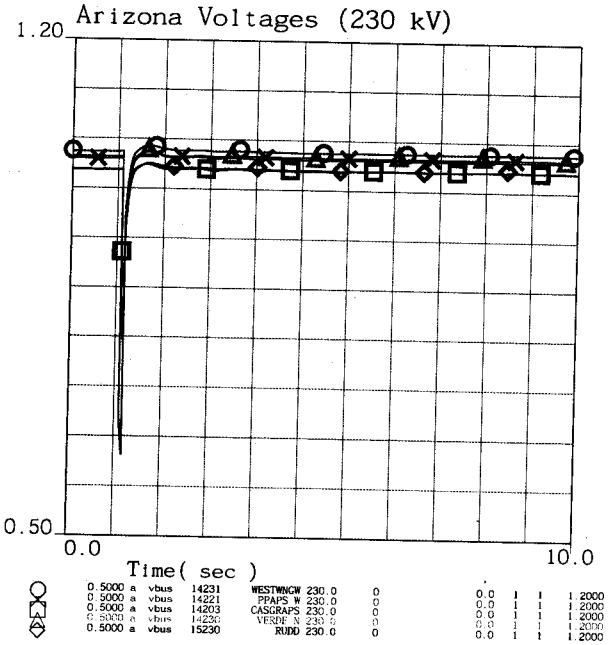

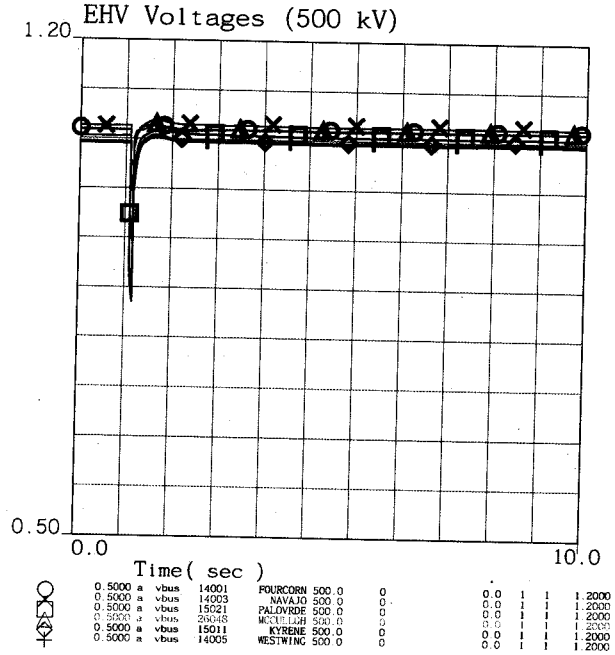

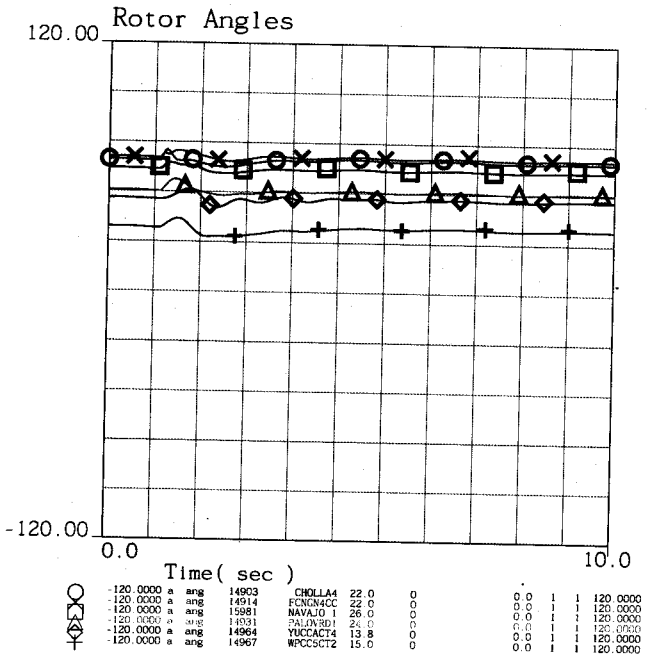

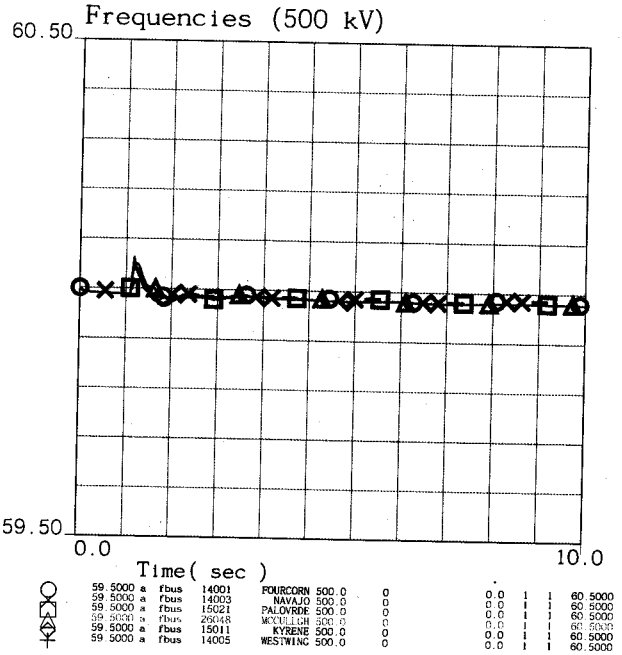

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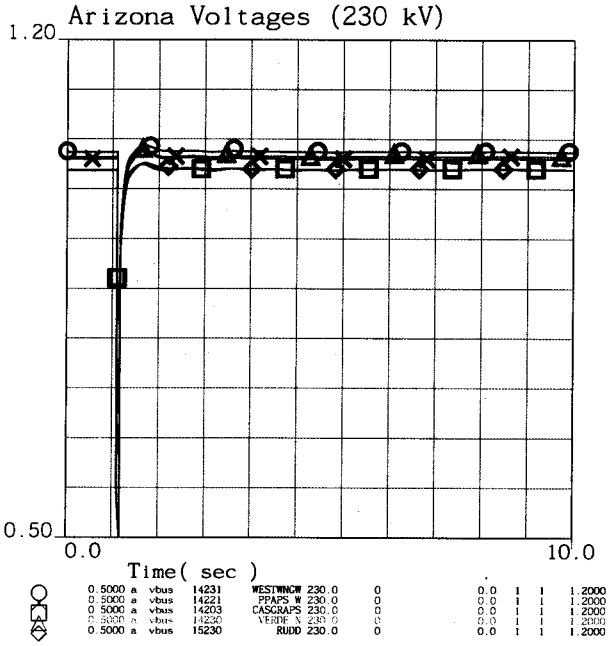

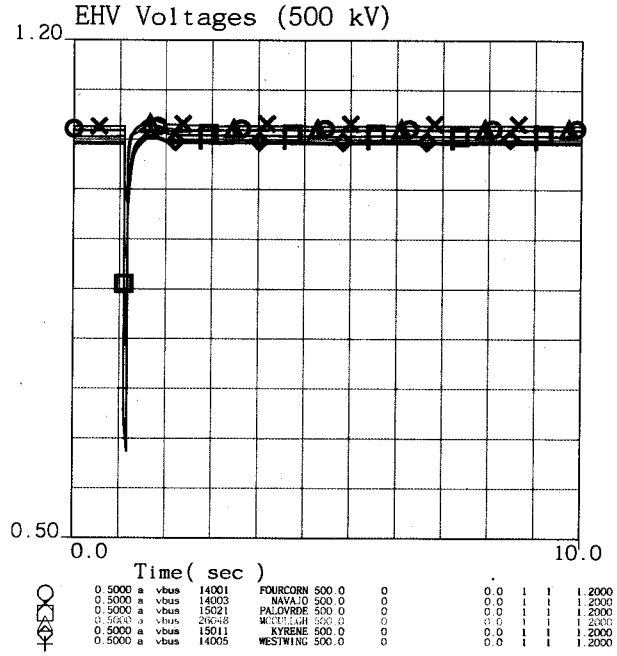

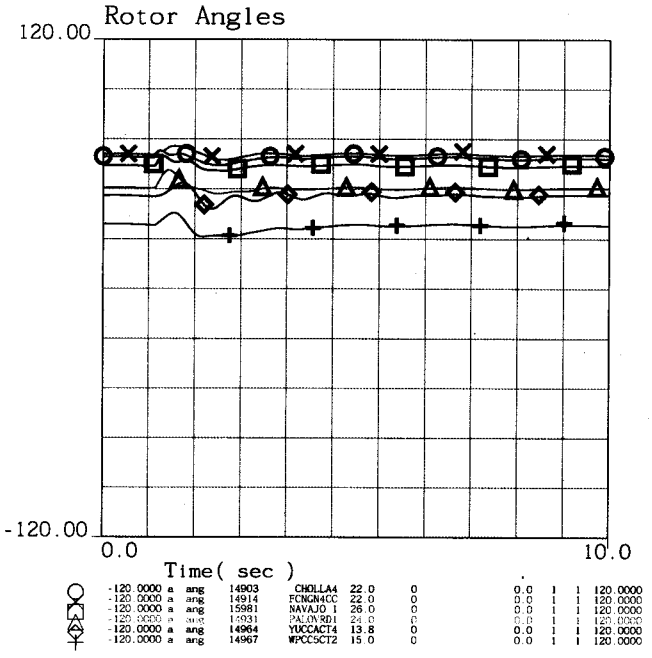

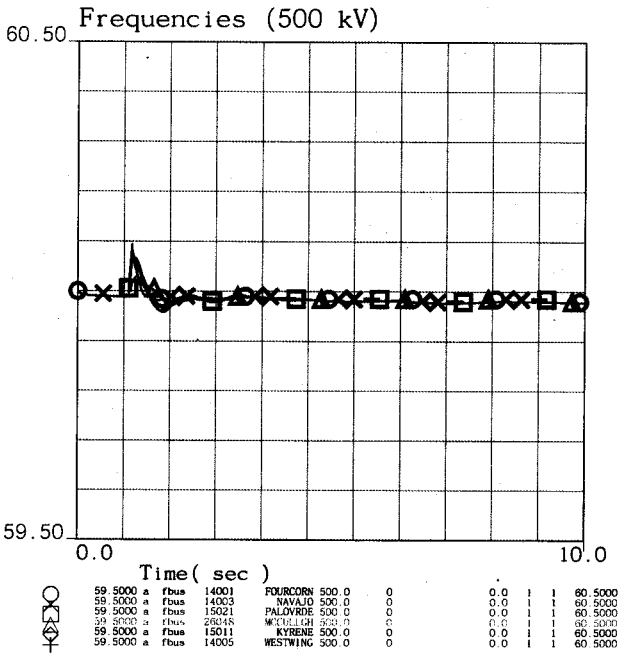

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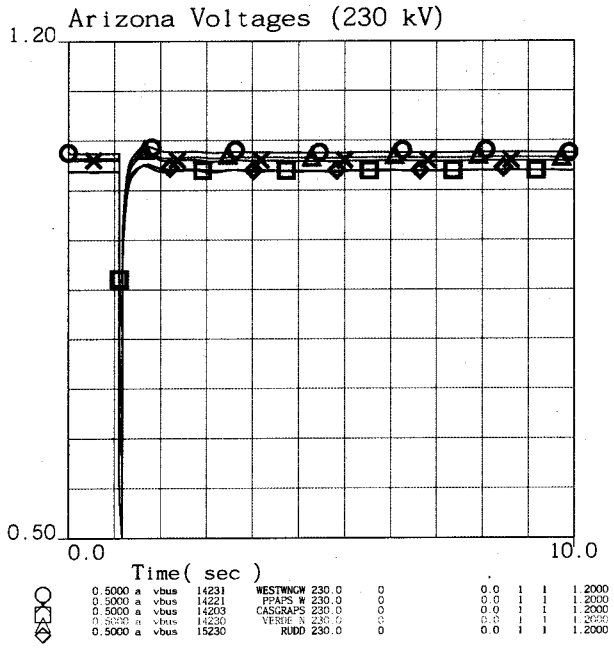

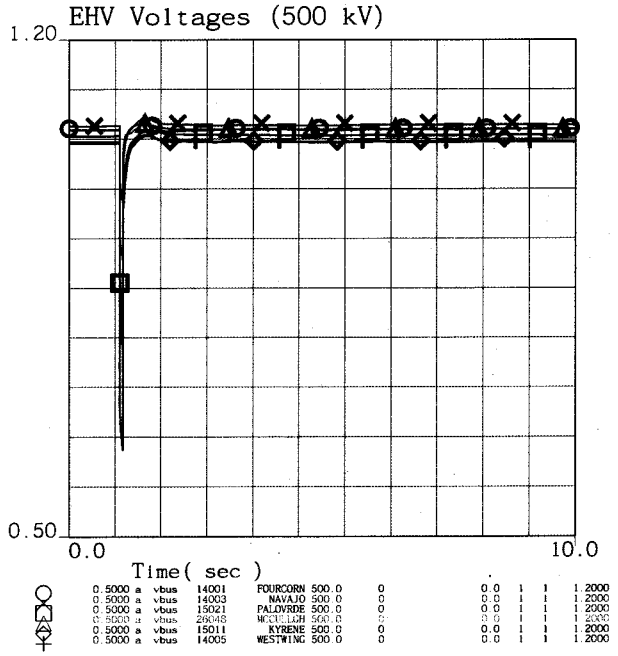

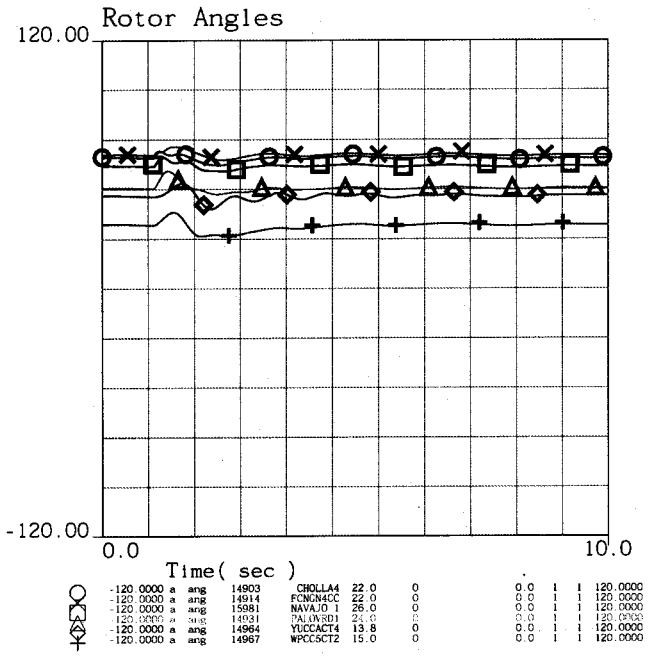

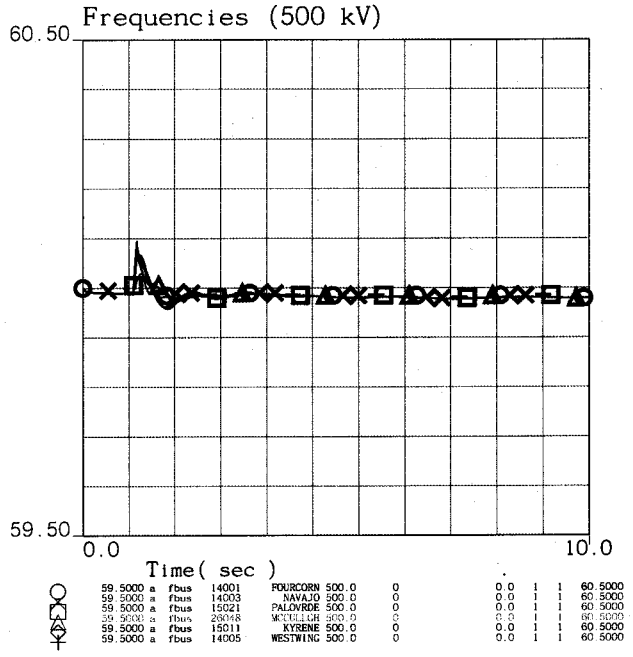

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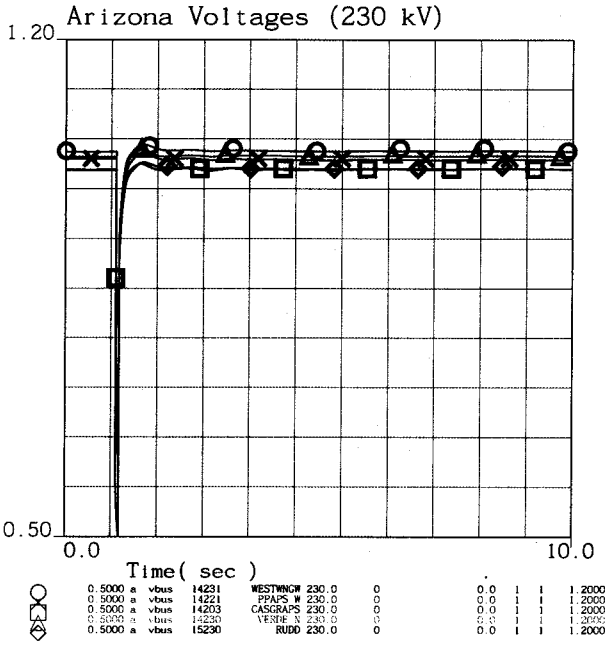

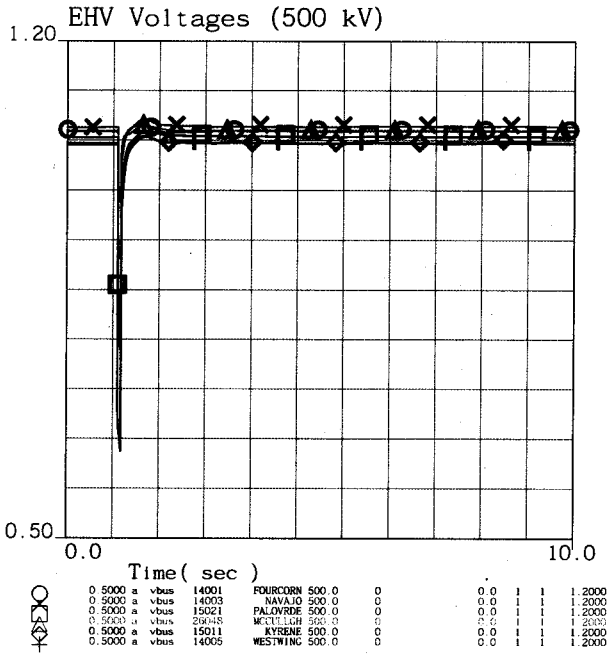

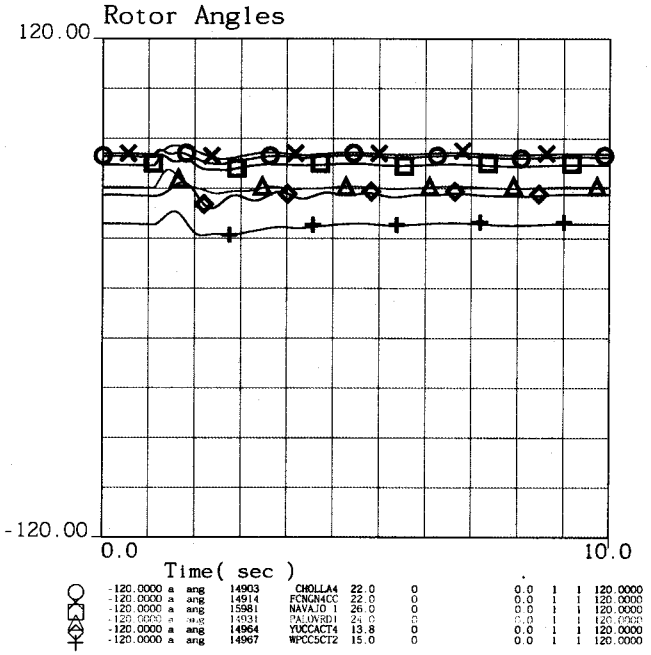

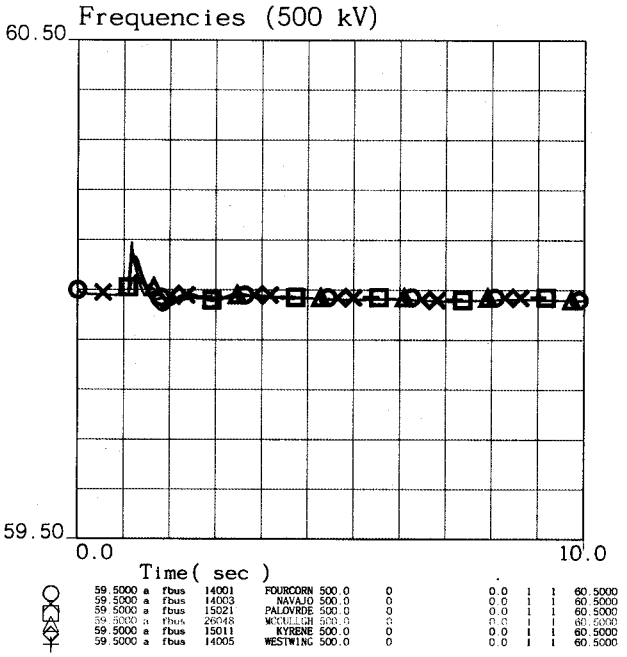

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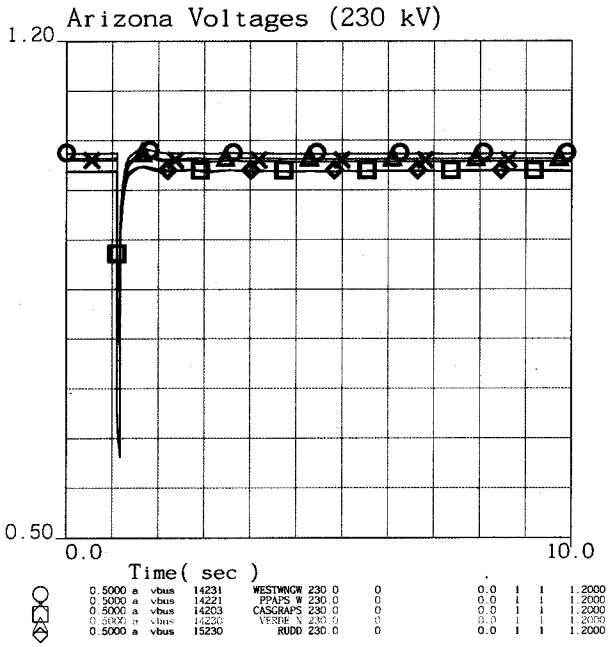

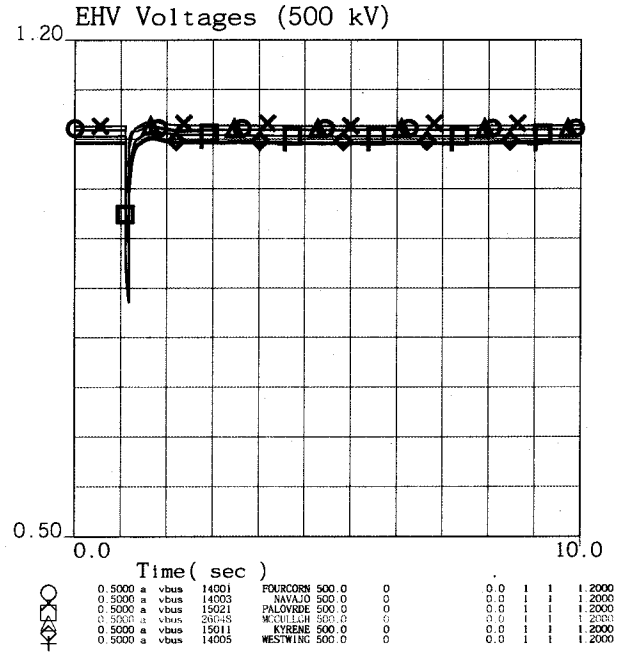

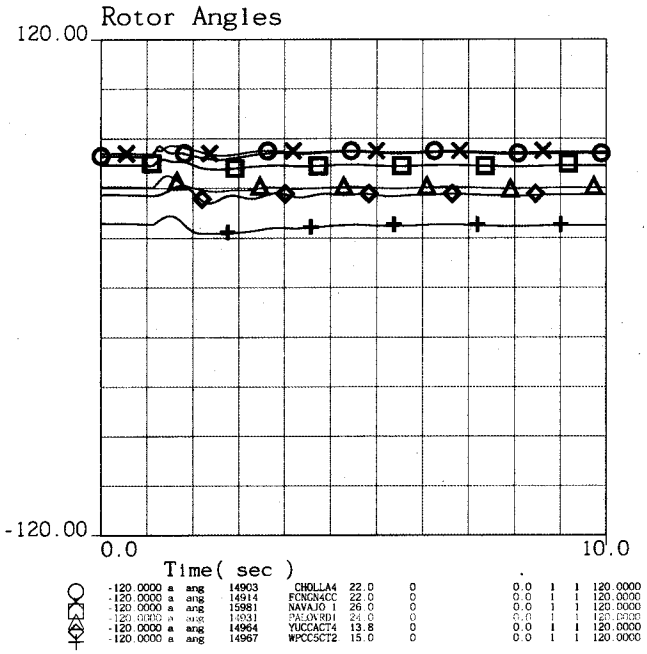

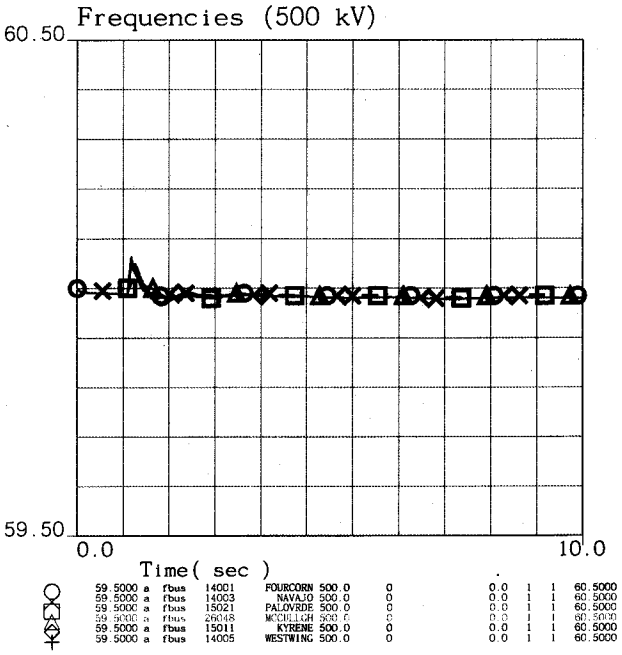

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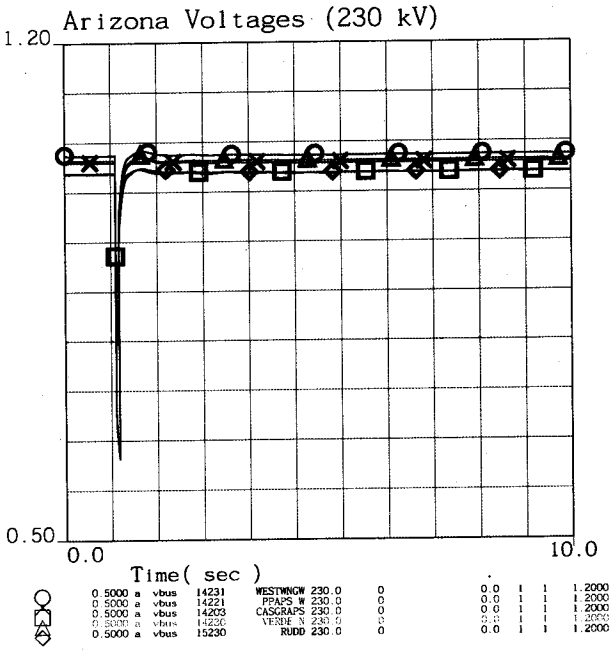

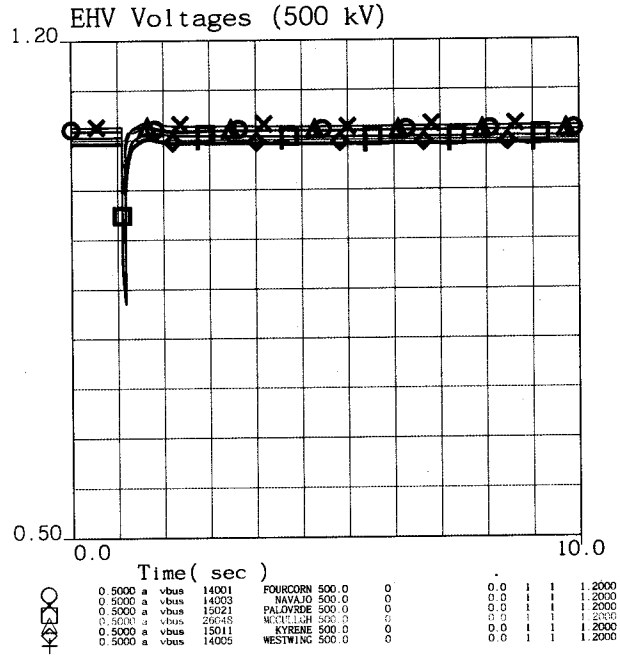

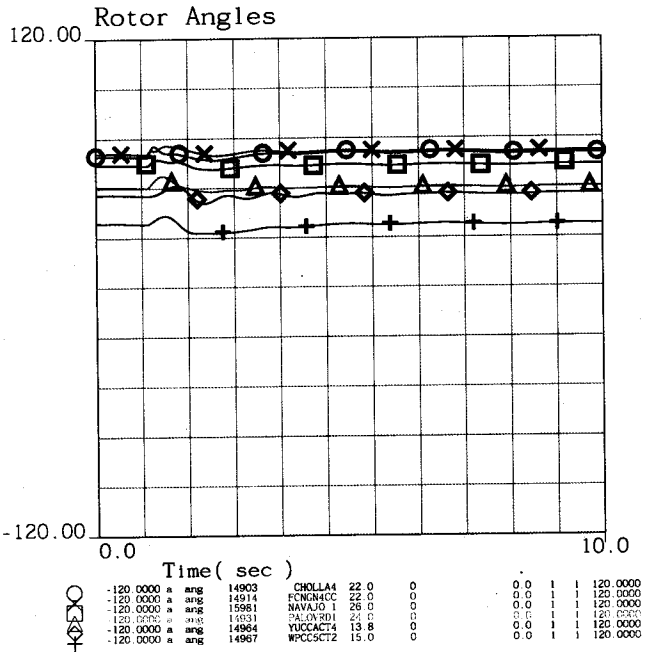

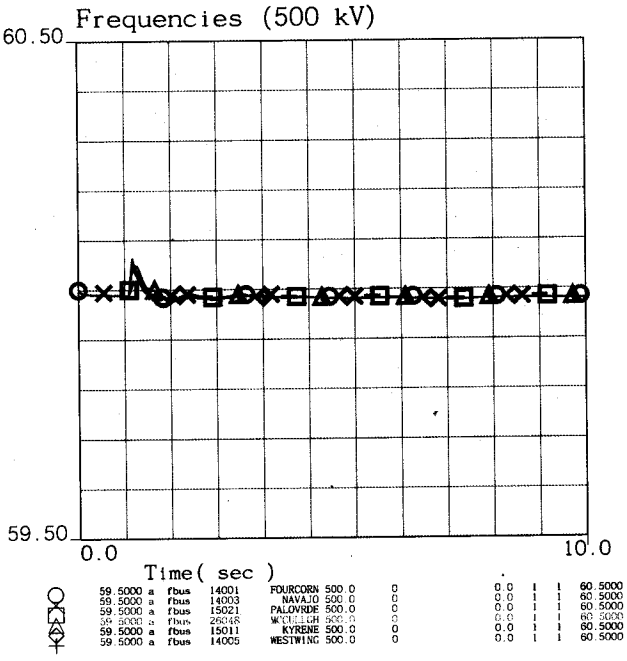

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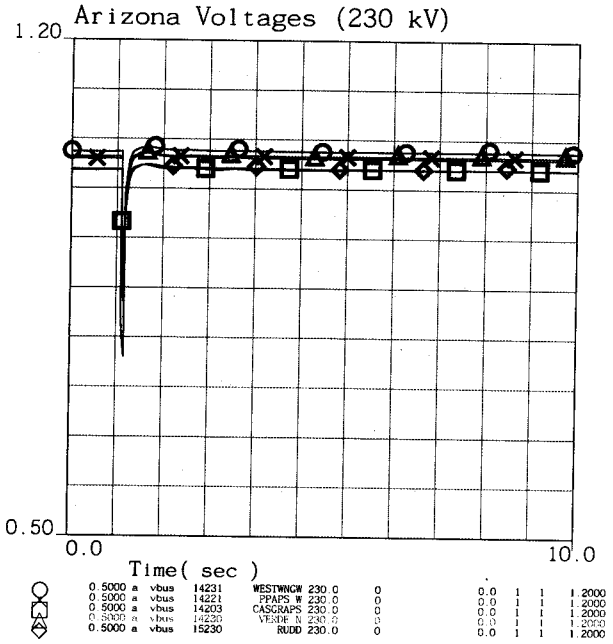

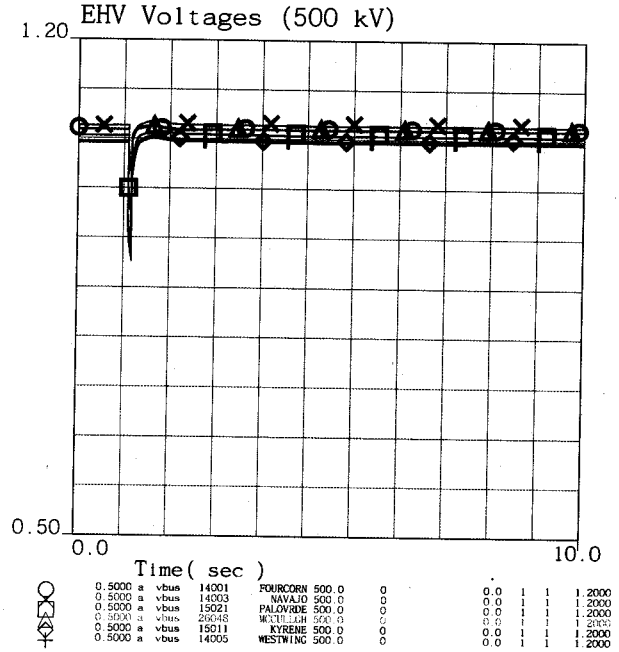

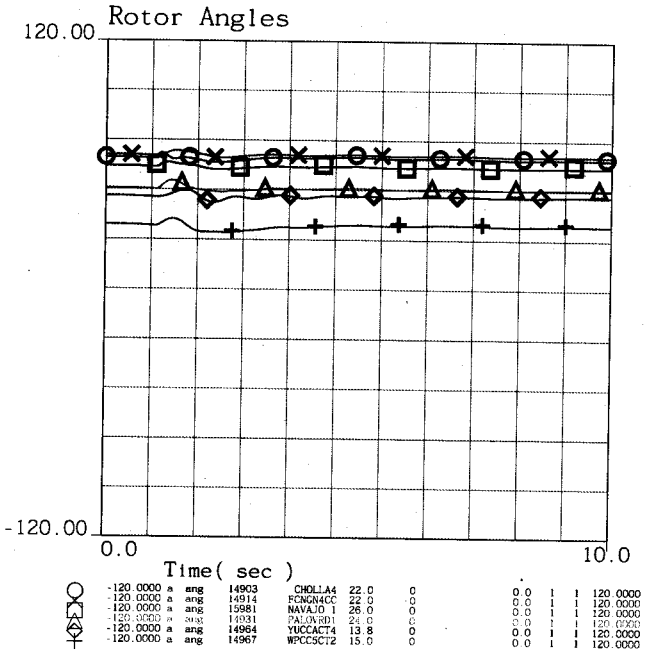

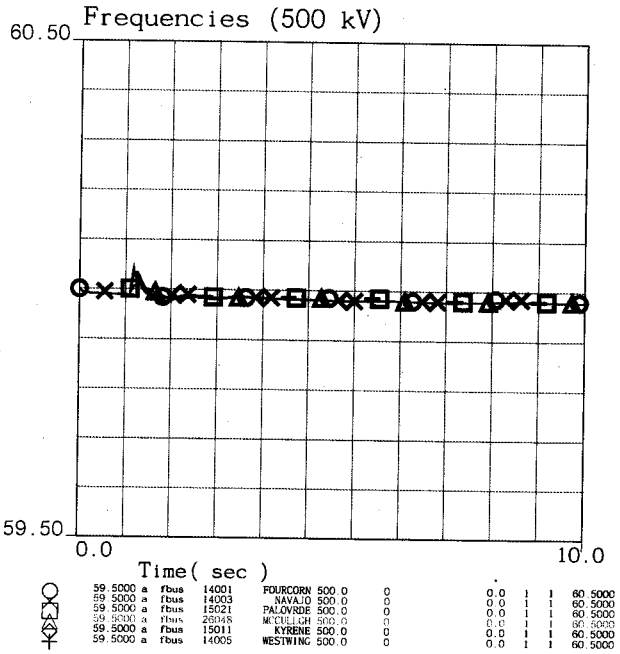

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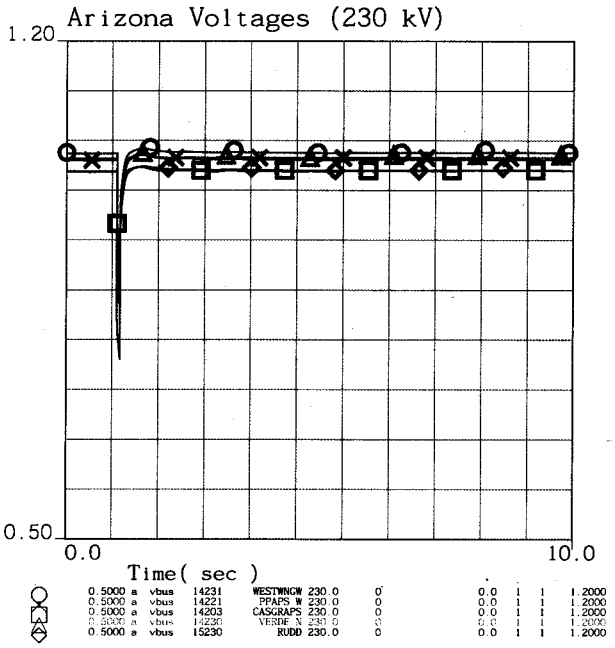

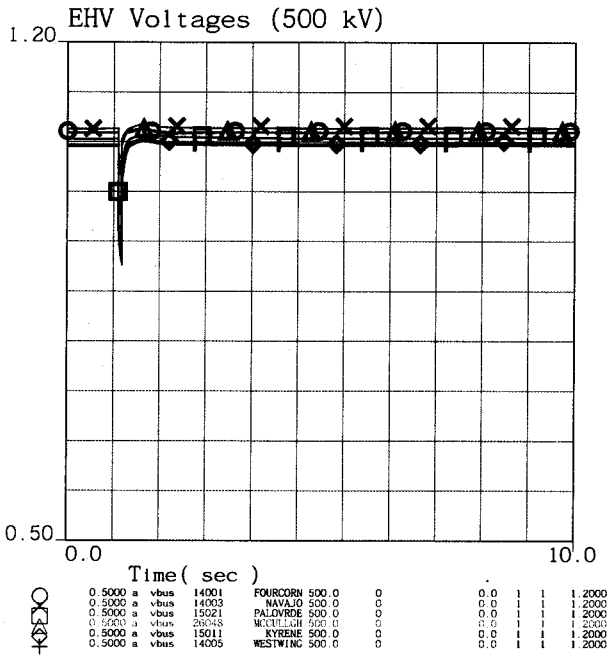

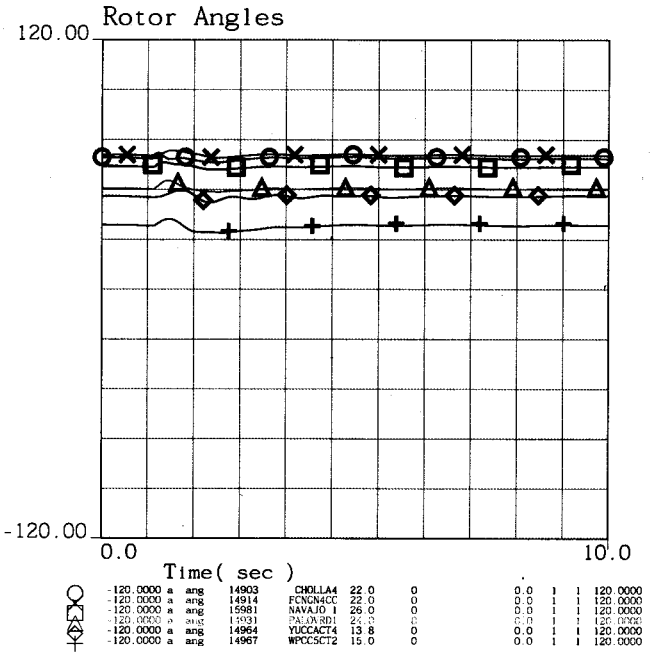

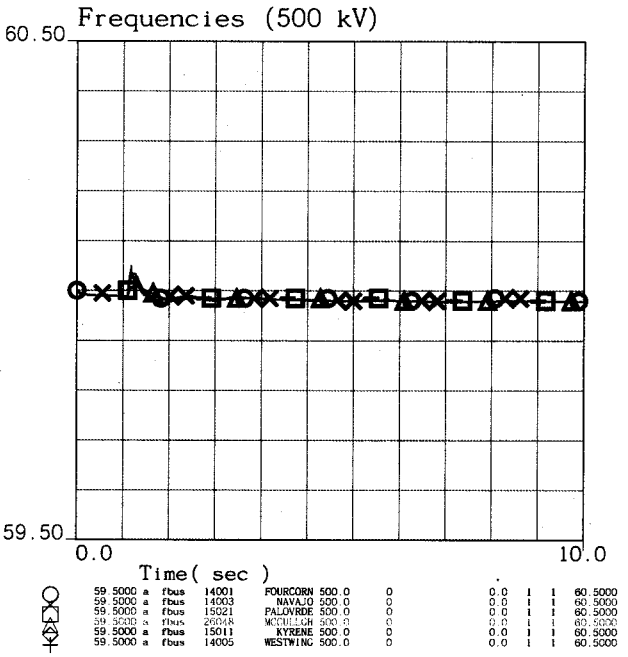

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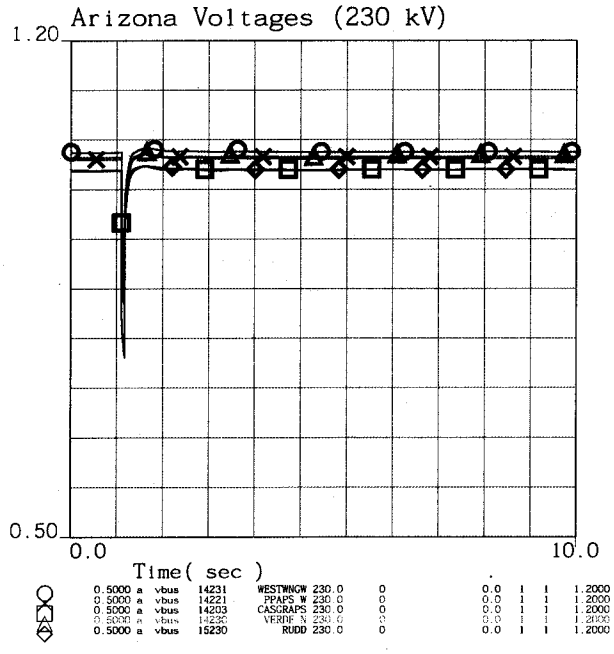
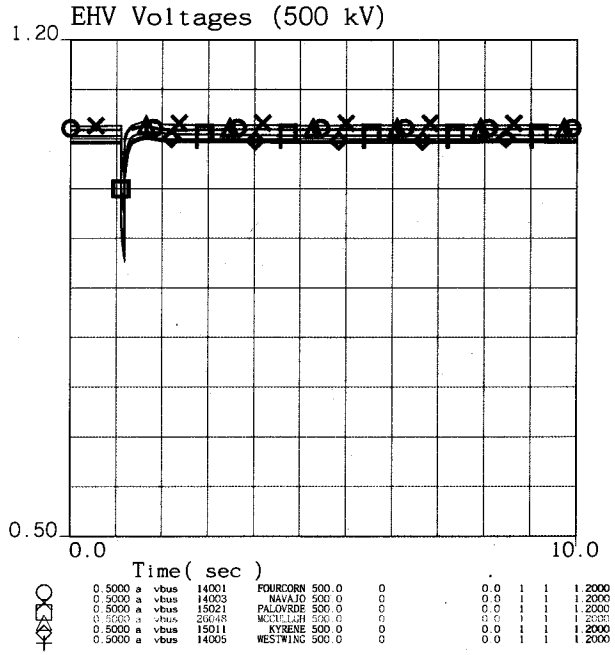
2018 Heavy Summer Detailed Planning Case

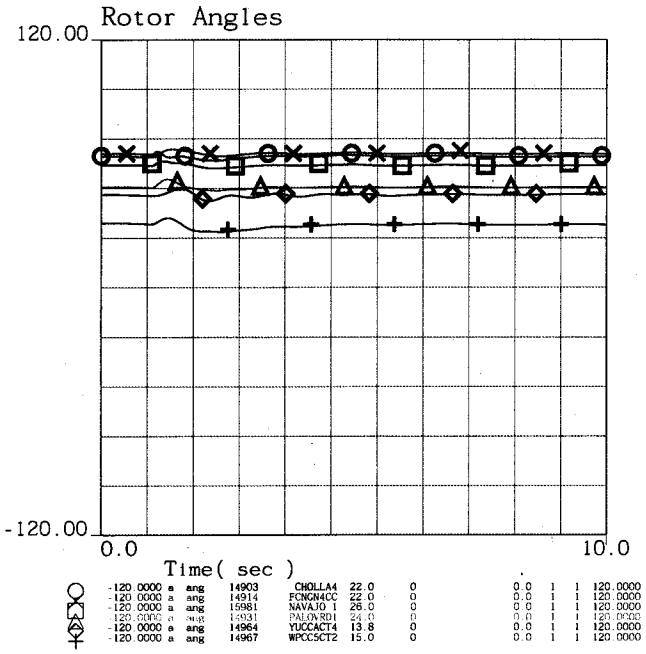
Arizona Voltages (230 kV)



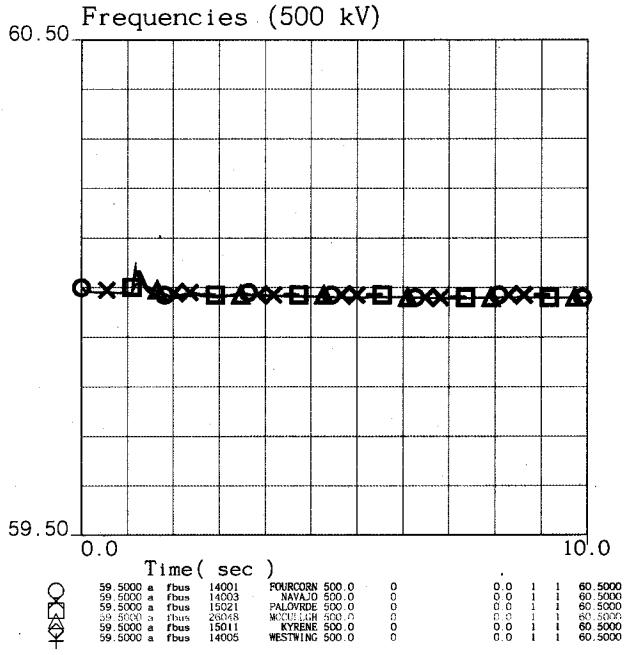
EHV Voltages (500 kV)



Rotor Angles



Frequencies (500 kV)



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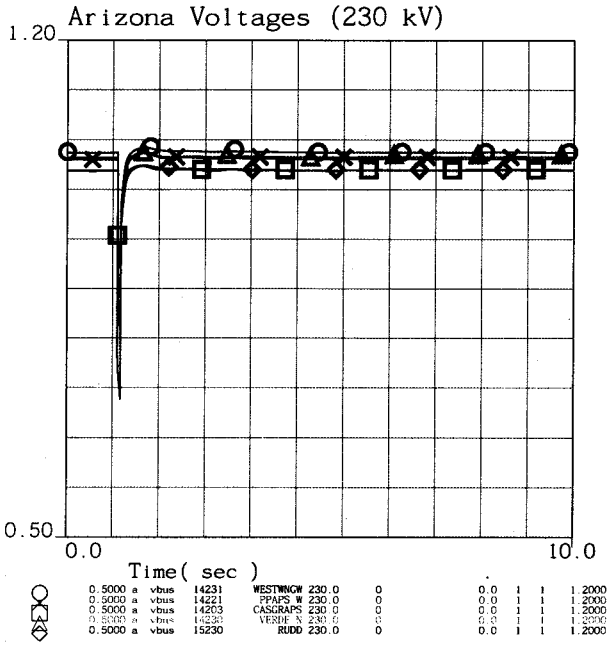

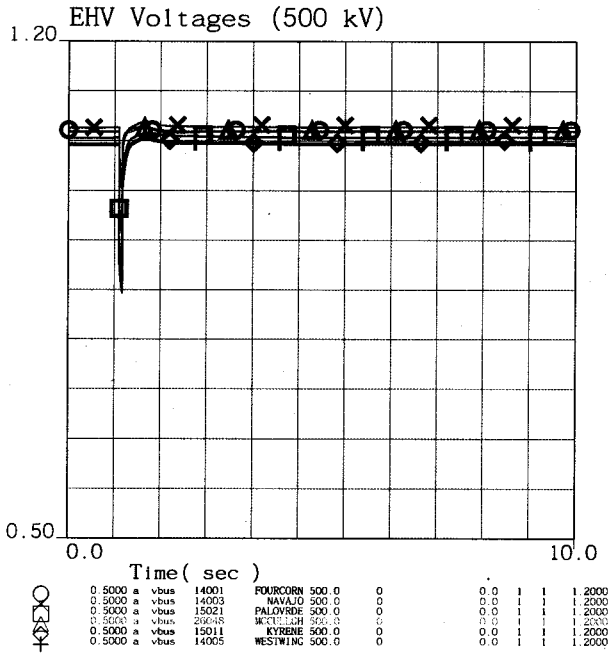

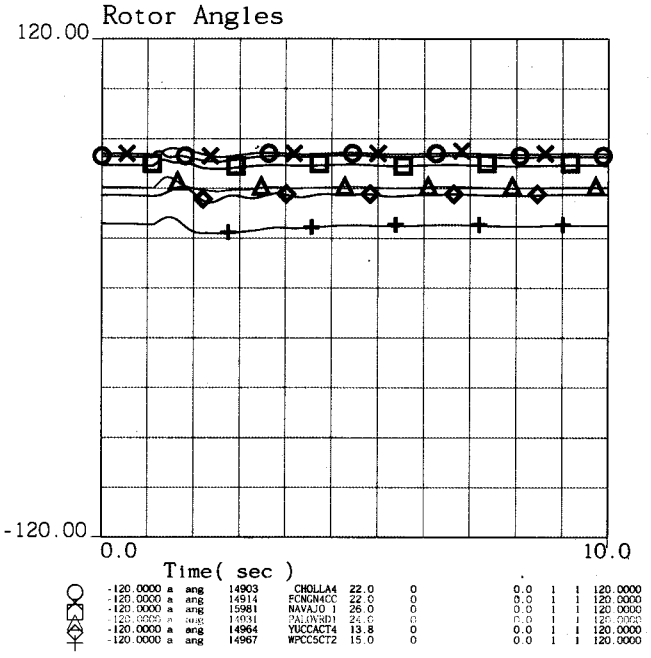

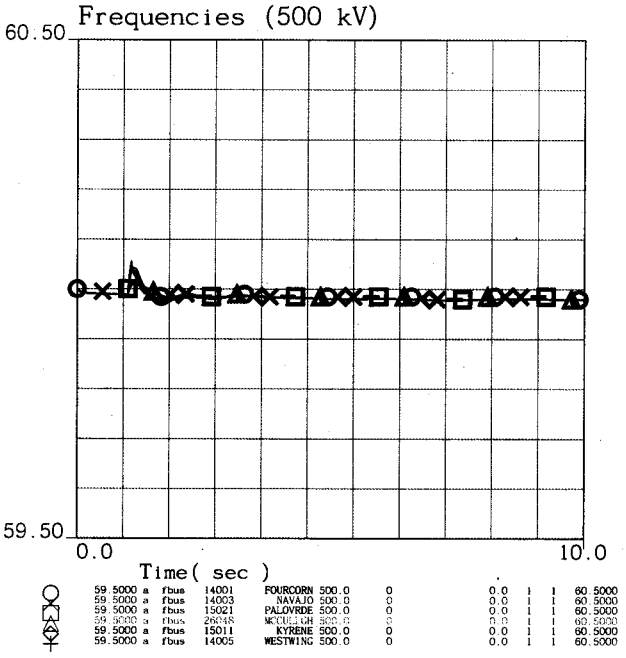

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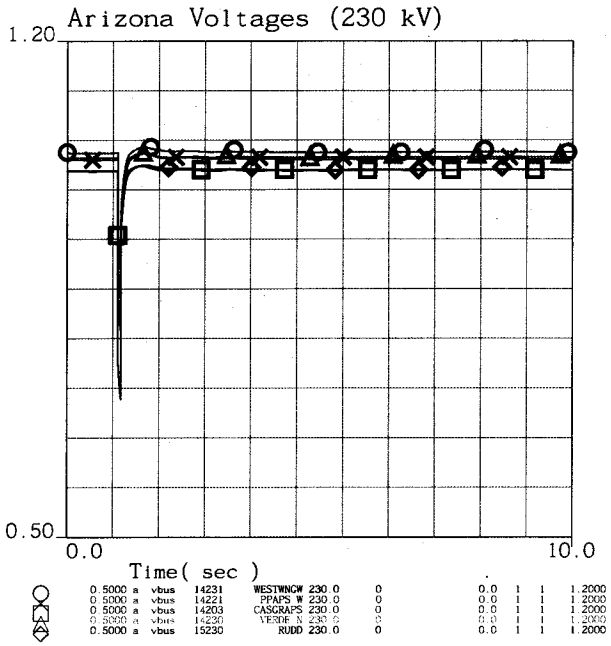
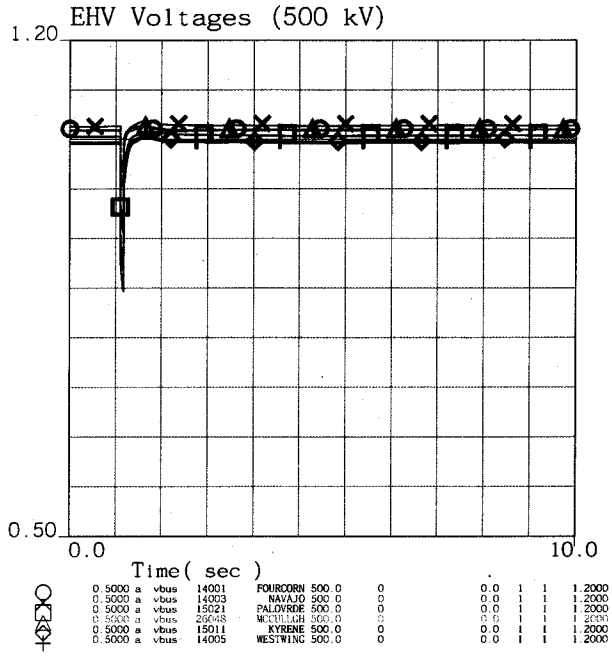
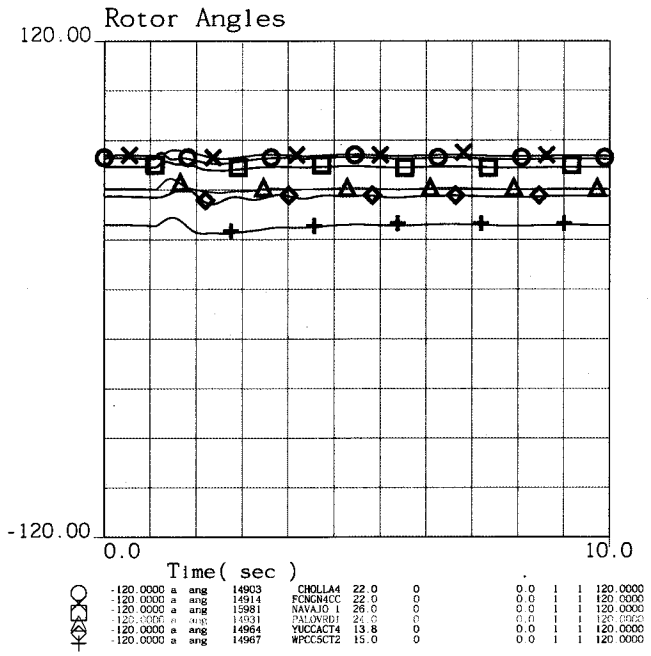
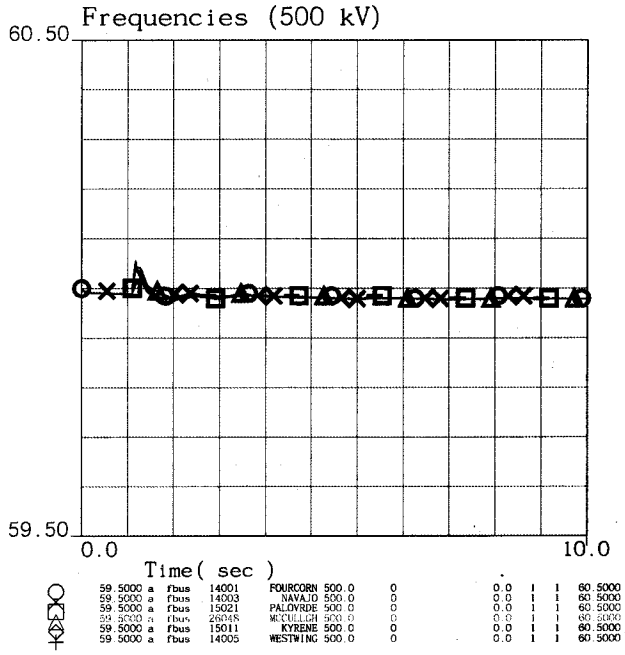
2018 Heavy Summer Detailed Planning Case









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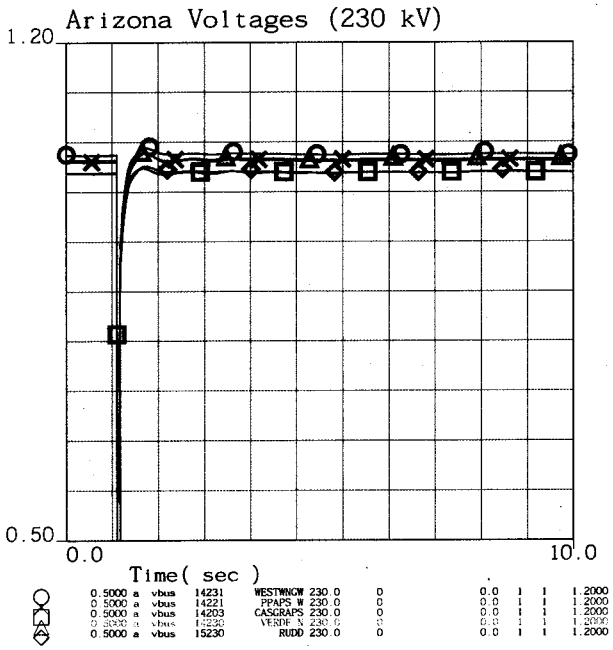

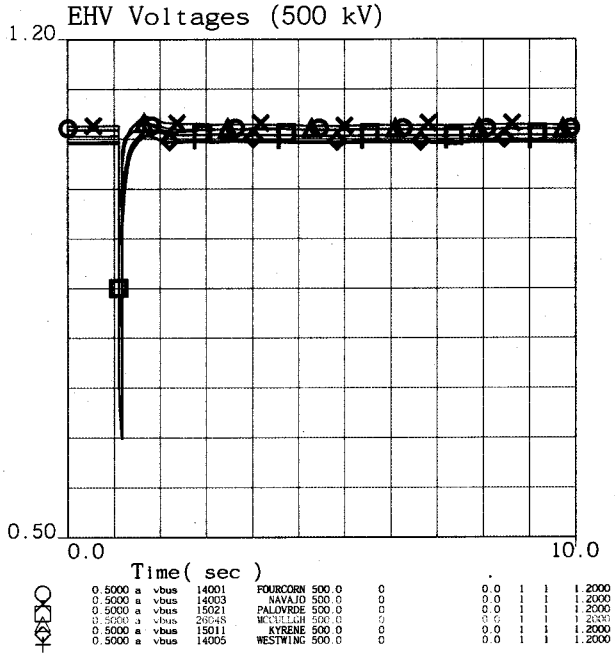

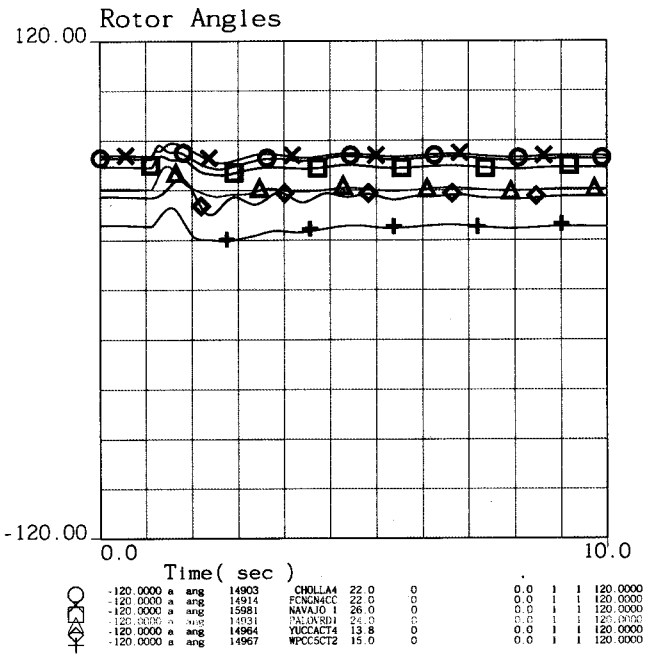

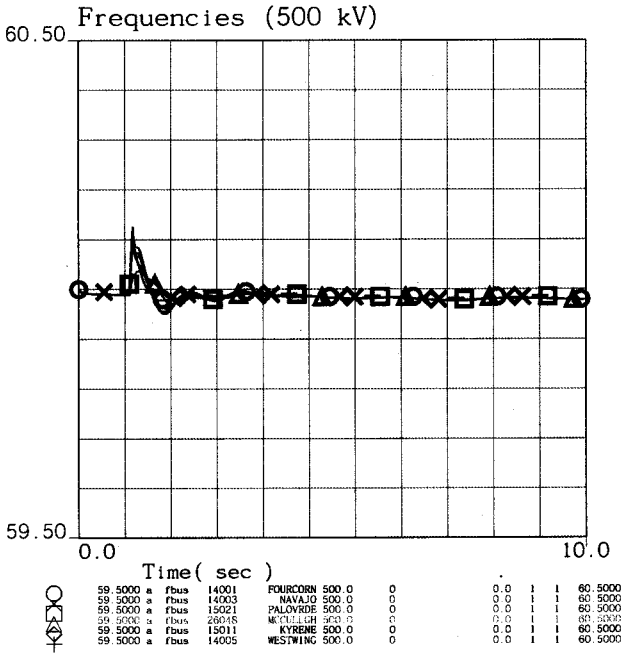

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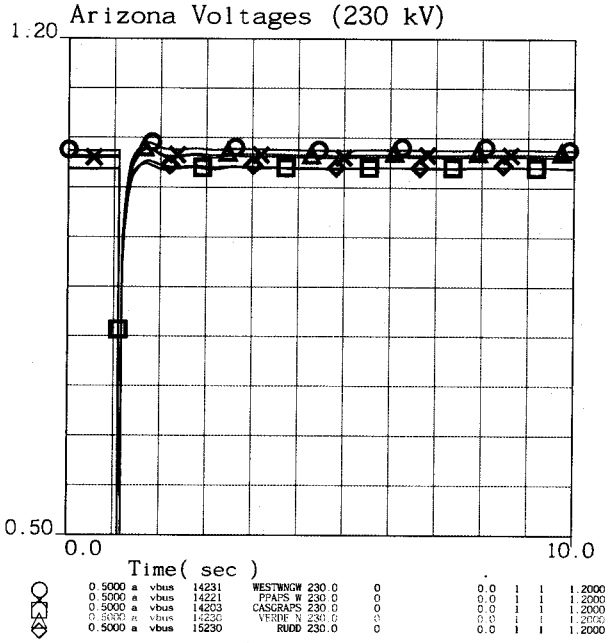

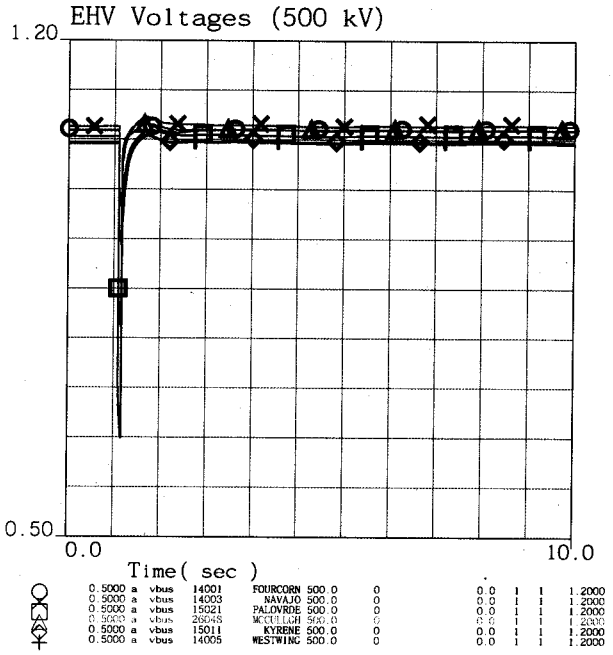

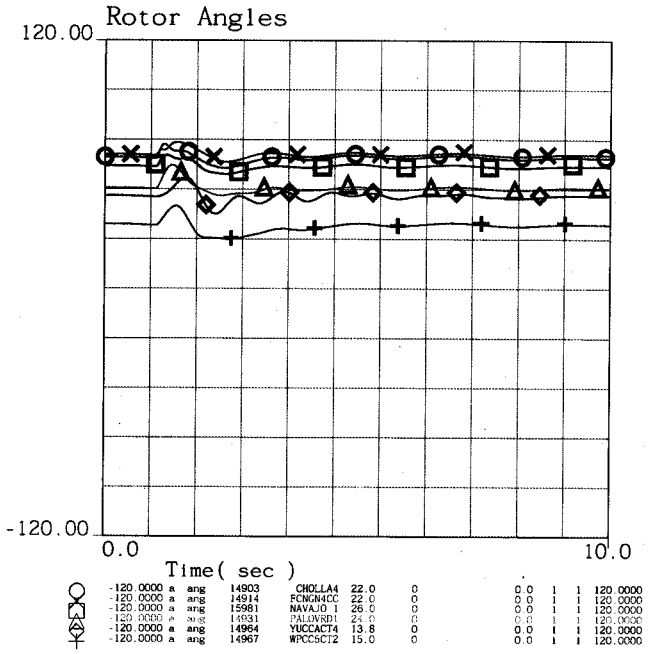

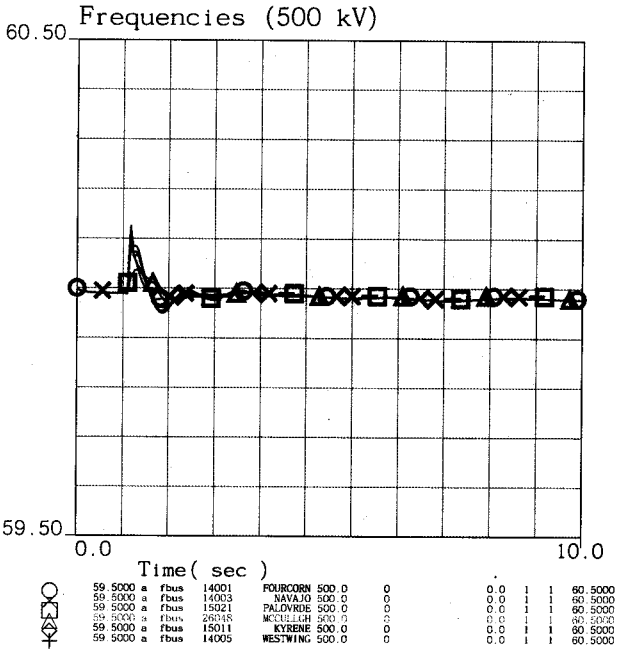

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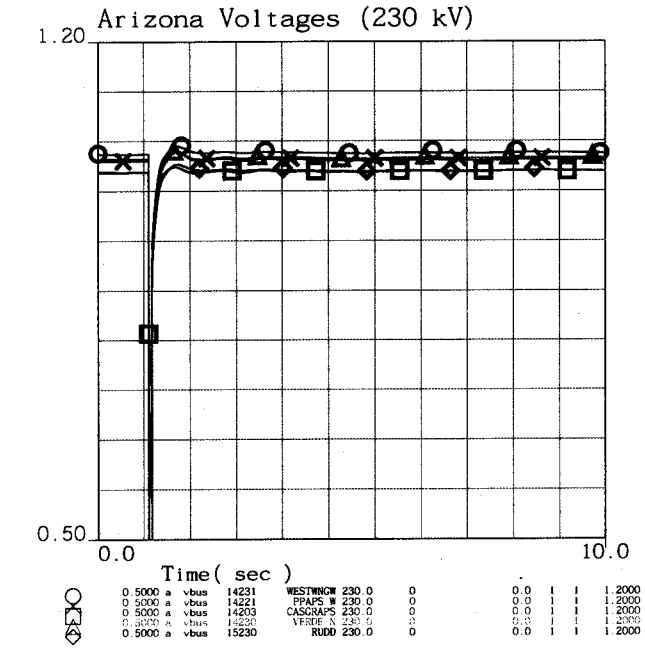

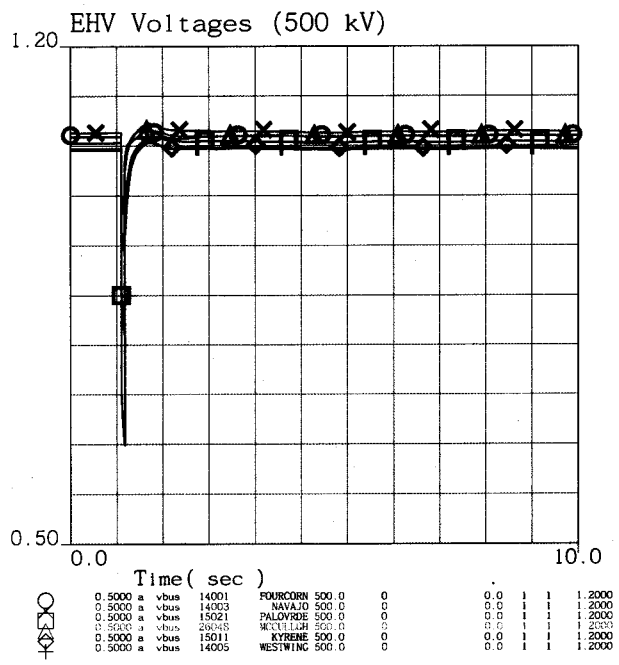

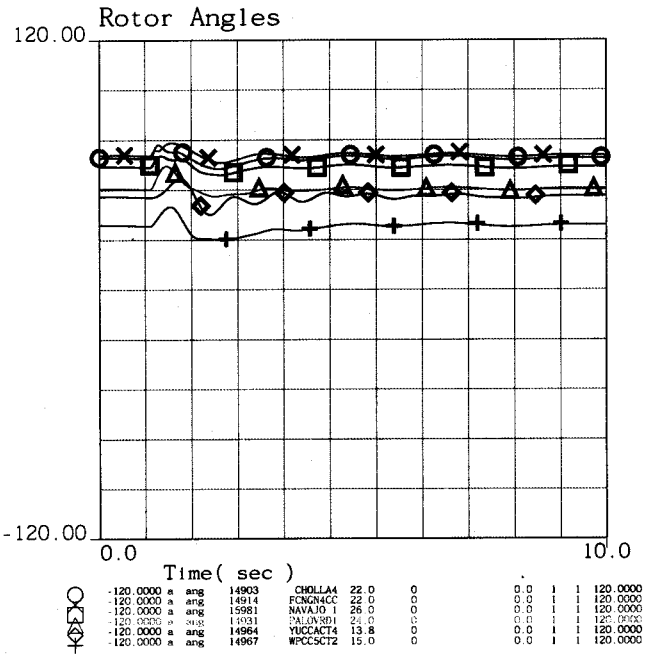

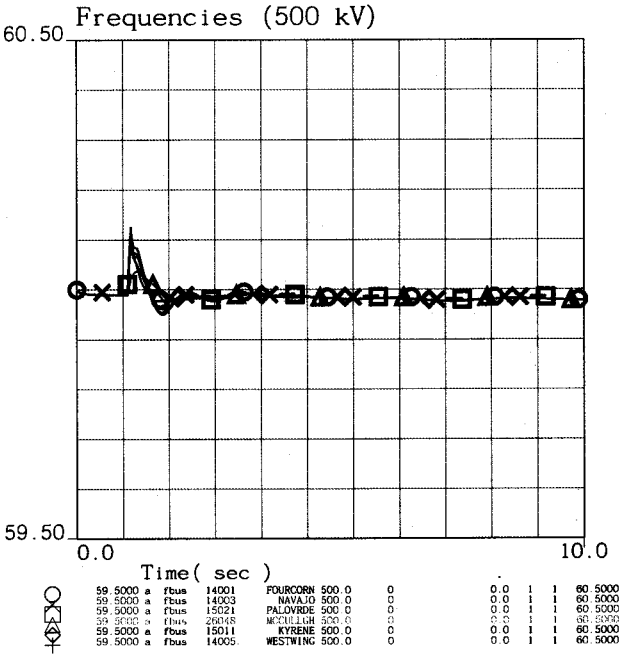

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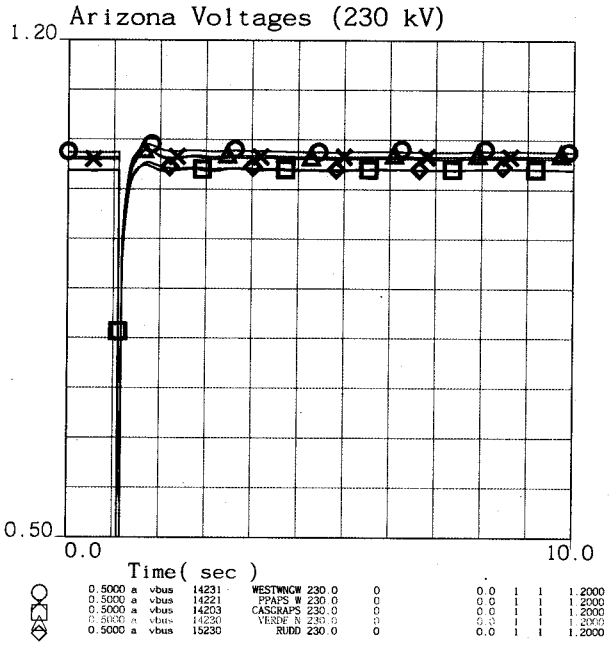

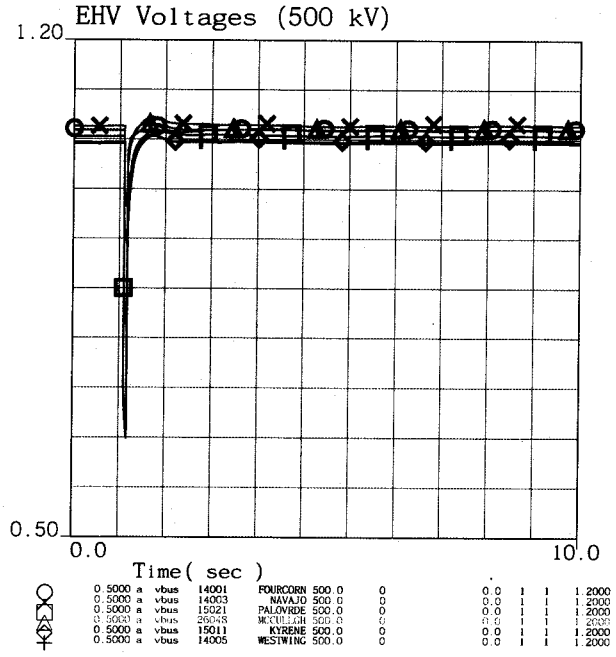

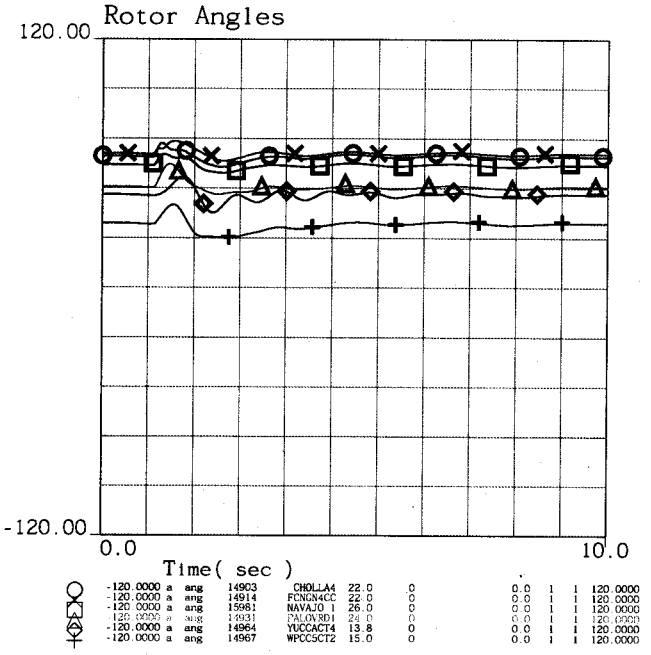

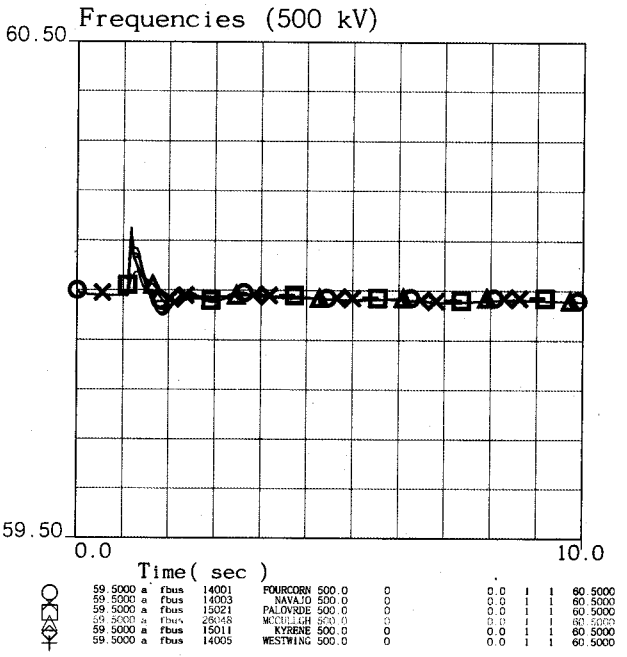

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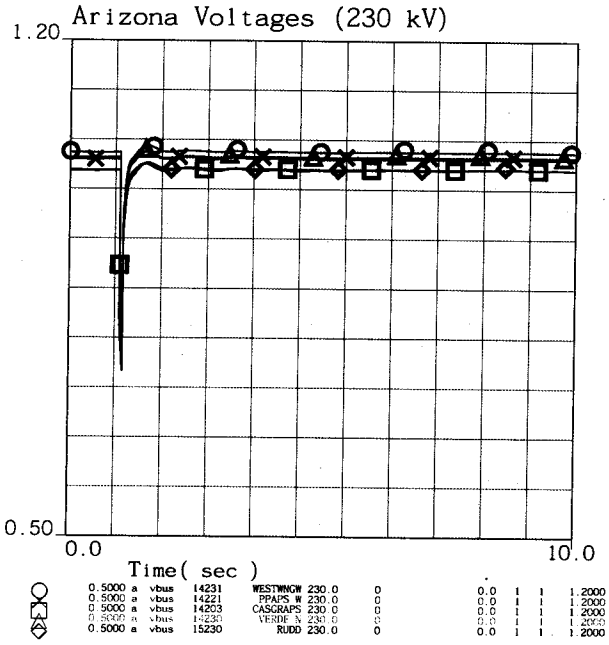

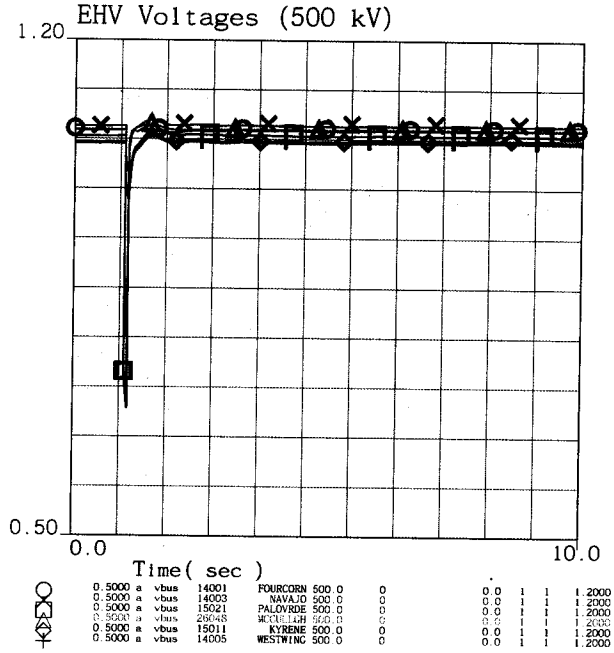

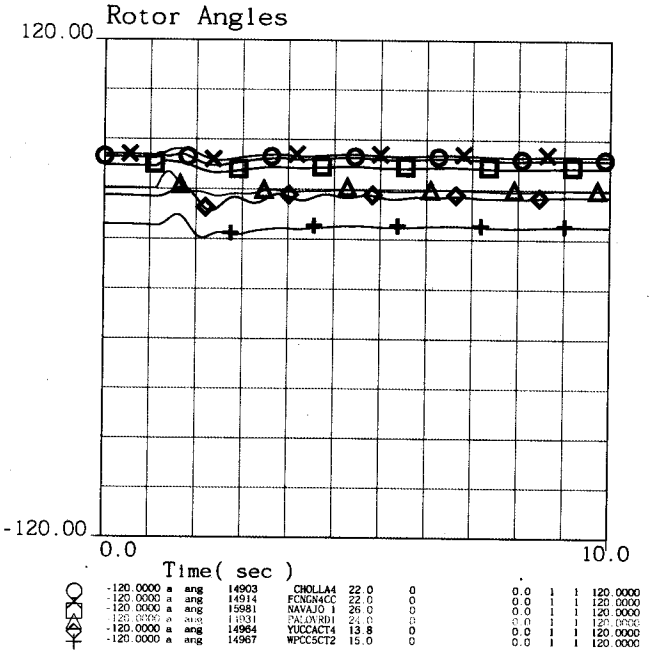

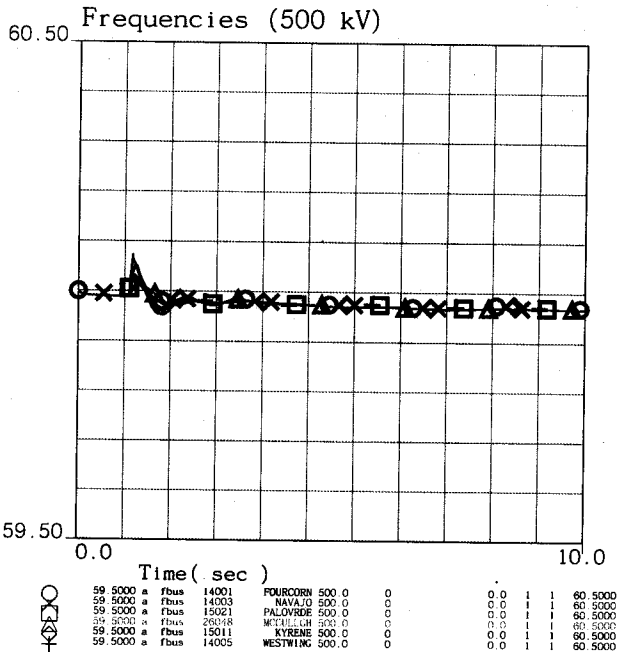

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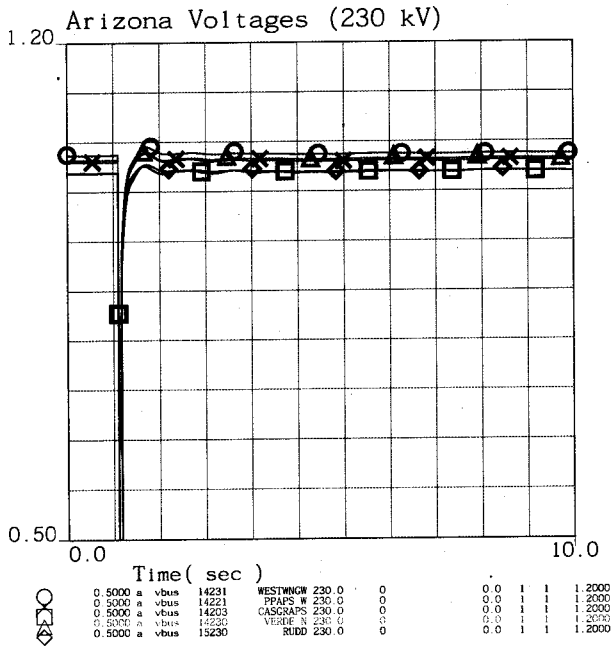

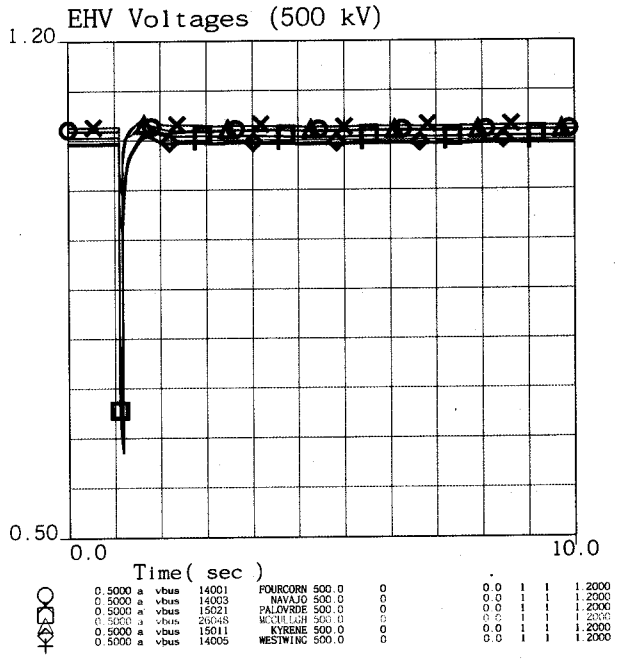

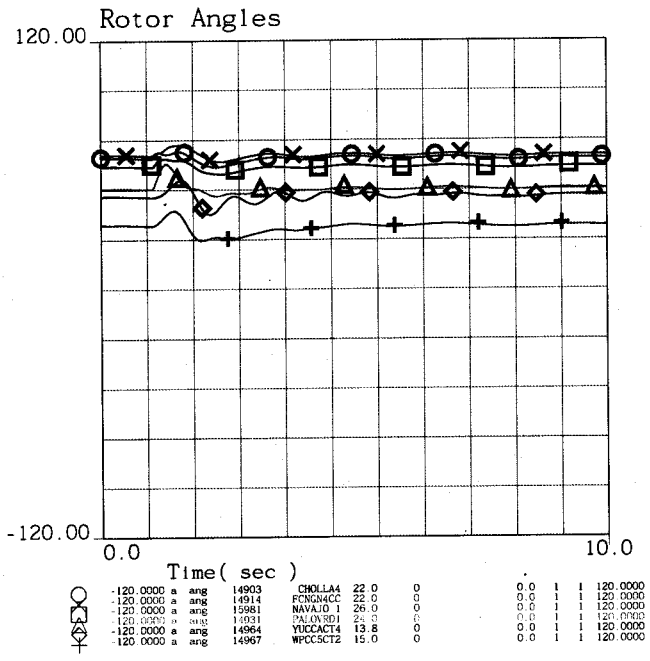

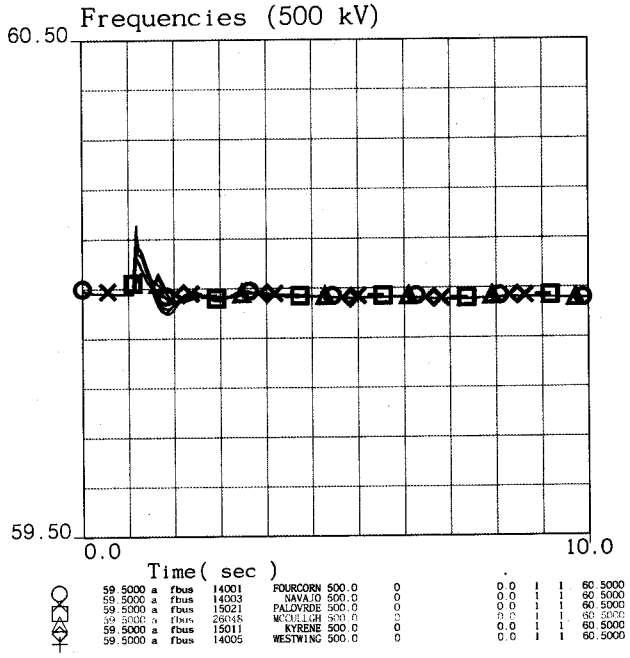

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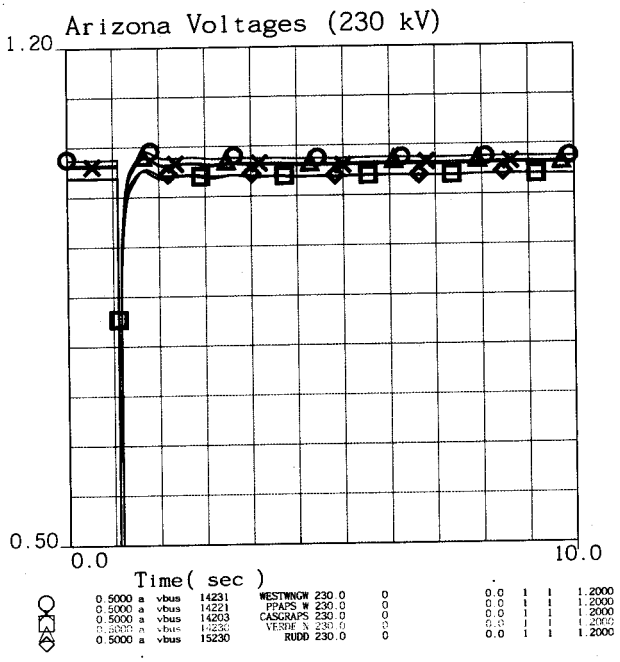

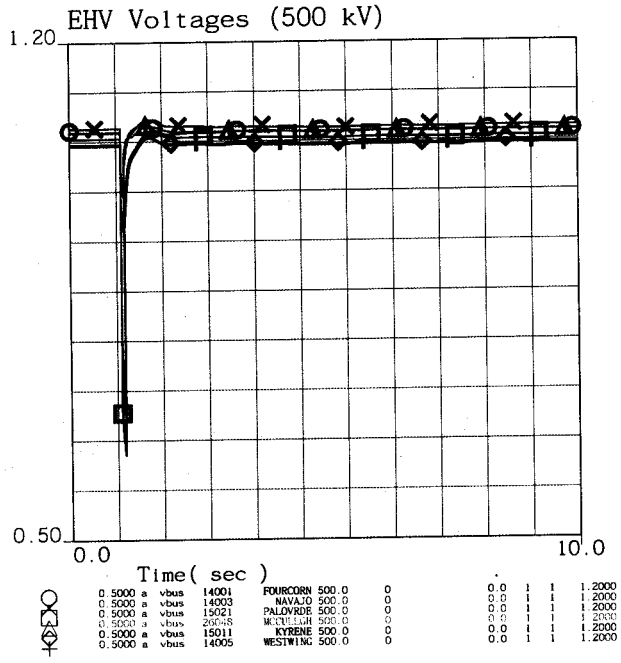

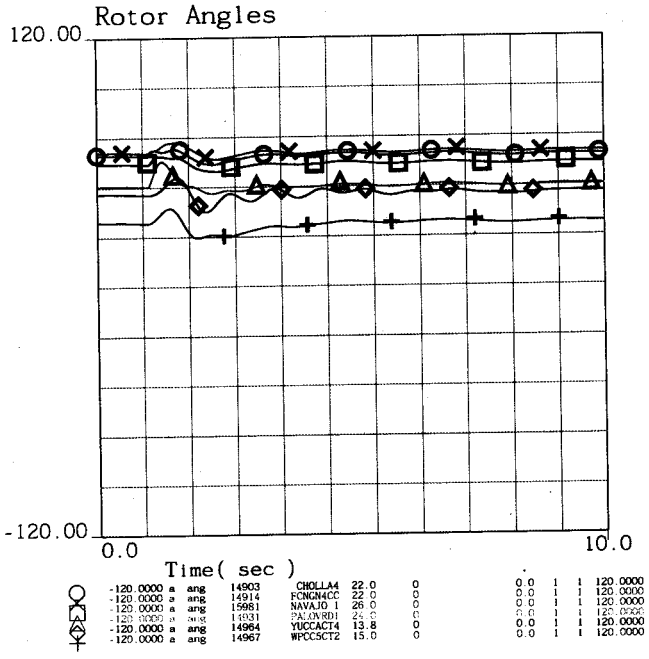

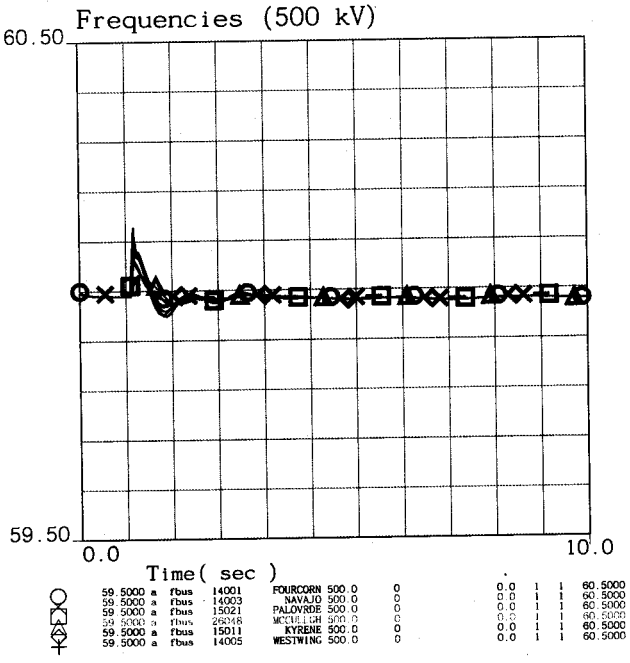

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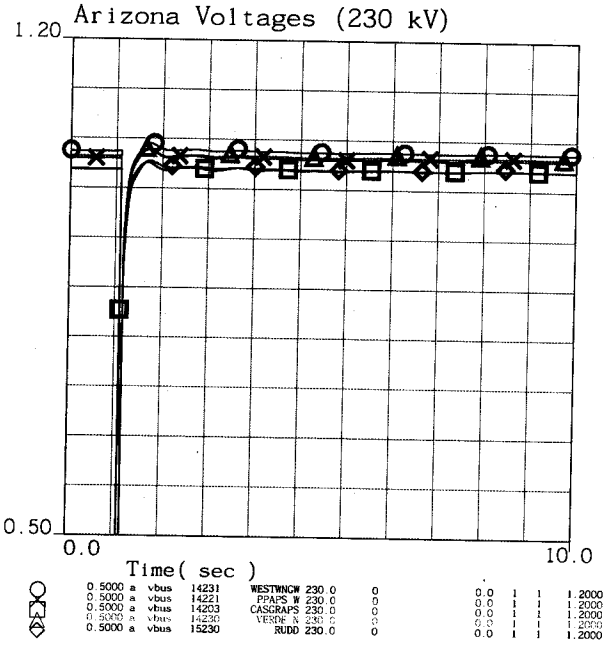

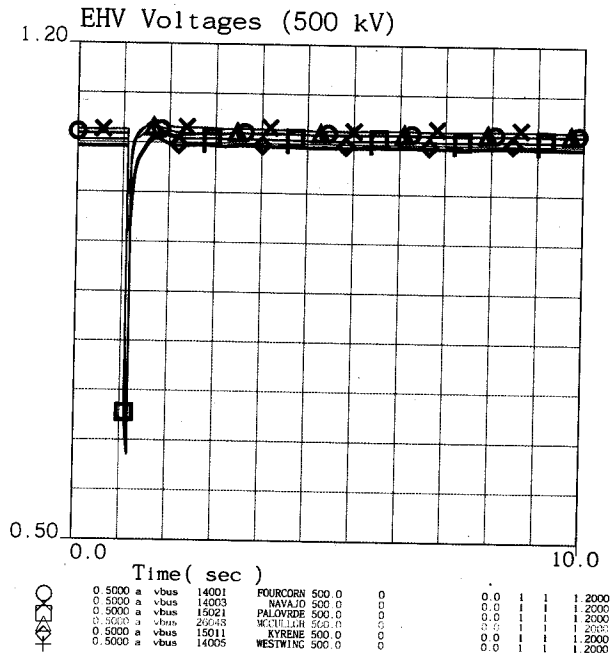

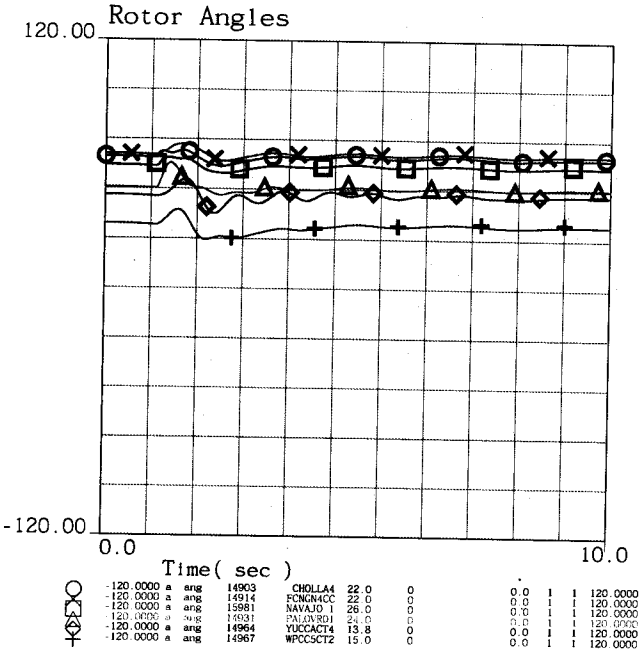

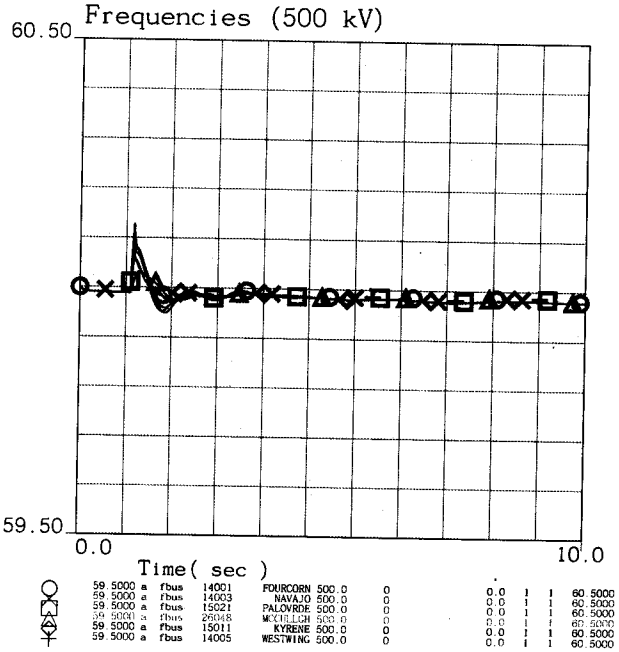

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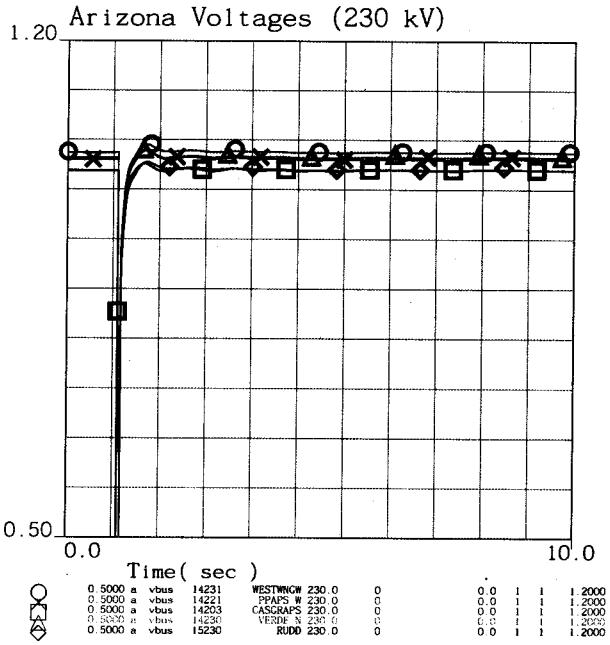

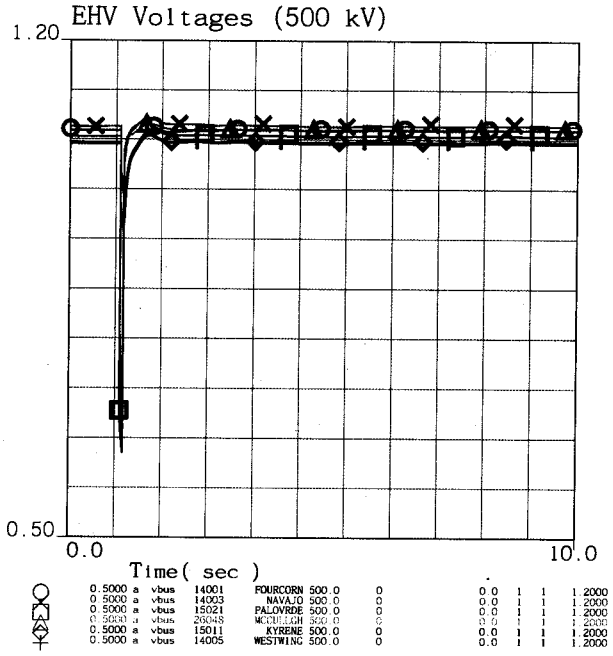

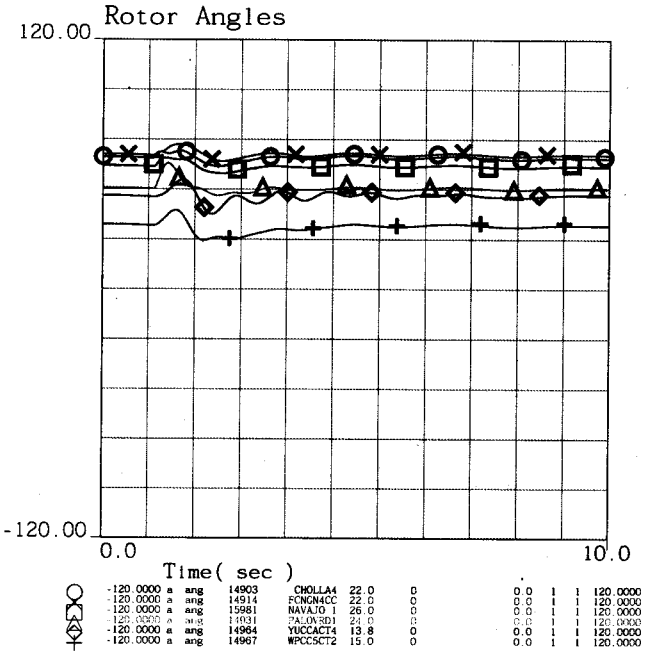

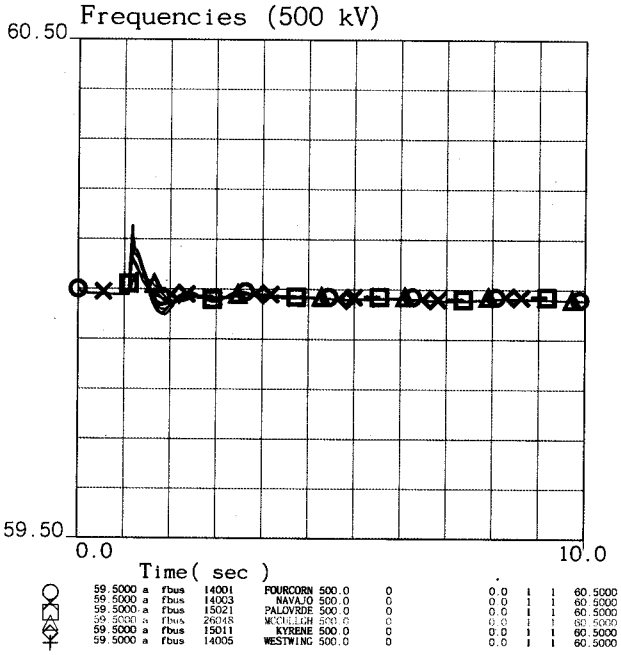

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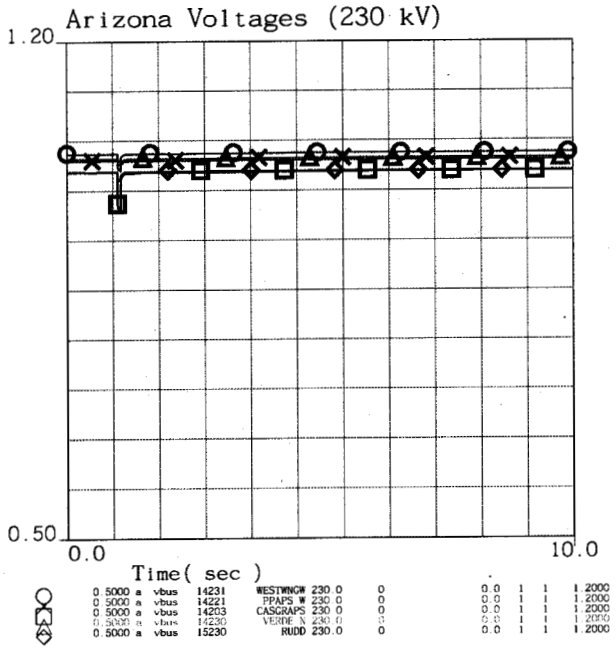

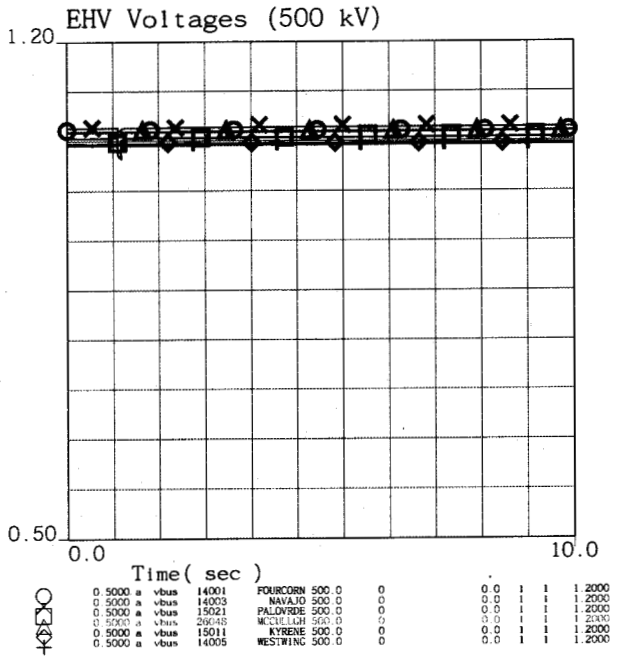

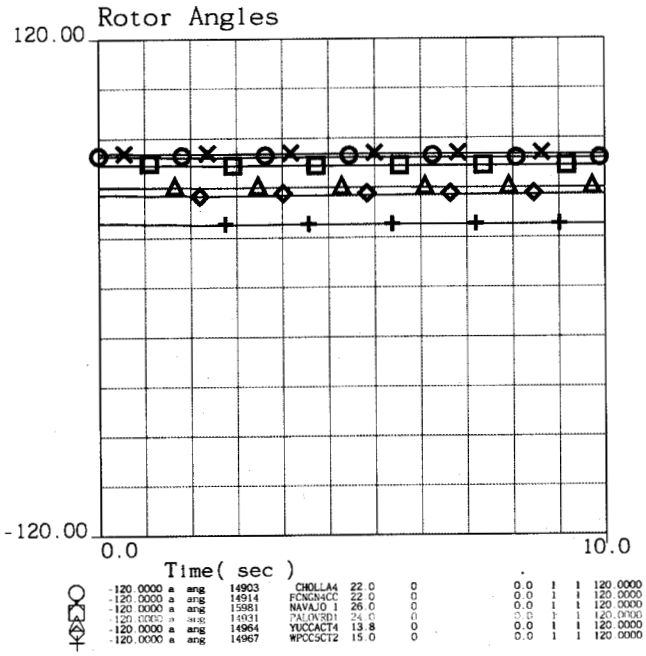

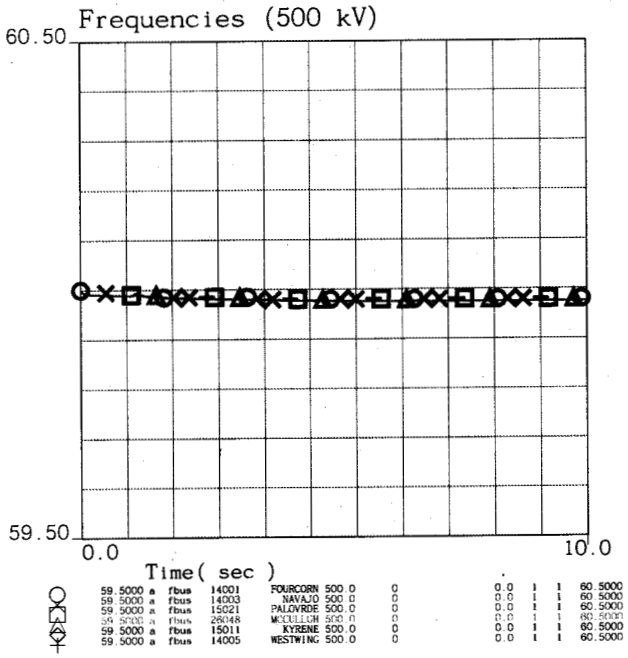

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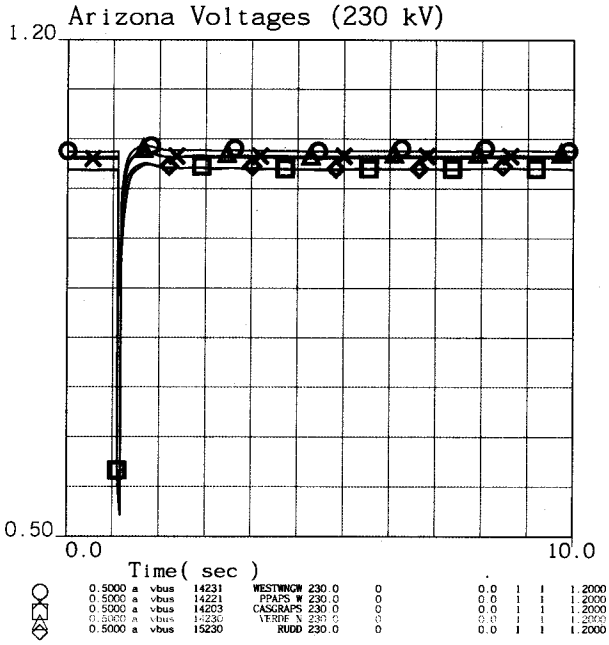

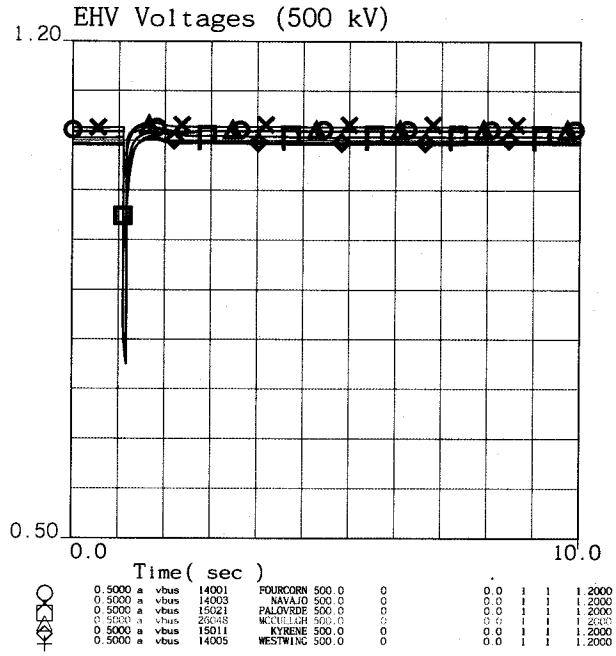

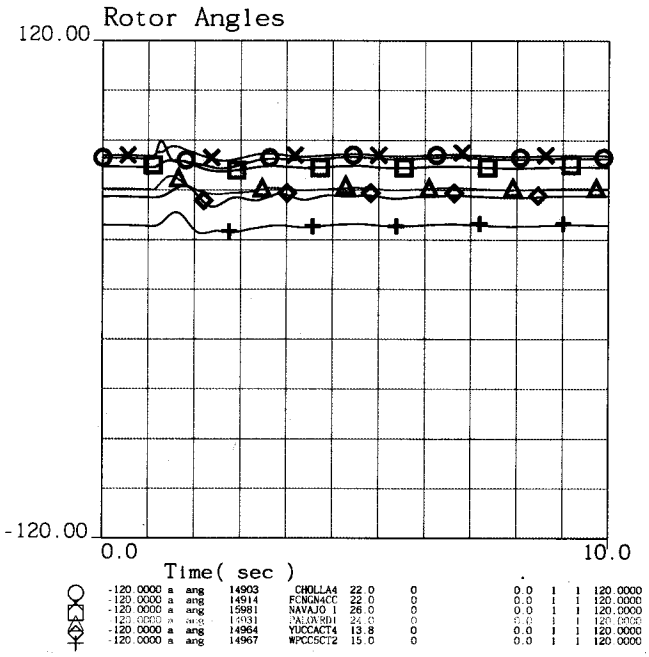

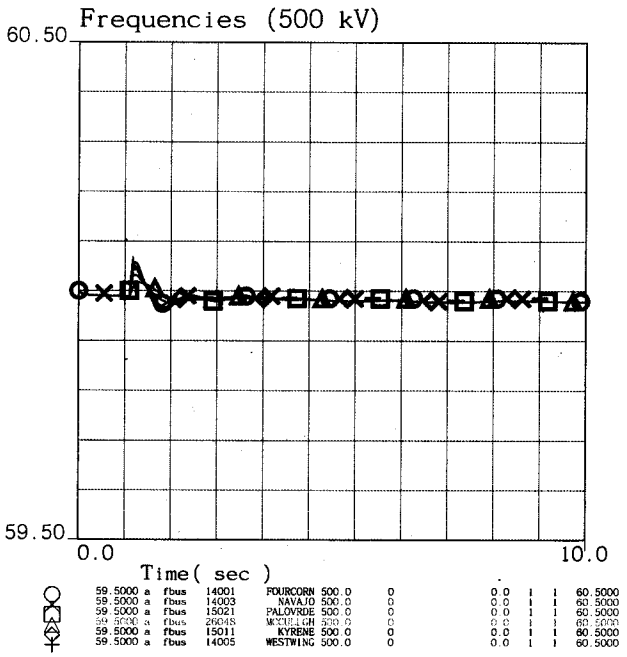

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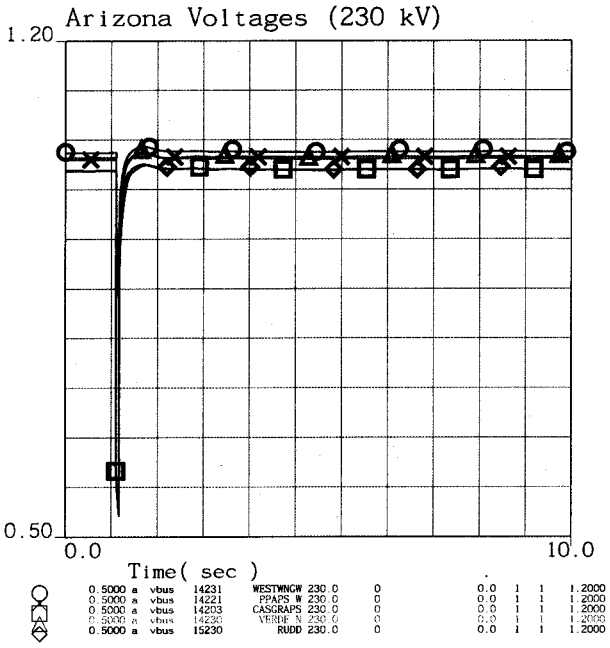

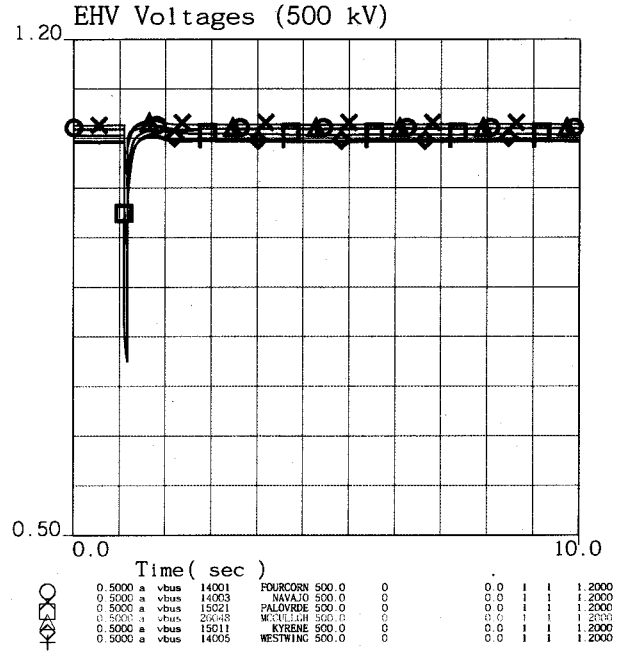

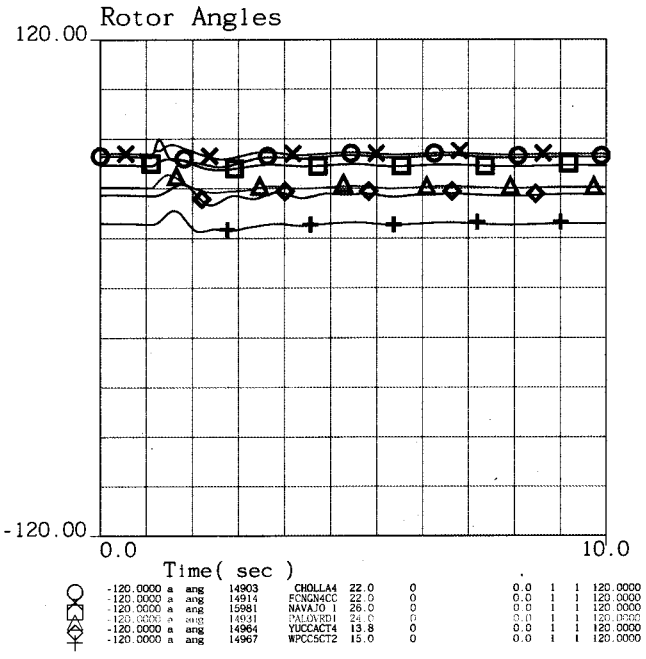

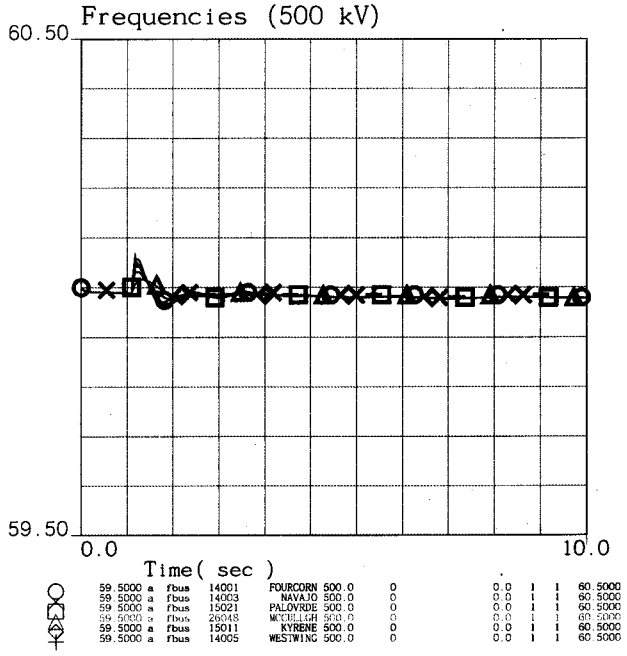

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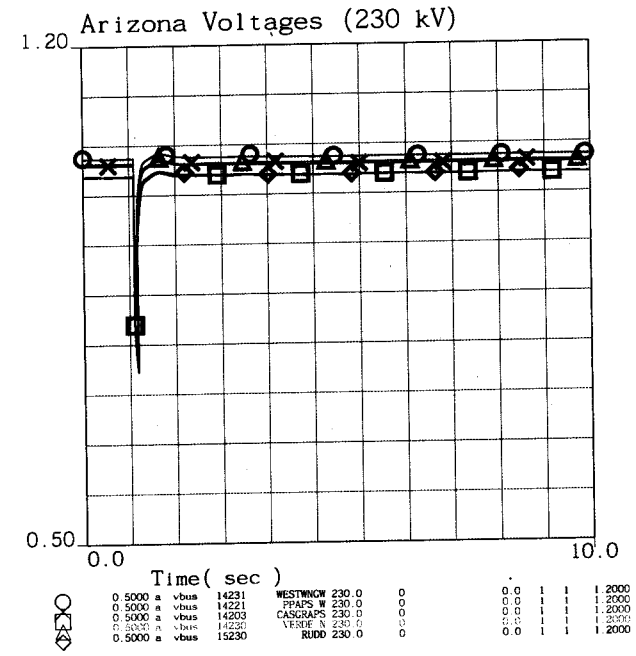

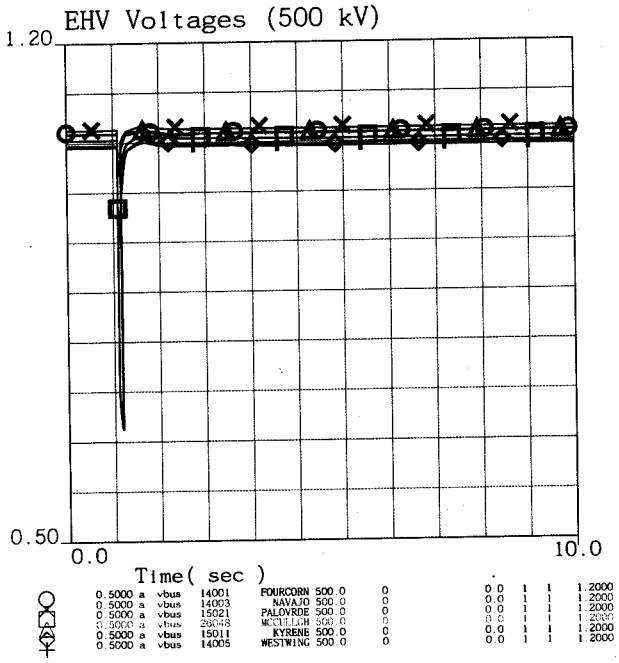

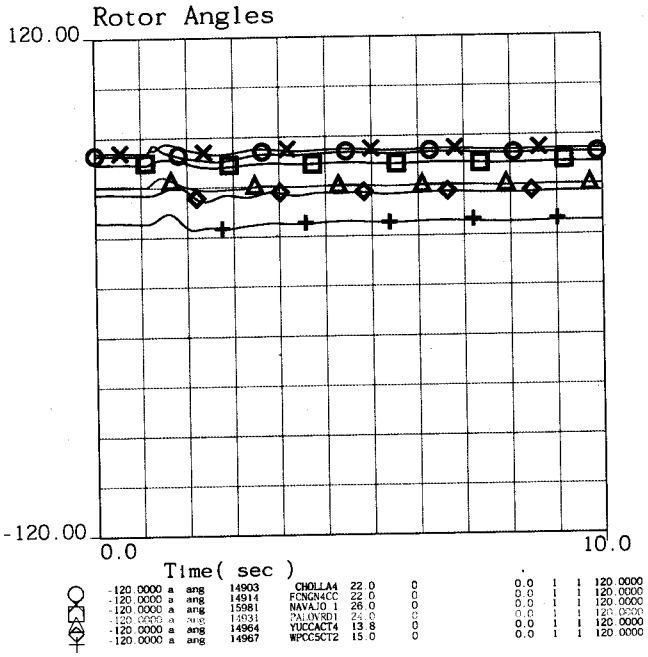

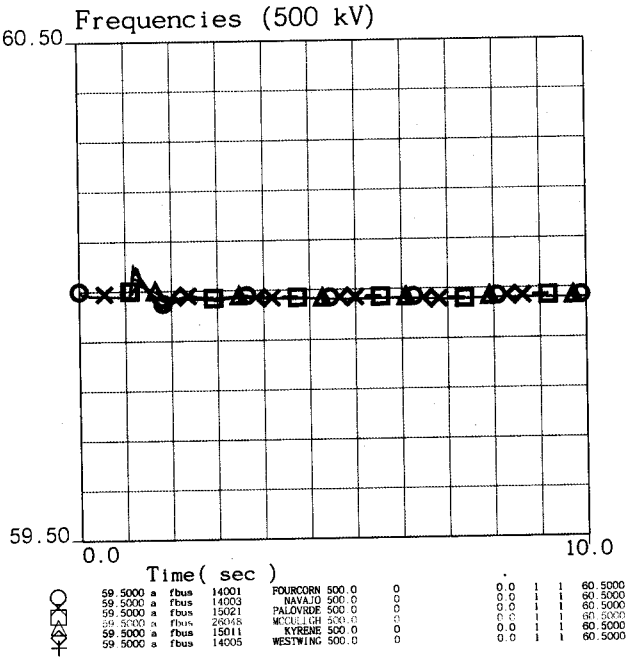

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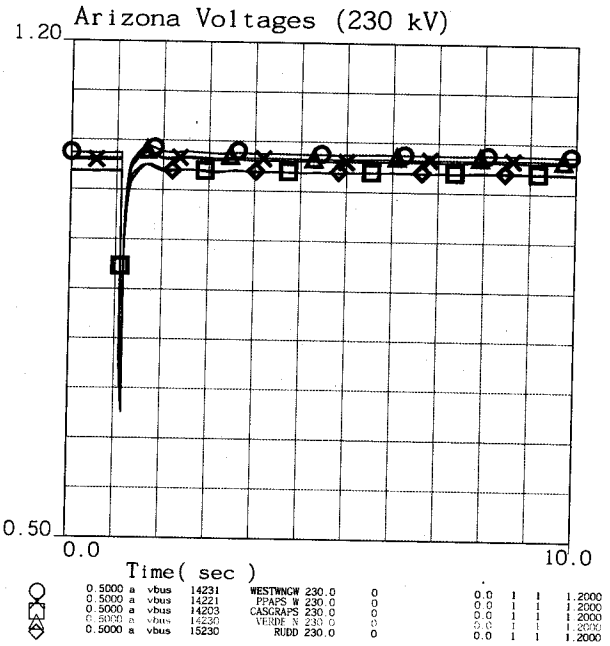
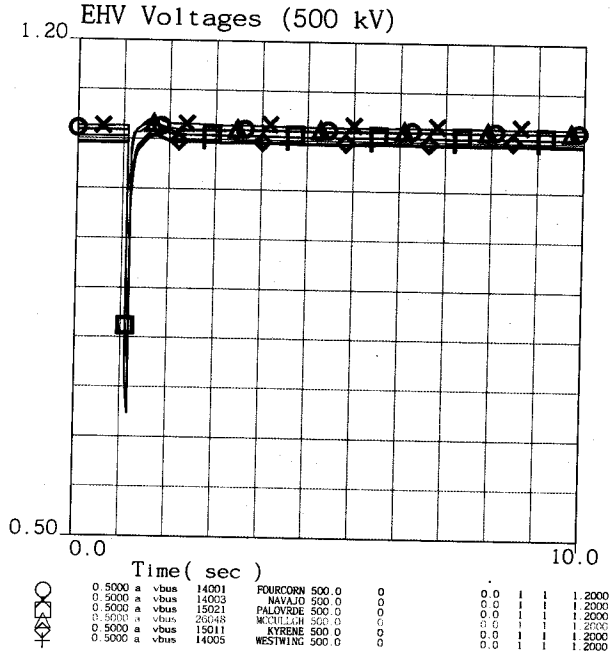
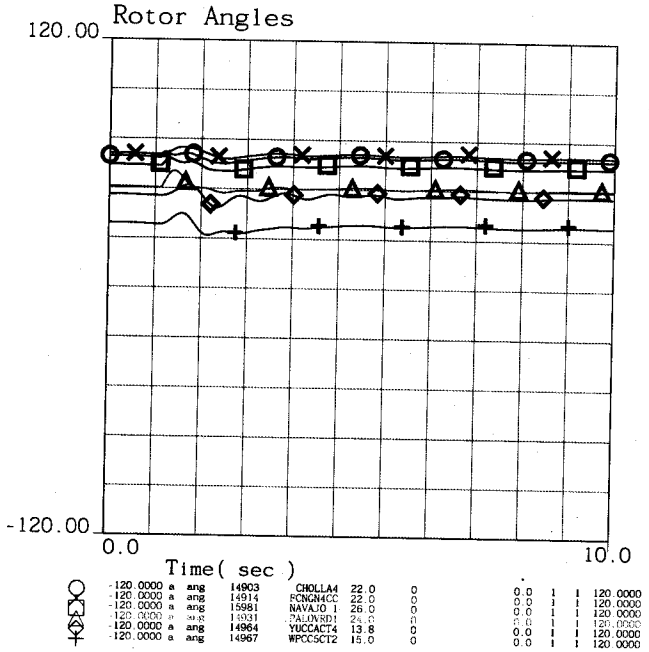
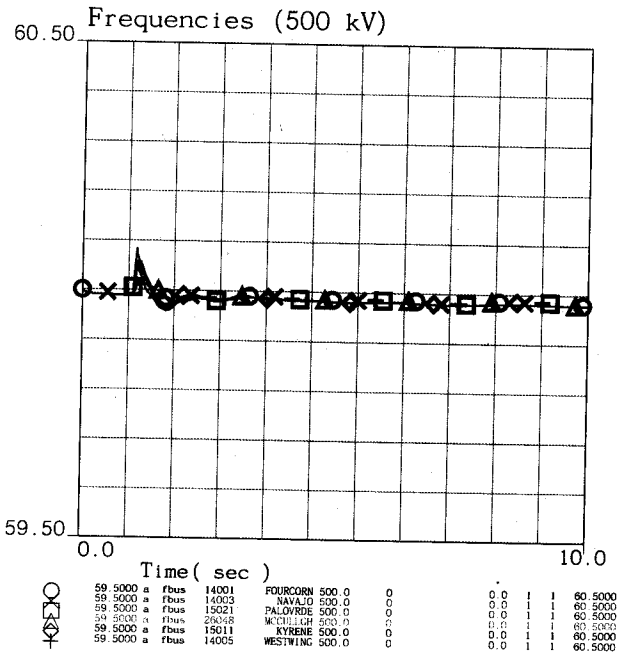
2018 Heavy Summer Detailed Planning Case









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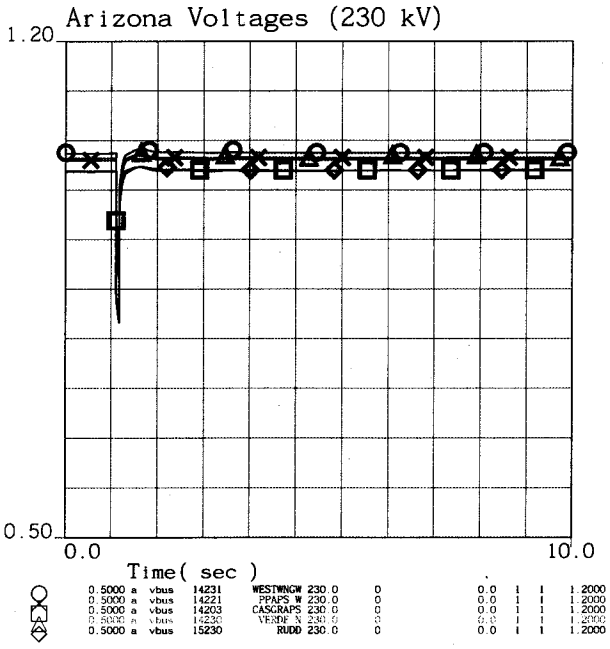

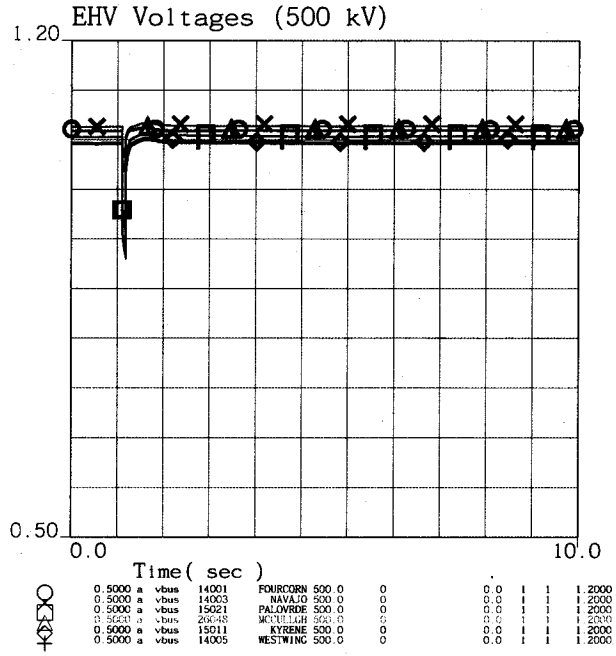

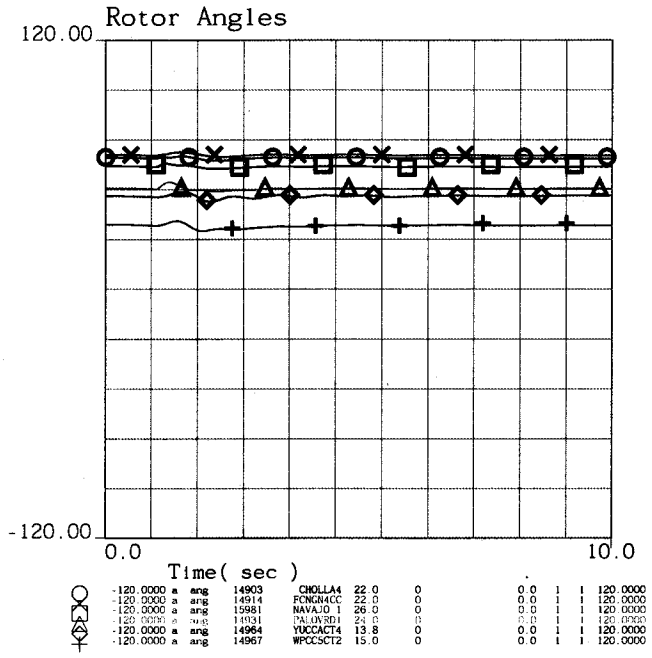

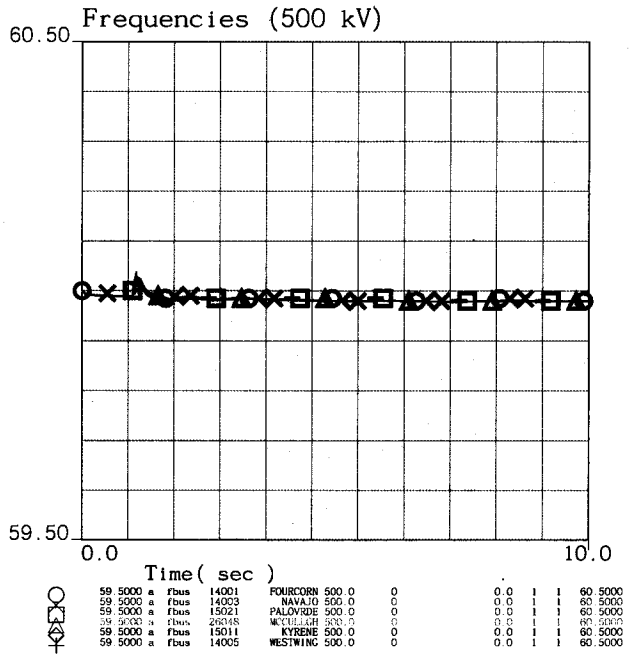

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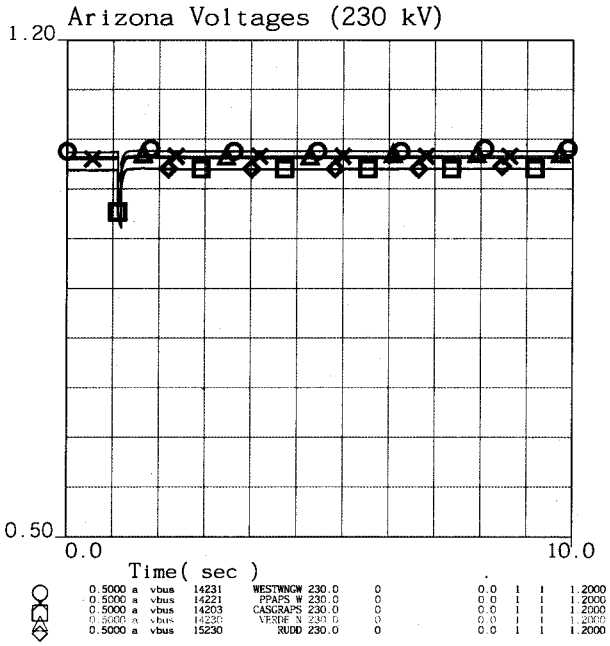

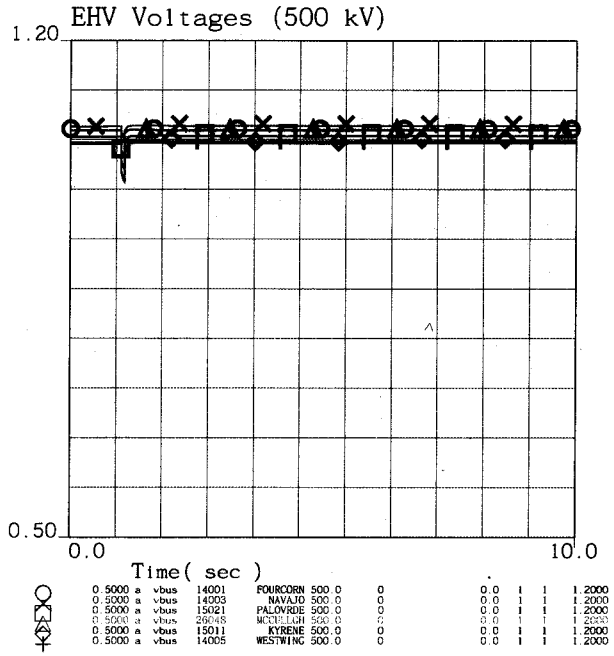

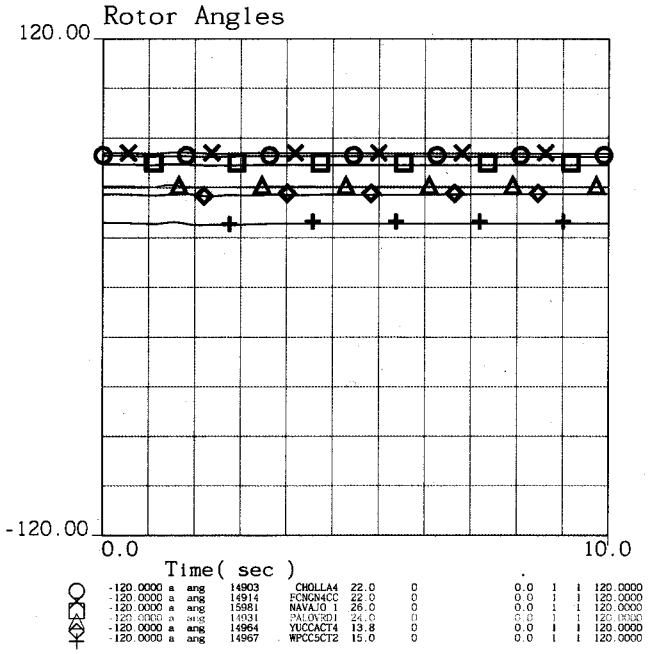

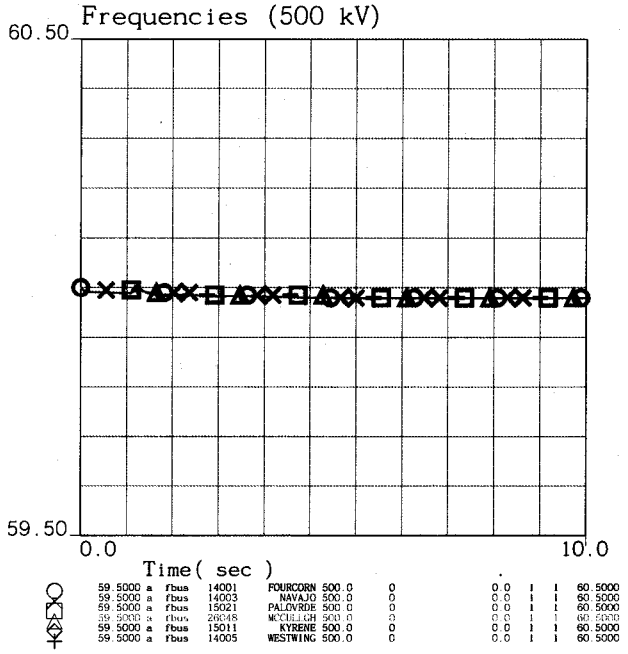

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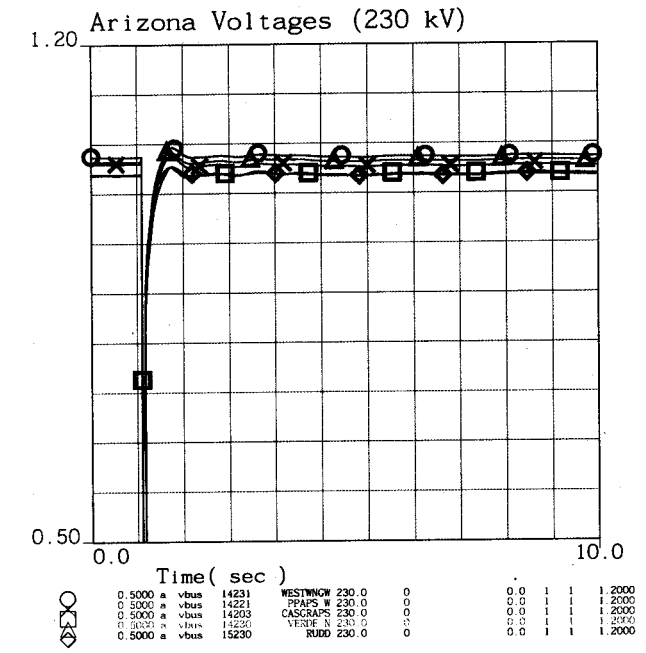

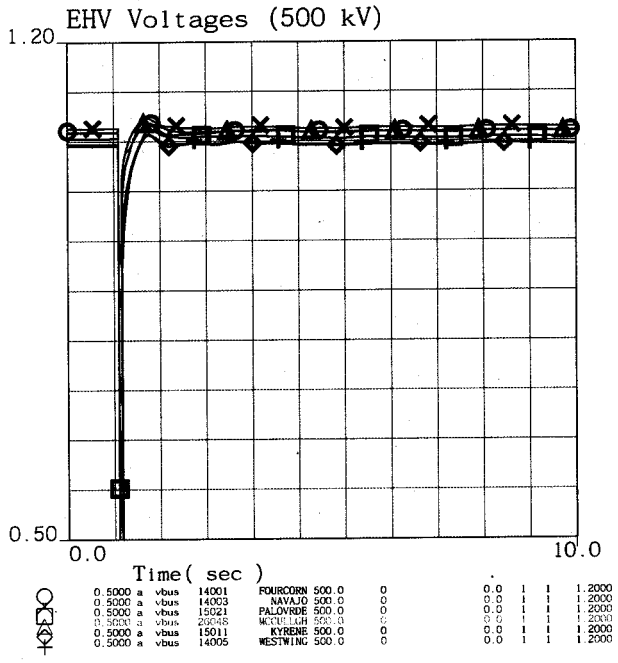

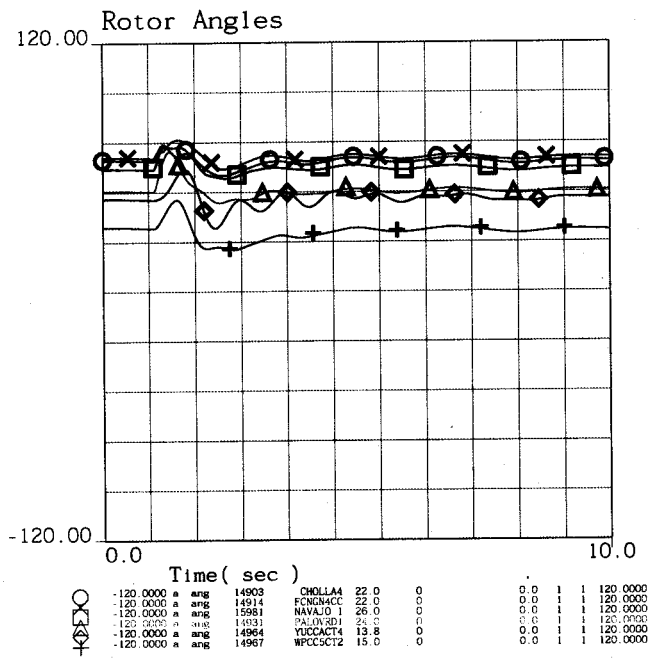

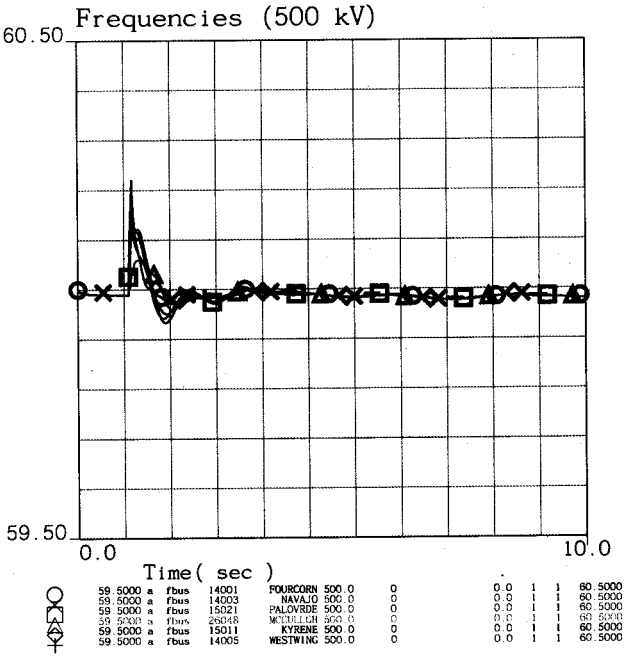

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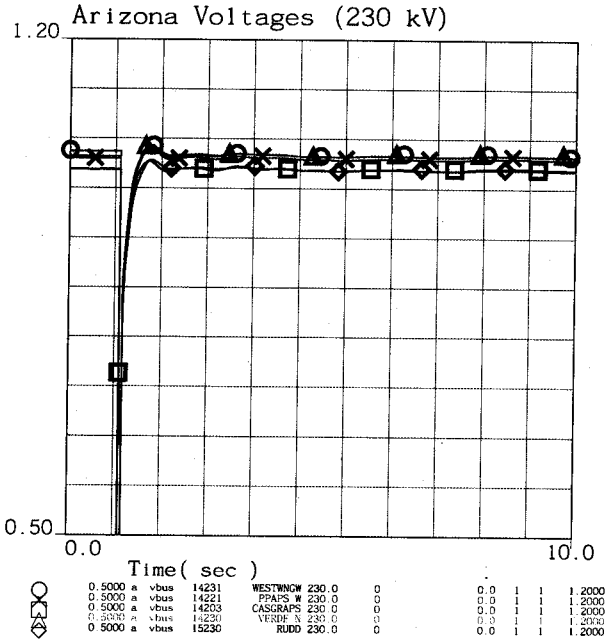

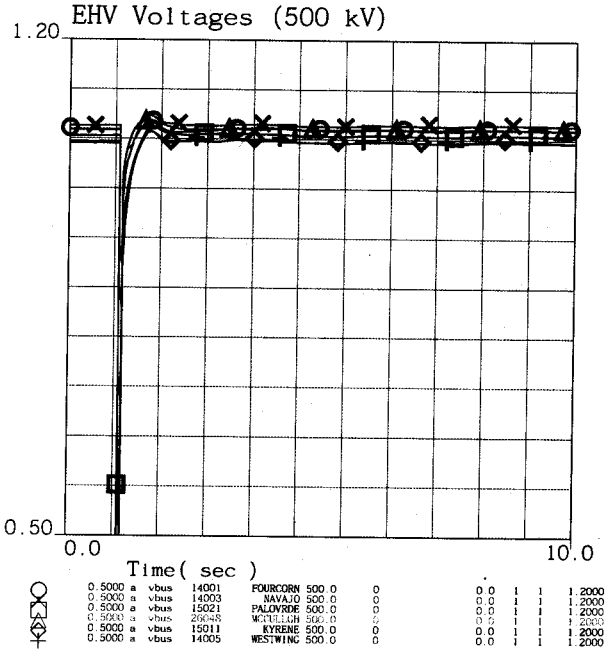

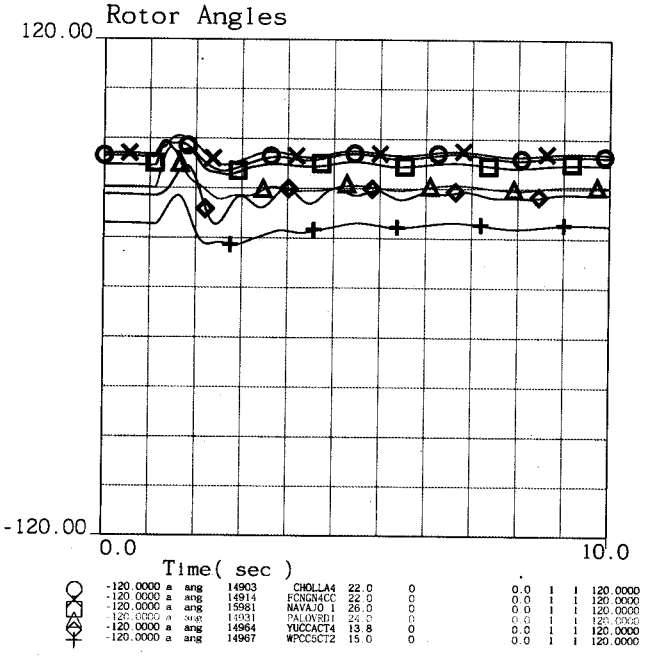

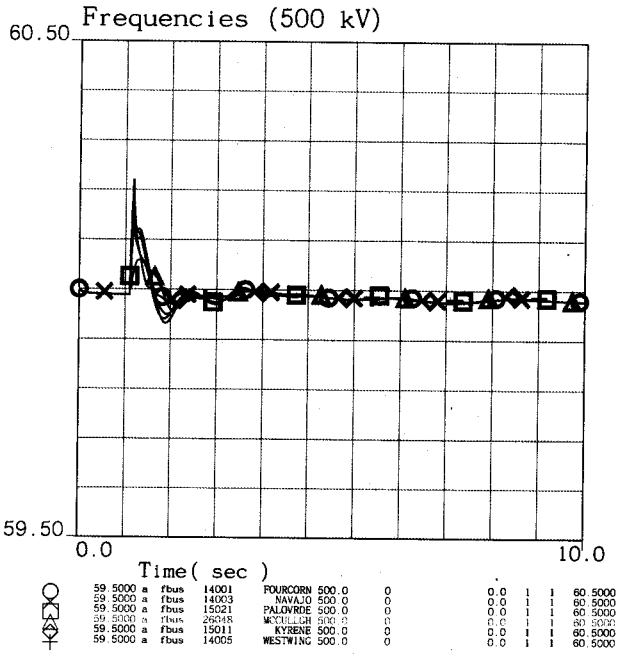

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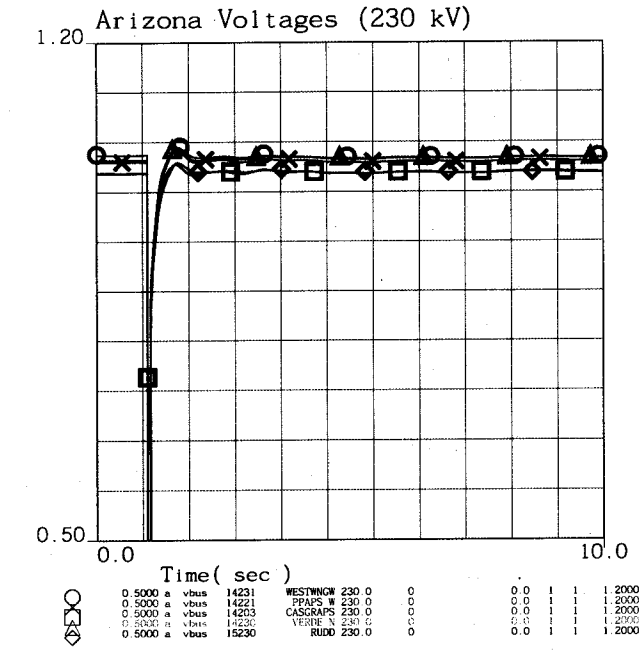

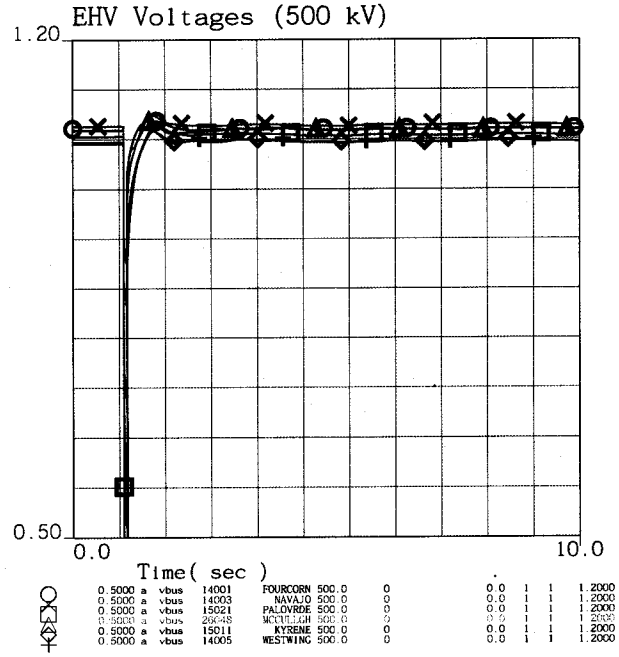

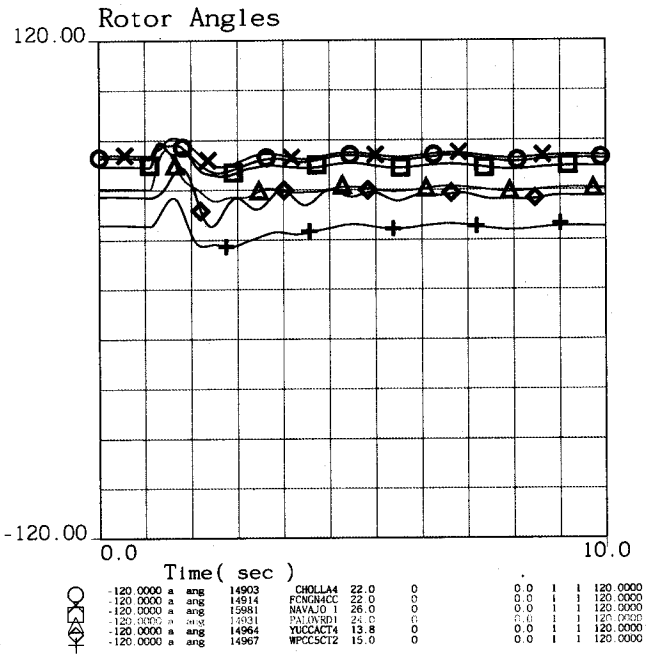

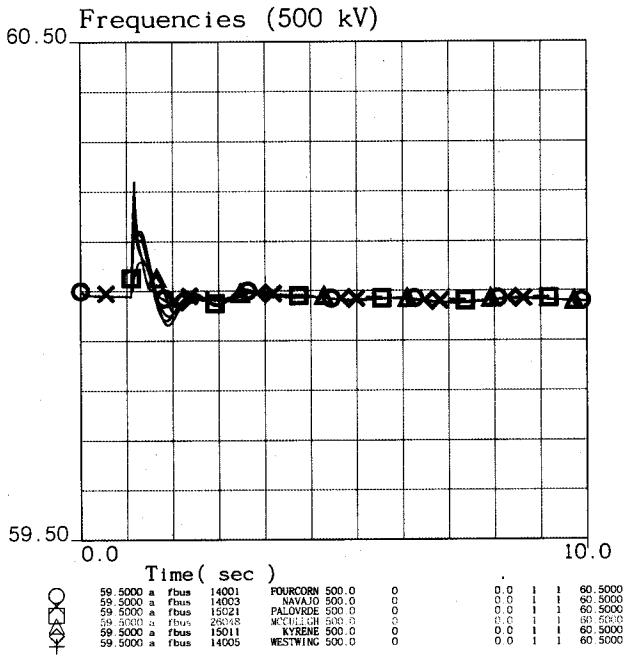

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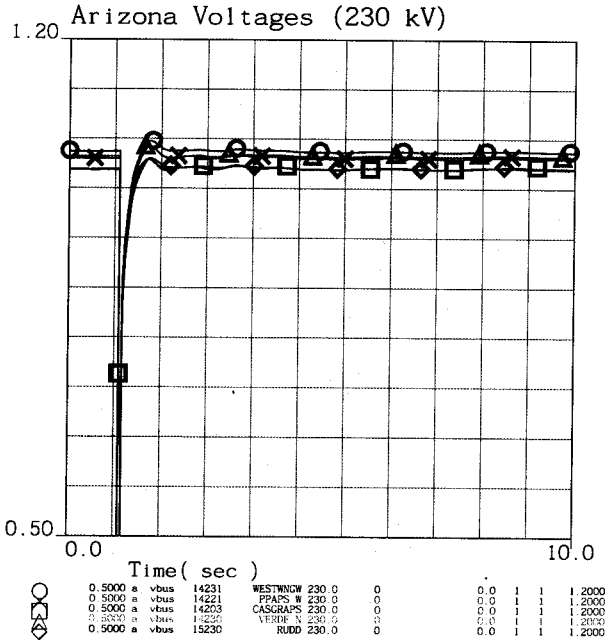

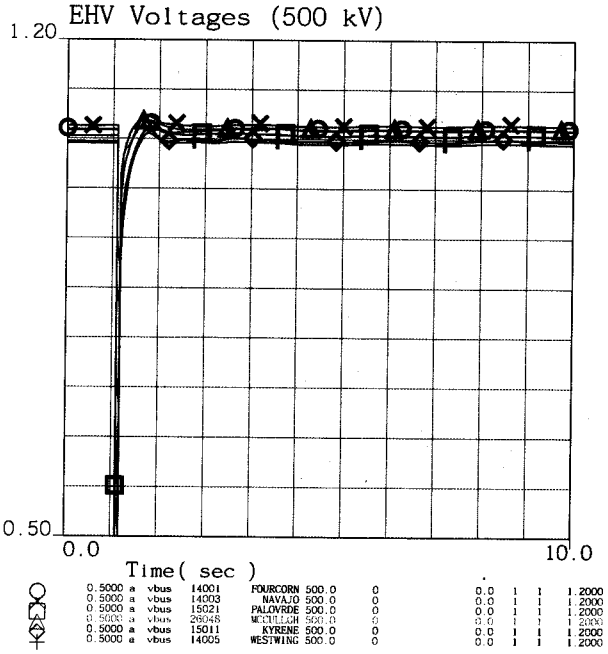

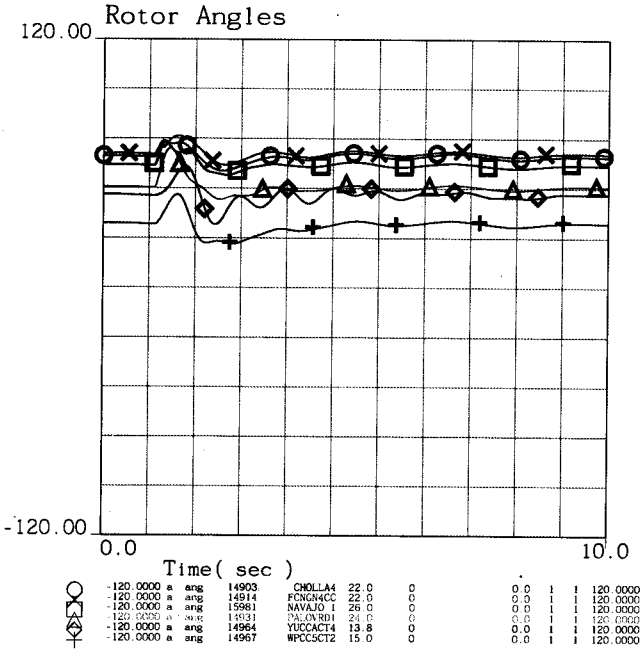

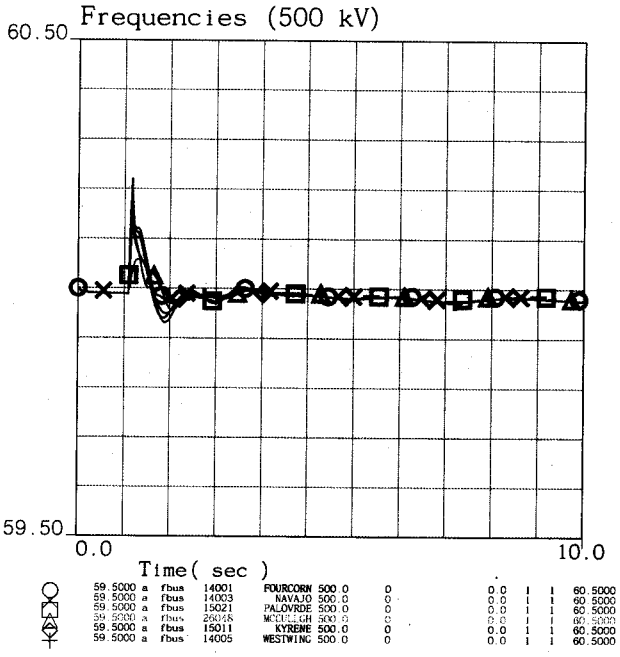

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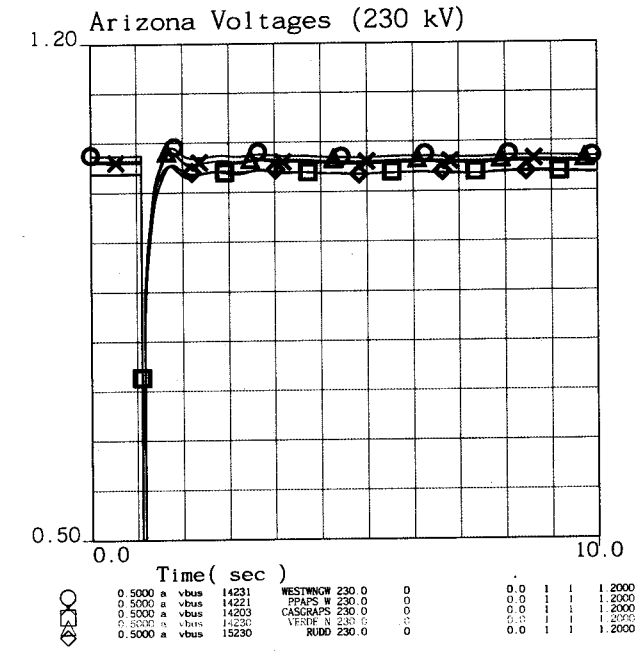

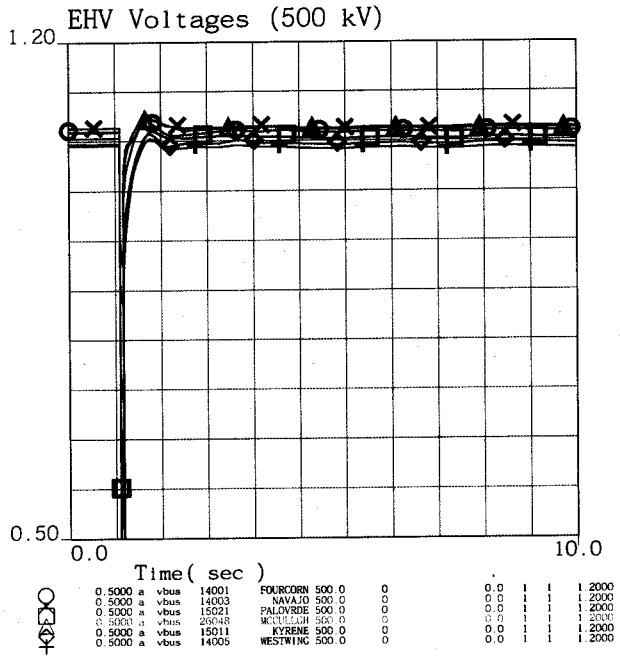

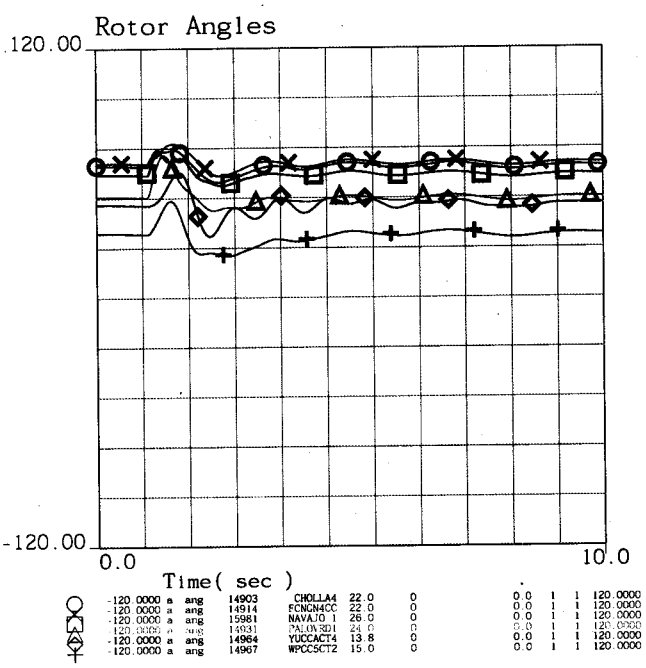

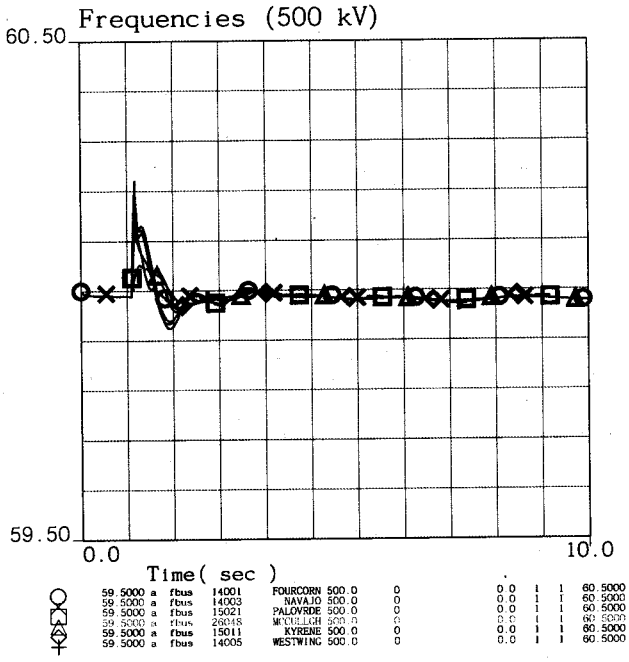

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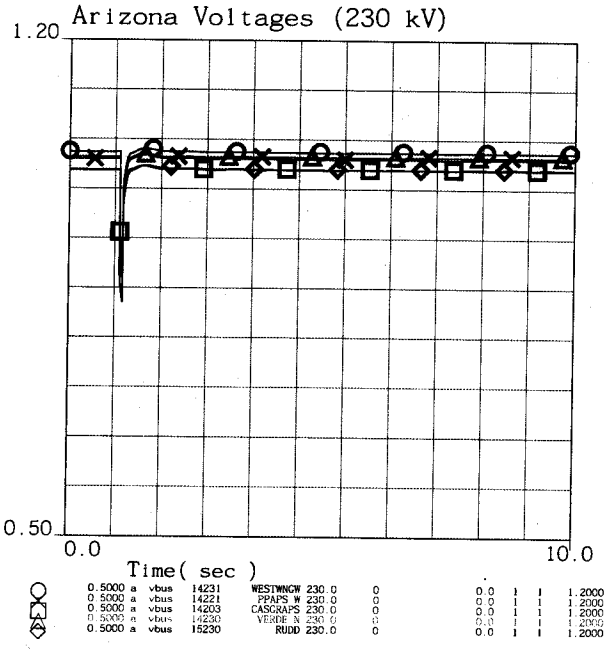

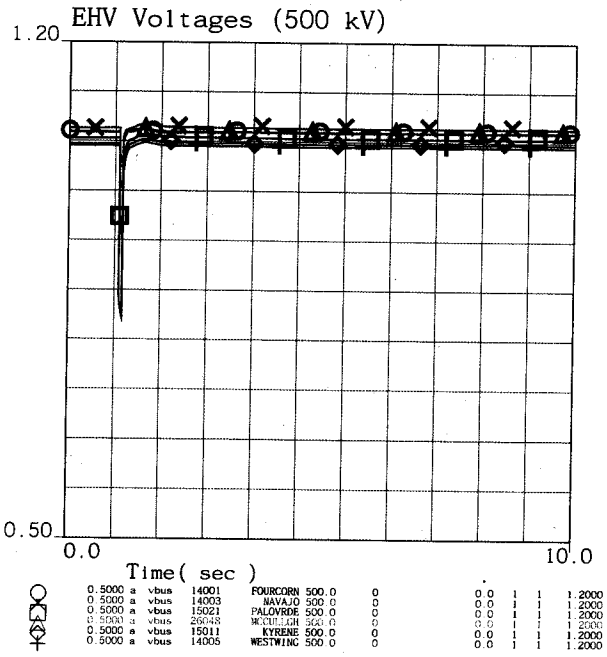

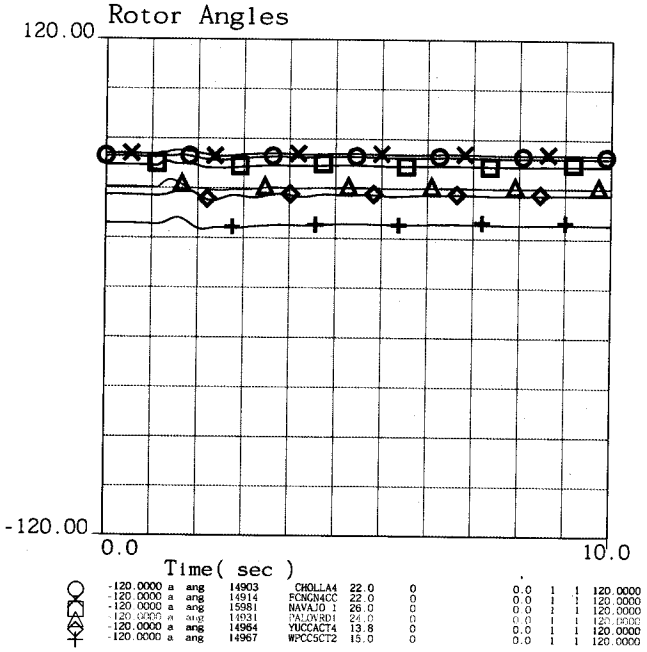

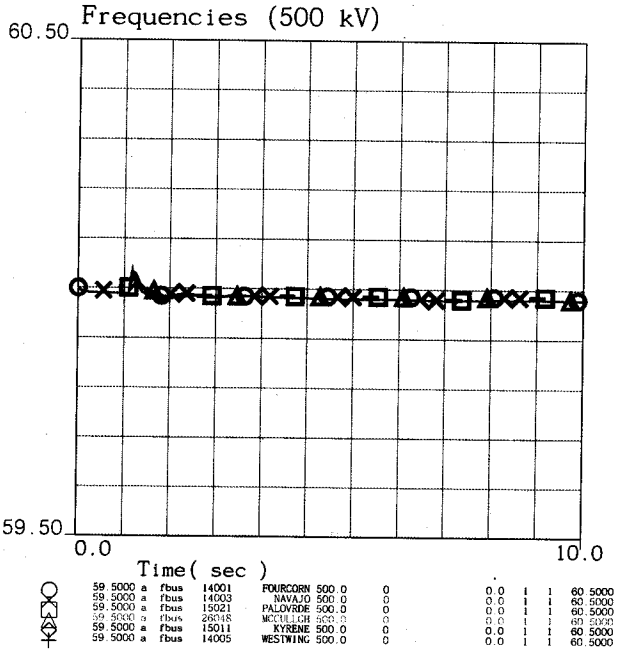

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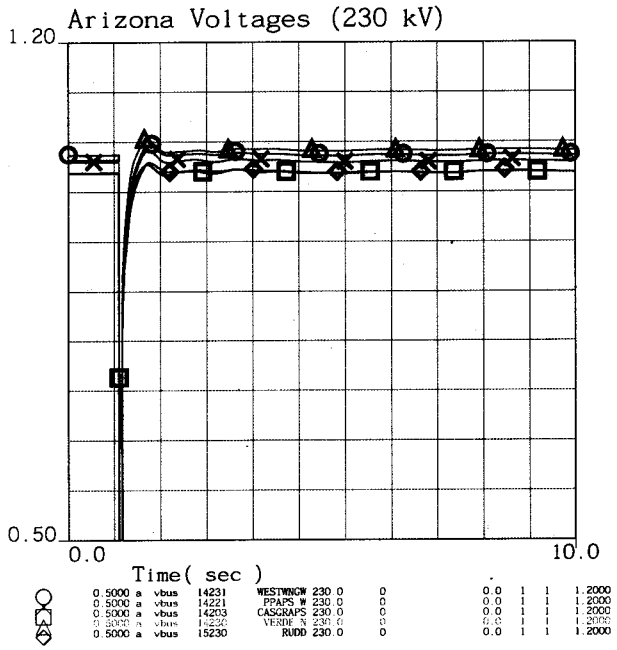

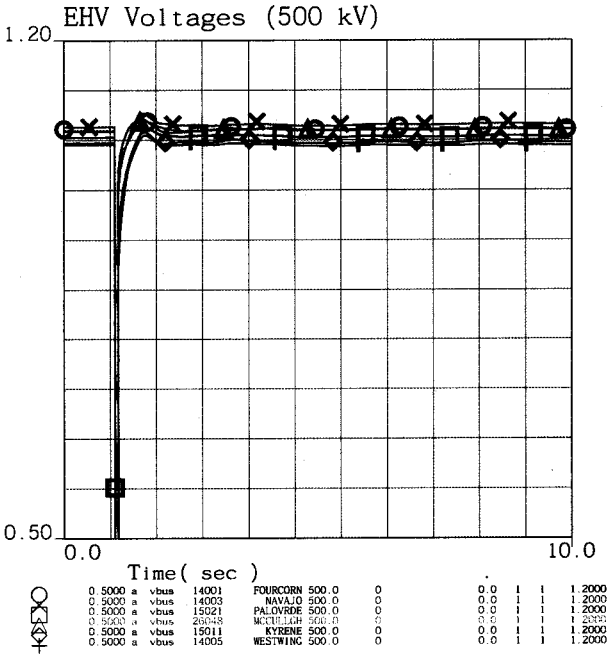

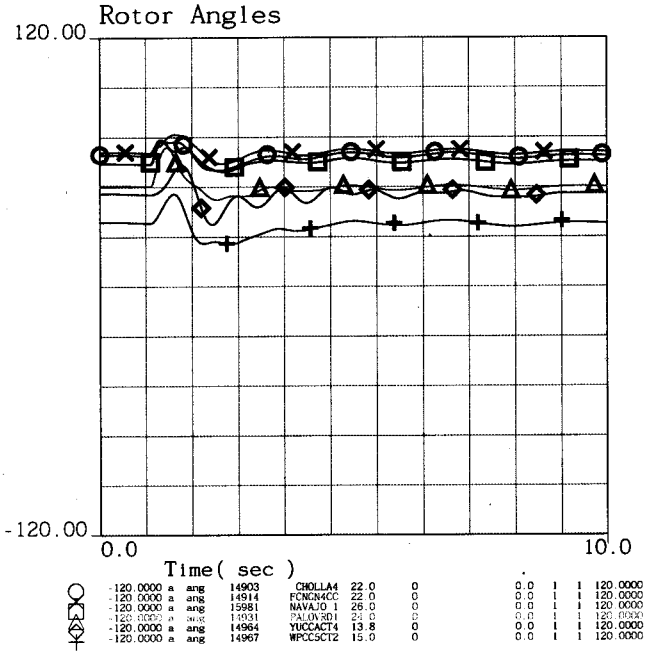

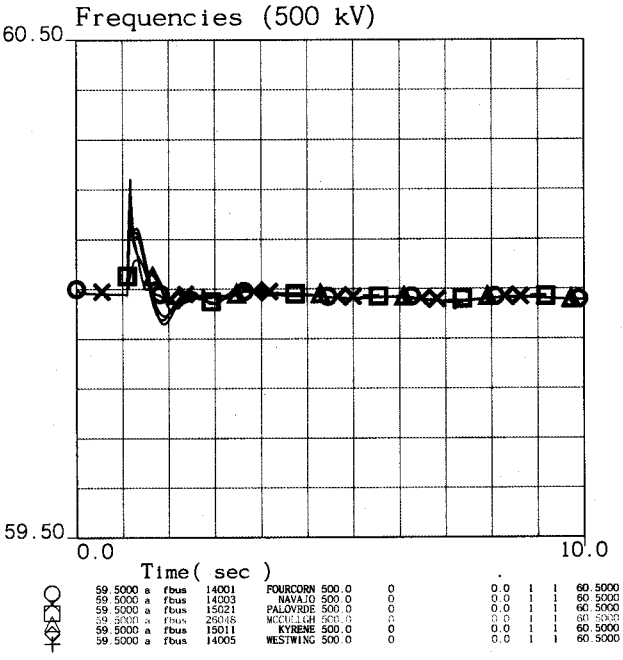

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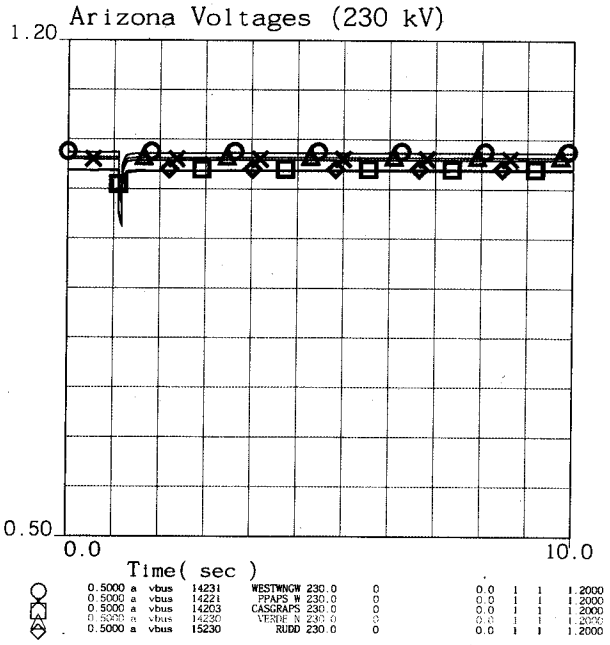

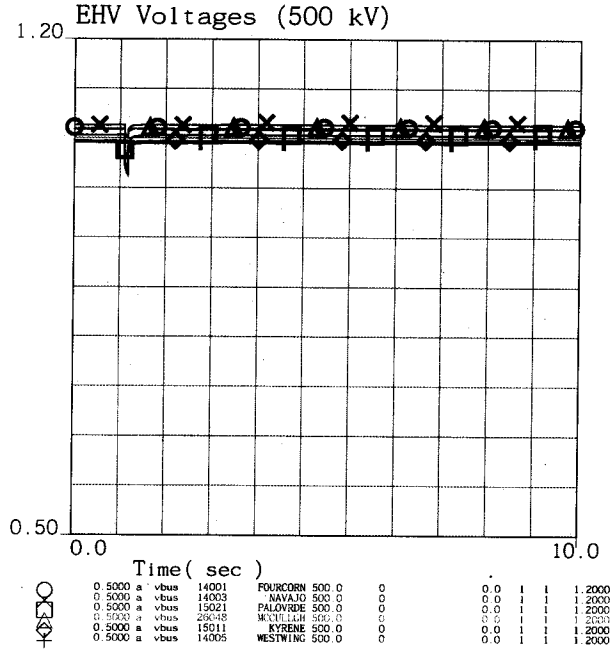

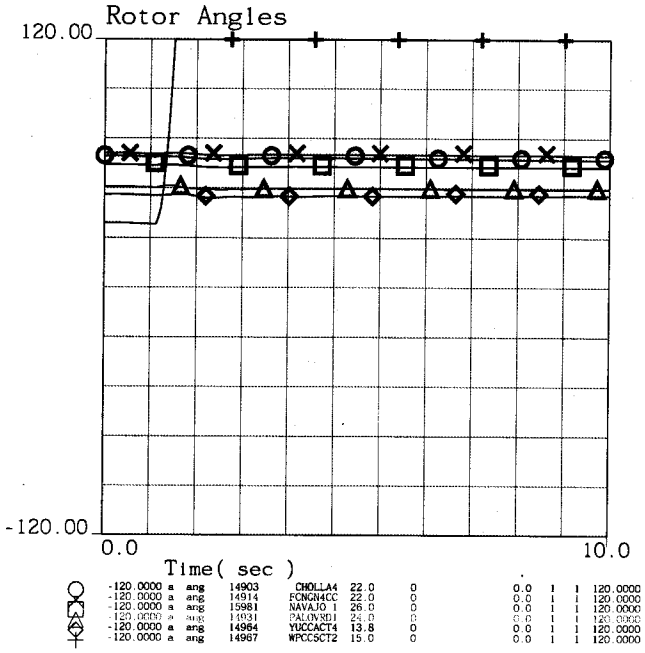

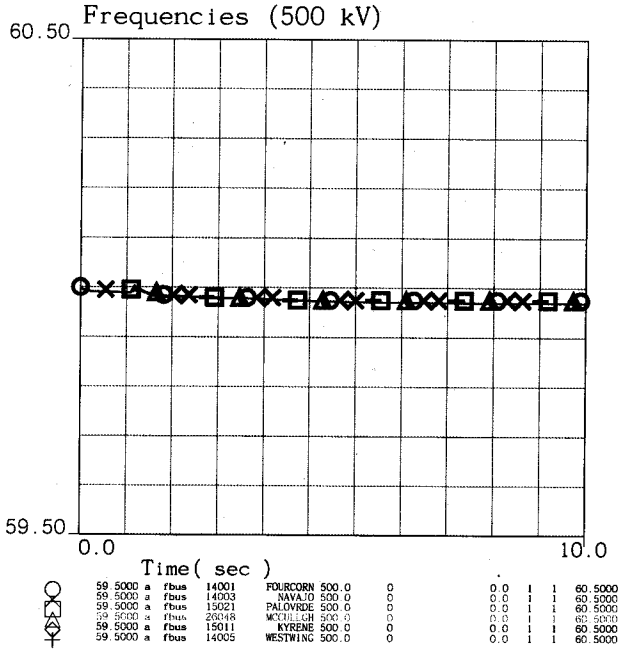

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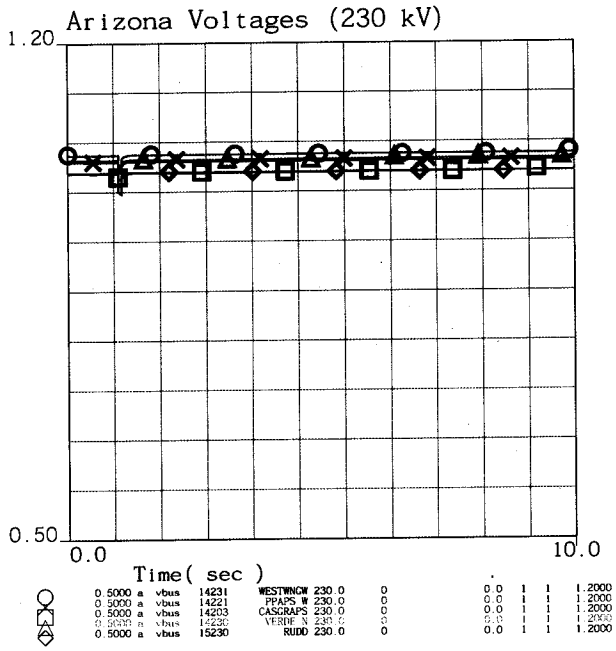

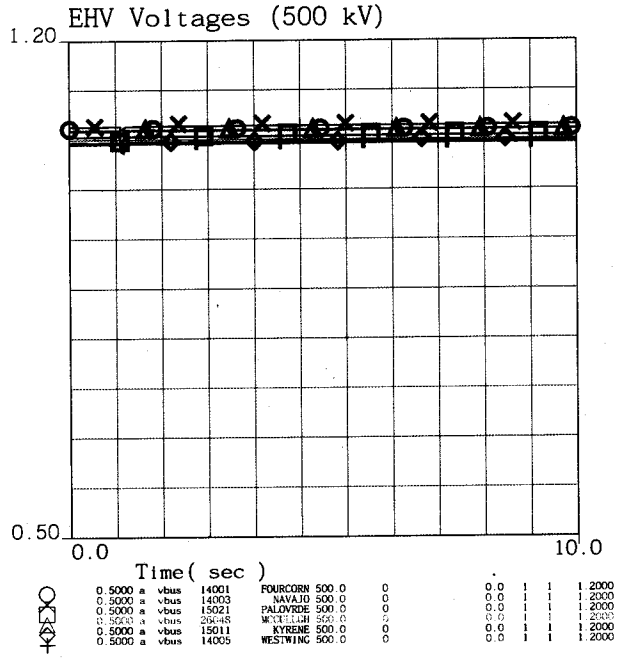

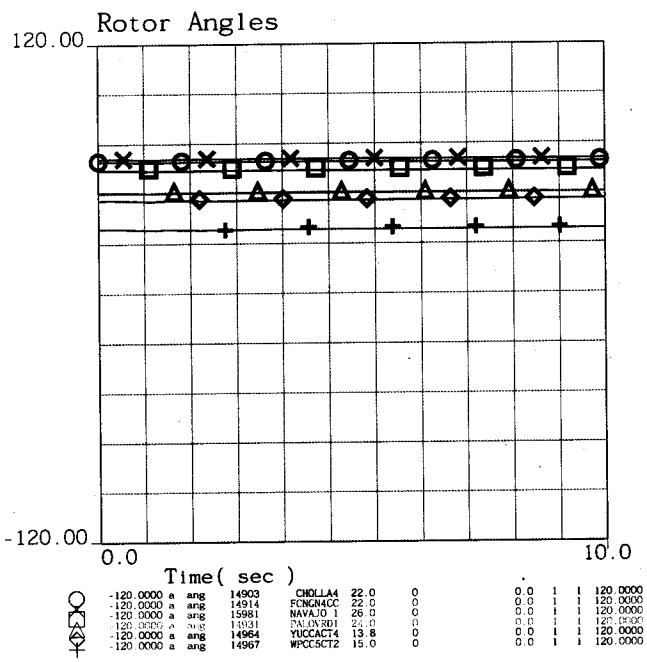

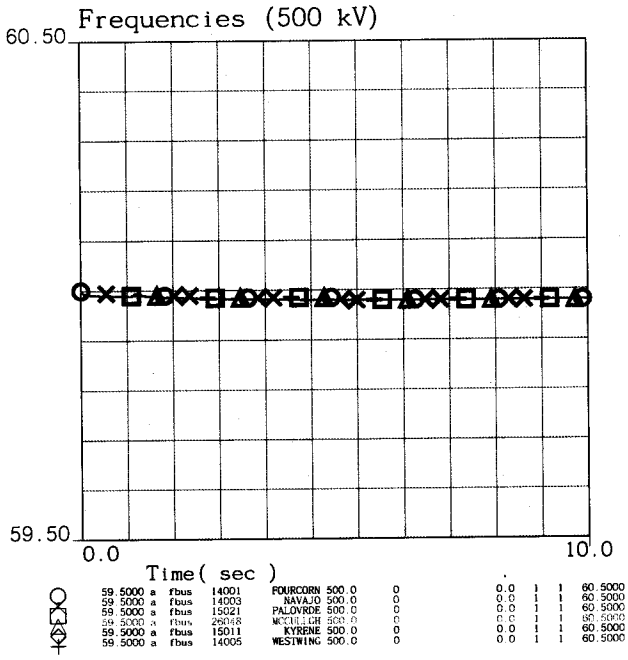

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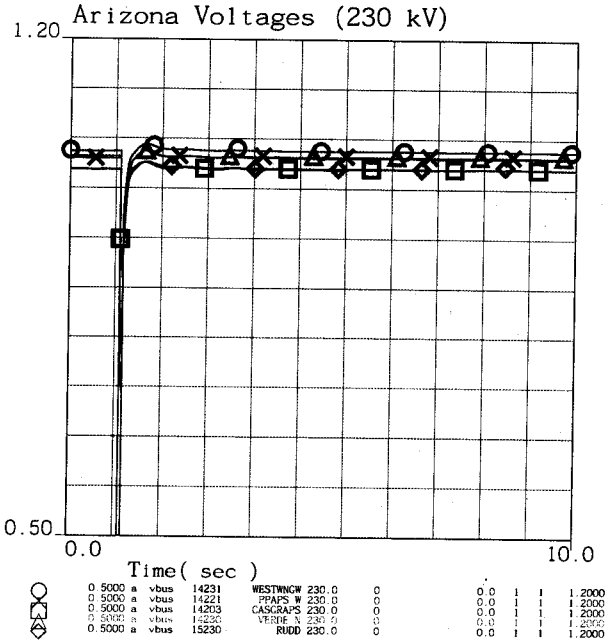

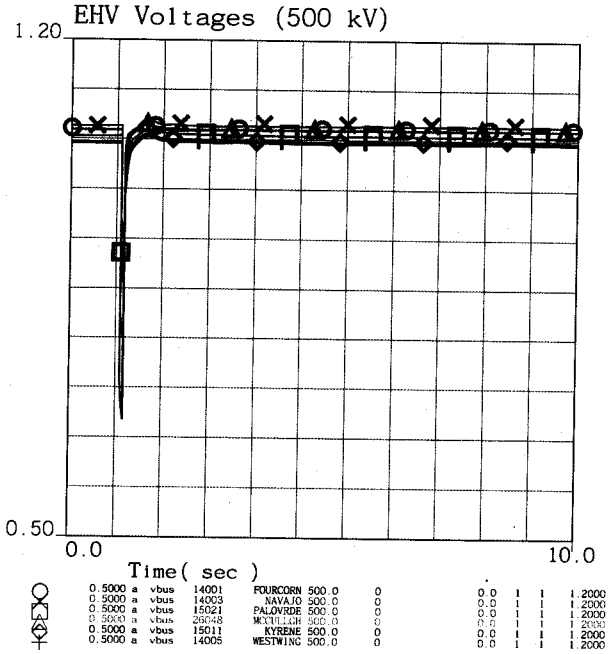

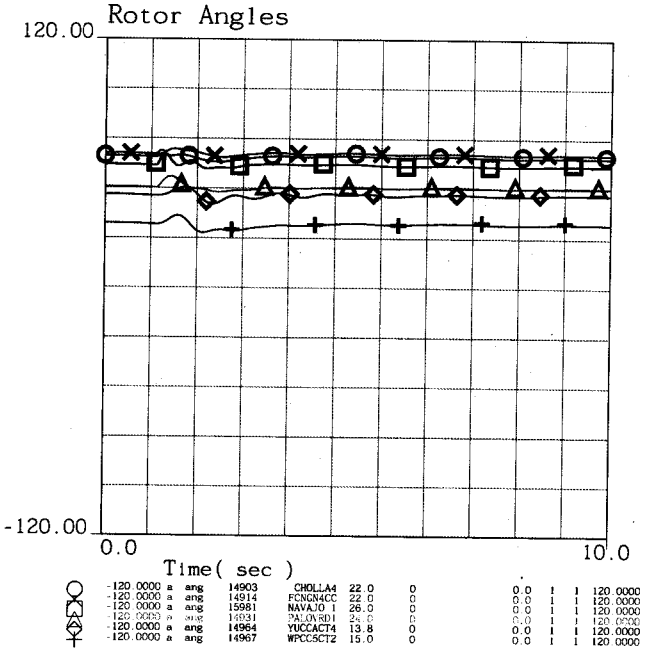

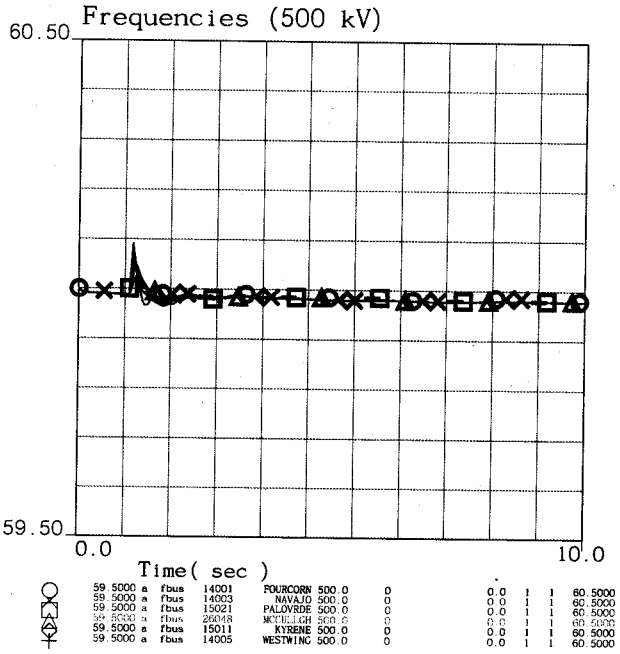

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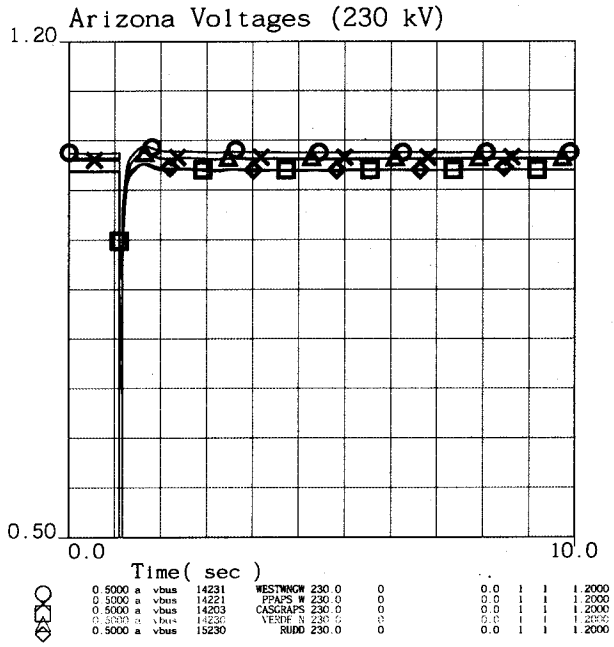

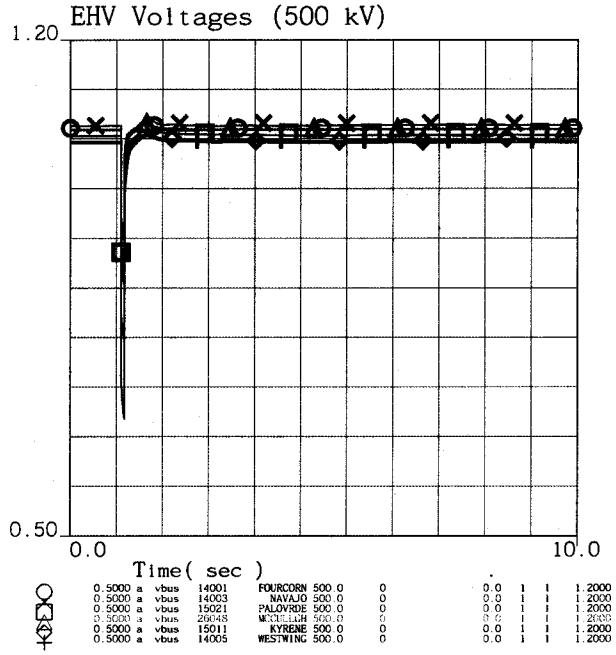

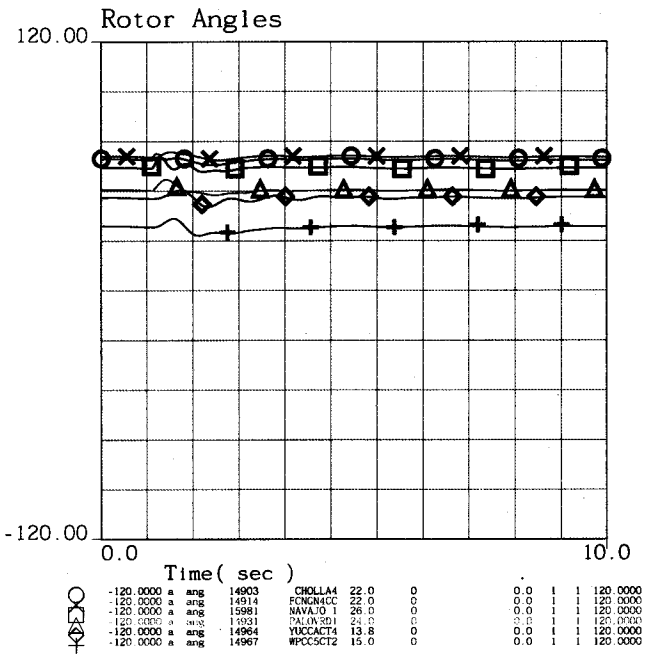

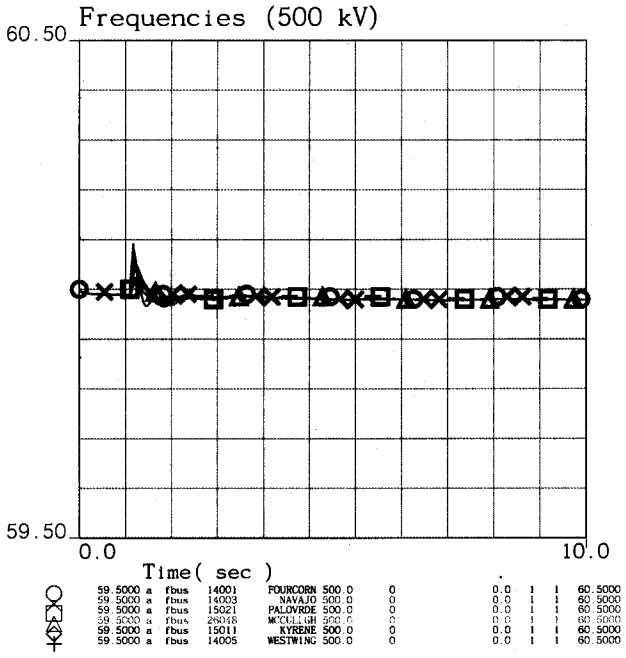

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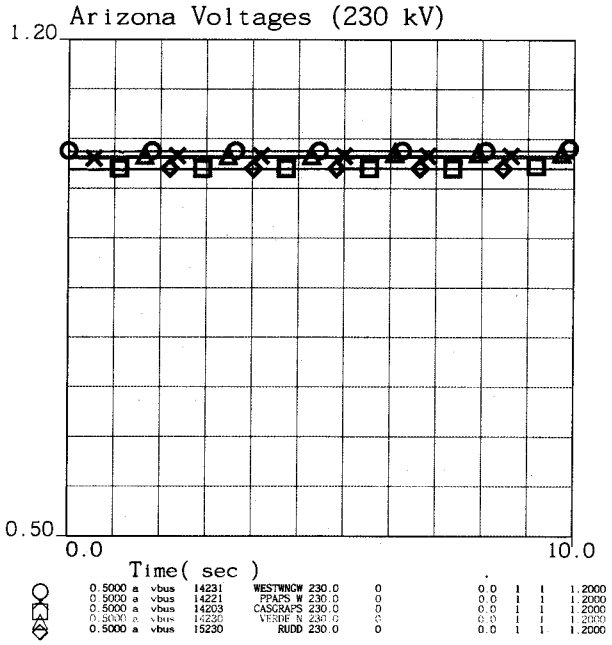
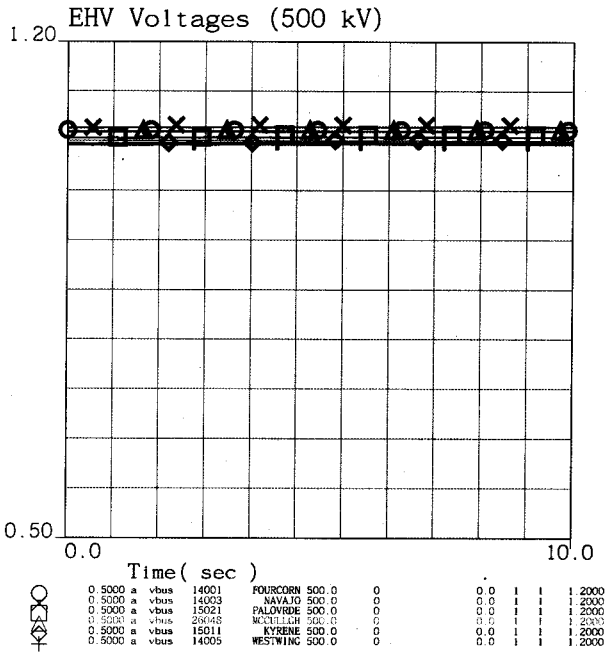
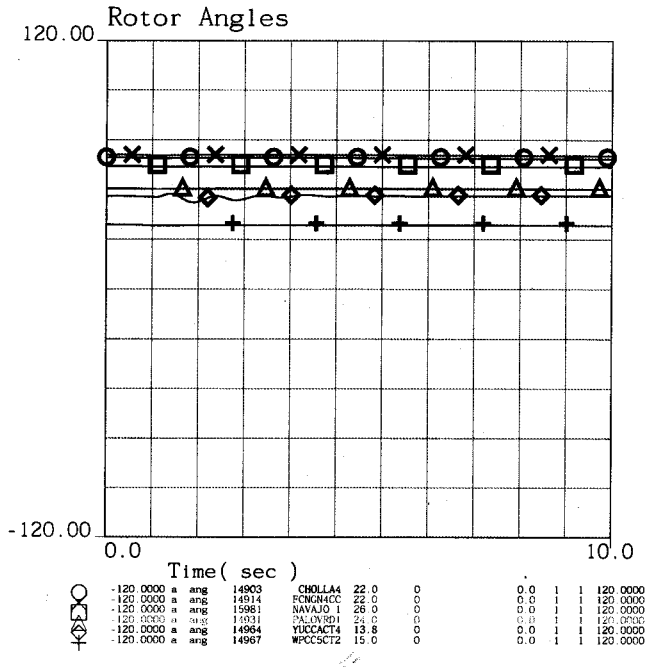
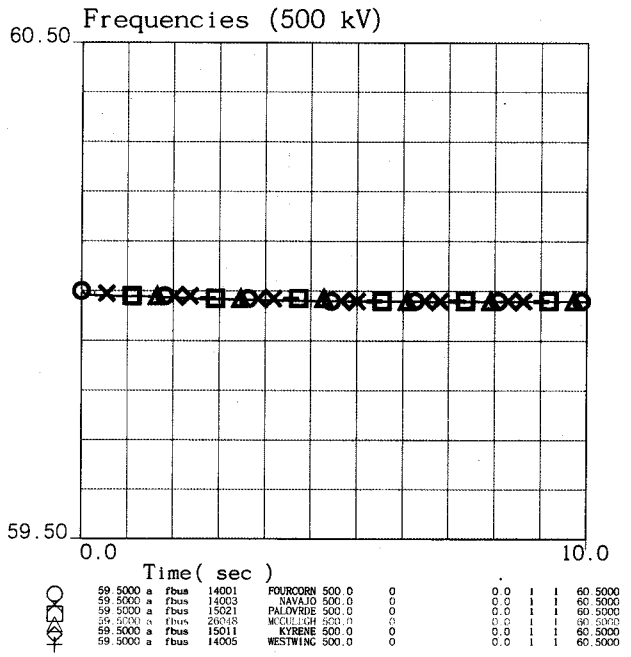
2018 Heavy Summer Detailed Planning Case









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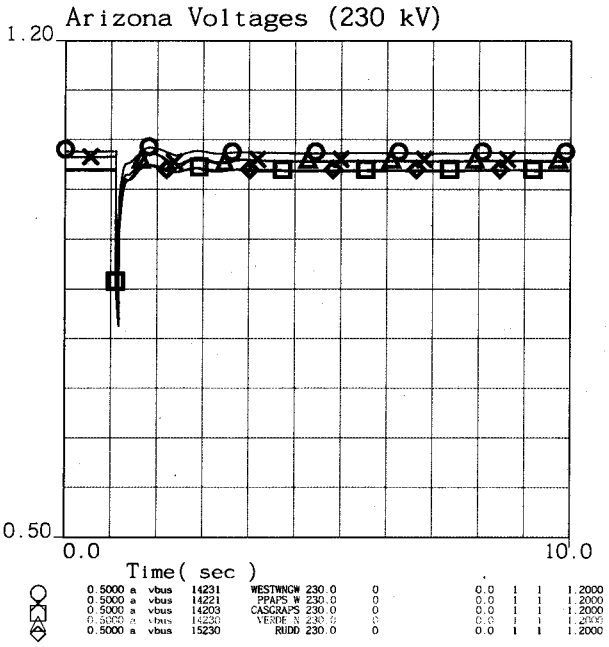
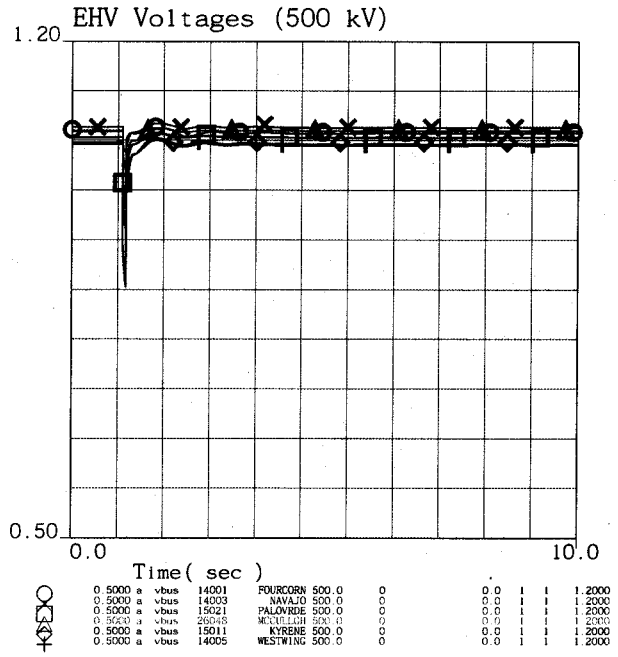
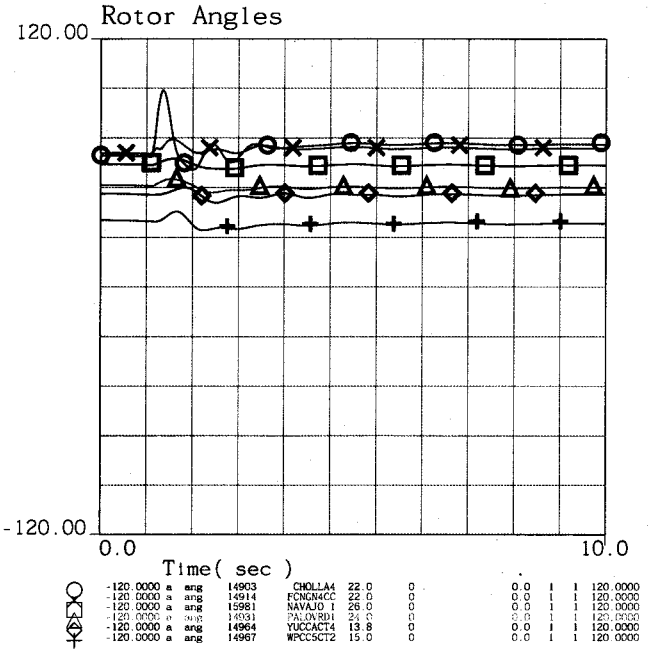
2018 HS – Ocotillo 330 MW Dispatch

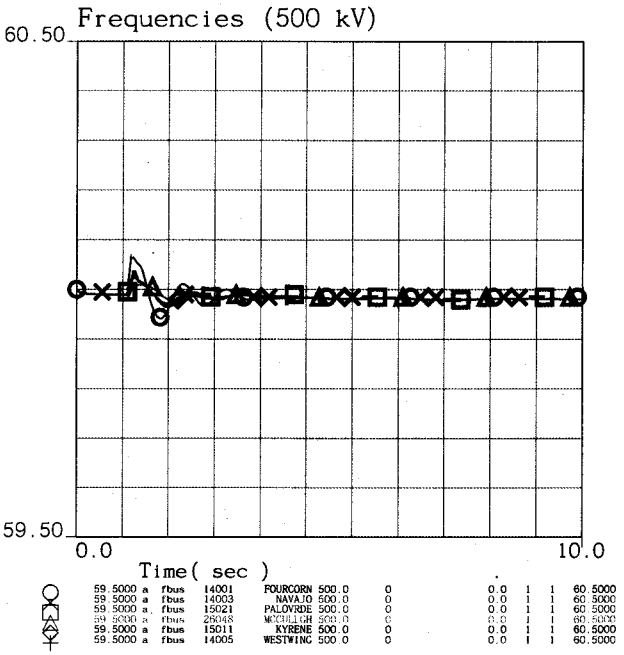
Multiple Element Contingencies

2018 Heavy Summer Detailed Planning Case









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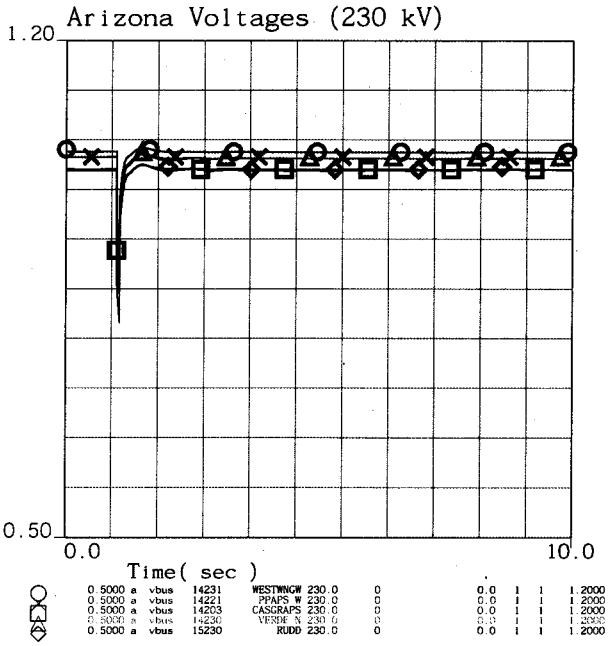
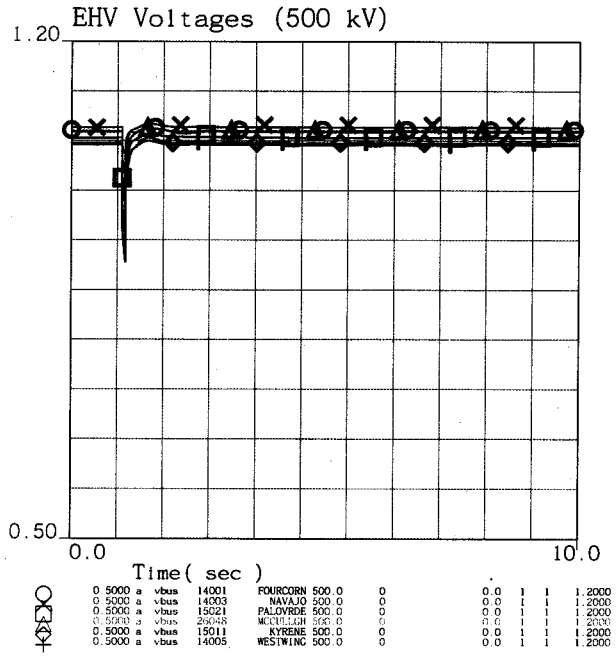
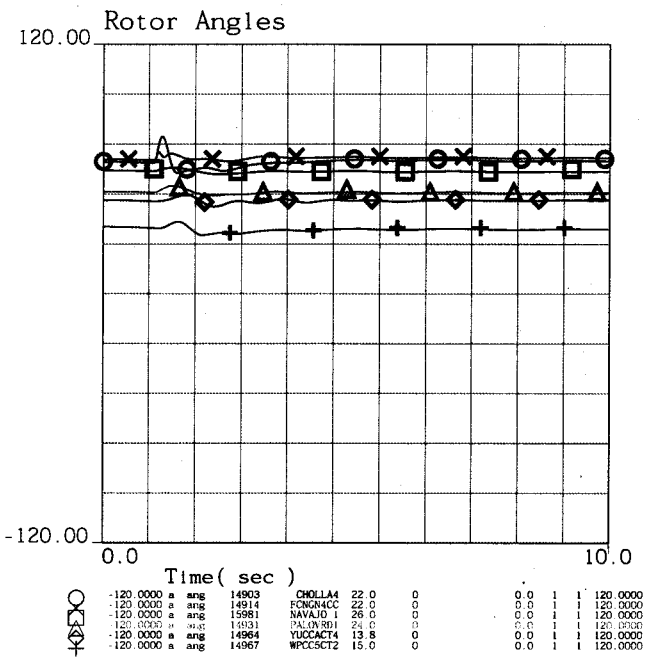
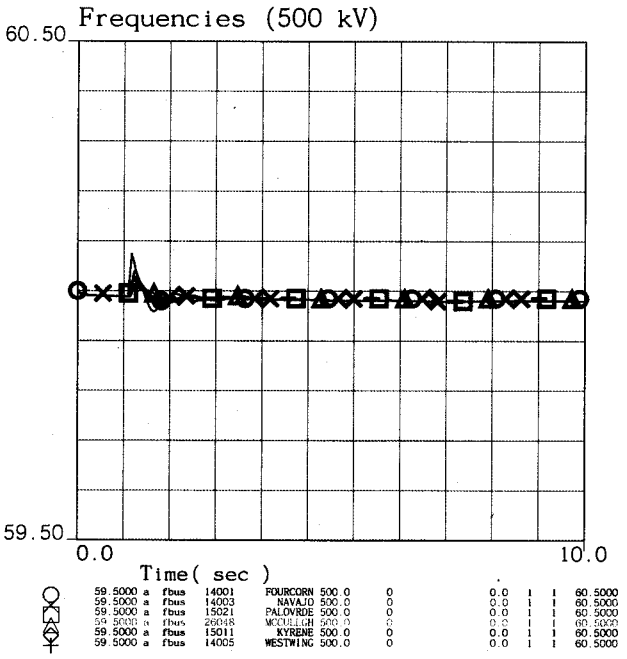
2018 Heavy Summer Detailed Planning Case









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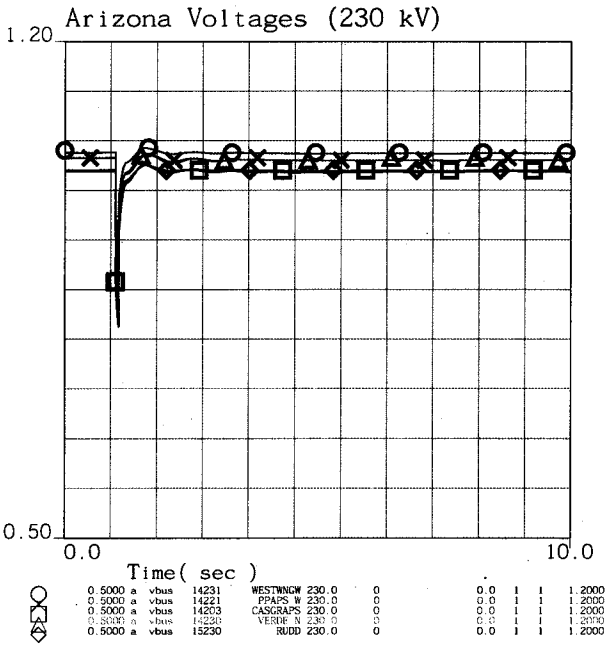

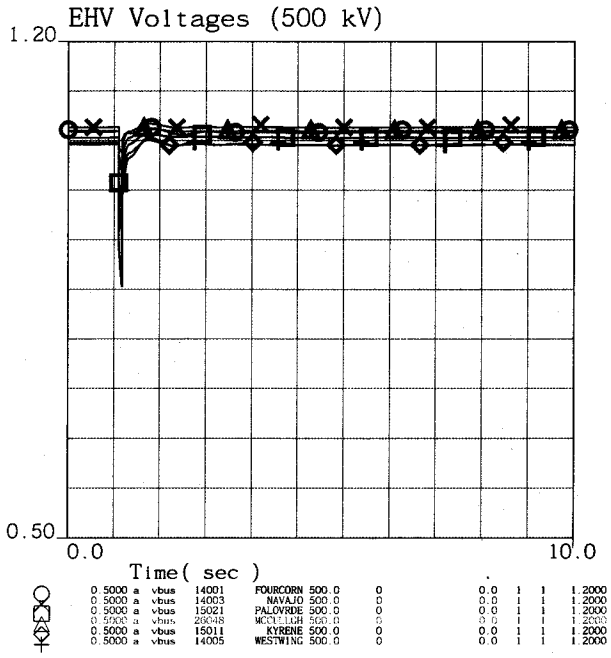

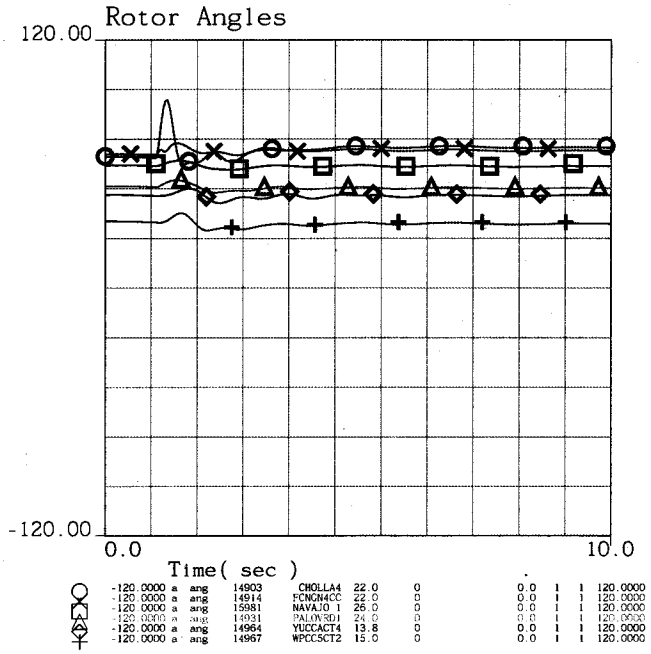

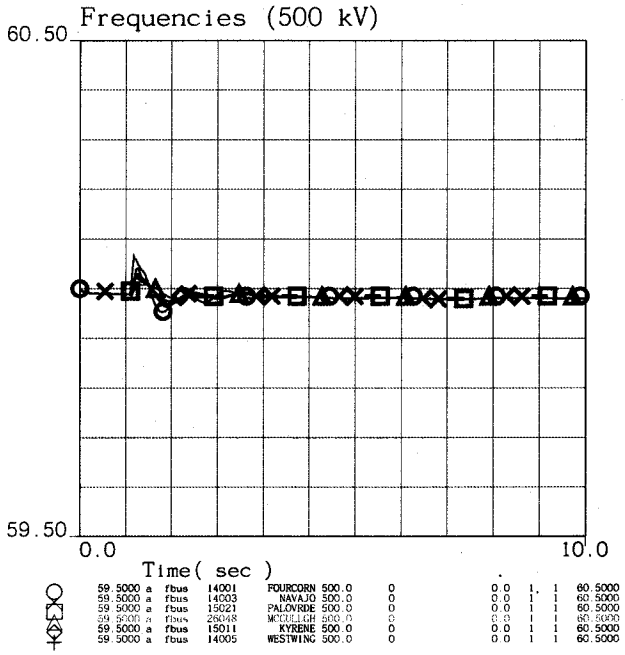

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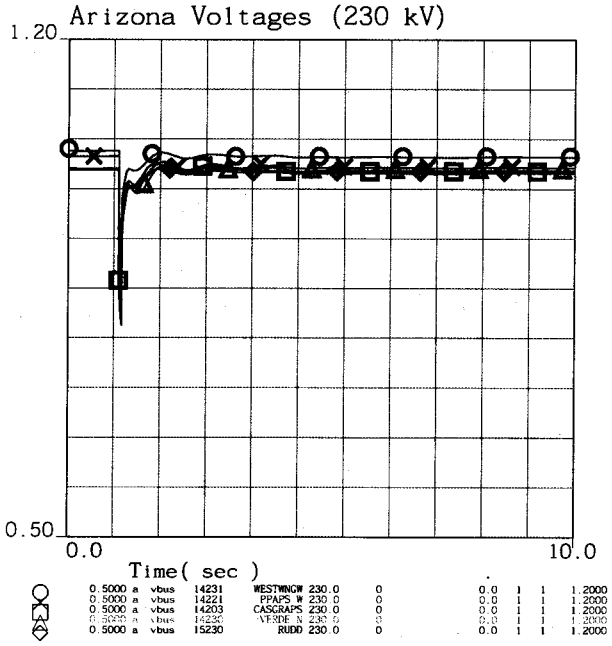
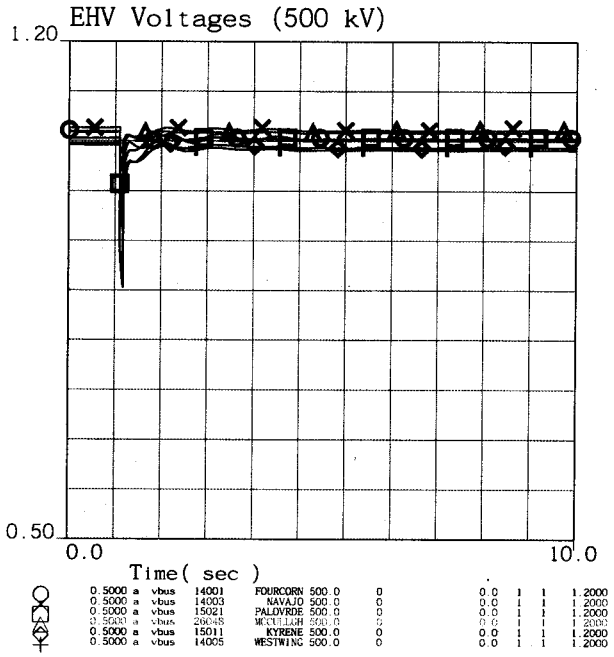
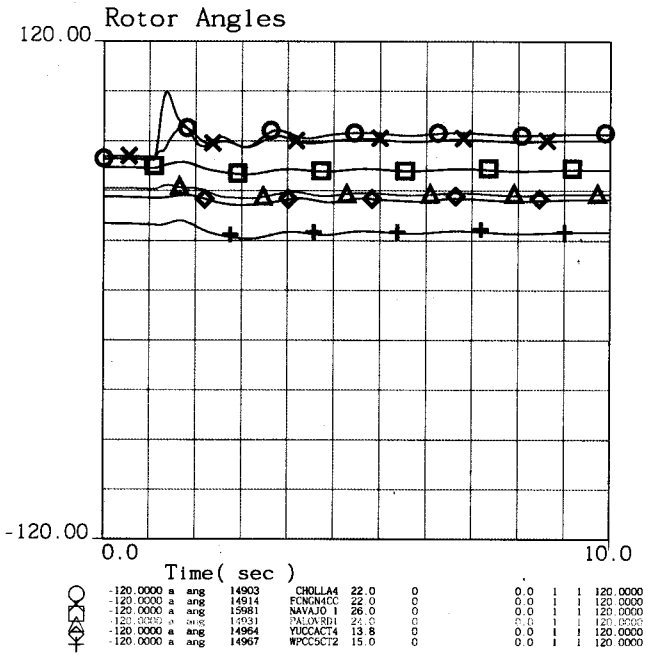
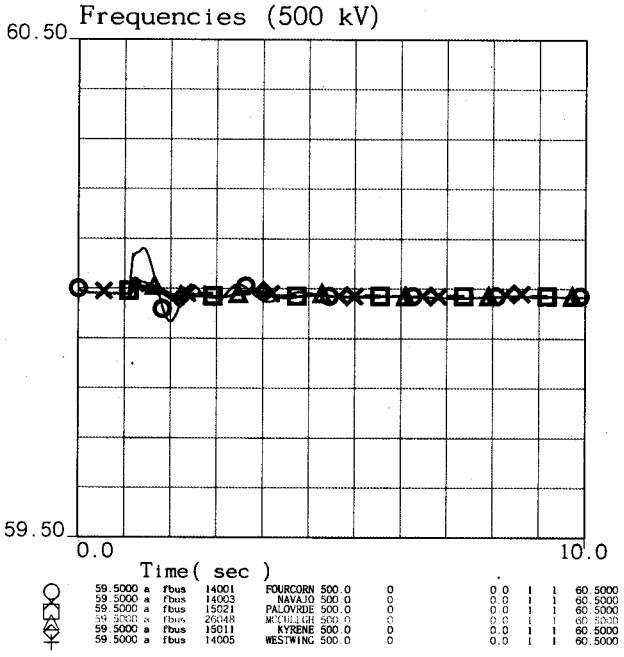
2018 Heavy Summer Detailed Planning Case









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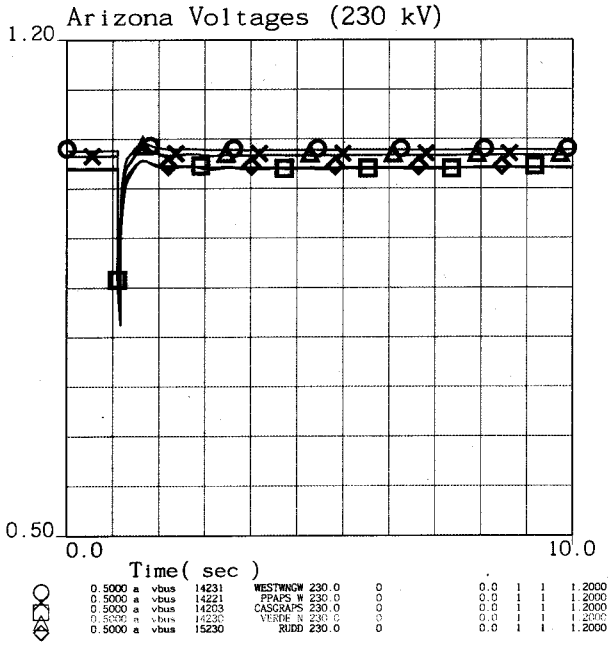

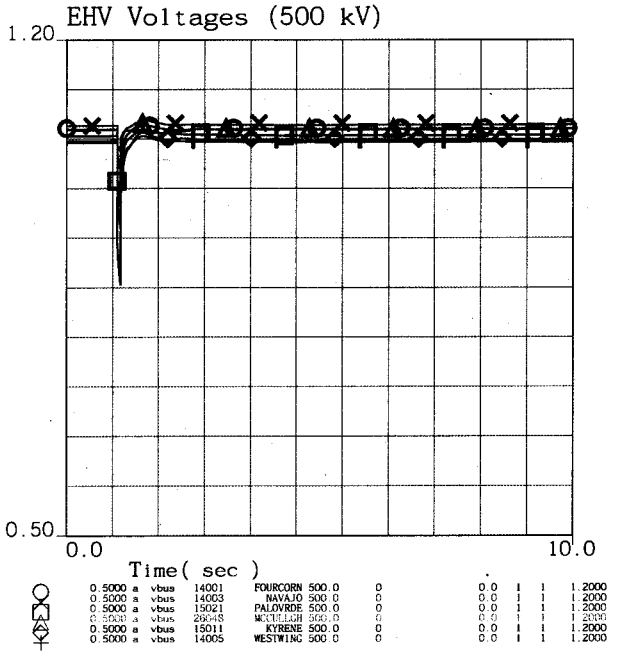

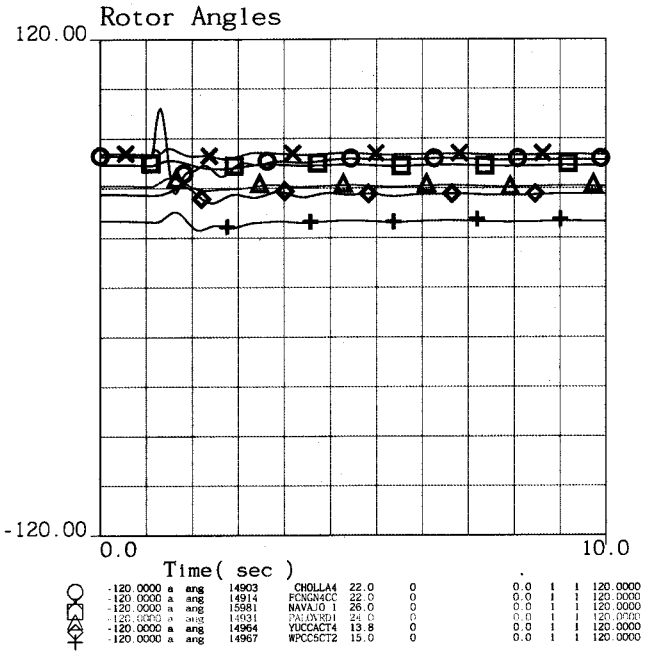

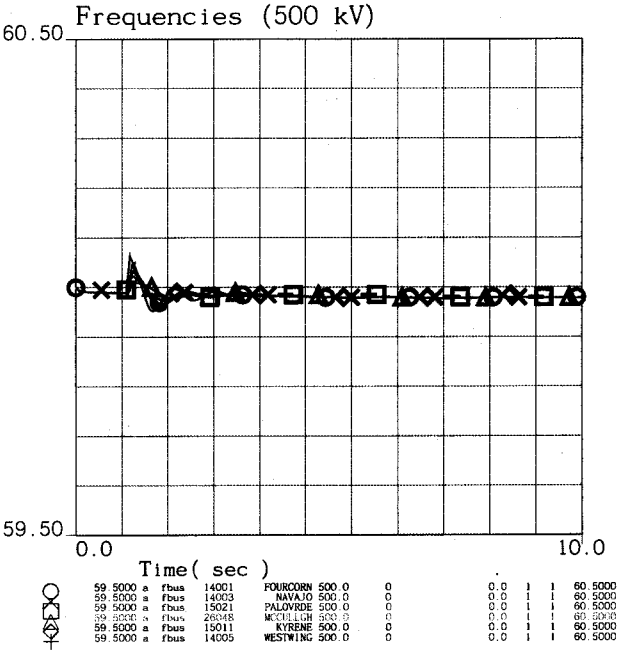

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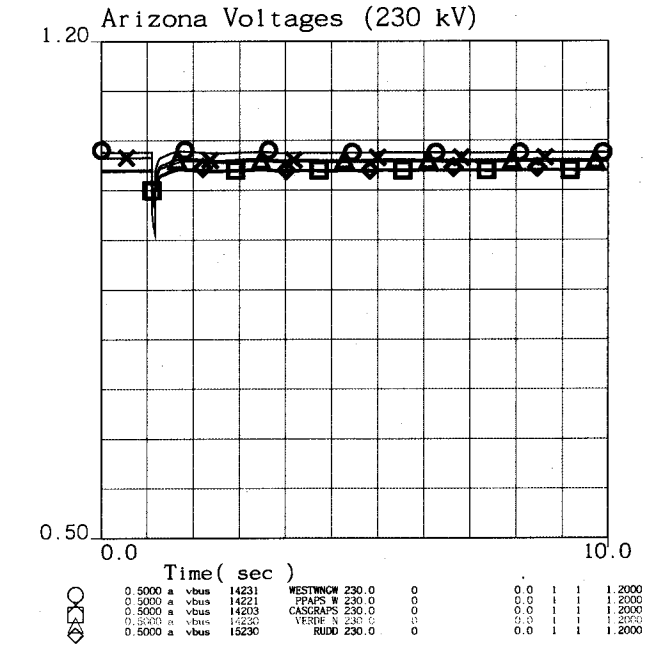

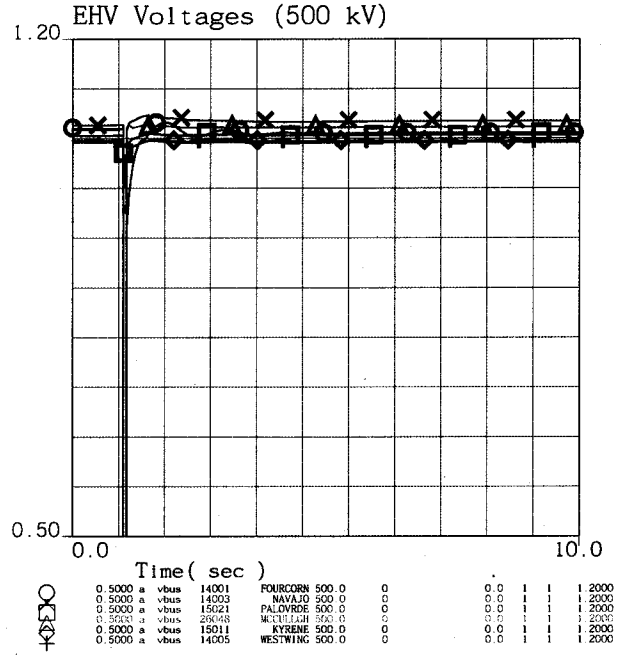

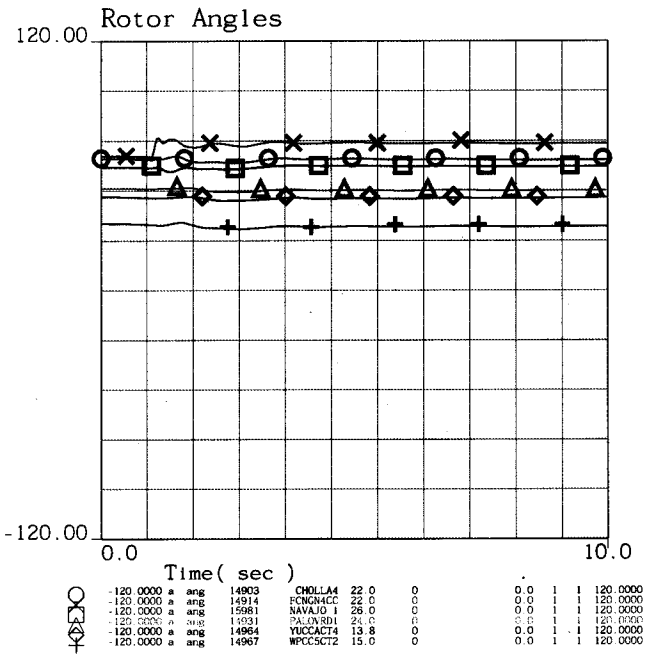

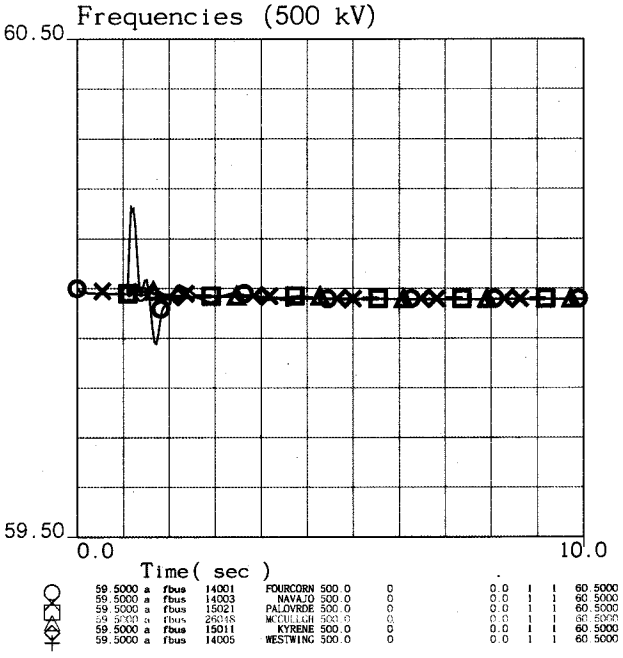

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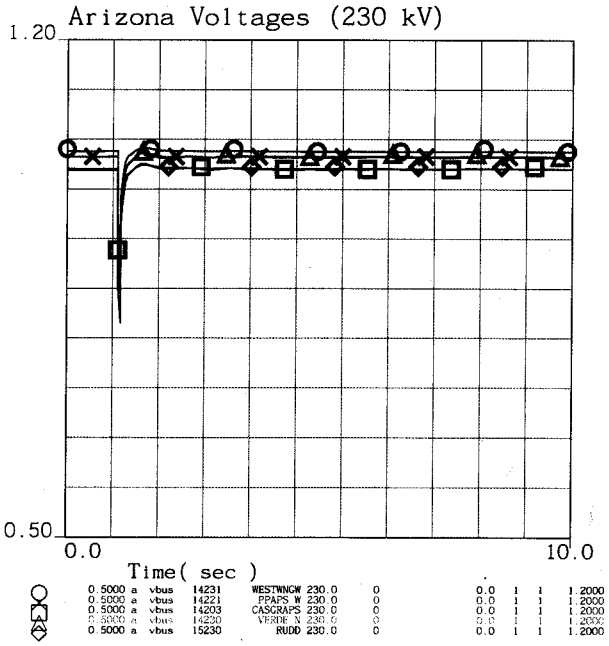

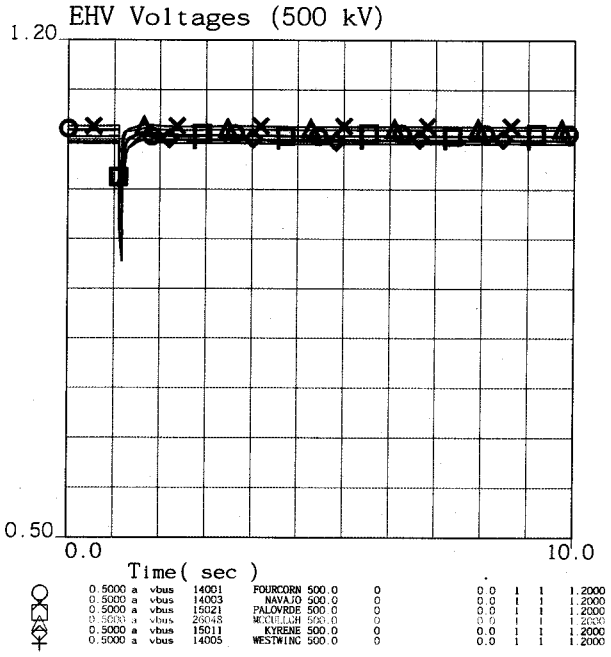

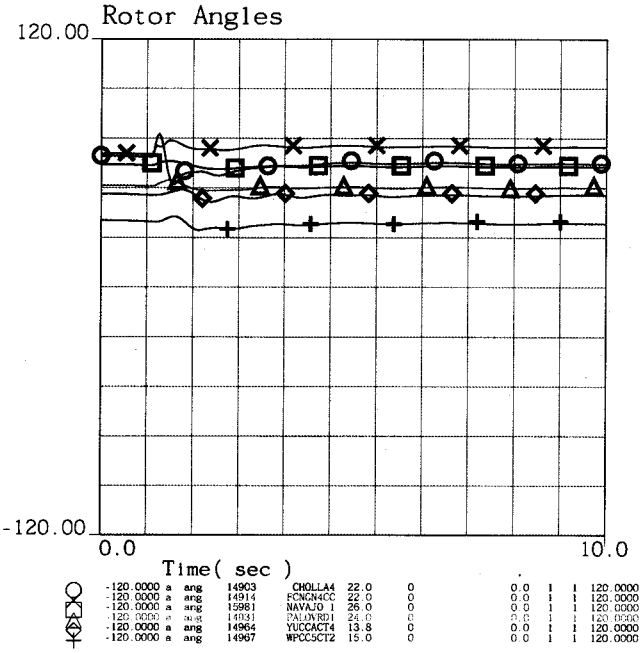

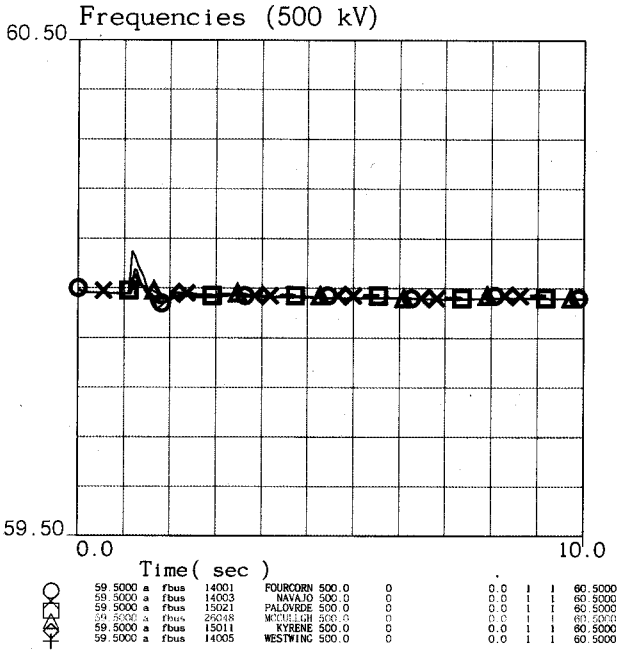

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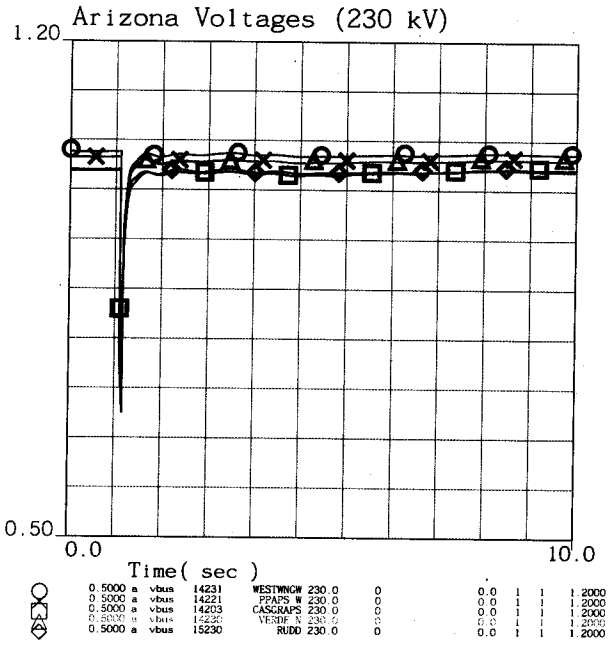

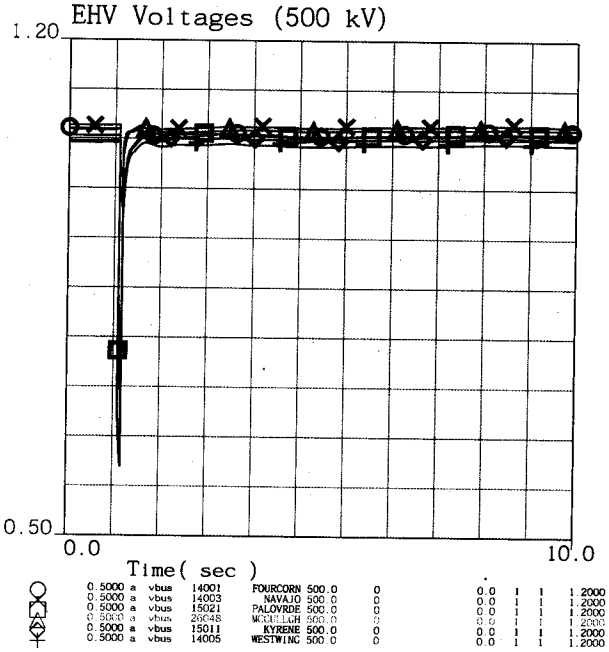

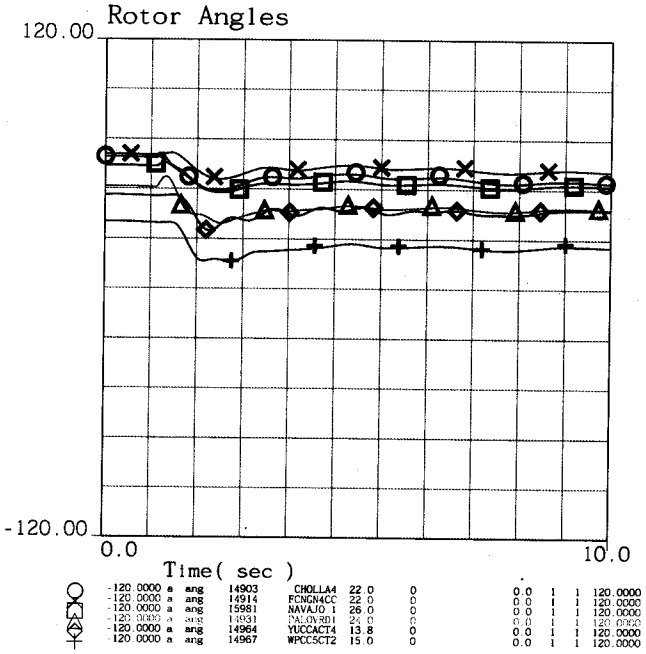

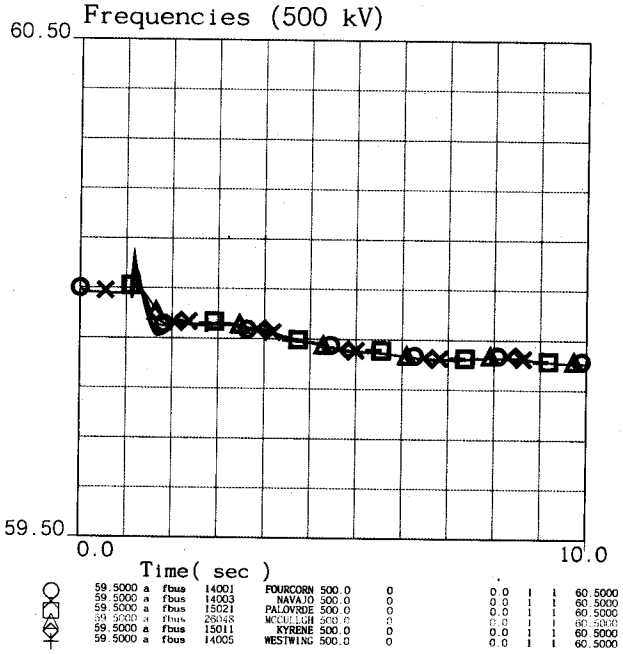

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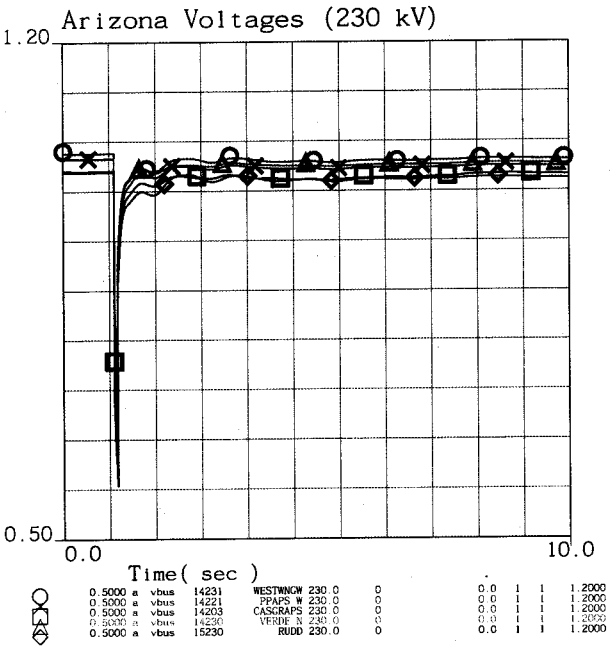

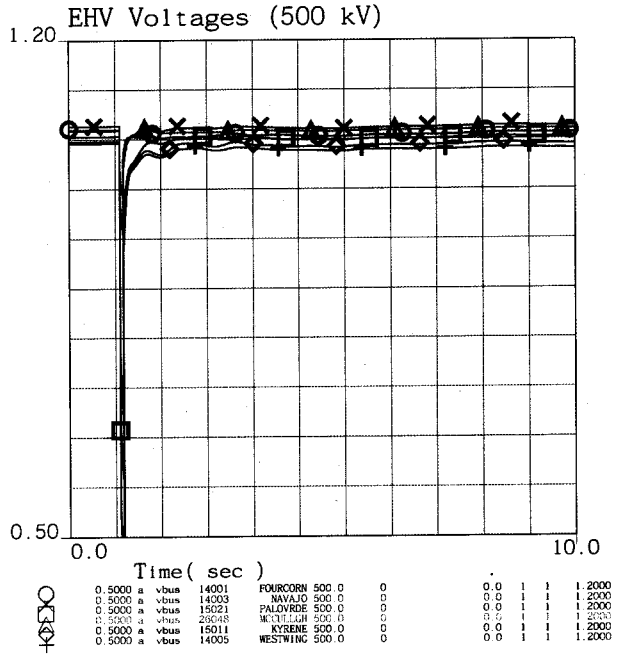

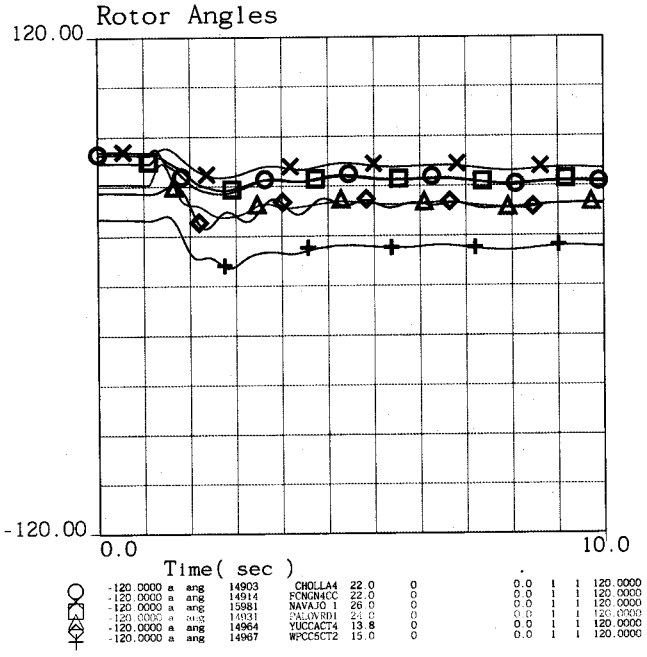

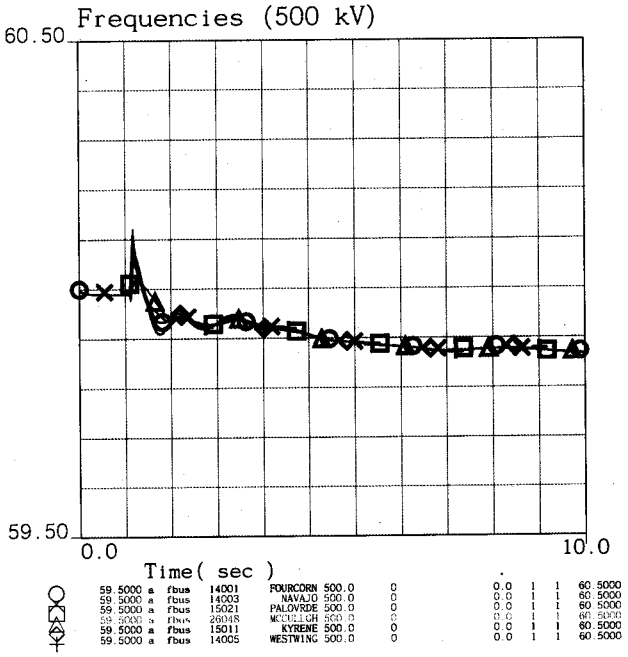

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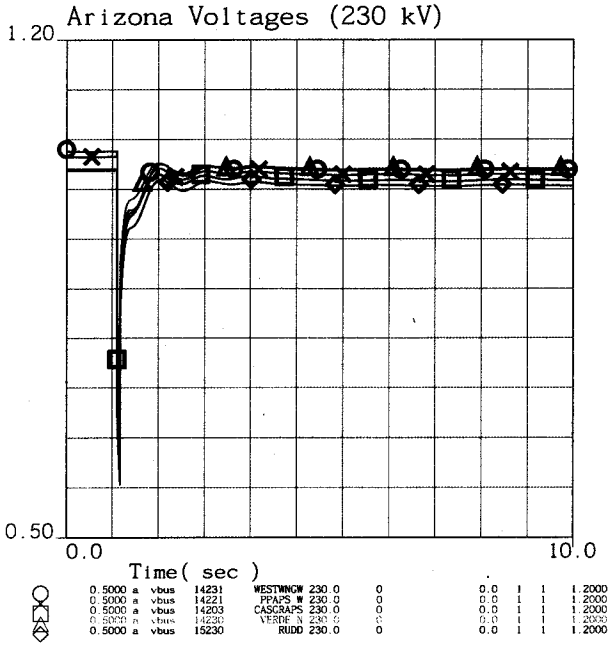

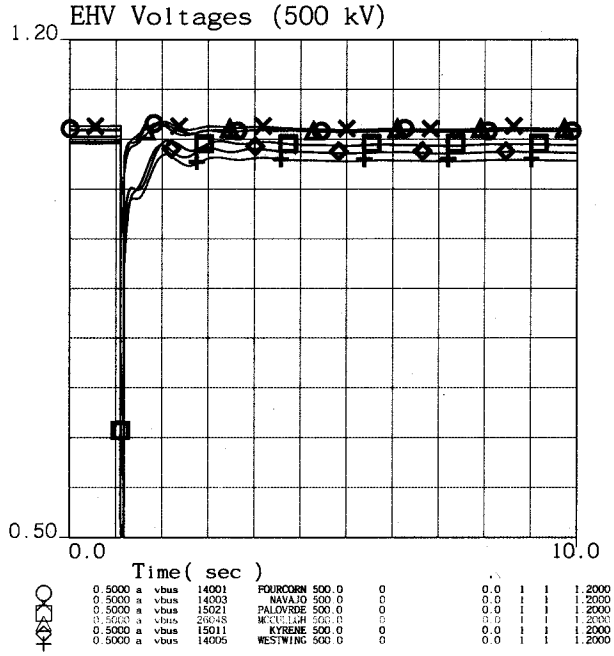

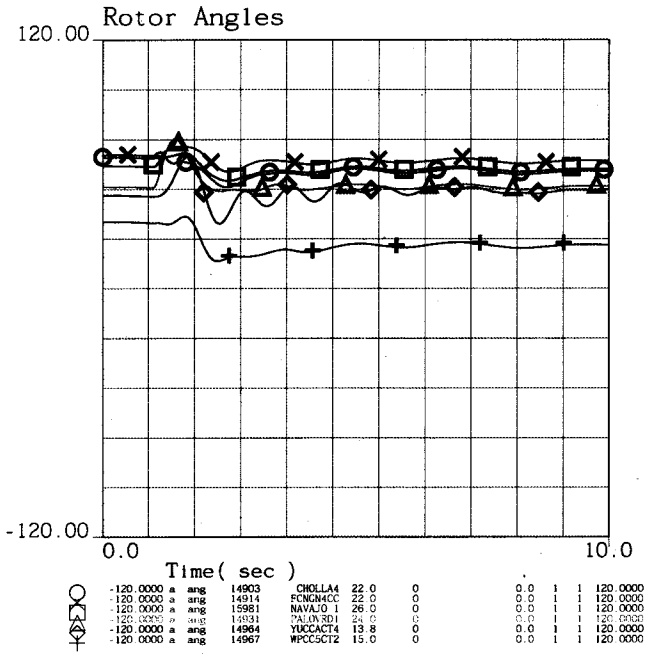

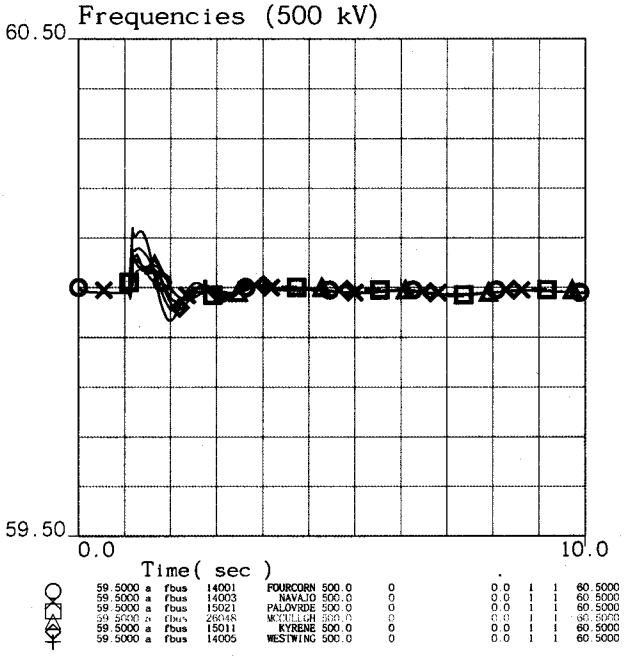

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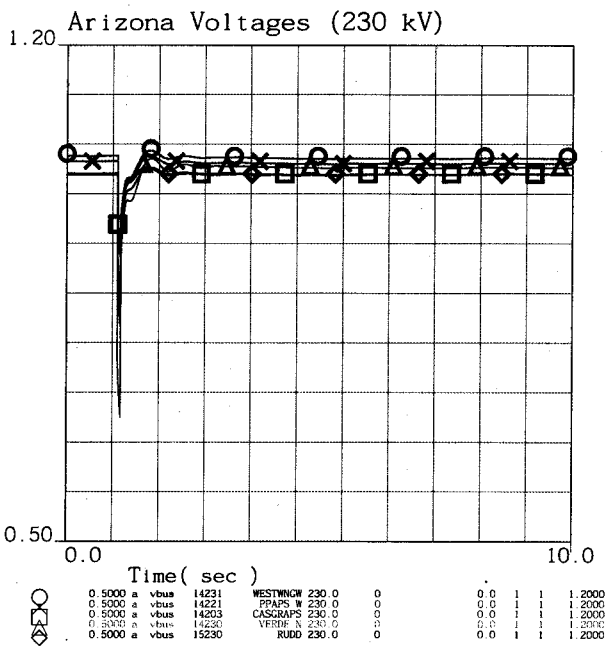

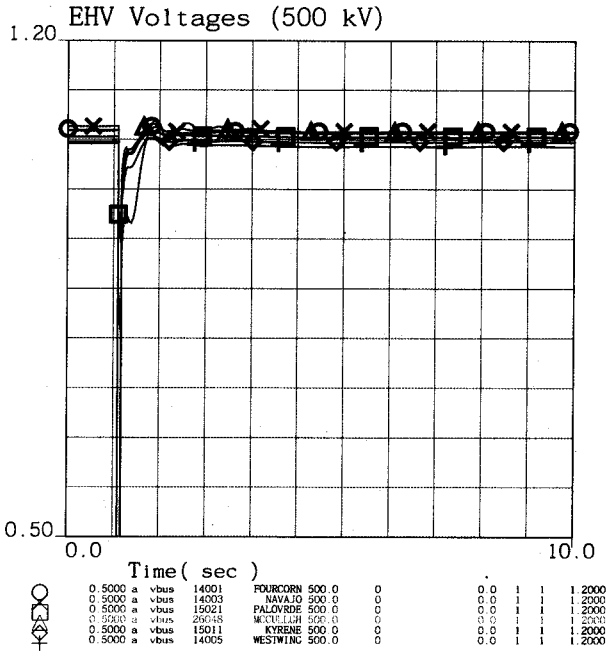

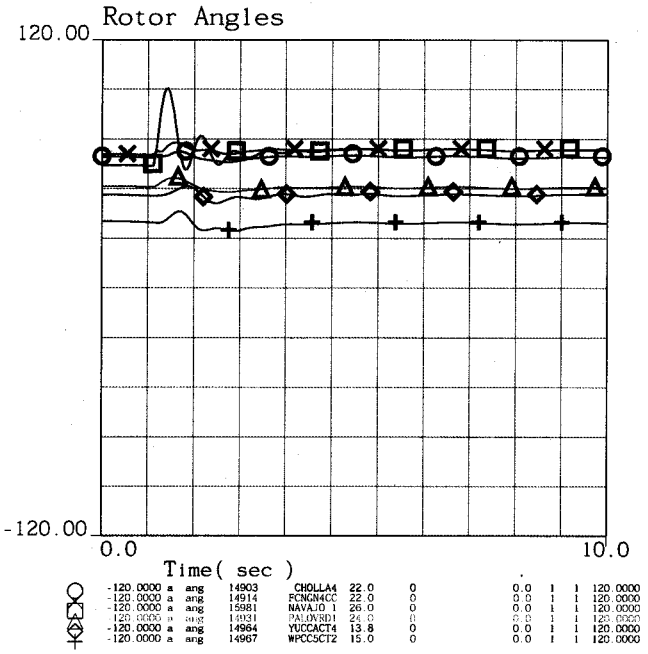

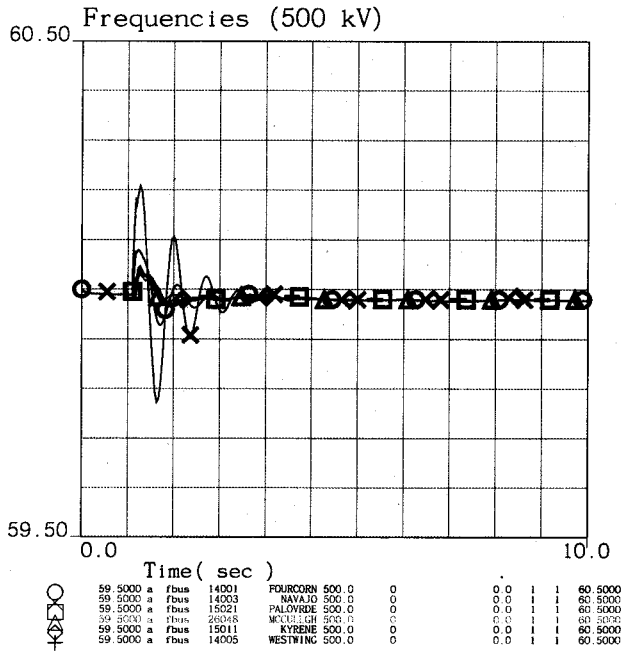

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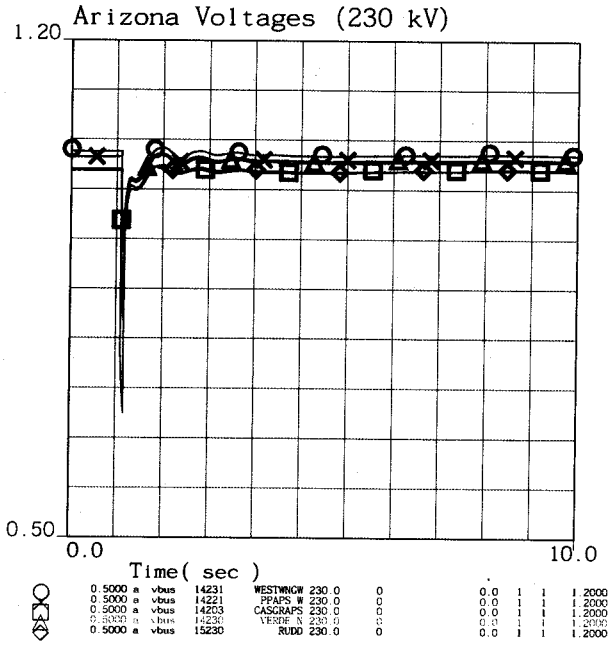

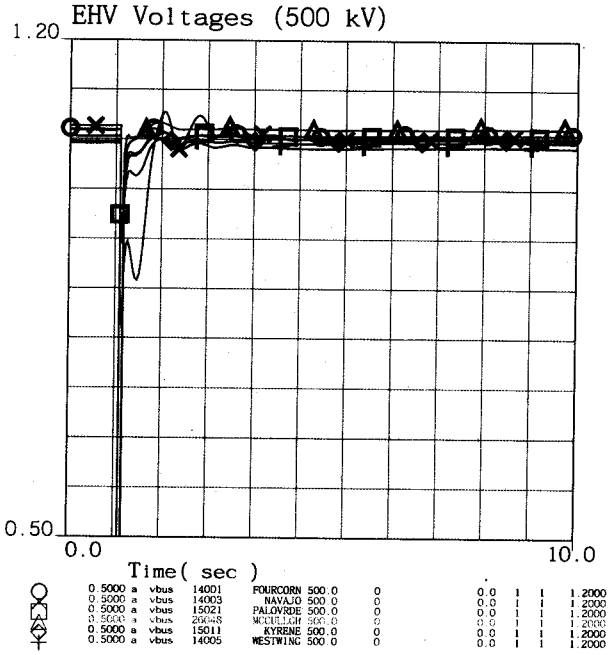

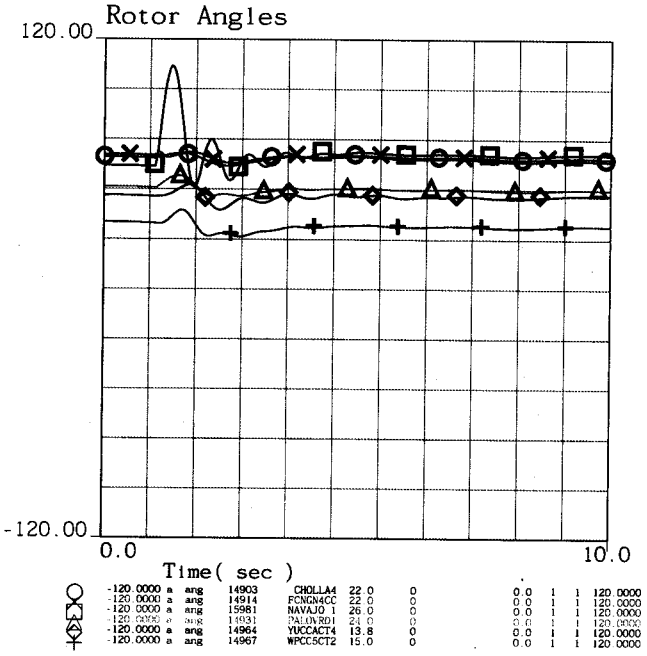

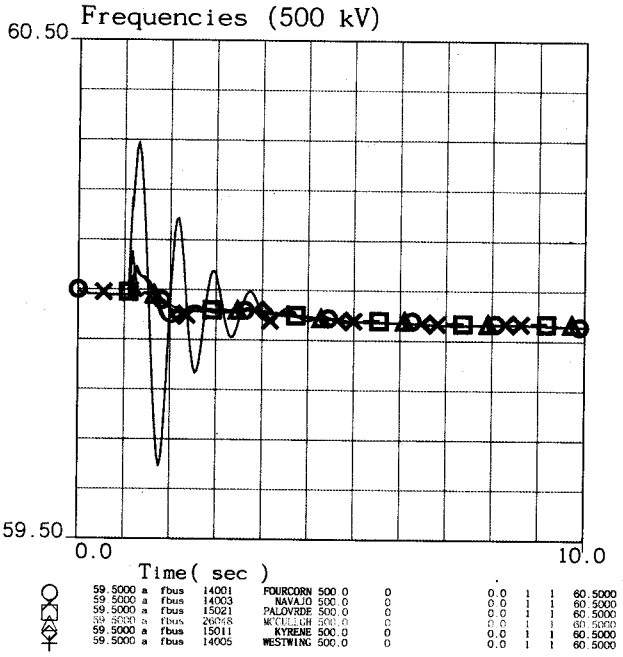

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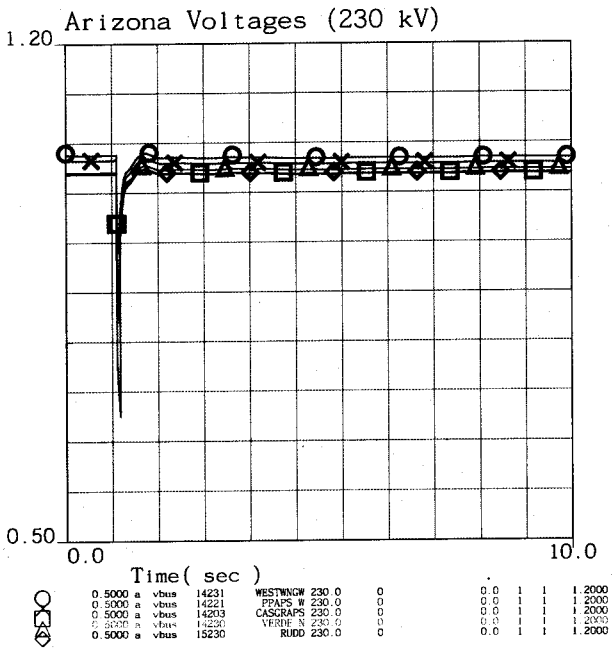

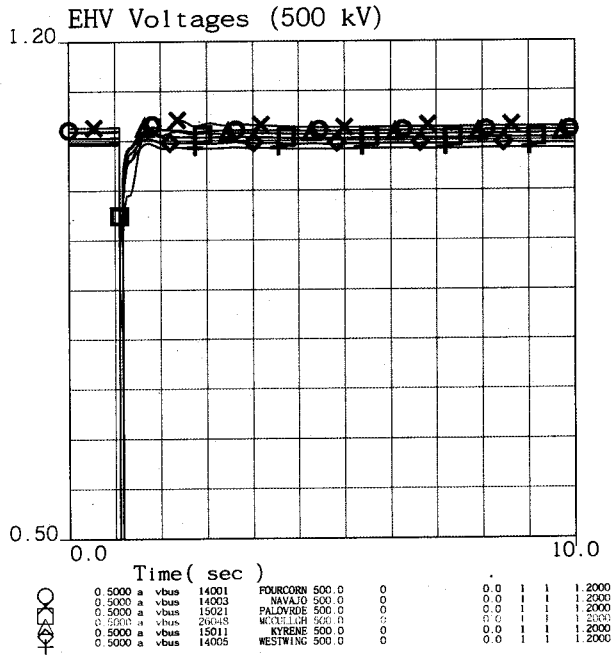

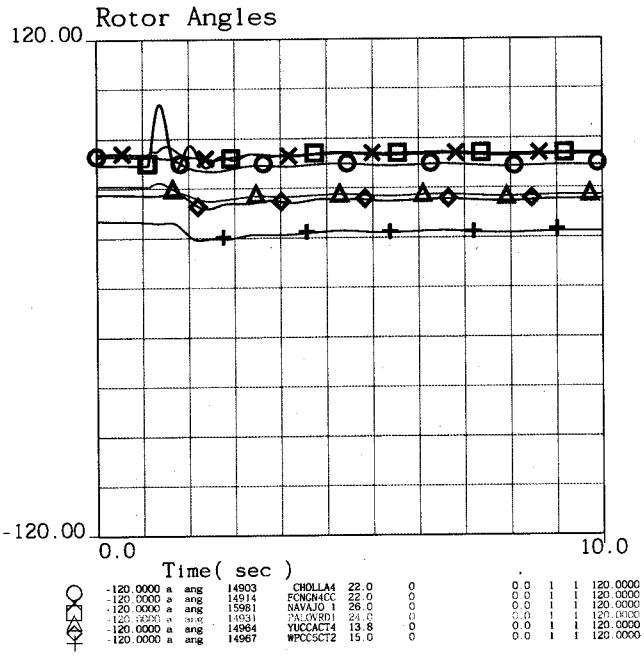

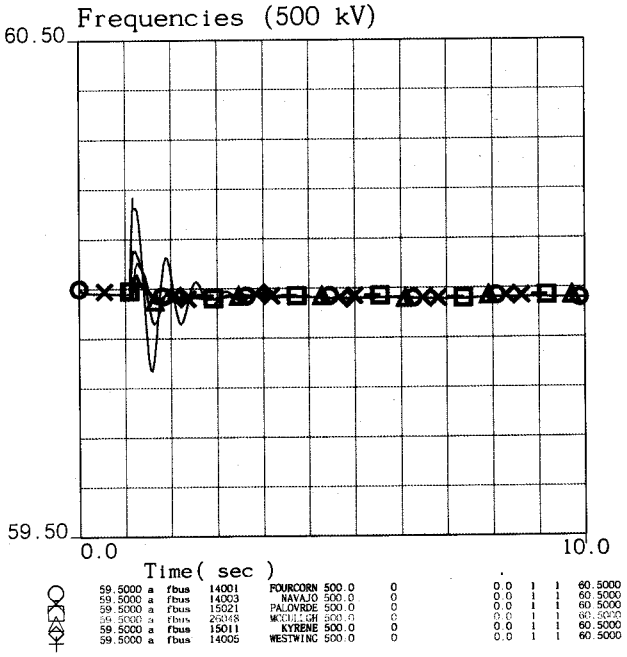

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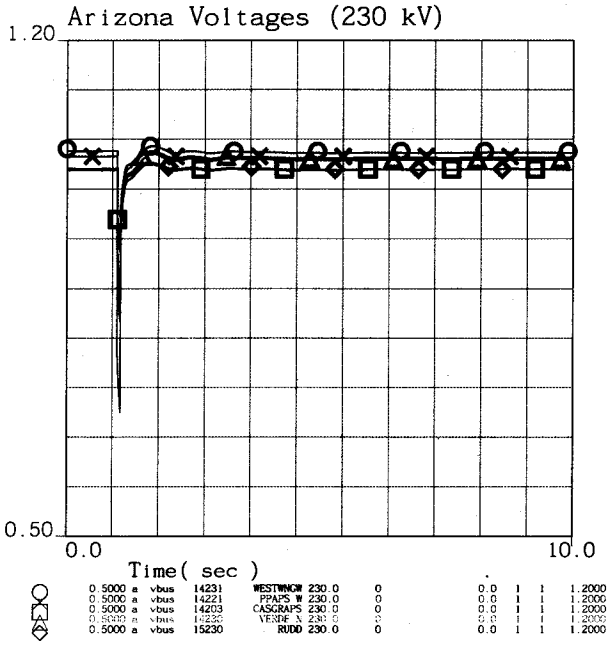
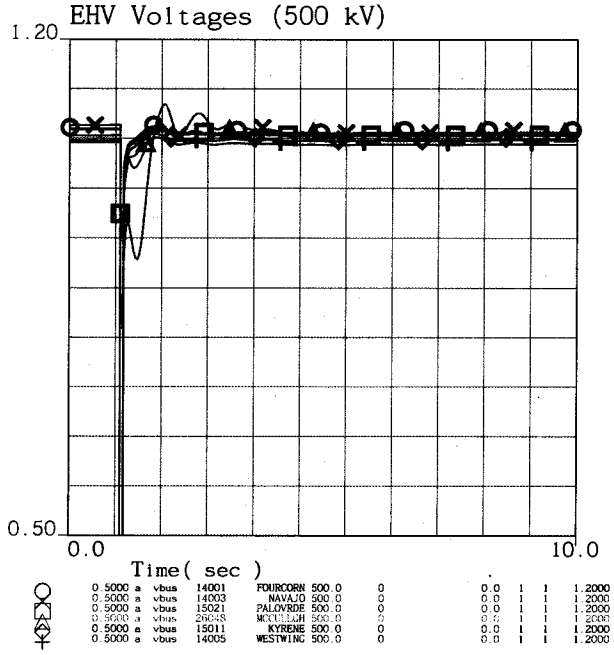
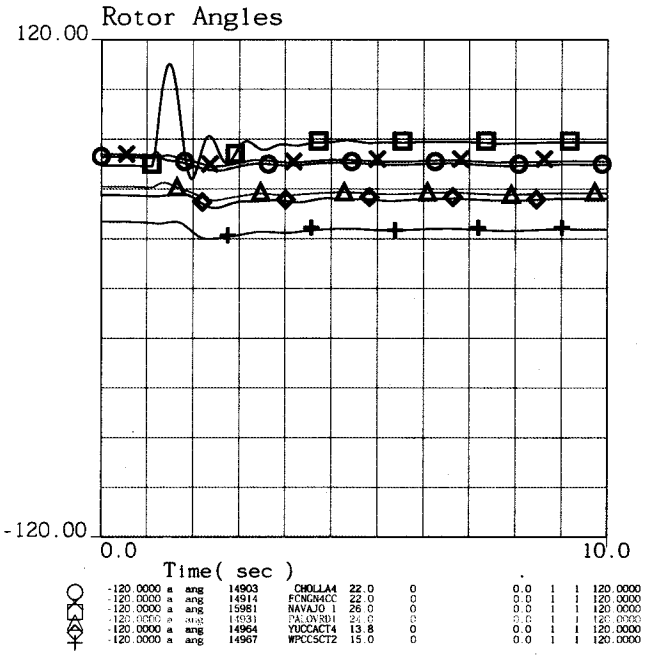
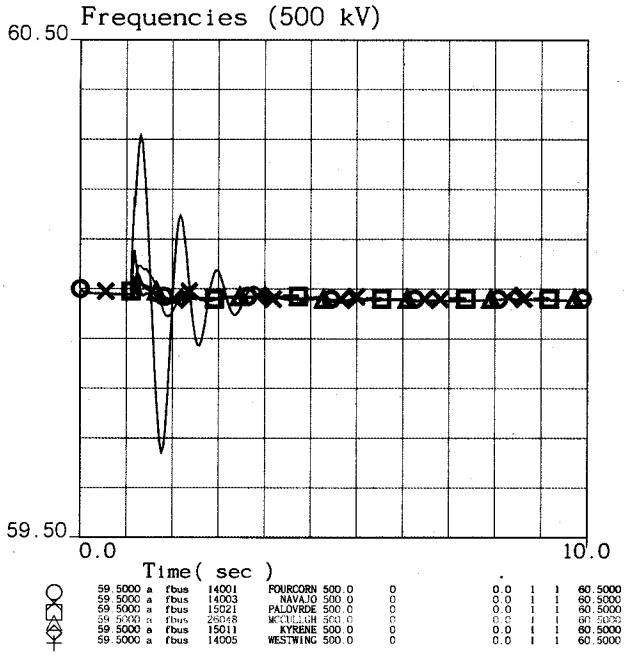
2018 Heavy Summer Detailed Planning Case









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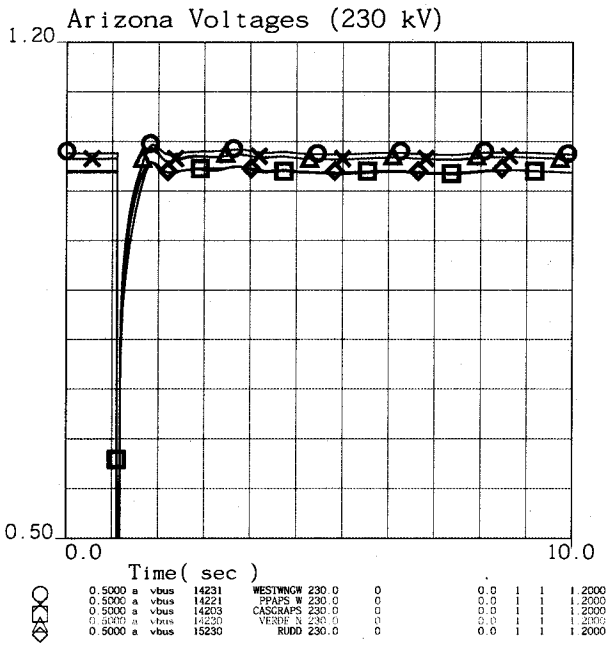

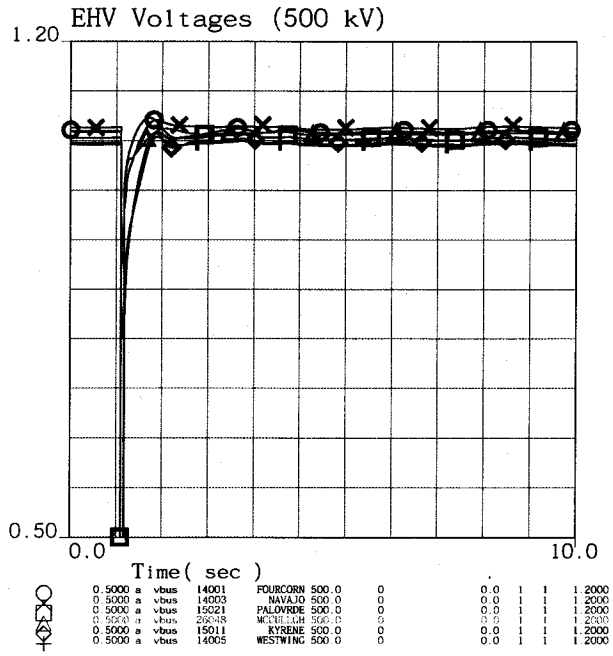

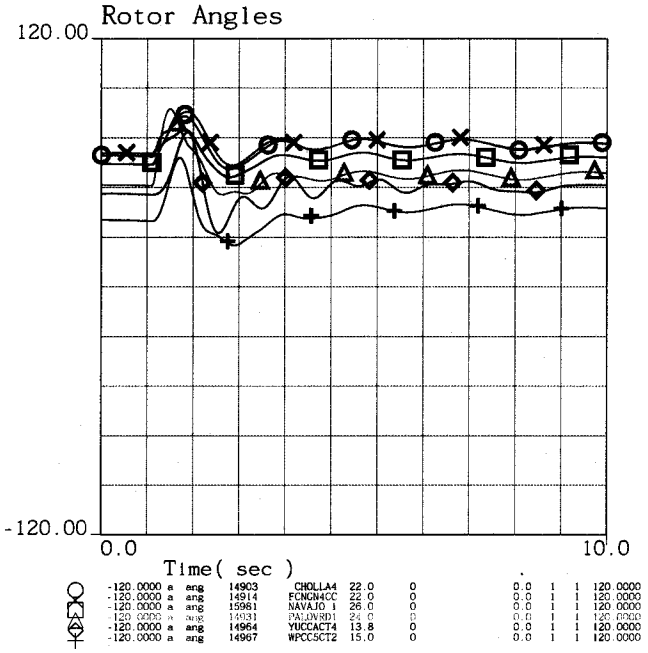

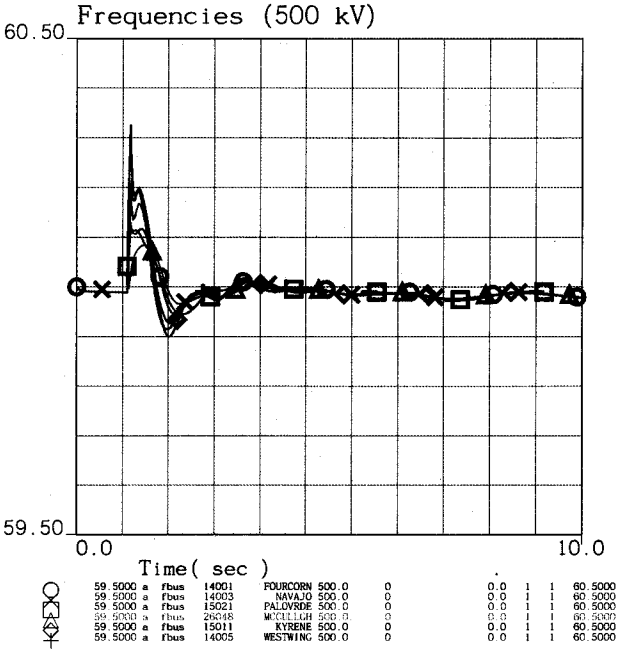

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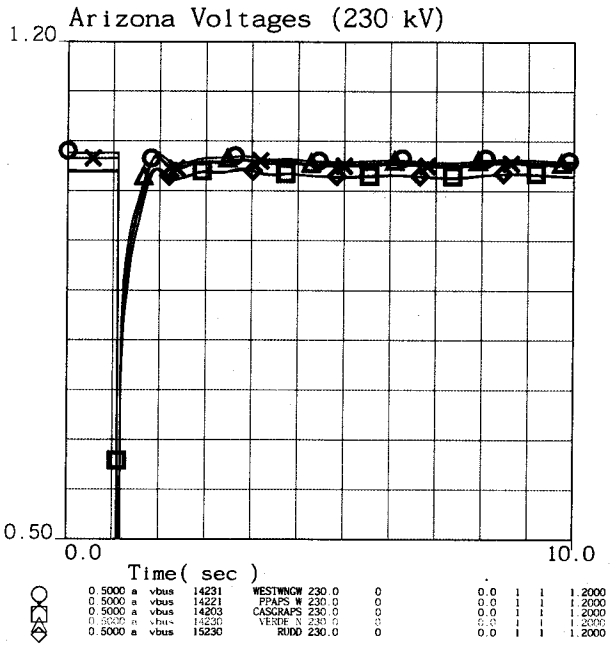

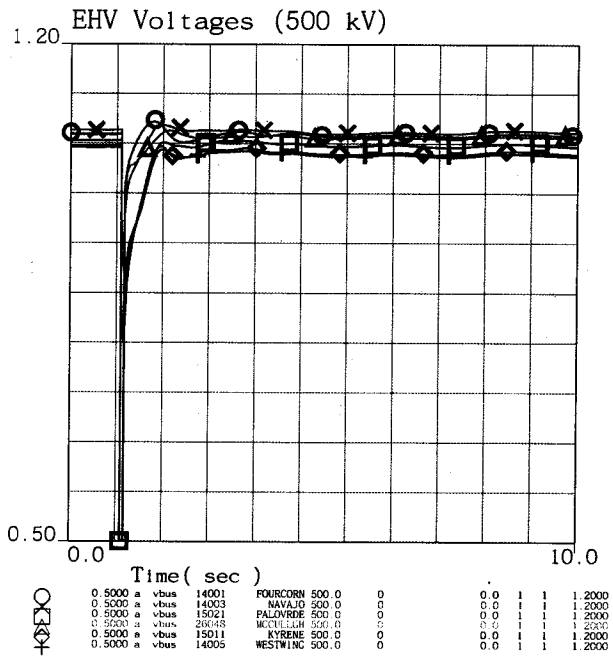

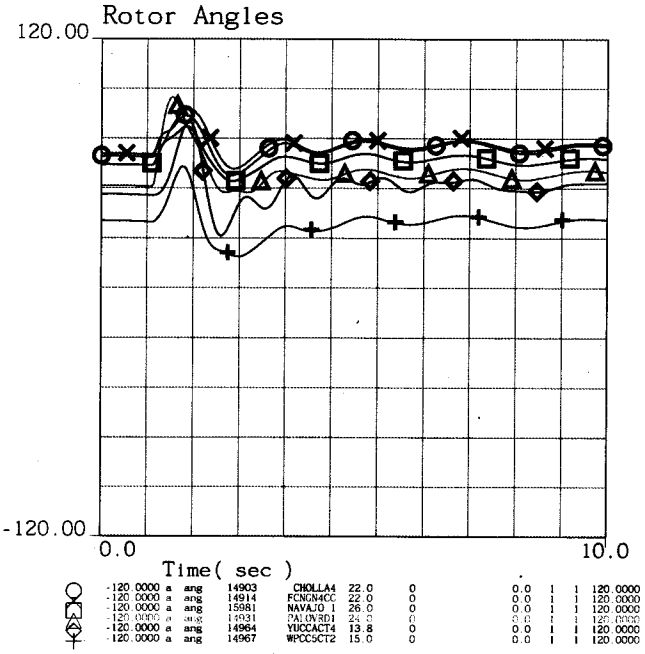

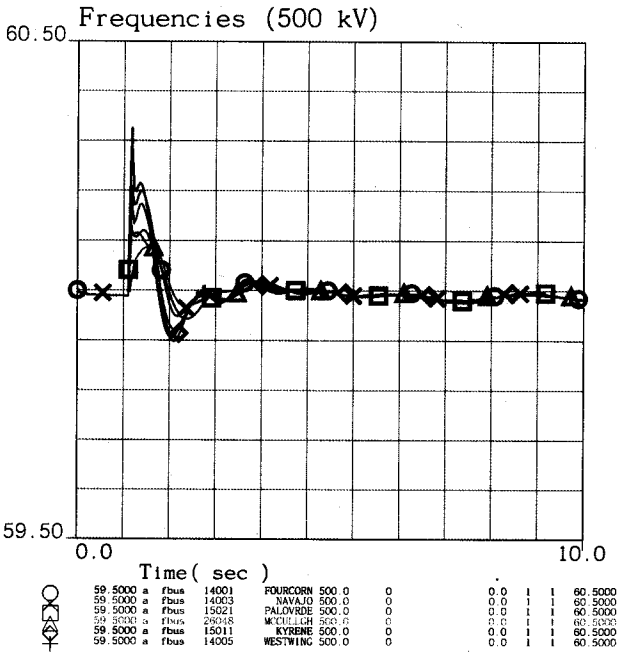

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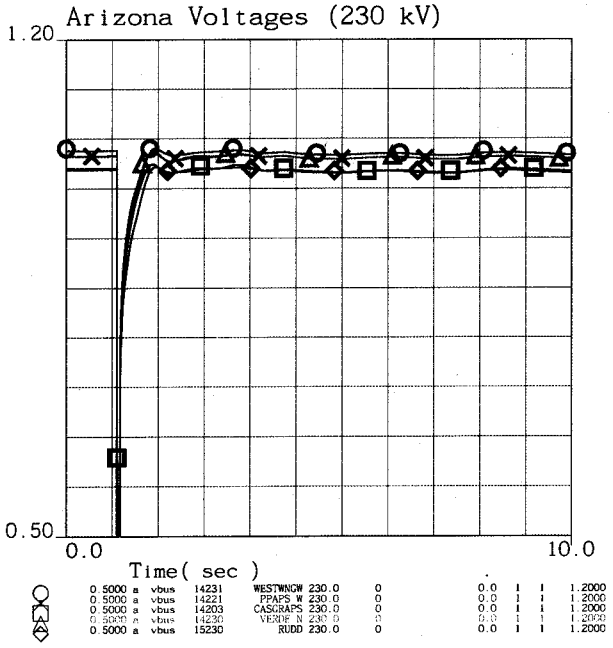

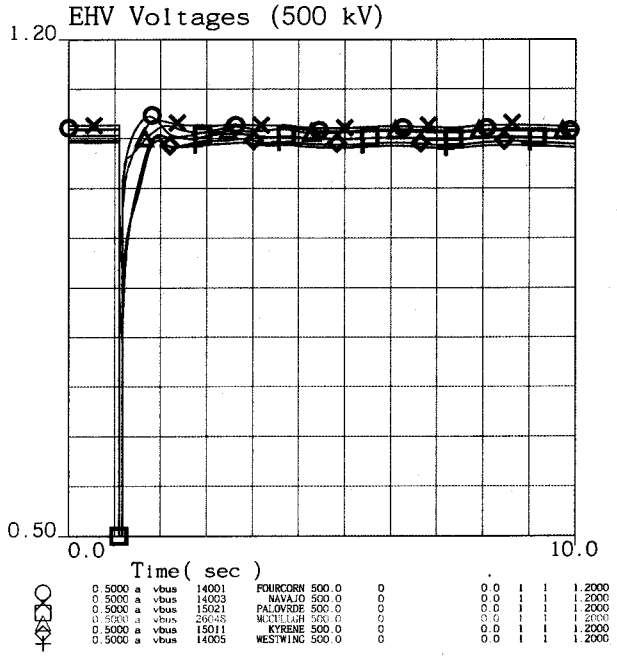

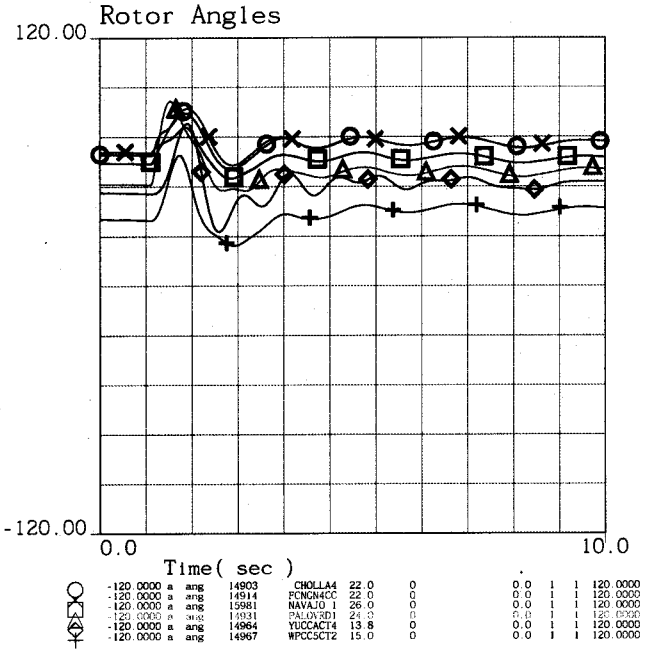

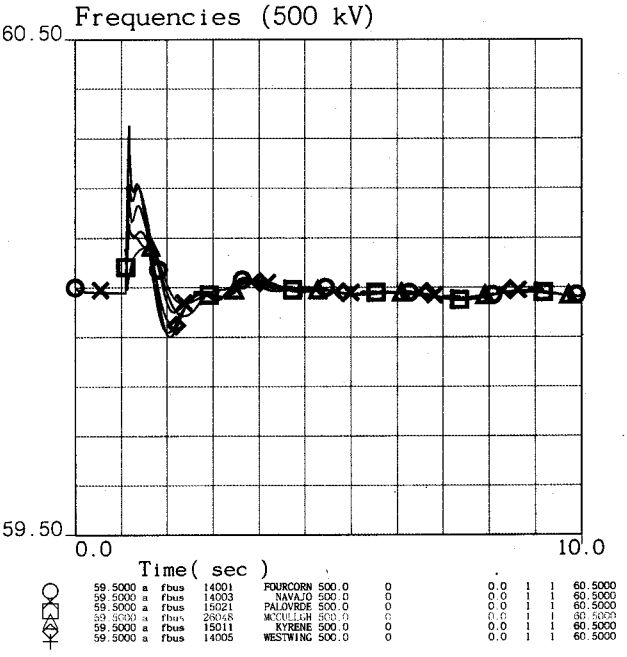

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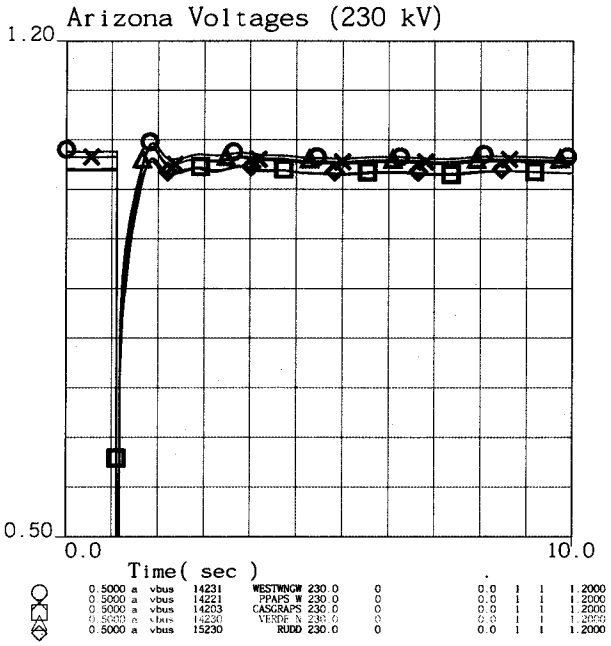

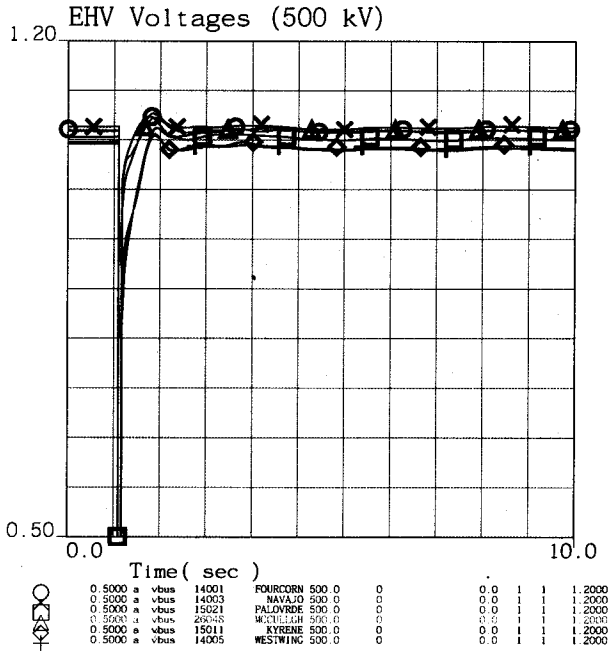

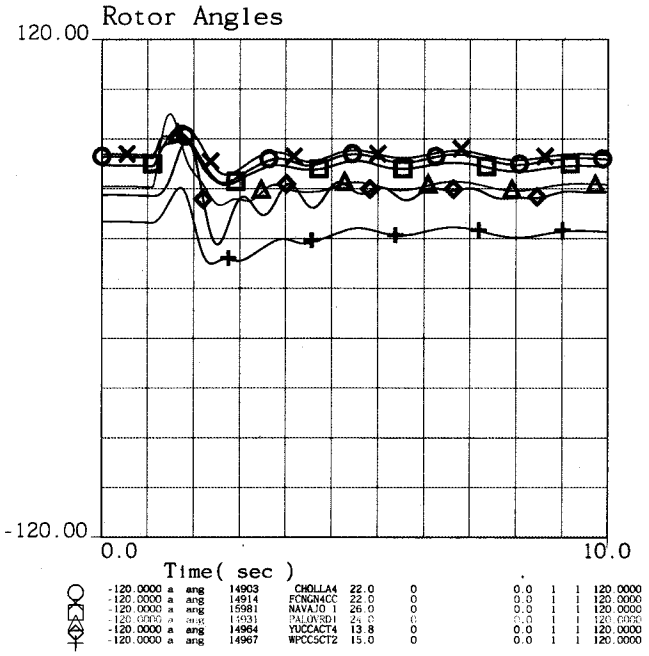

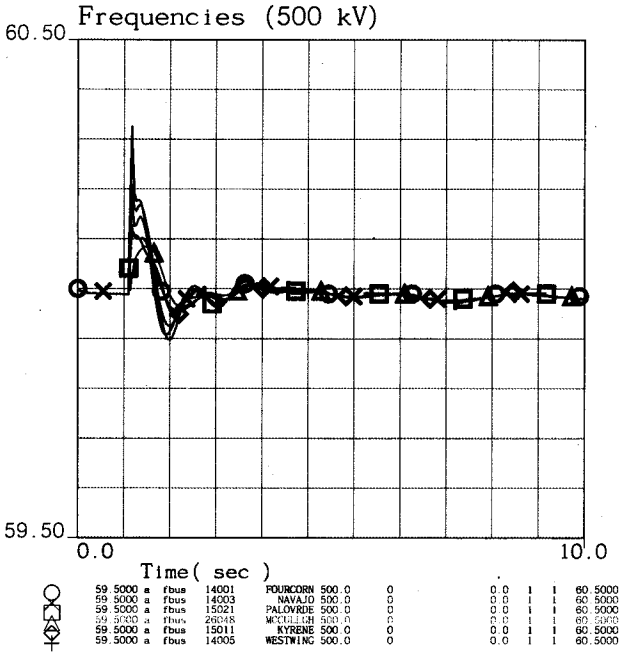

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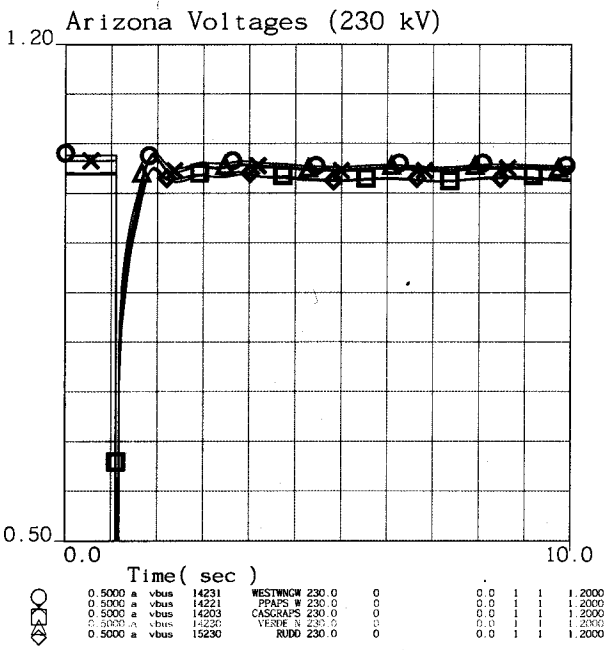

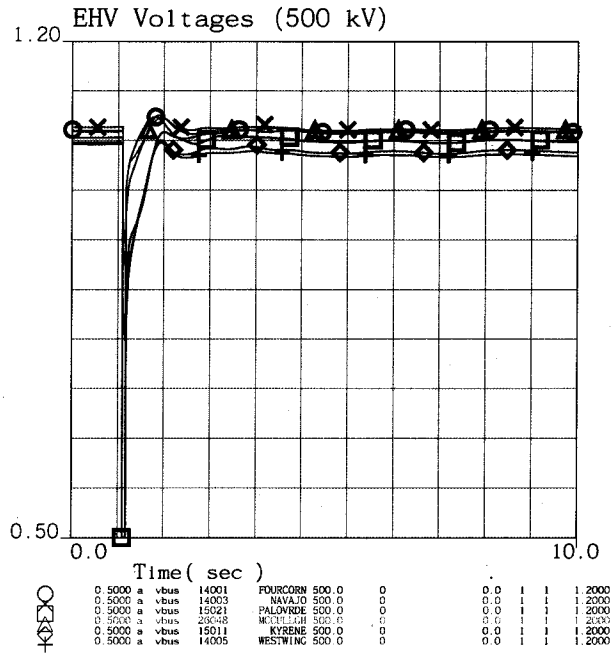

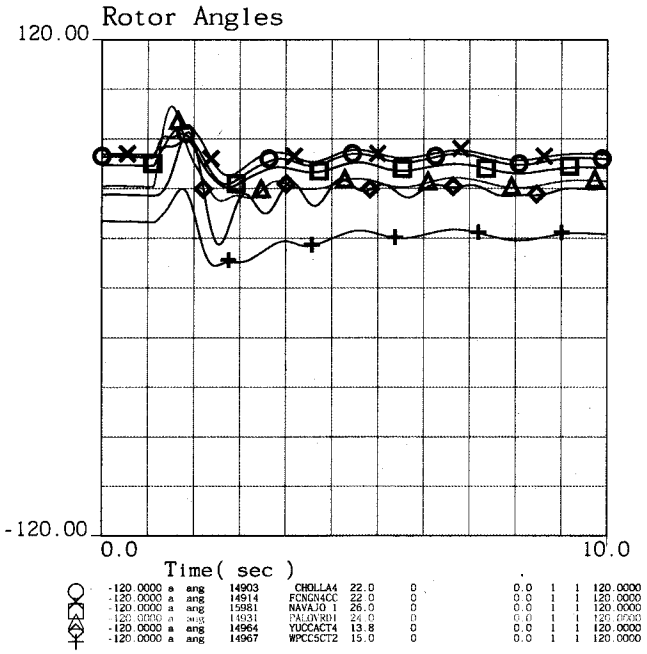

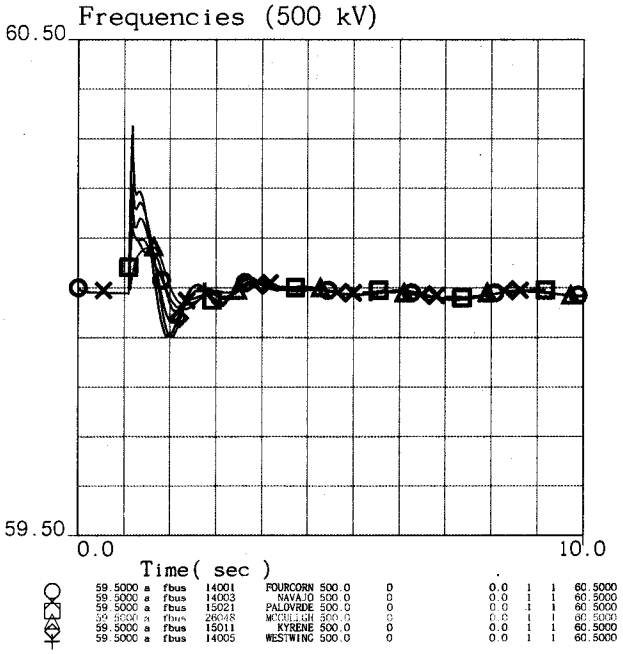

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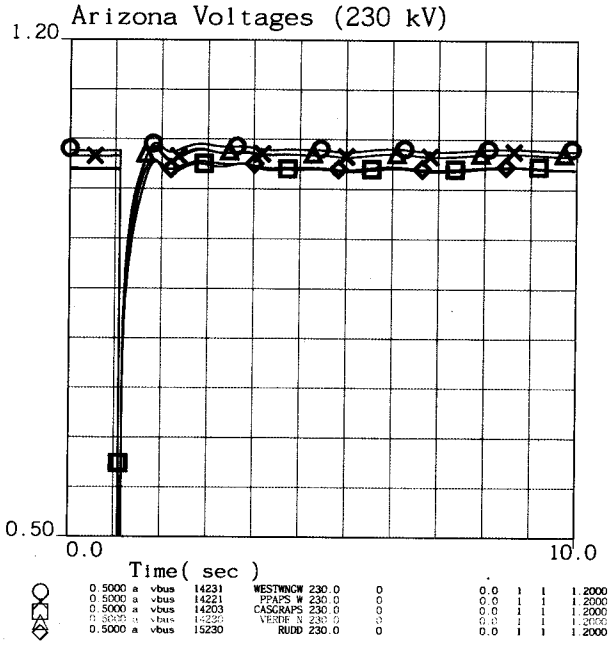

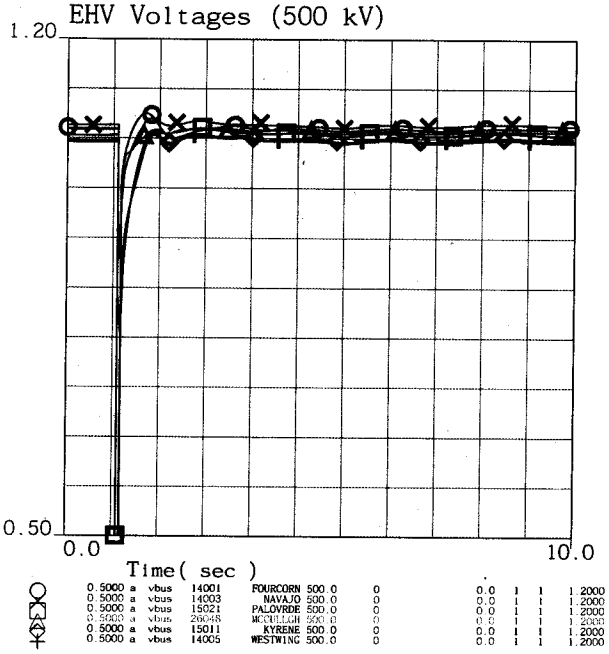

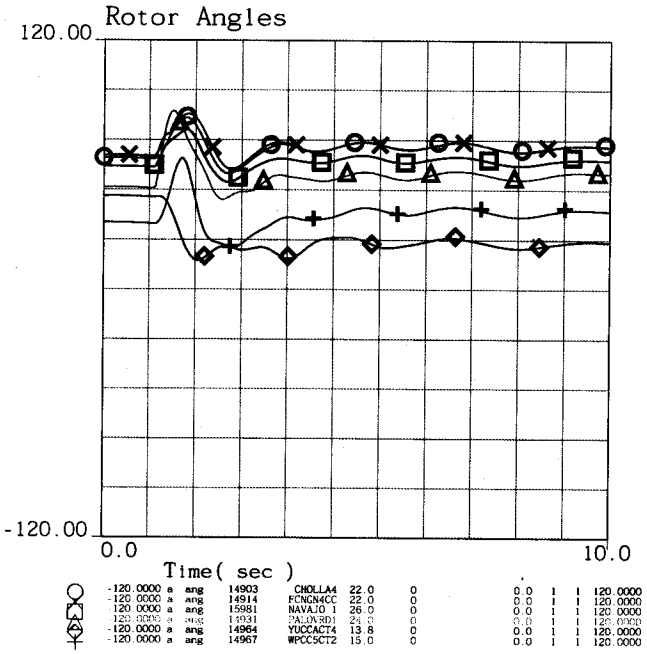

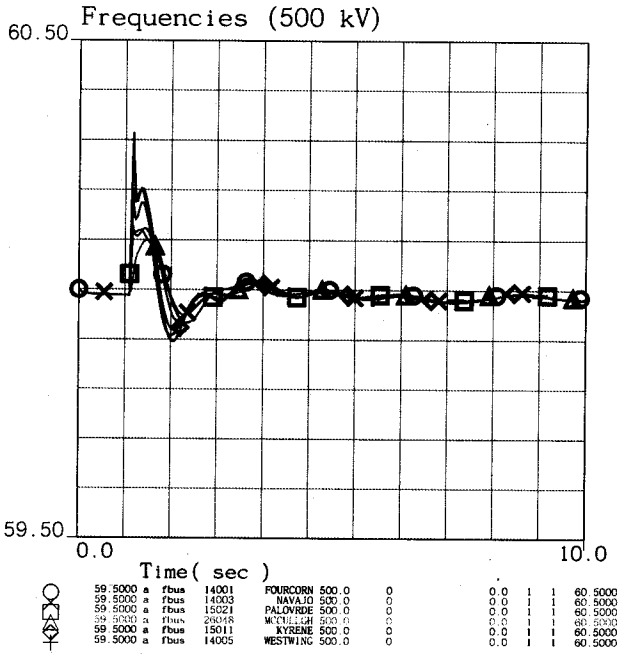

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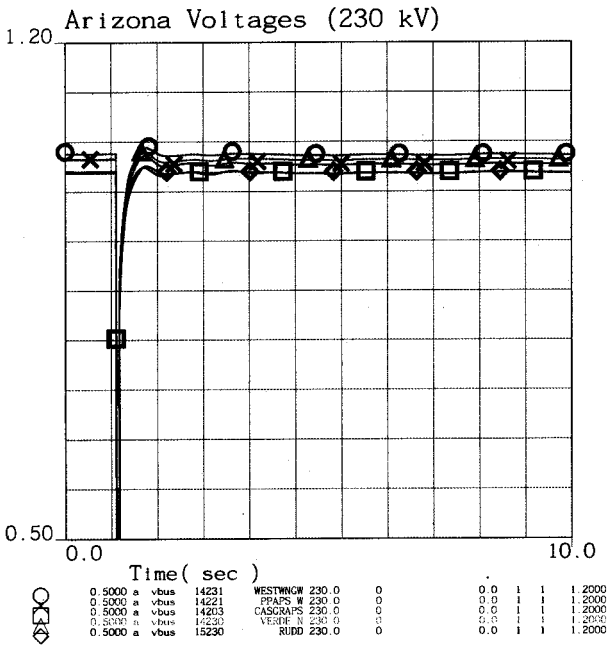

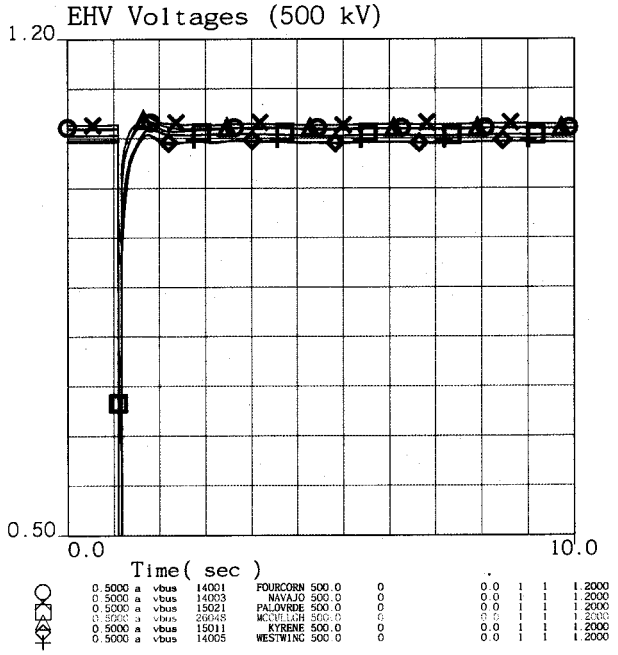

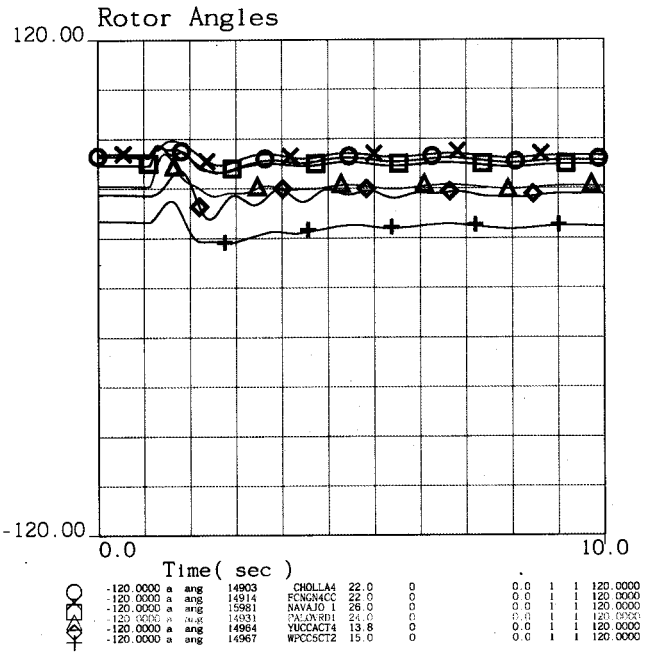

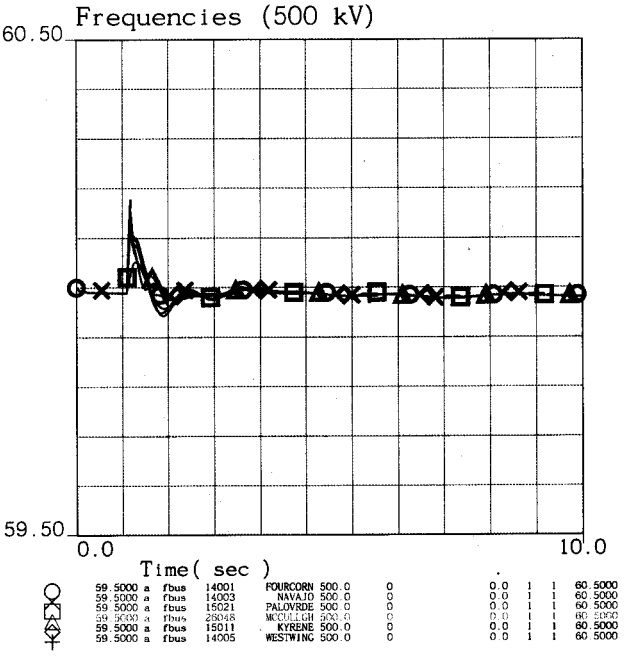

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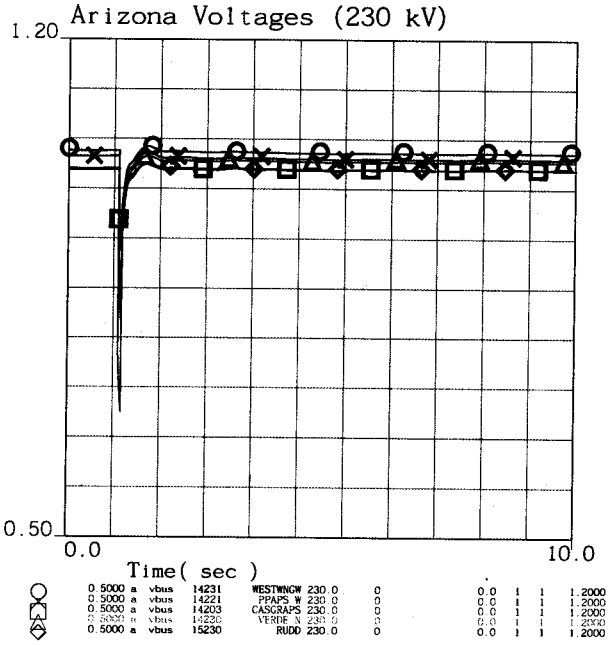

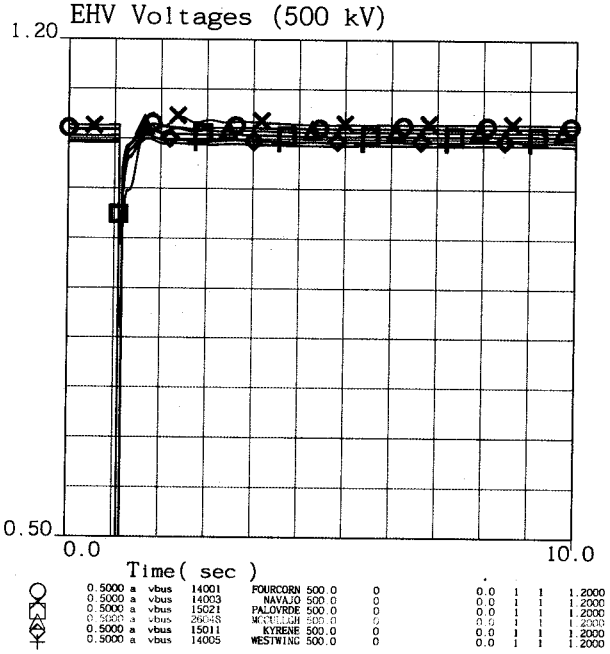

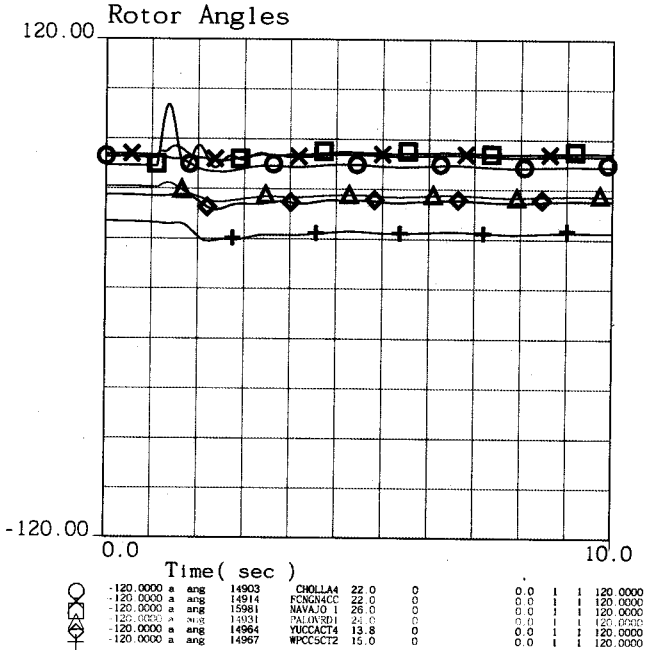

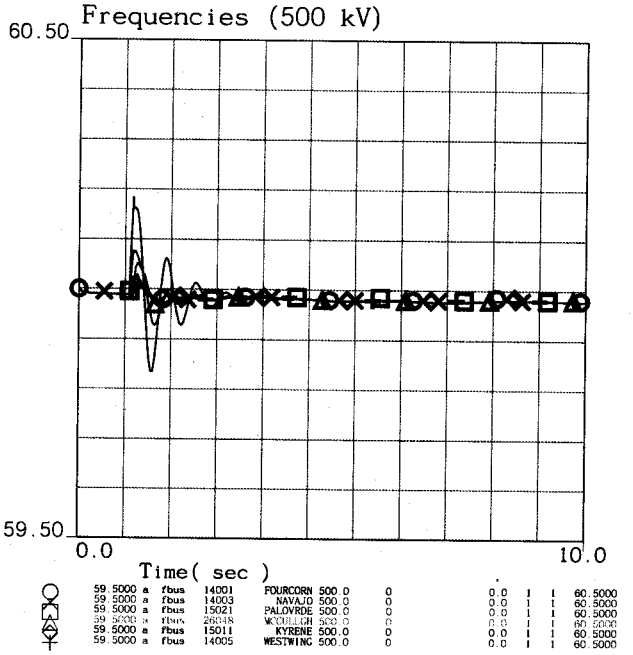

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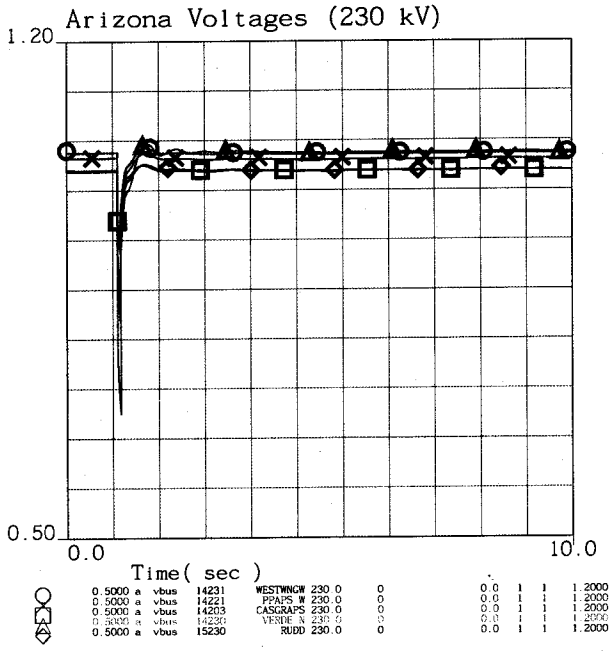

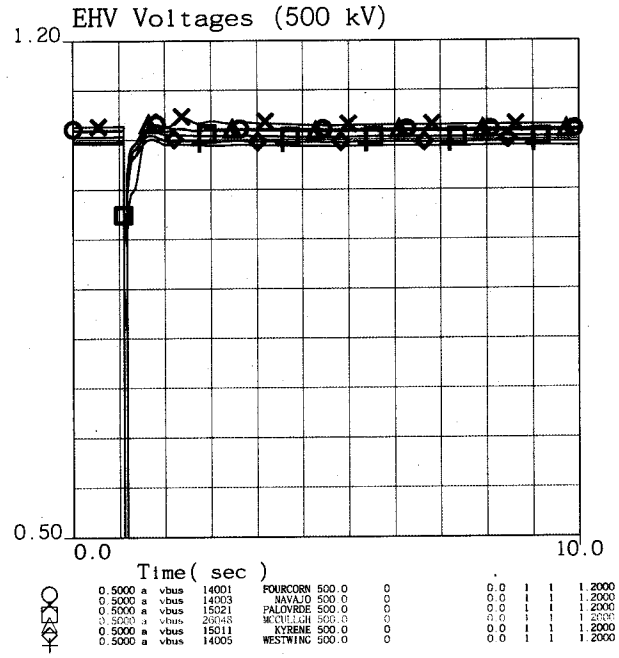

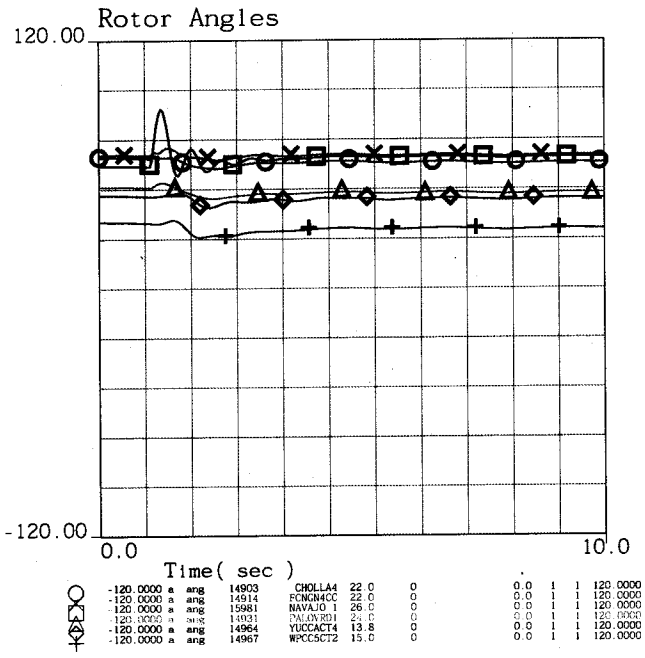

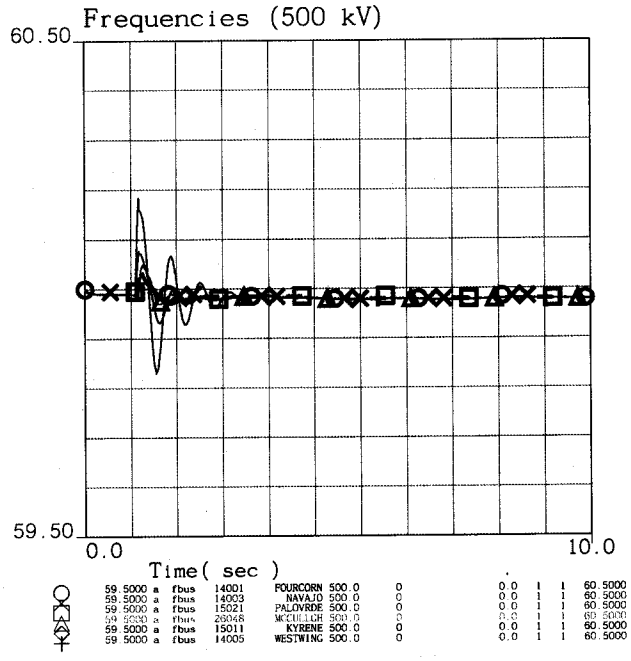

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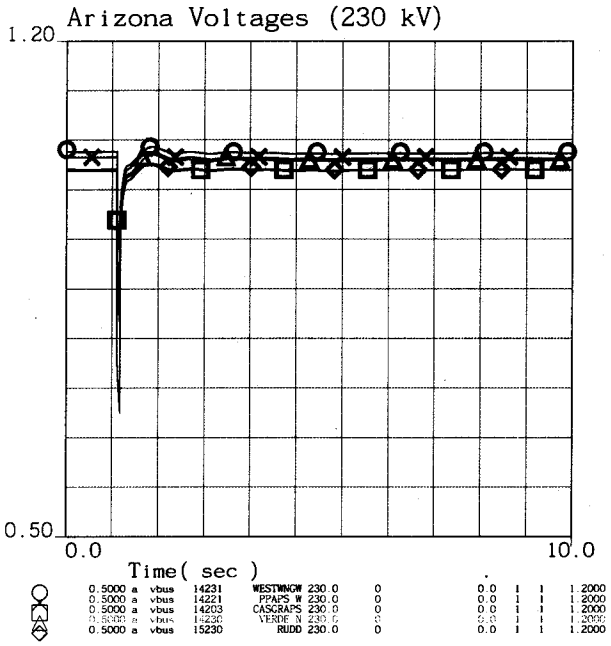

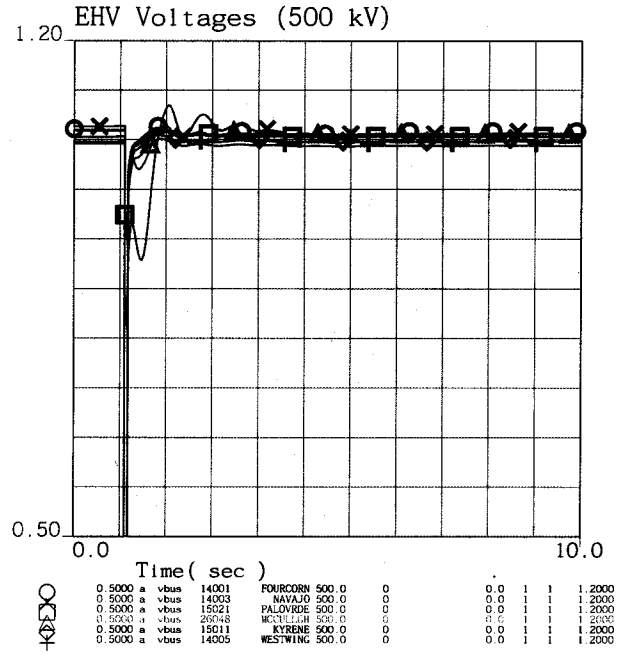

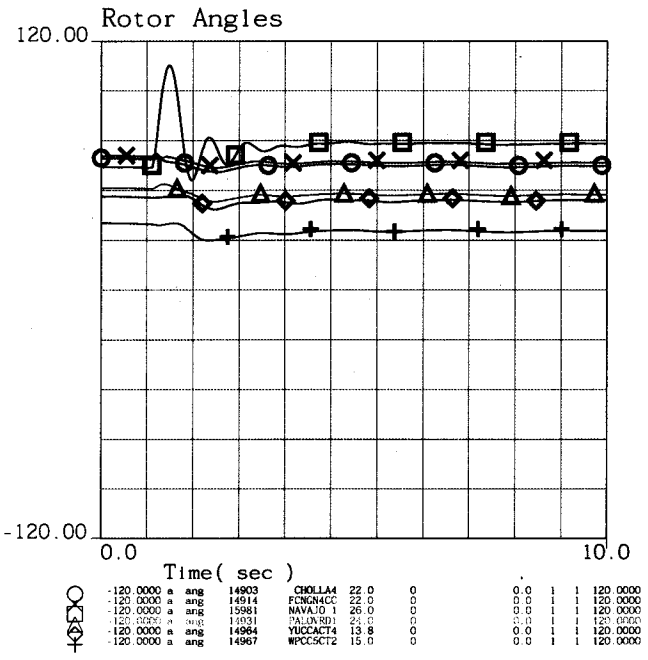

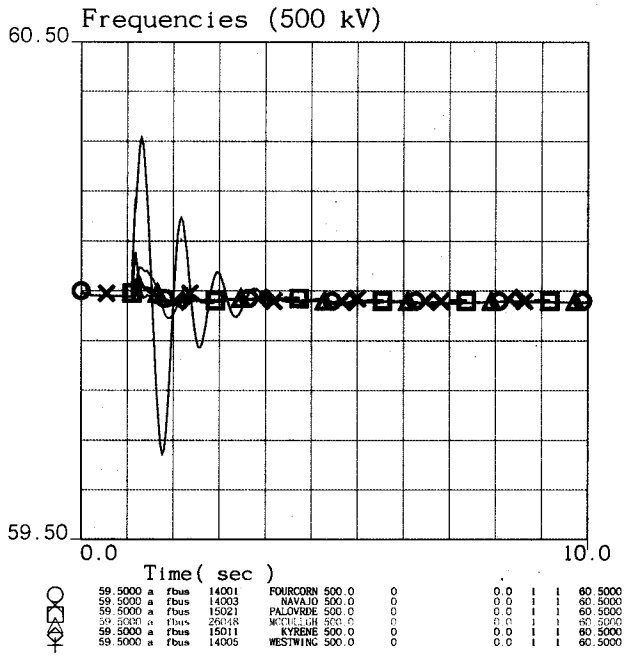

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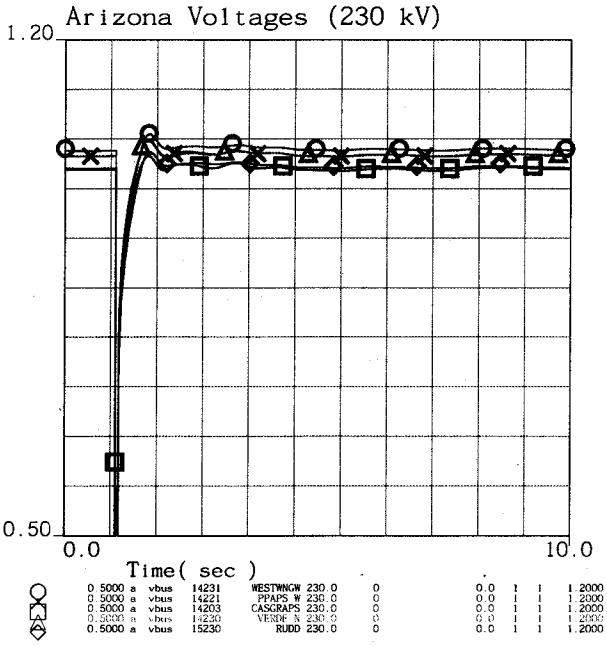

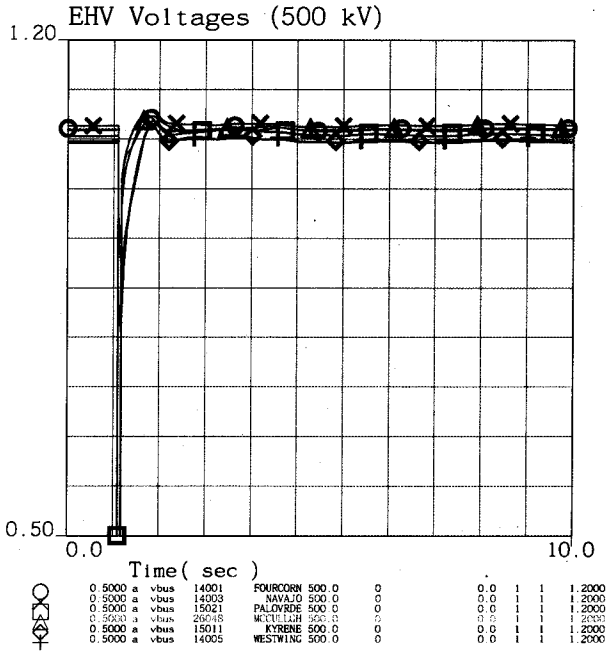

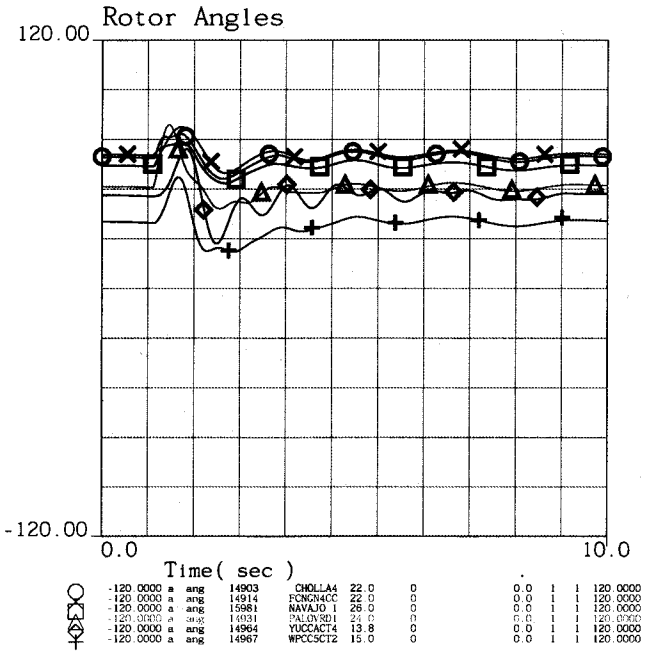

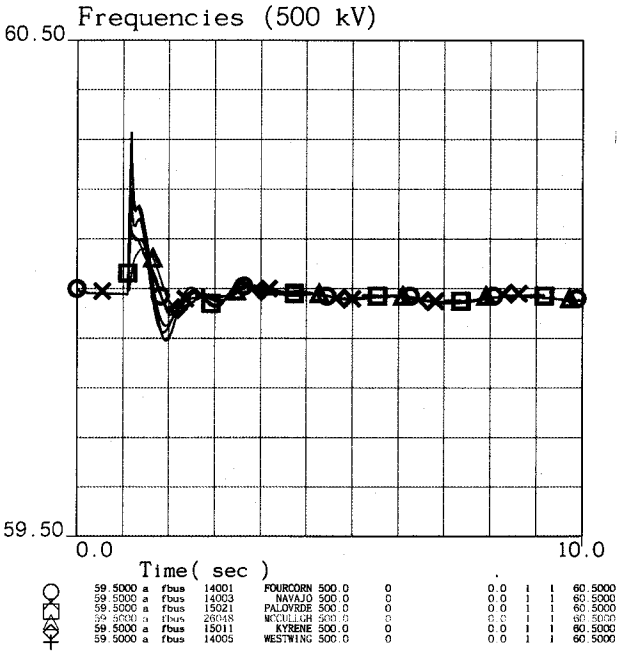

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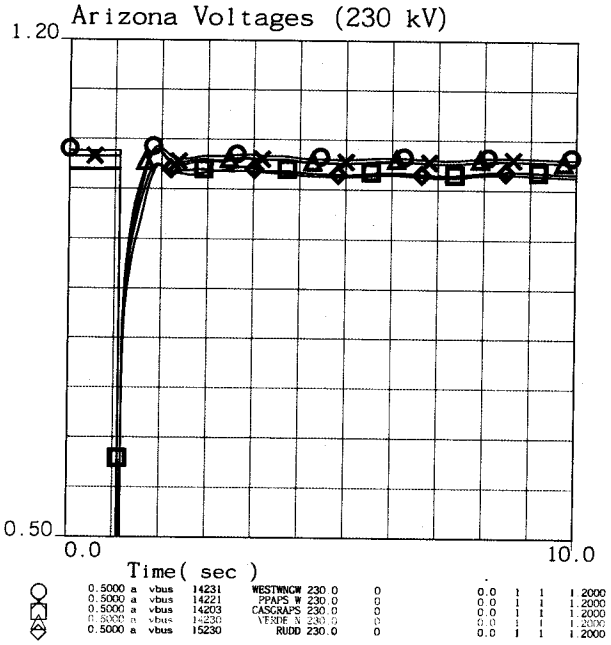

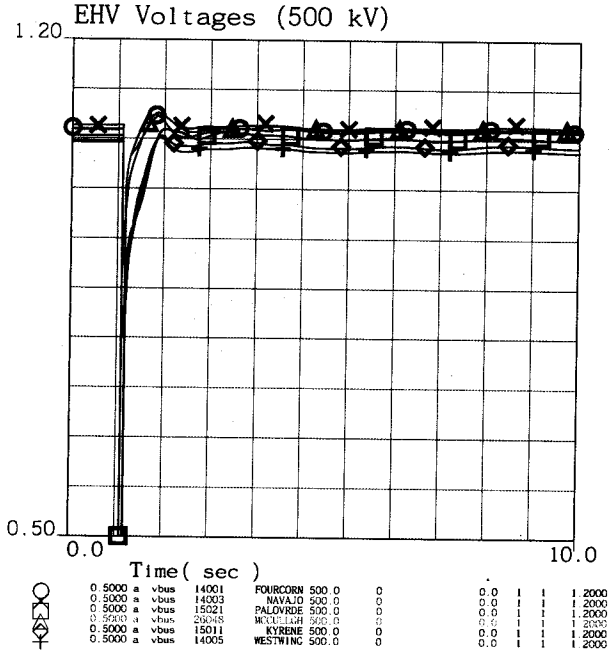

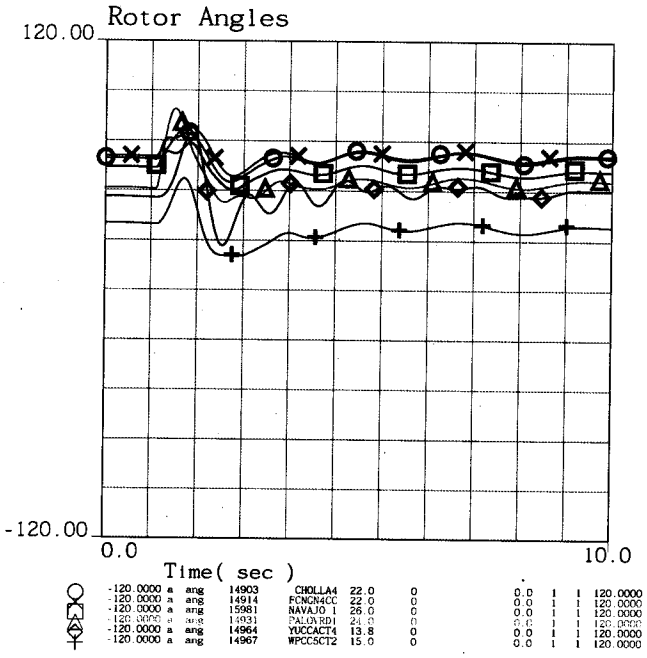

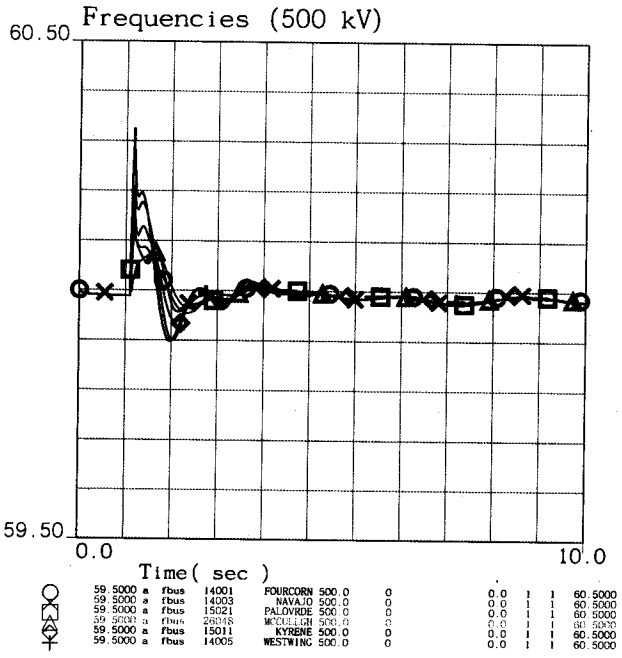

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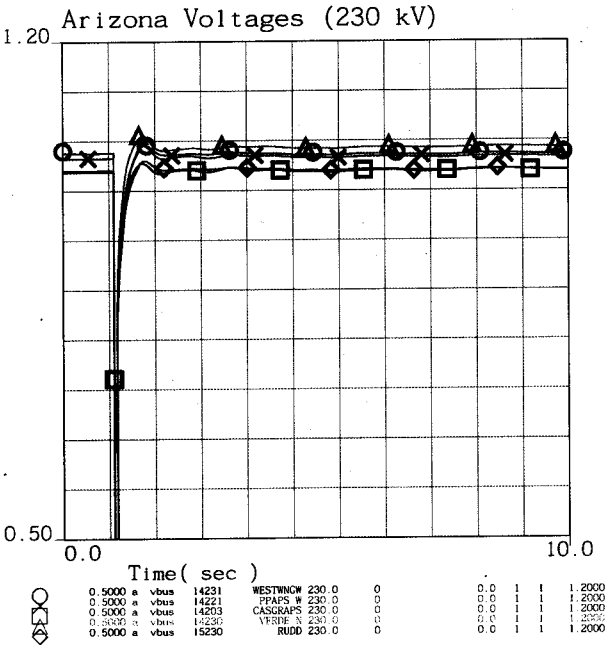

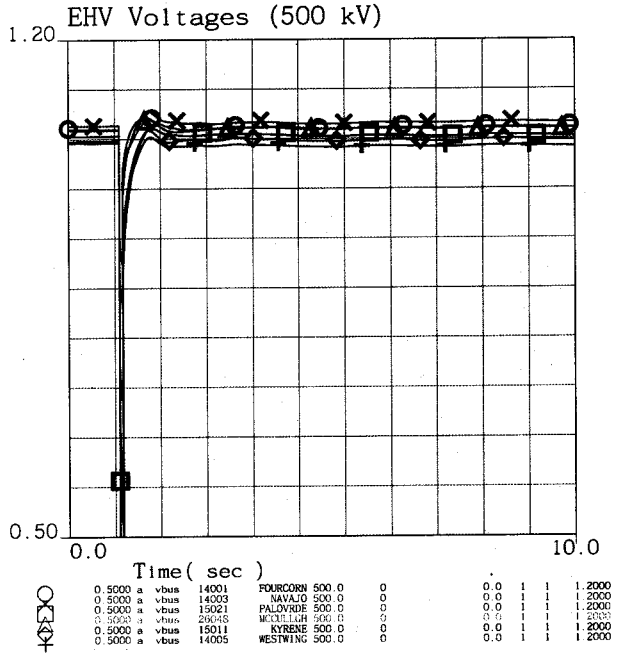

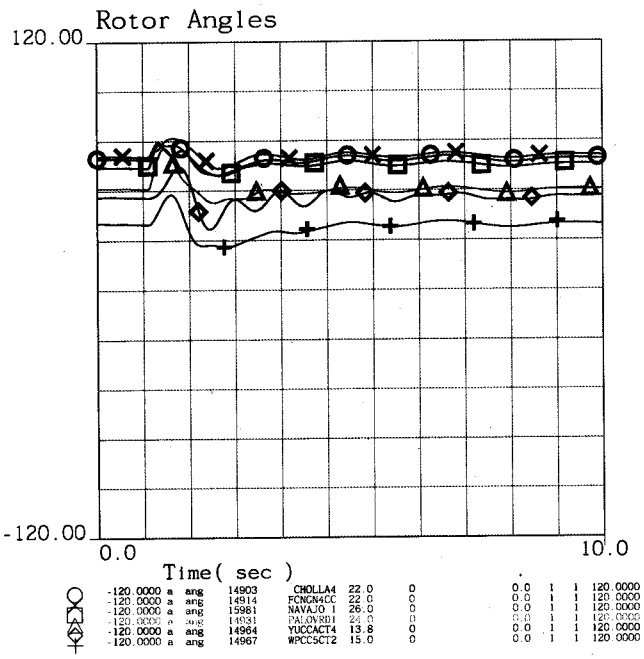

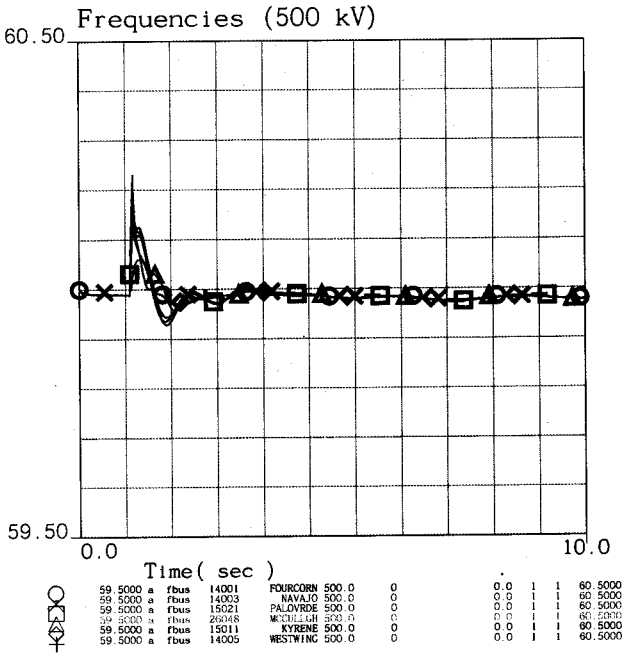

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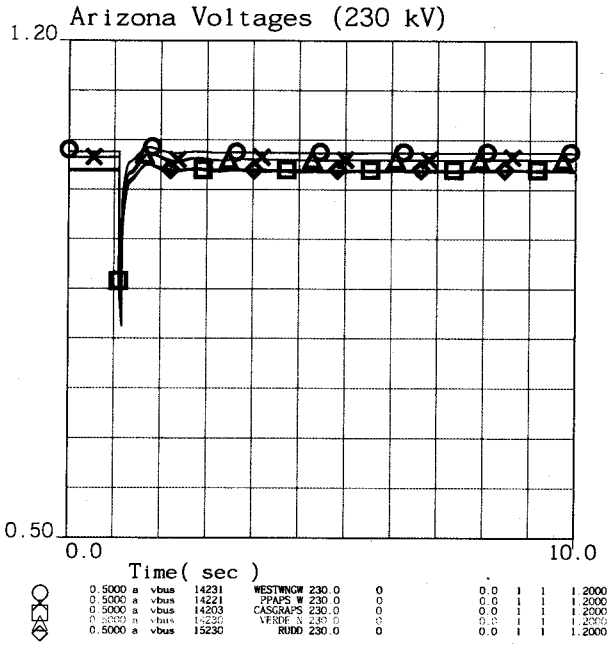
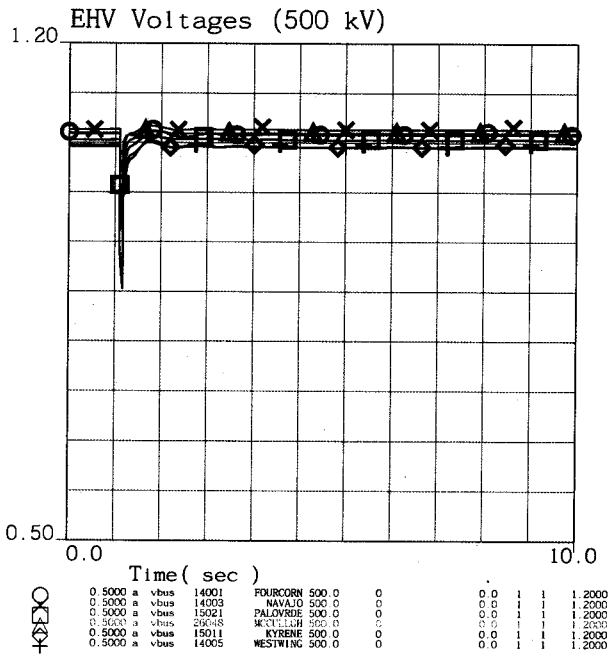
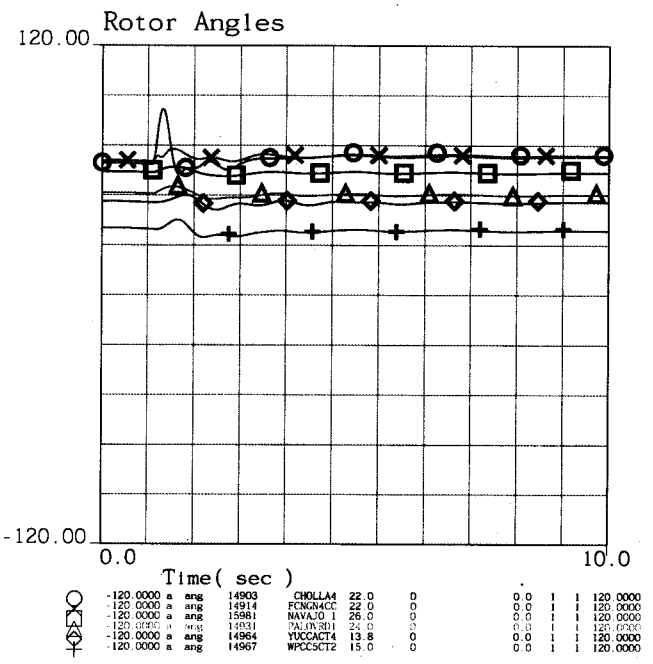
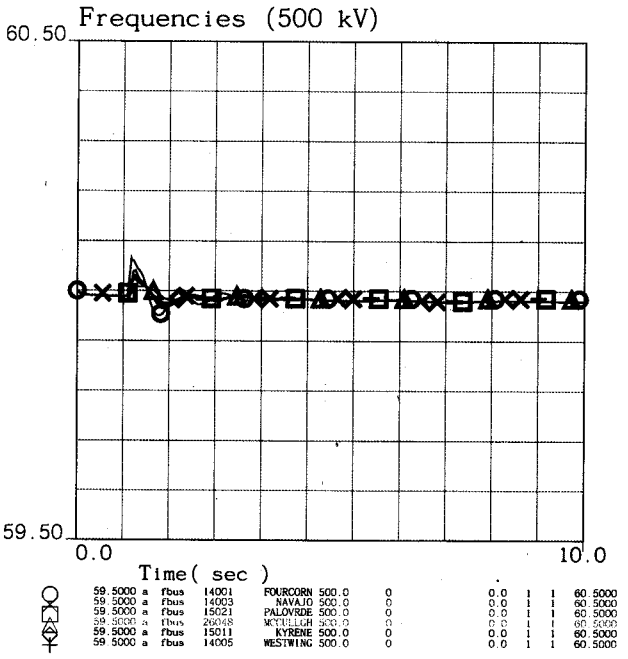
2018 Heavy Summer Detailed Planning Case









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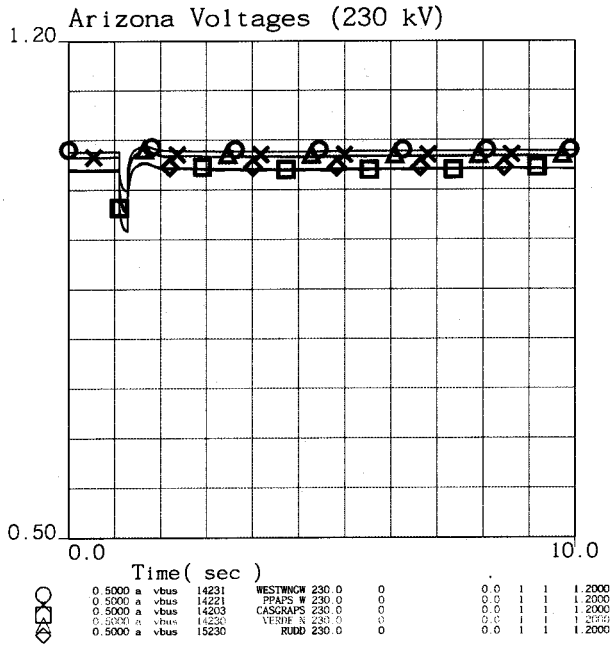

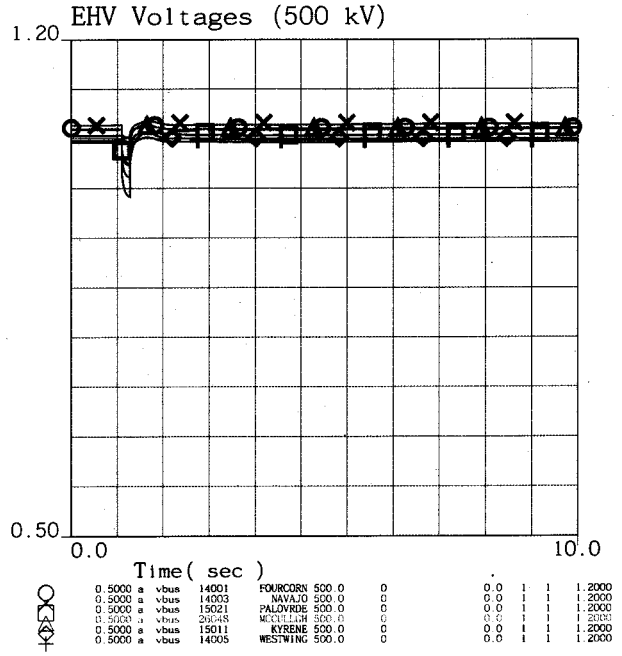

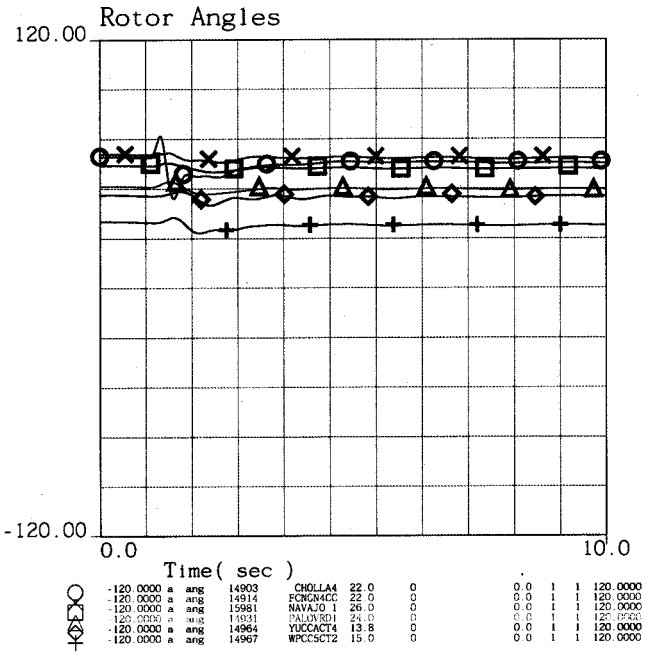

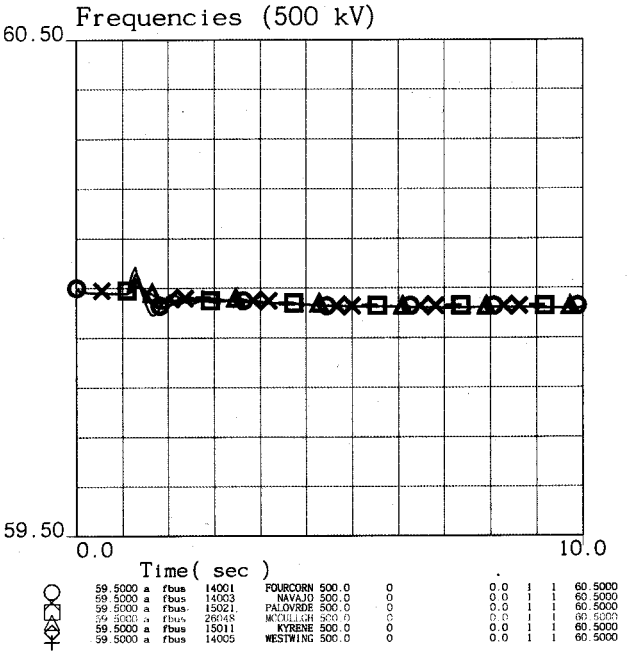

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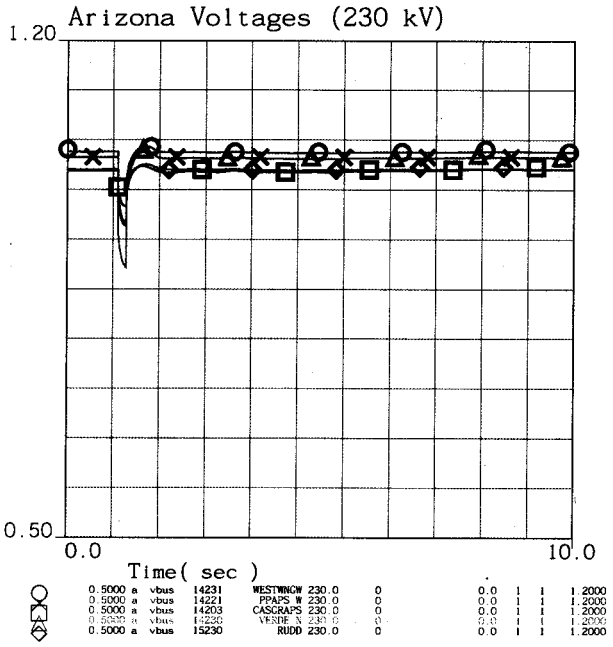

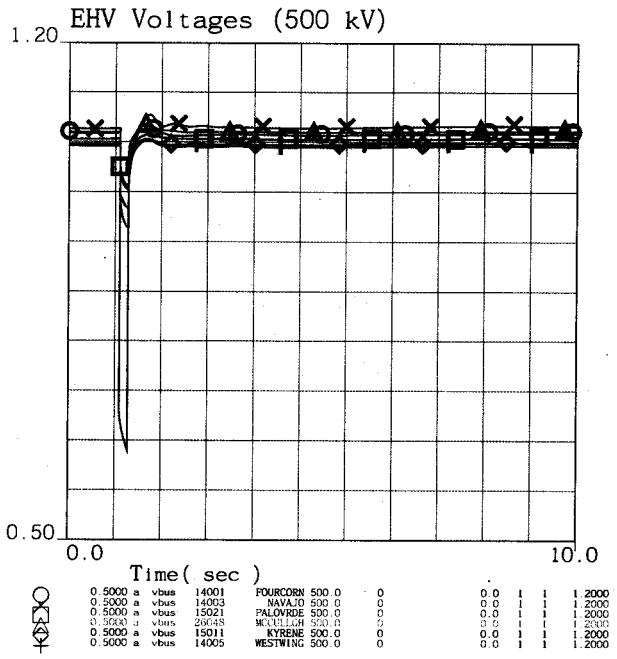

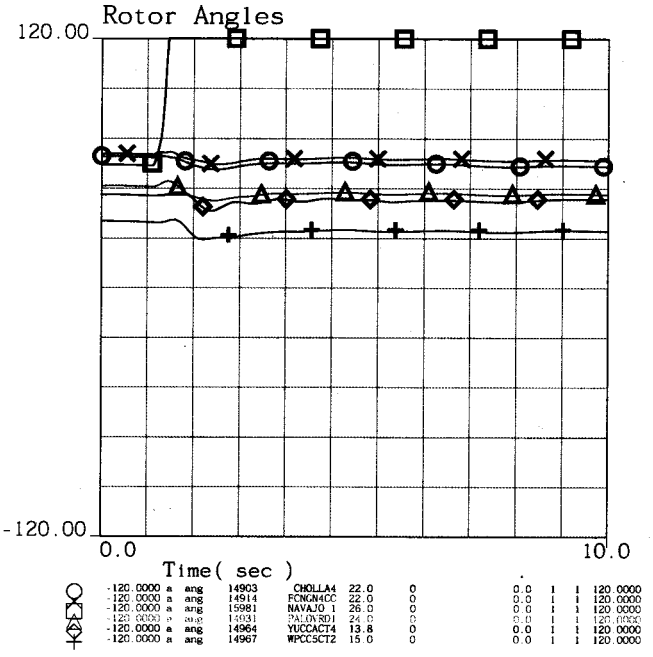

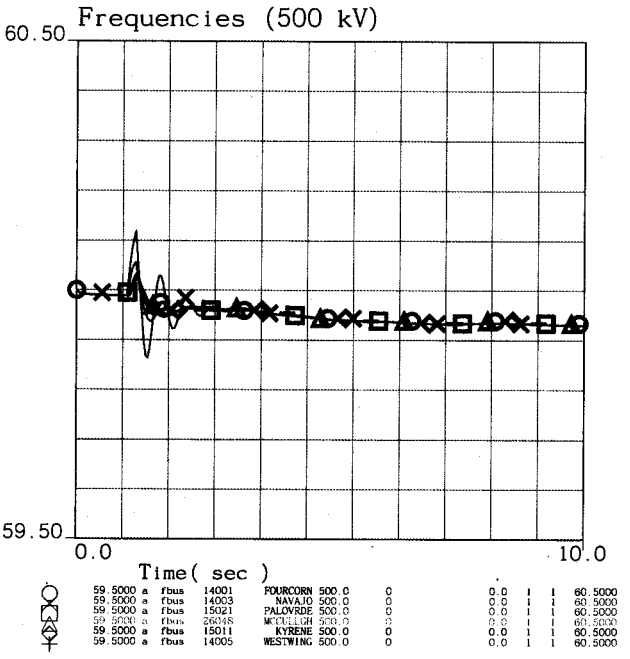

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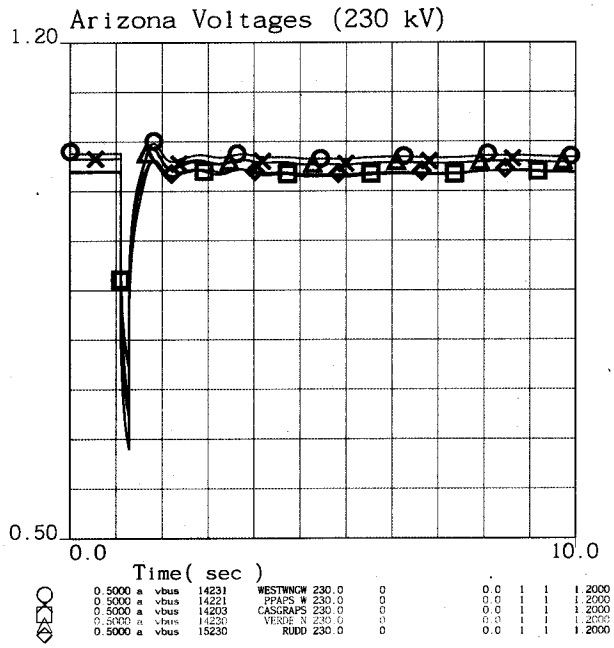

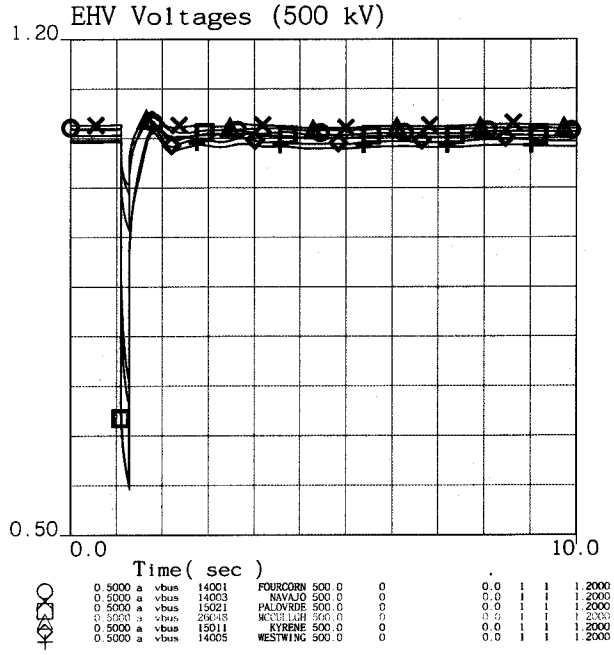

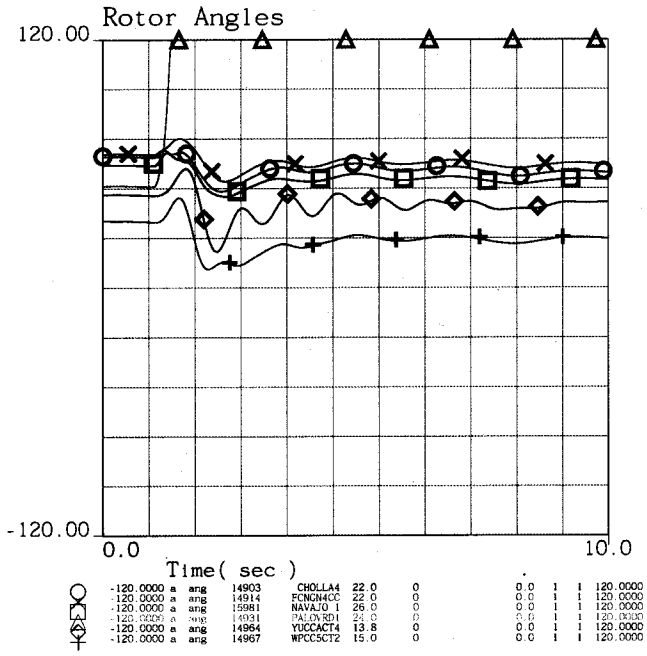

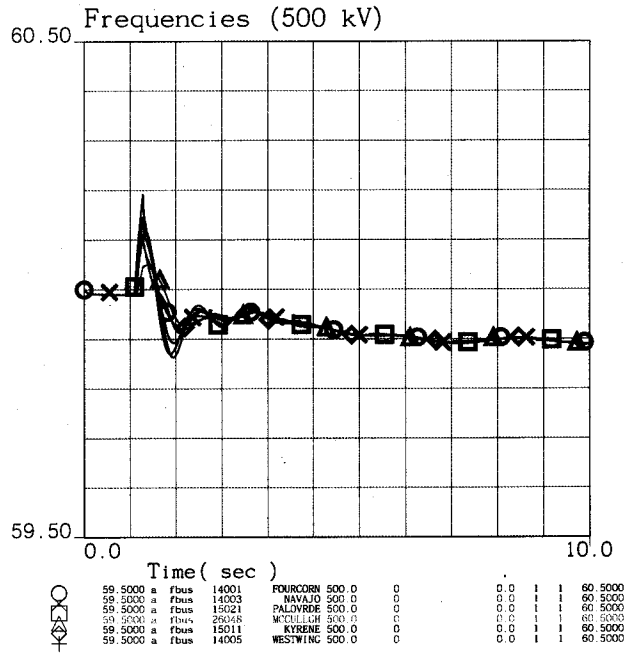

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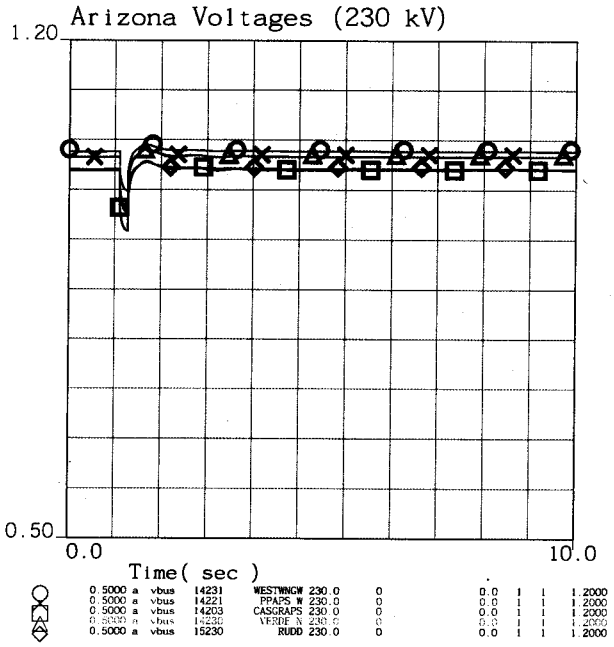

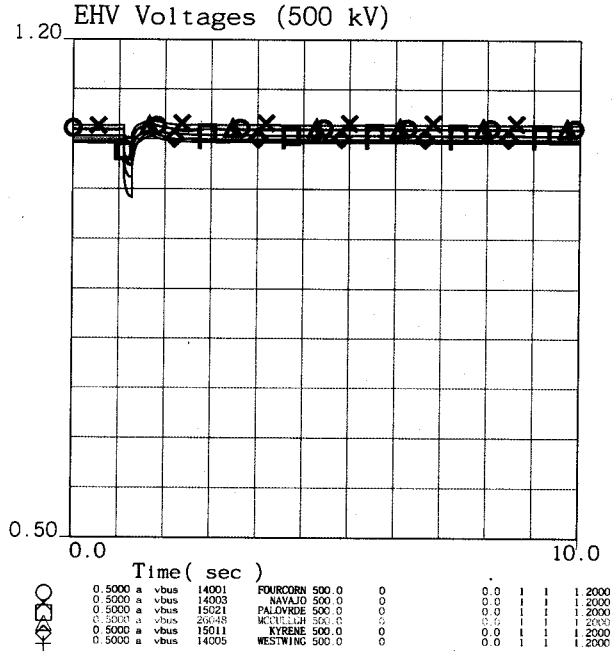

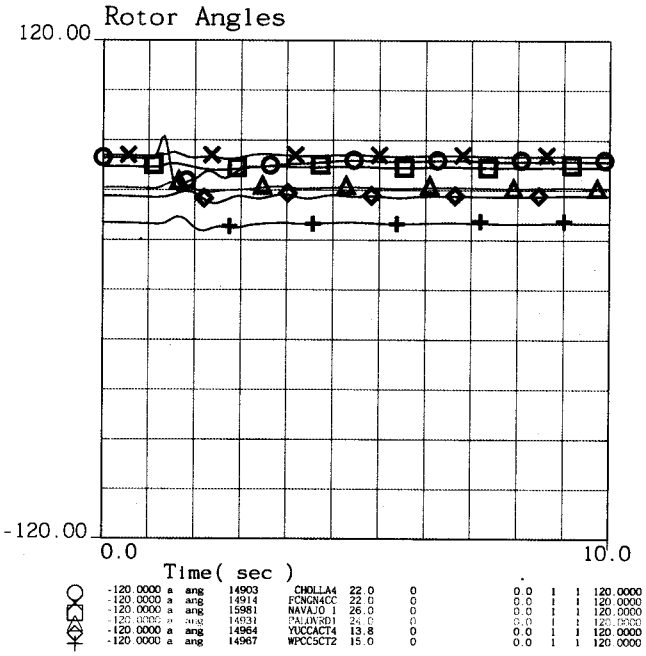

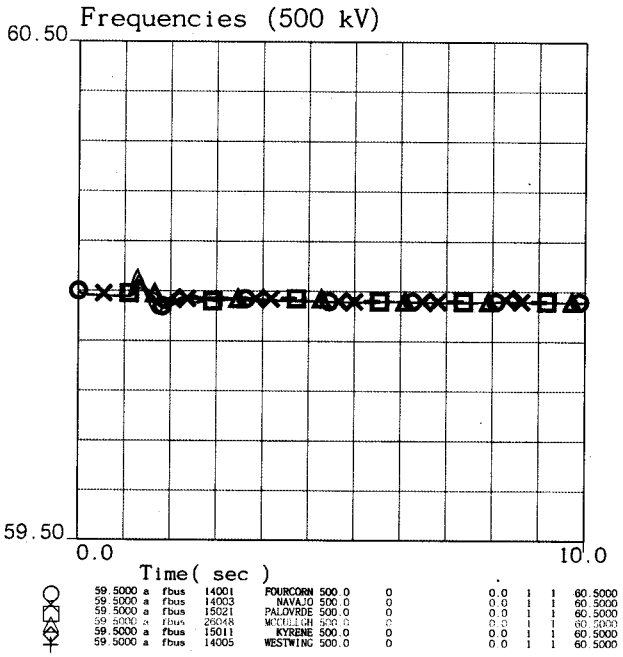

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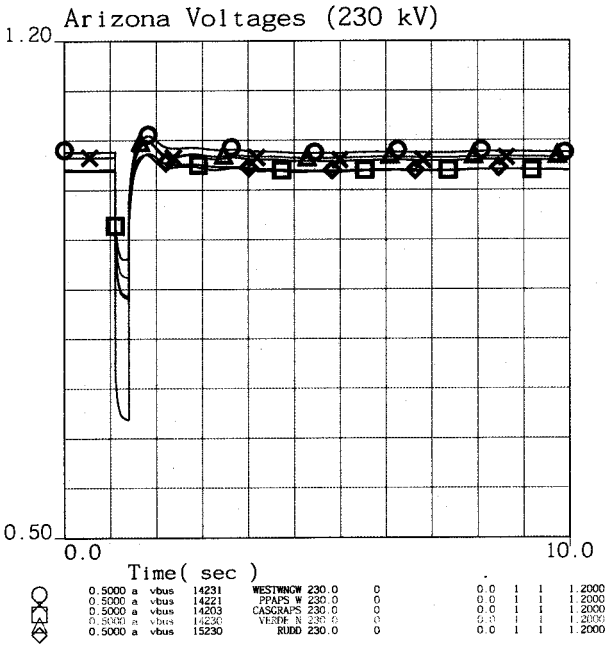

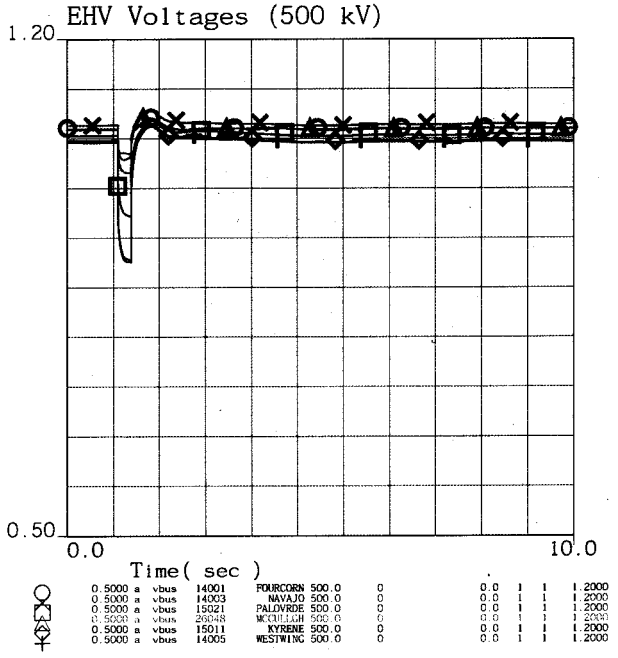

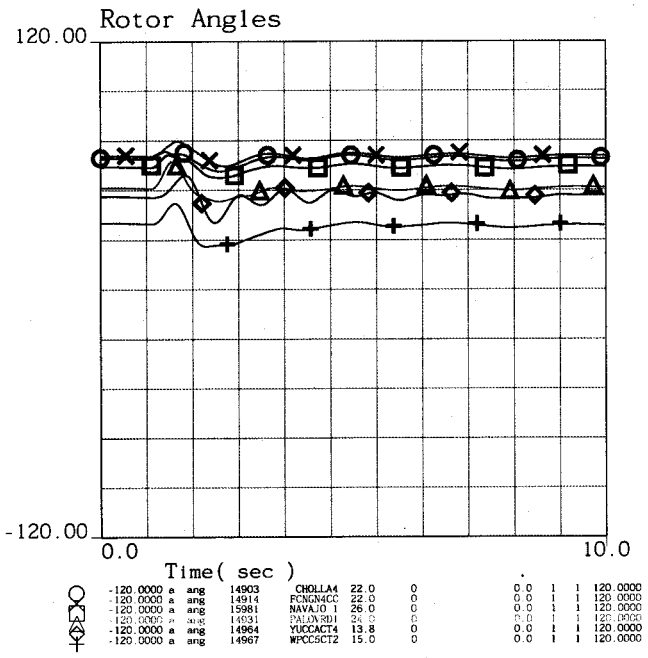

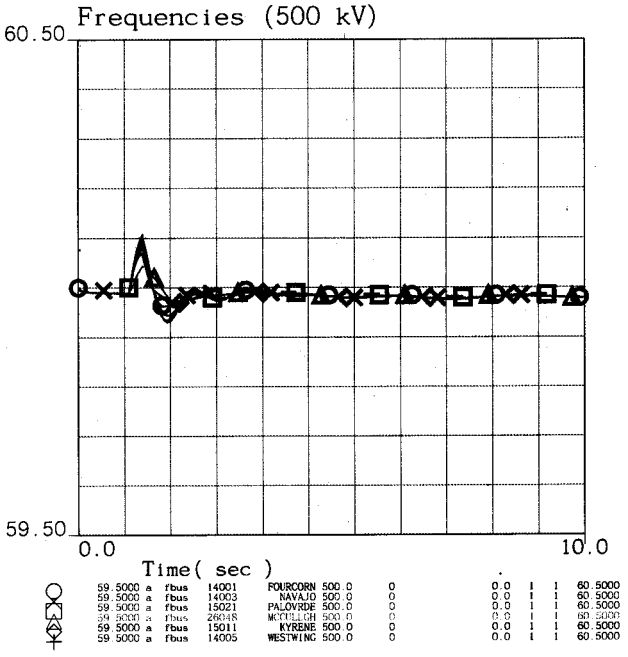

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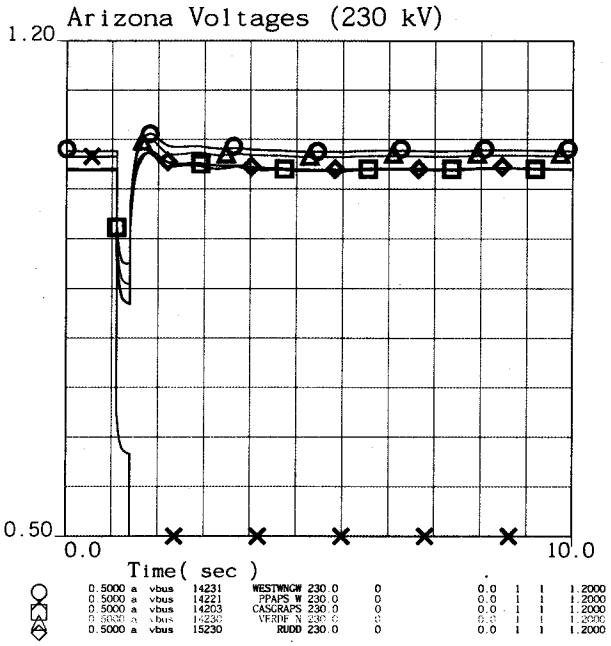

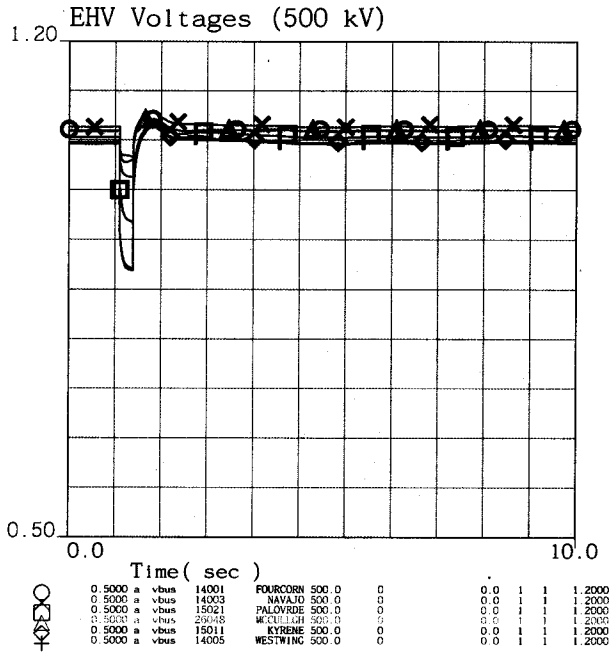

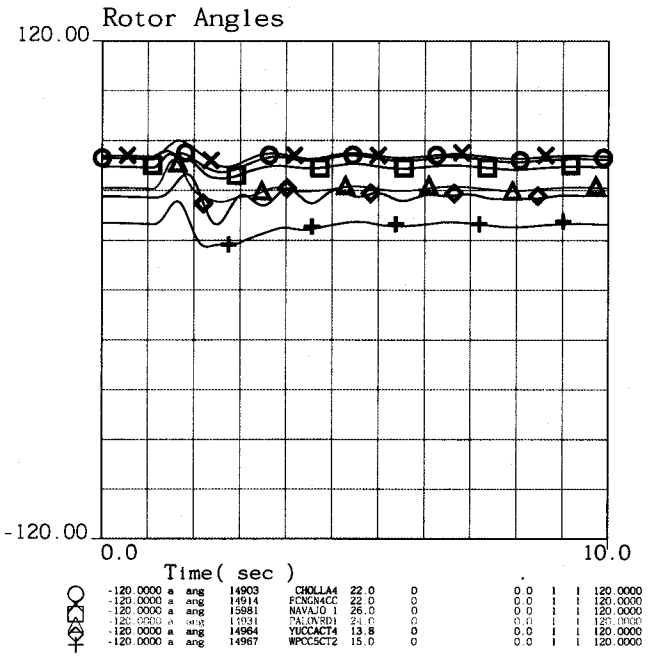

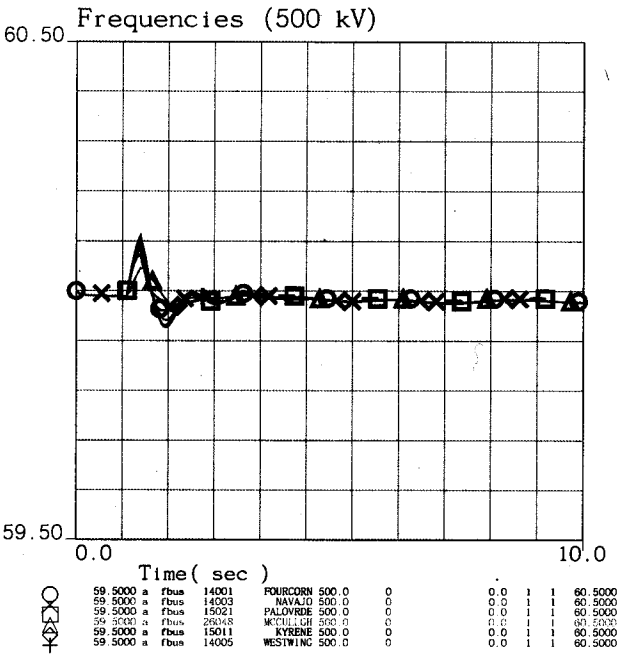

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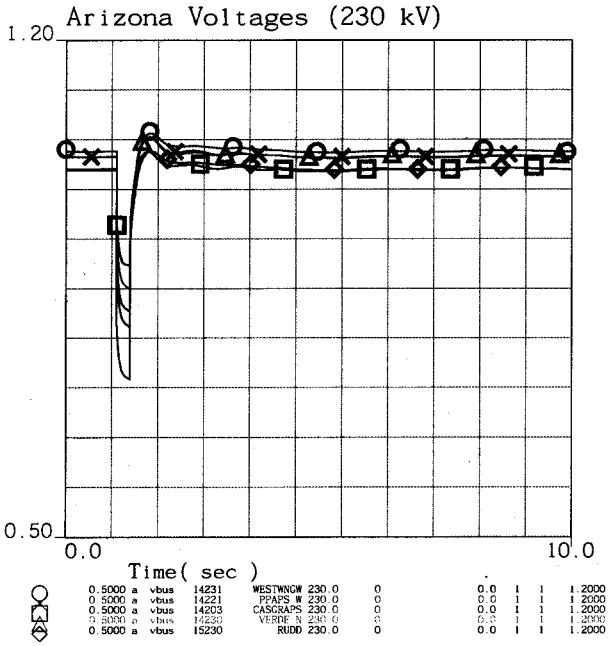

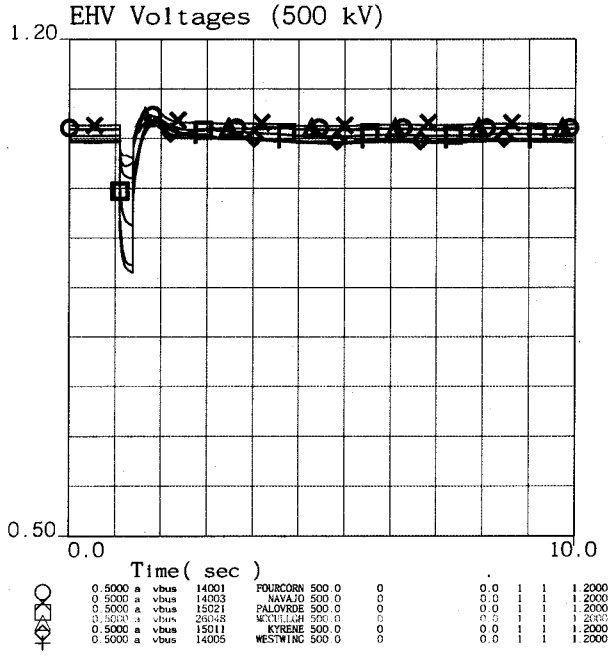

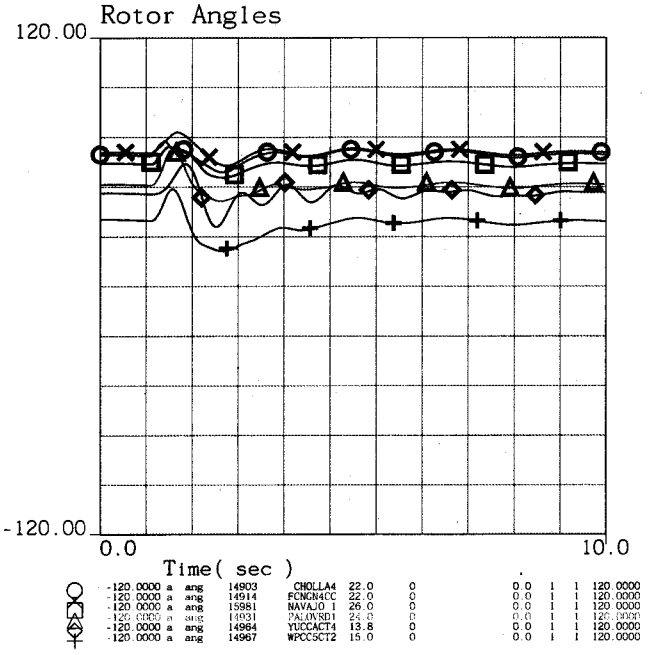

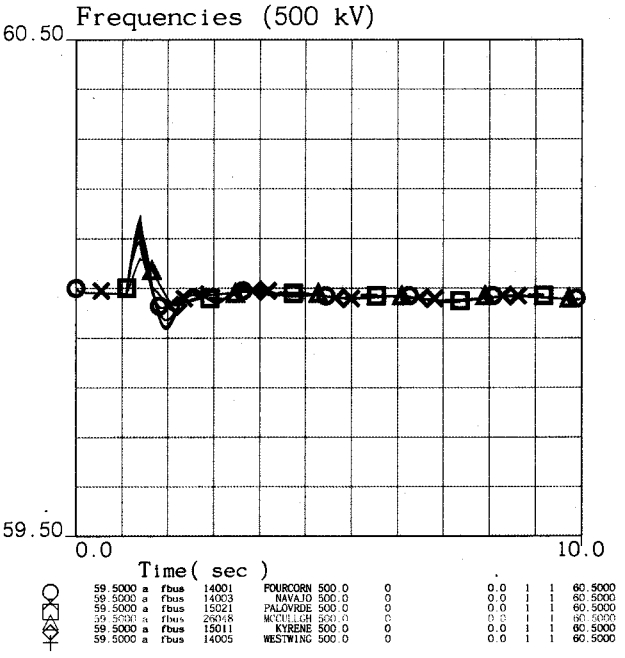

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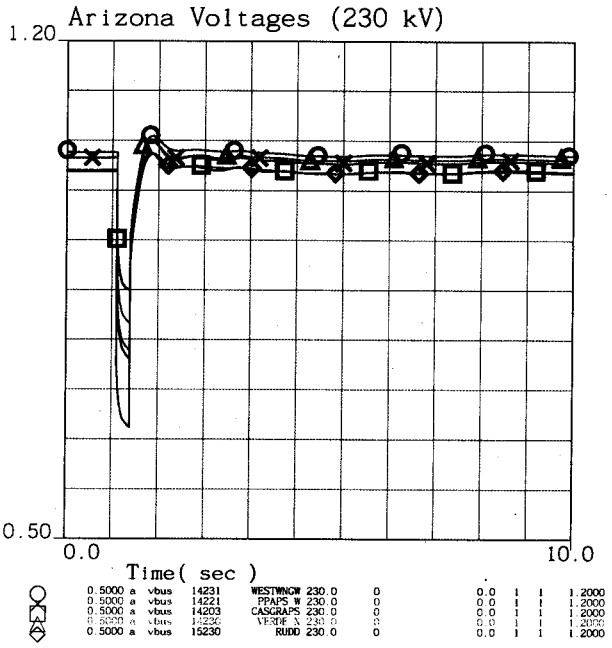

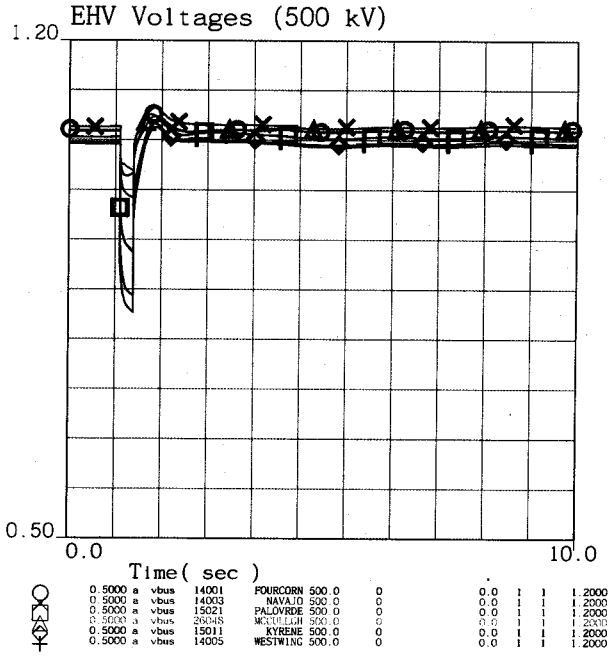

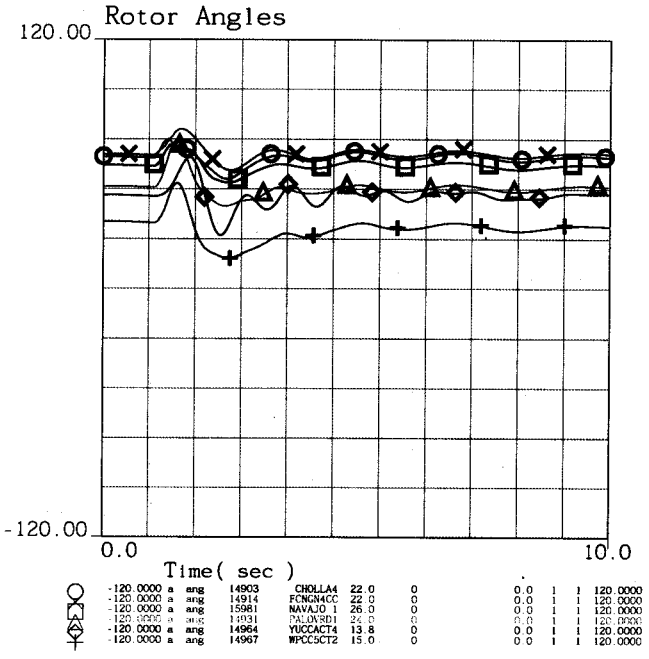

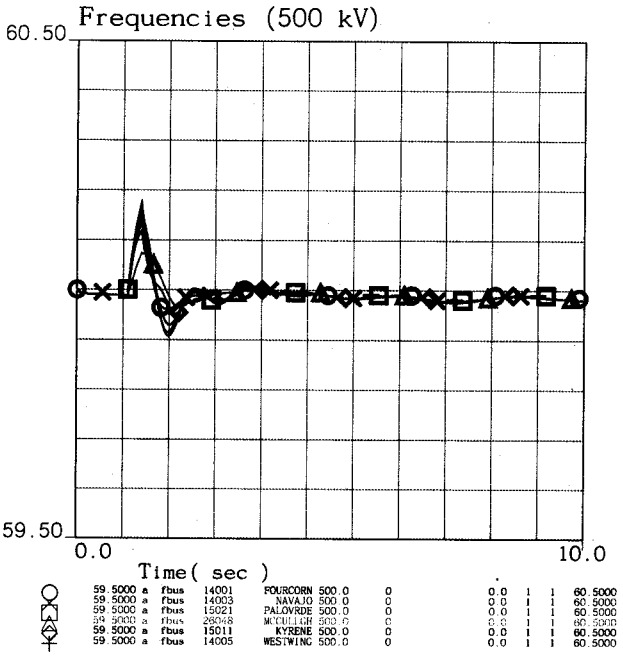

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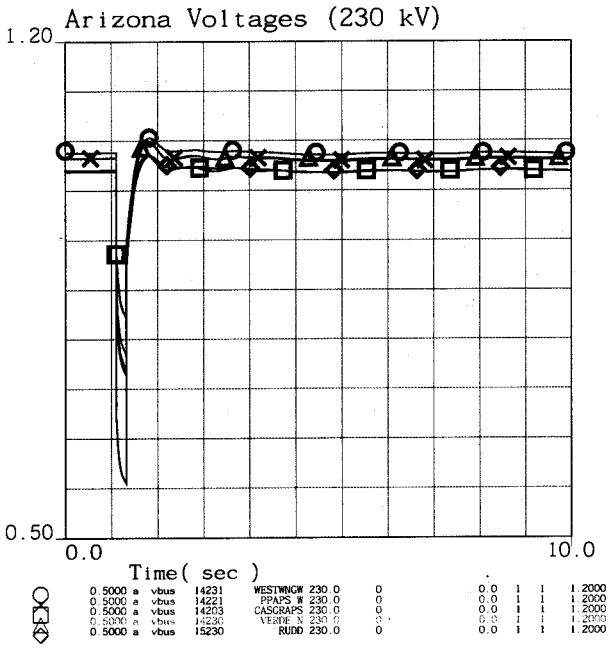

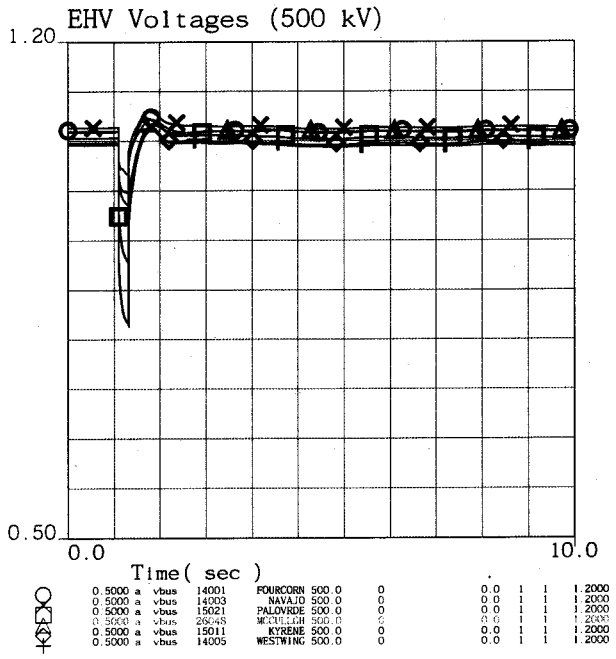

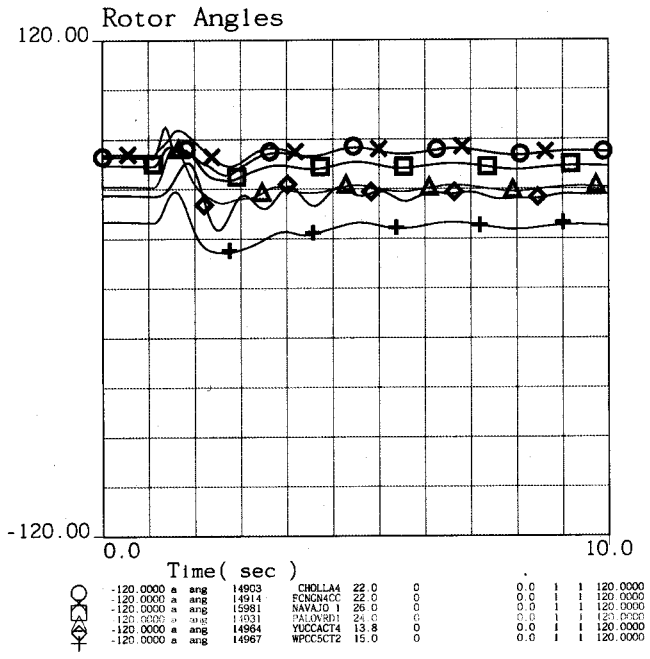

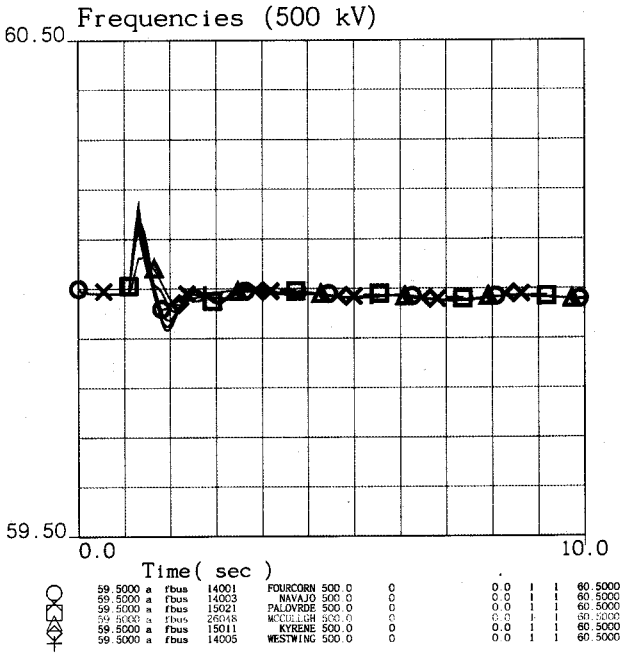

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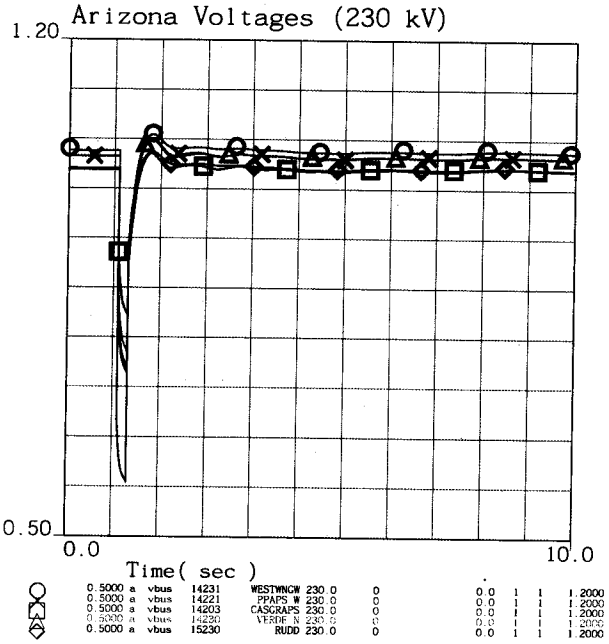

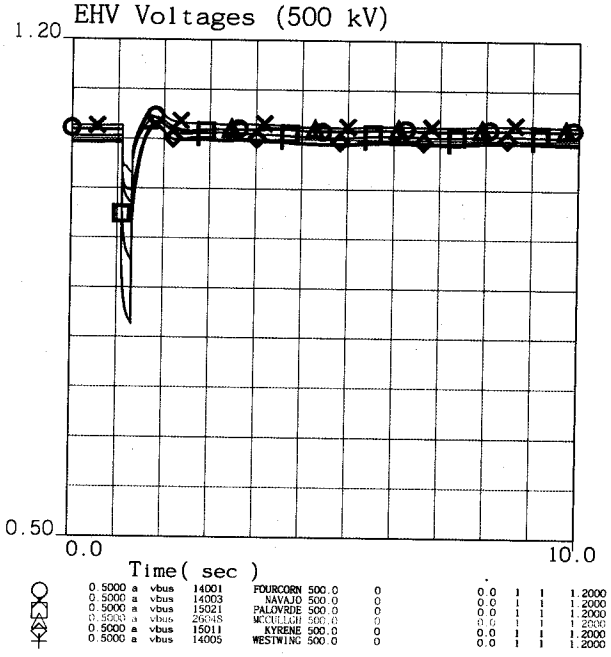

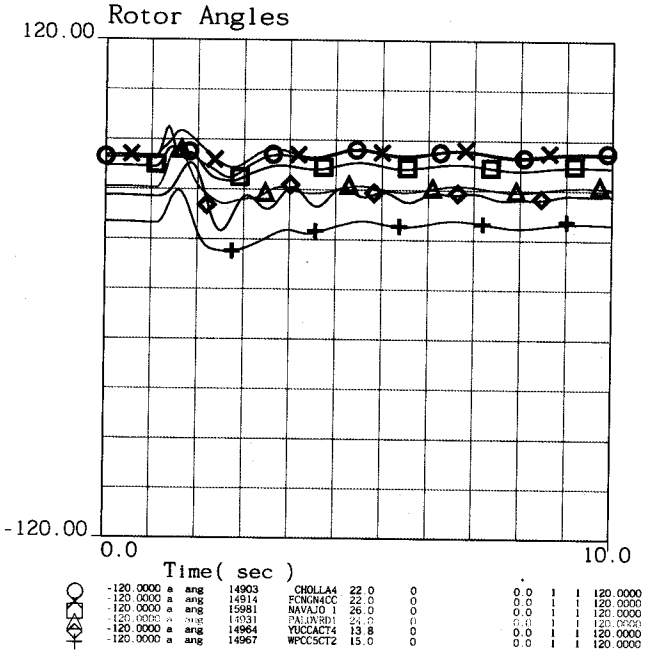

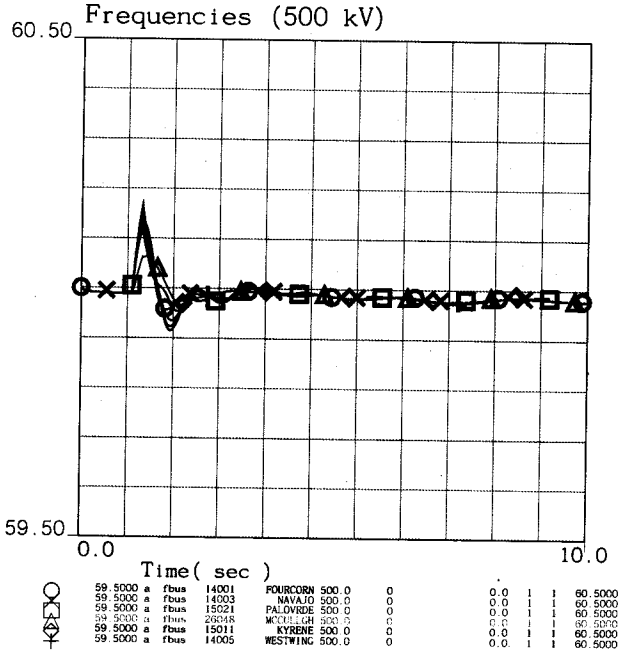

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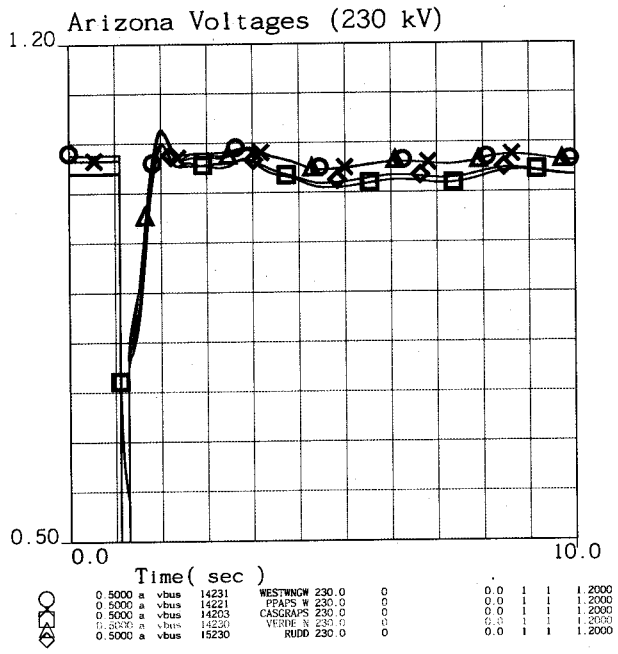

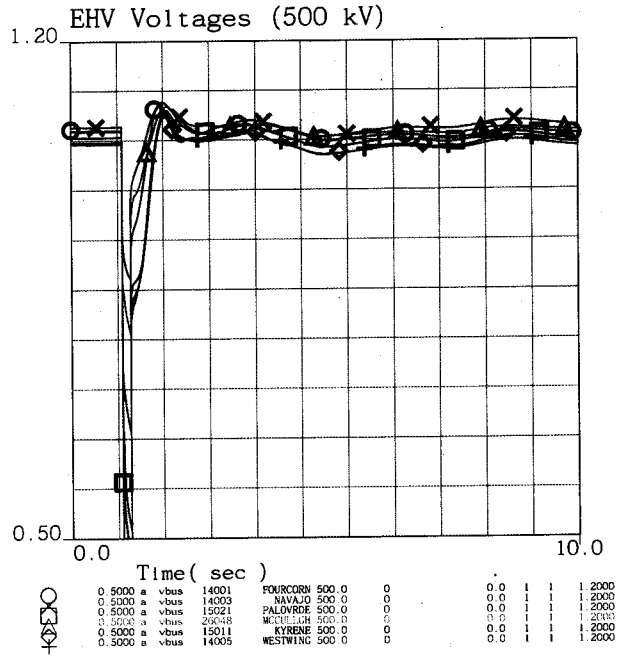

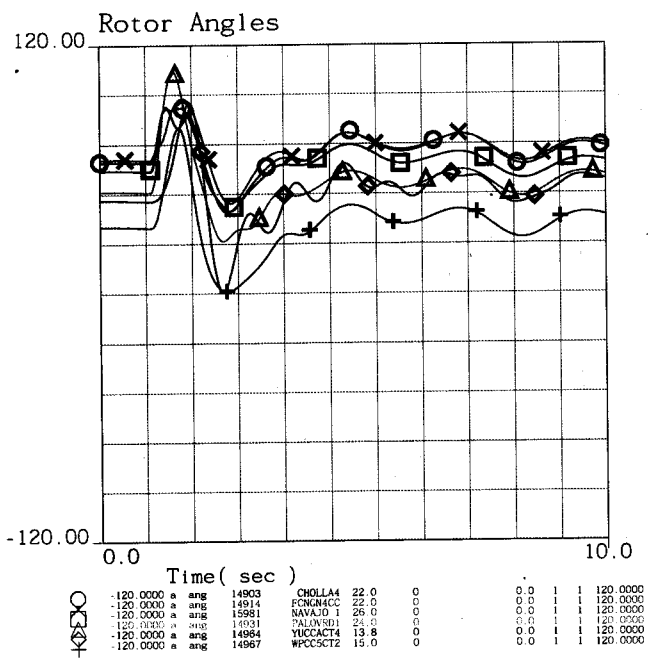

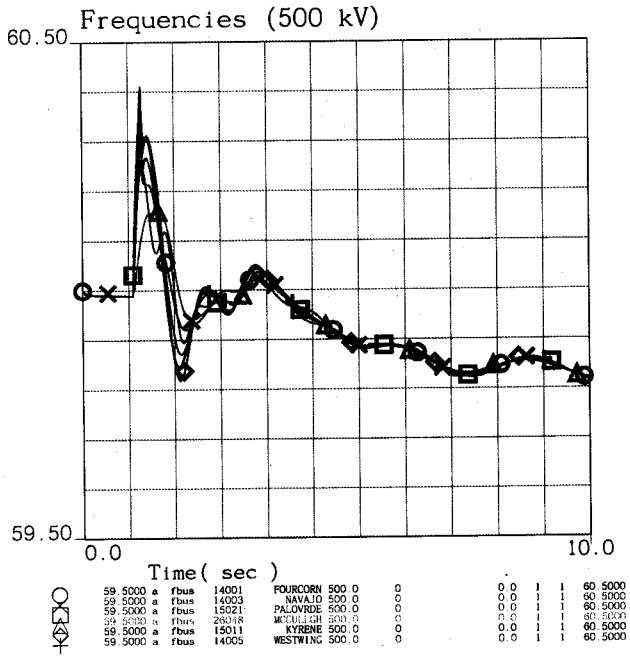

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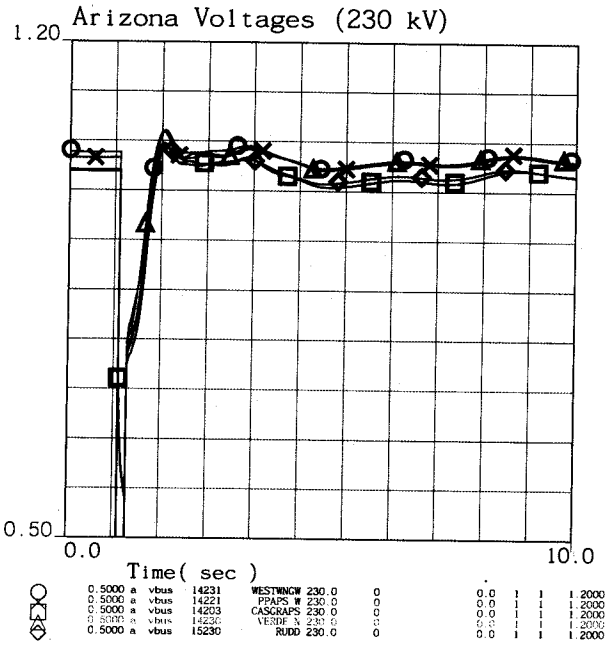

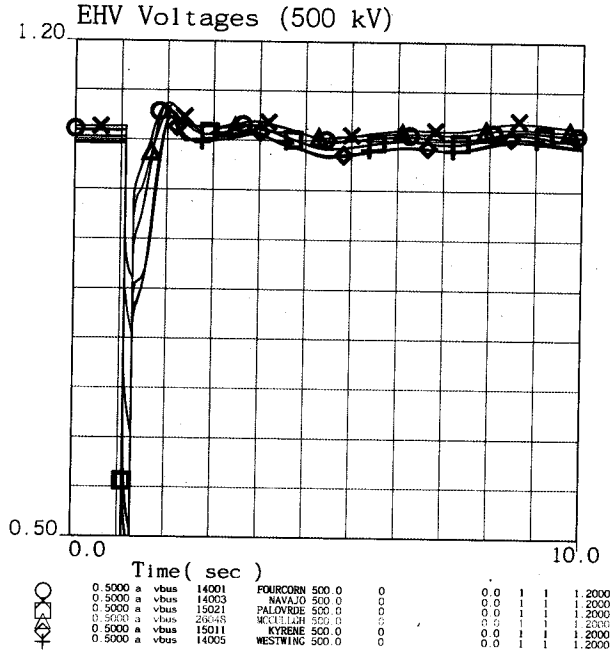

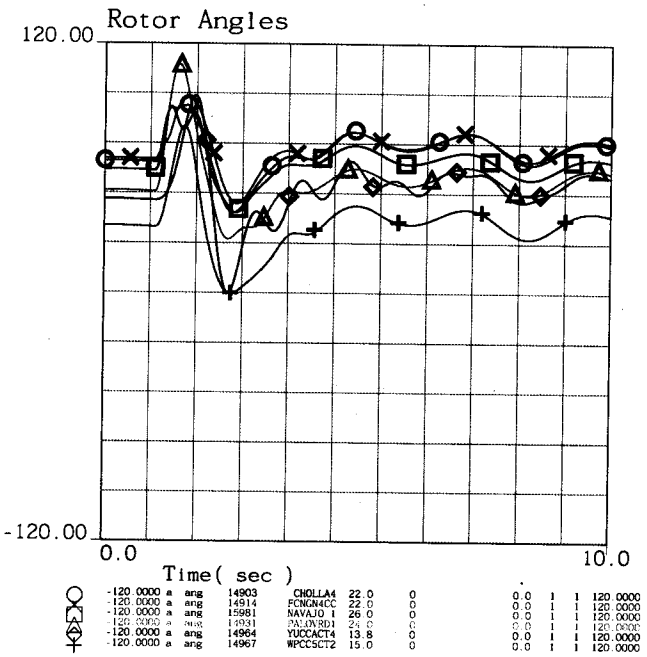

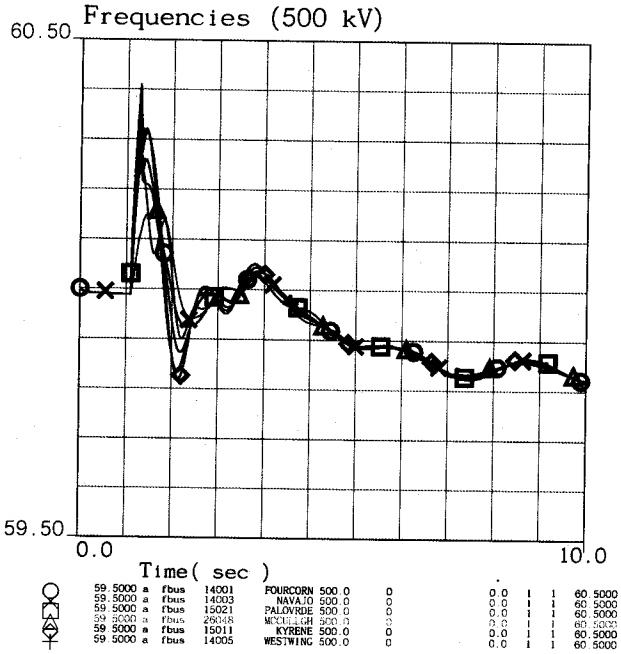

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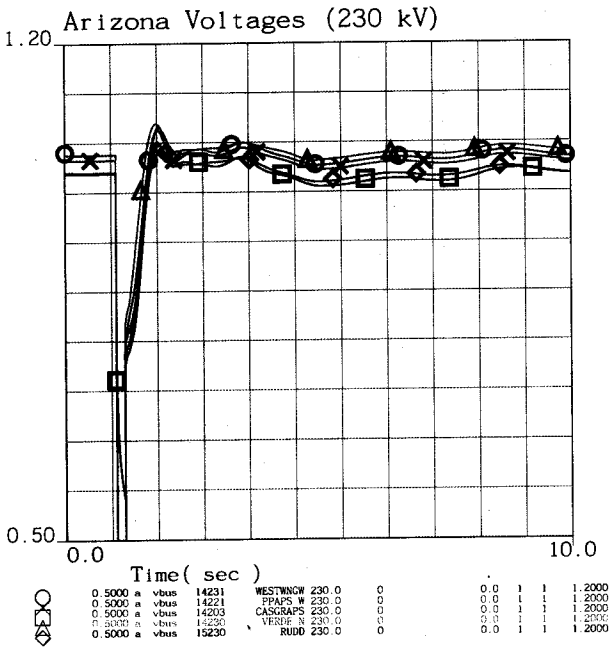

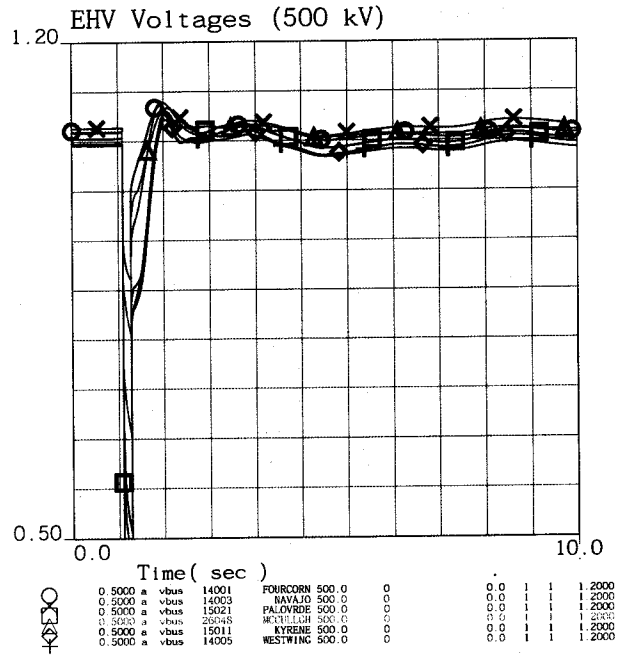

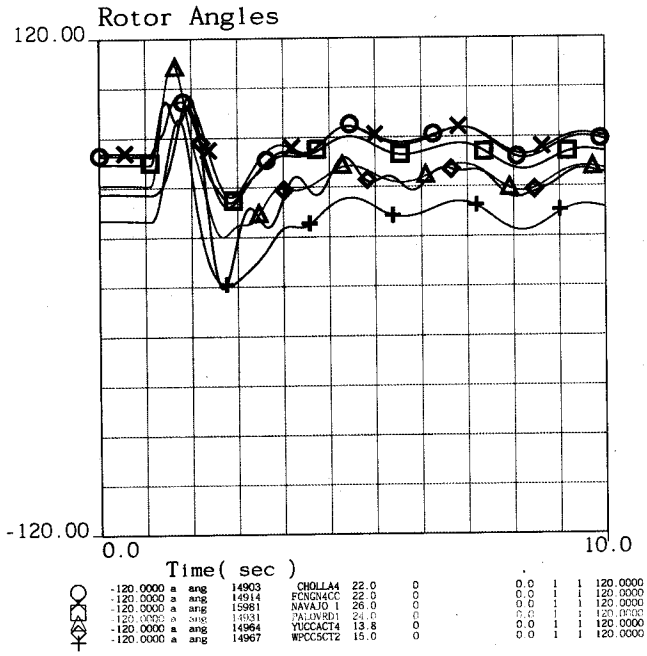

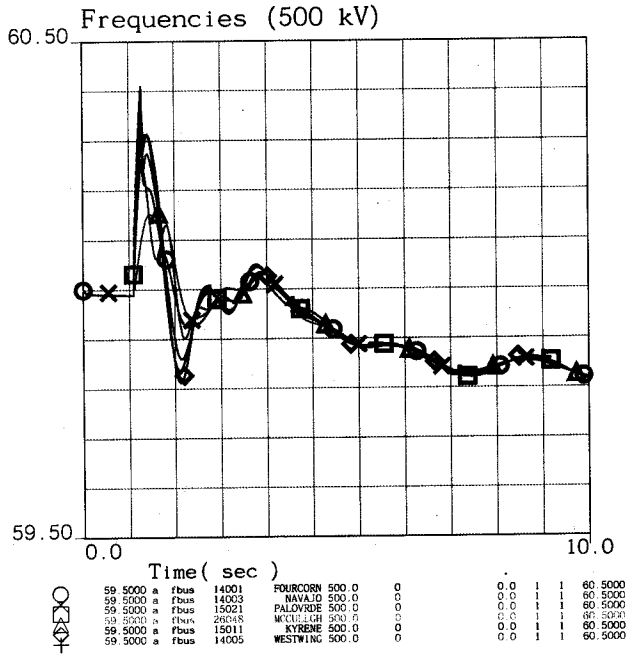

2018 Heavy Summer AZ Coordinated Case
Developed from WECC 18hs2a CASE
Updated by SRP,APS,WAPA,SWTC,TEP