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January 31, 2008

Arizona Corporation Commission
DOCKETED
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DOCKETED BY KK

Ernest Johnson
Director, Utilities Division
Arizona Corporation Commission
1200 W. Washington St.
Phoenix, Arizona 85007

Re: ARIZONA PUBLIC SERVICE COMPANY TEN-YEAR PLAN
DOCKET NO. E-00000D-07-0376.

Dear Mr. Johnson:

In compliance with A.R.S. § 40-360.02 and pursuant to Arizona Corporation Commission ("Commission") Decision No. 63876 (July 25, 2001), enclosed please find Arizona Public Service Company's ("APS" or "Company") 2008-2017 Ten-Year Plan for major transmission facilities, along with associated system ratings.

The 2008-2017 Ten-Year Plan describes planned transmission lines of 115 kV or higher that APS may construct over the next 10 years. This Ten-Year Plan includes approximately 181 miles of new 500 kV transmission lines, 96 miles of new 230 kV transmission lines, and 19 new bulk transformers. The APS investment needed to construct these projects is currently estimated to exceed $900 million. When completed, these projects are expected to add approximately 2000 MW of additional Extra-High Voltage scheduling capacity, as well as 3837 MW of import capability into the Metropolitan Phoenix Area and 272 MW of import capability into Yuma.

These new transmission projects, coupled with additional distribution and sub-transmission investments, will support reliable power delivery in APS' service area, Arizona, and in the western United States. The Ten-Year Plan as well as other APS reliability-related infrastructure investments, however, are premised on a number of assumptions including the regulatory treatment of such investments by the Commission and the Federal Energy Regulatory Commission ("FERC"), other state and federal policies affecting transmission, and, of course, APS' ability to finance large investments of this nature on commercially-reasonable terms.

In addition, ACC Decision No. 69389 (March 22, 2007) ordered that in the next Biennial Transmission Assessment, Commission regulated electric utilities, in consultation with the stakeholders, should prepare an assessment of Available Transmission Capacity for renewable energy and prepare a plan, including a description of the location, amount and transmission needs of renewable resources in Arizona, to bring available renewable resources to load. This assessment is currently being developed and discussed with Southwest Area Transmission ("SWAT") and other stakeholders and will be filed in this docket in the near future.

Please contact Jeff Johnson at 602-250-2661 if you have any questions or desire additional information concerning this filing.

Sincerely,

Barbara A. Klemstine

Cc: Docket Control (Original, plus 13 copies)
Jennifer A. Boucek, Assistant Attorney General
Brian Bozzo, Compliance & Enforcement

Enclosures

ARIZONA PUBLIC SERVICE COMPANY
2008–2017
TEN-YEAR PLAN

Prepared for the

Arizona Corporation Commission

January 2008

ARIZONA PUBLIC SERVICE COMPANY
2008–2017
TEN-YEAR PLAN

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ARIZONA PUBLIC SERVICE COMPANY
2008 - 2017
TEN-YEAR PLAN

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ARIZONA PUBLIC SERVICE COMPANY
2008–2017
TEN-YEAR PLAN

GENERAL INFORMATION

Pursuant to A.R.S. § 40-360.02, Arizona Public Service Company ("APS") submits its 2008-2017 Ten-Year Plan. Additionally, pursuant to Arizona Corporation Commission ("Commission") Decision No. 63876 (July 25, 2001) concerning the first Biennial Transmission Assessment, APS is including with this filing its Transmission Planning Process and Guidelines and maps showing system ratings on APS' transmission system. The Transmission Planning Process and Guidelines outline generally APS' internal planning for its high voltage and extra-high voltage transmission system, including a discussion of APS' planning methodology, planning assumptions, and its guidelines for system performance. The system ratings maps show continuous and emergency system ratings on APS' extra-high voltage system, and on its Metro, Northern, and Southern 230kV systems.

This 2008–2017 Ten-Year Plan describes planned transmission lines of 115kV or higher voltage that APS may construct, or participate in, over the next ten-year period. Pursuant to A.R.S. § 40-360(10), underground facilities are not included. There are approximately 181 miles of 500kV transmission lines, 96 miles of 230kV transmission lines, and 19 bulk transformers contained in the projects in this Ten-Year Plan filing. The total investment for the APS projects and the anticipated APS portion of the participation projects as they are modeled in this filing is estimated to be approximately $900 Million and the projects will add an expected 2000 MW of additional EHV scheduling capability. Also, over the next ten years the import capability into the Phoenix area will increase by 3837 MW, while the import capability into the Yuma area will increase by 272 MW. The following table shows a breakdown of the projects contained in this Ten-Year Plan.

	Projects in Ten-Year Plan
500kV transmission lines	181 miles
230kV transmission lines	96 miles
Bulk Transformers	19
Total Investment	$900 Million
EHV Scheduling Capability	+2000 MW (+28 %)[1]
Total Phoenix Area Import	+3837 MW (+28 %)[1]
Yuma Area Import	+272 MW (+65 %)[1]

[1]. Based on 2007 values.

Also, some of the previously reported facilities that have been completed, canceled, or deferred beyond the upcoming ten-year period are not included. The projects at the end of this Ten-Year Plan that have in-service dates of To Be Determined (TBD) are projects that have been identified, but are either still outside of the ten-year planning window or their in-service dates have not yet been established. They have been included in this filing for informational purposes. A summary of changes from last year's plan is provided below, along with a list of projects that have been added to this year's Ten-Year Plan. Also, a section is included that briefly describes any projects that are still in the feasibility planning phase.

For the convenience of the reader, APS has included system maps showing the electrical connections and in-service dates for all overhead transmission projects planned by APS for Arizona, the Phoenix Metropolitan Area, and the Yuma Area. Written descriptions of each proposed transmission project are provided on subsequent pages in the currently expected chronological order of each project. The line routings shown on the system maps and the descriptions of each transmission line are intended to be general, showing electrical connections and not specific routings, and are subject to revision. Specific routing is recommended by the Arizona Power Plant and Transmission Line Siting Committee and ultimately approved by the

Commission when issuing a Certificate of Environmental Compatibility and through subsequent right-of-way acquisition. Pursuant to A.R.S. § 40-360.02, this filing also includes technical study results for the projects identified. The technical study results show project needs which are generally based on either security (contingency performance), adequacy (generator interconnection or increasing transfer capability) or both.

APS participates in numerous regional planning organizations and in the WestConnect organization. Through membership and participation in these organizations the needs of multiple entities, and the region as a whole, can be identified and studied. This allows for the potential of maximizing the effectiveness and utilization of new projects. Regional organizations that APS is a member of include the Western Electricity Coordinating Council (WECC), the Southwest Area Transmission Planning (SWAT), and WestConnect which established a formal sub-regional transmission planning process during 2007. The plans included in this filing are the result of these coordinated planning efforts. APS is open to other entities participating in any existing or future planned projects.

APS believes that the projects identified in this 2008-2017 Ten-Year Plan, with their associated in-service dates, will ensure that APS' transmission system meets all applicable reliability criteria. Changes in regulatory requirements or underlying assumptions such as load forecasts, generation or transmission expansions, economic issues, and other utilities' plans, may substantially impact this Ten-Year Plan and could result in changes to anticipated in-service dates or project scopes. Additionally, future federal and regional mandates may impact this Ten-Year Plan specifically and the transmission planning process in general. This Ten-Year Plan is tentative information only and, pursuant to A.R.S. § 40-360.02(F), is subject to change without notice at the discretion of APS, based on land usage, growth pattern changes, regulatory or legal developments, or for other reasons.

Changes from 2007-2016 Ten-Year Plans

The following is a list of projects that were changed or removed from the Ten-Year plan filed last year, along with a brief description of why the change was made.

- Palo Verde – Sun Valley 500kV line & Sun Valley – TS9 500kV line

  The 2007-2016 Ten-Year Plan showed the TS5 500kV substation as one of the terminations of each of these lines. In the 2008-2017 Ten-Year Plan, the TS5 500kV substation has been renamed and referred to as the Sun Valley 500kV substation. Also, the last Ten-Year Plans showed the in-service date for Palo Verde-Sun Valley 500 kV & Sun Valley – TS1 230 kV projects as 2009. The latest planning studies show that the in-service date for the project can be delayed until 2010.

- TS9-Raceway-Avery-TS6-Pinnacle Peak 230 kV line

  The 2007-2016 Ten-Year Plans showed the in-service date for the proposed Raceway-Avery 230 kV line as 2009. Also, the 2007-2016 Ten-Year Plans showed the in-service date for the proposed Avery-TS6-Pinnacle Peak 230kV line as 2010. The latest planning studies show that the in-service date for the 230kV line between Raceway and Pinnacle Peak can be delayed until 2010, with the in-service date for the Avery substation being in 2013 and the in-service date for the TS6 substation being in 2012. Also, the in-service date for the 500/230kV transformer and 230kV line from TS9 to Raceway would be 2012.

- Sugarloaf loop-in of Coronado-Cholla 500 kV line

  The 2007-2016 Ten-Year plan has the Second Knoll loop-in of the 500 kV Coronado-Cholla line. In the 2008-2017 Ten year plan, Second Knoll substation has been renamed and referred to as the Sugarloaf substation.

- 345/69 kV Interconnection at Western's Flagstaff 345 kV bus

  The 2007-2016 Ten-Year Plans showed the in-service date for this interconnection as 2009. The latest planning studies show that the in-service date for the interconnection can be delayed until 2010.

- Jojoba loop-in of TS4-Panda 230 kV line.

The 2007-2016 Ten-Year Plans showed the in- service date for the proposed Jojoba loop-in of TS4- Panda 230 kV projects as 2011. The latest planning studies show that the in-service date for the project can be delayed until 2013.

- Sundance-Pinal South 230 kV line

  The 2007-2016 Ten-Year Plans showed a single circuit for the 230 kV Sundance-Pinal South line. The latest planning studies show that a second circuit between the two substations will allow APS to reliably and economically deliver energy to APS transmission system. The in-service date for the second circuit will be evaluated in future planning studies.

- Sun Valley – TS11 – Buckeye 230 kV line.

  The 2007-2016 Ten-year plans showed a 230 kV line between APS' Sun Valley and Buckeye substations. The 2008-2017 Ten-year plans show that a new TS11 substation will now be interconnected to the original 230 kV line.

New Projects in the 2008-2017 Ten-Year Plan

- Sun Valley-TS9 230 kV line.

  This project will be a 230 kV line built between future APS' future Sun Valley and TS9 substation. This 230 kV line originates from the Sun Valley 500/230 kV substation and is proposed to be the 230 kV portion of a double circuit with the Sun Valley- TS9 500 kV line. The timing of this project is to be determined.

- North Gila- Yucca 230 kV line

  This project will be a 230 kV line between APS' North Gila and Yucca Substations. The timing of this project is still to be determined.

- Sun Valley-TS10-TS11 230 kV line

  This project will be a 230 kV line from APS' Sun Valley substation to TS11 substation, with the future TS10 substation to be interconnected to the line. The timing of this project is still to be determined.

Conceptual Projects in the Feasibility Planning Phase

The following projects, described below for informational purposes, are still in a preliminary planning phase, and are dependent on future resource alternative selection.

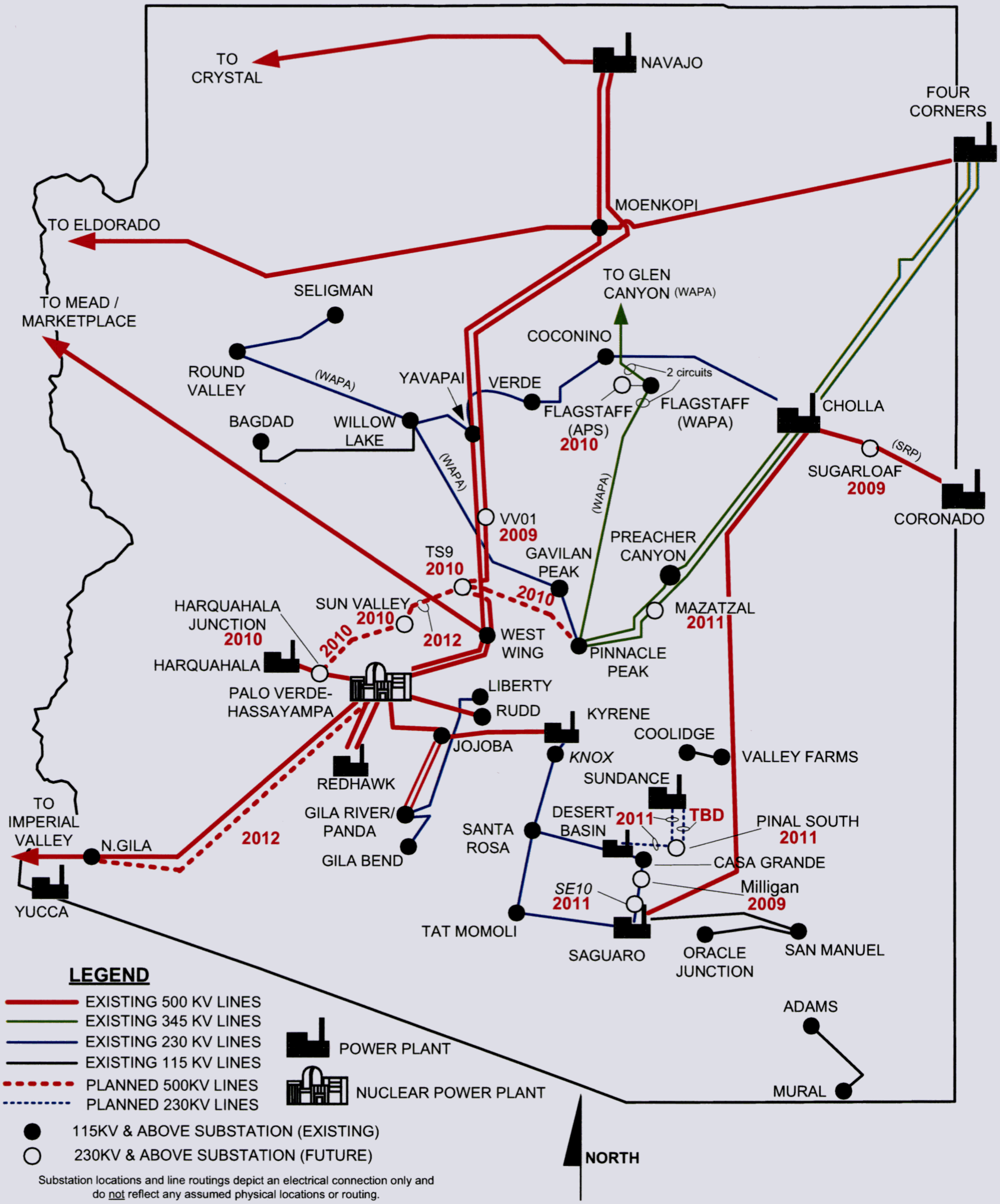
- TransWest Express Project

  In August 2007, APS entered into an agreement with PacifiCorp, National Grid and the Wyoming Infrastructure Authority to co-develop the TransWest Express project and PacifiCorp's recently announced Gateway South Transmission project. The Trans West Express Project involves construction of a 500 kV DC transmission line from Wyoming to Arizona with a capacity of 3000 MW. This project provides multiple benefits, which include the ability to meet the growing demand for electricity, improved reliability of the entire western grid, expanded access to renewable energy resources, lower environmental impact through combined use of transmission corridors and greater economies of scale. The proposed in-service date for this project is 2015.

- Cholla – Phoenix Metropolitan Area 500kV line

This project will be a 500kV line that will be built between APS' Cholla 500kV substation and the Phoenix Metropolitan area and is being studied as a means to provide access to Cholla area resources for APS. The scope and timing for this project is still under study.

APS EHV & OUTER DIVISION 115/230 KV TRANSMISSION PLANS 2008 - 2017

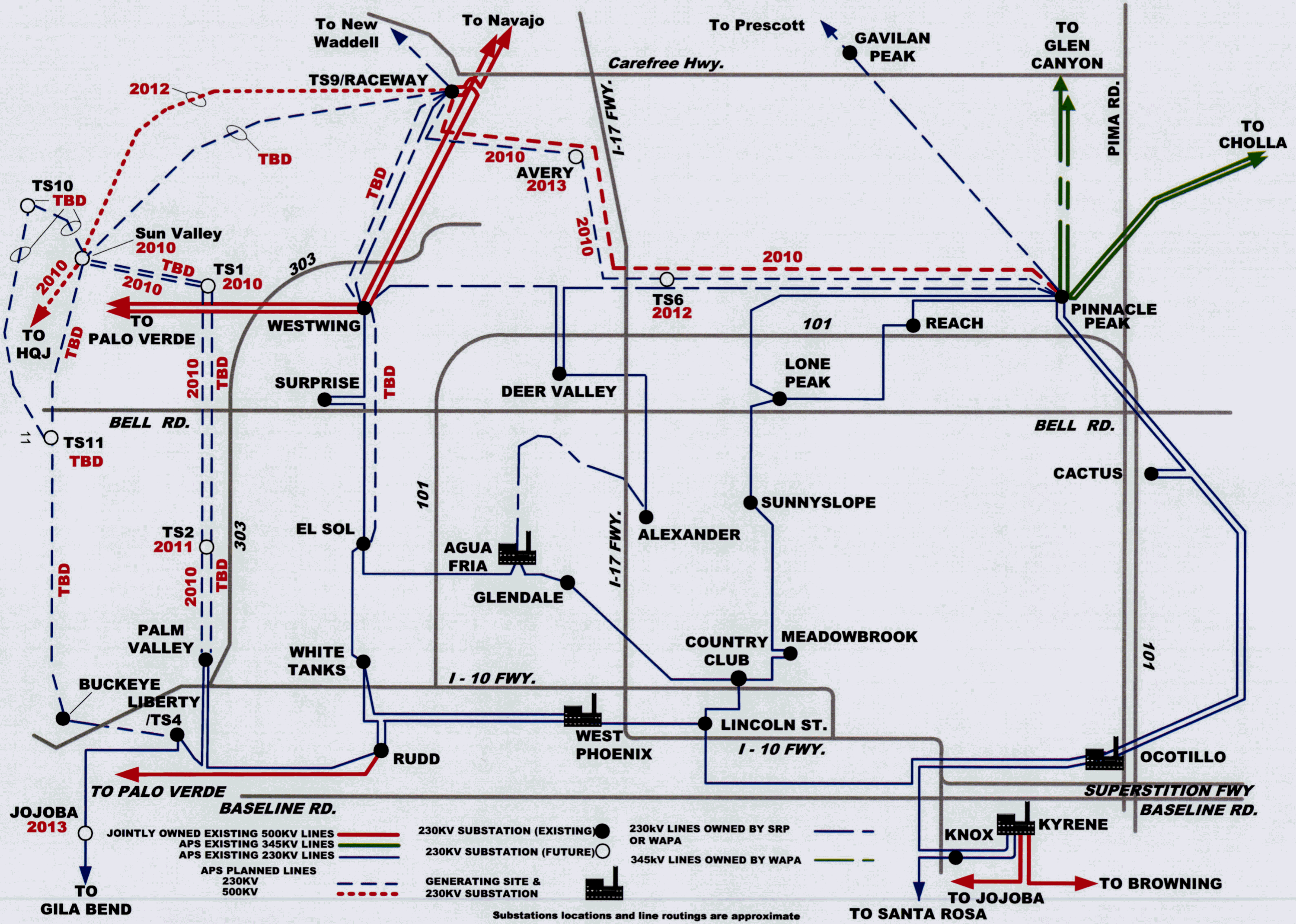


LEGEND

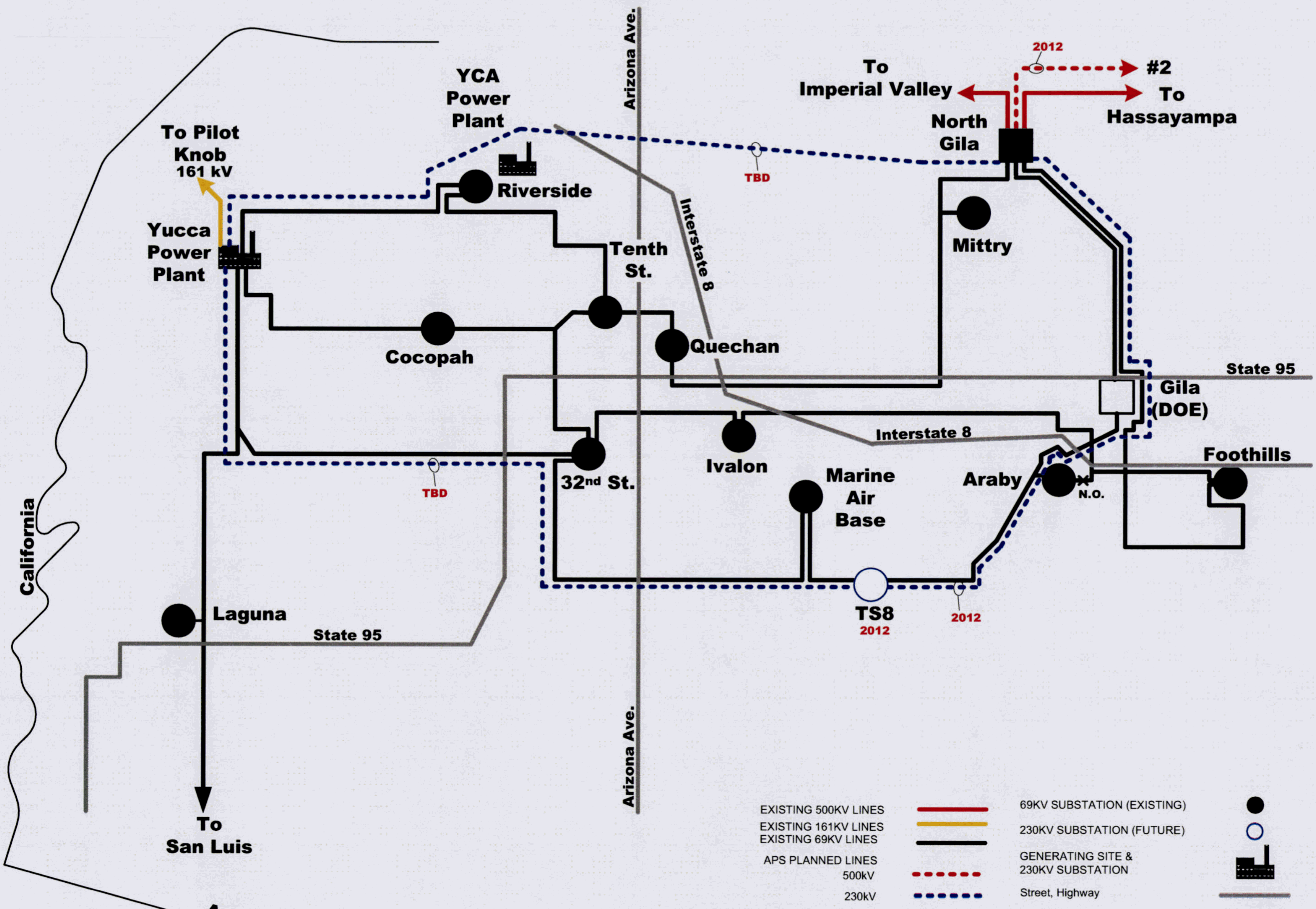
- EXISTING 500 KV LINES
- EXISTING 345 KV LINES
- EXISTING 230 KV LINES
- EXISTING 115 KV LINES
- PLANNED 500KV LINES
- PLANNED 230KV LINES
- POWER PLANT
- NUCLEAR POWER PLANT
- 115KV & ABOVE SUBSTATION (EXISTING)
- 230KV & ABOVE SUBSTATION (FUTURE)

Substation locations and line routings depict an electrical connection only and do not reflect any assumed physical locations or routing.

PHOENIX METROPOLITAN AREA TRANSMISSION PLANS 2008-2017



Yuma Area Transmission Plans 2008- 2017



Substation locations and line routings depict an electrical connection only and do not reflect any assumed physical locations or routing.

Project Name: Sugarloaf loop-in of Coronado - Cholla 500kV line

Planned In-Service Date: 2009

Project Sponsor: Arizona Public Service

Other Participants: SRP

Voltage Class: 525kV AC

Facility Rating: 240 MVA

Point of Origin: Coronado - Cholla 500kV line; Sec. 9, T14N, R21E

Point of Termination: Sugarloaf 500/69kV substation to be in-service in 2009; Sec. 9, T14N, R21E

Intermediate Points of Interconnection:

Length of Line (in miles): Less than 1 mile

General Route:

The Sugarloaf substation will be constructed adjacent to the existing Coronado-Cholla 500kV line.

Purpose of Project:

This project is needed to provide the electrical source and support to the sub-transmission system to serve the increasing need for electric energy in Show Low and the surrounding communities. The project will improve reliability and continuity of service for the growing communities in the area. The Sugarloaf substation will interconnect into SRP's Coronado-Cholla 500kV line, therefore SRP will construct, own, and operate the new Sugarloaf 500kV substation.

Schedule:

Construction Start: 2008

In-Service Date: 2009

Permitting / Siting Status:

It is not anticipated that a Certificate of Environmental Compatibility will be needed for this project.

Project Name: **Milligan loop-in of Saguaro-Casa Grande 230kV line**

Planned In-Service Date: **2009**

Project Sponsor: Arizona Public Service

Other Participants: None

Voltage Class: 230kV AC

Facility Rating: 188 MVA

Point of Origin: Saguaro-Casa Grande 230kV line; Sec. 18, T8S, R8E

Point of Termination: Milligan substation to be in-service by 2009; Sec. 18, T8S, R8E

Intermediate Points of Interconnection:

Length of Line (in miles): Less than 1 mile

General Route:

The Milligan 230/69kV substation will be constructed adjacent to the Saguaro-Casa Grande 230kV line.

Purpose of Project:

This project is needed to provide the electrical source and support to the sub-transmission system to serve the increasing need for electric energy in southern Pinal County, in the Eloy area. The project will also increase the reliability and continuity of service for those areas.

Schedule:

Construction Start: 2008

In-Service Date: 2009

Permitting / Siting Status:

It is not anticipated that a Certificate of Environmental Compatibility will be needed for this project.

Project Name: VV01 loop-in of Navajo - Westwing 500kV line

Planned In-Service Date: 2009

Project Sponsor: Arizona Public Service

Other Participants: None

Voltage Class: 525kV AC

Facility Rating: 240 MVA

Point of Origin: Navajo-Westwing 500kV line; approximately Sec. 24, T12N, R2E

Point of Termination: VV01 substation to be in-service by 2009; approximately Sec. 24, T12N, R2E

Intermediate Points of Interconnection:

Length of Line (in miles): Less than 1 mile

General Route:

The VV01 substation will be constructed adjacent to the Navajo-Westwing line.

Purpose of Project:

This project is needed to provide the electrical source and support to the sub-transmission system to serve the increasing electrical needs in the Verde Valley and Prescott areas. Also, the project will result in increased reliability and continuity of service for the Verde Valley and Prescott areas.

Schedule:

Construction Start: 2008

In-Service Date: 2009

Permitting / Siting Status:

It is not anticipated that a Certificate of Environmental Compatibility will be needed for this project.

Project Name: 345/69kV Interconnection at Western's Flagstaff 345kV bus

Planned In-Service Date: 2010

Project Sponsor: Arizona Public Service

Other Participants: None

Voltage Class: 345kV AC

Facility Rating: 200 MVA

Point of Origin: Western's Flagstaff 345kV substation; Sec. 24, T21N, R9E

Point of Termination: A new Flagstaff 69kV substation to be in-service by 2010; Sec. 24, T21N, R9E

Intermediate Points of Interconnection:

Length of Line (in miles): Less than 1 mile

General Route:

A 345/69kV transformer will interconnect into Western's Flagstaff substation.

Purpose of Project:

This project is needed to provide the electrical source and support to the sub-transmission system to serve the increasing need for electric energy in APS's northern service area. The project will also improve reliability and continuity of service for the growing communities in northern Arizona.

Schedule:

Construction Start: 2009

In-Service Date: 2010

Permitting / Siting Status:

It is not anticipated that a Certificate of Environmental Compatibility will be needed for this project.

Project Name: Palo Verde Hub - Sun Valley 500kV line

Planned In-Service Date: 2010

Project Sponsor: Arizona Public Service

Other Participants: SRP, CAWCD

Voltage Class: 525kV AC

Facility Rating: To be determined

Point of Origin: Palo Verde Switchyard or a new switchyard at Arlington Valley Energy Facility.

Point of Termination: Sun Valley substation to be in-service by 2010; Sec. 29, T4N, R4W

Intermediate Points of Interconnection: Proposed Harquahala Junction substation; approximately Sec. 25, T2N, R8W

Length of Line (in miles): Approximately 45 miles

General Route:

Generally leaving the Palo Verde Hub vicinity following the Palo Verde-Devers #1 and the Hassayampa-Harquahala 500kV lines until crossing the CAP canal. Then easterly, generally following the CAP canal, on the north side of the canal to the new Sun Valley substation.

Purpose of Project:

This project is needed to serve projected need for electric energy in the area immediately north and west of the Phoenix Metropolitan area. It will increase the import capability to the Phoenix Metropolitan area as well as increase the export capability from the Palo Verde hub. This is a joint participation project with APS as the project manager. The initial plan of service for the project will be a 500kV line between the Harquahala Junction switchyard and the Sun Valley substation. The need for the 500kV line portion between the Harquahala Junction switchyard and the Palo Verde (or Arlington) switchyard will be continuously evaluated in future studies. The Harquahala Junction switchyard will interconnect into the existing Hassayampa-Harquahala 500kV line.

Schedule:

Construction Start: 2008

In-Service Date: 2010

Permitting / Siting Status:

Certificate of Environmental Compatibility issued 8/17/05 (Case No. 128, Decision No. 68063, Palo Verde Hub to TS5 500kV Transmission project). APS, as project manager, holds the CEC.

Project Name: Sun Valley - TS1 230kV line

Planned In-Service Date: 2010

Project Sponsor: Arizona Public Service

Other Participants: None

Voltage Class: 230kV AC

Facility Rating: 3000 A

Point of Origin: Sun Valley substation to be in-service by 2010; Sec. 29, T4N, R4W

Point of Termination: TS1 substation to be in-service by 2010; Sec. 20, T4N, R2W

Intermediate Points of Interconnection:

Length of Line (in miles): Approximately 15 miles

General Route:

East from the Sun Valley substation along the CAP canal to approximately 243rd Ave., south to the existing 500kV transmission line corridor, and then east along the corridor to the TS1 substation.

Purpose of Project:

This project is required to serve the increasing need for electric energy in the western Phoenix Metropolitan area. Also, the project will provide more capability to import power into the Phoenix Metropolitan area along with improved reliability and continuity of service for growing communities in the area; such as El Mirage, Surprise, Youngtown, Buckeye, and unincorporated Maricopa county. The first circuit is scheduled to be in-service for the summer of 2009 and the in-service date for the second circuit will be evaluated in future planning studies.

Schedule:

Construction Start: 2008

In-Service Date: 2010

Permitting / Siting Status:

Certificate of Environmental Compatibility issued 5/5/05 (Case No. 127, Decision No. 67828, West Valley North 230kV Transmission Line project).

Project Name: Palm Valley - TS2 - TS1 230kV line

Planned In-Service Date: 2010

Project Sponsor: Arizona Public Service

Other Participants: None

Voltage Class: 230kV AC

Facility Rating: 3000 A

Point of Origin: Palm Valley substation; Sec. 24, T2N, R2W

Point of Termination: TS1 substation to be in-service by 2010; Sec. 20, T4N, R2W

Intermediate Points of Interconnection: TS2 substation to be in-service by 2011; Sec. 25, T3N, R2W

Length of Line (in miles): Approximately 12 miles

General Route:

North from the Palm Valley substation, generally following the Loop 303 to Cactus road, west on Cactus road to approximately 191st Avenue, and then north on 191st Avenue to the TS1 substation. The future TS2 substation is currently projected to be in-service in 2011.

Purpose of Project:

This project is required to serve the increasing need for electric energy in the western Phoenix Metropolitan area, providing more capability to import power into the Phoenix Metropolitan area along with improved reliability and continuity of service for growing communities in the area; such as El Mirage, Surprise, Youngtown, Goodyear, and Buckeye. The first circuit is scheduled to be in-service for the summer of 2010 and the in-service date for the second circuit will be evaluated in future planning studies.

Schedule:

Construction Start: 2008

In-Service Date: 2010

Permitting / Siting Status:

The Palm Valley-TS2 230kV line portion was sited as part of the West Valley South 230kV Transmission Line project and a Certificate of Environmental Compatibility was issued 12/24/03 (Case No. 122, Decision No. 66646). The TS1-TS2 230kV line portion was sited as part of the West Valley North 230kV Transmission Line project and a Certificate of Environmental Compatibility was issued 5/5/05 (Case No. 127, Decision No. 67828).

Project Name: TS9 - Pinnacle Peak 500kV line

Planned In-Service Date: 2010

Project Sponsor: Arizona Public Service

Other Participants: SRP

Voltage Class: 525kV AC

Facility Rating: To be determined

Point of Origin: TS9 substation to be in-service by 2010; Sec. 33, T6N, R1E

Point of Termination: Pinnacle Peak substation; Sec. 10, T4N, R4E

Intermediate Points of Interconnection:

Length of Line (in miles): Approximately 26 miles

General Route:

South from TS9 substation approximately 2 miles, generally paralleling the Navajo-Westwing 500kV lines, then turning east at approximately Dove Valley road to approximately Interstate 17. At Interstate 17 the line heads south to Happy Valley road where it turns east to the Pinnacle Peak substation, paralleling the existing 230kV transmission line corridor.

Purpose of Project:

This project is a result of joint planning through the SWAT forum. The project is needed to increase the import capability to the Phoenix Metropolitan area and strengthen the transmission system on the east side of the Phoenix Metropolitan valley. This is anticipated to be a joint participation project with APS as the project manager. The loop-in of the Navajo-Westwing 500kV line into the TS9 substation will be a part of the project. Also, the line will be constructed as 500/230kV double-circuit capable, with the TS9-Raceway-Avery-TS6-Pinnacle Peak 230kV line as the 230kV circuit.

Schedule:

Construction Start: 2008

In-Service Date: 2010

Permitting / Siting Status:

Certificate of Environmental Compatibility issued on 2/13/07 (Case No. 131, Decision No. 69343, TS9-Pinnacle Peak 500/230kV Project).

Project Name: TS9 - Raceway - Avery - TS6 - Pinnacle Peak 230kV line

Planned In-Service Date: 2010

Project Sponsor: Arizona Public Service

Other Participants: None

Voltage Class: 230kV AC

Facility Rating: 3000 A

Point of Origin: TS9 230kV substation to be in-service by 2012; Sec. 33, T6N, R1E

Point of Termination: Pinnacle Peak substation; Sec. 10, T4N, R4E

Intermediate Points of Interconnection:
Raceway substation; Sec. 4, T5N, R1E
Avery substation to be in-service by 2013; Sec. 15, T5N, R2E
TS6 substation to be in-service by 2012; Sec. 8, T4N, R3E

Length of Line (in miles): Approximately 27 miles

General Route:

South from the TS9 substation to the existing Raceway substation, then south from Raceway approximately 1 mile, paralleling existing transmission lines. Then east approximately 9 miles, paralleling Dove Valley Road to the location of the future Avery substation. From Avery the line will continue east along Dove Valley Road to Interstate 17. At Interstate 17 the route will head south 5 miles, generally paralleling the west side of Interstate 17 until Happy Valley Road. The line will turn east, generally parallel to the existing 230kV transmission line corridor, for approximately 10 miles to the existing Pinnacle Peak substation.

Purpose of Project:

This project is needed to serve the increasing need for electric energy in the area immediately north of the Phoenix Metropolitan area and the northern portions of the Phoenix Metropolitan area. Additionally, improved reliability and continuity of service will result for the growing communities in the area; such as Anthem, Desert Hills, New River, and north Phoenix. The in-service date for the 500/230kV transformer at TS9 is currently scheduled for 2012. The in-service dates for the Avery and TS6 substations are currently scheduled for 2013 and 2012, respectively. The in-service dates for the substations and 500/230kV transformer at TS9 will be continuously evaluated in future planning studies.

Schedule:

Construction Start: 2008

In-Service Date: 2010

Permitting / Siting Status:

Certificate of Environmental Compatibility was issued2/13/07 (Case No. 131, Decision No. 69343, TS9-Pinnacle Peak 500/230kV Project).

Project Name: Mazatzal loop-in of Cholla-Pinnacle Peak 345kV line

Planned In-Service Date: 2011

Project Sponsor: Arizona Public Service

Other Participants: None

Voltage Class: 345kV AC

Facility Rating: 200 MVA

Point of Origin: Cholla-Pinnacle Peak or Preacher Canyon-Pinnacle Peak 345kV line; near Sec. 3, T8N, R10E

Point of Termination: Mazatzal substation to be in-service by 2011; Sec. 3, T8N, R10E

Intermediate Points of Interconnection:

Length of Line (in miles): Less than 1 mile

General Route:

The Mazatzal 345/69kV substation will be constructed adjacent to the Cholla-Pinnacle Peak 345kV line corridor.

Purpose of Project:

This project is needed to provided the electric source and support to the sub-transmission system to serve the increasing need for electric energy in the area of Payson and the surrounding communities. Additionally, improved reliability and continuity of service will result for the growing communities in the Payson area.

Schedule:

Construction Start: 2010

In-Service Date: 2011

Permitting / Siting Status:

It is not anticipated that a Certificate of Environmental Compatibility will be needed for this project.

Project Name: SE10 loop-in of Saguaro-Casa Grande 230kV line

Planned In-Service Date: 2011

Project Sponsor: Arizona Public Service

Other Participants: None

Voltage Class: 230kV AC

Facility Rating: 188 MVA

Point of Origin: Saguaro-Casa Grande 230kV line; approximately Sec. 17, T10S, R10E

Point of Termination: SE10 substation to be in-service by 2011; Sec. 17, T10S, R10E

Intermediate Points of Interconnection:

Length of Line (in miles): Less than 1 mile

General Route:

The SE10 230/69kV substation will be constructed adjacent to the Saguaro-Casa Grande 230kV line. Approximately 2 miles west of the Saguaro Generating Facility.

Purpose of Project:

This project is needed to provide the electrical source and support to the sub-transmission system to serve the increasing need for electric energy in southern Pinal County. The project will also increase the reliability and continuity of service for those areas.

Schedule:

Construction Start: 2010

In-Service Date: 2011

Permitting / Siting Status:

It is not anticipated that a Certificate of Environmental Compatibility will be needed for this project.

Project Name: Desert Basin - Pinal South 230kV line

Planned In-Service Date: 2011

Project Sponsor: Salt River Project

Other Participants: Arizona Public Service

Voltage Class: 230kV AC

Facility Rating: To be determined

Point of Origin: Desert Basin Power Plant Switchyard; Sec. 13, T6S, R5E

Point of Termination: Pinal South substation to be in-service by 2011; Sec. 30, T6S, R8E

Intermediate Points of Interconnection:

Length of Line (in miles): Approximately 21 miles

General Route:

From the Desert Basin Generation Station, in Casa Grande near Burris and Kortsen Roads, approximately 6 miles generally south and east to a point on the certificated SEV 500kV line near Cornman and Thornton Roads (vicinity of the proposed CATSHV03 Substation). Then the 230kV line will be attached to the 500kV structures for approximately 15 miles to the proposed Pinal South Substation south of Coolidge, AZ.

Purpose of Project:

The project will improve the reliability of the 230kV system in the region by reducing the loading on existing lines in the area; increase local area system capacity; create one of the 230kV components of the CATS-HV proposed transmission system for the central Arizona area. Also, APS participation in the project, along with APS's Sundance-Pinal South 230kV line, will allow APS to increase the reliability to deliver the output of the Sundance Generation Facility.

Schedule:

Construction Start: 2009

In-Service Date: 2011

Permitting / Siting Status:

Authority for the portion of the 230kV line to be attached to the 500kV structures is provided for in the CEC granted in Case No. 126, awarded in 2005 (ACC Decision No. 68093 and No. 68291), and subsequently confirmed in Decision No. 69183, which approved SRP's compliance filing for Condition 23 of the CEC. SRP was granted a CEC for Case No. 132 in 2007 (ACC Decision No. 69647) for the approximately six mile portion of the project not previously permitted from Desert Basin Generating Station to the vicinity of Cornman and Thornton Roads south of Casa Grande.

Project Name: Sundance - Pinal South 230kV line

Planned In-Service Date: 2011

Project Sponsor: Arizona Public Service

Other Participants: ED-2

Voltage Class: 230kV AC

Facility Rating: 3000 A

Point of Origin: Sundance substation; Sec. 2, T6S, R7E

Point of Termination: Pinal South substation to be in-service by 2011; Sec. 30, T6S, R8E

Intermediate Points of Interconnection:

Length of Line (in miles): Approximately 6 miles

General Route:

The route has not yet been approved by the ACC, but will generally head south from the Sundance facility to to a point south of State Route 287/Florence Boulevard and then head east into the Pinal South substation.

Purpose of Project:

This project will serve increasing loads in Pinal County and will improve reliability and continuity of service for the rapidly growing communities in the area. Also, the project will increase the reliability of the Sundance Generation facility by providing a transmission line in a separate corridor than the existing lines that exit the plant. This project, in conjunction with the Desert Basin-Pinal South 230kV project, will allow APS to reliably and economically deliver energy from the Sundance Generation facility over APS's transmission system. The project will be constructed as a 230kV double-circuit capable line, but initially operated as a single-circuit. The in-service date for the second circuit will be evaluated in future planning studies.

Schedule:

Construction Start: 2009

In-Service Date: 2011

Permitting / Siting Status:

An application for a Certificate of Environmental Compatibility was filed in December, 2007 (Case No. 136). A decision from the ACC is expected in 2008.

Project Name: Sun Valley - TS9 500kV line

Planned In-Service Date: 2012

Project Sponsor: Arizona Public Service

Other Participants: SRP, CAWCD

Voltage Class: 525kV AC

Facility Rating: To be determined

Point of Origin: Sun Valley substation to be in-service in 2009; Sec. 29, T4N, R4W

Point of Termination: TS9 substation to be in-service in 2010; Sec. 33, T6N, R1E

Intermediate Points of Interconnection:

Length of Line (in miles): To be determined

General Route:

The route for this project has not yet been determined. Generally the line will head north-northeast out of the Sun Valley substation and then east to the TS9 substation.

Purpose of Project:

This project is needed to serve the increasing need for electric energy in the Phoenix Metropolitan area. It will increase the import capability to the Phoenix Metropolitan area, as well as increase the export capability from the Palo Verde hub. The line will also increase the reliability of the EHV system by completing a 500kV loop that connects the Palo Verde Transmission system, the Southern Navajo Transmission system, and the Southern Four Corners system. This project is anticipated to be 500/230kV double-circuit capable. It is anticipated that the project will be constructed as 500/230kV double-circuit capable.

Schedule:

Construction Start: 2010

In-Service Date: 2012

Permitting / Siting Status:

An application for a Certificate of Environmental Compatibility has not yet been filed. An application is expected to be filed in the second quarter of 2008.

Project Name: Palo Verde Hub - North Gila 500kV #2 line

Planned In-Service Date: 2012

Project Sponsor: Arizona Public Service

Other Participants: SRP, IID, WMIDD

Voltage Class: 525kV AC

Facility Rating: To be determined

Point of Origin: Hassayampa switchyard, Arlington Valley Power Plant, or Redhawk Power Plant

Point of Termination: North Gila substation; Sec. 11, T8S, R22W

Intermediate Points of Interconnection:

Length of Line (in miles): Approximately 110 miles

General Route:

This line will generally follow the route of the existing Hassayampa - North Gila 500kV #1 line.

Purpose of Project:

As a new transmission path to the Yuma area, this 500kV line will provide transmission capacity required to supplement limited transmission and generation resources in the Yuma area. This is a joint participation project with APS as the project manager.

Schedule:

Construction Start: 2009

In-Service Date: 2012

Permitting / Siting Status:

An application for a Certificate of Environmental Compatibility was filed 10/3/07 (Case No. 135). The CEC application was approved by the Arizona Power Plant and Transmission Line Siting Committee on November 20th. A final vote by the Arizona Corporation Commission is expected to take place in early 2008.

Project Name: North Gila - TS8 230kV line

Planned In-Service Date: 2012

Project Sponsor: Arizona Public Service

Other Participants: None

Voltage Class: 230kV AC

Facility Rating: 3000 A

Point of Origin: North Gila substation; Sec. 11, T8S, R22W

Point of Termination: TS8 substation to be in-service by 2012; Sec. 25, T9S, R23W

Intermediate Points of Interconnection:

Length of Line (in miles): Approximately 15 miles

General Route:

The routing for this line has not yet been determined.

Purpose of Project:

This project is needed to serve the increasing need for electric energy in the city of Yuma. Additionally, improved reliability and continuity of service will result for the fast growing Yuma County.

Schedule:

Construction Start: 2010

In-Service Date: 2012

Permitting / Siting Status:

An application for a Certificate of Environmental Compatibility has not yet been filed. An application is expected to be filed in 2008.

Project Name: **Jojoba loop-in of TS4-Panda 230kV line**

Planned In-Service Date: **2013**

Project Sponsor: Arizona Public Service

Other Participants: None

Voltage Class: 230kV AC

Facility Rating: 188 MVA

Point of Origin: TS4-Panda 230kV line; Sec. 25, T2S, R4W

Point of Termination: Jojoba 230/69 substation to be in-service by 2013; Sec. 25, T2S, R4W

Intermediate Points of Interconnection:

Length of Line (in miles): Less than 1 mile

General Route:

The Jojoba 230/69kV substation will be constructed adjacent to the TS4-Panda 230kV line.

Purpose of Project:

This project is needed to provide the electrical source and support to the sub-transmission system to serve the increasing need for electric energy for the growing communities in the area; such as Buckeye, Goodyear, and Gila Bend. The project will also increase the reliability and continuity of service for those areas.

Schedule:

Construction Start: 2012

In-Service Date: 2013

Permitting / Siting Status:

Certificate of Environmental Compatibility issued 10/16/00 (Case No. 102, Decision No. 62960, Gila River Transmission Project) for the Gila River Transmission Project included the interconnection of the 230kV substation.

Project Name: Sun Valley - TS11 - Buckeye 230kV line

Planned In-Service Date: To be determined

Project Sponsor: Arizona Public Service

Other Participants: None

Voltage Class: 230kV AC

Facility Rating: To be determined

Point of Origin: Sun Valley substation to be in-service by 2010; Sec. 29, T4N, R4W

Point of Termination: Buckeye substation; Sec. 7, T1N, R3W

Intermediate Points of Interconnection: TS11 substation; location to be determined

Length of Line (in miles): To be determined

General Route:

The routing for this line has not yet been determined.

Purpose of Project:

This project is needed to serve the increasing need for electric energy in the largely undeveloped areas west of the White Tank Mountains. This project will provide the first portion of the transmission infrastructure in this largely undeveloped area and provides a transmission connection between the northern and southern transmission sources that will serve the area. Improved reliability and continuity of service will result for this fast growing portion of Maricopa County. It is anticipated that this project will be constructed with double-circuit capability, but initially operated as a single circuit. The in-service date and location of the TS11 230/69kV substation will be determined in future planning studies based upon the development of the area.

Schedule:

Construction Start: TBD

In-Service Date: TBD

Permitting / Siting Status:

An application for a Certificate of Environmental Compatibility has not yet been filed.

Project Name: Sun Valley - TS10 - TS11 230kV line

Planned In-Service Date: To be determined

Project Sponsor: Arizona Public Service

Other Participants: None

Voltage Class: 230kV AC

Facility Rating: To be determined

Point of Origin: Sun Valley substation to be in-service by 2010; Sec. 29, T4N, R4W

Point of Termination: A future TS10 substation; location to be determined

Intermediate Points of Interconnection: A future TS11 substation; location to be determined

Length of Line (in miles): To be determined

General Route:

The route for this project has not yet been determined.

Purpose of Project:

This project will be needed to provide a transmission source to serve future load that emerges in the currently undeveloped areas northwest of the White Tank Mountains. This line is anticipated to be a 230kV line emanating from the Sun Valley substation, with the future TS10 230/69kV substation to be interconnected into the 230kV line.

Schedule:

Construction Start: TBD

In-Service Date: TBD

Permitting / Siting Status:

An application for a Certificate of Environmental Compatibility has not yet been filed.

Project Name: **Sun Valley - TS9 230kV line**

Planned In-Service Date: **To be determined**

Project Sponsor: Arizona Public Service

Other Participants: None

Voltage Class: 230kV AC

Facility Rating: To be determined

Point of Origin: Sun Valley substation to be in-service in 2010; Sec. 29, T4N, R4W

Point of Termination: TS9 substation to be in-service in 2010; Sec. 33, T6N, R1E

Intermediate Points of Interconnection: To be determined

Length of Line (in miles): To be determined

General Route:

The route for this project has not yet been determined. Generally the line will head north-northeast out of the Sun Valley substation and then east to the TS9 substation.

Purpose of Project:

This project will be needed to provide a transmission source to serve future load that emerges in the currently undeveloped areas south and west of Lake Pleasant. This line is anticipated to be the 230kV circuit on the Sun Valley-TS9 500/230kV double-circuit line.

Schedule:

Construction Start: TBD

In-Service Date: TBD

Permitting / Siting Status:

An application for a Certificate of Environmental Compatibility has not yet been filed. An application is expected to be filed in the second quarter of 2008.

Project Name: North Gila - Yucca 230kV line

Planned In-Service Date: To be determined

Project Sponsor: Arizona Public Service

Other Participants: None

Voltage Class: 230kV AC

Facility Rating: To be determined

Point of Origin: North Gila substation; Sec. 11, T8S, R22W

Point of Termination: Yucca substation; Sec. 36, T7S, R24W

Intermediate Points of Interconnection:

Length of Line (in miles): To be determined

General Route:

The routing for this line has not yet been determined.

Purpose of Project:

This project is needed to serve the increasing need for electric energy in the city of Yuma. Additionally, improved reliability and continuity of service will result for the fast growing Yuma County.

Schedule:

Construction Start: TBD

In-Service Date: TBD

Permitting / Siting Status:

An application for a Certificate of Environmental Compatibility has not yet been filed.

Project Name: Yucca - TS8 230kV line

Planned In-Service Date: To be determined

Project Sponsor: Arizona Public Service

Other Participants: None

Voltage Class: 230kV AC

Facility Rating: To be determined

Point of Origin: Yucca substation; Sec. 36 , T7S, R24W

Point of Termination: TS8 substation to be in-service in 2012; Sec. 25, T9S, R23W

Intermediate Points of Interconnection:

Length of Line (in miles): To be determined

General Route:

The routing for this line has not yet been determined.

Purpose of Project:

This project is needed to serve the increasing need for electric energy in the city of Yuma. Additionally, improved reliability and continuity of service will result for the fast growing Yuma County.

Schedule:

Construction Start: TBD

In-Service Date: TBD

Permitting / Siting Status:

An application for a Certificate of Environmental Compatibility has not yet been filed.

Project Name: **Westwing - El Sol 230kV line**

Planned In-Service Date: **To be determined**

Project Sponsor: Arizona Public Service

Other Participants: None

Voltage Class: 230kV AC

Facility Rating: To be determined

Point of Origin: Westwing substation; Sec. 12, T4N, R1W

Point of Termination: El Sol substation; Sec. 30, T3N, R1E

Intermediate Points of Interconnection:

Length of Line (in miles): Approximately 11 miles

General Route:

Per certificate. Generally following the existing Westwing-Surprise-El Sol 230kV corridor.

Purpose of Project:

This project will increase system capacity to serve growing demand for electric energy in the Phoenix Metropolitan area, while maintaining system reliability and integrity for delivery of bulk power from Westwing south into the APS Phoenix Metropolitan area 230kV transmission system.

Schedule:

Construction Start: TBD

In-Service Date: TBD

Permitting / Siting Status:

Certificate of Environmental Compatibility issued 7/26/73 (Case No. 9, Docket No. U-1345). Note that this Certificate authorizes two double-circuit lines. Construction of the first double-circuit line was completed in March 1975. Construction of the second line, planned to be built with double-circuit capability, but initially operated with a single circuit, is described above.

Project Name: Westwing - Raceway 230kV line

Planned In-Service Date: To be determined

Project Sponsor: Arizona Public Service

Other Participants: None

Voltage Class: 230kV AC

Facility Rating: To be determined

Point of Origin: Westwing substation; Sec. 12, T4N, R1W

Point of Termination: Raceway substation; Sec. 4, T5N, R1E

Intermediate Points of Interconnection:

Length of Line (in miles): Approximately 7 miles

General Route:

Northeast from Westwing substation paralleling existing transmission lines to the Raceway 230kV substation.

Purpose of Project:

This project will serve increasing loads in the far north and northwest parts of the Phoenix Metropolitan area and provide contingency support for multiple Westwing 500/230kV transformer outages. The in-service date will continue to be evaluated in future planning studies.

Schedule:

Construction Start: TBD

In-Service Date: TBD

Permitting / Siting Status:

Certificate of Environmental Compatibility issued 6/18/03 (Case No. 120, Decision No. 64473, North Valley 230kV Transmission Line Project).

Project Name: Palo Verde - Saguaro 500kV line

Planned In-Service Date: To be determined

Project Sponsor: CATS Sub-Regional Planning Group Participants

Other Participants: To be determined

Voltage Class: 525kV AC

Facility Rating: To be determined

Point of Origin: Palo Verde switchyard; Sec. 34, T1N, R6W

Point of Termination: Saguaro substation; Sec. 14, T10S, R10E

Intermediate Points of Interconnection: To be determined

Length of Line (in miles): Approximately 130 miles

General Route:

Generally south and east from the Palo Verde area to a point near Gillespie Dam, then generally easterly until the point at which the Palo Verde-Kyrene 500kV line diverges to the north and east. The corridor then is generally south and east again, adjacent to a gas line corridor, until meeting up with the Tucson Electric Power Company's Westwing-South 345kV line. The corridor follows the 345kV line until a point due west of the Saguaro Generating Station. The corridor then follows a lower voltage line into the 500kV yard just south and east of the Saguaro Generating Station.

Purpose of Project:

This line is the result of the joint participation CATS study. The line will be needed to increase the adequacy of the existing EHV transmission system and permit increased power delivery throughout the state.

Schedule:

Construction Start: TBD

In-Service Date: TBD

Permitting / Siting Status:

Certificate of Environmental Compatibility issued 1/23/1976 (Case No. 24, Decision No. 46802).

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TRANSMISSION PLANNING PROCESS AND GUIDELINES

APS Transmission Planning

January 2008

TRANSMISSION PLANNING PROCESS AND GUIDELINES

III. PLANNING ASSUMPTIONS

I. INTRODUCTION AND PURPOSE

The Transmission Planning Process and Guidelines (Guidelines) are used by Arizona Public Service Company (APS) to assist in planning its Extra High Voltage (EHV) transmission system (345kV and 500kV) and High Voltage transmission system (230kV and 115kV). In addition to these Guidelines, APS follows the Western Electricity Coordinating Council's (WECC) regional planning reliability criteria for system disturbance and performance levels. These WECC Reliability Criteria are (1) WECC/NERC Reliability Criteria for Transmission System Planning and (2) Minimum Operating Reliability Criteria, which can be found in their entirety on the WECC website; (http://www.wecc.biz/documents/library/procedures/CriteriaMaster.pdf). These Guidelines are for internal use by APS and may be changed or modified. Thus, others should not use these Guidelines without consultation with APS.

II. PLANNING METHODOLOGY

A. General

APS uses a deterministic approach for transmission system planning. Under this approach, system performance should meet certain specific criteria under normal conditions (all lines in-service) and for any single contingency condition (any one element out-of-service). In general, an adequately planned transmission system will:

- Provide an acceptable level of service that is cost-effective for normal and single contingency operating conditions.
- Maintain service to all firm loads for any single contingency outage; except for radial loads.
- Not result in overloaded equipment or unacceptable voltage conditions for single contingency outages.
- Not result in cascading for single or double contingency outages.
- Provide for the proper balance between the transmission import capability and local generation requirements for an import limited load area.

Although APS uses a deterministic approach for transmission system planning, the WECC reliability planning criteria provides for exceptions based upon a probalistic approach. APS uses these probabilistic criteria when/where appropriate in the transmission planning process. Historical system reliability performance is analyzed on a periodic basis and the results are used in the design of planned facilities.

These planning methodologies, assumptions, and guidelines are used as the basis for the development of future transmission facilities. Additionally, consideration of potential alternatives to transmission facilities (such as distributed generation or new technologies) is evaluated on a case-specific basis.

As new planning tools and/or information become available revisions or additions to these guidelines will be made as appropriate.

B. Transmission Planning Process

APS' transmission planning process consists of an assessment of the following needs:

- Provide adequate transmission to access designated network resources in-order to reliably and economically serve all network loads.
- Support APS' and other network customers' local transmission and sub-transmission systems.
- Provide for interconnection for new resources.
- Accommodate requests for long-term transmission access.

During this process, consideration is given to load growth patterns, other system changes affected by right-of-way, facilities siting constraints, routing of future transportation corridors, and joint planning with neighboring utilities, governmental entities, and other interested stakeholders (see APS OATT Attachment (E).

1. EHV Transmission Planning Process

APS' EHV transmission system, which consists of 500kV and 345kV, has primarily been developed to provide transmission to bring the output of large base-loaded generators to load centers, such as Phoenix. Need for new EHV facilities may result from any of the bullet items described above. APS' annual planning process includes an assessment of APS' transmission capability to ensure that designated network resources can be accessed to reliably and economically serve all network loads. In addition, biennial RMR studies are performed to ensure that proper balance between the transmission import capability and local generation requirements for an import limited load area are maintained.

2. <u>230kV Transmission Planning Process</u>

APS' 230kV transmission system has primarily been developed to provide transmission to distribute power from the EHV bulk power substations and local generators to the distribution system and loads throughout the load areas.

Planning for the 230kV system assesses the need for new 230/69kV substations to support local sub-transmission and distribution system growth and the reliability performance of the existing 230kV system. This process takes into account the future land use plans that were developed by government agencies, Landis aerial photo maps, master plans that were provided by private developers, and APS' long-range forecasted load densities per square mile for residential, commercial, and industrial loads.

3. <u>Transmission Facilities Required for Generation/Resource Additions</u>

New transmission facilities may also be required in conjunction with generation resources due to (1) a "merchant" request by an Independent Power Producer (IPP) for generator interconnection to the APS system, (2) a "merchant" request for point-to-point transmission service from the generator (receipt point) to the designated delivery point, or (3) designation of new resources or re-designation of existing units to serve APS network load (including removal of an older units' native load designation). These studies/processes are performed pursuant to the APS Open Access Transmission Tariff (OATT).

C. Ten Year Transmission System Plans

Each year APS uses the planning process described in section B to update the Ten-Year Transmission System Plan. The APS Ten Year Transmission System Plan identifies all new transmission facilities, 115kV and above, and all facility replacements/upgrades required over the next ten years to reliably and economically serve the load.

D. Regional Coordinated Planning

1. Western Electricity Coordinating Council (WECC)

APS is a member of the Western Electricity Coordinating Council. The focus of the WECC is on promoting the reliability of the interconnected bulk electric system. The WECC provides the means for:

- Developing regional planning and operating criteria.
- Coordinating future plans.
- Compiling regional data banks for use by the member systems and the WECC in conducting technical studies.
- Assessing and coordinating operating procedures and solutions to regional problems.
- Establishing an open forum with interested non-project participants to review the plan of service for a project.
- Through the WECC Transmission Expansion Policy Committee, performing economic transmission congestion analysis.

APS works with WECC to adhere to these planning practices.

2. Sub-Regional Planning Groups

Southwest Area Transmission Planning (SWAT) and other sub-regional planning groups provide a forum for entities within a region, and any other interested parties, to determine and study the needs of the region as a whole. It also provides a forum for specific projects to be exposed to potential partners and allows for joint studies and participation from interested parties.

3. WestConnect

APS and the other WestConnect members executed the WestConnect Project Agreement for Subregional Transmission Planning in May of 2007. This agreement promotes coordination of regional transmission planning for the WestConnect planning area by formalizing a relationship among the WestConnect members and the WestConnect area sub-regional planning groups including SWAT. The agreement provides for resources and funding for the development of a ten year integrated regional transmission plan for the WestConnect planning area. The agreement also ensures that the WestConnect transmission planning process will be coordinated and integrated with other planning processes within the Western Interconnection and with the WECC planning process.

4. Joint Studies

In many instances, transmission projects can serve the needs of several utilities and/or IPPs. To this end, joint study efforts may be undertaken. Such joint study efforts endeavor to develop a plan that will meet the needs and desires of all individual companies involved.

E. Generation Schedules

For planning purposes, economic dispatches of network resources are determined for APS' system peak load in the following manner:

a. Determine base generation available and schedule these units at maximum output.
b. Determine resources purchased from other utilities, IPPs, or power marketing agencies.
c. Determine APS' spinning reserve requirements.
d. Schedule intermediate generation (oil/gas steam units) such that the spinning reserve requirements, in section (c) above, are met.
e. Determine the amount of peaking generation (combustion turbine units) required to supply the remaining system peak load.

Phoenix area network resources are dispatched based on economics and any existing import limitations. When possible, spinning reserve will be carried on higher cost Phoenix area network generating units.

Generation output schedules for interconnected utilities and IPPs are based upon consultation with the neighboring utilities and IPPs or as modeled in the latest data in WECC coordinated study cases.

F. Load Projections

APS substation load projections are based on the APS Corporate Load Forecast. Substation load projections for neighboring interconnected utilities or power agencies operating in the WECC area are based on the latest data in WECC coordinated study cases. Heavy summer loads are used for the Ten-Year Transmission System Plans.

G. Alternative Evaluations

1. General

In evaluating several alternative plans, comparisons of power flows, transient stability tests, and fault levels are made first. After the alternatives are found that meet the system performance criteria in each of these three areas comparisons may be made of the losses, transfer capability, impact on system operations, and reliability of each of the plans. Finally, the costs of facility additions (capital cost items), costs of losses, and relative costs of transfer capabilities are determined. A brief discussion of each of these considerations follows.

2. Power Flow Analyses

Power flows of base case (all lines in-service) and single contingency conditions are tested and should conform to the system performance criteria set forth in Section IV of these Guidelines. Double or multiple contingencies are examined, but in general, no facilities are planned for such conditions. Normal system voltages, voltage deviations, and voltage extreme limitations are based upon operating experience resulting in acceptable voltage levels to the consumer. Power flow limits are based upon the thermal ratings and/or sag limitations of conductors or equipment, as applicable.

3. Transient Stability Studies

   Stability guidelines are established to maintain system stability for single contingency, three-phase fault conditions. Double or multiple contingencies are examined, but in general, no facilities are planned for such conditions.

4. Short Circuit Studies

   Three-phase and single-phase-to-ground fault studies are performed to ensure the adequacy of system protection equipment to clear and isolate faults.

5. Reactive Power Margin Analyses

   Reactive Power Margin analyses are performed when steady-state analyses indicate possible insufficient voltage stability margins. V-Q curve analyses are used to determine post-transient voltage stability.

6. Losses Analyses

   A comparison of individual element and overall transmission system losses are made for each alternative plan being studied. The losses computed in the power flow program consist of the I^2R losses of lines and transformers and the core losses in transformers, where represented.

7. Transfer Capability Studies

   In evaluating the relative merits of one or more EHV transmission plans, both simultaneous and non-simultaneous transfer capability studies are performed to determine the magnitude of transfer capabilities between areas or load centers.

8. Subsynchronous Resonance (SSR)

   SSR phenomenon result from the use of series capacitors in the network where the tuned electrical network exchanges energy with a turbine generator at one or more of the natural frequencies of the mechanical system. SSR countermeasures are applied to prevent damage to machines as a result of transient current or sustained oscillations following a system disturbance. SSR studies are not used directly in the planning process. SSR countermeasures are determined after the transmission plans are finalized.

9. FACTS (Flexible AC Transmission System)

FACTS devices are a recent application of Power Electronics to the transmission system. These devices make it possible to use circuit reactance, voltage magnitude and phase angle as control parameters to redistribute power flows and regulate bus voltages, thereby improving power system operation. FACTS devices can provide series or shunt compensation. These devices can be used as a controllable voltage source in series or as a controllable current source in shunt mode to improve the power transmission system operations. FACTS will be evaluated as a means of power flow control and/or to provide damping to dynamic oscillations where a need is identified and it is economically justified.

10. Economic Evaluation

In general, an economic evaluation of alternative plans consists of a cumulative present worth or equivalent annual cost comparison of capital costs.

III. PLANNING ASSUMPTIONS

A. General

1. Loads

Loads used for the APS system originate from the latest APS Corporate Load Forecast. In most cases, the corrected power factor of APS loads is 99.5% at 69kV substations.

2. Generation and Other Resources

Generation dispatch is based on firm power and/or transmission wheeling contracts including network resources designations.

3. Normal Voltage Levels

a. Nominal EHV design voltages are 500kV, 345kV, 230kV, and 115kV.

b. Nominal EHV operating voltages are 535kV, 348kV, 239kV, and 119kV.

4. Sources of Databases

WECC Heavy Summer base cases are the sources of the databases. Loop flow (unscheduled flow), of a reasonable amount and direction, will be allowed for use in planning studies.

5. Voltage Control Devices

Devices which can control voltages are shunt capacitors, shunt reactors, tap-changing-under-load (TCUL) and fixed-tap transformers, static VAR compensators, and machine VAR capabilities. If future voltage control devices are necessary, these devices will be evaluated based upon economics and the equipment's ability to obtain an adequate voltage profile on the EHV and HV systems.

6. Phase Shifters

In general, where phase shifters are used, schedules are held across the phase shifter in base case power flows and the phase shifter tap remains fixed in the outage cases.

7. Conductor Sizes

Existing transmission voltages utilized by APS are 230kV, 345kV, and 500kV. It is presently planned that the 345kV transmission system will not be expanded, thus all future APS EHV lines will be 500kV or 230kV. Planned 500kV lines will initially be modeled using tri-bundled 1780 kCM ACSR conductor (Chukar). Preferred construction for 230kV lines consists of 2156 kCM ACSS conductor on steel poles.

8. 69kV System Modeling

230kV facility outages may result in problems to the underlying 69kV system due to the interconnection of those systems. For this reason, power flow cases include a detailed 69kV system representation. Solutions to any problems encountered on the 69kV system are coordinated with the subtransmission planning engineers.

9. Substation Transformers

a. 500kV and 345kV Substations

Bulk substation transformer banks may be made up of one three-phase or three single-phase transformers, depending upon bank size and economics. For larger banks where single-phase transformers are used, a fourth (spare) single-phase transformer will be used in a jack-bus arrangement to improve reliability and facilitate connection of the spare in the event of an outage of one of the single-phase transformers. TCUL will be considered in the high voltage windings, generally with a range of plus or minus 10%. High voltage ratings will be 500kV or 345kV class and low voltage windings will be 230kV, 115kV, or 69kV class.

b. 230kV Substations

For high-density load areas, both 230/69kV and 69/12.5kV transformers can be utilized. 230/69kV transformers will be rated at 113/150/188 MVA with a 65°C temperature rise, unless otherwise specified. 69/12.5kV transformers will be rated at 25/33/41 MVA with a 65°C temperature rise, unless otherwise specified.

With all elements in service, a transformer may be loaded up to its top Forced Oil Air (FOA) rating without sustaining any loss of service life. For a single contingency outage (loss of one transformer) the remaining transformer or transformers may be loaded up to 20% above their top FOA rating, unless heat test data indicate a different overload capability. The loss of service life sustained will depend on the transformer pre-loading and the outage duration. Tap setting adjustment capabilities on 230/69kV transformers will be ±5% from the nominal voltage setting (230/69kV) at 2½% increments.

10. Switchyard Arrangements

a. 500kV and 345kV Substations

Existing 345kV switchyard arrangements use breaker-and-one-half, main-and-transfer, or modified paired-element circuit breaker switching schemes. Because of the large amounts of power transferred via 500kV switchyards and the necessity of having adequate reliability, all 500kV circuit breaker arrangements are planned for an ultimate breaker-and-one-half scheme. If only three or four elements are initially required, the circuit breakers are connected in a ring bus arrangement, but physically positioned for a breaker-and-one-half scheme. The maximum desired number of elements to be connected in the ring bus arrangement is four. System elements such as generators, transformers, and lines will be arranged in breaker-and-one-half schemes such that a failure of a center breaker will not result in the loss of two lines routed in the same general direction and will minimize the impact of losing two elements.

b. <u>230kV Substations</u>

Future 230/69kV substations should be capable of serving up to 452 MVA of load. 400 MVA has historically been the most common substation load level in the Phoenix Metropolitan area. Future, typical 230/69kV substations should accommodate up to four 230kV line terminations and up to three 230/69kV transformer bays. Based upon costs, as well as reliability and operating flexibility considerations, a breaker-and-one-half layout should be utilized for all future 230/69kV Metropolitan Phoenix Area substations, with provision for initial development to be a ring bus. Any two 230/69kV transformers are to be separated by two breakers, whenever feasible, so that a stuck breaker will not result in an outage of both transformers.

11. <u>Series Capacitor Application</u>

Series capacitors may be used on EHV lines to increase system stability, for increased transfer capability, and/or for control of power flow. The series capacitors may be lumped at one end of a line because of lower cost; however, the capacitors are generally divided into two banks, one at either end of a line, for improved voltage profile.

12. Shunt and Tertiary Reactor Application

Shunt and/or tertiary reactors may be installed to prevent open end line voltages from being excessive, in addition to voltage control. The open end line voltage must not be more than 0.05 per unit voltage greater than the sending end voltage. Tertiary reactors may also be used for voltage and VAR control as discussed above.

B. Power Flow Studies

1. System Stressing

Realistic generation capabilities and schedules should be used to stress the transmission system in order to maximize the transfer of resources during the maximum load condition.

2. Displacement

In cases where displacements (due to power flow opposite normal generation schedules) may have an appreciable effect on transmission line loading, a reasonable amount of displacement (Generation Units) may be removed in-order to stress a given transmission path.

C. Transient Stability Studies

1. Fault Simulation

When studying system disturbances caused by faults, two conditions will be simulated:

a. Three-phase-to-ground faults, and
b. Single-line-to-ground faults with a stuck circuit breaker in one phase with back-up delayed clearing.

2. Margin

a. Generation margin may be applied for the contingencies primarily affected by generation, or
b. Power flow margin may be applied for the contingencies primarily affected by power flow.

3. Unit Tripping

   Generator unit tripping may be allowed in-order to increase system stability performance.

4. Machine Reactance Representation

   For transient stability studies, the unsaturated transient reactance of machines with full representation will be used.

5. Fault Damping

   Fault damping will be applied to the generating units adjacent to faults. Fault damping will be determined from studies that account for the effect of generator amortisseur windings and the SSR filters.

6. Series Capacitor Switching

   Series capacitors, locations to be determined from short circuit studies, will be flashed and reinserted as appropriate.

D. Short Circuit Studies

Three-phase and single-phase-to-ground faults will be evaluated.

1. Generation Representation

   All generation will be represented.

2. Machine Reactance Representation

   The saturated subtransient reactance (X''_d) values will be used.

3. Line Representation

   The transmission line zero sequence impedance (X_0) is assumed to be equal to three times the positive sequence impedance (X_1).

4. Transformer Representation

   The transformer zero sequence impedance (X_0) is assumed to be equal to the positive sequence impedance (X_1). Bulk substation transformers are modeled as auto-transformers. The two-winding model is that of a grounded-wye transformer. The three-winding model is that of a wye-delta-wye with a solid ground.

E. Reactive Power Margin Studies

Using Q-V curve analyses, APS assesses the interconnected transmission system to ensure there are sufficient reactive resources located throughout the electric system to maintain post-transient voltage stability for system normal conditions and certain contingencies.

IV. SYSTEM PERFORMANCE

A. Power Flow Studies

1. Normal (Base Case Conditions)

a. Voltage Levels

1) General

(a) 500kV bus voltages will be maintained between 1.05 and 1.08 p.u. on a 500kV base.

(b) 345kV bus voltages will range between .99 and 1.04 p.u. on the 345kV system.

(c) 500kV and 345kV system voltages are used to maintain proper 230kV bus voltages.

(d) Voltage on the 230kV and 115kV system should be between 1.01 p.u. and 1.05 p.u.

(e) Tap settings for 230/69kV and 345/69kV transformers should be used to maintain low side (69kV) voltages of 1.03 to 1.04 p.u. Seasonal tap changes may be required.

2) Specific Buses

(a) APS Pinnacle Peak 230kV bus voltage should be between 1.025 p.u. and 1.035 p.u.

(b) APS Westwing 230kV bus voltage should be between 1.04 p.u. and 1.05 p.u.

(c) Saguaro 115kV bus voltage will be approximately 1.035 p.u.

(d) Voltage at the Prescott (DOE) 230kV bus should be approximately 1.02 p.u.

b. Facility Loading Limits

1) Transmission Lines

Transmission line loading cannot exceed 100% of the continuous rating, which is based upon established conductor temperature limit or sag limitation.

2) Underground Cable

Underground cable loading should not exceed 100% of the continuous rating with all elements in service. This rating is based on a cable temperature of 85°C with no loss of cable life.

3) Transformers

Transformers cannot exceed 100% of top FOA, 65°C rise, nameplate ratings.

4) Series Capacitors

Series Capacitors cannot exceed 100% of continuous rating.

c. Interchange of VARs

Interchange of VARs between companies at interconnections will be reduced to a minimum and maintained near zero.

d. Distribution of Flow

Schedules on a new project will be compared to simulated power flows to ensure a reasonable level of flowability.

2. Single Contingency Outages

a. Voltage Levels

Maximum voltage deviation on APS' major buses cannot exceed 5%. This deviation level yields a close approximation to the post-transient VAR margin requirements of WECC.

b. Facilities Loading Limits

1) Transmission Lines

Transmission line loading cannot exceed 100% of the lesser of the sag limit or the emergency rating (30-minute rating) which is based upon established conductor temperature limits.

2) Underground Cable

Underground cable loading should not exceed the emergency rating during a single-contingency outage. This rating is based on a cable temperature of 105°C for two hours of emergency operation with no loss of cable life.

3) Transformers

Transformers cannot exceed 120% of top FOA, 65°C rise, nameplate ratings.

4) Series Capacitors

Series Capacitors cannot exceed 100% of emergency rating.

c. Generator Units

Generator units used for controlling remote voltages will be modified to hold their base case terminal voltages.

d. Impact on Interconnected System

Single contingency outages will not cause overloads upon any neighboring transmission system.

B. Transient Stability Studies

Transient stability studies are primarily performed on the 500kV and 345kV systems.

1. Fault Simulation

Three-phase-to-ground faults and single-line-to-ground faults, simulating a stuck circuit breaker in one phase with back-up delayed clearing will be simulated. Fault clearing times of four cycles after fault inception (5 cycles for a 230kV fault) and a back-up clearing time of twelve cycles after fault inception is utilized. System elements are switched out at the appropriate clearing times, as applicable. Fault damping will be applied when applicable at fault inception.

2. Series Capacitor Switching

Series capacitors, at locations determined from short-circuit studies, will be flashed at fault inception and will be reinserted depending on their reinsertion types.

3. System Stability

The system will be considered stable if the following conditions are met:

a. All machines in the system remain synchronized as demonstrated by the relative rotor angles.
b. Positive system damping exists as demonstrated by the damping of relative rotor angles and the damping of voltage magnitude swings. For N-1 disturbances, voltages for the first swing after fault clearing should not drop below 75% of pre-fault value with maximum time duration of 20 cycles for voltage dip exceeding 20%.

4. Re-closing

Automatic re-closing of circuit breakers controlling EHV facilities is not utilized.

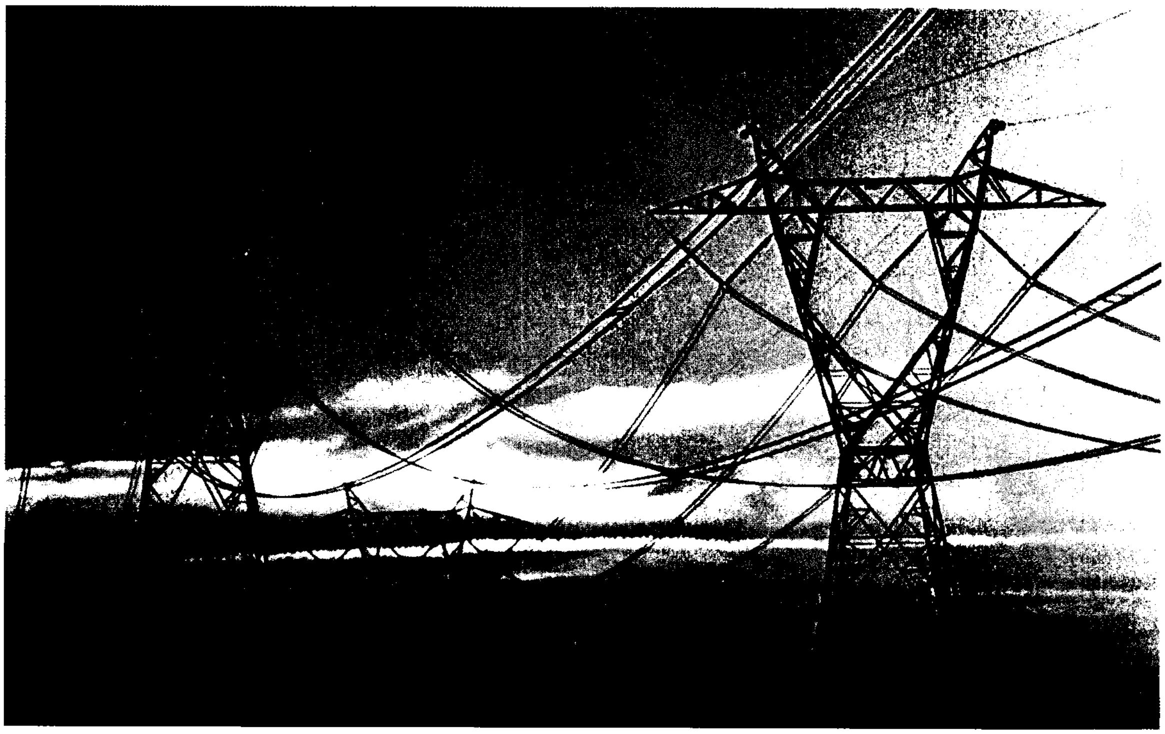
C. Short Circuit Studies

Fault current shall not exceed 100% of the applicable breaker fault current interruption capability for three-phase or single-line-to-ground faults.

D. Reactive Power Margin Studies

For system normal conditions or single contingency conditions, post-transient voltage stability is required with a path or load area modeled at a minimum of 105% of the path rating or maximum planned load limit for the area under study, whichever is applicable. For multiple contingencies, post-transient voltage stability is required with a path or load area modeled at a minimum of 102.5% of the path rating or maximum planned load limit for the area under study, whichever is applicable.

2007 SYSTEM RATING MAPS



PREPARED BY

TRANSMISSION OPERATIONS
AUGUST 2007

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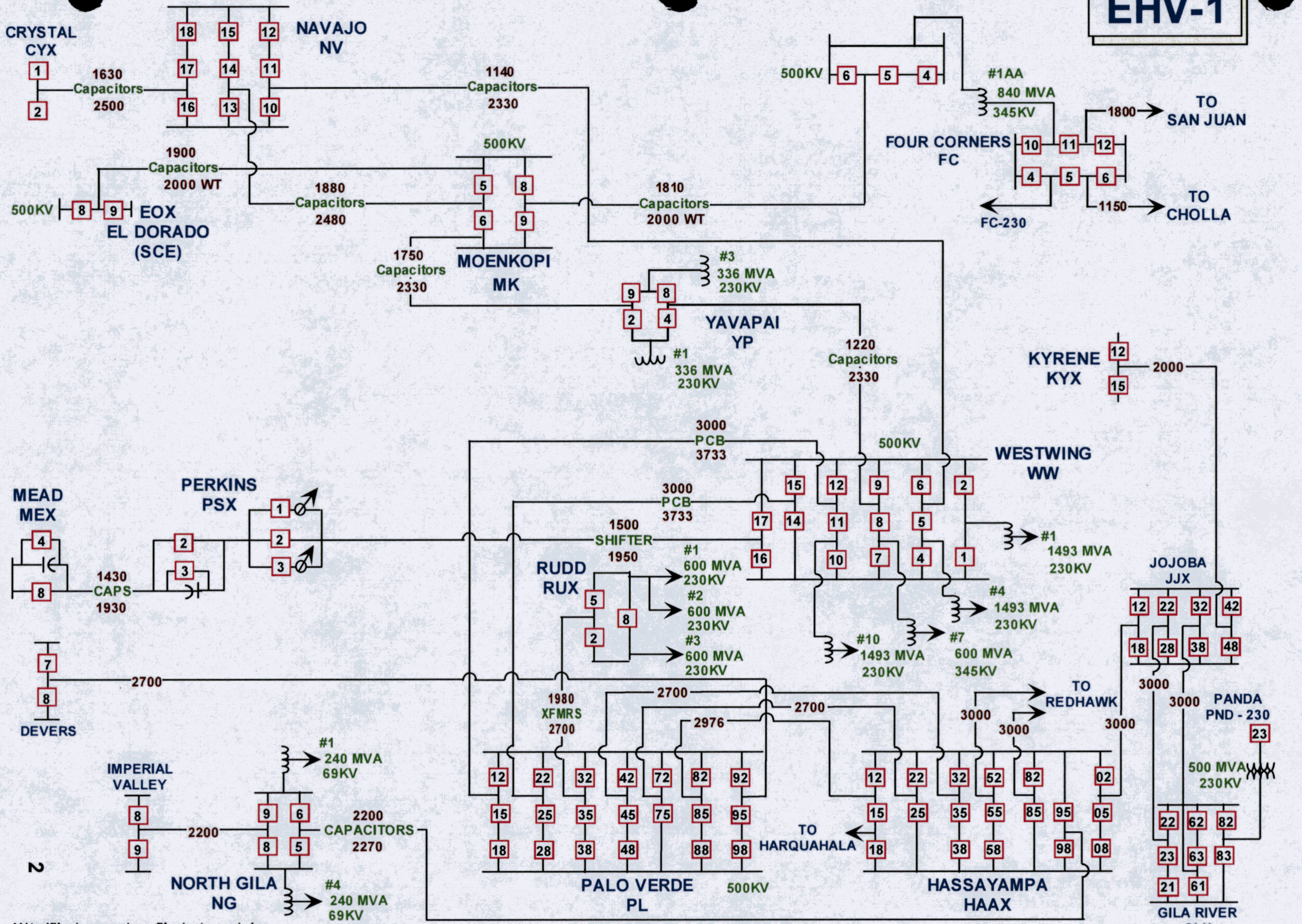
LEGEND
SYSTEM RATING MAPS

SYMBOL	DESCRIPTION
### ——###—— ###	CURRENT LIMIT IN AMPS LIMITING ELEMENT CONDUCTOR LIMIT IN AMPS
	TRANSFORMER LIMITS ARE IN MVA
————————	OVERHEAD TRANSMISSION LINE
- - - - - - - - -	UNDERGROUND CABLE
M	MOTOR OPERATED SWITCH
V	VACCUM SWITCH
H	HYDRAULIC SWITCH
1	BREAKER NUMBER

EHV-1



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EHV-1
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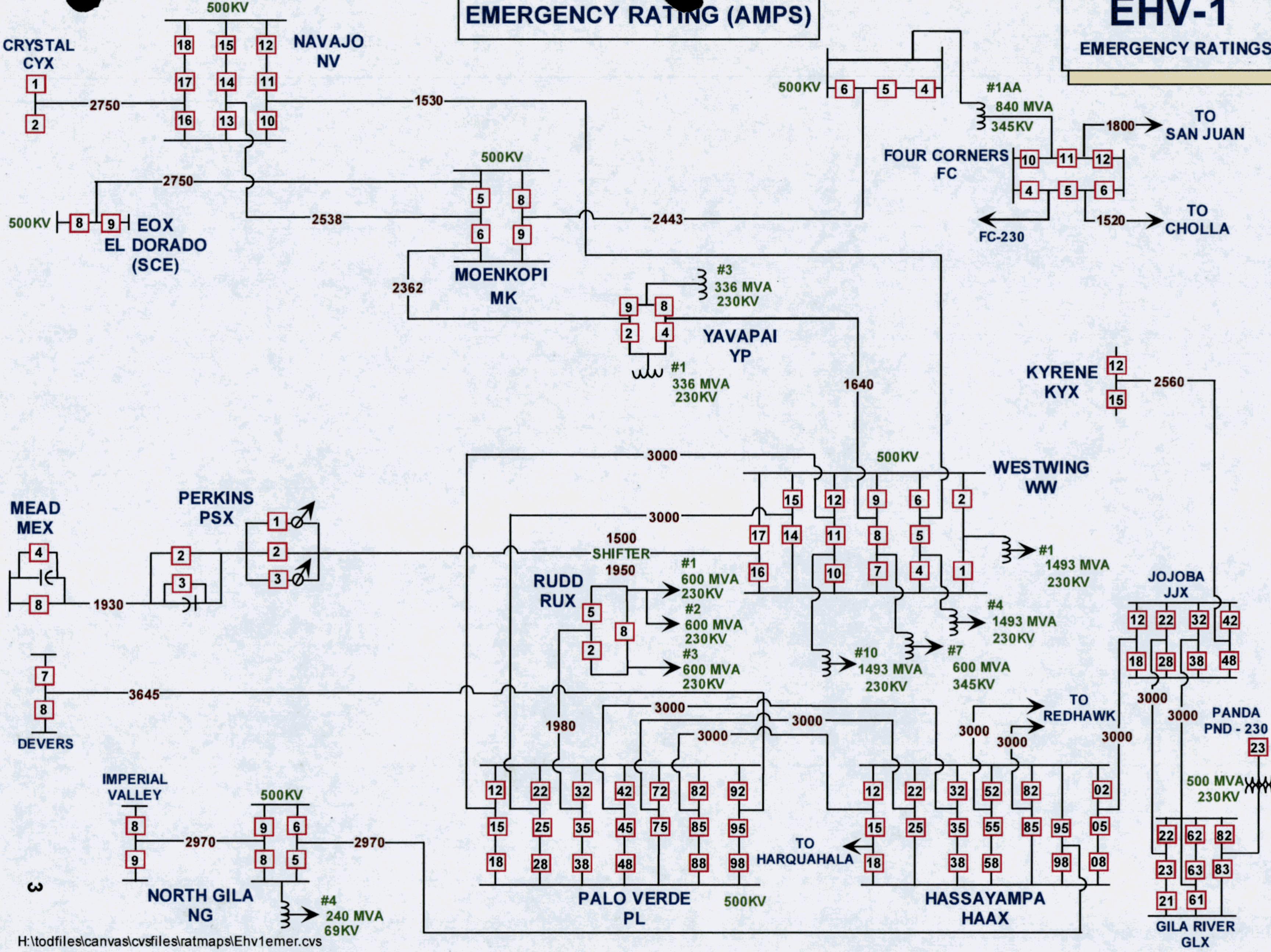
EMERGENCY RATING (AMPS)



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Rev. 8/22/06

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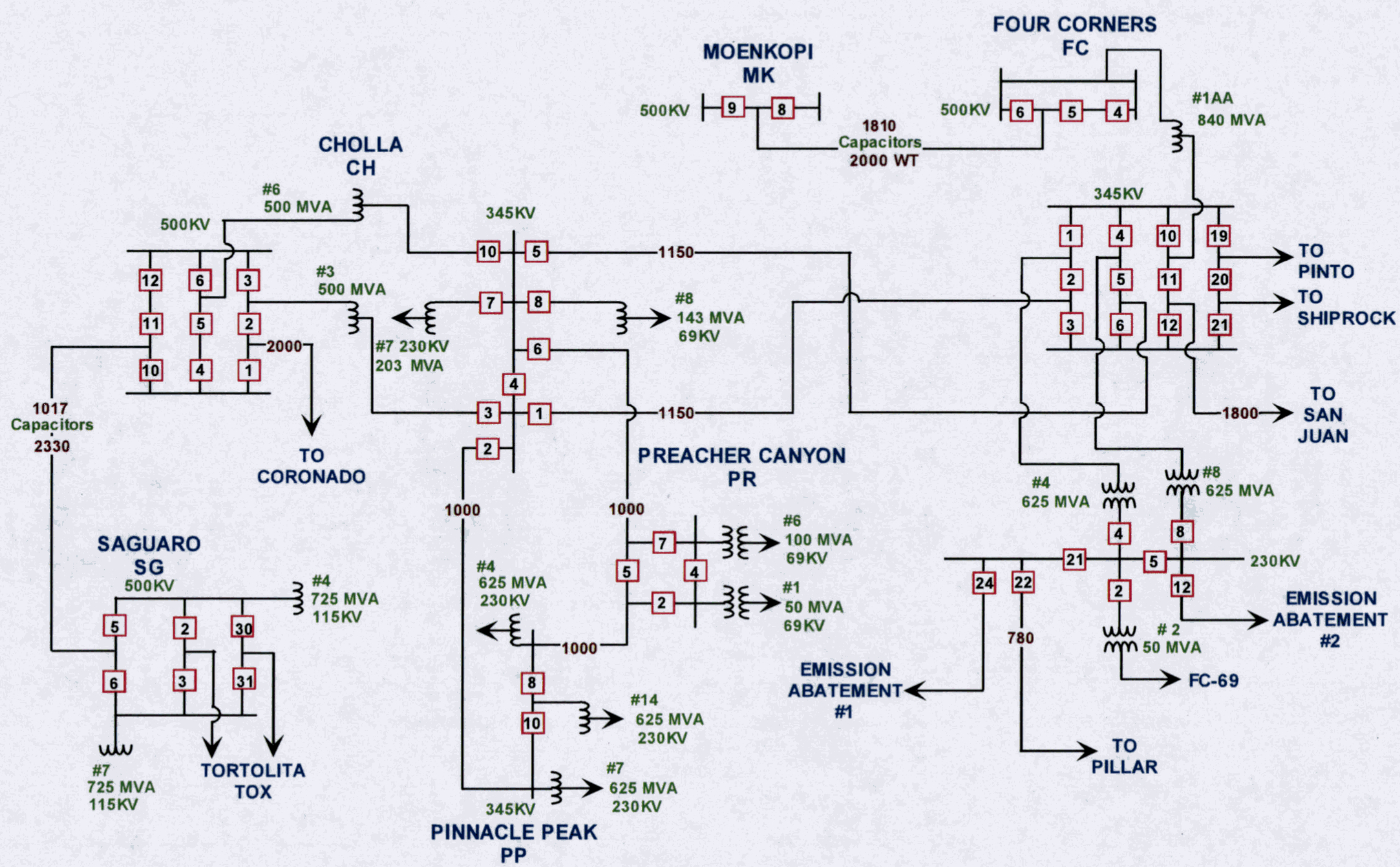

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EHV-2

EMERGENCY RATINGS

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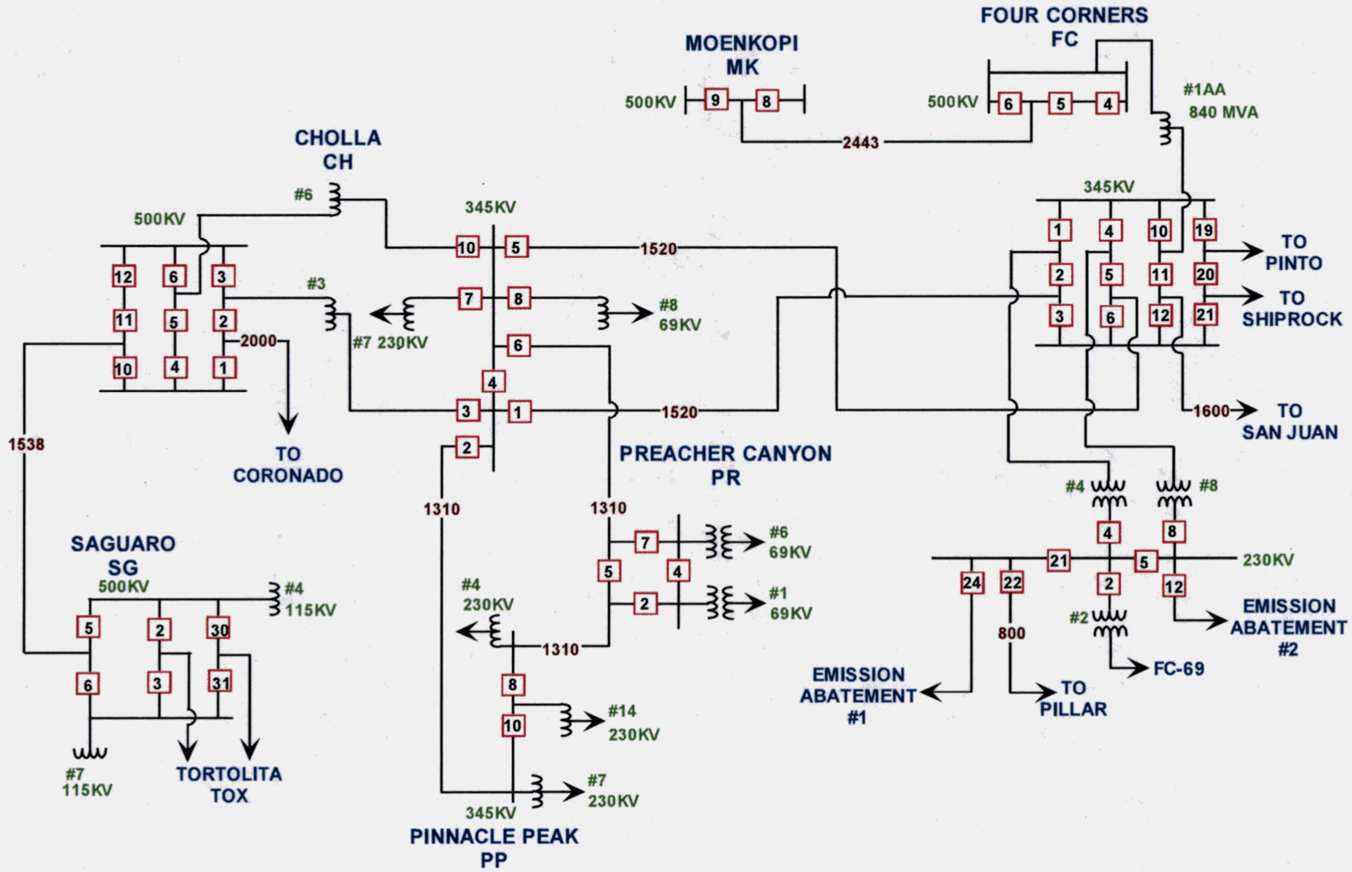

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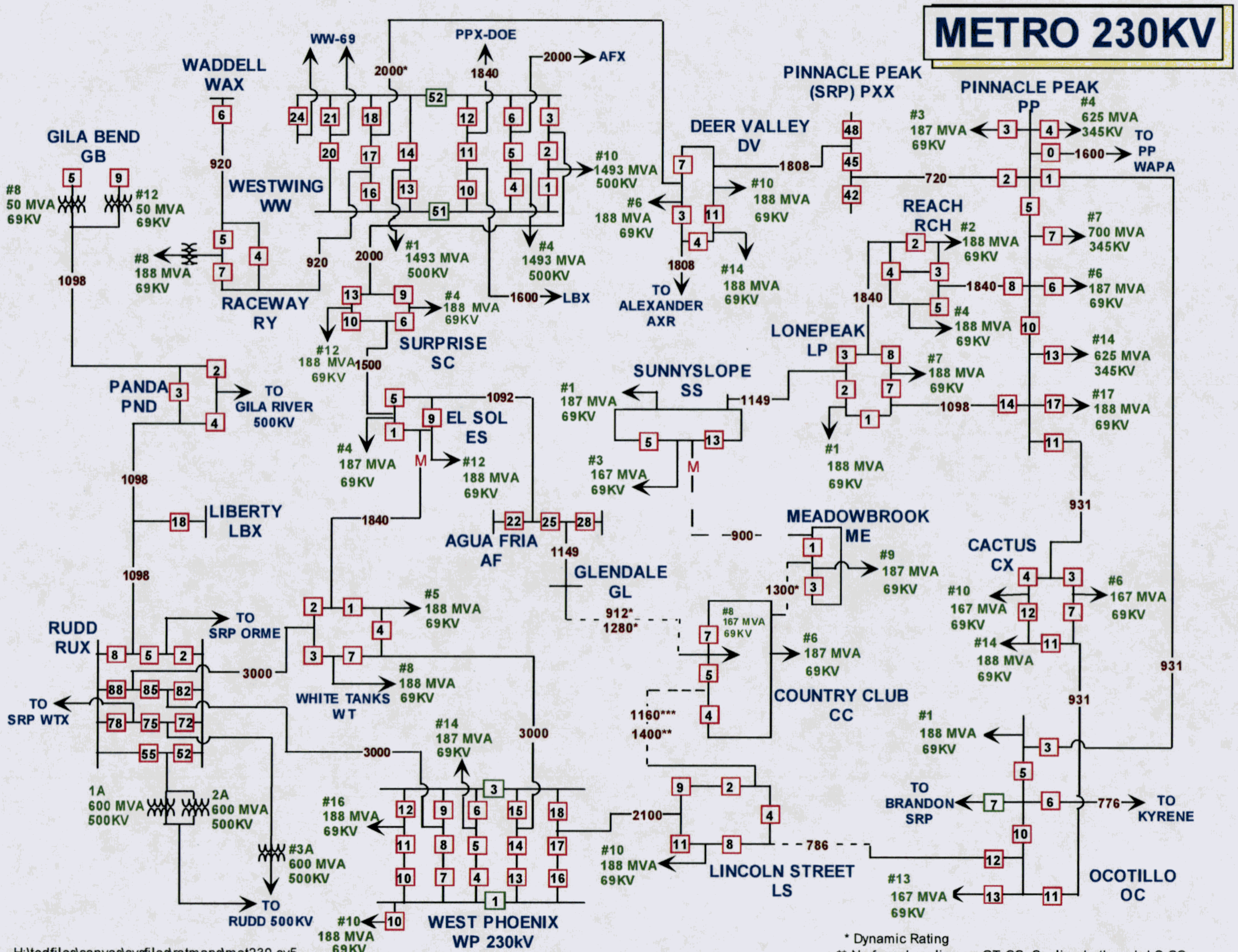
Rev. 08/22/06

METRO 230KV



* Dynamic Rating
** No forced cooling on GT-CC, Cooling both ends LS-CC
*** Forced cooling on GT-CC, Cooling one end LS-CC

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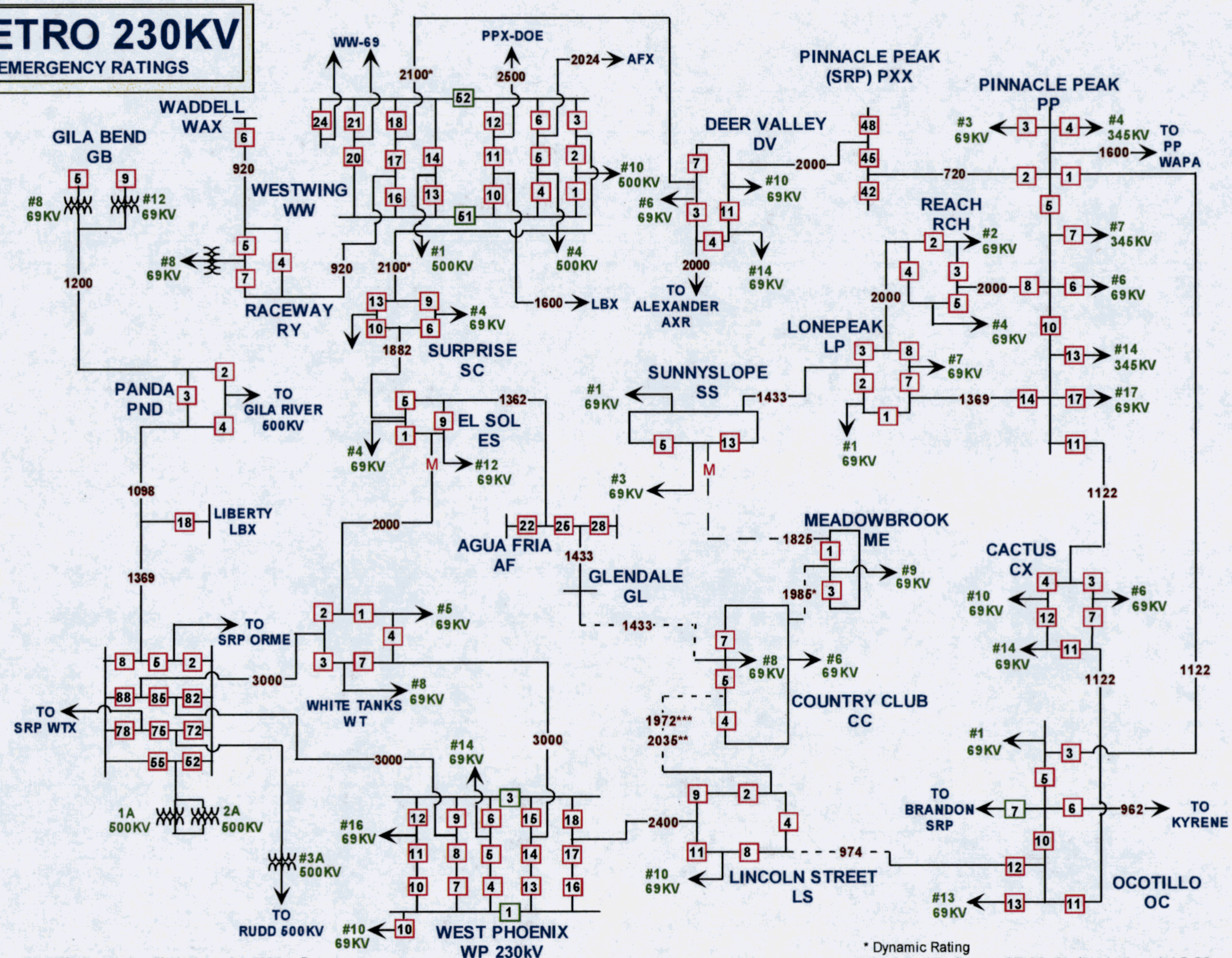
Rev. 08/22/06

METRO 230KV
EMERGENCY RATINGS



* Dynamic Rating
** No forced cooling on GT-CC, Cooling both ends LS-CC
*** Forced cooling on GT-CC, Cooling one end LS-CC

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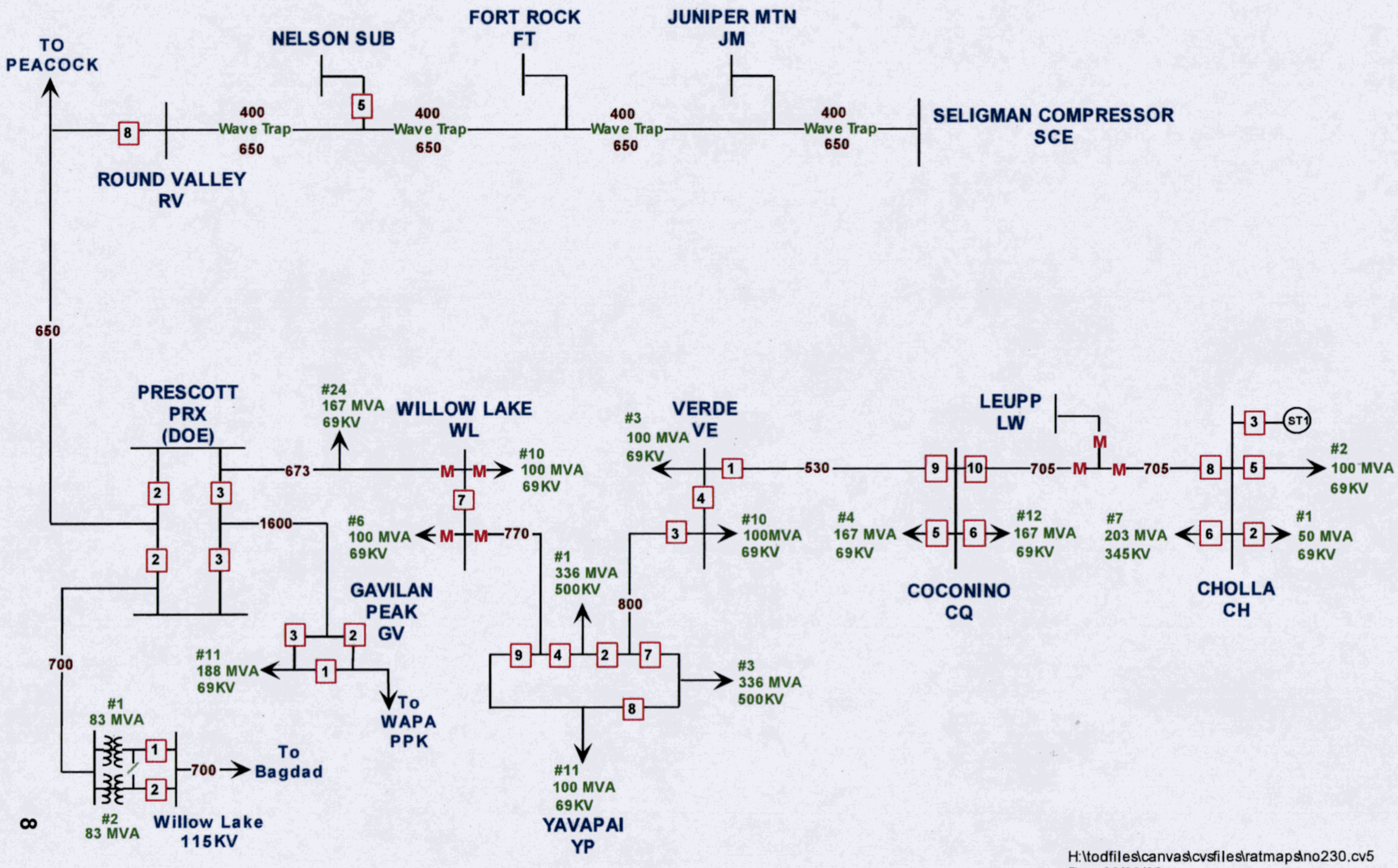
Rev. 08/22/06

NORTHERN 230KV



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Rev. 08/22/06

NORTHERN 230KV

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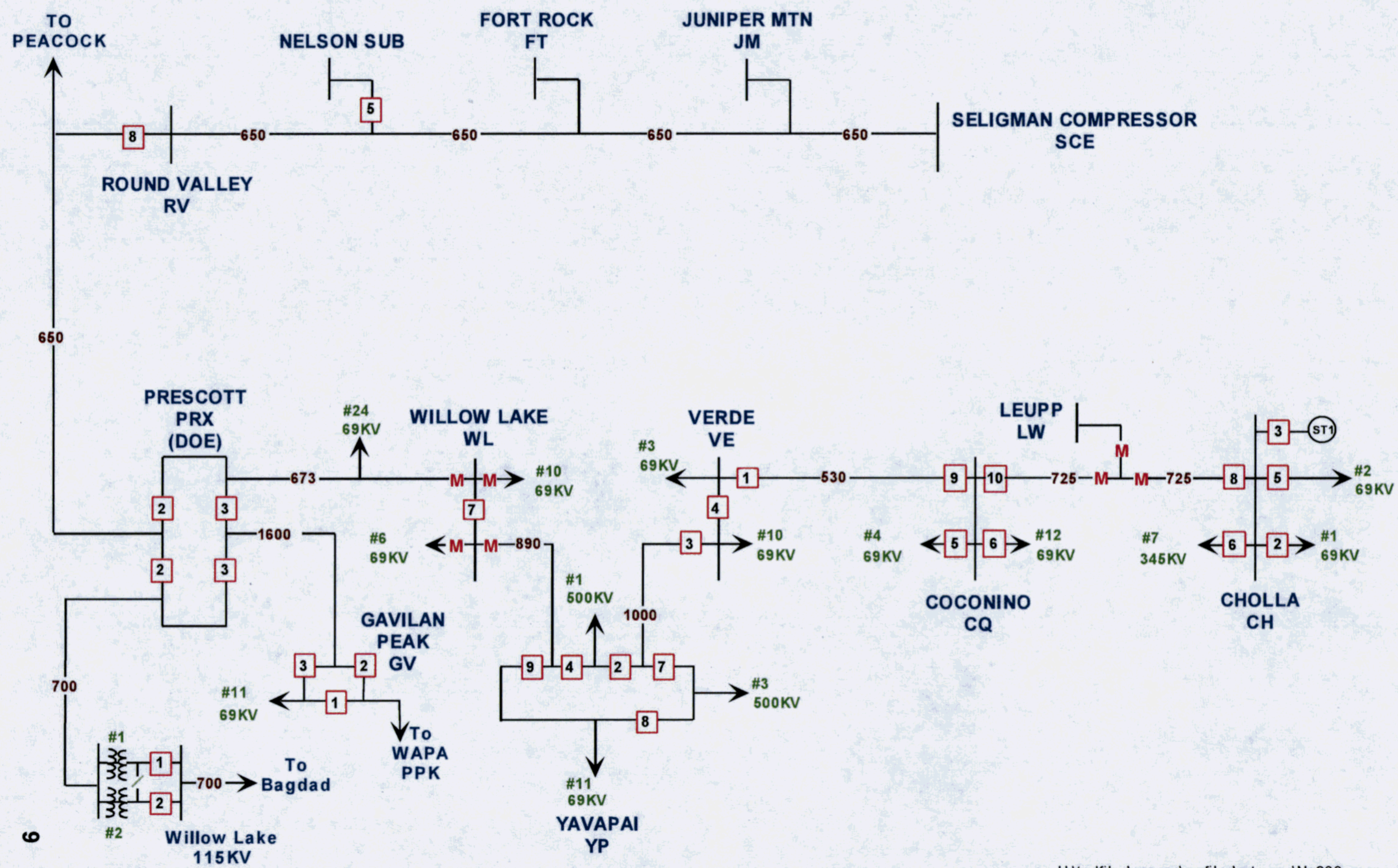

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Rev. 8/22/06

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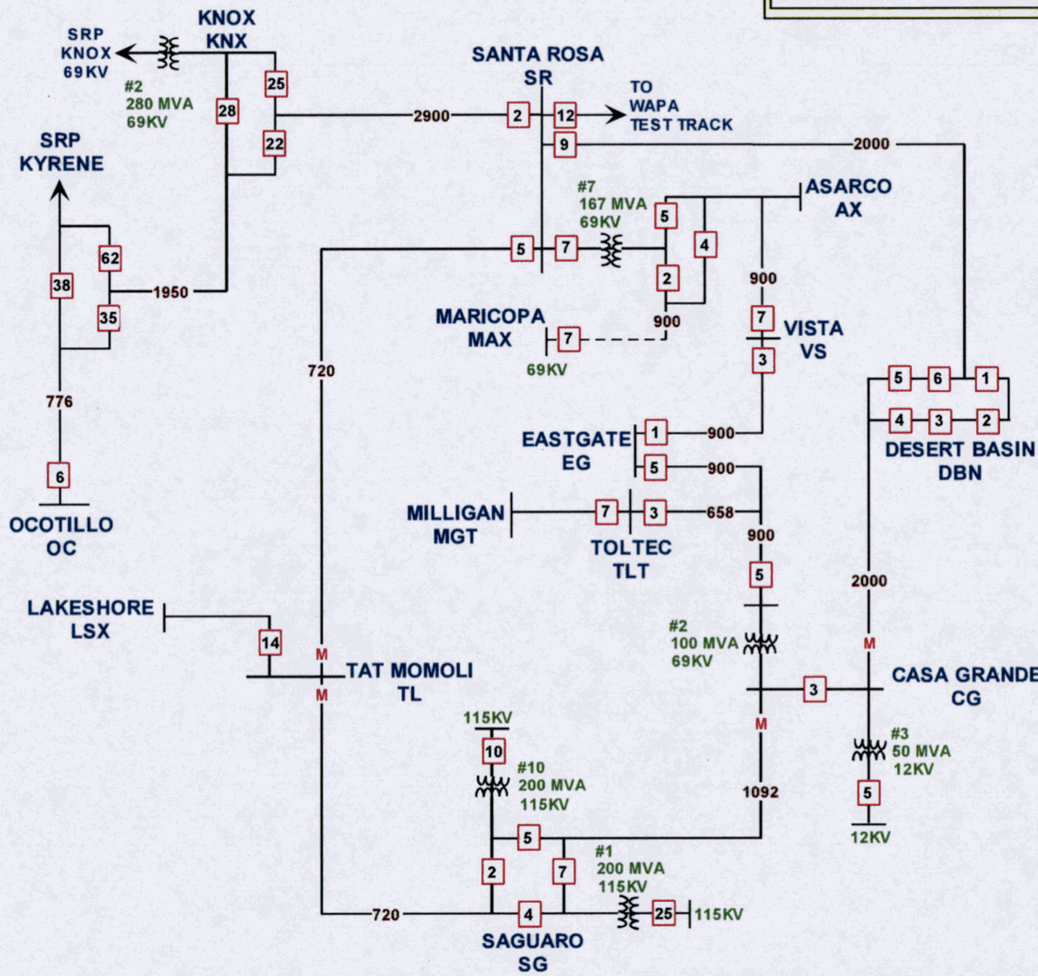

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Rev. 8/22/06

SOUTHERN 230KV

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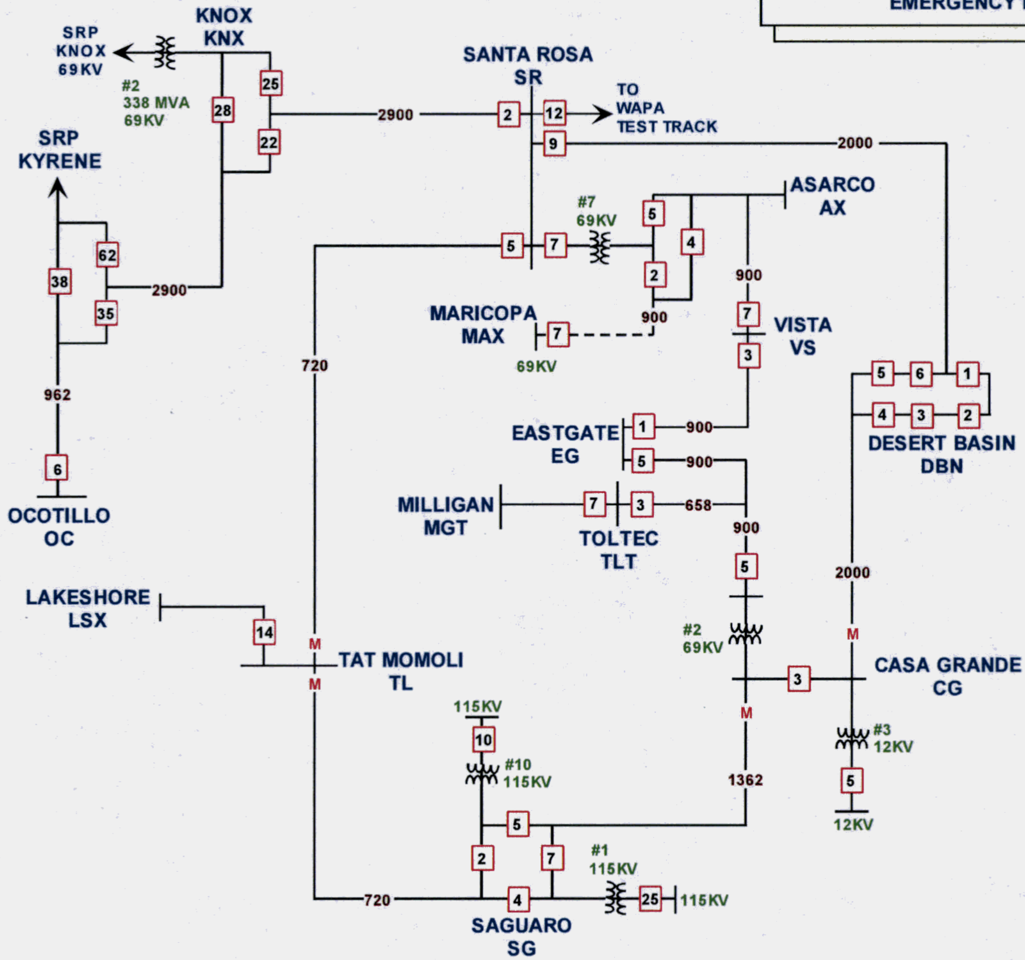

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Rev. 08/22/06

ARIZONA PUBLIC SERVICE COMPANY

TEN-YEAR PLAN

2008 – 2017

TECHNICAL STUDY REPORT

FOR

THE ARIZONA CORPORATION COMMISSION

JANUARY 2008

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ARIZONA PUBLIC SERVICE COMPANY
2008-2017
TEN-YEAR PLAN
TECHNICAL STUDY REPORT

I. Introduction

This technical study report is filed with the Arizona Corporation Commission ("Commission") pursuant to ARS 40-360.02 and Commission Decision No. 63876 (July 25, 2001). This report summarizes the results of power flow analyses and stability analyses for the APS system. Power flow analyses were performed for two scenarios: (i) assumption that all transmission system elements are in service and within continuous ratings; and (ii) assumption of an outage on a single element, with all remaining system elements remaining within emergency ratings. Voltage deviations for these scenarios must also be within established guidelines. These voltage deviation guidelines closely approximate post-transient VAR margin requirements of the Western Electricity Coordinating Council. More detail is provided in APS' Transmission Planning Process and Guidelines, which is also included in this filing.

The stability analyses were performed to simulate electrical disturbances on the transmission system and evaluate the system response. The desired result is that all generators will remain on line, no additional lines will open, and the system oscillations will damp out.

Results of the power flow and stability analyses aid in determining when and where new electrical facilities are needed because of reliability or security reasons. Additionally, some facilities are planned to address adequacy concerns. These include the interconnection of generation to the transmission system or efforts to increase import capability to load-constrained or other areas.

II. Power Flow Analyses

Power flow cases were created for each year of the 2008-2017 study time frame. These cases represent the latest transmission and sub-transmission plans, load projections, and resource plans of utilities and independent power producers. Base case and single contingency conditions are evaluated to determine system needs and timing. Various iterations of possible solutions lead to the final plans for transmission additions.

The contingency analysis involves simulations for every non-radial 115kV or above line that APS owns, partially owns, or operates. Transformer outages are also evaluated. Results of the power flow studies are tabulated in a Security Needs Table and an Adequacy Needs Table, below. These tables identify seventeen transmission projects that are included in this Ten-Year Plan filing. Some of the projects were classified as Adequacy Needs because of the uncertainty of generation location, size, and availability in the later years. As projects near the five-year planning time frame, they may be redefined as Security Needs projects. For the projects included in the Security Needs Table, selected maps of the power flow simulations are contained in the appendix.

Security Needs Table

Transmission Project	In Service Year	Critical Outage	Limiting Element	Map
Sugarloaf 500kV substation	2009	Cholla-Woodruff 69kV line	Voltage deviations and line overloads on the sub-transmission system in the area resulting in load shedding	A1-A2
Milligan loop-in of Saguaro-Casa Grande 230kV line	2009	Casa Grande-Toltec 69kV line or Casa Grande 230/69kV transformer	Overloads Santa Rosa-Asarco 69kV line	A3-A4
VV1 500kV substation	2009	Verde-Cottonwood 69kV line	Voltage deviations and line overloads on the sub-transmission system in the area resulting in load shedding	A5-A6
Flagstaff 345/69kV interconnection	2010	230/69kV transformers at Coconino	Voltage deviations on the sub-transmission system in the area resulting in load shedding	A7-A8
PV-Sun Valley 500kV line & Sun Valley-TS1 230kV line	2010	El Sol 230/69kV transformer	The remaining 230/69kV transformer at El Sol	A9-A10
Mazatzal 345kV substation	2011	Preacher Canyon-Tonto 69kV line	Voltage deviations on the sub-transmission system in the area resulting in load shedding	A11-A12
TS6 230kV substation	2012	Cielo Grande-North Valley 69kV line	Overloads Deer Valley-Rose Garden 69kV line	A13-A16
Loop-in of TS4-Panda 230kV line to Jojoba 230kV substation	2013	Buckeye 230/69kV #6 transformer	Buckeye 230/69kV #2 transformer	A17-A18

Adequacy Needs Table

Transmission Project	In Service Year	System Benefits
Palm Valley-TS2-TS1 230kV line	2010	Provides a second source for TS1 so TS1 is not served as a radial substation, thereby increasing system reliability. Also provides the transmission sources for the TS2 substation in 2011.
Loop-in of Navajo-Westwing 500kV into TS9 500kV substation and TS9-Pinnacle Peak 500kV line	2010	Increases import capability for the Phoenix Metropolitan area and export capability from the PV area. Increases transmission system reliability and ability to deliver power.
Loop-in of Saguaro-Casa Grande 230kV line into SE 10 230kV substation	2011	Provides a transmission source to serve the increasing regional growth and demand for electric energy.
Desert Basin-Pinal South 230kV line and Pinal South-Sundance 230kV line	2011	Provides another transmission path in the regional system, thereby increasing the system reliability and capacity in order to continue to serve the growing electrical demand in an economical and reliable manner. Increases the reliability of the Sundance generating facility and provides a transmission path for APS to deliver the full output of the Sundance generating facility.
TS9 230kV substation including a 500/230kV transformer, and TS9-Raceway 230kV line	2012	Provides a backup for outage of Westwing 500/230kV transformers and adds another source for the Raceway and TS6 230kV substations. Increases import capability for the Phoenix metropolitan area.
Sun Valley-TS9 500kV line.	2012	Provides a second source for Sun Valley. Increases import capability for the Phoenix Metropolitan area, increases the export capability from the PV area.
Palo Verde vicinity to North Gila 500kV.	2012	Increases import capability for the Yuma area allowing APS to serve the growing load. Increases transmission system reliability. Increases the export capability from the PV area.
North Gila-TS8 230kV line.	2012	Increase transmission system reliability and ability to deliver power within the Yuma area.
Avery	2013	Provides a transmission source to serve the increasing regional growth and demand for electricity in the area.

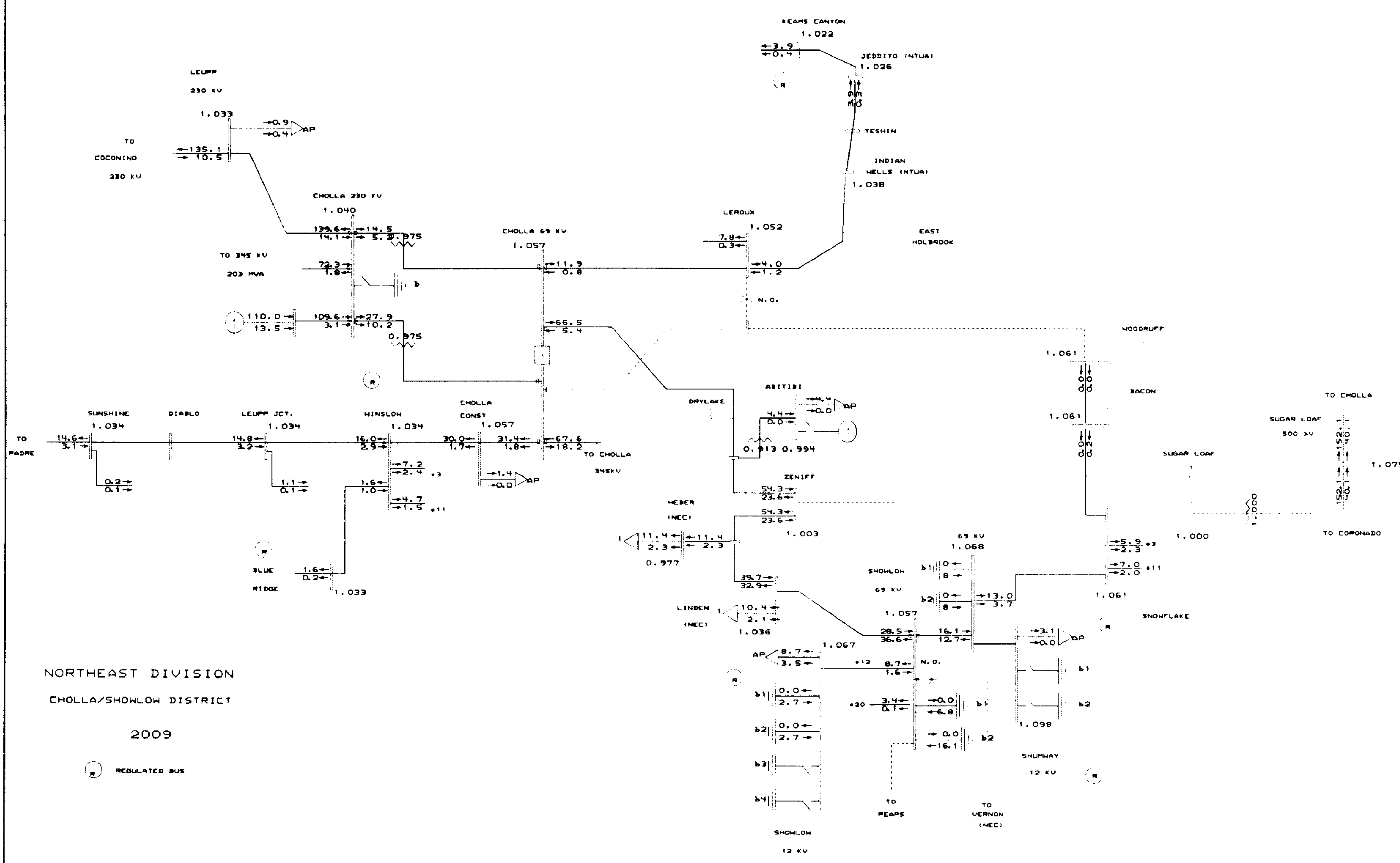
III. Stability Analyses

A stability simulation for simulated three-phase faults was performed for 2011 and 2016 for every 345kV or 500kV line that APS owns (totally or partially) or operates. It has been APS' experience that stability concerns do not manifest on the 230kV system, which is primarily designed to deliver power to load. Therefore, no 230kV simulations were performed. Additionally, every new proposed generation plant will be required to perform stability evaluations prior to receiving permission to interconnect to the transmission system.

Each simulation modeled a 3-phase bus fault, appropriate series capacitor flashing and reinsertion, and fault removal and transmission line removal. System performance was evaluated by monitoring representative generator rotor angles, bus voltages and system frequency. Plots of these system parameters are included in Appendices B and C. The stability simulations performed to date indicate that no stability problems limit the transmission system.

APPENDIX A

Power Flow Maps



sm09e14ns.sav

MW/MVAR

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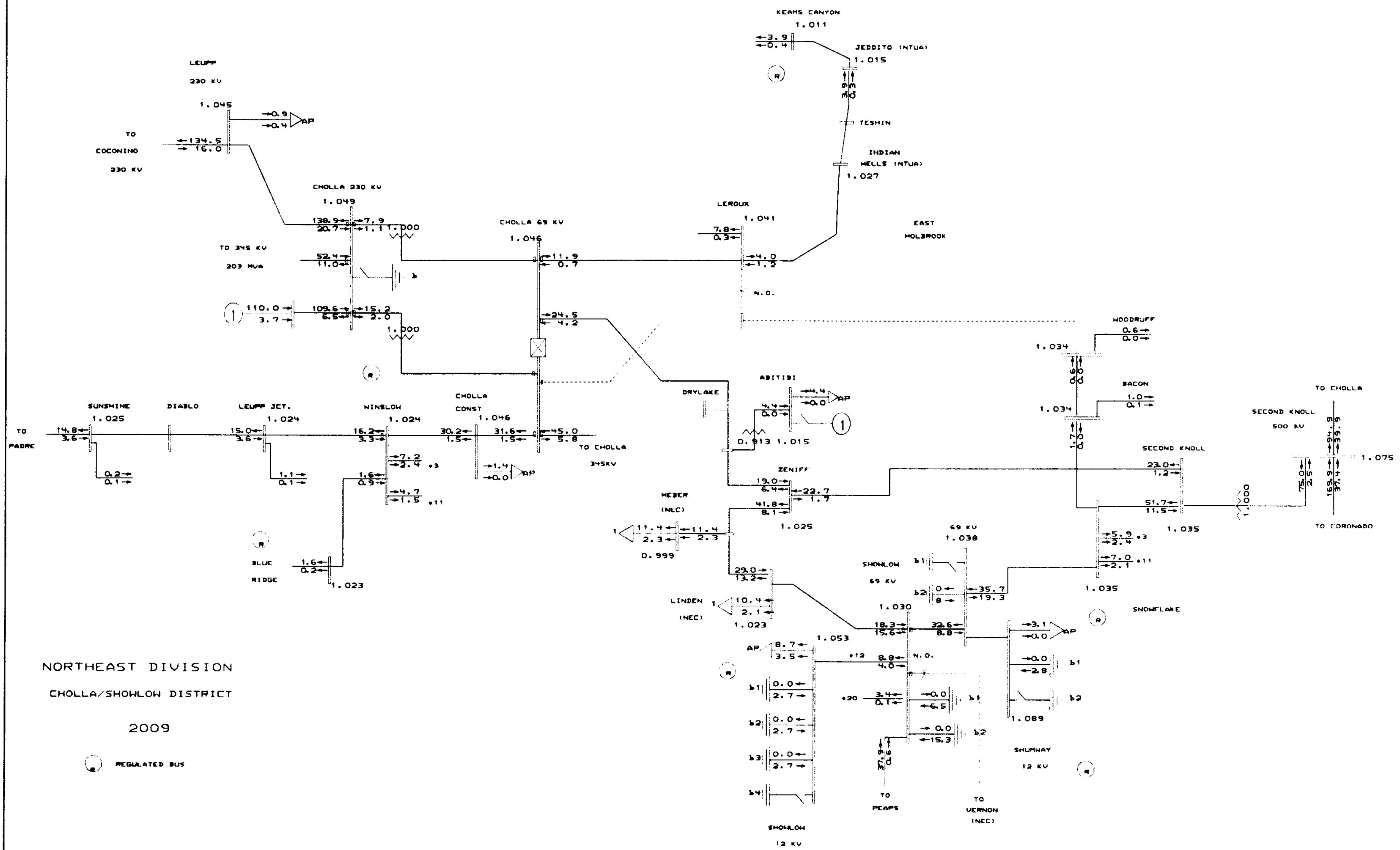

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MW/MVAR

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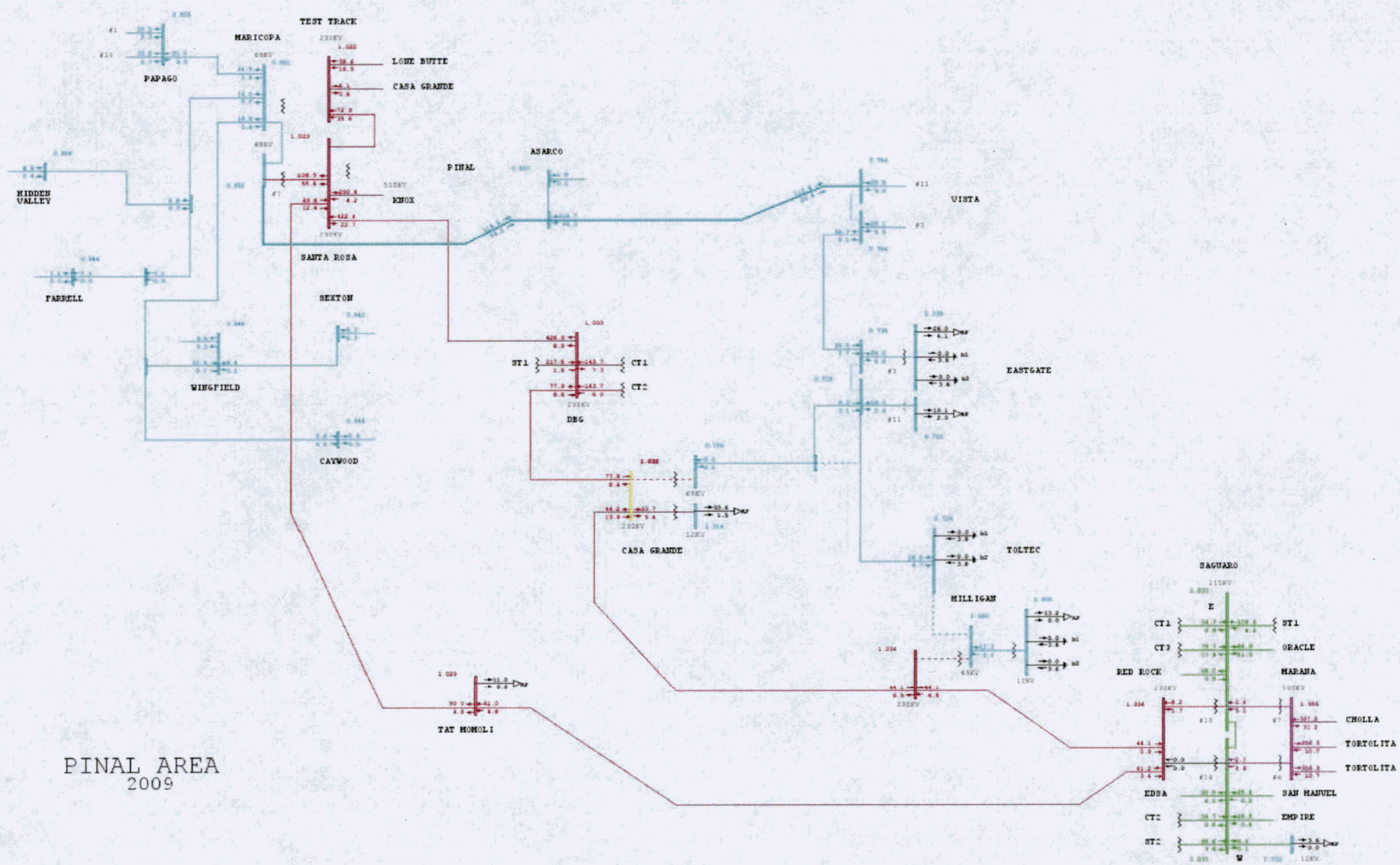
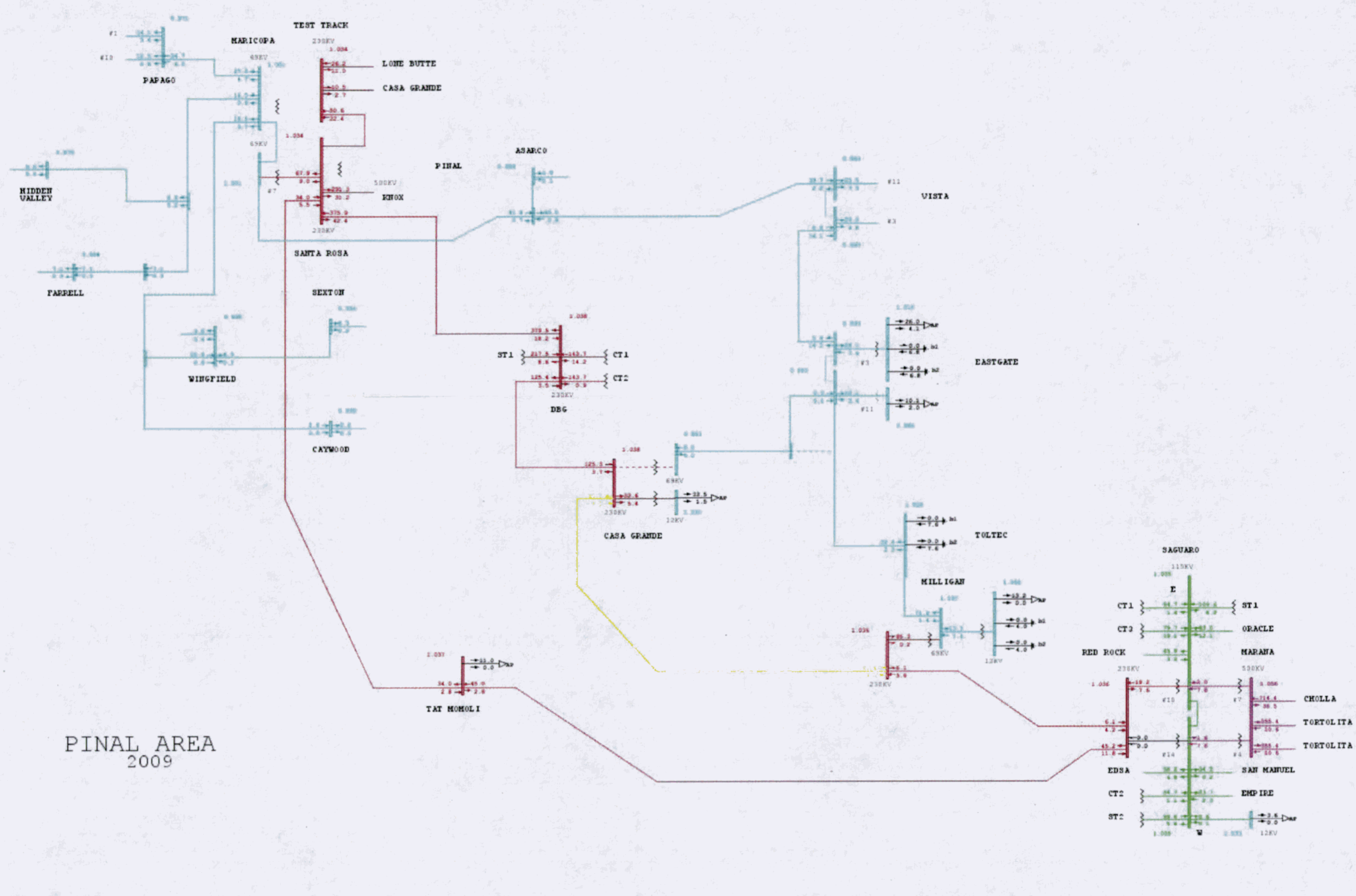
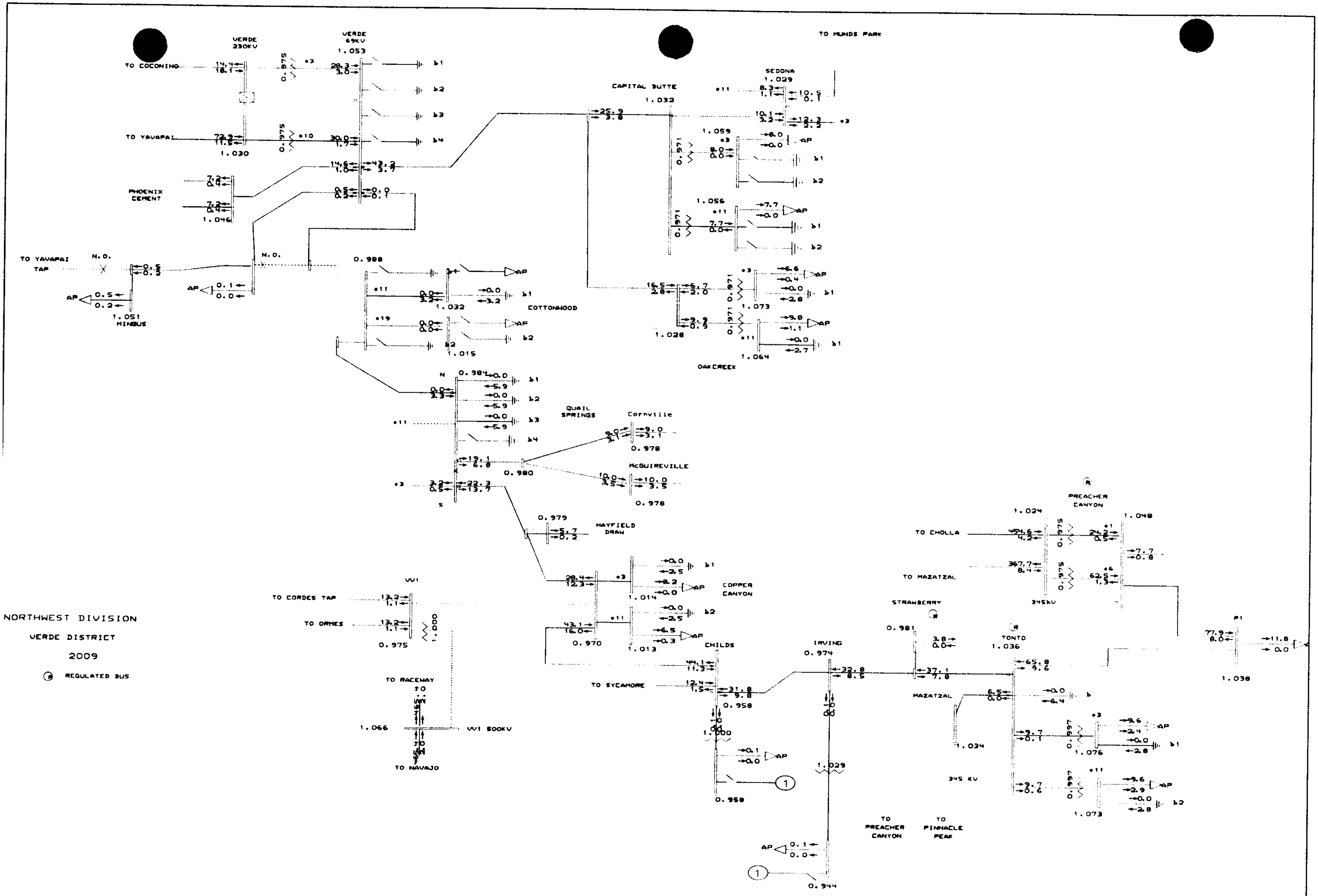


PINAL AREA
2009



TEST TRACK
230KV
LONE BUTTE
CASA GRANDE
MARICOPA
69KV
PAPAGO
HIDDEN VALLEY
FARRELL
SANTA ROSA
230KV
500KV
KNOX
PINAL
ASARCO
SEXTON
WINGFIELD
CAYWOOD
VISTA
EASTGATE
ST1
CT1
CT2
DBG
230KV
CASA GRANDE
69KV
12KV
TOLTEC
MILLIGAN
69KV
12KV
TAT MOMOLI
SAGUARO
115KV
E
W
ST1
ORACLE
MARANA
500KV
RED ROCK
230KV
CHOLLA
TORTOLITA
TORTOLITA
EDSA
SAN MANUEL
CT2
EMPIRE
ST2
12KV
PINAL AREA
2009

A4



cases\10yr transmision\verde09_wo_vv01.sav

MW/MVAR

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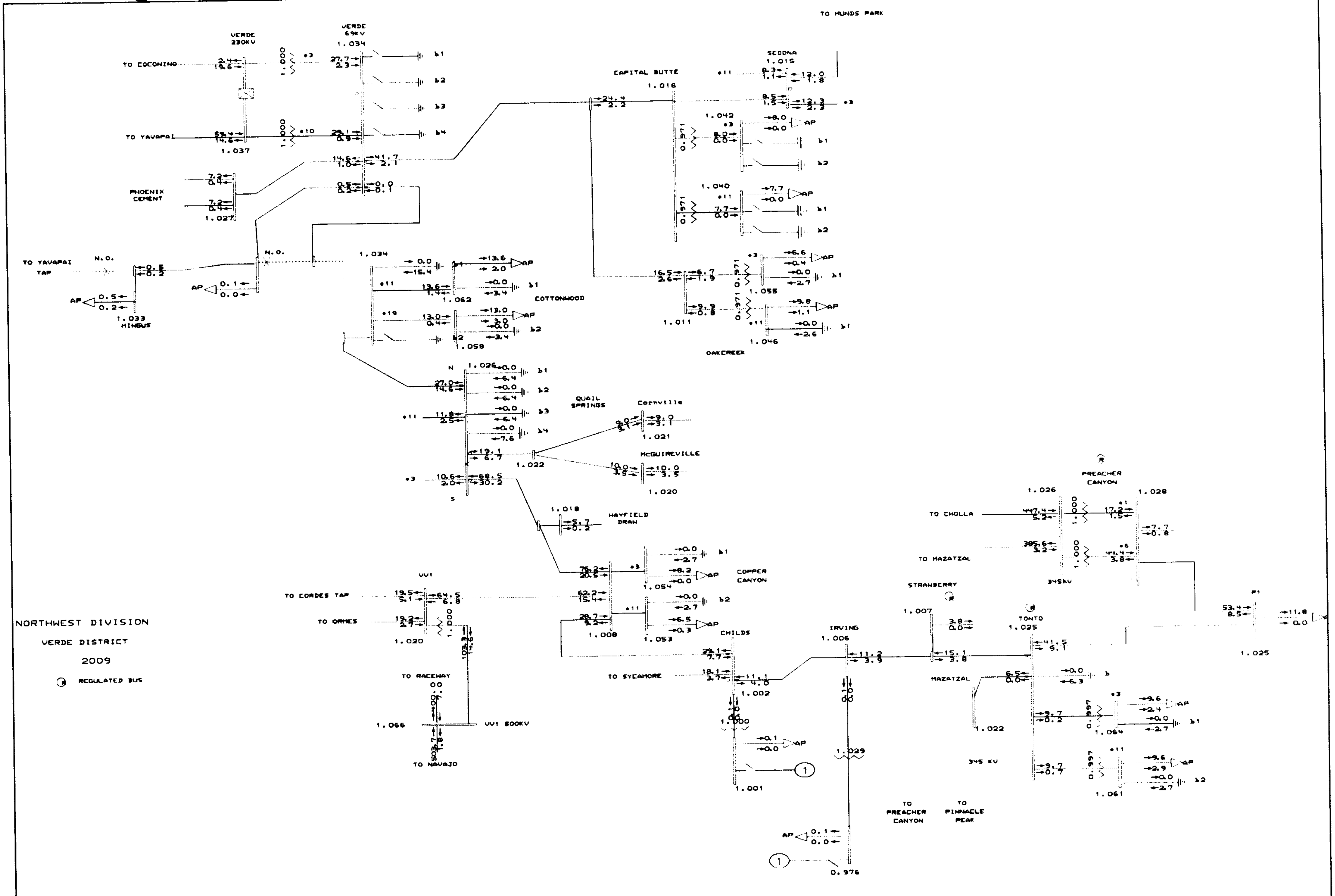
2009 BASE CASE sm09e14.sav Verde - Cottonwood 69kV Outage with 45.8 MW of load shed	A5	PSLF Program verde09.drw Rating = 1



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MW/MVAR

A6

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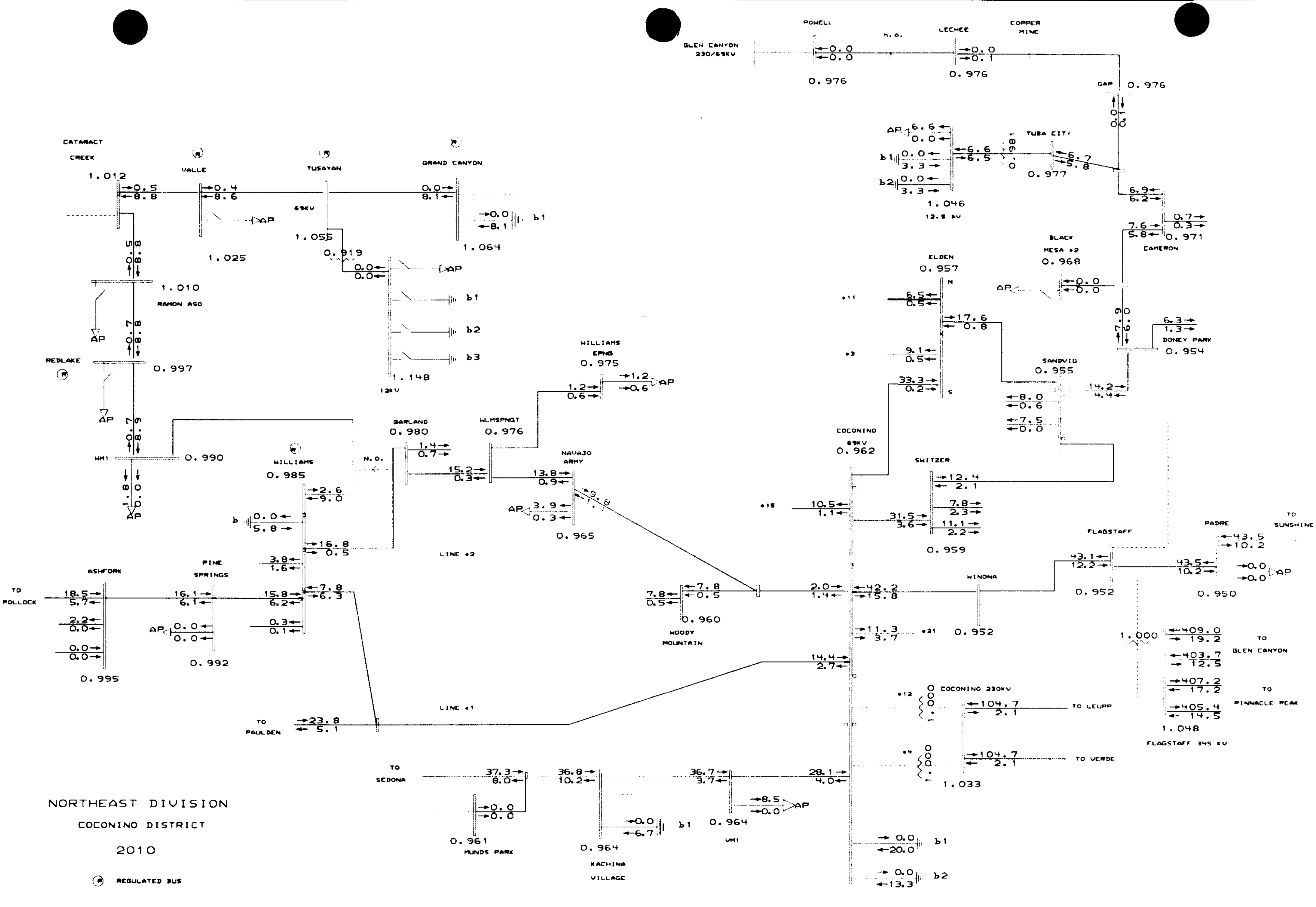
2009 BASE CASE

sm09e14.sav

PSLF Program

verde09.drw



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MW/MVAR

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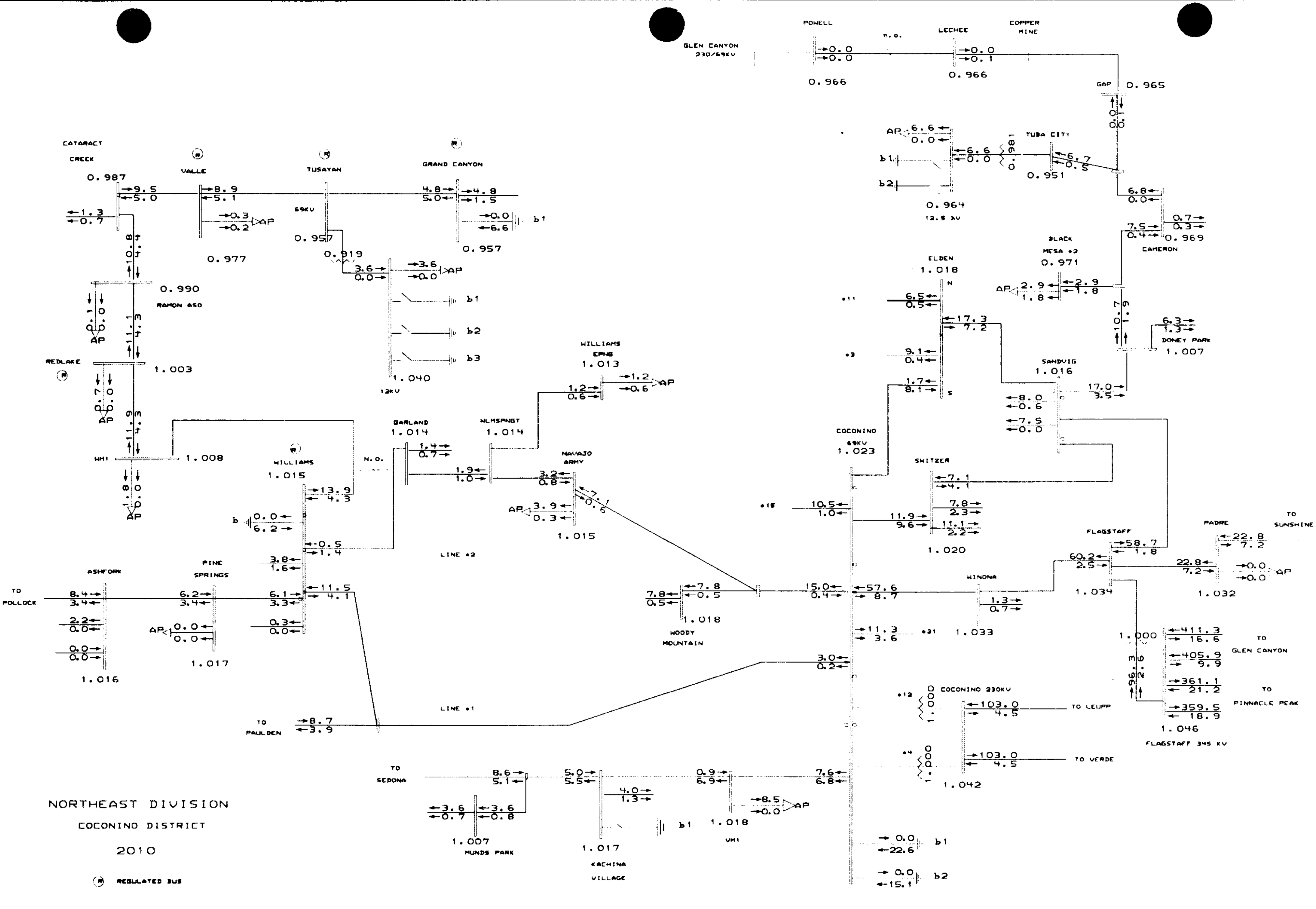

cases\10yr transmision\coconino10_flag.sav

MW/MVAR

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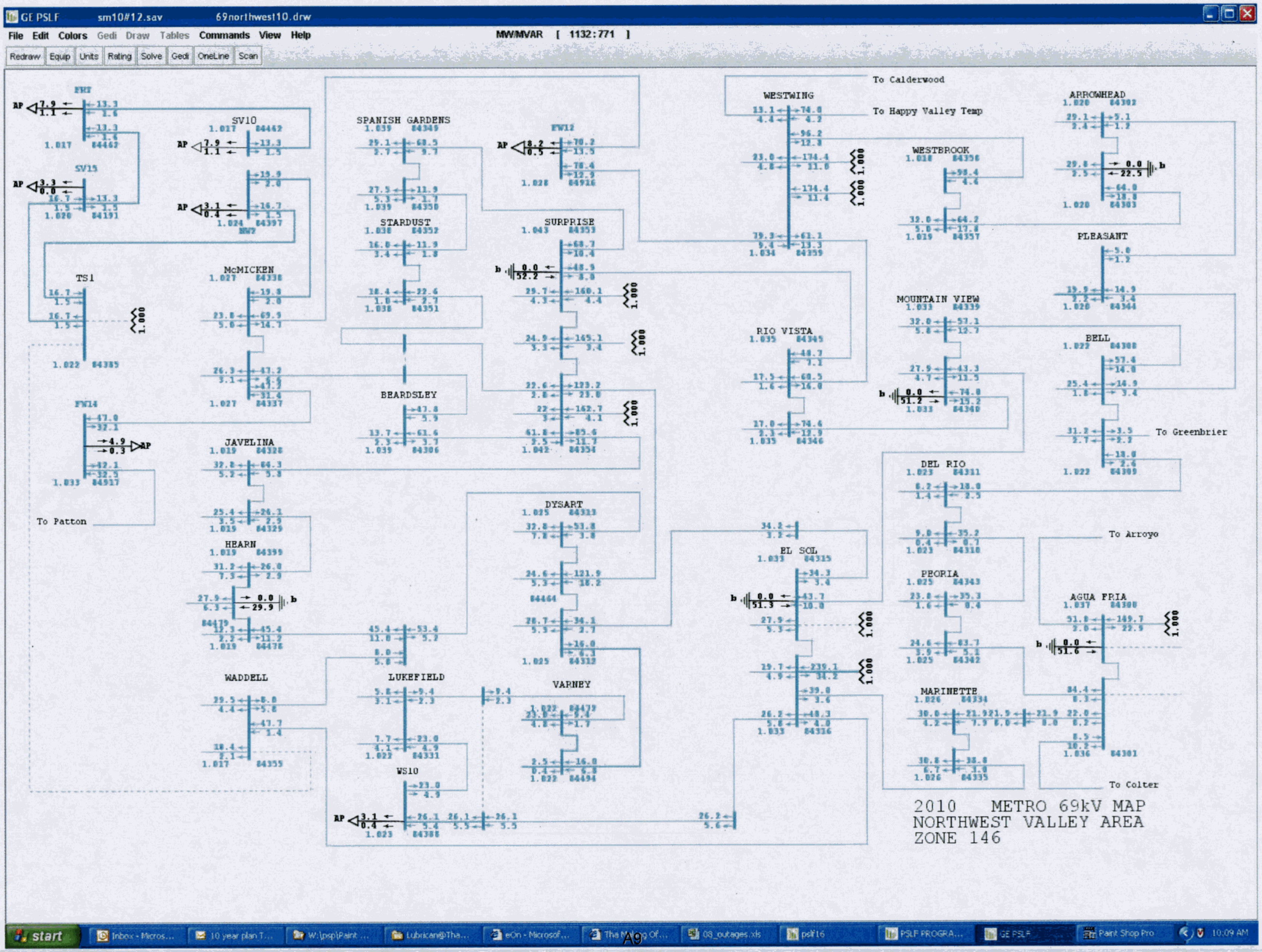
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Redraw Equip Units Rating Solve Gedi OneLine Scan
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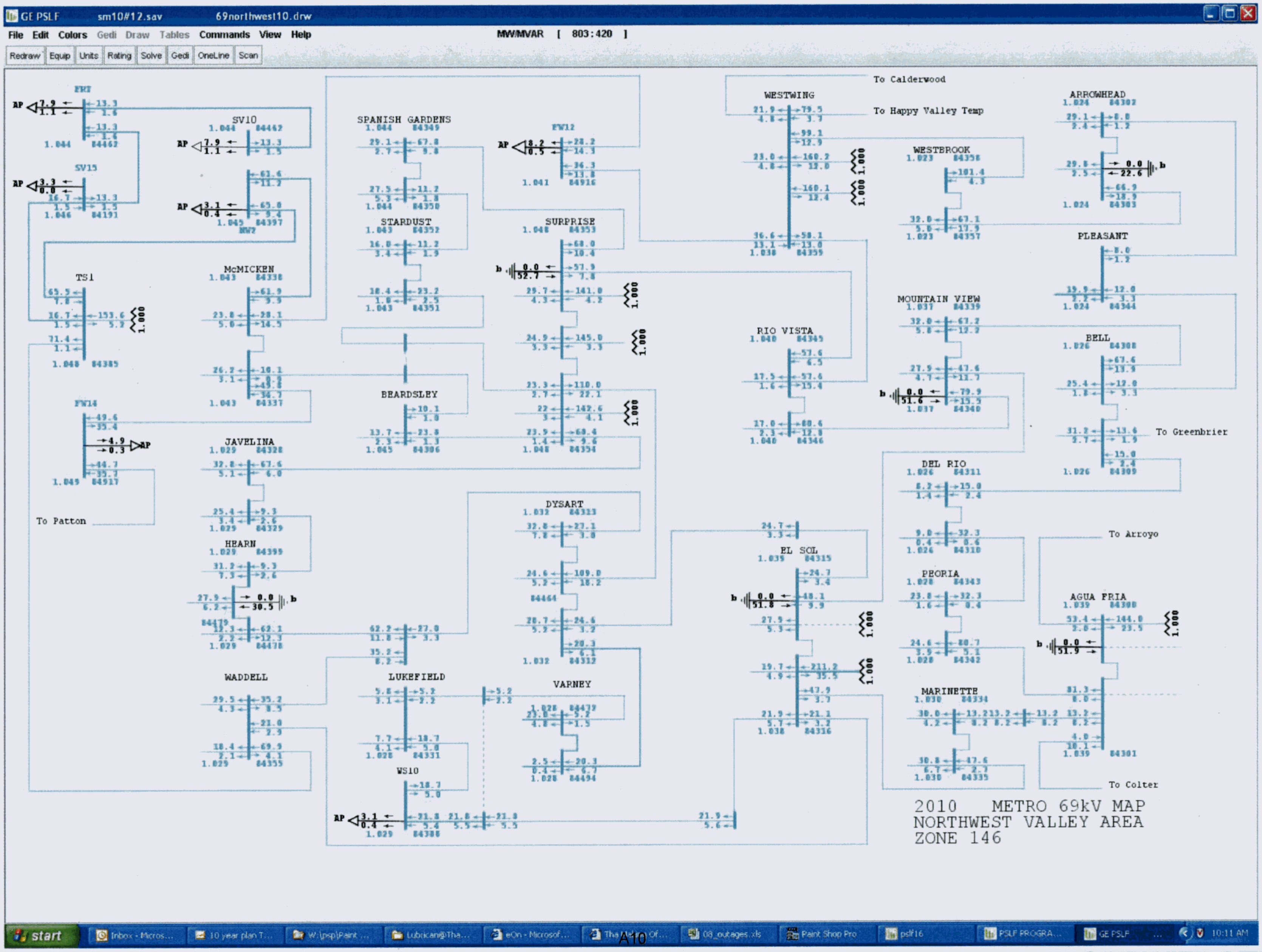
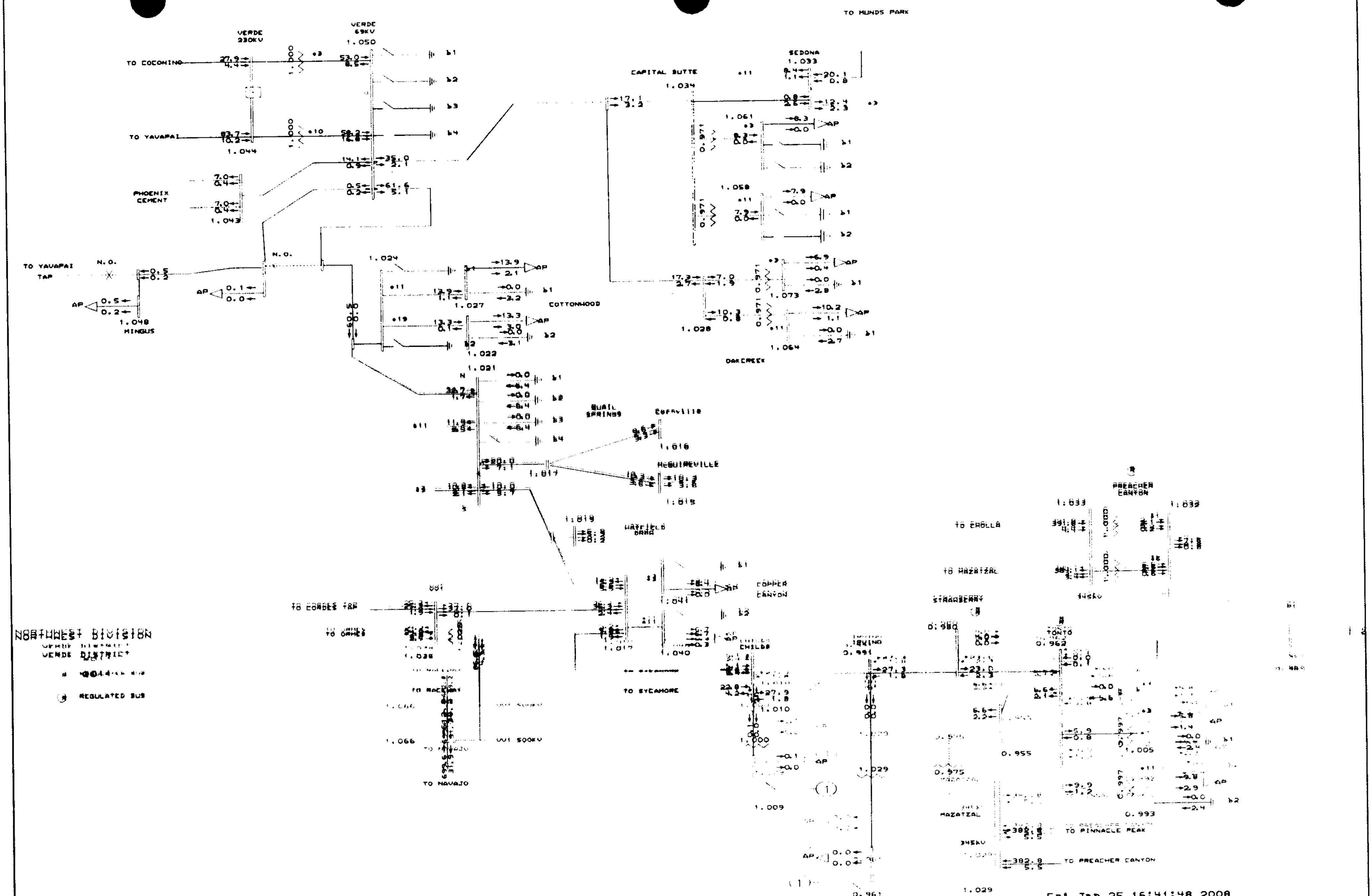
SV15
TS1
FW14
To Patton
SPANISH GARDENS
STARDUST
McMICKEN
BEARDSLEY
JAVELINA
HEARN
WADDELL
LUKEFIELD
WS10
SURPRISE
DYSART
VARNEY
WESTWING
To Calderwood
To Happy Valley Temp
RIO VISTA
EL SOL
WESTBROOK
MOUNTAIN VIEW
DEL RIO
PEORIA
MARINETTE
ARROWHEAD
PLEASANT
BELL
To Greenbrier
To Arroyo
AGUA FRIA
To Colter
2010 METRO 69kV MAP
NORTHWEST VALLEY AREA
ZONE 146

A9


GE PSLF sm10#12.sav 69northwest10.drw
File Edit Colors Gedi Draw Tables Commands View Help
MW/MVAR [803:420]
Redraw Equip Units Rating Solve Gedi OneLine Scan
To Calderwood
To Happy Valley Temp
WESTWING
ARROWHEAD
WESTBROOK
PLEASANT
SPANISH GARDENS
STARDUST
SURPRISE
SV10
SV15
TS1
McMICKEN
RIO VISTA
MOUNTAIN VIEW
BELL
To Greenbrier
BEARDSLEY
FW14
JAVELINA
DEL RIO
To Patton
DYSART
HEARN
EL SOL
To Arroyo
PEORIA
AGUA FRIA
WADDELL
LUKEFIELD
VARNEY
MARINETTE
WS10
To Colter
2010 METRO 69kV MAP
NORTHWEST VALLEY AREA
ZONE 146
start
10:11 AM

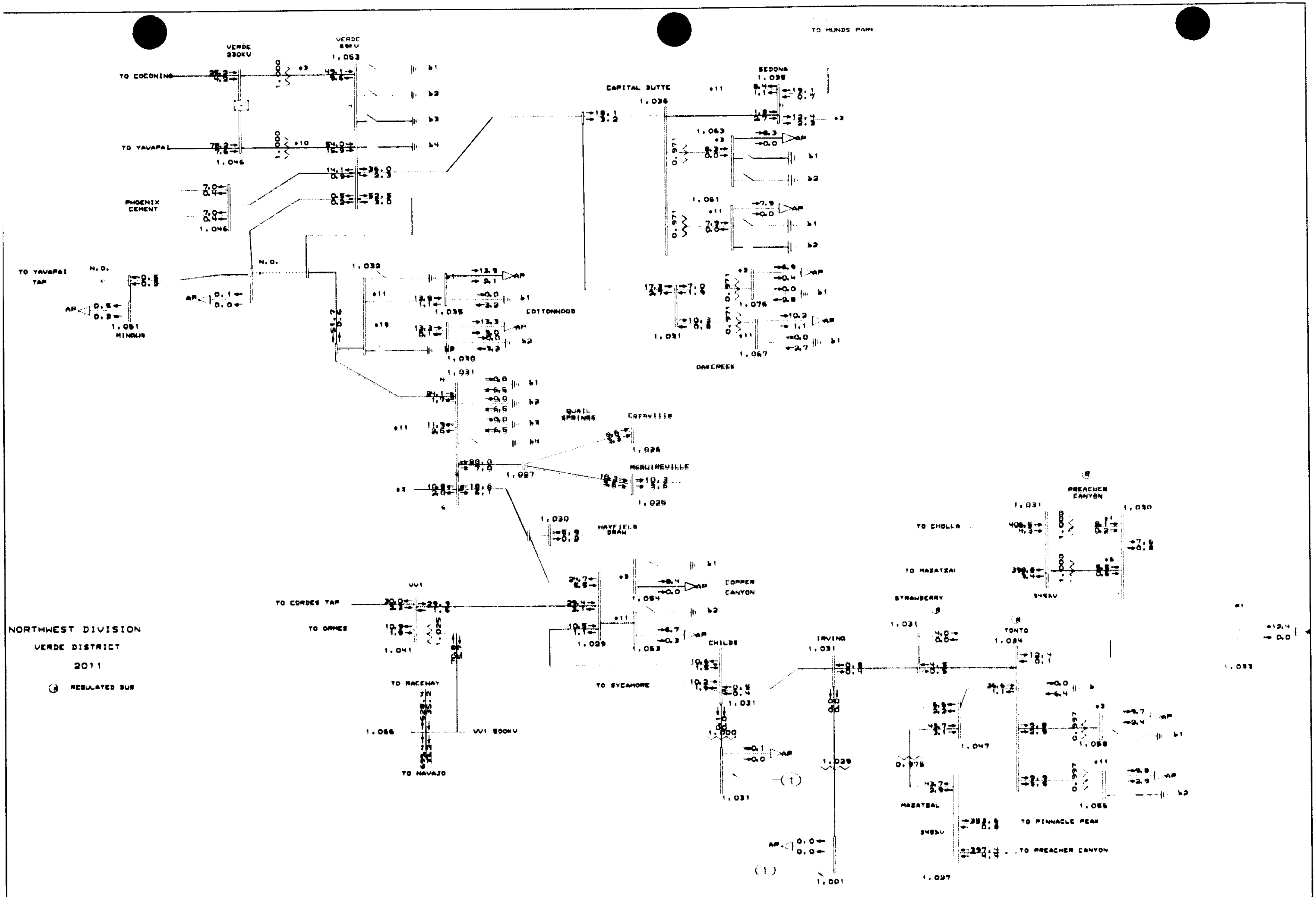
A10



cases\10yr transmision\verde11_mazatzal.sav

Fri Jan 25 16:41:48 2008

2011 BASE CASE 10yr transmision\verde11_mazatzal.sav 2011 BASE CASE Preacher Canyon - P1 69kV outage with 16.4 MW of load shed sm11e14.sav Preacher Canyon - P1 69kV outage with 16.4 MW of load shed	A11 MW/MVAR	Fri Jan 25 16:41:48 2008	PSLF Program verde11.drw PSLF Program Rating = 1 verde11.drw Rating = 1



cases\10yr transmision\verde11_mazatzal.sav

MW/MVAR

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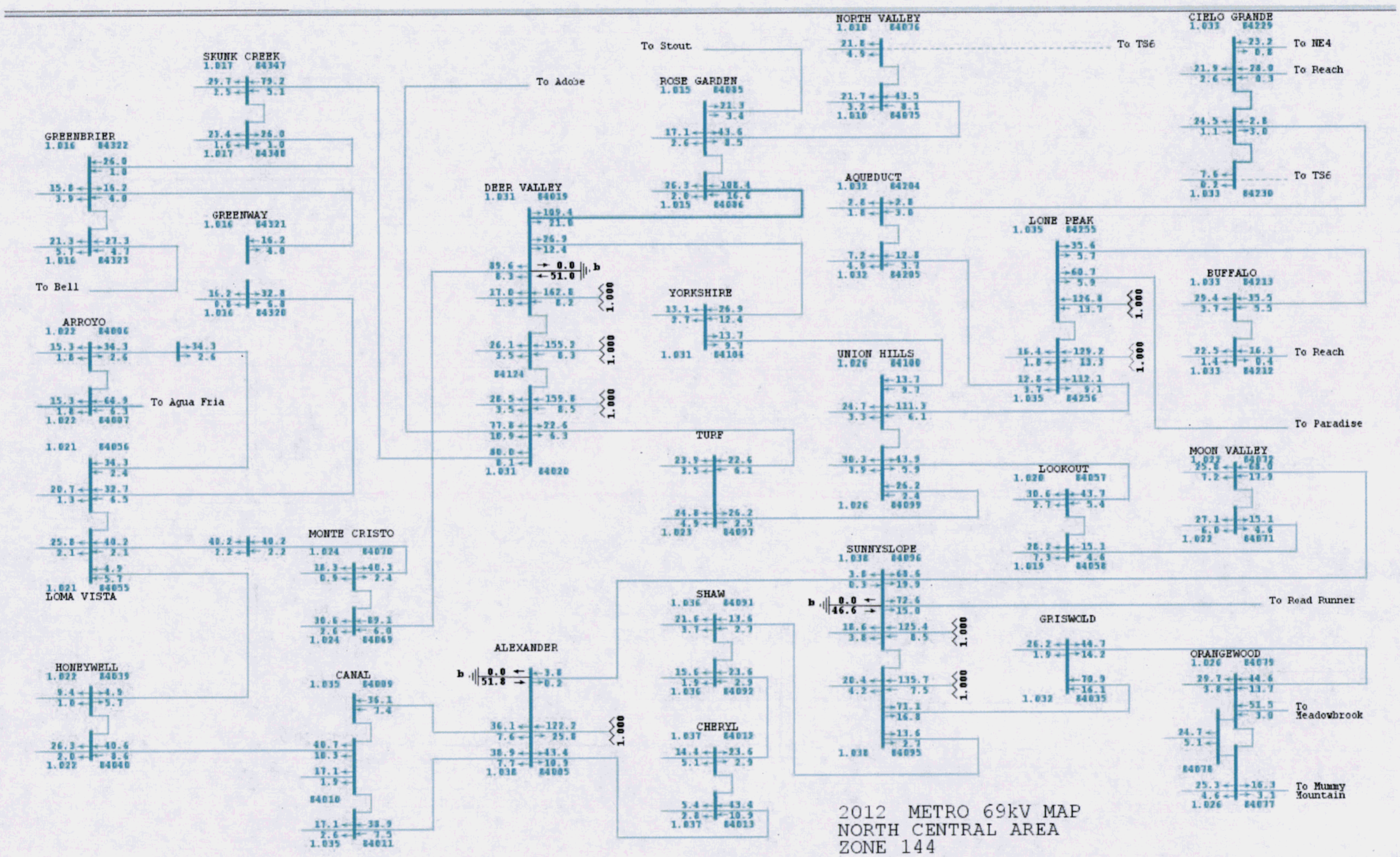
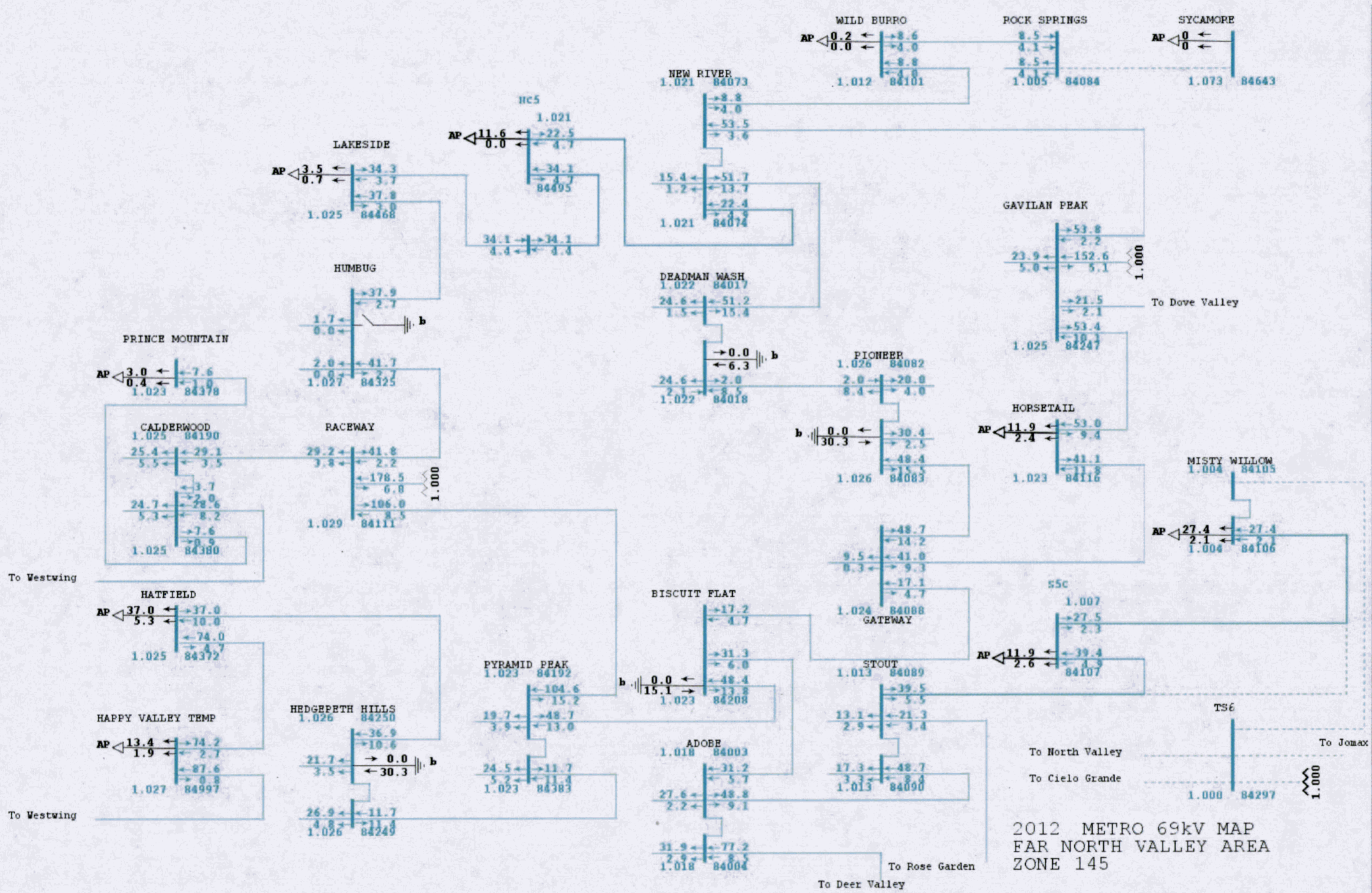
2011 BASE CASE sm11o14.sav Preacher Canyon - F1 69kV outage with Mazatzal 345/69kV online	A12	PSLF Program verde11.drw Rating = 1



2012 METRO 69kV MAP
NORTH CENTRAL AREA
ZONE 144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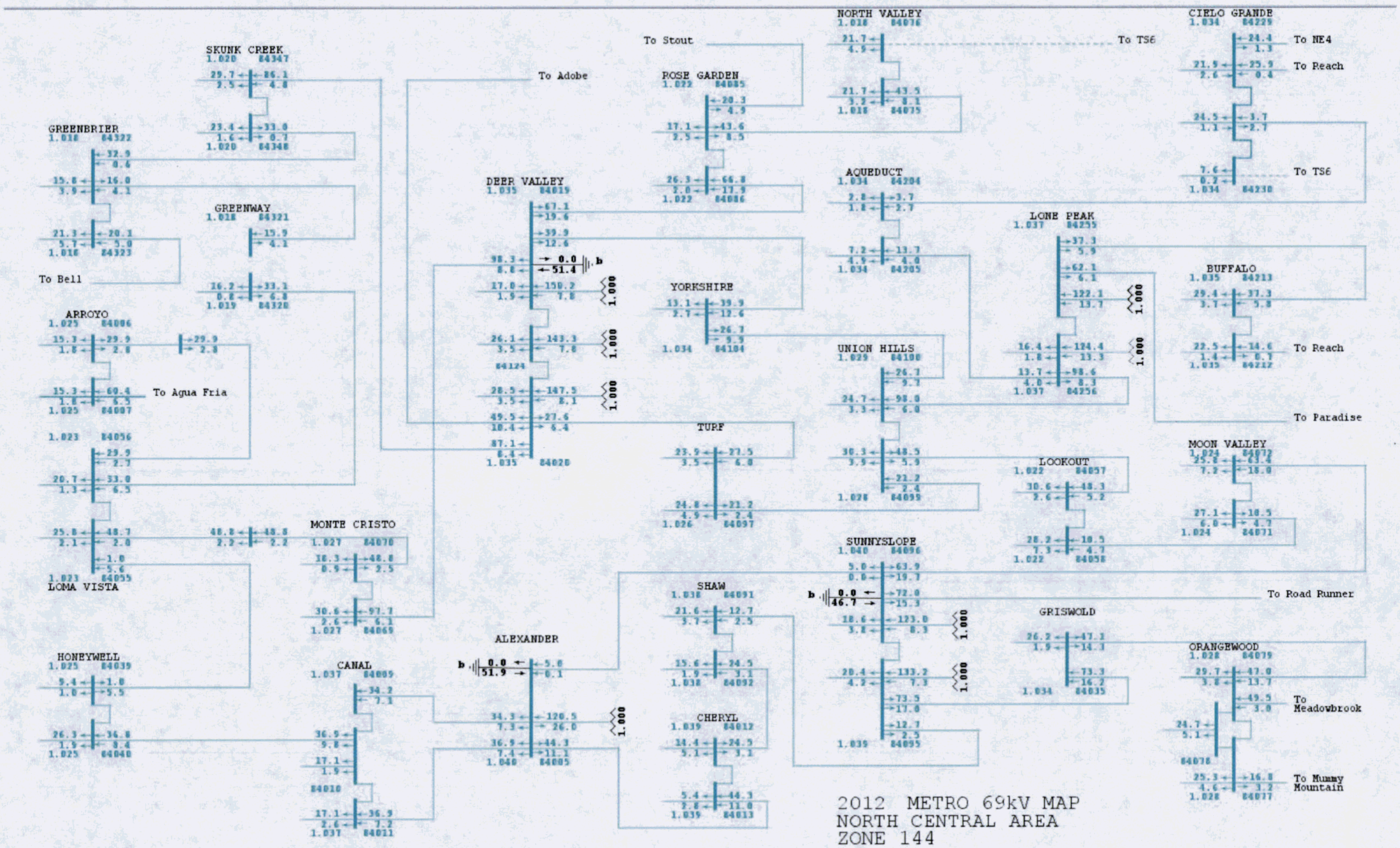
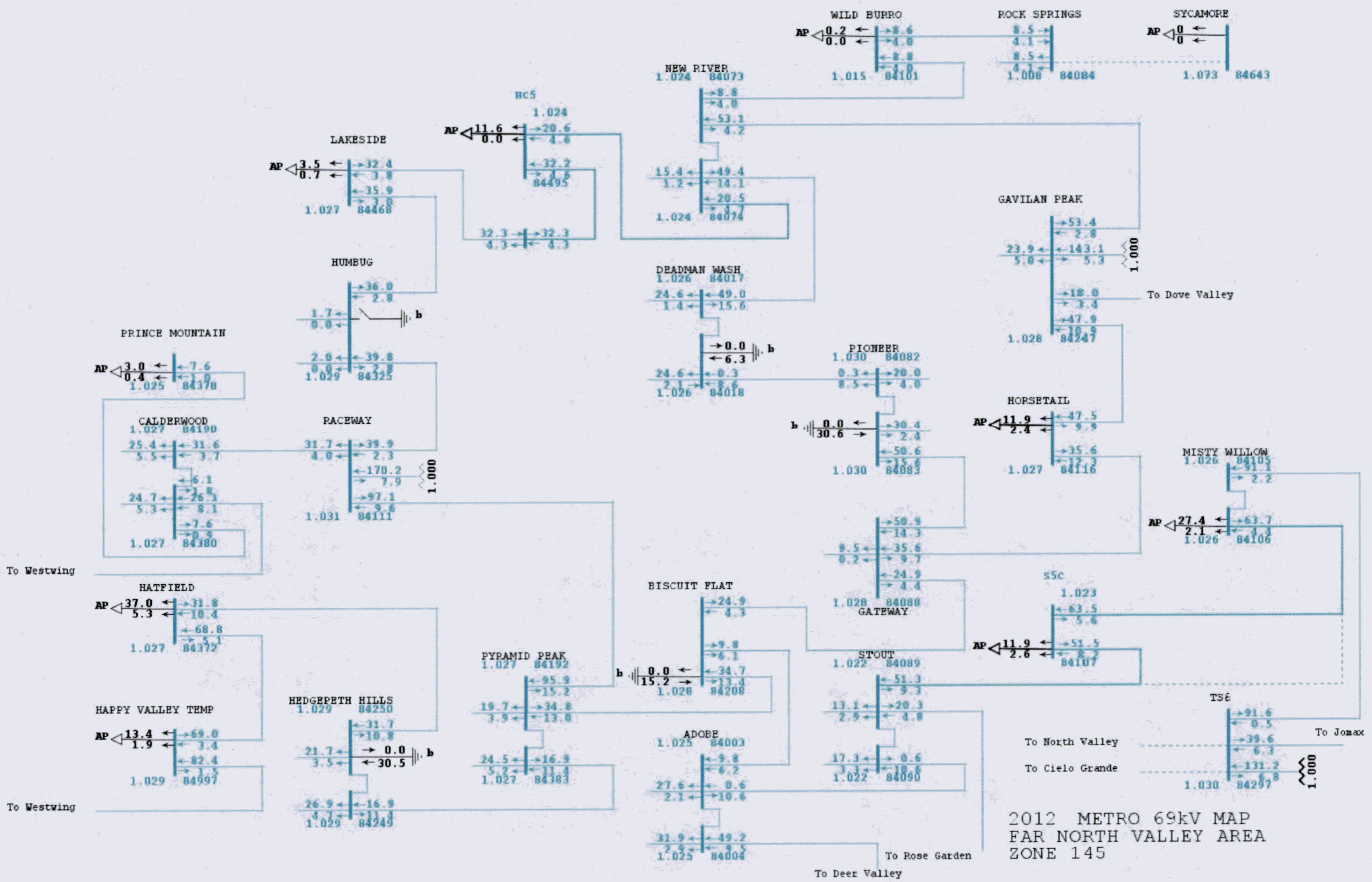
ROCK SPRINGS
SYCAMORE
NEW RIVER
HC5
LAKESIDE
GAVILAN PEAK
To Dove Valley
DEADMAN WASH
HUMBUG
PRINCE MOUNTAIN
PIONEER
HORSETAIL
CALDERWOOD
RACEWAY
MISTY WILLOW
To Westwing
HATFIELD
BISCUIT FLAT
GATEWAY
S5C
PYRAMID PEAK
STOUT
HEDGEPETH HILLS
HAPPY VALLEY TEMP
TS6
ADOBE
To North Valley
To Cielo Grande
To Jomax
To Westwing
To Rose Garden
To Deer Valley
2012 METRO 69kV MAP
FAR NORTH VALLEY AREA
ZONE 145

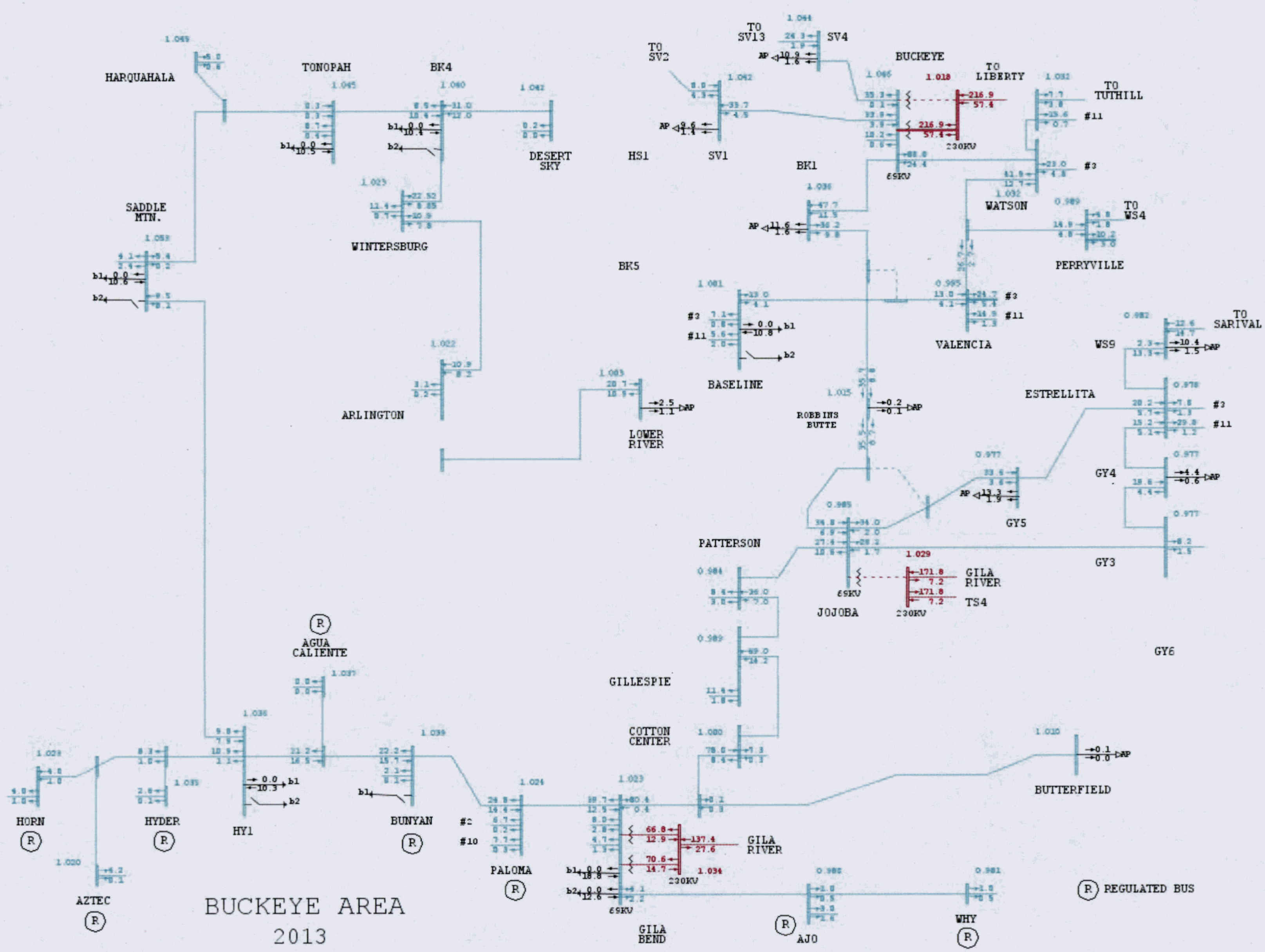


2012 METRO 69kV MAP
NORTH CENTRAL AREA
ZONE 144



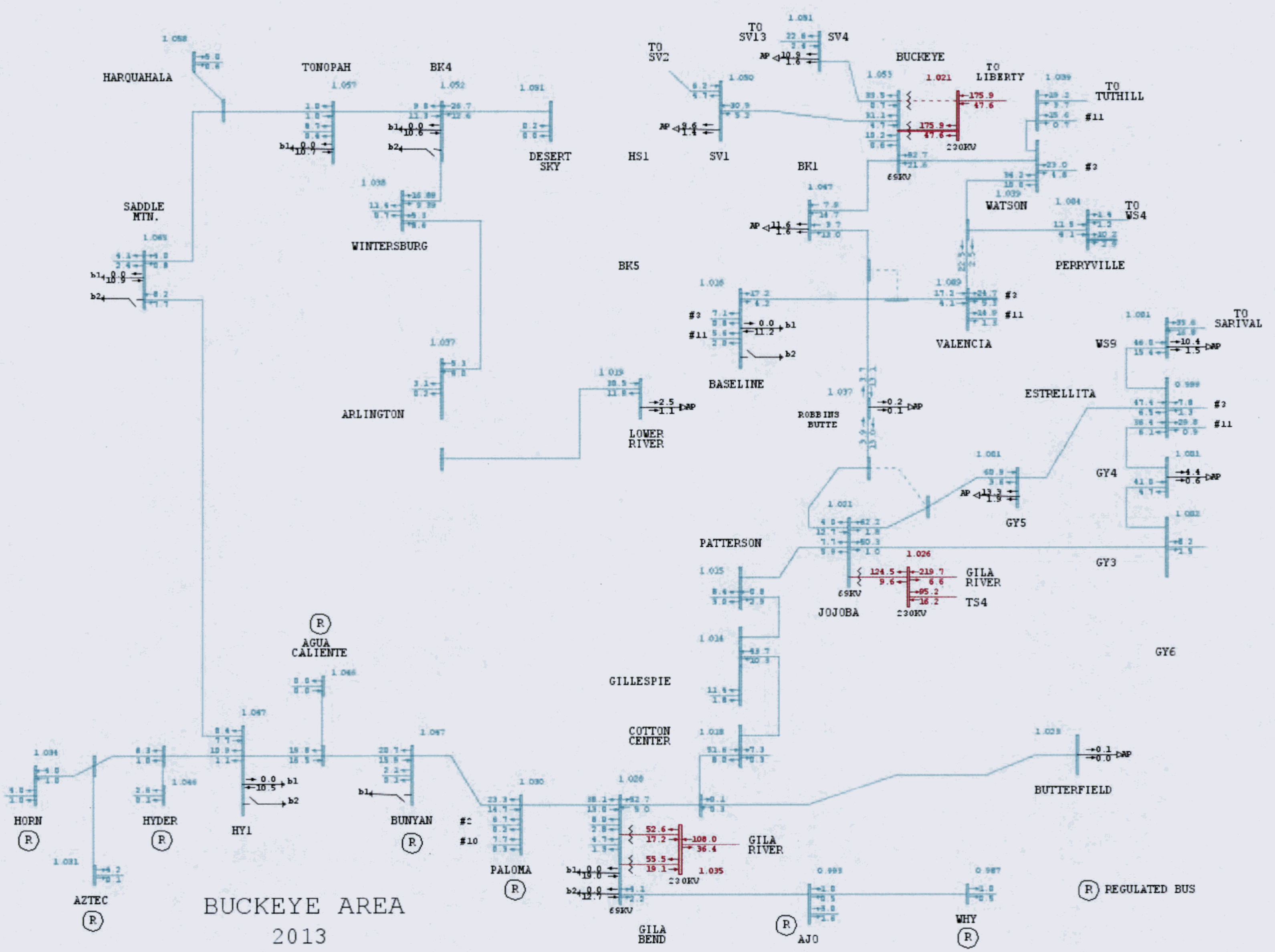
2012 METRO 69kV MAP
FAR NORTH VALLEY AREA
ZONE 145

A16



BUCKEYE AREA
2013

A17


HARQUAHALA
TONOPAH
BK4
DESERT SKY
HS1
SV1
TO SV2
TO SV13
SV4
BUCKEYE
TO LIBERTY
TO TUTHILL
230KV
69KV
BK1
WATSON
TO WS4
PERRYVILLE
SADDLE MTN.
WINTERSBURG
BK5
BASELINE
VALENCIA
TO SARIVAL
WS9
ESTRELLITA
ARLINGTON
LOWER RIVER
ROBBINS BUTTE
GY4
GY5
PATTERSON
JOJOBA
GILA RIVER
TS4
GY3
GY6
AGUA CALIENTE
GILLESPIE
COTTON CENTER
BUTTERFIELD
HORN
HYDER
HY1
BUNYAN
PALOMA
GILA BEND
AJO
WHY
AZTEC
R REGULATED BUS
BUCKEYE AREA
2013

APPENDIX B

2011
Stability Plots

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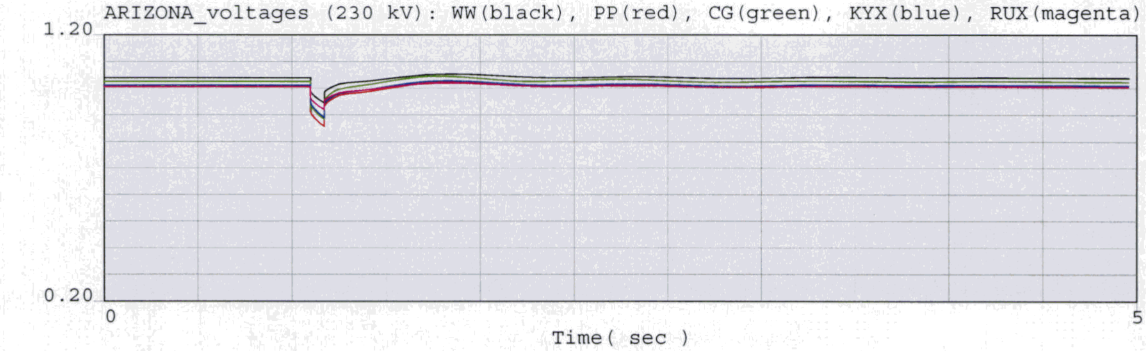
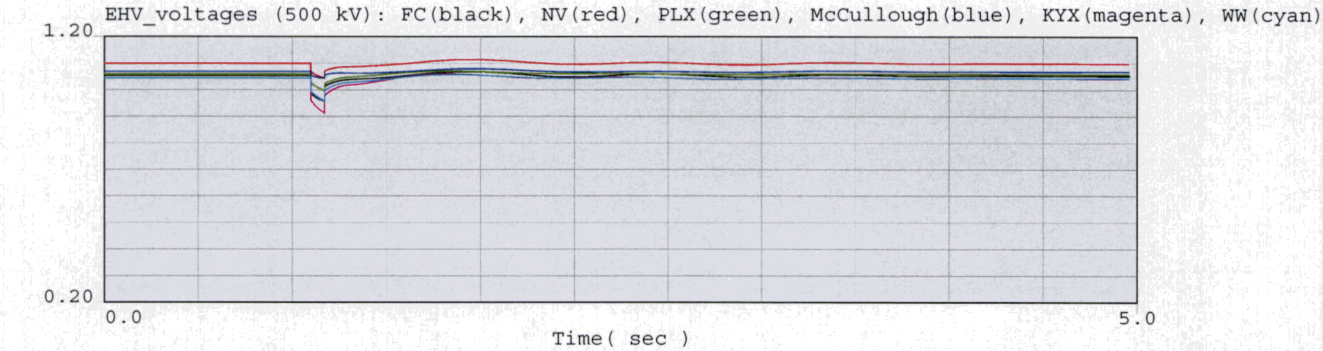
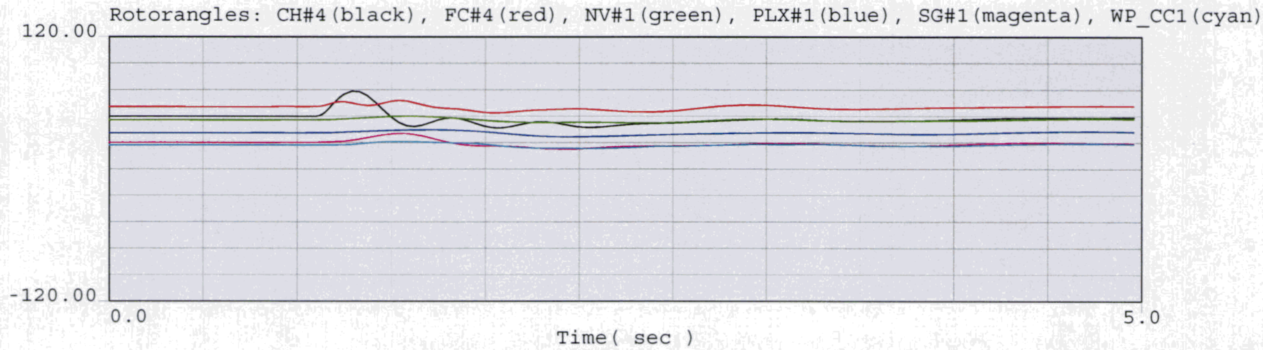
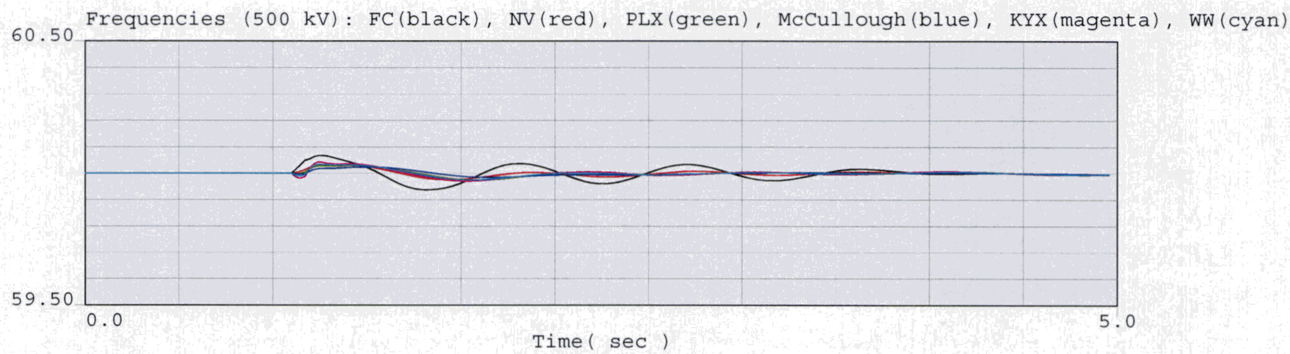
Simulation **Page**

2011 Heavy Summer WECC Power Flow









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year plan\2011 stability

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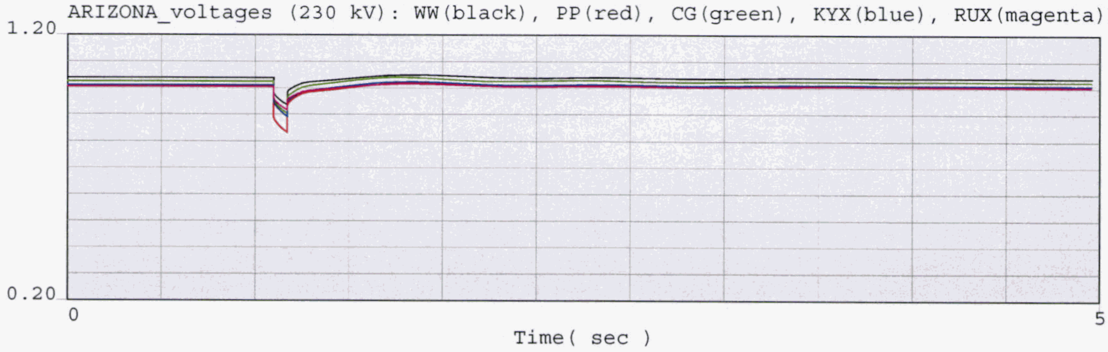
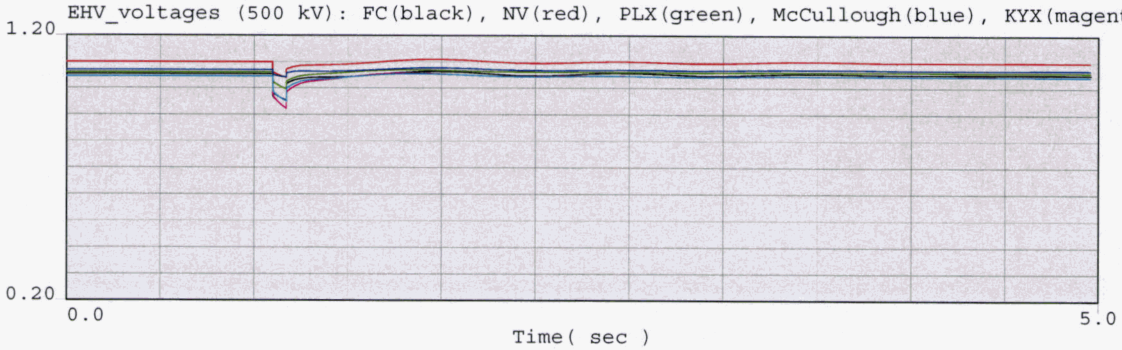
2011 Heavy Summer WECC Power Flow

ARIZONA_voltages (230 kV): WW(black), PP(red), CG(green), KYX(blue), RUX(magenta)



EHV_voltages (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



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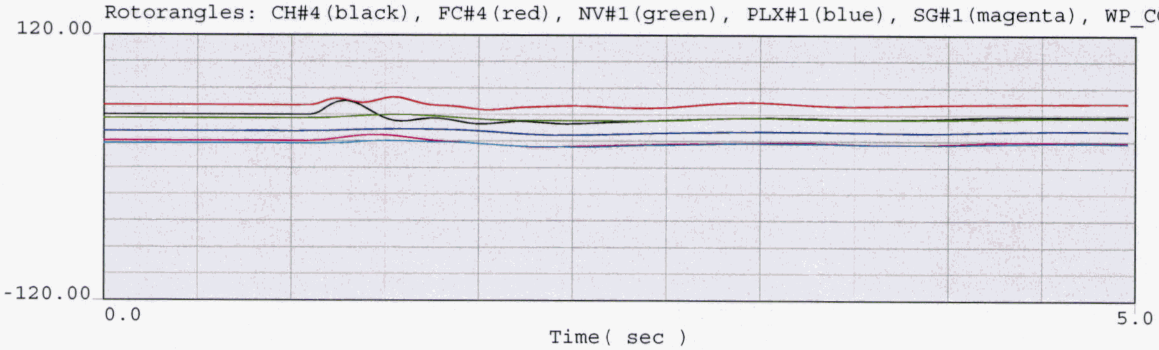
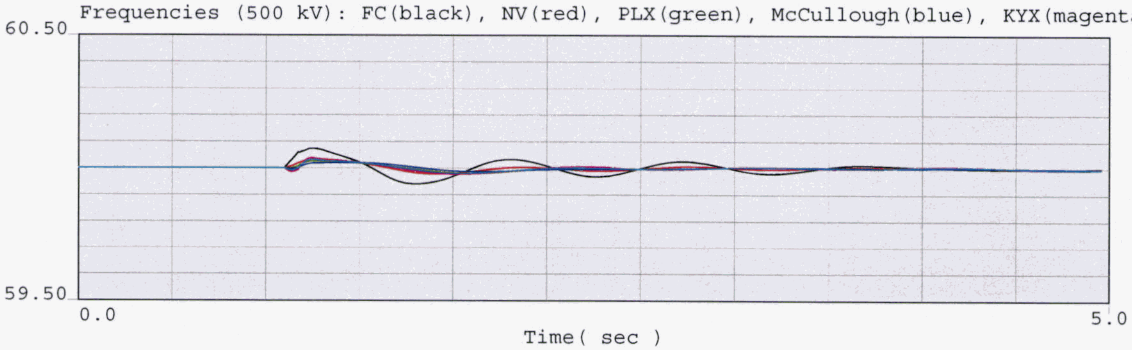


Frequencies (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



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2011 Heavy Summer WECC Power Flow

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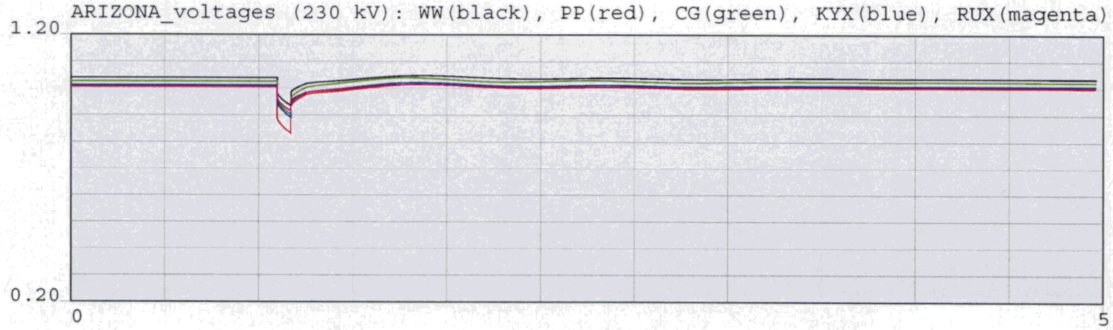

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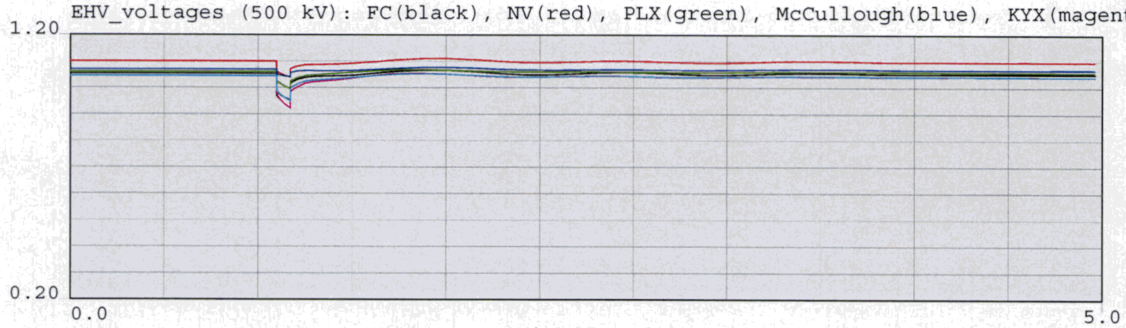

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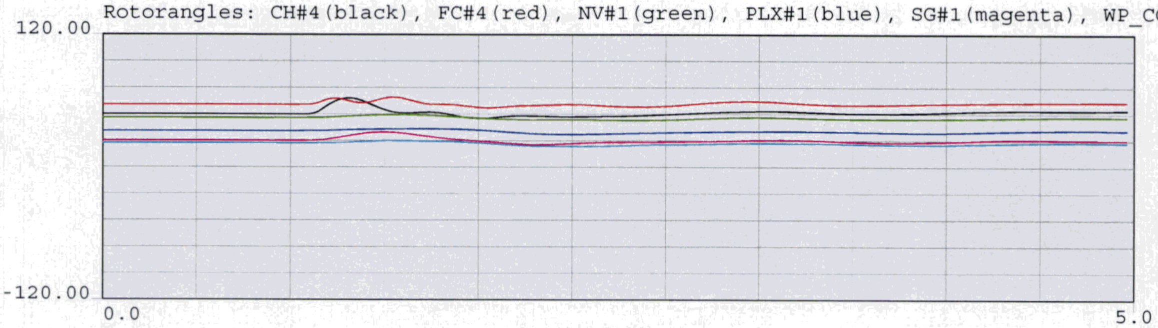

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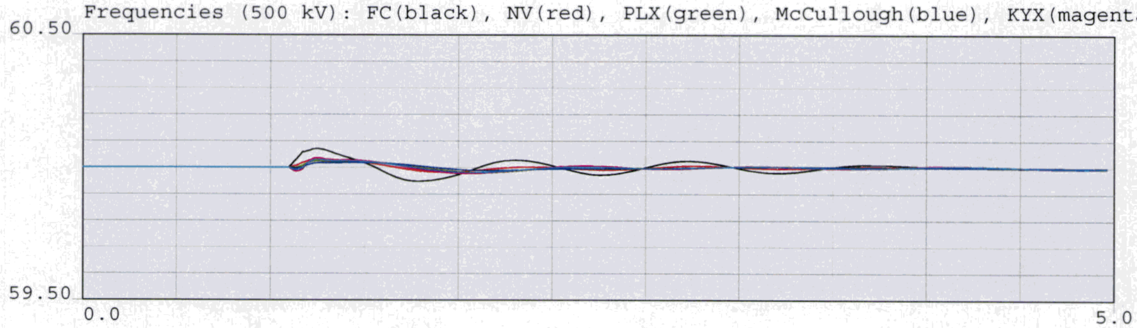

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2011 Heavy Summer WECC Power Flow

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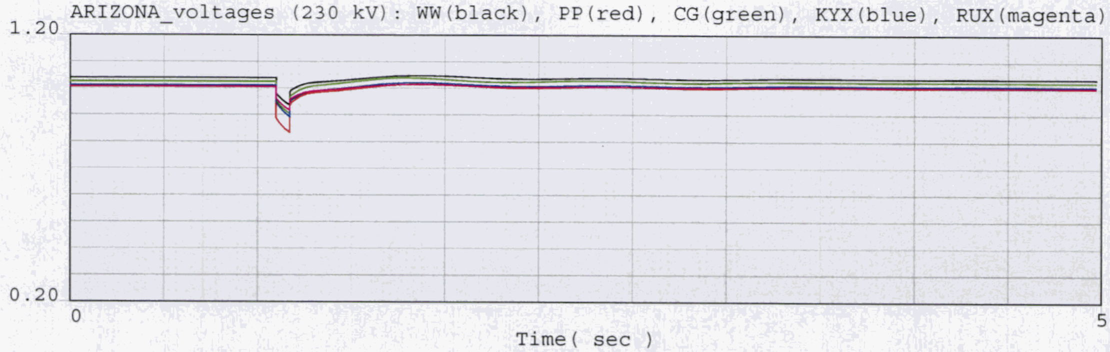

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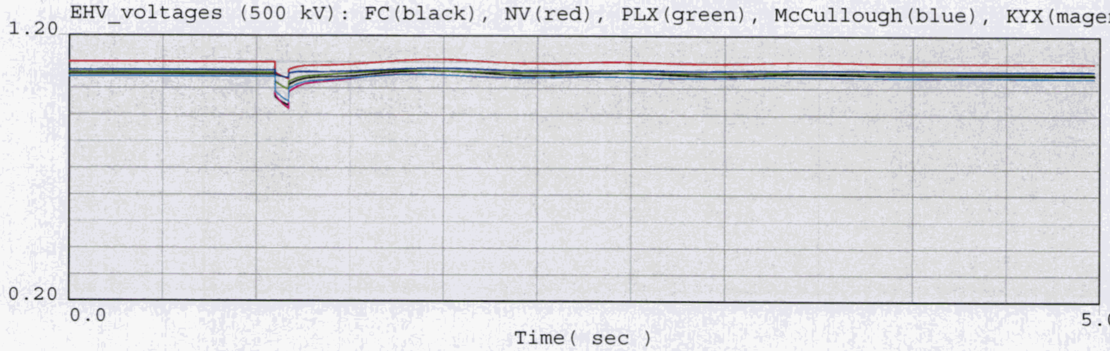

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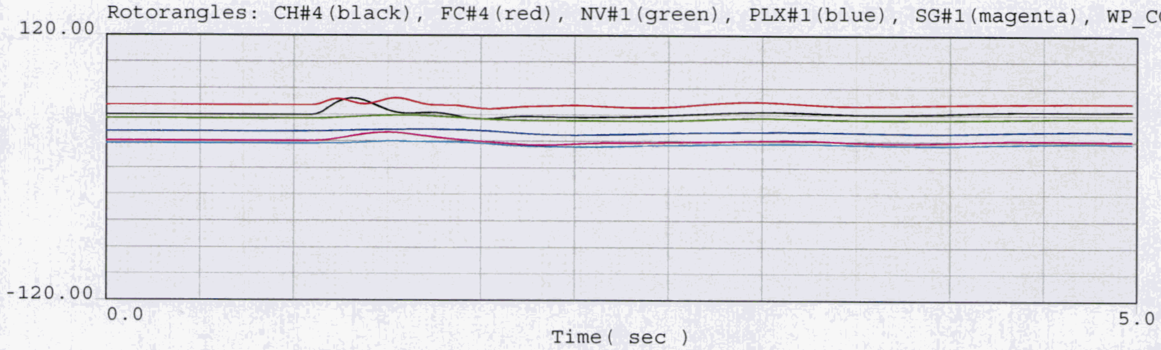

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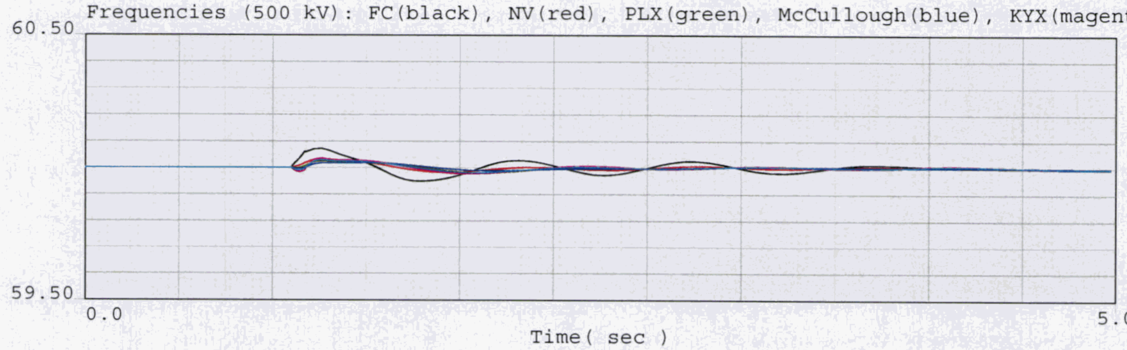

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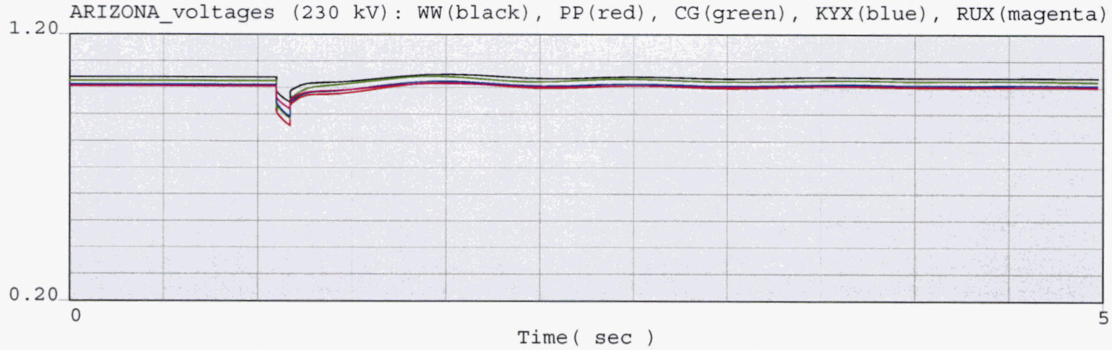

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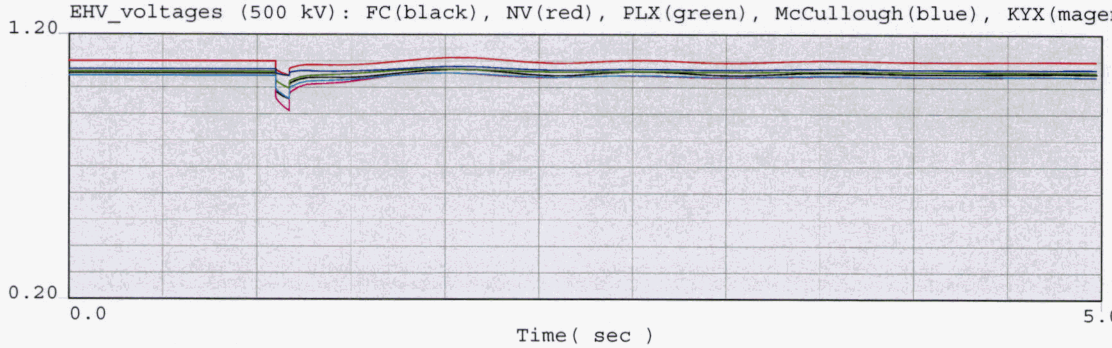

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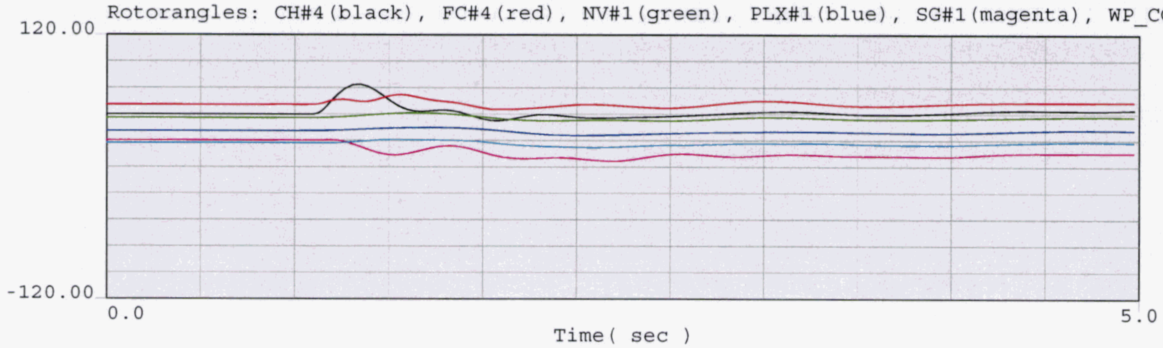

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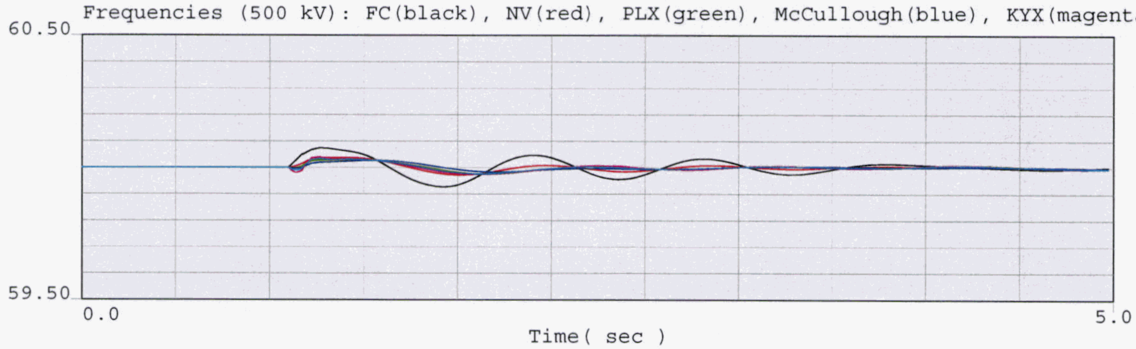

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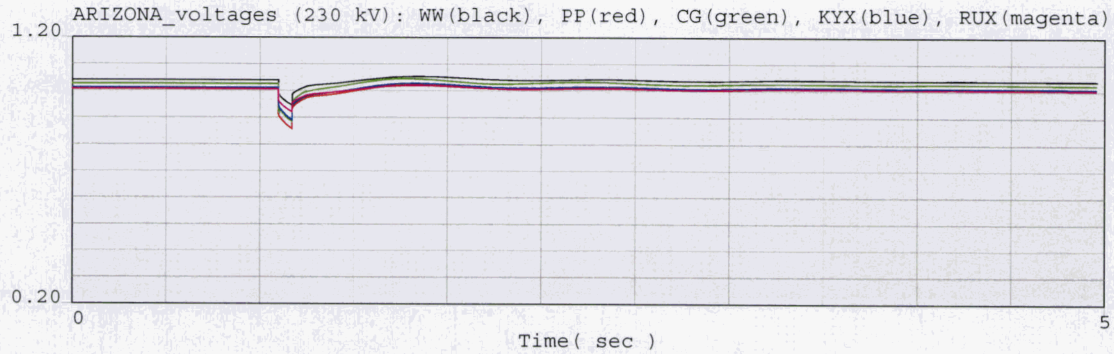

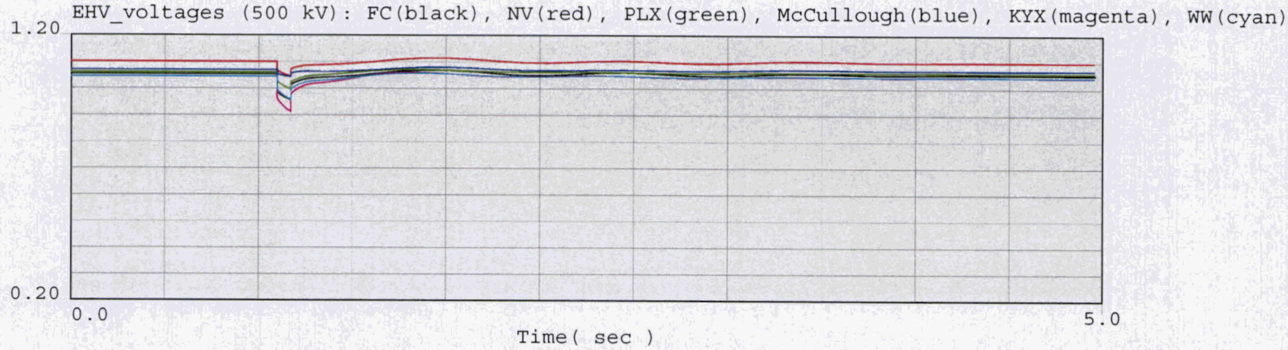

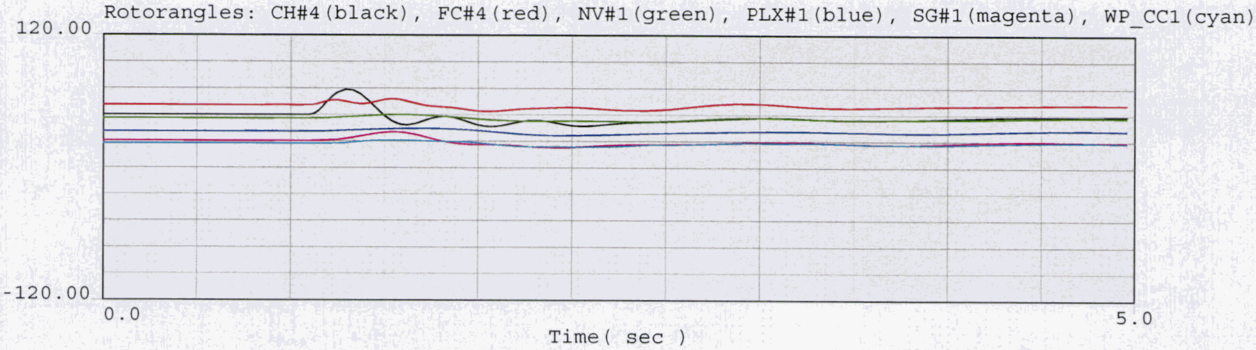

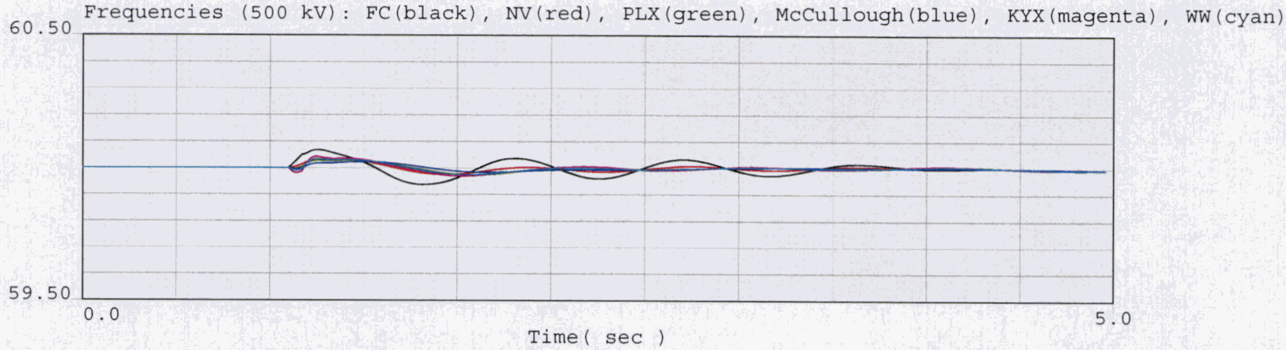

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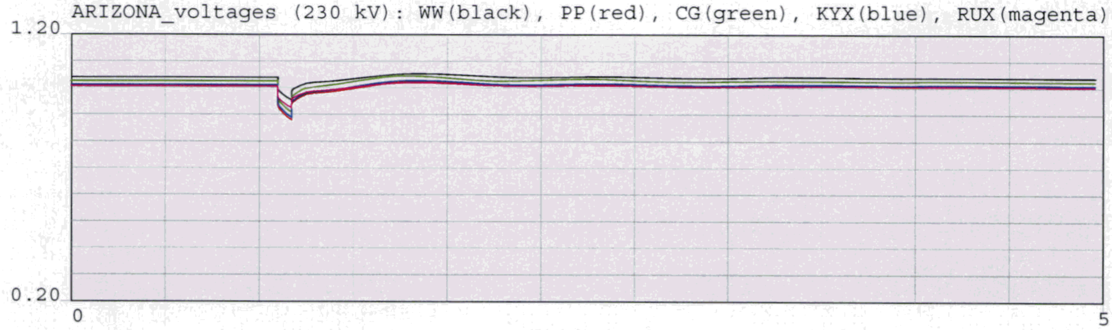

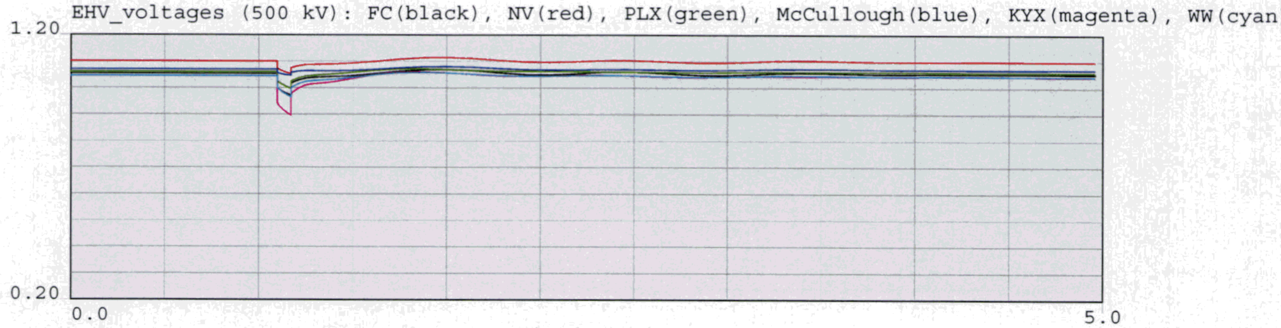

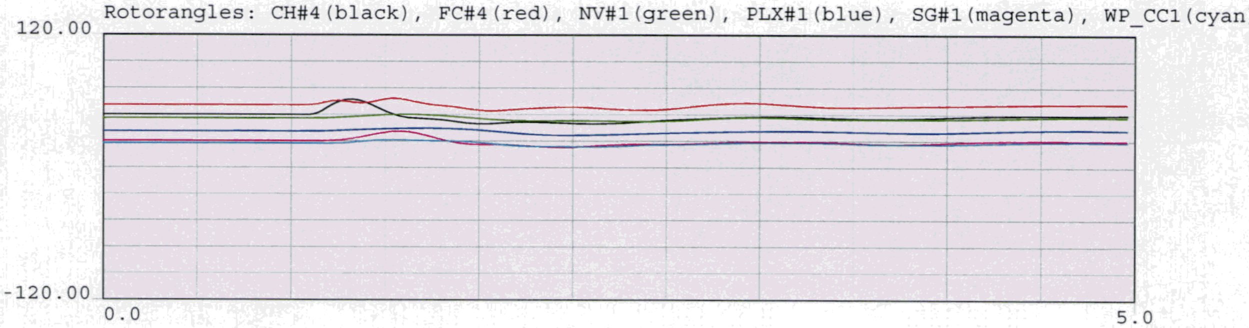

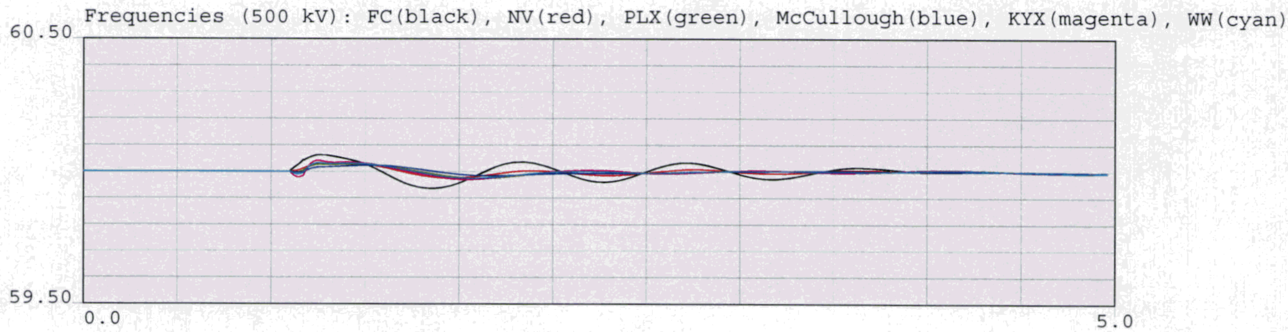

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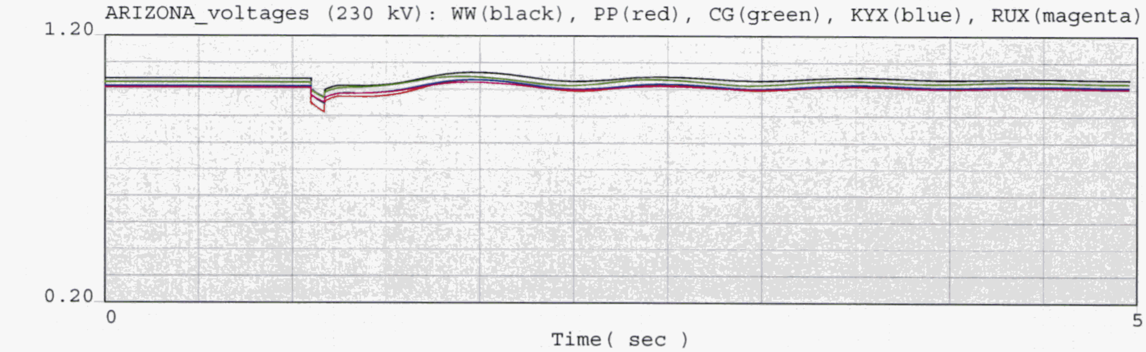

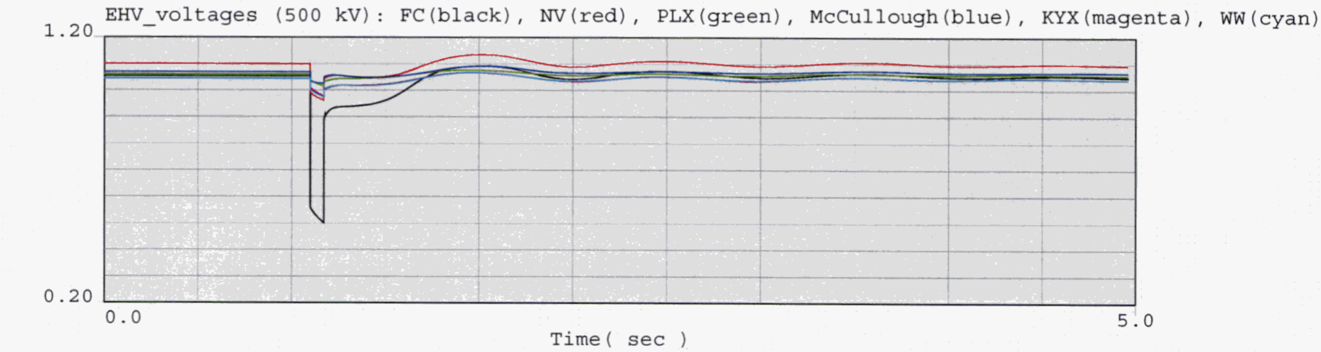

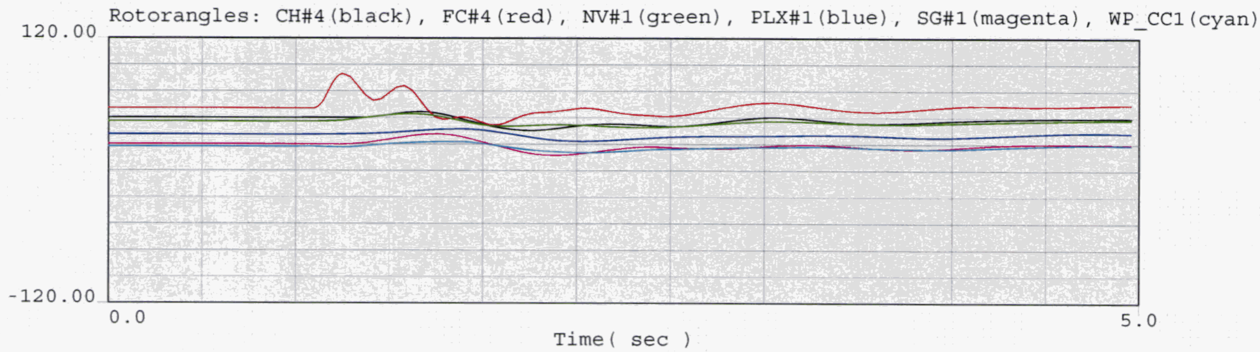

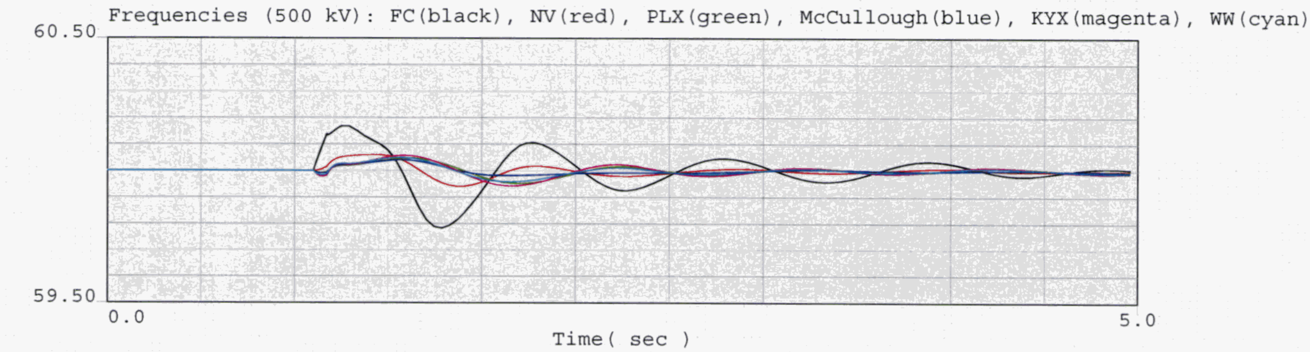

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2011 Heavy Summer WECC Power Flow

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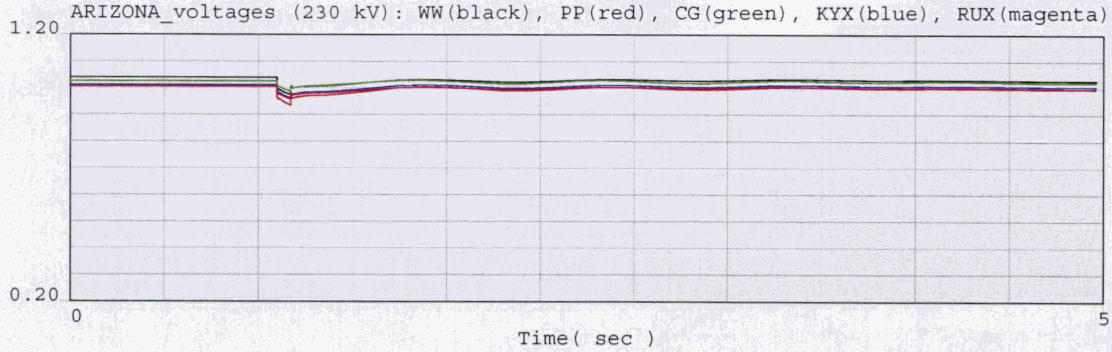

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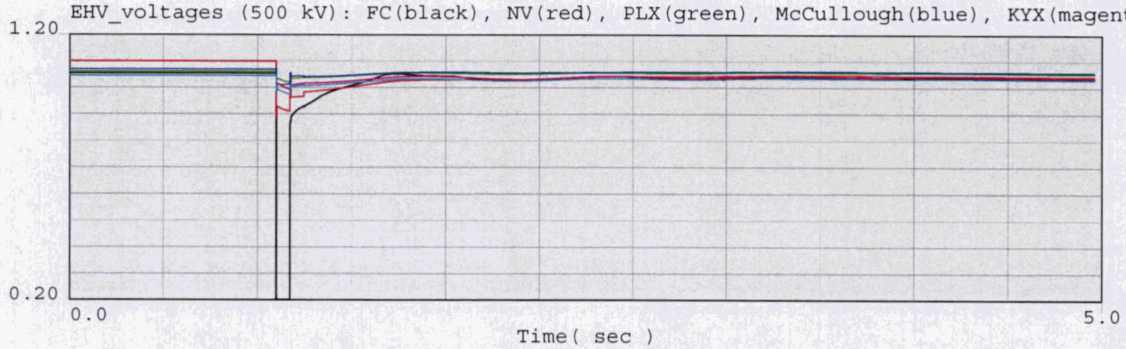
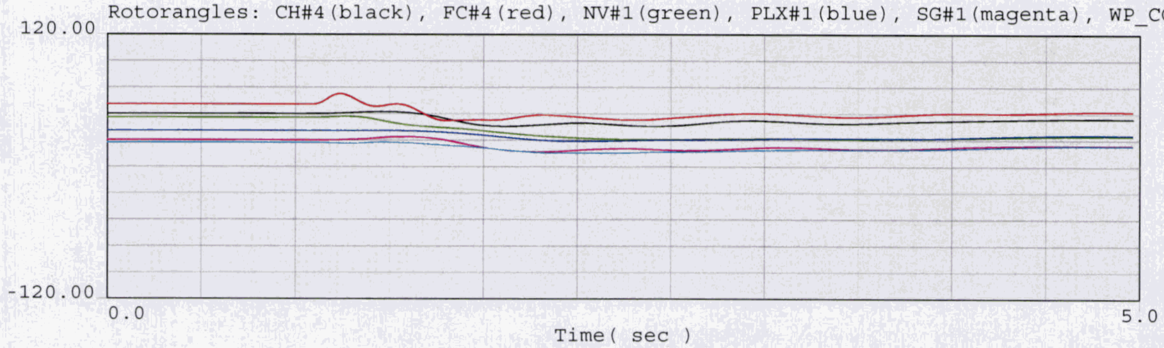
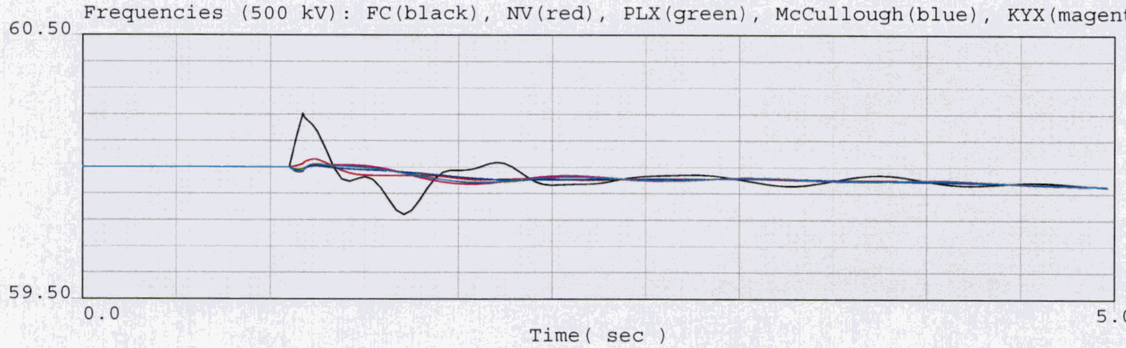


Rotorangles: CH#4(black), FC#4(red), NV#1(green), PLX#1(blue), SG#1(magenta), WP_CC1(cyan)



Frequencies (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



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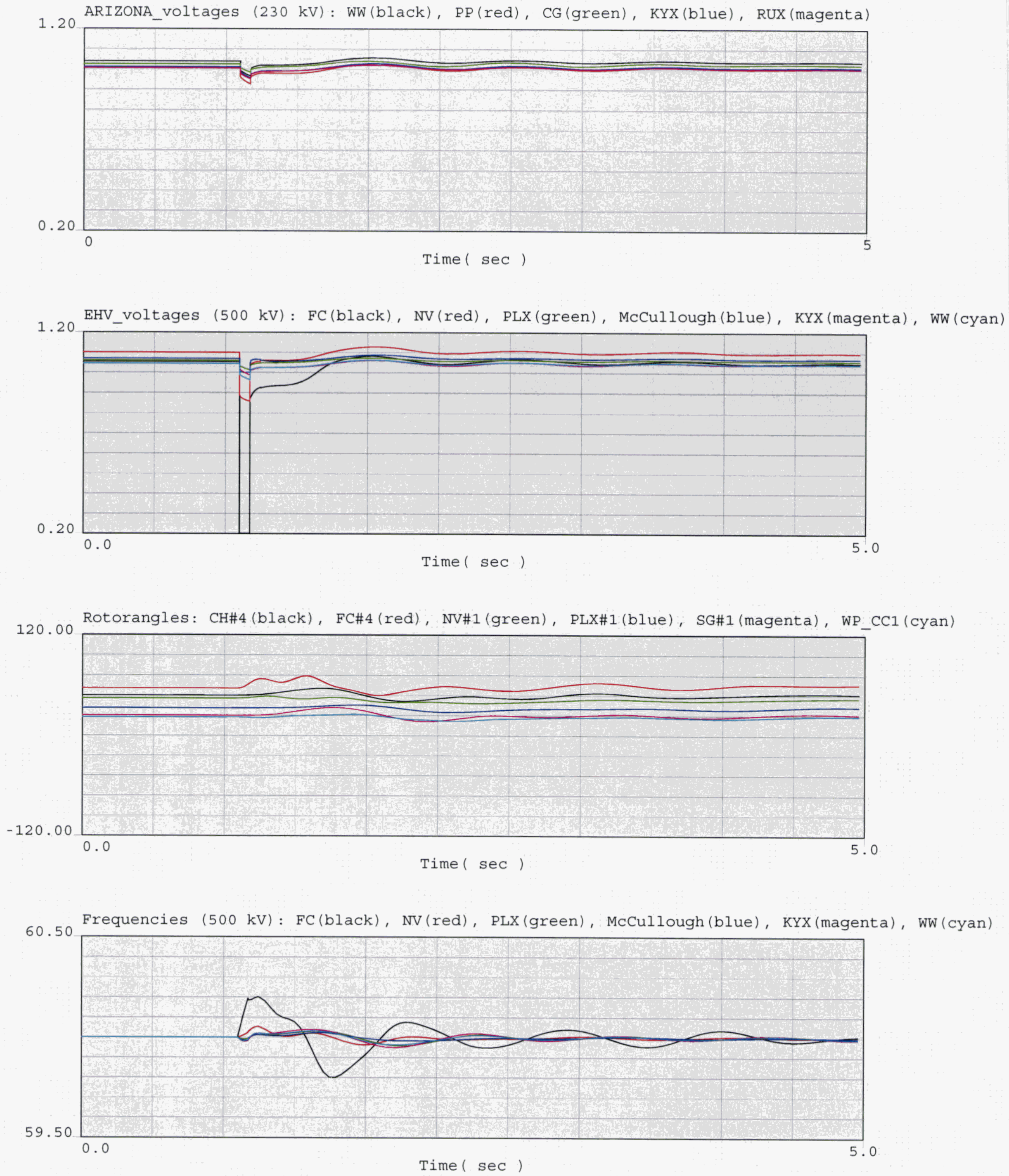
2011 Heavy Summer WECC Power Flow



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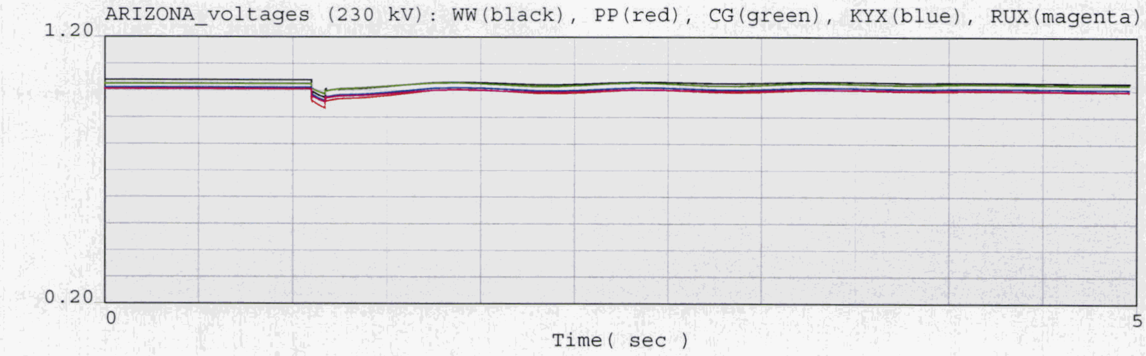
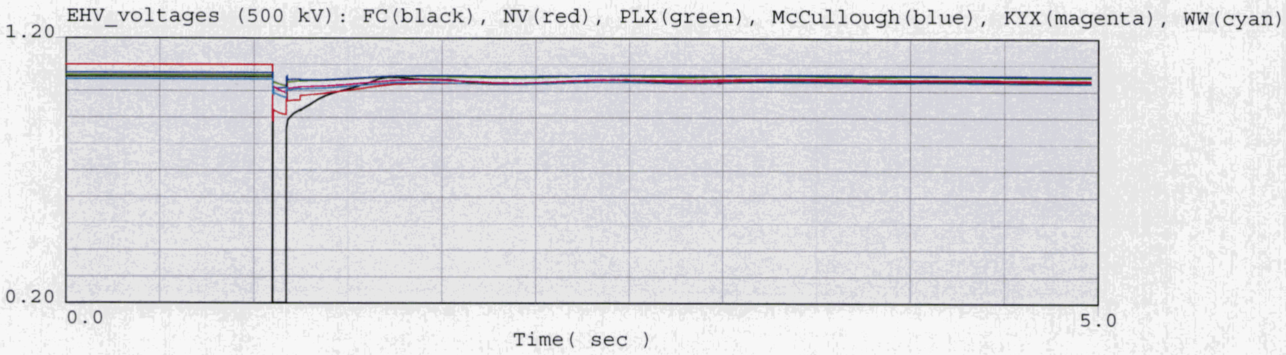
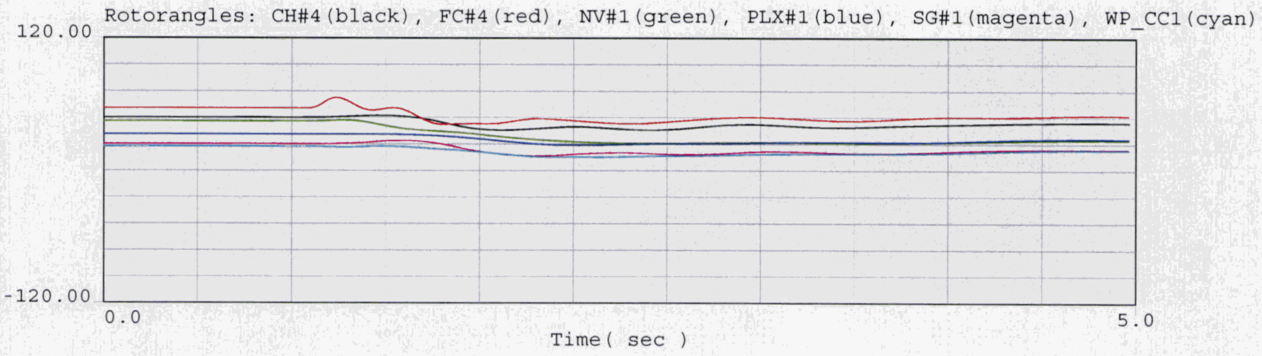
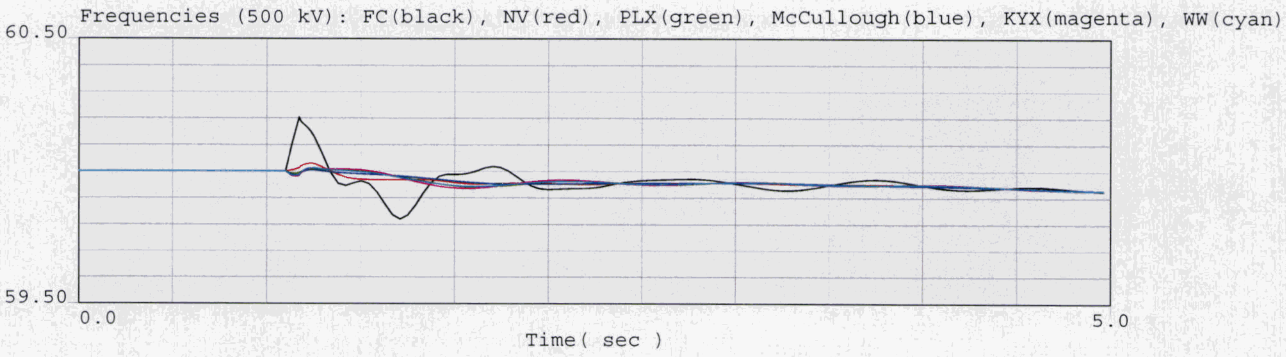
2011 Heavy Summer WECC Power Flow









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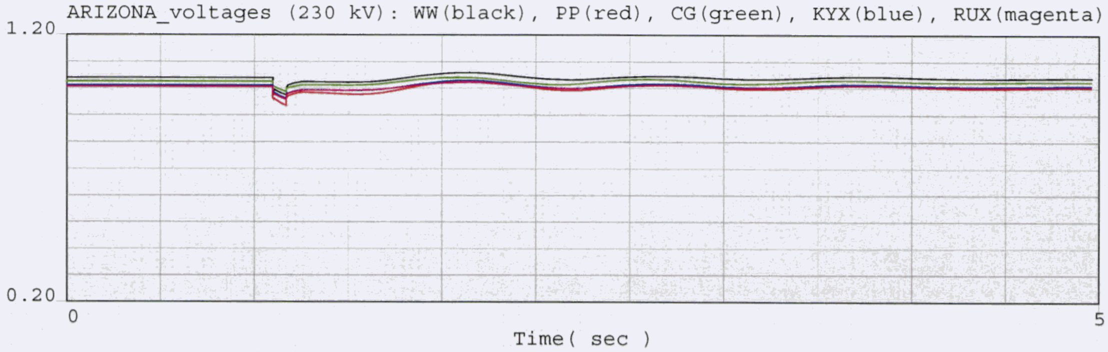
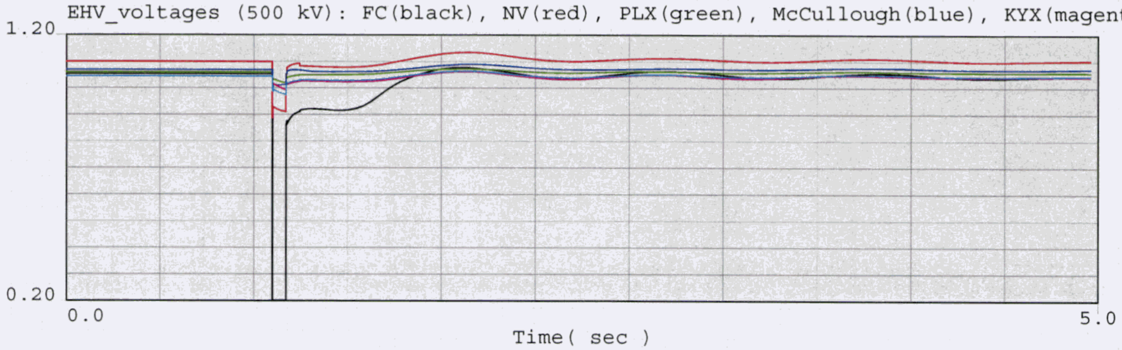
2011 Heavy Summer WECC Power Flow

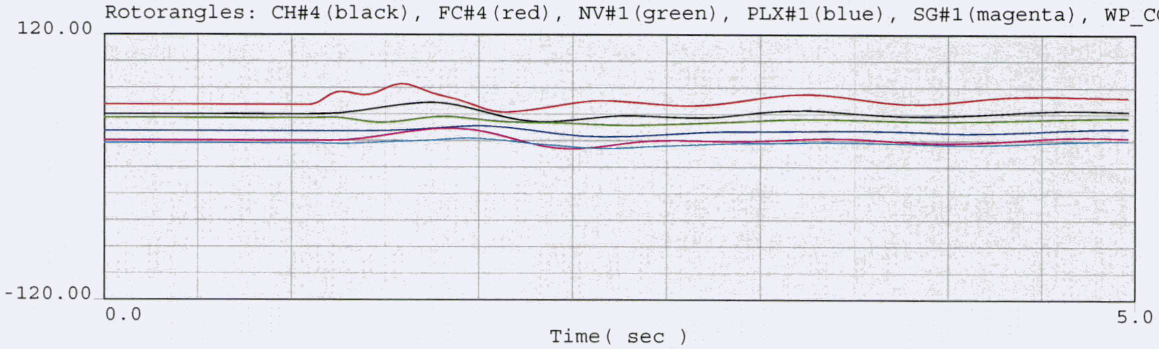
ARIZONA_voltages (230 kV): WW(black), PP(red), CG(green), KYX(blue), RUX(magenta)



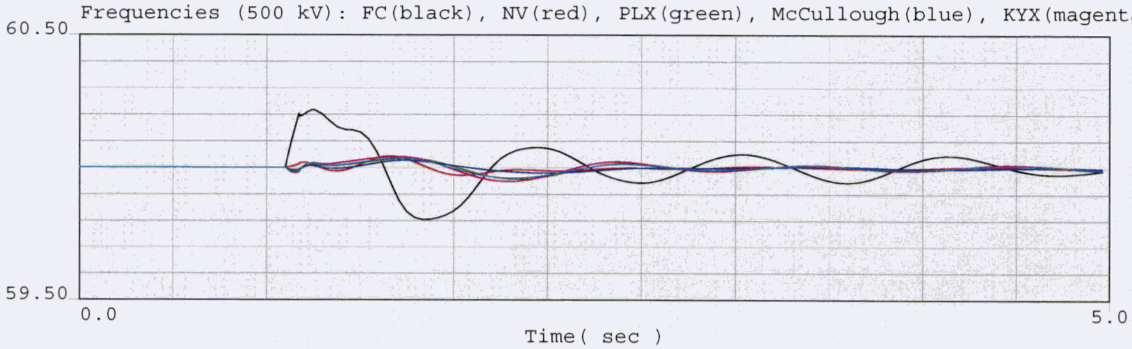
EHV_voltages (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



Rotorangles: CH#4(black), FC#4(red), NV#1(green), PLX#1(blue), SG#1(magenta), WP_CC1(cyan)



Frequencies (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



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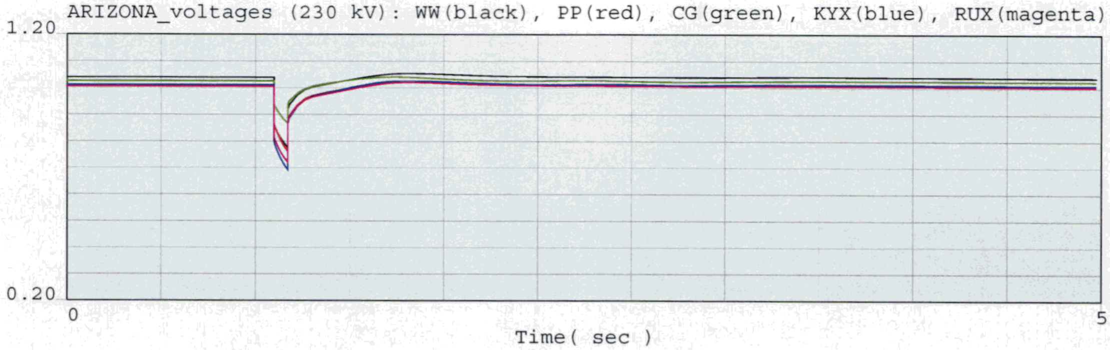
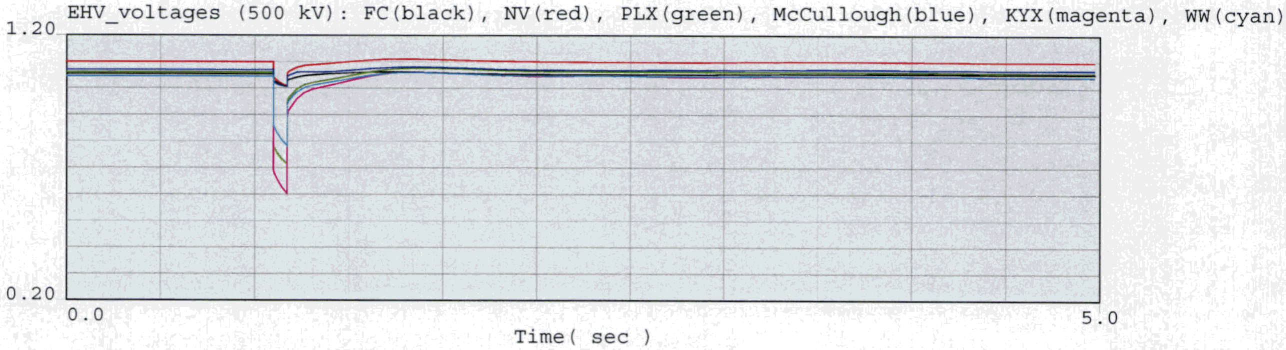
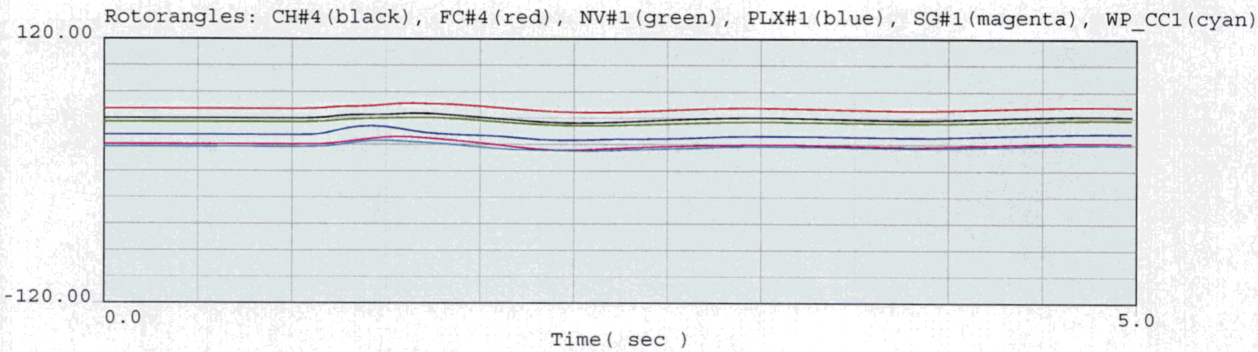
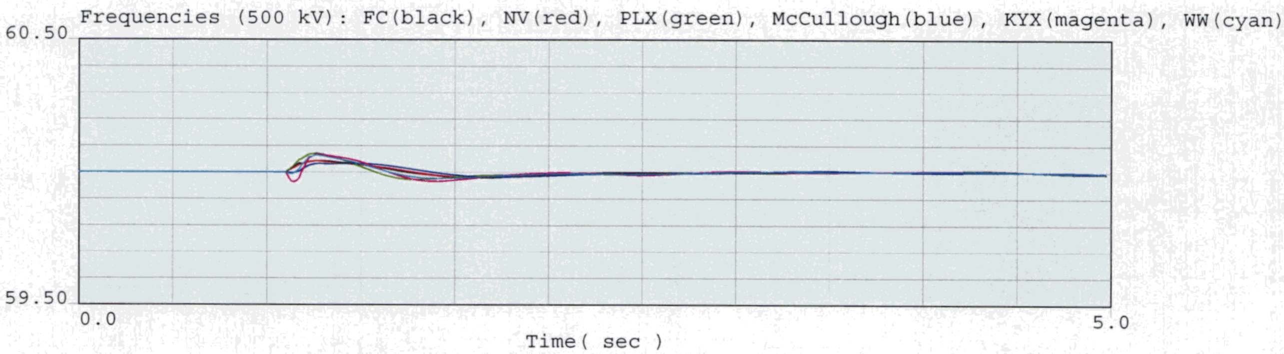
2011 Heavy Summer WECC Power Flow









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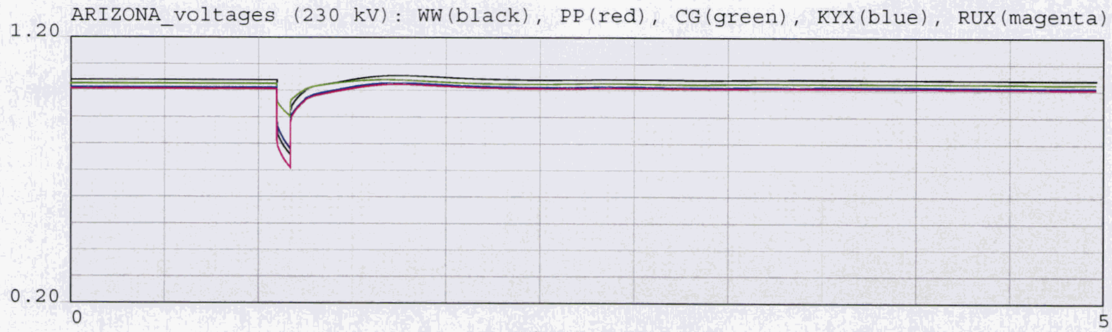
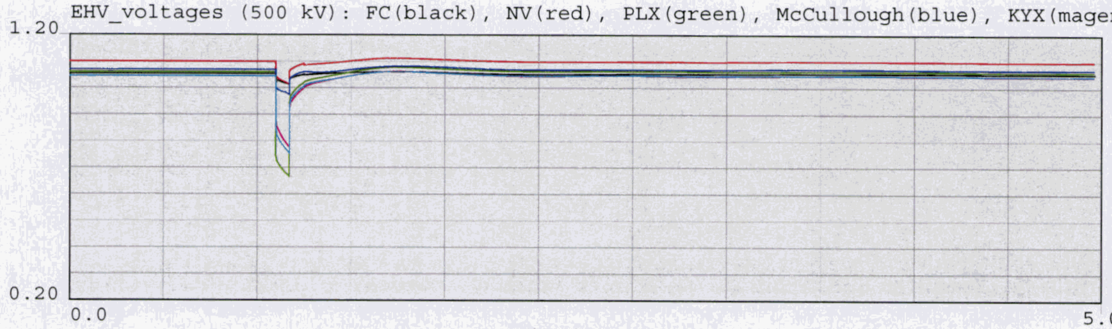
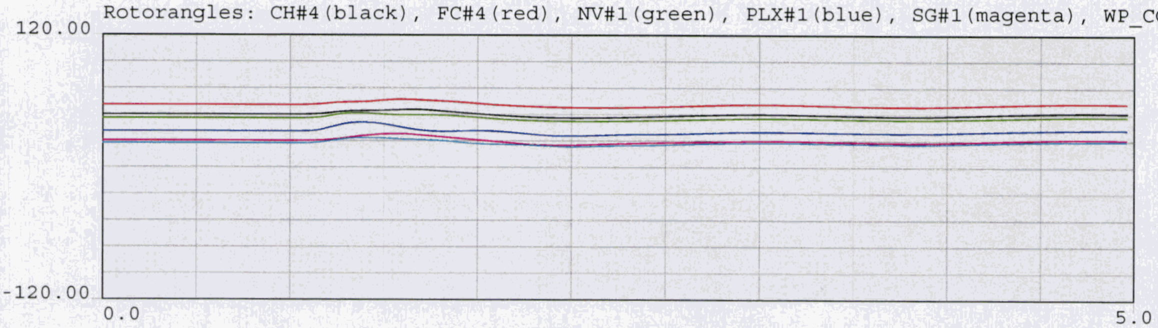
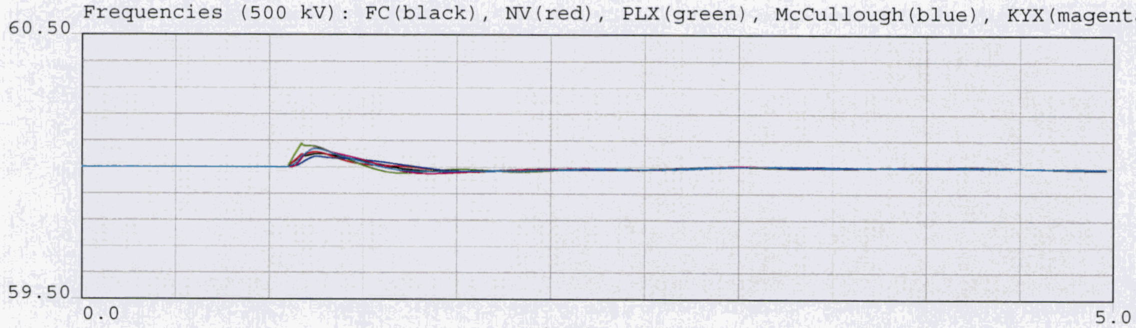
2011 Heavy Summer WECC Power Flow









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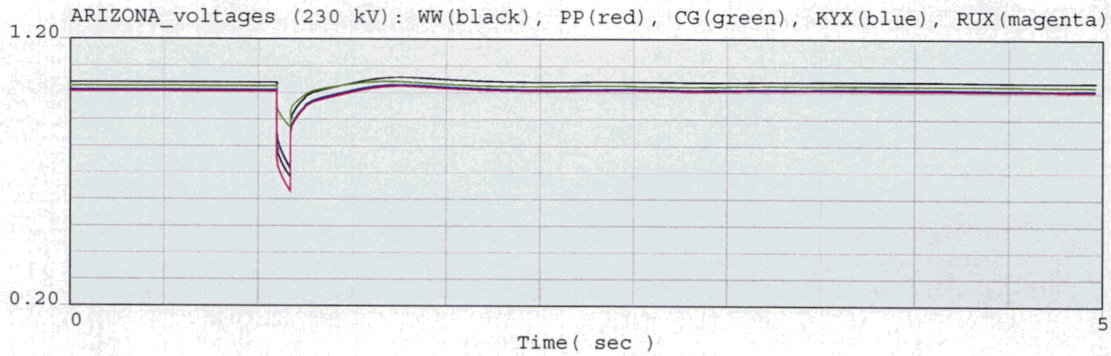
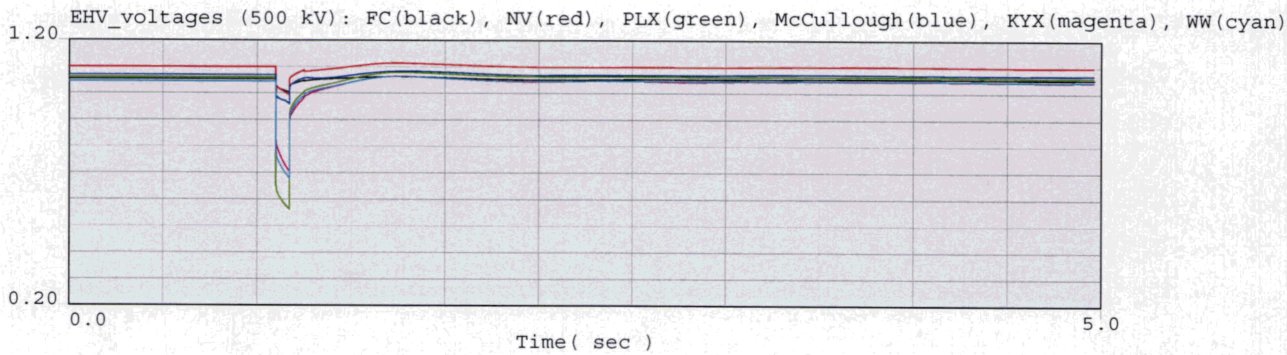
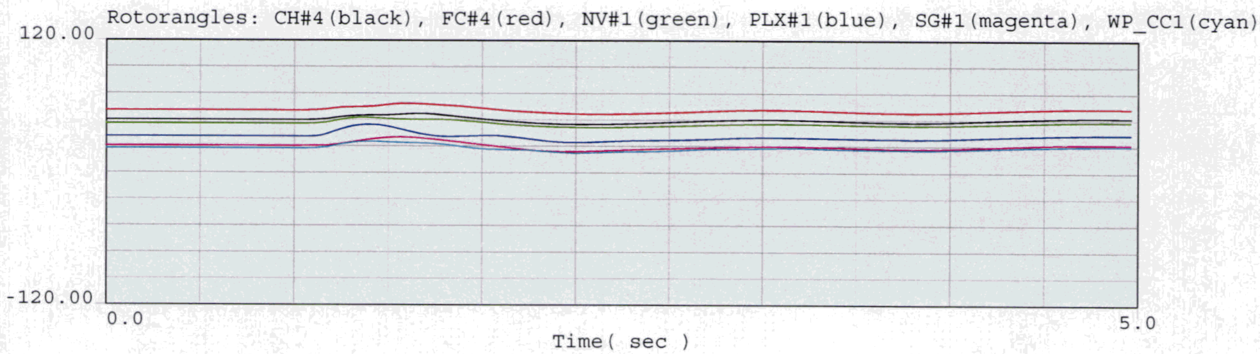
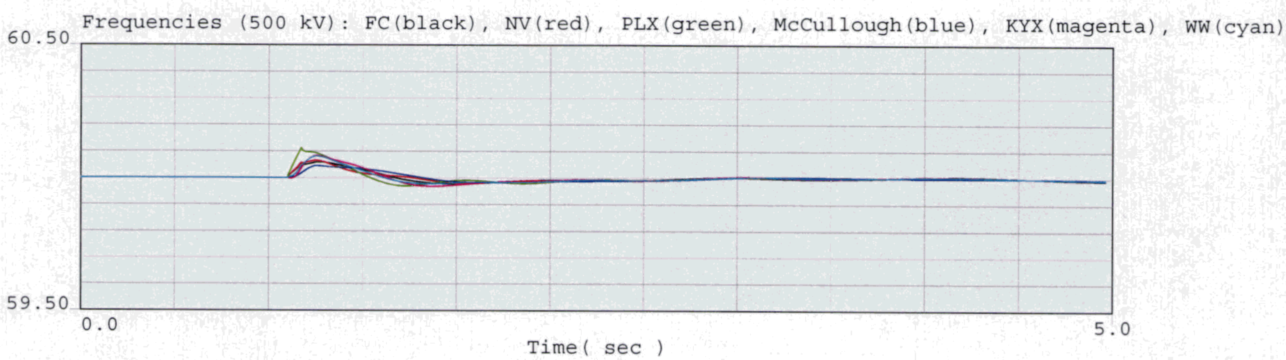
2011 Heavy Summer WECC Power Flow









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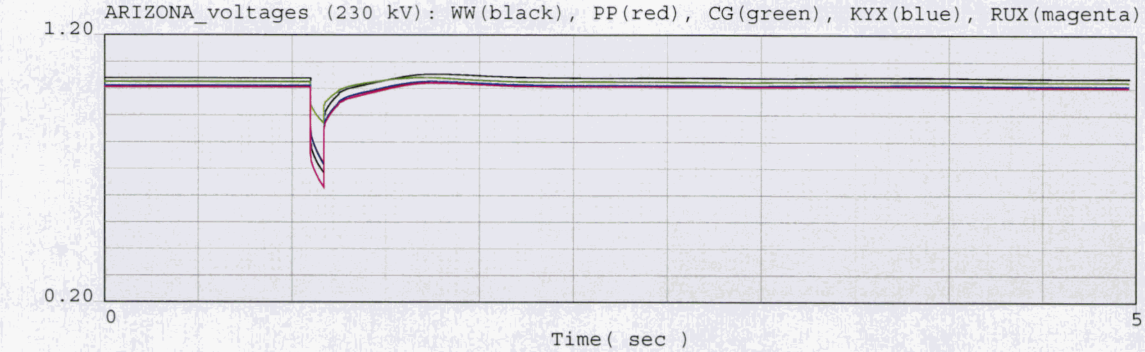
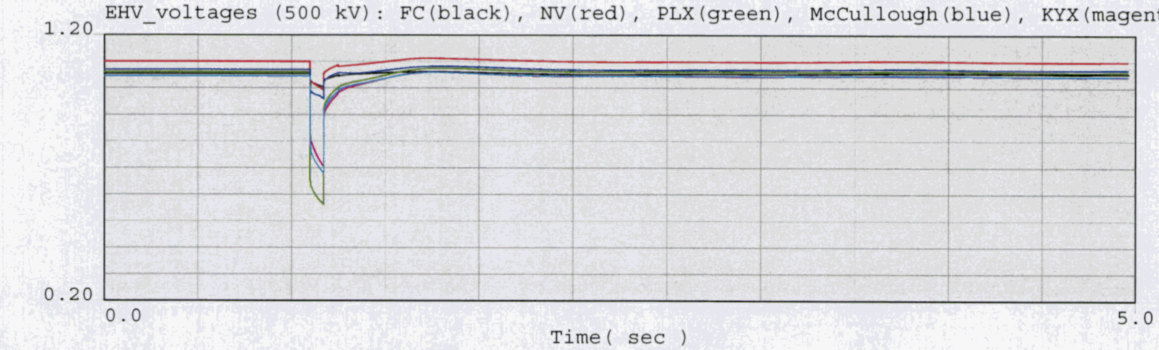
2011 Heavy Summer WECC Power Flow

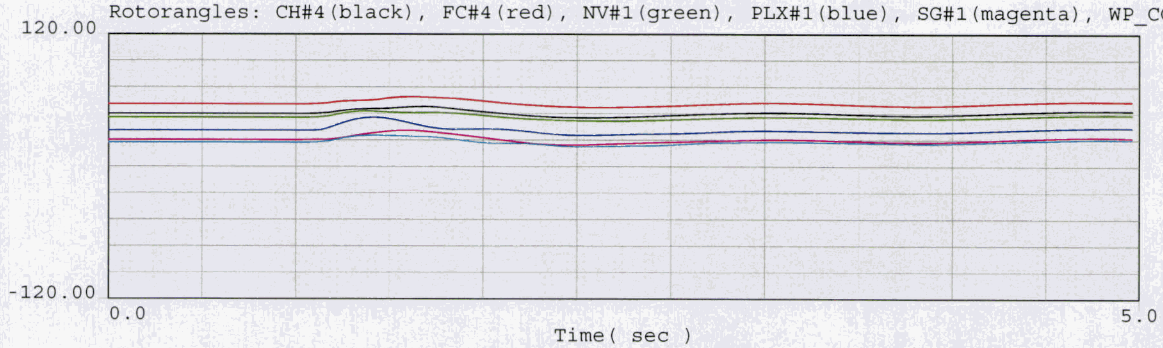
ARIZONA_voltages (230 kV): WW(black), PP(red), CG(green), KYX(blue), RUX(magenta)



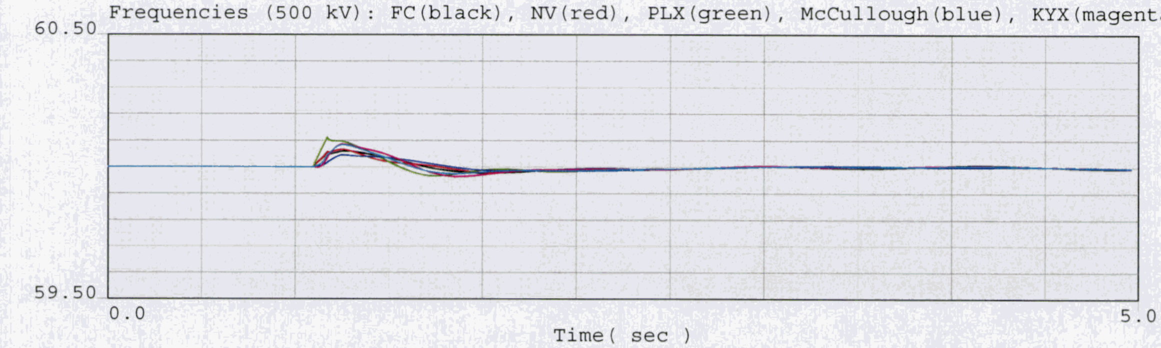
EHV_voltages (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



Rotorangles: CH#4(black), FC#4(red), NV#1(green), PLX#1(blue), SG#1(magenta), WP_CC1(cyan)



Frequencies (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



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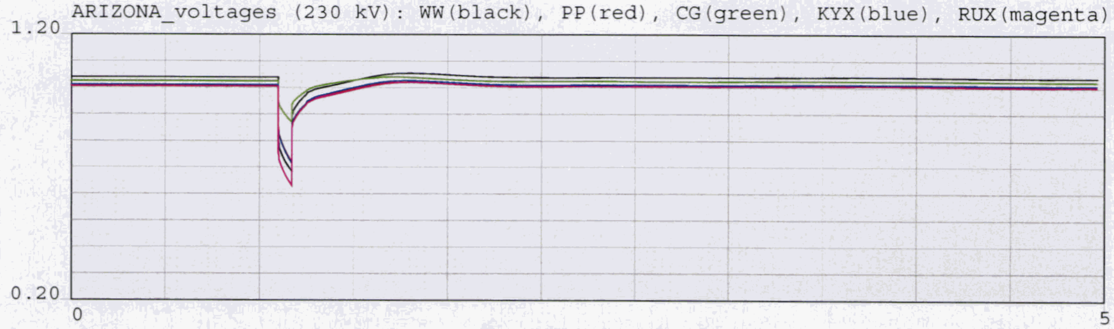
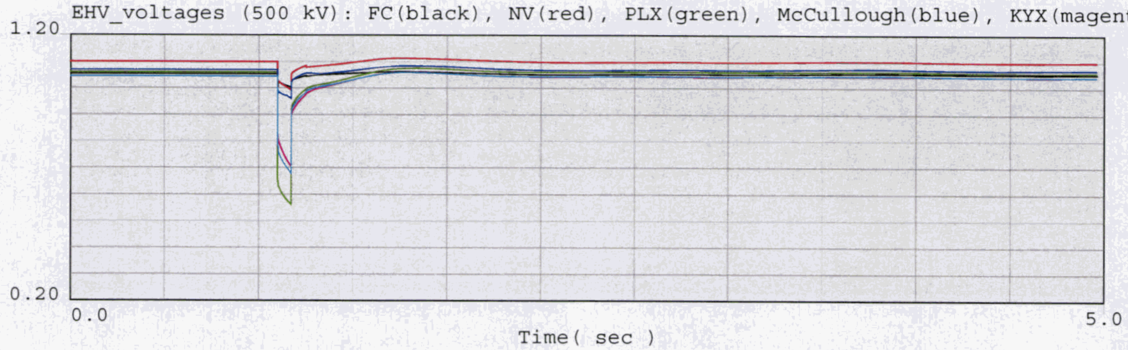
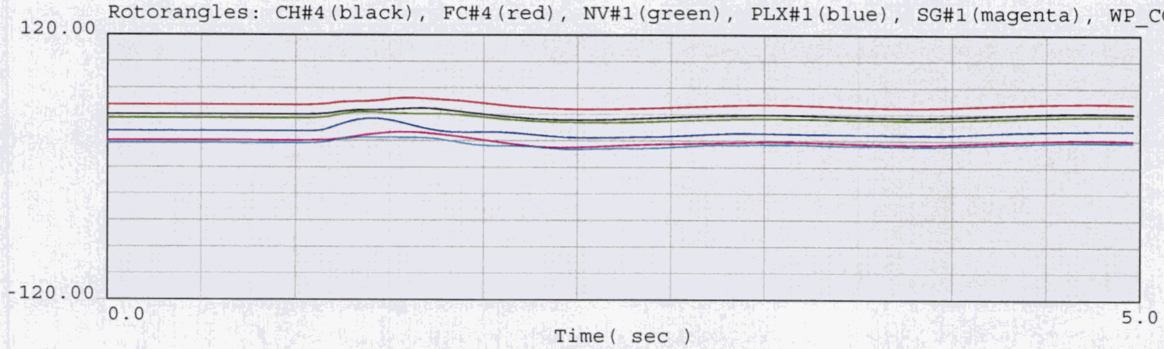


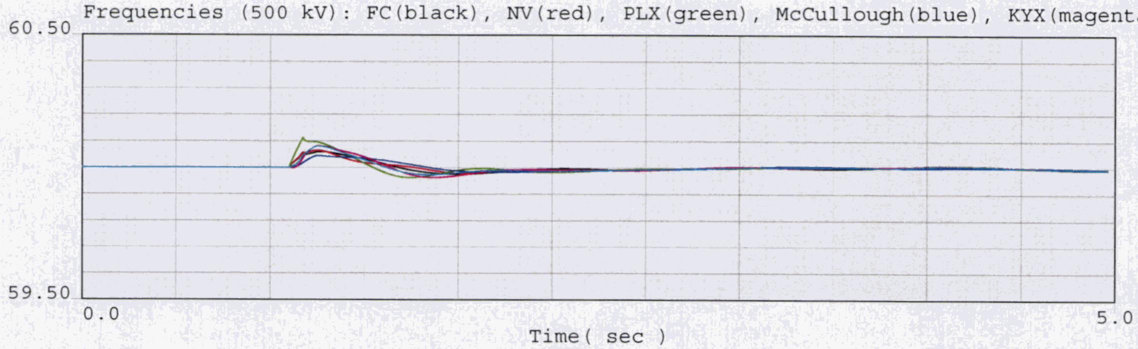
EHV_voltages (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



Rotorangles: CH#4(black), FC#4(red), NV#1(green), PLX#1(blue), SG#1(magenta), WP_CC1(cyan)



Frequencies (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



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2011 Heavy Summer WECC Power Flow

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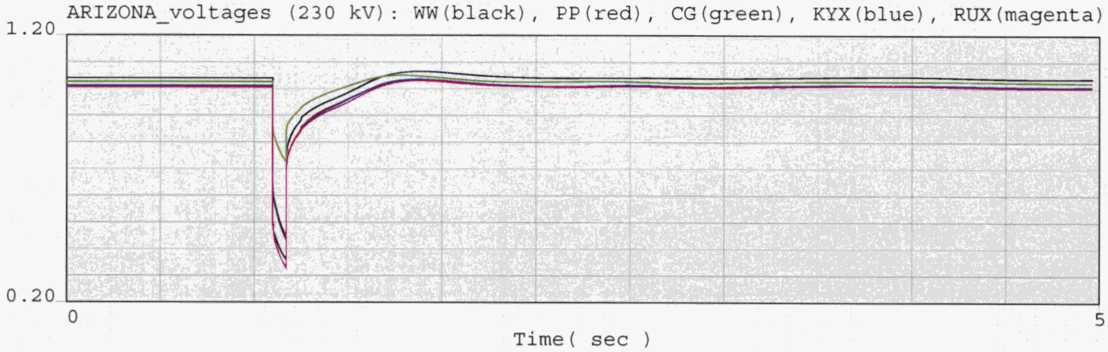
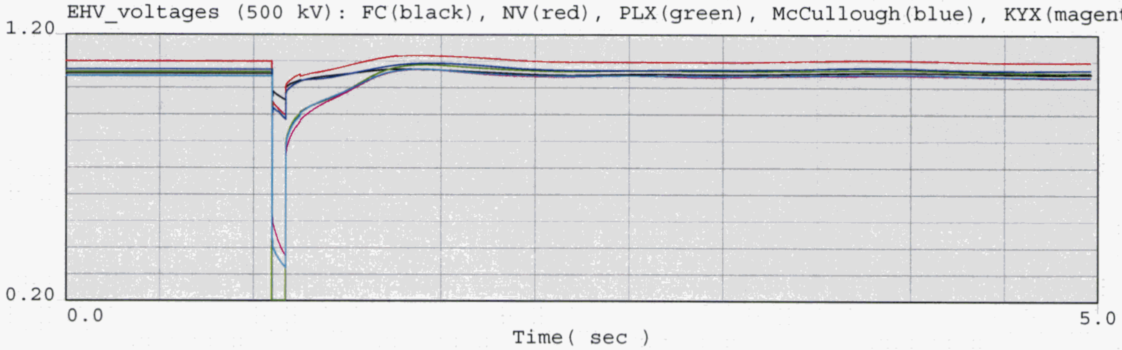


EHV_voltages (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



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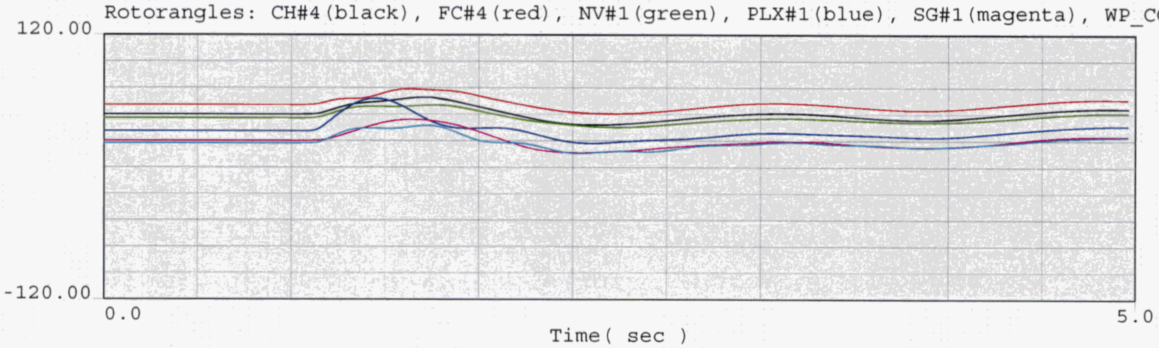
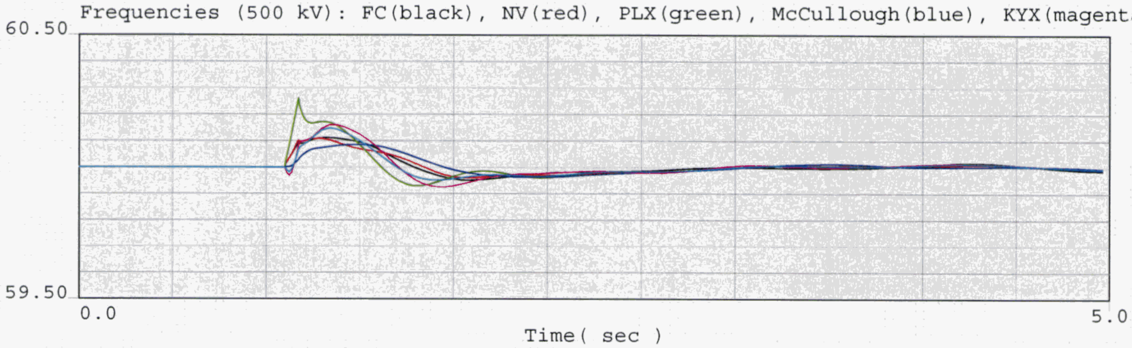


Frequencies (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



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2011 Heavy Summer WECC Power Flow

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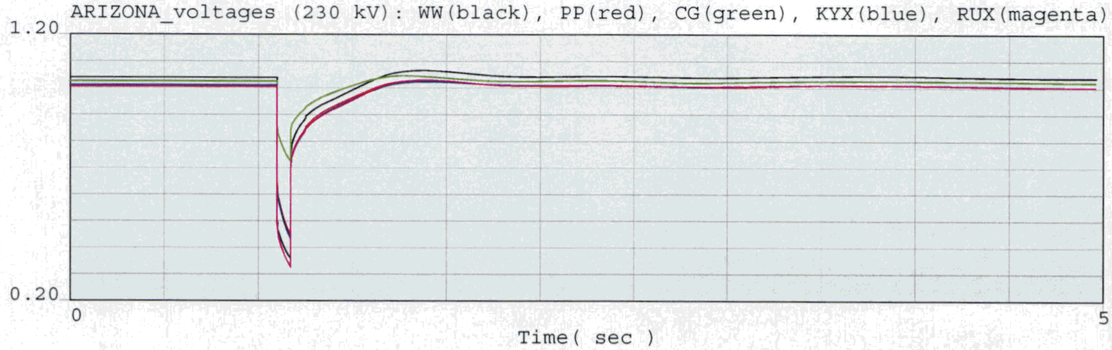
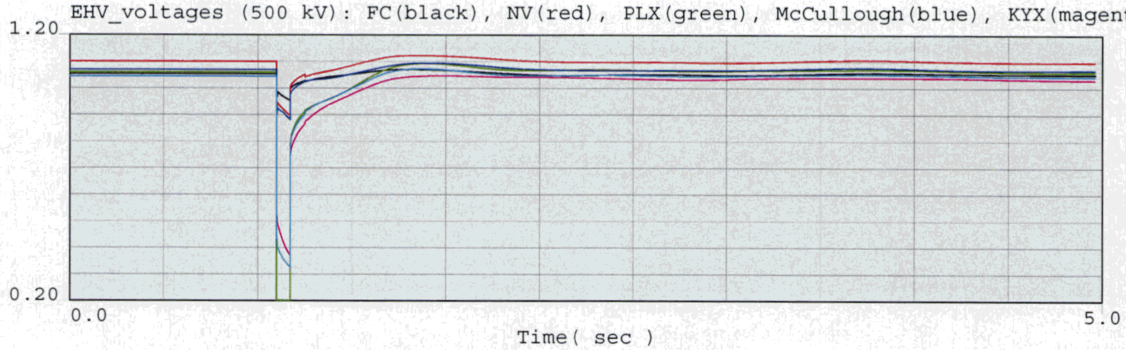


EHV_voltages (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



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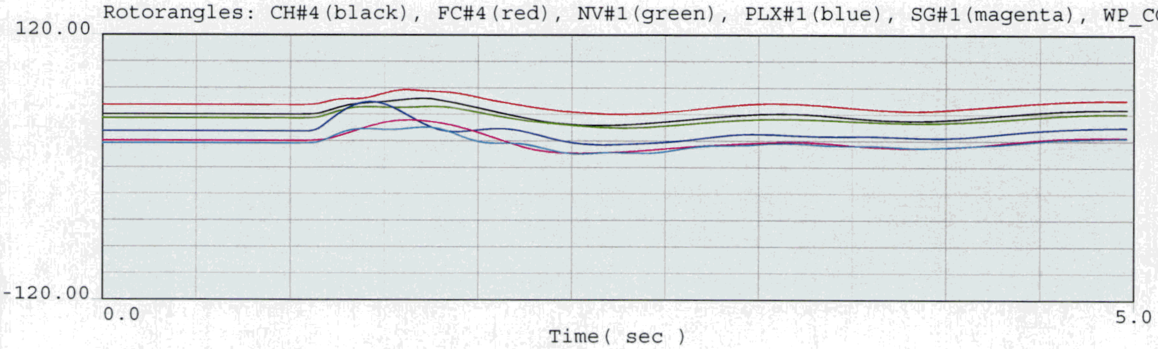
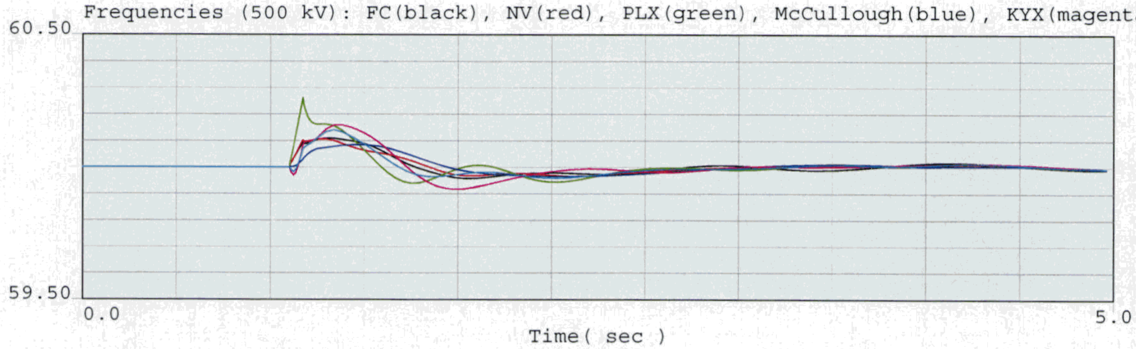


Frequencies (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



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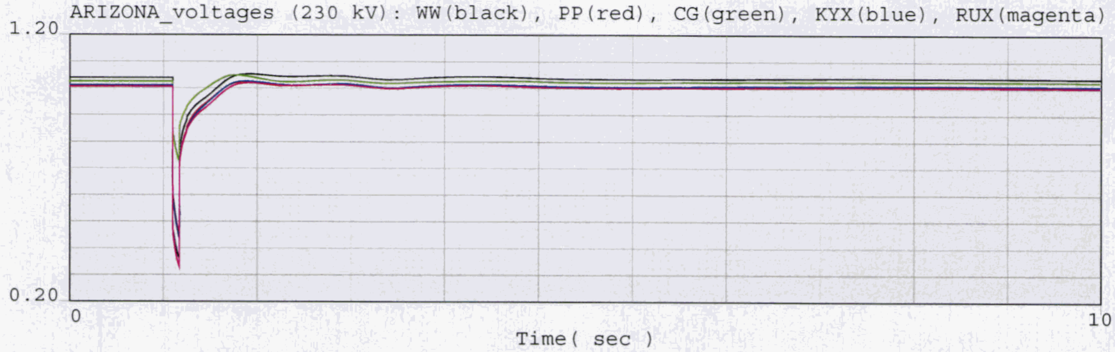
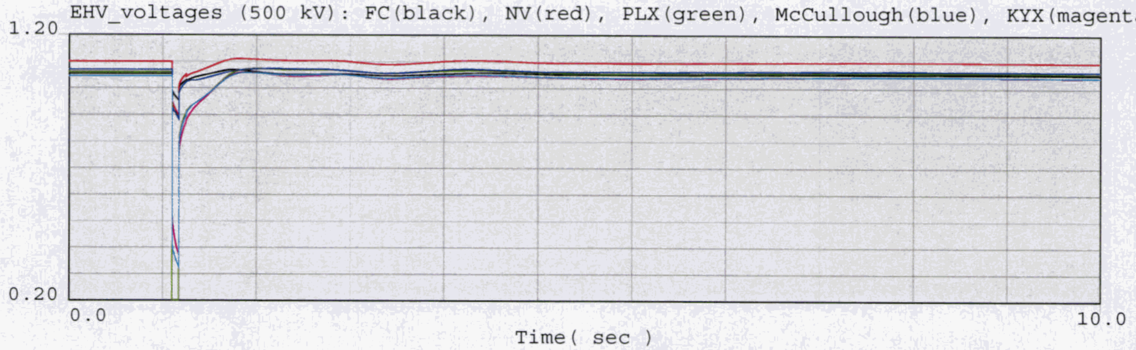
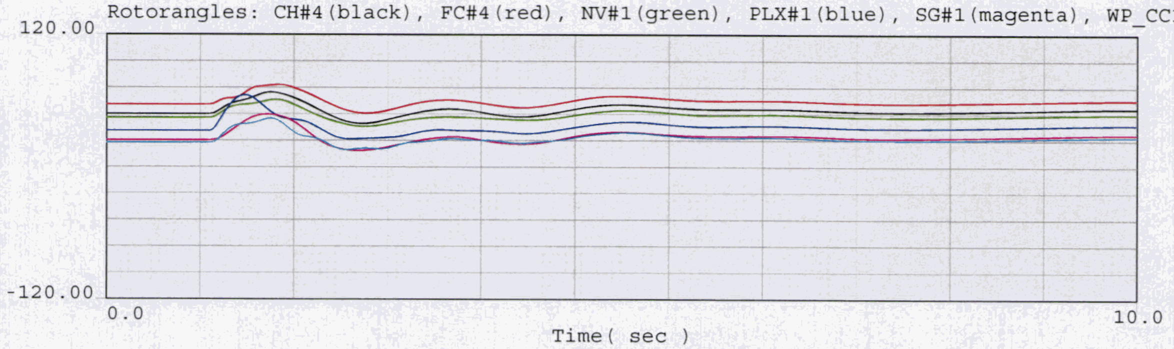


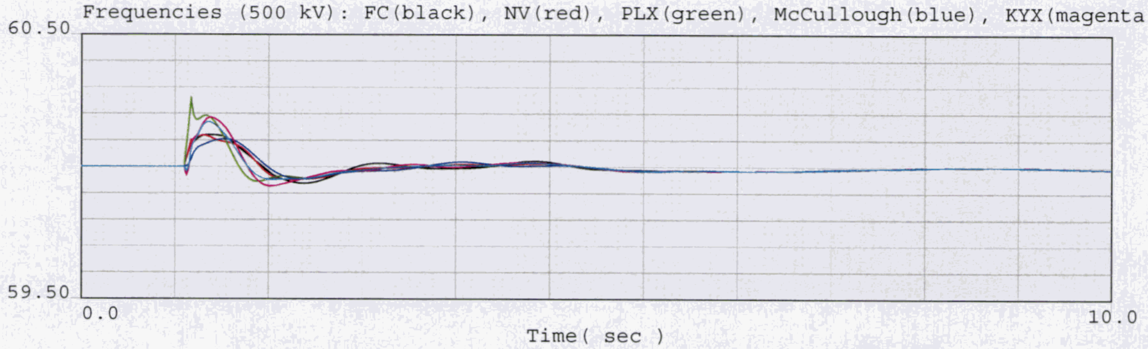
EHV_voltages (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



Rotorangles: CH#4(black), FC#4(red), NV#1(green), PLX#1(blue), SG#1(magenta), WP_CC1(cyan)



Frequencies (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



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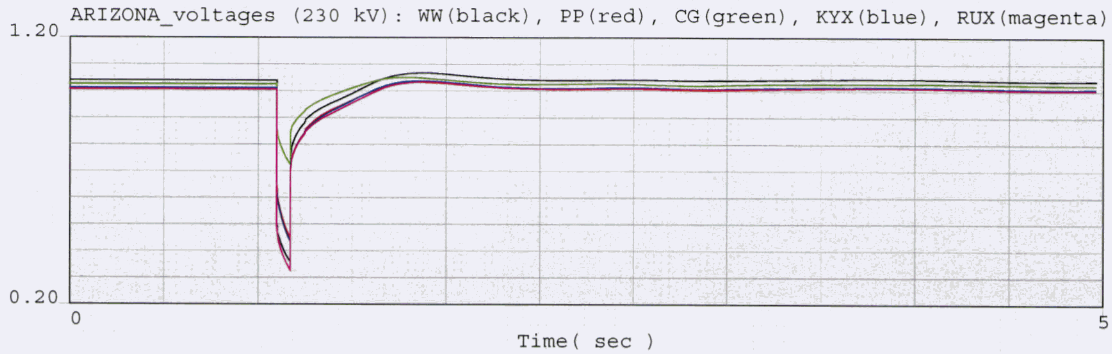

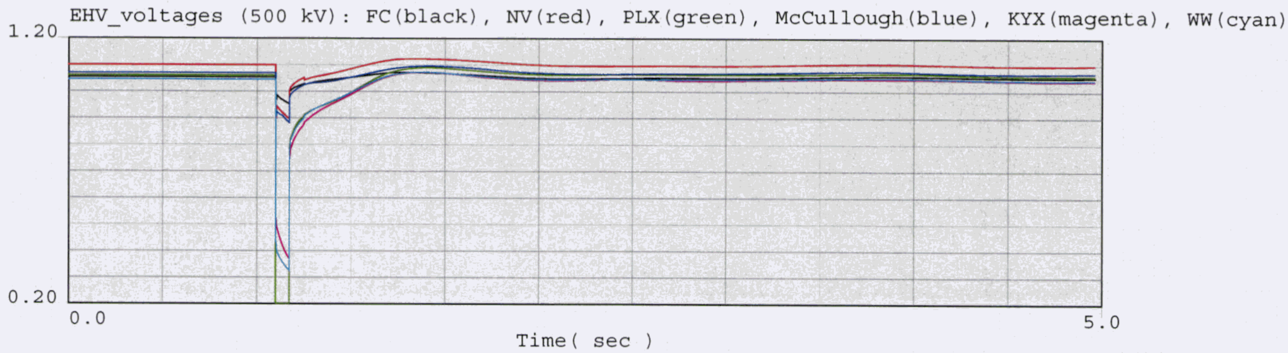

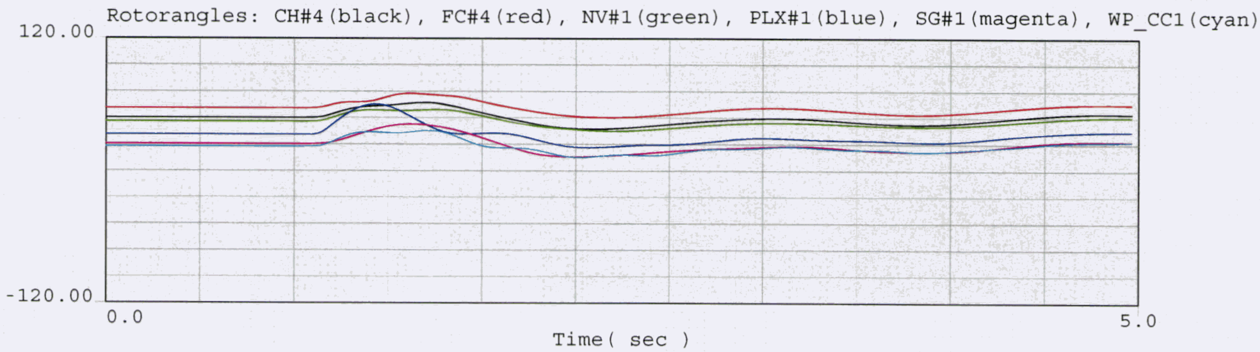

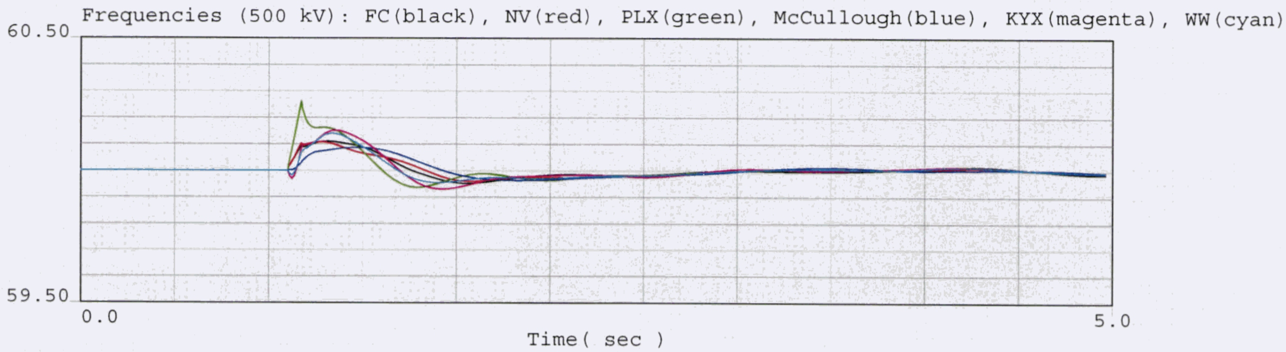

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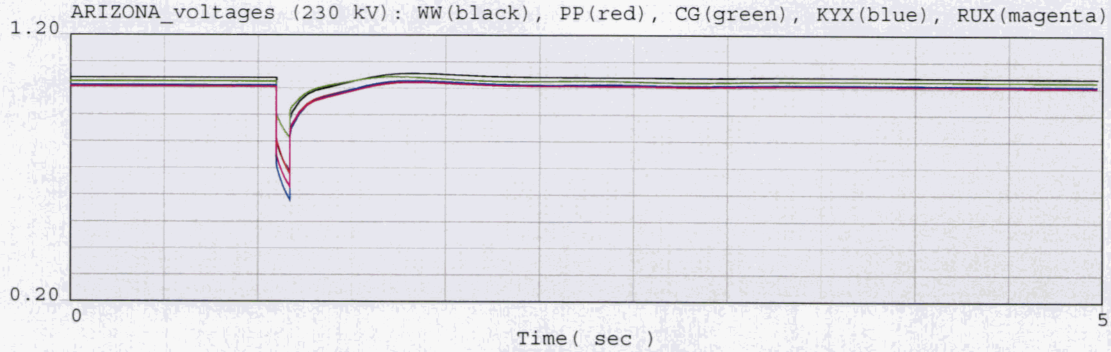

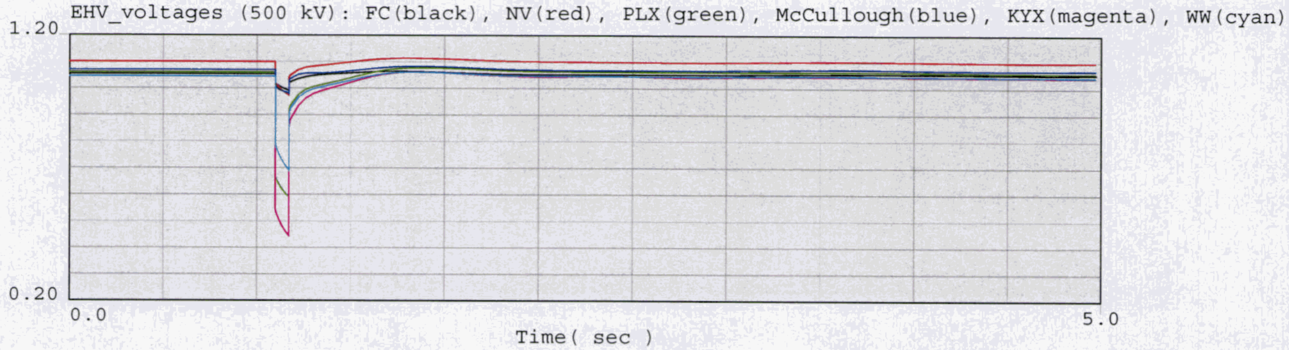

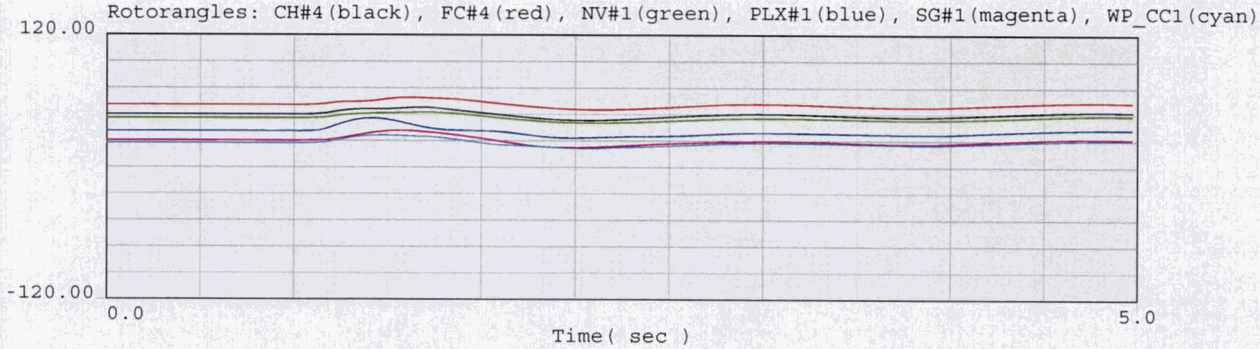

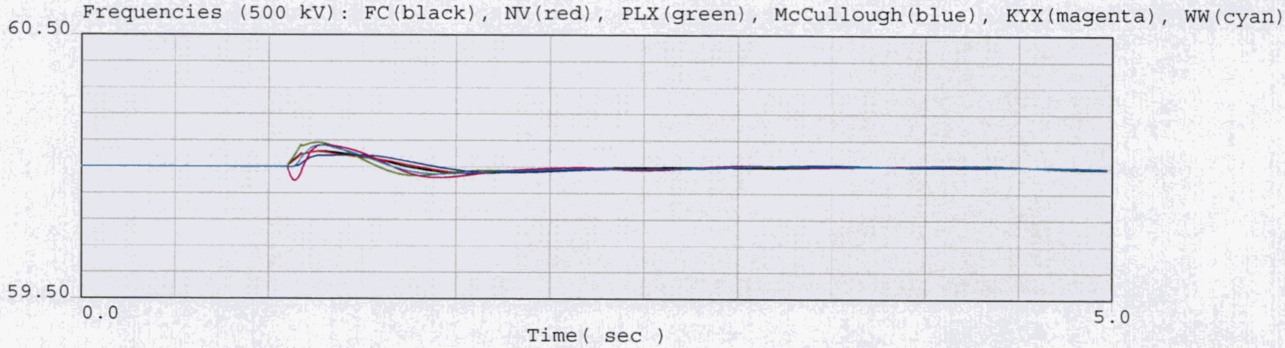

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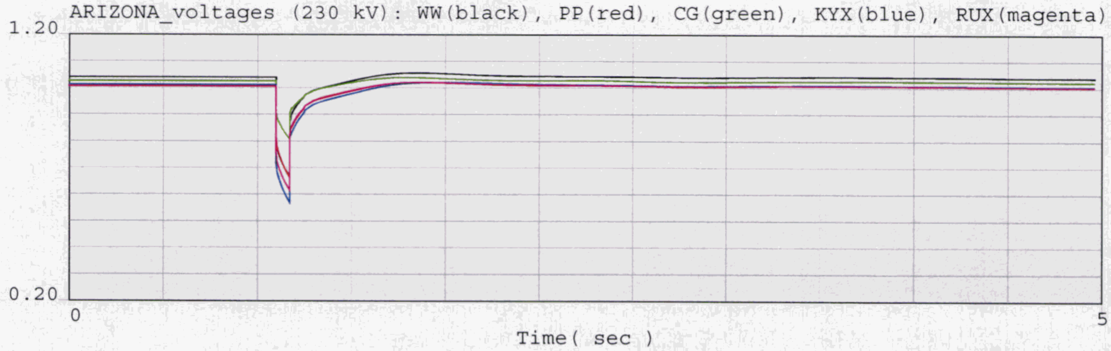
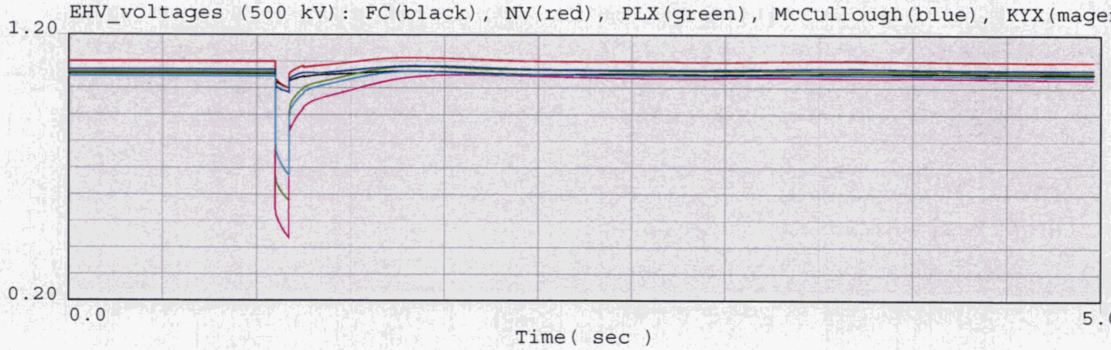
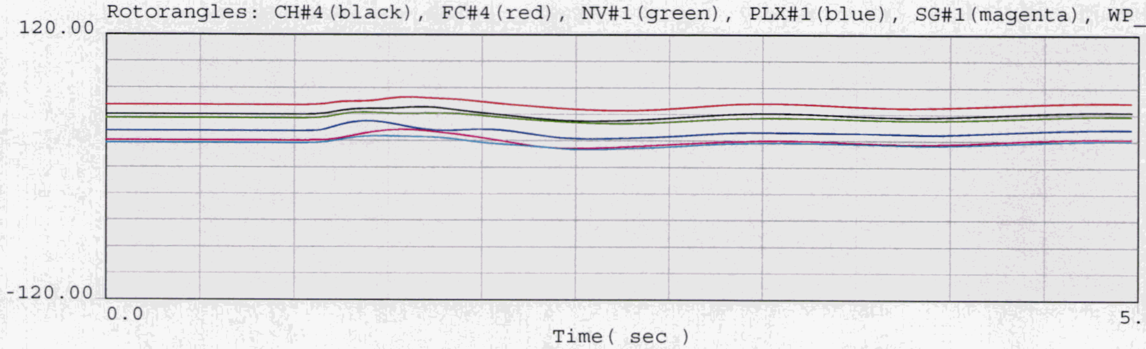
ARIZONA_voltages (230 kV): WW(black), PP(red), CG(green), KYX(blue), RUX(magenta)



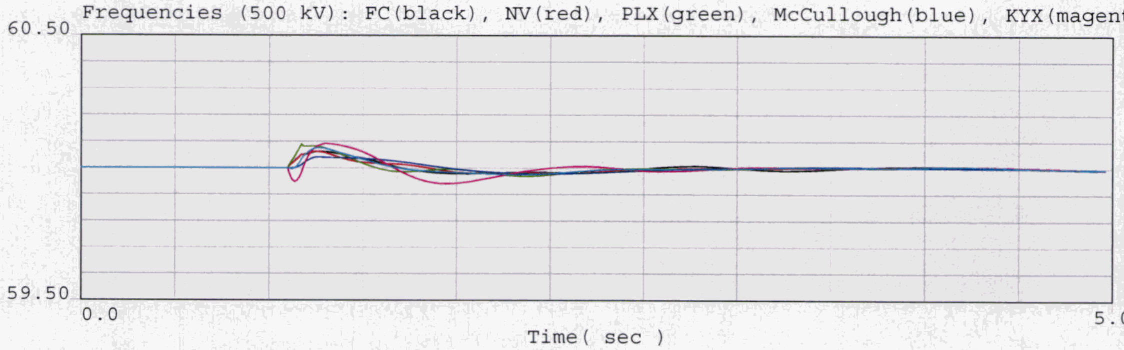
EHV_voltages (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



Rotorangles: CH#4(black), FC#4(red), NV#1(green), PLX#1(blue), SG#1(magenta), WP_CC1(cyan)



Frequencies (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



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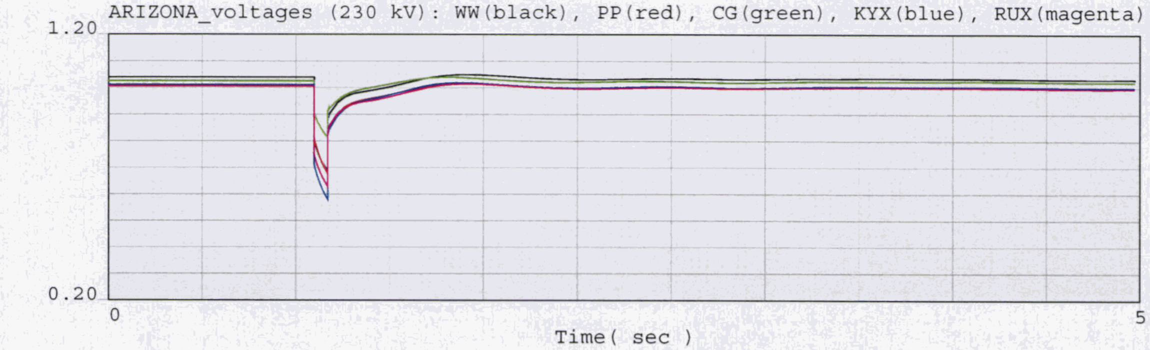

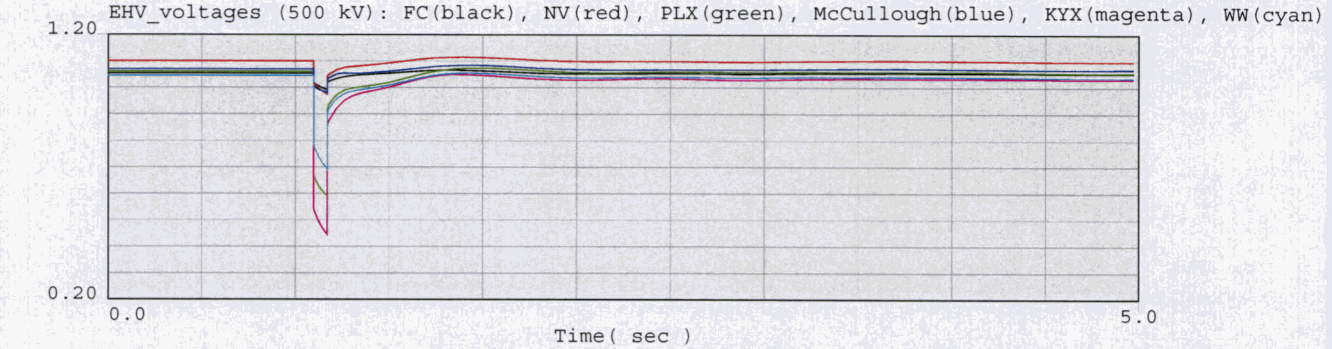

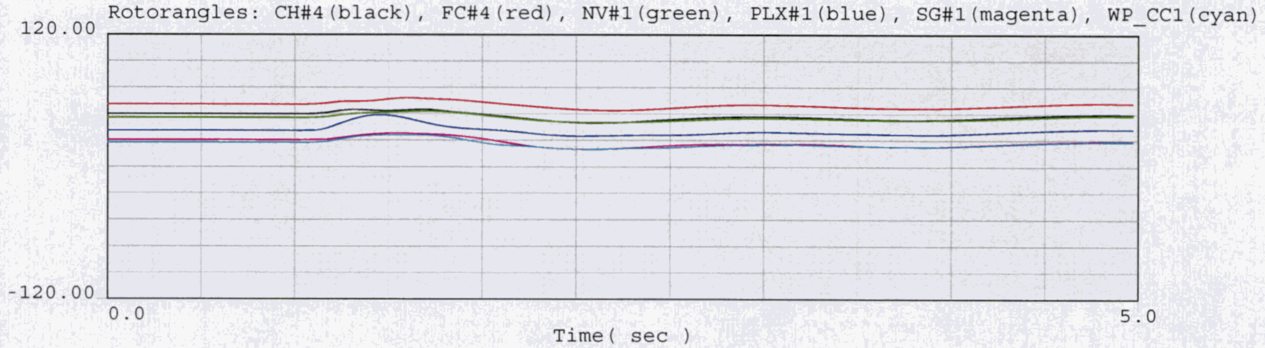

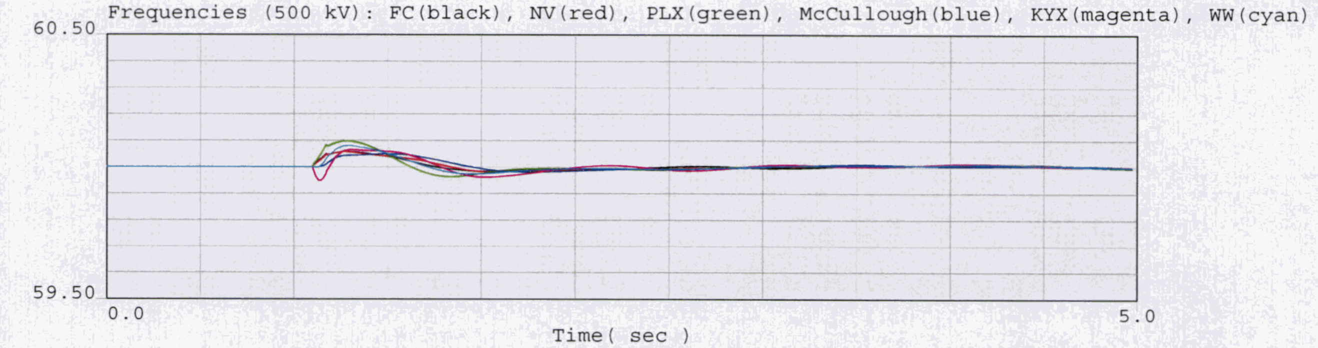

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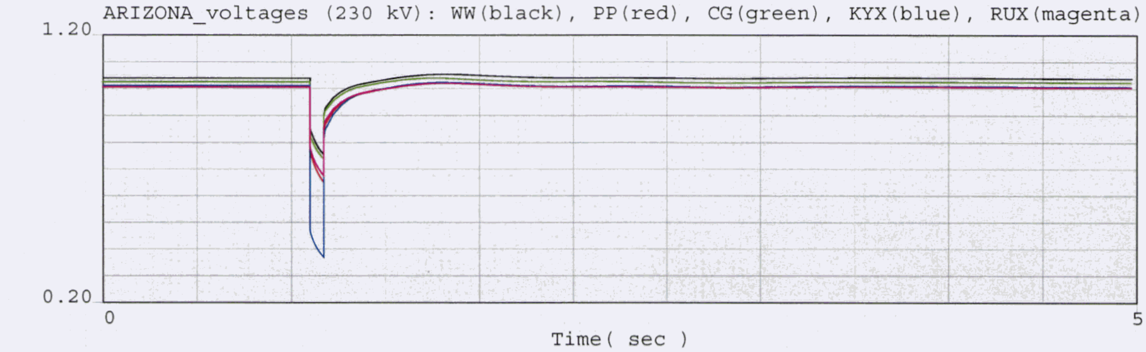

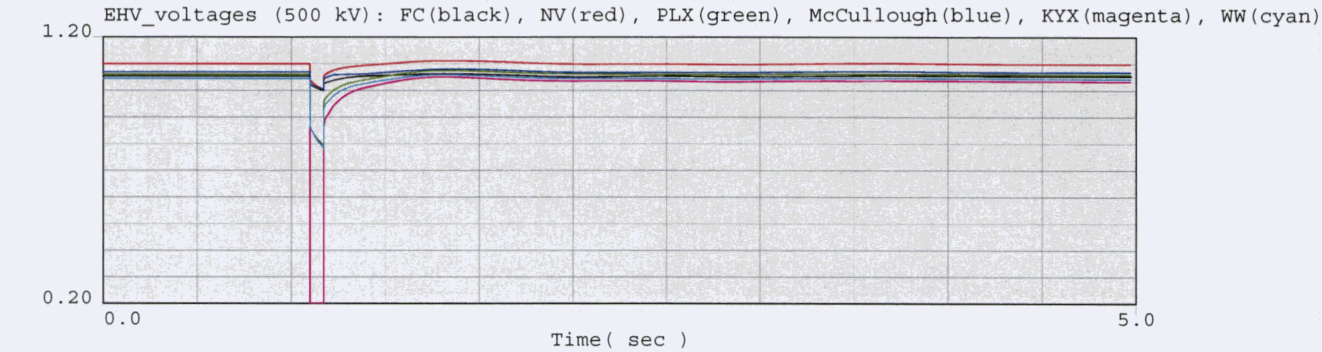

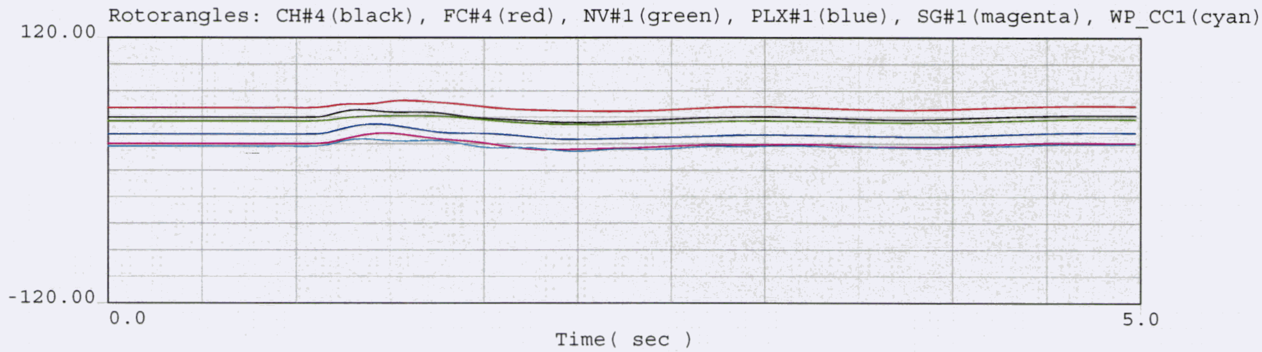

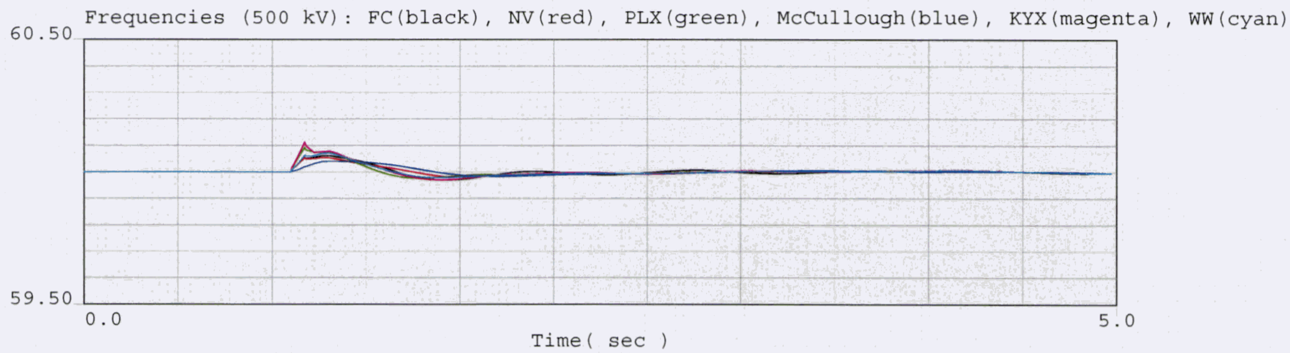

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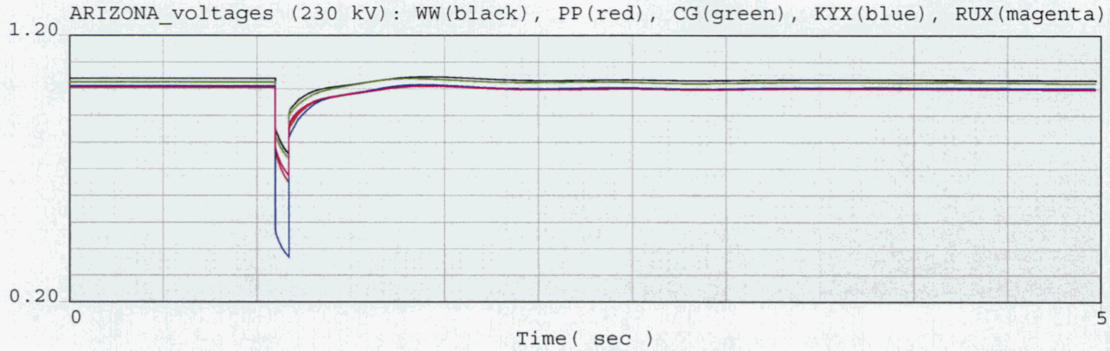
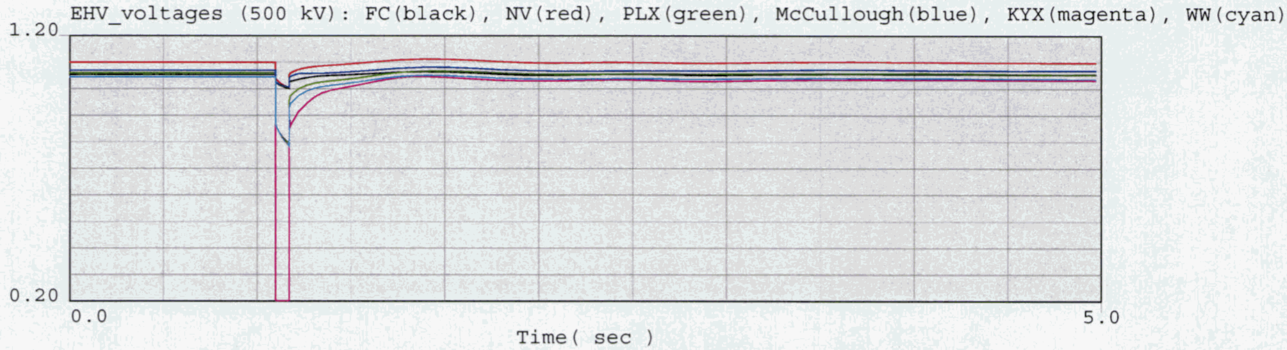
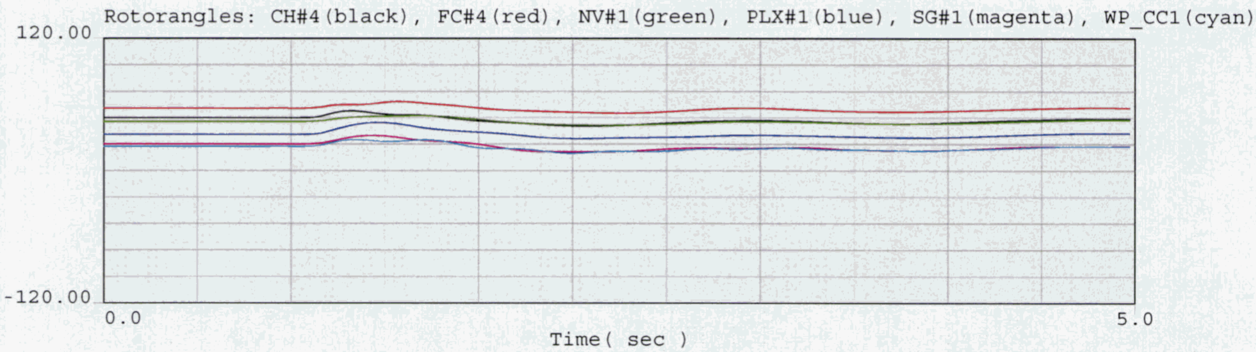
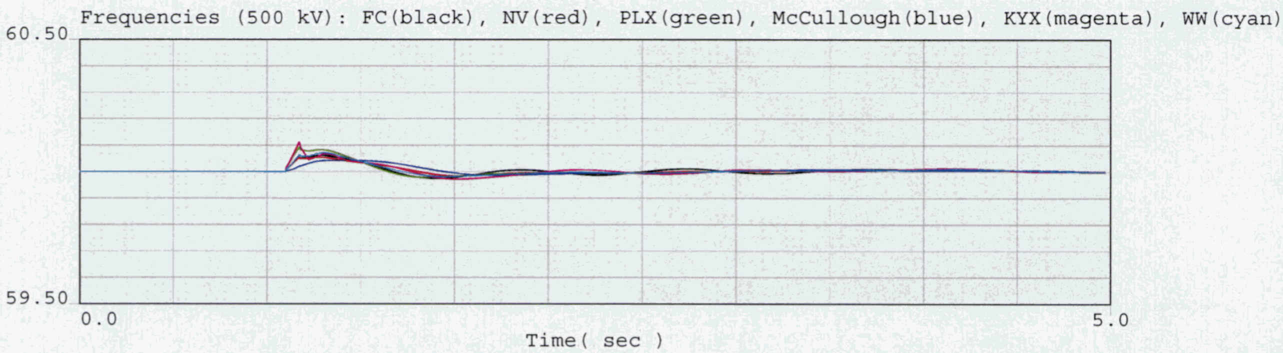
2011 Heavy Summer WECC Power Flow









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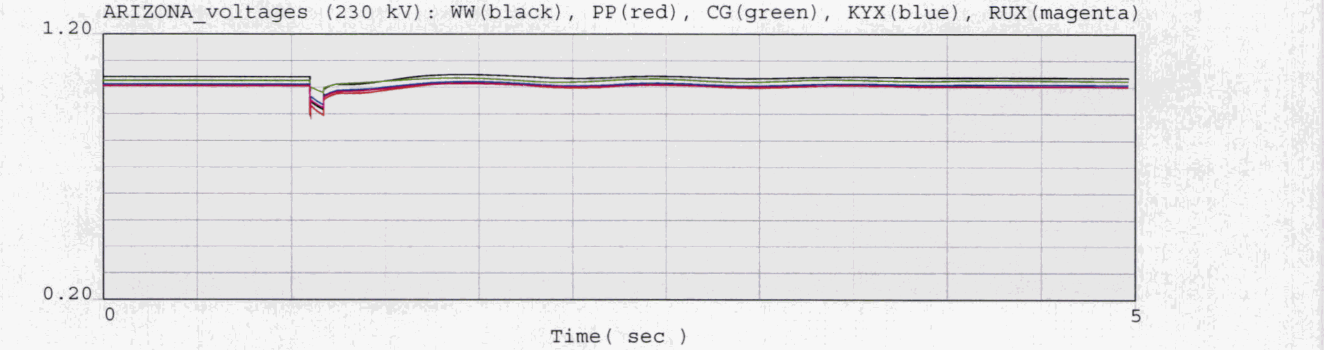

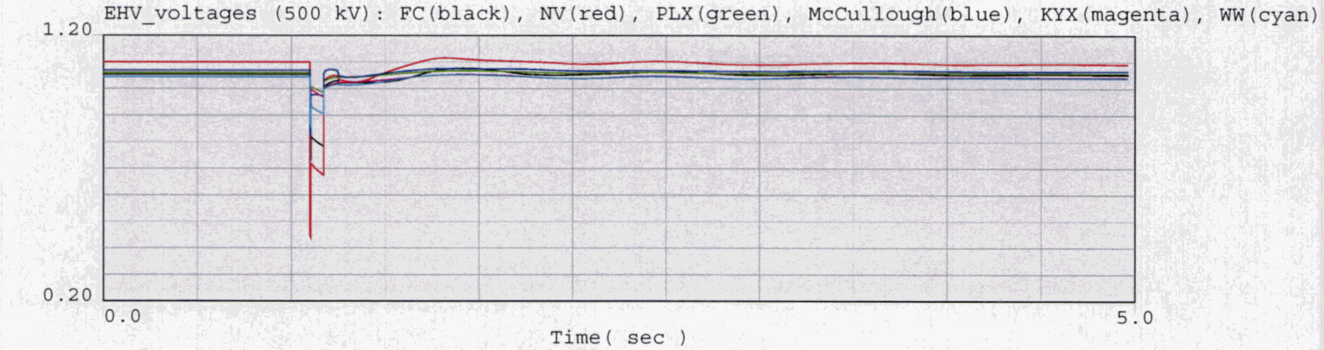

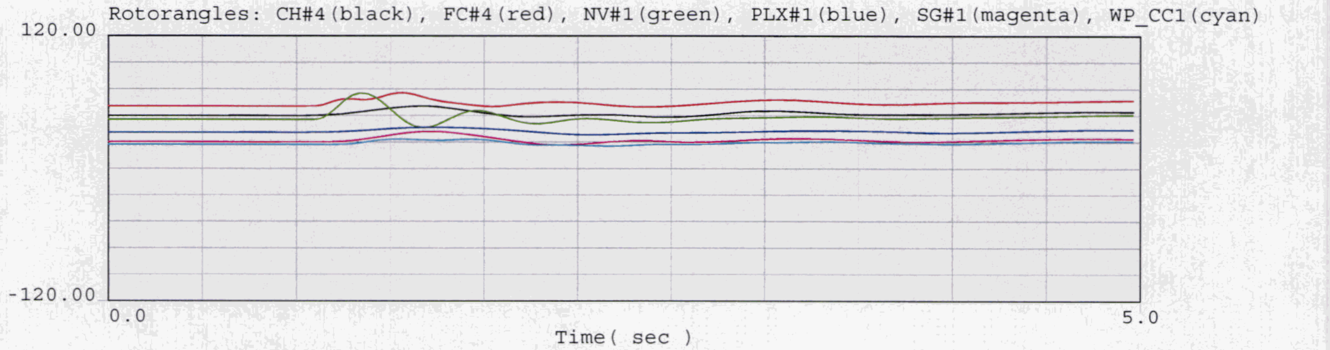

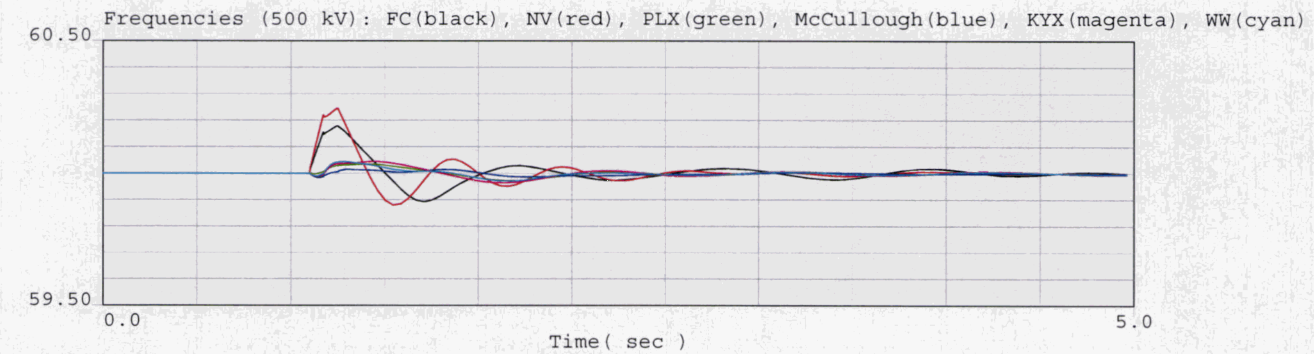

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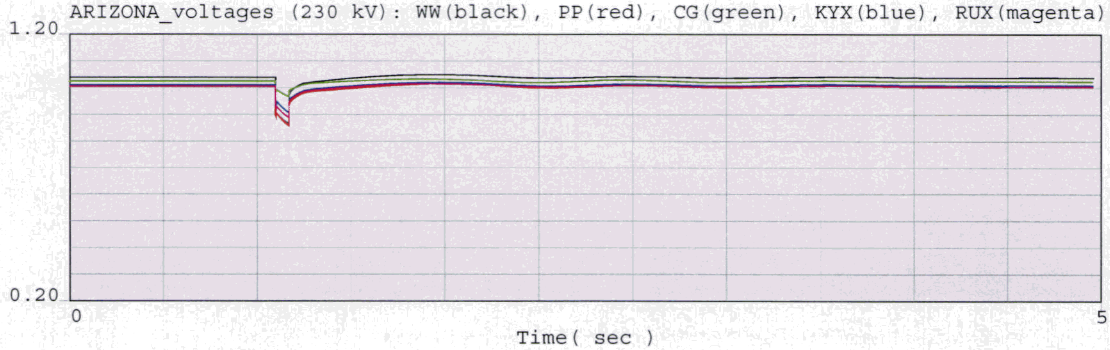
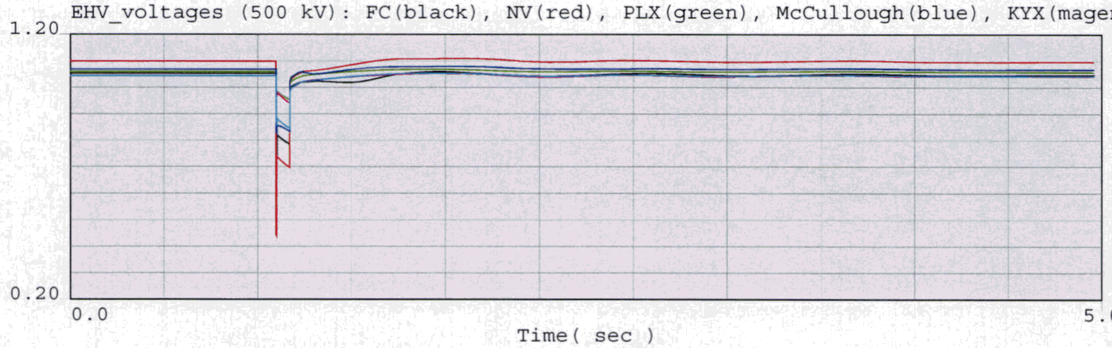
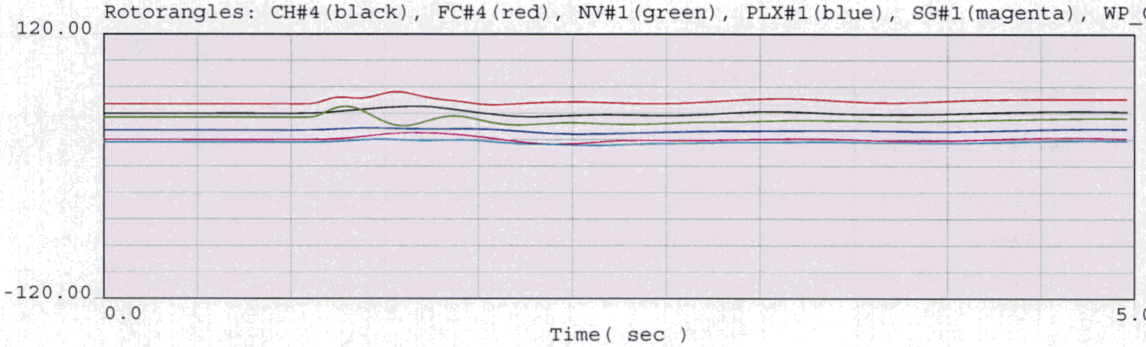
ARIZONA_voltages (230 kV): WW(black), PP(red), CG(green), KYX(blue), RUX(magenta)



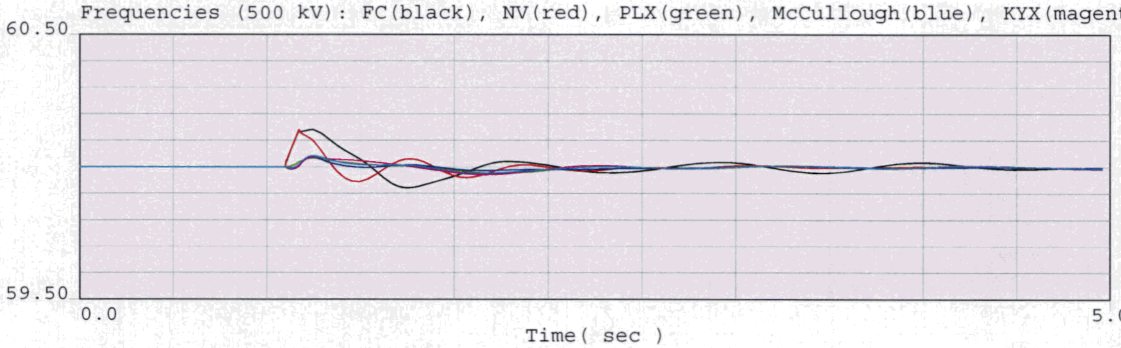
EHV_voltages (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



Rotorangles: CH#4(black), FC#4(red), NV#1(green), PLX#1(blue), SG#1(magenta), WP_CC1(cyan)



Frequencies (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



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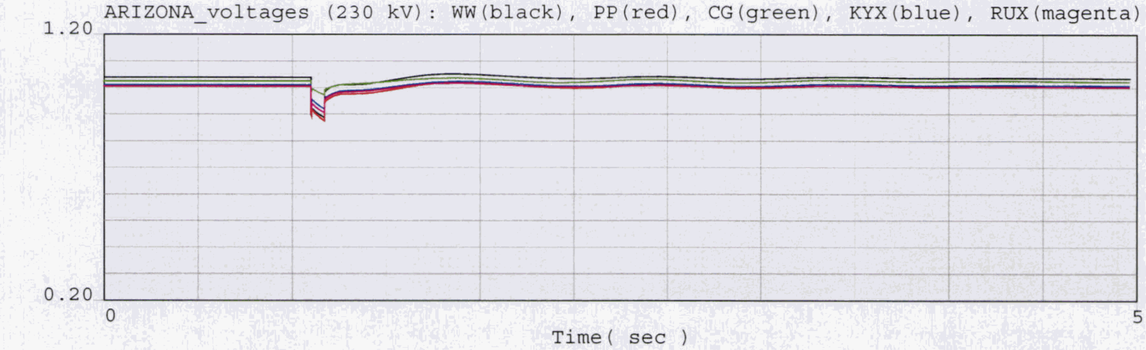
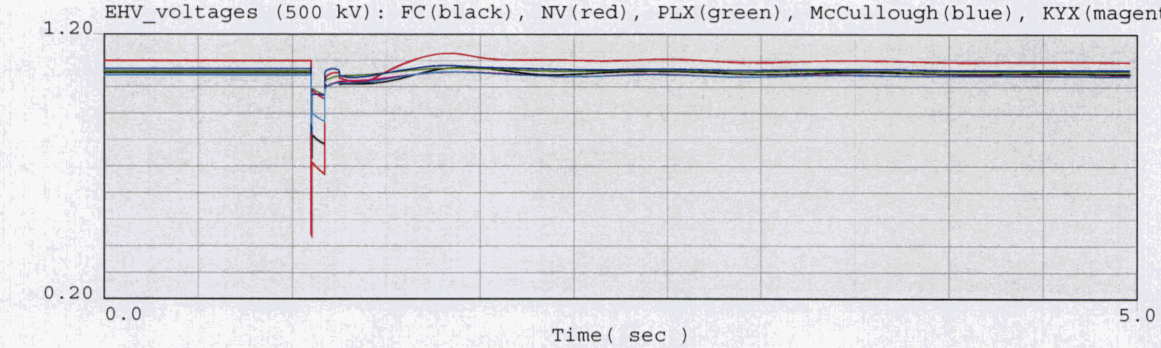
ARIZONA_voltages (230 kV): WW(black), PP(red), CG(green), KYX(blue), RUX(magenta)



EHV_voltages (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



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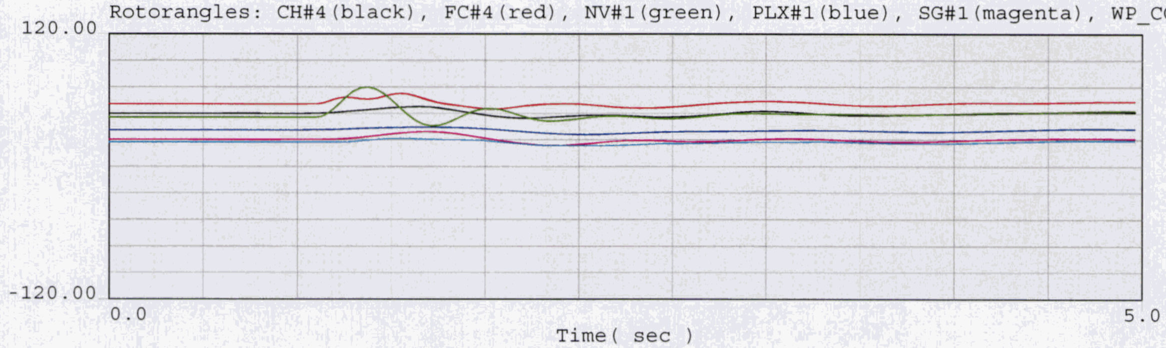
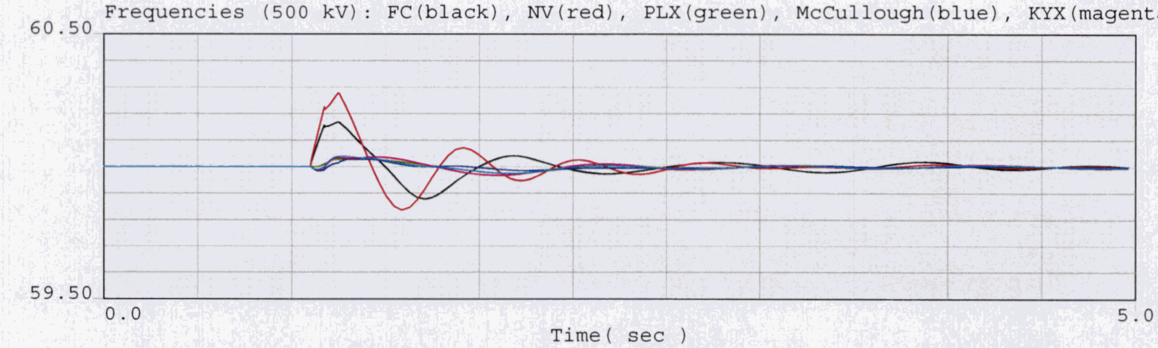


Frequencies (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



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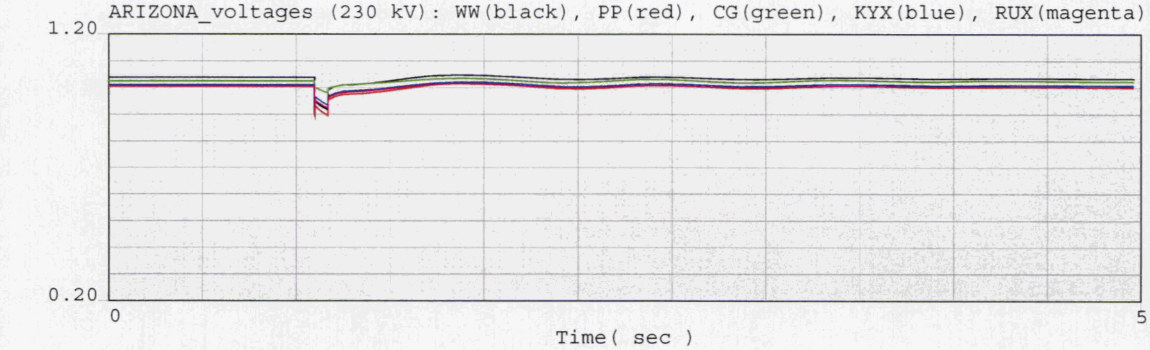
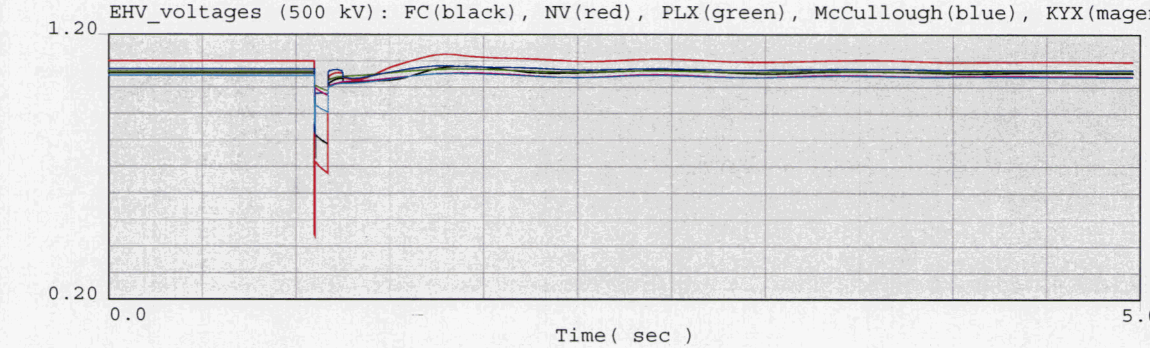
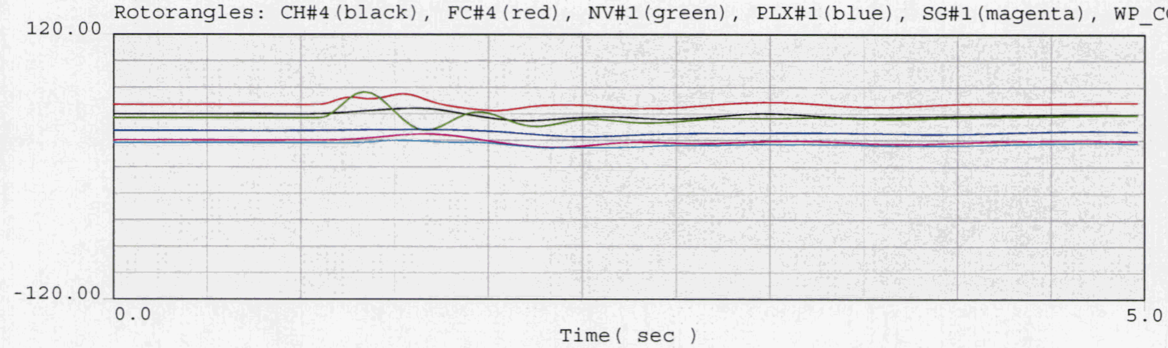
ARIZONA_voltages (230 kV): WW(black), PP(red), CG(green), KYX(blue), RUX(magenta)



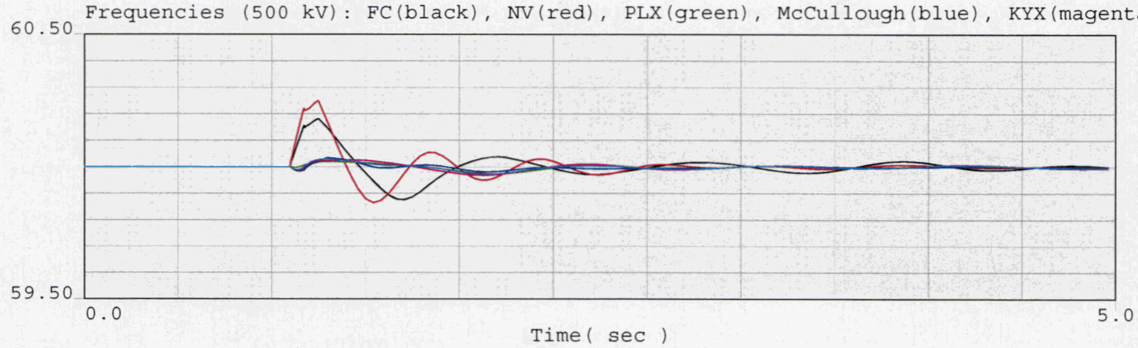
EHV_voltages (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



Rotorangles: CH#4(black), FC#4(red), NV#1(green), PLX#1(blue), SG#1(magenta), WP_CC1(cyan)



Frequencies (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



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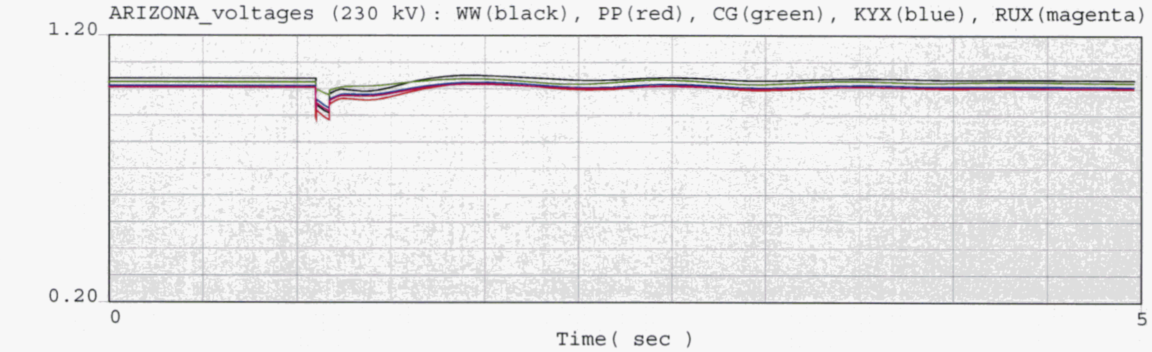

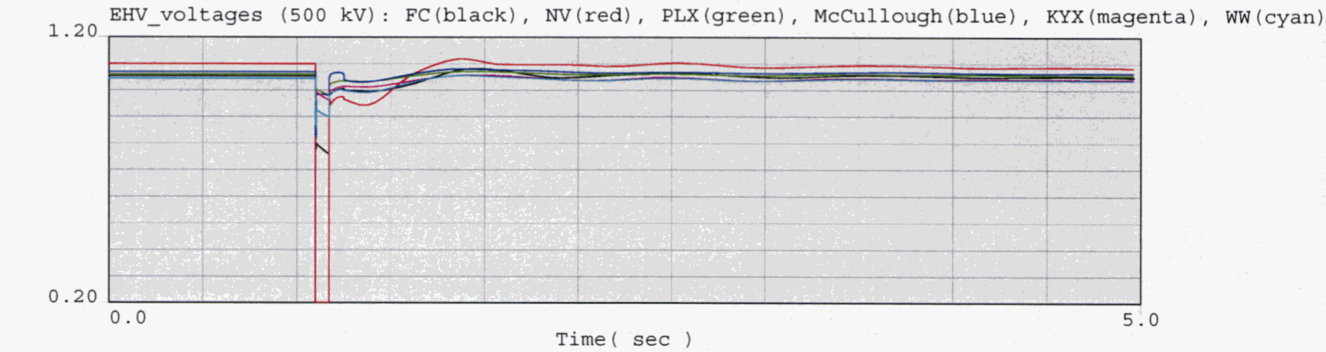

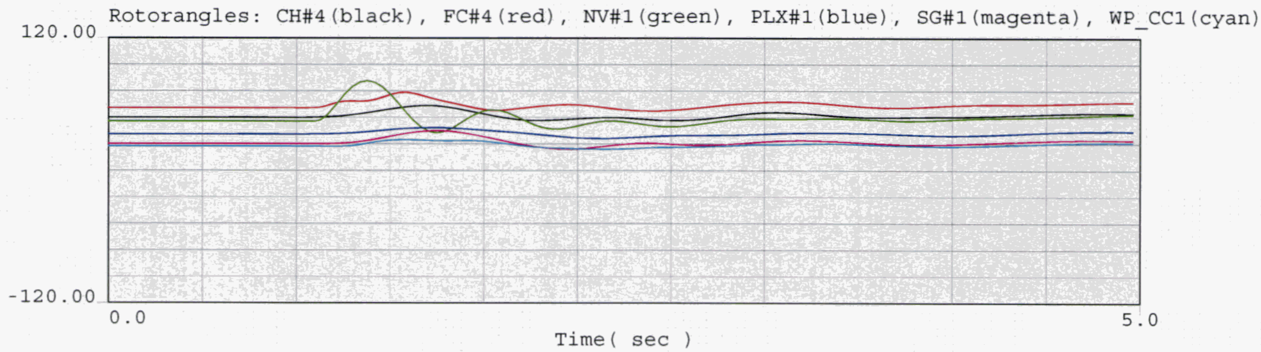

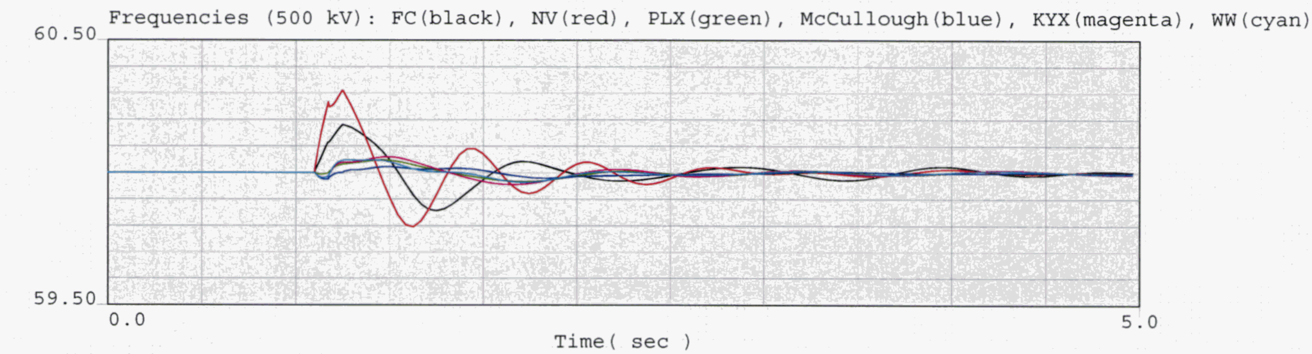

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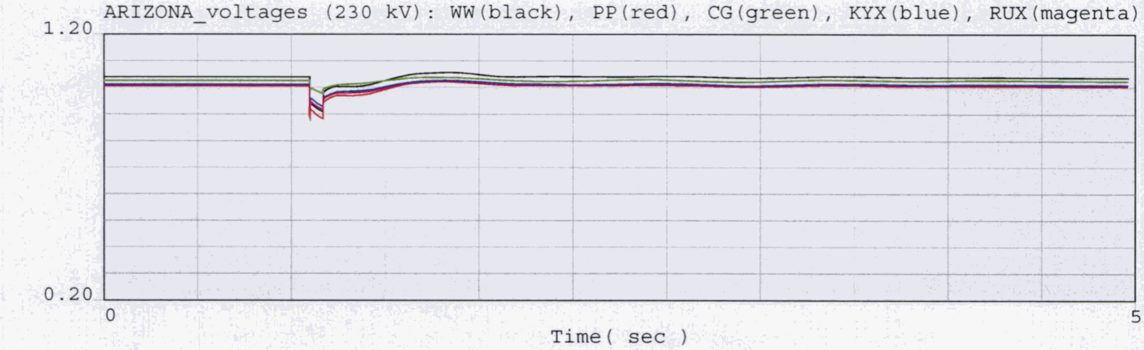

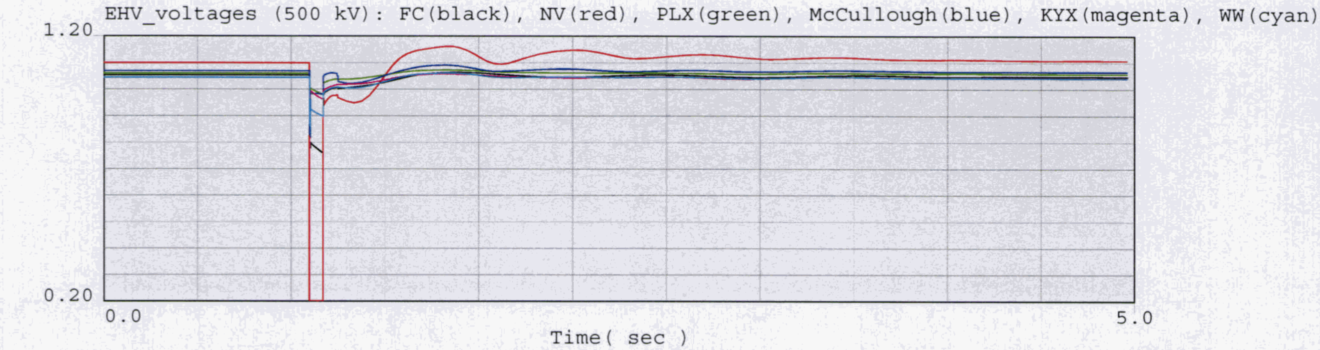

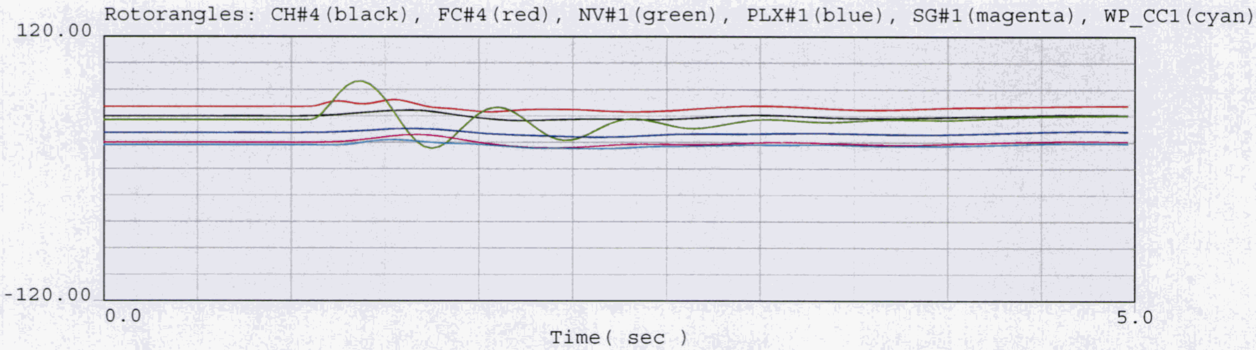

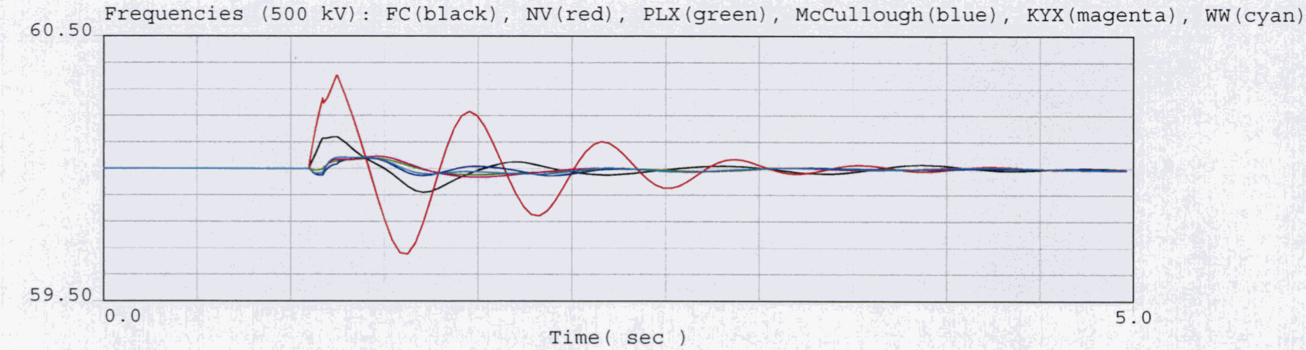

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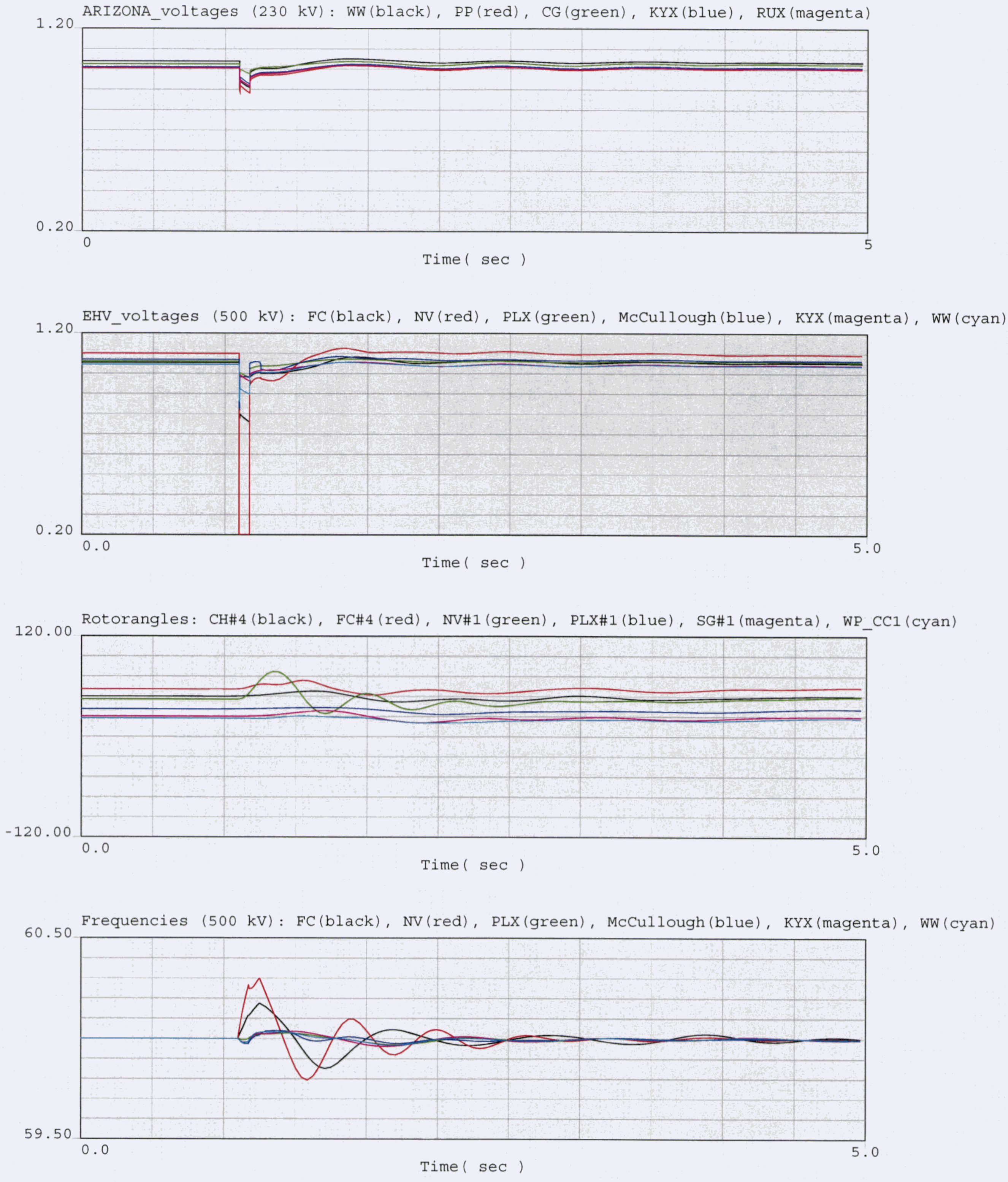

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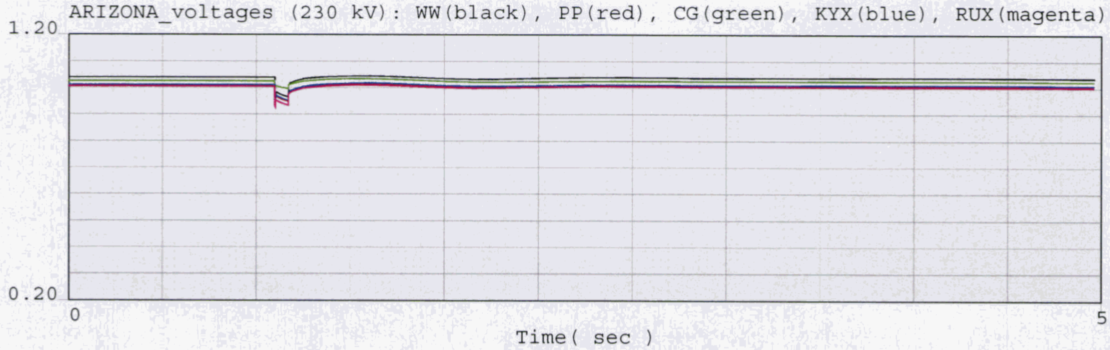
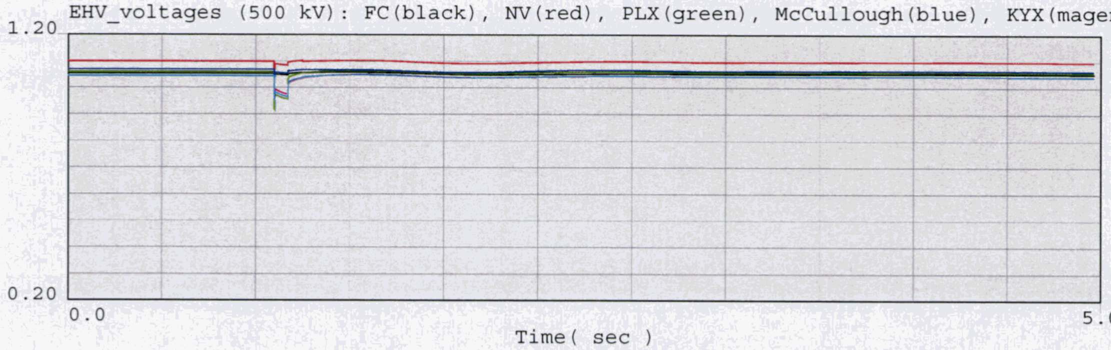
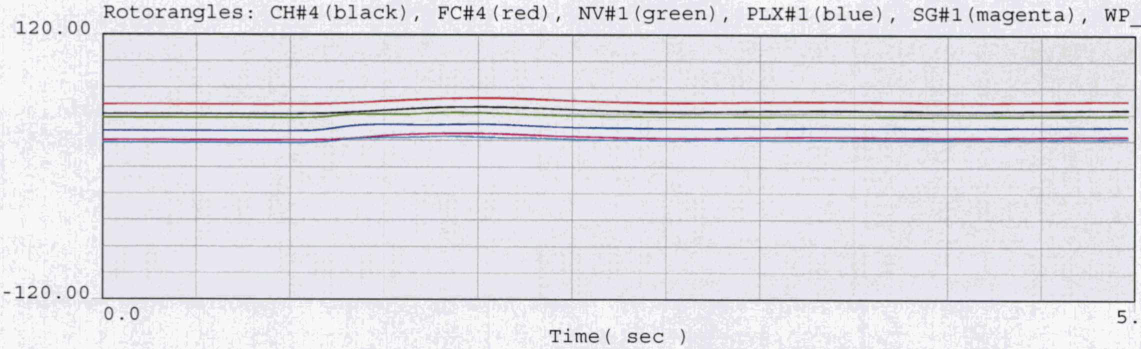
ARIZONA_voltages (230 kV): WW(black), PP(red), CG(green), KYX(blue), RUX(magenta)



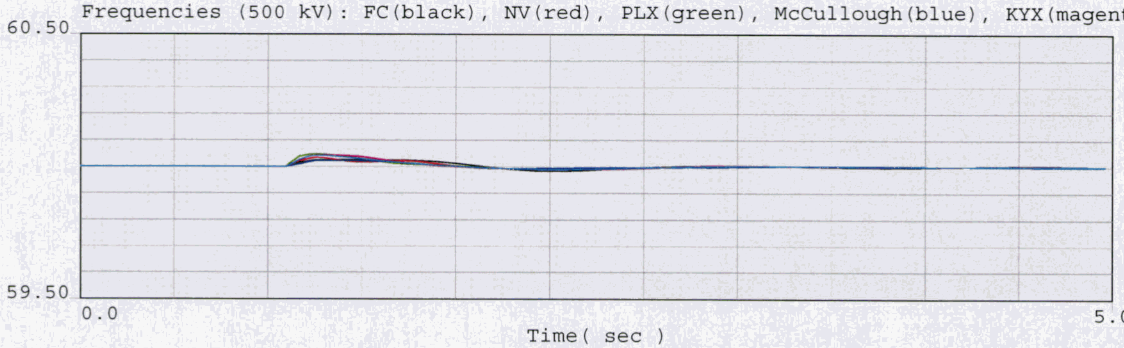
EHV_voltages (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



Rotorangles: CH#4(black), FC#4(red), NV#1(green), PLX#1(blue), SG#1(magenta), WP_CC1(cyan)



Frequencies (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



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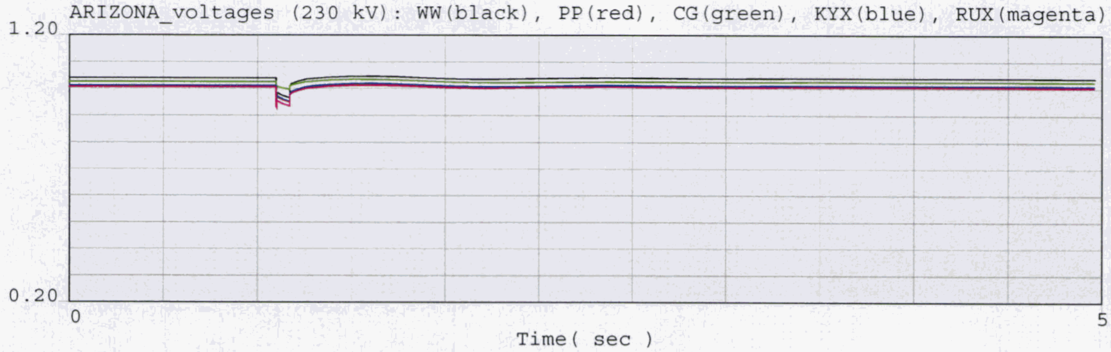
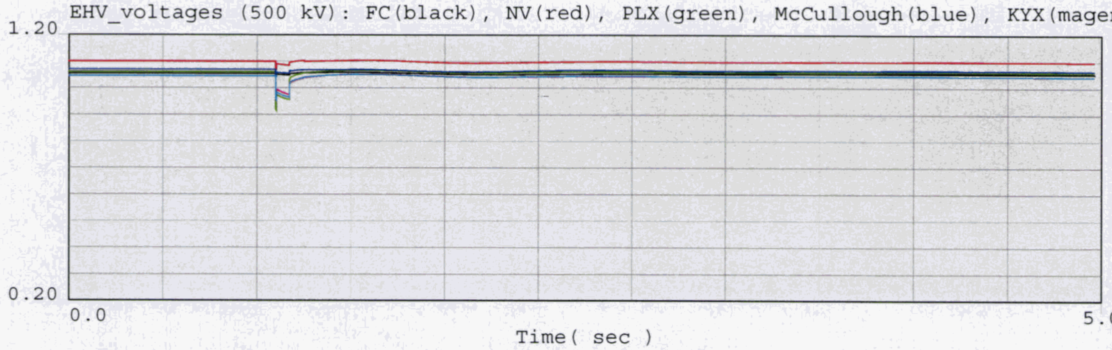
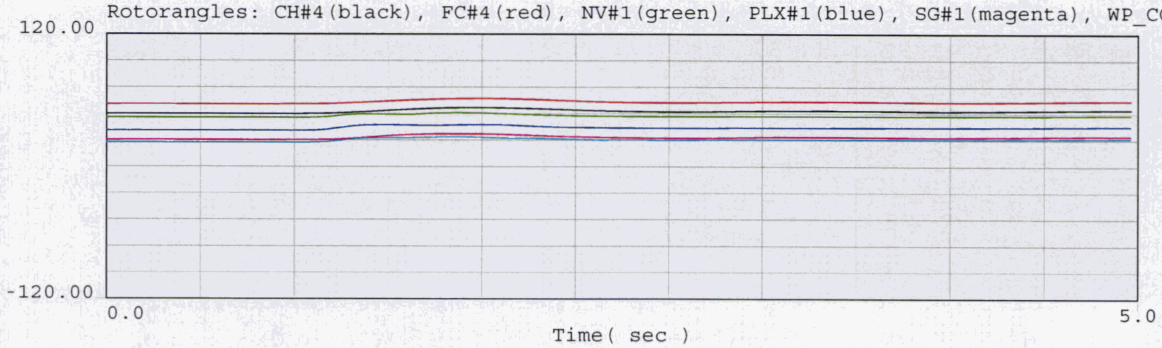
ARIZONA_voltages (230 kV): WW(black), PP(red), CG(green), KYX(blue), RUX(magenta)



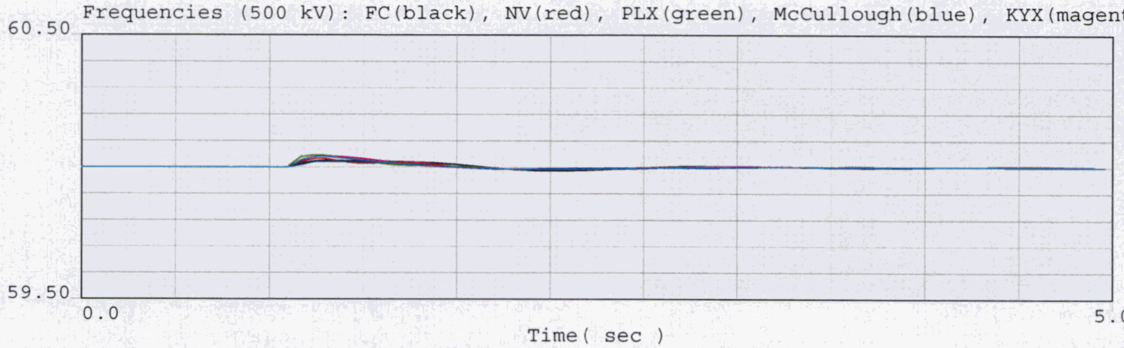
EHV_voltages (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



Rotorangles: CH#4(black), FC#4(red), NV#1(green), PLX#1(blue), SG#1(magenta), WP_CC1(cyan)



Frequencies (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



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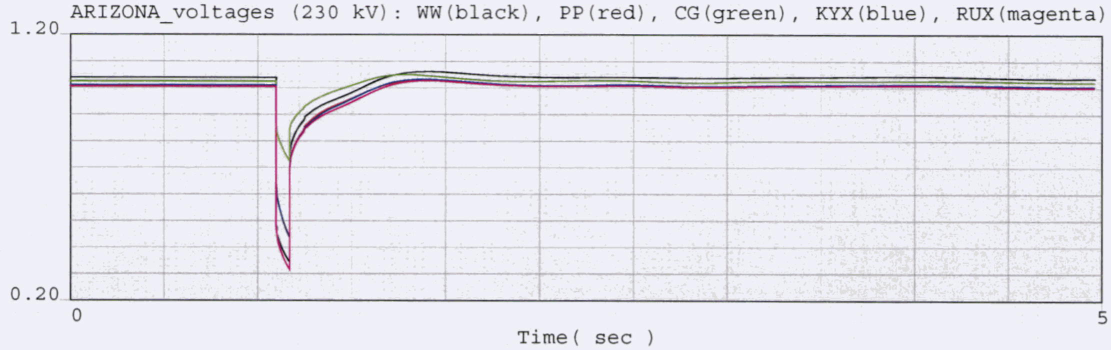

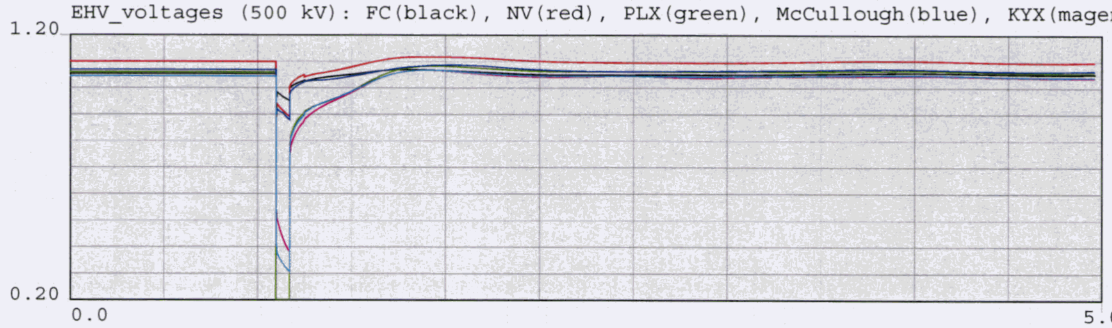

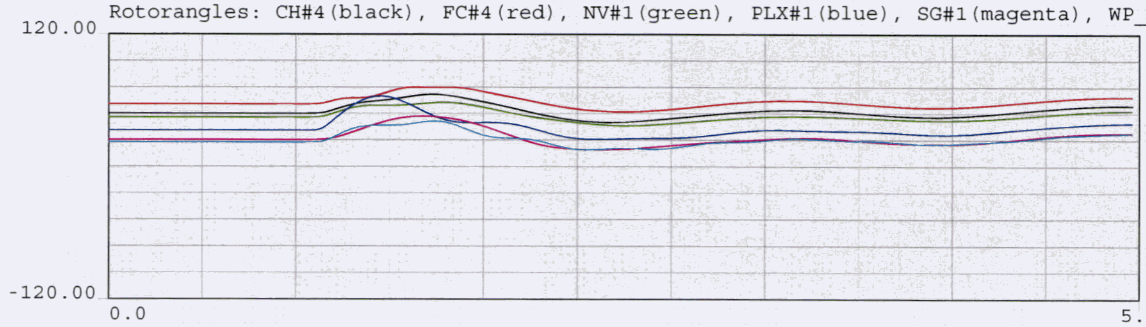

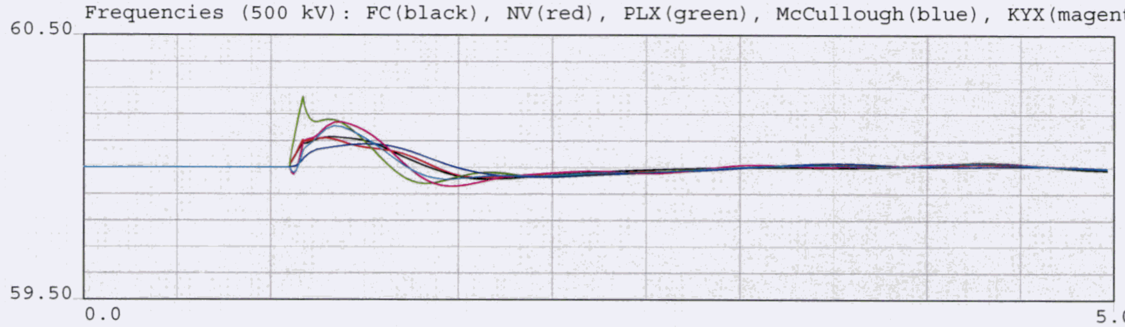

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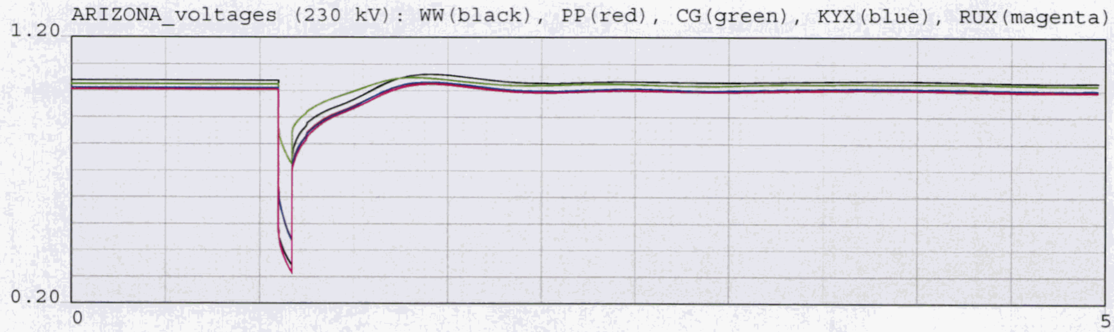

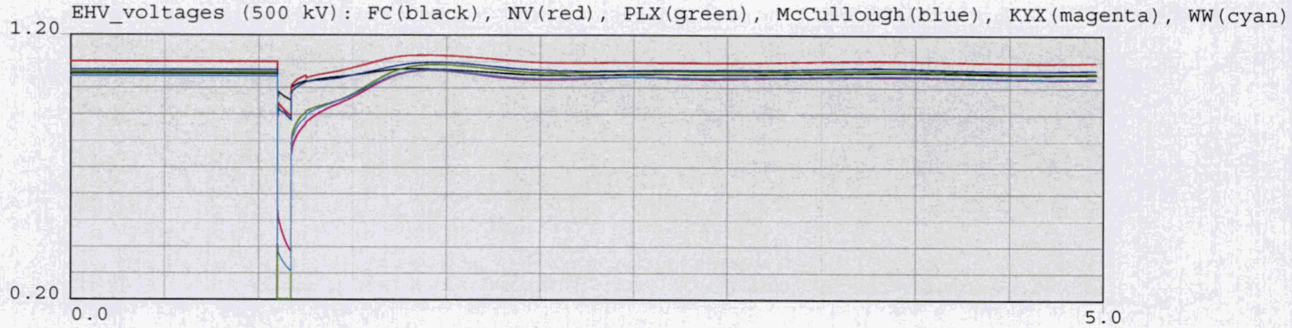

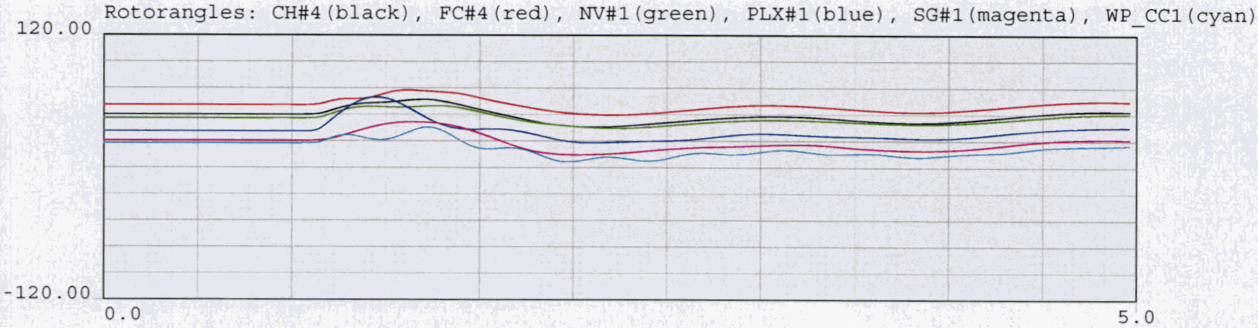

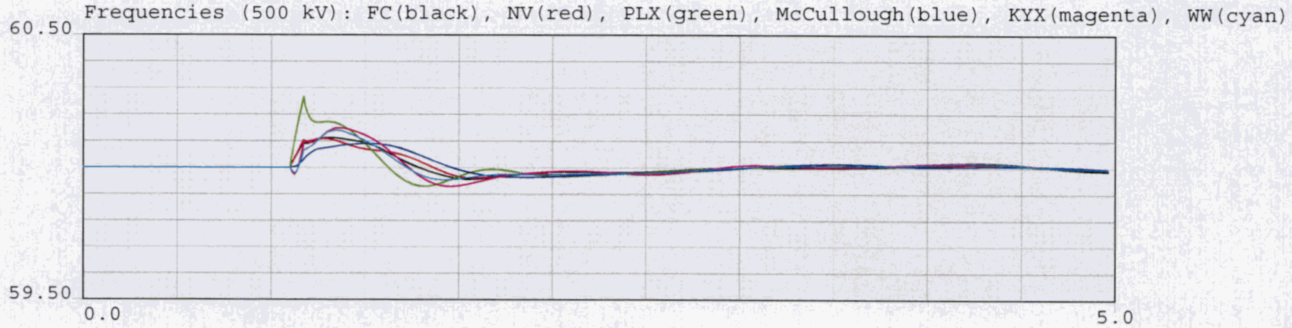

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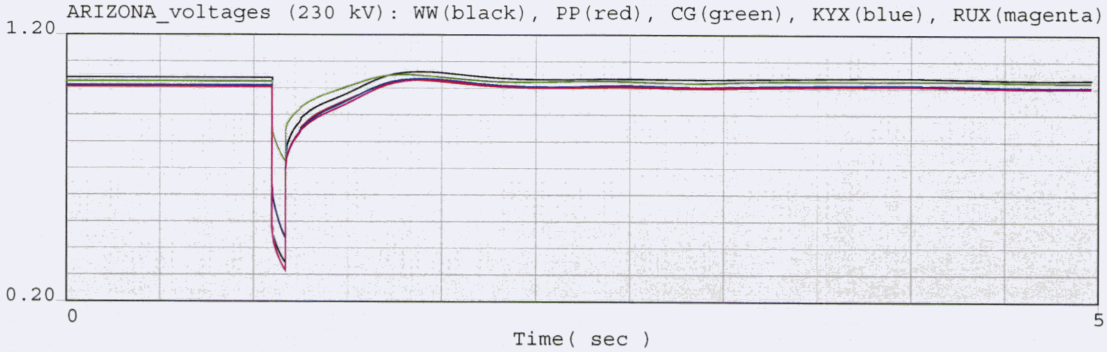
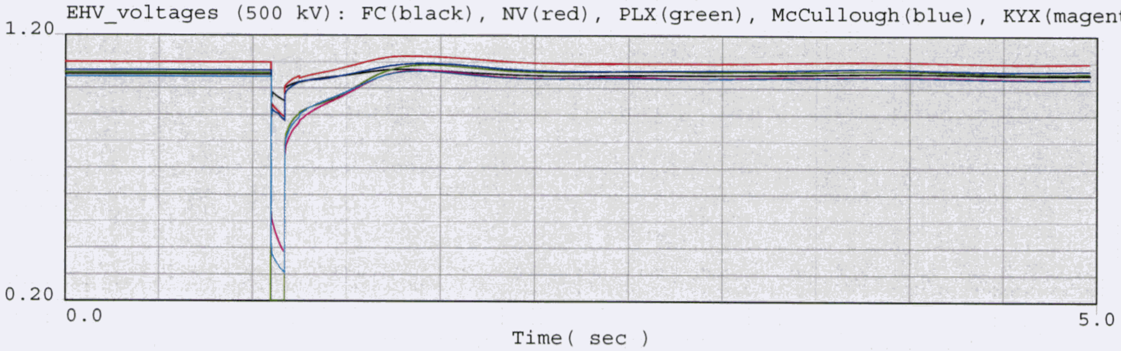
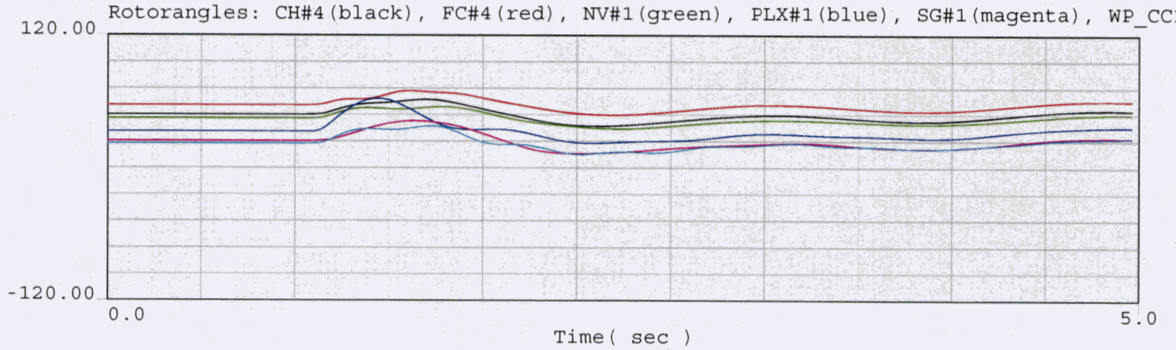
ARIZONA_voltages (230 kV): WW(black), PP(red), CG(green), KYX(blue), RUX(magenta)



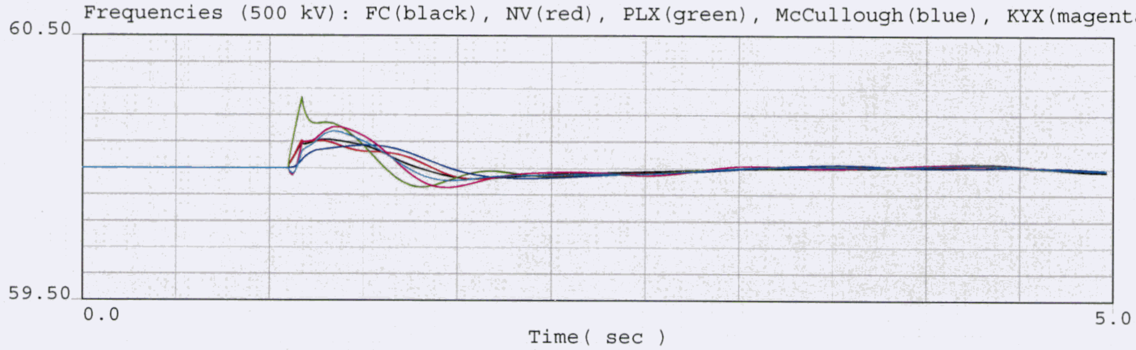
EHV_voltages (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



Rotorangles: CH#4(black), FC#4(red), NV#1(green), PLX#1(blue), SG#1(magenta), WP_CC1(cyan)



Frequencies (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



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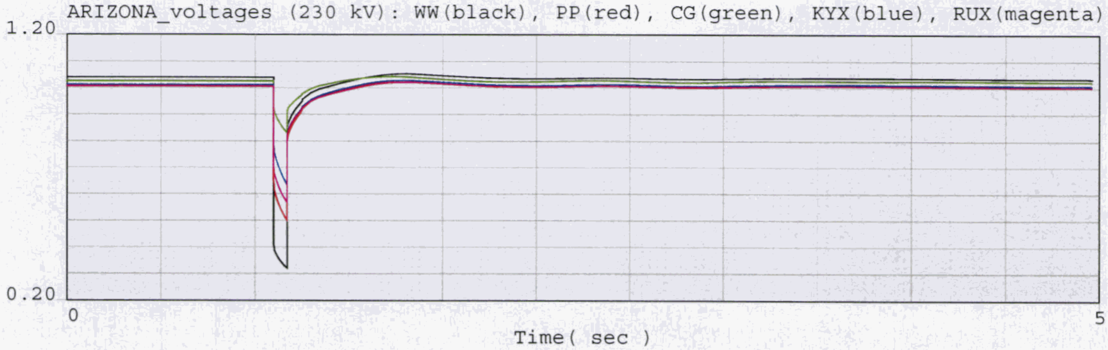
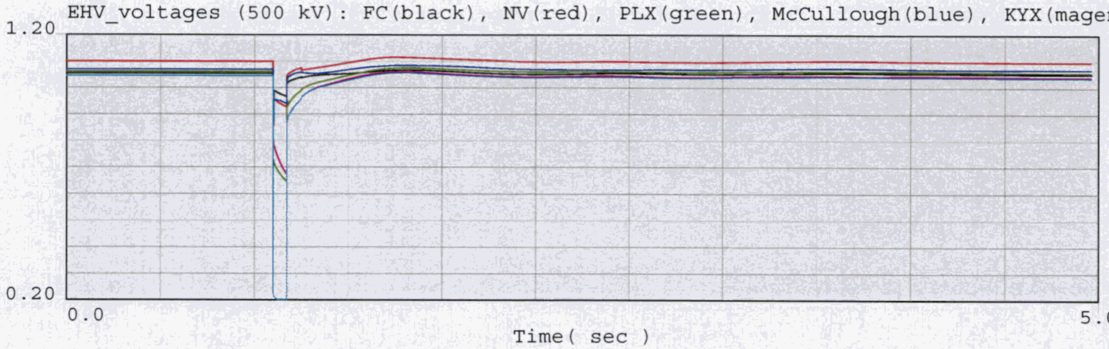
2011 Heavy Summer WECC Power Flow

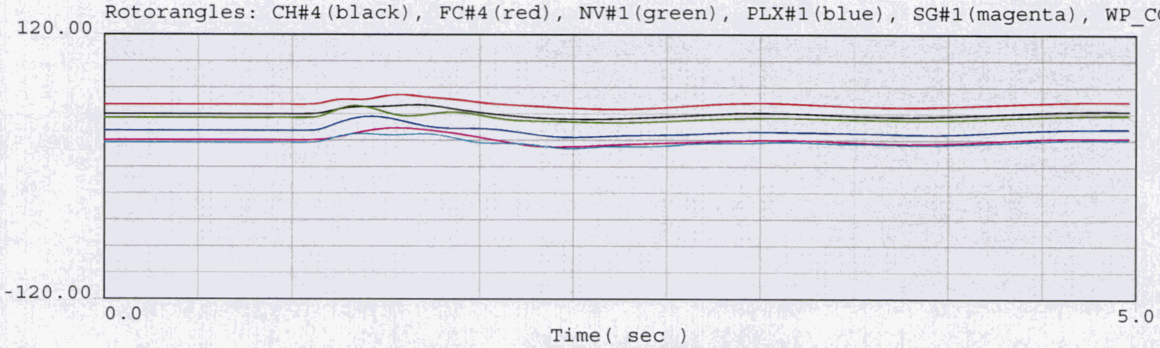
ARIZONA_voltages (230 kV): WW(black), PP(red), CG(green), KYX(blue), RUX(magenta)



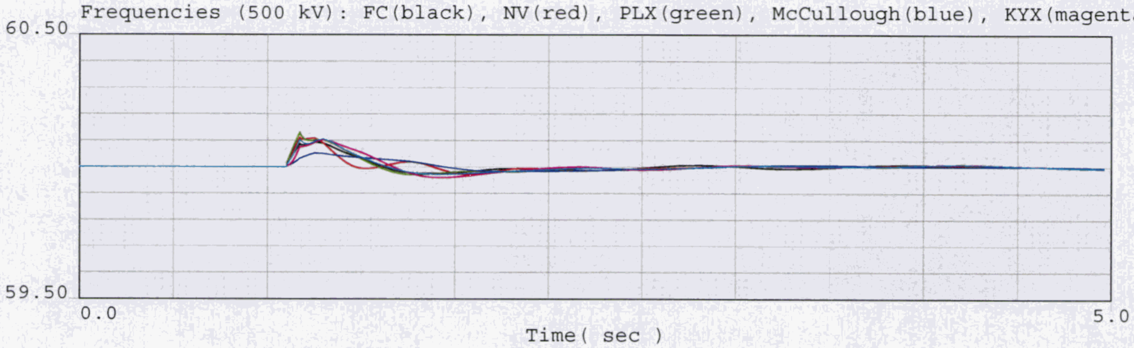
EHV_voltages (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



Rotorangles: CH#4(black), FC#4(red), NV#1(green), PLX#1(blue), SG#1(magenta), WP_CC1(cyan)



Frequencies (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



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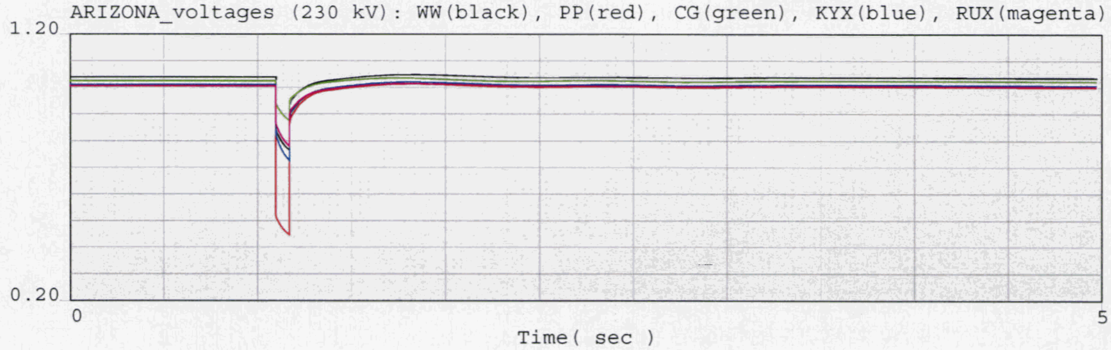

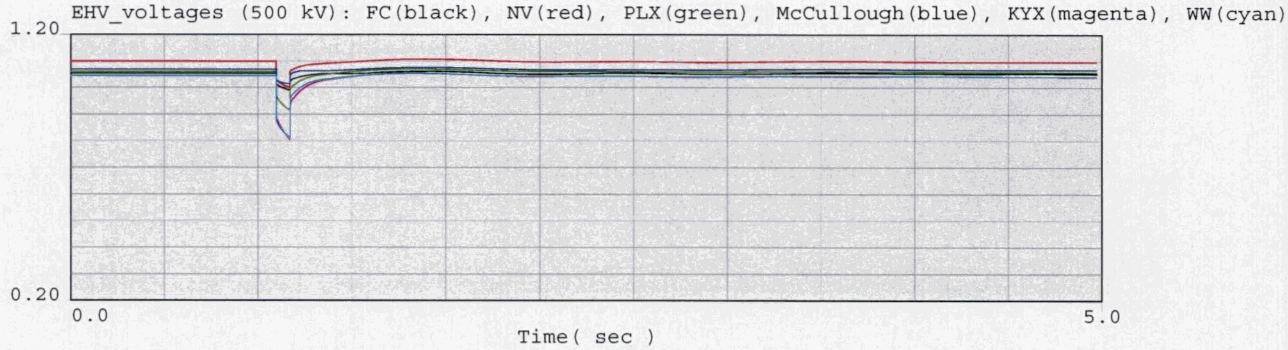

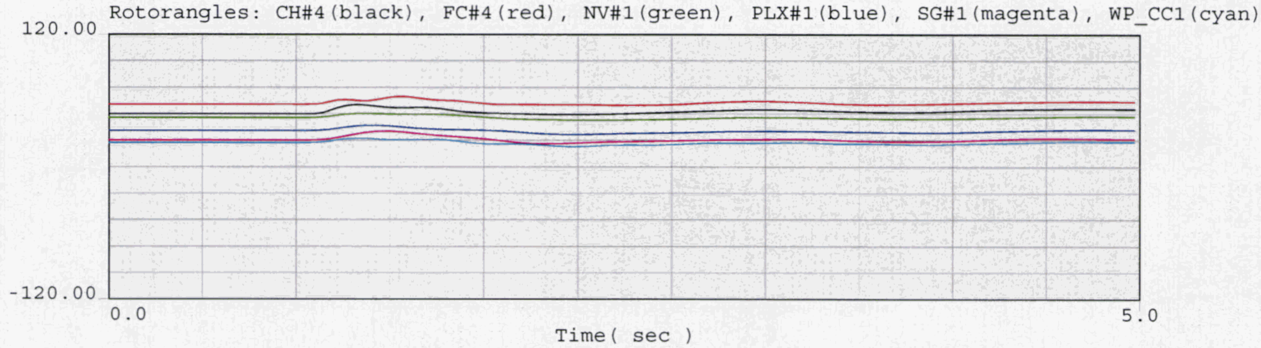

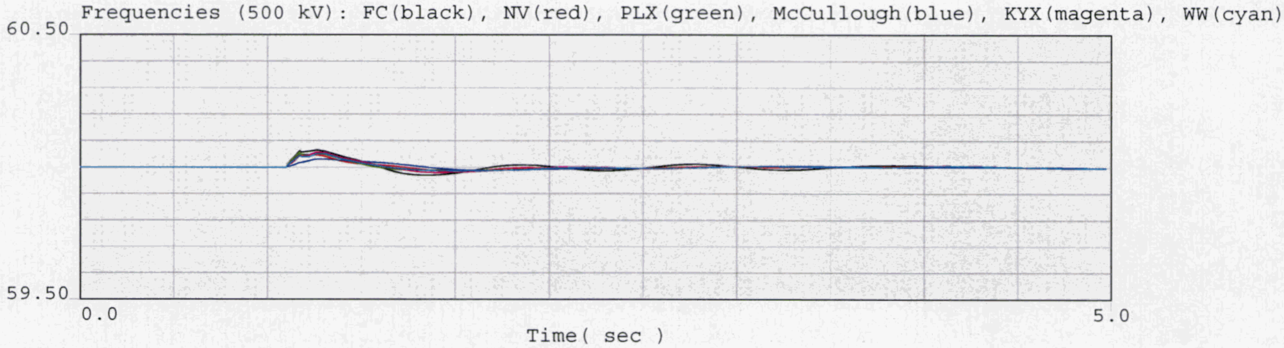

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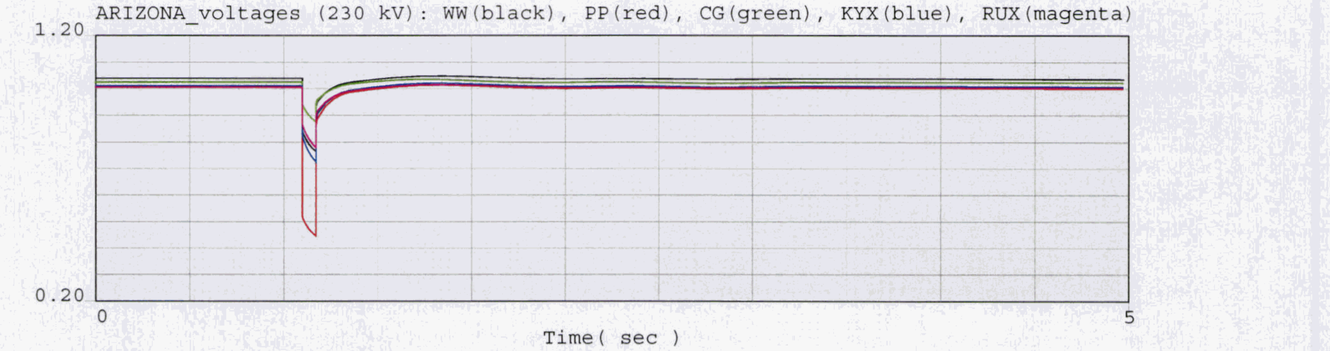

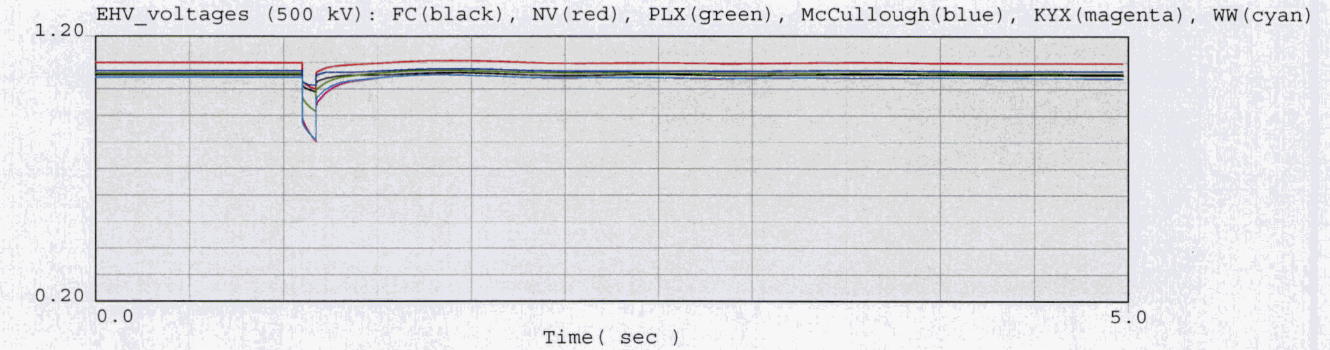

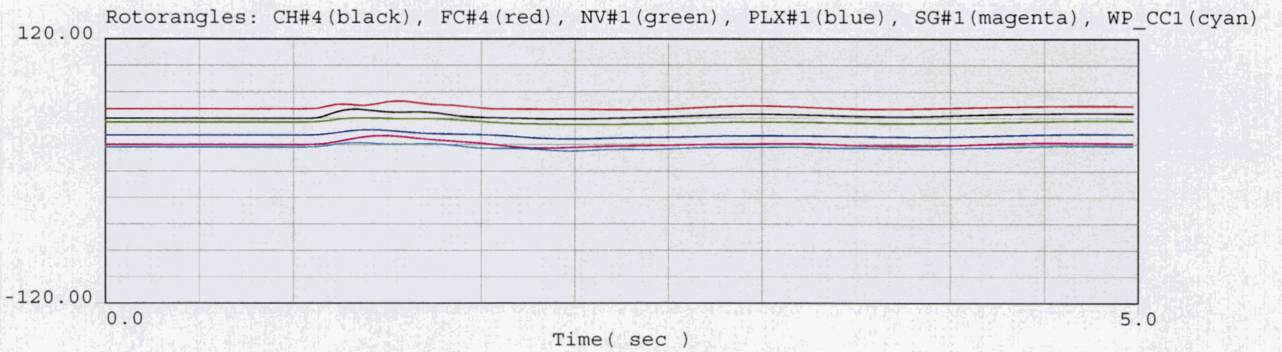

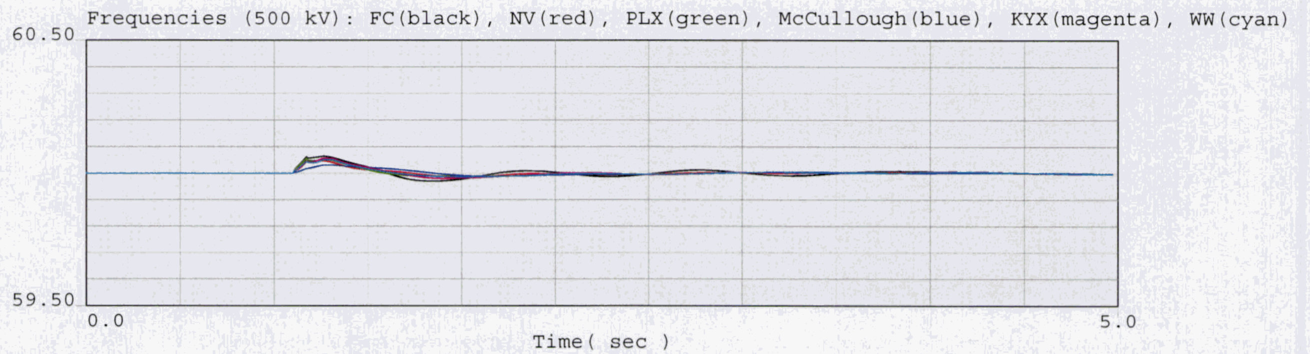

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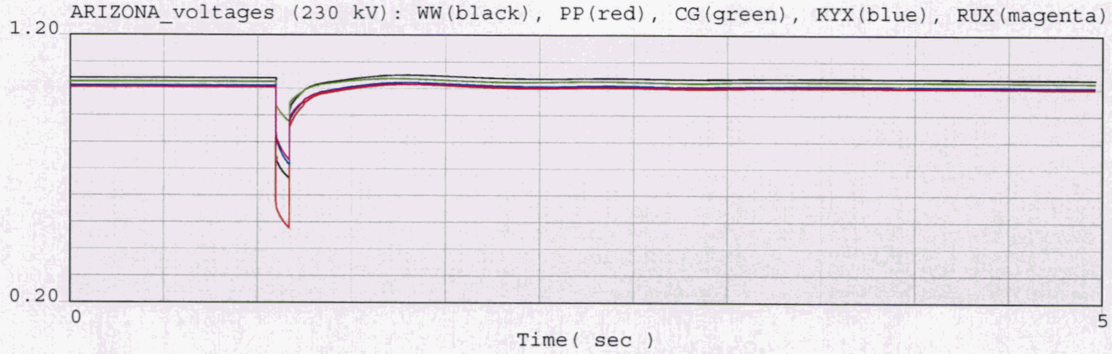
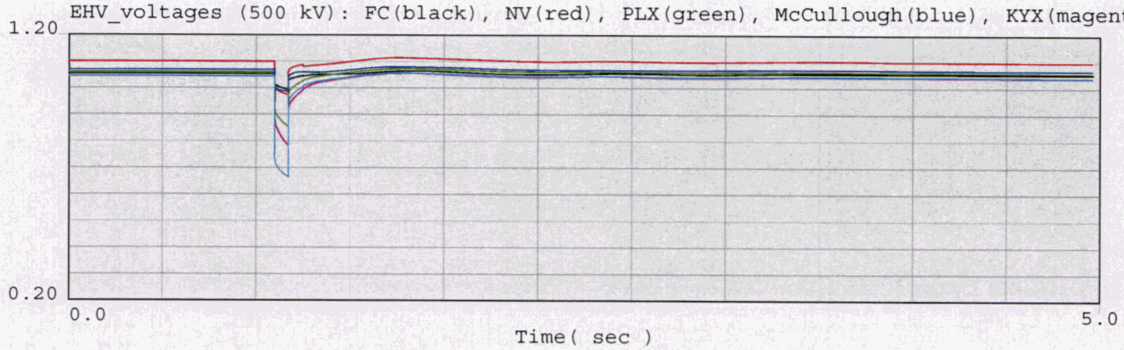
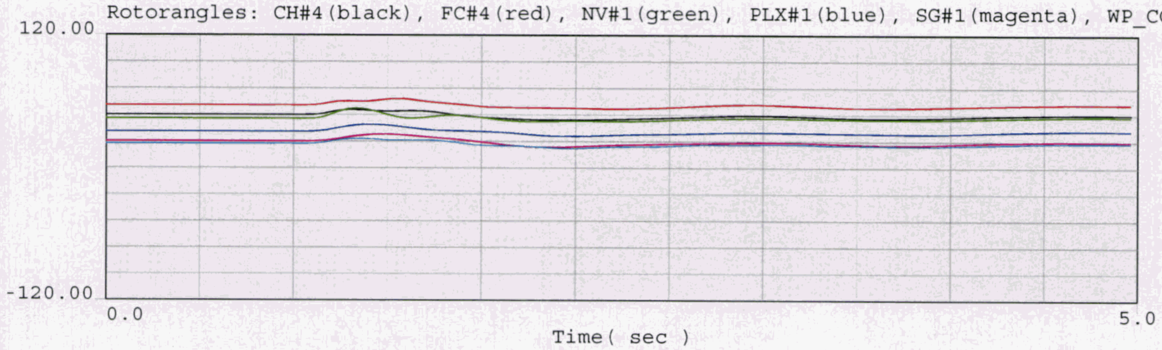
ARIZONA_voltages (230 kV): WW(black), PP(red), CG(green), KYX(blue), RUX(magenta)



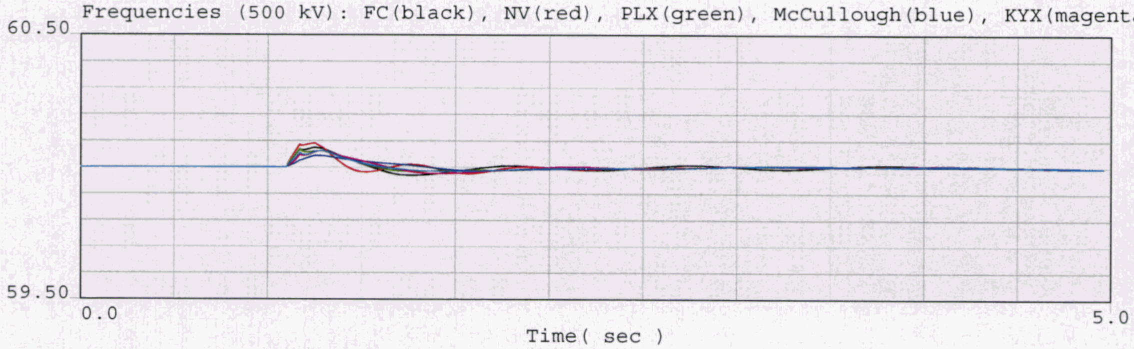
EHV_voltages (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



Rotorangles: CH#4(black), FC#4(red), NV#1(green), PLX#1(blue), SG#1(magenta), WP_CC1(cyan)



Frequencies (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



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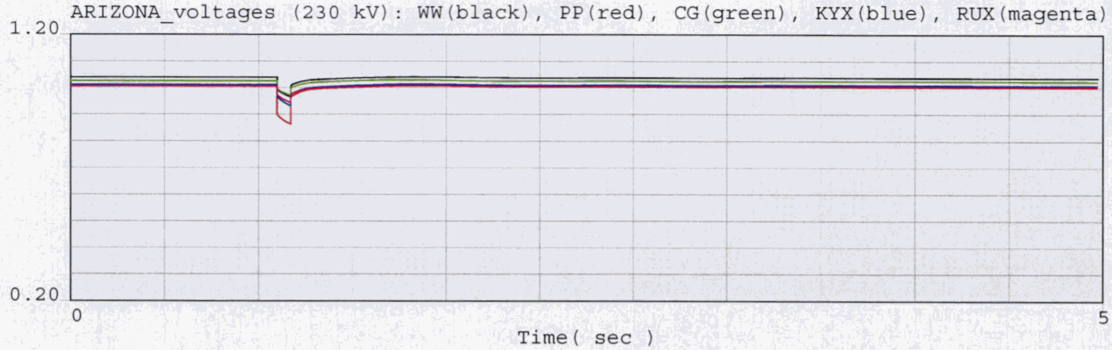
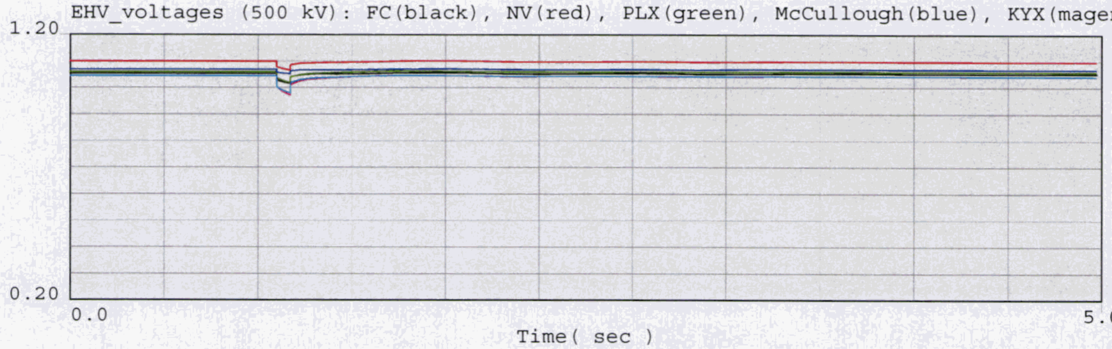
2011 Heavy Summer WECC Power Flow

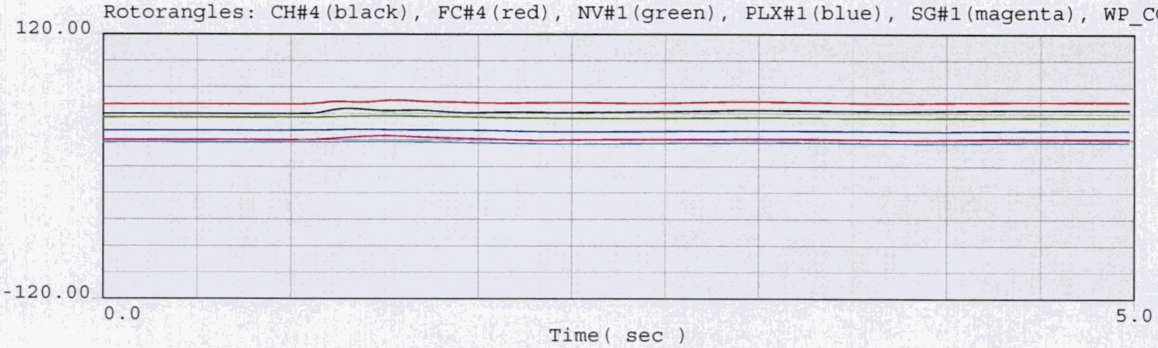
ARIZONA_voltages (230 kV): WW(black), PP(red), CG(green), KYX(blue), RUX(magenta)



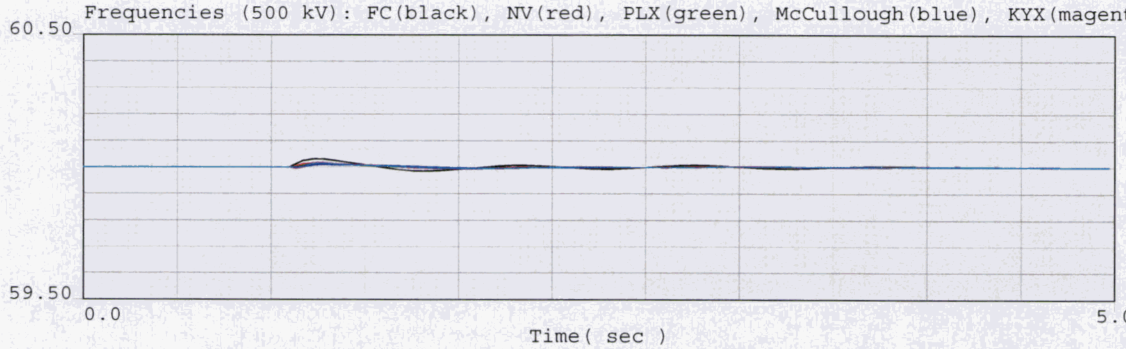
EHV_voltages (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



Rotorangles: CH#4(black), FC#4(red), NV#1(green), PLX#1(blue), SG#1(magenta), WP_CC1(cyan)



Frequencies (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



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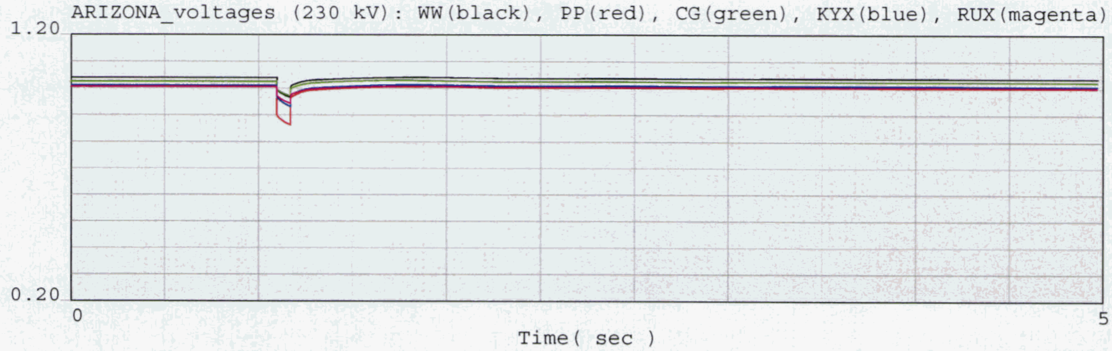
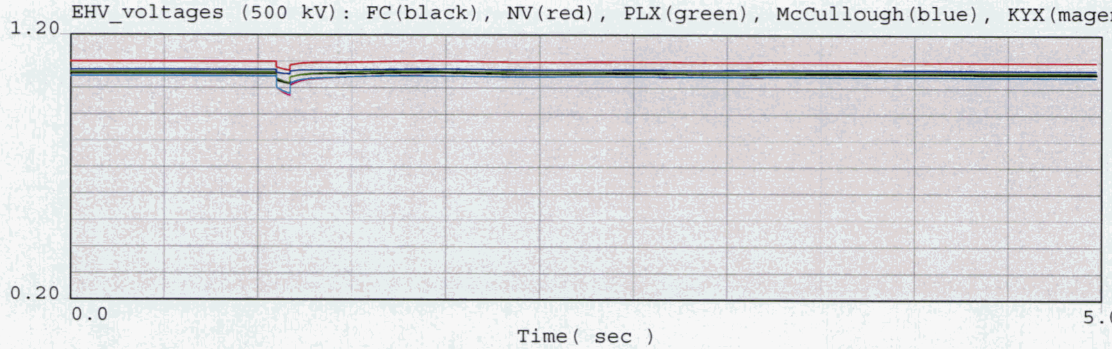
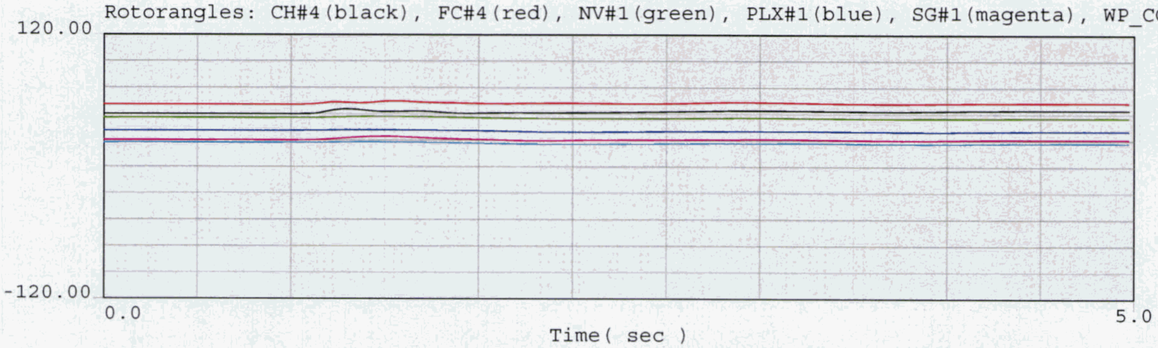
ARIZONA_voltages (230 kV): WW(black), PP(red), CG(green), KYX(blue), RUX(magenta)



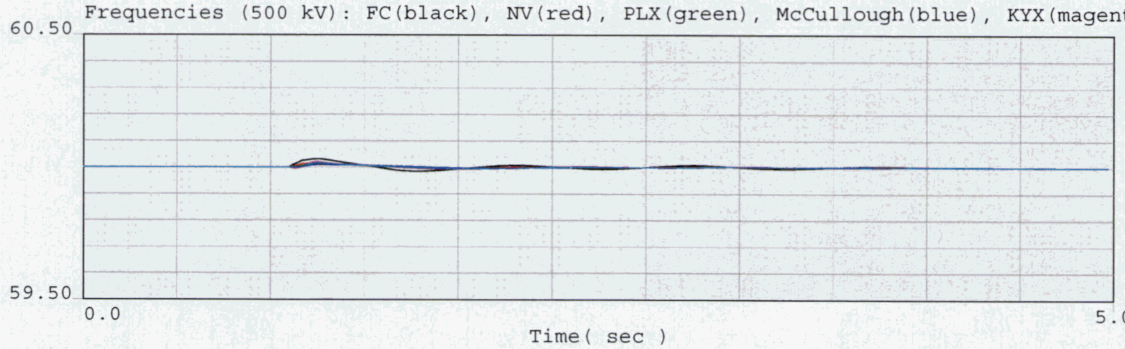
EHV_voltages (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



Rotorangles: CH#4(black), FC#4(red), NV#1(green), PLX#1(blue), SG#1(magenta), WP_CC1(cyan)



Frequencies (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



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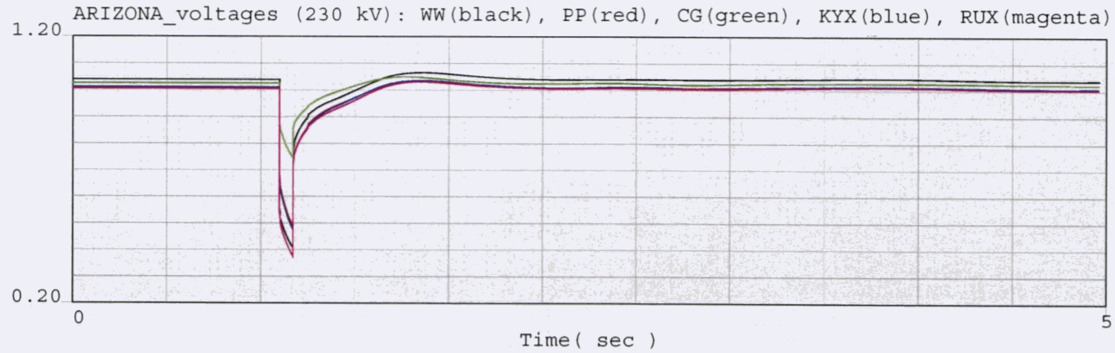

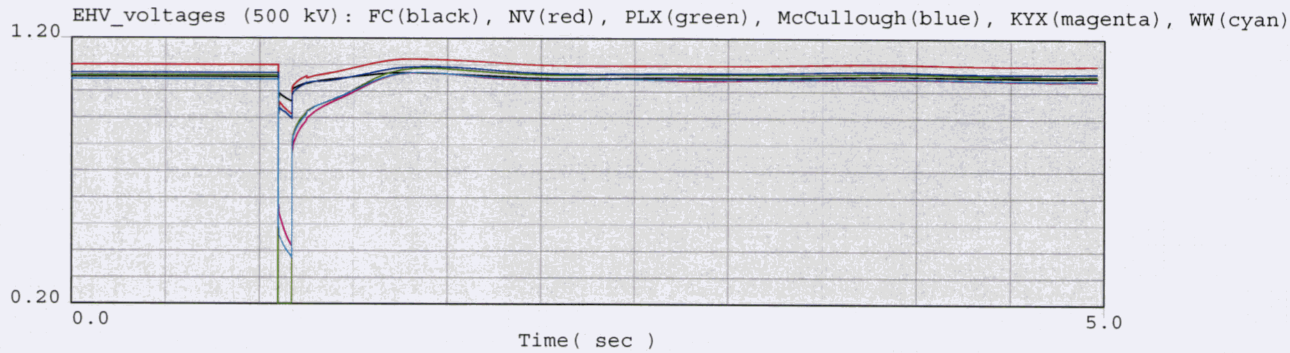

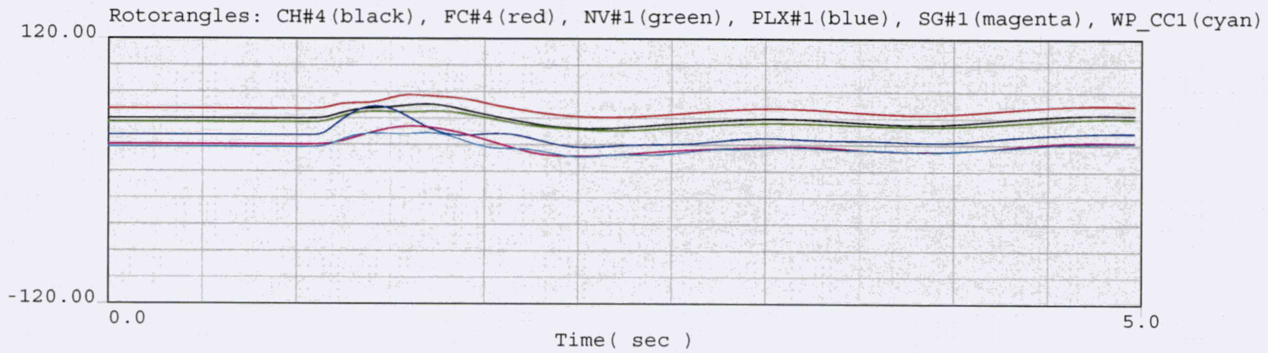

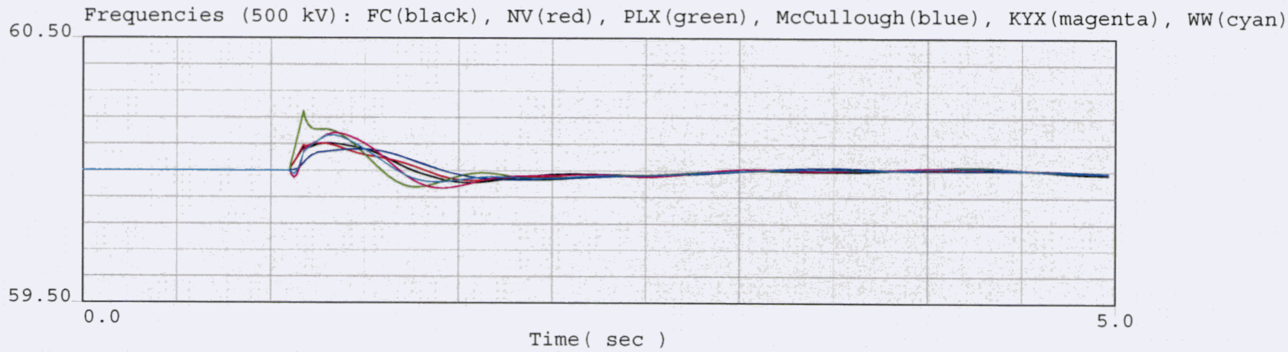

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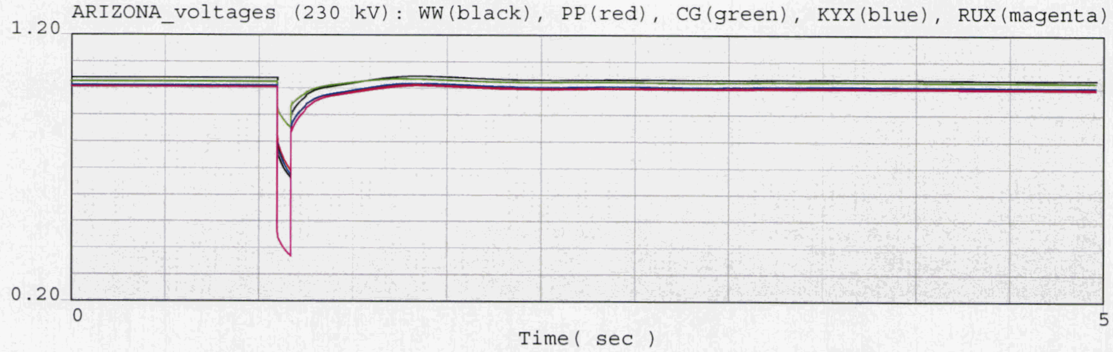
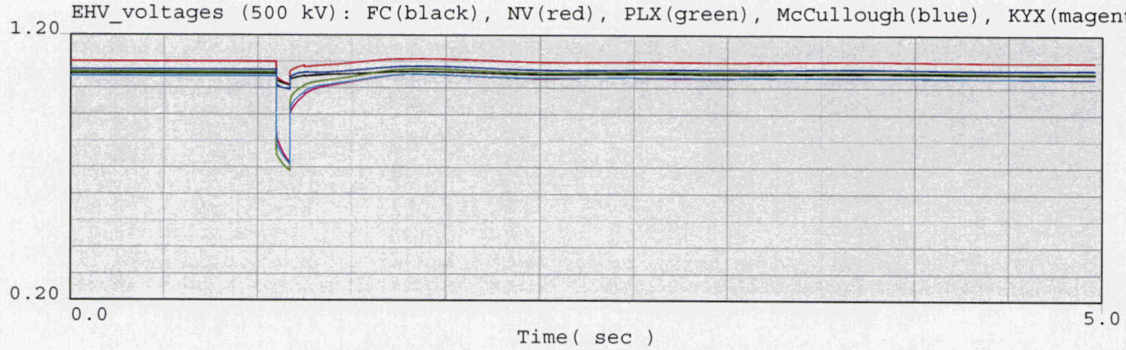
2011 Heavy Summer WECC Power Flow

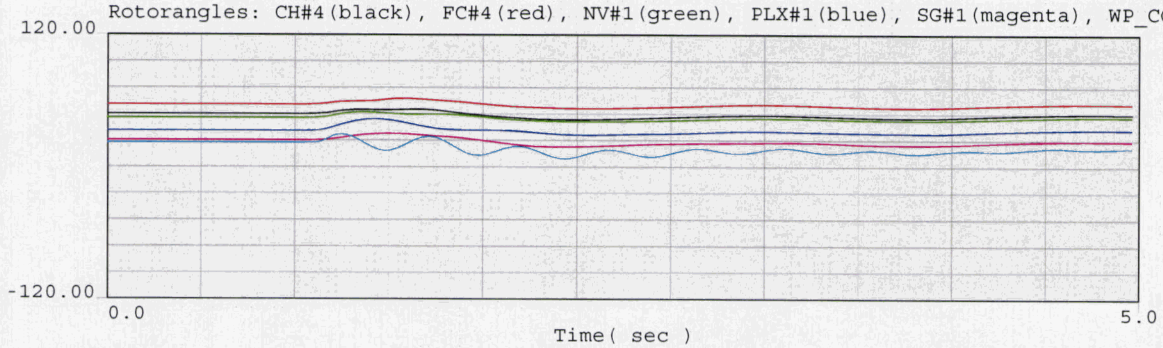
ARIZONA_voltages (230 kV): WW(black), PP(red), CG(green), KYX(blue), RUX(magenta)



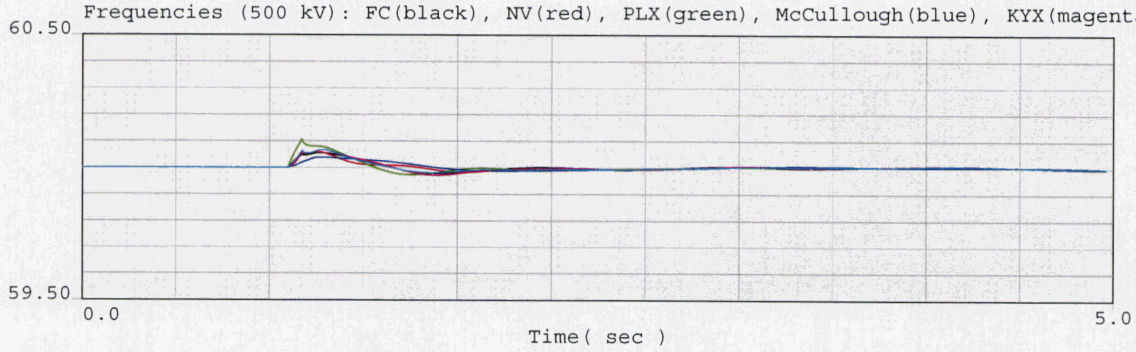
EHV_voltages (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



Rotorangles: CH#4(black), FC#4(red), NV#1(green), PLX#1(blue), SG#1(magenta), WP_CC1(cyan)



Frequencies (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



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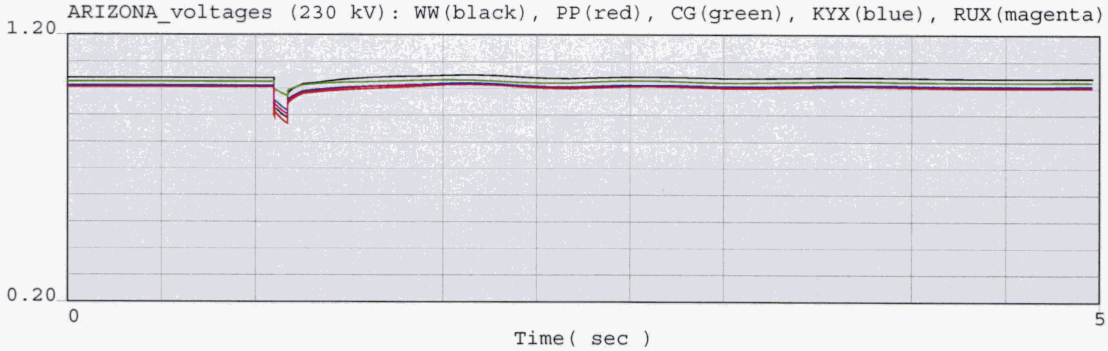
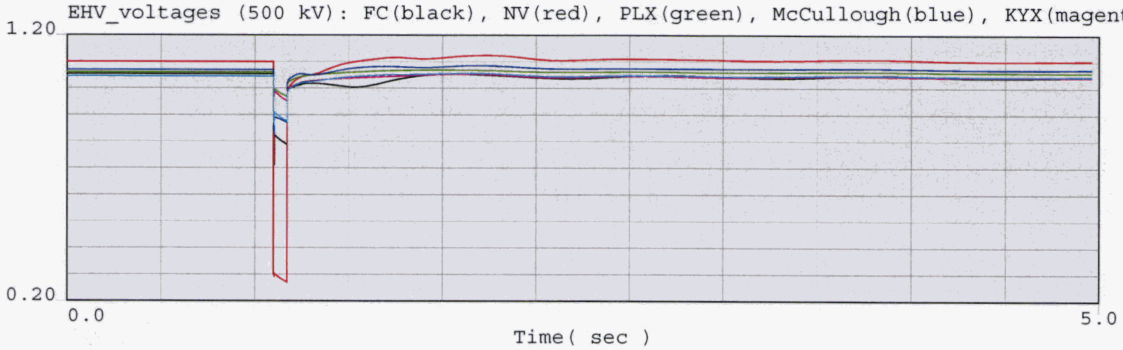
2011 Heavy Summer WECC Power Flow

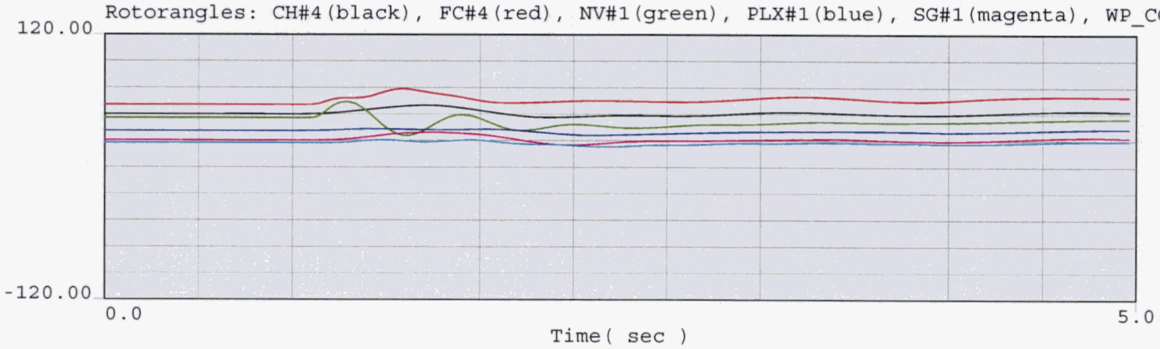
ARIZONA_voltages (230 kV): WW(black), PP(red), CG(green), KYX(blue), RUX(magenta)



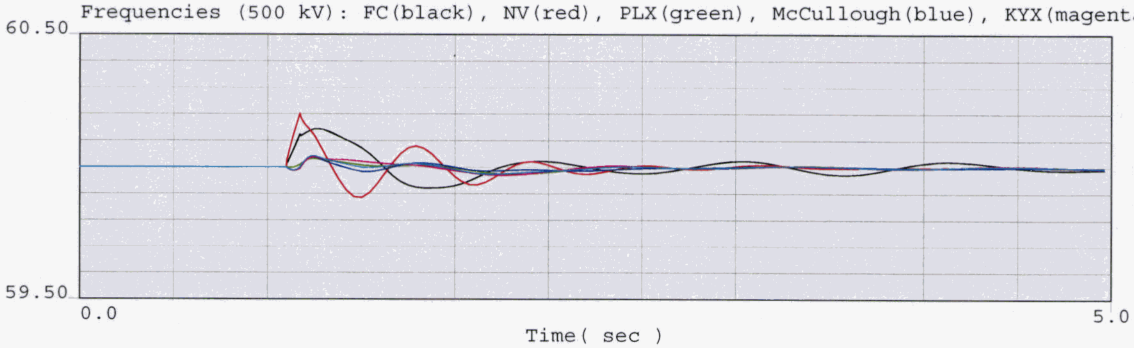
EHV_voltages (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



Rotorangles: CH#4(black), FC#4(red), NV#1(green), PLX#1(blue), SG#1(magenta), WP_CC1(cyan)



Frequencies (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



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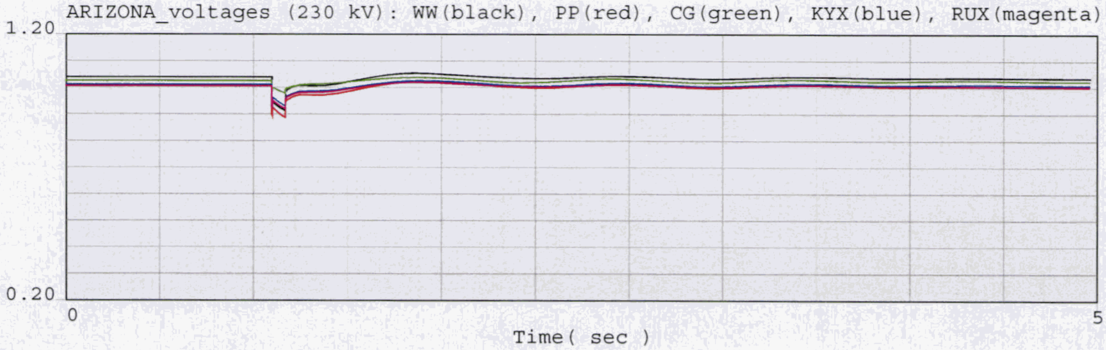
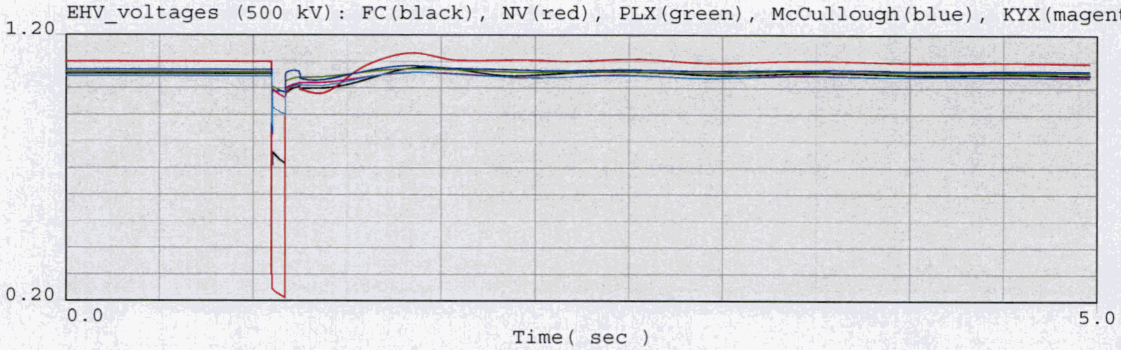
2011 Heavy Summer WECC Power Flow

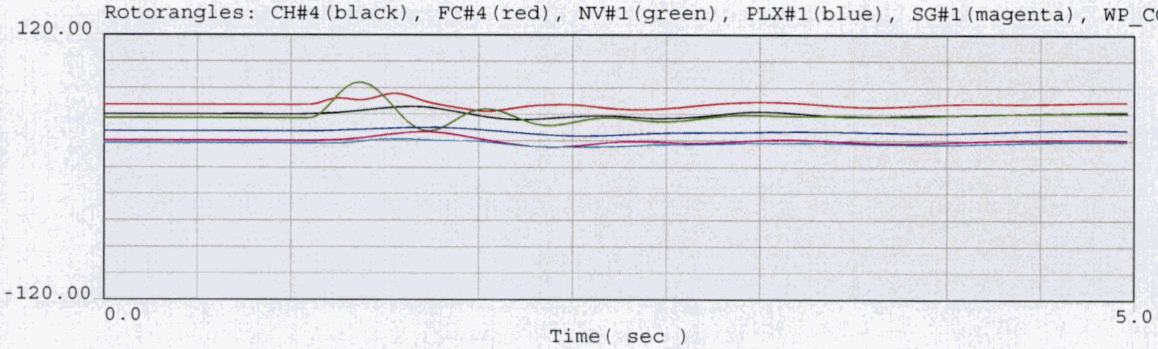
ARIZONA_voltages (230 kV): WW(black), PP(red), CG(green), KYX(blue), RUX(magenta)



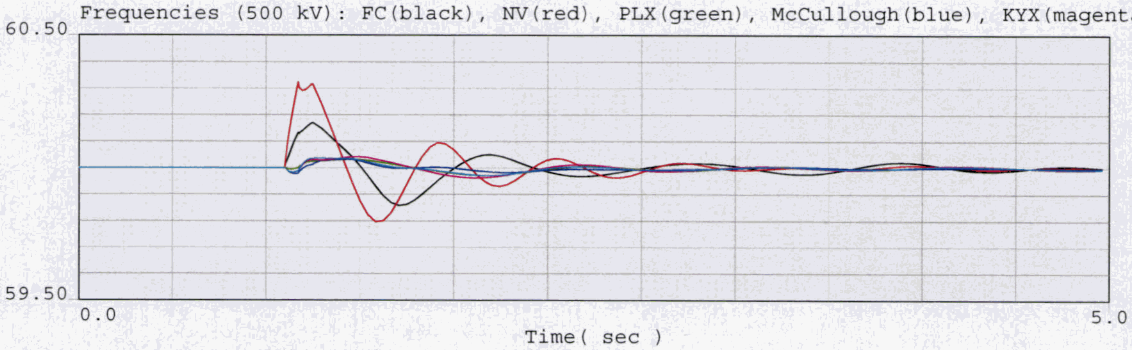
EHV_voltages (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



Rotorangles: CH#4(black), FC#4(red), NV#1(green), PLX#1(blue), SG#1(magenta), WP_CC1(cyan)



Frequencies (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



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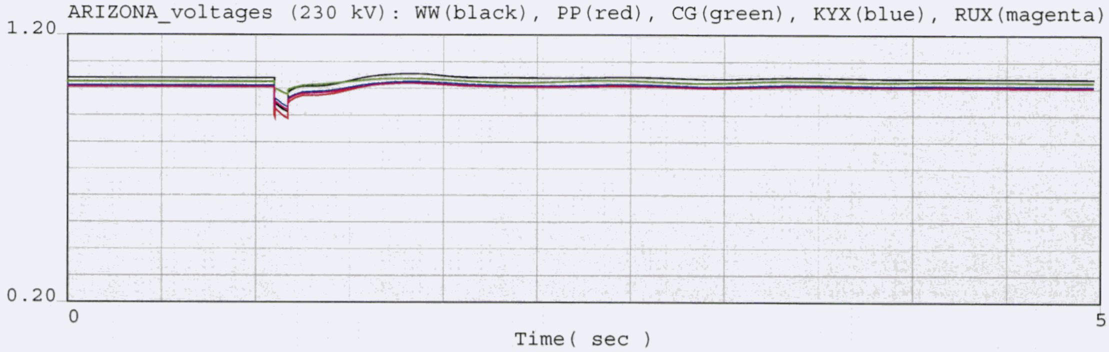
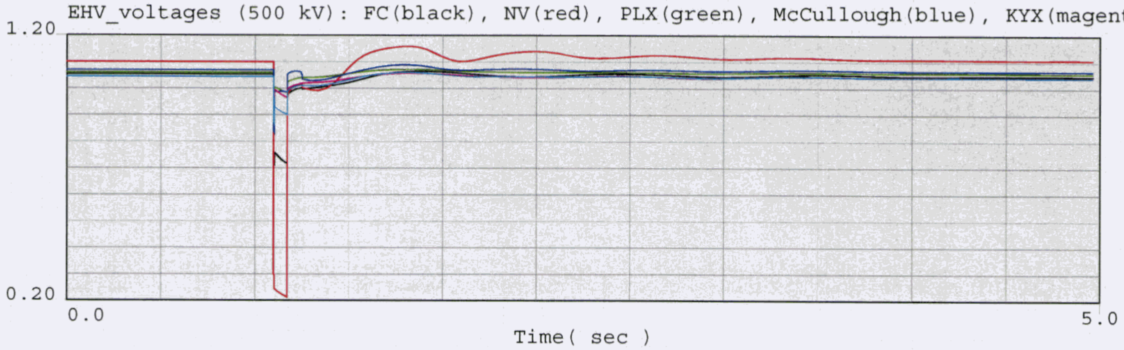
2011 Heavy Summer WECC Power Flow

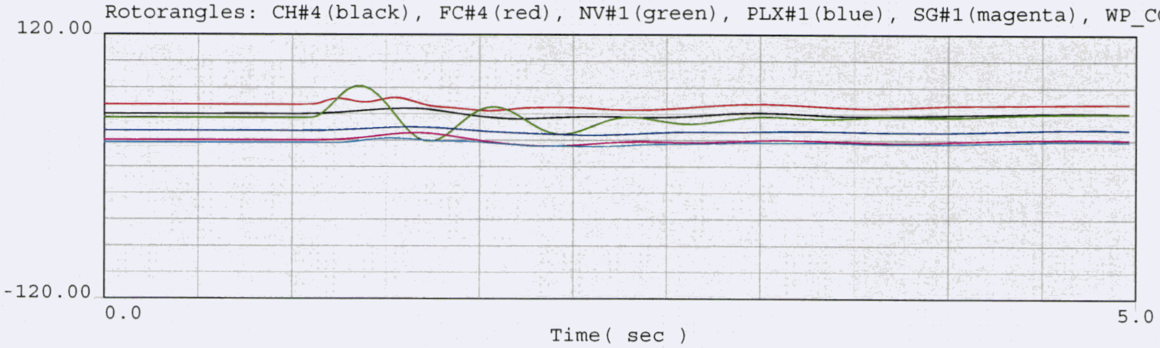
ARIZONA_voltages (230 kV): WW(black), PP(red), CG(green), KYX(blue), RUX(magenta)



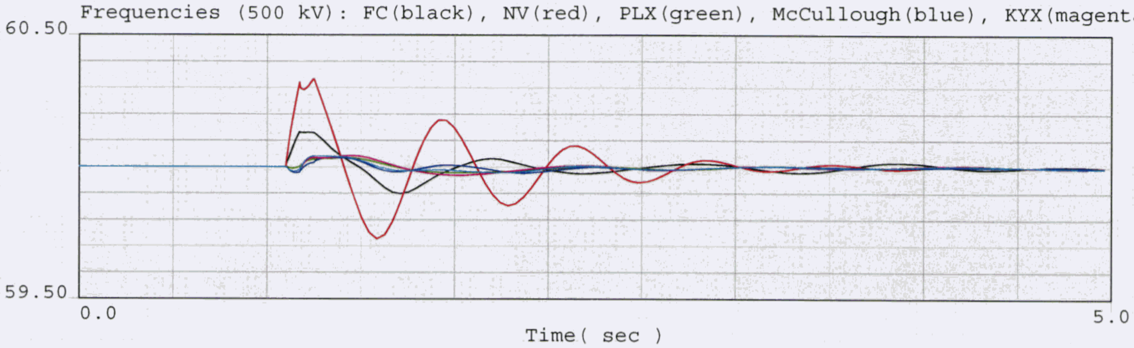
EHV_voltages (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



Rotorangles: CH#4(black), FC#4(red), NV#1(green), PLX#1(blue), SG#1(magenta), WP_CC1(cyan)



Frequencies (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



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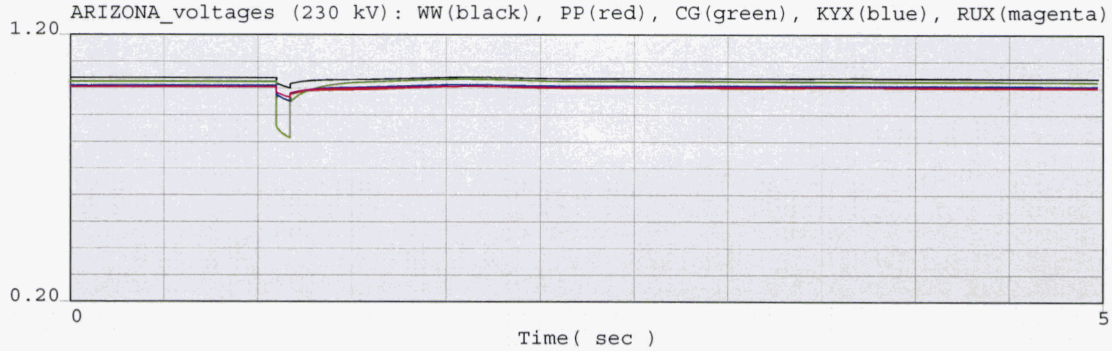
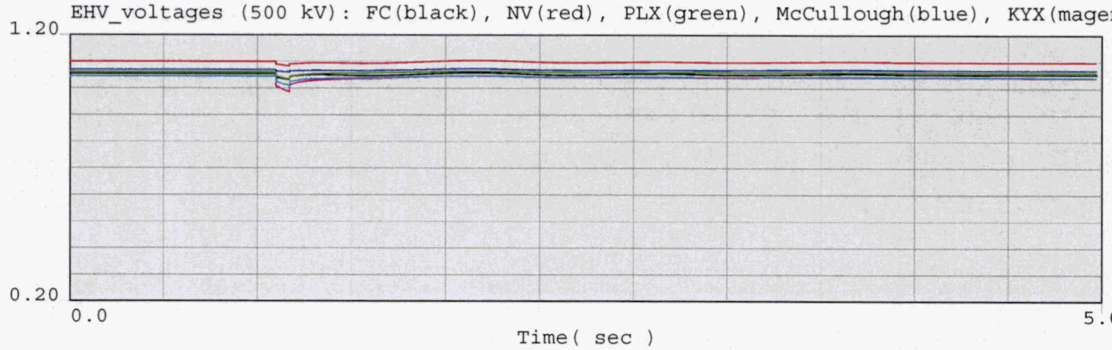
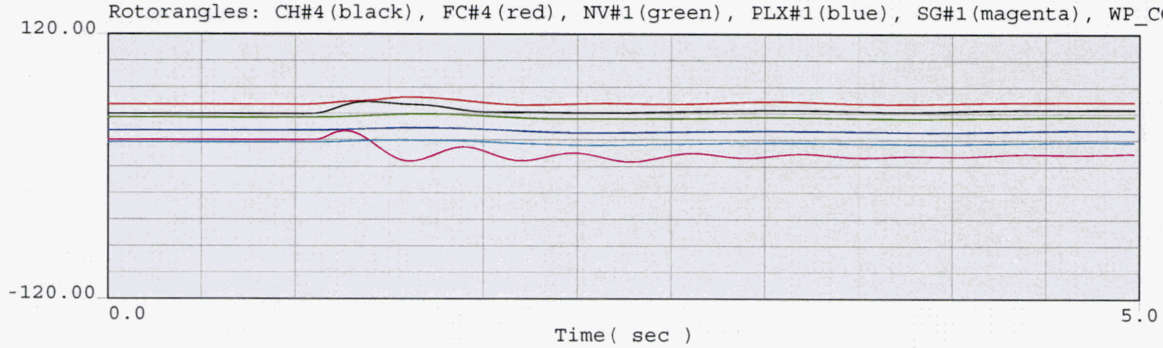
ARIZONA_voltages (230 kV): WW(black), PP(red), CG(green), KYX(blue), RUX(magenta)



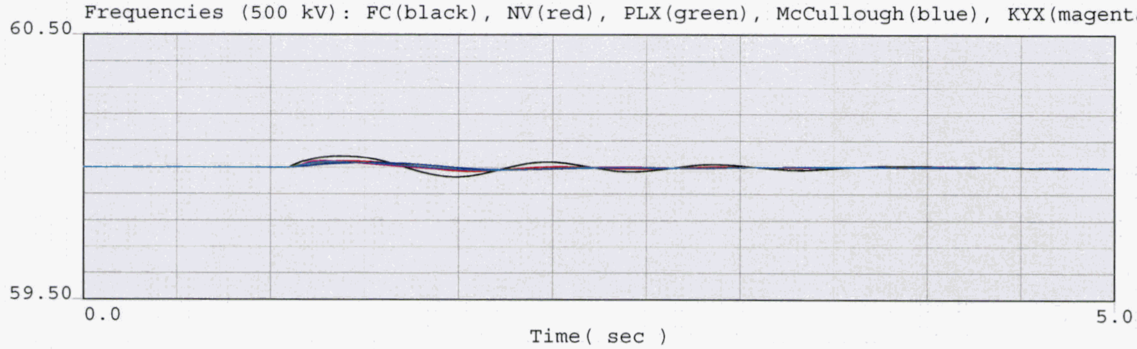
EHV_voltages (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



Rotorangles: CH#4(black), FC#4(red), NV#1(green), PLX#1(blue), SG#1(magenta), WP_CC1(cyan)



Frequencies (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



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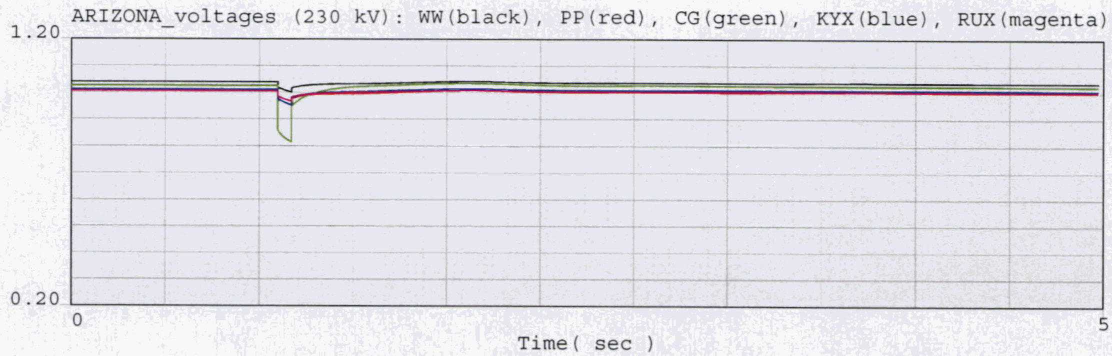

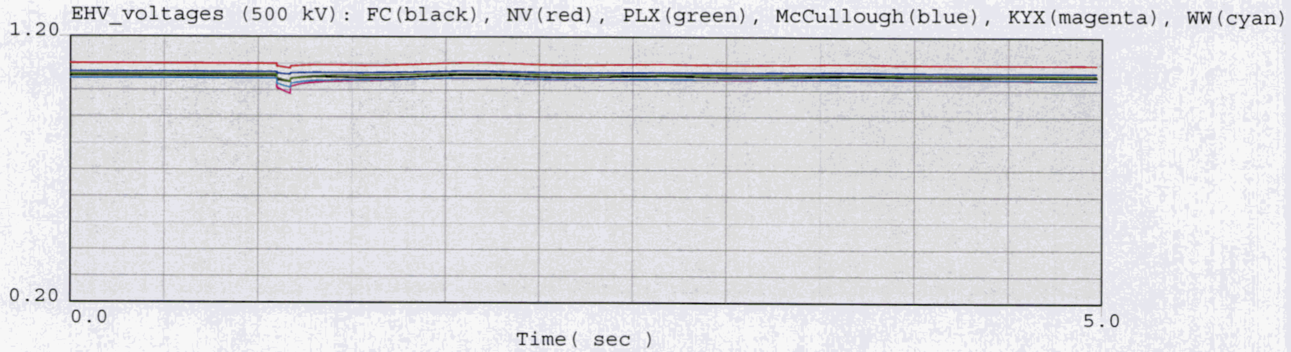

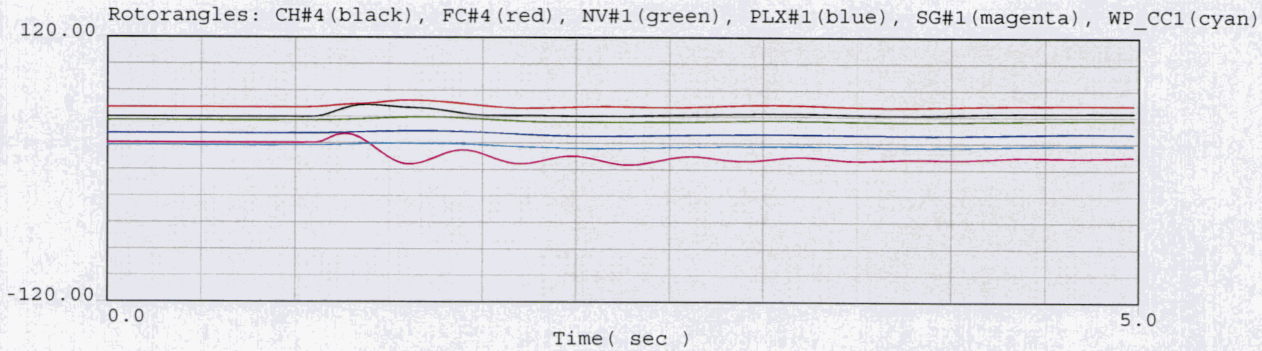

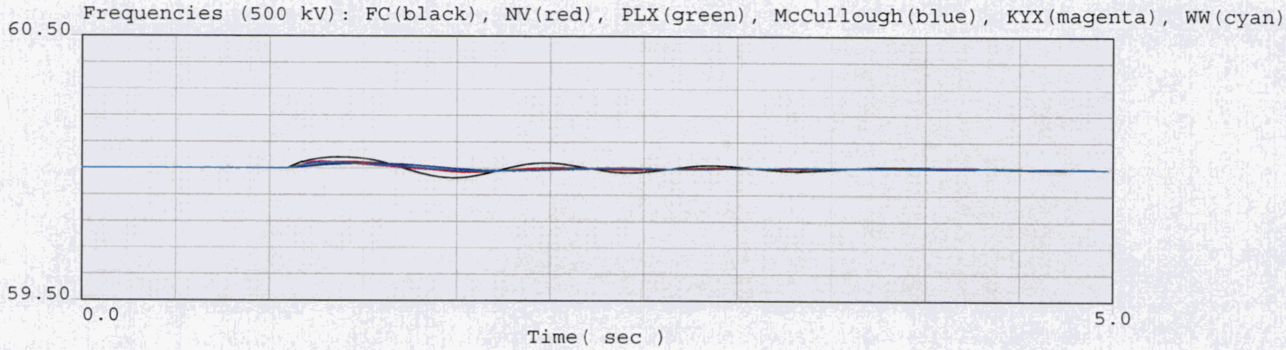

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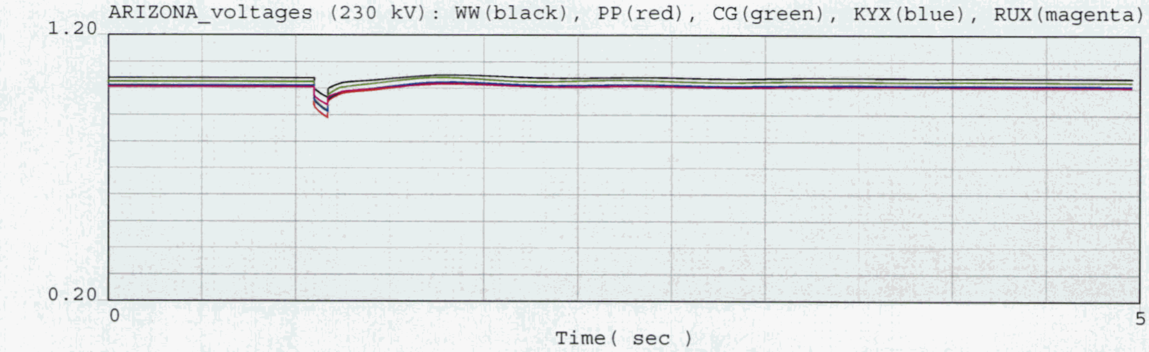

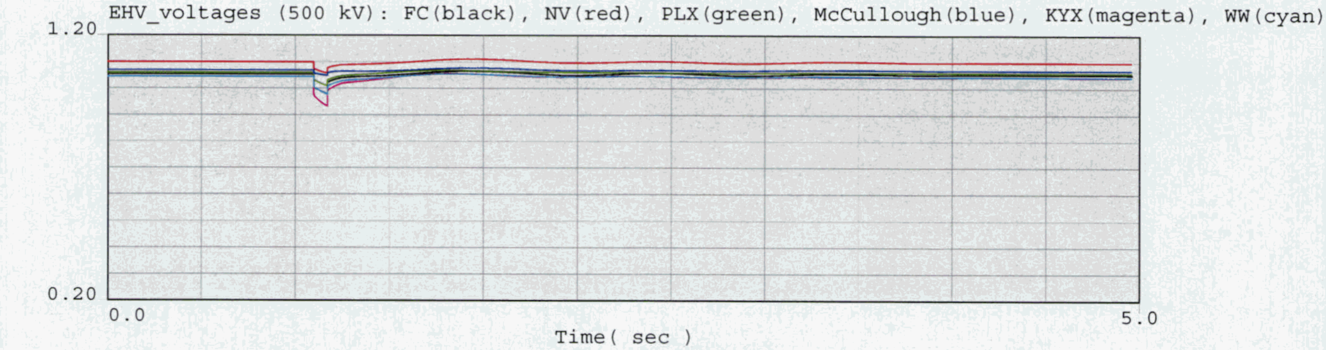

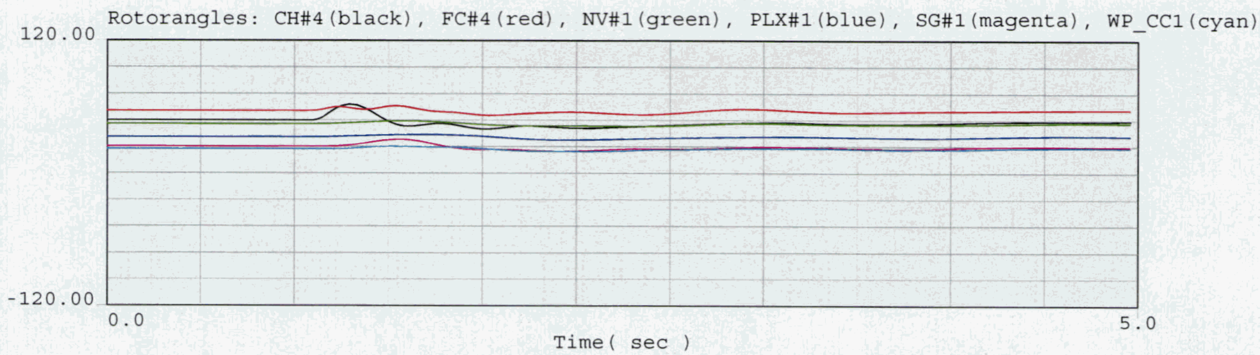

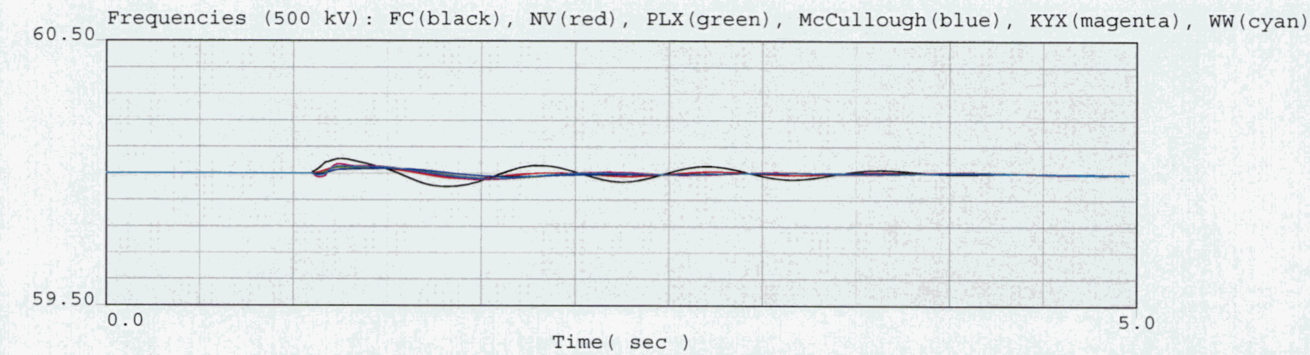

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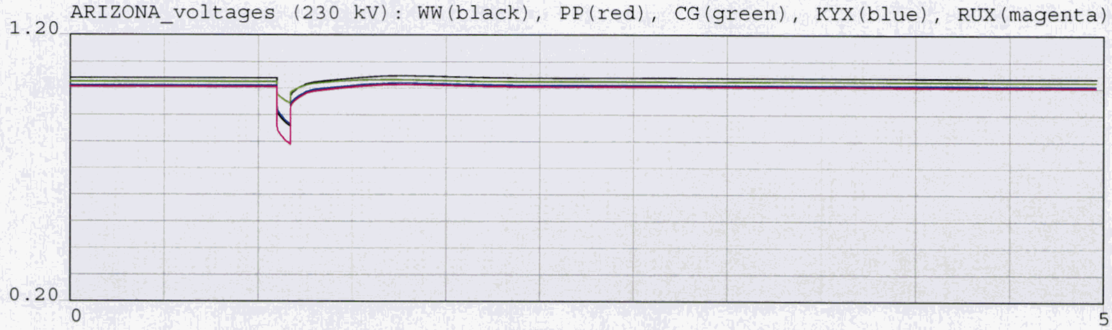

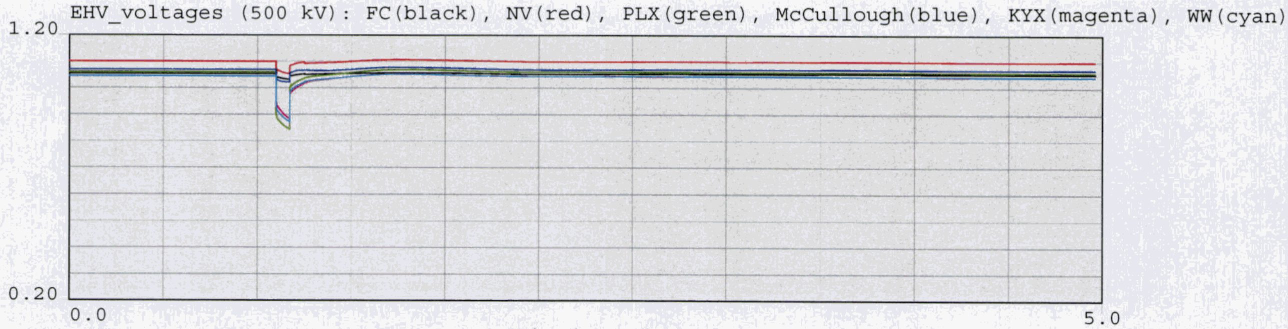

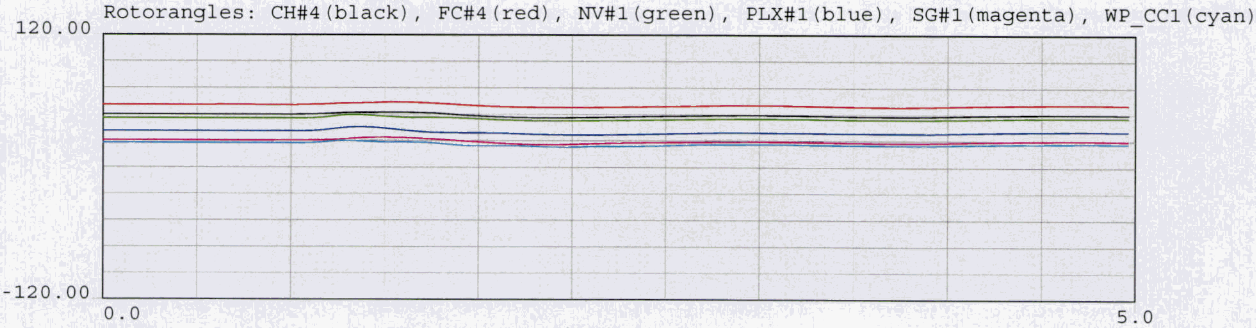

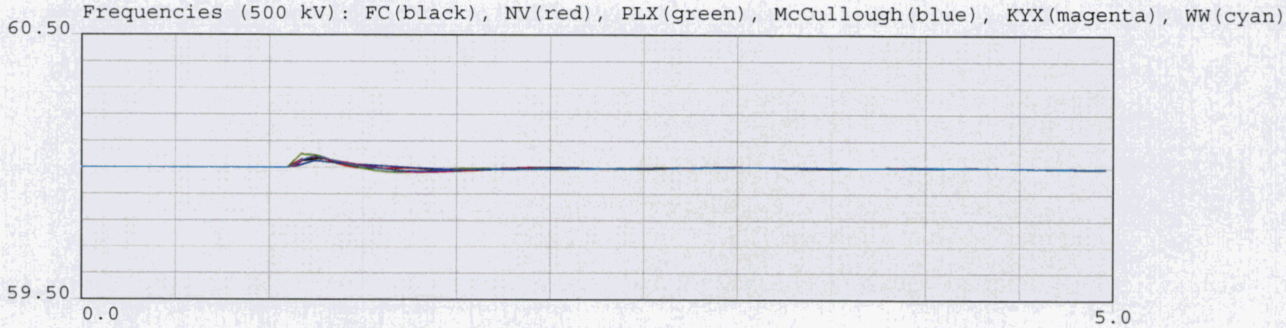

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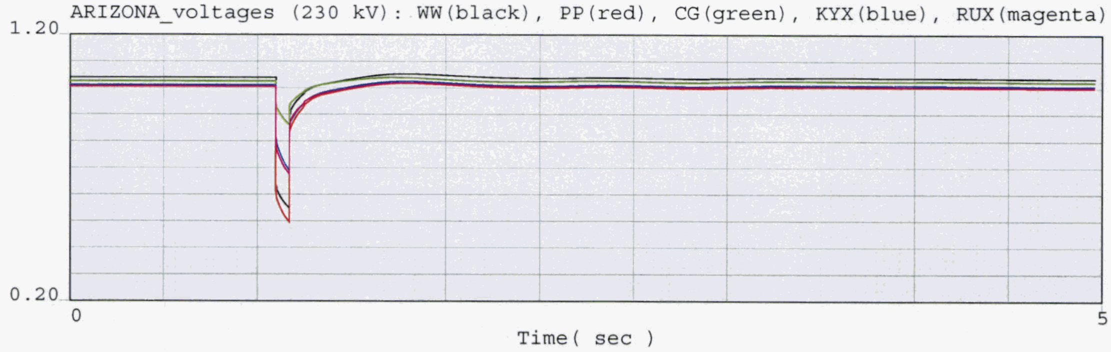
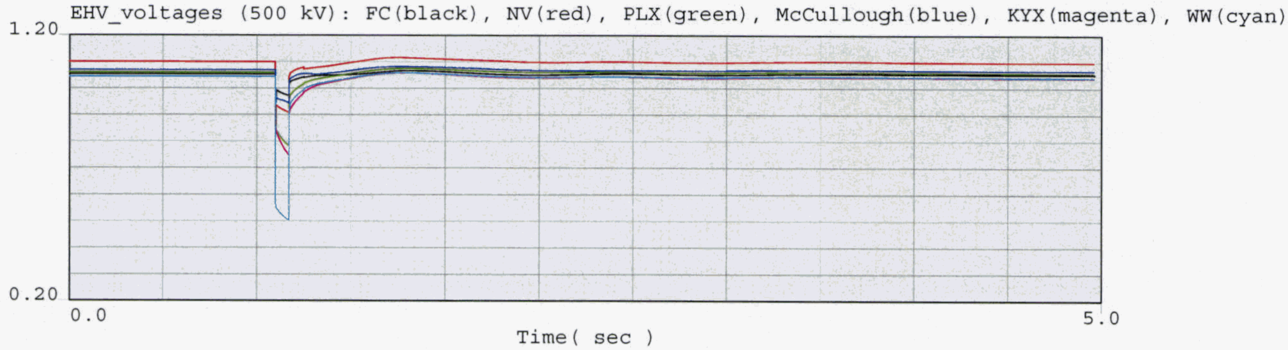
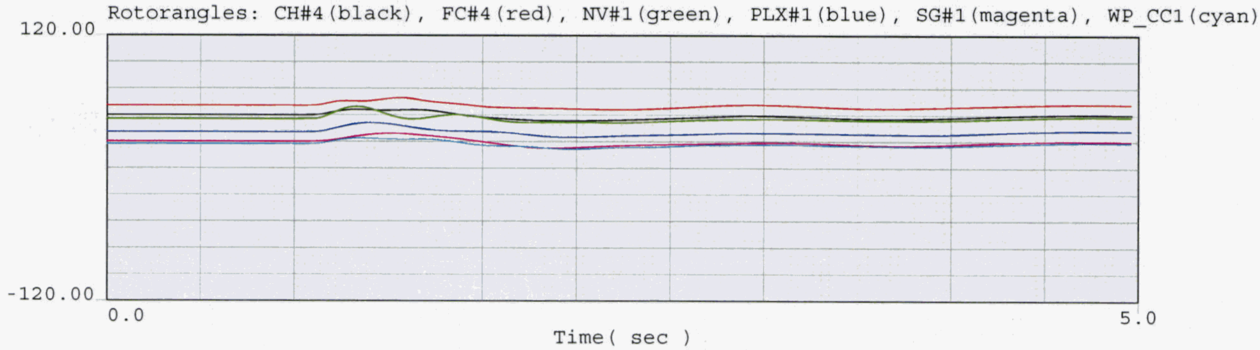
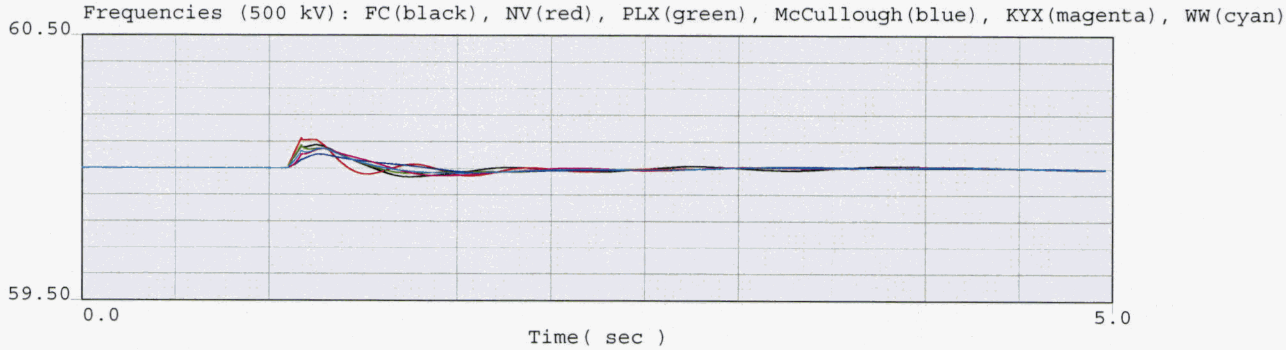
2011 Heavy Summer WECC Power Flow









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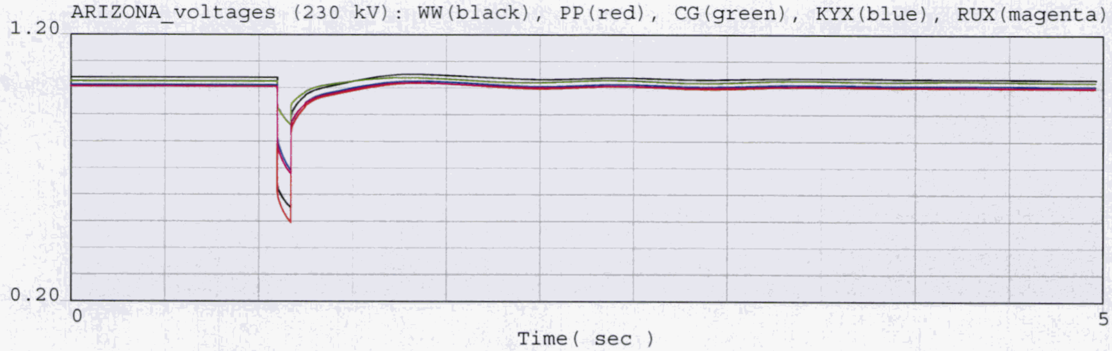
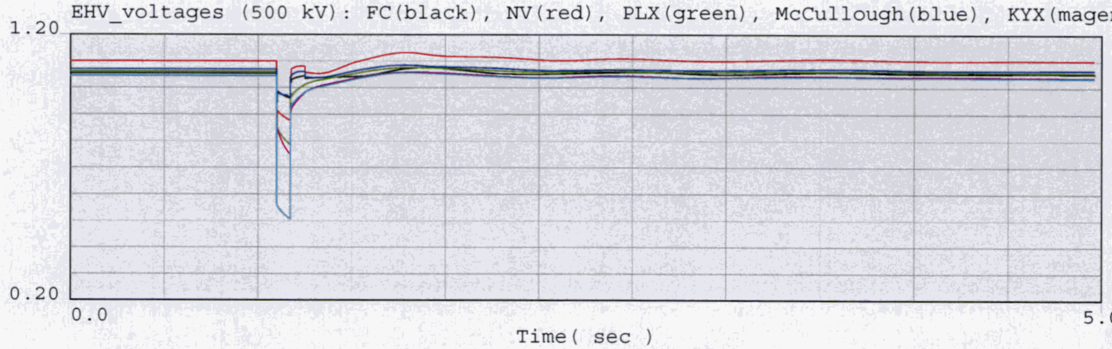
2011 Heavy Summer WECC Power Flow

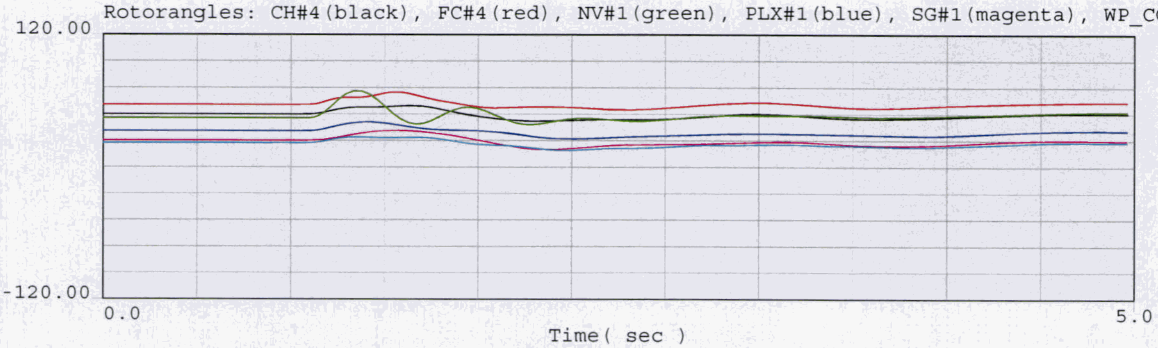
ARIZONA_voltages (230 kV): WW(black), PP(red), CG(green), KYX(blue), RUX(magenta)



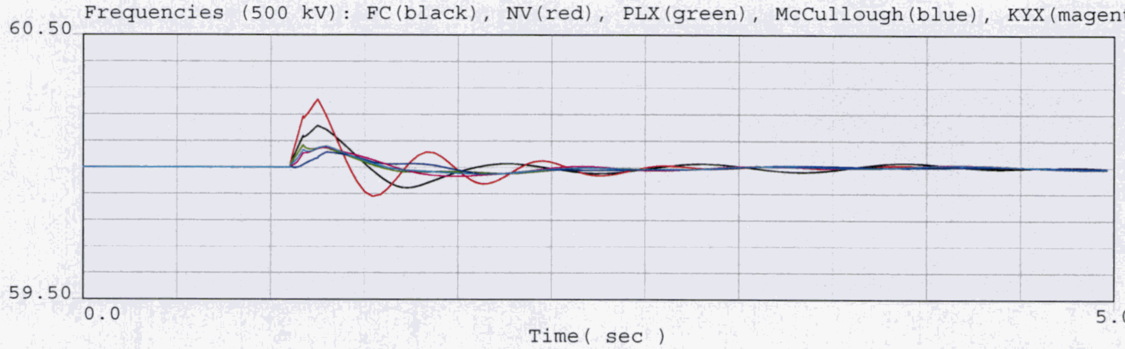
EHV_voltages (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



Rotorangles: CH#4(black), FC#4(red), NV#1(green), PLX#1(blue), SG#1(magenta), WP_CC1(cyan)



Frequencies (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



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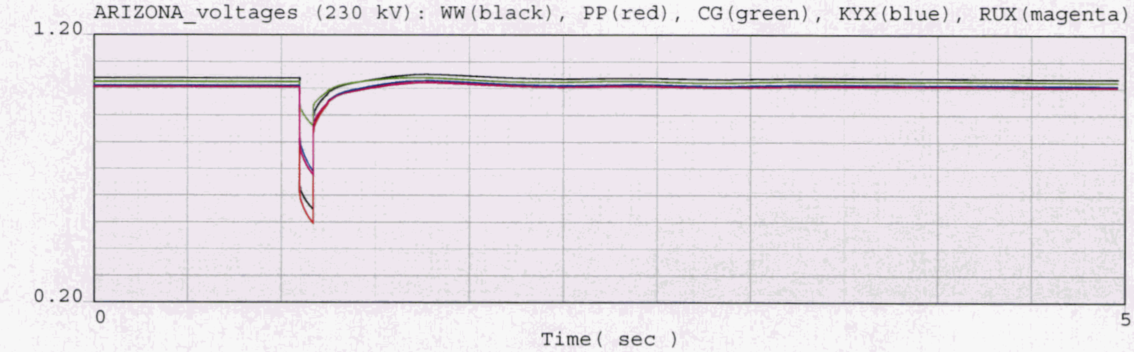
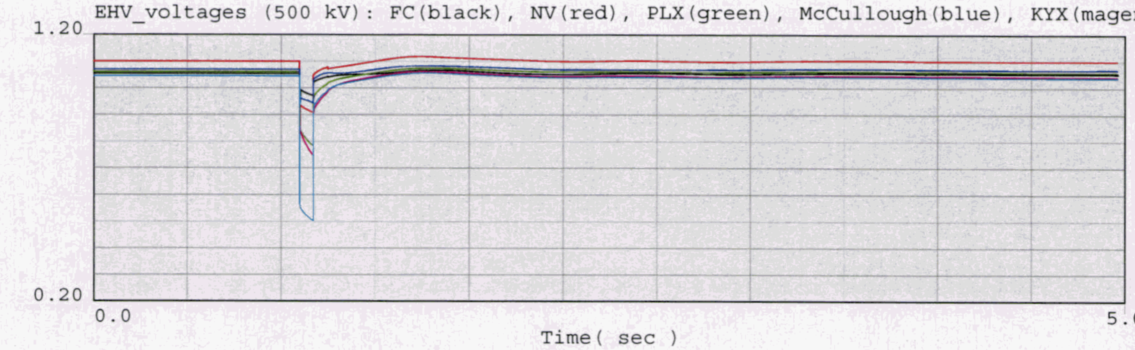
2011 Heavy Summer WECC Power Flow

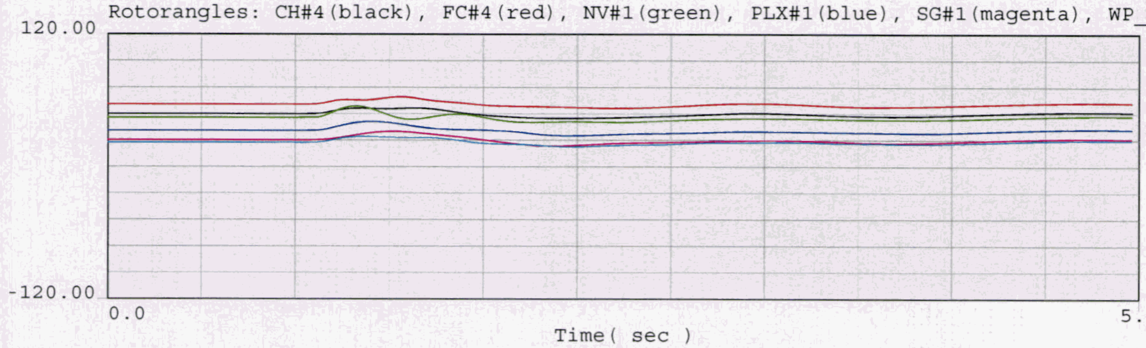
ARIZONA_voltages (230 kV): WW(black), PP(red), CG(green), KYX(blue), RUX(magenta)



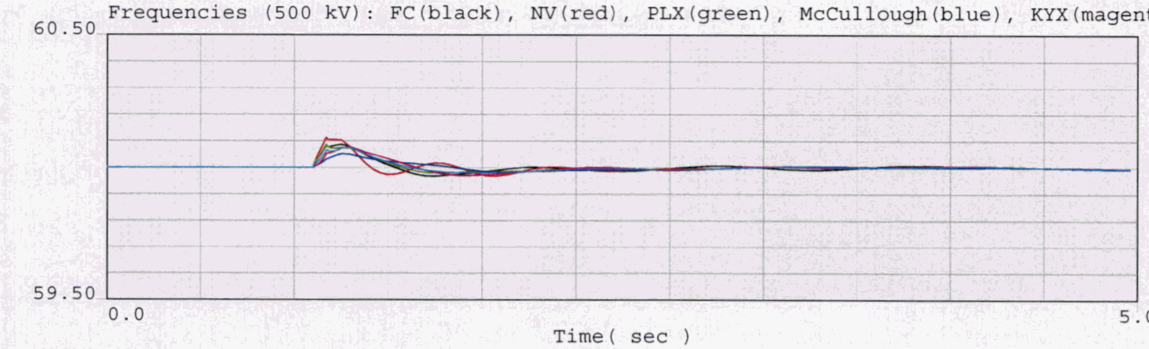
EHV_voltages (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



Rotorangles: CH#4(black), FC#4(red), NV#1(green), PLX#1(blue), SG#1(magenta), WP_CC1(cyan)



Frequencies (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



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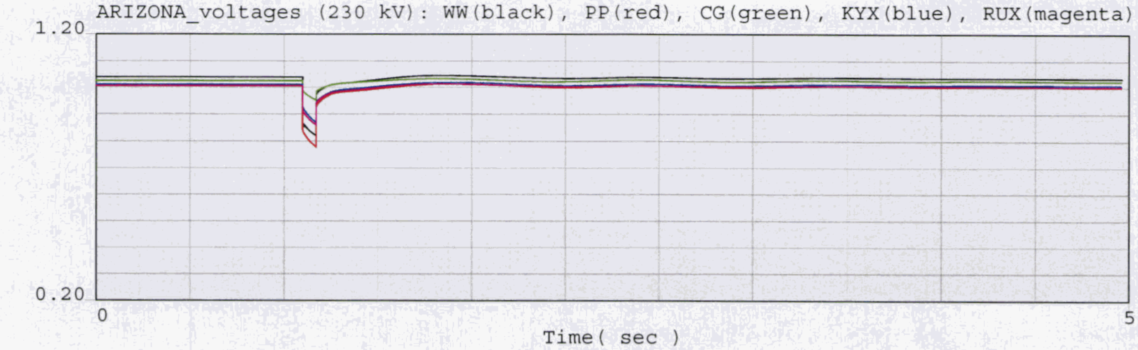
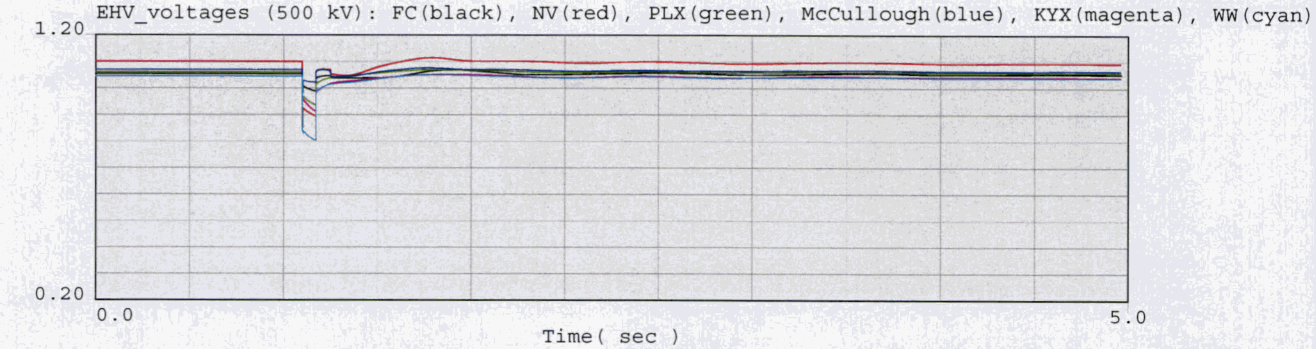
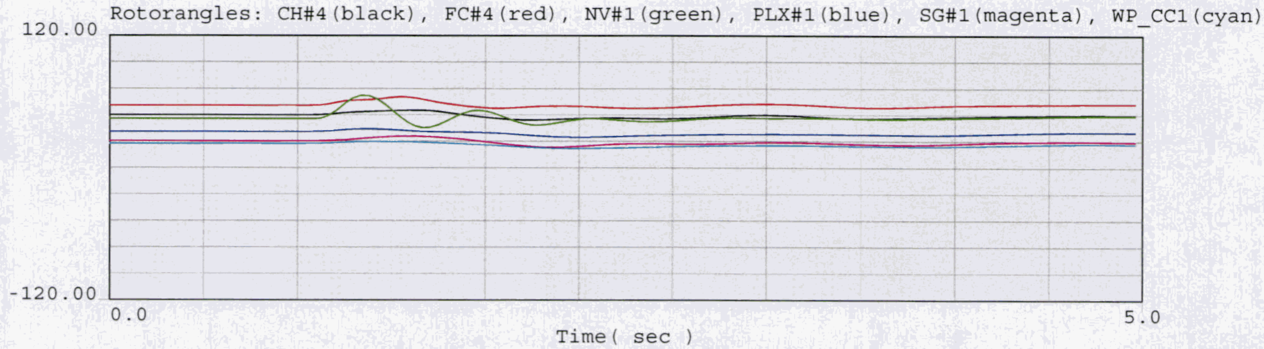
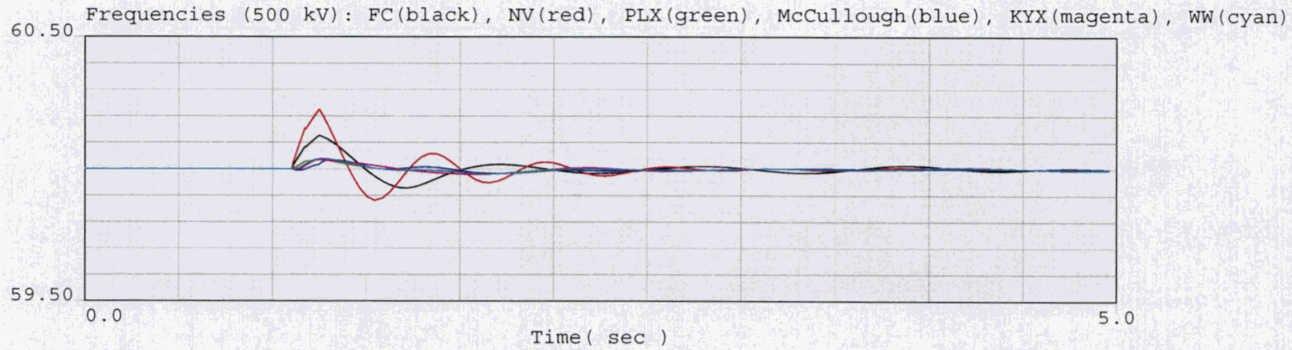
2011 Heavy Summer WECC Power Flow









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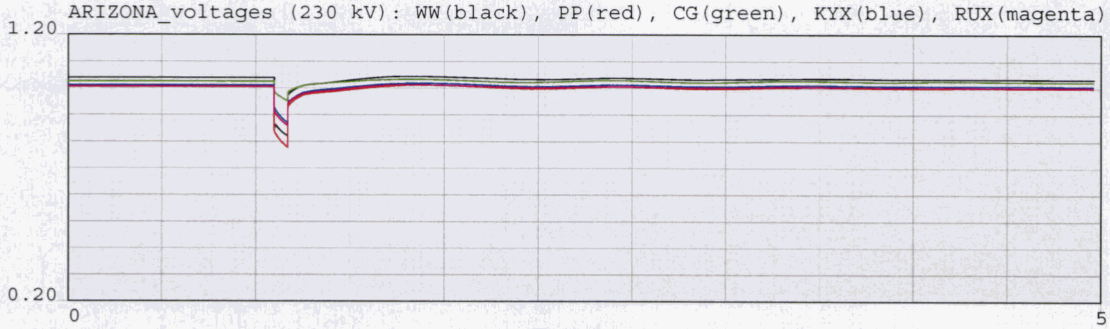

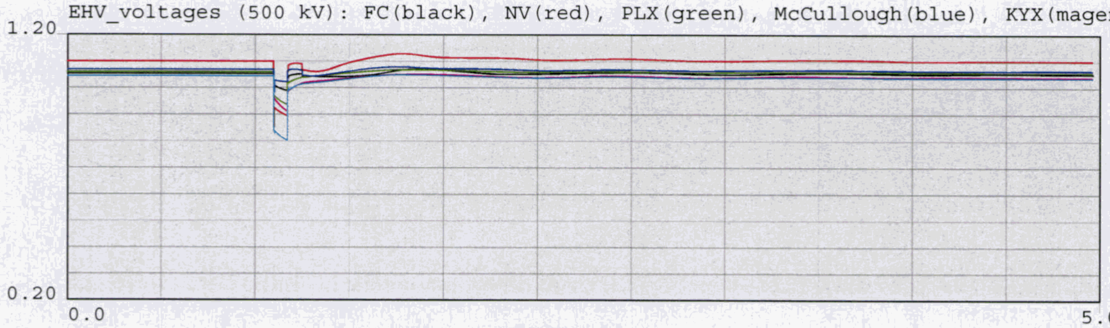

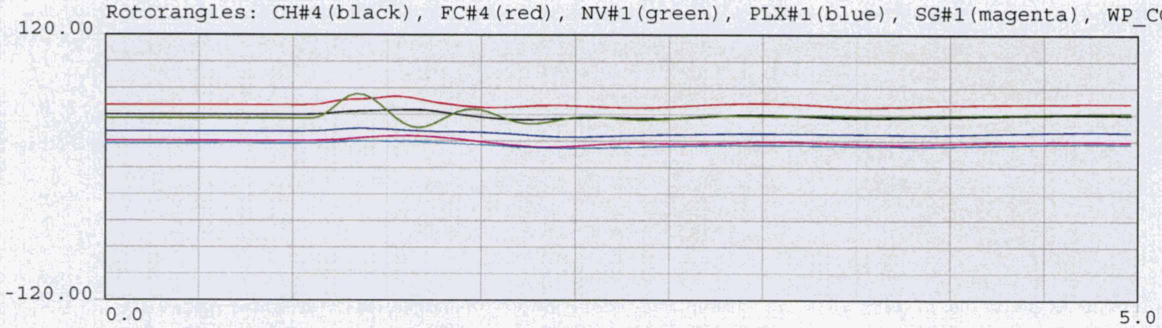

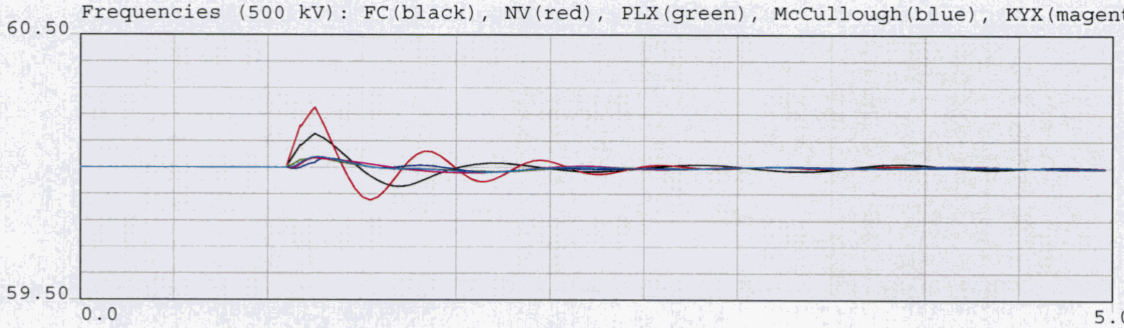

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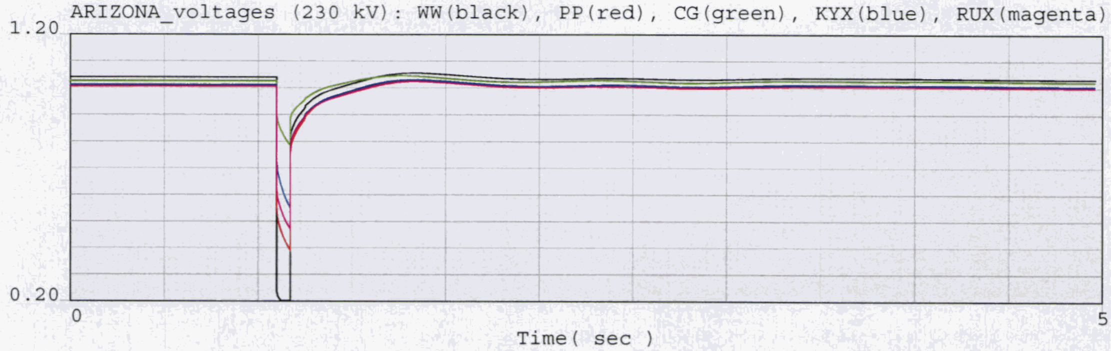
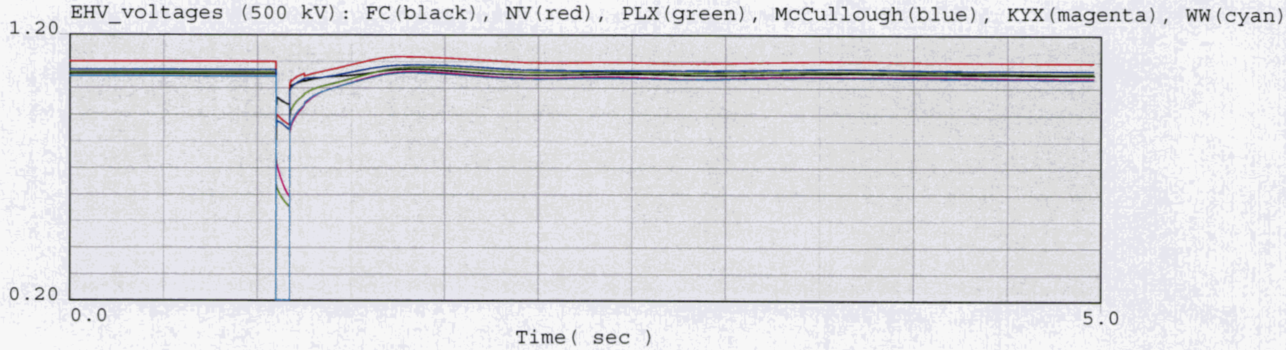
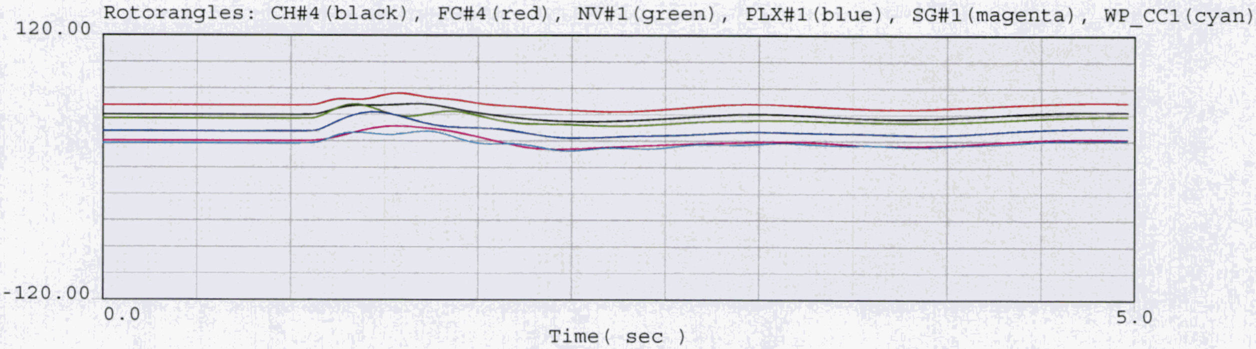
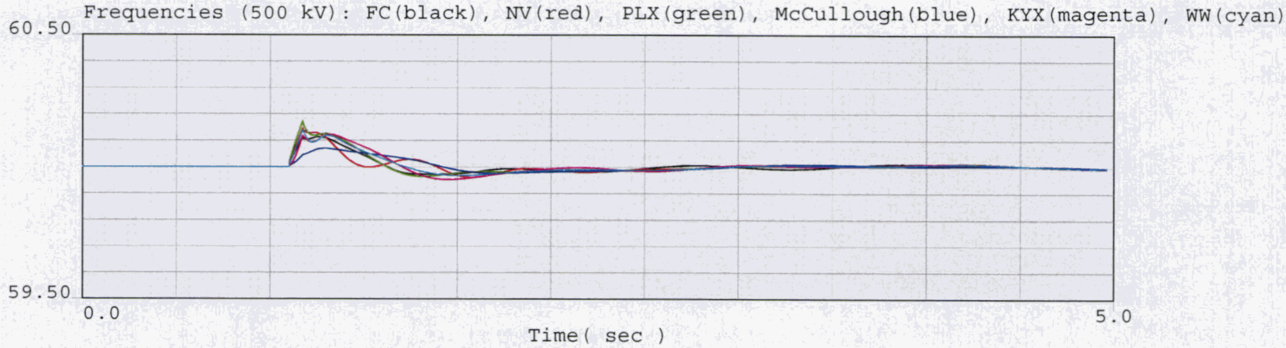
2011 Heavy Summer WECC Power Flow









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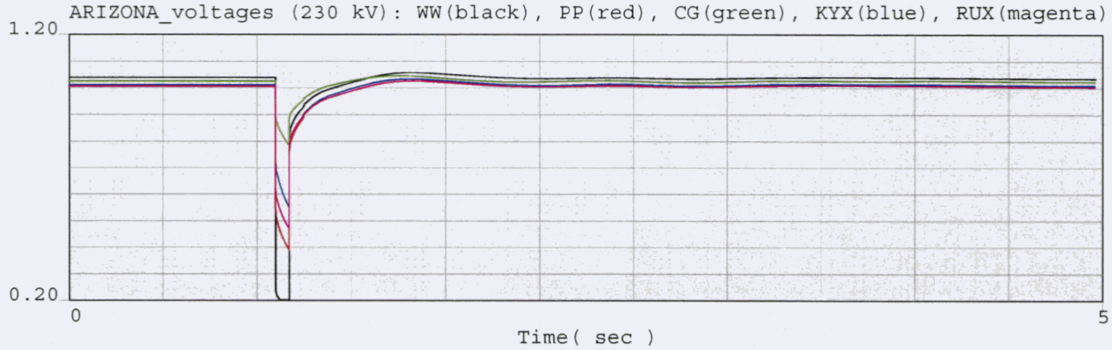
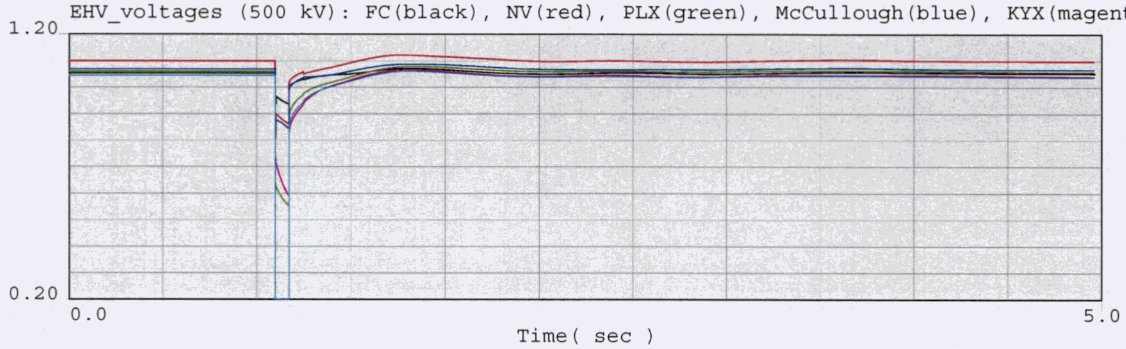
2011 Heavy Summer WECC Power Flow

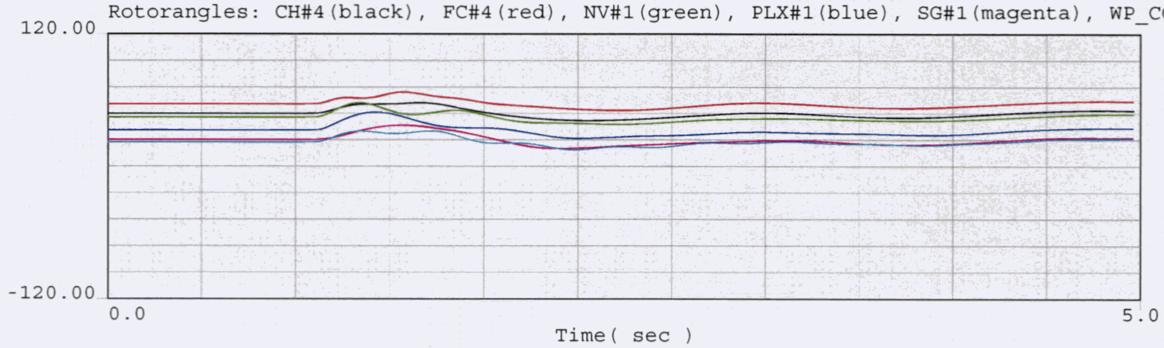
ARIZONA_voltages (230 kV): WW(black), PP(red), CG(green), KYX(blue), RUX(magenta)



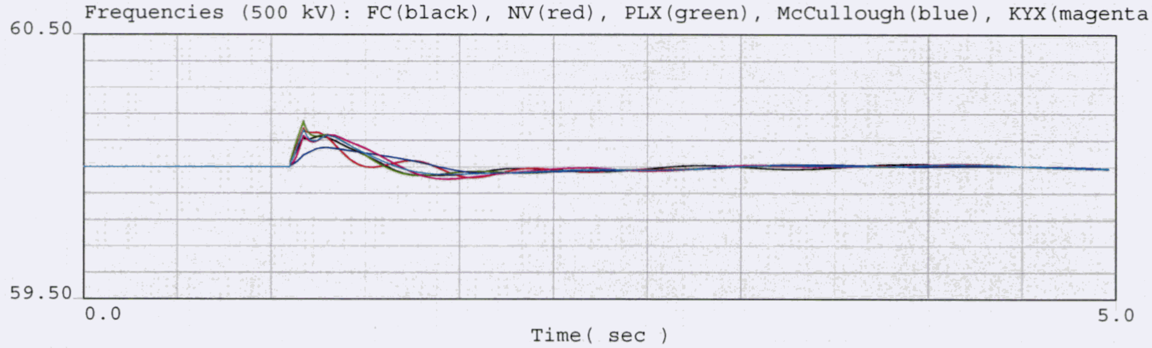
EHV_voltages (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



Rotorangles: CH#4(black), FC#4(red), NV#1(green), PLX#1(blue), SG#1(magenta), WP_CC1(cyan)



Frequencies (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



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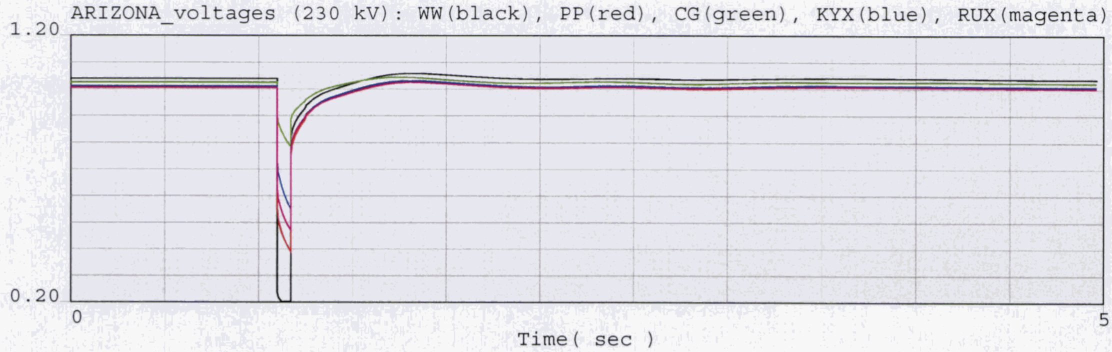
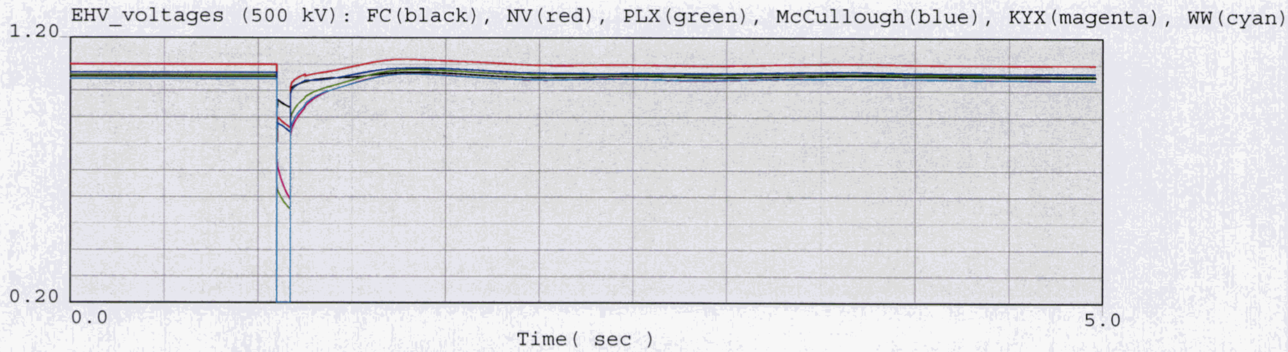
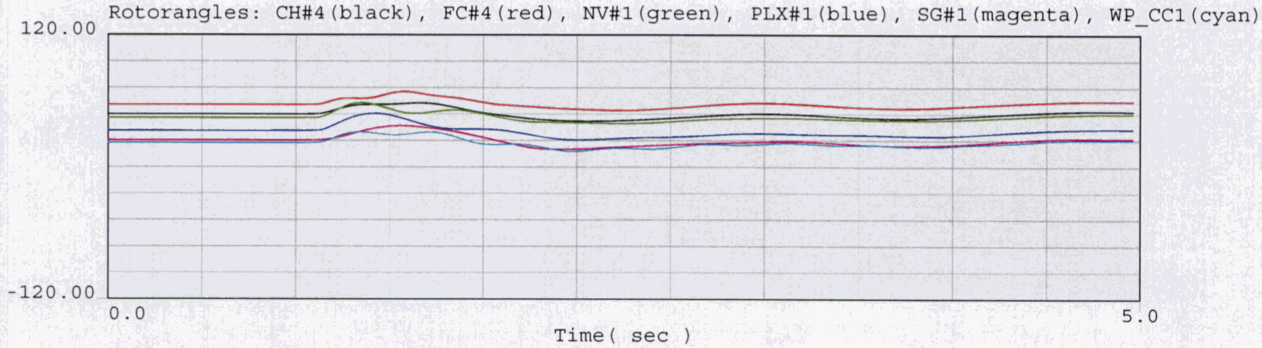
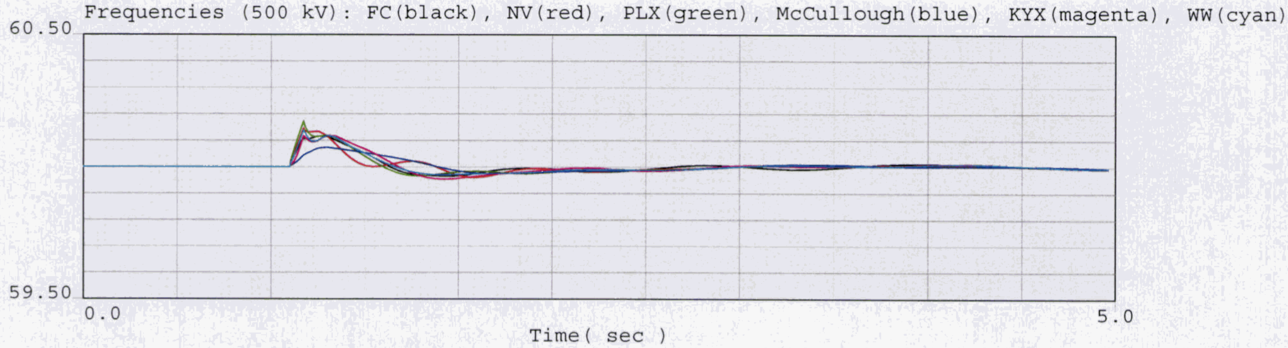
2011 Heavy Summer WECC Power Flow









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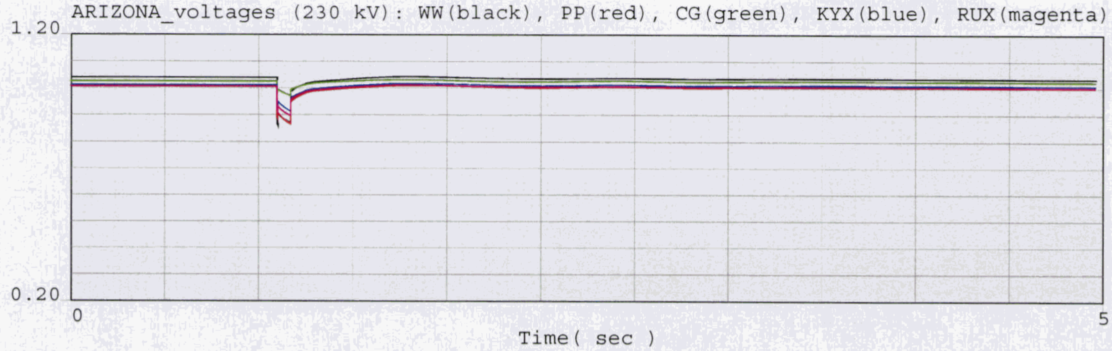
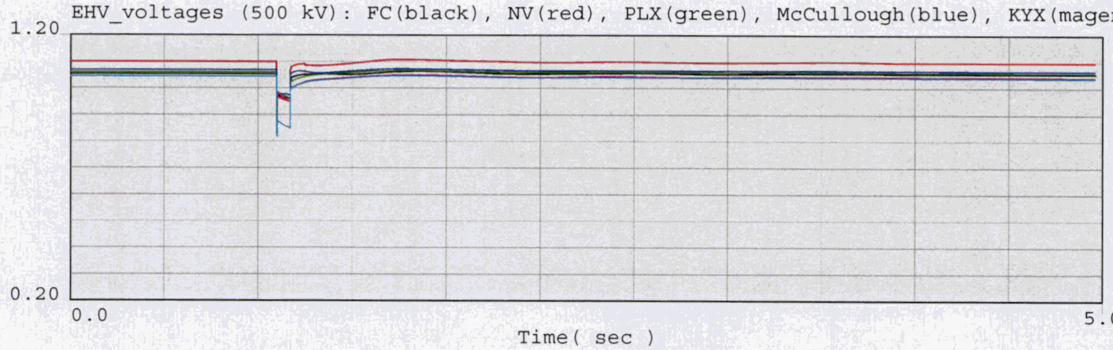
2011 Heavy Summer WECC Power Flow

ARIZONA_voltages (230 kV): WW(black), PP(red), CG(green), KYX(blue), RUX(magenta)



EHV_voltages (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



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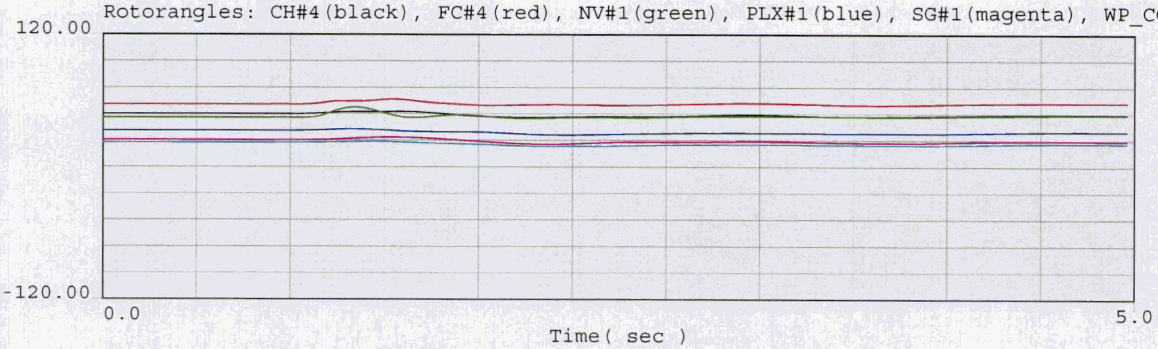

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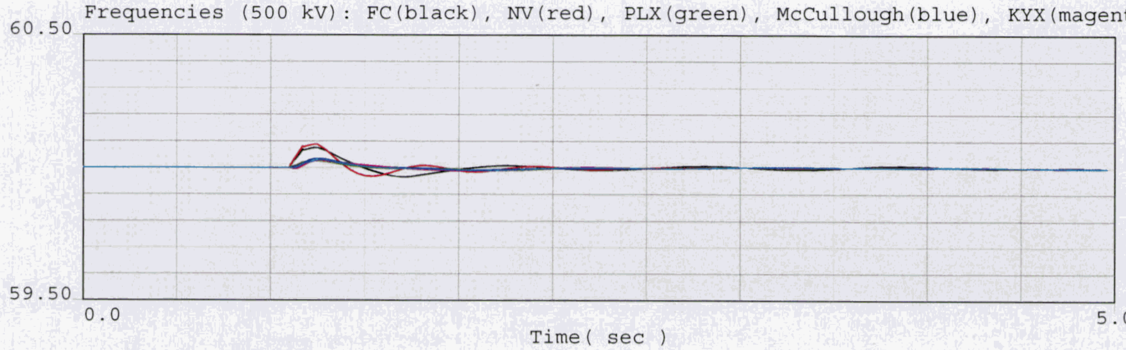

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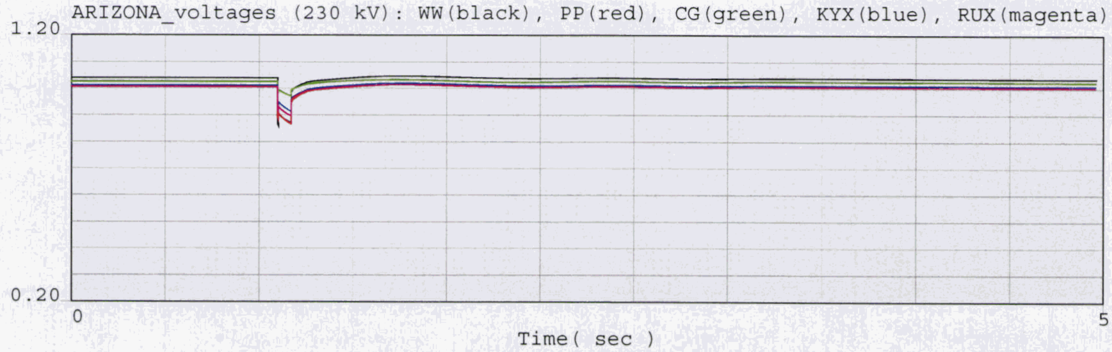
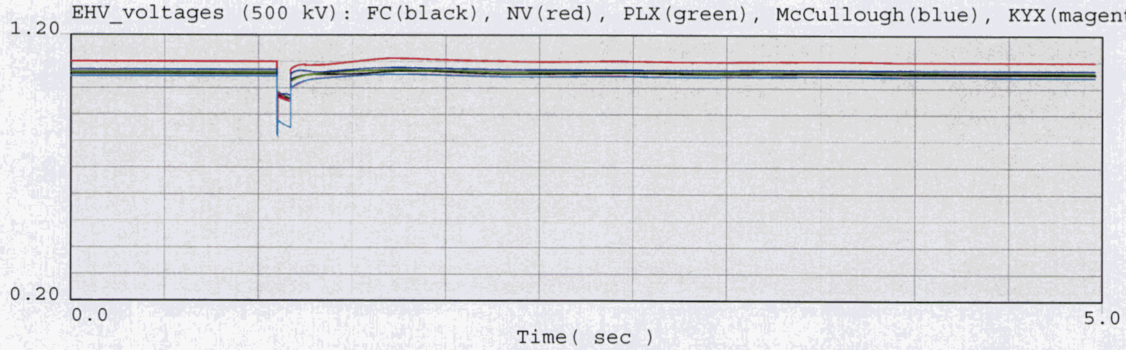
2011 Heavy Summer WECC Power Flow

ARIZONA_voltages (230 kV): WW(black), PP(red), CG(green), KYX(blue), RUX(magenta)



EHV_voltages (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



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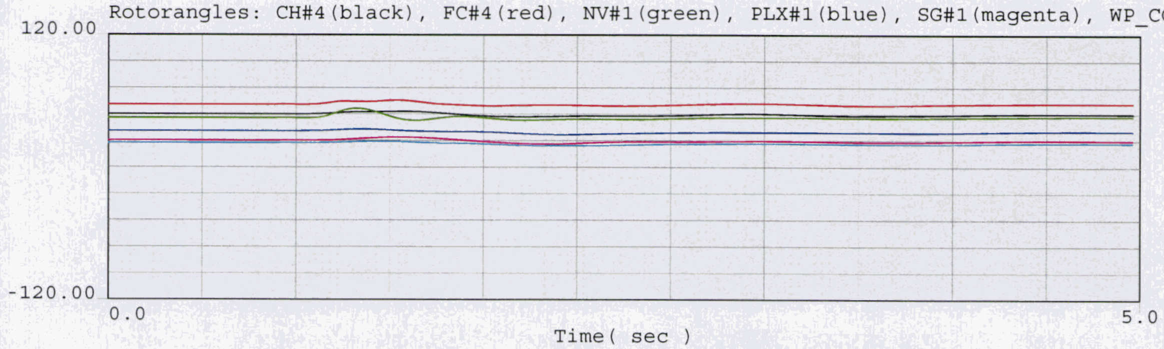
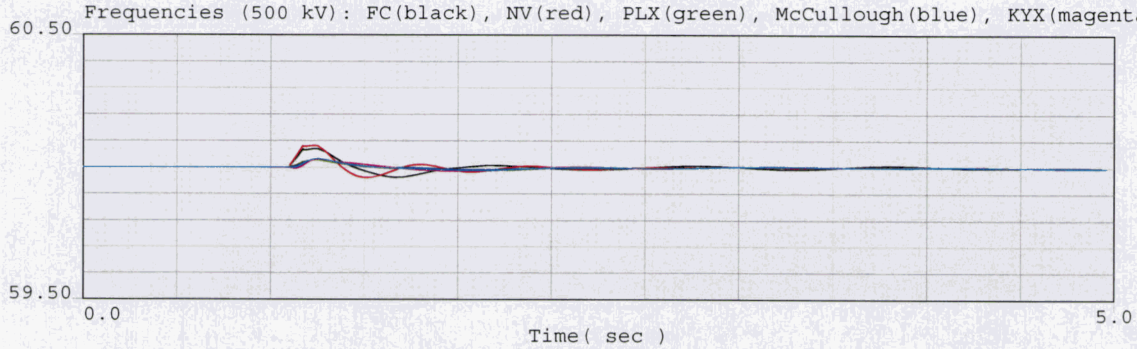


Frequencies (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



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APPENDIX C

2016
Stability Plots

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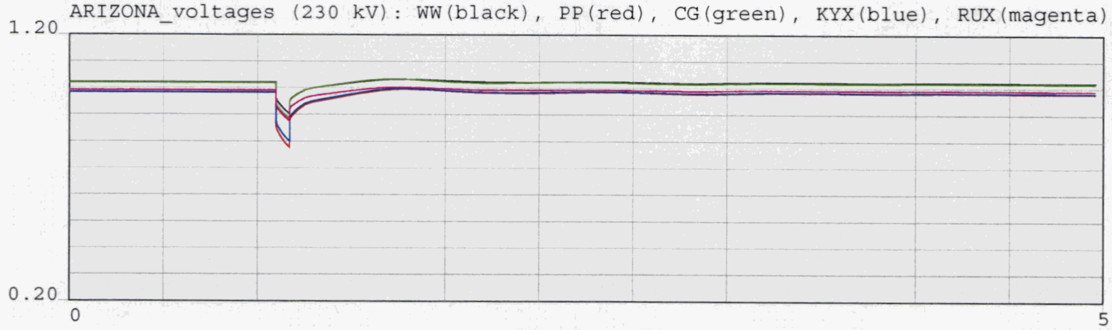
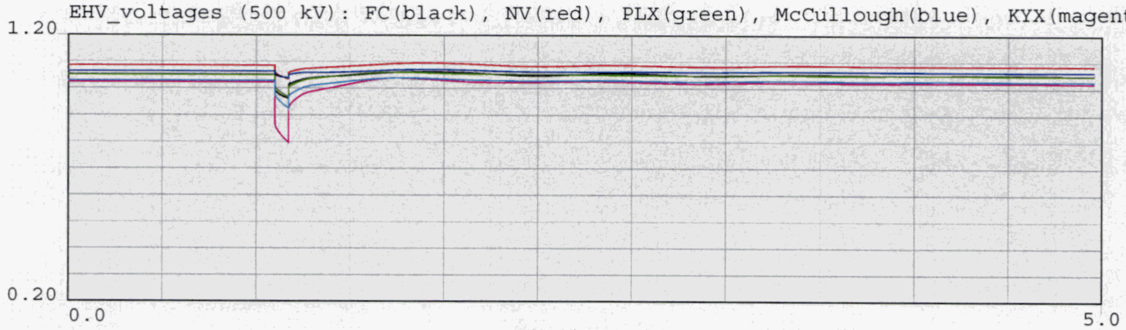
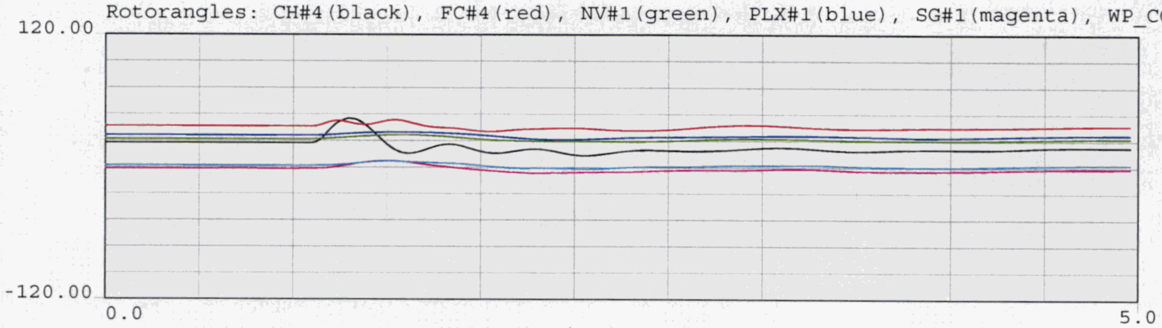
ARIZONA_voltages (230 kV): WW(black), PP(red), CG(green), KYX(blue), RUX(magenta)



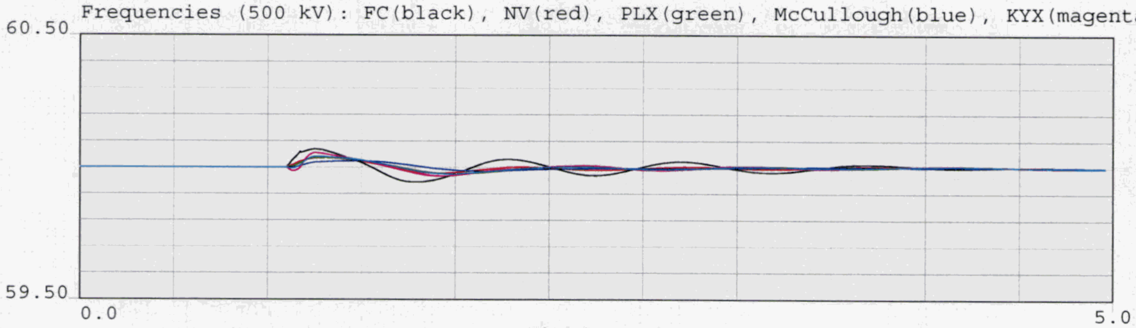
EHV_voltages (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



Rotorangles: CH#4(black), FC#4(red), NV#1(green), PLX#1(blue), SG#1(magenta), WP_CC1(cyan)



Frequencies (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



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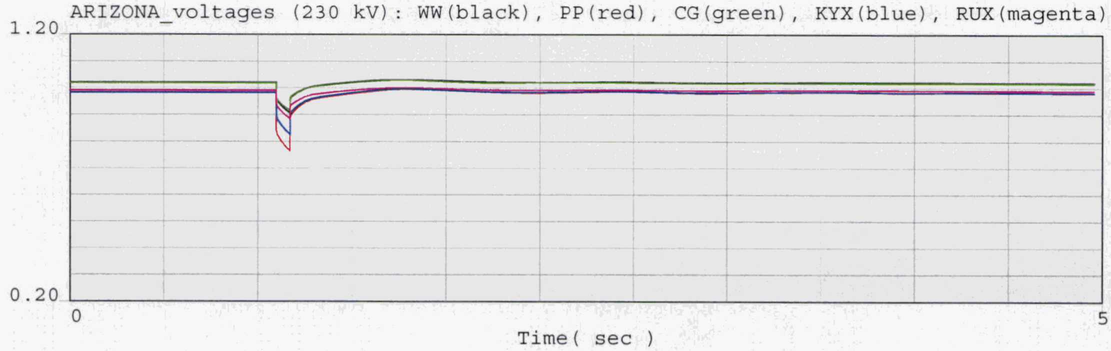
2016 Heavy Summer WECC Power Flow

ARIZONA_voltages (230 kV): WW(black), PP(red), CG(green), KYX(blue), RUX(magenta)



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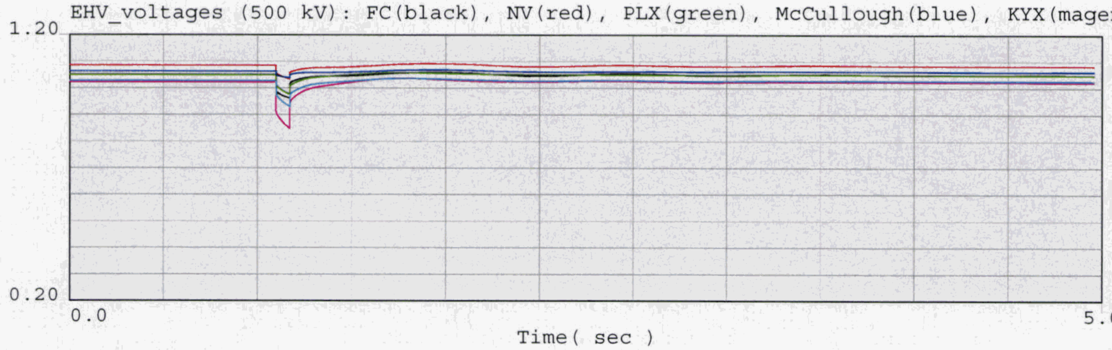
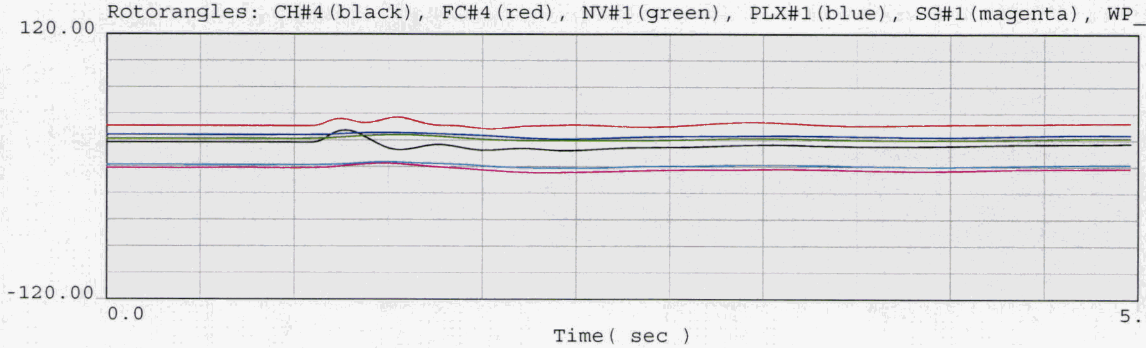
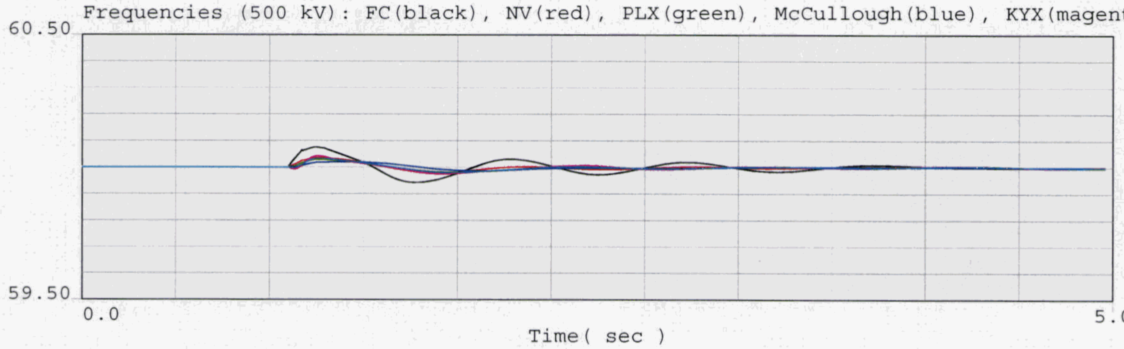


Rotorangles: CH#4(black), FC#4(red), NV#1(green), PLX#1(blue), SG#1(magenta), WP_CC1(cyan)



Frequencies (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



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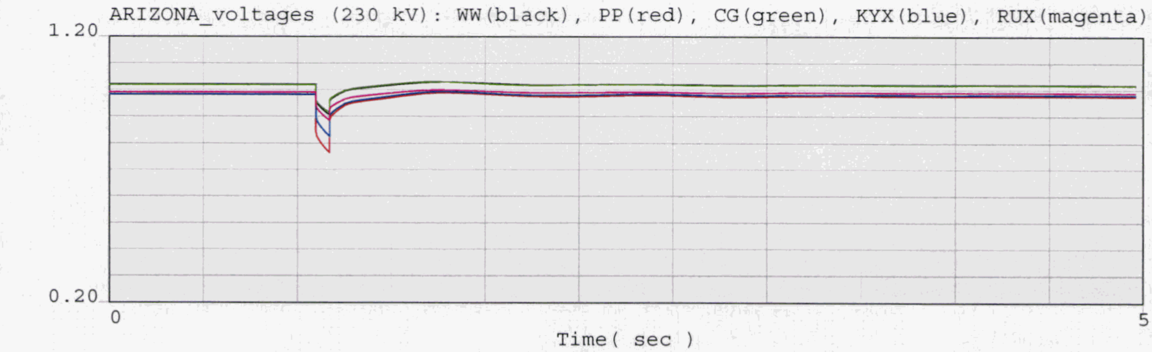

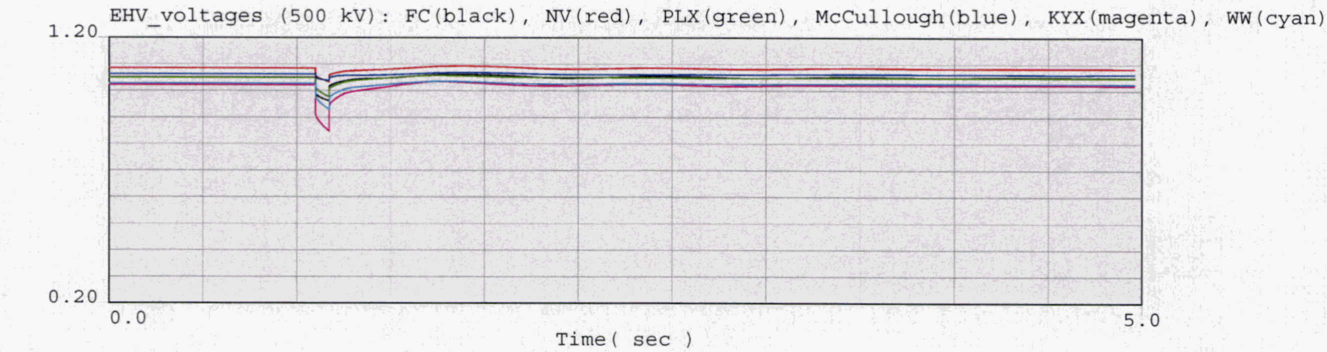

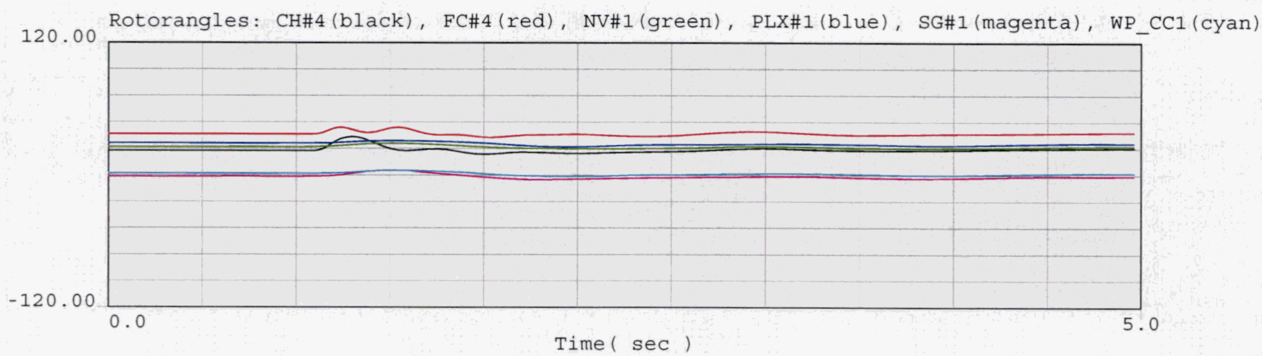

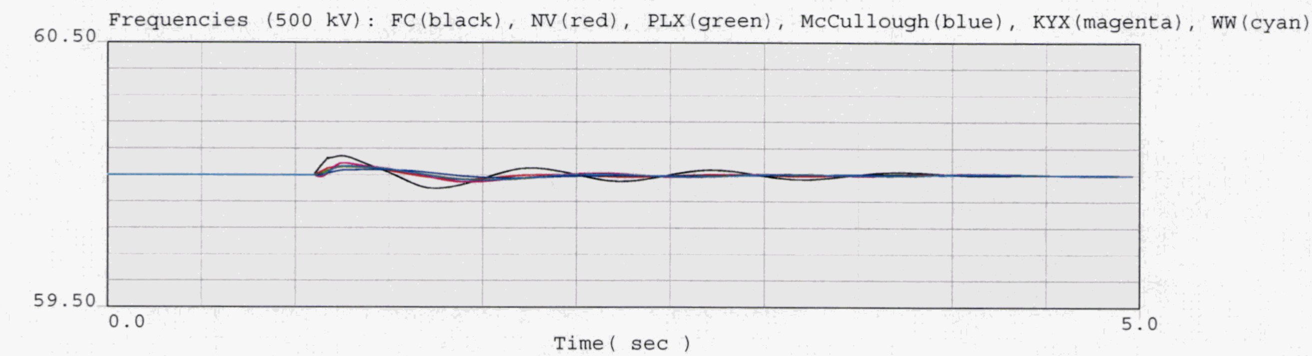

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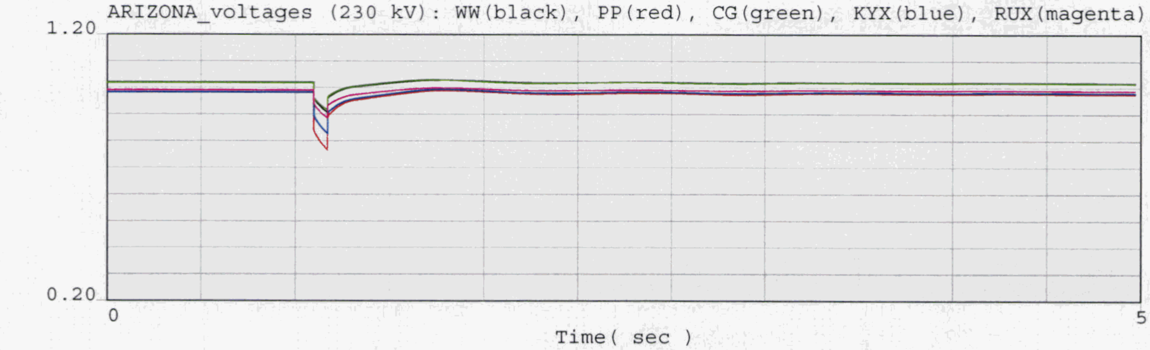
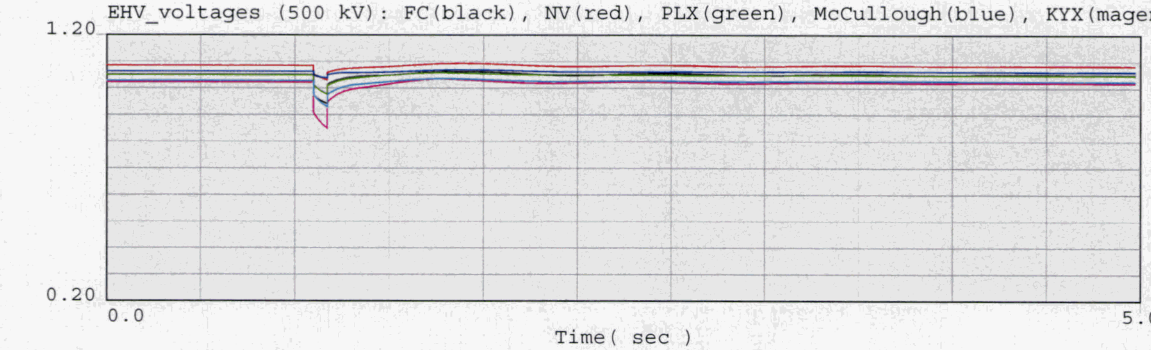
2016 Heavy Summer WECC Power Flow

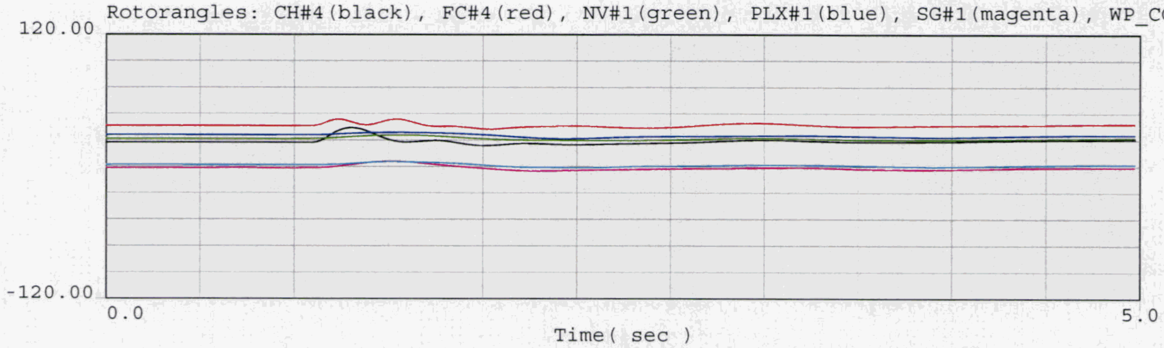
ARIZONA_voltages (230 kV): WW(black), PP(red), CG(green), KYX(blue), RUX(magenta)



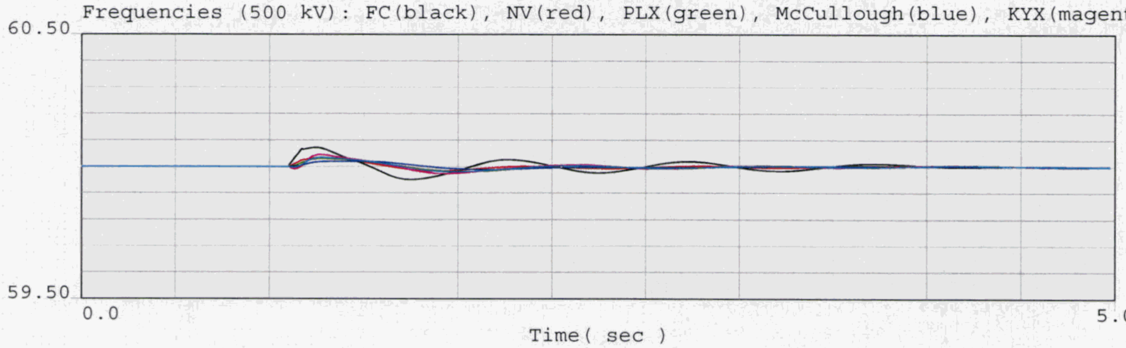
EHV_voltages (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



Rotorangles: CH#4(black), FC#4(red), NV#1(green), PLX#1(blue), SG#1(magenta), WP_CC1(cyan)



Frequencies (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



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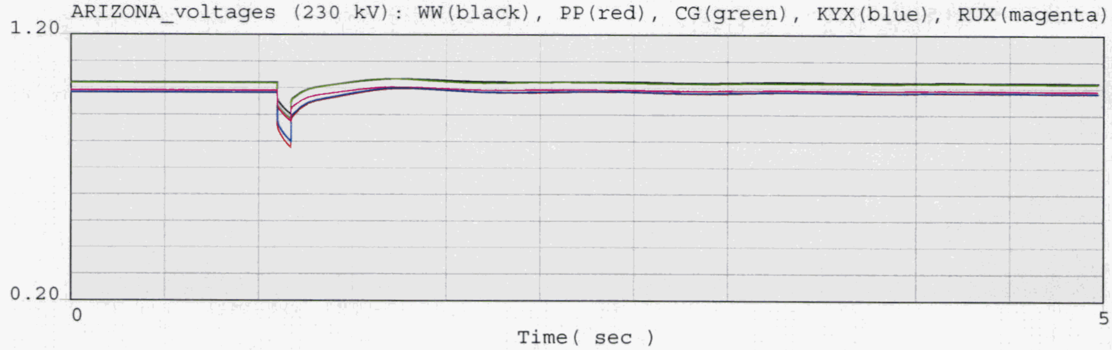
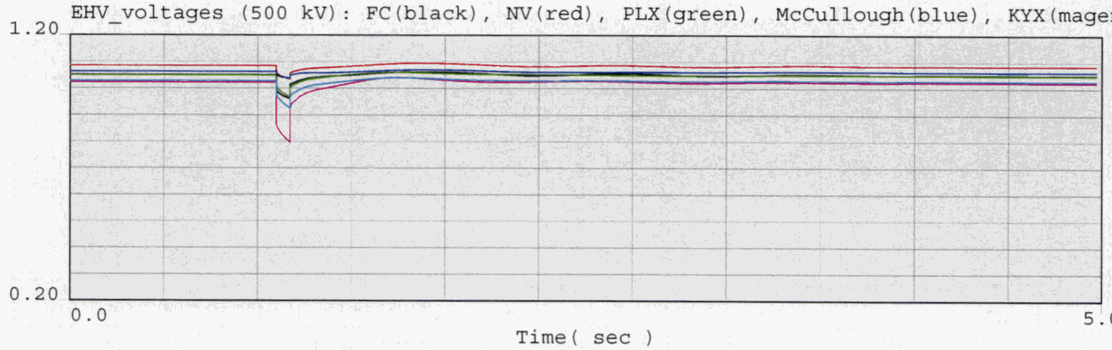
2016 Heavy Summer WECC Power Flow

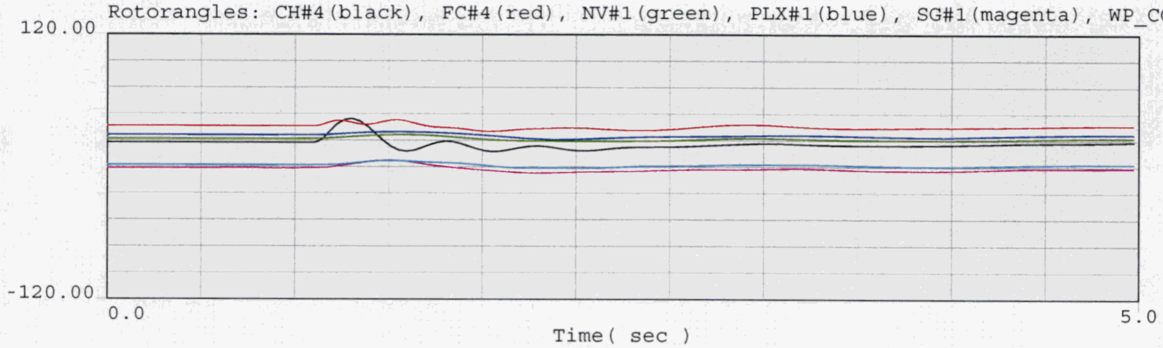
ARIZONA_voltages (230 kV): WW(black), PP(red), CG(green), KYX(blue), RUX(magenta)



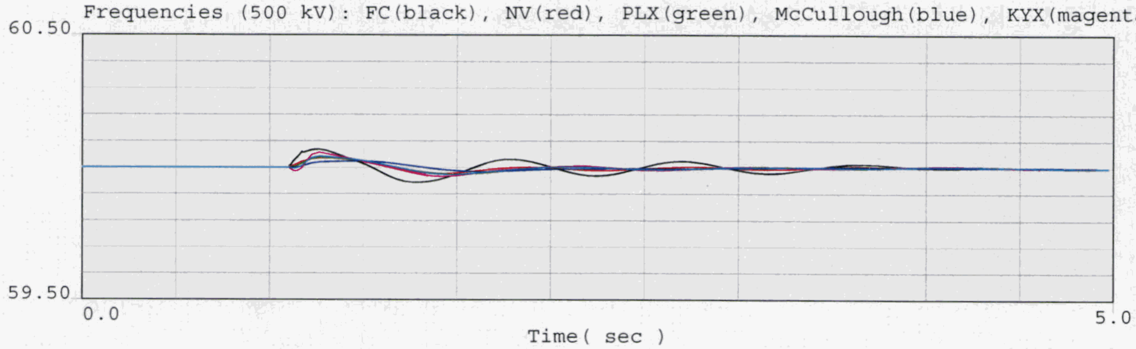
EHV_voltages (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



Rotorangles: CH#4(black), FC#4(red), NV#1(green), PLX#1(blue), SG#1(magenta), WP_CC1(cyan)



Frequencies (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



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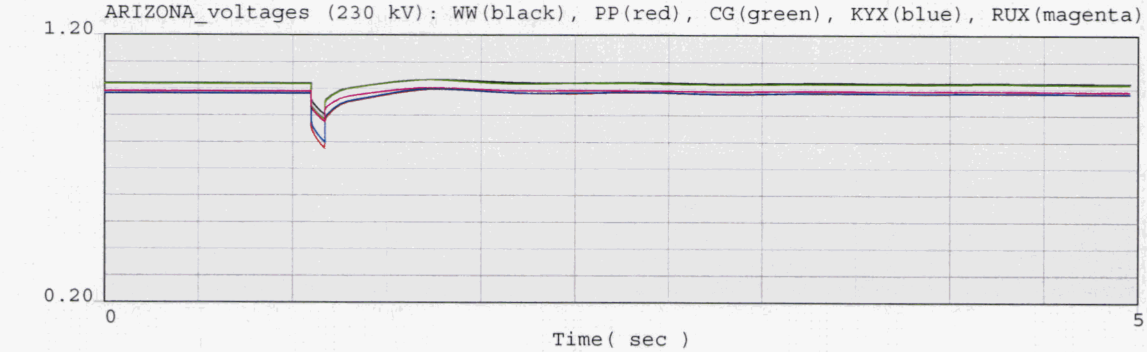

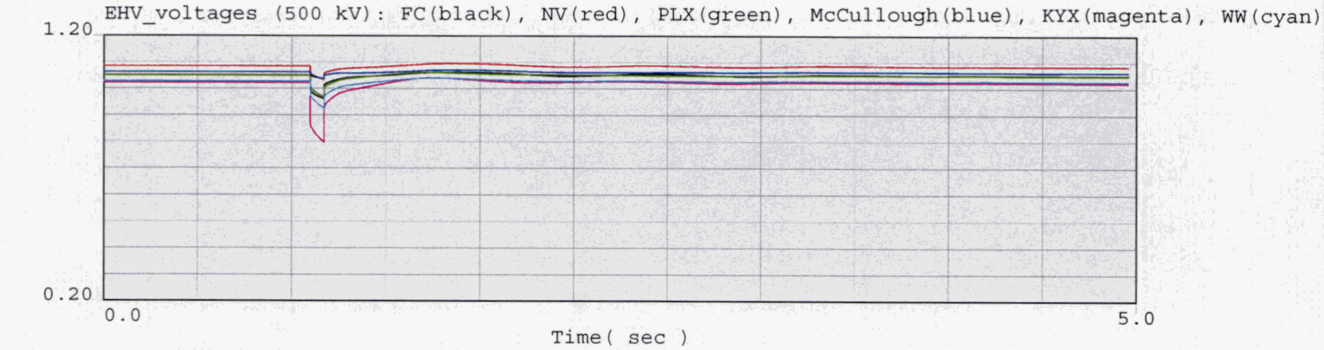

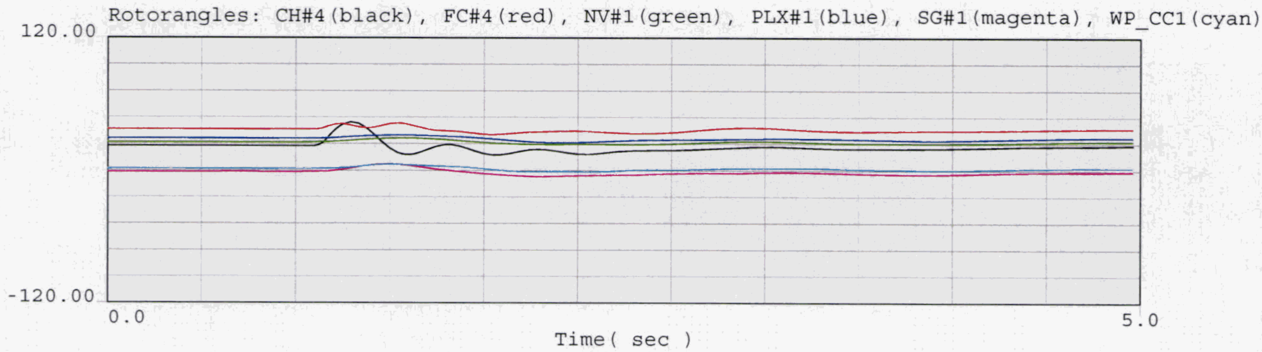

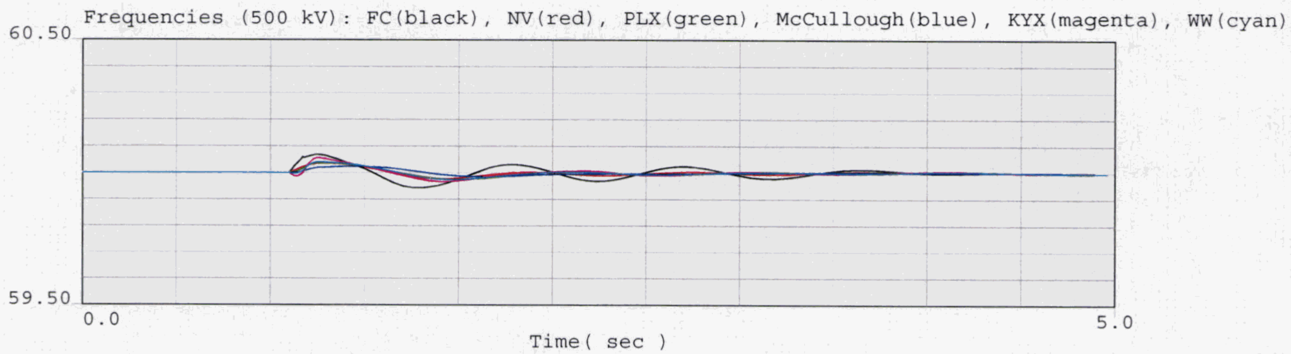

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MAY 30, 2006

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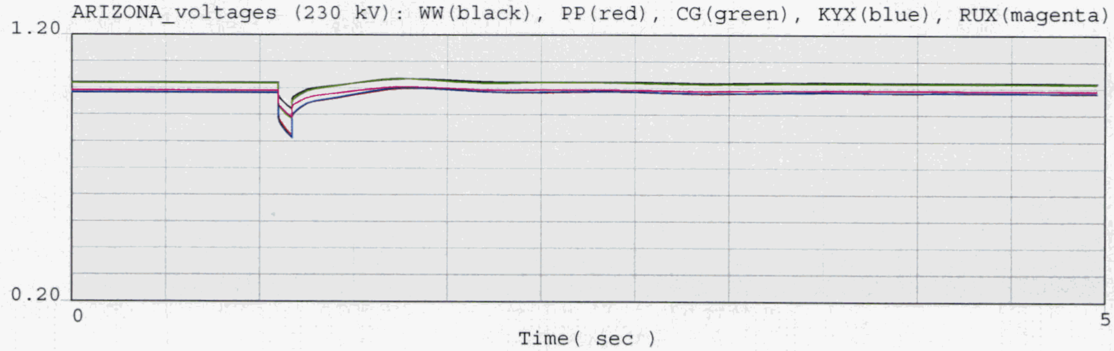
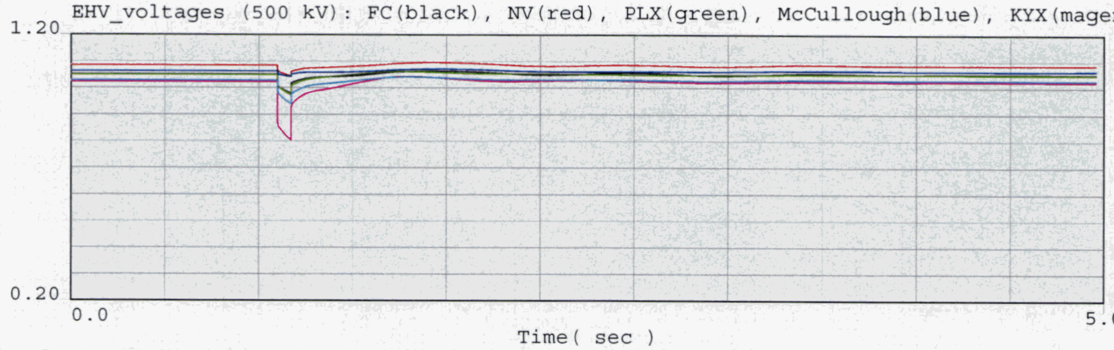
2016 Heavy Summer WECC Power Flow

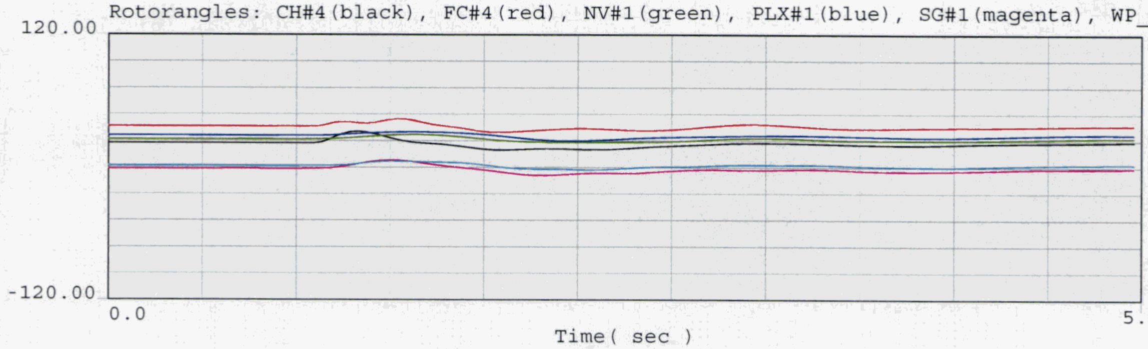
ARIZONA_voltages (230 kV): WW(black), PP(red), CG(green), KYX(blue), RUX(magenta)



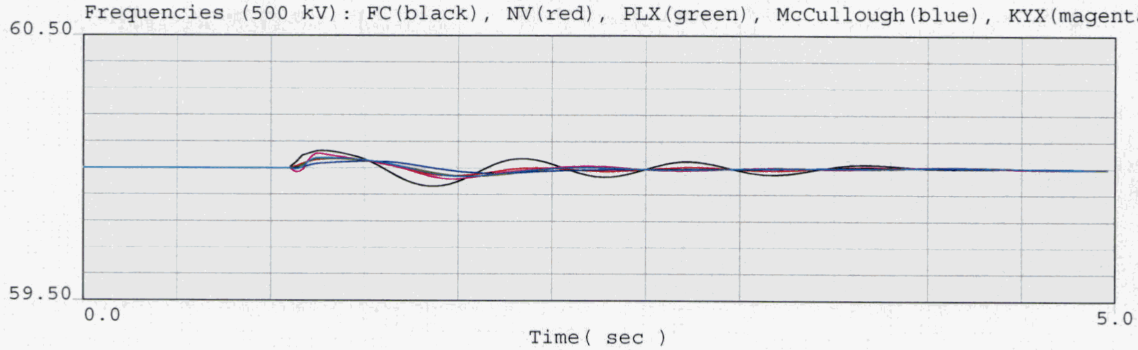
EHV_voltages (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



Rotorangles: CH#4(black), FC#4(red), NV#1(green), PLX#1(blue), SG#1(magenta), WP_CC1(cyan)



Frequencies (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



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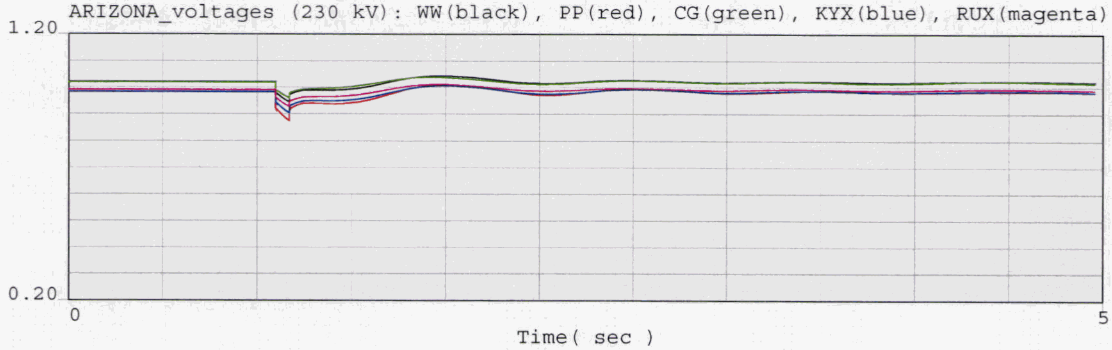
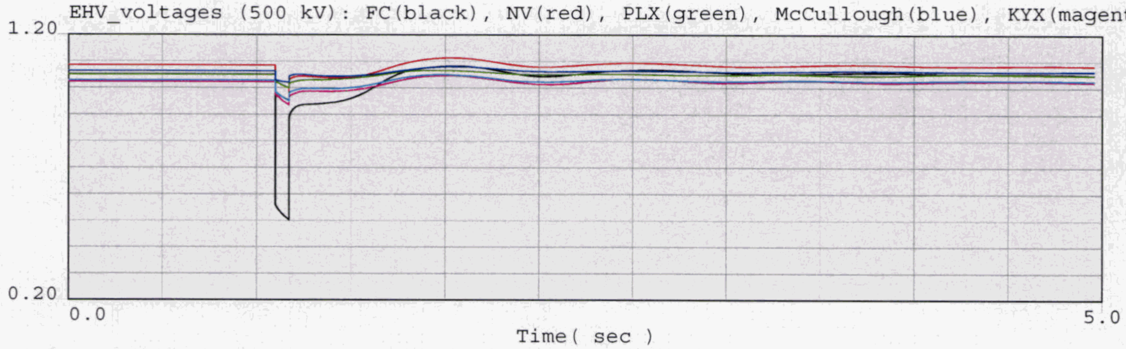
2016 Heavy Summer WECC Power Flow

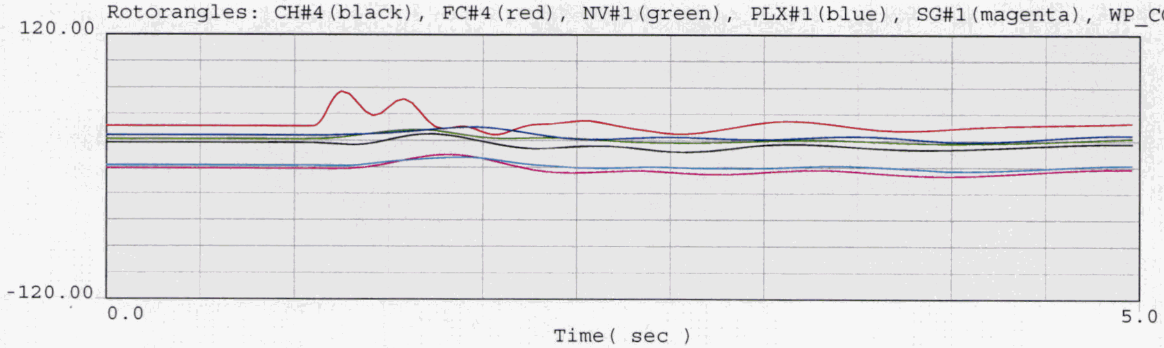
ARIZONA_voltages (230 kV): WW(black), PP(red), CG(green), KYX(blue), RUX(magenta)



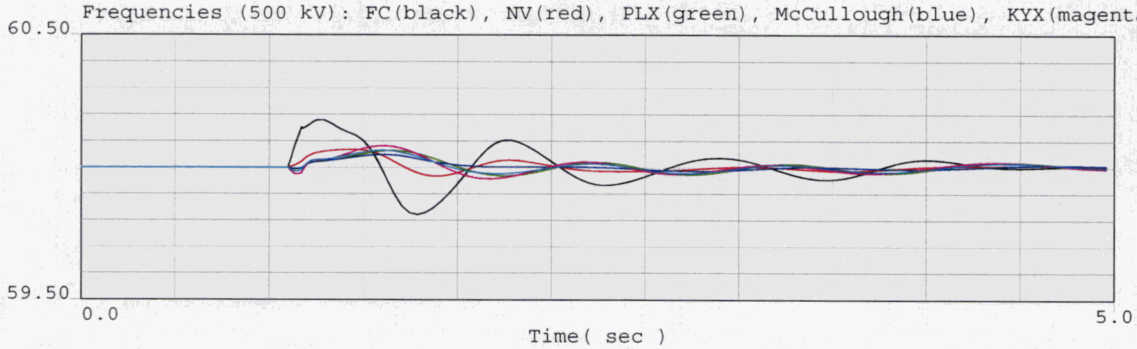
EHV_voltages (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



Rotorangles: CH#4(black), FC#4(red), NV#1(green), PLX#1(blue), SG#1(magenta), WP_CC1(cyan)



Frequencies (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



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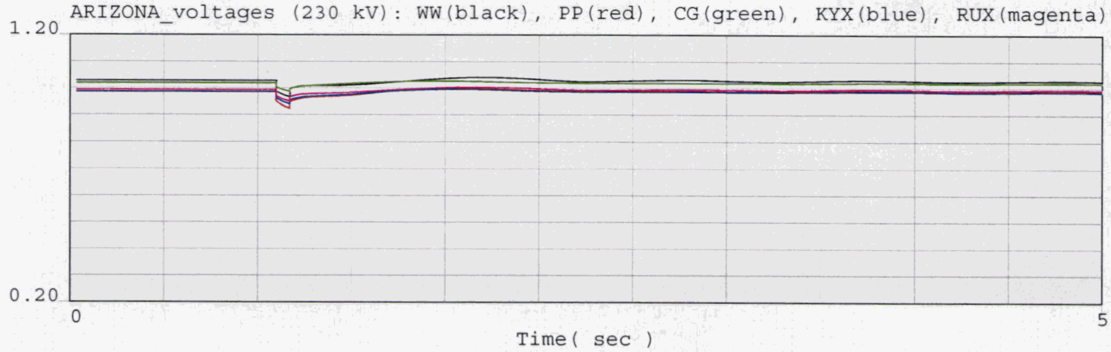
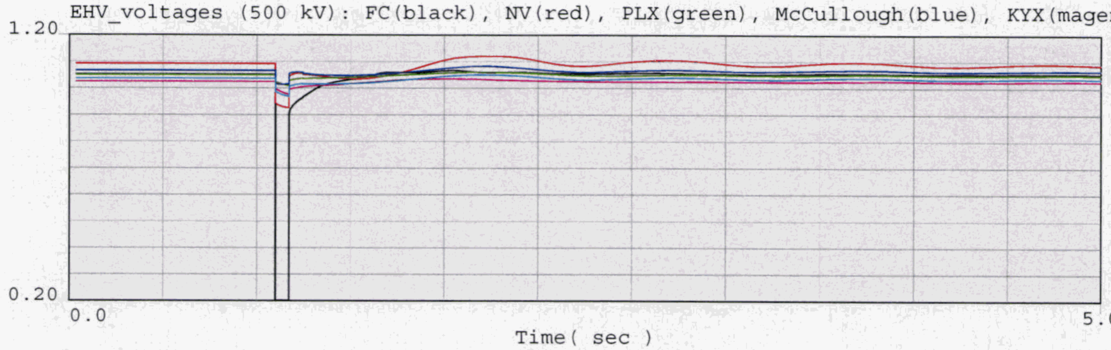
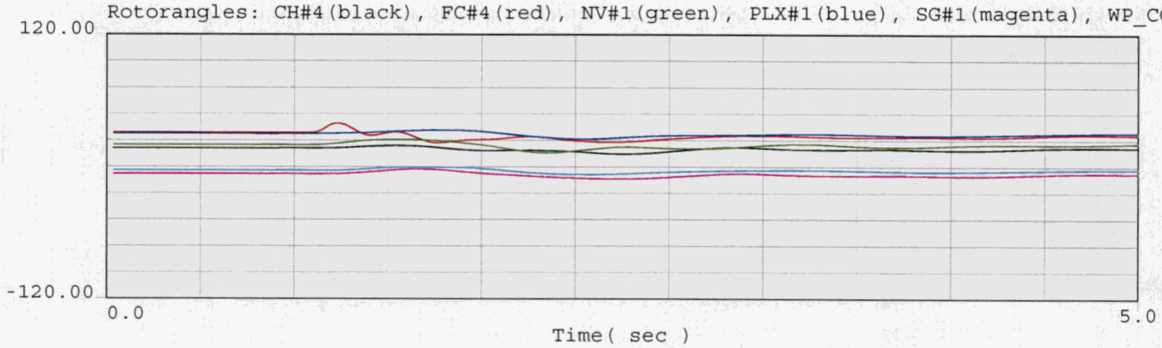
ARIZONA_voltages (230 kV): WW(black), PP(red), CG(green), KYX(blue), RUX(magenta)



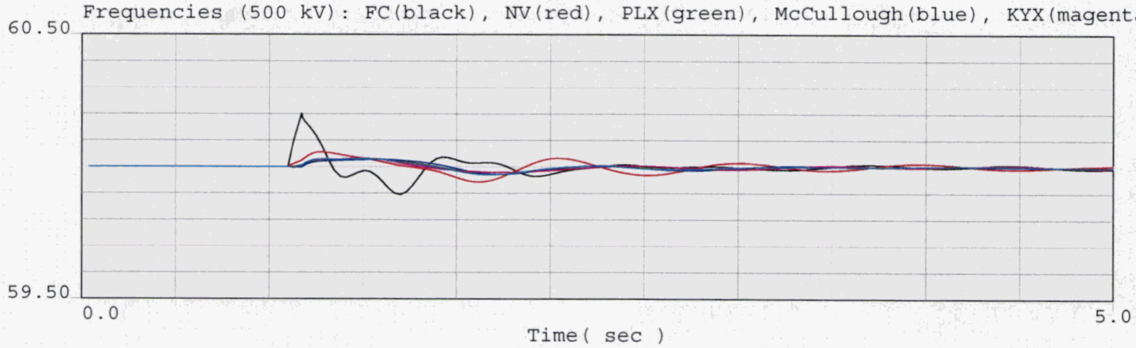
EHV_voltages (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



Rotorangles: CH#4(black), FC#4(red), NV#1(green), PLX#1(blue), SG#1(magenta), WP_CC1(cyan)



Frequencies (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



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fc_fcw

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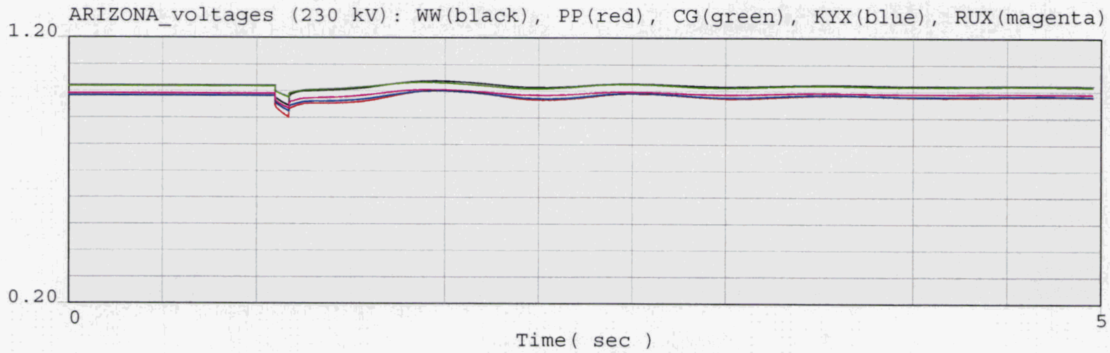

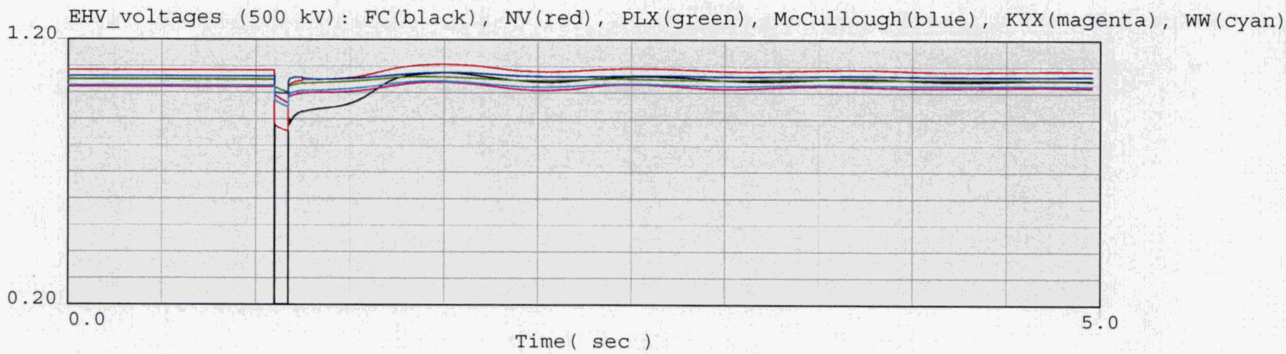

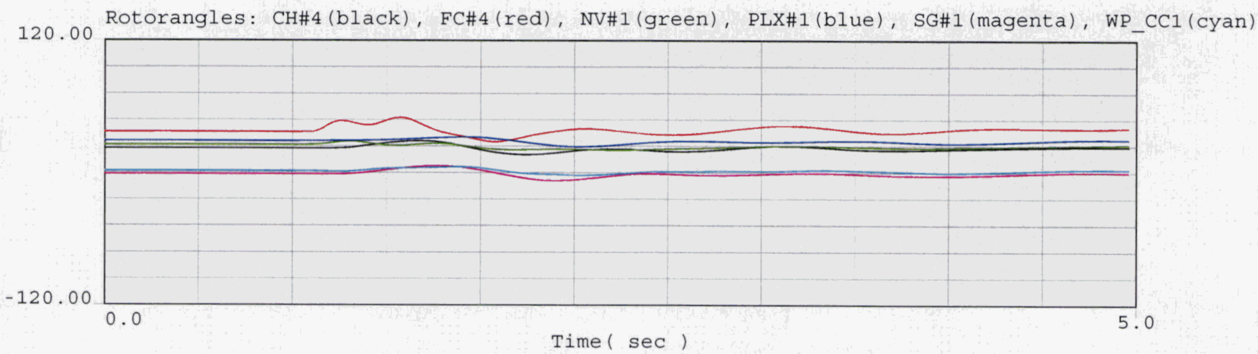

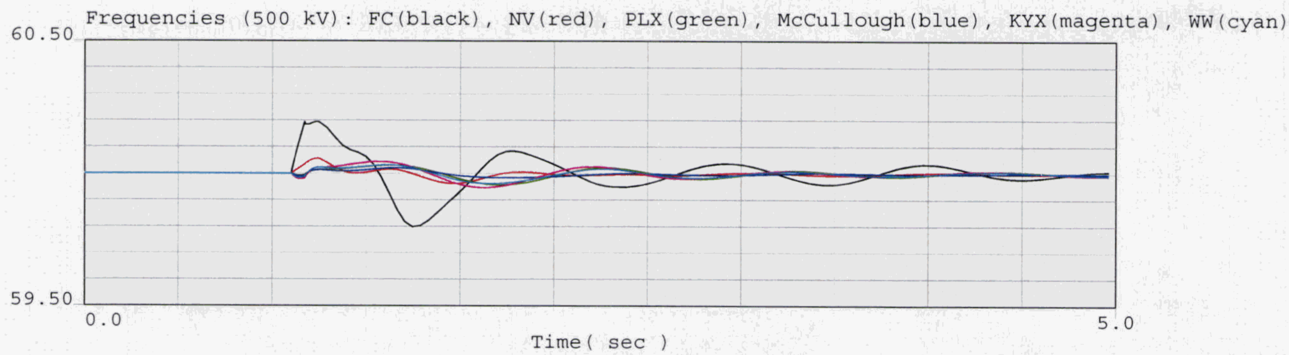

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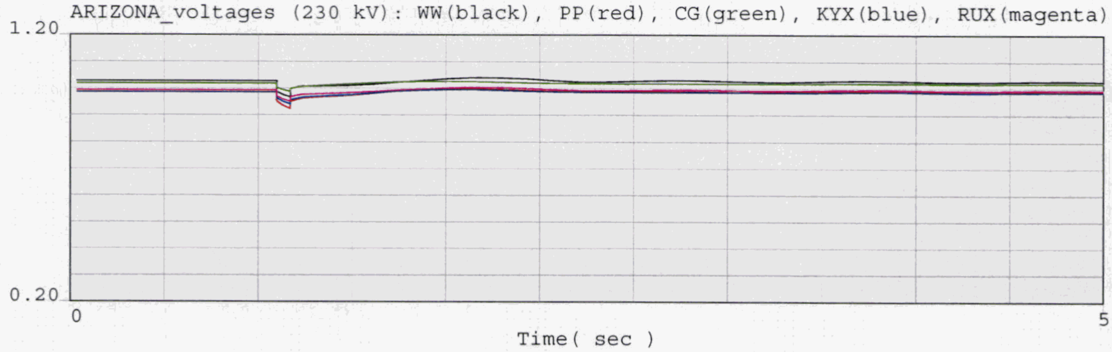
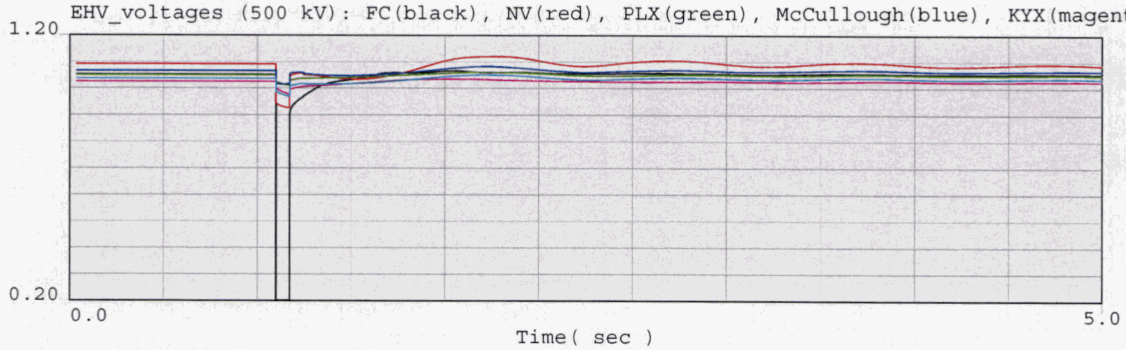
2016 Heavy Summer WECC Power Flow

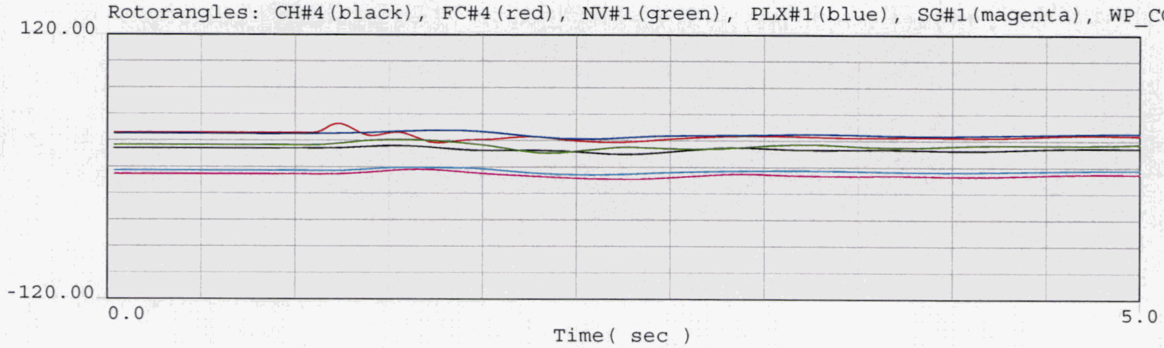
ARIZONA_voltages (230 kV): WW(black), PP(red), CG(green), KYX(blue), RUX(magenta)



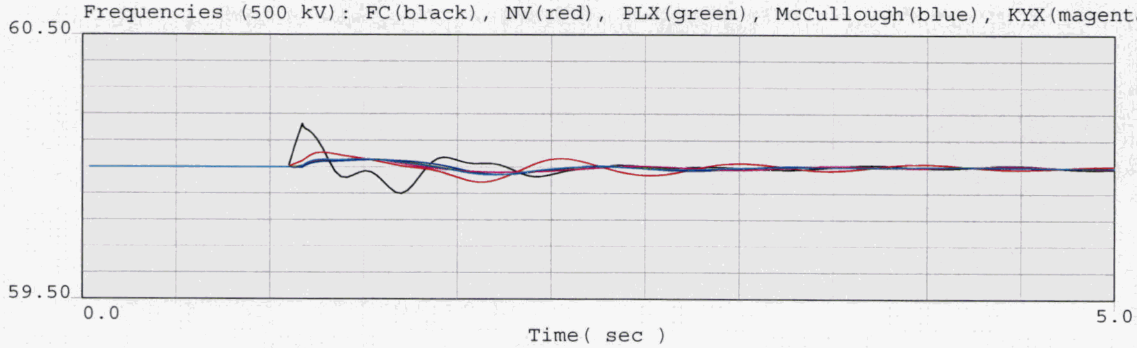
EHV_voltages (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



Rotorangles: CH#4(black), FC#4(red), NV#1(green), PLX#1(blue), SG#1(magenta), WP_CC1(cyan)



Frequencies (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



WESTERN ELECTRICITY COORDINATING COUNCIL
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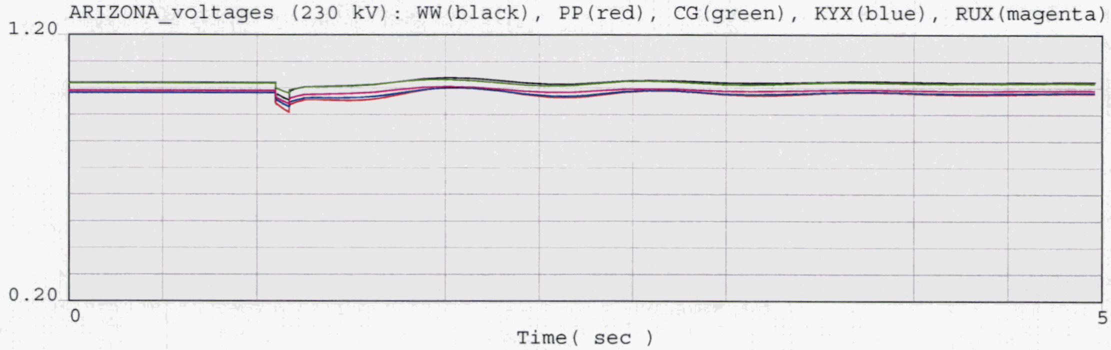
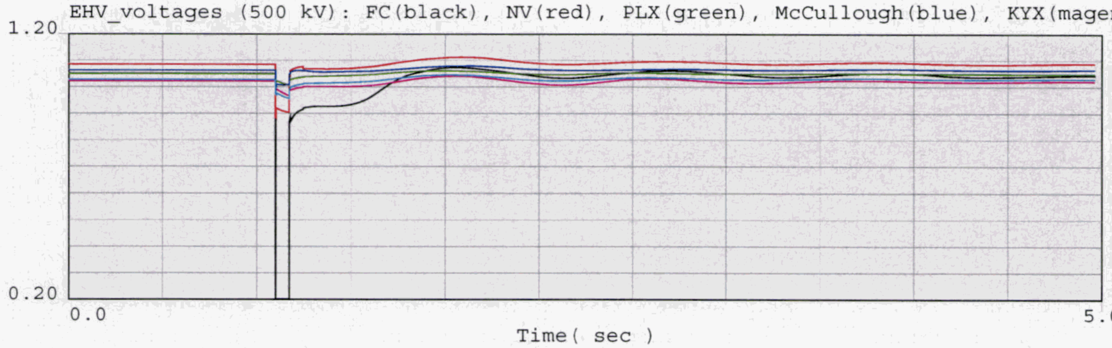
fcw_fc

2016 Heavy Summer WECC Power Flow

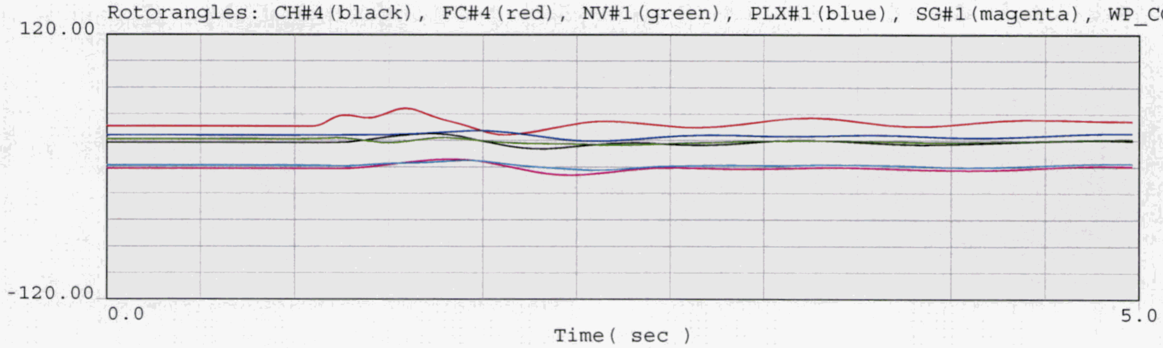
ARIZONA_voltages (230 kV): WW(black), PP(red), CG(green), KYX(blue), RUX(magenta)



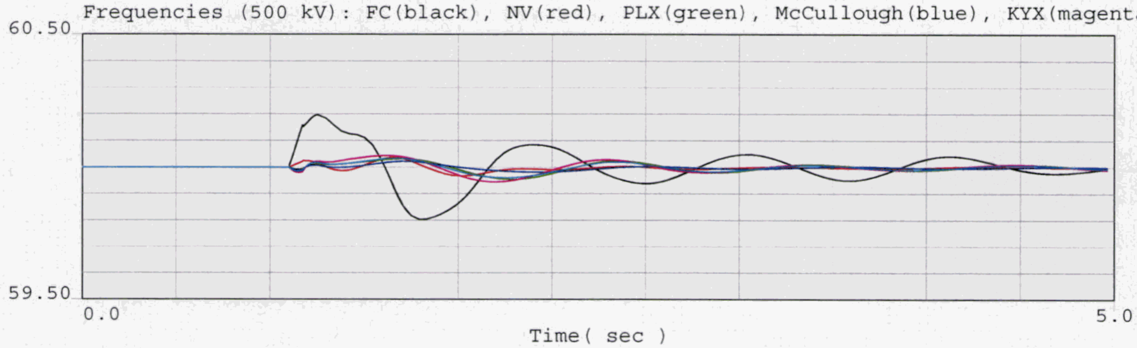
EHV_voltages (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



Rotorangles: CH#4(black), FC#4(red), NV#1(green), PLX#1(blue), SG#1(magenta), WP_CC1(cyan)



Frequencies (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



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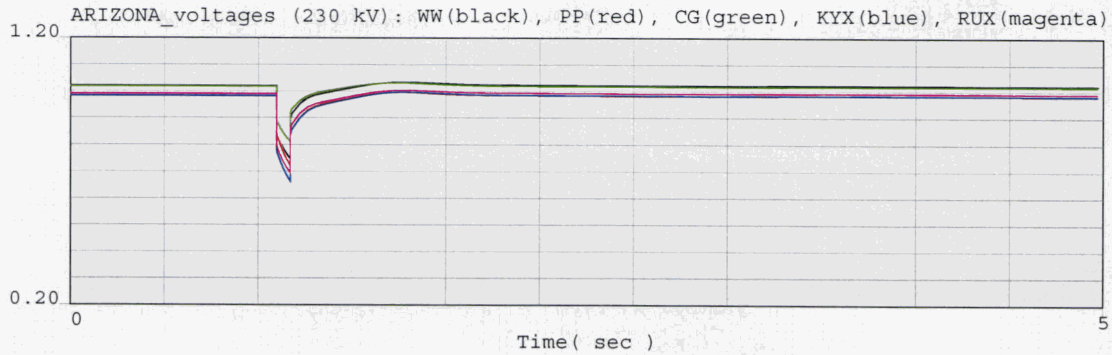
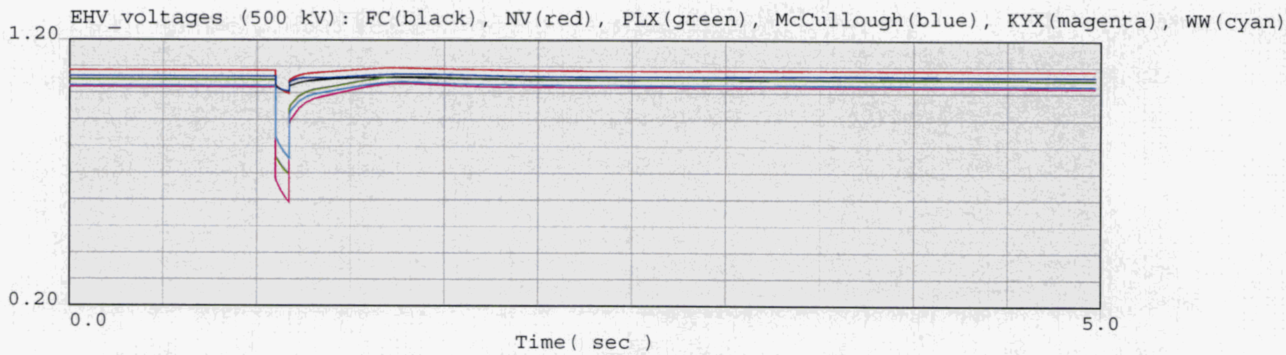
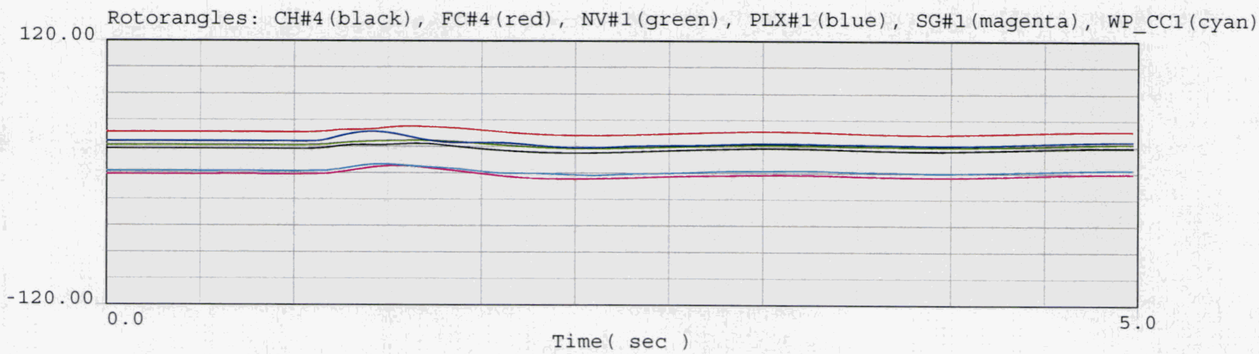
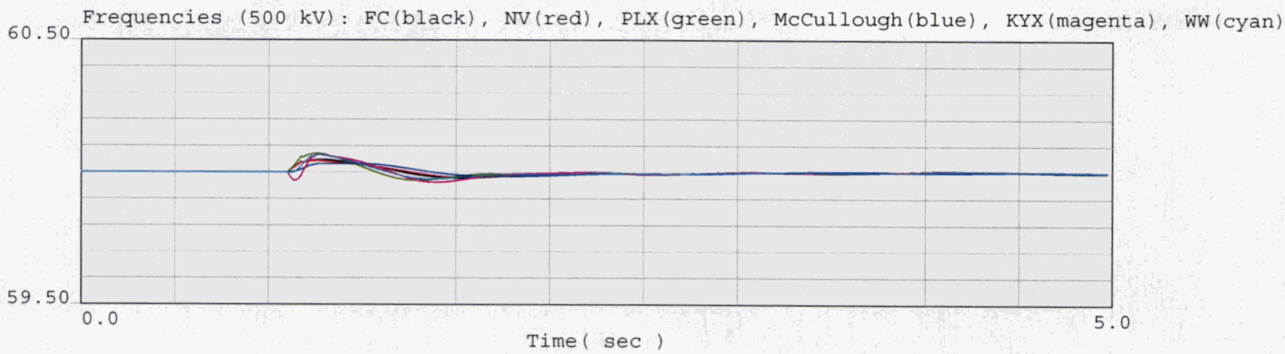
2016 Heavy Summer WECC Power Flow









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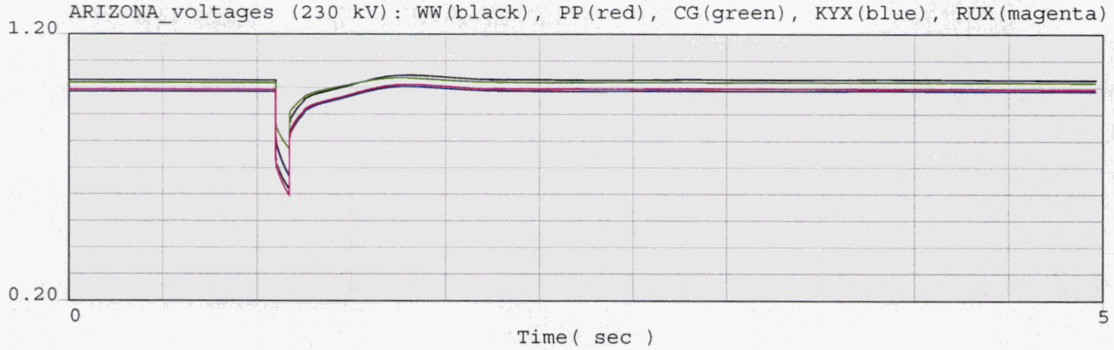
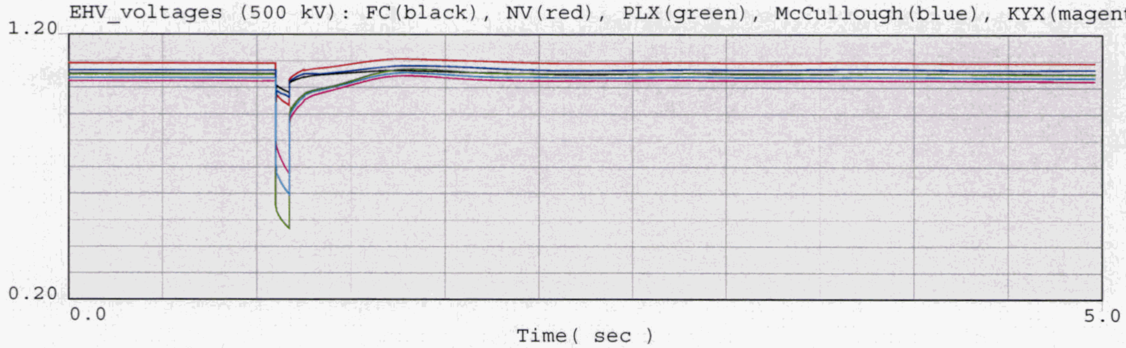
2011 Heavy Summer WECC Power Flow

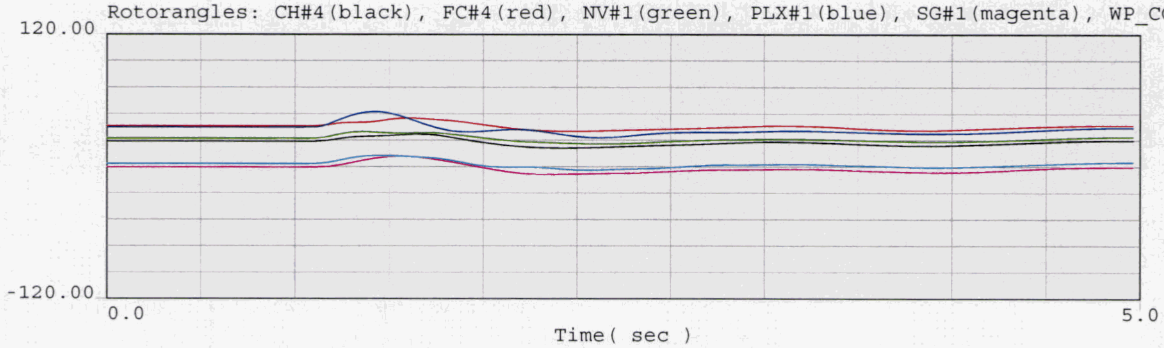
ARIZONA_voltages (230 kV): WW(black), PP(red), CG(green), KYX(blue), RUX(magenta)



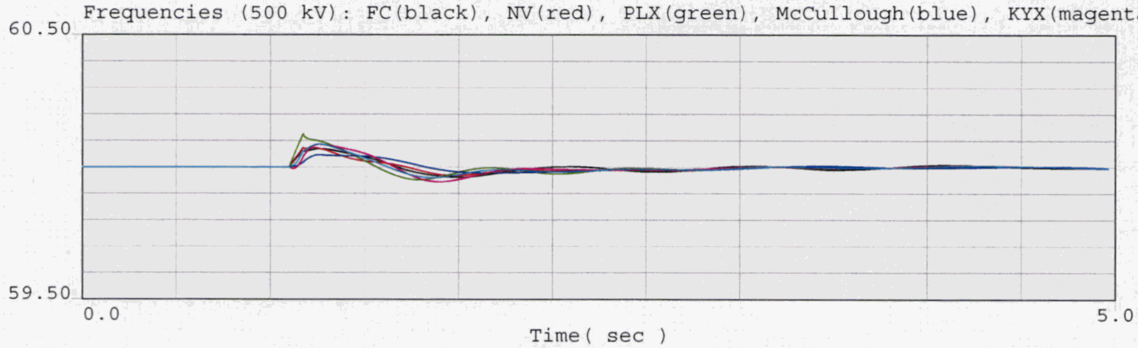
EHV_voltages (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



Rotorangles: CH#4(black), FC#4(red), NV#1(green), PLX#1(blue), SG#1(magenta), WP_CC1(cyan)



Frequencies (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



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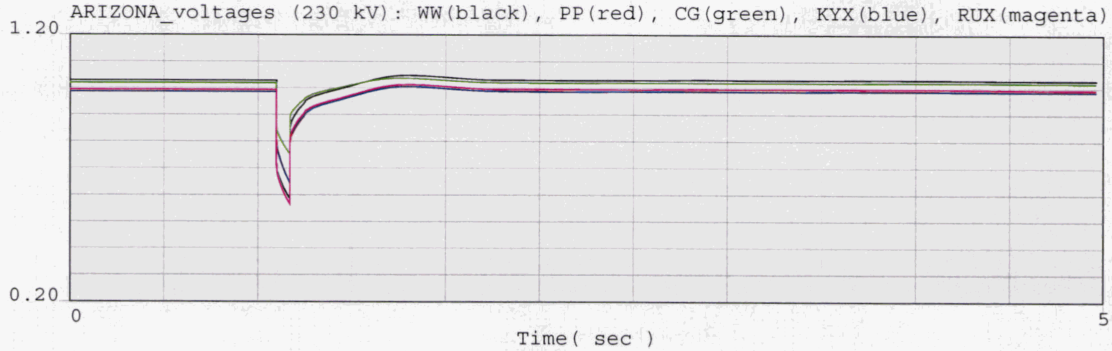
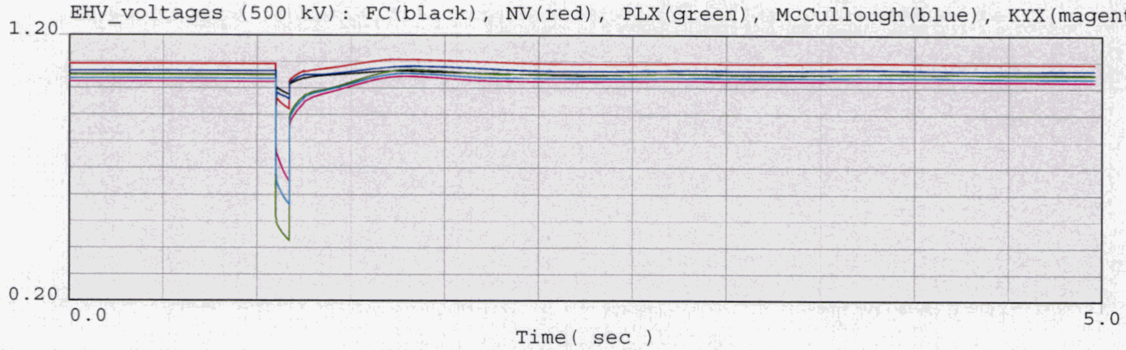
2011 Heavy Summer WECC Power Flow

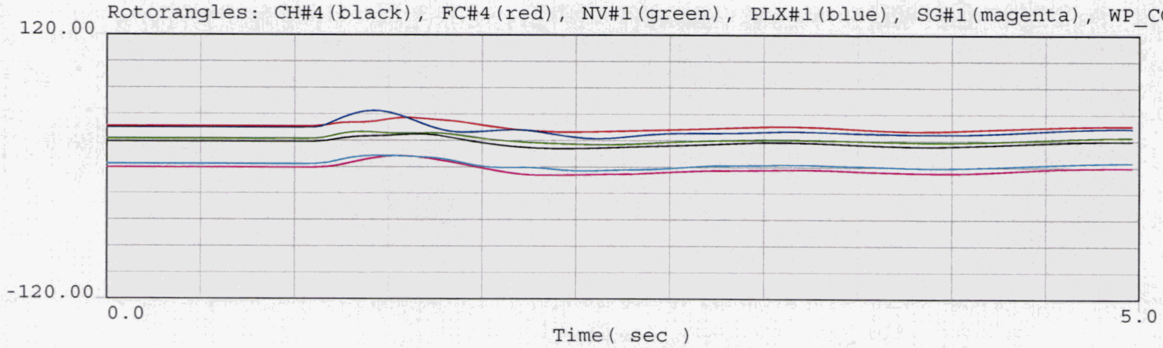
ARIZONA_voltages (230 kV): WW(black), PP(red), CG(green), KYX(blue), RUX(magenta)



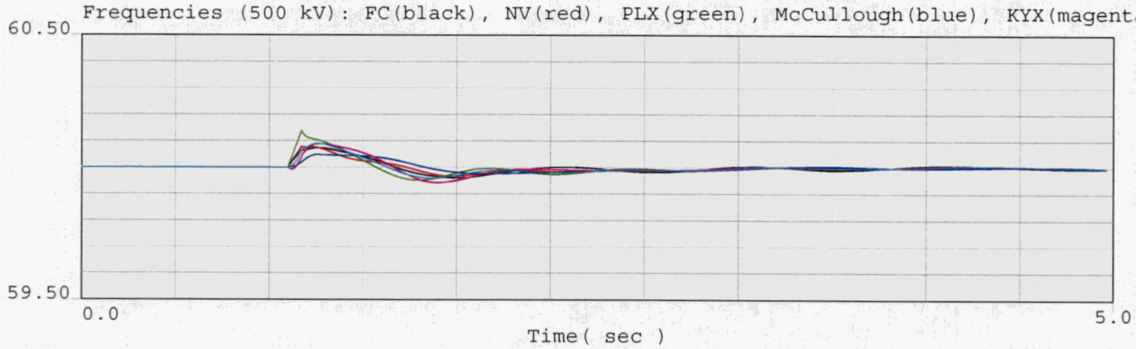
EHV_voltages (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



Rotorangles: CH#4(black), FC#4(red), NV#1(green), PLX#1(blue), SG#1(magenta), WP_CC1(cyan)



Frequencies (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



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stability\2011 stability

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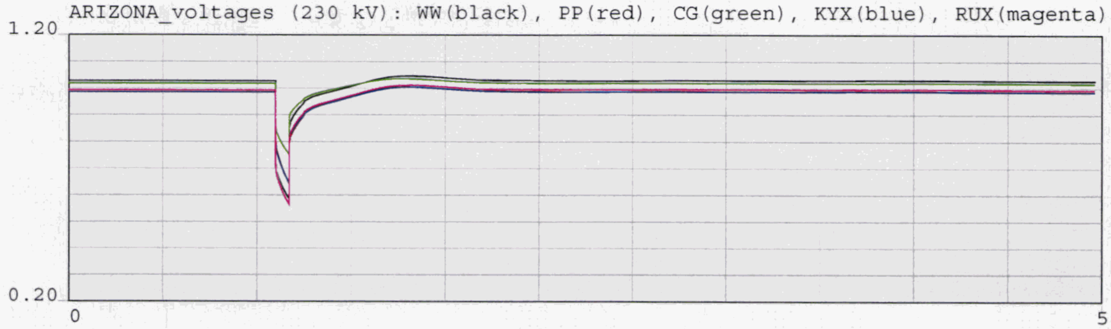
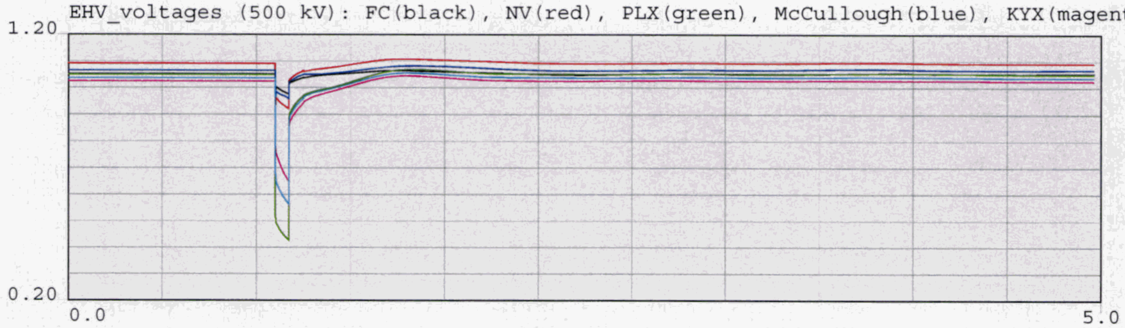
2011 Heavy Summer WECC Power Flow

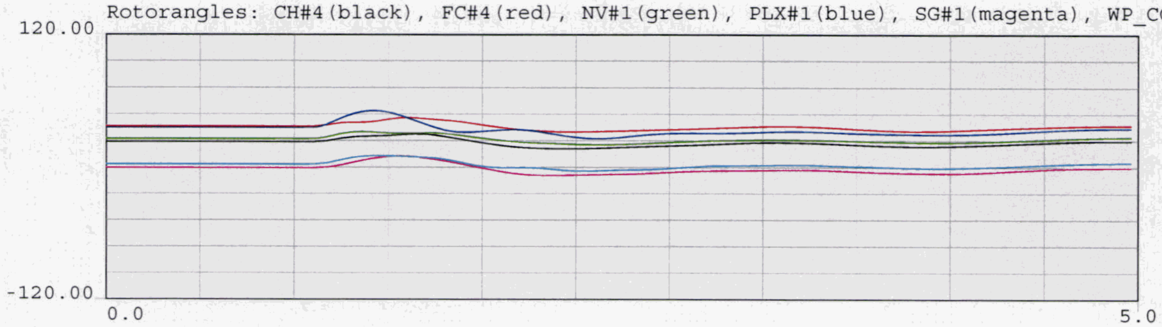
ARIZONA_voltages (230 kV): WW(black), PP(red), CG(green), KYX(blue), RUX(magenta)



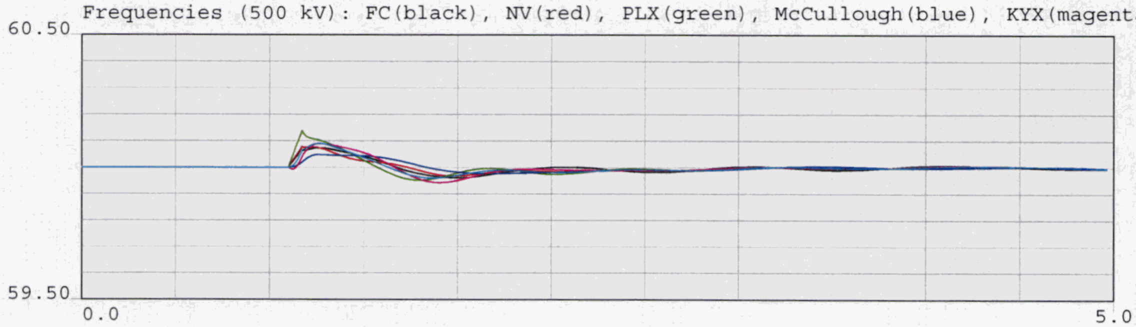
EHV_voltages (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



Rotorangles: CH#4(black), FC#4(red), NV#1(green), PLX#1(blue), SG#1(magenta), WP_CC1(cyan)



Frequencies (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



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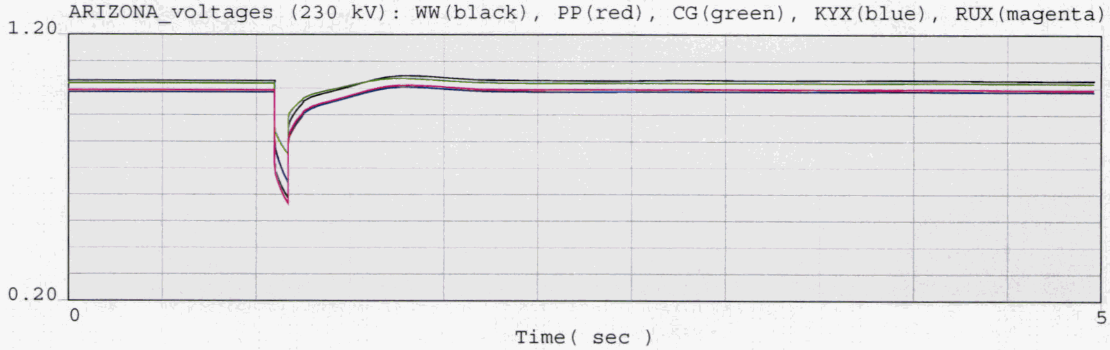
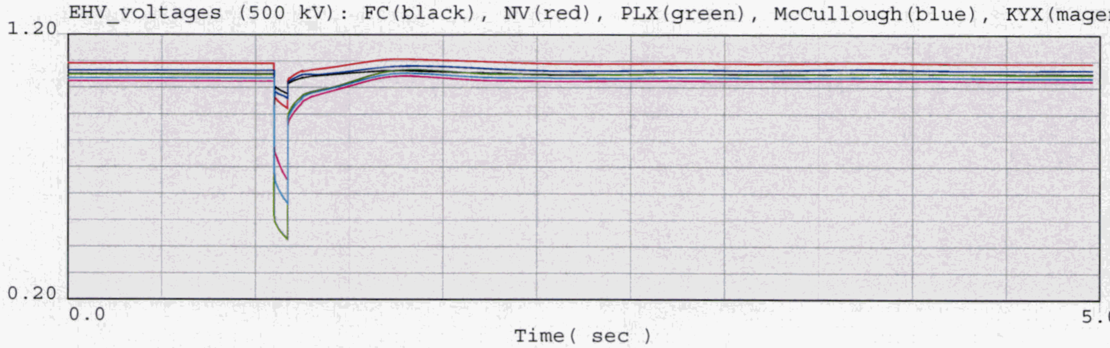
2011 Heavy Summer WECC Power Flow

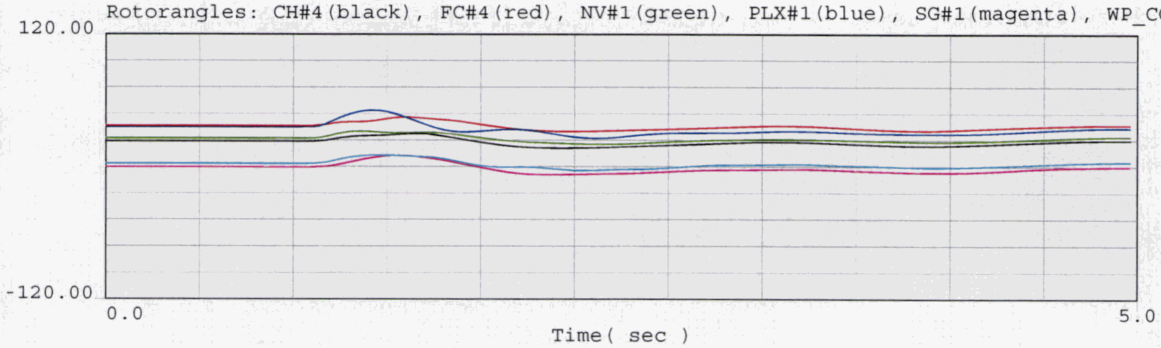
ARIZONA_voltages (230 kV): WW(black), PP(red), CG(green), KYX(blue), RUX(magenta)



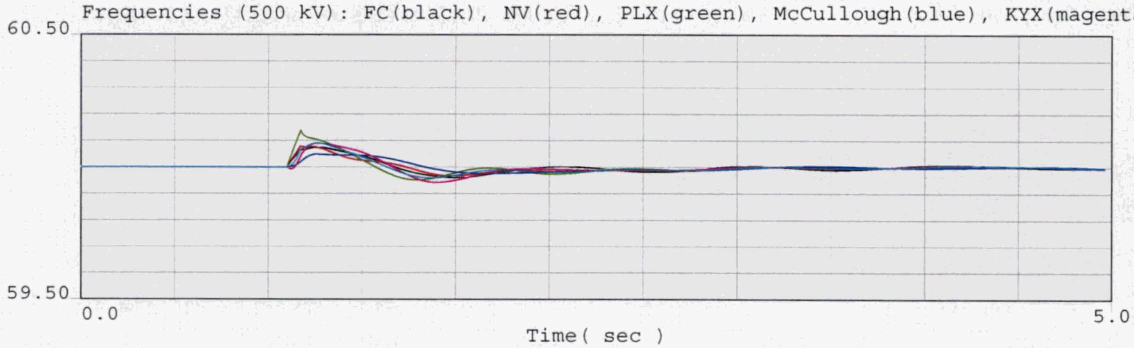
EHV_voltages (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



Rotorangles: CH#4(black), FC#4(red), NV#1(green), PLX#1(blue), SG#1(magenta), WP_CC1(cyan)

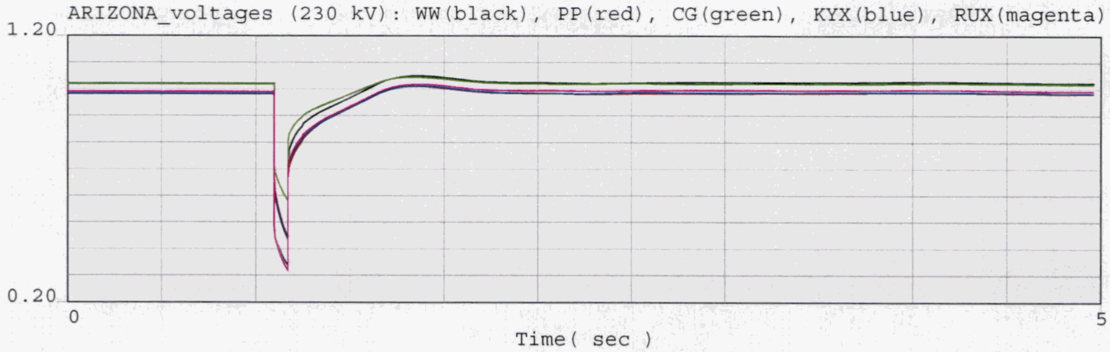


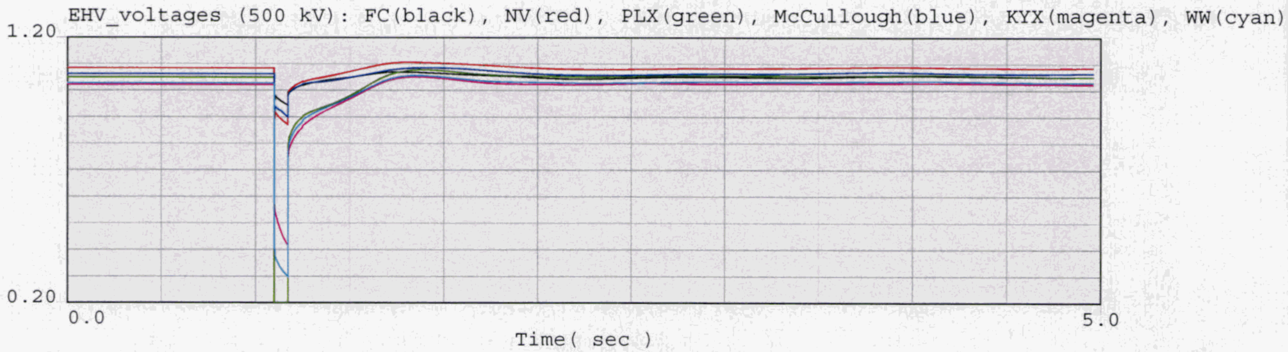
Frequencies (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)

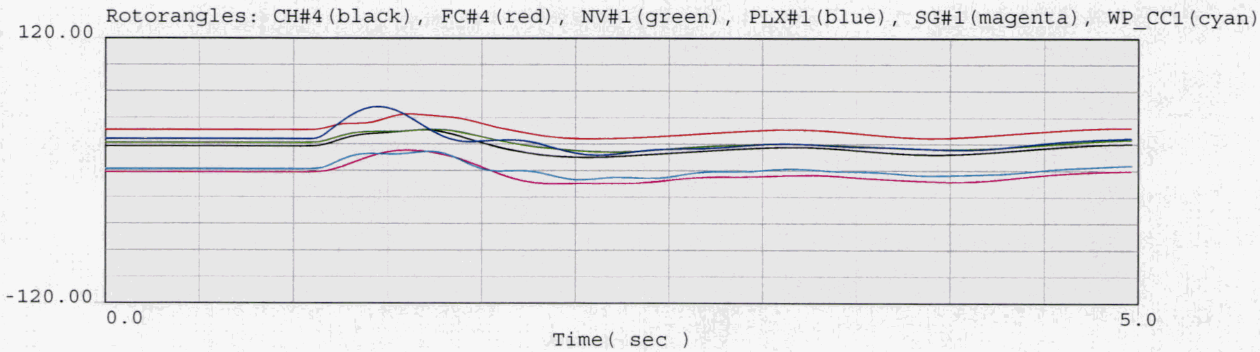


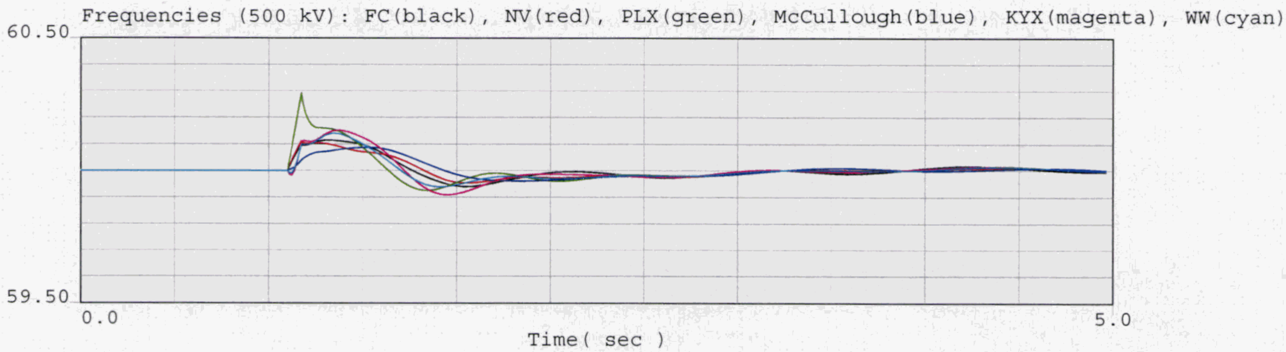
WE RN ELECTRICITY COORDINATING COUNCIL
2 HS1A APPROVED BASE CASE
MAY 30, 2006
ALL COMMENTS RESULTING FROM THE TSS REVIEW HAVE BEEN ADDED.

2016 Heavy Summer WECC Power Flow









WE[illegible]RN ELECTRICITY COORDINATING COUNCIL
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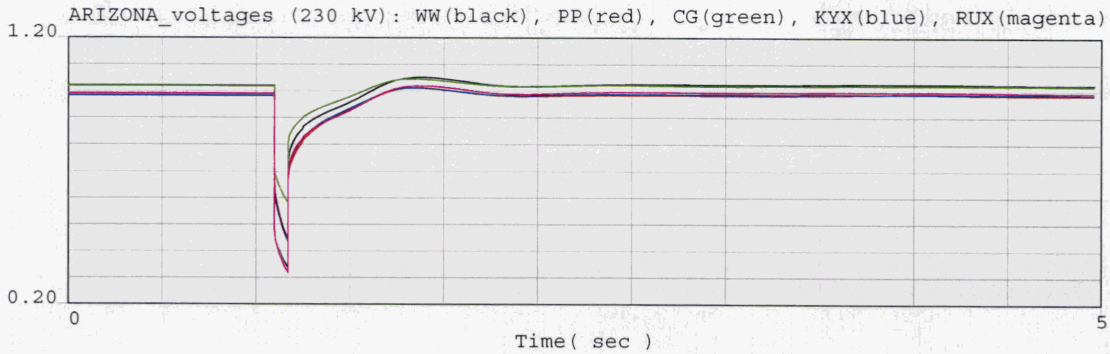
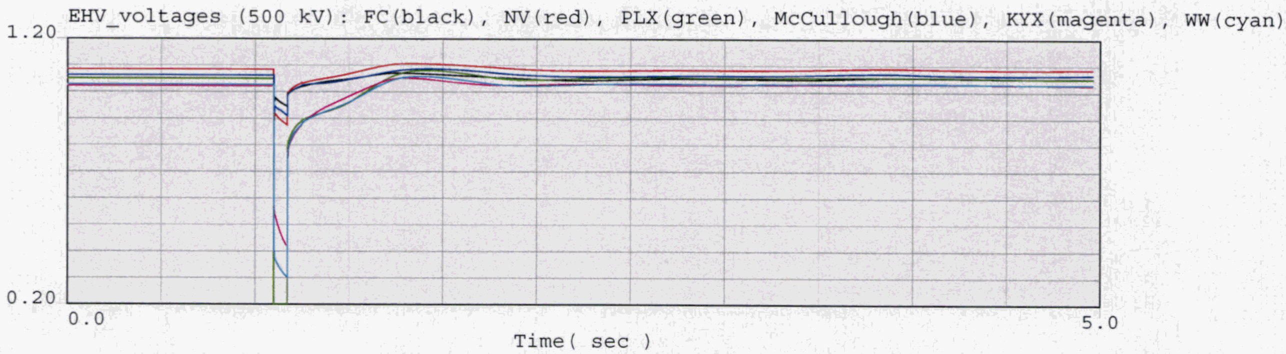
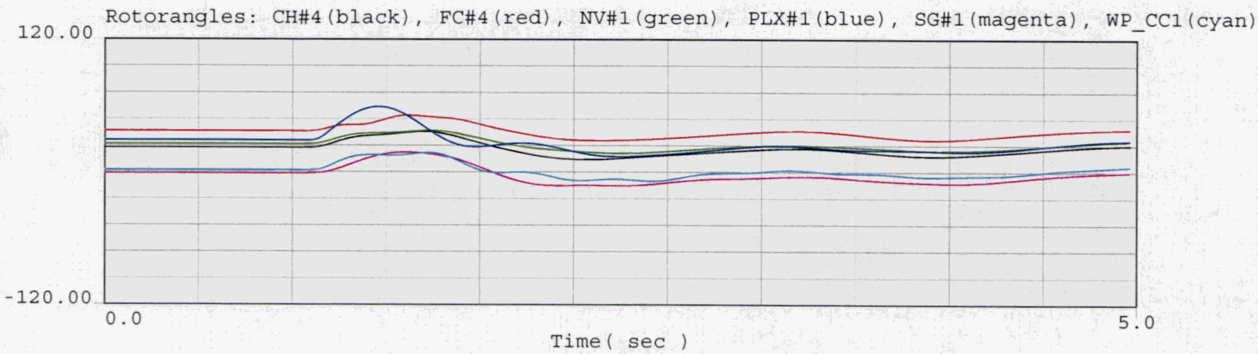
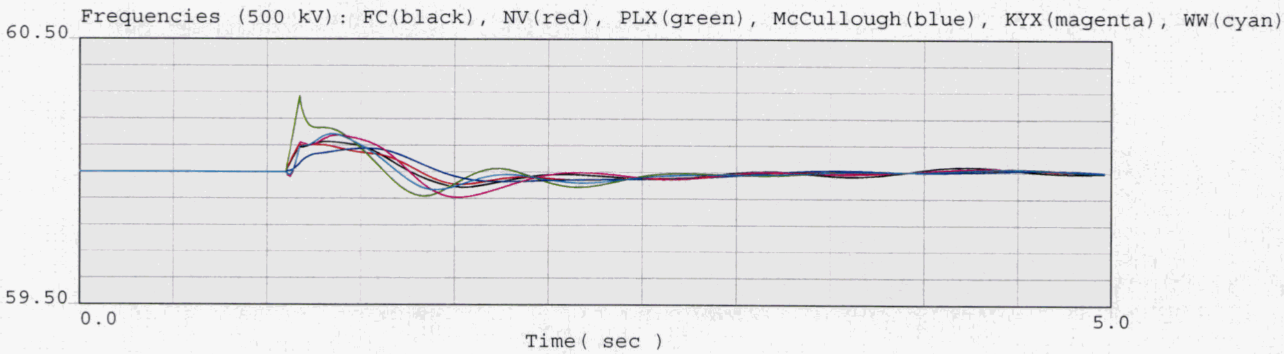
2016 Heavy Summer WECC Power Flow









WE RN ELECTRICITY COORDINATING COUNCIL
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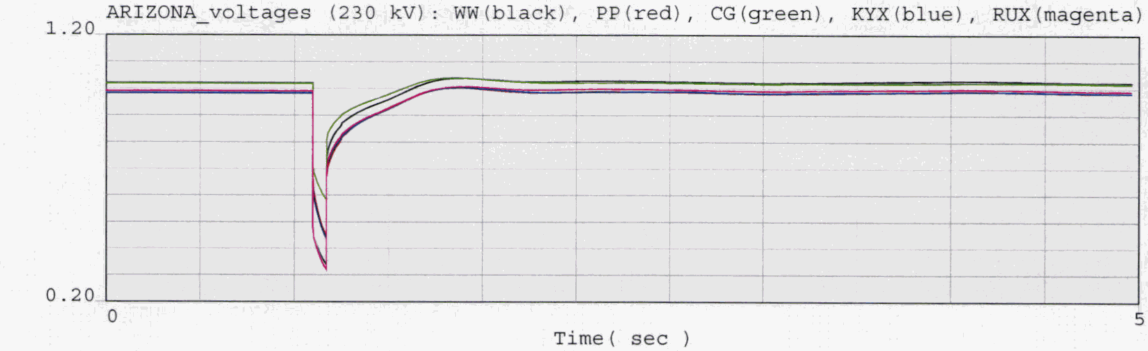
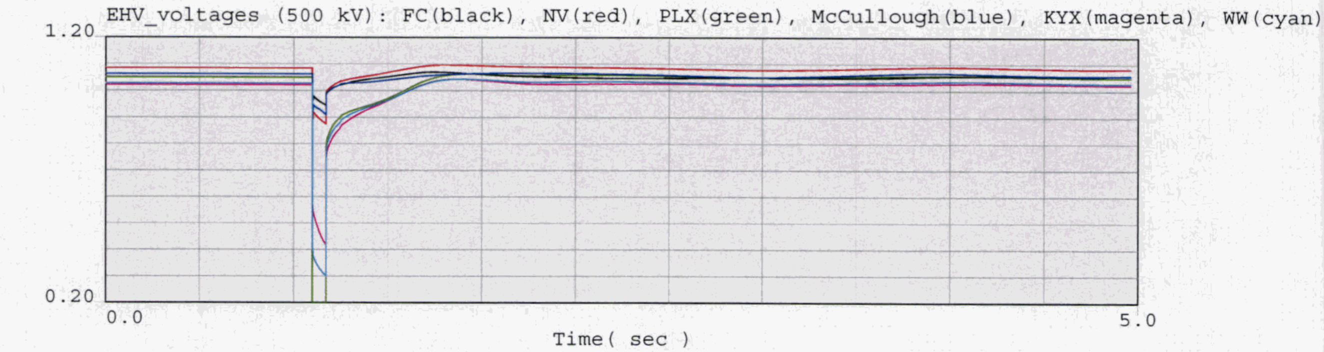
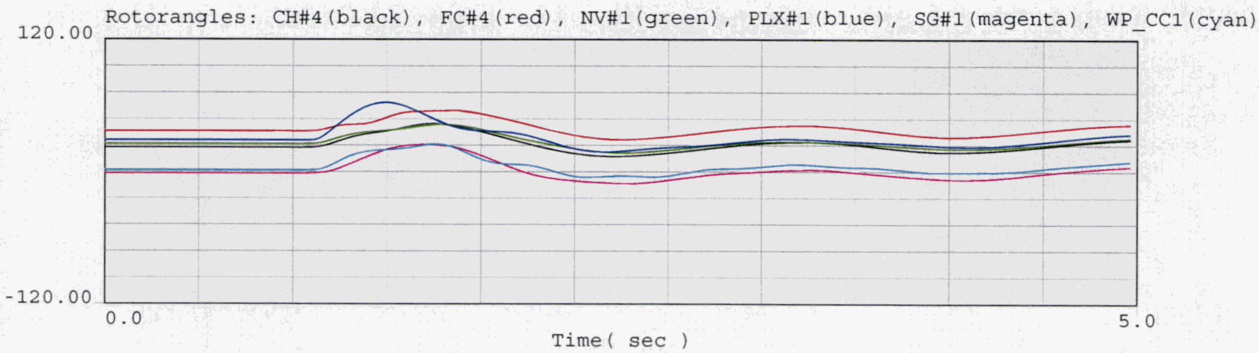
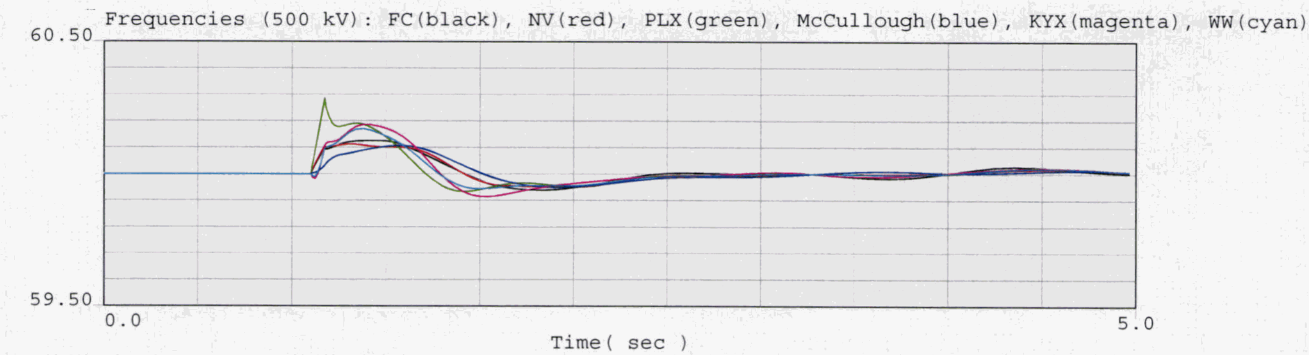
2016 Heavy Summer WECC Power Flow









WE[illegible]RN ELECTRICITY COORDINATING COUNCIL
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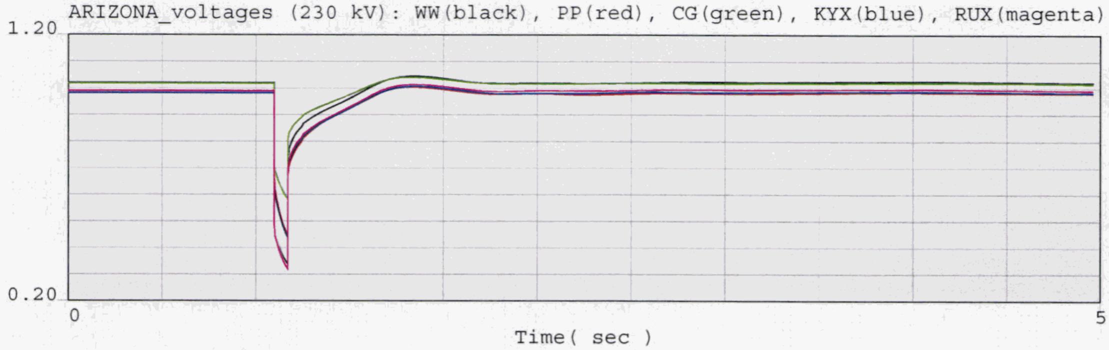
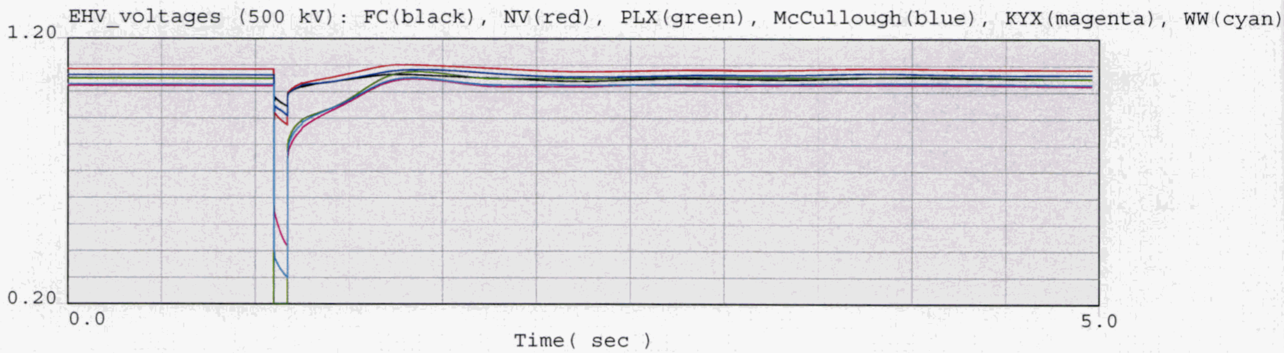
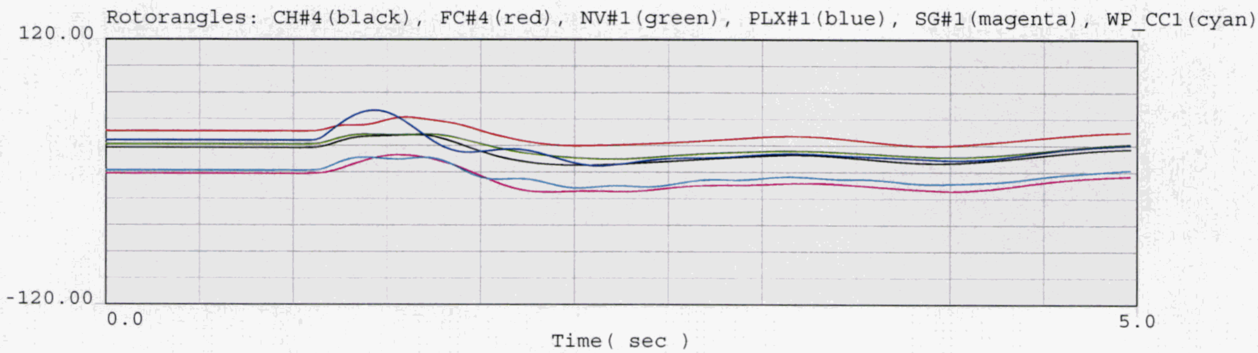
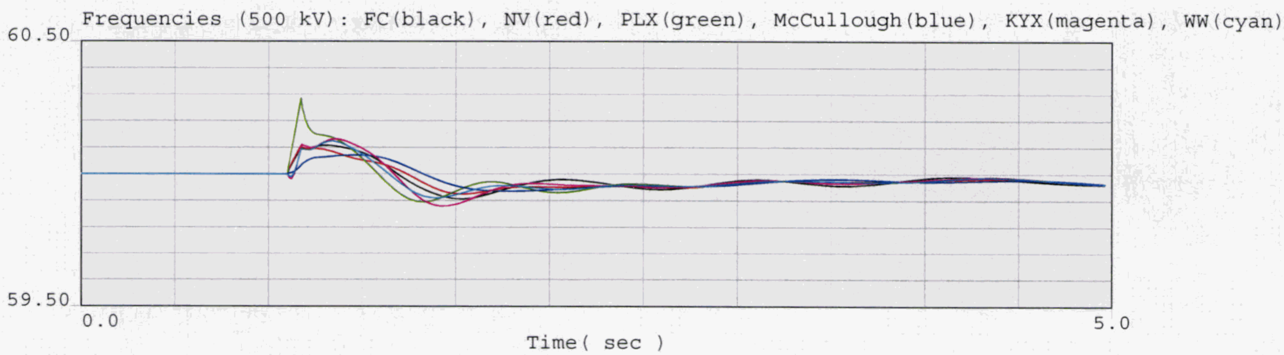
2016 Heavy Summer WECC Power Flow









WESTERN ELECTRICITY COORDINATING COUNCIL
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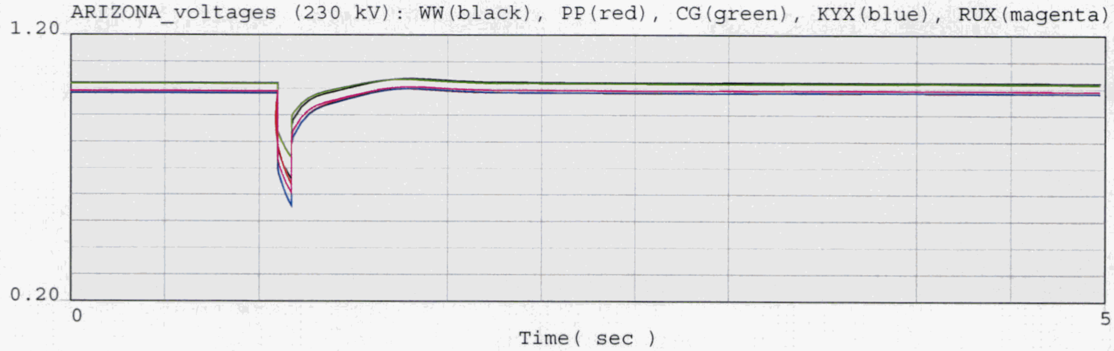

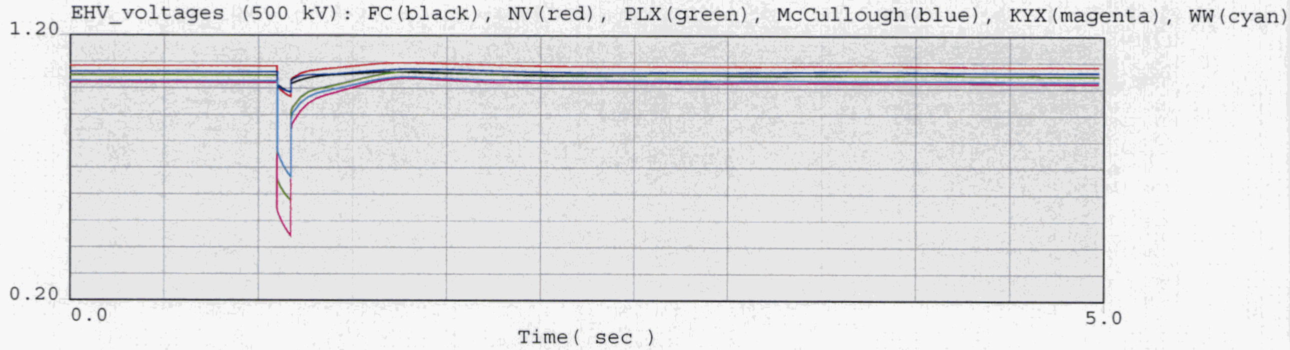

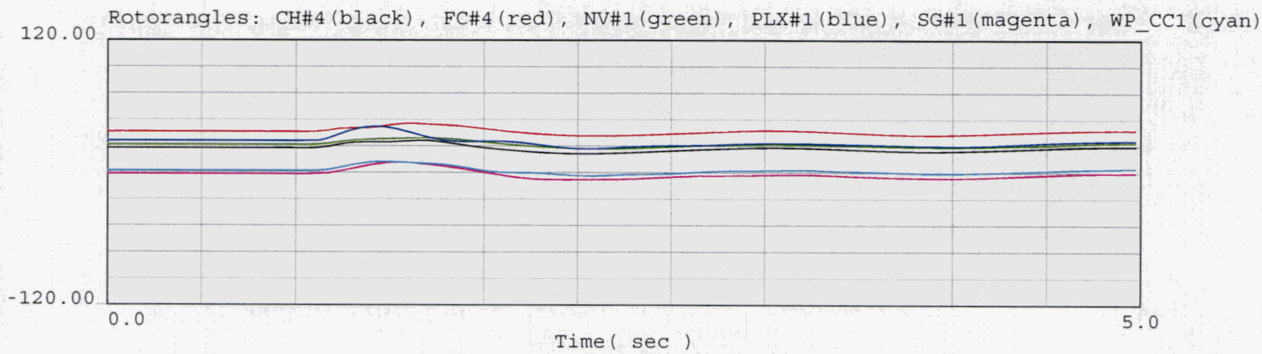

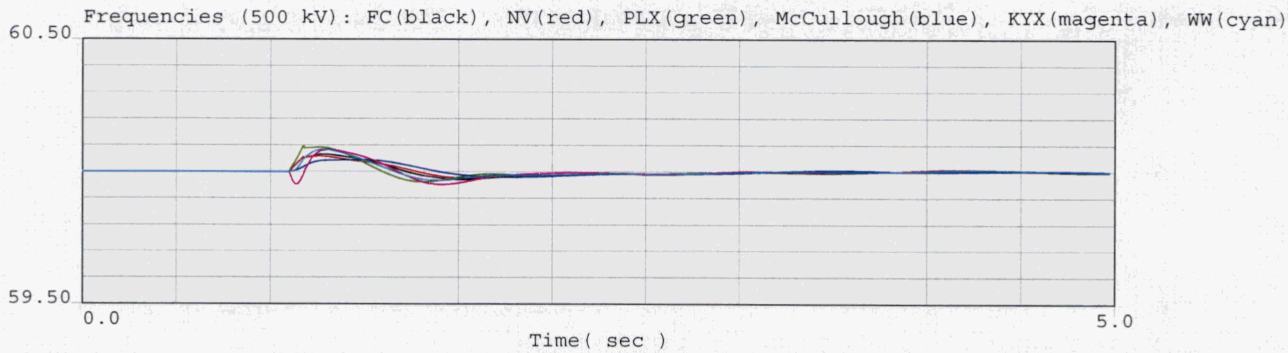

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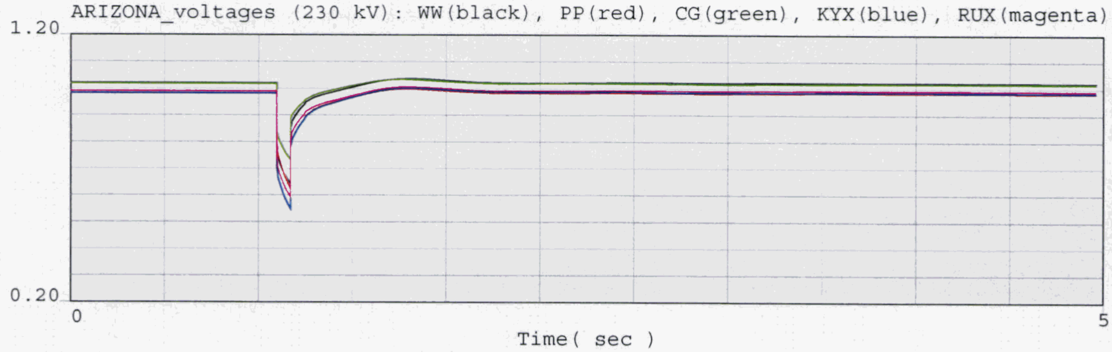
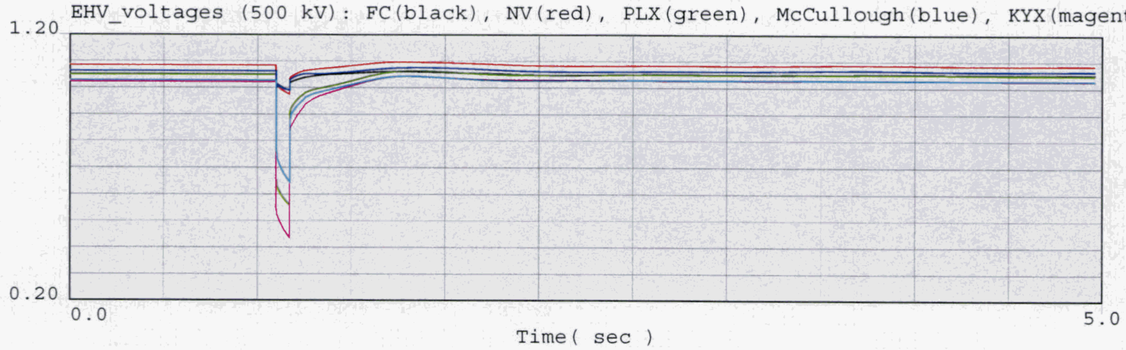
2016 Heavy Summer WECC Power Flow

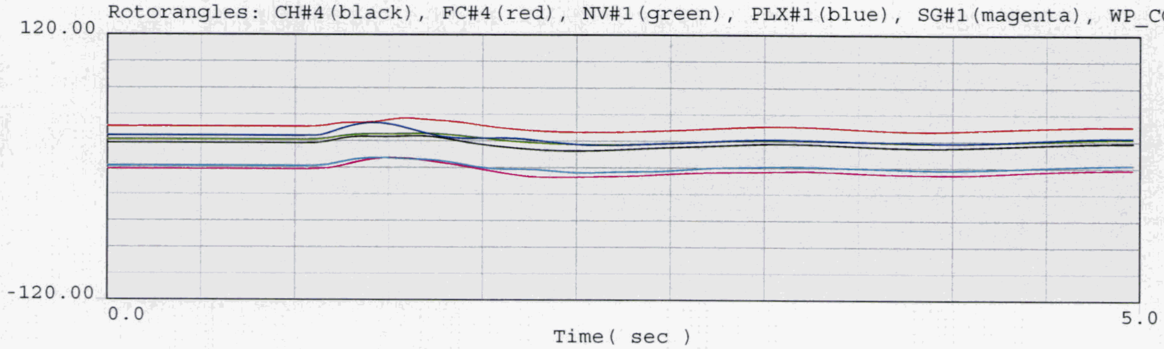
ARIZONA_voltages (230 kV): WW(black), PP(red), CG(green), KYX(blue), RUX(magenta)



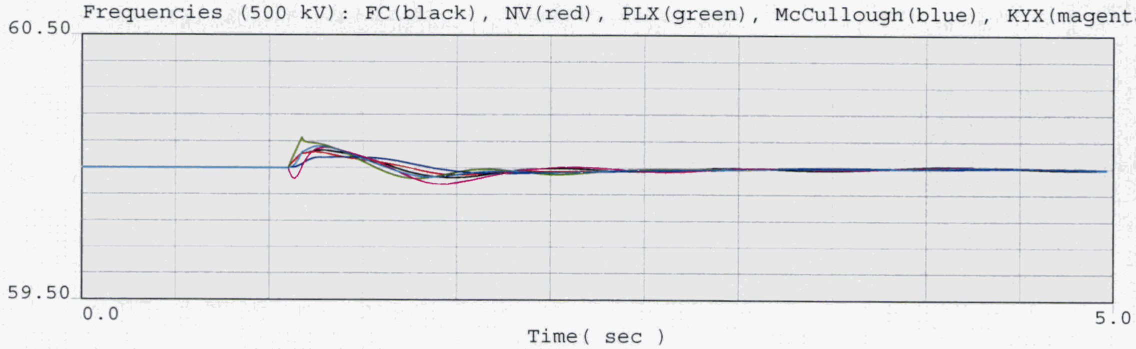
EHV_voltages (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



Rotorangles: CH#4(black), FC#4(red), NV#1(green), PLX#1(blue), SG#1(magenta), WP_CC1(cyan)



Frequencies (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



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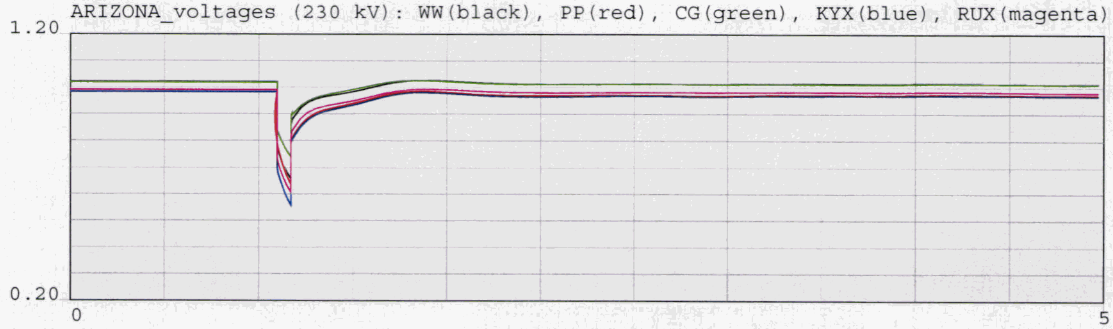
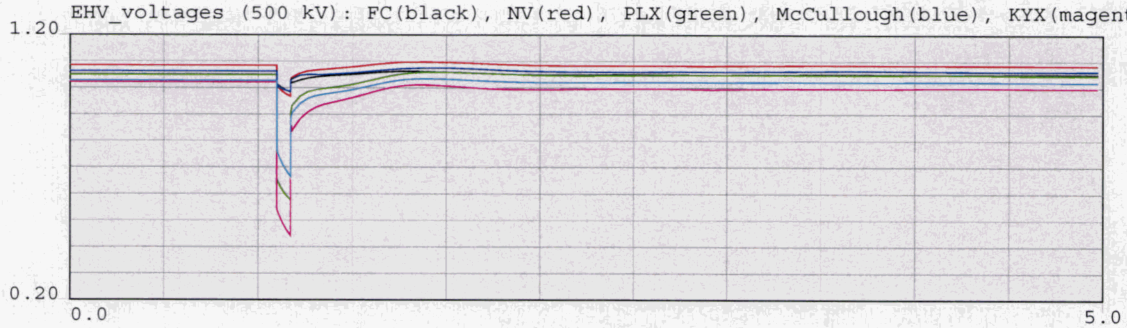
2016 Heavy Summer WECC Power Flow

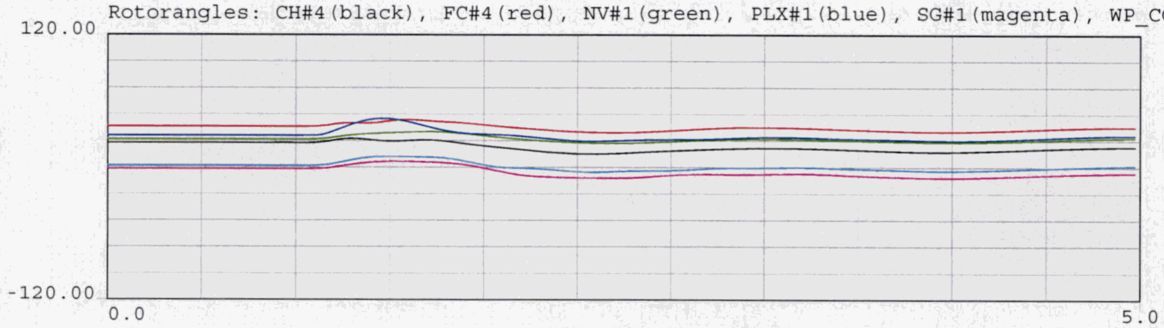
ARIZONA_voltages (230 kV): WW(black), PP(red), CG(green), KYX(blue), RUX(magenta)



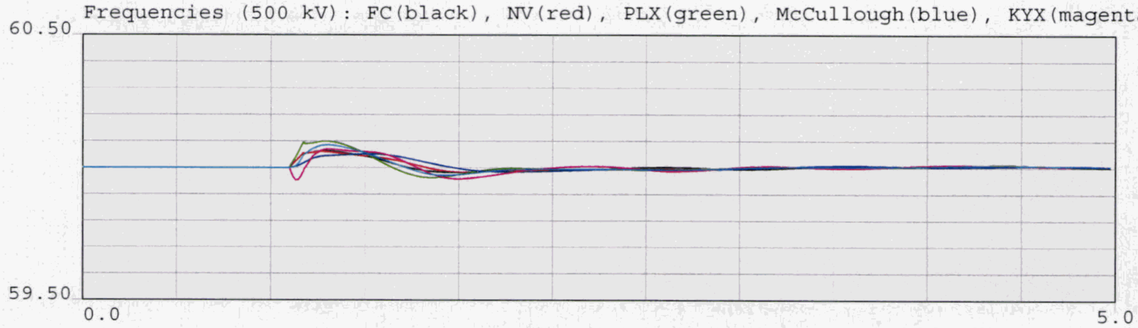
EHV_voltages (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



Rotorangles: CH#4(black), FC#4(red), NV#1(green), PLX#1(blue), SG#1(magenta), WP_CC1(cyan)



Frequencies (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



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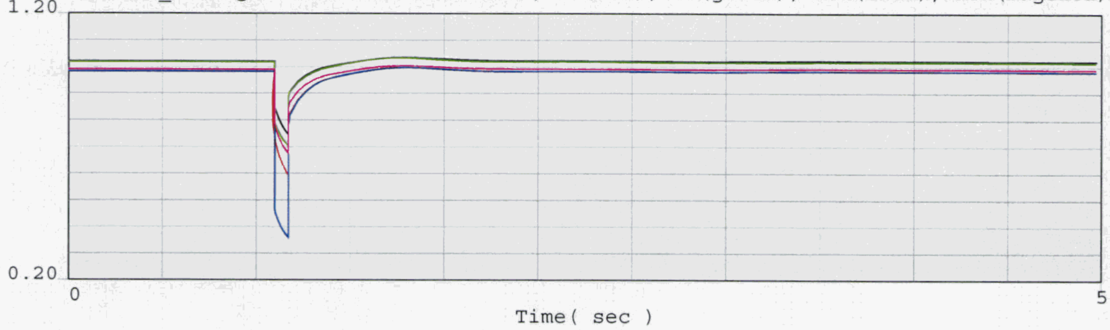
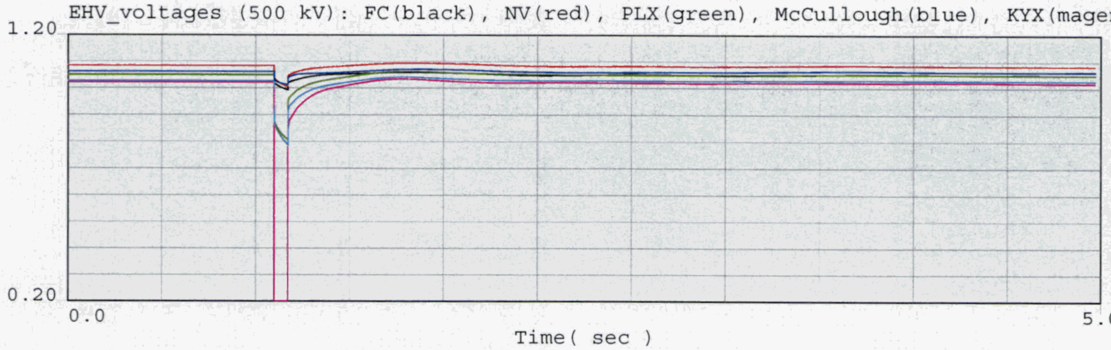
2016 Heavy Summer WECC Power Flow

ARIZONA_voltages (230 kV): WW(black), PP(red), CG(green), KYX(blue), RUX(magenta)



EHV_voltages (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



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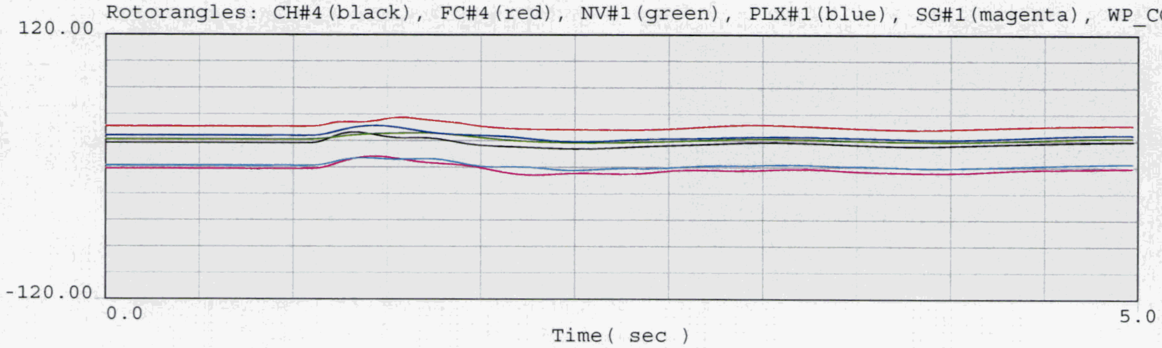
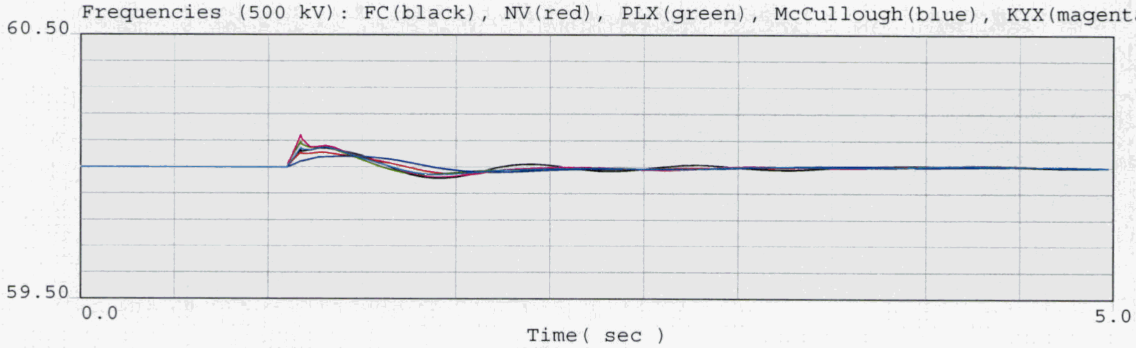


Frequencies (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



WESTERN ELECTRICITY COORDINATING COUNCIL
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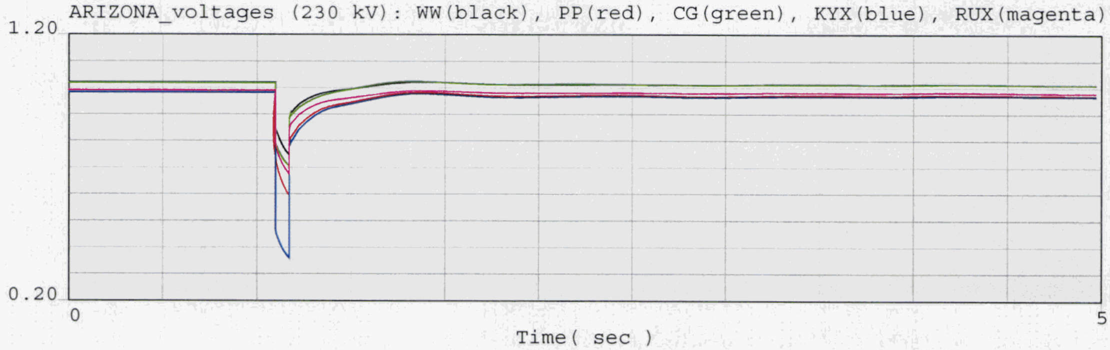
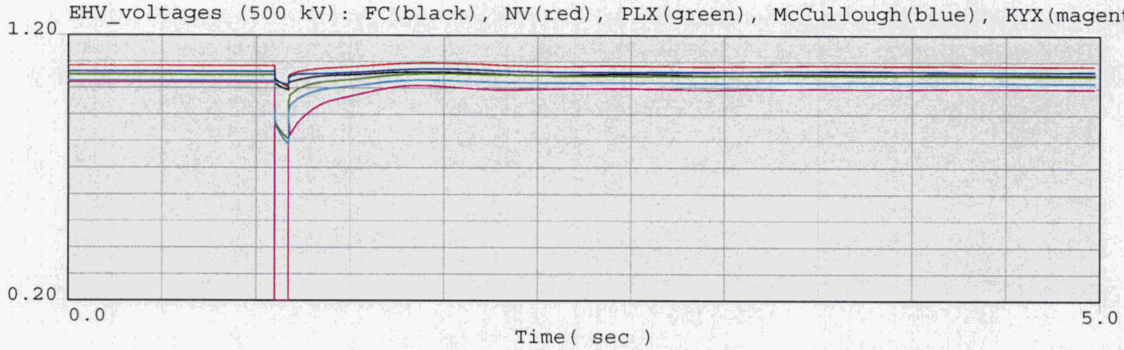
2016 Heavy Summer WECC Power Flow

ARIZONA_voltages (230 kV): WW(black), PP(red), CG(green), KYX(blue), RUX(magenta)



EHV_voltages (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



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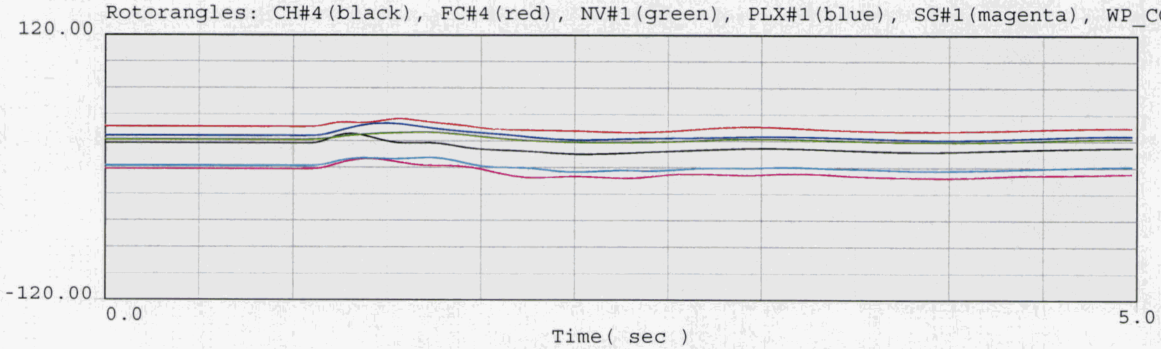

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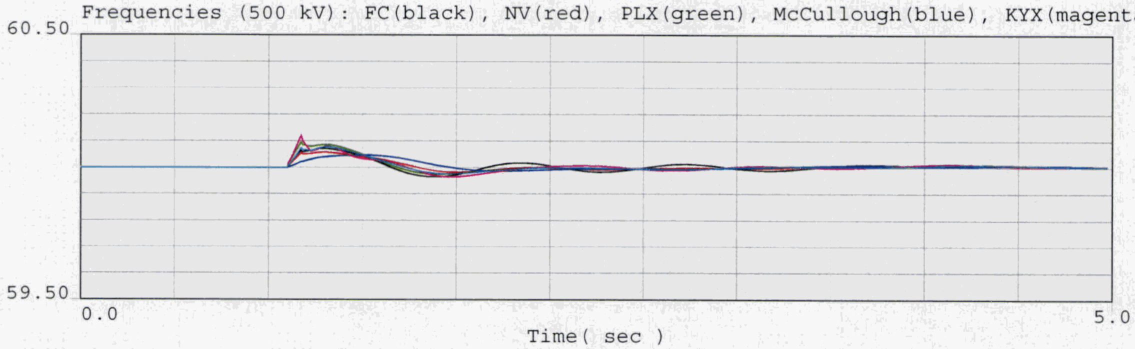

WE[illegible]ERN ELECTRICITY COORDINATING COUNCIL
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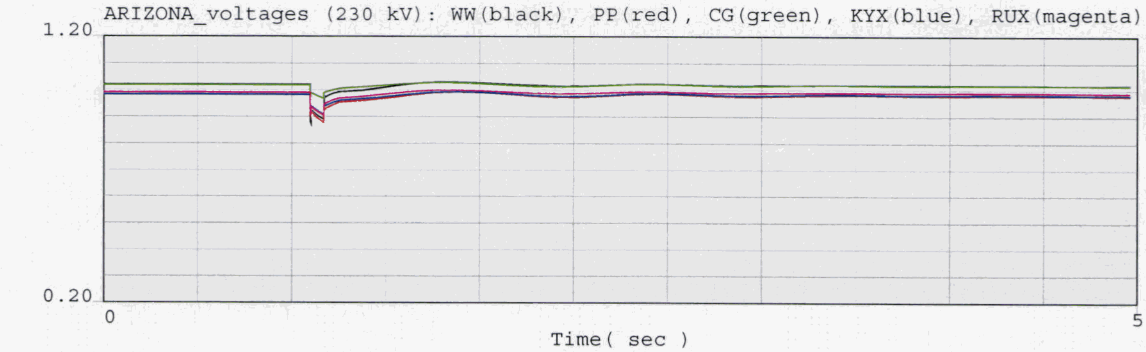
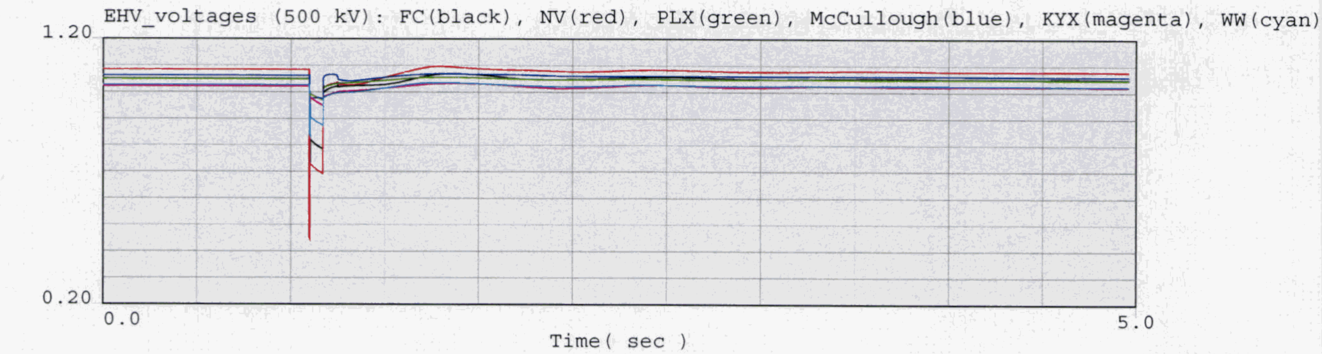
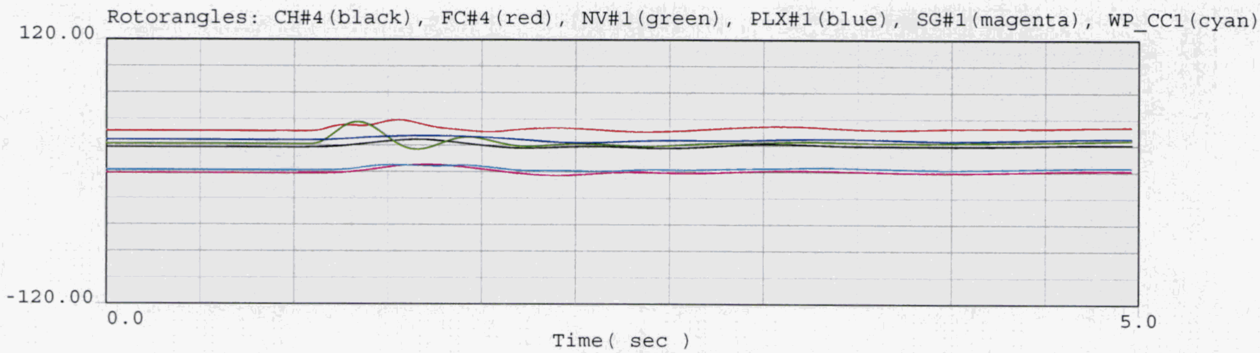
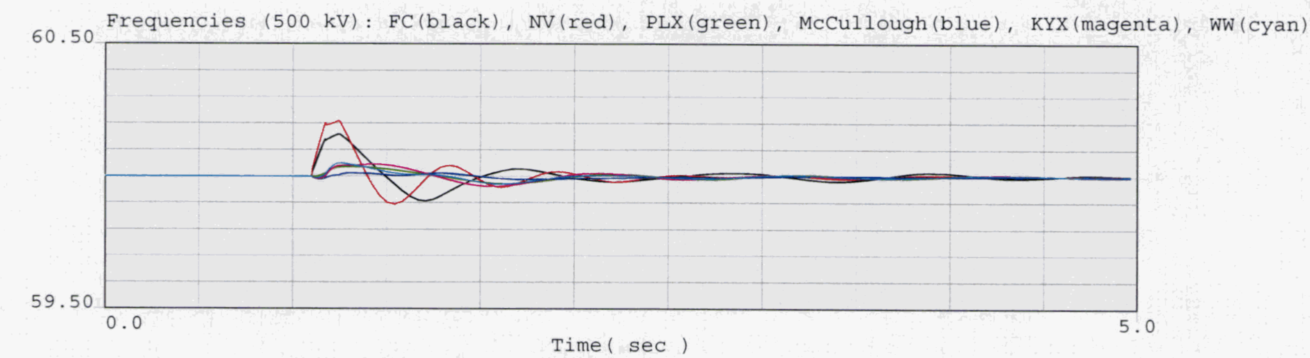
2016 Heavy Summer WECC Power Flow









W ERN ELECTRICITY COORDINATING COUNCIL
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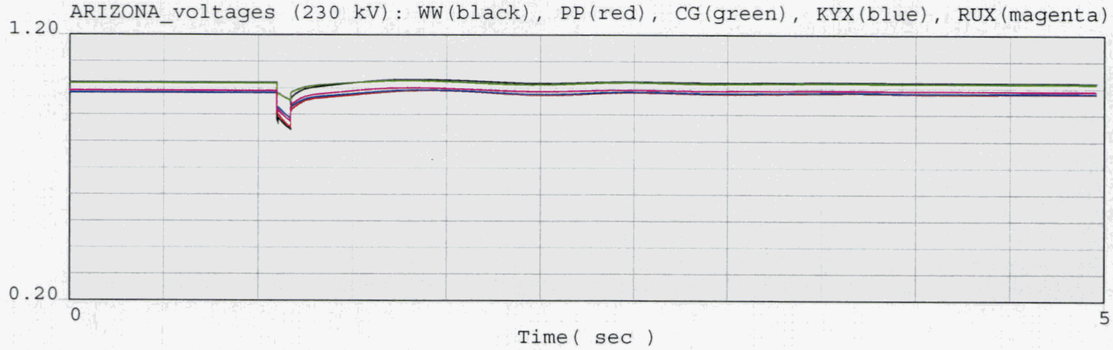
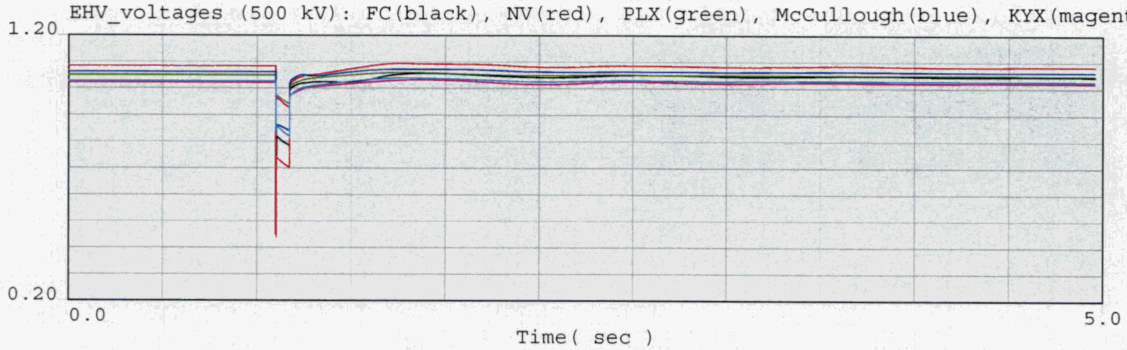
2016 Heavy Summer WECC Power Flow

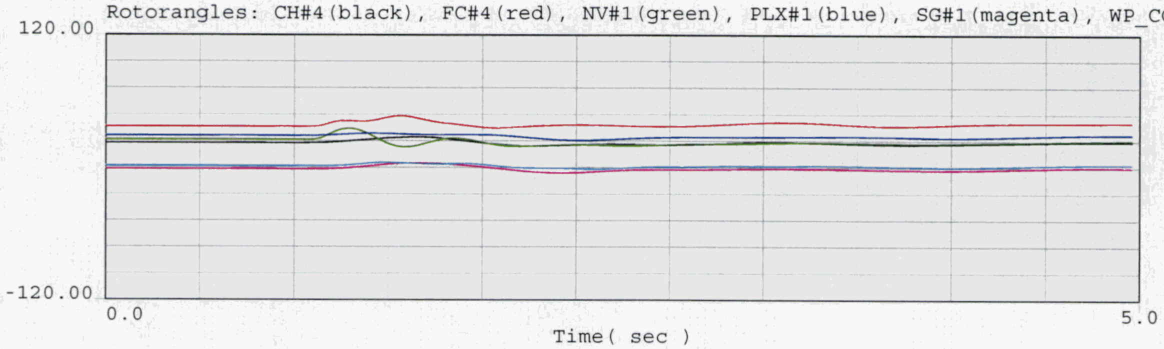
ARIZONA_voltages (230 kV): WW(black), PP(red), CG(green), KYX(blue), RUX(magenta)



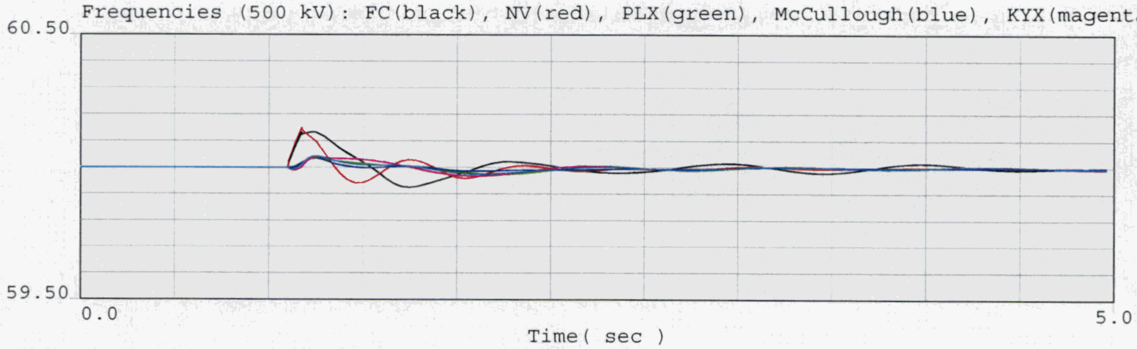
EHV_voltages (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



Rotorangles: CH#4(black), FC#4(red), NV#1(green), PLX#1(blue), SG#1(magenta), WP_CC1(cyan)



Frequencies (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



WESTERN ELECTRICITY COORDINATING COUNCIL
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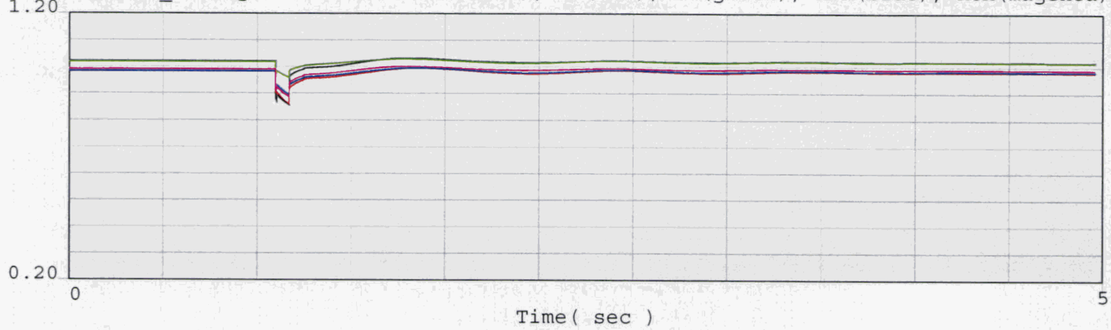
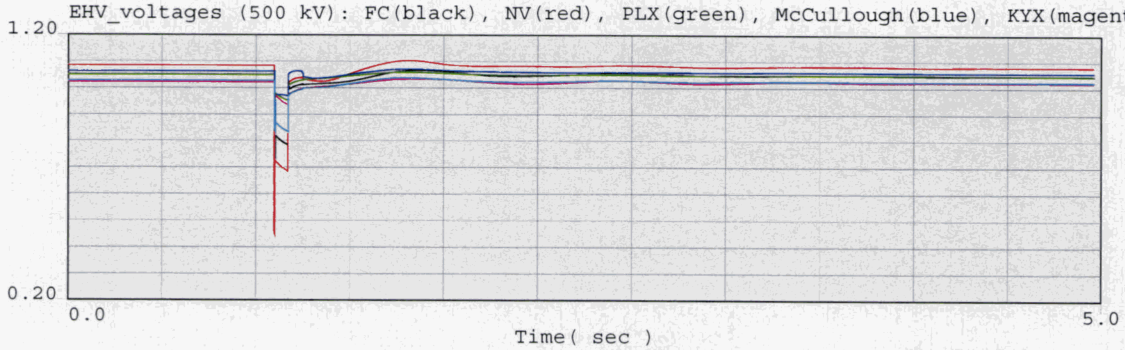
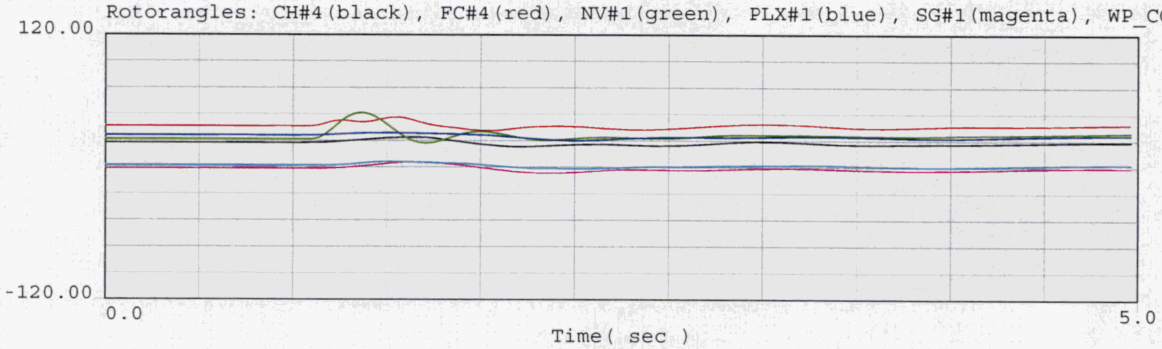
ARIZONA_voltages (230 kV): WW(black), PP(red), CG(green), KYX(blue), RUX(magenta)



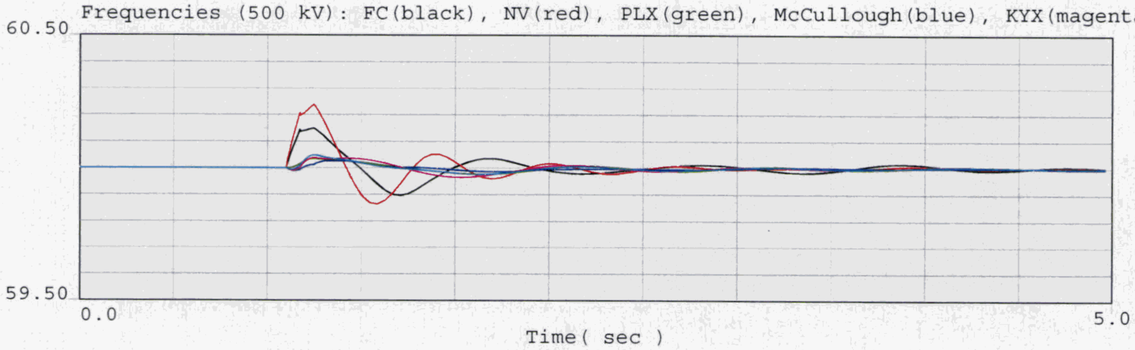
EHV_voltages (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



Rotorangles: CH#4(black), FC#4(red), NV#1(green), PLX#1(blue), SG#1(magenta), WP_CC1(cyan)



Frequencies (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



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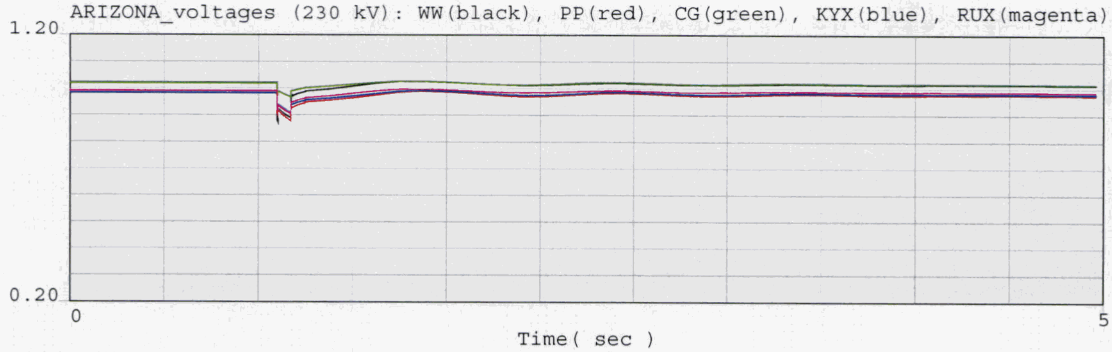
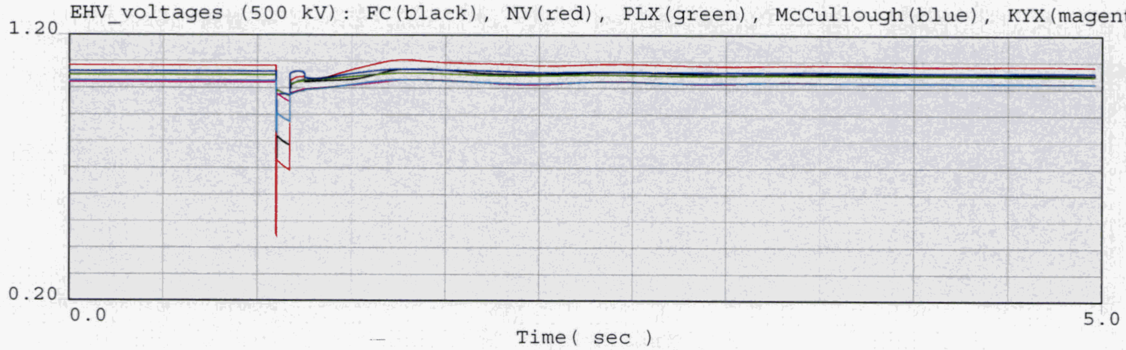
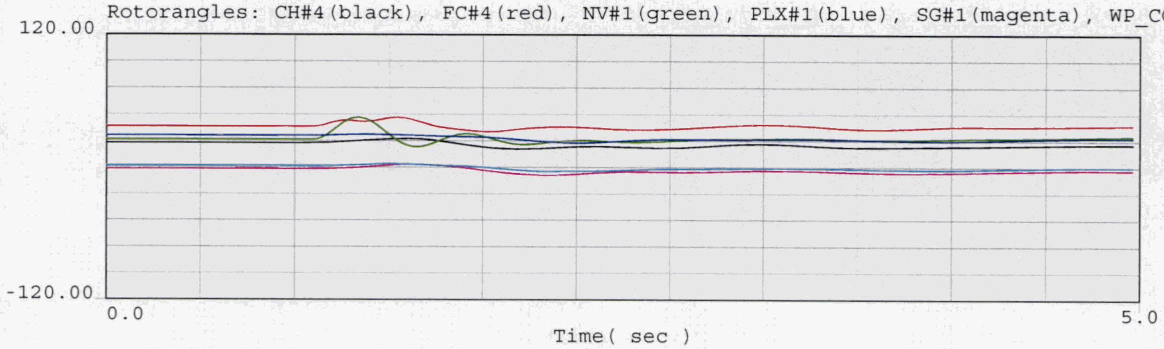
ARIZONA_voltages (230 kV): WW(black), PP(red), CG(green), KYX(blue), RUX(magenta)



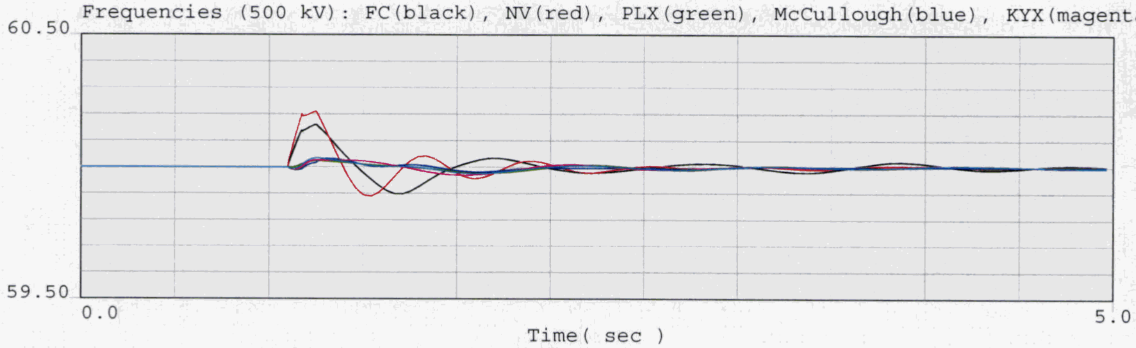
EHV_voltages (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



Rotorangles: CH#4(black), FC#4(red), NV#1(green), PLX#1(blue), SG#1(magenta), WP_CC1(cyan)



Frequencies (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



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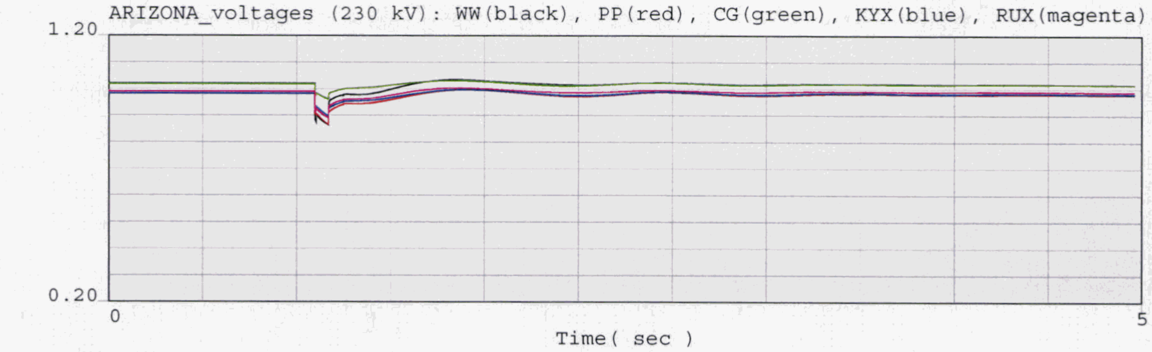

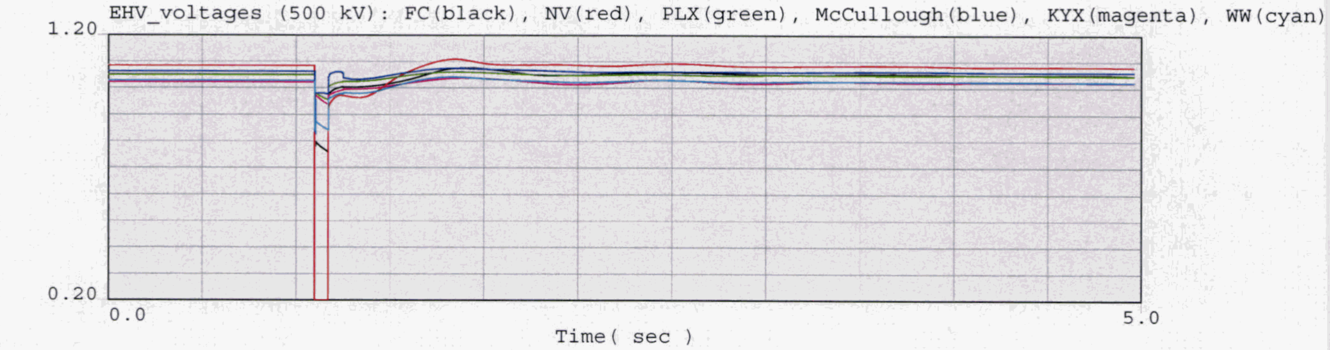

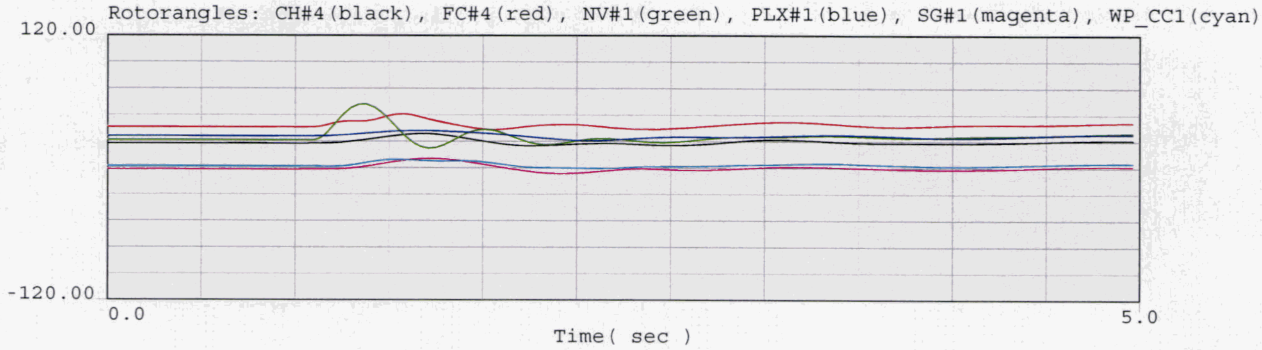

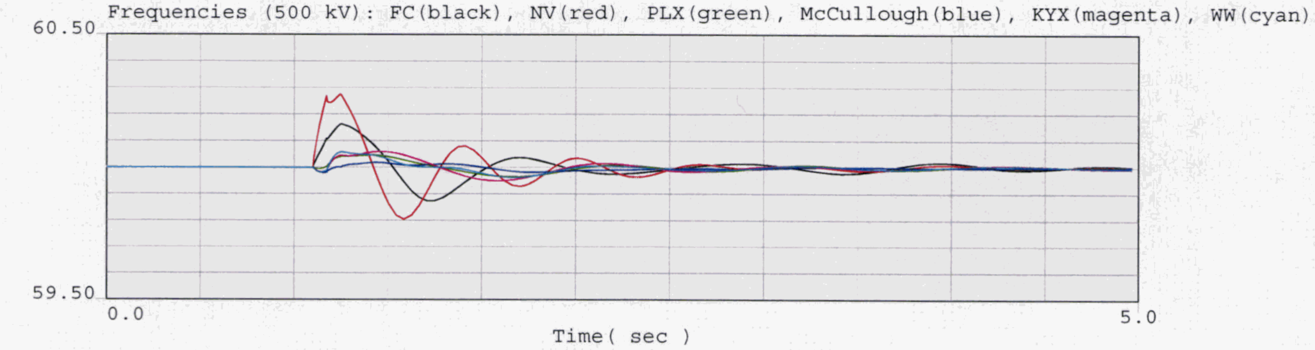

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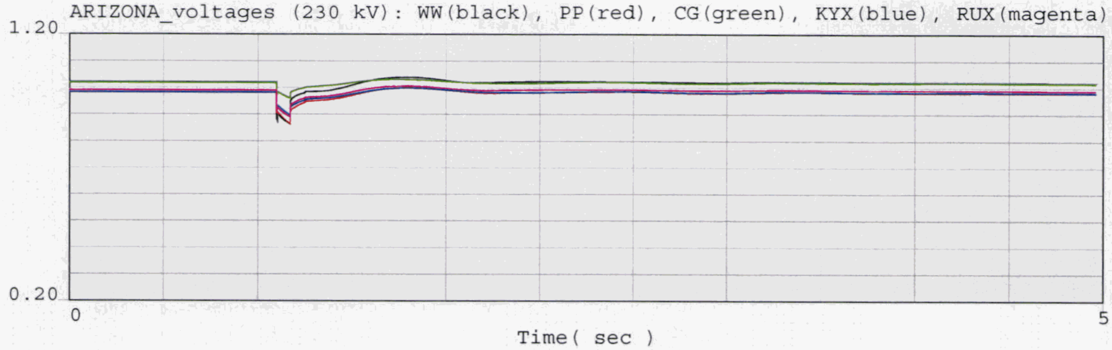
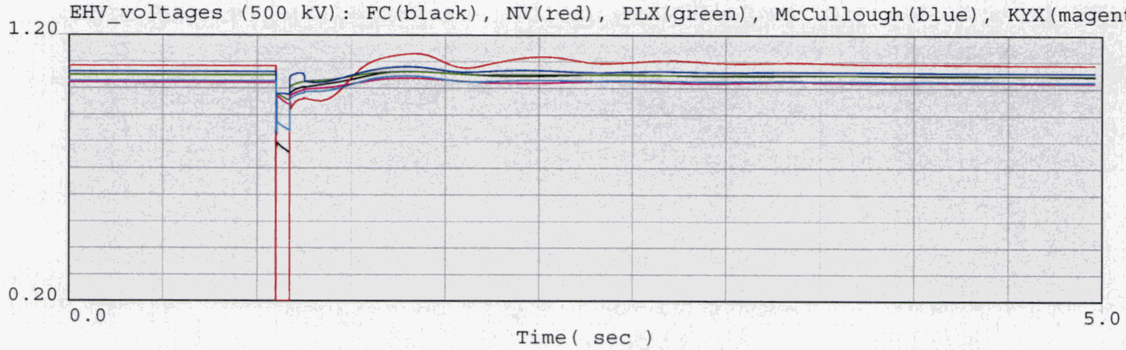
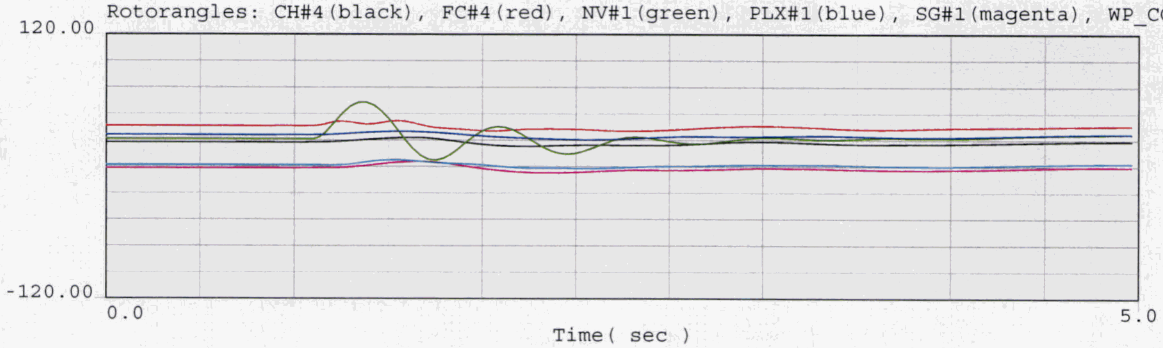
ARIZONA_voltages (230 kV): WW(black), PP(red), CG(green), KYX(blue), RUX(magenta)



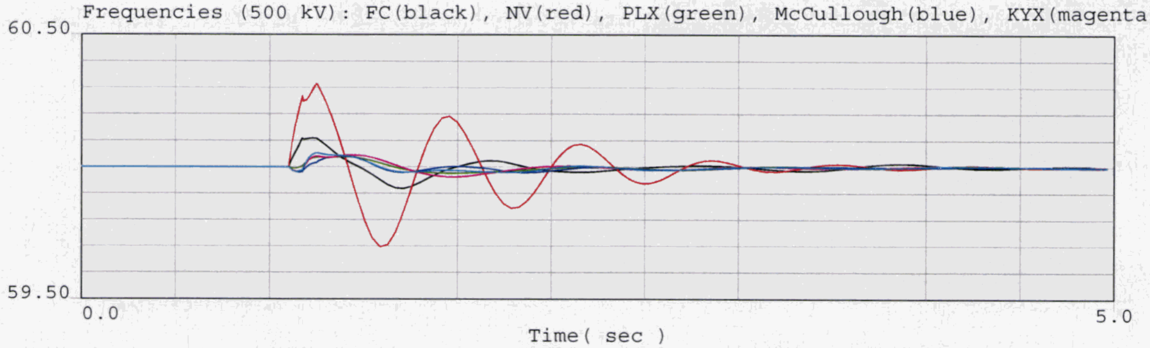
EHV_voltages (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



Rotorangles: CH#4(black), FC#4(red), NV#1(green), PLX#1(blue), SG#1(magenta), WP_CC1(cyan)



Frequencies (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



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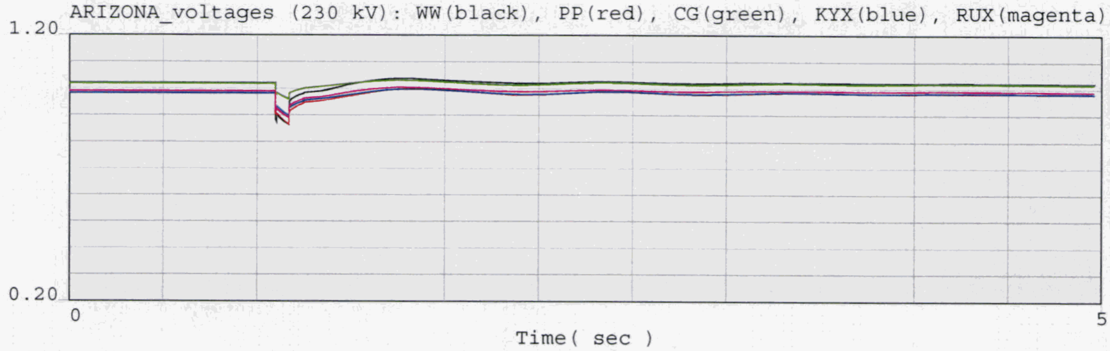
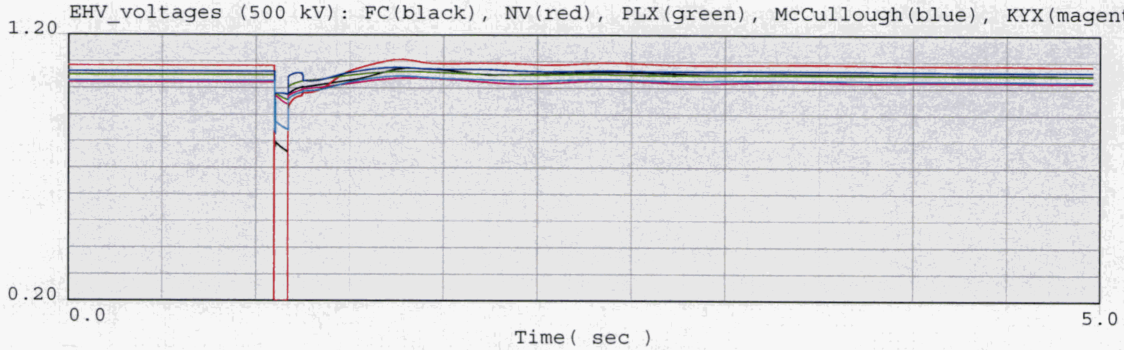
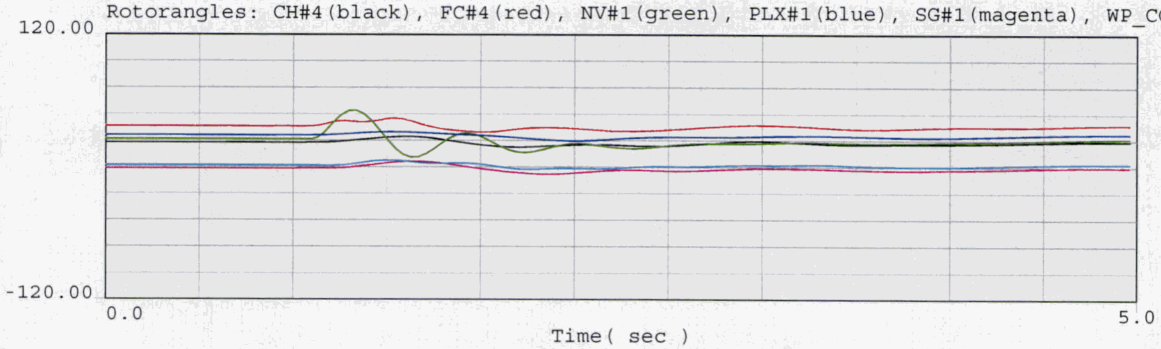
ARIZONA_voltages (230 kV): WW(black), PP(red), CG(green), KYX(blue), RUX(magenta)



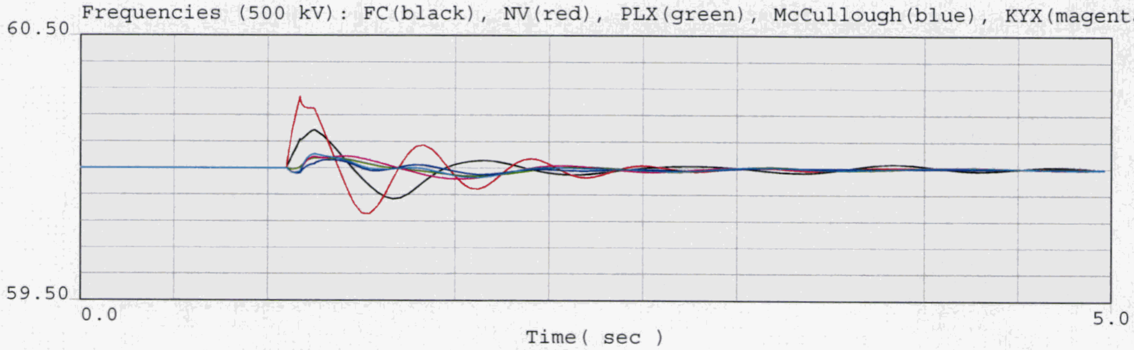
EHV_voltages (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



Rotorangles: CH#4(black), FC#4(red), NV#1(green), PLX#1(blue), SG#1(magenta), WP_CC1(cyan)



Frequencies (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



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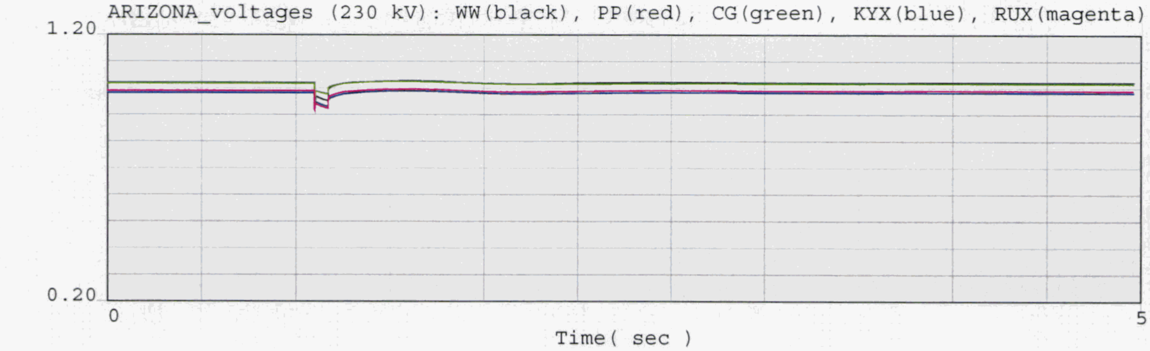
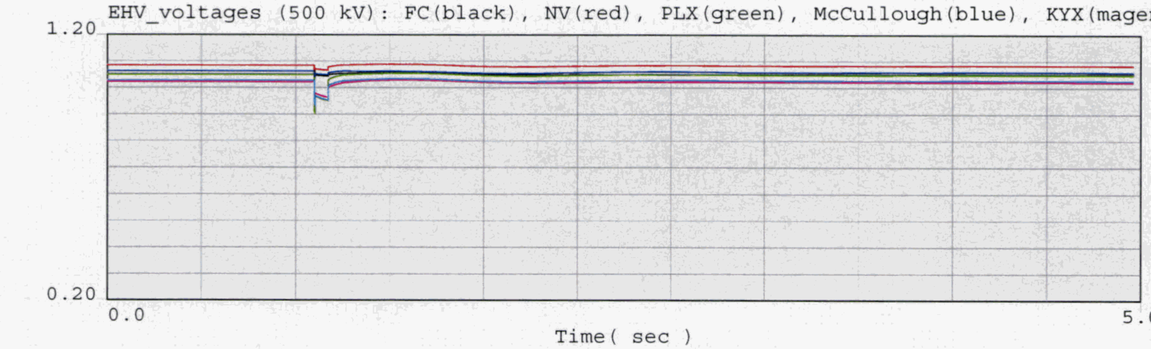
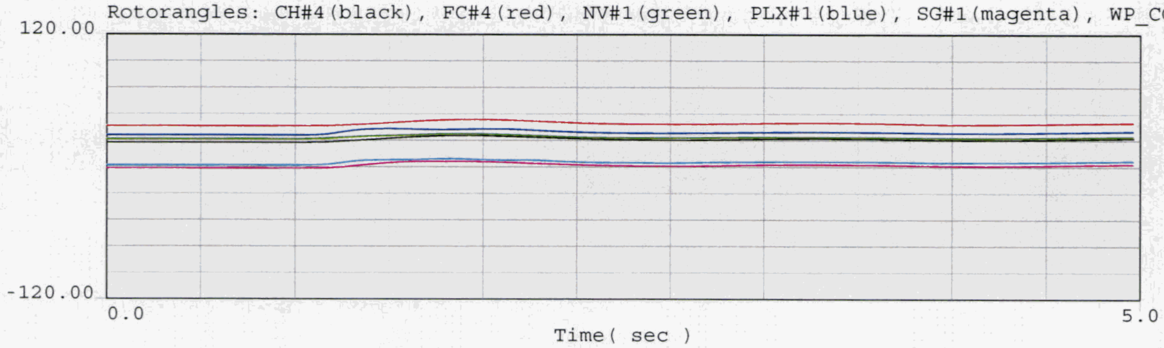
ARIZONA_voltages (230 kV): WW(black), PP(red), CG(green), KYX(blue), RUX(magenta)



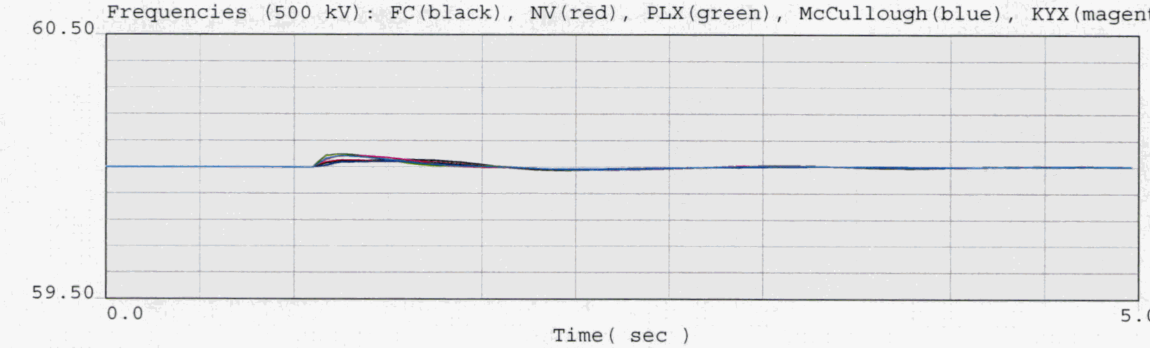
EHV_voltages (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



Rotorangles: CH#4(black), FC#4(red), NV#1(green), PLX#1(blue), SG#1(magenta), WP_CC1(cyan)



Frequencies (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



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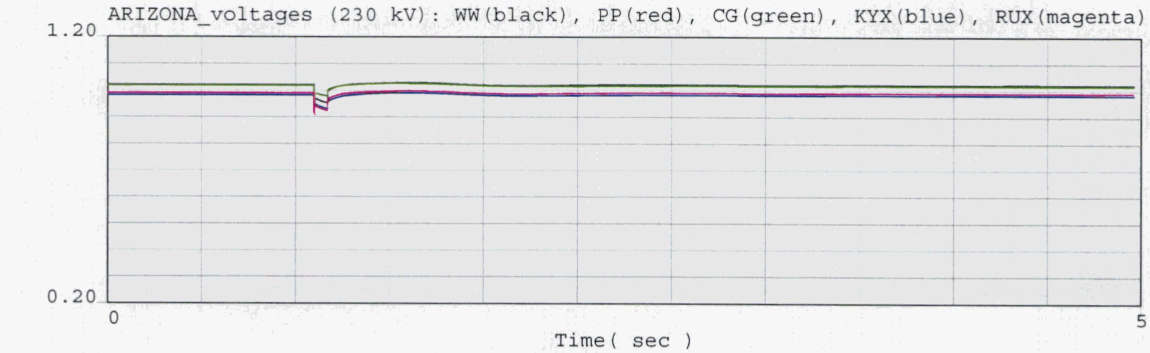

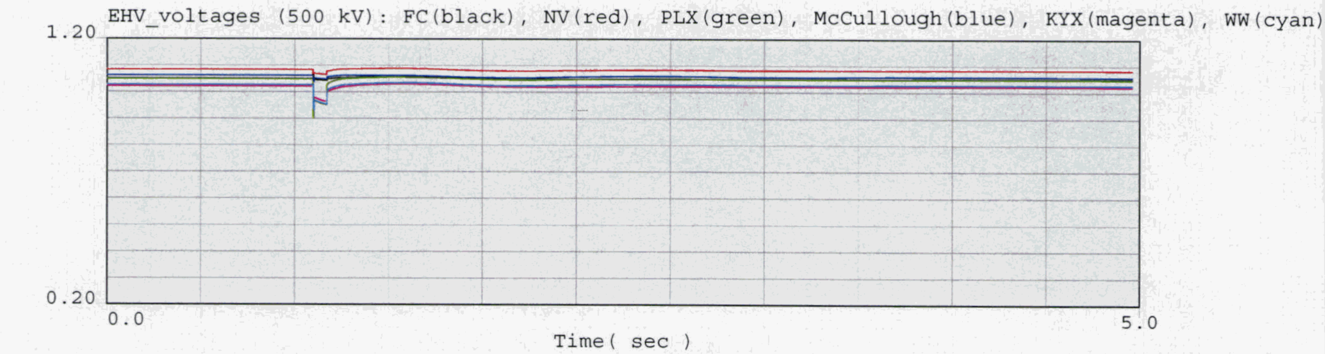

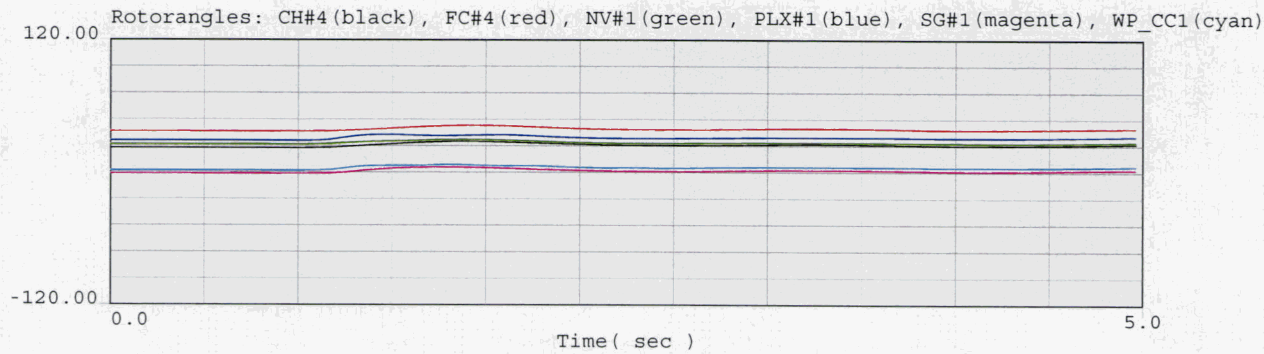

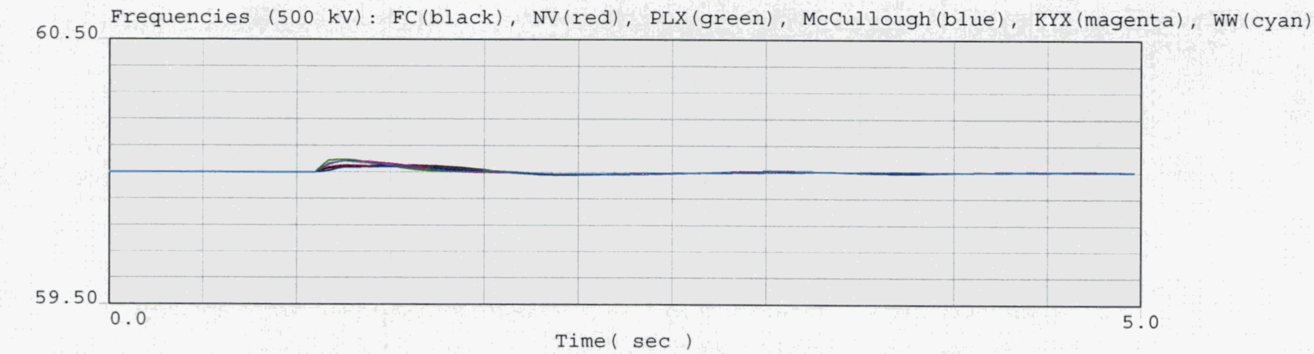

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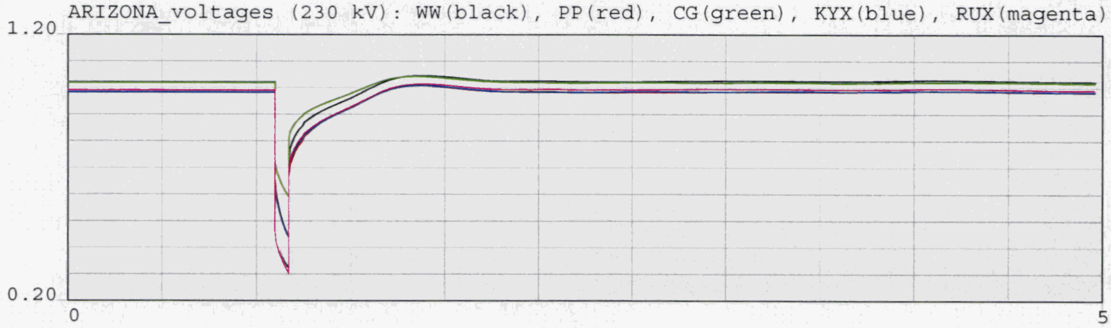
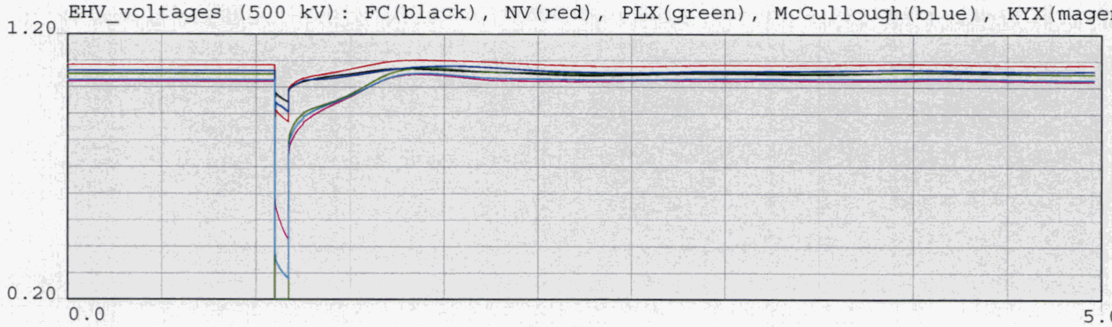
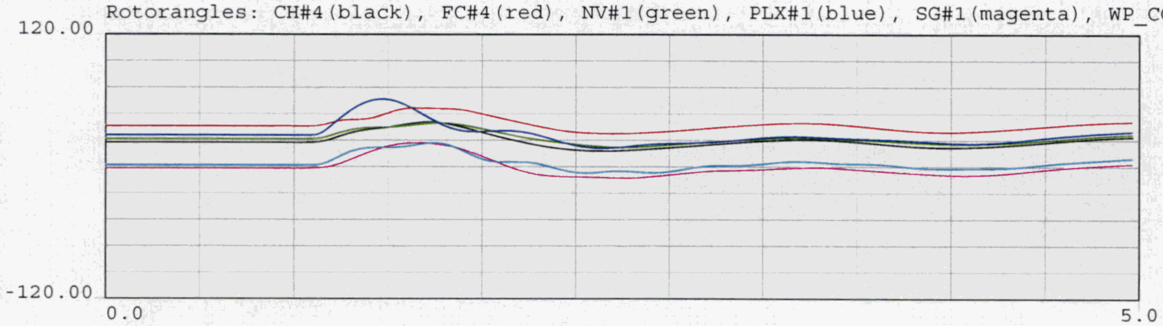
ARIZONA_voltages (230 kV): WW(black), PP(red), CG(green), KYX(blue), RUX(magenta)



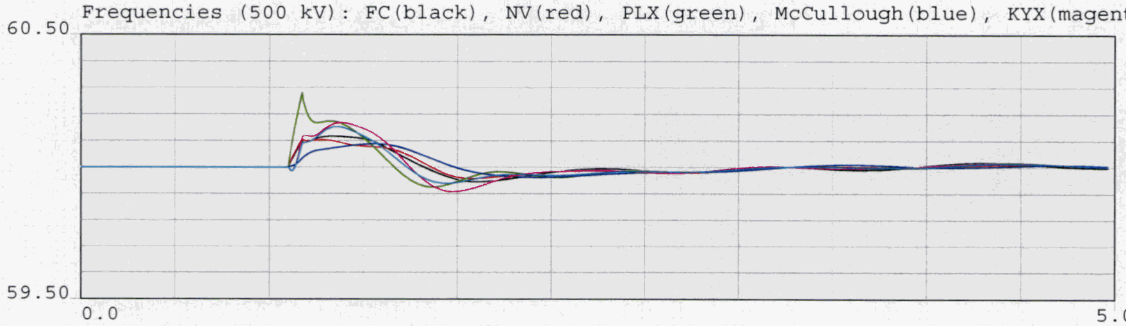
EHV_voltages (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



Rotorangles: CH#4(black), FC#4(red), NV#1(green), PLX#1(blue), SG#1(magenta), WP_CC1(cyan)



Frequencies (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



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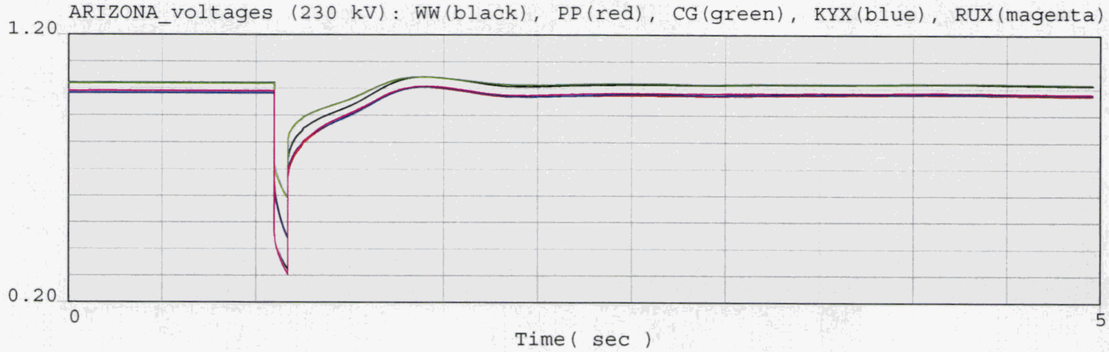
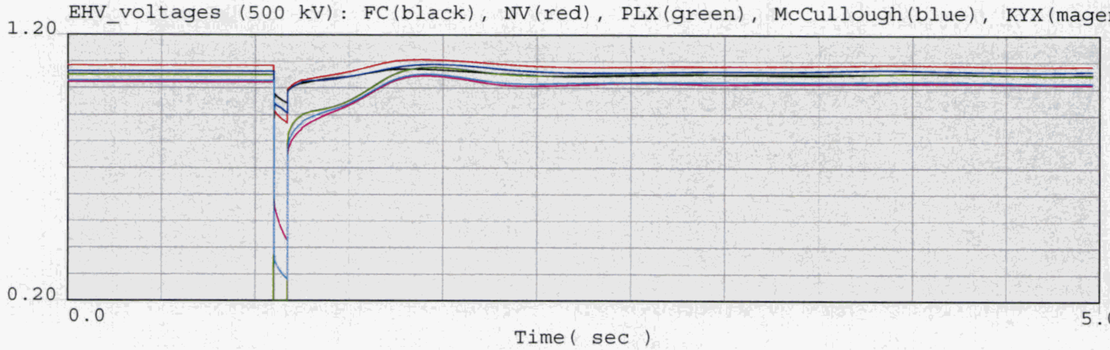
ARIZONA_voltages (230 kV): WW(black), PP(red), CG(green), KYX(blue), RUX(magenta)



EHV_voltages (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



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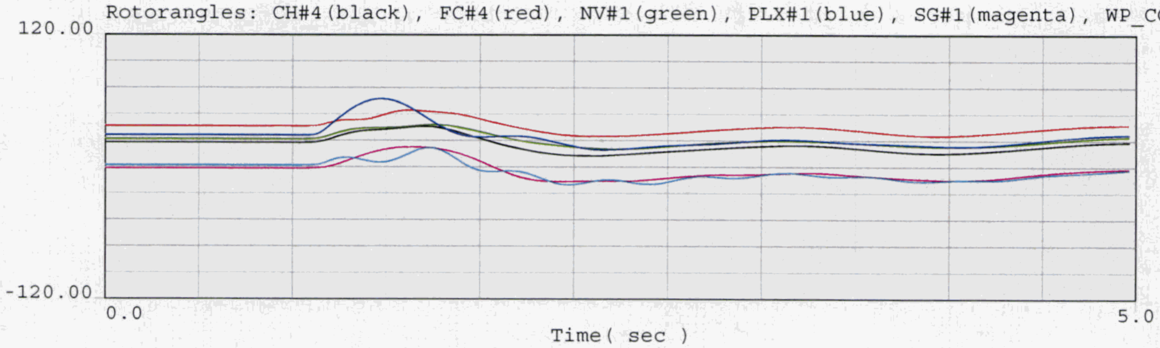

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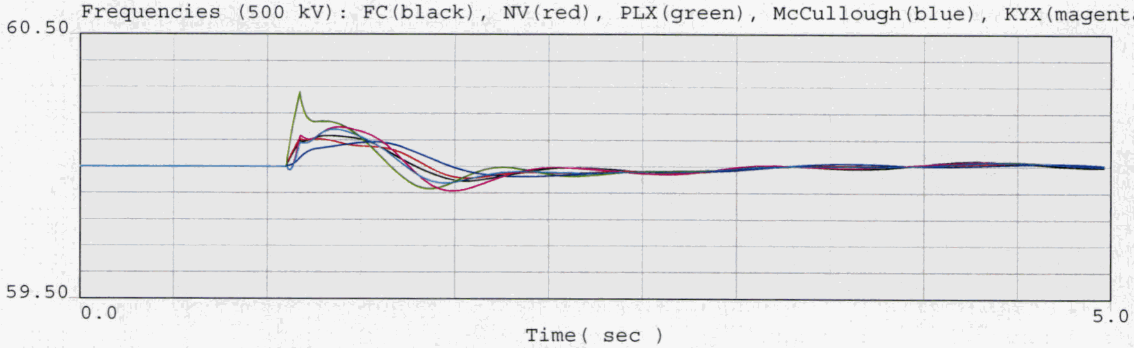

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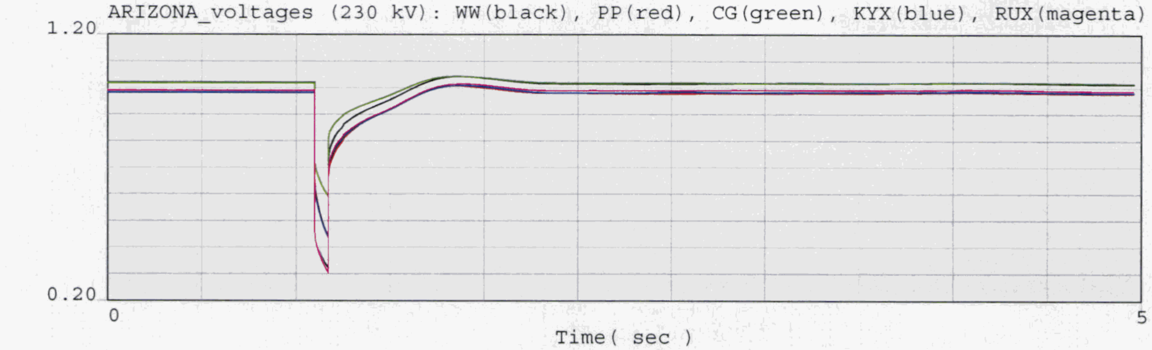
ARIZONA_voltages (230 kV): WW(black), PP(red), CG(green), KYX(blue), RUX(magenta)



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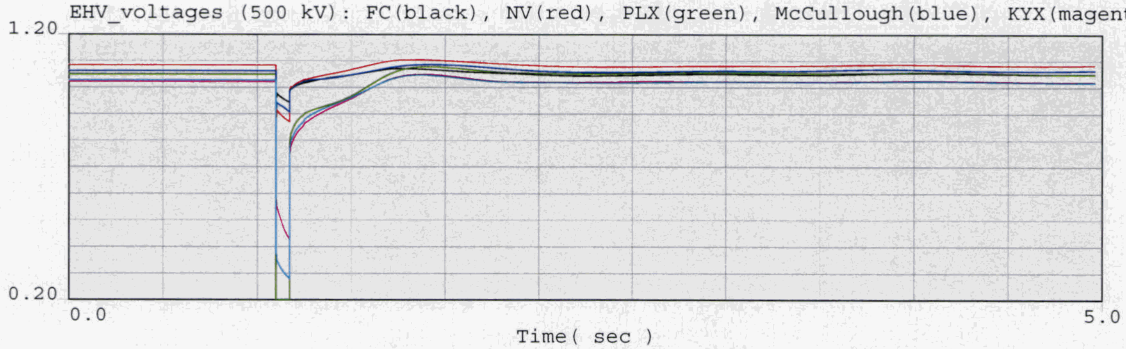

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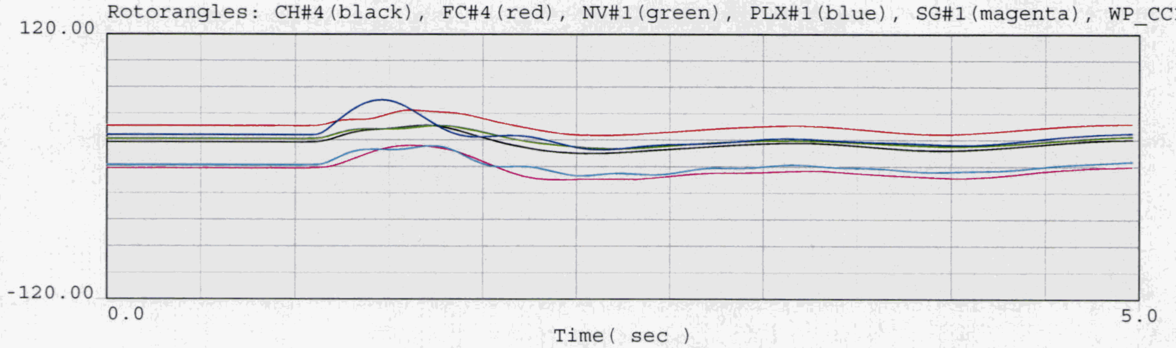

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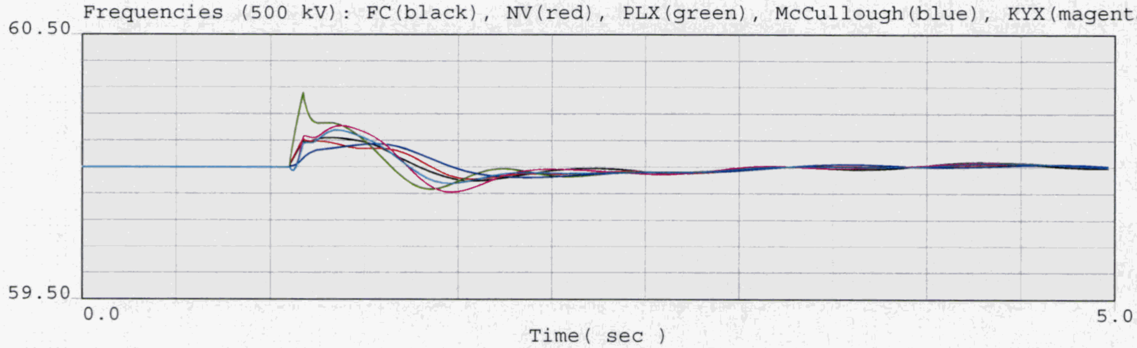

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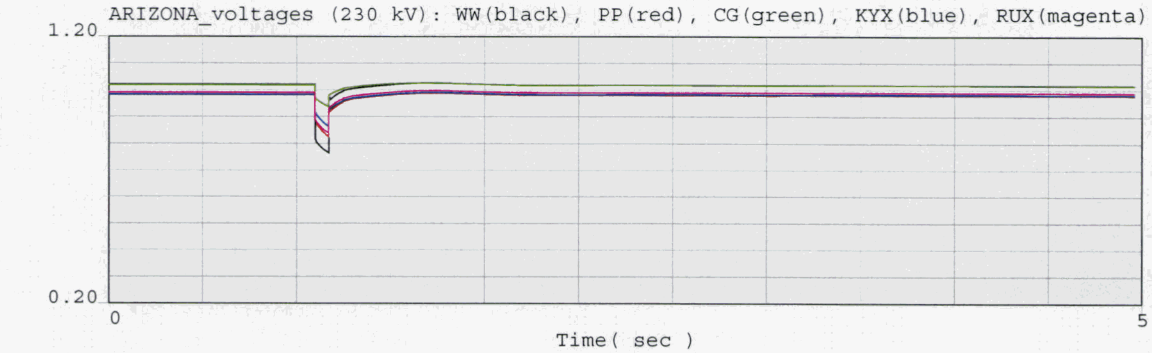

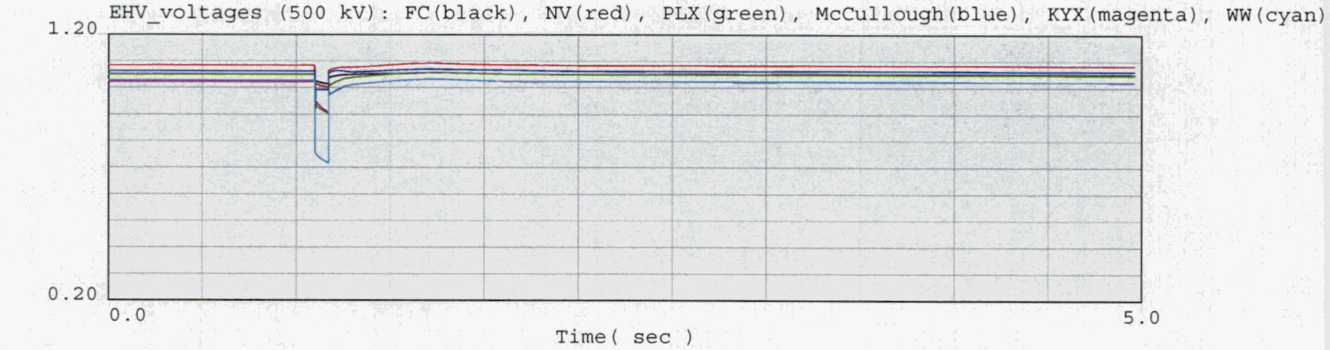

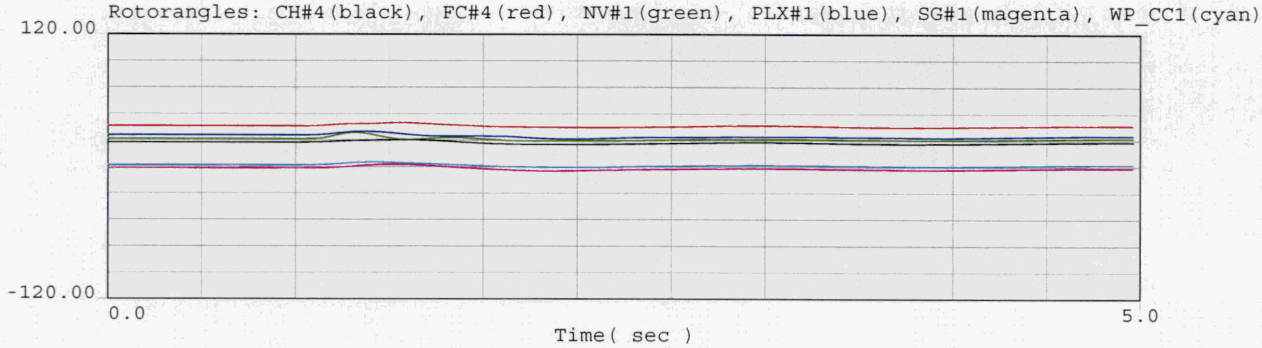

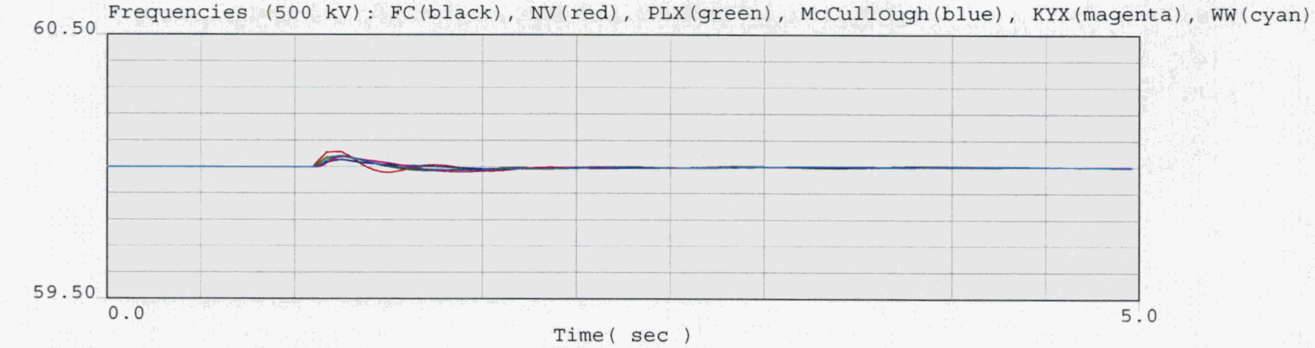

WE[illegible]RN ELECTRICITY COORDINATING COUNCIL
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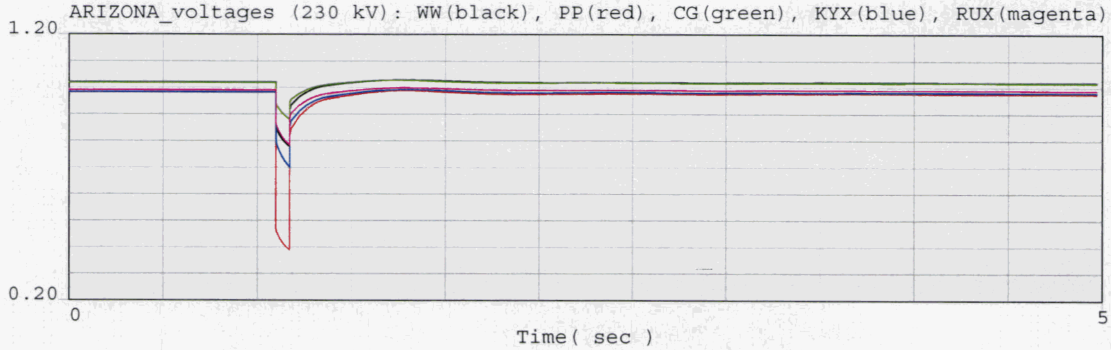
ARIZONA_voltages (230 kV): WW(black), PP(red), CG(green), KYX(blue), RUX(magenta)



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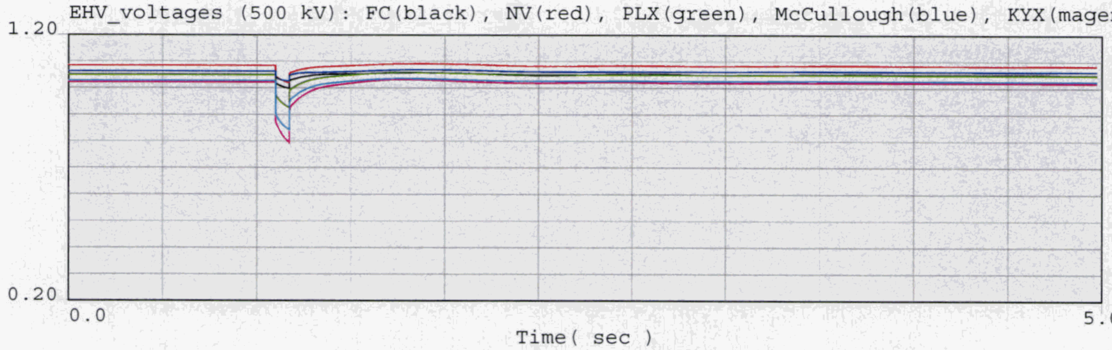
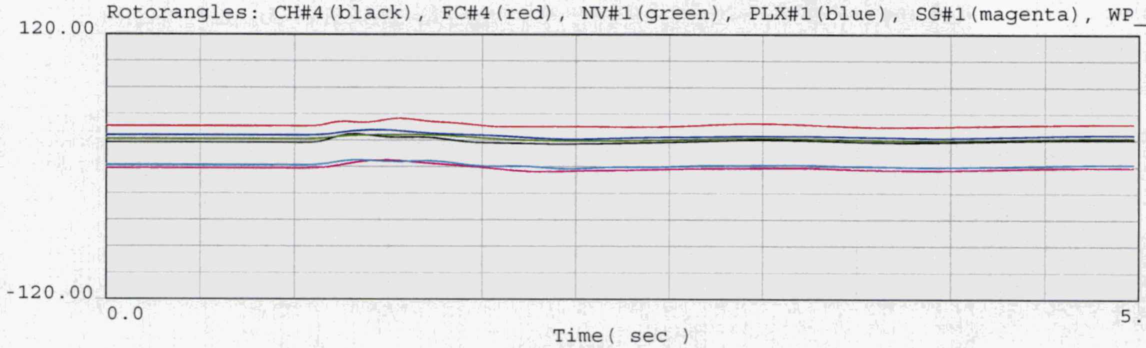
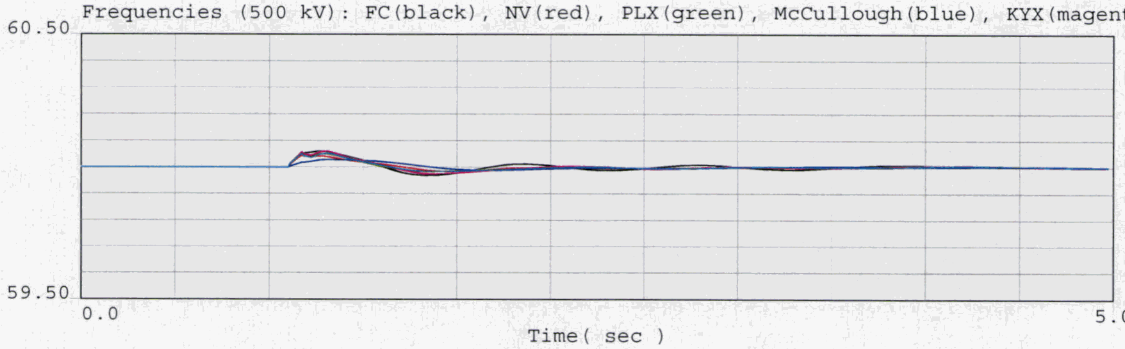


Rotorangles: CH#4(black), FC#4(red), NV#1(green), PLX#1(blue), SG#1(magenta), WP_CC1(cyan)



Frequencies (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



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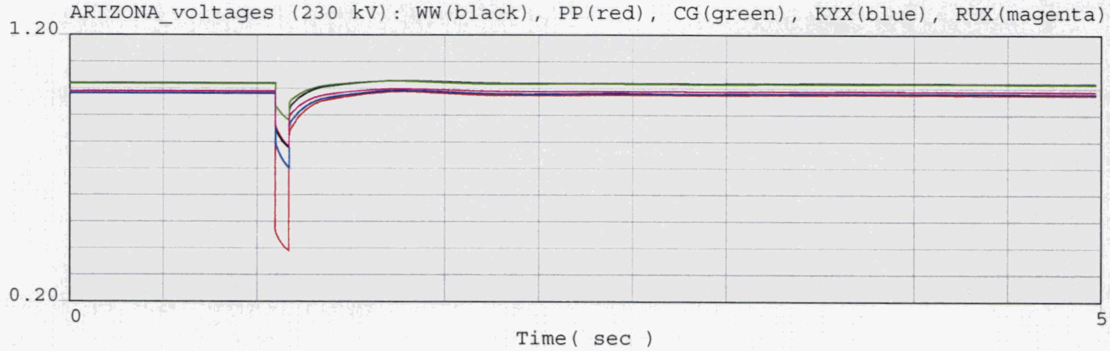
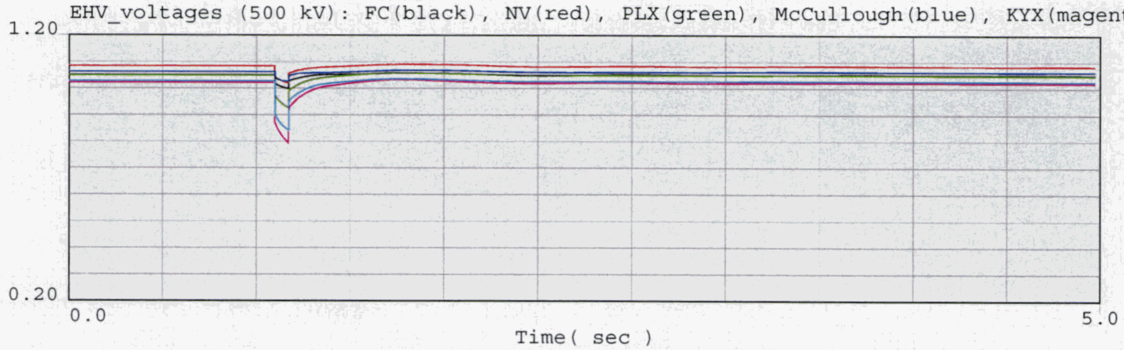
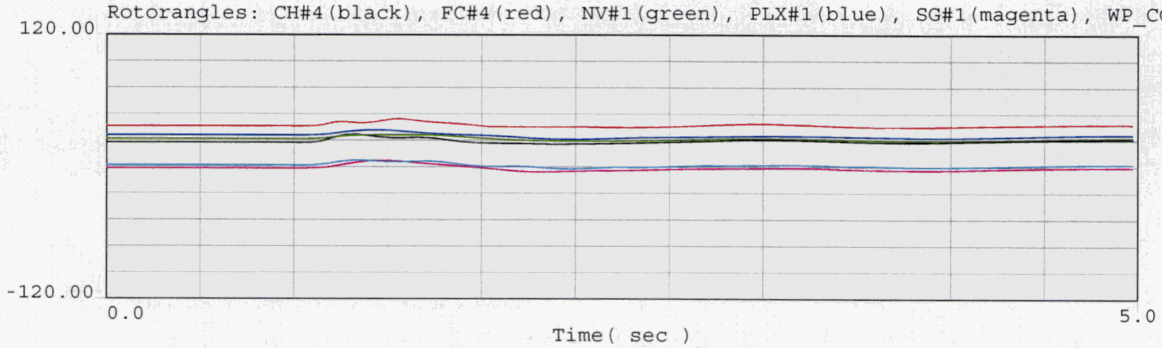
ARIZONA_voltages (230 kV): WW(black), PP(red), CG(green), KYX(blue), RUX(magenta)



EHV_voltages (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



Rotorangles: CH#4(black), FC#4(red), NV#1(green), PLX#1(blue), SG#1(magenta), WP_CC1(cyan)



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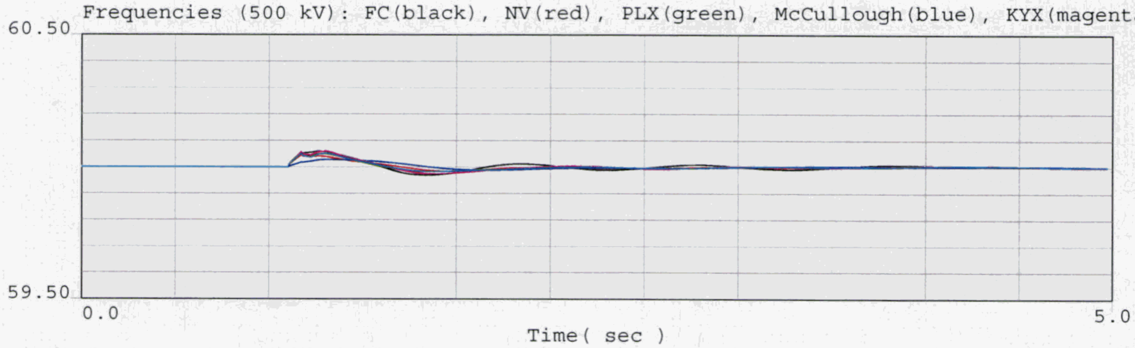

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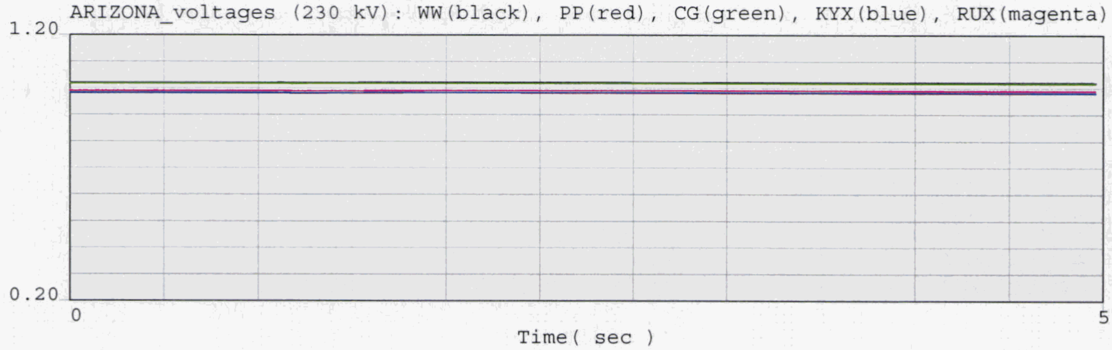
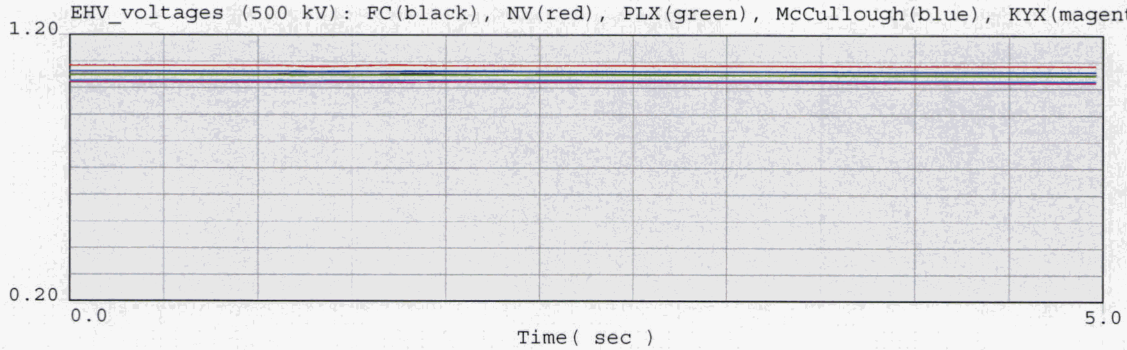
ARIZONA_voltages (230 kV): WW(black), PP(red), CG(green), KYX(blue), RUX(magenta)



EHV_voltages (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



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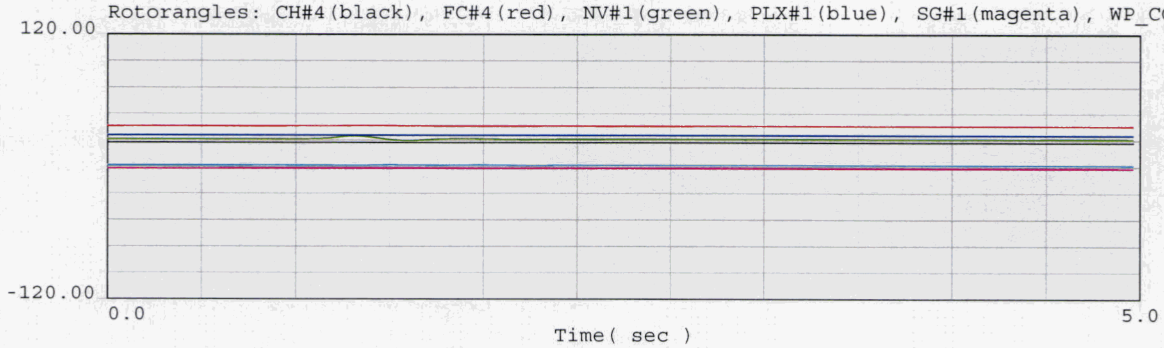

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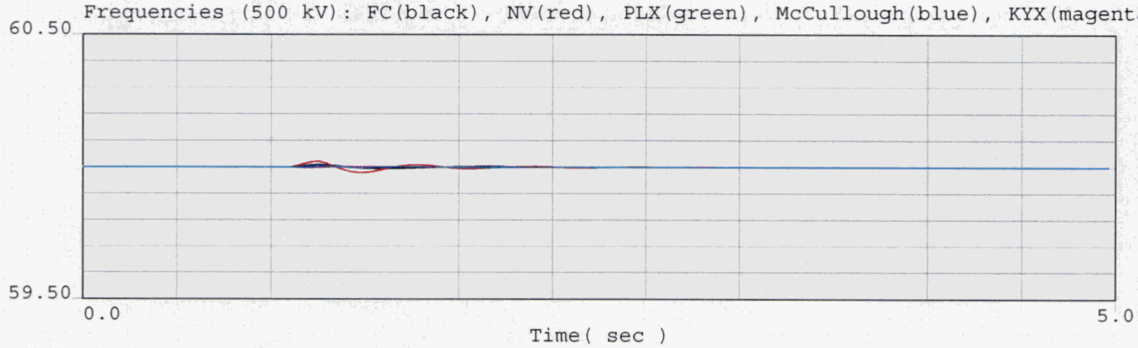

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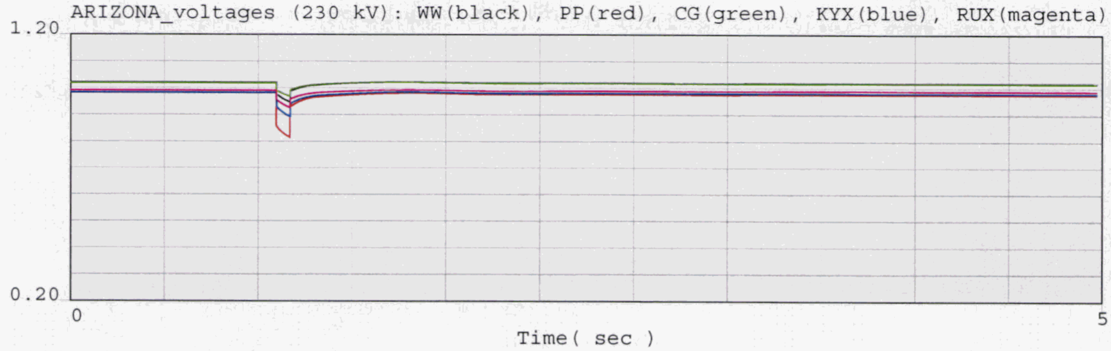
ARIZONA_voltages (230 kV): WW(black), PP(red), CG(green), KYX(blue), RUX(magenta)



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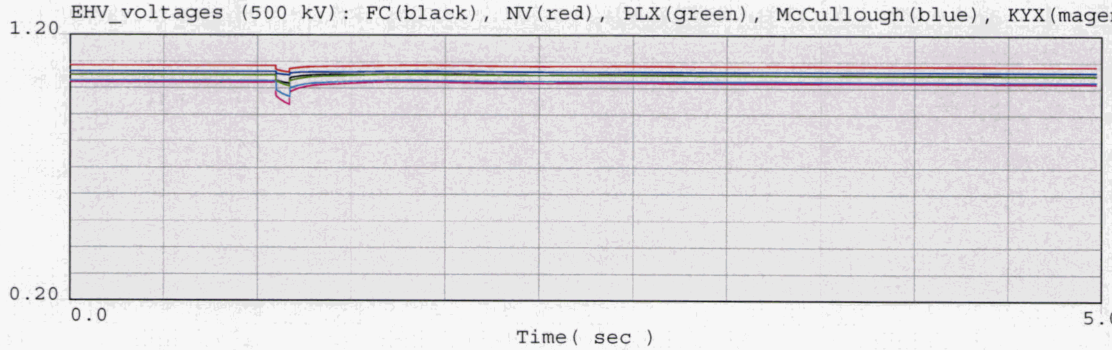

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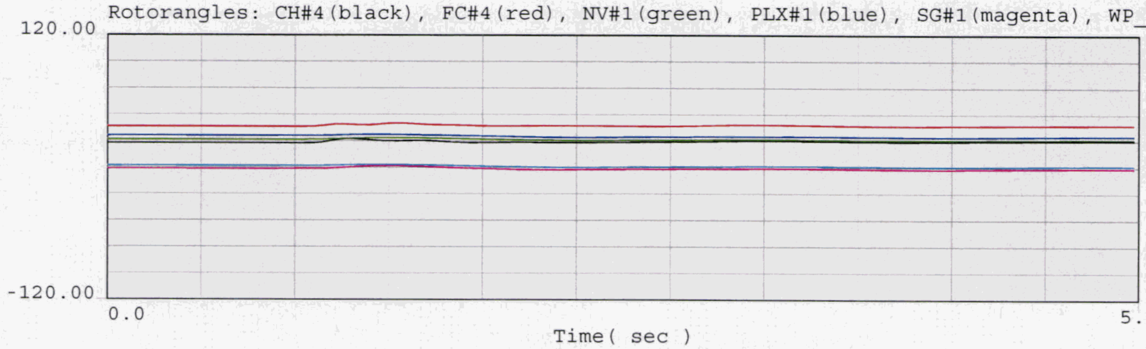

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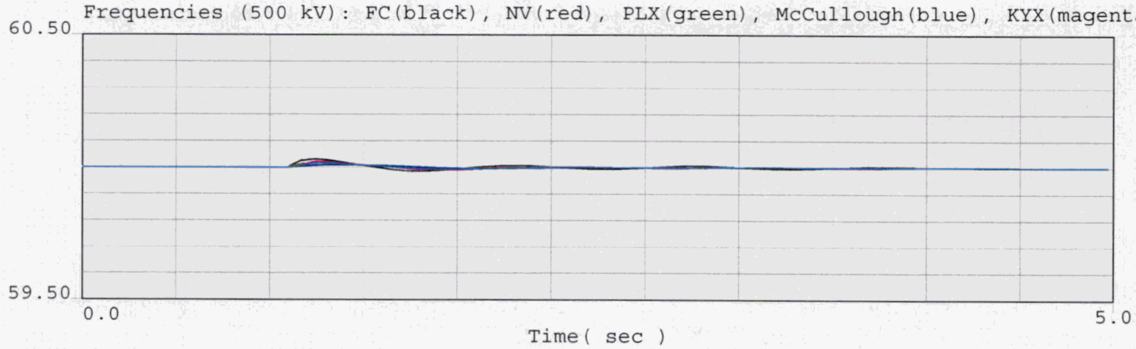

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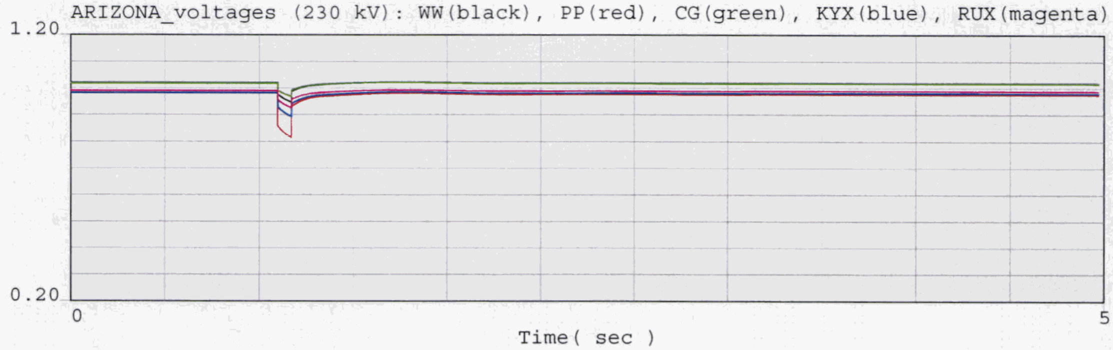
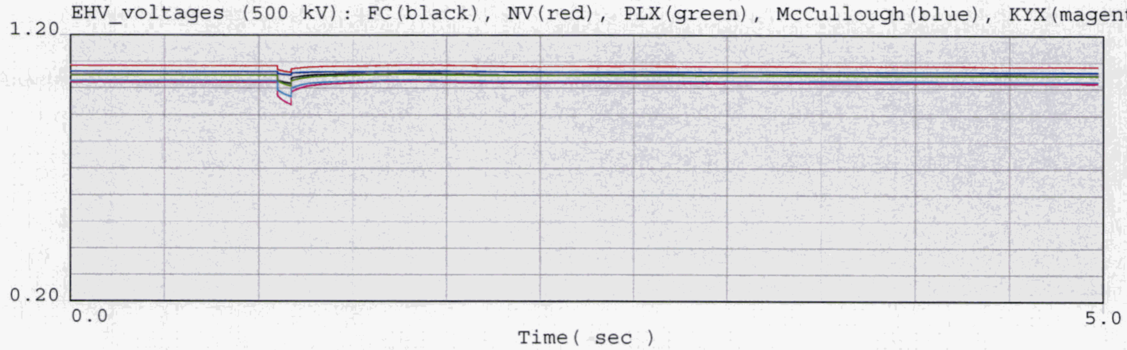
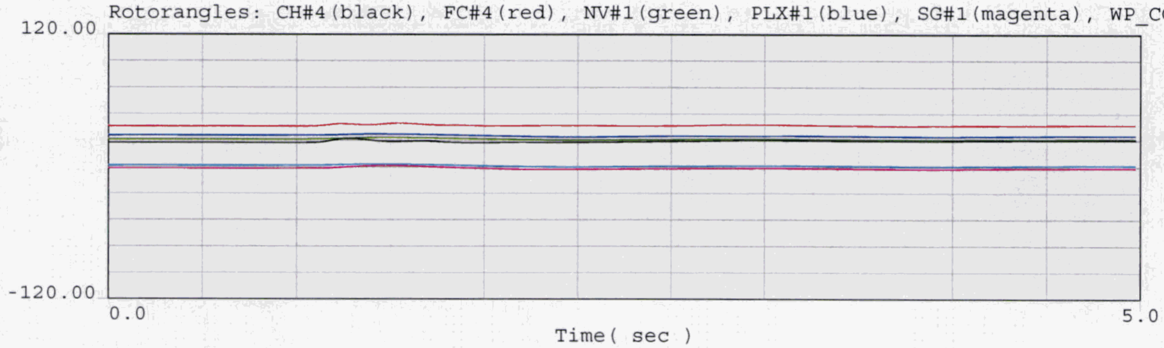
ARIZONA_voltages (230 kV): WW(black), PP(red), CG(green), KYX(blue), RUX(magenta)



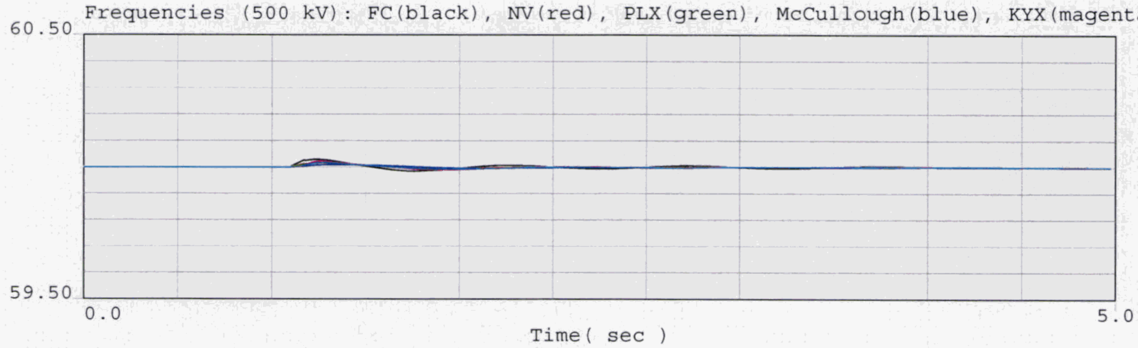
EHV_voltages (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



Rotorangles: CH#4(black), FC#4(red), NV#1(green), PLX#1(blue), SG#1(magenta), WP_CC1(cyan)



Frequencies (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



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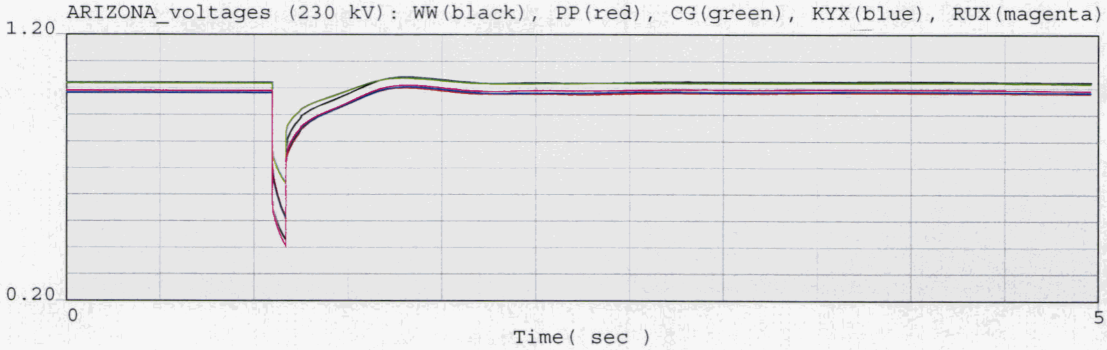
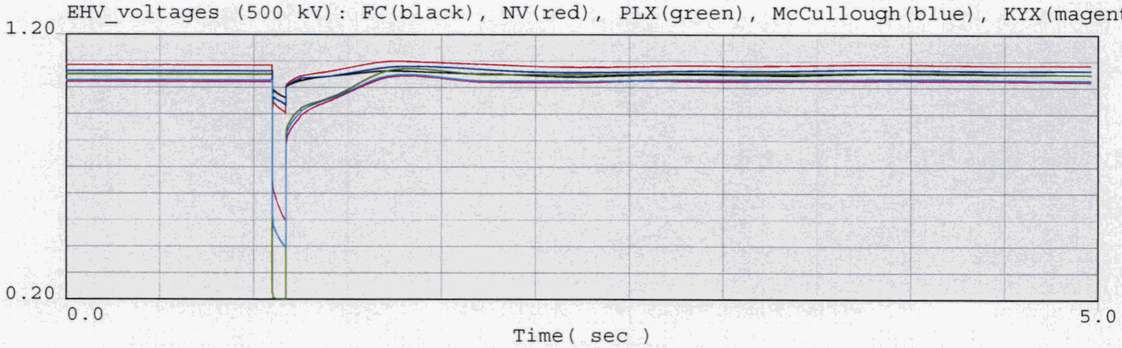
2016 Heavy Summer WECC Power Flow

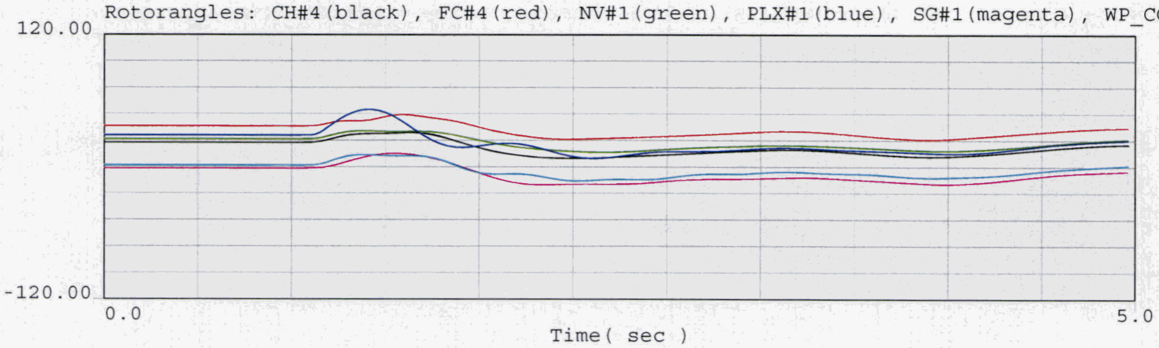
ARIZONA_voltages (230 kV): WW(black), PP(red), CG(green), KYX(blue), RUX(magenta)



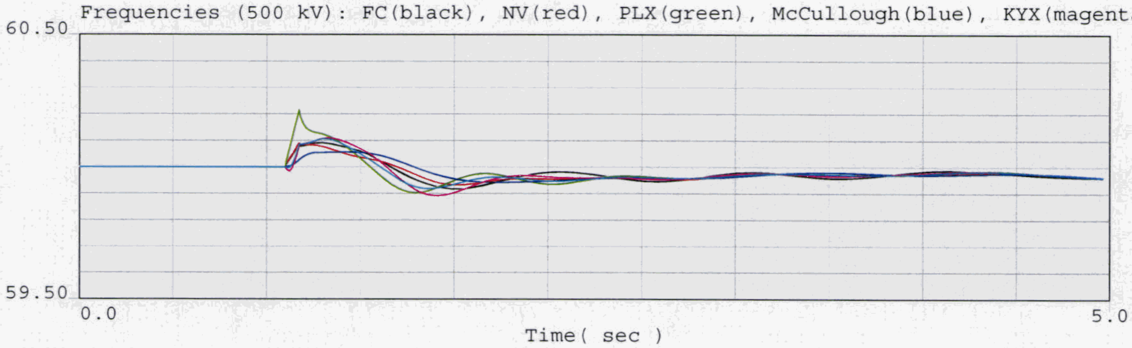
EHV_voltages (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



Rotorangles: CH#4(black), FC#4(red), NV#1(green), PLX#1(blue), SG#1(magenta), WP_CC1(cyan)



Frequencies (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



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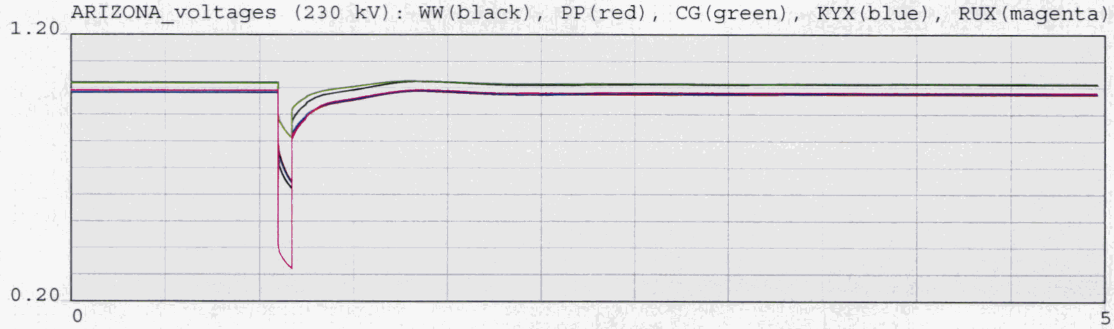
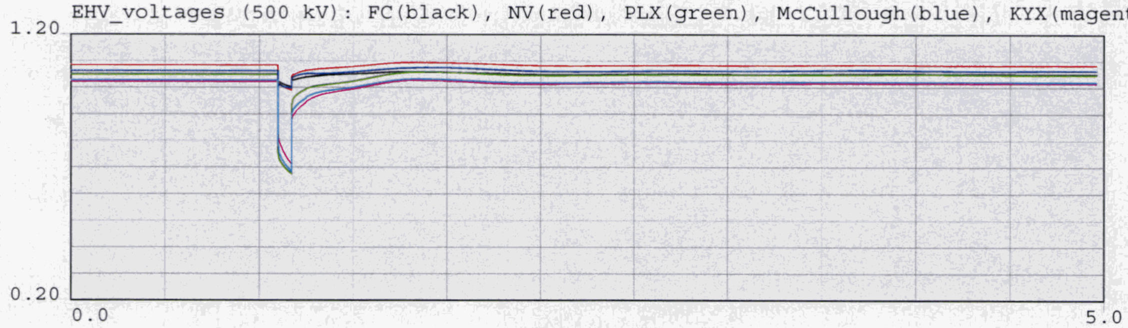
2016 Heavy Summer WECC Power Flow

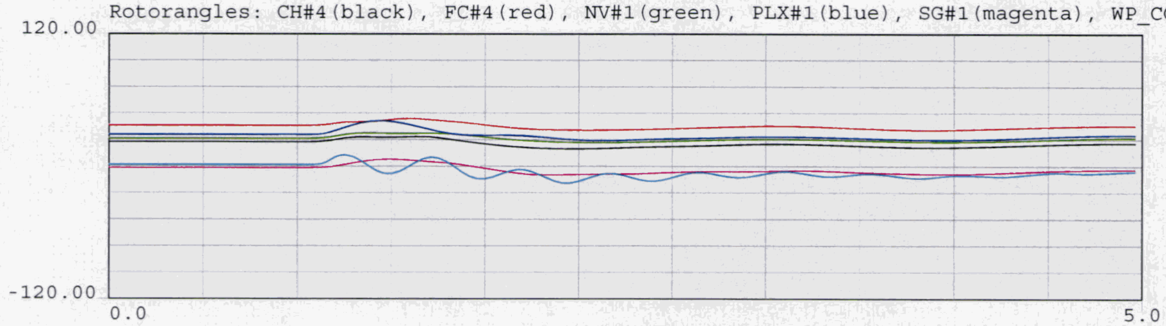
ARIZONA_voltages (230 kV): WW(black), PP(red), CG(green), KYX(blue), RUX(magenta)



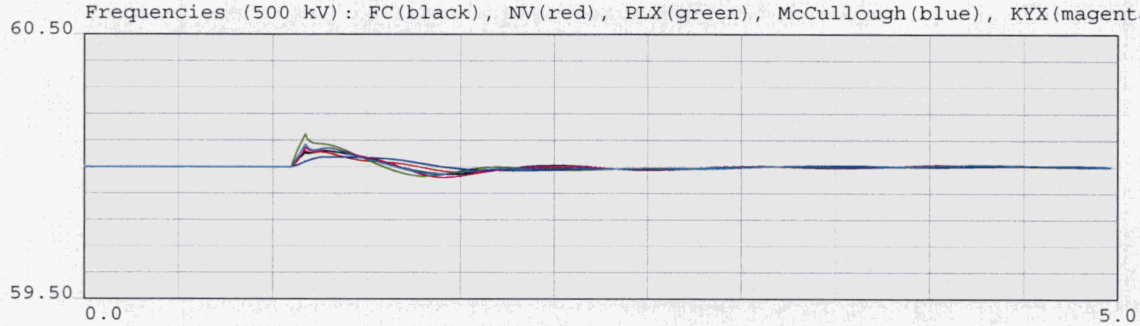
EHV_voltages (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



Rotorangles: CH#4(black), FC#4(red), NV#1(green), PLX#1(blue), SG#1(magenta), WP_CC1(cyan)



Frequencies (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



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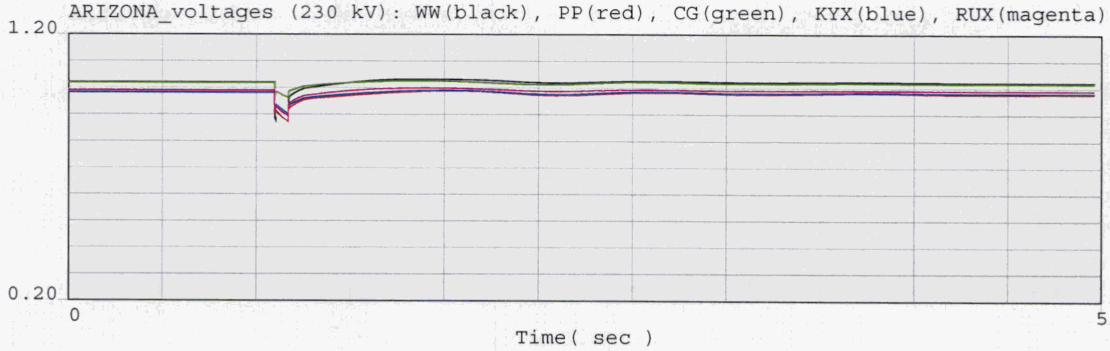

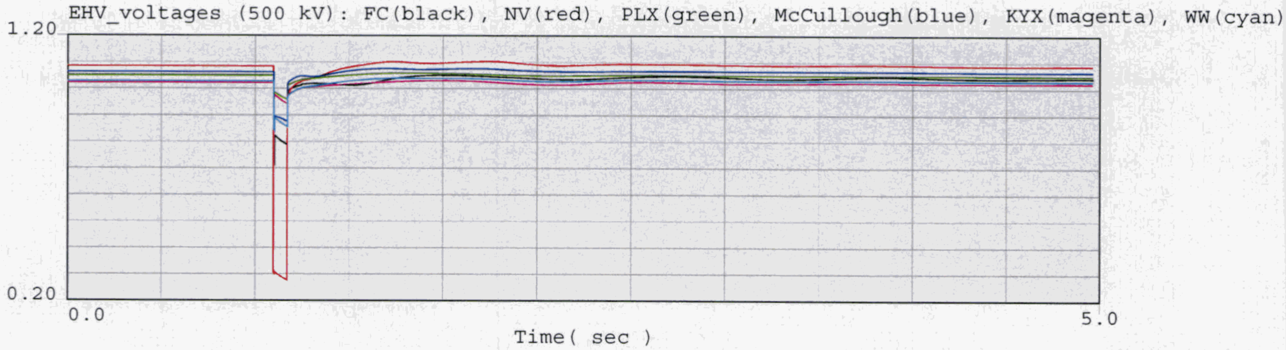

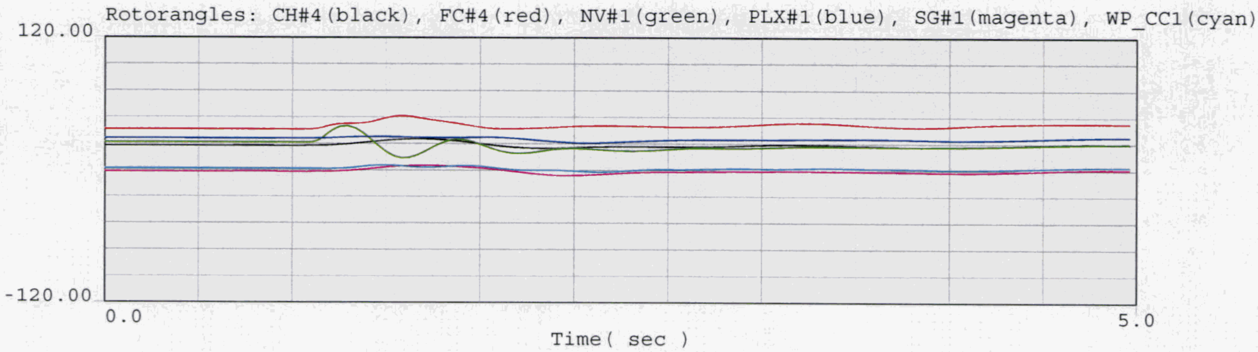

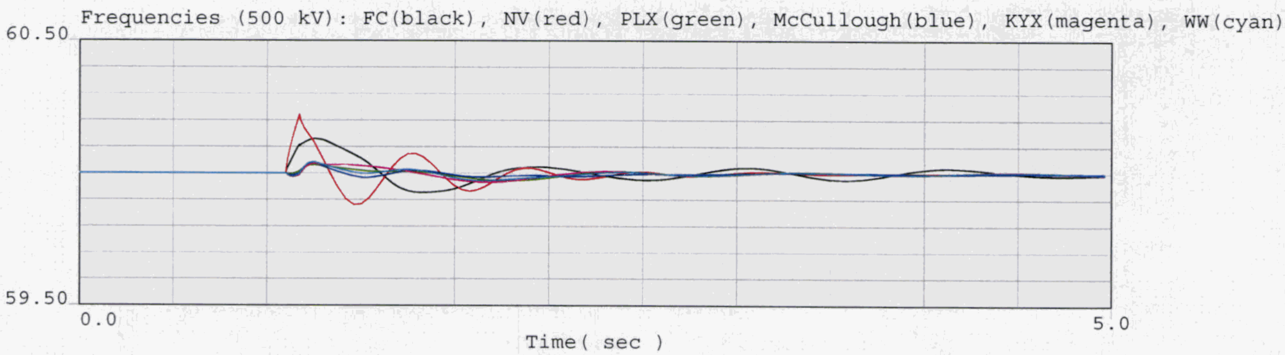

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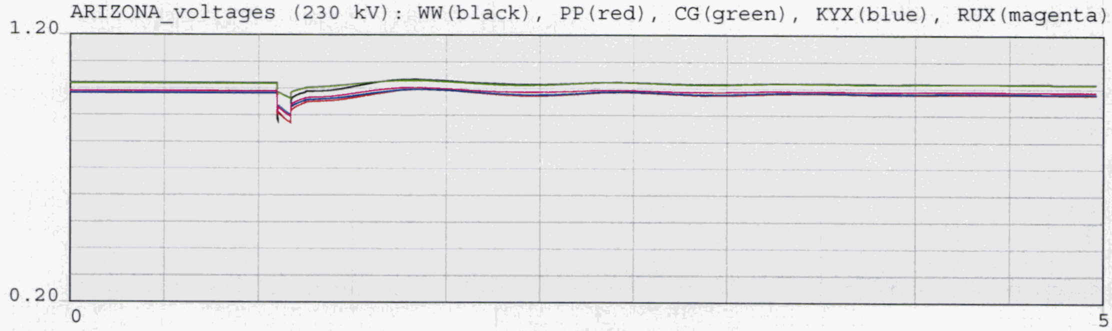
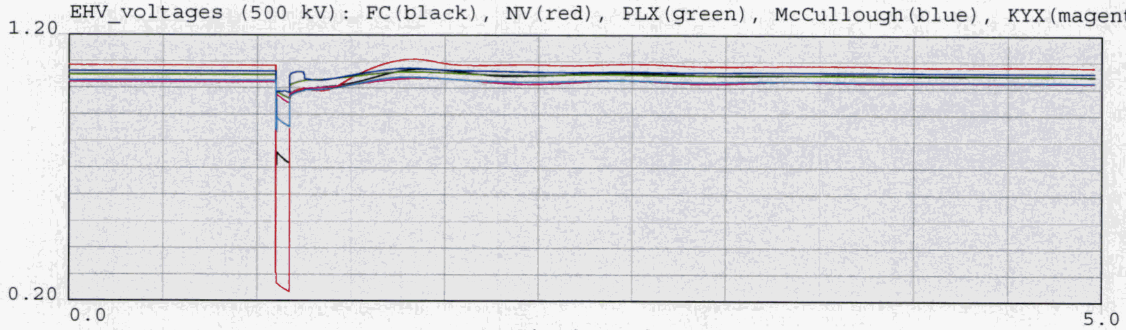
2016 Heavy Summer WECC Power Flow

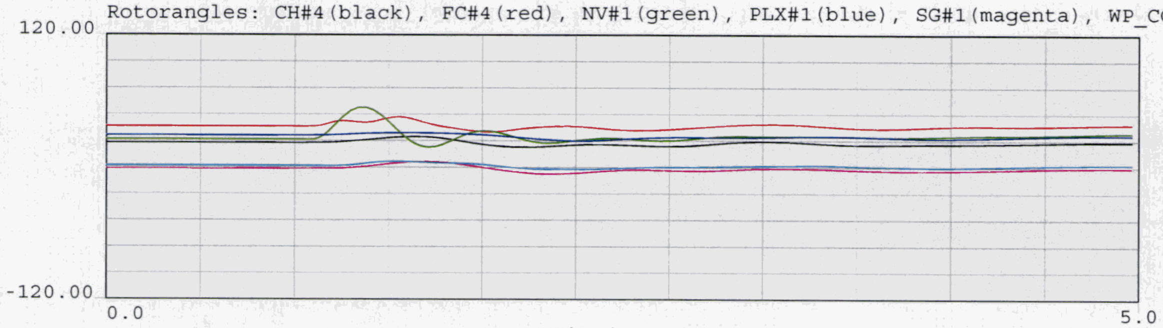
ARIZONA_voltages (230 kV): WW(black), PP(red), CG(green), KYX(blue), RUX(magenta)



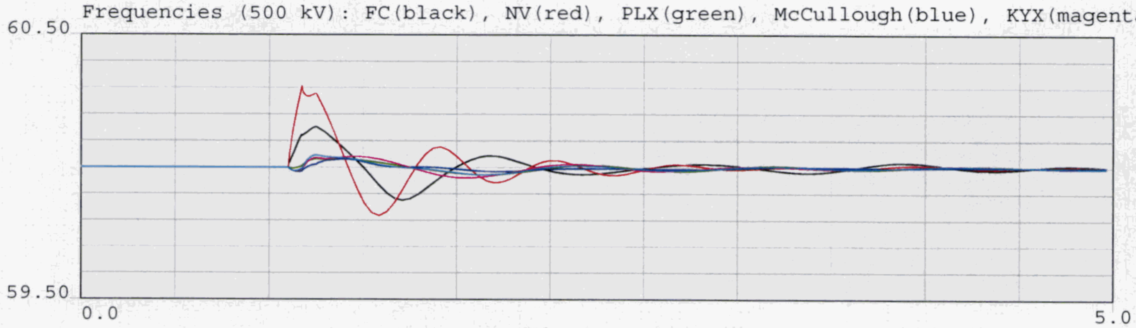
EHV_voltages (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



Rotorangles: CH#4(black), FC#4(red), NV#1(green), PLX#1(blue), SG#1(magenta), WP_CC1(cyan)



Frequencies (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



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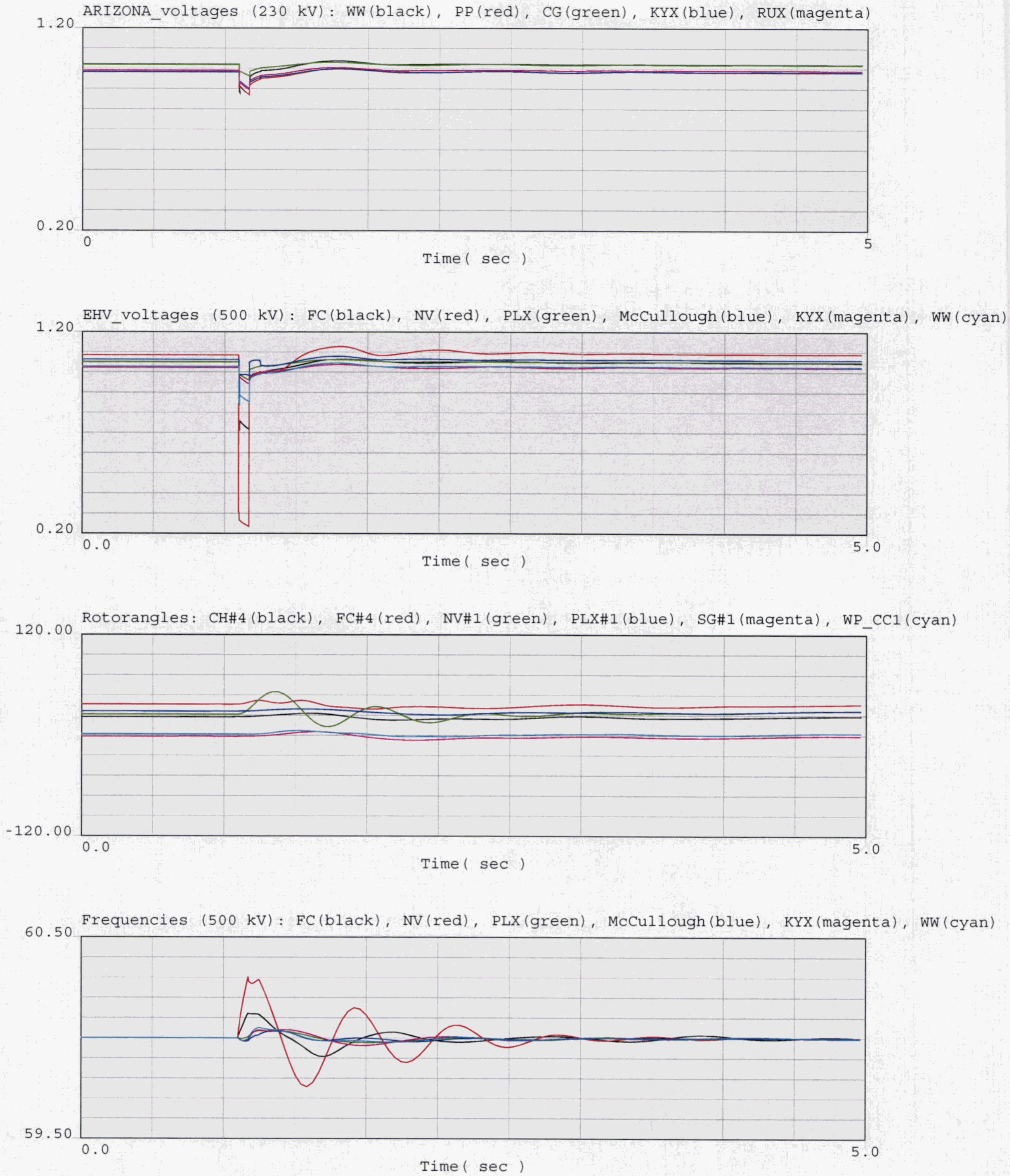
2016 Heavy Summer WECC Power Flow



WE[illegible]RN ELECTRICITY COORDINATING COUNCIL
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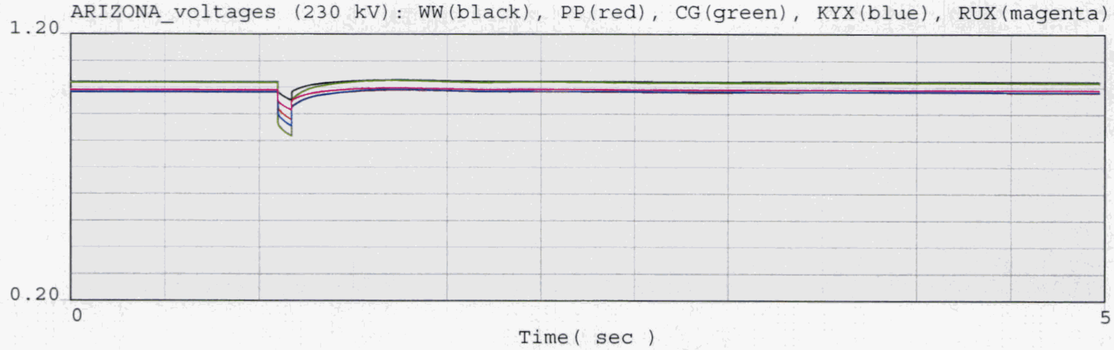
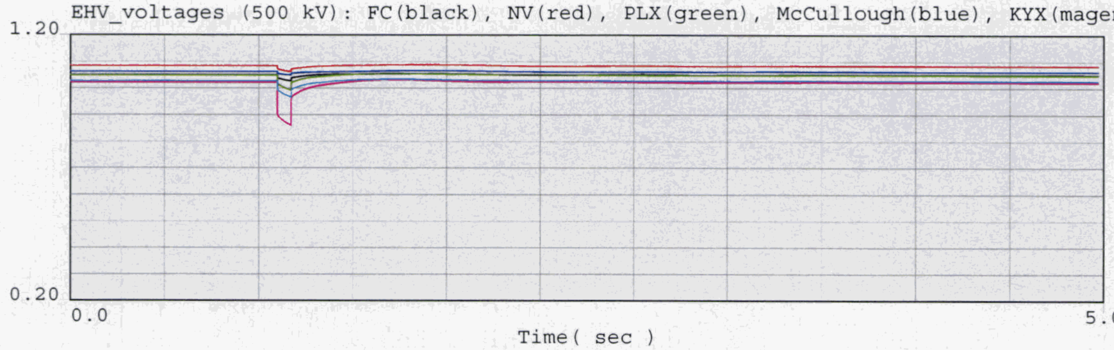
2016 Heavy Summer WECC Power Flow

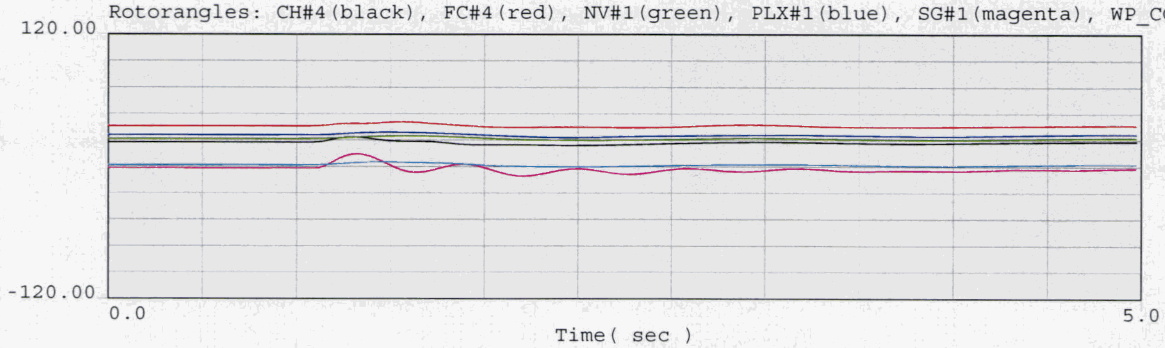
ARIZONA_voltages (230 kV): WW(black), PP(red), CG(green), KYX(blue), RUX(magenta)



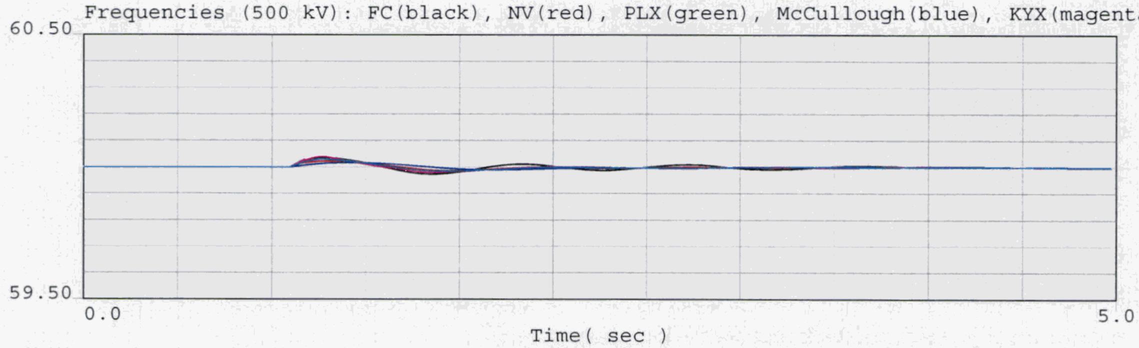
EHV_voltages (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



Rotorangles: CH#4(black), FC#4(red), NV#1(green), PLX#1(blue), SG#1(magenta), WP_CC1(cyan)



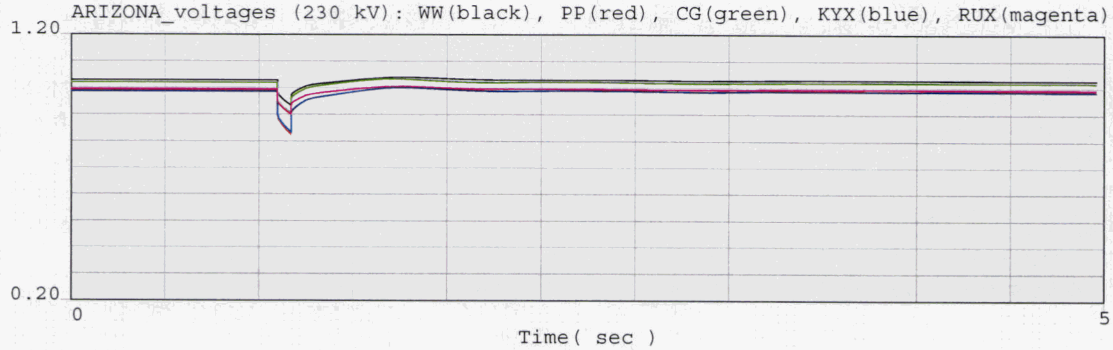
Frequencies (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



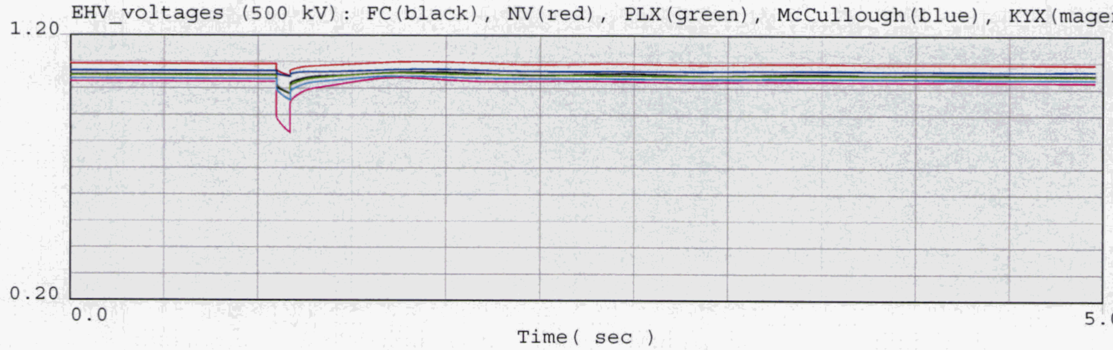
WE[illegible]RN ELECTRICITY COORDINATING COUNCIL
2[illegible]HS1A APPROVED BASE CASE
MAY 30, 2006

2011 Heavy Summer WECC Power Flow

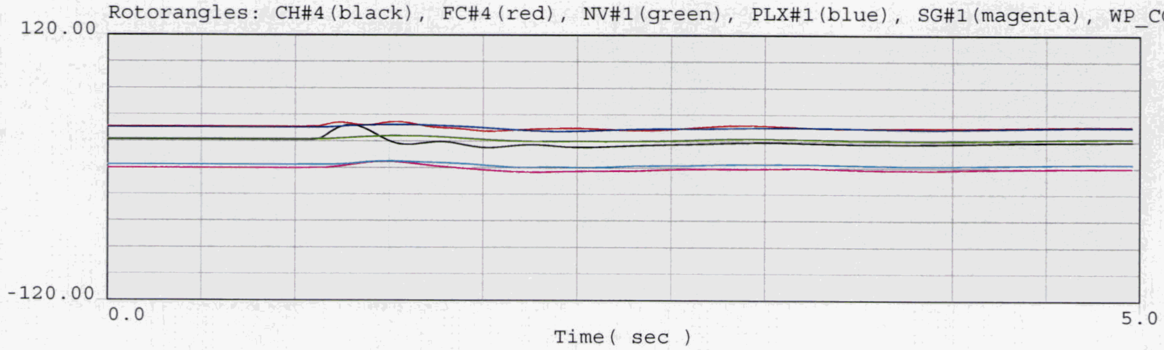
ARIZONA_voltages (230 kV): WW(black), PP(red), CG(green), KYX(blue), RUX(magenta)



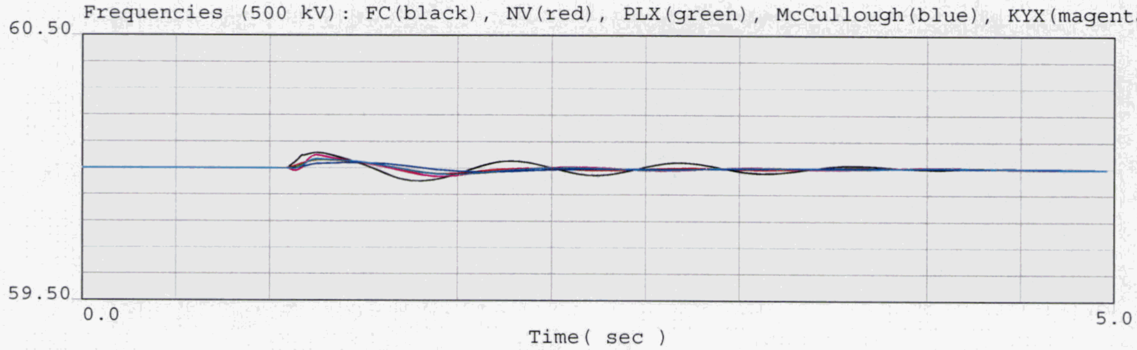
EHV_voltages (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



Rotorangles: CH#4(black), FC#4(red), NV#1(green), PLX#1(blue), SG#1(magenta), WP_CC1(cyan)



Frequencies (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



WE RN ELECTRICITY COORDINATING COUNCIL
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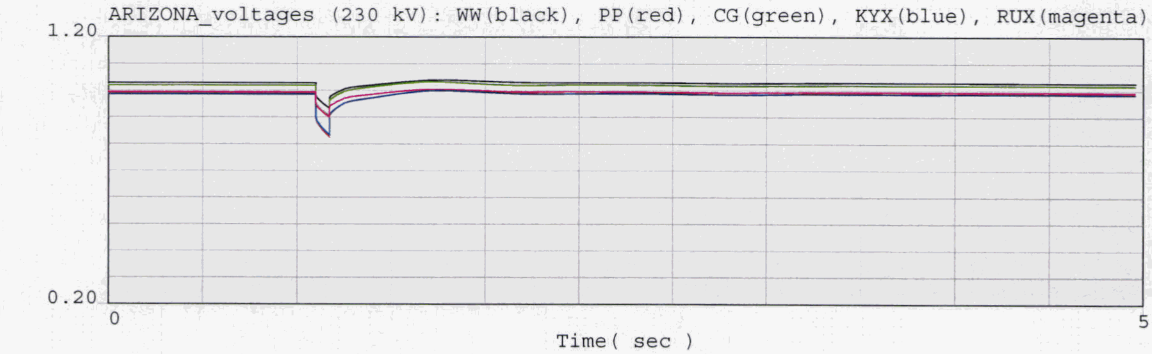
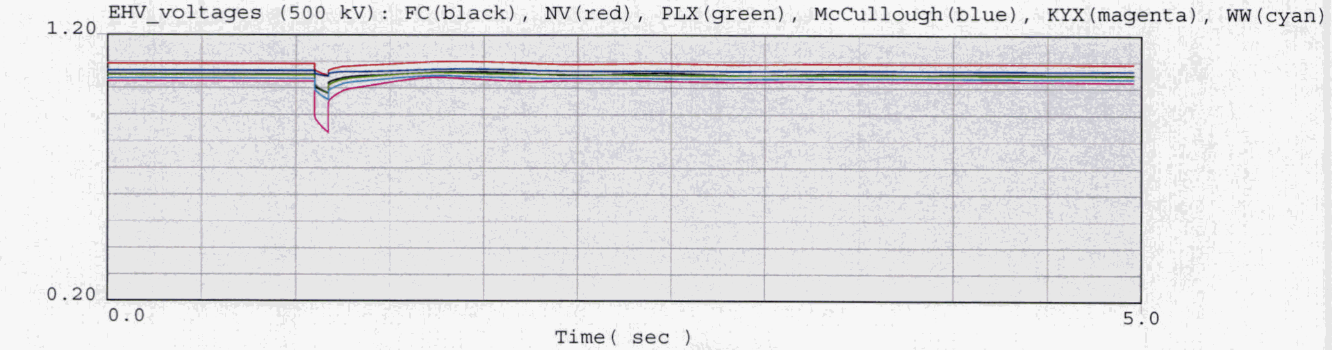
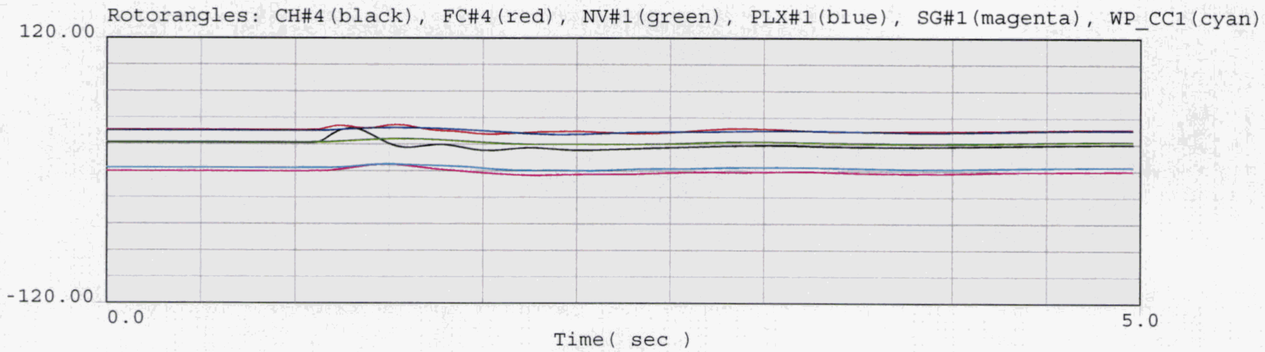
MAY 30, 2006
ALL COMMENTS RESULTING FROM THE TSS REVIEW HAVE BEEN ADDED.

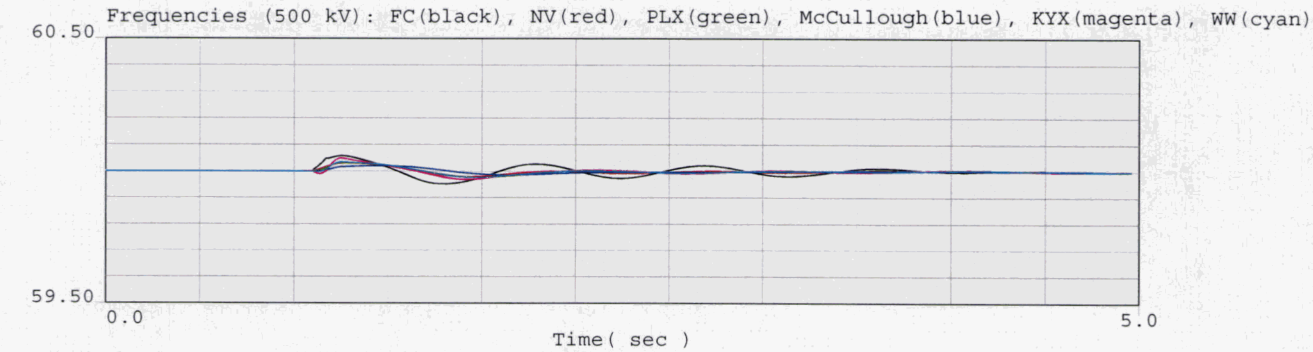
	2016_sn_ch.chf	stability\2011 stability Fri Jan 25 15:40:11 2008

2011 Heavy Summer WECC Power Flow









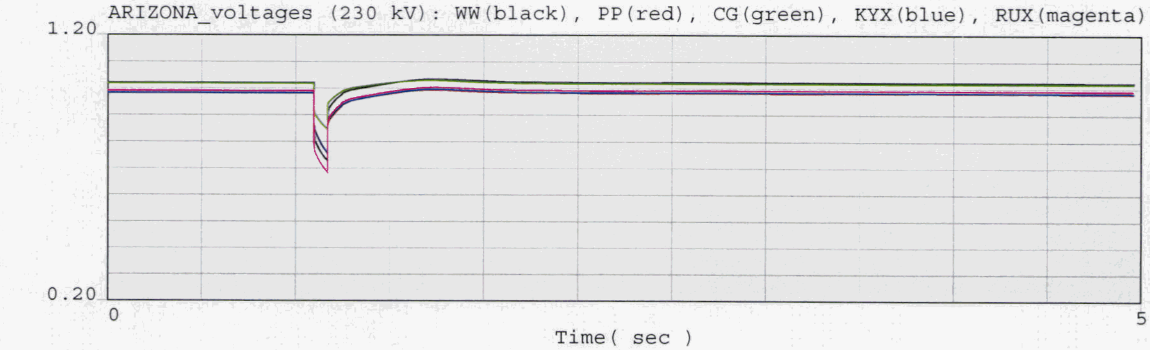
WE RN ELECTRICITY COORDINATING COUNCIL
2 HS1A APPROVED BASE CASE
MAY 30, 2006
ALL COMMENTS RESULTING FROM THE TSS REVIEW HAVE BEEN ADDED.

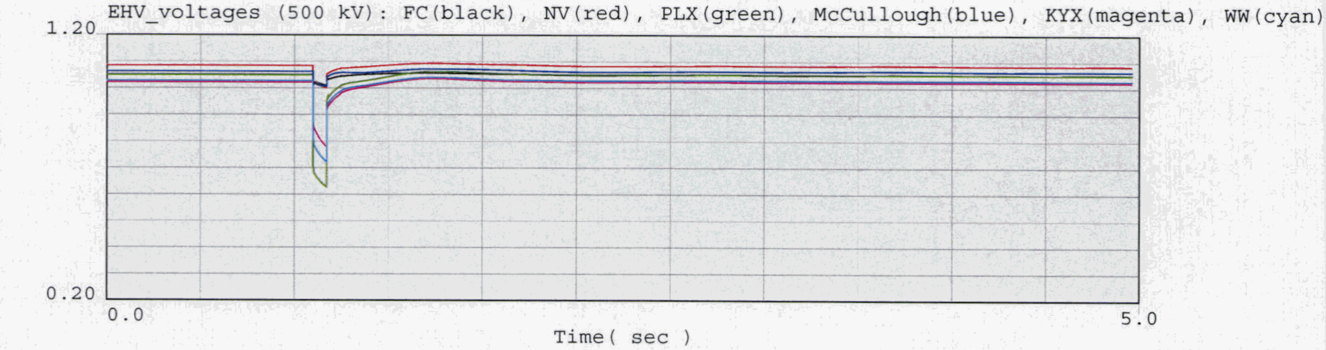
2016_sn_cnx.chf

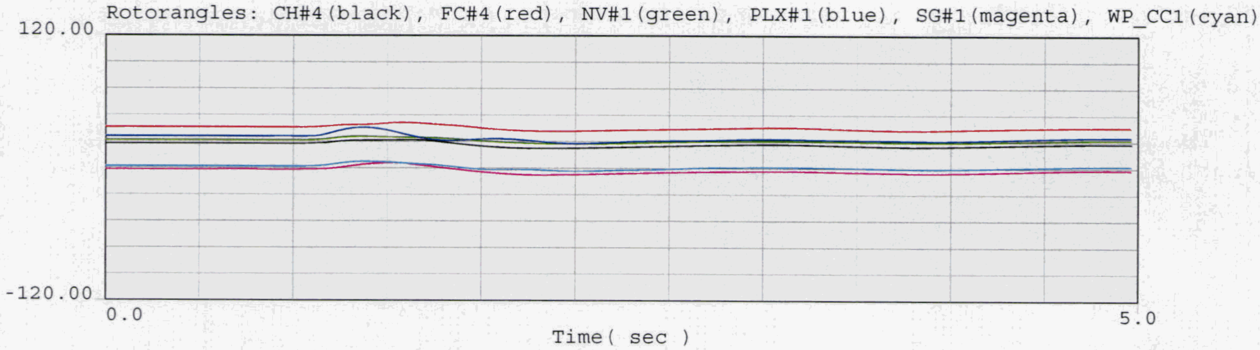
stability\2011 stability

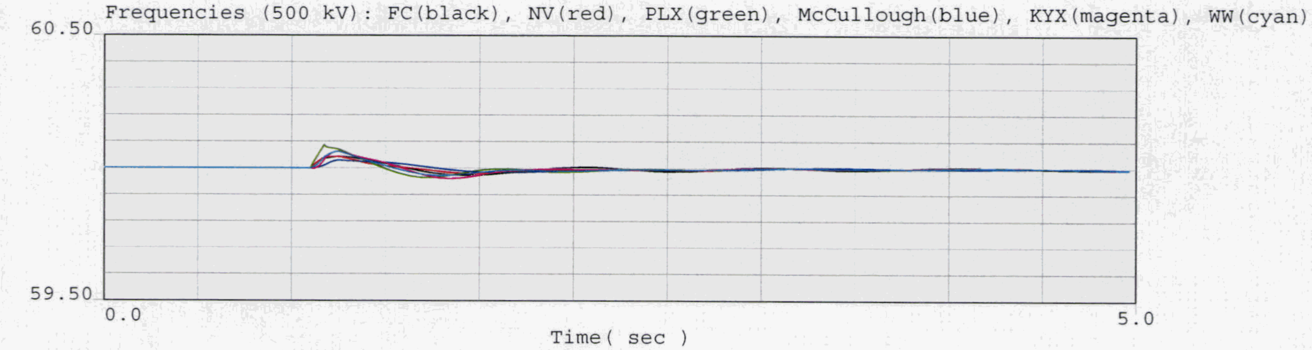
Fri Jan 25 15:41:07 2008

2016 Heavy Summer WECC Power Flow









WESTERN ELECTRICITY COORDINATING COUNCIL
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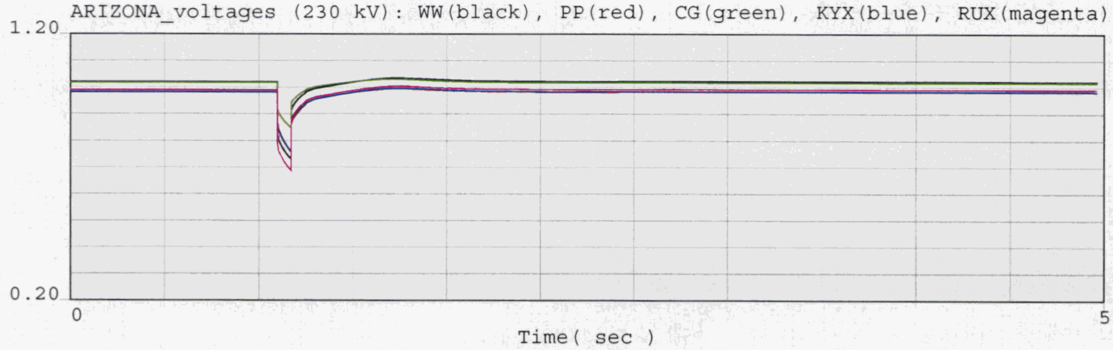
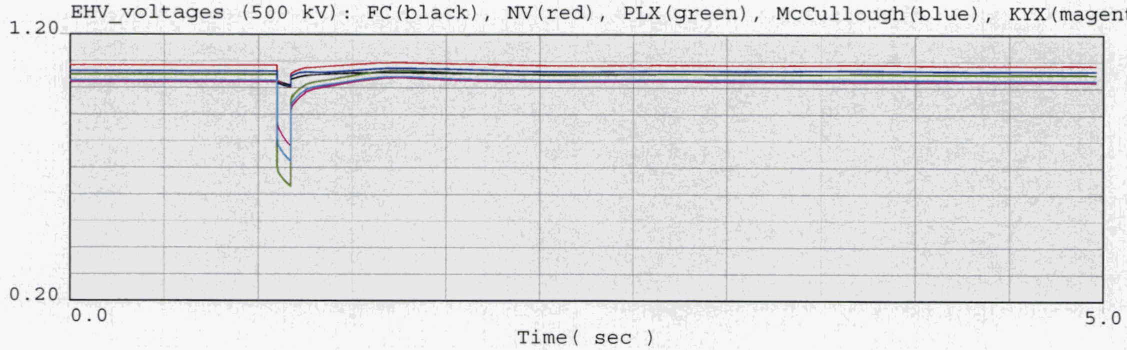
2016 Heavy Summer WECC Power Flow

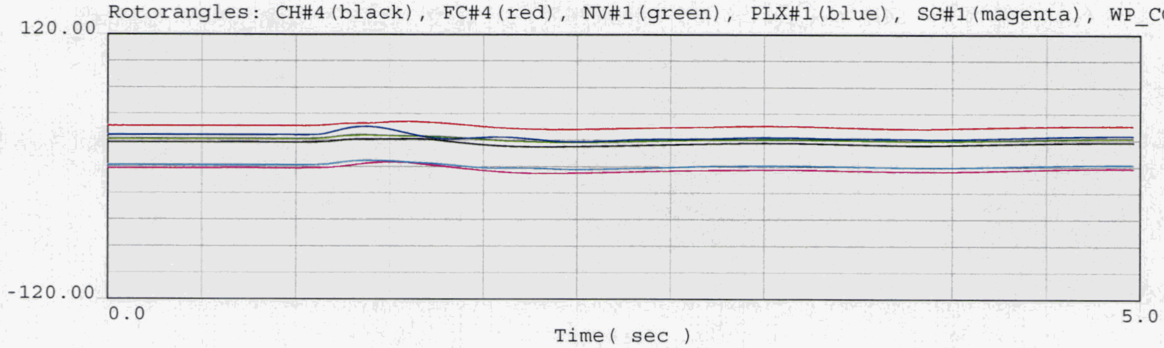
ARIZONA_voltages (230 kV): WW(black), PP(red), CG(green), KYX(blue), RUX(magenta)



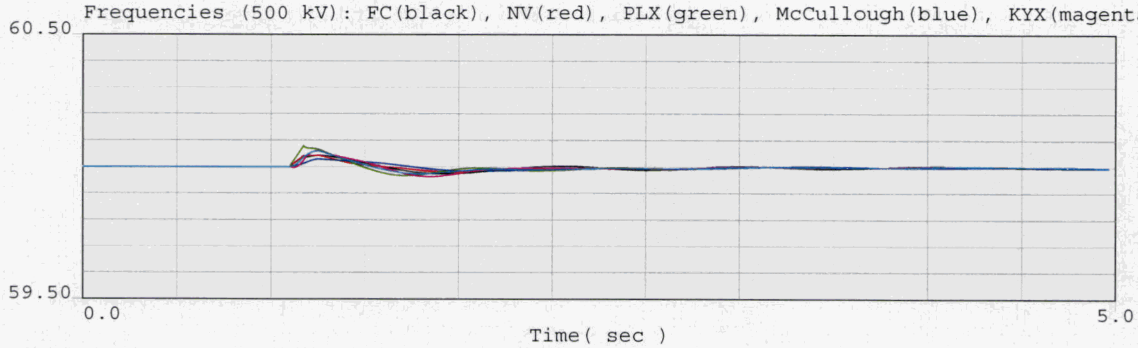
EHV_voltages (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



Rotorangles: CH#4(black), FC#4(red), NV#1(green), PLX#1(blue), SG#1(magenta), WP_CC1(cyan)



Frequencies (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



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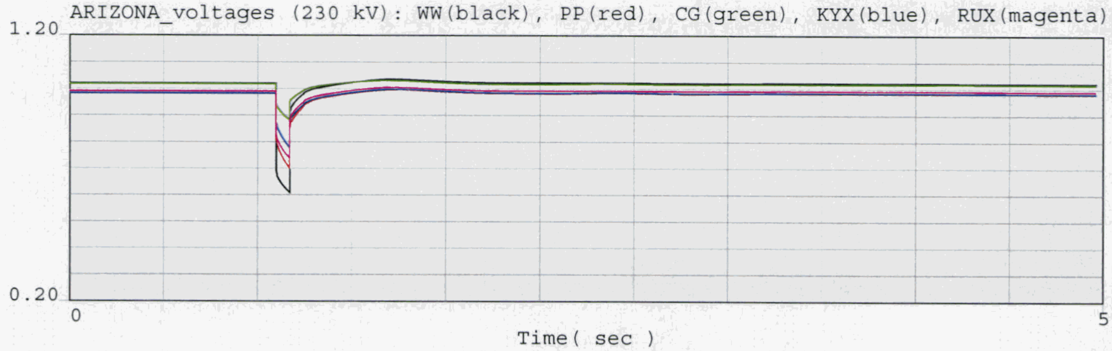
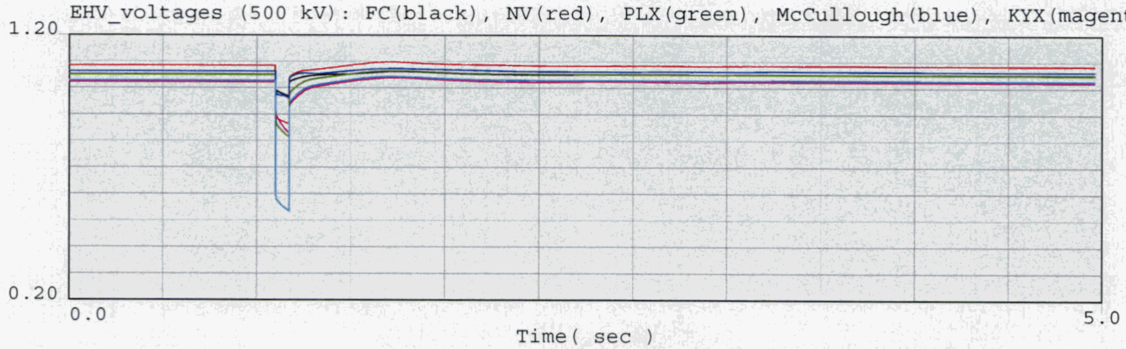
2016 Heavy Summer WECC Power Flow

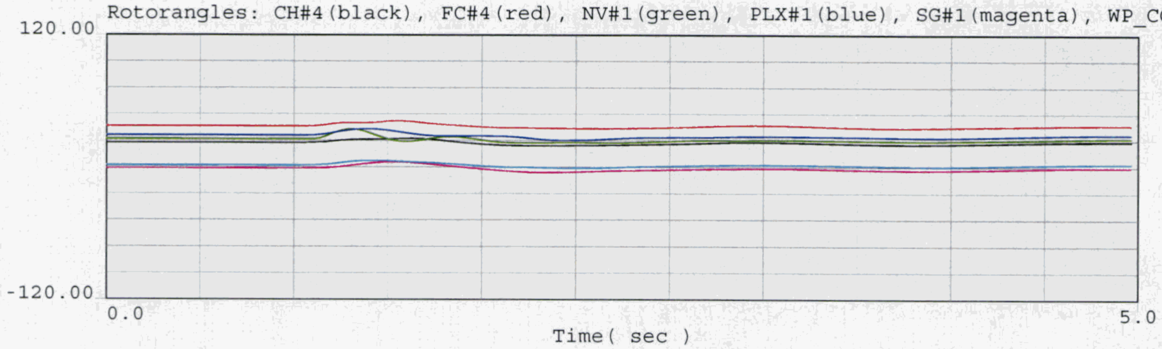
ARIZONA_voltages (230 kV): WW(black), PP(red), CG(green), KYX(blue), RUX(magenta)



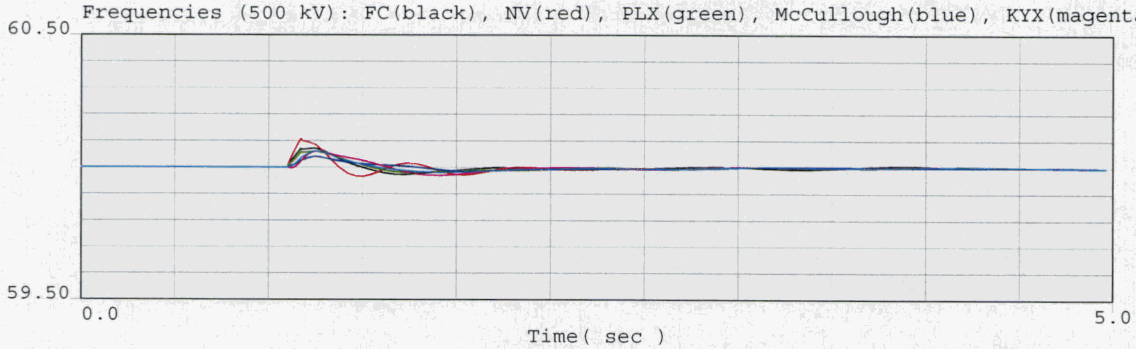
EHV_voltages (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



Rotorangles: CH#4(black), FC#4(red), NV#1(green), PLX#1(blue), SG#1(magenta), WP_CC1(cyan)



Frequencies (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



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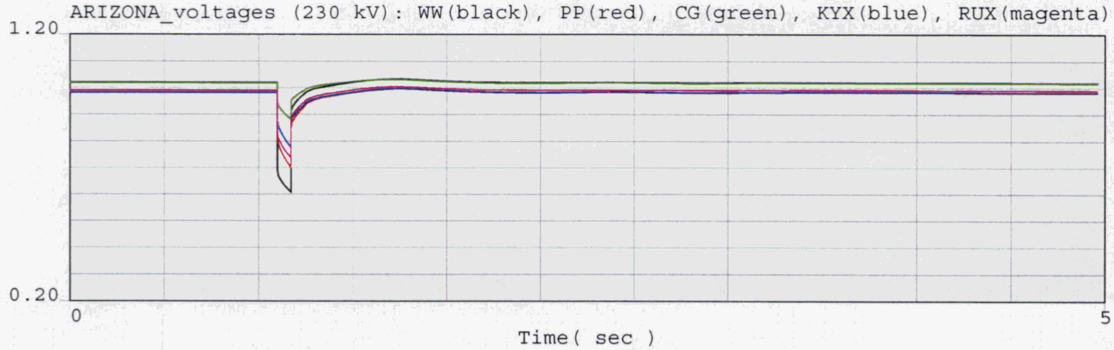
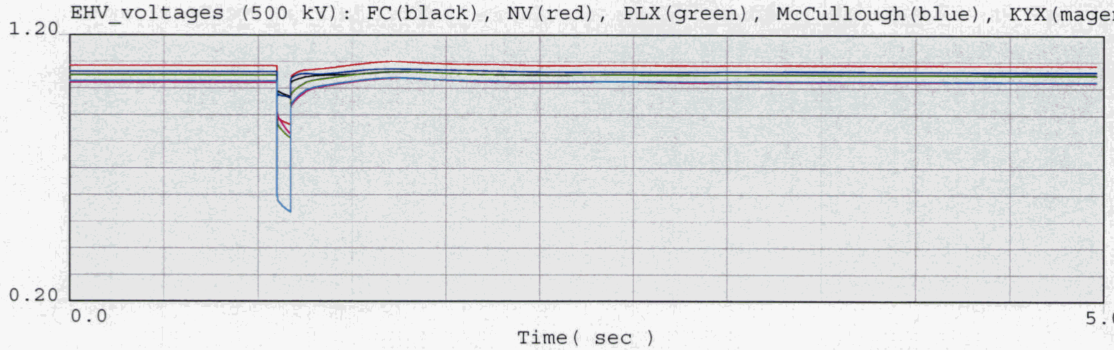
2016 Heavy Summer WECC Power Flow

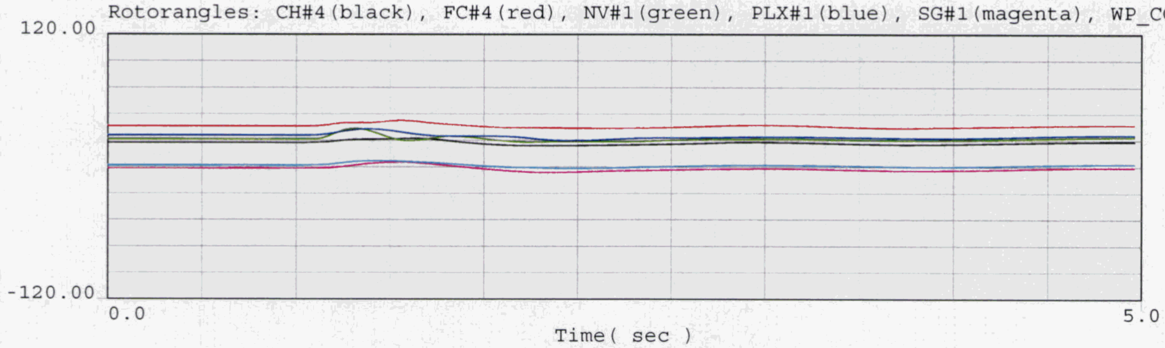
ARIZONA_voltages (230 kV): WW(black), PP(red), CG(green), KYX(blue), RUX(magenta)



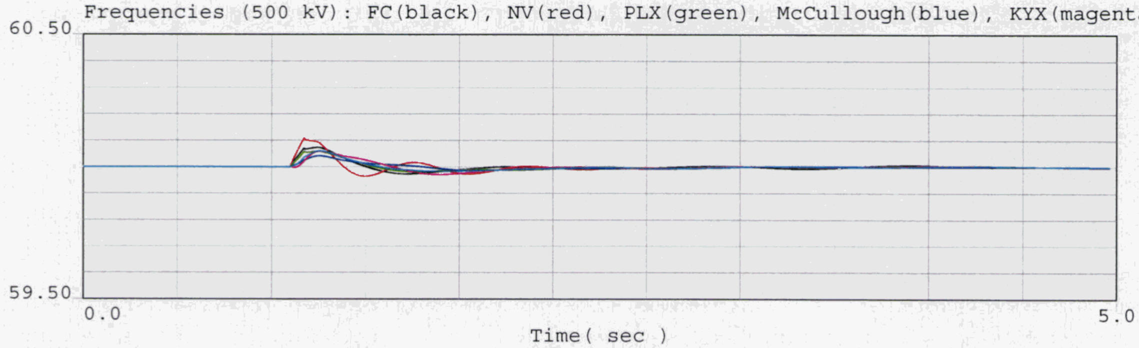
EHV_voltages (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



Rotorangles: CH#4(black), FC#4(red), NV#1(green), PLX#1(blue), SG#1(magenta), WP_CC1(cyan)



Frequencies (500 kV): FC(black), NV(red), PLX(green), McCullough(blue), KYX(magenta), WW(cyan)



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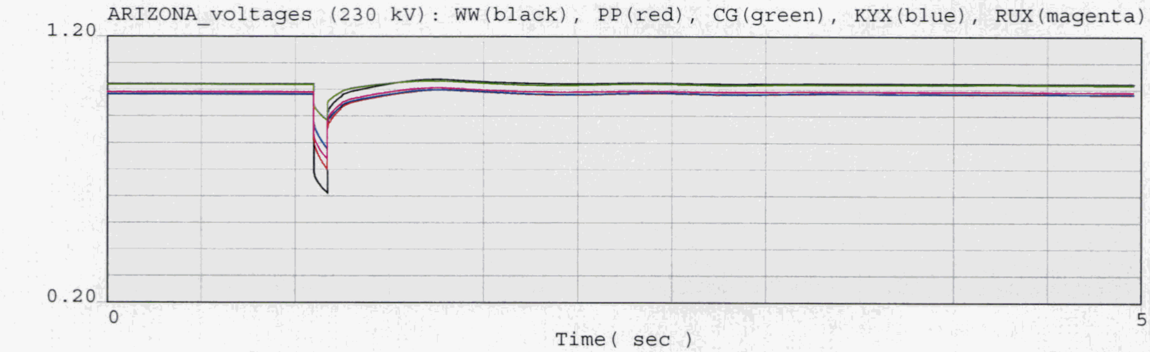

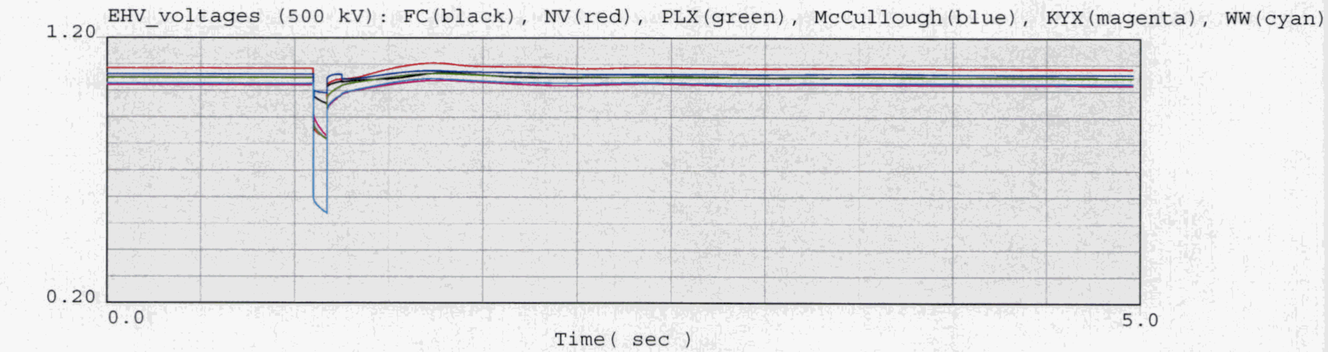

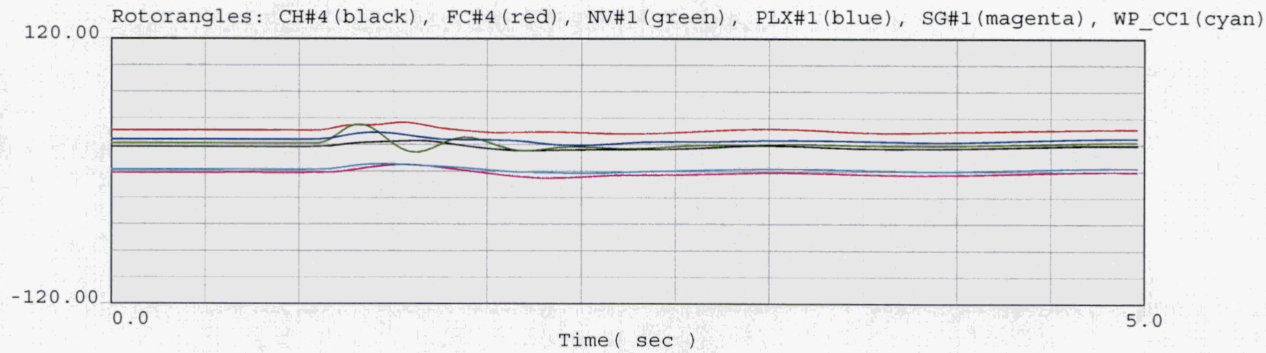

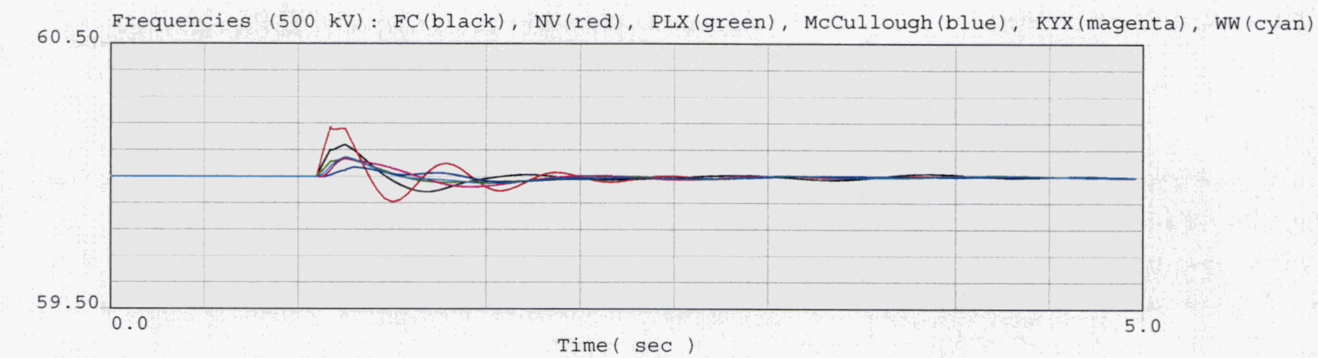

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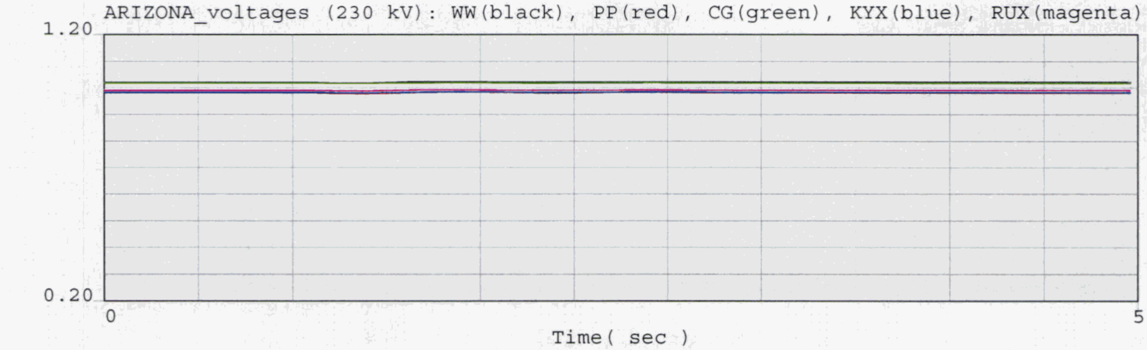
ARIZONA_voltages (230 kV): WW(black), PP(red), CG(green), KYX(blue), RUX(magenta)



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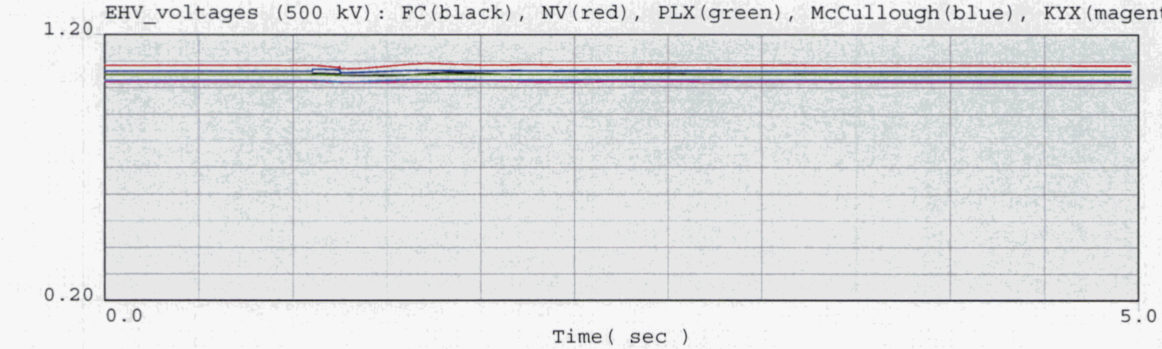

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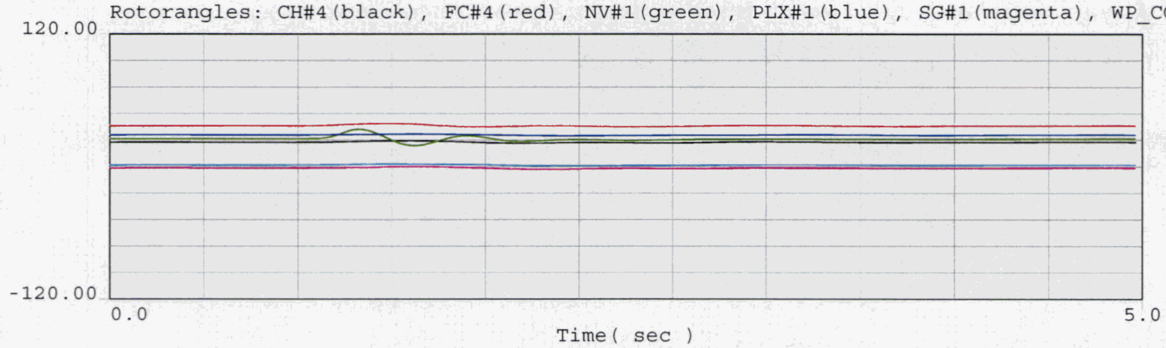

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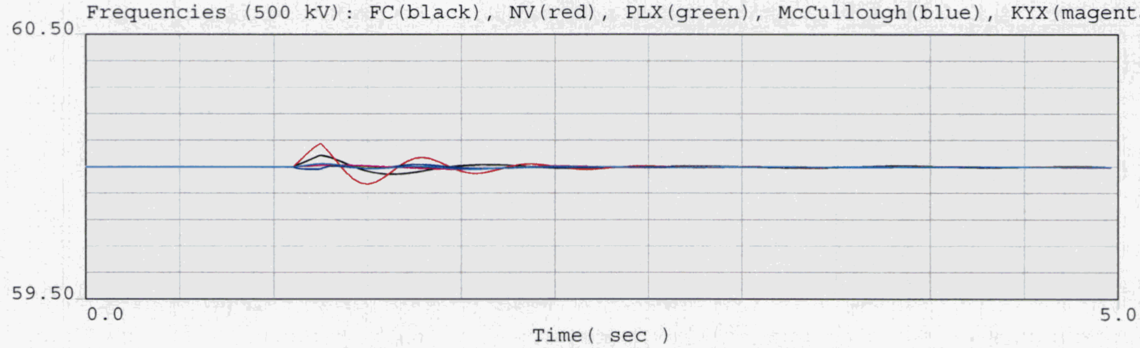

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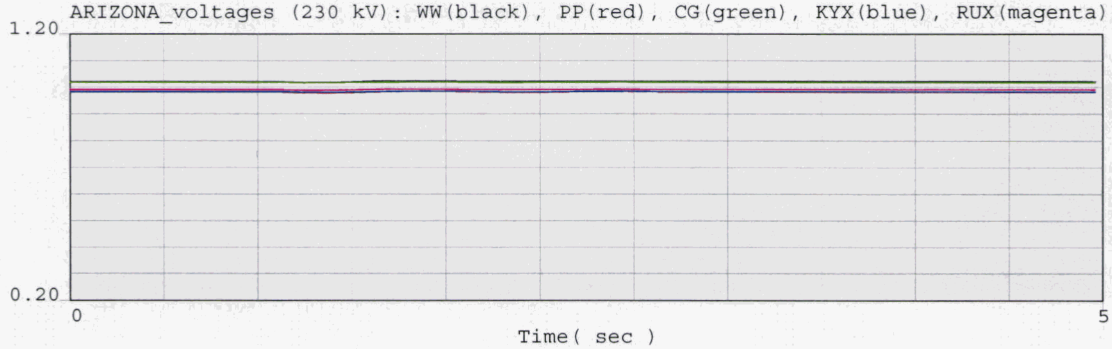

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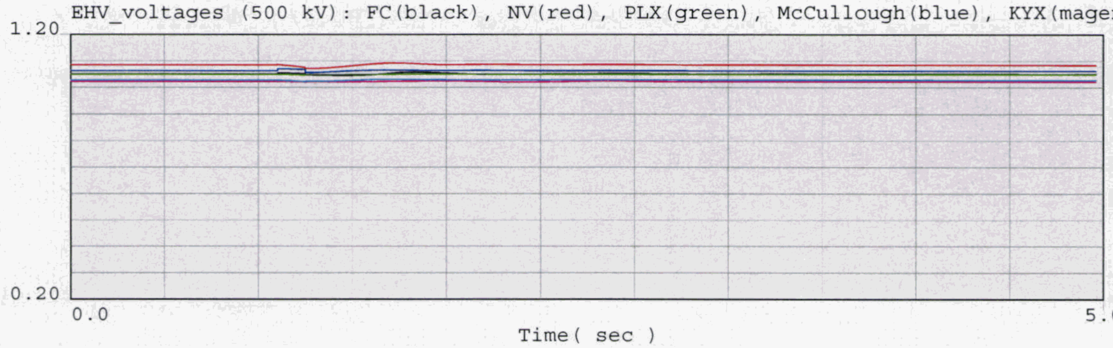

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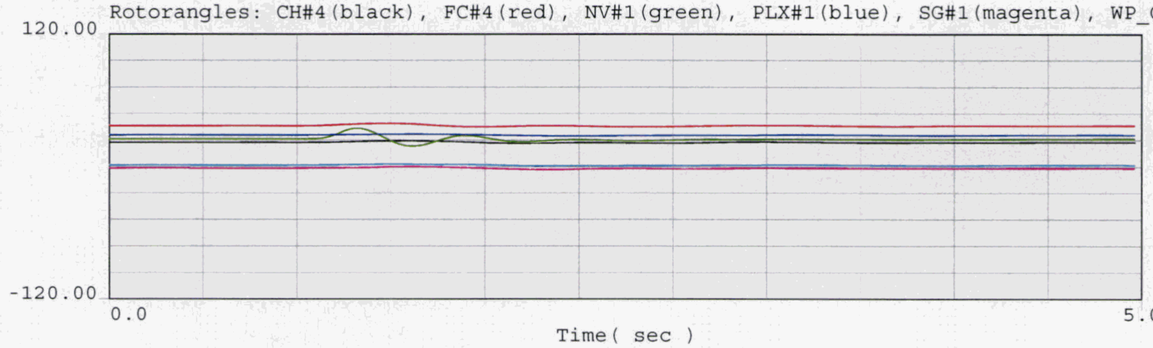

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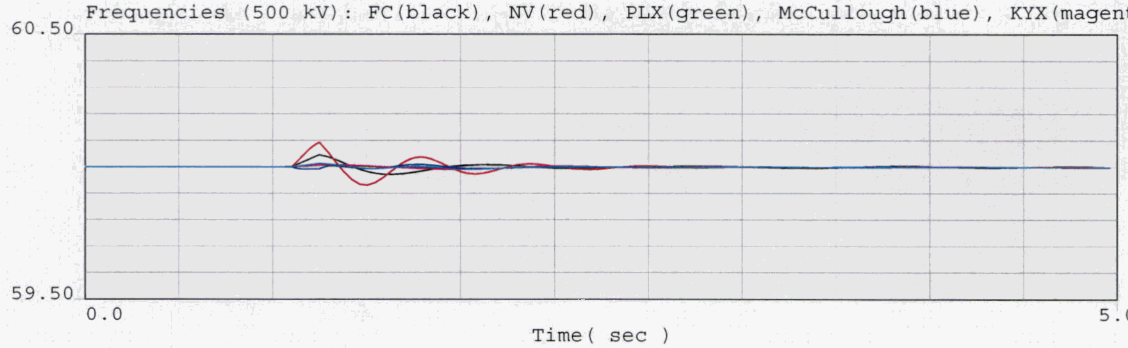

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2016 Heavy Summer WECC Power Flow

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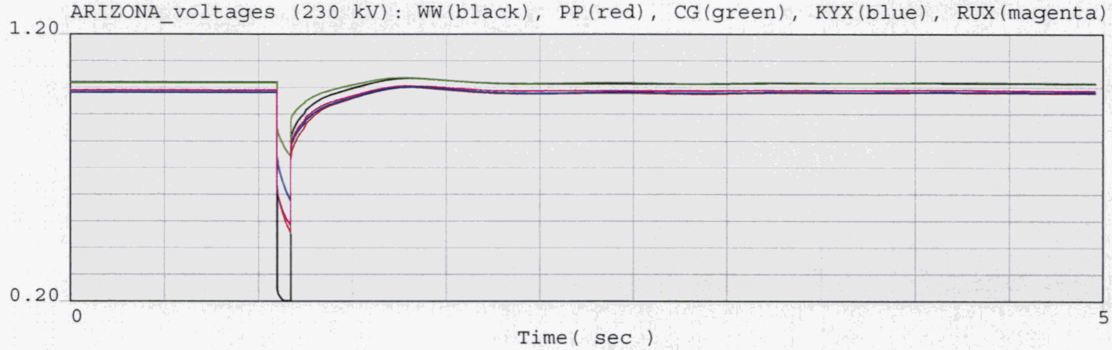

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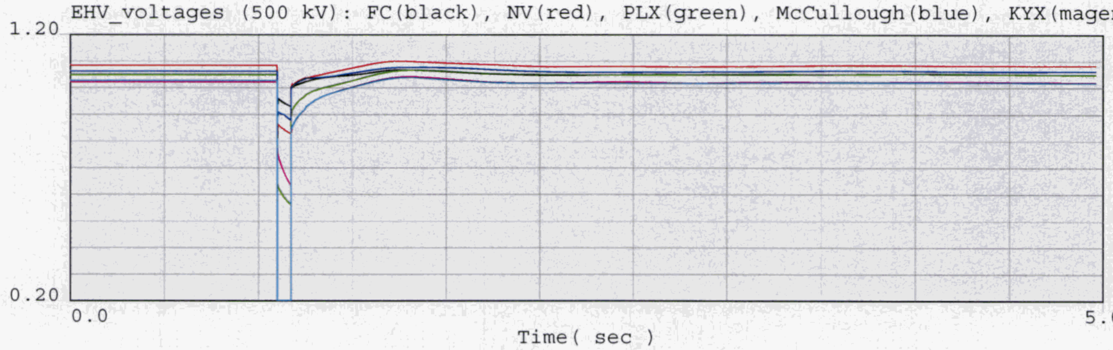

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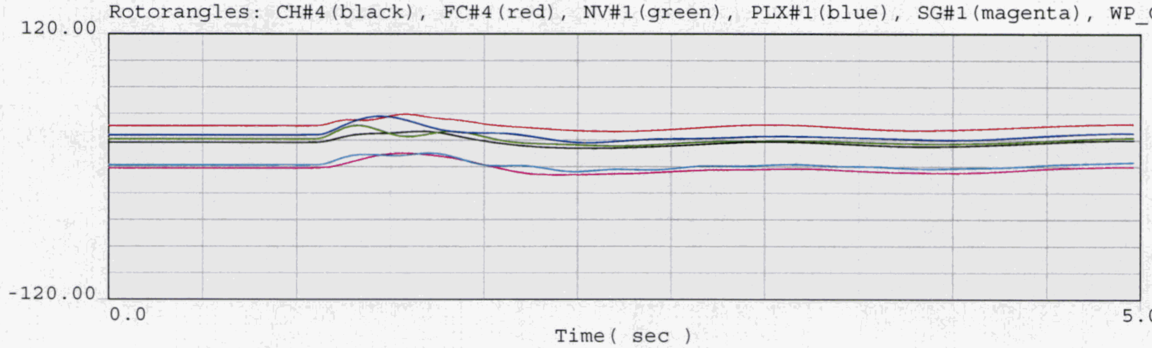

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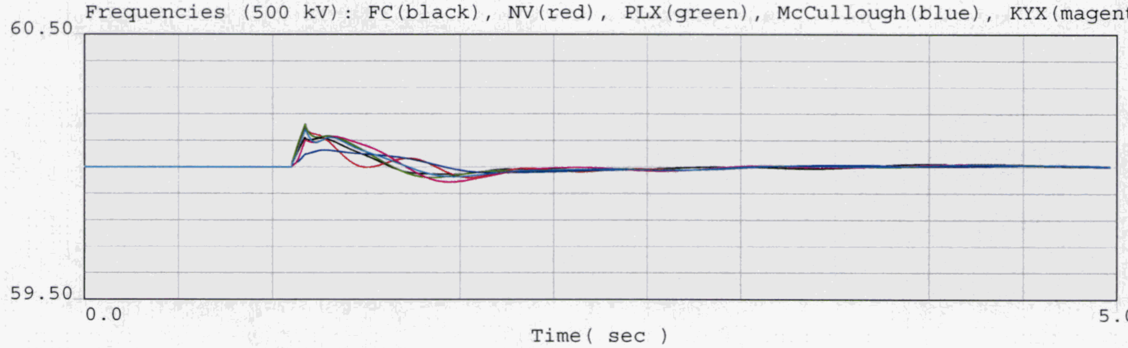

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2016 Heavy Summer WECC Power Flow

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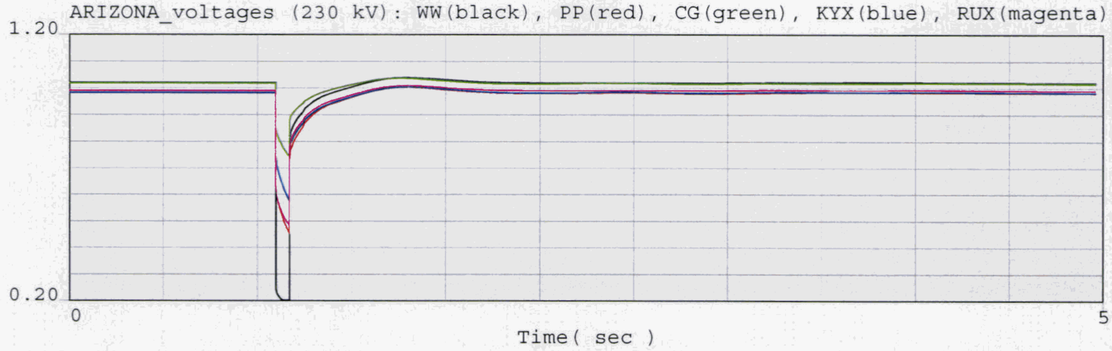

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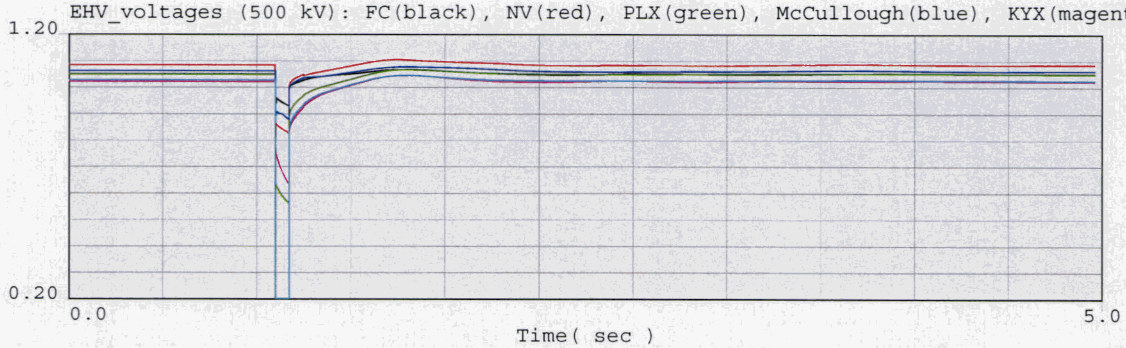

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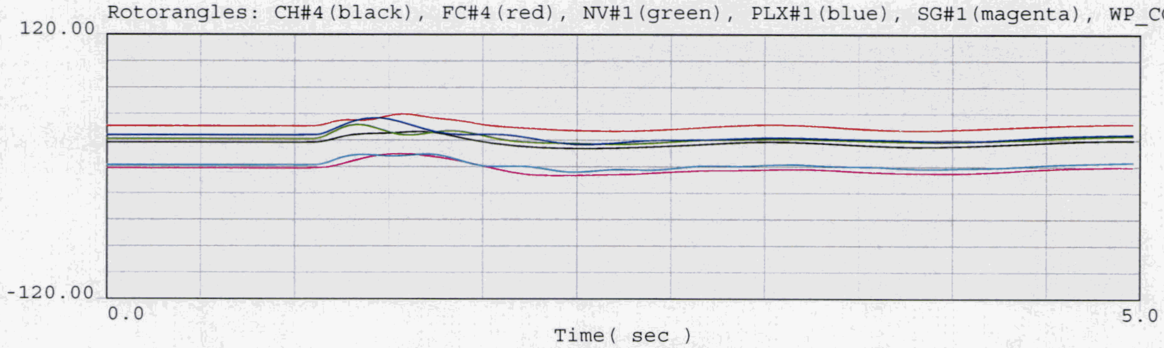

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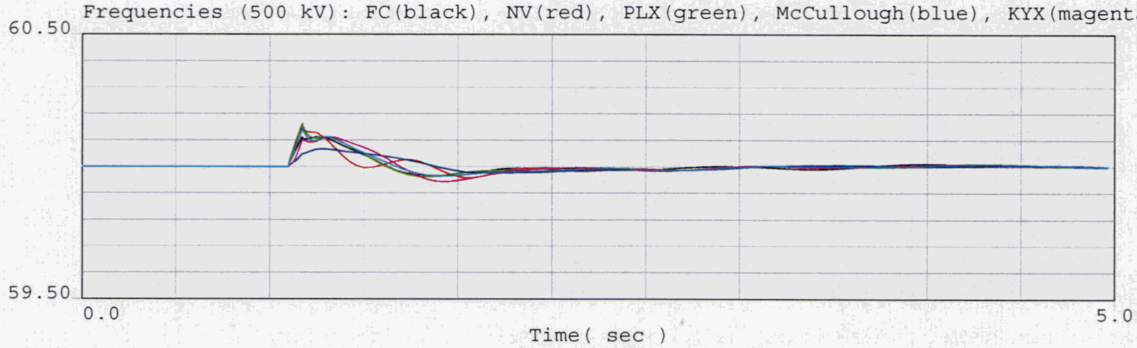

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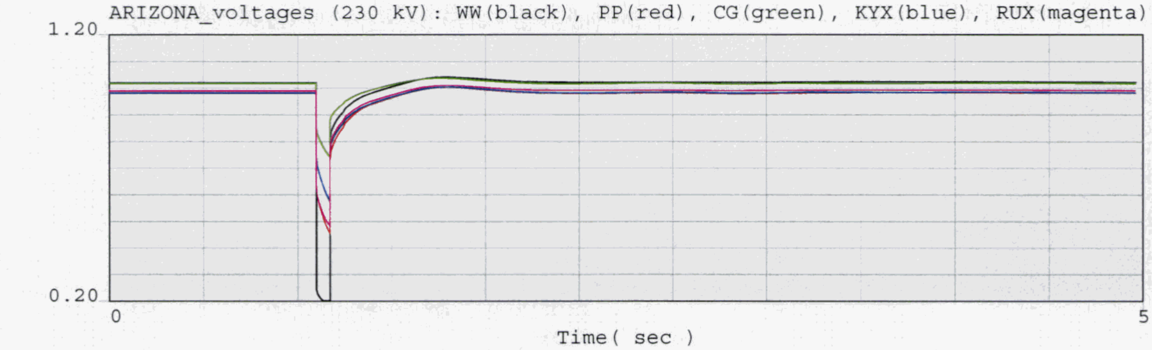

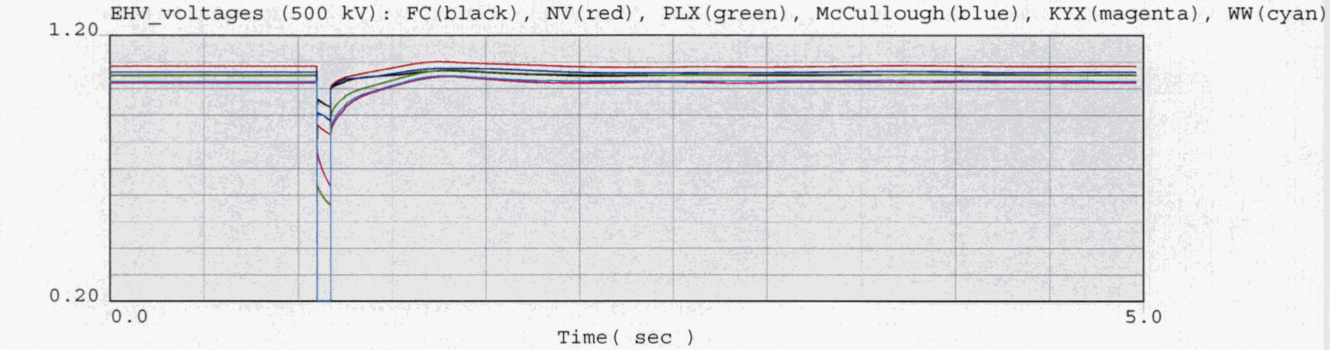

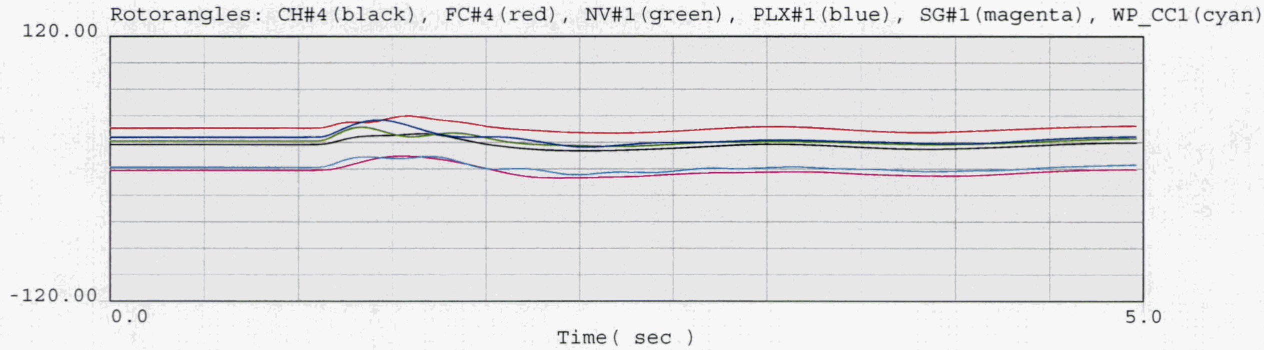

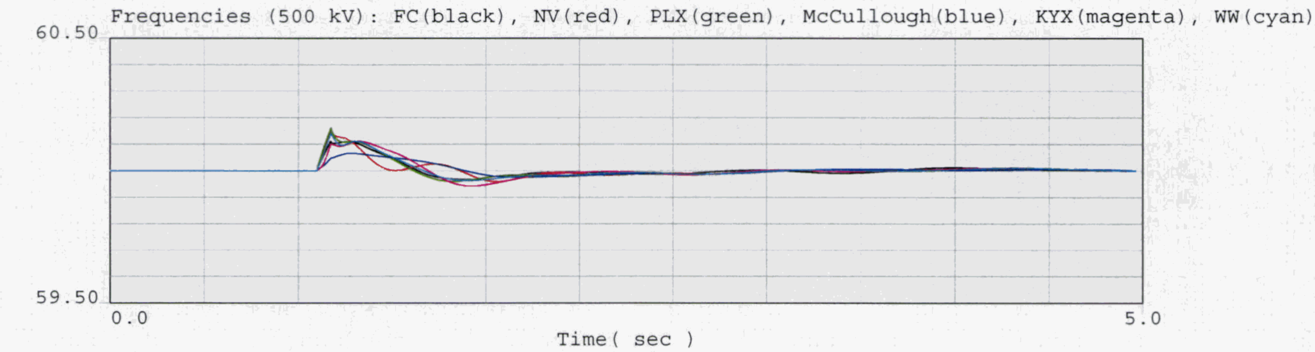

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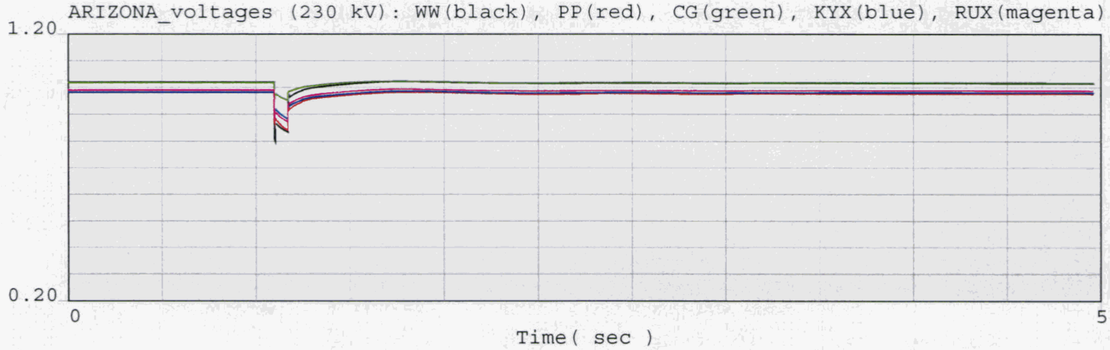

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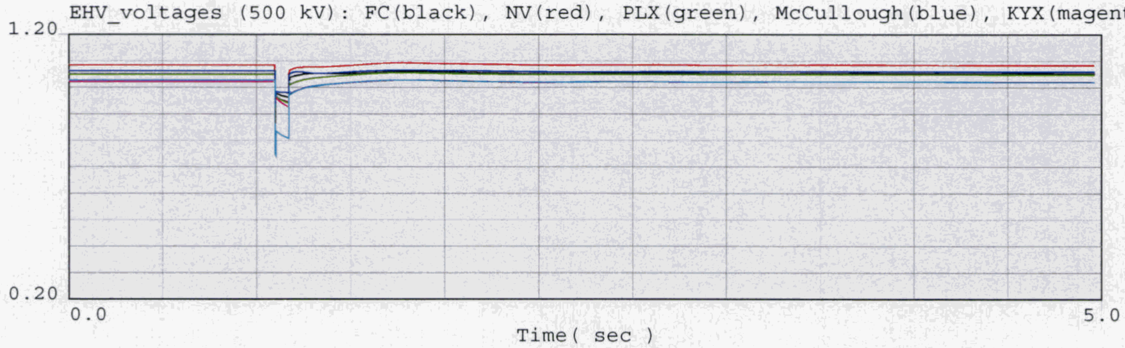

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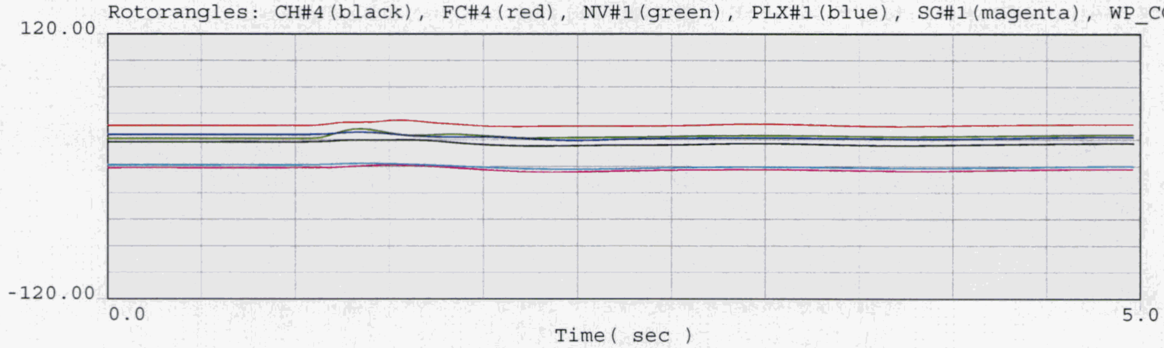

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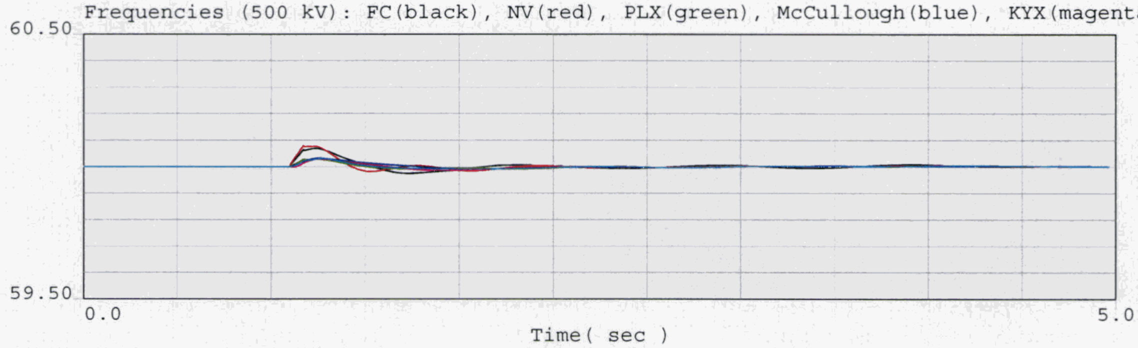

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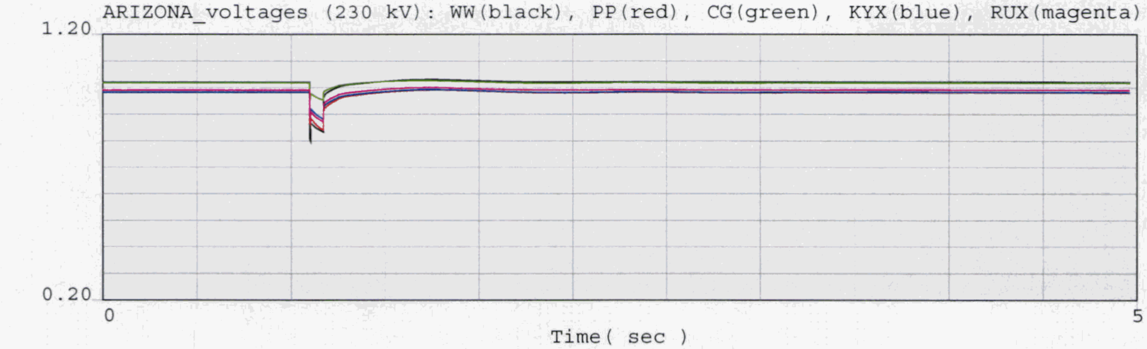

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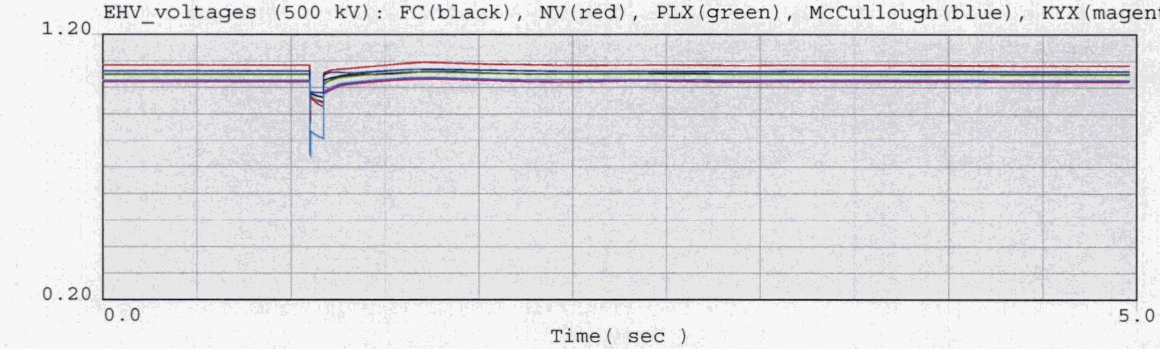

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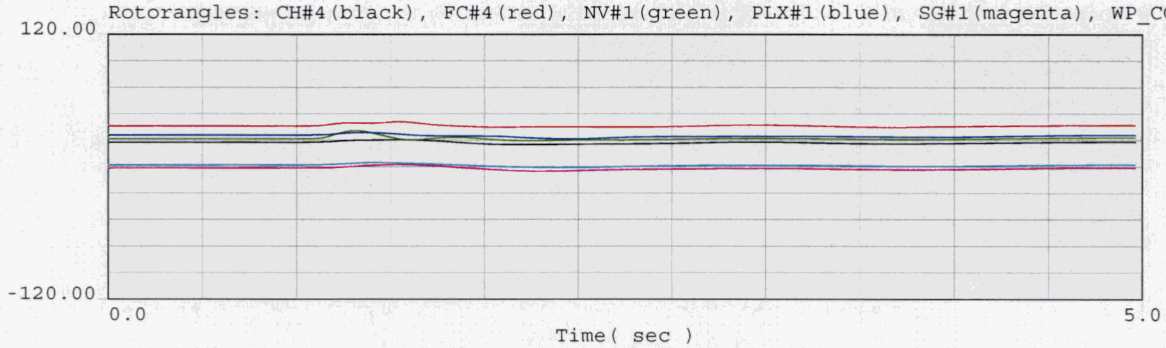

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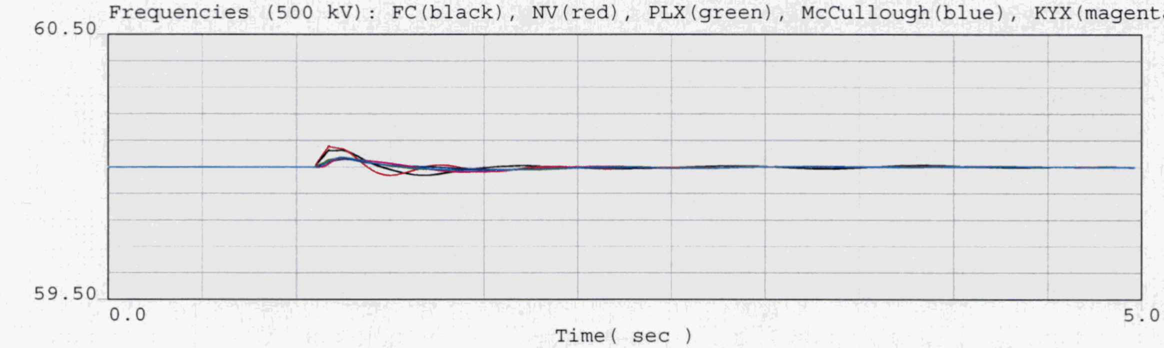

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Reliability Must-Run Analysis

2008–2017

January 30, 2008
APS Transmission Planning

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APS Reliability Must-Run Analysis 2008-2017

I. Executive Summary

This report documents the study methodology, results, and conclusions of Arizona Public Service Company's (APS) Reliability Must-Run (RMR) Analysis for the ten years from 2008 to 2017 (2008 RMR Analysis). This analysis was conducted in response to the Arizona Corporation Commission's (ACC) Second Biennial Transmission Assessment and Decision No. 65476 (December 19, 2002). The 2008 RMR Analysis covers a ten-year period and includes detailed analysis of the years 2011 and 2016.

If a city or load pocket must be served by local generating units at certain peak times, then those units are designated as "reliability must-run" or RMR units. There are two major areas where load cannot be served totally by power imported over transmission lines in the APS service territory – the Phoenix metropolitan area, which is served by a combination of APS and Salt River Project (SRP) facilities, and the APS service territory in the Yuma area.

Although ninety-nine percent of the Phoenix area energy requirements can be met by remote generation, local generation is critically important for the reliability of the local power system. The November 2003 U.S.-Canada Power System Outage Task Force Interim Report: Causes of the August 14th Blackout in the United States and Canada pointed out the importance of the reactive capability of voltage support from local generation. Local generation can provide critical support for transmission contingencies and other power system disturbances and can prevent customer outages including blackout conditions such as those experienced in the Northeast on August 14, 2003.

Comments during the workshop for the 2003 RMR analysis held in February 2003 indicated that electric power system industry participants desired to have a more participative role in the 2004 RMR analysis. To facilitate this participation, APS and the other Arizona transmission providers utilized the Central Arizona Transmission Study (CATS) forum to publicly develop the 2004 RMR study plan, after extensive discussion on study models and preliminary results. APS and the other Arizona transmission providers conducted a workshop on January 15, 2004 to present the study results for comment. This process led to the decision to study the Phoenix area as a combined APS and SRP network and a determination of the specific loads to include in the Phoenix area for the study years.

The ACC Third Biennial Transmission Assessment (BTA) determined that RMR studies must be performed on a biennial basis, with the next report being filed with the ten year plan in January 2006. The ACC Fourth BTA reaffirmed that RMR studies will continue to be performed on a biennial basis, with two representative years being studied and publicly available data being utilized. The Southwest Area Transmission (SWAT) planning group was utilized to facilitate the public discussions and input for this 2008 RMR Analysis. The years 2011 and 2016 were selected because the SWAT planning group was coordinating power flow base cases for these years. Preliminary results of this analysis were presented and agreed upon at the January 16, 2008 SWAT meeting.

Unlike previous RMR studies, where the first year was used as a benchmark to compare the results to the RMR study preceding it, in this study, only a general comparison to the results in the previous RMR study can be made. This is due to the different years studied and in the assumption about which transmission projects would be in-service for the various years studied. However, the results of this study are similar to those from the previous RMR studies in that there is negligible impact of RMR in Phoenix. Also, in the previous RMR study, it was noted that the available Phoenix generation reserves, with the planned transmission projects, were projected to meet or exceed the required generation reserves through 2015. The 2008 RMR study also shows that, with the planned transmission projects, the available Phoenix generation reserves are projected to meet or exceed the required generation reserves through 2016.

The cost of using must-run units can be measured by the difference between generation costs with the transmission limit and costs without the limit. This report looks at and compares the cost of serving these two areas with and without the existing transmission constraints.

This report concludes that for the Phoenix metropolitan area, the cost of RMR is not significant and does not at present outweigh the cost of transmission improvements beyond those already included in the APS and SRP ten-year plans. For Yuma, the report shows that there is some RMR cost for 2011. The 2016 results show that the planned Palo Verde to North Gila 500-kV transmission line and the North Gila to TS8 230-kV line, included in the present APS ten-year plan, are sufficient to mitigate the costs associated with the RMR conditions. Due to the minimal costs associated with the RMR conditions in 2011, it would not be warranted to advance their in-service dates. Environmental effects for both areas with and without transmission constraints are also documented in this report. Because there is such a small RMR requirement for both areas in the two years studied, the environmental effects of RMR are minimal.

A. Study Overview

The existence of transmission import limited areas is not uncommon in the United States, and particularly in the West where load centers are generally separated by long distances. APS has transmission import-limited areas in Phoenix and Yuma. An import area is transmission limited when all load cannot be served solely by importing resources over local transmission lines, thus requiring some use of local generating units to reliably meet peak load.

The two transmission import-limited areas in APS' system were studied to determine:

- The system simultaneous import limit (SIL), which is the maximum amount of capacity that can be reliably imported into an area with no local generation;
- The maximum load serving capability (MLSC), which is the total load that can be served from imports and from local generation;
- The load serving capability and local generation reserves, at the peak forecasted load;
- Annual RMR conditions, including magnitude of load in excess of the import capability and number of hours the load exceeds the SIL; and
- Estimated economic and environmental impacts of the import limits.

The Phoenix area is a tight network of APS and SRP load, resources, and transmission facilities. Because the Phoenix system is highly integrated, the import limits must be determined for the combined area. This analysis was coordinated with SRP personnel, who had significant involvement in the study and were helpful in the overall analysis. The Western Area Power Administration (WAPA) also coordinated with APS and SRP in the study because their transmission facilities interface with the Phoenix network.

After the combined import limits for the Phoenix area were determined, RMR conditions were evaluated for the Phoenix area based on the Phoenix area import limits, the Phoenix area load, and Phoenix area local generation, which includes generation owned by APS and SRP.

The Yuma area, which has a forecast 2011 summer peak demand of approximately 475 MW, is served by an internal APS 69-kV sub-transmission network containing the entire load in the import-limited area. There are external ties to WAPA and the Imperial Irrigation District (IID), as well as a bulk power interface at North Gila with 500kV ties east to the Palo Verde Hub and west to Imperial Valley in California. This analysis was coordinated with the WAPA Phoenix office to ensure accurate modeling.

B. Summary of Results

Results of the analysis for the two years of the study, 2011 and 2016, assumed that present plans for system improvements, in place when the study was conducted, are completed on schedule.

The following table summarizes the estimated RMR conditions and costs for the Phoenix area.

Table ES1
Phoenix Area RMR Conditions and Costs

Year	SIL[1] (MW)	Peak Demand (MW)	Import @ Peak (MW)	RMR[2] @ Peak (MW)	RMR[3] Hours	RMR Energy[4] (GWH)	RMR Energy (% of total)	RMR Cost[5] ($M)
2011	11,245	13,433	11,513	1,920	317	168	0.3	0
2016	13,136	15,542	13,623	1,919	285	155	0.2	0

Table Key:
[1]**SIL** – System Simultaneous Import Limit is the maximum amount of capacity that can be reliably imported into the area with no local generation operating.
[2]**RMR** @ Peak – The amount of local generation required to meet the area peak demand (Peak Demand minus Import Capability at peak load – See figures 3 and 4).
[3]**RMR Hours** – The number of hours that the area's demand exceeds the SIL, thus requiring the use of local generation to meet load, even if otherwise economically dispatched.
[4]**RMR Energy** – The annual energy required to be met by local generation (even if otherwise economically dispatched).
[5]**RMR Cost** – The difference in annual generation cost with and without the transmission limitation (this accounts for generation economically dispatched).

The following table summarizes the estimated RMR conditions and costs for the Yuma area.

Table ES2
Yuma Area RMR Conditions and Costs

Year	SIL[1] (MW)	Peak Demand (MW)	Import @ Peak (MW)	RMR[2] @ Peak (MW)	RMR[3] Hours	RMR Energy[4] (GWH)	RMR Energy (% of total)	RMR Cost[5] ($M)
2011	258	475	281	194	2,258	146	7.1	1
2016	415	553	409	144	719	30	1.3	0

Table Key:
[1]**SIL** – System Simultaneous Import Limit is the maximum amount of capacity that can be reliably imported into the area with no local generation operating.
[2]**RMR @ Peak** – The amount of local generation required to meet the area peak demand (Peak Demand minus Import Capability at peak load – See figures 7 and 8).
[3]**RMR Hours** – The number of hours that the area's demand exceeds the SIL, thus requiring the use of local generation to meet load, even if otherwise economically dispatched.
[4]**RMR Energy** – The annual energy required to be met by local generation (in excess of the SIL).
[5]**RMR Cost** – The difference in annual generation cost with and without the transmission limitation (this accounts for generation economically dispatched).

APS determined the Phoenix area reserve requirements by performing a probabilistic analysis that considered the size and forced outage rates of the local generating units and resulted in 99 percent reliability level. This analysis resulted in reserve requirements of 865 MW for the Phoenix area for the years studied.

The Simultaneous Import Limit (SIL) and Maximum Load Serving Capability (MLSC) are determined by performing power flow studies. The SIL and MLSC results are utilized to develop the Phoenix area Load Serving Capability (LSC) graphs, determining the amount of local Phoenix generation that is required to serve the projected peak demand, and determining the import capability at the projected peak demand. The Phoenix area projected reserves are calculated from the total local Phoenix generation less the amount of local generation required at peak demand. The following table shows the projected Phoenix area reserve capacity.

Table ES3
Phoenix Area Reserve Capacity

Year	Local Generation	Peak Demand (MW)	Import @ Peak (MW)	RMR @ Peak (MW)	Projected Reserves[1]	Required Reserves
2011	3,678	13,433	11,513	1,920	1,758	865
2016	3,678	15,542	13,623	1,919	1,759	865

Table Key:
[1]**Projected Reserves** – The amount of local generation minus the amount of RMR @ Peak.

APS determined the reserve requirement for Yuma based on Loss of Load Probability (LOLP) criteria of one day in ten years. Based on Yuma area load, import capability and the availability of local generation, this criteria would result in not being able to meet Yuma load one day in ten years. The 1/10 criteria translates to a reserve requirement of 97 MW during the time frame studied.

Similarly to the Phoenix area analysis, the Yuma area SIL and MLSC are determined and utilized to develop the Yuma area LSC graphs and calculating the projected reserves. The following table summarizes the Yuma area reserve capacity.

Table ES4
Yuma Area Reserve Capacity

Year	Local Generation	Peak Demand (MW)	Import @ Peak (MW)	RMR @ Peak (MW)	Projected Reserves[1]	Required Reserves
2011	313	475	281	194	119	97
2016	313	553	409	144	169	97

Table Key:
[1]**Projected Reserves** – The amount of local generation minus the amount of RMR @ Peak.

Local generating units are dispatched based on cost. Thus, most of the RMR hours shown above are dispatched in merit order. However, the presence of a transmission constraint may require local generation to be dispatched out of merit order or "out of the money." This report considered Phoenix area and Yuma area transmission limitations and generation resources in determining the overall RMR situation. The economic impact of RMR can be seen from the following tables.

Taking economic generation into account the Phoenix load area did not reach its transmission import limits. The following table shows, for the years of 2011 and 2016, Phoenix generation is not expected to run out of economic dispatch.

Table ES5

Phoenix Area RMR Outside Economic Dispatch

Year	Hours outside economic dispatch	Energy outside economic dispatch (GWH)	RMR Cost ($M)
2011	0	0	0
2016	0	0	0

The following table summarizes the estimated total number of hours that APS local Yuma generation may run out of economic dispatch, the amount of energy that is produced out of economic dispatch and the associated cost.

Table ES6
APS Yuma Area RMR Outside Economic Dispatch

Year	Hours outside economic dispatch	Energy outside economic dispatch (GWH)	RMR Cost ($M)
2011	265	25	1
2016	25	1	0

In addition to economic modeling, the emissions impact of RMR generation is also evaluated. The Phoenix load area did not have generation dispatched outside of economic dispatch, so there is no emissions impact to the Phoenix area. The following table summarizes the emissions impact of RMR generation for the Phoenix area.

Table ES7
Phoenix Area Air Emissions Impact of RMR

Pollutant	RMR Impact[1] (tons/year)	Phoenix Area Emissions RMR Impact (% of total emissions from all sources)
NO_x	0.0	0.000
CO	0.0	0.000
PM_{10}	0.0	0.000
VOC	0.0	0.000

[1]2011 and 2016 results

Similarly to the Phoenix area, the emissions impact in the Yuma area, due to RMR generation was determined. Removing the transmission constraints would reduce total Yuma area air emissions by a minimal amount for the years 2011 and 2016. The following table summarizes the emissions impact of RMR generation for the Yuma area.

Table ES8
Yuma Area Air Emissions Impact of RMR

Pollutant	RMR Impact (tons/year)		Yuma Area Emissions RMR Impact (% of total emissions from all sources)	
	2011	**2016**	**2011**	**2016**
NO_x	20	2	N/A	N/A
CO	4	1	N/A	N/A
PM_{10}	0.48	0.04	0.001	0.000
VOC	0.45	0.03	N/A	N/A

C. Report Conclusions

Phoenix area Conclusions

1. Phoenix area existing and planned transmission and local generation are adequate to reliably serve Phoenix area peak load in 2011 and 2016 with the projected local generation reserve margin exceeding the required reserve margin.

2. During the summer, Phoenix area load is expected to exceed the available transmission import capability for approximately 317 hours in 2011 and 285 hours in 2016. These hours represent less than one percent of the annual energy requirements for the Phoenix area.

3. From a total Phoenix load, transmission, and resources viewpoint, local generation is not expected to be dispatched out of economic dispatch order in 2011 and 2016.

4. Because there is not expected to be an out of merit order cost of Phoenix area RMR generation, advancement of transmission projects to increase import capability are presently not cost justified.

5. The Phoenix load area did not reach its transmission import limits in 2011 and 2016, so there is no emission impact to the Phoenix area.

6. Since the Phoenix load area did not reach its transmission import limits in 2011 and 2016, there is no impact to local generation capacity factor and total yearly natural gas consumption by the Phoenix area generators.

Yuma Area Conclusions

7. Yuma area existing and planned transmission and local generation are adequate to reliably serve Yuma area peak load in 2011 and 2016 with the projected local generation reserve margin exceeding the required reserve margin.

8. The Yuma area load is expected to exceed the available transmission import capability for 2,258 hours in 2011 and 719 hours in 2016. These hours represent approximately 7% of the annual energy requirements for Yuma in 2011 and approximately 1% in 2016.

9. From a total Yuma load, transmission, and resources viewpoint, the import constraint could cause APS Yuma generation to be dispatched out of economic dispatch order for 265 hours in 2011 and 25 hours in 2016.

10. The estimated annual economic cost of Yuma area generation required to run out of economic dispatch order is approximately $1 million for 2011. Due to the planned addition of another EHV line to Yuma and the addition of an HV line within the Yuma area, as indicated in APS' 10-Year Plan, those costs are negligible by 2016.

11. Removing the transmission constraint would reduce total Yuma area air emissions by a minimal amount for years 2011 and 2016.

12. Removing the import restriction into the Yuma area could reduce the APS Yuma generation capacity factor from 3.3 percent to 2.1 percent in 2011 and from 1.5 percent to 1.4 percent in 2016.

13. Removing the transmission constraint could reduce total yearly natural gas consumption by the Yuma area generators by 0.294 BCF and 0.019 BCF for 2011 and 2016, respectively.

D. Report Organization

This report is organized in seven sections. Section I provides an executive summary of the report. Section II provides general background information of the study requirements, an overview of RMR, and describes the study methodology. Section III describes the Phoenix area, the nature of the import limit, the resulting import limits for 2011 and 2016, and the impact of various generators in and around the Phoenix area on the import limit. Section IV provides a similar discussion of the Yuma area. Section V describes the RMR conditions such as number of hours, maximum capacity, and annual energy for the Phoenix and Yuma areas. Section VI provides results of the economic analysis of the Phoenix and Yuma area RMR conditions performed utilizing a planning model (PROMOD) and emissions impact. Finally, Section VII lists the conclusions of the analysis.

II. INTRODUCTION

A. Background of Study Requirement

Like all large electric utilities, Arizona utilities have historically relied on both transmission, to deliver remote generation into its load centers, as well as local generation to reliably serve its customers. Due in part to environmental, economic, and fuel availability considerations, large base-load thermal generators have typically been located away from the load centers while smaller but less efficient intermediate and peaking units, with lower capacity factors, were located within the load centers. Although this local generation is relied on for a relatively small amount of energy, this local generation is critically important for the reliability of the local power system. The November 2003 U.S.-Canada Power System Outage Task Force Interim Report: Causes of the August 14th Blackout in the United States and Canada pointed out the importance of the reactive capability of voltage support from local generation. Local generation can provide critical support for transmission contingencies and other power system disturbances and can prevent customer outages including blackout conditions such as those experienced in the Northeast on August 14, 2003. Local generation also results in lower power system losses and lower capital expenses for transmission infrastructure.

In the past, vertically-integrated utilities, such as APS, managed the siting and construction of both generation and transmission resources needed to serve their customers. Electric systems were designed based on a detailed integrated resource planning process used to evaluate the appropriate balance of generation, transmission, and demand-side resources. Interconnections with neighboring systems were primarily intended to improve system reliability and lower the costs of reserves by allowing for sharing of capacity reserves by multiple systems. Each utility's system was primarily designed to accommodate that utility's resources and that utility's load.

The Commission's Second Biennial Transmission Assessment (BTA) required "any [Utility Distribution Company] that currently relies on local generation, or foresees a future time period when utilization of local generation may be required to assure reliable service for a local area, [to] perform and report the findings of an RMR study as a feature of their ten year plan filing with the Commission in January 2003 and 2004." The Assessment required that the RMR study filed in January 2003 evaluate RMR conditions through the 2005 summer peak. The January 2004 RMR study covers the 10-year period from 2004 to 2013. The Commission's Third BTA determined that RMR studies must be performed on a biennial basis, with the next report being filed with the ten year plan filed in January 2006. The Commission's Fourth BTA reaffirmed that RMR studies will continue to be performed on a biennial basis, with two representative years being studied and publicly available data being utilized.

B. Overview of RMR

Local "load pockets" are areas that do not have enough transmission import capability to serve all load in the area solely by importing remote generation over local transmission facilities. For these areas, during peak hours of the year, local generation is required to serve that portion of the load that cannot reliably be served by transmission imports. This local generation requirement is often referred to as Reliability Must-Run or RMR generation. In these areas, during peak conditions, load is served by a combination of importing remote generation over transmission lines and operating local generation.

The maximum load that can be served in a load pocket with all of the local generation operating – in other words, the maximum load that can be served by importing remote generation and local generation – is referred to as the system Maximum Load Serving Capability (MLSC). The MLSC is established through technical studies by ensuring that:

- With the local load at the MLSC and all local generation operating there are no transmission system normal operating (N-0) limit violations of thermal loading or voltages, and
- Under all single contingency outage events (N-1) there are no emergency operating limit violations of thermal loading or voltages, and no system instability.

The maximum load that can be served in a load pocket with no local generation operating — in other words, the maximum load that can be served solely by importing remote generation — is referred to as the system Simultaneous Import Limit (SIL). The SIL is established through technical studies by ensuring that:

- With the local load at the SIL and no local generation operating there are no transmission system normal operating (N-0) limit violations of thermal loading or voltages, and
- Under all single contingency outage events (N-1) there are no emergency operating limit violations of thermal loading or voltages, and no system instability.

C. Study Methodology

Import limit analysis was performed for the Phoenix and Yuma areas. The import limit area or load pocket is defined as that load which, when increased, would increase the severity of the limiting contingency. For example, load in Flagstaff has no impact on the severity of the limiting contingency for the Phoenix import limited area, and therefore Flagstaff is not included in the Phoenix load pocket. In contrast, downtown Phoenix load does impact the severity of the limiting contingency and therefore is included in the load pocket. All area contingencies known to result in system stress were evaluated to determine the critical contingency for the area. Import limits were determined by contingency conditions of thermal loading at the emergency rating of a facility, steady state voltages at the emergency voltage limit, and system instability including voltage instability.

Import limits were determined for the Phoenix and Yuma areas with no local generation operating, with maximum local generation operating, and sufficient points in between to determine curves which define import limits at all load levels. This methodology was applied to studies of the Phoenix area, which for 2011 is constrained by voltage instability and in 2016 is constrained by thermal loadings. For the Yuma studies, the limitations are primarily post-disturbance thermal constraints.

From each year's forecasted peak load and historical daily load cycles, the annual RMR conditions were determined, including magnitude of local load, both demand and energy, expected to exceed the SIL and the annual hours for which local load is expected to exceed the SIL.

An economic analysis was performed in each area for each year using the NewEnergy PROMOD production cost simulation program to determine the cost of the import limits. Much of the data used in modeling comes from public sources and has been obtained from the WECC.

Additional transmission alternatives to mitigate the import limits of the Yuma area were not studied due to the minimal amounts of RMR conditions that were identified in the study. The cost for any transmission alternative would significantly exceed the costs associated with any RMR conditions. This report concludes that there is no additional cost of Phoenix metropolitan area RMR because the Phoenix load area did not reach its transmission import limits in 2011 and 2016.

D. Determination of SIL and RMR Conditions

In this analysis, assessments of the SIL and RMR conditions for the Phoenix area and the Yuma area were performed for the years 2011 and 2016. The years 2011 and 2016 were selected because the SWAT planning group was coordinating power flow base cases for these years. To consider potential economic effects resulting from using local generation or arising from RMR conditions, an economic analysis was performed using the NewEnergy PROMOD model. Much of the data used in the production cost model comes from publicly available WECC Transmission Expansion Planning Policy Committee (TEPPC) power plant data. At the time this RMR study was performed, the TEPPC 2017 data test case October 1, 2007 version was used in the RMR economic analysis. The years 2011 and 2016 are also good representative years during the ten-year window. Base case and contingency power flow, stability, and voltage stability analyses were performed to determine import limitations. The initial starting cases were based on WECC heavy summer full loop base cases in GE Power Flow format for the corresponding year. Those base cases model the entire Western Interconnection's transmission system and were reviewed and then updated to represent expected loads and system configuration for 2011 and 2016. Both cases were coordinated between APS, SRP, Tucson Electric Power Company (TEP), Southwest Transmission Cooperative (SWTC), and WAPA to capture the most accurate expected operating conditions for the Arizona transmission system.

III. PHOENIX LOAD POCKET

A. Description of Phoenix Area

During summer 2011, the Phoenix area — which consists of both APS' and SRP's integrated network — will be served from the following major Extra High Voltage (EHV) substations: Westwing, Pinnacle Peak, Kyrene, Rudd, Browning, Silverking, South East Valley (SEV), Sun Valley, and TS9. These EHV stations form the "cornerstones" of an extensive internal network of 230-kV transmission lines that constitute the high voltage energy delivery system within the Phoenix load area. Between the summers of 2011 and 2016, there will not be any new EHV substations serving the Phoenix area.

Since the summer of 2002, APS has served some northwest Phoenix area load from the Raceway 230-kV substation, which has been built as an interconnection to the WAPA Westwing-to-Waddell 230-kV line. Because this line has no interconnections with other Phoenix area 230-kV lines, this load does not significantly impact the contingency response of the Phoenix area and is therefore not included in the Phoenix area load determination, until 2010, when the Raceway 230-kV substation will have become interconnected to Pinnacle Peak substation and the new 500-kV substation.

Because the City of Mesa load is served by dedicated resources external to Phoenix, the economic RMR analysis is performed with this load excluded.

Energy flows into the EHV delivery points from the EHV transmission lines and then is stepped down to 230-kV and transmitted into the load center via the 230-kV transmission lines. These loads, with area losses, are measured by determining the flows from the EHV substations into the load area to include all of these load stations. The specific loads to be included in the Phoenix area load for each of the years was determined by sensitivity analysis performed in a previous RMR study effort which determined the impact of various loads on the severity of the critical contingencies. Figure 1 shows all of the loads included for the 2011 study. Figure 2 shows all of the loads included for the 2016 study.

Figure 1

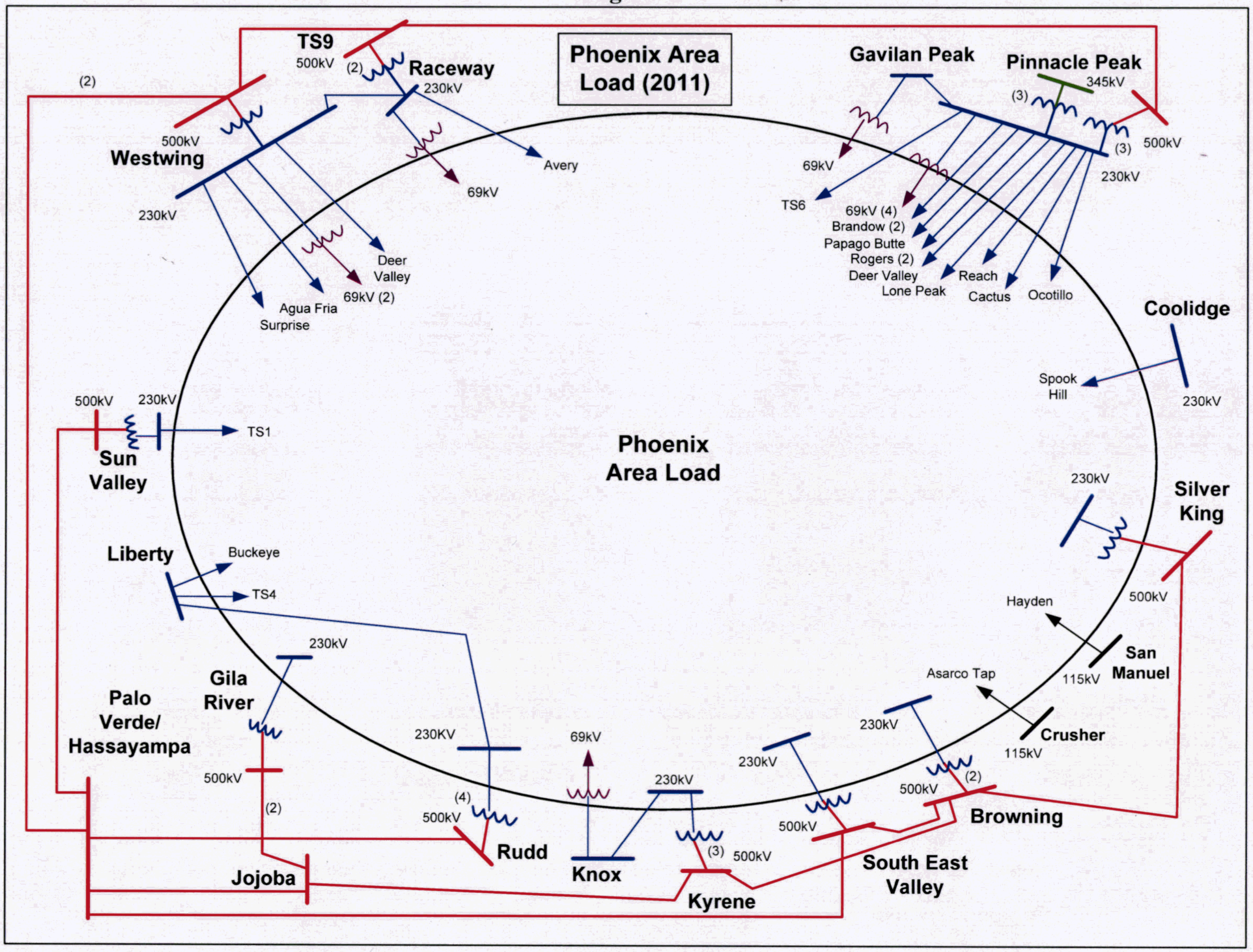
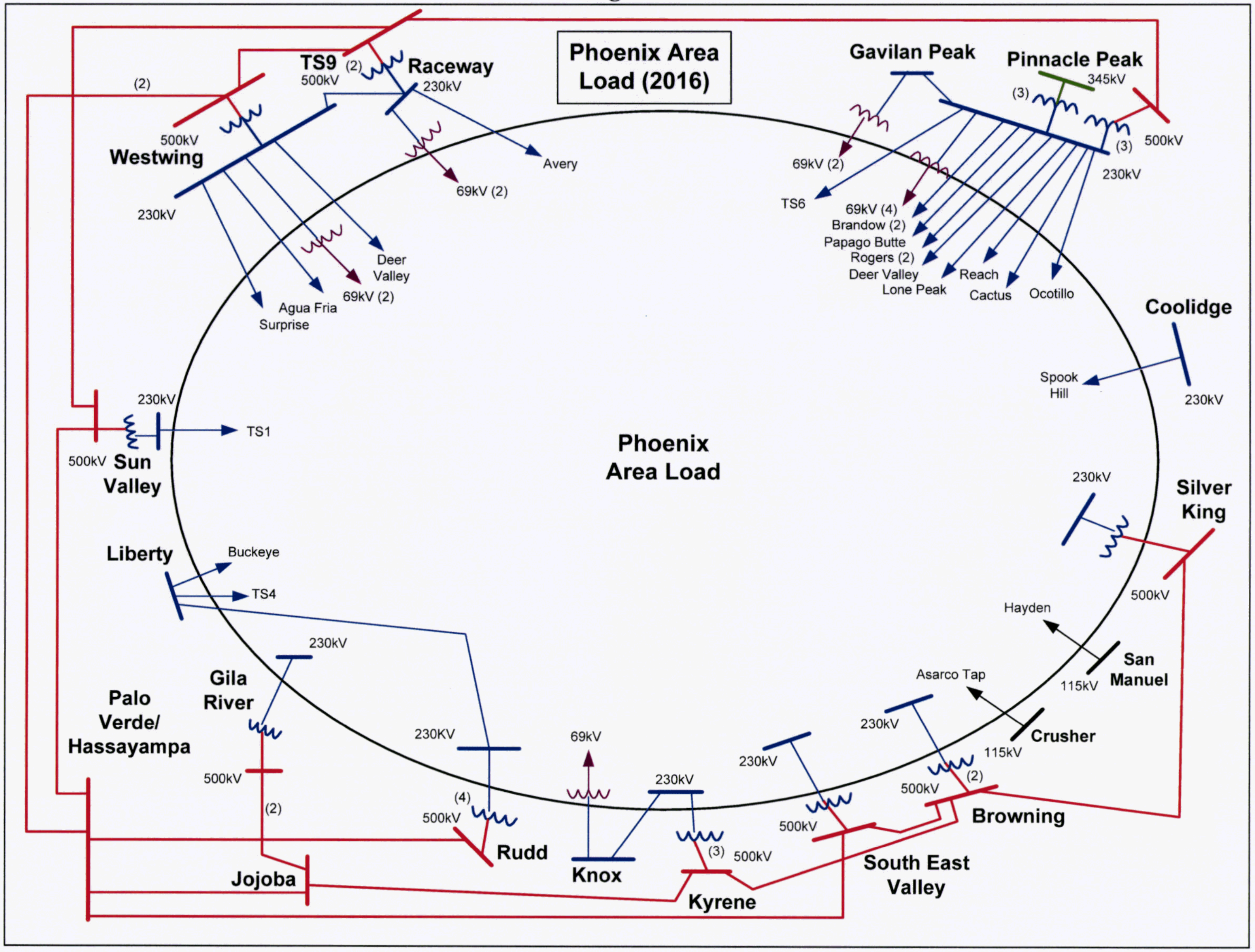

Phoenix Area Load (2011)
TS9
500kV
(2)
Raceway
230kV
Westwing
500kV
230kV
Avery
69kV
Deer Valley
69kV (2)
Agua Fria
Surprise
Gavilan Peak
Pinnacle Peak
345kV
(3)
500kV
230kV
69kV
TS6
69kV (4)
Brandow (2)
Papago Butte
Rogers (2)
Deer Valley
Lone Peak
Reach
Cactus
Ocotillo
Coolidge
Spook Hill
230kV
Phoenix Area Load
Sun Valley
500kV
230kV
TS1
Silver King
230kV
500kV
Liberty
Buckeye
TS4
Hayden
San Manuel
115kV
Asarco Tap
Crusher
115kV
Gila River
230kV
500kV
(2)
Palo Verde/ Hassayampa
230KV
(4)
500kV
Rudd
69kV
Knox
230kV
Kyrene
(3)
500kV
230kV
500kV
South East Valley
230kV
500kV
(2)
Browning
Jojoba

Figure 2


Phoenix Area Load (2016)
Phoenix Area Load
TS9
500kV
(2)
Raceway
230kV
Westwing
500kV
230kV
Avery
69kV (2)
Deer Valley
69kV (2)
Agua Fria
Surprise
Gavilan Peak
Pinnacle Peak
345kV
(3)
500kV
230kV
69kV (2)
TS6
69kV (4)
Brandow (2)
Papago Butte
Rogers (2)
Deer Valley
Lone Peak
Reach
Cactus
Ocotillo
Coolidge
Spook Hill
230kV
Sun Valley
TS1
Liberty
Buckeye
TS4
Silver King
Hayden
San Manuel
115kV
Asarco Tap
Crusher
Browning
South East Valley
Kyrene
Knox
69kV
230KV
Rudd
(4)
Gila River
Jojoba
Palo Verde/ Hassayampa

In performing the Phoenix area studies several planned projects were added to reflect transmission system upgrades, in the Phoenix area High Voltage (HV) system and the Arizona Extra-High Voltage (EHV) system, for the next ten years. They are listed below; under one of the two study years they will first appear:

Projects in service by 2011

- Hassayampa-Pinal Pinal West 500-kV line and 500/345-kV transformer at Pinal West
- Pinal West 345-kV looped in and out of Westwing-South 345-kV line
- A new Santa Rosa 500-kV substation
- A new Pinal West-Santa Rosa-Pinal South-SEV-Browning 500-kV line
- A new South East Valley (SEV) 500/230-kV substation with two 500/230-kV transformers
- Shunt capacitors added in the eastern portion of the system
- A new Harquahala Junction 500-kV substation looped into the Harquahala-Hassayampa 500-kV line
- A new Sun Valley 500-kV and 230-kV substation with a 500/230-kV transformer and Harquahala Junction-Sun Valley 500-kV line
- A new TS1 230-kV substation with a 230/69-kV transformer and Sun Valley-TS1 230-kV line
- A new TS1-Palm Valley 230-kV line
- A new TS9 500-kV substation with two 500/230-kV transformers and looped into the Navajo-Westwing 500-kV line
- A new Pinnacle Peak 500-kV substation with three 500/230-kV transformers and a 500-kV line to the TS9 500-kV substation
- A new Raceway-Pinnacle Peak 230-kV line
- A new TS6 230/69-kV substation with a 230/69-kV transformer and looped in the Raceway-Pinnacle Peak 230-kV line
- New coal generation at Four Corners of 1400 MW; owned and operated by an Independent Power Producer (IPP)
- A new Red Mesa East 500-kV substation connected to Navajo-Moenkopi 500-kV line
- A new Harquahala Junction-Devers 500-kV line
- A new Four Corners-Red Mesa East 500-kV line
- A third 500/230-kV transformer at Kyrene substation

Projects in service by 2016

- A new Sun Valley-TS9 500-kV line
- A new Avery 230/69-kV substation with a 230/69-kV transformer and looped in the Raceway-TS6 230-kV line
- A new TS2 230/69-kV substation with a 230/69-kV transformer and looped into the TS1-Palm Valley 230-kV line
- Lincoln Street 2nd 230/69-kV transformer addition
- Shunt capacitors added in the eastern portion of the system

B. Phoenix Area Critical Outages

1. 2011

The analysis determined that the critical single contingency for the Phoenix load area at all load and generation levels is the loss of the Palo Verde-to-Rudd 500-kV transmission line. The loss of this major 500-kV line results in significantly higher flows on the remaining transmission lines and the underlying 230-kV transmission system and causes a large increase in reactive power (Var) losses in the transmission network. The increase in Var consumption results in insufficient Vars for voltage support in the load area. Consequently, this condition creates low voltages in the system and makes the area deficient in reactive power.

2. **2016**

The analysis determined that the critical single contingency for the Phoenix load area at the SIL point is the loss of the Palo Verde-to-Rudd 500-kV transmission line. The loss of this major 500-kV line to the Phoenix area results in a thermal overload of the Rudd-to-Liberty 230-kV line. With local Phoenix area generation at high levels the critical single contingency for the Phoenix load area is the loss of one of the two Orme-to-Rudd 230-kV lines. The loss of this 230kV line results in a thermal overload of the second Orme-to-Rudd 230-kV line. Thus, the system is constrained by these thermal overloads at the two ends of the nomogram.

The voltage stability analysis was performed using Q-V analysis on the most reactive deficient buses in the Phoenix area. These buses were the Kyrene 500-kV, Kyrene 230-kV, Browning 230-kV, and the Pinnacle Peak 230-kV buses.

Q-V analysis is performed by adding reactive load at the critical bus until the voltage reaches a minimum value which indicates potential voltage instability. The import limit is determined as the lesser of 95% of the import with zero reactive margin or 100% of the import with a 5% voltage drop following the worst single-contingency per WECC planning criteria.

C. Phoenix Area – SIL and MLSC for 2011 and 2016

Analysis of the Phoenix area transmission network resulted in area import limits based on the limits discussed in the previous section (B. Phoenix Area Critical Outages). Operation of the Phoenix system within these limits ensures that the area does not experience voltage instability or thermal overloading of a system element after a critical contingency. Voltage instability is characterized by a progressive fall in voltage magnitude at a particular location of the power system that may spread throughout the network causing a complete area voltage collapse and blackout. A thermal overload occurs when more power flows through an element than the emergency rating of that element. The Phoenix area SIL and MLSC for the years 2011 and 2016 are outlined in Table 1.

Table 1
2011 and 2016 Phoenix area Simultaneous Import Limit

Year	SIL (MW)	MLSC (MW)
2011	11,245	15,436
2016	13,136	17,747

The maximum Phoenix area load-serving capability for various generation levels is shown in Figures 3 and 4.

Figure 3

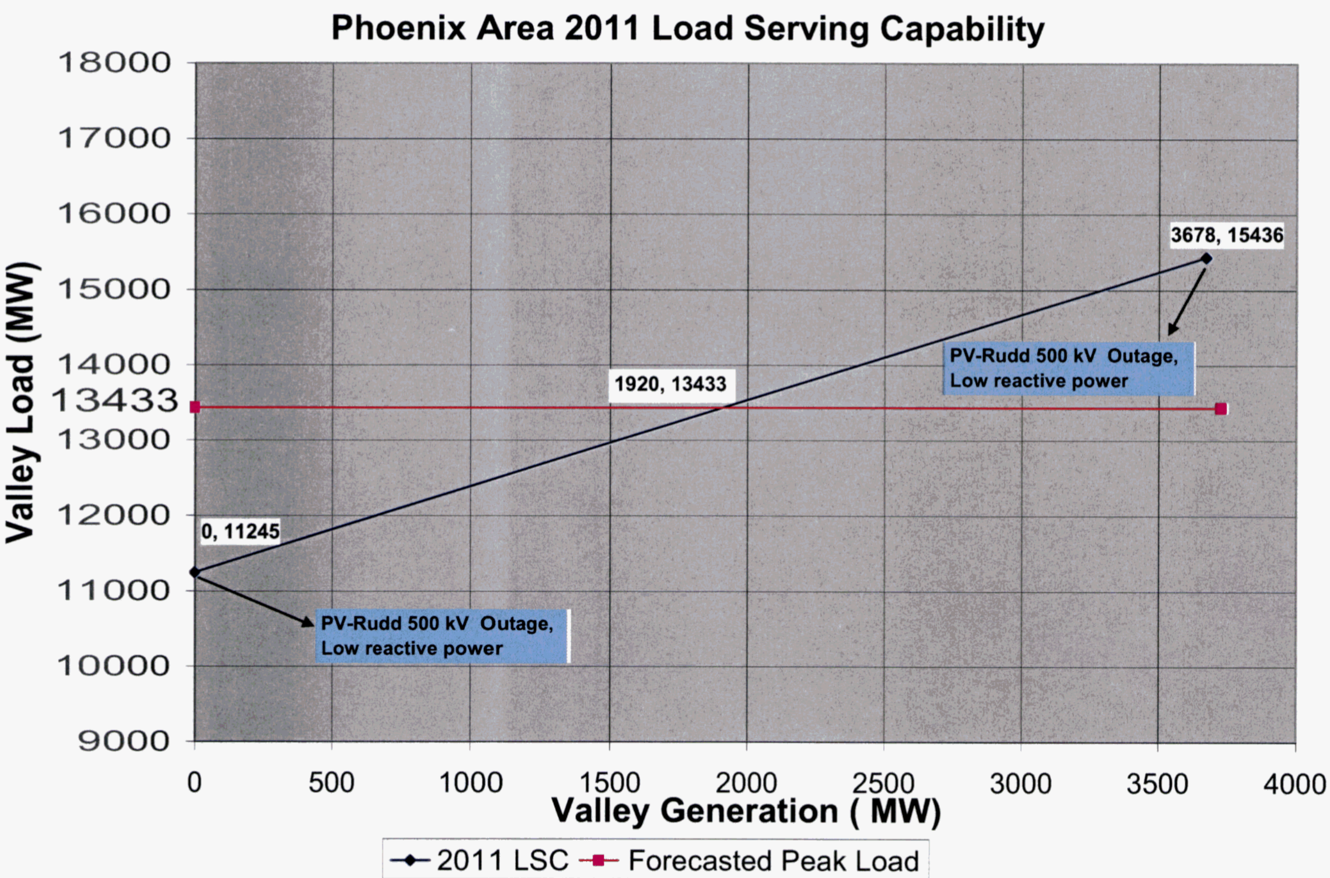
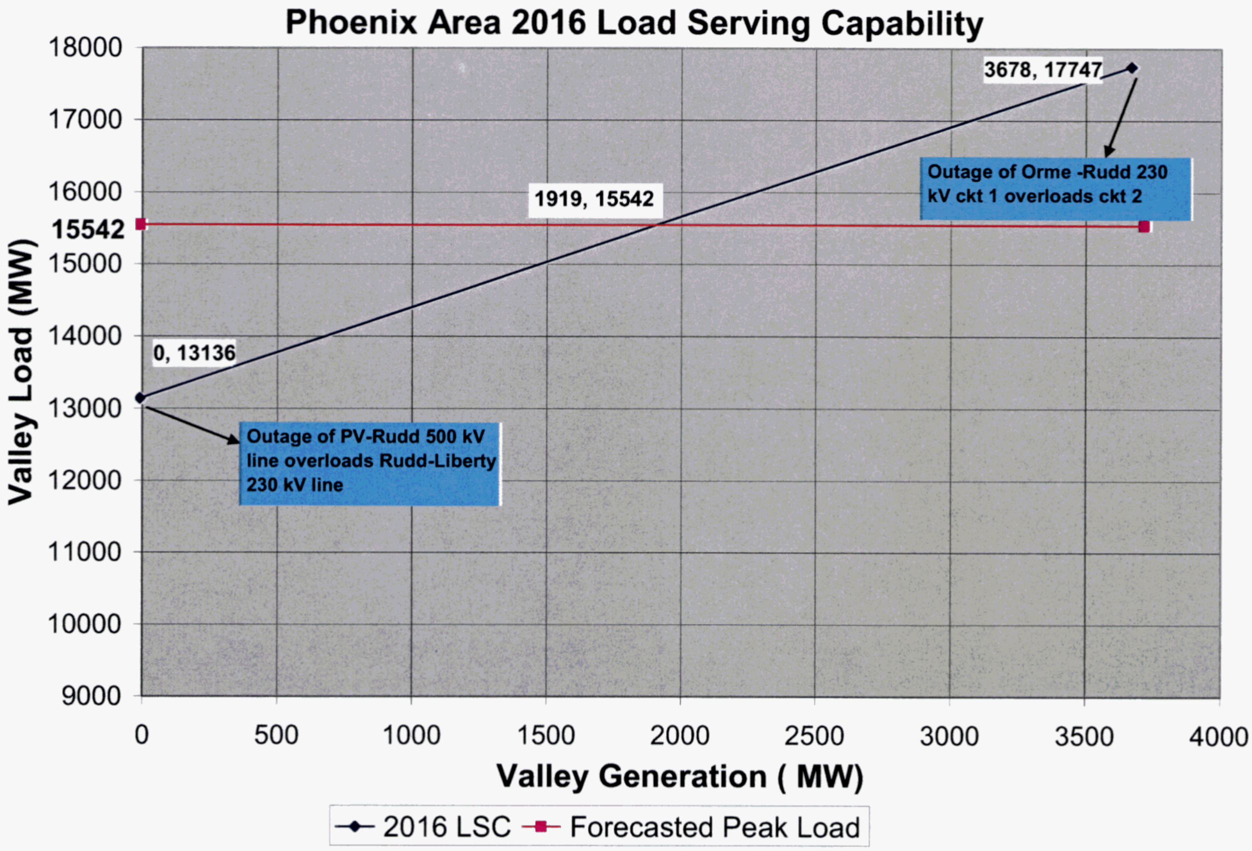


Figure 4



D. Generation Sensitivities

Sensitivity analyses of generation impact on load-serving capability were also conducted. These sensitivities were done with the maximum level of local generation. The following tables provide the results of these analyses for units that are both within and outside the Phoenix area.

Generation sensitivities inside the Phoenix area are listed in Table 2.

Table 2
Generation Sensitivities Inside Phoenix

Generation Source Increase by 100 MW	2011 Load Serving Capability Change (MW)	2016 Load Serving Capability Change (MW)
Agua Fria Generation	+100	No Impact
Kyrene Generation	+10	+150
Ocotillo Generation	+120	+50
Santan Generation	-10	+100
West Phoenix Generation	+120	-80

Generation sensitivities outside of the Phoenix Metro area are listed in Table 3.

Table 3
Generation Sensitivities Outside Phoenix

Generation Source Increase by 100 MW	2011 Load Serving Capability Change (MW)	2016 Load Serving Capability Change (MW)
Sundance Generation	0	60
Desert Basin Generation	0	70
Hassayampa Area Generation	20	0
Gila River Power Station Generation	10	20

As seen in previous RMR studies, the results indicate that the effectiveness of a generator is dependant upon the critical outage, the critical element, and the location of the generator in respect to the direction the power is flowing through the critical element. For example, in 2016, with the critical outage being one of the two Rudd-Orme 230-kV lines and the critical element being the remaining Rudd-Orme 230-kV line, the Kyrene generators are most effective in increasing the load-serving capability because they inject power into Kyrene, which is directly downstream of the power flow on the Rudd-Orme 230-kV line. In contrast, with the West Phoenix generators injecting power upstream of the critical element, they will exacerbate the overload and decrease the load-serving capability.

IV. Yuma Area

A. Description of Yuma Area

Currently the Yuma area is served from three transmission sources:

- APS' North Gila 500/69-kV substation, which is located east of Yuma. Two 69-kV lines extend west and southwest from this substation into Yuma to serve Yuma area load. A third 69-kV line interconnects into WAPA's Gila 161/69-kV substation.
- WAPA's Gila 161/69-kV substation, which is also located east of Yuma. From this substation, APS has one 69-kV line into the Yuma load area and one 69-kV tie to APS' North Gila substation.
- APS' Yucca 69-kV station, which is located on the west side of Yuma near the Colorado River. APS' local generation is located at this station, along with three 69-kV lines into the load area and an interconnection to IID's 161-kV system through two 161/69-kV transformers. The IID 75 MW steam-generating unit is also located at this substation.

Starting in 2008, 96 MW of new generation was assumed to be in-service and connected at the Yucca substation. Figure 5 shows the transmission system in 2011 and the metering points for the Yuma area load pocket. Listed below, under one of the two study years they will first appear, is a list of the planned projects that were added to reflect the system upgrades for the next ten years.

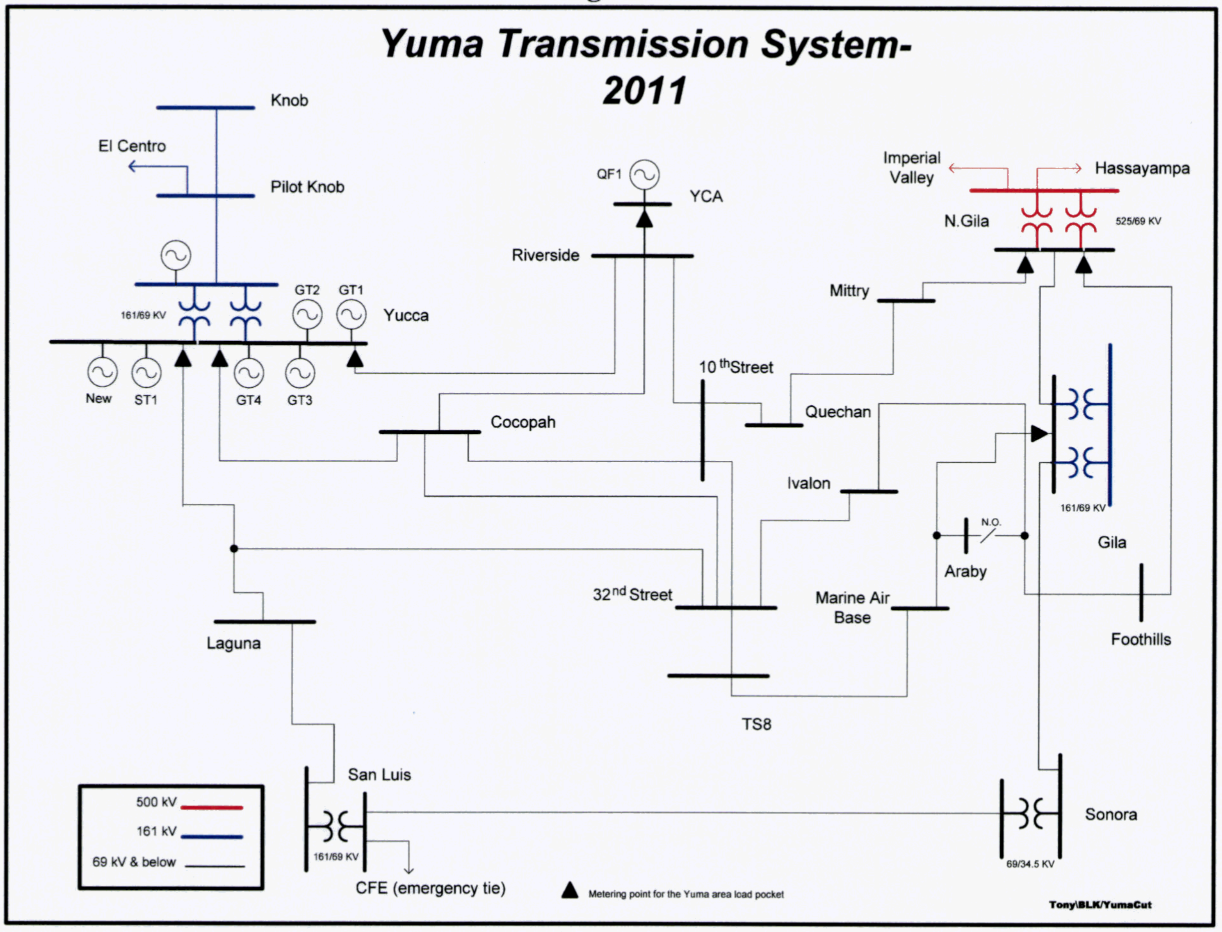
Projects in service by 2011

- 96 MW of new generation at Yucca substation
- TS8 69-kV substation looped in and out of Marine Air Base-32nd Street 69-kV line
- Riverside-Cocopah and Cocopah-32nd Street 69-kV line
- Reconductor Foothills-Foothills tap 69 kV line
- Reconductor Yucca-Laguna Tap 69-kV line
- Reconductor Ivalon-Araby 69 kV line

Projects in service by 2016

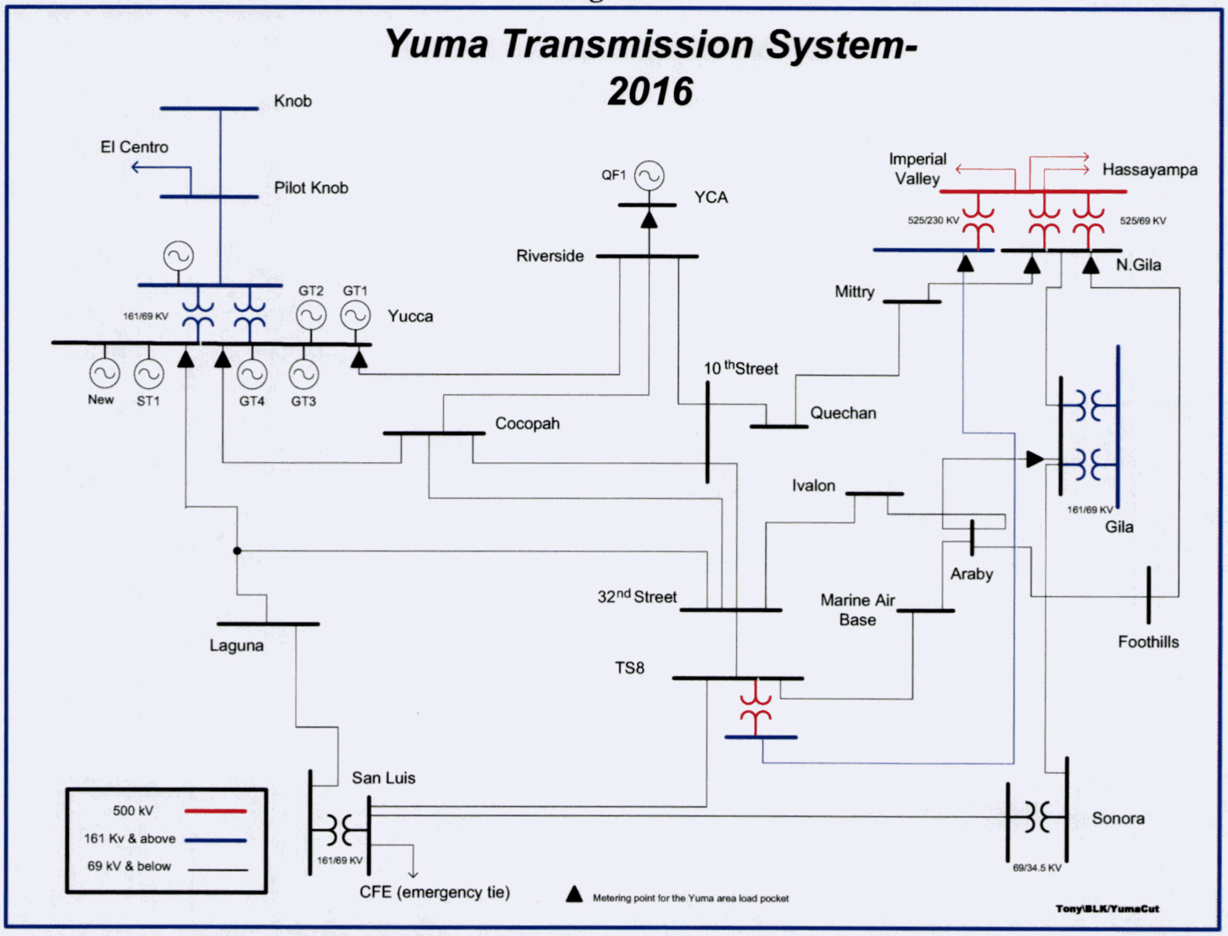
- Construct a new North Gila-Hassayampa 500-kV line
- Construct a new North Gila 230-kV bus with a 500/230-kV transformer
- Construct a new TS8 230-kV substation with a 230/69-kV transformer and a North Gila-TS8 230-kV line
- Construct a new TS8-San Luis 69-kV line
- Reconductor North Gila-Mittry and Mittry-Quechan 69-kV lines
- Reconductor TS8-Marine Air Base 69-kV line

Figure 5



New additions to the system in the Yuma area for 2016 were the additions of a 69-kV line from TS8 to San Luis, a 230-kV line from North Gila to the new TS8 230-kV substation, and a second 500-kV line from the Palo Verde area to North Gila. This can be seen in Figure 6.

Figure 6



B. Yuma Area Critical Outages

Several critical contingencies exist affecting the determination of the system import limit for the Yuma area during the 2011 and 2016 time frame. For the 2011 year, the primary critical outage is the existing Hassayampa-N.Gila 500-kV line and the limiting element is a thermal overload on the Pilot Knob-Yucca 161 kV line. In 2016, the critical outage is the N.Gila-Imperial Valley 500 kV line and the limiting element is a thermal overload of the Gila 230/161 kV transformer.

C. Yuma Area – SIL and MLSC for 2011 and 2016

With planned system additions for the Yuma area, including the 96 MW of new generation, the SIL and MLSC for the Yuma area will increase enough to serve the rapidly growing load and maintain the desired generation reserves. For 2011 and 2016 the SIL will be 258 MW and 415 MW, respectively. The MLSC for 2011 and 2016 will be 610 MW and 716 MW, respectively. Results of these studies are shown in Figures 7 and 8.

Figure 7

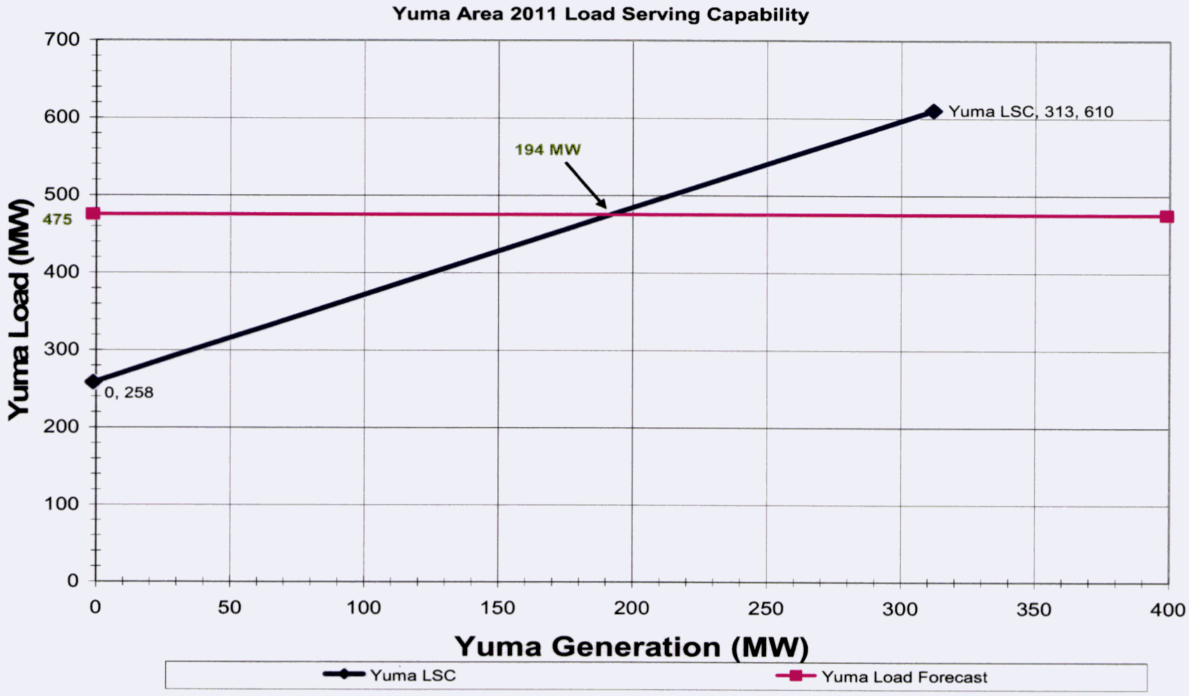
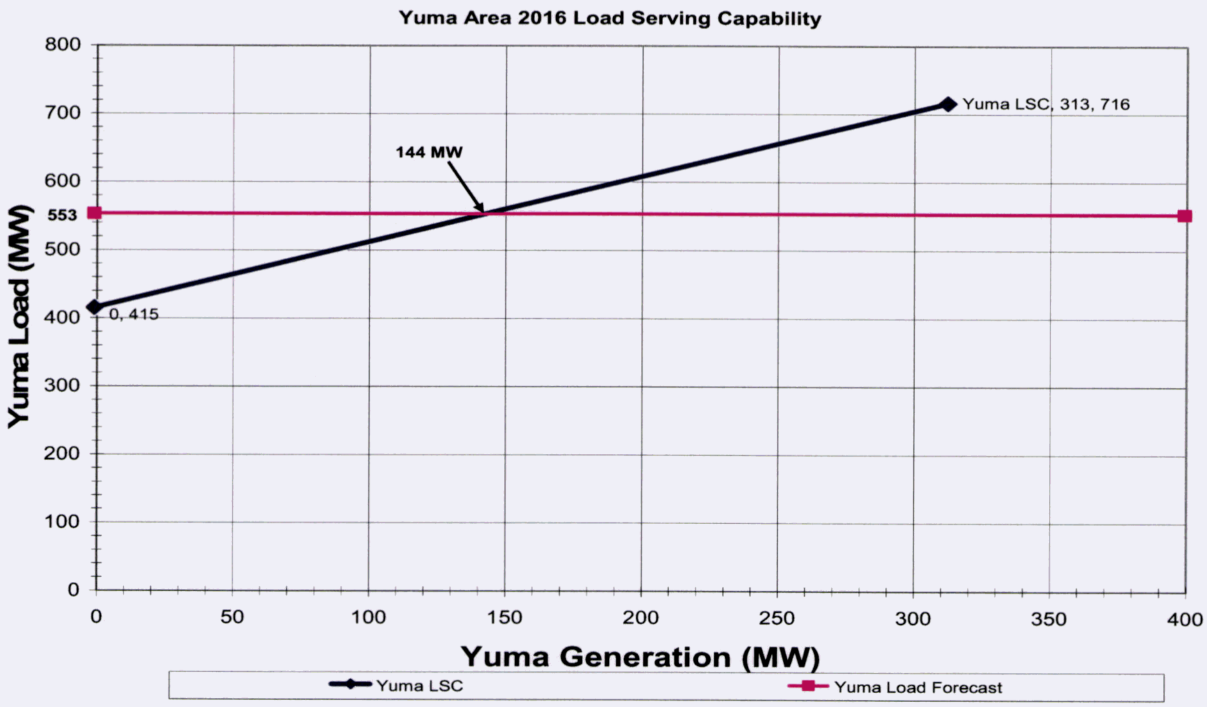


Figure 8



V. Analysis of RMR Conditions

A. Phoenix Area

1. Annual RMR Conditions

An RMR condition exists when the local load is greater than the SIL. In such cases, the RMR condition is the amount of generation that must be located inside of the constrained load area to meet the utility's peak load. RMR conditions for the Phoenix area are shown in Table 4 and are represented in the load-duration curves in Figures 9 and 10.

Table 4

Phoenix RMR Conditions
(MW)

	PHOENIX	
	2011	2016
Peak Load	13,433	15,542
Import Capability @ Peak	11,513	13,623
Must-Run Generation @ Peak	1,920	1,919
Hours Load Exceeds SIL	317	285
Energy - GWH	168	155
Energy Percent of Valley Load	0.3%	0.2%

Figure 9

PHOENIX LOAD DURATION & RMR CONDITION (2011)

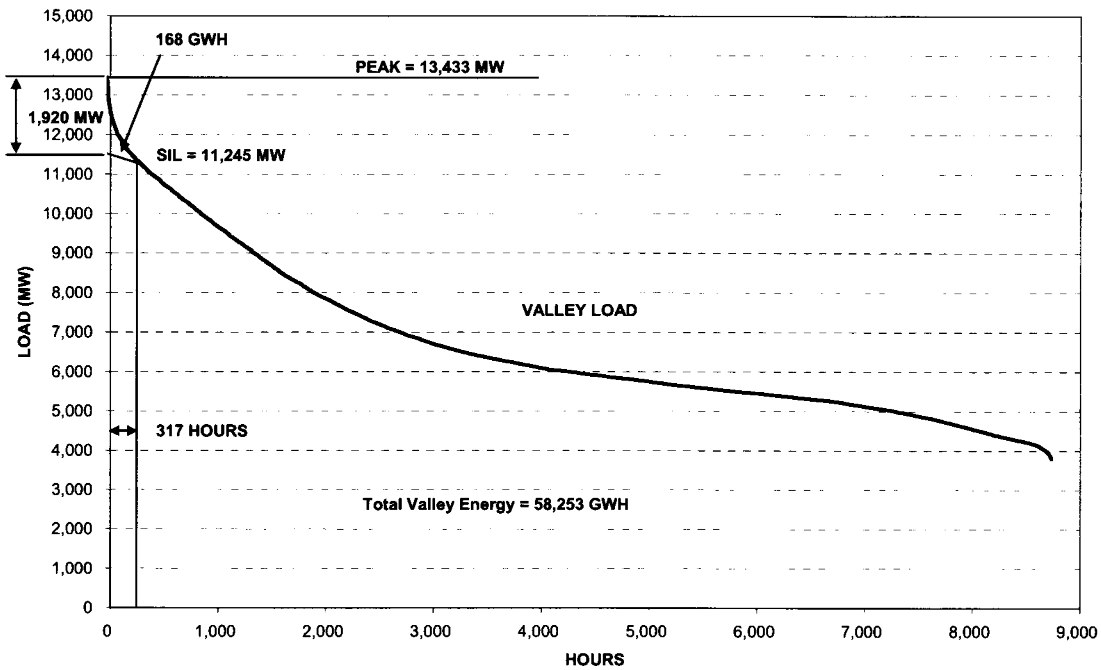


Figure 10

PHOENIX LOAD DURATION & RMR CONDITION (2016)

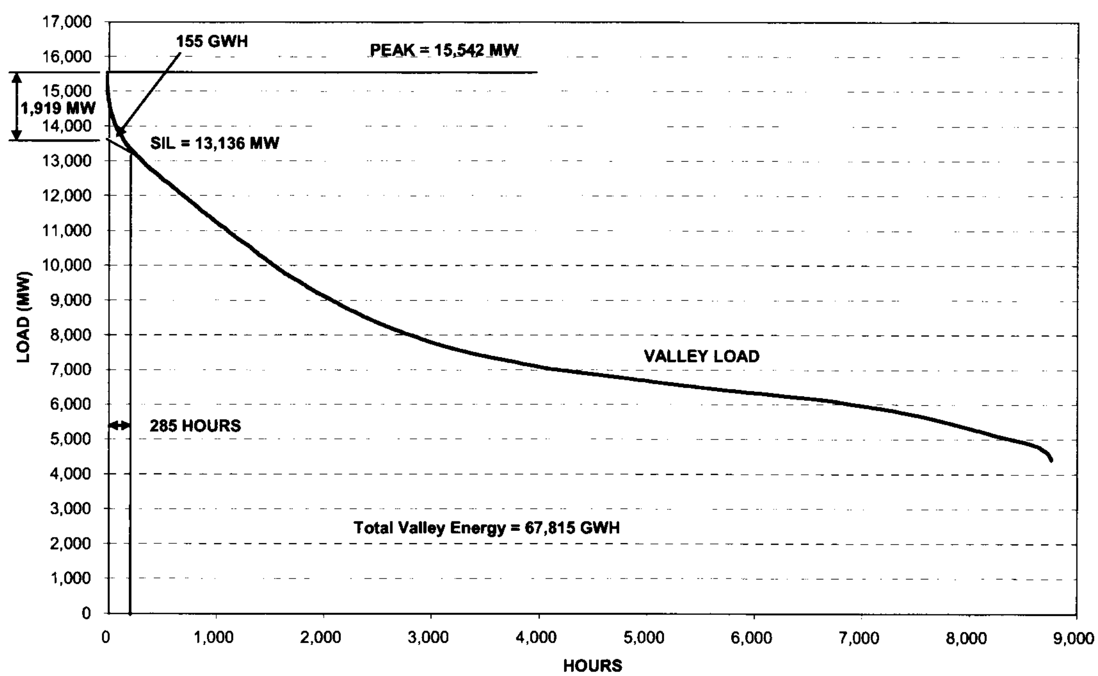


Table 4 shows that Phoenix is expected to require about 1,920 MW of local generation resources over and above its import capability to meet peak load in 2011 and 2016. For Phoenix, generation is estimated to be in a must-run condition for 317 hours in 2011 and 285 hours in 2016. However, because RMR occurs only at peak, the amount of associated energy is less than one percent of the total Phoenix area energy requirements, as shown in Figures 9 and 10.

2. Phoenix Area Reserve Capacity

MLSC is the maximum load that can be served in the load pocket. It is the import capability plus the generation capability located inside the load pocket. Based on the load forecast and SIL presented in this analysis, and existing and planned local generation, the MLSCs for Phoenix were developed. The SIL and MLSC are utilized to develop the Phoenix Area Load Serving Capability graphs; Figures 3 and 4. The import capability and the amount of local generation required, at the forecasted peak load, are determined. The difference between the amount of local generation required at peak load and the total valley generation are the projected reserves for that year. The approach used shows how much generation or transmission may be needed to reliably meet load.

The generation and transmission assumptions are depicted in Table 5. As shown on this table, additional resources, beyond those projects in APS' Ten-Year Plan, are not required in years 2011 and 2016.

Table 5

Phoenix Area Reserve Capacity
(MW)

	PHOENIX	
	2011	2016
Peak Load	13,433	15,542
Import Capability @ Peak	11,513	13,623
Valley Generation	3,678	3,678
Valley Gen + Import	15,191	17,301
Reserves	1,758	1,759
Required Reserves	865	865

3. Area Load Forecast

The historical peak load within the Phoenix area constraint is shown in Table 6 for 2003-2007, along with forecasted peak load for 2011 and 2016. This peak load represents load growth as well as the expanding boundaries of the Phoenix area, as discussed in Section III, part A and shown in Figures 1 and 2. Forecasted peak load is based on the same assumptions embodied in APS' total system load forecast used for budgeting and planning. This peak load is the load measured within the defined Phoenix area constraint.

Table 6

Phoenix and Yuma Load and Energy Forecast
(MW / GWH)

	HISTORICAL					FORECAST	
	2003	2004	2005	2006	2007	2011	2016
PHOENIX							
LOAD	10,187	10,046	10,744	11,836	11,486	13,433	15,542
ENERGY	43,343	44,128	45,812	47,884	48,725	58,253	67,815
Load Factor	48.6%	50.0%	48.7%	46.2%	48.4%	49.5%	49.7%
APS YUMA							
LOAD	336	342	370	404	415	475	553
ENERGY	1,420	1,518	1,609	1,717	1,811	2,045	2,382
Load Factor	48.2%	50.5%	49.7%	48.5%	49.8%	49.0%	49.0%

Phoenix area APS load forecasts were developed through the use of a multiple regression model using historic hourly load data, weather, and number of customers. These historic relationships (correlations) were combined with the metro area customer forecast and normal Phoenix weather to produce the APS Phoenix area load. The SRP forecast, obtained from SRP, was then added to the APS forecast to obtain a total valley load forecast.

4. Generation

Currently, APS owns 1,300 MW and SRP owns 2,378 MW of generation electrically located inside the Phoenix area. Table 7 shows operational data associated with each unit.

Table 7

PHOENIX AREA GENERATION

OWNER	PLANT	TYPE	SUMMER CAPABILITY	MINIMUM LOAD	MINIMUM UP TIME	MINIMUM DOWN TIME	FOR	EFOR	FUEL TYPE
APS	Ocotillo 1	ST	110	20	8	8	4%	6%	NG
APS	Ocotillo 2	ST	110	20	8	8	4%	6%	NG
APS	Ocotillo GT1	GT	50	4	2	1	10%	12%	NG
APS	Ocotillo GT2	GT	50	4	2	1	10%	12%	NG
APS	West Phoenix GT1	GT	50	4	2	1	10%	12%	NG
APS	West Phoenix GT2	GT	50	4	2	1	10%	12%	NG
APS	West Phoenix CC1	CC	80	20	8	6	3.5%	7%	NG
APS	West Phoenix CC2	CC	80	20	8	6	3.5%	7%	NG
APS	West Phoenix CC3	CC	80	55	8	6	3.5%	7%	NG
APS	West Phoenix CC4	CC	110	77	8	3	5%	7%	NG
APS	West Phoenix CC5	CC	530	160	8	6	8%	10%	NG
SRP	Agua Fria 1	ST	113	15	8	8	4%	6%	NG
SRP	Agua Fria 2	ST	113	15	8	8	4%	6%	NG
SRP	Agua Fria 3	ST	181	22	8	8	4%	6%	NG
SRP	Agua Fria 4	GT	73	5	2	1	10%	12%	NG
SRP	Agua Fria 5	GT	73	5	2	1	10%	12%	NG
SRP	Agua Fria 6	GT	73	5	2	1	10%	12%	NG
SRP	Crosscut HY1	HY	3	N/A	N/A	N/A	0%	0%	WAT
SRP	Kyrene 1	ST	34	10	8	8	4%	6%	NG
SRP	Kyrene 2	ST	72	12	8	8	4%	6%	NG
SRP	Kyrene GT4	GT	59	5	2	1	10%	12%	NG
SRP	Kyrene GT5	GT	53	7	2	1	10%	12%	NG
SRP	Kyrene GT6	GT	53	7	2	1	10%	12%	NG
SRP	Kyrene CC1	CC	250	161	8	6	8%	10%	NG
SRP	Santan 1	CC	92	21	8	6	3.5%	7%	NG
SRP	Santan 2	CC	92	21	8	6	3.5%	7%	NG
SRP	Santan 3	CC	92	21	8	6	3.5%	7%	NG

SRP	**Santan 4**	**CC**	**92**	**21**	**8**	**6**	**3.5%**	**7%**	**NG**
SRP2	**Santan 5**	**CC**	**582**	**156**	**8**	**6**	**8%**	**10%**	**NG**
SRP2	**Santan 6**	**CC**	**277**	**179**	**8**	**6**	**8%**	**10%**	**NG**
SRP	**South Consolidated 1**	**HY**	**1**						**WAT**
PHOENIX TOTAL			**3,678**						

NOTES:

1) APS data based on APS Resource Planning Assumptions, 2007 Q3 Long Range Forecast
2) SRP minimum load based on WECC Transmission Planning data, 10/1/2007 version

APS owns West Phoenix CC 1-2-3-4-5, West Phoenix CT 1-2, Ocotillo ST 1-2, and Ocotillo CT 1-2. With the exception of West Phoenix CC 4-5, these units collectively have a 660 MW summer rating, have historically operated at capacity factors in the 3-30 percent range, and are operating at lower capacity factors (about 7%) over the last few years as new high-efficiency plants came on line in Arizona and the Southwest. West Phoenix CC 4 (110 MW), which went into service in June 2001, and West Phoenix CC 5 (530 MW), which came on-line in July 2003, improve reliability to the Phoenix area. These units have operated at capacity factors in the 10-50 percent range.

SRP owns the Agua Fria, Kyrene and Santan generating stations inside the Phoenix area, totaling 2,378 MW of generation. These units were built in the late 1950s to the mid-1970s, with three exceptions -- a new Kyrene CC unit went into service in 2002, a new Santan 5 unit went into service in 2005, and a new Santan 6 unit went into service in 2006.

5. Reserves

Reliability within a load pocket such as Phoenix must be evaluated differently than for an unconstrained system. For example, although a 15 percent reserve margin may be adequate for unconstrained total system loads, it may not provide adequate reliability to load pockets that may not have access to all reserves present in the WECC interconnected system. APS performs an analysis that considers the size, forced outage rate, and effective forced outage rate of each generating unit in the load pocket to determine the probability that enough generation will be available when needed. The required reserve values used for this study were based on a 99% reliability criteria. This criteria results in a reserve requirement for Phoenix of 865 MW. It means that at least 2813 MW (3678 MW Phx generation less 865 MW reserves) will be available to meet load 99% of the time.

B. Yuma Area

1. Annual RMR Conditions

RMR conditions for the Yuma constrained area are shown in Table 8 and pictorially represented in a load-duration curve in Figures 11 and 12. Table 8 shows that APS requires 194 MW (2011) of resources over and above its transmission import capability to meet peak load in Yuma. These resources can be APS-owned generation or non-APS owned generation located within the constrained area. APS is in a must-run condition for 2,258 hours in 2011 and 719 hours in 2016 in Yuma. The amount of associated energy is 7 percent of Yuma's total energy requirement in 2011 and 1 percent in 2016.

Table 8

Yuma RMR Conditions (MW)		YUMA
	2011	2016
Peak Load	475	553
Import Capability @ Peak	281	409
Must-Run Generation @ Peak	194	144
Hours Load Exceeds SIL	2,258	719
Energy - GWH	146	30
Energy Percent of Yuma Load	7.1%	1.3%

Figure 11

YUMA LOAD DURATION & RMR CONDITION (2011)

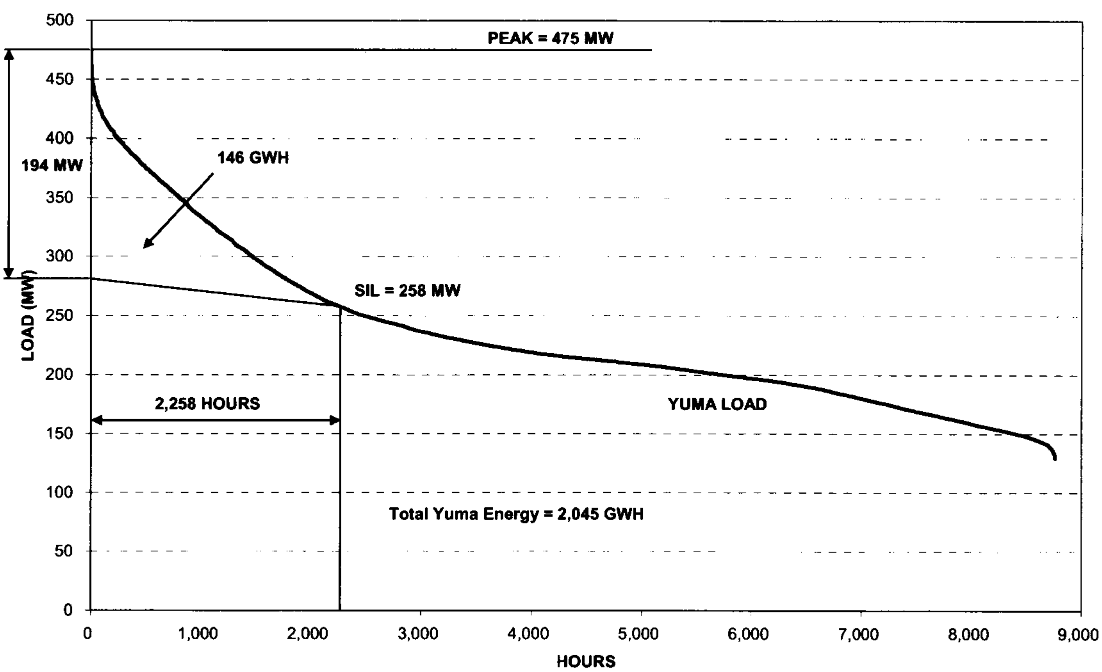
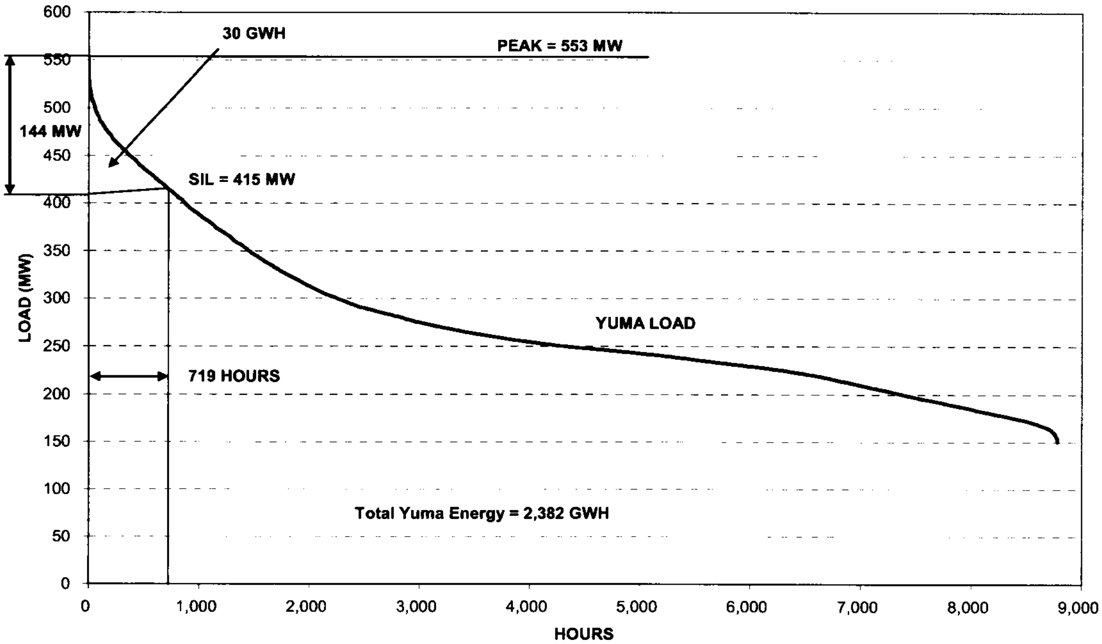


Figure 12

YUMA LOAD DURATION & RMR CONDITION (2016)



2. Yuma Area Reserve Capacity

The generation and transmission assumptions are depicted in Table 9. As shown on this table, additional resources, beyond those projects in APS' Ten-Year Plan, are not required in years 2011 and 2016. With a load forecast of between 475 MW to 553 MW, the local generation requirements can be met from either APS or non-APS owned generation (Yucca steam and YCA units) within the load pocket.

Table 9

Yuma Area Reserve Capacity
(MW)

	YUMA	
	2011	**2016**
Peak Load	475	553
Import Capability @ Peak	281	409
Local Generation	313	313
Local Gen + Import	594	722
Reserves	119	169
Required Reserves	97	97

3. Area Load Forecast

Table 6 shows APS' Yuma historical peak load for 2003-2007 and forecasted peak load for 2011 and 2016. Forecasted peak load is based on the same assumptions used in APS' total system load forecast used for budgeting and planning. This peak is the load measured just inside the Yuma area. Yuma load represents approximately 6 percent of APS' total system load. Yuma area APS load forecasts were developed through the use of a multiple regression model using historic hourly load data, weather, and number of customers. These historic relationships (correlations) were combined with the Yuma area customer forecast, and normal Yuma weather to produce the Yuma area load.

4. Generation

APS (Yucca CTs 1-4), IID (Yuma Axis 1) and YCA (Yuma Cogen 1,2) own generation within the Yuma load pocket. These plants have an aggregate summer capacity rating of 217 MW. Six of the seven units run on natural gas while the other plant (Yucca CT 4) runs on oil. IID's Yuma Axis 1 full load summer capability is 75MW. The unit is used to regulate IID's system, and therefore may not be operating at full load during Yuma peak load hours. Based on historical performance, it is assumed that Yuma Axis 1 contributes 25MW to Yuma reliability. Also by 2008, 96 MW of new generation (new units Yucca CT 5 and Yucca CT 6) is assumed to be in-service at the Yucca substation which would bring the total generation inside the Yuma load pocket to 313 MW. Additional power plant data for this generation is provided in Table 10.

Although operated by APS, IID dispatches its steam plant to meet its load and spinning reserve needs. YCA is a cogeneration plant that has a contract with San Diego Gas & Electric (SDG&E). Although APS has no dispatch rights to these units, whenever the units are running they provide internal generation in the Yuma area for purposes of using the import nomogram.

Table 10

YUMA AREA GENERATION									
OPERATOR	**PLANT**	**TYPE**	**SUMMER CAPABILITY[1]**	**MINIMUM LOAD**	**MINIMUM UP TIME**	**MINIMUM DOWN TIME**	**FOR**	**EFOR**	**FUEL TYPE**
APS	Yucca GT1	GT	18	2	2	1	10%	10%	NG
APS	Yucca GT2	GT	18	2	2	1	10%	10%	NG
APS	Yucca GT3	GT	52	5	2	1	10%	10%	NG
APS	Yucca GT4	GT	51	5	2	1	10%	10%	FO2
APS	Yucca GT5	GT	48	32	2	1	2%	2%	NG
APS	Yucca GT6	GT	48	32	2	1	2%	2%	NG
APS SUBTOTAL			235						
IID	Yuma Axis 1	ST	25	18	8	8	4%	6%	NG
YCA	Yuma Cogen 1	CC	36	14	N/A	N/A	3.5%	7%	NG
YCA	Yuma Cogen 2	CC	17	7	N/A	N/A	3.5%	7%	NG
YCA SUBTOTAL			53						
YUMA TOTAL			313						

NOTE: 1) Based on APS Resource Planning Assumptions, 2007 Q3 Long Range Forecast

5. *Reserves*

The required reserve margin for Yuma was calculated to be 97 MW. The reserve requirement for Yuma is based on Loss of Load Probability (LOLP) criteria of one day in ten years. In other words, based on Yuma area load, import capability and the availability of local generation, this criteria would result in not being able to meet Yuma load one day in ten years. The 1/10 criteria translates to a reserve requirement of 97 MW during the time frame studied.

VI. ECONOMIC ANALYSIS OF RMR

A. Introduction

To consider potential economic effects resulting from using local generation or arising from RMR conditions, an economic analysis was performed using a economic dispatch model. For this economic analysis, the production cost of meeting Phoenix loads was determined with the existing transmission import limitations in place. Next, a second hypothetical case was built in which the transmission import limits were removed. Comparing the two cases shows the economic costs of the transmission constraint.

These two cases were simulated with PROMOD and their outputs were compared to determine the cost of transmission constraints. PROMOD is a detailed production cost model that includes generation and transmission of SRP and APS control areas. PROMOD dispatches all generators on an economic basis to meet the combined SRP and APS system loads, within constraints for individual system control area's reserve requirements and within transmission constraints.

Much of the data used in the production cost model comes from publicly available WECC Transmission Expansion Planning Policy Committee (TEPPC) power plant data. APS supplemented the WECC data with its current load forecast and unit characteristics for generation located inside the load pockets. At the time this RMR study was performed, the TEPPC 2017 data test case October 1, 2007 version was used in the RMR economic analysis. This model includes all new generation expected to be built in the West by 2011, including 96 MW at Yucca. The 2016 model also assumes new generation is built near Four Corners by an Independent Power Producer (IPP).

The following items were quantified based on the PROMOD simulations:

- Number of hours per year the Phoenix and Yuma area transmission system is expected to be constrained by the import limits;
- Phoenix and Yuma generation capacity factors;
- Cost to serve the APS and SRP systems, including fuel, variable O&M, and purchase power;
- Phoenix and Yuma generation emissions;
- Phoenix and Yuma natural gas consumption.

B. Phoenix

1. Phoenix Imports

Table 11 shows that under economic dispatch conditions for Phoenix area generation, Phoenix did not reach its transmission import limits in 2011 and 2016.

Table 11

IMPACT OF ELIMINATING PHOENIX IMPORT LIMITS	With Import Limits		Without Import Limits		Difference (With minus Without)	
	2011	2016	2011	2016	2011	2016
Hours Limiting	0	0	0	0	0	0
Phx Plant Generation (GWH)	3,698	3,141	3,698	3,141	0	0
Phx Plant Capacity Factor	10.7%	9.1%	10.7%	9.1%	0.0%	0.0%
Cost of Constraints ($M)					0	0

2. *Operation of Phoenix area Generating Units*

Historically, since 1999, the Phoenix area's combined-cycle power plant capacity factors have ranged from 23 to 53 percent, with an average of about 34 percent. Capacity factors for steam-fired plants ranged from 4 to 42 percent, averaging about 17 percent. Capacity factors for simple-cycle combustion turbines ranged from less than 1 percent to 25 percent, averaging about 6 percent. Historical capacity factors are shown in Table 12 by plant type for the period 1999 to 2007.

Capacity factors of these units in 2000-2001 were higher than the historical average because the Western Interconnection and the Phoenix area both experienced high price volatility, high load growth, and few new generation resources had been added since the 1980s. With new higher-efficiency power plants coming on line, as well as the presence of the Palo Verde-Rudd 500 kV transmission line, the older Phoenix area units are expected to run at lower capacity factors. As noted above, however, these units remain critical to maintaining Phoenix area reliability.

Even if the Phoenix area transmission import limits were totally eliminated, these older units would still be needed to economically meet summer peak loads. Elimination of the constraints would have minimal impact on the capacity factors of all Phoenix area plants. Table 11 summarizes the results of the simulation analysis.

Table 12

PHOENIX AREA POWER PLANT HISTORICAL CAPACITY FACTOR (%)									
	1999	2000	2001	2002	2003	2004	2005	2006	2007
TOTAL PHOENIX									
STEAM	23.1	40.2	42.3	14.4	9.0	8.2	4.3	4.2	5.6
COMBINED CYCLE	29.0	53.1	50.5	27.7	25.1	23.7	28.8	31.5	34.3
COMBUSTION TURBINE	3.7	14.9	24.7	2.8	0.9	1.2	0.4	0.5	0.6
TOTAL	18.9	36.3	39.9	17.2	15.8	14.9	18.6	21.2	23.3

3. *Cost Impacts*

An estimate of the cost of the transmission import constraints can be determined by comparing the system cost to serve Phoenix customers with and without constraints. Costs included in the analysis are fuel, variable O&M, and purchased power. The results of this analysis showed the Phoenix load area did not reach its transmission import limits in 2011 and 2016, and hence there was no cost impact due to the transmission import constraints. See Table 11.

4. *Emissions Impact*

In addition to economic modeling, the PROMOD analysis evaluated the change in plant air emissions that would result from removing the transmission constraint. The Phoenix load area did not reach its transmission import limits in 2011 and 2016, so there is no emission impact to the Phoenix area for the four criteria pollutants routinely tracked for power plants: NO_X, CO, VOCs and PM_{10}. Maricopa County is a non-attainment area for CO and PM_{10}. NO_X and VOCs are precursors for ozone and therefore are included.

Table 13
Phoenix Area Air Emissions Impact of RMR

Pollutant	RMR Impact[1] (tons/year)	Phoenix Area Emissions RMR Impact (% of total emissions from all sources)
NO_x	0.0	0.000
CO	0.0	0.000
PM_{10}	0.0	0.000
VOC	0.0	0.000

[1]2011 and 2016 results

Table 14 shows Phoenix area power plant emissions by type.

Table 14

PHOENIX POWER PLANT EMISSIONS (TONS)						
	With Import Limits		Without Import Limits		Difference (With minus Without)	
	2011	2016	2011	2016	2011	2016
NO_X	896	663	896	663	0	0
CO	132	100	132	100	0	0
PM_{10}	76	63	76	63	0	0
VOC	48	41	48	41	0	0

5. Natural Gas Impact

The PROMOD analysis was used to evaluate the change in natural gas consumption that would result from removing the transmission constraint. The Phoenix load area did not reach its transmission import limits in 2011 and 2016, so there is no natural gas consumption impact.

C. Yuma

1. Yuma Imports

Unlike the Phoenix area, the Yuma imports do reach their limits at various times throughout the summer. Table 15 shows that, for 2011, APS could be constrained for 265 hours in the year. The energy associated with these hours amount to 25 GWH. Table 15 also shows that, for 2016, APS could be constrained for 25 hours in the year. The energy associated with these hours amount to 1 GWH. During these hours, it would have been more economical to import cheaper power either generated on APS' own units outside the Yuma area or purchased from the wholesale market if the import limits were increased.

Table 15

IMPACT OF ELIMINATING YUMA IMPORT LIMITS

	With Import Limits		Without Import Limits		Difference	
	2011	2016	2011	2016	2011	2016
Hours Limiting	265	25	0	0	265	25
APS Yuma Generation (GWH)	70	32	45	31	25	1
APS Yuma Plant Capacity Factor	3.3%	1.5%	2.1%	1.4%	1.2%	0.1%
Cost of Constraints ($M)					1	0

2. Operation of Yuma Units

Historically, the APS Yucca CTs have operated at capacity factors that range between 1 and 18 percent, averaging about 5%. Historical capacity factors are shown in Table 16 by unit for the period 1999 to 2007.

Table 16

YUMA POWER PLANTS HISTORICAL CAPACITY FACTOR (%)

	1999	2000	2001	2002	2003	2004	2005	2006	2007
YUCCA									
CT1	1.4	5.0	23.4	4.0	2.6	2.8	1.7	1.8	2.0
CT2	1.4	6.9	21.8	4.6	2.3	3.6	1.2	1.3	1.5
CT3	3.5	12.2	22.0	14.4	6.8	9.2	6.5	4.1	2.0
CT4	0.3	4.8	11.9	0.3	0.4	0.5	0.0	0.3	0.2
Total Yucca	1.8	7.9	18.4	6.6	3.3	4.4	2.8	2.0	1.3

3. *Cost Impacts*

The PROMOD analysis indicates that the Yuma import limit will be constraining for 265 hours in 2011 and for 25 hours in 2016. The cost of this constraint in 2011 is less than $1,000,000. The cost of this constraint in 2016 is negligible. See Table 15.

4. *Emission Impacts*

The emission impact on the Yuma area due to a potential relieving of transmission constraints and "moving" generation outside of the Yuma area was determined by PROMOD similarly to the Phoenix analysis. Unlike Phoenix, however, Yuma County is a non-attainment area for PM_{10} only. Impacts on power plant emissions in Yuma were estimated by using average emission rates of normal operation of APS units along with the change in energy production. For comparison purposes, total PM_{10} emissions in Yuma County were measured by Arizona Department of Environmental Quality in 2006. To put the results into perspective, changes in Yuma area power plant emissions are shown as a percentage of total Yuma County PM_{10} emissions. Changes in emissions resulting from entirely eliminating the transmission import constraint into Yuma are shown in Table 17.

Table 17
Yuma Area Air Emissions Impact of RMR

Pollutant	RMR Impact (tons/year)		Yuma Area Emissions RMR Impact (% of total emissions from all sources)	
	2011	2016	2011	2016
NO_x	20	2	N/A	N/A
CO	4	1	N/A	N/A
PM_{10}	0.48	0.04	0.001	0.000
VOC	0.45	0.03	N/A	N/A

Table 18 shows APS Yuma area power plant emissions by type.

Table 18

APS YUMA POWER PLANT EMISSIONS (TONS)

	With Import Limits		Without Import Limits		Difference (With minus Without)	
	2011	2016	2011	2016	2011	2016
NOx	50	22	30	20	20	2
CO	10	5	6	4	4	1
PM_{10}	1.21	0.54	0.73	0.50	0.48	0.04
VOC	1.22	0.57	0.77	0.54	0.45	0.03

5. Natural Gas Impact

The PROMOD analysis was used to evaluate the change in natural gas consumption that would result from removing the transmission constraint. In 2011, by entirely eliminating the transmission import constraint into Yuma, the generation units within Yuma would reduce their consumption of natural gas by 0.294 BCF. For 2016, the Yuma units would reduce their consumption of natural gas by 0.019 BCF.

VII. CONCLUSIONS

Phoenix area Conclusions

1. Phoenix area existing and planned transmission and local generation are adequate to reliably serve Phoenix area peak load in 2011 and 2016 with the projected local generation reserve margin exceeding the required reserve margin.

2. During the summer, Phoenix area load is expected to exceed the available transmission import capability for approximately 317 hours in 2011 and 285 hours in 2016. These hours represent less than one percent of the annual energy requirements for the Phoenix area.

3. From a total Phoenix load, transmission, and resources viewpoint, local generation is not expected to be dispatched out of economic dispatch order in 2011 and 2016.

4. Because there is not expected to be an out of merit order cost of Phoenix area RMR generation, advancement of transmission projects to increase import capability are presently not cost justified.

5. The Phoenix load area did not reach its transmission import limits in 2011 and 2016, so there is no emission impact to the Phoenix area.

6. Since the Phoenix load area did not reach its transmission import limits in 2011 and 2016, there is no impact to local generation capacity factor and total yearly natural gas consumption by the Phoenix area generators.

Yuma Area Conclusions

7. Yuma area existing and planned transmission and local generation are adequate to reliably serve Yuma area peak load in 2011 and 2016 with the projected local generation reserve margin exceeding the required reserve margin.

8. The Yuma area load is expected to exceed the available transmission import capability for 2,258 hours in 2011 and 719 hours in 2016. These hours represent approximately 7% of the annual energy requirements for Yuma in 2011 and approximately 1% in 2016.

9. From a total Yuma load, transmission, and resources viewpoint, the import constraint could cause APS Yuma generation to be dispatched out of economic dispatch order for 265 hours in 2011 and 25 hours in 2016.

10. The estimated annual economic cost of Yuma area generation required to run out of economic dispatch order is approximately $1 million for 2011. Due to the planned addition of another EHV line to Yuma and the addition of an HV line within the Yuma area, as indicated in APS' 10-Year Plan, those costs are negligible by 2016.

11. Removing the transmission constraint would reduce total Yuma area air emissions by a minimal amount for years 2011 and 2016.

12. Removing the import restriction into the Yuma area could reduce the APS Yuma generation capacity factor from 3.3 percent to 2.1 percent in 2011 and from 1.5 percent to 1.4 percent in 2016.

13. Removing the transmission constraint could reduce total yearly natural gas consumption by the Yuma area generators by 0.294 BCF and 0.019 BCF for 2011 and 2016, respectively.