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Voltage and VAR Control		Distribution Restriction: None	


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Purpose

Provides guidelines for maintaining acceptable voltage levels and VAR flow on the ISO Controlled Grid.

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1. Responsibilities

ISO System Operator	Maintains acceptable voltage levels and VAR flow on the ISO Controlled Grid using all voltage control support equipment.
Participating Generator (PG)	Participating Generators are required to operate within a specified power factor band. Notify the PTO & the ISO of changes as soon as practical, but within 30 minutes to the status of automatic voltage regulator control (AVR) and power system stabilizers (PSS).
Participating Loads	Participating Loads are required to maintain VAR flow at Grid interface points within a specified power factor band. Loads operating within this range shall receive no compensation for Voltage Support.
Participating Transmission Owner (PTO)	Transmission Owners operate Voltage Support equipment to maintain normal voltage and VAR flow according to the ISO Protocols. Dispatch of Voltage Support equipment will not be compensated, provided that the specified power factor range is maintained. Provide generator operators voltage schedules as required.

2. Scope/Applicability


2.1 Background

As deemed appropriate, the ISO operates the ISO Controlled Grid to ensure System Reliability. This may include the use of any available Voltage Support equipment so that the operation of the ISO Controlled Grid will meet or exceed the operating criteria as specified by the North American Electric Reliability Council (NERC) and the Western Electricity Coordinating Council (WECC). The ISO will operate and monitor the system in accordance with the Good Utility Practice to ensure safe and reliable operations. The ISO has also signed a Coordinated Functional Registration (CFR) agreement with PTOs, which delegates the responsibility to provide voltage schedules to Generator Operators in their area and the responsibility to direct the operation of devices to regulate transmission voltage and reactive flow as necessary.

2.2 Scope / Applicability

This procedure applies to voltage levels and VAR controls.

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3. Procedure Detail

3.1 ISO System Operator Responsibilities

3.1.1 Monitor Transmission Equipment and Generators


Take the following actions as necessary:

ISO System Operator
<ol style="list-style-type: none"> 1. Monitor Loads and Generators to verify that the grid is operated at the appropriate voltage level. 2. Verify that each Participating Entity is complying with Voltage Support requirements. 3. Coordinate adjustments to prevent offsetting or competing Voltage Support measures. 4. If notified of the loss of an automatic voltage regulator control (AVR), <u>and</u> the Scheduling Coordinator (SC) has <u>not</u> notified the PTO, <ul style="list-style-type: none"> • Instruct the Scheduling Coordinator to have the Generator operator notify their PTO and request a voltage schedule. <p><i>Note: The PTO will direct the Generator operator to maintain or change either its voltage Schedule or its Reactive Power Schedule as appropriate.</i></p> 5. Notify the RC of any AVR/PSS outage, change of status, or limitation.

3.1.2 Monitor Balancing Areas

Take the following actions as necessary:

ISO System Operator
<ol style="list-style-type: none"> 1. Monitor the interface points between the ISO Controlled Grid and Interconnections with Balancing Areas to confirm that the interconnected power system is operated at the appropriate voltage level with acceptable VAR exchange. 2. Coordinate adjustments with interconnected Balancing Areas. 3. Monitor State Estimator results for accuracy and to ensure that the ISO Controlled Grid remains within the appropriate voltage parameters.

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3.1.3 Operate ISO Controlled Grid Voltage Equipment

Take the following actions to operate ISO Controlled Grid voltage equipment:


ISO System Operator
<ol style="list-style-type: none"> 1. Maintain operational awareness of the Voltage Support equipment available, <u>and</u> 2. <u>Prior to</u> requesting that Participating Generation Units provide Voltage Support, <ul style="list-style-type: none"> • Dispatch Reliability Must Run units first. 3. Coordinate the use and switching of Voltage Support equipment among PTOs, UDCs, Generators, and other Balancing Areas to ensure that the BES is operating within established voltage limits and criteria as specified in ISO Operating Procedure 3100 Establishing System Operating Limits for the Operations Horizon.

3.2 Participating Entities Responsibilities

3.2.1 Participating Generator

The Participating Generator is responsible for the following actions:

Participating Generator (PG)
<ol style="list-style-type: none"> 1. Operate Generation within established protocols and procedures, specifically normal MW/VAR Capacity profiles, at the applicable Voltage Schedule. 2. Comply with the Voltage Schedule in automatic voltage control mode (AVR in service and controlling voltage). 3. Produce or consume reactive power when requested by the ISO. 4. Notify the ISO of system conditions including, coordination of switching of Voltage Support equipment. 5. Notify the ISO of events and changes that impact the MW/VAR Capacity, reliability, or ability to operate within the power factor band. 6. Notify the applicable PTO and the ISO as soon as possible, within 30 minutes of changes to the status of AVR or PSSs. 7. Respond to emergency requests.

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3.2.2 Participating Loads/UDCs

Participating Loads / UDCs are responsible for the following actions


Participating Loads, Utility Distribution Company (UDC)
<ol style="list-style-type: none"> 1. Operate in accordance with Good Utility Practice within established protocols and Operating Procedures, <u>and</u> adhere to specified Voltage Schedules. 2. Maintain reactive power flow at grid interface points within the power factor band of 0.97 lag and 0.99 lead. 3. Notify the ISO of system conditions, including coordinated switching of Voltage Support equipment. 4. Notify the ISO of events and changes that impact the Voltage Support equipment availability, reliability, or ability to operate within the power factor band. 5. Respond to ISO and PTO requests for Voltage Support while operating within the power factor band. 6. Respond to emergency requests.

3.2.3 Participating Transmission Owners

Participating Transmission Owners (PTOs) are responsible for the following actions:

Participating Transmission Owner (PTO)
<ol style="list-style-type: none"> 1. Operate the system in accordance with Good Utility Practice and in a manner that ensures safe and reliable operation. 2. Operate the system within voltage limits and criteria specified in ISO Operating Procedure 3100 Establishing System Operating Limits for the Operations Horizon. 3. Provide appropriate Voltage Schedule(s) to generators in their area in order to operate within System Operating Limits and Interconnection Reliability Operating Limits. 4. When A Generator Operator or the ISO notifies the PTO of changes to the status of AVRs or PSSs, direct the Generator Operator to maintain or change either its voltage Schedule or its Reactive Power Schedule as appropriate. 5. Notify the ISO of system conditions <u>and</u> coordinate switching of Voltage Support equipment. 6. Notify the ISO of events and changes that impact the Voltage Support equipment availability, or reliability. <p><i>Note: The ISO has the authority to coordinate the use of all Voltage Support equipment as required.</i></p> <ol style="list-style-type: none"> 7. Respond to requests for Voltage Support. 8. Respond to emergency requests.

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3.3 General Voltage/VAR Control Guidance

3.3.1 Voltage, VARs and Power Factors Adjustment

Use the table below for guidance on how to adjust voltage, VARs, or Power Factors (includes preventing voltage collapse):


To increase voltage, produce VARs, and/or shift power factor towards lag...	To decrease voltage, consume VARs, and/or shift power factor towards lead...
Increase Generator terminal Voltage (over-excite, move power factor toward lag)	Decrease Generator terminal Voltage (under-excite, move power factor toward lead)
De-energize shunt reactors	Energize shunt reactors
Energize shunt capacitors	De-energize shunt capacitors
Energize HVDC harmonic filters	De-energize HVDC harmonic filters
Boost synchronous condensers (over-excite, move power factor toward lead)	Buck synchronous condensers (under-excite, move power factor toward lag)
Synchronize additional equipment (generators, condensers) capable of producing VARs	Synchronize additional equipment capable of consuming VARs
Energize additional circuits (high voltage transmission lines and cables)	De-energize circuits (high voltage transmission lines and cables capable of being unloaded)
Reduce Load	Increase load (e.g. pump load)

3.3.2 Other Measures

The following are other miscellaneous measures that can be taken to adjust Voltage / VARs:

- Transformer Bank Taps can be changed to push VARs.
- Generally, increasing the high side voltage and decreasing the low-side voltage will cause VARs to flow towards the high side and away from the low side.
- Series Capacitor switching will change the MW and VAR loading on associated line(s) and parallel lines. This will generally impact transfer capability.

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4. Supporting Information

Operationally Affected Parties

Shared with **the** Public.

References

Resources studied in the development of this procedure and that may have an effect upon some steps taken herein include but are not limited to:

CAISO Tariff	
ISO Operating Procedure	3100 Establishing System Operating Limits for the Operations Horizon
NERC Requirements	TOP-002-2.1b R8 TOP-004-2 R6.1 VAR-001-4 R2 VAR-001-4 R3
WECC Criterion	
Other References	LADWP: Operating Bulletin 31 - System Voltage and MVAR Control PG&E: O-59 Transmission System Voltage Control SCE: System Operating Bulletin SOB 17 - System Voltage Control SDG&E: TMC1005 - Transmission System Voltage and VAR Control


Definitions

Unless the context otherwise indicates, any word or expression defined in the Master Definitions Supplement to the CAISO Tariff shall have that meaning when capitalized in this Operating Procedure.

The following additional terms are capitalized in this Operating Procedure when used as defined below:

Participating Entity	A Participating Generator, Participating Load/UDC, or PTO.
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Version History

Version	Change	Date
6.0	Annual review. Section 3.3.1 Step 4 CAISO Operator Actions: Changed from "Notify PTO" to "Notify SC" to align with current practice. Section 3.3.1 Step 5 CAISO Operation Actions: Added step 5 to notify WECC RC.	10/23/2012
7.0	Periodic Review: Section 2: added reference to CFR agreements and delegation of responsibilities to PTOs. Section 3.1.3: Removed tariff specific voltage requirements and added umbrella requirement to meet limits and criteria in Procedure 3100. Section 3.2.3: Updated PTO actions to maintain voltage per CFR agreement. Section 3.3.3: Deleted Voltage Guidelines section. This Procedure now references Procedure 3100 for voltage limits and criteria. Changed WECC RC to Peak RC throughout procedure. Removed references to compensation for voltage support.	6/30/2015
7.1	Changed all references from CAISO to ISO. Updated formatting and grammar. Changed the role names used in this procedure to their new role names.	11/16/2016
8.0	Periodic Review: Replaced Peak RC with the RC. Minor format and grammar updates. Removed version history prior to 5-years.	2/29/2020

5. Periodic Review Procedure


Review Criteria & Incorporation of Changes

There are no specific review criteria identified for this procedure, follow instructions in ISO Operating Procedure [5510](#).

Frequency

Every 3 years.

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Appendix

No references at this time.