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<b>Voltage and VAR Control</b>		<b>Distribution Restriction:</b> <b>None</b>

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## Purpose

Provides guidelines for maintaining acceptable voltage levels and Volt Ampere Reactive (VAR) flow on the California ISO (CAISO) Controlled Grid.

### 1. Responsibilities

<b>CAISO System Operator</b>	Maintains acceptable voltage levels and VAR flow on the CAISO Controlled Grid using all voltage control support equipment.
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<b>Participating Generator (PG)</b>	Participating Generators are required to operate within a specified power factor band. Notify the PTO and the CAISO of changes as soon as practical, but within 30 minutes to the status of automatic voltage regulator control (AVR) and power system stabilizers (PSS).
<b>Participating Loads</b>	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.
<b>Participating Transmission Owner (PTO)</b>	Participating Transmission Owners operate Voltage Support equipment to maintain normal voltage and VAR flow according to the CAISO 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 CAISO operates the CAISO Controlled Grid to ensure System Reliability. This may include the use of any available Voltage Support equipment so that the operation of the CAISO 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 CAISO will operate and monitor the system in accordance with the Good Utility Practice to ensure safe and reliable operations. The CAISO 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 CAISO System Operator Responsibilities

##### 3.1.1 Monitor Transmission Equipment and Generators

Take the following actions as necessary:


CAISO System Operator
<ol style="list-style-type: none"> <li>1. <b>Monitor</b> Loads and Generators to <b>verify</b> that the grid is operated at the appropriate voltage level.</li> <li>2. <b>Verify</b> that each Participating Entity is complying with Voltage Support requirements.</li> <li>3. <b>Coordinate</b> adjustments to <b>prevent</b> offsetting or competing Voltage Support measures.</li> <li>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"> <li>• <b>Instruct</b> the Scheduling Coordinator to have the Generator operator <b>notify</b> their PTO <u>and</u> <b>request</b> a voltage schedule.</li> </ul> <p style="margin-left: 40px;"><i><b>Note:</b> The PTO will direct the Generator operator to maintain or change either its voltage Schedule or its Reactive Power Schedule as appropriate.</i></p> </li> <li>5. <b>Notify</b> the RC of any AVR/PSS outage, change of status, or limitation.</li> </ol>

##### 3.1.2 Monitor Balancing Areas

Take the following actions as necessary:

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

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### 3.1.3 Operate CAISO Controlled Grid Voltage Equipment

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

CAISO System Operator
<ol style="list-style-type: none"> <li>1. <b>Maintain</b> operational awareness of the Voltage Support equipment available, <u>and</u></li> <li>2. <b>Coordinate</b> the use and switching of Voltage Support equipment among PTOs, UDCs, Generators, and other Balancing Areas to <b>ensure</b> that the Bulk Electric System (BES) is operating within established voltage limits and criteria as specified in CAISO Operating Procedure <a href="#">3100 Establishing System Operating Limits for the Operations Horizon</a>.</li> </ol>


## 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"> <li>1. <b>Operate</b> Generation within established protocols and procedures, specifically normal MW/VAR Capacity profiles, at the applicable Voltage Schedule.</li> <li>2. <b>Comply</b> with the Voltage Schedule in automatic voltage control mode (AVR in service and controlling voltage).</li> <li>3. <b>Produce or consume</b> reactive power when requested by the CAISO.</li> <li>4. <b>Notify</b> the CAISO of system conditions including coordination of switching of Voltage Support equipment.</li> <li>5. <b>Notify</b> the CAISO of events and changes that impact the MW/VAR Capacity, reliability, or ability to operate within the power factor band.</li> <li>6. <b>Notify</b> the applicable PTO and the CAISO as soon as possible, <u>within 30</u> minutes of changes to the status of AVR or PSSs.</li> <li>7. <b>Respond</b> to emergency requests.</li> </ol>

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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"> <li>1. <b>Operate</b> in accordance with Good Utility Practice within established protocols and Operating Procedures and <b>adhere</b> to specified Voltage Schedules.</li> <li>2. <b>Maintain</b> reactive power flow at grid interface points within the power factor band of 0.97 lag and 0.99 lead.</li> <li>3. <b>Notify</b> the CAISO of system conditions, <b>including</b> coordinated switching of Voltage Support equipment.</li> <li>4. <b>Notify</b> the CAISO of events and changes that impact the Voltage Support equipment availability, reliability, or ability to operate within the power factor band.</li> <li>5. <b>Respond</b> to CAISO and PTO requests for Voltage Support while operating within the power factor band.</li> <li>6. <b>Respond</b> to emergency requests.</li> </ol>

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

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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 <b>increase</b> voltage, <b>produce</b> VARs, and/or <b>shift</b> power factor towards lag...	To <b>decrease</b> voltage, <b>consume</b> VARs, and/or <b>shift</b> power factor towards lead...
<b>Increase</b> Generator terminal Voltage (over-excite, move power factor toward lag). This option may only be utilized by the PTO, as CAISO Operators are not authorized to request changes in generator terminal voltage changes.	<b>Decrease</b> Generator terminal Voltage (under-excite, move power factor toward lead). This option may only be utilized by the PTO, as CAISO Operators are not authorized to request changes in generator terminal voltage changes.
<b>De-energize</b> shunt reactors	<b>Energize</b> shunt reactors
<b>Energize</b> shunt capacitors	<b>De-energize</b> shunt capacitors
<b>Energize</b> HVDC harmonic filters	<b>De-energize</b> HVDC harmonic filters
<b>Boost</b> synchronous condensers (over-excite, move power factor toward lead)	<b>Buck</b> synchronous condensers (under-excite, move power factor toward lag)
<b>Synchronize</b> additional equipment (generators, condensers) capable of producing VARs	<b>Synchronize</b> additional equipment capable of consuming VARs
<b>Energize</b> additional circuits (high voltage transmission lines and cables)	<b>De-energize</b> circuits (high voltage transmission lines and cables capable of being unloaded)
<b>Reduce</b> Load	<b>Increase</b> 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.

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- Series Capacitor switching will change the MW and VAR loading on associated line(s) and parallel lines. This will generally impact transfer capability.

## 4. Supporting Information

### Operationally Affected Parties


Shared with the Public.

### References

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

CAISO Tariff	
CAISO Operating Procedure	<a href="#">3100 Establishing System Operating Limits for the Operations Horizon</a>
NERC Requirements	TOP-001-6 R10.4, R10.6 TOP-002-5 R8 VAR-001-5 R2, R3
WECC Criterion	
Other References	LADWP: <a href="#">Operating Bulletin 31 - System Voltage and MVAR Control</a> PG&E: <a href="#">O-59 Transmission System Voltage Control</a> SCE: System Operating Bulletin <a href="#">SOB 17 - System Voltage Control</a> SDG&E: <a href="#">TMC1005 Transmission System Voltage and VAR Control</a>

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## 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:

<b>Participating Entity</b>	A Participating Generator, Participating Load/UDC, or PTO.
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## Version History

<b>Version</b>	<b>Change</b>	<b>Date</b>
8.0	Periodic Review: Replaced Peak RC with the RC. Minor format and grammar updates. Removed version history prior to 5-years.	2/29/20
8.1	Periodic Review: Section 3.1.3: Correction made to Item 2, for dispatching "Legacy" RMR units first. Updated NERC Requirements. Added reference to 3320A to appendix section. Removed history prior to five years. Minor format and grammar edits for procedures consistency.	12/13/22
8.2	Section 3.1.3: Removed Item 2, for dispatching "Legacy" RMR units first, as there are no longer any Legacy RMR units as of 1/02/24.	1/01/24
8.3	Purpose section: Defined Voltage Ampere Reactive (VAR). Section 1: Included "Participating" with detail of Participating Transmission Owners for consistency. Section 3.1.3: Defined Bulk Electric System (BES). Section 3.3.1: Updated Increase or Decrease Generator terminal Voltage by included statement that this option may only be used by the PTO. References: Updated TOP-001 reference version. Minor formatting and grammar edits.	9/12/24
8.4	Periodic Review: Minor formatting and grammar edits and removed history prior to five years.	12/04/25

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## 5. Periodic Review Procedure

### Review Criteria & Incorporation of Changes

There are no specific review criteria identified for this procedure, follow instructions in CAISO Operating Procedure 5510.

### Frequency

Every three (3) years.

## Appendix

3320A High Voltage SOL Exceedance