**Standard Development Timeline**

This section is maintained by the drafting team during the development of the standard and will be removed when the standard becomes effective.

**Project Roadmap**

| **Completed Actions** | **Completion Date** |
| --- | --- |
| 1. SAR received
 | February 11, 2014 |
| 1. SAR deemed Complete/Valid/Team Site created
 | February 11, 2014 |
| 1. WSC approved the SAR
 | March 12, 2014 |
| 1. WSC solicits/assigns a drafting team (DT)
 | March 12, 2014 |
| 1. DT announced/notice sent to DT members
 | March 12, 2014 |
| 1. First DT meeting
 | April 8, 2014 |
| 1. WSC changed scope of SAR to subsume VAR-501-WECC-1. WSC approved posting for 45-day comment.
 | June 25, 2014 |
| 1. Posting 1 Open
 | July 1, 2014 |
| 1. Posting 1 Closed
 | August 14, 2014 |
| 1. Posting 1 Responses Posted
 | September 26, 2014 |
| 1. Posting 2 Open
 | October 15, 2014 |
| 1. Posting 2 Closed
 | November 14, 2014 |
| 1. WSC approved posting of responses and granted permission for the late posting.
 | December 3, 2014 |
| 1. Posting 2 Responses Posted
 | December 4, 2014[[1]](#footnote-2) |
| 1. Posting 3 Open
 | December 18, 2014 |
| 1. FERC approved new WECC Reliability Standards Development Procedures.
 | December 23, 2014 |
| 1. Posting 3 Closed
 | January 19, 2015[[2]](#footnote-3) |
| 1. Posting 3 Responses Posted
 | February 2, 2015  |
| 1. Posting 4 Open
 | April 17, 2015 |
| 1. Posting 4 Closed
 | May 19, 2015 |
| 1. DT meets to respond to comments
 | May 28, 2015 |
| 1. Posting 4 Responses Posted
 | June 12, 2015 |
| 22.a. Revised Posting 4 Responses Posted | July 2, 2015 |
| 23. Posting 5 Open | July 7, 2015 |
| 24. Posting 5 Closed | August 6, 2015 |
| 25. DT meets to respond to comments | August 7, 2015 |
| 26. Posting 5 Responses Posted |  |
| 1. Ballot Pool open
 |  |
| 1. Ballot Pool closed
 |  |
| 1. Joint Session noticed
 |  |
| 1. Joint Session
 |  |
| 1. Ballot Open
 |  |
| 1. Ballot Closed
 |  |
| 1. WSC approves forwarding to the WECC Board of Directors
 |  |
| 1. Posted for 30 days prior to WECC Board meeting
 |  |
| 1. Board meets to approve
 |  |
| 1. Sent to NERC
 |  |

**Version History**

|  |  |  |  |
| --- | --- | --- | --- |
| **Version** | **Date** | **Action** | **Change Tracking** |
| 0 | April 23, 2004 | WECC Effective Date: VAR-502-WECC-0.1 |  |
| 1 | July 1, 2011 | FERC Effective Date: VAR-501-WECC-1  |  |
| 2 | May 28, 2014 | WECC Ballot Body Approved  | Paragraph 81 clean-up |
| 3 |  |  |  |

**Implementation Plan**

VAR-501-WECC-3, Power System Stabilizers (PSSs)

**Standards Authorization Request**

[WECC-0107 VAR-501-WECC-3 Power System Stabilizers Standards Authorization Request](https://www.wecc.org/Reliability/SAR%20Form%20WECC-0107%20PSS%20Design%20and%20Performance.pdf)

**Applicable Standards**

* VAR-501-WECC-3, Power System Stabilizers (PSSs)

**Requested Retirements**

* VAR-501-WECC-2, Power System Stabilizer

**Applicable Entities**

* Generator Operator
* Generator Owner

**Conforming Changes to Other Standards**

N/A

**Effective Date**

Where approval by an applicable governmental authority is required, Reliability Standard VAR-501-WECC-3, Requirements R1, R2, R4, and R5 shall become effective on the first day of the first calendar quarter after the effective date of the applicable governmental authority’s order approving the standard, or as otherwise provided for by the applicable governmental authority. For units placed in first-time service after regulatory approval, Reliability Standard VAR-501-WECC-3, Requirement R3 shall become effective the first day of the first calendar quarter after the effective date of the applicable governmental authority’s order approving the standard. For units placed in service prior to final regulatory approval, Requirement R3 shall become effective the first day of the first calendar quarter that is five years after the effective date of the applicable governmental authority’s order approving the standard.

Where approval by an applicable governmental authority is not required, VAR-501-WECC-3, Requirements R1, R2, R4, and R5 shall become effective on the first day of the first calendar quarter after the date the standard is adopted by the NERC Board of Trustees, or as otherwise provided for in that jurisdiction. For units placed in first-time service after regulatory approval, Reliability Standard VAR-501-WECC-3, Requirement R3 shall become effective the first day of the first calendar quarter after the date the standard is adopted by the NERC Board of Trustees, or as otherwise provided for in that jurisdiction. For units placed in service prior to final regulatory approval, Requirement R3 shall become effective the first day of the first calendar quarter that is five years after the standard is adopted by the NERC Board of Trustees.

**Retirement Date**

Reliability Standard VAR-501-WECC-2 shall be retired immediately prior to the effective date of VAR-501-WECC-3 in the particular jurisdiction in which the revised standard is becoming effective.

**Justification**

With the exception of Requirement R3, VAR-501-WECC-3 has a standardized Effective Date.

Use of this separate Effective Date for Requirement R3 highlights the fact that the reliability-related tasks included in Requirement R3 are a change from existing tuning parameters and could impose an entity-specific burden that is moderate to severe, depending on the existing practices of each entity. The tiered implementation of Requirement R3 ameliorates the burden.

Units placed into first-time service after regulatory approval will require initial testing, tuning, and set-up. As such, immediate compliance with Requirement R3 for new units should impose no additional undue burden. Many of the units already in service prior to regulatory approval and tuned to existing tuning parameters are currently and adequately tuned to pre-Requirement R3 parameters and need not be immediately revisited. The five-year applicability date for those units already in service lessens the burden while targeting a uniform tuning across the Western Interconnection.

**Consideration of Early Compliance**

Early compliance should impose no negative impacts. Because many of the Requirements are based on existing WECC policies, many Applicable Entities within WECC will already be in voluntary compliance.

**Definitions of Terms**

No new definitions are proposed.

# A. Introduction

### Title: Power System Stabilizers (PSSs)

1. **Number:** VAR-501-WECC-3
2. **Purpose:** To ensure the Western Interconnection is operated in a coordinated manner under normal and abnormal conditions by establishing the performance criteria for WECC power system stabilizers.
3. **Applicability:**

### 4.1 Generator Operator

### 4.2 Generator Owner

### 5. Facilities: This standard applies to synchronous generators that meet the definition of Commercial Operation.

**6. Effective Date:** The first day of the first quarter following regulatory approval, except for Requirement R3.

For units placed in first-time service after regulatory approval, Requirement R3 is effective the first day of the first quarter following final regulatory approval.

For units placed in service prior to final regulatory approval, Requirement R3 is effective the first day of the first quarter that is five years after regulatory approval.

For further detail, refer to the Implementation Plan.

**B. Requirements and Measures**

### R1. Each Generator Owner shall provide to its Transmission Operator, within 180 days of the PSS’s Commercial Operation date or any changes to the PSS operating specifications, the Generator Owner’s written Operating Procedure or other document(s) describing those known circumstances during which the Generator Owner’s PSS will not be providing an active signal to the Automatic Voltage Regulator (AVR*). [Violation Risk Factor: Low] [Time Horizon: Planning Horizon]*

### M1. Each Generator Owner will have documented evidence that it provided to its Transmission Operator, within the time allotted as described in the procedures required under Requirement R1, written Operating Procedures or other document(s) describing those known circumstances during which the Generator Owner’s PSS will not be providing an active signal to the AVR.

### For auditing purposes, because Requirement R1 conditions are intended to be unchanged unless the Transmission Operator is otherwise notified, the Generator Owner only needs to provide the documentation to the Transmission Operator one time, or whenever the operating specifications change.

### For auditing purposes, if a PSS is in service but is not providing an active signal to the AVR as described in Requirement R1, the disabled period does not count against the Requirement R2 mandate to be in service except as otherwise allowed.

**R2.** Each Generator Operator shall have its PSS in service while synchronized, except during any of the following: *[Violation Risk Factor: Medium] [Time Horizon:* *Operating Assessment]*

* Component failure
* Testing of a Bulk Electric System Element affecting or affected by the PSS
* Maintenance
* As agreed upon by the Generator Operator and the Transmission Operator

**M2.** Each Generator Operator will have documentation of each claimed exception specified in Requirement R2. Documentation may include, but is not limited to:

* A written explanation covering the bulleted exception that describes the circumstances of the exception as allowed in Requirement R2.
* Documented evidence that the Generator Operator and the Transmission Operator agreed the PSS would not be operating during a specified set of circumstances, where the exception is claimed under the last bullet of Requirement R2.

For auditing purposes, the presumption is that the PSS was in service unless otherwise exempted in Requirement R2. Evidence need only be provided to prove the circumstances when the PSS was not in service.

**R3.** Each Generator Owner shall tune its PSS to meet the following inter-area mode criteria, except as specified in Requirement R3, Part 3.5 below: *[Violation Risk Factor: Medium] [Time Horizon:* *Operating Assessment]*

**3.1.** PSS shall be set to provide the measured, simulated, or calculated compensated minimum-load VT/Vref frequency response of the excitation system and synchronous machine such that the phase angle will not exceed ± 30 degrees through the frequency range from 0.2 Hertz to the lesser of 1.0 Hertz or the highest frequency at which the phase of the Vt/Vref frequency response does not exceed 90 degrees.

**3.2.** PSS output limits shall be set to provide at least ±5% of the synchronous machine’s nominal terminal voltage.

**3.3.** PSS gain shall be set to between 1/3 and 1/2 of maximum practical gain.

**3.4.** PSS washout time constant shall be no greater than 30 seconds.

**3.5**. Units that have an excitation system or PSS that is incapable of meeting the tuning requirements of Requirement R3 are exempt from Requirement R3 until the voltage regulator is either replaced or retrofitted such that the PSS becomes capable of meeting the tuning requirements.

**M3.** Each Generator Owner will have documented evidence that its PSS was tuned to meet the specifications of Requirement R3.

 If the exception under Requirement R3, Part 3.5, is claimed, the Generator Owner will have documented evidence describing: 1) the conditions that render the PSS incapable of meeting the tuning requirements, and 2) the date the voltage regulator was last replaced or retrofitted.

 For auditing purposes, minimum load in Requirement R3, Part 3.1, is the minimum stable load that the unit can maintain without violating environmental or other regulatory mandates.

**R4.** Each Generator Owner shall install and complete start-up testing of a PSS on its generator within 180 days of either of the following events: *[Violation Risk Factor: Medium] [Time Horizon: Operational Assessment]*

* The Generator Owner connects a generator to the BES, after achieving Commercial Operation, and after the Effective Date of this standard.
* The Generator Owner replaces the voltage regulator on its existing excitation system, after achieving Commercial Operation for its generator that is connected to the BES, and after the Effective Date of this standard.

**M4.** Each Generator Owner will have evidence that it installed and completed start-up testing of a PSS on its generator within 180 days of either of the conditions described in Requirement R4, and when those conditions occur after the Effective Date of this standard.

For auditing purposes of Requirement R4, bullet one only applies to equipment on its initial (first energization) connection to the BES.

**R5.** Each Generator Owner shall repair or replace a PSS within 24 months of that PSS becoming incapable of meeting the tuning specifications stated in Requirement R3. *[Violation Risk Factor: Medium] [Time Horizon: Operational Assessment]*

**M5.** Each Generator Owner will have evidence that it repaired or replaced its PSS within 24 months of that PSS becoming incapable of meeting the tuning specifications of Requirement R3. Evidence may include, but is not limited to, documentation of the date the PSS became incapable of meeting the Requirement R3 tuning specifications, and the date the PSS was returned to service, demonstrating that the span of time between the two events was less than 24 months.

**C. Compliance**

**1. Compliance Monitoring Process**

**1.1 Compliance Enforcement Authority**

NERC or the Regional Entity, or any entity as otherwise designated by an Applicable Governmental Authority, in their respective roles of monitoring and/or enforcing compliance with mandatory and enforceable Reliability Standards in their respective jurisdictions.

**1.2 Compliance Monitoring and Assessment Processes**

* + - Compliance Audits
		- Self-Certifications
		- Spot Checking
		- Compliance Investigations
		- Self-Reporting
		- Complaints

**1.3 Evidence Retention**

The following evidence retention periods identify the period of time an entity is required to retain specific evidence to demonstrate compliance.  For instances where the evidence retention period specified below is shorter than the time since the last audit, the Compliance Enforcement Authority may ask an entity to provide other evidence to show that it was compliant for the full time period since the last audit.

Each Generator Operator shall keep evidence for all Requirements of the document for a period of three years plus calendar current.

**1.4 Additional Compliance Information**

None

**Table of Compliance Elements**

| **R** | **Time Horizon** | **VRF** | **Violation Severity Levels** |
| --- | --- | --- | --- |
| **Lower VSL** | **Moderate VSL** | **High VSL** | **Severe VSL** |
| **R1** | Planning Horizon | Low | NA | NA | NA | The Generator Owner failed to provide its PSS operating specifications to the Transmission Planner as required in Requirement R1.  |
| **R2** | Operations Assessment | Medium  | NA | NA | NA | The Generator Operator failed to have its PSS in service, except where allowed in Requirement R2.  |
| **R3** | Operations Assessment | Medium  | The Generator Owner’s PSS failed to meet any of the required performances in Requirement R3, two times or fewer during the audit period.  | The Generator Owner’s PSS failed to meet any of the required performances in Requirement R3, three times during the audit period.  | The Generator Owner’s PSS failed to meet any of the required performances in Requirement R3, four times during the audit period.  | The Generator Owner’s PSS failed to meet any of the required performances in Requirement R3, five times or more during the audit period.  |
| **R4** | Operational Assessment | Medium | NA | NA | NA | The Generator Owner failed to install on its generator a PSS, as required in Requirement R4.  |
| **R5** | Operational Assessment | Medium | NA | NA | NA | The Generator Owner failed to repair or replace a non-operational PSS as required in Requirement R5.  |

**Guideline and Technical Basis**

PSS systems are used to minimize real power oscillations by rapidly adjusting the field of the generator to dampen the low-frequency oscillations.

It is necessary for large numbers of PSS devices to be in operation in the Western Interconnection in order to provide the required system damping while still allowing for some of these units to be out of service whenever necessary.

**Mandate to Install a PSS**

Nothing in this Reliability Standard should be construed to require installation of PSSs solely because a PSS is not currently installed as of the Effective Date of this standard. However, when triggering events described in the Reliability Standard occur after the Effective Date of the standard, installation of PSSs will become mandatory pursuant to the Requirements therein. It should be noted that a PSS is neither Transmission nor generation.

**Requirement R1**

Requirement R1 addresses normal operating conditions.

Requirement R1 recognizes that PSS systems have varying states, such as on, off, active, and non-active. As long as the PSS is operating in accordance with the documentation provided to the Transmission Planner, this is not considered a status change for purposes of this standard.

This Requirement eliminates the requirement to count hours as required in the previous version of this standard while also allowing the Generator Owner to create a unit-specific operating plan.

The intent of Requirement R1 is to provide the Transmission Planner the PSS operating zone in which the PSS is “active”; i.e., providing damping to the power system. Some PSSs may be programmed to become “active” at a specified megawatt loading level and above while others may be programmed to be “active” in a particular band of megawatt loading levels and are “non-active” only when passing through the “rough zone” or some other band.  A “rough zone” is a megawatt loading band in which the generator-turbine system could contribute to system instability.

**Requirement R2**

Unlike Requirement R1, Requirement R2 addresses exceptions to normal operation.

The intent of Requirement R2 is to remove the previous requirement to log hours for PSSs in service. In this standard’s previous version, the logged hours were totaled quarterly to meet the 98% in-service requirement.  Instead of documenting the number of hours excluded, this Requirement simplifies the process by allowing the Generator Operator to communicate to the Transmission Operator the circumstances that render the PSS unavailable to the Transmission Operator (such as component failure, maintenance, and testing).

**Requirement R3**

The intent of Requirement R3 is to specify the tuning requirements of the PSS. Unlike the language in Requirement R5 that looks *backward* to address units that were once operating but are no longer capable of operating, Requirement R3 looks *forward*, requiring that units be tuned to the specified parameters.

The PSS transfer function should compensate the phase characteristics of the generator, exciter, and power (GEP) system transfer function so the compensated transfer function ((PSS(s) \* GEP(s)) has a phase characteristic of ± 30 degrees in the frequency range.

The GEP(s) transfer function is a theoretical transfer function, and its phase characteristic cannot be directly measured during field tests (only via simulation). Thus, the Requirement recognizes the practical approach of measuring the frequency response between voltage reference set point and terminal voltage (Et/Vref) and using the phase characteristic of such frequency response as being the phase characteristic of GEP(s). The phase characteristic of Et/Vref is a better approximation to the phase characteristic of GEP(s) when the frequency response Et/Vref is obtained with the generator synchronized to the grid at its minimum stable power output.

In an effort to allow for reasonable wash-out time constants, the Requirement specifies 0.2 Hz as the applicable threshold. The 0.2 Hz threshold more closely aligns with the observed oscillation frequencies.

A properly tuned PSS should provide positive damping to the local mode of oscillation, which typically has a frequency higher than 1.0 Hz.

This Requirement modifies the requirement associated with the adjustment of the PSS gain. The standard no longer defines the PSS gain in terms of gain margin but instead requires the final PSS gain to be between 1/3 and 1/2 of the maximum practical gain that could be achieved during PSS commissioning. The maximum practical gain might be associated with the excessive noise or raised higher-frequency oscillations in the closed loop response (exciter mode) or any other form if there is inadequate closed-loop performance, as determined during PSS commissioning. It is now part of Measure M3 to show the field test results that led to the determination of the maximum practical gain.

**Requirement R4**

Requirement R4 requires a Generator Owner to install a PSS on new applicable units or when excitation systems are replaced or retrofitted on existing applicable units. This Requirement applies to new excitation systems and not to existing systems that do not have PSSs. The Requirement also allows a reasonable amount of time for commissioning of new PSSs.

**Requirement R5**

Unlike the language in Requirement R3 that looks *forward* to ensure that a unit is tuned, Requirement R5 looks *backward.* Specifically, the language in Requirement R5, “becoming incapable,” indicates the unit was previously capable of meeting the tuning requirements in Requirement R3, but is no longer capable. Restated, Requirement R5 addresses units that were previously working but are now no longer working.

The intent of Requirement R5 is to remove the “tiered” approach to PSS repair/replacement following a failure.  A simple, streamlined approach to allow the Generator Owner sufficient time to repair or replace a broken PSS has been written.  Consideration has been given for the need to procure parts or new equipment, schedule an equipment/unit outage, and install and test the repaired or replaced PSS.  It is recognized that in some instances, it may require (1) replacement of an AVR and (2) the existence of a PSS, OR both the AVR and the PSS may need to be replaced to achieve a functioning system.

The 24-month time frame is sufficient to return a functional, operating PSS to service.

1. On December 3, 2014, the WECC Standards Committee (WSC) granted the drafting team an extension for posting responses. The WSC agreed that quality was preferable to timeliness. [↑](#footnote-ref-2)
2. This document was posted for a 30-day public comment period from December 12, 2014, through January 12, 2015. Late comments were received until January 20, 2015, 10:00 a.m. (Mountain) when the drafting team met to respond to comments. The window was extended because a closing date in the mandated notice did not match text in the posted document. [↑](#footnote-ref-3)