

Definitions of Terms Used in Standard

This section includes all newly defined or revised terms used in the proposed standard. Terms already defined in the NERC Reliability Standards Glossary of Terms or the MRO Reliability Standards Glossary of Terms are not repeated here. New or revised definitions listed below become approved when the proposed standard is approved. When the standard becomes effective, these defined terms will be removed from the individual standard and added to the Midwest Reliability Organization (MRO) Glossary. NERC and MRO defined terms are capitalized in the standard.

A. Introduction

1. **Title:** Power System Stabilizer Requirement and Small Signal Stability Assessment
2. **Number:** PRC-502-MRO-02
3. **Purpose:** To ensure that power system stabilizers are designed, installed and tuned as required to dampen power system oscillations in the Midwest Reliability Organization (MRO). To ensure small signal stability assessments are performed. To ensure testing programs are developed and oscillations with inadequate damping are analyzed and corrected.
4. **Applicability**
 - 4.1. Planning Coordinator
 - 4.2. Transmission Planner
 - 4.3. Generator Owner
 - 4.4. Generator Operator
5. **Effective Date:** 1st day of the 1st ~~quarter-month, one year~~ following all appropriate Regulatory Authority approvals, financial sanctions will become effective.

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B. Requirements

- R1. ~~Each~~The Generator Owner shall install power system stabilizers on all new¹ or substantially modified² generator units with a nameplate rating 100 MVA or larger, prior to the generator's in-service date, or as required by changes in system conditions, when all of the following conditions exist: [*Violation Risk Factor: Medium*] [*Time Horizon: ~~Real-time-Operations~~ Planning? ~~I don't think this is a real-time-operations requirement~~ double-check*]
- R1.1 Small signal stability assessments performed by the Transmission Planner or Planning Coordinator provide evidence of high generator relative participation (factors greater than 10%) in a range of local, inter-plant, and inter-area modes (i.e. 0.1 to 2.0 Hz) that show small signal instability or inadequate damping³.
- R1.2 System performance assessments performed by the Transmission Planner or Planning Coordinator for disturbances defined in all categories, other

¹ A new generator is a generator that receives Planning Coordinator agreement to interconnect to the Bulk Electric System after the effective date of this standard.

² A generator modification is considered substantial if it results in a change in the real power output by more than 10% of the original nameplate rating or more than 20 MW, whichever is less or includes any of the following: generator rewind, rotor replacement, new or refurbished excitation system, or turbine replacement. A substantially modified generator is a generator that receives Planning Coordinator agreement to make the generator modification after the effective date of this standard.

³ Inadequate damping is defined as a violation of the minimum acceptable damping criteria determined by the Planning Coordinator for local and inter-plant modes as defined in MRO Regional Reliability Standard PRC-502-MRO-02_R8 and determined by the MRO for inter-area modes as defined in MRO Regional Reliability Standard TPL-503-MRO-02.

than extreme events, detailed in the currently approved NERC TPL Standards show inadequate damping.

R1.3 The generator is equipped with a suitable exciter that is able to enhance the effectiveness of the Power System Stabilizer (PSS) in providing positive damping to local, inter-plant and inter-area modes. The Transmission Planner shall determine whether the Generator Owner's exciter is suitable for a PSS installation. The exciter assessment shall consider the measured or calculated closed-loop phase response of the generator, exciter and power system and the ability of the PSS to overcome the combined phase lag.

~~R2.~~ ~~Each Generator Owner shall at a minimum~~ ~~When conditions R1.1 and R1.2 do not exist but R1.3 does exist, the Generator Owner, at minimum, shall~~ make provisions to allow for the future addition of a PSS on all new generator units 100 MVA or larger, prior to the generator's in-service date ~~when conditions R1.1 and R1.2 do not exist but R1.3 does exist.~~ The provisions shall include at minimum: *[Violation Risk Factor: Lower] [Time Horizon: Operations Planning]*

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~~R2.1~~ The automatic voltage regulator shall be designed ~~such that it is~~ capable of accepting a PSS input signal.

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~~R1.3.1~~~~R2.2~~ ~~The~~ appropriate PSS input signal transducers, determined by the Planning Coordinator, shall be installed.

~~R2.3.~~ ~~The~~ ~~Each~~ Transmission Planner and Planning Coordinator shall ~~each~~ perform a small signal stability assessment for its portion of the Bulk Electric System. The assessment shall be conducted at least every five (5) years unless it can be demonstrated that significant system changes have not occurred since the last assessment that would require a new small signal stability assessment. In the event a study is not conducted after five (5) years, system conditions shall be reviewed annually until a new small signal stability assessment is conducted. An assessment shall also be conducted for all new or substantially modified generator units with a nameplate rating 100 MVA or larger. The initial system conditions for small signal stability assessments shall include: *[Violation Risk Factor: Lower] [Time Horizon: Long-term Planning]*

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~~R2.1~~~~R3.1~~ The effect of different system loading conditions (spring light load, off-peak and peak load).

~~R2.2~~~~R3.2~~ The effect of transmission outages defined by all categories of contingencies, other than extreme events, detailed in the currently approved NERC TPL Standards prior to the implementation of any post-contingency system adjustments that may be manually implemented by the System Operator.

~~R2.3~~~~R3.3~~ The effect of increasing the power transfer to the Total Transfer Capability (TTC) limit on stability constrained flowgates.

~~R3.4.~~ ~~Each~~ The Transmission Planner and Planning Coordinator shall ~~each~~ determine corrective plan(s) for its portion of the Bulk Electric System to achieve the required system damping performance when a small signal stability assessment

study as described in [Requirement R32](#), indicates small signal instability or inadequate damping; or simulation studies, as required in the currently approved NERC TPL standard(s), indicate inadequate damping. [Violation Risk Factor: Medium] [Time Horizon: Long-term Planning]

~~R4.R5.~~~~Each~~The Transmission Planner and Planning Coordinator shall ~~each~~ demonstrate through valid assessment for its portion of the Bulk Electric System that any PSS required in accordance with [Requirement R1](#) or [Requirement R3-R4](#) has been planned, ~~designed and tuned to have a positive damping effect to meet the~~ [required damping criterion for](#) local, inter-plant and inter-area modes without significantly impacting turbine-generator shaft torsional oscillation damping. To be valid, the Planning Coordinator and Transmission Planner PSS assessments shall: [Violation Risk Factor: Lower] [Time horizon: Long-term Planning]

~~R4.1~~~~R5.1~~ Be made prior to the in-service date of the generator and as required by changes in system conditions.

~~R4.2~~~~R5.2~~ Demonstrate that machine rotor angle oscillations are within damping criteria in accordance with [Requirement R118](#) and TPL-503-MRO-02.

~~R4.3~~~~R5.3~~ Include results from small signal stability model data verification tests as prescribed in [Requirement R76](#).

~~R4.4~~~~R5.4~~ Include results from small signal stability assessments done in accordance with [Requirement R32](#) that are required in the design of the PSS.

~~R4.5~~~~R5.5~~ Demonstrate that the addition of the PSS does not degrade the damping ratio of each torsional mode by more than 10% on the generating unit where the PSS is installed.

[R5.6](#) Studies performed by the Planning Coordinator that are required to address inter-area modes shall be performed on a complete model of the Eastern Interconnection. Remote generators outside of the MRO region shall not be grouped together and equivalenced.

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~~R5.R6.~~~~The~~~~Each~~ Planning Coordinator and Transmission Planner shall, ~~for its portion of the Bulk Electric System, shall,~~ within thirty (30) ~~calendar~~ days of ~~a request or~~ completion of any assessment ~~required by Requirement R3 or R5~~ or corrective plan(s) ~~required by Requirement R3 for its portion of the Bulk Electric System or upon request by the MRO,~~ provide to the MRO and adjacent Planning Coordinator(s), and all Generator Owner(s) ~~within the Planning Coordinator's area of responsibility identified in the assessment(s) or corrective plan(s) the~~ results of ~~its latest~~ ~~the~~ [small signal stability, PSS-assessment\(s\)](#) or corrective plan(s). [Violation Risk Factor: Lower] [Time Horizon: Operations Assessment]

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[R7.](#) ~~Each~~The Generator Owner shall perform small signal stability model and performance verification tests for excitation systems (including automatic voltage regulator controls and power system stabilizers) on all generating units ~~that have an operational power system stabilizer with a nameplate rating 100 MVA or larger~~

that have an operational power system stabilizer. The Generator Owner may perform the tests in accordance with MRO Generator Testing Guidelines.

~~The Generator Owner shall, within thirty (30) days of a request, provide to the MRO and its Planning Coordinator and Transmission Planner the results of its most recent small signal stability model and performance verification tests for excitation systems (including automatic voltage regulator controls and power system stabilizers). [Violation Risk Factor: Lower] [Time Horizon: Operations Assessment]~~

The small signal stability model and performance verification tests shall include at minimum: *[Violation Risk Factor: Lower] [Time Horizon: Operations Planning]*

R6.1R7.1 A frequency-response test to verify the closed-loop automatic voltage regulator (AVR) transfer function without the PSS in-service. The generator is disconnected from the grid and operating at rated speed.

R6.2R7.2 A frequency-response test to verify the PSS open-loop transfer function, if the PSS is of analog type. The PSS output is disconnected from the AVR summing junction. Digital systems that have been type tested are exempt from the frequency-response field test. The Generator Owner shall supply manufacturer data and field settings of parameters for digital systems.

R6.3R7.3 A step-response test with the generator synchronized to the grid to verify that the gains and time constants of excitation systems (including automatic voltage regulator controls and power system stabilizers) have been designed and tuned to have a positive damping effect on local generator oscillations. A step-change in terminal voltage reference of the AVR is performed with and without the PSS in-service. The step change shall be designed to avoid hitting excitation limits or violating applicable voltage criteria.

R6.4R7.4 A load-ramping test at the typical generating unit ramp rate to ensure that the PSS does not produce undesirable modulation of the generating unit's terminal voltage.

R8. ~~Each Generator Owner shall, within thirty (30) calendar days of completion of a small signal stability model and performance verification tests for excitation systems (including automatic voltage regulator controls and power system stabilizers) described by Requirement R7 and R9 or upon request by the MRO, a request, provide to the MRO and its Planning Coordinator and Transmission Planner the results of its most recent the small signal stability model and performance verification tests for excitation systems (including automatic voltage regulator controls and power system stabilizers). [Violation Risk Factor: Lower] [Time Horizon: Operations Assessment]~~

R9. ~~Each Generator Owner shall conduct the tests described in Requirements R6.1 through R6.4 above shall be conducted~~ during commissioning of a new generation

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unit or during commissioning of a substantial modification of a generation unit to develop the model and to verify performance. The tests shall be repeated or the model may be compared against a system disturbance once every five (5) years thereafter ~~as specified by MRO Generator Testing Guidelines~~ for ongoing model and performance verification.

For a system disturbance to be valid for model and performance validation, the following minimum conditions shall be met: [Violation Risk Factor: Lower] [Time Horizon: Operations Planning]

R9.1 ~~A valid disturbance must cause a sudden change in system voltage of at least 2% of nominal bus voltage or a sudden change in reactive power of at least 10% of the rated generator MVA. The voltage regulator must have been in automatic voltage control mode and the PSS in service during the disturbance. The disturbance shall cause a sudden change in system voltage of at least 2% of nominal bus voltage or a sudden change in reactive power of at least 10% of the rated generator MVA.~~

R9.2 ~~The voltage regulator shall be in automatic voltage control mode and the PSS shall be in service during the disturbance.~~

~~**R7-R10.**~~ **R10.** ~~Each Generator Owner~~ Operator shall keep the PSS operational wwhere a PSS is required on a generating unit(s) in accordance with Requirement R1 or Requirement R4 3, ~~the Generator Owner shall keep the PSS operational~~ with the following exceptions: *[Violation Risk Factor: Medium] [Time Horizon: Same Day Operations]*

R7.1R10.1 ~~Maintenance, repair and testing.~~

R7.2R10.2 ~~PSS does not operate properly due to a failed component.~~

R7.3R10.3 ~~Generator unit is operating in synchronous condenser mode (near zero power level).~~

R7.4R10.4 ~~A hydro unit is passing through a range of output that causes undesirable terminal voltage variations (i.e. rough-zone gate position).~~

~~**R8-R11.**~~ **R11.** ~~Each~~ The Planning Coordinator shall define and document a rotor angle oscillation damping criteria and calculation methodology for local and inter-plant modes. The Planning Coordinator shall make documentation of this damping criteria and calculation methodology available to adjacent Planning Coordinator(s) or the MRO within ~~thirty-ninety (930)~~ calendar days of a request. *[Violation Risk Factor: Lower] [Time Horizon: Long Term Planning]*

~~**R9-R12.**~~ **R12.** ~~Each~~ Planning Coordinator and Transmission Planner shall determine and identify individual and joint responsibilities for performing the required studies for the Planning Assessments defined in Requirement R23 through Requirement R56 and provide the determination to the MRO within ~~thirty-ninety (3090)~~ calendar days of a request. *[Violation Risk Factor: Lower] [Time Horizon: Long-term Planning]*

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C. Measures

- R9.M1.** ~~_____~~ The Generator Owner shall provide evidence ~~(i.e. such as a commissioning report)~~ it has installed ~~or is planning to install~~ power system stabilizers ~~s~~ prior to the generator's in-service date or as required by changes in system conditions as specified in [Requirement R1](#).
- M2.** The Generator Owner shall provide evidence it has made provisions to permit the installation of power system stabilizers in the future as required by changes in system conditions prior to the generator's in-service date as specified in Requirement R2.
- M2.M3.** ~~_____~~ The Planning Coordinator and Transmission Planner shall each provide evidence of a valid small signal stability assessment for its portion of the Bulk Electric System as specified in [Requirement R3](#)~~2~~. If the entity determined that a study was not performed within 5 years, the entity shall provide evidence showing why it was not necessary, and also provide evidence of an annual review.
- M3.M4.** ~~_____~~ The Planning Coordinator and Transmission Planner shall each provide evidence of corrective plan(s) ~~(i.e. installing or retuning a power system stabilizer(s))~~ for its portion of the Bulk Electric System to achieve the required system damping performance as specified in [Requirement R4](#)~~3~~.
- M4.M5.** ~~_____~~ The Planning Coordinator and Transmission Planner shall each provide evidence of a valid power system stabilizer assessment for its portion of the Bulk Electric System. This assessment shall document that any PSS has been planned, ~~designed and tuned~~ as specified in [Requirement R5](#)~~4~~.
- M5.M6.** ~~_____~~ The Planning Coordinator and Transmission Planner shall each provide evidence it reported the results of its small signal and PSS assessments and corrective plans for its portion of the Bulk Electric System as specified in [Requirement R6](#)~~5~~.
- M6.M7.** ~~_____~~ The Generator Owner shall provide evidence it performed ~~small signal stability tests and that, on request, the entity provided the test results to the MRO and its applicable Planning Coordinator(s) and Transmission Planner(s) as~~ specified in [Requirement R7](#)~~6~~.
- M8.** The Generator Owner shall provide evidence it provided the test results to the MRO and its applicable Planning Coordinator(s) and Transmission Planner(s) as specified in Requirement R8.
- M9.** The Generator Owner shall provide evidence it conducted the tests during commissioning and verified the models at least once every five(5) years thereafter as specified in Requirement R9.
- M7.M10.** ~~_____~~ The Generator ~~Owner Operator~~ shall provide evidence ~~(e.g. operational log records)~~ that ~~the PSS units were~~as kept operational, ~~on generator unit(s) except~~ as specified in [Requirement R10](#)~~7~~. ~~The Generator Owner shall also provide evidence that it maintained documentation of the PSS and provided the documentation to the MRO according to Requirement~~per [R7](#).

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~~M8.M11.~~ **M11.** The Planning Coordinator shall provide documentation describing its rotor angle damping criteria and calculation methodology for local and inter-plant modes and provide evidence it made the methodology available to adjacent Planning Coordinator(s) ~~and other Transmission Planner(s)~~, and the MRO as specified in [Requirement R118](#).

~~M9.M12.~~ **M12.** The Planning Coordinator and Transmission Planner shall [each](#) provide evidence that they have jointly determined the responsibilities for performing the required studies defined in [Requirement R32](#) through [Requirement R65](#) and provided the evidence to the MRO ~~according as specified into Requirement per~~ [Requirement R129](#).

D. Compliance

1. Compliance Monitoring Process

1.1. Compliance Monitoring Responsibility.

ERO as delegated to Midwest Reliability Organization

1.2. Compliance Monitoring Period and Reset Timeframe.

The Performance-Reset period shall be one (1) calendar year from the last finding of non-compliance.

1.3. Data Retention.

The Planning Coordinator shall retain assessments for five (5) years or until the next assessment is completed. The Generator Owner shall retain information from the most current and prior small signal stability model data verification tests.

In addition, entities found non-compliant shall keep information related to the non-compliance until found compliant.

The Compliance Monitor shall retain the last audit and all subsequent compliance records.

1.4. Additional Compliance Information.

The Planning Coordinator, Transmission Planner and Generator Owner shall demonstrate compliance through the following methods, as determined by the compliance monitor: (1) self-certification or (2) audit (periodic, as part of targeted monitoring or initiated by complaint or event).

2. Violation Severity Levels

R #	Lower VSL	Moderate VSL	High VSL	Severe VSL
R1	Not applicable	Not applicable Generator Owner did not make provisions for the future addition of a PSS per R1.	Not applicable	The Generator Owner did not install a PSS on a new or substantially modified generator per R1. OR Generator Owner did not install or retune a PSS in accordance with a corrective plan as required by changes in system conditions per R1.
R2	Not applicable	Not applicable	Not applicable	Generator Owner did not make provisions for the future addition of a PSS per R2.
R3R2	Not applicable	Not applicable	Planning Coordinator or Transmission Planner small signal assessment failed to include one or more of the assessment requirements given in R2R3.1 through R2R3.3 .	Planning Coordinator or Transmission Planner failed to perform a small signal stability assessment in accordance with R32 .
R4R3	Not applicable	Not applicable	Not applicable	Planning Coordinator or Transmission Planner failed to determine a corrective plan(s) in accordance with R3R4 .
R5R4	Not applicable	Not applicable	Planning Coordinator or Transmission Planner PSS assessment(s) failed to include one or more of the assessment requirements given in R4R5.1 through R4R5.56 .	Planning Coordinator or Transmission Planner failed to perform a PSS assessment in accordance with R4R5 .

<u>R6R5</u>	<p>Planning Coordinator or Transmission Planner failed to provide results from its latest small signal stability assessment, PSS assessment or corrective plan(s) to adjacent Planning Coordinators, Generator Owner(s) <u>identified in the assessment(s) or corrective plan(s) within the Planning Coordinators area of responsibility</u> and the MRO within 30 <u>calendar</u> days. The results were provided between 30 and 45 days.</p>	<p>Planning Coordinator or Transmission Planner failed to provide results from its latest small signal stability assessment, PSS assessment or corrective plan (s) to adjacent Planning Coordinators, Generator Owner(s) <u>identified in the assessment(s) or corrective plan(s) within the Planning Coordinators area of responsibility</u> and the MRO within 30 <u>calendar</u> days. The results were provided between 46 and 60 days.</p>	<p>Planning Coordinator or Transmission Planner failed to provide results from its latest small signal stability assessment, PSS assessment or corrective plan (s) to to one of the following: adjacent Planning Coordinators, Generator Owner(s) <u>identified in the assessment(s) or corrective plan(s) within the Planning Coordinators area of responsibility</u> or the MRO.</p>	<p>Planning Coordinator or Transmission Planner failed to provide the results from its latest small signal stability assessment, PSS assessment or corrective plan (s) to adjacent Planning Coordinators, Generator Owner(s) <u>identified in the assessment(s) or corrective plan(s) within the Planning Coordinators area of responsibility</u> and the MRO per <u>R65</u>.</p>
<u>R7R6</u>	<p>Not applicableGenerator Owner failed to provide results of the small signal stability model and performance verification tests to its Planning Coordinator and the MRO within 30 days. The results were provided between 30 and 45 days.</p>	<p>Not applicableGenerator Owner failed to provide results of the small signal stability model and performance verification tests to its Planning Coordinator and the MRO within 30 days. The results were provided between 45 and 60 days.</p>	<p>Generator Owner failed to perform <u>one</u>2 or more of the verification tests specified in <u>R6R7</u>.1 through <u>R6R7</u>.4.</p>	<p>Generator Owner failed to perform small signal stability model and performance verification tests for excitation systems (including automatic voltage regulator controls and PSSs) per <u>R6R7</u>.</p>
<u>R8</u>	<p>Generator Owner failed to provide results of the small signal stability model and performance verification tests to its Planning Coordinator, Transmission Planner and the MRO within 30 calendar days. The results were provided between 30 and 45 days.</p>	<p>Generator Owner failed to provide results of the small signal stability model and performance verification tests to its Planning Coordinator, Transmission Planner and the MRO within 30 calendar days. The results were provided between 45 and 60 days.</p>	<p><u>Not applicable</u></p>	<p>Generator Owner failed to provide results of the small signal stability model and performance verification tests to its Planning Coordinator, Transmission Planner and the MRO per <u>R8</u>.</p>

R9	Not applicable	Not applicable	Generator Owner failed to repeat small signal stability model and performance verification tests for excitation systems (including automatic voltage regulator controls and PSSs) every five(5) years per R9.	Generator Owner failed to perform small signal stability model and performance verification tests for excitation systems (including automatic voltage regulator controls and PSSs) during commissioning per R9.
R10R7	Not applicable Generator Owner failed to provide a PSS operational log to the MRO within 30 days. The log was provided between 30 and 45 days.	Not applicable Generator Owner failed to provide a PSS operational log to the MRO within 30 days. The log was provided between 45 and 60 days.	Generator Operator failed to provide evidence that the PSS was kept operational. such as a PSS operational log.	Generator Owner failed to maintain a PSS operational log. OR Generator Owner Operator failed to keep the PSS operational except as specified in R7R10.1 through R7.4.
R11R8	Planning Coordinator failed to provide its rotor angle damping criteria and calculation methodology to adjacent Planning Coordinators or the MRO within thirty-90 calendar days of a request. Documentation provided between 30-90 and 45-120 days.	Planning Coordinator failed to provide its rotor angle damping criteria and calculation methodology to adjacent Planning Coordinators or the MRO within thirty-90 calendar days of a request. Documentation provided between 45-120 and 1860 days.	Not applicable	Planning Coordinator failed to develop and document a rotor angle damping criteria and calculation methodology per R118 .
R12R9	Not applicable	Not applicable	Not applicable	The Planning Coordinator and Transmission Owner failed to provide identification of responsible entities for performing studies and planning assessments per R129 .

Version History

Version	Date	Action	Change Tracking