

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.

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A. Introduction

- 1. **Title:** Power System Stabilizer Requirement and Small Signal Stability Assessment
- 2. **Number:** PRC-502-MRO-02
- 3. **Purpose:** a) To ensure that power system stabilizers are **planned**, installed and tuned as required to dampen power system oscillations in the Midwest Reliability Organization (MRO). b) To ensure small signal stability assessments are performed. c) **To verify that the excitation control system model (including power system stabilizer model) and the model parameters used in small signal stability simulations that assess Bulk Electric System (BES) reliability accurately represent generator excitation control system behavior.** d) To ensure oscillations with inadequate damping are analyzed and **corrective plan(s) are developed.**

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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 calendar quarter after applicable regulatory approval, this standard will be effective. In those jurisdictions where no regulatory approval is required, this standard becomes effective on the 1st day of the 1st calendar quarter after NERC Board of Trustees adoption.

B. Requirements

- R1.** Each Generator Owner shall install power system stabilizers on all new¹ or substantially modified² generator units with a nameplate rating 100 MVA or larger that are interconnected to the Bulk Electric System, prior to the generator's in-service date, or as required by a corrective plan(s) per Requirement R5, when all of the following conditions exist: *[Violation Risk Factor: Medium] [Time Horizon: Operations Planning]*

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 net 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.

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- 1.1 Small signal stability assessments performed by the Transmission Planner or Planning Coordinator per Requirement R3 or Requirement R4 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.
 - 1.2 System performance assessments performed by the Transmission Planner or Planning Coordinator for disturbances defined in all categories, other than extreme events, detailed in the currently approved NERC TPL Standards show inadequate damping.
 - 1.3 The generator is equipped with a suitable exciter that is able to enhance the effectiveness of a power system stabilizer (PSS) in providing positive damping to local, inter-plant and inter-area modes.⁴
- R2.** Each Generator Owner shall make provisions to allow for the future addition of a PSS on all new generator units 100 MVA or larger interconnected to the Bulk Electric System, prior to the generator's in-service date when a PSS is not required per Requirement R1 but the generator is equipped with a suitable exciter per Requirement 1.3. The provisions shall include at minimum: *[Violation Risk Factor: Lower] [Time Horizon: Operations Planning]*
- 2.1 The automatic voltage regulator shall be designed such that it is capable of accepting a PSS input signal.
 - 2.2 The appropriate PSS input signal transducers, determined by the Planning Coordinator, shall be installed.
- R3.** Each Planning Coordinator shall perform **and possess the documentation of** 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 **since the last assessment** significant system changes have not occurred that would require a new small signal stability assessment. In the event a study is not conducted **within** five (5) years, system conditions shall be reviewed annually until a new small signal stability assessment is conducted. The Planning Coordinator shall document the rationale for not conducting the small signal assessment **in each annual post-five-year review**. The initial system conditions for small signal stability **assessment** shall include: *[Violation Risk Factor: Lower] [Time Horizon: Long-term Planning]*
- 3.1 The effect of different system loading conditions that are expected to produce more severe system impacts.

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, **R12** and determined by the MRO for inter-area modes as defined in MRO Regional Reliability Standard TPL-503-MRO-02.

⁴ 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.

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3.2 The effect of transmission outages defined by all categories of contingencies, other than extreme events, detailed in the currently approved NERC TPL Standards **that are expected to produce more severe system impacts** prior to the implementation of any post-contingency system adjustments that may be manually implemented by the System Operator.

3.3 The effect of **different** power transfer **levels that are expected** to **produce more severe system impacts**.

R4. Each Transmission Planner and Planning Coordinator shall perform **and possess the documentation of** a small signal assessment **for its portion of the Bulk Electric System** for all new or substantially modified generator units with a nameplate rating 100 MVA or larger interconnected to the Bulk Electric System prior to the generator's in-service date. *[Violation Risk Factor: Lower] [Time Horizon: Operations Planning]*

R5. Each Transmission Planner and Planning Coordinator shall 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, as described in Requirement R3 or Requirement R4, 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]*

R6. Each Transmission Planner and Planning Coordinator shall demonstrate through valid assessment for its portion of the Bulk Electric System that any PSS required in accordance with Requirement R1 or Requirement R5 has been planned to meet the required damping criterion for local, inter-plant and inter-area modes without significantly impacting turbine-generator shaft torsional oscillation damping. **These** assessments **at a minimum** shall: *[Violation Risk Factor: Lower] [Time horizon: Long-term Planning]*

6.1 Be made prior to the in-service date of the generator and as required by changes in system conditions.

6.2 Demonstrate that machine rotor angle oscillations are within damping criteria in accordance with Requirement R12 and TPL-503-MRO-02.

6.3 Include results from small signal stability model data verification tests as prescribed in Requirement R8.

6.4 Include results from small signal stability assessments done in accordance with Requirement R3 that are required in the design of the PSS.

6.5 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.

6.6 Be performed using a model of the Eastern Interconnection. Remote generators outside of the MRO region shall not be grouped together and equivalenced.

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R7. Each Planning Coordinator and Transmission Planner for its portion of the Bulk Electric System shall, within ninety (90) calendar days of completion of any assessment required by Requirement R3, Requirement R4 or Requirement R6 or corrective plan(s) required by Requirement R5, provide to adjacent Planning Coordinator(s), and all Generator Owner(s) identified in the assessment(s) or corrective plan(s) the results of the assessment(s) or corrective plan(s). *[Violation Risk Factor: Lower] [Time Horizon: Operations Assessment]*

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R8. Each Generator Owner shall perform **and possess the documentation of** small signal stability model and performance verification tests⁵ for excitation systems (including automatic voltage regulator controls and power system stabilizers) on all generating units that **require a power system stabilizer in accordance with Requirement R1 or Requirement R5.**

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8.1 Be performed during commissioning of a new generation unit or during commissioning of a substantial modification of a generation unit.

8.2 Include 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.

8.3 Include a frequency-response test to verify the PSS open-loop transfer function, if the PSS is of analog type. If the PSS is of digital type and has been type tested, the manufacturer data and field settings of parameters may be supplied instead of the results from a frequency-response test.

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8.4 Include a step-response test with the generator synchronized to the grid to verify that the gains and time constants of **the excitation system** (including **AVR and PSS**) have been designed and tuned to have **the planned** 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, **exceeding generator unit operating limits** or violating applicable voltage criteria.

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8.5 Include 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.

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R9. Each Generator Owner shall, within ninety (90) calendar days of completion of a small signal stability model and performance verification tests for excitation systems (including **AVR and PSS**) described by Requirement R8 and Requirement R10, provide to its Planning Coordinator and Transmission Planner,

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⁵ MRO Generator Testing Guidelines. Approved by the MRO Board of Directors on March 2007. Prepared by the MRO Generator Testing Review Task Force.

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the small signal stability model and the results of the validation tests. *[Violation Risk Factor: Lower] [Time Horizon: Operations Assessment]*

- R10. Each Generator Owner shall **confirm the accuracy of the small signal stability model and perform performance verification tests for excitation systems (including automatic voltage regulator controls and power system stabilizers) on all generating units with a nameplate rating 100 MVA or larger interconnected to the Bulk Electric System that have an operational power system stabilizer. At minimum, the step-response test** described in part 8.4 shall be repeated or the model shall be compared against a system disturbance once every **ten (10)** years for ongoing model and performance verification.

A system disturbance qualifies for model performance verification if the following minimum conditions are met: *[Violation Risk Factor: Lower] [Time Horizon: Operations Planning]*

- 10.1 The disturbance **caused** 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.
- 10.2 The voltage regulator **was** in automatic voltage control mode and the PSS **was** in service during the disturbance.

- R11. Each Generator Operator shall keep the PSS operational, where a PSS is required on a generating unit(s) in accordance with Requirement R1 or Requirement R4, with the following exceptions: *[Violation Risk Factor: Medium] [Time Horizon: Same Day Operations]*

- 11.1 Maintenance, repair and testing.
- 11.2 PSS does not operate properly due to a failed component.
- 11.3 Generator unit is operating in synchronous condenser mode (i.e. near zero power level).
- 11.4 A hydro unit is passing through a range of output that causes undesirable terminal voltage variations (i.e. rough-zone gate position).

- R12. Each 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) within ninety (90) calendar days of a request. *[Violation Risk Factor: Lower] [Time Horizon: Long Term Planning]*

- R13. 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 **R4** through Requirement **R7**. *[Violation Risk Factor: Lower] [Time Horizon: Long-term Planning]*

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C. Measures

- M1. The Generator Owner shall have documented evidence it has installed power system stabilizers prior to the generator’s in-service date or as required by a corrective plan(s) as specified in Requirement R1.
- M2. The Generator Owner shall have documented 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.
- M3. The Planning Coordinator shall have documented evidence of a valid small signal stability assessment for its portion of the Bulk Electric System as specified in Requirement R3. If a study was not performed within 5 years, the Planning Coordinator shall have documented evidence showing an annual review was performed and a rational for why the small signal study was not necessary.
- M4. The Planning Coordinator and Transmission Planner shall each have documented evidence of a valid small signal stability assessment for its portion of the Bulk Electric System as specified in Requirement R4.
- M5. The Planning Coordinator and Transmission Planner shall each have documented evidence of corrective plan(s) for its portion of the Bulk Electric System as specified in Requirement R5.
- M6. The Planning Coordinator and Transmission Planner shall each have documented evidence of a valid power system stabilizer assessment for its portion of the Bulk Electric System as specified in Requirement R6.
- M7. The Planning Coordinator and Transmission Planner shall each have documented evidence it reported the results of its small signal and PSS assessments and corrective plan(s) for its portion of the Bulk Electric System as specified in Requirement R7.
- M8. The Generator Owner shall have documented evidence it **developed a** small signal model and **performed** performance verification tests **during commissioning** as specified in Requirement R8.
- M9. The Generator Owner shall have documented evidence it provided the small signal stability model and performance verification test results to the MRO and its applicable Planning Coordinator(s) and Transmission Planner(s) as specified in Requirement R9.
- M10. The Generator Owner shall have documented evidence it **verified the accuracy of** small signal model **by performing** verification tests **or by comparing the model response against disturbances** at least once every **ten (10)** years, as specified in Requirement R10.
- M11. The Generator Operator shall have documented evidence that the PSS was kept operational on **the** generator unit(s) as specified in Requirement R11.
- M12. The Planning Coordinator shall have documented evidence describing its rotor angle damping criteria and calculation methodology for local and inter-plant

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modes and have documented evidence it made the methodology available to adjacent Planning Coordinator(s) as specified in Requirement R12.

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M13. The Planning Coordinator and Transmission Planner shall each have documented evidence that they have jointly determined the individual and joint responsibilities for performing the required studies and planning assessments defined in Requirement R4 through Requirement R7 as specified in Requirement R13.

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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 Transmission Planner shall retain assessments from last finding of full compliance until the next assessment is completed.

The Planning Coordinator shall retain assessments from last finding of full compliance until the next assessment is completed.

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The Generator Owner shall retain information from the most current and prior small signal stability model data verification tests.

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The Generator Operator shall retain power system stabilizer operational records for two (2) years.

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

The Compliance Monitor shall retain any audit data for three (3) years.

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1.4. Additional Compliance Information.

The Planning Coordinator, Transmission Planner, Generator Owner and Generator Operator 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).

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2. Violation Severity Levels

R #	Lower VSL	Moderate VSL	High VSL	Severe VSL
R1	Not applicable	Not applicable	Not applicable	The Generator Owner did not install a PSS on a new or substantially modified generator per Requirement R1. OR Generator Owner did not install a PSS as required by a corrective plan(s) per Requirement R1.
R2	Not applicable	Not applicable	Not applicable	Generator Owner did not make provisions for the future addition of a PSS per Requirement R2.
R3	Not applicable	Not applicable	Planning Coordinator small signal assessment failed to include one or more of the assessment requirements given in part 3.1 through part 3.3.	Planning Coordinator failed to perform a small signal stability assessment in accordance with Requirement R3.
R4	Not applicable	Not applicable	Not applicable	Planning Coordinator or Transmission Planner failed to perform a small signal stability assessment in accordance with Requirement R4.
R5	Not applicable	Not applicable	Not applicable	Planning Coordinator or Transmission Planner failed to determine a corrective plan(s) in accordance with Requirement R5.

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R6	Not applicable	Not applicable	Planning Coordinator or Transmission Planner PSS assessment(s) failed to include one or more of the assessment requirements given in part 6.1 through part 6.6.	Planning Coordinator or Transmission Planner failed to perform a PSS assessment in accordance with Requirement R6.
R7	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) identified in the assessment(s) or corrective plan(s) within 90 calendar days. The results were provided between 90 and 120 days.	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) identified in the assessment(s) or corrective plan(s) within 90 calendar days. The results were provided between 120 and 180 days.	Not applicable	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) identified in the assessment(s) or corrective plan(s) per Requirement R7.
R8	Not applicable	Not applicable	Generator Owner failed to perform one or more of the verification tests specified in part 8.1 through part 8.4.	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 Requirement R8.

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R9	Generator Owner failed to provide results of the small signal stability model and performance verification tests to its Planning Coordinator, Transmission Planner within 90 calendar days. The results were provided between 90 and 120 days.	Generator Owner failed to provide results of the small signal stability model and performance verification tests to its Planning Coordinator, Transmission Planner within 90 calendar days. The results were provided between 120 and 180 days.	Not applicable	Generator Owner failed to provide results of the small signal stability model and performance verification tests to its Planning Coordinator, Transmission Planner per Requirement R9.
R10	Not applicable	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 ten (10) years per R10.
R11	Generator Operator failed to provide evidence that the PSS was kept operational.	Not applicable	Not applicable	Generator Operator failed to keep the PSS operational as specified in Requirement R11.
R12	Planning Coordinator failed to provide its rotor angle damping criteria and calculation methodology to adjacent Planning Coordinators within 90 calendar days of a request. Documentation provided between 90 and 120 days.	Planning Coordinator failed to provide its rotor angle damping criteria and calculation methodology to adjacent Planning Coordinators within 90 calendar days of a request. Documentation provided between 120 and 180 days.	Not applicable	Planning Coordinator failed to develop and document a rotor angle damping criteria and calculation methodology per Requirement R12.

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R13	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 Requirement R13.
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