

ISO NEW ENGLAND PLANNING PROCEDURE NO. 11

**PLANNING PROCEDURE TO SUPPORT GEOMAGNETIC DISTURBANCE
ANALYSIS**

EFFECTIVE DATE: 03/03/2022

REFERENCES:

- NERC TPL-007-4 Transmission System Planned Performance for Geomagnetic Disturbance Events
- NERC Application Guide Computing Geomagnetically-Induced Current in the Bulk-Power System, December 2013 (NERC GIC Application Guide)
- NERC Geomagnetic Disturbance Planning Guide, December 2013
- NERC Supplemental Geomagnetic Disturbance Event Description, October 2017
- NERC 2012 Special Reliability Assessment Interim Report: Effects of Geomagnetic Disturbances on the Bulk-Power System, February 2012
- NERC Glossary of Terms
- NPCC Geomagnetically Induced Current (GIC) Modeling Data Collection White Paper, June 2016
- ISO New England Operating Procedure No. 18 - Metering and Telemetry Criteria (OP-18)

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1. Purpose

The purpose of this “ISO New England Planning Procedure No. 11 - Planning Procedure to Support Geomagnetic Disturbance Analysis” (Planning Procedure) is to define the entities that must provide to ISO New England (ISO) the data that is needed to conduct Geomagnetic Disturbance (GMD) analysis pursuant to NERC Reliability Standard TPL-007-4 - Transmission System Planned Performance for Geomagnetic Disturbance Events. This Planning Procedure also defines the roles and responsibilities for maintaining models and performing GMD studies.

Capitalized terms used but not defined in this Planning Procedure have the meanings ascribed to them in the NERC Glossary of Terms.

2. Applicable Entities

2.1 This Planning Procedure applies to:

- 2.1.1 An Applicable Transmission Planner (Applicable TP) subject to TPL-007-4, which is any NERC registered TP with a planning area containing a Facility or Facilities that include power transformer(s) with a high side, wye-grounded winding with terminal voltage greater than 200 kV (Applicable BES Power Transformer(s)).
- 2.1.2 An Applicable Transmission Owner (Applicable TO), which is any NERC registered Transmission Owner (TO) who owns a Facility or Facilities that include Applicable BES Power Transformer(s).
- 2.1.3 An Applicable NERC registered Generator Owner (Applicable GO) who owns a Facility or Facilities that include an Applicable BES Power Transformer(s), and its respective Lead Market Participant (Lead MP). Data for Applicable GOs is provided by their respective Lead MPs.
- 2.1.4 All entities which previously provided data under Section 2.2.
- 2.1.5 ISO New England as the Planning Coordinator for New England.

2.2 This Planning Procedure may also apply to other TOs and Lead MPs for GOs that own a Facility or Facilities not described in Section 2.1 if the ISO deems it necessary to obtain Geomagnetically Induced Current (GIC) modeling data from them. Such data will be obtained as described in Section 3.1 of this Planning Procedure.

3. Roles and Responsibilities

The individual and joint responsibilities for maintaining models and performing GMD studies are as follows:

3.1 Provision of GIC Model Information

Upon receipt of a notification from ISO, Applicable TOs and Lead MPs for Applicable GOs as identified in Section 2.1 shall provide the GIC modeling data described in Appendix 1 for all Facilities connected at greater than 200 kV, or provide certification/updates of previously submitted GIC modeling data, to the ISO, by the date specified in the ISO's notification. Such date will be set to a minimum of 90 calendar days from receipt of the ISO's notification.

GIC modeling information for a Facility or Facilities connected at 200 kV or below associated with an entity as identified in Section 2.1 or Section 2.2 will be provided to the ISO by that entity if: (i) the entity responsible for such Facility or Facilities determines that providing the data is appropriate; or (ii) the ISO issues a written request for the data. The entity receiving the written request shall provide the GIC modeling data to the ISO by the date specified in the ISO's written request. Such date shall be set to a minimum of 90 calendar days from receipt of the ISO's written request.

3.2 Collation of Modeling Data

The ISO will review and collate the necessary GIC information and modeling data into a New England-wide GIC model.

3.3 Acceptable System Steady State Voltage Performance Criteria

The ISO, in conjunction with each TP that owns transmission facilities, shall develop criteria for acceptable System steady state voltage performance for its System during the GMD events described in TPL-007-4.

3.4 Benchmark GMD Vulnerability Assessment Responsibility

The ISO shall be responsible for the benchmark GMD Vulnerability Assessment of the Near-Term Transmission Planning Horizon for the New England Bulk Electric System (BES). This Assessment shall follow the Needs Assessment process outlined in Attachment K to the ISO New England Open Access Transmission Tariff ("Attachment K").

3.5 Provision of Benchmark GMD Event GIC Flow Information to Applicable GOs and TOs

The ISO shall provide benchmark GMD event GIC flow information to the Applicable TOs or Lead MP for Applicable GOs for their respective Applicable BES Power Transformers, in accordance with NERC TPL-007-4 Requirement R5.

3.6 Applicable TO and Applicable GO Benchmark Thermal Impact Assessments

Each Applicable TO and Applicable GO shall complete the benchmark thermal impact assessment for its solely and jointly owned Applicable BES Power Transformers in accordance

with TPL-007-4 Requirement R6. Each Applicable TO and Applicable GO shall determine the need for any actions to address thermal impacts on transformers from GIC flows. Each Applicable TO and Applicable GO shall coordinate these actions with the ISO.

3.7 Benchmark GMD Vulnerability Corrective Action Plans

Applicable TPs shall determine corrective actions necessary to address benchmark GMD vulnerability issues related to their own non-PTF BES facilities, in accordance with NERC TPL-007-4 Requirement R7, and shall coordinate those actions with the ISO. The ISO shall follow the Solutions Study or Competitive Solutions Process, as described in Attachment K, to determine corrective actions necessary to address benchmark GMD vulnerability issues on all PTF BES facilities, in accordance with NERC TPL-007-4 Requirement R7.

3.8 Supplemental GMD Vulnerability Assessment Responsibility

The ISO shall be responsible for the supplemental GMD Vulnerability Assessment of the Near-Term Transmission Planning Horizon for the New England Bulk Electric System (BES). This Assessment shall follow the Needs Assessment process outlined in Attachment K to the ISO New England Open Access Transmission Tariff (“Attachment K”).

3.9 Provision of Supplemental GMD Event GIC Flow Information to Applicable GOs and TOs

The ISO shall provide supplemental GMD event GIC flow information to the Applicable TOs or Lead MP for Applicable GOs for their respective Applicable BES Power Transformers, in accordance with NERC TPL-007-4 Requirement R9.

3.10 Applicable TO and Applicable GO Supplemental Thermal Impact Assessments

Each Applicable TO and Applicable GO shall complete the supplemental thermal impact assessment for its solely and jointly owned Applicable BES Power Transformers in accordance with TPL-007-4 Requirement R10. Each Applicable TO and Applicable GO shall determine the need for any actions to address thermal impacts on transformers from GIC flows. Each Applicable TO and Applicable GO shall coordinate these actions with the ISO.

3.11 Supplemental GMD Vulnerability Corrective Action Plans

Applicable TPs shall determine corrective actions necessary to address supplemental GMD vulnerability issues related to their own non-PTF BES facilities, in accordance with NERC TPL-007-4 Requirement R11, and shall coordinate those actions with the ISO. The ISO shall follow the Solutions Study or Competitive Solutions Process, as described in Attachment K, to determine corrective actions necessary to address supplemental GMD vulnerability issues on all PTF BES facilities, in accordance with NERC TPL-007-4 Requirement R11.

3.12 Process to Obtain GIC Monitor Data

- 3.12.1** Each Applicable TO that is also an Applicable TP and owns at least one Applicable BES Power Transformer located in the ISO Planning Coordinator (PC) area shall: (i) install and own a GIC monitor on one of those transformers; (ii) maintain a process to obtain GIC monitor data from the GIC monitor it owns and has installed on the transformer; and (iii) provide the obtained GIC monitor data to ISO in accordance with the applicable requirements of ISO New England Operating Procedure No. 18 - Metering and Telemetry Criteria (OP-18).
- 3.12.2** Each Applicable TO or GO that owns at least one Applicable BES Power Transformer located in the ISO PC area that, if the transformer is lost, would directly result in greater than 1,000 MW of net source loss, shall: (i) install and own a GIC monitor on each of those transformers; (ii) maintain a process to obtain GIC monitor data from the GIC monitors it owns and has installed on each of those transformers; and (iii) provide the obtained GIC monitor data to ISO in accordance with the applicable requirements of OP-18¹ (effective June 1, 2023).
- 3.12.3** In addition to the GIC monitors and associated data provision obligations required under Sections 3.12.1 and 3.12.2 of this Planning Procedure, any Applicable TO or GO that owns a GIC monitor installed on an Applicable BES Power Transformer located in the ISO PC area may provide GIC monitor data to the ISO at its discretion (unless otherwise required pursuant to this Planning Procedure). Any data that is voluntarily provided shall comply with the applicable requirements of OP-18.
- 3.12.4** The ISO shall maintain a process to obtain GIC monitor data from all GIC monitors installed in the ISO PC area as described in Sections 3.12.1, 3.12.2, and 3.12.3 of this Planning Procedure.

3.13 Process to Obtain Geomagnetic Field Data

The ISO shall maintain a process to obtain geomagnetic field data for the ISO PC area.

¹ Requirement 3.12.2 does not apply to facilities with a commercial operation date before June 1, 2023.

Document History²

Rev. 0 Rec.: RC – 05/23/2017; Rec. PC – 06/29/2017; Eff. 06/29/2017

Rev. 1 Rec.: RC – 04/24/2019; Rec. PC – 05/03/2019; Eff. 05/03/2019

Rev. 2 Rec.: RC – 02/15/2022; Rec. PC – 03/03/2022; Eff. 03/03/2022

² This Document History documents action taken on the equivalent NEPOOL Procedure prior to the RTO Operations Date as well as revisions to the ISO New England Procedure subsequent to the RTO Operations Date.

Appendix 1 – Data Considerations for GMD Analysis

General Modeling Data Instructions

This Appendix provides an overview of the type of modeling data necessary to model and study GMD on the New England Transmission system. Not all applicable entities will be required to provide data from every equipment category outlined in this Appendix. Each TO or Lead MP will be required to provide relevant modeling data for the equipment it is responsible for. As an example, a Lead MP representing a GO that owns only a generator step up transformer with a high side, wye-grounded winding with terminal voltage greater than 200 kV for interconnecting a particular generation plant (but does not own a transmission line or substation) will be required to provide modeling data only for the generator step up transformer.

Additional technical details for the modeling data requirements in this Appendix can be found in:

- NERC’s “*Application Guide Computing Geomagnetically-Induced Current in the Bulk-Power System*,” which is available at:
http://www.nerc.com/comm/PC/Geomagnetic%20Disturbance%20Task%20Force%20GMDTF%202013/GIC%20Application%20Guide%202013_approved.pdf
- NPCC “*Geomagnetically Induced Current (GIC) Modeling Data Collection White Paper*,” which is available at:
<https://www.npcc.org/content/docs/public/library/publications/other/npcc-gic-data-collection-white-paper.pdf>

Modeling data for all relevant equipment owned by the same entity must be submitted in a single standardized Excel file. Appendix 2 includes a link to the standardized Excel file that specifies all of the GIC modeling data parameters needed to perform a GMD assessment.

Below are descriptions of some key parameters required for creating the GMD models. Note that some Lead MPs may not have access to certain data, such as PSS®E bus numbers and ID data points for a particular facility. In those cases, the Lead MP will work directly with the ISO to coordinate the exchange of such modeling data.

Substation and Bus Data

The substation data necessary to complete the analysis includes:

- a. Substation Number (I): if the substation has multiple bus numbers in the PSS®E power flow base case, then the lowest bus number of the highest voltage level in the base case must be used. For example, the Orrington substation comprises multiple voltage levels. For the Orrington substation, the lowest 345 kV bus number used in the PSS®E power flow base cases would be used as the Orrington substation number.
- b. List of Buses: a correlation between buses in the PSS®E power flow base case and their corresponding substation is needed to perform GMD studies. For each

- substation, each applicable entity should provide a list PSS®E power flow bus numbers that comprise the substation. Buses connected via zero impedance lines, two-winding, or three-winding transformers are considered by the GIC analysis to be part of the same substation.
- c. Substation Name (NAME): the name may be up to twelve characters, and the actual substation name, *e.g.* ORRINGTON, should be used.
 - d. Substation Geographic Latitude and Longitude in Degrees (LATITUDE, LONGITUDE): this data is used to calculate the length of branches that connect between substations, and the resulting applied GMD voltage. Such coordinate data must be cross-checked with the corresponding coordinate data in the NX-9 application, and any needed corrections must be submitted to the ISO by the applicable entity (*i.e.* TO or a Lead MP for a GO) using the NX-9 application.
 - e. Substation Grounding DC Resistance in Ohms (RG): this data is needed to calculate the geomagnetically induced current flowing from the various elements connected to a substation into the substation's ground. The grounding resistance of the substation can be obtained by direct measurement.

Information for border buses should be included. Border buses are the artificial buses used in the PSS®E power flow cases to identify the borders of a transmission line owned by different entities. Border buses connected to substation buses through zero impedance branches will assume the coordinates of the substation. Other border buses will be represented by artificial substations to assign them coordinates. Border buses shall have a substation grounding DC resistance value of 99.0 Ω to represent them as ungrounded substations. Use the same naming convention that the border buses currently used in the PSS®E power flow base case.

Information on taps or switching stations shall also be included. A bus with no grounded equipment and that is not connected to a substation via zero impedance line(s) is considered a tap or switching station. Taps or switching stations shall have a substation grounding DC resistance value of 99.0 Ω to represent them as ungrounded substations.

Transformer Data

The complete modeling of transformers requires a series of data that is not found in the data used in power flow studies. The most common place to find this information is the manufacturer's transformer test report. Refer to NERC's *"Application Guide Computing Geomagnetically-Induced Current in the Bulk-Power System"* for additional technical explanation of the DC model of transformers and the individual data points required. Key parameters for transformer GMD models include:

- a. DC Resistance of Winding 1, 2, and 3 (for 3 Winding Transformers) (WRI, WRJ, WRK): these parameters are specified at nominal tap, in Ohms/Phase at 75 °C.

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- b. Grounding DC Resistance of Winding 1, 2, and 3 (for 3 Winding Transformers) in Ohms (GRDWRI, GRDWRJ, GRDWRK).
 - c. Presence of GIC Blocking Device in Neutral of Winding 1, 2 or 3 (GICBDI, GICBDJ, GICBDK): this parameter is used to specify if a GIC blocking device is present in the neutral windings of a transformer.
 - d. Vector Group (VECGRP): this parameter is used to specify the transformer winding grounding connections and phase angles.
 - e. Number of Cores (CORE): this parameter is used to specify the number of cores in a transformer.
 - f. KFACTOR: this factor is used to calculate transformer reactive power loss from GIC flowing through its winding (MVAR/AMP).
 - g. Transformer Model (TMODEL): this identifier is used to define the configuration of a transformer (*e.g.* two-winding/three-winding/auto transformer or a T model in DC network).

Note: Explicit three-winding transformer models must be provided for three winding transformers. The modeling of three-winding transformers as three two-winding transformers is not acceptable. Applicable entities shall verify that the Bus Numbers and IDs for three-winding transformers included with any provided GIC modeling data match the corresponding bus numbers and IDs used in the PSS®E power flow network data.

Fixed Shunt Data

Similar to transformers, fixed shunt reactors provide a path to ground for neutral currents in the case of a GMD event. Key data includes:

- a. PSS®E power flow Bus Number (I): the bus number to be included in the GMD modeling information that matches the number currently shown in the PSS®E power flow network data.
- b. PSS®E power flow Shunt Identifier (ID): the shunt identifier that matches the identifier currently shown in the PSS®E power flow network data.
- c. DC Resistance at 75 °C in Ohms/Phase (R).
- d. Grounding DC Resistance in Ohms at 75 °C (RG).

Note: Applicable entities shall verify that the Bus Number matches the number used in the power flow network data and that the ID matches the ID used in the power flow network data.

Branch Data

The branch resistance is used, together with the branch length, to calculate the magnitude of the geomagnetically induced current. This data can be calculated from the conductor's manufacturer specification sheet. Please refer to NERC's "*Application Guide Computing Geomagnetically-Induced Current in the Bulk-Power System*" for further technical guidance. The key data for the GMD modeling of Branch Data is:

- a. Branch DC Resistance in Ohms/Phase (RBRN): the individual phase dc resistance adjusted to 50 °C, or a technically supported equivalent methodology. PSS®E uses one third of this individual phase DC resistance in the GIC analysis. Specifying RBRN information is not required for zero impedance lines. In case of series capacitors, refer to the NERC Application Guide for further guidance.
- b. Branch GMD Induced Electric Field (INDVP, INDVQ): underground cables enclosed in steel, or other types of ferromagnetic metal casings experience a reduction in GMD induced voltages but remain paths for GICs to flow; in this case, applicable entities shall consider providing data for INDVP and INDVQ. However, underground cables not enclosed in a casing made of ferromagnetic metal will not experience a reduction in induced geoelectric field and should be treated the same as overhead branches.

Note: Applicable entities shall verify that the Bus Number matches the number used in the power flow network data and that the ID matches the ID used in the power flow network data.

Switched Shunt Data

Switched shunt reactors provide a path to ground for neutral currents in the case of a GMD event. Key data includes:

- a. PSS®E power flow Bus Number (I): the bus number to be included in the GMD modeling information that matches the number currently shown in the PSS®E power flow network data.
- b. DC Resistance at 75 °C in Ohms/Phase (R).
- c. Grounding DC Resistance in Ohms at 75 °C (RG).

Note: Applicable entities shall verify that the Bus Number matches the number used in the power flow network data used in the power flow network data.

Two-Terminal DC Data

DC network data must be specified for rectifier and inverter converter stations that are connected to AC network through converter transformers. Key data includes:

- a. DC Line Name (NAME): the name of the DC line that matches the name currently shown in the PSS®E power flow network data.

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- b. PSS®E power flow Bus Number (I): the bus number of the rectifier or inverter converter AC bus to be included in the GMD modeling information that matches the number currently shown in the PSS®E power flow network data.
 - c. Ground Path Identifier (ID): this is a GIC specific ID (not used in used in PSS®E power flow network data) to specify more than one ground path at a rectifier or inverter ac bus.
 - d. DC Resistance at 75 °C in Ohms/Phase (R) of the grounded winding of converter transformer.
 - e. Grounding DC Resistance in Ohms at 75 °C (RG).

Note: Applicable entities shall verify that the Bus Number matches the number used in the power flow network data used in the power flow network data.

Other Modeling Data

Other categories of parameters required for creating GMD models include VSC DC Data, Multi-Terminal DC Data, FACTS Device Data, and Load Data. Modeling data for these categories should be provided as applicable.

Note: Applicable entities shall verify that the Bus Number matches the number used in the power flow network data and that, if required, the ID matches the ID used in the power flow network data.

GIC Monitor Data

Obtaining GIC monitor data is useful for model validation and situational awareness.

New GIC monitor installations should be on Applicable BES Power Transformers located in areas found to have high GIC flows based on system studies. Where possible, sites in the vicinity of transportation systems using direct current (e.g., subways or light rail) should be avoided when installing GIC monitors due to the possibility of interference from these systems.

Additional information on considerations for providing GIC monitor data can be found in:

- Supporting material of NERC’s “*TPL-007-4- Transmission System Planned Performance for Geomagnetic Disturbance Events*,” which is available at:
<https://www.nerc.com/ layouts/15/PrintStandard.aspx?standardnumber=TPL-007-4&title=Transmission%20System%20Planned%20Performance%20for%20Geomagnetic%20Disturbance%20Events&Jurisdiction=United%20States>
- Chapter 9 of NERC’s “*2012 Special Reliability Assessment Interim Report: Effects of Geomagnetic Disturbances on the Bulk-Power System*,” which is available at:
<https://www.nerc.com/pa/RAPA/ra/Reliability%20Assessments%20DL/2012GMD.pdf>

Appendix 2 – GIC Modeling Data Parameters Spreadsheet

The standardized Excel file that specifies all of the GIC modeling data parameters needed to perform a GMD assessment is available at <https://www.iso-ne.com/participate/rules-procedures/planning-procedures>