

## **Standard Development Timeline**

This section is maintained by the drafting team during the development of the standard and will be removed when the standard is adopted by the NERC Board of Trustees (Board).

### **Description of Current Draft**

This is the first draft of the proposed standard for a formal 45-day comment period.

<b><u>Completed Actions</u></b>	<b><u>Date</u></b>
<u>Standards Committee approved Standard Authorization Request (SAR) for posting</u>	<u>January 20, 2021</u>
<u>SAR posted for comment</u>	<u>March 4 – April 2, 2021</u>

<b><u>Anticipated Actions</u></b>	<b><u>Date</u></b>
<u>45-day formal or informal comment period with ballot</u>	<u>September – November 2022</u>
<u>45-day formal or informal comment period with additional ballot</u>	<u>February – April 2023</u>
<u>10-day final ballot</u>	<u>May 2023</u>
<u>Board adoption</u>	<u>August 2023</u>

### **New or Modified Term(s) Used in NERC Reliability Standards**

This section includes all new or modified terms used in the proposed standard that will be included in the *Glossary of Terms Used in NERC Reliability Standards* upon applicable regulatory approval. Terms used in the proposed standard that are already defined and are not being modified can be found in the *Glossary of Terms Used in NERC Reliability Standards*. The new or revised terms listed below will be presented for approval with the proposed standard. Upon Board adoption, this section will be removed.

**Term(s):**

None.

## **A. Introduction**

1. **Title:** Coordination of Generating Unit or Plant Capabilities, Voltage Regulating Controls, and Protection

2. **Number:** ~~PRC-019-2~~PRC-019-3

3. **Purpose:** To verify coordination of generating unit or Facility ~~or synchronous condenser~~ voltage regulating controls, limit functions, equipment capabilities ~~and Protection System settings, and protective functions.~~

4. **Applicability:**

### **4.1. Functional Entities**

4.1.1 Generator Owner

4.1.2 Transmission Owner ~~that owns synchronous condenser(s)~~

**4.2. Facilities:** For the purpose of this standard, the term, “applicable Facility” or “Facility” shall mean any one of the following:

~~4.2.1 Individual generating unit greater than 20 MVA (gross nameplate rating) directly connected to the Bulk Electric System resource identified through Inclusion I2 of the BES definition.~~

4.2.2 Generating plant/Facility identified through Inclusion I2 of the BES definition.

~~4.2.2 Individual synchronous condenser greater than 20 MVA (gross nameplate rating) directly connected to the Bulk Electric System.~~

~~4.2.3 Generating plant/ Facility consisting of one or more units that are connected to the Bulk Electric System at a common bus with total generation greater than 75 MVA (gross aggregate nameplate rating).~~

4.2.3 ~~4.2.3.1~~ This includes individual generating units of the dispersed power producing Dynamic reactive resources identified through Inclusion I4 of the Bulk Electric System definition where voltage regulating control for the facility is performed solely at the individual generating unit of the dispersed power producing resources. ~~I5 of the BES definition with a gross (individual or aggregate) nameplate rating greater than 20 MVA including:~~

~~4.2.3.1 Synchronous condenser.~~

4.2.4 Inverter-based resource (IBR) generating plant/Facility identified through Inclusion I4 of the BES definition, including:

4.2.4.1 Individual IBR units;

4.2.4.2 Collector bus(es) and collector feeder(s);

4.2.4.3 Static or dynamic reactive compensating devices;

4.2.4.4 Main power transformer (MPT);<sup>1</sup>

4.2.4.5 Generator step-up (GSU) transformer(s);<sup>2</sup>

4.2.5 Any Blackstart Resource.

~~4.2.4 Any generator, regardless of size, that is a blackstart unit material to and designated as part of a Transmission Operator's restoration plan.~~

**5. Effective Date:** See the Implementation Plan for ~~PRC-019-2~~PRC-019-3.

## **B. Requirements and Measures**

**R1.** At a maximum of every ~~five~~six calendar years, each Generator Owner and Transmission Owner with applicable Facilities shall coordinate<sup>3</sup> the voltage regulating system controls, ~~(including in-service<sup>1</sup> limiters and protection functions)~~ with the applicable equipment capabilities and settings of the applicable ~~Protection System devices and functions~~protective functions.<sup>4</sup> Equipment capabilities, control functions, and protective functions for the applicable Facilities include, but are not limited to those listed in Attachment 1. [Violation Risk Factor: Medium] [Time Horizon: Long-term Planning]

**1.1.** ~~Assuming~~For synchronous generators or synchronous condensers, assuming the normal automatic voltage regulator control loop and steady-state system operating conditions, verify the following coordination items ~~for each applicable Facility:~~

**1.1.1.** The in-service ~~limiters~~limiter functions<sup>5</sup> are set to operate before the ~~Protection System protective functions~~ of the applicable Facility in order to avoid disconnecting the generator unnecessarily.

**1.1.2.** The applicable in-service ~~Protection System devices~~protective functions are set to operate to isolate or de-energize equipment in order to limit the extent of damage when operating conditions exceed equipment capabilities ~~or stability limits.~~

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<sup>1</sup> For the purpose of this standard, the MPT is the power transformer that steps up voltage from the collection system voltage to the nominal transmission/interconnecting system voltage for dispersed power producing resources.

<sup>2</sup> For the purpose of this standard, the GSU is the power transformer that steps up voltage from the individual IBR unit to the nominal collection system voltage for dispersed power producing resources.

<sup>3</sup> As-left settings shall be utilized in a protection and control coordination study.

<sup>4</sup> ~~Limiters or protection functions that are installed and activated on the generator or synchronous condenser.~~

<sup>4</sup> A protective function includes an action performed by a Protection System device or an action performed by a control system that replicates the behavior of a Protection System device in order to mitigate the consequences of an event that exceeds equipment design basis.

<sup>5</sup> Limiter functions that are installed and activated on the generator or synchronous condenser.

1.2. For IBR generating Facilities, assuming the voltage control mode is enabled in the power plant controller and/or IBR unit(s)<sup>6</sup> and steady-state system operating conditions, verify the following coordination items:

1.2.1. The in-service control functions of the power plant controller are set to operate before the protective functions of the applicable Facilities in order to avoid disconnecting any of the Facilities listed under Section 4.2.4 unnecessarily.

1.2.2. The in-service control functions of IBR unit(s) are set to operate before protective functions of the applicable Facilities in order to avoid disconnecting any of Facilities listed under Section 4.2.4 unnecessarily.

1.2.3. The applicable in-service protective functions are set to operate to isolate or de-energize equipment in order to limit the extent of damage when operating conditions exceed equipment capabilities.

M1. Each Generator Owner and Transmission Owner with applicable Facilities will have evidence such as a graphical representation(s) of coordination including a P-Q Diagram, R-X Diagram, Inverse Time Diagram, equivalent tables, steady-state calculations, dynamic simulation studies, or other evidence that it performed a coordination study as specified in Requirement R1. This evidence should include dated documentation that demonstrates the coordination was performed.

R2. ~~Within 90 calendar days following the identification of~~ Each Generator Owner and Transmission Owner shall perform the coordination described in Requirement R1 ~~prior to~~ implementation of systems, equipment ~~or setting~~, or settings changes that will affect the coordination described in Requirement R1, ~~each Generator Owner and Transmission Owner with applicable Facilities shall perform the coordination as described in Requirement R1;~~ and update associated coordination documentation within 90 calendar days after the return to in-service date. These possible systems, equipment or settings changes include, but are not limited to, the following:  
*[Violation Risk Factor: Medium] [Time Horizon: Long-term Planning]:*

- Voltage regulating settings or equipment changes;
- ~~Protection System~~ Protective function settings or component changes;
- ~~Generating IBR unit, synchronous generator~~ or synchronous condenser equipment capability changes; ~~or~~
- ~~Generator IBR unit, synchronous generator~~ or synchronous condenser step-up transformer changes;
- IBR unit control system firmware or settings changes; or

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<sup>6</sup> IBR unit includes the inverter, converter, or wind turbine generator.

- Power plant controller firmware or settings changes.

### **C. Measures**

~~M1. Each Generator Owner and Transmission Owner with applicable Facilities will have evidence (such as examples provided in PRC-019 Section G) that it coordinated the voltage regulating system controls, including in-service<sup>2</sup> limiters and protection functions, with the applicable equipment capabilities and settings of the applicable Protection System devices and functions as specified in Requirement R1. This evidence should include dated documentation that demonstrates the coordination was performed.~~

M2. Each Generator Owner and Transmission Owner with applicable Facilities will have evidence of the coordination study required by the events listed in Requirement R2. This evidence should include dated documentation that demonstrates ~~the specified intervals in~~ Requirement R2 ~~have~~ has been met.

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<sup>2</sup> ~~Limiters or protection functions that are installed and activated on the generator or synchronous condenser.~~

## **C. D. Compliance**

### **1. Compliance Monitoring Process**

**1.1. Compliance Enforcement Authority:** “Compliance Enforcement Authority” means 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.

~~The Regional Entity shall serve as the Compliance enforcement authority unless the applicable entity is owned, operated, or controlled by the Regional Entity. In such cases the ERO or a Regional entity approved by FERC or other applicable governmental authority shall serve as the CEA.~~

#### ~~1.2. Evidence Retention~~

**1.2. Evidence Retention:** The following evidence retention ~~periods~~ period(s) identify a 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 ~~compliance~~ 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.

The applicable entity shall keep data or evidence to show compliance as identified below unless directed by its Compliance Enforcement Authority to retain specific evidence for a longer period of time as part of an investigation.

- The Generator Owner and Transmission owner shall keep data or evidence of Requirement R1 of the most recent coordination study.
- The Generator Owner and Transmission Owner shall ~~retain evidence of compliance with Requirements R1 and R2, Measures M1 and M2 for six years.~~ keep data or evidence of Requirement R2 of the most recent coordination study.

**1.3. Compliance Monitoring and Enforcement Program:** As defined in the NERC Rules of Procedure, “Compliance Monitoring and Enforcement Program” refers to the identification of the processes that will be used to evaluate data or information for the purpose of assessing performance or outcomes with the associated Reliability Standard.

**Standard ~~PRC-019-2~~ PRC-019-3 — Coordination of Generating Unit or Plant Capabilities, Voltage Regulating Controls, and Protection**

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~~If a Generator Owner or Transmission Owner is found non-compliant, the entity shall keep information related to the non-compliance until mitigation is complete and approved or for the time period specified above, whichever is longer.~~

~~The Compliance Enforcement Authority shall keep the last periodic audit report and all requested and submitted subsequent audit records.~~

**~~1.3. Compliance Monitoring and Assessment Processes~~**

~~Compliance Audit~~

~~Self-Certification~~

~~Spot-Checking~~

~~Compliance Investigation~~

~~Self-Reporting~~

~~Complaint~~

**~~1.4. Additional Compliance Information~~**

~~None~~

## **2. Violation Severity Levels**



**Standard PRC-019-2-PRC-019-3 — Coordination of Generating Unit or Plant Capabilities, Voltage Regulating Controls, and Protection**

R #	<b>Violation Severity Levels</b>			
	Lower VSL	Moderate VSL	High VSL	Severe VSL
<b>R1.</b>	The Generator Owner or Transmission Owner coordinated equipment capabilities, <del>limiters</del> <u>control functions</u> , and protection specified in Requirement R1 <del>more than 5 calendar years but less than or equal to 5 calendar years plus 4</del> <u>between 6 years (72 months) and 76</u> months after the previous coordination.	The Generator Owner or Transmission Owner coordinated equipment capabilities, <del>limiters</del> <u>control functions</u> , and protection specified in Requirement R1 <del>more than 5 calendar years plus 4 months but less than or equal to 5 calendar years plus 8</del> <u>between 77 and 81</u> months after the previous coordination.	The Generator Owner or Transmission Owner coordinated equipment capabilities, <del>limiters</del> <u>control functions</u> , and protection specified in Requirement R1 <del>more than 5 calendar years plus 8 months but less than or equal to 5 calendar years plus 12</del> <u>between 82 and 86</u> months after the previous coordination.	The Generator Owner or Transmission Owner <del>failed to coordinate</del> <u>coordinated</u> equipment capabilities, <del>limiters</del> <u>control functions</u> , and protection specified in Requirement R1 <del>within 5 calendar years plus 12</del> <u>more than 86</u> months after the previous coordination.  <u>OR</u> <u>The Generator Owner or Transmission Owner failed to coordinate equipment capabilities, limiters, and protection as specified in Requirement R1.</u>
<b>R2R2.</b>	The Generator Owner or Transmission Owner <del>coordinated equipment capabilities, limiters, and protection specified in Requirement R1</del> <u>more than 90 calendar days but less than or equal to 100 calendar days following the identification or implementation of a change in equipment or settings that affected the coordination.</u> <u>updated</u>	The Generator Owner or Transmission Owner <del>coordinated equipment capabilities, limiters, and protection specified in Requirement R1</del> <u>more than 100 calendar days but less than or equal to 110 calendar days following the identification or implementation of a change in equipment or settings that affected the coordination.</u>	The Generator Owner or Transmission Owner <del>coordinated equipment capabilities, limiters, and protection specified in Requirement R1</del> <u>more than 110 calendar days but less than or equal to 120 calendar days following the identification or implementation of a change in equipment or settings that affected the coordination.</u> <u>updated</u>	<u>The Generator Owner or Transmission Owner failed to update associated coordination documentation as specified in Requirement R2 within 151 calendar days after return to in-service date.</u>  <u>OR</u>

**Standard ~~PRC-019-2~~ PRC-019-3 — Coordination of Generating Unit or Plant Capabilities, Voltage Regulating Controls, and Protection**

R #	<b><u>Violation Severity Levels</u></b>			
	Lower VSL	Moderate VSL	High VSL	Severe VSL
	<u>associated coordination documentation as specified in Requirement R2 between 91 and 120 calendar days after return to in-service date.</u>	<u>updated associated coordination documentation as specified in Requirement R2 between 121 and 150 calendar days after return to in-service date.</u>	<u>associated coordination documentation as specified in Requirement R2 between 151 and 180 calendar days after return to in-service date.</u>	The Generator Owner or Transmission Owner failed to coordinate equipment capabilities, limiters, and protection specified in Requirement R1 <del>within 120 calendar days following the identification or implementation of</del> <u>prior to the implementing</u> a change in equipment or settings that affected the coordination.

**D. ~~E.~~ Regional Variances**

None.

**E. ~~F.~~ Associated Documents**

“Underexcited Operation of Turbo Generators”, AIEE Proceedings T Section 881, Volume 67, 1948, Appendix 1, C. G. Adams and J. B. McClure.

”Protective Relaying For Power Generation Systems”, Boca Raton, FL, Taylor & Francis, 2006, Reimert, Donald

“Coordination of Generator Protection with Generator Excitation Control and Generator Capability”, a report of Working Group J5 of the IEEE PSRC Rotating Machinery Subcommittee

“IEEE C37.102-2006 IEEE Guide for AC Generator Protection”

**Standard ~~PRC-019-2~~ PRC-019-3 — Coordination of Generating Unit or Plant Capabilities, Voltage Regulating Controls, and Protection**

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“IEEE C50.13-2005 IEEE Standard for Cylindrical-Rotor 50 Hz and 60 Hz Synchronous Generators Rated 10 MVA and Above”

“IEEE C37.106 IEEE Guide for Abnormal Frequency Protection for Power Generating Plants”

## Version History

Version	Date	Action	Change Tracking
1	February 7, 2013	Adopted by NERC Board of Trustees	New
1	March 20, 2014	FERC Order issued approving PRC-019-1. (Order becomes effective on 7/1/16.)	
2	February 12, 2015	Adopted by NERC Board of Trustees	Standard revised in Project 2014-01: Applicability revised to clarify application of requirements to BES dispersed power producing resources
2	May 29, 2015	FERC Letter Order in Docket No. RD15-3-000 approving PRC-019-2	Modifications to adjust the applicability to owners of dispersed generation resources.
<u>3</u>	<u>TBD</u>	<u>Adopted by NERC Board of Trustees</u>	<u>Standard revised in Project 2021-01</u>

## **G. Reference**

### **Examples of Coordination**

The evidence of coordination associated with Requirement R1 may be in the form of:

- P-Q Diagram (Example in Attachment 1), or
- R-X Diagram (Example in **Attachment 2**), or **1: Equipment Capabilities, Types of Limiters, and Protective Functions**

**NOTE:** This standard does not require the installation or activation of any of the limiter or protection functions for synchronous generation or IBR.

- ~~Inverse Time Diagram (Example in Attachment 3) or,~~
- ~~Equivalent tables or other evidence~~

A. This evidence should include the Synchronous generation equipment capabilities and the operating region for the limiters and protection functions, control functions, and protective functions, which shall be coordinated if enabled, include but are not limited to:

- Synchronous generator/condenser reactive capabilities;

~~Equipment limits, types of limiters and protection functions which could be coordinated include (but are not limited to):~~

- ~~Field over-excitation limiter and associated protection functions.~~protective function;
- ~~Inverter over current limit and associated protection functions.~~
- ~~Field under-excitation limiter and associated protection functions.~~protective function;
- ~~Generator or synchronous condenser reactive capabilities.~~
  - ~~Volts per hertz limiter and associated protection functions.~~protective function;
  - ~~Stator over-voltage protection system settings.~~;
  - ~~Generator Synchronous generator/condenser~~ and transformer volts per hertz capability.;
  - ~~Time vs. field current or time vs. stator current.~~; and
  - Distributed control system (DCS) voltage/VAR limit settings.

B. IBR generating Facility equipment capabilities, control functions, and protective functions, which shall be coordinated if enabled, include but are not limited to:

- Transformer overvoltage protective function;
- Transformer undervoltage protective function;
- Transformer volts per hertz capability and protective function;
- Collector bus overvoltage protective function;

- Collector bus undervoltage protective function;
- Reactive compensating devices voltage control functions;
- Reactive compensating devices voltage protective function;
- Collector feeder phase overvoltage protective function;
- Collector feeder phase undervoltage protective function;
- Collector feeder overcurrent limiter;
- IBR unit phase lock loop protective function;
- IBR unit overcurrent limiter;
- IBR unit momentary cessation (cease current injection) protective function;
- IBR unit phase overvoltage protective function;
- IBR unit phase undervoltage protective function; and
- IBR unit phase overcurrent protective function.

~~NOTE: This listing is for reference only. This standard does not require the installation or activation of any of the above limiter or protection functions.~~

~~For this example, the Steady State Stability Limit (SSSL) is the limit to synchronous stability in the under-excited region with fixed field current.~~

~~On a P-Q diagram using  $X_d$  as the direct axis saturated synchronous reactance of the generator,  $X_s$  as the equivalent reactance between the generator terminals and the “infinite bus” including the reactance of the generator step-up transformer and  $V_g$  as the generator terminal voltage (all values in per-unit), the SSSL can be calculated as an arc with the center on the Q axis with the magnitude of the center and radius described by the following equations~~

$$C = V_g^2 / 2 * (1/X_s - 1/X_d)$$

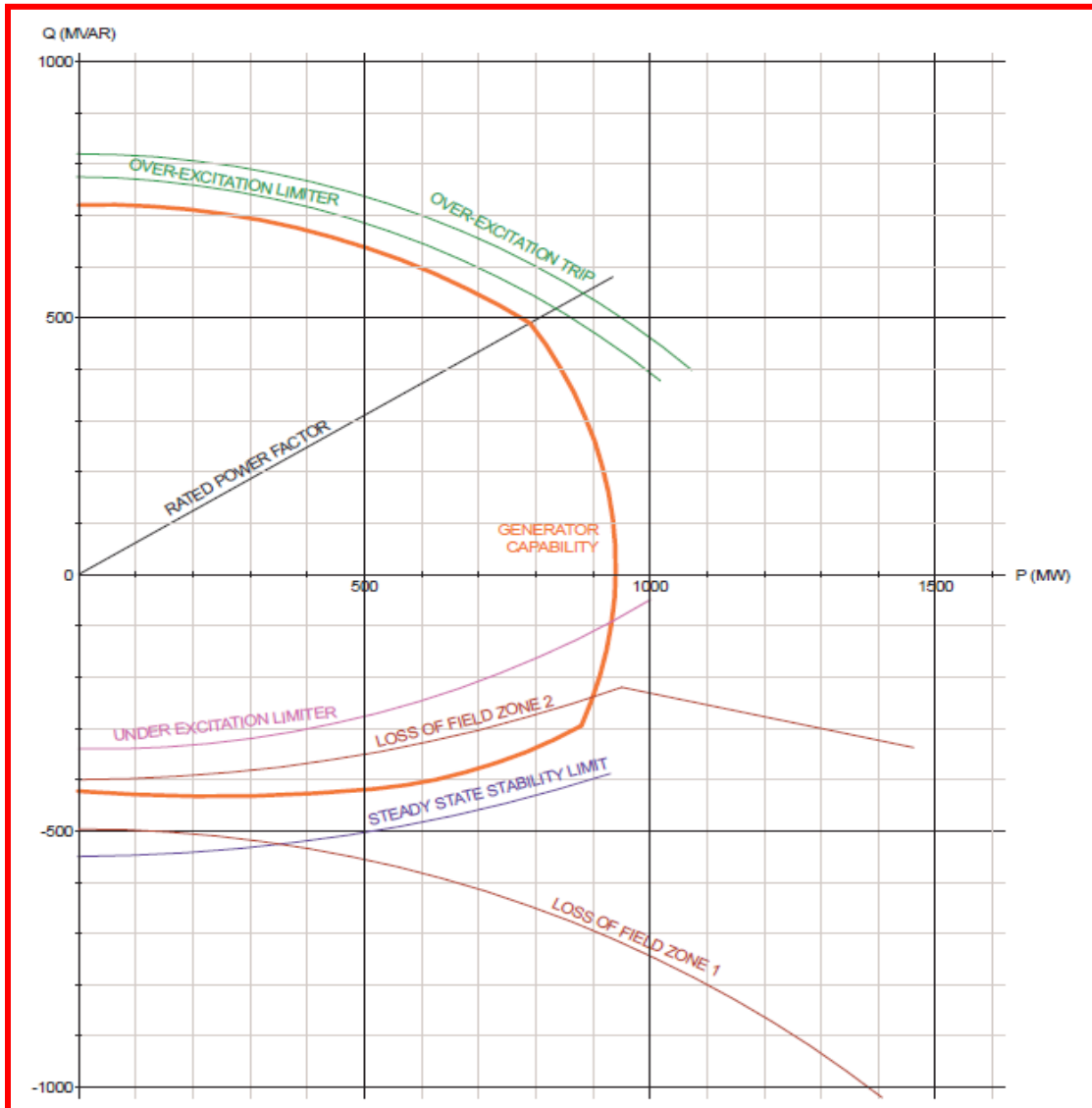
$$R = V_g^2 / 2 * (1/X_s + 1/X_d)$$

~~On an R-X diagram using  $X_d$  as the direct axis saturated synchronous reactance of the generator, and  $X_s$  as the equivalent reactance between the generator terminals and the “infinite bus” including the reactance of the generator step-up transformer the SSSL is an arc with the center on the X axis with the center and radius described by the following equations:~~

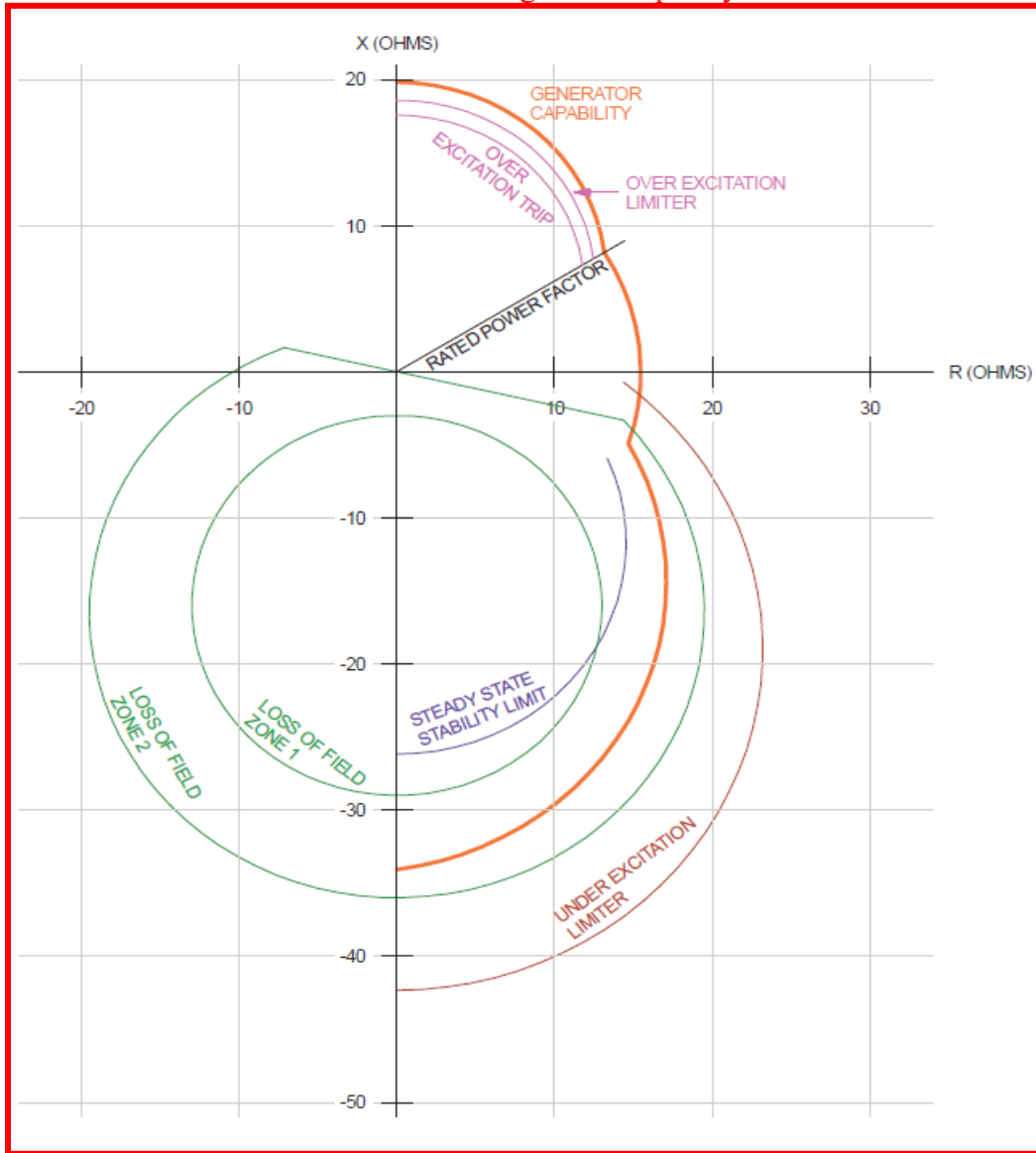
$$C = (X_d - X_s) / 2$$

$$R = (X_d + X_s) / 2$$

**Section G Attachment 1** — Example of Capabilities, Limiters and Protection on a P-Q Diagram at nominal voltage and frequency

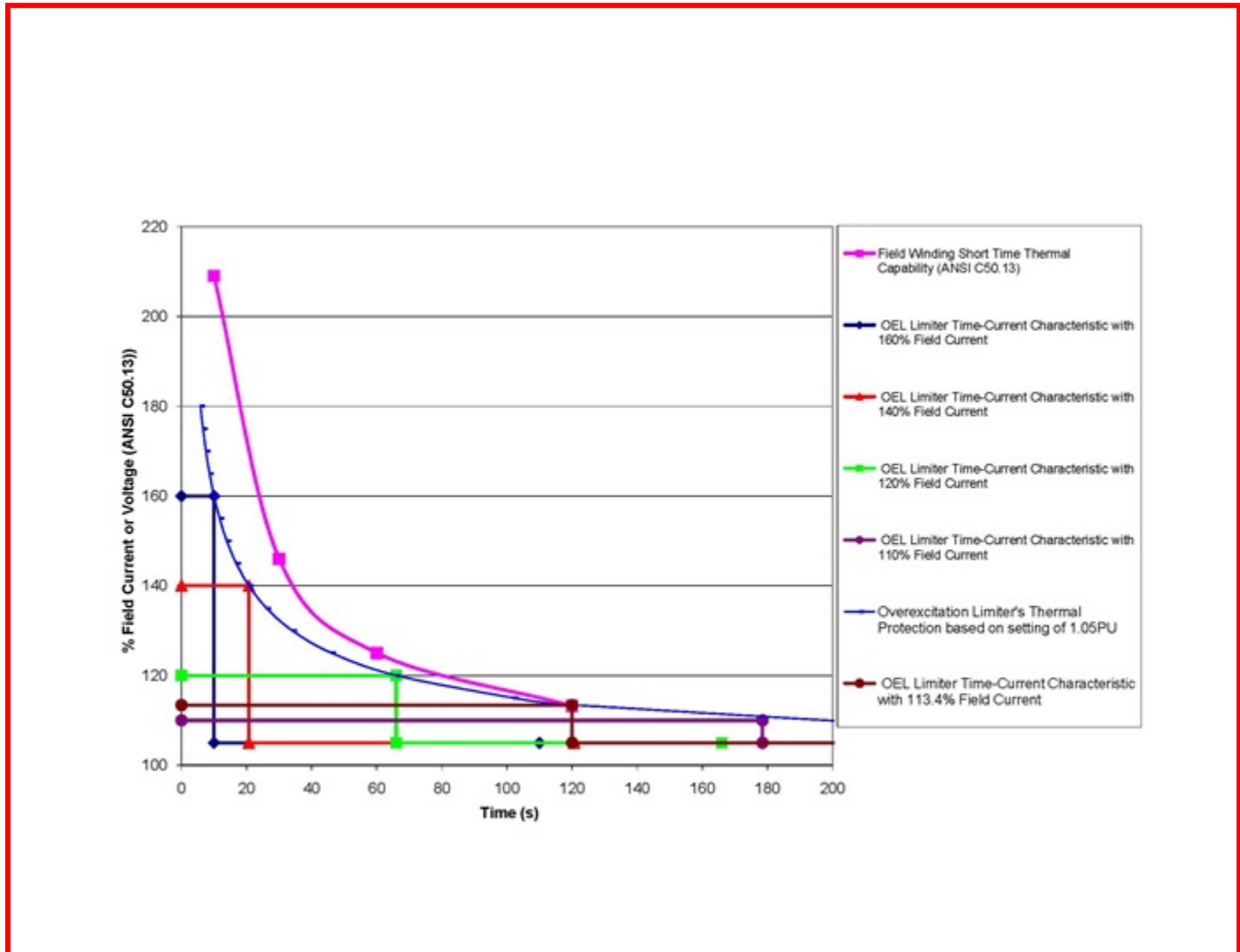


**Section G Attachment 2 — Example of Capabilities, Limiters, and Protection on an R-X Diagram at nominal voltage and frequency**



**Section G Attachment 3 — Example of Capabilities, Limiters, and Protection on an Inverse Time Characteristic Plot**





**Rationale:**

~~During development of this standard, text boxes were embedded within the standard to explain the rationale for various parts of the standard. Upon BOT approval, the text from the rationale text boxes was moved to this section.~~

**~~Rationale for Facilities section 4.2.3.1~~**

~~For those dispersed power producing facilities that only perform voltage regulating control at the individual generating unit level, the SDT believes that coordination should take place at the individual generating unit level of the dispersed power producing resource. These facilities need to consider the Protection Systems at the individual units and their compatibility with the reactive and voltage limitations of the units. Where voltage regulating control is done at an aggregate level, applicability is already included under Facilities section 4.2.3.~~