

## 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

PRC-024-3 is posted for a 45-day formal comment period with initial ballot.

Completed Actions	Date
Standards Committee approved Standard Authorization Request (SAR) for posting	December 2018
SAR posted for comment	December 19, 2018– January 19, 2019
Standards Committee accepted the revised SAR	February 20, 2019

Anticipated Actions	Date
45-day formal comment period with ballot	April – June 2019
45-day formal or informal comment period with additional ballot	July – August 2019
10-day final ballot	October 2019
Board adoption	November 2019

## A. Introduction

1. **Title:** Generator Frequency and Voltage Protection Settings
2. **Number:** PRC-024-3
3. **Purpose:** To set generator protection, such that generating resource(s) remain connected, continuing to support the BES during defined frequency and voltage excursions.
4. **Applicability:**
  - 4.1. **Functional Entities:**
    - 4.1.1. Generator Owners that apply protection listed in Section 4.2.1.
    - 4.1.2. Transmission Owners that own a BES generator step-up (GSU) transformer or collector transformer and apply protection listed in Section 4.2.1.
  - 4.2. **Facilities:**
    - 4.2.1 Frequency, voltage or volts per hertz protection, including frequency or voltage protective functions within control systems that provide tripping or momentary cessation signals to all or part of the generating resource, applied to the following:
      - 4.2.1.1 Bulk Electric System (BES) generating resource(s).
      - 4.2.1.2 BES GSU transformer(s).
      - 4.2.1.3 High side of the generator-connected unit auxiliary transformer installed on BES generating resource(s).
      - 4.2.1.4 Individual dispersed power producing resources identified in the BES Definition, Inclusion I4.
      - 4.2.1.5 Elements utilized in aggregation of the dispersed power producing resources.
      - 4.2.1.6 Collector transformer of resources identified in the BES Definition, Inclusion I4.
5. **Effective Date:** See Implementation Plan for PRC-024-3

## B. Requirements and Measures

- R1.** Each Generator Owner or Transmission Owner shall set its applicable frequency protection such that the generating resource does not trip or enter momentary cessation within the “no trip zone” of PRC-024 Attachment 1, subject to the following exception: *[Violation Risk Factor: Medium] [Time Horizon: Long-term Planning]*
- Generating resource(s) may be set to trip or enter momentary cessation within the “no trip zone” of PRC-024 Attachment 1 for documented and communicated regulatory or equipment limitations in accordance with Requirement R3.
- M1.** Each Generator Owner or Transmission Owner shall have evidence that the applicable frequency protection has been set in accordance with Requirement R1, such as dated setting sheets, calibration sheets, calculations, or other documentation.
- R2.** Each Generator Owner or Transmission Owner shall set its applicable voltage protection such that the generating resource does not trip or enter momentary cessation within the “no trip zone” of PRC-024 Attachment 2 during a voltage excursion at the high side of the GSU or collector transformer, subject to the following exceptions: *[Violation Risk Factor: Medium] [Time Horizon: Long-term Planning]*
- If the Transmission Planner allows less stringent voltage protection settings than those required to meet PRC-024 Attachment 2, then the Generator Owner or Transmission Owner may set its protection within the voltage recovery characteristics of a location-specific Transmission Planner’s study.
  - Generating resource(s) may trip or enter momentary cessation within a portion of the “no trip zone” of PRC-024 Attachment 2 for documented and communicated regulatory or equipment limitations in accordance with Requirement R3.
- M2.** Each Generator Owner or Transmission Owner shall have evidence that applicable voltage protection has been set in accordance with Requirement R2, such as dated setting sheets, voltage-time boundaries, calibration sheets, coordination plots, dynamic simulation studies, calculations, or other documentation.
- R3.** Each Generator Owner or Transmission Owner shall document each known regulatory or equipment limitation<sup>1</sup> that prevents an applicable generating resource(s) with generator frequency or voltage protection from meeting the protection setting criteria in Requirements R1 or R2, including (but not limited to) study results, experience from an actual event, or manufacturer’s advice. *[Violation Risk Factor: Lower] [Time Horizon: Long-term Planning]*
- 3.1.** The Generator Owner or Transmission Owner shall communicate the documented regulatory or equipment limitation, or the removal of a previously

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<sup>1</sup> Excludes limitations that are caused by the setting capability of the generator frequency and voltage protection itself but does not exclude limitations originating in the equipment that it protects.

documented regulatory or equipment limitation, to its Planning Coordinator and Transmission Planner within 30 calendar days of any of the following:

- Identification of a regulatory or equipment limitation.
- Repair of the equipment causing the limitation that removes the limitation.
- Replacement of the equipment causing the limitation with equipment that removes the limitation.
- Creation or adjustment of an equipment limitation caused by consumption of the cumulative turbine life-time frequency excursion allowance.

**M3.** Each Generator Owner or Transmission Owner shall have evidence that it has documented and communicated any known regulatory or equipment limitations that resulted in an exception to Requirements R1 or R2 in accordance with Requirement R3, such as a dated email or letter that contains such documentation as study results, experience from an actual event, or manufacturer's advice.

**R4.** Each Generator Owner or Transmission Owner shall provide its applicable generator protection settings associated with Requirements R1 and R2 to the Planning Coordinator or Transmission Planner that models the associated generating resource(s) within 60 calendar days of receipt of a written request for the data and within 60 calendar days of any change to those previously requested settings unless directed by the requesting Planning Coordinator or Transmission Planner that the reporting of protection setting changes is not required. *[Violation Risk Factor: Lower]*  
*[Time Horizon: Operations Planning]*

**M4.** Each Generator Owner or Transmission Owner shall have evidence that it communicated applicable generator protection settings in accordance with Requirement R4, such as dated e-mails, correspondence or other evidence and copies of any requests it has received for that information.

## C. 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.

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

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 or Transmission Owner shall keep data or evidence of Requirements R1 through R4 for 3 years or until the next audit, whichever is longer.
- If a Generator Owner or Transmission Owner is found non-compliant, the Generator Owner or Transmission Owner shall keep information related to the non-compliance until mitigation is complete and approved for the time period specified above, whichever is longer.

**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.

## Violation Severity Levels

R #	Violation Severity Levels			
	Lower VSL	Moderate VSL	High VSL	Severe VSL
R1.	N/A	N/A	N/A	The Generator Owner or Transmission Owner failed to set its applicable frequency protection so that it does not trip or enter momentary cessation according to Requirement R1.
R2.	N/A	N/A	N/A	The Generator Owner or Transmission Owner failed to set its applicable voltage protection so that it does not trip or enter momentary cessation according to Requirement R2.
R3.	The Generator Owner or Transmission Owner documented the known non-protection system equipment limitation that prevented it from meeting the criteria in Requirement R1 or R2 and communicated the documented limitation to its Planning Coordinator and Transmission Planner more than 30 calendar days	The Generator Owner or Transmission Owner documented the known non-protection system equipment limitation that prevented it from meeting the criteria in Requirement R1 or R2 and communicated the documented limitation to its Planning Coordinator and Transmission Planner more than 60 calendar days	The Generator Owner or Transmission Owner documented the known non-protection system equipment limitation that prevented it from meeting the criteria in Requirement R1 or R2 and communicated the documented limitation to its Planning Coordinator and Transmission Planner more than 90 calendar days	The Generator Owner or Transmission Owner failed to document any known non-protection system equipment limitation that prevented it from meeting the criteria in Requirement R1 or R2.  OR The Generator Owner or Transmission Owner failed to communicate the

R #	Violation Severity Levels			
	Lower VSL	Moderate VSL	High VSL	Severe VSL
	but less than or equal to 60 calendar days of identifying the limitation.	but less than or equal to 90 calendar days of identifying the limitation.	but less than or equal to 120 calendar days of identifying the limitation.	documented limitation to its Planning Coordinator and Transmission Planner within 120 calendar days of identifying the limitation.
<b>R4.</b>	<p>The Generator Owner or Transmission Owner provided its generator protection settings more than 60 calendar days but less than or equal to 90 calendar days of any change to those settings.</p> <p>OR</p> <p>The Generator Owner or Transmission Owner provided generator protection settings more than 60 calendar days but less than or equal to 90 calendar days of a written request.</p>	<p>The Generator Owner or Transmission Owner provided its generator protection settings more than 90 calendar days but less than or equal to 120 calendar days of any change to those settings.</p> <p>OR</p> <p>The Generator Owner or Transmission Owner provided generator protection settings more than 90 calendar days but less than or equal to 120 calendar days of a written request.</p>	<p>The Generator Owner or Transmission Owner provided its generator protection settings more than 120 calendar days but less than or equal to 150 calendar days of any change to those settings.</p> <p>OR</p> <p>The Generator Owner or Transmission Owner provided generator protection settings more than 120 calendar days but less than or equal to 150 calendar days of a written request.</p>	<p>The Generator Owner or Transmission Owner failed to provide its generator protection settings within 150 calendar days of any change to those settings.</p> <p>OR</p> <p>The Generator Owner or Transmission Owner failed to provide generator protection settings within 150 calendar days of a written request.</p>

## D. Regional Variances

### D.A. Variance for the Quebec Interconnection

This Interconnection-wide Variance shall be applicable in the Quebec Interconnection and replaces, in its entirety, continent-wide Requirement R2 with the following:

**D.A.2.** Each Generator Owner or Transmission Owner shall set its applicable voltage protection such that the generating resource does not trip or enter momentary cessation within the “no trip zone” of PRC-024 Attachment 2a during a voltage excursion at the high side of the GSU or collector transformer, subject to the following exceptions: *[Violation Risk Factor: Medium] [Time Horizon: Long-term Planning]*

- If the Transmission Planner allows less stringent voltage protection settings than those required to meet PRC-024 Attachment 2a, then the Generator Owner or Transmission Owner may set its protection within the voltage recovery characteristics of a location-specific Transmission Planner’s study.
- Generating resource(s) may trip or enter momentary cessation within a portion of the “no trip zone” of PRC-024 Attachment 2a for documented and communicated regulatory or equipment limitations in accordance with Requirement R3.
- Inverter-based resources voltage protection settings may be set to enter momentary cessation within the “no trip zone” of PRC-024 Attachment 2a during a voltage excursion at the high side of the MPT under the following conditions:
  - After a minimum delay of 0.022 s, when the positive-sequence voltage exceeds 1.25 per unit (p.u.) Normal operation must resume once the voltage drops back below 1.25 p.u.
  - After a minimum delay of 0.022 s, when the phase-to-ground root mean square (RMS) voltages exceeds 1.4 p.u., as measured at generator terminals, on one or multiple phases. Normal operation must resume once the voltage drops back below the 1.25 p.u.

**M.D.A.2.** Each Generator Owner or Transmission Owner shall have evidence that applicable voltage protection has been set in accordance with Requirement R2, such as dated setting sheets, voltage-time boundaries, calibration sheets, coordination plots, dynamic simulation studies, calculations, or other documentation.

## E. Associated Documents

Implementation Plan

[Industry Recommendation I – Loss of Solar Resources during Transmission Disturbances Due to Inverter Settings](#)

[Industry Recommendation II – Loss of Solar Resources during Transmission Disturbances due to Inverter Settings](#)

[Blue Cut Fire Disturbance](#)

[Canyon 2 Fire Disturbance](#)

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

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

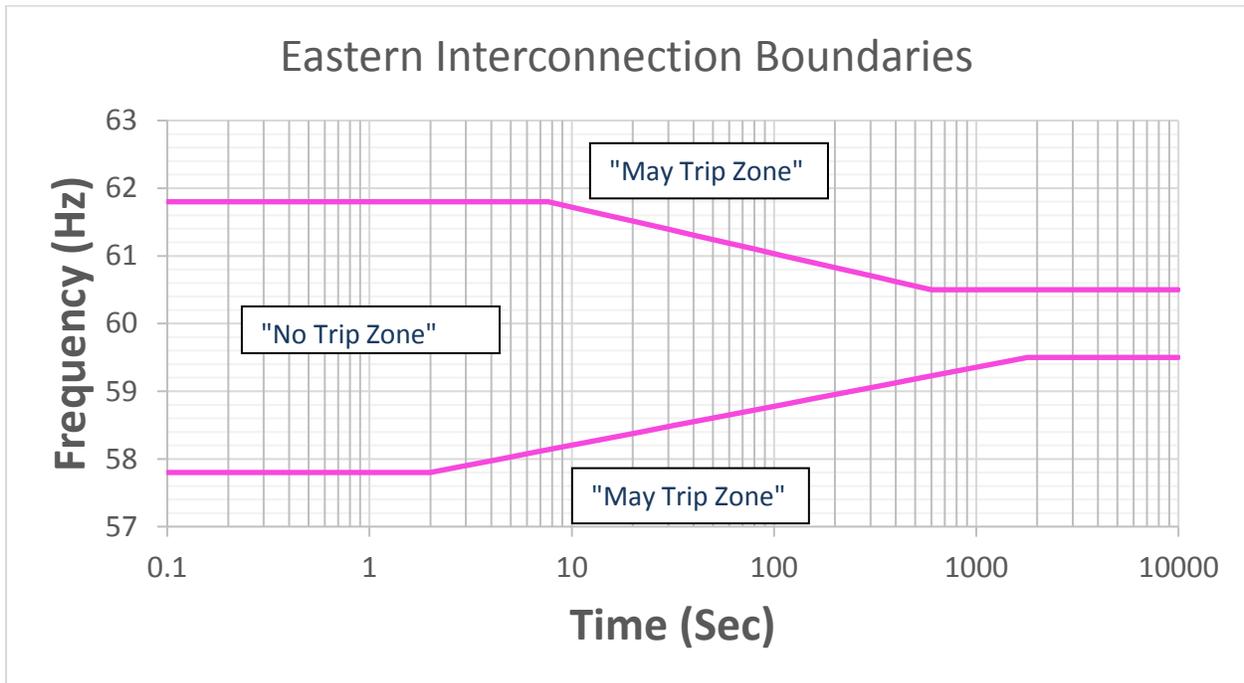
“IEEE C50.13 IEEE Standard for Cylindrical-Rotor 50 Hz and 60 Hz Synchronous Generators Rated 10 MVA and Above”

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

## Version History

Version	Date	Action	Change Tracking
1	May 9, 2013	Adopted by the NERC Board of Trustees	
1	March 20, 2014	FERC Order issued approving PRC-024-1. (Order becomes effective on 7/1/16.)	
2	February 12, 2015	Adopted by the 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-024-2	Modifications to adjust the applicability to owners of dispersed generation resources.

## Attachment 1 (Frequency No Trip Boundary by Interconnection)



**Figure 1**

### Frequency Boundary Data Points – Eastern Interconnection

High Frequency Duration		Low Frequency Duration	
Frequency (Hz)	Minimum Time (Sec)	Frequency (Hz)	Minimum Time (sec)
≥61.8	0.10	≤57.8	0.10
≥60.5	$10^{(90.935-1.45713*f)}$	≤59.5	$10^{(1.7373*f-100.116)}$
<60.5	Continuous operation	> 59.5	Continuous operation

**Table 1**

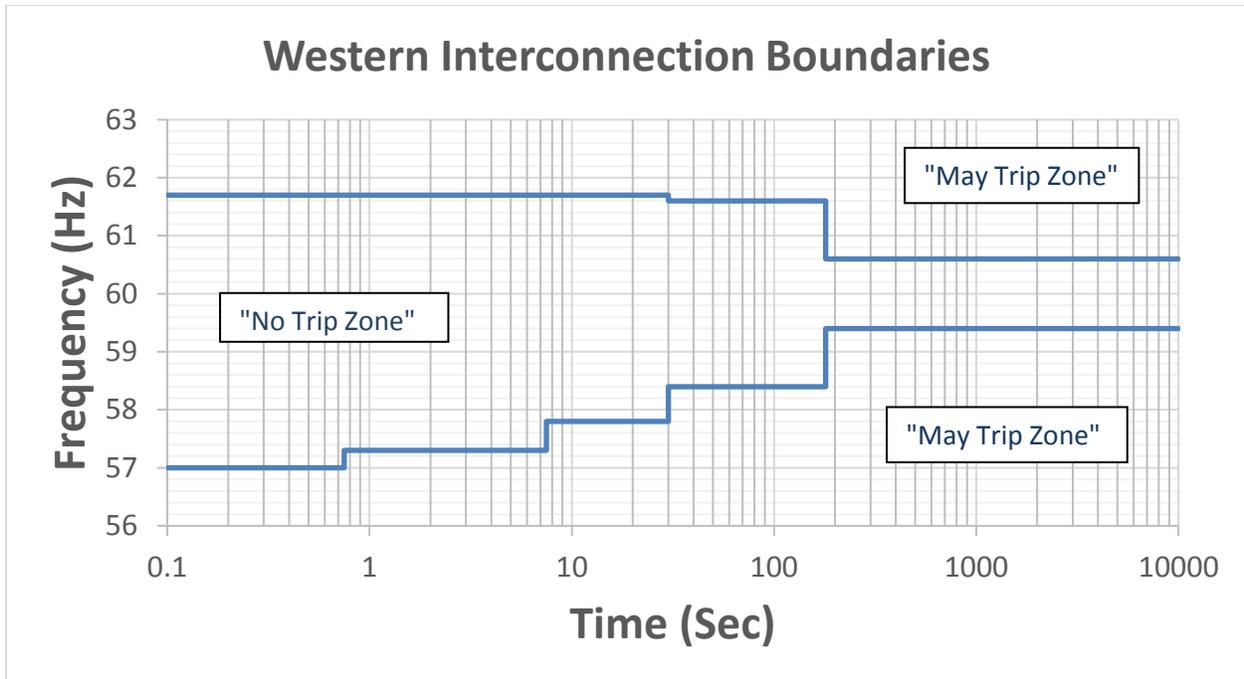


Figure 2

Frequency Boundary Data Points – Western Interconnection

High Frequency Duration		Low Frequency Duration	
Frequency (Hz)	Minimum Time (Sec)	Frequency (Hz)	Minimum Time (sec)
≥61.7	0.10	≤57.0	0.10
≥61.6	30	≤57.3	0.75
≥60.6	180	≤57.8	7.5
<60.6	Continuous operation	≤58.4	30
		≤59.4	180
		>59.4	Continuous operation

Table 3

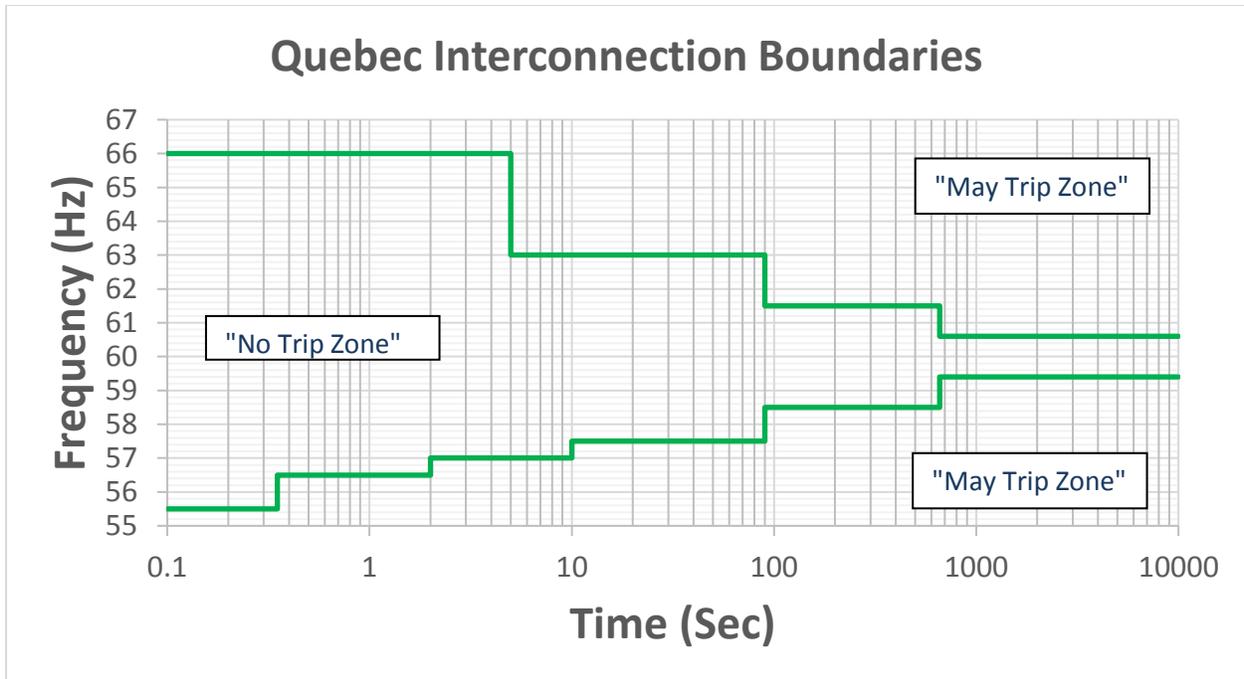


Figure 4

Frequency Boundary Data Points – Quebec Interconnection

High Frequency Duration		Low Frequency Duration	
Frequency (Hz)	Minimum Time (Sec)	Frequency (Hz)	Minimum Time (Sec)
>66.0	0.10	<55.5	0.10
≥63.0	5	≤56.5	0.35
≥61.5	90	≤57.0	2
≥60.6	660	≤57.5	10
<60.6	Continuous operation	≤58.5	90
		≤59.4	660
		>59.4	Continuous operation

Table 2

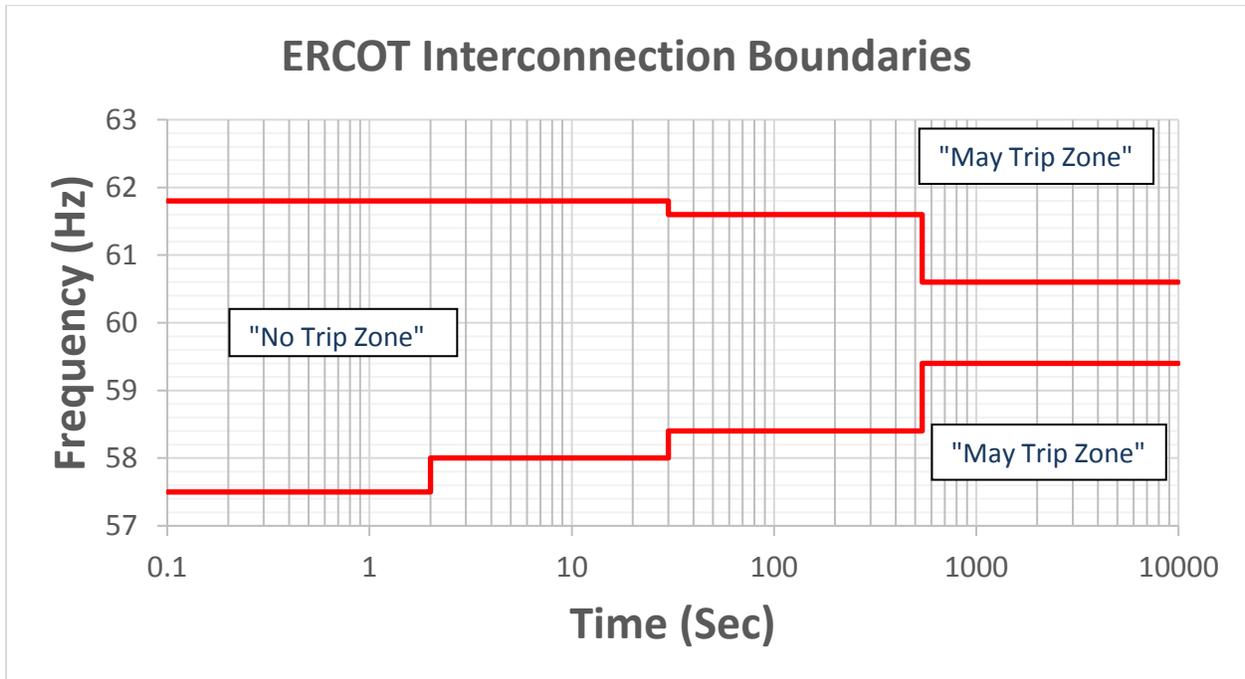


Figure 5

**Frequency Boundary Data Points – ERCOT Interconnection**

High Frequency Duration		Low Frequency Duration	
Frequency (Hz)	Minimum Time (Sec)	Frequency (Hz)	Minimum Time (sec)
≥61.8	0.10	≤57.5	0.10
≥61.6	30	≤58.0	2
≥60.6	540	≤58.4	30
<60.6	Continuous operation	≤59.4	540
		>59.4	Continuous operation

Table 3

## PRC-024— Attachment 2 (Voltage No-Trip Boundary – Eastern, Western, and ERCOT Interconnections)

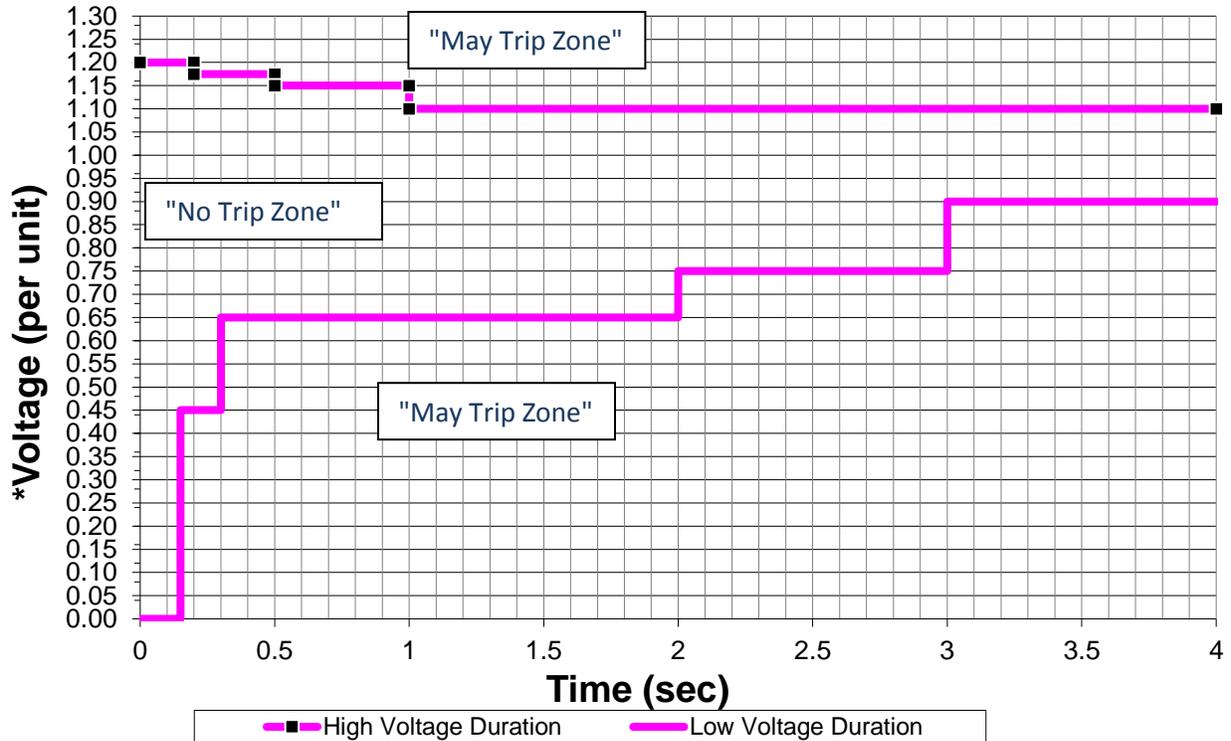


Figure 1

### Voltage Boundary Data Points

High Voltage Duration		Low Voltage Duration	
Voltage (pu)	Minimum Time (sec)	Voltage (pu)	Minimum Time (sec)
≥1.200	0.00	<0.45	0.15
≥1.175	0.20	<0.65	0.30
≥1.15	0.50	<0.75	2.00
≥1.10	1.00	<0.90	3.00
<1.10	4.00	≥ 0.90	4.00

Table 1

\* Voltage at the high-side of the GSU or collector transformer.

## **Voltage Boundary Clarifications – Eastern, Western, and ERCOT Interconnections**

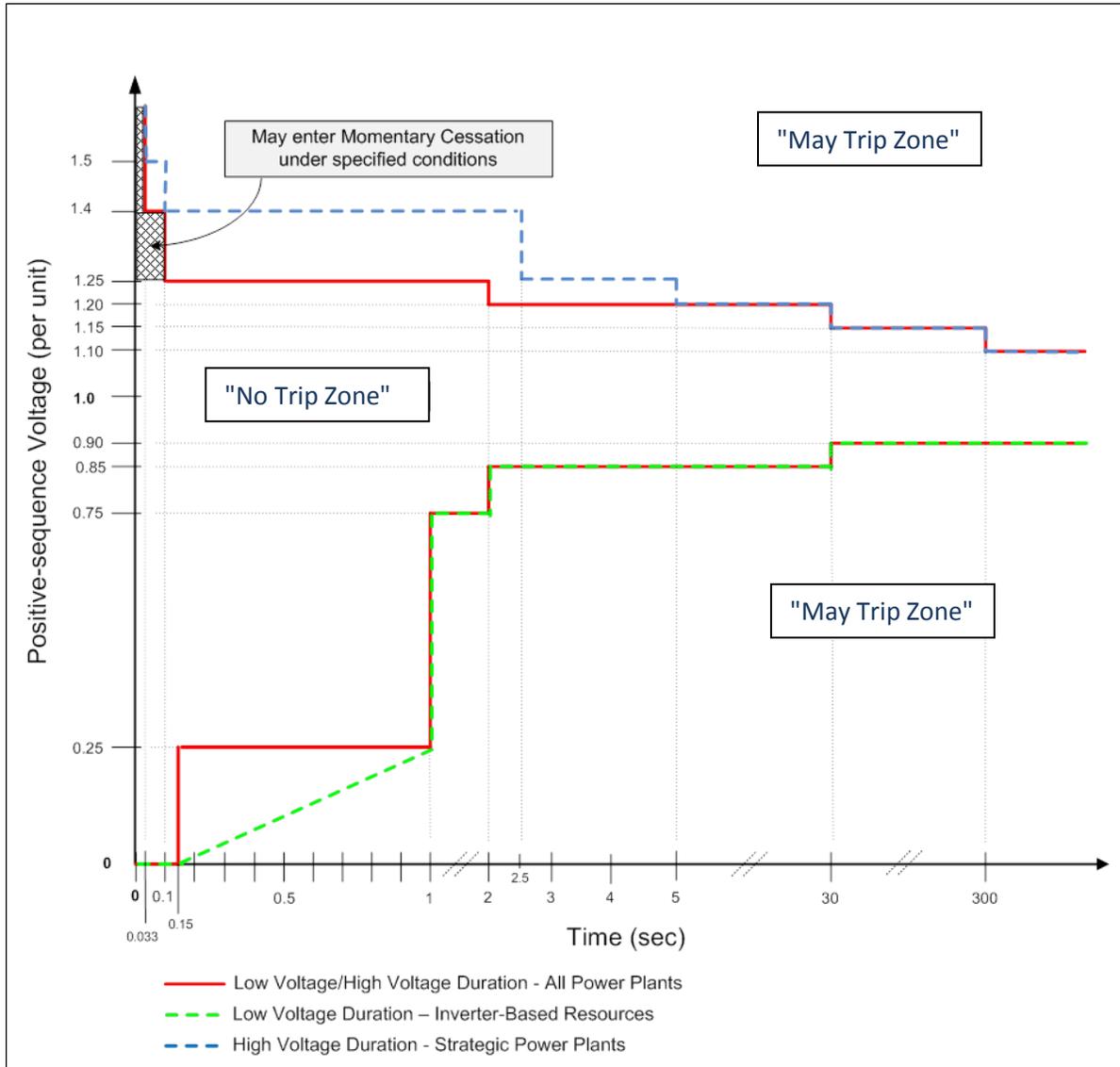
### **Boundary Details:**

1. The per unit voltage base for these boundaries is the nominal operating voltage (e.g., 115 kV, 138 kV, 230 kV, 345 kV, 500 kV, etc.).
2. The boundaries apply to voltage excursions regardless of the type of initiating event.
3. The values in the table represent the minimum time durations allowed for specified voltage excursion thresholds.
4. The boundaries assume a system frequency of 60 Hertz. When evaluating volts per hertz protection, magnitude of the high voltage boundary can be adjusted in proportion to deviations of frequency below 60 Hertz.
5. Voltages in the boundaries assume RMS fundamental frequency phase-to-ground or phase-to-phase voltage.
6. The “no trip zone” ends at 4 seconds.

### **Evaluating Protection Settings:**

1. Use either the following assumptions or loading conditions that are believed to be the most probable for the unit under study to evaluate voltage protection setting calculations on the static case for steady state initial conditions:
  - a. All of the units connected to the same transformer are online and operating.
  - b. All of the units are at full nameplate real-power output.
  - c. Power factor is 0.95 lagging (i.e. supplying reactive power to the system) as measured at the generator terminals.
  - d. The automatic voltage regulator is in automatic voltage control mode.
2. Evaluate voltage protection settings assuming that additional installed generating plant reactive support equipment (such as static VAR compensators, synchronous condensers, or capacitors) is available and operating normally.
3. Evaluate voltage protection settings accounting for the actual tap settings of transformers between the generator terminals and the high side of the GSU or collector transformer.

## PRC-024— Attachment 2a (Voltage No Trip Boundaries – Quebec Interconnection)



**Figure 1**

**Voltage Boundary Data Points – Quebec Interconnection**

High Voltage Duration for all Power Plants		High Voltage Duration for strategic <sup>1</sup> Power Plants	
Voltage (pu)	Minimum Time (sec)	Voltage (pu)	Minimum Time (sec)
---	---	>1.50	0.033
>1.40	0.033	>1.40	0.10
>1.25	0.10	>1.25	2.50
>1.20	2.00	>1.20	5.00
>1.15	30	>1.15	30
>1.10	300	>1.10	300
≤1.10	continuous	≤1.10	continuous

**Table 1**

**Voltage Boundary Data Points – Quebec Interconnection**

Low Voltage Duration for all Power Plants		Low Voltage Duration for Inverter-Based Resources	
Voltage (pu)	Minimum Time (sec)	Voltage (pu)	Minimum Time (sec)
<0.25	0.15	<0.25	$3.4 * V(\text{pu}) + 0.15$
<0.75	1.00	<0.75	1.00
<0.85	2.00	<0.85	2.00
<0.90	30	<0.90	30
≥0.90	continuous	≥0.90	continuous

**Table 2**

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<sup>1</sup> Power Plants designated by the Transmission Planner for protecting the integrity of Transmission System equipment.

## Voltage Boundary Clarifications – Quebec Interconnection

### Boundary Details:

1. The per unit voltage base for these boundaries is the nominal operating voltage (e.g., 115 kV, 138 kV, 230 kV, 345 kV, 500 kV, etc.).
2. The boundaries apply to voltage excursions regardless of the type of initiating event.
3. The values in the table represent the minimum time durations allowed for specified voltage excursion thresholds.
4. The boundaries assume a system frequency of 60 Hertz. When evaluating volts per hertz protection, magnitude of the high voltage boundary can be adjusted in proportion to deviations of frequency below 60 Hertz.
5. Voltages in the boundaries assume positive-sequence values.

### Evaluating Protection Settings:

1. Use either the following assumptions or loading conditions that are believed to be the most probable for the unit under study to evaluate voltage protection setting calculations on the static case for steady state initial conditions:
  - a. All of the units connected to the same transformer are online and operating.
  - b. All of the units are at full nameplate real-power output.
  - c. Power factor is 0.95 lagging (i.e. supplying reactive power to the system) as measured at the generator terminals.
  - d. The automatic voltage regulator is in automatic voltage control mode.
2. Evaluate voltage protection settings assuming that additional installed generating plant reactive support equipment (such as static VAR compensators, synchronous condensers, or capacitors) is available and operating normally.
3. Evaluate voltage protection settings accounting for the actual tap settings of transformers between the generator terminals and the high side of the GSU or collector transformer.