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Project 2020-02

Modifications to PRC-024 (Generator Ride-through)
PRC-024-4 and PRC-029-1
June 14, 2024

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Applicability Section Update

- BES used in interim
  - June 27th, changes to Rules of Procedure approved
  - Additional facilities to be added in next draft
  - Consistent with new Registration criteria for Category 2 GO/GOPs
- IBR Definition
  - Previously Approved but could not be used
  - Will be added in next draft
  - Consistent with updated IBR plant level term – See Project 2020-06

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Order 901 Milestone 2 Update

- Comment Period and Ballot - Close **July 8th**

- IBR Definition to post July 12th – August 12th
- Next Draft will go out July 22nd – August 12th

- IBR Definition will be included – expected to pass

- Implementation Plans to be aligned for IBR Registration Rollout Strategy

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Project 2020-02 Drafting Team- SAR and Standards

Drafting Team Roster

	Name	Entity
Chair	Xiaoyu (Shawn) Wang	Enel North America
Vice Chair	Husam Al-Hadidi	Manitoba Hydro
Members	Ebrahim Rahimi	California ISO
	John B. Anderson	Xcel Energy
	Johnny C. Carlisle	Southern Company Services, Inc.
	Robert J. O'Keefe	American Electric Power
	Rajat Majumder	Invenergy
	Alex Pollock	RES
	Ebrahim Rahimi	California ISO
	Fabio Rodriguez	Duke Energy
	Kenneth Silver	8minute Solar Energy
	Ovidiu Vasilachi	Independent Electricity System Operator (IESO)
	John Zong	Electric Power Engineers
NERC Staff	Jamie Calderon	North American Electric Reliability Corporation

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Project 2020-02 SAR1

- **Title**: Revision of relevant Reliability Standards to include applicability of transmission-connected dynamic reactive resources
- **Date Submitted**: Feb 24, 2020 (Revised on February 3, 2022)

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Project 2020-02 SAR2

- **Title**: **Generator Ride-Through Standard (PRC-024-03 Replacement)**
- **Date Submitted**: April 28, 2022 (revised March 31, 2023)
- **Industry Need:**
- Based on the ERO Enterprise analyzing over 10 disturbances reports highlighting key findings and recommendations
  - A widespread loss of generating resources – solar PV, wind, synchronous generation, and battery energy storage systems (BESS)
  - Multiple IBR experience abnormally tripping, ceasing current injection, or reducing power output with control interactions.
  - The unexpected loss of widespread generating assets poses a significant risk to BPS reliability.
- The existing PRC-024-3 is an equipment settings standard focused solely on voltage and frequency protection and is inadequate to address the IBR performance issues
- The proposed standards project will address this known reliability risk with a more suitable performance-based standard that ensures generating resource ride-through performance for expected or planned BPS disturbances

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Project 2020-02 SDT Approach

- Modify PRC-024-3 to retain the Reliability Standard as a protection-based standard with applicability to only synchronous generators and synchronous condensers.
- Create a new Reliability Standard (PRC-029-1) to address inverter-based resource (IBR) disturbance ride-through performance criteria.
- Coincide with ride-through requirements of IEEE standards but structure to follow language from FERC Order No. 901, which states that “NERC has the discretion to consider during its standards development process whether and how to reference IEEE standards in the new or modified Reliability Standards.”

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Project 2020-02 after 1st Comment Period

- The comment period and initial ballot for the first draft: 3/27/2024 – 4/27/2024
- The first draft failed the initial ballot and received ~200 pages of comments from different stakeholders
- The drafting team went through a series of meetings to address all the comments in May and early June, including an in-person meeting and dedicated meetings with specific stakeholders, e.g. EPRI
- PRC-029 has been extensively updated by revising or adding clarifications to the previous requirement languages, as per the comments from the stakeholders
- PRC-024 has been updated as per the comments from the stakeholders
- See details in the next couple of slides

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Project 2020-02 Draft Language PRC-024-4

PRC-024-4 —Frequency and Voltage Protection Settings for Synchronous Generators, Type 1 and Type 2 Wind Resources, and Synchronous Condensers

A. Introduction

1. **Title:** **Frequency and Voltage Protection Settings for Synchronous Generators, Type 1 and Type 2 Wind Resources, and Synchronous Condensers**

2. **Number:** **PRC-024-4**

3. **Purpose:** To assure that protection of synchronous generators, type 1 and type 2 wind resources, and synchronous condensers do not cause tripping during defined frequency and voltage excursions in support of the Bulk Power System (BPS).

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Project 2020-02 Draft Language PRC-024-4

4.2. Facilities[2]:

4.2.1 Frequency, voltage, and volts per hertz protection (whether provided by relaying or functions within associated control systems) that respond to electrical signals and: (i) directly trip the generating resource(s); or (ii) provide signals to the generating resource(s) to trip; and are applied to the following:

4.2.1.1 Bulk Electric System (BES) synchronous generators.

4.2.1.2 BES GSU transformer(s) for synchronous generators.

4.2.1.3 High-side of the synchronous generator-connected unit auxiliary transformer[3] (UAT) installed on BES generating resource(s).

4.2.1.4 Individual dispersed power producing type 1 or type 2 wind resource(s) identified in the BES Definition, Inclusion I4.

~~**4.2.1.4**~~**4.2.1.5** Elements that are designed primarily for the delivery of capacity from multiple synchronous generators connecting to a common bus or individual dispersed power producing type 1 or type 2 wind resources identified in the BES Definition, Inclusion I4, to the point where those resources aggregate to greater than 75 MVA.

~~**4.2.1.5**~~**4.2.1.6** MPT of multiple synchronous generators connecting to a common bus or MPT of individual dispersed power producing type 1 or type 2 wind resources as identified in the BES Definition, Inclusion I4.

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Project 2020-02 Draft Language PRC-024-4

R1. Each Generator Owner and Transmission Owner shall set applicable frequency protection[4] in accordance with PRC-024-4 Attachment 1 such that the applicable protection does not cause the ~~synchronous generator(s) or condenser(s)~~Facility to which it is applied to trip within the "no trip zone" during a frequency excursion with the following exceptions: *[Violation Risk Factor: Medium] [Time Horizon: Long-term Planning]*

- Applicable frequency protection may be set to trip within a portion of the "no trip zone" for documented and communicated regulatory or equipment limitations in accordance with Requirement R3.

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Project 2020-02 Draft Language PRC-029-1

4. Applicability:

4.1 Functional Entities:

4.1.1. Generator Owner

4.1.2. Transmission Owner[1]

4.2 Facilities: ~~**For purposes of this standard, the term "applicable Inverter-Based Resource" or "applicable Inverter-Based Resources" refers to the following:**~~

4.2.1. BE~~P~~S inverter-based resources[2] ~~IBRs~~

4.2.2. IBR Registration Criteria

~~**5.**~~ **Effective Date:** See Implementation Plan for Project 2020-02 – PRC-029-1

Standard-Only Definition: None

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[1] For owners of Voltage Source Converter – High-voltage Direct Current (VSC-HVDC) transmission facilities that are dedicated connections for IBR to the BPS

[2] For the purpose of this standard, "inverter-based resources" refers to a collection of individual solar photovoltaic (PV), Type 3 and Type 4 wind turbines, battery energy storage system (BESS), or fuel cells that operate as a single plant/resource. In case of offshore wind plants connecting via a dedicated VSC-HVDC, the inverter-based resource includes the VSC-HVDC system.

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Project 2020-02 Draft Language PRC-029-1

R1. Each Generator Owner or Transmission Owner ~~of an applicable IBR~~ shall ensure th~~e~~at design and operation is such that each facility~~IBR~~ adheres to Ride-through requirements,~~remains electrically connected and continues to exchange current~~ in accordance with the "must Ride-through[3] ~~no-trip~~ zone~~s~~" ~~and operation regions~~ as specified in Attachment 1, except for the following: ~~unless needed to clear a fault or a documented equipment limitation exists in accordance with Requirement R6.~~
[Violation Risk Factor: High] [Time Horizon: Operations Assessment]

- The facility needed to electrically disconnect in order to clear a fault;
- A documented equipment limitation exists in accordance with Requirement R4; or
- The instantaneous positive sequence voltage phase angle change is more than 25 electrical degrees at the high-side of the main power transformer and is initiated by a non-fault switching event on the transmission system; or
- The Volts per Hz (V/Hz) at the high-side of the main power transformer exceed 1.1 per unit for longer than 45 seconds or exceed 1.18 per unit for longer than 2 seconds.

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Project 2020-02 Draft Language PRC-029-1

R2. Each Generator Owner or Transmission Owner ~~of an applicable IBR~~ shall ensure the design and operation is such that ~~at during a System disturbance, each IBR's~~ the voltage performance for each facility adheres to the following during a voltage excursion, unless a documented equipment limitation exists in accordance with Requirement R4~~6~~. *[Violation Risk Factor: High] [Time Horizon: Operations Assessment]*

2.1. While the voltage at the high-side of the main power transformer[4] remains within the ~~C~~continuous ~~O~~operation ~~R~~region as specified in Attachment 1, each ~~IBR~~ facility shall:

2.1.1 Continue to deliver the pre-disturbance level of active power or available active power, whichever is less.[5] ~~,~~

~~**2.1.1**~~**2.1.2** ~~and c~~Continue to deliver reactive power ~~and reactive power~~ up to its ~~apparent~~ reactive power limit and according to its controller settings.

~~**2.1.2**~~**2.1.3** If the facility~~IBR~~ cannot deliver both active and reactive power due to a current ~~or apparent power~~ limit or reactive power limit, when the ~~applicable~~ voltage is below 95~~%~~ per unit and still within the ~~C~~continuous ~~o~~Operation ~~R~~region, then preference shall be given to active or reactive power according to requirements if required ~~specified~~ by the Transmission Planner, Planning Coordinator, Reliability Coordinator, or Transmission Operator.

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Project 2020-02 Draft Language PRC-029-1

2.2. While voltage at the high-side of the main power transformer is within the ~~M~~mandatory o~~O~~peration ~~R~~region as specified in Attachment 1, each IBR shall exchange current, up to the maximum capability to provide voltage support, on the affected phases during both symmetrical and asymmetrical voltage disturbances, either under[6]:

- ~~**2.2.1**~~ Reactive power priority by default; or~~Exchange current, up to the maximum capability while maintaining automatic voltage regulation, on the affected phases during both symmetrical and asymmetrical voltage disturbances.~~
- ~~**2.2.2**~~ Active ~~djust reactive current injection at the high-side of the main~~ power priority ~~transformer so that the magnitude of the reactive current responds to changes in voltage at the high-side of the main power transformer in accordance with default reactive prioritization unless the~~ if required by the Transmission Planner, Planning Coordinator, Reliability Coordinator, or Transmission Operator. ~~specifies a certain magnitude of reactive power response to voltage changes or specifies active power priority instead of reactive power priority.~~

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Project 2020-02 Draft Language PRC-029-1

2.3. While ~~The IBR shall not itself cause~~ voltage at the high-side of the main power transformer is within the permissive operation region~~to exceed the applicable~~, as specified in Attachment 1, each facility ~~Table 1 or Table~~ may operate in current block mode if necessary to avoid tripping. Otherwise, each facility shall follow the requirements for the ~~2 no-trip zone voltage thresholds and time durations in its response from M~~mandatory ~~or Permissive O~~operation ~~R~~region in Requirement R2.2~~s to the Continuous Operating Region~~.

~~2.3.~~2.3.1 If a facility enters current block mode, it shall restart current exchange in less than or equal to five cycles of positive sequence voltage returning to a continuous operation region or mandatory operation region.

2.4. Each ~~IBR~~ facility shall not itself cause ~~restore active power output to the pre-disturbance or available level within 1.0 second when the~~ voltage at the high-side of the main power transformer ~~returns~~ to exceed the applicable high voltage thresholds and time durations in its response as voltage recovers from the mandatory or permissive operation regions to the ~~C~~continuous ~~O~~operation ~~R~~region ~~from the Mandatory Operation Region or Permissive Operation Region (including operation in current block mode) as specified in **Attachment 1**, unless the Transmission Planner, Planning Coordinator, Reliability Coordinator, or Transmission Operator specifies a lower post-disturbance active power level requirement or specifies a different post-disturbance active power restoration time~~.

2.5. Each ~~IBR~~ facility shall restore active power output to the pre-disturbance or available level (whichever is lesser) within 1.0 second~~only trip to prevent equipment damage,~~ when the voltage at the high-side of the main power transformer returns from the mandatory operation region or permissive operation region (including operating in current block mode), ~~is outside of the no-trip zone~~ as specified in Attachment 1, unless the Transmission Planner, Planning Coordinator, Reliability Coordinator, or Transmission Operator requires a lower post-disturbance active power level requirement or requires a different post-disturbance active power restoration time.[7]

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R3. Each Generator Owner or Transmission Owner of an applicable IBR shall ensure that during a transient overvoltage as a result of a switching event whereby instantaneous voltage at the high-side of the main power transformer exceeds 1.2 per unit, each IBR shall either: *[Violation Risk Factor: Lower] [Time Horizon: Operations Assessment]*

- Remain electrically connected and continue to exchange current in accordance with instantaneous transient overvoltage levels and durations specified in Attachment 2; or
- Remain electrically connected in current block mode in accordance with instantaneous transient overvoltage levels and durations specified in **Attachment 2**, and restart current exchange within 5 cycles of the instantaneous voltage falling below (and remaining below) 1.2 per unit.

M3. Each Generator Owner and Transmission Owner shall have evidence of actual recorded data or other evidence for each applicable IBR demonstrating adherence to performance requirements, as specified in Requirement R3, during each transient overvoltage period which has occurred within the associated Planning Coordinator(s) area(s).

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~~R4.~~R3. Each Generator Owner or Transmission Owner ~~of an applicable IBR~~ shall ensure the design and operation is such that each ~~IBR~~ facility~~remains electrically connected and continues to exchange current~~ adheres to Ride-through requirements during a frequency excursion event whereby the System frequency remains within the "~~no trip~~must Ride-through zone" according to Attachment ~~2~~3 and the absolute rate of change of frequency (R~~O~~oC~~O~~oF)[8] magnitude is less than or equal to 5 Hz/second. *[Violation Risk Factor: ~~Lower~~High] [Time Horizon: Operations Assessment]*

Attachment ~~2~~3: Frequency Ride-Through Criteria

Table ~~3~~3: Frequency Ride-Through Capability Requirements

~~Averaged~~ System Frequency (Hz)	Minimum Ride-Through Time (sec)
≥64	May trip
< 64 and ≥61.8	6
< 61.8 and ≥~~>~~ 61.5	299
< 61.5 and > 61.2	660
≤ 61.2 and < 58.8	Continuous
≤ 58.8 and < 58.8	660
< 58.5 and ≥ 57	299
< 57.0 and ≥ 56	6
< 56	May trip

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R5. Each Generator Owner or Transmission Owner of an applicable IBR shall ensure each IBR remains electrically connected and continues to exchange current during instantaneous positive sequence voltage phase angle changes that are initiated by non-fault switching events on the transmission system and are changes of less than 25 electrical degrees at the high-side of the main power transformer. *[Violation Risk Factor: Lower] [Time Horizon: Operations Assessment]*

5.1. When the instantaneous positive sequence voltage phase angle change is more than 25 electrical degrees at the high-side of the main power transformer and is initiated by a non-fault switching event on the transmission system, the IBR may trip, but shall only trip to prevent equipment damage.

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~~R6.~~R4. Each Generator Owner and Transmission Owner identifying a facility that is in-service by the effective date of PRC-029-1, has known hardware~~with a documented equipment~~ limitations that ~~would~~ prevent the facility~~an applicable IBR that is in-service by the effective date of this standard~~ from meeting voltage ~~r~~Ride-through ~~requirements~~ criteria as detailed in Requirements R1 and R2, and requires an exemption from specific voltage Ride-through criteria shall ~~communicate each equipment limitation to the associated Planning Coordinator(s), Transmission Planner(s), and Reliability Coordinator(s). [Violation Risk Factor:~~[9] *Lower] [Time Horizon: Long-term Planning]*

~~6.1.~~4.1. ~~Each Generator Owner and Transmission Owner shall include in its~~ ~~d~~Document information supporting the identified hardware limitation no later than 12 months following the effective date of PRC-029-1. This documentation shall include~~ation~~:

~~6.1.1~~4.1.1 Identifying information of the IBR (name, facility #, other);

~~6.1.2~~4.1.2 Which aspects of voltage ride-through requirements that the IBR would be unable to meet and the capability of the equipment due to the limitation;

~~6.1.3~~4.1.3 Identify the specific piece(s) of equipment causing the limitation;

4.1.4 Supporting technical documentation verifying the limitation is due to hardware that needs to be physically replaced or that the limitation cannot be removed by software updates or setting changes, and;

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~~6.1.4~~4.1.5 Information regarding any plans to ~~repair or~~ remedy~~place~~ the ~~limiting~~ equipment ~~that would remove the~~ limitation (such as an estimated date ~~of repair/replacement~~).

4.2. Provide a copy of the information detailed in Requirement R4.1 to the applicable Planning Coordinator(s), Transmission Planner(s), Transmission Operator(s), Reliability Coordinator(s), and to the Regional Entity no later than 12 months following the effective date of PRC-029-1.

4.2.1 Any response to additional information requested by the applicable Planning Coordinator(s), Transmission Planner(s), Transmission Operator(s), Reliability Coordinator(s), and to the Regional Entity shall be provided back to the requestor within 90 days of the request.

4.3. Each Generator Owner and Transmission Owner with a previously ~~communicated~~ submitted request for exemption~~equipment limitation~~ that ~~repairs or~~ replace~~s~~ the equipment causing the limitation shall document and communicate such an equipment change to the associated Planning Coordinator(s), Transmission Planner(s), Transmission Operator(s), and Reliability Coordinator(s) within ~~3~~90 days of the equipment change.

~~6.2.~~4.3.1 When existing equipment is replaced, the exemption for that Ride-through criteria no longer applies.

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Table 2: Voltage Ride-Through Requirements for All Other ~~IBR~~Inverter-based Resource Facilities

Voltage (per unit)[13]	Operation Region	Minimum Ride-Through Time (sec)
≥~~≥~~1.20~~0~~	N/A[14]	N/A
≤ 1.20 and > ~~≥~~1.1	Mandatory Operation Region	1.0
≤ 1.10 and > ~~≥~~1.05	Continuous Operation Region	1800
≤ 1.05 and ≥ 0.90	Continuous Operation Region	Continuous
< 0.90 and ≥ 0.70	Mandatory Operation Region	6.00
< 0.70 and ≥ 0.50	Mandatory Operation Region	3.00
< 0.50 and ≥ 0.25	Mandatory Operation Region	1.20
< 0.25 and ≥ 0.10	Mandatory Operation Region	0.32
< 0.10	Permissive Operation Region	0.32

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Project 2020-02 Next Steps

- Relevant information
  - Project page
- Planned Ballot dates
  - 15 day formal comment period and additional ballot

    June 18th 2024 to July 8th 2024
- Contact information
  - Jamie Calderon: Jamie.Calderon@nerc.net
  - Xiaoyu (Shawn) Wang: xiaoyu.wang@enel.com
  - Husam Al-Hadidi: halhadidi@hydro.mb.ca

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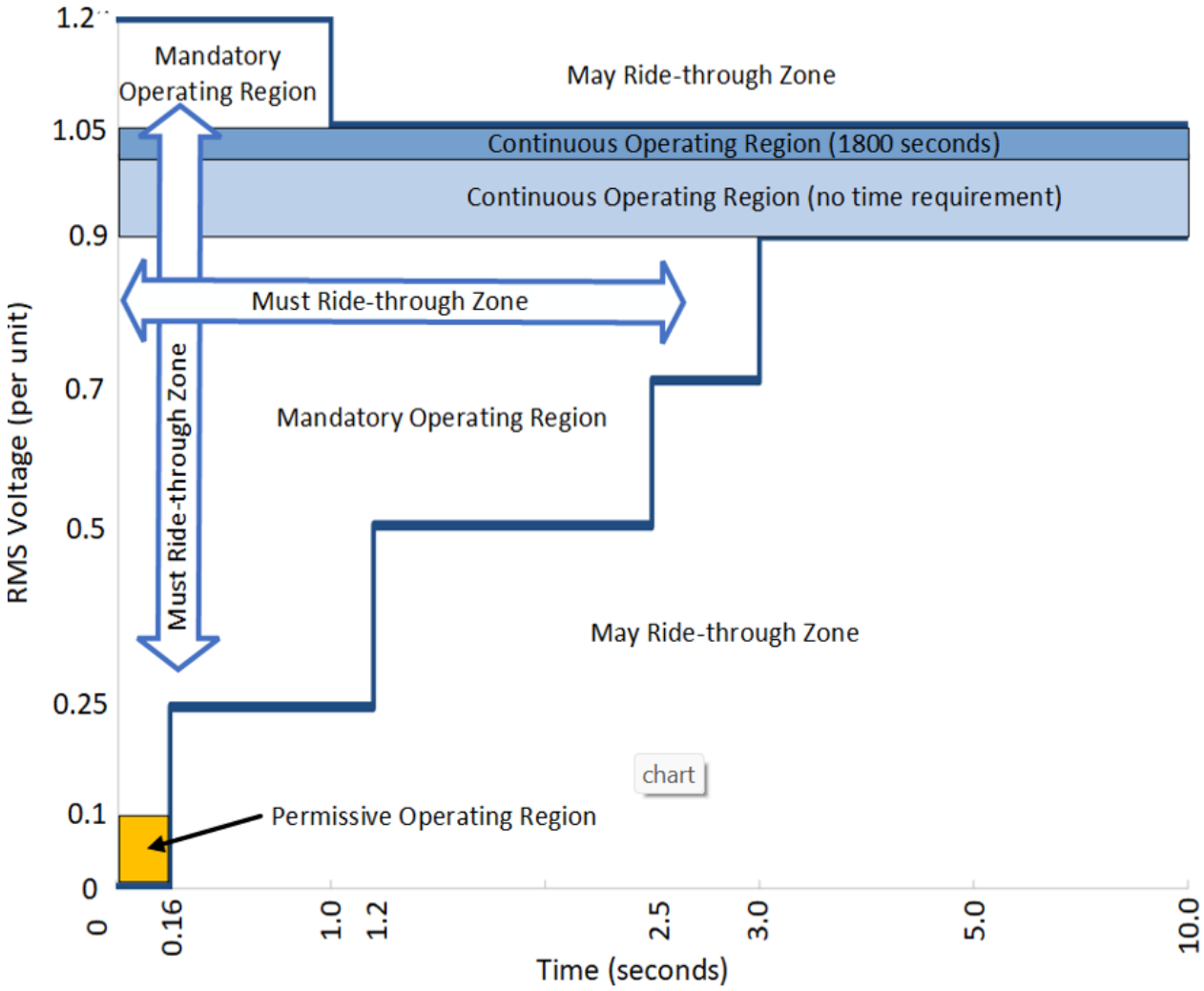

Figure 1: Voltage Ride-Through Requirements for AC-Connected Wind Facilities

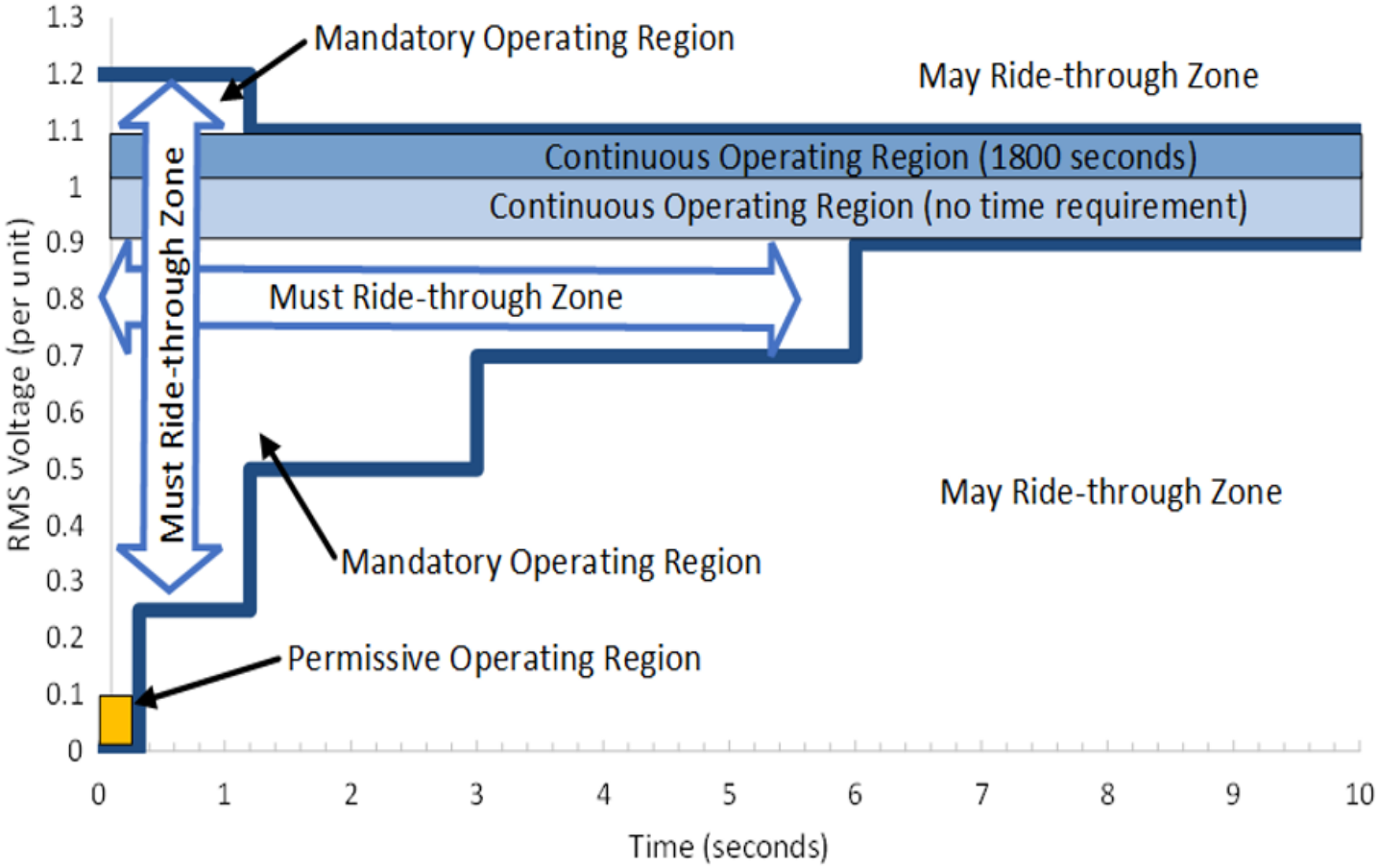

Figure 2: Voltage Ride-Through Requirements for All Other IBR

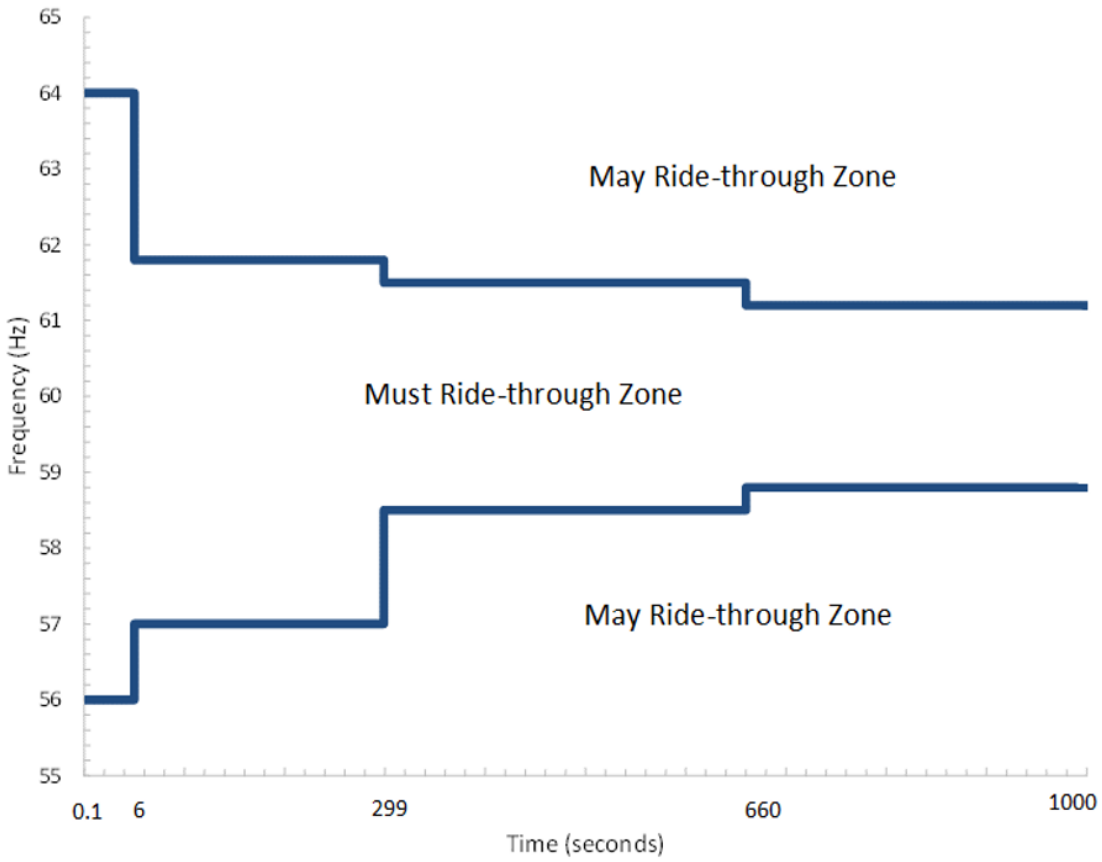

Figure 3: PRC-029 Frequency ~~Envelopes~~Ride-through Requirement