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

Completed Actions	Date
Standards Committee accepted revised Standard Authorization Request (SAR) for posting	April 19, 2023
Standards Committee approved waivers to the Standards Process Manual	December 13, 2023
Standards Committee approved waivers to the Standards Process Manual	December 13, 2023

Anticipated Actions	Date
15-day formal comment period and additional ballot	June 18 – July 8, 2024
Final Ballot	July 16 - 20, 2024
Board adoption	August 14, 2024

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):

Ride-through: Remaining connected, synchronized with the Transmission System, and continuing to operate in response to System conditions through the time-frame of a System Disturbance.

~~**Continuous Operating Region –** The range of voltages, measured at the high-side of the main power transformer, that are ≥ 0.9 per unit and ≤ 1.1 per unit.~~

~~**Mandatory Operating Region –** The range of voltages, measured at the high-side of the main power transformer, that are > 0.1 per unit and < 0.9 per unit – or – > 1.1 and ≤ 1.2 per unit.~~

~~**Permissive Operating Region –** The range of voltages, measured at the high-side of the main power transformer, that is ≤ 0.1 per unit.~~

A. Introduction

1. **Title:** **Frequency and Voltage Ride-through Requirements for Inverter-Based ~~Generating~~ Resources**
2. **Number:** **PRC-029-1**
3. **Purpose:** To ensure that Inverter-Based Resources (IBRs) adhere to Ride-through requirements ~~remain connected and perform operationally~~ as expected to support ~~of~~ the Bulk Power System (BPS) during and after defined frequency and voltage excursions.
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

[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.

B. Requirements and Measures

R1. Each Generator Owner or Transmission Owner ~~of an applicable IBR~~ shall ensure th~~eat~~ 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.

M1. Each Generator Owner and Transmission Owner ~~shall~~ have evidence of dynamic simulations, studies, or other evidence to demonstrate the design of each facility will adhere to Ride-through requirements, as specified in Requirement R1. Each Generator Owner and Transmission Owner have evidence of actual disturbance monitoring (i.e. Sequence of Event Recorder, Dynamic Disturbance Recorder, and Fault Recorder) ~~recorded~~ to demonstrate that the operation of each facility did adhere to Ride-through requirements, as specified in Requirement R1. If the Generator Owner and Transmission Owner choose to utilize Ride-through exemptions that occur within the "must Ride-through zone" and are caused by non-fault initiated phase jumps of greater than 25 electrical degrees, then each Generator Owner and Transmission Owner also have evidence of actual disturbance monitoring (i.e. Sequence of Event Recorder, Dynamic Disturbance Recorder, and Fault Recorder) data to demonstrate that the facility failed to Ride-through during a phase jump of greater than or equal to 25 electrical degrees, and documentation from their Transmission Planner, Reliability Coordinator, Planning Coordinator, or Transmission Operator that a non-fault initiated switching event occurred.~~data or other evidence for each applicable IBR demonstrating adherence to ride-through requirements, as specified in **Requirement R1.**~~

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]*

[3] Includes no tripping associated with phase lock loop loss of synchronism

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~~O~~peration ~~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.

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.~~

[4] For the purpose of this standard, the main power transformer is the power transformer that steps up voltage from the collection system voltage to the nominal transmission/interconnecting system voltage for inverter-based resources. In case of offshore wind plants connecting via a dedicated VSC-HVDC, the main power transformer is the onshore main power transformer.

[5] Except if this would occur during a frequency excursion. The active power response should recover in accordance with the primary frequency controller.

[6] In either case and if required, the magnitude of active power and reactive current shall be as specified by the Transmission Planner, Planning Coordinator, Reliability Coordinator, or Transmission Operator.

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]

M2. Each Generator Owner and Transmission Owner ~~shall~~ have evidence of dynamic simulations, studies, or other evidence to demonstrate the design of each facility will adhere to requirements, as specified in Requirement R2. Each Generator Owner and Transmission Owner also have evidence of actual disturbance monitoring (i.e. Sequence of Event Recorder, Dynamic Disturbance Recorder, and Fault Recorder)~~recorded~~ data ~~or other evidence for each applicable IBR~~to ~~demonstrating~~demonstrating that the operation of each facility did adhere~~nce~~ to performance requirements, as specified in Requirement R2, during each ~~System~~ voltage excursion measured at the high-side of the main power transformer. The Generator Owner or Transmission Owner have evidence of receiving such

[7] Except if this would occur during a frequency excursion. The active power response should recover in accordance with the primary frequency controller.

performance requirements, (e.g. email exchange, contract information) if the Transmission Planner, Transmission Operator, Reliability Coordinator, or ~~disturbance which has occurred within the associated~~ Planning Coordinator~~(s) area(s)~~ has required the Generator Owner or Transmission Owner to follow performance requirements other than those in Requirement R2 (e.g. ramp rates, reactive power prioritization).

~~**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).~~

~~**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]*

M~~4~~3. Each Generator Owner and Transmission Owner ~~shall~~ have evidence of dynamic simulations, studies, or other evidence to demonstrate the design of each facility will adhere to Ride-through requirements, as specified in Requirement R3. Each Generator Owner and Transmission Owner also have evidence of actual disturbance monitoring (i.e. Sequence of Event Recorder, Dynamic Disturbance Recorder, and Fault Recorder) ~~recorded~~ data ~~or other evidence~~ to demonstrate the operation of~~for~~ each ~~applicable IBR~~facility did ~~demonstrating~~ adherence to ~~r~~Ride-through requirements, as specified in Requirement R~~4~~3, during each frequency excursion event measured ~~which has occurred within the associated Planning Coordinator(s) area(s)~~ at the high-side of the main power transformer.

[8] Rate of change of frequency (ROCOF) is calculated as the average rate of change for multiple calculated system frequencies for a time period of greater than or equal to 0.1 second. ROCOF is not calculated during the fault occurrence and clearance.

~~**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.~~

~~**M5.** Each Generator Owner and Transmission Owner shall have evidence of actual recorded data or other evidence for each applicable IBR demonstrating adherence to ride-through requirements, as specified in Requirement R5, during instantaneous positive sequence voltage phase angle changes that are changes of less than 25 electrical degrees at the high-side of the main power transformer and that such changes are not initiated by non-fault switching events.~~

~~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;

[9] The exemption requests for a non-US Registered Entity should be implemented in a manner that is consistent with, or under the direction of, the applicable governmental authority or its agency in the non-US jurisdiction

~~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.

M~~6~~4. Each Generator Owner and Transmission Owner seeking an exemption for facilities that are in-service by the effective date of PRC-029-1 ~~shall~~ have evidence of submission to the Regional Entity consistent with the information listed ~~equipment limitations, as specified~~ in Requirement R~~6~~4.1~~, documented prior to the effective date of PRC-029-1~~. Each Generator Owner and Transmission Owner have evidence of communicated copies of each submission in accordance with Requirement R4.2 and to the applicable entities described in Requirement R4.2. Acceptable type of evidence for submittals include but are not limited to, meeting minutes, agreements, copies of procedures or protocols in effect, or email correspondence. Acceptable types of evidence for an equipment limitation may include but is not limited to, documentation that contains study results, experience from an actual event, or manufacturer's advice. Each Generator Owner and Transmission Owner that replace ~~with changes to~~ equipment at a facility that is directly associated with an approved exemption and that equipment is the cause for the limitation, ~~shall~~ have evidence of communicating the equipment change to the applicable entities described in Requirement R4.3 within 30 calendar days of the equipment replacement~~communication to each associated Planning Coordinator, Transmission Planner, and Reliability Coordinator. Acceptable types of evidence may include, but are not limited to, meeting minutes, agreements, copies of procedures or protocols in effect between entities or between departments of a vertically integrated system, or email correspondence~~.

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.

- Each Generator Owner and Transmission Owner shall retain evidence with Requirements R1, R2, and R3 in this standard for 36 calendar months.
- Each Generator Owner and Transmission Owner shall retain evidence with Requirement R4 ~~each requirement~~ in this standard for five calendar years.

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.	The Generator Owner or Transmission Owner failed to demonstrate the capability of each applicable facility to Ride-through in accordance with Attachment 1, except for those conditions identified in Requirement R1.~~N/A~~	N/A	N/A	The Generator Owner or Transmission Owner failed to demonstrate each applicable facility adhered to Ride-through requirements in accordance with Attachment 1, except for those conditions identified in ~~IBR remains electrically connected and continued to exchange current in accordance with Attachment 1, unless needed to clear a fault, in accordance with~~ Requirement R1.
R2.	The Generator Owner or Transmission Owner failed to demonstrate the capability of each applicable facility to adhere to performance requirements during voltage excursions, as specified in Requirement R2.~~N/A~~	N/A	N/A	The Generator Owner or Transmission Owner failed to demonstrate each applicable facility adhered to performance requirements during voltage excursions~~IBR adhered to performance requirements during each System disturbance~~, as specified in Requirement R2.
~~**R3.**~~	~~N/A~~	~~N/A~~	~~N/A~~	~~The Generator Owner or Transmission Owner failed to demonstrate each applicable~~

R #	Violation Severity Levels			
	Lower VSL	Moderate VSL	High VSL	Severe VSL
				~~IBR adhered to performance requirements during each transient overvoltage period as specified in Requirement R3.~~
R34.	The Generator Owner or Transmission Owner failed to demonstrate the capability of each applicable facility to Ride-through in accordance with Attachment 2.~~N/A~~	N/A	N/A	The Generator Owner or Transmission Owner failed to demonstrate each applicable facility adhered to Ride-through requirements in accordance with Attachment 2.~~IBR adhered to performance requirements during each frequency excursion event, as specified in Requirement R4.~~
~~**R5.**~~	~~N/A~~	~~N/A~~	~~N/A~~	~~The Generator Owner or Transmission Owner failed to demonstrate each applicable IBR adhered to performance requirements during each instantaneous positive sequence voltage phase angle change of less than 25 electrical degrees, as specified in Requirement R5.~~
R46.	The Generator Owner or Transmission Owner with a previously communicated	The Generator Owner or Transmission Owner with a previously communicated	The Generator Owner or Transmission Owner with a previously communicated	The Generator Owner or Transmission Owner failed to document complete

R #	Violation Severity Levels			
	Lower VSL	Moderate VSL	High VSL	Severe VSL
	equipment limitation that repairs or replaces the documented limiting equipment but failed to document and communicate the change to its Planning Coordinator(s), Transmission Planner(s), Transmission Operator(s), ~~and~~ Reliability Coordinator(s), and Regional Entity more than 30 calendar days but less than or equal to 60 calendar days after the change to the equipment. OR The Generator Owner or Transmission Owner provided a copy to the applicable entities as detailed in R4.2 more than 12 months but less than or equal to 15 months after the effective date of R4.	equipment limitation that repairs or replaces the documented limiting equipment but failed to document and communicate the change to its Planning Coordinator(s), Transmission Planner(s), ~~and~~ Reliability Coordinator(s), Transmission Operator(s), and Regional Entity more than 60 calendar days but less than or equal to 90 calendar days after the change to the equipment.	equipment limitation that repairs or replaces the documented limiting equipment but failed to document and communicate the change to its Planning Coordinator(s), Transmission Planner(s),~~and~~ Reliability Coordinator(s), Transmission Operator(s), and Regional Entity more than 90 calendar days but less than or equal to 120 calendar days after the change to the equipment.	information for facilities identified with known hardware~~evidence of equipment~~ limitations that prevent the facility from meeting voltage Ride-through criteria as detailed in Requirements R1 or R2~~consistent with Requirement R6 and prior to the effective date of PRC-029-1 Requirement R6~~. OR The Generator Owner or Transmission Owner with a previously communicated equipment limitation that repairs or replaces the documented limiting equipment but failed to document and communicate the change to its Planning Coordinator(s), Transmission Planner(s),~~-~~ Transmission Operator(s),~~and~~ Reliability Coordinator(s), and Regional Entity more than 120 calendar

R #	Violation Severity Levels			
	Lower VSL	Moderate VSL	High VSL	Severe VSL
				days after the change to the equipment. OR The Generator Owner or Transmission Owner failed to provide a copy to the applicable entities as detailed in R4.2 within 24 months after the effective date of R4.

D. Regional Variances

None.

E. Associated Documents

Implementation Plan .

Version History

Version	Date	Action	Change Tracking
Initial Draft	3/27/24	DRAFT	
DRAFT 2	6/4/24	Revised follow initial comment review	

Attachment 1: Voltage Ride-Through Criteria

Table 1: Voltage Ride-Through Requirements for AC-Connected Wind ~~IBR~~ Facility[10]

Voltage (per unit)[11]	Operation Region	Minimum Ride-Through Time (sec)
≥ 1.20~~0~~	N/A[12]	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	3.00
< 0.70 and ≥ 0.50	Mandatory Operation Region	2.50
< 0.50 and ≥ 0.25	Mandatory Operation Region	1.20
< 0.25 and ≥ 0.10	Mandatory Operation Region	0.16
< 0.10	Permissive Operation Region	0.16

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

[10] Type 3 and type 4 wind resources directly connected to the AC Transmission System
[11] Refer to bullet #5 below.
[12] These conditions are referred to as the "may Ride-through zone".
[13] Refer to bullet #5 below.
[14] These conditions are referred to as the "may Ride-through zone".

1. Table 1 applies to type 3 and type 4 wind facilities ~~applicable wind IBR~~ unless connected via a dedicated VSC-HVDC transmission facility.
2. Table 2 applies to all other inverter-based resource facility ~~IBR~~ types not covered in Table 1; including, but not limited to, the following ~~IBR~~facilities:
   a. ~~Isolated~~ Inverter-based resources~~IBR~~, regardless of their energy resource, interconnecting via a dedicated VSC-HVDC transmission facility.
   b. Other ~~IBR~~ inverter-based resource plants or hybrid plants consisting of photovoltaic (PV) and BESS.
3. The applicable voltage for Voltage Source Converter High Voltage Direct Current (VSC HVDC) system with a dedicated connection to an inverter-based resource is on the AC side of the transformer(s) that is (are) used to connect the VSC HVDC system to the interconnected transmission system

~~3.~~4. Table 1 applies to hybrid facilities consisting of wind (type 3 or type 4) ~~In the case of hybrid IBR consisting of wind~~ and various other IBR technologies~~, the applicable table shall be based on direction by the Transmission Planner~~. Otherwise, Table 2 applies to hybrid facilities with no wind (type 3 or type 4).

~~4.~~5. The voltage base for per unit calculation is the nominal phase-to-ground or phase-to-phase transmission system voltage unless otherwise defined by the Planning Coordinator or Transmission Planner.

~~5.~~6. The applicable voltage for Tables 1 and 2 is identified as the voltage max/min of phase to neutral or phase to phase fundamental root mean square (RMS) voltage at the high side of the ~~MPT~~main power transformer.

~~6.~~7. Tables 1 and 2 are only applicable when the frequency is within the "must Ride-through~~no trip~~ zone" as specified in Table 3 of Attachment ~~3~~2.

~~7.~~8. At any given voltage value, each ~~IBR~~ facility shall Ride-through~~ not trip until~~ unless the time duration at that voltage has exceed~~s~~ed the specified minimum R~~r~~ide-through time duration. If the voltage is continuously varying over time, it is necessary to add the duration within each band of Tables 1 and 2 over ~~the~~ any 10~~-~~second time period~~ to determine compliance~~.

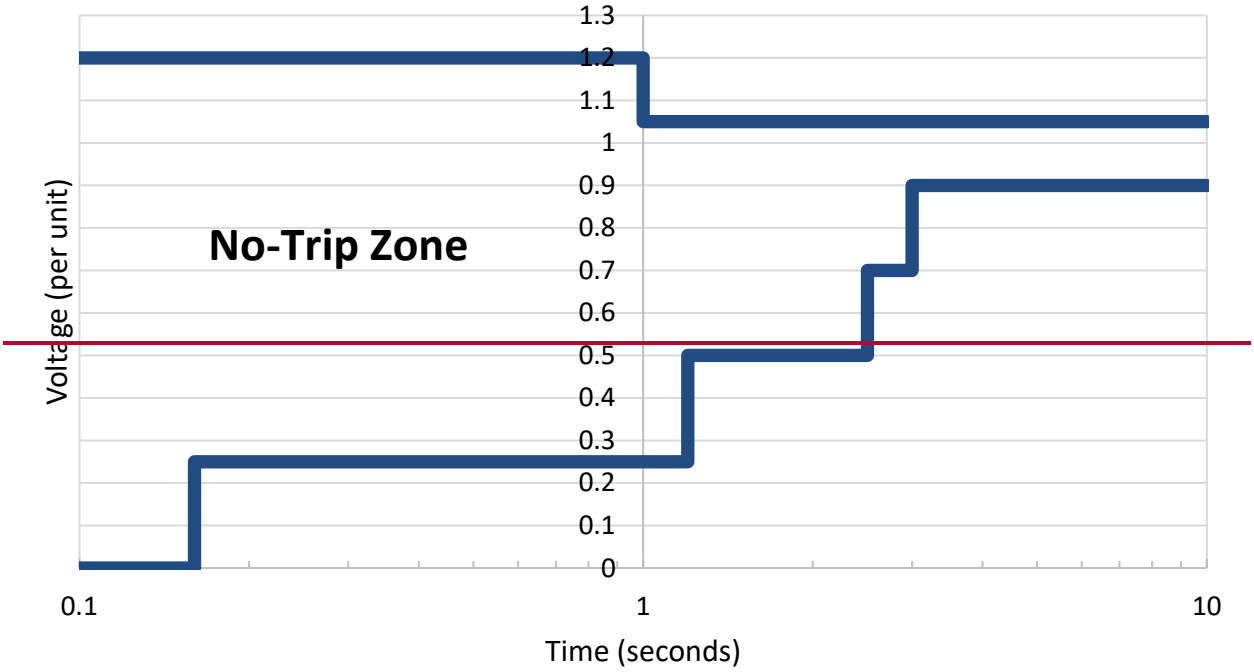
~~8.~~9. The specified duration of the ~~M~~mandatory ~~O~~operation ~~R~~regions and the ~~P~~permissive ~~O~~operation ~~R~~regions in Tables 1 and 2 is cumulative over one or more disturbances within any 10 second time period.

~~9.~~10. The ~~IBR~~ facility may trip for more than four deviations of the applicable voltage at the high-side of the main power transformer outside of the ~~C~~continuous ~~O~~operation ~~R~~region within any 10 second time period.

11. Instantaneous trip settings based on instantaneously calculated voltage measurements with less than filtering lengths of one cycle (16.6 msec) are not permissible.

12. The “must Ride-through zone” is the combined area of the mandatory operating regions, the continuous operating regions, and the permissive operating region. All area outside of these operating regions is referred to as the “may Ride-through zone”.

~~10. If the positive sequence voltage at the high-side of the main power transformer enters the Permissive Operation Region, an IBR may operate in current block mode if necessary to protect the equipment.~~


No-Trip Zone
Voltage (per unit)
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.1
1
10
Time (seconds)

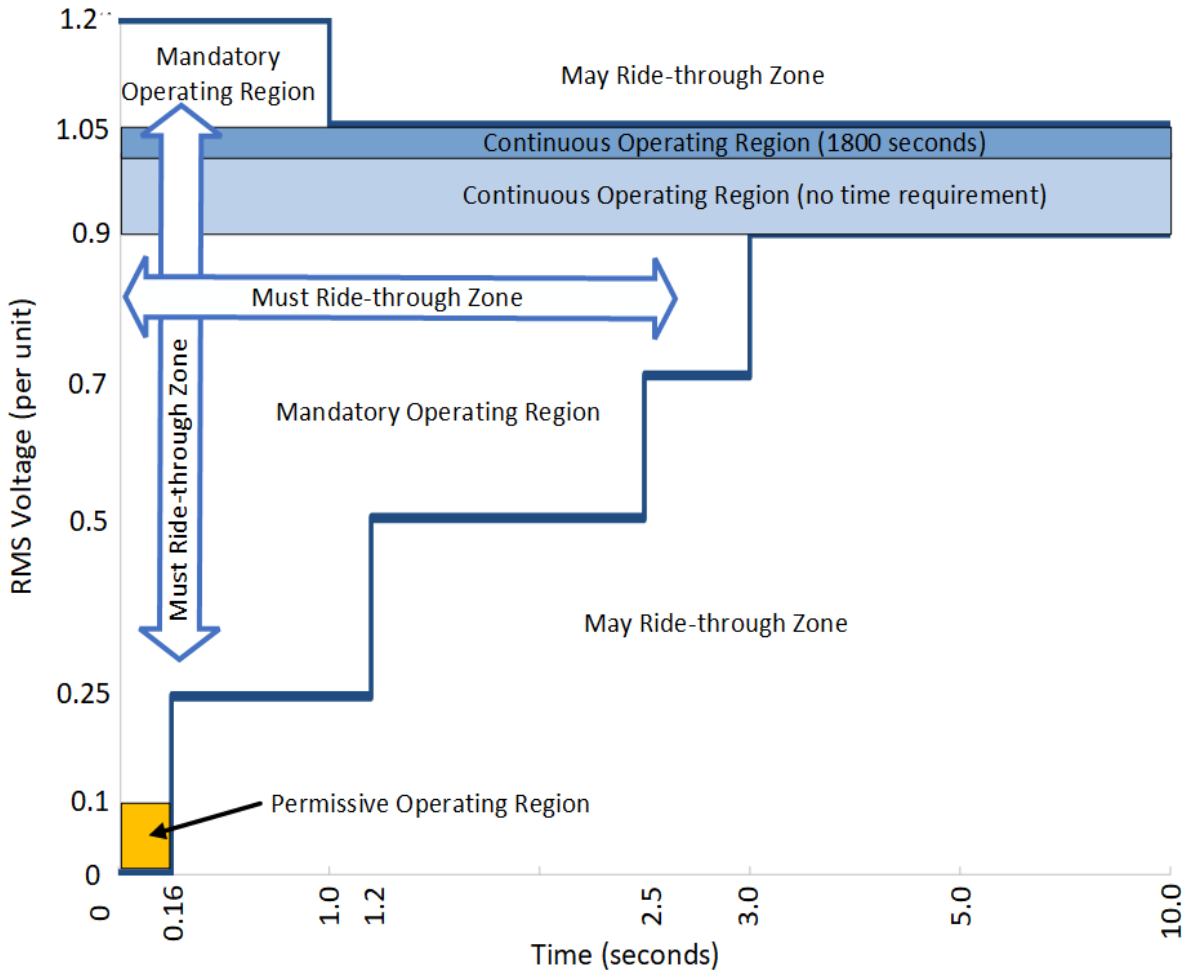


Figure 1: Voltage Ride-Through Requirements for AC-Connected Wind Facilities~~IBR~~

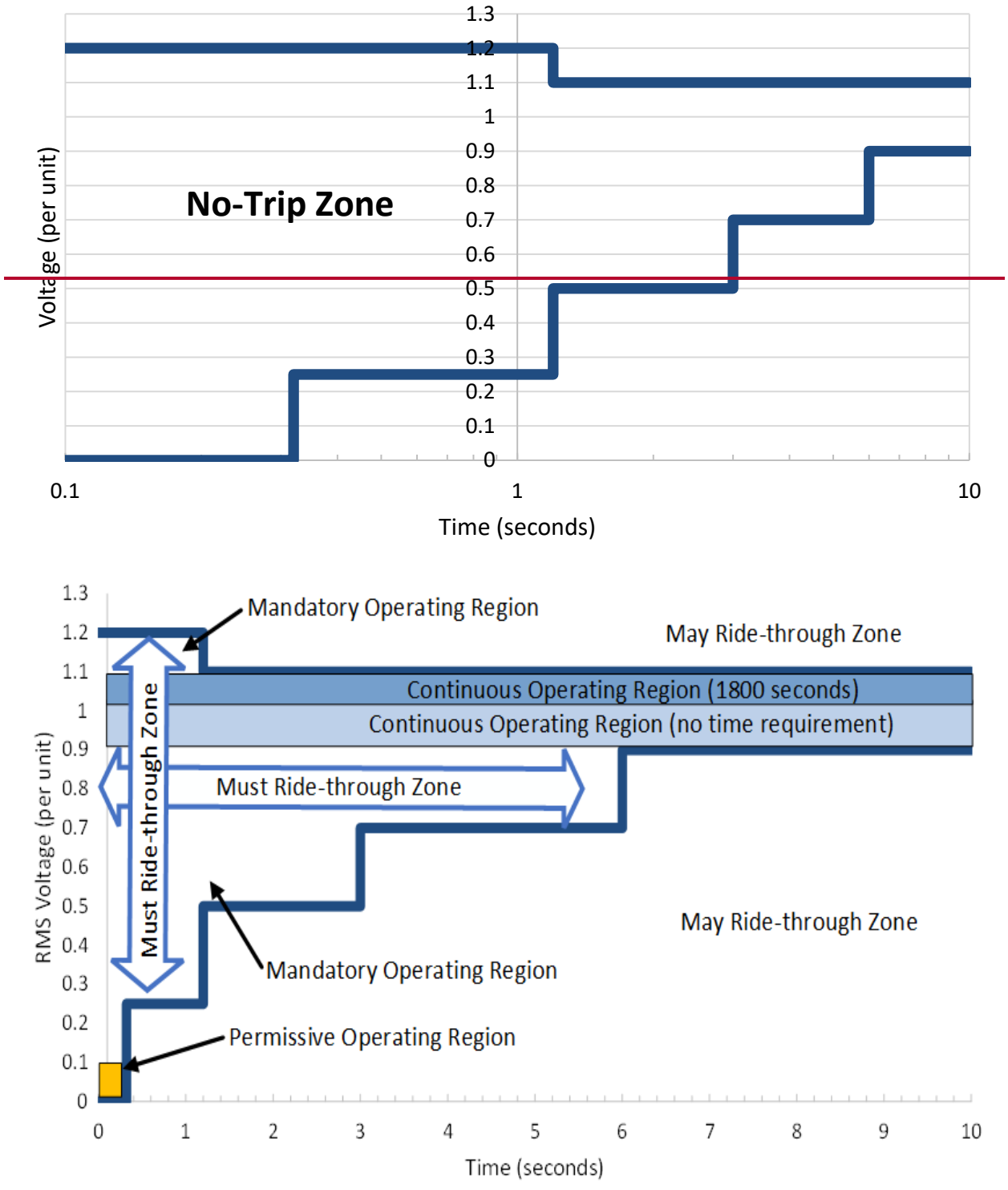


Figure 2: Voltage Ride-Through Requirements for All Other IBR

~~Attachment 2: Transient Overvoltage Ride-Through Criteria~~

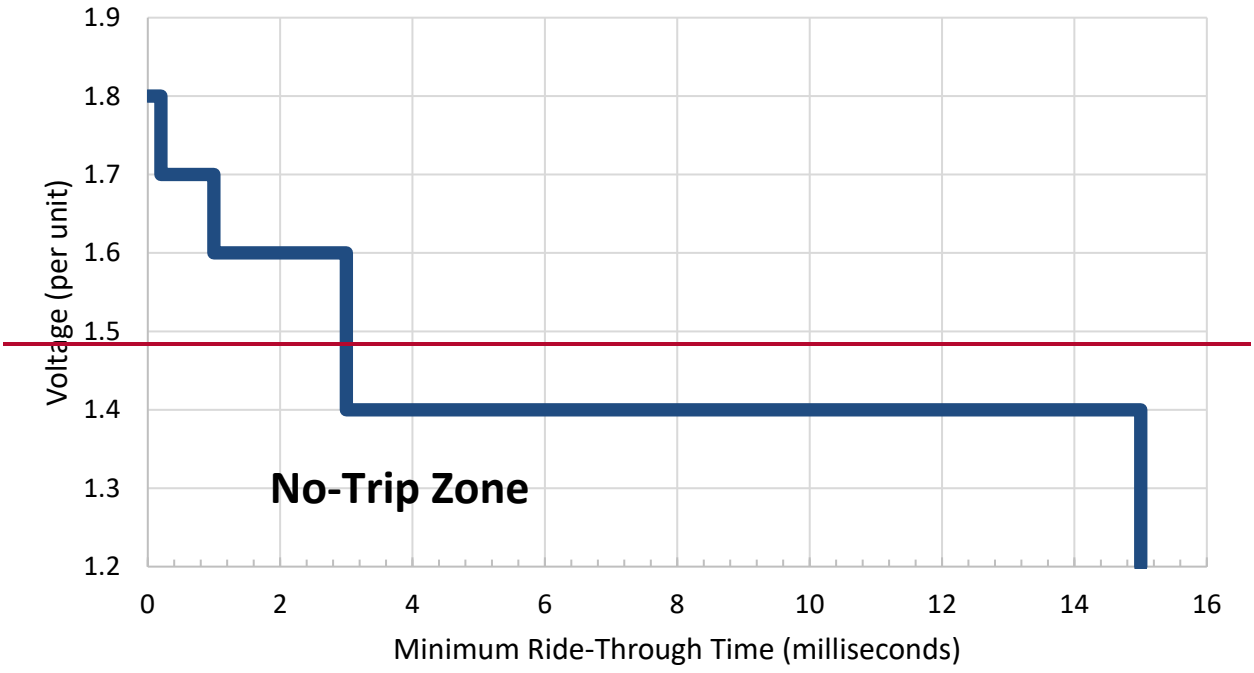
~~Table 3: Transient Overvoltage Ride-Through Criteria~~

~~Voltage (per unit) at the high-side of the MPT~~	~~Minimum Ride-Through Time (millisec)~~
~~> 1.8~~	~~May trip~~
~~> 1.7~~	~~0.2~~
~~> 1.6~~	~~1.0~~
~~> 1.4~~	~~3.0~~
~~> 1.2~~	~~15.0~~

1. ~~The voltage base for per unit calculation is the nominal instantaneous phase-to-ground or phase-to-phase voltage at the high side of the MPT unless otherwise defined by the Planning Coordinator or Transmission Planner.~~

1. ~~If surge protection devices are installed within the plant, the per unit voltage refers to the residual voltage with the surge arresters applied.~~

2. ~~Each IBR shall not trip unless the cumulative time of one or more instances over a 1-minute time window in which the instantaneous voltage exceeds the respective voltage threshold and the minimum ride-through time.~~



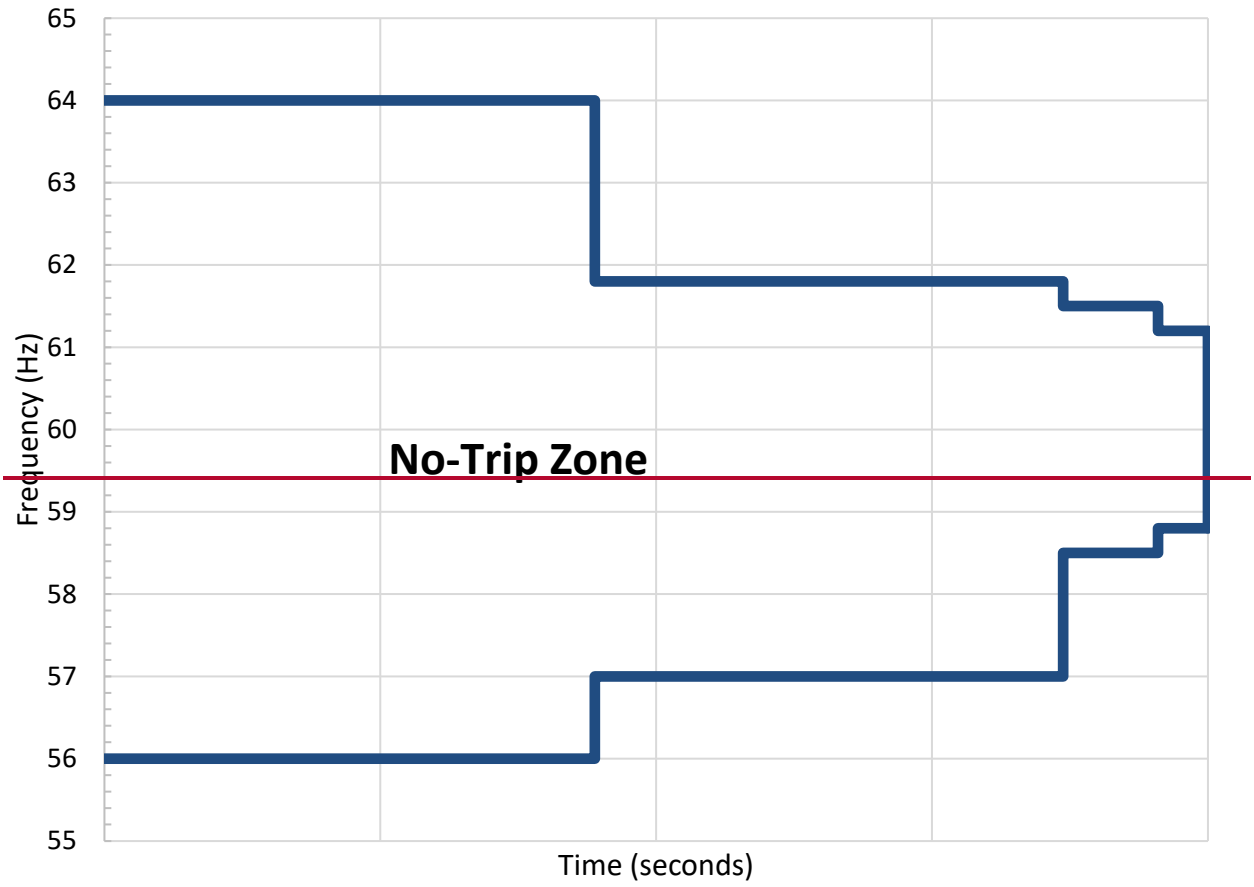
~~Figure 3: Transient Overvoltage Ride-Through Criteria~~

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

Table 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

1. Frequency ~~M~~measurements are taken at the high-side of the main power transformer ~~for each phase (phase to neutral)~~.
2. Frequency is ~~M~~measured~~ments are averaged~~ over a ~~set time~~ period of time (typically~~such as~~ 3-6 cycles) to calculate ~~averaged~~ system frequency at the high-side of the main power transformer.
3. Instantaneous or single points of measurement may not be used in the determination of control settings.
4. At any given frequency value~~s~~, each ~~IBR~~ facility shall Ride-through~~not trip until~~ unless the time duration at that frequency has exceeded~~s~~ the specified minimum ride-through time duration.
5. The specified durations of Table 3~~4~~ are cumulative over one or more disturbances within a 15-minute time period.


65
64
63
62
61
60
59
58
57
56
55
Frequency (Hz)
No-Trip Zone
Time (seconds)

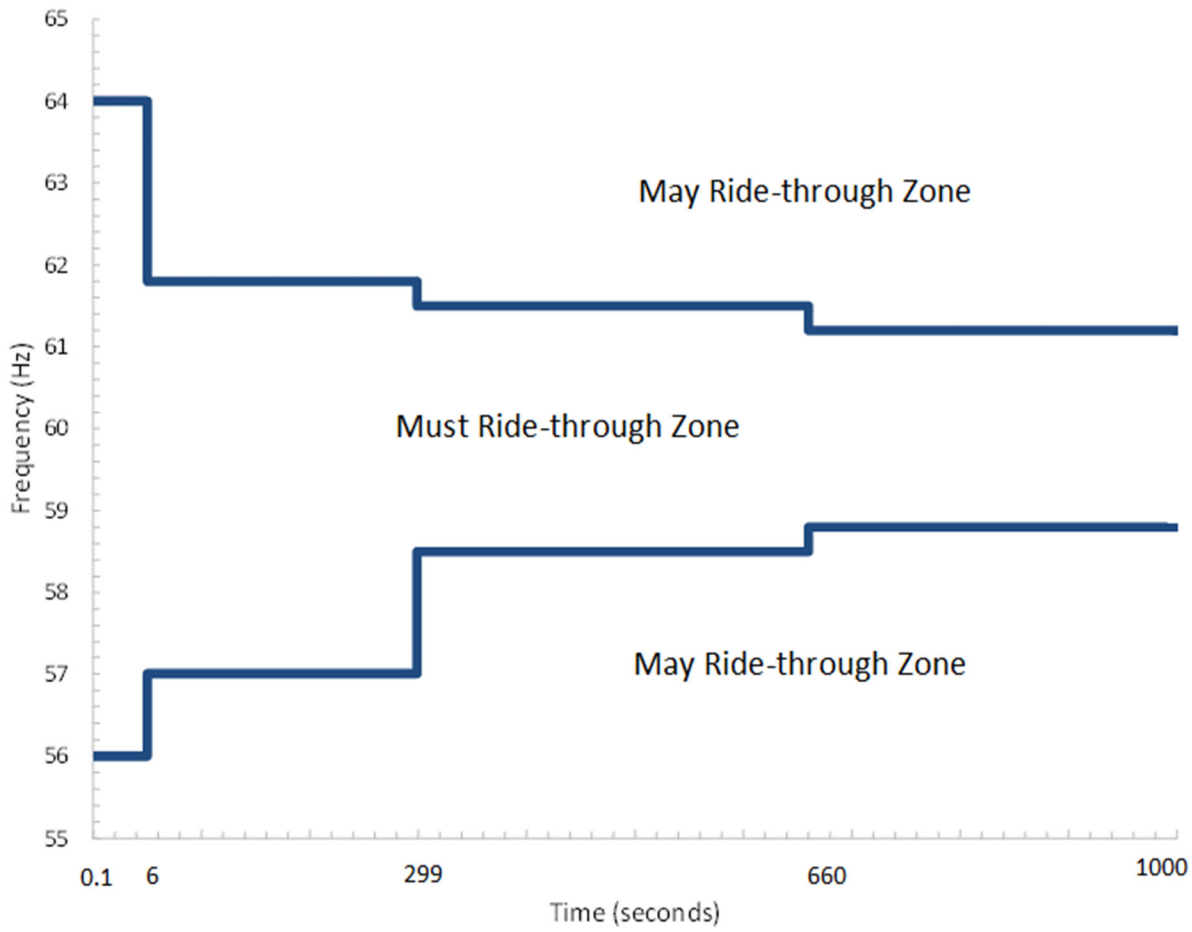


Figure 43: PRC-029 Frequency ~~Envelopes~~Ride-Through Requirements