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| NOGRR Number | [245](https://www.ercot.com/mktrules/issues/NOGRR245) | NOGRR Title | Inverter-Based Resource (IBR) Ride-Through Requirements |

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| Date | September 13, 2023 |

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| Market Segment | Independent Generator |

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| Comments |

These comments:

1. Update language to partially conform with the 8/18/23 ERCOT comments
2. Clarify the “behind the meter” co-located discussion at ROS
3. Refine reporting requirements
4. Incorporate 9/5/23 GE Vernova comments
5. Other minor cleanup

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| Revised Cover Page Language | | | |
| Nodal Operating Guide Sections Requiring Revision | 2.6.2, Generators and Energy Storage Resources  2.6.2.1, Frequency Ride-Through Requirements for Transmission-Connected Inverter-Based Resources (IBRs) (new)  2.6.2.1, Frequency Ride-Through Requirements for Distribution Generation Resources (DGRs) and Distribution Energy Storage Resources (DESRs)  2.6.4, Commercially Reasonable Efforts (new)  2.9, Voltage Ride-Through Requirements for Generation Resources  2.9.1, Voltage Ride-Through Requirements for Intermittent Renewable Resources Connected to the ERCOT Transmission Grid  2.9.1.1, Voltage Ride-Through Requirements for Transmission-Connected Inverter-Based Resources (IBRs) (new) |
| Revision Description | This Nodal Operating Guide Revision Request (NOGRR) replaces the current voltage ride-through requirements for Intermittent Renewable Resources (IRRs) with voltage ride-through requirements for Inverter-Based Resources (IBRs) and provides new frequency ride-through requirements for IBRs consistent with or beyond requirements identified in the new 2800-2022 - Institute of Electrical and Electronics Engineers (IEEE) Standard for Interconnection and Interoperability of Inverter-Based Resources (IBRs) Interconnecting with Associated Transmission Electric Power Systems (“IEEE 2800-2022 standard”). It also requires all IBRs to improve performance to meet these standards, and establishes compliance requirements for Resource Entities when it is commercially reasonable to do so. |
| Business Case | ERCOT submits this NOGRR based on reliability issues associated with the inability of some IBRs to ride-through system disturbances, and in light of the IEEE 2800-2022 standard. In its recently issued guidance document *Inverter-Based Resource Strategy*, theNorth American Reliability Corporation (NERC) noted it has supported the development of the IEEE 2800-2022 standard (and continues to support the IEEE P2800.2, Recommended Practice for Test and Verification Procedures for Inverter-based Resources (IBRs) Interconnecting with Bulk Power Systems, standards development efforts). Among other things, the document also highlights that:   * New technology can introduce significant risks if not integrated properlywhich requires ERCOT and market participants to cooperate on solutions; * Inverter and plant controls and protection systems must support the reliable operation of the bulk power system during system disturbances; * Disturbance reports, alerts, guidelines, and other deliverables have shown that abnormal IBR performance issues pose a risk to bulk power system reliability that needs to be addressed going forward; * Analyzed events identified new performance issues such as momentary cessation, inverter or plant-level tripping issues, controller interactions and instabilities, and other performance risks that must be mitigated; and * Generation ride-through and provision of essential reliability services is a core principle for reliable operation of the bulk power system.   IEEE 2800-2022 states that the entity to determine compliance with the standard is the entity that governs the interconnection process, strongly implying that these standards are intended to be implemented on a prospective basis for new interconnections. For example, Section 1.4 of the standard states:  “The application of this standard may be limited to IBR plants for which interconnection requests are submitted after the date by which this standard is enforced by the responsible authority governing interconnection requirements (AGIRs); this standard may not apply to IBR plants that are either already interconnected or for which interconnection requests had been submitted prior to the standard’s enforcement date (grandfathering). Any substantial changes in an existing IBR plant, e.g., the “repowering” of a wind power plant, may require retrofitting that IBR plant to meet all of the requirements of this standard.”  This NOGRR proposes ride-through requirements for IBRs with specificity consistent with or beyond the IEEE 2800-2022 standard where appropriate (e.g., applying to the Point of Interconnection Bus (POIB) instead of the “Resource Point of Applicability”). The revisions specify the ride-through requirements for IBRs rather than IRRs or Energy Storage Resources (ESRs) because they are not necessarily IBRs and the IBR attributes create unique ride-through requirements. Some clarifications included from the IEEE 2800-2022 standard may not require additional “capability” but provide additional specificity for settings that can prevent failures rather than adjustments being made after a failure occurs.  Failure of IBRs to ride-through normal frequency and voltage deviations on the ERCOT System can lead to severe consequences such as instability, cascading outages, or triggering an Under-Frequency Load Shed (UFLS) event. However, in many cases, ERCOT relies on IBRs to meet system demand. Because of these complex risks, and with the recognition that the IEEE 2800-2022 standard may be limited to new interconnections with some mechanism for grandfathering, this NOGRR requires all Resources, even grandfathered ones, to undergo an annual review of what commercially reasonable efforts can be taken to come into compliance, and proposes an accelerated interconnection process for Resources that choose to re-power. This NOGRR proposes that all IBRs with a Standard Generation Interconnection Agreement (SGIA) executed prior to June 1, 2026 (“existing IBRs”), maximize ride-through capability to meet or exceed the new voltage ride-through profile and the new frequency ride-through profile as soon as practicable if it is commercially reasonable to do so. IBRs that cannot meet the new ride-through requirements will need to submit a report by June 1, 2024 documenting such to give ERCOT an accurate understanding of the physical limitations and maximum ride-through capability. If ERCOT has evidence that a Resource Entity’s review of commercially reasonable efforts to comply is not in good faith, then it must report the entity to the Reliability Monitor.  This compliance date for existing IBRs is in the future, because many original equipment manufacturers (“OEM”) have stated that they are not yet capable of compliance with the IEEE 2800-2022 standard, and in some cases because they were waiting on the development of IEEE 2800.2 before being able to evaluate the ability to comply.  The proposed requirements will help improve several of the major failure modes identified in the Odessa disturbances in 2021 and 2022. Market Participants in the Inverter Based Resource Task Force encouraged ERCOT to focus on enhancements adopting portions of the IEEE 2800-2022 standard or NERC Reliability Guidelines that would provide the most reliability benefit in the short-term rather than a holistic approach. |

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| Revised Proposed Guide Language |

***2.6.2 Frequency Ride-Through Requirements for Generation Resources and Energy Storage Resources***

(1) Except for Generation Resources and Energy Storage Resources (ESRs) subject to Sections 2.6.2.1, Frequency Ride-Through Requirements for Transmission-Connected Inverter-Based Resources (IBRs) or 2.6.2.2, Frequency Ride-Through Requirements for Distribution Generation Resources (DGRs) and Distribution Energy Storage Resources (DESRs), if under-frequency relays are installed and activated to trip the Generation Resource or ESR, these relays shall perform such that the automatic removal of individual Generation Resources or ESRs from the ERCOT System meets or exceeds the following requirements:

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| --- | --- |
| **Frequency Range** | **Delay to Trip** |
| Above 59.4 Hz | No automatic tripping  (continuous operation) |
| Above 58.4 Hz up to  and including 59.4 Hz | Not less than 9 minutes |
| Above 58.0 Hz up to  and including 58.4 Hz | Not less than 30 seconds |
| Above 57.5 Hz up to  and including 58.0 Hz | Not less than 2 seconds |
| 57.5 Hz or below | No time delay required |

(2) Except for Generation Resources subject to Sections 2.6.2.1 or 2.6.2.2, if over-frequency relays are installed and activated to trip the Generation Resource or ESR, they shall perform such that the automatic removal of individual Generation Resources or ESRs from the ERCOT System meets or exceeds the following requirements:

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| --- | --- |
| **Frequency Range** | **Delay to Trip** |
| Below 60.6 Hz down to and including 60 Hz | No automatic tripping (continuous operation) |
| Below 61.6 Hz down to and including 60.6 Hz | Not less than 9 minutes |
| Below 61.8 Hz down to and including 61.6 Hz | Not less than 30 seconds |
| 61.8 Hz or above | No time delay required |

(3) If installed and activated to trip a Generation Resource or ESR, frequency protection schemes shall use filtered quantities or add sufficient time delays to prevent misoperations while providing the desired equipment protection. Protection schemes shall not trip a Generation Resource or ESR based on an instantaneous frequency measurement.

(4) This Section shall not affect the Resource Entity’s responsibility to protect Generation Resources or ESRs from damaging operating conditions. The Resource Entity for a Generation Resource or ESR subject to paragraphs (1) and (2) above that is unable to remain reliably connected to the ERCOT System as set forth in paragraphs (1) and (2), shall provide to ERCOT the reason(s) for that inability, including study results or manufacturer advice. The limitation description shall include the Generation Resource’s or ESR’s frequency ride-through capability in the format shown in the tables in paragraphs (1) and (2) above.

***2.6.2.1 Frequency Ride-Through Requirements for Transmission-Connected Inverter-Based Resources (IBRs)***

(1) All IBRs and Type 1 and Type 2 Wind-powered Generation Resources (WGRs) interconnected to the ERCOT Transmission Grid shall ride through the frequency conditions at the IBR’s Point of Interconnection Bus (POIB) specified in the following table:

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| --- | --- |
| Frequency (f) in (Hz) | Minimum Ride-Through Time  (seconds) |
| f > 61.8 | May ride-through or trip |
| 61.6 < f ≤ 61.8 | 299 |
| 61.2 < f ≤ 61.6 | 540 |
| 58.8 ≤ f ≤ 61.2 | continuous |
| 58.4 ≤ f < 58.8 | 540 |
| 57.0 ≤ f < 58.4 | 299 |
| f < 57.0 | May ride-through or trip |

(2) Nothing in paragraph (1) above shall be interpreted to require an IBR or Type 1 WGR or Type 2 WGR to trip for frequency conditions beyond those for which ride-through is required.

(3) If installed and activated to trip the IBR or Type 1 WGR or Type 2 WGR, all protection systems (including, but not limited to protection for over-/under-frequency, rate-of-change of frequency, anti-islanding, and phase angle jump) shall enable the IBR or Type 1 WGR or Type 2 WGR to ride through frequency conditions beyond those defined in paragraph (1) above to the maximum extent possible. An IBR or Type 1 WGR or Type 2 WGR shall ride through frequency excursions during which ride-through is required and the absolute rate-of-change of frequency magnitude does not exceed 5.0 Hz/second. The rate-of-change of frequency shall be considered the average rate of change of frequency over a period of at least 0.1 seconds unless ERCOT or the interconnecting Transmission Service Provider (TSP) specifies otherwise.

(4) An IBR or Type 1 WGR or Type 2 WGR shall inject electric current during all periods requiring ride-through.

(5) IBR or Type 1 WGR or Type 2 WGR plant controls or inverter controls shall not disconnect the IBR or Type 1 WGR or Type 2 WGR from the ERCOT System or reduce IBR output during frequency conditions where ride-through is required unless necessary for providing appropriate frequency response or preventing equipment damage.

(6) An IBR or Type 1 WGR or Type 2 WGR with a Standard Generation Interconnection Agreement (SGIA) executed prior to June 1, 2026, must make commercially reasonable efforts to comply with paragraphs (1) through (5) above as soon as practicable.

The Resource Entity or Interconnecting Entity (IE) for an IBR or Type 1 WGR or Type 2 WGR with an SGIA executed prior to June 1, 2026 that cannot comply with paragraphs (1) through (5) above shall, by June 1, 2024 for all IBRs for Type 1 WGRs or Type 2 WGRs with an SGIA executed after January 16, 2014 or by December 1, 2024 for all remaining IBRs or Type 1 WGRs or Type 2 WGRs (or as part of the interconnection process), submit to ERCOT a report and supporting documentation containing the following and in each case, only to the extent such information is reasonably available from the original equipment manufacturers and other parties:

(a) The current IBR or Type 1 WGR or Type 2 WGR frequency ride-through capability in a format similar to the table in paragraph (1) above;

(b) Any known technical limitations on the IBR or Type 1 WGR or Type 2 WGR frequency ride-through capability, to the extent the Resource Entity can reasonably identity them. Such limitations may include general limitations from the manufacturers or other parties;

(c) The proposed commercially reasonable modifications to maximize the IBR or Type 1 WGR or Type 2 WGR frequency ride-through capability and allow the IBR or Type 1 WGR or Type 2 WGR to increase the level of compliance or to comply with the frequency ride-through requirements in paragraphs (1) through (5) above.;

ERCOT may allow an exception to the highest and lowest frequency ride-through bands where an existing IBR or Type 1 WGR or Type 2 WGR with an SGIA executed before June 1, 2026, provides documented evidence from the original equipment manufacturer (or subsequent inverter/turbine vendor support company if original equipment manufacturer is no longer in business) stating no engineering, replacement, or retrofit solutions exist to fully meet the required duration of the lowest and highest frequency ride-through bands in paragraph (1) above if, after maximizing its frequency ride-through capabilities, it can ride through the frequency ride-through band between 57.0 Hz and 58.4 Hz for at least ten seconds and the frequency ride-through band between 61.6 Hz and 61.8 Hz for at least thirty seconds;

(d) A schedule for implementing those modifications as soon as commercially reasonable; and

(e) As contemplated in paragraph (2) of Section 2.6.4, Commercially Reasonable Efforts, the Resource Entity shall update this evaluation by June 1 of each year if there have been any material changes, or alternatively submit an attestation signed by an officer or executive with authority to bind the Resource Entity..



(7) If an IBR or Type 1 WGR or Type 2 WGR fails to perform in accordance with the applicable frequency ride-through requirements, the Resource Entity for the IBR or Type 1 WGR or Type 2 WGR shall investigate the event and report to ERCOT the cause of the failure. The Resource Entity’s investigation must include a diligent review of commercially reasonable efforts to avoid future failures. All impacted TSPs shall provide available information to ERCOT to assist with event analysis.

(8) This Section shall not affect the Resource Entity’s responsibility to protect IBRs or Type 1 WGRs or Type 2 WGRs from damaging operating conditions. The Resource Entity for an IBR or Type 1 WGR or Type 2 WGR subject to paragraph (1) above that is unable to remain reliably connected to the ERCOT System as set forth in paragraph (1), shall provide to ERCOT the reason(s) for that inability, including study results or manufacturer advice. The limitation description shall include the Generation Resource’s or ESR’s frequency ride-through capability in the format shown in the table in paragraph (1) above. Any such IBR or Type 1 WGR or Type 2 WGR that cannot comply with the applicable frequency ride-through requirements must evaluate commercially reasonable efforts needed to comply with the requirements or increase the IBR’s frequency ride-through capabilities as described in Section 2.6.4, Commercially Reasonable Efforts.

(9) An IBR or Type 1 WGR or Type 2 WGR is not required to comply with these requirements if doing so would cause it to violate its Subsynchronous Resonance (SSR) Mitigation plan developed to comply with Protocol Section 3.22.1.2, Generation Resource or Energy Storage Resource Interconnection Assessment.

(10) The addition of a co-located Load that results in the initiation of a Generator Interconnection or Modification (GIM) on or after June 1, 2026 or an amendment to an SGIA on or after June 1, 2026 shall not trigger a change in frequency ride-through requirements. In those cases, the Resource Entity shall continue to be subject to paragraph (6) above using the SGIA date applicable before the amendment.











***2.6.2.2 Frequency Ride-Through Requirements for Distribution Generation Resources (DGRs) and Distribution Energy Storage Resources (DESRs)***

(1) For any short-circuit fault or open-phase condition that occurs on the circuit to which the DGR or DESR is connected, the DGR or DESR will cease to energize and trip offline, and this will take priority over the frequency ride-through function.

(2) DGRs and DESRs must have over-/under-frequency relays set to ride through frequency conditions as specified in the following table:

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| Frequency (Hz) | Ride-Through Mode | Minimum Ride-through Time  (seconds) |
| *f > 61.8* | No ride-through requirements | |
| 61.2 < f ≤ 61.8 | Mandatory Operation | 299 |
| 58.8 ≤ f ≤ 61.2 | Continuous Operation | continuous |
| 57.0 ≤ f < 58.8 | Mandatory Operation | 299 |
| *f < 57.0* | No ride-through requirements | |

(3) Any Resource Entity with a DGR or DESR utilizing inverter-based generation that achieved Initial Synchronization before April 1, 2020 that is not capable of complying with the requirements of paragraph (2) above may request an exemption from those requirements. Such a request shall be submitted by November 2, 2020 and shall include documentation that demonstrates the DGR’s or DESR’s frequency ride-through capability to ERCOT’s satisfaction. If, after reviewing the request and documentation, ERCOT determines the DGR or DESR is not capable of complying with the requirements of paragraph (2), then the DGR or DESR shall be exempt from those requirements, but shall be required to comply with those requirements to the greatest degree possible within its capability, as determined in writing by ERCOT. Upon replacement or retirement of the inverter, the DGR or DESR shall no longer be exempt and shall at that time be required to comply with the requirements of paragraph (2) or other applicable requirement.

**2.6.4 Commercially Reasonable Efforts**

(1) Any references to commercially reasonable efforts in Section 2, System Operations and Control Requirements, is a reference to this Section 2.6.4, Commercially Reasonable Efforts.

(2) Beginning June 1, 2024, a Resource Entity that must consider commercially reasonable efforts to increase the level of compliance with the voltage and frequency ride-through requirements of Section 2, System Operations and Control Requirements, must submit a detailed report as described in paragraph (3) of Section 2.9.1, Voltage Ride-Through Requirements for Transmission-Connected Inverter-Based Resources (IBRs), and paragraph (6) of Section 2.6.2.1, Frequency Ride-Through Requirements for Transmission-Connected Inverter-Based Resources (IBRs), regarding its evaluation of its facilities and what modifications, if any, can be made to its equipment. No later than June 1 of each subsequent year, such Resource Entities must update this evaluation if there have been any material changes, or alternatively submit an attestation signed by an officer or executive with authority to bind the Resource Entity that there have been no material changes since the prior submission.

(3) When considering commercially reasonable efforts, the Resource Entity may consider factors such as the availability and/or cost of firmware or hardware, whether those improvements are technically feasible, the depreciated value of the facility, the cost of capital, the availability of capital, the expected profitability for the remainder of the facility’s expected lifespan, whether the modifications would cause the Resource to be out of compliance with other ERCOT requirements, or any other relevant factor.

(4) If commercially reasonable efforts to increase compliance involve repowering a facility, then ERCOT must make reasonable efforts to reduce the time required for interconnection of the new facility when it is possible to do so.

(5) If a Resource Entity upgrades a Resource to increase its level of compliance, but does not fully comply, those efforts may be considered when evaluating additional modifications. ERCOT, in its sole discretion, may determine that a particular Resource has achieved a sufficient level of compliance so that ongoing commercially reasonable efforts evaluation are no longer necessary.

(6) If ERCOT has evidence that a Resource Entity has not identified commercially reasonable compliance plans, it may refer the Resource Entity to the Reliability Monitor. Evidence may include the filings of other similarly situated Resource Entities, data provided by original equipment manufacturers, or other similar information. Nothing herein requires ERCOT to run its own financial analysis on what is considered a good investment or commercially reasonable. Prior to a referral to the Reliability Monitor, ERCOT shall offer the Resource Entity 45 days to provide any additional relevant information. When ERCOT provides any evidence it used to make a determination to the Reliability Monitor, it must also provide it to the Resource Entity.

(7) All information provided to ERCOT about commercially reasonable efforts or analysis shall be considered as Confidential Information.

**2.9 Voltage Ride-Through Requirements for Generation Resources**

(1) Except for Generation Resources and Energy Storage Resources (ESRs) subject to Sections 2.9.1, Voltage Ride-Through Requirements for Transmission-Connected Inverter-Based Resources (IBRs) and Type 1 and Type 2 Wind-powered Generation Resources (WGRs) , or 2.9.2, Voltage Ride-Through Requirements for Distribution Generation Resources (DGRs) and Distribution Energy Storage Resources (DESRs), each Generation Resource or ESR must remain reliably connected to the ERCOT Transmission Grid during the following:

(a) Generator terminal voltages are within 5% of the rated design voltage and volts per hertz are less than 105% of generator rated design voltage and frequency;

(b) Generator terminal voltage deviations exceed 5% but are within 10% of the rated design voltage and persist for less than ten seconds;

(c) Generator volts per hertz conditions are less than 116% of generator rated design voltage and frequency and last for less than 1.5 seconds;

(d) A transmission system fault (three-phase, single-phase or phase-to-phase), but not a generator bus fault, is cleared by the protection scheme coordinated between the Generation Entity and the Transmission Service Provider (TSP) on any line connected to the generator’s transmission interconnect bus, provided such lines are not connected to induction generators described in paragraph (12) of Protocol Section 3.15, Voltage Support; and

(e) In the case of a generator bus fault or a primary transmission system relay failure, the generator protective relaying may clear the generator independent of the operation of any transmission protective relaying.

(2) During operating conditions listed in paragraph (1) above, each Generation Resource and ESR subject to paragraph (1) shall not, during and following a transient voltage disturbance, cease providing real or reactive current except to the extent needed to provide frequency support or aid in voltage recovery.

(3) Synchronous Generation Resources required to provide Voltage Support Service (VSS) shall have and maintain the following capability:

(a) Over-excitation limiters shall be provided and coordinated with the thermal capability of the generator field winding and protective relays in order to permit short-term reactive capability that allows at least 80% of the unit design standard (ANSI C50.13-1989), as follows:

Time (seconds) 10 30 60 120

Field Voltage % 208 146 125 112

After allowing temporary field current overload, the limiter shall operate through the automatic AC voltage regulator to reduce field current to the continuous rating. Return to normal AC voltage regulation after current reduction shall be automatic. The over-excitation limiter shall be coordinated with the over-excitation protection so over-excitation protection operates only for failure of the voltage regulator/limiter.

(b) Under-excitation limiters shall be provided and coordinated with loss-of-field protection to eliminate unnecessary generating unit disconnection as a result of operator error or equipment malfunction.

(4) Generation Resources and ESRs shall have protective relaying necessary to protect equipment from abnormal conditions and be consistent with protective relaying criteria described in Section 6.2.6.3.4, Generator Protection and Relay Requirements.

(5) The voltage ride-through requirements do not apply to faults between the generator terminals and the transmission voltage side of the Main Power Transformer (MPT), or when clearing the fault effectively disconnects the Generation Resource from the ERCOT System.

(6) A Generation Resource or ESR may be tripped Off-Line or curtailed after the fault clearing period if part of an approved Remedial Action Scheme (RAS).

(7) Each Generation Resource and ESR shall provide to ERCOT technical documentation of voltage ride-through capability upon request.

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| ***[NOGRR204: Replace Section 2.9 above with the following upon system implementation of NPRR989:]***  **2.9 Voltage Ride-Through Requirements for Generation Resources and Energy Storage Resources**  (1) Except for Generation Resources and Energy Storage Resources (ESRs) subject to Sections 2.9.1, Voltage Ride-Through Requirements for Transmission-Connected Inverter-Based Resources (IBRs), or 2.9.2, Voltage Ride-Through Requirements for Distribution Generation Resources (DGRs) and Distribution Energy Storage Resources (DESRs), each Generation Resource and ESR must remain reliably connected to the ERCOT Transmission Grid during the following:  (a) Generator or inverter terminal voltages are within 5% of the rated design voltage and volts per hertz are less than 105% of generator rated design voltage and frequency;  (b) Generator or inverter terminal voltage deviations exceed 5% but are within 10% of the rated design voltage and persist for less than ten seconds;  (c) Generator or inverter volts per hertz conditions are less than 116% of rated design voltage and frequency and last for less than 1.5 seconds; and  (d) A transmission system fault (three-phase, single-phase or phase-to-phase), but not a unit bus fault, is cleared by the protection scheme coordinated between the Resource Entity and the Transmission Service Provider (TSP) on any line connected to the Resource’s Point of Interconnection (POI), provided such lines are not connected to induction generators described in paragraph (12) of Protocol Section 3.15, Voltage Support.  (2) In the case of a unit bus fault or a primary transmission system relay failure, the unit protective relaying may clear the unit independent of the operation of any transmission protective relaying.  (3) During operating conditions listed in paragraph (1) above, each Generation Resource and ESR subject to paragraph (1) shall not, during and following a transient voltage disturbance, cease providing real or reactive current except to the extent needed to provide frequency support or aid in voltage recovery. Each ESR, if it is consuming active power from the ERCOT System when operating in the charging mode, shall reduce or cease power consumption as necessary to aid in voltage recovery during and following transient voltage disturbances.  (4) Synchronous Generation Resources required to provide Voltage Support Service (VSS) shall have and maintain the following capability:  (a) Over-excitation limiters shall be provided and coordinated with the thermal capability of the generator field winding and protective relays in order to permit short-term reactive capability that allows at least 80% of the unit design standard (ANSI C50.13-1989), as follows:  Time (seconds) 10 30 60 120  Field Voltage % 208 146 125 112  After allowing temporary field current overload, the limiter shall operate through the automatic AC voltage regulator to reduce field current to the continuous rating. Return to normal AC voltage regulation after current reduction shall be automatic. The over-excitation limiter shall be coordinated with the over-excitation protection so over-excitation protection operates only for failure of the voltage regulator/limiter.  (b) Under-excitation limiters shall be provided and coordinated with loss-of-field protection to eliminate unnecessary generating unit disconnection as a result of operator error or equipment malfunction.  (5) Generation Resources and ESRs shall have protective relaying necessary to protect equipment from abnormal conditions and be consistent with protective relaying criteria described in Section 6.2.6.3.4, Generation Resource and Energy Storage Resource Protection and Relay Requirements.  (6) The voltage ride-through requirements do not apply to faults at or behind the POI, when clearing the fault effectively disconnects the Resource from the ERCOT System.  (7) A Generation Resource or ESR may be tripped Off-Line or curtailed after the fault clearing period if part of an approved Remedial Action Scheme (RAS).  (8) Each Generation Resource and ESR shall provide to ERCOT technical documentation of voltage ride-through capability upon request. |

***2.9.1 Voltage Ride-Through Requirements for Transmission-Connected*** ***Inverter-Based Resources (IBRs)***

(1) Except as specified below, all Inverter-Based Resources (IBRs) and Type 1 WGRs and Type 2 WGRs interconnected to the ERCOT Transmission Grid shall comply with voltage ride-through requirements as follows:

(a) Section 2.9.1.1, Voltage Ride-Through Requirements for Transmission-Connected Inverter-Based Resources (IBRs) shall apply to:

(i) IBRs with a Standard Generation Interconnection Agreement (SGIA) executed on or after June 1, 2026.

(ii) IBRs that implement any modification, as described in paragraph (1)(c) of Planning Guide Section 5.2.1, Applicability, for which a Generator Interconnection or Modification (GIM) was initiated on or after June 1, 2026.

(iii) Any other IBR or Type 1 WGR or Type 2 WGR, subject to paragraph (3) below.

(2) IBRs: (i) with an SGIA executed on or after June 1, 2026 or (ii) that implement any modification, as described in paragraph (1)(c) of Planning Guide Section 5.2.1, Applicability, for which a GIM was initiated on or after June 1, 2026, shall meet or exceed the capability and performance requirements in the following sections of Institute of Electric Engineers (IEEE) 2800-2022, Standard for Interconnection and Interoperability of Inverter-Based Resources (IBRs) Interconnecting with Associated Transmission Electric Power Systems “IEEE 2800-2022 standard” or any successor IEEE standard, including any intra-standard cross references or definitions, unless otherwise clarified, modified, or exempted in the ERCOT Protocols, these Operating Guides, or Planning Guide:

(a) Section 5, Reactive power-voltage control requirements within the continuous operation region;

(b) Section 7, Response to TS abnormal conditions; and

(c) Section 9, Protection.

All IBR plant requirements and all IBR unit requirements described in the IEEE 2800-2022 standard apply at the Point of Interconnection Bus (POIB) and the individual inverter based unit terminal respectively unless otherwise clarified, modified, or exempted in the ERCOT Protocols.

ERCOT and the interconnecting TSP may exempt an IBR from Section 7.2.2.3.5, including Table 13, of the IEEE 2800-2022 standard when studies indicate a slower response time may be required or if the IBR may not be able to meet response times noted in Table 13 for certain system conditions, or when meeting the requirements in Table 13 would negatively impact other performance requirements of greater importance. If so, greater response time and settling time are allowed with mutual agreement among an IBR owner, ERCOT and the interconnecting TSP.

(3) An IBR or Type 1 WGR or Type 2 WGR with an SGIA executed prior to June 1, 2026 must make commercially reasonable efforts to comply with paragraphs (1) through (8) of Section 2.9.1.1, Voltage Ride-Through Requirements for Transmission-Connected IBRs, as soon as practicable.

The Resource Entity or Interconnecting Entity (IE) for an IBR or Type 1 WGR or Type 2 WGR with an SGIA executed prior to June 1, 2026 that cannot comply with the voltage ride-through requirements above shall, by June 1, 2024 for IBRs or Type 1 or Type 2 WGRs with an SGIA executed after January 16, 2014, or by December 1, 2024 for all remaining IBRs or Type 1 WGRs or Type 2 WGRs (or as part of the interconnection process), submit to ERCOT a report and supporting documentation containing the following, and in each case, only to the extent such information is reasonably available from the manufacturers or other parties:

(a) The current IBR or Type 1 WGR or Type 2 WGR voltage ride-through capability in a format specified by ERCOT;

(b) Any known technical limitations on the IBR or Type 1 WGR or Type 2 WGR’s voltage ride-through capability, to the extent the Resource Entity can reasonably identify them. Such limitations may include general limitations from the manufacturer and other parties;

(c) The proposed commercially reasonable modifications, if any, to maximize the IBR or Type 1 WGR or Type 2 WGR voltage ride-through capability and allow the IBR or Type 1 WGR or Type 2 WGR to increase the level of compliance or to comply with the voltage ride-through requirements in Section 2.9.1, Voltage Ride-Through Requirements for Transmission-Connected Inverter-Based Resources (IBRs), and Section 2.9.1.1, Voltage Ride-Through Requirements for Transmission-Connected Inverter-Based Resources (IBRs);

(d) A schedule for implementing those modifications as soon as commercially reasonable.

(e) As contemplated in paragraph (2) of Section 2.6.4, Commercially Reasonable Efforts, the Resource Entity shall update this evaluation by June 1 of each subsequent year if there have been any material changes, or alternatively submit an attestation signed by an officer or executive with authority to bind the Resource Entity that there have been no material changes since the prior submission.

(4) An IRR that interconnects to the ERCOT Transmission Grid pursuant to a SGIA (i) executed on or before January 16, 2014 and (ii) under which the IRR provided all required financial security to the TSP on or before January 16, 2014, is not required to meet any high voltage ride-through requirement greater than 1.1 per unit voltage unless the interconnected IRR includes one or more turbines that differ from the turbine model(s) described in the SGIA (including any attachment thereto), as that agreement existed on January 16, 2014. Notwithstanding the foregoing, if the Resource Entity that owns or operates an IRR that was interconnected pursuant to an SGIA executed before January 16, 2014, under which the IRR provided all required financial security to the TSP on or before January 16, 2014, demonstrates to ERCOT’s satisfaction that the high voltage ride-through capability of the IRR is not lower than the capability of the turbine model(s) described in the SGIA (including any attachment thereto), as that agreement existed on January 16, 2014, that IRR is not required to meet the high voltage ride-through requirement in this Section.

(5) An IRR that interconnects to the ERCOT System pursuant to an SGIA executed prior to November 1, 2008 is not required to meet voltage ride-through requirements presented in this Section. However, any Wind-powered Generation Resource (WGR) that is installed on or after November 1, 2008 and that initially synchronizes with the ERCOT System, pursuant to an SGIA (i) executed on or before January 16, 2014, and (ii) under which the IRR provided all required financial security to the TSP on or before January 16, 2014 (except for an IRR installed pursuant to an SGIA executed before November 1, 2008) shall be voltage ride-through capable in accordance with the low voltage ride-through requirements in this Section and high-voltage requirements in this Section up to 1.1 per unit voltage unless the interconnected IRR includes one or more turbines that differ from the turbine model(s) described in the SGIA (including any attachment thereto), as that agreement existed on January 16, 2014 in which case the IRR shall also be required to comply with the high voltage ride-through requirements of this Section, subject to the exemption described in paragraph (a), above.

(6) This Section shall not affect the Resource Entity’s responsibility to protect IBRs or Type 1 WGRs or Type 2 WGRs from damaging operating conditions. The Resource Entity for an IBR or Type 1 WGR or Type 2 WGR unable to remain reliably connected to the ERCOT System as set forth in Section 2.9.1.1, including those subject to paragraphs (4) and (5) above, shall provide to ERCOT the reason(s) for that inability, including study results or manufacturer advice. The limitation description shall include the Generation Resource or ESR voltage ride-through capability in the format specified by ERCOT. Any such IBR or Type 1 WGR or Type 2 WGR that cannot comply with the applicable voltage ride-through requirements must evaluate commercially reasonable efforts needed to comply with the requirements or increase voltage ride-through capabilities as described in Section 2.6.4, Commercially Reasonable Efforts.

(7) An IBR or Type 1 WGR or Type 2 WGR is not required to comply with the voltage-ride through requirements above if doing so would cause it to violate its Subsynchronous Resonance (SSR) Mitigation plan developed to comply with Protocol Section 3.22.1.2, Generation Resource or Energy Storage Resource Interconnection Assessment.

(8) The addition of co-located load that results in the initiation of a GIM on or after June 1, 2026 or an amendment to a SGIA on or after June 1, 2026 shall not trigger a change in voltage ride-through requirements. In those cases, the Resource Entity shall continue to be subject to paragraph (3) of above, using the SGIA date applicable before the amendment.

***2.9.1.1 Voltage Ride-Through Requirements for Transmission-Connected*** ***Inverter-Based Resources (IBRs)***

(1) All IBRs subject to this Section in accordance with paragraph (1) of Section 2.9.1, Voltage Ride-Through Requirements for Transmission-Connected Inverter-Based Resources (IBRs) and Type 1 and Type 2 WGRs, shall ride through the root-mean-square voltage conditions in Tables A or B below, as applicable, and the instantaneous phase voltage conditions in Table C below, as measured at the IBR’s Point of Interconnection Bus (POIB):

**Table A: Applicable to WGR IBRs**

|  |  |
| --- | --- |
| Root-Mean-Square Voltage  (p.u. of nominal) | Minimum Ride-Through Time  (seconds) |
| V > 1.20 | May ride-through or trip |
| 1.10 < V ≤ 1.20 | 1.0 |
| 0.90 ≤ V ≤ 1.10 | continuous |
| 0.70 ≤ V < 0.90 | 3.0 |
| 0.50 ≤ V < 0.70 | 2.5 |
| 0.25 ≤ V < 0.50 | 1.2 |
| V < 0.25 | 0.16 |

**Table B: Applicable to PhotoVoltaic Generation Resources (PVGRs) and ESR IBRs**

|  |  |
| --- | --- |
| Root-Mean-Square Voltage  (p.u. of nominal) | Minimum Ride-Through Time  (seconds) |
| V > 1.20 | May ride-through or trip |
| 1.10 < V ≤ 1.20 | 1.0 |
| 0.90 ≤ V ≤ 1.10 | continuous |
| 0.70 ≤ V < 0.90 | 6.0 |
| 0.50 ≤ V < 0.70 | 3.0 |
| 0.25 ≤ V < 0.50 | 1.2 |
| V < 0.25 | 0.32 |

In the event of multiple excursions, the minimum ride-through time in Tables A or B is a cumulative time over a ten second time window.

**Table C**

|  |  |
| --- | --- |
| Instantaneous Phase-to-Phase or Phase-to-Ground Voltage  (p.u. of nominal) | Minimum Ride-Through Time  (milliseconds) |
| V > 1.80 | May ride-through or trip |
| 1.70 < V ≤ 1.80 | 0.2 |
| 1.60 < V ≤ 1.70 | 1.0 |
| 1.40 < V ≤ 1.60 | 3.0 |
| 1.20 < V ≤ 1.40 | 15.0 |

The instantaneous voltages in Table C above are the residual voltages with surge arrestors, if applied. During the conditions identified in Table C, an IBR should continue injecting current, but need not respond to the sub-cycle transient overvoltage. If required by equipment limitations, the IBR may operate in current blocking mode when instantaneous voltage exceeds 1.20 p.u. at the POIB. If the IBR operates in current blocking mode, it shall restart current exchange in less than or equal to five cycles following instantaneous voltage falling below, and remaining below, 1.2 p.u. at the POIB. In the event of multiple excursions, the minimum ride through time in Table C is a cumulative time over a one minute time window.

(2) Nothing in paragraph (1) above shall be interpreted to require an IBR to trip for voltage conditions beyond those for which ride-through is required.

(3) If installed and activated to trip the IBR, all protection systems (including, but not limited to protection for over-/under-voltage, rate-of-change of frequency, anti-islanding, and phase angle jump) shall enable the IBR to ride through voltage conditions beyond those defined in paragraph (1) above to the maximum extent possible.

(4) An IBR shall inject electric current during all periods requiring ride-through. When the POIB voltage is outside the continuous operating voltage range, an IBR shall continue to deliver pre-disturbance active current unless reduction is needed to allow for voltage support or otherwise specified by ERCOT or the interconnecting TSP. Any necessary reductions in active current to prioritize reactive current shall be relative to the voltage change at the POIB. Typically, more aggressive reductions in active current to allow for additional reactive current (if needed to stay within its current limitations) will occur at lower voltages (e.g., 0.4 pu or lower) but settings should be made based on the local needs of the ERCOT system where the IBR interconnects and ensures sufficient active current is available for protection system sensing. active An IBR shall return to its pre-disturbance level of real power injection as soon as possible but no more than one second after POIB voltage recovers to normal operating range.

(5) IBR plant controls or inverter controls shall not disconnect the IBR from the ERCOT System or reduce IBR output during voltage conditions where ride-through is required unless necessary to provide appropriate frequency response or prevent equipment damage.

(6) If installed and activated to trip the IBR, instantaneous over-current or over-voltage protection systems shall use filtered quantities to prevent misoperation while providing the desired equipment protection. Any instantaneous over-voltage protection that could disrupt IBR power output shall use a measurement window of at least one cycle of fundamental frequency.

(7) The IBR shall ride through multiple excursions outside the continuous operation range in Tables A or B in paragraph (1) above as applicable, unless the conditions and situations specified below exist, in which case the IBR may trip to protect equipment from the cumulative effect of successive voltage deviations:

(a) More than four voltage deviations at the POIB outside the continuous operation range within any ten second period.

(b) More than six voltage deviations at the POIB outside the continuous operation range within any 120 second period.

(c) More than ten voltage deviations at the POIB outside the continuous operation range within any 1,800 second period.

(d) Voltage deviations outside of continuous operation range following the end of a previous deviation outside of continuous operation range by less than twenty cycles of system fundamental frequency.

(e) More than two individual voltage deviations at the POIB below 50% of the nominal voltage (including zero voltage) within any ten second period.

(f) More than three individual voltage deviations at the POIB below 50% of the nominal voltage (including zero voltage) within any 120 second period.

(g) Individual wind turbines may trip for consecutive voltage deviations resulting in stimulation of mechanical resonances exceeding equipment limits.

Individual voltage deviations begin when the voltage at the POIB drops below the lower limit of the continuous operation range or exceeds the upper limit of the continuous operation range. Individual voltage deviations end when the root-mean-square voltage magnitude at the POIB, for the previous one-cycle period of fundamental frequency, returns to the continuous operation region.

(8) An IBR shall ride-through any grid disturbance during which ride-through is required and the positive-sequence angle change within a sub-cycle-to-cycle time frame does not exceed 25 electrical degrees. In addition, the IBR shall ride-through any change in the phase angle of individual phases caused by occurrence and clearance of unbalanced faults, provided the positive-sequence angle change does not exceed the stated criterion. Positively damped active and reactive current oscillations in the post-disturbance period are acceptable in response to phase angle changes.

(9) In its sole and reasonable discretion, ERCOT may allow a temporary extension to allow for upgrades or retrofits to confirm capability specified in paragraphs (7) and (8) above if the Resource Entity or IE provides documented evidence of technical infeasibility from its original equipment manufacturer (or subsequent inverter/turbine vendor support company if the original equipment manufacturer is no longer in business) along with the modifications and the schedule for implementing those modifications. The Resource Entity or IE shall maximize the phase angle jump and multiple excursion ride-through capability within known equipment limitations as soon as practicable. Any temporary extensions shall be minimized and not extend beyond December 31, 2028.

(10) If an IBR fails to perform in accordance with the voltage ride-through requirements of paragraphs (1) through (7) above, the Resource Entity for the IBR shall investigate the event and report to ERCOT the cause of the IBR failure. The Resource Entity’s investigation must include a diligent review of commercially reasonable efforts to avoid future failures. All impacted TSPs shall provide available information to ERCOT to assist with event analysis.

(11) Section 2, System Operations and Control Requirements, shall not affect the Resource Entity’s responsibility to protect Generation Resources, IBRs, or ESRs from damaging operating conditions. The Resource Entity for a Generation Resource, an IBR, or ESR subject to paragraphs (1) and (2) above that is unable to remain reliably connected to the ERCOT System as set forth in paragraphs (1) and (2), shall provide ERCOT the reason(s) for that inability, including study results or manufacturer advice. The limitation description shall include the Generation Resource’s or ESR’s voltage ride-through capability in the format specified by ERCOT. Any such Generation Resource, IBR, or ESR that cannot comply with the applicable voltage ride-through requirements must evaluate commercially reasonable efforts needed to comply or to increase the voltage ride-through capabilities as described in Section 2.6.4, Commercially Reasonable Efforts.



(12) An IBR is not required to comply with the requirements in Section 2 if doing so would cause it to violate its SSR Mitigation plan developed to comply with Protocol Section 3.22.1.2, Generation Resource or Energy Storage Resource Interconnection Assessment.