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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** | June 22, 2023 |

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| **Market Segment** | Not Applicable |

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| **Comments** |

ERCOT appreciates the feedback stakeholders provided on this Nodal Operating Guide Revision Request (NOGRR) through written comments and discussions in various stakeholder forums. ERCOT files these comments after careful consideration of the feedback received to date. To the extent possible, this proposal attempts to mitigate reliability risk on the ERCOT System stemming from Inverter-Based Resources’ (IBRs’) failure to ride through system disturbances while recognizing concerns raised by stakeholders of the challenges in retroactively applying more robust voltage ride-through curves 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”). Specifically, several commenters stated that the previously proposed requirements could require a large volume of retrofits and pose a significant reliability risk due to substantial retirements of IBRs. Based on this cited risk, ERCOT has significantly reduced retroactive application of the new IEEE 2800-2022 standard ride-through requirements in this revised proposal. However, ERCOT continues to view any proposal granting permanent exemptions from ride-through requirements as an unacceptable reliability risk given the current and increasing level of IBR penetration on the ERCOT System. As such, ERCOT is proposing that all existing IBRs satisfy the current voltage ride-through profile effectively removing any exemptions previously identified in the Nodal Operating Guides.

*Frequency Ride-Through Requirements*

ERCOT’s proposal as reflected in its comments would require IBRs with a Standard Generation Interconnection Agreement (SGIA) executed prior to June 1, 2023 (“existing IBRs”) to comply with the new frequency requirements as soon as practicable but no later than December 31, 2025. In the interim, existing IBRs must follow a temporary set of frequency ride-through provisions that will sunset on January 1, 2026. These provisions follow the current frequency ride-through requirements in the Nodal Operating Guides and require that IBR frequency ride-through capability be maximized to the fullest extent the equipment allows to meet or exceed the frequency ride-through curves (i.e., IBRs should not activate frequency protection if not needed to protect equipment and, if needed, should not be set right on the curve, but should be set at the equipment maximum capability). Existing IBRs that cannot comply with the new requirements must file a report with ERCOT by March 1, 2024 containing proposed modifications to maximize the IBR’s frequency ride-through capability to meet the new requirements and a schedule for implementing those modifications. Additionally, the Resource Entity for an IBR must provide a description of any limitation making it technically infeasible for an IBR to meet the new requirements.

The proposal explicitly expresses ERCOT’s authority to impose operational restrictions on an IBR to mitigate reliability risk. ERCOT may restrict an IBR’s operation or not permit it to operate on the ERCOT System if it cannot comply or fails to perform in accordance with the applicable frequency ride-through requirements. The proposal provides an opportunity - under certain circumstances - for ERCOT to lift such restrictions upon approval of a modification plan to resolve technical limitations or performance failures preventing compliance with the applicable frequency ride-through requirements.

*Voltage Ride-Through Requirements*

ERCOT’s proposal establishes two sets of voltage ride-through requirements. The “preferred” requirements apply to IBRs with an SGIA executed on or after June 1, 2023, any modified IBRs for which a Generator Interconnection or Modification (GIM) was initiated on or after June 1, 2023, and certain IBRs after December 31, 2027. The “legacy” requirements apply to other IBRs with an SGIA executed prior to June 1, 2023. Additionally, for IBRs with an SGIA executed on or after June 1, 2023 and any modified IBR for which a GIM was initiated on or after June 1, 2023, sections 5, 7, and 9 of the IEEE 2800-2022 standard are incorporated by reference.

The legacy provisions establish that existing IBRs must maximize their voltage ride-through capability with existing equipment as soon as practicable but no later than December 31, 2025. Existing IBRs must also submit a report by March 1, 2024 outlining the current and potential future IBR voltage ride-through capability, proposed modifications to maximize the IBR’s voltage ride-through capability and allow the IBR to comply with the new requirements, and a schedule for implementing those modifications. The report must also identify any limitation making it technically infeasible for the IBR to meet the new requirements, and a plan (e.g., the replacement of inverters, turbines, or power converters that would require an IBR to initiate a GIM) to comply with the new requirements no later than December 31, 2027. If based on this information ERCOT determines an IBR cannot comply with all applicable ride-through requirements, including maximizing the ride-through capabilities, ERCOT may restrict the IBR’s operation after December 31, 2025. Any IBR that will be upgraded to meet the “preferred” requirements in Section 2.9.1.1, Preferred Voltage Ride-Through Requirements for Transmission-Connected Inverter-Based Resources (IBRs), may operate without restrictions until December 31, 2027 so long as the IBR does not experience a ride-through failure and the IBR has maximized the ride-through capability on their existing equipment, protection, and controls prior to December 31, 2025.

Similar to the frequency ride-through provisions (and as noted above), ERCOT may restrict an IBR’s operation or not permit it to operate on the ERCOT System if the IBR cannot comply by the required deadlines. Additionally, upon the effective date of the NOGRR, an IBR may be restricted or not permitted to operate if it fails to perform in accordance with the applicable voltage ride-through requirements established by NOGRR245.

In addition to the changes highlighted above, ERCOT has removed language requiring phasor measurement unit and digital fault recorder data for performance failures and will address that topic in a separate NOGRR in the near future.

ERCOT is planning to adopt all IEEE 2800-2022 standard requirements unless otherwise clarified, modified, or exempted in the ERCOT rules. ERCOT encourages developers to consider implementation of the full IEEE 2800-2022 standard capabilities for IBRs when there is no conflict with ERCOT Protocols or Other Binding Documents. ERCOT is proposing that IBRs with an SGIA date on or after June 1, 2023 be designed to satisfy all IEEE 2800-2022 capabilities.

Given the reliability risks, ERCOT urges stakeholders to recommend approval of NOGRR245 as modified without delay. ERCOT remains open to considering minor edits as needed.

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| **Revised Cover Page Language** | |
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| 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)  2.6.2.1.1 Temporary Frequency Ride-Through Requirements for Transmission-Connected Inverter-Based Resources (IBRs) (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 Preferred Voltage Ride-Through Requirements for Transmission-Connected Inverter-Based Resources (IBRs) (new)  2.9.1.2 Legacy Voltage Ride-Through Requirements for Transmission-Connected Inverter-Based Resources (IBRs) (new) |
| 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 intergrated properlywhich could result in high impact and high likelihood events that require substantive action; * 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 significant risk to bulk power system reliability; * Analyzed events identified new performance issues such as momentary cessation, unwarranted inverter or plant-level tripping issues, controller interactions and instabilities, and other critical 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.   Consequently, 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. As such, ERCOT does not propose to grandfather existing IBRs indefinitely. Rather, ERCOT proposes that all IBRs with a Standard Generation Interconnection Agreement (SGIA) executed prior to June 1, 2023 (“existing IBRs”), maximize ride-through capability to meet or exceed the current voltage ride-through profile and the new frequency ride-through profile as soon as practicable but no later than December 31, 2025. IBRs that cannot meet the new ride-through requirements will need to submit a report by March 1, 2024 documenting such and provide a mitigation plan to give ERCOT an accurate understanding of the physical limitations and maximum ride-through capability. To minimize the reliability risk on the ERCOT System, this proposal stipulates existing IBRs that experience a ride-through failure or cannot meet the applicable ride-through requirements may be restricted or not be permitted to operate on the ERCOT System. An IBR that will be replaced to meet voltage ride-through requirements consistent with the IEEE 2800-2022 standard, may operate without restrictions until the end of 2027 provided it does not experience any ride-through failures.  ERCOT believes 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. As such, additional requirements on IBRs may be necessary based on additional event analyses, lessons learned, recommendations contained in the NERC Odessa 2022 report, IEEE requirements, and NERC Reliability Standard revisions. |

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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 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 to trip for frequency 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-frequency, rate-of-change of frequency, anti-islanding, and phase angle jump) shall enable the IBR to ride through frequency conditions beyond those defined in paragraph (1) above to the maximum extent possible. An IBR 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 shall inject electric current during all periods requiring ride-through.

(5) IBR plant controls or inverter controls shall not disconnect the IBR from the ERCOT System or reduce IBR output during frequency conditions where ride-through is required unless necessary for providing appropriate frequency response or prevent equipment damage. If an IBR requires any setting that would prevent it from riding through the frequency conditions as required in paragraph (1) above, the IBR operation may be restricted as set forth in paragraph (8) below.

(6) An IBR with a Standard Generation Interconnection Agreement (SGIA) executed prior to June 1, 2023, must comply with paragraphs (1) through (5) above as soon as practicable but no later than December 31, 2025. Such IBRs shall comply with the frequency ride-through requirements specified in Section 2.6.2.1.1, Temporary Frequency Ride-Through Requirements for Transmission-Connected Inverter-Based Resources (IBRs). until the IBR implements changes to comply with paragraphs (1) through (5).

The Resource Entity or Interconnecting Entity (IE) for an IBR with an SGIA executed prior to June 1, 2023 that cannot comply with paragraphs (1) through (5) above shall, by March 1, 2024, submit to ERCOT a report and supporting documentation containing the following:

(a) The current and potential future IBR frequency ride-through capability (including any associated adjustments to improve frequency ride-through capability) in a format similar to the table in paragraph (1) above;

(b) The proposed modifications to maximize the IBR frequency ride-through capability and allow the IBR to comply with the frequency ride-through requirements in paragraphs (1) through (5) above;

(c) A schedule for implementing those modifications as soon as practicable but no later than December 31, 2025; and

(d) Any limitations on the IBR’s frequency ride-through capability making it technically infeasible to meet the requirements in paragraphs (1) through (5) above.

Based on the information provided by the Resource Entity or IE, if ERCOT determines in its sole and reasonable discretion an IBR cannot comply with all applicable frequency ride-through requirements, the IBR operation may be restricted as set forth in paragraph (8) below.

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| ***[NOGRR245: Replace paragraph (6) above with the following on January 1, 2026.]***  (6) The Resource Entity or Interconnecting Entity (IE) for an IBR with a Standard Generation Interconnection Agreement (SGIA) executed prior to June 1, 2023 that cannot comply with Section 2.6.2.1 paragraphs (1) through (5) shall, by March 1, 2024, submit to ERCOT a report and supporting documentation containing the following:  (a) The current and potential future IBR frequency ride-through capability (including any associated adjustments to improve frequency ride-through capability) in a format similar to the table in paragraph (1) above;  (b) The proposed modifications to maximize the IBR frequency ride-through capability and/or allow the IBR to comply with the frequency ride-through requirements in Section 2.6.2.1 paragraphs (1) through (5);  (c) A schedule for implementing those modifications as soon as practicable but no later than December 31, 2025; and  (d) Any limitations on the IBR’s frequency ride-through capability making it technically infeasible to meet the requirements in Section 2.6.2.1 paragraphs (1) through (5).  Based on the information provided by the Resource Entity or Interconnecting Entity, if ERCOT determines in its sole and reasonable discretion that an IBR cannot comply with all applicable frequency ride-through requirements, the IBR operation may be restricted as set forth in paragraph (8) below. |

(7) If an IBR fails to perform in accordance with the applicable frequency ride-through requirements, the IBR operation may be restricted as set forth in paragraph (8) below. Additionally, the Resource Entity for the IBR shall investigate the event and report to ERCOT the cause of the IBR’s failure. All impacted TSPs shall provide available information to ERCOT to assist with event analysis.

(8) Any IBR that cannot comply with the applicable frequency ride-through requirements may be restricted or may not be permitted to operate on the ERCOT System unless ERCOT, in its sole and reasonable discretion, allows it to do so. Each Qualified Scheduling Entity (QSE) shall, for each IBR not permitted to operate, reflect in its Current Operating Plan (COP) and Real-Time telemetry a Resource Status of OFF, OUT, or EMR in accordance with Protocol Sections 3.9.1, Current Operating Plan (COP) Criteria, and 6.5.5.1, Changes in Resource Status, as appropriate. If the Resource Entity can implement IBR modifications to resolve the technical limitations or performance failures preventing compliance with applicable frequency ride-through requirements, the Resource Entity shall submit to ERCOT a report and supporting documentation containing the following:

(a) The current technical limitations and IBR frequency ride-through capability in a format similar to the table in paragraph (1) above;

(b) The proposed modifications and frequency ride-through capability allowing the IBR to comply with the frequency ride-through requirements in a format similar to the table in paragraph (1) above; and

(c) A schedule for implementing those modifications.

In its sole and reasonable discretion, ERCOT may accept the proposed modification plan. Upon completion of the accepted modification plan, ERCOT will remove the restrictions placed on the IBR unless the IBR experiences additional unresolved technical limitations or performance failures. ERCOT may allow the IBR to operate at reduced output prior to the implementation of an accepted modification plan if the reduced output allows the IBR to comply with the applicable ride-through requirements.

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

(1) This Section applies only to certain IBRs with an SGIA executed prior to June 1, 2023 in accordance with paragraph (6) of Section 2.6.2.1, Frequency Ride-Through Requirements for Transmission-Connected Inverter-Based Resources (IBRs).

(2) If under-frequency relays are installed and activated to trip the Generation Resource or ESR, the 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 |

(3) 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:

|  |  |
| --- | --- |
| **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 |

(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 (2) and (3) above that is unable to remain reliably connected to the ERCOT System as set forth in paragraphs (2) and (3), 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 (2) and (3) above.

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| ***[NOGRR245: Delete Section 2.6.2.1.1 above on January 1, 2026.]*** |

***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.

**2.9 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), 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) All Inverter-Based Resources (IBRs) interconnected to the ERCOT Transmission Grid shall comply with voltage ride-through requirements as follows:

(a) Section 2.9.1.1, Preferred 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, 2023.

(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, 2023.

(iii) Certain IBRs after December 31, 2027 in accordance with paragraph (8) of Section 2.9.1.2, Legacy Voltage Ride-Through Requirements for Transmission-Connected Inverter-Based Resources (IBRs).

(b) Section 2.9.1.2 shall apply to IBRs not subject to Section 2.9.1.1.

(2) IBRs: (i) with an SGIA executed on or (ii) after June 1, 2023 or 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, 2023, 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 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 standard are to be applied 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.

***2.9.1.1 PreferredVoltage 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), 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 Wind-powered Generation Resource (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 (PVGR) 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. 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.

(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 otherwise limited due to its current limit. Unless otherwise specified by ERCOT or the interconnecting TSP, an IBR shall minimize reductions in active current while maintaining robust reactive current response. Any necessary reductions in active current to prioritize reactive current shall be proportional to the voltage change at the POIB. 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. If an IBR requires any setting that would prevent it from riding through a voltage event as required in paragraph (1) above, the IBR operation may be restricted as set forth in paragraph (9) below.

(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 zone within any ten second period.

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

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

(d) Voltage deviations outside of continuous operation zone following the end of a previous deviation outside of continuous operation zone 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) If an IBR fails to perform in accordance with the voltage ride-through requirements of paragraphs (1) through (7) above, the IBR operation may be restricted as set forth in paragraph (9) below. Additionally, the Resource Entity for the IBR shall investigate the event and report to ERCOT the cause of the IBR failure. All impacted TSPs shall provide available information to ERCOT to assist with event analysis.

(9) Any IBR that cannot comply with the voltage ride-through requirements of paragraphs (1) through (7) above, may be restricted or may not be permitted to operate on the ERCOT System unless ERCOT, in its sole and reasonable discretion, allows it to do so. Each Qualified Scheduling Entity (QSE) shall, for each IBR not permitted to operate, reflect in its Current Operating Plan (COP) and Real-Time telemetry a Resource Status of OFF, OUT, or EMR in accordance with Protocol Sections 3.9.1, Current Operating Plan (COP) Criteria and 6.5.5.1, Changes in Resource Status, as appropriate. If the Resource Entity can implement IBR modifications to resolve the technical limitations or performance failures preventing compliance with applicable voltage ride-through requirements, the Resource Entity shall submit to ERCOT a report and supporting documentation containing the following:

(a) The current technical limitations and IBR voltage ride-through capability in a format similar to the tables in paragraph (1) above;

(b) The proposed modifications and voltage ride-through capability allowing the IBR to comply with the voltage ride-through requirements in a format similar to the tables in paragraph (1) above; and

(c) A schedule for implementing those modifications.

In its sole and reasonable discretion, ERCOT may accept the proposed modification plan. Upon completion of the accepted modification plan, ERCOT will remove the restrictions placed on the IBR unless the IBR experiences additional unresolved technical limitations or performance failures. ERCOT may allow the IBR to operate at reduced output prior to the implementation of an accepted modification plan if the reduced output allows the IBR to comply with the applicable ride-through requirements.

***2.9.1.2 Legacy 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), shall ride through the root-mean-square voltage conditions in Table A below as measured at the IBR’s Point of Interconnection Bus (POIB):

**Table A**

|  |  |
| --- | --- |
| Root-Mean-Square Voltage  (p.u. of nominal) | Minimum Ride-Through Time  (seconds) |
| V > 1.20 | May ride-through or may trip |
| 1.175 < V ≤ 1.2 | 0.2 |
| 1.15 < V ≤ 1.175 | 0.5 |
| 1.10 < V ≤ 1.15 | 1.0 |
| 0.90 ≤ V ≤ 1.10 | continuous |
| 0.0 < V < 0.90 | (V+0.084375)/0.5625 |
| V = 0.0 | 0.15 |

For voltage between zero and 0.9 pu the minimum ride-through time in Table A above is defined by a straight line mathematical function where the duration is 0.15 seconds at zero voltage and 1.75 seconds at 0.9 pu voltage. In the event of multiple excursions, the minimum ride-through time in Table A is a cumulative time over ten seconds.

(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. 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.

(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 otherwise limited due to its current limit. Unless otherwise specified by ERCOT or the interconnecting TSP, an IBR shall minimize reductions in active current while maintaining robust reactive current response. Any necessary reductions in active current to prioritize reactive current shall be proportional to the voltage change at the POIB. 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 for providing appropriate frequency response, or to prevent equipment damage. If an IBR requires any setting that would prevent it from riding through voltage conditions as required in paragraph (1) above, the IBR operation may be restricted as set forth in paragraph (10) below.

(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 period of at least one cycle (of fundamental frequency).

(7) The IBR shall ride through multiple excursions outside the continuous operation range in Table A in paragraph (1) above, 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 zone within any ten second period.

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

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

(d) Voltage deviations outside of continuous operation zone following the end of a previous deviation outside of continuous operation zone 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) The Resource Entity or Interconnecting Entity (IE) for each IBR shall maximize voltage ride-through capability with existing equipment as soon as practicable but no later than December 31, 2025, and shall by March 1, 2024, submit to ERCOT a report and supporting documentation containing the following:

(a) The current and potential future IBR voltage ride-through capability (including any associated adjustments to improve voltage ride-through capability) in a format similar to Table A in paragraph (1) above;

(b) The proposed modifications to maximize the IBR voltage ride-through capability and allow the IBR to comply with the voltage ride-through requirements in paragraphs (1) through (7) above;

(c) A schedule for implementing those modifications as soon as practicable but no later than December 31, 2025;

(d) Any limitations on the IBR’s voltage ride-through capability making it technically infeasible to meet the requirements in paragraphs (1) through (7) above; and

(e) A plan (e.g., replacing inverters, turbines, or power converters, etc.) to comply with the voltage ride-through requirements of Section 2.9.1.1, Preferred Voltage Ride-Through Requirements for Transmission-Connected Inverter-Based Resources (IBRs), as soon as practicable but no later than December 31, 2027 for any IBR that will be unable to comply with all of the requirements of paragraphs (1) through (7) above by December 31, 2025.

Based on the information provided by the Resource Entity or IE, if ERCOT determines in its sole and reasonable discretion an IBR cannot comply with all applicable voltage ride-through requirements, the IBR operation may be restricted after December 31, 2025 as set forth in paragraph (10) below. Any IBR that will be upgraded pursuant to paragraph (8)(e) above, may operate without restrictions until December 31, 2027, if it does not have any subsequent ride-through failures according to the voltage ride-through requirements of paragraphs (1) through (7) above.

(9) If an IBR fails to perform in accordance with the voltage ride-through requirements of paragraphs (1) through (7) above, the IBR operation may be restricted as set forth in paragraph (10) below. Additionally, the Resource Entity for the IBR shall investigate the event and report to ERCOT the cause of the IBR failure. All impacted TSPs shall provide available information to ERCOT to assist with event analysis.

(10) Any IBR that cannot comply with the voltage ride-through requirements of paragraphs (1) through (7) above, may be restricted or may not be permitted to operate on the ERCOT System unless ERCOT, in its sole and reasonable discretion, allows it to do so. Each QSE shall, for each IBR not permitted to operate, reflect in its Current Operating Plan (COP) and Real-Time telemetry a Resource Status of OFF, OUT, or EMR in accordance with Protocol Sections 3.9.1, Current Operating Plan (COP) Criteria and 6.5.5.1, Changes in Resource Status, as appropriate. If the Resource Entity can implement IBR modifications to resolve the technical limitations or performance failures preventing compliance with applicable voltage ride-through requirements, the Resource Entity shall submit to ERCOT a report and supporting documentation containing the following:

(a) The current technical limitations and IBR voltage ride-through capability in a format similar to Table A in paragraph (1) above;

(b) The proposed modifications and voltage ride-through capability allowing the IBR to comply with the voltage ride-through requirements in a format similar to Table A in paragraph (1) above; and

(c) A schedule for implementing those modifications.

In its sole and reasonable discretion, ERCOT may accept the proposed modification plan. Upon completion of the accepted modification plan, ERCOT will remove the restrictions placed on the IBR unless the IBR experiences additional unresolved technical limitations or performance failures. ERCOT may allow the IBR to operate at reduced output prior to the implementation of an accepted modification plan if the reduced output allows the IBR to comply with the applicable ride-through requirements.