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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** | August 18, 2023 |

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| **Submitter’s Information** | |
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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. ERCOT proposes the following comments and requirement changes to better address feasibility concerns raised by original equipment manufacturers and clarifications requested by stakeholders regarding the applicability to Type 1 and Type 2 Wind-powered Generation Resources (WGRs).

To the extent possible, this proposal still attempts to mitigate reliability risk on the ERCOT System stemming from Inverter-Based Resources’ (IBRs’) (and Type 1 and 2 WGRs) failure to ride through system disturbances while recognizing stakeholder concerns regarding 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”). ERCOT believes the changes proposed in these comments allow greater technical feasibility while significantly increasing ride-through capabilities.

While several commenters continue to state the previously proposed requirements could require a large number of retrofits and pose a significant reliability risk due to potential retirements of Resources because of the technical infeasibility, ERCOT’s discussions with major wind turbine original equipment manufacturers indicate the proposed revisions should allow far wider adoption of original equipment manufacturers solutions for their equipment. ERCOT agrees with the original equipment manufacturers’ comments that Resource Entities must ensure the remainder of the plant can comply with the requirements because NOGRR245 identifies the necessary coordination of controls, protective relays, and inverter/turbine controls to ensure ride-through capability can be achieved.

*Type 1 and Type 2 WGRs*

Existing requirements in Sections 2.6.2, Generators and Energy Storage Resources and 2.9, Voltage Ride-Through Requirements for Generation Resources, apply to all Generation Resources. ERCOT agrees with the other commenters’ clarification that Type 1 (squirrel-cage induction generator directly connected to the step-up transformer) and Type 2 (wound rotor induction generators directly connected to the step-up transformer) WGRs are not IBRs. Under the current provisions in paragraph (1)(b) of Section 2.9.1, Voltage Ride-Through Requirements for Intermittent Renewable Resources Connected to the ERCOT Transmission Grid, all Type 1 and 2 WGRs with a Standard Generation Interconnection Agreement (SGIA) executed prior to November 1, 2008 are exempt from the requirement to set generator voltage relays as illustrated in Figure 1 of Section 2.9.1. There are approximately 1395 MW of Type 1 WGR capacity and 625 MW of Type 2 WGR capacity in the ERCOT Region today. The technology is outdated and ERCOT knows of no plans to install additional Type 1 and Type 2 WGRs in the ERCOT Region.

However, Type 1 and Type 2 WGRs have contributed to events on the ERCOT System by failing to ride through normal system disturbances. This fact, combined with those WGRs being located close to known stability limits, causes ERCOT to continue believing Type 1 and Type 2 WGRs should have to ride through the same normal system disturbances as IBRs for system reliability. Failure to ride through normal system disturbances contributes to - or exacerbates - the impacts of an event up to and including uncontrolled loss of firm Load on the ERCOT System. ERCOT proposes clarifying the requirements to apply to Type 1 and Type 2 WGRs that would allow them to ride-through normal system disturbances.

Further, ERCOT recognizes that due to the inherent challenges related to Type 1 and Type 2 WGRs being able ride-through normal system disturbances, additional flexibility in mitigating that risk should be allowed. ERCOT proposes that dynamic reactive Resources or co-located Energy Storage Resources (ESRs) with proper configuration and capabilities, could be used as an option to offset the loss of real power and Reactive Power contribution to the ERCOT System.

*Frequency Ride-Through Requirements*

ERCOT’s proposal clarifies that the frequency ride-through requirements apply to Type 1 WGRs and Type 2 WGRs.

After visiting with several wind turbine original equipment manufacturers, ERCOT recognizes that some of the oldest Type 3 WGRs may not be able to meet all of ERCOT’s proposed frequency ride through requirements. While they could meet the frequency ride-through band requirements, they cannot meet the duration component. To address this issue, ERCOT proposes exemptions for the duration component if the Resource Entity provides ERCOT appropriate documentation from the original equipment manufacturer of the Resource’s inability to meet the duration requirement. This exclusion should allow wider adoption of the frequency ride-through requirements without a significant reduction in reliability because the outermost band and the capability to ride through several seconds is still available. Significant additional capability will be available when ride through capability is maximized for all other bands compared to current capability.

Finally, ERCOT is extending the deadline for Type 1 and Type 2 WGRs to provide the required report on capability in proposed paragraph (6) of Section 2.6.2.1, Frequency Ride-Through Requirements for Transmission-Connected Inverter-Based Resources (IBRs) and Type 1 and Type 2 Wind-powered Generation Resources (WGRs) as requested by some stakeholders.

*Voltage Ride-Through Requirements*

ERCOT’s proposal clarifies that the voltage ride-through requirements apply to Type 1 and Type 2 WGRs.

Discussions with several original equipment manufacturers highlighted several retrofit or setting change solutions that would significantly enhance voltage ride through above current capabilities but not meet 100% of the IEEE-2800-2022 standard voltage ride-through performance curves. ERCOT proposes edits to allow exceptions to meeting the full set of requirements in Sections 5, 7 and 9 of the IEEE 2800-2022 standard for retrofits or repowers implemented before January 1, 2028.

ERCOT also provides an exemption 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 IBRs cannot meet response times noted in Table 13 for certain system conditions. A greater response time and settling time are allowed with mutual agreement among an IBR owner, ERCOT and the Transmission Service Provider (TSP).

Also, to facilitate efficient adoption of the voltage ride-through requirements, ERCOT proposes allowing specific extensions for some of the oldest Type 3 WGRs to meet the phase angle jump and multiple fault ride-through requirements. Original equipment manufacturers have indicated those requirements are the most challenging for Type 3 WGRs and suggested providing additional time for implementation before restrictions to allow them to focus on easier adjustments sooner for a majority of the Type 3 WGRs. ERCOT still proposes holding IBRs accountable for failing to perform in accordance with the legacy IBR requirements, which could include restricting operations to ensure ERCOT can quickly and effectively remove that reliability risk from the ERCOT System.

ERCOT is providing additional clarifying edits to the expected active current response during a fault to recognize that some IBRs may utilize multiple break points to prioritize more aggressively reactive current over active current if the voltage deviation at the Point of Interconnection Bus (POIB) gets very low. ERCOT recognizes that additional coordination of those settings may be needed depending on the system strength and other characteristics to minimize frequency deviation while ensuring robust reactive response and protection system sensing current while not causing over-voltage or over-current issues.

Finally, ERCOT is providing additional time for the required report on capability in proposed paragraph (10) of Section 2.9.1.2, Legacy Voltage Ride-Through Requirements for Transmission-Connected Inverter-Based Resources (IBRs) and Type 1 and Type 2 Wind-Powered Generation Resources (WGRs), as requested by some stakeholders.

Given the reliability risks to the ERCOT System created by Resources’ failure or inability to ride-through voltage or frequency excursions, ERCOT urges stakeholders to recommend approval of NOGRR245 as modified in these comments without delay. ERCOT seeks to have NOGRR245 considered by the ERCOT Board at its October 17, 2023 meeting.

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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) and Type 1 and Type 2 Wind-Powered Generation Resources (WGRs) (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) and Type 1 and Type 2 Wind-Powered Generation Resources (WGRs) (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) and Type 1 and Type 2 Wind-Powered Generation Resources (WGRs) (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 Type 1 and Type 2 Wind-powered Generation Resources (WGRs) and provides new frequency ride-through requirements for IBRs and Type 1 and 2 WGRs 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”). |
| Business Case | ERCOT submits this NOGRR based on reliability issues associated with the inability of some IBRs or Type 1 WGRs or Type 2 WGRs 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 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 Electric System.   Consequently, this NOGRR proposes ride-through requirements for IBRs and Type 1 and Type 2 WGRs 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 some ESRs may not be IBRs and the IBR attributes create unique ride-through requirements. Additionally, due to Type 1 and 2 WGRs failing to ride through normal system disturbances, ERCOT proposes to apply several of the new requirements to these Resources. 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 and Type 1 and Type 2 WGRs 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 which would result in the uncontrolled loss of firm Load. As such, ERCOT does not propose to grandfather existing IBRs and Type 1 and Type 2 WGRs indefinitely. Rather, ERCOT proposes that all IBRs and Type 1 and Type 2 WGRs 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 and Type 1 and Type 2 WGRs that cannot meet the new ride-through requirements will need to submit a report by June 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 and Type 1 and Type 2 WGRs that experience a ride-through failure or cannot meet the applicable ride-through requirements may be restricted or not permitted to operate on the ERCOT System. An IBR or Type 1 WGR or Type 2 WGR that will be replaced or retrofitted to meet voltage ride-through requirements, 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 as well as numerous other ride-through failure events. 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) and Type 1 and Type 2 Wind-Powered Generation Resources (WGRs) 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) and Type 1 and Type 2 Wind-Powered Generation Resources (WGRs)***

(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) An 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 its output during frequency conditions where ride-through is required unless necessary for providing appropriate frequency response or preventing equipment damage. If an IBR or Type 1 WGR or Type 2 WGR requires any setting that would prevent it from riding through the frequency conditions required in paragraph (1) above, the IBR or Type 1 WGR or Type 2 WGR operation may be restricted as set forth in paragraph (8) below.

(6) An IBR or Type 1 WGR or Type 2 WGR 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 or Type 1 WGR or Type 2 WGR 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) and Type 1 and Type 2 Wind-Powered Generation Resources (WGRs), until the IBR or Type 1 WGR or Type 2 WGR implements changes to comply with paragraphs (1) through (5) above.

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, 2023 that cannot comply with paragraphs (1) through (5) above shall, (1) by June 1, 2024 for all IBRs or Type 1 WGRs or Type 2 WGRs with an SGIA executed after January 16, 2014 or (2) by December 1, 2024 for all remaining IBRs or Type 1 WGRs or Type 2 WGRs, submit to ERCOT a report and supporting documentation containing the following:

(a) The current and potential future IBR or Type 1 WGR or Type 2 WGR 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 or Type 1 WGR or Type 2 WGR frequency ride-through capability and allow it 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 or Type 1 WGR or Type 2 WGR frequency ride-through capability making it technically infeasible to meet the requirements in paragraphs (1) through (5) above with documentation from the IBR or Type 1 WGR or Type 2 WGR original equipment manufacturer (or subsequent inverter/turbine vendor support company if the original equipment manufacturer is no longer in business) attesting there are no engineering, replacement, or retrofit solutions available, if applicable.

Based on the information provided by the Resource Entity or IE, if ERCOT determines, in its sole and reasonable discretion, an IBR or Type 1 WGR or Type 2 WGR cannot comply with all applicable frequency ride-through requirements, ERCOT may restrict operation of the IBR or Type 1 WGR or Type 2 WGR as set forth in paragraph (8) below.

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, 2023, 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.

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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 or Type 1 WGR or Type 2 WGR with a Standard Generation Interconnection Agreement (SGIA) executed prior to June 1, 2023 that cannot comply with paragraphs (1) through (5) above shall, (1) by June 1, 2024 for all IBRs with an SGIA executed after January 16, 2014 or (2) by December 1, 2024 for all remaining IBRs or Type 1 WGRs or Type 2 WGRs, submit to ERCOT a report and supporting documentation containing the following:  (a) The current and potential future IBR or Type 1 WGR or Type 2 WGR 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 or Type 1 WGR or Type 2 WGR frequency ride-through capability and allow it 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 or Type 1 WGR or Type 2 WGR frequency ride-through capability making it technically infeasible to meet the requirements in paragraphs (1) through (5) above with documentation from the IBR or Type 1 WGR or Type 2 WGR original equipment manufacturer (or subsequent inverter/turbine vendor support company if the original equipment manufacturer is no longer in business) attesting there are no engineering, replacement, or retrofit solutions available, if applicable.  Based on the information provided by the Resource Entity or IE, if ERCOT determines in its sole and reasonable discretion an IBR or Type 1 WGR or Type 2 WGR cannot comply with all applicable frequency ride-through requirements, ERCOT may restrict operation of the IBR or Type 1 WGR or Type 2 WGR as set forth in paragraph (8) below.  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, 2023, 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. |

(7) If an IBR or Type 1 WGR or Type 2 WGR fails to perform in accordance with the applicable frequency ride-through requirements, ERCOT may restrict the IBR or Type 1 WGR or Type 2 WGR operation as set forth in paragraph (8) below. Additionally, 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. All impacted TSPs shall provide available information to ERCOT to assist with event analysis.

(8) ERCOT may restrict, or not permit to operate, any IBR or Type 1 WGR or Type 2 WGR that cannot comply with the applicable frequency ride-through requirements unless ERCOT, in its sole and reasonable discretion, allows it to do so or if the owner of the IBR or Type 1 WGR or Type 2 WGR has a documented exception described in paragraph (6) above. Each Qualified Scheduling Entity (QSE) shall, for each IBR or Type 1 WGR or Type 2 WGR 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 or Type 1 WGR or Type 2 WGR modifications to resolve the technical limitations or performance failures , it shall submit to ERCOT a report and supporting documentation containing the following:

(a) The current technical limitations and 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) The proposed modifications and frequency ride-through capability allowing the IBR or Type 1 WGR or Type 2 WGR 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 on the IBR or Type 1 WGR or Type 2 WGR unless it experiences additional unresolved technical limitations or performance failures. ERCOT may allow the IBR or Type 1 WGR or Type 2 WGR to operate at reduced output prior to the implementation of an accepted modification plan if the reduced output allows the IBR or Type 1 WGR or Type 2 WGR 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)*** ***and Type 1 and Type 2 Wind-Powered Generation Resources (WGRs)***

(1) This Section applies only to certain IBRs and Type 1 and Type 2 WGRs 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) and Type 1 and Type 2 Wind-Powered Generation Resources (WGRs).

(2) IBRs and Type 1 WGRs and Type 2 WGRs shall ride through the frequency conditions at the POIB specified in the following table:

|  |  |
| --- | --- |
| **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) IBRs and Type 1 WGRs and Type 2 WGRs shall ride through the frequency conditions at the POIB specified in the following table:

|  |  |
| --- | --- |
| **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 equipment from damaging operating conditions. The Resource Entity for an IBR or Type 1 WGR or Type 2 WGR 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 IBR or Type 1 WGR or Type 2 WGR 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:

|  |  |  |
| --- | --- | --- |
| 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) 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) The owner of each Generation Resource or ESR shall provide to ERCOT technical documentation of voltage ride-through capability upon request.

|  |
| --- |
| ***[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) 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 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) The owner of each Generation Resource or 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)and Type 1 and Type 2 Wind-Powered Generation Resources (WGRs)***

(1) All Inverter-Based Resources (IBRs) and Type 1 Wind-powered Generation Resources (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, 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 unless the modification was fully implemented prior to January 1, 2028 to comply with Section 2.9.1.2, Legacy Voltage Ride-Through Requirements for Transmission-Connected Inverter-Based Resources (IBRs) and Type 1 and Type 2 Wind-Powered Generation Resources (WGRs).

(b) Section 2.9.1.2 shall apply to IBRs not subject to Section 2.9.1.1, and Type 1 and Type 2 WGRs.

(2) IBRs with an SGIA executed on or 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 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 “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.

For IBRs with an original SGIA executed before June 1, 2023, any modifications implemented prior to January 1, 2028 for complying with Section 2.9.1.2 as described in paragraph (1)(c) of Planning Guide Section 5.2.1, for which a GIM was initiated are not required to meet or exceed the capability and performance requirements in sections 5, 7 and 9 of the IEEE 2800-2022 standard or any successor IEEE standard that are not required in the Protocols, these Operating Guides, or Planning Guide. Any IBR modifications implemented on after January 1, 2028 do not qualify for this exception.

For any modifications implemented after January 1, 2028, for an IBR with an original SGIA executed before June 1, 2023, ERCOT may in its sole and reasonable discretion, allow limited exceptions to the voltage ride through requirements in Table 11 of the IEEE 2800-2022 standard or successor IEEE standard for Type 3 WGRs that implement a repower modification as described in paragraph (1)(c) of Planning Guide Section 5.2.1, for which a GIM was initiated. The Resource Entity or Interconnecting Entity (IE) must have provided 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) that it maximized its voltage ride-through capability with the best available converter upgrade along with the repower and demonstrates it meets most of the low voltage ride-through curve portions in Table 11 of the IEEE 2800-2022 standard or successor IEEE standard as part of the repower modification.

Type 1 and Type 2 WGRs are not required to meet or exceed the capability and performance requirements in sections 5, 7 and 9 of the IEEE 2800-2022 standard or any successor IEEE standard but must meet or exceed the capability and performance requirements in Section 2.9.1.2.

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. If so, greater response time and settling time are allowed with mutual agreement among an IBR owner, ERCOT and the interconnecting TSP.

***2.9.1.1 Preferred 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 Wind-Powered Generation Resources (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 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 Resource (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.

(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. 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 (12) 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 the 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) An IBR shall ride-through any 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 unbalanced faults, provided the positive-sequence angle change does not exceed 25 electrical degrees. 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) In its sole and reasonable discretion, ERCOT may allow temporary extensions to the voltage ride-through performance Tables A and C in paragraph (1) above for Type 3 WGRs 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. During any temporary extension, the Resource Entity or IE shall maximize its voltage ride-through capability within known equipment limitations as soon as practicable. Any temporary extensions shall be minimized and not extend beyond December 31, 2028. Temporary extensions for performance that do not meet the voltage ride-through performance in Table A in paragraph (1) of Section 2.9.1.2, Legacy Voltage Ride-Through Requirements for Transmission-Connected Inverter-Based Resources (IBRs) and Type 1 and Type 2 Wind-Powered Generation Resources (WGRs), are not allowed.

(11) If an IBR fails to perform in accordance with the voltage ride-through requirements of paragraphs (1) through (8) above, ERCOT may restrict the IBR operation as set forth in paragraph (12) 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.

(12) In its sole and reasonable discretion, ERCOT may restrict or not permit to operate on the ERCOT System any IBR that cannot comply with the voltage ride-through requirements of paragraphs (1) through (8) above. 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 voltage ride-through capability in a format similar to the tables in paragraph (1) above;

(b) The planned 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 unless the IBR experiences additional unresolved technical limitations or performance failures. ERCOT may allow the IBR to operate at reduced output prior to 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) and Type 1 and Type 2 Wind-Powered Generation Resources (WGRs)***

(1) All IBRs and Type 1 and Type 2 WGRs 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 Wind-Powered Generation Resources (WGRs) shall ride through the root-mean-square voltage conditions in Table A below as measured at the IBR’s 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 or Type 1 WGR or Type 2 WGR to trip for voltage 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-voltage, 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 voltage conditions beyond those defined in paragraph (1) above to the maximum extent possible.

(4) An IBR or Type 1 WGR or Type 2 WGR shall inject electric current during all periods requiring ride-through. When the POIB voltage is outside the continuous operating voltage range, an IBR or Type 1 WGR or Type 2 WGR shall continue to deliver pre-disturbance active current unless reduction is needed 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 shall be based on the local needs of the area of the ERCOT System to which the IBR interconnects and ensure sufficient active current is available for protection system sensing. An IBR or Type 1 WGR or Type 2 WGR 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) Plant controls, turbine controls, or inverter controls shall not disconnect the IBR or Type 1 WGR or Type 2 WGR from the ERCOT System or reduce its output during voltage conditions where ride-through is required unless necessary to provide appropriate frequency response or prevent equipment damage. If an IBR or Type 1 WGR or Type 2 WGR requires any setting that would prevent it from riding through voltage conditions as required in paragraph (1) above, ERCOT may restrict the IBR or Type 1 WGR or Type 2 WGR as set forth in paragraph (12) below.

(6) If installed and activated to trip the IBR or Type 1 WGR or Type 2 WGR, 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 power output shall use a measurement period of at least one cycle (of fundamental frequency).

(7) The IBR or Type 1 WGR or Type 2 WGR 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, it 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 20 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 range.

(8) An IBR or Type 1 WGR or Type 2 WGR shall ride-through any 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 or Type 1 WGR or Type 2 WGR shall ride-through any change in the phase angle of individual phases caused by unbalanced faults, provided the positive-sequence angle change does not exceed 25 electrical degrees. 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 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 original equipment manufacturer is no longer in business) along with the modifications and the schedule for implementing those modifications. During any temporary extension, the Resource Entity or IE shall maximize its phase angle jump and multiple excursion ride-through capability within its known equipment limitations as soon as practicable. Any temporary extensions shall be minimized and not extend beyond December 31, 2028.

(10) The Resource Entity or IE for each IBR or Type 1 WGR or Type 2 WGR shall maximize voltage ride-through capability with existing equipment capability as soon as practicable but no later than December 31, 2025 and shall (1) by June 1, 2024 for all IBRs with an SGIA executed after January 16, 2014 or (2) by December 1, 2024 for all remaining IBRs or Type 1 WGRs or Type 2 WGRs, submit to ERCOT a report and supporting documentation containing the following:

(a) The current and potential future 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 voltage ride-through capability and allow compliance with the applicable voltage ride-through requirements in paragraphs (1) through (8) above;

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

(d) Any limitations on voltage ride-through capability making it technically infeasible to meet the requirements in paragraphs (1) through (8) above; and

(e) A plan (e.g., replacing inverters, turbines, or power converters, etc.) to comply with the voltage ride-through requirements of paragraphs (1) through (6) above as soon as practicable, but no later than December 31, 2027, for any IBR that has documented a technical infeasibility to comply with all requirements of paragraphs (1) through (6) by December 31, 2025.

(f) A plan (e.g., replacing turbines, power converters, installing supplemental dynamic reactive devices, etc.) to comply with the voltage ride-through requirements of paragraphs (1) through (6) above as soon as practicable, but no later than December 31, 2027, for any Type 1 WGR or Type 2 WGR that has documented a technical infeasibility to comply with the requirements of paragraphs (1) through (6) by December 31, 2025.

(g) A plan for upgrades or retrofits to confirm capability specified in paragraphs (7) and (8) above as soon as practicable, but no later than December 31, 2028, for any IBR or Type 1 WGR or Type 2 WGR that has documented a technical infeasibility to confirm compliance with the requirements of paragraphs (7) and (8) 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 or Type 1 WGR or Type 2 WGR cannot comply with all applicable voltage ride-through requirements, ERCOT may restrict operation of the IBR or Type 1 WGR or Type 2 WGR after December 31, 2025 as set forth in paragraph (12) below. Any IBR or Type 1 WGR or Type 2 WGR that will be upgraded pursuant to paragraph (10)(e) or (10)(f) above, may operate without restrictions until December 31, 2027 if it does not have any subsequent ride-through failures. Any IBR or Type 1 WGR or Type 2 WGR that will be upgraded pursuant to paragraph (10)(g) above may operate without restrictions until December 31, 2028 if it does not have any subsequent ride-through failures.

ERCOT, in its sole and reasonable discretion, may allow mitigation plans where a Resource Entity or IE for a Type 1 WGR or Type 2 WGR installs supplemental dynamic reactive resources or an ESR that can provide sufficient leading and lagging dynamic Reactive Power to meet all Reactive Power requirements and the applicable ride-through requirements.

(11) If an IBR or Type 1 WGR or Type 2 WGR (including any supplemental dynamic reactive resource) fails to perform in accordance with the voltage ride-through requirements, ERCOT may restrict its operation as set forth in paragraph (12) below. Additionally, the Resource Entity or IE shall investigate the event and report to ERCOT the cause of the failure. All impacted TSPs shall provide available information to ERCOT to assist with event analysis.

(12) In its sole and reasonable discretion, ERCOT may restrict or not permit to operate on the ERCOT System any IBR or Type 1 WGR or Type 2 WGR (including any supplemental dynamic reactive resource) that cannot comply with the voltage ride-through requirements. The QSE for an IBR or Type 1 WGR or Type 2 WGR not permitted to operate shall 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 modifications to resolve the technical limitations or performance failures, it shall submit to ERCOT a report and supporting documentation containing the following:

(a) The current technical limitations and 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 affected Resource 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 unless the Resource experiences additional unresolved technical limitations or performance failures. ERCOT may allow the IBR or Type 1 WGR or Type 2 WGR to operate at reduced output prior to the implementation of an accepted modification plan if the reduced output allows the Resource to comply with the applicable ride-through requirements.