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| NOGRR Number | [255](https://www.ercot.com/mktrules/issues/NOGRR255) | NOGRR Title | High Resolution Data Requirements |
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| **Date** | January 4, 2024 |
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| **Submitter’s Information** |
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| Cell Number | 512-426-4721 |
| Market Segment | Not Applicable |

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| Comments |

ERCOT submits the comments which build upon the 12/4/23 AEPSC comments.. The 12/4/23 AEPSC comments incorporated the 11/1/23 ERCOT comments and included additional edits that further synchronize with future North American Electric Reliability Corporation (NERC) Reliability Standard PRC-028 changes that the Standard drafting team have worked on and captured additional feedback that aligned with review discussions from the System Protection Working Group (SPWG). ERCOT has also reviewed the comments provided by all other commenters since the 11/1/23 ERCOT comments to incorporate any revisions it could support.

ERCOT does not support further delay of the adoption of this Nodal Operating Guide Revision Request (NOGRR) as some commenters have proposed. Federal Energy Regulatory Commission (FERC) Order 901, paragraph 85 highlighted the urgency and impact of such data.

“We further agree with the findings in NERC reports (e.g., a lack of high-speed data captured at the IBR or plant-level controller and low-resolution time stamping of inverter sequence of event recorder information has hindered event analysis) and direct NERC through its standard development process to address these findings.”

Many of the requirements for disturbance monitoring equipment already exist today, but these changes will help ensure consistency and availability of this critical information to event analysis staff. ERCOT has already agreed to defer language around certain phasor measurement unit streaming to ERCOT to a separate NOGRR. ERCOT also agrees to defer the language around the inverter unit level disturbance monitoring equipment so that the remainder of this NOGRR is not further delayed. ERCOT believes this addresses most concerns raised by generator owners. ERCOT will submit an additional NOGRR in the coming months to resynchronize that specific language to PRC-028, including the requirements around shunt dynamic reactive devices not currently captured in this NOGRR. Having additional disturbance monitoring equipment installed at the plant level for units that do not currently have that equipment installed is of high value and should begin without delay. Adjustments or upgrades to the triggers, duration, and resolutions required should also begin without delay to ensure the needed data is available.

These comments also modify the AEPSC proposed implementation timelines from three calendar years for 50% implementation and six calendar years for 100% implementation to two and four years, respectively. ERCOT has removed the term “calendar” to clarify that the deadline is two or four years from the Public Utility Commission of Texas (PUCT) approval date and not potentially greater than that (e.g. a PUCT approval date of April 11, 2024 could be interpreted as a December 31, 2026 deadline rather than April 11, 2026.) ERCOT believes these changes better balance the reliability needs and burden on Market Participants, especially in light of eighteen calendar month timelines in previous revisions related to disturbance monitoring equipment implementations.

These comments add language to accommodate the request in the 12/4/23 EDFR comments to allow units in commercial operation before January 1, 2017 to provide the data in IEEE C37.118.1-2005 format when it is infeasible to meet IEEE C37.118.1-2011 or later formats.

These comments also add language to Section 6.1.4.1.1, Sequence of Events Recording Data Requirements (new), clarifying requirements that align with the most recent PRC-028 draft proposal changes. While ERCOT recognizes that was the intent of from the 12/4/23 SPC and Invenergy comments, their proposed edits did not align with PRC-028 and would fail to capture critical breaker positions that could affect response to a disturbance whether the unit is located on the high or low voltage side of the Main Power Transformer (MPT) or on the feeder systems that make up the Inverter-Based Resource (IBR) plant.

ERCOT agrees to modifying the minimum retention period for disturbance monitoring data from 30 calendar days to 20 calendar days for IBRs to align with PRC-028; however, ERCOT retains the requirement to provide the requested information within 7 calendar days. The information is critical for event analysis and ERCOT has repeatedly encountered issues with entities providing data correctly and having to re-collect the data. It makes no sense to allow more time to provide the data than the retention time period. ERCOT believes the retention period should always allow for two or more times the time period to provide the data to account for errors in retrieving this critical data. Therefore, ERCOT maintains a 7 calendar day requirement (from the request date) to provide to ERCOT the requested information. ERCOT believes the language proposed in the 12/4/23 AEPSC comments balance the reliability needs and burden on Market Participants and reflect practical experience in the issues and timelines currently used in event analysis and, as such, ERCOT does not support timelines proposed by other generator owners because they do not maintain such balance. ERCOT will comment to the PRC-028 Standard drafting team accordingly.

ERCOT does not support removing the required frequency measurement for fault recording data and applicable binary status in Section 6.1.4.1.2, Fault Recording Data and Triggering Requirements, as proposed in the 12/4/23 SPC and Invenergy comments. As detailed in discussions around NOGRR245, Inverter-Based Resource (IBR) Ride-Through Requirements, and previous IBR events, unnecessary frequency protection trips is a known issue for IBR ride-through performance failures and, as such, should remain in the performance measurements. Additionally, paragraph (1)(b)(iii) of Nodal Operating Guides Section 6.1.3.3, Data Recording and Redundancy Requirements, already contains the requirement. ERCOT similarly retains the rate-of-change-of-frequency (df/dt) requirement in Section 6.1.4.3, Phasor Measurement Unit Equipment Requirements, as rate-of-change-of-frequency issues could potentially occur outside the two-second recording window of a fault recorder. For applicable binary status, these are the typical digital signals (true/false flags) permissible for relay or logic included with multifunction relays and other fault recording equipment to allow the engineer to align trip signals to the fault conditions during analysis. This critical information should remain in the requirements, aligning with Section 6.1.2.3, Fault Recording and Sequence of Events Recording Data Requirements, for non-IBR generator owners and should also apply to IBR generation owners. ERCOT will comment to the PRC-028 Standard drafting team accordingly.

ERCOT has further reduced the time synchronization requirements from those proposed in IEEE 2800 Table 19 (<1 microsecond) to align with the latest version of PRC-028 SDT (+/- 100 microseconds) and with language proposed in the 12/4/23 SPC and Invenergy comments.

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| **Revised Cover Page Language** |

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| Nodal Operating Guide Sections Requiring Revision  | 6.1, Disturbance Monitoring Requirements6.1.1, Introduction6.1.2, Fault Recording and Sequence of Events Recording Equipment6.1.2.1. Fault Recording Requirements6.1.2.2 Fault Recording and Sequence of Events Recording Equipment Location Requirements6.1.2.3, Fault Recording and Sequence of Events Recording Data Requirements6.1.2.4, Fault Recording and Sequence of Events Recording Data Retention and Reporting Requirements6.1.3, Phasor Measurement Recording Equipment Including Dynamic Disturbance Recording Equipment6.1.3.1, Dynamic Disturbance Recording Equipment Requirements (new)6.1.3.1, Recording and Triggering Requirements6.1.3.2, Location Requirements6.1.3.3, Data Recording and Redundancy Requirements6.1.3.4, Data Retention and Data Reporting Requirements6.1.3.2, Phasor Measurement Unit Requirements (new)6.1.3.2.1, Recording Requirements (new)6.1.3.2.2, Location Requirements (new)6.1.3.2.3, Data Recording and Redundancy Requirements (new)6.1.3.2.4, Data Retention and Data Reporting Requirements (new)6.1.4, Fault Recording, Sequence of Events Recording, and Phasor Measurement Unit Requirements for Inverter-Based Resources (IBRs) (new)6.1.4.1, Fault Recording and Sequence of Events Recording Equipment Requirements (new)6.1.4.1.1, Sequence of Events Recording Data Requirements (new)6.1.4.1.2, Fault Recording Data and Triggering Requirements (new)6.1.4.3, Phasor Measurement Unit Equipment Requirements (new)6.1.4.4, Data Retention and Data Reporting Requirements of Fault Recording, Sequence of Events Recording, and Phasor Measurement Unit Equipment (new)6.1.4, Maintenance and Testing Requirements6.1.5, Equipment Reporting Requirements6.1.6, Review Process8, Attachment M, Selecting Buses for Capturing Sequence of Events Recording and Fault Recording Data |

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| Revised Proposed Guide Language |

6.1 Disturbance Monitoring Requirements

(1) Disturbance monitoring equipment includes sequence of events recording equipment, fault recording equipment, dynamic disturbance recording equipment, and phasor measurement units.

(a) Sequence of events equipment includes any device capable of recording circuit breaker position (open/close) or other identified status points that allows analysis of the root cause of a dynamic disturbance based on the order of occurrence of events.

(b) Fault recording equipment captures data associated with an abnormal event on the system, such as phase-to-phase faults, phase-to-ground faults, etc. and includes digital fault recorders, certain protective relays, fault recording-capable meters, and some dynamic disturbance recording equipment.

(c) Dynamic disturbance recording equipment captures incidents that represent behavior of the power system during dynamic events, such as low frequency oscillations, abnormal under/over frequency, voltage excursions and system-wide transients. Some dynamic disturbance recording equipment can also serve as a phasor measurement unit.

(d) Phasor measurement involves measuring time synchronized phasors, frequency, and rate of change of frequency of the power system with accuracy in the order of one microsecond and is typically performed by a digital relay, fault recording equipment or dedicated phasor measurement unit.

6.1.1 Introduction

(1) Disturbance monitoring is necessary to:

(a) Determine performance of the ERCOT System;

(b) Determine effectiveness of protective relaying systems;

(c) Verify ERCOT System models;

(d) Determine causes of ERCOT System disturbances (trips, faults, and protective relay system actions);

(e) Determine causes of Generation Resource and Energy Storage Resource (ESR) ride-through performance failures and loss of Load events; and

(f) Meet the requirements of North American Reliability Corporation (NERC) Reliability Standards.

(2) To ensure ERCOT has adequate data for these activities, ERCOT establishes the disturbance monitoring requirements and procedures in these Operating Guides for the following:

(a) Fault recording, sequence of events recording, phasor measurement, and dynamic disturbance recording equipment owners; and

(b) Transmission Service Providers (TSPs) and Resource Entities with equipment for recording Geomagnetic Disturbance (GMD) data, including Geomagnetically-Induced Current (GIC) monitors and/or magnetometers for recording geomagnetic field data.

6.1.1.1 Applicability

(1) Section 6.1.2, Fault Recording and Sequence of Events Recording Equipment, and its subsections apply to all facilities that are not Inverter-Based Resource (IBR) facilities.

(2) Section 6.1.3, Dynamic Disturbance Recording Equipment Including Phasor Measurement Unit Equipment, and its subsections apply to all facilities that are not Inverter-Based Resource (IBR) facilities.

(3) Section 6.1.4, Fault Recording, Sequence of Events Recording, and Phasor Measurement Unit Requirements for Inverter-Based Resources (IBRs), and its subsections apply to IBR facilities.

6.1.2 Fault Recording and Sequence of Events Recording Equipment

(1) Fault recording equipment includes digital fault recorders, certain protective relays, meters with fault recording capability, and dynamic disturbance recording equipment meeting the associated requirements in this Section.

(2) Sequence of events recording equipment includes any device capable of recording circuit breaker position (open/close) or other identified status points meeting the associated requirements in this Section.

(3) Required fault recording shall be time synchronized with a Global Positioning System-based clock, or ERCOT-approved alternative, with sub-cycle (+/-2 microsecond) timing accuracy and performance of Coordinated Universal Time (UTC), with or without a local time offset for Central Prevailing Time (CPT).

(4) Required sequence of events recording equipment shall be time synchronized with a Global Positioning System-based clock, or ERCOT-approved alternative, with +/- 2 millisecond timing accuracy and performance of Coordinated Universal Time (UTC), with or without a local time offset for Central Prevailing Time (CPT).

6.1.2.1 Fault Recording Requirements

(1) Fault recording equipment shall meet the following requirements:

(a) Triggering for the following:

(i) Neutral (residual) overcurrent of 0.2 p.u. or less of rated current transformer secondary current;

(ii) Any phase under-voltage below 0.85 p.u. for two cycles or longer; or any phase overcurrent above the equipment’s maximum emergency current rating; or protective relay tripping for all protection groups;

(iii) Deviations to the above triggering minimum requirements must be reviewed and approved by ERCOT.

(iv) Additional triggering beyond the minimums above are allowed and do not require review and approval by ERCOT.

(b) Minimum recording rate of 16 samples per cycle; and

(c) A single record or multiple records that include a pre-trigger record length of at least two cycles and a total record length of at least 60 cycles for the same trigger point.

6.1.2.2 Fault Recording and Sequence of Events Recording Equipment Location Requirements

(1) The location criteria listed below apply to Transmission Facilities operated at or above 100 kV unless otherwise specified. The Facility owner shall install fault recording and sequence of events recording equipment at the following locations, at a minimum:

(a) Locations identified by the Transmission Facility owner utilizing the methodology in Section 8, Attachment M, Selecting Buses for Capturing Sequence of Events Recording and Fault Recording Data;

(b) Additional locations selected at the Transmission Facility owner’s discretion, utilizing the methodology in Section 8, Attachment M;

(c) Locations operating at or above 60 kV, as defined below.

(i) Interconnections with Control Areas outside the ERCOT Region;

(ii) Substations where electrical transfers can be made between the ERCOT Control Area and a Control Area outside the ERCOT Region;

(iii) All switchyards owned by a Generation Resource or ESR connected to the ERCOT System with an aggregated gross generating nameplate capacity above 100 MVA or at the remote line terminals of each generating station switchyard.

(d) For any individual Load consisting of one or more Facilities at a single site with an aggregate peak Demand greater than or equal to 20 MW that has experienced an abnormal trip or load reduction (including if caused by a Distribution Generation Resource (DGR), Distribution Energy Storage Resource (DESR), or Settlement Only Distribution Generator (SODG)) after a fault:

(i) ERCOT may require the installation of fault recording and sequence of events recording equipment;

(ii) The interconnecting Transmission Service Provider (TSP) or Distribution Service Provider (DSP) shall install the recording equipment’

(iii) A suitable location for the recording equipment will be coordinated between ERCOT and the interconnecting TSP or DSP;

(iv) The recording equipment will be installed as soon as practicable, but no longer than 18 months after ERCOT notifies the TSP or DSP it must install the equipment, unless ERCOT provides an extension;

(v) If the TSP or DSP determines that the recording equipment installation is infeasible due to engineering, technical or operational reasons, it will provide such rationale to ERCOT for consideration.

(e) For any individual Load consisting of one or more Facilities at a single site with an aggregate peak Demand greater than or equal to 75 MW behind one or more common Points of Interconnection (POIs) or Service Delivery Points:

(i) ERCOT may require the installation of fault recording and sequence of events recording equipment;

(ii) The interconnecting TSP or DSP shall install the recording equipment;

(iii) A suitable location for the recording equipment will be coordinated between ERCOT and the interconnecting TSP or DSP;

(iv) The recording equipment will be installed as soon as practicable, but no longer than 18 months after ERCOT notifies the TSP or DSP it must install the equipment, unless ERCOT provides an extension; and

(v) If the TSP or DSP determines that the recording equipment installation is infeasible due to engineering, technical or operational reasons, it will provide such rationale in writing to ERCOT for consideration.

(2) Facility owners shall install the fault recording and sequence of events recording equipment identified in paragraph (1) above as soon as practicable.

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| ***[NOGRR255: Replace paragraph (2) above with the following no earlier than <Insert Date at least two years after PUCT approval> and renumber accordingly:]***(2) Facility owners shall have at least 50% of the new fault recording and sequence of events recording equipment identified in paragraph (1) above installed. |

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| ***[NOGRR255: Delete paragraph (2) no earlier than <Insert Date at least four years after PUCT approval> and renumber accordingly:]*** |

(3) For any Generation Resource or ESR that has experienced an abnormal trip or power reduction after a fault, ERCOT may require the installation of fault recording and sequence of events recording equipment and the Resource Facility owner shall install the fault recording and sequence of events recording equipment at an ERCOT-specified location as soon as practicable but no longer than 18 months after ERCOT notifies the Facility owner it must install the equipment, unless the requestor provides and extension.

(4) For any identified location requiring fault recording and/or sequence of events recording where the Facility to be monitored (line, transformer, circuit breaker, bus, etc.) is owned by another Entity, and the identifying Facility owner is not recording the required data, then:

(a) The identifying Facility owner shall notify the other Facility owner of the requirement to monitor that Facility within 90 calendar days of finalizing the list of locations to be monitored; and

(b) The notified Facility owner shall have two years from the notification date to install the required monitoring equipment.

6.1.2.3 Fault Recording and Sequence of Events Recording Data Requirements

(1) Each Transmission Facility owner and Generation Resource owner shall have fault recording data to determine the following electrical quantities for each triggered fault recording for the locations specified in Section 6.1.2.2, Fault Recording and Sequence of Events Recording Equipment Location Requirements:

(a) Phase-to-neutral voltage for each phase of each specified bus with two sets of substation voltage measurements for breaker-and-a-half and ring bus substation configurations and one set of substation voltage measurements for each bus in other substation configurations.

(b) For transmission lines, each phase current and neutral (residual) current; and

(c) For transformers with a low-side operating voltage of 100kV or above, each phase current and the neutral (residual) current. These phase currents can be from either the high-side or low-side of the transformer.

(2) Each Transmission Facility owner and Generation Resource owner shall have sequence of events recording data per the following requirements:

(a) Circuit breaker position (open/close) for each circuit breaker it owns associated with the required monitored elements and connected directly to the transmission buses identified in paragraphs (1)(a) and (1)(b) of Section 6.1.2.2, Fault Recording and Sequence of Events Recording Equipment Location Requirements; and

(b) The following data as either part of the sequence of events recording data or fault recording digital status data:

(i) Circuit breaker position for each circuit breaker that it owns associated with monitored generator interconnects, transmission lines, and transformers;

(ii) Carrier transmitter control status (i.e. start, stop, keying) for associated transmission lines; and

(iii) Carrier signal receive status for associated transmission lines.

(3) Each Generation Resource owner and ESR owner shall have the following point-on-wave fault recording data for each triggered fault recording to determine:

(a) Time stamp;

(b) Phase-to-neutral voltage for each phase on high side of the Main Power Transformer (MPT);

(c) Each phase current and the residual or neutral current on high side of the MPT;

(d) Active and reactive power on high side of the MPT;

(e) Frequency and rate-of-change-of-frequency (df/dt) data for at least one generator-interconnected bus measurement;

(f) If applicable, dynamic reactive device input/output such as voltage, current, and frequency; and

(g) Applicable binary status.

(4) For each requested Load Facility identified by ERCOT, the interconnecting TSP or DSP shall have the following fault recording and sequence of events recording data for the identified Load elements to determine:

(a) Phase-to-neutral voltage for each phase of the transmission bus serving the Load, or other ERCOT approved voltages;

(b) Each phase current and neutral current for each Load terminal, or other ERCOT approved currents;

(c) Circuit breaker status for those transmission circuit breakers directly associated with the Load terminals.

6.1.2.4 Fault Recording and Sequence of Events Recording Data Retention and Reporting Requirements

(1) Each Transmission Facility owner and Generation Resource owner shall, upon request, provide to ERCOT fault recording and sequence of events recording data for the Transmission Elements identified in these requirements as follows:

(a) Data shall be maintained and retrievable for at a minimum:

(i) Twenty calendar days, including the day the data was recorded, for fault recording and sequence of events recording equipment installed on or replaced after January 1, 2024;

(ii) Ten calendar days, including the day the data was recorded, for fault recording and sequence of events recording equipment installed prior to January 1, 2024;

(b) Data subject to paragraph (1)(a) above will be provided within seven calendar days of request unless the requestor grants an extension;

(c) Sequence of events recording data will be provided in ASCII Comma Separated Value (CSV) format as follows: Date, Time, Local Time Code, Substation, Device, State;

(d) Fault recording data will be provided in electronic files formatted in conformance with Institute of Electrical and Electronic Engineers (IEEE) C37.111, IEEE Standard for Common Format for Transient Data Exchange (COMTRADE), revision C37.111-1999 or later;

(e) Data files will be named in conformance with C37.232, IEEE Standard for Common Format for Naming Time Sequence Data Files (COMNAME), revision C37.232-2011 or later; and

(f) If available, fault recording data may be provided in electronic files in SEL ASCII event report (.EVE), compressed ASCII (.CEV), or Motor Start Report (.MSR) in both raw and filtered format in addition to the data required above.

(2) The Transmission Facility owner and Generation Resource owner providing the requested fault recording and sequence of events recording data to ERCOT, the NERC Regional Entity, or NERC shall store the data for at least three years from the date the data was created.

6.1.3 Dynamic Disturbance Recording Equipment Including Phasor Measurement Unit Equipment

(1) By December 31, 2026, all dynamic disturbance recording equipment shall function as a phasor measurement unit and meet requirements in Section 6.1.3.1.2, Location Requirements, or a Facility Owner shall install a separate phasor measurement unit in addition to the dynamic disturbance recording equipment, and the phasor measurement unit shall have identical monitoring capabilities as the dynamic disturbance recording equipment.

(2) Dynamic disturbance recording equipment shall be time synchronized with a Global Positioning System-based clock, or ERCOT-approved alternative, with sub-cycle (+/-1 microsecond) timing accuracy and performance.

**6.1.3.1 Dynamic Disturbance Recording Equipment Requirements**

**6.1.3.1.1 Recording and Triggering Requirements**

(1) Dynamic disturbance recording equipment shall:

(a) Have either continuous data recording or triggering for at least the following:

(i) Any phase under-voltage below 0.85 p.u. for two cycles or longer;

(ii) Phase under-voltage that would trigger Under-Voltage Load Shed (UVLS);

(iii) Any phase over-voltage greater than 1.15 p.u. for two cycles or longer;

(iv) Frequency below 59.5 Hz or above 60.5 Hz; and

(v) Frequency rate of change for low frequency of -0.08125 Hz/sec or high frequency of 0.125 Hz/sec;

(vi) ERCOT must review and approve any requested deviations from the above-referenced requirements.

(vii) Additional triggering in excess of the minimums set forth in paragraph (a) above are permitted and do not require ERCOT’s review and approval.

(b) Triggered record lengths of at least three minutes;

(c) A minimum output recording rate of 30 samples per second; and

(d) A minimum input sampling rate of 960 samples per second.

***6.1.3.1.2 Dynamic Disturbance Recording Equipment Location Requirements***

(1) ERCOT shall identify and provide notification to Facility owners who shall install and maintain dynamic disturbance recording equipment at the following locations:

(a) A Generation Resource(s) that is not an IBR with:

(i) Gross individual nameplate rating greater than or equal to 500 MVA; or

(ii) Gross individual nameplate rating greater than or equal to 300 MVA if the gross plant/facility aggregate nameplate rating is greater than or equal to 1,000 MVA;

(b) Any Transmission Element part of a stability-related (angular or voltage) system operating limit;

(c) Each terminal of a high-voltage, direct current (HVDC) circuit with a nameplate rating greater than or equal to 300 MVA, on the alternating current side of a converter;

(d) One or more Transmission Elements part of an Interconnection Reliability Operating Limit (IROL); and

(e) Any one Transmission Element within a major voltage sensitive area as defined by an area with an in-service UVLS program.

(2) ERCOT shall identify, and notify Facility owners of, a minimum dynamic disturbance recording coverage, including Transmission Elements identified above, of a least:

(a) One Transmission Element; and

(b) One Transmission Element per 3,000 MW of ERCOT’s historical simultaneous peak Demand.

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***6.1.3.1.3 Dynamic Disturbance Recording Data Recording and Redundancy Requirements***

(1) Recorded electrical quantities shall determine the following:

(a) For Transmission Facilities meeting the requirements in Section 6.1.3.1.2, Location Requirements:

(i) Phase-to-neutral voltage magnitude/angle data for each phase from at least two distinct transmission level element measurement points;

(ii) Single phase current magnitude/angle data for each phase from at least two distinct transmission lines; and

(iii) Frequency and rate-of-change-of-frequency (df/dt) data for at least two Transmission Element measurement points.

(b) For Generation Resource owner locations meeting the requirements in Section 6.1.3.1.2:

(i) Phase-to-neutral voltage, or phase-to-phase voltage magnitude/angle data for each phase from at least one generator-interconnected bus measurement point;

(ii) Single phase current magnitude/angle data for each phase from each interconnected generator on the high or low side of a MPT; and

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| [NOGRR227: Replace item (ii) above with the following upon system implementation of NPRR973:](ii) Single phase current magnitude/angle data for each phase from each interconnected generator on the high or low side of a Main Power Transformer (MPT); and |

(iii) Frequency and df/dt data for at least one generator-interconnected bus measurement.

6.1.3.1.4 Dynamic Disturbance Recording Data Retention and Data Reporting Requirements

(1) A Market Participant required to have and maintain data regarding electrical quantities shall maintain and retain that data, at a minimum:

(a) A rolling ten calendar day period for all data;

(b) At least three years for event data used for model validation in accordance with NERC Reliability Standards; and

(c) At least three years for event data provided to ERCOT, the NERC Regional Entity, or NERC via written request recorded in the context of an event analysis or review.

(2) Each affected Market Participant shall provide to ERCOT, upon request, dynamic disturbance recording data as follows:

(a) Data must be retrievable for ten calendar days, including the day the data was recorded;

(b) Data subject to paragraph (2)(a) above within seven calendar days of a request unless the requestor grants an extension;

(c) Dynamic disturbance recording data in electronic files formatted in conformance with IEEE C37.111, revision C37.111-1999 or later;

(d) Data files named in conformance with IEEE C37.232, revision C37.232-2011 or later.

**6.1.3.2 Phasor Measurement Unit Requirements**

(1) Phasor measurement unit equipment includes all dynamic disturbance recording equipment with phasor measurement recording capability meeting the requirements in Sections 6.1.3.2.1, Recording Requirements, and 6.1.3.2.3, Data Recording and Redundancy Requirements.

(2) Phasor measurement unit equipment shall be time synchronized with a Global Positioning System-based clock, or ERCOT-approved alternative, with sub-cycle (+/-1 microsecond) timing accuracy and performance.

***6.1.3.2.1 Phasor Measurement Unit Recording Requirements***

(1) Recorded electrical quantities shall have continuous recording and shall:

(a) Comply with IEEE C37.118.1-2011 or later, IEEE Standard for Synchrophasor format;

(b) Have a minimum output recording rate of 30 samples per second;

(c) Have a minimum input sampling rate of 960 samples per second; and

(d) Be stored locally in accordance with the requirements in Section 6.1.3.2.4, Data Retention and Data Reporting Requirements*.*

***6.1.3.2.2 Phasor Measurement Unit Location Requirements***

(1) Facility owner(s) shall install phasor measurement unit equipment at the following locations:

(a) Flexible AC transmission system devices configured to actively control steady-state voltage or power transfer capability operated at or above 100 kV and energized after July 1, 2015;

(b) A Transmission Facility deemed necessary for each published generic transmission constraint within two years of receiving written notice from ERCOT;

(c) New Generation Resources or ESRs over 20 MVA aggregated at a single site and connected to a Transmission Facility at or above 60 kV and placed into service after January 1, 2017;

(d) Existing Generation Resources or ESRs over 20 MVA aggregated at a single site and connected to a Transmission Facility at or above 60 kV following any modification described in paragraph (1)(c) of Planning Guide Section 5.2.1, Applicability, with the modification’s Initial Synchronization after January 1, 2022;

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| ***[NOGRR177: Insert item (e) below upon system implementation of NPRR857 and renumber accordingly:]***(e) New Direct Current Ties (DC Ties) placed into service after January 1, 2019; |

(e) Any Generation Resource or ESR that experiences a frequency ride-through or voltage ride-through failure, if required by ERCOT. ERCOT may require a phasor measurement unit that transmits the data to an ERCOT phasor data concentrator via a communication link. The Generation Resource or ESR owner shall install the phasor measurement unit at a location specified by ERCOT as soon as practicable but no longer than two years after ERCOT notifies the Entity it must install the equipment. The equipment shall begin transmitting the data to the ERCOT phasor data concentrator within 60 days after installation is completed.

(f) Each Transmission Element considered part of a monitored IROL interface within two years of notification by ERCOT;

(g) Synchronous condensers supporting the transmission system installed after January 1, 2024.

(h) A Transmission Element within:

(i) A voltage sensitive area consisting of an area with an active UVLS program;

(ii) An area of the ERCOT System with 3,000 MW of ERCOT’s historical simultaneous peak Demand; and

(iii) An area with greater than 1,000 MW of Generation Resources and ESRs with a stability risk identified by ERCOT.

(iv) An area identified in items (i) through (iii) above shall have its equipment installed within two years of the date on which ERCOT informs the owner of the need to install the equipment.

(i) An individual Load consisting of one or more Facilities at a single site with an aggregate peak demand greater than or equal to 20 MW that experienced abnormal trips or Load reductions after a fault (including if caused by a DGR, DESR, or SODG) after a fault:

1. ERCOT may require installation of phasor measurement recording equipment;
2. The interconnecting Transmission Service Provider (TSP) or Distribution Service Provider (DSP) shall install the recording equipment;
3. A suitable location for the recording equipment will be coordinated between ERCOT and the interconnecting TSP or DSP;
4. The recording equipment will be installed as soon as practicable, but no longer than two years after ERCOT notifies the TSP or DSP it must install the equipment, unless the requestor provides an extension;
5. If the TSP or DSP determines it cannot install the recording equipment due to engineering, technical or operational constraints, it will provide to ERCOT, in writing, supporting data or documents.

(j) An individual Load consisting of one or more Facilities at a single site with an aggregate peak Demand greater than or equal to 75 MW behind one or more common Points of Interconnection (POIs) or Service Delivery Points if ERCOT requires phasor measurement recording equipment. If required:

(i) The interconnecting Transmission Service Provider (TSP) or Distribution Service Provider (DSP) shall install the recording equipment;

(ii) A suitable location for the recording equipment will be coordinated between ERCOT and the interconnecting TSP or DSP;

(iii) The recording equipment will be installed as soon as practicable, but no longer than two years after ERCOT notifies the TSP or DSP it must install the equipment, unless ERCOT grants an extension;

(iv) If the TSP or DSP determines it cannot install the recording equipment due to engineering, technical or operational constraints, it will provide to ERCOT, in writing, supporting data or documents.

(2) Facility owners shall install new phasor measurement units identified in paragraph (1) above as soon as practicable.

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| ***[NOGRR255: Replace paragraph (2) above with the following no earlier than <Insert Date at least two years after PUCT approval>:]***(2) Facility owners shall have at least 50% of new phasor measurement units identified in paragraph (1) above installed. |

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| ***[NOGRR255: Delete paragraph (2) no earlier than <Insert Date at least four years after PUCT approval>.]*** |

6.1.3.2.3 Phasor Measurement Unit Data Recording and Redundancy Requirements

(1) Recorded electrical quantities shall include data to determine the following:

(a) For Transmission Facility owner locations meeting the requirements in Section 6.1.3.2.2, Location Requirements:

(i) Time stamp;

(ii) Phase-to-neutral voltage magnitude/angle data for each phase from at least two distinct Transmission Element measurement points;

(iii) Single phase current magnitude/angle data for each phase from at least two distinct Transmission lines; and

(iv) Frequency and rate-of-change-of-frequency (df/dt) data for at least two Transmission Element measurement points.

(b) For Generation Resource or ESR locations meeting the requirements in Section 6.1.3.2.2:

 (i) Time stamp;

(ii) Phase-to-neutral voltage for each phase on the high side of the MPT;

(iii) Each phase current and the residual or neutral current on the high side of the MPT;

(iv) Active and reactive power on high side of the MPT;

(v) Frequency and df/dt data for at least one generator-interconnected bus measurement; and

(vi) If applicable, dynamic reactive device input/output such as voltage, current, and frequency.

(c) For Load Facilities identified by ERCOT in Section 6.1.3.2.2, Phasor Measurement Unit Location Requirements:

(i) Phase-to-neutral voltage, or phase-to-phase voltage magnitude/angle data for each phase from at least one transmission terminal bus measurement point, or other ERCOT approved voltages; and

(ii) Single phase current magnitude/angle data for each phase from each interconnected Load terminal on the high or low side of Load delivery point, or other ERCOT approved currents.

6.1.3.2.4 Phasor Measurement Unit Data Retention and Data Reporting Requirements

(1) Market Participants must maintain data regarding the minimum recorded electrical quantities for at least:

(a) A rolling 30 calendar day period for all data stored locally;

(b) At least three years for event data used for model validation in accordance with NERC Reliability Standards; and

(c) At least three years for event data provided to ERCOT, the NERC Regional Entity, or NERC via written request recorded in the context of an event analysis or review.

(2) Each affected Market Participant shall provide ERCOT, upon request, phasor measurement unit data for the Elements identified in these requirements as follows:

(a) Data must be retrievable for 30 calendar days, including the day the data was recorded;

(b) Data subject to item (2)(a) above within seven calendar days of a request unless the requestor grants an extension;

(c) Data in electronic files formatted in conformance with IEEE C37.111, revision C37.111-1999 or later;

(d) Data files named in conformance with IEEE C37.232, revision C37.232-2011 or later.

6.1.4 Fault Recording, Sequence of Events Recording, and Phasor Measurement Unit Requirements for Inverter-Based Resources (IBRs)

(1) Inverter-Based Resources (IBRs) include any source of electric power connected to the ERCOT System via a power electronic interface that consists of one or more IBR unit(s) capable of exporting active power from a primary energy source or energy storage system.

(2) All transmission-connected IBR facilities operating at 60 kV with gross aggregated nameplate capacity of 20 MVA at a single site must meet all requirements in this section.

(3) Facility owners shall install new fault recording and sequence of events recording equipment identified in this section as soon as practicable.

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| ***[NOGRR255: Replace paragraph (3) above with the following no earlier than <Insert Date at least two years after PUCT approval>:]***(3) Facility owners shall have at least 50% of new fault recording equipment, sequence of events recording equipment, and phasor measurement units identified in paragraph (2) above installed. |

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| ***[NOGRR255: Delete paragraph (3) no earlier than <Insert Date at least four years after PUCT approval>.]*** |

6.1.4.1 Fault Recording and Sequence of Events Recording Equipment Requirements

(1) Required fault recording equipment shall be time synchronized with a Global Positioning System-based clock, or ERCOT approved alternative, with synchronized device clock accuracy and performance withing +/- 100 microseconds of Coordinated Universal Time (UTC), with or without a local time offset for Central Prevailing Time (CPT).

(2) Required sequence of events recording equipment shall be time synchronized with a Global Positioning System-based clock, or ERCOT-approved alternative, with +/- 100 microseconds of Coordinated Universal Time (UTC), with or without a local time offset for Central Prevailing Time (CPT).

*6.1.4.1.1 Sequence of Events Recording Data Requirements*

(1) Generation Resource owners and ESR owners shall have sequence of events data for all positions (open/close) for circuit breakers associated with the MPT(s), collector bus, and shunt static or dynamic reactive device(s).

*6.1.4.1.2 Fault Recording Data and Triggering Requirements*

(1) Generation Resource owners and ESR owners shall have fault recording data to determine the following electrical quantities for each triggered fault recording record:

(a) Generation Resource or ESR level fault recording data:

(i) Time stamp;

(ii) Phase-to-neutral voltage for each phase on the high side of the MPT;

(iii) Each phase current and the residual or neutral current on the high side of the MPT;

(iv) Active and reactive power on the high side of the MPT;

(v) Frequency and rate-of-change-of-frequency (df/dt) data for at least one generator-interconnected bus measurement; and

(vi) If applicable, dynamic reactive device input/output such as voltage, current, and frequency.

(vii) Applicable binary status.

(2) Fault recording equipment shall meet the following requirements for a Generation Resource or ESR as described in paragraph (1) above:

(a) Triggering for at least the following:

(i) High-side of the MPT fault recording triggers and, if applicable, any dynamic reactive device FR triggers:

(A) Neutral (residual) overcurrent of 0.20 per unit (p.u.) or less of rated current transformer secondary current;

(B) Any phase under-voltage between 0.85 p.u. and 0.90 p.u., or

(1) Any phase overcurrent above 1.05 p.u. of the maximum emergency current rating, or

(2) Protective relay tripping for all protection groups;

(C) Any phase over-voltage greater that 1.10 p.u.;

(D) Frequency below 59.5 Hz or above 60.5 Hz;

(E) Frequency rate of change for low frequency of -0.08125 Hz/sec or high frequency of 0.125 Hz/sec;

(b) Minimum recording rate of:

(i) 64 samples per cycle for any Fault recording equipment installed on or replaced after January 1, 2024;

(ii) 16 samples per cycle for any Fault recording equipment installed prior to January 1, 2024; and

(c) A single record or multiple records that include pre-trigger record length of at least two cycles and a total record length of at least 2 seconds for the same trigger point.

6.1.4.3 Phasor Measurement Unit Equipment Requirements

(1) Phasor measurement unit equipment shall be time synchronized with a Global Positioning System-based clock, or ERCOT-approved alternative, with synchronized device clock accuracy and performance within +/- 100 microseconds of Coordinated Universal Time (UTC), with or without a local time offset for Central Prevailing Time (CPT).

(2) Recorded electrical quantities shall have continuous recording and be:

(a) Provided in IEEE C37.118.1-2011 or later, IEEE Standard for Synchrophasor format. However, Generation Resources in commercial operation before January 1, 2017 may provide the data in IEEE C37.118.1-2005 format when technically infeasible for its installed equipment to meet the IEEE C37.118.1-2011 or later format;

(b) A minimum output recording rate of 60 samples per second;

(c) A minimum input sampling rate of 960 samples per second; and

(d) Transmitted to an ERCOT phasor data concentrator via a communication link or stored locally per retention requirements in Section 6.1.4.4*.*

(3) Facility owners shall have phasor monitoring data to determine the following:

(a) Time stamp;

(b) Phase-to-neutral voltage, or phase-to-phase voltage magnitude/angle data for each phase from at least one generator-interconnected bus;

(c) Single phase current magnitude/angle data for each phase on the high or low side of an MPT that represents the flow from one or multiple IBR unit(s) behind the MPT;

(d) Frequency and rate-of-change-of-frequency (df/dt) data for at least one generator-interconnected bus; and

(e) Calculated active and reactive power output on the high or low side of the MPT that represents the flow from one or multiple IBR unit(s) behind the MPT.

6.1.4.4 Data Retention and Data Reporting Requirements for Fault Recording, Sequence of Events Recording, and Phasor Measurement Unit Equipment

(1) A Generation Resource owner or ESR owner required to have data regarding electrical quantities shall maintain and retain the data, at a minimum, for:

(a) A rolling 20 calendar day period for all data;

(b) At least three years (from the date the data was recorded) for event data used for model validation in accordance with NERC Reliability Standards; and

(c) At least three years for event data provided to ERCOT, the NERC Regional Entity, or NERC via written request recorded in the context of an event analysis or review.

(2) Each Generation Resource owner and ESR owner shall provide ERCOT, upon request, fault recording, sequence of events recording, and Phasor measurement unit data as follows:

(a) Data for 20 calendar days, including the day the data was recorded;

(b) Data subject to item (2)(a) above within seven calendar days of a request unless ERCOT grants an extension;

(c) Sequence of events data in ASCII Comma Separated Value (CSV) format as follows: Date, Time, Local Time Code, Substation, Device, State;

(d) Fault recording and phasor measurement unit data in electronic files formatted in conformance with Institute of Electrical and Electronic Engineers (IEEE) C37.111, IEEE Standard for Common Format for Transient Data Exchange (COMTRADE), revision C37.111-1999 or later;

(e) Data files named in conformance with IEEE C37.232, revision C37.232-2011 or later; and

(f) If available, fault recording data in electronic files in SEL ASCII event report (.EVE), compressed ASCII (.CEV), Motor Start Report (.MSR) and Sequential Events Recorder record (.SER) format.

6.1.5 Maintenance and Testing Requirements

(1) Each Market Participant with dynamic disturbance recording, phasor measurement recording, fault recording, or sequence of events recording equipment identified by Section 6.1.2, Fault Recording and Sequence of Events Recording Equipment, Section 6.1.3, Dynamic Disturbance Recording Equipment Including Phasor Measurement Unit Equipment, and Section 6.1.4, shall maintain and test its equipment as follows:

(a) Calibrate or configure the devices at installation and when records from the equipment indicate a calibration or configuration problem;

(b) To ensure data stored locally is available upon request by verifying data availability and quality at least once every 30 calendar days, or institute an automated notification system to detect when the equipment ceases recording required data or fails to timely refresh the data.

(2) Each Market Participant with dynamic disturbance recording equipment, phasor measurement recording, fault recording, or sequence of events recording equipment identified by Section 6.1.2, Fault Recording and Sequence of Events Recording Equipment, Section 6.1.3, Dynamic Disturbance Recording Equipment Including Phasor Measurement Unit Equipment, and Section 6.1.4, Fault Recording, Sequence of Events Recording, and Phasor Measurement Unit Requirements for Inverter-Based Resources (IBRs), shall, within 90 calendar days of discovering a failure of the required data production, either:

(a) Restore the recording capability, or

(b) Notify and submit to ERCOT a plan and timeline for restoring the equipment recording capabilities.

6.1.6 Equipment Reporting Requirements

(1) Each Market Participant with dynamic disturbance recording, phasor measurement recording, fault recording, or sequence of events recording equipment identified by Section 6.1.2, Fault Recording and Sequence of Events Recording Equipment, Section 6.1.3, Dynamic Disturbance Recording Equipment Including Phasor Measurement Unit Equipment, and Section 6.1.4, Fault Recording, Sequence of Events Recording, and Phasor Measurement Unit Requirements for Inverter-Based Resources (IBRs), shall:

(a) Maintain a current database summarizing disturbance monitoring equipment installations that includes installation location, type of equipment, equipment make and model, operational status, and a list of the major equipment monitored; and

(b) Have and maintain a complete list of all monitored points at each Facility and, when requested by ERCOT, the NERC Regional Entity, or NERC, provide the list within 30 days.

6.1.7 Review Process

(1) After December 31, 2025, ERCOT shall review disturbance monitoring equipment locations for adequacy when significant changes are made to the ERCOT System or at least every five calendar years.

(2) Transmission Facility owners shall review fault recording and sequence of events recording equipment locations for compliance at least every five calendar years.

(3) Existing Facility owners identified in the reviews shall have three years from the time of review, or from the time of notification from others, to install the equipment.

**ERCOT Nodal Operating Guides**

**Section 8**

**Attachment M**

**Selecting Buses for Capturing Sequence of Events Recording and Fault Recording Data**

**TBD**

This attachment provides the Transmission Facility owner the methodology to use for selecting bus locations for capturing sequence of events recording and fault recording data.

To identify monitored bulk electric system buses for sequence of events recording and fault recording data, each Transmission Facility owner shall follow sequentially, unless otherwise noted, the steps listed below:

Step 1. Determine a complete list of bulk electric system buses that it owns, excluding buses or Facilities solely representing Inverter-Based Resources (IBRs), as those locations are addressed outside of the process described in this attachment.

For the purposes of this attachment, a single bulk electric system bus includes physical buses with breakers connected at the same voltage level within the same physical location sharing a common ground grid. These buses may be modeled or represented by a single node in fault studies. For example, ring bus or breaker-and-a-half bus configurations are considered to be a single bus.

Step 2. Reduce the list to those bulk electric system buses that have a maximum available calculated three phase short circuit MVA of 1,500 MVA or greater. If there are no buses on the resulting list, proceed to Step 7.

Step 3. Determine the 11 bulk electric system buses on the list with the highest maximum available calculated three phase short circuit MVA level. If the list has 11 or fewer buses, proceed to Step 7.

Step 4. Calculate the median MVA level of the 11 bulk electric system buses determined in Step 3.

Step 5. Multiply the median MVA level determined in Step 4 by 20 percent.

Step 6. Reduce the bulk electric system buses on the list to only those that have a maximum available calculated three phase short circuit MVA higher than the greater of:

* 1,500 MVA or
* 20 percent of median MVA level determined in Step 5.

Step 7. If there are no bulk electric system buses on the list: the procedure is complete and no fault recording and sequence of events recording data will be required. Proceed to Step 9.

If the list has one or more but less than or equal to 11 bulk electric system buses: fault recording and sequence of events recording data is required at the bulk electric system bus with the highest maximum available calculated three phase short circuit MVA as determined in Step 3.

During re-evaluation efforts, if the three-phase short circuit MVA of the newly identified bulk electric system bus is within 15% of the three-phase short circuit MVA of the currently applicable BES bus with sequence of events recording and fault recording data than it is not necessary to change the applicable BES bus. Proceed to Step 9.

If the list has more than 11 bulk electric system buses: fault recording and sequence of events recording data is required on at least the 10 percent of the bulk electric system buses determined in Step 6 with the highest maximum available calculated three phase short circuit MVA. Proceed to Step 8.

Step 8. Fault recording and sequence of events recording data is required at additional bulk electric system buses on the list determined in Step 6. The aggregate of the number of bulk electric system buses determined in Step 7 and this Step will be at least 20 percent of the bulk electric system buses determined in Step 6. The additional bulk electric system buses are selected, at the Transmission Facility owner’s discretion, to provide maximum wide-area coverage for fault recording and sequence of events recording data. The following bulk electric system bus locations are recommended:

* Electrically distant buses or electrically distant from other disturbance monitoring equipment devices.
* Voltage sensitive areas.
* Cohesive load and generation zones.
* Bulk electric system buses with a relatively high number of incident transmission circuits.
* Bulk electric system buses with reactive power devices.
* Major Facilities interconnecting outside the Transmission Owner’s area.

Step 9. The list of monitored bulk electric system buses for fault recording and sequence of events recording data is the aggregate of the bulk electric system buses determined in Steps 7 and 8.