

TEXAS RE

Protection Systems and IBRs

Phil Bracy O&P Compliance Analyst

Blake Ianni Senior O&P Compliance Engineer

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Upcoming Texas RE Events





Upcoming Texas RE Events







Upcoming ERO Enterprise Events



Date	Event
March 17	<u>Technical Talk with RF</u>
March 25-27	Physical Security Workshop (SERC)
March 25-27	Reliability & Security Workshop (WECC)
April 2	Application of IBR Practice Guide Workshop (SERC)
April 3	2025 Virtual RAM Conference (MRO)
April 8-10	System Operator Conference 1 (SERC)
April 10	GridEx VIII Preparation Webinar (MRO)



Slido.com





A plant/facility consisting of individual devices that are capable of exporting Real Power through a power electronic interface(s) such as an inverter or converter, and that are operated together as a single resource at a common point of interconnection to the electric system. Examples include, but are not limited to, plants/facilities with solar photovoltaic (PV), Type 3 and Type 4 wind, battery energy storage system (BESS), and fuel cell devices.





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Slido Question

What kind of entity do you represent?

- A. Existing GO with only IBRs
- B. Existing GO with mix of conventional & IBRs
- C. Recently registered non-BES IBR
- D. TO/TOP/TP
- E. Other





IBRs and Compliance Landscape

Generation mix on the Bulk Power System (BPS) continues to change with more wind, solar photovoltaic (PV), and battery energy storage systems (BESSs) being added

Opportunities for inverter-based resources (IBRs) to improve performance during frequency and voltage events

FERC Order 901 required IBR-related ride-through performance requirements be established to support the BPS during and after defined frequency & voltage excursions

Creation of additional Standards for Disturbance Monitoring Data Capabilities & Data Sharing







Reliability Standards

Protection Settings	 PRC-024-3 PRC-024-4 PRC-029-1
Data Sharing	• PRC-030-1
Coordination and Misoperation	 PRC-004-6 PRC-027-1 PRC-019-2
Disturbance Monitoring	• PRC-028-1







Protection Systems & IBRs

PRC-024-3 Objectives



Ensure settings are properly calculated for applicable frequency and voltage protections Analyze the effects of frequency and voltage excursion on the system protection



Set frequency and voltage protection to prevent trips and momentary cessation within the "no trip zone"



PRC-024-3 Requirements

Frequency and Voltage Protection Settings for Generating Resources

- GO is responsible for:
 - Setting its frequency protection (R1)
 - Setting its voltage protection (R2)
 - Documenting each known equipment limitation that prevents unit from meeting protection criteria in R1 or R2 (R3)
 - Providing protection settings to its PC or TP when requested within 60 days (R4)

Ride-through vs. Protection Settings

- Remain connected during defined frequency and voltage events
- Should be specific to the voltage and frequency protective capabilities
- Outside of the curves is the "May-Trip Zone"





Frequency Boundary Data Points - ERCOT Interconnection

High Frequency Duration		Low Frequency Duration	
Frequency (Hz)	Minimum Time (Sec)	Frequency (Hz)	Minimum Time (sec)
≥61.8	Instantaneous ⁹	≤57.5	Instantaneous ⁹
≥61.6	30	≤58.0	2
≥60.6	540	≤58.4	30
<60.6	Continuous operation	≤59.4	540
		>59.4	Continuous operation



Protection Systems & IBRs

PRC-024-3 Requirement R2 Attachment 2





Upcoming Protection Settings Standards

PRC-024-4 Applicability

- Synchronous generators
- Type 1 and Type 2 wind resources
- Synchronous condensers

PRC-029-1 Applicability

- Inverter-based resources
- Bulk Electric System (BES) Facilities
- Non-BES IBRs with:
 - Aggregate nameplate ≥ 20 mVA <u>and</u>
 - Connected to common point of connection \ge 60 kV





PRC-029-1 Voltage Excursions Requirement R1

Specifies voltage "must Ride-through zone"

Two tables in Attachment 1 of Standard

Table 1: Voltage Ride-through Requirements for AC-Connected Wind IBR ¹³					
Voltage (per unit) ¹⁴	Operation Region	Minimum Ride- Through Time (sec)			
> 1.20	N/A ¹⁵	N/A			
≥ 1.10	Mandatory Operation Region	1.0			
> 1.05	Continuous Operation Region	1800			
≤ 1.05 and ≥ 0.90	Continuous Operation Region	Continuous			
< 0.90	Mandatory Operation Region	3.00			
< 0.70	Mandatory Operation Region	2.50			
< 0.50	Mandatory Operation Region	1.20			
< 0.25	Mandatory Operation Region	0.16			
< 0.10	Permissive Operation Region	0.16			

Attachment 1: Voltage Ride-Through Criteria Table 1: Voltage Ride-through Requirements for AC-Connected Wind IBR ¹

- Table 1 for AC-Connected Wind IBRs (Types 3 and 4) or hybrid IBRs with wind
- Table 2 for all other IBRs including: IBRs interconnecting via dedicated Voltage Source Converter – High Voltage Direct Current (VSC-HVDC) transmission facility and hybrid IBRs consisting of PV and BESS





PRC-029-1 Voltage Excursion Criteria Requirement R2

Subparts R2.1 - R2.5

 Detailed design and operation criteria that each IBR must adhere to during a voltage excursion to maintain reliability

Examples of evidence

• Dynamic simulations, studies, plant protection settings, and control settings design evaluation

Evidence of actual disturbance monitoring during each voltage excursion (measured at the high-side of the main power transformer)







PRC-029-1 Frequency Excursions & Limitations

Requirement R3

- Specifies frequency "must Ride-through zone"
- Attachment 2 includes table and graph

Requirement R4

- Includes exception criteria and process
- Situations in which a hardware limitation prevents IBR from meeting R1-R3 criteria and for which the GO needs an exemption
- R4.1 and R4.2: GO shall document and submit any identified hardware limitations it has within 12 months following the effective date of the Standard



Figure 1: PRC-029 Frequency Ride-through Requirements



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Slido Question

What are some practices or controls your organization uses to make sure your protection settings are accurate?









Protection Settings—Best Practices & Controls



Periodically perform an evaluation of Ride-through capability

Collaborate closely with equipment manufacturer on settings and any firmware upgrades, or parameter changes needed after installation

Base settings on equipment capability and leave a buffer zone between trip settings and the must Ride-through zone



PRC-030-1—Upcoming

Purpose

- Mitigate Unexpected IBR Change in Power Output
- BES IBRs
- Non-BES IBRs with:
 - Aggregate nameplate ≥ 20 mVA; and
 - Connected to common point of connection \ge 60 kV

Requirement R1

- Implement documented process to identify changes in Real Power output (within a 4 second period):
 - Complete facility loss of output; OR
 - Changes ≥20 MVA and ≥10% of plant's gross nameplate
- Changes in Real Power excluded:
 - Due to intermittent primary energy source availability (e.g., change in wind speed and solar irradiance)
 - Resource dispatch or ramping, planned outages or planned resource testing
 - Transmission or collection system loss configured to disconnect the IBR generator; **or**
 - Due to Misoperation being analyzed and corrected under PRC-004 Standard





PRC-030-1 R2

Requirement R2

- Within 90 calendar days of an R1 Real Power change event or following a request from the Reliability Coordinator (RC), Balancing Authority (BA), or Transmission Operator (TOP) that identified a change
- R2.1: Analyze the IBR facility performance during the event
 - Root cause(s) (R2.1.1)
 - Document Ride-through performance (including Reactive Power) (R2.1.2)
 - Assess issues identified and if corrective action needed (R2.1.3)
 - Applicability to other IBR facilities (R2.1.4)
- R2.2: Provide analysis results to RC, BA, or TOP, if requested







PRC-030-1 R3 & R4

Requirement R3

- If corrective actions were identified in R2.1.3, within 60 days of completing analysis:
 - Develop Corrective Action Plan (CAP), including all other applicable IBR facilities of the GO, **or**
 - Technical justification for why corrective actions won't be implemented
- CAP or technical justification must be provided to RC, BA, and TOP

Requirement R4

- For each CAP developed per R3:
 - Implement CAP (R4.1)
 - Update CAP if timetables or actions change (R4.2)
 - Notify RC(s) of any changes and when CAP is completed (R4.3)



PRC-019-2

Purpose

 Coordinate generating unit Facility or synchronous condenser voltage regulating controls, limit functions, equipment capabilities and Protection System settings

Applicability

- Generator Owner (GO)/ Transmission Owner (TO) that owns synchronous condenser(s)
- Individual generating unit or condenser ≥20 MVA and connected to BES
- Generating plant connected to the BES at common bus with total generation ≥75 MVA
- Blackstart units



PRC-019-2 R1 & R2

Requirement R1

- At least every five calendar years, GO and TO shall coordinate voltage regulating system controls with applicable equipment capabilities & settings of applicable Protection System devices/functions
- R1.1-under automatic voltage regulator control loop and steady state operating conditions, verify:
 - In-service limiters set to operate before Protection System (avoid disconnecting generator unnecessarily)(R1.1.1)
 - In-service Protection System devices set to isolate or de-energize equipment (limit the extent of damage when operating conditions exceed capabilities or the stability limits)(R.1.2)

Requirement R2

- Perform R1 verification when changes relevant to coordination occur (within 90 days of identification)
- Possible changes to:
 - Voltage regulating settings or equipment
 - Protection System settings or component(s)
 - Generating or synchronous condenser equipment capability, or
 - Generator or synchronous condenser step-up transformer





PRC-004-6 Overview

Applicability

- Transmission Owners (TOs)
- Generator Owners (GOs)
- Distribution Providers (DPs)
 - That own Protection Systems installed to detect and isolate Faults on BES Elements

- Prevent BES instability, separation, cascading sequence of failures
- Identify and correct the causes of Misoperations of Protection Systems for the BES

What is a Misoperation?

- Failure to Trip
 - A failure of a Composite Protection System to operate for a Fault condition for which it is designed. The failure of a Protection System component is not a Misoperation as long as the performance of the Composite Protection System is correct
- Slow Trip
 - A Composite Protection System operation that is slower than required for a Fault condition if the duration of its operating time resulted in the operation of at least one other Element's Composite Protection System
- Unnecessary Trip
 - An unnecessary Composite Protection System operation for a Fault Condition on another Element





PRC-004-6 Timeline(s)

Own the Device (R1/R2)

- 120 days to:
 - Identify if this was an Operation or Misoperation
 - Notify other Owners

Don't Own / Notification Received (R3)

- Within 60 days of notification OR 120 days of the operation, whichever is longer:
 - Identify whether its components caused a Misoperation



PRC-004-6 Owner Determined Misoperation





Protection Systems & IBRs

PRC-004-6 Process Development

How will you:

- Identify and track BES interrupting device operations?
- Identify ownership and point of contact?
- Evaluate the operation?
- Develop and implement CAPs?
- Document completion of activities within prescribed timeline(s)?





Population

• Misoperations that occurred during the monitoring period

Evidence

- Should be dated to show completion within the required timeline(s)
- Document the analysis and determination of needs for CAP
- CAPs (if applicable) should include:
 - Specific actions and expected timeline for implementation
 - Evaluation of applicability to other Protection Systems (including other locations)



PRC-027-1 Overview

Applicability

- Transmission Owners
- Generator Owners
- Distribution Providers
 - (that own Protection Systems installed to detect and isolate Faults on BES Elements)

- To maintain the coordination of Protection Systems such that they operate in the intended sequence during Faults
- Ensure that the minimum portion of the BES is removed from service by the operation of the Protection System to maintain reliability of the grid

What is Coordination?

- Coordination IS:
 - Ensuring that settings of Protection Systems are such that they will operate in the intended sequence during Faults
- Coordination is NOT:
 - "Collaboration" (Discussion/Planning etc.)







PRC-027-1 Process

Needs to Capture Details and Documentation

- Short-circuit model review and updates
- Protection System settings calculations
- Review(s)
- Study results
- Completion dates
- Coordination issues and resolution (as applicable)

Collaboration & Resolution

- Entities may agree to not mitigate all issues based on engineering judgement
- Entities may agree to delay resolution if system modifications were not identified in initial scope
- Entities may agree that protection philosophy differences do not create coordination issues



A PSCS should include Protection System functions identified in Attachment A that could operate for faults on the BES

- Option 1: Perform a PSCS within a sixcalendar year time interval
- Option 2: Compare present Fault current values to an established Fault current baseline and perform a PSCS when the comparison identifies at least a 15% deviation, all within a six-calendar year time interval

Option 3: Combination of 1 & 2 above

Protection System functions applicable to R2

- 21 Distance (if infeed or zerosequence mutual coupling is used in determining reach)
- 50 Instantaneous overcurrent
- 51 AC inverse time overcurrent
- 67 AC directional overcurrent (if used in a non-communicationaided protection)



PRC-027-1 Protection System Coordination Study

Determine Network Boundary

- Wide-area coordination or partial coordination
- Identify scenarios and configurations
- Define primary and backup relay coordination pairs
- Ensure correct models are used

Perform Coordination Study

- Static, step event analysis, or combination
- Perform coordination study using Option
 1, 2, or 3 from previous slide

Document Results & Implement process created per R1

- Update the short-circuit model with latest settings
- Collaborate with neighboring entities to complete coordination and/or resolve any coordination issues





Standardized process for developing new and revised settings

- Specific defined steps
- Consider Checklist(s)

Document maintenance process for accurate short-circuit models

- Ensure applicable BES elements/data are part of the model
- $\ensuremath{\circ}$ Include data source for parameters

Detailed review process

- Type of review
- o Additional review(s)?
- Document that settings meet coordination requirements

Coordination Studies

 Clearly document the method, evaluation, and results

Other

- O What to do if a response is not received?
- Review work of third-party vendors for accuracy



Upcoming Protection Settings Standards

PRC-002-4 Applicability

- Reliability Coordinator
- Transmission Owner
- Generator Owner

PRC-028-1 Applicability

- Generator Owner
 - Facilities:
 - BES Inverter-Based Resources
 - Non-BES IBRs that either have or contribute to an aggregate nameplate capacity of greater than or equal to 20 MVA, connected through a system designed primarily for delivering such capacity to a common point of connection at a voltage greater than or equal to 60 kV







PRC-028 Disturbance Monitoring and Reporting for IBRs

Purpose

 To have adequate data available from IBRs to evaluate IBR Ridethrough performance during System Disturbances and to provide data for IBR model validation

Requirements

- R1 Sequence of Event Recording (SER) data
- R2 & R3 Fault Recording (FR) data
- R4 & R5 Dynamic Disturbance Recording (DDR) data
- R6 Time synchronization
- R7 Providing data
- R8 Restoring recording capability



PRC-028 Applicability: Typical IBR Facility



Figure 1: Typical IBR Generating Facility Single Line Diagram

PRC-028-1 Technical Rationale



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Figure 2: IBR Interconnection – Applicability of PRC-002 versus PRC-028

PRC-028-1 Technical Rationale





Protection Systems & IBRs

PRC-028 Applicability: Transmission Owner Equipment



Figure 3: Transmission Owner owned Equipment within an IBR Plant

PRC-028-1 Technical Rationale







Figure 4: Hybrid Generating Facility

PRC-028-1 Technical Rationale





PRC-028 Data Formatting Requirements (R7)





Failure of Recording Capability for SER, FR, or DDR data (R8)

- Restore within 90 days of discovery, or
- Provide a CAP to the Regional Entity within 90 days and implement according to timeline specified







<u>NERC Alert IBR</u> <u>Performance Issues-</u> <u>Industry</u> <u>Recommendation</u> (March 14, 2023)	<u>CMEP Practice Guide</u> <u>Regarding IBRs</u>	Project 2020-02 Modifications to PRC- 024 (Generator Ride- through)	Project 2023-02 Analysis and Mitigation of BES Inverter-Based Resource Performance Issues (PRC-030-1)
Project 2010-05.1 Protection System (Misoperations)	A Systematic Approach to Meet NERC PRC-027- <u>1 Requirements –</u> Beyond Compliance (selinc.com)	Project 2021-04 Modifications to PRC- 002 - Phase II	<u>PRC-028-1 Technical</u> <u>Rationale</u>



Protection Systems & IBRs

Questions?

