NOGRR245 - Inverter-Based Resource (IBR) Ride-Through Requirements

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Southern Power

Original Equipment Manufacturer (OEM) Feedback

- Southern Power collected feedback from solar and wind OEMs relating to its existing IBRs' capabilities to meet NOGRR245 requirements
  - Assumes requirements are applied at IBR unit terminals; vendor modeling / studies needed to fully assess if an IBR facility complies with requirements
- Feedback included "yes", "no", and "additional studies needed"
- Additional time needed to evaluate if software or hardware upgrades are needed for existing IBR equipment to meet NOGRR245 requirements

Existing IBR Capabilities

- Table summarizes Southern Power's current understanding of its existing IBRs technical capabilities / limitations
- Info is subject to change as Southern Power continues to review and engage with OEMs

NOGRR245 Requirement	Can legacy equipment (Photovoltaic Inverter & Wind Turbine Generator) meet NOGRR245 requirements today
2.6.2.1 Frequency ride-through	**All** legacy equipment should be able to comply with frequency ride-through requirement.
	All legacy equipment should be able to inject current during all periods requiring frequency ride-through
2.9.1 Voltage ride-through	**None** of the legacy equipment can fully comply with root-mean-square (RMS) voltage ride-through requirements.
	None of the legacy equipment can comply and are not required to comply with instantaneous voltage ride-through requirements.
	Most legacy equipment should be able to inject current during RMS voltage ride-through and should be able to limit active power curtailment while in Q-priority mode.
	All legacy equipment should be able to return to pre-disturbance real power injection within 1-sec after exiting momentary cessation.
	None of the legacy equipment are tested to comply with consecutive voltage ride-through requirements.
2.6.2.1 & 2.9.1 (5) Protection settings	**Most** legacy equipment does not have an explicit ROCOF protection that can be set.
	Most legacy equipment does not have an explicit Phase-jump protection that can be set. For some PV inverters, it is part of anti-islanding protection.
	All legacy PV inverters should be able to have anti-islanding protection disabled.
	Some legacy equipment filters current and/or voltage measurements.

Southern Power Company Feasibility Review

Table 1 - Frequency Ride Through	
Frequency (f) in (Hz)	**Minimum Ride-Through Time (seconds)**
$f > 61.8$	No ride-through requirement
$61.6 < f \leq 61.8$	299
$61.2 < f \leq 61.6$	540
$58.8 \leq f \leq 61.2$	continuous
$58.4 \leq f < 58.8$	540
$57.0 \leq f < 58.4$	299
$f < 57.0$	No ride-through requirement

Table 2 - Voltage Ride Through	
Root-Mean-Square Voltage (p.u. of nominal)	**Minimum Ride-Through Time (seconds)**
$V > 1.20$	No ride-through requirement
$1.10 < V \leq 1.20$	1
$0.90 \leq V \leq 1.10$	continuous
$0.70 \leq V < 0.90$	3
$0.50 \leq V < 0.70$	2.5
$0.25 \leq V < 0.50$	1.2
$V < 0.25$	0.16

Table 3 - Transient Overvoltage Ride Through	
Instantaneous Phase Voltage (p.u. of nominal)	**Minimum Ride-Through Time (milliseconds)**
$V > 1.80$	No ride-through requirement
$1.70 < V \leq 1.80$	0.2
$1.60 < V \leq 1.70$	1
$1.40 < V \leq 1.60$	3
$1.20 < V \leq 1.40$	15

Table 4 - Successive Voltage Ride Through Out side of Continuous Operation Zone	
# of deviations outside of continuous region	**Within [x] second period**
< 4	10s
< 6	120s
< 10	1800s

Table 5 - Successive Low Voltage Ride Through Below 0.5pu (including zero voltage)	
# of deviations below 0.5pu (including zero)	**Within [x] second period**
< 2	10s
< 3	120s

Southern Power Company Feasibility Review

[2.6.2.1] Frequency Ride-Through Requirements for Transmission-Connected Inverter-Based Resources (IBRs)	
Item 1	Can IBR Unit's be set to ride-through frequency conditions specified in **Table 1**?
Item 4	Can IBR Unit inject electric current during all periods requiring frequency ride-through?
Item 5	Can ROCOF protection be disabled?
	If ROCOF cannot be disabled, can it be set to *not disconnect* the IBR for frequency excursions having an absolute ROCOF magnitude *less than or equal to 5.0 Hz/second* ?
	Is ROCOF measured based on the *average rate of change of frequency* over a period of *at least 0.1 seconds* ?
	Can anti-islanding protection be disabled?
	Can phase angle jump be disabled?
	If phase angle jump cannot be disabled, can it be set to ride through *positive-sequence phase angle changes within a sub-cycle-to-cycle time frame* of the applicable voltage of *less than or equal to 45 electrical degrees* ?
	Are there protection setting or inverter controls that can disconnect IBR Unit or reduce IBR output during ride-through conditions?

[2.9.1] Voltage Ride-Through Requirements for Transmission-Connected Inverter-Based Resources (IBRs)	
Item 1	Can IBR Unit's be set to ride-through *RMS voltage* conditions specified in **Table 2**?
	Can IBR Unit's be set to ride-through *instantaneous phase voltage* conditions specified in **Table 3**?
	Can IBR continue to inject current during sub-cycle transient overvoltage defined in **Table 3**?
	If IBR Unit *operates in current blocking mode during sub-cycle transient overvoltage* , can it restart current exchange in *less than or equal to 5-cycles* following instantaneous voltage falling below, and remaining below, 1.2pu?
Item 4	Can IBR Unit continue to deliver pre-disturbance active power current unless otherwise limited due to its current limit or Reactive Power priority mode?
	Can IBR return to its *pre-disturbance level of real power injection* as soon as possible but no more than *1-second* after POIB voltage recovering to normal operating range?
Item 6	Does instantaneous over-current or over-voltage protection systems use filtered quantities with a measurement window of at least one-cycle (of fundamental frequency)?
Item 7	Can IBR Unit ride through multiple excursions for conditions specified in **Table 4** and **Table 5**?
	Can IBR Unit ride through successive voltage deviations outside of continuous operation zone defined in **Table 2** if the end of a previous deviation is more than 20 cycles of system fundamental frequency?

Research Results

[2.6.2.1] Frequency Ride-Through Requirements for Transmission-Connected Inverter-Based Resources (IBRs)		OEM Response	OEM Response	OEM Response	OEM Response	OEM Response
Item 1	Can IBR Unit's be set to ride-through frequency conditions specified in Table 1?	Yes	Yes	Yes	Yes	No
Item 4	Can IBR Unit inject electric current during all periods requiring frequency ride-through?	Yes	Yes	Yes	Yes	Yes
Item 5	Can ROCOF protection be disabled?	N/A	N/A	N/A	N/A	N/A
	If ROCOF cannot be disabled, can it be set to *not disconnect* the IBR for frequency excursions having an absolute ROCOF magnitude *less than or equal to 5.0 Hz/second* ?	N/A	No	N/A	N/A	N/A
	Is ROCOF measured based on the *average rate of change of frequency* over a period of *at least 0.1 seconds* ?	N/A	Yes	N/A	N/A	N/A
	Can anti-islanding protection be disabled?	N/A	No	Yes	Yes	No
	Can phase angle jump be disabled?	N/A	No	Yes	No	N/A
	If phase angle jump cannot be disabled, can it be set to ride through *positive-sequence phase angle changes within a sub-cycle-to-cycle time frame* of the applicable voltage of *less than or equal to 45 electrical degrees* ?	N/A	No	N/A	No	N/A
	Are there protection setting or inverter controls that can disconnect IBR Unit or reduce IBR output during ride-through conditions?	No	Yes	Yes	Yes	Yes
[2.9.1] Voltage Ride-Through Requirements for Transmission-Connected Inverter-Based Resources (IBRs)						
Item 1	Can IBR Unit's be set to ride-through *RMS voltage* conditions specified in Table 2?	No	No	Yes	No	No
	Can IBR Unit's be set to ride-through *instantaneous phase voltage* conditions specified in Table 3?	No	No	No	No	No
	Can IBR continue to inject current during sub-cycle transient overvoltage defined in Table 3?	No	No	No	No	Yes
	If IBR Unit *operates in current blocking mode during sub-cycle transient overvoltage* , can it restart current exchange in *less than or equal to 5-cycles* following instantaneous voltage falling below, and remaining below, 1.2pu?	No	N/A	No	N/A	No
Item 4	Can IBR Unit continue to deliver pre-disturbance active power current unless otherwise limited due to its current limit or Reactive Power priority mode?	Yes	No	Yes	No	Yes
	Can IBR return to its *pre-disturbance level of real power injection* as soon as possible but no more than *1-second* after POIB voltage recovering to normal operating range?	Yes	Yes	Yes	Yes	No
Item 6	Does instantaneous over-current or over-voltage protection systems use filtered quantities with a measurement window of at least one-cycle (of fundamental frequency)?	No	Yes	Yes	No	No
Item 7	Can IBR Unit ride through multiple excursions for conditions specified in Table 4 and Table 5?	No	No	No	No	No
	Can IBR Unit ride through successive voltage deviations outside of continuous operation zone defined in Table 2 if the end of a previous deviation is more than 20 cycles of system fundamental frequency?	No	No	No	No	No

Research Results (continued)

[2.6.2.1] Frequency Ride-Through Requirements for Transmission-Connected Inverter-Based Resources (IBRs)		Can requirement be met without HW or SW Mod?	Can requirement be met without HW or SW Mod?	Can requirement be met without HW or SW Mod?	Can requirement be met without HW or SW Mod?	Can requirement be met without HW or SW Mod?
Item 1	Can IBR Unit's be set to ride-through frequency conditions specified in Table 1?	Yes	Yes	Yes	Yes	N/A
Item 4	Can IBR Unit inject electric current during all periods requiring frequency ride-through?	Yes	Yes	Yes	Yes	N/A
Item 5	Can ROCOF protection be disabled?	N/A	No	Yes	Yes	N/A
	If ROCOF cannot be disabled, can it be set to *not disconnect* the IBR for frequency excursions having an absolute ROCOF magnitude *less than or equal to 5.0 Hz/second* ?	N/A	No	N/A	N/A	N/A
	Is ROCOF measured based on the *average rate of change of frequency* over a period of *at least 0.1 seconds* ?	N/A	N/A	N/A	N/A	N/A
	Can anti-islanding protection be disabled?	N/A	N/A	Yes	Yes	N/A
	Can phase angle jump be disabled?	N/A	No	Yes	No	N/A
	If phase angle jump cannot be disabled, can it be set to ride through *positive-sequence phase angle changes within a sub-cycle-to-cycle time frame* of the applicable voltage of *less than or equal to 45 electrical degrees* ?	N/A	No	N/A	No	N/A
	Are there protection setting or inverter controls that can disconnect IBR Unit or reduce IBR output during ride-through conditions?	N/A	No	Yes	N/A	N/A
[2.9.1] Voltage Ride-Through Requirements for Transmission-Connected Inverter-Based Resources (IBRs)						
Item 1	Can IBR Unit's be set to ride-through *RMS voltage* conditions specified in Table 2?	No	No	Yes	No	N/A
	Can IBR Unit's be set to ride-through *instantaneous phase voltage* conditions specified in Table 3?	N/A	No	No	No	N/A
	Can IBR continue to inject current during sub-cycle transient overvoltage defined in Table 3?	N/A	No	No	No	N/A
	If IBR Unit *operates in current blocking mode during sub-cycle transient overvoltage* , can it restart current exchange in *less than or equal to 5-cycles* following instantaneous voltage falling below, and remaining below, 1.2pu?	N/A	N/A	No	N/A	N/A
Item 4	Can IBR Unit continue to deliver pre-disturbance active power current unless otherwise limited due to its current limit or Reactive Power priority mode?	Yes	No	Yes	No	N/A
	Can IBR return to its *pre-disturbance level of real power injection* as soon as possible but no more than *1-second* after POIB voltage recovering to normal operating range?	Yes	N/A	Yes	Yes	N/A
Item 6	Does instantaneous over-current or over-voltage protection systems use filtered quantities with a measurement window of at least one-cycle (of fundamental frequency)?	No	N/A	Yes	No	N/A
Item 7	Can IBR Unit ride through multiple excursions for conditions specified in Table 4 and Table 5?	No	No	No	No	N/A
	Can IBR Unit ride through successive voltage deviations outside of continuous operation zone defined in Table 2 if the end of a previous deviation is more than 20 cycles of system fundamental frequency?	No	No	No	No	N/A

Specific Technical Concerns

- Phase Angle Jump Protection
- Instantaneous & RMS Voltage Ride-Through Requirements
- Injecting real or reactive power during voltage-ride through
- Consecutive voltage ride-through requirements
- Demonstrating Compliance
  - Complexity of System Disturbances
  - Multiple abnormal system conditions can occur simultaneously or in succession; varying conditions across facility; interaction with other inverters / control system
- Legacy Inverter Control Limitations

Takeaways

- IEEE2800-2022 recognized that existing IBR equipment may have limitations in meeting the standard
- This issue is complex – additional time is needed to understand technical capabilities / limitations of existing IBRs
- Need for narrowly tailored infeasibility exemption process for existing IBRs
- Support adoption of IEEE2800-2022 to apply to new IBRs so that OEMs have sufficient notice to test / design equipment accordingly
- Issue is broader than IBR performance – need to improve transmission grid strength to mitigate impact of these grid disturbance events