PRC-024-2 Gaps Whitepaper

NERC Inverter-Based Resource Performance Task Force (IRPTF)

Purpose

The NERC Inverter-Based Resource Performance Task Force (IRPTF)[1] scope document[2] includes a deliverable on "recommendations on inverter-based resource performance and any modifications to NERC Reliability Standards related to the control and dynamic performance of these resources during abnormal grid conditions." The whitepaper presented here details the findings of the IRPTF as a result of investigations related to this deliverable. Specifically, the whitepaper details potential gaps and needed clarifications in PRC-024-2: *Generator Frequency and Voltage Protective Relay Settings*.[3] There is some overlap between the findings of this whitepaper and the Integration of Variable Generation Task Force (IVGTF) Summary and Recommendations of 12 Tasks[4] which was published in 2015.

Background

Multiple grid disturbances in the Western Interconnection have highlighted the potential risk of fault-induced solar photovoltaic (PV) tripping. While these disturbances have been prominent in the West, the underlying issues are systemic in the solar PV fleet across interconnections.

- On August 16, 2016, the Blue Cut Fire disturbance resulted in approximately 1200 MW of solar photovoltaic (PV) resources tripping offline or momentarily ceasing output in Southern California. NERC and WECC created an ad hoc task force to investigate causes of the solar PV tripping, develop a disturbance report[5], initiate remedial actions, and provide recommendations for future work.
- On October 9, 2017, the Canyon 2 Fire disturbance in Southern California resulted in approximately 900 MW of solar PV tripping or momentarily ceasing output. This disturbance involved voltage-related tripping, and highlighted an unintended interpretation of PRC-024-2. NERC and WECC developed a disturbance report[6], which included key findings and recommendations for mitigating action.

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[1] NERC Inverter-Based Resource Performance Task Force (IRPTF) webpage. Available: https://www.nerc.com/comm/PC/Pages/Inverter-Based-Resource-Performance-Task-Force.aspx.

[2] IRPTF Scope Document. Available: https://www.nerc.com/comm/PC/InverterBased%20Resource%20Performance%20Task%20Force%20IRPT/IRPTF_Scope_20170619.pdf.

[3] NERC Reliability Standard PRC-024-2 – Generator Frequency and Voltage Protective Relay Settings. Available: https://www.nerc.com/_layouts/15/PrintStandard.aspx?standardnumber=PRC-024-2&title=Generator%20Frequency%20and%20Voltage%20Protective%20Relay%20Settings&jurisdiction=United States.

[4] IVGTF Report. Available: https://www.nerc.com/comm/PC/Integration%20of%20Variable%20Generation%20Task%20Force%20I1/IVGTF%20Summary%20and%20Recommendation%20Report_Final.pdf

[5] Blue Cut Fire Disturbance Report. Available: http://www.nerc.com/pa/rrm/ea/1200_MW_Fault_Induced_Solar_Photovoltaic_Resource_/1200_MW_Fault_Induced_Solar_Photovoltaic_Resource_Interruption_Final.pdf.

[6] Canyon 2 Fire Disturbance Report. Available: https://www.nerc.com/pa/rrm/ea/Pages/October-9-2017-Canyon-2-Fire-Disturbance-Report.aspx.

Both disturbance reports have led to NERC Alerts to gather necessary data to understand the extent of the conditions identified as well as to recommend mitigating actions to these potential reliability risks to the Bulk Electric System (BES). Following completion of the Blue Cut Fire disturbance analysis, NERC formed the NERC IRPTF to continue focusing on inverter-based resource performance during steady-state

PRC-024-2 Issues

FERC approved the NERC Reliability Standard PRC-024-2: *Generator Frequency and Voltage Protective Relay Settings* in May 2015 and the standard went into effect on July 1, 2016. The original version of the standard, PRC-024-1, was approved by FERC in 2014. The purpose of PRC-024-2 is to "ensure Generator Owners set their generator protective relays such that generating units remain connected during defined frequency and voltage excursions." The primary purpose of the revision was not to ensure the protection of generation resources, but rather to aid BES stability without jeopardizing the generation resources. Hence, the standard includes requirements that generator protective relays be set such that they do not trip the applicable generating unit(s) when operating within specified frequency and voltage "no trip" zones.

Event analysis for both the Blue Cut Fire and Canyon 2 Fire disturbances revealed that misinterpretation of the requirements of PRC-024-2 led to the intentional and unnecessary tripping of solar PV resources during these events. In addition to identifying the need to provide clarity around the intent and requirements in PRC-024-2, the IRPTF also found errors within the standard. Based on these findings, the IRPTF has concluded that the following issues in PRC-024- 2 should be addressed:

- The standard is often interpreted and applied as a "ride-through standard", whereas it is fundamentally intended and approved to be a voltage and frequency protective settings standard. This white paper minimizes the use of the term "ride-through" and recommends eliminating its use in PRC-024-2 entirely to add clarity.[7]
- The region outside the "No-Trip" zone of the PRC-024-2 curves should be clearly marked as a "May-Trip" zone so it is not interpreted as a "Must-Trip" zone. The preferred behavior is for the generators to remain connected and producing current during disturbances to the greatest extent possible.
- There is inconsistency between the Curve Data Point tables and the Off Nominal Frequency Capability Curves as the table identifies "instantaneous" trip points while the time axis of the curve starts at 100 ms.
- There is confusion in point #5 of the Curve Details section of the Voltage Curve Clarifications regarding crest and RMS voltage relationship. There is also confusion regarding why the high voltage curve uses phase-to-phase voltage only but the low voltage curve uses phase-to-phase or phase-to-ground (this may be inconsistent with inverter-based resource protection practices). There is also confusion on the use of instantaneous tripping, particularly since inverter protection

[7] A "ride through standard" would include more definitive requirements as to how the resource should behave within the "ride through" zones, including controls performance and protection aspects. This would involve changing the purpose, scope, and intent of the standard. Therefore, the IRPTF is not providing recommendations on this topic at this time. However, the IRPTF will explore this concept in early 2019. See the *Other Issues for Consideration and IRPTF Next Steps* section of this document.

may be much faster than conventional relaying, which perform filtering on the incoming waveform.

- There is confusion regarding the inclusion of the four second cumulative timer functionality, as well as when the timer starts, stops, and resets.
- There is confusion regarding footnote 1 and the applicability of inverter protective functions within the inverter control systems.
- There is confusion as to the use of momentary cessation within the "No Trip" zone of PRC-024-2.

"Ride-Through" Standard vs. Protection Settings Standard

PRC-024-2 is often interpreted, or used by local utilities, as a "ride-through standard", meaning that the entire plant is expected ride through a disturbance within the PRC-024-2 curves. However, the standard requirements are specific in applying solely to the voltage and frequency protective settings and not to the overall plant. For example, a synchronous generating facility may trip on loss of synchronism, loss of auxiliary loads that could trip the turbine, or other forms of protection. As long as the resource has its voltage and frequency protective relaying set correctly, the resource is compliant with the standard. Similarly, for inverter-based resources, it is expected that a resource that trips on any DC bus protection, phase lock loop loss of synchronism, or other forms of inverter protection would also be compliant with the standard requirements so long as the voltage and frequency protective relaying is set according to the standard requirements. The IRPTF recommends a clear differentiation between "ride-through" and the PRC-024-2 protective relaying standard to bring clarity to requirements and applicability of the standard. IRPTF also recommends not using the term "ride-through" anywhere in the standard to avoid the confusion that has arisen.

A number of IRPTF members have stated that PRC-024-2 is being applied as a "ride-through standard" by local utility requirements for inverter-based resources in the absence of other NERC Standards requirements. A number of IRPTF members also generally agree that more comprehensive requirements for inverter-based resources should be explored including, but not limited to, details regarding resource behavior within the "ride-through" zones for both controls and protection aspects. Neither PRC-024-2 nor any other NERC Reliability Standards specify or provide acceptable bounds of performance within the "No-Trip" zone. Unlike synchronous machines, whose electrical response to fault events is predominantly driven by physics, an inverter-based responses to grid events entirely driven by controls.

The IRPTF will develop guidance on this topic immediately following completion of this white paper, and will bring any recommendations and potential SARs to the NERC Planning and Operating Committees, as necessary. Topics to be explored include, but are not limited to, type of current injection for different grid events, response to both unbalanced and balanced faults, response within the first 100 ms of a frequency excursion, and response to other transient conditions. The IRPTF will also explore other forms of protection not covered by PRC-024-2, including but not limited to, phase lock loop loss of synchronism, DC bus protection, and inverter current protection. These forms of tripping are not covered in PRC-024-2, are not particularly relevant for synchronous machines, yet are very relevant to inverter-based resource protection and performance during grid disturbances.

"Must-Trip" versus "May-Trip" Interpretation

PRC-024-2 specifies a "No-Trip" area for voltage and frequency excursions, as measured at the point of interconnection to the BES. According to the Blue Cut Fire Disturbance Analysis Report solar development owners and inverter manufacturers have misinterpreted the area outside of the "No-Trip" curve as a "Must-Trip" requirement. This is possibly due to the use of the term "instantaneous trip" in the tables following the voltage and frequency curves.

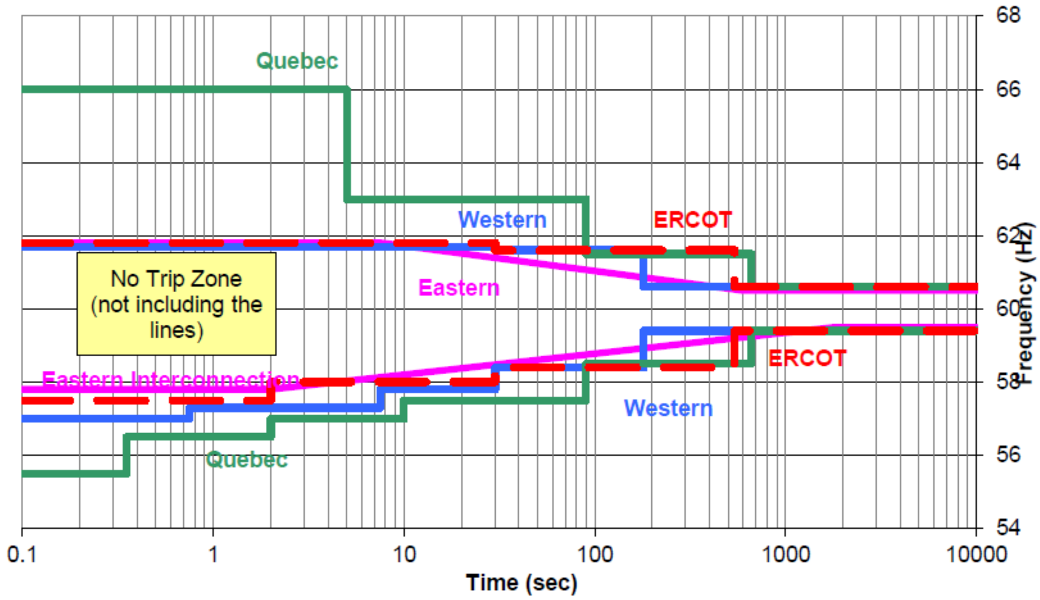

Figure 1: PRC-024-2 Frequency Curve

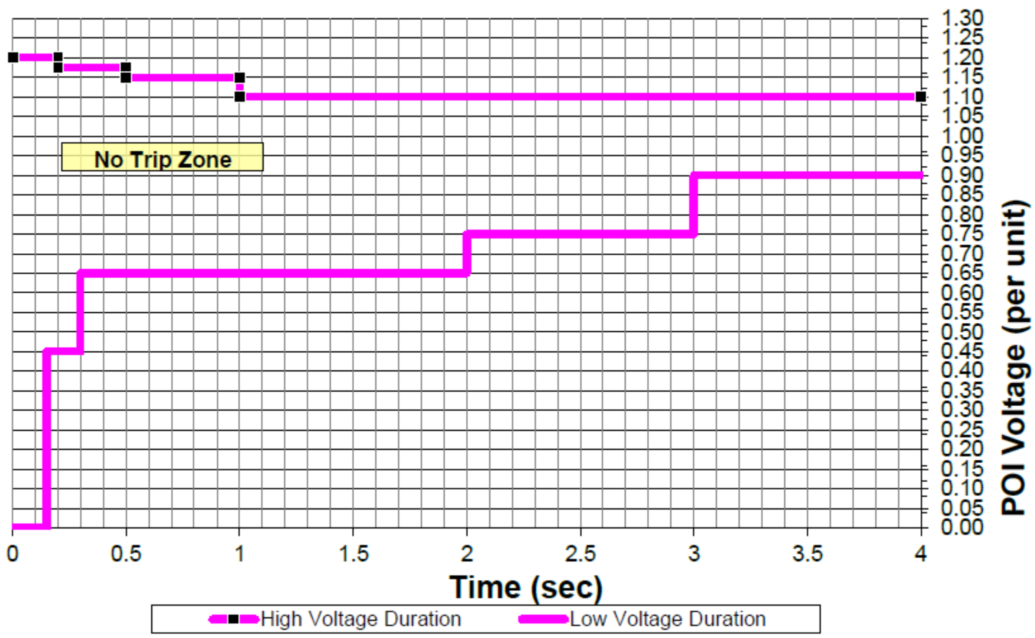

Figure 2: PRC-024-2 Voltage Curve

PRC-024-2 footnote 1 clarifies that Generator Owners are not required to have frequency or voltage protective relays. However, most inverter control systems have built-in protective controls for which the Generator Owners must provide settings. The Canyon 2 Fire Disturbance Report[8] found that all of the owners and manufacturers of the affected inverters had used the PRC-024-2 voltage curve to set the voltage protective settings. Several of the data request responses indicated that the "May- Trip" zone was being interpreted as a "Must-Trip" zone. Hence, despite the recognition in the Blue Cut Fire Disturbance Analysis Report of this misinterpretation, the industry was still setting the voltage protective settings according to the standard curve rather than on actual equipment voltage limitations, approximately 14 months after the Blue Cut Fire Event. Further, these set points were incorrectly applied at the inverter terminals, which are subject to wider voltage excursions than at the point of interconnection during transmission system disturbances due to voltage drop or rise across the collection system during the disturbance. The filters, capacitors, or cables in the collection system may augment the transient electrical disturbance that originated in the transmission system.

However, the intent of the PRC-024-2 voltage requirement is to define the minimum and maximum voltage conditions where generating resources may trip from protective relaying for voltage excursions. The region outside the "No-Trip" zone should be interpreted as a "May-Trip" zone and not a "Must-Trip" zone. Inverter settings should be determined based on equipment limitations and should be set to the greatest extent possible. This helps support bulk power system (BPS) reliability during and following grid events such as faults.

Similarly, frequency trip settings for generation resources should be set as wide as possible while still ensuring equipment protection and personnel safety to support BPS reliability. This aligns with the intent of PRC- 024-2. One possible solution could be to change the requirement such that relay settings be set based on equipment limitations but no narrower than the "No-Trip" zones.

Inconsistency between Curves and Tables

PRC-024-2 Attachments 1 and 2 include graphics showing the off-nominal frequency capability curve and the voltage curve, respectively, with curve data point tables describing the curves in tabular form. The curves and tables define the frequency and voltage protective relay setting minimum performance requirements. Each table contains a value for which a generation resource is allowed to instantaneously trip, essentially describing at what frequency or voltage a generator is no longer required to stay connected to the system.

The task force that analyzed the Blue Cut Fire event found that, "[a] significant amount of solar PV resources disconnected due to a perceived system frequency below 57 Hz. This perceived frequency was due to the Phase Locked Loop logic indicating a near instantaneous frequency during the transient/distorted waveform period as less than 57 Hz. The solar development owner and inverter manufacturer interpreted outside of the PRC-024-2 no- trip curve area as a must-trip area. The frequency table in PRC-024-2 for the Western Interconnection indicates instantaneous trip for frequency equal to or

[8] Canyon 2 Fire Disturbance Report. Available: https://www.nerc.com/pa/rrm/ea/Pages/October-9-2017-Canyon-2-Fire-Disturbance-Report.aspx.

less than 57 Hz. Therefore, the inverters were set to trip instantaneously upon seeing a frequency of 57 Hz."

However, in generation resource control systems, frequency is calculated over a window of time. Instantaneously derived frequency should not be used for protection. Frequency calculation methods use various types of time windows and filtering methods in order to accurately calculate grid frequency. Typically, these methods use a sliding window with a window width on the order of 100 ms (6 cycles). Thus, a delay would occur even if the protective relay algorithm had no intentional time delay. This measurement interval should be reflected in the standard.

Further, the Off Nominal Frequency Capability Curve of PRC-024-2 is a logarithmic graph that starts at time t=0.1 seconds. Thus, the Curve Data Point table "Instantaneous trip" value is inconsistent with the graphic.

Voltage Curve Clarification Error

Point #5 in the Curve Details section of the "Voltage Curve Clarifications" of PRC-024-2 states, "voltages in the curve assume minimum fundamental frequency phase to ground or phase to phase voltage for the low duration curve and the greater of maximum RMS (Root Mean Square) or crest phase to phase voltage for the high voltage duration curve."

Any voltage measured and compared with the PRC-024-2 voltage ride- through curve should be a well-filtered, fundamental frequency component of the voltage waveform. This filters out spurious voltage spikes caused by switching actions on the BPS. Voltage protective relays should not operate at the voltage levels specified in the voltage curve (e.g., 1.2 pu) using instantaneously sampled values, although it is reasonable for a generator resource to trip for instantaneous voltage spikes above equipment limitations if they can be properly detected. The other issue with this clarification is that the overvoltage component of the clarification states "the greater of maximum RMS or crest phase-to-phase voltage". There is ambiguity and technical concern on how this is applied, and should be clarified.

Further, PRC-024-2 clarifies that the low voltage duration curve is based on either phase-to-ground or phase-to-phase voltage, the high voltage duration curve is only based on phase-to-phase voltage. It is not clear why phase-to-ground voltage should not also be considered for the high voltage curve. Without addressing these, there may be reliability issues, as identified in the Canyon 2 Fire Disturbance Analysis Report.

Confusion in Cumulative Timer Start and Stop Time

The PRC-024-2 voltage curve ends at four seconds, and the curve uses a cumulative time duration for the "No-Trip" zone. Protective relays must be set to accommodate the cumulative nature of curves. Under the current version of PRC-024-2, it is not clear at what points the cumulative values reset or what are the starting and ending criteria. This cumulative aspect is also applied in the Volts/Hertz relay protection that covers both synchronous generation resources and generator step up transformers and needs to have clarification for the action to trip or reset.

Footnote 1 Applicability Confusion

Footnote 1 is intended to clarify that Generator Owners are not required to have frequency or voltage protective relaying, thus the requirements only apply if they do have such relays. The footnote contains a parenthetical with an “including but not limited to” statement that is intended to further clarify and provide examples of the types of relays that are applicable. The list contained within the parenthetical includes “protective functions within control systems that directly trip or provide tripping signals to the generator resource based on frequency or voltage inputs.”

As noted in the Blue Cut Fire disturbance report, “PRC-024-2 uses language that is more common for conventional synchronous rotating ac generators with traditional protective relays.” Because of the language in the bulk of the standard, there is confusion regarding whether the parenthetical list in the footnote is intended to make inverter controls applicable to the requirements of the standard, and if so, what operating modes or functions are considered “tripping” the generating resource. For example, is the use of momentary cessation in inverter controls considered tripping and, therefore, unacceptable? Further, if PRC-024-2 applies to inverter controls, do the requirements apply to individual inverters or to the generation resource as a whole? As an example, if 50% of inverters within a generation resource trip for a grid disturbance within the “No Trip” zone of the curves, but the generation resource does not trip at a plant level, does that meet the intent of the requirements? These points of confusion should be addressed.

Momentary Cessation

The use of momentary cessation was not considered nor defined in the development of PRC-024-2. Therefore, it was previously unclear as to whether the use of momentary cessation within the “No Trip” zone of PRC-024-2 curves was acceptable. However, IRPTF simulations and studies show that widespread use of momentary cessation within the “No Trip” zone of PRC-024-2 can have a detrimental effect to grid stability, particularly if incorrectly used. From an overall BPS perspective, the nearly instantaneous loss of current injection (and consequently power injection) into the BPS has similar effects as resource tripping. This is particularly true if a significant delay or long ramping period is used prior to the plant recovering its active current output. Therefore, momentary cessation often gets equated to tripping, since from the system-side these look very similar. However, inverters include protective functions that, for example, open the AC circuit breaker. Yet they also have a vast amount of controls that determine the current injection of the resource. Due to the negative impacts of momentary cessation controls, the IRPTF recommends that the use of momentary cessation within the “No Trip” zone of PRC-024-2 should be eliminated (or at least minimized) to the extent possible. Some cases may exist where momentary cessation is used briefly (e.g., during severe fault conditions) for the purpose of improving inverter controls response.

A future Standard Draft Team should closely consider, and possibly consult with the IRPTF, on use of momentary cessation for very low voltages (i.e., less than or equal to, say, 0.3 pu) within the “No Trip” zone of PRC-024-2. At these very low voltages, inverters may have trouble tracking electrical quantities, which is required for reliable current injection into the BPS. The IRPTF will continue exploring this concept, and possibly develop a position on this subject. The position will be based on studies, which will serve as the technical basis for such decision.

Brief Discussion of Terms Used

The IRPTF suggests the following clarifications, as described more thoroughly in the *Reliability Guideline: BPS-Connected Inverter-Based Resource Performance*:

- **Ride-Through Capability**: The capability of generating facilities to remain connected to the BES during grid disturbances involving voltage and/or frequency excursion away from a nominal operating range. As it relates to inverter-based resources, this includes capability to continue injecting current (both active and reactive, as necessary), consideration of momentary cessation, and minimum voltage and frequency capability range.
- **Momentary Cessation:** A mode of operation in which no current is injected into the grid by the inverter during low or high voltage conditions outside the continuous operating range. The power electronic firing commands are blocked, and the inverter does not produce active or reactive current (and therefore no active or reactive power).[9]
  - Momentary cessation is often used outside of the PRC-024-2 curves, particularly for extreme sub-cycle overvoltage conditions at the inverter terminals. These periods are brief, and momentary cessation is often used as a form of self-protection in those instances.
  - Momentary cessation inside of the PRC-024-2 curves is not recommended, and should be eliminated to the extent possible. This has conventionally been used as an operating mode during disturbance events. However, the current recommendation is to continue injection of active and reactive current based on the recommended performance specifications outlined in the *Reliability Guideline: BPS-Connected Inverter-Based Resource Performance*.
- **Recovery from Momentary Cessation:** After momentary cessation occurs within an inverter, the inverter is programmed to return to current injection to reach a new operating state. The recovery typically may involve some type of delay and active current ramp rate upon recovery. The recovery of momentary cessation should be differentiated from the initiating act of entering momentary cessation.
- **Inverter Protective Functions:** All inverters include some protective functions within their controls systems. Inverter tripping for abnormal system frequency and voltages are included in virtually all inverters available today. The set points for these protective functions are often configurable and may be specified by the Generator Owner. This capability is essentially the same as that provided by discrete voltage and frequency relays.
- **Controls:** The protective functions within an inverter should be differentiated from the controls that determine the current injection of the inverter-based resource. PRC-024-2 pertains specifically to the protective aspects of resources, and does not specify controls aspects. However, the IRPTF believes

[9] IEEE Std. 1547-2018 includes the following definition for momentary cessation: "Temporarily cease to energize an EPS, while connected to the Area EPS, in response to a disturbance of the applicable voltages or the system frequency, with the capability of immediate Restore Output of operation when the applicable voltages and the system frequency return to within defined ranges."

that momentary cessation (a control function) should be disallowed within the "No Trip" zone of PRC-024-2 due to its negative impact on the BPS.

Other Issues for Consideration and IRPTF Next Steps

The IRPTF has identified additional issues that are considered outside the scope of the above-described topics that specifically pertain to PRC-024-2. However, the IRPTF will be discussing these issues in more detail and may recommend further work or additional revisions to NERC Reliability Standards after the IRPTF has had more time to discuss each issue in detail.

#	Issue
1	A clear differentiation between "ride-through" and the PRC-024-2 protective relaying standard is needed to bring clarity to requirements and applicability of the standard. A number of IRPTF members have expressed a need for a full "ride-through standard" for inverter-based resources, with clear requirements as to how the resource can behavior within the "ride-through" zones. This includes both controls and protection aspects. Inverter-based resource vendors are working to meet local ride-through criteria apart from PRC-024-2, and future NERC standards could definitely provide clarity on these issues. Similarly, a performance-based standard could be developed rather than a protective relay settings standard.
2	Power electronic equipment within an inverter may be equipped with self-protection that may disconnect the switching devices for instantaneous (or sub-cycle) measurement spikes once critical thresholds have been reached to protect equipment integrity. Such instantaneous spikes may be filtered in a RMS signal; therefore, comparison of sub-cycle measurements against a RMS profile (particularly for overvoltage) is problematic. In these cases, the resources may be prone to tripping on sub-cycle spikes in voltage while the RMS signal is within the curve profile. This needs to be clarified in future revisions to PRC-024-2 or other future standards related to ride-through performance. The RMS criteria can only be applicable in the case of RMS simulations or comparison to RMS waveforms. If this RMS criteria is used to evaluate 3 phase signals coming from EMT software simulations or from real measurements, the trip due to an instantaneous overvoltage needs to be taken into account. An instantaneous single-phase limit could also be established. A similar argument can also be made for frequency; however, this is less of a concern based on practical event analysis. Simulations mechanisms for comparing performance versus requirements can also be considered.
3	There are many other forms of inverter protection that can trip an inverter off-line during a disturbance. A number of these protections have been observed in analyses during the Blue Cut Fire and Canyon 2 Fire disturbances. These include, but are not limited to, phase lock loop loss of synchronism, DC bus protection, and inverter current protection. These forms of tripping are not covered in PRC-024-2, yet are highly relevant to the performance and overall ride-through capability of inverter-based resources. These transient-based forms of protection are not particularly relevant for synchronous machines; however, are very relevant to inverter-based resource protection and performance during grid disturbances. Not considering these types of protection could degrade overall system reliability.

#	Issue
4	During a transient grid event, the voltage at the Point of Interconnection is a function of both the characteristics of the transmission system and the behavior (current flow) of the interconnected generation resource. PRC-024-2 does not differentiate responsibilities between these two parties, and strictly applies to ensuring setting voltage and frequency protective relaying such that the resource will not trip on these protective functions for specified Point of Interconnection conditions. However, if the protective relaying philosophy of PRC-024-2 is incorrectly applied or misinterpreted for local studies or requirements, this can lead to issues meeting more rigorous "ride-through" requirements that could be based on PRC-024-2. This should be further explored and corrected, to the extent possible.
5	Instantaneous tripping on frequency measurements was a contributing factor for recent BPS disturbances involving solar PV plants. However, the frequency protection settings of those generators were set incorrectly. Actual frequency ride-through capability of inverter-based resources is such that no instantaneous frequency-related protective actions should be allowed. While synchronous machines have different operating characteristics that expose them to loss of life issues, inverter-based resources do not have these same types of issues.
6	PRC-024-2, nor any NERC Reliability Standard, specifies the performance of resources within the "No-Trip" zone when connected to the BES. Unlike synchronous machines, whose electrical response to fault events is predominantly driven by Newtonian laws of physics, an inverter-based resource's response to grid events is driven entirely by controls. Upon disallowing momentary cessation within the "No Trip" zone of the PRC-024-2 curves, it is necessary to provide guidance and possibly specification of the type of current injection desired for different grid events. This is important for both unbalanced and balanced faults. This is outside the scope of PRC-024-2, but is considered by many to be of critical importance for maintaining grid stability and reliability at higher penetrations of inverter-based resources. The IRPTF will continue discussions as to the appropriate venues for providing this guidance or requirement.
7	Momentary cessation has been used to handle certain disturbance events where the resource would otherwise be unable to reliable track the grid and be unable to ascertain the correct electrical response. For example, momentary loss of phase lock loop synchronism, DC overvoltage due to a transient high AC system voltage upon fault clearing, and other DC bus dynamics. The existing standard is silent on these issues; however, these types of issues are critical to overall ride-through of inverter-based resources. The IRPTF will consider whether the scope of "ride-through" should be expanded based on these issues.
8	PRC-024-2 does not specify recovery requirements should the plant, or part of the plant, trip or momentarily cease injection of current. Inverter-based resources, being dispersed power producing resources, are subject to partial tripping or partial use of momentary cessation. The standards were not designed with this in mind, and it is unclear if this performance is acceptable.
9	There should be clarification of how inverter-based resources are expected to respond upon the first 100 ms of a disturbance, particularly for frequency excursions.
10	Consideration needs to be given to the operating conditions that are expected to be encountered by inverter-based resources, and ensure that proper studies are performed to identify issues such as ride-through behavior, partial or full plant tripping, and other issues. This includes further consideration for electromagnetic transient (EMT) simulations to identify any phase-based issues rather than strictly positive sequence RMS issues.

#	Issue
11	Tripping of resources may occur if transient or non-fundamental harmonic content occurs in the bulk grid that exceeds 1.2 pu. These conditions may be natural components of the bulk system response, but cannot be correctly simulated using 60 Hz phasor modeling tools, and may require several seconds to damp following severe events. The topic of harmonics, "ride-through", and protection should be discussed in more detail.