IEEE 1547-2018 Rapid Voltage Change Requirements for Distributed Energy Resources

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Background and Scope

IEEE Std 1547-2018[1] is the current interconnection and interoperability standard applicable to grid-connected Distributed Energy Resources. The standard defines a range of technical requirements, including "limitation of voltage fluctuations induced by the DER". [2] The voltage fluctuation section has separate requirements for Rapid Voltage Change (RVC) and Flicker caused by the DER.[3] This paper focuses only on the RVC aspect of voltage fluctuation as applied to DER interconnections.

RVC Thresholds

The IEEE 1547-2018 RVC requirements prohibit the DER from causing RMS voltage step or ramp changes in nominal voltage, averaged over a one second period, which exceed thresholds stated in subclause 7.2.2. The standard RVC threshold depends on whether the Point of Common Coupling (PCC) is at medium or low voltage levels.[4] Medium voltage is associated with distribution system primary voltages whereas low voltage is associated with service voltages supplied from the "low-side" of distribution service transformers. Table 1 shows the IEEE 1547-2018 RVC thresholds and detailed requirements found in subclause 7.2.2.

Table 1. IEEE 1547-2018 RVC Thresholds

PCC Location	RVC Threshold	IEEE 1547-2018 RVC Language
Medium Voltage	***3%***	*"DER shall not cause ramp or step changes in RMS voltage at the PCC exceeding 3% of nominal and exceeding 3% per second averaged over one second period."*
Low Voltage	**5%**	*"DER shall not cause ramp or step changes in RMS voltage at the PCC exceeding 5% of nominal and exceeding 5% per second averaged over one second period."*

Applicability

IEEE 1547-2018 lists DER operations or events included or excluded from the standard's RVC requirements. Table 2 below summarizes these conditions. While some ambiguity exists in the standard between the "abrupt output changes caused by DER misoperation" and "unplanned tripping", each has the potential to cause active power output swings equal to the full DER nameplate. DER misoperation can include inverter power conversion problems causing a DER to exhibit abrupt output changes or to enter a cease to energize state. Unplanned tripping can be caused by a grid voltage or frequency condition that requires the DER to trip.

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[1] IEEE 1547-2018 (Revision of IEEE Std 1547-2003), IEEE Standard for Interconnection and Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power System Interfaces. Available for purchase at: https://standards.ieee.org/standard/1547-2018.html

[2] IEEE 1547-2018, subclause 7.2

[3] Rapid Voltage Change is covered in section IEEE 1547-2018, subclause 7.2.2 and Flicker in subclause 7.2.3

[4] The PCC is the interface between the DER system and utility distribution system, typically at the location of the utility meter.

Table 2. IEEE 1547-2018 applicable RVC events

Included **as RVC Events**	***Excluded*** **as RVC Events**
• Abrupt output changes caused by DER misoperation; • Frequent transformer energization; or • Frequent capacitor switching	• Infrequent switching; • Transformer energization related to commissioning, fault restoration, or maintenance; or • Unplanned tripping

IEEE 1547-2018 defines requirements at either the output of a DER unit (i.e. point of DER connection) or at the interface between the customer's electric system and the utility's distribution system (i.e. point of common coupling).[5] Other system-level impacts, such as wear and tear on voltage regulation equipment, are not contemplated by IEEE 1547-2018.[6]

Technical justification

Rational for including RVC thresholds for DER in IEEE 1547-2018 is provided in Appendix G.2 of the standard. It notes potential issues on the end-user side from RVC, for instance, potentially damaging stress on motor loads, in addition to visible impacts on lighting that might be problematic for customer but are not captured by flicker indices. On the utility side, the IEEE 1547-2018 Appendix G.2 notes that RVC can introduce incompatibilities with utility voltage regulation and protection equipment. In summary, RVC events have the potential to cause power quality issues affecting both customer and utility equipment.

[5] The standard includes requirements for determining the Reference Point of Applicability, the location at which all the interconnection and interoperability requirements apply, in Subclause 4.2.

[6] Excessive voltage regulation equipment operation is just one of many system-level issues that are not within the purview of IEEE 1547-2018, which utilities address separately to protect safety, reliability, and power quality. Other examples include equipment thermal overloads and system protection impacts.