Revision Notes

Rev.	Date	Author	Approved By	Comments
01	11/19/2020	Peter Niknejad	Kim Gauntner	*- Document created*
02	08/06/2021	Peter Niknejad	Kim Gauntner	*- Voltage and Frequency trip settings have changed to comply PJM and NERC guidelines (sections II and III, Figure 1 and 2, Table 1, 2, 3, and 4).* *- Attachment A (Figure A-1) updated based on the revised settings*
03	2/17/2023	Peter Niknejad	Kim Gauntner	*- time setpoints for voltage and frequency trip setting have been corrected to match the protection ride through coordination rev1 (6-17-21)*
04	11/30/2023	Peter Niknejad	Kim Gauntner	*- the time setpoint for OV2 has changed back from 0.2 to 0.16 to align with IEEE 1547 guideline for over-voltage ride through settings*

I. Background

PPL Electric Utilities "PPL EU" has developed voltage and frequency ride-through settings for inverter-based generation connected to the Distribution System in compliance with the IEEE 1547-2018 standard. these standards consider both the stability of the bulk electric system as well as the safe and reliable operation of the distribution system.

PPL EU completed technical reviews of and incorporated the voltage and frequency ride-through requirements for bulk electric system generators under PRC-024-2: *Generator Frequency and Voltage Protective Relay Settings*. These ride-through settings a delineated to allow DER to "ride through" or remain connected to the distribution system during system disturbances slightly longer than the requirements in the NERC Standard in order to maintain the stability of the Bulk Electric System by allowing the centralized generators to ride through system disturbances before DER trip offline. If DER trip offline before bulk electric system generators, system disturbances would be exacerbated and it could jeopardize the stability of the grid when DER penetration levels are significant.

Also taken into consideration was the safe and reliable operation of the distribution system. With the proliferation of automated devices on the PPL EU Distribution system, ensuring that the DER ride through settings do not conflict with reclosing cycles is imperative to ensure reliability is maintained.

IEEE 1547 has three categories of Voltage Ride-Through parameters; Levels 1, 2 and 3. Each of these levels has set points that can be adjusted over a specific range to customize and coordinate DERs riding through system disturbances with protective devices on the distribution system while maintaining system stability. PPL EU developed the Voltage Ride-Through settings within this document, based on a variation of IEEE 1547-2018 Voltage Ride Through Category 2, and Frequency Ride-Through settings, based on PRC-024 as outlined in Attachments A and B, respectively.

II. PPL EU Voltage Ride-Through Settings

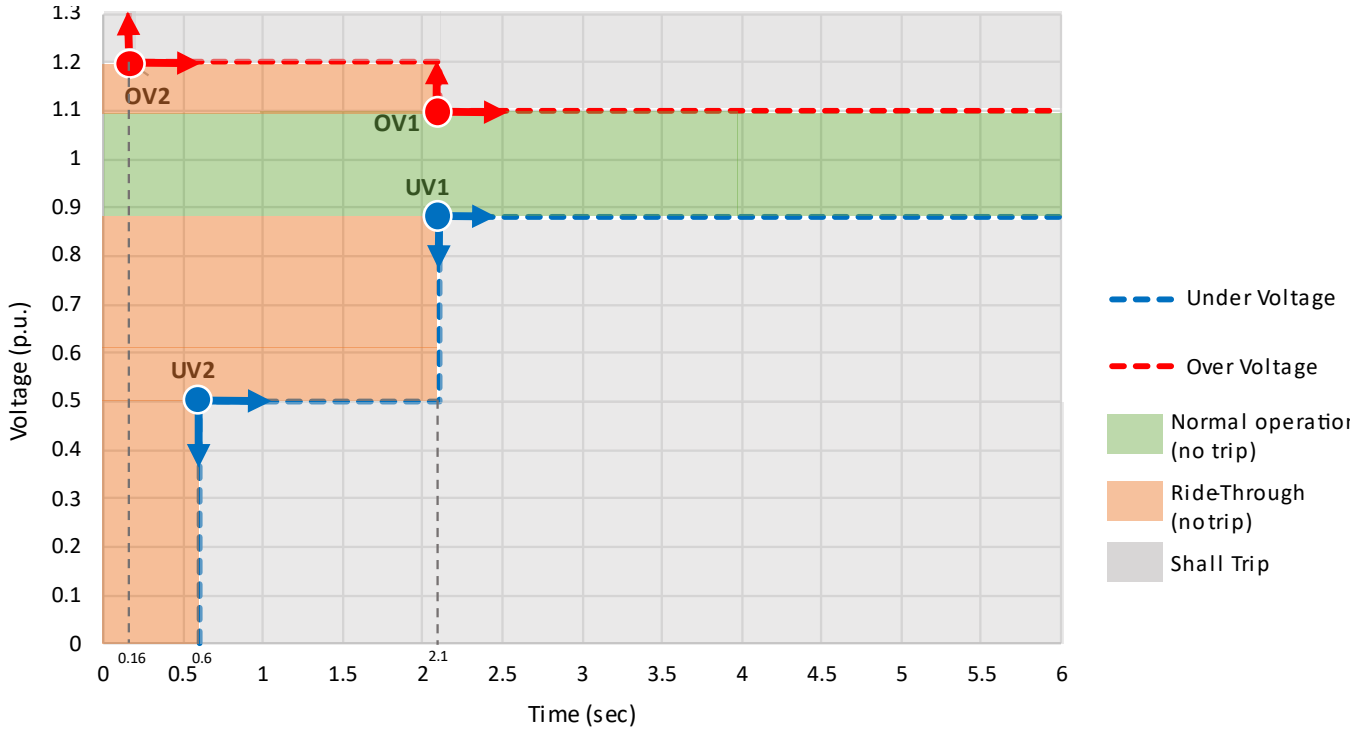

Figure 1: PPL EU Voltage Ride-Through Settings

Table 1: PPL EU Required Low Voltage Shall Ride-Through and Shall Trip Settings

Under Voltage Requirements *Shall Ride Through* and *Shall Trip* curves are identical (overlapping) and defined in this table.		
Shall Trip Function	Voltage (p.u. of nominal voltage)	Time (sec)
UV1	0.88	2.1
UV2	0.5	0.6

Table 2: PPL EU Required High Voltage Shall Ride-Through and Shall Trip Settings

Over Voltage Requirements *Shall Ride Through* and *Shall Trip* curves are identical (overlapping) and defined in this table.		
Shall Trip Function	Voltage (p.u. of nominal voltage)	Time (sec)
OV1	1.1	2.1
OV2	1.2	0.16

III. PPL EU Frequency Ride Through Settings

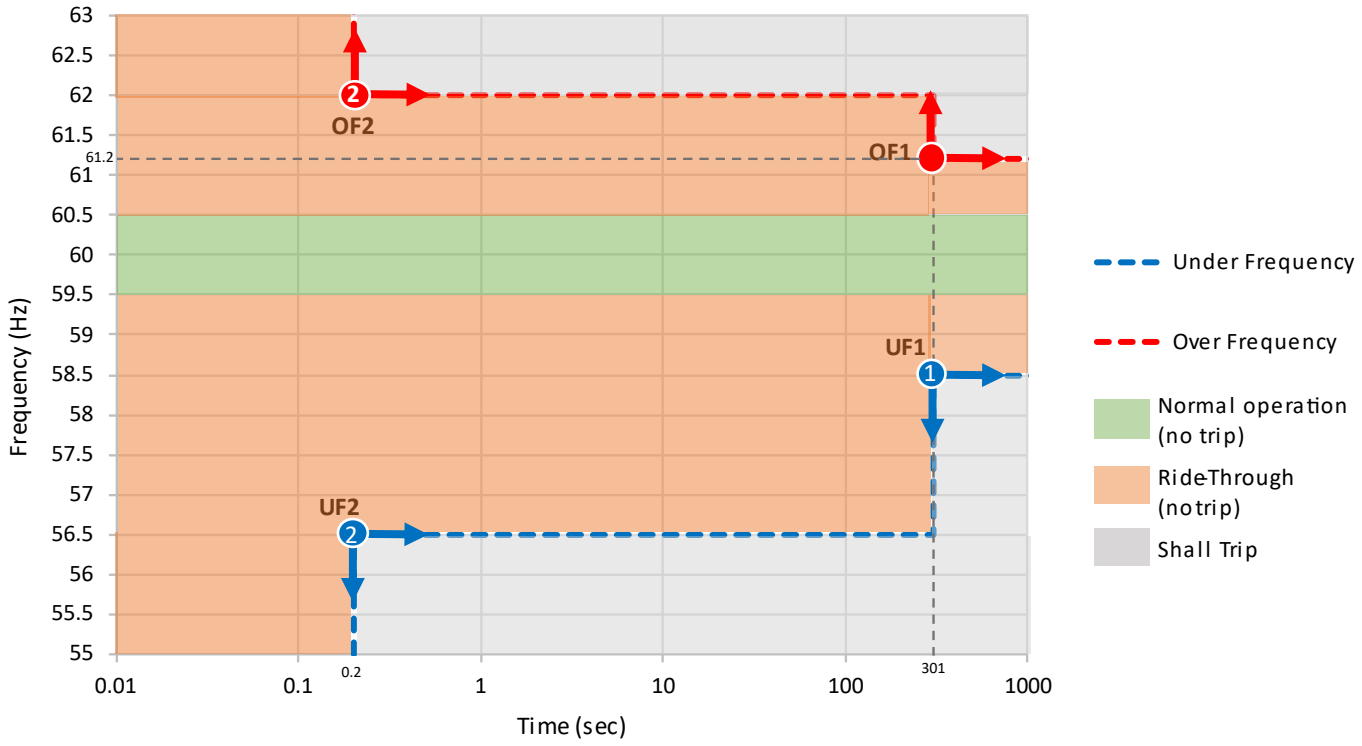

Figure 2: PPL EU Frequency Ride-Through Settings

Table 3: PPL EU Required Under Frequency Ride-Through Settings

Shall Trip – Under Frequency Requirements		
Shall Trip Function	Frequency (Hz)	Clearing Time (sec)
UF1	58.5	301
UF2	56.5	0.2

Table 4: PPL EU Required Over Frequency Ride-Through Settings

Shall Trip – Over Frequency Requirements		
Shall Trip Function	Frequency (Hz)	Clearing Time (sec)
OF1	61.2	301
OF2	62	0.2

Attachment A:

PPL EU Under Voltage Ride-Through Setting vs. NERC PRC-024

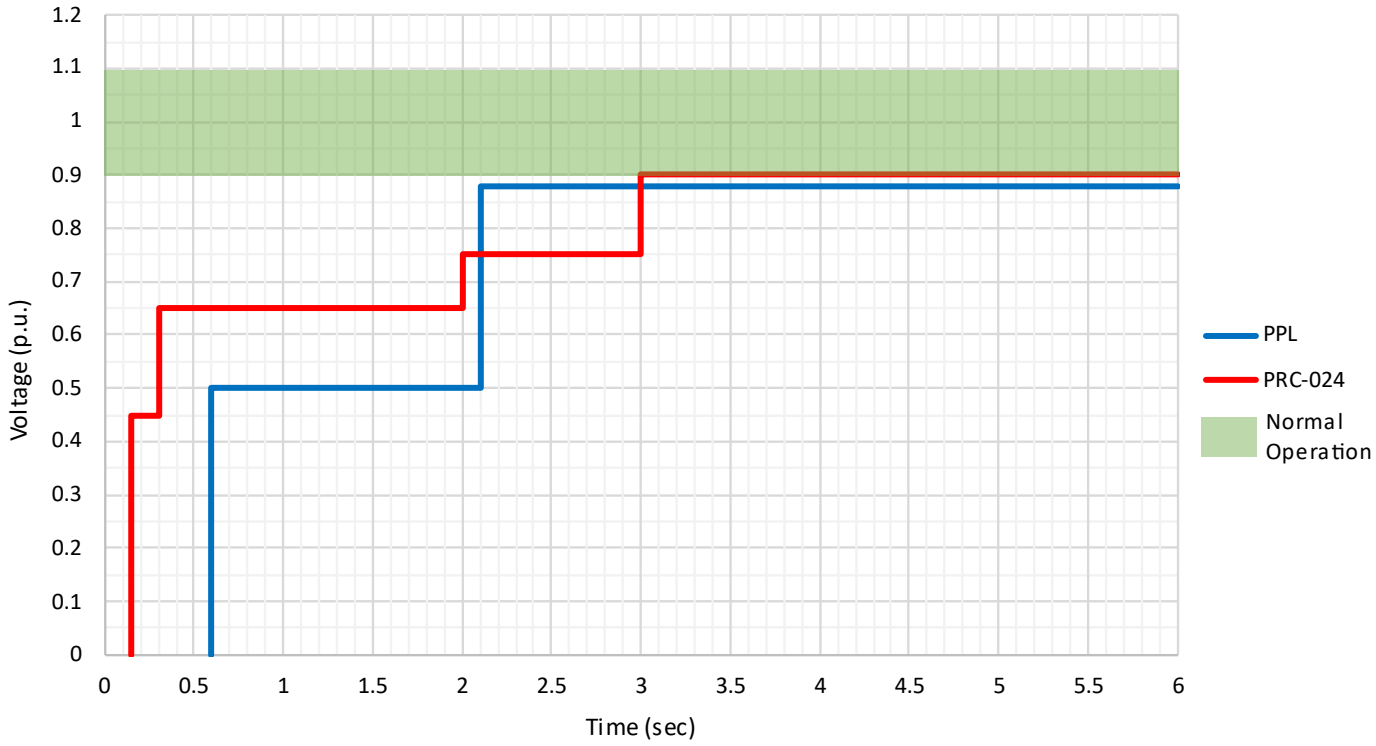

Figure A-1: PPL EU Under Voltage Ride-Through Settings compared to PRC-024

Attachment B: IEEE 1547-2018 Ride-Through Settings

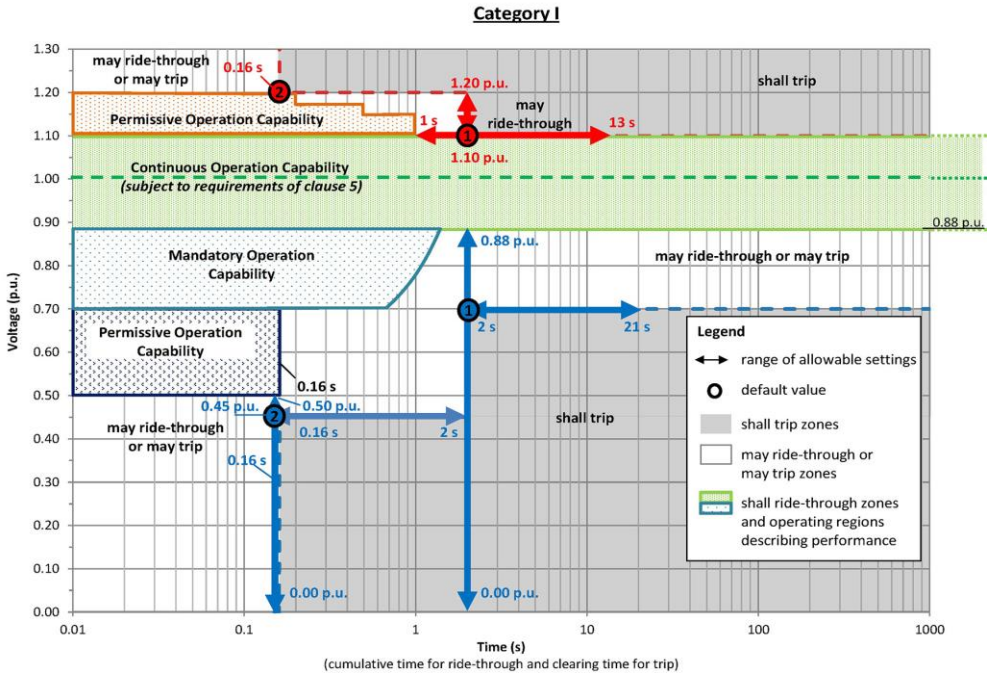

Figure B-1: IEEE 1547-2018 Category I Voltage Ride-Through Settings (Figure H.7, Page 133, IEEE 1547-2018 Standard)

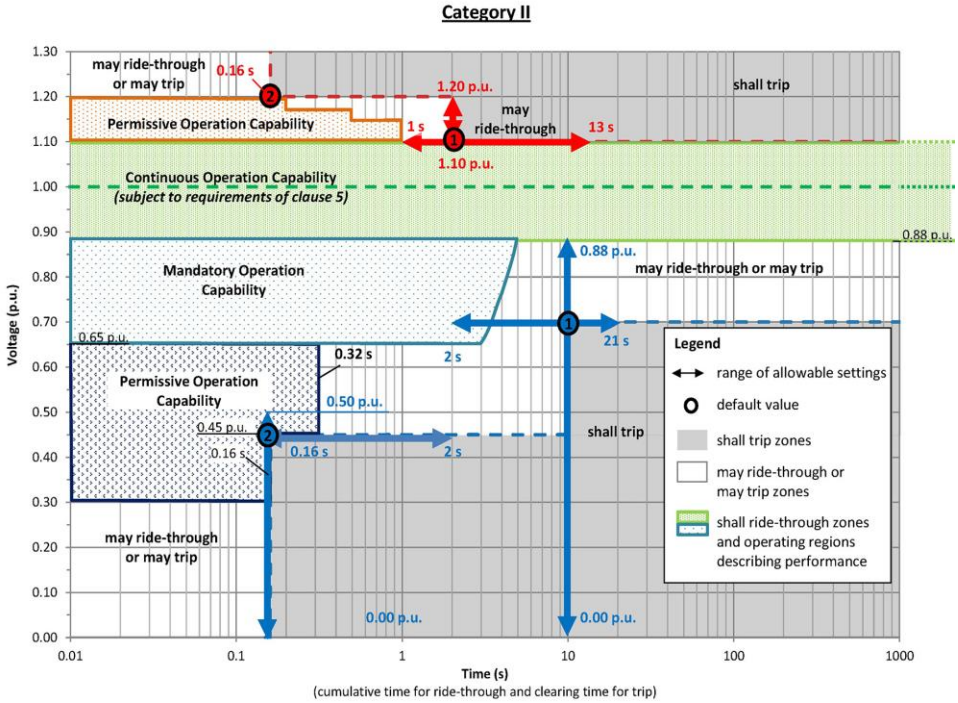

Figure B-2: IEEE 1547-2018 Category II Voltage Ride-Through Settings (Figure H.8, Page 134, IEEE 1547-2018 Standard)

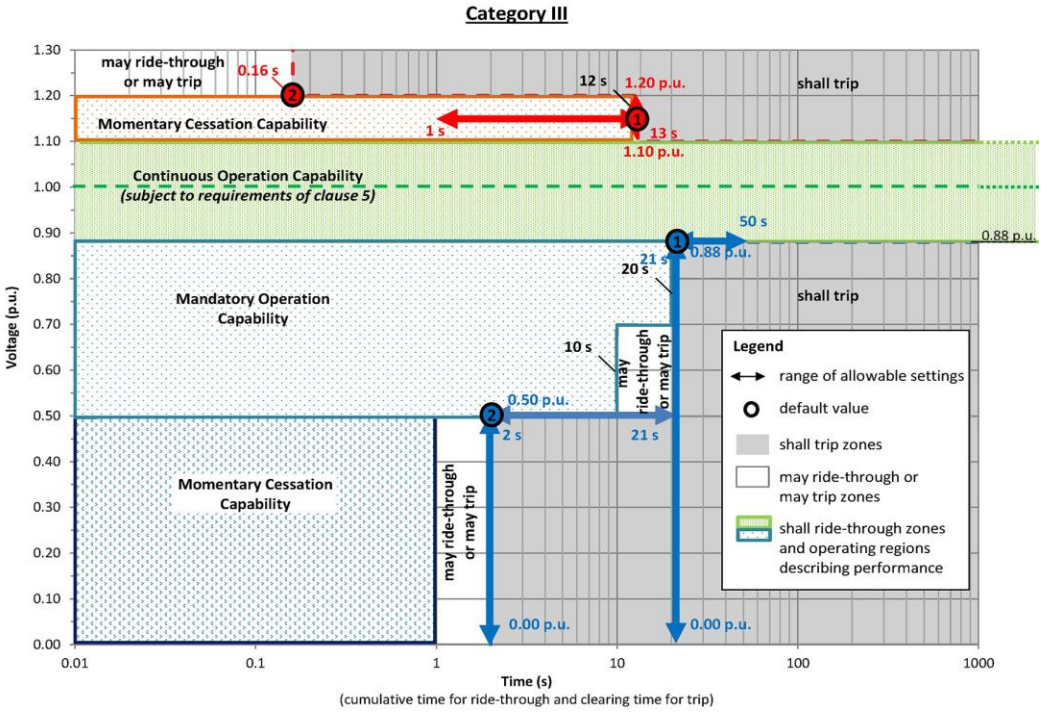

Figure B-3: IEEE 1547-2018 Category III Voltage Ride-Through Settings (Figure H.9, Page 134, IEEE 1547-2018 Standard)

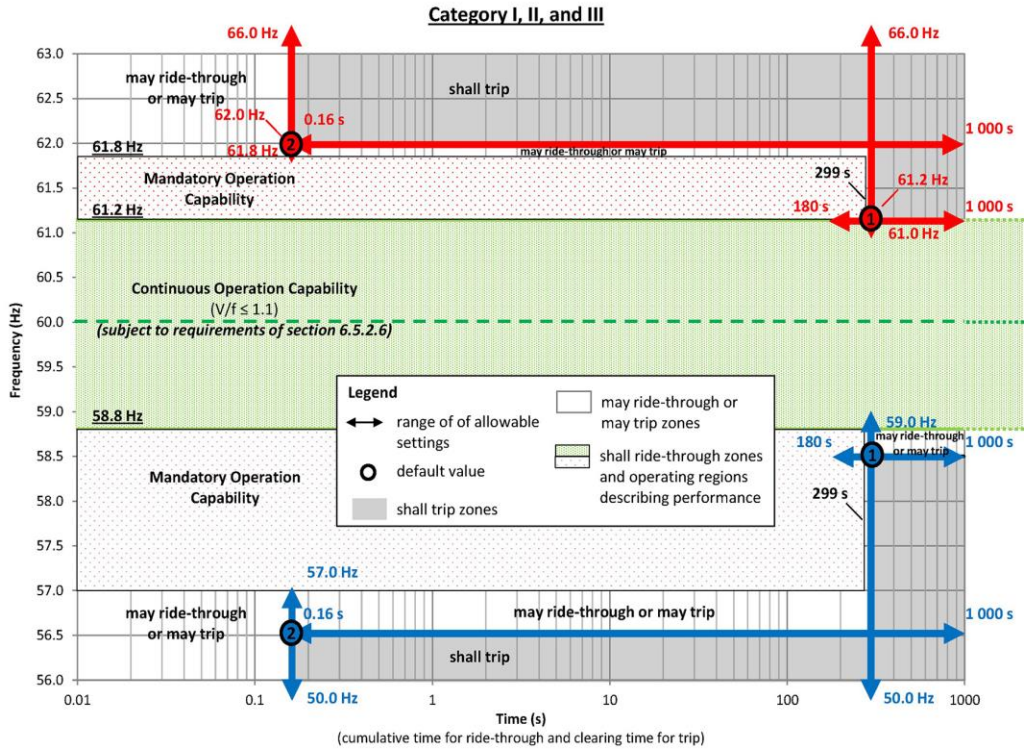

Figure B-4: IEEE 1547-2018 Category I, II, III Frequency Ride-Through Settings (Figure H.10, Page 135, IEEE 1547-2018 Standard)