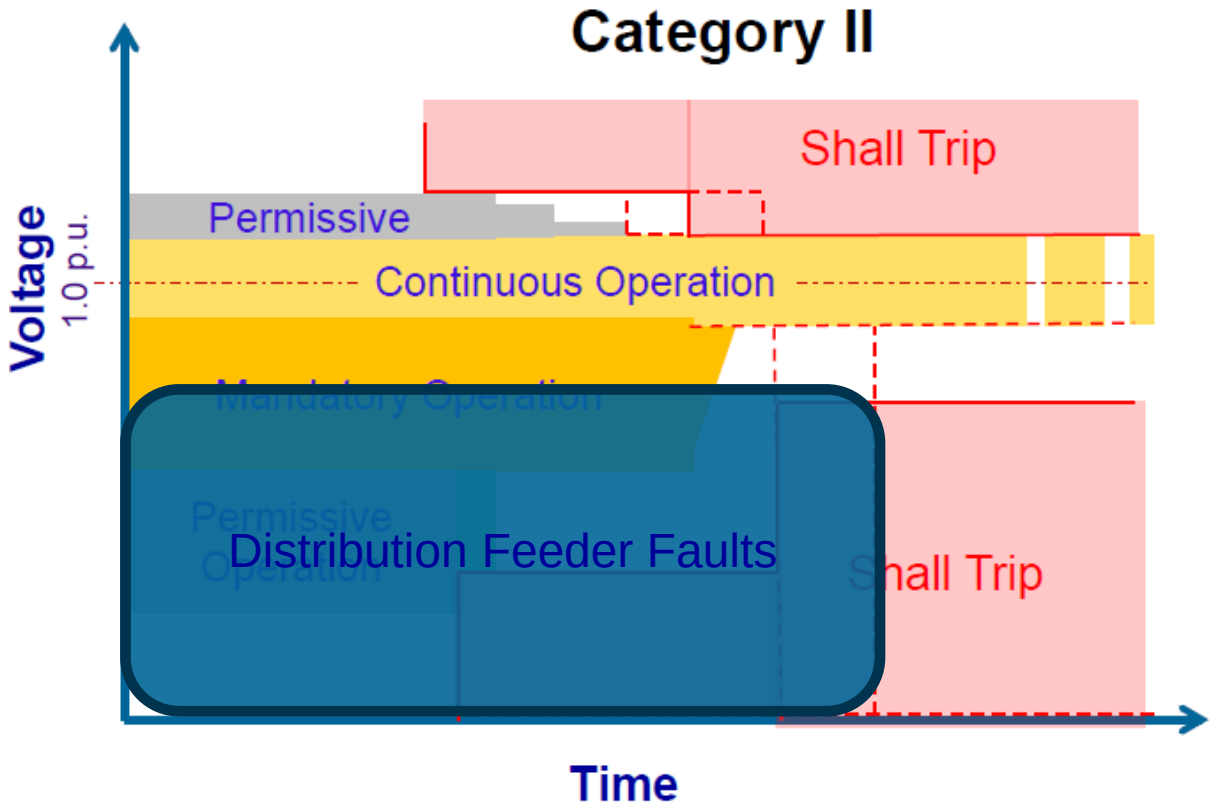
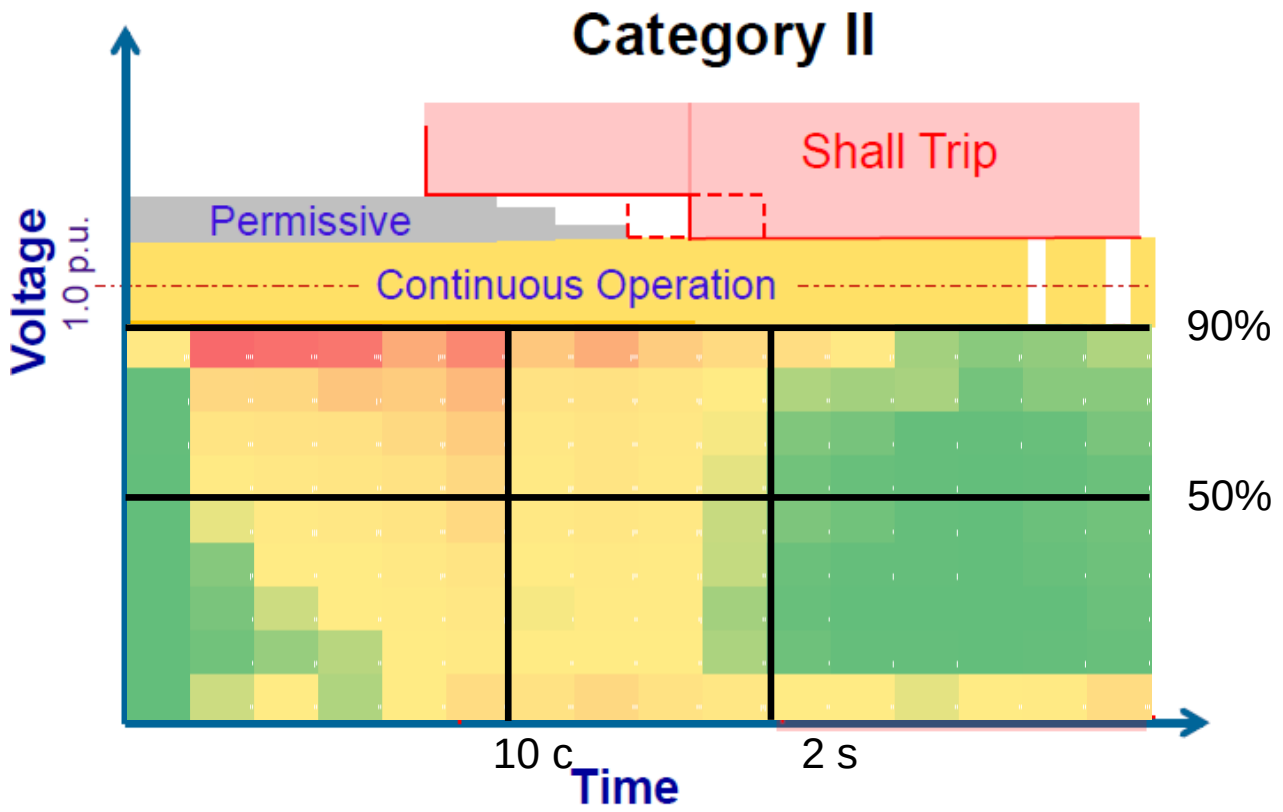
Report out from REMOTE BREAK-OUT (excludes 5 in-person break out groups)

Structure of Voltage Ride Through



Dashed lines indicate permissible range of trip adjustment, solid lines indicate default settings. Figure are approximate and solely for illustration, refer to IEEE P1547 for actual requirements

Approximately how many events per year



Transmission–Distribution Power Quality Report (TPQ-DPQ III). EPRI, Palo Alto, CA: 2014. 3002003905.

Data overlay for TPQ-DPQ III, Distribution Voltage Only, Voltage Sags Per 365 Days

Visualization by Justin Price of FirstEnergy

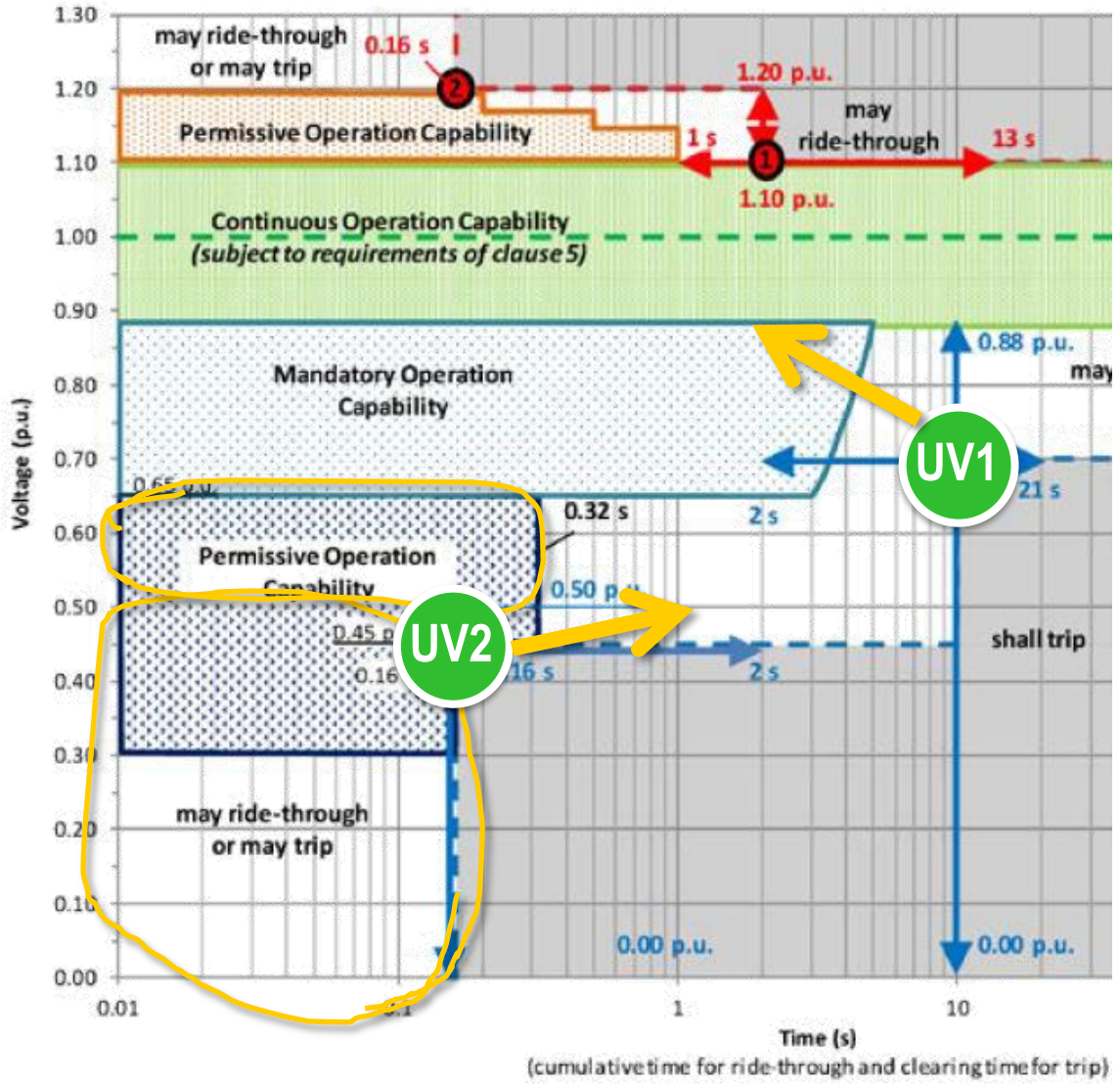
“Strawman” for PJM DER Voltage Ride Through

IEEE 1547-2018 “Category II” with adjusted trip settings & additions:

a) UV1 time decreased→2 seconds and volts increased→88% for arc-flash and recloser concerns.
CONFLICTS W/ NERC PRC-024-2 BUT IS W/IN IEEE STD 1547-2018.

b) UV2 increased→1.1 seconds and 50% to support delayed transmission fault clearing.

c) “Permissive Operation” range and very low voltage “may trip” range is specified to “Mandatory Operation” for V > 0.50 and “Momentary Cessation” for V < 0.50.



Guidance Principles

1. Consider bulk system reliability concerns
   - Meet or exceed NERC PRC-024
   - Consider depressed post-fault distribution voltages
   - Reduce uncertainty of DER performance in transmission modeling

2. Consider distribution safety and reliability concerns
   - Momentary Cessation alleviates many concerns related to UV2 setting

3. Stay as close to strawman or other existing settings, e.g., ISO NE
   - DER vendors prefer a small set of utility-required profiles (URPs)

REMOTE BREAK-OUT Proposal for PJM DER Voltage Ride Through

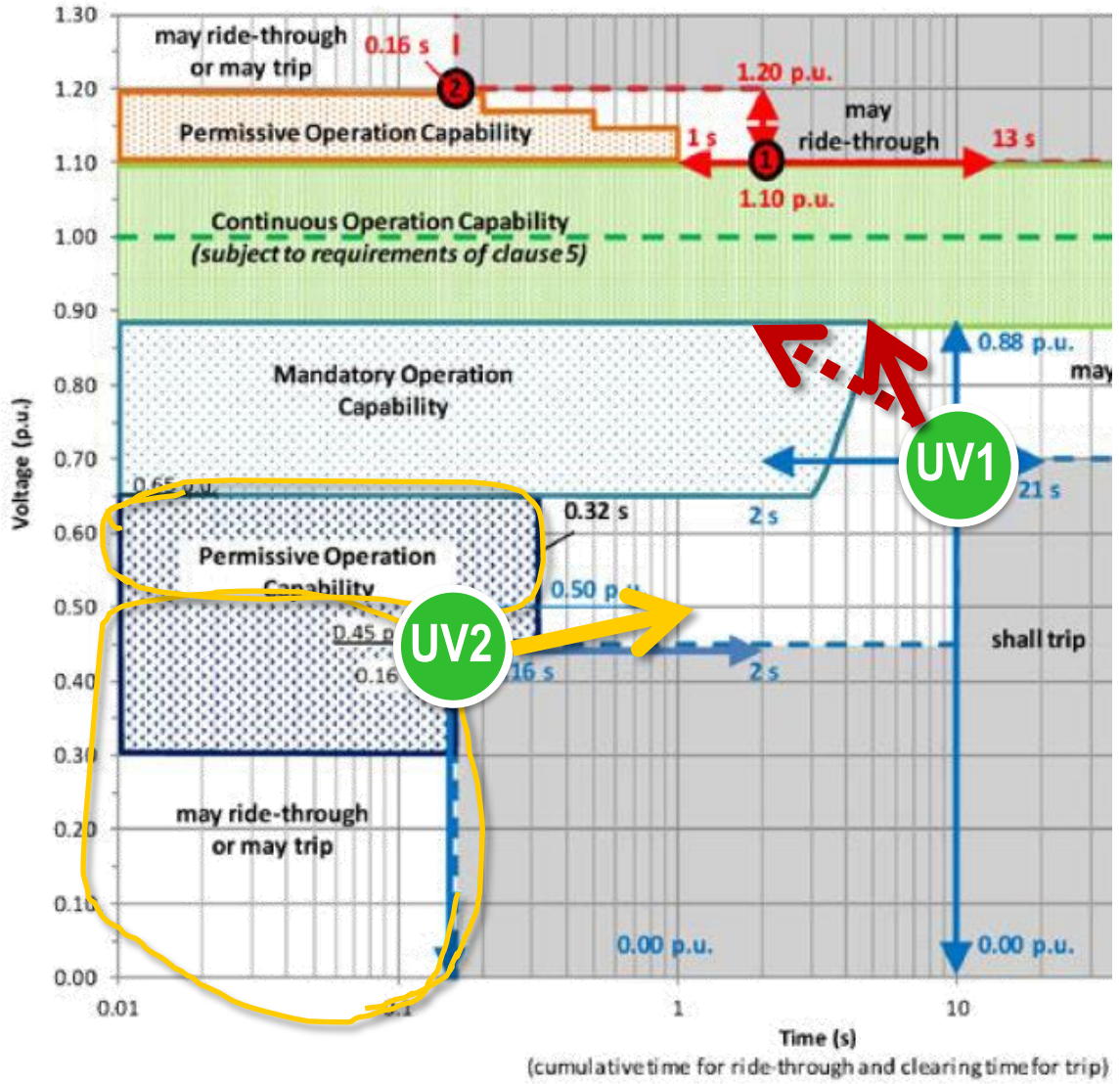
IEEE 1547-2018 “Category II” with adjusted trip settings & additions:

a) UV1 time decreased→5.16 seconds and volts increased→88% for arc-flash and recloser concerns.
~~CONFLICTS W/ NERC PRC-024-2 BUT IS W/IN IEEE STD 1547-2018.~~

b) UV2 increased→1.1 seconds and 50% to support delayed transmission fault clearing.

c) “Permissive Operation” range and very low voltage “may trip” range is specified to “Mandatory Operation” for V > 0.50 and “Momentary Cessation” for V < 0.50.

d) No concerns on default overvoltage settings OV1 and OV2



Next Steps

Future topics for model studies

- BES stability under 2031 high-DER scenario with 1547-2003 behavior as well as 1547-2018 Cat II 600-ms-long momentary cessation at a 50% undervoltage threshold following bad 3-phase 230kV trip
- Arc flash safety follow-up research--impacts of ride through and mitigation from momentary cessation and trip

Literate review topics for education

- Literature survey and education items:
- Anti-islanding
- Island sustainability
- Quantify impact of reclosing into an out of phase DER island
- Quantify cost of hot blocking/dead permissive reclose
- Distribution protection masking
- Presentation on NERC studies justifying the PRC-024 ride through values (esp. 3 seconds at 88%)

Survey questions for distribution utilities

- Substation first-try reclose times
- Substation relay settings: what are typical pickup values, time-inverse, time-current, etc.?
- Adjustable reclosers
- Distribution Automation and FLISR and relevant timing
- Regular use of hot blocking (dead permissive) for substation reclosers with presence of DER
- Any available data on retained voltage during arc faults, esp. worst case scenarios
- Which modeling software is used on distribution for:
  - Steady state power flow (e.g. Distribution Engineering workstation)
  - Arc flash safety (e.g. Arcpro)
    - Study assumptions: phase-to-ground vs phase-to-phase, arc impedance
  - Short circuit (e.g. ASPEN)
  - Voltage balance and voltage profile

Resources

- PJM Workshop Proceedings: https://www.pjm.com/committees-and-groups/stakeholder-meetings/der-ride-through-workshop.aspx

- EPRI Training Modules on IEEE Std 1547-2018™
  - Overview on IEEE Std 1547-2018™: https://www.epri.com/#/epri-u/course/ce5e54a2-f32f-4ad3-bfc3-288f6bf4119e?lang=en
  - DER Ride-Through Performance Categories and Trip Settings: *coming soon*
  - T+D Coordination for DER Ride-Through and Trip Requirements: *coming soon*

Resources (cont.)

Fact Sheet
available on epri.com

NRECA *Revision of IEEE Standard 1547™* Articles	Availability
1. *The Background for Change*, Nov. 2016	Public
2. *New Reactive Power and Voltage Regulation Capability Requirements*, Dec. 2016	Public
3. *New Disturbance Response Requirements*, Feb. 2017	Public
4. *New Power Quality and Islanding Issues*, Apr. 2017	Public

EPRI White Papers	Availability
5. *Minimum Requirements for DERs Ride-Through*, May 2015	Public
6. *Communications Interface and Interoperability*, Jul. 2017	Public
7. *Power Quality Considerations for DERs*, Dec. 2017	Public
8. *Impacts of DER Ride-through on Anti-Islanding and Distribution Protection*	Draft

IEEE Std 1547-2018 Settings (refer to figures for ranges of allowable settings)	Issues, their limiting factors, and desired values				
	Arc-flash	**Reclosing**	**Distribution Protection**	**Ground-fault overvoltage**	**Bulk System Reliability**
UV1 clearing time and voltage threshold (high impedance faults) ▪ 0.88pu@5.16s	▪ Clearing time < personal protective equipment (PPE) rating (*)	▪ Clearing time < reclose time (may use islanding detection as alternative) (***) ▪ High only if used as back-up to islanding detection	▪ May be relevant for high impedance faults ▪ *How is this different from feeders without DER?* ▪ *How impactful are inverter-based DER versus synchronous DER?*		▪ Clearing time ≥ 3.16 s of NERC PRC-024 ▪ If distribution FIDVR exists, then longer clearing time and/or lower voltage threshold
UV2 clearing time and voltage threshold (most feeder faults) ▪ 0.45pu@1.1s	▪ No impact when combined with Momentary Cessation ▪ If not combined with MC, time incremental impact (**)	▪ No impact when combined with Momentary Cessation ▪ If no MC applied, then clearing time < reclose time (may use islanding detection as alternative)	▪ No impact when combined with Momentary Cessation ▪ If no MC applied, then coordinate with sequential tripping	▪ No impact when combined with Momentary Cessation ▪ If no MC applied, then more complicated.	▪ Clearing time ≥ 0.32 s of NERC PRC-024 ▪ Trip clearing times shall be close to ride-through to reduce uncertainty of actual behavior for transmission modeling
Momentary Cessation (MC) voltage threshold • **0.5 pu**	▪ High enough to account for typical retained voltages during SLG faults	▪ High enough to account for typical retained voltages during islanded conditions	▪ High enough to account for typical retained voltages during feeder faults ▪ Not so relevant for adjacent feeder faults		▪ For modest DER penetrations, as low MC threshold as distribution protection practices allow for
OV1 clearing time and voltage threshold • **1.1pu@2s**		▪ Using OV as AI backup for PDER > Pload.	▪ Already some exposure to GF-OV even with DER. ▪ 110% seems OK for OV1.		▪ Anything greater than 1 sec is good enough.
OV2 clearing time and voltage threshold • **1.2pu@0.16s**		▪ Does not seem to impact.	▪ Default values appear acceptable		▪ Default values appear acceptable.

(*) Arc flash involves faults driving voltage into Momentary Cessation and/or UV2, so UV1 settings are actually less relevant. (**) System grounding practices are the critical factor. (***) Voltage may collapse immediately when recloser opens and UV1 may not be needed to coordinate with reclosing.