Solutions Matrix and Ride Through and Trip Envelopes, Including PJM Straw Proposal v3 and ComEd Smart Inverter Tariff

Andrew Levitt
Senior Business Solution Architect
Applied Innovation
PJM DER Ride Through Task Force
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Summary of Additions to Matrix

• Implementation – the interim “Source Requirements Document” path via UL1741SA vs. the final IEEE 1547-2018 path.
• IEEE 1547-2018 Abnormal Conditions Category – Adding Category III
• UV1 – Adding trip points from ComEd (they have two - 11 seconds and 21 seconds).
• UV2 – Adding trip points from ISO New England (1.1 seconds), ComEd (1.5 seconds), and 1547 Category III (2 seconds).
• Adding ISO New England momentary cessation and mandatory operation threshold of 50%.
• OV1 and OV2 – Adding 1547 Category III defaults.
Summary of Trip and Ride Through Profiles Reviewed Here

1. ComEd Smart Inverter tariff rider and similar options within 1547-2018 framework
2. PJM Straw Proposal v3 Options A

APPENDIX
1. IEEE 1547-2003
2. NERC PRC-024-02
3. PJM Straw Proposal v3 Option B (IEEE 1547-2018 Cat II)
4. California Rule 21 and IEEE 1547-2018 Cat III
Transmission Interests

**Undervoltage Trip**

- Multiphase transmission faults $\rightarrow$ wide area undervoltage
- DER trips before transmission fault cleared in ~100 ms
- Fault-Induced Delayed Voltage Recovery > 2 s

**Frequency Trip**

- Catastrophic islanding of interconnection
- Black start
Safety of lineworkers working on hot primary lines exposed to arc flash risk

Calorie rating of personal protective equipment vs. duration of nearby arc flash

How low do arcs faults drive feeder voltage, e.g. < 30%?

Reclosing with failed anti-islanding

If DER could sustain an island, then to avoid out-of-phase reclose, DER should trip prior to distribution recloser timing.

Similar concern for Distribution Automation to avoid reclosing into an island

System Protection

For feeder-level faults, avoid desensitizing existing relay schemes by entering “momentary cessation” mode immediately
Modes for Different Voltage and Frequency Conditions

- **Mandatory Ops** = Ride through, don’t trip, continue to supply power.
- **Momentary Cessation** = Ride through, don’t trip, stop supplying power within 83ms and then come back 400ms after conditions return to normal.
- **Shall Trip** = Stop supplying power immediately and stay offline for at least a few minutes.
- **Continuous Ops** = Normal conditions.
- **May Trip** = May continue supplying power, or enter momentary cessation, or trip, or anything in between.
ComEd “Smart Inverter” Tariff vs. IEEE 1547-2018 Cat III

Voltage %
Nominal

Continuous Ops

Shall Trip

IEEE 1547-2018 Cat III

Shall Trip

Momentary cessation

May Trip

Mandatory Ops

https://www.comed.com/SiteCollectionDocuments/MyAccount/MyBillUsage/CurrentRates/Ratebook.pdf page 659 of PDF
Similar to ComEd: Cat II

Voltage %
Nominal

Continuous Ops

Mandatory Ops

May Trip

Shall Trip

0s 1s 2s 10s 20s 30s

0% 30% 50% 65% 88% 100%

UV1

UV2
Similar to ComEd: Cat II vs. Actual ComEd

- **Mandatory Ops**: Continuous and Ride Through
- **May Trip**: Actual ComEd Trip
- **Shall Trip**: UV1 at 20s, UV2 at 10s

Voltage % Nominal:
- 0%
- 30%
- 50%
- 65%
- 88%
- 100%

Time:
- 0s
- 1s
- 2s
- 10s
- 20s
- 30s

www.pjm.com
Similar to ComEd: Cat III

- Continuous Ops
- Mandatory Ops
- Momentary cessation
- May Trip
- Shall Trip

Voltage %

Nominal

<table>
<thead>
<tr>
<th>Voltage %</th>
<th>0%</th>
<th>50%</th>
<th>70%</th>
<th>88%</th>
<th>100%</th>
</tr>
</thead>
<tbody>
<tr>
<td>UV1</td>
<td>0s</td>
<td>1s</td>
<td>2s</td>
<td></td>
<td></td>
</tr>
<tr>
<td>UV2</td>
<td></td>
<td>5%</td>
<td>100%</td>
<td></td>
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</tbody>
</table>

https://www.comed.com/SiteCollectionDocuments/MyAccount/MyBillUsage/CurrentRates/Ratebook.pdf page 659 of PDF
Similar to ComEd: Cat III vs. Actual ComEd

- Continuous Ops
- Mandatory Ops
- Momentary cessation
- Ride Through

Actual ComEd
- 0%
- 50%
- 88%

Actual ComEd Trip
- May Trip

Shall Trip
- 0s
- 1s
- 2s
- 10s
- 20s
- 30s

Voltage % Nominal

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APPENDIX
EXAMPLE TO DEMONSTRATE MODES

- Voltage % Nominal
  - 100%
  - 88%
  - 70%
  - 50%
  - 0%

- Continuous Ops
- Mandatory Ops
- Momentary cessation
- May Trip
- Shall Trip

- UV1
- UV2

- 0s
- 1s
- 2s
- 3s
- 4s
- 5s
STRAW PROPOSAL v3 Option A w/ IEEE 1547-2003 Overlay

- **Mandatory Ops**
- **May Trip**
- **IEEE 1547-2003 Trip**

Voltage % Nominal:

- 0% to 30%
- 30% to 65%
- 65% to 100%

- Continuous Ops
- Shall Trip
- May Trip
- Mandatory Ops

Momentary Cessation:

- UV1
- UV2

IEEE 1547-2003 Trip

- 0s
- 1s
- 2s
- 3s
- 4s
- 5s
STRAW PROPOSAL v3 Option A w/ PRC-024 Overlay

- Momentary cessation
- May Trip
- Mandatory Ops
- Shall Trip
- Continuous Ops

Voltage %
- Nominal
- 0%
- 5%
- 10%
- 15%
- 20%
- 25%
- 30%
- 35%
- 40%
- 45%
- 50%
- 55%
- 60%
- 65%
- 70%
- 75%
- 80%
- 85%
- 90%
- 95%
- 100%

Time
- 0s
- 1s
- 2s
- 3s
- 4s
- 5s
STRAW PROPOSAL v3 Option B w/ IEEE 1547-2003 Overlay

- Continuous Ops
- Mandatory Ops
- May Trip
- IEEE 1547-2003 Trip
- Shall Trip

Voltage %
Nominal

0% 30% 65% 88%

0s 1s 2s 3s 4s 5s

Mandatory Ops
May Trip
IEEE 1547-2003 Trip
Shall Trip

UV1 Shall Trip at 10s <88%

Momentary cessation
CA Rule 21 and 1547-2018 Cat III

- Continuous Ops
  - Mandatory Ops
    - Continuous Operations
    - UV2
  - Shall Trip
    - May Trip
    - Trip at 21s
  - Trip at 20s
  - Trip at 10s
  - Trip at 1s
  - Trip at 0s

Voltage % Nominal

0% 50% 88% 100%

0s 1s 2s 3s 4s 5s
CA Rule 21 and 1547-2018 Cat III w/ IEEE 1547-2003 and PRC-024 Overlay

- Mandatory Ops
- Continuous Ops
- IEEE 1547-2003 Trip
- Momentary cessation
- May Trip
- Shall Trip
- PRC-024 Mandatory Ops
- Thru 20s
- Thru 10s
- Trip at 21s

Voltage % Nominal:
- 100%
- 90%
- 88%
- 85%
- 80%
- 75%
- 70%
- 65%
- 60%
- 50%
- 45%
- 40%
- 35%
- 30%
- 25%
- 20%
- 15%
- 10%
- 5%
- 0%
CA Rule 21 and PJM Straw Proposal Option A

- Mandatory Ops
- Straw Proposal A Mandatory Ops
- Straw Proposal A Trip
- Momentary cessation
- May Trip
- Shall Trip
- Continuous Ops
- Trip at 21s
- Thru 20s
- Thru 10s
- Thru 20s

Voltage %

Nominal

0%
30%
45%
50%
60%
70%
88%
100%
ISO New England Inverter Source Requirement Document

- **Continuous Ops**
- **Mandatory Ops**
- **May Trip**
- **Shall Trip**

### Voltage % Nominal
- 0% Nominal
- 30%
- 50%
- 65%
- 88%
- 100%

### Time Intervals
- 0s
- 0.160s
- 0.320s
- 1.1s
- 2s
- 4s
- 5s

- **UV1**: 4s
- **UV2**: 2s

- **Moment Cess**
- **Cess**
ISO-NE Inverter Source Requirement Document w/ PJM Straw Proposal Option A Overlay

Voltage % Nominal

0% 30% 50% 65% 88% 100%

0s 1s 2s 3s 4s 5s

Mandatory Ops
Straw Proposal A Mandatory Ops
May Trip
Straw Proposal A Trip
Continuous Ops
Shall Trip
Shall Trip

4s
3s
2s
1s
0s
Straw Proposal B\n
Mandatory Ops\n
May Trip\n
Straw Proposal B Trips\n
Straw Proposal B UV1: Shall Trip at 10s <88%

Straw Proposal B UV2: Shall Trip at 88%

Continuous Ops

Shall Trip

Voltage % Nominal

0% 30% 50% 65% 88% 100%