

# Implementation of the IEEE 1547 Standard in Massachusetts



Debbie Lew for Babak Enayati, PhD, PE  
Lead Engineer, National Grid  
Waltham, MA

Email: [babak.enayati@nationalgrid.com](mailto:babak.enayati@nationalgrid.com)

Office: 781-907-3242

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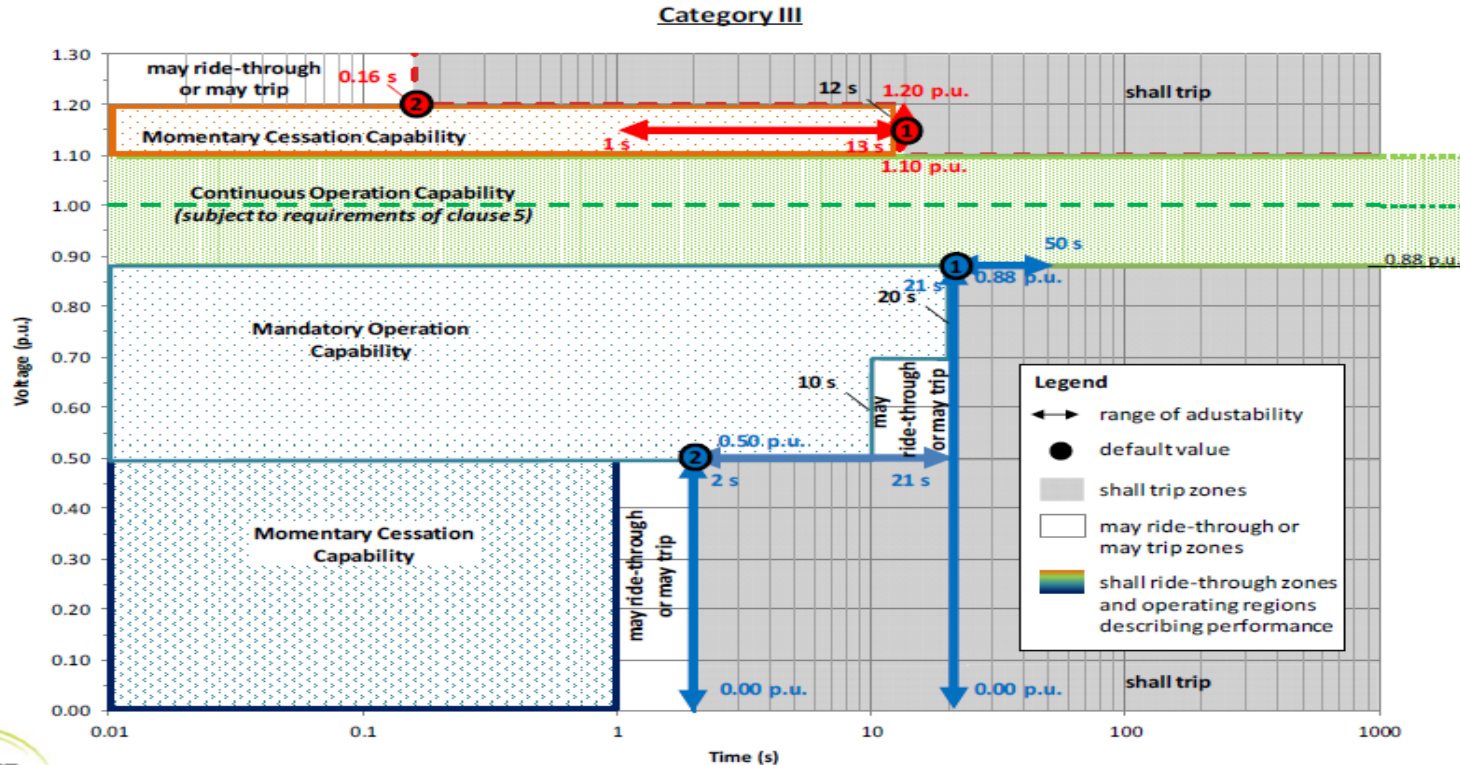
- Abnormal performance categories
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# Abnormal Performance Categories

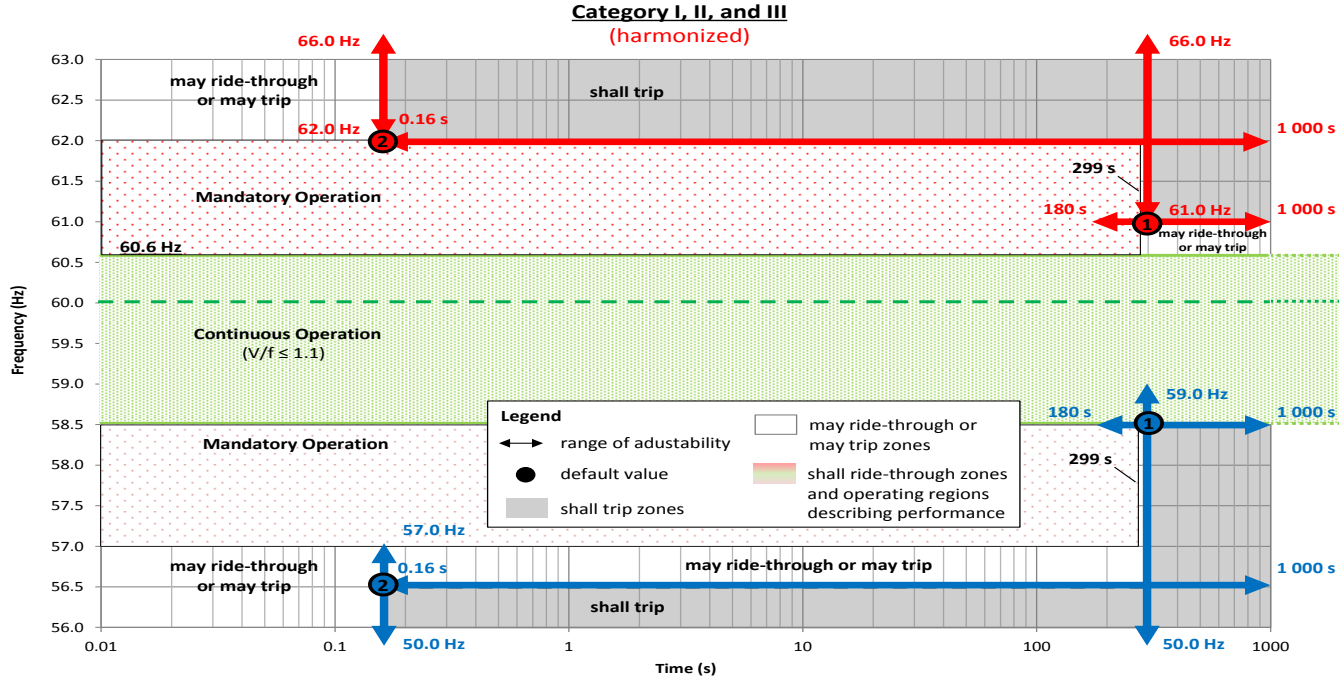
Category	Objective	Foundation
I	Essential bulk system needs and reasonably achievable by all current state-of-art DER technologies	German grid code for synchronous generator DER
II	Full coordination with bulk power system needs	Based on NERC PRC-024, adjusted for distribution voltage differences (delayed voltage recovery)
III	Ride-through designed for distribution support as well as bulk system	Based on California Rule 21 and Hawaii Rule 14H

Category II and III are sufficient for bulk system reliability.

# 1547 Example of New Requirements for Voltage Ride-Through

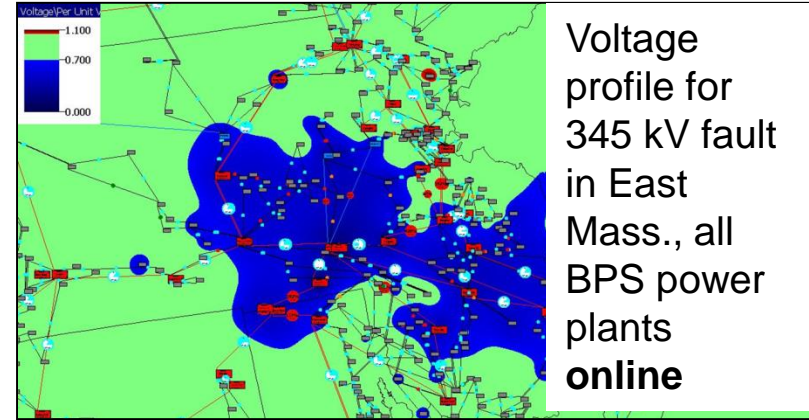
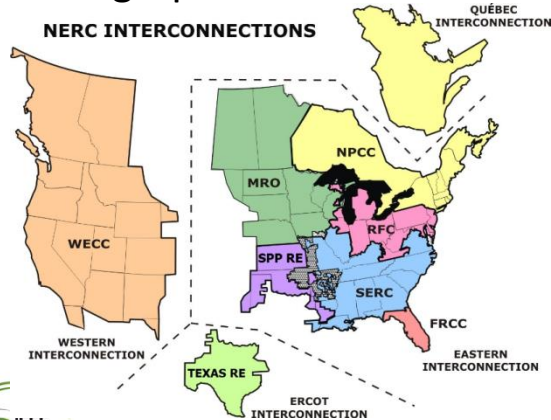


# 1547 Example New Requirements for frequency Ride Through



# Driver for new ride-through requirements: Potential for widespread DER tripping

- System frequency is defined by balance between load and generation
- Frequency is similar across entire interconnection; all DER can trip simultaneously during disturbance
- Impact the same whether or not DER is on a high-penetration feeder



Source: ISO-New England

- Transmission faults can depress distribution voltage over very large areas
- Sensitive voltage tripping (i.e., 1547-2003) can cause massive loss of DER generation
- Resulting BPS event may be greatly aggravated

# ISO-NE Final 2018 PV Forecast

## *Cumulative Nameplate, MWac*

States	Cumulative Total MW (AC nameplate rating)										
	Thru 2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
CT	365.6	454.3	541.0	630.9	711.5	784.4	838.2	890.3	940.9	989.9	1037.3
MA	1602.3	1898.9	2126.9	2354.9	2570.3	2785.6	3000.9	3216.3	3351.4	3482.3	3608.9
ME	33.5	43.6	53.8	64.0	73.6	83.3	92.9	102.5	112.1	121.8	131.4
NH	69.7	83.5	97.4	111.2	124.3	137.3	150.4	163.5	176.5	189.6	202.7
RI	62.2	96.7	131.2	162.6	192.3	221.9	251.6	281.2	310.9	340.5	370.2
VT	257.2	288.7	311.2	333.7	355.0	376.2	397.5	418.7	440.0	461.2	482.5
<b>Regional - Cumulative (MW)</b>	<b>2390.5</b>	<b>2865.8</b>	<b>3261.6</b>	<b>3657.4</b>	<b>4026.9</b>	<b>4388.8</b>	<b>4731.4</b>	<b>5072.5</b>	<b>5331.8</b>	<b>5585.3</b>	<b>5832.9</b>

Source: ISO-NE

# Interim Ride Through Solution

- Because of the rapid growth of PV generation in NE and because the timeline for full implementation of the revision to IEEE 1547 is 2020 or later, ISO-NE sought out an interim solution for obtaining ride-through for voltage and frequency variations.
- UL 1741SA has the capabilities required by ISO-NE in the interim
- Key players in this ride through requirements adoption process were, ISO-NE, distribution and transmission engineers, PV manufacturers, and PV developers.
- MA Technical Standards Review Group (TSRG) was identified as the venue for this collaboration.



# Interim Ride Through Solution- Voltage Trip Settings

Shall Trip – IEEE Std 1547-2018 (2 <sup>nd</sup> ed.) Category II					
Shall Trip Function	Required Settings		Comparison to IEEE Std 1547-2018 (2 <sup>nd</sup> ed.) default settings and ranges of allowable settings for Category II		
	Voltage (p.u. of nominal voltage)	Clearing Time(s)	Voltage	Clearing Time(s)	Within ranges of allowable settings?
OV2	1.20	0.16	Identical	Identical	Yes
OV1	1.10	2.0	Identical	Identical	Yes
UV1	0.88	2.0	Higher (default is 0.70 p.u.)	Much shorter (default is 10 s)	Yes
UV2	0.50	1.1	Slightly higher (default is 0.45 p.u.)	Much longer (default is 0.16 s)	Yes

# Interim Ride Through Solution- Voltage Ride Through

Voltage Range (p.u.)	Operating Mode/ Response	Minimum Ride-through Time(s) (design criteria)	Maximum Response Time(s) (design criteria)	Comparison to IEEE Std 1547-2018 (2 <sup>nd</sup> ed.) for Category II
$V > 1.20$	Cease to Energize	N/A	0.16	Identical
$1.175 < V \leq 1.20$	Permissive Operation	0.2	N/A	Identical
$1.15 < V \leq 1.175$	Permissive Operation	0.5	N/A	Identical
$1.10 < V \leq 1.15$	Permissive Operation	1	N/A	Identical
$0.88 \leq V \leq 1.10$	Continuous Operation	infinite	N/A	Identical
$0.65 \leq V < 0.88$	Mandatory Operation	Linear slope of 8.7 s/1 p.u. voltage starting at 3 s @ 0.65 p.u.: $T_{VRT}$ $= 3 \text{ s} + \frac{8.7 \text{ s}}{1 \text{ p.u.}}(V - 0.65 \text{ p.u.})$	N/A	Identical
$0.45 \leq V < 0.65$	Permissive Operation <sup>a,b</sup>	0.32	N/A	See footnotes a & b
$0.30 \leq V < 0.45$	Permissive Operation <sup>b</sup>	0.16	N/A	See footnote b
$V < 0.30$	Cease to Energize	N/A	0.16	Identical

The following additional operational requirements shall apply for all inverters:

- a. In the Permissive Operation region above 0.5 p.u., inverters shall ride-through in Mandatory Operation mode, and
- b. In the Permissive Operation region below 0.5 p.u., inverters shall ride-through in Momentary Cessation mode with a maximum response time of 0.083 seconds.

# Interim Ride Through Solution- Frequency Trip Settings

Shall Trip Function	Required Settings		Comparison to IEEE Std 1547-2018 (2 <sup>nd</sup> ed.) default settings and ranges of allowable settings for Category I, Category II, and Category III		
	Frequency (Hz)	Clearing Time(s)	Frequency	Clearing Time(s)	Within ranges of allowable settings?
OF2	62.0	0.16	Identical	Identical	Yes
OF1	61.2	300.0	Identical	Identical	Yes
UF1	58.5	300.0	Identical	Identical	Yes
UF2	56.5	0.16	Identical	Identical	Yes

## Interim Ride Through Solution- Frequency Ride Through Capability

Frequency Range (Hz)	Operating Mode	Minimum Time(s) (design criteria)	Comparison to IEEE Std 1547-2018 (2 <sup>nd</sup> ed.) for Category II
$f > 62.0$	No ride-through requirements apply to this range		Identical
$61.2 < f \leq 61.8$	Mandatory Operation	299	Identical
$58.8 \leq f \leq 61.2$	Continuous Operation	Infinite	Identical
$57.0 \leq f < 58.8$	Mandatory Operation	299	Identical
$f < 57.0$	No ride-through requirements apply to this range		Identical

# Full adoption of the IEEE 1547 Standard in MA

- Dynamic voltage regulation is currently being discussed
  1. Impact on protection
  2. VAR coordination issues
- Frequency regulation is currently being discussed
  1. Impact on the passive anti-islanding protection

# Grid Support Utility Interactive Inverter Functions Status

Function	Default Activation State
SPF, Specified Power Factor	OFF <sup>2</sup>
Q(V), Volt-Var Function with Watt or Var Priority	OFF
SS, Soft-Start Ramp Rate	ON Default value: 2% of maximum current output per second
FW, Freq-Watt Function OFF	OFF



Contact: Babak Enayati

[Babak.Enayati@nationalgrid.com](mailto:Babak.Enayati@nationalgrid.com)

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