Revising IEEE Std. 1547 and 1547.1 to Maintain Power System Reliability and Safety with High Penetration of Distributed Generation

Informal report based on IEEE P1547/Draft 5.0 (August 2016)

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EPRI

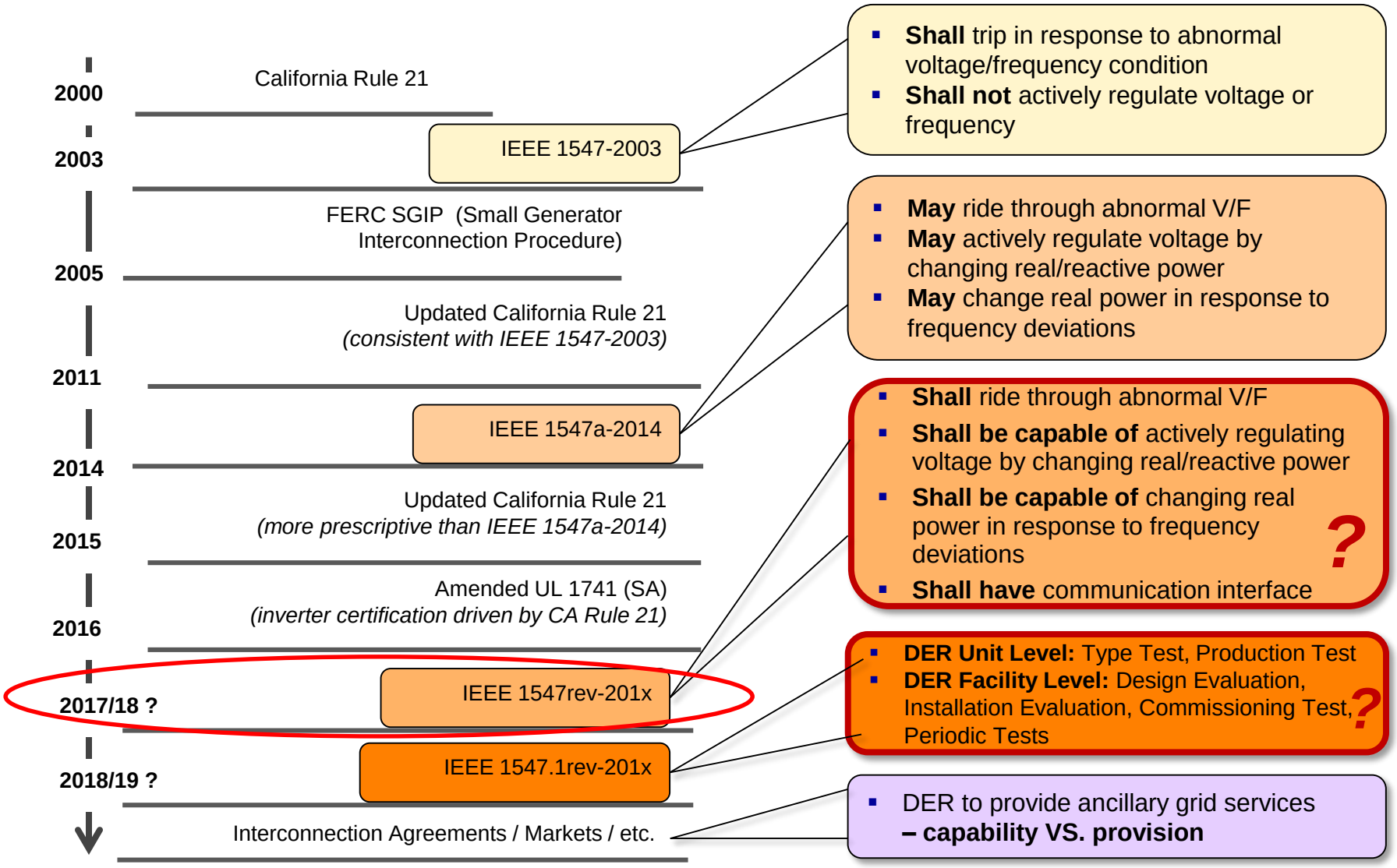
CIGRE Grid of the Future Colloquium

Paper Session 2A - Distribution Technical Track
Microgrids and Distributed Generation Session

November 2, 2016
Philadelphia, PA

Major Changes to IEEE Std 1547 in a Nutshell

CA Rule 21 and UL 1741(SA) are leading the way for IEEE Stds 1547 and 1547.1



IEEE P1547 WG Meetings

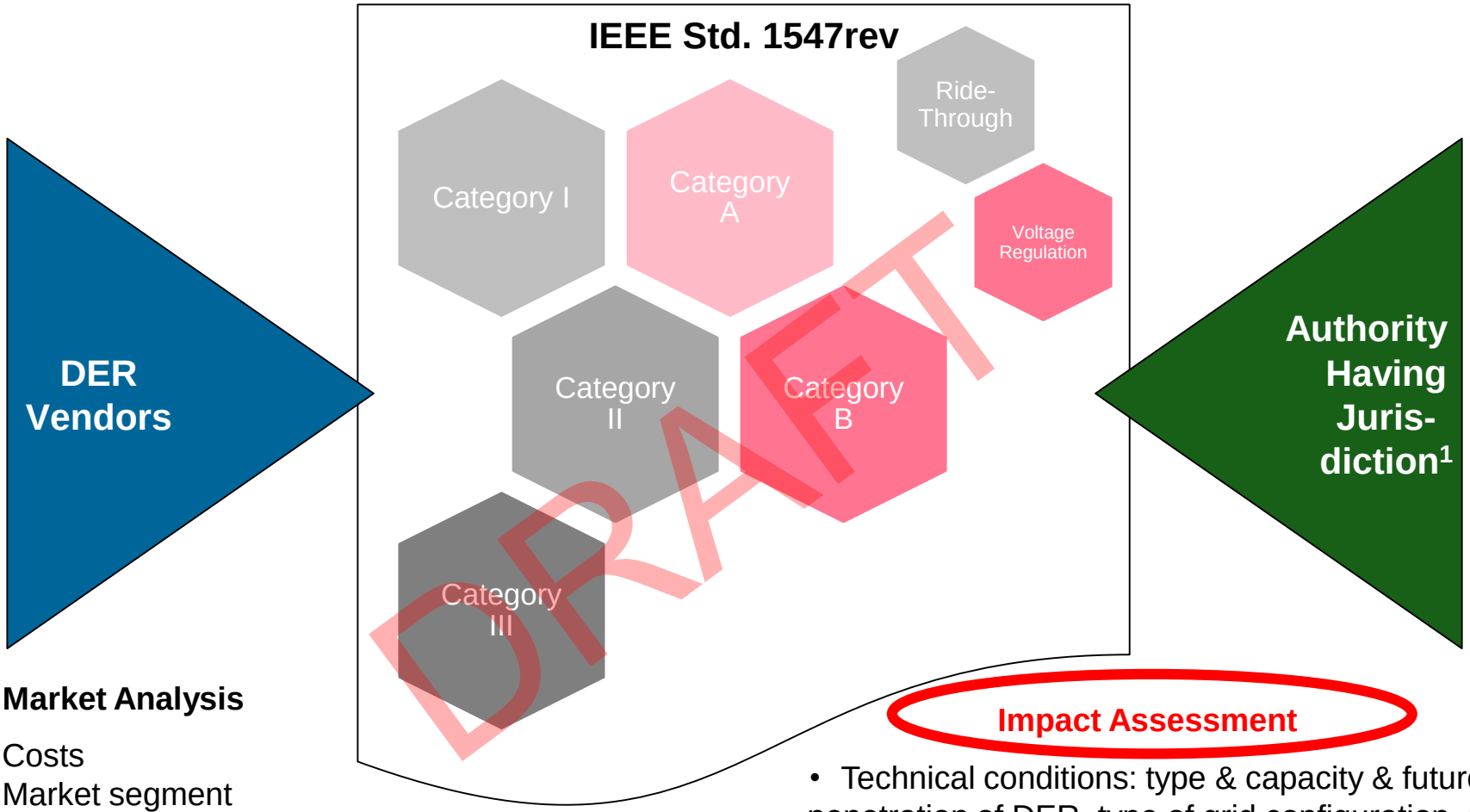
1. April 23-25, 2014 Las Vegas, NV
2. June 26-27, 2014 Las Vegas, NV
3. Nov 4-7, 2014 Atlanta, GA (NERC)
4. Feb 10-12, 2015 Arlington, VA (NRECA)
5. June 1-3, 2015 Waltham, MA (National Grid)
6. Oct 27-29, 2015 Tempe, AZ (Salt River Project)
7. Mar 8-9, 2016 Juno Beach, FL (NextEra Energy)
8. June 14-15, 2016 Portland, OR (Portland General Electric)
9. Oct 25-26, 2016 Chicago, IL (ComEd)
10. Feb 27-28, 2017 Atlanta, GA (NERC)

- Spring/Fall 2017 Balloting process can take six months or longer

http://grouper.ieee.org/groups/scc21/1547_revision/1547revision_index.html

Performance-Based Category Approach

IEEE P1547 – Proposed Major Change



Market Analysis

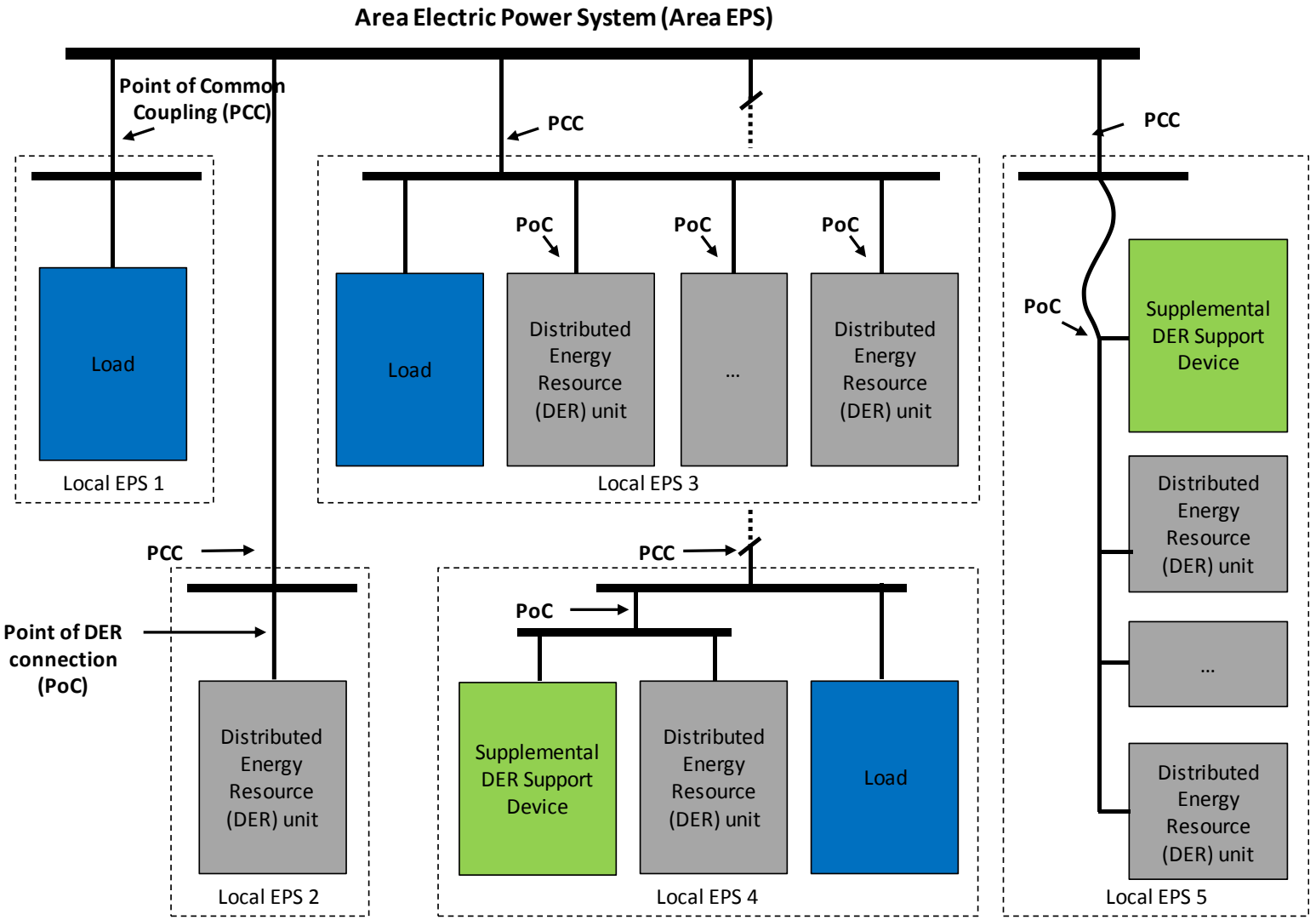
- Costs
- Market segment
- Etc.

Impact Assessment

- Technical conditions: type & capacity & future penetration of DER, type of grid configuration, etc.
- Non-technical issues: DER use case, impacts on environment, emissions, and sustainability, etc.

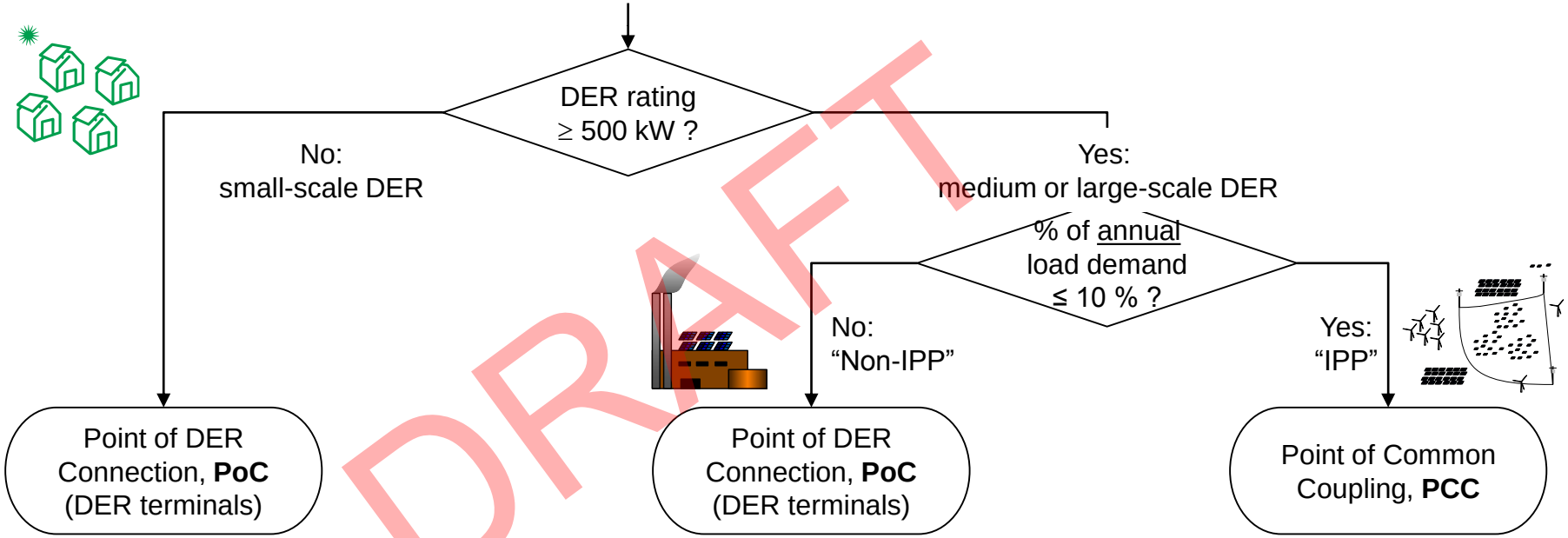
[1] State Regulator, Area EPS or bulk system operator, etc.

Applicability of Requirements: PCC vs PoC



Applicability of Requirements

IEEE P1547 – Proposed Major Change

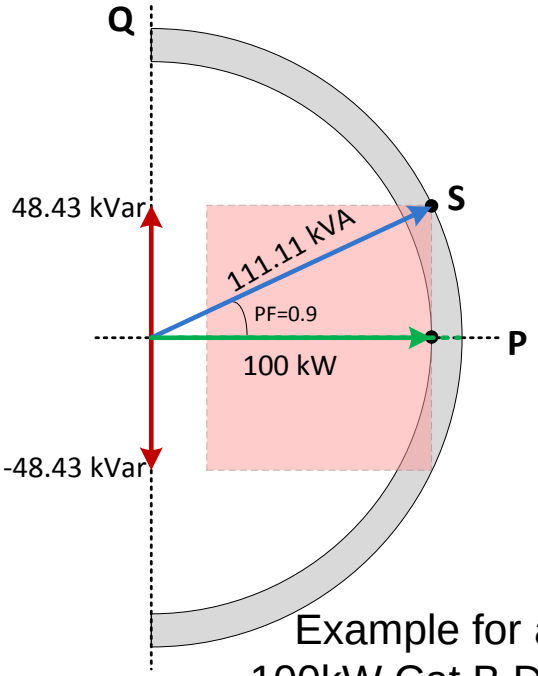


The reference point has implications for testing & conformance requirements in IEEE P1547 & P1547.1 !!!

Required Reactive Power Capability of the DER

IEEE P1547 – Proposed Major Change

The DER shall be capable of injecting reactive power (over-excited) and absorbing reactive power (under-excited) equal to the minimum reactive power (kVar) corresponding to the value given in the Table below **at all active power output equal to 20% to 100% of nameplate active power rating (kW)**.



Example for a 100kW Cat B DER

Minimum Reactive Power Injection and Absorption Capability

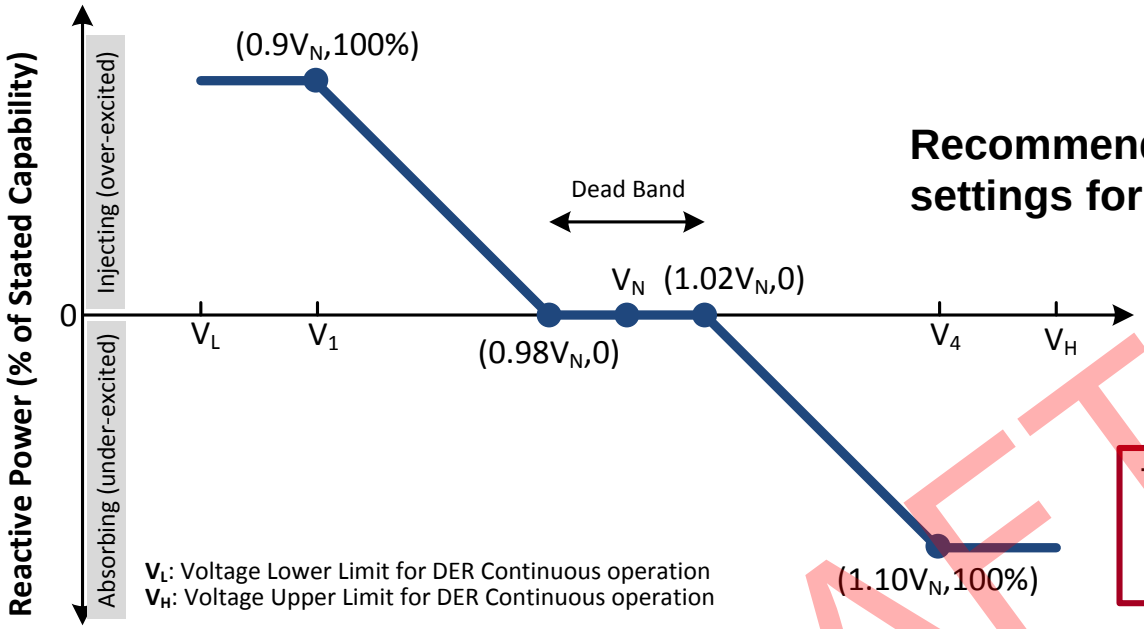
Category	Injection (Over-Excited) Capability as % of Nameplate Apparent Power (kVA) Rating	Absorption (Under-Excited) Capability as % of Nameplate Apparent Power (kVA) Rating
A (at DER rated voltage)	44	25
B (at ANSI range A)	44	44

Recommended Voltage Regulation Control Modes

DER Category	Cat A	Cat B
Voltage Regulation by Reactive Power Control		
Adjustable Constant Power Factor (PF)	Mandatory	Mandatory
Voltage – Reactive Power (Volt-var)	Mandatory	Mandatory
Active Power – Reactive (Watt-Var) Mode	Optional	Mandatory
Adjustable Constant Reactive Power (kVar)	Mandatory	Mandatory
Voltage and Active Power Control		
Voltage – Real Power (Volt-Watt)	Optional	Mandatory

- The DER shall be capable of activating any of these modes individually.
- Adjustable constant power factor mode with unity power factor setting shall be the default mode of the installed DER unless otherwise specified by the area EPS operator.
- The Area EPS operator shall specify the required voltage regulation control modes and the corresponding parameter settings. Modifications of the settings and mode selected by the EPS operator shall be implemented by the DER operator.

Voltage – Reactive Power (Volt-var) Mode

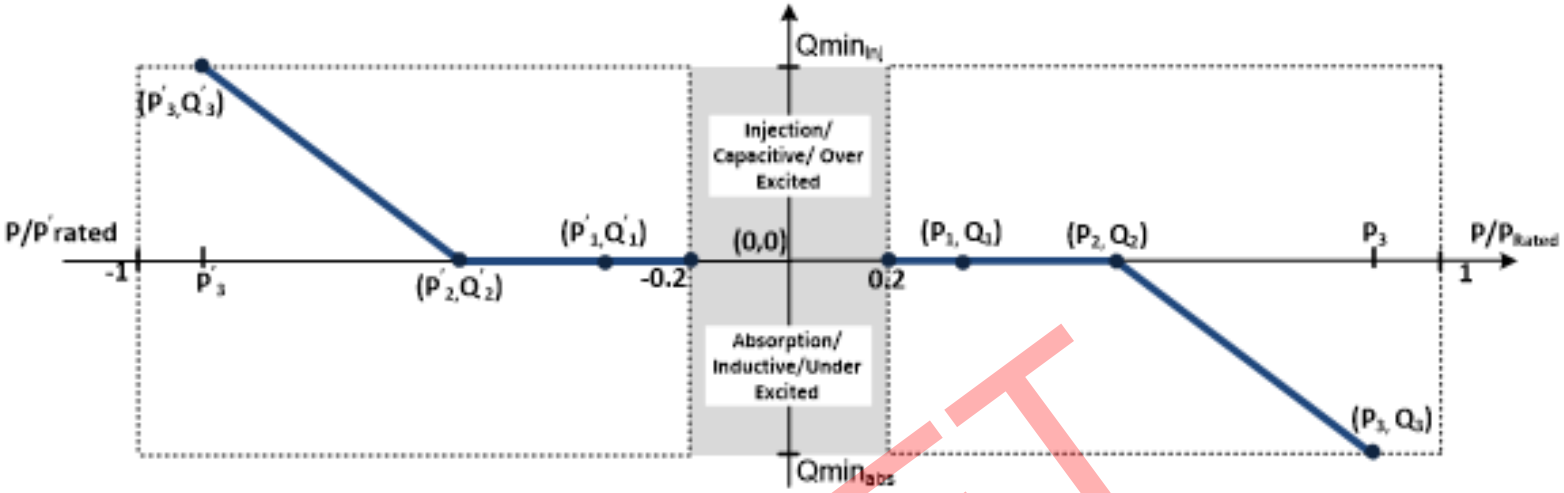


Recommended Default Volt-Var settings for Cat B DER

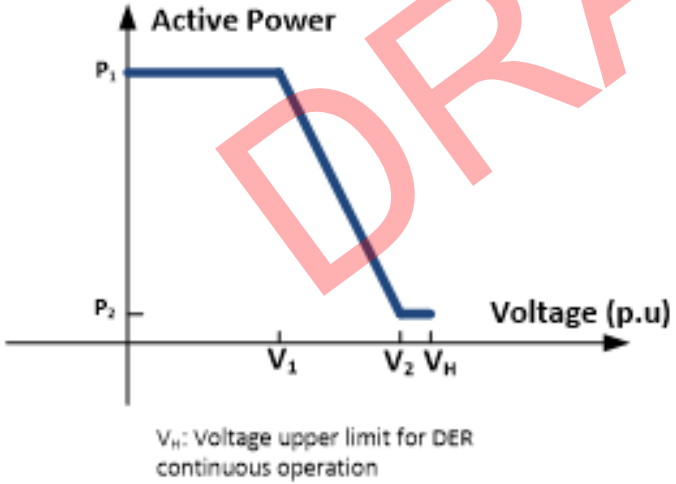
The volt-var characteristics are allowed to be adjusted locally and/or remotely as specified by the area EPS operator.

Volt-var Parameters	Definitions	Default Values for Cat A DER	Default Values for Cat B DER	Adjustable Range	
				Minimum	Maximum
V_{Ref}	Reference voltage	Nominal Voltage (V_N)	Nominal Voltage (V_N)	0.95 V_N	1.05 V_N
V_2	Dead band lower Voltage Limit	Nominal Voltage (V_N)	$V_{Ref} - 0.02\ V_N$	Cat A: V_{ref} Cat B; $V_{Ref} - 0.03\ V_N$	V_{Ref} [c]
Q_2	Reactive power injection or absorption at voltage V_2	0	0	0	100% of stated reactive capability
V_3	Dead band upper Voltage Limit	Nominal Voltage (V_N)	$V_{Ref} + 0.02\ V_N$	V_{Ref}[c]	Cat A: V_{ref} Cat B: $V_{Ref} + 0.03\ V_N$
Q_3	Reactive power injection	0	0		100% of stated reactive

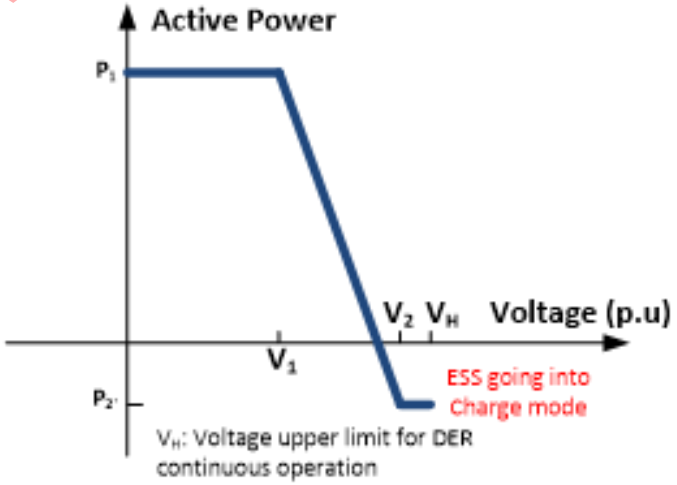
Active Power – Reactive (Watt-Var) Mode



Voltage – Real Power (Volt-Watt) Mode



VH: Voltage upper limit for DER continuous operation



VH: Voltage upper limit for DER continuous operation

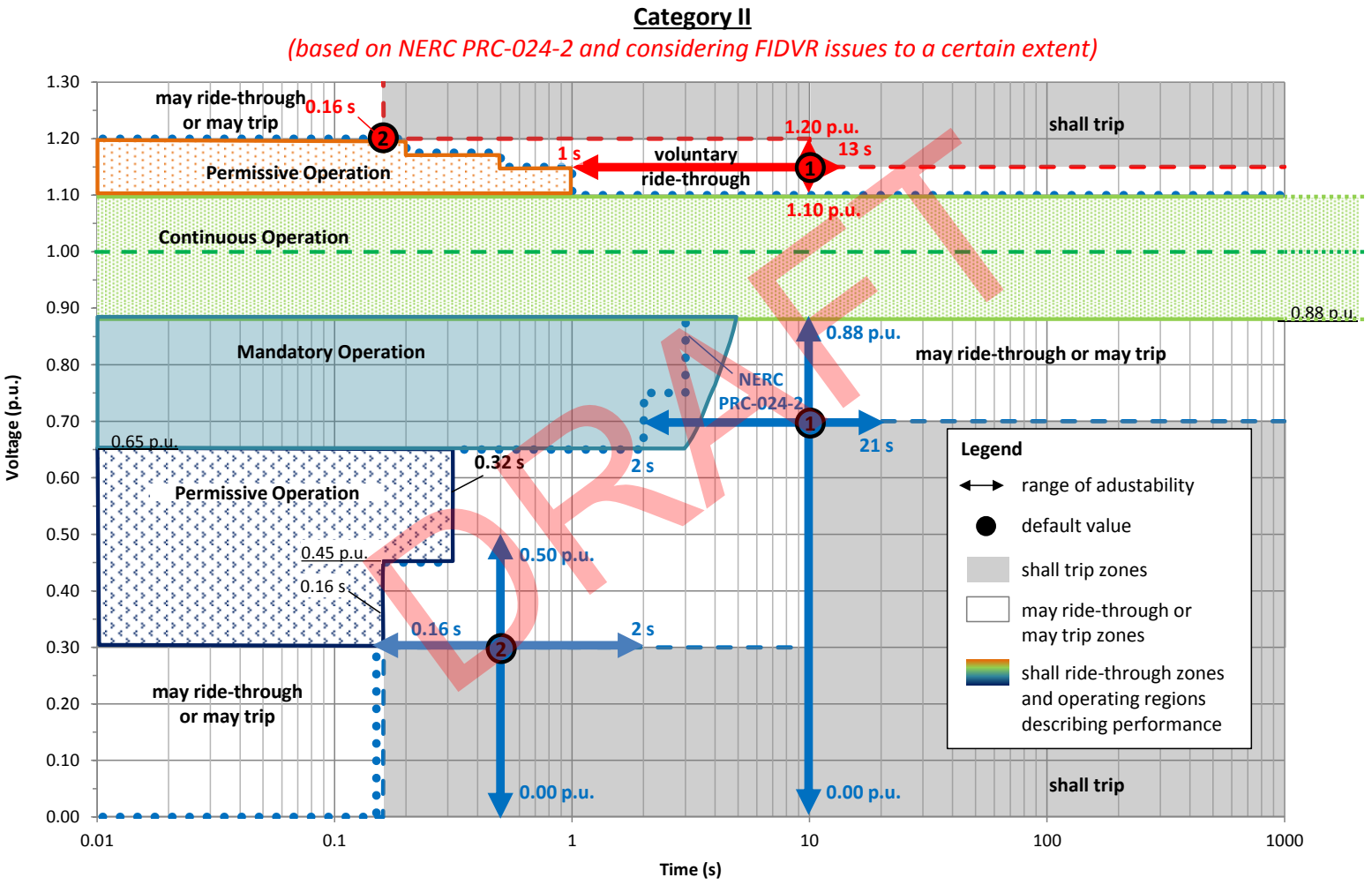
Foundations for Voltage & Frequency Ride-Through

IEEE P1547 – Proposed Major Change

Requirement	Category	Foundation	Justification
Voltage Ride-Through	Category I	German grid code for medium voltage-connected synchronous generator-based DER	• *Essential* bulk system needs. • Attainable by all state-of-the-art DER technologies.
	Category II	NERC PRC-024-2 but w/o stability exception, extended LVRT duration for 65-88% V_{nom} ➢ based on EPRI White Paper (May 2015)	• *All* bulk system needs. • Coordinated with existing reliability standards. • Considering fault-induced delayed voltage recovery.
	Category III	CA Rule 21 and Hawaii, minor modifications	• All bulk system needs. • Considering fault-induced delayed voltage recovery. • Distribution system operation.
Frequency Ride-Through	All Categories (harmonized)	CA Rule 21 and Hawaii, exceeds PRC-024-2 ➢ based on EPRI White Paper (May 2015)	• All bulk system needs. • Low inertia grids.

Voltage Ride-Through Requirements for Cat II DER

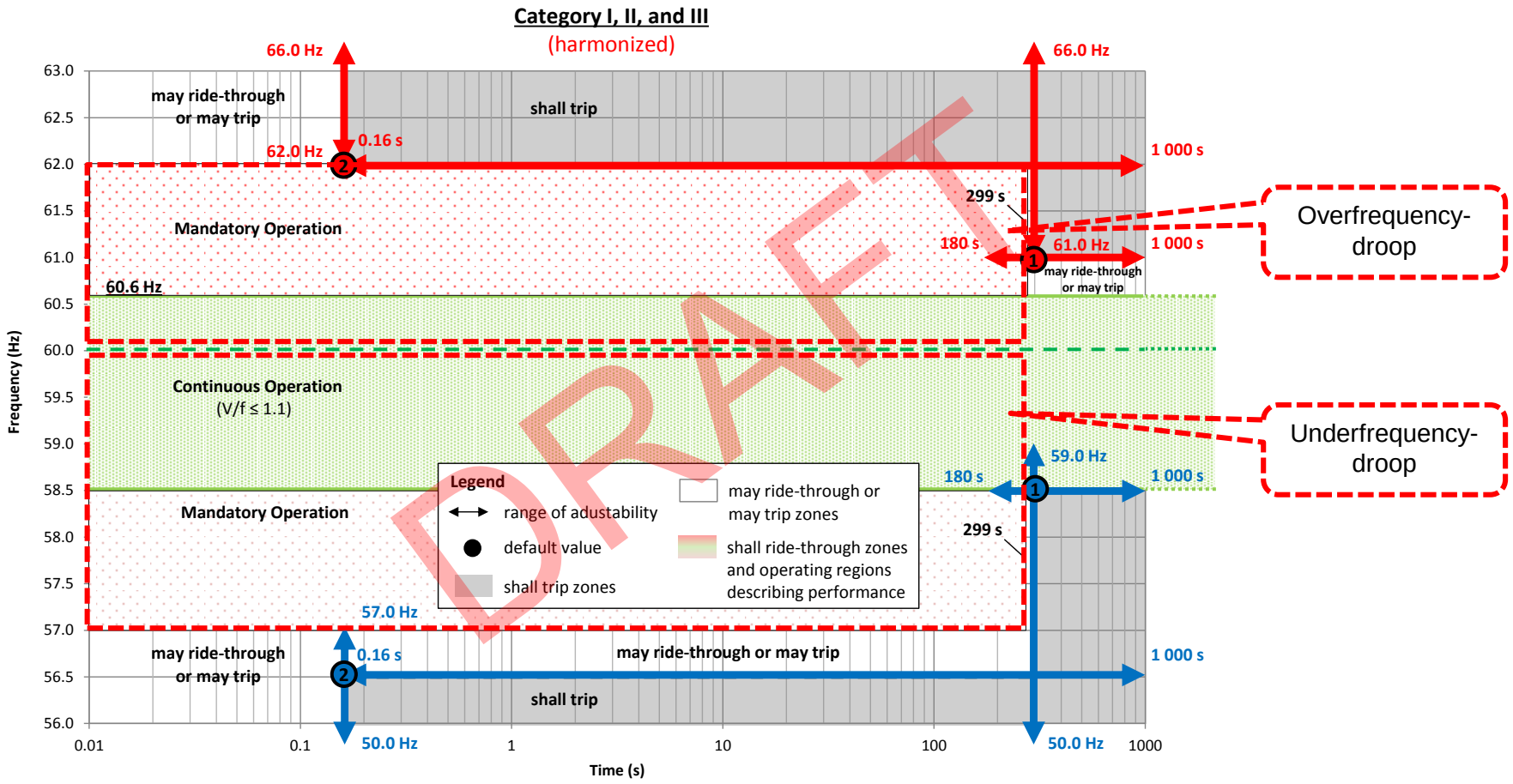
IEEE P1547 – Proposed Major Change



Source: *Draft Standard for Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power Systems*, IEEE P1547/D3, 2016.

Frequency Ride-Through Requirements for All DER

IEEE P1547 – Proposed Major Change



Source: *Draft Standard for Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power Systems*, IEEE P1547/D3, 2016.

Minimum Measurement Accuracy

IEEE P1547 – Proposed Major Change

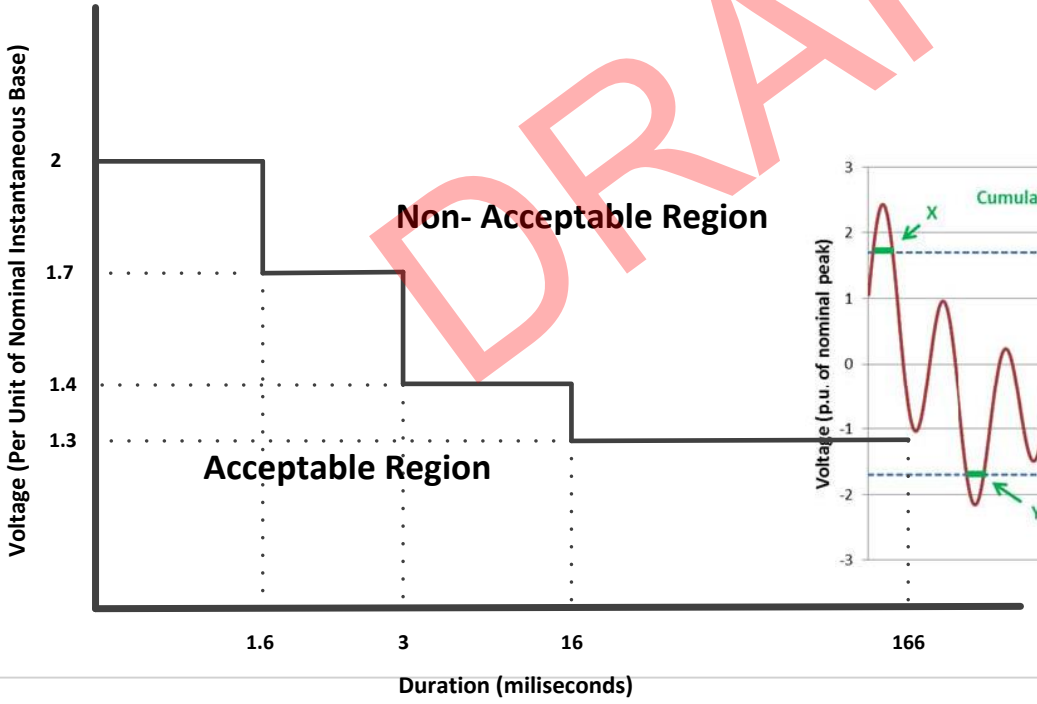
Table – Minimum Requirements for Manufacturers Stated Measurement Accuracy.

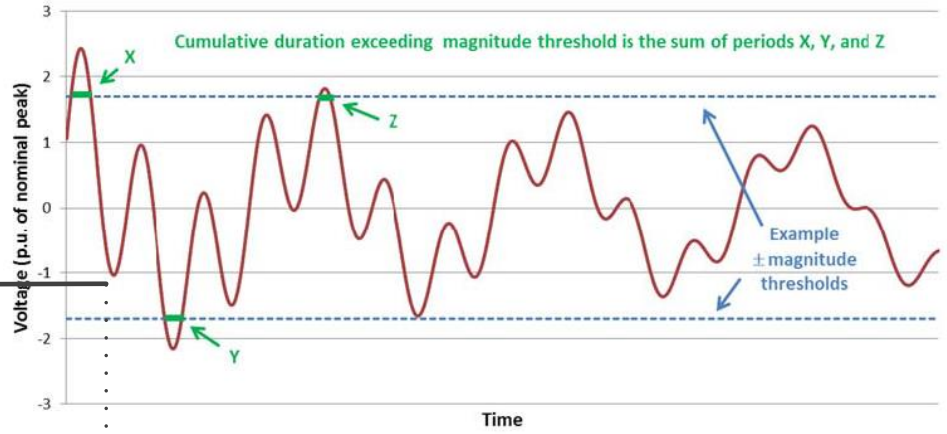
Minimum Requirements for Manufacturers Stated Measurement Accuracy*						
Parameter	**Minimum Measurement Accuracy**	**Sensing Speed**	**Range**	**Minimum Measurement Accuracy**	**Sensing Speed**	**Range**
Voltage	(+/- 1% V_{nom})	5 cycles	50% to 120%	(+/- 1% V_{nom})	[5 cycles]	50% to 120%
Apparent Current	(+/- 2% $I_{max\ rated}$)	10 cycles	0% to 110%	(+/- 2% $I_{max\ rated}$)	10 cycles	0% to 110%
Frequency	10 mHz	60 cycles	50 to 66 Hz	100 mHz	5 cycles	50 to 66 Hz
Active Power	(+/- 5% P_{rated})	10 cycles	20% < P < 100%	N/A	N/A	N/A
Reactive Power	(+/- 5% Q_{rated})	10 cycles	20% < Q < 100%	N/A	N/A	N/A
Power Factor	(0.05 Pf_{rated})	10 cycles	20% < P < 100%	N/A	N/A	N/A
Time	1%	N/A	5 sec to 10 min	2 grid cycles	N/A	100 msec < 5 sec
*Reference condition for all parameters in this table are voltage THD < 2.5% and individual voltage harmonics of the simulated utility odd harmonic limits in Table 3 of IEEE Std 1547.						

Limitation of Over Voltage Contribution

IEEE P1547 – Proposed Major Change

- The DER shall not contribute to instantaneous or RMS over voltages with the following limits:
  - The DER shall not cause the RMS line-ground (or line-line) voltage on any portion of the Area EPS that is designed to operate effectively grounded, as defined by IEEE C62.92.1, to exceed 138% of its nominal line-ground (line-line) RMS voltage for duration of exceeding one fundamental frequency Period.
  - The RMS voltage measurements of this sub-clause shall be based on one fundamental frequency period.





IEEE P1547 - Other Major Changes Proposed

- Minimum measurement accuracy for voltage, current, frequency, power quantities
- Maximum allowable limitations for rapid voltage changes
- Limitations for short-term and long-term flicker and guidance regarding evaluation time
- Guidance regarding interharmonic current distortion
- Interoperability and Communication requirement at the DER (much of the interoperability discussion will be in IEEE 2030 standards)
- Guidance regarding unintentional and intentional islanding requirements
- Directions regarding interconnection test specifications and requirements (type, production, interconnection installation evaluation, commissioning, and periodic interconnection tests)

Conclusions

- IEEE Std. 1547rev is an **opportunity to harmonize** advanced DER requirements to maintain bulk system reliability in the long-term.

- A technology-agnostic, performance-based requirements approach in IEEE Std. 1547rev would **lead technological development and innovation of DER performance** while giving sufficient flexibility to State Regulators et al. to account for regional system characteristics and societal benefits.

- Success in balloting depends on stakeholders' educated involvement! Get involved ….. !

Questions

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