IEEE P1547

Standard for Interconnecting Distributed Energy Resources with Electric Power Systems

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Point of Evaluation

Requirements shall be met at the Point of Common Coupling (PCC) for all Local EPS

- having an aggregate DER nameplate rating of 500 kW or greater, and
- having an average load demand of equal or less than 10% of the DER nameplate rating.

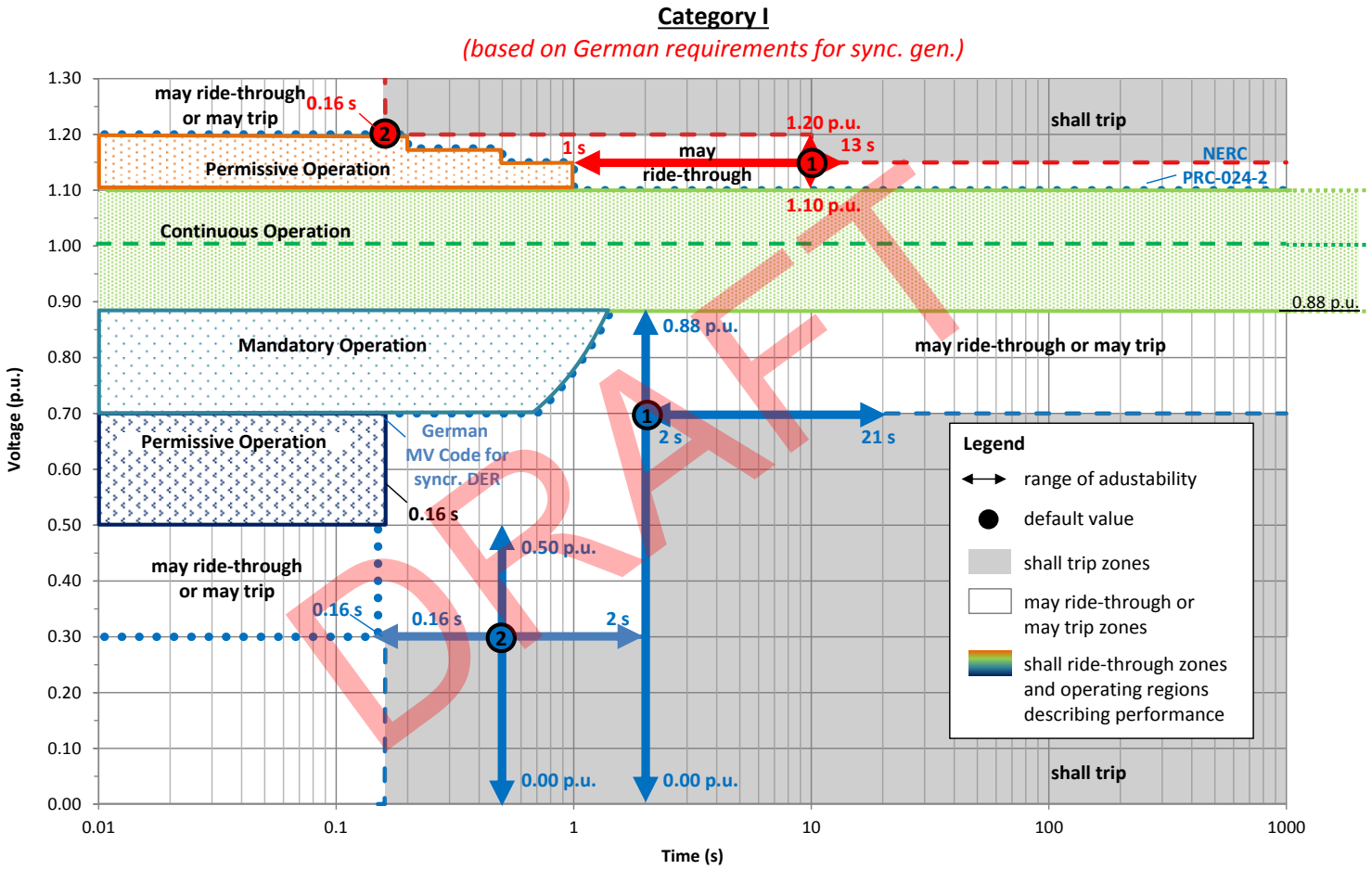
In all other situations, the applicable point for meeting performance requirements shall be the Point of DER connection

P1547 New Requirements for Ride Through (Work In Progress)

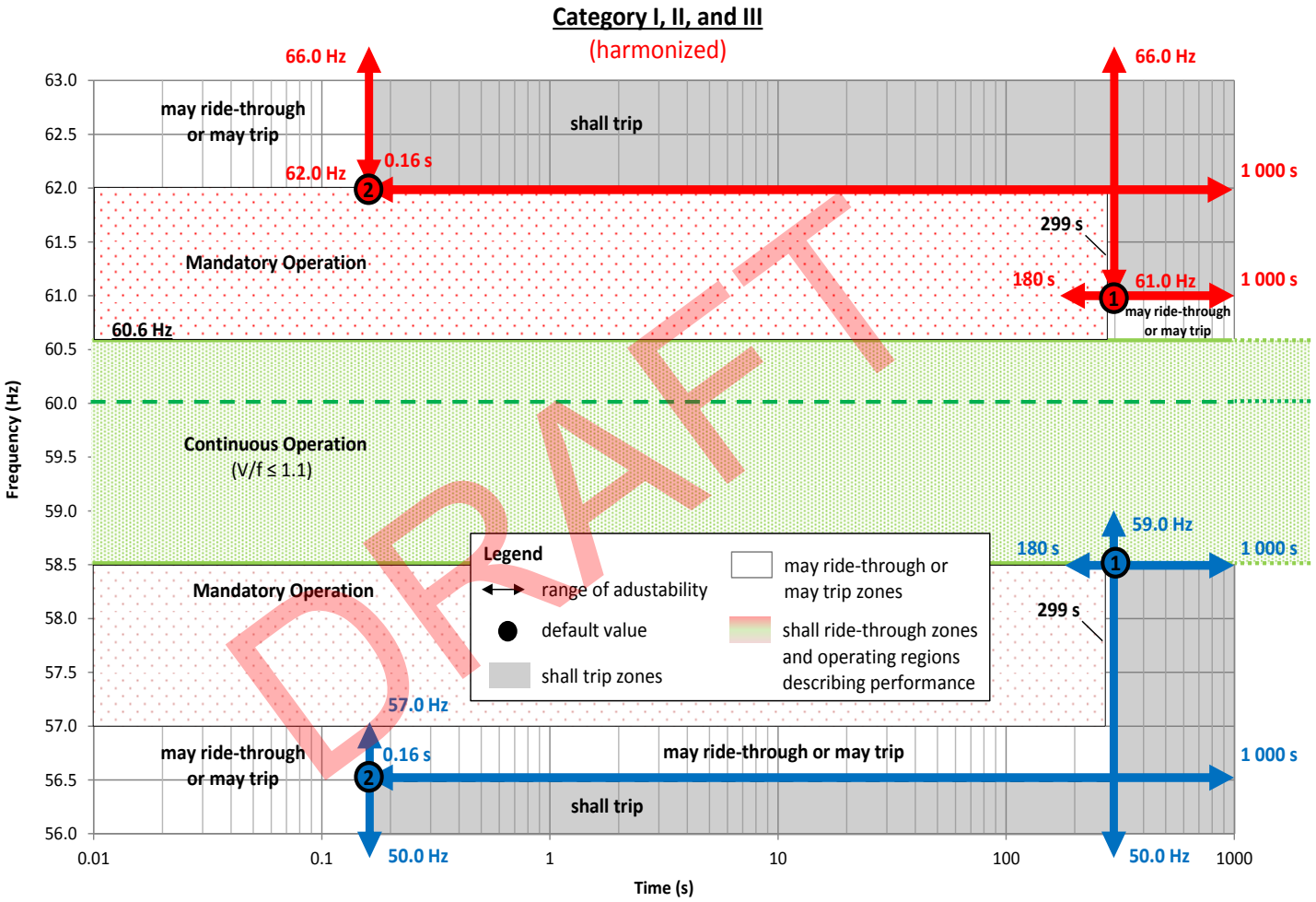
- Three Categories of DER Operational Responses to Support the Grid -- Based on Local and Farther Reaching Grid Requirements and DER

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.

P1547 Example New Requirements for Ride Through (work in progress)



P1547 Example New Requirements for Ride Through (work in progress)



P1547 voltage regulation

(Work In Progress)

- Two performance categories are defined for DERs with voltage regulation capabilities:

a) Category A covers minimum performance capabilities needed for Area EPS voltage regulation and are reasonably attainable by all state-of-the-art DER technologies

b) Category B covers all requirements within Category A and specifies additional requirements to mitigate voltage variations due to resource variability

P1547 Example New Reactive Power Requirements

(Work In Progress)

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 Table TBD at all active power output equal to 20% to 100% of nameplate active power rating (kW).

Table TBD – Minimum Reactive Power Injection and Absorption Capability

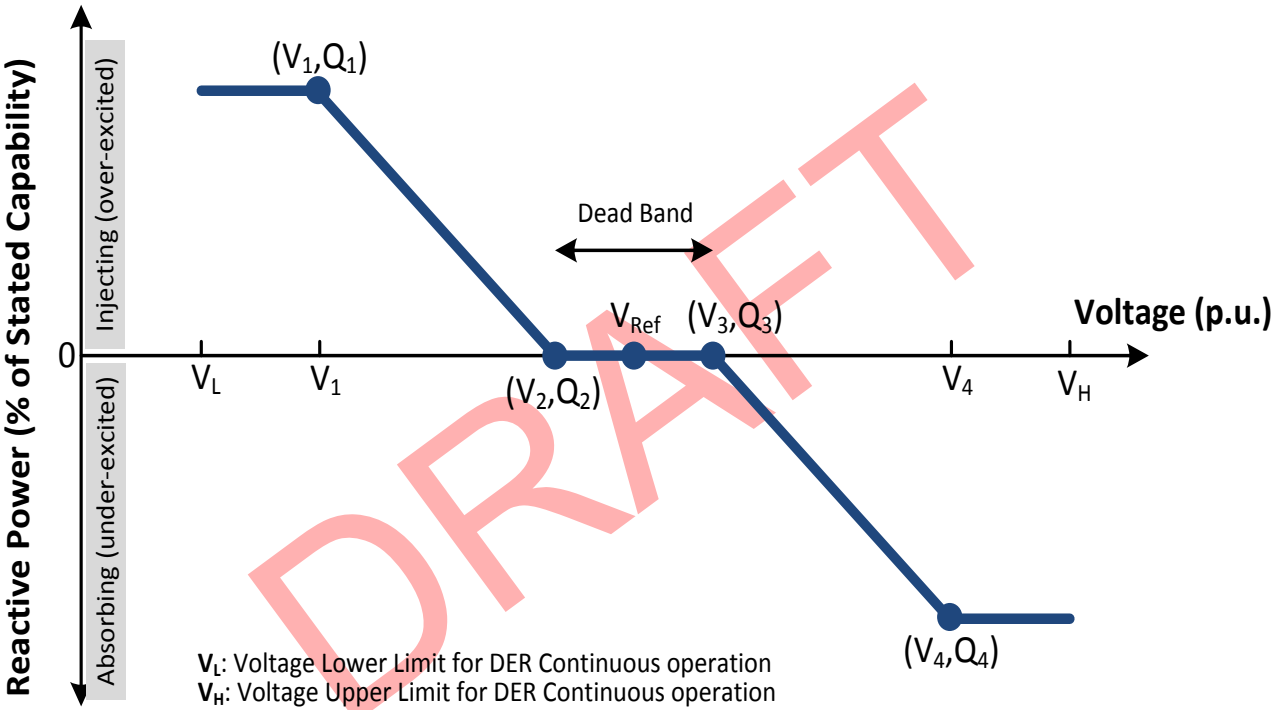
Category	**Injection Capability as % of Nameplate Apparent Power (kVA) Rating $Qmin_{inj}$**	**Absorption Capability as % of Nameplate Apparent Power (kVA) Rating $Qmin_{abs}$**
A (at DER rated voltage)	44 Full load PF=0.9	25 Full load PF=0.97
B (at ANSI range A)	44 Full load PF=0.9	44 Full load PF=0.9

Voltage and Reactive Power Control

The DER shall provide the capabilities of the following modes of reactive power control functions:

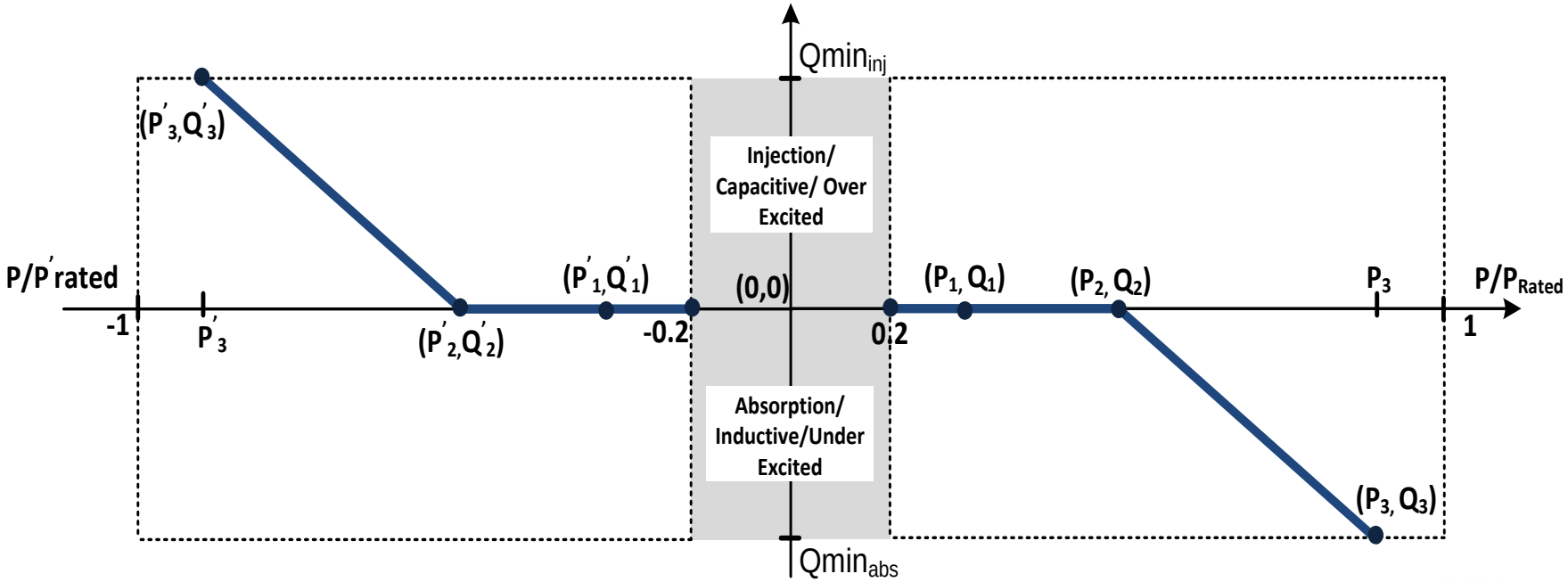
1. Adjustable Constant Power factor mode – The capability is mandatory for categories A and B
2. Voltage-reactive power (Volt-var) mode – The capability is mandatory for categories A and B
3. Active power-reactive power mode (watt-var) – The capability is optional for category A and mandatory for categories B
4. Reactive power mode – The capability is mandatory for categories A and B

P1547 Example New Reactive Power Requirements (Work In Progress)



Active Power – Reactive Power (Watt-Var or P - Q) Mode

When in this mode, the DER shall actively control the reactive power output as a function of the real power output following a target real power – reactive power (Watt-Var or P-Q) characteristic.

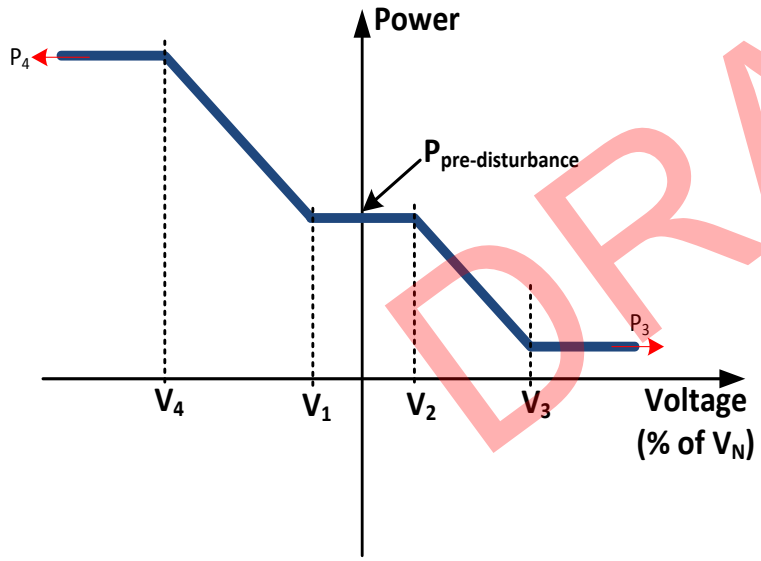


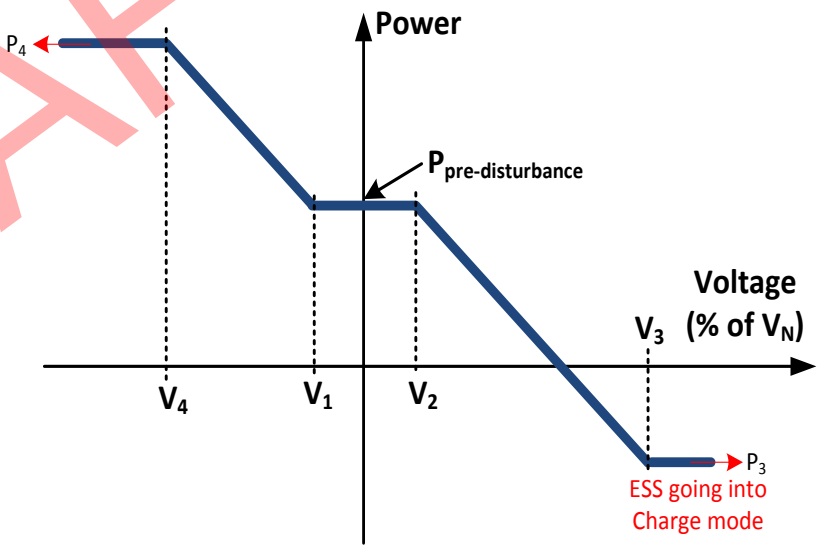
P1547 Example New Voltage Regulation Requirements

(Work In Progress)

Voltage-Real Power (Volt-Watt) Mode

When in this mode, the DER shall actively control the real output power as a function of the system voltage following a target voltage – active power (volt-watt) characteristic curve.





Transition from abnormal to normal voltage conditions

The requirements of the voltage regulation clause (4.1) apply to normal voltage range when the voltage is between 0.88 and 1.1 V_N. The voltage conditions outside of this range are defined to be abnormal. The DER shall return to its pre-disturbance operating mode after the system voltage returns to its normal range.

Rapid voltage changes (RVC)

- Rapid voltage changes are considered to be changes in fundamental frequency voltage less than one second . The DER shall not cause the ΔV/V voltage variations to go outside the limits specified in table X.

Number of Changes n	ΔV/V %	
n ≤ 4 per day	5-6	
n ≤ 2 per hour and > 4 per day	4	
2 < n ≤ 10 per hour	3	

Flicker

Flicker- Flicker is the subjective impression of fluctuating luminance caused by voltage fluctuations. Assessment methods for flicker are defined in IEC 61000-3-7.

- $P_{st99\%}$ (99^{th} percentile value) shall not be greater than 0.9. If not specified differently, the Pst evaluation time is 10 minutes.
- $P_{lt99\%}$ (99^{th} percentile value) shall not be greater than 0.7. If not specified differently, the P_{lt} evaluation time is 2 hours.

P1547 Example New Power Quality Requirements (Work in progress)

Harmonics:

- When the DER is serving balanced linear loads, harmonic current injection into the Area EPS at the Point of DER interconnection shall not exceed the limits stated below.
- The harmonic current injections shall be exclusive of any harmonic currents due to harmonic voltage distortion present in the Area EPS without the DER connected.

Table 3—Maximum odd harmonic current distortion in percent of rated current (I)a

Individual odd harmonic order h	h < 11	11≤ h < 17	17 ≤ h < 23	23 ≤ h < 35	35 ≤h	Total demand distortion up to the h=50 harmonic (TDD)
Percent (%)	4.0	2.0	1.5	0.6	0.3	5.0

Table 4—Maximum even harmonic current distortion in percent of rated current (I)a

Individual even harmonic order h	h=2	h=4	h=6	8≤h
Percent (%)	1.0	2.0	3.0	Associated range specified in Table 3

P1547 Example New Power Quality Requirements Over Voltage Contribution (Work in progress)

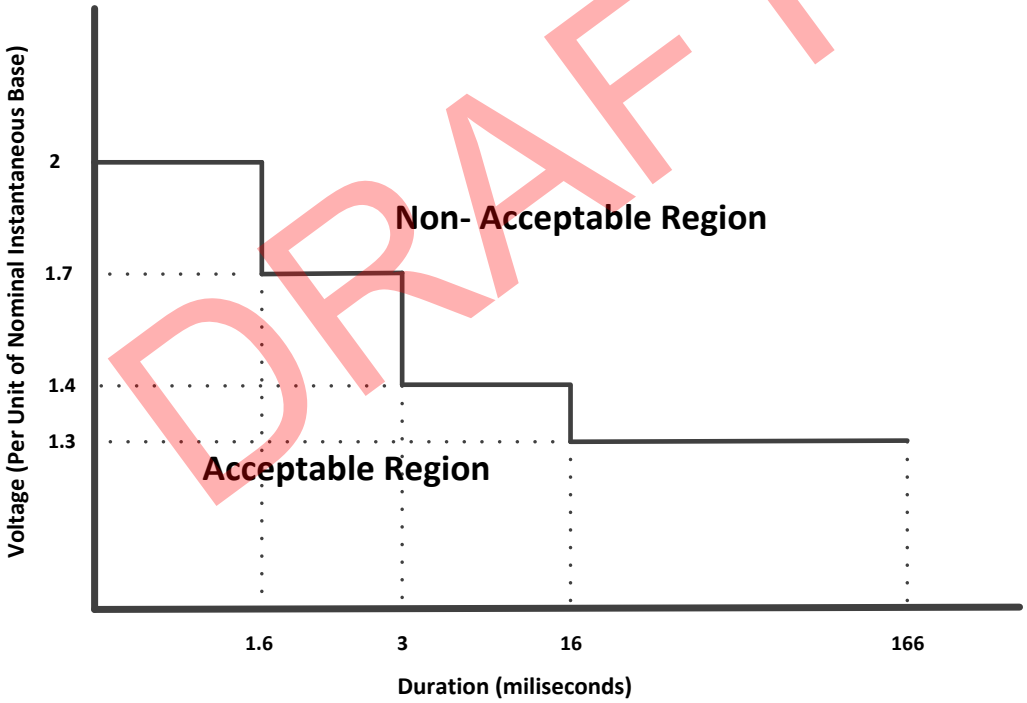
The DER shall not contribute to instantaneous or RMS over voltages with the following limits:

- The DER shall not cause the RMS Line-Ground 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 RMS voltage for duration of exceeding one fundamental frequency period.
- The DER shall not cause the L-L RMS voltage to exceed 138% of its nominal L-L RMS voltage at any location on the Area EPS distribution system for duration of exceeding one fundamental frequency period.

The RMS voltage measurements of this sub-clause shall be based on one fundamental frequency period.

P1547 Example New Power Quality Requirements Over Voltage Contribution (Work in progress)

- The DER shall not cause the instantaneous voltage at the point of common coupling (PCC) to exceed the magnitudes and cumulative durations shown in figure TBD. The cumulative duration shall only include the sum of periods for which the instantaneous voltage exceeds the respective threshold.



Interoperability and interfaces:

Significant New Additions to IEEE 1547

- Interoperability elements included as mandatory requirements
- Additional interfaces addressed – not only the PCC
- Informative material to be included

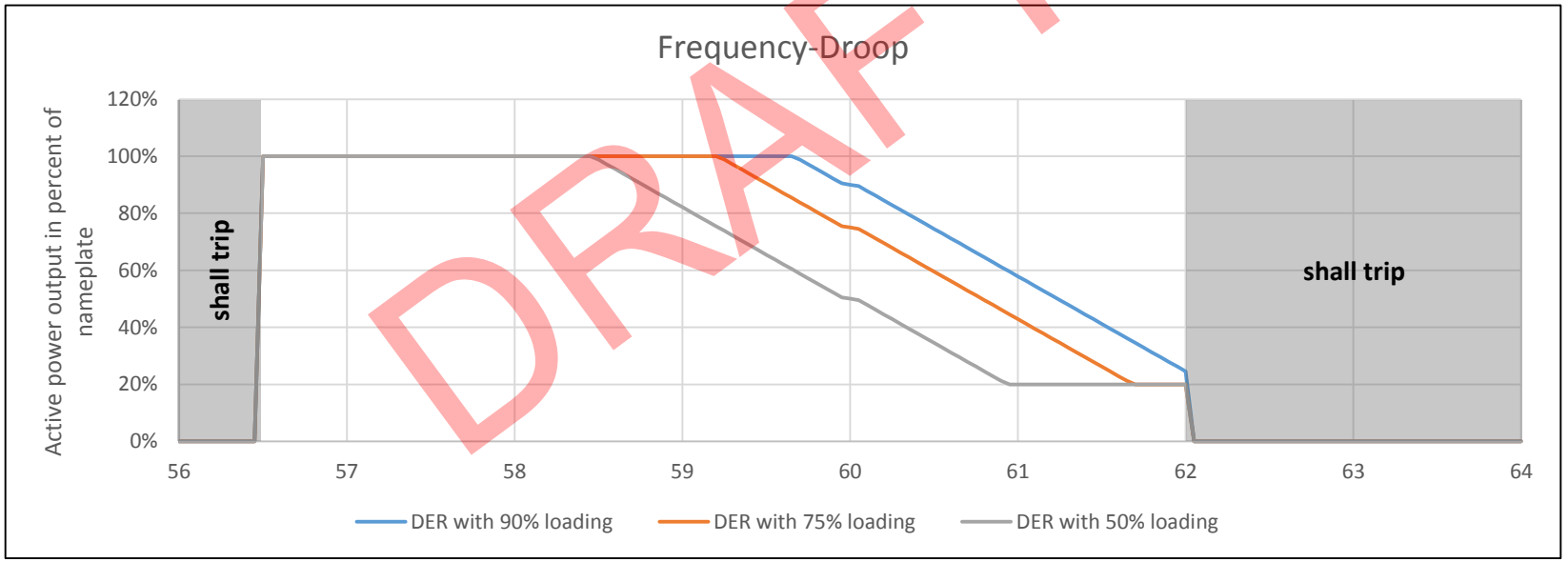
Frequency Droop

During temporary frequency disturbances, for which the system frequency is outside the adjustable deadband db_{OF} and db_{UF} , but still between the trip settings, the DER shall adjust its active power output from the pre-disturbance levels, according to the formulas in Table below:

Formula for frequency-droop (frequency/power) operation	
Operation for Low-Frequency Ride-Through	**Operation for High-Frequency Ride-Through**
$p = \min_{f<60-\mathrm{db_{UF}}} \left\{ p_{\mathrm{pre}} + p_{\mathrm{rated}} \cdot \frac{(60 - \mathrm{db_{UF}}) - f}{60 \cdot \mathrm{k_{UF}}}, p_{\mathrm{avl}} \right\}$	$p = \max_{f>60+\mathrm{db}_{OF}} \left\{ p_{\mathrm{pre}} - p_{\mathrm{rated}} \cdot \frac{f - (60 + \mathrm{db_{OF}})}{60 \cdot \mathrm{k_{OF}}}, p_{\mathrm{min}} \right\}$

Frequency Droop Example

Example of a frequency-droop function with a 5% droop, 36 mHz deadband, and 20% minimum active power output



Other areas being discussed in P1547

- Voltage Ride-Through requirements for consecutive temporary voltage disturbances
- Dynamic voltage support
- Steady state voltage regulation
- Island systems
- Interoperability
- ……..

Thank you

Questions?