## Technical Requirements from Rule 21 for LADWP Implementation

### Definitions

Capitalized terms used in these requirements, and not defined in LADWP's Rules, ESR, or other tariffs shall have the meaning ascribed to such terms as follows below. The definitions set forth below in these requirements shall only apply to these requirements and LADWP interconnection studies, and may not apply to LADWP's other documents.

**Anti-Islanding**: A control scheme installed as part of the Generating or Interconnection Facility that senses and prevents the formation of an Unintended Island.

**Applicant**: The entity submitting an Interconnection Request pursuant to these requirements.

**Certification Test**: A test pursuant to these requirements that verifies conformance of certain equipment with Commission-approved performance standards in order to be classified as Certified Equipment. Certification Tests are performed by Nationally Recognized Test Laboratories (NRTLs).

**Certified**: The documented results of a successful Certification Testing.

**Certified Equipment**: Equipment that has passed all required Certification Tests.

**Commission**: The Public Utilities Commission of the State of California.

**Continuous Operation**: The Smart Inverter operates indefinitely without tripping. Any functions that protect the Smart Inverter from damage may operate as needed.

**Customer**: The entity that receives or is entitled to receive energy through LADWP's Distribution System or is a retail Customer of LADWP. The Customer is the owner, whether a person or business association, or any person or agency authorized to represent the owner's interests.

**$db_{OF}$**: A single-sided deadband value for high-frequency in Hz.

**$db_{UF}$**: A single-sided deadband value for low-frequency in Hz.

**Distributed Energy Resource (DER)**: A source of electric power that is not directly connected to a bulk power system. DER includes both generators and energy storage technologies capable of exporting active power to an EPS. An interconnection system or a supplemental DER device that is necessary for compliance with this standard is part of a DER.

**DER Interconnection System**: The collection of all interconnection and interoperability equipment and functions, taken as a group, used to interconnect a DER to an Area EPS.

**Distribution System**: All electrical wires, equipment, and other facilities owned or provided by LADWP, other than Interconnection Facilities, by which LADWP provides energy to its Customers.

**Emergency**: Whenever in LADWP's discretion an Unsafe Operating Condition or other hazardous condition exists or whenever access is necessary for emergency service restoration, and such immediate action is necessary to protect persons, LADWP's facilities or property of others from damage or interference caused by Applicant's Generating Facility, or the failure of protective device to operate properly, or a malfunction of any electrical system equipment or a component part thereof.

**Enter Service Delay**: The period of time the Smart Inverter waits before beginning operation of the Generating Facility in parallel with the Distribution System.

**Electric Power System (EPS)**: Facilities that deliver electric power to a load. An EPS may include generation units.

**Function**: Some combination of hardware and software designed to provide specific features or capabilities. Its use, as in Protective Function, is intended to encompass a range of implementations from a single-purpose device to a section of software and specific pieces of hardware within a larger piece of equipment to a collection of devices and software.

**Generating Facility**: All Generators, electrical wires, equipment, and other facilities, excluding Interconnection Facilities, owned or provided by Producer for the purpose of producing electric power, including storage.

**Generator**: A device converting mechanical, chemical, or solar energy into electrical energy, including all of its protective and control functions and structural appurtenances. One or more Generators comprise a Generating Facility.

**Host Load**: The electrical power, less the Generator auxiliary load, consumed by the Customer, to which the Generating Facility is connected.

**Interconnection**: The physical connection of a Generating Facility in accordance with these requirements so that Parallel Operation with LADWP's Distribution System can occur (has occurred).

**Interconnection Agreement**: An agreement between LADWP and Producer providing for the Interconnection of a Generating Facility that gives certain rights and obligations to effect or end Interconnection. For the purpose of these requirements, Net Energy Metering or power purchase agreements authorized by LADWP are also defined as Interconnection Agreements.

**Interconnection Facilities**: The electrical wires, switches and related equipment that are required in addition to the facilities required to provide or receive electric energy to a Customer to allow Interconnection. Interconnection Facilities may be located on either side of the Point of Common Coupling as appropriate to their purpose and design. Interconnection Facilities may be integral to a Generating Facility or provided separately. Interconnection Facilities may be owned by either Producer or LADWP.

**Interconnection Request**: An Applicant's request to interconnect a new Generating Facility or to make a Material Modification to the operating characteristics of, an existing Generating Facility that is interconnected with LADWP's Distribution System.

**Island; Islanding**: A condition on LADWP's Distribution System in which one or more Generating Facilities deliver power to Customers using a portion of LADWP's Distribution System that is electrically isolated from the remainder of LADWP's Distribution System.

$\mathbf{k_{OF}}$: The per-unit frequency change corresponding to 1 per-unit power output change (frequency droop)

$\mathbf{k_{UF}}$: The per-unit frequency change corresponding to 1 per-unit power output change (frequency droop)

**Local DER Generating Facility Communication Interface**: Interface at the Generating Facility capable of communicating to support the information exchange requirements specified in these Requirements and as required in IEEE 1547-2018 for all applicable functions that are in these Requirements.

**Los Angeles Department of Water and Power (LADWP)**: The distribution service provider.

**Mandatory Operation**: The Smart Inverter operates at maximum available current without tripping during LADWP's Transmission or Distribution System excursions outside the region of Continuous Operation. Any functions that protect the Smart Inverter from damage may operate as needed.

**Material Modification**: Those modifications that have a material impact on cost or timing of any Interconnection Request with the same or a later queue priority date, or a change in Point of Interconnection, or a Type II Modification that requires a new Interconnection Request. A Material Modification does not include (i) a change in ownership of a Generating Facility, (ii) a Type I Modification, or (iii) a Type II Modification that does not require a new Interconnection Request.

**Momentary Cessation**: The Smart Inverter momentarily reduces current output to LADWP's Distribution System to below 10 percent of the maximum continuous output current rating. The Smart Inverter is allowed to increase current output to LADWP's Distribution System without any intentional reconnection delay once voltage exits the Momentary Cessation region and enters a Permissive Operation region or Continuous Operation region.

**Momentary Parallel Operation**: The Interconnection of a Generating Facility to the Distribution System for one second (60 cycles) or less.

**Nationally Recognized Testing Laboratory (NRTL)**: A laboratory accredited to perform the Certification Testing requirements under these requirements. A NRTL is a private organization that applies its own unique registered certification mark after performing product safety tests on certain products according to a proprietary set of testing standards.

**Net Energy Metering (NEM)**: Metering for the receipt and delivery of electricity between Producer and LADWP.

**Nominal**: Standard frequency and voltage.

**Non-Emergency**: Conditions or situations that are not Emergencies, including but not limited to meter reading, inspection, testing, routine repairs, replacement, and maintenance.

**Non-Islanding**: Designed to detect and disconnect from a stable Unintended Island with matched load and generation. Reliance solely on under/over voltage and frequency trip is not considered sufficient to qualify as Non-Islanding.

**Open Loop Response Time**: The duration from a step change in control signal input (reference value) until the output changes by 90% of its final change, before any overshoot.

**Parallel Operation**: The simultaneous operation of a Generator with power delivered or received by LADWP while Interconnected. For the purpose of these requirements, Parallel Operation includes only those Generating Facilities that are Interconnected with LADWP's Distribution System for more than 60 cycles (one second).

**Party, Parties**: Applicant or LADWP

**Permissive Operation**: The Smart Inverter is allowed, but not required, to operate at any current level.

**Point of Common Coupling (PCC)**: The point where the electrical conductors of LADWP's Distribution System are connected to the Customer's conductors and where any transfer of electric power between the Customer and LADWP takes place.

**Point of Interconnection (POI)**: The point where the Interconnection Facilities connect with LADWP's Distribution System. This may or may not be coincident with the Point of Common Coupling.

**Point of Generating Resource Connection (POC)**: The point where a DER unit is electrically connected in a Generating Facility and meets these Requirements.

**Producer**: The entity that executes a Interconnection Agreement with LADWP. Producer may or may not own or operate the Generating Facility, but is responsible for the rights and obligations related to the Interconnection Agreement.

**Protective Function(s)**: The equipment, hardware and/or software in a Generating Facility (whether discrete or integrated with other functions) whose purpose is to protect against Unsafe Operating Conditions.

**Reference Point of Applicability (RPA)**: The location where the Generating Facility interconnection and interoperability performance requirements shall be met.

**Requirements:** This LADWP Smart Inverter Technical Requirements document.

**Short Circuit Contribution Ratio (SCCR)**: The ratio of the Generating Facility's short circuit contribution to the short circuit contribution provided through LADWP's Distribution System for a three-phase fault at the high voltage side of the distribution transformer connecting the Generating Facility to LADWP's Distribution System.

**Smart Inverter**: A Generating Facility's Inverter that performs functions that when activated can autonomously contribute to grid support during excursions from normal operating voltage and frequency system conditions by providing dynamic reactive/real power support, voltage and frequency ride-though, ramp rate controls, communication systems with ability to accept external commands and other functions.

**System Integrity**: The condition under which LADWP's Distribution and Transmission System is deemed safe and can reliably perform its intended functions in accordance with the safety and reliability rules of LADWP.

**Transmission System**: Transmission facilities owned by LADWP.

**Trip**: The act of a Generating Facility to cease to energize or disconnect from LADWP's Distribution System automatically due to LADWP's Transmission or Distribution System disturbance. Following trip, the Smart Inverter must delay re-energization or reconnection for a preset period of time once the voltage and frequency of LADWP's Transmission or Distribution System are within normal ranges.

**Unintended Island**: The creation of an Island, usually following a loss of a portion of LADWP's Distribution System, without the approval of LADWP.

**Unsafe Operating Conditions**: Conditions that, if left uncorrected, could result in harm to personnel, damage to equipment, loss of System Integrity or operation outside pre-established parameters required by the Interconnection Agreement.

## Smart Inverter Technical Requirements

When requirements for "Smart Inverter" are specified in these Requirements, those requirements can also be met by a "DER Interconnection System" as defined in these Requirements.

These Smart Inverter Technical Requirements shall apply for interconnection of inverter-based technologies. These inverter requirements are intended to be consistent with UL 1741 – Supplement SB using as the source requirement document ANSI/IEEE 1547-2018 and IEEE 1547.1-2020 Standard for Interconnecting Distributed Resources with Electric Power Systems where possible. In the event of a conflict between these Requirements and UL 1741 – Supplement SB and/or IEEE 1547-2018 or IEEE 1547.1-2020, these Requirements shall take precedence.

The Smart Inverter default settings and default activation states shall be modified upon mutual agreement between Applicant or Producer and LADWP. The Smart Inverter default settings and default activation states shall also be modified at the sole discretion of LADWP for safety or reliability reasons as determined solely by LADWP.

Process for changing default settings for new Interconnection Requests:

- LADWP, in the study process for new Generating Facilities, may determine and provide the optimum Smart Inverter Settings for the reactive power settings, including changes to the reactive power default settings (Example: Deactivate Volt/Var and activate Fixed Power Factor at given power factor).

- LADWP, in the study process for new Generating Facilities, may determine and provide the optimum Smart Inverter Settings for the Ramp Rate settings depending on the Generating Facility technology (such as solar, storage).

- LADWP, in the study process for new Generating Facilities, may determine the optimum Smart Inverter Settings for the volt/watt settings, including changes to the default settings (Example: Change the volt/watt set points). The Applicant may select to agree on the new settings or select to perform upgrades to operate using the existing default volt/watt settings.

- Default settings for voltage ride-through, frequency ride-through requirements, and Frequency/Watt should not be modified on an individual project basis unless the Interconnection Studies have determined that the default settings may not meet grid reliability requirements.

Process for changing default settings for Generating Facilities with an executed Interconnection Agreement:

- When grid changes or Generating Facility changes require that the Smart Inverter operating parameters be reevaluated, LADWP or Producer may request changes to the Smart Inverter operating parameters. The request must include the reason for and timing of the proposed changes. The requested changes must be within the Smart Inverter function adjustability limits, must be within the limits specified in these Requirements, and must be mutually agreed upon. LADWP may also notify Producer of required changes to the Smart Inverter operating parameters for safety or reliability reasons as determined solely by LADWP. In the event of this LADWP notification, Producer shall make the required changes and provide written notification to LADWP within a reasonable time determined by LADWP.

1. General Interconnection and Protective Function Requirements.

The Protective Functions and these Requirements are designed to protect LADWP's Distribution and Transmission System and not the Generating Facility. A Producer shall be solely responsible for providing adequate protection for its Generating Facility and Interconnection Facilities. Producer's Protective Functions shall not impact the operation of other Protective Functions on LADWP's Distribution and Transmission System in a manner that would affect LADWP's capability of providing reliable service to its customers.

a) Protective Functions Required

Smart Inverters operating in parallel with LADWP's Distribution System shall be equipped with the following Protective Functions to sense abnormal conditions on LADWP's Distribution System and cause the Smart Inverter to be automatically disconnected from LADWP's Distribution System or to prevent the Smart Inverter from being connected to LADWP's Distribution System inappropriately:

i) Over and under voltage trip functions and over and under frequency trip functions;

ii) A voltage and frequency sensing and time-delay function to prevent the Smart Inverter from energizing a de-energized Distribution System circuit and to prevent the Smart Inverter from reconnecting with LADWP's Distribution System unless LADWP's Distribution System service voltage and frequency is within the ANSI C84.1-1995 Table 1 Range B voltage Range of 106 volts to 127 volts (on a 120 volt basis), inclusive, and a frequency range of 59.0 Hz to 60.5 Hz, inclusive, and are stable for at least 60 seconds (Enter Service Delay); and

iii) A function to prevent the Smart Inverter from contributing to the formation of an Unintended Island, and cease to energize LADWP's Distribution System within two seconds of the formation of an Unintended Island.

The Smart Inverter shall cease to energize LADWP's Distribution System for faults on LADWP's Distribution System circuit to which it is connected (IEEE 1547-2018, 6.2.1). The Smart Inverter shall cease to energize LADWP's Distribution circuit prior to re-closure by LADWP's Distribution System equipment (IEEE 1547-2018, 6.3).

iv) Open-phase condition: Generating Facility shall detect and cease to energize and trip all phases within two seconds of any open phase condition in accordance with IEEE 1547-2018, 6.2.2.

The Smart Inverter Facility shall cease to energize LADWP's Distribution System for faults on LADWP's Distribution System circuit to which it is connected (IEEE 1547-2018, 6.2.1). The Generating Facility shall cease to energize LADWP's Distribution circuit prior to re-closure by LADWP's Distribution System equipment (IEEE 1547-2018, 6.3).

b) Momentary Paralleling Generating Facilities

See Section 1 of the Electric Service Requirements.

c) Suitable Equipment Required

Circuit breakers or other interrupting equipment located at the Point of Common Coupling (PCC) must be Certified or "Listed" (as defined in Article 100, the Definitions Section of the National Electrical Code) as suitable for their intended application. This includes being capable of interrupting the maximum available fault current expected

at their location. Producer's Smart Inverter and Interconnection Facilities shall be designed so that the failure of any single device or component shall not potentially compromise the safety and reliability of LADWP's Distribution and Transmission System. The Smart Inverter paralleling-device shall be capable of withstanding 220% of the Interconnection Facility rated voltage (IEEE 1547-2018, 4.11.3). The Interconnection Facility shall have the capability to withstand voltage and current surges in accordance with the environments defined in IEEE Std C62.41.2-2002 or IEEE Std C37.90.1-2002 as applicable and as described in L.3.e (IEEE 1547-2018, 4.11.2).

d) Visible Disconnect Requirements

i) See Sections 8 and 8i of the Electric Service Requirements.

e) Drawings Required

i) See Sections 8 and 8i of the Electric Service Requirements.

f) Generating Facility Conditions Not Identified

i) See to Sections 8 and 8i of the Electric Service Requirements.

g) Generating Facilities that use certified Power Control Systems (PCS) must use PCS listed in the CEC pre-approved list. Also see Section 8 and 8i of the Electric Service Requirements.

h) Smart Inverter Certification and Settings Reporting Requirements

Producer shall provide the following reports to LADWP upon request:

i) Certified Equipment Data Sheet

Producer shall provide the Certified Equipment data sheet for each unique Smart Inverter which includes the following information:

When equipment is Certified by an NRTL, the NRTL shall provide to the manufacturer, at a minimum, a Certificate with the following information for each device:

Administrative:

(1) The effective date of Certification or applicable serial number (range or first in series), and/or other proof that certification is current;

(2) Equipment model number(s) of the Certified equipment;

(3) The software version utilized in the equipment, if applicable;

(4) Test procedures specified (including date or revision number); and

(5) Laboratory accreditation (by whom and to what standard).

Technical (as appropriate):

(1) Device ratings (kW, kV, Volts, amps, etc.);

(2) Maximum available fault current in amps per IEEE 1547-2018, 11.4;

(3) In-rush Current in amps;

(4) Trip points, if factory set (trip value and timing);

(5) Trip point and timing ranges for adjustable settings; and

(6) Nominal power factor or range if adjustable;

It is the responsibility of the equipment manufacturer to ensure that Certification information is made publicly available by the manufacturer, the testing laboratory, or by a third party.

ii) Verification of Settings

Producer shall provide reports to LADWP for all device settings confirming the LADWP-approved settings specified in this Smart Inverter Technical Requirements document. The settings report shall be submitted in a format provided by LADWP.

2. Prevention of Interference

Producer shall not operate Smart Inverters that superimpose a voltage or current upon LADWP's Distribution or Transmission System that interferes with LADWP operations, service to LADWP Customers, or communication facilities. If such interference occurs, Producer must diligently pursue and take corrective action at its own expense after being given notice and reasonable time to do so by LADWP. If Producer does not take corrective action in a timely manner, or continues to operate the facilities causing interference without restriction or limit, LADWP may, without liability, disconnect Producer's facilities from LADWP's Distribution System, in accordance with Section K of the Design Guide for Customer-Owned Parallel Generating System of the Electric Service Requirements. To eliminate undesirable interference caused by its operation, each Smart Inverter shall meet the following criteria:

Except as otherwise stated, the RPA for all performance requirements shall be met at the PCC.

When the Generating Facility is less than 500kVA, the RPA may be the Point of Generating Resource Connection (POC).

a) Voltage Regulation

If approved by LADWP, the Smart Inverter may actively regulate the voltage at the PCC while in parallel with LADWP's Distribution System. The Smart Inverter shall not cause the service voltage at other customers to go outside the requirements of ANSI C84.1-1995, Range A (IEEE 1547-2018, 5.1).

b) Voltage Trip and Ride Through Setting

The voltage ranges in Table 1a and 1b define protective trip limits for the Protective Function and are not intended to define or imply a voltage regulation Function. Generating Facilities shall cease to energize LADWP's Distribution System within the prescribed trip time whenever the voltage at the PCC deviates from the allowable voltage operating range. The Protective Function shall detect and respond to voltage on all phases to which the Generating Facility is connected.

i) Smart Inverters

Smart Inverters shall be capable of operating within the voltage range normally experienced on LADWP's Distribution System from plus to minus 5% of the nominal voltage (e.g. 114 volts to 126 volts, on a 120-volt base), at the service panel or PCC. The trip settings at the generator terminals may be selected in a manner that minimizes nuisance tripping in accordance with Table 1a to compensate for voltage drop between the generator terminals and the PCC. Voltage may be detected at either the PCC or the Point of Interconnection. However, the voltage range at the PCC, with the generator on-line, shall stay within +/-5% of nominal.

ii) Voltage Disturbances

Whenever LADWP's Distribution System voltage at the RPA varies from and remains outside the Continuous Operation region for the predetermined parameters set forth in Table 1b, the

Smart Inverter's Protective Functions shall cause the Smart Inverter(s) to become isolated from the LADWP Distribution System as required in Table 1a:

(1) The Smart Inverter shall stay connected to the LADWP Distribution System while the grid remains within the "Voltage Range (p.u.)" and must stay connected in the corresponding "Operating Mode".

(2) If the LADWP Distribution System voltage does not exit the ride-through region and recovers to normal system voltage, the Smart Inverter shall restore continuous operation within two seconds.

(3) If the LADWP Distribution System voltage does not exit the ride-through region and returns from the V<0.5 p.u. region to the 0.5≤V<0.7 or 0.7≤V<0.88 p.u. region, the Smart Inverter shall restore available current within two seconds.

(4) Different voltage-time settings could be permitted by LADWP.

Table 1a: Smart Inverter Voltage Trip Settings

| Shall Trip Function | Voltage Trip Default Settings (p.u. of nominal voltage) | Voltage Range of Shall Trip Function (p.u. of nominal voltage) | Default Clearing Time (s) |
|---|---|---|---|
| OV2 | 1.20 | V >= 1.20 | 0.16 |
| OV1 | 1.10 | 1.10 <= V < 1.20 | 13.0 |
| Continuous Operation | NA | 0.88 < V < 1.10 | NA |
| UV1 | 0.88 | 0.50 < V <= 0.88 | 21.0 |
| UV2 | 0.50 | V <= 0.50 | 2.0 |

Table 1b: Smart Inverter Voltage Ride-Through Settings

| Voltage Range (p.u.) | Operating mode/response | Minimum ride-through time (s) | Maximum response time (s) |
|---|---|---|---|
| V >= 1.20 | Cease to Energize | NA | 0.16 |
| 1.10 < V <= 1.20 | Momentary Cessation | 12 | 0.083 |
| 0.88 <= V <= 1.10 | Continuous Operation | Infinite | NA |
| 0.70 <= V < 0.88 | Mandatory Operation | 20 | NA |
| 0.50 <= V < 0.70 | Mandatory Operation | 10 | NA |
| V < 0.50 | Momentary Cessation | 1 | 0.083 |

iii) Voltage Phase Angle Change Ride-Through

Voltage phase angle change ride-through as specified in IEEE 1547-2018, 6.5.2.6.

c) Paralleling

The Smart Inverter shall parallel with LADWP's Distribution System without causing a voltage fluctuation at the PCC greater than plus/minus 5% of the prevailing voltage level of LADWP's Distribution System at the PCC, and meet the flicker requirements below in section d, Flicker.

d) Flicker

The Generating Facility shall not create objectionable flicker for other Customers on LADWP's Transmission or Distribution System. To minimize the adverse voltage effects experienced by other Customers, flicker at the PCC caused by the Generating Facility should not exceed the limits of IEEE 1547-2018, 7.2.3. This requirement is necessary to minimize the adverse voltage affects

experienced by other Customers on LADWP's Distribution or Transmission System. Generators may be connected and brought up to synchronous speed (as an induction motor) provided these flicker limits are not exceeded.

e) Integration with LADWP's Distribution System Grounding

The grounding scheme of the Smart Inverter shall not cause over-voltages that exceed the rating of the equipment connected to LADWP's Distribution System and shall not disrupt the coordination of the ground fault protection on LADWP's Distribution System (IEEE 1547-2018, 4.12) (See Section G.1.i, line configuration).

f) Frequency

LADWP controls system frequency, and the Smart Inverter shall operate in synchronism with LADWP's Transmission or Distribution System. Whenever LADWP's Transmission or Distribution System frequency at the PCC varies from and remains outside normal (nominally 60 Hz) by the predetermined amounts set forth in Table 2a, the Smart Inverter's Protective Functions shall cease to energize LADWP's Distribution System within the stated maximum trip time.

i) Frequency Ride-Through Requirements

Smart Inverter based systems shall remain connected to the LADWP Distribution System while the grid is within the frequency-time range indicated in Table 2b, and shall disconnect from the electric grid during a high or low frequency event that is outside that frequency time range as indicated in Table 2b.

Table 2a: Frequency Trip Settings Table

| Shall Trip Function | Frequency Trip Default Setting (Hz) | Resulting Range of Shall Trip Function (Hz) | Default Clearing Time (s) |
|---|---|---|---|
| OF2 | 62.0 | $f \geq 62$ | 0.16 |
| OF1 | 61.2 | $61.2 \leq f < 62$ | 300 |
| Continuous Operation | Not Applicable | $58.5 < f < 61.2$ | Not Applicable |
| UF1 | 58.5 | $56.5 < f \leq 58.5$ | 300 |
| UF2 | 56.5 | $f \leq 56.5$ | 0.16 |

Table 2b: Frequency Ride-Through Settings Table

| Frequency (Hz) | Operating Mode | Minimum Time (s) |
|---|---|---|
| $f > 62$ | No Ride-Through requirements apply to this range | Not Applicable |
| $61.2 < f \leq 61.8$ | Mandatory Operation | 299 seconds |
| $58.8 \leq f \leq 61.2$ | Continuous Operation | Infinite |
| $57.0 \leq f < 58.8$ | Mandatory Operation | 299 seconds |
| $f < 57.0$ | No Ride-Through requirements apply to this range | Not Applicable |

ii) Rate of Change of Frequency (ROCOF) Ride-through

Smart Inverter shall not trip for frequency excursion having magnitude rates of change of frequency (ROCOF) that is less than or equal to 3.0Hz per second as specified in IEEE1547-2018, section 6.5.2.5 category III. For ROCOF greater than 3Hz per second, it is preferred for Smart Inverter to ride-through as long as frequency remains in the continuous operating region, low frequency ride-though region (and corresponding duration times), or high frequency region (and corresponding duration times).

g) Harmonics

When the Smart Inverter is serving balanced linear loads, harmonic current injection into LADWP's Distribution System at the PCC shall not exceed the limits stated in IEEE 1547-2018,

7.3. The harmonic current injections shall be exclusive of any harmonic currents due to harmonic voltage distortion present in LADWP's Transmission or Distribution System without the Smart Inverter connected. The harmonic distortion of a Smart Inverter shall be evaluated using the same criteria as for the Host Loads.

h) Direct Current Injection

Smart Inverter should not inject direct current greater than 0.5% of rated output current into the LADWP Distribution System.

i) Smart Inverter Reactive Power Requirements

Smart Inverter Reactive Power capabilities shall comply with IEEE 1547-2018, Section 5.2 Category B requirement.

j) Dynamic Volt/Var Operations

The Smart Inverter shall be capable of supporting dynamic reactive power compensation (dynamic Volt/Var operation) within the following constraints:

The Smart Inverter shall be able to consume reactive power in response to an increase in line voltage, and produce reactive power in response to a decrease in line voltage as indicated in Table 3.

Dynamic Volt/Var Operations Default Settings

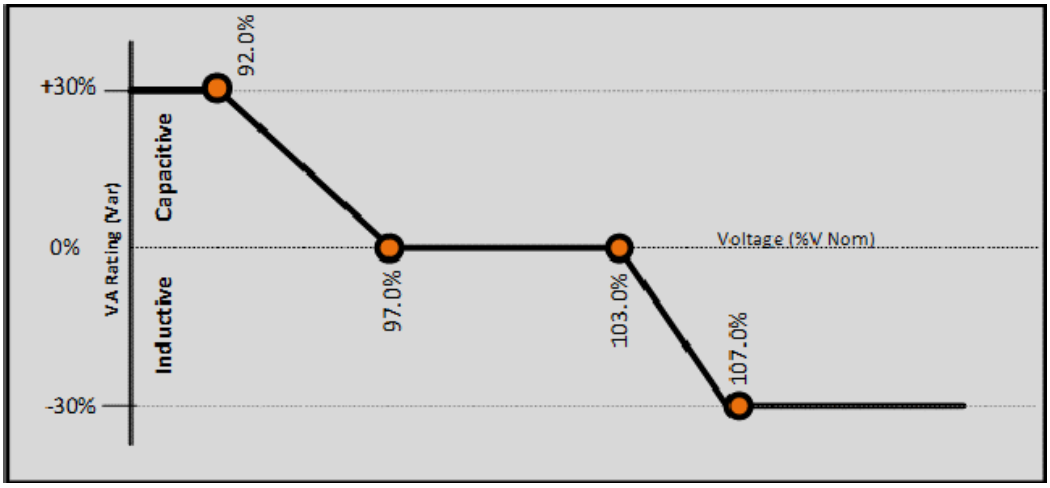
Table 3 and Figure 1 depict the default setting, which should be applied for all inverter size. Specific volt/var settings may be required for larger generating facilities (such as 100 kW or greater) or for specific areas with LADWP's Distribution System as determined by LADWP.

Default Open Loop Response Time for volt/var operation setting should be five (5) seconds.

Table 3: Voltage and Reactive Default Settings

| Voltage Setpoint | Voltage Value | Reactive Setpoint | Reactive Value | Operation |
|---|---|---|---|---|
| V1 | 92.0% | Q1 | 30% | Reactive Power Injection |
| V2 | 97% | Q2 | 0 | Unity Power Factor |
| V3 | 103% | Q3 | 0 | Unity Power Factor |
| V4 | 107.0% | Q4 | 30% | Reactive Power Absorption |

Figure 1: Voltage and Reactive Default Settings




k) Enter Service Ramp Rate Requirements

The Smart Inverter is required to have the following ramp controls

- Enter Service ramp control requirements as outlined in IEEE 1547-2018, Section 4.10.3 with the following default settings:
    - Delay enter service shall be 60 seconds per Section 1.a.ii
    - Default Enter Service Duration shall be 50 seconds

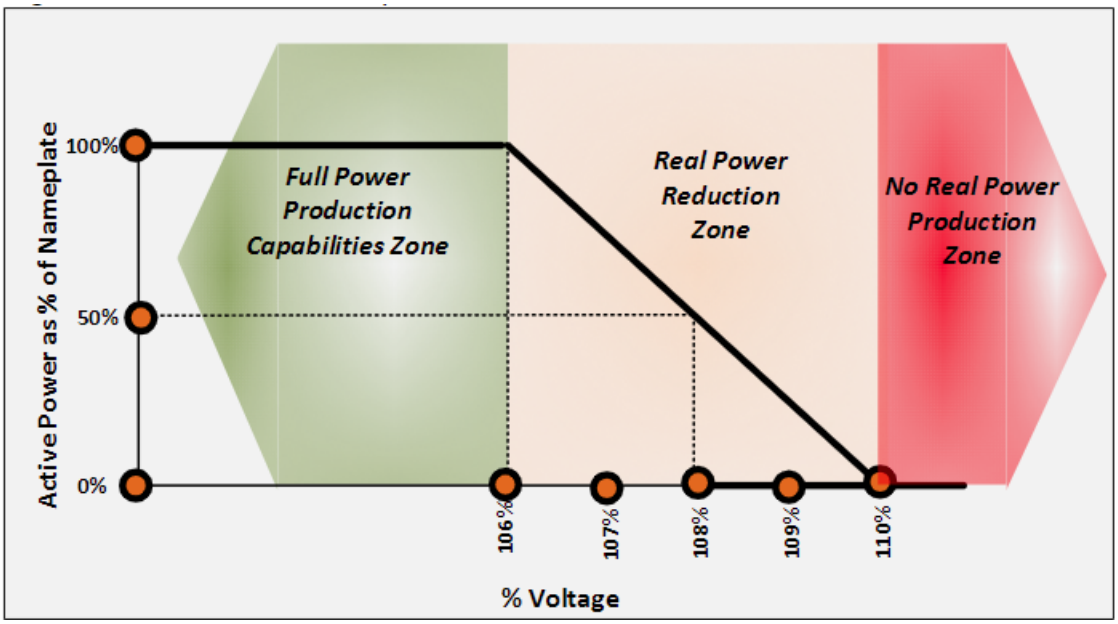
l) Frequency Droop (Frequency Power, Frequency Watt) Requirements
Smart Inverters shall change their real power production as a function of system frequency in accordance with IEEE 1547-2018, 6.5.2.7 with the following default settings: Deadband 36 mHz, $db_{OF}$ and $db_{UF}$. $k_{OF}$ and $k_{UF}$ would be 0.05, open loop response time of 5 seconds.

m) Voltage-Watt Default Settings Requirements

Smart Inverters shall reduce their real power production as a function measured voltage at the inverter terminal or at the Generating Facility Point of Common Coupling (PCC) in accordance with the following:

- When the measured voltage is greater than 106% of nominal voltage (Example: 127.2 volts on 120 volts nominal), the export of active power at the PCC or the production of active power by the Smart Inverter shall be reduced at a rate of 25% of active power nameplate rating per one percent of nominal voltage. Figure 3 Volt-Watt Requirements illustrate the required rate of reduction. When export of active power is controlled, a certified inverter and control system shall be used.
- When the measured voltage is greater than 110% of nominal voltage (Example: 132 volts on 120 volts nominal), the export of active power to the grid at the PCC or the production of active power by the Smart Inverter shall be reduced to 0 watts.
- Open loop response time shall be 5 seconds.

Figure 3: Volt-Watt Requirements




n) Dynamic Reactive Power Support Function

The capability for this requirement will become mandatory for Generating Facilities utilizing inverter-based technologies for which an Interconnection Request is submitted twelve (12) months after approval of a nationally recognized standard that includes the function. The utilization of this function is permissible under mutual agreement between LADWP and the generating facility before the effective date.

o) Default Activation States

Unless otherwise provided by LADWP, the default settings will be as follows:

Table 5: Default Activation States

| Function | State |
|---|---|
| Anti-islanding | Activated |
| Low/High Voltage Ride Through | Activated |
| Low/High Frequency Ride Through | Activated |
| Dynamic Volt/Var operations | Activated |
| Enter Service Ramp Control | Activated |
| Storage Inverter Normal Operation Ramp Control | Activated under mutual agreement |
| Fixed power factor | Deactivated |
| Reconnect by “soft-start” methods | Activated |
| Frequency/Watt | Activated |
| Volt/Watt | Activated |
| Constant Reactive Power Mode | Deactivated |
| Set Active Power Function Mode (Optional) | Activated under mutual agreement |
| Dynamic Reactive Power Support Mode (Optional) | Activated under mutual agreement |

These default activation states may be modified by mutual agreement between LADWP and Producer.

p) Load Shedding or Transfer

The voltage and frequency ride-through requirements of Tables 1a, 1b, 2a, and 2b shall not apply if either: a) The real power across the PCC is continuously maintained at a value less than 10% of the aggregate rating of the Smart Inverters connected to the Generating Facility prior to any voltage disturbance, and the Generation Facility disconnects from LADWP's Distribution System, along with Generating Facility load, such that the net change in real power flow from or to the LADWP Distribution System is less than 10% of the aggregate Smart Inverter capacity; or b) Generating Facility load real power demand equal to 90% to 120% of the pre-disturbance aggregate Smart Inverter real power is shed within 0.1 seconds of Smart Inverter disconnection.

q) Measurement and Calculation Accuracy

Smart Inverter shall meet minimum steady-state and transient measurement and calculation accuracy as required in IEEE 1547-2018, Section 4.4.

r) Prioritization of Smart Inverter Responses

i) The response to disable permit to service as specified in Section 8.a shall take precedence over any other tripping requirements.

ii) Prioritization of tripping requirements not related to disabling permit to service shall meet IEEE 1547-2018, Section 4.7.

s) Storage Inverter Normal Operation Ramp Control Requirements

Smart Inverters used for energy storage applications may optionally include ramp-up rate control. The default value shall be 100% of maximum current output per second or slower if required by Applicant. Other ramp-up control settings can be used, when required, as mutually agreed upon by LADWP and the Applicant.

t) Ride-through of Consecutive Voltage Disturbances

Ride-through of consecutive voltage disturbances shall be in accordance with IEEE 1547-2018, 6.4.2.5.

u) Restore output without dynamic voltage support

Restore output without dynamic voltage support shall be in accordance with IEEE 1547-2018, 6.4.2.7.1.

v) Transition between performance operating regions

Transition between performance operating regions should be in accordance with IEEE 1547-2018, 6.4.2.7.3.

w) Constant Reactive Power Mode

When in this mode, the Smart Inverter shall maintain a constant reactive power. The target reactive power level and mode (injection or absorption) shall be specified by LADWP and shall be within the same range specified in IEEE 1547-2018, Section 5.3.5. The reactive power settings are allowed to be adjusted locally and/or remotely as specified by LADWP. The maximum Smart Inverter response time to maintain constant reactive power shall be 10 seconds or less.

x) Generating Facility Rapid Voltage Changes (RVC)

Generating step or ramp changes shall meet the requirements as specified in IEEE 1547-2018, Section 7.2.2.

y) Limitations of Overvoltage Over One Fundamental Frequency Period

Generating Facility shall not contribute to instantaneous or fundamental frequency overvoltage conditions per IEEE 1547-2018, 7.4.1.

z) Limitation of Cumulative Instantaneous Overvoltage

Generating Facility shall not cause the instantaneous voltage on any portion of the Distribution or Transmission System to exceed the magnitudes per IEEE 1547-2018, 7.4.2.

3. Technology Specific Requirements

Grid-interactive inverters do not require separate synchronizing equipment. Non-grid-interactive or "stand-alone" inverters shall not be used for Parallel Operation with LADWP's Distribution System.

4. Supplemental Smart Inverter Requirements

a) Fault Detection

A Smart Inverter with an SCCR exceeding 0.1 or one that does not cease to energize LADWP's Distribution System within two seconds of the formation of an Unintended Island shall be equipped with Protective Functions designed to detect Distribution System faults, both line-to-line and line-to-ground, and cease to energize LADWP's Distribution or Transmission System within two seconds of the initiation of a fault.

b) Transfer Trip

For a Generating Facility that cannot detect Distribution or Transmission System faults (both line-to-line and line-to-ground) or the formation of an Unintended Island, and cease to energize LADWP's Distribution System within two seconds, LADWP may require a Transfer Trip system or an equivalent Protective Function.

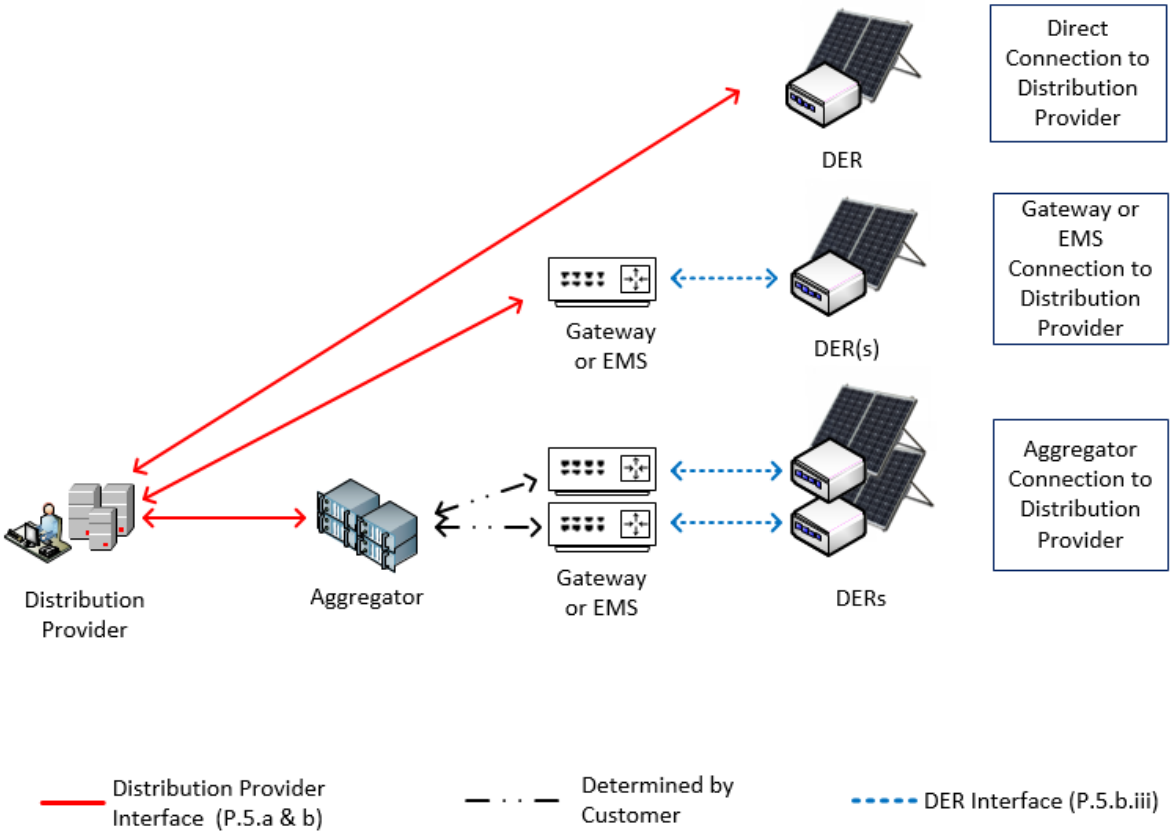
c) Reclose Blocking

Where the aggregate Generating Facility capacity exceeds 15% of the peak load on any automatic reclosing device, LADWP may require additional Protective Functions, including, but not limited to reclose-blocking on some of the automatic reclosing devices.

5. Communication Requirements

Should communications to LADWP be required, Generating Facilities utilizing inverter-based technologies must adhere to the following communication requirements for communications between LADWP and the Generating Facility. The diagram below shows the interface requirements as applicable for this Section 5. The LADWP Interface (solid red line) is described in Sections 5.a and 5.b. The local DER interface at the Generating Facility (dotted blue line) is described in Section 5.b.iii. The top row shows a direct connection between LADWP and the DER. The middle row shows a connection between LADWP and a gateway (GW) or Energy Management System (EMS). The lower row shows a connection between LADWP and an aggregator.

Figure 5: Generating Facility Communications




The communication protocol requirements herein shall be between:

(i) LADWP and the individual DER, GW, or EMS;

(ii) LADWP and communication to the Generating Facility through an aggregator not co-located or part of the Generating Facility; or

(iii) other communication options as mutually agreed to by Applicant and LADWP.

a) The communications requirements in this Section pertain to communications between LADWP and communications option selected, or required, from this Section 5. These requirements do not specify the communication between the selected communication option and Smart Inverter but performance will be enforced by compliance with these requirements:

   i) Shall be capable of communications;

   ii) Software shall be updateable via communications remotely;

   iii) The transport level protocol shall be TCP/IP; and,

   iv) The default application-level protocol shall be IEEE 2030.5 as defined in the latest final version of the Common Smart Inverter Profile (CSIP) and the California IEEE 2030.5 Implementation Guide. Other application-level protocols may be used by mutual agreement of the Parties including IEEE 1815/DNP3 for SCADA real-time monitoring and control and IEC 61850.

b) Additional communication protocol requirements shall also apply to Generating Facilities utilizing inverter-based technologies as provided in the following documents:

i) LADWP Electric Service Requirements, which shall include:

- Details and guidelines for the implementation of communications with Generating Facilities utilizing inverter-based technologies;
- Cybersecurity and privacy requirements (these may additionally or alternatively be included in the application-level protocol implementation guide); and,
- Generic device communications registration management requirements, including how to register individual Generating Facilities, Generating Facilities with energy management systems, and aggregators (these requirements additionally or alternatively may be included in the application-level protocol implementation guide); and
- Conditions under which communication functions are mandatory.

ii) Application-Level Protocol Implementation Guide, which shall provide:

- Detailed communication requirements and implementation guidelines to ensure consistent interoperability of the Generating Facilities with LADWP and all other California investor-owned utilities.

iii) Communication Protocol and Performance Requirements

- Communication performance requirements for the interface to the Generating Facility shall comply with IEEE 1547-2018, 10.8.
- The protocol requirements at the Generating Facility shall be per IEEE 1547-2018, 10.7.
- If choosing IEEE 2030.5 as the protocol, then CSIP certification is required.

6. Scheduling Capability Requirements:

Generating Facilities which incorporate Smart Inverters shall incorporate scheduling capabilities with minimum scheduling memory capability of at least 24 events. The utilization of this function is permissible under mutual agreement between LADWP and the generating facility before the effective date. Each event is composed of modifications to each, selected group of, or all of the following Smart Inverter function:

- Modifications to the voltage and reactive set-points of the Dynamic volt/var function.
- Modifications to the reactive power set-points for the fixed power factor function.
- Modifications to the voltage and watt-reduction level set-points for the volt/watt function.

The Generating Facility's scheduling capability requirement herein shall be met by one or more of the following options:

- Scheduling capability requirements may be implemented at the GW/EMS. The GW/EMS shall communicate the necessary commands to the Smart Inverters within 10 minutes, or by mutual agreement, from when the GW/EMS receives the scheduling information.
- Scheduling capability requirements may be implemented at the DER within the Generating Facility.
- Scheduling capability requirements may be stored at an aggregator not co-located within the Generating Facility. The aggregator shall communicate the necessary commands to the Smart Inverter within 15 minutes of the aggregator receiving the scheduling information.
- Other options may be utilized by mutual agreement between the Applicant and LADWP.

The selected scheduling control system shall store the schedules and shall send operational commands to the Smart Inverters as required by the schedule received from LADWP. The Smart Inverter shall respond by changing its mode of operation as commanded at the schedule start time with no unreasonable delay.

Each scheduled mode of operation shall include and start-time and duration. The Smart Inverter should return to its default settings at the end of the duration time or shall enter a new operational mode as directed by the scheduling control system.

7. Monitoring and Telemetry Requirements:

The Smart Inverter shall have the capability to communicate its performance information per IEEE 1547-2018, 10.5 Table 29:

- Smart Inverter production or consumption of active power (watts)
- Smart Inverter consumption or production of reactive power (vars)
- Phase measured at the AC terminals of the Smart Inverter (volts)
- Frequency measured at the AC terminals of the Smart Inverter (Hz)
- Connection Status
- Alarm Status

When the Generating Facility includes energy-storage with Smart Inverters, the following monitoring and telemetry capability is required:

The Smart Inverter shall be capable of communicating the operational state of charge as a percent of energy storage capacity.

Operational State as In-Service or not In-service communication capability requirements. The Smart Inverter shall be capable of communicating when the Smart Inverter is capable of providing electric services as follows:

- In-Service: An operational state which indicates that the Smart Inverter is connected to the electric system and operating as determined locally by the Generating Facility operator or by a scheduling control system as outlined in Section 6.
- Not In-Service: An operating state which indicates that the Smart Inverter is not capable of connecting to the electric system and not capable of providing any type of electrical support as required locally or as commanded by a scheduling control system as outlined in Section 6.

Monitoring and performance information should be communicated in aggregate at the Generating Facility as follows:

- When the Generating Facility includes only Smart Inverters, the production or consumption of active and reactive power shall be communicated as an aggregate of all Smart Inverters within the Generating Facility.
- When a Generating Facility includes Smart Inverters and other technologies such as synchronous or induction generation systems, the Generating Facility shall communicate the following:
    - The production or consumption of active and reactive power shall be communicated in aggregate of all Smart Inverters within the Generating Facility.
    - The production or consumption of active and reactive power shall be communicated in aggregate of all the other technologies within the Generating Facility.
- When the Generating Facility with Smart Inverters includes one or multiple energy storage systems, the available operational energy should be communicated as an aggregate of all the energy storage systems.
- Nameplate information shall be available through a local Generating Facility Interface as required in IEEE 1547 2018, 10.3 and must include the information as required in IEEE 1547-2018, Table 28.

- Configuration information shall be available through a Local Generating Facility Interface as required in IEEE 1547-2018, 10.4. This information represents the present capacity and ability of the Generating Facility. When a configuration update changes the Generating Facility nameplate information, it may require a study depending on the change.

8. Control through communication capabilities:

The utilization of these functions are permissible under mutual agreement between LADWP and the generating facility before the effective date. Smart Inverters shall have the capabilities of accepting operational controls through communications in accordance to the following:

a) Disable permit to service control command:

When the Smart Inverter receives a disable permit service command through communication, the Smart Inverter cease-to energize and trip within 2 seconds or initiate the opening of the switch referenced in the inverter terminal in order to galvanically isolate the Smart Inverter from the LADWP Distribution System.

b) Return to service control command:

When the Smart Inverter receives a return-to-service control command, the Smart Inverter may return to service operation as required by Generating Facility operator or as required by the scheduling control system as required by Section 6. This shall be accomplished by enabling permit service as required in IEEE 1547-2018, 4.10.3.

c) Limit Active Power Command:

When the Smart Inverter receives a command to limit its production of real power, the Smart Inverter shall reduce its real power production to the specified percent of real power capacity of the Smart Inverter or to a specified real power value. In no more than 30 seconds or in the time it takes for the primary energy source to reduce its active power output to achieve the requirements of the active power limit set point, whichever is greater.

d) Set Active Power Level Mode Function:

The capability for this requirement will become mandatory for Generating Facilities utilizing inverter-based technologies for which an Interconnection Request is submitted twelve (12) months after approval of a nationally recognized standard that includes the function. The utilization of this function is permissible under mutual agreement between LADWP and the generating facility before the effective date.

e) Suspension of Active Power restriction:

When the Smart Inverter receives a command to suspend the command for active power reduction, the Smart Inverter may return to normal operation as required by Generating Facility operator or as required by the scheduling control system as required by Section 6.

f) Transition between operating modes

Transition between modes shall commence in no more than 30 seconds after the mode setting change is received at the local Generating Facility communication interface.

Changes of control functional modes shall be executed such that the Smart Inverter output is transitioned smoothly over a time period between 5 and 300 seconds.

Ramping of Smart Inverter output is not required for control parameter setting changes.

For all control and protective function parameter settings, the time following the input to the local Generating Facility communication interface and preceding the point in time when the invoked action begins shall be no greater than 30 seconds.