# INVERTER-BASED
# DISTRIBUTED ENERGY RESOURCES
# Technical Interconnection Requirements

Released May 1, 2019

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## Preface

This document has been prepared to identify Technical Interconnection Requirements for Inverter-Based Distributed Energy Resources connecting to the ATCO Electricity distribution system. It provides additional background to and does not supersede the "Standard for the Interconnection of Generators to ATCO Electricity's Distribution Systems" or commercial terms established by ATCO Electricity.

## Document Ownership and Updating

This document is completed by the Operational and Facilities Planning Section of ATCO Electricity. Distribution Planning is the owner of this document and is responsible for periodic review and updating.

## Revision History

R0 – Original – May 1, 2019

# Table of Contents

# 1 PURPOSE

The purpose of this document is to identify the minimum technical and operating requirements for Inverter-Based Distributed Energy Resources (DERs) interconnection to ATCO Electricity's (AE's) distribution facilities. It is intended to provide general background information and does not supersede any regulations or standards. This document does not replace the "Standard for the Interconnection of Generators to ATCO Electricity's Distribution Systems" and is intended to be added on to the requirements within that standard. During the interconnection process, additional requirements may need to be met to ensure safe and reliable operation for both the DER owner and the DFO.

All performance requirements presented in this document are based on the following four standards. If there are any discrepancies between this document and one of the following four standards, the information in the standard shall prevail.

- IEEE 1547-2018 , IEEE 1547.1-2020
- Underwriters Laboratory UL 1741 SA or SB
- CSA C22.3 No. 9-20.
- CSA C22.2 No. 257-06.

Additionally, all DERs connecting to ATCO Electricity's system shall comply with the following standards:

- Standard for the Interconnection of Generators to ATCO Electricity's Distribution System
- Alberta Micro Generation Regulation
- CSA 22.2-107.1
- Alberta ISO Rule 804 Off-Nominal Frequency Load Shedding and Restoration
- ATCO Electric System Standard for the Installation of New Loads

# 2 BACKGROUND

Historically, utility distribution systems have been designed and operated based on one-way energy flow from the transmission connected substation out to customers. DERs have existed, and comprised mainly synchronous generators; however, the penetration levels have been low and their effects on the grid was typically limited. Connection requirements specified that the DERs could not actively regulate system voltages and should meet anti-islanding requirements specified in CSA C22.2 no. 257 and CSA C22.3 No. 9. This resulted in the utilities determining the maximum DER output and associated power factor that they could tolerate across the expected range of operating conditions.

Increased interest in renewables, along with lower cost for Photovoltaic (PV) systems and increased inverter functionality, is driving the need to enable greater levels of DER connection, and inverter-based generators are proliferating. In the short term, the approach specifying a prescribed operating point approach will continue to be employed; however, the intent of these technical interconnection requirements is to position both ATCO Electricity and DER developers to migrate to a higher level of coordinated operation, enabling maximum penetration of renewable energy sources.

The requirements contained in this document only apply to new DERs, and any existing generator will be grandfathered.

# 3 AUTONOMOUS CONTROL FUNCTIONAL REQUIREMENTS AND SPECIFICATIONS

All inverter-based DERs connecting to ATCO Electricity's distribution system should have all provisions to meet all functional requirements specified in this section. Compliance to requirements may be verified at the Point of Common Coupling (PCC) at the discretion of ATCO Electricity.

The autonomous (local) operation of any or all of the functions described in this section may be superseded by an external signal issued by ATCO Electricity to support the operation of the interconnected system. The time responses for all functions in this section shall be adjustable, for either autonomous control or external signal.

**Table 1 - Summary of Autonomous Function required for New Installed Smart Inverters**

| | Function | Description |
|---|---|---|
| 1 | Low/High Voltage Ride Through | Stay online through a wider range of voltage disturbances |
| 2 | Low/High Frequency Ride Through | Stay online through a wider range of frequency disturbances |
| 3 | Volt/VAR Control | Inject VARs when needed to support grid voltage |
| 4 | Anti-Islanding | Trip offline during a grid outage |
| 5 | Ramp Rate Control | Control inverter output to smooth out rapid fluctuations |
| 6 | Reactive Power Support | Operate at a fixed non-unity power factor |
| 7 | Soft Start | Reconnect to the grid only after voltage and frequency return to normal |

## 3.1 Reactive Power Capability Requirements

In order to coordinate with ATCO Electricity's existing voltage regulating devices, inverter-based DERs shall be capable of absorbing (under-excited) or supplying (over-excited) reactive power to the extent of maintaining a power factor in the full range of ± 90%. This range is deemed to be sufficient to allow for balancing load reactive power demands for cases where generation and load become nearly matched at a feeder level.

## 3.2 Adjustable Constant Power Factor Mode

When in this mode, the DER shall operate at a constant power factor, regardless of its instantaneous power output. The purpose of establishing fixed DER power factor is to manage the voltage profile along a feeder, as well as to help compensate the aggregate feeder power factor resulting from loads and other DERs. This is currently the standard operating mode of any DER connected to ATCO Electricity's distribution system and is typically prescribed by ATCO Electricity during the interconnection's planning stage.

## 3.3 Adjustable Constant Reactive Power Mode

When in this mode, the DER shall maintain a constant reactive power input or output. This mode is typically not employed but can be used to control the exchange of reactive power.

## 3.4 Adjustable Voltage-Reactive Power (Volt-VAR) Mode

Dynamic reactive power compensation operation is intended to provide a mechanism through which the DER may be configured to counteract voltage deviations from the nominal voltage level (but still within normal operating ranges) by consuming or producing reactive power.

When in this mode, the DER shall actively control its reactive power output as a function of voltage following a Volt-VAR piecewise-linear characteristic such as that shown in Figure 1. The DER system shall be capable to consume reactive power in response to an increase in line voltage and produce reactive power in response to a decrease in line voltage.

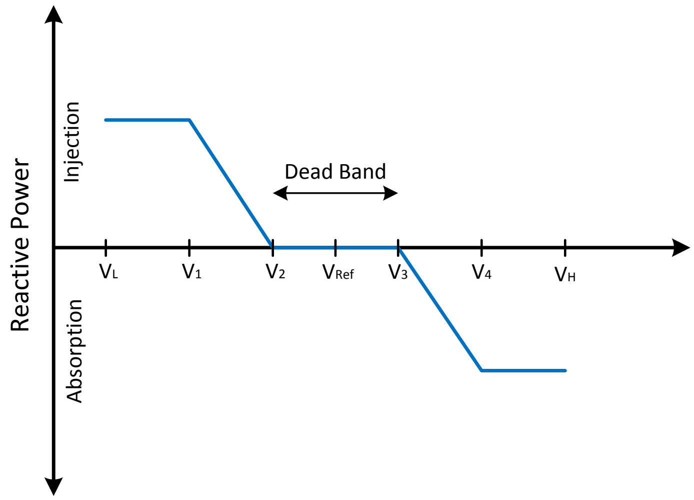


Figure 1. Volt-VAR Characteristic

The desired VAR level must remain constant for voltages below $V_1$, and above $V_4$. When operating within the Dead Band (voltages between $V_2$ and $V_3$), the power factor is set to unity. Voltages outside the range $V_L$-$V_H$ are those where the DER should not operate (i.e., should be disconnected).

As this function essentially allows the DER to control the system voltage at the PCC, the requirement whether to operate in this mode is the prerogative of ATCO Electricity, who would also recommend set-points for this function.

## 3.5 Adjustable Active Power-Reactive Power (Watt-VAR) Mode

This function is intended to provide a mechanism through which the DER shall actively control the reactive power output as a function of the real power output following a Watt-VAR piecewise-linear characteristic such as that shown in Figure 2.

The left-hand side of this figure (active power absorption) is only applicable if the DER is capable of performing under this condition, such as in the case where Battery Storage is present.

The requirement whether to operate in this mode is the prerogative of ATCO Electricity, who would also recommend set-points for this function. This mode is typically not employed.

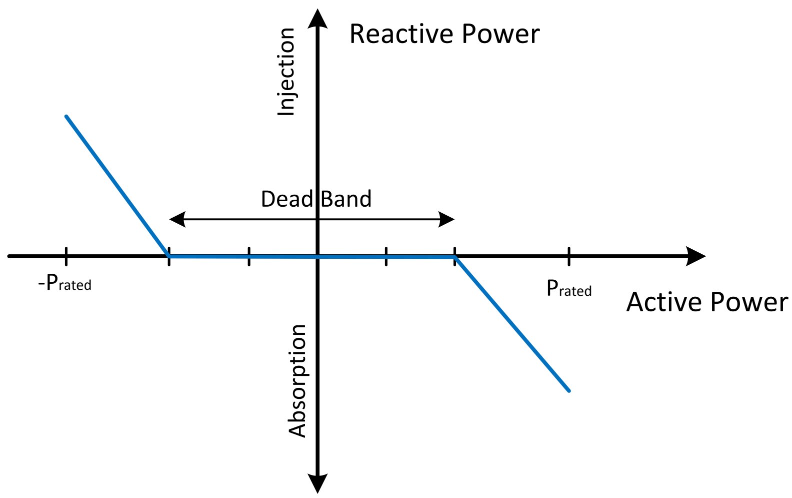


Figure 2. Watt-VAR Characteristic

## 3.6 Adjustable Voltage-Active Power (Volt-Watt) Mode

This function is intended to provide a mechanism through which the DER may be configured to manage Active Power output in response to the local service voltage. When in this mode, the DER shall actively control its active power output as a function of voltage following a Volt-Watt piecewise-linear droop characteristic such as that shown in Figure 2.

The requirement whether to operate in this mode is the prerogative of ATCO Electricity, who would also recommend set-points for this function.

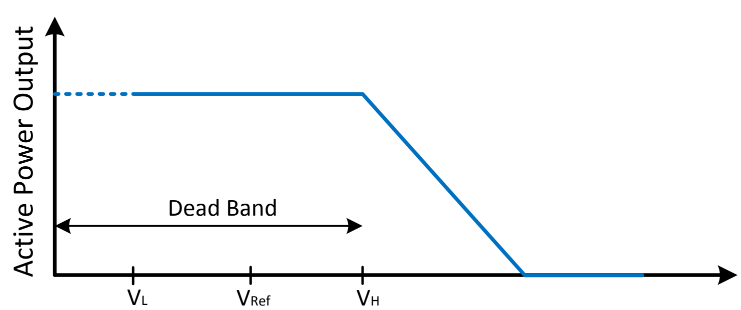


Figure 3. Volt-Watt Characteristic

## 3.6 Adjustable Frequency-Active Power (f-Watt) Mode

This function is intended to provide a mechanism through which the DER may be configured to manage Active Power output in response to the local service frequency. When in this mode, the

DER shall actively control its active power output as a function of frequency following a f-Watt piecewise-linear droop characteristic such as that shown in Figure 4.

The requirement whether to operate in this mode is the prerogative of ATCO Electricity, who would also recommend set-points for this function.

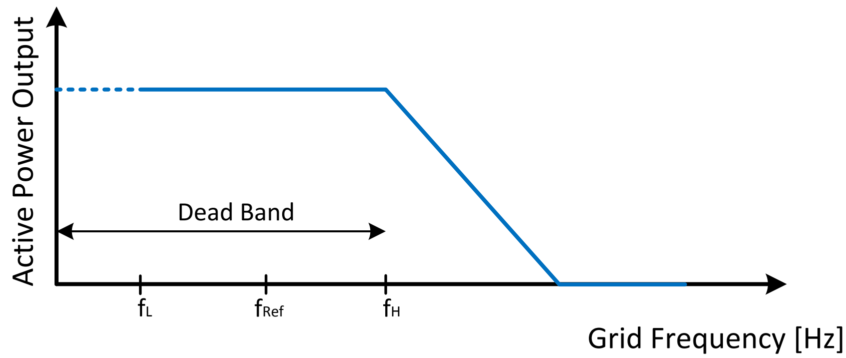


Figure 4. Frequency-Watt Characteristic

# 4 REMOTE VISIBILITY AND SUPERVISORY CONTROL

## 4.1 DER Real-time Visibility

Visibility of DERs is defined as the remote monitoring of operating information from the control device; this information will include connection status, real power output, reactive power output, voltage at the point of interconnection and other readings as required. To ensure compatibility with ATCO Electricity's existing monitoring platform ATCO Electricity shall specify the allowable communications protocols, and acceptable communications equipment that will be used for monitoring the operation of the DER.

Currently, DER facilities with aggregate nameplate capacity of 5 MW or more are required to provide visibility to the Alberta Electric System Operator (AESO) and to ATCO's SOC. This requirement consists of providing SCADA data that is communicated to the AESO System Control Centre.

Historically, ATCO Electricity has not had a specified DER visibility requirement. This lack of visibility means that smaller DERs cannot be accounted for in the utility load forecast; consequently, the overall gross demand will be inaccurate. As DER development increases, the total volume of those below the 5 MW threshold will grow, further affecting the accuracy of the load forecasts.

ATCO Electricity requires all DERs 1kW and above to have the provision for visibility. ATCO Electricity will determine whether visibility must be enabled at the time of interconnection and reserves the right to instruct the DER owner to provide visibility at a later date, as conditions dictate. For smaller scale DERs where only visibility is required, lower cost communications options will be acceptable.

## 4.2 DER Real-Time Supervisory Controllability

Lack of coordinated control between DERs and the utility grid creates a number of issues in both transmission and distribution system operation. The sub-sections below discuss several different forms of control that may be performed by ATCO Electricity in the future.

Provision to provide any or all of these is required for all DERs larger than 250kW connecting to the ATCO Electricity system. This can be achieved using the same interface that is required for the monitoring platform mentioned in 4.1. Implementation of coordinated supervisory control methodology will supersede the autonomous control modes identified in the previous section.

### 4.2.1 On/Off Control

The ability for a utility system operator to manually direct a facility on or off is essential for safety and reliability. Today, most DERs do not have the means to accommodate this.

For example, system restoration following a major outage or blackout requires control of the balance between the supply and demand at any point during the restoration. Presently when an outage occurs, the DERs disconnect from the distribution system as required by current anti-islanding requirements[1]. During system restoration, the DERs wait until they sense preset voltage at their PCC, and then automatically reconnect to the distribution system after a specified time delay. The time delay is generally 5-10 minutes, but guidelines allow it to be set between 1-60 minutes.

During wide scale system restoration, management of load is critical to overall stability of the network. Restarting of DERs under these conditions may destabilize the restoration process. Therefore, system operator control to disable automatic restart during wide scale outages is required for all DERs. Implementation of this feature will be the prerogative of ATCO Electricity and activation will be at the direction of the AESO.

In case of local outages, the DERs would be disconnected by the anti-islanding protection.

[1] Current anti-islanding schemes are required to cease a generator's output in 2 seconds or less.

#### 4.2.2 Power Limiting

Reliable operation of a power system may require the need to limit the power output from any energy source. Although DERs are rarely subject to system-initiated runbacks, as overall penetration increases, the AESO may need to implement specific protection requirements to manage the overall contribution to grid supply in a similar fashion as ISO Rule 502 (Wind Aggregated Generating Facilities Technical Requirements).

#### 4.2.3 Voltage Control and regulation of DERs

Ongoing DER development will result in changing network conditions that may result in the requirement for AE to adjust the control modes or control generator output voltage to maintain reliability and satisfactory operating conditions as described in Section 3. Therefore, connecting DERs must have the capability to implement external set-point adjustment at a future date. Implementation of this feature will be the prerogative of ATCO Electricity.

### 4.3 DER Effect on Load Shedding: Under Frequency and Under Voltage

All utilities employ both Under Frequency Load Shedding (UFLS) and Under Voltage Load Shedding (UVLS) schemes to maximize overall grid reliability during significant disturbances. In both schemes, ensuring as much operating generation as possible stays on line is a critical factor. Consequently, all DERs connected to the ATCO Electricity network must be capable of meeting the frequency and voltage ride-through specifications (see Section 5).

## 5 Response to Distribution System Abnormal Conditions

Abnormal conditions arising on ATCO's distribution system may require a certain degree of performance from a DER. This response contributes to the system stability, safety of maintenance personnel, and the general public, as well as the avoidance of damage to connected equipment, including the DER itself. A protection SLD identifying protective device functions for the facility and UL 1741 SA and IEEE 1547-2018 compliance needs to be supplied by the DER owner along with the synchronizing settings for $\Delta V$ and $\Delta f$.

Each DER shall have adjustable set-points for:

- Over-frequency
- Under-frequency
- Over-voltage
- Under-voltage

- Return to Service
- Frequency-Watt

## 5.1 Anti-Islanding

Risk of a DER islanding with a portion of the distribution system, as well as with transmission elements, must be avoided. If islanding occurs, there is risk related to safety as well as damage to equipment and facilities belonging to third parties, the DER and ATCO Electricity. Islands may be formed when faults occur and are cleared or when interrupters are inadvertently opened during switching operations.

### 5.1.1 Line Faults

Typically line faults are momentary events with whatever caused the contingency falling away. Therefore, it is normal utility practice to have automatic reclose following line faults to restore service.

#### *5.1.1.1 Distribution System*

Because the DER will also feed into a distribution line fault, the expectation is that the generator protection will react to separate it from the faulted line. However, if the DER happens to remain online, reclosing will result in an unsynchronized connection.

If the fault clears without the DER tripping, there is also risk of the voltage and frequency deviating outside of permissible limits in the interim until the feeder breaker recloses.

#### *5.1.1.2 Transmission System*

As with distribution line faults, most transmission line faults are momentary events and it is normal utility practice to have an automatic reclose. However, because there is a greater level of impedance between the DER and a transmission fault, there is lower probability the DER protection will detect the fault. This is only problematic from an islanding perspective when the transmission connection is a tap or radial feed.

### 5.1.2 Open Lines

#### *5.1.2.1 Distribution System*

If any portion of the distribution circuit which has a DER connection becomes separated from the grid there is risk of voltage and frequency deviating outside of permissible limits if the DER remains on-line.

For both faults and open line conditions, the risk is greatest if the line loading is not at least twice as great as the DER output[2]. Here the maximum generation and low load conditions are used to ensure that "worst case" conditions are considered.

#### *5.1.2.2 Transmission System*

As with the open distribution line condition, a DER operating with any transmission facilities that are separated from the main network poses risks. In this case there is potential for very high voltage.

### 5.1.3 Mitigation Strategies

Inverter based generation is standard with solar arrays and is becoming common with wind generation. The inverter is supplied with direct current (DC) input and, using power electronics and control algorithms, creates an alternating current (AC) output.

Most modern inverters meet the requirements of UL-1741-SA and IEEE 1547, which requires that inverters can detect islanded conditions and take themselves offline within 2 seconds. Where the developer confirms that the inverter meets these criteria, the anti-islanding features of the inverter will be satisfactory.

For larger DERs, especially those in in Distributed Generation category, ATCO Electricity will also implement the following steps to ensure safety and reliability (illustrated in Figure 5):

1. Ensure that the 25 kV feeder breaker reclosing is a minimum of 5 seconds at the POD.
2. Coordinate timing of all reclose elements on the feeder, upstream of the DER, with the revised breaker reclosing time.
3. Implement logic comprised of any one of the following, to trip the POD circuit breaker hosting the DER.
    - Transformer or POD out-of-service (O/S) condition will initiate a trip of the DER feeder breaker.
    - 25 kV bus voltage of 1.15 p.u., or greater, will initiate a DER feeder breaker after a 10-cycle time delay. The intent is to minimize risk of damage to substation arrestors.
    - 25 kV bus voltage of 1.07 p.u., or greater, and reverse or zero power flow from high to low side at the POD will initiate a DER feeder breaker trip after a 30 second delay. This permits some time for a runback to be sent via any SCADA telemetry in place.

[2] When load is less than twice generation, there is risk that traditional protection elements (under/over voltage and under/over frequency) at the generation site may not recognize that islanding has occurred in a timely fashion. Therefore, this has been selected as the requirement for DTT to ensure that the DG does not inadvertently supply energy into the utility system when islanded. To ensure all possible conditions are covered, minimum feeder loading will be used.

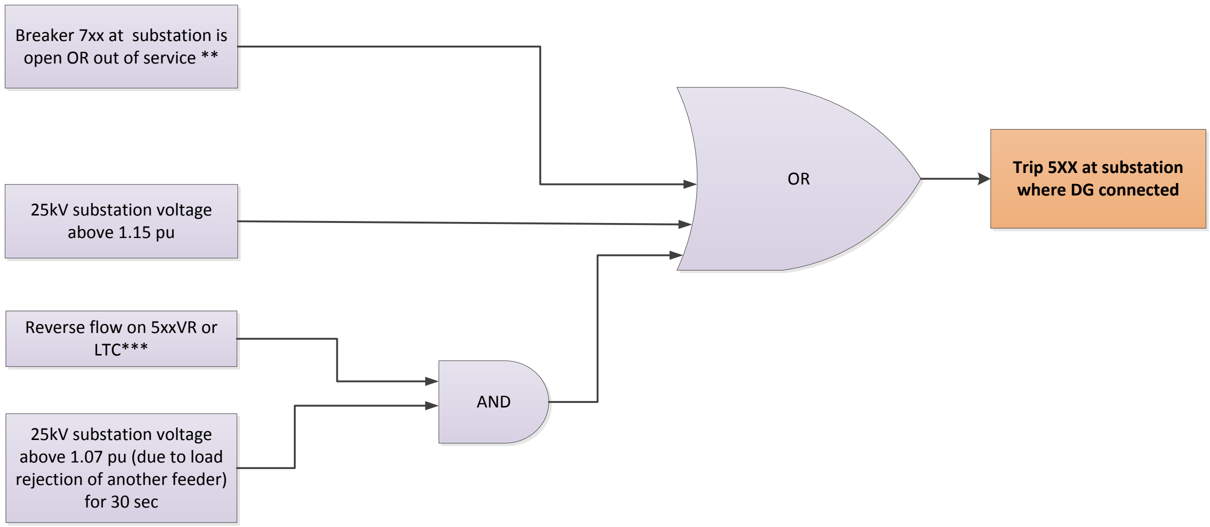


Figure 5. Generic POD Anti-Islanding Logic Diagram for Inverter-Based Interconnections

Transmission has agreement with Distribution to treat inverter technologies the same whether with or without an STS contract. Hence, in this circumstance the LTC will have a bi-directional controller installed and programmed as if there was an STS contract. Management of STS levels is left up to the AESO.

This anti-islanding logic will not result in unnecessary tripping of the DER, for the following reasons:

- For the first condition, the POD or 25 kV bus will be isolated from the transmission network when the transmission breaker (7xx) opens, so tripping the feeder breaker (5XX) does not introduce an outage that would not have otherwise occurred.

- For the second condition, the substation arrestors flashover when the voltage exceeds 1.15 p.u. This will cause an outage at the POD and potentially damage the arrestors, which will result in an extended outage. Therefore, the trip logic does not cause an outage that would otherwise not occur and reduces the risk of equipment damage.

- For the third condition, the DER is the primary reason for extended high voltage on the 25 kV bus. Although a trip wouldn't necessarily happen without the logic, overvoltage damage is a real potential if left unchecked for an extended period. Without the runback signal available with the DTT, there is no means to reduce the DER output to lower the 25 kV voltage, so a trip & reclose is required to remove the generation and mitigate damage.

## 5.2 Low-Voltage and High-Voltage Ride-Through Requirements (Inverter Based DERs only)

Refer to AESO Trip and Ride-Through Requirements:
https://www.aeso.ca/assets/DER-Ride-Through-Performance-Recommendations.pdf

## 5.3 Must-Trip Voltage Requirements

Refer to AESO Trip and Ride-Through Requirements:
https://www.aeso.ca/assets/DER-Ride-Through-Performance-Recommendations.pdf

In addition, ATCO requires customer to trip off if an overvoltage of 1.07pu is sustained for 90 seconds

## 5.4 Low-Frequency and High-Frequency Ride-Through Requirements (Inverter Based DERs only)

Refer to AESO Trip and Ride-Through Requirements:
https://www.aeso.ca/assets/DER-Ride-Through-Performance-Recommendations.pdf

## 5.5 Must-Trip Frequency Requirements

Refer to AESO Trip and Ride-Through Requirements:
https://www.aeso.ca/assets/DER-Ride-Through-Performance-Recommendations.pdf

[6] Under normal operation the DER, being a non-dispatchable generator, may remain in production or cease production freely unless directed otherwise by ATCO Electricity.

Refer to AESO Trip and Ride-Through Requirements:
https://www.aeso.ca/assets/DER-Ride-Through-Performance-Recommendations.pdf

### 5.6 Rate-Of-Change-Of-Frequency Ride-Through Requirements

Under normal operating conditions, the DER shall remain in operation for rates of change of frequency (ROCOF) that are less than or equal to 3 Hz/s. The ROCOF element shall be set to the average rate of change of frequency over a duration of at least 0.1 seconds.

For DERs generators that utilize ROCOF as part of their anti-islanding protection suite, the set-points may be within the required ride-through range described above. This will allow for a conservative method of disconnection where dependability is more important than security.

## 6 Power Quality

### 6.1 Limitation of DC Injection

The DER shall not inject DC current greater than 0.5% of the full rated output current at the PCC.

## 6.2 Limitation of voltage fluctuations induced by the DER

The DER shall not create unacceptable rapid voltage changes at the PCC or objectionable flicker for other customers[7].

### 6.2.1 Voltage Fluctuations

Voltage fluctuations are considered to be step changes in fundamental frequency voltage less than one second. Typical causes of voltage fluctuations include step variations in load or generation. The DER shall not cause the ΔV/V voltage variations to go outside the limits specified in Table 5[8].

**Table 5—Maximum allowable limitations for voltage fluctuations[9]**

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

### 6.2.2 Flicker

Flicker is the subjective impression of fluctuating luminance caused by voltage fluctuations. Assessment methods for flicker are defined in IEC 61000-3-7. Flicker measurements, for the purpose of performance verification, need to be assessed over a period of one week. This is a test performed by the manufacturer.

$P_{st99\%}$ ($99^{th}$ percentile value) shall not be greater than 0.9[10]

$P_{lt99\%}$ ($99^{th}$ percentile value) shall not be greater than 0.7

If the DER does not meet these requirements, an external compensation device will be allowed to mitigate the flicker.

[7] Assessments for emission limits are made at the point of evaluation, which usually is the PCC. Recommended limits used to assess this requirement are provided in IEC 61000-3-7 and 61000-3-14.
[8] This item does not address the issues associated with slow voltage variations, which can be caused by cloud passes, wind speed changes, etc.
[9] This table is adopted from IEC 61000-3-7.
[10] If an area is experiencing harmful flicker, and therefore complaints are being received from power consumers, then *Pst* values will possibly indicate the issue much sooner than the required one week performance evaluation period.

$P_{st}$ is defined in IEEE 1453-2015 as the short-term flicker severity. If not specified differently, the $P_{st}$ evaluation time is 10 minutes.

$P_{lt}$ is defined in IEEE 1453-2015 as the long-term flicker severity. If not specified differently, the $P_{lt}$ evaluation time is 2 hours and is obtained from the equation below.

$$P_{lt} = \sqrt[3]{\frac{1}{12}\sum_{i=1}^{12} P_{st_i}^3},$$

where (i = 1, 2, 3 ...) are consecutive readings of the short-term severity $P_{st}$.

## 6.3 Limitation of Harmonic Current Injection

When the DER is serving balanced linear loads, harmonic current injection at the PCC shall not exceed the limits stated below in Tables 6 and 7. The methodology for measuring harmonic and interharmonic values in this requirement is adopted from IEEE Std 519-2014[11].

Any aggregated interharmonic current distortion between any harmonic frequency *h*+/-5Hz shall be limited to the associated harmonic order *h* limit in Tables 6 and 7. Any aggregated interharmonics current distortion between h+5Hz and (h+1)-5Hz shall be limited to the lesser magnitude limit of *h* and *h*+1 harmonic order.

The harmonic current injections shall be exclusive of any harmonic currents due to harmonic voltage distortion present in the distribution system without the DER connected. Upon mutual agreement between ATCO and the DER owner/operator the DER may inject harmonic current in excess of Table 6, when it is used as an active filtering device.

**Table 6—Maximum odd harmonic current distortion in percent of Rated Current[12]**

| Individual odd harmonic order h | h < 11 | 11≤ h < 17 | 17 ≤ h < 23 | 23 ≤ h < 35 | 35 ≤ h | Total Rated Demand Distortion (TRD) up to the h=50 harmonic |
|---|---|---|---|---|---|---|
| Percent (%) | 4.0 | 2.0 | 1.5 | 0.6 | 0.3 | 5.0 |

[11] Harmonic *N* shall be calculated as the rms of the spectral component value of the actual integer multiple of the fundamental frequency and the adjacent +/- 5Hz bins from the gapless 12 cycle (200msec) measurement window. All of the other 5Hz bins spectral components are similarly summed (rms) into the interharmonic value between adjacent harmonics.

[12] Rated Current is defined as the greater of the facility maximum load current integrated demand (15 or 30 minutes) without the DER unit, or the DER unit rated current capacity (transformed to the PCC when a transformer exists between the DER unit and the PCC).

## Table 7—Maximum even harmonic current distortion in percent of Rated Current

| 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 |

## 6.4 Limitation of over-voltage contribution

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

1. The DER shall not cause the RMS Line-Ground voltage on any portion of the distribution system 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 for duration of exceeding one fundamental frequency period.
2. The RMS voltage measurements shall be based on one fundamental frequency period.

The DER shall not cause the instantaneous voltage at the PCC to exceed the magnitudes and cumulative durations shown in Figure 6. The cumulative duration shall only include the sum of periods for which the instantaneous voltage exceeds the respective threshold.

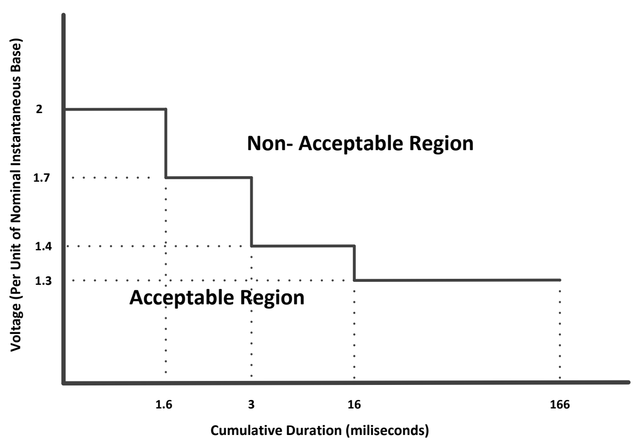


Figure 6. Transient overvoltage limits

Effective grounding and TOV requirements must be met during normal and island conditions (including ground fault over-voltage and load rejection over-voltage). This must be proven through EMT study.

Ground fault over-voltage with a fault impedance of 0 ohms and 20 ohms

Load rejection is loss of source through switching of protection devices. Refer to IEEE 1547.1-2020 for more information.

Inverter-based DER must also meet the TOV requirements outlined in this document: https://www.atco.com/content/dam/web/for-business/electricity/technical-interconnection-requirements-for-inverter-based-generation.pdf

## 6.5 Voltage Unbalance

Any three-phase DER must not exceed a phase-to-phase voltage unbalance of 1%, as measured with no load and with balanced three-phase loading. The voltage unbalance definition used in this standard is derived from NEMA MG1-1993 14.35:

Unbalance [%] = 100 x [(maximum deviation from average) / (average)].

# 7 Connection

ATCO Electricity will witness the commissioning of all DERs under the Distributed Generation category and will require compliance tests to be performed on site. ATCO reserves the right to employ the same, or similar commissioning requirement to other DERs (those not in the Distributed Generation category), if ATCO deems it necessary.