Ameren Illinois Company d/b/a Ameren Illinois
Smart Inverter Specifications
1st Revised Informational Sheet Supplemental to Rider CGR – Customer Generation Rebate
Canceling Original Informational Sheet Supplemental to Rider CGR
Sheet Nos. 59 – 59.005 of Electric Service Schedule Ill. C. C. No. 1
Effective January 5, 2023

## 1. SCOPE OF WORK

### 1.1 Purpose

This document is formulated to provide guidance to SMART inverter installers in Illinois. The document provides the minimum specification for inverters that interconnect with Ameren Illinois' (Company) electric service territory according to the Distributed Generation Rebate (Sec. 16-107.6).

## 2. SUMMARY

### 2.1 Safety

Ameren Illinois is committed to both the safety of the public and their employees and to the reliable operation of their distribution system.

### 2.2 Inverters

"SMART inverter" means a device that converts direct current into alternating current and meets the IEEE 1547-2018 equipment standards. Until devices that meet the IEEE 1547-2018 standard are available, devices that meet the UL 1741 SA standard are acceptable. SMART Inverters can autonomously contribute to grid support during excursions from normal operating voltage and frequency conditions by providing each of the following: dynamic reactive and real power support, voltage and frequency ride-through, ramp rate controls, communication systems with ability to accept external commands, and other functions from the electric utility. (**Sec. 16-107.6)**

SMART inverters are distinguished from regular inverters in three ways:

(1) They can modify their real power (Watt) and reactive power (VAR) output to provide grid support;

(2) They can respond autonomously to voltage/frequency changes, and

(3) They can respond to communication signals.

### 2.3 General Capabilities Requirements

SMART inverter installations connected to the Company's system shall meet the minimum specifications listed in Table 1. The SMART inverter must meet at leas one standard in each row of this table. **After the earlier of March 31, 2023 or when IEEE 1547-2018 certified inverters are commercially available, inverters that are not certified under IEEE 1547-2018 will be ineligible to receive a SMART inverter rebate for all new interconnections.**

*Table 1: Summary of Inverter Standards/Guidelines*

| Standard / Reference | Description |
|---|---|
| **IEEE 1547-2003, IEEE 1547a, IEEE 1547-2018** | SMART Inverters connected to the Company's system shall be compliant with at least one of the listed IEEE 1547 standards. See Appendix A for additional information on these standards. SMART Inverters certified to IEEE 1547-2018 must be capable of operating at Category B Normal Operating Performance requirements and Category III Abnormal Operating Performance requirements (as defined by the source document). |
| **UL 1741 SA, UL 1741 SB** | SMART Inverters connected to the Company's system shall be compliant with UL 1741 and should be certified as having passed testing as defined in either Supplement A (SA) or Supplement B (SB) of this standard. |
| **California Rule 21** | SMART Inverters connected to the Company's system shall be compliant with California Rule 21 Phase 1 functions (Section Hh. of the Rule 21) |

Additional details of these standards/guidelines are provided in Appendix A

**2.4 Interconnection Applications**
Customers or certified installers will still need to apply for interconnection. Ameren Illinois' Interconnection application forms can be found at Distributed Generation.

**2.5 Ownership & Control**
The Customer shall be financially responsible for the smart inverter. The Company shall have the ability to operate and control the SMART inverter directly or through aggregators in accordance with the most current governing interconnection rules. Moreover, the Company will either own the communication device and be responsible for communication costs incurred during operation, or approve an appropriately secure third party owned communication device to communicate with Ameren's system.

**2.6 Aggregate Device Control**
If a customer owns multiple inverters on site, the Company will need access to each SMART inverter or appropriate aggregating controllers in accordance to the most current governing interconnection rules.

**2.7 Location of SMART inverter**
The SMART inverter utility interface connection shall be placed at a location that is safely accessible by the Company and capable of maintaining reliable communication. Additional costs for connecting from the Company's communication device to a reliable antennae site location will be paid by the customer.

**2.8 List of Approved SMART inverters**

For an inventory of approved SMART inverters, please refer to the California Energy Commission's list of **Grid Support Inverters** found here on the California Energy Commission's web site. This interactive list contains an extensive collection of SMART inverters and Illinois' customers are encouraged and advised to double check each SMART Inverter with the minimum requirements set forth in this document. Note that inverters not found in this list may still be eligible for the SMART inverter rebate provided they meet the requirements defined in Section 2.3 above and, upon review, are approved by Ameren Illinois.

## 3. COMMUNICATION REQUIREMENT

All SMART inverters must meet the communication requirements outlined below. Table 2 presents the Company's acceptable communication and transport protocols, as well as the required interface layer. SMART inverter must be capable of providing one of the protocols, transport, and physical interface in Table 2. [NOTE: All SMART inverters connected to the Company system MUST be capable of communications, additionally, any firmware or software updates shall be updateable via communications remotely].

*Table 2: Minimum Requirement for communication and interface*

| Protocol | Transport | Physical Interface/Layer |
|---|---|---|
| IEEE 1815 (DNP3) | TCP/IP | Ethernet |
| SunSpec Modbus | TCP/IP | Ethernet |
| Sunspec Modbus | N/A | RS-485 |
| IEEE 2030.5 (Sep 2.0) | TCP/IP | Ethernet |

The Company will install, at an appropriate time, a communication module/device to communicate with the SMART inverter. The Company shall own the communication module, and shall be responsible for the communication module/device installation and operating costs. As noted above, the customer is responsible for any costs required to connect the communication device to a reliable antenna site. [NOTE: The Company may choose not to install the communication device at the time of SMART Inverter inspection / commissioning and will make appropriate arrangements to install the device at a later date].

## 4. OPERATING MODES AND CONTROL SETTINGS

Default Operating Modes and Control Settings are presented in Section 4. The Company shall reserve the right to change or modify device settings at the mutual agreement of the generation owner and the utility. After the cutoff date for requiring IEEE 1547-2018 certified inverters is reached (referenced in section 2.3), the Company may submit a revised informational sheet to the Commission for approval to include default settings similar to the requirements laid out for pre-IEEE 1547-2018 certified inverters in section 4.1.

The reference point of applicability (RPA) for a given DER installation shall be determined by the Company during the interconnection review process.

The following tables in section 4.1 define operating criteria for inverters that are certified to IEEE 1547 prior to the 2018 revision (UL1741 SA certification still required):

### 4.1 Operating Modes and Control Settings (prior to IEEE 1547-2018 certification)

Modes of operations are presented in Table 3.

*Table 3: Modes of Operations*

| Mode of Operation | Required/Optional | Description | Default Activation Status |
|---|---|---|---|
| Anti-Islanding | Required | Refers to the ability of a DER to detect loss of utility source and cease to energize | Activated |
| Adjustable constant power factor (SPF) | Required | Power Factor set to a fixed value. Some manufactures refer to this as 'Specified Power Factor (SPF)' | Deactivated |
| Voltage – Reactive (Volt/Var) | Required | Refers to active control of reactive power output as a function of voltage | Activated |
| Ramp Rates | Required | Refers to ability to have an adjustable entry service ramp rate when a DER restores output of active power or changes output levels over the normal course of operation. | Activated |
| Voltage Ride through (L/HVRT) | Required | Refers to ability of SMART Inverter to ride through a certain range of voltages before tripping off | Activated |

| | | | |
|---|---|---|---|
| Frequency Ride through (L/HFRT) | Required | Refers to ability of SMART Inverter to ride through a certain range of frequencies before tripping off | Activated |
| Voltage – Active Power (Volt/Watt) | Required as available | Refers to active control of real power output as a function of voltage | If capable, deactivated |
| Adjustable Constant Reactive Power | Required as available | Reactive Power set to a fixed value | If capable, deactivated |
| Frequency - Watt | Required as available | Refers to control of real power as a function of frequency | If capable, deactivated |

Control settings are presented in Tables 4-7.

*Table 4: Response to Islanding faults and open phase conditions*

| Condition | Trip Time (s) |
|---|---|
| Open Phase/Faults | 2 |

*Table 5: Low/High Voltage Ride Through (L/HVRT) minimum requirement – ACTIVATED*

| Region | Voltage range (% of nominal voltage) | Operating Mode/Response | Min. ride-through time (s) | Max. Trip Time (s) |
|---|---|---|---|---|
| *HIGH VOLTAGE 2 (HV2)* | V ≥ 120 | Cease to Energize | N/A | 0.16 |
| *HIGH VOLTAGE 1 (HV1)* | 110 < V < 120 | Momentary Cessation | 12 | 13 |
| *NEAR NOMINAL VOLTAGE (NN)* | 88 ≤ V ≤ 110 | Continuous Operation | Infinite | N/A |
| *LOW VOLTAGE 1 (LV1)* | 70 ≤ V < 88 | Mandatory Operation | 20 | 21 |
| *LOW VOLTAGE 2 (LV2)* | 50 ≤ V < 70 | Mandatory Operation | 10 | 11 |
| *LOW VOLTAGE 3 (LV3)* | V < 50 | Momentary Cessation | 1 | 1.5 |

*Table 6: Low/High Frequency Ride Through (L/HFRT) minimum requirement – ACTIVATED*

| Region | System Frequency Default Settings | Minimum Range of Adjustability | Ride-Through Until | Ride-Through Operational Mode | Maximum Trip Time |
|---|---|---|---|---|---|
| HIGH FREQ 2 (HF2) | f > 62 | 62.0 – 64.0 Hz | No Ride-Through | NA | 0.16s |
| HIGH FREQ 1 (HF1) | 60.5 < f ≤ 62 | 60.1 – 62.0 Hz | 299 | Man. Operation | 300s |
| NEAR NOMINAL (NN) | 58.5 ≤ f ≤ 60.5 | NA | Indefinite | Con. Operation | NA |
| LOW FREQ 1 (LF1) | 57.0 ≤ f ≤ 58.5 | 57.0 – 59.9 Hz | 299 | Man. Operation | 300s |
| LOW FREQ 2 (LF2) | f < 57.0 | 53.0 – 57.0 Hz | No Ride-Through | NA | 0.16s |

*Table 7: Volt-VAR Settings for DER – ACTIVATED*

| Volt-VAR parameters | Definitions | Default Values (% of Nominal Voltage |
|---|---|---|
| V2 | Dead band lower voltage limit | 96.7% |
| Q2 | Reactive power injection or absorption at voltage V2 | 0 |
| V3 | Dead band upper voltage limit | 103.3% |
| Q3 | Reactive power injection or absorption at voltage V3 | 0 |
| V1 | Voltage at which DER shall inject Q1 reactive power | 92.0% |
| Q1 | Reactive power injection at voltage V1 | 30% |
| V4 | Voltage at which DER shall absorb Q4 reactive power | 107.0% |
| Q4 | Reactive power absorption at voltage V4 | 30% |
| Open loop response time | Time to 90% of the reactive power change in response to the change in voltage | 5 seconds |

Note: The SMART inverter shall operate with a reactive power priority, and shall be capable of producing or absorbing reactive power to the ranges specified in Table 7 irrespective of active power production.

**4.2 Operating Modes and Control Settings (for IEEE 1547-2018 certified inverters)**

The following define requirements for smart inverters certified to IEEE 1547-2018:

All new smart inverters interconnected to the Ameren Illinois distribution system must be capable of Category B Normal Operating Performance criteria and Category III Abnormal Operating Performance criteria as defined in IEEE 1547-2018. The default settings on new smart inverter installations should match those defined by Category B Default Settings in IEEE 1547-2018. If default settings are not outlined, then the settings outlined in section 4.1 shall be used, provided that the Company reserves the right to change or modify device settings at the mutual agreement of the generation owner and the utility.

There may be a need to revisit this standard once more information is available regarding the typical capabilities of IEEE 1547-2018 certified inverters.

**4.3 Ramp Rate Settings (applicable to all smart inverters):**

- Normal ramp-up rate: For transitions between energy output levels over the normal course of operation. The default value is 100% of maximum current output per second with a range of adjustment between 1% to 100%.

- Connect/Reconnect Ramp-up rate: Upon starting power into the grid, following a period of inactivity or a disconnection, the inverter shall wait for 300 seconds before beginning current injection. For Inverters that utilize a linear current ramp function, the current shall ramp no faster than 2% of maximum allowed output current per second. For inverters that utilize a step-based ramp function, the overall time required to reach maximum allowed output must be greater than or equal to 50 seconds.

## Appendix A – Summary of Inverter Standards / Guidelines

1. **UL 1741**
   UL 1741 is a standard maintained by Underwriters Laboratories to establish safe construction practices for inverter-based systems as well as test procedures to verify that the inverter meets the specifications defined in the IEEE 1547 standard. Supplement A (SA) was added to this standard in 2016 to define tests to validate advanced inverter functions related to grid stability support in conformance with the IEEE standard 1547.1. In September 2021, UL released Supplement B (SB) which is intended to build on the tests introduced in SA by adding new tests for additional inverter functionality defined in the IEEE standard 1547-2018 and IEEE 1547.1-2020.

2. **IEEE 1547 & 1547.1**
   IEEE 1547 is a standard for interconnecting DER with electric power systems. This standard was originally approved in 2003 and has since seen multiple revisions. The latest version is IEEE 1547-2018, which builds on previous versions of the 1547 standard, with significant focus on specifications related to inverter functions intended to support grid stability and allow integration with standard control and monitoring systems. New inverter control functions are defined which allow the unit to actively adjust its output voltage, as well as real and reactive power output in response to measured grid conditions. In addition, the standard defines control functions to enhance the ability of the inverter to ride through abnormal grid conditions such as low/high voltage and low/high frequency. The standard also addresses interoperability by defining communications protocols and data / control points that must be supported by the inverter.

   IEEE 1547.1 is the standard that lists the conformance test procedure for equipment interconnecting DER with electric power systems. The standard was approved in 2005. In 2015 an amendment known as IEEE 1547.1a was approved. A full revision process began in 2016, and the final IEEE 1547.1-2020 standard containing conformance test procedures for smart inverters was approved in March 2020. This version aligns with the specifications in IEEE 1547-2018 and UL 1741-SB.

3. **California Rule 21 – Phase 1 Functions**
   The following functions are California Rule 21 Phase 1 requirements:
   - Anti-Islanding
   - Low/High Voltage Ride-Through
   - Low/High Frequency Ride-Through
   - Dynamic Volt/Var operations
   - Ramp rates
   - Fixed power factor
   - Reconnect by “soft-start” methods
   - Frequency-Watt (Optional)
   - Volt/Watt (Optional)