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SunSpec UL1741 Supplement SA/ Rule 21 Implementation Guide

SunSpec Alliance Application Note

Abstract

The SunSpec UL1741 Supplement SA Implementation Guide outlines the SunSpec information models used to implement UL1741 Supplement SA/Rule 21 compliant functionality. UL1741 Supplement SA validates compliance with grid interactive features which are not yet covered in IEEE 1547 2003.

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San Jose, CA 95117

Prepared by the SunSpec Alliance

4030 Moorpark Avenue, Suite 109

Website: www.sunspec.org

Email: info@sunspec.org

Revision History

Revision	Date	Reason
0.1	09-15-2015	Initial version
0.2	03-19-2017	Revised based on updated UL 1741 SA and updated ride-through curve specification.
0.3	05-08-2017	Updated Volt-Watt and Freq-Watt support description, issues, and proposed information models.

About the SunSpec Alliance

The SunSpec Alliance is a trade alliance of developers, manufacturers, operators and service providers, together pursuing open information standards for the distributed energy industry. SunSpec standards address most operational aspects of PV, storage and other distributed energy power plants on the smart grid—including residential, commercial, and utility-scale systems—thus reducing cost, promoting innovation, and accelerating industry growth.

Over 70 organizations are members of the SunSpec Alliance, including global leaders from Asia, Europe, and North America. Membership is open to corporations, non-profits, and individuals. For more information about the SunSpec Alliance, or to download SunSpec specifications at no charge, please visit www.sunspec.org.

About the SunSpec Specification Process

SunSpec Alliance specifications are initiated by SunSpec members desiring to establish an industry standard for mutual benefit. Any SunSpec member can propose a technical work item. Given sufficient interest and time to participate, and barring any significant objections, a workgroup is formed and its charter is approved by the board of directors. The workgroup meets regularly to advance the agenda of the team.

The output of the workgroup is generally in the form of an Interoperability Specification. These documents are considered to be normative, meaning that there is a matter of conformance required to support interoperability. The revision and associated process of managing these documents is tightly controlled. Other documents are informative, or make some recommendation with regard to best practices, but are not a matter of conformance. Informative documents can be revised more freely and frequently to improve the quality and quantity of information provided.

SunSpec Interoperability Specifications follow this lifecycle pattern of DRAFT, TEST, APPROVED and SUPERSEDED.

For more information or to download a SunSpec Alliance specification, go to http://www.sunspec.org/specifications.

Table of Contents

Nomenclature

Abbreviation	Meaning

Introduction

This document outlines the SunSpec information models used to create a UL1741 Supplement SA/Rule 21 compliant implementation.

This document uses the SunSpec Inverter Models Specification to provide the general operational description of each information model referenced. Examples are provided in this document that address the specific characteristics and values associated with UL1741 SA. When grid code specific values are required in an example, CPUC Rule 21 values are used.

This document is intended as a companion document to UL1741 Supplement SA and does not duplicate information presented there. This document is organized to align with the appendices of the UL1741 SA document.

Several new SunSpec information models (139-145) are being proposed to address additional requirements in UL1741 SA and CPUC Rule 21. This document references them in their current proposed state.

SunSpec Model Control Enable

The enable indication for any control functionality that has an associated enable point must be rewritten after any value change to the control even if the control is already enabled. The new control values should not take effect until the enable indication is written. This behavior provides synchronization of the new control parameters if more than value associated with the control is changed. Writing an enable indication always updates to the last written values.

If updated control values are written, the last values written should be returned on a subsequent read. This behavior can cause the current active values to be hidden if values for a control are updated while it is active.

SA8 Anti-islanding Protection

SunSpec information models are not applicable to anti-islanding support so there are no specific SunSpec implementation requirements for anti-islanding protection.

SA9 L/HVRT - Low and High Voltage Ride-Through

The High and Low Voltage Ride-Through functionality is implemented by supporting the following regions: High Voltage 2 (HV2), High Voltage 1 (HV1), Near Nominal (NN), Low Voltage 1 (LV1), Low Voltage 2 (LV2), and Low Voltage 3 (LV3).

The CPUC Rule 21 values associated with these regions are shown in the following table:

Region	Voltage (% Nominal Voltage)	Ride-Through Until	Operating Mode	Maximum Trip Time (s)
High Voltage 2 (HV2)	V ≥ 120			0.16 s

High Voltage 1 (HV1)	110 < V < 120	12 s	Momentary Cessation	13 s
Near Nominal (NN)	88 ≤ V ≤ 110	Indefinite	Continuous Operation	Not Applicable
Low Voltage 1 (LV1)	70 ≤ V < 88	20 s	Mandatory Operation	21 s
Low Voltage 2 (LV2)	50 ≤ V < 70	10 s	Mandatory Operation	11 s
Low Voltage 3 (LV3)	V < 50	1 s	Momentary Cessation	1.5 s

Curve Representation

Trip and momentary cessation curves are represented as piece-wise linear curves that define the regions associated with voltage and frequency trip and momentary cessation behavior. It is desirable to use a mechanism to represent the curves that is flexible and handles as many use cases as possible.

The threshold requirements can be represented by supplying a method to designate the following regions: *trip*, and *momentary cessation*. Each region is defined with a piece-wise linear curve demarcating the boundary, e.g., when crossing the *trip* curve, the DER is in the *trip* region.

The difference between *trip* and *momentary cessation* is the process of resuming operation once that region has been entered. The exact resumption process may vary based on grid code and additional parameters but the general distinction is that resumption from *momentary cessation* may be done fully and immediately on leaving the region while resumption from *trip* may require additional considerations such as a delay and ramping operation. Due to the limits in some DER, galvanic isolation may or may not be provided on a trip.

Trip

When this region is entered, the DER shall trip.

Momentary Cessation

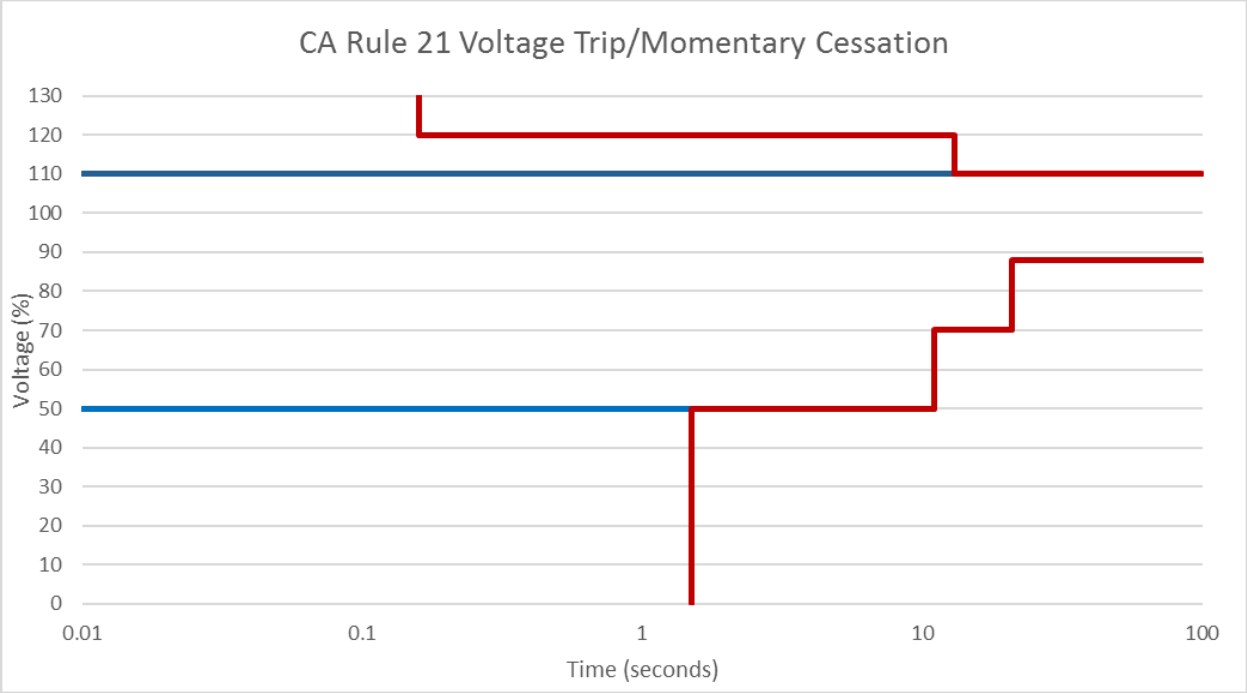
When this region is entered, the DER shall cease to energize but shall not trip.

Curve Hierarchy

The curves have a defined hierarchy, i.e.,

1. Trip
2. Momentary Cessation

such that when crossing a curve of higher precedence (*trip* is the highest), the DER must assume the behavior of the higher precedence.



Curve	Points
LV Trip (model 129)	(1.5, 0), (1.5, 50), (11, 50), (11, 70), (21, 70), (21, 88), (22, 88)
LV Momentary Cessation (model 139)	(0, 50), (1.5, 50)
HV Trip (model 130)	(.16, 130), (.16, 120), (13, 120), (13, 110), (14, 110)
HV Momentary Cessation (model 140)	(0, 110), (14, 110)

Each information model allows the specification of time and voltage pairs that are used specify the boundary between the respective regions.

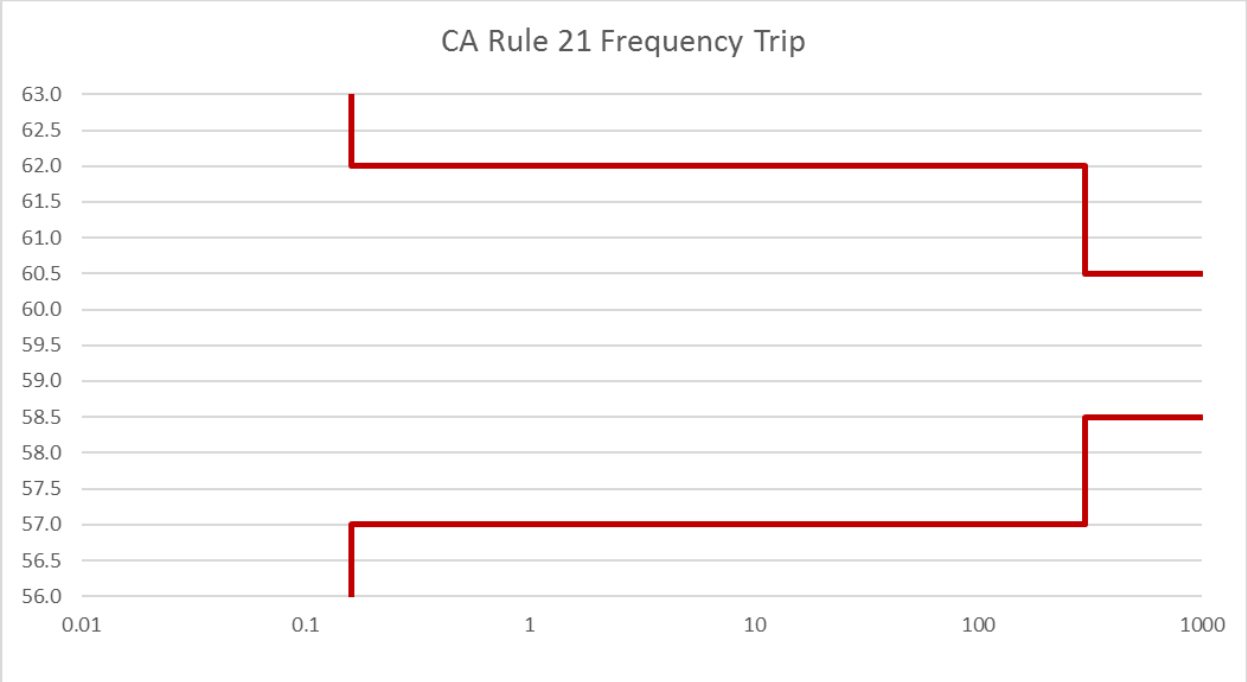
SA10 L/HFRT - Low and High Frequency Ride-Through

The High and Low Frequency Ride-Through functionality is implemented by supporting the following regions: High Frequency 2 (HF2), High Frequency 1 (HF1), Near Nominal (NN), Low Frequency 1 (LF1), and Low Frequency 2 (LF2).

The CPUC Rule 21 values associated with these regions are shown in the following table:

Region	System Frequency Default Settings	Minimum Range of Adjustability (Hz)	Ride-Through Until (s)	Ride-Through Operational Mode	Trip Time (s)
High Frequency 2 (HF2)	f > 62	62.0 – 64.0	No Ride-Through	Not Applicable	0.16
High Frequency 1 (HF1)	60.5 < f ≤ 62	60.1 – 62.0	299	Mandatory Operation	300
Near Nominal (NN)	58.5 < f ≤ 60.5	Not Applicable	Indefinite	Continuous Operation	Not Applicable
Low Frequency 1 (LF1)	57.0 < f ≤ 58.5	57.0 – 59.9	299	Mandatory Operation	300
Low Frequency 2 (LF2)	f ≤ 57.0	53.0 – 57.0	No Ride-Through	Not Applicable	0.16

These regions are supported in SunSpec with the LFRT and three HFRT information models.



Curve	Points
LF Trip (model 135)	(0.16, 0), (0.16, 57), (300, 57), (300, 58.5), (400, 58.5)
HF Trip (model 136)	(0.16, 63), (0.16, 62), (300, 62), (300, 60.5), (400, 60.5)

SA11 RR - Normal Ramp Rate and SS - Soft-Start Ramp Rate

SunSpec supports the following global ramp rates:

Point	Model	Description
WGra	121	Default ramp rate specified as a percentage of max power.
AGra	145	Default ramp rate specified as a percentage of max current.
NomRmpUpRte	145	Ramp up rate specified as a percentage of max current.
NomRmpDnRte	145	Ramp down rate specified as a percentage of max current.
EmgRmpUpRte	145	Emergency ramp up rate specified as a percentage of max current.
EmgRmpDnRte	145	Emergency ramp down rate specified as a percentage of max current.
ConnRmpUpRte	145	Connect ramp up rate specified as a percentage of max current.
ConnRmpDnRte	145	Connect ramp down rate specified as a percentage of max current.

In general, an implementation would use either WGra or AGra to specify the base default ramp rate. Additional ramp rate can be specified to address specific conditions.

If different ramp rates are required for ramping up and down during normal operation, NomRmpUpRte and NomRmpDnRte can be used. These ramp rates should be used to implement the normal ramp rate function specified as normal ramp rates in UL1741 SA. If these ramp rates are not provided, WGra or AGra can be used for both ramp rates.

If different ramp rates are required for ramping up and down during a connect operation, ConnRmpUpRte and ConnRmpDnRte can be used. These ramp rates should be used to implement the soft-start ramp rate function specified in UL1741 SA. If these ramp rates are not provided, NomRmpUpRte and NomRmpDnRte can be used if provided. WGra or AGra can be used for both ramp rates if no other ramp rates are provided.

SA12 SPF - Power Factor

SunSpec supports a fixed power factor setting using the related points in model 123. The following points relate to the fixed power factor setting:

Point	Description
OutPFSet	Set power factor to specific value – cosine of angle.
OutPFSet_WinTms	Time window for power factor change.
OutPFSet_RvrtTms	Timeout period for power factor.
OutPFSet_RmpTms	Ramp time for moving from current setpoint to new setpoint.

OutPFSet_Ena	Fixed power factor enable/disable.

SA13 Volt/Var Mode

SunSpec supports Volt/Var curves using model 126. The curves specified in UL1741 SA can be fully supported using this SunSpec information model.

SA14 Frequency-Watt - Optional

SunSpec supports two information models for frequency-watt control: Parameterized frequency-watt (127), and curve-based frequency-watt (134).

FW21 as specified in IEC 61850-90-7 is based on the parameterized form of frequency-watt control and would utilize the functionality provided in SunSpec model 127.

It is not clear that the UL1741 SA specification of the Frequency-Watt function will be adopted as it has some differences from the proposed updated IEEE 1547 specification. It is anticipated that the IEEE 1547 specification will ultimately be adopted for this function.

The Frequency-Watt (Frequency-Droop) functionality contained in the current draft of IEEE P1547 (D6.7) that is referenced in CA Rule 21 Phase 3 support and specified in the Hawaiian Electric Companies UL1741 SA Source Requirements Document (SRD) is not fully supported by model 127 or 134.

The issues are:

1. Since the behavior of the function is based on a snapshot of active power at the time of the frequency disturbance, the fixed curve model 127 is not well suited so only 134 can be considered.

2. Model 127 only supports over-frequency settings and does not support under-frequency settings.

3. Model 127 does not contain an open loop response time setting that is specified in P1547.

Due to these issues, a new information model (146) is proposed that supports the P1547 Frequency-Droop specification more directly. The adjustable settings are provided in this information model and the functional behavior should be as described in P1547.

The following open questions exist for model 146:

- Should the new model be aligned with the terminology in IEEE 1547 as it is currently constructed or use the terminology in the existing model 127?

SA15 Volt-Watt - Optional

SunSpec supports Volt-Watt curves using model 132. The Volt-Watt functionality specified in UL1741 SA contains parameters in addition to the curve points. It is not clear that the UL1741 SA specification of the Volt-Watt function will be adopted as it has some differences from the proposed updated IEEE 1547 specification. It is anticipated that the IEEE 1547 specification will ultimately be adopted for this function.

The Volt-Watt functionality contained in the current draft of IEEE P1547 (D6.7) that is referenced in CA Rule 21 Phase 3 support and specified in the Hawaiian Electric Companies UL1741 SA Source Requirements Document (SRD) is not fully supported by model 132.

The issues are:

1. The P1547 specification specifies that the volt-watt curve be defined by two sets of points where the first power point value is determined at the time of the voltage disturbance. Model 132 does not currently support this functionality.

2. The P1547 specification specifies support for an open loop response time with a sub-second range. Model 132 does not support open loop support time or sub-second times.

Due to these issues, a new information model (147) is proposed that supports the P1547 Volt-Watt functionality. The new model is an extension of model 132 with additional functionality to support the P1547 functionality.

An additional dependent reference (DeptRef) enumeration is added. The new enumeration (3=%WPreV) indicates that point W1 is determined at voltage disturbance time and V1, W2, V2 would be used as described in the P1547 standard. In this model, voltage and power points are specified in percentage rather than per unit (p.u.). Percentage is obtained by multiplying per unit values by 100.

An open loop response time is added (TResp) with a scale factor (TResp_SF) to allow support for sub-second times.

The following open questions exist for model 147:

- Should the new model be similar to 132 with the addition of the %WPreV enumeration and open loop response time with scale factor be created? In this case, the current points are expressed in percent rather than per unit as in the specification. Is that an issue? Should any of the existing points be changed to use the time scale factor to support sub-second times?

- Or should a new model with just support for the P1547 functionality be created? In this case should the points be expressed as p.u. or percent?