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SunSpec Modbus IEEE 1547-2018 Profile Specification and Implementation Guide

SunSpec Profile Specification



Abstract

This document describes considerations for SunSpec Modbus IEEE 1547-2018 Profile implementations.

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Prepared by the SunSpec Alliance

Website: sunspec.org

Email: info@sunspec.org

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1 Overview

This document specifies the requirements for implementing the SunSpec Modbus IEEE 1547-2018 Profile along with additional information and guidance.

The information is organized into two main sections.

The SunSpec Modbus IEEE 1547-2018 Profile section describes the 1547-2018 to SunSpec Modbus mapping along with additional context and usage information. This section is informative and is intended to expand as additional explanation is needed on areas that require clarification.

The SunSpec Modbus IEEE 1547-2018 Profile Requirements section specifies the SunSpec Modbus points that are required for a fully conformant implementation. This section is normative and is only changed to correct errors or omissions.

The requirements specified in the *SunSpec Device Information Model Reference* and the *SunSpec DER Information Model Reference* are also requirements in this profile. This document may restate some of the requirements specified in those documents for convenience, but all requirements specified in those documents are still in effect for this profile unless explicitly stated otherwise. This document is intended to augment those specifications and should not be considered a replacement.

2 SunSpec Modbus IEEE 1547-2018 Profile

This section describes the SunSpec Modbus information model content that is used to support the SunSpec Modbus IEEE 1547-2018 Profile. Additional implementation and usage information is also provided for clarification.

2.1 SunSpec Modbus Information Models

The SunSpec Modbus IEEE 1547-2018 Profile is implemented using SunSpec Information Models 701-713. The following table provides a high-level mapping of IEEE 1547-2018 functionality to the relevant SunSpec Modbus Information Model.

| IEEE Std 1547-2018 Interoperability Functionality | SunSpec Modbus Information Model |
|---|---|
| Nameplate Information | DERCapacity (702), DERStorageCapacity (713) |
| Configuration Information | DERCapacity (702) |
| Monitoring Information | DERMeasurementAC (701) |
| Constant Power Factor | DERCtlAC (704) |
| Voltage-Reactive Power | DERVoltVar (705) |
| Active Power-Reactive Power | DERWattVar (712) |
| Constant Reactive Power | DERCtlAC (704) |
| Voltage-Active Power | DERVoltWatt (706) |
| Voltage Trip | DERTripLV (707), DERTripHV (708) |
| Momentary Cessation (optional) | DERTripLV (707), DERTripHV (708) |
| Frequency Trip | DERTripLF (709), DERTripHF (710) |
| Frequency Droop | DERFreqDroop (711) |
| Enter Service | DEREnterService (703) |
| Cease to Energize and Trip | DEREnterService (703) |
| Limit Maximum Active Power | DERCtlAC (704) |

Table 1 - IEEE 1547-2018 SunSpec Modbus Models

2.2 Nameplate Information

This section describes the nameplate information content as specified in IEEE 1547-2018.

The table below contains the IEEE 1547-2018 required nameplate information, the associated IEEE 1547.1-2020 results reporting label, and the SunSpec Modbus point mapping.

| IEEE Std 1547-2018 | IEEE Std 1547.1-2020 RR | SunSpec Modbus |
|---|------------------------------|---------------------|
| Active power rating at specified over-excited power factor | NP_P_MAX | 702.WMaxRtg |
| Specified over-excited power factor | NP_P_MAX_OVER_PF | 702.WOvrExtRtg |
| Specified over-excited power factor | NP_OVER_PF | 702.WOvrExtRtgPF |
| Active power rating at specified under-excited power factor | NP_P_MAX_UNDER_PF | 702.WUndExtRtg |
| Specified under-excited power factor | NP_UNDER_PF | 702.WUndExtRtgPF |
| Apparent power maximum rating | NP_VA_MAX | 702.VAMaxRtg |
| Normal operating performance category | NP_NORMAL_OP_CAT | 702.NorOpCatRtg |
| Abnormal operating performance category | NP_ABNORMAL_OP_CAT | 702.AbnOpCatRtg |
| Reactive power injected maximum rating | NP_Q_MAX_INJ | 702.VarMaxInjRtg |
| Reactive power absorbed maximum rating | NP_Q_MAX_ABS | 702.VarMaxAbsRtg |
| Active power charge maximum rating | NP_P_MAX_CHARGE | 702.WChaRteMaxRtg |
| Apparent power charge maximum rating | NP_APPARENT_POWER_CHARGE_MAX | 702.VAChaRteMaxRtg |
| AC voltage nominal rating | NP_AC_V_NOM | 702.VNomRtg |
| AC voltage maximum rating | NP_AC_V_MAX | 702.VMaxRtg |
| AC voltage minimum rating | NP_AC_V_MIN | 702.VMinRtg |
| Supported control mode functions | NP_SUPPORTED_MODES | 702.CtrlModes |
| Reactive susceptance that remains connected to the area EPS in the cease-to-energize and trip state | NP_REACTIVE_SUSCEPTANCE | 702.ReactSusceptRtg |
| Manufacturer | NP_MANUFACTURER | 1.Mn |

| | | |
|---------------|---------------|------|
| Model | NP_MODEL | 1.Md |
| Serial number | NP_SERIAL_NUM | 1.SN |
| Version | NP_FW_VER | 1.Vr |

Table 2 - Nameplate Information to SunSpec Modbus Mapping

The table below contains the IEEE 1547-2018 optional nameplate information, the associated IEEE 1547.1 results reporting label, and the SunSpec Modbus point mapping.

| IEEE Std 1547-2018 | IEEE Std 1547.1-2020 RR | SunSpec Modbus |
|-----------------------------|---------------------------|---------------------|
| Intentional Island Category | NP_INTENTIONAL_ISLAND_CAT | 702.IntIslandCatRtg |

2.3 Configuration Information

This section describes the configuration information content as specified in IEEE 1547-2018. Configuration Information is optional in IEEE 1547-2018.

The table below contains the IEEE 1547-2018 optional configuration information, the associated IEEE 1547.1 results reporting label, and the SunSpec Modbus point mapping.

| IEEE Std 1547-2018 | IEEE Std 1547.1-2020 RR | SunSpec Modbus |
|---|------------------------------|------------------|
| Active power rating at specified over-excited power factor | NP_P_MAX-AS | 702.WMax |
| Specified over-excited power factor | NP_P_MAX_OVER_PF-AS | 702.WMaxOvrExt |
| Specified over-excited power factor | NP_OVER_PF-AS | 702.WOvrExtPF |
| Active power rating at specified under-excited power factor | NP_P_MAX_UNDER_PF-AS | 702.WMaxUndExt |
| Specified under-excited power factor | NP_UNDER_PF-AS | 702.WUndExtPF |
| Apparent power maximum rating | NP_VA_MAX-AS | 702.VAMax |
| Intentional Island Category | NP_INTENTIONAL_ISLAND_CAT-AS | 702.IntIslandCat |
| Reactive power injected maximum rating | NP_Q_MAX_INJ-AS | 702.VarMaxInj |
| Reactive power absorbed maximum rating | NP_Q_MAX_ABS-AS | 702.VarMaxAbs |

| | | |
|--------------------------------------|---------------------------------|-----------------|
| Active power charge maximum rating | NP_P_MAX_CHARGE-AS | 702.WChaRteMax |
| Apparent power charge maximum rating | NP_APPARENT_POWER_CHARGE_MAX-AS | 702.VAChaRteMax |
| AC voltage nominal rating | NP_AC_V_NOM-AS | 702.VNom |

Table 3 - Configuration Information to SunSpec Modbus Mapping

2.4 Monitoring Information

This section describes the monitoring information content as specified in IEEE 1547-2018.

The table below contains the IEEE 1547-2018 required monitoring information, the associated IEEE 1547.1 results reporting label, and the SunSpec Modbus point mapping.

The voltage points that are applicable must be implemented.

| IEEE Std 1547-2018 | IEEE Std 1547.1-2020 RR | SunSpec Modbus |
|-----------------------------|-------------------------|--|
| Active Power | N/A | 701.W |
| Reactive Power | N/A | 701.Var |
| Voltage | N/A | 701.LLV, 701.LNV, 701.VL1L2, 701.VL1, 701.VL2L3, 701.VL2, 701.VL3L1, 701.VL3 |
| Frequency | N/A | 701.Hz |
| Operational State | N/A | 701.St |
| Connection Status | N/A | 701.ConnSt |
| Alarm Status | N/A | 701.Alrm |
| Operational State of Charge | N/A | 713.SoC |

Table 4 - Monitoring Information to SunSpec Modbus Mapping

2.5 Constant Power Factor

This section describes the constant power factor content as specified in IEEE 1547-2018.

The table below contains the IEEE 1547-2018 required constant power factor adjustable settings, the associated IEEE 1547.1 results reporting label, and the SunSpec Modbus point mapping.

| IEEE Std 1547-2018 | IEEE Std 1547.1-2020 RR | SunSpec Modbus |
|-----------------------------------|-------------------------|----------------|
| Constant Power Factor Mode Enable | CONST_PF_MODE_ENABLE-AS | 704.PFWInjEna |
| Constant Power Factor | CONST_PF-AS | 704.PFWInj.PF |

| | | |
|----------------------------------|------------------------|----------------|
| Constant Power Factor Excitation | CONST_PF_EXCITATION-AS | 704.PFWInj.Ext |
|----------------------------------|------------------------|----------------|

Table 5 - Constant Power Factor to SunSpec Modbus Mapping

The CONST_PF-AS label is a proposed extension for the constant power factor applied setting as the current applied settings names do not support a single power factor setting without specifying the direction of reactive power flow.

2.6 Voltage-Reactive Power

This section describes the voltage-reactive power content as specified in IEEE 1547-2018.

The table below contains the IEEE 1547-2018 required voltage-reactive power adjustable settings, the associated IEEE 1547.1 results reporting label, and the SunSpec Modbus point mapping.

| IEEE Std 1547-2018 | IEEE Std 1547.1-2020 RR | SunSpec Modbus |
|------------------------------------|-------------------------|-------------------|
| Voltage-Reactive Power Mode Enable | QV_MODE_ENABLE-AS | 705.Ena |
| VRef | QV_VREF-AS | 705.VRef |
| Autonomous VRef Adjustment Enable | QV_VREF_AUTO_MODE-AS | 705.VRefAutoEna |
| VRef Adjustment Time Constant | QV_VREF_OLRT-AS | 705.VRefAutoTms |
| Open Loop Response Time | QV_OLRT-AS | 705.RspTms |
| Curve Point V1 | QV_CURVE_V1-AS | 705.Crv.Pt[1].V |
| Curve Point Q1 | QV_CURVE_Q1-AS | 705.Crv.Pt[1].Var |
| Curve Point V2 | QV_CURVE_V2-AS | 705.Crv.Pt[2].V |
| Curve Point Q2 | QV_CURVE_Q2-AS | 705.Crv.Pt[2].Var |
| Curve Point V3 | QV_CURVE_V3-AS | 705.Crv.Pt[3].V |
| Curve Point Q3 | QV_CURVE_Q3-AS | 705.Crv.Pt[3].Var |
| Curve Point V4 | QV_CURVE_V4-AS | 705.Crv.Pt[4].V |
| Curve Point Q4 | QV_CURVE_Q4-AS | 705.Crv.Pt[4].Var |

Table 6 - Voltage Reactive Power to SunSpec Modbus Mapping

2.7 Active Power-Reactive Power

This section describes the active power-reactive power content as specified in IEEE 1547-2018.

The active power-reactive power curve in IEEE 1547-2018 has six possible points as shown in the figure below.

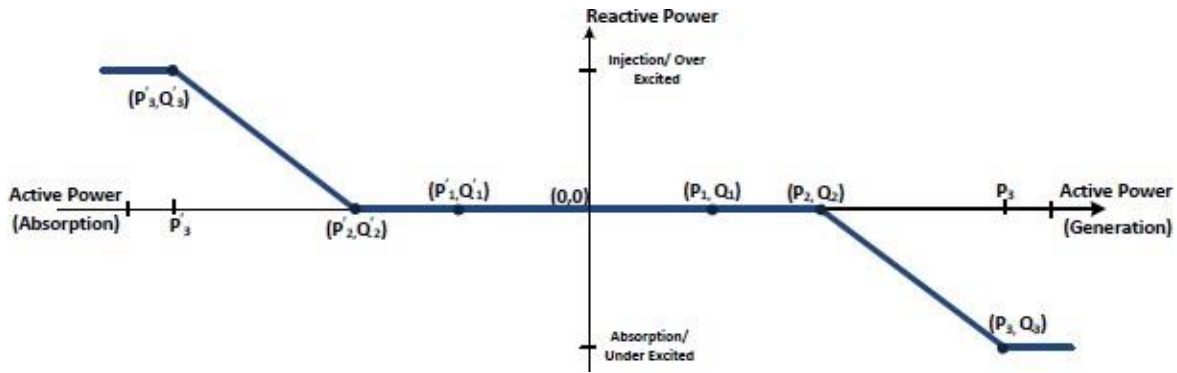


Figure 1 - IEEE Std 1547-2018 Active Power-Reactive Power Curve

The active power-reactive power function in IEEE 1547-2018 is implemented in SunSpec Modbus using the DERWattVar information model (712).

The IEEE 1547-2018 to SunSpec Modbus point mapping is specified in the table below. The SunSpec Modbus curve point indexes are 1-based in this table where index 1 is the first point in the curve.

| IEEE Std 1547-2018 | IEEE Std 1547.1-2020 RR | SunSpec Modbus |
|---|-------------------------|-------------------|
| Active Power-Reactive Power Mode Enable | QP_MODE_ENABLE-AS | 712.Ena |
| P3 | QP_CURVE_P3_GEN-AS | 712.Crv.Pt[6].W |
| P2 | QP_CURVE_P2_GEN-AS | 712.Crv.Pt[5].W |
| P1 | QP_CURVE_P1_GEN-AS | 712.Crv.Pt[4].W |
| P'1 | QP_CURVE_P1_LOAD-AS | 712.Crv.Pt[3].W |
| P'2 | QP_CURVE_P2_LOAD-AS | 712.Crv.Pt[2].W |
| P'3 | QP_CURVE_P3_LOAD-AS | 712.Crv.Pt[1].W |
| Q3 | QP_CURVE_Q3_GEN-AS | 712.Crv.Pt[6].Var |
| Q2 | QP_CURVE_Q2_GEN-AS | 712.Crv.Pt[5].Var |
| Q1 | QP_CURVE_Q1_GEN-AS | 712.Crv.Pt[4].Var |
| Q'1 | QP_CURVE_Q1_LOAD-AS | 712.Crv.Pt[3].Var |
| Q'2 | QP_CURVE_Q2_LOAD-AS | 712.Crv.Pt[2].Var |
| Q'3 | QP_CURVE_Q3_LOAD-AS | 712.Crv.Pt[1].Var |

Table 7 - Active Power-Reactive Power to SunSpec Modbus Mapping

Many systems may not support the first three points that are applicable when absorbing active power.

SunSpec Modbus IEEE 1547-2018 Profile implementations must support a curve containing six points. If the first three points of the curve are not used in the implementation, they should be ignored. If it is desired to set a curve that does not utilize the first three points, the curve point values can be set to 0.

2.8 Constant Reactive Power

This section describes the constant reactive power content as specified in IEEE 1547-2018.

The table below contains the IEEE 1547-2018 required constant power factor adjustable settings, the associated IEEE 1547.1 results reporting label, and the SunSpec Modbus point mapping.

| IEEE Std 1547-2018 | IEEE Std 1547.1-2020 RR | SunSpec Modbus |
|-------------------------------|-------------------------|----------------|
| Constant Reactive Mode Enable | CONST_Q_MODE_ENABLE-AS | 704.VarSetEna |
| Constant Reactive Power | CONST_Q-AS | 704.VarSetPct |

Table 8 - Constant Reactive Power to SunSpec Modbus Mapping

2.9 Voltage-Active Power

This section describes the voltage-active power content as specified in IEEE 1547-2018.

The table below contains the IEEE 1547-2018 required voltage-active power adjustable settings, the associated IEEE 1547.1 results reporting label, and the SunSpec Modbus point mapping.

| IEEE Std 1547-2018 | IEEE Std 1547.1-2020 RR | SunSpec Modbus |
|----------------------------------|-------------------------|-----------------|
| Voltage-Active Power Mode Enable | PV_MODE_ENABLE-AS | 706.Ena |
| Open Loop Response Time | PV_OLRT-AS | 706.RspTms |
| Curve Point V1 | QV_CURVE_V1-AS | 706.Crv.Pt[1].V |
| Curve Point P1 | QV_CURVE_P1-AS | 705.Crv.Pt[1].W |
| Curve Point V2 | QV_CURVE_V2-AS | 705.Crv.Pt[2].V |
| Curve Point P2 (gen) | QV_CURVE_P2_GEN-AS | 705.Crv.Pt[2].W |
| Curve Point P2 (load) | QV_CURVE_P2_LOAD-AS | 705.Crv.Pt[2].W |

Table 9 - Voltage-Active Power to SunSpec Modbus Mapping

2.10 Voltage Trip

This section describes the voltage trip content as specified in IEEE 1547-2018 and how to map from 1547-2018 voltage trip settings to SunSpec information models.

The SunSpec information in this section is based on the content in the *SunSpec DER Information Model Specification* section 3.3 Trip/Momentary Cessation Settings.

SunSpec uses curves to specify the voltage trip settings. The ranges in 1547-2018 are specified for categories I, II, and III. Category III is referenced in the examples, but the concepts are the same for each.

Table 13 in IEEE 1547-2018 specifies ranges and default for high and low voltage trip.

Table 13—DER response (shall trip) to abnormal voltages for DER of abnormal operating performance Category III (see Figure H.9)

| Shall trip function | Shall trip—Category III | | | |
|---------------------|-----------------------------------|-------------------|---|-------------------|
| | Default settings ^a | | Ranges of allowable settings ^b | |
| | Voltage (p.u. of nominal voltage) | Clearing time (s) | Voltage (p.u. of nominal voltage) | Clearing time (s) |
| OV2 | 1.20 | 0.16 | fixed at 1.20 | fixed at 0.16 |
| OV1 | 1.10 | 13.0 | 1.10–1.20 | 1.0–13.0 |
| UV1 | 0.88 | 21.0 | 0.0–0.88 | 21.0–50.0 |
| UV2 | 0.50 | 2.0 | 0.0–0.50 | 2.0–21.0 |

The following diagram maps the curve points used in the SunSpec information model to the adjustable settings in 1547-2018. Both high and low voltage trip settings map to five points in the respective SunSpec voltage trip curves in SunSpec models 707 and 708.

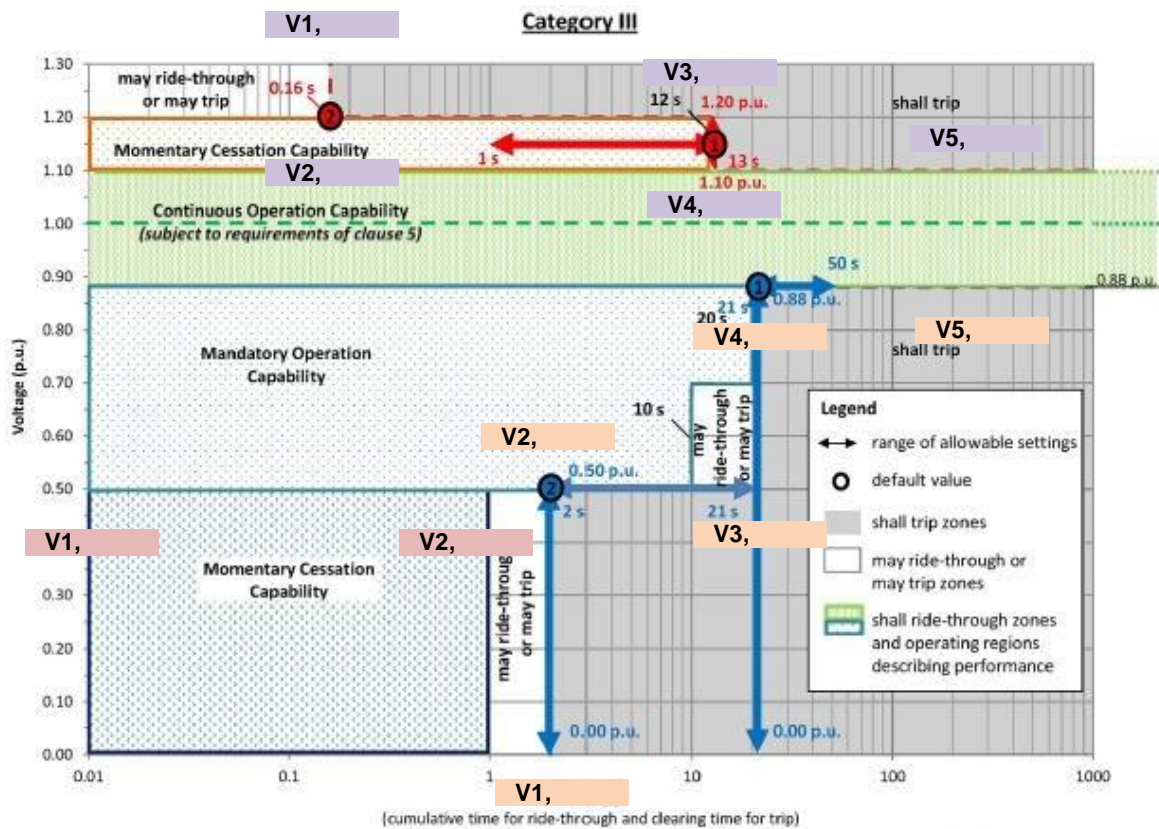


Figure H.9—DER response to abnormal voltages and voltage ride-through requirements for DER of abnormal operating performance Category III

Each segment in a curve is represented by two points. Even though the information in the curve may be able to be represented with less points in some circumstances, all the points are specified to provide a uniform method of representing all curves.

In the case of 1547-2018 trip curves, five points are used. The second and fourth points contain the voltage and time information needed. The other three points complete the uniform curve representation.

To create the over-voltage SunSpec curve form from the 1547-2018 trip settings the following steps can be performed:

V2 = OV2 voltage

Tms2 = OV2 clearing time

V4 = OV1 voltage

Tms4 = OV1 clearing time

V1 = any voltage > V2 to establish the segment slope

Tms1 = Tms2

V3 = V2

Tms3 = Tms4

V5 = V4

Tms5 = any time > Tms4 to establish the segment slope

To create the under-voltage SunSpec curve form from the 1547-2018 trip settings the following steps can be performed:

V2 = UV2 voltage

Tms2 = UV2 clearing time

V4 = UV1 voltage

Tms4 = UV1 clearing time

V1 = any voltage < V2 to establish the segment slope

Tms1 = Tms2

V3 = V2

Tms3 = Tms4

V5 = V4

Tms5 = any time > Tms4 to establish the segment slope

Based on the trip ranges in Table 13 the following V and Tms ranges are possible for low voltage:

| | | |
|--|---|-----|
| | V | Tms |
|--|---|-----|

| | | |
|---|--------|---------|
| 1 | < V2 | 2 - 21 |
| 2 | 0 - 50 | 2 - 21 |
| 3 | 0 - 50 | 21 - 50 |
| 4 | 0 - 88 | 21 - 50 |
| 5 | 0 - 88 | > Tms4 |

The default low voltage trip curve would be:

| | V | Tms |
|---|----|-----|
| 1 | 0 | 2 |
| 2 | 50 | 2 |
| 3 | 50 | 21 |
| 4 | 88 | 21 |
| 5 | 88 | 22 |

Based on the trip ranges in Table 13 the following V and Tms ranges are possible for high voltage:

| | V | Tms |
|---|-----------|--------|
| 1 | > V2 | .16 |
| 2 | 120 | .16 |
| 3 | 120 | 1 - 13 |
| 4 | 110 - 120 | 1 - 13 |
| 5 | 110 - 120 | > Tms4 |

The default high voltage trip curve would be:

| | V | Tms |
|---|-----|------|
| 1 | 121 | .16 |
| 2 | 120 | .16 |
| 3 | 120 | 13 |
| 4 | 110 | 13 |
| 5 | 110 | > 13 |

Momentary cessation is represented by a horizontal two-point curve that specifies the voltage threshold for the momentary cessation. The default curve points for low voltage are (V1=50, Tms1=0), (V2=50, Tms2=2). The default curve points for high voltage are (V1=110, Tms1=0), (V2=110, Tms2=13).

The table below contains the IEEE 1547-2018 required voltage trip adjustable settings, the associated IEEE 1547.1 results reporting label, and the SunSpec Modbus point mapping.

| IEEE Std 1547-2018 | IEEE Std 1547.1-2020 RR | SunSpec Modbus |
|--------------------|-------------------------|----------------------------|
| UV2 Voltage | UV2_TRIP_V-AS | 707.MustTrip.Crv.Pt[2].V |
| UV2 Clearing Time | UV2_TRIP_T-AS | 707.MustTrip.Crv.Pt[2].Tms |
| UV1 Voltage | UV1_TRIP_V-AS | 707.MustTrip.Crv.Pt[4].V |
| UV1 Clearing Time | UV1_TRIP_T-AS | 707.MustTrip.Crv.Pt[4].Tms |
| OV2 Voltage | OV2_TRIP_V-AS | 708.MustTrip.Crv.Pt[2].V |
| OV2 Clearing Time | OV2_TRIP_T-AS | 708.MustTrip.Crv.Pt[2].Tms |
| OV1 Voltage | OV1_TRIP_V-AS | 708.MustTrip.Crv.Pt[4].V |
| OV1 Clearing Time | OV1_TRIP_T-AS | 708.MustTrip.Crv.Pt[4].Tms |

Table 10 - Voltage Trip to SunSpec Modbus Mapping

2.11 Momentary Cessation

This section describes the momentary cessation content as specified in IEEE 1547-2018. Support for the adjustment of momentary cessation is optional in 1547-2018.

The table below contains the IEEE 1547-2018 optional voltage momentary cessation adjustable settings, the associated IEEE 1547.1 results reporting label, and the SunSpec Modbus point mapping.

| IEEE Std 1547-2018 | IEEE Std 1547.1-2020 RR | SunSpec Modbus |
|--------------------------------------|-------------------------|---------------------------|
| UV Momentary Cessation Voltage | Not specified | 707.MomCess.Crv.Pt[1].V |
| UV Momentary Cessation Clearing Time | Not specified | 707.MomCess.Crv.Pt[1].Tms |
| OV Momentary Cessation Voltage | Not specified | 708.MomCess.Crv.Pt[1].V |
| OV Momentary Cessation Time | Not specified | 708.MomCess.Crv.Pt[1].Tms |

Table 11 - Momentary Cessation to SunSpec Modbus Mapping

2.12 Frequency Trip

This section describes the frequency trip content as specified in IEEE 1547-2018.

SunSpec uses curves to specify the frequency trip settings. This information outlines how to map from 1547-2018 to the SunSpec information models (709, 710).

The SunSpec information in this section is based on the content in the *SunSpec DER Information Model Specification* section 3.3 Trip/Momentary Cessation Settings.

SunSpec uses curves to specify the voltage trip settings. The ranges in 1547-2018 are specified for categories I, II, and III. Category III is referenced in the examples, but the concepts are the same for each.

Table 18 in IEEE 1547-2018 specifies ranges and default for high and low frequency trip.

Table 18 —DER response (shall trip) to abnormal frequencies for DER of abnormal operating performance Category I, Category II, and Category III (see Figure H.10)

| Shall trip function | Default settings ^a | | Ranges of allowable settings ^b | |
|---------------------|-------------------------------|--------------------|---|-------------------|
| | Frequency ^c (Hz) | Clearing time (s) | Frequency (Hz) | Clearing time (s) |
| OF2 | 62.0 | 0.16 | 61.8–66.0 | 0.16–1 000.0 |
| OF1 | 61.2 | 300.0 | 61.0–66.0 | 180.0–1 000.0 |
| UF1 | 58.5 | 300.0 ^c | 50.0–59.0 | 180.0–1 000 |
| UF2 | 56.5 | 0.16 | 50.0–57.0 | 0.16–1 000 |

The following diagram maps the curve point used in the SunSpec information model to the adjustable settings in 1547-2018. Both high and low frequency trip settings map to five points in the respective SunSpec frequency trip curves in SunSpec models 709 and 710.

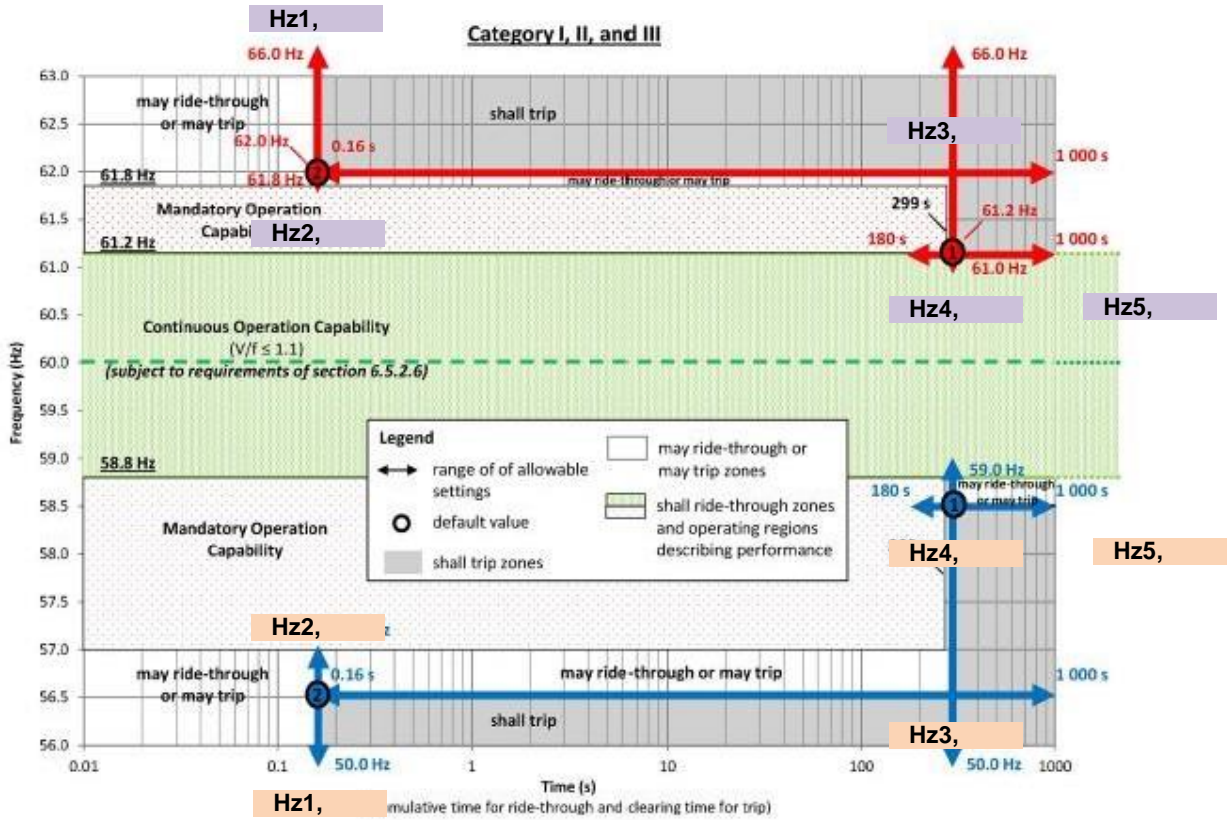


Figure H.10—DER default response to abnormal frequencies and frequency ride-through requirements for DER of abnormal operating performance Category I, Category II, and Category III

The same curve construction process is applied to the frequency curves as the voltage curves. See the Voltage Trip section above to get more details on 1547-2018 settings to SunSpec Modbus curve mapping.

Based on the trip ranges in Table 18 the following Hz and Tms ranges are possible for low frequency:

| | Hz | Tms |
|---|---------|------------|
| 1 | < Hz2 | .16 - 1000 |
| 2 | 50 - 57 | .16 - 1000 |
| 3 | 50- 57 | 180 - 1000 |
| 4 | 50 - 59 | 180 - 1000 |
| 5 | 50 – 59 | > Tms4 |

The default low frequency trip curve would be:

| | Hz | Tms |
|--|----|-----|
| | | |

| | | |
|---|------|-------|
| 1 | 50 | .16 |
| 2 | 56.5 | .16 |
| 3 | 56.5 | 300 |
| 4 | 58.5 | 300 |
| 5 | 58.5 | > 300 |

Based on the trip ranges in Table 18 the following Hz and Tms ranges are possible for high frequency:

| | Hz | Tms |
|---|-----------|------------|
| 1 | > Hz2 | .16 - 1000 |
| 2 | 61.8 - 66 | .16 - 1000 |
| 3 | 61.8 - 66 | 180 - 1000 |
| 4 | 61 - 66 | 180 - 1000 |
| 5 | 61 – 66 | > Tms4 |

The default high frequency trip curve would be:

| | Hz | Tms |
|---|------|-------|
| 1 | 63 | .16 |
| 2 | 62 | .16 |
| 3 | 62 | 300 |
| 4 | 61.2 | 300 |
| 5 | 61.2 | > 300 |

The table below contains the IEEE 1547-2018 required frequency trip adjustable settings, the associated IEEE 1547.1 results reporting label, and the SunSpec Modbus point mapping.

| IEEE Std 1547-2018 | IEEE Std 1547.1-2020 RR | SunSpec Modbus |
|--------------------|-------------------------|----------------------------|
| UF2 Frequency | UF2_TRIP_F-AS | 709.MustTrip.Crv.Pt[2].Hz |
| UF2 Clearing Time | UF2_TRIP_T-AS | 709.MustTrip.Crv.Pt[2].Tms |
| UF1 Frequency | UF1_TRIP_F-AS | 709.MustTrip.Crv.Pt[4].Hz |
| UF1 Clearing Time | UF1_TRIP_T-AS | 709.MustTrip.Crv.Pt[4].Tms |

| | | |
|-------------------|---------------|----------------------------|
| OF2 Frequency | OF2_TRIP_F-AS | 710.MustTrip.Crv.Pt[2].Hz |
| OF2 Clearing Time | OF2_TRIP_T-AS | 710.MustTrip.Crv.Pt[2].Tms |
| OF1 Frequency | OF1_TRIP_F-AS | 710.MustTrip.Crv.Pt[4].Hz |
| OF1 Clearing Time | OF1_TRIP_T-AS | 710.MustTrip.Crv.Pt[4].Tms |

Table 12 - Frequency Trip to SunSpec Modbus Mapping

2.13 Frequency Droop

This section describes the frequency droop content as specified in IEEE 1547-2018.

The table below contains the IEEE 1547-2018 required frequency droop adjustable settings, the associated IEEE 1547.1 results reporting label, and the SunSpec Modbus point mapping.

| IEEE Std 1547-2018 | IEEE Std 1547.1-2020 RR | SunSpec Modbus |
|----------------------------|-------------------------|----------------|
| Over-frequency Droop dbOF | PF_DBOF-AS | 711.Ctl.DbOf |
| Under-frequency Droop dbUF | PF_DBUF-AS | 711.Ctl.DbUf |
| Over-frequency Droop kOF | PF_KOF-AS | 711.Ctl.KOf |
| Under-frequency Droop kUF | PF_KUF-AS | 711.Ctl.KUf |
| Open Loop Response Time | PF_OLRT-AS | 711.Ctl.RspTms |

Table 13 - Frequency Droop to SunSpec Modbus Mapping

2.14 Enter Service

This section describes the enter service content as specified in IEEE 1547-2018.

The table below contains the IEEE 1547-2018 required frequency trip adjustable settings, the associated IEEE 1547.1 results reporting label, and the SunSpec Modbus point mapping.

| IEEE Std 1547-2018 | IEEE Std 1547.1-2020 RR | SunSpec Modbus |
|---------------------|-------------------------|----------------|
| Permit Service | ES_PERMIT_SERVICE-AS | 703.ES |
| ES Voltage High | ES_V_HIGH-AS | 703.ESVHi |
| ES Voltage Low | ES_V_LOW-AS | 703.ESVLo |
| ES Frequency High | ES_F_HIGH-AS | 703.ESHHzHi |
| ES Frequency Low | ES_F_LOW-AS | 703.ESHHzLo |
| ES Delay | ES_DELAY-AS | 703.ESDlyTms |
| ES Randomized Delay | ES_RANDOMIZED_DELAY-AS | 703.ESRndTms |
| ES Ramp Rate | ES_RAMP_RATE-AS | 703.ESRmpTms |

Table 14 - Enter Service to SunSpec Modbus Mapping

2.15 Cease to Energize and Trip

The cease to energize and trip function is performed by disabling the permit service setting in the enter service function. Once the permit service setting is set to enabled, the DER returns to service based on the enter service settings.

2.16 Limit Maximum Active Power

This section describes the limit maximum active power content as specified in IEEE 1547-2018.

The table below contains the IEEE 1547-2018 required limit maximum active power adjustable settings, the associated IEEE 1547.1 results reporting label, and the SunSpec Modbus point mapping.

| IEEE Std 1547-2018 | IEEE Std 1547.1-2020 RR | SunSpec Modbus |
|--|-------------------------|-------------------|
| Limit Maximum Active Power Mode Enable | Not specified | 704.WMaxLimPctEna |
| Maximum Active Power | Not specified | 704.WMaxLimPct |

Table 15 - Limit Maximum Active Power to SunSpec Modbus Mapping

3 SunSpec Modbus IEEE 1547-2018 Profile Requirements

This section specifies the required SunSpec information model requirements for the IEEE 1547-2018 SunSpec Modbus profile.

3.1 General Requirements

This section specifies general requirements that apply across all information models.

If a point that is specified in the information model as writable only supports a single value, it MUST support the writing of that value to the point.

Models with curves and curve sets MUST implement the first curve as read-only which contains the current settings.

Models with curves MUST implement the second curve as writable that can be used for settings updates.

Models with curves MAY implement additional curves. Additional curves MAY be writeable or read-only. Additional read-only curves SHOULD be placed at the end of the curve collection.

All the enumerated values specified in the following model specific sections MUST be supported.

3.2 Common Model (1)

The table below specifies the required points and associated enumerated point values in the common (1) information model for the SunSpec Modbus IEEE 1547-2018 Profile.

| |
|----|
| ID |
| L |
| Mn |
| Md |
| SN |
| Vr |

Table 16 - Common Model (1) Required Points

3.3 DERMeasureAC Model (701)

The table below specifies the required points and associated enumerated point values in the DERMeasureAC (701) information model for the SunSpec Modbus IEEE 1547-2018 Profile.

The voltage points that are applicable must be implemented.

| |
|--------|
| ID |
| L |
| W |
| Var |
| LLV |
| LNV |
| VL1L2 |
| VL1 |
| VL2L3 |
| VL2 |
| VL3L1 |
| VL3 |
| Hz |
| St |
| ConnSt |
| Alrm |

Table 17 - DERMeasureAC Model (701) Required Points

3.4 DERCapacity Model (702)

The table below specifies the required points and associated enumerated point values in the DERCapacity (702) information model for the SunSpec Modbus IEEE 1547-2018 Profile.

| |
|--------------|
| ID |
| L |
| WMaxRtg |
| WOvrExtRtg |
| WOvrExtRtgPF |
| WUndExtRtg |
| WUndExtRtgPF |
| VAMaxRtg |
| NorOpCatRtg |
| AbnOpCatRtg |

| |
|-----------------|
| VarMaxInjRtg |
| VarMaxAbsRtg |
| WChaRteMaxRtg |
| VAChaRteMaxRtg |
| VNomRtg |
| VMaxRtg |
| VMinRtg |
| CtrlModes |
| ReactSusceptRtg |

Table 18 - DERCapacity Model (702) Required Points

The table below specifies the optional points and associated enumerated point values in the DERCapacity (702) information model that correspond to the configuration information specified as optional in IEEE 1547-2018.

| |
|--|
| IntIslandCatRtg [UNCATEGORIZED, INT_ISL_CAPABLE, BLACK_START_CAPABLE, ISOCH_CAPABLE] |
| WMax |
| WMaxOvrExt |
| WOvrExtPF |
| WMaxUndExt |
| WUndExtPF |
| VAMax |
| IntIslandCat |
| VarMaxInj |
| VarMaxAbs |
| WChaRteMax |
| VAChaRteMax |
| VNom |

Table 19 - DERCapacity Model (702) Optional Points

3.5 DEREnterService Model (703)

The table below specifies the required points and associated enumerated point values in the DEREnterService (703) information model for the SunSpec Modbus IEEE 1547-2018 Profile.

| |
|------------------------|
| ID |
| L |
| ES [DISABLED, ENABLED] |
| ESVHi |
| ESVLo |
| ESHzHi |
| ESHzLo |
| ESDlyTms |
| ESRmpTms |
| V_SF |
| Hz_SF |

Table 20 - DEREnterService Model (703) Required Points

The table below specifies the optional points and associated enumerated point values in the DEREnterService (703) information model for the SunSpec Modbus IEEE 1547-2018 Profile.

| |
|----------|
| ESRndTms |
|----------|

Table 21 - DEREnterService Model (703) Optional Points

3.6 DERCtlAC Model (704)

The tables below specify the required points and associated enumerated point values in the DERCtlAC (704) information model for constant power factor for the SunSpec Modbus IEEE 1547-2018 Profile.

| |
|--|
| ID |
| L |
| PFWInjEna [DISABLED, ENABLED] |
| PF_SF |
| PFWInj.PF |
| PFWInj.Ext |
| VarSetEna [DISABLED, ENABLED] |
| VarSetMod [W_MAX_PCT, VAR_MAX_PCT, VA_MAX_PCT] |
| VarSetPri [REACTIVE] |
| VarSetPct |

| |
|-----------------------------------|
| VarSetPct_SF |
| WMaxLimPctEna [DISABLED, ENABLED] |
| WMaxLimPct |
| WMaxLimPct_SF |

Table 22 - DERCtlAC Model (704) Required Points

3.7 DERVoltVar Model (705)

The table below specifies the required points and associated enumerated point values in the DERVoltVar (705) information model for the SunSpec Modbus IEEE 1547-2018 Profile.

| |
|--|
| ID |
| L |
| Ena [DISABLED, ENABLED] |
| AdptCrvReq |
| AdptCrvRslt [IN_PROGRESS, COMPLETED, FAILED] |
| NPt |
| NCrv |
| V_SF |
| DeptRef_SF |
| RspTms_SF |
| Crv.ActPt |
| Crv.DeptRef [W_MAX_PCT, VAR_MAX_PCT, VA_MAX_PCT] |
| Crv.Pri [REACTIVE] |
| Crv.VRef |
| Crv.VRefAutoEna [DISABLED, ENABLED] |
| Crv.VRefAutoTms |
| Crv.RspTms |
| Crv.ReadOnly [RW, R] |
| Crv.Pt[1-4].V |
| Crv.Pt[1-4].Var |

Table 23 - DERVoltVar Model (705) Required Points

3.8 DERVoltWatt Model (706)

The table below specifies the required points and associated enumerated point values in the DERVoltWatt (706) information model for the SunSpec Modbus IEEE 1547-2018 Profile.

| |
|--|
| ID |
| L |
| Ena [DISABLED, ENABLED] |
| AdptCrvReq |
| AdptCrvRslt [IN_PROGRESS, COMPLETED, FAILED] |
| NPt |
| NCrv |
| V_SF |
| DeptRef_SF |
| RspTms_SF |
| Crv.ActPt |
| Crv.DeptRef [W_MAX_PCT] |
| Crv.RspTms |
| Crv.ReadOnly [RW, R] |
| Crv.Pt[1-2].V |
| Crv.Pt[1-2].W |

Table 24 - DERVoltWatt Model (706) Required Points

3.9 DERTripLV/ DERTripHV Models (707/708)

The table below specifies the required points and associated enumerated point values in the DERTripLV (707) and DERTripHV (708) information models for the SunSpec Modbus IEEE 1547-2018 Profile.

The 1547-2018 standard does not require the ability to disable the voltage trip function. Under normal operation the function should be enabled. An implementation may support the DISABLED value for the Ena point. If the DISABLED value is not supported, the Ena point must still be writable and accept writing of the ENABLED value.

| |
|---------------|
| ID |
| L |
| Ena [ENABLED] |

| |
|--|
| AdptCrvReq |
| AdptCrvRslt [IN_PROGRESS, COMPLETED, FAILED] |
| NPt |
| NCrvSet |
| V_SF |
| Tms_SF |
| Crv.ReadOnly [RW, R] |
| Crv.MustTrip.ActPt |
| Crv.MustTrip.Pt[1-5].V |
| Crv.MustTrip.Pt[1-5].Tms |

Table 25 - DERTripLV/DERTripHV Models (707/708) Required Points

The table below specifies the optional points and associated enumerated point values in the DERTripLV (707) and DERTripHV (708) information models for momentary cessation for the SunSpec Modbus IEEE 1547-2018 Profile.

| |
|--------------------|
| Crv.MomCess.ActPt |
| Crv.MomCess.Pt.V |
| Crv.MomCess.Pt.Tms |

Table 26 - DERTripLV/DERTripHV Models (707/708) Optional Points

3.10 DERTripLF/ DERTripHF Models (709/710)

The table below specifies the required points and associated enumerated point values in the DERTripLF (709) and DERTripHF(710) information models for the SunSpec Modbus IEEE 1547-2018 Profile.

The 1547-2018 standard does not require the ability to disable the frequency trip function. Under normal operation the function should be enabled. An implementation may support the DISABLED value for the Ena point. If the DISABLED value is not supported, the Ena point must still be writable and accept writing of the ENABLED value.

| |
|--|
| ID |
| L |
| Ena [ENABLED] |
| AdptCrvReq |
| AdptCrvRslt [IN_PROGRESS, COMPLETED, FAILED] |

| |
|--------------------------|
| NPt |
| NCrvSet |
| Hz_SF |
| Tms_SF |
| Crv.ReadOnly [RW, R] |
| Crv.MustTrip.ActPt |
| Crv.MustTrip.Pt[1-5].Hz |
| Crv.MustTrip.Pt[1-5].Tms |

Table 27 - DERTripLF/DERTripHF Models (709/710) Required Points

3.11 DERFreqDroop (711)

The table below specifies the required points and associated enumerated point values in the DERFreqDroop (711) information model for the SunSpec Modbus IEEE 1547-2018 Profile.

The 1547-2018 standard does not require the ability to disable the frequency droop function. Under normal operation the function should be enabled. An implementation may support the DISABLED value for the Ena point. If the DISABLED value is not supported, the Ena point must still be writable and accept writing of the ENABLED value.

| |
|--|
| ID |
| L |
| Ena [ENABLED] |
| AdptCtlReq |
| AdptCtlRslt [IN_PROGRESS, COMPLETED, FAILED] |
| NCtl |
| Db_SF |
| K_SF |
| RspTms_SF |
| Ctl.DbOf |
| Ctl.DbUf |
| Ctl.KOf |
| Ctl.KUf |
| Ctl.RspTms |
| Ctl.ReadOnly [RW, R] |

Table 28 - DERFreqDroop Model (711) Required Points

3.12 DERWattVar (712)

The table below specifies the required points and associated enumerated point values in the DERWattVar (712) information model for the SunSpec Modbus IEEE 1547-2018 Profile.

The Crv.Pri point must support writing of the REACTIVE (1) value even if it is the only value supported.

The implementation MUST support a curve containing six points. If the first three points of the curve are not used in the implementation, they MUST be ignored. If it is desired to set a curve that does not utilize the first three points, the curve point values MUST be set to 0.

| |
|--|
| ID |
| L |
| Ena [DISABLED, ENABLED] |
| AdptCrvReq |
| AdptCrvRslt [IN_PROGRESS, COMPLETED, FAILED] |
| NPt |
| NCrv |
| W_SF |
| DeptRef_SF |
| Crv.ActPt |
| Crv.DeptRef [W_MAX_PCT, VAR_MAX_PCT, VA_MAX_PCT] |
| Crv.Pri [REACTIVE] |
| Crv.ReadOnly [RW, R] |
| Crv.Pt[1-6].W |
| Crv.Pt[1-6].Var |

Table 29 - DERWattVar Model (712) Required Points

3.13 DERStorageCapacity (713)

The table below specifies the required points and associated enumerated point values in the DERStorageCapacity (713) information model for the SunSpec Modbus IEEE 1547-2018 Profile.

If the implementation does not support storage, the DERStorageCapacity model and the SoC point are optional. If the model and SoC point is implemented in a system without storage, the value of SoC MUST be set to 0.

| |
|----|
| ID |
|----|

| |
|-----|
| L |
| SoC |

Table 30 - DERStorageCapacity Model (713) Required Points