Document #: **X99999**

Status: Draft

Version: 1.0-02-01-2021

SunSpec DER Information Model Specification

SunSpec Specification

Abstract

This document describes the SunSpec Distributed Energy Resource (DER) information models that provide support for the Institute of Electrical and Electronics Engineers (IEEE) 1547-2018 functionality using SunSpec information modeling.

License Agreement and Copyright Notice

Prepared by the SunSpec Alliance

4040 Moorpark Avenue, Suite 110

San Jose, CA 95117

Website: sunspec.org

Email: info@sunspec.org

Revision History

Version	Date	Comments
1.0	12-1-2020	Initial release

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 100 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, visit sunspec.org.

About the SunSpec Specification Process

SunSpec Alliance specifications are initiated by SunSpec members 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 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 a SunSpec 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 more frequently to improve the quality and quantity of information provided.

SunSpec Interoperability Specifications follow a lifecycle pattern of: DRAFT, TEST, APPROVED, and SUPERSEDED.

For more information or to download a SunSpec Alliance specification, go to https://sunspec.org/about-sunspec-specifications/.

Table of Contents

Index of Tables

Table of Figures

1 Introduction

The SunSpec DER Information Model Specification defines SunSpec Device Information Models for DERs. A primary goal of this specification is to define a standard way for DERs and interfacing systems to exchange information. DERs and controlling entities that implement the models described in this specification can reliably perform DER management by implementing one or more of the following models, which comprise the complete set of DER related functions:

- DER AC Measurement
- DER Capacity
- DER Enter Service
- DER AC Controls
- DER Volt-Var
- DER Volt-Watt
- DER Trip LV
- DER Trip HV
- DER Trip LF
- DER Trip HF
- DER Frequency Droop
- DER Watt-Var
- DER DC Measurement

This specification is intended to be used in conjunction with the SunSpec Device Information Model Specification and is compliant with the information modeling requirements specified in that standard.

This specification supports reading and writing Information Model points implemented in a DER. This document describes the full SunSpec DER Information Model Specification. Developers can choose how much or how little to implement.

DER information models aim to achieve the following:

- Adhere to the SunSpec Device Information Model specification.
- Support all DER interoperability functionality specified in IEEE 1547-2018
- Define consistent implementation guidelines for all DERs that make it easy for developers to implement interoperable DER solutions.

1.1 Document Organization

Chapter 2 lists the standards documents that are normative references for this document.

Chapter 3 provides an introduction to DER management functions and the application of the DER Information Model.

Chapter 4 provides a detailed specification for each of the standardized SunSpec DER Information Models, specifying points, point groups, and their valid attributes and values.

1.2 Terminology

Definition element	Definition elements are associated with a Device Information Model and describe the model data structure and usage. A definition element can have a value or provide a container for other elements. The Device Information Model defines the following elements: • model • point • point group • symbol • comment Definition elements have attributes that qualify or describe the element.
Device	A device is an entity that exchanges data across communications interfaces. A device has a data set, modeled by Device Information Models, that describes physical and state information about the device. The device data set is the set of logically-related data points specific to the device type. The collections of Device Information Models that describe the data set correspond to the full set of device data points supported by the device.
Device Information Model	The Device Information Model is used to structure device data for exchange across communications interfaces. The model provides a mechanism for specifying the data set supported by a device, which consists of a set of standardized definition elements.
Device Information Model definition	A Device Information Model definition specifies the data points that make up the particular Device Information Model and the usage information associated with each data point. There is one definition for each Device Information Model. Device Information Model definitions represent collections of device data points. The canonical form of Device Information Model definitions are specified using JSON encoding.
Device Information Model instance	A Device Information Model instance is created from a Device Information Model definition. The instance includes data point values specified for each of the defined data points. There can be any number of instances of a Device Information Model.
May trip	A set of conditions where a DER is allowed to trip but is not required to trip.

Model	A Device Information Model *model* element defines a logical grouping of *points*. Each *model* has a unique model ID.
Momentary cessation	Suspension of injection of active power based on current conditions. It implies the ability to resume injection immediately on a change of conditions.
MUST, MUST NOT, REQUIRED, SHALL, SHALL NOT, SHOULD, SHOULD NOT, RECOMMENDED, MAY, and OPTIONAL	The keywords "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this specification, are to be interpreted as described in IETF RFC 2119.
Must trip	A set of conditions where a DER must trip.
Point	A Device Information Model *point* element defines a device data point and has a value.
Point group	A Device Information Model *group* element contains a group of *points* and/or other *point groups*.
Point group, top-level	The top-level point group is the first element of a Device Information Model and contains all other elements.
Reversion timer	A timer that limits the duration of a control, which implies a behavior to revert to on the termination of the control based on timer expiration.
Symbol	A Device Information Model *symbol* element defines a name-value pair. It is used to represent a constant value associated with the enumerated value or bit position of a *point*.
Trip	Cessation of injection of power by the DER. Implies a set of conditions must be met to resume injection of power.

2 Normative References

[RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", BCP 14, RFC 2119, DOI 10.17487/RFC2119, March 1997, <https://www.rfc-editor.org/info/rfc2119>.

IEEE 1547-2018, Standard for Interconnection and Interoperability of Distributed Energy Resources With Associated Electric Power Systems Interfaces, Apr. 2018, <https://ieeexplore.ieee.org/document/8332112>.

SunSpec X99999; SunSpec Device Information Model Specification, version 0.1, May 2019.

3 Overview

This section presents the following general DER topics that apply to multiple information models:

- Curve management as applied to control functions that use linear curves to indicate the behavior associated with the function. Some information models have curve instances as data points.
- Reversion timers, which are used to limit the time a function operates with a specific set of settings.
- A trip/momentary cessation curve encoding for representing behavior during frequency and voltage disturbances.

3.1 Curve Management

Some control functions use piece-wise linear curves to indicate the behavior associated with the function. All functions that utilize curves have a set of curve management points, which can be updated to modify basic curve management functionality:

Symbol	Description	Access
`Ena`	Determines if the function is enabled or disabled.	read/write
`AdptCrvReq`	Select a new curve setting.	read/write
`AdptCrvRslt`	Result of the AdptCrvReq operation.	read-only
`NPt`	Number of possible curve points in each curve instance.	read-only
`NCrv`	Number of curve instances.	read-only
`ActPt`	Number of active points in the curve	read/write

Table 1: Curve Management Points

3.1.1 Curve Layout

A control function information model that uses a curve contains a configurable number of curves that have a configurable number of points:

- number of curves (`NCrv`)
- number of points in each curve (`NPt`)

Device Information Model curve instances occupy sequential locations in the information model. Each curve instance is represented by a sequential set of points that together define the behavior associated with the curve function. Each point is represented by one or more values, and the `NPt` point specifies the number of possible points in each curve instance. The `ActPt` point specifies the number of points that currently active in the curve.

A Device Information Model that uses curves SHALL contain at least two curve instances. The first curve instance is a read-only curve instance that contains the current curve settings. Subsequent curve instances hold curve settings that can be used to update the current curve settings.

3.1.2 Curve Update

The enable point (`Ena`) determines if the function is enabled or disabled. If the enable point is set to zero (`0`) the function is disabled, and the setting associated with the function SHALL NOT be effective. If the enable point is set to one (`1`), the function SHALL be enabled, and the settings are active based on other points in the information model.

New curve settings SHALL be selected by writing one of the curve indexes to the adopt curve request point (`AdptCrvReq`). The index value SHALL be greater than one (`1`), which is the index of the active curve. This operation SHALL cause the settings located at the specified curve index to be copied to the active curve settings. The result of the operation SHALL update the adopt curve response point (`AdptCrvRslt`) with is one of the following values:

- `IN_PROGRESS`
- `COMPLETED`
- `FAILED`

If the result is COMPLETED, reading the curve settings at curve index one (`1`) SHALL reflect the updated settings.

If a set of active curve settings update is in progress, the current curve settings SHALL remain active until the updated curve settings are accepted and made operational. If the update fails, the current settings SHALL remain effective without interruption.

3.2 Reversion Timers

A reversion timer SHALL be used to limit the time a function operates with a specific set of settings. If a reversion timer is enabled for a function and the timer expires without an update, the function SHALL revert to an alternate set of settings. If a setting is updated while the reversion timer is active or the function is re-enabled, the reversion timer SHALL be reinitialized with the reversion timeout value, and the timer is restarted.

The following data points SHALL manage reversion timer functionality:

- reversion timeout value (`RvrtTms`)
- reversion time remaining (`RvrtRem`)
- alternate, function-dependent revision settings

The following figure shows reversion timer states and state transition events:

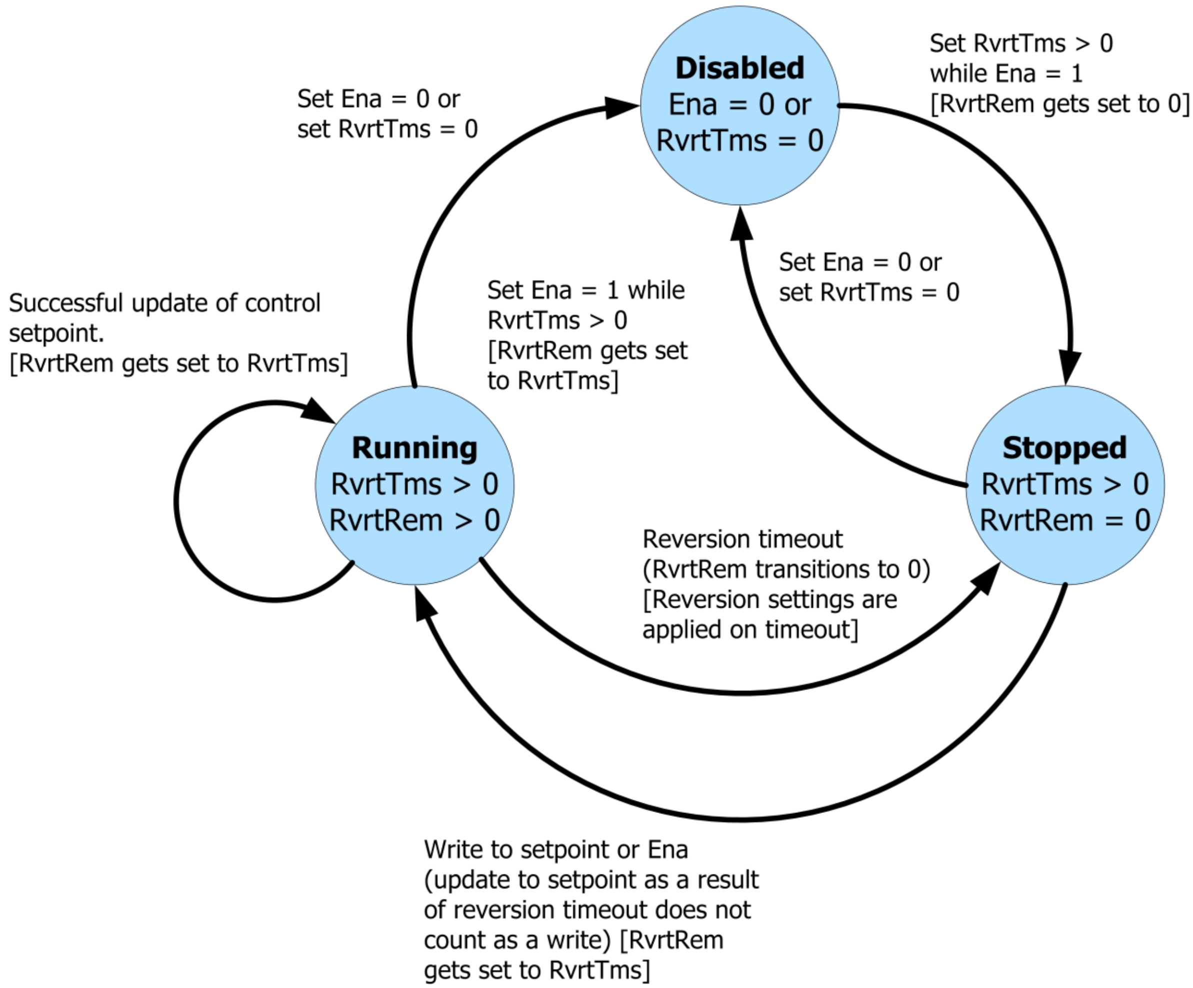


Figure 1: Reversion Timer States

A reversion timer SHALL be in one of the following states:

- Disabled
- Stopped
- Running

If a reversion timer is in the Disabled state, the reversion timer SHALL not affect the current function settings. In this state, the function SHALL be either not enabled or the reversion timeout value SHALL be set to zero (0).

If a reversion timer is in the Stopped state, the reversion timer SHALL not affect the current function settings. If a function setting is changed or the function re-enabled, the reversion timer SHALL be reinitialized with the reversion timeout value, and the timer SHALL be restarted.

If the reversion timer is in the Running state, the reversion time remaining SHALL indicate the time interval remaining until the reversion timer expires. When the revision timer expires, the specified alternate set of function settings SHALL be applied to the function and the reversion timer transitions to the Stopped state.

3.3 Trip/Momentary Cessation Settings

This section presents general information about the trip and momentary cessation settings for frequency and voltage disturbances.

3.3.1 Terminology Clarification

Historically, in communications information models, the term "ride-through" has been used as the general term referring to settings associated with voltage and frequency disturbance. However, IEEE 1547-2018 indicates that "ride-through" is a capability and that the term "ride-through" should not be used for settings. The preferred term that has been proposed generally is "disturbance response settings". It is recommended that the term "ride-through" SHOULD NOT be used to describe the settings.

3.3.2 Trip/Momentary Cessation Region Representation

It is desirable to use a flexible mechanism to represent voltage and frequency trip regions and to handle as many use cases as possible. For example, the curves in some standards[1] require diagonal segments that cannot be represented using rectangular regions.

The trip and momentary cessation curves can be represented as piece-wise linear curves that define the regions associated with voltage and frequency trip, and momentary cessation behavior.

Most threshold requirements can be represented by providing a method that defines the following three regions.

Region	DER Behavior	Precedence Hierarchy
trip	When the trip region is entered, the DER SHALL trip.	1 (highest)
may trip	When the may trip region is entered, the DER may either continue in its current operational mode or trip.	3
momentary cessation	When the momentary cessation region is entered, the DER SHALL cease to energize but SHALL NOT trip.	2

Table 2: Voltage and Frequency Trip Regions

Each region boundary is defined by a piece-wise linear curve such that when crossing the *may trip* curve, the DER is in the *may trip* region.

When crossing a curve of higher precedence, the DER SHALL assume the behavior of the higher precedence.

[1] European Network Code Requirements for Generators (RfG), "ENTSO-E Network Code for Requirements for Grid Connection Applicable to all Generators," 2016.

The difference between the *trip* and *momentary cessation* is the process of resuming operation after that region has been entered. 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. The exact resumption process may vary based on grid code and additional parameters. Because of the limits of some DERs, galvanic isolation may or may not be provided on a *trip*.

The following figure shows an example of the CA Rule 21 trip/momentary cessation curves for voltage, and Table 3 shows curve points for the voltage example reference.

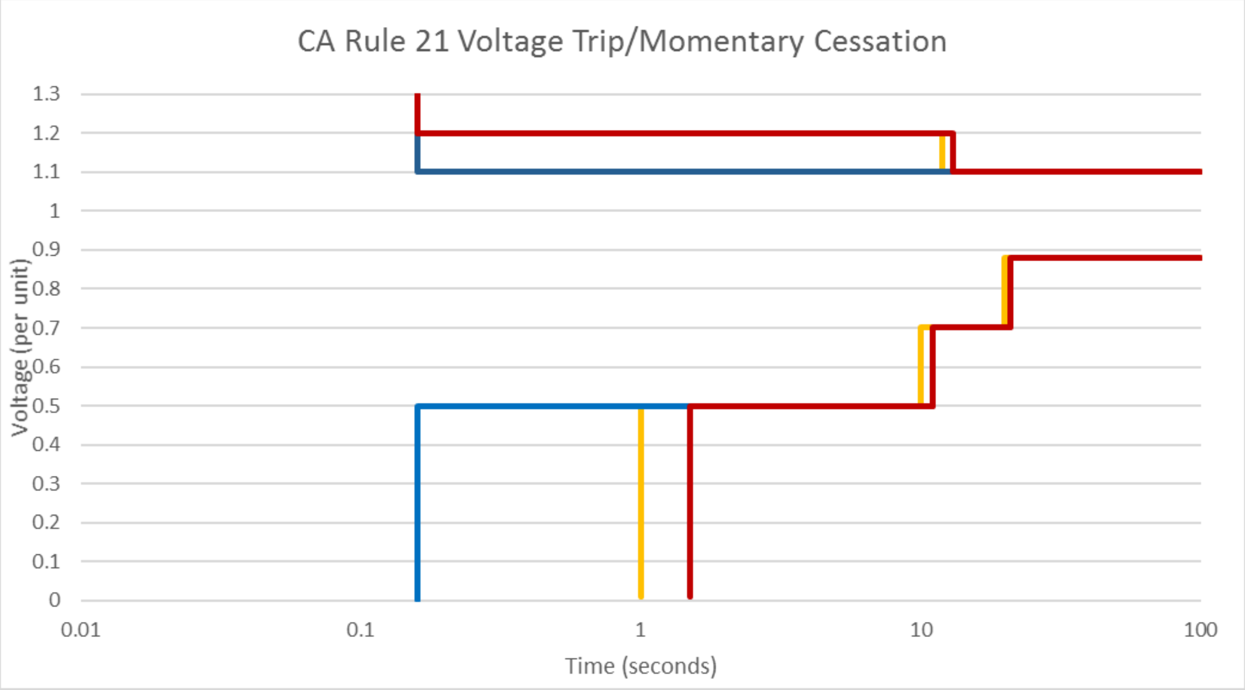


Figure 2: Voltage Trip Momentary Cessation

Curve	Points
LV Trip	(1.5, 0), (1.5, .5), (11, .5), (11, .7), (21, .7), (21, .88), (22, .88)
LV Momentary Cessation	(.16, 0), (.16, .5), (1.5, .5)
LM May Trip	(1,0), (1, .5), (10, .5), (10, .7), (20, .7), (20, .88), (22, .88)
HV Trip	(.16, 1.3), (.16, 1.2), (13, 1.2), (13, 1.1), (14, 1.1)
HV Momentary Cessation	(.16, 1.3), (.16, 1,1), (14, 1.1)
HV May Trip	(.16, 1.3), (.16, 1.2), (12, 1.2), (12, 1.1), (14, 1.1)

Table 3: Voltage Trip Momentary Cessation Points

3.3.3 Configuration

A DER is typically configured with only the trip and momentary cessation curves, provided the behavior complies with the interconnection certification standard. The *may trip* curve can be useful if the DER makes use of the optional regions. The *may trip* curve represents the minimum ride-through requirements.

Currently, frequency disturbance response standards do not include momentary cessation regions so only the *trip* curve SHALL be required. An optional *may trip* curve MAY be configured.

Curves are assumed to extend infinitely vertically from the first point on the curve (positive voltage direction for HV and negative voltage direction for LV), and horizontally (positive time) from the last point on the curve.

It is recognized that DERs might have significant limitations on the shape of the curves it can support. Many DERs might only be able to support curves with vertical and horizontal curve segments within very specific ranges.

3.4 Mandatory/Optional Points

The designation of points in a model as mandatory is based on the core functionality of the model. If a model would be become non-functional without the point being implemented, it is defined as mandatory. This designation is not meant to represent requirements for any other standard or juristic ion. Refer to the specific standards or jurisdictional guides for implementation requirements.

4 DER Information Models

This section describes each of the SunSpec DER Information Models:

- DER AC Measurement
- DER Capacity
- DER Enter Service
- DER AC Controls
- DER Volt-Var
- DER Volt-Watt
- DER Trip LV
- DER Trip HV
- DER Trip LF
- DER Trip HF
- DER Frequency Droop
- DER Watt-Var
- DER DC Measurement

These models provide a standardized way to implement communication protocols of DERs for common DER management functions. Each model specification includes a point summary for the model followed by a detailed description of each point. Points that are part of a point group are indicated in the descriptions.

The summary tables list the following attributes for each point of the model:

Point or Point Group name	The Point or Point Group name field is the acronym associated with the point. A Point Group has a name and a type and includes the points below it, as indicated by indentation.
Point label	The Point label field
Point data type	The Point data type field specifies the data type of the point.
Point access capability	The Point access capability field specifies whether the point read-only (`R`) or read-write (`RW`).
Point implementation requirement	The Point implementation requirement field specifies whether the point is mandatory (`M`), or optional (`O`).
Point value mutability	The Point value mutability field specifies if the value is static (S) or not.

The detailed point description of each point in a model includes:

- point or point group name, which is the same as the name in the point summary table.
- detailed description of the point or point group, including enumerated values for the point.

4.1 DER AC Measurement (701)

The DER AC Measurement information model contains the measurement data associated with the DER along with current status and alarm information. Neither the status nor the alarm information points are latched. They both reflect the current state of the DER and change when that status or alarm state changes.

Group/Point Name	Label	Data Type	RW Access (RW)	Mandatory (M)	Static (S)
DERMeasureAC	DER AC Measurement	group			
ID	DER AC Measure Model ID	uint16		M	S
L	DER AC Measure Model Length	uint16		M	S
ACType	AC Wiring Type	enum16			
St	Operating State	enum16			
ConnSt	Grid Connection State	enum16			
Alrm	Alarm Bitfield	bitfield32			
W	Active Power	int16			
VA	Apparent Power	int16			
VAR	Reactive Power	int16			
PF	Power Factor	uint16			
A	Total AC Current	int16			
LLV	Voltage LL	int16			
LNV	Voltage LN	int16			
Hz	Frequency	uint32			
TotWhInj	Total Energy Injected	unit64			
TotWhAbs	Total Energy Absorbed	unit64			
TotVarhInj	Total Reactive Energy Inj	unit64			
TotVarhAbs	Total Reactive Energy Abs	unit64			
TmpAmb	Ambient Temperature	int16			
TmpCab	Cabinet Temperature	int16			
TmpSnk	Heat Sink Temperature	int16			
TmpTrns	Transformer Temperature	int16			
TmpSw	IGBT/MOSFET Temperature	int16			
TmpOt	Other Temperature	int16			
WL1	Watts L1	int16			
VAL1	VA L1	int16			
VarL1	Var L1	int16			
PFL1	PF L1	uint16			
AL1	Amps L1	int16			
VL1L2	Phase Voltage L1- L2	int16			

Group/Point Name	Label	Data Type	RW Access (RW)	Mandatory (M)	Static (S)
VL1	Phase Voltage L1-N	int16			
TotWhInjL1	Total Watt-Hours Inj L1	uint64			
TotWhAbsL1	Total Watt-Hours Abs L1	uint64			
TotVarhInjL1	Total Var-Hours Inj L1	uint64			
TotVarhAbsL1	Total Var-Hours Abs L1	uint64			
WL2	Watts L2	int16			
VAL2	VA L2	int16			
VarL2	VAR L2	int16			
PFL2	PF L2	uint16			
AL2	Amps L2	int16			
VL2L3	Phase Voltage L2- L3	int16			
VL2	Phase Voltage L2-N	int16			
TotWhInjL2	Total Watt-Hours Inj L2	uint64			
TotWhAbsL2	Total Watt-Hours Abs L2	uint64			
TotVarhInjL2	Total Var-Hours Inj L2	uint64			
TotVarhAbsL2	Total Var-Hours Abs L2	uint64			
WL3	Watts L3	int16			
VAL3	VA L3	int16			
VarL3	Var L3	int16			
PFL3	PF L3	uint16			
AL3	Amps L3	int16			
VL3L1	Phase Voltage L3- L1	int16			
VL3	Phase Voltage L3-N	int16			
TotWhInjL3	Total Watt-Hours Inj L3	uint64			
TotWhAbsL3	Total Watt-Hours Abs L3	uint64			
TotVarhInjL3	Total Var-Hours Inj L3	uint64			
TotVarhAbsL3	Total Var-Hours Abs L3	uint64			
ThrotPct	Throttling In Pct	uint16			
ThrotSrc	Throttle Source Information	bitfield32			
A_SF	Current Scale Factor	sunssf			S
V_SF	Voltage Scale Factor	sunssf			S
Hz_SF	Frequency Scale Factor	sunssf			S
W_SF	Active Power Scale Factor	sunssf			S
PF_SF	Power Factor Scale Factor	sunssf			S
VA_SF	Apparent Power Scale Factor	sunssf			S
Var_SF	Reactive Power Scale Factor	sunssf			S
TotWh_SF	Active Energy Scale Factor	sunssf			S

Group/Point Name	Label	Data Type	RW Access (RW)	Mandatory (M)	Static (S)
TotVarh_SF	Reactive Energy Scale Factor	sunssf			S
Tmp_SF	Temperature Scale Factor	sunssf			S
MnAlrmInfo	Manufacturer Alarm Info	string			

Table 4: DER AC Measurement Points

DERMeasureAC Points

DERMeasureAC DER AC measurement model.

ID DER AC measurement model ID.

L DER AC measurement model length.

ACType AC wiring type:
- SINGLE_PHASE (1) = Single Phase
- SPLIT_PHASE (2) = Split Phase
- THREE_PHASE (3) = Three Phase

St Operating state of the DER:
- OFF (1) = Off
- ON (2) = On
- WARNING (3) = Warning
- ERROR (4) = Error

ConnSt Grid connection state of the DER:
- DISCONNECTED (1) = Disconnected
- CONNECTED (2) = Connected

Alrm	Active alarms for the DER: GROUND_FAULT (0) = Ground Ffault DC_OVER_VOLT (1) = DC Over Voltage AC_DISCONNECT (2) = AC Disconnect Open DC_DISCONNECT (3) = DC Disconnect Open GRID_DISCONNECT (4) = Grid Disconnect CABINET_OPEN (5) = Cabinet Open MANUAL_SHUTDOWN (6) = Manual Shutdown OVER_TEMP (7) = Over Temperature OVER_FREQUENCY (8) = Frequency Above Limit UNDER_FREQUENCY (9) = Frequency Under Limit AC_OVER_VOLT (10) = AC Voltage Above Limit AC_UNDER_VOLT (11) = AC Voltage Under Limit BLOWN_STRING_FUSE (12) = Blown String Fuse On Input UNDER_TEMP (13) = Under Temperature MEMORY_LOSS (14) = Generic Memory Or Communication Error (Internal) HW_TEST_FAILURE (15) = Hardware Test Failure MANUFACTURER_ALRM (16) = Manufacturer Alarm
W	Scale Factor: W_SF Total active power.
VA	Scale Factor: VA_SF Units: VA Total apparent power.
VAR	Scale Factor: Var_SF Units: Var Total reactive power.
PF	Scale Factor: PF_SF Power factor.
A	Scale Factor: A_SF Total AC current.
LLV	Line to line AC voltage as an average of active phases.
LNV	Line to neutral AC voltage as an average of active phases

`Hz`	Scale Factor: `Hz_SF` Units: Hz AC frequency.
`TotWhInj`	Scale Factor: `TotWh_SF` Units: Wh Total active energy injected (Quadrants 1 & 4).
`TotWhAbs`	Scale Factor: `TotWh_SF` Units: Wh Total active energy absorbed (Quadrants 2 & 3).
`TotVarhInj`	Scale Factor: `TotVarh_SF` Units: Varh Total reactive energy injected (Quadrants 1 & 2).
`TotVarhAbs`	Scale Factor: `TotVarh_SF` Units:Varh Total reactive energy absorbed (Quadrants 3 & 4).
`TmpAmb`	Scale Factor: `Tmp_SF` Ambient temperature.
`TmpCab`	Scale Factor: `Tmp_SF` Cabinet temperature.
`TmpSnk`	Scale Factor: `Tmp_SF` Heat sink temperature.
`TmpTrns`	Scale Factor: `Tmp_SF` Transformer temperature.

`TmpSw`	Scale Factor: `Tmp_SF` IGBT/MOSFET temperature.
`TmpOt`	Scale Factor: `Tmp_SF` Units: Other temperature.
`WL1`	Scale Factor: `W_SF` Active power L1.
`VAL1`	Scale Factor: `VA_SF` Units: VA Apparent power L1.
`VarL1`	Scale Factor: `Var_SF` Units: Var Reactive power L1.
`PFL1`	Scale Factor: `PF_SF` Power factor phase L1.
`AL1`	Scale Factor: `A_SF` Current phase L1.
`VL1L2`	Scale Factor: `V_SF` Phase voltage L1-L2.
`VL1`	Scale Factor: `V_SF` Phase voltage L1-N.
`TotWhInjL1`	Scale Factor: `TotWh_SF` Units: Wh Total active energy injected L1.

`TotWhAbsL1`	Scale Factor: `TotWh_SF` Units: Wh Total active energy absorbed L1.
`TotVarhInjL1`	Scale Factor: `TotVarh_SF` Units: Varh Total reactive energy injected L1.
`TotVarhAbsL1`	Scale Factor: `TotVarh_SF` Units: Varh Total reactive energy absorbed L1.
`WPL2`	Scale Factor: `W_SF` Active power L2.
`VAL2`	Scale Factor: `VA_SF` Units: VA Apparent power L2.
`VarL2`	Scale Factor: `Var_SF` Units: Var Reactive power L2.
`PFL2`	Scale Factor: `PF_SF` Power factor L2.
`AL2`	Scale Factor: `A_SF` Current L2.
`VL2L3`	Scale Factor: `V_SF` Phase voltage L2-L3.
`VL2`	Scale Factor: `V_SF` Phase voltage L2-N.

`TotWhInjL2`	Scale Factor: `TotWh_SF` Units: Wh Total active energy injected L2.
`TotWhAbsL2`	Scale Factor: `TotWh_SF` Units: Wh Total active energy absorbed L2.
`TotVarhInjL2`	Scale Factor: `TotVarh_SF` Units: Varh Total reactive energy injected L2.
`TotVarhAbsL2`	Scale Factor: `TotVarh_SF` Units: Varh Total reactive energy absorbed L2.
`WL3`	Scale Factor: `W_SF` Active power L3.
`VAL3`	Scale Factor: `VA_SF` Units: VA Apparent power L3.
`VarL3`	Scale Factor: `Var_SF` Units: Var Reactive power L3.
`PFL3`	Scale Factor: `PF_SF` Power factor L3.
`AL3`	Scale Factor: `A_SF` Current L3.
`VL3L1`	Scale Factor: `V_SF` Phase voltage L3-L1

VL3N	Scale Factor: V_SF Phase voltage L3-N.
TotWhInjL3	Scale Factor: TotWh_SF Units: Wh Total active energy injected L3.
TotWhAbsL3	Scale Factor: TotWh_SF Units: Wh Total active energy absorbed L3.
TotVarhInjL3	Scale Factor: TotVarh_SF Units: Varh Total reactive energy injected L3.
TotVarhAbsL3	Scale Factor: TotVarh_SF Units: Varh Total reactive energy absorbed L3.
ThrotPct	Throttling in Pct of maximum active power.
ThrotSrc	Active throttling source: MAX_W (0) = FIXED_W (1) = FIXED_VAR (2) = FIXED_PF (3) = VOLT_VAR (4) = FREQ_WATT (5) = DYN_REACT_CURR (7) = LVRT (8) = HVRT (9) = WATT_VAR (10) = VOLT_WATT (11) = SCHEDULED (12) = LFRT (13) = HFRT (14) = DERATED (15) =
A_SF	Current scale factor.

V_SF	Voltage scale factor.
Hz_SF	Frequency scale factor.
W_SF	Active power scale factor.
PF_SF	Power factor scale factor.
VA_SF	Apparent power scale factor.
VAR_SF	Reactive power scale factor.
TotWh_SF	Active energy scale factor.
TotVarh_SF	Reactive energy scale factor.
Tmp_SF	Temperature scale factor.
ManAlrmInfo	Manufacturer alarm information. Valid if MANUFACTURER_ALRM indication is active.

4.2 DER Capacity (702)

The DER Capacity information model contains ratings for the DER that are read-only and settings for the DER that can be used to override some ratings.

The settings that are made available in an installation SHOULD default to the rating value. If a setting is adjusted from the default value, the setting value SHALL be used in place of the associated rating for any functions that use that rating to determine functional behavior.

Group/Point Name	Label	Data Type	RW Access (RW)	Mandatory (M)	Static (S)
DERCapacity	DER Capacity	group			
ID	DER Capacity Model ID	uint16		M	S
L	DER Capacity Model Length	uint16		M	S
WMaxRtg	Active Power Max Rating	uint16			
WOvrExtRtg	Active Power (Over-Excited) Rating	uint16			
WOvrExtRtgPF	Specified Over-Excited PF	uint16			
WUndExtRtg	Active Power (Under-Excited) Rating	uint16			
WUndExtRtgPF	Specified Under-Excited PF	uint16			
VAMaxRtg	Apparent Power Max Rating	uint16			
VarMaxInjRtg	Reactive Power Injected Rating	uint16			
VarMaxAbsRtg	Reactive Power Absorbed Rating	uint16			
WChaRteMaxRtg	Charge Rate Max Rating	uint16			
WDisChaRteMaxRtg	Discharge Rate Max Rating	uint16			
VAChaRteMaxRtg	Charge Rate Max VA Rating	uint16			
VADisChaRteMaxRtg	Discharge Rate Max VA Rating	uint16			
VNomRtg	AC Voltage Nominal Rating	uint16			
VMaxRtg	AC Voltage Max Rating	uint16			
VMinRtg	AC Voltage Min Rating	uint16			
AMaxRtg	AC Current Max Rating	uint16			
PFOvrExtRtg	PF Over-Excited Rating	uint16			
PFUndExtRtg	PF Under-Excited Rating	uint16			
ReactSusceptRtg	Reactive Susceptance	uint16			
NorOpCatRtg	Normal Operating Category	enum16			
AbnOpCatRtg	Abnormal Operating Category	enum16			
CtrlModes	Supported Control Modes	bitfield32			
IntIslandCatRtg	Intentional Island Categories	bitfield32			
WMax	Active Power Max Setting	uint16	RW		
WMaxOvrExt	Active Power (Over-Excited) Setting	uint16	RW		
WOvrExtPF	Specified Over-Excited PF	uint16	RW		

Group/Point Name	Label	Data Type	RW Access (RW)	Mandatory (M)	Static (S)
WMaxUndExt	Active Power (Under-Excited) Setting	uint16	RW		
WUndExtPF	Specified Uneer-Excited PF	uint16	RW		
VAMax	Apparent Power Max Setting	uint16	RW		
VarMaxInj	Reactive Power Injected Setting	uint16	RW		
VarMaxAbs	Reactive Power Absorbed Setting	uint16	RW		
WChaRteMax	Charge Rate Max Setting	uint16	RW		
WDisChaRteMax	Discharge Rate Max Setting	uint16	RW		
VAChaRteMax	Charge Rate Max VA Setting	uint16	RW		
VADisChaRteMax	Discharge Rate Max VA Setting	uint16	RW		
VNom	Nominal AC Voltage Setting	uint16	RW		
VMax	AC Voltage Max Setting	uint16	RW		
VMin	AC Voltage Min Setting	uint16	RW		
AMax	AC Current Max Setting	uint16	RW		
PFOvrExt	PF Over-Excited Setting	uint16	RW		
PFUndExt	PF Under-Excited Setting	uint16	RW		
IntIslandCat	Intentional Island Categories	bitfield16	RW		
W_SF	Active Power Scale Factor	sunssf			S
PF_SF	Power Factor Scale Factor	sunssf			S
VA_SF	Apparent Power Scale Factor	sunssf			S
Var_SF	Reactive Power Scale Factor	sunssf			S
V_SF	Voltage Scale Factor	sunssf			S
A_SF	Current Scale Factor	sunssf			S
S_SF	Susceptance Scale Factor	sunssf			S

Table 5: DER Capacity Points

DERCapacity Points

DERCapacity DER capacity model.

ID DER capacity model ID.

L DER capacity model length.

WMaxRtg Scale Factor: W_SF

Maximum active power rating at unity power factor in watts.

`WOvrExtRtg`	Scale Factor: `W_SF` Active power rating at specified over-excited power factor in watts.
`WOvrExtRtgPF`	Scale Factor: `PF_SF` Specified over-excited power factor.
`WUndExtRtg`	Scale Factor: `W_SF` Active power rating at specified under-excited power factor in watts.
`WUndExtRtgPF`	Scale Factor: `PF_SF` Specified under-excited power factor.
`VAMaxRtg`	Scale Factor: `VA_SF` Units: VA Maximum apparent power rating in voltamperes.
`VarMaxInjRtg`	Scale Factor: `Var_SF` Units: Var Maximum injected reactive power rating in vars.
`VarMaxAbsRtg`	Scale Factor: `Var_SF` Units: Var Maximum absorbed reactive power rating in vars.
`WChaRteMaxRtg`	Scale Factor: `W_SF` Maximum active power charge rate in watts.
`WDisChaRteMaxRtg`	Scale Factor: `W_SF` Maximum active power discharge rate in watts.
`VAChaRteMaxRtg`	Scale Factor: `VA_SF` Units: VA Maximum apparent power charge rate in voltamperes.

VADisChaRteMaxRtg	Scale Factor: VA_SF Units: VA Maximum apparent power discharge rate in voltamperes.
VNomRtg	Scale Factor: V_SF AC voltage nominal rating.
VMaxRtg	Scale Factor: V_SF AC voltage maximum rating.
VMinRtg	Scale Factor: V_SF AC voltage minimum rating.
AMaxRtg	Scale Factor: A_SF AC current maximum rating in amps.
PFOvrExtRtg	Scale Factor: PF_SF Power factor over-excited rating.
PFUndExtRtg	Scale Factor: PF_SF Power factor under-excited rating.
ReactSusceptRtg	Reactive susceptance that remains connected to the Area EPS in the cease to energize and trip state. CAT_A(1) = CAT_B(2) =
NorOpCatRtg	Normal operating performance category as specified in IEEE 1547-2018: CAT_A (1) = CAT_B (2) =
AbnOpCatRtg	Abnormal operating performance category as specified in IEEE 1547-2018: CAT_1 (1) = CAT_2 (2) = CAT_3 (3) =

`CtrlModes`	Supported control mode functions: `MAX_W` = `FIXED_W` = `FIXED_VAR` = `FIXED_PF` = `VOLT_VAR` = `FREQ_WATT` = `DYN_REACT_CURR` = `LV_TRIP` = `HV_TRIP` = `WATT_VAR` = `VOLT_WATT` = `SCHEDULED` = `LF_TRIP` = `HF_TRIP` =
`IntIslandCatRtg`	Intentional island categories: `UNCATEGORIZED` = `INT_ISL_CAPABLE` = `BLACK_START_CAPABLE` = `ISOCH_CAPABLE` =
`WMax`	Maximum active power setting used to adjust maximum active power rating.
`WMaxOvrExt`	Active power setting at specified over-excited power factor in watts.
`WOvrExtPF`	Specified over-excited power factor.
`WMaxUndExt`	Active power setting at specified under-excited power factor in watts.
`WUndExtPF`	Specified under-excited power factor.
`VAMax`	Maximum apparent power setting used to adjust maximum apparent power rating.
`VarMaxInj`	Maximum injected reactive power setting used to adjust maximum injected reactive power rating.
`VarMaxAbs`	Maximum absorbed reactive power setting used to adjust maximum absorbed reactive power rating.

WChaRteMax	Maximum active power charge rate setting used to adjust maximum active power charge rate rating.
WDisChaRteMax	Maximum active power discharge rate setting used to adjust maximum active power discharge rate rating.
VAChaRteMax	Maximum apparent power charge rate setting used to adjust maximum apparent power charge rate rating.
VADisChaRteMax	Maximum apparent power discharge rate setting used to adjust maximum apparent power discharge rate rating.
VNom	Nominal AC voltage setting.
VMax	AC voltage maximum setting used to adjust AC voltage maximum rating.
VMin	AC voltage minimum setting used to adjust AC voltage maximum rating.
AMax	Maximum AC current setting used to adjust maximum AC current rating.
PFOvrExt	Power factor over-excited setting.
PFUndExt	Power factor under-excited setting.
IntIslandCat	Intentional island categories.
W_SF	Active power scale factor.
PF_SF	Power factor scale factor.
VA_SF	Apparent power scale factor.
Var_SF	Reactive power scale factor.
V_SF	Voltage scale factor.
A_SF	Current scale factor.
S_SF	Susceptance scale factor.

4.3 DER Enter Service (703)

The DER Enter Service information model contains the Permit Enter Service point which determines if a DER is permitted to energize on the grid as well as points that contain the conditions that must be present to allow the DER to reenergize after tripping. If the Permit Enter Service is set to disabled while energized, the DER SHALL cease to energize and trip.

Group/Point Name	Label	Data Type	RW Access (RW)	Mandatory (M)	Static (S)
DEREnterService	Enter Service	group			
ID	Enter Service ID	uint16		M	S
L	Enter Service Length	uint16		M	S
ES	Permit Enter Service	enum16	RW		
ESVHi	Enter Service Voltage High	uint16	RW		
ESVLo	Enter Service Voltage Low	uint16	RW		
ESHzHi	Enter Service Frequency High	uint32	RW		
ESHzLo	Enter Service Frequency Low	uint32	RW		
ESDlyTms	Enter Service Delay Time	uint32	RW		
ESRndTms	Enter Service Random Delay	uint32	RW		
ESRmpTms	Enter Service Ramp Time	uint32	RW		
V_SF	Voltage Scale Factor	sunssf			S
Hz_SF	Frequency Scale Factor	sunssf			S

Table 6: DER Enter Service Points

DEREnterService Points

DEREnterService — Enter service.

ID — Enter service model ID.

L — Enter service model length.

ES — Permit enter service:
DISABLED (0) = Cease to energize and trip, remain de-energized
ENABLED (1) = Permitted to energize

ESVHi — Scale Factor: V_SF
Units: Pct

Enter service voltage high threshold as a percent of normal voltage.

ESVLo	Scale Factor: V_SF Units: Pct Enter service voltage low threshold as a percent of normal voltage.
ESHzHi	Scale Factor: Hz_SF Units: Hz Enter service frequency high threshold
ESHzLo	Scale Factor: Hz_SF Units: Hz Enter service frequency low threshold.
ESDlyTms	Units: Secs Enter service delay time in seconds.
ESRndTms	Units: Secs Enter service random delay in seconds.
ESRmpTms	Units: Secs Enter service ramp time in seconds.
V_SF	Voltage scale factor.
Hz_SF	Frequency scale factor.

4.4 DER AC Controls (704)

The DER AC Controls information model provides a group of immediate controls that include power factor when injecting power, power factor when absorbing power, limit active power, set active power, and set reactive power. Each control also provides reversion timer functionality that, if implemented, SHALL conform to the reversion timer behavior specified in 3.2 Reversion Timers

Synchronization groups are used for all power factor value pairs as they consist of a power factor and excitation value. The power factor and excitation values SHALL be processed atomically when read and written.

Group/Point Name	Label	Data Type	RW Access (RW)	Mandatory (M)	Static (S)
DERCtlAC	DER AC Controls	group			
ID	Model ID	uint16		M	S
L	Model Length	uint16		M	S
PFWInjEna	Power Factor (W Inj) Enable	enum16	RW		
PFWInjRvrtEna	Power Factor (W Inj) Reversion Enable Setting	enum16	RW		
PFWInjRvrtTms	PF Reversion Time (W Inj)	uint32	RW		
PFWInjRvrtRem	PF Reversion Time Rem (W Inj)	uint32			
PFWAbsEna	Power Factor (W Abs) Enable	enum16	RW		
PFWAbsRvrtEna	PF (W Abs) Reversion Enable Setting	enum16	RW		
PFWAbsRvrtTms	PF Reversion Time (W Abs)	uint32	RW		
PFWAbsRvrtRem	PF Reversion Time Rem (W Abs)	uint32			
WMaxLimPctEna	Limit Max Active Power Pct Enable	enum16	RW		
WMaxLimPct	Limit Max Power Pct Setpoint	uint16	RW		
WMaxLimPctRvrt	Reversion Limit Max Power Pct	uint16	RW		
WMaxLimPctRvrtEna	Reversion Limit Max Power Pct Enable	enum16	RW		
WMaxLimPctRvrtTms	Limit Max Power Pct Reversion Time	uint32	RW		
WMaxLimPctRvrtRem	Limit Max Power Pct Rev Time Rem	uint32			
WSetEna	Set Active Power Enable	enum16	RW		
WSetMod	Set Active Power Mode	enum16	RW		
WSet	Active Power Setpoint (W)	int32	RW		

Group/Point Name	Label	Data Type	RW Access (RW)	Mandatory (M)	Static (S)
WSetRvrt	Reversion Active Power (W)	int32	RW		
WSetPct	Active Power Setpoint (Pct)	uint16	RW		
WSetPctRvrt	Reversion Active Power (Pct)	uint16	RW		
WSetRvrtEna	Reversion Active Power Enable	enum16	RW		
WSetRvrtTms	Active Power Reversion Time	uint32	RW		
WSetRvrtRem	Active Power Rev Time Rem	uint32			
VarSetEna	Set Reactive Power Enable	enum16	RW		
VarSetMod	Set Reactive Power Mode	enum16	RW		
VarSetPri	Set Reactive Power Priority	enum16	RW		
VarSet	Reactive Power Setpoint (Vars)	int32	RW		
VarSetRvrt	Reversion Reactive Power (Vars)	int32	RW		
VarSetPct	Reactive Power Setpoint (Pct)	uint16	RW		
VarSetPctRvrt	Reversion Reactive Power (Pct)	uint16	RW		
VarSetRvrtEna	Reversion Reactive Power Enable	enum16	RW		
VarSetRvrtTms	Reactive Power Reversion Time	uint32	RW		
VarSetRvrtRem	Reactive Power Rev Time Rem	uint32			
WRmp	Normal Ramp Rate	uint16	RW		
WRmpRef	Normal Ramp Rate Reference	enum16	RW		
VarRmp	Reactive Power Ramp Rate	uint16	RW		
PF_SF	Power Factor Scale Factor	sunssf			S
WMaxLim_SF	Limit Max Power Scale Factor	sunssf			S
WSet_SF	Active Power Scale Factor	sunssf			S
WSetPct_SF	Active Power Pct Scale Factor	sunssf			S
VarSet_SF	Reactive Power Scale Factor	sunssf			S

Group/Point Name	Label	Data Type	RW Access (RW)	Mandatory (M)	Static (S)
VarSetPct_SF	Reactive Power Pct Scale Factor	sunssf			S
DERCtlAC.PFWInj	Power Factor (W Inj)	sync			
PF	Power Factor (W Inj)	uint16	RW		
Ext	Power Factor Excitation (W Inj)	enum16	RW		
DERCtlAC.PFWInjRvrt	Reversion Power Factor (W Inj)	sync			
PF	Reversion Power Factor (W Inj)	uint16	RW		
Ext	Reversion PF Excitation (W Inj)	enum16	RW		
DERCtlAC.PFWAbs	Power Factor (W Abs)	sync			
PF	Power Factor (W Abs)	uint16	RW		
Ext	Power Factor Excitation (W Abs)	enum16	RW		
DERCtlAC.PFWAbsRvrt	Reversion Power Factor (W Abs)	sync			
PF	Reversion Power Factor (W Abs)	uint16	RW		
Ext	Reversion PF Excitation (W Abs)	enum16	RW		

Table 7: DER AC Controls Points

DERCtlAC Points

DERCtlAC — DER AC controls model.

ID — DER AC controls model ID.

L — DER AC controls model length.

PFWInjEna — Power factor enable when injecting active power.
DISABLED (0) = Disabled
ENABLED (1) = Enabled

PFWInjRvrtEna — Power factor reversion timer when injecting active power enable:
DISABLED (0) = Disabled
ENABLED (1) = Enabled

PFWInjRvrtTms	Units: Secs Power factor reversion timer when injecting active power.
PFWInjRvrtRem	Units: Secs Power factor reversion time remaining when injecting active power.
PFWAbsEna	Power factor enable when absorbing active power: DISABLED (0) = Disabled ENABLED (1) = Enabled
PFWAbsRvrtEna	Power factor reversion timer when absorbing active power enable: DISABLED (0) = Disabled ENABLED (1) = Enabled
PFWAbsRvrtTms	Units: Secs Power factor reversion timer when absorbing active power.
PFWAbsRvrtRem	Units: Secs Power factor reversion time remaining when absorbing active power.
WMaxLimPct	Limit maximum active power percent enable: DISABLED (0) = Disabled ENABLED (1) = Enabled
WMaxLimPctRvrt	Scale Factor: WMaxLim_SF Units: Pct Reversion limit maximum active power percent value.
WMaxLimPctRvrtEna	Scale Factor: WMaxLim_SF Units: Pct Reversion limit maximum active power percent value enable: DISABLED (0) = Disabled ENABLED (1) = Enabled
WMaxLimPctRvrtTms	Units: Secs Limit maximum active power percent reversion time.

`WMaxLimPctRvrtRem`	Units: Secs Limit maximum active power percent reversion time remaining.
`WSetEna`	Set active power enable: `DISABLED` (`0`) = Disabled `ENABLED` (`1`) = Enabled
`WSetMod`	Set active power mode: `W_MAX_PCT` (`1`) = Active Power As Max Percent `WATTS` (`2`) = Active Power As Watts
`WSet`	Scale Factor: `WSet_SF` Active power setting value in watts.
`WSetRvrt`	Scale Factor: `WSet_SF` Reversion active power setting value in watts.
`WSetPct`	Scale Factor: `WSetPct_SF` Units: Pct Active power setting value as a percent.
`WSetPctRvrt`	Scale Factor: `WSetPct_SF` Units: Pct Reversion active power setting value as percent.
`WSetRvrtEna`	Reversion active power function enable: `DISABLED` (`0`) = Disabled `ENABLED` (`1`) = Enabled
`WSetRvrtTms`	Units: Secs Set active power reversion time.
`WSetRvrtRem`	Units: Secs Set active power reversion time remaining.
`VarSetEna`	Set reactive power enable: `DISABLED` (`0`) = Disabled `ENABLED` (`1`) = Enabled

VarSetMod	Set reactive power mode: W_MAX_PCT (1) = Reactive Power As Watt Max Pct VAR_MAX_PCT (2) = Reactive Power As Var Max Pct VAR_AVAIL_PCT (3) = Reactive Power As Var Avail Pct VARS (4) = Reactive Power As Vars
VarSetPri	Reactive power priority: ACTIVE (1) = Active power priority REACTIVE (2) = Reactive power priority IEEE_1547 (3) = IEEE 1547 Power Priority PF (4) = PF Power Priority VENDOR (5) = Vendor Power Priority
VarSet	Scale Factor: VarSet_SF Units: Var Reactive power setting value in vars.
VarSetRvrt	Scale Factor: VarSet_SF Units: Var Reversion reactive power setting value in vars.
VarSetPct	Scale Factor: VarSetPct_SF Units: Pct Reactive power setting value as a percent.
VarSetPctRvrt	Scale Factor: VarSetPct_SF Units: Pct Reversion reactive power setting value as a percent
VarSetPctRvrtEna	Reversion reactive power function enable: DISABLED (0) = Disabled ENABLED (1) = Enabled.
VarSetRvrtTms	Units: Secs Set reactive power reversion time.
VarSetRvrtRem	Units: Secs Set reactive power reversion time remaining.

WRmp	Ramp rate for increases in active power during normal generation.
WrmpRef	Ramp rate reference unit for increases in active power or current during normal generation: A_MAX (1) = Max Current Ramp W_MAX (2) = Max Active Power Ramp
VarRmp	Ramp rate based on max reactive power per second.
PF_SF	Power factor scale factor.
WMaxLim_SF	Limit maximum power scale factor.
WSet_SF	Active power scale factor.
WSetPct_SF	Active power pct scale factor.
VarSet_SF	Reactive power scale factor.
VarSetPct_SF	Reactive power pct scale factor.
DERCtlAC.PFWInj	Power factor setpoint when injecting active power.
PF	Scale Factor: PF_SF Power factor setpoint when injecting active power.
Ext	Power factor excitation setpoint when injecting active power: OVER_EXCITED (0) = Over-excited UNDER_EXCITED (1) = Under-excited
DERCtlAC.PFWInjRvrt	Reversion power factor setpoint when injecting active power.
PF	Scale Factor: PF_SF Reversion power factor setpoint when injecting active power.
Ext	Reversion power factor excitation setpoint when injecting active power: OVER_EXCITED (0) = Over-excited UNDER_EXCITED (1) = Under-excited
DERCtlAC.PFWAbs	power factor setpoint when absorbing active power.

PF	Scale Factor: PF_SF Power factor setpoint when absorbing active power.
Ext	Power factor excitation setpoint when absorbing active power: OVER_EXCITED (0) = Over-excited UNDER_EXCITED (1) = Under-excited
DERCtlAC.PFWAbsRvrt	Reversion power factor setpoint when absorbing active power.
PF	Scale Factor: PF_SF Reversion power factor setpoint when absorbing active power.
Ext	Reversion power factor excitation setpoint when absorbing active power: OVER_EXCITED (0) = Over-excited UNDER_EXCITED (1) = Under-excited

4.5 DER Volt-Var (705)

The DER Volt-Var information model supports the setting of volt-var controls as piece-wise linear curves. The model allows multiple curves to be supported. The implementation SHALL provide the curve support behavior specified in 3.1 Curve Management.

Group/Point Name	Label	Data Type	RW Access (RW)	Mandatory (M)	Static (S)
DERVoltVar	DER Volt-Var	group			
ID	Model ID	uint16		M	S
L	Model Length	uint16		M	S
Ena	Module Enable	enum16	RW	M	
AdptCrvReq	Adopt Curve Request	uint16	RW	M	
AdptCrvRslt	Adopt Curve Result	enum16		M	
NPt	Number Of Points	uint16		M	S
NCrv	Stored Curve Count	uint16		M	S
RvrtTms	Reversion Timeout	uint32	RW		
RvrtRem	Reversion Time Remaining	uint32			
RvrtCrv	Reversion Curve	uint16	RW		
V_SF	Voltage Scale Factor	sunssf		M	S
DeptRef_SF	Var Scale Factor	sunssf		M	S
RspTms_SF	Open-Loop Scale Factor	sunssf		M	S
DERVoltVar.Crv	Stored Curves	group			
ActPt	Active Points	uint16	RW	M	
DeptRef	Dependent Reference	enum16	RW	M	
Pri	Power Priority	enum16	RW		
VRef	Vref Adjustment	uint16	RW		
VRefAuto	Current Autonomous Vref	uint16			
VRefAutoEna	Autonomous Vref Enable	enum16	RW		
VRefAutoTms	Auto Vref Time Constant	uint16	RW		
RspTms	Open Loop Response Time	uint32	RW		
ReadOnly	Curve Access	enum16			
DERVoltVar.Crv.Pt	Stored Curve Points	group			
V	Voltage Point	uint16	RW		
Var	Reactive Power Point	uint16	RW		

Table 8: DER Volt-Var Points

DERVoltVar Points

DERVoltVar	DER Volt-Var model.
`ID`	DER Volt-Var model ID.
`L`	DER Volt-Var model length.
`Ena`	Volt-Var control enable: `DISABLED` (`0`) = Disabled `ENABLED` (1) = Enabled
`AdptCrvReq`	Index of curve points to adopt. First curve index is 1.
`AdptCrvRslt`	Result of last set active curve operation: `IN_PROGRESS` (`0`) = Update In Progress `COMPLETED` (`1`) = Update Complete `FAILED` (`2`) = Update Failed
`NPt`	Number of curve points supported.
`NCrv`	Number of stored curves supported.
`RvrtTms`	Reversion time in seconds. No reversion time = `0`.
`RvrtRem`	Reversion time remaining in seconds
`RvrtCrv`	Default curve after reversion timeout.
`V_SF`	Scale factor for curve voltage points.
`DeptRef_SF`	Scale factor for curve var points.
`RspTms_SF`	Open loop response time scale factor.
`DERVoltVar.Crv`	Stored Curves
`ActPt`	Number of active points.

`DeptRef`	Curve dependent reference: `W_MAX_PCT` (1) = Percent Max Watts `VAR_MAX_PCT` (2) = Percent Max Vars `VAR_AVAL_PCT` (3) = Percent Available Vars `VA_MAX_PCT` (4)= Percent Max Apparent Power
`Pri`	Power priority: `ACTIVE` = Active power priority `REACTIVE` = Reactive power priority `IEEE_1547` = IEEE 1547-2018 power priority mode `PF` = Track PF setting derived from current active and reactive power settings `VENDOR` = Power priority is vendor-specific mode
`VRef`	Vref adjustment as a percentage of nominal voltage.
`VRefAuto`	Autonomous vref value as a percentage of nominal voltage.
`VRefAutoEna`	Enable autonomous vref: `ENABLED` (0) = Enabled `DISABLED` (1) = Disabled
`VRefAutoTms`	Autonomous Vref time constant.
`RspTms`	Scale Factor: `RspTms_SF` Units: Secs Open loop response time.
`ReadOnly`	Curve read-write access: `RW` (0) = Read-Write Access `R` (1) = Read-Only Access
`DERVoltVar.Crv.Pt`	Stored Curve Points
`V`	Units: VRefPct Curve voltage point as percentage.
`Var`	Scale Factor: `DeptRef_SF` Units: VarPct Curve reactive power point as set in DeptRef point.

4.6 DER Volt-Watt (706)

The DER Volt-Watt information model supports the setting of volt-watt controls as piece-wise linear curves. The model allows multiple curves to be supported. The implementation SHALL provide the curve support behavior specified in 3.1, Curve Management.

Group/Point Name	Label	Data Type	RW Access (RW)	Mandatory (M)	Static (S)
DERVoltWatt	DER Volt-Watt	group			
ID	Model ID	uint16		M	S
L	Model Length	uint16		M	S
Ena	Module Enable	bitfield16	RW	M	
AdoptCrvReq	Adopt Curve Request	uint16	RW	M	
AdoptCrvRslt	Adopt Curve Result	enum16		M	
NPt	Number Of Points	uint16		M	S
NCrv	Stored Curve Count	uint16		M	S
RvrtTms	Reversion Timeout	uint32	RW		
RvrtRem	Reversion Time Remaining	uint32			
RvrtCrv	Reversion Curve	uint16	RW		
V_SF	Voltage Scale Factor	sunssf		M	S
DeptRef_SF	Watt Scale Factor	sunssf		M	S
RspTms_SF	Open-Loop Scale Factor	sunssf		M	S
DERVoltWatt.Crv	Stored Curves	group			
ActPt	Active Points	uint16	RW	M	
DeptRef	Dependent Reference	enum16	RW	M	
RspTms	Open Loop Response Time	uint32	RW		
ReadOnly	Curve Access	enum16			
DERVoltWatt.Crv.Pt	Stored Curve Points	group			
V	Voltage Point	uint16	RW		
W	Dependent Reference	uint16	RW		

Table 9: DER Volt-Watt Points

DERVoltWatt Points

DERVoltWatt	DER Volt-Watt model.
`ID`	DER Volt-Watt model ID
`L`	DER Volt-Watt model length.
`Ena`	Volt-Watt control enable: `DISABLED` (`0`) = Disabled `ENABLED` (`1`) = Enabled
`AdoptCrvReq`	Index of curve points to adopt. The first curve index is 1.
`AdoptCrvRslt`	Result of last adopt curve operation: `IN_PROGRESS` (`0`) = Update In Progress `COMPLETED` (`1`) = Update Complete `FAILED` (`2`) = Update Failed
`NPt`	Number of curve points supported.
`NCrv`	Number of stored curves supported.
`RvrtTms`	Reversion time in seconds. 0 = No reversion time.
`RvrtRem`	Reversion time remaining in seconds.
`RvrtCrv`	Default curve after reversion timeout.
`V_SF`	Scale factor for curve voltage points.
`DeptRef_SF`	Scale factor for curve watt points.
`RspTms_SF`	Open loop response time scale factor.
`DERVoltWatt.Crv`	Stored Curves
`ActPt`	Number of active points.

`DeptRef`	Curve dependent reference: `W_MAX_PCT` (1) = `W_AVAL_PCT` (2) =
`RspTms`	Scale Factor: RspTms_SF Units: Secs Open loop response time.
`ReadOnly`	Curve read-write access: `RW` (0) = Read-Write Access `R` (1) = Read-Only Access
`DERVoltWatt.Crv.Pt`	Stored Curve Points
`V`	Units: VRefPct Curve voltage point as percentage.
`W`	Scale Factor: `DeptRef_SF` Units: DeptRef Active power in percent of rated active power.

4.7 DER Trip Low Voltage (707)

The DER Trip Low Voltage information model provides the trip and momentary cessation settings for low voltage conditions. The implementation SHALL provide the trip/momentary cessation support behavior specified in 3.1, Curve Management.

The information model organizes the curves as sets of three curves with each set containing a curve for must trip, may trip, and momentary cessation. Multiple curve sets can be supported in the model.

Group/Point Name	Label	Data Type	RW Access (RW)	Mandatory (M)	Static (S)
DERTripLV	DER Trip LV	group			
ID	DER Trip LV Model ID	uint16		M	S
L	DER Trip LV Model Length	uint16		M	S
Ena	DER Trip LV Module Enable	enum16	RW	M	
AdoptCrvReq	Adopt Curve Request	uint16	RW	M	
AdoptCrvRslt	Adopt Curve Result	enum16		M	
NPt	Number of Points	uint16		M	S
NCrvSet	Stored Curve Count	uint16		M	S
V_SF	Voltage Scale Factor	sunssf		M	S
Tms_SF	Time Point Scale Factor	sunssf		M	S
DERTripLV.Crv	Stored Curves	group			
ReadOnly	Curve Access	enum16			
DERTripLV.Crv.MustTrip	Must Trip Curve	group			
ActPt	Number Of Active Points	uint16	RW		
DERTripLV.Crv.MustTrip.Pt	Must Trip Curve Points	group			
V	Voltage Point	uint16	RW		
Tms	Time Point	uint32	RW		
DERTripLV.Crv.MayTrip	May Trip Curve	group			
ActPt	Number of Active Points	uint16	RW		
DERTripLV.Crv.MayTrip.Pt	May Trip Curve Points	group			
V	Voltage Point	uint16	RW		
Tms	Time Point	uint32	RW		
DERTripLV.Crv.MomCess	Momentary Cessation Curve	group			
ActPt	Number Of Active Points	uint16	RW		
DERTripLV.Crv.MomCess	Momentary Cessation Curve Points	group			
V	Voltage Point	uint16	RW		
Tms	Time Point	uint32	RW		

Table 10: DER Trip LV Points

DERTripLV Points

DERTripLV	DER low voltage trip model.
`ID`	DER low voltage trip model ID.
`L`	DER low voltage trip model length.
`Ena`	DER low voltage trip control enable: `DISABLED` (`0`) = Disnabled `ENABLED` (`1`) = Enabled
`AdoptCrvReq`	Index of curve points to adopt. The first curve index is 1.
`AdoptCrvRslt`	Result of last adopt curve operation: `IN_PROGRESS` (`0`) = Update In Progress `COMPLETED` (`1`) = Update Complete `FAILED` (`2`) = Update Failed
`NPt`	Number of curve points supported.
`NCrvSet`	Number of stored curves supported.
`V_SF`	Scale factor for curve voltage points.
`Tms_SF`	Scale factor for curve time points.
`DERTripLV.Crv`	Stored curve sets
`ReadOnly`	Curve read-write access: `RW`(`0`) = Read-Write Access `R`(`1`) = Read-Only Access
`DERTripLV.Crv.MustTrip`	Stored must trip curve.
`ActPt`	Number of active points in must trip curve.
`DERTripLV.Crv.MustTrip.Pt`	Must trip curve points.

`V`	Scale Factor: `V_SF` Units: VRefPct Curve voltage point as percentage.
`Tms`	Scale Factor: `Tms_SF` Units: Secs Curve time point in seconds.
`DERTripLV.Crv.MayTrip`	Stored may trip curve.
`ActPt`	Number of active points in the may trip curve.
`DERTripLV.Crv.MayTrip.Pt`	May trip curve points.
`V`	Scale Factor: `V_SF` Units: VRefPct Curve voltage point as percentage.
`Tms`	Scale Factor: `Tms_SF` Units: Secs Curve time point in seconds.
`DERTripLV.Crv.MomCess`	Stored momentary cessation curve.
`ActPt`	Number of active points in the momentary cessation curve.
`DERTripLV.Crv.MomCess.Pt`	Momentary cessation curve points.
`V`	Scale Factor: `V_SF` Units: VRefPct Curve voltage point as percentage.
`Tms`	Scale Factor: `Tms_SF` Units: Secs Curve time point in seconds.

4.8 DER Trip High Voltage (708)

The DER Trip High Voltage information model provides the trip and momentary cessation settings for low voltage conditions. The implementation SHALL provide the trip/momentary cessation support behavior specified in 3.3, Trip/Momentary Cessation Settings.

The information model organizes the curves as sets of three curves with each set containing a curve for must trip, may trip, and momentary cessation. Multiple curve sets can be supported in the model.

Group/Point Name	Label	Data Type	RW Access (RW)	Mandatory (M)	Static (S)
DERTripHV	DER Trip HV	group			
ID	DER Trip HV Model ID	uint16		M	S
L	DER Trip HV Model Length	uint16		M	S
Ena	DER Trip HV Module Enable	enum16	RW	M	
AdoptCrvReq	Adopt Curve Request	uint16	RW	M	
AdoptCrvRslt	Adopt Curve Result	enum16		M	
NPt	Number of Points	uint16		M	S
NCrv	Stored Curve Count	uint16		M	S
V_SF	Voltage Scale Factor	sunssf		M	S
Tms_SF	Time Point Scale Factor	sunssf		M	S
DERTripHV.Crv	Stored Curves	group			
ReadOnly	Curve Access	enum16			
DERTripHV.Crv.MustTrip	Must Trip Curve	group			
ActPt	Number Of Active Points	uint16	RW		
DERTripHV.Crv.MustTrip.Pt	Must Trip Curve Points	group			
V	Voltage Point	uint16	RW		
Tms	Time Point	uint32	RW		
DERTripHV.Crv.MayTrip	May Trip Curve	group			
ActPt	Number Of Active Points	uint16	RW		
DERTripHV.Crv.MayTrip.Pt	May Trip Curve Points	group			
V	Voltage Point	uint16	RW		
Tms	Time Point	uint32	RW		
DERTripHV.Crv.MomCess	Momentary Cessation Curve	group			
ActPt	Number Of Active Points	uint16	RW		
DERTripHV.Crv.MomCess.Pt	Momentary Cessation Curve Points	group			
V	Voltage Point	uint16	RW		
Tms	Time Point	uint32	RW		

Table 11: DER Trip HV Points

DERTripHV Points

DERTripHV	DER high voltage trip model.
`ID`	DER high voltage trip model ID.
`L`	DER high voltage trip model length.
`Ena`	Is DER high voltage trip control active: `DISABLED` (`0`) = Disabled `ENABLED` (`1`) = Enabled
`AdoptCrvReq`	Index of curve points to adopt. The first curve index is 1.
`AdoptCrvRslt`	Result of last adopt curve operation: `IN_PROGRESS` (`0`) = Update In Progress `COMPLETED` (`1`) = Update Complete `FAILED` (`2`) = Update Failed
`NPt`	Number of curve points supported.
`NCrv`	Number of stored curves supported.
`V_SF`	Scale factor for curve voltage points.
`Tms_SF`	Scale factor for curve time points.
`DERTripHV.Crv`	Stored curve sets.
`ReadOnly`	Curve read-write access: `RW`(`0`) = Read-Write Access `R`(`1`) = Read-Only Access
`DERTripHV.Crv.MustTrip`	Stored must trip curve.
`ActPt`	Number of active points in must trip curve.
`DERTripHV.Crv.MustTrip.Pt`	Must trip curve points

`V`	Scale Factor: `V_SF` Units: VRefPct Curve voltage point as percentage.
`Tms`	Scale Factor: `Tms_SF` Units: Secs Curve time point in seconds.
`DERTripHV.Crv.MayTrip`	Stored may trip curve.
`ActPt`	Number of active points in the may trip curve.
`DERTripHV.Crv.MayTrip.Pt`	May trip curve points.
`V`	Scale Factor: `V_SF` Units: VRefPct Curve voltage point as percentage.
`Tms`	Scale Factor: `Tms_SF` Units: Secs Curve time point in seconds.
`DERTripHV.Crv.MomCess`	Stored momentary cessation curve.
`ActPt`	Number of active points in the momentary cessation curve.
`DERTripHV.Crv.MomCess.Pt`	Momentary cessation curve points
`V`	Scale Factor: `V_SF` Units: VRefPct Curve voltage point as percentage.
`Tms`	Scale Factor: `Tms_SF` Units: Secs Curve time point in seconds.

4.9 DER Trip Low Frequency (709)

The DER Trip Low Frequency information model provides the trip and momentary cessation settings for low voltage conditions. The implementation SHALL provide the trip/momentary cessation support behavior specified in 3.3, Trip/Momentary Cessation Settings.

The information model organizes the curves as sets of three curves with each set containing a curve for must trip, may trip, and momentary cessation. Multiple curve sets can be supported in the model.

Group/Point Name	Label	Data Type	RW Access (RW)	Mandatory (M)	Static (S)
DERTripLF	DER Trip LF	group			
ID	DER Trip LF Model ID	uint16		M	S
L	DER Trip LF Model Length	uint16		M	S
Ena	DER Trip LF Module Enable	enum16	RW	M	
AdoptCrvReq	Adopt Curve Request	uint16	RW	M	
AdoptCrvRslt	Adopt Curve Result	enum16		M	
NPt	Number Of Points	uint16		M	S
NCrvSet	Stored Curve Count	uint16		M	S
Hz_SF	Frequency Scale Factor	sunssf		M	S
Tms_SF	Time Point Scale Factor	sunssf		M	S
DERTripLF.Crv	Stored Curves	group			
ReadOnly	Curve Access	enum16			
DERTripLF.Crv.MustTrip	Must Trip Curve	group			
ActPt	Number Of Active Points	uint16	RW		
DERTripLF.Crv.MustTrip.Pt	Must Trip Curve Points	group			
Hz	Frequency Point	uint32	RW		
Tms	Time Point	uint32	RW		
DERTripLF.Crv.MayTrip	May Trip Curve	group			
ActPt	Number Of Active Points	uint16	RW		
DERTripLF.Crv.MayTrip.Pt	May Trip Curve Points	group			
Hz	Frequency Point	uint32	RW		
Tms	Time Point	uint32	RW		
DERTripLF.Crv.MomCess	Momentary Cessation Curve	group			
ActPt	Number Of Active Points	uint16	RW		
DERTripLF.Crv.MomCess.Pt	Momentary Cessation Curve Points	group			
Hz	Frequency Point	uint32	RW		
Tms	Time Point	uint32	RW		

Table 12: DER Trip LF Points

DERTripLF Points

DERTripLF	DER low frequency trip model.
`ID`	DER low frequency trip model ID.
`L`	DER low frequency trip model length.
`Ena`	DER low frequency trip control enable: `DISABLED` (`0`) = Disabled `ENABLED` (`1`) = Enabled
`AdoptCrvReq`	Index of curve points to adopt. The first curve index is `1`.
`AdoptCrvRslt`	Result of last adopt curve operation: `IN_PROGRESS` (`0`) = Update In Progress `COMPLETED` (`1`) = Update Complete `FAILED` (`2`) = Update Failed
`NPt`	Number of curve points supported.
`NCrvSet`	Number of stored curves supported.
`Hz_SF`	Scale factor for curve frequency points.
`Tms_SF`	Scale factor for curve time points.
`DERTripLF.Crv`	Stored curve sets.
`ReadOnly`	Curve read-write access: `RW`(`0`) = Read-Write Access `R`(`1`) = Read-Only Access
`DERTripLF.Crv.MustTrip`	Stored must trip curve.
`ActPt`	Number of active points in must trip curve.
`DERTripLF.Crv.MustTrip.Pt`	Must trip curve points.

`Hz`	Scale Factor: `Freq_SF` Units: Hz Curve frequency point.
`Tms`	Scale Factor: `Tms_SF` Units: Secs Curve time point in seconds.
`DERTripLF.Crv.MayTrip`	Stored may trip curve.
`ActPt`	Number of active points in the may trip curve.
`DERTripLF.Crv.MayTrip.Pt`	May trip curve points.
`Hz`	Scale Factor: `Freq_SF` Units: Hz Curve frequency point.
`Tms`	Scale Factor: `Tms_SF` Units: Secs Curve time point in seconds.
`DERTripLF.Crv.MomCess`	Stored momentary cessation curve.
`ActPt`	Number of active points in the momentary cessation curve.
`DERTripLF.Crv.MomCess.Pt`	Momentary cessation curve points.
`Hz`	Scale Factor: `Freq_SF` Units: Hz Curve frequency point.
`Tms`	Scale Factor: `Tms_SF` Units: Secs Curve time point in seconds.

4.10 DER Trip High Frequency (710)

The DER Trip High Frequency information model provides the trip and momentary cessation settings for low voltage conditions. The implementation SHALL provide the trip/momentary cessation support behavior specified in section 3.3, Trip/Momentary Cessation Settings.

The information model organizes the curves as sets of three curves with each set containing a curve for must trip, may trip, and momentary cessation. Multiple curve sets can be supported in the model.

Group/Point Name	Label	Data Type	RW Access (RW)	Mandatory (M)	Static (S)
DERTripHF	DER Trip HF	group			
ID	DER Trip HF Model ID	uint16		M	S
L	DER Trip HF Model Length	uint16		M	S
Ena	DER Trip HF Module Enable	enum16	RW	M	
AdoptCrvReq	Adopt Curve Request	uint16	RW	M	
AdoptCrvRslt	Adopt Curve Result	enum16		M	
NPt	Number of Points	uint16		M	S
NCrvSet	Stored Curve Count	uint16		M	S
Hz_SF	Frequency Scale Factor	sunssf		M	S
Tms_SF	Time Point Scale Factor	sunssf		M	S
DERTripHF.Crv	Stored Curves	group			
ReadOnly	Curve Access	enum16			
DERTripHF.Crv.MustTrip	Must Trip Curve	group			
ActPt	Number of Active Points	uint16	RW		
DERTripHF.Crv.MustTrip.Pt	Must Trip Curve Points	group			
Hz	Frequency Point	uint32	RW		
Tms	Time Point	uint32	RW		
DERTripHF.Crv.MayTrip	May Trip Curve	group			
ActPt	Number Of Active Points	uint16	RW		
DERTripHF.Crv.MayTrip.Pt	May Trip Curve Points	group			
Hz	Frequency Point	uint32	RW		
Tms	Time Point	uint32	RW		
DERTripHF.Crv.MomCess	Momentary Cessation Curve	group			
ActPt	Number Of Active Points	uint16	RW		
DERTripHF.Crv.MomCess.Pt	Momentary Cessation Curve Points	group			
Hz	Frequency Point	uint32	RW		
Tms	Time Point	uint32	RW		

Table 13: DER Trip HF Points

DERTripHF Points

DERTripHF	DER high frequency trip model.
`ID`	DER high frequency trip model ID
`L`	DER high frequency trip model length.
`Ena`	DER high frequency trip control enable: `DISABLED` (`0`) = Disabled `ENABLED` (`1`) = Enabled
`AdoptCrvReq`	Index of curve points to adopt. The first curve index is `1`.
`AdoptCrvRslt`	Result of last adopt curve operation: `IN_PROGRESS` (`0`) = Update In Progress `COMPLETED` (`1`) = Update Complete `FAILED` (`2`) = Update Failed
`NPt`	Number of curve points supported.
`NCrvSet`	Number of stored curves supported.
`Freq_SF`	Scale factor for curve frequency points.
`Tms_SF`	Scale factor for curve time points.
`DERTripHF.Crv`	Stored curve sets.
`ReadOnly`	Curve read-write access: `RW`(`0`) = Read-Write Access `R`(`1`) = Read-Only Access
`DERTripHF.Crv.MustTrip`	Stored must trip curve.
`ActPt`	Number of active points in must trip curve.
`DERTripHF.Crv.MustTrip.Pt`	Must trip curve points.

`Hz`	Scale Factor: `Freq_SF` Units: Hz Curve frequency point.
`Tms`	Scale Factor: `Tms_SF` Units: Secs Curve time point in seconds.
`DERTripHF.Crv.MayTrip`	Stored may trip curve.
`ActPt`	Number of active points in may trip curve.
`DERTripHF.Crv.MayTrip.Pt`	May trip curve points.
`Hz`	Scale Factor: `Freq_SF` Units: Hz Curve frequency point.
`Tms`	Scale Factor: `Tms_SF` Units: Secs Curve time point in seconds.
`DERTripHF.Crv.MomCess`	Stored momentary cessation curve.
`ActPt`	Number of active points in the momentary cessation curve.
`DERTripHF.Crv.MomCess.Pt`	Momentary cessation curve points.
`Hz`	Scale Factor: `Freq_SF` Units: Hz Curve frequency point.
`Tms`	Scale Factor: `Tms_SF` Units: Secs Curve time point in seconds.

4.11 DER Frequency Droop (711)

The DER Frequency Droop information model supports frequency-watt settings as specified in IEEE 1547-2018. The terminology used in this information model corresponds directly to the IEEE 1547-2018 standard.

Group/Point Name	Label	Data Type	RW Access (RW)	Mandatory (M)	Static (S)
DERFreqDroop	DER Frequency Droop	group			
ID	DER Frequency Droop ID	uint16		M	S
L	DER Frequency Droop Length	uint16		M	S
Ena	DER Frequency Droop Enable	enum16	RW	M	
AdptCtlReq	Adopt Control Request	uint16	RW	M	
AdptCtlRslt	Adopt Control Result	enum16		M	
NCtl	Stored Curve Count	uint16		M	S
RvrtTms	Reversion Timeout	uint32	RW		
RvrtRem	Reversion Time Left	uint32			
RvrtCtl	Reversion Control	uint16	RW		
Db_SF	Deadband Scale Factor	sunssf		M	S
K_SF	Frequency Change Scale Factor	sunssf		M	S
RspTms_SF	Open-loop Scale Factor	sunssf		M	S
DERFreqDroop.Ctl	Stored Curves	group			
DbOf	Over-Frequency Deadband	uint32	RW	M	
DbUf	Under- Frequency Deadband	uint32	RW	M	
KOf	Over- Frequency Change Ratio	uint16	RW	M	
KUf	Under- Frequency Change Ratio	uint16	RW	M	
RspTms	Open-Loop Response Time	uint32	RW	M	
ReadOnly	Control Access	enum16			

Table 14: DER Frequency Droop Points

DERFreqDroop Points

DERFreqDroop	DER frequency droop model.
ID	DER Frequency Droop model ID.
L	DER Frequency Droop model length.

`Ena`	DER Frequency-Watt (Frequency-Droop) control enable: `DISABLED` (`0`) = Disabled `ENABLED` (`1`) = Enabled
`AdoptCtlReq`	Set active control: `0` = No active control
`AdoptCtlRslt`	Result of last set active control operation: `IN_PROGRESS` (`0`) = Update In Progress `COMPLETED` (`1`) = Update Complete `FAILED` (`2`) = Update Failed
`NCtl`	Number of stored curves supported.
`RvrtTms`	Reversion time in seconds. 0 = No reversion time.
`RvrtRem`	Reversion time remaining in seconds.
`RvrtCtl`	Default control after reversion timeout.
`Db_SF`	Deadband scale factor.
`K_SF`	Frequency change scale factor.
`RspTms_SF`	Open loop response time scale factor.
`DERFreqDroop.Ctl`	Stored curve sets.
`DbOf`	Scale Factor: `Db_SF` Units: Hz The deadband value for over-frequency conditions in Hz.
`DbUf`	Scale Factor: `Db_SF` Units: Hz The deadband value for under-frequency conditions in Hz.
`KOf`	Scale Factor: `K_SF` Frequency droop per-unit frequency change for over-frequency conditions corresponding to 1 per-unit power output change.

KUf	Scale Factor: K_SF Frequency droop per-unit frequency change for under-frequency conditions corresponding to 1 per-unit power output change.
RspTms	Scale Factor: RspTms_SF Units: Secs The open-loop response time in seconds.
ReadOnly	Control read-write access: RW (0) = Read-Write Access R (1) = Read-Only Access

4.12 DER Watt-Var (712)

The DER Watt-Var information model supports the setting of watt-var controls as piece-wise linear curves. The model allows multiple curves to be supported. The implementation SHALL provide the curve support behavior specified in 3.1, Curve Management.

Group/Point Name	Label	Data Type	RW Access (RW)	Mandatory (M)	Static (S)
DERWattVar	DER Watt-Var	group			
ID	Model ID	uint16		M	S
L	Model Length	uint16		M	S
Ena	Module Enable	enum16	RW	M	
AdptCrvReq	Set Active Curve Request	uint16	RW	M	
AdptCrvRslt	Set Active Curve Result	enum16		M	
NPt	Number Of Points	uint16		M	S
NCrv	Stored Curve Count	uint16		M	S
RvrtTms	Reversion Timeout	uint32	RW		
RvrtRem	Reversion Time Left	uint32			
RvrtCrv	Reversion Curve	uint16	RW		
W_SF	Active Power Scale Factor	sunssf		M	S
DeptRef_SF	Var Scale Factor	sunssf		M	S
DERWattVar.Crv	Stored Curves	group			
ActPt	Active Points	uint16	RW	M	
DeptRef	Dependent Reference	enum16	RW	M	
Pri	Power Priority	enum16			
ReadOnly	Curve Access	enum16	RW		
DERWattVar.Crv.Pt	Stored Curve Points	group			
W	Active Power Point	uint16	RW		
Var	Reactive Power Point	uint16	RW		

Table 15: DER Watt-Var Points

DERWattVar Points

DERWattVar	DER watt-var model.
ID	DER Watt-Var model ID.
L	DER Watt-Var model length.

`Ena`	Watt-Var control enable: `DISABLED` (0) = Disabled `ENABLED` (1) = Enabled
`AdptCrvReq`	Set active curve. No active curve = `0`.
`AdptCrvRslt`	Result of last set active curve operation: `IN_PROGRESS` (0) = Update In Progress `COMPLETED` (1) = Update Complete `FAILED` (2) = Update Failed
`NPt`	Number of curve points supported.
`NCrv`	Number of stored curves supported.
`RvrtTms`	Reversion time in seconds. No reversion time = `0`.
`RvrtRem`	Reversion time remaining in seconds
`RvrtCrv`	Default curve after reversion timeout.
`V_SF`	Scale factor for curve voltage points.
`DeptRef_SF`	Scale factor for curve var points.
`DERWattVar.Crv`	Stored curve sets.
`ActPt`	Number of active points.
`DeptRef`	Curve dependent reference: `W_MAX_PCT` (1) = Percent Max Watts `VAR_MAX_PCT` (2) = Percent Max Vars `VAR_AVAL_PCT` (3) = Percent Available Vars `VA_MAX_PCT` (4) = Percent Max Apparent Power
`Pri`	Power priority: `ACTIVE` (1) = Active power priority `REACTIVE` (2) = Reactive power priority
`ReadOnly`	Curve read-write access: `RW` (0) = Read-Write Access `R` (1) = Read-Only Access

DERWattVar.Crv.Pt	Stored curve points.
W	Units: VRefPct Curve active power point as percentage.
Var	Scale Factor: DeptRef_SF Units: VarPct Curve reactive power point as set in DeptRef point.

4.13 DER DC Measurement (713)

The DER DC Measurement information model contains the measurement data associated with the DER along with current status and alarm information. Neither the status nor the alarm information points are latched. They both reflect the current state of the DER and change when that status or alarm state changes.

The information model supports multiple DC ports.

Group/Point Name	Label	Data Type	RW Access (RW)	Mandatory (M)	Static (S)
DERMeasureDC	DER DC Measurement	group			
ID	DER DC Measure Model ID	uint16		M	S
L	DER DC Measure Model Length	uint16		M	S
PrtAlrm	Port Alarms	bitfield32			
NPrt	Number Of Ports	uint16			S
DCA	DC Current	int16			
DCW	DC Power	int16			
DCWhInj	DC Energy Injected	uint64			
DCWhAbs	DC Energy Absorbed	uint64			
DCA_SF	DC Current Scale Factor	sunssf			S
DCV_SF	DC Voltage Scale Factor	sunssf			S
DCW_SF	DC Power Scale Factor	sunssf			S
DCWH_SF	DC Energy Scale Factor	sunssf			S
Tmp_SF	Temperature Scale Factor	sunssf			S
DCMeasure.Prt		group			
PrtTyp	Port Type	enum16			
ID	Port ID	uint16			
IDStr	Port ID String	string			
DCA	DC Current	int16			
DCV	DC Voltage	uint16			
DCW	DC Power	int16			
DCWhInj	DC Energy Injected	uint64			
DCWhAbs	DC Energy Absorbed	uint64			
Tmp	DC Port Temperature	int16			
DCSt	DC Port Status	enum16			
DCAlrm	DC Port Alarm	bitfield32			

Table 16: DER AC Measurement Points

DERMeasureDC

DERMeasureDC	DER DC measurement model.
`ID`	DER DC measurement model ID.
`L`	DER DC measurement model length.
`PrtAlrm`	Bitfield of ports with active alarms: Active alarm bit value = `1`. No alarm bit value = `0`. Bit 0 is first port.
`NPrt`	Number of DC ports.
`DCA`	Total DC current for all ports.
`DCW`	Total DC power for all ports.
`DCWhInj`	Total cumulative DC energy injected for all ports.
`DCWhAbs`	Total cumulative DC energy absorbed for all ports.
`DCA_SF`	DC current scale factor.
`DCV_SF`	DC voltage scale factor.
`DCW_SF`	DC power scale factor.
`DCWH_SF`	DC energy scale factor.
`Tmp_SF`	Temperature scale factor.
`DERMeasureDC.Prt`	Port group.

`PrtTyp`	Port type: `PV` (1) = Photovoltaic `ESS` (2) = Energy Storage System `EV` (3) = Electric Vehicle `INJ` (4) = Generic Injecting `ABS` (5) = Generic Absorbing `BIDIR` (6) = Generic Bidirectional `DC_DC` (7) = DC to DC
`ID`	Port ID.
`IDStr`	Port ID string.
`DCA`	DC current for the port.
`DCV`	DC voltage for the port.
`DCW`	DC power for the port.
`DCWhInj`	Total cumulative DC energy injected for the port.
`DCWhAbs`	Total cumulative DC energy absorbed for the port.
`Tmp`	DC port temperature.
`DCSt`	DC port status: `OFF` (1) = Off `ON` (2) = On `WARNING` (3) = Warning `ERROR` (4) = Error

DCAlrm	DC port alarm: GROUND_FAULT (0) = Ground Fault INPUT_OVER_VOLTAGE (1) = Input Over Voltage DC_DISCONNECT (3) = DC Disconnect CABINET_OPEN (5) = Cabinet Open MANUAL_SHUTDOWN (6) = Manual Shutdown OVER_TEMP (7) = Over Temperature BLOWN_FUSE (12) = Blown Fuse UNDER_TEMP (13) = Under Temperature MEMORY_LOSS (14) = Memory Loss ARC_DETECTION (15) = Arc Detection RESERVED (19) = Reserved TEST_FAILED (20) = Test Failed INPUT_UNDER_VOLTAGE (21) = Under Voltage INPUT_OVER_CURRENT (22) = Over Current

Appendix A - DER Power Value Encoding

Active Power/Reactive Power/Power Factor Value Encoding

The objective of this effort is to document the encoding of values that represent active power, reactive power, and power factor in information models used for DER. This is necessary to have consistent monitoring and control usage for these elements. The primary issue is the reference chosen and the meaning of the accompanying sign conventions. It seems particularly confusing for DERs that support activity in all four quadrants.

What reference should be used for determining the sign of power, reactive power, and power factor?

What are the methods of representing a power factor value?

What is the behavior associated with reactive power when moving between active power injection and absorption?

Reference Orientation

The reference orientation consists of an active power producer (generator) and consumer (load). Typically, the utility system is identified as the producer and attached equipment as the consumer. In the case of DER, this convention is not appropriate because the DER is the power producer.

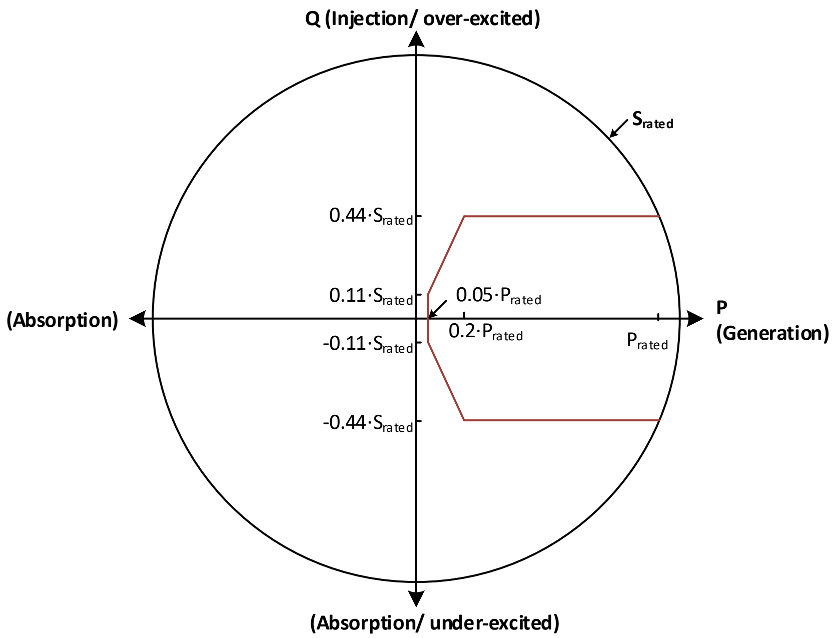
The current IEEE P1547 draft and IEC 61850-7-420 both assert that the generator reference/sign convention is preferred for DER.

The sign convention for active power and reactive power can be determined by looking at the respective summary figures in the sections below based on generator reference. Injection of active power or reactive power is indicated with a positive sign. Absorption of active power or reactive power is indicated with a negative sign.

IEEE P1547

The current P1547 draft specifies the generator sign convention should be used. Language and diagram from P1547:

Where applicable, the stated technical specifications and requirements are given in ***generator sign convention*** *which is opposite to load sign convention. In generator sign convention,*
· *a DER current* ***lagging*** *voltage provides /* ***injects*** *reactive power to the system (****over-excited*** *operation of DER,* ***positive*** *reactive power), and the* ***effect is an increase*** *of the applicable voltage;*
· *a DER current* ***leading*** *voltage consumes /* ***absorbs*** *reactive power from the system (****under-excited*** *operation of DER,* ***negative*** *reactive power), and the* ***effect is a decrease*** *of the applicable voltage.*

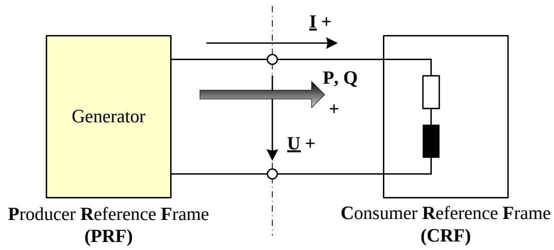


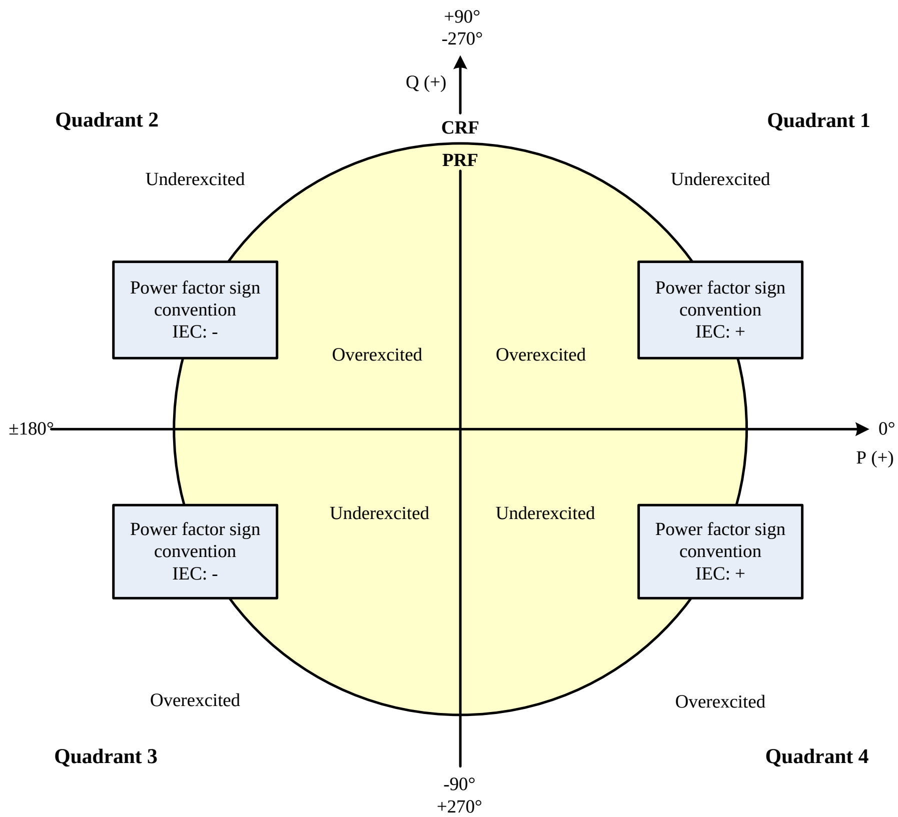
Category B

IEC 61850-7-520

The current IEC 61850-7-520 draft specifies the Producer Reference Frame (generator sign convention) should be used. Language and diagram from IEC 61850-7-520:

Error! Reference source not found. *shows the possible working areas of a DER system from both a Producer Reference Frame (PRF) and from a Consumer Reference Frame (CRF). In general for DER systems, the PRF is used, in which the 1st and 4th quadrants are for delivering power to the grid (vars either overexcited or underexcited, respectively), while the 2nd and 3rd quadrants are for receiving power from the grid (vars either overexcited or underexcited, respectively).*





Power Factor Representation

A power factor value consists of two elements: a value representing the ratio of active power to the apparent power, and the injection mode. The mode indicates whether reactive power is being injected or absorbed. Injection of reactive power is also referenced as one or more of the following: lagging, over-excited. Absorption of reactive power is also referenced as one or more of the following: leading, under-excited.

There are at least three methods of representing a power factor value: IEC, EEI (also sometimes referenced as IEEE), and Q sign.

IEC Power Factor

The IEC power factor is represented using two separate elements: an element for value and an element for injection mode (termed excitation). The sign of the IEC power factor value is the mathematical sign derived from the ratio calculation.

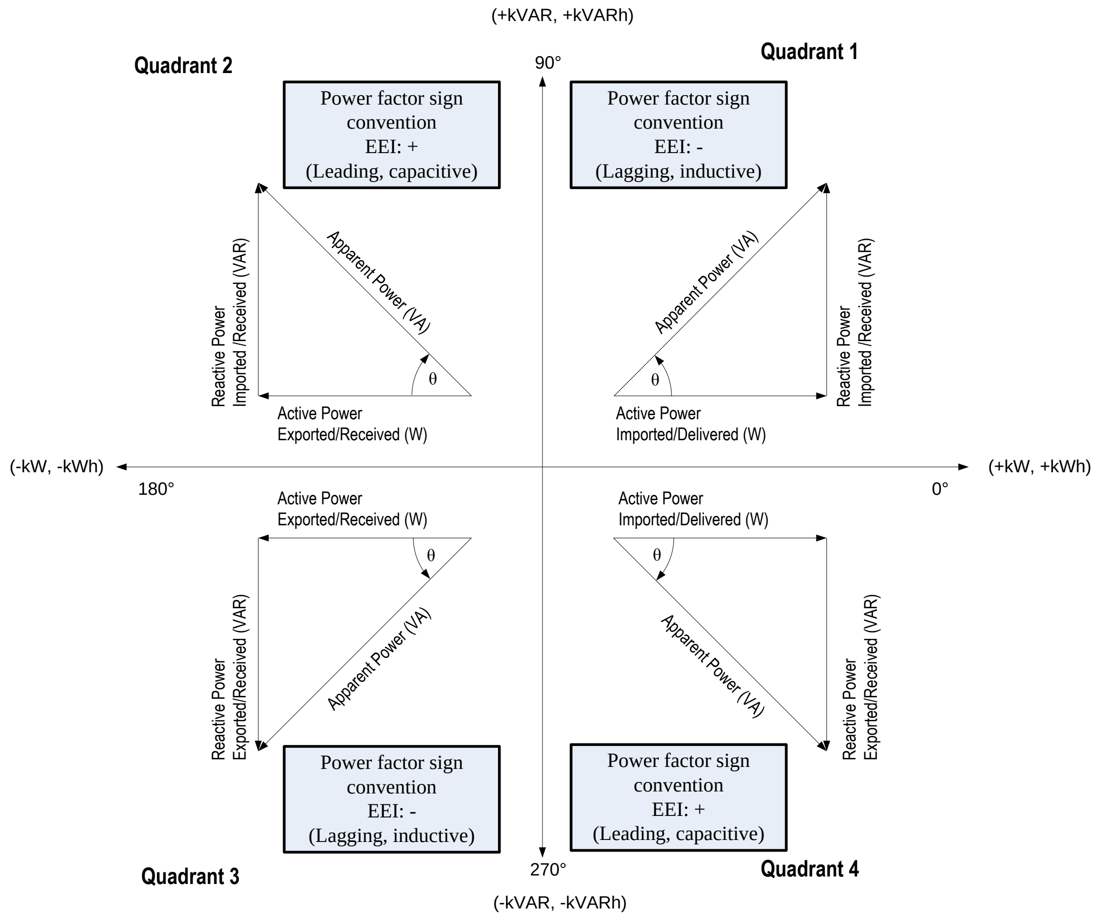
Below is a table from IEC 61850-7-520 with the two representations:

Quadrant	Excitation	PFSign Active Power (usually IEC)	PFSign (usually EEI)
I	Overexcited	+	–
II	Overexcited	–	+
III	Underexcited	–	–
IV	Underexcited	+	+

EEI Power Factor

The EEI power factor is represented using a single value where the mathematical sign is dropped and sign is instead used to indicate the injection mode. A positive sign indicates absorbing reactive power (leading, under-excited, capacitive), and a negative sign indicates injecting (lagging, over-excited, inductive). Below is a commonly referenced EEI power factor figure. Note that the diagram seems to use a generator reference for quadrants 1 and 4 and a consumer reference for quadrants 2 and 3.

The EEI Power Factor sign convention is based on the
Power Triangle acc. Handbook for Electricity metering (EEI) and IEC 61557-12 (2007).



Note: Need a definitive reference for EEI power factor and any IEEE references.

Q Sign

Q sign is an alternate power factor representation that is in use but does not appear to have a standardized reference. The Q sign power factor is represented using a single value where the mathematical sign is dropped and sign is instead used to indicate the mode. The sign reflects the sign of reactive power. A positive sign indicates injecting reactive power (lagging, over-excited) and a negative sign indicates absorbing reactive power (leading, under-excited).

Power Factor Representation Usage

Both IEEE 2030.5 and SunSpec currently use the EEI sign convention for power factor.

Four Quadrant Operation

A power factor setting acts as a control that varies reactive power based on active power. When providing a power factor setting, it is assumed to apply to operation in Q1/Q4 where active power is being injected by the DER.

For DER that operate in all four quadrants by also absorbing active power, the question arises:

How does a power factor setting apply to operation in Q2/Q3?

Three possible behaviors are outlined below: DER unity power factor, general compensation, individual DER compensation

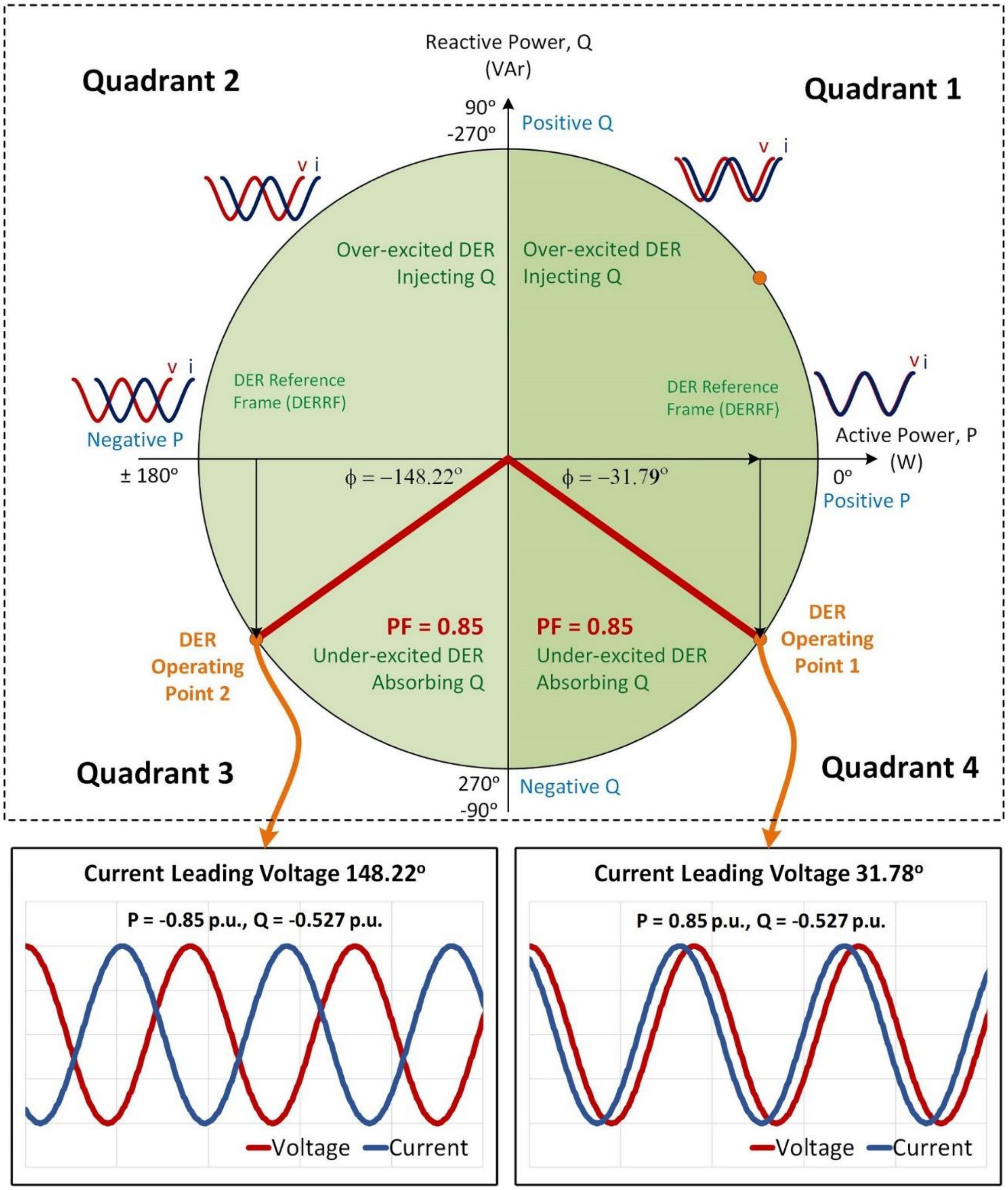
DER Unity Power Factor

One behavior is to maintain a unity power factor when absorbing active power. This behavior provides power factor compensation within the DER without providing additional voltage compensation for the effects of the DER on the grid.

General Compensation

When providing general grid compensation, a DER continues to provide reactive power in the same direction when the direction of active power changes. The rationale is that the grid would continue to need the same reactive power compensation whether the DER is injecting or absorbing active power.

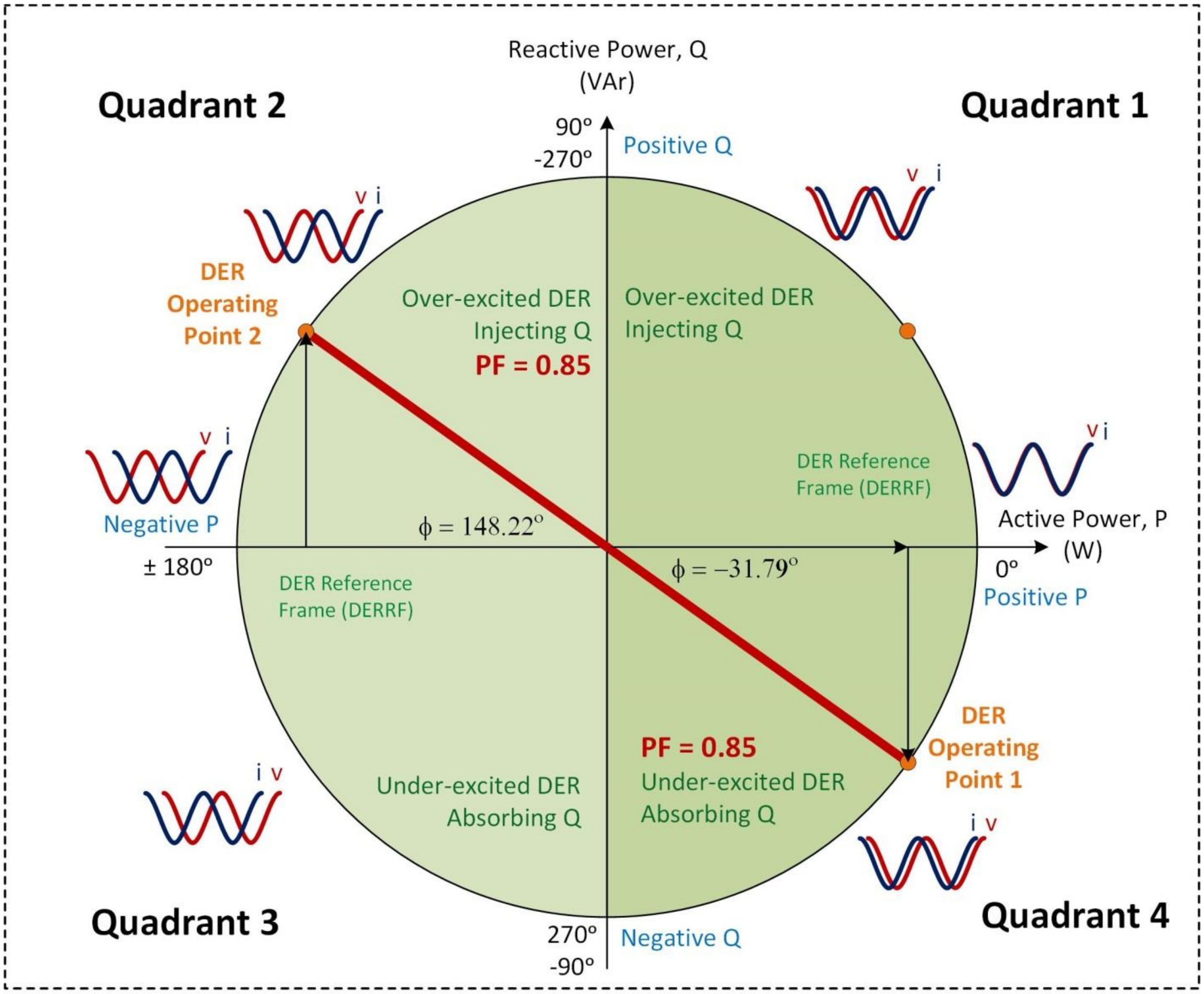
The following diagram illustrates an example of the change in phase angle to maintain a .85 power factor that is under-excited when switching from injecting to absorbing active power. The power factor remains under-excited under all active power conditions.



Individual DER Compensation

When providing individual DER compensation, a DER changes the direction of reactive power when the direction of active power changes. The rationale is that the purpose of reactive power in this case is to compensate for the effect of the DER on the grid.

The following diagram illustrates an example of the change in phase angle to maintain a .85 power factor that is under-excited when injecting active power and changes to over-excited when absorbing active power. The excitation of the power factor is dependent on the direction of active power.



Conclusions

Reference

Summary of reference usage:

1. DER values are specified using generator reference in all four quadrants.

Specified Power Factor

Summary of specified power factor usage:

1. A power factor setting acts as a control that varies reactive power based on active power. When providing a power factor setting, it is assumed to apply to operation in Q1/Q4 where active power is being injected by the DER.
2. It may be desired to support a separate power factor when active power is being absorbed to allow for different reactive power behavior in Q2/Q3 than Q1/Q4.

Power Factor Encoding Conventions

Summary of power factor encoding conventions:

1. IEC power factors require two fields to represent a power factor: value and excitation. Sign is the sign of active power.
2. EEI power factors require one field to represent a power factor. Sign is used to indicate excitation.
3. Q sign power factors require one field to represent a power factor. Sign is used to indicate excitation.

The following table summarizes the sign conventions:

Quadrant	Excitation	IEC	EEI	Q Sign
I	over-excited (injecting)	+	−	+
II	over-excited (injecting)	−	+	+
III	under-excited (absorbing)	−	−	−
IV	under-excited (absorbing)	+	+	−

Value Encoding Summary

Using a generator reference, the following describes values associated with a four quadrant-capable DER:

1. When a DER injects active power (generation/storage discharge) the sign of active power is positive.
2. When a DER is injecting active power, it is operating in quadrants 1 or 4.
3. When a DER absorbs active power (usage/storage charge) the sign of active power is negative.
4. When a DER is absorbing active power, it is operating in quadrants 2 or 3.
5. When a DER injects reactive power, the sign of reactive power is positive.
6. When a DER injects reactive power, it is over-excited (the effect is usually to raise voltage).
7. When a DER absorbs reactive power, the sign of reactive power is negative.
8. When a DER absorbs reactive power, it is under-excited (the effect is usually to lower voltage).
9. When an active power control is set to a positive value, it is directing the DER to inject active power.
10. When an active power control is set to a negative value, it is directing the DER to absorb active power.

11. When a reactive power control is set to a positive value, it is directing the DER to inject reactive power (over-excited operation).
12. When a reactive power control is set to a negative value, it is directing the DER to absorb reactive power (under-excited operation).
13. When providing a power factor setting, it is assumed to apply to operation in Q1/Q4 where active power is being injected by the DER.
14. When an EEI power factor control is set to a negative value while injecting power, it is directing the DER to inject reactive power (over-excited operation).
15. When an EEI power factor control is set to a positive value while injecting power, it is directing the DER to absorb reactive power (under-excited operation).

Recommendations

The following recommendations are proposed:

1. Use the IEC power factor representation (use separate fields for power factor value and excitation) for power factor settings in any new DER information models (IEC 61850, IEEE 2030.5, SunSpec, IEEE 1815 DNP3) to avoid confusion about the use of sign to represent excitation.
2. Support a separate power factor setting to be used when absorbing active power (Q2/Q3) in any new DER information models (IEC 61850, IEEE 2030.5, SunSpec, IEEE 1815 DNP3).

Additional References

The following sections contain additional descriptions of the properties of the four quadrants from different sources.

EPRI Common Inverter Functions Report

Figure from the EPRI Common Inverter Functions Report. Example of IEEE reference for power factor sign that is the same as EEI reference.

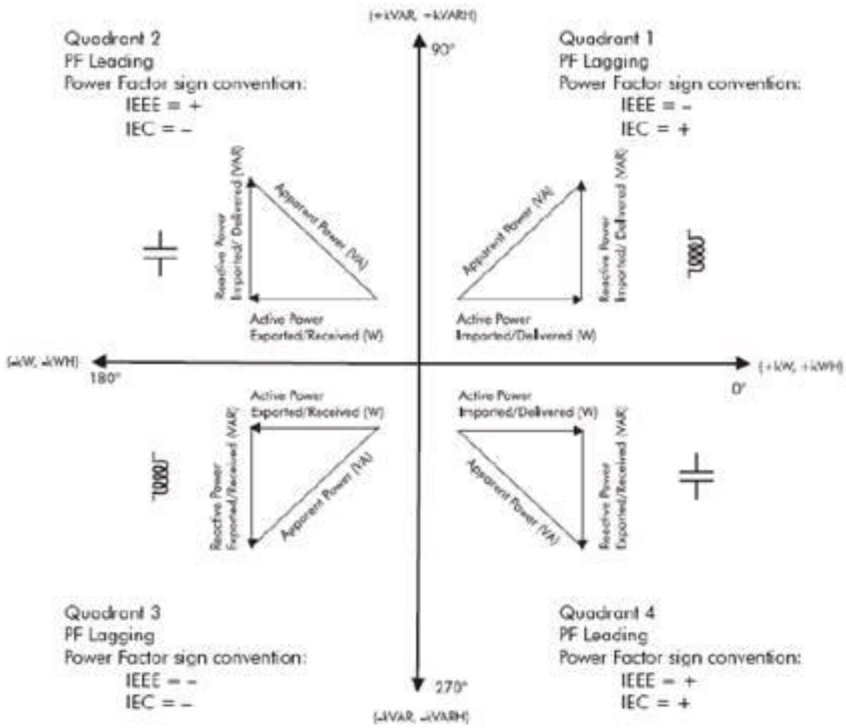


Figure 10-1
IEC and IEEE power factor sign conventions

IEEE Std 1459

Figure for load sign convention.

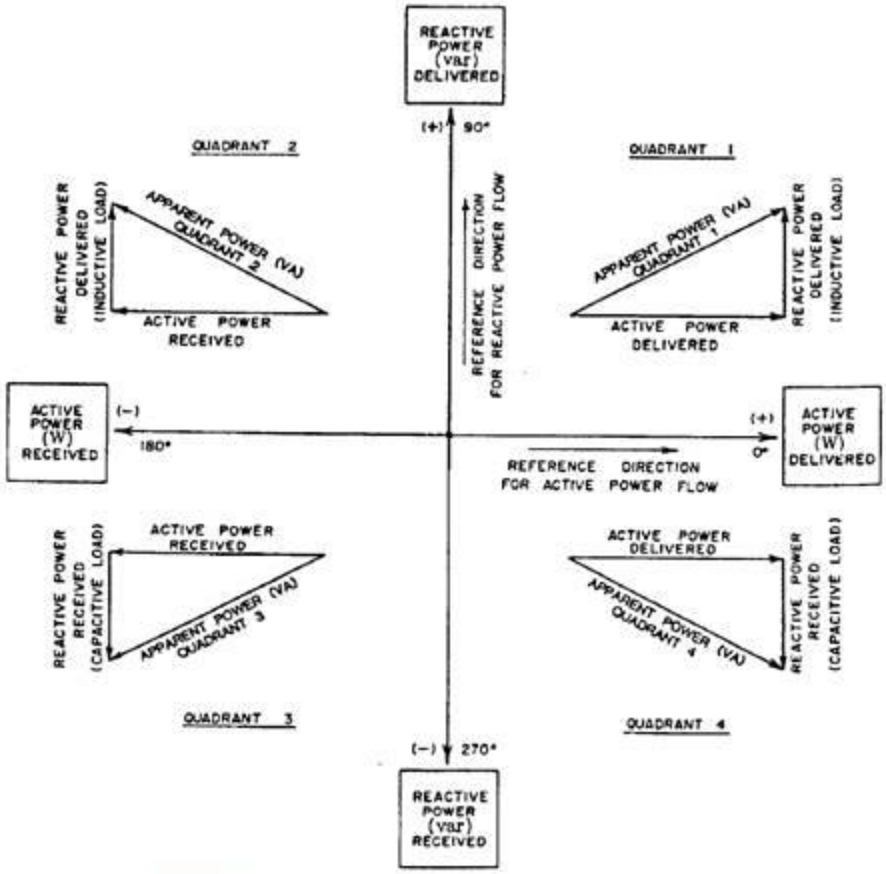


Figure 1—Four-quadrant power flow directions
(© 1983 IEEE. Reprinted, with permission, from the IEEE and R. H. Stevens [B19])

VDE AR

VDE AR load sign convention.

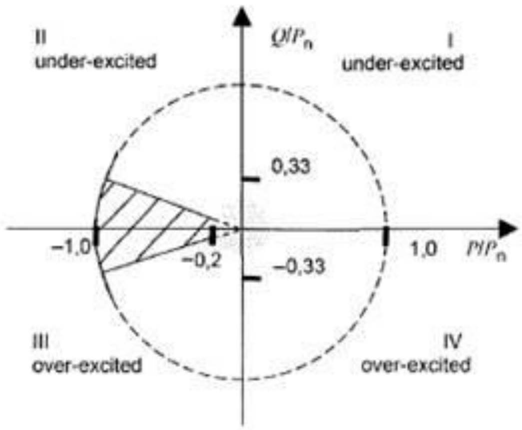


Figure 4 — Limit power range for the reactive power of a power generation system within the range of 3,68 kVA < $\sum S_{Emax}$ ≤ 13,8 kVA (load-reference arrow system)