OpenADR Adaptation for Managing Smart Inverters

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ABSTRACT

Grid-tied solar photovoltaic systems are being deployed in great numbers worldwide. To support these deployments, inverters have been developed with the capability to provide a wide range of grid-supportive services. One of the most challenging aspects of integrating these smart inverters with utility operations is the communication interface. Several communication protocols are presently being evaluated by utilities, each with certain advantages and disadvantages. Presently, it is unclear which protocols are best for a given situation and use case.

This report identifies a method for using existing messages in the OpenADR 2.0b standard in order to carry out monitoring and management of smart solar inverters. Although OpenADR 2.0b does not have native support for smart inverters, it is interesting to consider how it might be used in order to integrate smart solar inverters and smart loads in a common communication system. The context for the development of this method is a California Solar Initiative project. In this project, the Electric Power Research Institute (EPRI) and a number of partner organizations are performing lab testing and field demonstration of smart inverters that support the revisions being developed for the California Rule 21 interconnect guideline.

The project, entitled "Standard Communication Interface and Certification Test Program," involves the development of inverters with communication interfaces based on the IEC standard information model, the SunSpec protocol mapping, and the CEA-2045 modular port. With a modular communication approach, these inverters are intended to be compatible with any communication system, and thereby able to be economically mass-produced.

One of the network communication protocols being demonstrated in this project is OpenADR 2.0b. It is possible to make use of existing OpenADR 2.0b messages, repurposing them for Distributed Energy Resource (DER) control. This report identifies the specific way this was accomplished for this project. It is not an addition to the standard, nor is it a recommended method for future use. A proper extension to the OpenADR 2.0b standard to support DER is possible, but would likely involve extensive additions to the standard, rather than reuse of existing content as described herein.

Keywords
Smart inverter
Distributed energy resource
OpenADR
SunSpec
CEA-2045
California (CA) Rule 21

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1
INTRODUCTION

Overview

The "Standard Communication Interface and Certification Test Program" project consists of the development and demonstration of advanced inverters with standardized functionality and an open communication interface that can meet the requirements of the new California (CA) Rule 21 interconnection guideline. The communication interface will utilize the IEC standard information model, the SunSpec protocol, and the CEA-2045 modular interface to enable off-the-shelf inverters to be mass produced, and compatible with SCADA, AMI, or any other system.

The project will also develop a certification test program, including the test procedures, software, and facilities needed to validate that new inverter designs function and communicate per the standards. A certification process is a must-have because standards alone are not sufficient to produce interoperability. The certification process will be based on the California Rule 21 requirements, and will include testing of both the power and communication interfaces of the inverter. In this way, the inverters could be fielded immediately, with confidence that they could be successfully integrated with control systems at a later time, if and when needed.

One of the communication protocols being demonstrated in this project is OpenADR 2.0b. While OpenADR does not have native support for the DER device control required for this project, it is possible to implement the commands required by using functions intended for demand response (DR) applications and repurposing them for distributed energy resources (DER) inverter control.

Functions Successfully Supported by Repurposing OpenADR Messages

The following functions are supported using OpenADR:

- Download of Volt-VAR mode curves with Watt-Priority
- Enable/Disable a specific Volt-VAR curve
- Download of Volt-Watt mode curves
- Enable/Disable a specific Volt-Watt curve
- Download of Frequency-Watt mode curves
- Enable/Disable a specific Frequency-Watt curve
- Set Fixed Power Factor
- Set Fixed Real power output limit
- Set ramp rates for each function
- Report inverter alarms
- Report inverter instantaneous power, power factor, connection status, and totalized real power output

This approach for using OpenADR repurposes the EiEvent service to allow support for this set of DER functions. It cannot be overemphasized that this method is for demonstration purposes only. It is not a recommended approach for using OpenADR on future projects nor is it a recommendation for how the standard should be modified.

An OpenADR server is typically referred to as a virtual top node or a VTN, and an OpenADR client is referred-to as a virtual end node, or a VEN. This nomenclature is used throughout this document.

Much of the information on the functions to be supported was drawn from the publically available technical update, Common Functions for Smart Inverters, Version 3, EPRI product ID 3002002233. It is assumed that the parameters for these functions will be similar.

2
INDIVIDUAL FUNCTIONAL MAPPING

This chapter provides details on how the individual DER functions to be supported are mapped to existing OpenADR EiEvent functions. These functions are all based on the oadrDistributeEvent function which allows a wide range of flexibility.

The oadrDistributeEvent message is designed to notify the end device of a DR event that is currently taking place or will take place in the future. The event can have a single or multiple signals, and each signal can have a single or multiple intervals.

To support control of the selected inverter functions, additional signal names will be added to the EPRI OpenADR server. The OpenADR 2.0B client software will be modified to recognize these new signal names. The intent is to use the OpenADR client to poll the OpenADR server for new event updates rather than having the server push them down to the end devices.

Curve Download

This function will retrieve a curve from the OpenADR server. The curve will appear as a oadrDistributeEvent message from the VTN. The data returned will consist of a curve type, a duration of how long the curve will remain enabled after being triggered, a curve index, and X-Y number pairs to define the curve shape.

Volt-VAR Curve

In the case of a Volt-VAR curve, the X-Y data will consist of the percent of nominal voltage for the X axis and percent of available VARs for the Y axis. A simple Volt-VAR curve is shown in Figure 2-1.

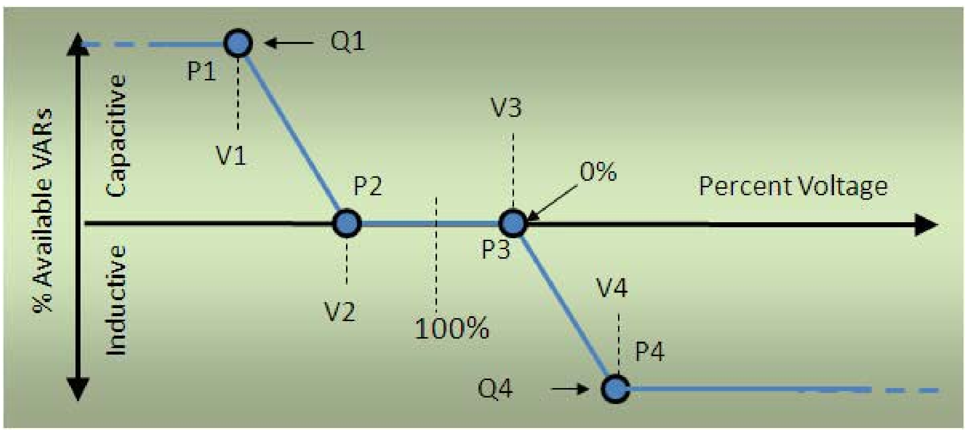

Figure 2-1
Simple Volt-VAr curve

This function has three parameters in addition to the event start time and duration:

- Percent voltage – This is an array of n values providing one side of the X-Y point pairs. This value is a floating point percentage of nominal voltage. The number of intervals must match the number of Percent available VARs intervals.
- Percent available VARs – This is an array of n values providing one side of the X-Y point pairs. This value is a floating point percentage of available VARs. The number of intervals must match the number of Percent voltage intervals.
- Ramp rate – The maximum rate at which the output may change at the time the mode is first made effective.

Volt-Watt Curve

In the case of a Volt-Watt curve, the X-Y data will consist of the percent of nominal voltage for the X axis and percent of maximum watt output for the Y axis. An example Volt-Watt curve is shown in Figure 2-2.

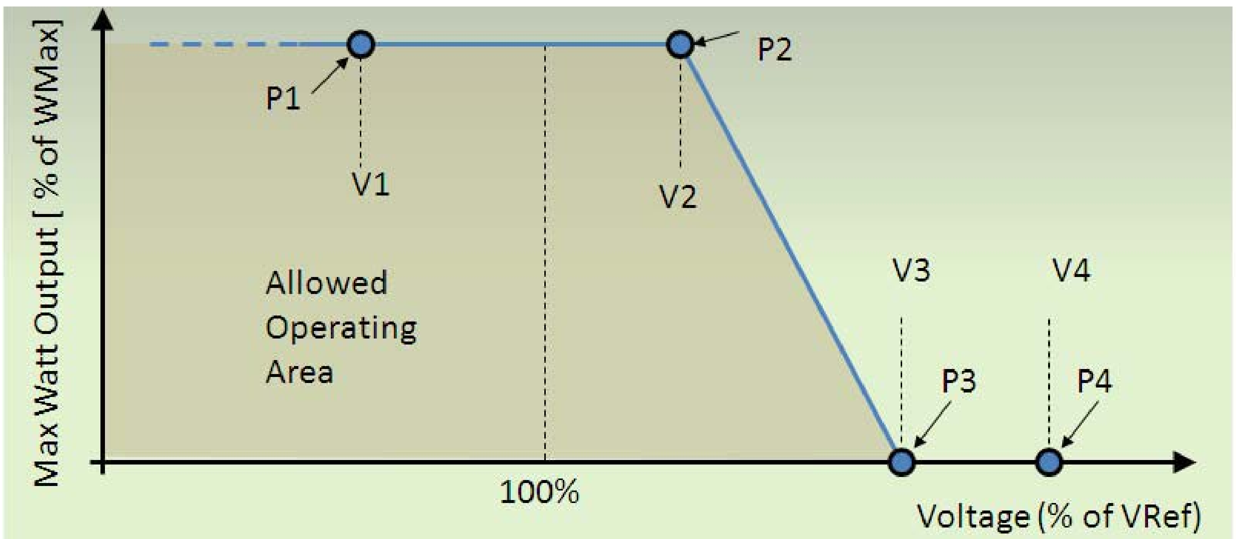

Figure 2-2
Example Volt-Watt curve

The Volt-Watt function limits active power generation or consumption when the line voltage exceeds nominal by a specified amount. The Volt-Watt curve is specified as an array of Volt-Watt pairs that are interpolated into a piecewise linear function with hysteresis. The x value of each pair specifies an AC RMS voltage. The y value specifies a corresponding active power output in percent of the inverter maximum real power output. An example array of value pairs could be as follows:

% of Reference Voltage	% Maximum Watt Output
90	100
105	100
110	0
120	0

This function has three parameters in addition to the event start time and duration:

- Percent reference voltage – This is an array of n values providing one side of the X-Y point pairs. This value is a floating point percentage of nominal voltage. The number of intervals must match the number of percent maximum watt output intervals.
- Percent maximum watt output – This is an array of n values providing one side of the X-Y point pairs. This value is a floating point percentage of available VARs. The number of intervals must match the number of Percent reference voltage intervals.
- Ramp rate – The maximum rate at which output may change at the time the mode is first made effective.

Frequency-Watt Curve

In the case of a Frequency-Watt curve, the X-Y data will consist of the percent of nominal voltage for the X axis and percent of maximum watt output for the Y axis. An example Frequency-Watt curve is shown in Figure 2-3.

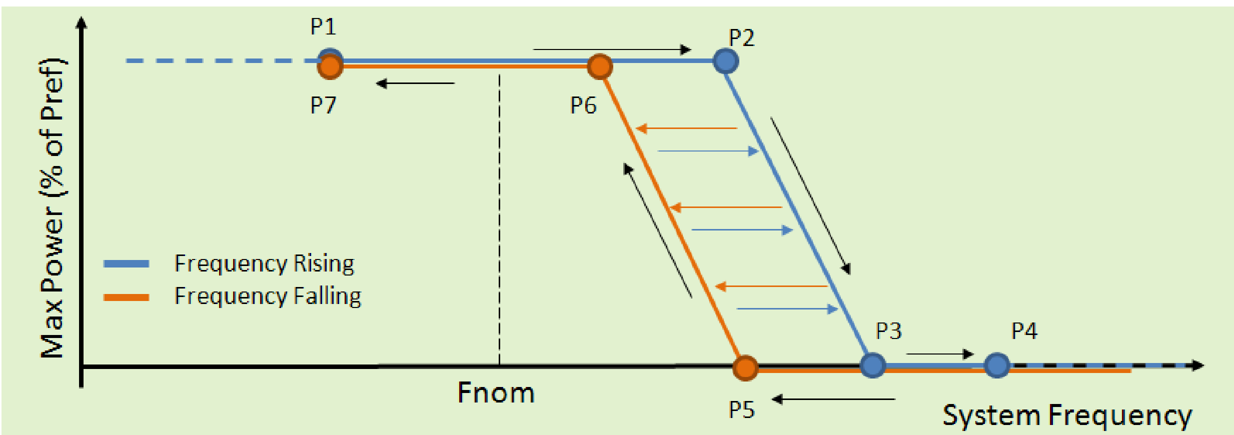

Figure 2-3
Example Frequency-Watt curve with hysteresis

An example array of value pairs could be as follows:

Frequency	% Maximum Watt Output
59	100
60.1	100
60.3	0
61	0

The Frequency-Watt function limits active power generation or consumption when the line frequency deviates from nominal by a specified amount. The Frequency-Watt curve is specified as an array of Frequency-Watt pairs that are interpolated into a piecewise linear function with hysteresis. The x value of each pair specifies a frequency in Hz. The y value specifies a corresponding active power output in percent of the inverter maximum real power output.

This function has three parameters in addition to the event start time and duration:

- Frequency – This is an array of n values providing one side of the X-Y point pairs. This value is a floating point percentage of the grid frequency. The number of intervals must match the number of percent maximum watt output intervals.
- Percent maximum watt output – This is an array of n values providing one side of the X-Y point pairs. This value is a floating point percentage of maximum watt output. The number of intervals must match the number of Percent voltage intervals.
- Ramp rate – The maximum rate at which the output may change at the time the mode is first made effective.

Message Structure

The oadrDistributeEvent message to support a DER curve download has the structure shown in Table 2-1.

Table 2-1
Volt-VAR/Volt-Watt/Freq-Watt curve download OpenADR function structure

Structure				Original Use	DER Use
Event				Defines a grid event	Defines a grid event
	start time			Start time for the event	Current date and time
	Duration			Duration of the event	Length of time before revert to normal operation
	Event status			Defines status of the event	Event status field is controlled by the server. The status values are near/far: the event has yet to start, active: the event is executing, complete: the event is complete, cancelled: the event was cancelled.
	Signals				
		signal 1 name		Predefined signal name	x-voltVARCurve / x-voltWattCurve / x-FreqWattCurve – New identifiers for a DER curve
		Signal 1 type		multiplier	multiplier
		Current value		Filled in by the VTN	n/a
		Interval 1			
			Duration	Interval 2 duration	n/a
			Payload	Value applied to signal	float curve number 0-4
		Signal 2 name		Predefined signal name	x-voltagePercent – Identifies following intervals as voltage values in % of nominal or x-frequency – Identifies following intervals as frequency values in Hz
		Signal 2 type		multiplier	multiplier
		Current value			n/a
		Interval 1			

Table 2-1 (continued)
Volt-VAR/Volt-Watt/Freq-Watt curve download OpenADR function structure

Structure				Original Use	DER Use
			Duration	Interval duration	n/a
			Payload	Value applied to signal	Curve x value #1
		Interval 2			
			Duration	Interval duration	n/a
			Payload	Value applied to signal	Curve x value #2
		Interval n			
			Duration	Interval duration	n/a
			Payload	Value applied to signal	Curve x value #n
		signal 3 name		Predefined signal name	x-varPercent – Identifies following intervals as VAr values in % of available VArs or x-wattPercent – Identifies following intervals as watt values in % of maximum watts
		Signal 3 type		multiplier	Multiplier
		Current value		Filled in by the VTN	n/a
		Interval 1			
			Duration	Interval duration	n/a
			Payload	Value applied to signal	Curve y value #1
		Interval 2			
			Duration	Interval duration	n/a
			Payload	Value applied to signal	Curve y value #2
		Interval n			
			Duration	Interval duration	n/a
			Payload	Value applied to signal	Curve y value #n
		signal 4 name		Predefined signal name	x-rampTime
		Signal 4 type		multiplier	Time in seconds
		Current value		Filled in by the VTN	n/a
		Interval 1			
			Duration	Interval duration	n/a
			Payload	Value applied to signal	The time to accomplish a change of 95%

Volt-VAR/Volt-Watt/Frequency-Watt Curve Enable

This function will activate a specific Volt-VAR, Volt-Watt, or Frequency-Watt curve when received from the OpenADR server. The curve enable will appear as a distributeEvent message from the VTN. The data returned will consist of a curve type, a duration of how long the curve will remain enabled after being triggered, and a curve index.

To disable a curve, cancel the event.

This function has two parameters in addition to the event start time and duration:

- Curve type – The curve type is specified in the signal 1 name. The value will be voltVARCurveEnable, voltWattCurveEnable, or FreqWattCurveEnable identifying the type of curve to be enabled.
- Curve ID – A number from 1 to 4 identifying the curve to be enabled.

The oadrDistributeEvent message to support a Volt-VAR curve enable/disable has the structure shown in Table 2-2.

Table 2-2
Volt-VAR curve enable/disable event structure

Structure				Original Use	DER Use
Event				Defines a grid event	Defines a grid event
	start time			Start time for the event	Date/time value when curve will become active
	Duration			Duration of the event	Integer value in seconds giving duration for curve to be enabled. A zero in this field means to run this curve until the event is cancelled.
	Event status			Defines status of the event	Event status field is controlled by the server. The status values are near/far: the event has yet to start, active: the event is executing, complete: the event is complete, cancelled: the event was cancelled.
	Signals				
		signal 1 name		Predefined signal name	x-voltVARCurveEnable / x-voltWattCurveEnable / x-FreqWattCurveEnable – New identifier for a DER curve enable
		Signal 1 type		multiplier	n/a
		Current value		Filled in by the VTN	n/a
		Interval 1			
			Duration	Interval duration	n/a
			Payload	Value applied to signal	Integer curve number 1-4. Selects the curve to be enabled.
		Interval 2			

Table 2-2 (continued)
Volt-VAR curve enable/disable event structure

Structure				Original Use	DER Use
			Duration	Interval duration	n/a
			Payload	Value applied to signal	The start randomization time in seconds
		Interval 3			
			Duration	Interval duration	n/a
			Payload	Value applied to signal	The duration of the event in seconds
		Interval 4			
			Duration	Interval duration	n/a
			Payload	Value applied to signal	Time to move to the new mode in seconds.

Note that the sum of the durations of each signal should equal the duration of the event, so the manner in which this project uses OpenADR events violates the standard.

One issue to address is the smooth transition from one curve to another without reverting to curve 0 (disabled). See chapter 4 for details on this issue.

Ramp Rate Download

The EPRI Common Functions for Smart Inverters report defines this as "The default ramp rate of change of active power" and is provided by the parameter WGra. This ramp rate value limits the rate of change of real power delivered due to either a change by a command or by an internal action such as a schedule change. This ramp rate does not replace a specific ramp rate that may be directly set by the commands or schedules, but acts as the default if no specific ramp rate is specified. WGra is defined as a percentage of WMax per second.

This function has one parameter in addition to the event start time and duration:

- Ramp rate – The default ramp rate of change of active power.

The message has the following structure:

The oadrDistributeEvent message to support a ramp rate download has the structure shown in Table 2-3.

Table 2-3
Ramp rate download event structure

Structure		Original Use	DER Use
Event		Defines a grid event	Defines a grid event
	start time	Start time for the event	Current date and time. Assumed to take effect immediately.
	Duration	Duration of the event	Set to 1? What if this is in the past when received?

Table 2-3 (continued)
Ramp rate download event structure

Structure				Original Use	DER Use
	Event status			Defines status of the event	Event status field is controlled by the server. The status values are near/far: the event has yet to start, active: the event is executing, complete: the event is complete, cancelled: the event was cancelled.
	Signals				
		Signal 1 name		Predefined signal name	x-WGra – Identifier for a ramp rate value
		Signal 1 type		multiplier	Percent
		Current value		Filled in by the VTN	n/a
		Interval 1			
			Duration	Interval duration	n/a
			Payload	Value applied to signal	Integer percentage of the maximum real power that the DER can deliver to the grid, per second

Fixed Power Factor

This function is intended to provide a simple mechanism through which the power factor of a DER may be set to a fixed value.

To cancel an event, send a distributeEvent message with the event status set to cancel.

This function has four parameters in addition to the event start time and duration:

- Power factor – A value between -1.00 and 1.00 that is the power factor which the DER will attempt to maintain during the event.
- Power factor type – Integer value either 1 or 2. 1 = IEC Convention and 2 = IEEE Convention.
- Randomizer time – The DER will delay for a random period between zero and the randomizer time at the start and end of the event.
- Ramp time – Time over which DER linearly places the new power factor setting into effect.

Refer to chapter 8, "Fixed Power Factor Function" in the EPRI *Common Functions for Smart Inverters* report. The message has the following structure:

The oadrDistributeEvent message to support a Volt-VAR curve enable/disable has the structure shown in Table 2-4.

Table 2-4
Fixed power factor event structure

Structure				Original Use	DER Use
Event				Defines a grid event	Defines a grid event
	start time			Start time for the event	Date/time value when the supplied power factor will become active.
	Duration			Duration of the event	Duration in seconds for a fixed power factor event.
	StartAfter			Set randomization period for start of event	Set randomization period for start and end of event
	Event status			Defines status of the event	Event status field is controlled by the server. The status values are near/far: the event has yet to start, active: the event is executing, complete: the event is complete, cancelled: the event was cancelled.
	Signals				
		Signal 1 name		Predefined signal name	x-powerFactor – Identifier for a power factor value
		Signal 1 type		multiplier	Percent
		Current value		Filled in by the VTN	n/a
		Interval 1			
			Duration	Interval duration	n/a
			Payload	Value applied to signal	Float value between -1.00 and 1.00 of desired power factor
		Signal 2 name		Predefined signal name	x-pfType
		Signal 2 type		multiplier	Integer value either 1 or 2. 1 = IEC Convention and 2 = IEEE Convention
		Current value		Filled in by the VTN	
		Interval 1			
			Duration	Interval duration	n/a
			Payload	Value applied to signal	Integer value between 1 or 2. 1 = IEC Convention and 2 = IEEE Convention.
		Signal 3 name		Predefined signal name	x-rampTime
		Signal 3 type		multiplier	Time in seconds
		Current value		Filled in by the VTN	n/a
		Interval 1			
			Duration	Interval duration	n/a
			Payload	Value applied to signal	Integer – Time over which DER linearly places new PF setting into effect.

Limit Maximum Real Power

This function is intended to provide a mechanism through which the maximum real power may be limited to a percentage of the DER maximum real power. Providing a duration of zero will terminate a currently active real power limit event.

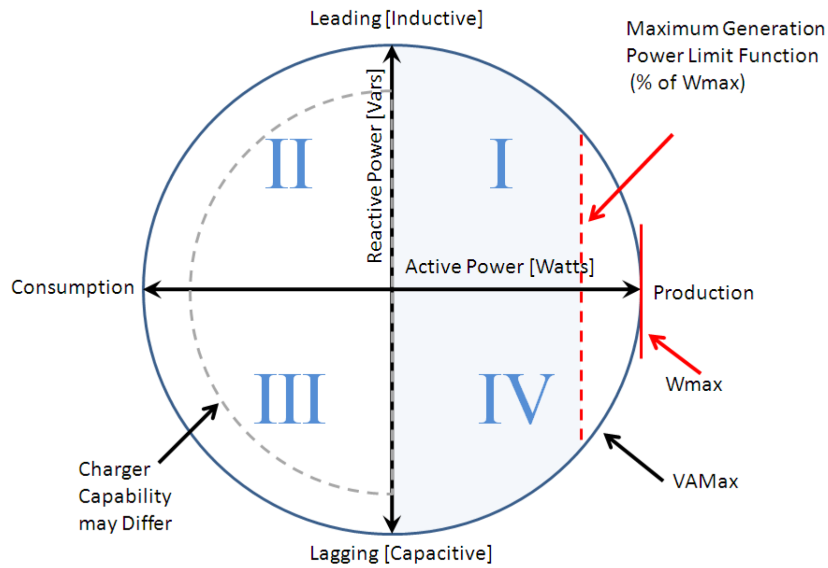

Figure 2-4
Limit Maximum Real Power

To cancel an event, send a distributeEvent message with the event status set to cancel.

This function has three parameters in addition to the event start time and duration:

- Power limit – The maximum power output to be applied to the DER in percent of maximum output.
- Randomizer time – The DER will delay for a random period between zero and the randomizer time at the start and end of the event.
- Ramp time – Time over which DER linearly places the new real power limit setting into effect.

The message has the following structure:

The oadrDistributeEvent message to support a limit maximum real power event has the structure shown in Table 2-5.

Table 2-5
Limit maximum real power event structure

Structure				Original Use	DER Use
Event				Defines a grid event	Defines a grid event
	start time			Start time for the event	Date/time value when the supplied real power limit will become active.
	Duration			Duration of the event	Duration in seconds for a real power limit event
	StartAfter			Set randomization period for start of event	Set randomization period for start and end of event
	Event status			Defines status of the event	Event status field is controlled by the server. The status values are near/far: the event has yet to start, active: the event is executing, complete: the event is complete, cancelled: the event was cancelled.
	Signals				
		Signal 1 name		Predefined signal name	x-realPowerLimit – Identifier for a real power limit value
		Signal 1 type		multiplier	Percent
		Current value		Filled in by the VTN	n/a
		Interval 1			
			Duration	Interval duration	n/a
			Payload	Value applied to signal	Value between 0 and 100 as a percentage of maximum real power output of DER
		Signal 2 name		Predefined signal name	x-rampTime
		Signal 2 type		multiplier	Time in seconds
		Current value		Filled in by the VTN	n/a
		Interval 1			
			Duration	Interval duration	n/a
			Payload	Value applied to signal	Integer – Time over which DER linearly places new real power limit setting into effect.

Connect/Disconnect

This function is intended to provide a mechanism to connect or disconnect the DER from local loads and the grid. This is intended to be a physical disconnect. It is possible to imitate this action on a DER without a disconnect switch by putting the output to zero watts. While this is not considered an acceptable solution for production units, it is workable for purposes of a demonstration. See Figure 2-5 for a graphical description of the connect/disconnect switch.

This event will connect the DER to the grid for the duration supplied, or if the duration is zero, until a distributeEvent message is received.

To cancel an event, send a distributeEvent message with the event status set to cancel. This will disconnect the DER from the grid. This function has no additional parameters beyond the event start time and duration.

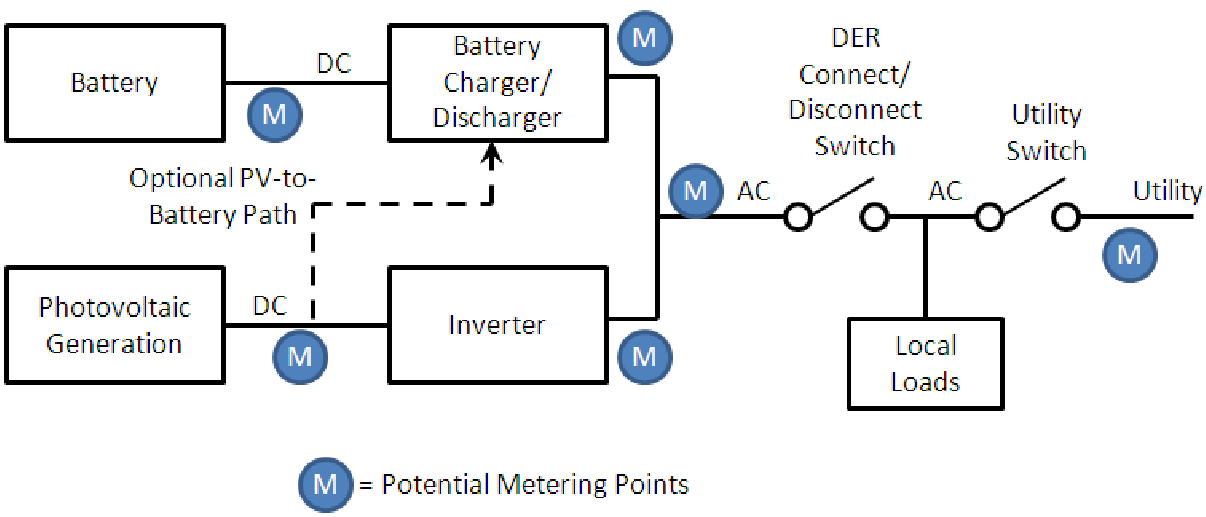

Figure 2-5
DER Connect/Disconnect switch

The oadrDistributeEvent message to support a connect/disconnect event has the structure shown in Table 2-6.

Table 2-6
Connect/Disconnect event structure

Structure				Original Use	DER Use
Event				Defines a grid event	Defines a grid event
	start time			Start time for the event	Date/time value when the supplied power factor will become active.
	Duration			Duration of the event	This will typically be sent with a duration of 0 to remain connected until cancelled.
	StartAfter			Set randomization period for start of event	Set randomization period for start and end of event
	Event status			Defines status of the event	Event status field is controlled by the server. The status values are near/far: the event has yet to start, active: the event is executing, complete: the event is complete, cancelled: the event was cancelled.
	Signals				
		Signal 1 name		Predefined signal name	x-invConnect – Identifier for a inverter connect
		Signal 1 type		multiplier	n/a
		Current value		Filled in by the VTN	n/a
		Interval 1			n/a
			Duration	Interval duration	n/a
			Payload	Value applied to signal	n/a.

This event will typically be sent with a duration of zero to stay connected until the event is cancelled.

Upload Inverter Alarms and Status

Reporting data from a VEN to a VTN is done in a three-step process. First, the VEN communicates available data to the VTN through an oadrRegisterReport message. This message describes the data types and specific data item available to be reported. It also defines the frequency at which the data is available. Second, the VTN sends a oadrCreateRequest message to the VEN, indicating what data points should be reported, how often the points should be sampled, and how often to report the data back to the VTN. Third, the VEN collects data at the specified sampling rate and reports data to the VTN at the specified interval through oadrUpdateReport messages.

The data reported by the VEN is currently defined as:

- Instantaneous real power
- Instantaneous power factor
- Interval energy readings
- Connection status
- Alarm flags

The VEN reports the interval data to the VTN using the using the oadrUpdateReport message. This is done on a specific schedule as specified in the oadrRegisterReport message mentioned above. Energy generation is captured every 5 minutes as the difference between total energy readings. All other items are sampled every 10 seconds.

The emix:itemBase element, specified in the oadrRegisterReport message, contains the units, which include power, (powerItem) and energy (energyItem). For intervals that don't have a matching unit under itemBase, customUnit is used to define one. This would include power factor, connection status, and alarms.

Custom units require specifying a description, units, and an si scale code. This implementation uses *power factor*, *connect status*, and *alarm status* for descriptions, and the units and si scale code are *none*. The structure for reporting all of the intervals is the same for custom and built in units (such as powerItem and energyItem).

The alarms are configured to report on a minimum time schedule and on state change. The on-change flag indicates the data point is only captured when the status changes. The OpenADR register report is detailed in Table 2-7.

Table 2-7
OpenADR Register Report

SunSpec Interval	OpenADR rID	emix Units	OADR SiScaleCode	Min/max sample period
Instantaneous real power Instantaneous power factor	power	PowerReal	none	PT10S/PT10S
Energy (5 min)	energy	EnergyReal	none	PT5M/PT5M
Connection status	connect status	Custom	none	PT10S/PT10S
Alarms	alarm flags	Custom	none	PT10S/PT10S

3
OPENADR TO SUNSPEC LIBRARY MAPPING

Function Mapping

This section defines the mapping between UCM OpenADR routines and the SunSpec C library. The calling functions in OpenADR are located in in the CommunicationsManager.cpp source file and handle the mapping to the specific SunSpec library functions. The main entry point into the SunSpec library is in the file inverter.c. The functions called out in Table 3-1 mapping are located there.

Table 3-1
OpenADR to SunSpec Function Map

OpenADR Function	SunSpec function in Inverter.c
Set default ramp rate	inv_set_wgra(m_device, wgra)
Set Volt-VAr curve	inv_volt_var_set_curve(m_device, index, curve)
Enable Volt-VAr curve	inv_volt_var_enable(m_device, act_crv, timers)
Disable Volt-VAr curve	inv_volt_var_disable(m_device)
Set Volt-Watt curve	inv_volt_watt_set_curve(m_device, index, curve)
Enable Volt-Watt curve	inv_volt_watt_enable(m_device, act_crv, timers)
Disable Volt-Watt curve	inv_volt_watt_disable(m_device)
Set Freq-Watt curve	inv_freq_watt_set_curve(m_device, index, curve)
Enable Freq-Watt curve	inv_freq_watt_enable(m_device, act_crv, timers)
Disable Freq-Watt curve	inv_freq_watt_disable(m_device)
Get Status	inv_volt_var_get_status(m_device, mod)
Enable Fixed Power Factor	inv_set_fixed_pf(m_device, fixed_pf)
Limit Maximum Real Power	inv_set_max_power(m_device, max_power)
Connect/Disconnect	inv_set_connect(m_device, connect)
Get Status	inv_get_connect(m_device, connect)
Get Status	inv_get_status(m_device, status)

The structures of the passed parameters are located in inverter.h. The full source code of the SunSpec c library can be downloaded from https://github.com/sunspec.

4 IDENTIFIED ISSUES

Signal Types Limitation

Note that new signal names can be created and are preceded by "x-." The OpenADR Alliance did not provide for adding custom signal types, so in many cases the signal type does not appear to conform to the signal name. This will not impact the function since the signal name is sufficient to determine the use of the payload.

Another limitation is that the payload values are always floating point numbers.

Smooth Transition between Curves

A more difficult problem to overcome is that two events cannot be active at the same time or even directly adjacent. This means that to switch from Volt-VAR curve 2 to Volt-VAR curve 3, it is necessary to first terminate the Volt-VAR event, disabling all Volt-VAR effects; then, after a delay, a new Volt-VAR event can be created for the desired curve.

There is a possible work around by keeping the original Volt-VAR event running and changing only the curve. The drawback to this is that there is no randomization, so all DERs receiving this message would switch at the same time.

Active Event Limitation

The OpenADR specification states that there cannot be overlapping events in the same market context, and this will be enforced by the VTN. Also, a VEN should not have two active events at the same time and be responding to both, although there is nothing in the specification to enforce this expectation. If a VEN receives overlapping events from different market contexts, the VEN can choose how to handle any conflicts. While an event with a higher priority should take precedence in a case where only one can be active, there is nothing that would prevent a VEN from responding to multiple events simultaneously where this does not cause functional conflicts.

For example, a Volt-VAR curve enabled event could be active at the same time as a real power limit event. However, a Volt-VAR curve enabled event could not coexist with a fixed power factor event. This limitation will require careful mapping of event types to specific market contexts to ensure that event types that cannot operate together are in the same context, while ones that need to operate in concert are in a different context. The market context is a string field in the EventDescriptor and can be easily edited.

5
REFERENCES

The following documents were used in the preparation of this report:

1. OpenADR 2.0 Profile Specification B Profile. OpenADR Alliance. Document Number: 20120912-1.
2. *Common Functions for Smart Inverters, Version 3*. EPRI, Palo Alto, CA: 2014. 3002002233. [technical update]

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