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SMART INVERTER SETTINGS SHEETS

LUMA Energy publishes the Technical Bulletin 2024-001 to provide supporting technical information to the current regulation, *Regulation for the Interconnection of Generators with the Distribution System of the Puerto Rico Electric Power Authority and to Participate in Net Metering Programs*, Regulation No. 8915, February 6, 2017. This bulletin seeks to apply the IEEE 1547-2018 standard for smart distributed energy resources (DERs) settings. Regulation 8915 in its Article of Control and Protection, #2 indicates that "In addition to the requirements contained in this Section, the customer's DG must comply with applicable standards, including, but not limited to, IEEE 1547, IEEE 519 and IEEE/ANSI C37.90 (Standard for Relays and Relay Systems Associated with Electric Power Apparatus)".

The main purpose of adopting the requirements in this bulletin is to improve the system stability and operations under high penetration of DERs. Starting **June 1, 2024**, all new Net Energy Metering applications must meet the default setting requirements that are specified in this bulletin.

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1. Required Smart Inverter Functions

Smart Inverters must be (a) set to conform to the default setting requirements and (b) capable of performing the default functions, both provided in this document, "Smart Inverter Settings Sheets", as applicable.

Customers must comply with the requirements set forth in this "Smart Inverter Settings Sheets" or, any alternative Smart Invert settings and functions that may be defined in the interconnection agreement. Any alternative settings and functions defined in the interconnection agreement will take precedent and override the default settings requirements and functions provided in this document. Notwithstanding the preceding provisions of this "Smart Inverter Settings Sheets", customer's Smart Inverter(s) shall conform with the requirements and functions required pursuant to interconnection agreement.

1.1. Communication Requirements

Table 1-1 lists minimum communication requirements for Smart Inverters connected to the distribution system.

Table 1-1- Minimum Requirements for Communication and Interface

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

1.2. Control Modes

Table 1-1 lists control modes that must be supported by Smart Inverters as well as default status of each control mode.

Table 1-2- Smart Inverter Control Modes

Applicable to Retail Customers Interconnected			
Mode of Operation	**Required/Optional**	**Description**	**Default Activation Status**
Anti-Islanding	Required	Refers to the ability to detect loss of utility source and cease to energize	Activated
Adjustable constant power factor	Required	Refers to Power Factor set to a fixed value.	Deactivated
Adjustable Constant Reactive Power	Required (If available)	Refers to Reactive Power set to a fixed value	If capable, deactivated
Voltage Ride through	Required	Refers to ability of Smart Inverter to ride through a certain range of voltages before tripping off	Activated
Frequency Ride through	Required	Refers to ability of Smart Inverter to ride through a certain range of frequencies before tripping off	Activated
Voltage – Reactive (Volt/Var)	Required	Refers to control of reactive power output as a function of voltage	Activated
Voltage – Active Power (Volt/Watt)	Required (If available)	Refers to control of real power output as a function of voltage	Activated
Frequency - Watt	Required (If available)	Refers to control of real power as a function of frequency	If capable, deactivated
Ramp Rates	Required	Refers to ability to have an adjustable entry service ramp rate when a DER restores output of active power or changes output levels over the normal course of operation.	Activated

2. Smart Inverter Function Settings

This section lists the required settings for smart inverter functions.

2.1. Anti-Islanding Settings

Smart Inverters shall detect the unintentional island and trip as specified in Table 2-1.

Table 2-1- Responses to Islanding and Open Phase Conditions - ACTIVATED

Applicable to Retail Customers Interconnected	
Condition	**Maximum Trip Time (s)**
Islanding/Open Phase	2

2.2. Voltage Settings

2.2.1. Voltage Trip Settings

Smart Inverters shall meet the abnormal voltage response requirements, as specified in Table 2-2.

Table 2-2- Smart Inverter Response to Abnormal Voltage

Voltage Trip Settings	Default Voltage (pu)	Adjustable Range for Voltage (pu)	Default Trip/Clearing Time (s)	Adjustable Range for Trip Time (s)
Over Voltage 2 (OV2)	V ≥ 1.2	0.16	Fixed at 1.2	Fixed at 0.16
Over Voltage 1 (OV1)	V ≥ 1.1	1.1 - 1.2	13	1 - 13
Under Voltage 1 (UV1)	V ≤ 0.88	0 - 0.88	21	11 - 50
Under Voltage 2 (UV2)	V ≤ 0.5	0 - 0.5	2	2 - 21

2.2.2. Voltage Ride-Through Settings

Smart Inverters shall meet the Low/High Voltage Ride-Through requirements, as specified in Table 2-3.

Table 2-3- Low/High Voltage Ride-Through Minimum Requirement – ACTIVATED

Voltage Ride-Through Settings	Voltage Range (pu)	Smart Inverter Response (Operating Mode)	Maximum Response Time (s)	Minimum Ride Through Time (s)
High Voltage 2 (HV2)	V ≥ 1.2	Cease to Energize	0.16	N/A
High Voltage 1 (HV1)	1.1 ≤ V ≤ 1.2	Momentary Cessation	0.083	12
Near Normal Voltage (NNV)	0.88 ≤ V ≤ 1.1	Continuous Operation	N/A	Infinite
Low Voltage 1 (LV1)	0.7 ≤ V ≤ 0.88	Mandatory Operation	N/A	20
Low Voltage 2 (LV2)	0.5 ≤ V ≤ 0.7	Mandatory Operation	N/A	10
Low Voltage 3 (LV3)	V ≤ 0.5	Momentary Cessation	0.083	1

2.3. Frequency Settings

2.3.1. Frequency Trip Settings

Smart Inverters shall meet the abnormal frequency response requirements, as specified in Table 2-4.

Table 2-4- Smart Inverter Response to Abnormal Frequency

Frequency Trip Settings	Default Frequency (Hz)	Adjustable Range for OF1 (Hz)	Default Trip/Clearing Time (s)	Adjustable Range for Trip Time (s)
Over Frequency 2 (OF2)	f ≥ 62	61.8 - 66	0.16	0.16 - 1000
Over Frequency 1 (OF1)	f ≥ 61.2	61.2 - 66	300	21 - 1000
Under Frequency 1 (UF1)	f ≤ 58.5	50 - 58.8	300	21 - 1000
Under Frequency 2 (UF2)	f ≤ 57	50 - 57	0.16	0.16 - 1000

2.3.2. Frequency Ride-Through Settings

Smart Inverters shall meet the Low/High Frequency Ride-Through requirements, as specified in Table 2-5.

Table 2-5- Low/High Frequency Ride-Through Minimum Requirement – ACTIVATED

Frequency Ride-Through Settings	High Frequency Range (Hz)	High Smart Inverter Response (Operating Mode)	Minimum Ride Through Time (s)
High Frequency 2 (HF2)	f ≥ 62	N/A	N/A
High Frequency 1 (HF1)	61.2 ≤ f ≤ 62	Mandatory Operation	299
Near Normal Frequency (NNF)	58.8 ≤ f ≤ 61.2	Continuous Operation	Infinite
Low Frequency 1 (LF1)	57 ≤ f ≤ 58.8	Mandatory Operation	299
Low Frequency 2 (LF2)	f ≤ 57	N/A	N/A

2.4. Voltage-Reactive Power Control Mode Settings

An example Volt-Var characteristic is shown in Figure 2-1. The voltage-reactive power characteristic shall be configured in accordance with the default parameter values specified in Table 2-6.

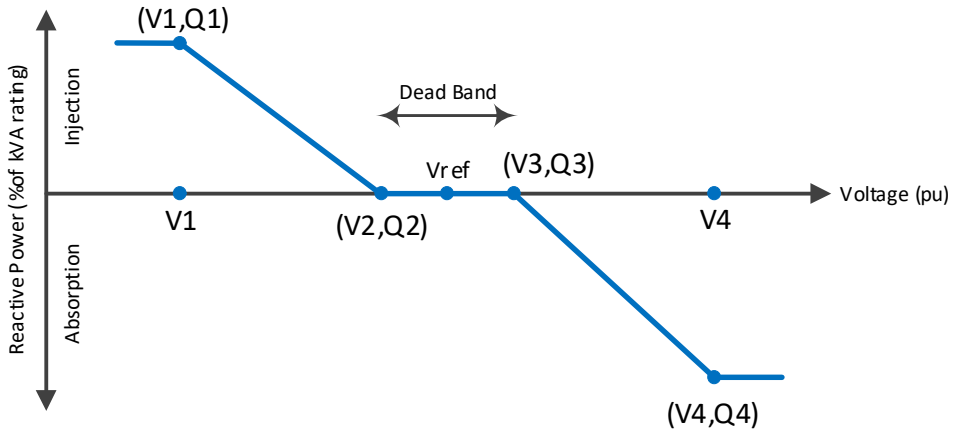

Figure 2-1. Example Volt-Var characteristic

Table 2-6- Volt-Var Settings – ACTIVATED

Volt-Var Parameters	Definitions	Default Values (% of nominal rating)	Allowable Range	
			Minimum	Maximum
Vref	Dead band center	VN	95% VN	105% VN
V2	Dead band lower voltage limit	98% VN	Vref – 3%VN	Vref
Q2	Reactive power injection or absorption at voltage V2	0	maximum reactive power capability, absorption	maximum reactive power capability, injection
V3	Dead band upper voltage limit	102% VN	Vref	Vref + 3%VN
Q3	Reactive power injection or absorption at voltage V3	0	maximum reactive power capability, absorption	maximum reactive power capability, injection
V1	Voltage at which DER shall inject Q1 reactive power	92% VN	Vref – 18%VN	V2 – 2%VN
Q1[(1)]	Reactive power injection at voltage V1	44%	0	maximum reactive power capability, injection
V4	Voltage at which DER shall absorb Q4 reactive power	108% VN	V3 + 2%VN	Vref + 18%VN
Q4[(1)]	Reactive power absorption at voltage V4	44%	maximum reactive power capability, absorption	0
Open loop response time	Time to 90% of the reactive power change in response to the change in voltage	5 sec	1 sec	90 sec

[(1)] This requires that the Smart Inverter operates with a reactive power priority and generate/absorb reactive power to the ranges specified in this table irrespective of active power production.

2.5. Voltage-Active Power Control Mode Settings

Two examples of these characteristics are shown in Figure 2-2. The characteristic shall be configured in accordance with the default parameter values specified in Table 2-7.

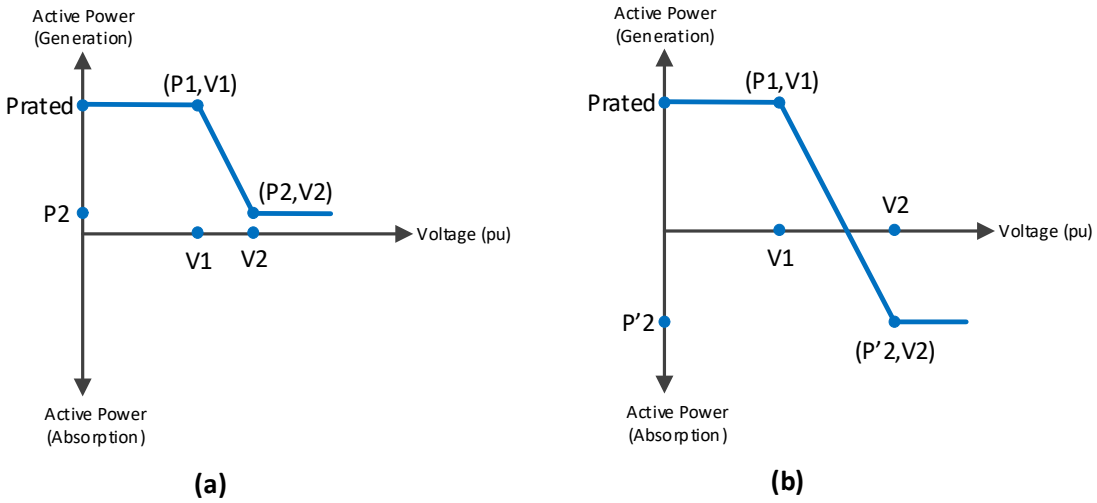

Figure 2-2. Example Volt-Watt characteristics

Table 2-7- Volt-Watt Settings – ACTIVATED

Voltage-active power parameters	Default Settings	Ranges of allowable settings	
		Minimum	Maximum
V1	106% VN	105% VN	109% VN
P1	P_{RATED}	NA	NA
V2	110% VN	V1 + 1% VN	110% VN
P2 (applicable to DER that can only generate active power)	The lesser of 0.2 P_{RATED} or P_{MIN}[(1)]	P_{MIN}	P_{RATED}
P'2 (applicable to DER that can generate and absorb active power)	0	0	P'_{RATED}[(2)]
Open-loop response time	10 sec	0.5 sec	60 sec

[(1)] P_{MIN} is the minimum active power output in p.u. of the DER rating (i.e., 1.0 p.u.).
[(2)] P'_{RATED} is the maximum amount of active power that can be absorbed by the DER.

2.6. Ramp Rate Settings

The following is the ramp-rate requirement during normal and reconnection operation of Smart Inverters:

- Normal ramp-up rate: For transitions between energy output levels over the normal course of operation, the default value is 100% of maximum current output per second with a range of adjustment between 1% to 100%.
- Connect/Reconnect Ramp-up rate: Upon starting power into the grid, following a period of inactivity or a disconnection, the inverter shall wait for 300 seconds before reconnecting and shall be able to control its rate of increase of power from 1 to 100% maximum current per second. The default value is 2% of maximum current output per second. The maximum active power step during restoring output is 20%