SUNPOWER

EQUINOX™

INSTALLATION GUIDE

February 2018

1.0 Overview and Scope

This guide describes how to install SunPower Equinox ("the system"). Do not attempt any aspect of the installation until you have thoroughly read this *entire* guide. Failure to follow these instructions can result in personal injury or equipment damage or failure, and may void the system warranty.

The system ships with the following components:

- SunPower AC modules and accessories (including extension cables)
- SunPower InvisiMount™ mounting system
- SunPower EnergyLink™ monitoring system

1.1 Safety and Warnings for Type C and Type D AC Modules

IMPORTANT SAFETY INSTRUCTIONS – SAVE THESE INSTRUCTIONS!

All personnel must adhere to the following safety procedures when working with the system, including inspection, installation, operation, service work, repair, and testing. Failure to comply with these precautions or with specific warnings elsewhere in this guide may violate safety standards of design, warranty, manufacture, and intended use of the equipment. SunPower assumes no liability for failure to comply with these requirements.

Warning! The installation, adjustment, or repair of a solar system involves the risk of contact with potentially lethal voltages and currents.

SunPower Type C and Type D AC modules meet all current requirements for rapid shutdown as defined in NEC *690.12 Rapid Shutdown of PV Systems on Buildings*. As part of the UL 1741 SA / UL 1741 Listing of the SunPower AC module product being grid support utility interactive, upon turning off the AC disconnect to de-energize the circuit to the AC modules on the roof, each AC module output will shut off within 2.0 seconds to comply with IEEE 1547. In this manner, all wiring leaving each AC module complies with the controlled conductor limits in 690.12.

Follow all applicable laws, including state and federal Occupational Safety and Health Administration (OSHA) standards when working on any construction project. Always reference the National Fire Protection Agency (NFPA) 70E, *Standard for Electrical Safety in the Workplace* when performing electrical work.

Perform the installation in accordance with all applicable codes. In addition, reference NEC Articles 250 and 690—as well as applicable IEC standards—for proper compliance when wiring and grounding the system. All state and federal guidelines and regulations must be followed as well.

1.1.1 Site Safety

- These installation instructions are for use by qualified personnel only.
- System access is intended for authorized personnel only.
- Only authorized persons may shut down the system or open any system enclosure.
- To reduce the risk of fire, connect only to a dedicated circuit that has overcurrent protection not exceeding the maximum value stated in the product's Listing (20 A) in accordance with the NEC, ANSI/NFPA 70. **Maximum dedicated branch circuit overcurrent protection: 20 A.**
- The metal components of the module can reach temperatures of approximately 176°F (80°C). Use appropriate safety procedures when handling modules.

1.1.2 General Warnings

- Do not attempt to service any portion of the system.
- Do not attempt installation during conditions involving rain, snow, ice, or high winds.
- Do not attempt to install or service the system if you are not a qualified, trained electrician or technician familiar with power electronic equipment.
- Always wear rubber insulating gloves rated for the appropriate voltage level, and suitable eye and head protection when working near live electrical equipment.
- Always have a cell phone available for calling emergency personnel.

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

Note: Perform all electrical installations in accordance with any local codes and the National Electrical Code (NEC).

1.2 Installer Responsibilities

Warning! If installing the Equinox system on a metal roof, you must verify with the AHJ whether additional bonding to the roof is required. Follow the instructions provided by the AHJ and by the roofing manufacturer.

SunPower Equinox is for residential 240 V split single-phase and 208 V three-phase wye double-pole applications only.

Installers are solely responsible for specific aspects of the system they are installing:

- Selection and verification of design parameters, including wind and snow load and all related aspects.
- Validation of third-party roof attachment design and interoperability, including any stipulations for rail overhang (cantilever) beyond the last roof attachment (standoff) at the end of a row. Use the SunPower Design Tool (https://invisimountdesign.us.sunpower.com/login.html) OR the *InvisiMount Span Tables* document (#524734) to verify spans between roof attachments and maximum cantilever. (Access the Tool by logging into the Portal and then clicking the *Design Tool* link.)
- Code compliance and permitting.
- Vetting system compatibility with the installation site and structures.
- Verifying the roof integrity prior to installation.
- Selecting the correct attachment and flashing type for the particular roof.
- Care of the roof during the installation.

1.3 Tools, Equipment, Components, and Torque Values

1.3.1 Tools

The following tools are required to install the system:

Tool	Task
10 mm and 15 mm deep sockets	Attaching L-foot nuts, mid clamps, end clamps, splices, and splice screws
Assorted screwdrivers and wire strippers	General electrical wiring
Caulk gun	Installing rooftop transition flashing
CHANNELLOCK® pliers (or equivalent)	Tightening fittings on rail-mounted J-box and rooftop transition flashing
Claw hammer	Installing rooftop transition flashing
Cordless drill with electrical conduit knockout tool or hole saw	Drilling holes in rooftop transition flashing and rail-mounted J-box
Flathead screwdriver	Removing and installing rail-mounted J-box cover
Metal saw	Cutting rails
Roofing bar	Installing rooftop transition flashing
Rubber mallet	Removing end clamp
Torque wrench	Verifying fastener torque
Utility knife	Installing rooftop transition flashing
In addition, ensure that you have all necessary tools to install your chosen roof attachments!	

1.3.2 Equipment

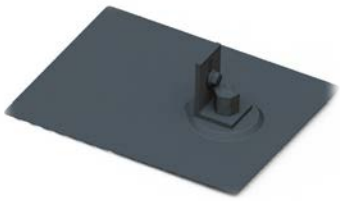
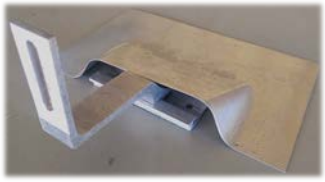
All applicable personal protective equipment (PPE) is always required, including:

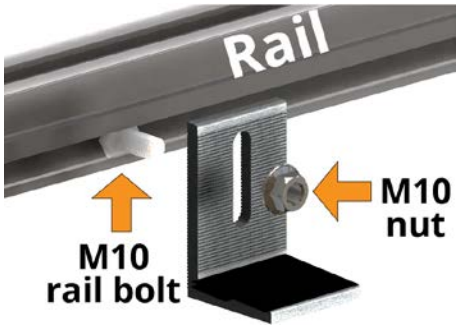
- Fall protection
- Gloves
- Safety glasses
- Hard hat
- Appropriate footwear
- All appropriate electrical PPE

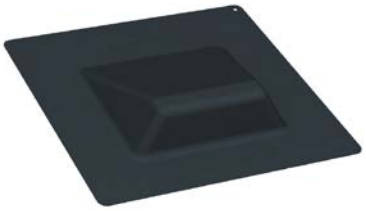
1.3.3 Components

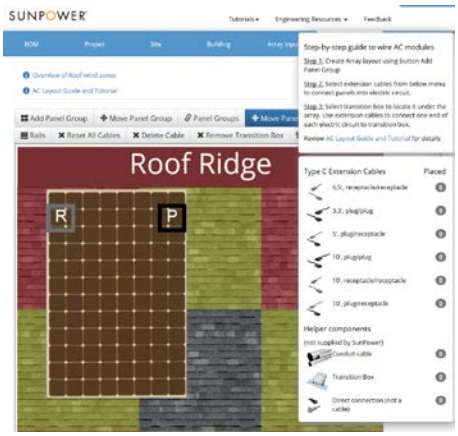
Important! SunPower requires that you use a torque wrench—*not an impact driver*—to enforce consistent fastener tightness and thereby ensure safe, high-quality installations.

Component		Definition	Tool and Torque
AC module		An assembly that includes a photovoltaic glass panel, a microinverter, a robust frame, and two electrical leads.	See *Mid clamp* and *End clamp*
AC rail clip (optional)		Attaches to rails and helps to support *a single* AC cable above the lower edge of the rails.	n/a
Disconnect tool		Unlocks AC cable plug–receptacle pairs after they have been connected.	n/a
End cap		Fits into the plug or the receptacle of the last module in a circuit. **Note:** The caps are different for plugs and receptacles.	n/a
End clamp		Module-to-rail fastener that fits into the end of a rail, clamps to secure each of the endmost modules in a given row, and provides equipment bonding from modules to the rail.	• 10 mm deep socket • 85 +5/−0 in-lb (9.6 N-m)
Extension cable		Premanufactured AC cables that enable connecting of non-adjacent AC modules.	n/a (*See* Disconnect tool)

Component		Definition	Tool and Torque
		Extension cables contain identical conductor composition as the built-in AC module cables (three-conductor, 12 AWG, type TC-ER), and are available in several lengths, with plug–plug, receptacle–receptacle, or plug–receptacle connector pairs. Cables are UL Recognized and conform to UL 6703 and UL 9703. The cable outside diameter is 11.2 mm (0.44 in).	
Flashing	 	Thin sections of material that are installed between the roof substrate and any rooftop penetration in order to prevent water from penetrating the roof. **Note:** Shown with with SunModo's roof attachment and L-foot for composition shingle roofs; and with their tile hook mount—separate components all available from SunPower.	n/a
L-foot		L-shaped bracket that provides interface between the roof attachment and the rail; typically made of stainless steel or aluminum.	Refer to the roof attachment manufacturer guidance. If using a roof attachment other than L-feet, refer to that attachment manufacturer guidance.

Component		Definition	Tool and Torque
L-foot bolt and nut		Hardware that secures the rail to the L-foot (or to the chosen roof attachement): **Bolt:** M10-1.5 × 25 mm DIN 933 SS304 **Nut:** M10-1.5 DIN 6923 SS304	• 10 mm deep socket • 375 +20/−0 in-lb (42 +2/−0 N-m)
Mid clamp		Module-to-rail fastener that attaches in the top rail channel; secures module frames; and provides equipment bonding between modules and the rail.	• 10 mm deep socket • 85 +5/−0 in-lb (9.6 N-m)
Plug		The AC cable connector end that has tabs on either side. **Note:** SunPower AC cable connectors are an approved means of disconnect.	n/a
Rail		Extruded aluminum component that attaches to the L-feet and supports clamped modules. Each rail section is 10′ 9″ (3.28 m) long.	For the nuts that fit onto the bolts which slide into the side channel: • 15 mm deep socket • 375 +20/−0 in-lb (42 +2/−0 N-m)
Rail-mounted J-box (optional)		Junctions array circuits on the roof; attaches to a rail with no tools.	For cover screws: • flathead screwdriver • 16 in-lb (1.8 N-m)

Component		Definition	Tool and Torque
Receptacle		The AC cable connector end that does not have tabs. **Note:** SunPower AC cable connectors are an approved means of disconnect.	n/a
Rooftop transition flashing (optional)		Installs on the rooftop and enables wiring to transition between the rooftop and the building interior. **Note:** If you are not using a transition box such as a SolaDeck™ enclosure, use the rooftop transition flashing along with the rail-mounted J-box (or attic-mounted J-box) to transition between building wiring and array wiring.	• Utility knife • Roofing bar • Caulk gun • Claw hammer • Drill with conduit knockout tool or hole saw • Two CHANNELLOCK tongue & groove pliers (or equivalent)
Row-to-row (R2R) spacer		Plastic spacer that snaps into the exterior module frame and uniformly enforces the distance between rows of adjacent modules.	n/a
Splice		Extruded aluminum connector that, along with splice screws, joins two rails.	*See* Splice screw
Splice screw		Black oxide coated stainless steel fastener that, in conjunction with a splice, attaches two sections of rail together.	• 10 mm deep socket • 40 +5/−0 in-lb (4.5 N-m)

Component		Definition	Tool and Torque
SunPower Design Tool		Enables complete array design online as well as providing the bill of materials for the array. invisimountdesign.us.sunpower.com/bom/index.html Access the Tool from the Portal.	n/a

1.3.4 EnergyLink Monitoring Components

Term		Definition
EnergyLink™ Monitoring		SunPower's proprietary monitoring solution that enables partners and customers to easily understand and view both system production and home energy consumption.
PVS5x		PV Supervisor 5x; commnicates with the AC modules to monitor system performance and transmit data to SunPower servers.

1.3.5 Torque Values

Fastener	Final Torque
End clamp	85 +5/−0 in-lb (9.6 N-m)
Mid clamp	
L-foot to rail nuts	375 +20/−0 in-lb (42 +2/−0 N-m)
Rail splice screws	40 in-lb (4.5 N-m) (This torque value is achieved by 1/3 turn of the screw after the screw face has contacted the rail face. After tightening in this manner, verify the applied torque with a torque wrench.)
L-foot to roof attachment	Refer to the roof attachment manufacturer's documentation (included in the roof attachment box). If using a roof attachment other than L-feet, refer to that attachment manufacturer's included documentation.

1.4 Listings, Classification, and FCC and IC Compliance

Important! This guide assumes you are installing **AC** modules on InvisiMount as part of a SunPower Equinox system; if you are installing **DC** modules on InvisiMount, do not use this guide—instead use the *InvisiMount Residential Mounting System Installation Guide.*

The InvisiMount system is UL 2703 Listed. For the most recent information, refer to the UL database http://database.ul.com/QHYZ.E478330. At the time of publication of this guide (*#518101 RevD*), the Listing **includes** the following SunPower Type C and Type D AC modules:

- SPR-X22-360-C-AC
- SPR-X21-345-C-AC
- SPR-X21-335-C-AC
- SPR-X21-335-BLK-C-AC
- SPR-X20-327-BLK-C-AC
- SPR-X20-327-C-AC
- SPR-E20-327-C-AC
- SPR-E19-320-C-AC

- SPR-X22-370-D-AC
- SPR-X22-360-D-AC
- SPR-X21-350-BLK-D-AC
- SPR-X21-345-D-AC
- SPR-X21-335-BLK-D-AC
- SPR-X21-335-D-AC
- SPR-X20-327-BLK-D-AC
- SPR-X20-327-D-AC
- SPR-E20-327-D-AC
- SPR-E19-320-D-AC

Grounding from the module to the rail is accomplished through both the mid clamp and the end clamp. The InvisiMount Listing also includes the following components, which have been evaluated for both mounting and bonding in accordance with UL 2703:

- end clamp
- mid clamp (UL 2703 Listing is also valid if a mid clamp is used as an alternative to an end clamp)
- rail
- splice and splice screw
- L-foot

1.4.1 Fire Classification

- The maximum distance between the roof deck and the bottom of the module frame is 3” (7.6 cm).
- In order to maintain the system classification, this assembly must be mounted over a fire resistant roof covering for the application.
- The system achieves a Class A fire rating when installed with modules having a Type 2 fire classification.
- The system achieves a Class A fire rating when installed in the manner specified in these instructions.
- The system was evaluated for use on roofs having a pitch ≥ 2"/foot (greater than or equal to 2:12).

1.4.2 FCC and IC Compliance

Note: For PVS5x FCC and compliance information, refer to Section 2.1.2.

The microinverter built into each AC module has been tested and fully complies with Federal Communication Commission (FCC) Part 15 Class B for digital devices; as well as Industry Canada (IC) Interference-Causing Equipment Standard ICES-003 Class B. The regulations in FCC Part 15 are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses, and can radiate radio frequency energy, and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications.

1.5 Rapid Shutdown, System Grounding, NEC Compliance, Ground Path, and Disconnects

Warning! If installing the Equinox system on a metal roof, you must verify with the AHJ whether additional bonding to the roof is required. Follow the instructions provided by the AHJ and by the roofing manufacturer.

This section is intended to provide a well-rounded understanding of all aspects of rapid shutdown, grounding, disconnect requirements, and NEC compliance for SunPower Equinox.

1.5.1 Rapid Shutdown

SunPower Type C and Type D AC modules meet all 2014 and 2017 NEC requirements for rapid shutdown as defined in NEC *690.12 Rapid Shutdown of PV Systems on Buildings*. As part of the UL 1741 SA / UL 1741 Listing of the SunPower AC module product being grid support utility interactive, upon turning off the AC disconnect to de-energize the circuit to the AC modules on the roof, each AC module output will shut off within 2.0 seconds to comply with IEEE 1547. In this manner, all wiring leaving each AC module complies with the controlled conductor limits in 690.12.
Refer to Section D.1, D.2, and D.3 for the Rapid Shutdown Certificates of Compliance.

1.5.2 System Grounding

The InvisiMount system is Listed to UL 2703 for integrated grounding; SunPower AC modules are an electrical bonding component and are Listed to UL 1741 SA / UL 1741; thus no additional grounding hardware, lugs, or copper wire are required on the roof.

- The SunPower AC module is one of the components that electrically bonds all of the metallic non-current carrying components in the system, and is Listed to UL 1741 SA (Type D AC modules) / UL 1741 (Type C AC modules).
- Only *AC* equipment grounding requirements apply when installing Listed AC modules to racking that is Listed to UL 2703—*neither DC system grounding requirements (GEC) nor DC equipment grounding requirements (EGC) apply.*
- The equipment grounding conductor (EGC) that is built into and Listed with the AC module cable system is sized appropriately and meets all of the AC equipment grounding requirements for the system.
- The AC dedicated branch circuit wiring from the distribution panel to the array must include an equipment grounding conductor (EGC) in the same raceway or cable as the AC circuit conductors. This EGC must be connected to the green conductor of the transition cable, which is part of the AC module cable system.
- The AC module connectors (plugs and receptacles) are rated for disconnect, both under load and not under load.
- A grounding electrode conductor (GEC) for the module or array is not required because the DC power is internal to the AC module. The existing AC GEC at the premises or structure utility service serves as the NEC-required GEC for the AC module system.
- The AC cable grounding path has been tested by UL, and its electrical continuity from the AC cable ground pin to the module frame has been evaluated as part of the AC module Listing.
- The AC module interconnecting cable system provides an internal EGC for grounding the AC modules.
- Neither the AC modules nor the array require a GEC. The AC module must be connected to a dedicated AC branch circuit with an appropriately sized equipment grounding conductor (EGC). The EGC must be connected to a grounding electrode using the existing premises wiring system, typically originating at the building service entrance or service panel.
- The AC interconnecting cable system attached to each module's microinverter is fully insulated and includes an internal EGC. The grounding pin is longer than the others in the plug, providing a "first-make, last-break" connection sequence.
- The green conductor in the AC cable is connected to the EGC from the utility dedicated branch circuit ("the building ground").

- The AC ground wire inside the microinverter terminates on the microinverter chassis with a bolted connection, and is environmentally sealed; and the microinverter chassis is bonded to the module frame with stainless steel hardware to provide ground continuity to the module frame.
- **If a module is removed from a circuit (for service or replacement, for example), remember that the AC module cable system is daisy-chained and that therefore you must first disconnect all power and then install a temporary EGC to bridge the gap by inserting an AC extension cable or other means, in order to maintain effective ground continuity to subsequent modules. Disconnecting a module from the circuit removes voltage and might also remove ground from the other downstream modules in the circuit. Extreme care should be taken to ensure that no other energized sources are adjacent to these ungrounded modules.** Refer to Appendix B.

Each SunPower AC module includes a factory-integrated microinverter (MI) that does not require a neutral wire to be connected to it for operation or for compliance with IEEE 1547. Power produced is conducted on the L1–L2 240 VAC or 208 wye VAC grid connection. Utility interactive functions in the MI circuitry have been evaluated to IEEE 1547, and use the ground wire instead of the neutral to determine grid values. This functionality is part of its UL Listing.

This product must only be connected to a single-phase system (L–L) of a premises with the neutral (N) bonded to ground at the service entrance per code. (The MI does not reference the N to ground internally, therefore this reference must be accomplished only at the service entrance.) Ensure that the installation site has a high-quality N-to-ground reference at the service. The MI determines L–N voltages based on measuring internally from L to the MI chassis, which is connected to the EGC.

1.5.3 NEC Compliance

The following are the grounding-related NEC Articles and their applicability to SunPower Equinox:

The following are the grounding-related NEC Articles and their applicability to SunPower Equinox:

- **690.11** pertains to DC arc fault circuit protection and is not applicable to SunPower Equinox.
- **690.12** requires rapid shutdown; SunPower AC modules (the heart of Equinox) meet all requirements for rapid shutdown as defined in NEC *690.12 Rapid Shutdown of PV Systems on Buildings*. As part of the UL 1741 SA / UL 1741 Listing of the SunPower AC module product being utility interactive, upon turning off the AC disconnect to de-energize the circuit to the AC modules on the roof, each AC module output will shut off within 2.0 seconds to comply with IEEE 1547. In this manner, all wiring leaving each AC module complies with the controlled conductor limits in 690.12.
- **690.31(D)** requires that the equipment be grounded using an equipment grounding conductor (EGC) inside the AC module cable. Equinox AC cables are compliant because they do include this EGC.
- **690.41** does not apply to AC modules. This section applies to the grounding of DC circuits (e.g., positively grounded PV systems). As such, it applies to photovoltaic source circuits or photovoltaic output circuits. Per 690.6, the output of an AC module is an *inverter* output circuit and therefore the requirements of 690 that pertain to photovoltaic source circuits or output circuits do not apply to AC modules.
- **690.42** does not apply to AC modules for the same reasons 690.41 does not.
- **690.43** covers equipment grounding, which is the only required type of grounding for an AC module. SunPower Equinox fully complies with the relevant portions of 690.43:

- 690.43**(A)** – SunPower Equinox is grounded when installed according to the instructions and connected to an equipment grounding conductor bonded to the premises grounding electrode system.
- 690.43**(B)** – SunPower Equinox requires the installation of an equipment grounding conductor between the array and other equipment (typically originating at the rooftop junction box and terminating at the grounding busbar or terminal in the main service panel).
- 690.43**(C)** – InvisiMount end clamps and mid clamps are Listed and identified for bonding module frames to rails.
- 690.43**(D)** – InvisiMount end clamps and mid clamps are Listed and identified for bonding module frames to rails.
- 690.43**(E)** – InvisiMount mid clamps are identified for the purpose of grounding modules.
- 690.43**(F)** – The integrated AC module cable and AC module extension cables do include an equipment grounding conductor.

- **690.45** specifies that EGCs should be sized based on 250.122. Equinox meets this requirement by including a 12 AWG equipment grounding conductor. The EGC in every AC module cable is 12 AWG. The maximum overcurrent protection for an AC module circuit is 20 A. The minimum EGC size based on the table at 250.122 is 12 AWG. If multiple circuits are routed with a single EGC for the array, 250.122(C) permits the installer to use 12 AWG for the combined EGC.
- **690.46** modifies 690.45 when the EGC is not protected within a raceway, and does not apply to SunPower Equinox. It modifies 690.45 by requiring a larger conductor when the EGC is not routed with circuit conductors and installed outside of a raceway. But SunPower Equinox does comply with 690.31(D) which requires that the EGC be contained within the cable assembly. 690.46 was inserted into the Code to prevent installers from using small conductors such as 14, 12, or 10 AWG to ground rails in systems having no integrated grounding.
- **690.47** does not apply to AC modules:
  - 690.47**(A)** does not apply to Equinox because the AC "system" was already existing on the premises (already installed per Article 250 of the code) and the AC module system connects to the load side of this service. Installing AC modules constitutes the installation of new "equipment" on an existing AC system. As such, the existing system already has a grounding electrode system, and the only requirement is to connect the new equipment to that system.
  - 690.47**(B)** applies to DC systems; it does not apply to AC modules, and does not apply to SunPower Equinox. This section pertains only to DC systems in which a photovoltaic source circuit would be either grounded or ungrounded; but 690.6 exempts AC modules from requirements pertaining to photovoltaic source circuits. Code language states that the intention of an auxiliary grounding electrode can be achieved through a properly installed EGC back to the premises grounding electrode. SunPower Equinox meets this intention for rooftop arrays by using the integrated grounding system along with a properly sized and installed EGC.
  - 690.47**(C)** does not apply to SunPower Equinox for the same reasons that 690.47(A) and 690.47(B) do not apply.
  - 690.47**(D)** only provides guidance for a "dc grounding electrode conductor" and does not apply to SunPower Equinox on residential rooftops where there is an existing adequate premises grounding electrode system. In most cases (99%), the premises wiring electrode eliminates the need for an additional array grounding electrode (Exception No. 2) and the equipment grounding conductor connected to the grounding busbar or terminal in the main service panel is sufficient for connecting the metallic surfaces of the array to ground.
- **690.48** addresses module removal. When an AC module is removed from a SunPower Equinox system, it interrupts the circuit and equipment grounding connection between modules. This can leave the equipment

ungrounded if it is not returned to service. Upon a module's removal, the modules downstream of the removed module are reconnected using an AC module extension cable to bridge the gap, which re-establishes the equipment grounding connection.

- **690.49** does not apply to Equinox because it refers to photovoltaic source and output circuit grounded conductors.
- **690.50** does not apply to Equinox because equipment bonding jumpers are not used.
- **690.52** requires that the AC module be marked with identification of its leads and that it provide five specific ratings. SunPower AC modules are so marked and are thus fully compliant.
- **705.12(D)(6)** previously required AC arc fault protection on the output of AC modules if the modules use rooftop cables that are not in a raceway; however, 705.12(D)(6) has been deleted by a tentative interim amendment (TIA) to the 2014 NEC, and has been deleted in the 2017 NEC:

  www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards?mode=code&code=70&tab=editions

  www.nfpa.org/assets/files/AboutTheCodes/70/TIA_70_14_11.pdf

  AFCI on the AC side **is not required** and is not included with SunPower AC modules.

  Section 4.1 of the *SunPower AC Module Safety and Installation Instructions* (#514744) states:

As a Listed product, *"SunPower AC modules shall be installed and used in accordance with any instructions included in the listing or labeling" (NEC 110.3(B)). In addition, SunPower AC modules "shall be grounded using the integrated equipment grounding conductor…no additional grounding conductor attachment to the AC module is required."*

1.5.4 Ground Path

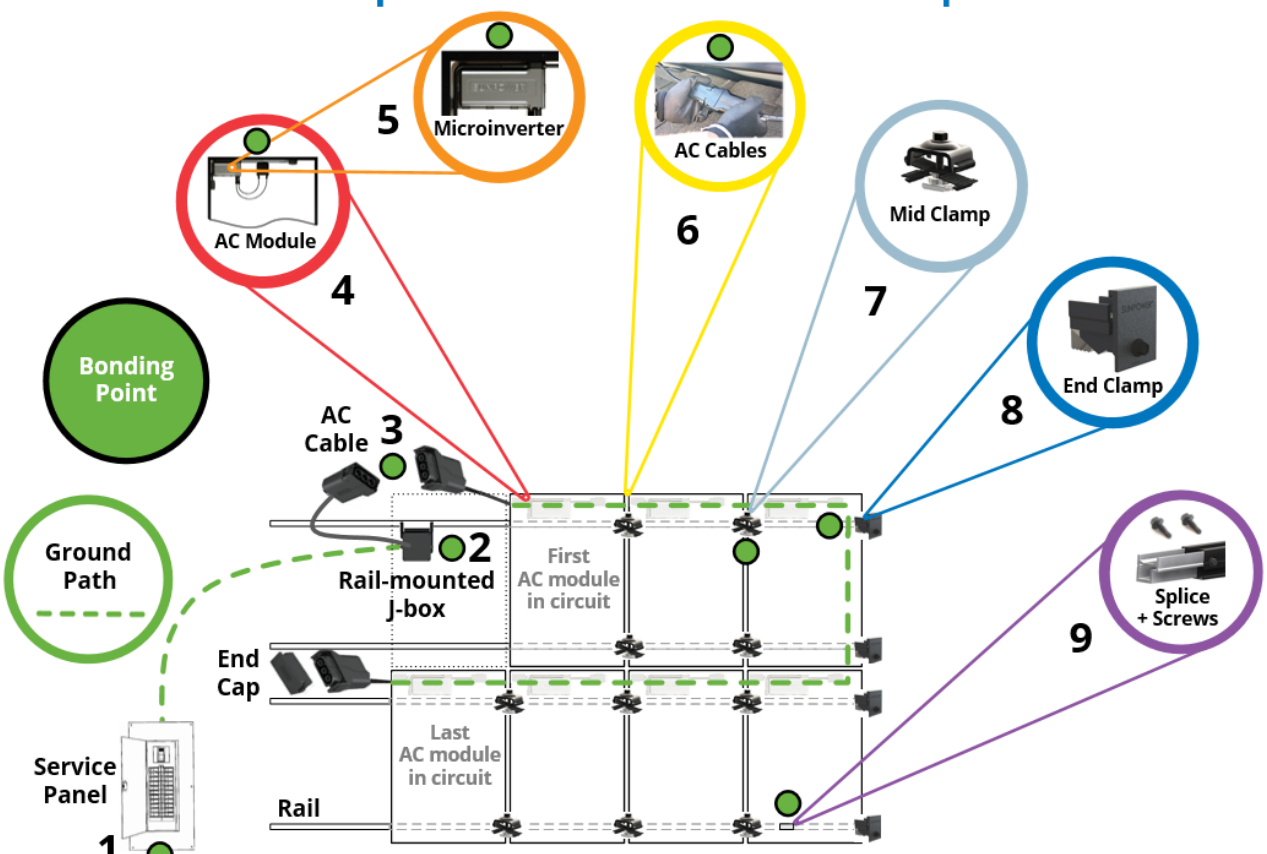
The system features:

- integrated module-to-rail as well as module-to-module bonding (achieved through the mid clamp and end clamp).
- integrated rail-to-rail bonding (achieved through the self-drilling splice screws and the splice).
- system bonding achieved through the equipment ground conductor (EGC).

The following diagram illustrates the key grounding and bonding aspects of the system:

- the system ground path
- each component
- each bonding point
- the applicable NEC and UL references

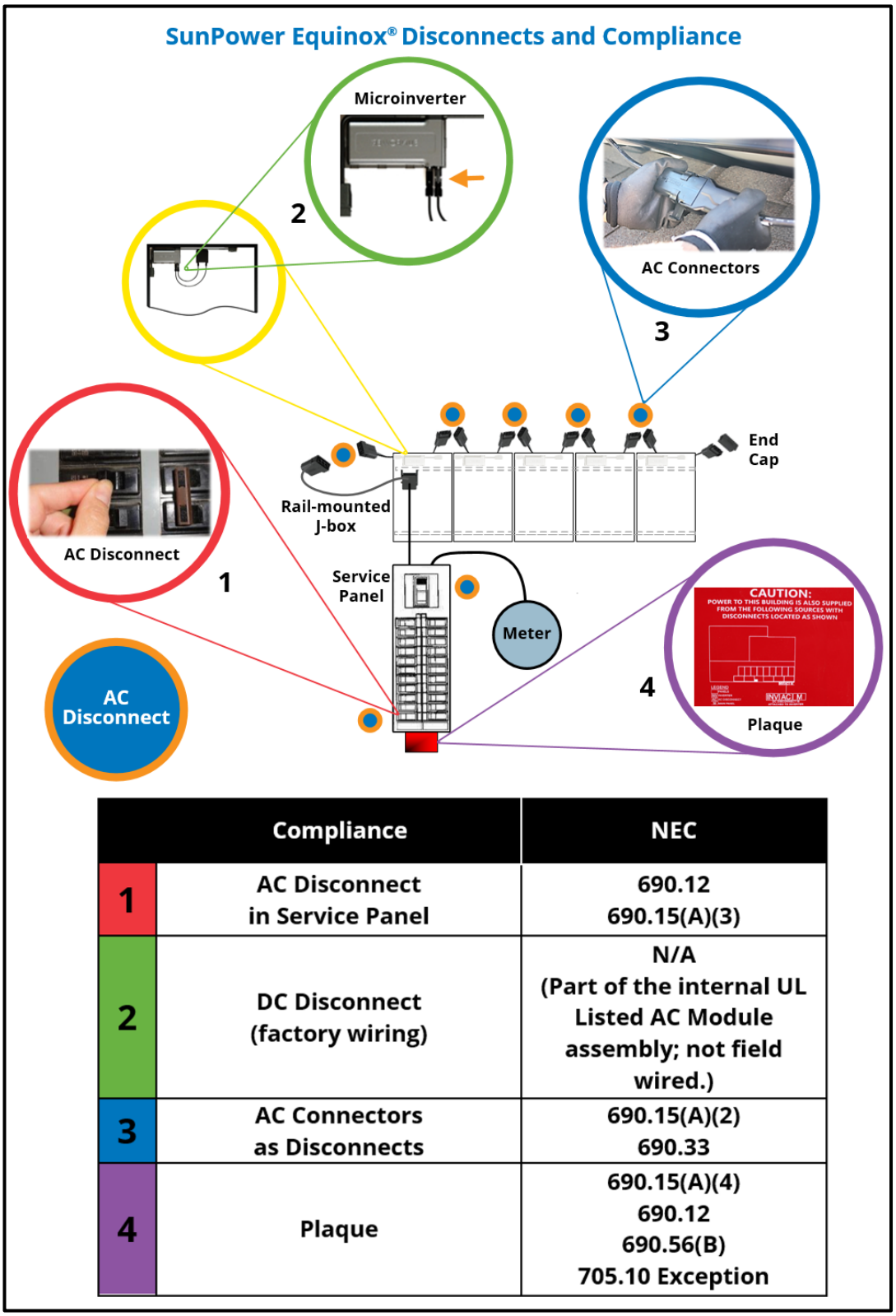
SunPower Equinox® Ground Path and Compliance



Bonding Components		Compliance	
		NEC	UL
1	Grounding Electrode to Service Panel	690.47(A) 690.47(D)	N/A
2	Service Panel to Ground Wire in Rail-Mounted J-Box	690.43	N/A
3	Rail-Mounted J-Box to AC Cable	690.43(A)	2703
4	AC Cable to Microinverter	N/A (part of Listing)	1703 1741
5	Microinverter to AC Module Frame	N/A (part of Listing)	1703 1741
6	AC Cable to AC Cable	690.31(D) 690.43(A) 690.43(D)	1741 6703 9703
7	AC Module Frame to Mid Clamp to Rail	690.43(A) 690.43(C) 690.43(D)	2703
8	AC Module Frame to End Clamp to Rail	690.43(A) 690.43(C) 690.43(D)	2703
9	Rail to Splice	690.43(A) 690.43(C) 690.43(D)	2703

1.5.5 Disconnects

The following diagram and text illustrate NEC conformance to each of the relevant disconnect aspects of the system, including the use of SunPower AC module connectors as disconnects.



	Compliance	NEC
1	AC Disconnect in Service Panel	690.12 690.15(A)(3)
2	DC Disconnect (factory wiring)	N/A (Part of the internal UL Listed AC Module assembly; not field wired.)
3	AC Connectors as Disconnects	690.15(A)(2) 690.33
4	Plaque	690.15(A)(4) 690.12 690.56(B) 705.10 Exception

SunPower AC modules require the use of cables and connectors that are UL Recognized and that conform to UL 6703 and UL 9703; the provided SunPower AC extension cables and their built-in connectors meet these requirements, contain an EGC, and are rated at 20 A and 600 V. **In addition, the AC module connectors *are* rated for disconnect under load**.

Applicable NEC context for AHJs evaluating a roof-mounted AC module array

AC modules must be installed per 690.6:

- **690.6(A):** DC photovoltaic source circuits don't apply to AC modules.
- **690.6(B):** The output of an AC module shall be considered an inverter output circuit.
- **690.15(A):** With respect to the AC output, an AC module installed on a roof is the equivalent of an inverter in a not readily accessible location.
- **690.15(A)(2):** An AC disconnecting means must be within sight of (or in) an inverter; the AC cable connectors can function as this disconnecting means as per 690.17 Exception; if and only if the connectors are rated for disconnect as per 690.33; the connectors on the SunPower AC cables (module and extension) are fully compliant in all these respects.

SunPower Equinox fully complies with NEC disconnect requirements

690.15(A) requires utility interactive inverters in not readily accessible locations to comply with certain provisions. Because the output of an AC module is to be "considered an inverter output circuit," it's reasonable to apply as much of 690.15 as applies to inverter output circuits, *but not photovoltaic source circuits:*

- **690.15(A)(1)** does not apply because it only applies to photovoltaic source or photovoltaic output circuits.
- **690.15(A)(2)** does apply and mandates that an AC disconnecting means shall be mounted within sight of or within the inverter.
- **690.15(A)(3)** does apply and mandates that an additional, readily accessible disconnecting means is required.

How does SunPower Equinox comply with 690.15(A)(2)?

The module-integrated AC module cable connectors (plugs and receptacles) **are** the AC disconnecting means, because **690.17(E) Exception** states that:

> *A connector shall be permitted to be used as an ac or dc disconnecting means, provided that it complies with the requirements of 690.33 and is listed and identified for use with specific equipment.*

How do the Equinox AC module connectors comply with 690.17(E) Exception?

Our connectors are UL Recognized for use with all of the module models listed in Section 1.4.

- **690.33(A):** Equinox connectors are polarized and noninterchangable with other receptacles on the premises.
- **690.33(B):** Equinox connectors are guarded (are touch-safe).
- **690.33(C):** Equinox connectors are of the locking type.
- **690.33(D):** Equinox connectors are first-make, last-break for the internal equipment grounding conductor (EGC).
- **690.33(E):** Equinox connectors are rated for interrupting current (load break) and are suitable as disconnects.

How do Equinox AC modules comply with 690.15(A)(3)?

The breaker in the readily accessible main service panel—or any other AC disconnect in the system—can be considered the readily accessible disconnecting means. But if the circuit runs through the house (as it will in many installations), it would seem then that SunPower AC modules must also comply with 690.31(E).

But while 690.31(E) does have special provisions for photovoltaic source and output circuits inside a building, a SunPower AC module is an *inverter* output circuit, and the provisions applying to photovoltaic source and output circuits thus do not apply to AC modules. (The clear intent of the code is to provide special protections for DC circuits, but there are no special provisions for AC circuits.)

Summary

In a SunPower Equinox system the required AC disconnect on the roof is the AC connector pair (a plug and a receptacle); the AC disconnect on the ground is the AC breaker in the service panel (or the external switch, if used). The integrated grounding solution incorporated into SunPower Equinox is 100% end-of-line tested and Listed by UL.

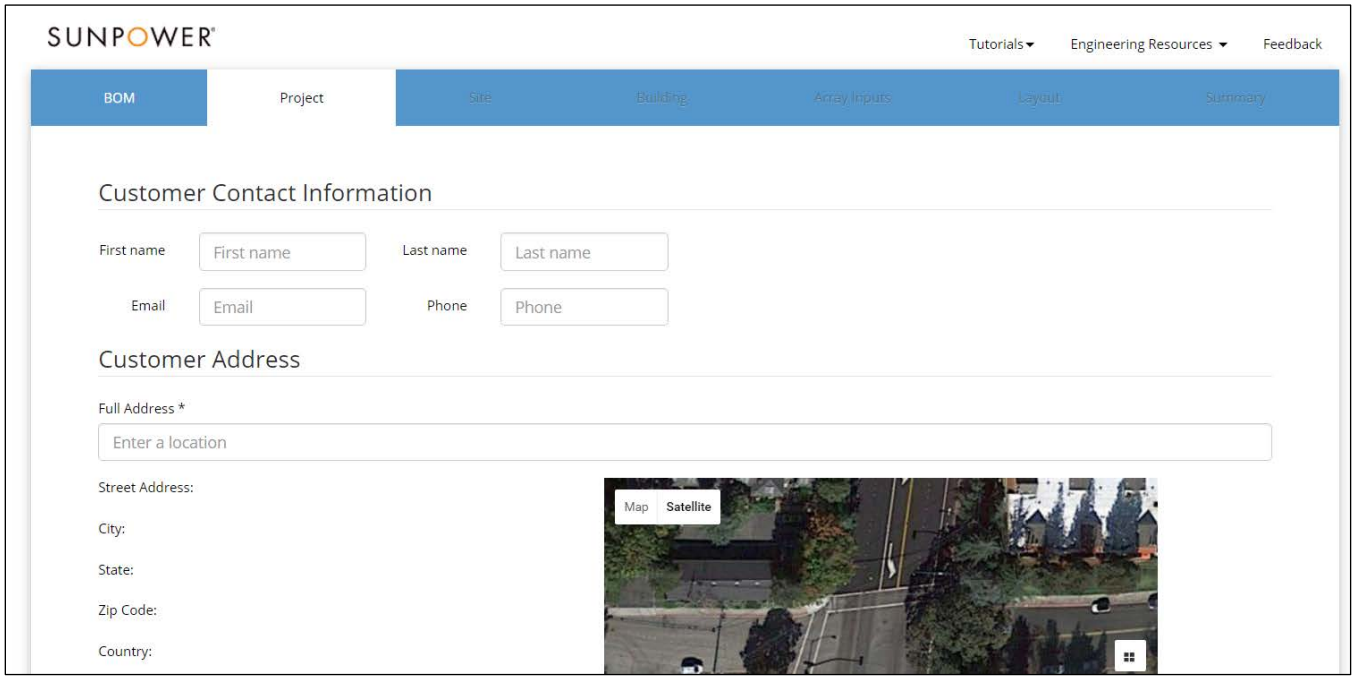
1.6 Pre-Installation Checklist

Important! SunPower strongly recommends using the online SunPower Design Tool (accessed from the Portal) to design your arrays and determine the accompanying bill of materials (BOM). In addition, always refer to the *InvisiMount Span Tables* document *(*#524734).

Best Practice: To help save time, ensure a safe and high-quality installation, and avoid any confusion about the system details, fill out the *SunPower System and Site Checklist* (located in Appendix A of this guide) ***as you build the array and install the system*.**

Your array should be fully designed and all required permitting obtained before you begin installing the system. Use the SunPower Design Tool **OR** the *InvisiMount Span Tables* document *(*#524734) to determine the actual span between attachments for a given system.

Designers can access the Tool by logging into the Portal and then clicking the *Design Tool* link. **The Tool yields all the racking–specific structural calculations that can then be provided to the AHJ and that are typically part of the permitting process**.



SunPower Design Tool

*Ensure that you bring the resulting PDF file to the site—**its cabling diagram offers you significant time savings!***

1.7 Installation Outline

1. Mark the rooftop for penetrations.
2. Install the flashings (if part of the attachment solution for your roof type) and the roof attachments.
3. Install the InvisiMount system and the AC modules.
4. Install the EnergyLink™ hardware (PV Supervisor 5x) monitoring system and set up EnergyLink.
5. Commission the system.

1.8 Install InvisiMount and AC Modules

Important! The maximum number of modules for a single 20 A circuit in a 240 V single-phase system is 12.

These instructions describe attaching the rails parallel to the roof peak ("E–W"). The rail section length is 10' 9" (3.28 m) and is optimized to accommodate three modules in portrait position; or two modules in landscape.

For composition shingle roofs, it is acceptable to attach InvisiMount to either the rafters or the roof deck. SunPower recommends the following attachments which have been integrated into the SunPower Design Tool for easy design and permitting:

- For **rafter** attachment: SunModo K10068-BK8 (SunPower #508329)
- For **deck** attachment SunModo K10068-BK7 (SunPower #508330)

Instructions for installing the above attachments can be found here:

sunmodo.com/wp-content/uploads/2015/04/D10011-V002-Guide-EZ-Roof-Mount.pdf

For **curved and flat tile** roofs, SunPower recommends Quick Mount PV QMHSS Quick Hook (SunPower #510083), which is also integrated into the SunPower Design Tool. Installation instructions can be found here:

www.quickmountpv.com/support/videos/qhk-quick-install.html

Important! Hook attachments may be attached to the *rafters only*—not to the roof deck.

1.8.1 Attachment Span and Rail Cantilever

The maximum span (distance between roof attachments) is 8' (2.4 m). The maximum rail overhang length (cantilever) beyond a rail's endmost attachment is 24" (61 cm). This distance may be less—*but never more*—based on site-specific conditions. Use the SunPower Design Tool (https://invisimountdesign.us.sunpower.com/login.html) OR the *InvisiMount Span Tables* document (#524734) to verify spans between roof attachments and maximum cantilever for your particular site.
Access the Tool by logging into the Portal and then clicking the *Design Tool* link.

Note: A spliced rail does not require any special allowance for span or cantilever.

1.8.2 Module Spacing

- Adjacent modules that share a mid clamp (side to side; L–R in a typical row): 0.8" (20 mm), governed and enforced when the mid clamps are installed.
- Adjacent rows (an upper and a lower row in a typical array): 13/16" (20 mm), governed and enforced by the row-to-row (R2R) spacers when used (refer to Fig. 23); minimum is 1/4" (6.5 mm).

1.8.3 Join Rails

The rails and the splices have pre-drilled holes for the splice screws: four in the splice and two in each rail end. You install ***one*** screw per rail section, *in the hole furthest from the rail end* (Fig. 1).

Important! The splice is an integral part of the ground path. There must be no interference between the splice screws and the L-feet.

1. Fit a splice halfway into a rail end, align the splice holes with the rail holes, secure the components so that they will not move, and then drive a splice screw through the aligned hole that is furthest from the rail end, stopping 1/3 turn after the screw face has contacted the rail face (Fig. 2). This method provides 40 +5/−0 in-lb (4.5 N-m) of torque. Use a torque wrench to verify and (if necessary) apply final torque to each screw.
2. Splice screws are single use. If a screw becomes dull or prevents smooth, consistent penetration of the splice, use a new screw in the original hole. If a screw breaks, use the other **existing** hole—do not reuse the original hole, and **do not drill additional holes.**
3. Fit the second rail all the way onto the splice protruding from the first rail, align the respective holes, and install the second screw.

   The rail holes and splice holes must be aligned; the rail ends are not required to be in contact with each other. The maximum distance between a spliced rail pair is 1/4" (6.4 mm).

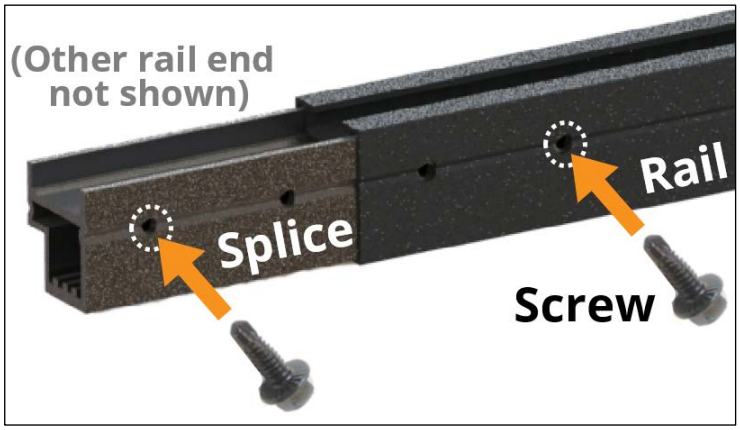


Fig. 1

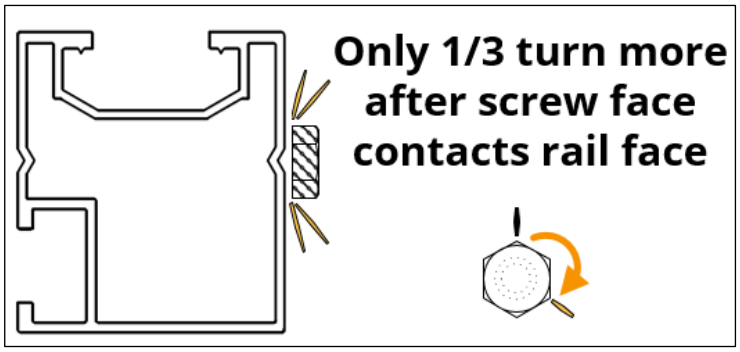


Fig. 2

1.8.4 Install Flashings, Roof Attachments, and Rails

1. Define the installation zone and array layout on the rooftop and mark it for penetrations as necessary.
2. Referring to the manufacturer guidance for both the flashing (if appropriate for the roof type) and for your chosen roof attachment:
   a. Install the flashings and the roof attachments.
   b. According to the roof attachment manufacturer guidance, attach an L-foot to each of the roof attachments. *Leave the hardware finger-tight for the moment*.
3. Position the rails on the roof, adjacent to the L-feet and such that the side channel of each rail is facing the roof peak (Fig. 3 and Fig. 5).
4. For each rail, determine the number of L-feet to which it will attach, and then slide that number of bolts into the rail's side channel (bolt heads fit into channel; Fig. 4). **For bolt specification see Section 1.33.**

   Important! For your roof attachment strategy, remember that a spliced rail is the same as a solid rail in that **a spliced rail does not require any special allowance in terms of overhang or attachments.**

Fig. 3

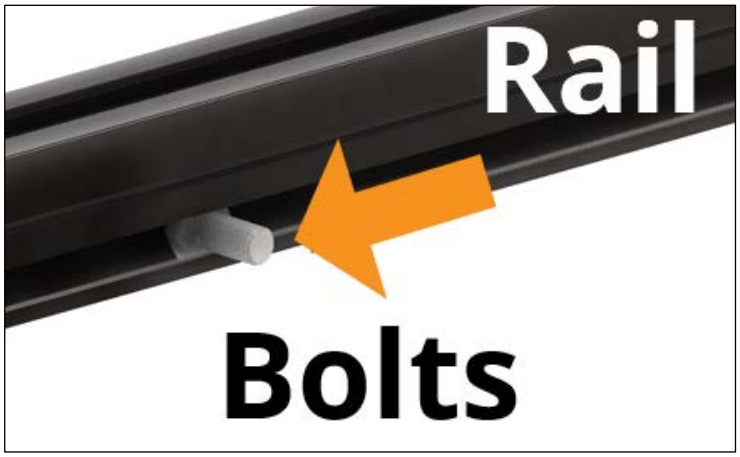


Fig. 4

5. Position the rail—with its side channel facing the peak—adjacent to and “below” (relative to the peak) the L-feet for the given row (Fig. 5).

   Note: L-feet must only “face” the peak (Fig. 5 and Fig. 6).

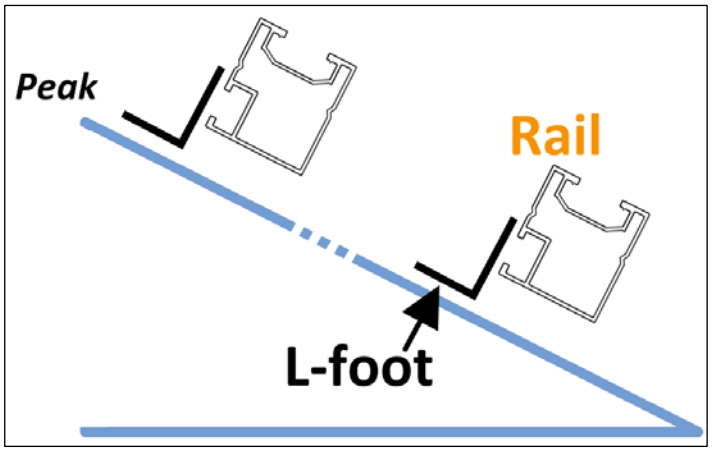


Fig. 5

6. Position the rail bolts a minimum of 2" (5 cm) from the end of a rail (Fig. 6); and a minimum of 2" (5 cm) from any rail joint (Fig. 7).

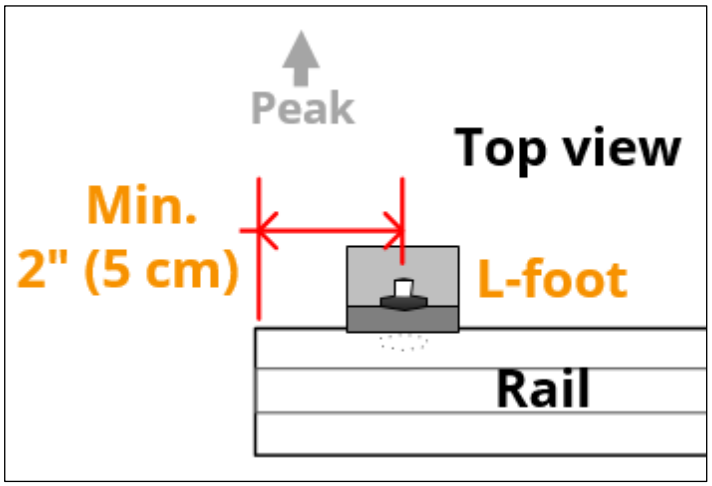


Fig. 6

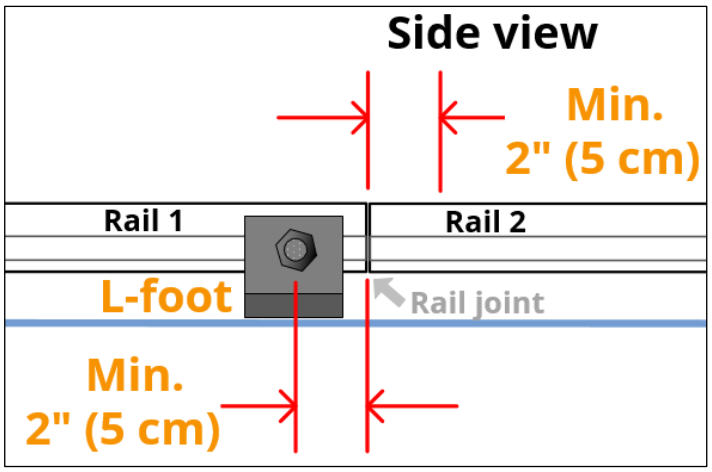


Fig. 7

7. Attach the rail to the L-feet by fitting the rail bolts through the slots on the L-feet and then *temporarily* finger-tightening an M10 nut on each of the bolts. (You will apply torque to these nuts in Step 9.)

> **Best Practice:** Position each bolt at the midpoint of the vertical slot in its L-foot (Fig. 8). This will provide the greatest vertical adjustment flexibility.

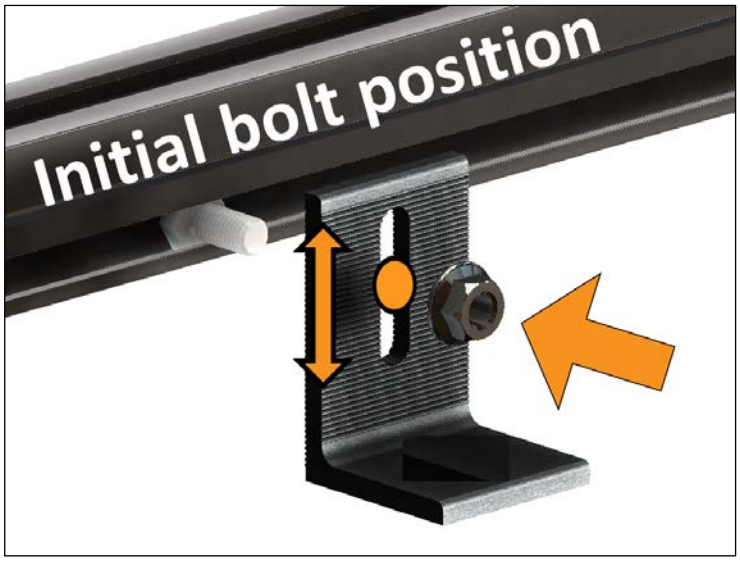


Fig. 8

8. To ensure that the installed modules will appear as an even plane, SunPower recommends that you use a string line and level (or other method) to ensure that the top surface of the rails is even (Fig. 9).
9. After you are satisfied that the rails are all of even height, tighten each L-foot nut to 375 +20/−0 in-lb (42 +2/−0 N-m).

   Note: The L-feet should still be only loosely attached *to the roof attachments.*
10. Tighten all of the L-foot-to-roof-attachment hardware according to the roof attachment manufacturer guidance. (If you are not using L-feet, tighten the attachment hardware if necessary, according to the attachment manufacturer guidance.)

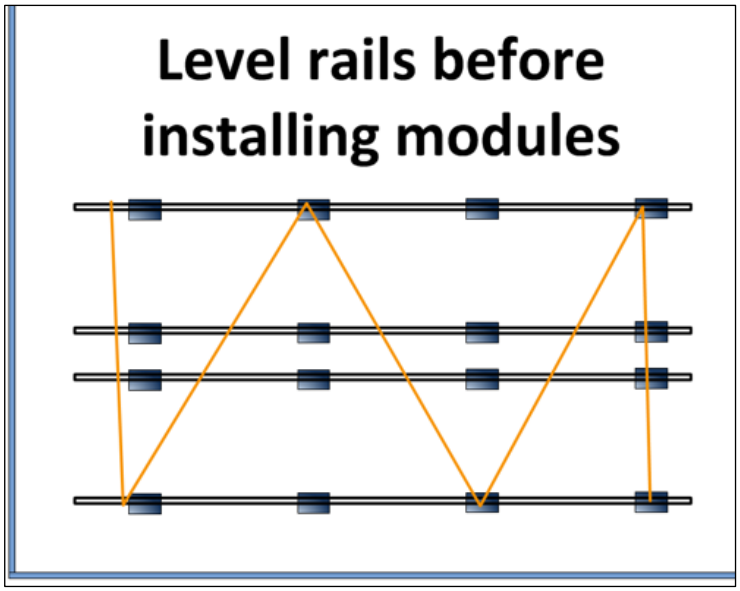


Fig. 9

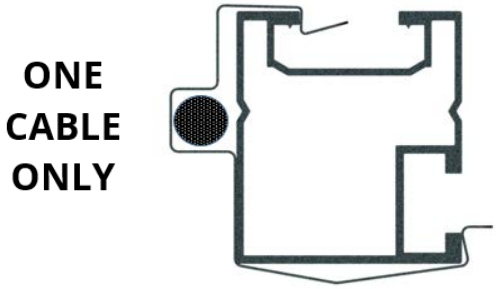
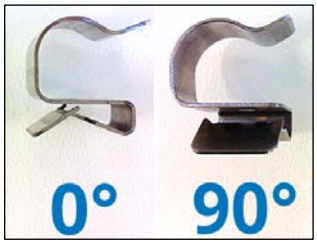
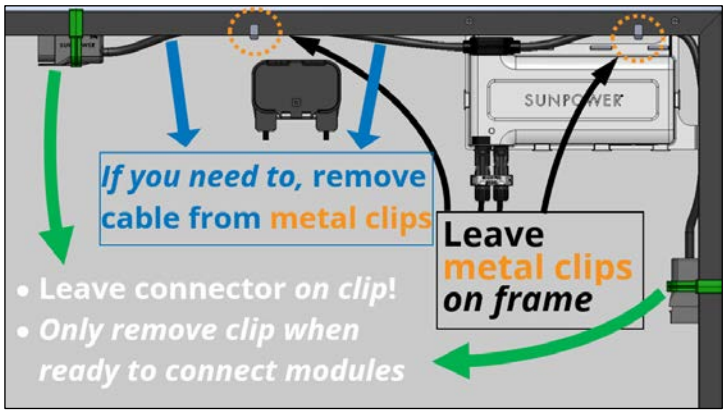
1.9 Prepare AC Modules and Transition Cable

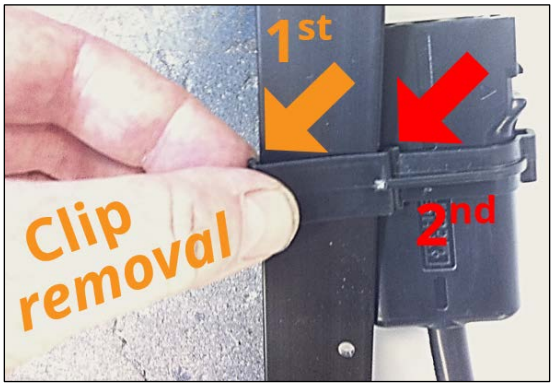
Performing efficient wire management steps *before* transporting modules to the roof can greatly simplify installation of the array.

Important! SunPower recommends that you use only cable clips, connector clips, and the proximity of the rails to secure the cables under the array and off the roof surface—*cable ties (also called "zip ties" or "wire ties") are not recommended.*

1.9.1 AC Module Clips Overview

Three types of AC module clips enable you to keep the AC cables off of the roof surface and out of sight: the AC rail clips are an optional accessory, and each AC module ships with metal cable clips and plastic connector clips preinstalled:

Type	Appearance	Best Practice
AC rail clip: Optional; metal; attaches to the rail and retains an AC cable along the rail.		 • Install before installing modules • Max. 24" (61 cm) apart
Cable clip: Metal; retains AC cables *and extension cables* to module frame—both during shipping as well as after the array is complete.		

Type	Appearance	Best Practice
Connector clip: Plastic; retains connectors (plugs and receptacles) to module frame both during shipping as well as after the array is complete.		 ***Important!*** To avoid breaking clips, release clip from frame by gently lifting the **outer** tab first. **The connector clips do not constitute proper cable management—*use the metal cable clips as well.***

Follow these guidelines for proper cable management:

- Use a minimum of one metal cable clip per section of AC cable.
- Always place a minimum of one cable clip within 4" (10 cm) of each connector pair (plug & receptacle).
- *Do not use the plastic connector clips in place of metal cable clips;* use them **in addition** for supplemental cable support.
- *In a finished array cables may never touch the roof!*

1.9.2 Prepare All Modules

Important! Use caution when unpacking each module to ensure that the cable ends do not accidentally swing free and damage the module backsheet. **The plastic connector clips are critical in this regard.**

Before transporting modules to the roof:

- Leave the metal cable clips securely attached to the module frame, but carefully remove the cables *from* the metal clips.
- Leave the plastic connector clips secured to the module edge (each holding a plug or receptacle).

After modules are in placed in the array:

- Leaving each plug and receptacle attached *to* their connector clip, remove the two connector clips from the frame by lifting the clip's *outer* tab first.
- Connect the plug and the receptacle to their respective mates in the circuit, still leaving the connector clips attached.

- Reattach the connector clips to the frame by fitting the inner part first, then pressing the outer tab down.

Important! *Plastic connector clips are NOT sufficient to secure the cables! Use metal cable clips!*

- Fit the cables back into the metal cable clips on the module frame.

In their final secured position, cables should not droop below the bottom edge of the rails.

1.9.2.1 Prepare and Wire the Transition Cable

Important! Refer to Appendix J and Appendix K before proceeding so that you can decide when to wire and install the transition cable.

To prepare the correct transition cable for your array, cut one end off of an AC extension cable, leaving the correct cable end intact in order to mate with the first module's available connector end. (Save the unused cut end for a future job.)

SunPower recommends a cost-effective, secure method for splicing the AC transition cable conductors to the conductors in the rail-mounted J-box (or attic-mounted J-box). For example, the following products are manufactured by IDEAL Industries for Buchanan (www.idealind.com) and can be sourced from Amazon as well:

- #C24 crimp tool
  AND
- #2006 crimp connector and #2007 splice cap insulator

OR

- #2011 crimp connector
  AND
- #2014 splice cap insulator

1.9.3 Install Modules

Important! If you are installing the rail-mounted J-box (refer to Appendix J), do so now before installing modules. If your wire management strategy includes the AC rail clips (Appendix K), it is easiest to install them *before* you install modules.

SunPower recommends that you begin closest to the rooftop transition, mounting and connecting each module as you move away. For arrays with two rows of modules, SunPower recommends installing the "bottom" row of modules (the row furthest from the peak) first.

The minimum distance between module rows is 1/4" (6.5 mm). The row-to-row spacers (refer to Fig. 23) enforce this minimum, enable aesthetically uniform rows, and help to ensure ample ventilation for and optimal performance of the array.

Important! To provide proper ventilation to the underside of the module, you *must ensure* that there is a minimum of 2" (5 cm) between the module frame and the mounting surface (Fig. 10). (This is the minimum distance required for the inverter NRTL certification.)

Position modules on the rails such that the rails are in the green (non-crosshatch) regions only, as follows: minimum of 2" (5 cm) but not more than 16" (40.6 cm) from any module corner (Fig. 11 and Fig. 12). Refer to the *Safety and Installation Instructions for AC Modules* (#514744).

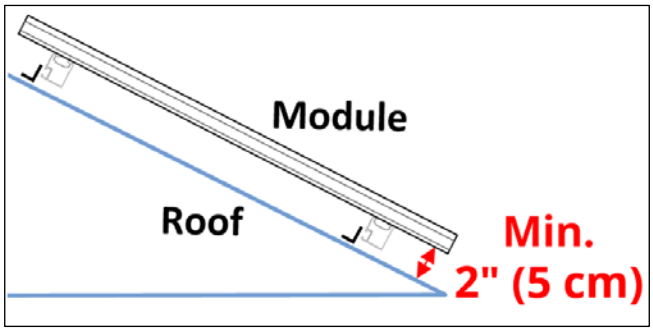


Fig. 10

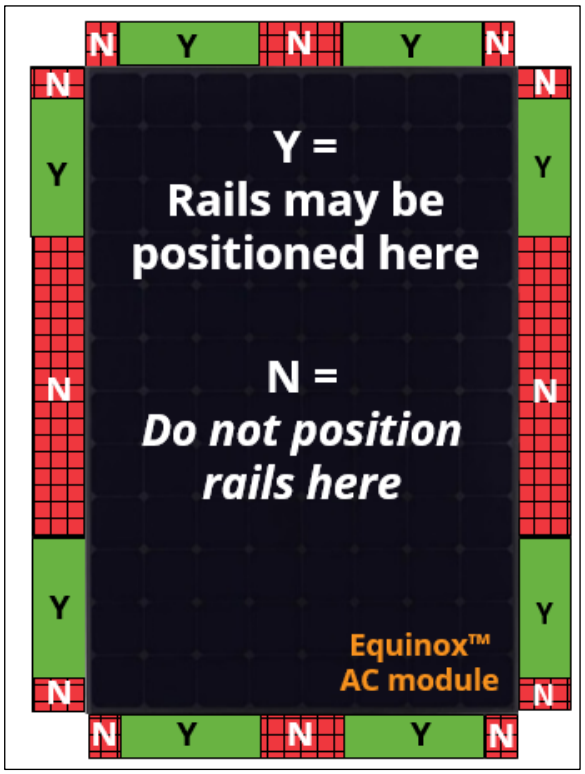


Fig. 11

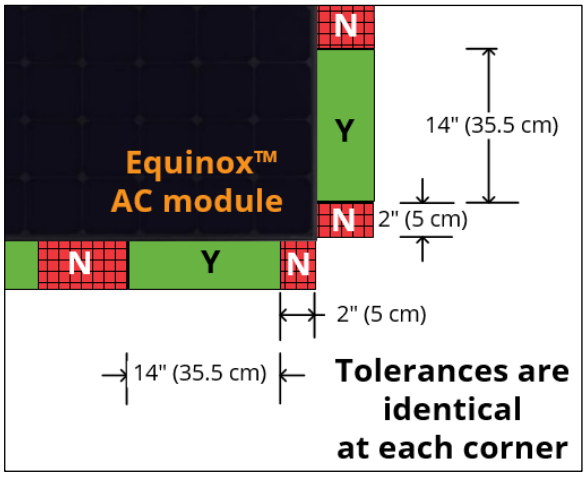


Fig. 12

Important! If an L-foot in its final installed position extends *above* the top surface of the rail, you must ensure that the L-foot *does not contact any part of the module, module frame, or microinverter (MI)* (Fig. 13).

Warning! Do not step on, stand on, or walk on the modules or the module frames, and **do not place anything on them**—even for a moment.

1. Peel two serial number stickers from the first module:

   - one from the microinverter (Fig. 14)
   - one from the module frame (Fig. 15)

   and place them together in the corresponding location in the **AC Module Array Layout** area on the checklist in Appendix A of this guide.

   Do this for every module you install.

   Important! Do not remove any stickers from the module backsheet.

2. Position the first module on top of the rails at the end of the row.

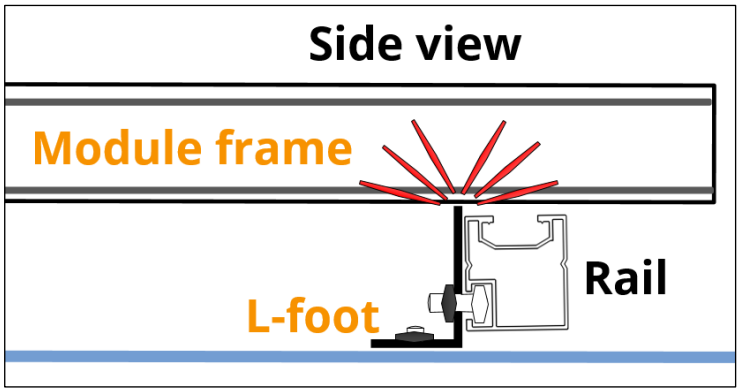


Fig. 13

Fig. 14

Fig. 15

3. With the SunPower logo upward and the engagement mechanism downward, insert an end clamp into each of the rail ends by holding the clamp with your thumb and middle finger, and pressing on the bolt head with your index finger as you slide the clamp as far into the rail as possible (Fig. 16). If the clamp does not slide in easily, push or tap on the bolt head.
4. Fit the top lip of the cover up and over the bottom edge of the module frame (Fig. 17). Do this for both end clamps.

   Verify correct module position and full end clamp engagement, and then tighten each end clamp bolt to 85 +5/−0 in-lb (9.6 N-m) with a 10 mm socket.

   Note: If you need to remove an end clamp, first loosen its bolt two full turns and then tap on its bolt head with a rubber mallet to free its engagement mechanism.
5. Fit one mid clamp down into the top channel of each of the row's two rails, rotate it 90° (Fig. 18), and slide it toward the first module. Leave the two mid clamps loose for now.
6. Position the second module next to the first module, with the two mid clamps in between the two modules.

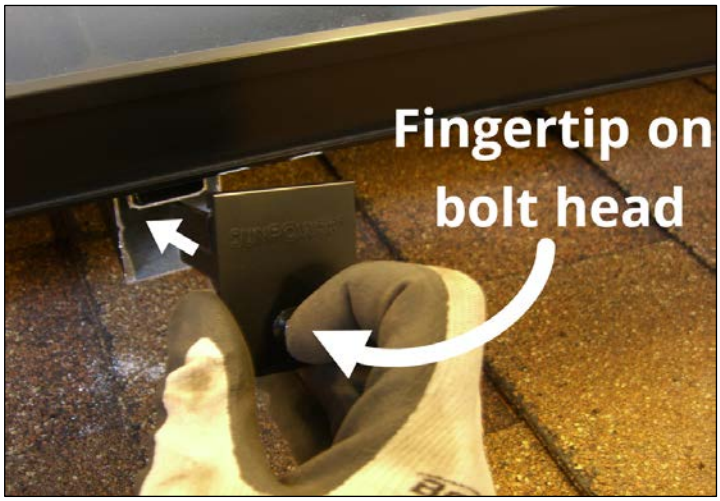


Fig. 16

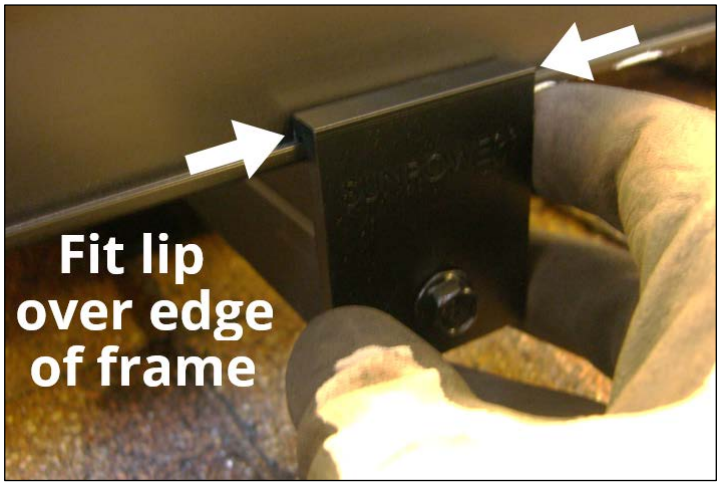


Fig. 17

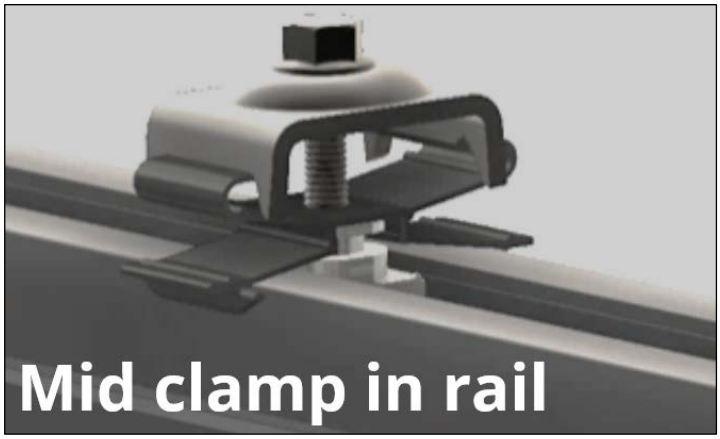


Fig. 18

7. For each of the two mid clamps: fit one side (two teeth) of each clamp over the respective adjacent frame edge of each of the two modules (the first and second modules) (Fig. 19; *second module not shown*). Tighten each of the two mid clamps to 85 +5/−0 in-lb (9.6 N-m).

   Important! Each mid clamp's four teeth must solidly engage the module frames to ensure continuity of the module–rail ground path (Fig. 19).

8. For each of the two modules: carefully remove the connector clips from the module frame *keeping the connectors attached to the clips* (refer to Section 1.9.1); remove the cable from the *cable* clips only as necessary; and securely connect the plug from the first module to the receptacle from the second module (or vice versa) (Fig. 20).

9. Fit the cables back into the metal cable clips!

10. If possible, carefully fit the plastic connector clips back onto the module frame.

11. Repeat Steps 5–10 until you have installed all except for the last module in the row.

12. For the last module in the row: position it on the rails in the desired final location, and then mark a cut line on each of the rails at the module edge (Fig. 21).

    Important! To ensure precise alignment with the finished array's footprint (perimeter), SunPower recommends that you cut rails only *after* you have adjusted them to an even height (Section 1.8.4, Fig. 9) and fully secured them to the attachments.

13. Remove the module to ensure it is not damaged in the cutting process, and then carefully cut the rails along the lines you marked.

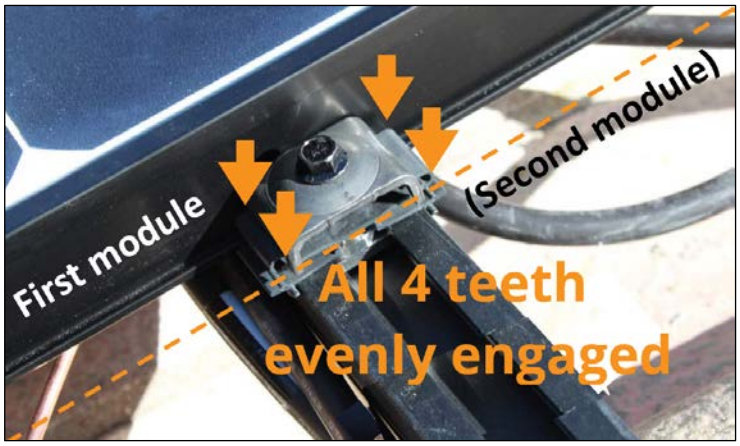


Fig. 19

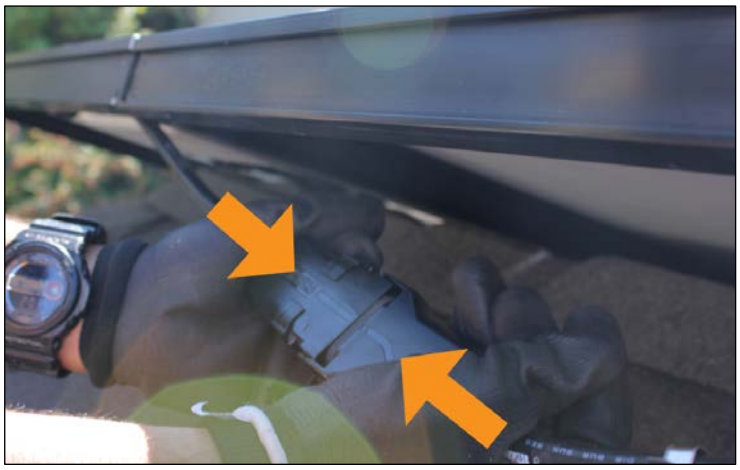


Fig. 20

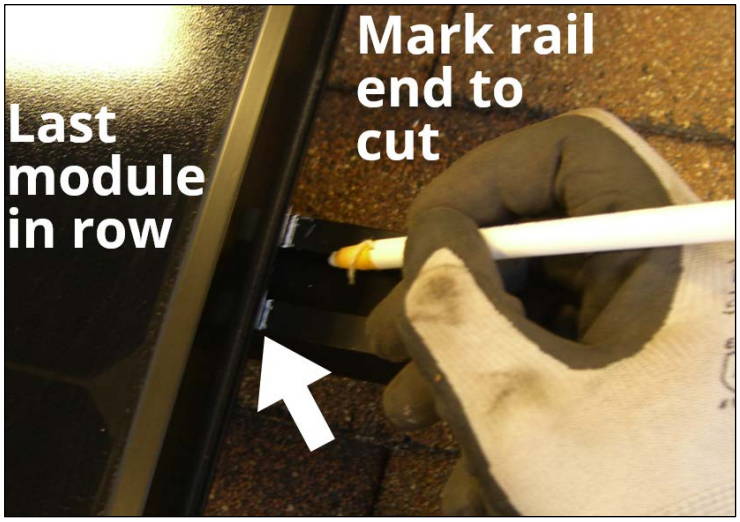


Fig. 21

Important! The maximum distance the module is permitted to overhang the rail is 1/4" (0.6 cm) (Fig. 22).

14. Place the module in position again and then add its two mid clamps (which also secure the second-to-last module in the row), tightening them as you did in Step 7.

15. Add and tighten the last module's two end clamps as you did in Steps 3–4.

    If you're installing a second row, add two row-to-row (R2R) spacers to the upper edge of *each* of the completed first row's modules.

    Note: The instructions in this guide assume that any second row you add will be "above" the first row (between the peak and the first row).

16. For each of the modules in the first row, fit two R2R spacers in its upper frame edge, one each approximately 8" (20 cm) away from each upper frame corner (Fig. 23 and Fig. 24).

17. Repeat Steps 1–15 to fully install the second row, allowing the second row's modules to gently rest evenly on the spacers.

    Note: The spacers provide no structural support for the modules. Leave the spacers in place after module installation.

Fig. 22

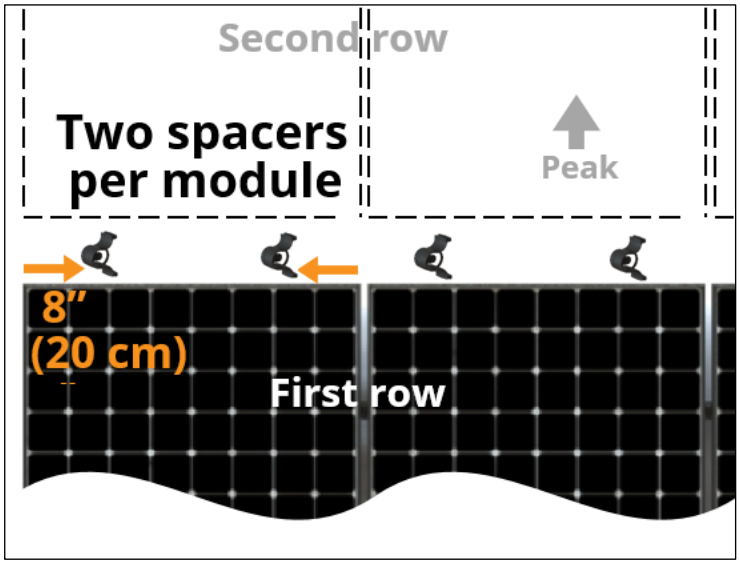


Fig. 23

Fig. 24

18. Connect the plug or receptacle on the transition cable to the appropriate AC cable end on the first module in the circuit (Fig. 25; *example only*).
19. Install an end cap in the last module in the circuit (Fig. 26; *example only*).

Important! It is critical to ensure that all of the AC cable connections are fully mated and solidly latched—feel for and listen for the click!

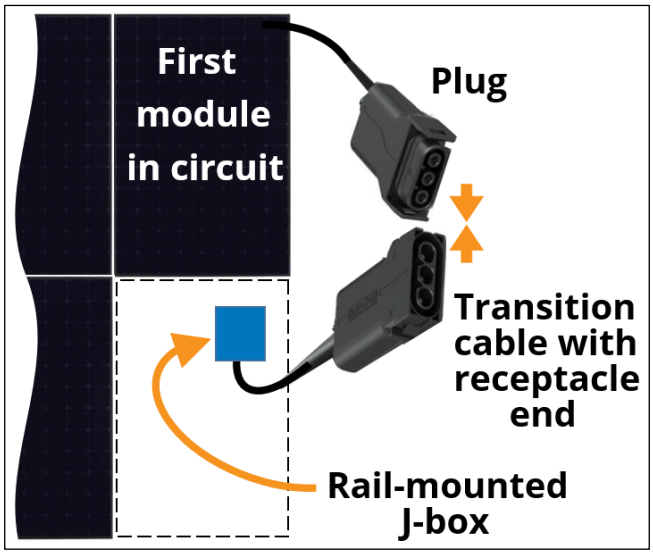


Fig. 25

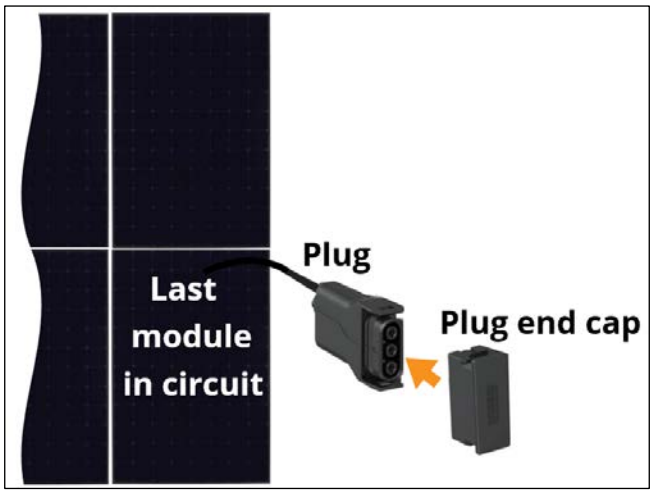


Fig. 26

1.9.4 Verify Voltage

After you have completed InvisiMount and AC module installation, but *before you commission the system,* power on the branch circuit, remove the connector cap (plug or receptacle) on the last module in each circuit, and check the branch circuit voltages, verifying that they are as follows:

	L1 to G (V)	L2 to G (V)	L1 to L2 (V)
Residential 240 V split single phase	120	120	240
Residential 208 V three-phase wye double pole	120	120	208

If you do not observe correct voltage readings at the last module, check the wire terminations on the circuit breaker or in the J-box. If you have no voltage readings, verify that the breaker is on and that the connectors on all of the modules are fully mated.

2.0 Install and Commission EnergyLink with PVS5x

To view training videos or enroll in training webinars go to www.sunpowerpartnerconnect.com, select **SunPower University,** and search for *Consumption Monitoring.* Access the Equinox Installation Support page for supporting documents: https://us.sunpower.com/support/install/equinox/

SunPower Equinox features SunPower EnergyLink™ with PV Supervisor 5x (PVS5x) hardware. Follow these instructions to install, configure, and commission PVS5x in order to receive monitoring data and set up the customer's EnergyLink monitoring account.

2.1 Safety, Compliance, and Certification

2.1.1 Safety Instructions

Perform all electrical installations in accordance with any national and local codes, including the National Electrical Code (NEC) ANSI/NFPA 70 for US installations. Field service is limited to the components contained in the lower compartment of the PVS5x. The following labels are used on the PVS5x:

	This label warns of hazardous voltage behind the AC terminal cover that can cause serious injury. This area is to be accessed only by qualified, trained personnel with the necessary skills and knowledge to work on this type of electrical equipment. Disconnect power before opening.
	This label warns of immediate danger due to exposed hazardous voltage that can cause serious injury or death. This area is to be accessed only by qualified, trained personnel with the necessary skills and knowledge to work on this type of electrical equipment. Disconnect power before opening.

- The PVS5x enclosure (Type 3R) is suitable for use indoors or outdoors; operating ambient temperatures between −22°F and 140°F (−30°C and 60°C). Do not mount the enclosure in a location where it will be exposed to direct sunlight—mount the enclosure in a shaded location if possible.
- Before connecting power, the PVS5X must be securely mounted to an inside or outside wall following the instructions in this document.
- The PVS5x can be connected to a branch circuit with any standard size breaker rating up to 20 A. The input operating current is less than 0.2 A with AC nominal voltages of 240 V (L1–L2).
- The PVS5x contains internal transient surge protection for connection to the load side of the service entrance AC service panel (overvoltage category). For installations in areas at risk of surges generated by high-voltage utilities, industry, or by lightning, SunPower recommends that an external surge-protective device also be installed.
- Do not attempt to repair the PVS5x. If the PVS5x malfunctions, please return it to SunPower for servicing. Tampering with or opening the upper compartment of the PVS5x voids the product warranty.

2.1.2 FCC Compliance

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions:

- This device may not cause harmful interference.
- This device must accept any interference received, including interference that may cause undesired operation.

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult an experienced radio/TV technician for assistance.

Radiation Exposure Statement

This equipment complies with FCC RF radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with minimum distance 9.8" (25 cm) between its radiator and your body.

Equipment Changes or Modifications

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment. This device and its antenna must not be co-located with or be operating in conjunction with any other antenna or transmitter except in accordance with FCC multi-transmitter product procedures.

2.1.3 Safety Certification

The PVS5X is UL Listed to UL 60950-1 ITE and UL 60950-22 for outdoor use.

The PVS5X is not a utility meter, disconnect device, or power distribution device.

2.2 Install PVS5x

2.2.1 Overview

The PVS5x collects system status and performance data from the AC modules. Using the homeowner's broadband internet via hardwired WAN, Wi-Fi, or power line communication (PLC)—and cellular backup—the PVS5x sends the collected data to SunPower servers at five-minute intervals. You and your customer can access this data using SunPower EnergyLink portals.

The PVS5x also includes the PVS Management App which you use to commission the monitoring system after installing the Equinox system and all monitoring hardware.

SunPower EnergyLink™ with PVS5x

The following websites apply to Equinox systems:

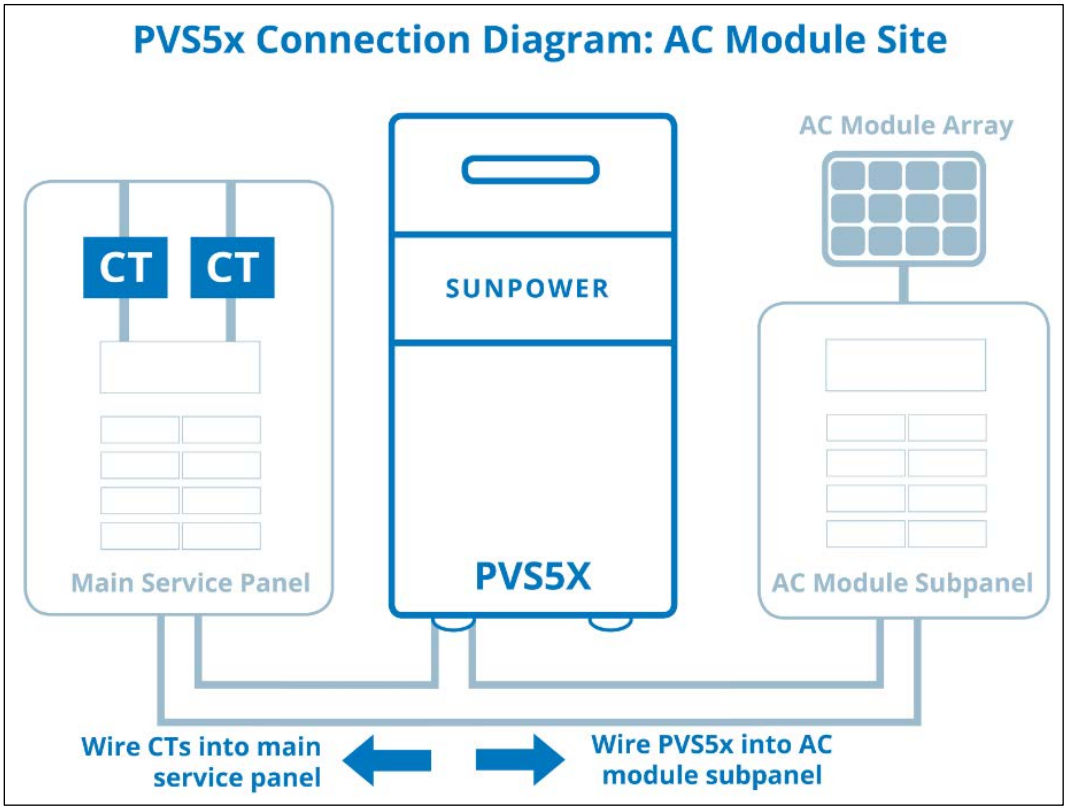
Site	Use
sunpowerconsole.com	Enables you to commission devices.
pvsmgmt.sunpower.com	Enables you to manage fleets.
monitor.us.sunpower.com	Enables customers to view their system information.

2.2.2 Kit Contents

Kit Components			Other Components	
PV Supervisor 5x (PVS5X) 	**Bracket** 	**Hardware** • two screws • two hole plugs	**100 A Current Transformer (CT)** (two; shipped separately) 	**PLC Ethernet Adapter** (optional accessory from SunPower) 

2.2.3 System Connection

Important! Ensure that the AC module branch circuit and the PVS5x are as close as possible electrically and such that there are no other house load breakers between the AC modules and the PVS5x.



PVS5x connections

2.2.4 Mount PVS5x

The PVS5x comes with two removable serial number stickers on a card attached to its face (Fig. 27). Remove the card now **but keep it handy** so that you can correctly remove and apply its two stickers as instructed in Section 2.4 and Appendix A.

1. Select an installation location that is not in direct sunlight, and mount the PVS5x bracket using hardware that is appropriate for the chosen mounting surface and that can support 15 lb (6.8 kg) (Fig. 28).
2. Fit the PVS5x onto the bracket until the mounting holes at the bottom are aligned.
3. Use a screwdriver to secure the PVS5x to the bracket using the provided screws. Do not overtighten.

Fig. 27

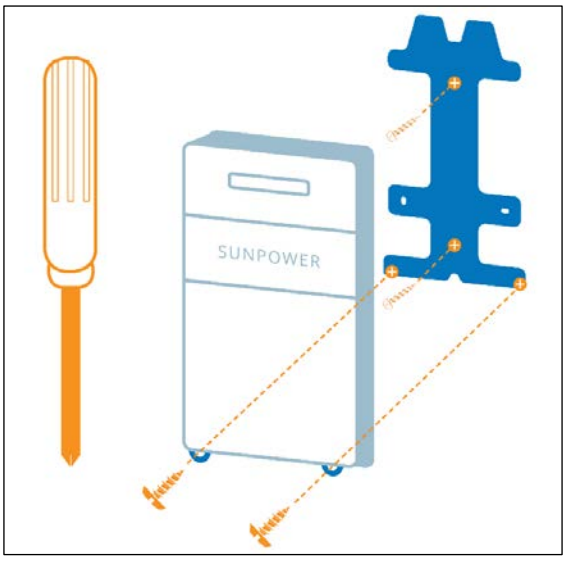


Fig. 28

2.2.5 Wire PVS5x Power

Danger! Hazardous voltage! Do not power up the system until Section 2.3.1.

1. Use a screwdriver—*do not use power tools*—to prepare the PVS5x for AC wiring:
   - Loosen the three screws on the bottom of the PVS5x enclosure and remove the cover (Fig. 29).
   - Remove the lower AC wiring cover (Fig. 29).
   - Remove the upper AC wiring cover (Fig. 29).
   - Flip the AC wiring partition to the *opposite* side of your incoming AC wiring (Fig. 30).
     Warning! **Do not use the AC wiring partition to secure cables or wiring!**
2. Run power conduit from the service panel to the PVS5x. If you use the rear conduit entrances, seal the holes on the bottom of the enclosure with the included hole plugs.

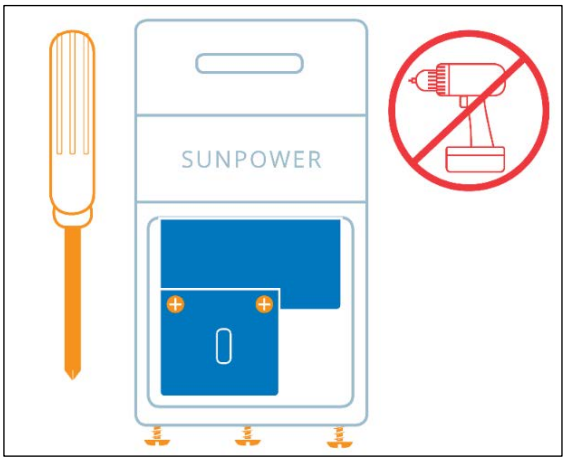


Fig. 29

3. Connect the PVS5x to either a 15 A (with 14 AWG) or a 20 A (with 12 AWG) UL Listed dedicated dual-pole breaker.
   Note: For AC modules, this breaker should be in the same service panel containing the AC module output circuits (refer to diagram in Section 2.2.3).
4. Strip wires and land according to the color-coded labels (black wire to L1; red wire to L2; white wire to N; green wire to GND) in the J5 terminals on the bottom left of the PVS5x board (Fig. 30). Tighten to 4.4–5.3 in-lb (0.5–0.6 N-m).
   Note: Do not overtighten the terminals.

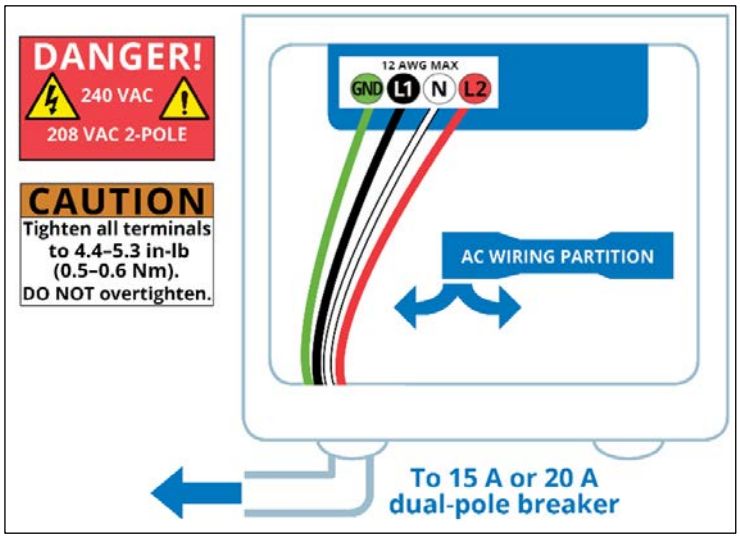


Fig. 30

2.2.6 Install and Wire Consumption CTs

Danger! Hazardous voltage! Do not power up the system until instructed to in Section 2.3.1.

The SunPower-provided current transformers (CTs) **are** suitable for use on 200 A conductors. The CTs may be labeled "100 A" but this is a calibration reference rating only. You may install CTs in parallel or bundled configurations.

1. Turn off all power to the main service panel in which you are installing the CTs.
2. Place the CTs in the main service panel, around incoming service conductors, with the side labeled **this side toward source** toward the utility meter and away from the loads. Never install in the section designated for the utility in the service panel.
   - Place **L1 CT** (black and white wires) around incoming Line 1 service conductor (Fig. 31).
   - Place **L2 CT** (red and white wires) around incoming Line 2 service conductor (Fig. 31).

   Note: Refer to Appendix N for alternate CT installation configurations.
3. Align the steel core pieces and snap the CTs closed.

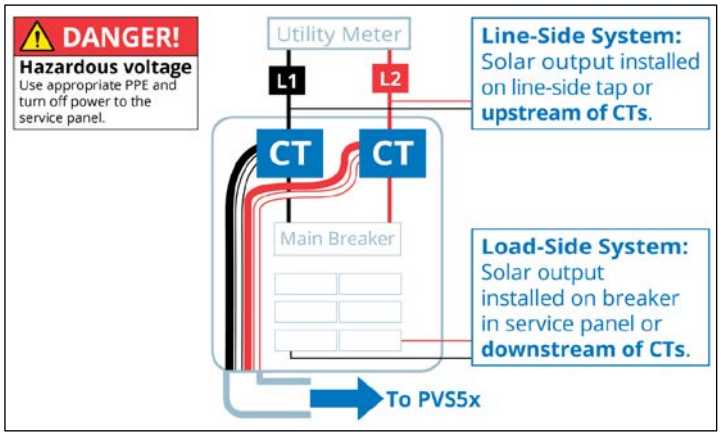


Fig. 31

4. Route CT wires through conduit to the PVS5x:
   - **Running CT wires:** You may run CT and AC wiring in the same conduit. Do not run CT wiring and internet communication cables in the same conduit.
   - **Extending CT leads:** Use Class 1 (300 V rated minimum, 16 AWG maximum) twisted-pair instrument cable and appropriate connectors; SunPower recommends the use of silicone-filled insulation displacement connectors (IDC) or telecom crimps; **do not use power cables (for example, THWN or Romex®) to extend the CT leads.**
     Note: See *Continental Control Systems: Current Transformer (CT) Wire Extension guide* at:

     https://ctlsys.com/support/current-transformer-ct-wire-extension/

     for suggested wire types and sourcing.
5. Land **L1 CT** and **L2 CT** wires in corresponding **CONS L1** and **CONS L2** in the J16 terminals on the bottom right terminals of the PVS5x board (Fig. 32). Tighten to 4.4–5.3 in-lb (0.5–0.6 N-m). If you shorten the leads, strip no more than 1/4" (6 mm).

   Note: Do not overtighten terminals.

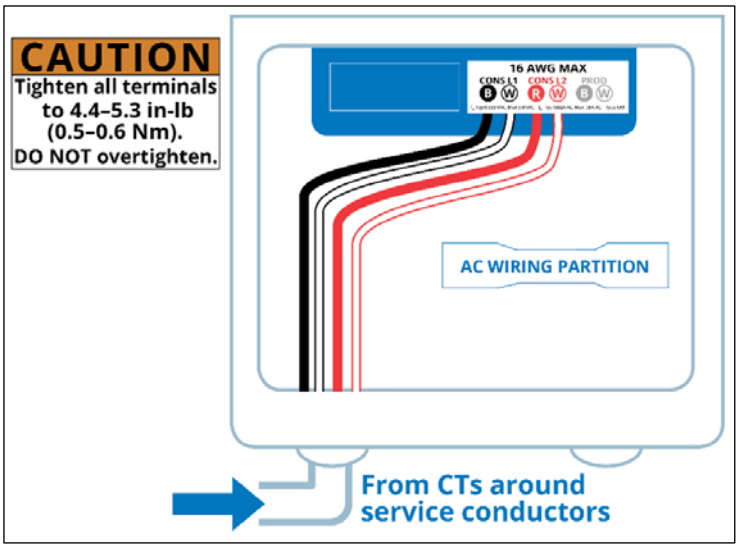


Fig. 32

2.2.7 Verify CT Voltage Phases

1. Turn on power to the PVS5x.
2. Use a voltmeter to measure the voltage between the PVS5x L1 terminal and the L1 incoming service conductor in the main service panel with the L1 CT in place.
   - If the voltmeter reads *0 V* (zero volts) the phases are correctly aligned.
   - If the voltmeter reads *240 V* the phases are incorrectly aligned. Move the CT to the other incoming service conductor and retest to verify *0 V.*
3. Repeat this same verification for L2.

2.2.8 Connect System Communication

1. Replace the upper AC wiring cover.
2. Replace the lower AC wiring cover over the AC power wires (on the left if you routed through the left hole; on the right if you routed through the right hole) (Fig. 33).
3. Run communication conduit to the PVS5x conduit opening. If you use the rear conduit entrances, seal the holes on the bottom of the enclosure with the included hole plugs.

   Warning! Never run inverter communications cables in the same conduit as AC wiring.
4. Verify that you connected the AC modules to the AC module subpanel. (No additional connection is required because the PVS5x communicates with the AC modules using PLC protocol.)

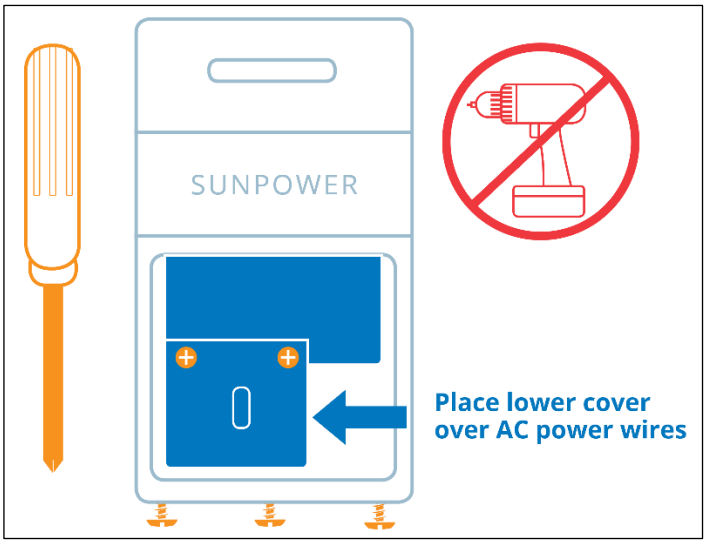


Fig. 33

2.2.9 Connect PVS5x to the Internet

Connect to the customer's internet using one of the following methods (Fig. 34):

- **Ethernet cable:** from PVS5x LAN2 to customer's router **(recommended method).**
- **Power Line EA:** to customer's router (optional accessory available from SunPower).
- **Customer's Wi-Fi network:** connect during commissioning using customer's Wi-Fi network name and password.

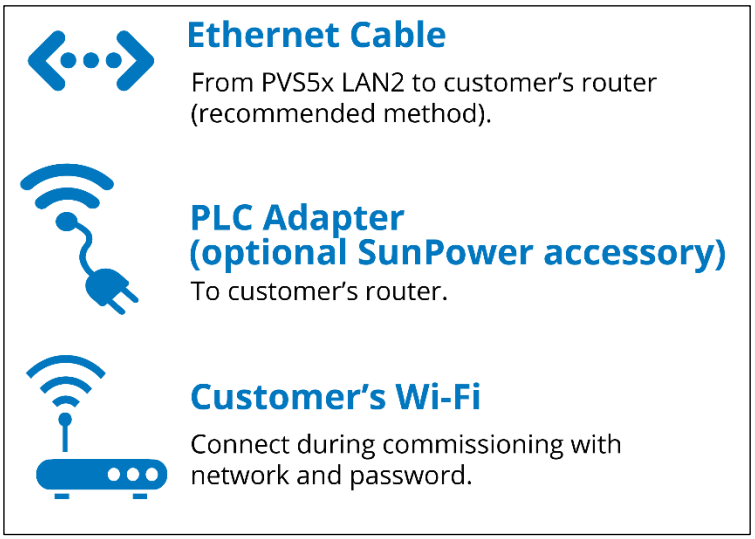


Fig. 34

2.3 Commission with PVS Management App

Important! Did you verify the branch circuit voltages? Refer to Section 1.9.4 now if you have not.

After installing all system hardware, use the PVS Management App to:

- Set up communication
- Check firmware
- Discover devices
- Configure devices
- Verify device operation
- Create the site layout map
- Commission the site

Important! The layout and commissioning steps can also be done remotely from pvsmgmt.us.sunpower.com.

2.3.1 Connect to PVS Management App

> ***Important!*** To ensure that your browser is up to date, perform the steps in Section L.7 now, before proceeding.

1. Verify that all devices are properly installed and that communication is connected.

   Note: A device in this context is an AC module; a meter; or a PVS5x.

2. Power on the array, the PVS5x, and all communication devices.
3. Turn off the Wi-Fi on your laptop.
4. Use an Ethernet cable to connect your laptop to PVS5x LAN 1 port (Fig. 35).
5. Access www.sunpowerconsole.com.
6. Follow the PVS Management App instructions to commission SMS.

Note: Inspectors can verify production data for this screen by following the instructions in this section and accessing www.sunpowerconsole.com/power.

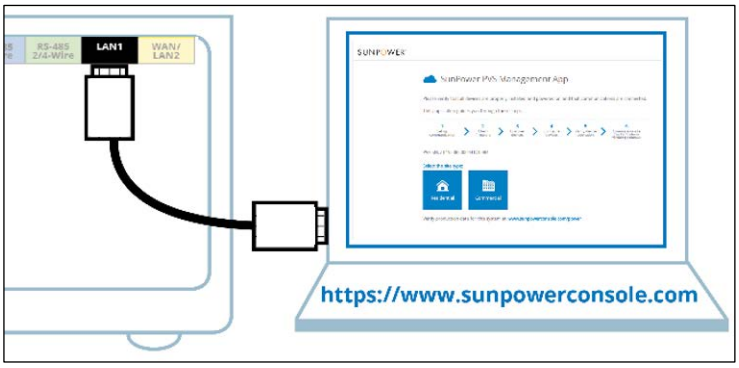


Fig. 35

2.3.2 Set Up Communication

In addition to cellular, set up one additional communication option (Fig. 36). Additional options are: hardwired Ethernet, Power Line EAs, or Wi-Fi.

If the site does not have cellular coverage, set up two additional communication options.

The customer's router, the internet, and the SunPower cloud must be connected for each communication option you choose to set up.

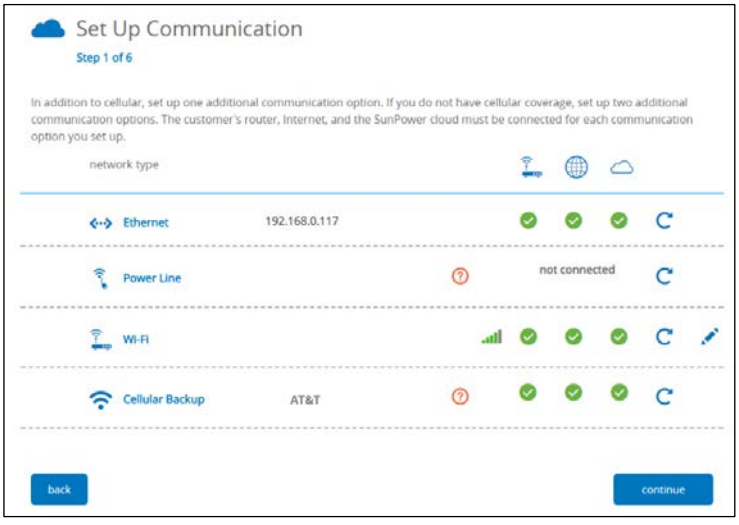


Fig. 36

2.3.3 Check Firmware

The PVS Management App **automatically** checks the firmware version, downloads a firmware update if it is available, and installs any available firmware updates.

2.3.4 Discover Devices

The PVS Management App **automatically** searches for and displays a list of all of the external devices and AC modules installed at the site. It will also display the internal consumption and production meters.

If you installed a device (an AC module or a meter) but it was not discovered, verify the its connections and use the **Rediscover** button on the *Configure Devices* page in the PVS Management App to search for the device again.

2.3.5 Configure Devices

Click the **configure** button (Fig. 37) for each device type row and enter the required information for each device.

Configure AC Modules

1. In the search field, type the wattage value of the AC module you installed (for example, *350*) and then select the correct value from the list (Fig. 38).
2. Click **apply to all** if all modules are the same wattage or enter each module wattage and select the model (Fig. 38).

Configure Meters

1. Select the consumption meter type from the dropdown (Fig. 39):
   - **Not Used:** You did not install consumption CTs.
   - **Consumption (Load Side PV):** You installed consumption CTs and the solar system is installed on a breaker in the service panel or downstream of the CTs.
   - **Consumption (Line Side PV):** You installed consumption CTs and the solar system is installed on a line-side tap or upstream of the CTs.
2. Enter the onboard consumption meter CT rated current in the Onboard Consumption field labeled **Amps** (Fig. 39). The CT rated current is the sum of the CT values per phase. For example, if you installed:
   - one 100 A CT on one phase, enter *100.*
   - two parallel 100 A CTs on one phase, enter *200.*
3. Select the production meter type from the dropdown (Fig. 39):
   - **Not Used:** You did not install consumption CTs.
   - **Production Meter:** You installed a CT for the onboard production meter.

Fig. 37

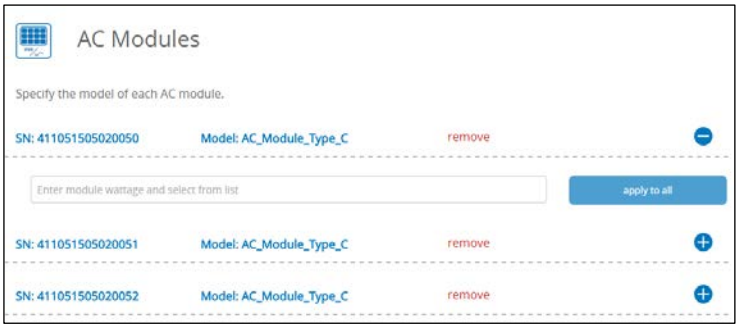


Fig. 38

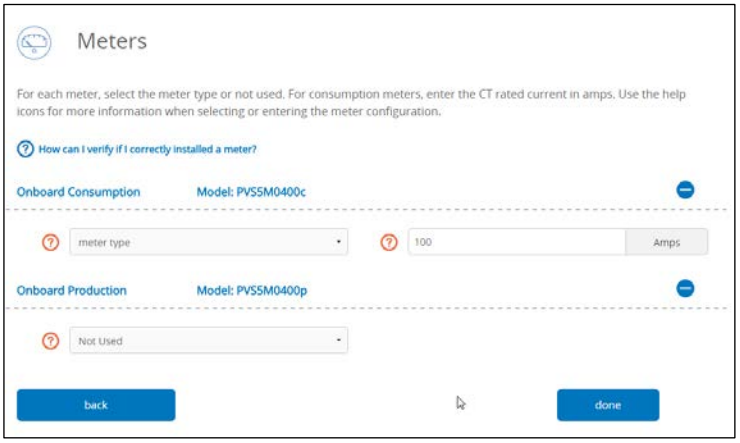


Fig. 39

2.3.6 Verify Device Operation

Note: Refer to Appendix N and Appendix P for CT installation instructions.

A list of all of the monitoring devices and AC modules configured at the site displays, with the status and power for each device (Fig. 40).

To verify the revenue-grade production meter power readings, verify that the meter power reading in the PVS Management App matches the PVS total power reading.

If the reading is inaccurate, return to the **Meters** page and verify that you selected the correct meter type and entered the correct CT rated current. In addition, confirm that your CTs are in the proper direction and the phase voltage current is consistent with the PVS5x and CTs.

If a device is not communicating or producing power, verify that you have powered up the solar system. If a device is still not operating, record the device serial number and continue commissioning using the PVS Management App. After the site is commissioned, please call SunPower at 1-855-977-7867 to troubleshoot.

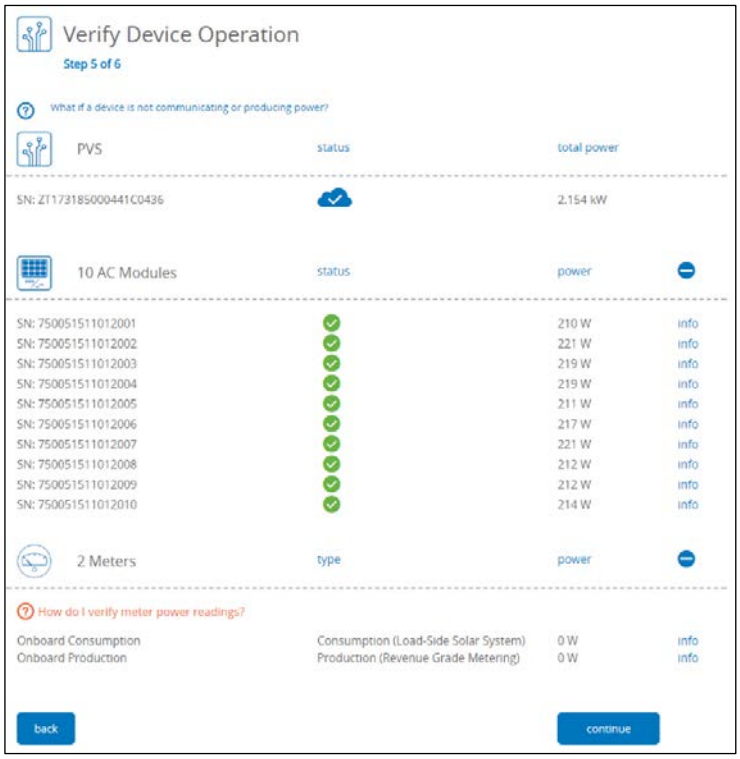


Fig. 40

2.3.7 Commission Devices

Important! Your monitoring website credentials are required in order to complete commissioning.

To complete commissioning: select the site, review the site information (Fig. 41), and recreate the module layout (Fig. 42).

As an option, you can choose to complete module layout and commissioning later from a remote location.

> For remote commissioning go to **pvsmgmt.us.sunpower.com**

Important! In order for you and the customer to receive monitoring data, you must complete commissioning in the PVS Management App by selecting the site (or creating the site); reviewing the site information; and creating the module layout.

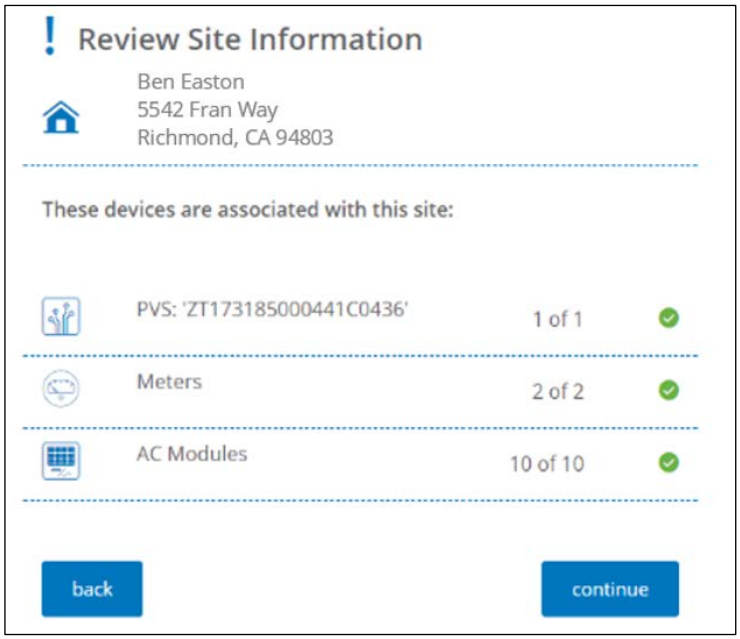


Fig. 41

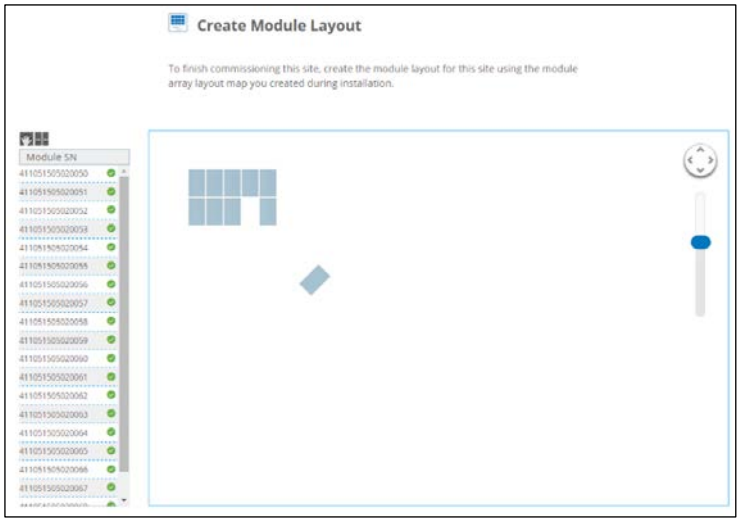


Fig. 42

2.4 Create EnergyLink Home Account for Customer Monitoring

Important! You must complete site commissioning *before* creating the customer's EnergyLink account.

When you have finished commissioning the site, create an EnergyLink monitoring account for the customer.

1. If you have not yet created an account for the customer, either select the **create customer account** button from the PVS Management App or access: https://monitor.us.sunpower.com/#/register/serial_number/no_email/thirdparty and follow the instructions to create the customer's EnergyLink Home account.

   Important! You must know the customer's preferred email address. Do no create the customer's EnergyLink Home account until after you have confirmed with the customer their preferred email address.

2. On the customer registration card (included in the PVS5x box), place the **Remove for customer records** serial number sticker in the **PVS device serial number** box, (Fig. 43).

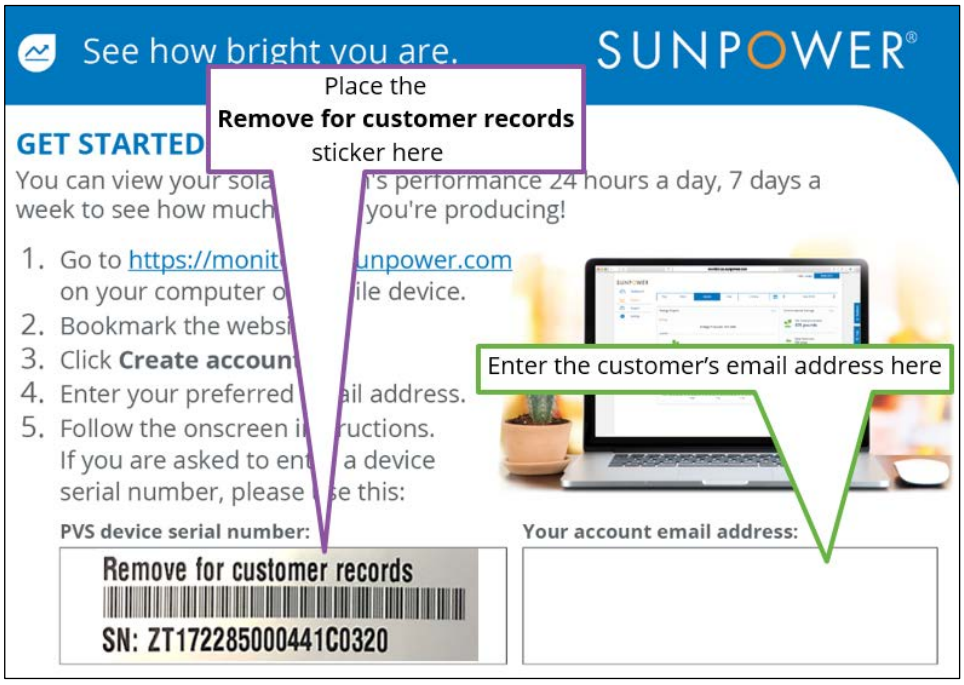


Fig. 43

3. In the **Your account email address** box, enter the email address you used to create the customer's account.
4. Give the card to the customer for their records.

The customer can download the PVS Management App from Apple Store (iTunes) or from Google Play. The PVS Management App supports both Apple and Android devices.

2.5 Replace PVS5x Enclosure Cover

1. Unplug your laptop from the PVS5x.
2. Replace the PVS5x enclosure cover.
3. Use a screwdriver to tighten the three screws on the bottom of the enclosure (Fig. 44).

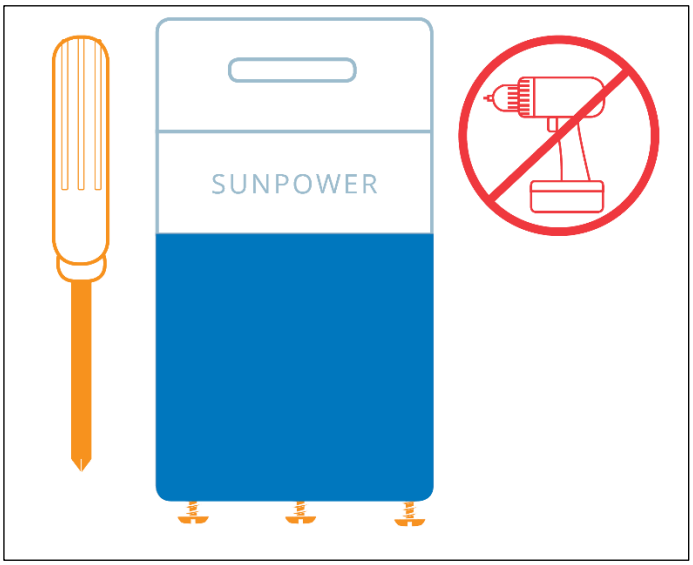


Fig. 44

Appendix A: System and Site Checklist and Array Layout Diagram

A.1 Complete SunPower System and Site Checklist and Create Array Layout Diagram

To save you time and to help ensure a high-quality installation, SunPower strongly recommends that you complete the entire *SunPower System and Site Checklist*—including creating an accurate re-creation of the array—in order to clearly show the position of each module in the array.

1. To create the array layout diagram: for each module, remove its frame sticker and its microinverter sticker and place them next to each other (in the same relative location as that module's actual location in the array) in the **AC MODULE ARRAY LAYOUT** area of the Checklist (Fig. A1):

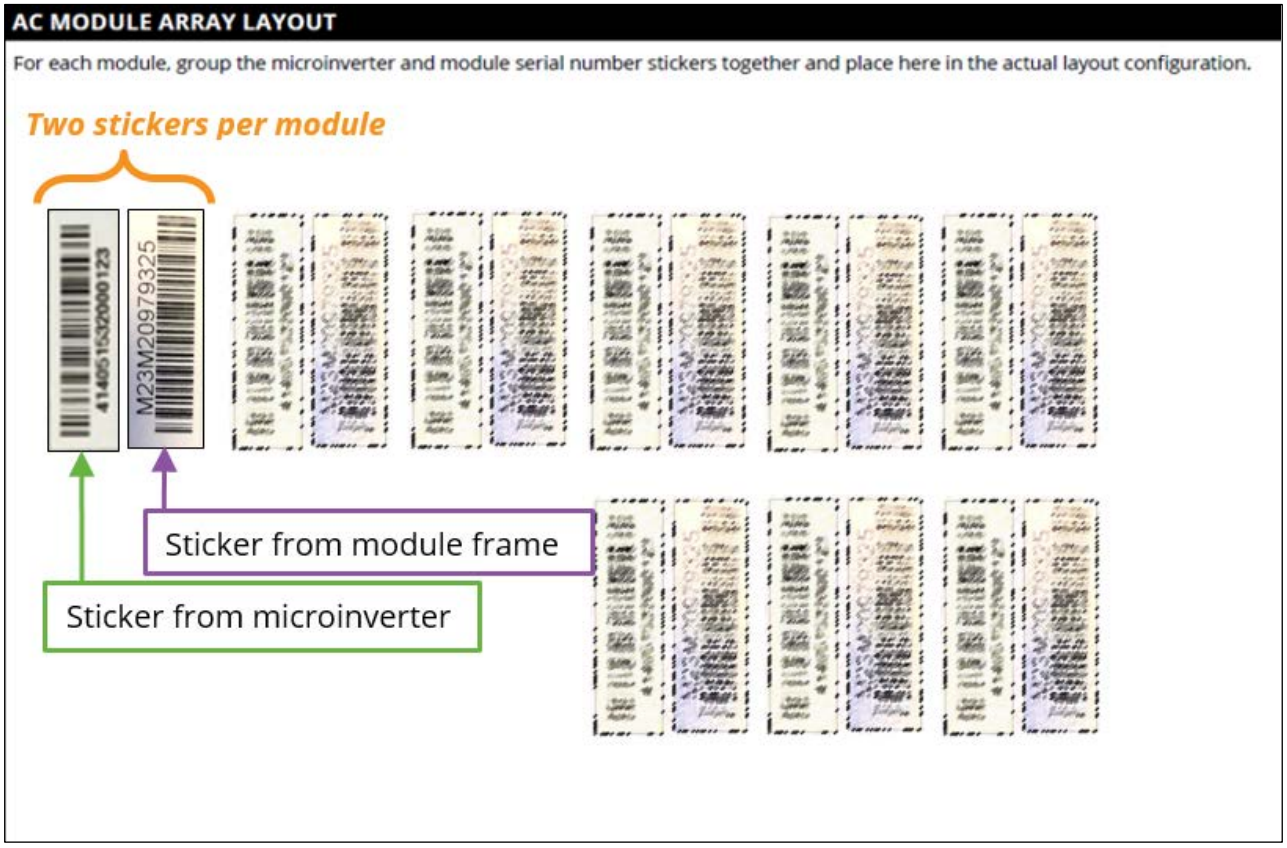


Fig. A1

Remove **only** these stickers:

- The sticker from the microinverter (MI) (Fig. A2).

Fig. A2

- The sticker from the module ***frame*** (Fig. A3)—*not from the module backsheet!* (Fig. A4).

Fig. A3

Fig. A4

2. Remove the **Remove for dealer records** sticker from the PVS5x sticker card (refer to Fig. 27) , and place it in the **PVS5X** section on the Checklist (Fig. A5):

PVS5X	
Serial number (place peelable sticker):	Remove for dealer records SN: ZT172285000441C0320
Voltage measurements:	L1–G: _____ L2–G: _____ L1–L2: _____ N–G: _____
Communication:	ETHERNET WI-FI PLC ADAPTER
☐ Wired PVS power according to labels	
☐ Tightened PVS screws to torque settings: 0.5 to 0.6 N-m (4.4 to 5.3 in-lb)	

Fig. A5

SunPower System and Site Checklist

CUSTOMER INFORMATION			
Contract #:		Date:	
Customer:		Address:	
Site nickname:			

Record information in each field and check each box after completion.

SITE AND SYSTEM INFORMATION	
Total modules installed:	
Operating voltage (circle one):	240 V or 208 V
Circuit Breaker (CB) for Modules and PVS5	
Modules and PVS to:	MAIN PANEL or SUBPANEL or COMBINER BOX
☐ Bonded N bus bar to GND bus bar at service entrance/combiner	
☐ Homerun and raceway properly secured	
☐ No wires touching roof surface	
☐ All panel and box covers correctly secured	
☐ Site free of debris and all trash discarded	

PVS5X	
Serial number (place peelable sticker):	
Voltage measurements:	L1–G: _____ L2–G: _____ L1–L2: _____ N–G: _____
Communication:	ETHERNET WI-FI PLC ADAPTER
☐ Wired PVS power according to labels	
☐ Tightened PVS screws to torque settings: 0.5 to 0.6 N-m (4.4 to 5.3 in-lb)	

METERS		
Consumption Meter		
Configuration (circle one):	LOAD-SIDE SYSTEM Solar installed in service panel downstream of CTs.	LINE-SIDE SYSTEM **Non-bundled:** Solar installed on the line side or upstream of CTs. **Bundled:** captures only load circuits (no modules).
CT scale factor (default = 100 A):		
☐ Installed consumption CTs		
☐ Wired according to labels on the PVS		
☐ Installed with the label facing the utility meter		
☐ Verified voltage between PVS5x L1 and main service panel L1 is 0 V		
☐ Verified voltage between PVS5x L2 and main service panel L2 is 0 V		
☐ Verified consumption meter readings using PVS Management App		
Production Meter (if required)		
Installed?	YES or NO	
☐ Installed production CT		
☐ Wired according to labels on the PVS		
☐ Installed with the engraved text facing the utility meter		

SITE PHOTOGRAPHS
Arrays and Conduit Runs
☐ Inside each rooftop junction box
☐ Junction box to attic penetration
☐ Wide angle of junction box with array wires entering attic penetration
☐ Installed rails before installing modules
☐ Roof attachment with flashing
☐ Complete array
☐ Wires and cable under array at transition junction box
☐ Side of array with InvisiMount rail ends flush to array
☐ Electrical transition box with entry of array conductors
☐ Conduit runs including rooftop, attic, and wall-mounted locations
Equipment (eBOS)
☐ Wide angle shot of all equipment
☐ Wide angle beauty shot of array for marketing materials
☐ DC disconnect with internal wiring (if applicable)
☐ AC disconnect with internal wiring (if applicable)
☐ Subpanel interior
☐ Point of interconnection with breaker or tap (closeup)
☐ Main service panel with all internal wiring
☐ Current Transformers (CTs) in main service panel
Monitoring Equipment
☐ Inside PVS5x enclosure with power and CT wiring terminations
☐ Inside PVS5x with communication cables
☐ Internet connection: Ethernet or PLC Ethernet Adapter (if used)
☐ Inside PVS5x with AC wiring partition and AC wiring covers

OTHER ONSITE ELECTRICAL EQUIPMENT
Record the type, model, and manufacturer of all onsite electrical equipment that may cause interference with power line communications. (For example: pool pump, VFD motors, light dimmers, and smart home devices.)
•
•
•
•
•

AC MODULES

- ☐ All modules secured to racking (performed module pull test)
- ☐ Verified each branch circuit voltage (tested at end of circuit)
- ☐ Installed end caps
- ☐ Placed all microinverter and module serial numbers on module layout map

Circuit	1	2	3	4	5	6	7	8	9	10
# of modules: Max. 12 for 240 V Max. 10 for 208 V										
Module model:										
Circuit label:										
V (AC) L1–L2:										
V (AC) L1–G:										
V (AC) L2–G:										

AC MODULE ARRAY LAYOUT

For each module, group the microinverter and module serial number stickers together and place here in the actual layout configuration.

Appendix B: Module Removal

Important! If you have to remove a module from an array, note that *leaving any module in the array when it is physically secured only by two end clamps is expressly prohibited!*

> **When a module is removed from a circuit, you must first disconnect all power and then install a temporary EGC to bridge the gap by inserting an AC extension cable (or via other NEC-compliant means), in order to maintain effective ground continuity to subsequent modules.**

To remove a module from an existing array:

1. Turn off the AC disconnect.
2. Using a clamp-on multimeter, verify that current flow has stopped on the module DC leads.
3. Using a clamp-on current meter, test each individual circuit conductor AND each equipment ground conductor on the rooftop before opening any module connectors (before disconnecting any module leads).
4. Using a voltage tester, verify that there is no voltage on the branch circuit conductors.
5. If the current is zero (0) amps, it is safe to proceed to Step 6.

   If there is any current present (greater than 0 amps), double-check that the circuit is in fact disconnected from the inverter, and then repeat Step 4.
6. Disconnect (unplug) the target module's two AC cables from the modules that are adjacent to the target module.
7. Remove the modules necessary to access the target module—ideally from the side of the row that contains fewer modules between the target module and the row end (Fig. B1 and Fig. B2). If there is any other grounding or wire management hardware present, remove it as well.
8. Remove the target module:
   - If the target module will be out of the array solely for the purposes of replacing it with another module immediately, ensure that you remain aware of the adjacent module's temporary partial securement, and execute the swap promptly, reusing all of the mid clamps and end clamps.
   - If the target module will be out of the array for an extended period, carefully attach two mid clamps to the now-exposed edge of the adjacent module (Fig. B1, Fig. B2, and Fig. B3) according to Section 1.9.3 of this guide (note that two of the teeth on these mid clamps will instead directly engage the top of the rail—this is acceptable). The mid clamps will keep the modules bonded to the rail, which is bonded to the equipment grounding conductor (EGC) and in turn the grounding electrode conductor (GEC). **Connect an appropriate extension cable between the modules on each "side" of the "hole" in the circuit left by the removed target module**.
9. After replacing or servicing the target module, reassemble the row according to the instructions in this guide.

   Important! When reinstalling a removed module, shift its original location slightly (min. 1/16" [1.6 mm]) relative to its original installed position and in the direction perpendicular to the rail before retightening the mid clamps and end clamps.

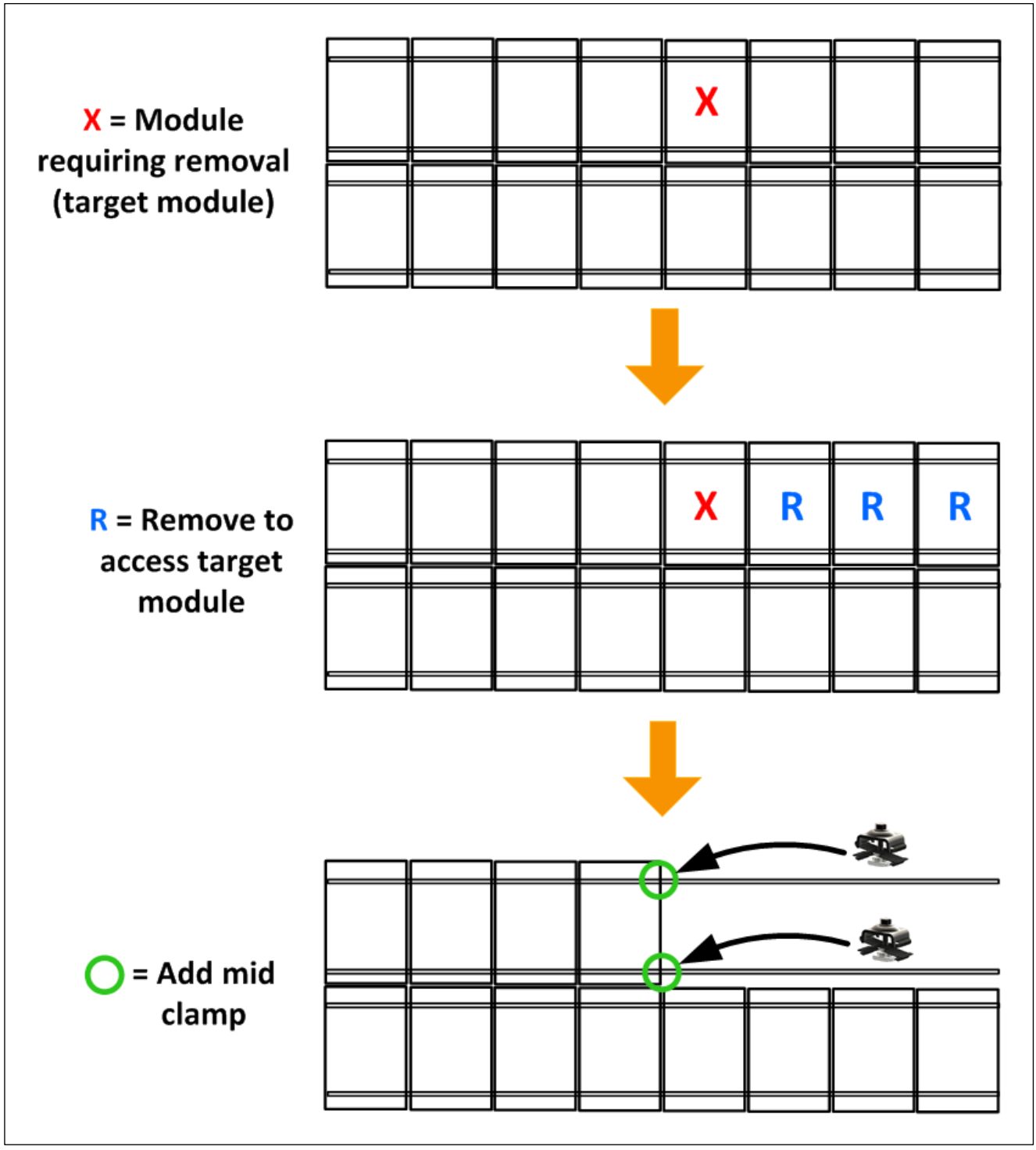

X = Module requiring removal (target module)
X
R = Remove to access target module
X
R
R
R
= Add mid clamp

Fig. B1

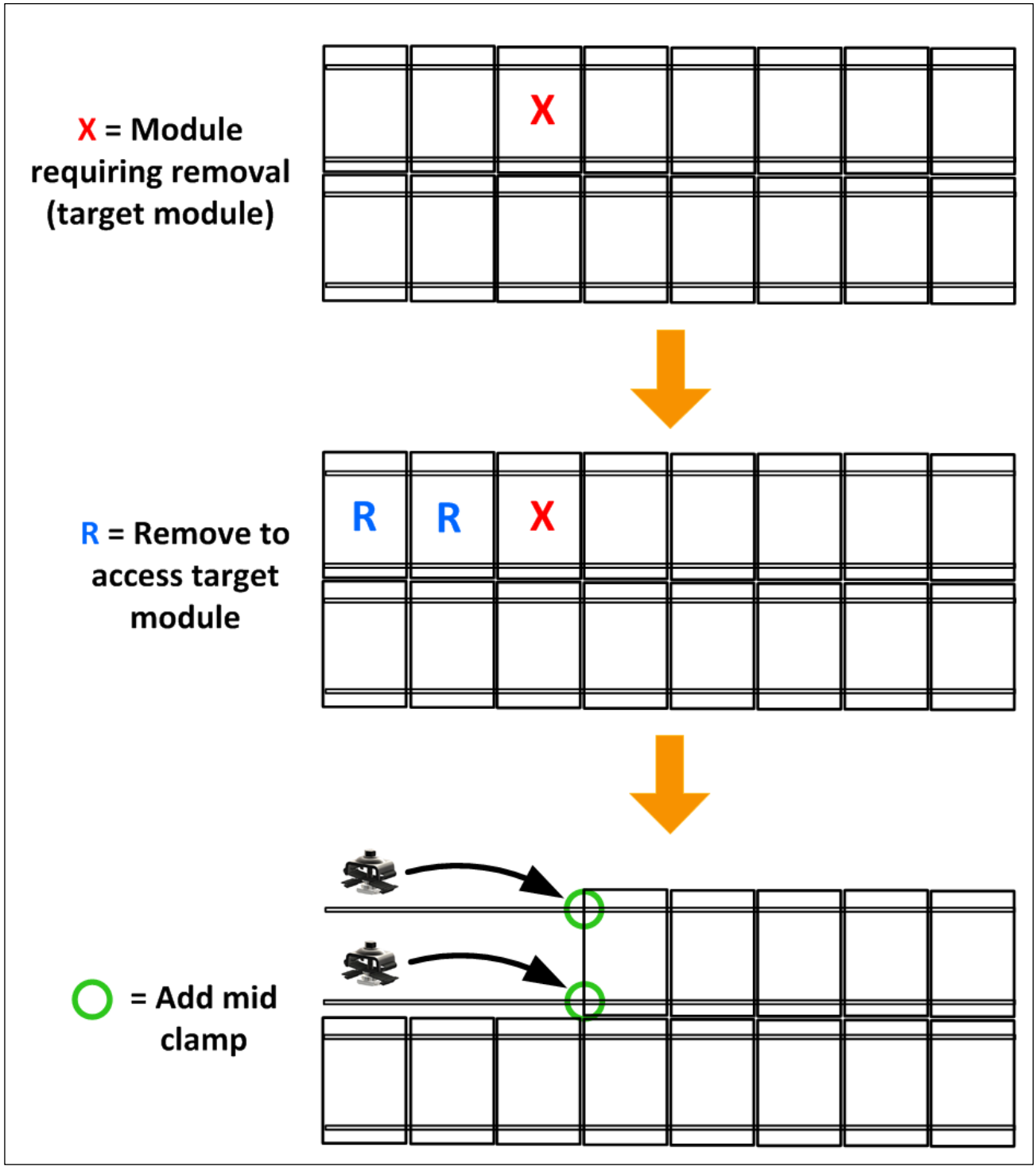

X = Module requiring removal (target module)
X
R = Remove to access target module
R
R
X
= Add mid clamp

Fig. B2

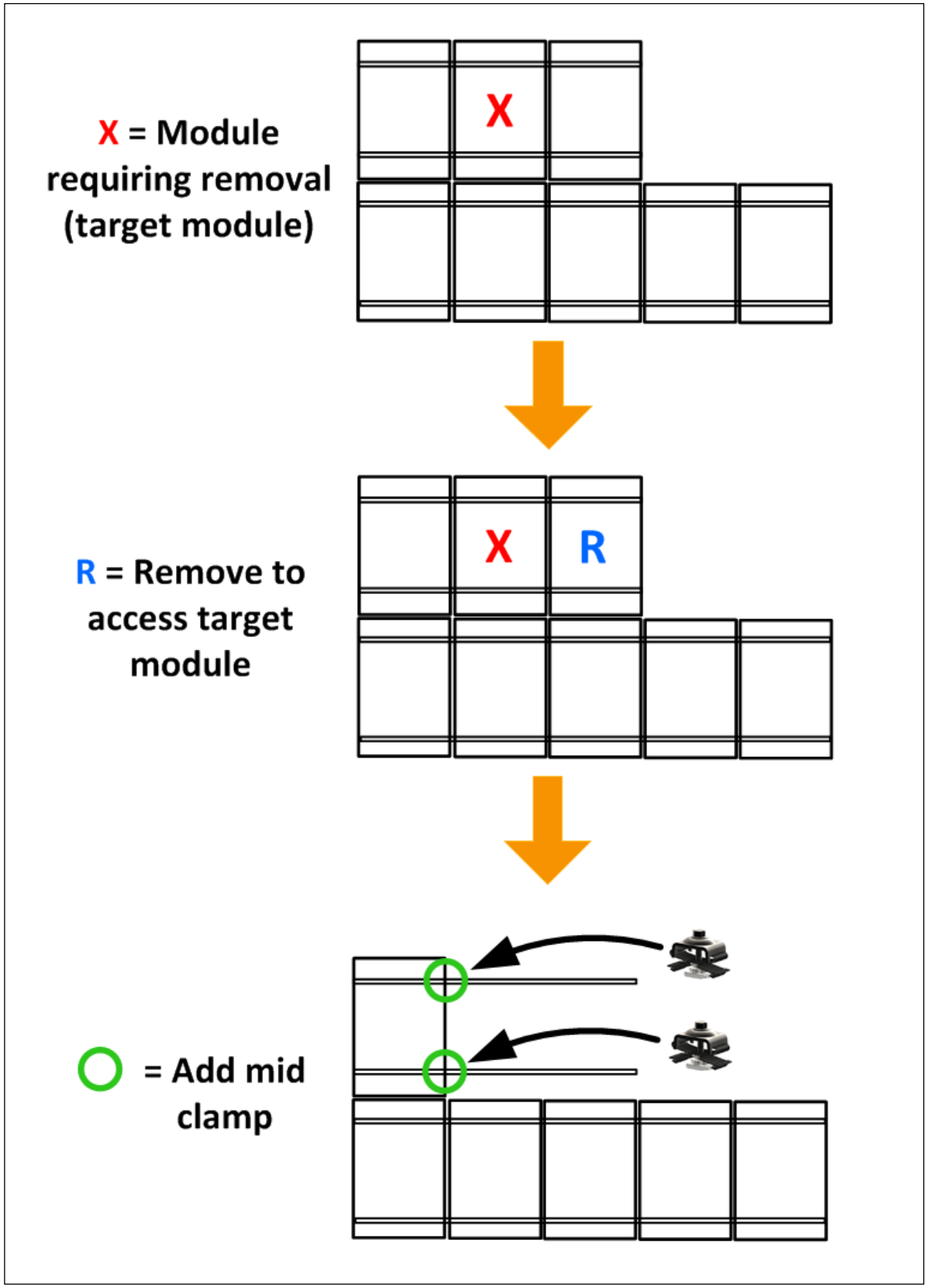

X = Module requiring removal (target module)
X
R = Remove to access target module
X
R
= Add mid clamp

Fig. B3

Appendix C: Conductor Selection

Before viewing the tables in this appendix, note that manual calculations may be required for:

- other temperatures
- longer distances
- voltage-drop calculations that are more conservative
- other conductors
- greater conduit fill
- terminal temperatures other than 60°C

Tables and correction factors are from the 2011 NEC.

Conductor sizes in the following table are based on the ambient temperature shown in the blue table header. Temperature correction factors used are for 194°F (90°C) conductors and 140°F (60°C) terminals, with no more than three current-carrying conductors in the cable or raceway. Maximum current, nominal voltage and acceptable range of voltage drop are shown as well.

Conductor & OCP Sizing Based on 50°C (120°F)

of AC Modules on a Single Circuit

One-Way Circuit Length	1	2	3	4	5	6	7	8	9	10	11	12
25	14 AWG 15 A	14 AWG 15 A	14 AWG 15 A	14 AWG 15 A	14 AWG 15 A	14 AWG 15 A	14 AWG 15 A	14 AWG 15 A	14 AWG 15 A	12 AWG 20 A	12 AWG 20 A	12 AWG 20 A
50	14 AWG 15 A	14 AWG 15 A	14 AWG 15 A	14 AWG 15 A	14 AWG 15 A	14 AWG 15 A	14 AWG 15 A	14 AWG 15 A	14 AWG 15 A	12 AWG 20 A	12 AWG 20 A	12 AWG 20 A
75	14 AWG 15 A	14 AWG 15 A	14 AWG 15 A	14 AWG 15 A	14 AWG 15 A	14 AWG 15 A	12 AWG 15 A	12 AWG 15 A	12 AWG 15 A	10 AWG 20 A	10 AWG 20 A	10 AWG 20 A
100	14 AWG 15 A	14 AWG 15 A	14 AWG 15 A	14 AWG 15 A	12 AWG 15 A	12 AWG 15 A	12 AWG 15 A	10 AWG 15 A	10 AWG 15 A	10 AWG 20 A	10 AWG 20 A	10 AWG 20 A
125	14 AWG 15 A	14 AWG 15 A	14 AWG 15 A	12 AWG 15 A	12 AWG 15 A	10 AWG 15 A	10 AWG 15 A	10 AWG 15 A	10 AWG 15 A	8 AWG 20 A	8 AWG 20 A	8 AWG 20 A
150	14 AWG 15 A	14 AWG 15 A	14 AWG 15 A	12 AWG 15 A	10 AWG 15 A	10 AWG 15 A	10 AWG 15 A	10 AWG 15 A	8 AWG 15 A	8 AWG 20 A	8 AWG 20 A	8 AWG 20 A
175	14 AWG 15 A	14 AWG 15 A	12 AWG 15 A	12 AWG 15 A	10 AWG 15 A	10 AWG 15 A	10 AWG 15 A	8 AWG 15 A	8 AWG 15 A	8 AWG 20 A	6 AWG 20 A	6 AWG 20 A
200	14 AWG 15 A	14 AWG 15 A	12 AWG 15 A	10 AWG 15 A	10 AWG 15 A	10 AWG 15 A	8 AWG 15 A	8 AWG 15 A	8 AWG 15 A	6 AWG 20 A	6 AWG 20 A	6 AWG 20 A

Conductor & OCP Sizing Based on 60°C (140°F)

of AC Modules on a Single Circuit

One-Way Circuit Length	1	2	3	4	5	6	7	8	9	10	11	12
25	14 AWG 15 A	14 AWG 15 A	14 AWG 15 A	14 AWG 15 A	14 AWG 15 A	14 AWG 15 A	14 AWG 15 A	14 AWG 15 A	14 AWG 15 A	12 AWG 20 A	12 AWG 20 A	12 AWG 20 A
50	14 AWG 15 A	14 AWG 15 A	14 AWG 15 A	14 AWG 15 A	14 AWG 15 A	14 AWG 15 A	14 AWG 15 A	14 AWG 15 A	14 AWG 15 A	12 AWG 20 A	12 AWG 20 A	12 AWG 20 A
75	14 AWG 15 A	14 AWG 15 A	14 AWG 15 A	14 AWG 15 A	14 AWG 15 A	14 AWG 15 A	12 AWG 15 A	12 AWG 15 A	12 AWG 15 A	10 AWG 20 A	10 AWG 20 A	10 AWG 20 A
100	14 AWG 15 A	14 AWG 15 A	14 AWG 15 A	14 AWG 15 A	12 AWG 15 A	12 AWG 15 A	12 AWG 15 A	10 AWG 15 A	10 AWG 15 A	10 AWG 20 A	10 AWG 20 A	8 AWG 20 A
125	14 AWG 15 A	14 AWG 15 A	14 AWG 15 A	12 AWG 15 A	12 AWG 15 A	10 AWG 15 A	10 AWG 15 A	10 AWG 15 A	10 AWG 15 A	8 AWG 20 A	8 AWG 20 A	8 AWG 20 A
150	14 AWG 15 A	14 AWG 15 A	14 AWG 15 A	12 AWG 15 A	10 AWG 15 A	10 AWG 15 A	10 AWG 15 A	8 AWG 15 A	8 AWG 15 A	8 AWG 20 A	8 AWG 20 A	8 AWG 20 A
175	14 AWG 15 A	14 AWG 15 A	12 AWG 15 A	12 AWG 15 A	10 AWG 15 A	10 AWG 15 A	8 AWG 15 A	8 AWG 15 A	8 AWG 15 A	8 AWG 20 A	6 AWG 20 A	6 AWG 20 A
200	14 AWG 15 A	14 AWG 15 A	12 AWG 15 A	10 AWG 15 A	10 AWG 15 A	8 AWG 15 A	8 AWG 15 A	8 AWG 15 A	8 AWG 15 A	6 AWG 20 A	6 AWG 20 A	6 AWG 20 A

Design Specifications		
AC Module Maximum Current	1.33	Amps
AC Module Nominal Output Voltage	240	Volts
Specified Max. Voltage Drop (J-box to POI)	1.5%	

Color Key: 14 AWG, 12 AWG, 10 AWG, 8 AWG, 6 AWG

Interpreting the Results

Choose the box that corresponds with the circuit length and the number of modules in the circuit. The box contains both the conductor and OCP size, as shown here:

Conductor Size:	10 AWG
Minimum Breaker Size:	20 A

Voltage drops in this table are based on an ambient temperature of 75°C (167°F) with conductors in NM cable or PVC conduit.

Voltage Drop on Field-Installed ACPV Conductors – 14 AWG

# of AC Modules on a Single Circuit

One-Way Circuit Length	1	2	3	4	5	6	7	8	9	10	11	12
25	0.21	0.41	0.62	0.82	1.03	1.24	1.44	1.65	1.86			
50	0.41	0.82	1.24	1.65	2.06	2.47	2.89	3.30	3.71			
75	0.62	1.24	1.86	2.47	3.09	3.71	4.33	4.95	5.57			
100	0.82	1.65	2.47	3.30	4.12	4.95	5.77	6.60	7.42			
125	1.03	2.06	3.09	4.12	5.15	6.18	7.22	8.25	9.28			
150	1.24	2.47	3.71	4.95	6.18	7.42	8.66	9.90	11.13			
175	1.44	2.89	4.33	5.77	7.22	8.66	10.10	11.54	12.99			
200	1.65	3.30	4.95	6.60	8.25	9.90	11.54	13.19	14.84			

Voltage Drop on Field-Installed ACPV Conductors – 12 AWG

# of AC Modules on a Single Circuit

One-Way Circuit Length	1	2	3	4	5	6	7	8	9	10	11	12
25	0.13	0.27	0.40	0.53	0.67	0.80	0.93	1.06	1.20	1.33	1.46	1.60
50	0.27	0.53	0.80	1.06	1.33	1.60	1.86	2.13	2.39	2.66	2.93	3.19
75	0.40	0.80	1.20	1.60	2.00	2.39	2.79	3.19	3.59	3.99	4.39	4.79
100	0.53	1.06	1.60	2.13	2.66	3.19	3.72	4.26	4.79	5.32	5.85	6.38
125	0.67	1.33	2.00	2.66	3.33	3.99	4.66	5.32	5.99	6.65	7.32	7.98
150	0.80	1.60	2.39	3.19	3.99	4.79	5.59	6.38	7.18	7.98	8.78	9.58
175	0.93	1.86	2.79	3.72	4.66	5.59	6.52	7.45	8.38	9.31	10.24	11.17
200	1.06	2.13	3.19	4.26	5.32	6.38	7.45	8.51	9.58	10.64	11.70	12.77

Voltage Drop on Field-Installed ACPV Conductors – 10 AWG

# of AC Modules on a Single Circuit

One-Way Circuit Length	1	2	3	4	5	6	7	8	9	10	11	12
25	0.08	0.16	0.24	0.32	0.40	0.48	0.56	0.64	0.72	0.80	0.88	0.96
50	0.16	0.32	0.48	0.64	0.80	0.96	1.12	1.28	1.44	1.60	1.76	1.92
75	0.24	0.48	0.72	0.96	1.20	1.44	1.68	1.92	2.15	2.39	2.63	2.87
100	0.32	0.64	0.96	1.28	1.60	1.92	2.23	2.55	2.87	3.19	3.51	3.83
125	0.40	0.80	1.20	1.60	2.00	2.39	2.79	3.19	3.59	3.99	4.39	4.79
150	0.48	0.96	1.44	1.92	2.39	2.87	3.35	3.83	4.31	4.79	5.27	5.75
175	0.56	1.12	1.68	2.23	2.79	3.35	3.91	4.47	5.03	5.59	6.14	6.70
200	0.64	1.28	1.92	2.55	3.19	3.83	4.47	5.11	5.75	6.38	7.02	7.66

Design Specifications		
AC Module Maximum Current	1.33	Amps
AC Module Nominal Output Voltage	240	Volts

Color Key:	
Up to the specified voltage drop as a percentage of	0.5%
	1.0%
	1.5%
	2.0%
	>2.0%

Interpreting the Results

Voltage drop is calculated according to the following equation:

$$V = R/1000 \times 2 \times D \times I$$

Where *R* is from NEC Chapter 9, Table 9, *D* is the one-way circuit length from the junction box to the point of interconnection and *I* is the AC module maximum current multiplied by the number of modules. All values are given in volts. Colors are coded based on the percentage of voltage drop from the nominal output voltage.

Appendix D: Certificates

This appendix contains copies of the certifications SunPower has received for the Equinox system components:

- Microinverter – Rapid Shutdown
- AC module – Type D and Type C
- AC extension cable
- InvisiMount system
- InvisiMount end clamp
- PVS5x

In addition to the certificates included in this appendix, the following links provide additional information:

Microinverter and Rapid Shutdown	http://database.ul.com/QIJW2.E479127
AC Module	http://database.ul.com/QHYZ.E478330
AC Cable and Connector	http://database.ul.com/QHZS2.E478711
InvisiMount	http://database.ul.com/QIMS.E466981

D.1 Microinverter Revision E: Rapid Shutdown

CERTIFICATE OF COMPLIANCE

Certificate Number	20170711-E479127
Report Reference	E479127-20170615
Issue Date	2017-JULY-11
Issued to:	SUNPOWER CORP 77 RIO ROBLES SAN JOSE CA 95134-1859
This is to certify that representative samples of	COMPONENT - STATIC INVERTERS AND CONVERTERS FOR USE IN INDEPENDENT POWER SYSTEMS; COMPONENT - PHOTOVOLTAIC RAPID SHUTDOWN SYSTEM EQUIPMENT SEE ADDENDUM PAGE
	Have been investigated by UL in accordance with the Standard(s) indicated on this Certificate.
Standard(s) for Safety:	SEE ADDENDUM PAGE
Additional Information:	See the UL Online Certifications Directory at www.ul.com/database for additional information

Only those products bearing the UL Certification Mark should be considered as being covered by UL's Certification and Follow-Up Service.

The UL Recognized Component Mark generally consists of the manufacturer's identification and catalog number, model number or other product designation as specified under "Marking" for the particular Recognition as published in the appropriate UL Directory. As a supplementary means of identifying products that have been produced under UL's Component Recognition Program, UL's Recognized Component Mark: ᴿᵁᴸ, may be used in conjunction with the required Recognized Marks. The Recognized Component Mark is required when specified in the UL Directory preceding the recognitions or under "Markings" for the individual recognitions.

Recognized components are incomplete in certain constructional features or restricted in performance capabilities and are intended for use as components of complete equipment submitted for investigation rather than for direct separate installation in the field. The final acceptance of the component is dependent upon its installation and use in complete equipment submitted to UL LLC.

Look for the UL Certification Mark on the product.

Bruce Mahrenholz, Director North American Certification Program

UL LLC

Any information and documentation involving UL Mark services are provided on behalf of UL LLC (UL) or any authorized licensee of UL. For questions, please contact a local UL Customer Service Representative at http://ul.com/aboutul/locations/

Page 1 of 7

CERTIFICATE OF COMPLIANCE

Certificate Number	20170711-E479127
Report Reference	E479127-20170615
Issue Date	2017-JULY-11

This is to certify that representative samples of the product as specified on this certificate were tested according to the current UL requirements.

MI-C-320-US208/240-1X. Where "X" is Code for marketing purposes
Only revision number "E" is covered by this report. Location of the Assembly/Revision code on the product label. The Assembly No. may change, but the revision code shall be "E".

Model MI-C-320-US208/240-1X inverter is intended for DC input from a single photovoltaic module.

The inverter is provided with transformer isolation between input and output.

The inverter is also evaluated as PV Rapid Shutdown equipment with Line 1 and Line 2 AC output conductors evaluated as the controlled conductors. Actuation is provided by opening the AC conductors by a breaker or other disconnect device.

Model MI-C-320-US208/240-1X inverter is identical in construction to Model MI-C-320-US208/240-XX covered in Volume 1 section 2 of this file dated 2016-11-09. Only the UL 1998 compliant firmware has been revised to provide SA functionality.

Standards for Safety:

Evaluated to the requirements of the Standard for Safety for Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources, UL 1741, Second Edition, dated January 28, 2010. Including the requirements in UL 1741 Supplement A, sections as noted in the Technical considerations

Additionally evaluated to CAN/CSA C22.2 No. 107.1-1, "General Use Power Supplies.", Reaffirmed 2011

Evaluated to the UL 1741 CRD for Photovoltaic Rapid Shutdown Equipment dated April 02, 2015

Bruce Mahrenholz, Director North American Certification Program

UL LLC

CERTIFICATE OF COMPLIANCE

Certificate Number 20170711-E479127
Report Reference E479127-20170615
Issue Date 2017-JULY-11

Components covered by this certificate provide functionality in compliance with UL 1741 Supplement A (SA) when used in a UL Listed end product which has been evaluated by UL for it's intended purpose. Compliance testing was conducted on samples of the products according to the test methods in the following sections of UL 1741 with compliant results:

Certified functions. Cross Reference table – UL 1741 SA to SRD	Source Requirement Document(s)	Test Standard(s) and Section(s)	Report Date
ANTI-ISLANDING PROTECTION - UNINTENTIONAL ISLANDING WITH GRID SUPPORT FUNCTIONS ENABLED	Electric Rule No. 21 Hh.1a	UL 1741 SA 8	2017-JUNE-21
LOW/HIGH VOLTAGE RIDE-THROUGH	Electric Rule No. 21 Table Hh.1	UL 1741 SA 9	2017-JUNE-21
LOW/HIGH FREQUENCY RIDE-THROUGH	Electric Rule No. 21 Table Hh.2	UL 1741 SA10	2017-JUNE-21
RAMP RATES	Electric Rule No. 21 Hh.2k	UL 1741 SA 11	2017-JUNE-21
RECONNECT BY "SOFT START"	Electric Rule No. 21 Hh.2k	UL 1741 SA 11	2017-JUNE-21
SPECIFIED POWER FACTOR	Electric Rule No. 21 Hh.2i	UL 1741 SA 12	2017-JUNE-21
DYNAMIC VOLT/VAR OPERATIONS	Electric Rule No. 21 Hh.2J	UL 1741 SA 13	2017-JUNE-21

Testing conducted to the requirements of UL 1741 SA corresponds to the minimum requirements for CA Rule 21, 2015. An enumeration of functions tested, including complete ratings, and available certified settings for the Grid Support functions, are recorded in the appendix to this document. Test data and detailed results of compliance testing are retained in the complete UL Report for this product.

Report prepared by:

John W. Carr
Staff engineer
Section 3018DNBK

Bruce Mahrenholz, Director North American Certification Program
UL LLC

CERTIFICATE OF COMPLIANCE

Certificate Number 20170711-E479127
Report Reference E479127-20170615
Issue Date 2017-JULY-11

Appendix

Detailed Testing Summary	Test Standard(s) and Section(s)	Fixed / Adjustable	Pass / Fail
UNINTENTIONAL ISLANDING WITH GRID SUPPORT FUNCTIONS ENABLED	UL 1741 SA 8	Fixed	Pass
HIGH VOLTAGE RIDE-THROUGH DURATION	UL 1741 SA 9.1	Fixed	Pass
HIGH VOLTAGE RIDE-THROUGH / MUST TRIP MAGNITUDES	UL 1741 SA 9.2	Adjustable	Pass
HIGH VOLTAGE MUST TRIP CLEARING TIMES	UL 1741 SA 9.2	Adjustable	Pass
LOW VOLTAGE RIDE-THROUGH DURATION	UL 1741 SA 9.1	Fixed	Pass
LOW VOLTAGE RIDE-THROUGH / MUST TRIP MAGNITUDES	UL 1741 SA 9.2	Adjustable	Pass
LOW VOLTAGE MUST TRIP CLEARING TIMES	UL 1741 SA 9.2	Adjustable	Pass
HIGH FREQUENCY RIDE-THROUGH DURATION	UL 1741 SA10.1	Fixed	Pass
HIGH FREQUENCY RIDE-THROUGH / MUST TRIP MAGNITUDES	UL 1741 SA10.2	Adjustable	Pass
HIGH FREQUENCY MUST TRIP CLEARING TIMES	UL 1741 SA10.2	Adjustable	Pass
LOW FREQUENCY RIDE-THROUGH DURATION	UL 1741 SA10.1	Fixed	Pass
LOW FREQUENCY RIDE-THROUGH / MUST TRIP MAGNITUDES	UL 1741 SA10.2	Adjustable	Pass
LOW FREQUENCY MUST TRIP CLEARING TIMES	UL 1741 SA10.2	Adjustable	Pass
NORMAL RAMP RATE	UL 1741 SA 11.2	Adjustable	Pass
"SOFT START" RAMP RATE	UL 1741 SA 11.4	Adjustable	Pass
SPECIFIED POWER FACTOR	UL 1741 SA 12	Adjustable	Pass
VOLT/VAR MODE (Q(V))	UL 1741 SA 13	Adjustable	Pass
FREQUENCY-WATT (FW)	UL 1741 SA 14	N/A	N/A
VOLT-WATT (VW)	UL 1741 SA 15	N/A	N/A

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CERTIFICATE OF COMPLIANCE

Certificate Number 20170711-E479127
Report Reference E479127-20170615
Issue Date 2017-JULY-11

Inverter Firmware Version:		
UL 1998	Date	Version/Revision
Compliant	2017-05-17	15732

Inverter Ratings - Output	All models, with individual differences as shown	
Output phase configuration	Split L1-G-L2 (No Neutral)	Split L1-G-L2 (No Neutral)
Nominal (line to line) output voltage V ac	240	208
Operating voltage range V ac	211~264	183~229
Line Synchronization Characteristics	Type 2	Type 2
Normal out frequency Hz	60	60
Rated output current (A ac)	1.33	1.54
Rated output power, (kW)	0.320	0.320
Max. Branch Circuit overcurrent protection (A ac)	20	20
Maximum Air Ambient (°C)	65 °C	65 °C

Other ratings:	
Max. output fault current (A) / duration (ms)	69.5 A_{pk}, 38 Arms, 5.53 ms
Max. utility backfeed current to PV input (A)	2.32 Apk, 5 Arms, 3.19 ms
Line Synchronization Characteristics / In-rush current	Type 2 / 0.2A
Limits of accuracy of voltage measurement	+/- 2.5 %
Limits of accuracy of frequency measurement	+ /- 0.05 Hz
Manufacturers stated accuracy of time response for voltage trips	0.05 sec
Manufacturers stated accuracy of time response for frequency trips	0.03 sec
*Enclosure Ratings	Type 4

INTERCONNECTION INTEGRITY TEST CATEGORIES:	
C62.42.2 Ring Wave Surge Category	B
C62.42.2 Combination Wave Surge Category	B
C37.90.1 RF Immunity - compliance	Yes
C37.90.2 Communication circuit - compliance	N/A

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CERTIFICATE OF COMPLIANCE

Certificate Number 20170711-E479127
Report Reference E479127-20170615
Issue Date 2017-JULY-11

Magnitude and time Limits - Utility interconnection voltage magnitude limits, Ride Through time limits and trip times:						
Nominal voltage	240 / 120 Single/Split phase 208 / 120 Single/Split phase					
UL 1741 SA9:	Magnitudes (% of nominal)		Ride Through (Seconds) (+)		Must Trip (Seconds)	
Boundary designation (++)	Min	Max	Min	Max	Min	Max
HV2	120	120	---	---	0.160	0.160
HV1	110	110	12	12	1.0	13
LV1	88	88	20	20	2.0	21
LV2	60	70	10	10	1.0	11
LV3	45	50	1.0	1.0	0.160	1.5

Magnitude and time Limits - Utility interconnection Frequency magnitude limits, Ride Through time limits and trip times:						
Nominal Frequency	60 Hz					
UL 1741 SA10:	Magnitudes (Frequency)		Ride Through (Seconds) (+)		Must Trip (Seconds)	
Boundary designation (++)	Min	Max	Min	Max	Min	Max
HF3	66.0	66.0	---	---	0.160	0.160
HF2	62.0	64.0	---	---	0.160	10
HF1	60.1	62.0	299	299	2.0	300
LF1	57.0	59.0	299	299	2.0	300
LF2	53.0	57.0	---	---	0.160	10
LF3	50.0	50.0	---	---	0.160	0.160

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Certificate Number 20170711-E479127
Report Reference E479127-20170615
Issue Date 2017-JULY-11

SA11 Ramp Rate test ratings (RR)		
Minimum normal ramp-up rate	1.00%	%Irated/SEC
Maximum normal ramp-up rate	100.0%	%Irated/SEC
Minimum soft start ramp-up rate	1.00%	%Irated /SEC
Maximum soft start ramp-up rate	100.0%	%Irated /SEC

SA12 SPF Specified Power Factor (INV3)	
Minimum Inductive (Underexcited) Power Factor (<0)	-0.85
Minimum Capacitive (Overexcited) Power Factor (>0)	0.85

SA13 Volt/Var Mode (VV) extent of curve range settings				
		Qmax Values - Maximums	Qmin Values - Minimums	Units
Reactive power production setting	Q_1	170	170	VAR
Reactive power absorption setting at the left edge of the deadband	Q_2	0	0	VAR
Reactive power absorption setting at the right edge of the deadband	Q_3	0	0	VAR
Reactive power absorption setting	Q_4	-170	-170	VAR

		Maximum	Minimum	Units
The voltage at Q_1	V_1	98.00%	90.00%	%Vnom
The voltage at Q_2	V_2	100.00%	97.00%	%Vnom
The voltage at Q_3	V_3	103.00%	100.00%	%Vnom
The voltage at Q_4	V_4	110.00%	102.00%	%Vnom

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D.2 Microinverter Revision D: Rapid Shutdown

CERTIFICATE OF COMPLIANCE

Certificate Number	20170622-E479127]
Report Reference	E479127-20161109]
Issue Date	2017-JUNE-22]
Issued to:	SUNPOWER CORP] 77 RIO ROBLES SAN JOSE CA 95134-1859]
This is to certify that representative samples of	COMPONENT - STATIC INVERTERS AND CONVERTERS FOR USE IN INDEPENDENT POWER SYSTEMS; COMPONENT - PHOTOVOLTAIC RAPID SHUTDOWN SYSTEM EQUIPMENT] SEE ADDENDUM PAGE]
	Have been investigated by UL in accordance with the Standard(s) indicated on this Certificate.
Standard(s) for Safety:	SEE ADDENDUM PAGE]
Additional Information:	See the UL Online Certifications Directory at www.ul.com/database for additional information

Only those products bearing the UL Certification Mark should be considered as being covered by UL's Certification and Follow-Up Service.

The UL Recognized Component Mark generally consists of the manufacturer's identification and catalog number, model number or other product designation as specified under "Marking" for the particular Recognition as published in the appropriate UL Directory. As a supplementary means of identifying products that have been produced under UL's Component Recognition Program, UL's Recognized Component Mark: ᴿᵁᴸ, may be used in conjunction with the required Recognized Marks. The Recognized Component Mark is required when specified in the UL Directory preceding the recognitions or under "Markings" for the individual recognitions.

Recognized components are incomplete in certain constructional features or restricted in performance capabilities and are intended for use as components of complete equipment submitted for investigation rather than for direct separate installation in the field. The final acceptance of the component is dependent upon its installation and use in complete equipment submitted to UL LLC.

Look for the UL Certification Mark on the product.[

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CERTIFICATE OF COMPLIANCE

Certificate Number	20170622-E479127
Report Reference	E479127-20161109
Issue Date	2017-JUNE-22

This is to certify that representative samples of the product as specified on this certificate were tested according to the current UL requirements.

MI-C-320-US208/240-1X. Where "X" is Code for marketing purposes
Only revision number "D" is covered by this report. Location of the Assembly/Revision code on the product label. The Assembly No. may change, but the revision code shall be "D".

Model MI-C-320-US208/240-XX inverter is intended for DC input from a single photovoltaic module.

The inverter is provided with transformer isolation between input and output.

The inverter is also evaluated as PV Rapid Shutdown equipment with Line 1 and Line 2 AC output conductors evaluated as the controlled conductors. Actuation is provided by opening the AC conductors by a breaker or other disconnect device.

STANDARDS

UL 1741 Standard for Safety for Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources
UL 1741 CRD for Photovoltaic Rapid Shutdown Equipment
CAN/CSA C22.2 No. 107.1-1 General Use Power Supplies

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D.3 Microinverter Revision C: Rapid Shutdown

CERTIFICATE OF COMPLIANCE

Certificate Number	20170622-E479127]
Report Reference	E479127-20150916]
Issue Date	2017-JUNE-22]
Issued to:	SUNPOWER CORP] 77 RIO ROBLES SAN JOSE CA 95134-1859]
This is to certify that representative samples of	COMPONENT - STATIC INVERTERS AND CONVERTERS FOR USE IN INDEPENDENT POWER SYSTEMS; COMPONENT - PHOTOVOLTAIC RAPID SHUTDOWN SYSTEM EQUIPMENT] SEE ADDENDUM PAGE]
	Have been investigated by UL in accordance with the Standard(s) indicated on this Certificate.
Standard(s) for Safety:	SEE ADDENDUM PAGE]
Additional Information:	See the UL Online Certifications Directory at www.ul.com/database for additional information

Only those products bearing the UL Certification Mark should be considered as being covered by UL's Certification and Follow-Up Service.

The UL Recognized Component Mark generally consists of the manufacturer's identification and catalog number, model number or other product designation as specified under "Marking" for the particular Recognition as published in the appropriate UL Directory. As a supplementary means of identifying products that have been produced under UL's Component Recognition Program, UL's Recognized Component Mark: ᴿᵁᴸ, may be used in conjunction with the required Recognized Marks. The Recognized Component Mark is required when specified in the UL Directory preceding the recognitions or under "Markings" for the individual recognitions.

Recognized components are incomplete in certain constructional features or restricted in performance capabilities and are intended for use as components of complete equipment submitted for investigation rather than for direct separate installation in the field. The final acceptance of the component is dependent upon its installation and use in complete equipment submitted to UL LLC.

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CERTIFICATE OF COMPLIANCE

Certificate Number	20170622-E479127
Report Reference	E479127-20150916
Issue Date	2017-JUNE-22

This is to certify that representative samples of the product as specified on this certificate were tested according to the current UL requirements.

Model MI-C-320-US208/240-0X. Where "X" is Code for marketing purposes
Only revision number "C" is covered by this report. Location of the Assembly/Revision code on the product label. The Assembly No. may change, but the revision code shall be "C".

The inverter is provided with transformer isolation between input and output.

The inverter is also evaluated as PV Rapid Shutdown equipment with Line 1 and Line 2 AC output conductors evaluated as the controlled conductors. Actuation is provided by opening the AC conductors by a breaker or other disconnect device.

STANDARDS

UL 1741 Standard for Safety for Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources
IEEE 1547 Standard for Interconnecting Distributed Resources with Electric Power Systems
IEEE 1547.1 Standard for Interconnecting Distributed Resources with Electric Power Systems
CAN/CSA 22.2 No. 107.1-1 General Use Power Supplies

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D.4 Microinverter First Revision: Rapid Shutdown

CERTIFICATE OF COMPLIANCE

Certificate Number	20161112-E479127
Report Reference	E479127-20150916
Issue Date	2016-NOVEMBER-12
Issued to:	SUNPOWER CORP 77 RIO ROBLES SAN JOSE CA 95134-1859
This is to certify that representative samples of	COMPONENT - STATIC INVERTERS AND CONVERTERS FOR USE IN INDEPENDENT POWER SYSTEMS; COMPONENT - PHOTOVOLTAIC RAPID SHUTDOWN SYSTEM EQUIPMENT See Addendum Page
	Have been investigated by UL in accordance with the Standard(s) indicated on this Certificate.
Standard(s) for Safety:	See Addendum Page
Additional Information:	See the UL Online Certifications Directory at www.ul.com/database for additional information

Only those products bearing the UL Certification Mark should be considered as being covered by UL's Certification and Follow-Up Service.

The UL Recognized Component Mark generally consists of the manufacturer's identification and catalog number, model number or other product designation as specified under "Marking" for the particular Recognition as published in the appropriate UL Directory. As a supplementary means of identifying products that have been produced under UL's Component Recognition Program, UL's Recognized Component Mark: ᴿᵁᴸ, may be used in conjunction with the required Recognized Marks. The Recognized Component Mark is required when specified in the UL Directory preceding the recognitions or under "Markings" for the individual recognitions.

Recognized components are incomplete in certain constructional features or restricted in performance capabilities and are intended for use as components of complete equipment submitted for investigation rather than for direct separate installation in the field. The final acceptance of the component is dependent upon its installation and use in complete equipment submitted to UL LLC.

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CERTIFICATE OF COMPLIANCE

Certificate Number	20161112-E479127
Report Reference	E479127-20150916
Issue Date	2016-NOVEMBER-12

This is to certify that representative samples of the product as specified on this certificate were tested according to the current UL requirements.

Permanently-Connected, Utility Interactive, Split Phase Micro-Inverter, Model MI-C-320-US208/240-XX Where "XX" is one of the allowed options in the nomenclature section below inverter is intended for DC input from a single photovoltaic module

The inverter is provided with transformer isolation between input and output.

The inverter is also evaluated as PV Rapid Shutdown equipment with Line 1 and Line 2 AC output conductors evaluated as the controlled conductors. Actuation is provided by opening the AC conductors by a breaker or other disconnect device

UL 1741 Inverters, Converters, Controllers and Interconnection System Equipment for use with Distributed Energy Resources

UL 1741 CRD for Photovoltaic Rapid Shutdown Equipment

CSA 22.2 No. 107.1-1, General Use Power Supplies

Bruce Mahrenholz, Director North American Certification Program

UL LLC

D.5 Type D AC Module

CERTIFICATE OF COMPLIANCE

Certificate Number	20171003-E478330]
Report Reference	E478330-20170615]
Issue Date	2017-OCTOBER-03]
Issued to:	SUNPOWER CORP] 77 RIO ROBLES SAN JOSE CA 95134-1859]
This is to certify that representative samples of	AC MODULES] Refer to Addendum Page for Models/Product]
	Have been investigated by UL in accordance with the Standard(s) indicated on this Certificate.
Standard(s) for Safety:	UL 1741, Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources; IEEE 1547, Interconnecting Distributed Resources with Electric Power Systems]
Additional Information:	See the UL Online Certifications Directory at www.ul.com/database for additional information

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CERTIFICATE OF COMPLIANCE

Certificate Number	20171003-E478330]
Report Reference	E478330-20170615]
Issue Date	2017-OCTOBER-03]

This is to certify that representative samples of the product as specified on this certificate were tested according to the current UL requirements.

Grid Support Utility Interactive AC Module with Rapid Shutdown Functionality

AC modules, Models:
SPR-X22-370-D-AC, SPR-X22-360-D-AC, SPR-X21-335-BLK-D-AC, SPR-X20-327-BLK-D-AC, SPR-X21-345-D-AC, SPR-X21-335-D-AC, SPR-X20-327-D-AC, SPR-E20-327-D-AC, SPR-E19-320-D-AC,

SPR-E18-300-D-AC, SPR-E19-315-D-AC, SPR-E20-335-D-AC, SPR-X19-315-D-AC, SPR-X19-315-BLK-D-AC, SPR-X20-335-D-AC, SPR-X20-335-BLK-D-AC, SPR-X21-350-D-AC, SPR-X21-350-BLK-D-AC, SPR-E21-335-D-AC, SPR-E18-305-C-AC]

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D.6 Type C AC Module

CERTIFICATE OF COMPLIANCE

Certificate Number	20170621-E478330]
Report Reference	E478330-20150916]
Issue Date	2017-JUNE-21]
Issued to:	SUNPOWER CORP] 77 RIO ROBLES SAN JOSE CA 95134-1859]
This is to certify that representative samples of	AC MODULES] USL - AC modules, Models SPR-X22-360-C-AC, SPR-X21-335-BLK-C-AC, SPR-X20-327-BLK-C-AC, SPR-X21-345-C-AC, SPR-X21-335-C-AC, SPR-X20-327-C-AC, SPR-E20-327-C-AC, SPR-E19-320-C-AC]
	Have been investigated by UL in accordance with the Standard(s) indicated on this Certificate.
Standard(s) for Safety:	UL 1741 Standard for Safety for Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources]
Additional Information:	See the UL Online Certifications Directory at www.ul.com/database for additional information

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D.7 AC Extension Cable

CERTIFICATE OF COMPLIANCE

Certificate Number	20160324-E478711
Report Reference	E478711-20160324
Issue Date	2016-MARCH-24
Issued to:	PHOENIX CONTACT GMBH & CO KG FLACHSMARKTSTRASSE 8 32825 BLOMBERG GERMANY
This is to certify that representative samples of	COMPONENT - DISTRIBUTED GENERATION WIRING SYSTEMS AND HARNESSES Photovoltaic Wiring Harness, Series PV-MI-YC-T-3-12-43, 6 S05
	Have been investigated by UL in accordance with the Standard(s) indicated on this Certificate.
Standard(s) for Safety:	UL 9703 – Standard of DISTRIBUTED GENERATION WIRING HARNESSES
Additional Information:	See the UL Online Certifications Directory at www.ul.com/database for additional information

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Recognized components are incomplete in certain constructional features or restricted in performance capabilities and are intended for use as components of complete equipment submitted for investigation rather than for direct separate installation in the field. The final acceptance of the component is dependent upon its installation and use in complete equipment submitted to UL LLC.

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D.8 InvisiMount System

CERTIFICATE OF COMPLIANCE

Certificate Number	20161025-E466981
Report Reference	E466981-20140903
Issue Date	2016-OCTOBER-25
Issued to:	SUNPOWER CORP 77 RIO ROBLES SAN JOSE CA 95134-1859
This is to certify that representative samples of	MOUNTING SYSTEMS, MOUNTING DEVICES, CLAMPING DEVICES AND GROUND LUGS FOR USE WITH PHOTOVOLTAIC MODULES AND PANELS InvisiMount Mounting and Bonding Systems for use with Photovoltaic Modules, consisting of the following components: L-Foot, Rail, Rail Splice, Mid Clamp, Ground Lug Assembly, End Clamp, SolarEdge P400 Microinverter Backplate, Row Clip Have been investigated by UL in accordance with the Standard(s) indicated on this Certificate.
Standard(s) for Safety:	UL 2703, the Standard for Mounting Systems, Mounting Devices, Clamping/Retention Devices, and Ground Lugs for use with Flat-Plate Photovoltaic Modules and Panels
Additional Information:	See the UL Online Certifications Directory at www.ul.com/database for additional information

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D.9 InvisiMount End Clamp

NOTICE OF COMPLETION
AND
AUTHORIZATION TO APPLY THE UL MARK

2017-02-10

MR. NATHAN SCHWELLER
SUNPOWER CORP
77 RIO ROBLES
SAN JOSE, CA, 95134-1859, US

Our Reference:	File E466981, Volume 1	Order:	11481157
		Project:	4787640254
Your Reference:	933036852		
Project Scope:	Alternate End Clamp evaluated for use with InvisiMount System - Phase 3 – Documentation & Certification		

Dear MR. NATHAN SCHWELLER:

Congratulations! UL's investigation of your product(s) has been completed under the above Reference Number and the product was determined to comply with the applicable requirements. This letter temporarily supplements the UL Follow-Up Services Procedure and serves as authorization to apply the UL Mark at authorized factories under UL's Follow-Up Service Program. To provide your manufacturer(s) with the intended authorization to use the UL Mark, you must send a copy of this notice to each manufacturing location currently authorized under File E466981, Volume 1.

Records in the Follow-Up Services Procedure covering the product are now being prepared and will be sent in the near future. Until then, this letter authorizes application of the UL Mark for 90 days from the date indicated above.

Additional requirements related to your responsibilities as the Applicant can be found in the document "Applicant responsibilities related to Early Authorizations" that can be found at the following web-site: http://www.ul.com/EAResponsibilities

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We are excited you are now able to apply the UL Mark to your products and appreciate your business. Feel free to contact me or any of our Customer Service representatives if you have any questions.

Very truly yours,

Jon Adonay
Staff Engineering Associate
Jon.Adonay@ul.com

Reviewed by:

Bruce A. Mahrenholz
CPO Director
Bruce.A.Mahrenholz@ul.com

D.10 PVS5x

CERTIFICATE OF COMPLIANCE

Certificate Number	20150820-E477122
Report Reference	E477122-A1-UL
Issue Date	2015-AUGUST-20
Issued to:	SUNPOWER CORP 1414 HARBOUR WAY S RICHMOND CA 94804-3694
This is to certify that representative samples of	INFORMATION TECHNOLOGY EQUIPMENT INCLUDING ELECTRICAL BUSINESS EQUIPMENT Photovoltaic Supervisor PVS5x
	Have been investigated by UL in accordance with the Standard(s) indicated on this Certificate.
Standard(s) for Safety:	UL 60950-1 Information Technology Equipment - Safety CAN/CSA C22.2 No. 60950-1-07 Information Technology Equipment - Safety
Additional Information:	See the UL Online Certifications Directory at www.ul.com/database for additional information

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Appendix E: Quick Start Guide – AC Module Cable Selection

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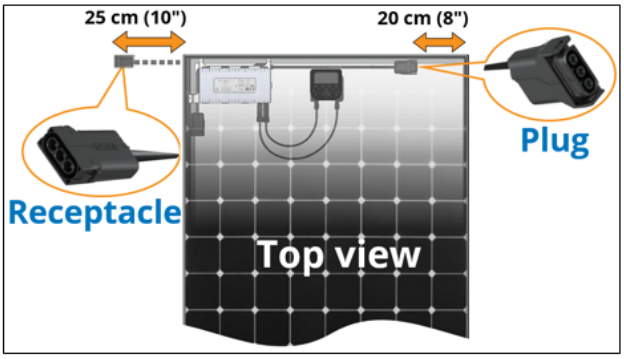
SUNPOWER | EQUINOX™

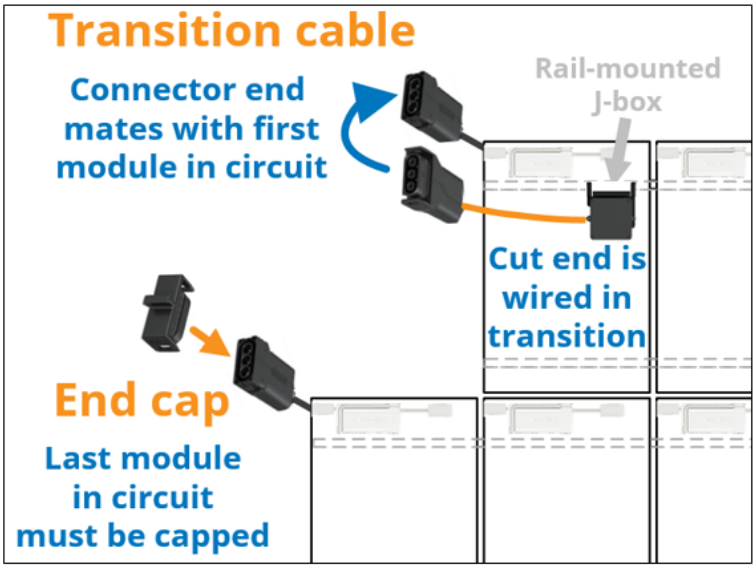
QUICK START GUIDE:
AC Module Cable Selection



- AC modules have two types of connectors: a **receptacle** and a **plug**. When a module is installed in portrait position, the **receptacle** is on the left and the **plug** is on the right.

- Metal **cable clips (**available in 0° and 90°) and **AC rail clips** are used to manage the integrated module cables as well as the **extension cables.** Cable clips attach above or below the module's bottom frame edge to enable optimal cable securement; AC rail clips simply snap onto the rail.

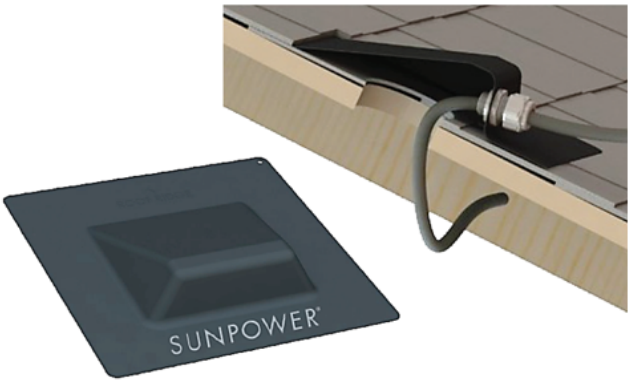
- **Extension cables** are available in four lengths with the following configurations:
  - **3.3'** plug/plug
  - **5'** plug/receptacle
  - **6.5'** receptacle/receptacle
  - **10'** plug/plug, plug/receptacle, and receptacle/receptacle



- You create a **transition cable** (from the array to the wiring transition) by cutting one end off of an **extension cable** so that you can then wire the cut end in the **rail-mounted J-box** (or other transition enclosure), and connect the other end to the first module in the circuit.

- If allowed by your AHJ, you can route the transition cable through the **rooftop transition flashing** for combining in an attic-mounted J-box.

- You must install an **end cap** on the remaining connector of the last module in the circuit (*end caps are different for receptacles and plugs*).



The snap-on **rail-mounted J-box** and low-profile **rooftop transition flashing** are accessories available from SunPower.

Best Practices and Tips & Tricks

Optimize your layout

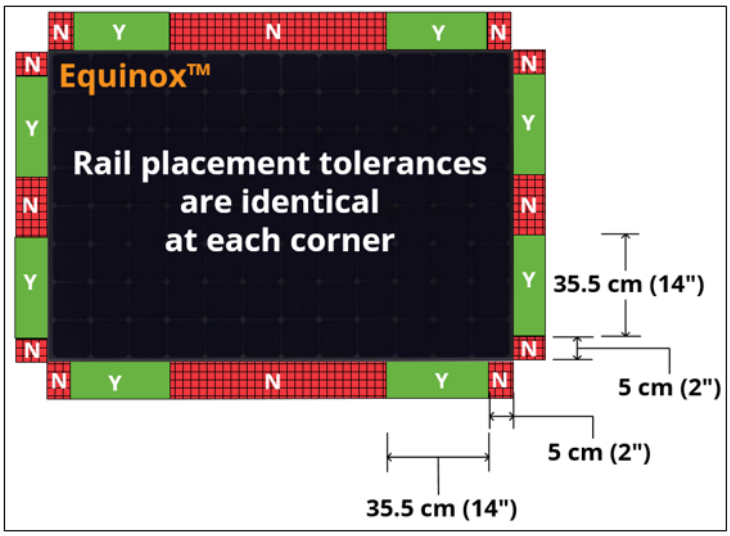
- Modules are optimized for portrait (short side) connections.
- When designing arrays, minimize landscape (long side) connections.
- Limit circuit design to a maximum of 12 modules per AC module circuit.
- Use junction boxes and transition cables to connect isolated array sections (subarrays); you may parallel circuit sections but may not exceed 12 modules per circuit.

Manage your cables

- Cable management strategy is up to the installer—in addition to using loops in conjunction with the metal cable clips and the AC rail clips, wherever possible use the rails themselves as additional support for the cables.
- Cables must not droop below the bottom edge of the rails, and must remain off of the roof surface.
- Cables must *never* have a bend radius smaller than 3".
- Cables can damage module backsheets—do not center a plug–receptacle union directly over a rail.
- Select extension cables so that you can route them along the frame and avoid any portion of cables being exposed.
- Note that you can also parallel circuits in J-boxes to minimize additional extension cables.

Mind your rail positions

With respect to the module frame, you may position rails only in the following areas:



Landscape configurations can be tricky

Use a 5′ plug-receptacle extension cable between *each pair* of modules when the rails are parallel to the module long side.

Aesthetics matter

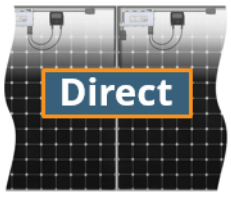
- Always locate the rooftop transition flashing and J-box(es) under the array.
- Cut rail ends flush, such that the module frame overhangs *no more than 1/4".*
- In the finished array, do not allow any cables or wiring to be visible.

Extension Cable Scenarios

1

Note: All of the scenarios shown are **bird's-eye** views with the modules in their installed position.

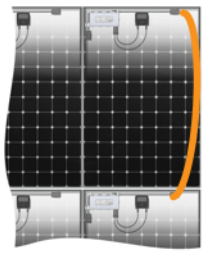
- Portrait
- Most common



Extension
NONE

2

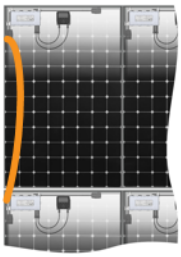
- Portrait
- Row to row
- Right end



Extension
6.5' R–R
513845

3

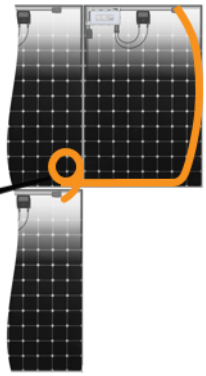
- Portrait
- Row to row
- Left end



Extension
3.3' P–P
513846

4

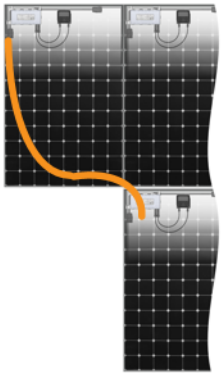
- Portrait
- Row to row
- Lower corner hole



Extension
10' R–R
513528

5

- Portrait
- Row to row
- Lower corner hole

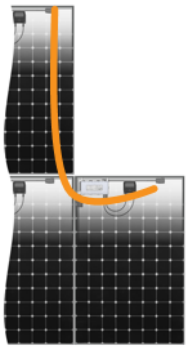


Extension
10' P–P
513713

Extension Cable Scenarios (continued)

6

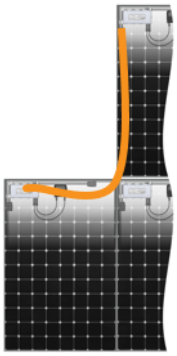
- Portrait
- Row to row
- Upper corner hole



Extension
10′ R–R
513528

7

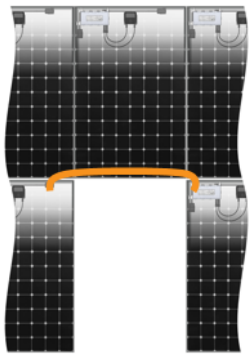
- Portrait
- Row to row
- Upper corner hole



Extension
10′ P–P
513713

8

- Portrait
- Module to module
- Lower hole



Extension
5′ P–R
513847

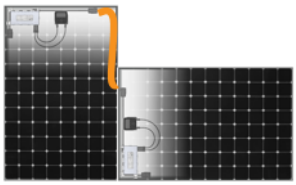
9

- Landscape
- Row to row
- Left end

Extension
NONE

10a

Landscape–Portrait

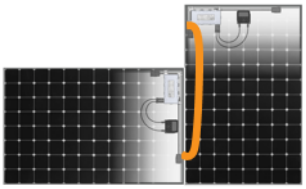


Extension
6.5′ R–R
513845

Extension Cable Scenarios (continued)

10b

Landscape–Portrait

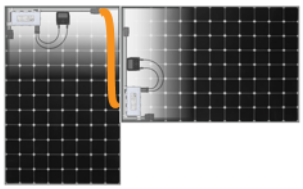


Direct *or* extension (either pair)

Extension
NONE *or* 5′ P–R 513847

11a

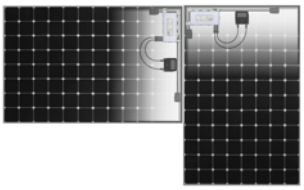
Landscape–Portrait



Extension
5′ P-R 513847

11b

Landscape–Portrait

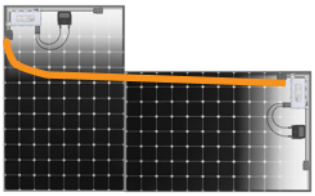


Direct (either pair)

Extension
NONE

12a

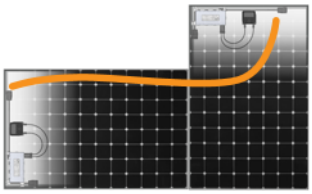
Landscape–Portrait



Extension
10′ P–P 513713

12b

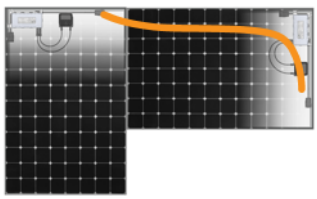
Landscape–Portrait



Extension
10′ R–R 513528

13a

Landscape–Portrait

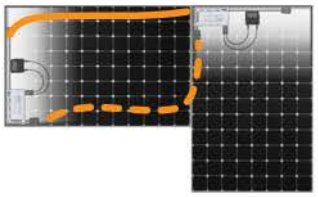


Extension
6.5′ R–R 513845

Extension Cable Scenarios (continued)

13b

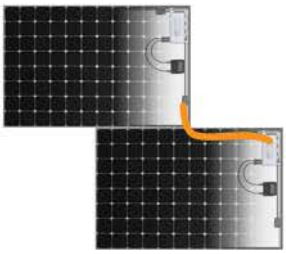
Landscape–Portrait



Extension
5′ P–R 513847 *or* 10′ P–P (dotted) 513713

14a

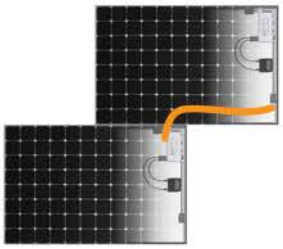
Landscape–Staggered



Extension
5′ P-R 513847

14b

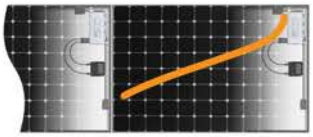
Landscape–Staggered



Extension
5′ P-R 513847

15

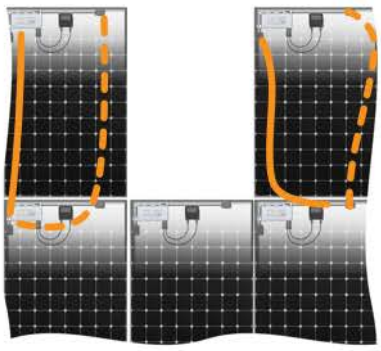
- Landscape
- End pair
- Right end



Extension
5′ P-R 513847

16a

- Portrait
- Module to module
- Upper hole

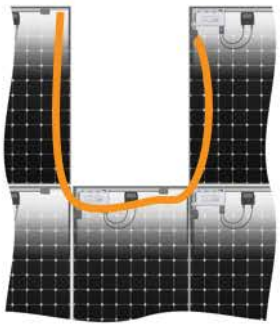


Extension Options	
Solid ———	Dashed - - - - -
3.3′ P–P 513846 *and* 5′ P–R 513847	5′ P–R 513847 *and* 6.5′ R–R 513845

Extension Cable Scenarios (continued)

16b

- Portrait
- Module to module
- Upper row hole

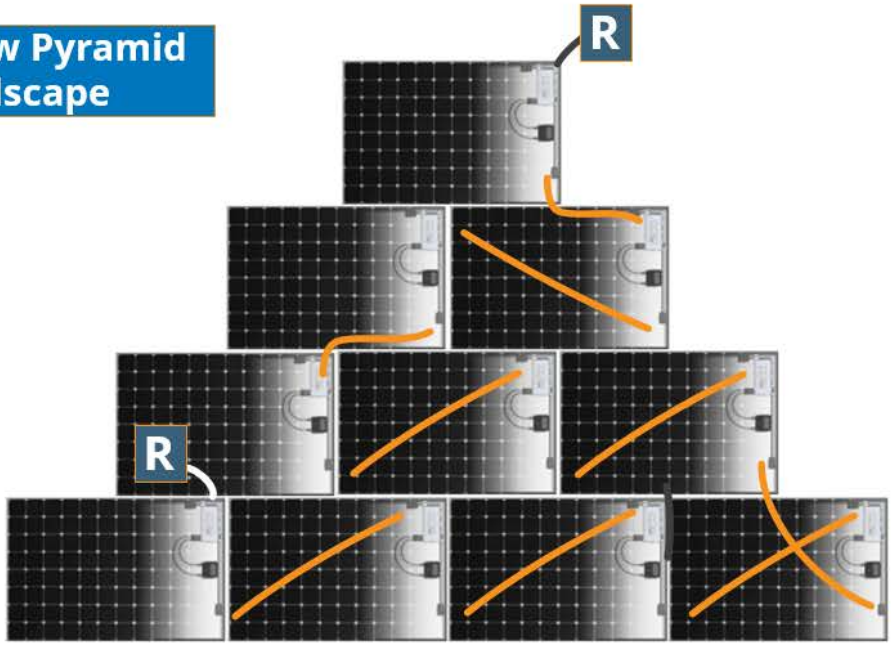


Extension

10′ R–R
513528
and
3.3′ P–P
513846

17

Four-Row Pyramid Landscape

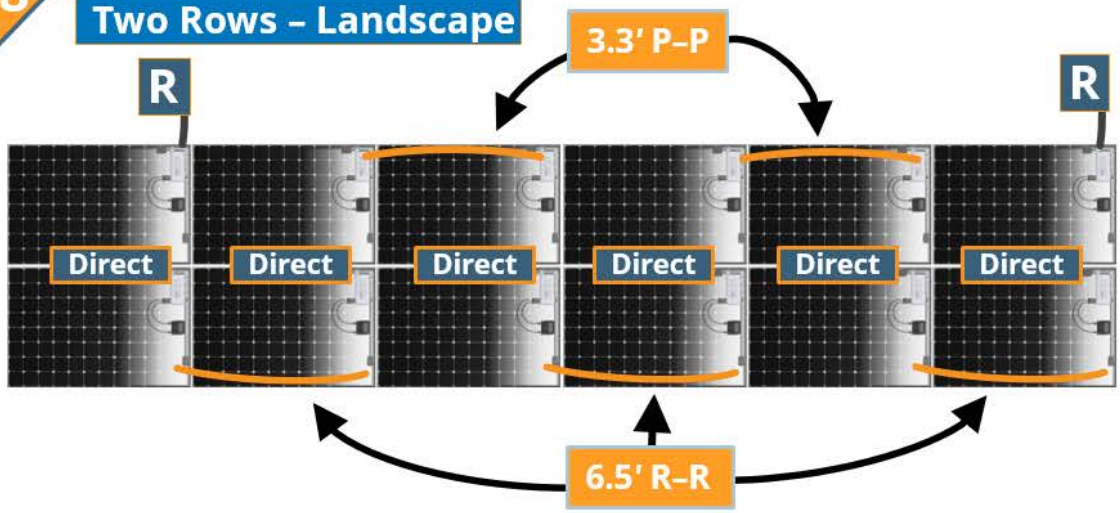


Extension

(8) 5′ P–R
513847
and
(1) 6.5′
R–R
513845

18

Two Rows – Landscape



Extension

(2) 3.3′
P–P
513846
and
(3) 6.5′
R–R
513845

Appendix F: Technical Specifications

F.1 Type C AC Module Ratings

F.1.1 X22-360-C-AC

Power Data	
	SPR-X22-360-C-AC
Nominal Power[3] (Pnom)	360 W
Power Tolerance	+5/-0%
Avg. Panel Efficiency[4]	22.2%
Temp. Coef. (Power)	–0.29%/° C
Shade Tolerance	• Three bypass diodes • Integrated module-level maximum power point tracking

AC Electrical Data	
Output @ 240 V (min./nom./max.)	211/240/264 V
Output @ 208 V (min./nom./max.)	183/208/229 V
Operating Frequency (min./nom./max.)	59.3/60.0/60.5 Hz
Output Power Factor (min.)	0.99
AC Max. Continuous Output Current @ 240 V	1.33 A
AC Max. Continuous Output Current @ 208 V	1.54 A
AC Max. Cont. Output Power	320 W
DC/AC CEC Conversion Efficiency	96.0%
Max. Units Per 20 A Branch Circuit @ 240 V	12 (single phase)
Max. Units Per 20 A Branch Circuit @ 208 V	10 (two pole)
No active phase balancing for 3 phase installations	

F.1.2 X21-345-C-AC and X21-335-C-AC

Power Data		
	SPR-X21-345-C-AC	SPR-X21-335-C-AC
Nominal Power[3] (Pnom)	345 W	335 W
Power Tolerance	+5/–0%	+5/–0%
Avg. Panel Efficiency[4]	21.5%	21.0%
Temp. Coef. (Power)	–0.29%/° C	
Shade Tolerance	• Three bypass diodes • Integrated module-level maximum power point tracking	

AC Electrical Data	
Output @ 240 V (min./nom./max.)	211/240/264 V
Output @ 208 V (min./nom./max.)	183/208/229 V
Operating Frequency (min./nom./max.)	59.3/60.0/60.5 Hz
Output Power Factor (min.)	0.99
AC Max. Continuous Output Current @ 240 V	1.33 A
AC Max. Continuous Output Current @ 208 V	1.54 A
AC Max. Cont. Output Power	320 W
DC/AC CEC Conversion Efficiency	96.0%
Max. Units Per 20 A Branch Circuit @ 240 V	12 (single phase)
Max. Units Per 20 A Branch Circuit @ 208 V	10 (two pole)
No active phase balancing for 3 phase installations	

F.1.3 X21-335-BLK-C-AC and X20-327-BLK-C-AC

Power Data		
	SPR-X21-335-BLK-C-AC	SPR-X20-327-BLK-C-AC
Nominal Power[3] (Pnom)	335 W	327 W
Power Tolerance	+5/–0%	+5/–0%
Avg. Panel Efficiency[4]	21.0%	20.4%
Temp. Coef. (Power)	–0.29%/° C	
Shade Tolerance	• Three bypass diodes • Integrated module-level maximum power point tracking	

AC Electrical Data	
Output @ 240 V (min./nom./max.)	211/240/264 V
Output @ 208 V (min./nom./max.)	183/208/229 V
Operating Frequency (min./nom./max.)	59.3/60.0/60.5 Hz
Output Power Factor (min.)	0.99
AC Max. Continuous Output Current @ 240 V	1.33 A
AC Max. Continuous Output Current @ 208 V	1.54 A
AC Max. Cont. Output Power	320 W
DC/AC CEC Conversion Efficiency	96.0%
Max. Units Per 20 A Branch Circuit @ 240 V	12 (single phase)
Max. Units Per 20 A Branch Circuit @ 208 V	10 (two pole)
No active phase balancing for 3 phase installations	

F.1.4 X20-327-C-AC

Power Data	
	SPR-X20-327-C-AC
Nominal Power[3] (Pnom)	327 W
Power Tolerance	+5/–0%
Avg. Panel Efficiency[4]	20.4%
Temp. Coef. (Power)	–0.29%/° C
Shade Tolerance	• Three bypass diodes • Integrated module-level maximum power point tracking

AC Electrical Data	
Output @ 240 V (min./nom./max.)	211/240/264 V
Output @ 208 V (min./nom./max.)	183/208/229 V
Operating Frequency (min./nom./max.)	59.3/60.0/60.5 Hz
Output Power Factor (min.)	0.99
AC Max. Continuous Output Current @ 240 V	1.33 A
AC Max. Continuous Output Current @ 208 V	1.54 A
AC Max. Cont. Output Power	320 W
DC/AC CEC Conversion Efficiency	96.0%
Max. Units Per 20 A Branch Circuit @ 240 V	12 (single phase)
Max. Units Per 20 A Branch Circuit @ 208 V	10 (two pole)
No active phase balancing for 3 phase installations	

F.1.5 E20-327-C-AC and E19-320-BLK-C-AC

Power Data		
	SPR-E20-327-C-AC	SPR-E19-320-C-AC
Nominal Power[3] (Pnom)	327 W	320 W
Power Tolerance	+5/–0%	+5/–0%
Avg. Panel Efficiency[4]	20.4%	19.9%
Temp. Coef. (Power)	–0.35%/° C	
Shade Tolerance	• Three bypass diodes • Integrated module-level maximum power point tracking	

AC Electrical Data	
Output @ 240 V (min./nom./max.)	211/240/264 V
Output @ 208 V (min./nom./max.)	183/208/229 V
Operating Frequency (min./nom./max.)	59.3/60.0/60.5 Hz
Output Power Factor (min.)	0.99
AC Max. Continuous Output Current @ 240 V	1.33 A
AC Max. Continuous Output Current @ 208 V	1.54 A
AC Max. Cont. Output Power	320 W
DC/AC CEC Conversion Efficiency	96.0%
Max. Units Per 20 A Branch Circuit @ 240 V	12 (single phase)
Max. Units Per 20 A Branch Circuit @ 208 V	10 (two pole)
No active phase balancing for 3 phase installations	

F.2 Type D AC Module Ratings

F.2.1 X22-370-D-AC and X22-360-D-AC

SunPower® X22-370-D-AC | Residential AC Module Series

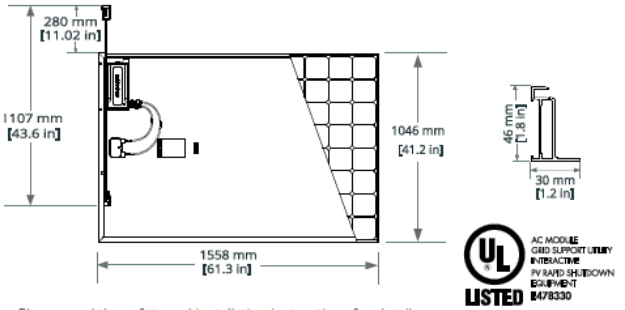
AC Electrical Data[3]			
SRD Profile		IEEE 1547a-2014[3] (default settings) min. / nom. / max.	CA Rule 21[3] min. / nom. / max.
Frequency (Hz)		59.5 / 60.0 / 60.5	58.5 / 60.0 / 60.5
Power Factor		0.99 / 1.00 / 1.00	0.85 lead. / 1.00 / 0.85 lag.
Reactive Power			±169 Var Volt-VAr
Voltage	@240 V @208 V	211.2 / 240 / 264 V 183 / 208 / 228.8 V	
Max. Current	@240 V @208 V	1.33 A 1.54 A	
DC/AC CEC Conversion Efficiency	@240 V @208 V	96.0% 95.5%	
Max. Units Per 20 A Branch Circuit	@240 V @208 V	12 (single phase) 10 (two pole) wye	
Power		320 W, 320 VA	
No active phase balancing for 3 phase installations			

DC Power Data		
	SPR-X22-370-D-AC	SPR-X22-360-D-AC
Nominal Power[4] (Pnom)	370 W	360 W
Power Tolerance	+5/−0%	
Panel Efficiency[5]	22.7%	22.1%
Temp. Coef. (Power)	−0.29%/° C	
Shade Tolerance	• Three bypass diodes • Integrated module-level maximum power point tracking	

Tested Operating Conditions	
Operating Temp.	−40° F to +149° F (−40° C to +65° C)
Max. Ambient Temp.	122° F (50° C)
Max. Load	Wind: 62 psf, 3000 Pa, 305 kg/m² front & back Snow: 125 psf, 6000 Pa, 611 kg/m² front
Impact Resistance	1 inch (25 mm) diameter hail at 52 mph (23 m/s)

Mechanical Data	
Solar Cells	96 Monocrystalline Maxeon Gen III
Front Glass	High-transmission tempered glass with anti-reflective coating
Environmental Rating	Outdoor rated
Frame	Class 1 black anodized (highest AAMA rating)
Weight	45.5 lbs (20.6 kg)
Recommended Max. Module Spacing	1.3 in. (33 mm)

Warranties and Certifications	
Warranties	· 25-year limited power warranty · 25-year limited product warranty
Certifications	UL listed to UL 1741 SA · SRDs: IEEE 1547-2003, IEEE 1547a-2014, CA Rule 21 Phase 1 · PV Rapid Shutdown Equipment · Equipment Grounding · UL 6703, UL 9703 Connectors and cables (load break disconnection) · UL 1741 AC Module (Type 2 fire rating) Enables installation in accordance with: · NEC 690.6 · NEC 690.12 Rapid Shutdown (inside and outside the array) · NEC 690.15 AC Connectors, 690.33(A) – (E)(1) FCC and ICES-003 Class B When used with InvisiMount racking (UL 2703): · Integrated grounding and bonding · Class A fire rated
PID Test	Potential-induced degradation free



Please read the safety and installation instructions for details.

AC MODULE GRID SUPPORT UTILITY INTERACTIVE PV RAPID SHUTDOWN EQUIPMENT E478330
LISTED
Module Fire Performance: Type 2

527025 RevA

[1] SunPower 360 W compared to a conventional panel on same-sized arrays (260 W, 16% efficient, approx. 1.6 m²), 4% more energy per watt (based on PVSyst pan files), 0.75%/yr. slower degradation (Campeau, Z. et al. *SunPower Module Degradation Rate*. San Jose CA, 2013).
[2] Based on search of datasheet values from websites of top 10 manufacturers per IHS, as of January 2017.
[3] #1 rank in "Fraunhofer PV Durability Initiative for Solar Modules: Part 3." *PV-Tech Power*, September 2015; Campeau, Z. et al. *SunPower Module Degradation Rate*. San Jose CA, 2013.
[4] Factory set to 1547a-2014 profile. CA Rule 21 profile set during commissioning. See the *Equinox Installation Guide #518101* for more information.
[5] Standard Test Conditions (1000 W/m² irradiance, AM 1.5, 25°C). NREL calibration standard: SOMS current, LACCS FF and voltage. All DC voltage is fully contained within the module.
See www.sunpower.com/facts for more reference information

F.2.2 X21-345-D-AC, X21-335-D-AC, and X20-327-D-AC

SunPower® X21-345-D-AC | Residential AC Module Series

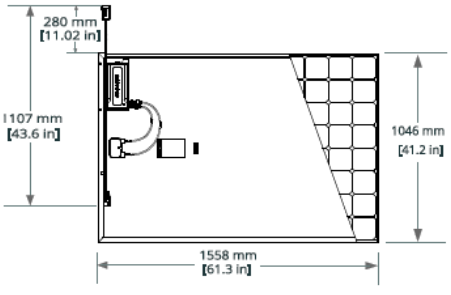
AC Electrical Data[3]			
SRD Profile		IEEE 1547a-2014[3] (default settings) min. / nom. / max.	CA Rule 21[3] min. / nom. / max.
Frequency (Hz)		59.5 / 60.0 / 60.5	58.5 / 60.0 / 60.5
Power Factor		0.99 / 1.00 / 1.00	0.85 lead. / 1.00 / 0.85 lag.
Reactive Power			±169 Var Volt-VAr
Voltage	@240 V @208 V	211.2 / 240 / 264 V 183 / 208 / 228.8 V	
Max. Current	@240 V @208 V	1.33 A 1.54 A	
DC/AC CEC Conversion Efficiency	@240 V @208 V	96.0% 95.5%	
Max. Units Per 20 A Branch Circuit	@240 V @208 V	12 (single phase) 10 (two pole) wye	
Power		320 W, 320 VA	
No active phase balancing for 3 phase installations			

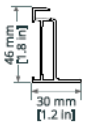
DC Power Data	X21-345-D-AC	X21-335-D-AC	X20-327-D-AC
Nominal Power[4] (Pnom)	345 W	335 W	327 W
Power Tolerance		+5/−0%	
Panel Efficiency[5]	21.5%	21.0%	20.4%
Temp. Coef. (Power)		−0.29%/° C	
Shade Tolerance		• Three bypass diodes • Integrated module-level maximum power point tracking	

Tested Operating Conditions	
Operating Temp.	−40° F to +149° F (−40° C to +65° C)
Max. Ambient Temp.	122° F (50° C)
Max. Load	Wind: 62 psf, 3000 Pa, 305 kg/m² front & back Snow: 125 psf, 6000 Pa, 611 kg/m² front
Impact Resistance	1 inch (25 mm) diameter hail at 52 mph (23 m/s)

Mechanical Data	
Solar Cells	96 Monocrystalline Maxeon Gen III
Front Glass	High-transmission tempered glass with anti-reflective coating
Environmental Rating	Outdoor rated
Frame	Class 1 black anodized (highest AAMA rating)
Weight	45.5 lbs (20.6 kg)
Recommended Max. Module Spacing	1.3 in. (33 mm)

Warranties and Certifications	
Warranties	· 25-year limited power warranty · 25-year limited product warranty
Certifications	UL listed to UL 1741 SA · SRDs: IEEE 1547-2003, IEEE 1547a-2014, CA Rule 21 Phase 1 · PV Rapid Shutdown Equipment · Equipment Grounding · UL 6703, UL 9703 Connectors and cables (load break disconnection) · UL 1741 AC Module (Type 2 fire rating) Enables installation in accordance with: · NEC 690.6 · NEC 690.12 Rapid Shutdown (inside and outside the array) · NEC 690.15 AC Connectors, 690.33(A) – (E)(1) FCC and ICES-003 Class B When used with InvisiMount racking (UL 2703): · Integrated grounding and bonding · Class A fire rated
PID Test	Potential-induced degradation free





Please read the safety and installation instructions for details.

AC MODULE GRID SUPPORT UTILITY INTERACTIVE PV RAPID SHUTDOWN EQUIPMENT
LISTED E478330
Module Fire Performance: Type 2

[1] SunPower 360 W compared to a conventional panel on same-sized arrays (260 W, 16% efficient, approx. 1.6 m²), 4% more energy per watt (based on PVSyst pan files), 0.75%/yr. slower degradation (Campeau, Z. et al. *SunPower Module Degradation Rate*. San Jose CA, 2013).
[2] Based on search of datasheet values from websites of top 10 manufacturers per IHS, as of January 2017.
[3] #1 rank in "Fraunhofer PV Durability Initiative for Solar Modules: Part 3." *PV-Tech Power*, September 2015; Campeau, Z. et al. *SunPower Module Degradation Rate*. San Jose CA, 2013.
[4] Factory set to 1547a-2014 profile. CA Rule 21 profile set during commissioning. See the *Equinox Installation Guide #518101* for more information.
[5] Standard Test Conditions (1000 W/m² irradiance, AM 1.5, 25°C). NREL calibration standard: SOMS current, LACCS FF and voltage. All DC voltage is fully contained within the module.

See www.sunpower.com/facts for more reference information.

527036 RevA

F.2.3 X21-350-D-AC, X21-335-BLK-D-AC, and X20-327-BLK-D-AC

SunPower® X21-350-BLK-D-AC | Residential AC Module Series

AC Electrical Data[3]			
SRD Profile		IEEE 1547a-2014[3] (default settings) min. / nom. / max.	CA Rule 21[3] min. / nom. / max.
Frequency (Hz)		59.5 / 60.0 / 60.5	58.5 / 60.0 / 60.5
Power Factor		0.99 / 1.00 / 1.00	0.85 lead. / 1.00 / 0.85 lag.
Reactive Power			±169 Var Volt-VAr
Voltage	@240 V @208 V	211.2 / 240 / 264 V 183 / 208 / 228.8 V	
Max. Current	@240 V @208 V	1.33 A 1.54 A	
DC/AC CEC Conversion Efficiency	@240 V @208 V	96.0% 95.5%	
Max. Units Per 20 A Branch Circuit	@240 V @208 V	12 (single phase) 10 (two pole) wye	
Power		320 W, 320 VA	
No active phase balancing for 3 phase installations			

DC Power Data	X21-350-BLK-D-AC	X21-335-BLK-D-AC	X20-327-BLK-D-AC
Nominal Power[4] (Pnom)	350 W	335 W	327 W
Power Tolerance	+5/−0%	+5/−0%	+5/−0%
Panel Efficiency[5]	21.5%	21.0%	20.4%
Temp. Coef. (Power)	−0.29%/° C		
Shade Tolerance	• Three bypass diodes • Integrated module-level maximum power point tracking		

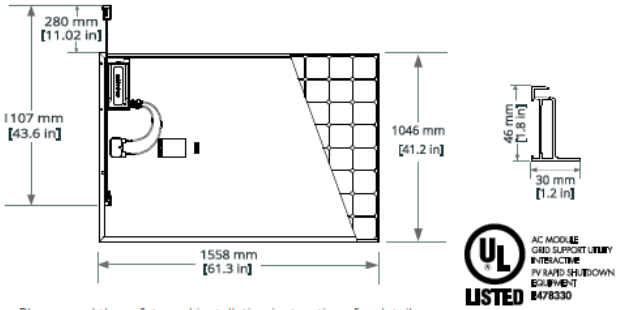
Tested Operating Conditions	
Operating Temp.	−40° F to +149° F (−40° C to +65° C)
Max. Ambient Temp.	122° F (50° C)
Max. Load	Wind: 62 psf, 3000 Pa, 305 kg/m² front & back Snow: 125 psf, 6000 Pa, 611 kg/m² front
Impact Resistance	1 inch (25 mm) diameter hail at 52 mph (23 m/s)

Mechanical Data	
Solar Cells	96 Monocrystalline Maxeon Gen III
Front Glass	High-transmission tempered glass with anti-reflective coating
Environmental Rating	Outdoor rated
Frame	Class 1 black anodized (highest AAMA rating)
Weight	45.5 lbs (20.6 kg)
Recommended Max. Module Spacing	1.3 in. (33 mm)

[1] SunPower 327 W compared to a conventional panel on same-sized arrays (260 W, 16% efficient, approx. 1.6 m²). 4% more energy per watt (based on PVSyst pan files), 0.75%/yr. slower degradation (Campeau, Z. et al. *SunPower Module Degradation Rate*. San Jose CA, 2013).
[2] Based on search of datasheet values from websites of top 10 manufacturers per IHS, as of January 2017.
[3] #1 rank in "Fraunhofer PV Durability Initiative for Solar Modules: Part 3." *PV-Tech Power*, September 2015; Campeau, Z. et al. *SunPower Module Degradation Rate*. San Jose CA, 2013.
[4] Factory set to 1547a-2014 profile. CA Rule 21 profile set during commissioning. See the *Equinox Installation Guide #518101* for more information.
[5] Standard Test Conditions (1000 W/m² irradiance, AM 1.5, 25°C). NREL calibration standard: SOMS current, LACCS FF and voltage. All DC voltage is fully contained within the module.

See www.sunpower.com/facts for more reference information.

Warranties and Certifications	
Warranties	· 25-year limited power warranty · 25-year limited product warranty
Certifications	UL listed to UL 1741 SA · SRDs: IEEE 1547-2003, IEEE 1547a-2014, CA Rule 21 Phase 1 · PV Rapid Shutdown Equipment · Equipment Grounding · UL 6703, UL 9703 Connectors and cables (load break disconnection) · UL 1741 AC Module (Type 2 fire rating) Enables installation in accordance with: · NEC 690.6 · NEC 690.12 Rapid Shutdown (inside and outside the array) · NEC 690.15 AC Connectors, 690.33(A) – (E)(1) FCC and ICES-003 Class B When used with InvisiMount racking (UL 2703): · Integrated grounding and bonding · Class A fire rated
PID Test	Potential-induced degradation free



Please read the safety and installation instructions for details.

AC MODULE GRID SUPPORT UTILITY INTERACTIVE PV RAPID SHUTDOWN EQUIPMENT E478330
Module Fire Performance: Type 2

527031 RevA

F.2.4 E20-327-D-AC and E19-320-D-AC

SunPower® E20-327-D-AC | Residential AC Module Series

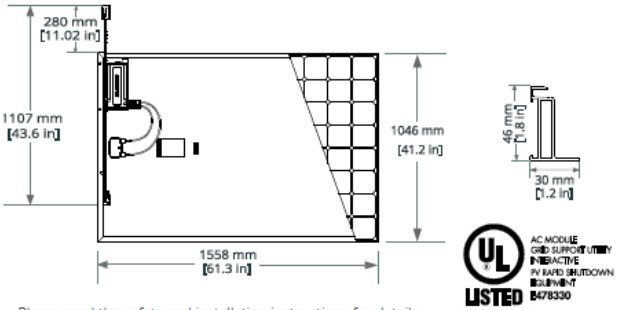
AC Electrical Data[3]			
SRD Profile		IEEE 1547a-2014[3] (default settings) min. / nom. / max.	CA Rule 21[3] min. / nom. / max.
Frequency (Hz)		59.5 / 60.0 / 60.5	58.5 / 60.0 / 60.5
Power Factor		0.99 / 1.00 / 1.00	0.85 lead. / 1.00 / 0.85 lag.
Reactive Power			±169 Var Volt-VAr
Voltage	@240 V @208 V	211.2 / 240 / 264 V 183 / 208 / 228.8 V	
Max. Current	@240 V @208 V	1.33 A 1.54 A	
DC/AC CEC Conversion Efficiency	@240 V @208 V	96.0% 95.5%	
Max. Units Per 20 A Branch Circuit	@240 V @208 V	12 (single phase) 10 (two pole) wye	
Power		320 W, 320 VA	
No active phase balancing for 3 phase installations			

DC Power Data	SPR-E20-327-D-AC	SPR-E19-320-D-AC
Nominal Power[4] (Pnom)	327 W	320 W
Power Tolerance	+5/−0%	
Panel Efficiency[5]	20.4%	19.9%
Temp. Coef. (Power)	−0.35%/°C	
Shade Tolerance	· Three bypass diodes · Integrated module-level maximum power point tracking	

Tested Operating Conditions	
Operating Temp.	−40° F to +149° F (−40° C to +65° C)
Max. Ambient Temp.	122° F (50° C)
Max. Load	Wind: 62 psf, 3000 Pa, 305 kg/m² front & back Snow: 125 psf, 6000 Pa, 611 kg/m² front
Impact Resistance	1 inch (25 mm) diameter hail at 52 mph (23 m/s)

Mechanical Data	
Solar Cells	96 Monocrystalline Maxeon Gen III
Front Glass	High-transmission tempered glass with anti-reflective coating
Environmental Rating	Outdoor rated
Frame	Class 1 black anodized (highest AAMA rating)
Weight	45.5 lbs (20.6 kg)
Recommended Max. Module Spacing	1.3 in. (33 mm)

Warranties and Certifications	
Warranties	· 25-year limited power warranty · 25-year limited product warranty
Certifications	UL listed to UL 1741 SA · SRDs: IEEE 1547-2003, IEEE 1547a-2014, CA Rule 21 Phase 1 · PV Rapid Shutdown Equipment · Equipment Grounding · UL 6703, UL 9703 Connectors and cables (load break disconnection) · UL 1741 AC Module (Type 2 fire rating) Enables installation in accordance with: · NEC 690.6 · NEC 690.12 Rapid Shutdown (inside and outside the array) · NEC 690.15 AC Connectors, 690.33(A) – (E)(1) FCC and ICES-003 Class B When used with InvisiMount racking (UL 2703): · Integrated grounding and bonding · Class A fire rated
PID Test	Potential-induced degradation free



Please read the safety and installation instructions for details.

AC MODULE GRID SUPPORT UTILITY INTERACTIVE PV RAPID SHUTDOWN EQUIPMENT
LISTED E478330
Module Fire Performance: Type 2

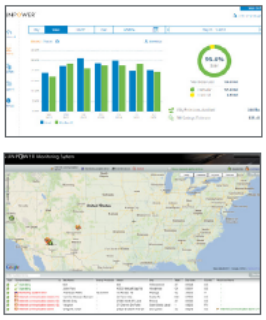
[1] SunPower 327 W compared to a conventional panel on same-sized arrays (260 W, 16% efficient, approx. 1.6 m²), 4% more energy per watt (based on PVSyst pan files), 0.75%/yr. slower degradation (Campeau, Z. et al. *SunPower Module Degradation Rate*. San Jose CA, 2013).
[2] Based on search of datasheet values from websites of top 10 manufacturers per IHS, as of January 2017.
[3] #1 rank in "Fraunhofer PV Durability Initiative for Solar Modules: Part 3." *PV-Tech Power*, September 2015; Campeau, Z. et al. *SunPower Module Degradation Rate*. San Jose CA, 2013.
[4] Factory set to 1547a-2014 profile. CA Rule 21 profile set during commissioning. See the *Equinox Installation Guide #518101* for more information.
[5] Standard Test Conditions (1000 W/m² irradiance, AM 1.5, 25°C). NREL calibration standard: SOMS current, LACCS FF and voltage. All DC voltage is fully contained within the module.
See www.sunpower.com/facts for more reference information.

527042 RevB

F.3 PVS5x

SunPower® EnergyLink™ | Residential PVS5x

SunPower Monitoring Websites



PVS5x

Multiple communication options include Ethernet, PLC, Wi-Fi, and cellular

Supports SunPower 96-cell AC modules, DC string inverters, and hybrid (DC and AC) systems

SunPower AC Modules

Site Requirements	
Compatible SunPower AC Modules (number supported per PVS5x)	SunPower 96-cell AC Modules (85)
Compatible String Inverters (number supported per PVS5x)	SMA (10) and ABB (30)
Internet Access	High-speed Internet access Accessible router or switch
Power	240 VAC, 50 or 60 Hz 208 VAC (two pole), 60 Hz

Mechanical	
Weight	5.5 lbs (2.5 kg)
Dimensions	13.6 × 8.1 × 3.6 in. (34.5 × 20.6 × 9.3 cm)
Enclosure Rating	UL Type 3R

Web and Mobile Device Support	
Customer Site	monitor.us.sunpower.com
Partner Site	pvsmgmt.us.sunpower.com
Browsers	Firefox, Safari, and Chrome
Mobile Devices	iPhone®, iPad®, and Android™
Customer App	1. Create account online at: monitor.us.sunpower.com. 2. On a mobile device, download the SunPower Monitoring app from Apple App Store℠ or Google Play™ store. 3. Sign in using account email and password.

Operating Conditions	
Temperature	–22°F to +140°F (–30°C to +60°C)
Humidity (maximum)	95%, non condensing

Communication	
RS-485	Inverters and meters
Integrated Metering	One channel of revenue-grade production metering (ANSI C12.20 Class 0.5) and two channels of consumption metering
Ethernet	1 LAN (or optional WAN) port
PLC	PLC for 96-cell AC modules
	Integrated HomePlug AV standard communication to PLC devices over AC wiring
Wi-Fi	802.11b/g/n 2.4 GHz
Cellular	3G UMTS or LTE/3G UMTS
ZigBee	IEEE 802.15.4 MAC, 2.4GHz ISM band
Data Storage	60 days
Upgrades	Automatic firmware upgrades

Warranty and Certifications	
Warranty	10-year Limited Warranty
Certifications	UL, cUL, EN60950, EN61326-, FCC Part 15 (Class B)

FCC ID: YAW513402

ITE: E477122

513829 RevC

F.4 InvisiMount™

InvisiMount Component Details		
Mid clamp	Black oxide stainless steel 300 series	63 g (2.2 oz)
End clamp	Black anodized aluminum 6000 series	110 g (3.88 oz)
Rail	Black anodized aluminum 6000 series	830 g/m (9 oz/ft)
Rail splice	Aluminum alloy 6000 series	830 g/m (9 oz/ft)
Rail bolt	M10-1.5 × 25 mm; DIN 933 SS304	nominal
Rail nut	M10-1.5; DIN 6923 SS304	nominal
Ground lug assembly	SS304; A2-70 bolt; tin-plated copper lug	106.5 g/m (3.75 oz)

InvisiMount Component LRFD Capacities[2]		
Mid clamp	Uplift	664 lbf
	Shear	540 lbf
End clamp	Uplift	899 lbf
	Shear	220 lbf
Rail	Moment: upward	548 lbf-ft
	Moment: downward	580 lbf-ft
Rail splice	Moment: upward	548 lbf-ft
	Moment: downward	580 lbf-ft
L-foot	Uplift	1000 lbf
	Shear	390 lbf

InvisiMount Operating Conditions	
Temperature	–40° C to 90° C (–40° F to 194° F)
Max. Load (LRFD)	• 3000 Pa uplift • 6000 Pa downforce

Roof Attachment Hardware Supported by Design Tool	
Application	• Composition Shingle Rafter Attachment • Composition Shingle Roof Decking Attachment • Curved and Flat Tile Roof Attachment • Universal interface for other roof attachments

InvisiMount Warranties And Certifications	
Warranties	• 25-year product warranty • 5-year finish warranty
Certifications	• UL 2703 Listed • Class A Fire Rated

Roof Attachment Hardware Warranties
Refer to roof attachment hardware manufacturer's documentation.

[1] Module frame that is compatible with the InvisiMount system required for hardware interoperability.

[2] SunPower recommends that all Equinox™, InvisiMount™, and AC module systems always be designed using the SunPower Design Tool. If a designer decides to instead use the component capacities listed in this document to design a system, note that the capacities shown are Load and Resistance Factor Design (LRFD) design loads, and are NOT to be used for Allowable Stress Design (ASD) calculations; and that a licensed Professional Engineer (PE) must then stamp all calculations. Should you have any questions please contact SunPower Technical Support at 1-800-SUNPOWER (1-800-786-7693).

sunpower.com
509506 RevF

F.5 Grid Support, Utility Interactive Inverters, and Regulatory Certification for Type C AC Modules

When the grid's voltage or frequency fluctuates outside of established limits, AC modules must stop producing power. These limits vary from country to country and state to state, and often vary within a given state. Variations can also occur between commercial and residential sites. The microinverter in Type C AC modules is a pulse-width modulation type. This section contains information about SunPower Type C AC modules.

F.5.1 Grid Profile: IEEE 1547 (2003)

Parameter	Levels			Times		
	Value	Units	Adjustable Range	Value	Units	Adjustable Range
Voltage Too High Level 3	n/a	V	n/a	n/a	Seconds	n/a
Voltage Too High Level 2	144.0		n/a	0.12		n/a
Voltage Too High Level 1	132.0		132.0–135.0	0.75		0.75–300.0
Voltage Too Low Level 1	106.0		85.0–106.0	1.5		1.5–300.0
Voltage Too Low Level 2	60.0		n/a	0.12		n/a
Voltage Too Low Level 3	n/a		n/a	n/a		n/a
Frequency Too High Level 3	n/a	Hz	n/a	n/a		n/a
Frequency Too High Level 2	n/a		n/a	n/a		n/a
Frequency Too High Level 1	60.5		n/a	0.12		n/a
Frequency Too Low Level 1	59.3		57.0–59.3	0.12		0.12–300.0
Frequency Too Low Level 2	57.0		n/a	0.12		n/a
Frequency Too Low Level 3	n/a		n/a	n/a		n/a

F.5.2 Microinverter Ratings

F.5.2.1 Input Specifications (DC)

Parameter	Value
Max. continuous input power	333 W
Max. input voltage	80 V
MPPT voltage	20–64 V
Max. input current	6.3 A

F.5.2.2 Output Specifications (AC)

Parameter	240 V	208 V
Max. output fault current and duration	11.9 Apk, 0.31 Arms; 1.2 ms	
Max. continuous output power	320 W	
Nominal output current	1.33 A	1.54 A
Nominal voltage	240 V	208 V
Operating voltage	211–264 V	183–229 V
Nominal frequency	60 Hz	
Operating frequency	59.3–60.5 Hz	
Power factor	> 0.99	
Total harmonic distortion	< 5%	
Max. units per 20 A branch circuit	12	10 (two pole)

F.5.2.3 Efficiency

Parameter	240 V	208 V
Peak inverter efficiency	96.4%	96.1%
CEC weighted efficiency	96%	
Nominal MPP tracking	> 99.5%	
Nighttime power consumption (tare)	< 65 mW	

F.6 Grid Support, Utility Interactive Inverters, and Regulatory Certification for Type D AC Modules

Distributed energy resources (DER) such as SunPower Type D AC modules must provide functionality that both supports and helps to stabilize the grid. SunPower Type D AC modules are UL tested and certified to UL 1741-SA Standard per CA Rule 21 Phase 1 SRD, are factory set to the IEEE 1547a-2014 grid profile, and provide this functionality. The microinverter in Type D AC modules is a pulse-width modulation type.

This section contains information about SunPower Type D AC modules.

F.6.1 Default Factory Settings for Type D AC Modules: IEEE 1547a-2014 Grid Profile

These are the default settings that should be used in the US with the exception of CA and HI, or any other local regions where the local utility specifically requires different settings. Voltage and frequency ride-through performance is not specified for settings under this grid profile.

Parameter	Trip Level			Trip Time		
	Default Value	**Units**	**Allowed Adjustable Range**	**Default Value**	**Units**	**Allowed Adjustable Range**
Voltage Too High Level 3	n/a	V	n/a	n/a	Seconds	n/a
Voltage Too High Level 2	144			0.16		n/a
Voltage Too High Level 1	132			1		1–13
Voltage Too Low Level 1	105.6			2		2–21

Parameter	Trip Level			Trip Time		
	Default Value	Units	Allowed Adjustable Range	Default Value	Units	Allowed Adjustable Range
Voltage Too Low Level 2	72			1		1–11
Voltage Too Low Level 3	54			0.16		n/a
Frequency Too High Level 3*	66			0.16		n/a
Frequency Too High Level 2	62			0.16		0.16–10
Frequency Too High Level 1	60.5			2		2–300
Frequency Too Low Level 1	59.5	Hz		2		2–300
Frequency Too Low Level 2	57			0.16		0.16–10
Frequency Too Low Level 3*	50			0.16		n/a

*Not required but added by SunPower to provide additional protection.

F.6.2 Legacy Support Settings: IEEE 1547-2003 Grid Profile

These settings should only be used for legacy support *only*: the replacement of systems in the field where the local utility is using old settings and does not wish system behavior to change. Voltage and frequency ride-through performance is not specified for settings under this grid profile.

Parameter	Trip Level			Trip Time		
	Default Value	Units	Allowed Adjustable Range	Default Value	Units	Allowed Adjustable Range
Voltage Too High Level 3	n/a			n/a		
Voltage Too High Level 2	144	V	n/a	0.16	Seconds	n/a
Voltage Too High Level 1	132			1		

Parameter	Trip Level			Trip Time		
	Default Value	Units	Allowed Adjustable Range	Default Value	Units	Allowed Adjustable Range
Voltage Too Low Level 1	105.6			2		
Voltage Too Low Level 2*	72			1		
Voltage Too Low Level 3	60			0.16		
Frequency Too High Level 3*	66	Hz		0.16		
Frequency Too High Level 2*	62			0.16		
Frequency Too High Level 1	60.5			0.16		
Frequency Too Low Level 1	59.3			0.16		
Frequency Too Low Level 2*	57			0.16		
Frequency Too Low Level 3*	50			0.16		

*Not required but added by SunPower to provide additional protection.

F.6.3 CA Rule 21 Phase 1 Settings for Type D AC Modules

Parameter	Trip Level			Trip Time		
	Default Value	Units	Allowed Adjustable Range	Default Value	Units	Allowed Adjustable Range
Voltage Too High Level 3	n/a	V	n/a	n/a	Seconds	n/a
Voltage Too High Level 2	144		n/a	0.16		
Voltage Too High Level 1	132		n/a	13		
Voltage Too Low Level 1	105.6		n/a	21		
Voltage Too Low Level 2	84		n/a	11		
Voltage Too Low Level 3	60		n/a	1.5		
Frequency Too High Level 3*	66	Hz	n/a	0.16		
Frequency Too High Level 2	62		62–64	0.16		
Frequency Too High Level 1	60.5		60.1–62	300		
Frequency Too Low Level 1	58.5		57–59.9	300		
Frequency Too Low Level 2	57		53–57	0.16		
Frequency Too Low Level 3	50		n/a	0.16		

*Not required but added by SunPower to provide additional protection.

F.6.3.1 CA Rule 21 Phase 1 Ride Through Operation

Ride Through Region	Range	Ride Through Time (seconds)	Operating Mode
Over Voltage Level 1	132–144 V	12	Momentary Cessation*
Under Voltage Level 1	84–105.6 V	20	Mandatory Operation
Under Voltage Level 2	60–84 V	10	Mandatory Operation
Under Voltage Level 3	0–60 V	1	Momentary Cessation*
Over Frequency Level 1	60.5–62 Hz	299	Mandatory Operation
Under Frequency Level 1	57–59.9 Hz	299	Mandatory Operation

*Momentary Cessation is when the unit ceases to energize its output within 0.16 seconds or less of when the parameter entered the ride through region.

F.6.4 Reactive Power Capability for Type D AC Modules

The SunPower Type D AC module also provides additional capabilities to support CA Rule 21.

IEEE 1547-2003 does not allow for reactive power operation. Instead, fixed power factor operation at unity is required. IEEE 1547a-2014 allows for reactive power operation, but the default is unity power factor, and reactive power operations are not mandated.

CA Rule 21 mandates reactive power capability, and has separate requirements based on system size: systems larger than 15 kW and systems smaller than 15 kW. SunPower has adopted the requirements for systems larger than 15 kW so that there are no limitations in system size when using Type D AC modules. The region of operation in which the units must be capable of operating is shown in Fig. F1. Reactive power capability is only required above 0.20 pu of Active (Real) Power operation. The sloped lines represent limits that correspond to power factor of 0.85.

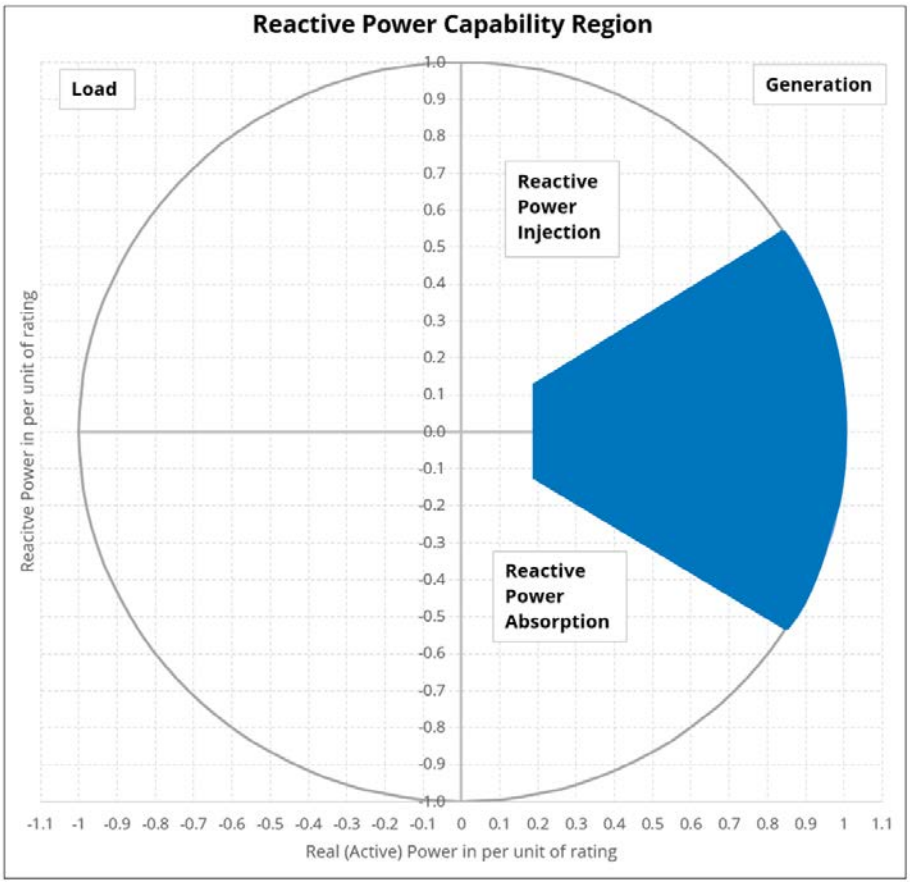


Fig. F1

The blue region represents the range in which SunPower's Type D module (microinverter) is capable of providing reactive power.

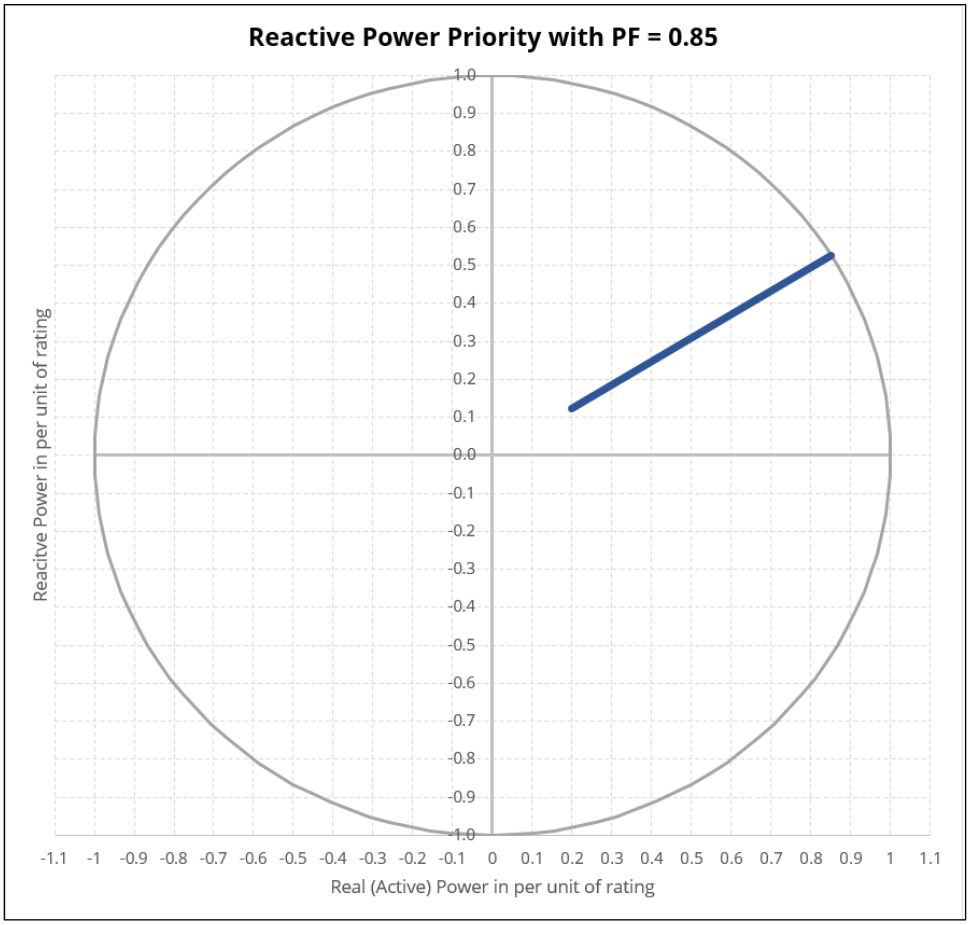
F.6.5 Reactive Power Control Accuracy for Type D AC Modules

SunPower's ability to control reactive power is specified at ± 0.14 pu (per unit). Typical performance is much better than that, but at full power unity power factor operation, highest efficiency is achieved with an actual power factor setpoint of 0.994.

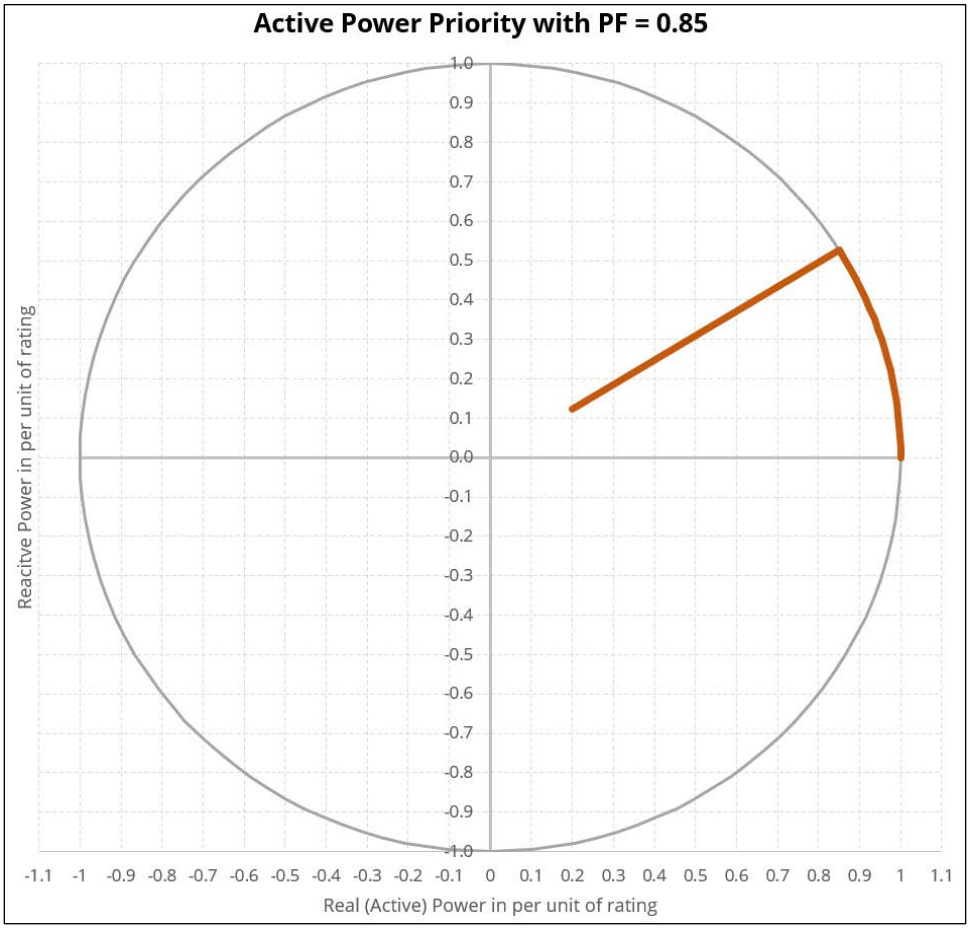
This setting enables maximizing the energy performance of the system while still maintaining the ability to control reactive power. This is within the implied power factor accuracy of ± 0.01 at unity.

F.6.6 Active or Reactive Power Priority for Type D AC Modules

The Example 1 and Example 2 graphs show ideal operation when the power factor is set to 0.85:


Reactive Power Priority with PF = 0.85
Reactive Power in per unit of rating
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
-0.9
-1.0
-1.1 -1 -0.9 -0.8 -0.7 -0.6 -0.5 -0.4 -0.3 -0.2 -0.1 0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1 1.1
Real (Active) Power in per unit of rating

Example 1



Example 2

Example 1 shows the operating curve when *reactive* power priority is enabled. Example 2 shows the operating curve when *active* power priority is enabled. Active power priority is the mode of operation currently required by CA Rule 21. As active power increases above 0.20 pu, the inverter will operate along the PF (power factor) = 0.85 line until active power reaches 0.85 pu. Further increases in active power will cause the AC module to follow the arc until finally active power reaches 1.0 pu and PF = 1.00. Active power priority is where active power generation has a higher priority than reactive power generation. Reactive power priority will prevent the inverter from going above 0.85 pu active power when PF = 0.85.

The SunPower Type D AC module is capable of operating in either active or reactive power priority.

F.6.7 Fixed Power Factor for Type D AC Modules

Type D AC modules are capable of fixed power factor operation from 0.85 to 1.00, in both injecting and absorbing modes. A power factor setting of −0.95[1] would be absorbing reactive power with negative VArs at a power factor of 0.95. Unity power factor (1.00), is the default setting for CA Rule 21. If fixed power factor operating mode is enabled, volt/VAr operation is disabled, and vice versa—if volt/VAr operation is enabled, fixed power factor operating mode is disabled.

F.6.8 Volt/VAr Operation for Type D AC Modules

The volt/VAr operating mode is used to help control voltage excursions within local grid operations. The reactive power output of the inverter (VArs) is controlled based upon a piecewise linear curve. Typically when voltage is low, injection of VArs will help to raise the voltage; and when voltage is high, absorption of VArs will help to lower the voltage. The addition of volt/VAr operation enables greater numbers of distributed generation PV systems to contribute to utility grids.

The curve is defined by four voltage and VAr points, (V1–4, Q1–4), typically defined in per unit (pu) terms (Fig. F2).

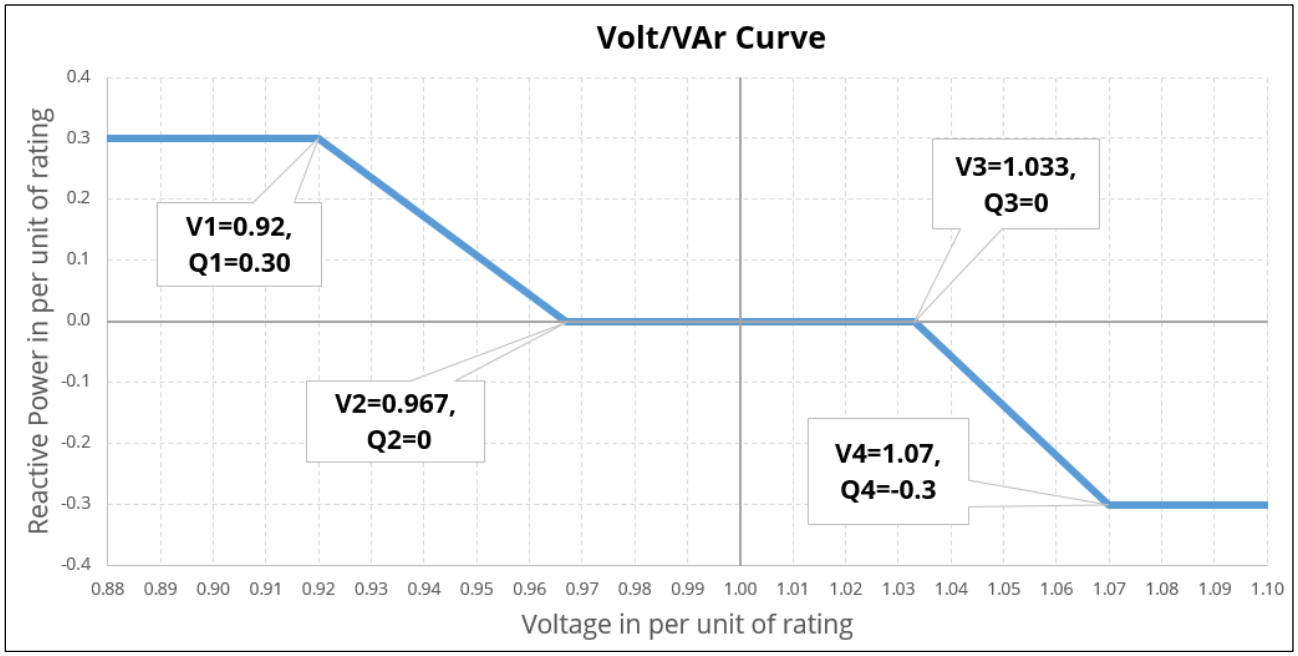


Fig. F2

Output of VArs due to volt/VAr operation is limited by the reactive power capability region. The actual VArs output by the unit will be the lesser of the region boundaries and the volt/VAr curve, whichever is lesser in magnitude.[1]

[1]Negative power factors are technically not possible, however industry has adopted the practice of using a negative sign to indicate absorbing reactive power and a positive sign to indicate injecting reactive power.

F.6.9 Microinverter Ratings for Type D AC Modules

F.6.9.1 Input Specifications (DC)

Parameter	Value
Max. continuous input power	333 W
Max. input voltage	80 V
MPPT voltage	20–64 V
Max. input current	6.3 A

F.6.9.2 Output Specifications (AC) per (factory default) IEEE 1547a-2014

Parameter	240 V	208 V Wye
Max. output fault current and duration	11.9 Apk, 0.31 Arms; 1.2 ms	
Max. continuous output power	320 W	
Nominal output current	1.33 A	1.54 A
Nominal voltage	240 V	208 V
Operating voltage	211–264 V	183–229 V
Nominal frequency	60 Hz	
Operating frequency	59.5–60.5 Hz	
Power factor	> 0.99	
Total harmonic distortion	< 5%	
Max. units per 20 A branch circuit	12	10 (two pole)

F.6.9.3 Efficiency

Parameter	240 V	208 V
Peak inverter efficiency	96.4%	96.3%
CEC weighted efficiency	96%	95.5%
MPPT tracking efficiency	> 99.7%	
Nighttime tare loss	≤ 0.10 W	

Appendix G: AC Module 3-Line Drawing Example

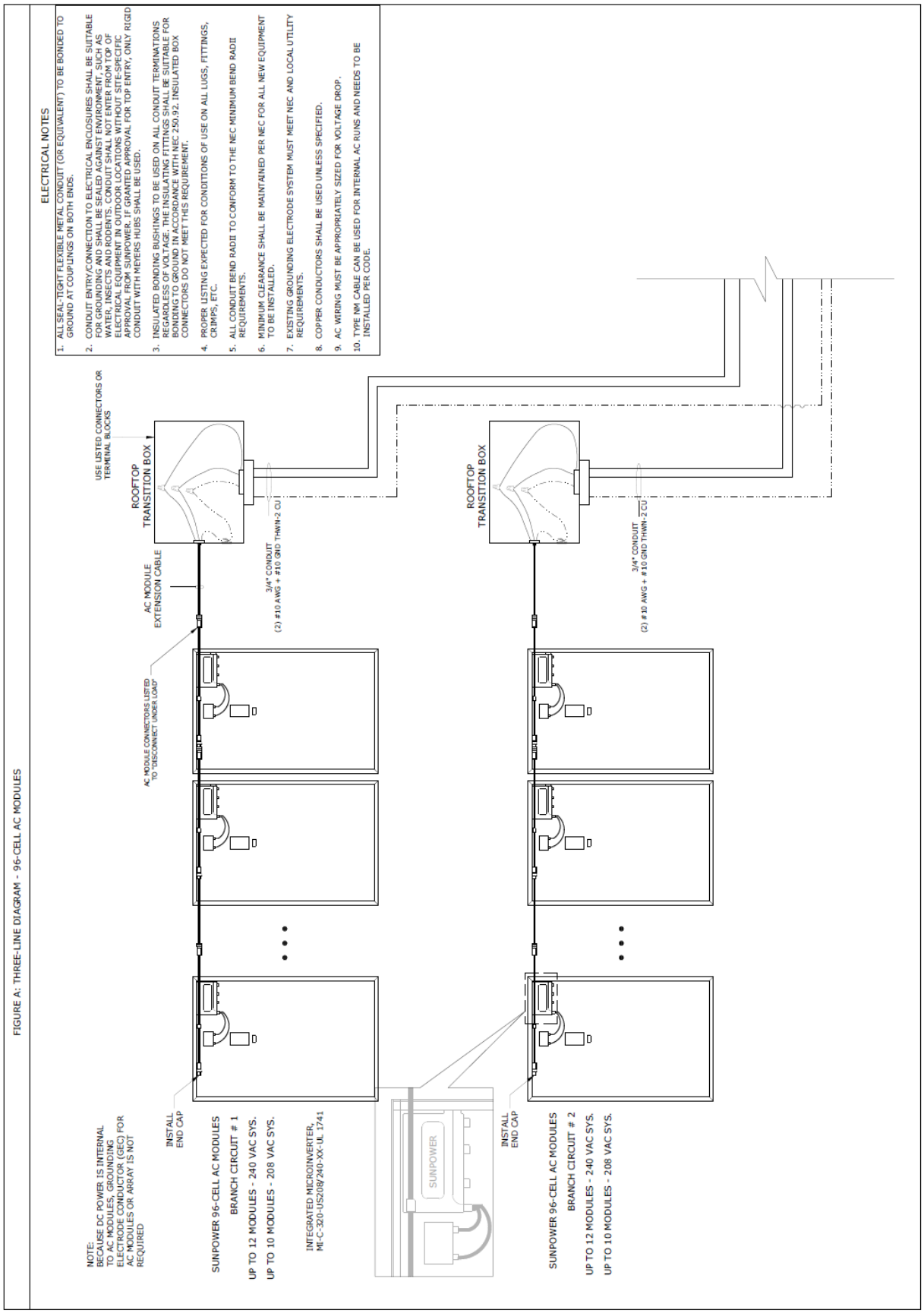
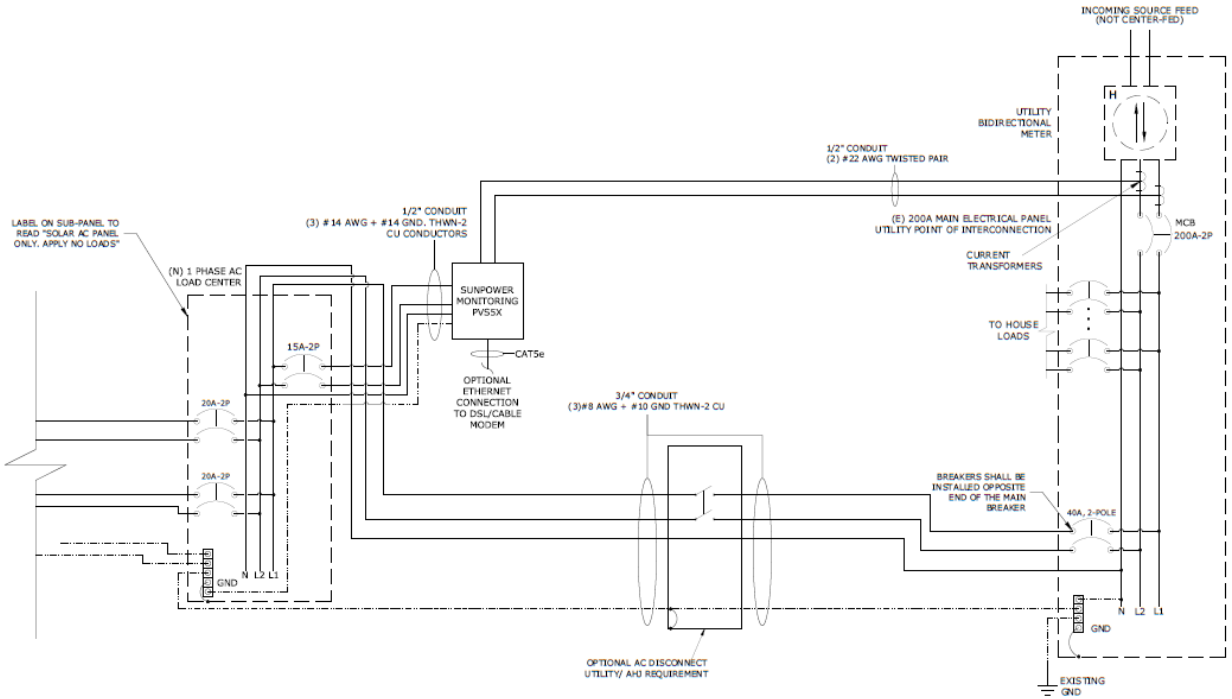


FIGURE A: THREE-LINE DIAGRAM - 96-CELL AC MODULES



NOTE:
SUM OF MAIN BREAKER AND PV BREAKER(S) MUST NOT EXCEED 120% OF THE BUSBAR RATING.

ELECTRICAL NOTES

1. ALL SEAL-TIGHT FLEXIBLE METAL CONDUIT (OR EQUIVALENT) TO BE BONDED TO GROUND AT COUPLINGS ON BOTH ENDS.
2. CONDUIT ENTRY/CONNECTION TO ELECTRICAL ENCLOSURES SHALL BE SUITABLE FOR GROUNDING AND SHALL BE SEALED AGAINST ENVIRONMENT, SUCH AS WATER, INSECTS AND RODENTS. CONDUIT SHALL NOT ENTER FROM TOP OF ELECTRICAL EQUIPMENT IN OUTDOOR LOCATIONS WITHOUT SITE-SPECIFIC APPROVAL FROM SUNPOWER. IF GRANTED APPROVAL FOR TOP ENTRY, ONLY RIGID CONDUIT WITH MEYERS HUBS SHALL BE USED.
3. INSULATED BONDING BUSHINGS TO BE USED ON ALL CONDUIT TERMINATIONS REGARDLESS OF VOLTAGE. THE INSULATING FITTINGS SHALL BE SUITABLE FOR BONDING TO GROUND IN ACCORDANCE WITH NEC 250.92. INSULATED BOX CONNECTORS DO NOT MEET THIS REQUIREMENT.
4. PROPER LISTING EXPECTED FOR CONDITIONS OF USE ON ALL LUGS, FITTINGS, CRIMPS, ETC.
5. ALL CONDUIT BEND RADII TO CONFORM TO THE NEC MINIMUM BEND RADII REQUIREMENTS.
6. MINIMUM CLEARANCE SHALL BE MAINTAINED PER NEC FOR ALL NEW EQUIPMENT TO BE INSTALLED.
7. EXISTING GROUNDING ELECTRODE SYSTEM MUST MEET NEC AND LOCAL UTILITY REQUIREMENTS.
8. COPPER CONDUCTORS SHALL BE USED UNLESS SPECIFIED.
9. AC WIRING MUST BE APPROPRIATELY SIZED FOR VOLTAGE DROP.
10. TYPE NM CABLE CAN BE USED FOR INTERNAL AC RUNS AND NEEDS TO BE INSTALLED PER CODE.

Appendix H: Install Rail-Mounted Junction Box

If you decide to use the rail-mounted J-box (RMJ), install it **before** you install modules.

Important! Only glands and fittings that have gaskets and that are suitable for wet locations may be used.

1. Determine the location for the RMJ. You can mount the RMJ “above” or “below” the rail but the box itself must be *between* the rails (Fig. H1).

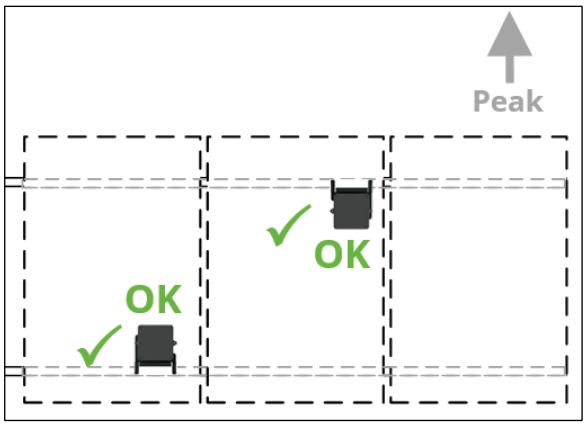


Fig. H1

2. According to your wire management strategy, determine, mark, and drill out the necessary entry locations on the sides of RMJ (do not drill the cover).

   Note: SunPower provides 1/2” cable glands; the maximum conduit size is 1".

3. Drill a weep hole (min. 1/8"; max. 1/4") in the RMJ at what will be its its lowest point in its installed position.
4. Install glands or conduit fittings in the RMJ. If you’re using a provided cable gland, torque its locknut to 4.5 N-m (40 +5/−0 in-lb). **Do not mount conduit or glands to the box *cover*.**
5. Fit the RMJ lip into the top channel of the rail (Fig. H2), and then tilt the RMJ downward until both of its tabs click around and fully engage the rail (Fig. H3).

Fig. H2

Fig. H3

6. Manually squeeze each tab upward to verify full engagement (Fig. H4).

Fig. H4

7. Remove the RMJ cover and insert the cable ends. For the provided glands, torque sealing nuts to 7.9 N-m (70 in-lb).
8. Complete the routing and installation of any conduit and wiring (Fig. H5; example only):

Fig. H5

9. Fit the cover on the RMJ and use the #2 square-drive screwdriver to torque each of the four cover screws to 16 in-lb (1.8 N-m).

Appendix J: Install Rooftop Transition Flashing

Important! The rooftop transition flashing is compatible with composition shingle roof types only.

Decide on the position of the installed flashing with respect to your array. Install the flashing only at a location that is both between the rafters and *within* the array perimeter, such that it will be *underneath and fully concealed by* the array when the array is complete.

1. After you have selected the location for the flashing, position the flashing on the roof as follows:
   - With its ROOF RIDGE arrow toward the peak.
   - Such that its lower alignment marks are positioned at (or a maximum of 1" [2.5 cm] above) the bottom edge of the second of the two affected shingle courses at your chosen location (Fig. J1).
   - Such that the left and right edges of the flashing are perpendicular to the shingle courses.

Fig. J1

2. Keeping the flashing in position, trace its perimeter onto the shingles, and mark the flashing's alignment marks on the shingles as well.
3. Remove the flashing and use a straight edge to trace the lines between the alignment marks onto the shingles (Fig. J2).

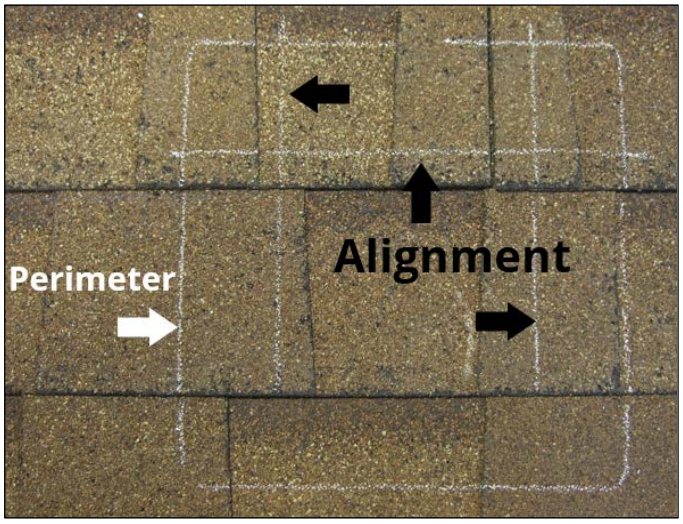


Fig. J2

4. Using a roofing bar, gently separate the two courses of affected shingles from underlying layers in the marked region, while leaving the shingles in place.

5. Cut and remove one layer of shingle material in the crosshatched area (Fig. J3 and Fig. J4).

> ***Important!*** DO NOT REMOVE ANY SHINGLE MATERIAL FROM ANY COURSES THAT EXTEND BELOW THE BOTTOM OF THE FLASHING, *EVEN IF THAT MATERIAL IS INSIDE THE BOX*. DO NOT CUT THROUGH THE ROOF MOISTURE BARRIER EXCEPT FOR THE TRANSITION HOLE INTO THE ATTIC OR BUILDING SPACE.

Fig. J3

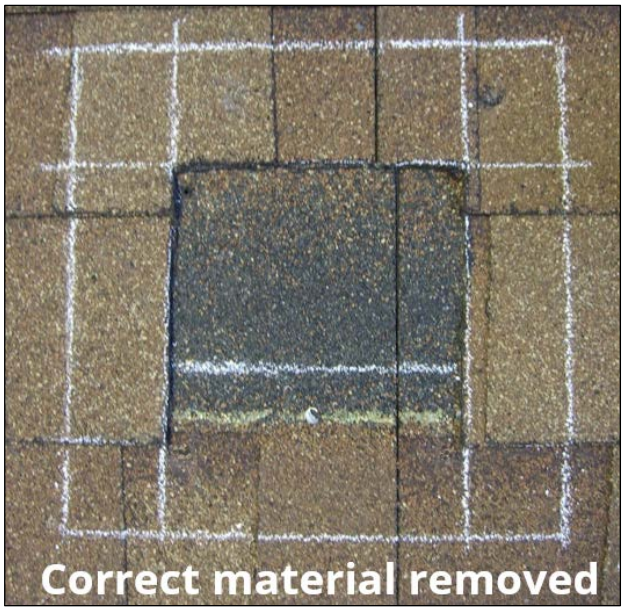


Fig. J4

6. To test fit, slide the flashing up under the shingle course that will align with the lower edge of the flashing (the "middle" course of the three affected courses). If roof nails are in the way, remove them with a roofing bar and seal the remaining holes with appropriate sealant for the particular roof type.

7. Remove the flashing.
8. Through the roof surface from which you removed material, drill a single pass-through hole no larger than 2" (5 cm), centered E–W, and no less than 4" (10.2 cm) from the lower edge of the flashing (Fig. J5).

   Important! The lowermost point of the hole must be a minimum of 4" (10.2 cm) from the bottom edge of the flashing.

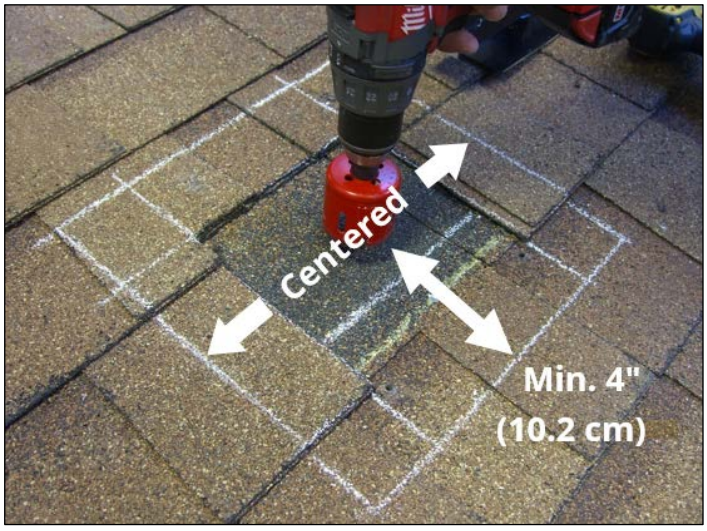


Fig. J5

9. The flashing comes with three hole locations each marked with a white dot. Allowing for the size of your chosen gland, drill the flashing with a step drill tip (or knockout tool) centered on one of the dots (Fig. J6).

   Important! Use only liquid-tight glands with gaskets appropriate for your chosen wire type.

   Note: Use only the three provided drill locations, and do not drill more holes than necessary.

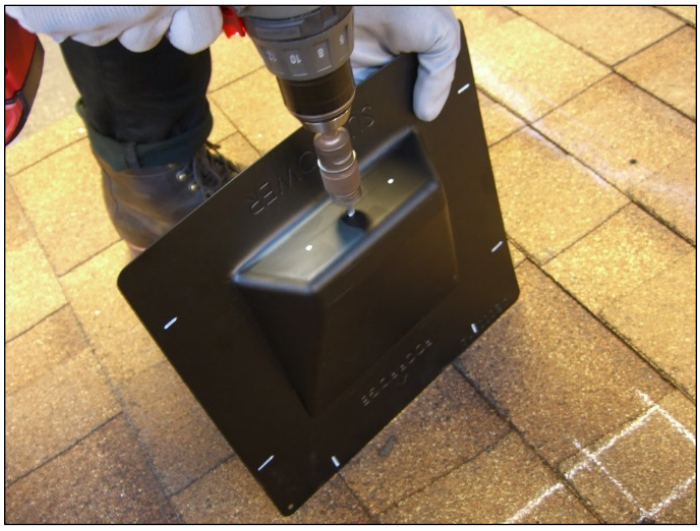


Fig. J6

10. Install and torque the gland and back nut as per the manufacturer guidance (Fig. J7 and Fig. J8).

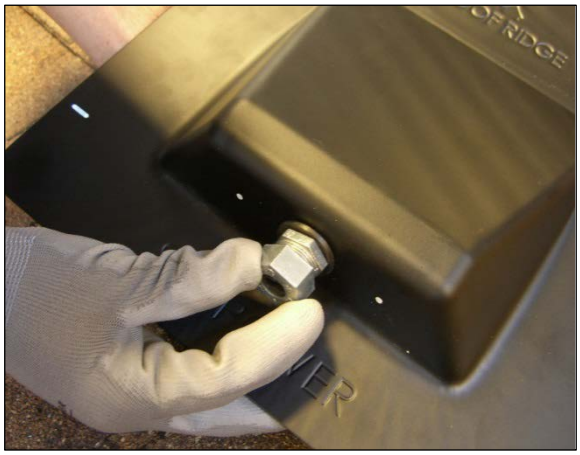


Fig. J7

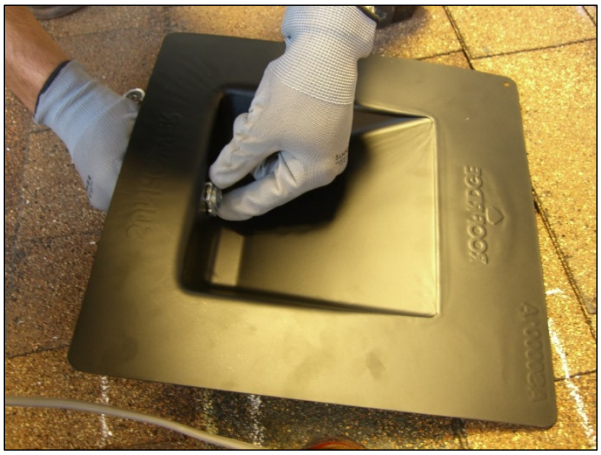


Fig. J8

Important! UF-B wire is used in this example because it is Listed for exterior and interior use. SunPower recommends that you refer to the applicable NEC edition for your region (some regions adopt editions later than others)—as well as consult with your AHJ—before choosing a wiring strategy.

11. Route and prepare a length of UF-B wire from the service panel entrance to the rooftop. Allow several extra feet for final installation.
12. Insert the cut end of the wire through the roof cutout, leaving sufficient length beyond the roof transition.
13. From the underside of the flashing, thread the UF-B wire through the gland, and then carefully slide the flashing into position (Fig. J9).

Fig. J9

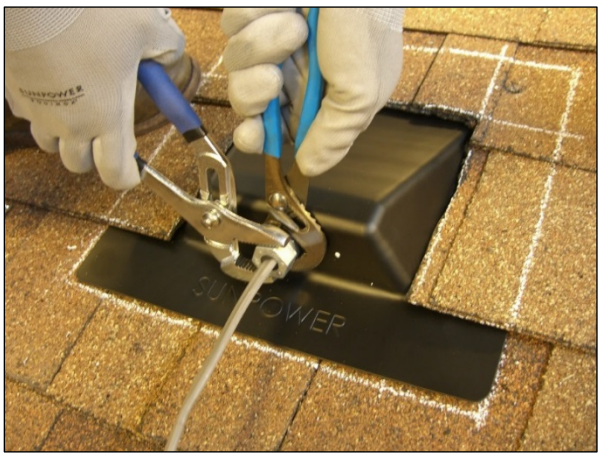


Fig. J10

14. Ensuring that you leave enough extra wire length, tighten the gland around the wire per the gland manufacturer guidance (Fig. J10).

    Important! Do not loosen the seal at the base of the gland!

15. Remove the flashing and turn it over, taking care to not disturb the gland.
16. Apply a single 1/2" continuous bead of sealant to the *underside* of the flashing, approximately 1" (2.5 cm) from its perimeter (Fig. J11).

Use only 100% silicone roof sealant, such as Henry 884 Tropi-Cool® or equivalent. Ensure that the sealant has not exceeded its shelf life and has not exceeded the recommended maximum time-to-use period after opening, as defined in the manufacturer guidance.

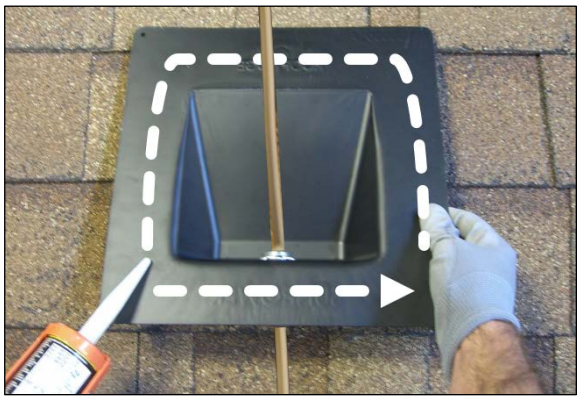


Fig. J11

17. Conforming to the exact outline you made previously, fit the flashing back into position while sliding the excess wire down into the attic space (Fig. J12).

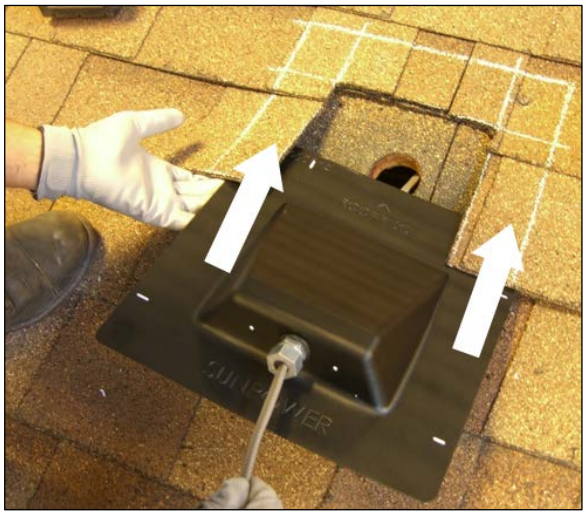


Fig. J12

Fig. J13

18. Lift the middle course of shingles and secure the flashing with one sheet metal screw (#9-15 1-1/2”); or nail (#12 ring shank 1-1/4”); on *each* side of the flashing; 1” (2.5 cm) from the flashing edge.
19. Apply a liberal cap of sealant on the head of each screw (or nail) (Fig. J13).
20. Lift the two courses of shingles and apply a horseshoe-shaped bead of sealant on the top surface of the flashing (as you did on the bottom of the flashing in Step 16) (Fig. J14).

Fig. J14

21. Press down firmly on the shingles over the flashing outline to properly bond the assembly to the roof surface.
22. Similar to Step 9, drill the flashing for conduit entry.
23. Install and torque all conduit fittings as per manufacturer guidance.
24. Mount conduit as per your array design. Conduit must be rated for the appropriate exposure. Exterior conduit and fittings must be rated liquid tight, and installed in an appropriate liquid-tight manner, including gaskets on all sealing faces where needed. A coupling can be used to connect interior and exterior raceways through the flashing.

For the flashing side of the conduit run, secure the conduit within 12" (30.5 cm) of either side (attic side or roof side) of the flashing.

Appendix K: Attach AC Rail Clips

The AC rail clips provide optional additional support for the AC cables. Use them as necessary to help keep all wiring off of the roof surface. Each AC clip can accommodate only a single AC cable, and should be spaced a maximum of 24" (61 cm) apart.

Note: Attaching rail clips is easiest to do *before* you mount the modules.

In addition, *always prevent wires from drooping below the lower edge of the rails*.

1. Place the AC cable into the clip channel, position the clip beneath the rail, and then fit the first lip into the side channel of the rail (Fig. K1).

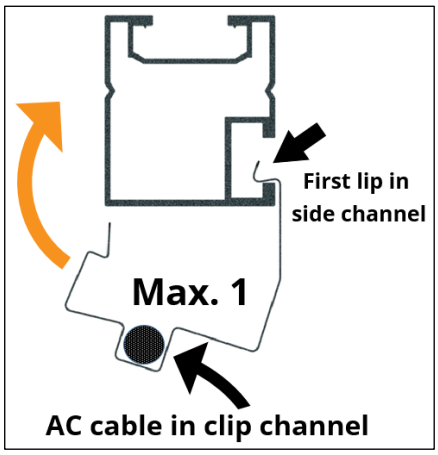


Fig. K1

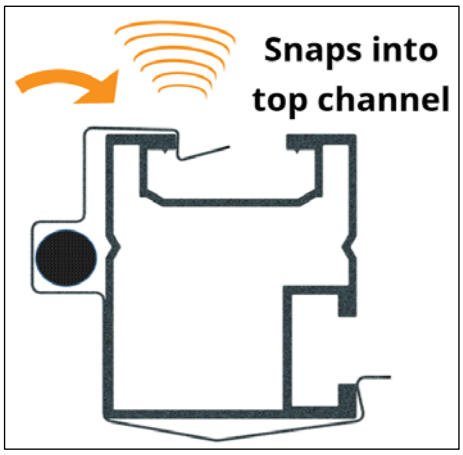


Fig. K2

2. *Holding the cable in position within the clip*, rotate the clip under and around toward the top of the rail, gently pushing the second lip over the top of the rail until it snaps into the top channel of the rail. (You should hear the second lip click into the channel.)

   To remove a clip, simply press down on the *first* lip to release it from the rail (Fig. K3).

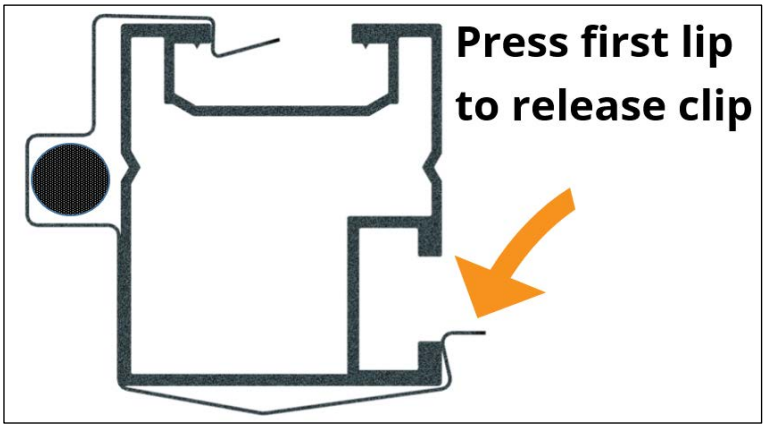


Fig. K3

Appendix L: Technical Notifications

L.1 PVS5x Site Wiring Check Procedure, T16008

SUNPOWER®

Technical Notification

Title : PVS5x Site Wiring Check Procedure, T16008
Date : November 29, 2016
Authors : Pranav Deopurkar, Product Engineer
Application : All Equinox Installations
Scope : All SunPower Residential Dealers

Overview

This document describes how to evaluate a homeowner's existing electrical wiring prior to installing a SunPower PVS5x; or before energizing a SunPower Equinox system after it has received its permit to operate. PVS5x failures due to faulty wiring or improper site conditions are not covered under SunPower warranty.

SunPower testing has revealed that a PVS5x field failure is most likely due to an issue with the electrical bonding between the neutral and ground bus bars at the service entrance. Poor electrical bonding can damage not only the PVS5x but also other electrical and electronic devices that are present, and, more importantly, it is a *safety concern* and as such must be addressed immediately.

PVS5x Required Voltage Values

1. Line 1 to Neutral: 120 VAC nominal. (min. 108 V, max. 128 V)
2. Line 2 to Neutral: 120 VAC nominal. (min. 108 V, max. 128 V)
3. Line 1 to Line 2: Split-phase 240 VAC nominal. (min. 198 V, max. 252 V)*
4. Neutral to Protective Earth (Ground) must always be less than 1 VAC (less than 0.5 is preferred).

Action Required

Before installing the PVS5x and before energizing the Equinox system, SunPower recommends that you measure and verify the following:

1. **With the PVS5x circuit breaker turned OFF,** perform these voltage measurements between the designated connection points:

Measure Between	Nominal Voltage	Minimum	Maximum
L1 and L2 at **grid side** of PVS5x breaker	240 VAC (208 VAC)*	216 VAC (198 VAC)*	252 VAC (219 VAC)*
L1 at **grid side** of PVS5x breaker and PVS5x neutral terminal	120 VAC	108 VAC	128 VAC
L2 at **grid side** of PVS5x breaker and PVS5x neutral terminal	120 VAC	108 VAC	128 VAC
Difference of L1 to Neutral, and L2 to Neutral from above measurements	0 VAC	-	3 VAC
Neutral and ground at **PVS5x terminals**	< 0.5 VAC (max.)	-	0.5 VAC

a) Confirm the measured voltages are within the nominal ranges specified above.
b) Confirm that the L1–Neutral voltage measurement, **plus** the L2–Neutral voltage measurement add up to within 5% of the *total* L1–L2 voltage measurement.*
c) Confirm that the L1–Neutral and L2–Neutral voltage measurements are within 3 volts of each other.

If the voltages are not within the ranges specified above, there is a strong likelihood that there is some issue with the site's electrical wiring. **In such cases, DO NOT turn on the PVS5x circuit breaker!** Instead, troubleshoot the site wiring before proceeding.

2. If and only if all of the voltage measurements specified in Step 1 are in compliance, turn ON the PVS5x circuit breaker.
3. Repeat all of the voltage measurements you took in Step 1, but this time measuring at the PVS5x AC wiring terminals:

Measure Between	Nominal Voltage	Minimum	Maximum
L1 and L2 **at PVS5x Terminals**	240 VAC (208 VAC)*	216 VAC (198 VAC)*	252 VAC (219 VAC)*
L1 and Neutral **at PVS5x terminals**	120 VAC	108 VAC	128 VAC
L2 and Neutral **at PVS5x terminals**	120 VAC	108 VAC	128 VAC
Difference of L1 to Neutral, **and** L2 to Neutral from above measurements	0 VAC	-	3 VAC
Neutral and ground at **PVS5x terminals**	< 0.5 VAC (max.)	-	0.5 VAC

Confirm that each of the measurements are identical to those that you measured in Step 1a–1c.

Important! *If the voltage difference between L1–N and L2–N is greater than 0.5 VAC, inspect and verify that the L1, L2, and N connections from the masthead or utility connection point to the service panel are clean and properly torqued (these conditions minimize connection resistance). If you are not equipped to do so, or if you have any doubts about how to proceed, refer to a licensed electrician proficient in proper torque and connection quality. If the imbalance cannot be corrected, contact the utility and request that the utility inspect the connections at the masthead and the pole. High-resistance neutrals are common and dangerous! DO NOT energize the PVS5x until any imbalances have been corrected.*

*For installations where utility distribution is 120/208 3-phase instead of 120/240 split phase, and where two of those 3-phase Lines along with Neutral are routed to the installation residence, both of the Line-to-Neutral voltages are nominal 120 V. However, the Line-to-Line voltage will be nominal 208 V instead of 240 V.

Result Expected

Verifying voltage requirements and ensuring that there are no site wiring issues before powering up the PVS5x will result in avoiding failure of the PVS5x.

Contacts

Phone		Email	
US & Australia	1-800-SUNPOWER (786-76937)	**US & Australia**	technicalsupport@sunpower.com
Europe	900 808068	**Spain**	soportetecnico@sunpowercorp.com
	0800-1812762	**Germany**	technischersupport@sunpowercorp.com
	800 795 730	**Italy**	serviziotecnico@sunpowercorp.com
	0 805 090 808	**France**	supporttechnique@sunpowercorp.com
	0800 786 35	**Belgium**	SunPowerBenelux.TechnischeDienst@sunpowercorp.com
	0800 023 39 80	**NL**	
	0808 281 8718	**UK**	techsupport.UK@sunpowercorp.com
Rest of the World		**Asia Pacific**	SunPower_TechSupport@sunpower.com

L.2 Installing SunPower AC Modules in High-Noise Environments, T16009

SUNPOWER®

Technical Notification

Title : Installing SunPower AC Modules in High-Noise Environments, T16009
Date : November 29, 2016
Authors : Pranav Deopurkar, Product Engineer
Application : All Equinox® and AC Module Installations
Scope : Installation Instructional Procedure

Overview

In some AC module installations, AC electrical noise can interfere with the ability of microinverters to effectively communicate with PVS5x in order to display AC module energy production for the homeowner. In such installations, a revenue-grade production current transformer (CT) should be installed and configured prior to commissioning to provide an indicator of system AC module energy production.

Background

This document provides the guidelines for installing AC modules in high-noise environments where equipment on the premises causes interference in detection and power line communication between the PVS5x monitoring hardware and the AC modules.
The PVS5x collects system status and performance data from the AC modules using power line communication. **The power line communication signals are exchanged over the same conductors that carry AC power.**

Power line noise is the interference that is caused by the other devices that use the same electrical wiring of a house or building. When the AC modules and PVS5x are both landed in the main service panel (MSP), the most probable reason for either intermittent detection of the AC modules by the PVS5x; or poor or absent communication of AC modules with the PVS5x; is high degrees of power line noise. **SunPower strongly recommends installing a dedicated subpanel for connecting the AC modules and the PVS5x.**

SunPower testing has revealed that variable frequency drive (VFD) pool pumps (as well as other similar devices) produce undesirable power line noise that causes communication issues for the power line communication of SunPower's Equinox system. Not all VFD devices exhibit high noise although some models produce higher noise than others. SunPower is continuing to test and identify various VFD pool pumps.

High-Noise Alerts

The possible scenarios that indicate the presence of high power line noise during system commissioning are:

1. Intermittent monitoring system errors on AC modules
2. Intermittent detection of AC modules
3. Intermittent reporting of AC module energy production

Action Required

When installing SunPower Equinox system (or SunPower AC modules) on sites where there is a VFD pool pump installed (and thus where there is suspicion of intermittent PVS5x detection or of communication of the AC modules with the PVS5x), SunPower recommends that you install a revenue-grade production CT. This step will ensure that the customer has and can view system energy production data in the EnergyLink home portal. Please perform the following steps:

1. At the subpanel to which you routed the PVS5x, install a SunPower revenue-grade production CT (SunPower #516990), which provides a Class 0.5 (0.5%) energy production accuracy.

Fig. 1 SunPower revenue-grade production CT

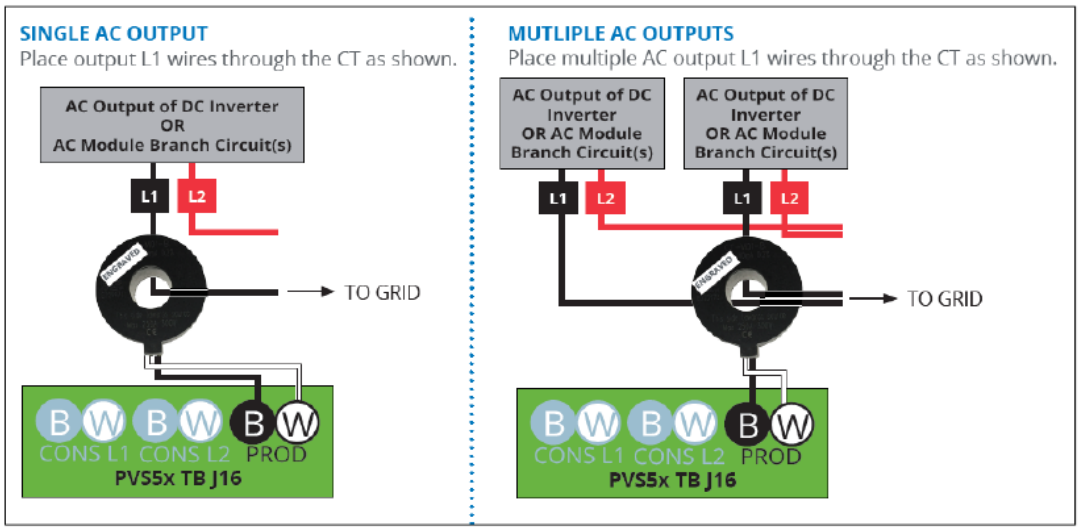


Fig. 2 Installing the CT

2. Turn off the suspected noise source (for example, the VFD pool pump).
3. Commission the system.
4. Turn on the suspected noise source.

Result Expected

- Installing the revenue-grade production CT will provide accurate system energy production information regardless of any noise interference that may be present.
- Commissioning the system with noise source turned off will ensure successful commissioning of the system.

Contacts

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L.3 Grounding SunPower Equinox Systems, T16013

SUNPOWER®

Technical Notification

Title: Grounding SunPower Equinox™ Systems, T16013
Date: February 13, 2017
Authors: Isaac Opalinsky, Technical Sales; Nathan Schweller, Certification Engineer; Benjamin Wong, System Integration Engineer
Application: All SunPower Equinox™ systems

Overview

SunPower® Equinox™ has been designed and engineered to be an integrated system which includes AC modules, mounting hardware, monitoring hardware, and online monitoring services. One key advantage of building an integrated system is a substantial reduction in the number of field-installed and field-assembled components through the use of factory assembled, Listed components.

In this application note, we will discuss one particular aspect of the Equinox system—integrated equipment grounding through the use of Listed Equinox components. Specifically, we will provide:

- An overview of the equipment grounding solution incorporated into each Equinox system
- A discussion of common questions and concerns relevant to the National Electric Code and electrical inspections
- Guidance on interpretation of the relevant Listing materials

By following the guidance in this application note, you will have even more confidence building code-compliant SunPower Equinox systems the way they were designed and engineered, and be fully empowered to educate AHJs and inspectors on the benefits of its Listed grounding solution.

References

- *NFPA 70: 2014 National Electric Code* ("the Code")
  Unless otherwise indicated in the text, all Code references are from the 2014 National Electric Code.
- *NFPA 70: 2017 National Electric Code.*
- *Analysis of Changes, NEC 2017.*

Equinox Integration Features and Design Benefits

SunPower Equinox has been designed and engineered to be an integrated solar power system. Key components include AC modules, AC module extension cables and accessories, InvisiMount™ mounting hardware, and EnergyLink™ monitoring hardware. In the context of this Application Note's discussion about equipment grounding, "integrated" means SunPower AC modules are engineered and Listed to work with SunPower AC module extension cables and InvisiMount mounting hardware.

There are clear benefits to an integrated system for installers and AHJ's, including:

1. Use of components exclusively Listed and identified for the specific purpose
2. All components sourced from a single supplier
3. Factory integration
4. 100% end-of-line factory testing
5. Easier installation, with fewer opportunities for mechanical failure or installation error
6. Fewer specialized skills required for installation
7. Easier inspection phase due to clear installation instructions and fewer opportunities for field modification

All of this adds up to a solution that enables installers and AHJ's to have increased confidence in the quality of installation and the integrity of the ground solution—all while reducing the number of components and installation steps.

There are several aspects to this integration: the frame of SunPower's AC module includes an external flange that is designed to be captured and penetrated by the teeth of the InvisiMount mid clamp. And the AC module cables include just three conductors: two ungrounded conductors and an equipment grounding conductor; unlike the output of most inverters, SunPower AC modules are designed *and Listed* to operate without a neutral.

A key aspect of this integration is equipment grounding. All of the rooftop hardware components are designed to electrically bond the non-current-carrying components of the system to each other. Every component in this electrical bonding system includes features that complete the bond, and which are Listed to perform their function.

The diagram on page 5 summarizes the components of the Equinox system and how they are bonded to each other. The third and fourth columns in the diagram's table reference relevant Code and Listing considerations. Ultimately the system is connected to ground (permanent earth or building ground), so we'll start from there and work our way up to the array components:

1. **Grounding Electrode & Grounding Electrode Conductor (GEC):** For most residential installations, a grounding electrode and GEC is already installed. Most AHJ's require the installer to verify that the grounding electrode is adequate for all services and equipment at the site. Generally, all grounding electrodes must be bonded together and all household equipment must be bonded together, and the equipment and grounding electrodes are connected by a single conductor—the GEC. If the existing grounding electrode and GEC are adequate, no further grounding work by the solar system installer is necessary.

2. **Equipment Grounding Conductor (EGC):** This is a field-installed conductor that must be installed along with the AC module output circuits. Typically it will originate at the grounding busbar or terminal block in the main service panel. It should be routed with the power circuits in the same raceway, conduit, or cable. The conductor should be installed according to NEC 690.43 and sized based on 690.45. For most AC module circuits, this means the EGC will be a minimum of 12 AWG (although it is not uncommon to use 10 AWG).

3. **Rooftop Junction Box to AC Module Extension Cable:** The EGC originating at the service panel must be connected to the EGC originating at the array, and its connection completes the electrical bond between the metallic frames and non-current-carrying hardware on the roof and on the ground. This connection is typically made inside an attic or a rooftop junction box. The Listed SunPower AC module cable (integrated into the module at the factory; as well as the standalone AC extension cables) include a 12 AWG equipment grounding conductor. The installer connects the EGC in the cable to the EGC from the service panel using a Listed device (such as a IDEAL's Buchanan® crimp hardware, or the grounding busbar inside a SolaDeck™ junction box).

4. **AC Module Extension Cable to AC Module Microinverter (MI):** The Listed AC module cable carries the equipment ground to a grounding terminal inside the MI. The AC module extension cables are Listed and specifically identified for use with SunPower AC modules. The MI is a part of the Listed AC module.

5. **MI to AC Module Frame:** The MI is bonded to the module frame in the factory. This is part of the product Listing, and the product is tested for all dead metal parts of the AC module (including the frame and the MI) to be grounded through the ground wire in the AC module extension cable.

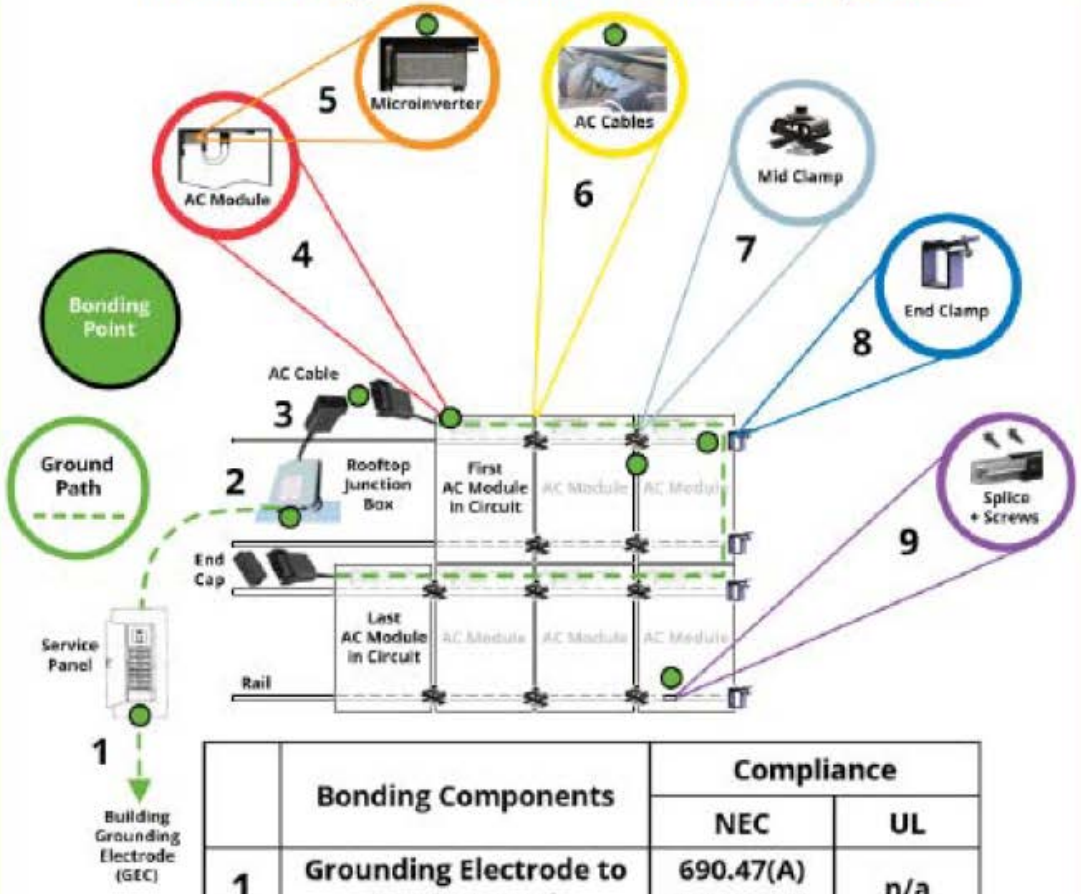
6. **AC Module Cable to AC Module Cable:** The AC module cable not only connects the EGC originating at the service panel to the first AC module—it also carries the equipment ground from module to module. This is not only very helpful because it eliminates the need for any external equipment grounding, it is also required by 690.31(D).

7. **AC Module Frame to InvisiMount Rail Using Mid Clamps:** Adjacent AC modules are mounted to the rail in an Equinox system using InvisiMount mid clamps. These mid clamps are part of the Listed InvisiMount mounting system, and they include teeth which not only secure the module in place, but also bite through the anodized coating on both the external flange of the module frame and rail to create a durable, high-quality electrical bond. InvisiMount rails and mid clamps have been evaluated by UL specifically for bonding the AC module frame to the rail.

8. **AC Module Frame to InvisiMount Rail Using End Clamps:** Non-adjacent modules (such as the last module in a row) are mounted to the rail using InvisiMount end clamps. Like the mid clamps, end clamps have been evaluated for bonding the rail to frame. The end clamp includes two stainless steel pins that penetrate the anodized coating of the module frame and rail to complete the bond.

9. **Rail-to-Rail Splice:** Adjacent sections of InvisiMount rail are connected together using rail splices and splice screws. The InvisiMount splice attaches to the rail by installing the screws into the pre-drilled holes in the splice and the rail ends, thereby both securing and bonding the rail and splice bar to each other. The splice and screws are part of the product Listing and have been evaluated for bonding rail sections together.

SunPower Equinox™ Ground Path and Compliance



	Bonding Components	Compliance	
		NEC	UL
1	Grounding Electrode to Service Panel	690.47(A) 690.47(D)	n/a
2	Service Panel to Rooftop Junction Box	690.43	n/a
3	Rooftop Junction Box to AC Cable	690.43(A)	1741 6703 9703
4	AC Cable to Microinverter	n/a (part of Listing)	1703 1741
5	Microinverter to AC Module Frame	n/a (part of Listing)	1703 1741
6	AC Cable to AC Cable	690.31(D) 690.43(A) 690.43(D)	1741 6703 9703
7	AC Module Frame to Mid Clamp to Rail	690.43(A) 690.43(C) 690.43(D)	2703
8	AC Module Frame to End Clamp to Rail	690.43(A) 690.43(C) 690.43(D)	2703
9	Rail to Splice	690.43(A) 690.43(C) 690.43(D)	2703

The National Electric Code and Equinox

Effectively grounding non-current-carrying metallic components of any electrical installation is critical to ensuring worker and occupant safety, as well as to preventing damage from failure or malfunction. With Equinox, grounding is completed by connecting the integrated components to an equipment grounding conductor that is bonded to the premises grounding electrode. (It is typically only in the case of a ground-mounted system or a home that has an inadequate existing grounding system that additional grounding electrodes or new grounding electrode conductors are required).

But this approach is relatively new and still unfamiliar to many designers, installers, and AHJs, hence commonly asked questions include:

- **Does the Code allow for an integrated grounding system?**
- **Does the Code also require an external grounding system or components in AC module systems?**
- **What are the disadvantages to external grounding components?**
- **Shouldn't SunPower Equinox require an auxiliary grounding electrode and GEC?**

Let's take a closer look at each of these questions.

- **Does the Code allow for an integrated grounding system?**

  Yes, in fact the Code *requires* an integrated grounding system for AC modules.

  SunPower AC modules use type TC-ER cables for connections between AC modules and from the AC modules to the field-installed cables or conductors. This cable includes one black, one red, and one green 12 AWG conductor. The Code specifically allows for TC-ER cables to be used:

  > **690.31(D) Multiconductor Cable.** Multiconductor cable Type TC-ER or Type USE-2 shall be permitted in outdoor locations in PV inverter output circuits where used with utility interactive inverters mounted in locations that are not readily accessible. The cable shall be secured at intervals not exceeding 1.8 m (6'). Equipment grounding for the utilization equipment shall be provided by an equipment grounding conductor within the cable.

  We should also keep in mind that an AC module is effectively an inverter output circuit (690.6(B)), and that rooftop-mounted AC modules are typically not readily accessible, so 690.31(D) requires that equipment grounding for the modules be accomplished by using the equipment grounding conductor within the cable. In this sense, grounding an AC module is very similar to grounding a consumer appliance such as a refrigerator: by plugging the AC module into a circuit having an equipment grounding conductor, the AC module is grounded.

- **Does the Code also require an external grounding system or components in AC module systems?**

  No, for residential rooftop AC system installations there is nothing in the Code that would require the use of external grounding components such as lugs or copper wire.

  This question boils down to this: does the equipment grounding solution integrated into every Equinox system meet the equipment grounding requirements of 690.41 through 690.49?
  We can address each of these provisions in turn:

  - 690.41 does not apply to AC modules. This section applies to the grounding of DC circuits (e.g., positively grounded PV systems). As such, it applies to photovoltaic source circuits or photovoltaic output circuits. Per 690.6, the output of an AC module **is** an inverter output circuit and the requirements of 690 that pertain to photovoltaic source circuits or output circuits do therefore not apply to AC modules.
  - 690.42 does not apply to AC modules for the same reasons 690.41 does not.
  - 690.43 – SunPower Equinox fully complies with the relevant portions of 690.43:
    - 690.43(A) – SunPower Equinox is grounded when installed according to the instructions and connected to an equipment grounding conductor bonded to the premises grounding electrode system.
    - 690.43(B) – SunPower Equinox requires the installation of an equipment grounding conductor between the array and other equipment (typically originating at the rooftop junction box and terminating at the grounding busbar or terminal in the main service panel).
    - 690.43(C) – InvisiMount end clamps and mid clamps are Listed and identified for bonding module frames to rails.
    - 690.43(D) – InvisiMount end clamps and mid clamps are Listed and identified for bonding module frames to rails.
    - 690.43(E) – InvisiMount mid clamps are identified for the purpose of grounding modules.
    - 690.43(F) – The integrated AC module cable and AC module extension cables do include an equipment grounding conductor. Installers shall ensure that field-installed cables or conductors in raceways also contain the equipment grounding conductor along with the other circuit conductors.

- 690.45 – SunPower Equinox meets this requirement by including a 12 AWG equipment grounding conductor. The EGC in every AC module cable is 12 AWG. The maximum overcurrent protection for an AC module circuit is 20 A. The minimum EGC size based on the table at 250.122 is 12 AWG. If multiple circuits are routed with a single EGC for the array, 250.122(C) allows the installer to use 12 AWG for the combined EGC.
- 690.46 does not apply to SunPower Equinox. It modifies 690.45 by requiring a larger conductor when the EGC is not routed with circuit conductors and installed outside of a raceway. But SunPower Equinox does comply with 690.31(D) which requires that the EGC be contained within the cable assembly. 690.46 was inserted into the Code to prevent installers from using small conductors such as 14, 12, or 10 AWG to ground rails in systems having no integrated grounding.
- 690.47(A) does not apply to SunPower Equinox. Installing AC modules constitutes the installation of new "equipment" on an existing AC system. As such, the existing system already has a grounding electrode system, and the only requirement is to connect the new equipment to that system.
- 690.47(B) does not apply to SunPower Equinox. This section pertains only to DC systems in which a photovoltaic source circuit would be either grounded or ungrounded; but 690.6 exempts AC modules from requirements pertaining to photovoltaic source circuits.
- 690.47(C) does not apply to SunPower Equinox for the same reasons that 690.47(A) and 690.47(B) do not apply.
- 690.47(D) does not apply to SunPower Equinox on residential rooftops where there is an existing adequate premises grounding electrode system. This will be discussed in detail later in this App Note, but in most cases (99%), the premises wiring electrode eliminates the need for an additional array grounding electrode (Exception No. 2) and the equipment grounding conductor connected to the grounding busbar or terminal in the main service panel is sufficient for connecting the metallic surfaces of the array to ground.
- 690.48. When an AC module is removed from a SunPower Equinox system, it interrupts the circuit and equipment grounding connection between modules. This can leave the equipment ungrounded if it is not returned to service. Upon a module's removal, the modules downstream of the removed module are reconnected using an AC module extension cable to bridge the gap, which reestablishes the equipment grounding connection.
- 690.49 does not apply to SunPower Equinox because it refers to photovoltaic source and output circuit grounded conductors.
- 690.50 does not apply to SunPower Equinox because equipment bonding jumpers are not used.

Returning to the original question, "Does the Code require any **external** grounding for SunPower Equinox?" we can see that when installed in accordance with the manufacturer's instructions, other than a properly sized and installed EGC originating at the array junction box and terminating at the main service panel, no additional grounding components are required.

- **What are the disadvantages to external grounding components?**

  Yes, external grounding components are subject to damage and corrosion, must be properly installed (sometimes using specialized tools and components), and must be properly specified including verifying the proper size, type, identification, and Listing. All of this adds up to opportunities for the external grounding components to be less effective than integrated grounding components.

  With SunPower Equinox, the EGC is sized appropriately; protected by the cable sheath and insulation; 100% end-of-line factory tested; and part of the product Listing. Metallic hardware in the system is bonded using components Listed and identified to work together and requires no specialized skills or tools to complete either mechanical or bonding connections. Completing grounding connections is as simple as tightening a mounting bolt or connecting a plug to a receptacle.

  With external grounding components, the AHJ must verify that the EGC is sized appropriately, and that it's upsized when installed separately from circuit conductors on the rooftop. EGCs must be connected to lugs that are Listed and identified for the purpose and suitable for the environment. Set screws or terminations must be installed correctly and tightened properly. Exposed copper must be isolated from other metals. This adds up to numerous opportunities for failure that in addition are difficult to detect or inspect. And even if the installation is completed properly, there is ample evidence that exposed ground lugs and exposed copper wire may not provide effective equipment grounding for the life of the system in some environments.

  In short, exposed copper and external ground lugs are not more effective than the SunPower Equinox internal grounding system—hence all of its achieved Listings and certifications.

- **Shouldn't SunPower Equinox require an auxiliary grounding electrode and GEC?**

  Because 690.47(D) does not apply to SunPower Equinox on residential rooftops where there is an existing adequate premises grounding electrode system, this simply leaves the question of how to connect the array to the premises wiring electrode.

  This section has been the subject of much controversy and misunderstanding in recent years, but the intention of this section is simply stated:

  > *The array must be connected to a grounding electrode located at the structure that supports the array.*

For a ground-mounted array, this might require the installation of new grounding electrodes unless the ground structure meets the requirements of 250.52. But the vast majority of residential rooftop arrays can use the existing premises wiring electrode. So how do we interpret the phrase, "*as close as practicable to the location of roof-mounted PV arrays*"? This phrase would simply apply to a structure that does not have an existing grounding electrode (such as a shed or barn).

The fact that a new grounding electrode and an associated grounding electrode conductor are not required for a residential rooftop array with an adequate premises grounding electrode system is illustrated in two ways:

The new 690.47(A) clarifies the requirements for a structure to have a grounding electrode. 690.47(B) makes a grounding electrode and grounding electrode conductor optional, but not mandatory:

> 690.47(B) Additional Auxiliary Electrodes for Array Grounding. Grounding electrodes shall be permitted to be installed in accordance with 250.52 and 250.54 at the location of ground- and roof-mounted PV arrays. The electrodes shall be permitted to be connected directly to the array frame(s) or structure. The grounding electrode conductor shall be sized according to 250.66. The structure of a ground-mounted PV array shall be permitted to be considered a grounding electrode if it meets the requirements of 250.52. Roof mounted PV arrays shall be permitted to use the metal frame of a building or structure if the requirements of 250.52(A)(2) are met.

The intention of the 2014 Code and the explicit changes to the 2017 Code are further illustrated by IAEI's *Analysis of Changes, NEC 2017* (emphasis added):

> ...The provisions of 690.47(D) [now 690.47(B)] pertaining to additional auxiliary electrodes for PV array grounding have been ***revised to clarify that auxiliary electrodes are permitted but not required***. For most PV systems installed on a rooftop, the large quantity of conductive metal increases the likelihood of a lightning strike. An auxiliary grounding electrode system would help to minimize the effects of such a lightning strike. The primary purpose of an auxiliary grounding electrode is to maintain the frames of the PV array to as close to local earth voltage potential as possible. ***This potential can also be achieved through a properly installed equipment grounding conductor back to an established grounding electrode system for the building or structure.*** As indicated by the language of 250.54 for auxiliary grounding electrodes, the ***additional grounding electrodes are permitted to be installed but are never a requirement*** as implied by the previous language at 690.47(D) and in the 2014 NEC.

Note in particular the language that states the intention of an auxiliary grounding electrode can be achieved through a properly installed EGC back to the premises grounding electrode. SunPower Equinox meets this intention for rooftop arrays by using the integrated grounding system along with a properly sized and installed EGC.

Use and Interpretation of Listing Materials

In numerous locations, the Code requires that PV equipment be Listed and identified for the use. In this context, "Listed" and "identified" have the same meanings in the Code. SunPower Equinox components have been Listed by UL, and have been specifically tested and are recognized by UL to perform certain functions identified in the Listing reports.

Additionally, the Code requires that Listed equipment be installed and used in accordance with instructions included in the Listing or labeling. This means that SunPower Equinox must be installed in accordance with the *AC Module Safety and Installation Instructions*, and the *SunPower Equinox Installation Guide*. Each of these documents includes instructions that are part of the Listing.

The following is a list of key Listing documents and some notes on their interpretation with regard to grounding SunPower Equinox:

- Certificate of Compliance – AC Modules. This is the proof of Listing for AC modules to UL 1741. The SunPower AC module product includes a Listed PV Module (UL 1703) and a Listed Microinverter (UL 1741), integrated at the factory. The Listing Report includes evaluation of the bond between the MI and AC module frame and states the requirement that AC modules shall be grounded using the integrated equipment grounding conductor. It identifies SunPower AC module extension cables as being the sole acceptable wiring between modules.

- Certificate of Compliance – SunPower Microinverter. This is the proof of Listing for the SunPower microinverter incorporated in the AC module to UL 1741. While technically a subcomponent of the Listed AC module, this is provided as evidence of the evaluation of the bond between the AC module cable and MI chassis and states the requirement that the MI shall be grounded using the integrated equipment grounding conductor. It identifies SunPower AC module extension cables as being the sole acceptable wiring between modules.

- Certificate of Compliance – AC Module Cables. This is the proof of Listing for AC module cables to UL 9703 – Standard for Distributed Generation Wiring Harnesses. This listing is for the models identified in the AC module and MI Listings. It specifies the internal wiring of the AC module extension cable and includes evaluation of the grounding connection.

- Certificate of Compliance – InvisiMount. This is the proof of Listing for InvisiMount to UL 2703, including evaluation for structural integrity, grounding, and fire classification. The Listing Report includes evaluation of the bond between SunPower G5 module frames (the frames used on SunPower AC modules) and InvisiMount rails using mid clamps and end clamps; between L-feet and the rails; and between adjacent rail sections using the InvisiMount splice.

- Certificate of Compliance – PV Module. This is the proof of Listing for the SunPower PV modules that are incorporated into the AC module to UL 1703. This includes identification of InvisiMount as an acceptable means of grounding and bonding.
- *SunPower AC Module Safety and Installation Instructions.* These instructions are part of the Listing for AC modules. In Section 4.1 they state that SunPower AC modules shall be grounded using the integrated grounding and that no external or additional connection to the AC module is required. It further states that grounding of mounting rails and other components is achieved through the proper installation of InvisiMount.
- *SunPower Equinox Installation Guide.* These instructions are part of the Listing for InvisiMount and for SunPower AC modules. In Section 4 there's a detailed description of the integrated equipment grounding solution and installation instructions for InvisiMount components required to complete the grounding connection.

Summary

SunPower Equinox includes an integrated equipment grounding solution that is easy to install and easy to verify. Equinox offers substantial benefits over external equipment grounding solutions. Integrated grounding for AC modules is not only a benefit for installers (it is easier and faster to install), and AHJs (it is easier to inspect and verify proper installation)—it is required by the Code.

The integrated grounding solution incorporated into SunPower Equinox is 100% end-of-line tested and Listed by UL. This consolidated information in this App Note will satisfy even the most diligent and pickiest of AHJs.

Please direct any questions on this topic to Technical Support, your RSM, or Technical Sales.

Contacts

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L.4 Rapid Shutdown Compliance for SunPower Equinox Type C AC Modules, T17002

SUNPOWER®

Technical Notification

Title : Rapid Shutdown Compliance for SunPower Equinox™ Type C AC Modules, T17002

Author : Nathan Schweller, Certification Engineer

Date : February 7, 2017

Application : SunPower UL Listed Type C AC Modules

Overview

The Listing requirement addressed in this technical notification applies only to the 2017 National Electrical Code (NEC), which contains the following new language in 690.12:

> *(D) Equipment. Equipment that performs the rapid shutdown functions, other than initiation devices such as listed disconnect switches, circuit breakers, or control switches, shall be listed for providing rapid shutdown protection.*

Controlled conductors for the purpose of rapid shutdown in the NEC apply to both DC and AC conductors outside the array boundary. The direct current (DC) component of an AC module is considered internal wiring per NEC 690.6(A), and the output of an AC module is considered an inverter output current per NEC 690.6(B). This means that the rapid shutdown function of the AC module shuts down the array as well as the conductors leaving the array.

As of November 12, 2016, all SunPower Type **C** AC modules have been UL certified for rapid shutdown, as required under NEC 690.12(D).

This UL certification applies specifically to the following UL 1741 compliant SunPower AC modules, any of which can be part of a SunPower Equinox™ system:

- SPR-E19-320-**C**-AC
- SPR-E20-327-**C**-AC
- SPR-X20-327-**C**-AC
- SPR-X20-327-BLK-**C**-AC
- SPR-X21-335-BLK-**C**-AC
- SPR-X21-345-**C**-AC
- SPR-X21-335-**C**-AC
- SPR-X22-360-**C**-AC

The UL Listing for rapid shutdown applies to SunPower microinverters with the model *MI-C-320-US208/240-XX* (where XX=00 or higher). This microinverter is factory integrated into the Listed AC modules shown above. A close read of the Certificate of Compliance shows that the controlled conductors evaluated for rapid shutdown are the L1 and L2 AC output conductors and that actuation is provided by opening an AC disconnect or circuit breaker in the circuit. This is consistent with the above modules being Listed as AC modules.

In jurisdictions where rapid shutdown is required, use SunPower AC modules and provide the relevant Listing information to your AHJ. The AC module is Listed for rapid shutdown, and actuation is achieved by opening an AC disconnect or circuit breaker. Turning the AC disconnect or breaker off will deenergize circuits both within the array as well as conductors leaving the array. Ensure that the breaker or AC disconnect is labeled in accordance with 690.56(C)(1)(a).

Please find on the next two pages the full microinverter Certificate of Compliance from UL:

CERTIFICATE OF COMPLIANCE

Certificate Number	20161112-E479127
Report Reference	E479127-20150916
Issue Date	2016-NOVEMBER-12
Issued to:	SUNPOWER CORP 77 RIO ROBLES SAN JOSE CA 95134-1859
This is to certify that representative samples of	COMPONENT - STATIC INVERTERS AND CONVERTERS FOR USE IN INDEPENDENT POWER SYSTEMS; COMPONENT - PHOTOVOLTAIC RAPID SHUTDOWN SYSTEM EQUIPMENT See Addendum Page
	Have been investigated by UL in accordance with the Standard(s) indicated on this Certificate.
Standard(s) for Safety:	See Addendum Page
Additional Information:	See the UL Online Certifications Directory at www.ul.com/database for additional information

Only those products bearing the UL Certification Mark should be considered as being covered by UL's Certification and Follow-Up Service.

The UL Recognized Component Mark generally consists of the manufacturer's identification and catalog number, model number or other product designation as specified under "Marking" for the particular Recognition as published in the appropriate UL Directory. As a supplementary means of identifying products that have been produced under UL's Component Recognition Program, UL's Recognized Component Mark: ᴿᵁᴸ, may be used in conjunction with the required Recognized Marks. The Recognized Component Mark is required when specified in the UL Directory preceding the recognitions or under "Markings" for the individual recognitions.

Recognized components are incomplete in certain constructional features or restricted in performance capabilities and are intended for use as components of complete equipment submitted for investigation rather than for direct separate installation in the field. The final acceptance of the component is dependent upon its installation and use in complete equipment submitted to UL LLC.

Look for the UL Certification Mark on the product.

Bruce Mahrenholz, Director North American Certification Program

UL LLC

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CERTIFICATE OF COMPLIANCE

Certificate Number	20161112-E479127
Report Reference	E479127-20150916
Issue Date	2016-NOVEMBER-12

This is to certify that representative samples of the product as specified on this certificate were tested according to the current UL requirements.

Permanently-Connected, Utility Interactive, Split Phase Micro-Inverter, Model MI-C-320-US208/240-XX Where "XX" is one of the allowed options in the nomenclature section below inverter is intended for DC input from a single photovoltaic module

The inverter is provided with transformer isolation between input and output.

The inverter is also evaluated as PV Rapid Shutdown equipment with Line 1 and Line 2 AC output conductors evaluated as the controlled conductors. Actuation is provided by opening the AC conductors by a breaker or other disconnect device

UL 1741 Inverters, Converters, Controllers and Interconnection System Equipment for use with Distributed Energy Resources

UL 1741 CRD for Photovoltaic Rapid Shutdown Equipment

CSA 22.2 No. 107.1-1, General Use Power Supplies

Bruce Mahrenholz, Director North American Certification Program

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	0 805 090 808	**France**	supporttechnique@sunpowercorp.com
	0800 786 35	**Belgium**	SunPowerBenelux.TechnischeDienst@sunpowercorp.com
	0800 023 39 80	**NL**	
	0808 281 8718	**UK**	techsupport.UK@sunpowercorp.com
Rest of the World		SunPower_TechSupport@sunpower.com	

L.5 Field Verification of Type C AC Module IEEE 1547 Utility Interactive Trip and Reconnect Functions, T16012

SUNPOWER®

Technical Notification

Title : Field Verification of Type C AC Module IEEE 1547 Utility Interactive Trip and Reconnect Functions, T16012

Date : December 09, 2016

Author : Steve Wurmlinger, Senior Regulatory Engineer

Application : SunPower UL Listed Type C AC Modules rated IEEE 1547 Utility Interactive

Definitions

AC module is off ("Off"). The AC module is not producing power. If the AC electrical supply is removed (if the AC breaker that's connected to the array is opened), the voltage and current at the output of the AC modules will be zero. If the AC electrical supply is connected, there will be voltage from the grid and some measureable current due to capacitors internal to the AC modules (refer to table at the end of Overview).

AC module is on ("On"). The module is connected to the grid and producing power. Both the AC electrical supply voltage and the current from the AC module output can be measured. (The amount of current will depend on the amount of sun.)

Tools and Materials

- Clamp-on ammeter that can measure both AC current and DC current
- Multimeter
- Stopwatch (timer)

Overview

This technical notification describes two microinverter (MI) functionality verifications per IEEE 1547 that must be performed in the field on installed systems as part of the commissioning of the system:

- **Trip.** AC module outputs stop producing power (turn off) when the AC electrical supply is removed (when the AC breaker connected to the array is opened).
- **Reconnect.** AC module outputs do not start producing power (turn back on) any sooner than 5 minutes after the breaker is closed (connected to the correct AC voltage and frequency; refer to the AC module's ratings and documentation for correct operating voltage ranges).

SunPower AC modules germane to this technical notification have a built-in SunPower microinverter (MI), model *MI-C-320-US208/240-xx,* that has been evaluated by UL to UL 1741, including IEEE 1547 requirements for a utility-interactive inverter.

Utility-interactive inverters (such as the SunPower MI) shut down automatically when the AC electrical supply to which they are connected goes outside the upper or lower limit specified in IEEE 1547. After such an occurrence and the accompanying automatic microinverter shutdown, a minimum of 5 minutes must elapse before the inverter begins producing power again (in order to allow the electrical supply voltage and frequency to return to defined values).

The SunPower MI design has undergone rigorous testing by UL to verify compliance with the protective functions required by IEEE 1547. SunPower also performs a production check in the factory on each MI in order to verify that the trip functions are operational within the stated accuracy. In addition, UL performs quarterly inspections to ensure compliance with this verification step.

Microinverter model *MI-C-320-US208/240-xx* tare vs. reactive values, where modules are Off but are connected to an AC electrical supply:

	Power	Current
Tare (real power)*	0.07 W	0.292 mA
Reactive Power (VARs) VA (volt-amps)**	35 VA	0.146 A

*Measured by UL as part of the CEC Efficiency testing.

**Calculated value based on output capacitance and 240 VAC. Field-measured values are typically ±20%, depending on the equipment used and associated voltage.

Step A: Assess Reactive Current

Warning! This procedure requires accessing the AC wiring from the array at the AC breaker panel and being exposed to wiring with hazardous voltages.

Determine the amount of reactive current draw for the system when connected to an AC electrical supply (branch circuit breaker closed) but with all AC modules Off.

The following procedure must be performed only by qualified and trained personnel:

1. Open the AC module system circuit breaker. Verify that the voltage is zero volts on the load side (the AC module side).
2. Verify that the voltage on the line side is nominal 240 VAC phase to phase.
3. Attach the clamp-on ammeter to one of the phases between the system circuit breaker and the AC modules output.
4. Verify that the current value is zero.
5. Leave the ammeter clamped on and close the circuit breaker.
6. Monitor the current for 30 seconds and record the steady state value. Leave the ammeter clamped on, continue to monitor the current, and proceed to Step B.

Step B: Assess Sunlight Conditions

Verify that there is sufficient sunlight to perform the testing and that all AC modules are operating:

1. Wait 5 minutes. With the circuit breaker still closed and the ammeter still clamped on, the AC modules should all turn on. (The PVS5x can also be used to verify that all modules are operating if there is any question in the level of power output.)

2. Measure and record the On (operating) current with the ammeter to ensure that the existing sunlight level is producing a measurable current.

   The recommended minimum threshold for a successful test is 30% of rated system output current; therefore, because module output power is 1.33 A per module, if the system contains 10 modules its output would be 13.30 A, and the recommended minimum for a successful test would be 13.30 × 0.30 or approximately 4 A.

   If performing this test at lower current levels, verify that the ammeter accuracy is sufficient to observe change in currents with just a single AC module operating—at the minimum 30% of rated output, this value could be as low as 0.4 amps per module. Leave the ammeter attached and proceed to Step C.

Step C: Verify Trip

1. With the ammeter still measuring On current, attach the multimeter to the load side of the circuit breaker and record the voltage.
2. Open the circuit breaker and verify that the voltage of the AC module output went to and stayed at zero, and that the current is also at zero. (Approximate time will be 0.16 seconds for the AC module to turn Off; for its output to stop producing power). Record the results.
3. Leave the circuit breaker open and proceed to Step D.

Step D: Verify Reconnect

Ensure that the voltage on the line side of the circuit breaker is still a nominal 240 VAC.

1. With the ammeter still connected, simultaneously close the circuit breaker (to connect the 240 VAC nominal AC supply voltage to the AC module output) and immediately start the timer.
2. Monitor the current during a 5-minute window to ensure that the value is the same as you recorded in Step A.
3. When the current *increases by more than 0.4 amps*, stop the timer and record the time.

The following table can be used to record results if the associated utility does not have a specific form for these measurements:

Branch Circuit	# of MIs (AC modules)	Operational Current (Step B)	Shutdown Immediately with 0 Amps? (Step C)	Calculated Reactive Current per circuit @ 240 V (# of MIs × reactive current per MI)	Time AC Disconnect closed (hh:mm:ss) (Step D)	Measured Reactive Current (Step A)	Time System Reconnected (Step D)	Time Delta (hh:mm:ss) (Step D)	Operational Current (Step D)
1			Y N						
2			Y N						
3			Y N						
n...			Y N						

L.6 InvisiMount™ and Equinox™ Rail-Mounted J-Box and Rooftop Transition Flashing Specifications, T17003

SUNPOWER®

Technical Notification

Title : InvisiMount™ and Equinox™ Rail-Mounted J-Box and Rooftop Transition Flashing Specifications, T17003
Date : May 19, 2017
Author : Kyle Feldman, Mechanical Product Designer
Application : SunPower Equinox and InvisiMount Installations

Overview

Based on your feedback we've made two new accessories available for Equinox and InvisiMount installations:

- Rail-Mounted J-Box
- Rooftop Transition Flashing

This notification provides the material specifications for each of these two accessories.

For complete installation instructions see the *Equinox Installation Guide 518101 RevC.*

Rail-Mounted J-Box

The rail-mounted J-box snaps securely onto the InvisiMount rail.

Element	Specification
Bracket	5000 series aluminum
Finish	powder coated
Cable glands	1/2" trade size (two included)
Material	PVC
Trade size	5 × 5 × 2″
Volume	639.1 cm^3 (39 in^3)
Rating	NEMA 4X
Lid fastener type	flathead or #2 square drive
Drainage	field-made weep hole, min. 1/8"; max. 1/4"

Rooftop Transition Flashing

The rooftop transition flashing provides a low-cost, low-profile transition, easily fitting under the array.

Element	Specification
Material	1000 series aluminum
Finish	powder coated
Dimensions	30.5 × 30.5 × 5.1 cm (12 × 12 × 2 in.)
Hole sizes (field made)	max. knockout size: 1 1/8" (max. conduit trade size 3/4")
	max. roof opening: 2"
Markings	• drill points: three pre-marked • shingle cut-in guides: six pre-marked
Compatible Roof Materials	• three-tab composition shingle • architectural composition shingle
Fasteners and Sealant (not included)	• two sheet metal screws (#9-15 1-1/2") OR • two roofing nails (#12 ring shank 1-1/4") AND • 100% Silicone roof sealant

Contacts

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L.7 Update Chrome Version for PVS Management App Commissioning, T16010

SUNPOWER®

Technical Notification

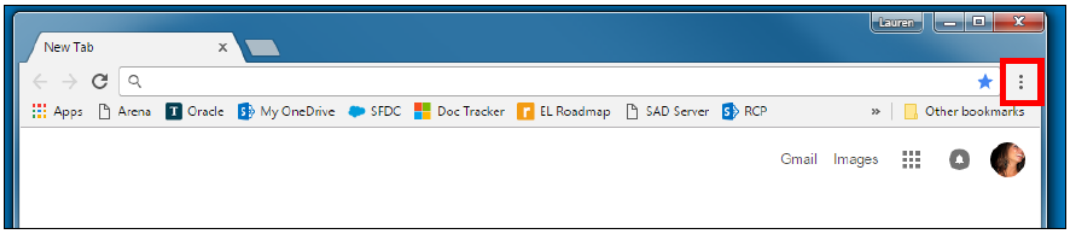
Title : Update Chrome Version for PVS Management App Commissioning (T16010)
Authors : Sally Derrick (EnergyLink Product Owner), Lauren Stauss (Technical Writer)
Date : November 16th, 2016
Application : SMS Commissioning & Monitoring Process
Scope : All PVS5 Installations and Systems with PVS5

Overview

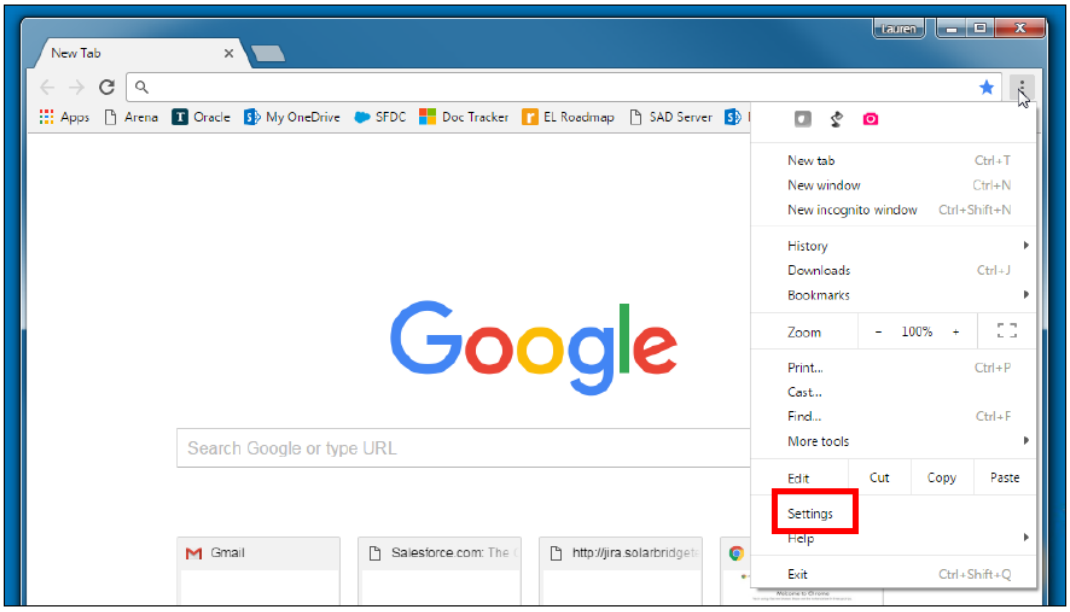
Outdated version of the Google Chrome browser may cause errors when using the PVS Management App to commission a PVS5. If you use Chrome to access the PVS Management App for commissioning, you must check for, and apply, any Google Chrome updates to ensure that you are not using a faulty version.

Check for, and apply, Google Chrome updates

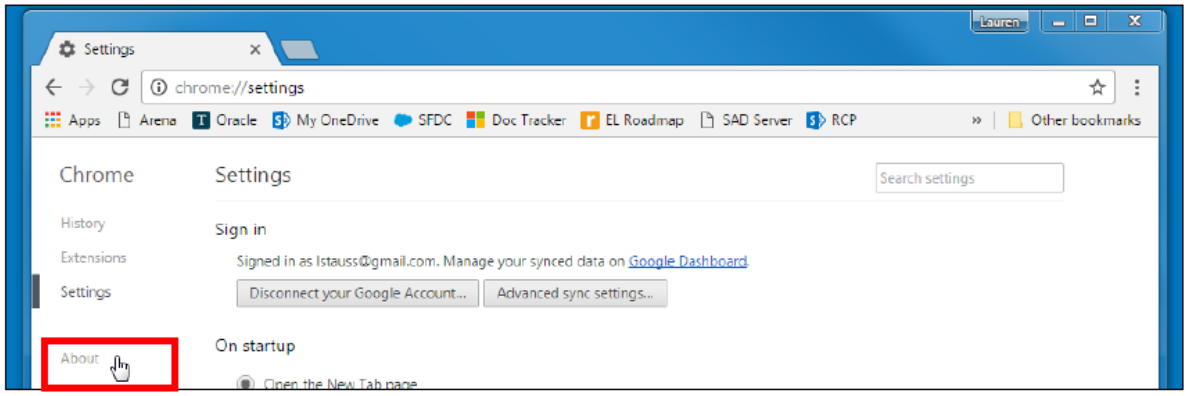
1. Before you go onsite, open a Chrome browser on your computer.
2. Click the **menu icon** in the upper right (three vertical dots).



3. Click **Settings**.



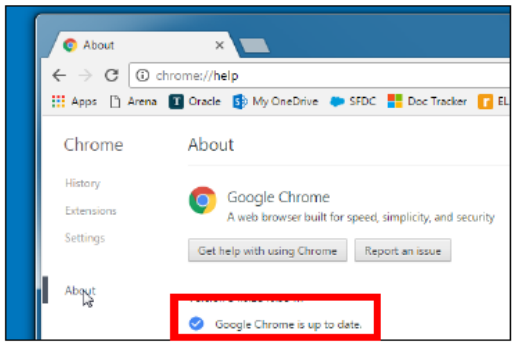
4. Click **About**.



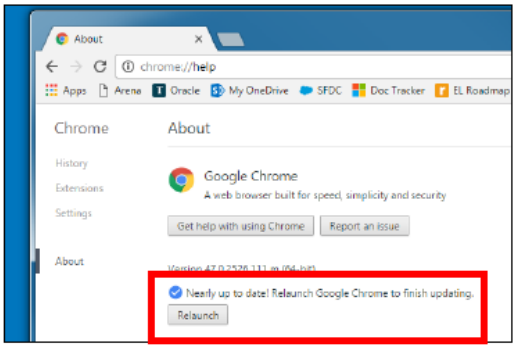
5. Google Chrome automatically searches for updates for your browser.

6. Google Chrome automatically applies updates. If you are prompted to finish updating, click **Relaunch**.

Google Chrome is up to date:



Relaunch required to update:



Action Required

You must update your Google Chrome browser in order to successfully use the PVS Management App for commissioning.

Result Expected

Updating your Google Chrome browser prevents errors in the PVS Management App due to a faulty browser version.

Contacts

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	0808 281 8718	**UK**	techsupport.UK@sunpowercorp.com
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L.8 Field Verification of Type D AC Module Trip and Reconnect Functions, T17006

SUNPOWER®

Technical Notification

Title : Field Verification of Type D AC Module Trip and Reconnect Functions, T17006

Date : July 07, 2017

Author : Greg Kern, Principal Power Electronics Engineer

Application : SunPower UL Listed Type D AC Modules

Definitions

AC module is off ("Off"). The AC module is not producing power. If the AC electrical supply is removed (if the AC breaker that's connected to the array is opened), the voltage and current at the output of the AC modules will be zero. If the AC electrical supply is connected, there will be voltage from the grid and some measurable current due to capacitors internal to the AC modules (refer to the table at the end of the Overview section).

AC module is on ("On"). The module is connected to the grid and producing power. Both the AC electrical supply voltage and the current from the AC module output can be measured. (The amount of current will depend on the amount of sun.)

Tools and Materials

Clamp-on ammeter that can measure both AC current and DC current; multimeter; stopwatch (timer).

Overview

This technical notification describes two microinverter (MI) functionality verifications that must be performed in the field on installed systems as part of the commissioning of the system:

- **Trip.** AC module outputs stop producing power (turn off) when the AC electrical supply is removed (when the AC breaker connected to the array is opened).
- **Reconnect.** AC module outputs do not begin producing power (turn back on) any sooner than 5 minutes after the breaker is closed (connected to the correct AC voltage and frequency; refer to the AC module's ratings and documentation for correct operating voltage ranges). For CA Rule 21, AC modules do not turn back on any sooner than 15 seconds.

SunPower AC modules germane to this technical notification have a built-in SunPower microinverter (MI), model *MI-C-320-US208/240-xx,* that has been evaluated by UL to UL 1741 SA.

A grid support utility interactive inverter (such as the SunPower MI) shuts down automatically when the AC electrical supply to which it is connected goes outside the upper or lower limit specified. After such an occurrence and the accompanying automatic microinverter shutdown, a minimum of 5 minutes must elapse before the microinverter begins producing power again (in order to allow the electrical supply voltage and frequency to return to defined values). For CA Rule 21, the minimum elapsed time is 15 seconds.

The SunPower MI design has undergone rigorous testing by UL to verify compliance with the protective functions required by UL 1741 SA. SunPower also performs a production check in the factory on each MI in order to verify that the trip functions are operational within the stated accuracy. In addition, UL performs quarterly inspections to ensure compliance with this verification step.

Microinverter model *MI-C-320-US208/240-xx* tare vs. reactive values, where modules are Off but are connected to an AC electrical supply:

Tare		Power	Current
Tare (real power)*		0.1 W	n/a
Reactive Power (VARs) VA (volt-amps)**	@240 V	35 VA	0.146 A
	@208 V	31 VA	0.128 A

*Measured by UL as part of the CEC Efficiency testing.

**Calculated value based on output capacitance and 240 VAC. Field-measured values are typically ±20%, depending on the equipment used and associated voltage.

Step A: Assess Reactive Current

Warning! This procedure requires accessing the AC wiring from the array at the AC breaker panel and being exposed to wiring with hazardous voltages.

Determine the amount of reactive current draw for the system when connected to an AC electrical supply (branch circuit breaker closed) but with all AC modules Off.

The following procedure must be performed only by qualified and trained personnel:

1. Open the AC module system circuit breaker. Verify that the voltage is zero volts on the load side (the AC module side).
2. Verify that the voltage on the line side is nominal 240 VAC phase to phase.
3. Attach the clamp-on ammeter to one of the phases between the system circuit breaker and the AC modules output.
4. Verify that the current value is zero.
5. Leave the ammeter clamped on and close the circuit breaker.
6. Monitor the current for 10 seconds and record the steady state value. Leave the ammeter clamped on, continue to monitor the current, and proceed to Step B.

Step B: Assess Sunlight Conditions

Verify that there is sufficient sunlight to perform the testing and that all AC modules are operating:

1. Wait 5 minutes (or 15 seconds for CA Rule 21). With the circuit breaker still closed and the ammeter still clamped on, the AC modules should all turn on. (The PVS5x can also be used to verify that all modules are operating if there is any question in the level of power output.)
2. Measure and record the On (operating) current with the ammeter to ensure that the existing sunlight level is producing a measurable current.

The recommended minimum threshold for a successful test is 30% of rated system output current; therefore, because module output power is 1.33 A per module, if the system contains 10 modules its output would be 13.30 A, and the recommended minimum for a successful test would be 13.30 × 0.30 or approximately 4 A.

If performing this test at lower current levels, verify that the ammeter accuracy is sufficient to observe change in currents with just a single AC module operating—at the minimum 30% of rated output, this value could be as low as 0.4 amps per module. Leave the ammeter attached and proceed to Step C.

Step C: Verify Trip

1. With the ammeter still measuring On current, attach the multimeter to the load side of the circuit breaker and record the voltage.
2. Open the circuit breaker and verify that the voltage of the AC module output went to and stayed at zero, and that the current is also at zero. (Approximate time will be 0.16 seconds for the AC module to turn Off; for its output to stop producing power). Record the results.
3. Leave the circuit breaker open and proceed to Step D.

Step D: Verify Reconnect

Ensure that the voltage on the line side of the circuit breaker is still a nominal 240 VAC.

1. With the ammeter still connected, simultaneously close the circuit breaker (to connect the 240 VAC nominal AC supply voltage to the AC module output) and immediately start the timer.
2. Monitor the current during a 5-minute window (or 15-second window for CA Rule 21) to ensure that the value is the same as you recorded in Step A.
3. When the current *increases by more than 0.4 amps*, stop the timer and record the time.

The following table can be used to record results if the associated utility does not have a specific form for these measurements:

Branch Circuit	# of MIs (AC modules)	Operational Current (Step B)	Shutdown Immediately with 0 Amps? (Step C)	Calculated Reactive Current per circuit @ 240 V (# of MIs × reactive current per MI)	Time AC Disconnect closed (hh:mm:ss) (Step D)	Measured Reactive Current (Step A)	Time System Reconnected (Step D)	Time Delta (hh:mm:ss) (Step D)	Operational Current (Step D)
1			Y N						
2			Y N						
3			Y N						
n...			Y N						

L.9 Using the PVS5 Management App to Set and Verify the California CPUC Rule 21 Grid Profile on Type D AC Modules, T17006

SUNPOWER®

Technical Notification

Title : Using the PVS5 Management App to Set and Verify the California CPUC Rule 21 Grid Profile on Type D AC Modules, T17006

Date : August 31, 2017

Author : Dylan Benjamin, Residential Systems Senior Integration Manager

Application: SunPower Type D AC Modules requiring CA Rule 21 grid profile settings

Overview

This technical notification describes the steps necessary to set and verify the California Rule 21 grid profile when commissioning SunPower Type D AC module systems with the SunPower PVS Management App.

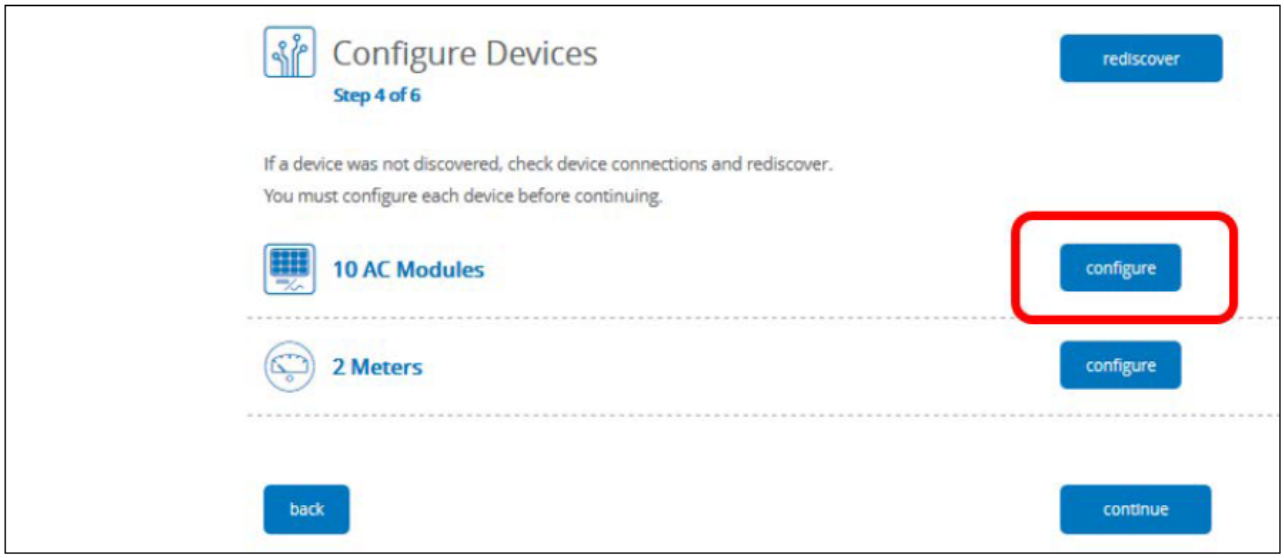
SunPower's new Type D AC Modules are UL tested and certified to UL 1741 SA and have the capacity to provide advanced smart inverter functions. SunPower Type D AC Modules are compliant with California Rule 21 Phase 1 requirements, and the Rule 21 grid profile is easily set during system commissioning with SunPower PVS5x monitoring hardware.

Summary of Steps

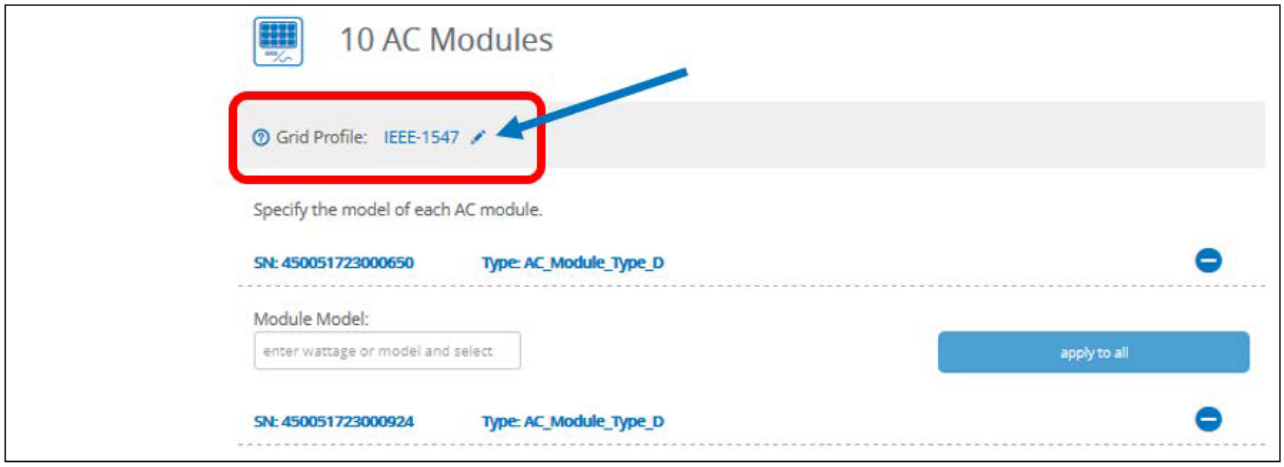
1. Install the PVS5x.
2. Commission the PVS5x through Step 3.
3. Select the grid profile in Step 4 (using the installation site zip code as the password).
4. Verify the grid in Step 5 or with the Management App.

Set Grid Profile

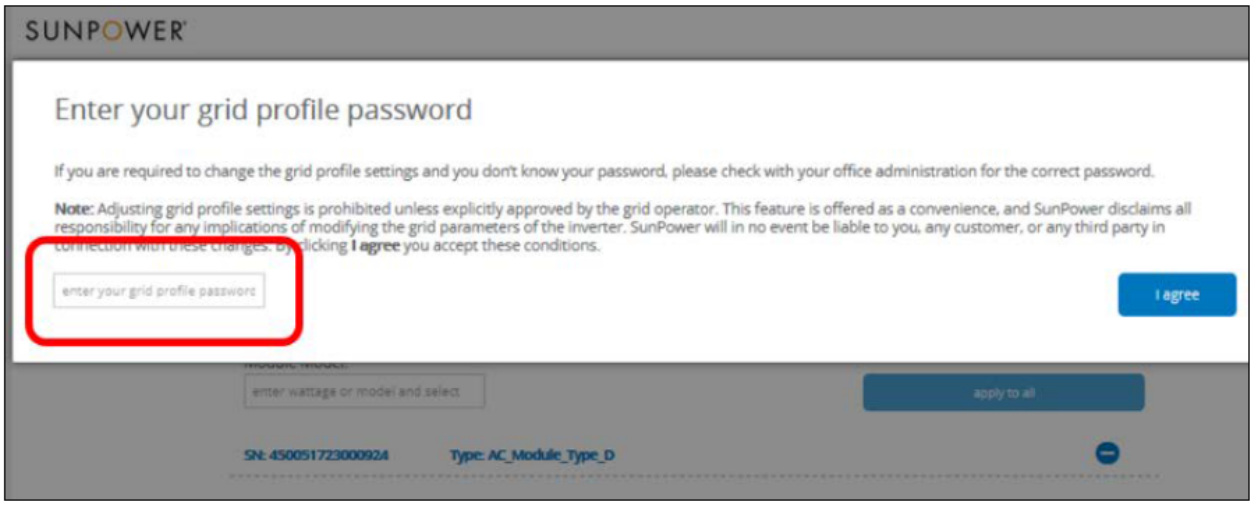
1. Complete Steps 1–3 in the PVS Management App as you normally would (set up communication; check firmware version; and discover devices).
2. When you get to Step 4, in the **AC Modules** row click the **configure** button:



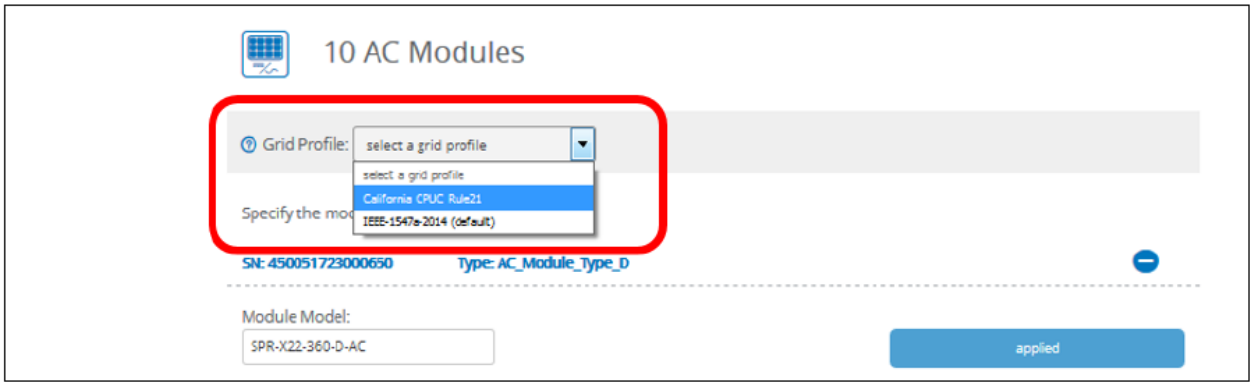
3. In the **Grid Profile** row, click the pencil icon:



4. When prompted for your grid profile password, simply enter the California zip code of the residence on which you installed the system and then click **I agree**:

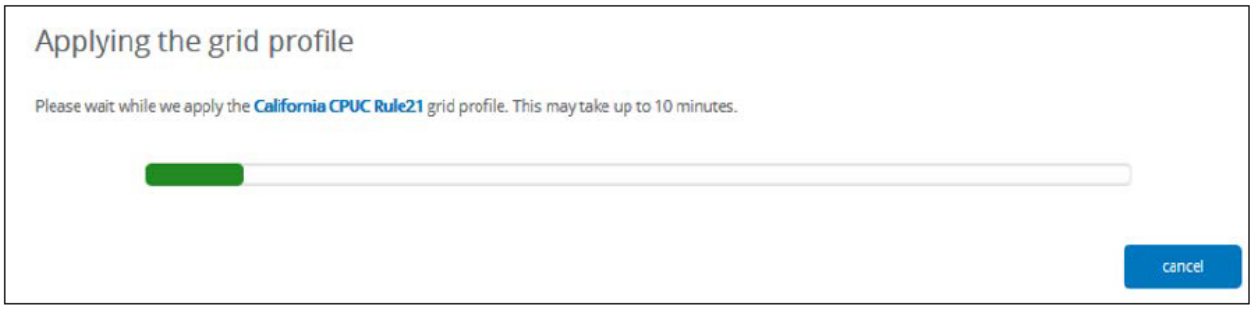


5. In the **Grid Profile** dropdown, select *California CPUC Rule21*. Doing so will apply the profile to all of the Type D AC modules in the system you installed:

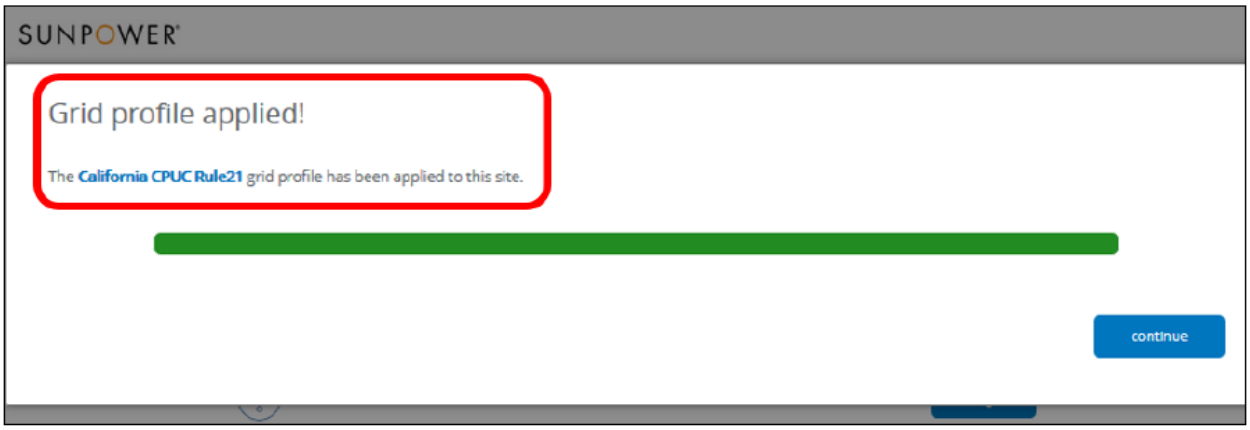


6. Click **continue** at the bottom of the page.

   The Rule 21 profile is applied to each Type D AC module at the site:



Wait until you receive the following confirmation:



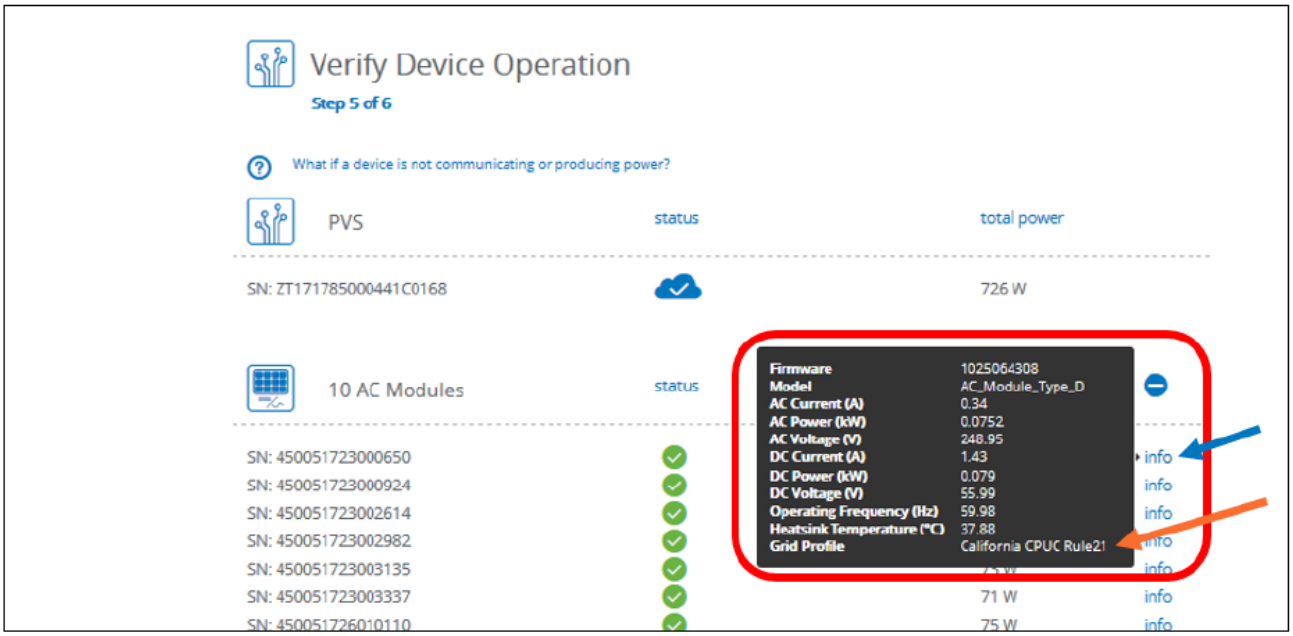
7. Execute the remainder of the PVS Management App steps to complete commissioning of the Type D AC Module system.

Verify Grid Profile

You can verify the grid settings while still at the site, or after you return to your office.

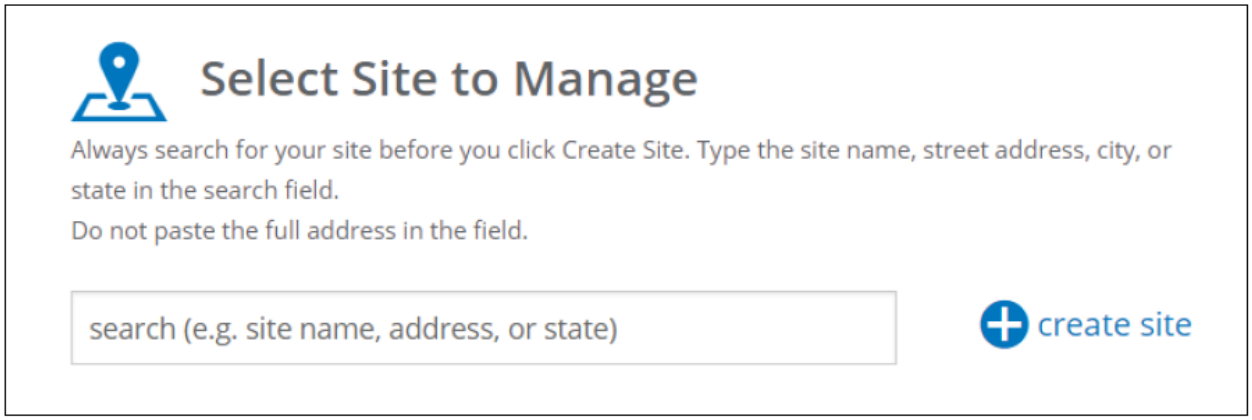
To verify while at the site:

From the **Step 5 of 6** screen, click the **info** link for any of the AC modules and then review the **Grid Profile** row.

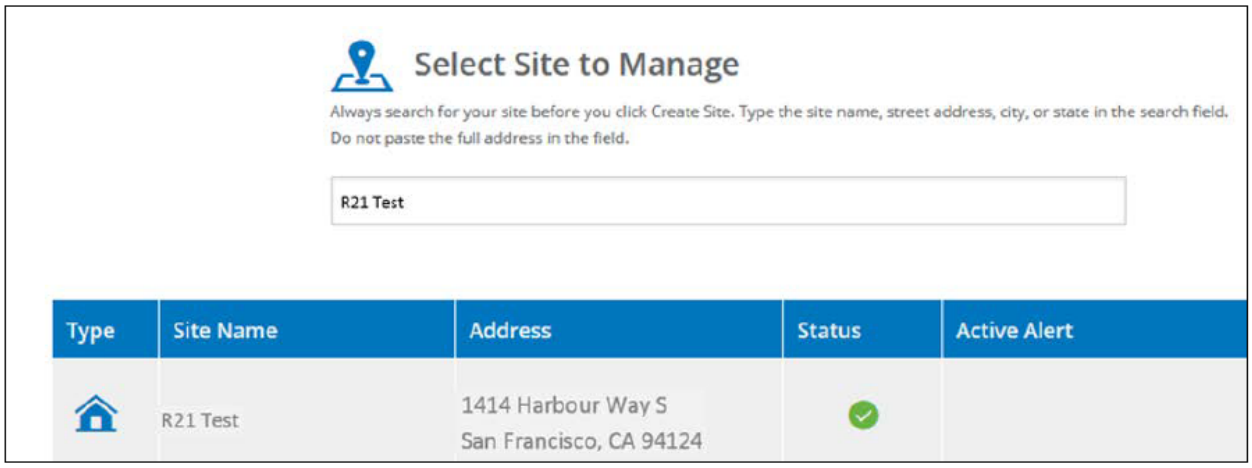


To verify from your office:

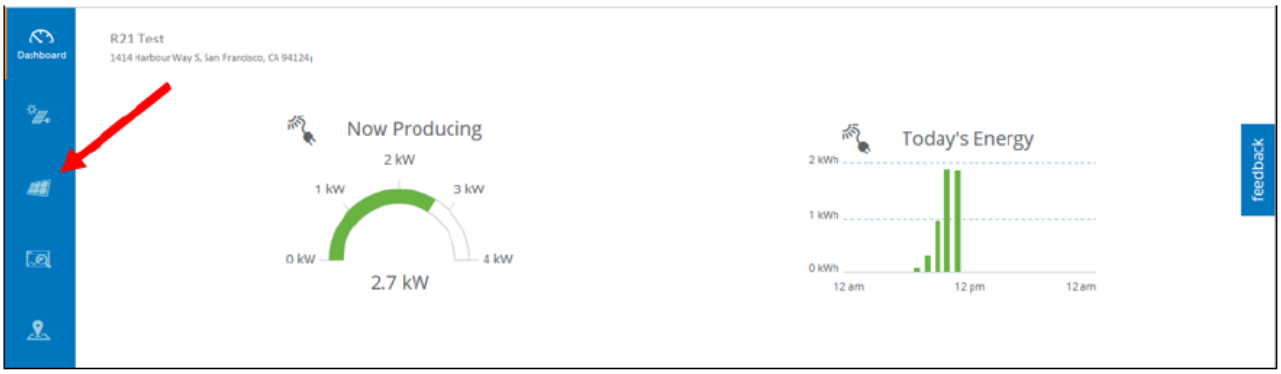
1. Log into the Management App: https://pvsmgmt.us.sunpower.com
2. Enter the site info in the search field:



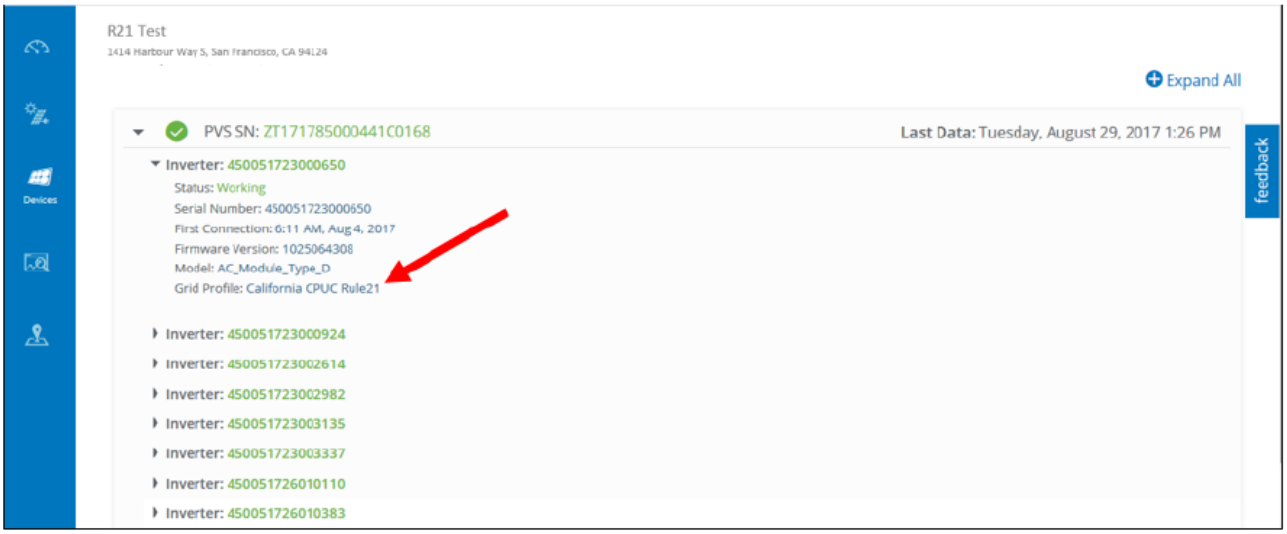
3. Click the **Site Name** of the site you want to verify:



4. Click the Devices icon in the left menu:



5. Expand any of the **Inverter** rows and then review the **Grid Profile** row:



Frequently Asked Questions

Q. Okay, I can *verify* the grid profile settings at the office but can I *change* the settings at the office?
A. No. At this time the CA R21 grid profile can only be *set* while onsite.

Q. Can I install the system but *not change* the grid profile settings?
A. Yes, you can leave the grid profile as it came from the factory: the default IEEE 1547 profile. You simply commission the site and skip setting the grid profile in Step 4.
Note. Some California utilities (such as LADWP) do not require California Rule 21 grid profile settings. Please check with your local utility if you have questions.

Q. If I neglect to do so during commissioning, can I change the grid profile settings at a later date?
A. Yes, grid profile changes can be changed after commissioning but require a site visit and the use of Step 4 in the PVS Management App.

Contacts

Phone		Email	
US & Australia	1-800-SUNPOWER (786-76937)	**US & Australia**	technicalsupport@sunpower.com
Europe	900 808068	**Spain**	soportetecnico@sunpowercorp.com
	0800-1812762	**Germany**	technischersupport@sunpowercorp.com
	800 795 730	**Italy**	serviziotecnico@sunpowercorp.com
	0 805 090 808	**France**	supporttechnique@sunpowercorp.com
	0800 786 35	**Belgium**	SunPowerBenelux.TechnischeDienst@sunpowercorp.com
	0800 023 39 80	**NL**	
	0808 281 8718	**UK**	techsupport.UK@sunpowercorp.com
Rest of the World		**Asia Pacific**	SunPower_TechSupport@sunpower.com

L.10 Using the PVS5 Management App to Set and Verify the Xcel Energy of Colorado Grid Profile on Type D AC Modules, T17008

SUNPOWER®

Technical Notification

Title : Using the PVS5 Management App to Set and Verify the Xcel Energy of Colorado Grid Profile on Type D AC Modules, T17008

Date : October 17, 2017

Author : Dylan Benjamin, Residential Systems Senior Integration Manager

Application: SunPower Type D AC Modules requiring Xcel Energy CO grid profile settings

Overview

Xcel Energy of Colorado is requiring that AC modules at some sites be set to a fixed power factor.

Please contact Xcel Energy for site-specific requirements regarding fixed power factor.

This technical notification describes the steps necessary to set and verify the Xcel Energy of Colorado grid profile when commissioning SunPower Type D AC module systems with the SunPower PVS Management App.

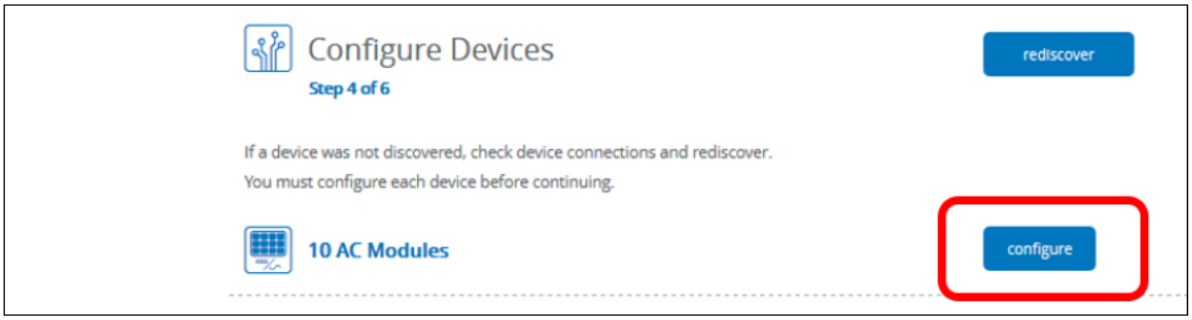
SunPower's new Type D AC modules are UL tested and certified to UL 1741 SA and have the capacity to provide advanced smart inverter functions. SunPower Type D AC modules are compliant with Xcel Energy CO requirements, and the required grid profile is easily set during system commissioning with SunPower PVS5x monitoring hardware.

Summary of Steps

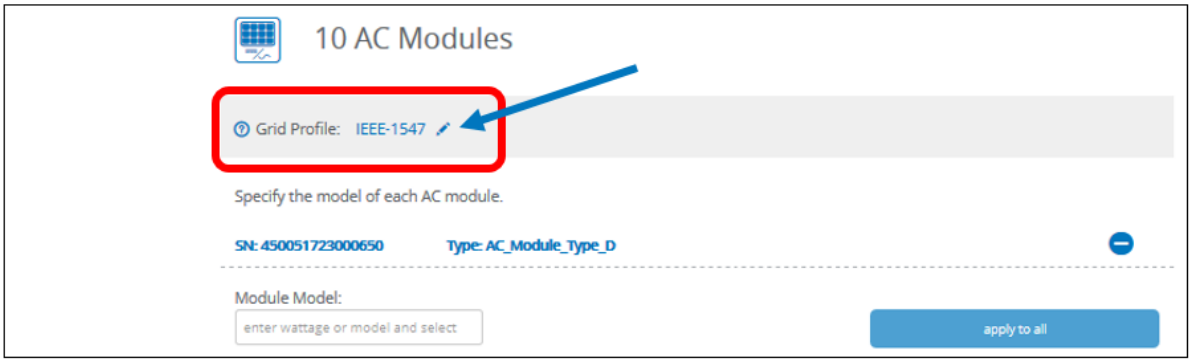
1. Install the PVS5x.
2. Commission the PVS5x through Step 3.
3. Select the grid profile in Step 4 (using the installation site zip code as the password).
4. Verify the grid profile in Step 5 or with the Management App.

Set Grid Profile

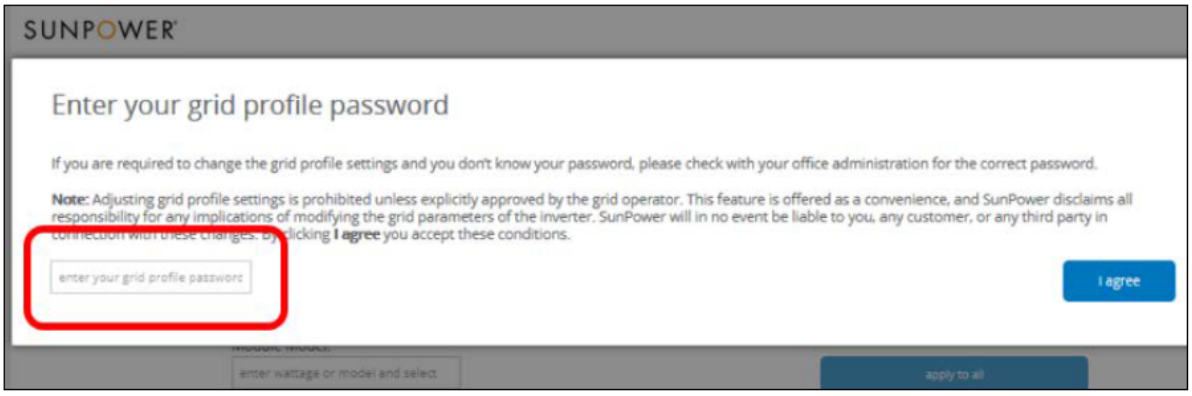
1. Complete Steps 1–3 in the PVS Management App as you normally would (set up communication; check firmware version; and discover devices).
2. When you get to Step 4, in the **AC Modules** row click the **configure** button:



3. In the **Grid Profile** row, click the pencil icon:

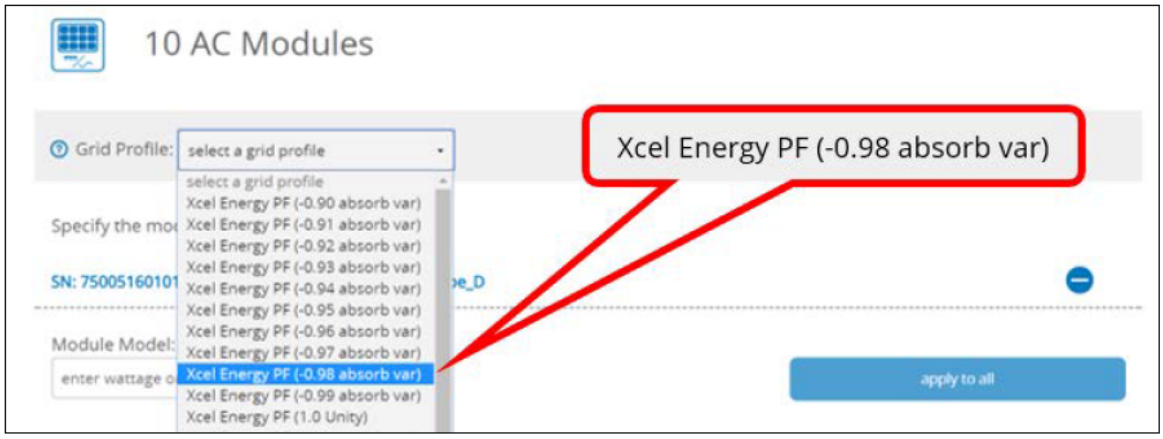


4. When prompted for your grid profile password, simply enter the Colorado zip code of the residence on which you installed the system and then click **I agree**:

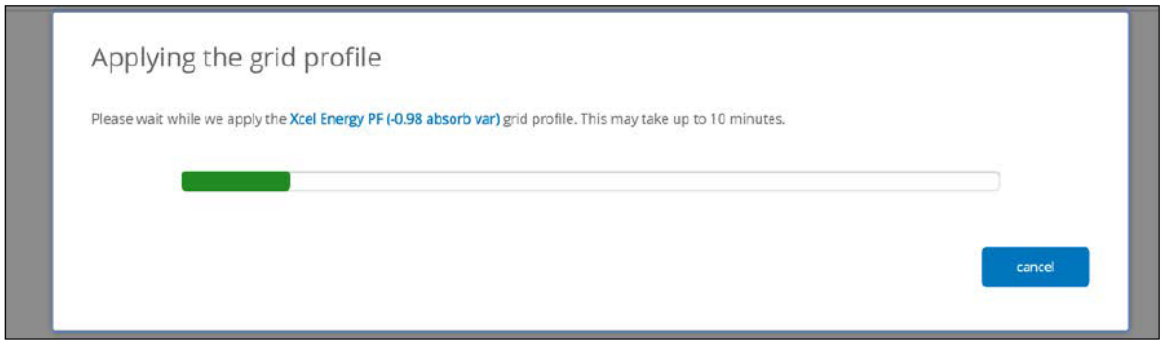


5. In the **Grid Profile** dropdown, select *Xcel Energy PF (-0.98 absorb var).* This is the Xcel Energy recommended setting for power factor; selecting it will apply the profile to all of the Type D AC modules in the system you installed.

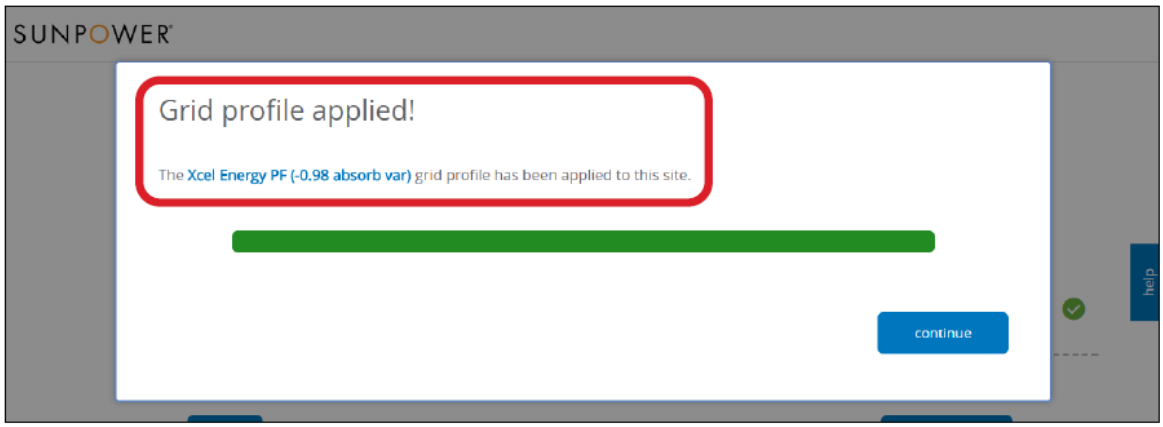
   Note: Xcel Energy of Colorado's recommended default setting for fixed power factor is *Xcel Energy PF (-0.98 absorb var)*. However, please confirm with Xcel Energy the specific fixed power factor for each site.



6. Click **done** at the bottom of the page. Xcel's grid profile is applied to each Type D AC module at the site:



Wait until you receive the following confirmation:



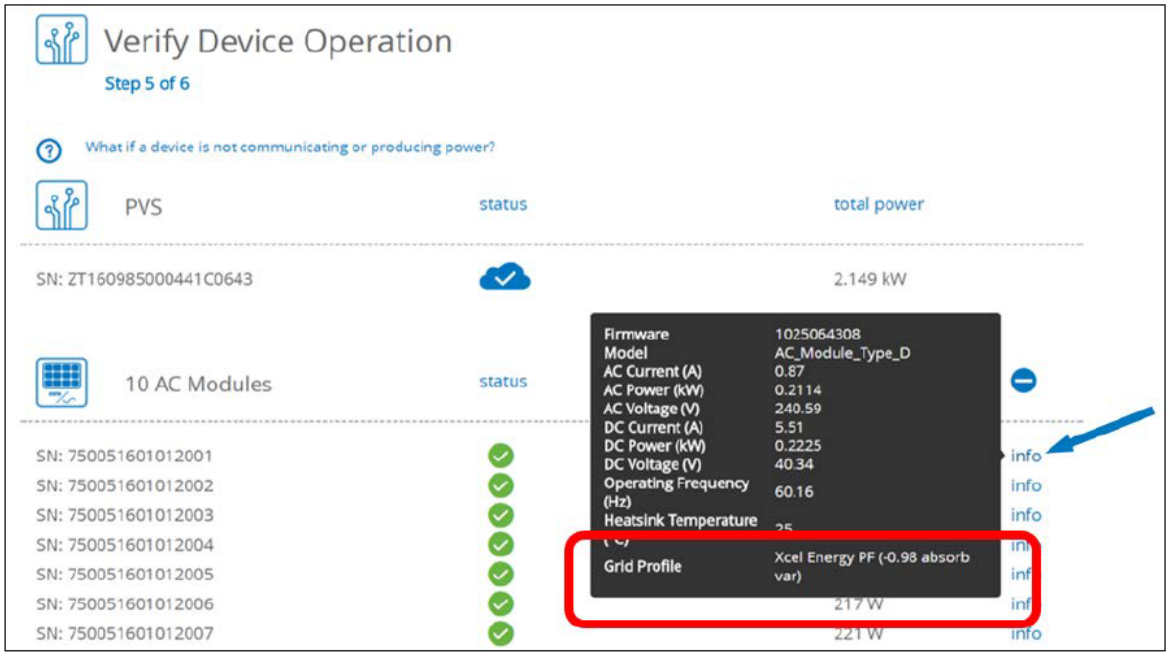
7. Execute the remainder of the PVS Management App steps to complete commissioning of the Type D AC module system.

Verify Grid Profile

You can verify the grid settings while still at the site, or after you return to your office.

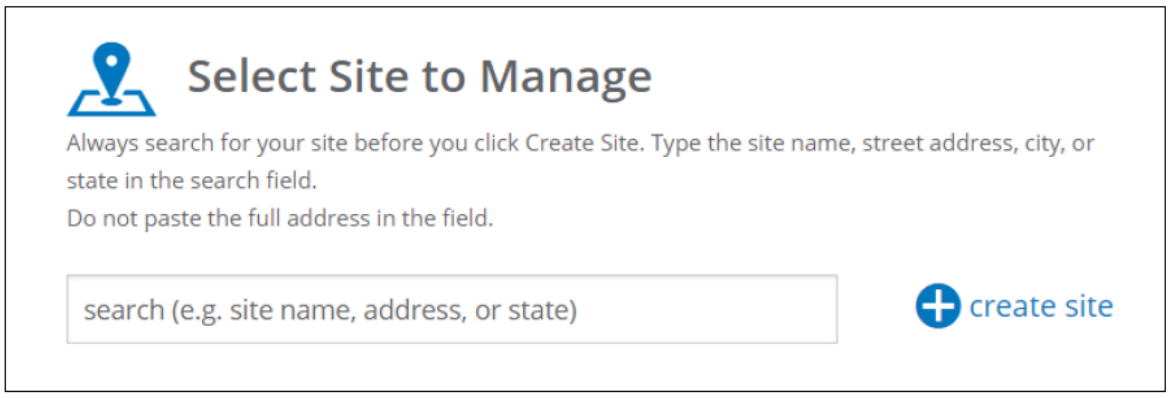
To verify while at the site:

From the **Step 5 of 6** screen, click the **info** link for any of the AC modules and then review the **Grid Profile** row.

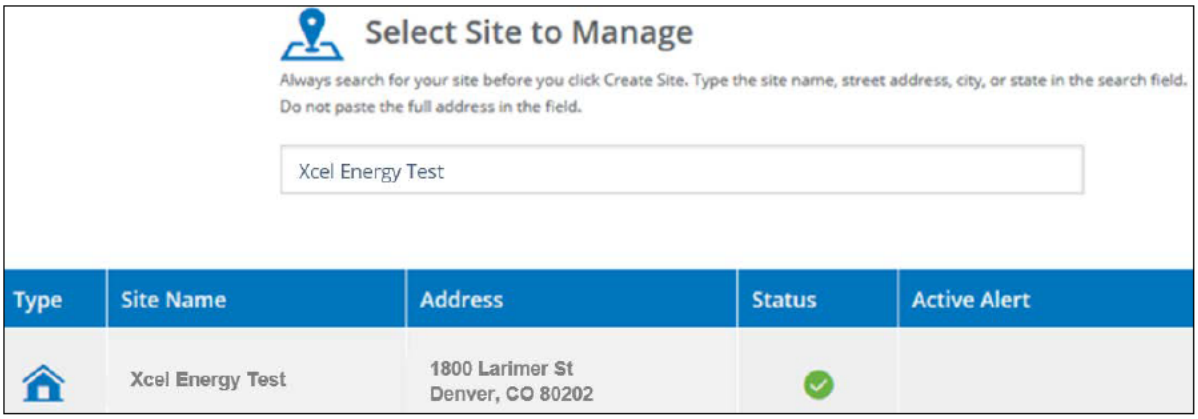


To verify from your office:

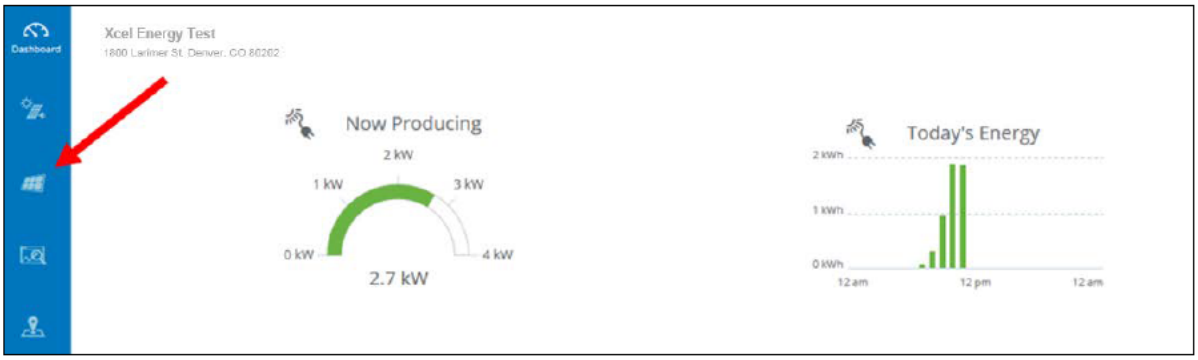
1. Log into the Management App: https://pvsmgmt.us.sunpower.com
2. Enter the site info in the search field:



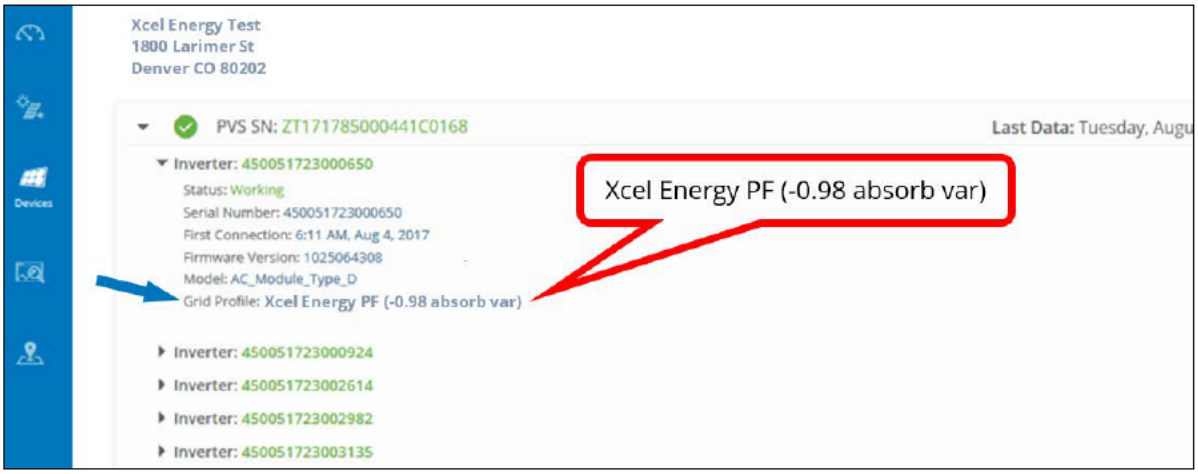
3. Click the **Site Name** of the site you want to verify:



4. Click the Devices icon in the left menu:



5. Expand any of the **Inverter** rows and then review the **Grid Profile** row:



Frequently Asked Questions

Q. Okay, I can *verify* the grid profile settings at the office but can I *change* the settings at the office?
A. No. At this time the Xcel Energy CO grid profile can only be *set* while onsite.

Q. Can I install the system but *not change* the grid profile settings?
A. Yes, you can leave the grid profile as it came from the factory: the default IEEE 1547 profile. You simply commission the site and skip setting the grid profile in Step 4.
Note. Some Colorado utilities (such as Tri-State or Black Hills Energy) do not require Xcel Energy Colorado grid profile settings. Please check with your local utility if you have questions.

Q. If I neglect to do so during commissioning, can I change the grid profile settings at a later date?
A. Yes, grid profile changes can be changed after commissioning but require a site visit and the use of Step 4 in the PVS Management App.

Contacts

Phone		Email	
US & Australia	1-855-977-7867	**US & Australia**	technicalsupport@sunpower.com
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	0800-1812762	**Germany**	technischersupport@sunpowercorp.com
	800 795 730	**Italy**	serviziotecnico@sunpowercorp.com
	0 805 090 808	**France**	supporttechnique@sunpowercorp.com
	0800 786 35	**Belgium**	SunPowerBenelux.TechnischeDienst@sunpowercorp.com
	0800 023 39 80	**NL**	
	0808 281 8718	**UK**	techsupport.UK@sunpowercorp.com
Rest of the World		**Asia Pacific**	SunPower_TechSupport@sunpower.com

L.11 Using the PVS5 Management App to Set and Verify United Illuminating of Connecticut Grid Profiles on Type D AC Modules, T17010

SUNPOWER®

Technical Notification

Title : Using the PVS5 Management App to Set and Verify United Illuminating of Connecticut Grid Profiles on Type D AC Modules, T17010

Date : October 17, 2017

Author : Dylan Benjamin, Residential Systems Senior Integration Manager

Application: SunPower Type D AC Modules requiring United Illuminating (CT) grid profile settings

Overview

United Illuminating of Connecticut is requiring AC modules at some sites to be set to a fixed power factor.

Please contact United Illuminating for site-specific requirements related to fixed power factor.

This technical notification describes the steps necessary to set and verify United Illuminating of Connecticut's grid profiles when commissioning SunPower Type D AC module systems with the SunPower PVS Management App.

SunPower's new Type D AC modules are UL tested and certified to UL 1741 SA and have the capacity to provide advanced smart inverter functions. SunPower Type D AC modules are compliant with United Illuminating requirements, and the required grid profile is easily set during system commissioning with SunPower PVS5x monitoring hardware.

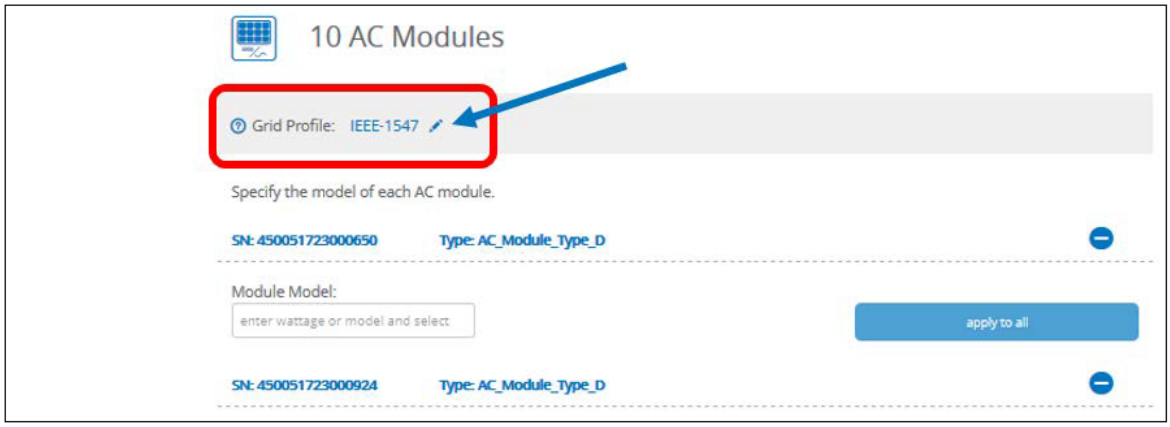
Summary of Steps

1. Install the PVS5x.
2. Commission the PVS5x through Step 3.
3. Select the grid profile in Step 4 (using the installation site zip code as the password).
4. Verify the grid in Step 5 or with the Management App.

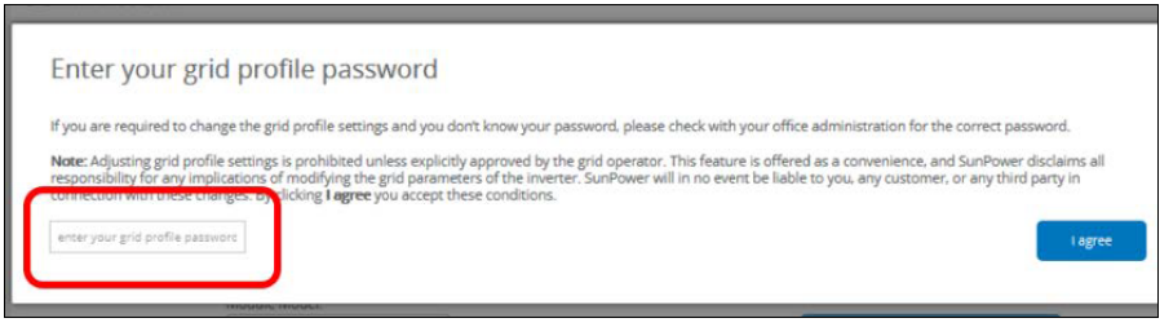
Set Grid Profile

1. Complete Steps 1–3 in the PVS Management App as you normally would (set up communication; check firmware version; and discover devices).
2. When you get to Step 4, in the **AC Modules** row click the **configure** button:

3. In the **Grid Profile** row, click the pencil icon:

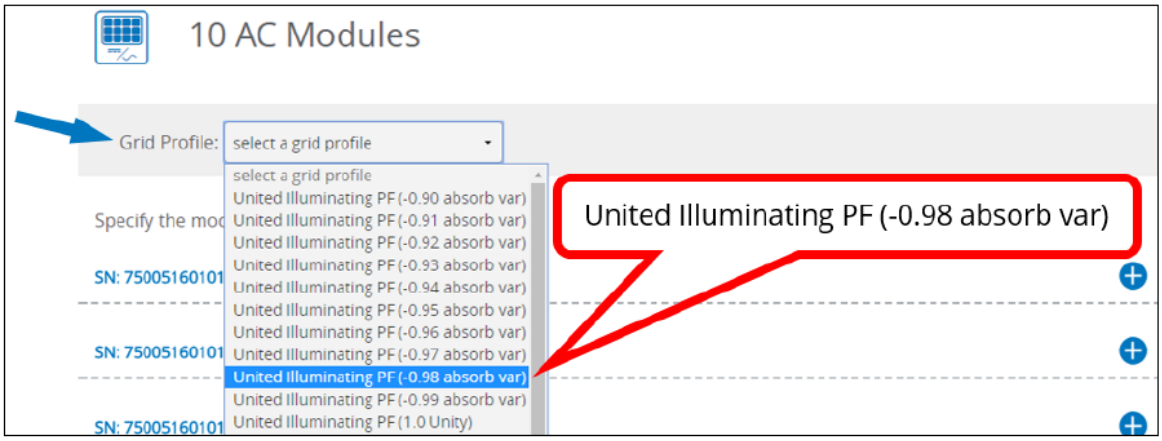


4. When prompted for your grid profile password, simply enter the Connecticut zip code of the residence on which you installed the system and then click **I agree**:



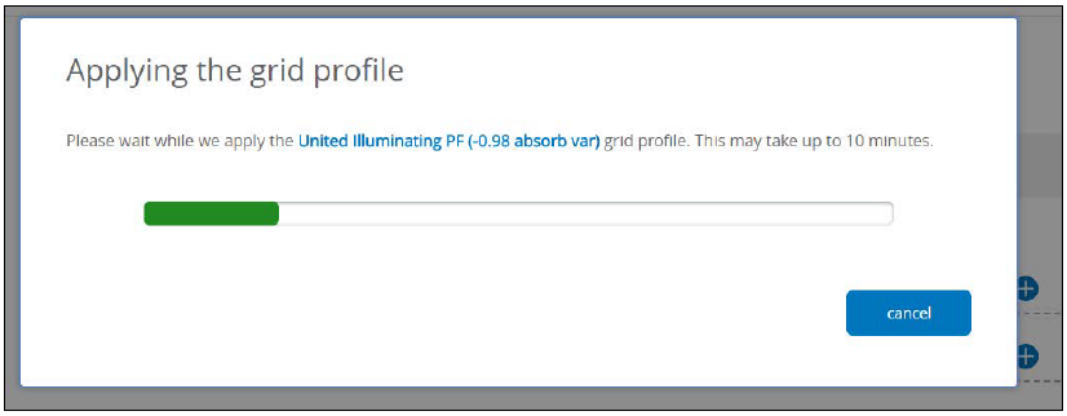
5. In the **Grid Profile** dropdown, select *United Illuminating PF (-0.98 absorb var)*. Selecting this profile will apply the profile to all of the Type D AC modules in the system you installed.

Note: United Illuminating's recommended default setting for fixed power factor is *PF (-0.98 absorb var)*. However, please confirm with United Illuminating the correct fixed power factor for each site.

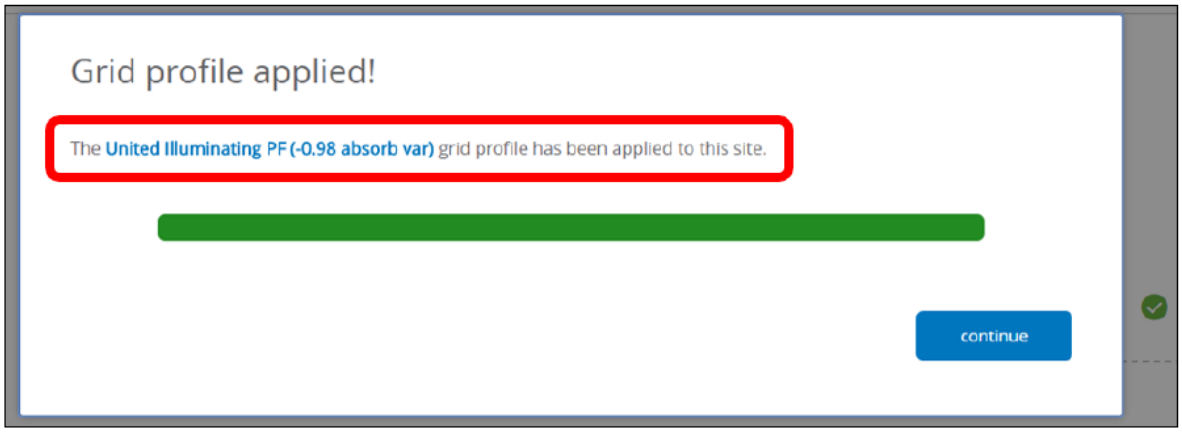


6. Click **done** at the bottom of the page.

The selected grid profile is applied to each Type D AC module at the site:



Wait until you receive the following confirmation:



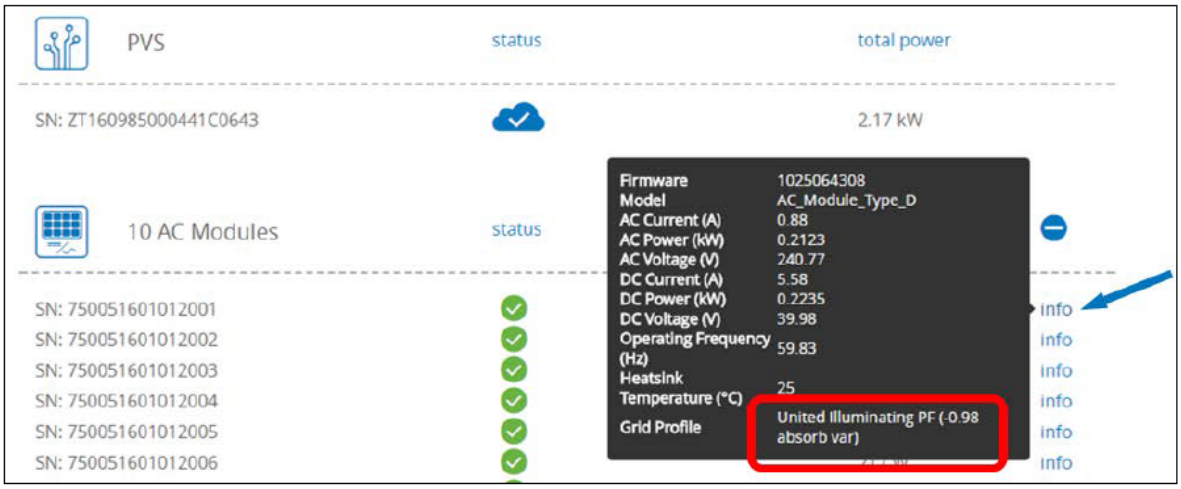
7. Execute the remainder of the PVS Management App steps to complete commissioning of the Type D AC module system.

Verify Grid Profile

You can verify the grid settings while still at the site, or after you return to your office.

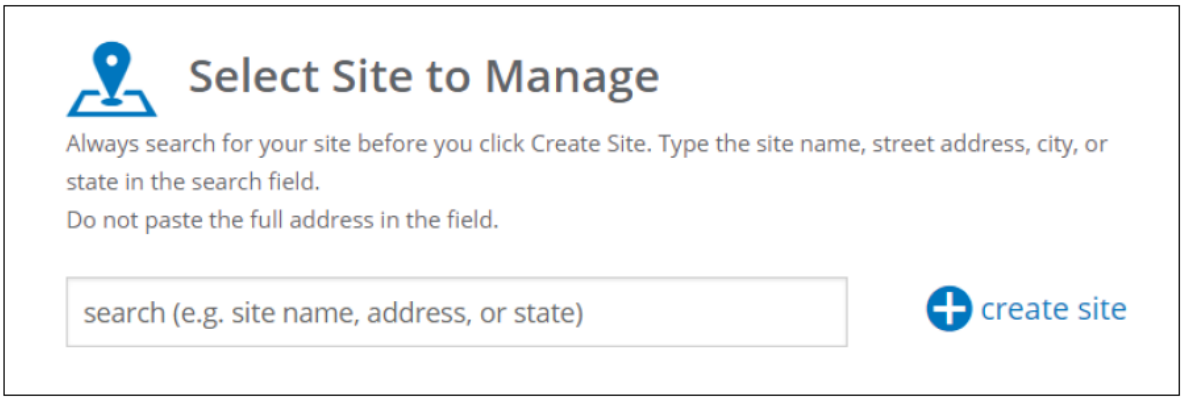
To verify while at the site:

From the **Step 5 of 6** screen, click the **info** link for any of the AC modules and then review the **Grid Profile** row.

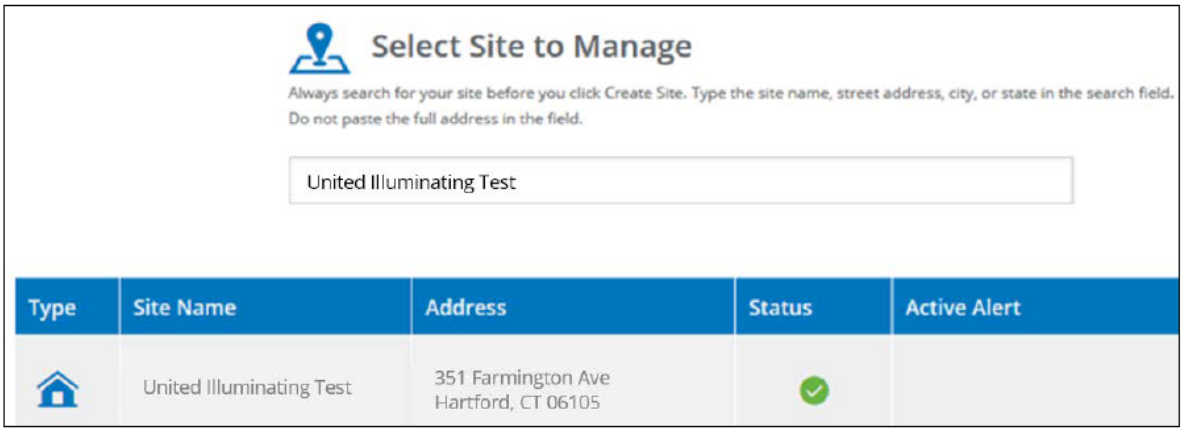


To verify from your office:

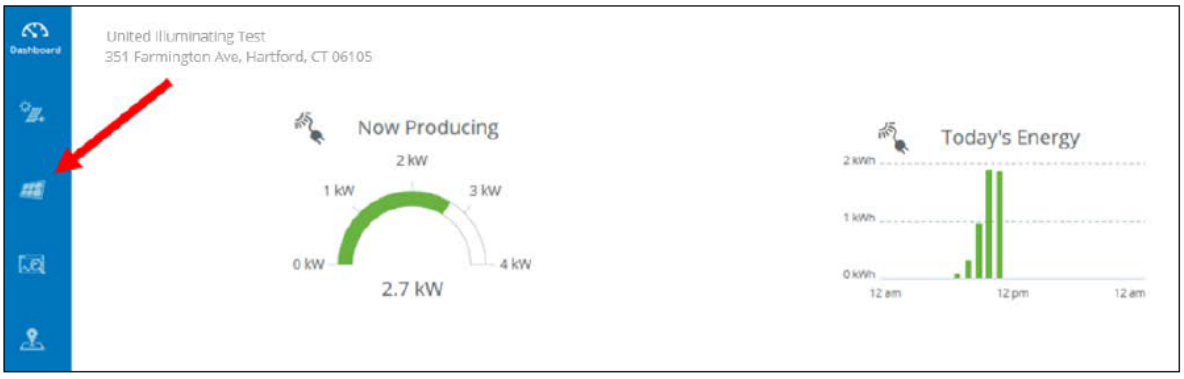
1. Log into the Management App: https://pvsmgmt.us.sunpower.com
2. Enter the site info in the search field:



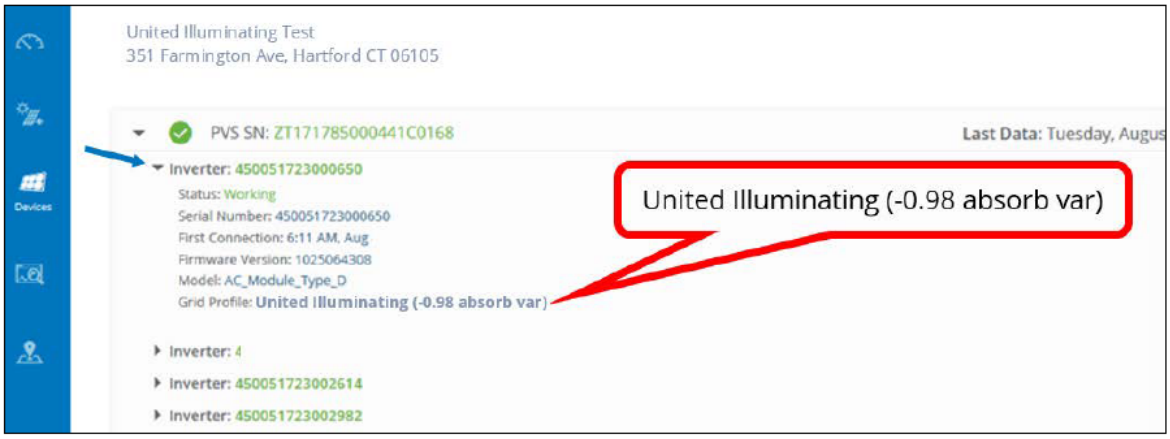
3. Click the **Site Name** of the site you want to verify:



4. Click the Devices icon in the left menu:



5. Expand any of the **Inverter** rows and then review the **Grid Profile** row:



Frequently Asked Questions

Q. Okay, I can *verify* the grid profile settings at the office but can I *change* the settings at the office?
A. No. At this time the CT grid profile can only be *set* while onsite.

Q. Can I install the system but *not change* the grid profile settings?
A. Yes, you can leave the grid profile as it came from the factory: the default IEEE 1547 profile. You simply commission the site and skip setting the grid profile in Step 4.
Note: Some Connecticut utilities (such as CL&P) do not require specific grid profile settings. Please check with your local utility if you have questions.

Q. If I neglect to do so during commissioning, can I change the grid profile settings at a later date?
A. Yes, grid profile changes can be changed after commissioning but require a site visit and the use of Step 4 in the PVS Management App.

Contacts

Phone		Email	
US & Australia	1-855-977-7867	**US & Australia**	technicalsupport@sunpower.com
Europe	900 808068	**Spain**	soportetecnico@sunpowercorp.com
	0800-1812762	**Germany**	technischersupport@sunpowercorp.com
	800 795 730	**Italy**	serviziotecnico@sunpowercorp.com
	0 805 090 808	**France**	supporttechnique@sunpowercorp.com
	0800 786 35	**Belgium**	SunPowerBenelux.TechnischeDienst@sunpowercorp.com
	0800 023 39 80	**NL**	
	0808 281 8718	**UK**	techsupport.UK@sunpowercorp.com
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L.12 Using the PVS5 Management App to Set and Verify New York Utility (NYSEG, RG&E) Grid Profiles on Type D AC Modules, T17009

SUNPOWER®

Technical Notification

Title : Using the PVS5 Management App to Set and Verify New York Utility (NYSEG, RG&E) Grid Profiles on Type D AC Modules, T17009

Date : October 17, 2017

Author : Dylan Benjamin, Residential Systems Senior Integration Manager

Application: SunPower Type D AC Modules requiring NY (NYSEG, RG&E) grid profile settings

Overview

New York State Electric and Gas (NYSEG) and Rochester Gas and Electric (RG&E) are requiring that AC modules at some sites be set to a lower frequency trip point of 57 Hz.

Please contact NYSEG and RG&E for site-specific requirements regarding lower frequency trip points.

This technical notification describes the steps necessary to set and verify New York grid profiles (NYSEG or RG&E) when commissioning SunPower Type D AC module systems with the SunPower PVS Management App.

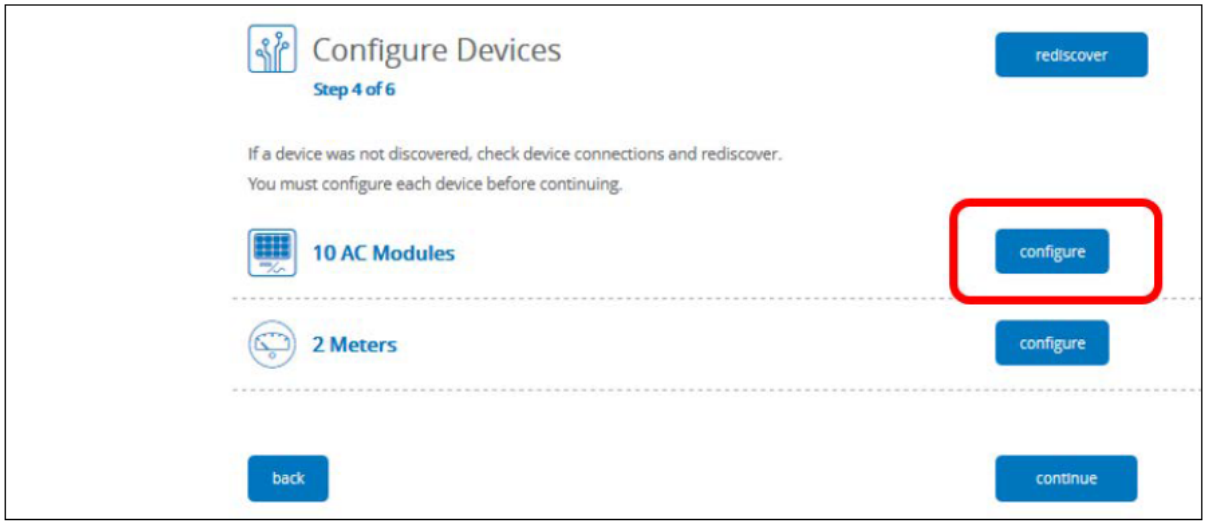
SunPower's new Type D AC modules are UL tested and certified to UL 1741 SA, and have the capacity to provide advanced smart inverter functions. SunPower Type D AC modules are compliant with NYSEG and RG&E requirements, and the required grid profile is easily set during system commissioning with SunPower PVS5x monitoring hardware.

Summary of Steps

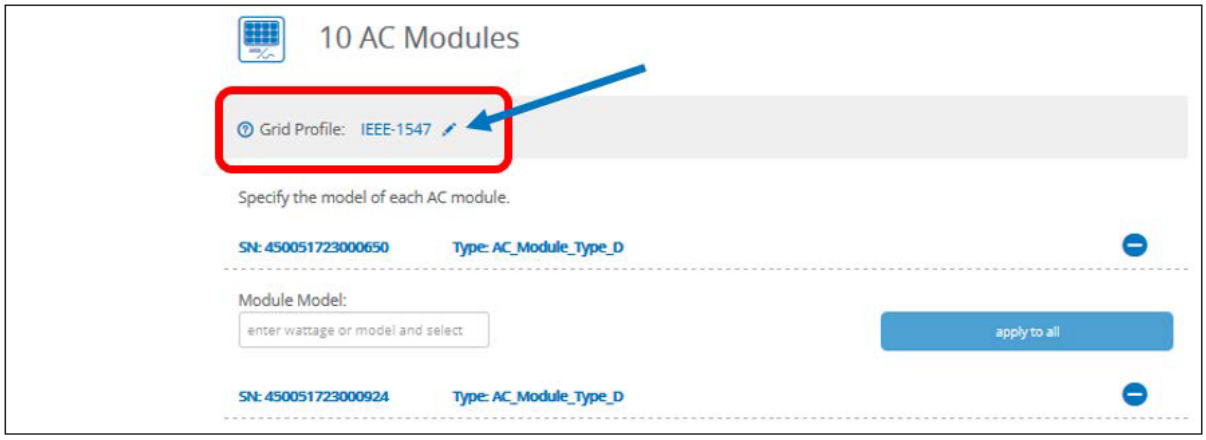
1. Install the PVS5x.
2. Commission the PVS5x through Step 3.
3. Select the grid profile in Step 4 (using the installation site zip code as the password).
4. Verify the grid in Step 5 or with the Management App.

Set Grid Profile

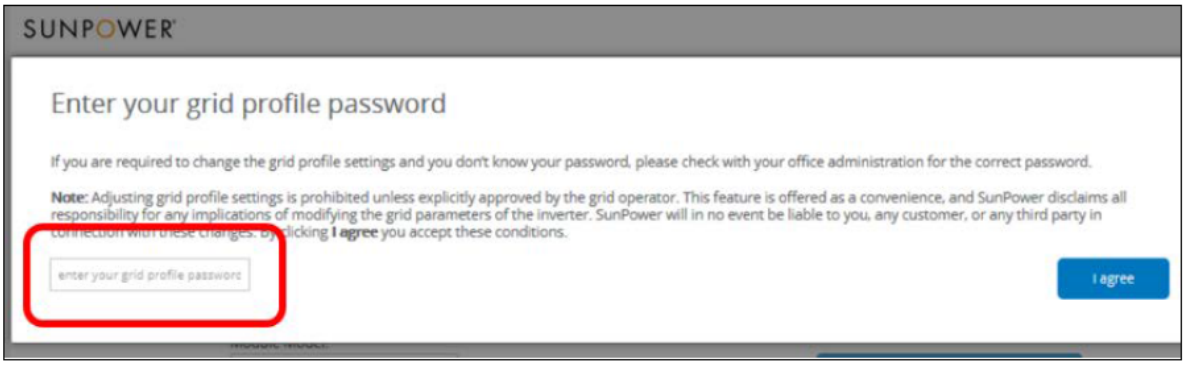
1. Complete Steps 1–3 in the PVS Management App as you normally would (set up communication; check firmware version; and discover devices).
2. When you get to Step 4, in the **AC Modules** row click the **configure** button:



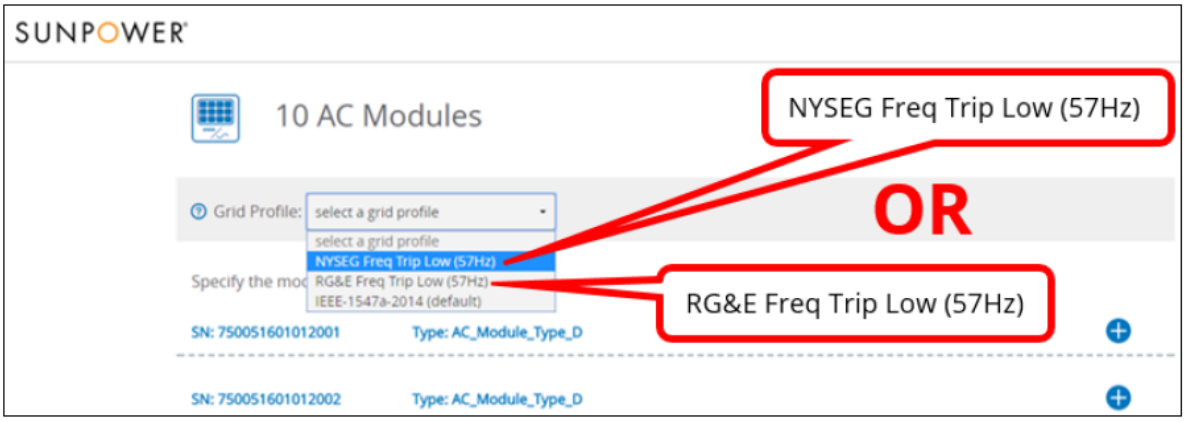
3. In the **Grid Profile** row, click the pencil icon:



4. When prompted for your grid profile password, simply enter the New York zip code of the residence on which you installed the system and then click **I agree**:

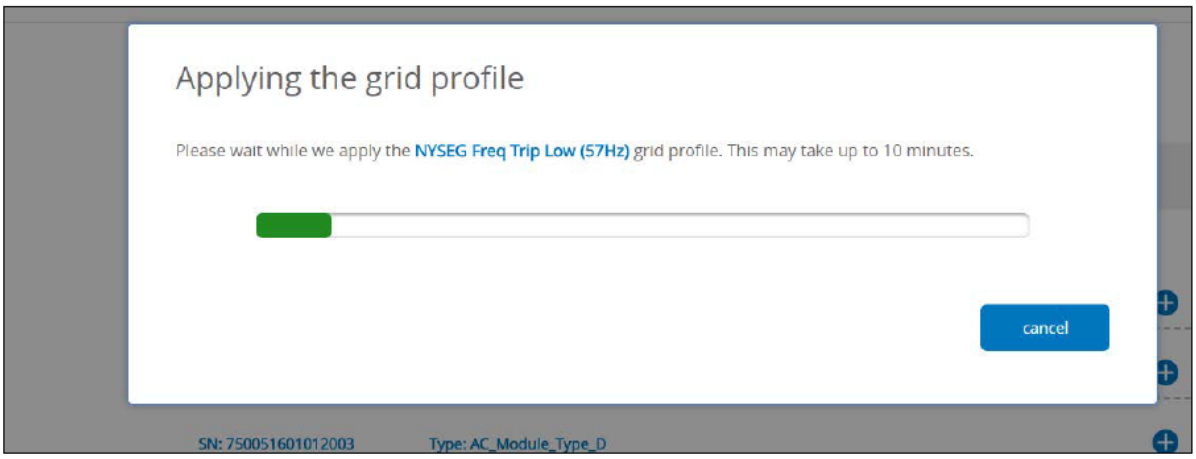


5. In the **Grid Profile** dropdown, select the option which corresponds to the utility grid on which the AC module system will be placed in service. Doing so will apply the profile to all of the Type D AC modules in the system you installed:

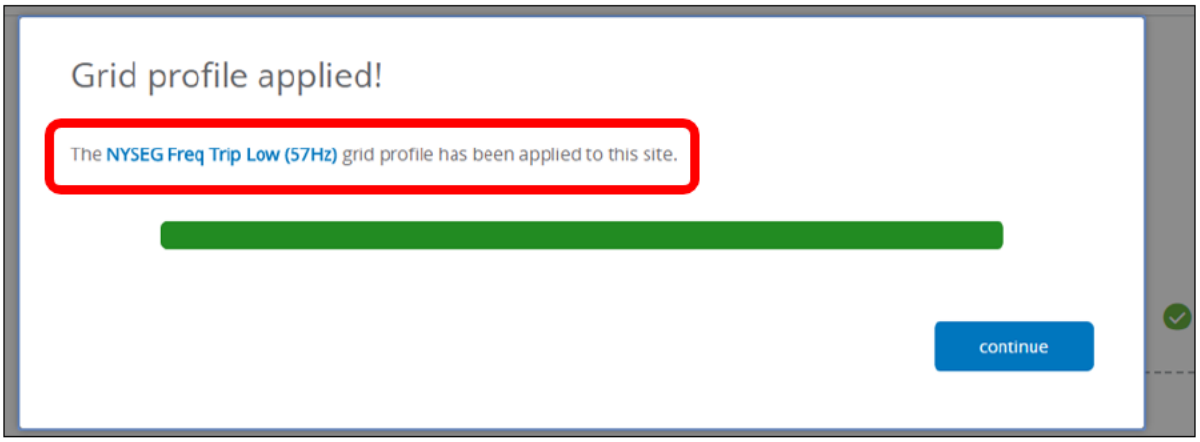


6. Click **done** at the bottom of the page.

   The selected grid profile is applied to each Type D AC module at the site:



Wait until you receive the following confirmation:



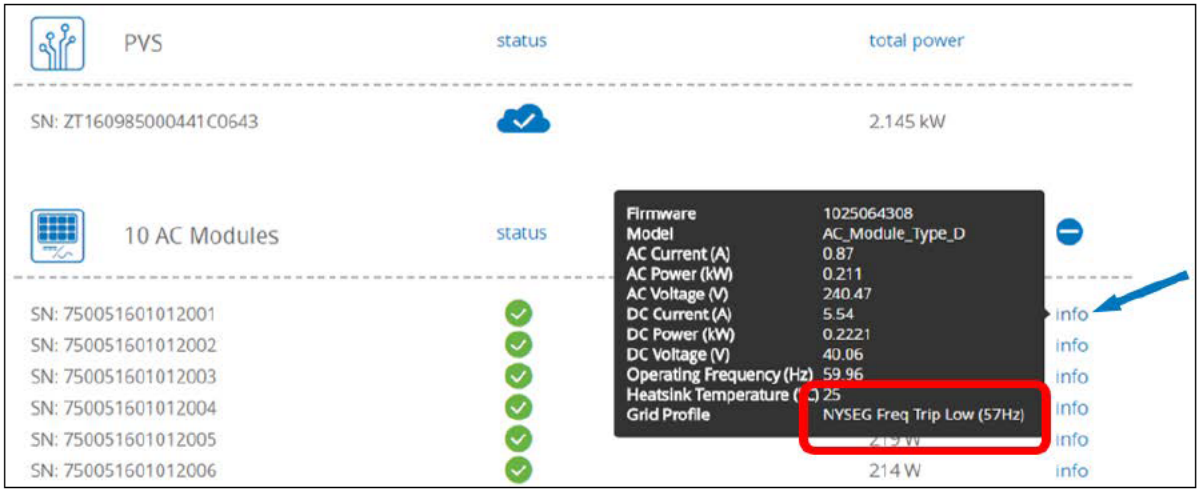
7. Execute the remainder of the PVS Management App steps to complete commissioning of the Type D AC module system.

Verify Grid Profile

You can verify the grid settings while still at the site, or after you return to your office.

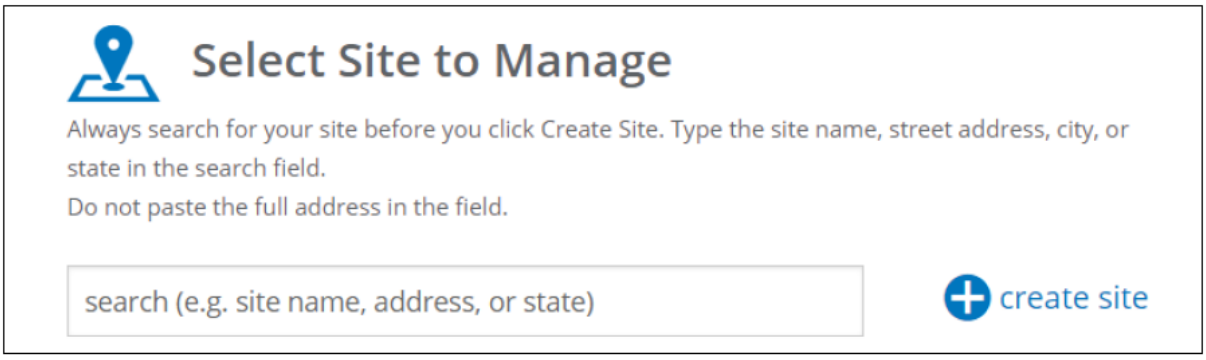
To verify while at the site:

From the **Step 5 of 6** screen, click the **info** link for any of the AC modules and then review the **Grid Profile** row.

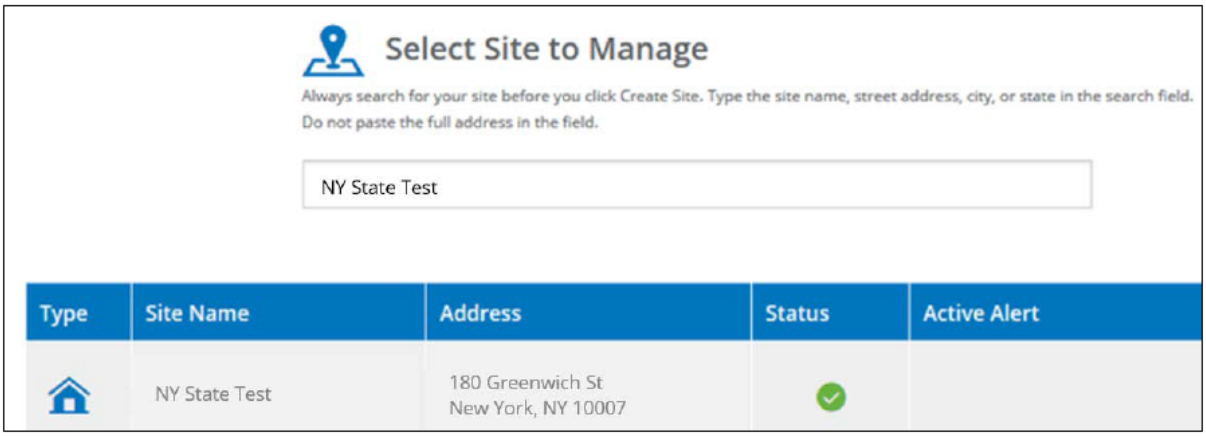


To verify from your office:

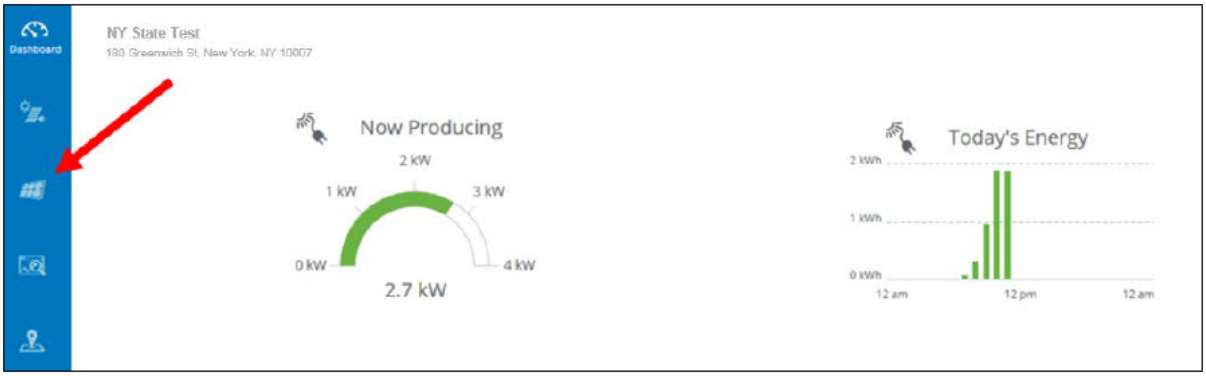
1. Log into the Management App: https://pvsmgmt.us.sunpower.com
2. Enter the site info in the search field:



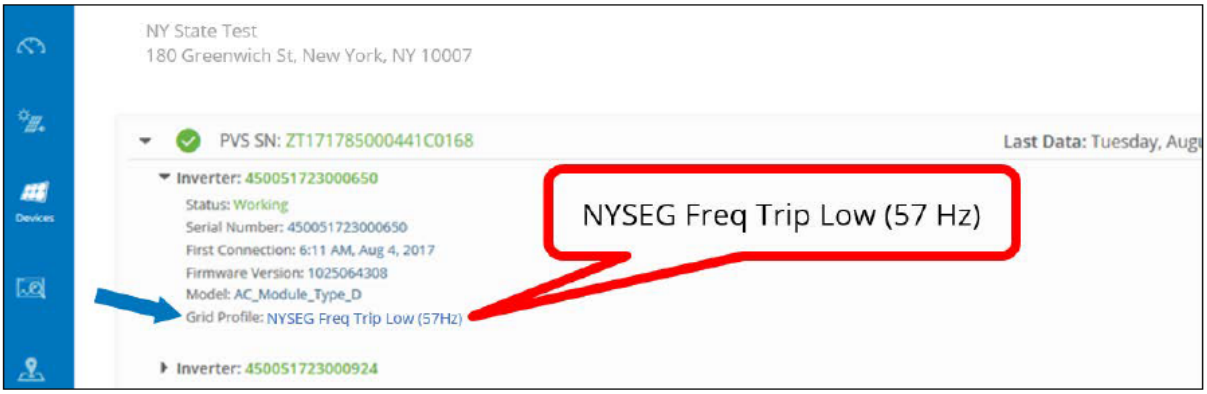
3. Click the **Site Name** of the site you want to verify:



4. Click the Devices icon in the left menu:



5. Expand any of the **Inverter** rows and then review the **Grid Profile** row:



Frequently Asked Questions

Q. Okay, I can *verify* the grid profile settings at the office but can I *change* the settings at the office?
A. No. At this time the NY grid profile can only be *set* while onsite.

Q. Can I install the system but *not change* the grid profile settings?
A. Yes, you can leave the grid profile as it came from the factory: the default IEEE 1547 profile. You simply commission the site and skip setting the grid profile in Step 4.
Note: Some New York utilities (such as National Grid) do not require specific grid profile settings. Please check with your local utility if you have questions.

Q. If I neglect to do so during commissioning, can I change the grid profile settings at a later date?
A. Yes, grid profile changes can be changed after commissioning but require a site visit and the use of Step 4 in the PVS Management App.

Contacts

Phone		Email	
US & Australia	1-855-977-7867	**US & Australia**	technicalsupport@sunpower.com
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	0800 786 35	**Belgium**	SunPowerBenelux.TechnischeDienst@sunpowercorp.com
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	0808 281 8718	**UK**	techsupport.UK@sunpowercorp.com
Rest of the World		**Asia Pacific**	SunPower_TechSupport@sunpower.com

L.13 PVS Management App Enhanced Functionality for Residential Commissioning, T17013

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Technical Notification

Title : PVS Management App Enhanced Functionality for Residential Commissioning, T17013
Date : November 7, 2017
Author : Dylan Benjamin, Residential Systems Senior Integration Manager
Application : All residential PVS5x installations

Overview

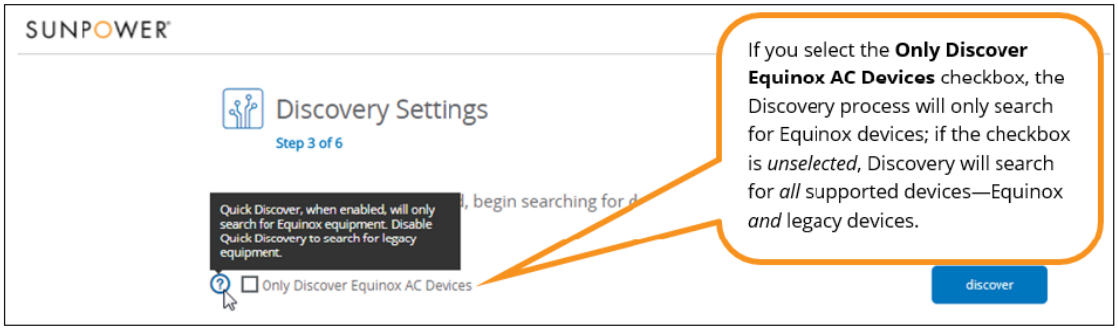
SunPower is announcing two upcoming new features in the PVS Management App commissioning process:

- Shorter Discovery times for Equinox™ systems
- An improved device configuration page that enables you to claim only the AC modules that are part of the system you installed

> The new features will be available on **11/9/17** as part of the PVS5 Management automatic zero-day firmware upgrade process during commissioning.

Discovery Settings Screen

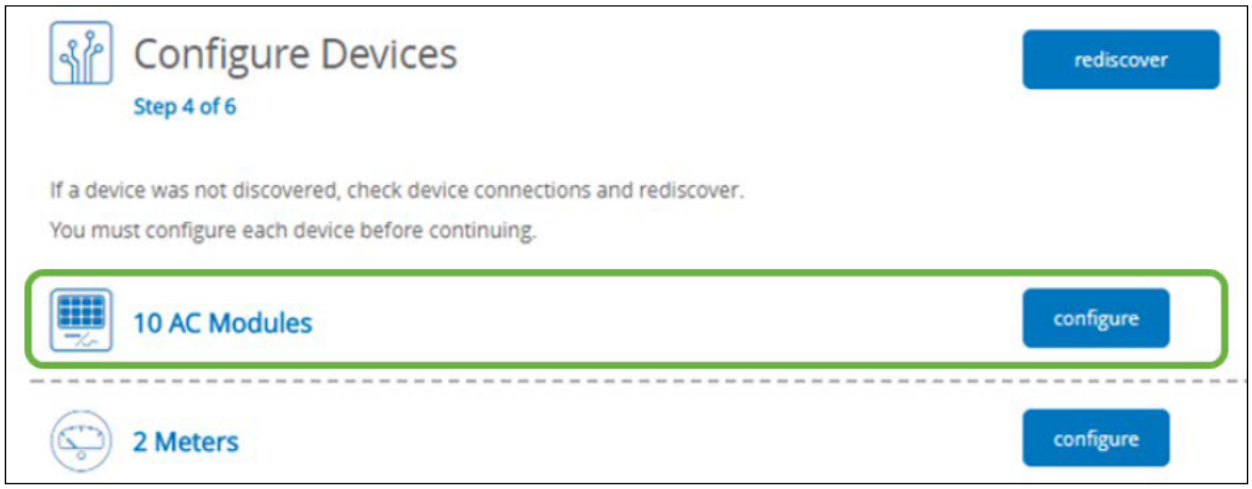
A new feature called *Quick Discover* enables rapid discovery of Equinox devices (AC modules and internal meters):



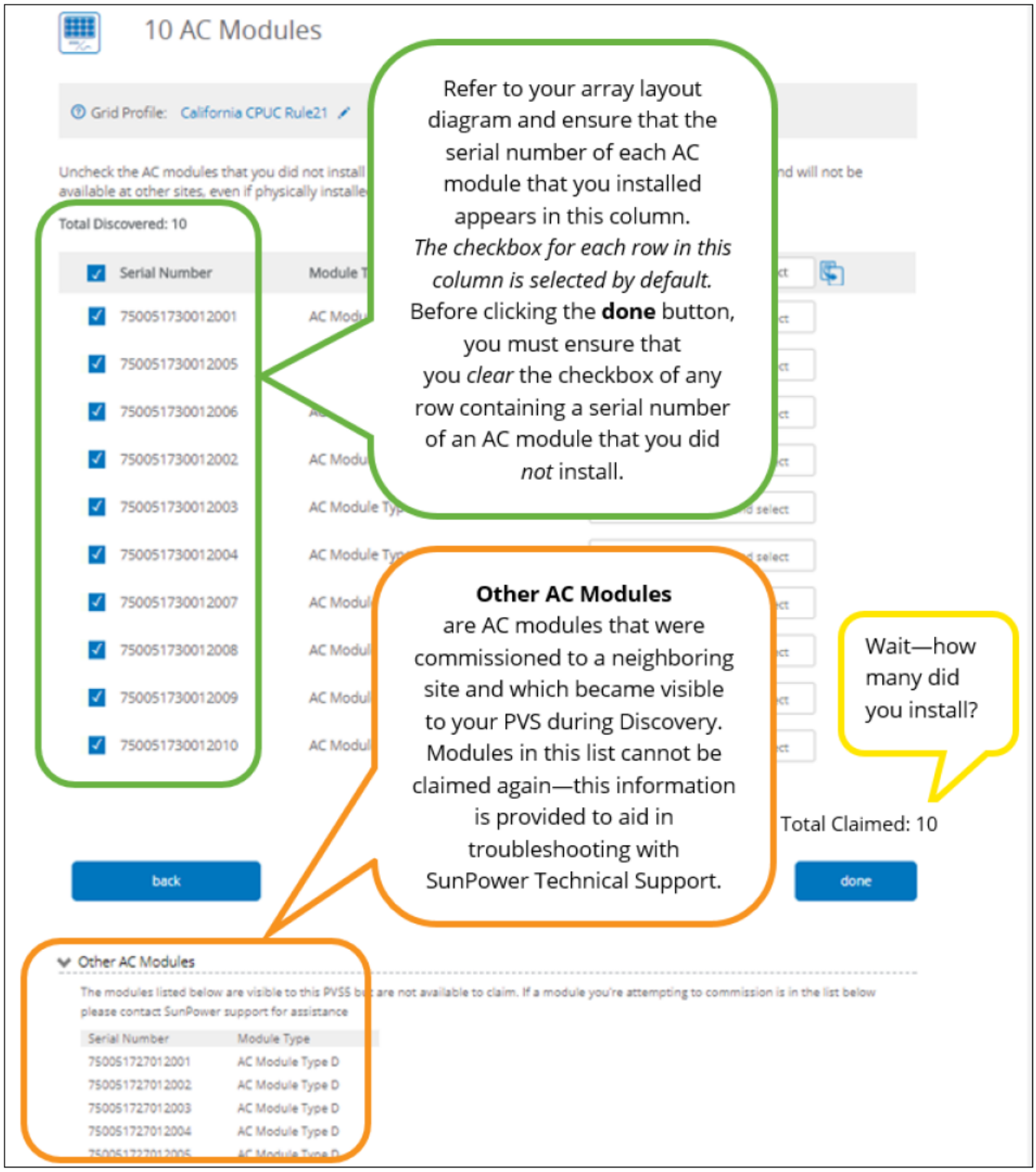
If you do not select the **Only Discover Equinox AC Devices** checkbox, the discovery process functions as it did prior to this enhancement—searching for and discovering all supported devices (AC modules, internal meters, external meters, and supported string inverters).

Device Configuration

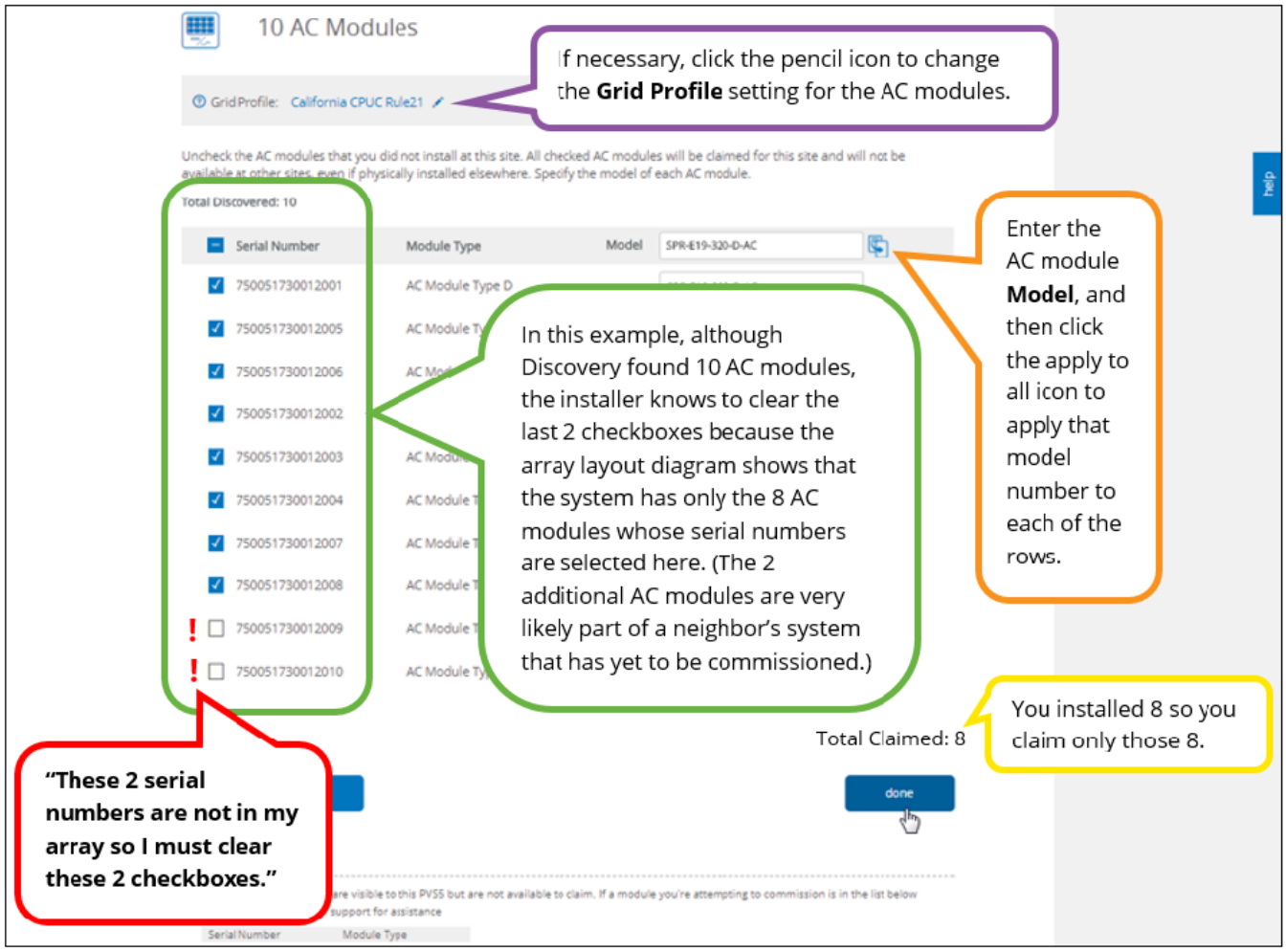
After discovery completes, you then configure the devices that were discovered:



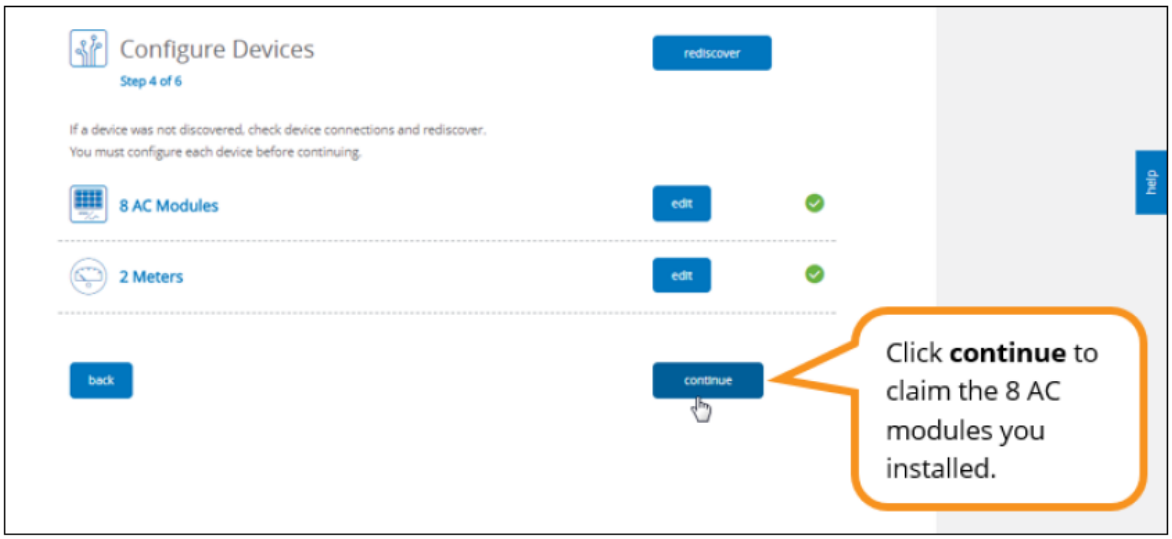
After you click **configure** in the AC Modules row, you must on the next screen verify that the **Serial Number** checkboxes are selected for ***only*** those AC modules which are installed at the site that you want to commission:



Improved functionality enables you to select and then claim only those AC modules which truly belong to the array that you installed at the site:



8 AC Modules displays here because you only left selected the checkboxes for the 8 installed serial numbers from your array layout diagram:



Click **continue** to claim the AC modules you configured, and then proceed with the commissioning flow as you normally would (verify device operations; create site; and module layout).

Action Required

The PVS5x will automatically download an updated version of the PVS Management App that includes these updates when you connect your laptop to the PVS5x. You simply need to be aware of—and correctly execute—the new functionality.

Result Expected

Installers will benefit from the new Equinox-only discovery feature because it will reduce the discovery time and provide an ability to select only those AC modules that they wish to commission.

Contacts

Phone		Email	
US & Australia	1-855-977-7867	**US & Australia**	technicalsupport@sunpower.com
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L.14 PVS Management App Q2 2017 Updates for Residential Commissioning, T17005

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Technical Notification

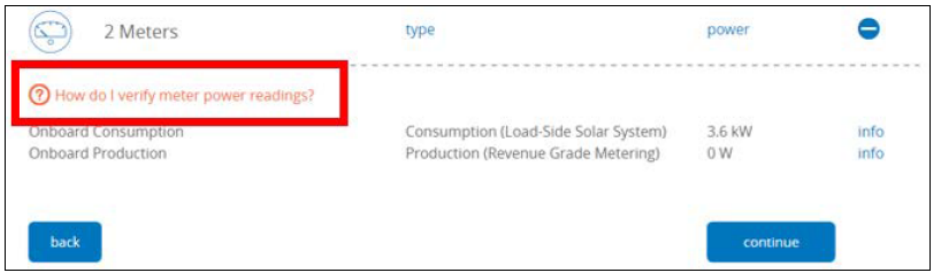
Title : PVS Management App Q2 2017 Updates for Residential Commissioning, T17005
Authors : Dylan Benjamin (Residential System Integration Sr. Manager), Lauren Stauss (Technical Writer)
Date : June 27th , 2017
Application : Commissioning Process for Monitoring Devices
Scope : All PVS5x Installations and Systems with PVS5x

Overview

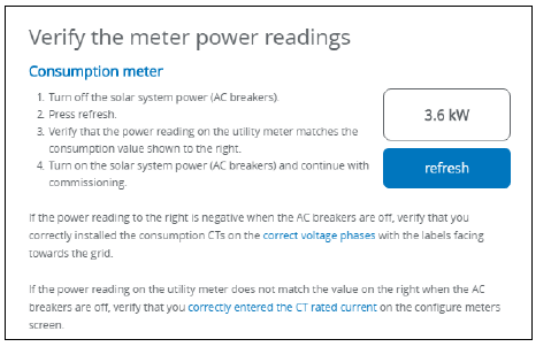
In the second quarter of 2017, improvements to the PVS Management App commissioning process will be available on all PVS5x systems. This Tech Note provides a summary of the new, expanded, and updated features.

Improved Help for Verifying Correct Meter Installation and Readings

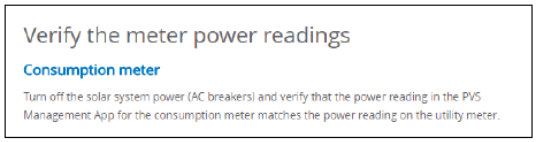
On the *Verify Devices* page you can click **How do I verify meter power readings?** to view instructions for verifying correct meter installation and readings based on the type of meter you installed:



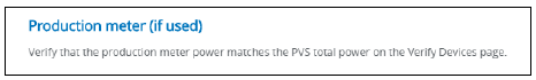
Verify Consumption Meter Power Readings for a Load-Side Solar System:



Verify Consumption Meter Power Readings for a Line-Side Solar System:

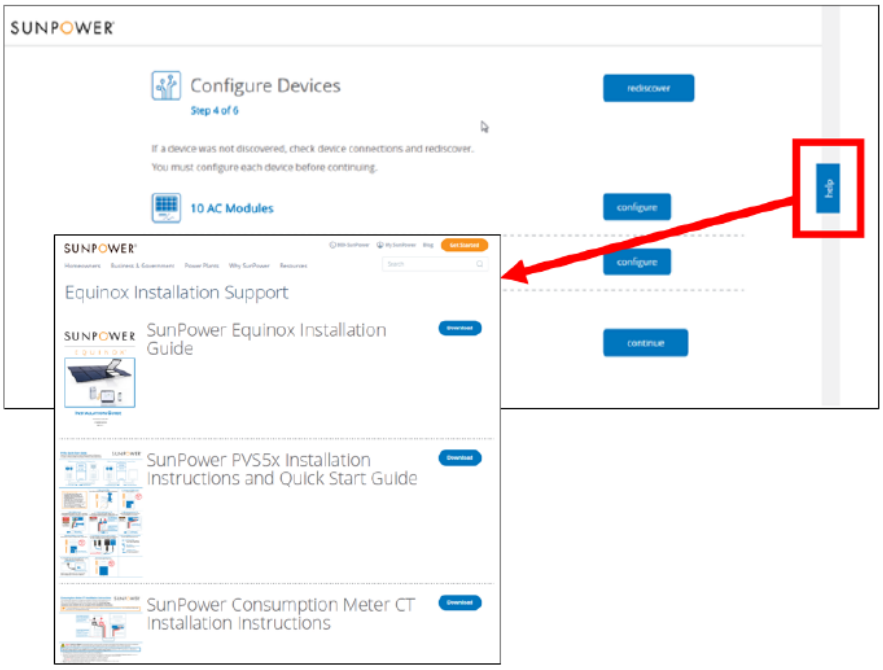


Production Meter:



Access to Equinox Installation Documents

After you have connected the PVS5x communication, you can click the **help** tab and click a link to access Equinox installation documents:



Enhanced Site Search and Selection Instructions

Always search for the site *before* you click **create site!**

On the Select Site to Commission page, type the site name, street address, city, or state in the search field—**do not copy and paste the entire address in the field:**

For additional information, refer to *Technical Notification: PVS Management App Select or Create Site to Commission (T16007).*

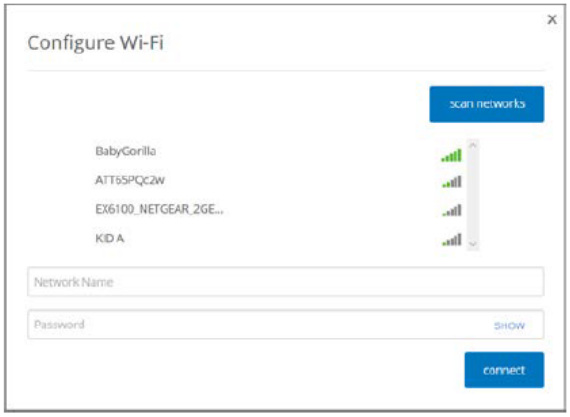
Added Customer Ability to Connect to Wi-Fi Network and Password

During commissioning you'll have multiple options to configure communication so that the PVS5x can send the solar system performance data over the internet. Most customers will choose to connect the PVS5x via their Wi-Fi network. We've added a feature in customers' SunPower monitoring accounts so that they can set

up their Wi-Fi option or update their network and password without a support call or installer visit.

To set up or update Wi-Fi network and password settings, the customer can:

1. Sign into their SunPower monitoring account at: https://monitor.us.sunpower.com.
2. Navigate to the **Settings** page.
3. Select the **My Wi-Fi header [...]** and select the **gear icon**.
4. Select their network and enter their password.



Improvements to App Stability

We made improvements to the app stability. We have improved the commissioning app stability based on feedback from installers in the field including: fixed error messaging and time out issues, updated screens and menus for ease of use, improved the automatic firmware check.

Action Required

There is no action required on your part for these updates. The PVS5x will automatically download an updated version of the PVS Management App that includes these updates when you connect your laptop to the PVS5x.

Result Expected

Installers and dealers will benefit from a more streamlined and intuitive commissioning process.

Contacts

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	0 805 090 808	**France**	supporttechnique@sunpowercorp.com
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	0808 281 8718	**UK**	techsupport.UK@sunpowercorp.com
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L.15 Equinox Commissioning Best Practices, T17016

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Technical Notification

Title : Equinox Commissioning Best Practices, T17016
Date : February 21, 2018
Author : Dylan Benjamin, Residential Systems Senior Integration Manager
Application : All Equinox installations

Overview

This Technical Notification describes a new PVS Management App versioning feature; and presents best practices for commissioning Equinox systems. This Technical Notification is also available on the Equinox Installation Support page, which you should bookmark (if you have not already) because it is your go-to repository of information to help ensure safe, smooth, high-quality Equinox installations: https://us.sunpower.com/support/install/equinox/

Firmware Versioning

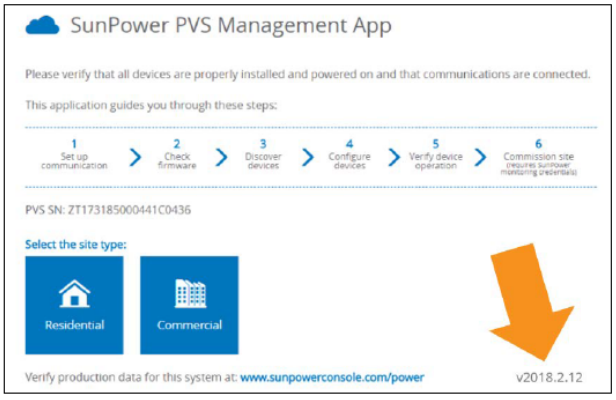
When you initiate the commissioning process, the system automatically checks to see whether there is a firmware update available. If an update is available, it will begin downloading automatically. After the firmware update completes, you will be redirected to the SunPower PVS Management App page. At that point:

You must refresh the page before you do anything else.

In addition, every single time you land on the SunPower PVS Management App page during the commissioning process, you must refresh the page before you do anything else.

Doing so will save you time and speed the successful commissioning of the system.

After you refresh the page, verify that a firmware version displays in the lower right corner of the SunPower PVS Management App page:



Firmware version number

If you do not see a version number, refresh the page again.

Commissioning Best Practices

- Use **only** Google Chrome OR Mozilla Firefox as your browser—*do not use Internet Explorer or any other browser.*
- **Every single time you arrive at the SunPower PVS Management App page, refresh the page. Yes—every time.**
- Exit your browser completely after you finish the commissioning process.

Result Expected

Installers will enjoy a smoother, more intuitive commissioning experience.

Contacts

Phone		Email	
US & Australia	1-855-977-7867	**US & Australia**	technicalsupport@sunpower.com
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	0808 281 8718	**UK**	techsupport.UK@sunpowercorp.com
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Appendix M: PVS5x Installation Instructions and Quick Start Guide

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PVS5x Installation Instructions

Follow these instructions to install and commission the PVS Supervisor 5x (PVS5x) to receive monitoring data. **See the *Equinox Installation Guide (#518101)* for the complete Equinox (AC Modules, InvisiMount, and PVS5x) installation instructions.**

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Kit includes:

- PVS Supervisor 5x (PVS5x)
- Mounting bracket
- (2) Screws
- (2) Hole plugs
- (2) 100 A Current Transformers (shipped separatley)
- PLC Ethernet Adapter (optional accessory from SunPower)

You will need:

- Phillips screwdriver
- Small flathead screwdriver
- Hardware that supports 6.8 kg (15 lbs) to install the bracket
- RJ45 crimp tool
- Wire cutter
- Wire stripper
- Laptop with latest Chrome or Firefox version installed
- Ethernet cable
- Your SunPower monitoring website credentials
- (Optional) Customer's Wi-Fi network and password

Routing wire and cable:

- **Fill all openings in the enclosure with components rated Type 4 or better to maintain the integrity of the enclosure's environmental system**
- Drill extra openings with appropriate knockout tools (**do not** use screwdriver and hammer)
- Use only the provided conduit openings or knockout locations and never cut holes in the top or sides of the enclosure
- Never run inverter or Ethernet communication cable in the same conduit as AC wiring
- CT and AC wiring may be run in the same conduit

1. Mount the PVS5x

1. Select an installation location that is not in direct sunlight.
2. Mount the PVS5x bracket using appropriate hardware for the mounting surface and that can support 6.8 kg (15 lbs).
3. Fit the PVS5x onto the bracket until the mounting holes at the bottom are aligned.
4. Use a screwdriver to secure the PVS5x to the bracket using the provided screws. Do not overtighten.

2. Wire the PVS5x power

***Danger!* Hazardous voltages! Do not power up the system until after you complete Sections 1 through 3.** Accessing the system involves possible contact with potentially lethal voltages and currents. No attempt to access, install, adjust, repair, or test the system should be made by anyone who is not qualified to work on such equipment.

1. Use a screwdriver—do not use power tools—to prepare the PVS5x for AC wiring:
   - Loosen the three captive screws on the bottom of the PVS5x enclosure and remove the cover
   - Remove the lower AC wiring cover
   - Remove the upper AC wiring cover
   - Flip the AC wiring partition to the opposite side of where your AC wiring will be incoming
   Warning! Do not use the AC wiring partition to secure cables or wiring.
2. Run power conduit from the service panel to the PVS5x. If you use the rear conduit entrances, seal the holes on the bottom of the enclosure with the included hole plugs.
3. Connect the PVS5x to either a 15 A (with 14 AWG) or a 20 A (with 12 AWG) UL Listed dedicated dual-pole breaker.
   Note: For AC modules, this breaker should be in the same service panel containing the AC module output circuits.
4. Strip wires and land according to the color-coded labels (black wire to **L1**, red wire to **L2**, the white wire to **N**, and green wire to **GND**) in the J5 terminals on the bottom, left of the PVS5x board. Tighten to 0.5–0.6 N-m (4.4–5.3 in-lb).
   Caution! Do not overtighten terminals.

3. Install and wire the consumption CTs

***Danger!* Hazardous voltages! Do not power up the system until after you complete Sections 1 through 3.** Accessing the system involves possible contact with potentially lethal voltages and currents. No attempt to access, install, adjust, repair, or test the system should be made by anyone who is not qualified to work on such equipment.

The SunPower-provided CTs are suitable for use on 200 A conductors. CTs may be labeled "100 A" but this is a calibration reference rating only. You may install CTs in parallel or bundled configurations. **Refer to the *Consumpion Meter CT Installation Instructions*.**

1. Turn off all power to the main service panel in which you are installing CTs.
2. Place the CTs in the main service panel, around incoming service conductors, with the side labeled **THIS SIDE TOWARD SOURCE** *toward the utility meter* and *away from the loads*. Never install CTs in the utility-designated section of the the service panel.
   - Place **L1 CT** (black and white wires) around incoming Line 1 service conductor
   - Place **L2 CT** (red and white wires) around incoming Line 2 service conductor
3. Align the steel core pieces and snap the CTs closed.
4. Route CT wires through conduit to PVS5x.
   - **Running CT wires:** You may run CT and AC wiring in the same conduit. Do not run CT wiring and internet communication cables in the same conduit.
   - **Extending CT leads:** Use Class 1 (300V rated minimum, 16 AWG maximum) twisted-pair instrument cable and appropriate connectors; SunPower recommends the use of silicone-filled insulation displacement connectors (IDC) or telecom crimps; do not use power cables (for example, THWN or Romex) to extend the CT leads.
     Note: See *Continental Control Systems: Current Transformer (CT) Wire Extension* guide at: https://ctlsys.com/current_transformer_wire_extension for suggested wire types and sources.
5. Land **L1 CT** and **L2 CT** wires in corresponding **CONS L1** and **CONS L2** in the J16 terminals on the bottom, right terminals of the PVS5x board. Tighten to 0.5–0.6 N-m (4.4–5.3 in-lb). If you shorten the leads, strip no more than 6mm (1/4").
   Caution! Do not overtighten terminals.

4. Verify CT Voltage Phases

1. Turn on power to the PVS5x.
2. Use a voltmeter to measure voltage between the PVS5x L1 terminal and the L1 incoming service conductor in the main service panel with the L1 CT in place.
3. If the voltmeter reads:
   - 0V the phases are correctly aligned.
   - 240V the phases are incorrectly aligned. Move the CT to the other incoming service conductor and retest to verify 0V.
4. Repeat Steps 4.2 and 4.3 for L2.

5. Connect the system communication

1. Replace the upper AC wiring cover.
2. Replace the lower AC wiring cover over the AC power wires (on the left if you ran through left hole; on the right if you ran through the right hole).
3. Run communication conduit to the PVS5x conduit opening. If you use the rear conduit entrances, seal the holes on the bottom of the enclosure with the included hole plugs.
   Warning! Never run inverter communications cable in same conduit as AC wiring.
4. Connect communication for each device using corresponding port:
   - **AC modules**: Verify that you connected the AC modules to the AC module subpanel. No additional connection is required, the PVS5x communicates with AC Modules using PLC protocol.
   - **SMA US-22 inverter:** Connect an RS-485 communication cable from the PVS5x **RS-485 2-WIRE** port (blue) and to the first (or only) inverter in the daisy chain. Follow the manufacturer's instructions to daisy-chain additional SMA US-22 inverters.
   - **SMA US-40 inverter:** Connect a tested Ethernet cable from the PVS5x **LAN1** port to first (or only) SMA US-40 port A or B. Follow the manufacturer's instructions to daisy-chain additional SMA US-40 inverters using Ethernet cables.

6. Connect the PVS5x to the internet

Connect to customer's Internet using either:

- **Ethernet cable:** from PVS5x LAN2 to customer's router **(recommended method)**
- **Power Line EA:** to customer's router (optional accessory available from SunPower)
- **Customer's Wi-Fi network:** connect during commission (Section 6) using customer's Wi-Fi network name and password

7. Commission with the PVS Management App

1. Turn laptop Wi-Fi off.
2. Use an Ethernet cable to connect your laptop to either the PVS5x or the inverter based on installation type:
   - **AC module or SMA US-22:** Connect laptop to PVS5x **LAN 1** port.
   - **SMA US-40 inverter:** Connect laptop to available communication port **(A or B)** in the last (only) inverter.
3. Open a browser (the latest version of either Chrome or Firefox) and type: www.sunpowerconsole.com.
4. Follow the PVS Management App onscreen instructions.
5. Replace the PVS5x enclosure cover and use a screwdriver to tighten the three screws on the bottom of the enclosure.

Safety & Certifications

Safety Instructions

Installation and field service is to be performed only by qualified, trained personnel with the necessary skills and knowledge to work on this type of electrical device. Field service is limited to the components contained in the lower compartment of the PVS5x.

- Perform all electrical installations in accordance with any national and local codes, such as the National Electrical Code (NEC) ANSI/NFPA 70.
- This enclosure is suitable for use indoors or outdoors (Type 3R). Operating ambient from –30°C to 60°C.
- Before connecting power, the PVS5x must be securely mounted to an inside or outside wall following the instructions in this document.
- For electrical wiring code compliance, connect the PVS5x to a dedicated UL Listed 15 A rated breaker using 14 AWG wiring, or a UL Listed 20 A rated breaker using 12 AWG wiring. The input operating current is less than 0.1 amp with AC nominal voltages of 240 VAC (L1–L2).
- The PVS5x contains internal transient surge protection for connection to the load side of the service entrance AC service panel (overvoltage category III). For installations in areas at risk of surges generated by high-voltage utilities, industry, or by lightning, it is recommended that an external surge protective device also be installed.
- Do not attempt to repair the PVS5x. Tampering with or opening the upper compartment voids the product warranty.

Safety Certification

- UL Listed to UL60950-1 ITE and UL60950-22 for outdoor use.
- The PVS5x is not a utility meter, disconnect device, or power distribution device.

FCC Compliance

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions:
(1) This device may not cause harmful interference, and
(2) This device must accept any interference received, including interference that may cause undesired operation.
NOTE: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.

IMPORTANT NOTES:
Radiation Exposure Statement
This equipment complies with FCC RF radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with minimum distance 25 cm (9.84 in) between the device and your body.

CAUTION:
Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment. This device and its antenna(s) must not be co-located or operating in conjunction with any other antenna or transmitter except in accordance with FCC multi-transmitter product procedures.

PVS5x Quick Start Guide

Follow these instructions to install, configure, and commission the PVS Supervisor 5x (PVS5x) to begin receiving monitoring data. **Refer to the *PVS5x Installation Instructions on the other side* for the complete PVS5x installation instructions.**

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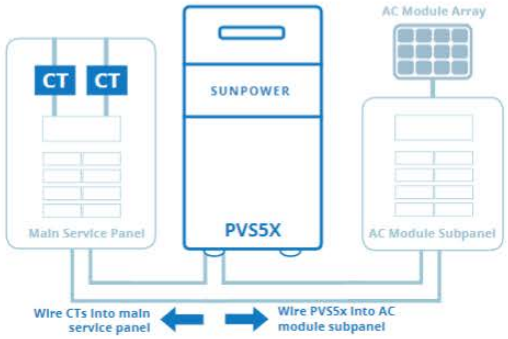
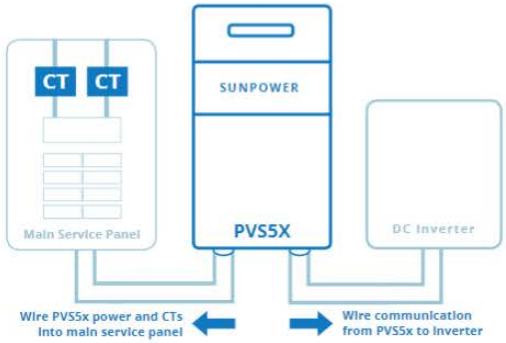
PVS5x Connection Diagram: AC Module Site



PVS5x Connection Diagram: DC Inverter Site

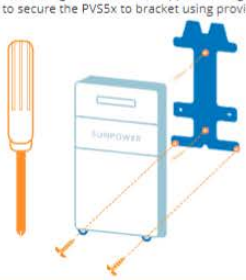


Routing wire and cable:

- **Fill all openings in the enclosure with components rated Type 4 or better to maintain the integrity of the enclosure's environmental system**
- Drill extra openings with appropriate knockout tools (**do not** use screwdriver and hammer)
- Use only the provided conduit openings or knockout locations and never cut holes in the top or sides of the enclosure
- Never run inverter or Ethernet communication cable in the same conduit as AC wiring
- CT and AC wiring may be run in the same conduit

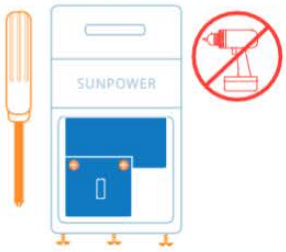
1. Mount the PVS5x

Mount PVS5x bracket using hardware that supports 6.8 kg (15 lbs) and use screwdriver to secure the PVS5x to bracket using provided screws.



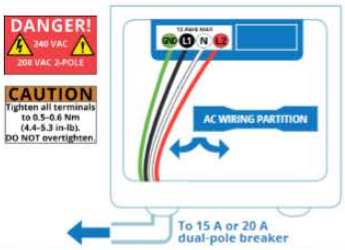
2. Remove all PVS5x covers

Use screwdriver to remove enclosure and AC wiring covers.



3. Wire PVS5x power

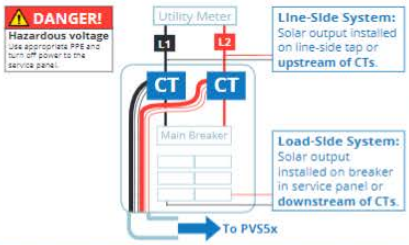
Install a dedicated 240 or 208 VAC circuit. Flip AC wiring partition to opposite side of incoming AC wiring. Land wires in J5 terminals: black to L1, red to L2, white to N, and green to GND.



4. Install consumption CTs

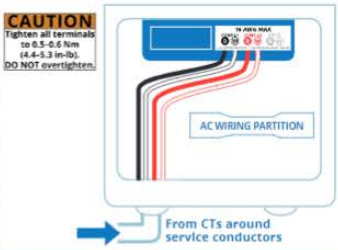
Refer to Section 3 on the other side for complete CT installation instructions.

Place CTs around incoming service conductors: L1 CT (black and white wires) around Line 1 and L2 CT (red and white wires) around Line 2.



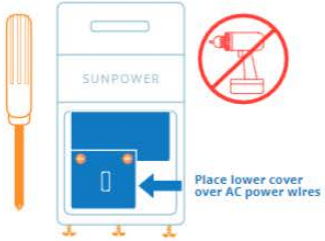
5. Wire consumption CTs

Land wires in J16 terminals: L1 CT and L2 CT wires in corresponding CONS L1 and CONS L2.



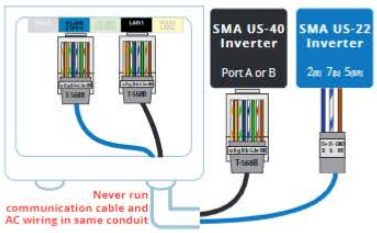
6. Replace PVS5x wiring covers

Use screwdriver to replace AC wiring covers over AC power wires.



7. Connect DC inverter communication

If DC inverter is installed, connect communication from DC inverter to the PVS5x. No additional connection is required for AC modules.



8. Connect PVS5x to the internet

Connect to customer's internet with either:

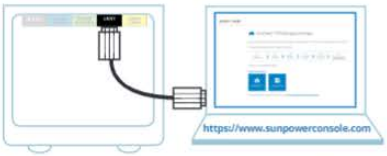
Ethernet Cable
From PVS5x LAN2 to customer's router (recommended method).

PLC Adapter
(optional SunPower accessory)
To customer's router.

Customer's Wi-Fi
Connect during commissioning with network and password.

9. Commission with PVS Management App

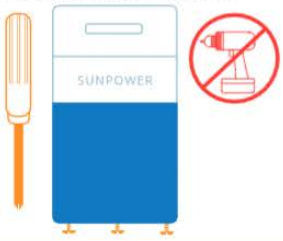
Turn off laptop Wi-Fi off, connect Ethernet cable from PVS5x LAN1 to laptop, open latest Chrome or Firefox, type www.sunpowerconsole.com, and follow instructions.



Note: For sites with SMA US-40 DC inverter, connect Ethernet cable from laptop to port A or B in the last (or only) inverter.

10. Replace PVS5x cover

Use screwdriver to replace enclosure cover.



Appendix N: Consumption Meter CT Installation Instructions and Alternate CT Installation Configurations

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Consumption Meter CT Installation Instructions

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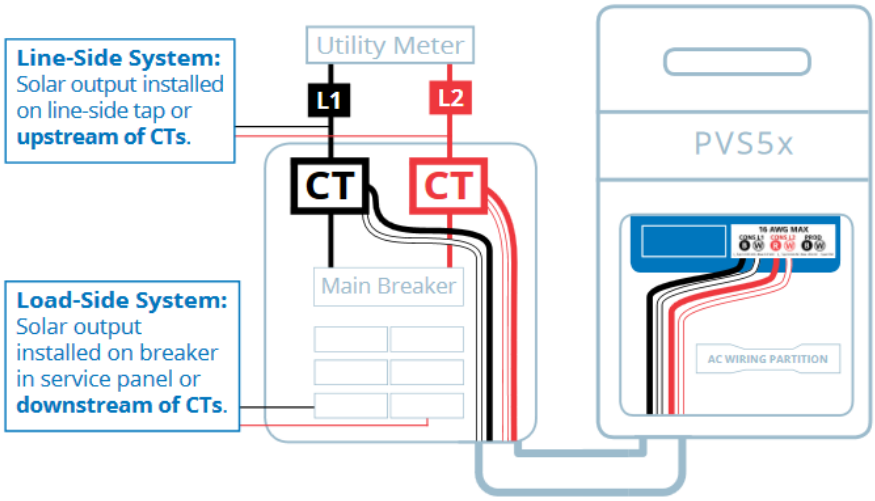
To monitor the customer's energy consumption with the PVS5x onboard meter, you must follow these instructions to install the SunPower-provided split-core current transformers (CTs) for consumption metering. **See the *PVS5x Installation Guide (#522351)* for the complete PVS5x installation instructions.**

To see training videos or enroll in training webinars: go to **www.sunpowerpartnerconnect.com**, select **SunPower University**, and search for *Consumption Monitoring*.



Warning! Accessing the system involves possible contact with potentially lethal voltages and currents. No attempt to access, install, adjust, repair, or test the system should be made by anyone who is not qualified to work on such equipment.

The SunPower-provided CTs are suitable for use on 200 A conductors. CTs may be labeled "100 A" but this is a calibration reference rating only. You may install CTs in parallel or bundled load configurations.

1. Turn off all power to the main service panel in which you are installing CTs.
2. Place the CTs in the main service panel, around incoming service conductors, with the side labeled **THIS SIDE TOWARD SOURCE** *toward the utility meter* and *away from the loads.* Never install in the section designated for the utility in the service panel.
   - Place **L1 CT** (black and white wires) around incoming Line 1 service conductor.
   - Place **L2 CT** (red and white wires) around incoming Line 2 service conductor.

   Note: If CTs do not fit in this location, refer to *Alternate CT Installation Configurations* on page 2 of these instructions.
3. Align the steel core pieces and snap the CTs closed.
4. Route CT wires through conduit to the PVS5x.
   - **Running CT wires:** You may run CT and AC wiring in the same conduit. Do not run CT wiring and internet communication cables in the same conduit.
   - **Extending CT leads:** Use Class 1 (600 V rated minimum, 16 AWG maximum) twisted-pair instrument cable and appropriate connectors; SunPower recommends the use of silicone-filled insulation displacement connectors (IDC) or telecom crimps; do not use power cables (for example, THWN or Romex) to extend the CT leads.
     Note: See *Continental Control Systems: Current Transformer (CT) Wire Extension* guide at: https://ctlsys.com/current_transformer_wire_extension for suggested wire types and sourcing.
5. Land **L1 CT** and **L2 CT** wires in corresponding **CONS L1** and **CONS L2** in the J16 terminals of the PVS5x wiring compartment (refer to the diagram above). Tighten to 0.5–0.6 N-m (4.4–5.3 in-lb). If you shorten the leads, strip no more than 6 mm (1/4").
   Important! Do not overtighten terminals.
6. Verify CT voltage phases:
   a. Turn on power to the PVS5x.
   b. Use a voltmeter to measure voltage between the PVS5x L1 power terminal (J5) and the L1 incoming service conductor in the main service panel with the L1 CT in place.
   c. If the voltmeter reads:
      - 0 V the phases are correctly aligned.
      - 240 V the phases are incorrectly aligned. Move the CT to the other incoming service conductor and retest to verify 0 V.
   d. Repeat Steps 6.b and 6.c for L2.
7. When commissioning the system with the PVS Management App, set the CT rated current on the configure meter screen to **100 Amps** (the sum of CT values per phase).

Alternate CT Installation Configurations

Below are examples of parallel CTs (multiple conductors) and bundled load (inaccessible service conductors) configurations. Not all possible configurations are represented.

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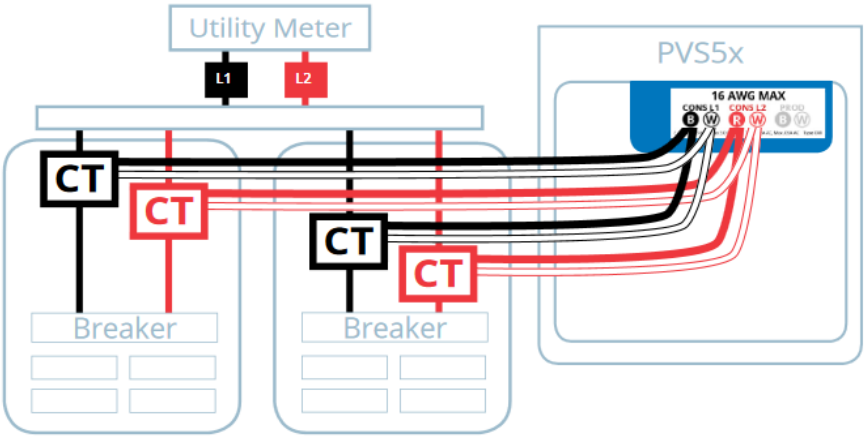
Parallel Sets of CTs

To capture multiple conductors, install parallel sets of same size CTs:

1. Twist matching CT leads together or splice onto a single conductor, then land each set of **L1 CTs** and **L2 CTs** wires in corresponding **CONS L1** and **CONS L2** PVS5x terminals.
2. Verify that both sets of **L1 CTs** are on **L1** conductors and **L2 CTs** are on **L2** conductors.
3. Verify CT voltage phases by completing Step 6 on page 1 of these instructions.
4. When configuring meters during commissioning, set the *CT rated current* to **200 Amps** (sum of CT values per phase).

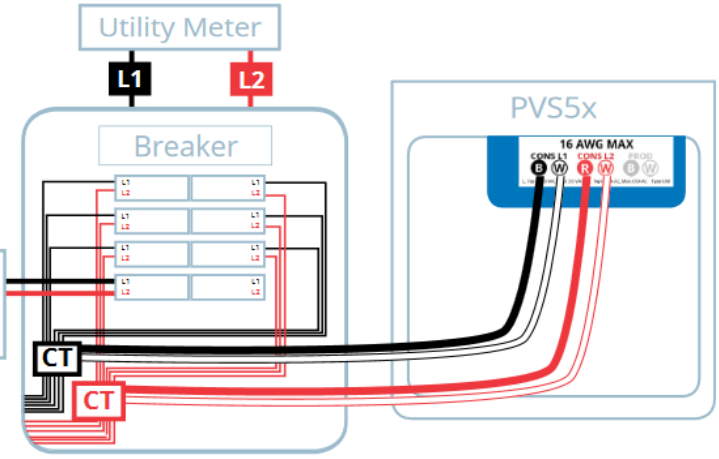


Bundled Loads, Single Set of CTs

If the service conductors are inaccessible, install the CTs on bundled load circuits:

1. Separate all load circuits into **L1** and **L2** groups and route through corresponding **L1 CTs** and **L2 CTs**. **Do not route solar system output circuits through CTs.**
2. Verify that the side labeled THIS SIDE TOWARD SOURCE *is toward the utility meter* and *away from the loads.*
3. Land **L1 CT** and **L2 CT** wires in corresponding **CONS L1** and **CONS L2** PVS5x terminals.
4. Verify CT voltage phases by completing Step 6 on page 1 of these instructions.
5. When configuring meters during commissioning, set th
   - *CT rated current* to **100 Amps** (sum of CT values per phase).
   - *Onboard Consumption Meter* to **Line-Side Solar System** for systems with bundled loads.

Solar System Output: AC modules or DC inverters

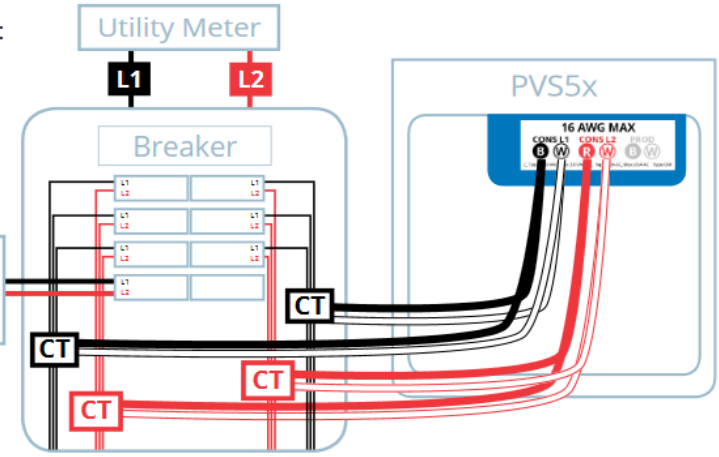


Bundled Loads, Parallel Sets of CTs

To install parallel sets of same size CTs on bundled load circuits:

1. Separate all load circuits into **L1** and **L2** groups and route through corresponding **L1 CTs** and **L2 CTs**. **Do not route solar system output circuits through CTs.**
2. Verify that the side labeled THIS SIDE TOWARD SOURCE *is toward the utility meter* and *away from the loads.*
3. Twist matching CT leads together or splice onto a single conductor, then land each set of **L1 CTs** and **L2 CTs** wires in corresponding **CONS L1** and **CONS L2** PVS5x terminals.
4. Verify that **L1 CTs** are on **L1** conductors and **L2 CTs** are on **L2** conductors.
5. Verify CT voltage phases by completing Step 6 on page 1 of these instructions.
6. When configuring meters during commissioning, set the:
   - *CT rated current* to **200 Amps** (sum of CT values per phase).
   - *Onboard Consumption Meter* to **Line-Side Solar System** for systems with bundled loads.

Solar System Output: AC modules or DC inverters



Appendix P: Production Meter CT Installation Instructions

Production Meter CT Installation Instructions

To monitor the customer's energy production with the PVS5x revenue-grade onboard meter, you must follow these instructions to install the optional SunPower, revenue-grade, solid-core current transformer (CT) for production metering. **See the *PVS5x Installation Guide (#522351)* for the complete PVS5x installation instructions.**

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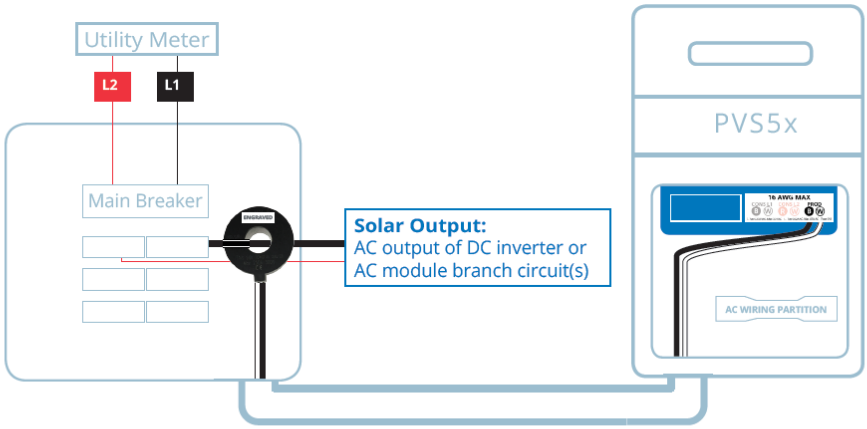

Warning! **Hazardous voltages!** Accessing the system involves possible contact with potentially lethal voltages and currents. No attempt to access, install, adjust, repair, or test the system should be made by anyone who is not qualified to work on such equipment.

1. Power off AC modules or DC inverters.
2. Place the solid-core production CT over the combined or grouped individual **AC L1** outputs with the engraved markings on the CT *facing the grid and facing away from the inverter or combiner*.
   Important! Do not overfill CT. Do not install parallel production CTs.
3. Route CT wires through conduit to the PVS5x.
   - **Running CT wires:** You may run CT and AC wiring in the same conduit. Do not run CT wiring and internet communication cables in the same conduit.
   - **Extending CT leads:** Use Class 1 (300V rated minimum, 16 AWG maximum) twisted-pair instrument cable and appropriate connectors; SunPower recommends the use of silicone-filled insulation displacement connectors (IDC) or telecom crimps; do not use power cables (for example, THWN or Romex) to extend the CT leads.
4. Land the CT leads in corresponding J16 **PROD** terminals of the PVS5x wiring compartment (refer to the diagram above). Tighten to 0.5–0.6 N-m (4.4–5.3 in-lb).
   Important! Do not overtighten terminals.

Equipment Specifications
- SunPower part number: 516990
- Rated Amps: 100 A
- Maximum Amps: 250 A (maximum amps are the maximum continuous currents the CTs can sustain without overheating)

Environmental Specifications
- Operating Temperature: –40°C to +85°C (–40°F to 185°F)
- Operating Humidity: Non-condensing, 0 to 100% relative humidity (RH)
- Operating Altitude: Up to 3000m
- Pollution: POLLUTION DEGREE 2
- Indoor Use: Suitable for indoor use
- Outdoor Use: Suitable for outdoor use when mounted in a NEMA 3R or 4 (IP 66) rated enclosure, provided the ambient temperature will not exceed 55°C (131°F).

Safety Instructions
- Only qualified personnel or licensed electricians should install the current transformer (CT). The line voltages of 120 Vac to 600 Vac can be lethal!
- Install in accordance with ANSI/NFPA 70, National Electrical Code (NEC). Follow all local electrical codes.
- Electrical codes prohibit installation of CTs in equipment where they exceed 75% of the wiring space of any cross-sectional area.
- Do not install CTs where they block ventilation openings.
- Do not install CTs in the area of breaker arc venting.
- The CT lead wires are considered Class 1 wiring (as defined by the NEC) and must be installed accordingly. They are not suitable for Class 2 wiring methods and should not be connected to Class 2 equipment.
- Verify that the line currents will not exceed the Maximum Amps under normal operation.
- Do not install the CT where it may be exposed to temperatures below –40°C or above 85°C (–40°F to 185°F), excessive moisture, dust, salt spray, or other contamination.
- If the equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.

Appendix Q: EnergyLink PVS5x Knockout Template

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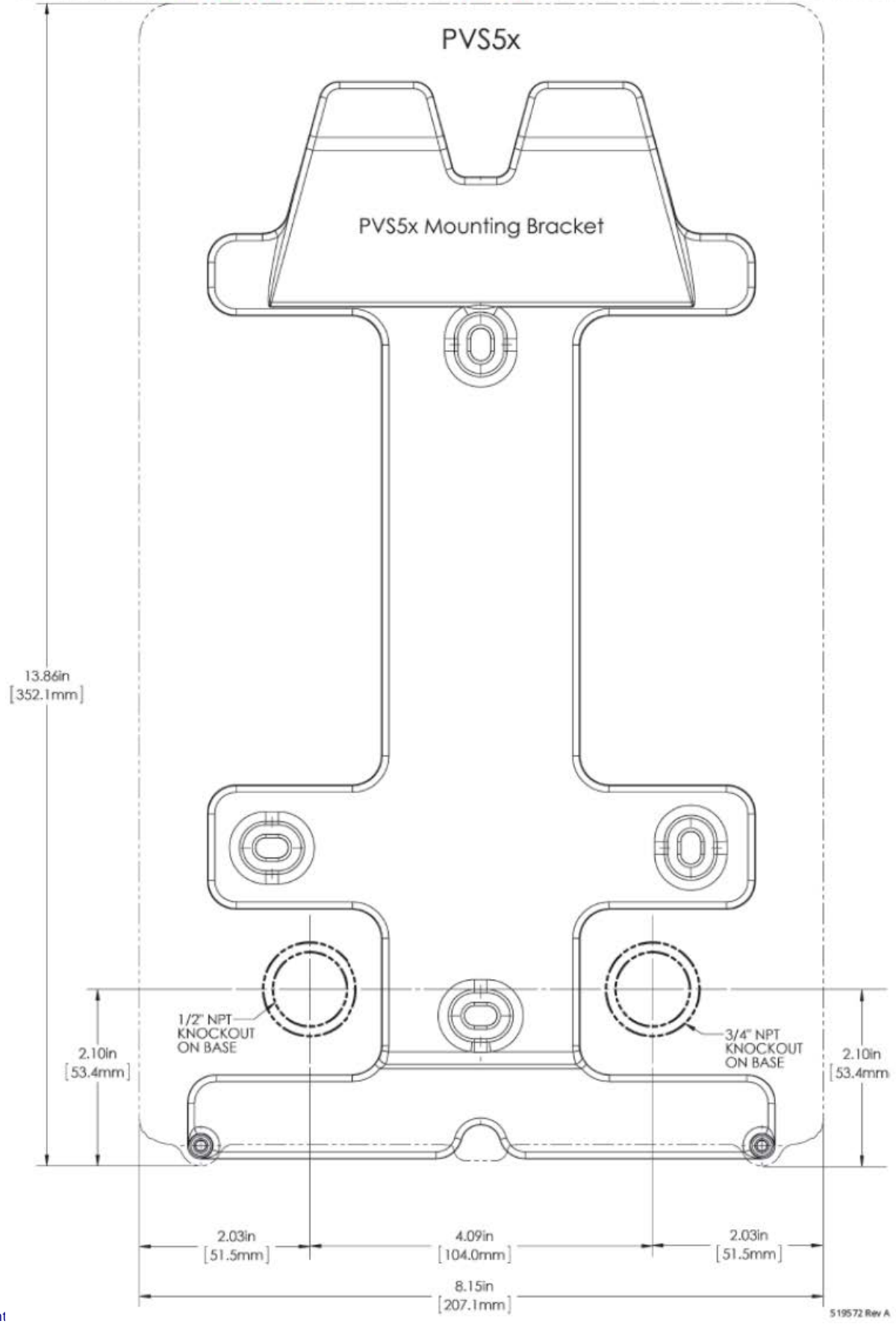
EnergyLink™ PVS5x Knockout Template

See the SunPower *Quick Start Guide: EnergyLink™ with PVS5x* for installation instructions.

Print this template on **11" x 17" paper**, in **Portrait** orientation and select **Actual Size** in print options dialogue for accurately scaled dimensions.



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