MANUAL, INSTALLATION, T5 SOLAR ROOF TILE

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SunPower T5 Solar Roof Tile

INSTALLATION MANUAL

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1.0 Introduction

Warning! Do not attempt any aspect of the installation until you have thoroughly read this *entire* installation manual.

The SunPower™ T5 Solar Roof Tile System features photovoltaic (PV) modules installed at a five-degree tilt to capture and generate maximum energy. The array incorporates aerodynamic and structural design features to maintain array integrity. The system operates invisibly with the existing electrical network, comes with a 30-year design life, and is engineered to resist wind uplift.

1.1 Overview

The SunPower T5 Solar Roof Tile System ("the system") has a distributed base weight of 2.2 lbs/ft^2 (11.5 kg/m^2) and can be installed on most buildings without exceeding roof loading limits. The modules ship nested for easy transport, handling, and installation.

Note. The distributed weight may vary depending on the ballast requirements for the site.

1.1.1 System Features

- **Pre-Engineering.** The system is a complete, pre-engineered solar product, specifically designed for fast and easy installation and maximum energy capture.
- **Thirty-Year Design Life.** All structural components are made of inert, UV-resistant polymeric materials, and individual modules do not require grounding. The components also protect the roof from the damaging effects of weather and UV degradation.
- **Easy Installation.** The system does not require mechanical roof attachments in most applications, which means large-scale solar arrays can be rapidly and easily installed. Each module uses an identical set of installation components, allowing arrays to be virtually any shape or size.
- **Interlocking Components.** The system features an exclusive interlocking module design that enables easy electrical and mechanical installation.

1.1.2 System Benefits

- **Increased Energy Production.** The angled or sloped system is more efficient at capturing sunlight than flat systems and thus offers increased solar energy production.
- **Non-Obstructive Design.** The system is designed to allow for unobstructed drainage of the roof and will not interfere with roof operations or maintenance.

1.1.3 System Scope

Note. It may be necessary for SunPower Dealers to source some system components independently.

Complete systems comprise the following components:

- Arrays of interconnecting modules
- Ballast blocks and tubes installed throughout the array (when required)
- Wind deflectors constructed of UV-resistant polymeric materials
- Combiner boxes
- Plug-in electrical connectors
- DC wiring
- DC disconnects
- Grid-connected inverters
- AC disconnects
- Data acquisition and monitoring system (DAS)
- Isolation transformers

The DC source circuits are connected at the end of specific rows as specified in the final project specifications. The inverter must be wired to the site utility distribution grid through an appropriate step-up isolation transformer with the appropriate level of protection as required by the local authority having jurisdiction (AHJ).

The work includes furnishing all labor, materials, and equipment necessary to complete installation of the system.

1.1.4 Warranties

The system (excluding the modules and inverter) is warranted as specified in the Purchase Agreement; SunPower Dealers should refer to the Equipment Purchase Agreement.

- The modules are covered by the manufacturer's limited warranty which is passed from SunPower to the customer.
- The inverter is covered by the manufacturer's limited warranty which is passed from SunPower to the customer; SunPower Dealers should refer to the SunPower Dealer Portal for inverter warranty information.

1.1.5 Quality Assurance

- SunPower modules are certified by the Canadian Standards Association (CSA) to Underwriters' Laboratories (UL) Standard 1703.
- SunPower modules meet or exceed the requirements set forth by the International Electrotechnical Commission (IEC) 61215 Edition 2 for PV Modules for Class A Applications.

1.1.6 Electrical Characteristics

The wires built onto the modules—as well as the homerun wires—incorporate USE-2 wire and quick-connect plug connectors to ensure secure connections and ample power-handling capacity throughout the array.

In addition:

- Modules can be connected in series or in parallel to achieve the desired electrical output, but must not exceed system design voltage (600 VDC in the United States; 1000 VDC in Europe).
- Fusing requirements and limitations on the maximum number of modules that can be connected in parallel are subject to local codes and regional authorities.
- Only modules of the same type should be used together in a combined source circuit.
- A given module may produce greater current, voltage, or both than reported for standard test conditions (STC). Sunny, cool weather and reflection from snow or water can increase current and power output. Therefore, the I_{SC} and V_{OC} values marked on the module should be multiplied by a factor of 1.25 when determining component voltage ratings, conductor ampacities, fuse sizes, and the size of controls connected to PV output. An additional 1.25 multiplier may be required by certain local codes for sizing fuses and conductors. Refer to the authority having jurisdiction (AHJ).

1.1.7 Mounting Considerations

- The modules are designed to be installed without anchors on rooftops having a pitch no greater than 1:12.
- The integrated support structure limits the module angle to 5 degrees relative to the roof surface.
- The modules shall be installed over a fire-resistant roof covering rated for the application, including a slip sheet when required on the PPF or the drawings.

1.1.8 Delivery, Storage, and Handling

Care must be taken to protect the modules during delivery, storage, unpacking, and installation. To avoid frame damage, always ensure that two workers handle a given module—*modules should never be transported by just one person.*

Warning! *Do not step, stand, or walk on the modules!*

Appropriate protective clothing must be worn when handling the materials. Such clothing must include hard hats, protective eyewear, and steel-toe boots when lifting materials, and insulated gloves when working on an electrically active system.

1.1.9 Maintenance

The system owner's responsibilities include ensuring regular inspections of the system to confirm perimeter security, system operation, as well as maintenance and repairs to ensure integrity and maximum performance of the system.

1.1.10 Product Information

SunPower T5 technology is protected by US Patent Numbers 5,505,788 and 5,746,839. In addition, other US or international patents issued or pending may apply.

Suppliers

- **Modules.** The system incorporates SunPower® modules.
- **Inverters.** Inverters must be provided by a SunPower-approved supplier. For SunPower Dealers, the inverters are typically included in a packaged equipment purchase.
- **Additional Components.** Remaining system components are supplied by SunPower, the Dealer, or by the general contractor with approval from SunPower.

Manufactured Units

Refer to the SunPower T5 Solar Roof Tile datasheet for complete electrical and physical characteristics:

http://us.sunpowercorp.com/commercial/products-services/rooftop-solar-systems/T5/

Values for the electrical characteristics are within ±10 percent of the indicated values of I_{SC}, V_{OC}, and were determined under Standard Test Conditions (STC):

Irradiance = 1,000 W/m$^{2;}$ Cell Temperature = 25° C; Spectral Irradiance per ASTM E892.

System Electrical

All electrical components must be rated for the particular site and application and must be installed according to the specific instructions in this manual.

Wind Loading

System structural design and ballast requirements must be reviewed and approved by SunPower Technical Support in order for the system design to be approved for purchase, or for the system to be commissioned and warranted; and must meet the local standards for design wind loads for the particular application.

SunPower will inspect all Dealer-installed systems for adherence to the approved SunPower Commercial Pre-Purchase Form (PPF) which includes the original approved layout and project-related site and system details.

Uplift, Seismic Loading, and Snow Loading

System structural design must be reviewed and approved by SunPower Technical Support in order for the system to be covered under warranty, and must meet the local standards for seismic and snow loads for the particular application.

The following uplift and load values are applicable to all T5 systems:

	US	EU
Uplift	215 lbs (97.6 kg)	97.6 kg (215 lbs)
Lateral Load (for seismic areas)	400 lbs (182 kg)	182 kg (400 lbs)

Installation Standards

System installation must conform to SunPower installation standards, and either the PPF or the approved SunPower project drawing set (“the drawings”).

All local, National Electrical Code (NEC), and International Electrotechnical Commission (IEC) articles and standards must be observed.

1.2 Site Safety Procedures

All personnel must adhere to the following safety procedures when working on the system, including inspection, installation, operation, service work, repair, and testing. Failure to comply with these precautions or with specific warnings elsewhere in this manual 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 the system involves the risk of contact with potentially lethal voltages and currents.

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

These installation instructions are for use by qualified personnel only.

In addition, it is very important that you understand the following safety precautions:

- Site access is intended for authorized personnel only.
- Only authorized persons may shut down the system or open any system enclosure.
- The inverters contain energy storage devices that require a full 15 minutes to safely discharge lethal voltages.
- The plug-in electrical connectors are not for current interrupt. *Do not disconnect the electrical connectors unless the system is an open circuit and has been checked for a short circuit.*
- Fuses are never to be opened under load. Unless rated for load-break, disconnect switches should only be opened under load in an emergency. All disconnect operations for maintenance purposes must be done under no-load conditions.
- Broken modules must be handled with extra caution: if the glass on a module breaks, tiny shards of glass cover its surface. Gloves should be used at all times when handling broken modules.

In addition, installers must 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.

Warning! Depending on the module type used, the system may require positive grounding. If positive grounding is required for the system that you are installing, the *negative* leads must be fused—**DO NOT** fuse the positive conductors.

In addition, for positively grounded systems, the positive conductors in combiner boxes must be white or labeled with white tape. **Always refer to the PPF or the drawings so that you are certain of the grounding requirements for the modules you are installing.** In addition, refer to Section 8.0.

1.3 General Warnings

- After each module is removed from its pallet and placed on the roof surface, ensure that its deflector remains securely installed.
- Do not stand or walk on the modules.
- Do not place anything whatsoever on the modules.
- 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.
- Do not direct artificially concentrated sunlight onto the modules.
- 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 fully charged, operational cell phone available for calling emergency personnel.
- Never attempt to service any portion of the solar electric system unless you understand its electrical operation and are fully qualified.
- Never disassemble any of the modules or remove any parts without specific consultation and written approval from SunPower.
- Never connect or disconnect a module when the system is under load. Make sure that the array string is an open circuit by opening the appropriate disconnects before connecting or disconnecting a module.
- Never remove warning labels.

1.4 Key Terms

Familiarize yourself with these terms and definitions before you proceed with the installation.

Term	Definition
array	A group of **modules** connected to a single inverter.
block	A group of **segments** which can be operated separately as an integrated whole.
column	A line of **modules** that is positioned N–S.
combiner box	A junction box in which multiple DC **strings** are electrically connected together and converted into one combined output.
concrete ballast blocks	Blocks that fit into trays and are used to ballast the **arrays.**
conduit anchor bracket	A small bracket that attaches to a **module** foot and secures the **array** end of conduit.

Term	Definition
connector	An assembly that includes a male knurled knob that has an embedded bolt, and a female knurled knob that has an integrated nut; that secures **module feet** together to form a **junction.**
Dealer	A SunPower authorized reseller.
deflector	A polymeric panel at the north end of each **module** that is positioned at either a 60° or 85° angle.
drawings	The SunPower project drawing package for the specific installation.
foot	A portion of a **module** frame that contacts the roof and through which a **connector** is inserted. Each **module** has four **feet.**
homerun	A photovoltaic source circuit wire that connects individual **string** ends to the **combiner box.**
jumper	A wire that enables two **modules** in different **rows** or subarrays to electrically connect to each other.
junction	The point of engagement for two or more **module feet.**
line	A **row** or a **column.**
module	The assembly that includes cell **strings,** a photovoltaic glass panel, a robust polymeric frame, and two electrical leads. **Modules** ship on pallets in stacks of 22.
PPF	SunPower Commercial Pre-Purchase Form, which includes the original approved layout, and project-related site and system details.
row	A **line** of **modules** that is positioned E–W.
spacer	A knurled knob that is inserted between a **connector** assembly and a **module foot** to enable uniform module-to-module gap while preserving a robust **junction.**
string	A group of **modules** electrically connected in series.

2.0 Installation Notes and Warnings

The Construction Manager and installation team must thoroughly understand and adhere to the site-specific requirements for assembly, ballasting, and anchoring of the system. The system is designed to handle site wind conditions only *after* it is fully assembled. Always refer to the PPF or the drawings when determining proper placement and ballasting of arrays.

Warning! To enable maximum wind resistance in the event of sudden gusts or variability in local weather forecasts, SunPower strongly recommends that there *always be a deflector installed on each module.* Modules ship with deflectors already installed (Section 9.0). As you unpack modules, leave the deflectors in place until the point in the installation sequence at which you must remove them (to route wiring or add ballast, for example).

2.1 Wind Precautions

Warning! It is critical that the Construction Manager and installation team always remain aware of projected wind conditions for the site. If any of the following steps need to be taken to protect the array, you must allow substantial preparation time to secure materials.

Over the course of the entire installation period, you must secure any incomplete sections of the array—as well as any uninstalled materials—as described in the following table, in the event of any of the following conditions:

Conditions	Wind Speeds	Procedure
Light Winds and **Overnight**	Less than 10 mph (16 km/h)	• Install and hand-tighten all of the connectors. **Note.** All connectors must *eventually* be tightened to 150 in-lbs (17 N-m). Ensure that none of the hand-tightened connectors is subsequently overlooked at final torquing. • Position north row deflectors at 60°; remainder at 85°. • Physically secure or ballast all materials on the roof before every evening; these include packing materials, cardboard, and modules. You must secure the material in stacks no higher than 48″ (122 cm).
Moderate Winds and **Over Weekends**	10–25 mph (16–40 km/h)	• Install all connectors, and tighten them to 150 in-lbs (17 N-m). • Position north row deflectors at 60°; remainder at 85°. • Physically secure or ballast all pallets and materials in stacks no higher than 42″ (107 cm).
High Winds and **Storm Winds**	Greater than 25 mph (40 km/h)	• Install all connectors, and tighten them to 150 in-lbs (17 N-m). • Install all deflectors, ballast, and penetrations (if applicable) on all parts of the established array. • Physically secure or ballast all materials in stacks no higher than 36″ (92 cm).

2.2 Material Handling

Use the following material management strategy to reduce the amount of time spent transporting parts around the site, and to help prevent material and site damage:

- **Lifting Materials.** *Because of the length of the module pallet, you must use either 6' (1.8 m) forks or fork extenders.* When lifting from the top, you must ensure that lifting bars, straps, and spreader bars are sized such that excessive pressure is not placed on the topmost modules in the stack. If you are not familiar with best practices for rigging, SunPower recommends that you hire a professional rigger to safely transport materials and equipment to the roof for you.

Module pallet

- **Unloading.** To prevent damage to the modules, ensure that the entire length of the pallet has cleared the container before tipping the pallet. For example, if you are using a pallet jack to unload onto a platform for staging purposes, ensure that the surfaces are of the same height. If the staging surface is lower or higher, the pallet may rotate when the pallet jack transitions from the truck bed to the staging surface.
- **Roof protection.** Create protected areas on the roof for pallets and materials. When properly weighted, cardboard, plywood, or foam can provide effective material-staging areas. Protect high-traffic areas of the roof to ensure that insulation is not damaged.
- **Material carts.** Use roofing carts to facilitate moving pallets, cardboard, and materials around the roof. Carts should have pneumatic tires to protect the roof. Check with the roof warranty holder for acceptable storage and handling of materials.
- **Belt pouches.** Use pouches to enable installers to carry quantities of smaller parts around the roof, and prevent materials from being left on the roof or on modules where they could cause damage or become trip hazards.

Warning! Extreme care should be taken to protect the roof surface from damage from pallets and other materials throughout the installation.

3.0 Site Preparation and Installation Outline

Carefully preparing the site helps to ensure maximum safety and can reduce build times.

3.1 Roof Preparation

The initial line for each array is the line from which you will build the array, so it is usually best to place it on one of the critical dimensions or the longest continuous column or row. *Columns* are aligned north–south (N–S); *rows* are aligned east–west (E–W). If a large crew will be working on the array, mark the initial line in the middle of the array so that workers can build from the center of the array outward in both directions.

Ensure that the following steps are taken to prepare the roof:

1. A professional roof survey must be completed prior to the date scheduled for the start of the installation. However, before you actually begin the installation, you must again assess the condition of the roof. Look for wear and cracking, and look for standing water (or ponding).

   It is acceptable to install modules atop standing water if and only if the following conditions are met:

   A. The water has a maximum depth of 1 1/2″ (3.8 cm).

   B. All module, jumper, and homerun connections use MC4 (Multi-Contact 4) or equivalent IP67-rated connectors.

   C. All wiring is secured a minimum of 3″ (7.6 cm) above the roof surface.

   If you identify wear or cracks, or water greater than 1 1/2″ deep; or if the water is less than 1 1/2″ deep *but condition B or C cannot be met,* contact the customer immediately and advise them of the situation. Verify with the customer whom to contact in order that the roof conditions be rectified so that you can begin the installation. Contact SunPower as well if conditions such as these exist, and do not begin the installation until these issues have been rectified.

   Note. The system must be installed over an appropriate fire-resistant roof covering.

2. Ensure that the roof is free of any debris.
3. Verify that the actual roof dimensions are the same as the dimensions shown on the PPF or the drawings. Check the array dimensions in relation to any roof obstacles or boundaries and make sure that the initial line will accommodate the array layout. Note where any roof obstacles will occur in the array, and try to maximize the efficiency of the array in accommodating these obstacles. If necessary, you can modify the design according to the array design guidelines. Any changes not sanctioned by the system design guidelines must be reviewed and approved by SunPower.
4. Mark the initial lines (using paint, chalk, or string) based upon straight lines from strings, lasers, or boundaries. Refer to the perimeter of the array as indicated in the PPF or the drawings to mark these lines the appropriate distance from roof boundaries and edges.

   Important! Because roof boundaries are not always straight, ensure that you use a “best-fit” line for the array area.

5. (Optional) Place slip sheet. Some roof types will require that a manufacturer-approved slip sheet be installed between the array and the roof surface in order to satisfy roofing manufacturer’s requirements. Refer to the PPF or the drawings for slip sheet type and associated installation instructions. If working directly with a roofing company, first ensure that any materials and installation practices used are sanctioned by the holder of the roof warranty.

3.2 Material Staging

Properly distributed materials facilitate rapid system installation. The modules ship nested in pallets of 22 (in some cases pallets may contain 15 or 20 modules). To avoid unnecessary relocation of materials, plan the distribution carefully. Keep the following in mind as you place materials on the roof:

- During the lift phase, distribute materials across the roof in order to evenly load the roof while keeping materials clear of the lift area, and with consideration for where you will begin building the array.
- Locate the planned array on the roof and identify build points.
- In order to prevent materials from getting in the way during array installation, establish a general idea of the array perimeter.
- Identify the starting build locations and build directions of the array in order to stage materials around these areas so that they will not interfere with the initial array line layout. For example, if you are going to build the array from east to west, place materials westward.

Here's an example of module pallets positioned within an array field:

Pallet staging example

Materials destined for areas furthest from the lift point should be placed first. This enables crews to maintain a clear path while materials are distributed. Stage specific materials as follows:

- **Modules.** Position modules regularly throughout the array field in full pallets or in shorter stacks. Spacing of module stacks should be equivalent to the amount of space the assembled array will displace. It's helpful to mark the roof to indicate stack locations.

  Important! When dispersing partial stacks of modules from the pallets, ensure the modules remain neatly stacked and properly nested with their stacking features fully engaged.

- **Deflectors.** Deflectors ship already installed on each module. *Leave the deflectors installed until the point at which you have to remove them (to route wiring or place ballast, for example), and then reinstall them immediately afterward.*

- **Electrical materials.** Place electrical connectors, wiring, and combiner boxes outside the planned array field and in the vicinity of the intended combiner box locations.

- **Smaller parts.** Place module connectors, spacers, and ballast materials at convenient locations outside the planned array field. It's helpful to set up central depots for these materials close to the various array sections.

3.3 Installation Outline

The system must be installed according to a specific sequence, although there are instances where some of the steps overlap and can be performed simultaneously.

Important! This section presents only a high-level overview of how the system is installed; *do not* use this in place of the detailed instructions in the subsequent sections of this manual.

1. Prepare the roof surface.
2. Mark the array lines.
3. Stage the materials.
4. Position and mechanically connect the modules; engaging connectors loosely (the mechanical connectors at the module feet, *not* the electrical inter-module wire connectors).
5. Position and add ballast (you can often add ballast as you position the modules).
6. Connect the module leads to create strings.
7. Install combiner boxes and create homerun wiring (string-end conductor and interconnection wires).
8. Pull and position wiring throughout the array.
9. Reposition the deflectors on the modules as necessary.

   Note. Depending on site wind conditions, you may need to reposition the deflectors sooner.
10. Land the homeruns in the combiner box.
11. Secure the array to the roof.
12. Commission the system and verify its operation.

4.0 Position Modules

Important! Read through this *entire* manual before you begin installation of the system. *The installation of modules and ballast can in some cases be performed at the same time.* Read this entire manual so that you understand the sequence thoroughly. Always follow the approved module layout from the PPF or the drawings.

You should have already created the chalk lines, as instructed in Section 3.1.

The sequence in which you actually place the modules depends on the roof characteristics, the direction in which you will build the columns and rows, the presence of obstructions (or "holes" in the array), and the space available for staging the materials. In general, you should start with the critical dimension. If the critical dimension is not the longest continuous row, you can build up to it (or over to it).

Note. It's possible that a long, completed row in the middle of your installation can subsequently interfere with the movement of materials, and that the initial completion of such a row may not be realistic because materials you've *already* positioned are in its path.

If you lay out the first SW–SE row, for example, and then build a long column off of that, you can expedite the installation because it will enable crews to work in separate quadrants at the same time. Similarly, if you can first lay out a single column near the *middle* of the array and then build rows out from it, you can effectively create four (or more) areas within which your crew can build simultaneously.

Warning! The number of modules you will eventually connect in series in any single string is a function of voltage limitations, and is shown on the PPF or the drawings. Do not deviate from the SunPower-approved system design.

4.1 Determine Build Lines

The way in which you must mechanically align the modules will affect how you decide to build the arrays. Refer also to Section 4.5.

You can build the array in lines: row by row (rows are aligned E–W), or column by column (columns are aligned N–S).

Note. Building the array from the southernmost row, row by row, can make ballast installation and crew performance more efficient.

The following tables describe two potential build strategies:

First Line: Row	Second Line: Row	Third Line: Row
SW→SE (southernmost row)	SW→SE north of first row	SW→SE north of second row

First Line: Column	Second Line: Column	Third Line: Column
SW→NW (westernmost column)	SW→NW east of first column	SW→NW east of second column

You do not have to finish the previous row or column before you begin the adjacent row or column. Whichever line you place next, you must maintain the straightness of the array. If you choose column-by-column installation, it is important to remember which of the modules will require ballast.

Always identify any potential obstructions to your proposed build lines, and refer to Section 4.2 for information on contending with obstructions.

Warning! Maintaining straight array lines is critical; any initial deviation will cause difficulty later in the installation.

4.2 Contend with Obstructions

Use a shading measurement device to ensure that modules are not unnecessarily shaded by any obstructions. If a module is shaded, its power output can be dramatically affected. Modules should be placed no closer to an obstruction than a distance equal to two times (2 ×) the height of that obstruction.

Although all of the major obstructions on the rooftop should have been taken into consideration during the site audit and array design activities, there may be situations where there is an unforeseen obstruction within the field of an array. In such cases, build around the obstruction to the extent possible, ensuring that you continue to enforce the project ballast requirements and array shape guidelines.

Important! *Never place modules over roof vents or any other type of obstruction.*

If necessary, you can decide to *not* install a particular module if its installed position would be on top of or impeded by an obstruction. However, if the only realistic method of contending with an obstruction is to not install a particular module, you must contact SunPower for approval, and so that the electrical string maps can be adjusted accordingly.

4.3 Unstack Modules

Unstack modules adjacent to the start of the first column or row, being careful to remove the packing material without damaging the modules. Ensure that any accumulating materials are not blown off the roof and that they do not impede your crew. Define a manageable location to stack and temporarily store packing materials, and remove the materials from the roof throughout the day.

As you remove each module from the stack, ensure its deflector is secure, and inspect its glass and frame for any signs of defects or shipping damage.

Always handle and transport modules only when they are in the flat position (Fig. 1). Modules are heavy and bulky, so always have *two* installers handle each module and ensure they wear safety gloves when doing so.

Handling modules vertically can result in damage to the module frames (Fig. 2).

Warning! Do not step, stand, or walk on the modules (Fig. 3). Do not place anything on the modules—*even temporarily*—because that kind of "hard" shading on a portion of a module can cause irreparable electrical damage.

Fig. 1

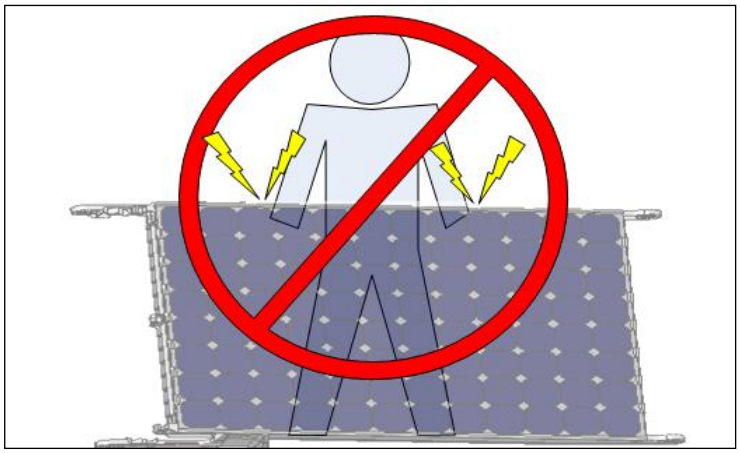


Fig. 2

Fig. 3

4.4 Connectors, Spacers, and Junctions

A connector is an assembly that secures modules to each other, through the slots in the module feet. The connector assembly includes two plastic knurled knobs, one of which has a bolt, and the other a nut. (There is no “left” or “right” connector half; either connector knob can be used on either side of a junction or foot.)

The point at which module feet engage is called a junction. Some junctions require the use of spacers during connector installation. A spacer is the same knurled knob used in connector assemblies, except that it does not have a bolt or nut attached. Spacers fill the gaps present in some junction types, and enable preservation of module frame integrity while also enabling robust and secure module junctions. Spacers also enable the use of a single-length connector bolt throughout the array—independent of junction type.

A given array can have up to nine different possible junction types (Fig. 4). Each junction must be secured with a connector assembly.

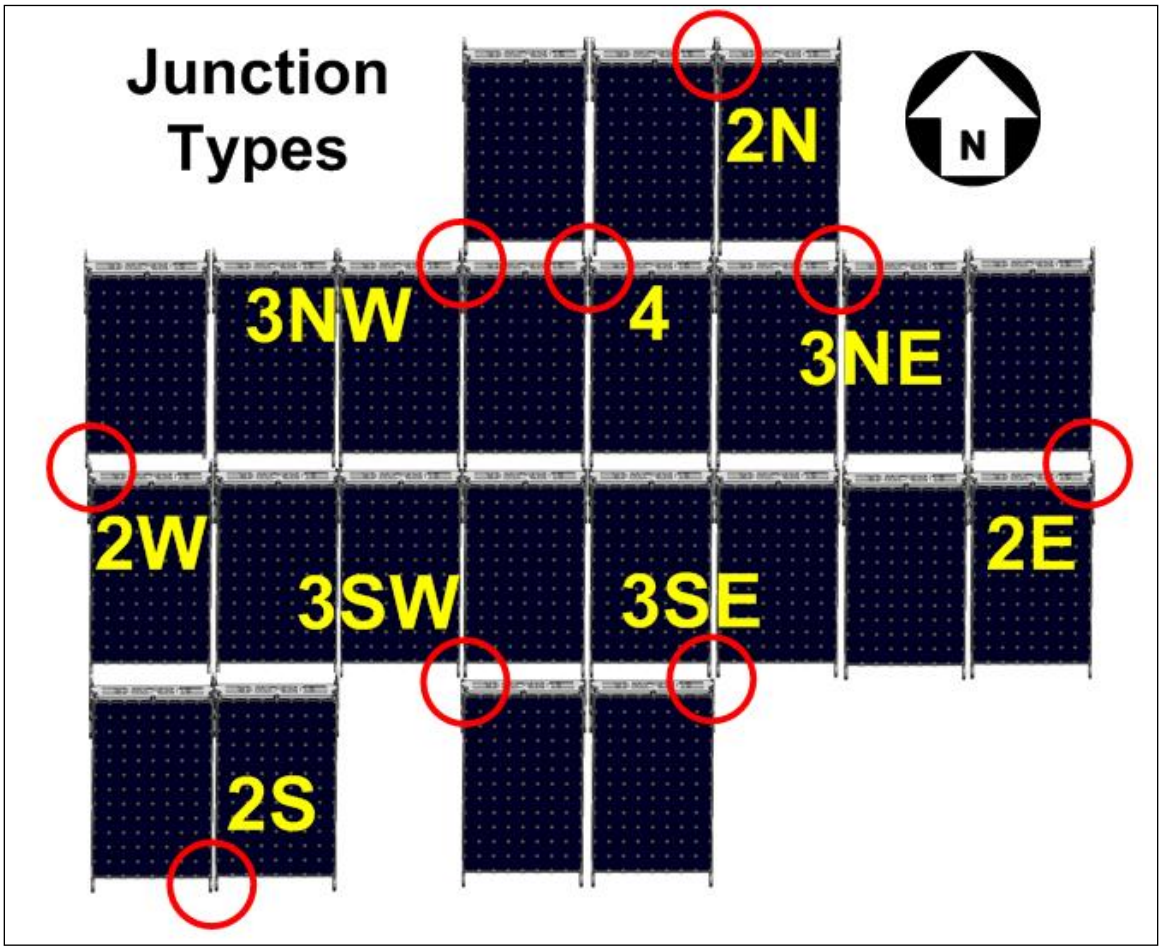
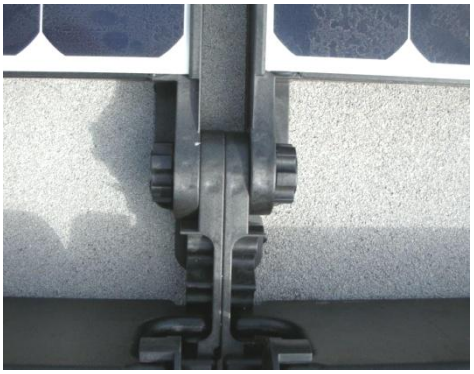
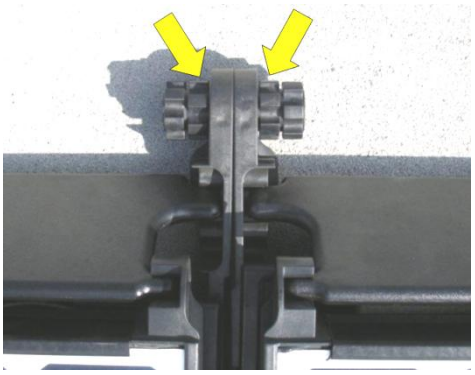
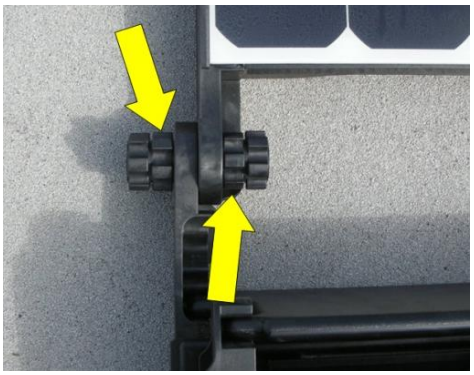
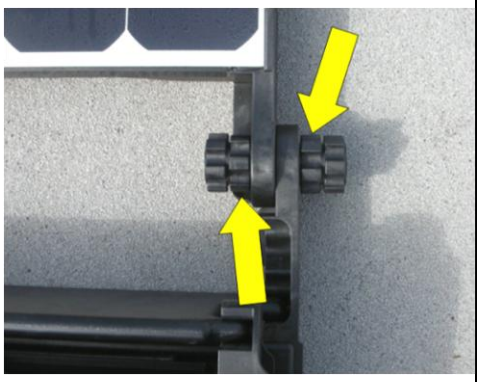
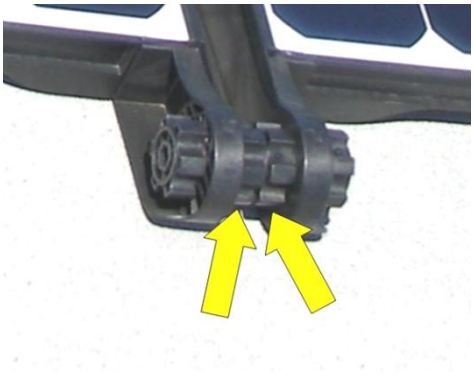
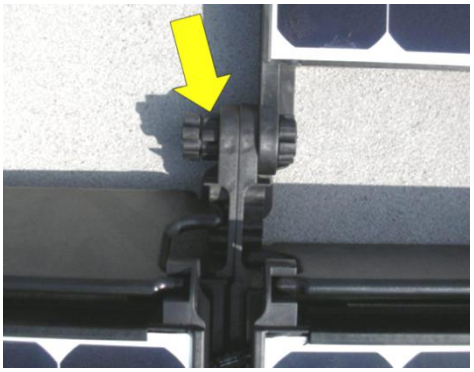
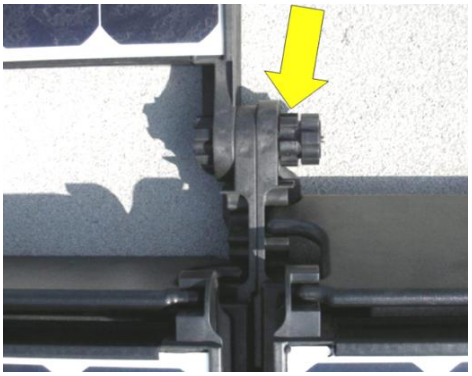
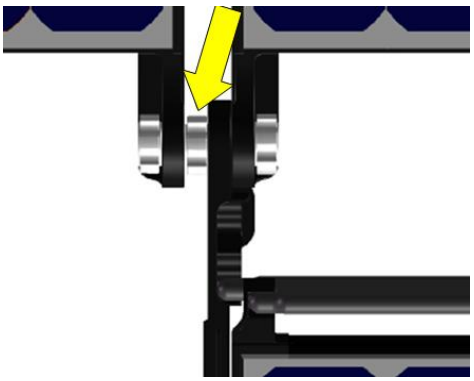
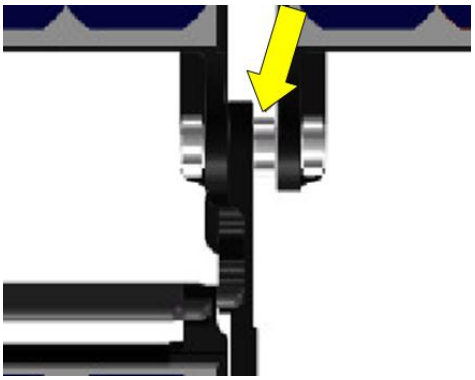


Fig. 4

Use the techniques described in the following table as you perform the steps in Section 4.5:

Type	Spacers Required	How to Secure	Illustration
4	None	In a given array, this is the most numerous junction type. In this junction, the feet of *four* different modules come together: The feet of the two south modules engage and then fit *inside* the feet of the two north modules. Align these four feet and then attach the connector (do not use any spacers).	
2N	Two	Position a spacer on *each side* of the junction, between the connector and the engaged feet, and then attach the connector.	
2W	Two	Position a spacer on *each side* of the junction, between the connector and the engaged feet, and then attach the connector. **Note.** The foot of the south module engages the *west* side of the foot of the north module.	

Type	Spacers Required	How to Secure	Illustration
2E	Two	Position a spacer on *each side* of the junction, between the connector and the engaged feet, and then attach the connector. **Note.** The foot of the south module engages the *east* side of the foot of the north module.	
2S	Two	Insert two spacers *between the feet* to create the junction, and then attach the connector.	
3NW	One	In this junction, the feet of *three* different modules come together—two are north feet and one is a south foot. The feet of the two south modules align and engage *to the west of and with* the SW foot of the lone north module. Align these three feet, insert a single spacer between the connector and the west side of the junction, and then attach the connector.	
3NE	One	In this junction, the feet of *three* different modules come together—two are north feet and one is a south foot. The feet of the two south modules align and engage *to the east of and with* the SE foot of the lone north module. Align these three feet and insert a single spacer between the connector and the east side of the junction, and then attach the connector.	

Type	Spacers Required	How to Secure	Illustration
3SW	One	In this junction, the feet of *three* different modules come together—two are south feet and one is a north foot. The NW foot of the lone south module forms a junction by engaging (from the west) with the SW foot of the module directly to its north. Insert a spacer between this junction and the adjacent north module's SE foot, and then attach a connector.	
3SE	One	In this junction, the feet of *three* different modules come together—two are south feet and one is a north foot. The NE foot of the lone south module forms a junction by engaging (from the east) with the SE foot of the module directly to its north. Insert a spacer between this junction and the adjacent north module's SW foot, and then attach a connector.	

4.5 Place and Mechanically Connect Modules

Connecting modules to form *electrical strings* is described in Section 7.

Note. Remember, you can combine module placement with ballast installation. SunPower recommends that you do so (Section 5.0).

1. To become familiar with how the feet engage depending on the junction type, position the first four modules as follows (Fig. 5):
   - Place the first module (ideally at the SW corner of one of your chalk line intersections).
   - Place the second module to the north of the first.
   - Place the third module to the east of the first.
   - Place the fourth module to the north of the third.

   You can also start at a southern corner of the array and build northward and eastward; or northward and westward; actual build patterns can vary (Fig. 6).
2. As you place each module, align each of the feet so that a single connector can be easily attached that will capture however many feet come together at a given junction. Do not yet attach the connectors.

   Note. When unevenness on the roof is revealed (as gaps beneath the module feet), use the play in the vertical foot slots to adjust the position of the feet *before* fully tightening the connectors (Fig. 7). Ensure that each module rests at its lowest possible position on the roof surface.

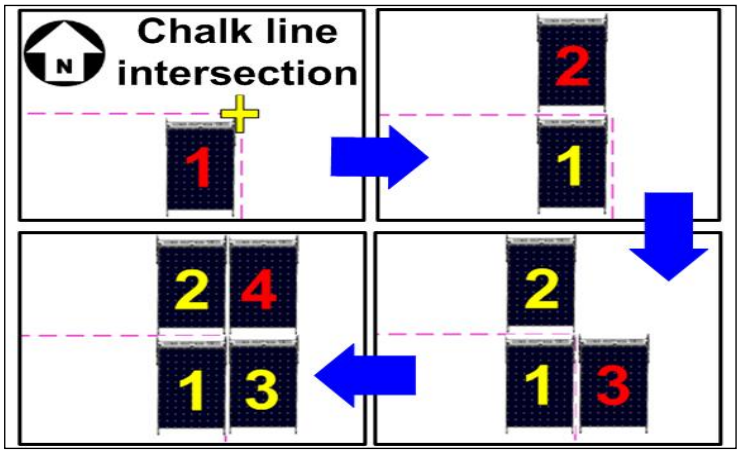


Fig. 5

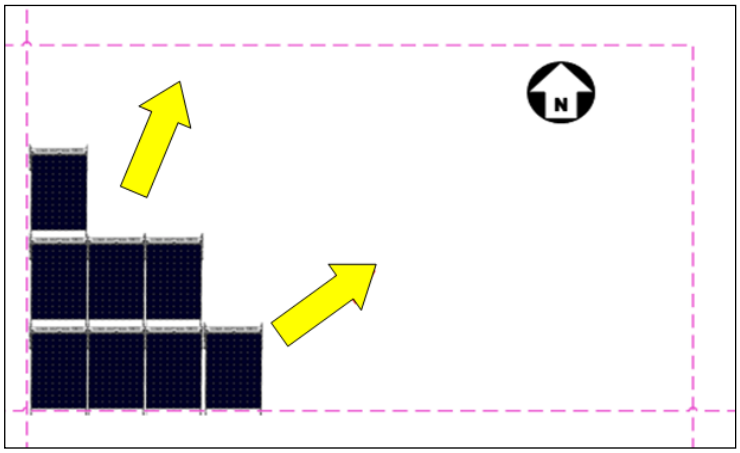


Fig. 6

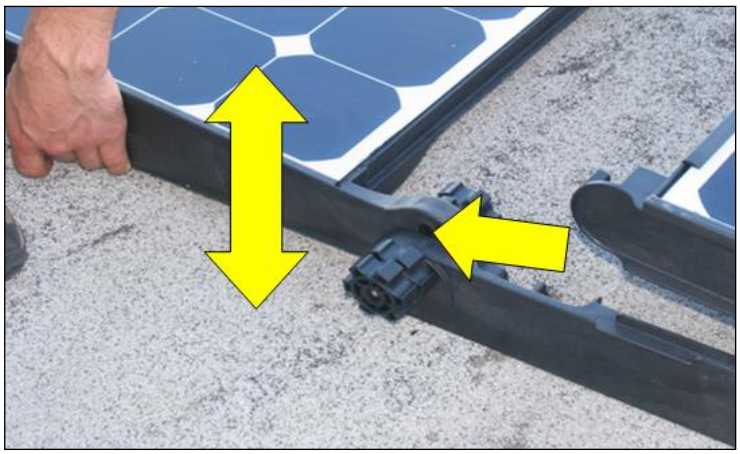


Fig. 7

3. After a given module is in alignment with all of the other modules that are to be positioned immediately around it, attach a connector loosely at each of the junctions using the techniques described in the table in Section 4.4 (Fig. 8 and Fig. 9). Hand-tighten the connectors. (You will tighten the connectors with a torque wrench later.)

Fig. 8

Important! When attaching the female half of the connector, ensure that the *solid* side faces inward, toward the connector bolt (Fig. 8 and Fig. 9). If you incorrectly position the *hollow* side facing the bolt (Fig. 10), the embedded nut will pull out when you tighten the knob.

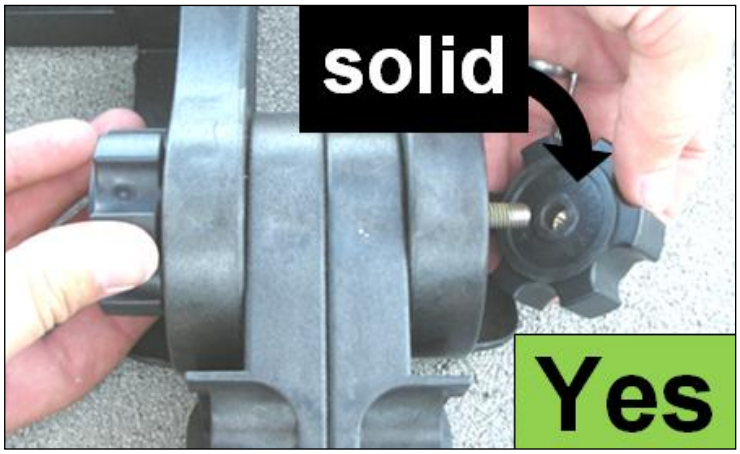


Fig. 9

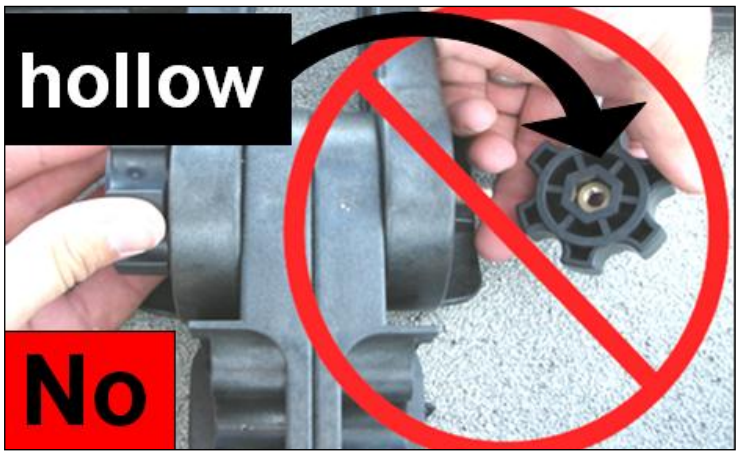


Fig. 10

4. As you position the remaining modules of each row and column in the array, you must periodically sight down the row or column to ensure the straightness of the array.

   Note. Because south internal tube installation (Section 5.0) requires that the north end of modules be raised, the north feet of modules requiring ballast must at that point have their connectors completely removed.

5.0 Ballast and Anchor the System

Refer to the tables in this section *and* the PPF or the drawings to ensure that you distribute and install ballast correctly. The number of ballast tubes, and trays and blocks required per module is specified in the PPF or drawings.

Important! Before you add ballast or anchor the array, ensure that the array is aligned correctly; and ensure that you maintain the correct alignment throughout ballast installation. Repositioning rows and columns after ballast installation or anchor attachment can be a very time-consuming process.

Some systems require the use of anchors, as well as up to four types of ballast:

- Type A: trays containing a project-specific number of concrete blocks
- Type B: tubes that fit into the module frame from the underside
- Type C: tubes that attach using the connectors
- Type D: tubes that fit into deflector slots

The three tube-style ballast types (B, C, and D) are easily distinguished by the features on their ends (Fig. 11):

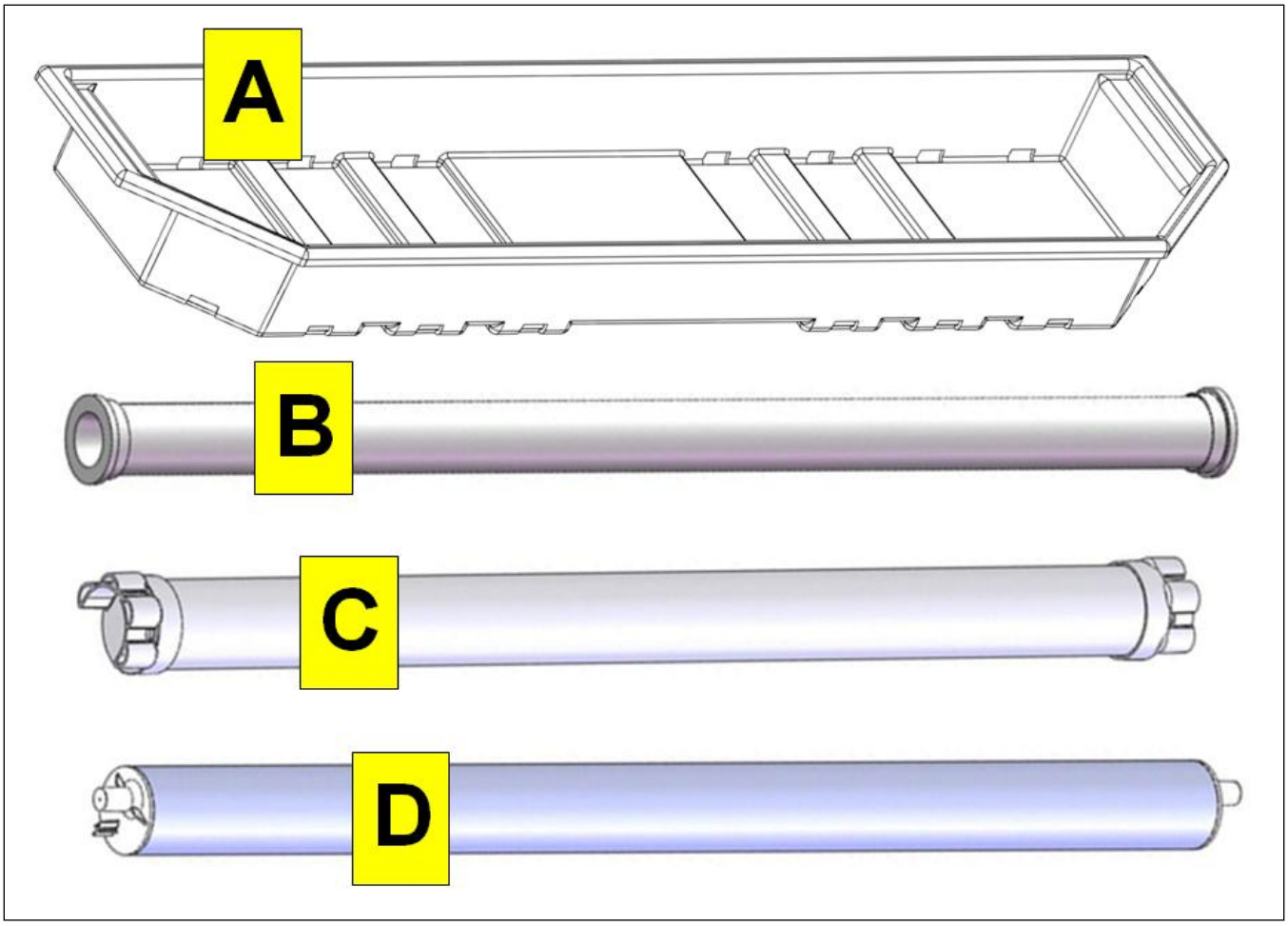


Fig. 11

5.1 Overview of Type A and Type B Ballast

You install Type A and Type B ballast *before* you install Type C and Type D ballast.

5.1.1 Type A Ballast

Type A ballast engages with and fits under the north end of the modules, and accepts a specific number of concrete ballast blocks as defined in the PPF or the drawings. Ballast blocks (sometimes called *pavers*) must conform to the specifications in SunPower document 1505-511.

Important! Do not break ballast blocks. The clearly defined installation patterns eliminate any need to break the blocks.

5.1.2 Type B Ballast

Type B ballast fits E–W into the underside of the south end of the module frame, as defined in the PPF or the drawings. The maximum number of Type B ballast is three per module.

Important! Begin the installation pattern at the *westernmost* module in each row.

5.1.3 Ballast Distribution

The following table shows how to distribute Type A ballast:

Blocks Required Per Module	Tray Installation Pattern	Block Installation Pattern	Quantity of Blocks to Install	Module Interval
0.5	1-0-1-0-1	1-0-1-0-1	1	Every other
1.0	1-0-1-0-1	2-0-2-0-2	2	Every other
1.5	1-0-1-0-1	3-0-3-0-3	3	Every other
2.0	1-0-1-0-1	4-0-4-0-4	4	Every other
2.5	1-1-1-1-1	3-2-3-2-3	3-2-3-2-3	Every
3.0	1-1-1-1-1	3-3-3-3-3	3	Every
3.5	1-1-1-1-1	4-3-4-3-4	4-3-4-3-4	Every
4.0	1-1-1-1-1	4-4-4-4-4	4	Every

The following table shows how to distribute Type B, Type C, and Type D ballast:

Number Required Per Module	Installation Pattern	Quantity to Install	Module Interval
0.5	1-0-1-0-1	1	Every other
1.0	1-1-1-1-1	1	Every
1.5	2-1-2-1-2	2, then 1, then 2, then 1, and so on	Every
2.0	2-2-2-2-2	2	Every
2.5	3-2-3-2-3	3, then 2, then 3, then 2, and so on	Every
3.0	3-3-3-3-3	3	Every

The westernmost module *and* the easternmost module in a given row (the row-end modules) *must both* be ballasted (Fig. 12).

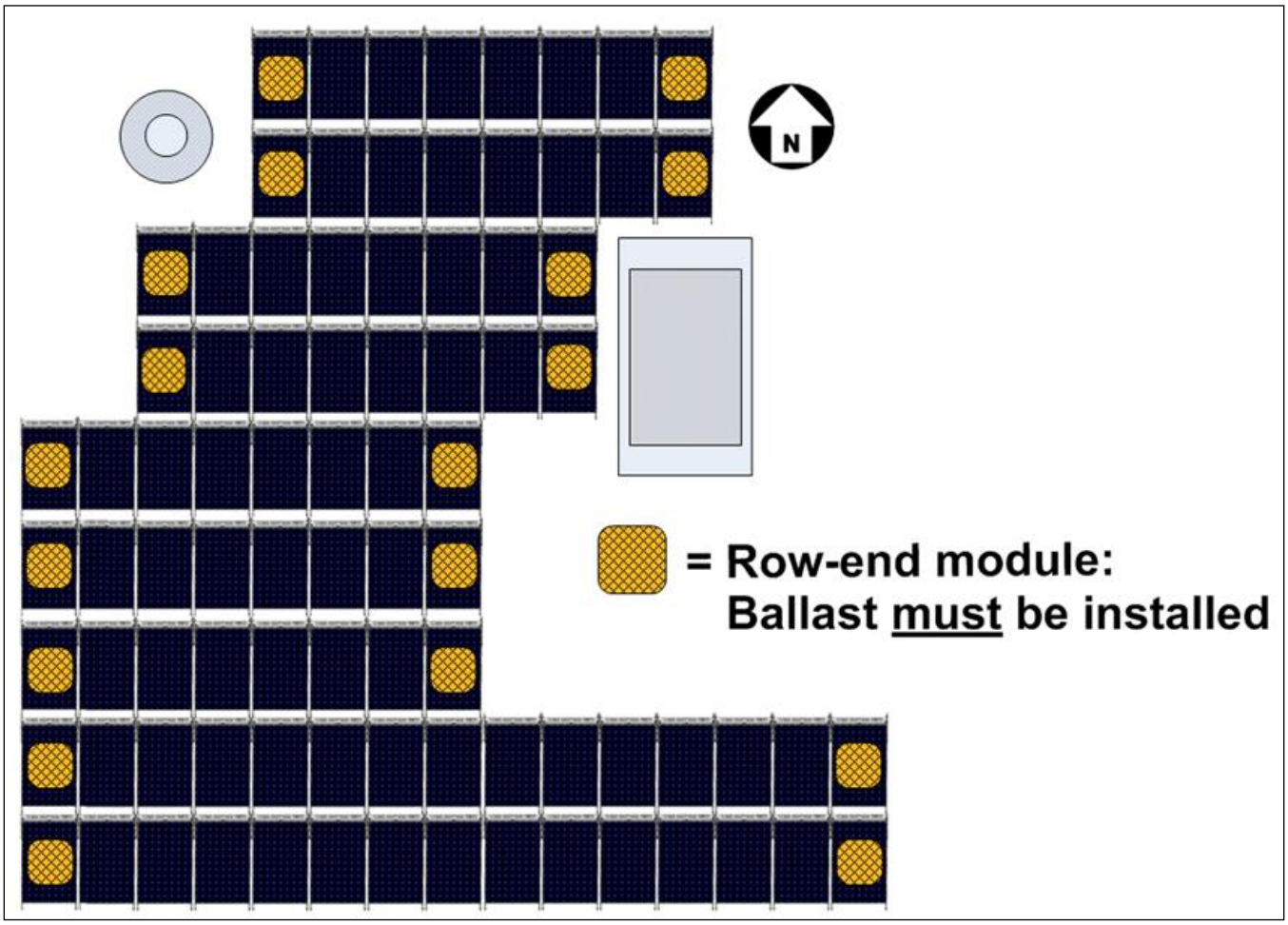


Fig. 12

You begin ballast installation with the westernmost module in each row. Therefore, if the installation pattern when applied as directed yields a ballast-free *eastern* row-end module, you must install in that module the same amount of ballast (trays, blocks, *and* tubes) that you installed in the module immediately *west* of it.

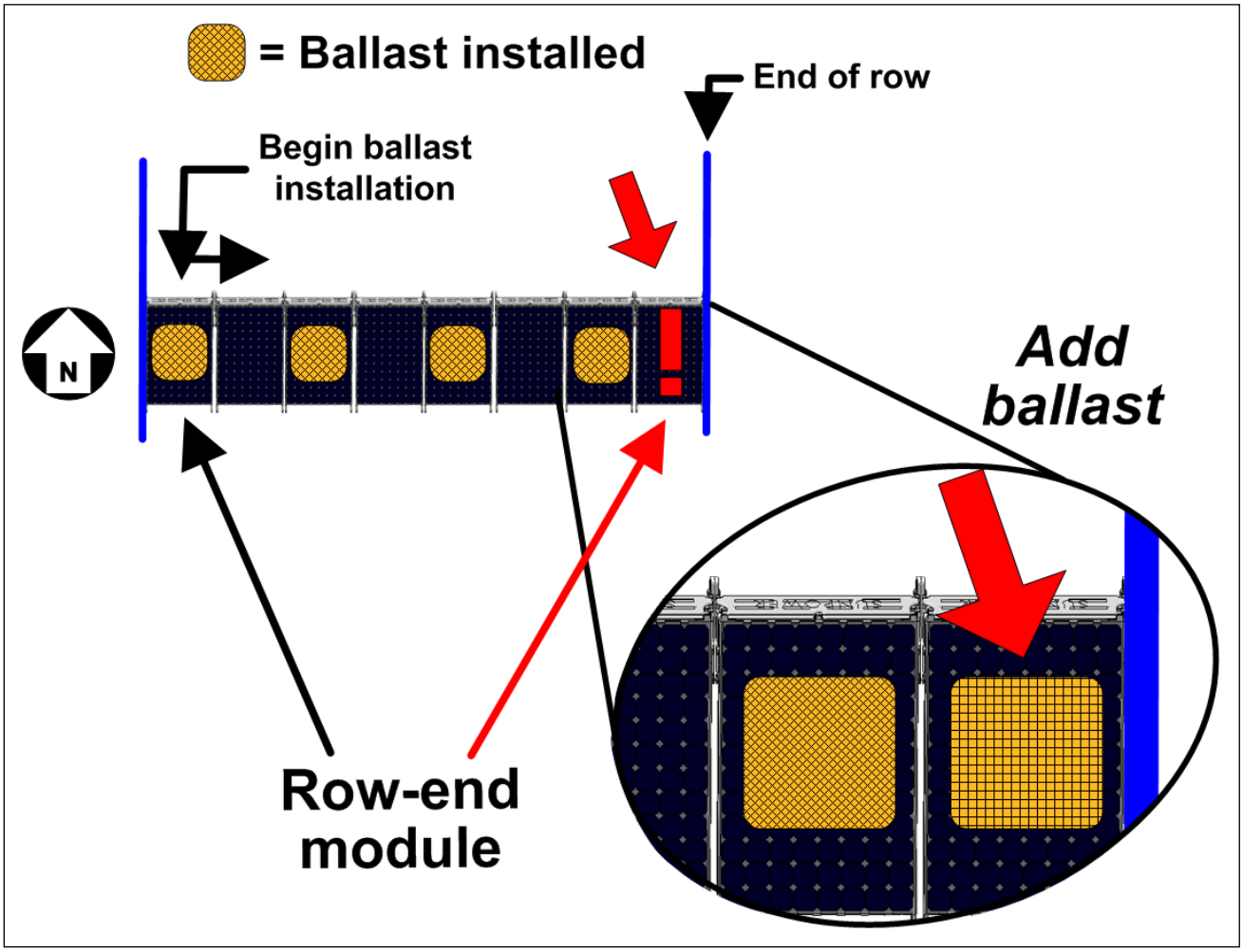


Fig. 13

You must similarly enforce this requirement for *all* of the rows in *all* of the arrays, adding the appropriate ballast to any ballast-free eastern row-end module (Fig. 13).

If you have any questions about ballast apportionment, contact SunPower:

TechnicalSupport@sunpowercorp.com

For Systems: 1-800-251-9728

For Dealers: 1-800-SUNPOWER (1-800-786-7693)

5.2 Install Type B Ballast

In order to maintain the original alignment and stabilize the modules, SunPower recommends that you connect the south feet of the modules together before installing Type B ballast.

Important! Refer to the PPF or the drawings and Section 5.1.1 for ballast distribution and apportionment.

1. Tilt the north end of the module upward, toward the south (Fig. 14).

2. Fit the tubes into the underside of the module frame (Fig. 15), and then slide them toward the south feet until the ends of the first (or only) tube rest against the V-shaped notch built onto the inner edge of the south feet (Fig. 16).

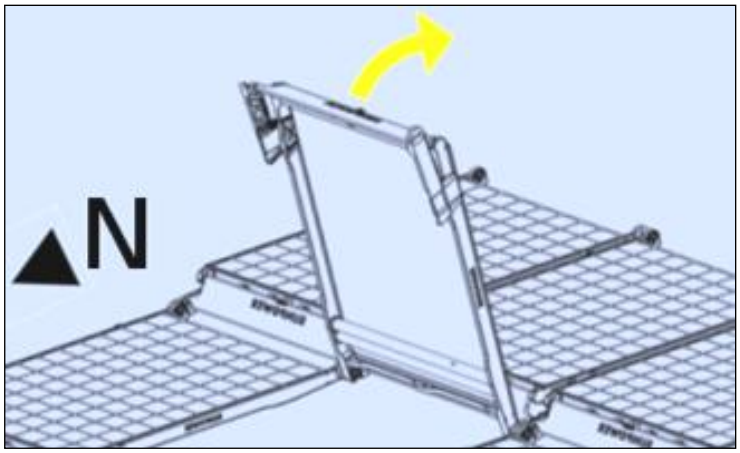


Fig. 14

Fig. 15

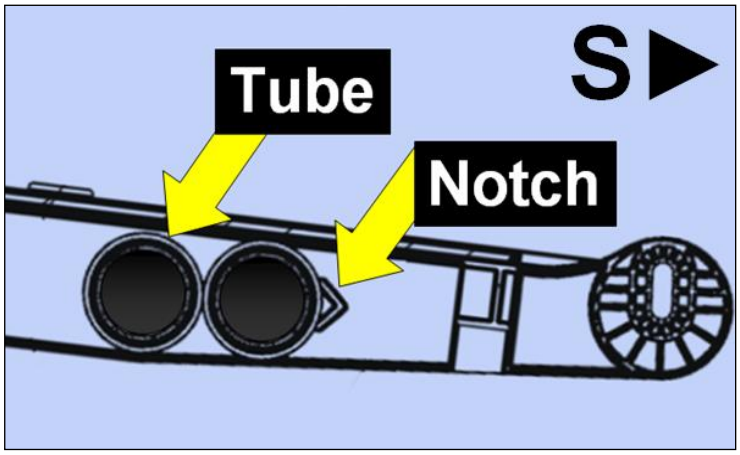


Fig. 16

5.3 Install Type A Ballast

Use caution when positioning trays. Do not pinch or bind module wires. Secure all wires out of the way before installing ballast trays.

Important! Do not pass ballast blocks or trays over the modules, because of the risk of damaging modules.

1. With its angled corners toward the module (Fig. 17), position the tray lengthwise along the north edge of the module (Fig. 18).

2. Place the prescribed amount of ballast into the tray (Fig. 19), as specified in Section 5.1.1 and the PPF or the drawings. Distribute the blocks evenly within the tray.

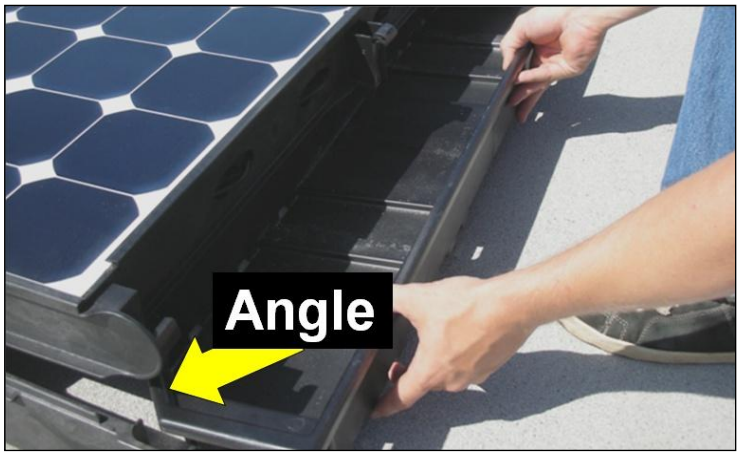


Fig. 17

Fig. 18

Fig. 19

3. Each north foot of each module has a long N–S tab that engages the groove around the perimeter of the underside of the ballast tray (Fig. 20). Lift or rock the south end of the tray so that the tray rests on the tabs, and then slide the tray southward until the tray drops slightly as the tabs fit up into the tray's groove (Fig. 21).

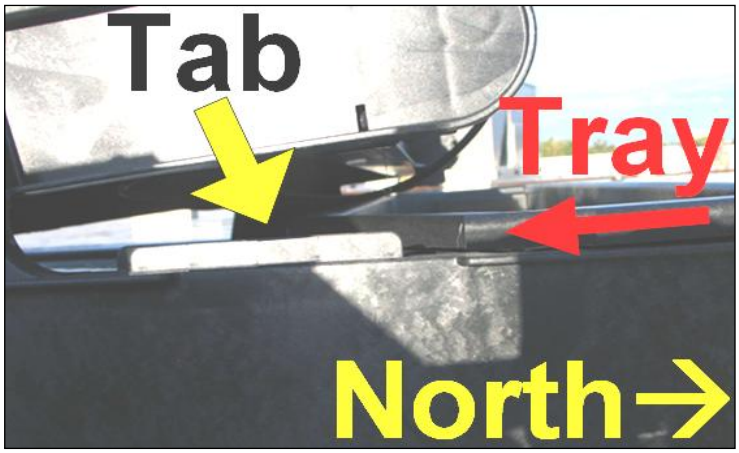


Fig. 20

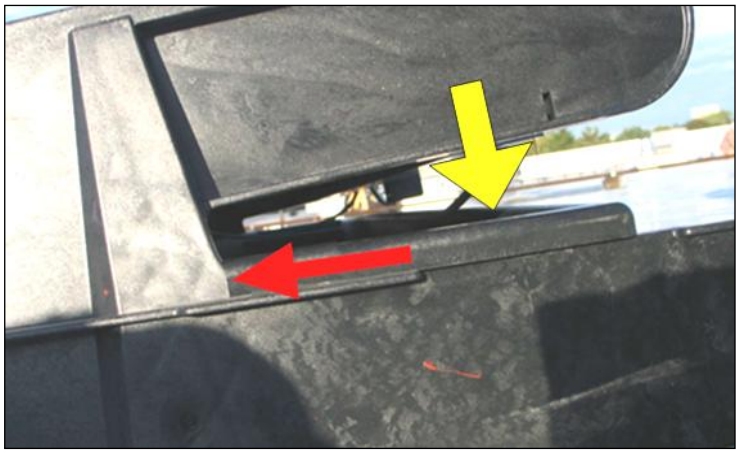


Fig. 21

4. Inspect each tab/groove interface to ensure that the tray is fully seated on the legs. (Fig. 22).

Fig. 22

5.4 Overview of Type C and Type D Ballast

You install Type C and Type D ballast *after* you install Type A and Type B ballast.

Important! Always refer to the PPF or to the drawings to determine the correct ballast distribution and comprehensive ballast requirements for the system you are installing.

Refer also to Section 4.4 for junction descriptions, and connector and spacer use.

5.4.1 Type C Ballast

Type C ballast engages and fits under the inner connector at each south foot of the module (Fig. 23 and Fig. 24).

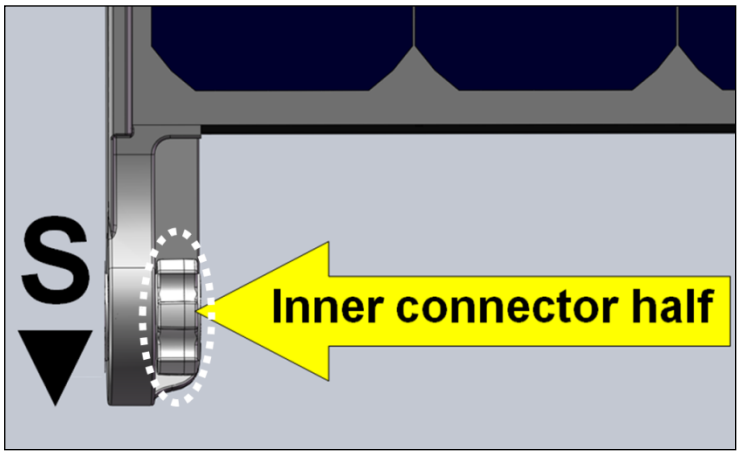


Fig. 23

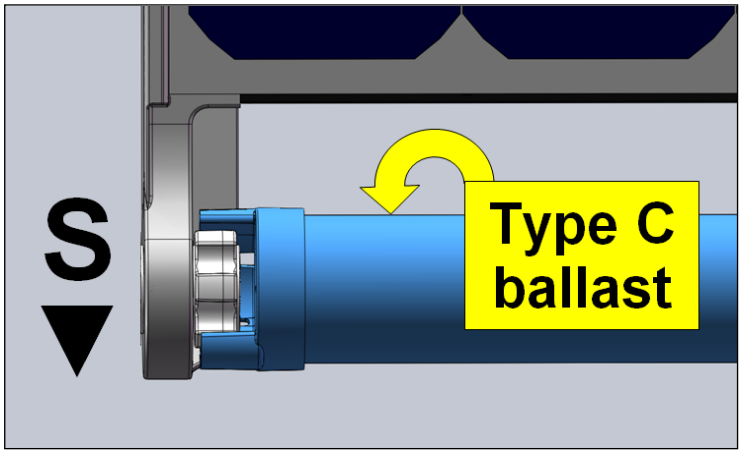


Fig. 24

5.4.2 Type D Ballast

Each north foot of each module has built-in slots that engage the deflector and enable the two different deflector positions (Fig. 25 and Section 9.0).

Type D ballast engages the slot pair that normally engages the deflector at the 85° angle (the south slot pair). Therefore, when Type D ballast is required on a given module, that module's *deflector* must then be installed in the only available slot pair—the north slot pair—regardless of the module's position within the array (Fig. 26).

Important! If Type D ballast *is not* required on a module, use the instructions in Section 9.0 to guide deflector positioning.

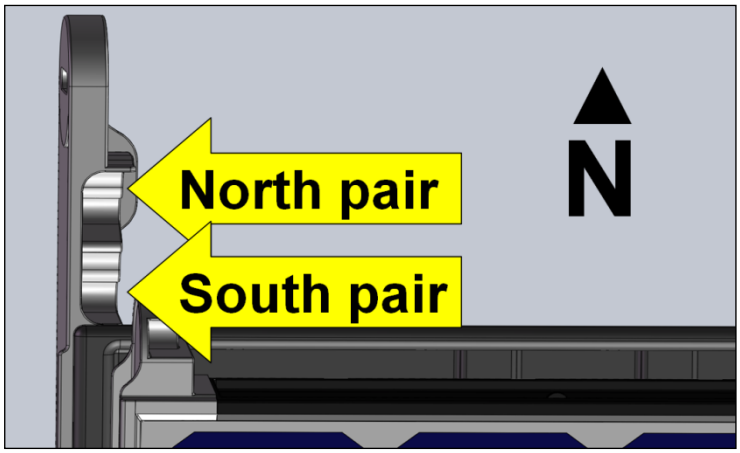


Fig. 25

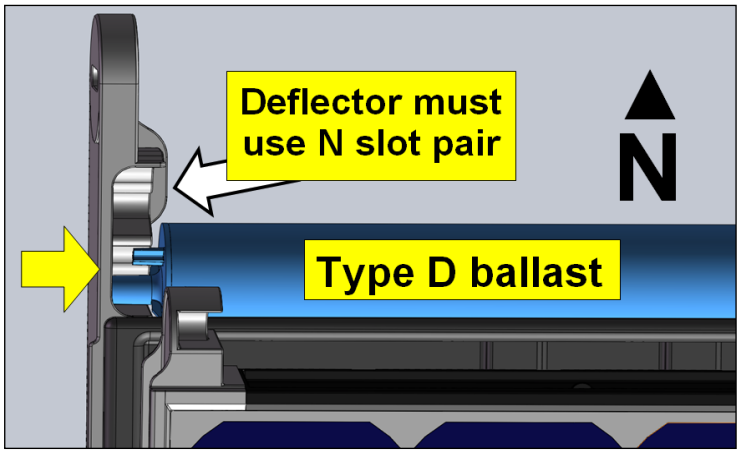


Fig. 26

5.4.3 Spacers and Type C Ballast

To accommodate the installation of Type C ballast:

- Two of the junction types (2W and 2E; refer to Section 4.4) require repositioning of spacers.
- All of the bare (orphan) module feet require installation of connectors and spacers.

Junction Type: 2W

Instead of leaving a spacer on either side of the junction, reposition the inner spacer so that both spacers are on the *outside* (the west side) of the junction (Fig. 27 and Fig. 28), and then retorque the connector to 150 in-lbs (17 N-m).

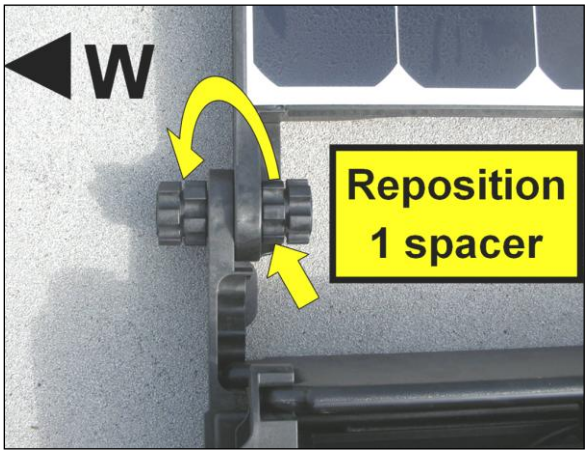


Fig. 27

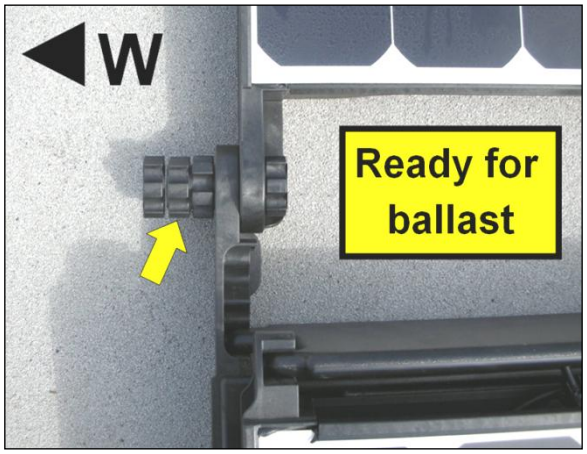


Fig. 28

Junction Type: 2E

Instead of leaving a spacer on either side of the junction, reposition the inner spacer so that both spacers are on the *outside* (the east side) of the junction (Fig. 29 and Fig. 30), and then retorque the connector to 150 in-lbs (17 N-m).

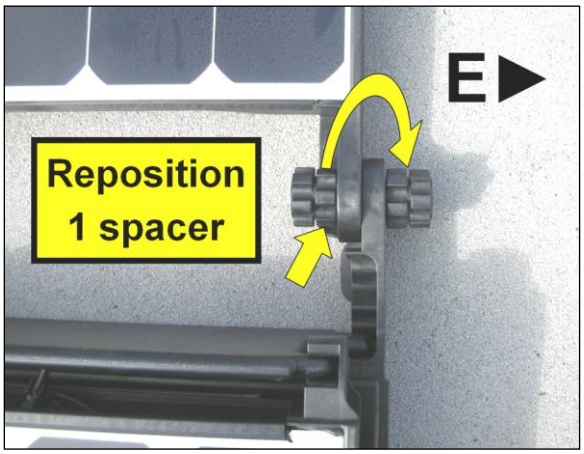


Fig. 29

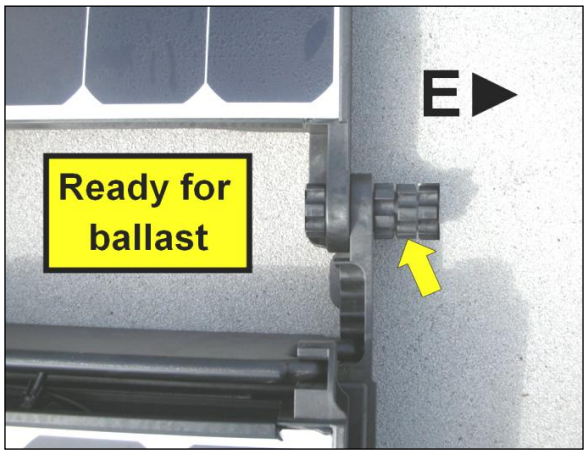


Fig. 30

Bare South Feet

For each module that requires Type C ballast but has a bare (orphan) foot (Fig. 31), add three spacers on the *outside* of the bare foot, and a connector (Fig. 32), and then torque the connector to 150 in-lbs (17 N-m) (Section 6.0).

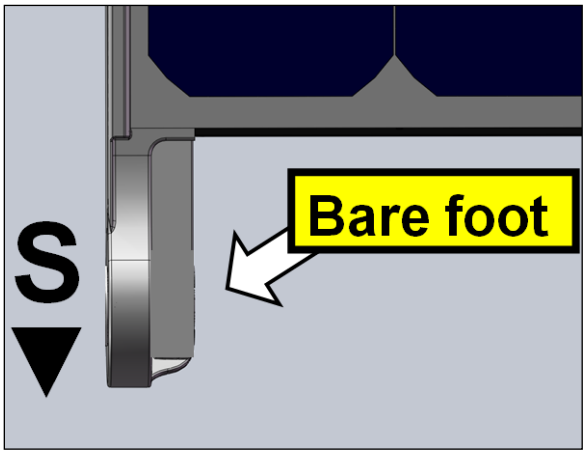


Fig. 31

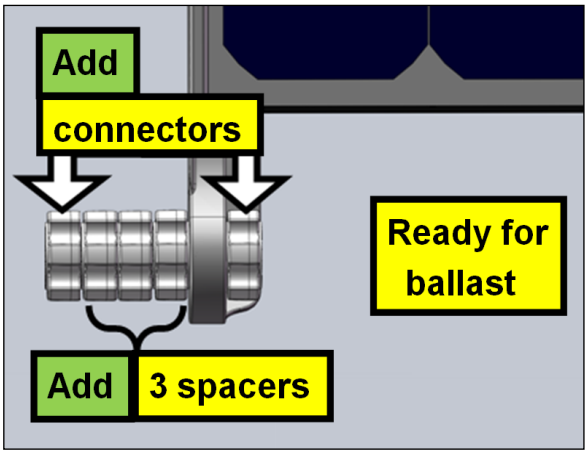


Fig. 32

5.5 Install Type C Ballast

Each end of the Type C ballast has four extrusions in a semi-circle (Fig. 33).

1. Fit the ends of the ballast under the inner connector and then rotate the ballast (Fig. 34) so that the northernmost of its two inner extrusions rests at bottom dead center (Fig. 35).
2. If the connector is positioned so far down within the vertical slots in the module feet that you cannot fit the ballast end under the connector, loosen and then raise the connector only enough so that you can fit the ballast beneath it. After you have established the lowest possible connector position that will still accommodate the ballast, retorque the connector as described in Section 6.0 and then install the ballast as described in Step 1 of this section.

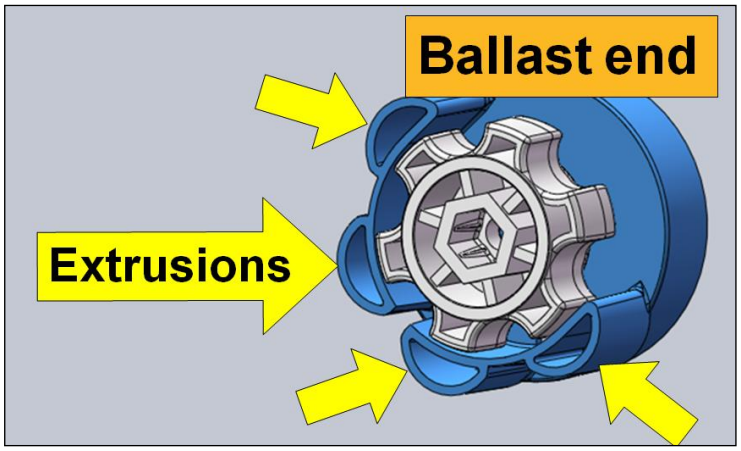


Fig. 33

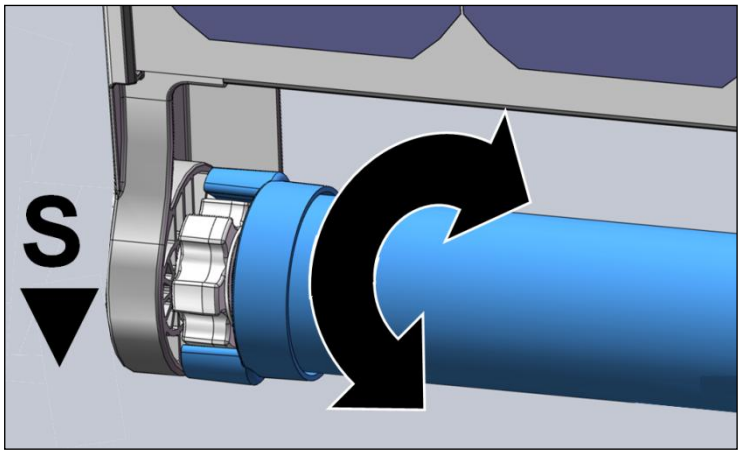


Fig. 34

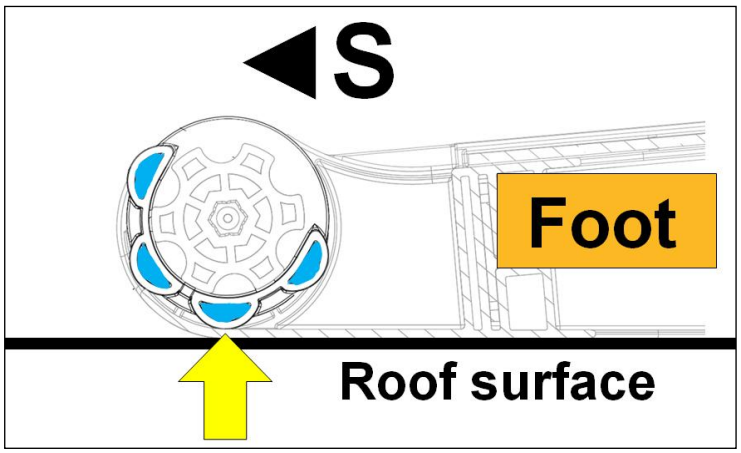


Fig. 35

5.6 Install Type D Ballast

In general, and to expedite overall system installation, follow this sequence when installing ballast at the north end of modules:

1. Insert Type A ballast (Section 5.3).
2. Install Type D ballast (this section).
3. Install deflector (Section 9.0).

Important! You must install Type A ballast *before* the Type D ballast; and before the deflector.

After Type A ballast is installed:

1. Fit the ends of the Type D ballast into the south slot pairs on the north module feet (Fig. 36).
2. Ensure that the larger, cylindrical extension at the end of the ballast fits into the lower of the south slot pairs, and that the smaller cross-shaped extension fits into the upper of the south slot pairs (Fig. 37 and Fig. 38).

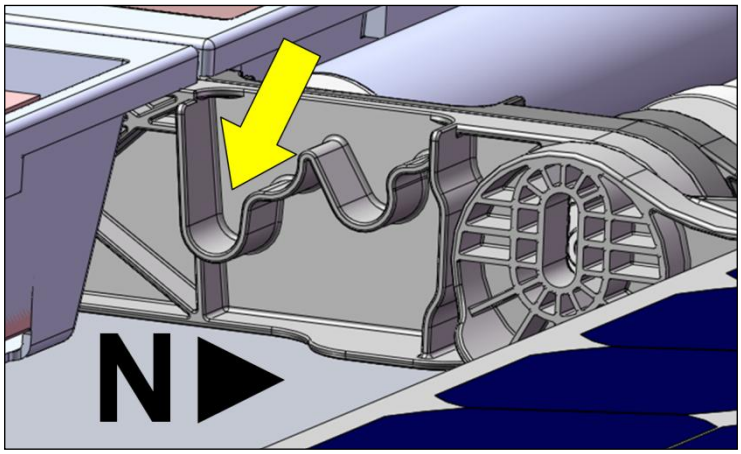


Fig. 36

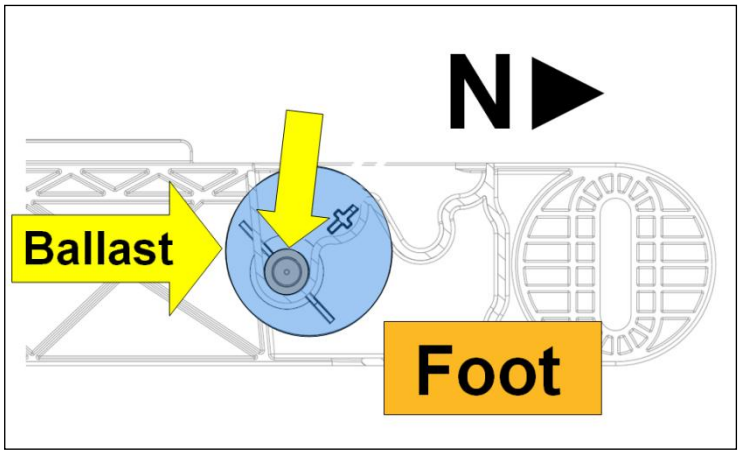


Fig. 37

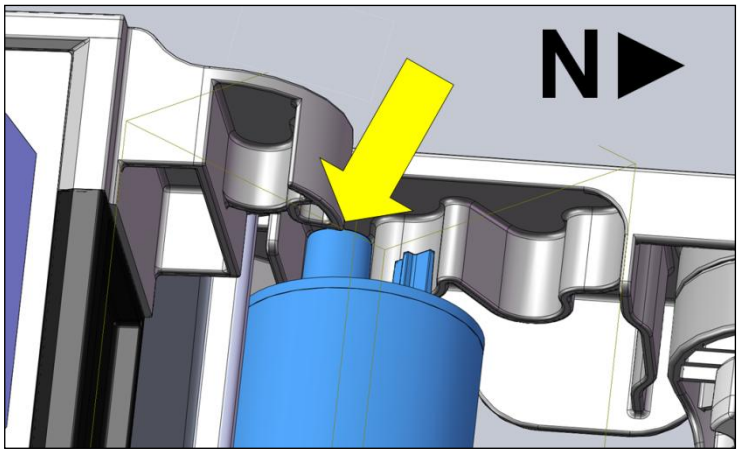


Fig. 38

5.7 Attach Anchors

Depending on the array design, building conditions, and environmental factors, portions of the system might require anchors.

When specified on the PPF or drawings, the system must be anchored to the roof using installer-supplied third-party components that meet SunPower specifications.

On sections of the array that require anchoring, distribute the anchors evenly along the relevant row or column. In addition, *each **end** module of each column and each row must also be anchored*.

Install the anchors at the locations specified in the PPF or the drawings, according to the anchor manufacturer's instructions. Place each anchor as accurately as possible, *and do so only after verifying the correct alignment of the array.* Each anchor must be installed within the given tolerances with respect to the adjacent connector assembly.

You attach the anchors to the modules by using an anchor *bracket* (Fig. 39) and the slots in the north and south module feet, as specified on the PPF or the drawings (Fig. 40).

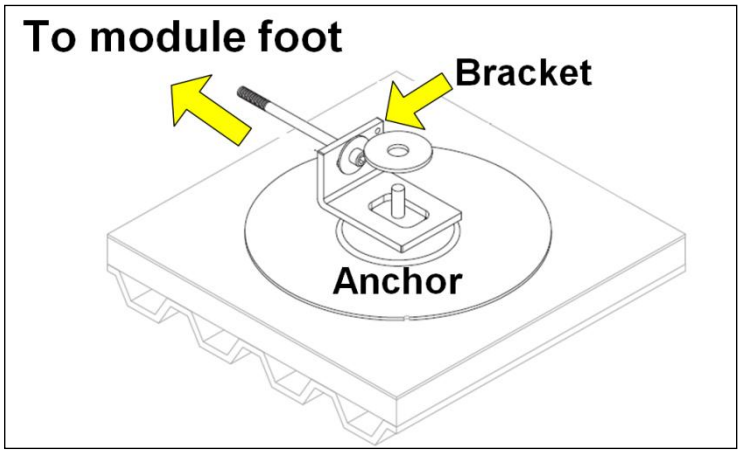


Fig. 39

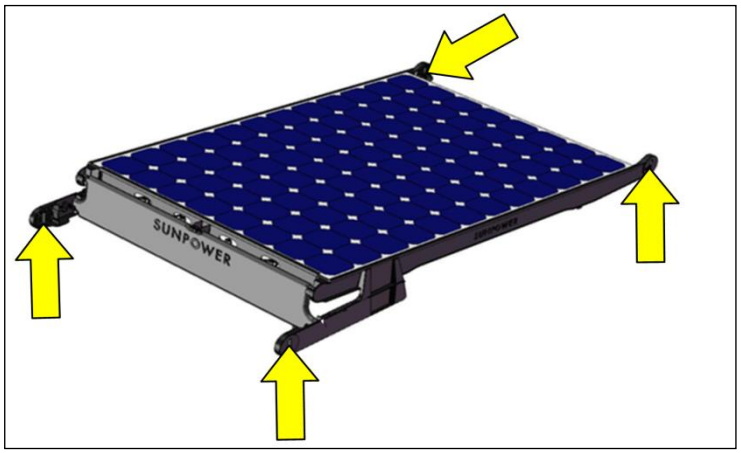


Fig. 40

At each foot or union adjacent to which you will install an anchor, remove the male half of the connector assembly, and then remove the bolt from its connector. Pushing the bolt out does not require much force because it is only pressed into the connector half (Fig. 41).

Important! When attempting to remove the bolt, do not push the bolt into the roof surface.

After positioning the anchor bracket and hardware, and according to the instructions from the anchor manufacturer and from the drawings, reinstall the connector and secure the anchor bracket to the union or foot by using the removed capscrew, the washer from the anchor kit, and the nut still embedded in the female half of the connector assembly.

To attach the anchor bracket to the anchor itself, use the anchor mounting bolt supplied with the anchor. Tighten the anchor mounting bolt to 240 in-lbs (27 N-m); and then torque the connector to 150 in-lbs (17 N-m) (Fig. 42).

Note. Anchor appearance may vary. Figure 42 is an example.

Important! It is the installer's responsibility to obtain complete installation instructions for the anchor from the anchor manufacturer.

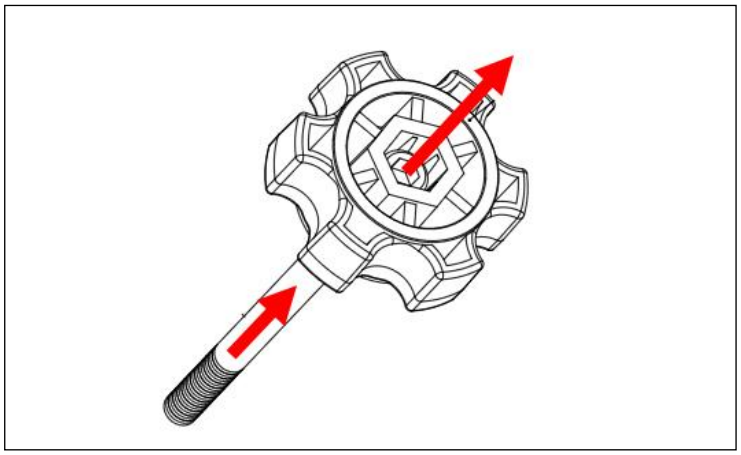


Fig. 41

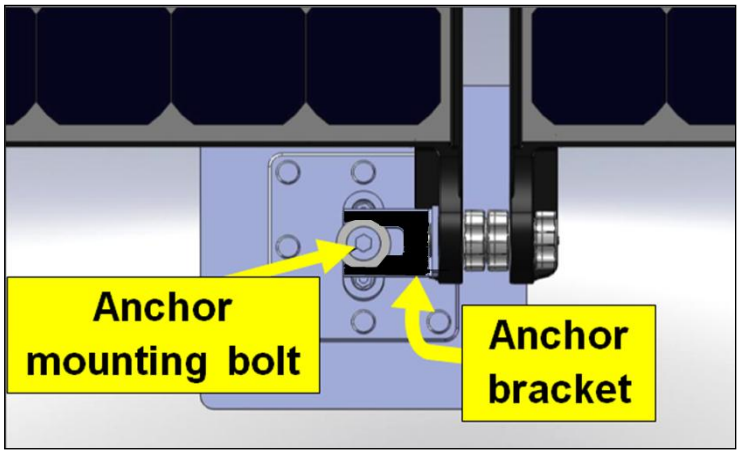


Fig. 42

6.0 Torque Connectors

Warning! Do not use a standard cordless drill with a clutch, nor an impact drill gun to torque the connectors. SunPower recommends the Bosch® Exact line, or a similar tool that has a calibrated and repeatable shut-off clutch. If no others are available, you must use a standard calibrated manual torque wrench.

Important! All ballast must be installed before torquing the connectors.

1. Assess the overall straightness of the rows and columns in the array and make corrections if necessary.
2. For *each* connector in the *entire* array, use the connector tool, a torque wrench, and a 6 mm Allen (hex) bit (Fig. 43) to turn the male connector to apply 150 in-lbs (17 N-m) of torque (Fig. 44). Hold one side of the connector to prevent the side you are tightening from slipping (Fig. 45).

Fig. 43

Fig. 44

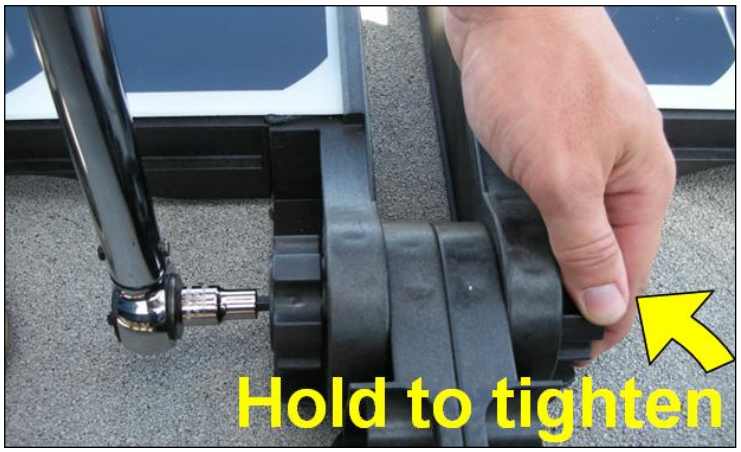


Fig. 45

7.0 Electrically Connect Modules

Refer to the PPF or drawings to determine the number of modules that make up each string. *Do not exceed the maximum number of modules allowed in a string.*

Important! Where this manual specifies using wire ties, use only UV-rated, military-grade wire ties (such as the Cable Tie Express CTE-175LBBLK from EMI Supply, Inc., or equivalent). *Do not use plastic-coated steel ties.*

7.1 Jumpers

Jumpers are wires that enable modules that are *not* immediately adjacent to one another to still comprise an electrical string. This occurs most often when a single string exists in more than one row of the array.

Note. You create jumpers in the field, as necessary.

You route jumper wires the same way you route N–S homerun wires: along the channel between columns.

Where possible avoid allowing the module leads or jumper wires to touch the roof, and ensure that they do not pinch or bind anywhere, and that they do not and will not otherwise become abraded by the roof surface. In addition, always observe minimum bend radius per NEC.

7.2 Connect Module Wires

Module wires connect to form strings; strings may exist in a single row, or may span two or more rows.

The modules come packaged with their lead wires already attached to retaining features that are built onto the north face of the module frame (Fig. 46). This placement makes it easy to locate, release, and connect the wires after the modules have been positioned in the array. Gently freeing the wires enables you to connect them to adjacent modules.

The wires on the modules are marked positive (+) or negative (–) on the connectors. You simply plug in the wires male-to-female (Fig. 47). However, you must insert the red disconnect tool to *unplug* the module wires (Fig. 48).

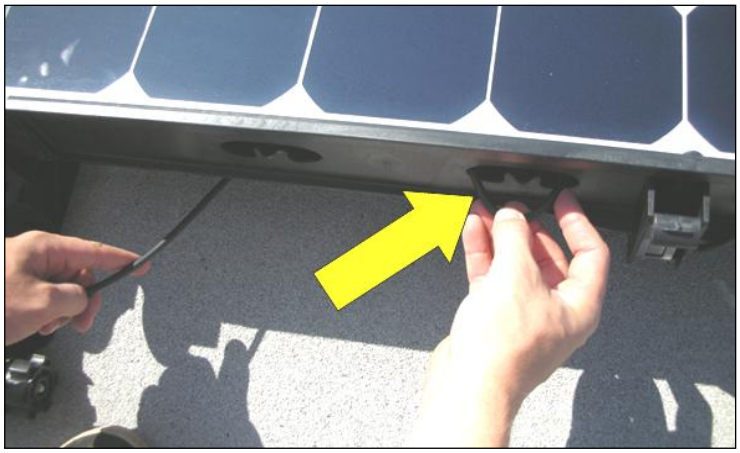


Fig. 46

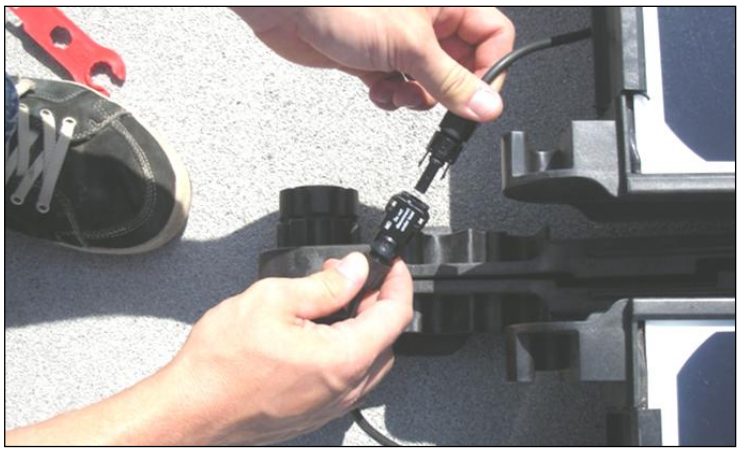


Fig. 47

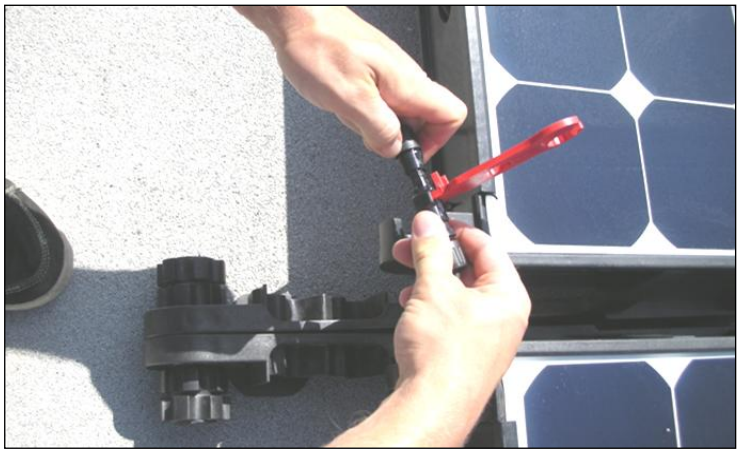


Fig. 48

7.2.1 Connect Strings that Occur in a Single Row

For the instructions in this section, we consider the easternmost module in the row as “the first module.” In addition, the colors used on the module lead wires in Fig. 49 are for illustrative purposes only.

1. Leave the negative wire of the first module exposed toward the east (Fig. 49). (It will either become the string end to which you attach the negative homerun wire, or you’ll attach a jumper to connect it to an adjacent row to complete a string).
2. Connect the positive wire of the first module to the negative wire of the module to the west of the first module, tuck the wire underneath the module frame, and then use a UV-rated, military-grade wire tie to secure the wire (or wires) to the frame, through one of the holes in the frame face (Fig. 50), securing the wires behind the frame as much as possible (Fig. 51).

   Note. You may need to temporarily remove ballast trays to access and position wires. Ensure you replace the trays correctly (Section 5.3).

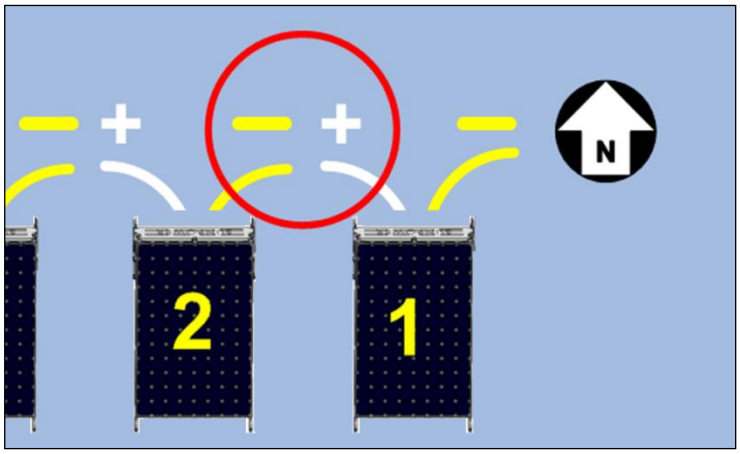


Fig. 49

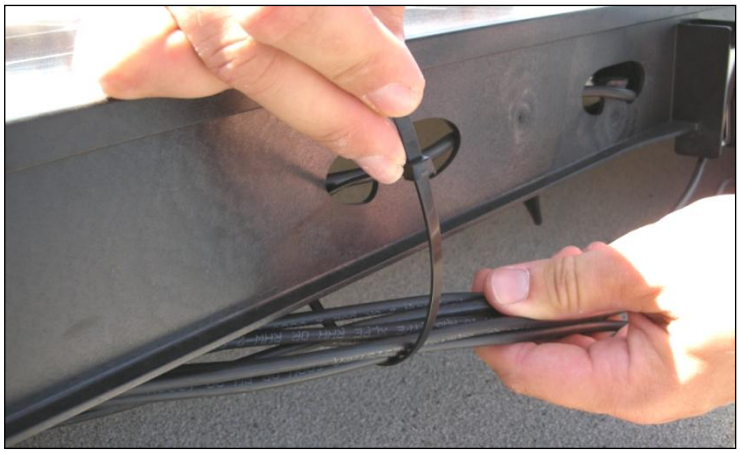


Fig. 50

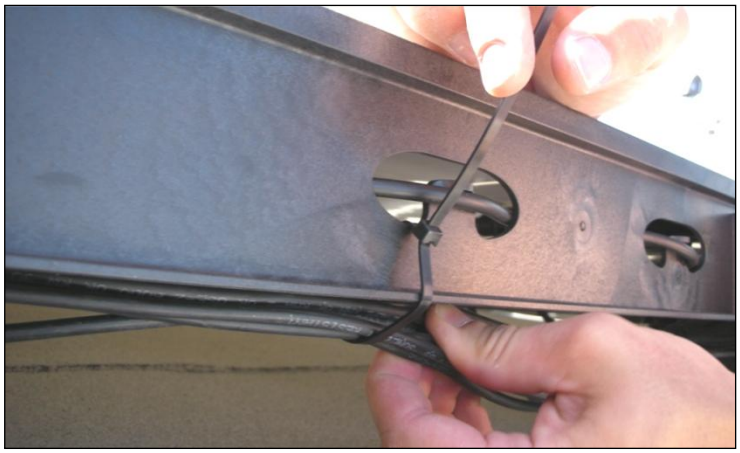


Fig. 51

3. Continue connecting module wires in a similar fashion, one after the other until you reach the end of a row or until you complete a string. Ensure that you interconnect the wires snugly.
4. At the end of each string, leave the positive wire of the last module in the string disconnected, and then begin a new string.

7.2.2 Connect Strings that Span Over Two or More Rows

Depending on the string shapes and number of modules in a given row, you may need to continue a string in an *adjacent* row. In rare cases a string may span *three* rows.

Important! If you reach the end of a row but not the end of the *string,* you must "jump" to an adjacent row to continue and complete the string, connecting modules while moving *in the opposite direction.* In such cases, you must accordingly switch the position of the module leads as you connect them in the adjacent row (Fig. 52).

Note. The colors used on the module lead wires in Fig. 52 are for illustrative purposes only.

1. Attach a jumper between the appropriate module leads, keeping the jumper *within* the array perimeter (Fig. 52).
2. Route the jumper along the gap between the module rows, in the same manner that you route the homerun wires.

   Note. As with homeruns, jumpers also require that you use supports (Section 10.1).

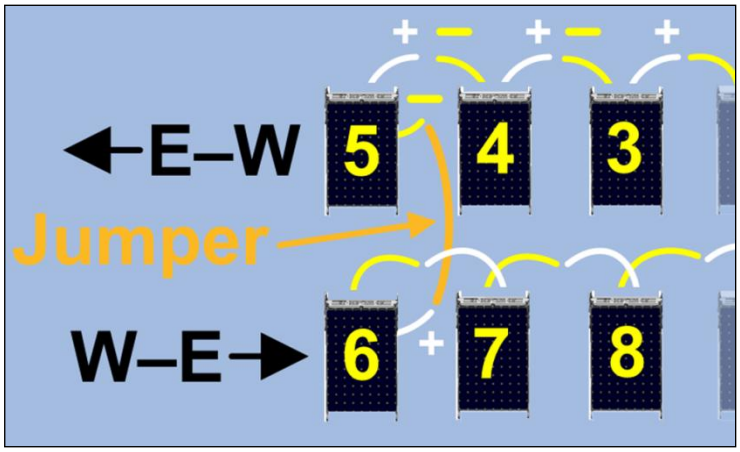


Fig. 52

8.0 Install Combiner Boxes and Create Homerun Wires

Important! Wiring connectors must be MC4 or other IP67-rated connectors. If greater than 1 1/2″ (3.8 cm) of ponding is present, all wiring must be secured min. 3″ (7.6 cm) above the roof surface.

The homeruns are the wires that you attach to the string ends, which then connect the array to the combiner box. Use the drawings to guide your creation of the homeruns.

When creating the homerun wires, the following aspects are very important:

- The shapes of the strings within the array. This reveals where the string ends occur, where the homeruns must attach, and thus how long each homerun must be.
- The paths by which the homeruns traverse and exit the array. This reveals where you must position and mount the exit conduit.

  Important! The homeruns must not bind or pinch anywhere.
- The number of homeruns in each exit path.

  Important! The maximum number of homerun wires you can place in each N–S gap is 36; and the maximum for the E–W homeruns is also 36 wires in a given row. The maximum number of wires exiting the array in a given exit conduit is 36.
- The locations of the combiner boxes. Refer to the PPF or drawings for the locations of the combiner boxes, which enable you to efficiently plan each array's conduit exit points.

Warning! Depending on the module type, the system may require positive grounding. If positive grounding is required for the system you are installing, then the *negative* leads must be fused—**DO NOT** fuse the positive conductors. In addition, for positively grounded systems, the positive conductors in combiner boxes must be white or labeled with white tape. **Always refer to the PPF or the drawings so that you are certain of the grounding requirements for the modules you are installing.**

The homerun wires pass through conduit on their way to the combiner boxes, and electrically connect each string in the array to a combiner box. If the homeruns are not provided you must create them at the site.

Each string within the array must have a homerun coming from each of its ends (two homeruns per string): an ungrounded conductor and a grounded conductor:

- For **positively grounded systems,** the fused conductor is always the negative string, and the non-fused connector is always the positive string.
- For **negatively grounded systems,** the fused conductor is always the positive string, and the non-fused connector is always the negative string.

Refer to the PPF or the drawings to install the combiner boxes now, before proceeding.

Note. Individual strings are ultimately bonded to ground inside the inverter after they are combined in the combiner box.

To create the homerun wires:

1. Place the spool of wire approximately 10′ (3 m) behind the combiner box.
2. Determine the eventual path of each homerun, from its string end origin, through the array, and to its combiner box destination, so that when you walk each wire out to its destination—in the next step—you do so following all of the actual angles that the homerun wire must conform to once it's connected. Keep in mind that the homeruns will route E–W behind the deflectors (Fig. 53 and Fig. 54), and N–S along the gaps between the module frames (Fig. 55).

   Note. You can attach the connector ends (pins or sockets) to the wire end now, before you actually pull the wires out to their destinations.
3. Have two workers pull wire, walking it along its actual path, from the spool to the positive and negative ends of each string to ensure you pull the necessary length for each homerun. Ensure that the wire is not damaged during this process. Do not drag wire over sharp edges or around corners. For now, you can place the wires over the top of or adjacent to the modules.
4. At the spool end, cut the wire to create each homerun, leaving enough additional length at each end so that there will be enough slack to easily connect the wire inside the combiner box.
5. Label each wire with the string number and polarity.

   Important! Take extra care to ensure you correctly label the wire ends.

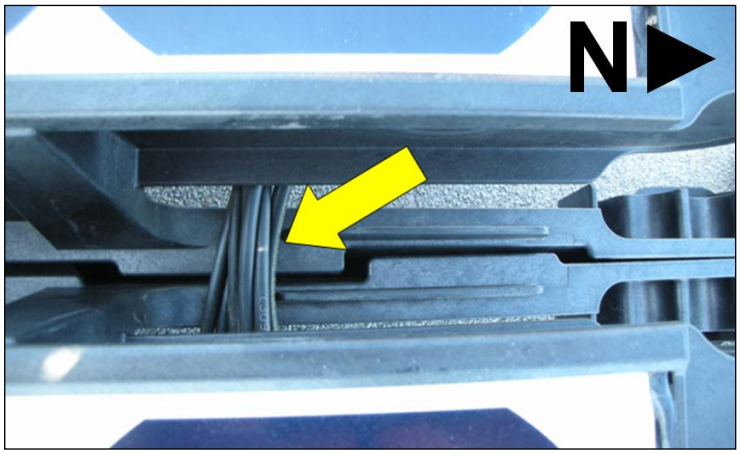


Fig. 53

Fig. 54

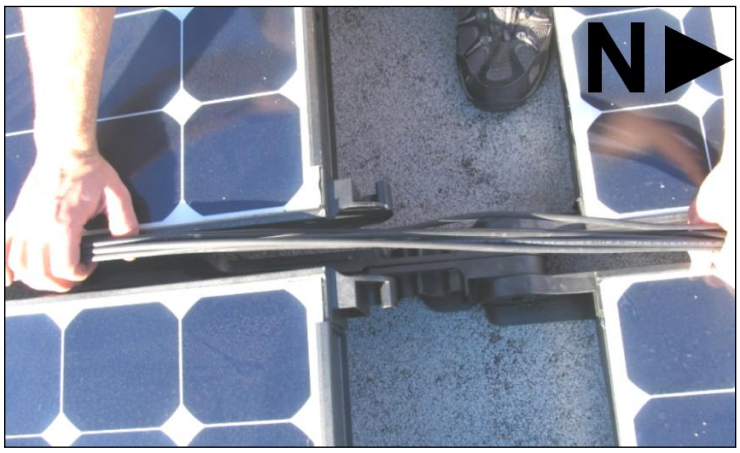


Fig. 55

6. If you have not done so already, at the string end, attach a pin or socket to properly mate with the connector on the positive or negative end of the string, and then clearly mark the string number and polarity on the homerun at the string end as well. *Do not connect the connectors.*

   Important! Follow the manufacturer's instructions for connector attachment. Use negative (pin) connectors for positive homerun wires; use positive (socket) connectors for negative homerun wires.

7. At the string end, tape the homerun wire to its module lead mate, placing the tape approximately 10″ (25.4 cm) from the end of the connectors. This will enable you to connect them easily later, without violating the maximum allowable bend radius of the wires (Fig. 56).

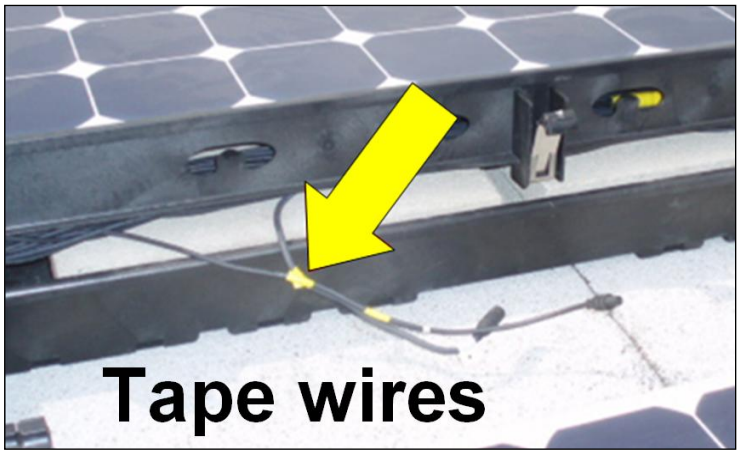


Fig. 56

9.0 Position Deflectors

Deflectors arrive onsite already fully installed on their respective modules (in the 60° position). *Leave the deflectors installed at all times*, and only remove them for the following reasons:

- to install Type A ballast
- to access and complete the array wiring
- to position each deflector at its correct final angle

Note. Most modules require that their deflector's final position be 85° (refer to Fig. 58).

9.1 Overview

The system is designed such that you complete the ballast installation, inter-module wiring, and homerun wiring *before* you position the deflectors at their final angle. However, at the discretion of the installation supervisor, you can combine or overlap some of the installation steps as long as doing so does not compromise your ability to perform all of the steps correctly.

Important! You must remain aware of changes in wind conditions, and your crew must be capable of rapidly positioning *all* of the deflectors in the event of threatening weather (Section 2.1).

Deflectors must be positioned at one of two possible angles (60° or 85°), depending on their respective module's location within the array (Fig. 57, Fig. 58, Fig. 59, and Fig. 60):

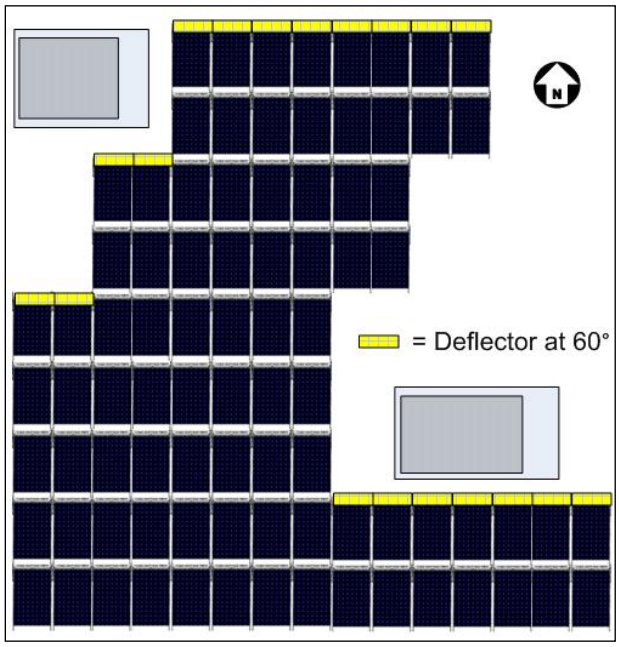


Fig. 57

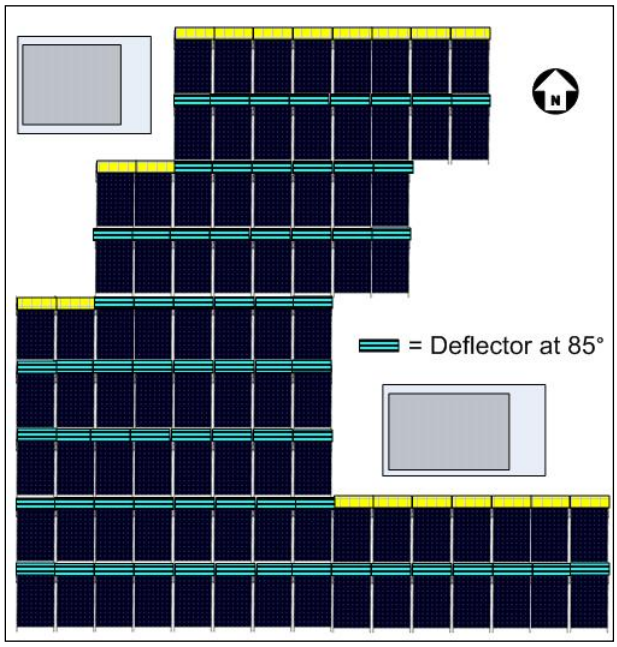


Fig. 58

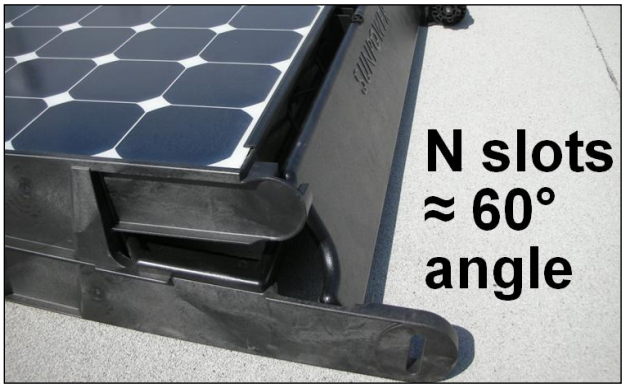


Fig. 59

Fig. 60

Each north foot of each module includes two pairs of slots (a north pair and a south pair) on each foot's inner surface (Fig. 61).

Each deflector has a mounting *tip* at each upper end and a mounting *tab* at each lower end (Fig. 62).

Each deflector's final installed position is dictated by its module's position in the array with respect to the array perimeter:

Module Position	Slots / Angle
• Northernmost row (refer to Fig. 57) • Does not engage a module to its north	North / 60° White arrows in Fig. 61
• All other modules (refer to Fig. 58)	South / 85° Yellow arrows in Fig. 61

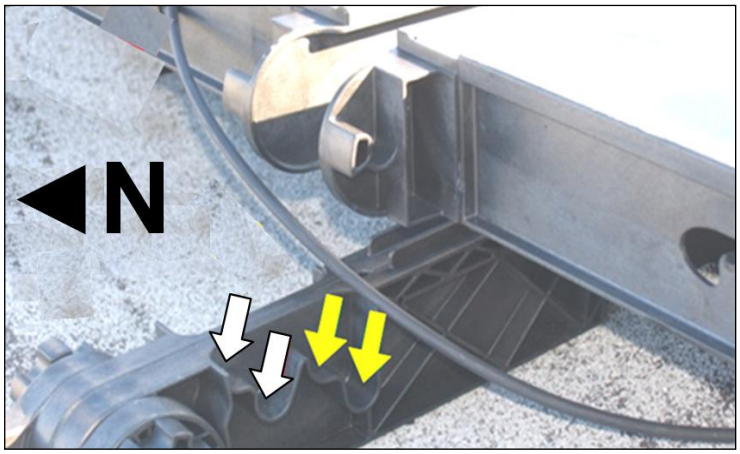


Fig. 61

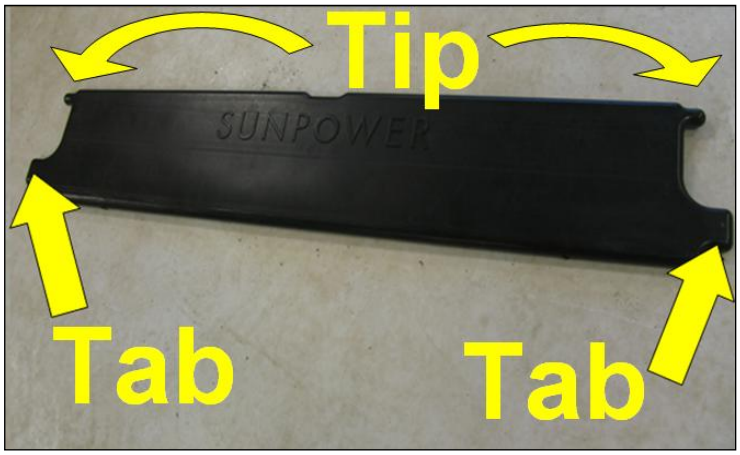


Fig. 62

9.2 Remove and Reposition Deflectors

To reposition a deflector, you must first remove it from the module.

Important! While working with deflectors, ensure that inter-module and homerun wires do not pinch or bind.

9.2.1 Remove Deflectors

Push up the retainer at the top center of the deflector (Fig. 63), tilt the deflector toward you (northward) (Fig. 64), and then lift it out of its slots.

Fig. 63

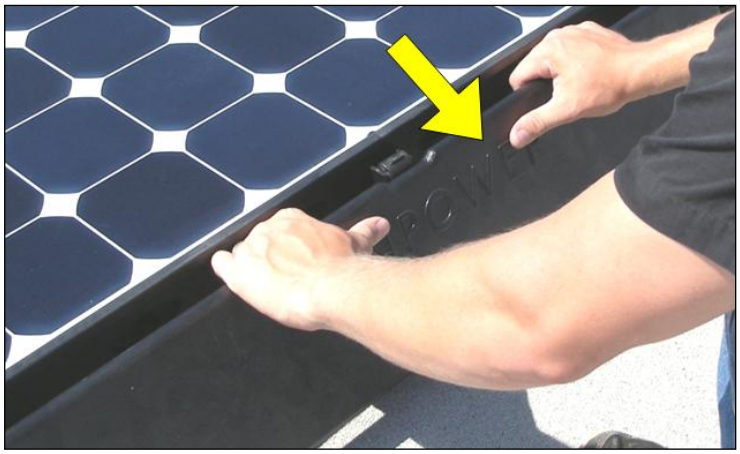


Fig. 64

9.2.2 Reposition Deflectors

After a deflector has been removed, do the following to reposition the deflector at either of the two possible angles:

1. Fit both of the deflector tips into the notches above the feet (Fig. 65). You might have to push back on the retainer with the deflector slightly to get both of the tips into the notches.

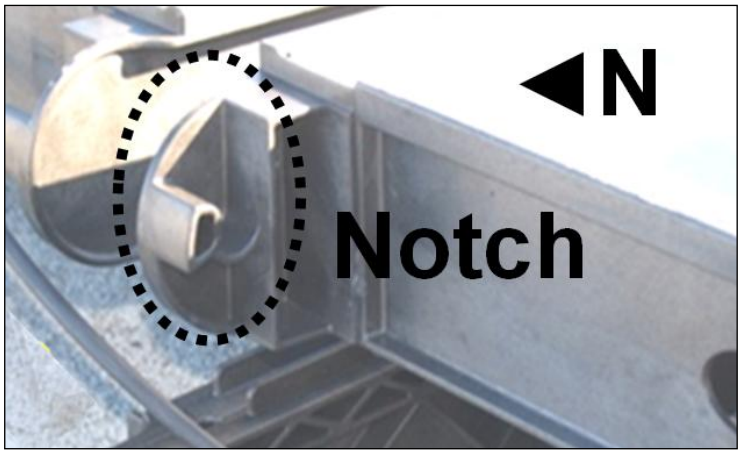


Fig. 65

2. Using whichever slot pair is correct for the given module, fit the deflector tabs evenly into the upper (shallower) of the slot pair (Fig. 66).

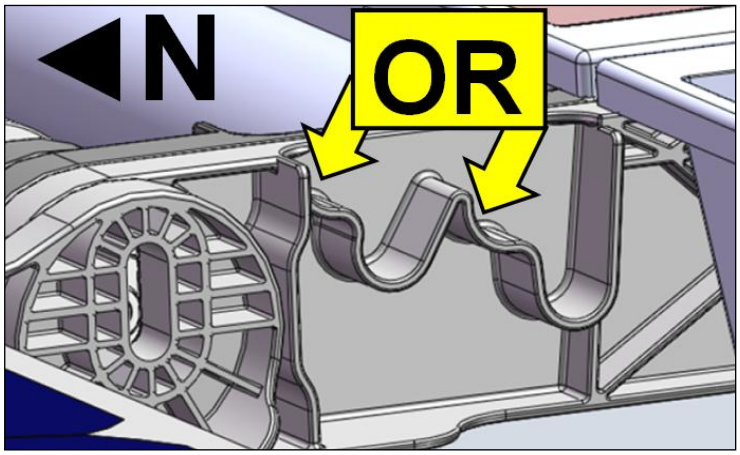


Fig. 66

3. Hold the deflector with both hands and evenly tilt the bottom half of the deflector toward the module (Fig. 67) until the tabs slip down into the deeper slots of the slot pair.

Fig. 67

4. As the tabs slip down the tips will simultaneously drop to the bottom of the notches (Fig. 68).

   Note. Fig. 68 shows a deflector installed in its module's north slot pair, at the 60° angle.

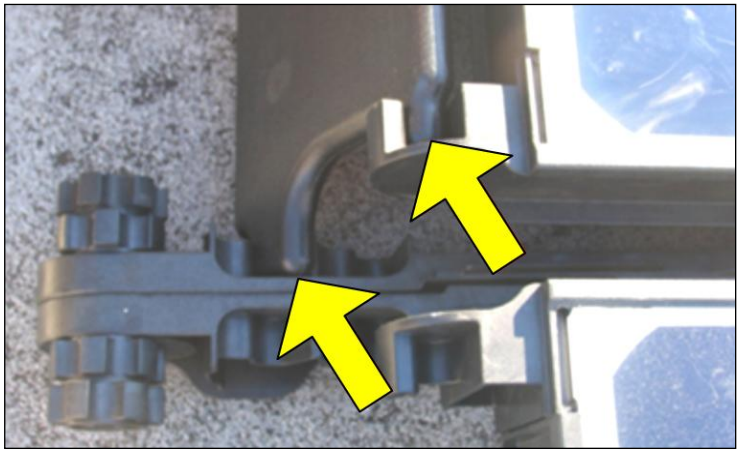


Fig. 68

5. Pull the retainer toward you (northward) to ensure that it fully captures the upper edge of the deflector (Fig. 69).

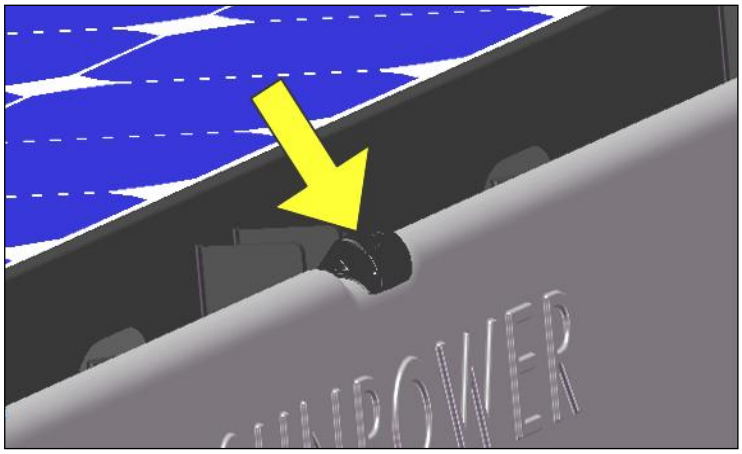


Fig. 69

10.0 Route Homerun Wires, Pull Wire, and Position Array Conduit

Conduit protects the homeruns and provides a clean, finished look to the array. Exit conduit forms sections of the pathways by which the homerun wires exit the array.

The general array wiring installation sequence is as follows:

1. Route the homerun wires.
2. Position conduit.
3. Pull wire through conduit.
4. Verify string polarity.

Important! The previous steps are only a high-level overview of the wiring procedure; do not use them in place of the detailed instructions in the following sections.

Note. If you are required to physically secure the conduit to the array, refer to Appendix B.

10.1 Route Homeruns

The wire bundles exit the array at these points:

- North side of the array: at the gap between two modules in the northernmost row.
- East or west side of the array: through the gap above the southernmost part of a module's north foot.

Important! The maximum number of homerun wires you can place in each N–S gap is 36; for the E–W homeruns the limit in any given row is also 36.

1. E–W: Removing and reinstalling the deflectors as necessary, route the homeruns on top of the north module feet and on top of the ballast trays (if present), behind the deflectors (Fig. 70 and Fig. 71).

   Important! When routing the E–W homerun wires, fit them underneath *one at a time* to avoid any pinching between the ballast tray and the module frame.

2. N–S: Route the homeruns adjacent to the gap between the modules (Fig. 72).

Fig. 70

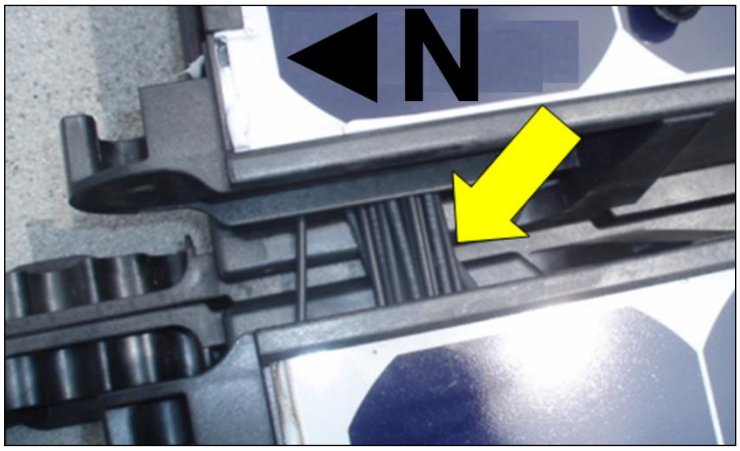


Fig. 71

Fig. 72

3. Bundle the N–S homeruns and temporarily wrap the bundle with electrical tape (Fig. 73), to enable you to easily position the homeruns between the modules.
4. Special X-shaped wire supports help keep the N–S homeruns from touching the roof surface. These supports flex slightly to enable you to fit them between the modules.

   For the N–S bundles, you will install two of the X-shaped wire supports as follows:

   - In the N–S channel between *each* module pair along which wires route.
   - Horizontally, concave side up (Fig. 74).
   - In “portrait” position: longer side situated E–W (Fig. 75).
   - One support 24″ (61 cm) from the module south connection point (midway between the 4th and 5th cell from the south edge of the module) (Fig. 76).
   - One support 42″ (107 cm) from the module south connection point (midway between the 4th and 5th cell from the north edge of the module) (Fig. 76).

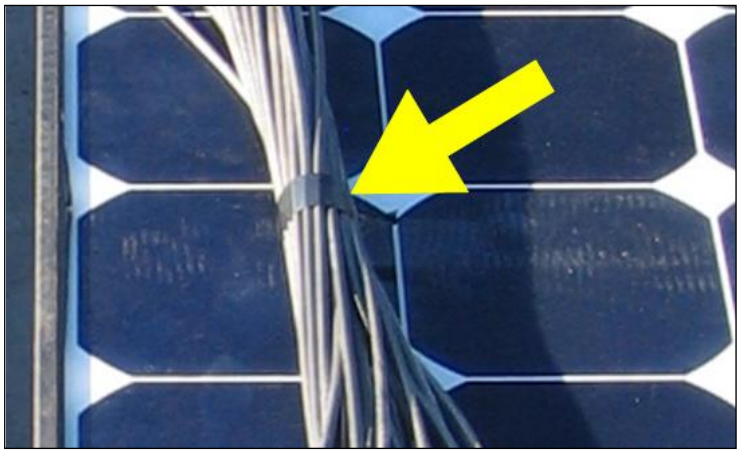


Fig. 73

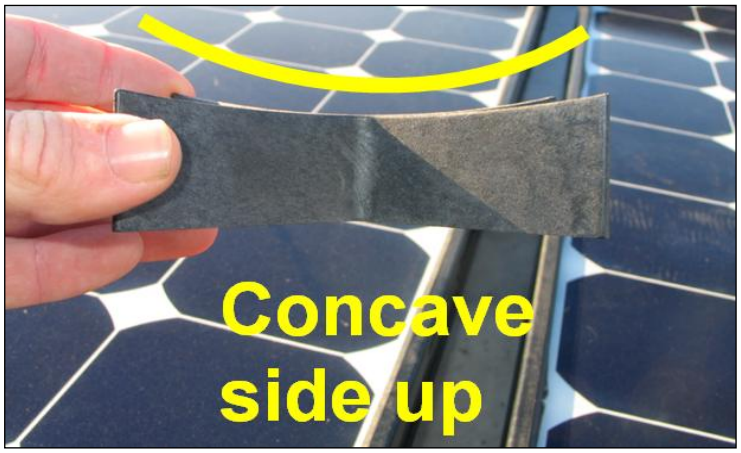


Fig. 74

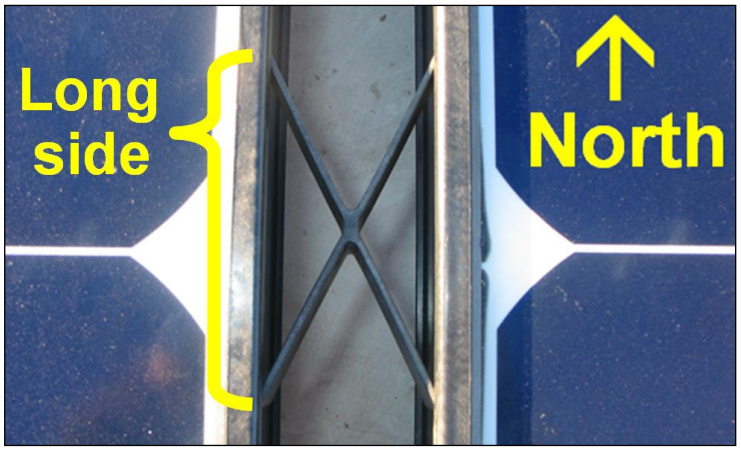


Fig. 75

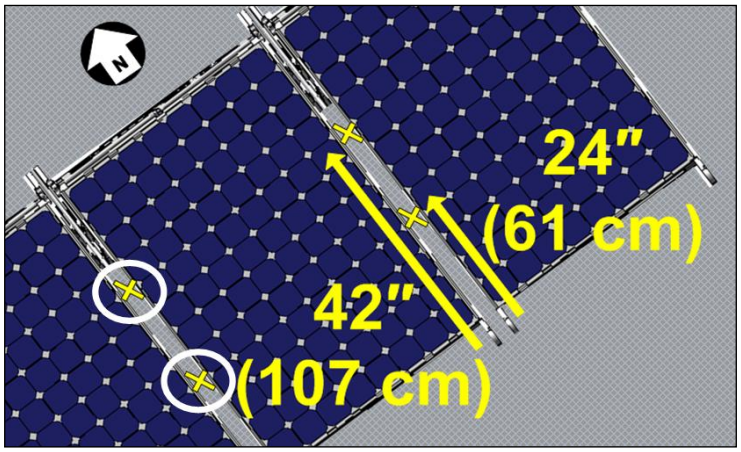


Fig. 76

5. Route a UV-rated, military-grade wire tie under the supports, position the wire bundle atop the support, and then secure the wires to the support using the wire tie (Fig. 77 and Fig. 78).

   Note. Alternatively, you can position the supports between the modules, place the wire bundle atop the supports, *and then* wrap them with the wire ties.

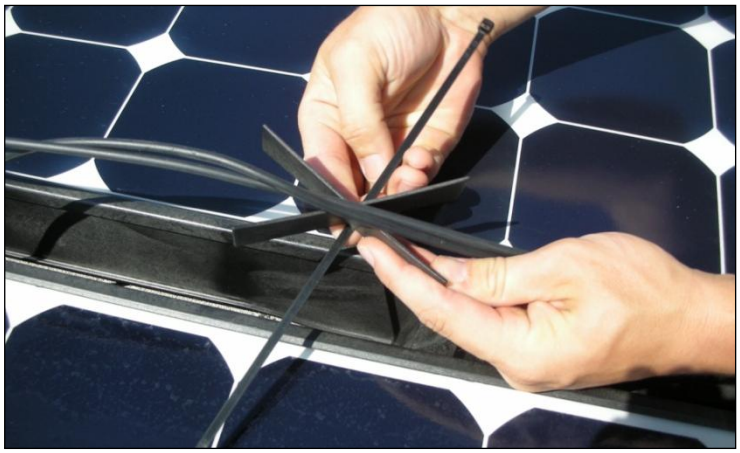


Fig. 77

Fig. 78

6. Snip off the excess tie, leaving approximately 1/4″ (6 mm) remaining (Fig. 79).

   Important! The remaining wire tie must not be able to cause any shading on the surface of the module.

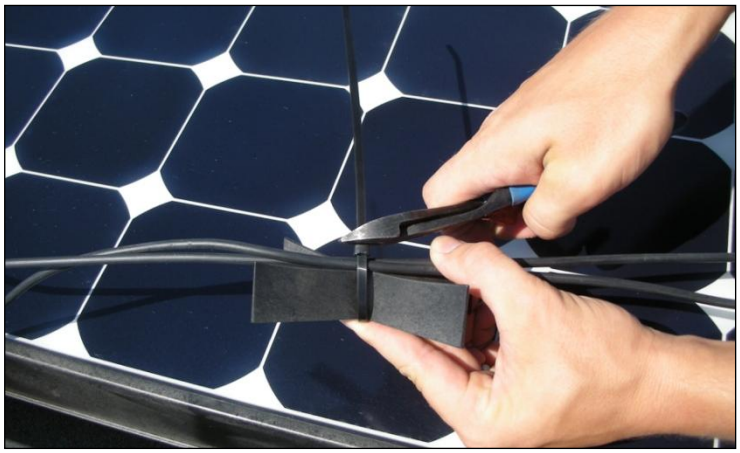


Fig. 79

7. Fit the support and the wire bundle down in between the modules (Fig. 80 and Fig. 81).

   Important! Ensure that the module-to-module leads remain routed *under* the homerun bundle.

8. Remove the electrical tape wraps and replace each with a loosely secured wire tie.

9. Re-check the location of each X-shaped support and verify that its position remains correct (Step 4).

   Important! Ensure that the wire bundles are fully and securely nestled down between the modules—below the PV surface—so that no wires protrude that could cause shading on any PV surface.

Fig. 80

Fig. 81

10.2 Pull Wire

Note. Performing the open circuit voltage test and the array resistance test after you complete this section, can save you time later when you're ready to commission the system (Section 12.2 and Section 12.4).

Before you pull wire, refer to Section 10.3.2 to determine whether you must pull a ground conductor as well.

When properly attached, a conduit bushing provides strain relief and wire protection during wire pull. *The maximum number of wires permissible in the conduit is 36, including the ground conductor.*

1. Ensure that the homerun wires are *not* plugged into the string ends at the modules (Fig. 82).
2. Pull the homerun bundles and the ground conductor through the conduit (Fig. 83), toward the combiner box.

   Note. Although you must also pull a permanent copper ground conductor for each section of EMT or rigid conduit that routes between a combiner box and an array (Section 10.3.1), *a ground conductor is not required where flexible non-metallic conduit is used.*
3. Ensure that all the strings are labeled according to the string wiring plan. It's helpful to mark the fuse holders themselves with the string number.

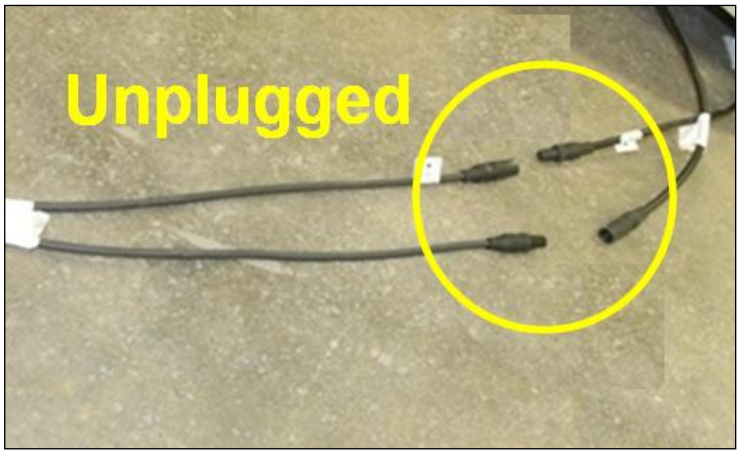


Fig. 82

Fig. 83

10.3 Position and Ground the Array Conduit

All conduit must, in its final position, be low enough so that it does not cause module shading.

Note. It is acceptable to position conduit at the *south* edge of an array as well but only if doing so does not cause module shading.

10.3.1 Position Conduit

Any conduit type used must meet the specifications in the PPF or the drawings, and must conform to all applicable NEC requirements for:

- uses permitted
- securement and support
- bends
- grounding and bonding

Refer to the specific NEC conduit section to ensure conformance. Refer to local jurisdiction requirements, and to the PPF or the drawings for information about the types and length of conduit required.

Important! Conduit runs must include thermal expansion joints when the distance in any one direction exceeds 100′ (30 m). **Refer to the *Conduit Expansion/Contraction Guidelines* (SunPower document # 001-57492).**

1. Bend conduit as necessary to route between each conduit mount and its adjacent combiner box (Fig. 84, example only).

   Note. All bends must conform to local NEC and IEC articles and standards.

2. Following the conduit mount component manufacturer's instructions, attach the conduit to the mount.
3. Attach the conduit to the combiner box.
4. Terminate the conduit inside the combiner box.

Note. If you must attach the conduit to the array, refer to Appendix B.

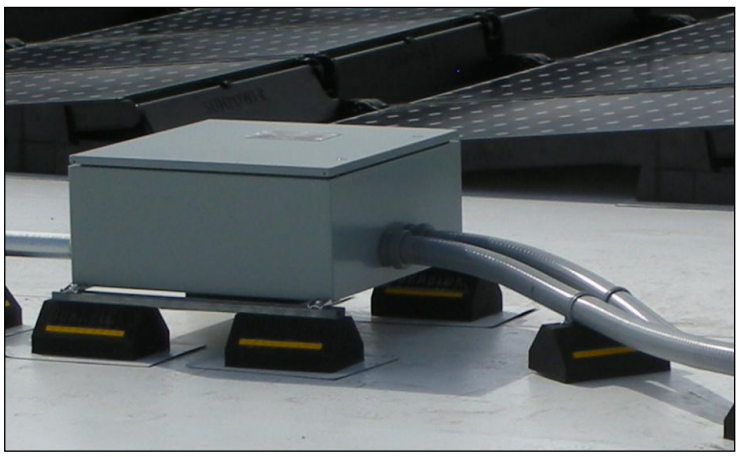


Fig. 84

10.3.2 Ground Array Conduit

Although the individual modules do not require grounding, you must ground any *metallic* conduit as follows:

- Attach an ILSCO GBL4-DBT lay-in lug (or equivalent; sized per NEC) to the array end of the conduit.
- Attach the permanent copper ground conductor to the lay-in lug; route it *through* the conduit; and land it in the combiner box (Fig. 85).

Important! If non-metallic conduit is used, a ground conductor is *not* required.

If you are in question, consult the latest enforced version of the NEC.

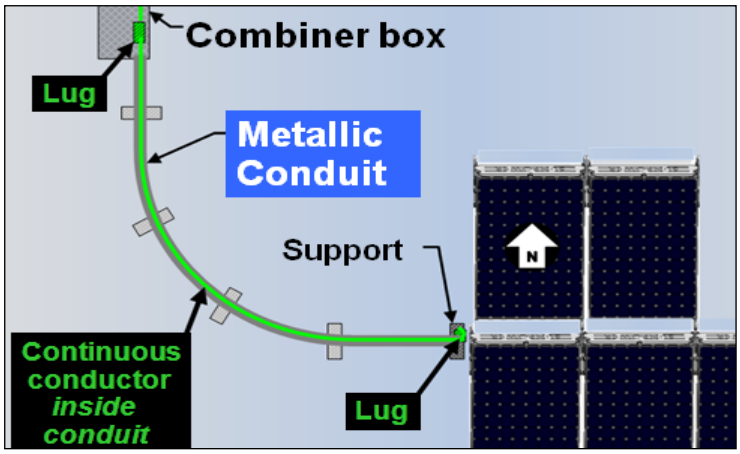


Fig. 85

10.4 Verify String Polarity

Performing the open circuit voltage test now can save you time later when you're ready to commission the system (Section 12.2).

After you have created the homeruns and taped them to their string-end mates, routed them through the array and the conduit, and then routed them to the combiner box, you must verify their polarity before you *land* them in the combiner box.

Important! This step must be completed by a licensed electrician.

Warning! The system may be positively grounded. If the system you are installing is positively grounded, the *negative* leads are fused—**NOT** the positive conductors. Ensure that all parties involved understand whether the system is positively or negatively grounded before continuing.

1. Position an electrician in the array field and another at the combiner box.
2. Within the array, connect the homeruns (positive and negative) to the module wires, string by string, and use a voltmeter at the combiner box to verify the polarity and string identity.
3. After testing each string, unplug the negative and positive homeruns from the module wires.
4. Land the wires in the combiner box according to the PPF or the drawings.
5. Connect the homerun wires to the string ends within the array.

11.0 Complete the Intertie

SunPower strongly recommends electrical insulating gloves (Class 0 or better) and electrical insulating boots. In addition, all installers must reference all relevant NEC Articles, including Article 250 and 690 and appropriate IEC standards, for proper compliance.

Warning! These steps must be completed by a licensed electrician. Do not perform any servicing unless you are qualified to do so.

11.1 Mount Inverter and Disconnects

Refer as well to the inverter manual, and the PPF or the drawings before you install the inverter, combiner box, and disconnects.

You mounted the combiner boxes in Section 8.0; refer to the array layout and the drawings to locate and mount the following components near the main service panel:

- Utility lockable AC disconnect
- Meter housing
- Isolation transformer (inverter AC disconnect is built onto the transformer)
- Inverter (inverter DC disconnect is built onto the inverter)

Install the meter housing between the isolation transformer and the utility lockable AC disconnect.

11.2 Complete the Building Intertie

The following are the intertie paths for US and EU installations:

- **US:** Main Service Panel > Utility Lockable Disconnect > Meter Housing > Inverter AC Disconnect > Isolation Transformer > Inverter > Inverter DC disconnect > Combiner Box
- **EU:** Grid Connection > Meter Housing > Main Service Panel > Inverter > Inverter DC Disconnects > Combiner Box (String Box)

Warning! These steps must be completed only by a licensed electrician.

1. Ensure that the inverter AC and DC disconnect switches are open.
2. Complete the interconnection by landing the AC conductors on the overcurrent device or bus tap at the main service panel.

12.0 Start and Commission System

Upon completion of the installation, the following tests and steps must be performed only by qualified and approved personnel in order to start up the system and initiate its warranty.

Warning! Megohmmeters induce high voltage onto circuits and equipment during testing. When performing these tests you must first ensure that all wiring and equipment under test is electrically isolated from other wiring and equipment not being tested. In addition, you must ensure that all persons in the area are notified of the testing prior to initiating the tests. You must also ensure that all wiring and equipment is secure and that unauthorized person cannot come in contact with the equipment during the test. Equipment such as inverters and modules can be damaged if these tests are performed improperly. You must follow all written procedures carefully; and contact SunPower with any questions *prior* to performing any tests on the equipment.

Warning! Improper commissioning endangers the installers as well as the system. Only personnel approved by SunPower should attempt to perform the procedures in this section. The system must be checked for any active ground faults before performing any of the tests in this section.

Contact SunPower Technical Support with any questions regarding the steps in this section:

TechnicalSupport@sunpowercorp.com

For Systems: 1-800-251-9728

For Dealers: 1-800-SUNPOWER (1-800-786-7693)

12.1 Check Inverter and Start the System

Do not perform the system startup until the entire installation is complete and has been approved by the installation supervisor.

12.1.1 Verify the Disconnects

Referring to the inverter manufacturer's manual, verify that the installation of the AC disconnect, DC disconnect, and DC wiring is correct.

12.1.2 Start Up the Inverter

Referring to the inverter manual, follow the procedures for applying AC and DC power.

Refer to the inverter manual for instructions on system shutdown as well.

12.2 Test Open Circuit Voltage

This test ensures that all strings are properly connected, and that all modules are functioning properly.

Note. Common problems that will reduce V_{oc} include field wiring errors, poorly crimped connections, inadequately seated connections, shorted bypass diodes, poorly soldered junction box tabs, and soldering failures in the laminate, as well as dysfunctional cells.

Purpose	Open circuit voltage testing provides a simple method to determine that all strings are properly connected and that all modules are producing an appropriate voltage level.
Party	SunPower personnel
Scope	All strings
Equipment and Materials	• rubber insulating gloves • rubber insulating glove tester • safety glasses • voltmeter with probes, with an accuracy of at least 1% of reading • fuse puller • V_{OC} module rating (as noted on back of modules)
Conditions	Ideally this test should be conducted under full sun (>500 W/m^2) and stable sky conditions, generally between the hours of 10:00 A.M. and 2:00 P.M. (local time). The test may be performed at lower irradiance levels or under unstable sky conditions; however, under poor conditions, test results will be used only to determine whether strings are properly connected, and not to judge their voltage performance. When testing under lower irradiance levels, calculation of the expected V_{OC} will require accurate estimates of module and string voltage at low irradiance. A reasonable attempt must be made to perform this test under ideal sky conditions; however, if ideal weather is not anticipated because of seasonal changes, perform the test under the best conditions available and evaluate the strings based on the results.

Criteria	For stable sky conditions and irradiance above 500 W/m2, string voltages should conform to within 5% of expected voltage, and each string should conform to within 3% of the average string voltage in the same combiner box under identical temperature and irradiance conditions. 1. Expected voltage may be calculated for strings using Step 2 plus a logarithmic correction for irradiance between 200–500 W/m2. For irradiance less than 200 W/m2, test results may be used only to confirm proper string connection, and not to evaluate voltage performance. Investigate strings that are outside of this range until module non-compliance, if applicable, is determined. 2. In the cases where a string's voltage is not within the acceptable range, perform the following steps to identify a faulty module within an electrical string: a. Make sure that the inverter is off and that the fuse has been removed from the faulty electrical string. b. Disconnect the electrical connectors at both ends of the string to be tested, as well as between the two centermost modules *within* the string. c. Attach a jumper wire to each end of the electrical string. d. Using a voltmeter, check the V_{OC} of each half-string (for 9-module 1000 V strings, check the 4-module portion and the remaining 5-module portion as well). The string segment containing the faulty module should be significantly lower than the other half. e. Divide the lower voltage string segment in half and repeat steps a–d until the faulty module or lead is located.
Comments	Common problems that will reduce V_{OC} include field wiring errors, poorly crimped connections, inadequately seated connections, shorted bypass diodes, poorly soldered junction box tabs, and soldering failures in the laminate, as well as dysfunctional cells.

Procedure	1. Shut off the inverter. ***Warning!*** If you do not shut off the inverter, arcing may occur and will damage the fuse holders. 2. Open each string by removing the string's fuse or opening the string's fuse holder. 3. Wearing rubber insulating gloves (and using a fuse puller if necessary), carefully remove the fuses from the combiner box, or open the fuse holder. Failure to remove the fuses will result in identical voltage measurements for every string since they are in parallel with the fuses in place. 4. Place the positive lead on the terminal screw of the string you are testing while the negative lead is attached to the negative block or terminal lug. Leave the negative lead in place and continue testing each string by moving to each positive string terminal screw. Test and record the voltage and temperature of each electrical string.

Compare the voltage of each string, and verify that no string's voltage varies more than ± 5% with respect to the others. If any string exceeds that variance, contact SunPower Technical Support:

TechnicalSupport@sunpowercorp.com

For Systems: 1-800-251-9728

For Dealers: 1-800-SUNPOWER (1-800-786-7693)

12.3 Test DC Current

This test ensures that all strings are producing appropriate operating current.

Purpose	The purpose of this test is to ensure that all strings are producing an adequate and consistent operating current.
Party	SunPower personnel
Scope	All strings
Equipment and Materials	• rubber insulating gloves (Class 0 or better) • rubber insulating glove tester • safety glasses • DC clamp-on ammeter with proper scale and accuracy within 2% of full scale • ammeter with an accuracy of at least 1% of reading

Conditions	Measurements must be made during clear and stable sky conditions. The total inverter output must be at least 50% of the aggregate rating of the active inverters. This test should be conducted under full sun conditions (>500 W/m^2), generally between the hours of 10:00 A.M. and 2:00 P.M. (local time). Irradiance must be greater than 200 W/m^2.
Criteria	Under clear and stable sky conditions with irradiance greater than 500 W/m^2, current readings within each combiner box should be within 5% of the average under identical sky conditions.
Comments	This is typically the first test performed on an operating system that has already been through the commissioning inspection. Readings with greater than allowed deviation from the average in the combiner box should be rechecked against other circuits to ensure that the deviation is not due to measurement or irradiance anomalies. A string that contains cracked cells or poor electrical connections will sometimes show proper V_{OC} yet produce very little current. If the inverter MPPT system is operating the array at maximum power voltage, this test will find the malfunctioning strings. Once the malfunctioning strings have been identified and cross-referenced with the array map, troubleshooting can continue.

Procedure	1. Start the inverter if it is not already running, making sure all fuses are installed. Wait five minutes for the power tracking to stabilize. 2. Open the combiner box, turn on the ammeter, and carefully zero the ammeter in proximity to live circuits that are to be tested; in order to obtain accurate readings, zero the meter frequently. Keep the clamp away from large bundles of wire, because they will affect the zero point, and therefore the actual reading on the meter. 3. Wearing rubber insulating gloves, clamp the meter near the wire. Zero the meter. 4. While still wearing the gloves, clamp the meter on each service loop in the box, and record the current readings. 5. Calculate and record the actual string currents as the difference between the string current reading and the zero value. For example: Zero value = 0.3 A Current reading = 3.0 A Actual current = 3.0 A − 0.3 A = 2.7 A All of the strings should operate within 5% of each other under similar environmental conditions. For this test to be valid, test conditions (sun intensity and tile temperatures) must be similar for each string. If they do not operate within 5% of each other, check for the partial shading of a module within the string, and, if all other conditions are equal, check the voltage on individual modules.

12.3.1 Troubleshoot Low Test Results

If the V_{OC} is *lower* (or zero) on a particular string than it is on other strings in the array, to pinpoint the low voltage problem first turn off the system and isolate the questionable strings by removing the DC fuse, and then:

1. Check the string's homeruns.
2. Check the module-to-module connections within the string.
3. Check the voltage on that string's individual modules.

If the V_{OC} is relatively *equal* to the other strings in array:

1. Look for areas of shading.
2. Look at the string with an infrared (IR) camera to identify any high resistance spots.
3. Perform an IV curve trace: first on the string, and then on the individual modules.

12.4 Test Array Resistance

Sometimes referred to as a “dry megohmmeter test,” this test measures the degree of isolation between the string conductors and ground. You must test the strings as well as the combined DC feeders (the larger wires that route from the combiner boxes and recombiner boxes to the inverter).

Note. It is easiest to perform this test when you are wiring the combiner boxes.

Purpose	This test evaluates the array’s electrical insulation under dry conditions. This test will verify that the insulation integrity of the array and its wiring are intact.
Party	Trained electrician or SunPower personnel
Scope	All strings
Equipment and Materials	• rubber insulating gloves • megohmmeter with an accuracy of at least 3% of full scale • voltmeter with an accuracy of at least 1% of reading
Conditions	The size of the array test section will depend on the array configuration (number of modules in series and parallel, frequency and location of array combiner boxes) and on the megohmmeter used to make the measurements. The minimum allowable meter reading (which is a function of the array test section voltage, meter characteristics, and the minimum leakage resistance criteria defined below) should be within a reasonable measurement range on the meter. All voltage surge protection devices should be disconnected from the array test section prior to testing to avoid damaging them.
Criteria	A dry megger test will only reveal flaws if a conductor is close enough to ground such that an arc will jump across the air gap, or if a conductor is actually in contact with a grounded conductive surface. An example of this would be a homerun wire getting pinched by a piece of sheet metal severely enough to pierce the insulation jacket.
Comments	This test uncovers faults to earth on the normally energized parts of the array. It is effective in finding those faults that do not cause any fuses to blow. Examples of problems include metal shavings inside an enclosure providing a fault path to earth and wiring pinched behind mounting bolts. However, this test will only uncover faults where there is a direct conductive path between the energized parts and earth. It is quite common for segments with even multiple wet resistance test failures to pass the dry resistance test. Refer to the module datasheet for information regarding the amount, direction, and duration of voltage applied to strings.

Procedure	1. Check the batteries of the megger to ensure they are charged. 2. Turn off the inverter and, wearing rubber insulating gloves, remove all fuses from the combiner box using a fuse puller. **Note.** The homeruns must all be connected to the bus bar before you execute this step. 3. Remove all of the grounded homeruns from the grounded conductor bus bar, or disconnect the grounded bus bar from the inverter. All conduits and equipment—including the array and combiner boxes—must be fully and continuously grounded through equipment grounding conductors for this test. 4. For the string-level test, while wearing rubber insulating gloves place the positive lead of the megger on the negative lead of a string inside the combiner box, and attach the negative lead of the megger to the grounding lug of the combiner box. Follow the instructions included with the meter to perform the test. Wait for the reading to stabilize as the megger charges each string up to 500 V. All strings should read 50 MΩ or higher. 5. Repeat Step 4 for all strings in the system. 6. For the combined DC feeder test, while wearing rubber insulating gloves place the positive lead of the megger on the negative output of a combiner box, and attach the negative lead of the megger to the grounding lug of the inverter. Follow the instructions included with the meter to perform a test. Wait for the reading to stabilize as the megger charges each string up to 500 V. All strings should read 50 MΩ or higher. ***Warning!*** After disconnecting the megger, be aware that the string will still be charged and will discharge over approximately five minutes.

12.5 Gather Location and Component Data

It is important that you gather all relevant serial numbers as well as the location of the building interconnection point for the Data Acquisition System (DAS), and for the inverter for future maintenance. Gather and record the following information and then report it to SunPower Technical Support:

TechnicalSupport@sunpowercorp.com

For Systems: 1-800-251-9728

For Dealers: 1-800-SUNPOWER (1-800-786-7693)

Data	Specific Information	Your Site's Data
Job Number	SunPower job number (if applicable)	
Circuit Number	Panel number and breaker number	
DAS Circuit Number	Breaker number	
DAS Panel Number	Panel in which the breaker is installed	
DAS Wiring Panel Number	Number which describes the wiring configuration on the logger face	
DAS Serial Number	Number on the silver can containing the DAS circuitry	
Pyranometer Number	Serial number printed on the side of the LI-COR sensor	
Inverter Number	Serial number from the body of the inverter—*not* the model number	
Inverter Circuit Number	Breaker number	
Inverter Panel Number	Panel in which the breaker is mounted	

Appendix A: Quick Reference Guide (QRG)

Warning! *Do not use this QRG in place of the installation manual! The QRG is supplemental only.*

1. Prepare roof

Verify roof dimensions against drawings.

1. Observing obstructions, place critical line on longest continuous column or row, or in middle of array.
2. Remove all debris.
3. Mark initial lines, using a "best-fit" line for the array.
4. Position slip sheet if required.

2. Mark array lines and stage materials

Distribute materials starting furthest from lift point.

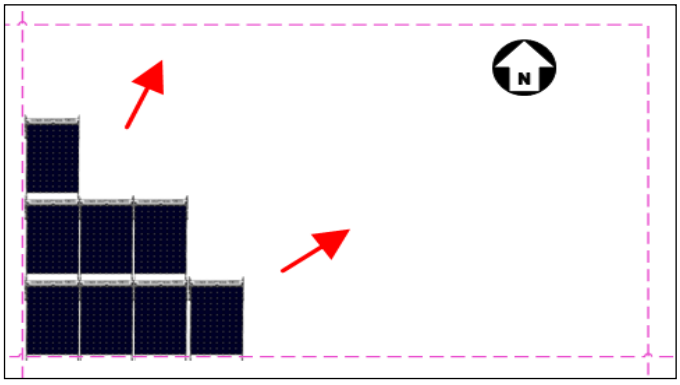
1. Mark array lines.
2. Identify build points.
3. Load roof evenly.
4. Establish array perimeter
5. Identify starting locations and directions.
6. Position modules across array fields.
7. Leave deflectors in place on each module until final positioning.
8. Place electrical materials outside array field, near intended combiner box locations.
9. Place small parts outside array.

3. Determine build strategy

Build out from array corners; or clockwise from first module.

1. Begin array at either SW **or** SE corner.
2. Build northward and eastward; **or** northward and westward; actual build patterns can vary.

Note. Position modules around any obstruction *first* to maintain positional integrity of array.



4. Position and secure modules

An array can have up to nine different junction types.

1. Position modules according to PPF or drawings.
2. Align each of the feet at junctions as you place modules.
3. Place a connector assembly and spacers near each junction.
3. Ensure straightness of array after each completed row and column.

5. Install ballast

1. Lift modules and install Type B ballast.
2. Position Type A ballast along north edge of respective modules.
3. Place correct number of blocks into each tray and evenly slide tray southward until positioned correctly.
4. Ensure that tray is evenly placed on underside edges and parallel to north edge of module.
5. Install Type C and Type D ballast as required.

6. Tighten connectors

Use recommended tool to torque the connectors.

1. Assess overall straightness of lines in the arrays.
2. If you have not installed connectors already, do so now, and apply 150 in-lbs (17 N-m) of torque to each connector.

7. Interconnect modules

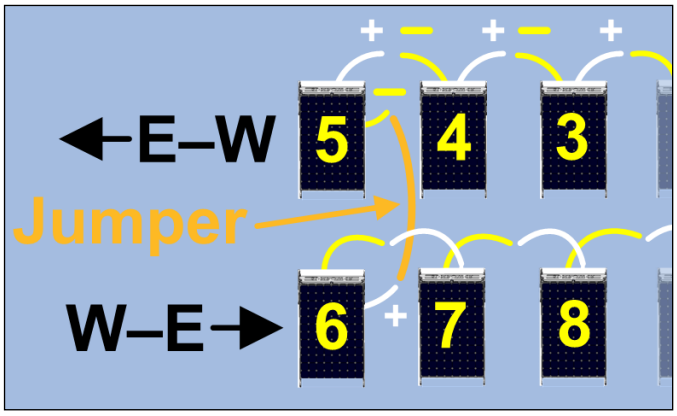
Wires on modules are marked positive (+) or negative (-) on connectors.

A. Connect strings that occur in a single row:

1. Leave negative wire of first (easternmost) module exposed.
2. Connect positive wire of first module to negative wire of adjacent module in the same row.
3. Repeat Step 2 for subsequent modules until end of string (refer to PPF or drawings).
4. At end of string, leave positive wire of last module disconnected and easily visible.

B. Connect strings that span over two or more rows:

1. Attach jumper between appropriate module leads.
2. Route jumper in gap between the modules.



8. Create homerun wiring

1. Place spool of array wire near combiner box.
2. Refer to PPF or drawings to determine wire paths.
3. Pull wire to positive and negative ends of each string.
4. At spool end, cut wire to create each homerun.
5. Label wires with correct string number and polarity.
6. Tape each homerun wire to its mate.

Important! Wiring connectors must be MC4 or other IP67-rated connectors. If greater than 1 1/2″ of ponding is present, all wiring must be secured min. 3″ above the roof surface.

9. Position deflectors

Position deflectors at correct angle.

1. For all modules in northernmost row in each array; for every module that does *not* have a module to its immediate north; and for every module that has north external ballast: seat lower end tabs of deflector in forward (N) slots on module's feet.
2. For all other modules, seat lower end tabs of deflector in rear (S) slots on module's feet.
3. Press top center of deflector back against retainer built onto module.
4. Shift lower deflector end tabs into the lower slot of correct slot pair in module foot, and upper tabs into the upper slots.

10. Pull wires

Conduit should not yet be attached.

1. Ensure that homeruns are not plugged into string ends at modules.
2. Pull homerun bundles through conduit to combiner box.
3. Ensure that all strings are labeled according to PPF or drawings.

11. Install conduit

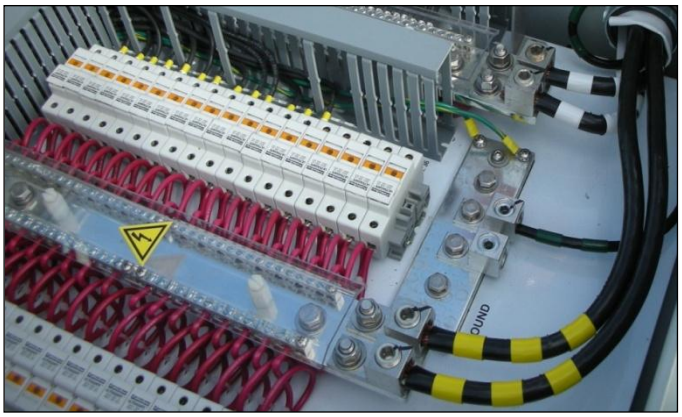
Conduit is secured on mounts.

1. Determine at which points to position conduit mounts.
2. Bend conduit as necessary (if metallic conduit is used).
3. Attach conduit to conduit mount and to combiner boxes.
4. Terminate conduit inside the combiner boxes.
5. If required, attach conduit mount to array (Appendix B).
6. ***Important!*** If using **metallic** conduit, you must route and attach a ground conductor.

12. Verify string polarity

Verification must be completed by a licensed electrician.

1. Connect homeruns to module wires string by string.
2. Verify polarity and string identity using voltmeter.
3. Unplug positive and negative homeruns after each string testing.
4. Land wires in combiner box.
5. Connect homerun wires to string ends within array.

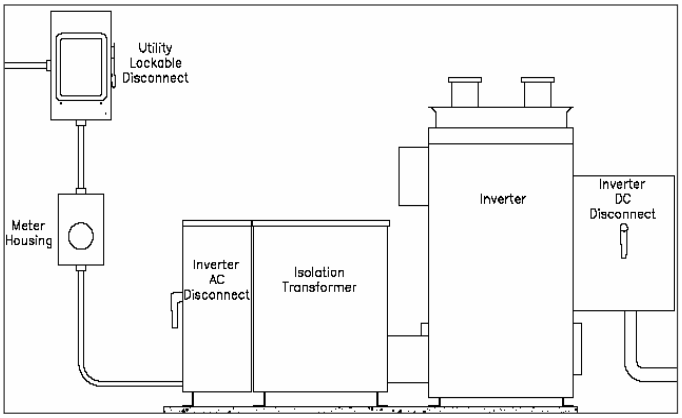


13. Complete intertie

A licensed electrician must complete intertie.

1. Refer to PPF or drawings to locate and mount AC disconnect, meter housing, isolation transformer, and inverter.
2. Ensure inverter AC and DC disconnect switches are open.
3. Land AC conductors on bus tap at main service panel.

   Note. Illustration is for reference only.



14. Start and commission system

Start system only after completing the following tests:

1. Verify disconnects and start up inverter.
2. Perform open circuit voltage test.
3. Perform DC amperage test.
4. Perform array resistance test.
5. Gather serial numbers and location of building interconnection point for monitoring records (DAS).

Appendix B: Secure Conduit to the Array

When securing conduit to the array is required, follow the instructions in this appendix.

Note. After you secure the conduit, it must be low enough so that module shading does not occur. It is acceptable to position a terminated conduit run at the *south* edge of an array but only if doing so will not cause module shading.

To mount and attach conduit, SunPower recommends that you use the following components:

- Cooper B-Line B6374 3-hole corner angle (L-bracket) (or equivalent)
- Cooper B-Line Dura-Blok™ rooftop support (conduit mount) (or equivalent)
- Unistrut® channel (or equivalent)

All deflectors should already be positioned at their correct final angle before mounting conduit.

In general, it is easier to attach the conduit mount to the array before attaching the conduit to the mount.

B.1 Attach Conduit to Array

When installing the L-bracket, only fit it between the innermost of the exterior spacer (or connector) and the module foot (Fig. B1).

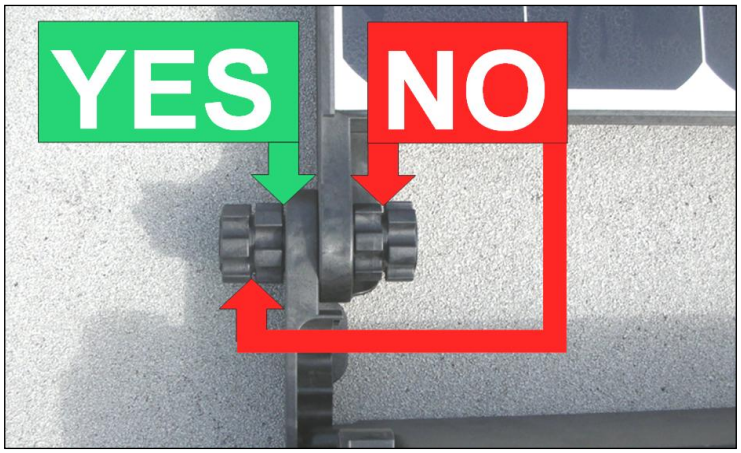


Fig. B1

1. Remove the required connectors, fit the L-bracket onto the connector bolt, and position the L-bracket so that its tab faces away from the array (Fig. B2).
2. Retorque the connectors to 150 in-lbs (17 N-m).
3. Attach a short section of strut channel to the L-bracket tab and to the built-in channel on the conduit mount (Fig. B2).
4. Secure the conduit to the mount.

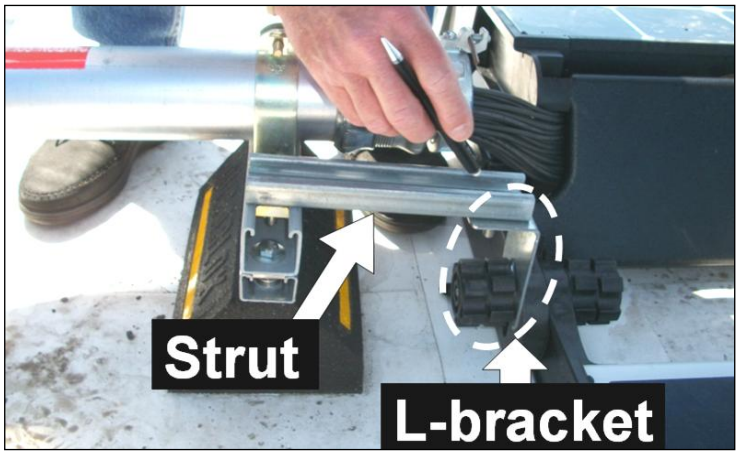


Fig. B2

Appendix C: Module Removal and Replacement

To remove a module, follow the instructions in this appendix.

C.1 Remove and Replace Module

1. Wearing electrical safety gloves and safety goggles, turn off the inverter.
2. Perform lockout and tagout procedures as described in SunPower document 001-03772.
3. Remove the fuse from the string containing the module to be replaced.
4. Using a clamp-on ammeter, verify that the circuit is open (current is zero).
5. Disconnect the module electrical connectors, and any homerun wires from adjacent modules.
6. Remove the deflector (Section 9.0).
7. Remove the ballast tray (Section 5.3).
8. Remove the connectors at each corner of the module (Section 6.0).
9. Tilt the module to the south and remove south ballast tubes (Section 5.2).
10. Lift the module out of the array.
11. Install the new module, following the procedures previously described for module installation (Section 4.0).

Important! Ensure you properly retorque the connectors (Section 4.5).