Installation Instructions

Timberline Solar™

Solar Roofing System

Integrated rooftop solar for composition shingle steep-sloped roofs

GAF Energy LLC
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Notices

Copyright

Trademark

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Warranty and Disclaimer

All Timberline Solar 2 Roofing System Products are covered the by Timberline Solar 2 Shingle & Accessory Limited Warranty. Any deviation from the installation methods recommended in this manual may result in denial of a homeowner's warranty claim.

When GAF Certified Contractors install a qualifying GAF roofing system at the same time as the GAF Energy Timberline Solar 2 Roofing System, the installation may be eligible for one or more enhanced warranties backed by GAF.

For complete details on eligibility, see www.gaf.energy/warranty and for questions relating to the installation of the GAF roofing system, refer to the most current version of the *GAF Pro Field Guide for Steep-Slope Roofs*.

Always follow local building codes. State and local building codes vary from region to region. It is the responsibility of every quality installer to KNOW and FOLLOW local building codes for roof and solar installation.

The Timberline Solar 2 Roofing System is designed to be installed with GAF Roofing products. No testing has been done to ensure compatibility with other manufacturers' roofing materials. Accordingly, use of such other manufacturers' roofing materials may significantly diminish GAF Energy's and GAF's warranty coverage.

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1. Introduction

The Timberline Solar™ 2 system is designed by GAF Energy. GAF Energy is a sister company to GAF, North America's largest roofing manufacturer. Timberline Solar 2 was developed with roofing best practices, simplicity of installation, performance, safety, and aesthetics in mind. This Manual contains safety and installation instructions for the Timberline Solar 2 system.

For purposes of this Manual only, "Timberline Solar 2 system" refers to Timberline Solar 2 Energy Shingles and the hardware components listed in "2. Timberline Solar 2 Overview" on page 10.

Installation instructions covering GAF shingles can be found at www.gaf.com. It is also recommended that installers consult the *GAF Pro Field Guide for Steep-Slope Roofs*, version 2.0, September 2020.

IMPORTANT SAFETY INSTRUCTIONS:

WARNING: Read these instructions entirely and thoroughly to reduce the risk of injury and to ensure a problem-free installation.

SAVE THIS MANUAL FOR FUTURE REFERENCE. As part of its continuing efforts to improve the performance of its products, GAF Energy periodically makes changes to its products. GAF Energy reserves the right to change or modify any of the information, requirements, specifications, or policies contained herein. Be sure to check **www.gaf.energy** for the most up-to-date version of this Manual or any technical bulletins for this product.

Symbol List

CAUTION: Use caution and fully understand the instructions before proceeding.

DANGER: Indicates a hazardous situation. Failure to follow these instructions could lead to serious injury or death.

NOTE: Follow these instructions closely for optimal system operations and best installation practices.

DON'T: An X symbol illustrates an incorrect practice or installation technique.

DO: A check mark illustrates the correct or preferred method of installation.

AC  Indicates alternating current.

DC  Indicates direct current.

Acronym and Abbreviation List

These acronyms and abbreviations are used in this manual. For a list of basic solar roofing terms, see the glossary on the GAF Energy website.

- **American National Standards Institute (ANSI).** A private non-profit organization that oversees the development of voluntary consensus standards for products, services, processes, systems, and personnel in the United States.
- **American Society for Testing and Materials (ASTM).** An international standards organization that develops and publishes voluntary consensus technical standards for a wide range of materials, products, systems, and services.
- **balance of system (BoS).** All components of a photovoltaic system other than the photovoltaic modules.
- **equipment grounding conductor (EGC).** Bonds all metal elements to the electrical system's grounding electrode
- **electrical metallic tubing (EMT).** An unthreaded thinwall raceway of circular cross section designed for the physical protection and routing of conductors and cables and for use as an equipment grounding conductor when installed utilizing appropriate fittings.
- **junction box (J-box).** An enclosure on the PV module housing electrical connections between internal and external wiring. This enclosure typically has one positive and one negative conductor as outputs.

Acronym and Abbreviation List, continued

- **National Electrical Code (NEC).** A regionally adoptable standard for the safe installation of electrical wiring and equipment in the United States.
- **National Fire Protection Association (NFPA).** An international nonprofit organization devoted to eliminating death, injury, property and economic loss due to fire, electrical and related hazards.
- **Occupational Safety and Health Administration (OSHA).** A large regulatory agency of the United States Department of Labor that originally had federal visitorial powers to inspect and examine workplaces.
- **oriented strand board (OSB).** An engineered wood panel made using waterproof heat-cured adhesives and rectangularly shaped wood strands that are arranged in cross-oriented layers. It is similar in strength and performance as plywood, resisting deflection, warping and distortion.
- **overcurrent protection device (OCPD).** A piece of electrical equipment—like a fuse or circuit breaker—used to protect service, feeder, and branch circuits and equipment from excess current by interrupting the flow of current.
- **photovoltaic rapid shutdown equipment (PVRSE).** Items used in a rapid shutdown system that reduces the voltage to a safe level.
- **personal protective equipment (PPE).** Items used for individual safety, including masks, gloves, safety glasses and shoes, earplugs or muffs, hard hats, respirators, or coveralls, vests, and body suits.
- **personal fall arrest system (PFAS).** Items used to mitigate falls, including an OSHA-approved anchor point, a full-body harness approved for electrical workers, rope or cable, and specific connecting hardware.
- **photovoltaic (PV).** A device that generates electricity directly from sunlight.
- **photovoltaic hazard control system (PVHCS).** A system that meets rapid shutdown requirements at a system level, meaning all major components are tested and certified together. In a critical state, the photovoltaic system is controllable in accordance with NEC 690.12.
- **jumper module (JM).** A Timberline Solar 2 Energy Shingle that allows PV circuit conductors to be transferred from one column of Energy Shingles to another.
- **rapid shutdown device (RSD).** A device installed in PV circuits to reduce shock hazard for firefighters in accordance with NEC 690.12.
- **rapid shutdown system (RSS).** A system designed to reduce shock hazard for firefighters in accordance with NEC 690.12.
- **standard test conditions (STC).** Conditions under which all solar modules are tested in laboratories, which allow manufacturers to define the electrical parameters of their PV modules.
- **Underwriters Laboratories (UL).** A global safety science company that performs testing and regular inspections on products in the areas of electrical and fire safety, hazardous substances, water quality, food safety, performance testing, safety and compliance education, and environmental sustainability. Products that meet their standards receive a UL Mark.

General Safety Precautions

- **Must be installed by a qualified person.** The Timberline Solar 2 system must be installed by a PROPERLY TRAINED and QUALIFIED INSTALLER. It is the responsibility of every installer to know and follow local code requirements.
- **Follow OSHA.** GAF Energy recommends compliance with OSHA guidelines for Residential Fall Protection.
- **Wear personal protective equipment (PPE).** Use proper PPE and follow safety policies and procedures. Proper PPE when dealing with rooftop solar systems includes, but is not limited to, the following:
  - » **Hard hats.** For falling objects, as well as risk of contact with energized conductors. An ANSI Z89 Class A helmet satisfies this OSHA requirement.
  - » **Work gloves.** For slip, abrasion, and thermal resistance. Solar modules tend to get very hot when exposed directly to the sun.
  - » **Electrical-insulating gloves.** When working on energized circuits.
  - » **Appropriate footwear.** Footwear with extra traction and/or heat-resistant soles.
  - » **Personal fall arrest system (PFAS).** Consists of an OSHA-approved anchor point, a full-body harness approved for electrical workers, rope or cable, and specific connecting hardware.
  - » **Eye protection.** For site-specific hazards.

Figure 1. Personal protective equipment (PPE)

- **Work only in dry conditions.** Use dry equipment and dry tools. Protect all electrical equipment against weather elements.
- **Eliminate trip and fall hazards.** Keep work areas on the roof and ground staging areas organized and clean.
- **Inspect for damage.** Do not use Timberline Solar 2 components if there are visible signs of damage from transport or handling.
- **Working Safely with PV systems.** Be aware of the hazards at the jobsite as well as the hazards of working on PV systems. Be alert at all times. Never work alone on roofs or PV systems. Always have at least two people installing solar systems on the roof.

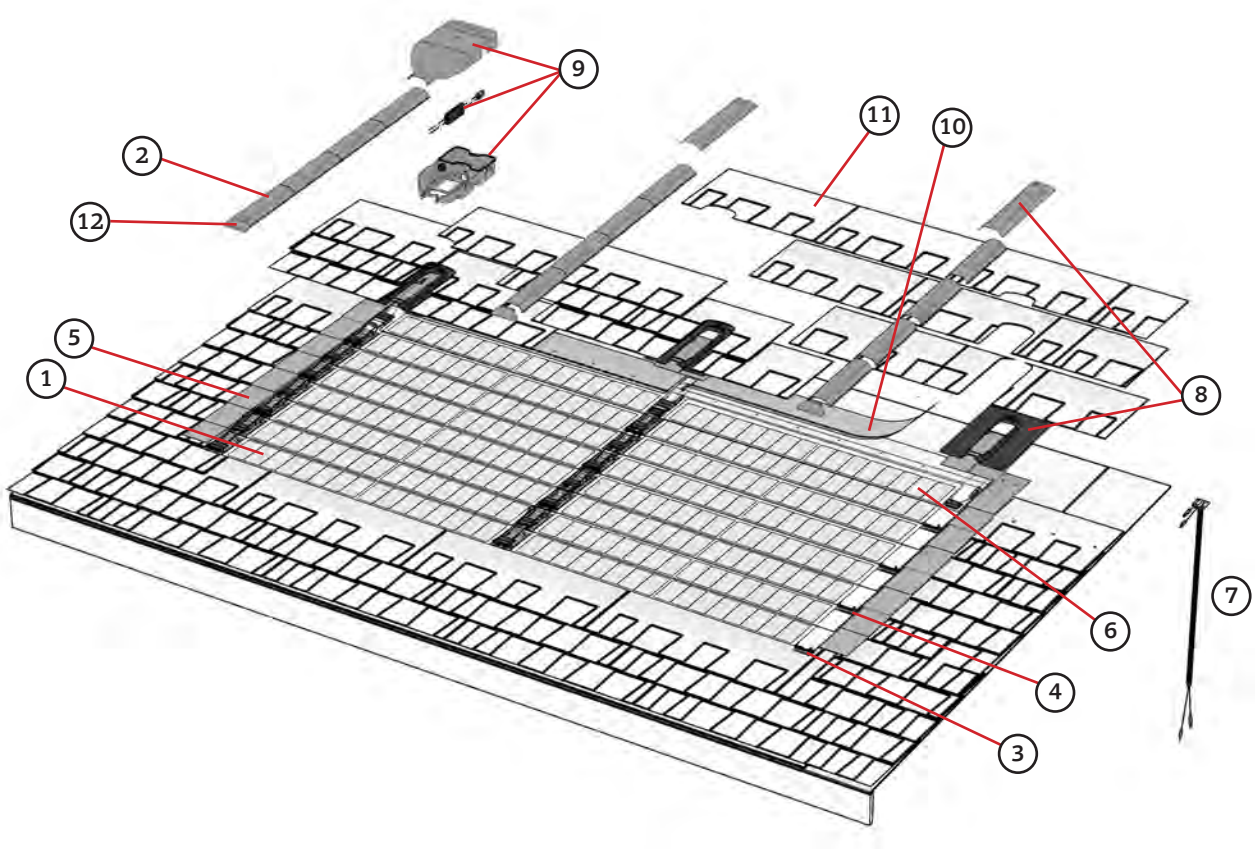
General Safety Precautions, continued

Electrical Safety Precautions

- **Must be competent with electrical safety work practices.** Timberline Solar 2 is an electric power generation system. The installer must be qualified according to state and local requirements.
- **De-energize.** All work must be performed on circuits that have been de-energized. Timberline Solar 2 modules produce voltage whenever exposed to light. Installers should assume wiring on the roof is likely to be energized and to follow safe electrical practices at all times.
- **Use proper wire management techniques.** Ensure that none of the AC or DC wires are pinched or damaged during installation. Do not exceed the bend radius of the cables.
- **Do not modify factory-applied connectors, terminals, or jumper cables.** Do not customize or modify the provided DC or AC cables or connectors in the field, except as specified in this manual.
- **Do not repair.** Timberline Solar 2 does not contain any user-serviceable parts. Replacement products should be obtained through GAF Energy and must be installed by qualified persons approved by GAF Energy. Tampering with the Timberline Solar 2 system voids the warranty.
- **Thermal hazard.** Certain parts of the Timberline Solar 2 system may become extremely hot due to continued exposure to the sun. The installer should take care to avoid incidental contact with bare skin.
- **Follow codes.** Perform all installations in accordance with all applicable building codes, ordinances, and the National Electrical Code (NEC) ANSI/NFPA 70 for U.S. installations.
- **Re-inspection.** The Timberline Solar 2 system should be periodically re-inspected for any signs of damage. This is important especially after storms and in areas prone to hail and high winds. Any damaged parts should be replaced immediately by a qualified person.
- **Qualified person.** Installing AC or DC circuits, disconnects, tie-in to the PV point of connection, OCPDs, and initial startup of the PV system must be performed by a qualified person. Make all electrical connections (e.g., conductor termination, fuses, potential earth connection) in accordance with the electrical standards prescribed by the applicable NEC wiring methods and in compliance with local regulations and codes.

2. Timberline Solar 2 Overview

System Hardware Components



1. Energy Shingle
2. Wire cover
3. Cover hook
4. Floating bracket
5. Step flap
6. Jumper module (JM)
7. Option 1: Pass-thru device for in-attic wiring
8. Top flashing
9. Option 2: Transition box for wiring on the exterior of the home
10. GAF QuickStart® Peel and Stick starter roll
11. Asphalt shingles
12. Bottom cap

Figure 2. Timberline Solar 2 hardware components

The balance of system (BoS) components that make up the remainder of the solar installation are outside the scope of this manual.

Component Details

Energy Shingle features

As used in this manual, "Energy Shingle" refers to the Timberline Solar 2 Energy Shingle (ES).

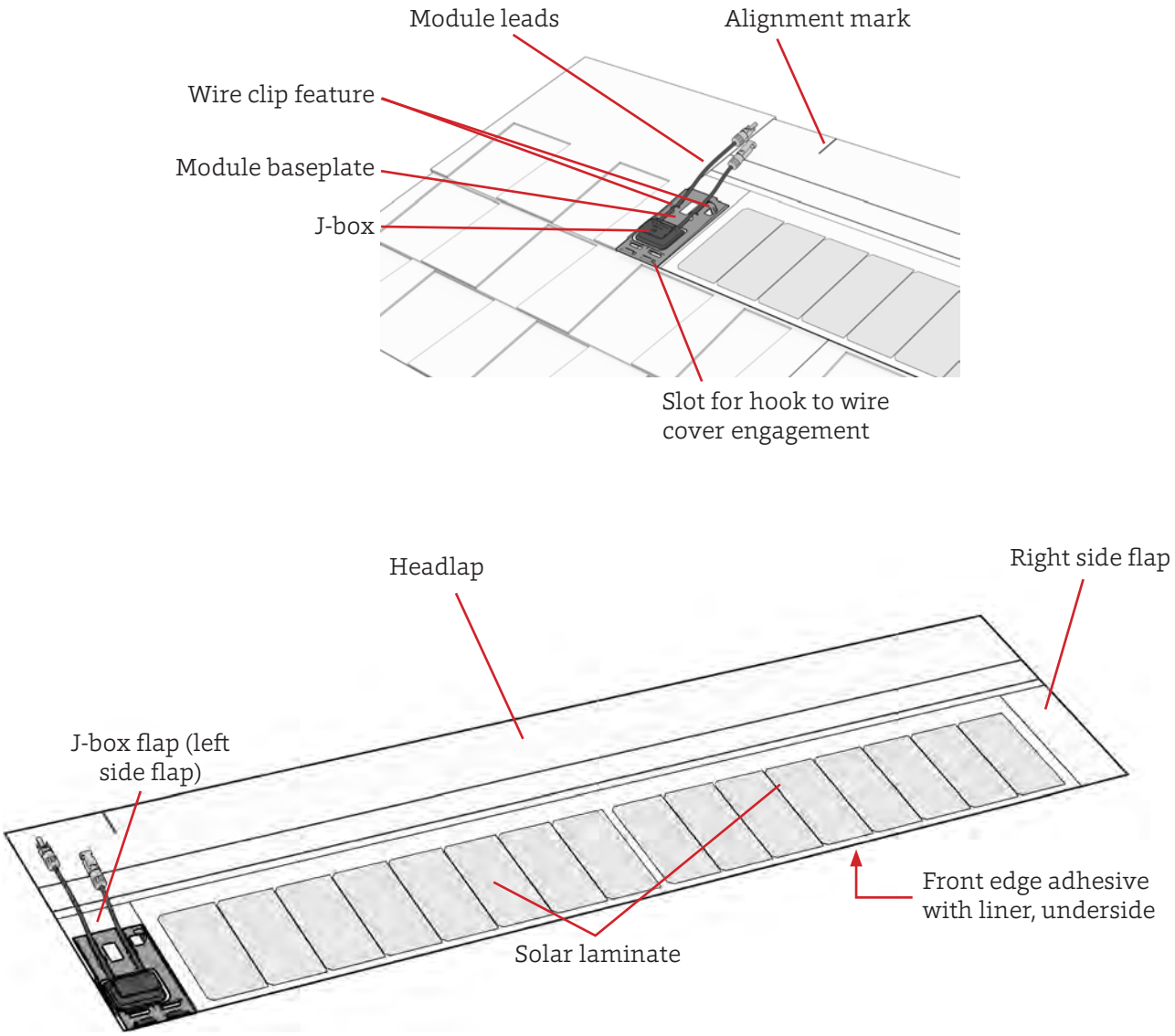


Figure 3. Energy Shingle features

Component Details, continued

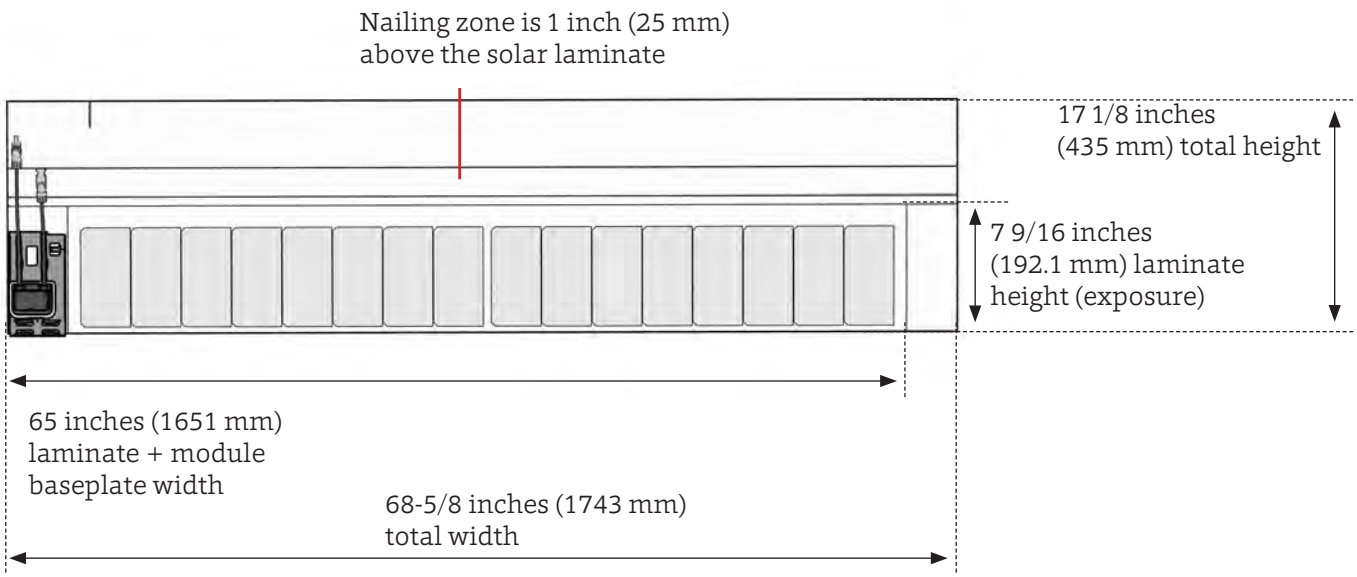


Figure 4. Energy Shingle dimensions

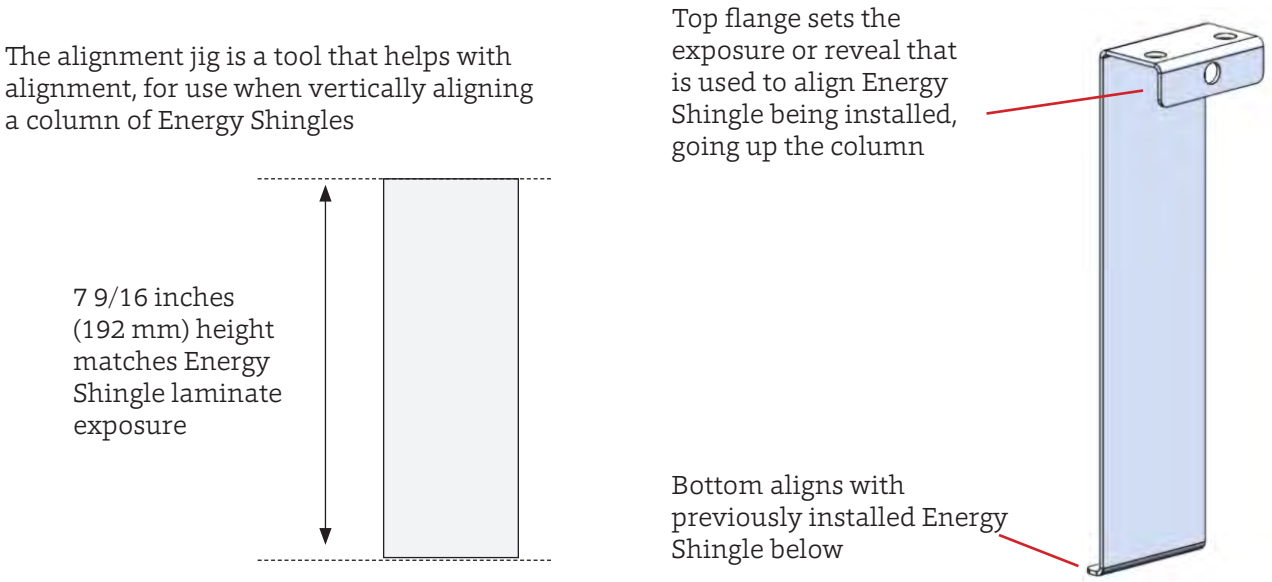


Figure 5. Alignment jig dimensions

Component Details, continued

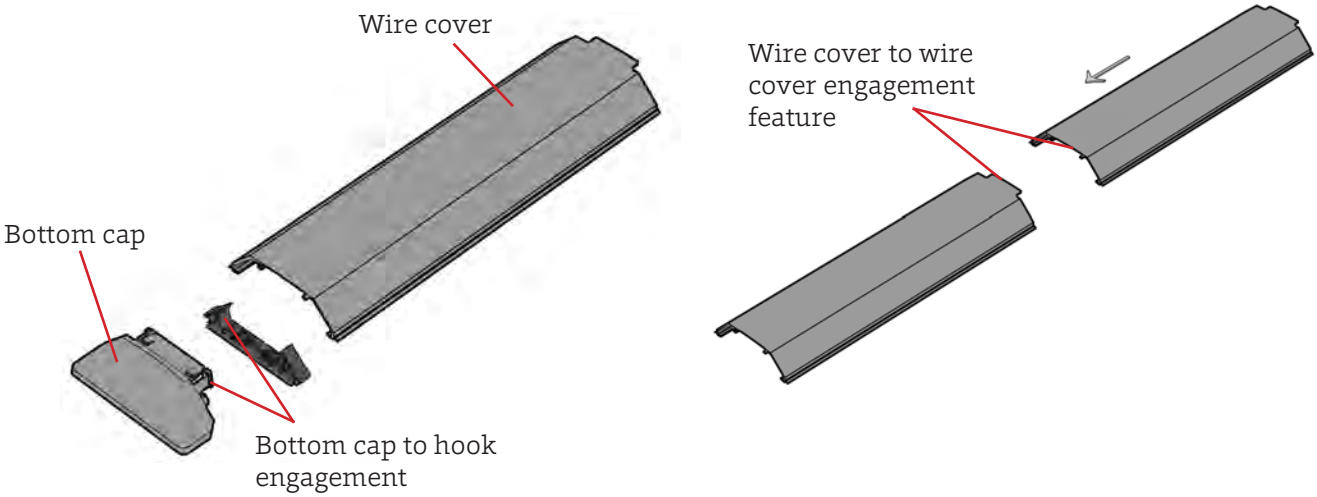


Figure 6. Wire cover and bottom cap

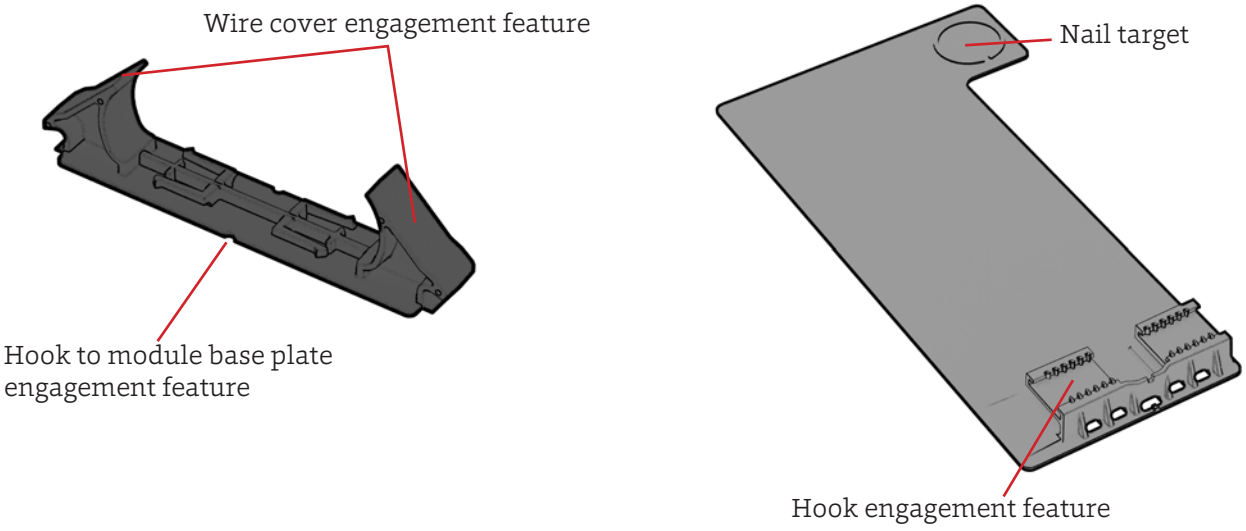


Figure 7. Hook and floating bracket

Component Details, continued

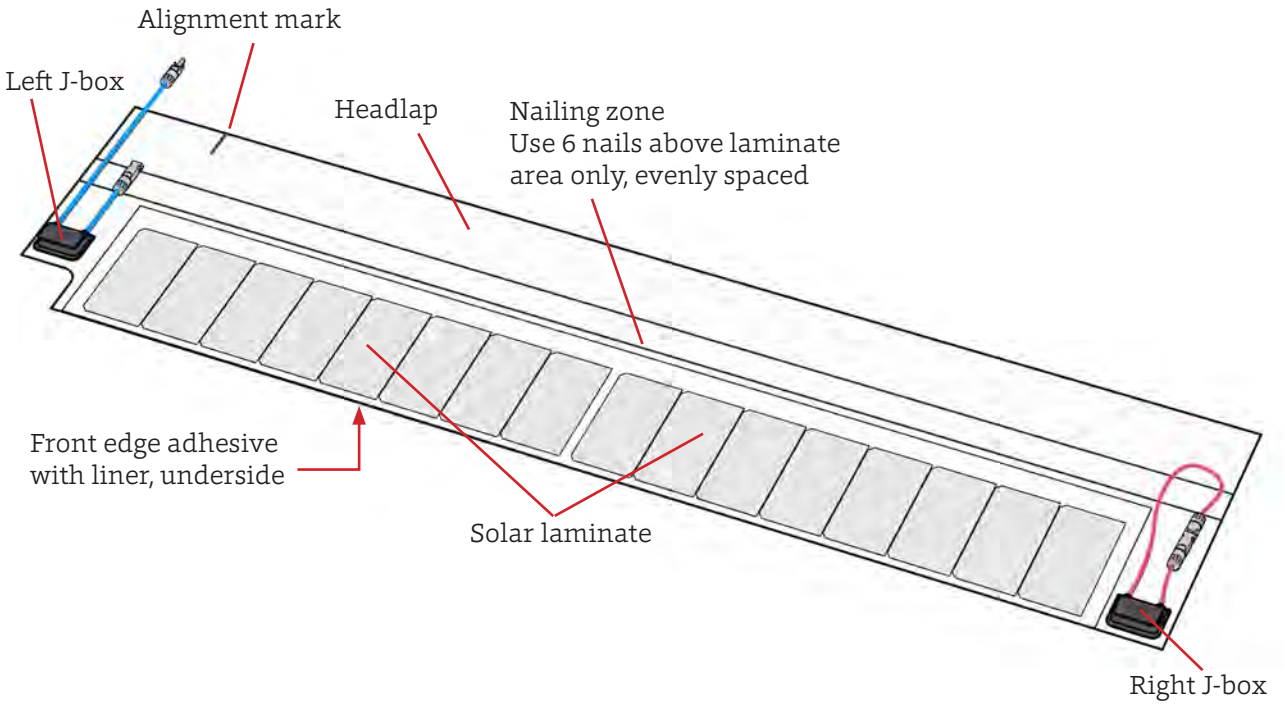


Figure 8. Jumper module (JM)

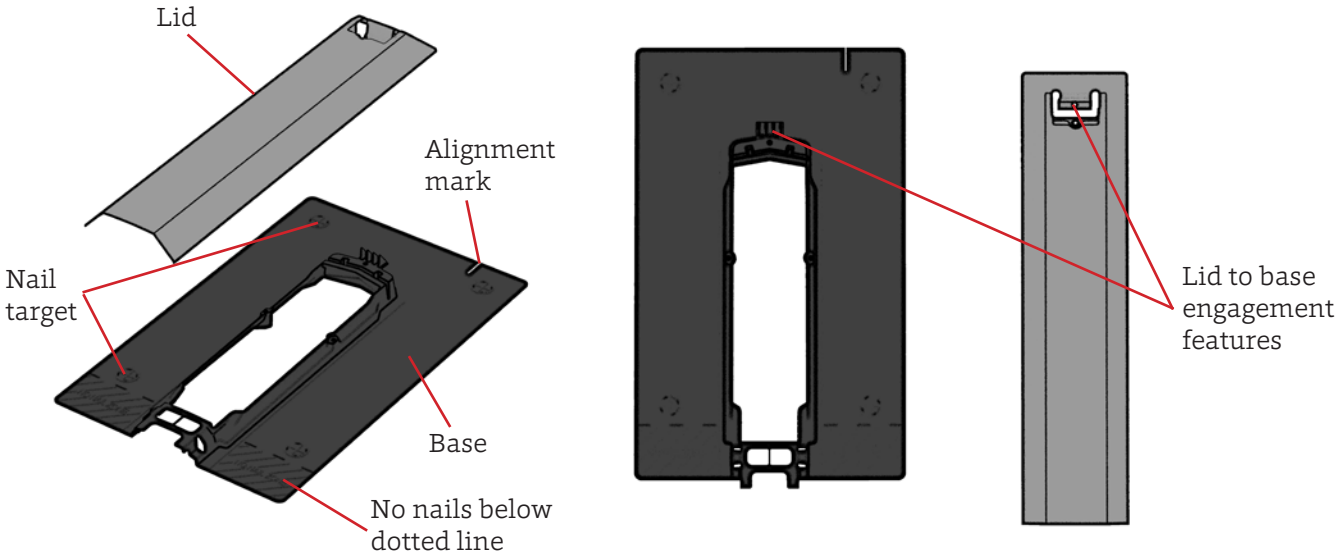


Figure 9. Top flashing

Component Details, continued

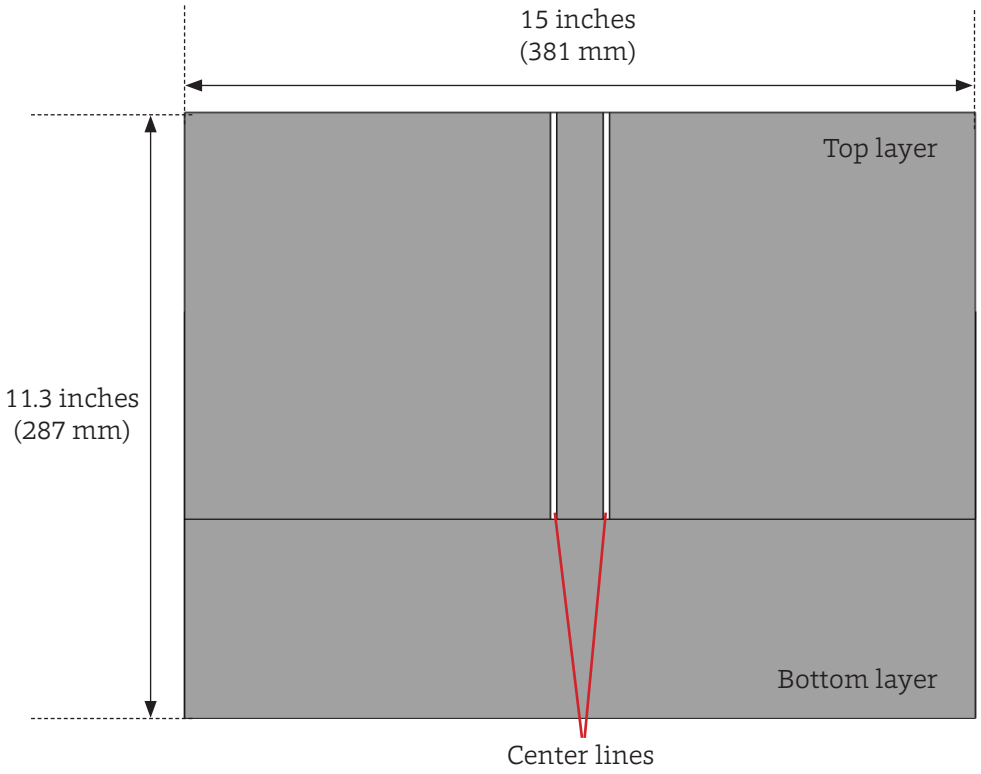


Figure 10. Step flap

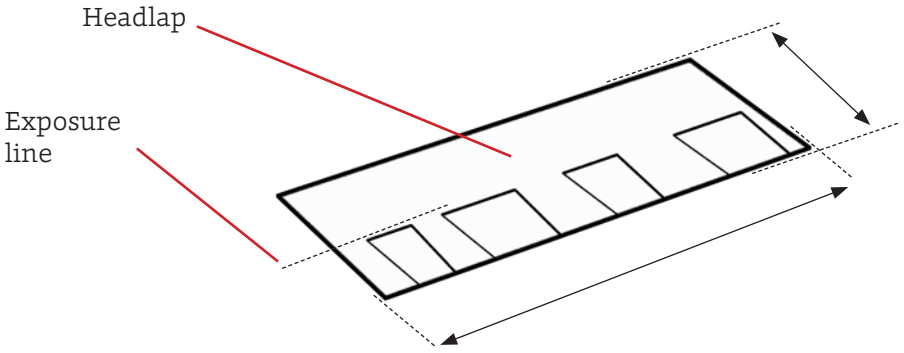


Figure 11. Asphalt shingle (uncut)

Component Details, continued

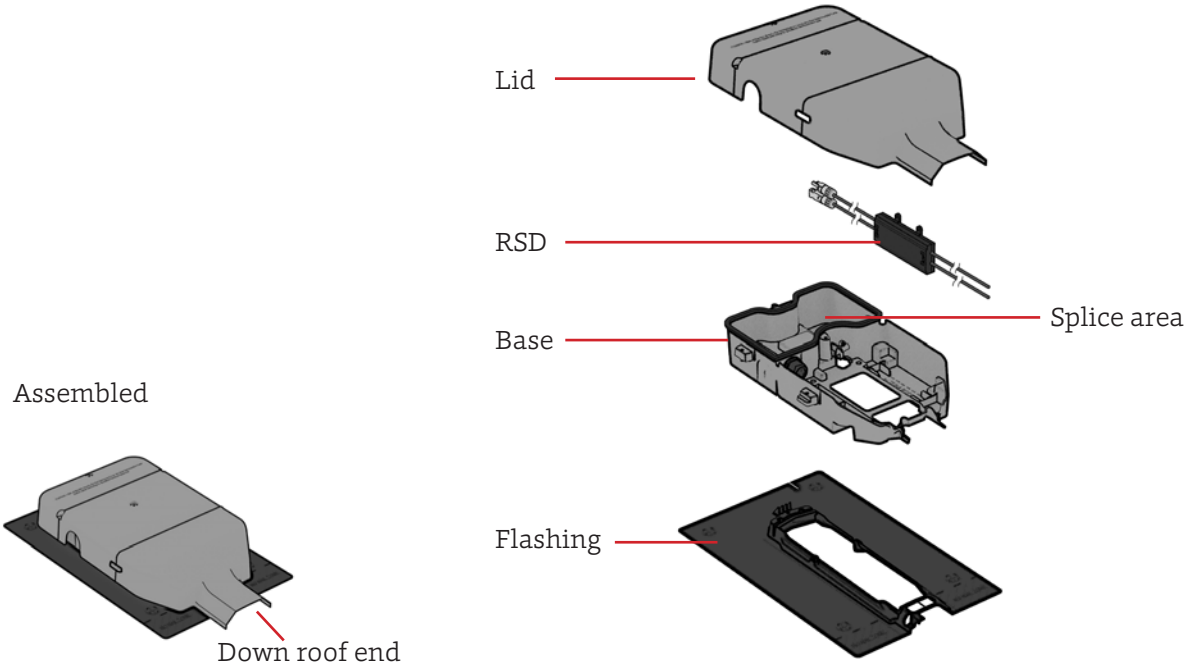


Figure 12. Transition box

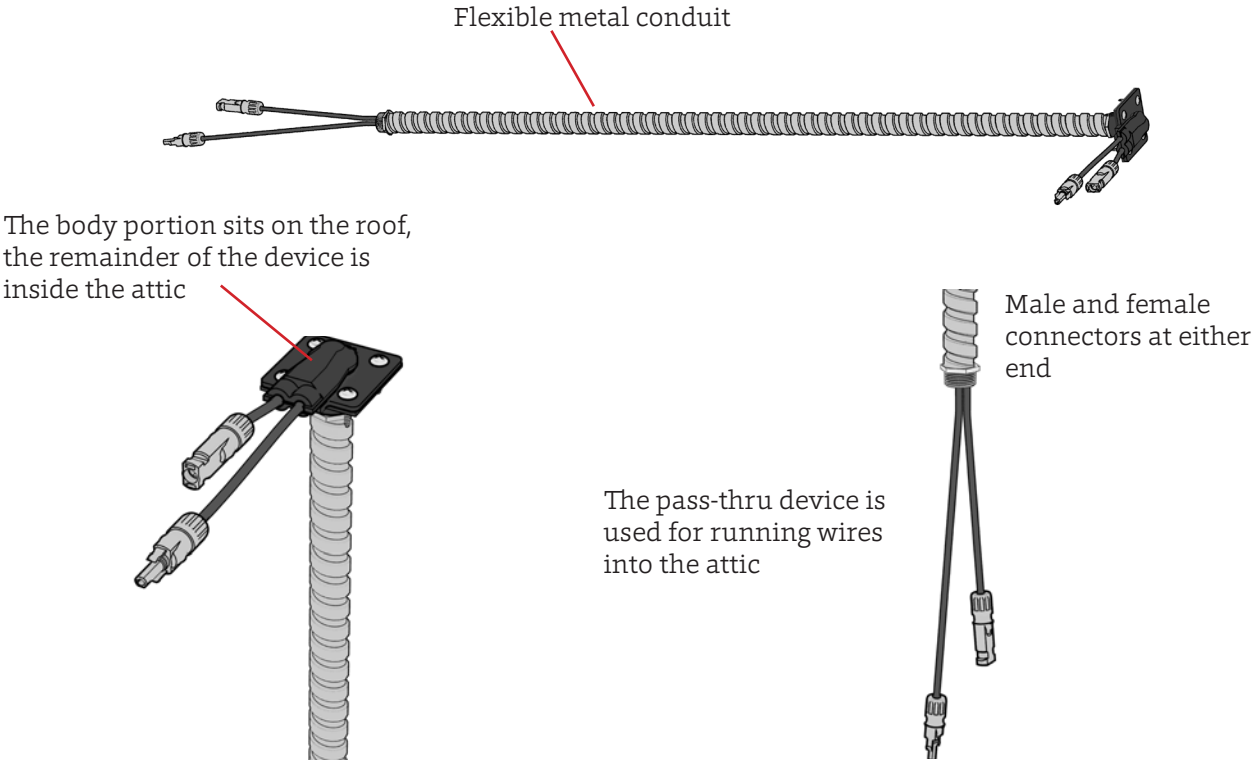


Figure 13. Pass-thru device

Component Details, continued

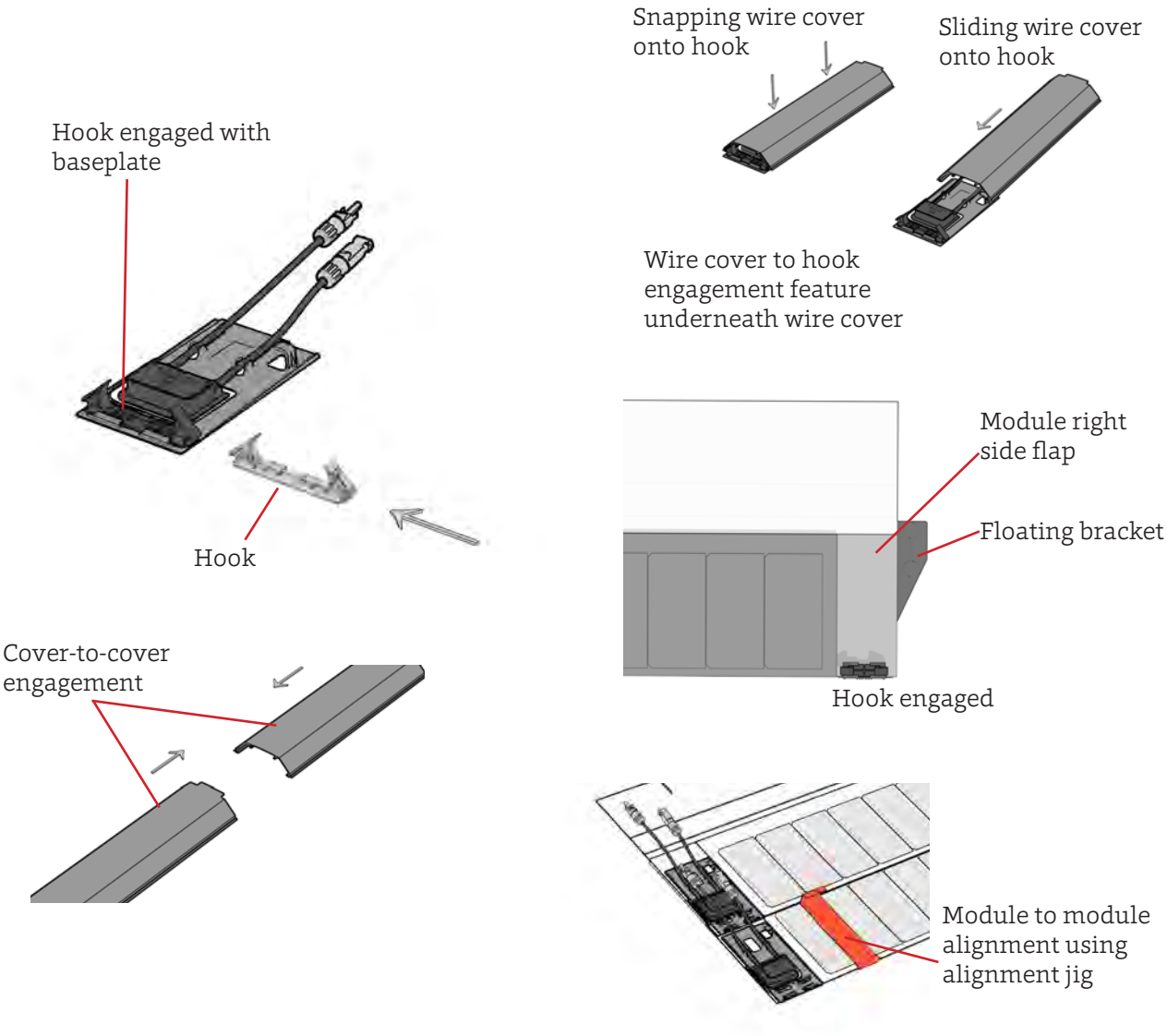


Figure 14. Alignment and engagement features, fitting

Module and Component SKUs

Separate tables show SKUs for parts made by GAF Energy, third-party components, and fasteners.

Table 1. GAF Energy SKU numbers for solar array

Component	GAF Energy SKU #
Energy Shingle	TLS-2
Floating bracket	294000731
Hook	294000546
Wire cover	294000865
Bottom cap	294000631
Wire holder	294000761
Top flashing assembly	294000640
Step flap	294001156
Aesthetic jumper module (AJM)	TLS-2AJM
Powered jumper module (PJM)	TLS-2J
Transition box	TB-2
Pass-thru device	PTD-2
QuickStart® Peel & Stick starter roll	1122000ST
Staubli MC4-Evo 2 disconnect tool	294000737
Module alignment jig	294000280

Module and Component SKUs, continued

Table 2. TLS-2 compatible asphalt shingles and sealants

Component	Manufacturer	Provided By
Timberline Solar HDZ	GAF	Installer
Timberline HDZ	GAF	Installer
Timberline Ultra HDZ	GAF	Installer
Timberline Armorshield II	GAF	Installer
Timberline NS	GAF	Installer
Timberline HDZ RS	GAF	Installer
Loctite PL Max	Loctite	Installer

Table 3. Third-party components

Component	Manufacturer	Provided By
Buchanan 2006S & 2007 copper crimp connector and cap (wire splice), used with crimp tool model C-24	Ideal Industries Inc.	GAF Energy
Staubli MC4 (column return wire) FLEX-SOL-EVO-DX cable with PV-KBT4-EVO2 / PV-KST4-EVO2 or PV-KBT4/6I-UR / PV-KST4/6I-UR connectors	Staubli	GAF Energy
Lay-in ground lug	Various	GAF Energy
M4 10 mm bolt	Various	GAF Energy

Table 4. Fastener specifications

Fastener Type	Where Used	Provided By
Cap nails	Roofing underlayment	Installer
Roofing nails	Attaching array components to roof deck	Installer

RSD/PVRSA/PVHCS Components and Requirements

Timberline Solar 2, in combination with the electrical components listed in the table below, has been evaluated as a system to the requirements in ANSI/CAN UL 3741 Photovoltaic Hazard Control. When installed in accordance with these instructions, this system meets the requirements of Article 690.12 of the National Electrical Code for 2014, 2017, 2020, and 2023.

The terms to describe this function vary slightly in each code cycle:

- **2014: Rapid Shutdown (RSD):** Conductors leaving the array must drop to 30V or less within 10 seconds of rapid shutdown initiation. Equipment must be listed, but standards are not specified. *2014 NEC 690.12.*
- **2017: PV Rapid Shutdown Array (PVRSA):** A listed assembly or system designed to "*reduce but not eliminate risk of electric shock hazard within a damaged PV array during fire-fighting procedures.*" *2017 NEC 690.12(B)(2)(1).*
- **2020 and 2023: PV Hazard Control System (PVHCS):** Equipment or multiple pieces of equipment listed to UL 3741 "*to reduce the risk of electric shock hazard within a damaged PV array for fire fighters.*" *2020 and 2023 NEC 690.12(B)(2)(1).*

Table 5. RSD/PVRSA/PVHCS components and requirements

Component and Function	Manufacturer	Model No.	Certification Standards	Years of Compliance to 690.12
PV rapid shutdown system	MidNite Solar *	MNSSR-600S MNSSR-600S-SS	UL 1741 PVRSE	2014, 2017, 2020, 2023
Smart rapid shutdown system (Smart RSS)	Delta Electronics *	GPI00010105	UL 1741 PVRSE	2014, 2017, 2020, 2023
Inverters	Delta Electronics *	M4-TL-US M5-TL-US M6-TL-US M8-TL-US M10-4-TL-US	UL 1741	2014, 2017, 2020, 2023
Inverters	Growatt *	MIN3000TL-XH-US MIN3800TL-XH-US MIN5000TL-XH-US MIN6000TL-XH-US MIN7600TL-XH-US MIN8200TL-XH-US MIN9000TL-XH-US MIN10000TL-XH-US MIN11400TL-XH-US	UL 1741	2014, 2017, 2020, 2023

Component and Function	Manufacturer	Model No.	Certification Standards	Years of Compliance to 690.12
Inverters	Solis *	Solis1P3.6K-4G-US Solis1P5K-4G-US Solis1P6K-4G-US Solis1P7K-4G-US Solis1P7.6K-4G-US Solis1P8.6K-4G-US Solis1P9K-4G-US Solis1P10K-4G-US	UL 1741	2014, 2017, 2020, 2023
Energy Shingle	GAF Energy	TLS-2	UL 61730 UL 7103	2014, 2017, 2020, 2023
Wire cover	GAF Energy	294000865	Tested in end-product to UL 3741 & UL 7103	2014, 2017, 2020, 2023
Top flashing assembly	GAF Energy	294000640	Tested in end-product to UL 3741 & UL 7103	2014, 2017, 2020, 2023
Transition box	GAF Energy	TB-2	Tested in end-product to UL 3741 & UL 7103	2014, 2017, 2020, 2023
Pass-thru device	GAF Energy	PTD-2	Tested in end-product to UL 3741 & UL 7103	2014, 2017, 2020, 2023
Powered jumper module (PJM)	GAF Energy	TLS-2J	UL 7103 and evaluated in end-product to UL 3741	2014, 2017, 2020, 2023
Aesthetic jumper module	GAF Energy	TLS-2AJM	UL 7103 and evaluated in end-product to UL 3741 ; UL 7103 and evaluated in end-product to UL 3741	
* For the most current specifications, instructions and limitations on the use of MidNite, Delta, Growatt, and Solis electronics, refer to each manufacturer's website.				

Table 6. RSD/PVRSA/PVHCS installation requirements

Requirement	Specification
Maximum system voltage	600V_{DC}
Maximum array internal voltage after actuation	600V_{DC} (cold weather V^{OC})
RSD voltage output after actuation	≤30V_{DC}
Voltage bleed-down interval.	≤30 secs.
Maximum series-connected Energy Shingles per PV series string	48

Other Installation Instructions

- PVRSE must be secured inside the enclosure (transition box, Hoffman box, or other listed enclosure) using provided fasteners.
- One PVRSE must be connected to each series string (48 Energy Shingles max.) or separate mounting plane subarray string. PVRSE may be installed on subarrays smaller than 48 series-connected Energy Shingles.
- Verification that each PVRSE is installed with 48 or fewer modules shall be documented for inspection by as-built string diagrams and/or voltage measurement logs. Voltage output per string is not to exceed 600V.
- The Delta PVRSE has a metal enclosure and shall be bonded to the EGC using the lay-in lug and M4 bolt provided, or by equivalent means approved in the NEC.
- A designated PV system disconnect shall serve as the RSD/PVRSA/PVHCS initiator and shall be sized, installed and labeled in accordance with NEC requirements. The specific part shall be identified on the as-built system drawings.

Balance of System Components

The roofing and solar system installer provides the remaining typical balance of system (BoS) items, including:

- Roofing materials
  - » Roofing underlayment (GAF Tiger Paw™ or underlayment certified to ASTM D226, D4869, D1970, or D6757)
  - » Roofing adhesive
  - » Drip edge
  - » Starter strip
  - » Ridge cap
  - » Flashings
  - » Roofing fasteners
  - » Cap nails/staples

A qualified person must perform final electrical tie-in. Depending on the site-specific array design, they might provide the following additional items:

- Listed raintight conduit fittings
- Electrical conduit and wiring
- Inverter
- AC/DC disconnect
- Back-fed breaker or fused AC disconnect (OCPD)
- Meter
- Panelboards

3. System Considerations and Installation Requirements

System Design Considerations

- **Slope limitations:** The Timberline Solar 2 system (solar array) is intended for use on roofs having a slope of 2:12 or greater.
- **Deck mounting:** The Timberline Solar 2 system must be deck-mounted with prescribed underlayment. Timberline Solar 2 shingles are to be installed only on a clean deck. All debris should be removed and old nails should be removed or pounded flush with the deck surface.
- **Deck requirements:** The roof deck must be a minimum of 15/32 inch (12 mm) thick plywood or 7/16 inch (11 mm) OSB decking as recommended by APA – The Engineered Wood Association. Wood plank decking must be well-seasoned and supported, having a maximum 1/8 inch (3 mm) spacing between boards with a minimum nominal thickness of 1 inch (25 mm) x maximum 6 inch (152 mm) lumber. Installers should ensure that the deck is properly fastened per local building code requirements. If any damaged sheathing is discovered during tear-off, replace and fasten in compliance with applicable codes and these instructions. Refer to the *GAF Pro Field Guide for Steep-Slope Roofs*.
- **Landscape orientation:** The Timberline Solar 2 Energy Shingles are designed for landscape orientation only.
- **Solar array wiring:** Refer to the permit design drawings for the system wiring details. The system electrical design is outside the scope of this manual.
- **Operating temperature:** The Timberline Solar 2 system is intended for an environmental ambient temperature range of -40°C to + 50°C (-40°F to 122°F) on average, as measured and documented by meteorological services for the intended installation's geographic location.
- **DC electrical output:** Under certain environmental conditions, the Timberline Solar 2 system may produce more current and/or voltage than reported at standard test conditions (STC: irradiance of 1000 W/m^2, AM 1.5 spectrum, and a cell temperature of 25°C [77°F]). The solar designer should account for these conditions when designing the solar array.
- **Suitable ambient conditions:** Artificially concentrated sunlight shall not be directed on the Timberline Solar 2 system. The modules must neither be immersed in water nor be exposed to continuous wetting (e.g., by fountains). Exposure to salt or sulfur (sulfur sources, volcanoes) increases a risk of corrosion of exposed metal components (e.g., EMT). The system must not be used on boats or vehicles. The system must not be exposed to extraordinary chemical loads (e.g., emissions from manufacturing plants). The GAF Energy Timberline Solar™ 2 should not be installed on stables.
- **Paint:** Do not apply unapproved paint to any part of the Timberline Solar 2 system.
- **Roof setbacks:** The Timberline Solar 2 system requires the installation of a minimum of one full row of shingles at the eave and the ridge. Refer to the local building and fire codes for additional setback and pathway requirements.
- **Mounting hardware:** Timberline Solar 2 is intended to be mounted to a roof using only the specified hardware. Using other unapproved means is a violation of the product's certification.

System Design Considerations, continued

- **Fire classification:** Timberline Solar 2 has been rated as Class A for resistance to external fire exposure per UL 790 when installed with GAF Tiger Paw™ Premium Roof Deck Protection or with underlayment certified to ASTM D226, D4869, D1970, or D6757.
- **Nonstructural component:** These products have been evaluated for serving as a nonstructural component of a building only.
- **Wind resistance and load ratings:**
  - The Energy Shingle wind uplift classification is ASTM D3161 Class F.
  - Energy Shingles have a positive design load rating of 1600 Pa with a safety factor of 2400 Pa (1.5X design load rating).
  - Each Energy Shingle weighs 10.1 lb. (4.58 kg.).
  - The installed system weight, including all components and underlayment, imposes a dead load of 3.36 pounds per square foot.
- **Impact resistance:** Timberline Solar 2 has achieved a Class 1 rating under UL 2218 *Impact Resistance of Prepared Roof Covering Materials*.
- **Roof obstructions:** Do not install any portion of the solar system over any roof obstructions, plumbing, or attic vents. Do not attempt to cut or modify the Energy Shingles to accommodate any roof projections. Roof obstructions must be removed or relocated.
- **Ice dams:** Refer to the *GAF Pro Field Guide for Steep-Slope Roofs* for installing leak barriers.
- **Shingle mismatch:** When installing a Timberline Solar 2 system on an existing roof, all the shingles in the plane of the roof with the solar array must be removed and replaced with any GAF Energy approved asphalt shingles, except as otherwise authorized in writing by GAF Energy.
- **Safety first:** Follow all of the guidelines in "General Safety Precautions" on page 8 as well as other safety precautions outlined in this manual.
- **Follow roofing best practices:** Follow all related shingle application instructions and industry best practices. Special attention is needed when stripping the shingles, installing underlayment, and trimming around the Timberline Solar 2 system. Refer to the *GAF Pro Field Guide for Steep-Slope Roofs* for best practices, including tearing off existing roofs and installing leak barriers.
- **Obtain permits:** The installer must comply with local, regional, and state building codes and obtain necessary permits and approvals from the local jurisdiction prior to installing the Timberline Solar 2 system.
- **Contact local utility:** Contact your local power provider for grid connection requirements prior to the system design and installation.
- **Deck-height variations:** Repair roof if deck-height variation (either a peak or valley) is greater than 1 inch (25 mm) over a 32 inch (813 mm) span or if there are any steps in decking 1/4 inch (6 mm) or greater.

System Design Considerations, continued

- **Electrical classification:** The Timberline Solar 2 system has been listed to UL 7103 ***Building Integrated Photovoltaic Roof Coverings***, which includes listing to UL 61730-1 and UL 61730-2 as a Class II Building-Integrated Photovoltaic module. The module electrical characteristics shown in Table 5, below, are under standard test conditions (STC: 1000 W/m^2, 25°C +/-2°C, AM 1.5 according to IEC 60904-3).

  Under real world conditions, PV modules may produce more current or voltage than reported at STC. The system designer shall apply any correction factors required by the National Electrical Code (ANSI/NFPA 70) to account for irradiance above STC and/or temperature below STC.

  NOTE: UL 61730-1 and 61730-2 supersede UL 1703 as of 12/4/19. All PV modules certified in the U.S. after this date, including Timberline Solar 2, are certified to UL 61730-1 and UL 61730-2.

- The Timberline Solar 2 system is listed to UL 3741 ***Photovoltaic Hazard Control*** and complies with the rapid shutdown requirements of Article 690.12 in the 2023, 2020, 2017, and 2014 NEC (ANSI/NFPA 70). Additional listed PVRSE is required to complete a Timberline Solar 2 installation that meets the following requirements:

  » Listed PV Hazard Control System (2023, 2020 NEC 690.12(B)(2)(1))

  » Listed Rapid Shutdown PV Array (2017 NEC 690.12(B)(2)(1))

  » Listed PV Rapid Shutdown Equipment (2014 NEC 690.12 (1) - (5))

  See Table 4 on page 20 for a complete list of required GAF Energy and PVHCS/PVRSE components.

- **WARNING:** To reduce the risk of injury, read all instructions.

System Design Considerations, continued

Table 7. System electrical characteristics *

Isc:	6.6A +/- 5%	Ipmax:	6.3A +/- 5%
Voc:	10.9V +/- 5%	Vpmax:	9.0V +/- 5%
Pmax:	56W +/- 5%	Equipment class:	II
Temp coefficient Isc:	+0.06%/C	Max modules in series:	48
Temp coefficient Voc:	-0.30%/C	Max recommended parallel strings:	2
Temp coefficient Pmax:	-0.39%/C	Diode:	Schottky 12A 45V, Diodes Inc. #SBR12U45LH1-13
Vsys:	1000v ***	Connector:	Staubli PV-KST4-EVO2/6II-UR (F) PV-KBT4-EVO2/6II-UR (M) ** Staubli PV-KST4/6X-UR (F) PV-KBT4/6X-UR (M) **
Max installation altitude:	4000m/13,100 ft.	Max series fuse rating:	15A

* All electrical ratings shown are within tolerance both initial and stabilized conditions.

** All Staubli Evo 2-series connectors are fully compatible with all Staubli MC4-series connectors. For the most current specifications, instructions, and limitations on the use of Staubli connectors, refer to Staubli's website, https://www.staubli.com.

*** PV system DC circuits on or in one- and two-family dwellings shall be permitted to have a maximum voltage no greater than 600 volts.

Table 8. Component ratings, transition box, and pass-thru device

Specification	Transition Box	Pass-thru Device
Type rating	Type 3R	Type 4
Max input voltage (DC)	1000 V	1000 V
Max input current (AC or DC)	12 to 14 AWG @ 20 A	20 A
	6 to 10 AWG @ 30 A	
Normal operation temperature range	-40°C to 50°C ambient	-40°C to 50°C ambient
Conductor AWG range	14 AWG to 6 AWG	14 AWG to 6 AWG

Recommended Tools for Installation

The following tools are recommended to properly install a Timberline Solar 2 system. This list is representative only; additional tools may be required depending on the installation.

- Nail gun
- Unibit or graduating drill bit
- Hole saw or paddle bit
- Channel locks
- Chalk line
- Multimeter
- Phillips tip screwdriver
- Caulking gun
- Drill
- Alignment jig for use with Energy Shingles
- Wire strippers

Pre-Installation Checklist

The following should be completed prior to the installation of the Timberline Solar 2 system:

- **Review documentation:** Review the installation instructions, permit drawings, and other site-specific drawings thoroughly.
- **Ensure materials are onsite:** Ensure that all the correct materials in the appropriate quantities are present onsite.
- **Display permits:** Ensure all building/electrical permits are posted in a visible location onsite.
- **Discuss with the building owner:** Confirm access roads, material staging area, and ladder access area (as shown in the permit design drawings). Also discuss work hours, installation noise, and electrical panel shutdown timing with the building owner.
- **Review site:** Review site conditions prior to installation. If the installer notices any abnormalities, do **NOT** proceed with the installation until the matter is resolved with the building owner and with GAF Energy. Typical abnormalities could include:
  - Conditions do not match planned design
  - Roof obstructions
  - Excessive deck-height variations

4. Installation Procedure

The following steps outline the procedure to install the Timberline Solar 2 system:

Step 1	Set Up the Array Layout
Step 2	Set Up the Column Layout
Step 3	Install the First Energy Shingle
Step 4	Install the First Column of Energy Shingles
Step 5	Install the Remaining Columns
Step 6	Install the Jumper Modules (JMs)
Step 7	Connect Column Wiring and Add Wire Cover Hooks
Step 8	Install the Asphalt Shingles Along Array Edges and Floating Brackets
Step 9	Install the Top Flashing
Step 10	Install Asphalt Shingles over the Array
Step 11	Install the Wire Covers
Step 12	Connect the Array Wiring
Step 13	Final Check

Conventions for These Instructions

The installation instructions sometimes use terms like ***up***, ***down***, ***previous***, ***next***, and so on when referring to positions of Energy Shingles and asphalt shingles. Sometimes components are layered one on top of the other, and sometimes components are positioned or aligned to be touching but not covering one another.

Refer to the following conventions when reading through the instructions, and consult the illustrations for clarification.

- above = up roof, toward the peak
- below = down roof, toward the eave
- adjacent = usually horizontal, but can mean touching in any direction
- previous = left side, usually
- next = right side, usually
- on top of or covering = layered
- beneath = layered underneath
- vertical = up roof or down roof
- horizontal = right or left on the roof
- left = on the left side of the roofing plane, facing up roof
- right = on the right side of the roofing plane, facing up roof
- top = farthest point up roof
- bottom = farthest point down roof

Step 1. Set Up the Array Layout

Summary:

a. Prep the roof deck and install the necessary roofing components, including the underlayment.

b. Define each array's dimensions.

c. Locate the bottom left corner of the array.

d. Install asphalt shingle courses up to the array starting point.

Step 1a. Prep the roof deck and install the necessary roofing components, including the underlayment.

- Ensure that the roof substrate is free from debris, with all existing fasteners either removed or hammered flush to the deck surface.
- Confirm that the roof sheathing meets the product minimum requirements, and is secured in accordance with applicable building codes and manufacturer's instructions. Make any necessary repairs before proceeding. Refer to GAF product installation instructions and the *GAF Pro Field Guide for Steep-Slope Roofs* for asphalt shingles, roofing underlayment, and other roofing products.
- Install the approved starter strips and the first course of shingles in accordance with the instructions in the *GAF Pro Field Guide for Steep-Slope Roofs*.

Figure 15. Install roofing underlayment

Step 1. Set Up the Array Layout, continued

Step 1b. Define each array's dimensions.

- Width is the total number of columns x 65 inches, + 5 inches for the right side wire channel of the rightmost column (#columns x 1524 mm, + 127 mm).
- Height is the number of Energy Shingle exposures x 7 9/16 inches, + 22 inches for the top flashing (#exposures x 192 mm, + 559 mm).

Figure 16. Compute array dimensions

Step 1c. Locate the bottom left corner of the array.

- Some jurisdictions require access pathways for rooftop fire operations. These may be at the rake, ridge, and/or valleys. Refer to your permitted plans and do not place the array in fire access pathways.
- Check for roof obstructions.
- Measure from the eave up to the bottom start of the array in order to determine the number of courses required. Start the array on a full course of asphalt shingles by adjusting the bottom edge up or down roof to align with a multiple of asphalt shingle reveal plus overhang. After adjustment make sure the array does not interfere with obstructions or setbacks.
- Based on all these considerations, choose an optimal starting point at the bottom left corner of the array.

Step 1. Set Up the Array Layout, continued

Locate the Array Starting Point

The figure below illustrates an example with 3 courses of shingles below the array. Actual installations may vary in the number of shingle courses.

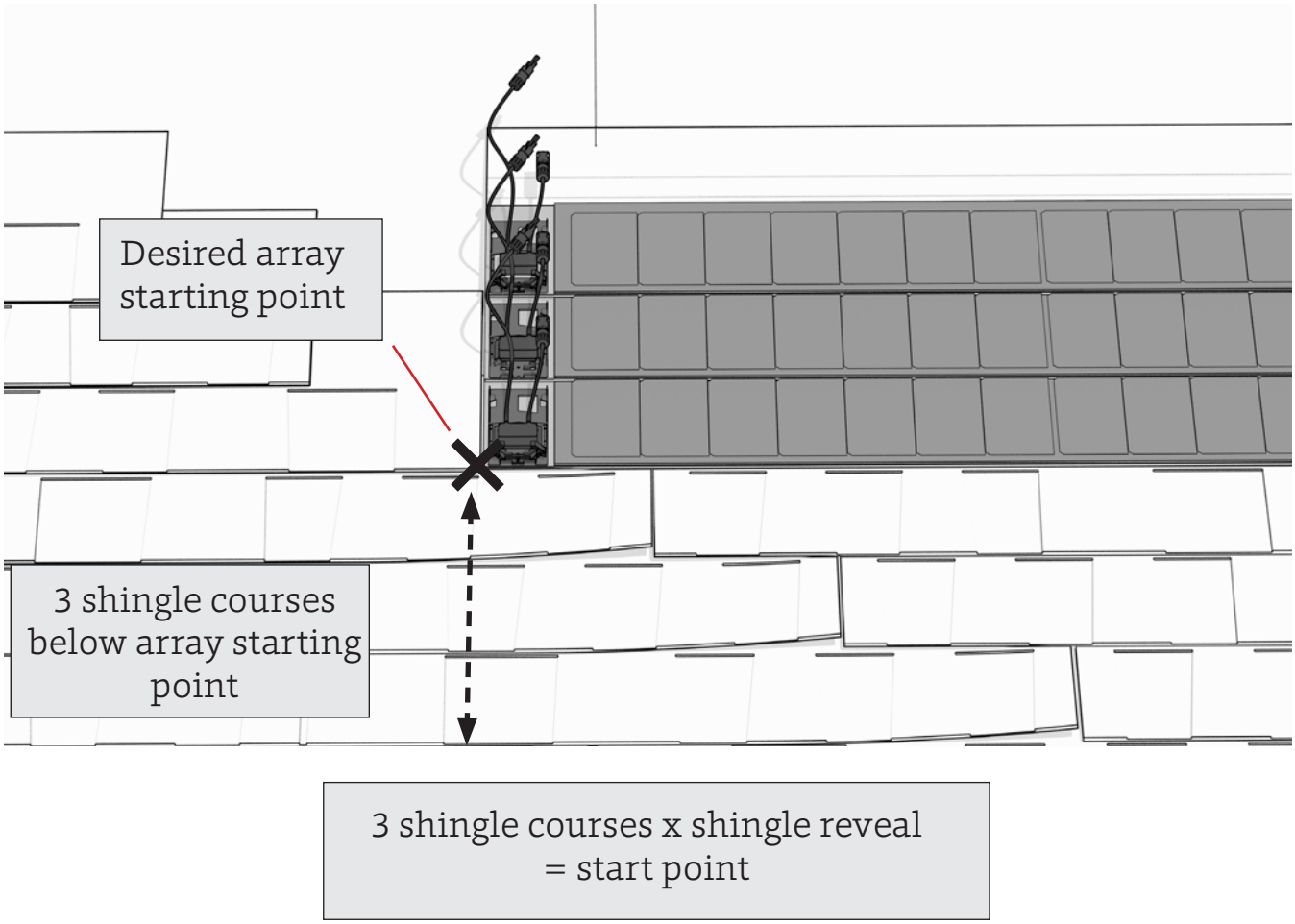


Figure 17. Array starting point, example with three shingle courses

Step 1. Set Up the Array Layout, continued

Figure 18. Locate array starting point

Step 1d. Install asphalt shingle courses up to the array starting point.

- Install the starter strip and asphalt shingles, referring to the GAF application instructions for the roofing products being used.
- Maintain the manufacturers required shingle offset up to the array.
- When there is an asphalt shingle butt joint within 8 inches of the bottom left array corner, install a step flap under the joint.
- Any asphalt shingle that is overlapped by an Energy Shingle requires an additional 4 nails at the top of each headlap.

Figure 19. Bottom course of asphalt shingles

Step 2. Set Up the Column Layout

Summary:

a. Snap a horizontal chalk line along the array bottom edge.

b. Snap a vertical chalk line to align the first column to.

c. Snap vertical chalk lines at 65 inches to align the remaining columns to.

Step 2a. Snap a horizontal chalk line along the array bottom edge.

- Align the chalk line with the asphalt shingle reveal.
- This is where the bottom edge of the first row of Energy Shingles will be aligned to.

Figure 20. Snap horizontal chalk line along array bottom edge

Step 2. Set Up the Column Layout, continued

Step 2b. Snap a vertical chalk line to align the first column to.

- From the bottom left array corner, measure 6 inches (152 mm) to the right and mark the asphalt shingle on the horizontal chalk line.
- Snap a straight vertical chalk line up from the mark on the asphalt shingle. The straightness of this line is critical to the aesthetics of the installed system.

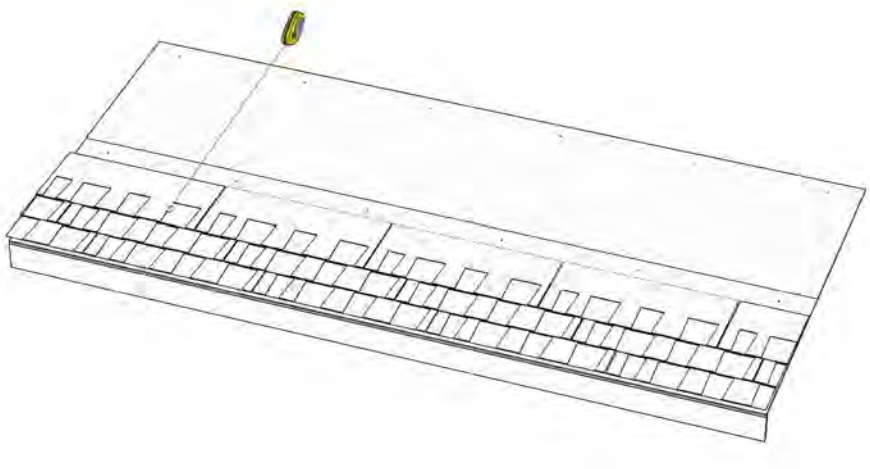


Figure 21. Snap the first column's vertical line

Step 2. Set Up the Column Layout, continued

Step 2c. Snap vertical chalk lines to align the remaining columns to.

- When the first vertical line is down, chalk additional vertical lines 65 inches (1651 mm) apart for each addition column to be installed.

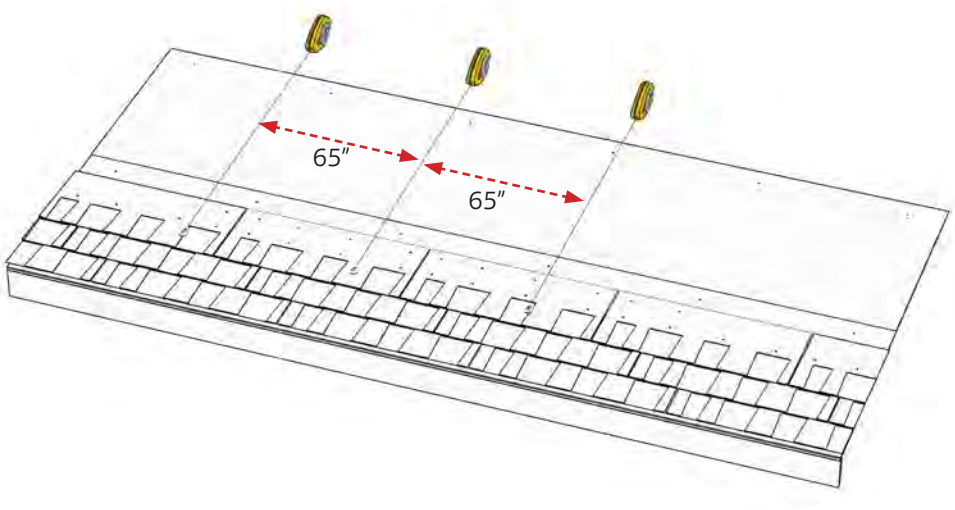


Figure 22. Each column's vertical lines in place

Step 3. Install the First Energy Shingle

Summary:

a. Install the first step flap.

b. Install the first Energy Shingle.

Step 3a. Install the first step flap

- Position the step flap's left center line 6 inches (152.4 mm) from the first vertical chalk line on the deck.
- Align the bottom of step flap 2 inches (51 mm) above asphalt shingle exposure.
- Place two nails in the top right corner of the step flap.

Figure 23. Nail the step flap in place

NOTE ON WIND RESISTANCE AND HAND SEALING: The Energy Shingles have a special thermal sealant that bonds the shingles together after installation when exposed to sun and warm temperatures. If the Energy Shingles are damaged by winds before sealing, or are not exposed to adequate surface temperatures, or if the self-sealant gets dirty, the shingles may never seal. Failure to seal under these circumstances results from the nature of self-sealing shingles, and is not a manufacturing defect. If shingles are to be applied during PROLONGED COLD (below 40°F for three or more days) or in areas where airborne dust or sand can be expected before sealing occurs, all Energy Shingles MUST be hand sealed by applying a 1/4 inch bead of GAF Energy-approved sealant directly above the front edge butyl on the Energy Shingle, following the length and gaps of each bead of butyl.

Step 3. Install the First Energy Shingle, continued

Step 3b. Install the first Energy Shingle.

- Position the first Energy Shingle on the roof, lining up the bottom edge of the Energy Shingle with the horizontal chalk line.
- Align the mark on the headlap with the first column's vertical chalk line on the deck.
- Place the first Energy Shingles junction box (J-box) flap on top of the step flap. The left side of the Energy Shingle should align with the left center line on the step flap.

Figure 24. Install the first Energy Shingle

- Secure the Energy Shingle using 6 evenly spaced nails, in the outlined nailing zone above the active area of the Energy Shingle only. ***Do not nail above the J-box or right side flaps. Nails must be driven fully and flat to the headlap.*** Use the same proper nailing practices as used with the asphalt shingles and as described in the *GAF Pro Field Guide for Steep-Slope Roofs*.
- When secured, completely remove the release liner under the bottom edge

Step 4. Install the First Column of Energy Shingles

Summary:

a. Install a step flap at each joint from the asphalt shingle to the Energy Shingle on the left of the array.

b. Align and install the following Energy Shingles up the column.

c. Check for column squareness every 5 courses.

Step 4a. Install a step flap at each joint from the asphalt shingle to the Energy Shingle on the left edge of the array.

- Install a step flap under every asphalt shingle/Energy Shingle butt joint, on the left edge of the array.
- Align the step flap bottom edge 2 inches (51 mm) up from the top of the lower Energy Shingle baseplate of the previous Energy Shingle in the column.
- Align the step flaps left center line with the left side of the Energy Shingle.
- Place two nails in the top right corner of the step flap.

Figure 25. Align the next step flap up the column

Step 4. Install the First Column of Energy Shingles, continued

Step 4b. Align and install the following Energy Shingles up the column.

- Align the mark on the headlap of the Energy Shingle with the columns vertical chalk line on the deck.
- Use two alignment jigs on each side of the Energy Shingle to align the bottom edge of the Energy Shingle correctly with the Energy Shingle below.

Figure 26. Next Energy Shingle going up the column

- The J-box flap should cover the right half and both center lines on the step flap.
- Secure the Energy Shingle using 6 evenly spaced nails, in the outlined nailing zone above the active area of the Energy Shingle only. *Do not nail above the J-box or right side flaps.*
- When secured, completely remove the release liner under the bottom edge.

Step 4. Install the First Column of Energy Shingles, continued

Step 4c. Check for column squareness every 5 courses.

- Pull a tape from the left and right sides of the front edge of the first course Energy Shingle up to the 5th Energy Shingle being installed.
- Verify that the measurement is the same on both sides of the Energy Shingle being installed.
- If the measurements are not the same, make small adjustments no bigger than 1/8 inch.

Step 5. Install the Remaining Columns

Summary:

a. When the next column(s) are uneven, install asphalt shingles up to the next common row and snap a horizontal chalk line

b. Install the first Energy Shingle at the bottom of the column.

c. Install the following Energy Shingles in a column.

d. Confirm all alignment features are being used properly for a straight wire channel.

e. Install step flaps along the right edge of the array.

Step 5a. When the next column(s) are uneven, install asphalt shingles up to the next common row and snap a horizontal chalk line

- Refer to the planset to determine the common row location.
- Install asphalt shingles up to the common row location.
- Measure from the eave to the common row in the column already installed and transfer this measurement over to the right side of the new column and mark.
- Snap a chalk line from the front edge of the Energy Shingle already installed in the common row to the mark.
- If the common row line falls within the headlap of the asphalt shingles, install a short course of asphalt shingles so that the common row line falls within the reveals instead.

Step 5. Install the Remaining Columns, continued

Step 5b. Install the first Energy Shingle at the bottom of the column.

- Place the J-box flap of the Energy Shingle over the right side flap of the Energy Shingle to its left and under the right side flap of the Energy Shingle above.
- Align the bottom edge of the Energy Shingle to the horizontal chalk line at the asphalt shingle.
- Align the alignment mark on the headlap of the Energy Shingle to the vertical chalk line.
- When secured, completely remove the release liner under the front edge and if the Energy Shingle is installed over the exposure of asphalt shingles, apply GAF Energy approved hand sealant 1 inch (25 mm) above the adhesive line following the adhesive pattern on the backside of the Energy Shingle.

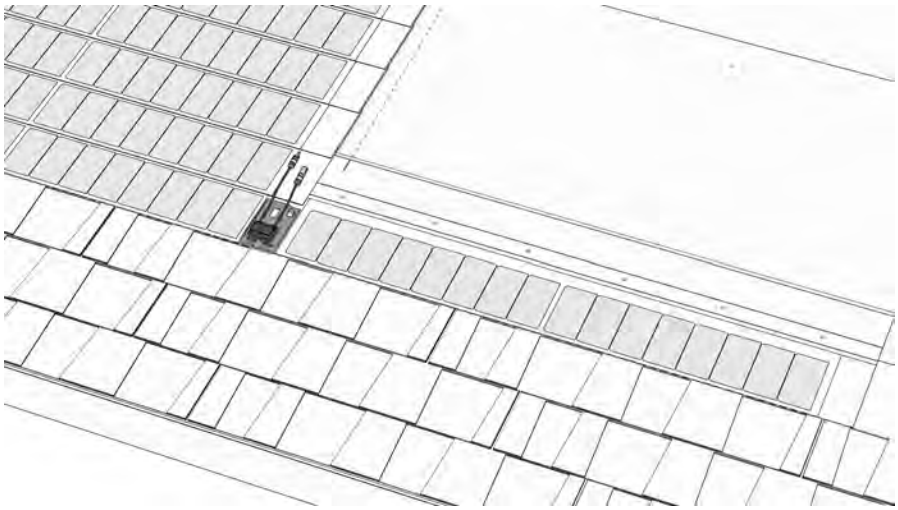


Figure 27. Install the first Energy Shingle in the next column

Step 5. Install the Remaining Columns, continued

Step 5c. Install the following Energy Shingles in a column.

- Interweave the flaps to ensure proper water-shedding integrity of the array.
  - » The J-box flap of an Energy Shingle covers the right side flap of the adjacent Energy Shingle from the previous column in the same course.
  - » The headlap portion of an Energy Shingle will be underneath the right side flap of any Energy Shingle above it.
- Align the alignment mark on the headlap with the corresponding column's chalk line on the deck.
- Use the previous column to set the reveal on the left side of the Energy Shingle by visually aligning its left side with the adjacent Energy Shingle.
- Use the alignment jig to set the reveal on the right side of the Energy Shingle.
- Fasten the Energy Shingle with 6 evenly spaced nails.
- When secured, completely remove the release liner under the bottom edge.

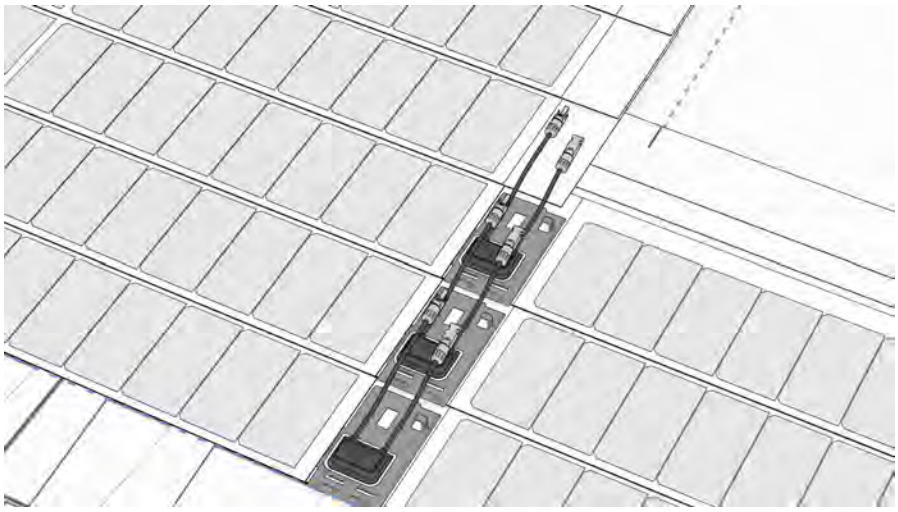


Figure 28. Install Energy Shingles in a column

Step 5. Install the Remaining Columns, continued

Step 5d. Confirm all alignment features are being used properly for a straight wire channel.

Step 5e. Install step flaps along the right edge of the array.

- Install a step flap under every asphalt shingle/Energy Shingle butt joint on the right edge of the array.
- Align the step flap bottom edge 2 inches (51 mm) up from the bottom edge of the Energy Shingle in the same course.
- Align the right center line on the step flap with the right side of the Energy Shingle.
- Nail the step flap with two nails on the top left corner.

Figure 29. Step flaps going up the right side of a column

Step 6. Install the Jumper Modules (JMs)

Summary:

a. Locate the jumper module (JM) positions and types from the plan set.

b. Install a step flap at the asphalt shingle-to-JM joint on the left edge of the array.

c. Install the JMs where they are required.

d. Install a step flap underneath the rightmost jumper modules-to-asphalt shingles butt joints.

Step 6a. Locate the JM positions from the plan set.

- The plan set for the site installation shows where to locate the JMs.
- The plan set identifies the type of JM. It is critical to the production of the system that the correct type of jumper module is installed. Both aesthetic and powered jumper modules are installed the exact same way. Only powered produces power and has measurable voltage.
- Typically JMs are installed across the entire top row of an array. The JM cannot be installed with an Energy Shingle to its right but can be installed with an Energy Shingle to its left.

Step 6b. Install a step flap at the asphalt shingle-to-JM joint on the left edge of the array.

- Align the step flap bottom edge 2 inches (51 mm) up from the top of the lower Energy Shingle baseplate of the previous Energy Shingle in the column.
- Align the step flaps left center line with the left edge of the Energy Shingle.
- Place two nails in the top right corner of the step flap.

Figure 30. Continue step flaps for the JM on the left edge of the array

Step 6. Install the Jumper Modules, continued

Step 6c. Install the JMs where they are required.

- Align a JM the same way that the Energy Shingles are positioned.
- Use two alignment jigs on each side of the JM to align the bottom edge of the JM correctly with the Energy Shingle below.
- Align the alignment mark on the headlap with the corresponding column's vertical chalk line on the deck.
- Secure the JM using 6 evenly spaced nails, in the outlined nailing zone above the active area of the Energy Shingle only. *Do not nail above the side flaps.*
- When secured, completely remove the release liner under the bottom edge.

Figure 31. Position a JM at top of columns, per planset

Step 6. Install the Jumper Modules, continued

Step 6d. Install a step flap underneath each of the rightmost JM-to-asphalt shingle butt joints.

- Install a step flap under the asphalt shingle/JM butt joint on the right edge of the array.
- Align the step flaps bottom edge 2 inches (51 mm) up from the bottom edge of the JM.
- Align the right center line of the step flap with the right side of the JM.
- Nail the step flap with two nails on its top left corner.

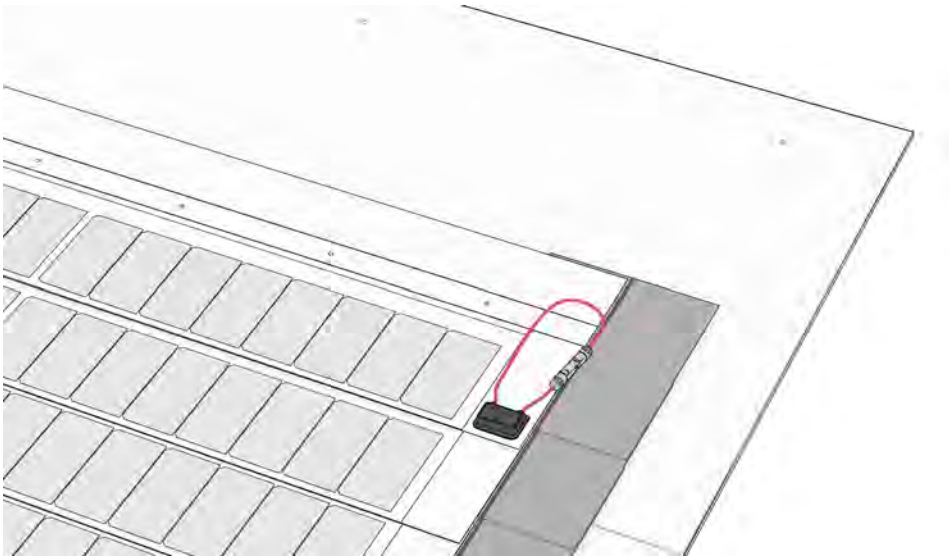


Figure 32. Continue step flaps for the JM on the right edge of the array

Step 7. Connect Column Wiring and Add Wire Cover Hooks

Summary:

a. Install hooks every other course starting from the bottom.

b. Connect Energy Shingle to Energy Shingle leads starting from the bottom.

c. Install column return wires for each column.

d. Confirm column open circuit voltage (Voc).

Step 7a. Install hooks every other course starting from the bottom.

- Every other J-box baseplate will receive a hook starting at the first course.
- Slide the hooks into the center position.

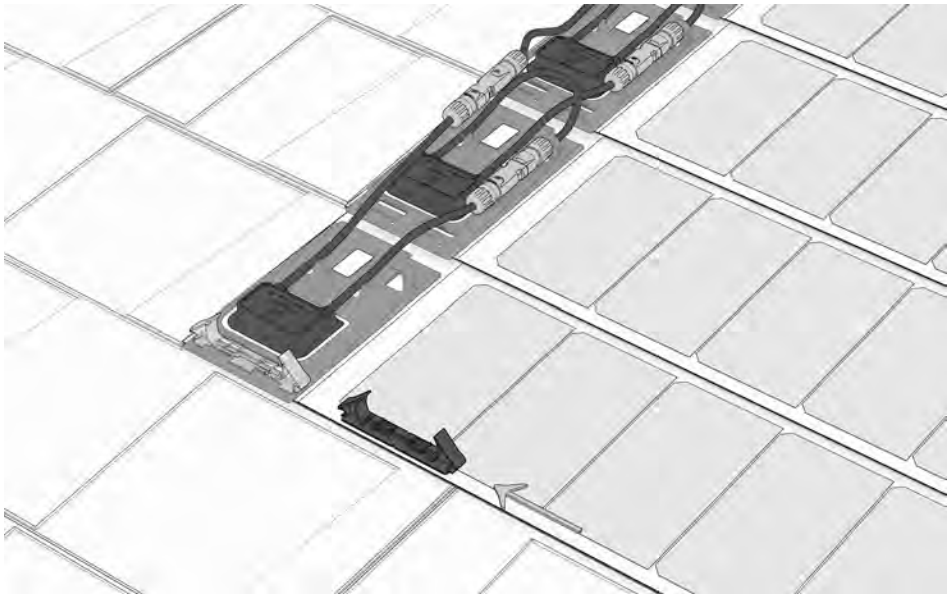


Figure 33. Slide the hook into the center position

Step 7. Connect Column Wiring and Add Wire Cover Hooks, continued

Step 7b. Connect Energy Shingle to Energy Shingle leads starting from the bottom.

- Each Energy Shingle plugs into the Energy Shingle above it. When the connectors are plugged together, you should hear and feel a positive mechanical "click." To confirm the connectors are fully seated, gently try to pull them apart.
- Take the male connector (the positive) from the Energy Shingle above and connect it to the female connector (the negative) below for every Energy Shingle to Energy Shingle connection.
- Repeat the same for the JM left side J-box with blue wires to Energy Shingle connection.
- The JM right side wires are red and should stay plugged in to each other until it is time to connect columns together.
- Use the module baseplate wire clip features to keep wire management tight and neat.

Step 7c. Install column return wires for each column.

- Route the column return wire(s) from the bottom of the Energy Shingle's male (positive) connector up to the top flashing.
- Use the module baseplate wire clip features and hooks to keep wire management tight and neat.

NOTE: Each column should always have a male (positive) and female (negative) connector in the top flashing that are NOT plugged together.

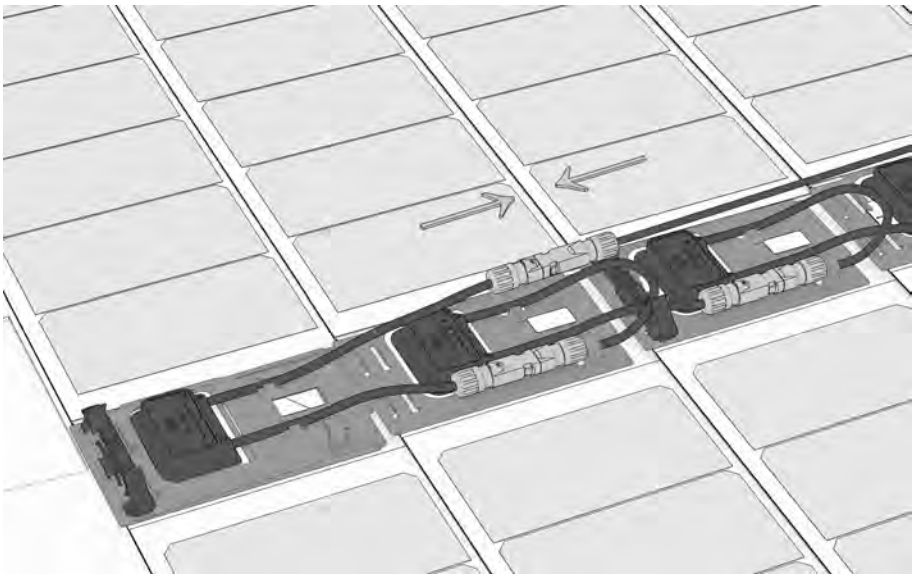


Figure 34. Use the features of the built-in wire clips to secure the wires

Step 7. Connect Column Wiring and Add Wire Cover Hooks, continued

Step 7d. Confirm column open circuit voltage (Voc).

- Leave one male (positive) connector from the bottom module and one female (negative) connector from the top module disconnected in each top flashing.
- Measure column Voc using a DC voltmeter to confirm that it matches expectations.
  - » Expected column Voc can be estimated using this equation:
    Column Voc = # of Energy Shingles in column x Energy Shingle Voc
  - » For example, consider a column with 20 Energy Shingles, and an Energy Shingle Voc of approximately 10 volts. This column would have an open circuit voltage of about 200 volts (20 Energy Shingles x 10 V each).

Step 8. Install the Asphalt Shingles Along Array Edges and Floating Brackets

Summary:

a. Install adjoining asphalt shingles on the left edge of the array.

b. Snap a chalk line over the right side flaps at the right edge of the array for floating bracket alignment.

c. Install floating brackets along the right edge of the array starting on the first course and every other course after.

d. Along with floating brackets, install asphalt shingles on the right edge of the array after all step flaps and floating brackets have been installed.

Step 8a. Install adjoining asphalt shingles on the left edge of the array.

- Shingles must be installed up the left edge to the top of the array before installation of the leftmost top flashing.
- Trim the asphalt shingles flush to the edge of the Energy Shingle side flap. Place the asphalt shingle over any step flaps covering the asphalt shingles nail zone and reveal, and tuck the shingle under the step flaps that do not extend beyond the nail zone and reveal.
- Place a high nail on the asphalt shingle underneath the step flap above to eliminate exposed nailheads.
- Follow roofing best practices for asphalt shingle offsets. Follow the manufacturer's product manual for asphalt shingles.
- Continue weaving asphalt shingles into the step flaps on the left edge of the array, stopping at the last Energy Shingle or JM in the column.
- Step flaps should not be visible after the left edge of the array is shingled.

Figure 35. Shingles on the left edge of the array

Step 8. Install the Asphalt Shingles Along Array Edges and Floating Brackets, continued

Step 8b. Snap a chalk line over the right side flaps at the right edge of the array for floating bracket alignment.

- At the bottommost Energy Shingle at the right edge of the array, measure 65 inches (1651 mm) from the center of the baseplate to the right side flap and place a mark.
- Repeat this measurement and mark at the topmost Energy Shingle.
- Snap a chalk line using the marks created on the right side flaps.

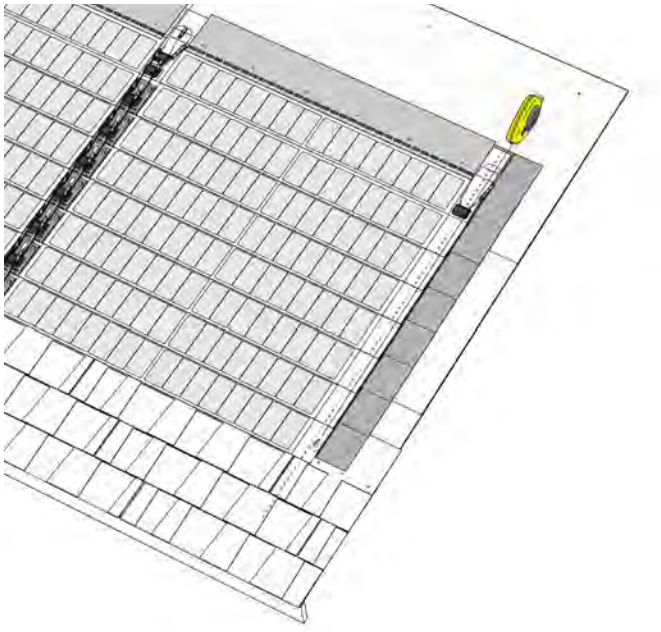


Figure 36. Snap a chalk line over the right side flaps

Step 8c. Install floating brackets along the right edge of the array starting on the first course and every other course after.

- Starting at the first course, tuck the floating bracket underneath the right side step flap and align the center of the floating bracket with the chalk line, and then peel the release liner.
- When positioned, lift the step flap and nail the floating bracket in the two targets.
- Finish installing floating brackets minimum every other course starting at the first course up the right edge of the array. When the JM is not located at the top of a column, a floating bracket is required in the courses below and above the JM.

Step 8. Install the Asphalt Shingles Along Array Edges and Floating Brackets, continued

Figure 37. Install and nail floating bracket underneath right side flap and step flap

Step 8d. Along with floating brackets, install asphalt shingles on the right edge of the array.

- Shingles must be installed up the right edge to the top of the array before the installation of the rightmost top flashing.
- At the first course, butt the asphalt shingle to the edge of the Energy Shingle's right side flap. Place the asphalt shingle over any step flaps covering the asphalt shingles nail zone and reveal, and tuck the shingle under the step flaps that do not extend beyond the nail zone and reveal.

Step 8. Install the Asphalt Shingles Along Array Edges and Floating Brackets, continued

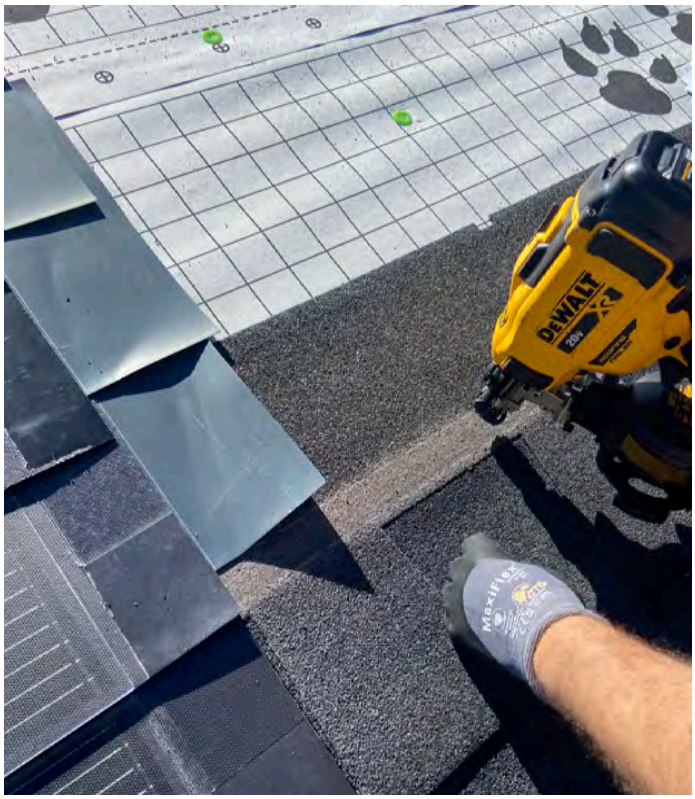


Figure 38. Butt asphalt shingle to the right side flap

- Place a high nail on the asphalt shingle underneath the step flap above to eliminate exposed nailheads.
- Follow roofing best practices for asphalt shingle offsets. Follow the manufacturer's product manual for asphalt shingles.

Step 8. Install the Asphalt Shingles Along Array Edges and Floating Brackets, continued

Figure 39. Lift the step flap when nailing the asphalt shingle

- Continue weaving asphalt shingles into the step flaps and installing floating brackets on every other course up the right edge of the array, stopping at the last energy shingle or JM in the column.

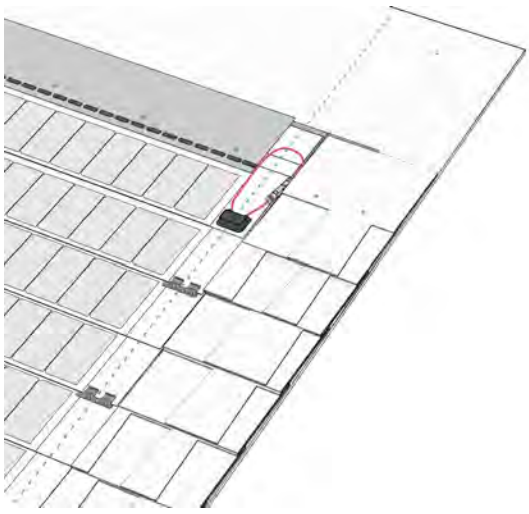


Figure 40. Floating brackets and asphalt shingles up the right edge

Step 9. Install the Top Flashing

Summary:

a. Apply QuickStart® across each headlap at the top of each column.

b. Install two step flaps at the top of every wire channel.

c. Align and install the top flashing at the top of every wire channel.

Step 9a. Apply QuickStart across each headlap at the top of each column.

- Run 60.25 inch (1530 mm) strips of QuickStart across each headlap at the top of a column.
- Do not install QuickStart inside the interior area of the wire channel where it could contact wires or wire connectors.
- Align the QuickStart with the alignment jig.
- Remove the release liner from the QuickStart and apply pressure to stick it in place.
- Using 6 evenly spaced nails, fasten the QuickStart in place along the nail zone of the ES/JM below.

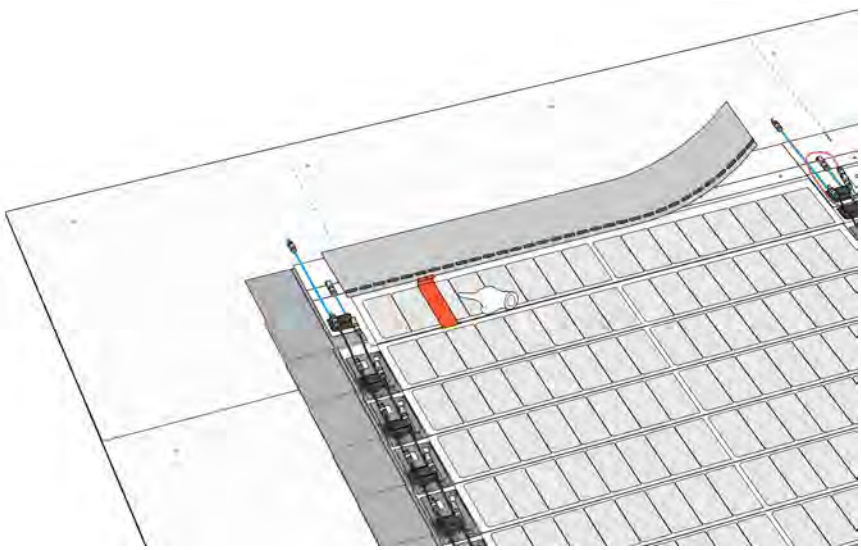


Figure 41. Install QuickStart on top of each column

Step 9. Install the Top Flashing, continued

Step 9b. Install two step flaps at the top of every wire channel.

- Place the first step flap over the QuickStart and align it 5 inches (127 mm) up from the bottom edge of the QuickStart.
- Center the step flap over the wire channel.
- Nail the step flap at the top left and right corners.
- Place the second step flap over the first and align it 7 inches (178 mm) up from the bottom edge of the first step flap, center it with the wire channel, and nail in the top left and right corners.

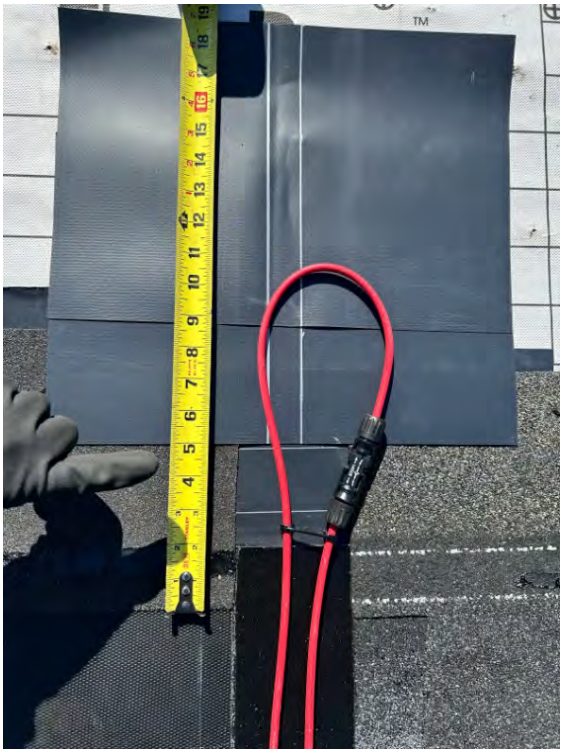


Figure 42. Install step flaps at the top of every wire channel

Step 9c Align and install the top flashing at the top of every wire channel.

- Before installing the leftmost and rightmost top flashing, asphalt shingles must be installed up the entire left and right edges of the array.
- Position the top flashing on top of the wire channel, centered over the J-box below. Pull the wires through the top flashing before nailing in place.
- Use the alignment jig to align with the Energy Shingle or JM below.
- Align the alignment mark in the top right corner to the vertical chalk line used to align the column.
- Confirm that no wires are pinched between the top flashing and the deck.

Step 9. Install the Top Flashing, continued

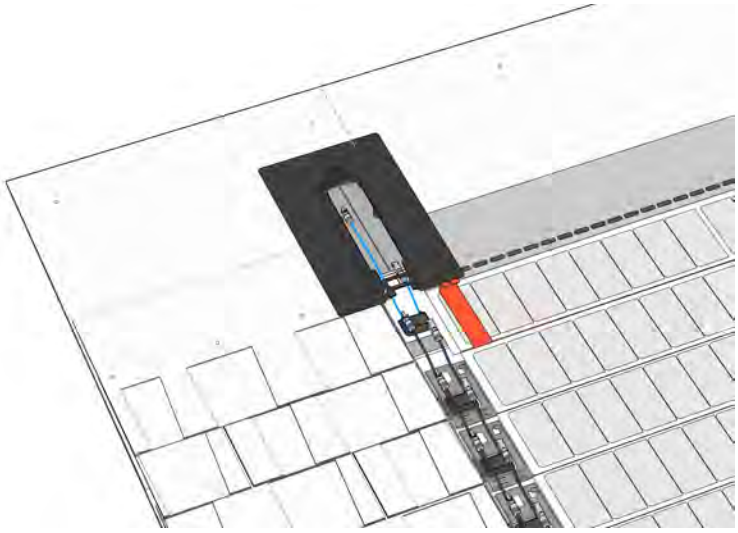


Figure 43. Position the top flashing at the top of the wire way

- When the top flashing is aligned, secure it using 4 nails: 2 at the top corners, and 2 on either side in the nail targets.
- Make sure to nail in only the targets of the top flashing.

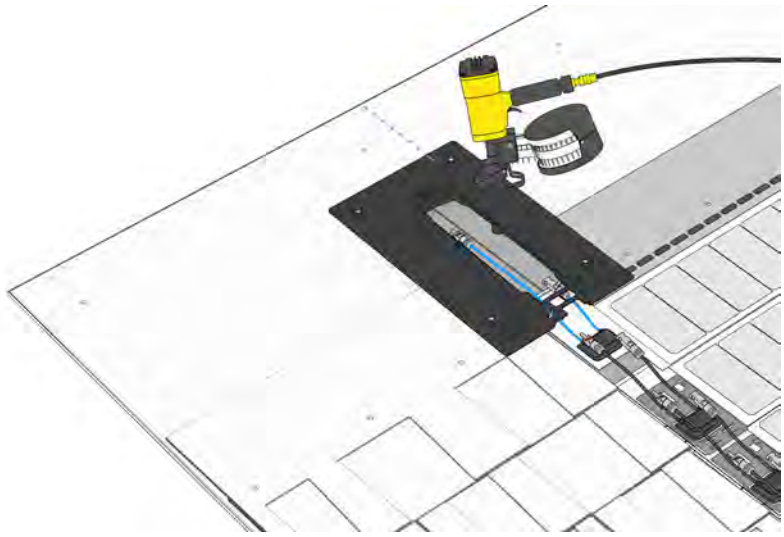


Figure 44. Fasten the top flashing in the nail targets

Step 10. Install Asphalt Shingles over the Array

Summary:

a. Maintain the required horizontal shingle offset and vertical exposure.

b. Cut the shingles across the top of the array to fit around the top flashings and across the roof.

c. Apply an approved sealant to the top side of the top flashing.

Step 10a. Maintain the required horizontal shingle offset and vertical exposure.

- If the asphalt shingles along the sides of the array do align, continue installing shingles across the top of the array maintaining the manufacturer offset.
- If the asphalt shingles along the sides of the array do not align, install a short course of shingles above the array before installing top flashings and apply any GAF Energy approved hand sealant onto the underside of the short coursed shingles along their seal strip.

Step 10b. Cut the shingles across the top of the array to fit around the top flashings and across the roof.

- Leave a 1/2 inch (13 mm) water channel along the edges of the top flashing.
- Dog ear (45 degrees) cut the top shingle corner leading into the top flashing. This prevents water from traveling across the top of the shingle.

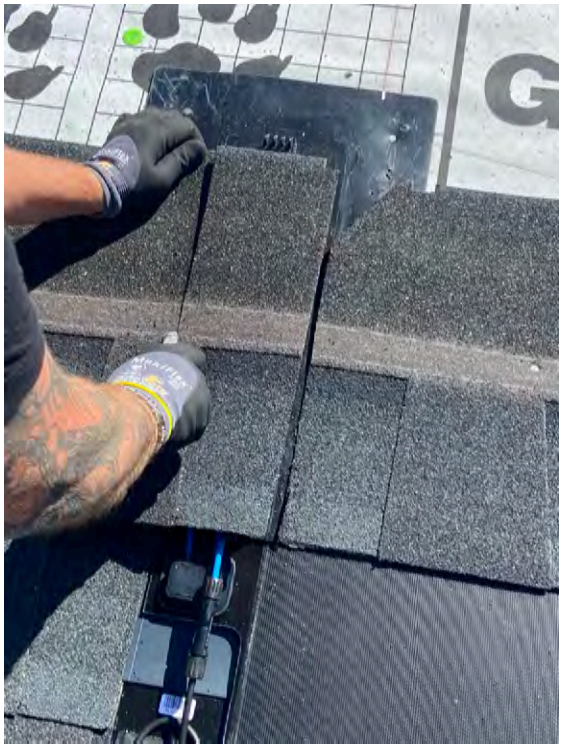


Figure 45. Cutting shingles around top flashing

Step 10. Install Asphalt Shingles over the Array, continued

Step 10c. Apply an approved sealant to the top side of the top flashing base.

- Use a continuous bead of sealant in an upside down U shape.
- Apply the sealant inside of the top flashing nail zone. Make sure all nails are located outside of the bead of sealant.
- After trimming and sealant, secure asphalt shingles in place. Follow roofing best practices for asphalt shingle offsets. Follow the manufacturer's product manual for asphalt shingles.

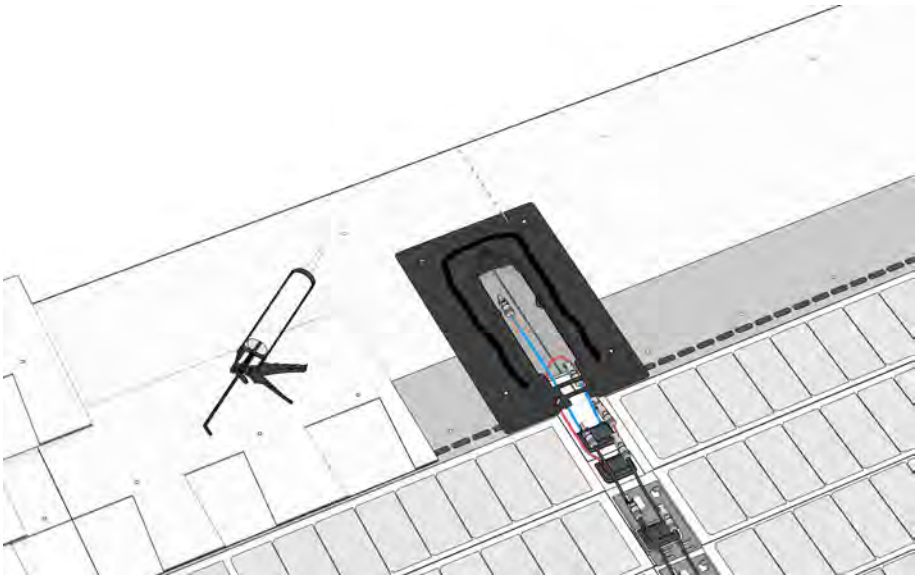


Figure 46. Apply sealant to top flashing base

Step 11. Install the Wire Covers

Summary:

a. Install bottom caps on the bottom of each wire channel.

b. Install the first wire cover going up each wire channel.

c. Install the remaining wire covers going up each wire channel.

d. Attach the top flashing lids.

e. Straighten the wire covers.

Step 11a. Install bottom caps on the bottom of each wire channel.

- Slide the bottom caps up into the hooks along the first course.

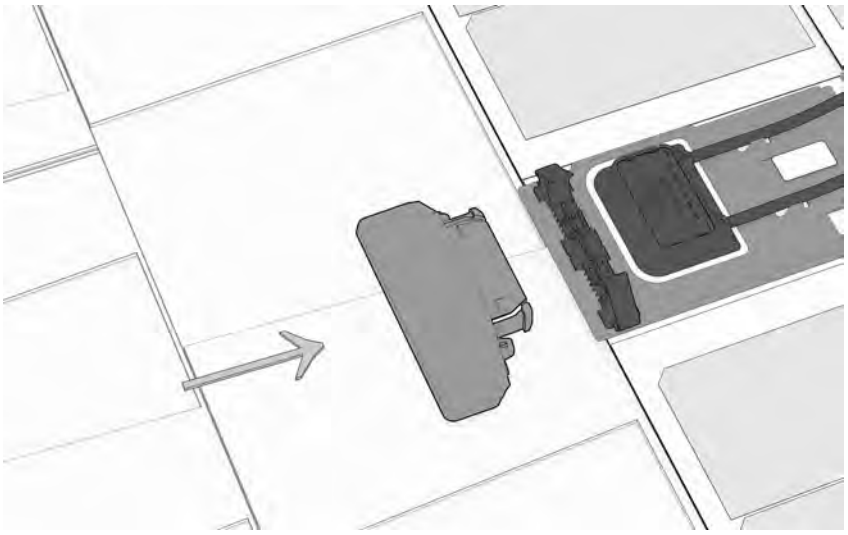


Figure 47. Slide the bottom cap into the hook

Step 11. Install the Wire Covers, continued

Step 11b. Install the first wire cover going up each wire channel.

- Snap the first wire cover onto the hooks below and slide it down to fully seat with the bottom cap.

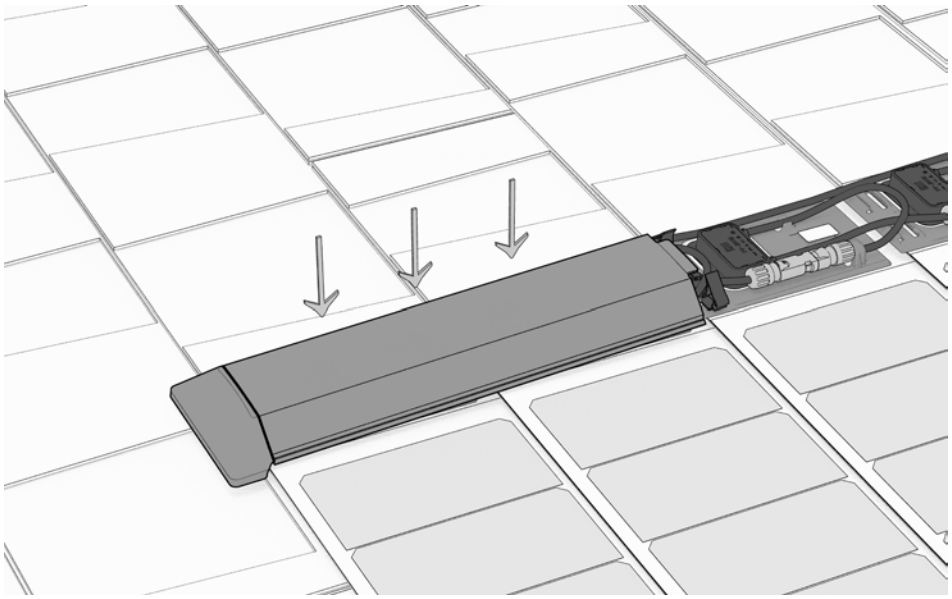


Figure 48. Snap the wire cover and seat it up against the bottom cap

Step 11. Install the Wire Covers, continued

Step 11c. Install the remaining wire covers going up each wire channel.

- Snap the remaining wire covers onto the hooks up the column and slide them down to seat with one another.

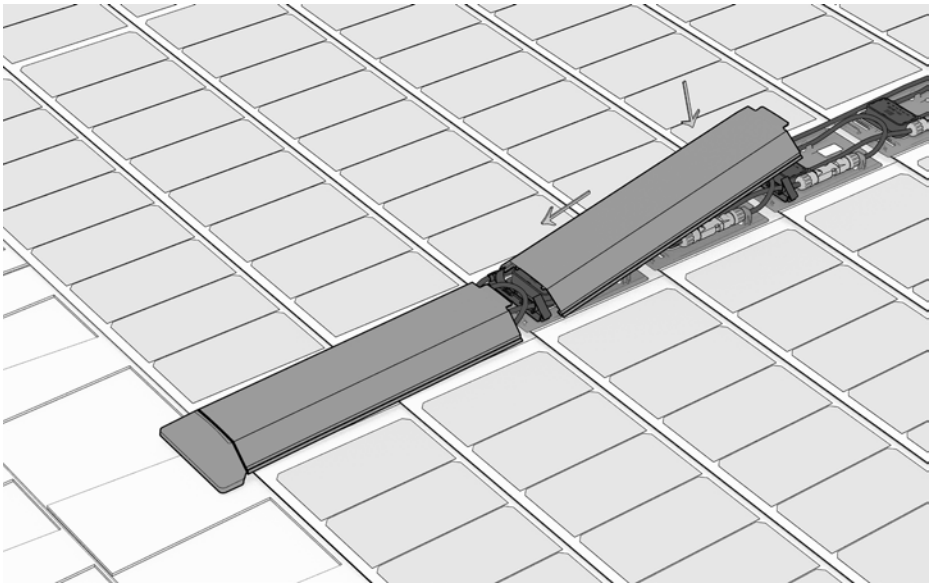


Figure 49. Couple the wire covers together

Step 11d. Attach the top flashing lids.

- Install the top flashing lid onto the top flashing base by hooking the lid to the base at the bottom.
- The top end of the top flashing lid has a snap feature that gets clipped onto the top end of the top flashing base.
- Secure the lid using the provided Phillips tip screw.
- When properly engaged and placed, verify that the lid is fully secured to the base by tugging slightly.

Step 11. Install the Wire Covers, continued

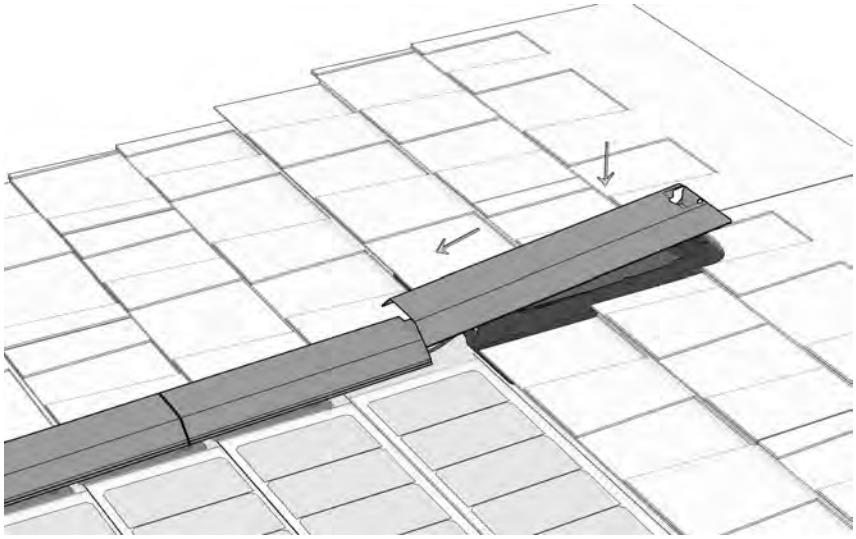


Figure 50. Attach top flashing lids

Step 11e. Straighten the wire covers.

- After installation, set the wire covers straight by pushing the wire covers and hooks in the desired direction.

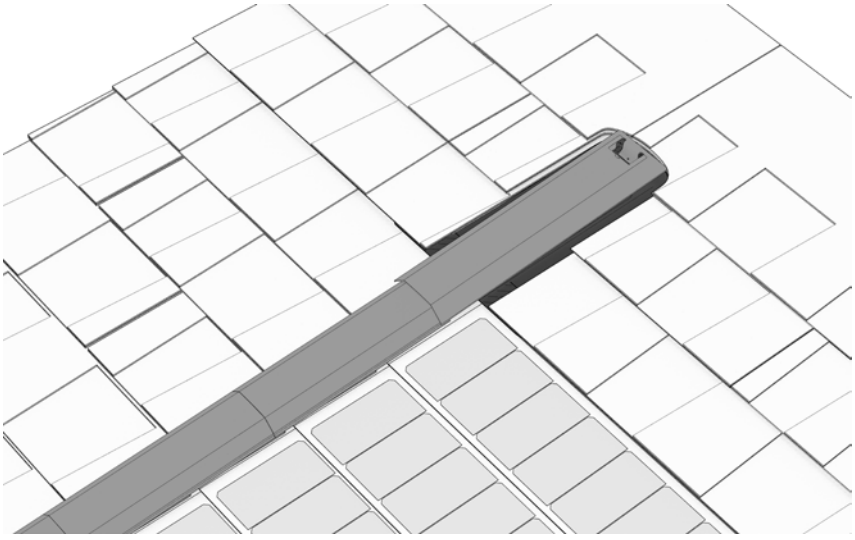


Figure 51. Complete wire cover installation

Step 12. Connect the Array Wiring

Summary:

a. Identify any columns where a transition box or pass-thru device is to be installed.

b. Remove the top flashing lid.

c. Connect the column return wires to the JMs and verify the full PV string voltage.

d. Install a pass-thru device or transition box, as required.

e. Connect the positive column return wire and the negative from the topmost ES or JM (or a similar combination) to the RSD or pass-thru device (if used).

f. Bond the rapid shutdown device (when required) with the equipment grounding conductor.

g. Install the transition lid box and/or top flashing lids.

NOTE: Either a pass-thru device or a transition box is used in this procedure, but not both. This selection is outlined in step 12a.

Step 12a. Identify any columns where a transition box or pass-thru device is to be installed.

- Typically, these are installed at the side of the array closest to the inverter location or other array. The plan set may have a recommended location.
- Install a pass-thru device for an attic conduit run; use a transition box for a rooftop conduit run.

Step 12b. Remove the top flashing lid.

- Every column has a top flashing. Remove the lid of the top flashing at the top of the column by disengaging the snap feature and sliding the lid up roof to disengage the hook.

Step 12c. Connect the column return wires to the JMs and verify the full PV string voltage.

- Use JMs to connect the columns together as required by the plans.
- Leave one male (positive) and one female (negative) connector disconnected in the final top flashing where the transition box or pass-thru device will be located.
- Measure column Voc using a DC voltmeter to confirm it matches expectations.
  - » Use this equation: String Voc = # of Energy Shingles in string x Energy Shingle Voc
  - » For example, consider an array with 48 Energy Shingles, and an Energy Shingle Voc of approximately 10 volts. This column would have an open circuit voltage of about 480 volts (48 Energy Shingles x 10 volts each).

Step 12. Connect the Array Wiring, continued

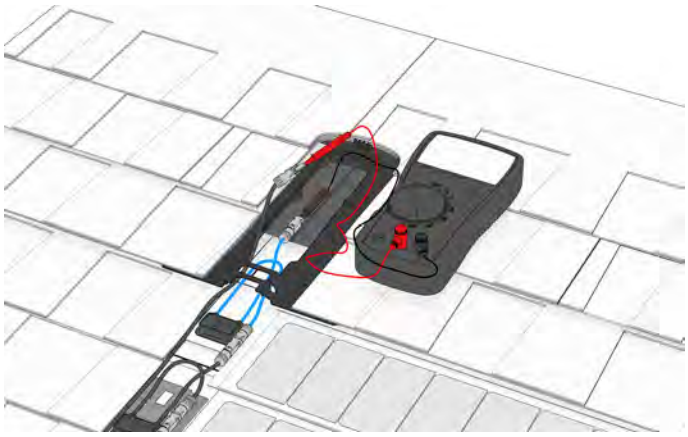


Figure 52. Verify Voc matches expected

Step 12d Install a transition box or pass-thru device, as required.

- Use either a transition box or a pass-thru device, but not both. Refer to the plan set.

If using a transition box:

- Mount the transition box onto the top flashing with its down roof end oriented down roof and secure with the provided screws. Torque the screws to 2.0 - 2.2 Nm. Refer to Figure 12 in Section 2 for transition box orientation.
- Drill one 1-1/8 inch (trade size 3/4 inch) hole on the side of the transition box where the rooftop conduit will enter using the indented guideline for hole saw placement.
- Install 3/4 inch (19 mm) (up to 1 inch (25.4 mm)) trade size UL 514B listed fittings/connectors and conduit to the transition box.
- Any metallic conduit used must be bonded and grounded according to the National Electrical Code.
- Pull the wires through the conduit from the inverter to the upper section of the transition box.
- The upper section of the transition box is Type 3R rated.

Step 12. Connect the Array Wiring, continued

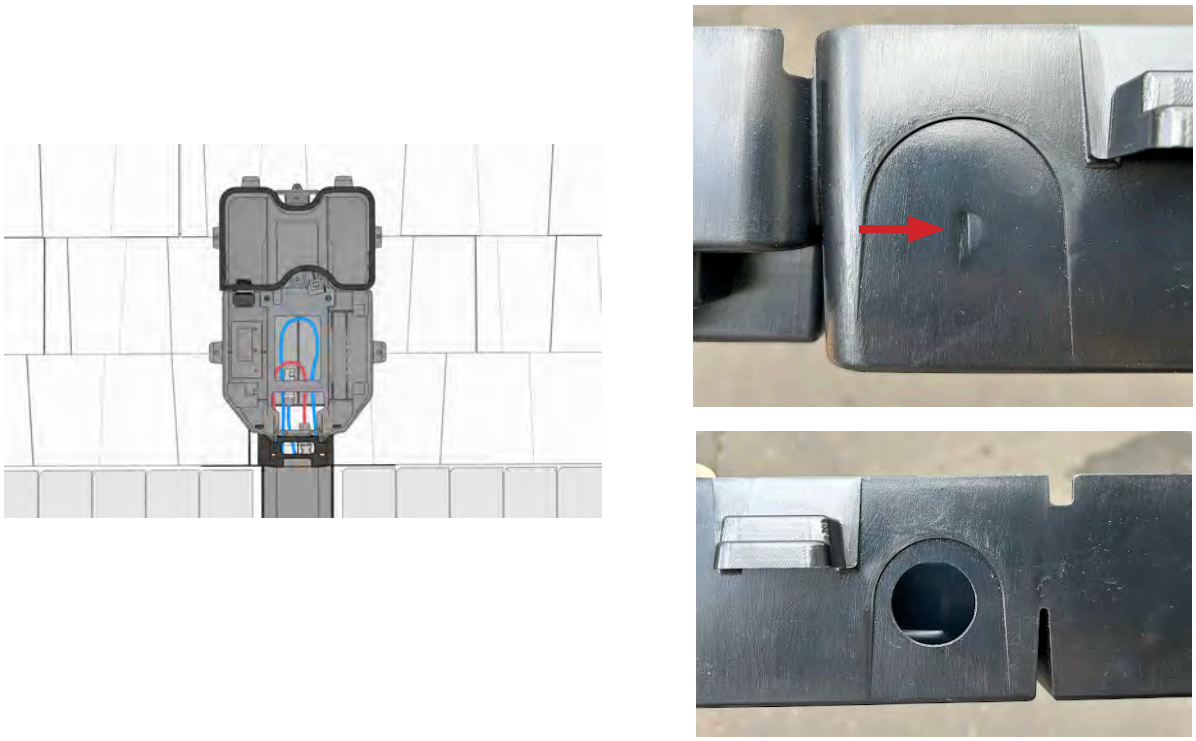


Figure 53. Mount the transition box and drill a hole for conduit

If using a pass-thru device:

- When routing the conduit through the attic, the pass-thru device is installed inside the top flashing. Wiring from the pass-thru device is then connected to an enclosure in the attic. The conduit routes the array wiring to the inverter from the attic enclosure.
- Drill a 1-3/8 inch (35 mm) hole through the decking inside the top flashing and a minimum 1/2 inch (13 mm) away from all interior walls of the top flashing.
- Do NOT drill through any structural members, such as rafters.
- Pass the conduit end of the pass-thru device into the attic.
- Fasten the pass-thru device to the roof deck, torquing the screws provided to 2.2-2.5 Nm.

Step 12. Connect the Array Wiring, continued

Figure 54. Install the pass-thru device

- Make the final wiring connections on the roof (after all other connections and wires have been terminated in the inverter).

Step 12e Connect the positive column return wire and the negative from the topmost ES or JM (or a similar combination) to the RSD or pass-thru device (if used)

If using a transition box:

- Mount the rapid shutdown device in the lower section of the transition box.
- Route the string home runs into the transition box, measure and confirm the expected Voc, then connect them to the input side of the RSD.
- Splice the RSD output conductors to the inverter wiring in the upper section of the transition box using Buchanan® copper crimp connectors and caps or an NEC-approved equivalent.

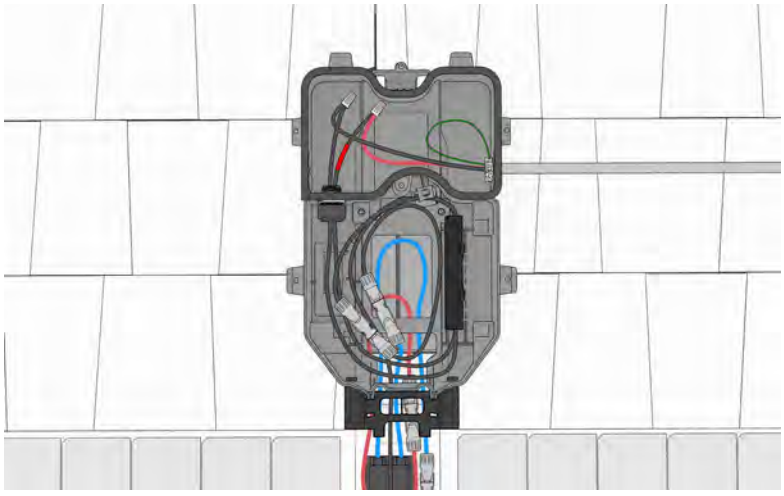


Figure 55. Wire the RSD inside of the transition box

Step 12. Connect the Array Wiring, continued

If using a pass-thru device:

- In the attic, mount the attic enclosure so that the pass-thru device's connector can terminate in it. The length of the PTD is 39.4 inches (1 m).
- Connect the PTD to the attic enclosure to transition from PV wire to indoor wiring.
- Route the conduit to the attic enclosure, pull the wires from the inverter and splice home runs using Buchanan® copper crimp connectors and caps or an NEC-approved equivalent.
- Bond the pass-thru device to the grounded metallic attic enclosure using the lockring on the interior end.
- Keep the top of the enclosure 1 inch (25 mm) below the roof deck to avoid nails.
- Ensure that the metallic attic enclosure is properly grounded and bonded by installing a lay-in ground lug inside the enclosure and landing an equipment grounding conductor on the lug.

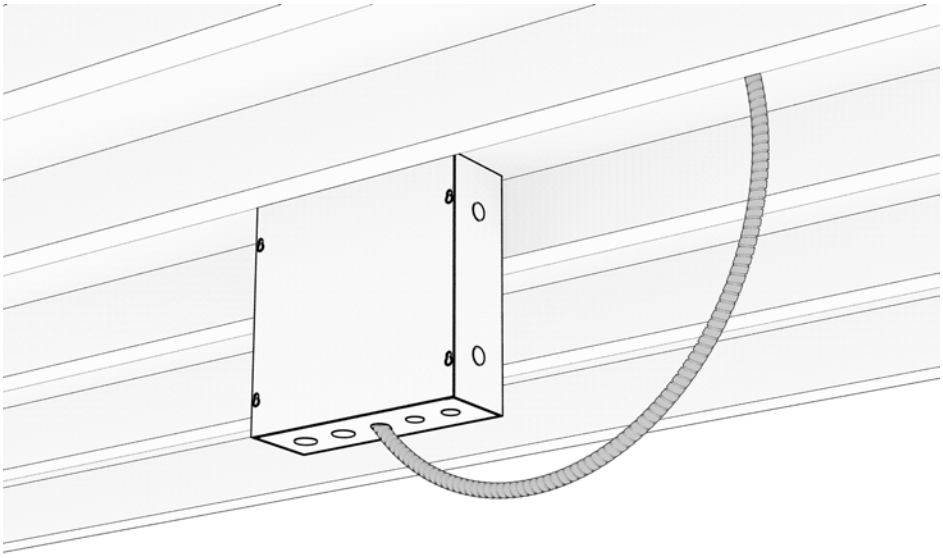


Figure 56. Conduit to attic enclosure

Step 12. Connect the Array Wiring, continued

Step 12f Bond the rapid shutdown device (when required) with the equipment grounding conductor.

- Fasten a lay-in ground lug on the rapid shutdown device grounding terminal where required (Delta RSS uses an M4 bolt).
- Land the equipment grounding conductor on the lay-in ground lug.

Figure 57. Smart RSS device showing M4 bolt

Step 12g Install the transition box lid and/or top flashing lids.

- Place the transition box lid on the transition box. Place the top flashing lids on top flashings.
- Secure the lids using the snap features.
  - » Use #8x3/4 inch (19 mm) type screws as another method to secure the lid. Torque the screws to 2.0-2.2 Nm.
  - » Do not use an impact driver or electric screwdriver when fastening the screws.

Step 13. Final Check

Roofing system - confirm all:

- Energy Shingles and JMs are installed as per plans and waterproofing of the roof system is correct per GAF Energy requirements.
- Asphalt shingles are installed properly and waterproofing of the roof system is correct per GAF requirements.
- Wire covers, transition boxes and lids, top flashings and lids, and pass-thru devices are secured and installed properly.
- Rooftop electrical connections, including column return wires, are made up properly and column DC voltage has been taken and matches expectations.
- Rooftop wiring is hidden from view and not touching the asphalt shingles
- All waste is removed from the roof/site.

Array wiring - confirm all:

- Conduit runs and fittings, wire terminations, and attic enclosures are secured and attached per National Electrical Code requirements.
- Electrical connections and splices are National Electrical Code compliant.
- Rapid shutdown devices are installed in the proper location as per plans.
- Column and PV string open circuit voltage measurements are as expected.
- All waste is removed from the roof/site.

Array Wiring

The wiring diagrams below provide guidance on connecting column return wires and JMs, through the transition box or pass-thru device.

- Wire management is vertical going up the array, across JMs, through the transition box or pass-thru device, and then off the roof.
- Array wiring connections are made "in series," with JMs between all columns except for the rightmost column. For the leftmost column, the positive and negative "home runs" terminate either inside the transition box at the RSD or at the pass-thru device.
- Wiring from the transition box or pass-thru device to the inverter is performed by a qualified person.
- Visually confirm all metallic components are grounded and bonded in accordance with the NEC.
  - » Where required, the RSS has a lay-in ground lug bonded to the EGC.
  - » Conduit end of pass-thru device is bonded to metallic attic enclosure with lockring.
  - » Metallic attic enclosure is bonded with lay-in ground lug or other NEC-approved method.
  - » All metallic conduit is bonded in accordance with NEC requirements.

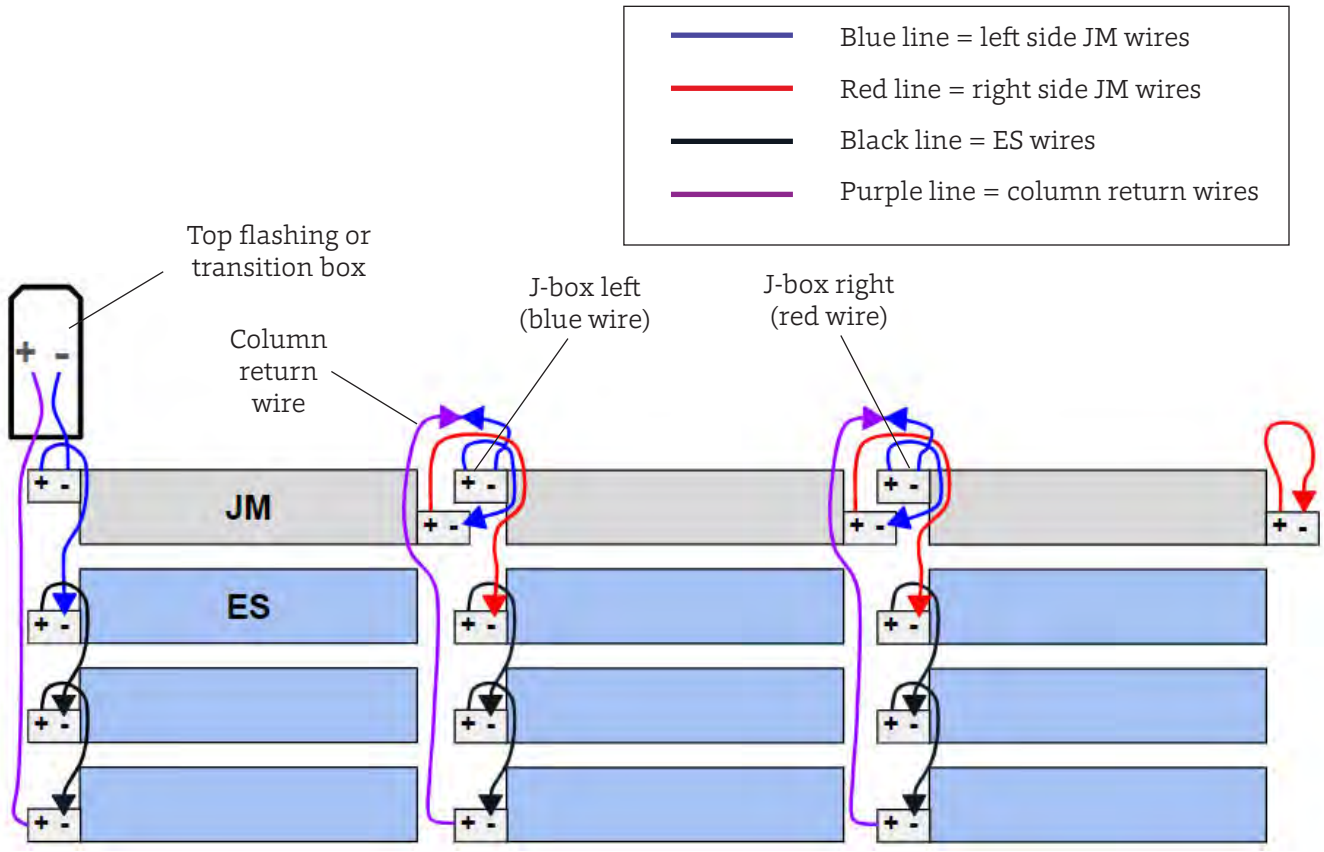


Figure 58. Array wiring

Array Wiring, continued

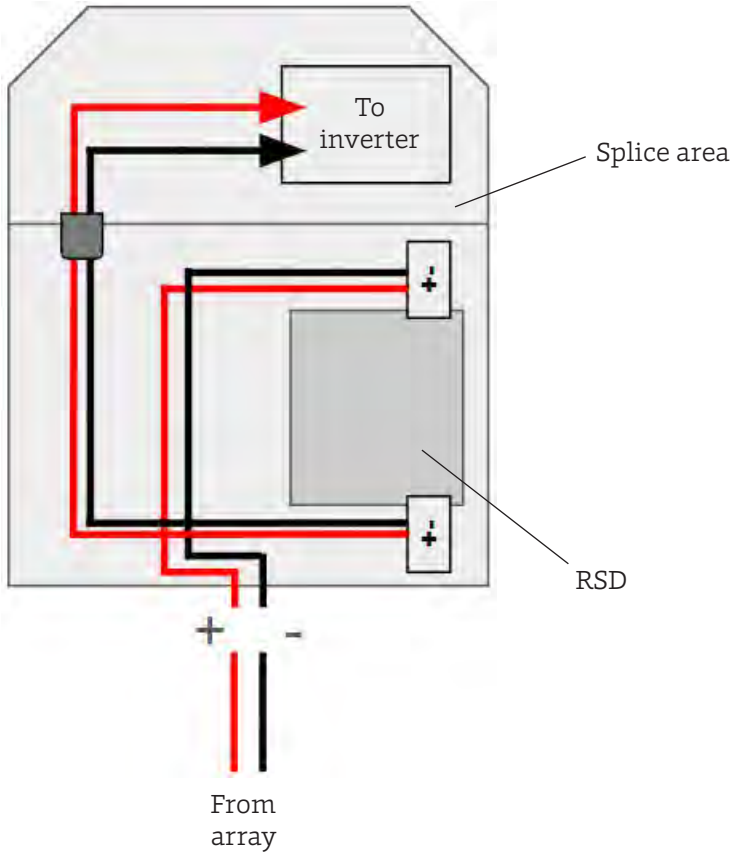


Figure 59. Array wiring inside the transition box

Array Wiring, continued

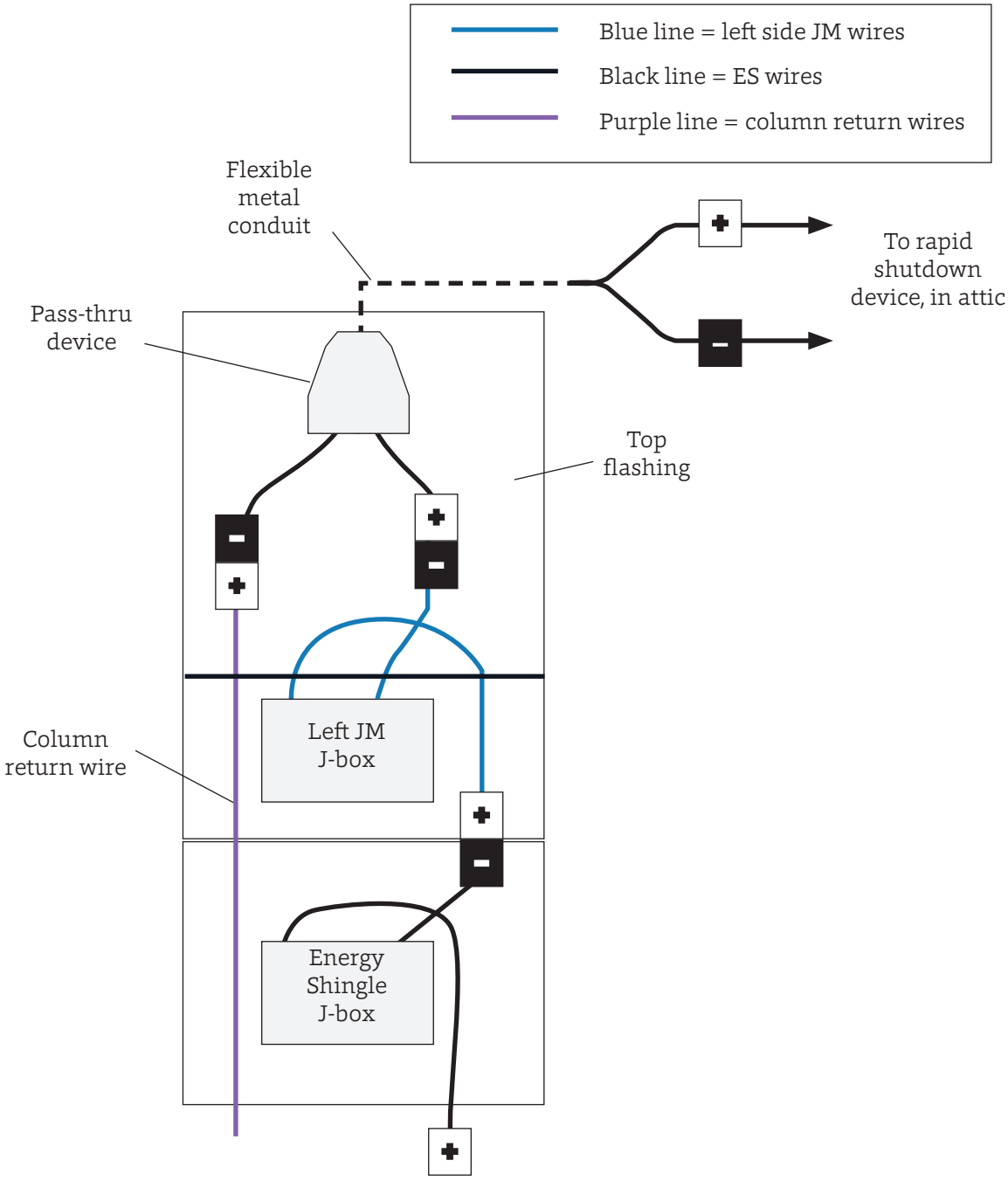


Figure 60. Array wiring for pass-thru device

NOTE: Initiation of the photovoltaic hazard control system (PVHCS) is triggered by any interruption of connection to the grid. Any method of disconnecting means allowed by the NEC may be used to initiate the shutdown, including but not limited to disconnects, breakers, OCPD, etc. The disconnecting means used to initiate the PVHCS shall be installed in an accessible location on the exterior of the building and shall be clearly marked in accordance with the NEC.

System Maintenance

- **WARNING:** The Timberline Solar 2 system has no user-serviceable parts and requires no routine maintenance. However, the system should be periodically re-inspected for any signs of damage. This is important especially after storms and in areas prone to hail and high winds. Any damaged parts should be replaced immediately with parts provided by GAF Energy, by qualified persons approved by GAF Energy.
- Do NOT attempt to dismantle the equipment or make any internal repairs. Any attempt to open the equipment could compromise the integrity of the system.
- Do not attempt to clean soiled Energy Shingles with a high-pressure washer, as this may damage the system. The Energy Shingle is naturally cleaned by seasonal rains. In the event that a more intensive cleaning is required, contact your installer for assistance.
- Direct all inquiries to GAF Energy Technical Support at 1-877-GAF-ROOF.
- For more information on GAF Energy solar products and services for solar applications, visit **www.gaf.energy**.

Document Version Control

Document Revision Number	Date	Notes
A0.1	January 2023	First manual version, based on previous Timberline Solar manual
A0.2	March 2023	Updated name to Timberline Solar 2
1.0	June 2023	Set up for deliverable.
1.1	September 2023	Replaced some images, added minor updates
1.2	March 2024	Minor updates throughout
1.3	March 2024	Updates to content and images throughout
1.4	June 2024	Minor updates to part numbers
1.5	August 2024	Minor updates
1.6	August 2024	Replaced several images, text updates, reorganized
2.0	October 2024	Updated text and images for shingle agnostic design updates
2.1	November 2024	Updated text and images
2.2	December 2024	Minor text updates

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