UniRac® THE STANDARD IN PV MOUNTING STRUCTURES™

SunFrame®

Planning and Assembly

for Threaded Slot Rail

Installation Manual 808.1

Contents

UniRac welcomes input concerning the accuracy and user-friendliness of this publication. Please write to **publications@unirac.com.**

June 2006

Scope and installer responsibility

Please review this manual thoroughly before installing SunFrame Systems using threaded slot rails.

The installer is solely responsible for

- Complying with all applicable local or national building codes, including any that may supercede this manual;
- Ensuring that UniRac and other products are appropriate for the particular installations and are designed for the installation environment;
- Ensuring that the roof, its rafters, connections, and other structural support members can support the array under live load conditions;
- Ensuring that lag screws have adequate pullout strength and shear capacities;
- Maintaining the waterproof integrity of the roof, including selection of appropriate flashing; and
- Ensuring safe installation of all electrical aspects of the PV array.

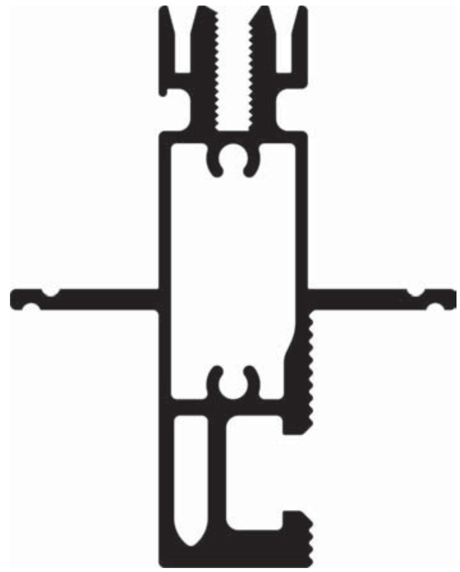

Figure 1.SunFrame threaded slot rail, cross section, actual size.

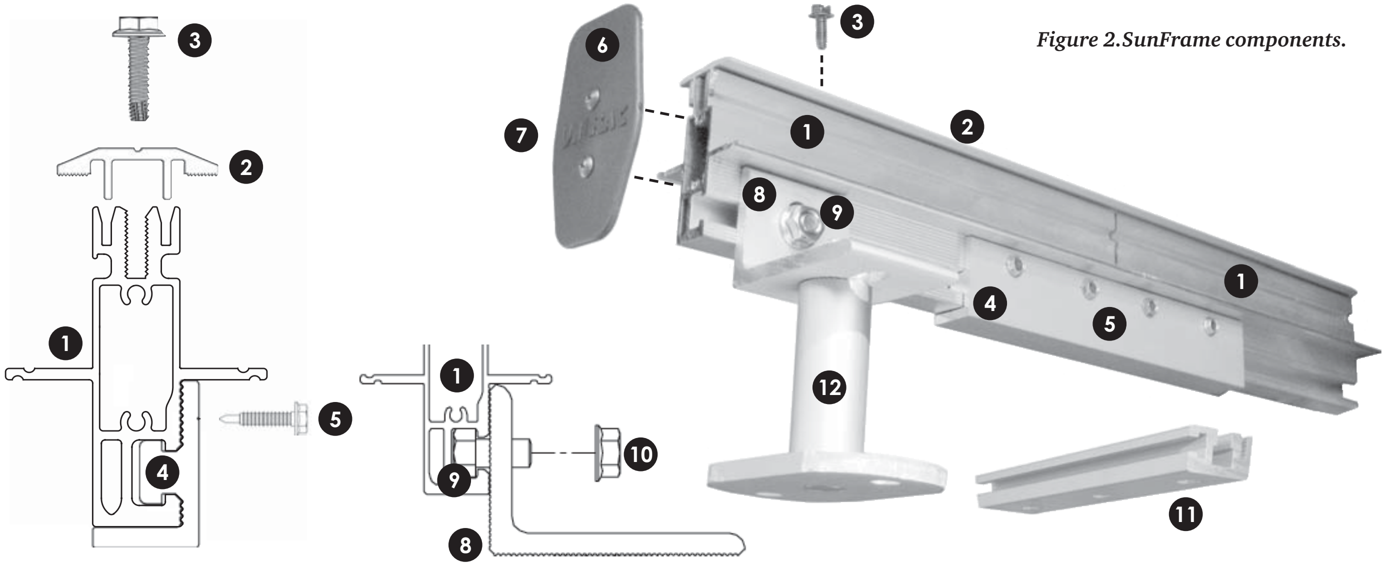

Figure 2.SunFrame components.

SunFrame® components

1. **Rail**—Supports PV modules. Use one per row of modules plus one. Shipped in 8- or 16-foot lengths. 6105-T5 aluminum extrusion, anodized (clear or dark bronze) to match PV module frame.
2. **Cap strip**—Secures PV modules to rails and neatly frames top of array. Lengths equals rail lengths. Cap strips are sized for specific PV modules. Shipped in 8- or 16-foot lenghs. Predrilled every 8 inches. 6105-T5 aluminum extrusion, anodized (clear or dark bronze) to match PV module frame.
3. **Cap strip screw** (¼-20, Type F thread cutting)—Use to secure each cap strip (and PV modules) to rail, one per predrilled hole. Use an additional end screw wherever a predrilled hole does not fall within 4 inches of the end of any cap strip segment. 18-8 stainless steel, clear or dark to match cap strip.
4. **Rail splice**—Joins rail sections into single length of rail. It can form either a rigid or thermal expansion joint. 8 inches long, predrilled. 6105-T5 aluminum extrusion, anodized (clear or dark bronze) to match PV module frame.
5. **Self-drilling screw** (No. 10 x 3/4")—Use 4 per rigid splice or 2 per expansion joint. Galvanized steel.
6. **End caps**—Use one to neatly close each rail end. UV resistant black plastic.
7. **Truss-head sheet metal screw** (No. 8 x 5/8")—Use 2 per end cap to secure end cap to rail. 18-8 stainless steel; with black oxide coating to match end caps.
8. **L-foot**—Use to secure rails either through roofing material to rafters, to L-foot adjusting sliders, or to standoffs. Use no less than one L-foot per 4 feet of rail. 6105-T5 aluminum extrusion, anodized (clear or dark bronze) to match PV module frame.
9. **L-foot bolt** (3/8" x 1 1/4")—Use one per L-foot to secure rail to L-foot. 304 stainless steel.
10. **Flange nut** (3/8")—Use one per L-foot bolt. 304 stainless steel. Required torque: 30 to 35 foot-pounds.
11. **L-foot adjusting slider** (optional)—Use one beneath each L-foot or aluminum two-piece standoff, except in lowest row. 6105-T5 aluminum extrusion. Sliders allow easier alignment of rails and better snugging of PV modules between rails. Includes 3/8" x 1 1/4" bolt with flange nut for attaching L-foot or standoff shaft, and two 5/16" x 2 1/2" lag bolts with flat washers for securing sliders to rafters.
12. **Flattop standoff** (optional)—Use if L-foot cannot be secured directly to rafter (with tile or shake roofs, for example). Sized to minimize roof to rail spacing. Use one per L-foot. **Two-piece** (pictured): 6105-T5 aluminum extrusion. Includes 3/8" x 3/4" bolt with lock washer for attaching L-foot, and two 5/16" x 3 1/2" lag bolts. **One-piece**: Service Condition 4 (very severe) zinc-plated welded steel. Includes 3/8" x 1 1/4" bolt with lock washer for attaching L-foot. **Flashings:** Use one per standoff. UniRac offers appropriate flashings for both standoff types.

Stainless steel hardware can seize up, a process called galling. To significantly reduce its likelihood, (1) apply lubricant to bolts, preferably an anti-seize lubricant, available at auto parts stores, (2) shade hardware prior to installation, and (3) avoid spinning on nuts at high speed. See Installation Supplement 910, Galling and Its Prevention, at www.unirac.com.

Installer supplied materials

Lag screw for L-foot—Attaches L-foot or standoff to rafter. Determine length and diameter based on pull-out values in Table 3 (page 8). If lag screw head is exposed to elements, use stainless steel. Under flashings, zinc plated hardware is adequate. *Note: Lag screws are provided with L-foot adjusting sliders and standoffs.*

Waterproof roofing sealant—Use a sealant appropriate to your roofing material.

Clamps for standing seam metal roof—See "Frequently Asked Questions . . ." (p. 16).

Planning your SunFrame® installations

When installing SunFrame threaded rail installations, note the following:

- This bulletin addresses only wind loads. Wind generally produces the maximum load factor affecting an installation. However, verify that other local conditions, such as snow loads and earthquake effects, do not exceed the wind loads. If any loading type does exceed wind loads, give precedence to that factor and consult a local professional engineer or your local building authority.
- The roof on which the SunFrame will be installed must be capable of withstanding the design dead load and design live load per footing, listed in Table 2 on pages 7–8.

1. Determine basic wind speed at your installation site.

For the United States, The Uniform Building Code (1997) supplies wind speeds in its chart, "Minimum Basic Wind Speeds in Miles per Hour," reproduced on page 5 on this manual. The International Building Code (2003) includes a similar chart, also reproduced on page 5.

If you need clarifications or further assistance or if your installation is outside the United States, consult a local professional engineer or your local building authority.

2. Determine exposure category of your installation site.

The Uniform Building Code* defines wind exposure categories as follows:

EXPOSURE B has terrain with buildings, forests or surface irregularities, covering at least 20 percent of the ground level area extending 1 mile (1.61 km) or more from the site.

EXPOSURE C has terrain that is flat and generally open extending ½ mile (0.81 km) or more from the site in any quadrant.

EXPOSURE D represents the most severe exposure in areas with basic wind speeds of 80 miles per hour (mph) (129 km/h) or greater and has terrain that is flat and unobstructed facing large bodies of water over 1 mile (1.61 km) in width relative to any quadrant of the building site. Exposure D extends inland from the shoreline ¼ mile (0.40 km) or 10 times the building height, whichever is greater.

The *International Building Code†* defines wind exposure categories as follows:

EXPOSURE B. Urban and suburban areas, wooded areas or other terrain with numerous closely spaced obstructions having the size of single-family dwellings or larger. Exposure B shall be assumed unless the site meets the definition of another type of exposure.

EXPOSURE C. Open terrain with scattered obstructions, including surface undulations or other irregularities, having heights generally less than 30 feet (9144 mm) extending more than 1,500 feet (457.2 m) from the building site in any quadrant. This exposure shall also apply to any building located within Exposure B–type terrain where the building is directly adjacent to open areas of Exposure C–type terrain in any quadrant for a distance of more than 600 feet (182.9 m). This category includes flat open country, grasslands and shorelines in hurricane-prone regions.

EXPOSURE D. Flat, unobstructed areas exposed to wind flowing over open water (excluding shorelines in hurricane-prone regions) for a distance of at least 1 mile (1.61 km). Shoreline in Exposure D include inland waterways, the Great Lakes and costal areas of California, Oregon, Washington and Alaska. This exposure shall apply only to those buildings and other structures exposed to the wind coming from over the water. Exposure D extends inland from the shoreline a distance of 1,500 feet (460 m) or 10 times the height of the building or structure, whichever is greater.

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* *Uniform Building Code 1997, Vol. 2, Structural Engineering Design Provisions, chap. 16, div. III, Wind Design, p. 7. The 2001 California Building Code uses the same definitions.*

† *International Building Code 2003, chap. 16, "Structural Design," p. 290.*

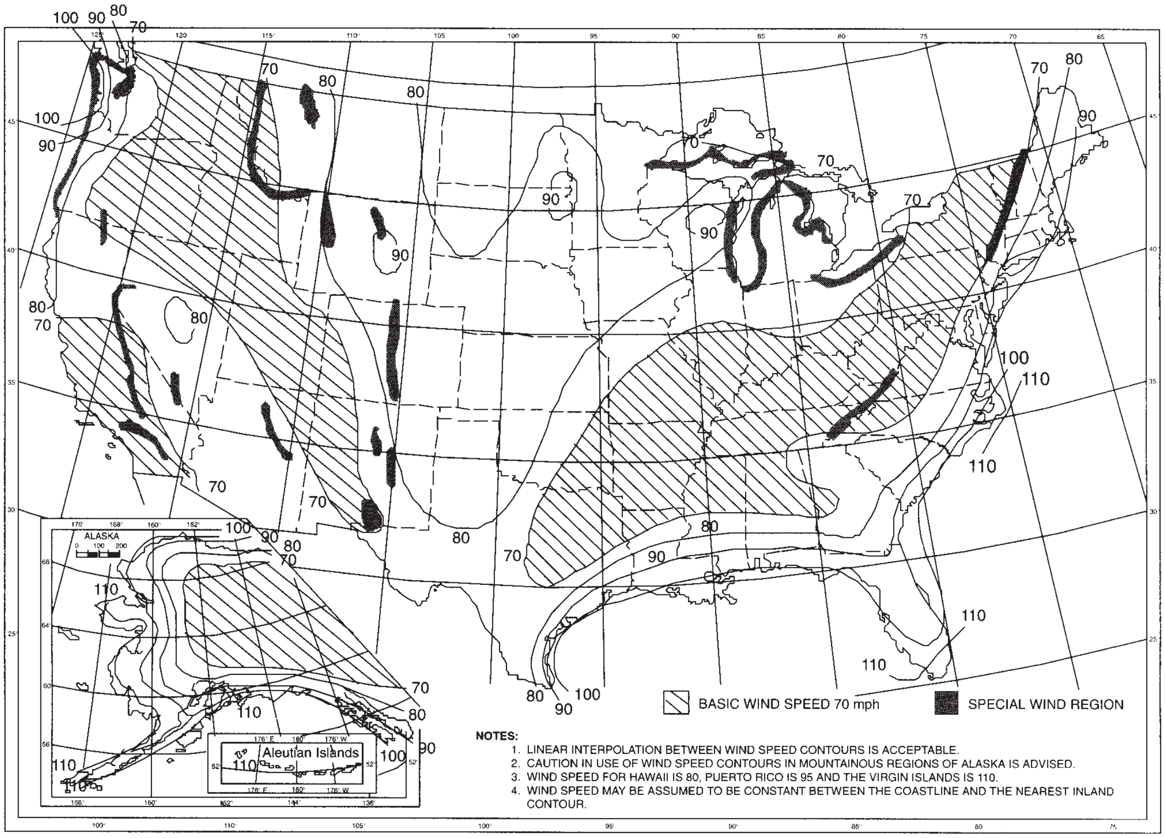


Figure 3. Minimum Basic Wind Speeds. Reproduced from Uniform Building Code 1997, Vol. 2, Structural Engineering Design Provisions, chap. 16, Div. III, Wind Design, Fig. 16.1, "Minimum Basic Wind Speeds in Miles per Hour," p. 36. The 2001 California Building code refers to the same map.

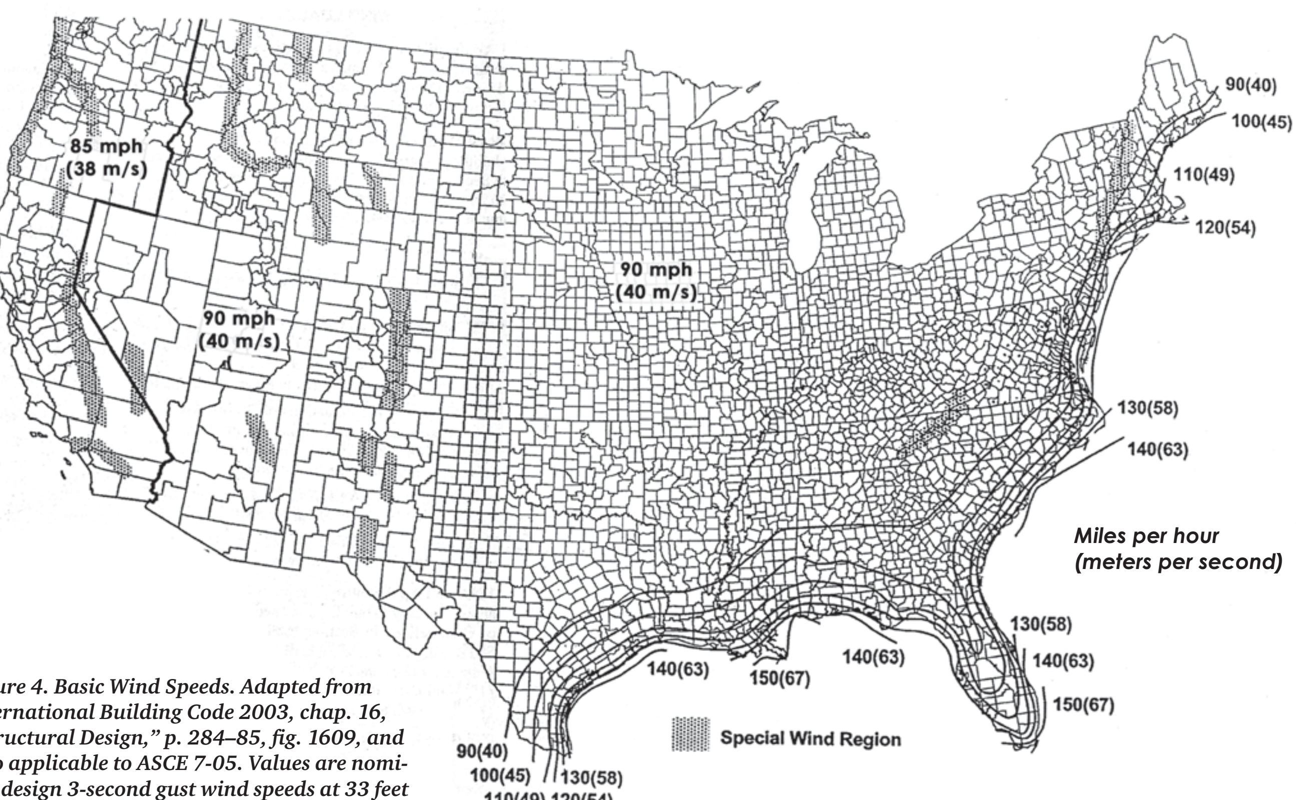


Figure 4. Basic Wind Speeds. Adapted from International Building Code 2003, chap. 16, "Structural Design," p. 284–85, fig. 1609, and also applicable to ASCE 7-05. Values are nominal design 3-second gust wind speeds at 33 feet above ground for Exposure Category C.

3. Determine the design wind pressure required for your installation.

Design wind pressure is the amount of wind pressure that a structure is designed to withstand, expressed here in pounds per square foot (psf). To determine the design wind pressure required for your installation, apply the following factors using Table 1:

- your basic wind speed (determined in step 1),
- your exposure category (determined in step 2), and
- the height of your roof above the ground.

If your values fall outside the range of the table, or if your design wind pressure exceeds 50 psf, consult UniRac, a professional engineer, or your local building authority.

Module manufacturers provide wind pressure rating for their modules. Confirm that they meet or exceed the wind speed rating for your installation. If in doubt, contact the module manufacturer.

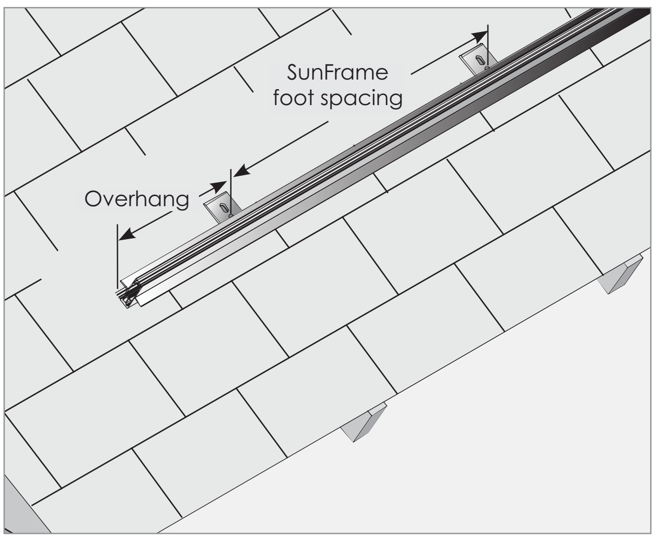


Figure 5. Foot spacing and overhang defined.

Table 1. Design wind pressure (psf) by wind speed and exposure category

	Basic wind speed (mph)						
	70	*80*	*90*	*100*	*110*	*120*	*130*
Category B							
15' roof height	10	13	17	21	25	30	35
20' roof height	11	14	18	22	27	32	38
25' roof height	12	15	19	24	29	35	41
30' roof height	12	16	21	25	31	36	43
Category C							
15' roof height	17	23	29	35	43	51	60
20' roof height	19	24	31	38	46	54	64
25' roof height	19	25	32	40	48	57	67
30' roof height	20	26	33	41	50	59	69
Category D							
15' roof height	23	30	38	46	56	67	78
20' roof height	24	31	39	48	58	70	82
25' roof height	25	32	41	50	60	72	84
30' roof height	25	33	42	51	62	74	87

*Source: These design wind pressure (P) values are based on the formula P = Ce * Cq * qs * Iw (UBC 1997, Vol. 2, Structural Engineering Design Provisions, Chapter 16, Div. III, Wind Design, p. 7). Assumptions: Iw = 1 and Cq = 1.3.*

4. Determine minimum design dead and live loads for standard rafter spacing.

Footing spacing refers to the space between L-feet (or standoffs, if used) along the same SunFrame rail (Fig. 5). Footing spacing may not exceed 48 inches. For the rafter spacing at your installation, consult Table 2 to determine your minimum design live loads and design dead loads per footing. Locate the manufacturer and model of the PV module that you plan to install and the rafter spacing at your installation site.

Read or interpolate live loads for the design wind pressure you determined in Step 3. For assistance on this point, consult a local professional engineer.

Verify that roof framing members have adequate capacity to support these design loads. If they do not, try a closer footing spacing. If the result is still not acceptable, relocate the array to a stronger area of the roof or strengthen the inadequate framing elements.

5. Verify acceptable rail end overhang.

Rail overhang (Fig. 5) must not exceed 50 percent of footing spacing. For example, if footing spacing is 48 inches, the rail overhang cannot be more than 24 inches. In this case, two footings can support a rail as long as 96 inches (48 inches between the footings and 24 inches of overhang at each end).

Table 2. SunFrame Loads (pounds per footing) at Standard Rafter Spacings

Your design point loads (capacity per footing) must be at or above the loads listed here. The installer is solely responsible for verifying that the roof can withstand these design point loads. For specifications based on design wind pressure values greater than 50 pounds per square foot, contact UniRac. In general, the minimum design live load equals the footing spacing (in feet) times the rail spacing (in feet) times the design wind presure from Table 1.

	Minimum design dead load	*Minimum design live load as a function of design wind pressure*			
		20 psf	*30 psf*	*40 psf*	*50 psf*
BP Solar BP3125					
Rafter/footing spacing: 24″	29	276	375	474	573
32″	39	392	524	656	788
48″	59	661	NA	NA	NA
BP Solar BP3150, -3160; -4175; BPSX160, -170					
Rafter/footing spacing: 24″	31	289	394	498	603
32″	41	410	549	689	NA
48″	61	687	NA	NA	NA
Evergreen EC102, EC110, EC115					
Rafter/footing spacing: 24″	30	288	392	496	600
32″	41	408	546	685	NA
48″	61	684	NA	NA	NA
GE Energy GEPV100M, -110M					
Rafter/footing spacing: 24″	30	272	369	466	563
32″	40	387	516	645	774
48″	59	653	NA	NA	NA
GE Energy GEPV173M					
Rafter/footing spacing: 24″	30	272	369	466	563
32″	40	387	516	645	775
48″	60	653	NA	NA	NA
Isofoton I-100					
Rafter/footing spacing: 24″	30	250	336	422	508
32″	40	357	472	586	701
48″	60	608	780	NA	NA
Isofoton I-150S					
Rafter/footing spacing: 24″	30	250	336	422	508
32″	40	357	472	586	701
48″	60	608	780	NA	NA
Kyocera KC130GT					
Rafter/footing spacing: 24″	31	266	360	453	547
32″	41	379	504	629	753
48″	62	641	NA	NA	NA
Kyocera KC170GT					
Rafter/footing spacing: 24″	28	245	330	415	499
32″	38	351	464	577	690
48″	56	599	768	NA	NA
Kyocera KC200GT					
Rafter/footing spacing: 24″	31	266	360	453	547
32″	41	379	504	628	753
48″	62	641	NA	NA	NA
Mitsubishi MF110EC3, MF120EC3					
Rafter/footing spacing: 24″	30	265	359	452	546
32″	40	378	502	627	752
48″	60	639	NA	NA	NA
Mitsubishi MF125A2LF, MF130EA2LF					
Rafter/footing spacing: 24″	28	239	321	403	484
32″	37	343	452	561	670
48″	55	586	750	NA	NA
Mitsubishi MF160B3, -165B3, -170EB3					
Rafter/footing spacing: 24″	31	288	391	495	599
32″	42	408	546	684	NA
48″	63	684	NA	NA	NA
Photowatt PW1650					
Rafter/footing spacing: 24″	29	239	320	401	482
32″	39	343	451	559	667
48″	58	586	749	NA	NA
Sanyo HIP-180BA3, -185BA3, -190BA3, -196BA3, -200BA3					
Rafter/footing spacing: 24″	27	248	335	421	508
32″	36	355	470	586	701
48″	55	605	778	NA	NA
Schott Solar ASE285, ASE300, ASE315					
Rafter/footing spacing: 24″	58	356	480	604	728
32″	77	499	664	NA	NA
48″	NOT APPLICABLE				
Sharp ND-072ERU/LU (72W nonrectagular end module), and ND-N2ECU (142W)					
Rafter/footing spacing: 24″	24	224	300	377	453
32″	32	322	424	526	628
48″	47	556	709	NA	NA
Sharp ND-L3EJEA (123W), ND-L5E1U (125W)					
Rafter/footing spacing: 24″	34	279	378	476	575
32″	45	397	528	659	790
48″	68	667	NA	NA	NA
Sharp ND-162U1, ND-167U3A					
Rafter/footing spacing: 24″	29	250	336	423	509
32″	38	357	472	588	703
48″	57	608	781	NA	NA
Sharp NE-170U1					
Rafter/footing spacing: 24″	33	289	392	495	599
32″	44	409	547	685	NA
48″	66	686	NA	NA	NA
Sharp ND-200U1, ND-208U1					
Rafter/footing spacing: 24″	33	298	406	513	621
32″	45	421	565	709	NA
48″	67	704	NA	NA	NA
Shell 165P, -PC, 175P, -PC					
Rafter/footing spacing: 24″	35	297	404	510	617
32″	47	420	562	704	NA
48″	70	703	NA	NA	NA

Continued on page 8

NA = not applicable. Never allow total load (live load plus dead load) to exceed 800 pounds per footing.

Table 2 (continued from p. 7). SunFrame Loads (pounds per footing) at Standard Rafter Spacings

Your design point loads (capacity per footing) must be at or above the loads listed here. The installer is solely responsible for verifying that the roof can withstand these design point loads. For specifications based on design wind pressure values greater than 50 pounds per square foot, contact UniRac. In general, the minimum design live load equals the footing spacing (in feet) times the rail spacing (in feet) times the design wind presure from Table 1.

	Minimum design dead load	*Minimum design live load as a function of design wind pressure*			
		20 psf	*30 psf*	*40 psf*	*50 psf*
SunPower SPR200, SPR210					
Rafter/footing spacing: 24″	32	286	388	490	593
32″	43	405	542	678	NA
48″	64	680	NA	NA	NA
SunWize SW115, SW120					
Rafter/footing spacing: 24″	30	269	363	458	553
32″	40	382	509	635	762
48″	61	646	NA	NA	NA
SunWize SW155L, SW165L					
Rafter/footing spacing: 24″	30	301	412	523	634
32″	40	425	573	721	NA
48″	60	710	NA	NA	NA
UniSolar ES62T					
Rafter/footing spacing: 24″	15	228	310	393	475
32″	20	328	438	548	658
48″	30	564	729	NA	NA
UniSolar US64					
Rafter/footing spacing: 24″	23	250	340	429	519
32″	30	358	477	597	716
48″	45	609	788	NA	NA
Yingli YL80, YL85					
Rafter/footing spacing: 24″	26	227	304	381	458
32″	35	327	430	532	635
48″	52	563	717	NA	NA

NA = not applicable. Never allow total load (live load plus dead load) to exceed 800 pounds per footing.

6. Ensure that live loads do not exceed pull-out limits.

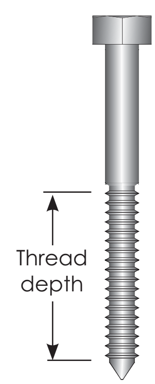
Based on the characteristics of your roof truss lumber and the lag screws, consult Table 3 to determine the lag pull-out value per 1-inch thread depth. Compare that value to the minimum design live load per footing determined in step 4. Based on these values, determine the length of the lag-screw thread depth you require to resist the design live load. The lag pull-out value per footing must be greater than the footing design live load.

If your SunFrame rails require splices, see also "Footing and splicing requirements" (p. 11), before beginning your installation.

If your SunFrame requires standoffs, always use at least two lag screws to secure each standoff to the structural member. Bolt the L-foot to the standoff through the slot nearest the bend in the L-foot.

Table 3. Lag screw design pull-out values (pounds per embedded 1" thread depth) in typical roof truss lumber

	Specific gravity	*Lag screw* 5/16"	*Lag screw* 3/8"
Douglas Fir—Larch	0.50	266	304
Douglas Fir—South	0.46	235	269
Engelmann Spruce, Lodgepole Pine (MSR 1650 f & higher)	0.46	235	269
Hem—Fir	0.43	212	243
Hem—Fir (North)	0.46	235	269
Southern Pine	0.55	307	352
Spruce, Pine, Fir	0.42	205	235
Spruce, Pine, Fir (E of 2 million psi and higher grades of MSR and MEL)	0.50	266	304



Sources: Uniform Building Code 1997, American Wood Council.

Notes: (1) Thread must be embedded in a rafter or other structural roof member. (2) Pull-out values incorporate a 1.6 safety factor recommended by the American Wood Council. (3) See Uniform Building Code for required edge distances.

Installing the array

Safe, efficient SunFrame installation involves three principal tasks:

A. Laying out the installation area and planning for material conservation.

B. Installing footings and rails, beginning with the *lowest* row and moving up the roof.

C. Placing modules and cap strips, beginning with the *highest* row and moving down the roof.

The following illustrated steps describe the procedure in detail. Before beginning, please note these important considerations.

Footings must be lagged into structural members. Never attach them to the decking alone, which leaves both the array and roof susceptible to severe damage.

For array widths or lengths greater than 32 feet, contact UniRac concerning thermal expansion issues.

Sample layout, illustrated in Figure 4

Assumptions: 12 modules (60″ x 36″), arranged in 3 rows of 4 modules

Array width = 144″ (36″ module width x 4 modules per row)

Array length = 180″ (60″ module length x 3 rows)
+ 3″ (1½″ end rail width x 2 rails)
+ 1½″ (¾″ between-module rail width x 2 rails)
= 184½″

1. Laying out the installation area

Always install SunFrame rails perpendicular to rafters. (These instructions assume typical rafters that run from the gutter to the peak of the roof. If this is not the case, contact UniRac.) Rails are typically mounted horizontally (parallel to the lower edge of the roof), and *must* be mounted within 10 degrees of horizontal.

Leave adequate room to move safely around the array during installation. During module installation, you will need to slide one module in each row about a foot beyond the end of the rails on one side. Using the number of rows and the number of modules per row in your installation, determine the size of your array area following Figure 6.

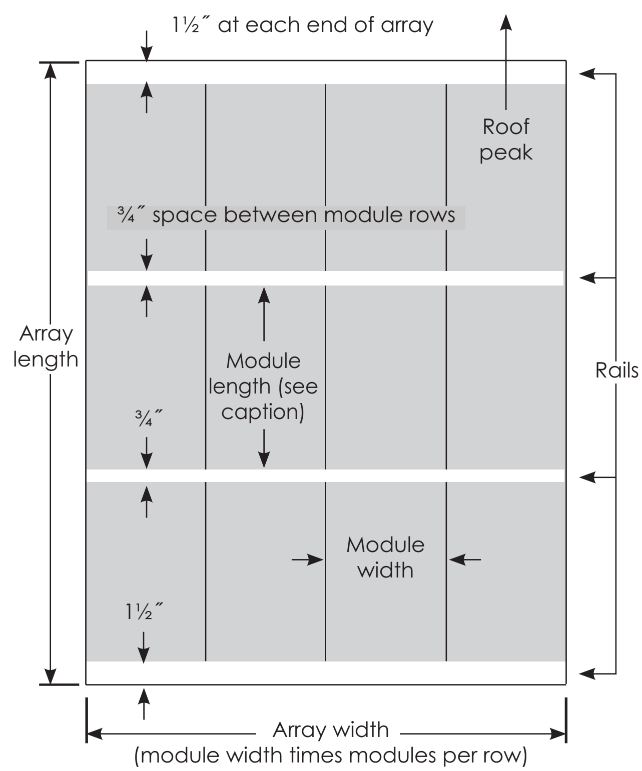


Figure 6. Installation area layout. Note: Module length is not necessarily measured from the edges of the frame. Some frames have lips. Others are assembled with pan-head screws. All such features must be included in module length.

2. Installing the lowest row of L-feet and rail

In the lowest row, it is not necessary to use L-foot adjusting sliders, even if you plan to use them in subsequent rows. Install L-feet directly onto low profile roofing material such as asphalt shingles or sheet metal. (For high profile roofs, such as tile or shake, use optional standoffs with flashing to raise L-feet. L-feet must be flush with or above the highest point of the roof surface.)

L-feet can be placed with the double-slotted side against the roof surface (as in Fig. 7) or with the single-slotted side against the roof (which increases air circulation beneath modules). Module-to-roof dimensions are listed on page 15 for both arrangements.

If you are using L-foot adjusting sliders, you must use the short side of the the L-foot against the roof in the first row. See Figure 9 below.

If you are using both L-foot adjusting sliders and standoffs, see the upper box on page 11.

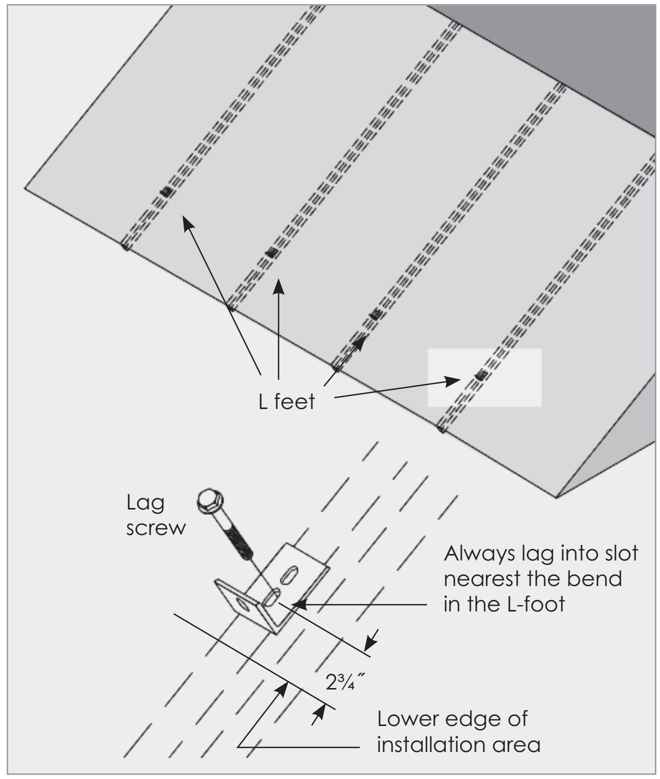


Figure 7. Placement of first L-foot row.

Install the first row of L-feet at the lower edge of the installation area (Fig. 8). Ensure feet are aligned by using a chalk line. (A SunFrame rail can also be used as a straight edge.) Position the L-feet with respect to the lower edge of the roof as illustrated in Figures 7 and 8.

Drill a pilot hole through roof into the center of rafter at each L-foot lag screw hole location. Apply weatherproof sealant into the hole and onto shafts of the lag screws. Seal the underside of the L-feet with a suitable weatherproof sealant.

Fasten the L-feet to the roof with the lag screws. ***If the double slotted sides of the L-feet are against the roof, lag through the slot nearest the bend in the L-foot (Figs. 7 and 8).***

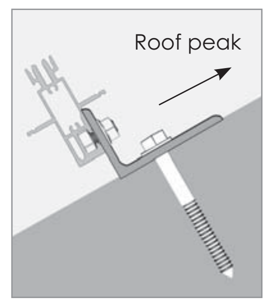


Figure 8. L-Foot orientation.

Cut the rails to your array width, being sure to keep rail slots free of roofing grit or other debris. If your installation requires splices, assemble them prior to attaching L-feet (see "Footing and splicing requirements," p. 11, and "Material planning for rails and cap strips," p. 13). Slide the 3/8-inch mounting bolts into the footing slots. *If more than one splice is used on a rail, slide L-foot bolt(s) into the footing slot(s) of the interior rail segment(s) before splicing.*

Loosely attach the rails to the L-feet with the flange nuts. Ensure that rails are oriented with respect to the L-feet as shown in Figure 9. Align the ends of the rail to the edge of the installation area. Ensure that the rail is straight and parallel to the edge of the roof. Securely tighten the lag screws.

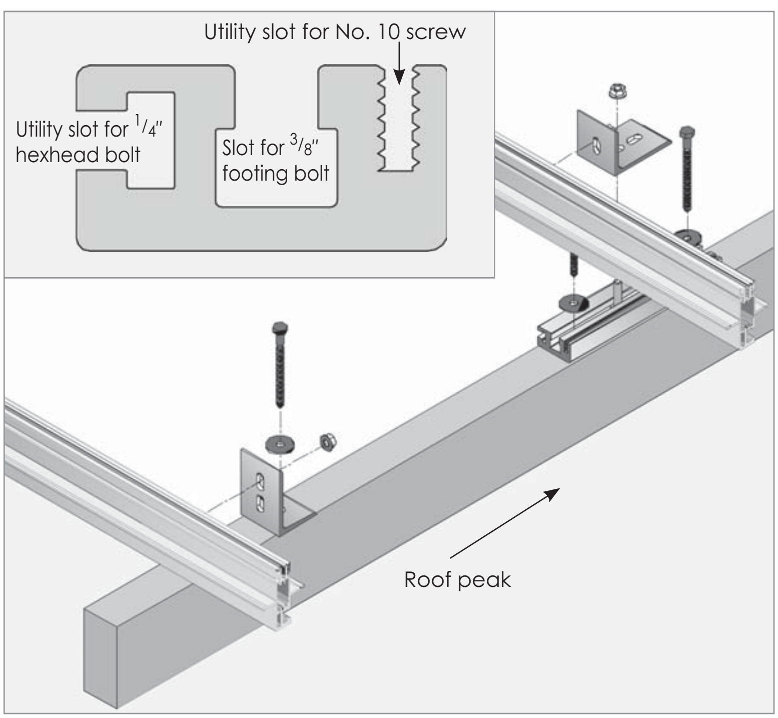
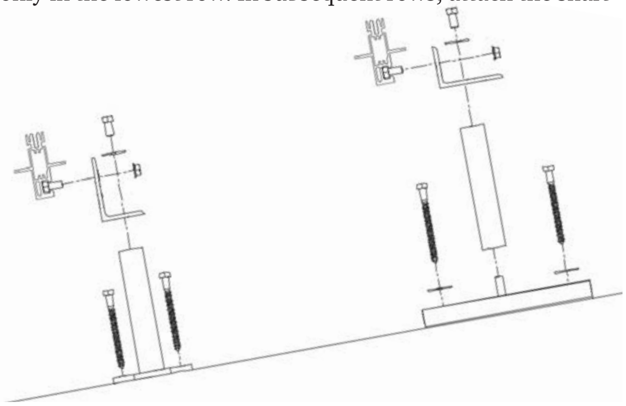


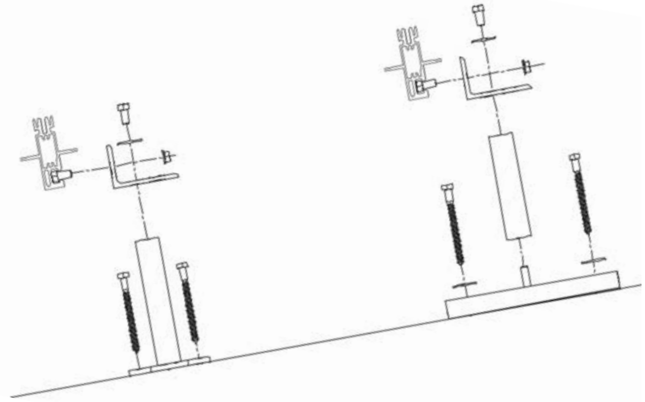
Figure 9. L-foot orientation in conjunction with L-foot adjusting sliders. The sliders include two utility slots to secure module wiring, combiner boxes, and other system components.

Using standoffs with L-foot adjusting sliders

Two-piece aluminum standoffs may be used with footing sliders, although flashings may not be available to cover the entire length of the slider. Use the bases of the standoffs only in the lowest row. In subsequent rows, attach the shaft of each standoff to the slider using the slider's 3/8-inch hex-head bolt. Note that L-feet are positioned long side up on the lowest rows and with long side down in subsequent rows—in the same manner as an installation with no standoffs.



With standoffs of equal length, orient L-foot to compensate for height difference.



If the standoff supporting the lowest rail is 1 inch taller than the standoffs on the footing sliders, place both L-feet in the same orientation—either both long side up or both short side up.

This example assumes a rail seven times the length of the footing spacing (A). A splice may be located in any of the shaded areas. If more than one splice is used, be sure the combination does not violate Requirements 5, 6, or 7.

Footing and splicing requirements

The following criteria are required for sound installations.

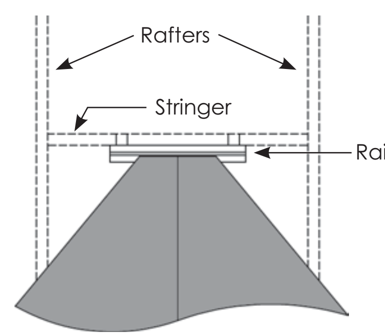
While short sections of rail are structurally permissable, they can usually be avoided by effective planning, which also promotes superior aesthetics. See "Material planning for rails and cap strips" (p. 13).

The installer is solely responsible for ensuring that the roof and its structural members can support the array and its live loads.

For rail lengths exceeding 48 feet, thermal expansion joints may be necessary. Please contact UniRac.

1. Footing spacing along the rail (A in illustration above) is determined by wind loading (see pp. 5–8, especially step 4). Foot spacing must never exceed 48 inches.
2. Overhang (B) must be no more than half the length of the maximum footing spacing (A). For example, if Span A is 32 inches, Overhang B should not exceed 16 inches.
3. Do not locate a splice in the center third of the span between two adjacent feet.
4. In a spliced length of rail, all end sections must be supported by no less than two L-feet.
5. All interior rail sections must be supported by no less than one L-foot.
6. Interior rail sections supported by only one L-foot must be adjacent, on at least one side, to a rail section supported by no less than two L-feet.
7. Rail sections longer than half the footing spacing require no fewer than two L-feet.

Modules should always be fully supported by rails. In other words, modules should never overhang rails. This is especially critical when supporting the short side of a non-rectangular module. When a rail supports a pair of non-rectangular modules by themselves (right), it must be supported by at least two L-feet. The rail should be at least 14 and no more than 24 inches long, which will likely require a stringer between rafters to ensure proper footings.



Non-rectangular modules

3. Laying out and installing the next row of L-feet

With L-feet only: Position the second row of L-feet in accordance with Figure 10. Ensure that you measure between the lower bolt hole centers of each row of L-feet. Install the second row of L-feet in the same manner and orientation as the first row, but leave the lag screws a half turn loose. Be aware of the set-up time of your sealant; the L-feet will not be fully tightened until Step. 4.

With L-foot adjusting sliders: Use a chalk line to mark the position of the slider center holes of the next row. The illustration below provides spacing guidelines. The length of the module (A in Fig. 11) includes any protrusions, such as lips or pan-head screws in its frame.

Attach and seal L-foot adjusting slider: Install lower lag first, *footing bolt next,* and upper lag last. Attach an L-foot with its short side up to each slider.

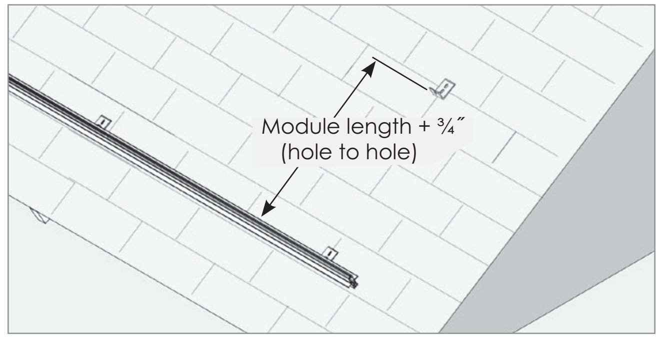


Figure 10. L-foot separation. See the note on module length in the caption of Figure 4 (p. 9).

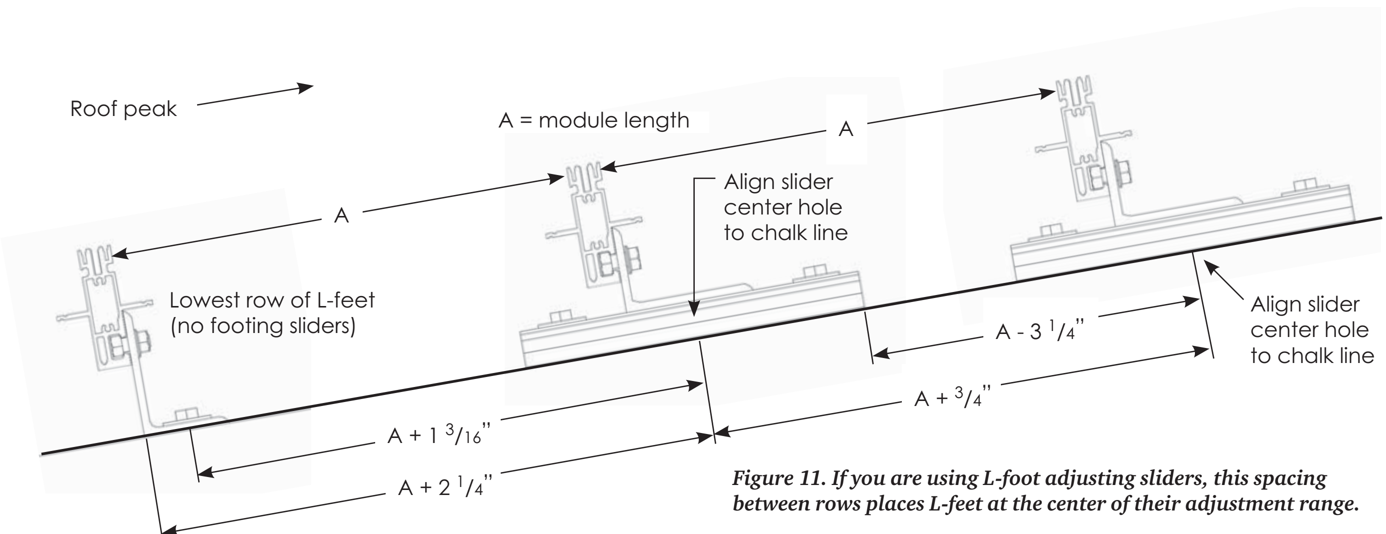


Figure 11. If you are using L-foot adjusting sliders, this spacing between rows places L-feet at the center of their adjustment range.

4. Installing the second rails

With L-feet only (Fig. 12): Install and align the second rail in the same manner and orientation as the first rail. After rail alignment, securely tighten the rail mounting bolts to between 30 and 35 foot-pounds.

Lay one module in place at one end of the rails, and snug the upper rail (Fig. 12) toward the lower rail, leaving no gap between the ends of the modules and either rail. (If pan-head screw heads represent the true end of the modules, be sure the screw heads touch the rails on both ends.) Securely tighten the lag screw on that end. Slide the module down the rails, snugging the rails and tightening the remaining lag screws as you go.

With L-foot adjusting sliders: Install rails on first and second rows of L-feet. Verify spacing by placing a module onto the rails at several points along the row. Adjust L-foot positions as needed.

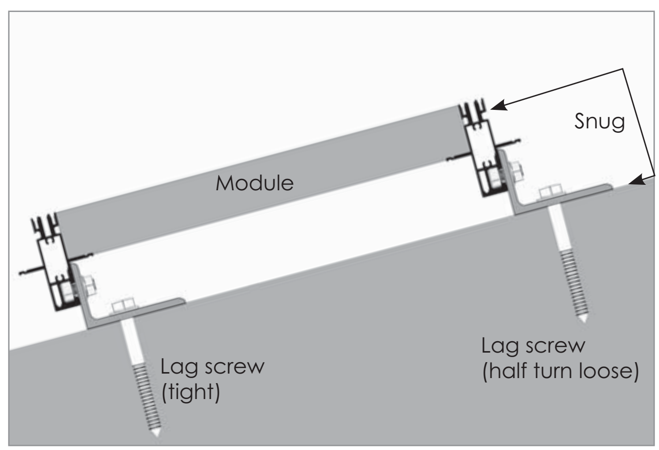


Figure 12. Position and secure top rail.

5. Installing remaining L-feet and rails

Install the L-feet and the rails for the remaining rows, following Steps 3 and 4. You may use the same module to space all the rows. When complete, confirm that:

- All rails are fitted and aligned.
- All footing bolts and lag screws are secure.
- The module used for fitting is resting (but not secured) in the highest row.

Material planning for rails and cap strips

Preplanning material use for your particular array can prevent structural or asthetic problems, particularly those caused by very short lengths of rail or cap strip. This example illustrates one approach.

Stuctural requirements for rails are detailed in "Footing and splicing requirements" (p.11). Structurally, cap strips require:

- A screw in every prepunched hole (which occur every 8 inches, beginning 4 inches from the ends of the rails).
- One screw 4 inches or less from the each end of every rail segment. Wherever there is no prepunched hole within 4 inches of an end of a segment, drill a 1/4-inch hole 2 inches from the end of the segment and install a cap strip screw. (In most cases, you can avoid this situation with good material planning.)

Structural requirements always take precedence, but usually good planning can also achieve both material conservation and superior aesthetics. This example conserves material and achieves two specific aesthetic goals:

- Cap strip screws must align across the rails.
- End screws must be equidistant from both sides of the array.

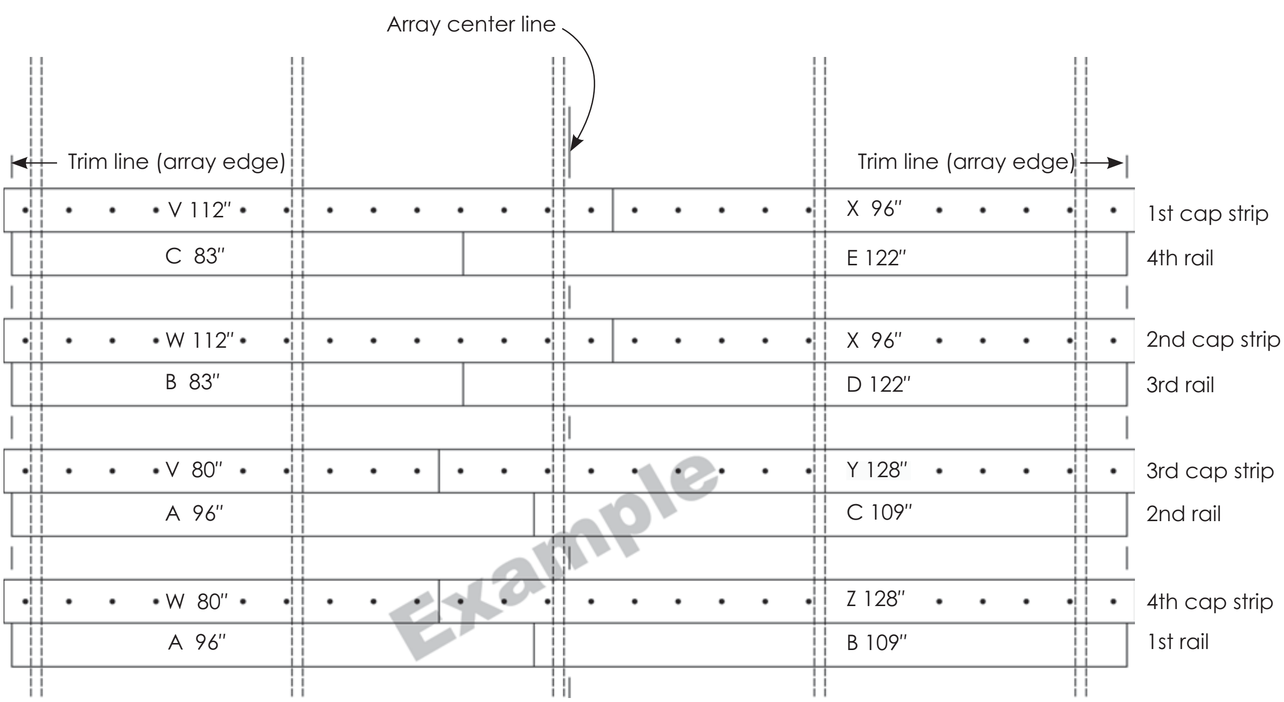
The example assumes an array of three rows, each holding five modules 41 inches wide. Thus, four 205-inch rail assemblies and cap strip assemblies need to be cut and spliced from 192-inch sections of rail and cap strip. The example illustrates one means of doing so, without violating structural requirements or aesthetic goals.

Rail segments come from five 192-inch lengths, lettered A thru E. Rail A, for example, is cut into two 96-inch segments, with one segment spliced into each of the first two rails. Similarly, five 192-inch cap strips are designated V through Z.

All cap strip segments are cut at the midpoint between prepunched screw holes. For each rail, start with the cap strip segment that crosses the array center line, and position over the center line so that the appropriate holes are spaced equally on either side.

Position each cap strip onto its rail and mark its trim point. Remove and trim before final mounting.

Preliminary footing and splice positions must be checked against structural requirements in "Footing and splicing requirements" (p.11). In this example, the center of the array is offset 2 inches from the center rafter. This prevents rail splices BD (3rd rail) and CE (4th rail) from falling too close to the center of the spans between footings (Requirement 3, p. 11). Because footings are not visible from ground level, there is negligible aesthetic loss.



Usable remainder: D, 70"; E, 70"; Y, 64"; Z, 64"

6. Securing the first module

Gather sufficient lengths of cap strip to cover the length of the first rail. For maximum visual appeal and material conservation see “Material planning for rails and cap strips” (p. 13).

Slide the first module into final position at one end of the array. Lay the remaining modules in the top row, leaving a gap about a foot wide between the first and second modules (Fig. 13).

The temporary gap allows the installer to place one of his feet between modules. He can access the section of the cap strip he needs to secure while leaning toward the peak of the roof. For the time being, the last module may overhang the rail by up to one third its width.

Attach the end of the cap strip with the cap strip screws (Fig. 13, inset), so that the upper end of the first module is secure.

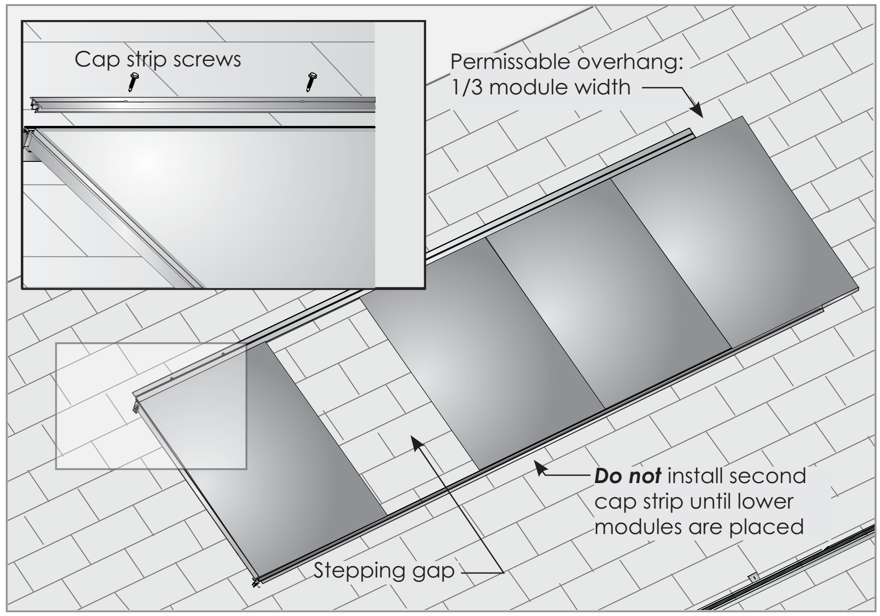


Figure 13. Begin cap strip installation.

The structural integrity of your array requires that cap strip screws fully engage the threaded rail. Use the cap strip screws supplied with your cap strips. Any substitute screws must be ¼-20 Type F thread cutting (18-8 stainless steel) and the correct length. See Table 4 (pg. 15) to match screw length to the size cap strip in your installation.

Every cap strip segment must have a cap strip screw 4 inches or less from each end. If the nearest predrilled hole falls more than 4 inches from any end, drill a ¼-inch hole 2 inches from the end and install an additional screw.

Wherever it is necessary to make a new cap strip hole, drill a ¼-inch hole before installing the cap strip screw.

7. Installing the remaining modules in the top row

Slide the next module into final position and install the screws to secure it (Fig. 14). For a neat installation, use cable ties to attach excess wiring to the rail beneath the flanges. UniRac’s cable ties can be attached to the SunFrame rail by drilling a ¼-inch hole in the rail and pushing the end of the tie into the hole.

Continue the process until all modules in the top row are in final place and secured from the top. When complete, every prepunched hole in the cap strip will be secured by a screw, and the top end of the first row of modules will be secure.

8. Installing the remaining modules row by row

Repeat Steps 6 and 7 for the remaing rows (Fig. 15). Each subsequent cap strip will secure the tops to the modules being installed and the bottoms of the modules in the row above.

Place the final cap strip in the lowest rail, securing the bottom of the lowest module row.

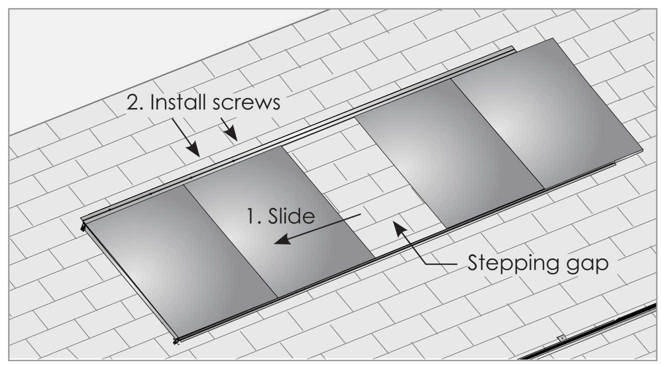


Figure 14. Position and secure modules one by one.

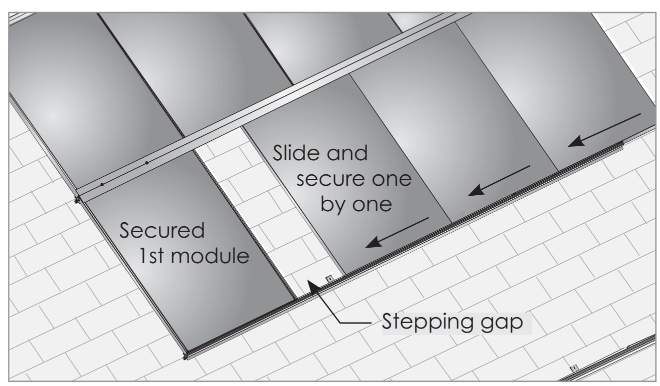


Figure 15. As modules slide into place, the stepping gap shifts, always allowing access to the section of cap strip being secured.

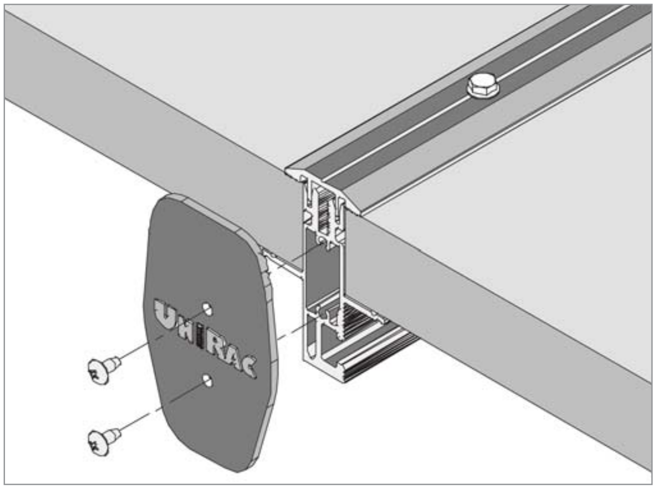


Figure 16. End cap installation.

9. Installing the end caps

Attach the end caps to the ends of the rails by securing with the truss head sheet metal screws provided (Fig. 16).

Table 4: PV module, cap strip, and cap strip screw compatibility

To ensure code compliance and a structurally sound array, cap strip sizes and cap strip screw lengths must be compatible with the PV modules in your installation. All cap strip screws must be ¼-20 Type F thread cutting (18-8 stainless steel).

Module thickness or type		*Cap strip cross section*	*Cap strip size*	*Required screw length (inches)*
inches	*mm*			
1.34–1.42	34–36		C	¾"
1.50–1.57	38–40		D	¾"
1.77–1.85	45–47		F	1¼"
1.93–2.01	49–51		E	1¼"
Sharp lipped modules			G	1"
Sanyo lipped modules			H	¾"

Frequently asked questions about standoffs and roof variations

How high above the roof is a SunFrame array?

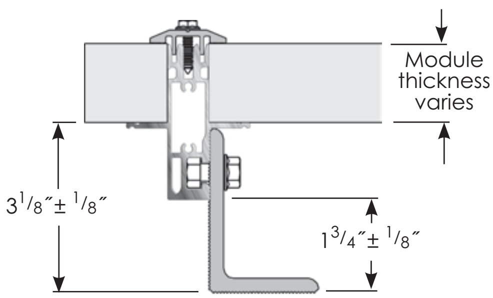
The answer depends on the orientation of your L-feet and the length of your standoffs, if used. See the illustration appropriate to your installation.

How can I seal the roof penetration required when standoffs are lagged below the roofing material?

Many types and brands of flashing can be used with SunFrame. UniRac offers a Oatey® "No-Calk" flashings for its steel standoffs and Oatey® or UniRac flashings for its aluminum two-piece standoffs. See our SunFrame Pro-Pak Price List.

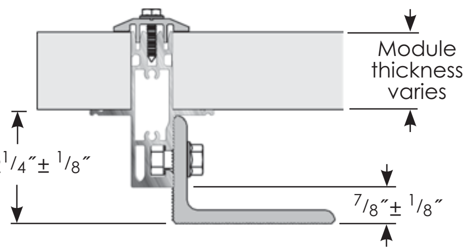
How do I attach SunFrame to a standing-seam metal roof?

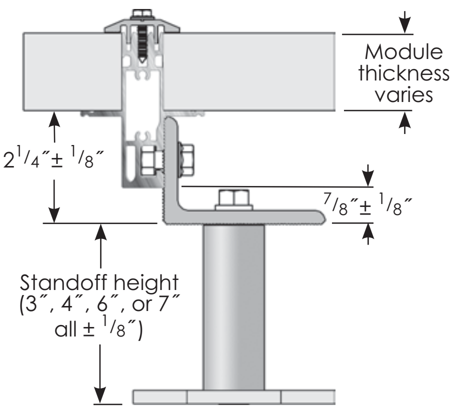
A good solution comes from Metal Roof Innovations, Ltd. (MRI). It manufactures the S-5!™ clamp, designed to attach a wide variety of products to most standing-seam metal roofs. It is an elegant solution that eliminates flashings and penetrations altogether.



SunFrame L-feet will mount to the top of the S-5! clamps with the 3/8-inch stainless steel bolt provided with the S-5! See www.s-5solutions.com for different clamp models and details regarding installation.

When using S-5! clamps, make sure that there are enough clamp/L-feet attachments to the metal roof to meet the Metal Roof Manufacturers' and MRI specifications regarding wind loads, etc.





10 year limited Product Warranty, 5 year limited Finish Warranty

UniRac, Inc., warrants to the original purchaser ("Purchaser") of product(s) that it manufactures ("Product") at the original installation site that the Product shall be free from defects in material and workmanship for a period of ten (10) years, except for the anodized finish, which finish shall be free from visible peeling, or cracking or chalking under normal atmospheric conditions for a period of five (5) years, from the earlier of 1) the date the installation of the Product is completed, or 2) 30 days after the purchase of the Product by the original Purchaser ("Finish Warranty").

The Finish Warranty does not apply to any foreign residue deposited on the finish. All installations in corrosive atmospheric conditions are excluded. The Finish Warranty is VOID if the practices specified by AAMA 609 & 610-02 – "Cleaning and Maintenance for Architecturally Finished Aluminum" (www.aamanet.org) are not followed by Purchaser. This Warranty does not cover damage to the Product that occurs during its shipment, storage, or installation.

This Warranty shall be VOID if installation of the Product is not performed in accordance with UniRac's written installation instructions, or if the Product has been modified, repaired, or reworked in a manner not previously authorized by UniRac IN WRITING, or if the Product is installed in an environment for which it was not designed. UniRac shall not be liable for consequential, contingent or incidental damages arising out of the use of the Product by Purchaser under any circumstances.

If within the specified Warranty periods the Product shall be reasonably proven to be defective, then UniRac shall repair or replace the defective Product, or any part thereof, in UniRac's sole discretion. Such repair or replacement shall completely satisfy and discharge all of UniRac's liability with respect to this limited Warranty. Under no circumstances shall UniRac be liable for special, indirect or consequential damages arising out of or related to use by Purchaser of the Product.

Manufacturers of related items, such as PV modules and flashings, may provide written warranties of their own. UniRac's limited Warranty covers only its Product, and not any related items.

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