

A D V A N C E D
MODULAR

SOLAR PV GROUND MOUNT
Installation Manual

step-by-step
assembly and installation

Release: August 2016

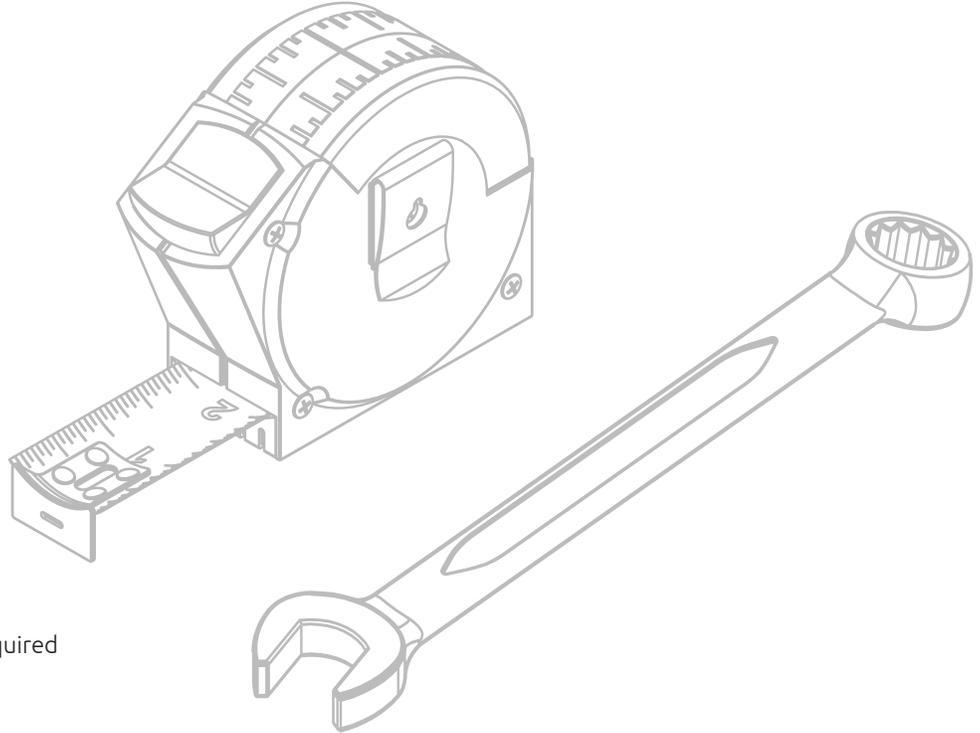
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EQUIPMENT REQUIRED

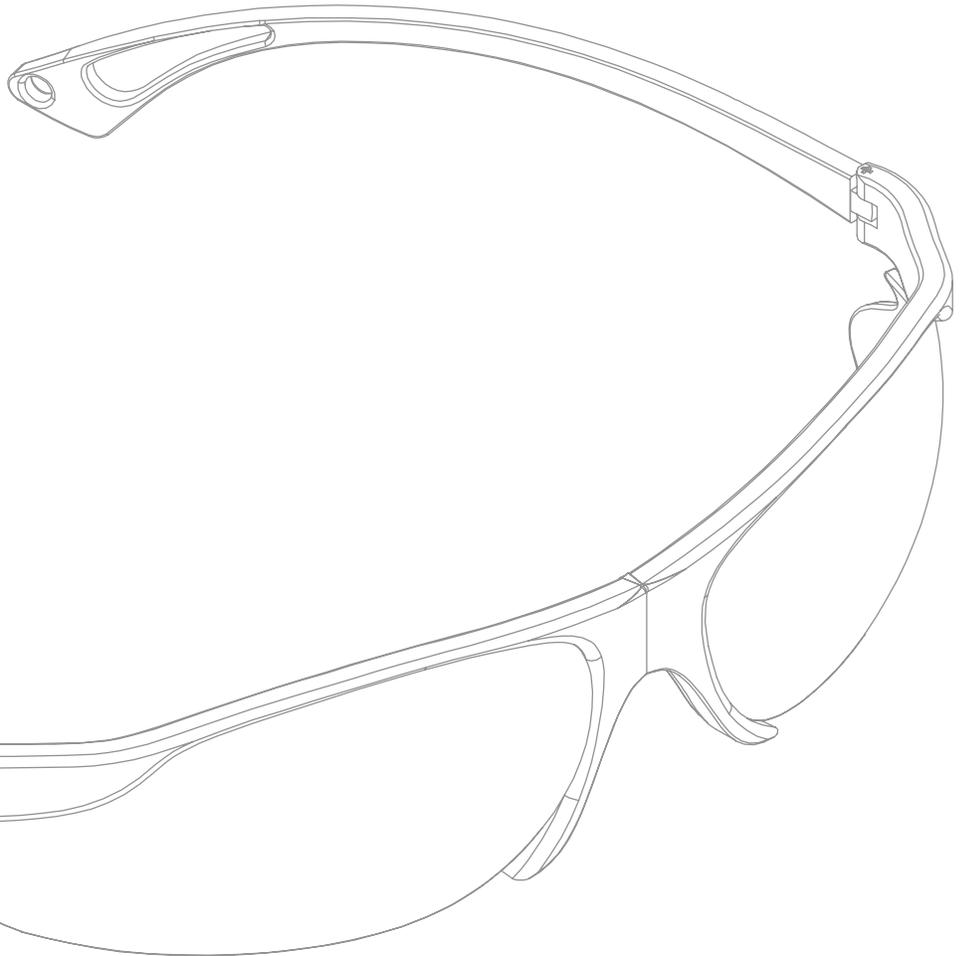
Anchor Driving Equipment

TOOLS REQUIRED

- Tape Measure
- Level
- Angle Indicator
- Torque Wrench
- Cordless Drill or Impact Driver
- Rubber Mallet
- Socket Wrench
- Socket Driver (9/16" & 5/16")
- Box End Wrench (9/16" & 5/16")
- Adjustment Rod
- String Line
- Other common construction tools as required

**SAFETY EQUIPMENT (PPE)**

- Safety Glasses
- Hard Hat
- Steel-toe Boots
- Reflective Safety Vest or Shirt
- Gloves - when required
- Kevlar Sleeves or equivalent - when required



PARTS & ASSEMBLIES

1 ANCHOR POST ASSEMBLY

ANCHOR POST
HELIX ASSEMBLY
BOLT
NUT

2 ZEE PURLIN

3 TILT BRACKET ASSEMBLY

TILT BRACKET
3/8-16X0.75" PUSH-IN STUD

4 CARTRIDGE ASSEMBLY

5 SOLAR PV MODULES (not provided)

6 STRUT ASSEMBLY

STRUT PURLIN
3/8-16X0.75" PUSH-IN STUD

7 END STOP ASSEMBLY

END STOP SADDLE
3/8-16X0.75" SERRATED FLANGE BOLT
3/8-16 CHANNEL NUT

8 SNAP CLIP

9 HARD BRACE

10 CABLE BRACE

LONG BRACE
SHORT BRACE

11 BRACE CLAMP

HARDWARE

12 3/8-16X2.75" SERRATED FLANGE BOLT

13 3/8-16X0.75" SERRATED FLANGE BOLT

14 3/8-16 SERRATED FLANGE NUT

15 1/4-20X2.75" SERRATED FLANGE BOLT

16 1/4-20 SERRATED FLANGE NUT

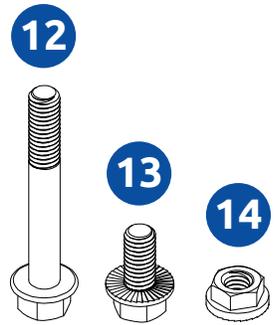
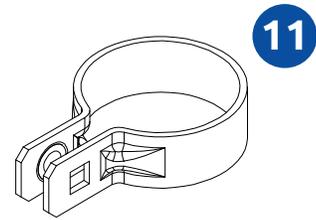
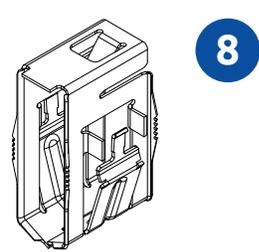
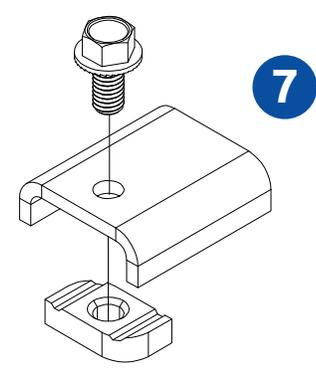
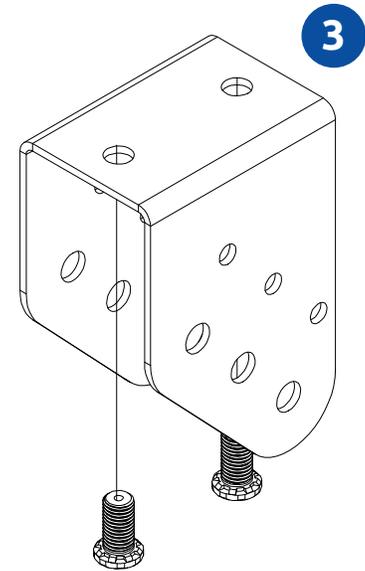
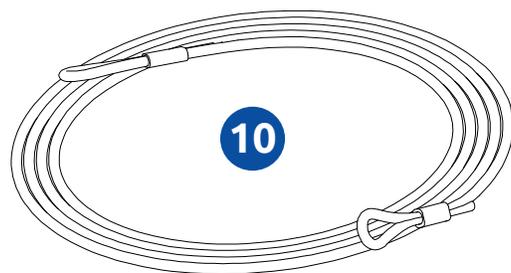
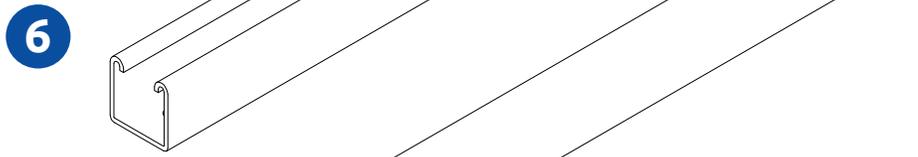
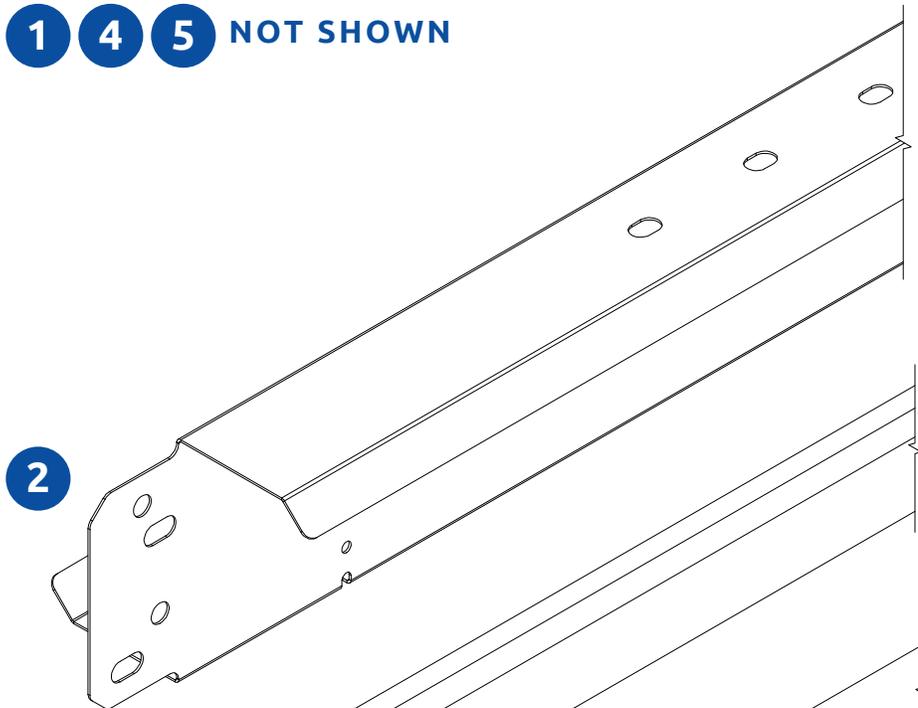
17 CABLE BRACE BOLT

SPARE PARTS

18 3/8-16 CHANNEL NUT

19 3/8-16X0.75" PUSH-IN STUD

1 4 5 NOT SHOWN



A. HAZARDS & OBSTACLES

Site preparation should be conducted prior to construction. This will typically involve grubbing, rock and debris removal, and any other preparation that will facilitate swift and unhindered installation. Site preparation does not typically include grading or other major earthworks projects. See note "Conforming to the Terrain".

B. SURVEYING

To ensure the solar array is installed according to customer plans, the beginning and end of each row must be surveyed and staked, according to spacing determined by AP Alternatives. This will typically be two (2) anchor points each end, per row: the northern and southern

anchor points at the eastern and western-most locations. Rows longer than 250 feet will also require additional, auxiliary stakes, to assist in keep rows straight.

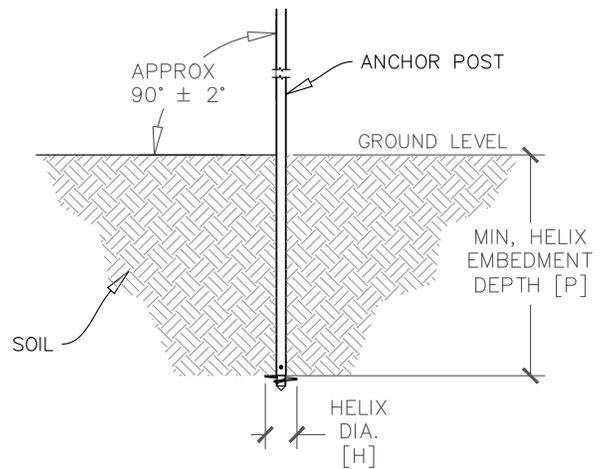
NOTE:

For medium to large projects, anchor locations should be staked by a professional surveyor, who can stake out end of row post locations to the highest precision.

C. UTILITIES

All utilities should be marked before any construction begins.

After the site preparation has been completed and the site surveying is done, the anchor posts are ready to be installed. It is the responsibility of the site lead to review and understand the site anchoring layout, the project's surroundings, the installation procedures; and to manage the project from start to completion. Each project has different anchoring requirements that need to be met according to site testing and data gathered prior to the start of the project. The site lead needs to verify that the anchor posts on site match the purchase order and the given criteria for helix size and tube lengths. Anchor post lengths determine the degree tilt and front lip height of the array.



ANCHOR POST INSTALLATION OVERVIEW

The helical anchor posts are typically driven in sets; a short south anchor and a long north anchor. These are installed with the anchor vehicle and can be driven in either the east or west direction. There are two measurements that the site lead needs to verify on the first two sets of anchor posts; the north-south and east-west, these are indicated on the site specific layout and can vary from project to project.

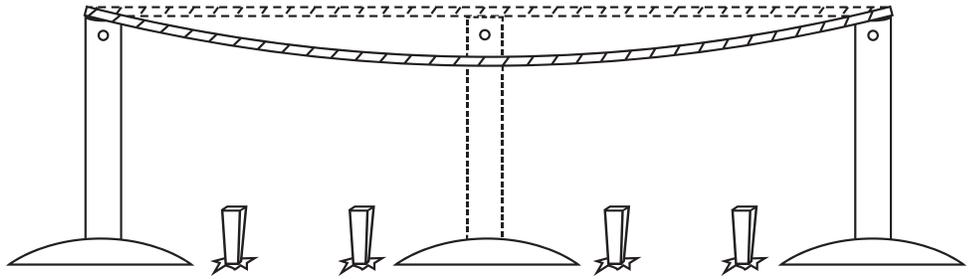
Once these measurements have been verified, according to the site specific layout, the field can be completely installed with the anchor posts by following the surveyed markings for each row.

During the anchor post installation process the anchor tube lengths are set up to control the front lip height; ground clearance, and the system tilt angle. Each of these dimensions affect the others, and typically not all three can be maintained as site terrain varies.



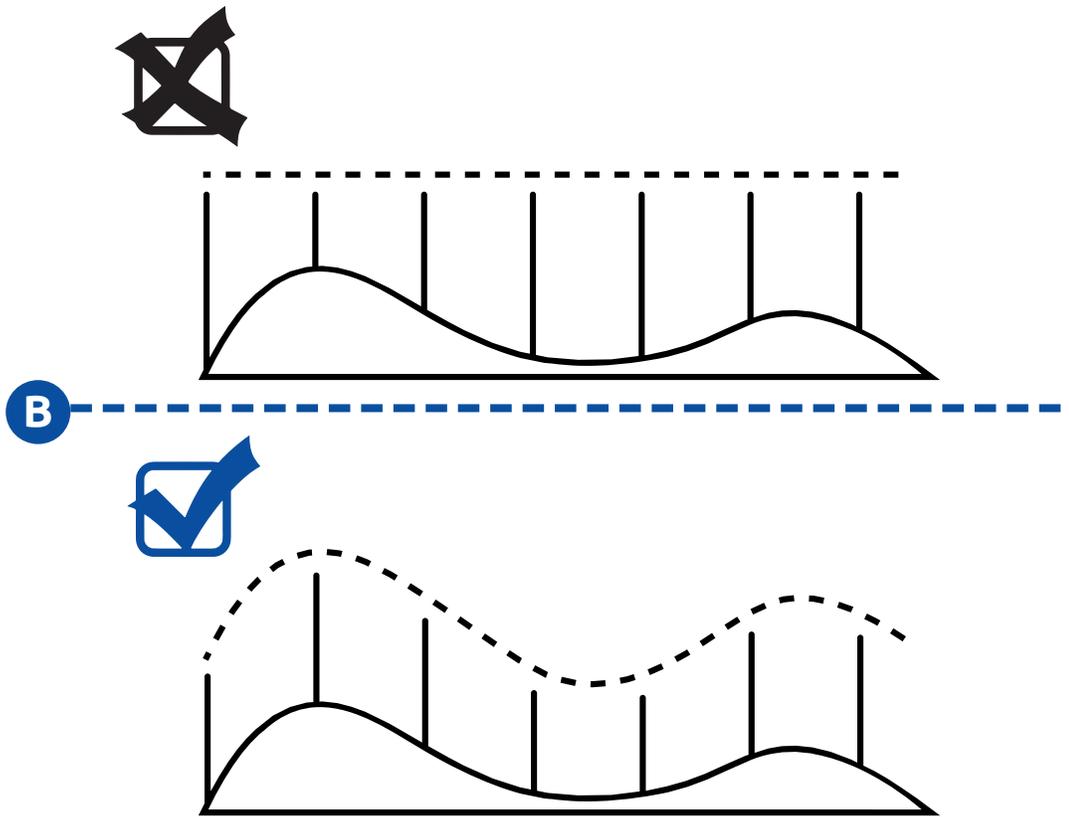
A. FLAT SITES

Drive posts with anchor cart or single-point, starting at one end. Use location lasers or gps to keep in a straight line. Use height lasers to ensure correct depth, or story sticks if not equipped. If using a story stick, ensure measurements are taken from the relative ground height, and not a localized non-conformance, ie. mole hills, divots, rocks



B. UNEVEN GROUND

For sites with ungraded or rolling topology, the string method cannot be used. It is important to ensure the posts are set to the correct depths and the finished system should appear to conform to the landscape (fig. B). These posts will need to be measured individually from the ground to the top to ensure they are at the correct height. In cases in which post locations can not be marked on the ground (uneven terrain), it is advised to have the surveyor mark the location of every post, rather than just the beginning and end of each row.



C. OBSTRUCTIONS

If an impassable object is encountered at the desired post location, it is best to relocate it 6-8" east or west of the original location (fig. C). You must also move it's mating post. Example: If you move a north (tall) post, you must also move the south (short) post (and vise versa) in the same direction and distance to ensure they properly mate.

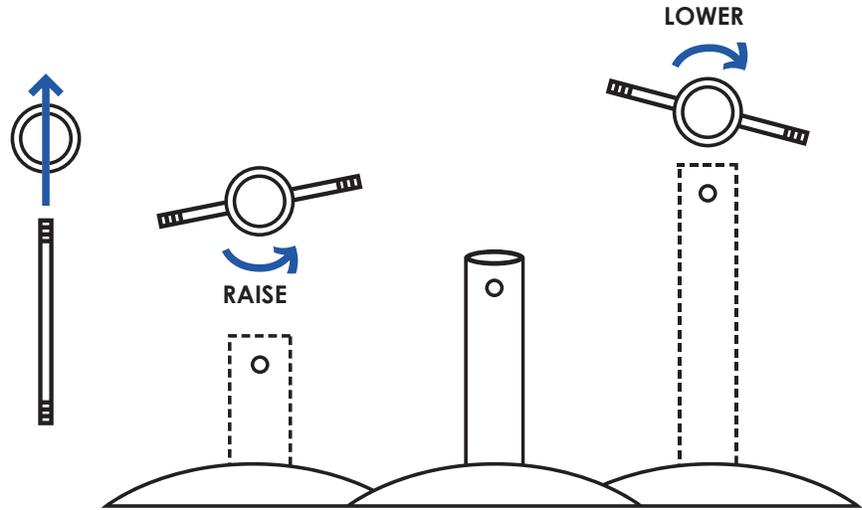
NOTE ON SQUARENESS:

Ensuring the squareness of the array from early in the project is essential in preventing problems later into a build.

Make certain the eastern-most anchor set is exactly spaced and perpendicular to the row. After installing several anchor sets, create a 3-4-5 triangle to ensure squareness. Out-of-squareness should be remedied immediately.

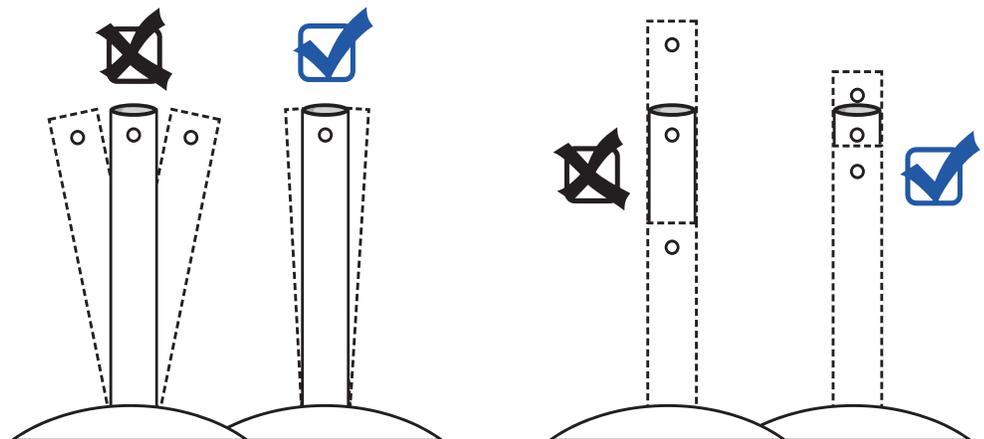
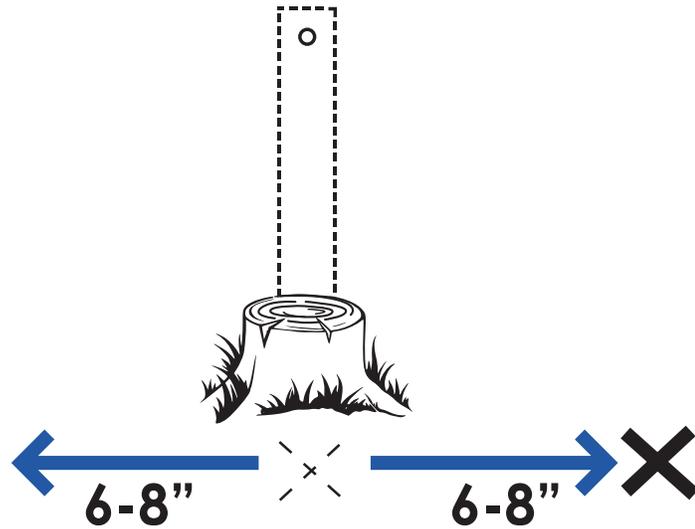
D. HEIGHT ADJUSTMENTS

When posts are driven at the incorrect height, an adjustment may need to be made. Tie a string from one known good height post to another, skipping several. Use this line to determine the correct height for the enclosed posts. If the post is too tall, the top may be cut off and a new 13/32" drilled 1" from the top. Alternatively, the post may be turned clockwise to lower it or counter-clockwise to raise it. This is accomplished using a pipe wrench or post adjustment rod or lever (fig. D).



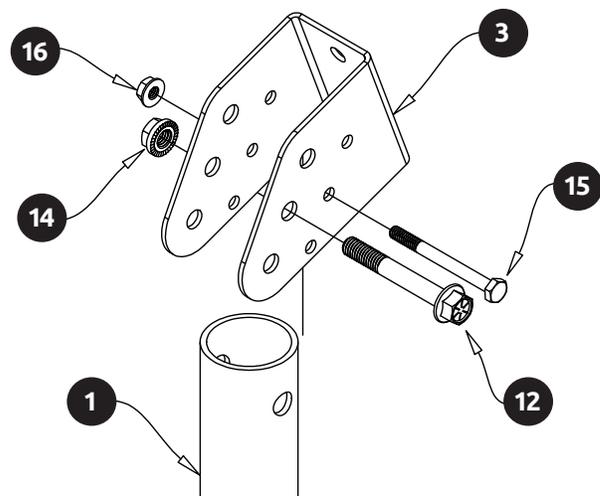
NOTE:

While it is very difficult to make every post perfectly plumb and at the correct height, care should be taken to keep them within the tolerances specified in the plans, to ensure the system fits and functions as intended (fig. E).



A. BRACKET-TO-ANCHOR

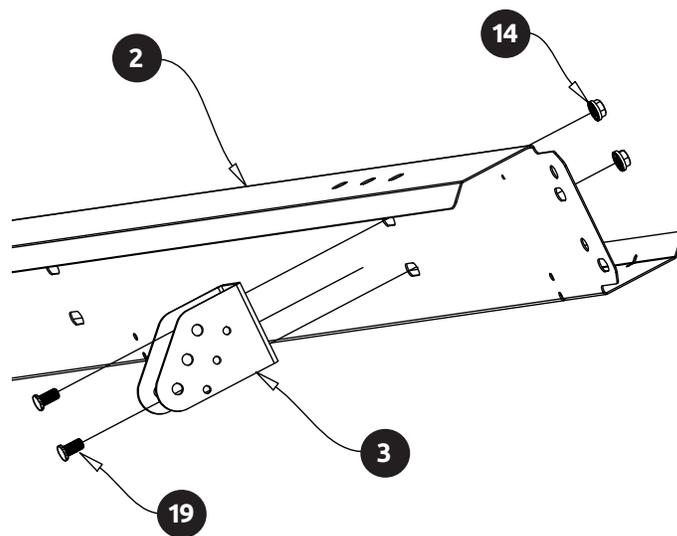
1. Place one (1) tilt bracket over each installed anchor post. Ensure the sloped edge of the bracket is facing the front (typically south) of the rack.
2. Fasten with 3/8 bolt through 3/8 hole (middle hole) and fasten loosely with 3/8 nut.
3. Place a 1/4 bolt through middle 1/4 hole and fasten loosely with nut.
4. Ensure the 1/4 bolt straddles the rear surface of the post.
5. Ensure the same hole location is used for both the large and small bolt (lower, middle, or upper).
6. Repeat steps for all remaining posts.



| | |
|---|----------|
| [1] Anchor Post (Galv) | A711-XXX |
| [3] Tilt Bracket (Galv) | A731-003 |
| [12] 3/8-16x2.75" Serrated Flange Bolt (S/S) | A388-035 |
| [14] 3/8-16 Serrated Flange Nut (S/S) | A388-005 |
| [15] 1/4-20x2.75" Hex Head Bolt (S/S) | A380-008 |
| [16] 1/4-20 Serrated Flange Nut (S/S) | A382-002 |

B. BRACKET-TO-ZEE

1. Place zee purlin over tilt bracket and align the set of holes in the wall of the zee purlin with the set of studs protruding from the tilt bracket. Ensure top flange of zee bracket is facing the front of the rack (typically south). Triple hole sets should be on top flange of zee.
2. Secure both studs, each with a nut. Fasten loosely.



| | |
|--|----------|
| [2] Zee Purlin (Galv) | A720-XXX |
| [3] Tilt Bracket (Galv) | A731-003 |
| [19] 3/8-16x0.75" Push-In Stud (S/S) | A388-033 |
| [14] 3/8-16 Serrated Flange Nut (S/S) | A388-005 |

C. REPLACING PUSH-IN STUDS

Tilt brackets are delivered with push-in studs already correctly installed with the proper force and alignment. In the event a push-in stud has not been installed, installed incorrectly, or is damaged, the push-in stud may be replaced with a 3/8-16X0.75" Serrated Flange Bolt (PN: A388-033).

NOTE:

It is recommended to loosely assemble hardware until final adjustments have been made. Then go back through and tighten all hardware. Stainless hardware may gall and be difficult to loosen after it has been tightened to torque specs.

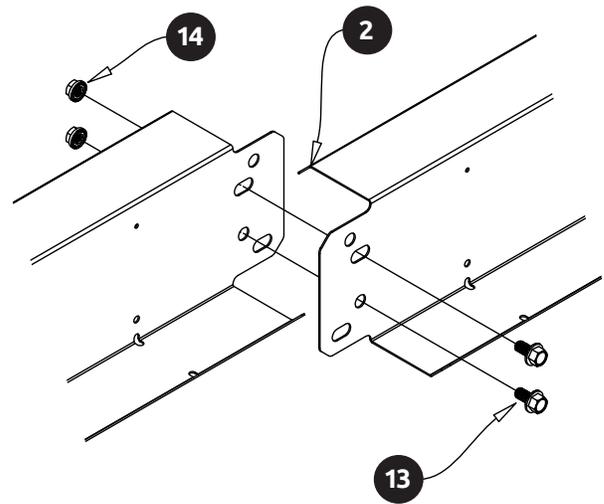
A. ZEE-TO-ZEE SPLICE

1. Join adjacent zee purlins together using the slot and hole combinations at the end of each zee purlin. Typically the interior sets of holes/slots, on both pieces, should be used to splice zee purlins together.
2. As the site dictates, either due to extreme topography resulting in large changes in slopes, or due to inaccurate placement of posts, the outer sets of holes/slots may be used.
3. Place a bolt through each hole, and secure with a nut. Fasten loosely.

[2] Zee Purlin (Galv) A720-XXX

[13] 3/8-16X0.75" Serrated Flange Bolt (S/S) A388-034

[14] 3/8-16 Serrated Flange Nut (S/S) A388-005



B. MISALIGNMENT OF SPLICES

In the event that one purlin end cannot be matched to the other, the posts, tilt brackets, and/or zee purlins should first be adjusted to accommodate proper splice alignment. In extreme cases, it may not be possible to mate zee ends with a splice. When this occurs, care should be taken that splice ends are as close as possible. Next these ends should be marked with a flag to identify them. Inform the site lead of the unspliced ends and follow the auxiliary splice bonding steps found in the appendix of this document.

NOTE ON SAFETY:

NEVER place your fingers between the gaps where the two ends splice!

If one end is joined and the other is free, there is always the chance the free end may fall or be raised by another coworker who's not paying attention. If your fingers were to become trapped between the gap, a pinch point, the sharp edges could come together and a severe injury could occur. If you see a coworker placing their fingers between the gaps, stop them immediately and inform them of the risk.

ADJUSTMENTS

A. TILT BRACKET & ZEE PURLIN ADJUSTMENTS

After installing the tilt brackets and zee purlins, it will be necessary to adjust each to ensure all parts are at the proper height and tilt angle, to ensure zee purlins flow into each other and adhere to the terrain, and to ensure the splice connections are properly fitted together. On flat sections of terrain, or on section of terrain without abrupt slope changes, a string-line may be strung from a tilt bracket at one end of the section to the other. Ensure these are properly adjusted, then adjust all interior tilt brackets and zee purlins to follow the string-line. Fine height adjustments may be made by moving the bolts in the tilt bracket up or down a hole (must move both the small and large bolts in tandem. For height adjustments greater than 1", posts may need to be

readjusted following the previous "Anchor Post Adjustment" section. Once all adjustments have been made in a section, and the height, tilt, and splice alignment has been verified, the previously loosely fastened connections may be tightened to the correct torque values, as provided in the construction documentation and at the beginning of this document.

A. STRUT-TO-ZEE

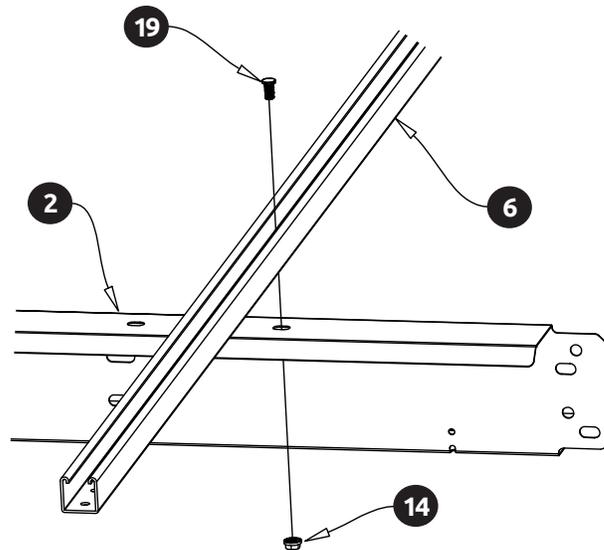
If using pre-assembled cartridges (panels and endstops pre-installed onto struts), skip ahead to the section:

PRE-ASSEMBLED CARTRIDGE INSTALLATION

1. Place the strut purlin over the front and rear zee purlins.
2. Align each of the pre-installed push-in studs with a set of three slots on the top flange of the zee purlins.
3. Drop the push-in studs through the correct slot (see note) and secure each with a nut.
4. Ensure the strut purlin is square with the zee purlins, and properly spaced with adjacent strut purlins, then fasten nut to proper torque.

NOTE: The correct slot is determined based on the specifications given by the module manufacturer and will change from project to project. Refer to the construction documentation to determine the correct slots to use for each project.

| | | |
|-------------|----------------------------------|----------|
| [2] | Zee Purlin (Galv) | A720-XXX |
| [6] | Strut Purlin (Galv) | A732-XXX |
| [19] | 3/8-16x0.75" Push-In Stud (S/S) | A388-033 |
| [14] | 3/8-16 Serrated Flange Nut (S/S) | A388-005 |

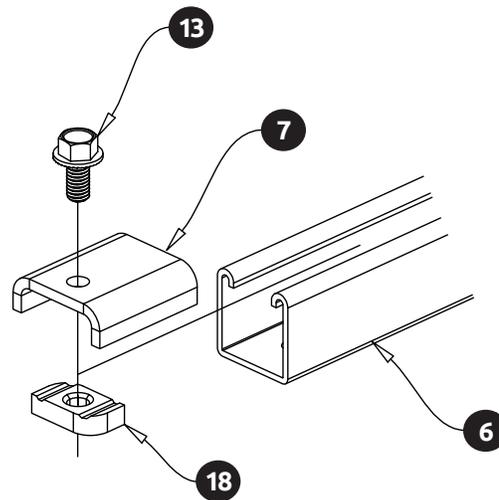


B. LOWER END STOP-TO-STRUT

To ensure panel edges are aligned, correctly locate the proper location for the end stop saddle on the strut. This can be accomplished by using a string-line and marker.

1. Tie a string-line near the bottom edge of the first strut and fasten it near the bottom edge of another strut, a good distance away.
2. Ensure the string-line touches all the struts in the middle.
3. On the first and last strut, mark a distance above the string-line (indicated in construction documentation).
4. Slide the string-line up to meet both marks and mark all remaining struts at the string-line. These marks now indicate the location of one edge of the end stop saddles.
5. Slide an end stop assembly over each strut, ensuring the edge with the bolt is closest to the front of the rack (bottom of the strut).
6. Align the top edge of end stop with the previous marks, and fasten bolt to proper torque.

| | | |
|-------------|---|----------|
| [6] | Strut Purlin (Galv) | A732-XXX |
| [7] | End Stop Saddle (Galv) | A340-001 |
| [13] | 3/8-16x0.75" Serrated Flange Bolt (S/S) | A388-034 |
| [18] | 3/8-16 Channel Nut (Galv) | A392-036 |

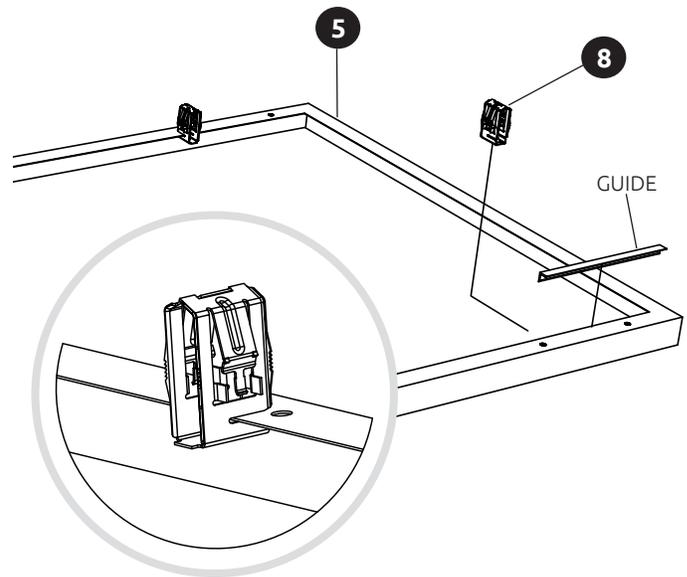


C. SNAP CLIP-TO-PV MODULE

1. Take a panel and flip it upside down (so the glass is facing away from you) on a soft, non-marring surface.
2. Taking the snap clip guide (see appendix for instructions on creating a snap clip guide/jig), straddle it over the long side, aluminum panel flange and slide it all the way to the right or left until it is tight against the short edge flange.
3. Take a snap clip and butt it up against the guide.
4. Using pressure, push the snap clip into the aluminum flange until it can no longer move.
5. Repeat steps for the remaining three snap clips, one in each corner of the module.

[5] PV Module/Panel (AL frame)
Snap Clip Guide

[8] Snap Clip (Galv) A340-100



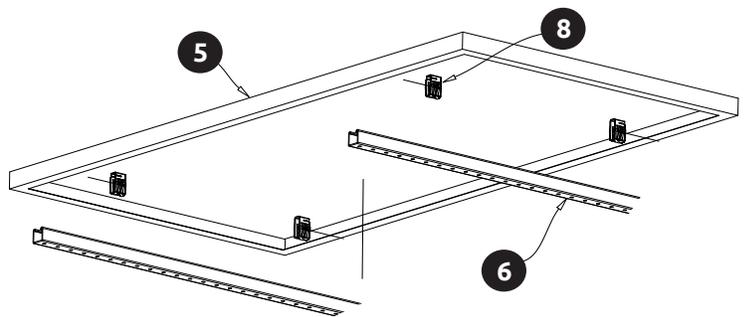
D. SNAP CLIP-TO-STRUT

1. With the snap clips firmly installed on the panel, set the panel in the proper location above the end stop saddles installed onto the struts.
2. Push down on each of the four corners of the panel, ensuring the panel is fully seated into the strut. Each time a snap clip is fully engaged, you should hear a distinct snapping sound each time to confirm proper installation.
3. Repeat for the remaining panels on each set of mating struts, placing each panel directly above the previously installed panel.
4. Ensure all panels are fully engaged, or “snapped” into place.

[5] PV Module/Panel (AL frame)

[6] Strut Purlin (Galv) A731-003

[8] Snap Clip (Galv) A340-100



E. UPPER END STOP-TO-STRUT

1. Install upper end stops on each strut, mirroring the installation of the lower end stops.
2. Leave a one to two finger gap (approx. 1/2” - 1”) between the edge of the panel and edge of the end stop, to allow for thermal expansion. Ensure the bolt end of the end stop is facing away from the panel.
3. Fasten to proper torque value. Refer to Lower End Stop-to-Strut step for list of assembly components.

TECHNICAL NOTE ABOUT THERMAL EXPANSION

The aluminum frame of a solar panel will expand (lengthen) as it heats up and contract (shorten) as it expands. Panels in use may see large temperature shifts from one season and operating schedule to another. A half inch gap above four panels allows for a eighth inch of expansion per panel. This gives the panels room to expand over an approximately 300° F difference in temperature.

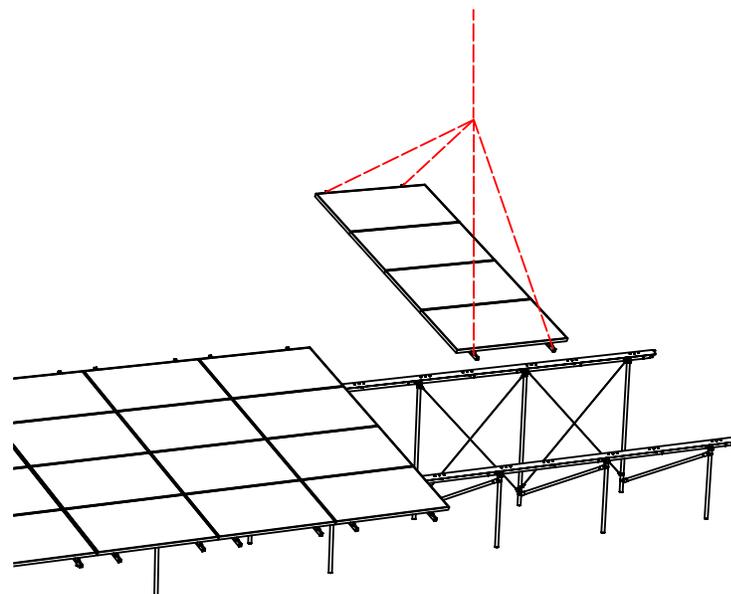
A. PRE-ASSEMBLED CARTRIDGE-TO-ZEE

If rack is completely installed in the field (ie. pv modules arrive separately in a box) skip to the next section.

NOTE ON SAFETY:

When using lifting equipment or working in the vicinity of lifting equipment, ensure you and your coworkers are following all safety precautions and are wearing all applicable personal protection equipment!

1. Ensure pallets of pre-assembled cartridges are located near the intended installation site.
2. Maneuver the lifting machine close enough to the pallets to ensure the cartridge will not swing when lifted.
3. Attach the lifting straps/cables to all contact points on the cartridge and ensure they are attached securely.
4. Slowly lift the cartridge to prevent damage and to keep the crew safe.
5. Raise the cartridge above the zee purlins, at the correct location, and slowly lower onto zee purlins.
6. Assistants can now correctly maneuver the push-in studs on the cartridge to the correct slotted holes on the top flange of the zee purlin. Refer to the construction documentation for identifying the correct slots.
7. When all push-in studs are in the correct slots, each may be loosely fastened with a nut.
8. Once the cartridge is fastened to the rack, the straps/cable may be unhooked so the lifting machine can move them out of the way.
9. Shift the cartridge until it is square with the rack and equally spaced to adjacent cartridges.
10. Fasten nuts to proper torque values.



NOTE:

Verify the orientation of the cartridge to ensure it conforms to the specification and location indicated in the construction documentation. Depending on the project, not all cartridges may be alike.

[2] Zee Purlin (Galv) A720-XXX

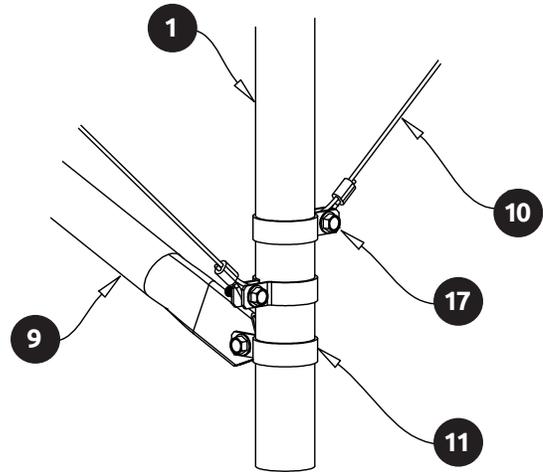
[14] 3/8-16 Serrated Flange Nut (S/S) A388-005

B. ALTERNATE APPROACH, MANUAL LIFTING

A fully assembled cartridge may weigh up to 250 lbs or more. If the contract documentation allows for it, cartridges may be installed with a four-man team. Each team member should securely grab one end of a strut and in tandem, lift and position the cartridge in place on a zee purlin. See instructions above for further detail, adhere to all safety recommendations, and lift safely. Do not rest the cartridge with the weight bearing on the push-in studs. They may be damaged and require replacement. Damaged studs may be replaced with a 3/8-16X0.75" Serrated Flange Bolt (PN: A388-033).

A. HARD BRACE-TO-ANCHOR POST

1. If clamps were not installed prior to installing the tilt brackets (highly recommended), spread the clamp apart, slide around the post, and re-compress it. Install one clamp each on the north and south anchor posts.
2. Position a hard brace between the two clamps, and ensure the front (south) clamp is near the top of the post and the rear (north) clamp is at the bottom of the post.
3. Fit the hard brace in the gap in each clamp.
4. Thread a bolt into each clamp and secure hard brace to clamps, loosely.
5. Slide the rear (north) clamp to slightly above ground level and tighten.
6. Tighten the other clamp.
7. Repeat for all front/rear anchor sets, or as indicated in the construction documentation.

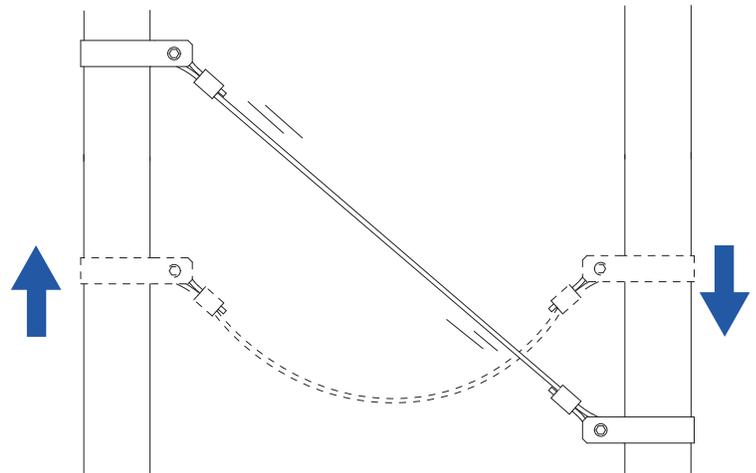


| | | |
|------|-------------------------|------------|
| [1] | Anchor Post (Galv) | A711-XXX |
| [9] | Hard Brace (Galv) | A359-XXX |
| [10] | Cable Brace (S/S) | A353/4-XXX |
| [11] | Brace Clamp (Galv) | A352-002 |
| [17] | Brace Clamp Bolt (Galv) | A381-034 |

B. CABLE BRACE-TO-ANCHOR POST

Depending on the array, a set of anchor posts may get multiple sets of cable braces to limit movement and reduce fatigue. There is typically a set, in crossed-configuration, between sets of east and west adjacent anchor posts. Refer to the construction documentation for locations, and frequency of cable bracing.

1. If clamps were not installed prior to installing the tilt brackets, install above hard brace clamps, using the procedure above.
2. Once clamps are installed string a cable between the two clamps (note: there may be multiple size cables on one job, refer to construction documentation to use the correct one).
3. Secure with bolts, loosely. Ensure the bolts are pointing to the interior of the rack.
4. Position one clamp slightly above the installed hard brace clamp and fasten tightly.
5. Slide the other clamp as far a possible and fasten bolt tightly. Cables should be taut and have no noticeable slack.
6. Repeat for all remaining cables as indicated in the construction documentation.



NOTE:
Cable braces are not used to induce static tension, like trusses of a bridge, but instead only keep the posts from spreading and moving about.