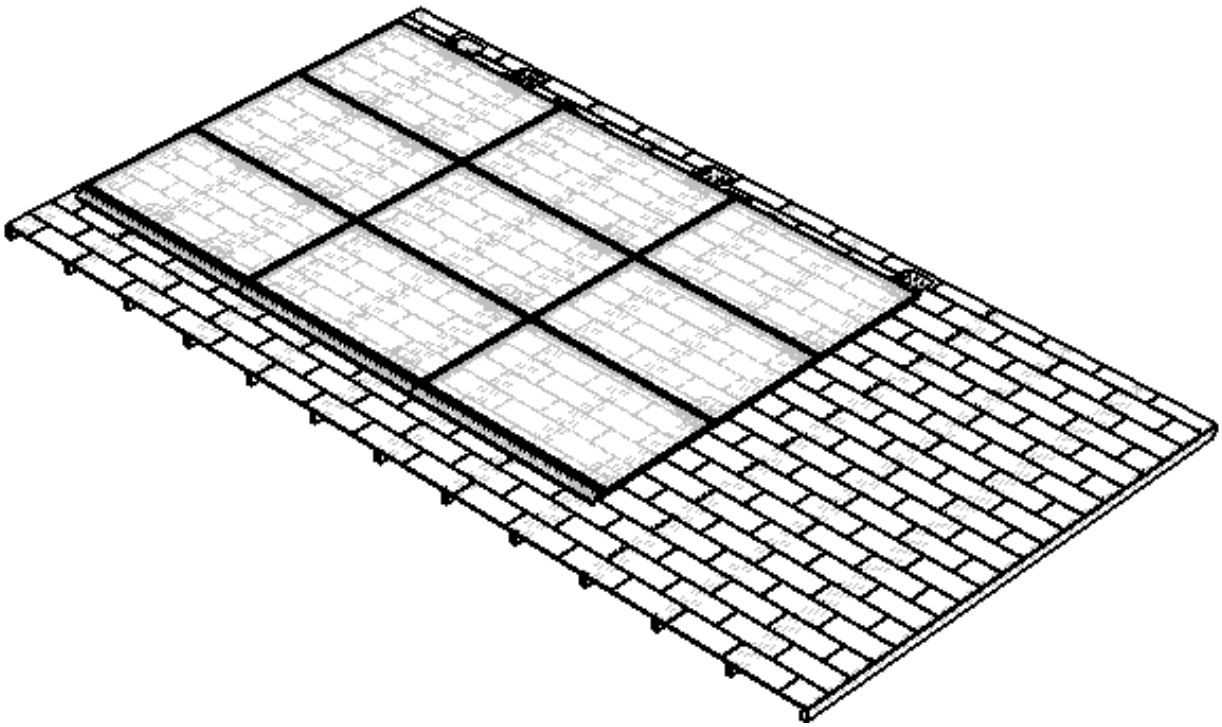
FX MOUNTING SYSTEM ENGINEERING & DESIGN GUIDE
Version 0.4



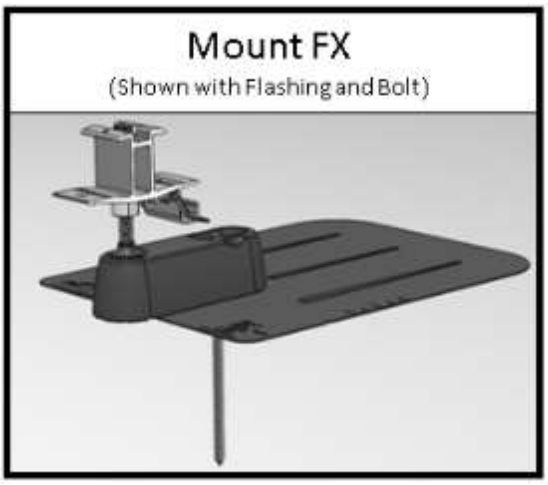
Contents

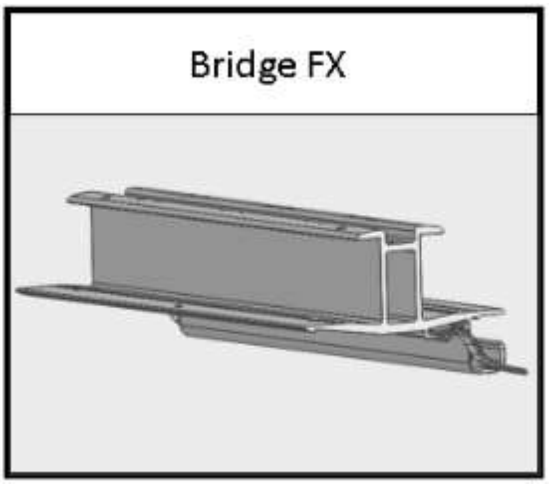
1.0 OVERVIEW OF FX SYSTEM 3
2.0 DEFINE SITE CONDITIONS & MODULE BEING USED 3
2.1 Environmental Considerations 3
2.2 Roof Considerations 4
2.3 Module Compatibility 4
2.4 Predesign Worksheet 5
3.0 DESIGN 6
3.1 Define Roof Zones (RZ) 6
3.2 Determine Maximum Allowable Spans & Cantilevers 7
3.3 Layout Modules on Roof 7
3.4 Place Mounts 8
3.5 Bridge Placement 12
3.7 Electrical Grounding 15
3.8 Generate Bill of Materials (BOM) 16
4.0 Example Arrays 16
5.0 Optimizing Designs 21
5.1 Landscape is superior to Portrait 21
5.2 Optimizing Components 21
5.3 Trim Can Be Omitted as Desired 21

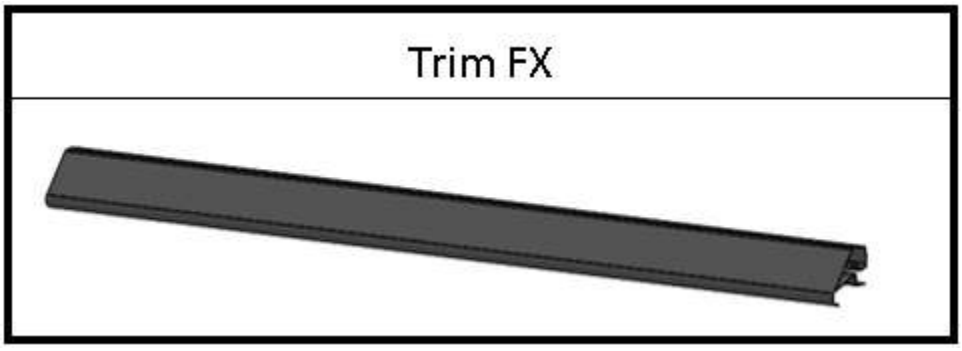
1.0 OVERVIEW OF FX SYSTEM

The IronRidge FX Mounting System is a rail-less system for mounting solar modules on composition shingle pitched roofs. At the heart of the system is the Mount FX, which both supports and electrically bonds modules. The innovative grip design of the Mount eliminates the need for traditional clamps and associated steps to tighten them as well as setting a mount and gripping a module, speeding up installs. Integrated bonding features throughout the system ensure redundant bonding paths within the array – both N-S and E-W directions – without any additional hardware and meets the highest levels of UL 2703. Like all IronRidge products, the FX System can support extreme wind and snow loads and uses only aluminum and stainless steel components to ensure complete corrosion resistance.

The following images show the core FX system components.







2.0 DEFINE SITE CONDITIONS & MODULE BEING USED

2.1 Environmental Considerations

Wind/Snow Loads

Because PV is installed outdoors, your system will need to withstand regional wind and snow loads. Contact your local building authority to obtain the values for your site location.

Exposure Category

Exposure category refers to the way obstacles protect buildings and the structures on top of them from the force of wind storms. Therefore, based on your setting (urban, rural, or on flat unobstructed terrain), you will design to one of the following Exposure Categories.

The majority of buildings in urban areas have an exposure category B.

Wind Exposure Category	Surface Roughness
Exposure B	Urban and suburban areas, wooded areas, or other terrain with numerous closely spaced obstructions having the size of single-family dwellings.
Exposure C	Open terrain with scattered obstructions having heights generally less than 30 feet. This category includes flat open country and grass-lands.
Exposure D	Flat, unobstructed areas and water surfaces. This category includes smooth mud flats, salt flats, and unbroken ice.

Risk Category

Structural performance of the FX System has been evaluated with ASCE 7-10 Risk Category II loads (equivalent to ASCE 7-05 Occupancy Category II loads) resulting in the FX System having the same structural integrity and reliability as the building it is deployed on.

2.2 Roof Considerations

Rafter Spacing

Rafter spacing must be established by surveying the building. This number impacts where you can place attachments as you lay out your system.

The FX system can be installed on roofs with slopes of 9.5 to 45 degrees.

2.3 Module Compatibility

The FX system has been approved for use with the following PV modules. Unless otherwise noted, “xxx” refers to the module power rating and both black and silver frames are included in the certification.

MANUFACTURER	MODELS
Canadian Solar	Canadian Solar modules with 40 mm frames and module identifier CS6Y-xxxZ, where "Y" can be K, P, or V; "xxx" refers to the module power rating; and "Z" can be M, MS, P, PX, or P-SD
Hanwha Q CELLS	Hanwha QCells modules with 32 mm frames and module identifier Q.YY.ZZ.xxx, where "YY" can be PLUS, PRO, or PEAK, "ZZ" can be G4, G4.1, L-G4, L-G4y, BFR-G4, BFR-G4.1, BFR G4.1 XXX, BFR G4.3, BLK-G4.1, G4/SC, G4.1/SC, G4.1/SC, G4.1/TAA, BFR G4.1/TAA, BLK G4.1/TAA, or G4.1/MAX; and "xxx" is the module power rating
Hyundai	Hyundai modules with 35 mm frames and model identifier HiS-YxxxZZ, where "Y" can be M or S; "xxx" refers to the module power rating; and "ZZ" can be MF, MG, SG, RG, or TG
JA Solar	JA Solar modules with 40 frames and model identifier JAyyzz-60-xxx/aa, where "yy" can be M6 or P6; "zz" can be blank, (K), (L), (R), (V), (BK), (FA), (SE), (TG), (FA)(R), (K)(SE), (K)(TG), (L) (BK), (L)(TG), (H)(BK), (H)(TG), (V)(BK), (BK)(TG), or (L)(BK)(TG); "xxx" is the module power rating; and "aa" can be MF, SI, PR, RE, 3BB, 4BB, 4BB/RE
Jinko	Jinko modules with 40 mm frames and model identifier JKMYxxxZZ-aa, where "Y" can either be blank or S; "xxx" is the module power rating; "ZZ" can be M, P, PP, or -V; and "aa" can be blank, 60, 60B, 60-J4, 60B-J4, or 60(Plus)
LG	LG modules with 40 mm frames are module identifier LGxxxy1z-bb, where "xxx" is the module power rating, "y" can be A, N, S, or Q, "z" can be C or K; and "bb" can be G4 or A5" (G4 Models not compatible with portrait installations)
Panasonic	Panasonic modules with 40 mm frames are model identifier VBHNxxxYYzz, where "xxx" refers to the module power rating; "YY" can be either SA or KA; and "zz" can be either 03, 04, 17 or 18
Trina	Trina modules with 35 mm frames and model identifier TSM-xxxYYZZ, where "xxx" refers to the module power rating; "YY" can be PA05, PC05, or PD05; and "ZZ" can be blank or A or A.05 or A.08
Yingli	YGE and YLM series modules with 35 and 40 mm frames

2.4 Predesign Worksheet

Tip!
Before starting design, make sure you that you have collected all the relevant information in the table below.

Wind Speed	
Ground Snow Load	
Exposure Category	
Risk Category	RC II
Rafter Spacing	
Roof Slope	
Selected Module for Design	
Is selected module compatible with FX system?	Yes / No
How thick are the frames of the modules?	32mm / 35mm / 40mm

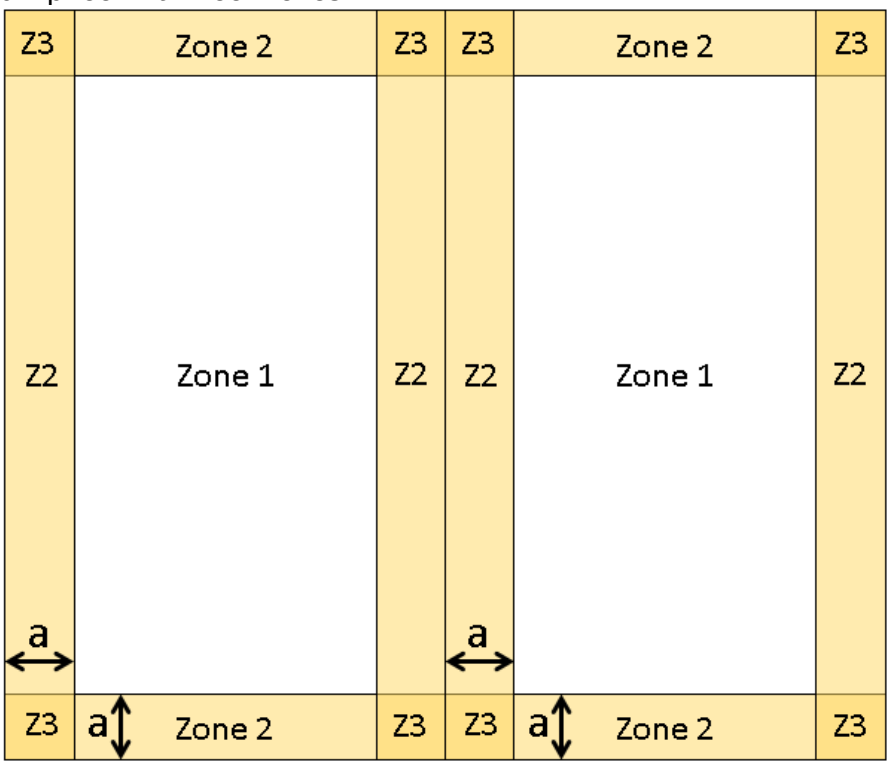
3.0 DESIGN

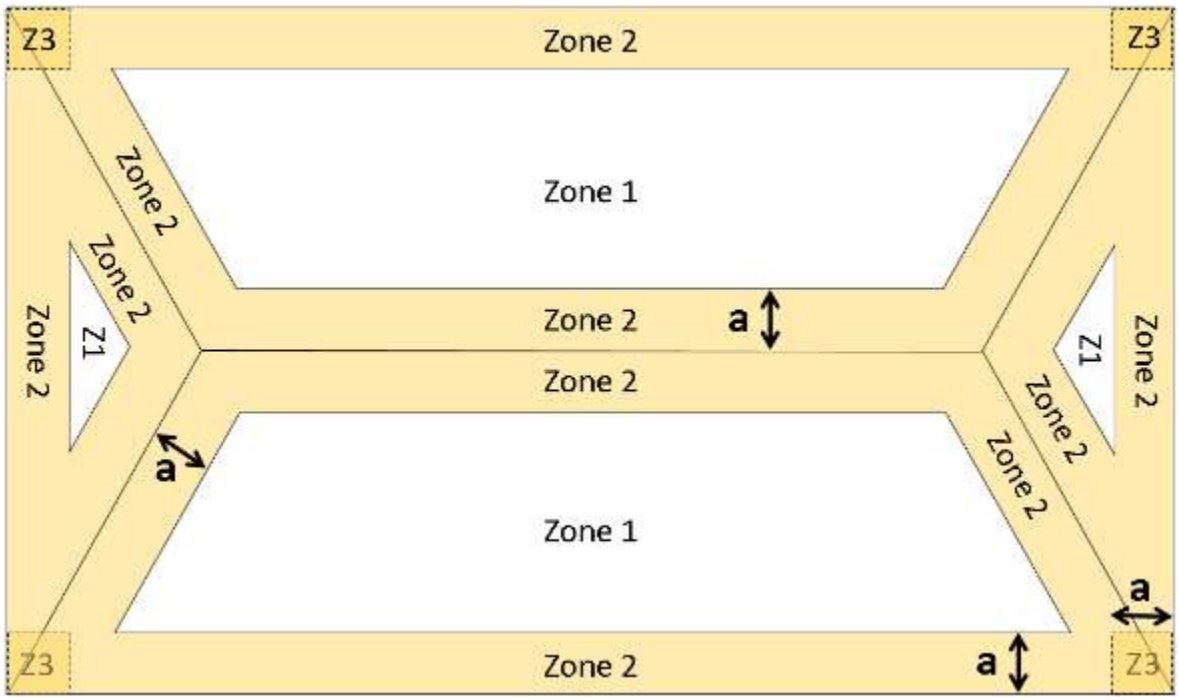
3.1 Define Roof Zones (RZ)

Roof Zones are determined based on ASCE 7-10 (see Chapter 30).

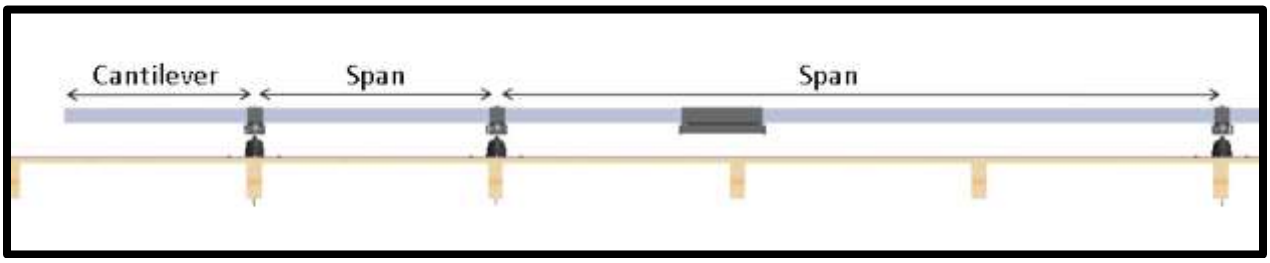
- In most residential applications, a = 3ft.

Gable roof and hip roof with Roof Zones:





3.2 Determine Maximum Allowable Spans & Cantilevers



Definitions
Span: The distance between two adjacent Mounts, measured at the center of the hanger bolt.

Cantilever: The section of a module extending beyond a Mount.

Use the Span Tables (Appendix A) to determine maximum allowable spans and cantilevers.

- Maximum Span is a function of (5) factors: Wind Exposure Category, Wind Speed, Roof Slope, Roof Zone, and Module Orientation (i.e. portrait or landscape).
- Maximum Cantilever = 1/3 of Maximum Span

Tip!
Record your span and cantilever values for the respective roof zones in a table:

	RZ 1	RZ 2	RZ 3
Max Span (in)			
Max Cantilever (in)			

3.3 Layout Modules on Roof
Layout the modules on the roof, noting which roof zone(s) each module is occupying.

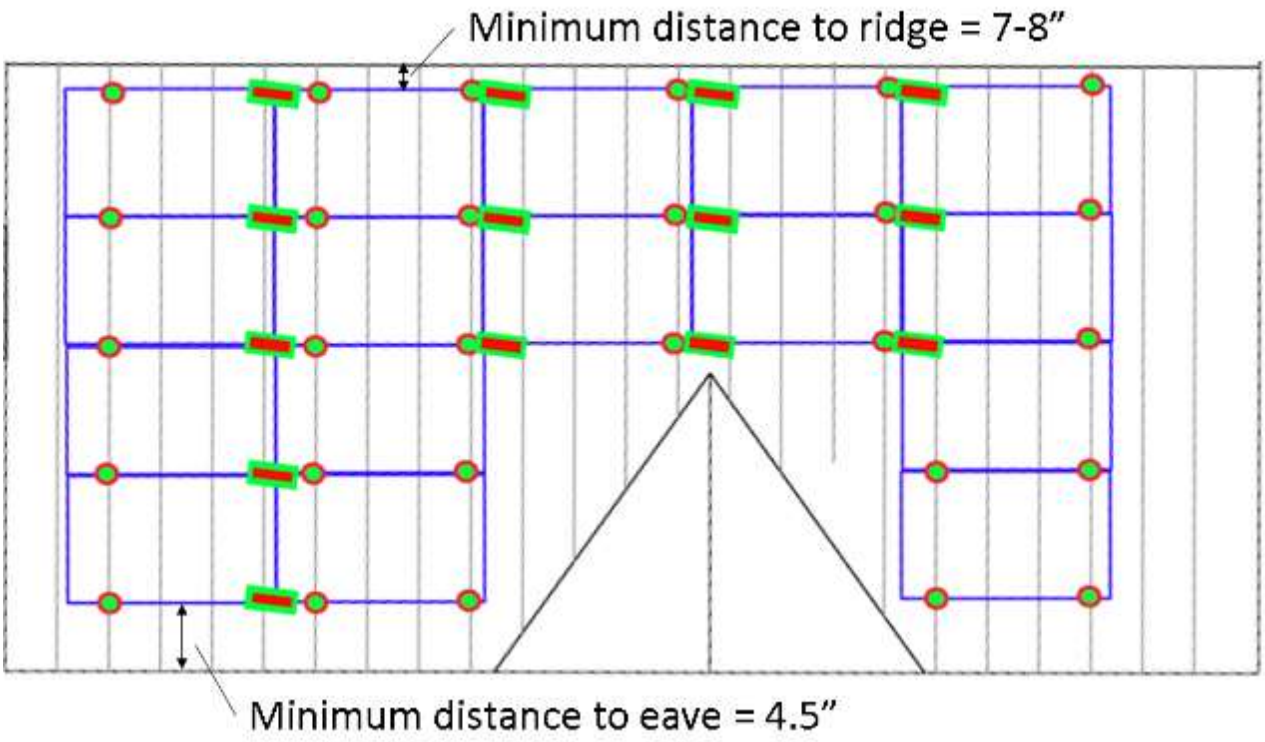
If there is flexibility in the module layout, it is best to:

- Keep all modules in Landscape orientation
- Keep modules out of Roof Zone 3
- Minimize the number of modules in the Roof Zone 2 regions

Spacing Between Modules
To accommodate the FX System hardware, the spacing between modules along a row (E-W direction) and between rows (N-S direction) is ½" and ¾", respectively.

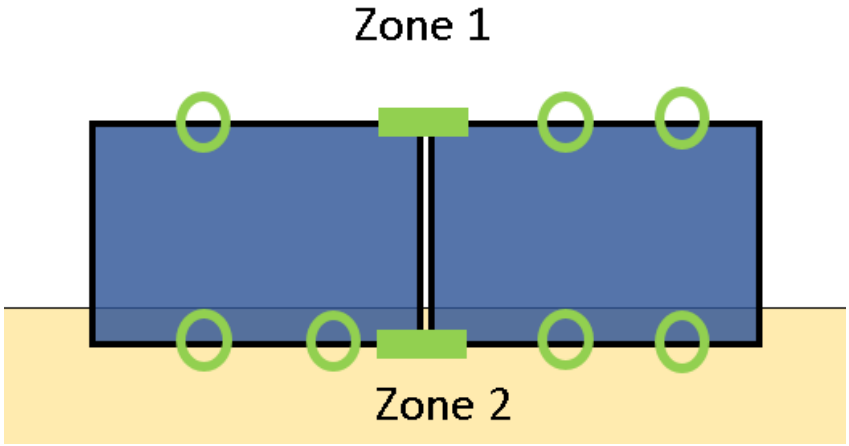
Proximity to Eave and Ridge
The Trim extends another 4.5" from the southern edge of the module. The Trim must not extend beyond the roof eave.

Modules can be placed up to 7-8" from the roof ridge.



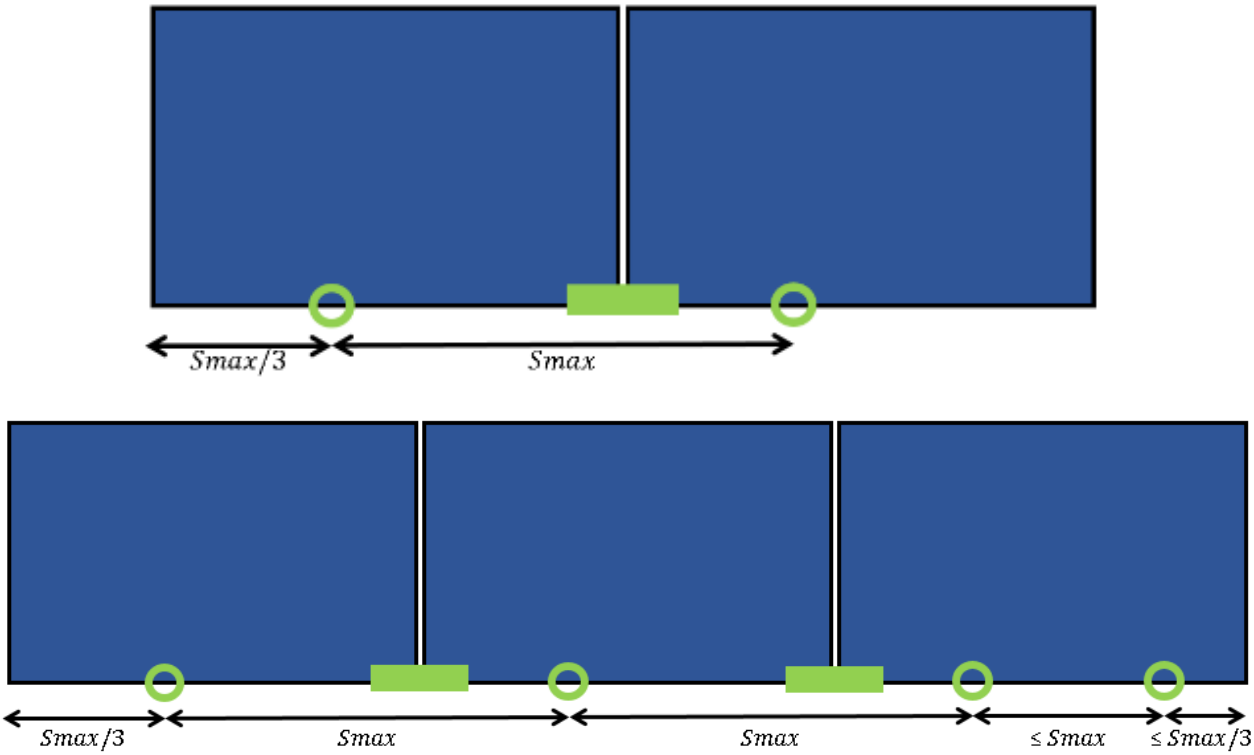
3.4 Place Mounts

It is important to note that Mount spacing may be different on the south edge versus the north edge of a module based on Roof Zone. Therefore, it is important to make sure that RZs are properly determined prior to placing the mounts.



Starting with the first row of modules, work your way left to right across the row, and then up the roof applying the Roof Zone Rules (3.4.1) until all Mounts have been placed.

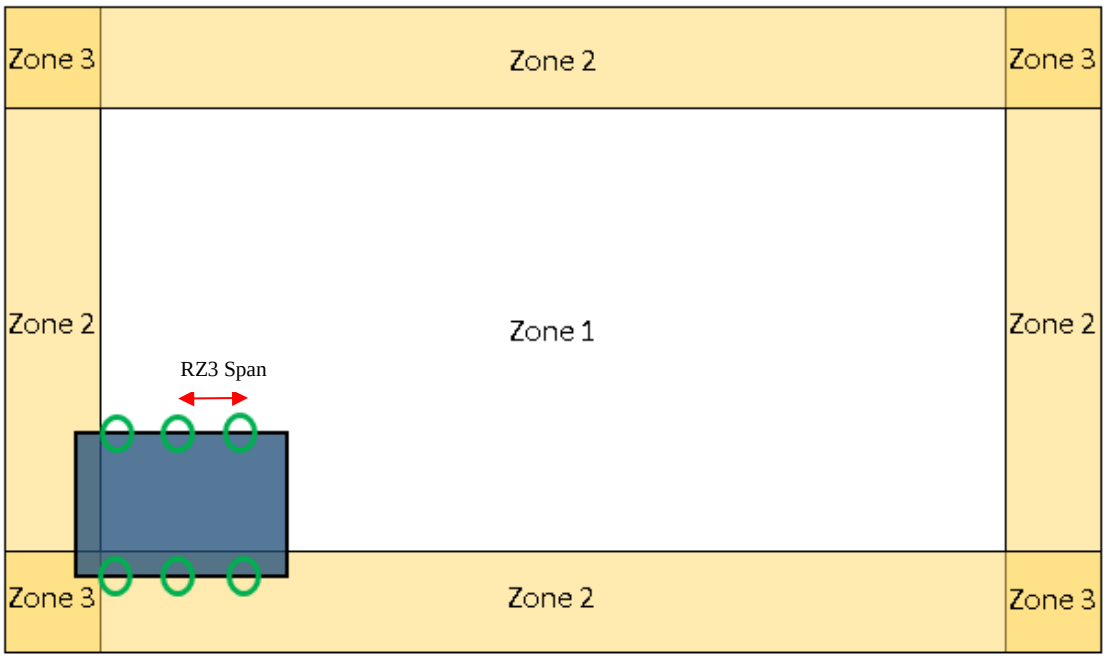
Use the maximum cantilever ($S_{max}/3$) when placing the first Mount, then use the maximum span (S_{max}) to place the next Mount.



3.4.1 Apply Roof Zone Rules

Roof Zone 3

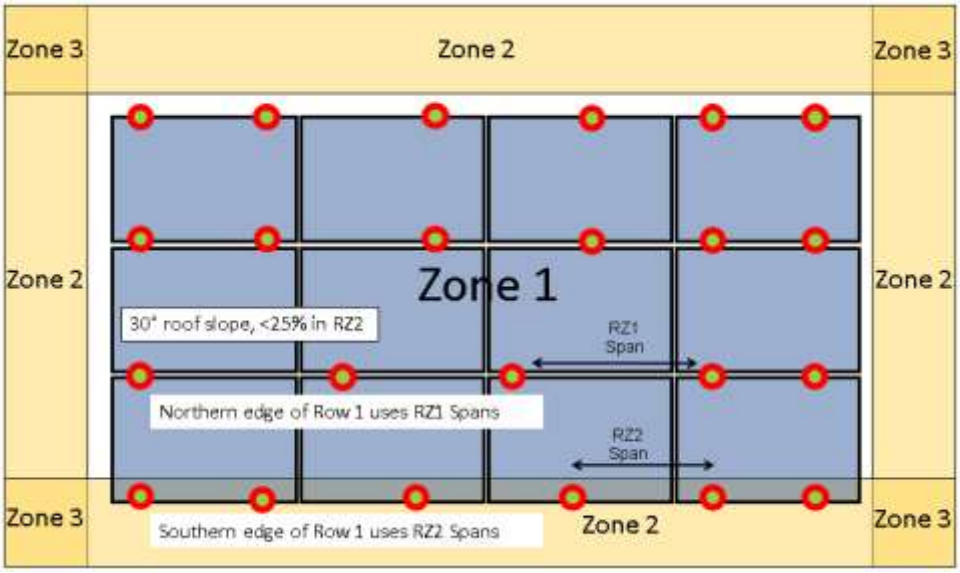
If any part of a module falls within RZ 3, all Mounts touching this module must follow a RZ 3 span/cantilever.



Roof Zone 2 – South Edge Only

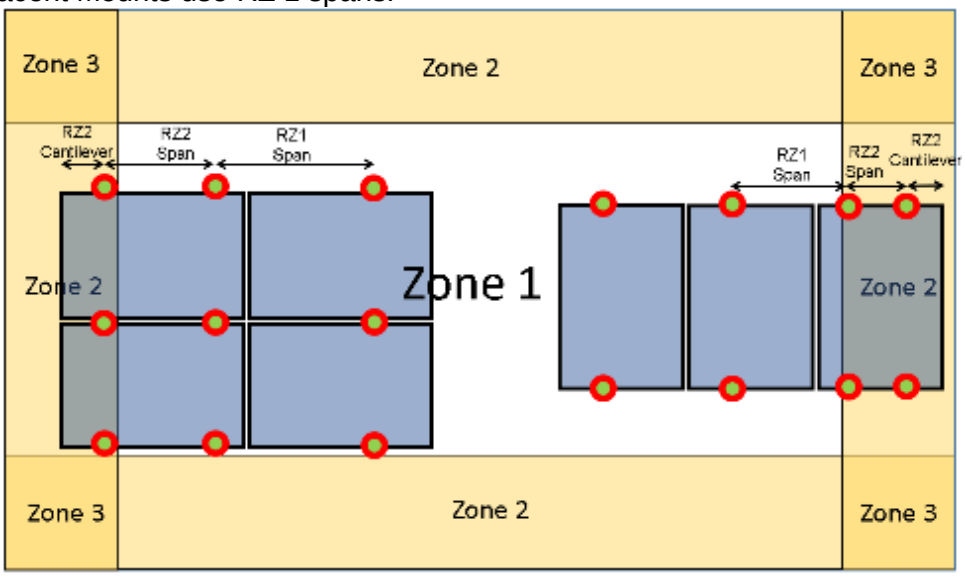
- If more than 25% of a module's southern edge falls within RZ2, all mounts along the southern row of the module follow RZ2 span/cantilever

Example: On a 30° roof, the southernmost row falls in Roof Zone 2.



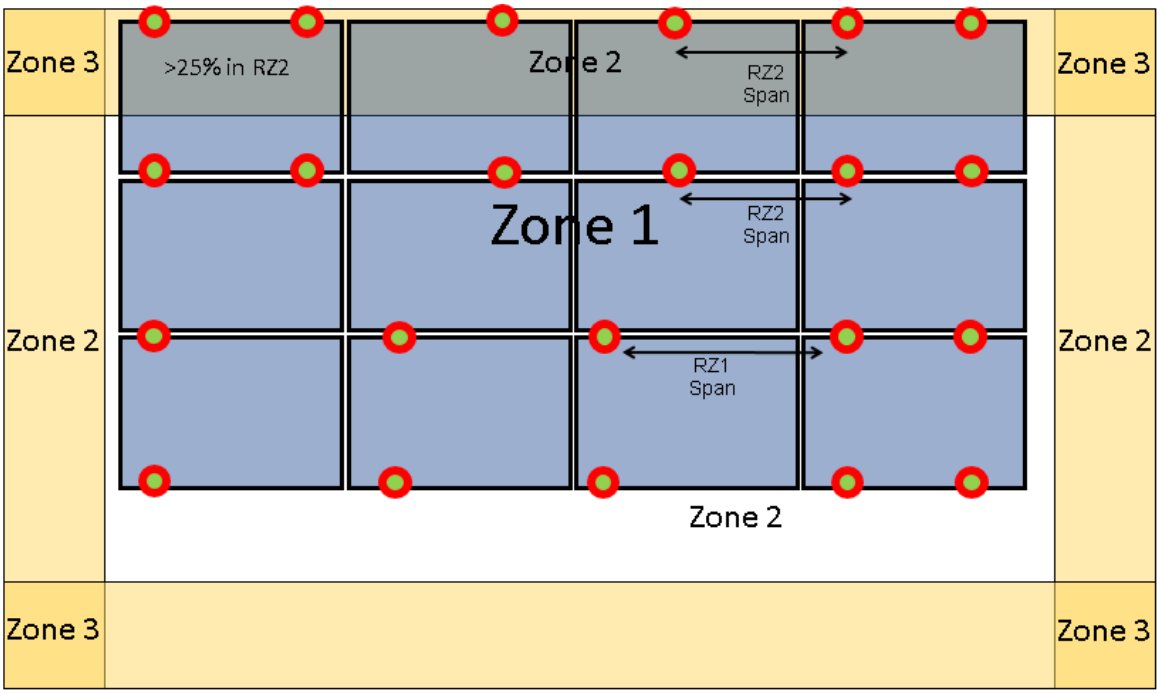
Roof Zone 2 – East and West Edges

- Mounts touching the column of modules located (partially) in RZ 2, use RZ 2 spans.
- Adjacent Mounts use RZ 1 spans.



Roof Zone 2 – North Edge

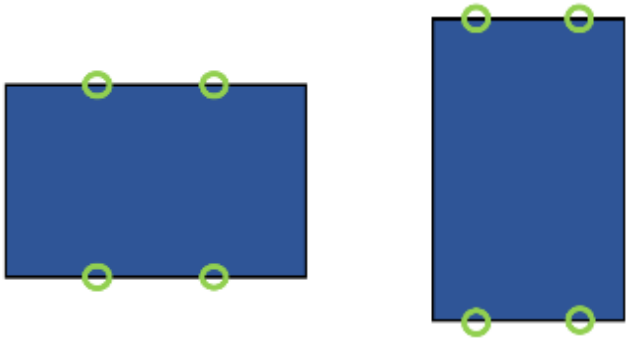
If more than 25% of a module falls in Roof Zone 2, use RZ2 spans for all Mounts touching that module.



3.4.2 Mount Placement Check

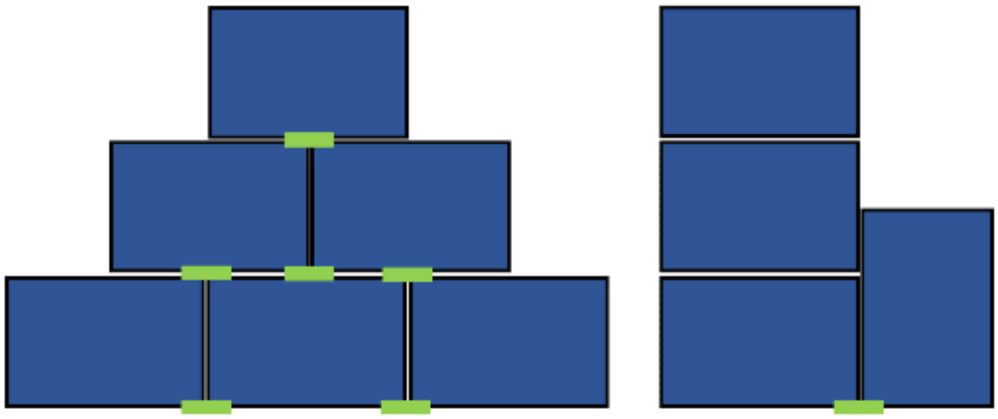
1. Verify each module must have at least one Mount on its north (up-slope) edge and one on its south (down-slope) edge.

2. Any single module columns (orphan module) must have at least (2) Mounts per supporting edge.

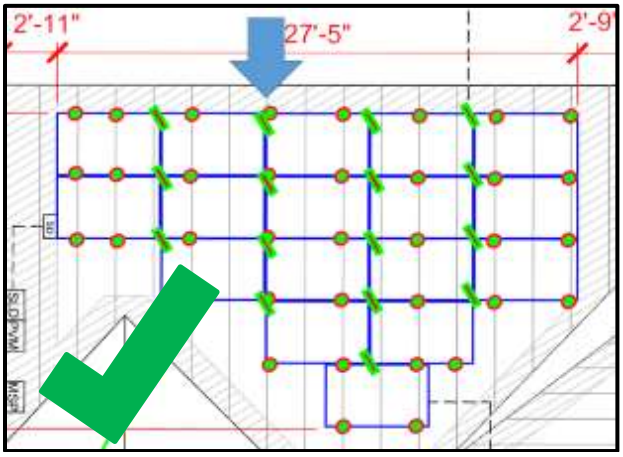


3.5 Bridge Placement

Bridges are placed at all East-West module junctions.

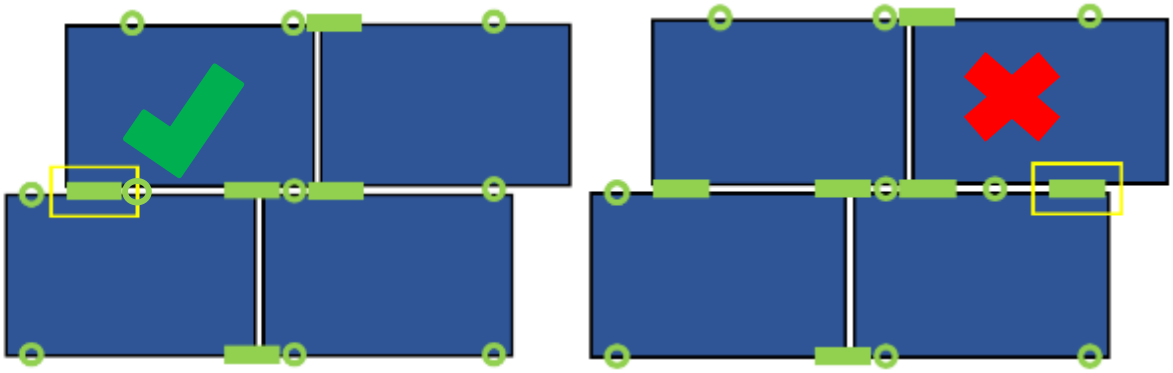


Similar to the method used for placing Mounts, start with the first row of modules, work your way left to right across the row, and then up the roof until all Bridges have been placed. Note that co-locating Mounts and Bridges is OK.

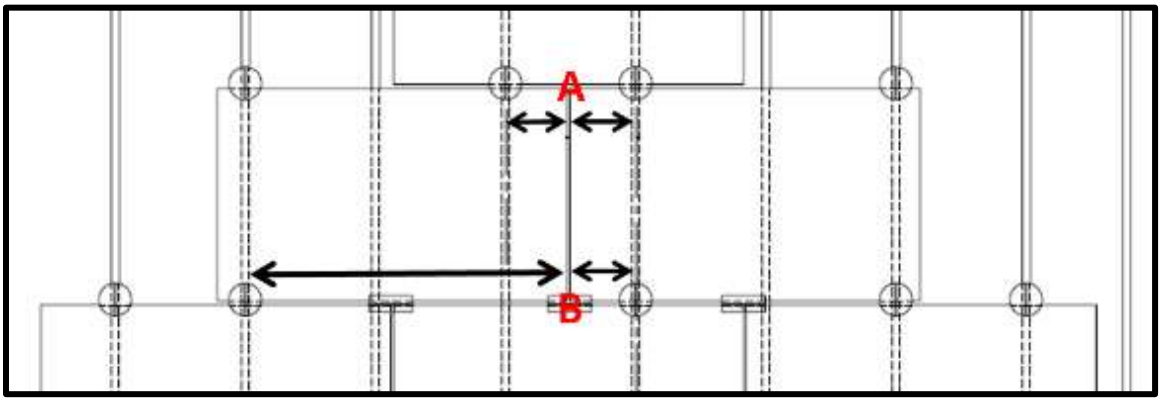


3.5.1 Bridge Placement Check

1. Verify that each Bridge is located between (2) Mounts.



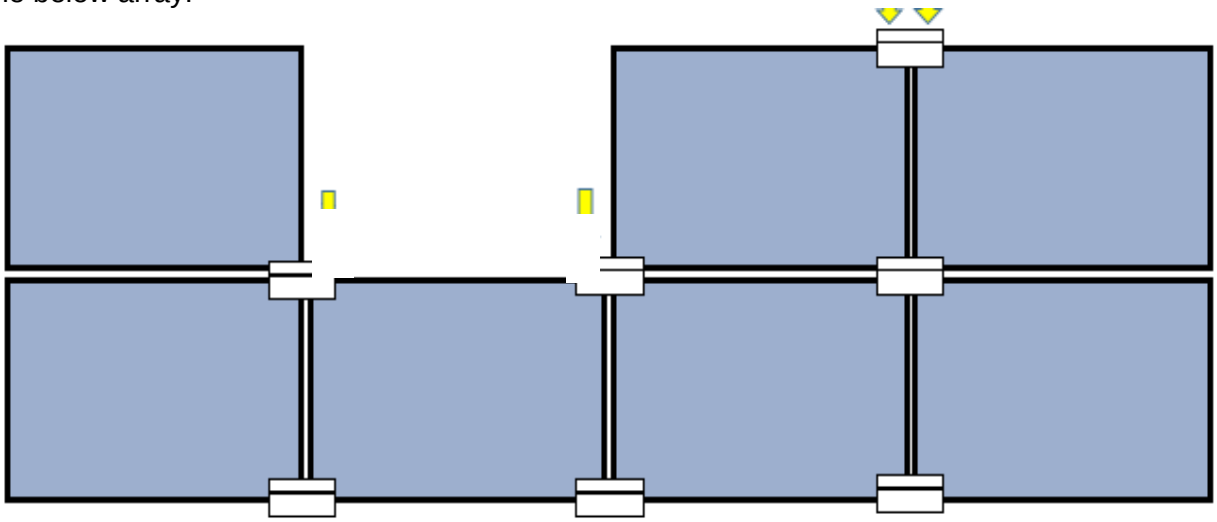
2. A Bridge is not required at an east-west junction if each of the modules being joined with a Bridge is within the cantilever requirement. For example, in the drawing below, Junction A does not require a Bridge. At Junction B, the module on the right is properly cantilevered, but the module on the left requires a Bridge to complete the span.



Note: A Bridge may be necessary for electrical bonding, even if it is unnecessary for structural support (see Section 3.7 – Electrical Grounding).

3.5.2 North Bridge Thumb Screws

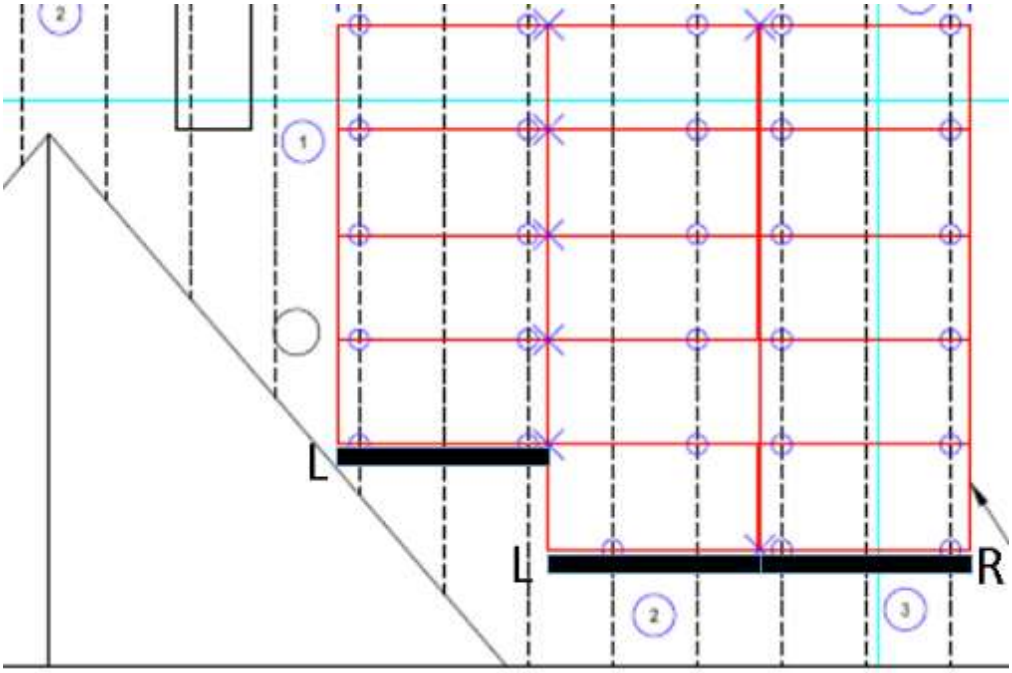
Any Bridge that does not have a module on the “north” side of the Bridge will require a thumb screw to be installed. The yellow arrows indicate where Thumb Screws would be required on the below array.



3.6 Trim and End Cap Placement

While Trim is never necessary for proper installation of an FX system, it is ALWAYS recommended. It is recommended that any module with its south-edge fully exposed have Trim installed.

Trim End Caps (L and R) are used to cover the exposed end of a Trim piece. If the Trim butts up against a module (e.g. on the inside of stair-step array), no End Cap is necessary.

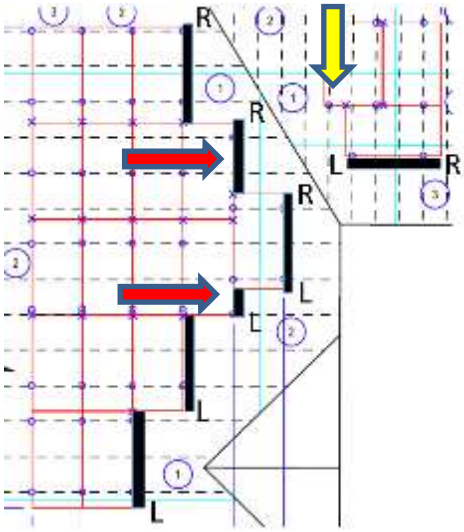


Therefore, in the image above, (3) pieces of Trim and (3) End Caps (2 Left and 1 Right) are appropriate

Both of the two arrays in the image below are staggered. They both have modules with partially-exposed southern edges. The designer can choose to omit partial pieces of Trim in such cases, based on the aesthetic benefit versus the cost of the part.

In this case, the designer decided to include partial pieces of Trim as indicated by the red arrows, and omit a partial piece of trim indicated by the yellow arrow. Trim is made from aluminum and can be cut in the field using an electric saw. The two partial pieces shown could be cut from a single piece of trim.

This design would require (6) pieces of Trim (landscape), (5) left End Caps and (4) right End Caps.



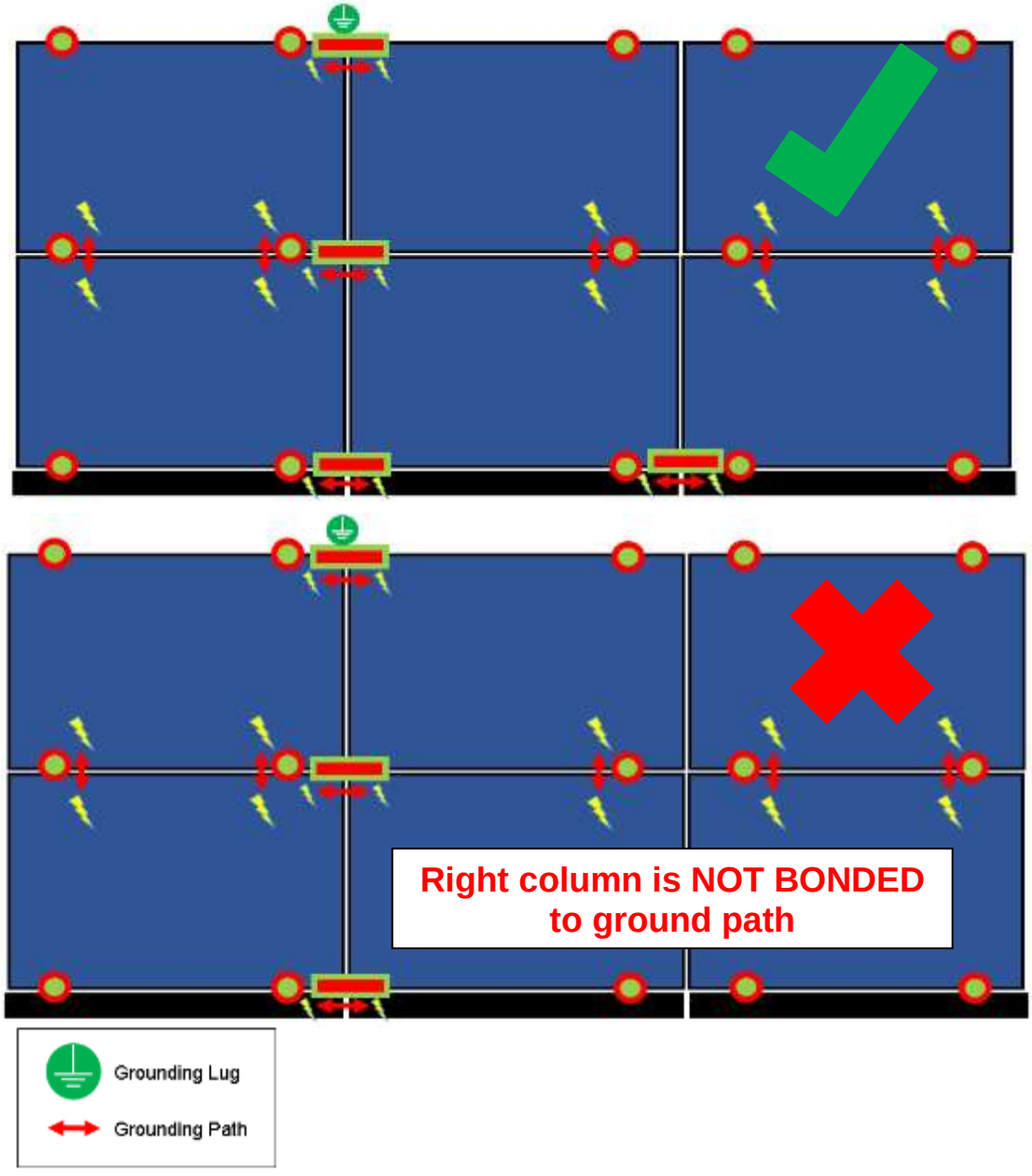
3.7 Electrical Grounding

Every module must be electrically bonded. The FX system makes bonding simple through integrated bonding.

- One Grounding Lug is required per continuous array.
- The Grounding Lug attaches easily to any Bridge along the north edge of the array.
- Each Bridge provides east-west bonding, but only along the south (down-slope) side.
    - FX can be installed without Trim, in which case the Bridges on the southern edge of the array can be turned around to provide east-west bonding.
- Each Mount provides north-south bonding

Bonding Example

In the arrays shown below, no Bridges are required between the right column and the center column for structural reasons. BUT, at least one Bridge is required for bonding.



3.8 Generate Bill of Materials (BOM)

Once all Mounts and Bridges have been placed, count up each component to generate the BOM.

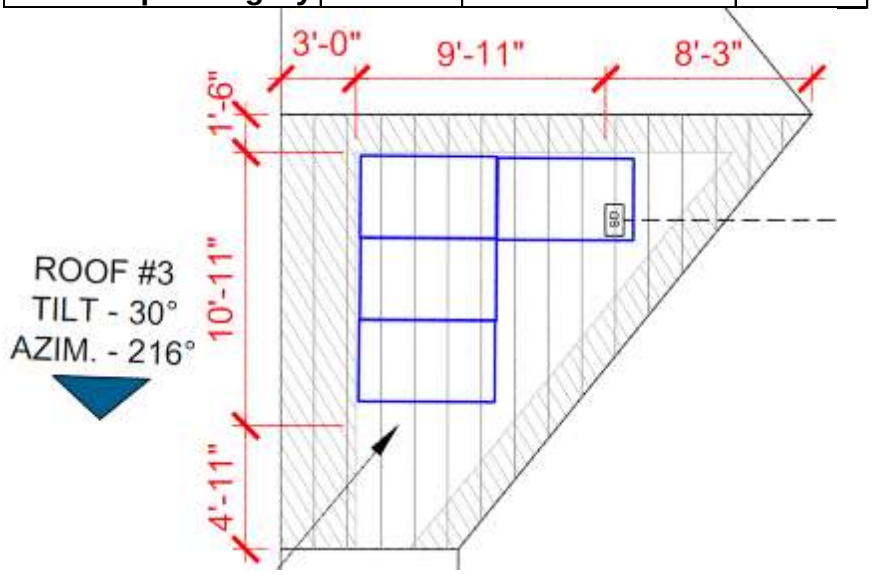
Component	Qty Req'd
Mount FX	
Bridge FX	
North Bridge Thumb Screws	
Flash FX & Hardware	
Lug FX	
Trim FX	
Trim End Caps	

4.0 Example Arrays

Example 1

Using the rules outlined above, place Mounts and Bridges on the array shown. **Assume all modules are in Roof Zone 1.**

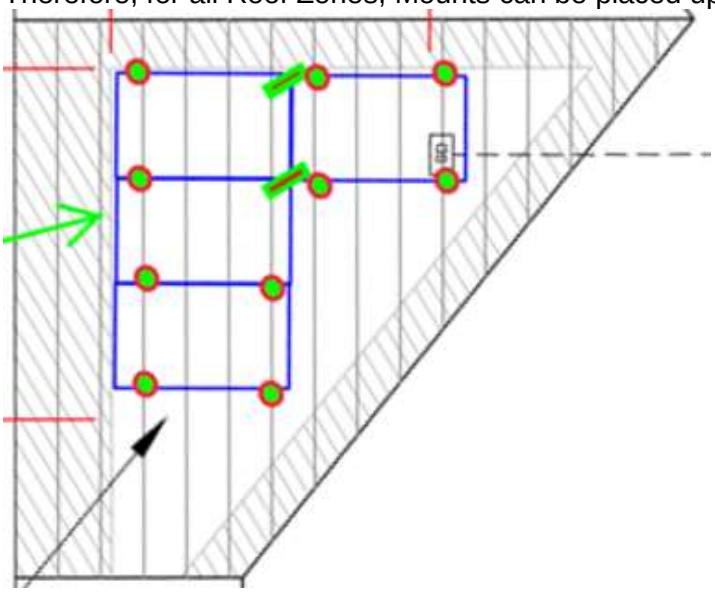
Wind Speed	115mph	**Roof Tilt**	30°
Ground Snow Load	40 psf	**Rafter Spacing**	16" OC
Exp. Category	B		



For the given site conditions, maximum spans and cantilevers are as follows:

	RZ1	RZ2	RZ3
Max Span	65"	65"	65"
Max Cantilever	22"	22"	22"

Therefore, for all Roof Zones, Mounts can be placed up to (4) rafters apart (16” x 4 = 64”).

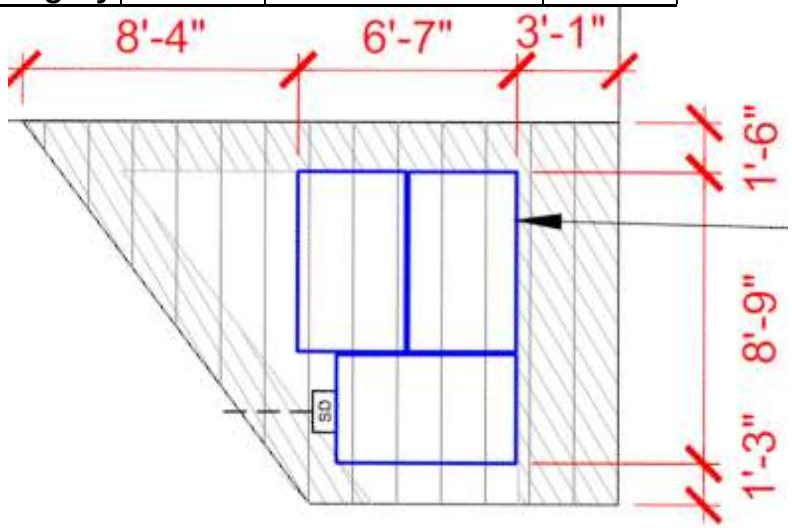


Bill of Materials	
	Qty.
Mounts	10
Bridges	2
Trim	2

Example 2

Using the rules outlined above, place Mounts and Bridges on the array shown. **Assume all modules are in Roof Zone 1**.

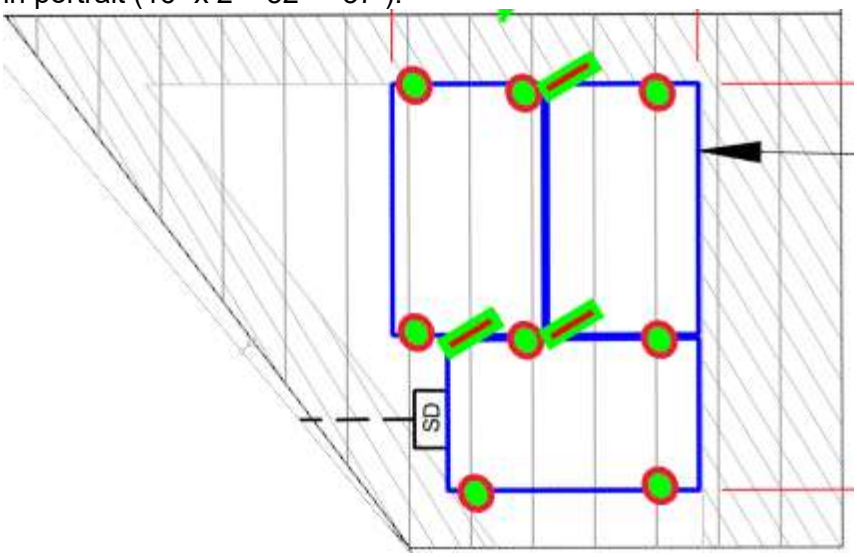
Wind Speed	115mph	**Roof Tilt**	30°
Ground Snow Load	40 psf	**Rafter Spacing**	16” OC
Exp. Category	B		



For the given site conditions, maximum spans and cantilevers are as follows:

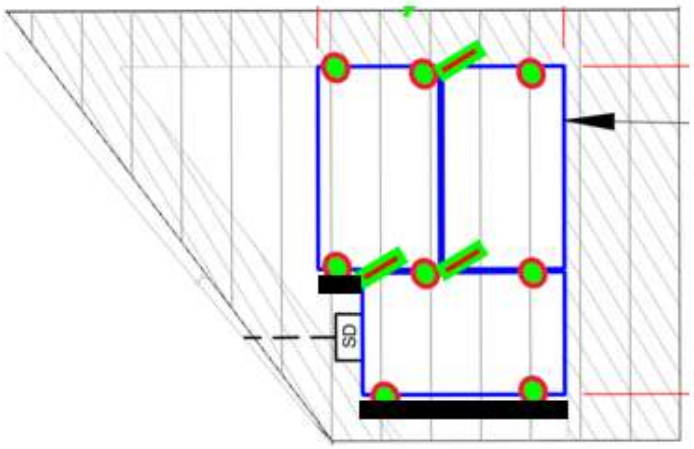
	RZ1	RZ2	RZ3
Max Span (landscape)	65"	65"	65"
Max Canti. (landscape)	22"	22"	22"
Max Span (portrait)	37"	37"	37"
Max Canti. (portrait)	12"	12"	12"

Therefore, Mounts can be placed up to (4) rafters apart in landscape, and up to (2) rafters apart in portrait (16” x 2 = 32” < 37”).



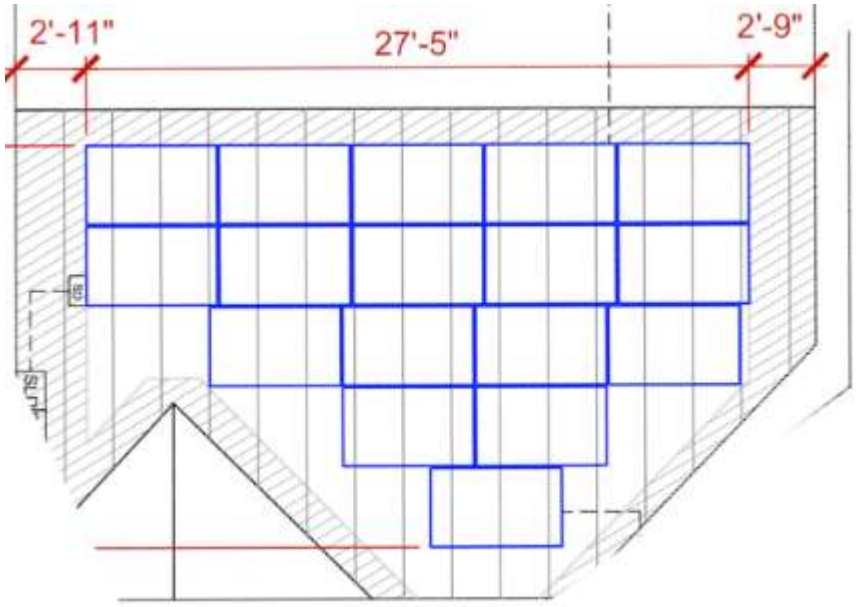
Bill of Materials	
	Qty.
Mounts	8
Bridges	3
Trim	1*

*Note: only a single piece of Trim is called out for this array. A piece of Trim could be cut to length on-site to cover the stagger, as shown below, but is not necessary. The designer will have to make an aesthetic/economic decision, whether to include such partial pieces.

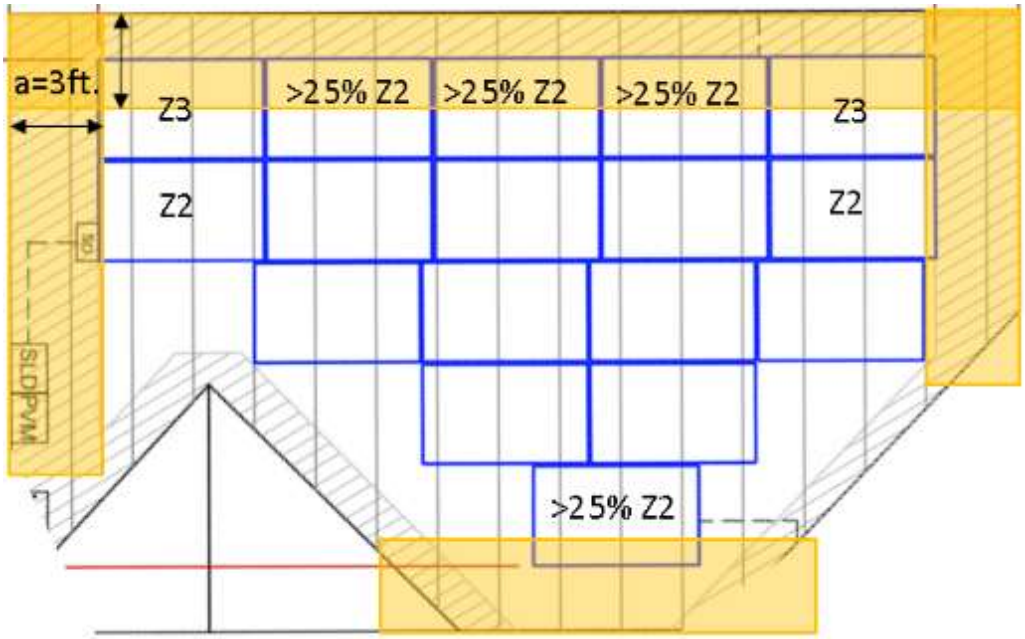


Example 3
Using the rules outlined above, place Mounts and Bridges on the array shown. **First determine Roof Zones.**

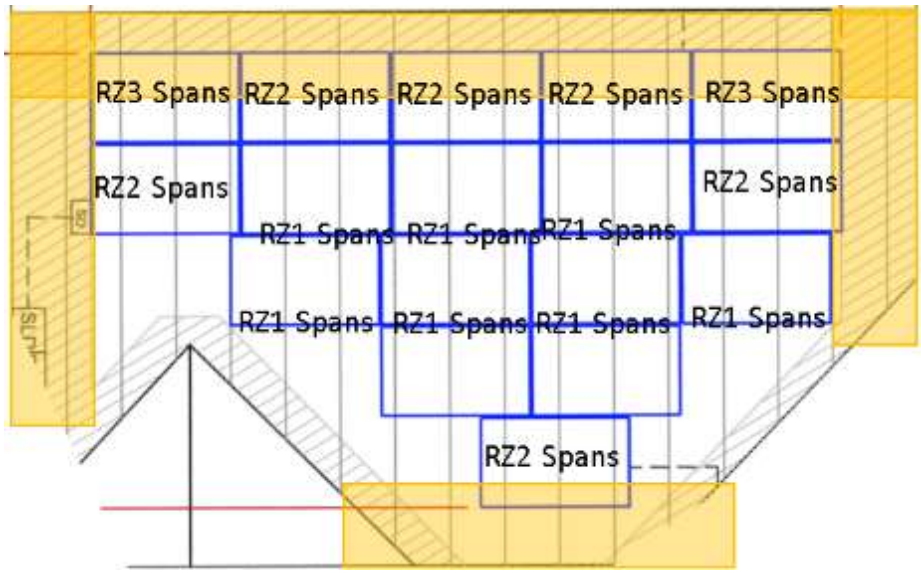
Wind Speed	115mph	**Roof Tilt**	30°
Ground Snow Load	40 psf	**Rafter Spacing**	24” OC
Exp. Category	B		



Roof Zones Applied:



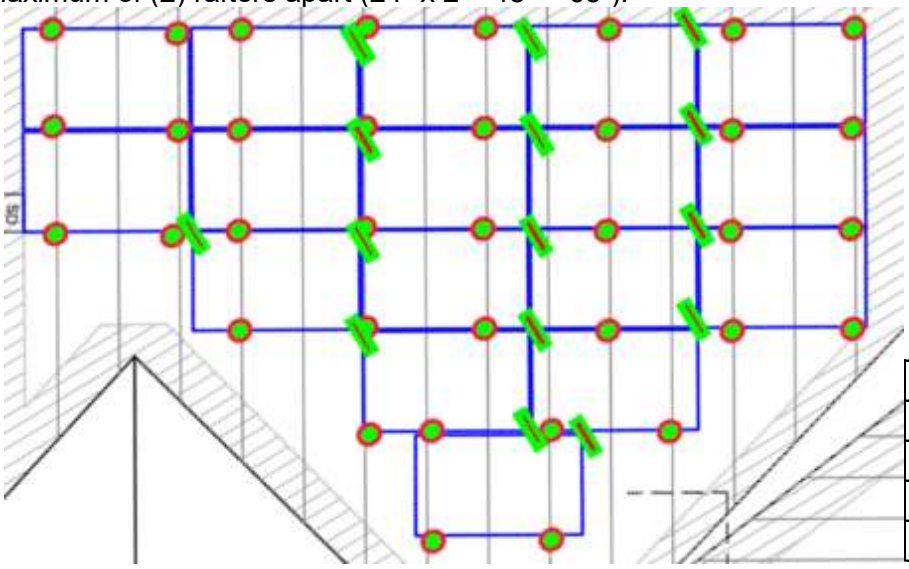
- (2) modules fall into Roof Zone 3. All Mounts touching these modules follow RZ3 spans.
- (3) modules along the north edge are >25% in Roof Zone 2. All Mounts touching these modules follow Roof Zone 2 spans.
- (2) modules along the east/west edges enter into Zone 2. Mounts touching these modules follow Roof Zone 2 spans.
- (1) module along the south edge is >25% in Roof Zone 2. Mounts touching this module follow Roof Zone 2 spans.



For the given site conditions, maximum spans and cantilevers are as follows:

	RZ1	RZ2	RZ3
Max Span	65"	65"	65"
Max Cantilever	22"	22"	22"

In this instance, maximum spans are identical across all Roof Zones. Mounts can be placed a maximum of (2) rafters apart (24" x 2 = 48" < 65").



Bill of Materials	
	Qty.
Mounts	36
Bridges	15
Trim	5

5.0 Optimizing Designs

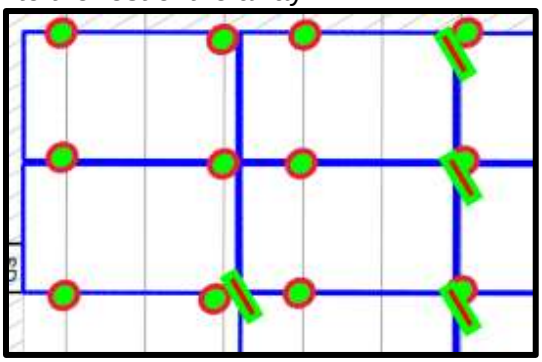
Design optimization will save the Installer both time and money.

5.1 Landscape is superior to Portrait

In most scenarios, it is more efficient and cost effective to layout modules in landscape than in portrait when using the FX system.

5.2 Optimizing Components

Example Array 3 illustrates optimization of Bridges based on 4.1.10. Structurally, the leftmost column in the array can stand on its own without any Bridges. A single Bridge is used to electrically bond the column to the rest of the array.



5.3 Trim Can Be Omitted as Desired

Especially on staggered array, where the aesthetic value is uncertain, Trim can be omitted at the designer's discretion. *See Example Array 2.*