

# Grounding Basics: Solar Panels

Grounding Made <sup>Simpler</sup> ~~Simple~~

The subject of grounding is a complex, multifaceted subject, that is often treated as an after-thought but needs to be considered from the beginning of the design and build process of any DIY Solar/Battery Project.

This is Part 3 of a 4-part series on grounding Basics.

1. [AC & Household](#)

Part 1 covers the basics of grounding for household AC systems. Even if you are familiar with house wiring, it is suggested that the reader review this paper to become familiar with the terminology concepts and practices of grounding.

2. [Stationary Systems](#)

Part 2 introduces the grounding principles of DC wiring, inverters and multiple power sources.

3. **Solar Panels (This Paper)**

Part 3 is a short overview of how to properly ground the frames and mounting racks of Solar arrays.

4. [Mobile Systems](#)

Part 4 goes through designing the grounding scheme that addresses the unique situations encountered in a mobile system.

Each of the 4 parts are written to be usable and understandable as a stand-alone paper. However, to get a broad understanding of grounding and grounding principles, it is recommended that all 4 papers be read.

# Grounding solar panel frames and mounts.

Particular attention should be paid to the grounding of solar panel frames and mounting systems.

- Solar panels are exposed to weather and therefore grounding connections can quickly degrade if not done properly.
- Solar panels are particularly susceptible to electrical storms so proper grounding becomes critical.
- Solar panel frames are often made of Anodized aluminum. The anodized coating is an insulator, so it is important to use approved components that are designed for use with the aluminum components.
- Aluminum and copper will have galvanic corrosion if they touch so properly selected grounding components are critical.
- The metal mounting frame for the panels must be connected to ground as well as the solar panel frames.
- The NEC requires that the removal of one component does not interrupt the grounding of other components.
- The Grounding conductor of the PV array must be bonded with the building equipment ground. In addition, it is permitted to have additional grounding electrodes tied directly to the PV Grounding Conductor.

There are two common types of grounding systems for PV panels and mounts:

1. Traditional: Daisy Chained Copper Wire between components.
2. Washer, Electrical Equipment Bond (WEEB)

These will both be discussed on the following pages

# Grounding solar panel frames and mounts – Traditional Daisy Chain.

The traditional method for tying ground to the Solar Panel Frames and mounts is to daisy chain a grounding conductor connecting all of the metal components.

- An approved Grounding lug that is designed to press through the Anodized layer is used on each component. These lugs use stainless steel grub screws to prevent galvanic corrosion. Note that just bolting aluminum components together does not provide adequate electrical bonding. ALL the components must have a lug to tie to the grounding conductor.
- A single grounding conductor is used to daisy chain all the components together. The Grounding conductor must either be continuous or, if spliced it must be a permanent splice using a weld or an approved crimp device.
- To avoid galvanic corrosion, the copper grounding wire must not be allowed to come into contact with the aluminum components.
- To size the equipment grounding conductor for the PV Array, use NEC table 250.122 shown in Appendix A. However, you must use 125% of the PV  $I_{max}$  as a proxy for the OCPD size in the table. (PV  $I_{max}$  is 125% of  $I_{sc}$  times the number of parallel strings. The 1.25 multiplier is there to account for increases due to temperature or irradiance variations.) This means the calculation for the grounding conductor sizing is:

$$N_p \times 1.25 \times I_{max} = 1.25 \times (N_p \times 1.25 \times I_{sc}) = \mathbf{1.56 \times I_{sc} \times N_p}$$

( $N_p$  = number of parallel strings of panels)



# Grounding solar panel frames and mounts – W.E.E.B.

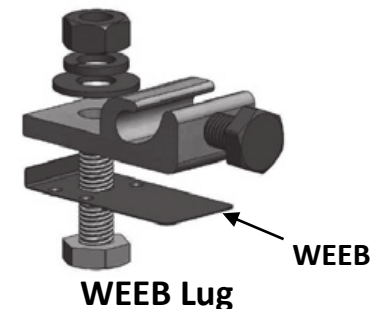
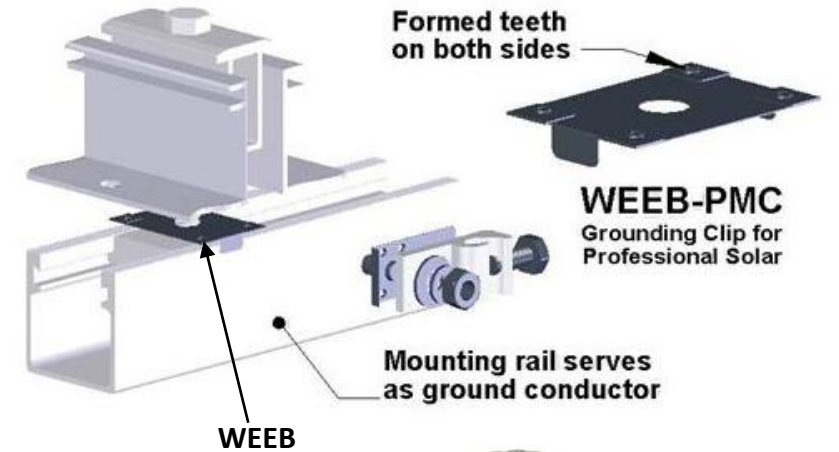
- The Washer, Electrical Equipment Bond (WEEB) is a stainless-steel washer with burs or teeth that are specifically designed to dig into the aluminum components. When bolted between the components the WEEB creates a solid electrical connection between the components.
- By using a WEEB between the panels and the mounting frame as well as between different parts of the mounting frame, all of the components are tied together into a single electrical component.

Note: The WEEB must be designed for the mounting system used.  
(Nearly all of the common mounting systems have WEEBs available for them.)

Note: There is often a need to use a WEEB Bonding jumper between rail components

- A WEEB Grounding lug can then be used to connect the whole assembly to the grounding conductor.
- To size the PV Array grounding conductor, use NEC table 250.66 shown in Appendix A. However, you must use 125% of the PV I<sub>max</sub> as a proxy for the OCPD size in the table. (PV I<sub>max</sub> is 125% of I<sub>sc</sub> times the number of parallel strings. ) This means the calculation for the grounding conductor sizing is:

$$N_p \times 1.25 \times I_{max} = 1.25 \times (N_p \times 1.25 \times I_{sc}) = \mathbf{1.56 \times I_{sc} \times N_p} \quad (N_p = \text{number of parallel strings of panels})$$

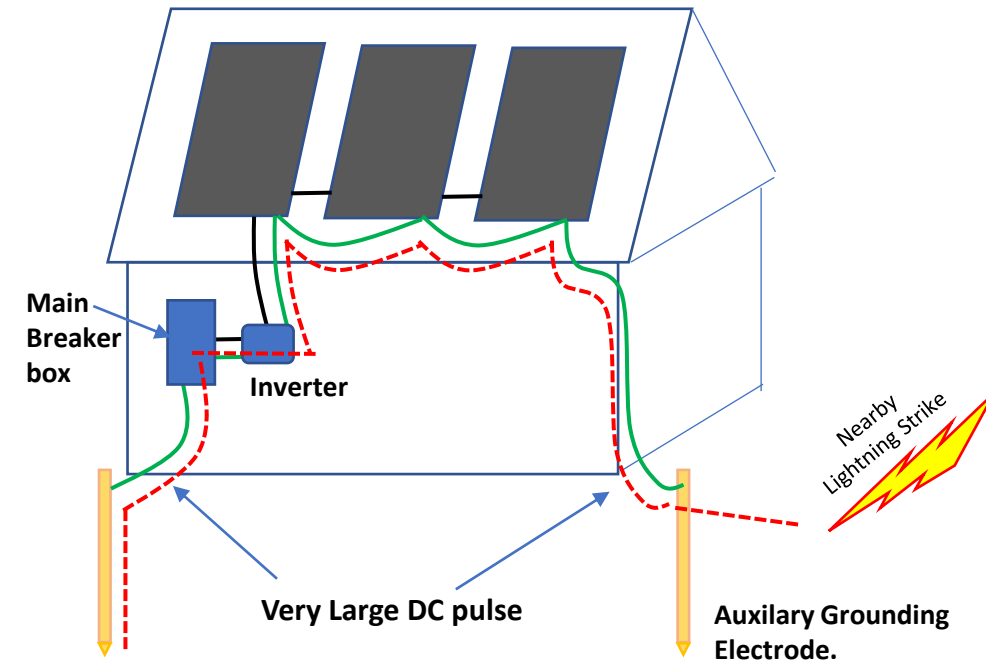


# Separate Grounding Rod for the Solar Array: DON'T DO IT!

The NEC allows (Does not require) an auxiliary Grounding Electrode for the Solar Array as shown below, but this is a bad idea. Contrary to what many internet sources tell you, adding an auxiliary grounding electrode will not help and may cause problems. Studies have shown that equipment is more likely to be damaged by lightning when there are multiple electrodes as shown in the diagram below.

The first thing to understand is that the grounding system does not and can not protect against a direct lightning strike. What tying to earth ground can do is discharge static charge and induced current from nearby lightning strikes but having an auxiliary grounding electrode can actually make things worse.

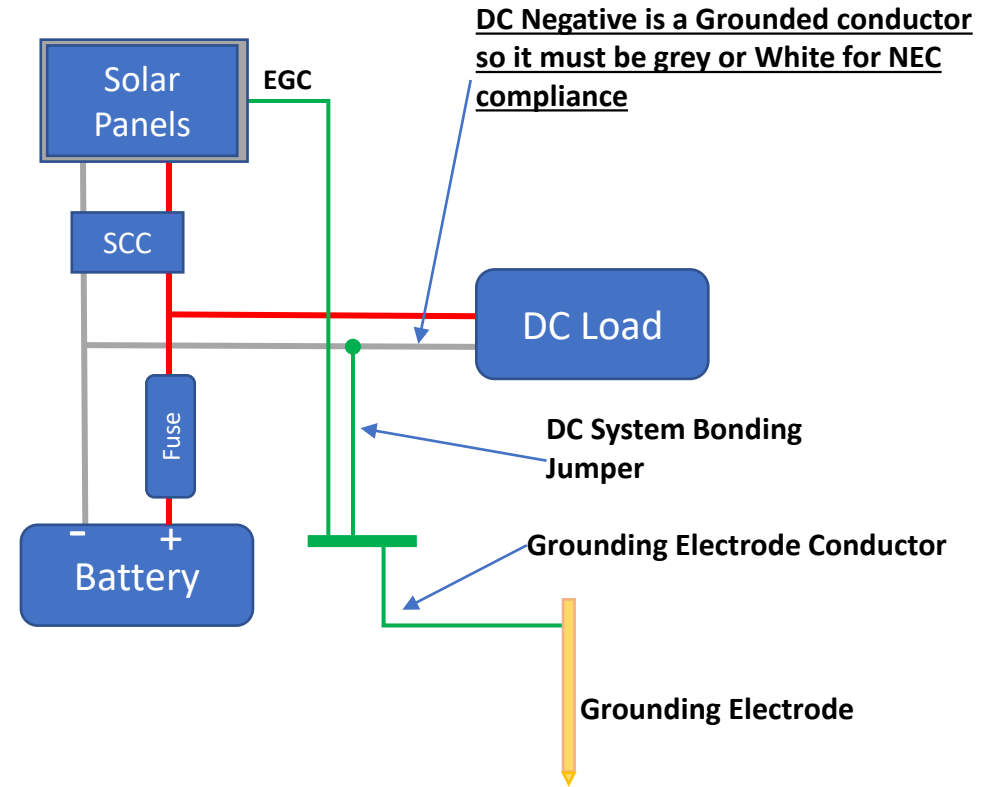
This is contrary to what many (most?) internet sources will tell you. They will tell you the auxiliary electrode 'keeps the lightning outside' However, that is not what happens. A direct strike will cause significant damage no matter how the system is grounded. However, a nearby lightning strike can cause a significant potential difference in earth ground between the two grounding electrodes. Since the grounding system represents a low impedance path, a very high voltage pulse of current can be created across the grounding system. Even if it does not arc between conductors (which it can), this high frequency pulse is a safety hazard and can induce large voltages on all the electronics around it causing significant equipment damage.



Once all of the panels and mounting frame components are tied together, the single grounding conductor should be routed to the grounding system.

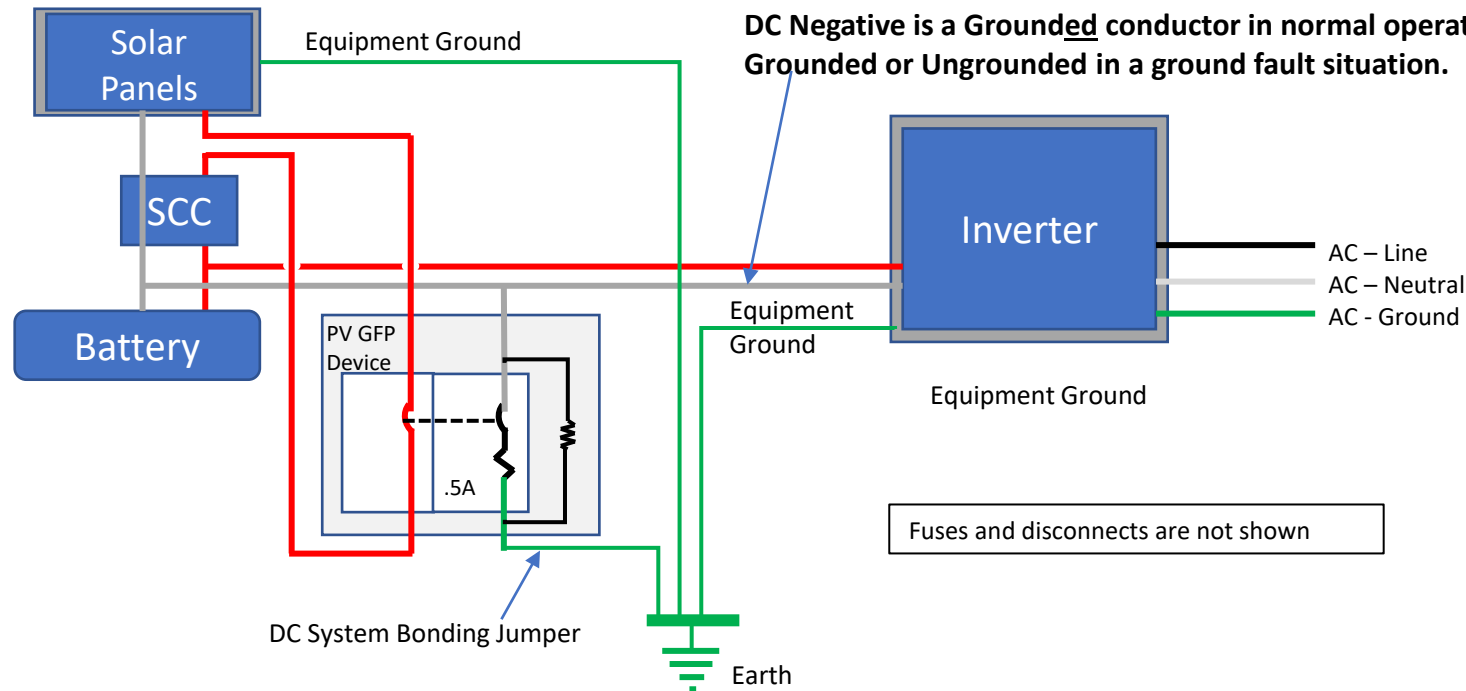
NEC requires that any dc circuit that operates at 50V or higher must be bonded to ground. To determine Max voltage, the NEC uses 125% of VOC for the max voltage of a single panel. Therefore even 2 12V solar panels in series might require the DC circuit to be grounded.

Many (most?) solar charge controllers tie PV negative to battery Negative so if your main DC circuit is tied to ground, nothing more is needed.



## Special Case: PV Ground Fault Protection and DC bonding to Equipment ground.

The rules for bonding DC circuits to equipment ground apply to Solar Panel Array circuits, but there is a special situation that should be pointed out. Normally, it is not appropriate to put a switch, fuse or breaker in a grounding circuit. However, some PV Ground Fault Protectors use a ~.5A-1A circuit breaker or fuse in series with the system bonding jumper to detect ground faults. In this case, if a ground fault occurs and the breaker trips, the DC circuit is no longer solidly grounded. In the diagram below, once the circuit breaker opens, the DC is grounded through a resistor and at that point it is a 'functionally grounded' circuit. If the PV GFP device does not have the resistor, the DC becomes 'ungrounded' when the breaker trips. Both with and without the resistor are acceptable solutions to meet NEC requirements for grounding and for Ground Fault Protection.



For more information about PV Ground Fault Protection solutions, see the resource at:

<https://diysolarforum.com/resources/ground-fault-protection-on-solar-panel-arrays.148/>

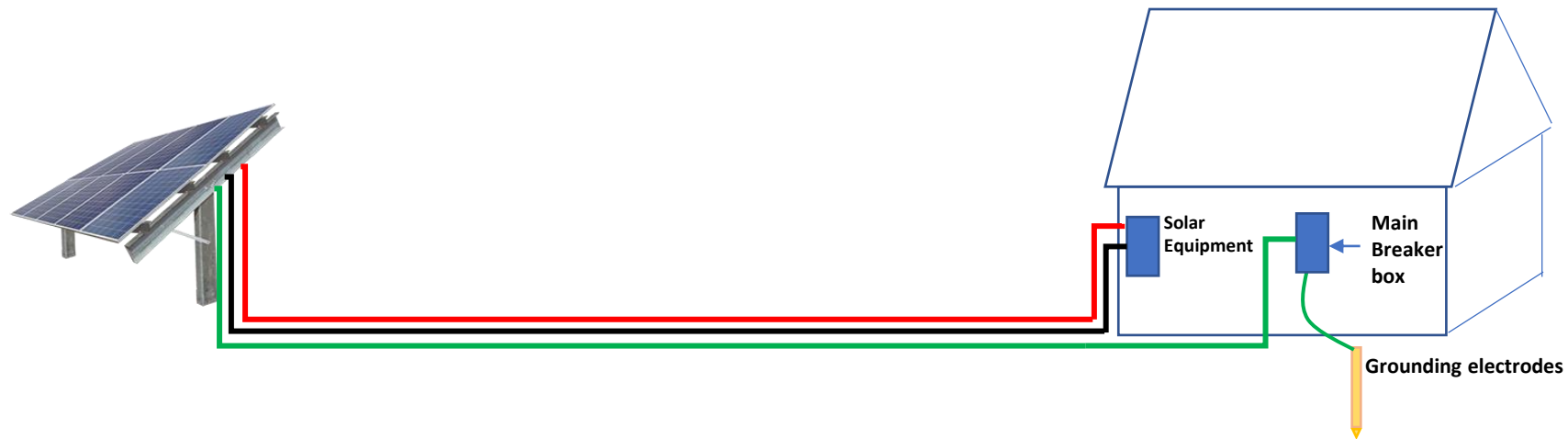
# Ground mount Panels

When there are ground mount panels pretty much all the NEC rules are the same.

- The panel frames must be connected back to the house grounding system.
- Approved grounding connections to the panel frames must be used
- Etc.

Where things get a little 'interesting' is whether there should be a grounding electrode at the panels. The NEC does not require it, but many people still do it. My preference is to not use a grounding electrode at the panels, but isolation from earth ground can be difficult to realistically achieve.

- If the mounting rack is metal, there will be some amount of grounding even if there are no dedicated grounding electrodes.
- Even with a wood mounting rack, when it is wet there will be some amount of grounding.



However, I like to tie the required ground to the house system as close to the grounding electrode as possible. In the diagram above, it is tied into the house main breaker panel. Even better would be directly to the grounding electrodes. This will keep any pulse coming down the line away from the rest of the electrical system.

## Appendix A: NEC Table 250.122

Table 250.122 Minimum Size Equipment Grounding Conductors for Grounding Raceway and Equipment

Rating or Setting of Automatic Overcurrent Device in Circuit Ahead of Equipment, Conduit, etc., Not Exceeding (Amperes)	Size (AWG or kcmil)	
	Copper	Aluminum or Copper-Clad Aluminum*
15	14	12
20	12	10
30	10	8
40	10	8
60	10	8
100	8	6
200	6	4
300	4	2
400	3	1
500	2	1/0
600	1	2/0
800	1/0	3/0
1000	2/0	4/0
1200	3/0	250
1600	4/0	350
2000	250	400
2500	350	600
3000	400	600
4000	500	800
5000	700	1200
6000	800	1200

Note: Where necessary to comply with 250.4(A)(5) or (B)(4), the equipment grounding conductor shall be sized larger than given in this table.

\*See installation restrictions in 250.120.

### International Note

The sizing requirements for equipment ground may be different outside the US

## Corrections

Feedback, Corrections and suggestions are welcome. You can post them in the comment section for the resource at the following link.

<https://diysolarforum.com/resources/grounding-made-simpler-part-3-solar-panels.160/>

Updates to this document can be found there as well.

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## About the author

I am **\*not\*** a licensed electrician.

I have a degree in electrical engineering. I know a lot about electrical wiring, solar systems and batteries from both personal experience and on-line research. I have studied a lot of the NEC code but do not consider myself an expert on it.

I gladly share my knowledge for free, but you should not consider my advice as 'professional' advice.