Ground Fault Protection(GFP) on Solar Arrays

This paper provides a basic description of Ground Fault Protection on your solar panels.

Note: PV ground Fault Protection is very different in both purpose and implementation than GFCI sockets in household AC wiring.

Disclaimer: Unless otherwise noted, I have tried to keep this document in alignment with the National Electric Code (NEC). However, this document does not address all aspects of the related code. Examples of other aspects include labeling, listing and location on various components of the system (There are others as well).

PV Ground Faults

A PV ground fault is any connection causing current to flow from the PV array to equipment ground. This can be caused by a short between one of the power lines from the array to a conductor or equipment chassis that is tied to equipment ground.

PV Ground faults can be hard to detect but can dump a substantial amount of current through the equipment ground circuit, particularly for large arrays with multiple serial strings. Consequently, a PV ground fault can pose a significant safety risk.

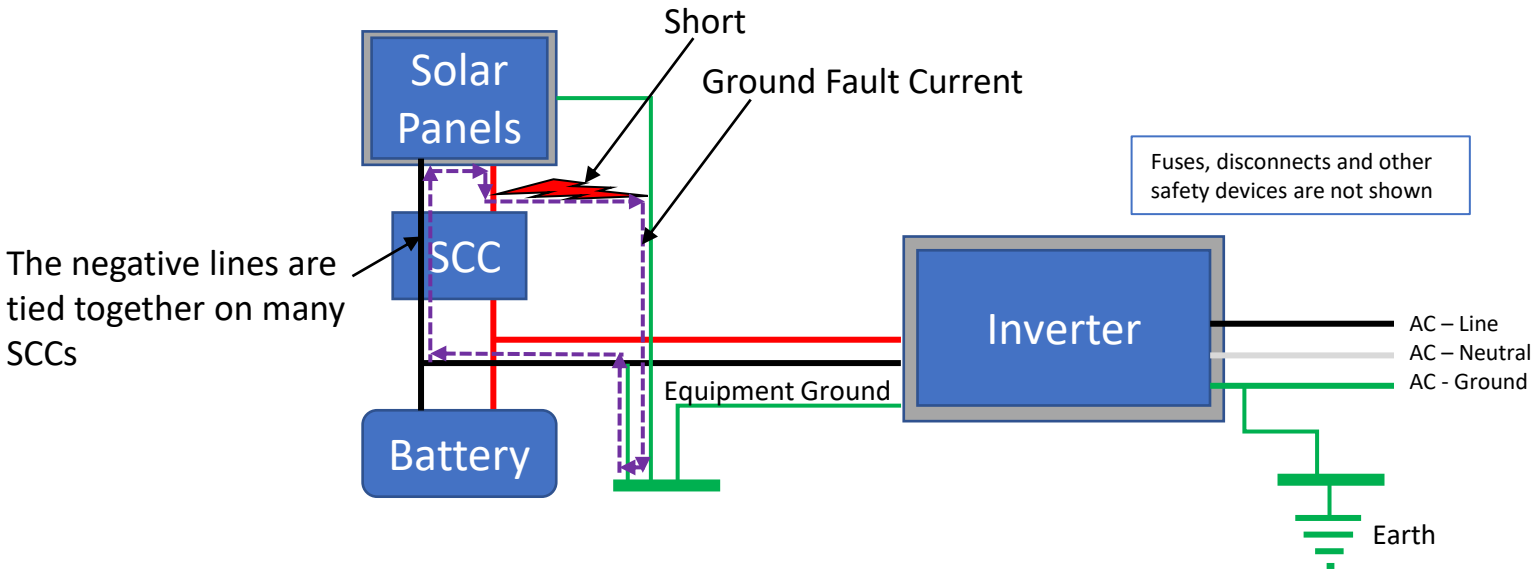
The NEC code requires virtually all PV systems that run the DC lines into a building have PV Ground fault protection (GFP).
The PV Ground fault protection must:

1. Detect the ground fault
2. Stop the ground fault current
3. Disconnect the circuit from all other equipment
4. Provide an indication that a ground fault has occurred.

Note: The PV GFP device can not also be the PV disconnect.

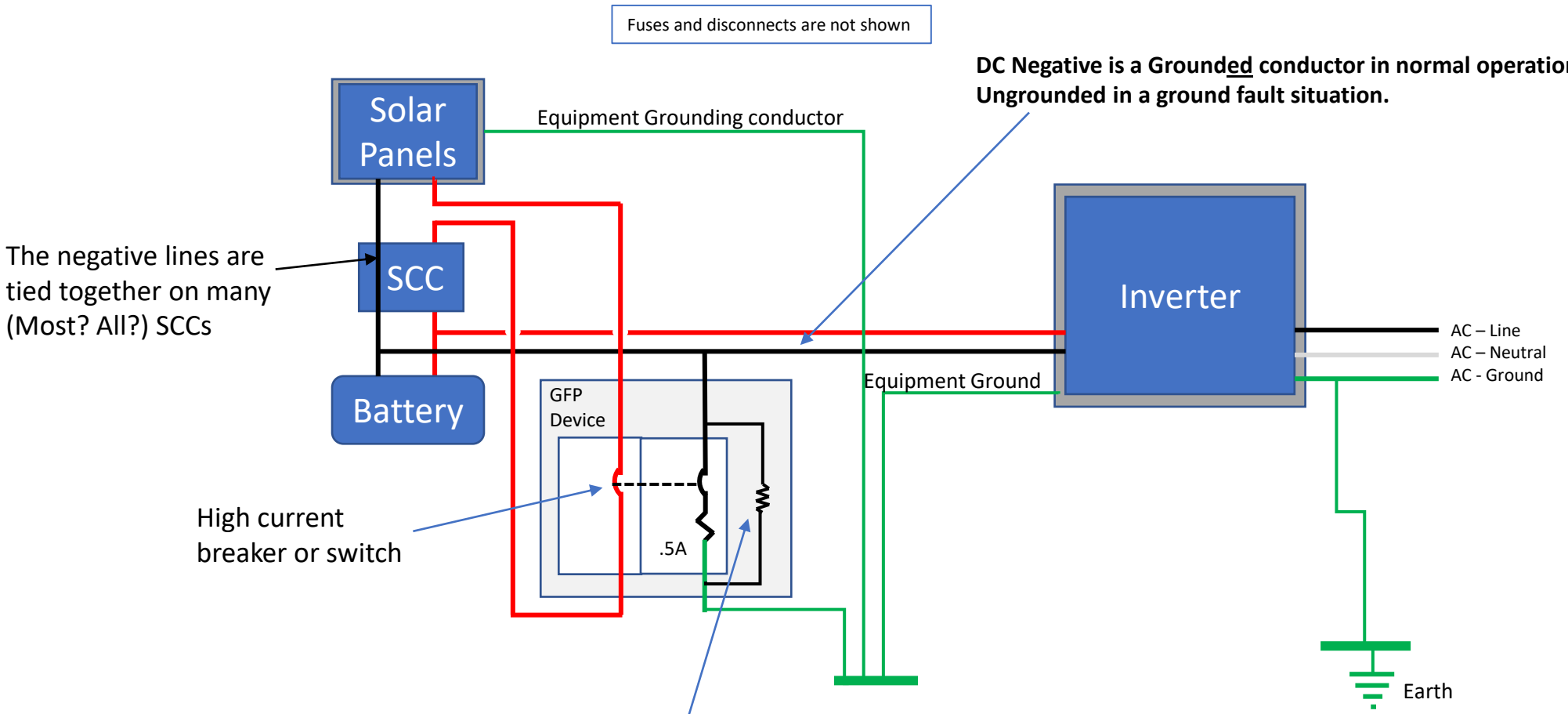
(There are additional NEC requirements like, labeling, listing and location that will not be addressed in this paper)

Note 1: PV GFP devices are primarily for fire prevention, not shock prevention.
Note 2: **PV GFP is totally different and unrelated to the AC GFP sockets that may be on your Inverter or Home AC wiring.**



PV Ground Fault Detection and Interrupt Method 1: Breaker in grounding path:

One method of detecting a ground fault and disconnecting the circuit is to put a ganged low current breaker in the ground path. (Any current through the breaker is an indication of a ground fault.) When the low current breaker reaches 0.5A, the breaker trips and 1) interrupts the ground fault and 2) disconnects the positive.

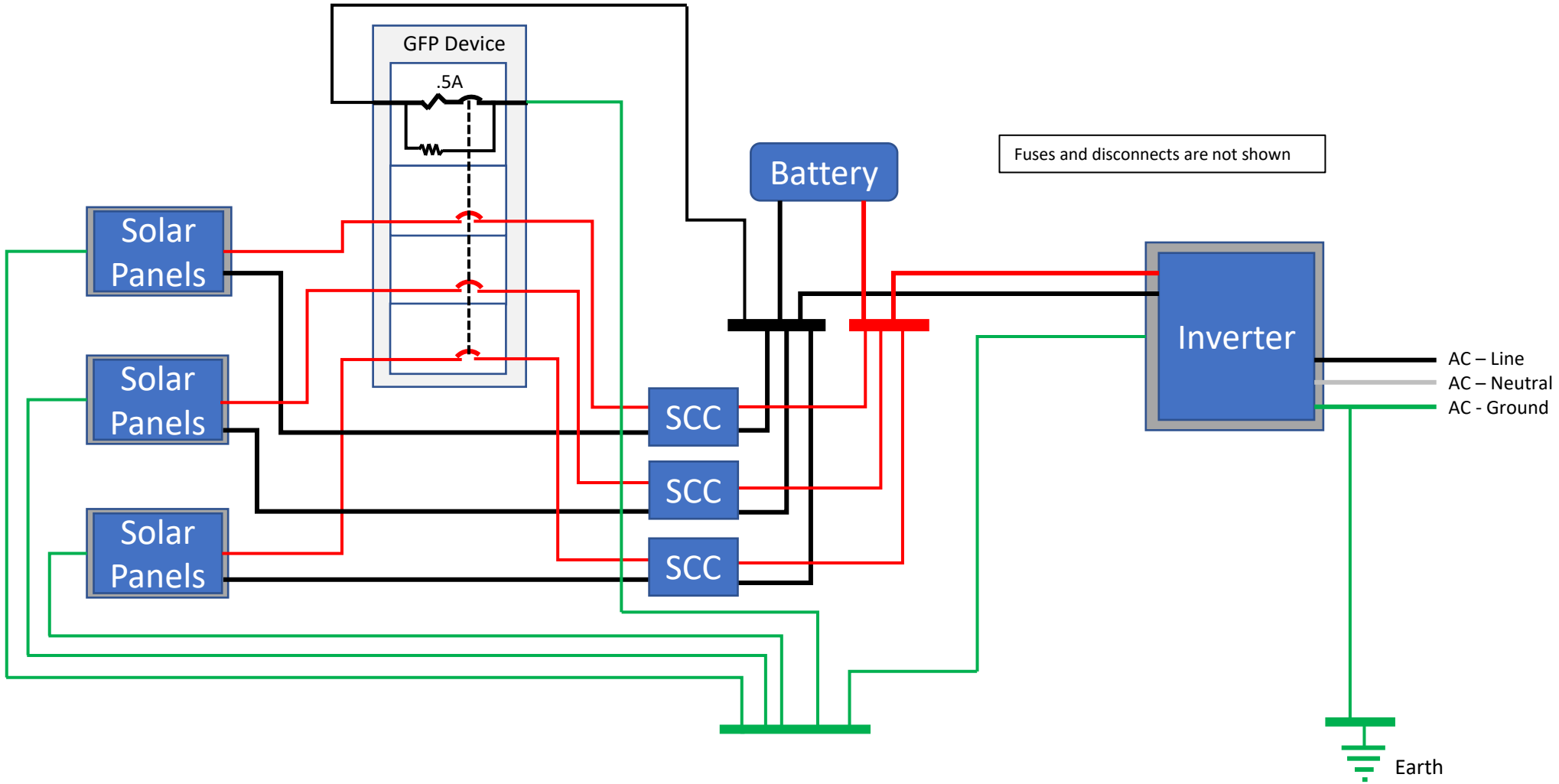


Some GFP devices place a high impendence resistor (~47Kohm) across the breaker. It is there to prevent a high static charge buildup on the DC neg after the breaker blows. However, It is not required by code.

Note: Some Arc Fault protection devices will be set up to disconnect both the positive and negative circuits from the panels in the event of a ground fault.

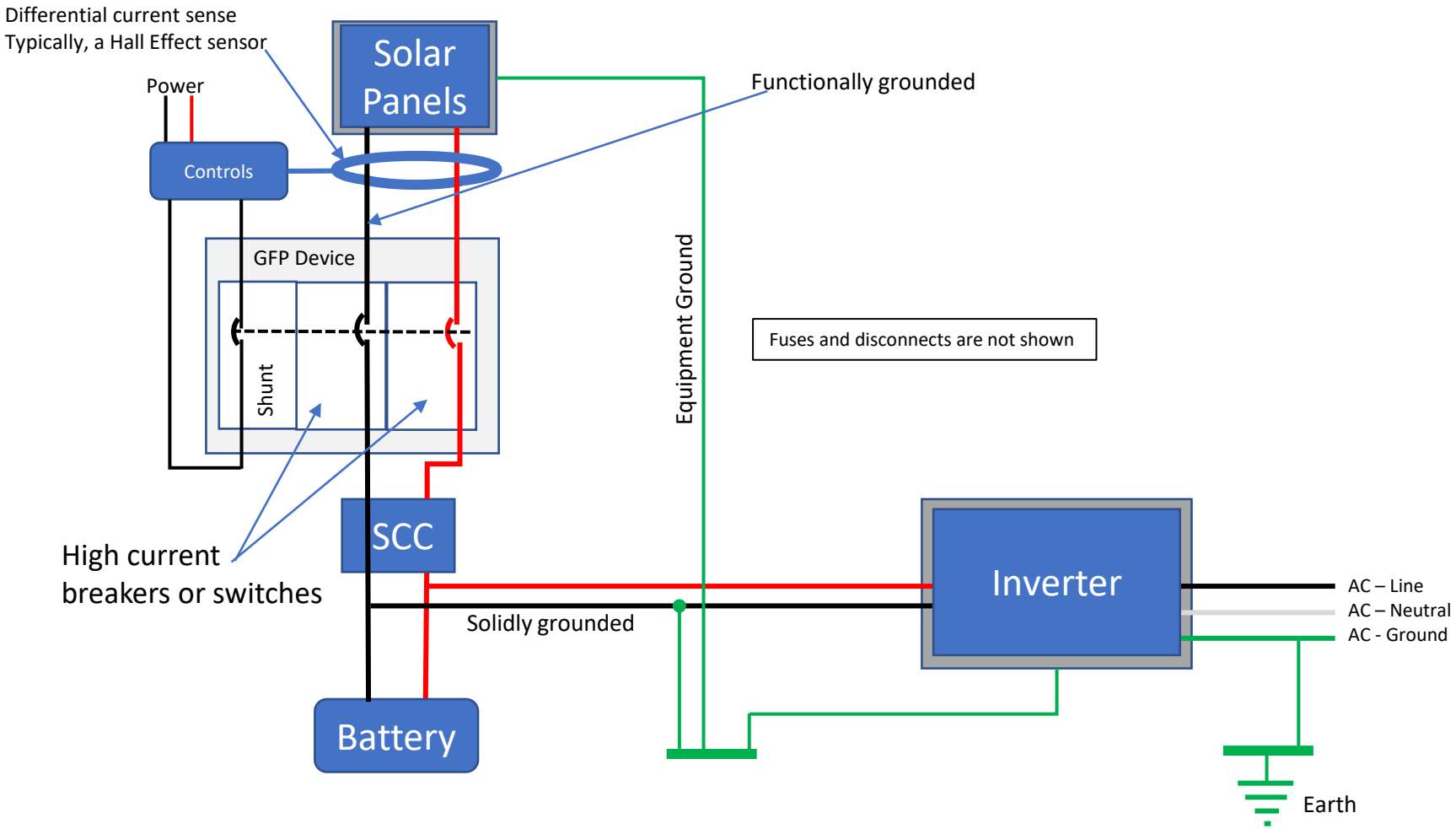
PV Ground Fault Detection and Interrupt Method 1: Breaker in ground path (with multiple arrays and SCCs).

With this design, **there can only be one breaker in the ground path.** If there were multiple breakers, the ground fault current through any one of them might not be enough to trip the breaker. Furthermore, having multiple GFPDs of this style would effectively create multiple Ground-Negative bonds which causes other issues. Consequently, if there are multiple arrays with SCCs, the one breaker must disconnect all the arrays.



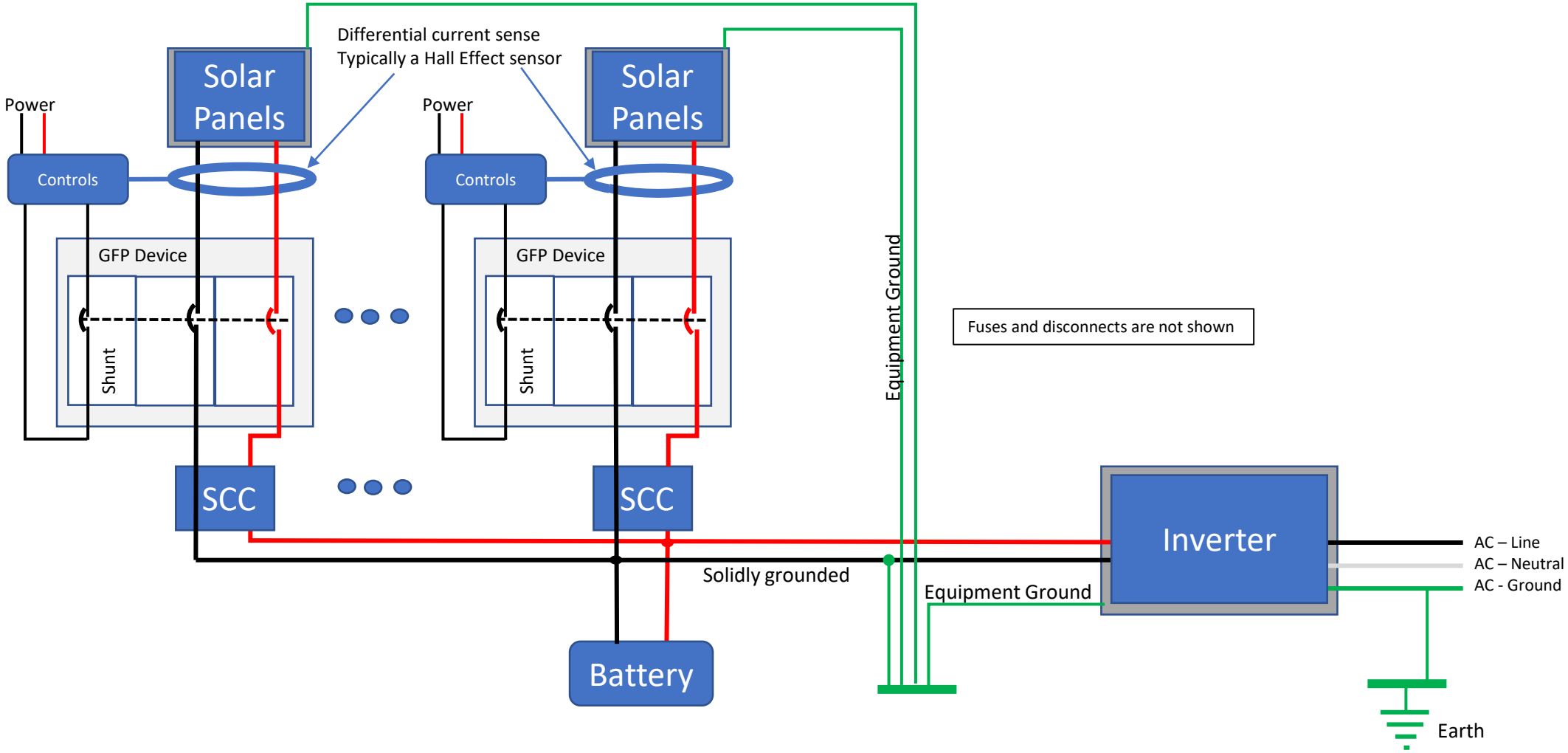
PV Ground Fault Detection and Interrupt Method 2: Current sense and compare

A second way of sensing a ground fault is by measuring the difference between the Positive and negative branches of the PV circuit. Any difference between the two is a clear indication of a ground fault. If a ground fault is detected a shunt-controlled switch is triggered to disconnect the positive and negative branches of the PV circuit. The two advantages of this is that 1) The majority of the DC negative remains solidly grounded at all times and 2) if there are multiple PV array and SCC pairs, each can have it's own separate GFP device. The downside of this method is that this type of GFP device tends to be very expensive.



PV Ground Fault Detection and Interrupt Method 2: Current sense and compare – Multiple GFPDs

Since the differential current can be measured separately for each array, it is possible to put a separate GFP device of this type on each array. Consequently, one array can have a ground fault and go offline without affecting the others



PV Ground Fault Detection and Interrupt Method 2: Current sense and compare built into the SCC.

Some Solar Charge Controllers such as the Midnite Classic have built in ground fault detection and outputs that can drive the sunt of a PV GFP Device