Bulletin 50-2-1

Grounding and bonding of solar photovoltaic systems

Rules: 10-102, 10-204,*10-208*, 10-400, 10-702, 10-808, 10-814, Tables 16 and 17

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Supersedes Bulletin 50-2-0

Scope

(1) Introduction
(2) Grounding of solar photovoltaic sources, DC grounding
  (a) Grounding of AC modules
(3) Grounding of solar photovoltaic system output, AC grounding
  (a) *Grounding of solar photovoltaic systems located remotely from the utility interface switch*
(4) Bonding

(1) Introduction

Background:

- Solar photovoltaic systems are often installed on the roofs of the buildings.
- Most have aluminum frames and exposed conductors.
- In urban areas, they may be installed near transmission lines.
- Many of the utility-interactive solar photovoltaic systems operate up to 600 Vdc. These voltages are much higher than the normal AC voltages in homes and smaller commercial buildings.

DC grounding is provided in order to:

- protect from shock and fire hazards due to generated energy
- limit the DC voltage under the fault condition
- minimize the future problems considering the life expectancy of photovoltaic modules and conductors and their exposure to the harsh environment for many years

(2) Grounding of solar photovoltaic sources, DC grounding

The following are examples of Code compliant photovoltaic system grounding scenarios:

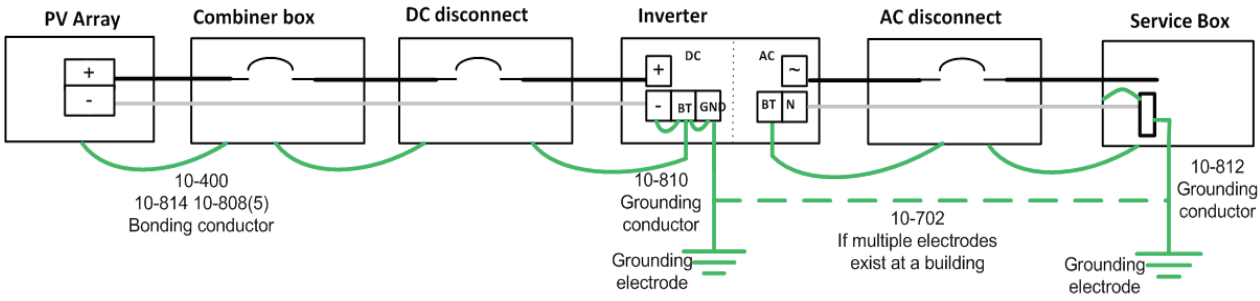
- Example 1, Diagram B1 shows remote PV grid installations e.g. remote ground mount PV “tracking systems”. The DC system is grounded to a separate grounding electrode installed at the inverter which serves as a central point for grounding connections.

  According to Rule 10-810 requirements, the grounding conductor size for DC systems shall be not less than that of the largest conductor supplied by the system.

  If DC and AC grounding electrodes exist at the same building, they shall be interconnected as per Rule 10-702 requirements.

  The DC grounding system shall have a single-point connection that connects the DC grounded circuit conductor (usually negative) to a common grounding point where the DC equipment bonding conductors and the DC grounding conductor are connected, as per Diagram B1 and B3.

Diagram B1 – Grounding of solar photovoltaic source, Example 1

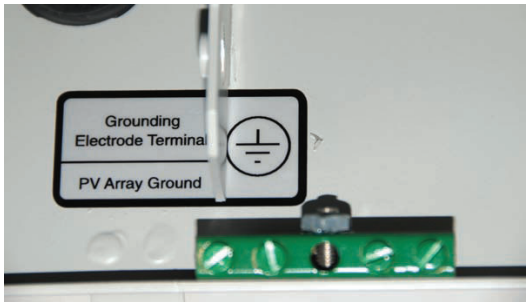


BT – equipment bonding terminal

GND – grounding conductor (electrode) terminal

Photo B1 shows an example of an inverter grounding terminal for connection of the DC equipment bonding conductors and the DC grounding conductor.

Photo B1 – Inverter grounding terminal

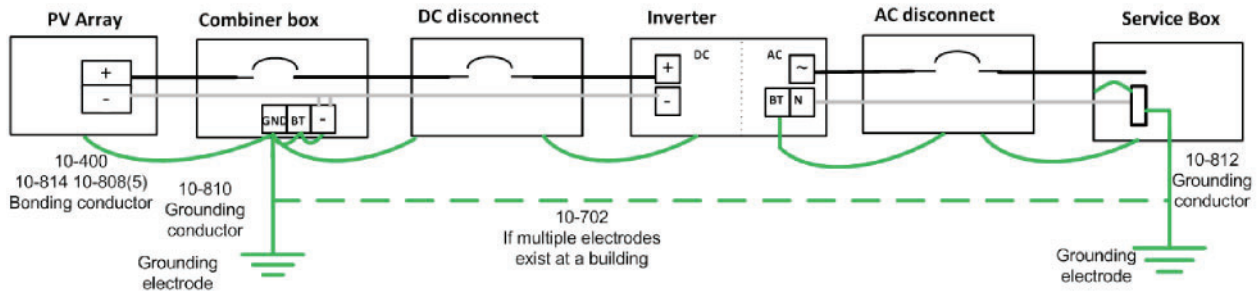


- Example 2, Diagram B2; the DC system is grounded to a separate grounding electrode installed at any point of the photovoltaic output circuit (Diagram B2 shows connection at the combiner box).

  Requirements for grounding conductor size and interconnection of DC and AC grounding electrodes (if both exist at the same building) are the same as in Example 1.

  The DC grounding system shall have a single-point connection that connects the DC grounded circuit conductor (usually negative) to a common grounding point where the DC equipment bonding conductors and the DC grounding conductor are connected, as per Diagram B2.

Diagram B2 – Grounding of solar photovoltaic source, Example 2



BT – equipment bonding terminal

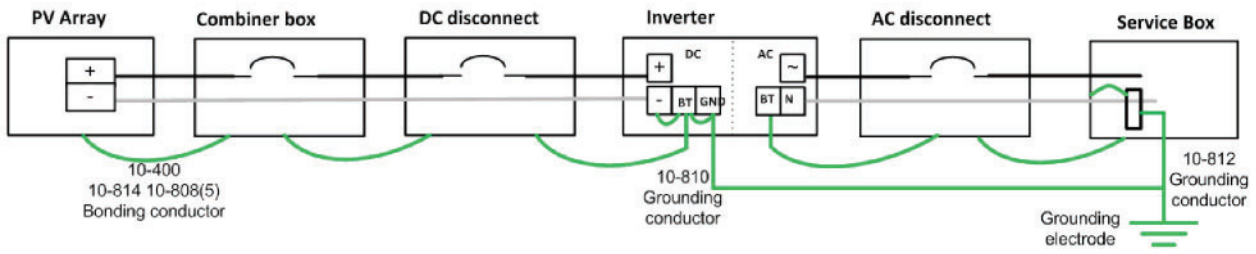
GND – grounding conductor (electrode) terminal

- Example 3, Diagram B3 shows the PV grid installations at the same building as the service equipment; e.g. PV grid installed on a roof.

  The DC grounding conductor and AC grounding conductor are connected to a single grounding electrode.

  Requirements for grounding conductor size and single-point grounding are the same as in Example 1.

Diagram B3 – Grounding of solar photovoltaic source, Example 3



BT – equipment bonding terminal

GND – grounding conductor (electrode) terminal

Most inverters certified to both UL (UL 1741) and CSA (C22.2 No 107.1) standards are designed to work with grounded photovoltaic systems and are equipped with DC ground fault protection. Although not required by the OESC, ESA recommends that DC ground fault protection be used with grounded photovoltaic systems if it is provided within the inverter.

When the inverter contains a ground fault protection device, caution should be exercised to ensure the DC grounding is located at the inverter (as per Example 1) in order to utilize the ground fault protection. Any grounding point installed externally to the inverter (as per Example 2) would bypass the inverter ground fault protection, which is not recommended.

(a) Grounding of AC modules and micro-inverters

Rule 50-002 defines AC module and Bulletin 50-1-* provides clarification for AC module unique installation requirements.

For AC modules where the inverter is an integral part of the generator (i.e. photovoltaic system) and there is no accessible DC wiring, there is no requirement or provision for DC grounding.

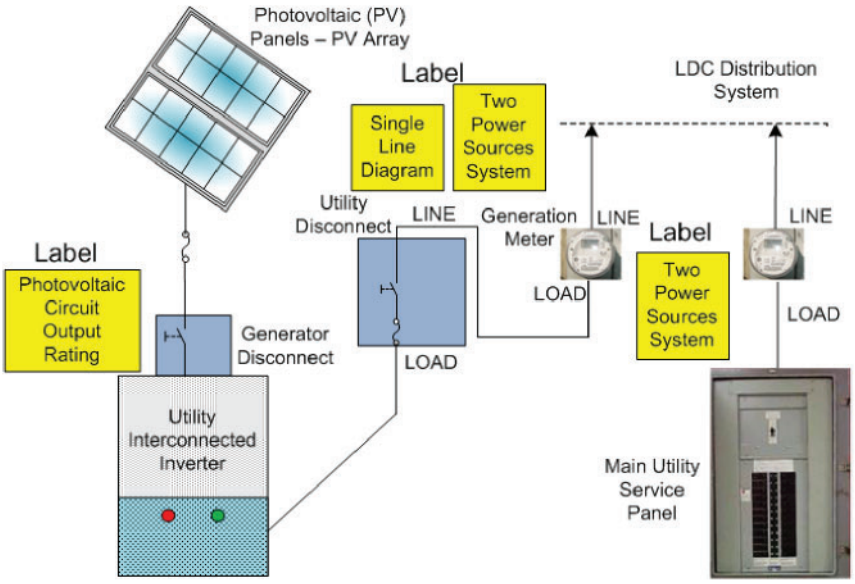
(3) Grounding of solar photovoltaic system output, AC grounding

For parallel connection of solar photovoltaic systems, depending on the point of the connection, the utility disconnecting means may be required to be an approved service box as per Diagrams B4 and B6.

- Diagram B4 shows the parallel connection of solar photovoltaic systems where the PV system is directly connected to the supply authority. The utility disconnecting means is required to be an approved service box. In accordance with Rule 10-204, the utility disconnecting means is required to be grounded as per Rule 10-106(1) requirements.

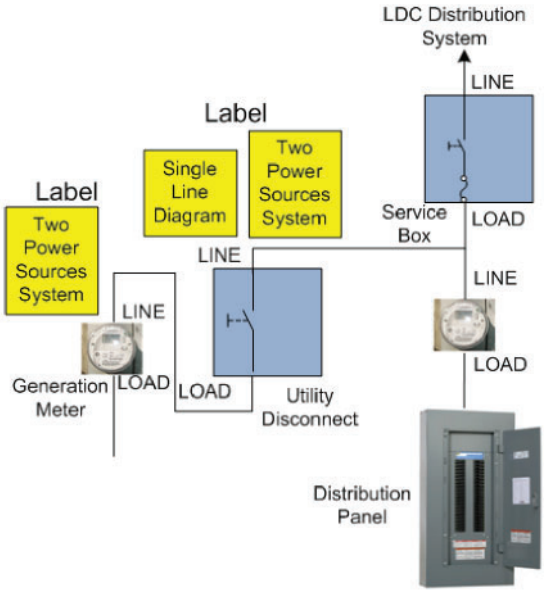
  The same requirements related to Diagram B4 are applicable where the PV system is indirectly connected to the supply authority, on the line side of the customer meter.

Diagram B4 –PV system is directly connected to the supply authority



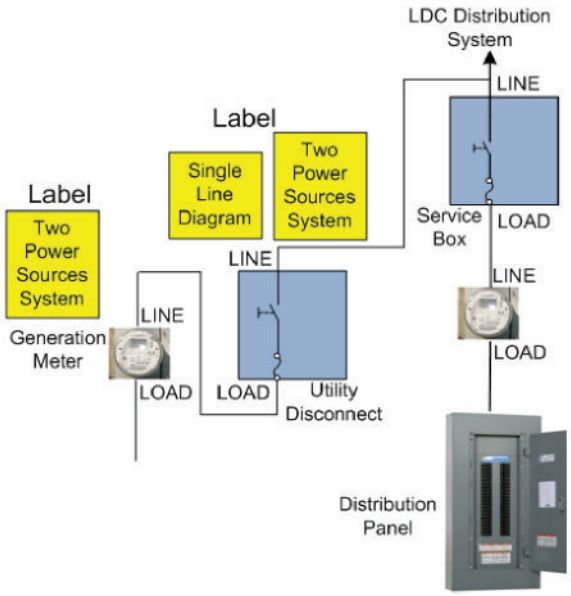
- Diagram B5 shows the parallel connection of solar photovoltaic systems where the PV system is indirectly connected to the supply authority, on the load side of the service box. The utility disconnecting means is not required to be an approved service box. Rule 10-204(1)(c) requires that no connection between the grounded circuit conductor and ground, be made on the load side of the service disconnecting means. It is important not to connect the neutral conductor to the generation meter enclosure in order to eliminate parallel paths for neutral current. The neutral bonding jumper in the generation meter enclosure shall be removed or the neutral block shall be isolated from the meter base to prevent unintentional connection. Bonding from the meter enclosure to the utility disconnecting means as well as to the inverter shall be maintained.

Diagram B5 – PV system is indirectly connected to the supply authority, on the load side of the service box



- Diagram B6 shows the parallel connection of solar photovoltaic systems where the PV system is indirectly connected to the supply authority, on the line side of the service box. The utility disconnecting means is required to be an approved service box. In accordance with Rule 10-204, the utility disconnecting means is required to be grounded as per Rule 10-106(1) requirements. The same requirements of not connecting the neutral conductor to the generation meter enclosure as clarified with Diagram 5 are applicable.

Diagram B6 – PV system is indirectly connected to the supply authority, on the line side of the service box



Where the utility disconnecting means is required to be an approved service box, to satisfy Rule 10-204 requirements, the utility disconnect service box shall be grounded to:

- a new grounding electrode installed for the new service box. The two grounding electrodes (the new and the existing) shall be interconnected as per Rule 10-702 requirements (as per Diagram B7); or
- the new service box is grounded to the existing grounding electrode (as per Diagram B8)

Diagram B7 – Service box grounded to a new grounding electrode

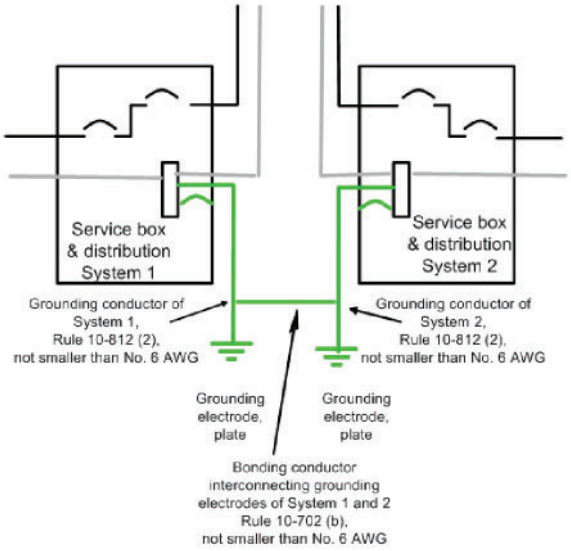
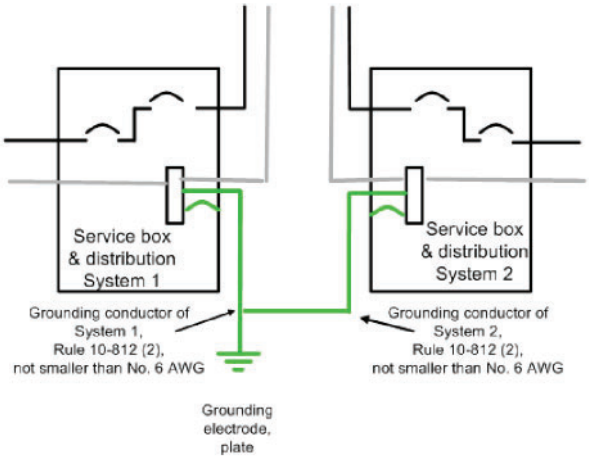


Diagram B8 – Service box grounded to the existing grounding electrode



(a) *Grounding of solar photovoltaic systems located remotely from the utility interface switch*

Question 1

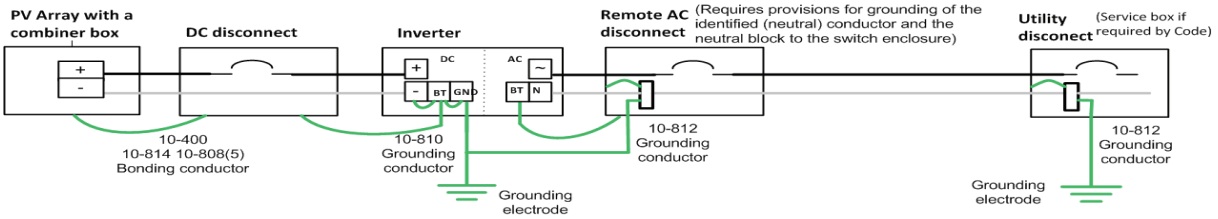
For Distributed Generation systems where the generator(s) and inverter(s) are located remotely from the utility interface switch and meter base, is it permitted to re-establish grounding of the identified (neutral) conductor at the remote location in accordance with Rule 10-208 (a) in lieu of carrying the circuit bonding conductor with the circuit conductors?

Answer 1

Yes, it is permitted to re-establish grounding of the identified (neutral) conductor at the remote location provided that the identified (neutral) conductor is routed from utility interface switch (service box) to the remote location and is grounded in a code compliant manner. Examples of acceptable remote locations where the grounding is permitted to be re-established:

- A disconnect switch that has provisions for grounding of the identified (neutral) conductor as well as bonding of the neutral block to the switch/device enclosure as per Diagram B9.
- An inverter that has a provision for grounding of the identified (neutral) conductor and termination of the grounding conductor.

Diagram B9 – Grounding of solar photovoltaic systems at a disconnect switch located remotely from the utility interface switch



Rationale 1

The answer is provided applying Rule 10-208 and considering the remote generation structure as a remote structure fed from the main building or the pole where the LDC metering and main service box are located. Rule 10-208 permits the practice for other types of installations where two or more buildings or structures are fed from a single service, and in fact requires this for buildings housing livestock.

(4) Bonding

Rule 10-400 requires exposed, non-current-carrying metal parts of fixed equipment to be bonded to ground. Therefore, non-current-carrying metal parts of PV panels, equipment and conductor enclosures shall be bonded. The bonding conductor shall be sized as per Rule 10-814 and shall be not less than that given in Table 16.

The equipment bonding conductor shall be installed in accordance with Rule 10-808(5) and (6) requirements. Rule 10-808(5)(b) and (6)(b) requires a bonding conductor smaller than No. 6 AWG copper or No. 4 AWG aluminum respectively, *to be installed and protected in the same manner as the circuit conductors, or be installed in a raceway or armoured cable*.

In accordance with Rule 50-018 requirements, the connection to a module or panel shall be arranged so that removal of a module or panel from a photovoltaic source circuit shall not interrupt a bonding conductor to other photovoltaic source equipment. Photo B2 is an example of non-compliant installation.

There is more than one way to satisfy this rule requirement, e.g. bonding the frame, where the frame is electrically continuous or connecting the bonding conductor as per Photo B3

Photo B2 – Unacceptable bonding conductor connection

Photo B3 – Example of acceptable connection of bonding conductor