

Enphase Microinverters and Ungrounded PV Arrays

Enphase M250 and new M215 with Integrated Ground—no need for a separate GEC

Overview

Enphase has developed a new microinverter family that includes the M250 and new M215 with integrated (DC isolated) ground. *Because the DC circuit is isolated and insulated from ground, these microinverters do not require a Grounding Electrode Conductor (GEC) connected between each microinverter.* The Enphase Microinverters with Integrated Ground are compatible with most 60-cell PV modules (210W to 300W STC or higher) and install quickly and easily. They work with either three-phase 208 VAC or single-phase 240 VAC services. Enphase Microinverters ship with integrated DC and AC cables and connectors. The DC connectors attach to the PV module, while the AC connector attaches to the Engage™ Cable. No additional cabling is needed.

An ungrounded array, when coupled with sophisticated features of the Enphase Microinverters with Integrated Ground, offers greater safety for the installer, system owner, and maintenance personnel. In addition to enhancing safety, the integrated ground technology streamlines, simplifies, and economizes the installation process for installers and inspectors of all project types.

This document clarifies solar grounding terminology and describes NEC (National Electrical Code) compliant grounding methods for Enphase® Microinverters with integrated (DC isolated) ground. The 2008, 2011 and 2014 editions of the NEC allow for ungrounded PV arrays based on the provisions specified in NEC article 690.35.

Features

- **Integrated ground eliminates the need for a GEC:** Enphase Microinverters with Integrated Ground isolate the DC conductors from ground. This has the significant advantage of eliminating the need for a GEC connection between microinverters.
- **Ground fault detection on board:** Enphase Microinverters with Integrated Ground offer advanced features to detect DC ground faults on either DC positive or negative conductors and always check the insulation resistance before exporting power. This eliminates the hidden ground faults that often go undetected with less mature microinverter technologies.
- **Smart disconnects:** As on all Enphase Microinverters, the AC and DC connectors are rated and listed as disconnect devices under load per the NEC requirements. This simplifies design and eliminates the need for redundant and hard-to-locate disconnect devices.
- **Ruggedized DC wiring:** Each Enphase Microinverter with Integrated Ground is built with PV (Photovoltaic) Wire for all DC conductors. This provides double insulation for protection against wire damage and meets all wiring requirements of NEC 690.35. The PV module must also use PV Wire.

PV Grounding Terms

Under NEC definitions in Article 100, two conductor types provide paths to ground. These are the Equipment Grounding Conductor (**EGC**) and the Grounding Electrode Conductor (**GEC**). Distinguishing between the **EGC** and the **GEC** is important when ensuring a photovoltaic array is code-compliant and safe. The following describes key terms from the NEC related to PV system grounding relevant to Enphase Microinverters.

For reference, grounding requirements for microinverters are covered in UL1741 while grounding requirements for photovoltaic systems are covered in the NEC under Article 250 with amendments in Article 690. Always check with your jurisdiction for information about local amendments to the code.

Underwriters Laboratory (UL) Standard 1741 grounding requirement:

In Spring 2012, UL issued a document amending UL 1741 to address inverters for connection to ungrounded PV arrays. Enphase Microinverters with Integrated Ground have been successfully evaluated against this document. Therefore, a grounding electrode terminal for the attachment of a **GEC** is not required for this microinverter. All required grounding for Enphase Microinverters with Integrated Ground is met by the AC **EGC** supplied by the Engage Cable system and meets both NEC and UL requirements.

National Electric Code grounding definitions:

The Grounding Electrode System: Described more fully in NEC Article 250 Part III, the grounding electrode system provides a network of conductors, bus bars and bonding within a facility through which a direct connection to earth is established. The grounding electrode system is comprised of the equipment ground conductor, the grounded conductor, the grounding electrode conductor, and the grounding electrode.

Grounding Electrode: Is a conducting object through which a direct connection to earth is established per the requirement outlined in NEC 250.52. Typical examples of a grounding electrode are a ground rod, buried metal pipe, plate electrode, concrete encased ground (UFER), and/or a ground ring.

Equipment Grounding Conductor (EGC): Provides a conductive path to connect normally non-current-carrying metal parts of equipment together. **EGCs** are also found in traditional household wiring and connected to the rounded contact in a three-hole, grounded wall socket. The **EGC** is also used in the PV industry to connect all exposed metal parts such as PV module frame, racking structure, wiring enclosure (combiner and junction boxes), and the microinverter chassis. With Enphase Microinverters with Integrated Ground, the **EGC** is supplied through the Engage Cable system.

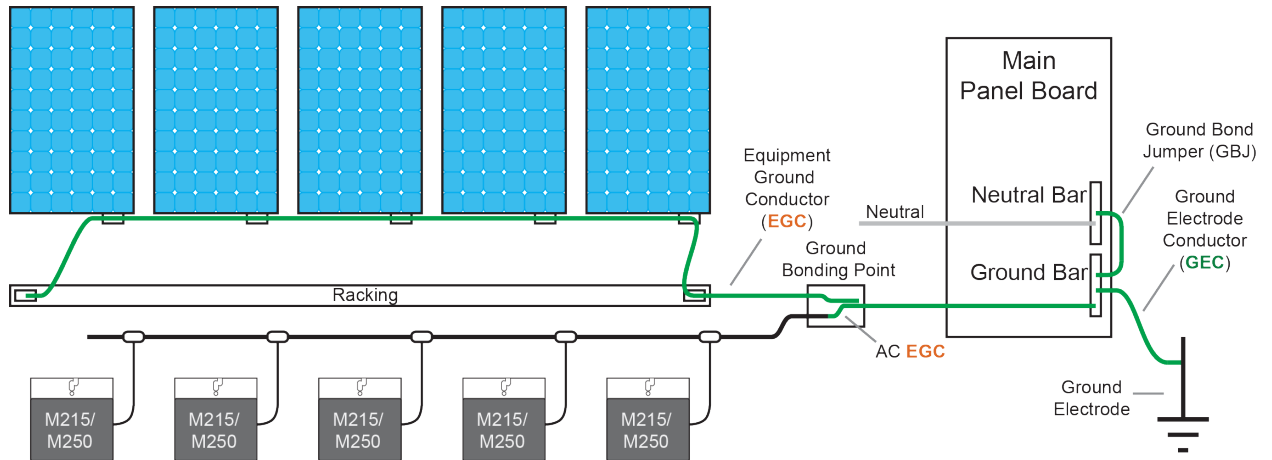
Grounded Conductor: The NEC defines the grounded conductor as a current-carrying conductor that is intentionally grounded. Examples are the Neutral conductor found in an AC system or a grounded DC conductor found in many PV systems. The point at which the current-carrying conductor is connected to ground must be connected to the grounding electrode with a **GEC**.

Grounding Electrode Conductor (GEC): The purpose of the **GEC** is to provide a conductive path to connect the common grounding point of the power system (AC or PV power systems) to the grounding electrode or to a grounding electrode system. AC or PV power system grounding is established when a current-carrying conductor is intentionally connected to ground by a **GEC**.

Building Arrays with Grounding in Mind

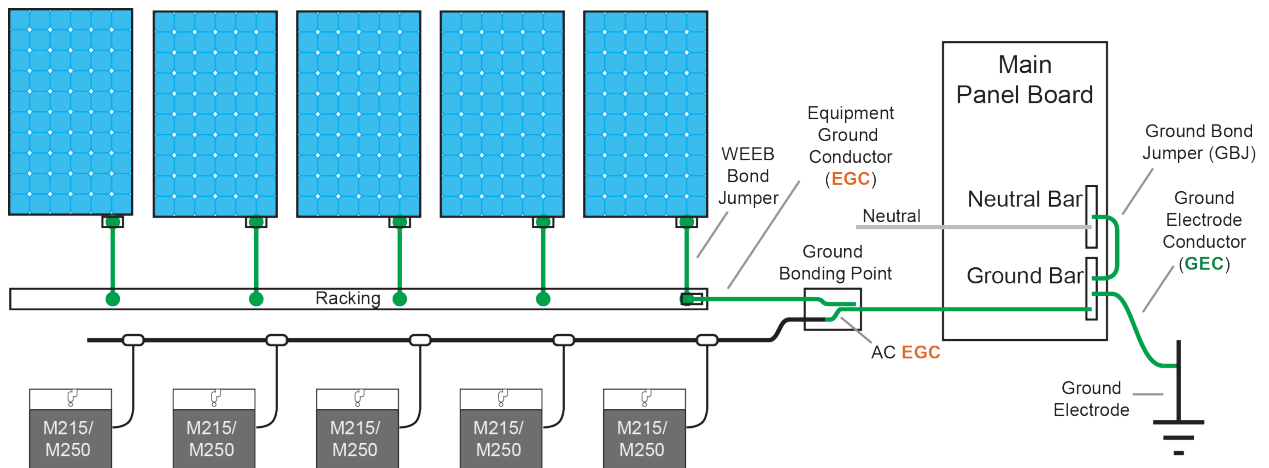
Many methods are available for installing PV systems that enable a variety of approaches both to system design and to system grounding. We discuss two common methods and place emphasis on specific grounding requirements.

- Wire EGC:** The PV modules are mounted to the racking platform with mechanical clamps and clips. As per NEC 690.43, all exposed metal must be grounded. An **EGC** provides a conductive path for the racking and PV module frames. The **EGC** is connected to each PV module frame and all racking members. The **EGC** from the array can be connected to the AC **EGC** that then connects to the AC ground system.



Enphase Microinverters with Integrated Ground with EGC Connecting PV Frames and Racking

- WEEBs:** WEEB equipment bonding washers can be used to connect the PV modules to each other or to the racking for the purpose of equipment grounding. NEC 690.43 and 250.136(A) allow for the equipment to be electrically connected to mounting structures that are themselves grounded, and the electrical connection bonds the equipment frame to ground. To be considered grounded, the mounting structure must be connected to an equipment-grounding conductor. WEEBs can only be used as part of the **EGC** system.

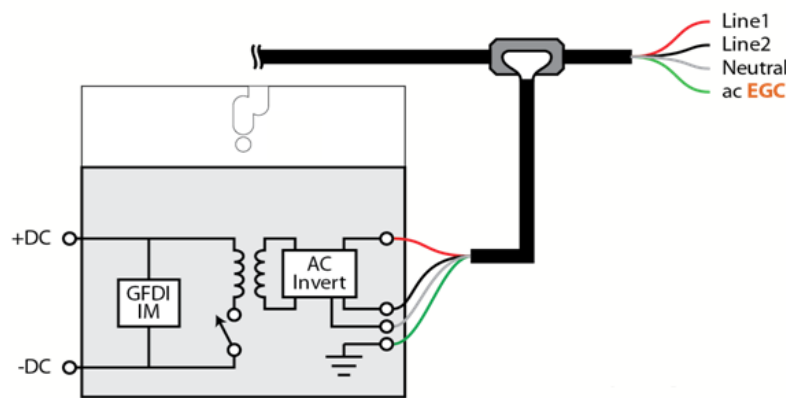


Enphase Microinverters with Integrated Ground with WEEB Ground Jumpers

Fully Integrated Microinverter System Ground

Like the Enphase M190 and the previous-generation M215, the Enphase Microinverters with Integrated Ground are utility-interactive microinverters. All Enphase Microinverters use transformer coupling to isolate the DC and AC circuits. The major difference between the grounded and integrated ground models lies within the DC input stage of the microinverter, where DC power from the module enters the microinverter. Enphase Microinverters with Integrated Ground do not ground the DC input, as did their predecessors. By isolating the DC conductors from ground, Enphase Microinverters with Integrated Ground enable the installer to create an NEC-compliant Ungrounded PV Power System (690.35, 690.41).

With the Enphase Microinverters with Integrated Ground, the grounding requirement is satisfied with an **EGC**, so a **GEC** is not required. The **EGC** is provided through the Engage Cable system that has been certified and listed for this application.



Enphase Microinverters with Integrated Ground: Ground Connections

In previous models, the DC input was bonded to ground through a GFDI circuit. This essentially grounded the PV module's output. This construction required connection from this point to the grounding electrode using a **GEC**. However, since Enphase Microinverters with Integrated Ground isolate the DC conductors from ground, only a simpler **EGC** is required. The **EGC** is provided within the Engage Cable system, which connects seamlessly to the AC power system output of the microinverter.

Enphase Microinverters with Integrated Ground detect ground faults in either the DC positive or negative conductor of the PV module by detecting the insulation resistance of each conductor to ground. Also new to Enphase Microinverters with Integrated Ground is the Insulation Monitor (IM), which measures the insulation resistance of the DC circuit with respect to ground. Together, these features offer greater safety than previously possible in any inverter technology.

Acronyms and Definitions

AC	Alternating Current
DC	Direct Current
EGC	Equipment Grounding Conductor
Engage Cable	Enphase cable system listed for use with Enphase products
GEC	Grounding Electrode Conductor
GFDI	Ground Fault Detection and Interruption
IM	Insulation Monitor
NEC	National Electrical Code
PV	Photovoltaic
WEEB	Washer, Electrical Equipment Bonding