



ELECTRICAL CONNECTIONS

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Inverters in Photovoltaic Systems

In general, inverters convert the output of an intended power source to an appropriate AC voltage and frequency for direct domestic and industrial use. More complex units can also supply power to the utility grid. Inverters are available in numerous types, sizes and configurations. Code authorities often have questions about the installation of inverters and what is needed to achieve a safe, code-compliant photovoltaic (PV) inverter installation.

Many of these concerns can be resolved by understanding what is covered by the inverter's certification, and by referencing the installation instructions.

Inverters intended to be operated in parallel with an electric power system to supply power to common loads, or as an independent power source, are investigated in accordance with the requirements in UL 1741, the Standard for Safety for Inverters, Converters, Controllers and Interconnection System Equipment for use with Distributed Energy Resources. Inverters covered by UL 1741 are intended for use in stand-alone (not grid-connected) or utility-interactive (grid-connected) power systems. Inverters

covered by these requirements are intended to be installed in accordance with the National Electrical Code (NEC).

However, not all inverters are intended to be installed with PV systems. Other types of power sources, such as fuel cells, microturbines and wind turbines, supply power through inverters specifically identified for the application. Source-type codes are marked on the inverter to identify the application for which the inverter has been evaluated. PV system inverters are identified with the source-type code "PV". The source-type codes for other inverters are "FC" (fuel cell), "MT" (microturbine), "WT" (wind turbine), "HT" (hydro turbine), and "B" (battery).



Photo provided courtesy of SMA

NEC requires listed inverters

There are several sections within the NEC that require the use of listed inverters:

- NEC Section 551.32 requires that inverters used in recreation vehicles are to be listed and installed in accordance with the terms of the listing.
- NEC Section 690.4(D) requires that inverters used with PV systems are to be identified and listed for PV systems.
- NEC Section 690.35(G) requires that inverters used in PV systems with an ungrounded PV source and output circuits are to be specifically listed for use with an ungrounded PV system.

Inverters in Photovoltaic Systems (continued)

- NEC Section 694.7(B) requires that inverters used in small wind electric systems are to be identified and listed for wind systems.
- Where inverters are installed within interactive electrical systems, NEC Sections 690.60 and 694.60 require them to be listed and identified for interactive system use.
- NEC Section 705.4 requires utility-interactive inverters used as part of an interconnected electric power production source to be listed and identified for interconnection service.

Listed inverters

Inverters are listed under the Static Inverters, Converters and Accessories for use in Independent Power Systems product category (QIKH), which is located within the UL White Book or by accessing the [UL Online Certifications Directory](#).

This category covers permanently connected inverters and converters for use in electric power systems. Inverters are devices that change DC power to AC power, whereas converters are devices that accept AC or DC power input and converts it to another form of AC or DC power for direct utilization by a load or accumulation in an energy storage system (batteries, capacitors, etc.). Devices covered under this category are classed as Utility Interactive, Stand-alone or Multimode. Utility Interactive devices operate in parallel with the utility grid. Stand-alone devices are intended to operate independent of the utility grid, whereas Multimode devices can operate as both or either Stand-alone or Utility Interactive devices.

Inverters may be connected to different types and combinations of distributed generation sources, including generator sets, photovoltaic cells, fuel cells, wind

and microturbines or other sources as specified in the manufacturer’s installation instructions. Inverters intended to be installed and operated with an external transformer are provided with markings and instructions to indicate the type of transformer required.

Inverters may also require external output overcurrent protection, which is specified within the product markings and installation instructions. These products require external overcurrent protection to be sized at 125 percent of the product output current rating unless otherwise specified. They may also require that overcurrent protection be provided in the source circuits. These protection ratings are also specified in the installation instructions.

Markings and instructions

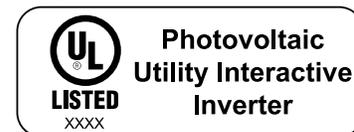
Listed inverters are marked with source types (Photovoltaic, Wind Turbine etc.), output types (Utility Interactive, Stand-alone etc.), utility applications (Anti-islanding, over/under voltage and frequency fluctuations), isolation (transformer or transformerless), input and output power configuration (Single-phase or Three-phase), maximum overcurrent protection, enclosure environmental rating, maximum ambient temperature of continuous operation at full rated power and maximum ambient operation temperature.

UL Certified inverters include a UL Listed Mark on each product.

If units are shipped in multiple sections and must be field assembled to make a complete listed product, each enclosure section is provided with a “Section ____ of ____” marking. The second blank indicates the total number of enclosure sections while the first blank indicates the respective enclosure section number bearing the UL Mark, such as Section 2 of 4.

However, for units shipped in multiple sections consisting of a complete end product and associated optional accessories the complete end product has a single Listing Mark and any accessories are labeled with one of the product designations, preceded by the words “Accessory for”.

Sample UL Listed Label



Installation instructions are required to be provided with listed inverters. These instructions include important information that is required to make sure the products are installed in accordance with their listing. Code authorities should require and review the inverter installation instructions as part of the inspection process.

For additional information on listed inverters, please contact Jeff Fecteau at Jeffrey.Fecteau@ul.com or at +1.952.838.5452.

