

NEC 2014 — Enphase System Code Compliance

Overview

This technical brief discusses new NEC 2014 requirements that apply to Enphase Microinverter Systems. It is useful for installers, electricians, and electrical inspectors or authorities having jurisdiction (AHJs) in understanding how code-compliance is handled where NEC 2014 is adopted. Main topics discussed in this document are:

- NEC 2014 Section 690.12 Rapid Shutdown of PV Systems on Buildings
- NEC 2014 Section 705.12 Point of Connection
- NEC 2014 Section 690.11 DC Arc-Fault Circuit Protection

NEC 2014 Section 690.12 Rapid Shutdown of PV Systems on Buildings

Enphase Microinverter Systems fully meet the rapid shutdown requirement without the need to install additional electrical equipment. Properly labeling the PV system power source and rapid shutdown ability is required per NEC Section 690.56 (B) and (C).

Solar electric PV systems with Enphase Microinverters have one utility-interactive inverter directly underneath each solar module, converting low voltage DC to utility grid-compliant AC. When the utility grid is available and the sun is shining, each microinverter verifies that the utility grid is operating within the IEEE 1547 requirements. Only then does it export AC power into the electric service for use by loads onsite or export power to the utility grid for others to use. When the utility grid has a failure, or the PV system AC circuits are disconnected from the utility service via an AC breaker, AC disconnect, or removal of the solar or main utility service meter, the microinverters stop producing AC power in fewer than six AC cycles. Enphase Microinverters are not capable of operating as an AC voltage source. This means that without an AC utility source, Enphase Microinverters are not able to energize connected wiring and no AC voltage or current can be injected into the inverter output circuits or the grid.

When the AC utility source is removed from the inverter output circuits via any means, such as an AC breaker, AC disconnect or removal of the solar or main utility service meter, this equipment performs the rapid shutdown function per 690.12. With an Enphase Microinverter System this shutdown occurs well within the 690.12 required 10 seconds, and there are no other conductors energized more than 1.5 m (5 ft) in length inside a building or more than 3 m (10 ft) from a PV array.

Code Reference

690.12 Rapid Shutdown of PV Systems on Buildings. PV system circuits installed on or in buildings shall include a rapid shutdown function that controls specific conductors in accordance with 690.12(1) through (5) as follows.

- (1) Requirements for controlled conductors shall apply only to PV system conductors of more than 1.5 m (5 ft) in length inside a building, or more than 3 m (10 ft) from a PV array.
- (2) Controlled conductors shall be limited to not more than 30 volts and 240 volt-amperes within 10 seconds of rapid shutdown initiation.
- (3) Voltage and power shall be measured between any two conductors and between any conductor and ground.
- (4) The rapid shutdown initiation methods shall be labeled in accordance with 690.56(B).
- (5) Equipment that performs the rapid shutdown shall be listed and identified.

NEC 2014 Section 705.12 Point of Connection (AC Arc-Fault Protection)

In this section we explain how to comply with NEC 2014 Section 705.12 Point of Connection when installing Enphase Energy Systems with:

- Supply Side Connection
- Load-Side Connection to Single-Phase 120/240 Volt Services
- Three-Phase 208/120 Volt Services

Supply Side Connection

Solution: No AC AFCI (Arc-Fault Circuit Interrupter) protection is required.

Code Reference

705.12 Point of Connection The output of an interconnected electric power source shall be connected as specified in 705.12(A), (B), (C) **or** (D).

Since the operator “OR” is used to define connection types, the code seems to intend that if one criteria is met, for example (A), the other criteria are not applicable.

Code Reference

705.12(A) Supply Side. An electric power production source shall be permitted to be connected to the supply side of the service disconnecting means as permitted in 230.82(6). The sum of the ratings of all overcurrent devices connected to power production sources shall not exceed the rating of the service.

705.12(B) Integrated Electrical Systems. ...

705.12(C) Greater Than 100 kW. ...

705.12(D) Utility-Interactive Inverters. ...

230.82(6) lists solar photovoltaic systems as eligible for equipment permitted to be connected to the supply side of the service disconnecting means. Since Enphase Energy Systems are solar photovoltaic systems, a supply side connection of an Enphase System may be accepted by AHJs to fully meet Code section 705.12. Since 705.12(A) requirements are met, it seems logical that the 705.12(D) requirements for connections to the load-side of the service disconnect means are not applicable.

Load-Side Connection to Single-Phase 120/240 Volt Services

Solution: Refer to section 90.4 and the previous code edition, NEC 2011. No **listed backfeed capable** AC AFCI solutions or acceptable equipment to enclose the cable harness exist. Until such products are generally available from manufacturers, when making load side connections, complying with **NEC 2014** Section 705.12 (D) (6) is achieved by discretionary guidance per NEC 2014 Section 90.4. This means to refer to the previous code edition **NEC 2011** Section 705.12, where AC Arc-Fault Circuit Protection is not a requirement for utility-interactive inverters.

NEC 2014 Code Reference

705.12(D) Utility Interactive Inverters. The output of a utility-interactive inverter shall be permitted to be connected to the load side of the service disconnecting means of the other source(s) at any distribution equipment on the premises. Where distribution equipment, including switchgear, switchboards, or panelboards, is fed simultaneously by a primary source(s) of electricity and one or more utility-interactive inverters, and where this distribution equipment is

capable of supplying multiple branch circuits or feeders, or both, the interconnecting provisions for the utility-interactive inverter(s) shall comply with 705.12(D)(1) through (D)(6).

705.12 (D) (4) Suitable for Backfeed. Circuit breakers, if backfed, shall be suitable for such operation.

705.12(D)(6) Wire Harness and Exposed Cable Arc-Fault Protection. A utility-interactive inverter(s) that has a wire harness or cable output circuit rated 240 V, 30 amperes, or less, that is not installed within an enclosed raceway, shall be provided with listed ac AFCI protection.

This NEC 2014 code section allows connection of an electric power source to the load side of service disconnect means and requires that the “interconnecting provisions for the utility-interactive inverter(s) shall comply with 705.12(D)(1) through (D)(6)”. Since the Enphase system contains one or more microinverters, which are the utility-interactive inverter(s), this section applies when connecting a system to the load side of a service disconnecting means. 705.12(D)(6) specifically requires that exposed AC cable systems, such as the Enphase Engage Cable, which is not feasibly run in enclosed raceway, to be protected by **listed** AC Arc-Fault Circuit Interrupter (AC AFCI) functionality. Given that utility-interactive inverters cannot operate without a utility service source, the location of the AC AFCI protecting the cable must logically be applied at the utility source side of the circuit. AC AFCI circuit breakers are the commonly available devices for single-phase branch circuits.

No suitable for backfeed AC AFCI circuit breakers exist.

Since Enphase Microinverters are utility-interactive inverters that backfeed into the electrical service through the overcurrent protection device, any AC AFCI circuit breakers must be specifically **backfeed capable**, per 705.12(D)(4).

If terminals of circuit breaker AFCIs are marked “Line” and “Load,” then the AFCI product is not backfeed capable.

No UL standard for backfeed testing exists for AC AFCI circuit breakers.

Furthermore, 705.12(D)(6) requires that ac AFCI protection must be “**listed**.” For a product or product category to become “listed,” a standard safety test procedure, such as a UL standard, must exist. The testing standard for AFCI circuit breakers is UL1699, which currently does not have provisions for testing this product category for backfeed applications. It is clear, that the code requirement is ahead of new product availability.

Summary

Until **suitable for backfeed** and **listed** AC AFCI circuit breakers become generally available, an AHJ is permitted to refer to 90.4, i.e., the previous code edition, NEC 2011.

Code Reference

90.4 Enforcement.

This Code may require new products, constructions, or materials that may not yet be available at the time the Code is adopted. In such event, the authority having jurisdiction may permit the use of the products, constructions, or materials that comply with the most recent previous edition of this Code adopted by the jurisdiction.

Three-Phase 208/120 Volt Services

Solution: The compliance solution for systems interconnected to three-phase systems is to defer to NEC 90.4. There are no three-phase AC AFCI detection devices in existence. Until backfeed capable three-phase AC AFCI circuit breakers become generally available, an AHJ is permitted to refer to 90.4, i.e., the previous code edition, NEC 2011. Additionally, the NEC 210.12 code intention for any AC AFCI protection is for single-phase applications in dwellings or dormitory units and not meant for three-phase applications, example:

Code Reference

210.12 Arc-Fault Circuit-Interrupter Protection. ...

210.12(A) Dwelling Units. All 120-volt, single-phase, 15- and 20-ampere branch circuits.....

210.12(B) Branch Circuit Extensions or Modifications — Dwelling Units. ...

210.12(C) Dormitory Units. All 120-volt, single-phase, 15- and 20-ampere branch circuits

Although Chapter 7 applies to “Special Conditions,” the industry must be able to supply generally available equipment that is safe to use and meets the requirements for these special applications. For 705.12(D) (6) this is not the case for three-phase applications as there are no listed three-phase AC AFCI detection devices available.

NEC 2014 Section 690.11 DC Arc-Fault Circuit Protection

This requirement is for direct current (DC) Arc-Fault Circuit protection and only applies to systems with DC voltages above 80 VDC. Enphase Microinverter systems are exempted from this requirement as they always operate well below 80 VDC. The requirement is basically unchanged from the NEC 2011, and it is unnecessary to add DC AFCI to an Enphase Microinverter System installation.

Code Reference

690.11 Arc-Fault Circuit Protection (Direct Current). Photovoltaic systems with dc source circuits, dc output circuits, or both, operating at a PV system maximum system voltage of 80 volts or greater, shall be protected by a listed (dc) arc-fault circuit interrupter, PV type, or other system components listed to provide equivalent protection.