690.11 Arc-Fault Circuit Protection (Direct Current)

PV systems operating at 80V dc or greater between any two conductors must be protected by a listed PV arc-fault circuit interrupter or other component listed to provide equivalent protection. The system must detect and interrupt arcing faults from a failure in the continuity of the conductor, connection, module, or other dc system component.

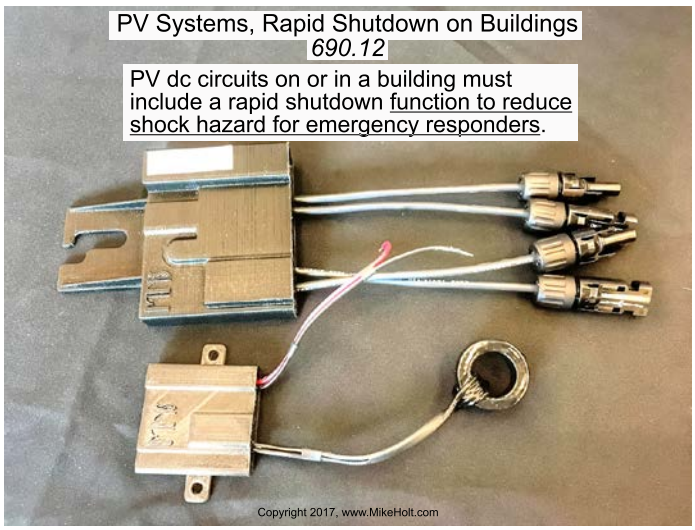
Note: Annex A includes the reference for the Photovoltaic DC Arc-Fault Circuit Protection product standard.

Ex: AFCI protection isn't required for PV systems not installed on or in buildings, PV output circuits and dc-to-dc converter output circuits that are direct buried, or if installed in metallic raceways. A detached structure whose sole purpose is to house PV system equipment isn't considered a building according to this exception.

690.12 Rapid Shutdown of PV Systems on Buildings

Scan this QR code for a video of Mike explaining this topic; it's a sample from the DVDs that accompany this textbook.

PV dc circuits on or in a building must include a rapid shutdown function to reduce shock hazard for emergency responders in accordance with 690.12(A) through (D). ▸Figure 690–54



▸Figure 690–54

Ex: A rapid shutdown system isn't required for ground-mounted PV system circuits that enter buildings whose sole purpose is to house PV system equipment.

(A) Controlled Conductors. The rapid shutdown system requirements only apply to PV dc circuit conductors.

(B) Controlled Limits. The use of the term "array boundary" in this section is defined as 1 ft from the array in all directions. Controlled conductors outside the array boundary must comply with 690.12(B)(1) and those inside the array boundary must comply with 690.12(B)(2).

(1) Outside the Array Boundary. Effective January 1, 2017, PV dc circuit conductors located further than 1 ft from the array or more than 3 ft from the point of entry inside a building must have a rapid shutdown system that limits the PV dc circuits conductors to not more than 30V within 30 seconds of rapid shutdown initiation.

(2) Within the Array Boundary. Effective January 1, 2019, PV array conductors within 1 ft of the array must have a rapid shutdown system in accordance with one of the three following requirements:

(1) The PV array must be listed or field labeled as a rapid shutdown PV array.

Note: A listed or field labeled rapid shutdown PV array is evaluated as an assembly or system.

(2) PV dc circuit conductors located within 1 ft of the PV array or not more than 3 ft from the point of penetration of the surface of the building must be limited to not more than 80V within 30 seconds of rapid shutdown initiation.

(3) A rapid shutdown system isn't required for PV dc circuit conductors having no exposed wiring methods, no exposed grounded conductive parts, and installed more than 8 ft from exposed grounded conductive parts.

(C) Initiation Device. The rapid shutdown initiation device, when placed in the "off" position, will initiate rapid shutdown of the PV array. For one-family and two-family dwellings, the rapid shutdown initiation device must be located outside the building at a readily accessible location.

The rapid shutdown initiation device must be one or more of the following:

(1) The service disconnecting means

(2) The PV system disconnecting means (ac disconnect)

(3) A readily accessible switch that plainly indicates whether it's in the "off" or "on" position

Where multiple PV systems are installed with rapid shutdown functions on a single service, the initiation device(s) must consist of not more than six switches or six sets of circuit breakers. The initiation device(s) must initiate the rapid shutdown of all PV systems with rapid shutdown functions on that service.

Where auxiliary initiation devices are installed, these auxiliary devices must control all PV systems with rapid shutdown functions on that service.

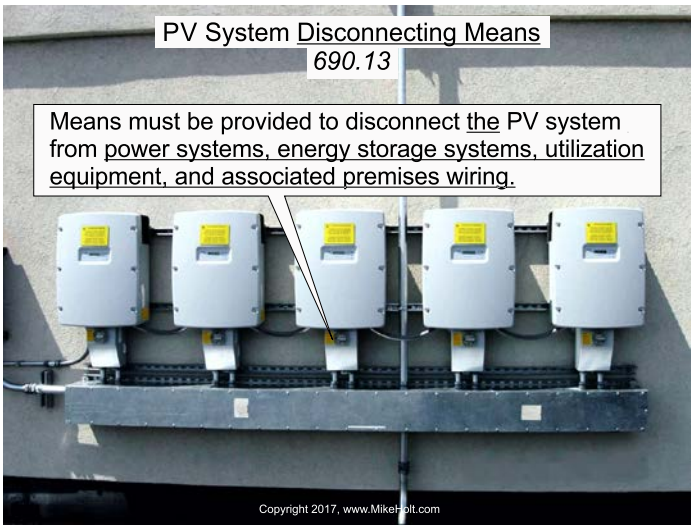
(D) Equipment. Equipment that performs the rapid shutdown functions, other than initiation devices, must be listed for providing rapid shutdown protection.

Note: Inverter input dc circuit conductors can remain energized for up to 5 minutes with inverters not listed for rapid shutdown.

Part III. Disconnecting Means

690.13 PV System Disconnecting Means

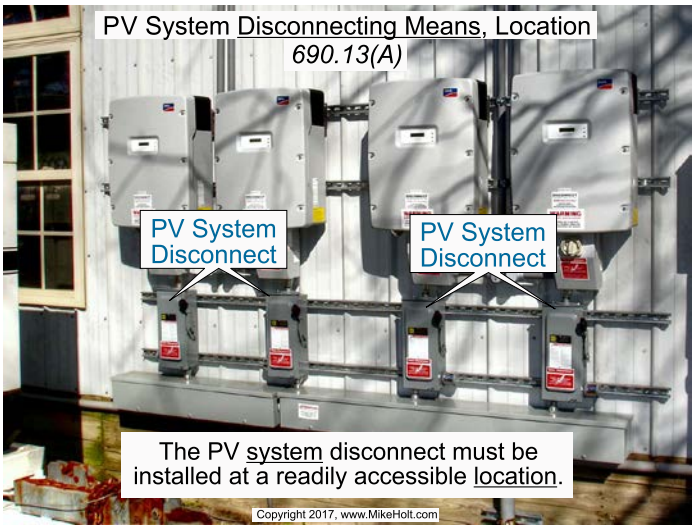
Means must be provided to disconnect the PV system from power systems, energy storage systems, utilization equipment, and associated premises wiring. ▸Figure 690–55



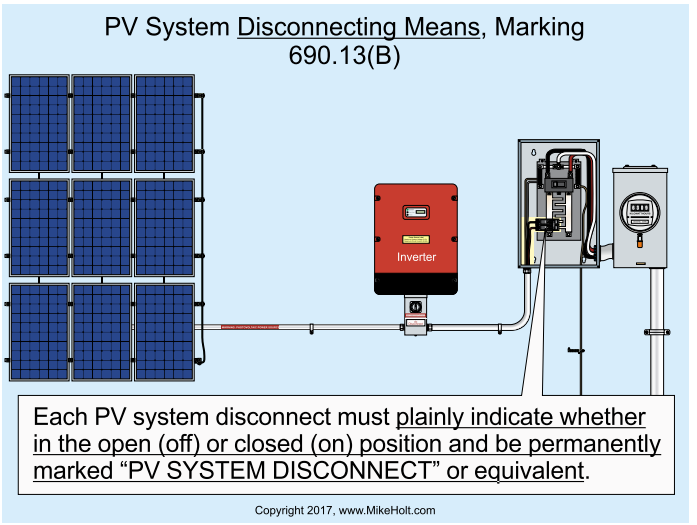
▸Figure 690–55

(A) Location. The PV system disconnect must be installed at a readily accessible location. ▸Figure 690–56

(B) Marking. Each PV system disconnect must plainly indicate whether in the open (off) or closed (on) position and be permanently marked "PV SYSTEM DISCONNECT" or equivalent. ▸Figure 690–57



▸Figure 690–56



▸Figure 690–57

Where the PV system disconnect also opens the dc circuit conductors, the dc line and load terminals of the PV system disconnect may be energized in the open position. In this case, the PV system disconnect must be marked with a warning sign that's permanently affixed, having sufficient durability to withstand the environment involved [110.21(B)] with the following words or equivalent:

WARNING: ELECTRIC SHOCK HAZARD
TERMINALS ON THE LINE AND LOAD SIDES
MAY BE ENERGIZED IN THE OPEN POSITION

APPENDIX

A

ANALYSIS OF 2017 *NEC* CHANGES RELATING TO SOLAR PHOTOVOLATIC SYSTEMS

This appendix contains the summaries and analyses of of the changes to the 2017 *NEC* relating to solar photovolatic systems.

ARTICLE 690—SOLAR PHOTOVOLTAIC (PV) SYSTEMS

690.1 Scope

The scope of this article was changed to correlate with the new Article 691, and the existing diagrams in this section were replaced with new ones.

Analysis

NEW

The 2017 *NEC* added a new Article 691—Large-Scale PV Electric Power Production Facility; due to this, the scope of Article 690 needed to be revised to specifically accept those systems, as they have their own unique hazards and therefore their own unique provisions in Article 691.

The new diagrams included in 690.1 are intended to help the *Code* user identify and understand some of the various components in a PV installation related to Article 690. The new graphic helps us understand that the PV system ends at the PV system disconnect, which can be on the dc or ac side. These graphics are particularly useful to those who aren't familiar with PV systems. The hybrid system diagram in the 2014 *NEC* was removed and replaced by two new ones.

690.2 Definitions

Some definitions have been deleted, others added, and some clarified.

Analysis

CLARIFIED

Array. This definition was changed to clarify that an array can create either a dc or ac power-producing unit. The previous definition only included direct current, which left alternating-current modules in a sort of no man's land.

EDITED

Bipolar Photovoltaic Array. The change to this definition clarifies that a bipolar PV array is a dc system only.

NEW

DC-to-DC Converter Output Circuit. This new term was added to provide a definition in order to delineate some of the new requirements in Article 690.

NEW

DC-to-DC Converter Source Circuit. This new term was also added to provide a definition in order to delineate some of the new requirements in this article.

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690.12 Rapid Shutdown of PV Systems on Buildings

The requirements for rapid shutdown have been extensively revised.

Analysis

CLARIFIED

When you make a new rule as significant as the 2014 rapid shutdown requirement, you're probably going to be rewriting the entire thing to fix the mistakes nobody thought about. The people who submit input and comments, and the members of the Code Making Panels are all doing the best they can, but things get missed and mistakes are made and technologies change rapidly. A new rule like this usually takes at least three *Code* cycles (nine years) before it says what everyone wanted it to say in the first place. Most of the changes to this edition of 690.12 came from input provided by the International Association of Fire Fighters (IAFF) and the Solar Energy Industries Association (SEIA).

The first change is to the opening paragraph of this section, which clarifies that the intent of this rule is to protect emergency responders. Without coming right out and saying it, this rule is for fire fighters. PV systems create a major additional hazard to those who now must worry about the fire and being electrocuted by the PV system!

An exception was added for buildings that house only PV equipment. The concern in these instances isn't losing the building, it's ensuring that the surrounding environment isn't destroyed as well. Losing such a building is certainly painful, but containing and confining it to just that building and preventing a forest fire (for example) is much more important.

The areas/equipment to which 690.12 applies have been clarified and are now referred to as the "array boundary." Of particular interest is a change from 10 seconds to 30 seconds in the time required for the voltage reduction to occur. This change happened for two reasons. First, manufacturers simply couldn't do it in 10 seconds, and secondly, there's no reason to do it that quickly. The TIA for this change from June of 2016 actually indicates the reason to go to 30 seconds stemmed from the utilities desire to "ride through grid disturbances for up to 20 seconds." "…to help distinguish between a full shutdown of ac supply for safety and intermittent problems with the utility supply." http://www.nfpa.org/assets/files/AboutTheCodes/70/ProposedTIA%201223_NFPA_70.pdf].

The fire fighter groups who provided input to this rule were fine with 30 seconds. Since this rule is for them, why not let them dictate the time? An effective date of January 1, 2019 was put into the *NEC* in order for the product standard to be completed.

The location of the rapid shutdown device is now discussed [690.12(C)], as is the type of device used [690.12(C)(1) and (2)]. The device must be installed at a readily accessible location outside of the building for one- and two-family dwellings. The device can be the service disconnect, the PV disconnect, or another device that plainly indicates "on" and "off."

Revised text discusses voltage thresholds and proximity (i.e. 80V or less within 30 seconds inside the array and within 1 meter (3 ft) of the outer edge of the array within 30 seconds after initiation, effective January 1, 2019).

690.13 PV System Disconnecting Means

The section dealing with PV disconnects was reorganized, language about disconnects on the supply side of the service was added, and a new subsection was relocated from 690.17 to indicate the types and ratings of disconnects permitted.

Analysis

REORGANIZED

Due to the amount of input to change Article 690 over the last several years, many sections receive complete makeovers every *Code* cycle; in 2017, it's Section 690.13.

Some of the language in 690.15 was moved to 690.13, as it's more applicable. Portions of the grouping subsection 690.13(E) were moved into the opening paragraph of the rule, as the statement "a PV disconnecting means shall not

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