

Field Guide for Testing Existing Photovoltaic Systems for Ground Faults and Installing Equipment to Mitigate Fire Hazards

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Purpose of the Field Guide

- Provide practical guidance to field technicians on how best to perform testing on PV systems with known and unknown ground faults.
- Discuss need for residual current monitors on grounded PV systems to improve ground fault detection to a safe level.
- Discuss equipment and methods of installation for residual current monitors that can be retrofitted to any grounded PV system.
- Discuss need for arc fault detection equipment to complete the safety hardware necessary to cover remaining known fire hazards.

Key Points

- Existing PV system owners need to consider retrofits to reduce fire risk.
- Many current designs still have the ability to start fires.
- Properly applying the NEC will lead to selecting products that will dramatically reduce the likelihood of ground fault and arc faults fires.
- <http://www.nrel.gov/docs/fy15osti/61018.pdf>

Other Equipment to Mitigate Fires

- Arc fault detectors are available in most string inverters.
- Arc fault products that are independent of inverters are slow in coming. Products must be evaluated with each inverter.
- The combination of high resolution ground fault detection and arc fault detection will help reduce the probability of a PV system fire to nearly zero.

PHASE 2: Establish PV Grounding Related NEC Proposed Revisions



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Proposed changes to the 2017 NEC related to PV System Grounding and Ground Fault Protection

- 1. Remove separate section in Article 690.35 for Ungrounded PV Systems.
- 2. Make all PV systems (with very limited exception of small solidly grounded PV systems) installed exactly the same way.
 - A) One fuse per circuit
 - B) Disconnecting means in both positive and negative conductors
 - C) Exposed cables PV Wire only
 - D) Ground Fault protection required for all systems
 - E) Arc Fault protection required for all systems
 - F) Warning labels about ground fault voltages removed (no longer necessary)
 - G) PV Systems do not need dc grounding electrode conductors

Rapid Shutdown of PV Systems

Firefighter Safety in the 2014 National Electrical Code

by Bill Brooks and Jim Rogers

As PV systems become increasingly safer, NFPA has targeted firefighter safety in the 2014 NEC for PV systems. In addition to several requirements included in the 2011 NEC for firefighter safety — [690.4(F), which provided specific PV conductor installation requirements; 690.11, which provides a requirement for dc arc-fault protection; and 690.31(E), which provides further installation and marking requirements for PV conductors in a building] — NFPA established a task group in Code-Making Panel 4 (CMP-4) to address potential proposals for the 2014 NEC. The primary outcome of the firefighter safety task group was the development of a new code section 690.12, entitled “Rapid Shutdown of PV Systems on Buildings.” The focus of this new section is to allow first responders to quickly and easily control the PV system circuits leaving an array in a PV system. Although the most predominant issue of concern was “rooftop systems,” the requirement would also extend to ground-mounted systems if the conductors enter a building for more than 5 feet. Multiple methods to achieve rapid shutdown were discussed at length during the proposal and comment peri-

ods, resulting in the language that is currently in the 2014 NEC.

As with any new code language, it is helpful to understand what the committee was attempting to accomplish with the language so that those involved in either the installation of PV systems or the electrical code enforcement for the installation can appropriately understand and apply the electrical code requirements to the unique system installation. This article is intended to explain the language of the new section 690.12 and provide context and examples of how to understand and enforce the requirements. These examples that are portrayed in this article are not intended to be an exhaustive treatment of how to comply with 690.12, but rather are intended to show that there are numerous ways, with existing PV products, to meet the requirements of 690.12 and improve safety for emergency responders.

Background

Emergency responders are becoming more aware of the presence of PV systems as well as some of their inherent safety hazards. This awareness is particularly true in areas of the country where PV systems are common such as California, New Jersey, Hawaii, Massachusetts, just to name a few. One of the first questions a firefighter or other emergency responder asks is, “How do I shut the system down so I won’t get shocked?” This simple question may have a complicated answer for many PV systems. Thinking that a PV system is similar to utility electrical services, many fire departments have required a rooftop disconnecting means so that firefighters can turn off a PV system switch during rooftop operations believing that once they open the disconnect their concerns are alleviated.



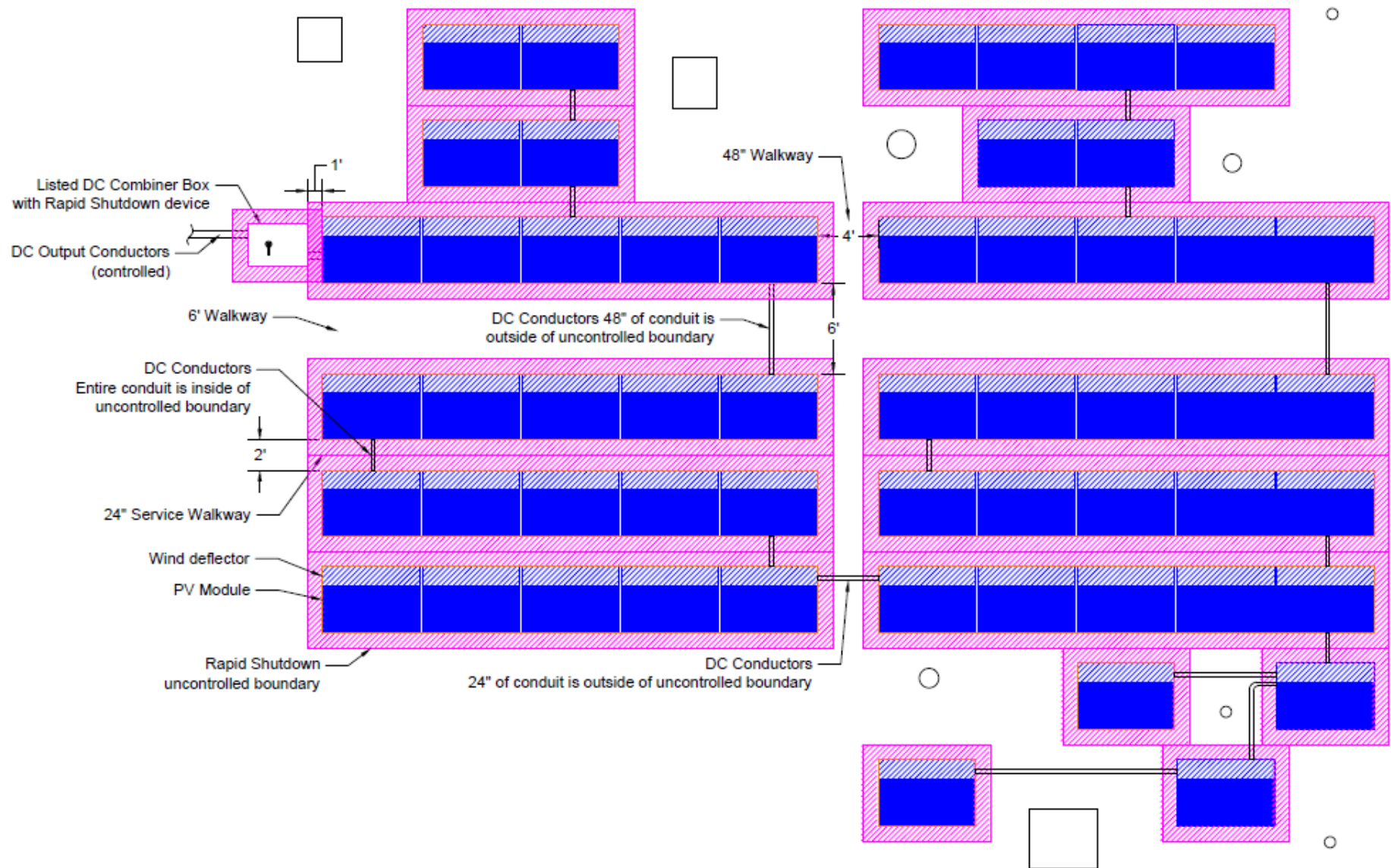
690.12 Rapid Shutdown of PV Systems on Buildings

- 2 main proposals considered by CMP₄ (SEIA and IAFF)
- CMP₄ merged these proposals for the 1st Draft of 2017 NEC 690.12.
- NFPA Fire Fighter Safety and PV Systems Task Group has met consistently for over 6 months to refine 1st language.

Current Version of 690.12 for 2nd Draft submittal

- **(A) Controlled Conductors.**
Requirements for controlled conductors shall apply only to PV circuits supplied by the PV system.
- The use of the term, array boundary, in this section is defined as 30 cm (1 ft) from the array in all directions.

ARRAY BOUNDARY



(1) Outside the array boundary

- Controlled conductors located outside the boundary or more than 1 m (3 ft) from the point of entry inside a building shall be limited to not more than **30 volts within 10 seconds** of rapid shutdown initiation.

(2) Inside the array boundary

- 2 OPTIONS
- (a) The PV array is listed and labeled or field labeled as a **rapid shutdown PV array**
- (b) Controlled conductors located inside the boundary or not more than 1 m (3 ft) from the point of penetration of the surface of the building or structure shall be limited to not more than **80 volts within 10 seconds** of rapid shutdown initiation.
- The requirement of 690.12(B)(2) shall become effective **January 1, 2018**.

(C) Initiation Device

- The rapid shutdown initiation device(s) shall consist of at least one of the following.
 - (1) Service disconnecting means.
 - (2) PV system disconnecting means.
 - (3) Readily-accessible switch that plainly indicates whether it is in the “off” or “on” position.

(D) Equipment

- **Equipment** that performs the rapid shutdown functions, other than initiation devices such as listed disconnect switches, circuit breakers, or control switches, **shall be listed and labeled for providing rapid shutdown protection.**

MARKINGS

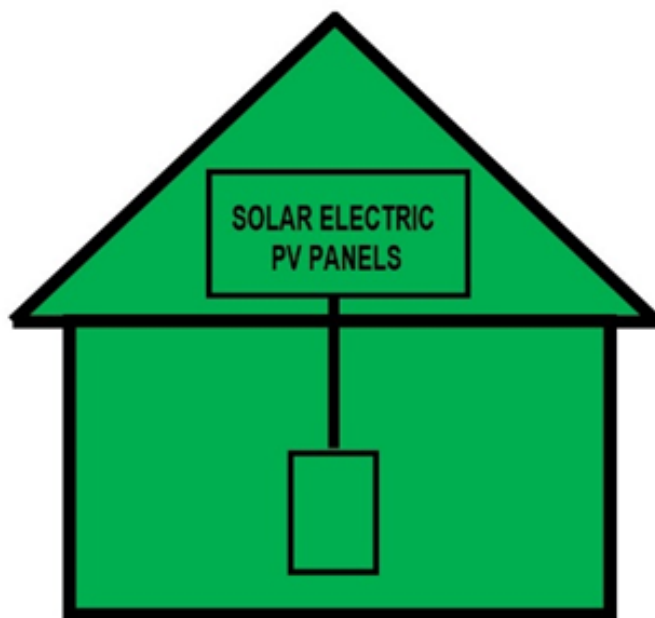
690.56(c) (C) Buildings with Rapid Shutdown.

- (1) Rapid Shutdown Type. The type of PV system rapid shutdown shall be labeled as described in a) or b):
 - (a) For PV systems that shutdown the array and conductors leaving the array:
 - (b) For PV systems that only shutdown conductors leaving the array:

For PV systems that shutdown the array and conductors leaving the array:

**EMERGENCY RESPONDER
THIS SOLAR PV SYSTEM EQUIPPED
WITH RAPID SHUTDOWN**

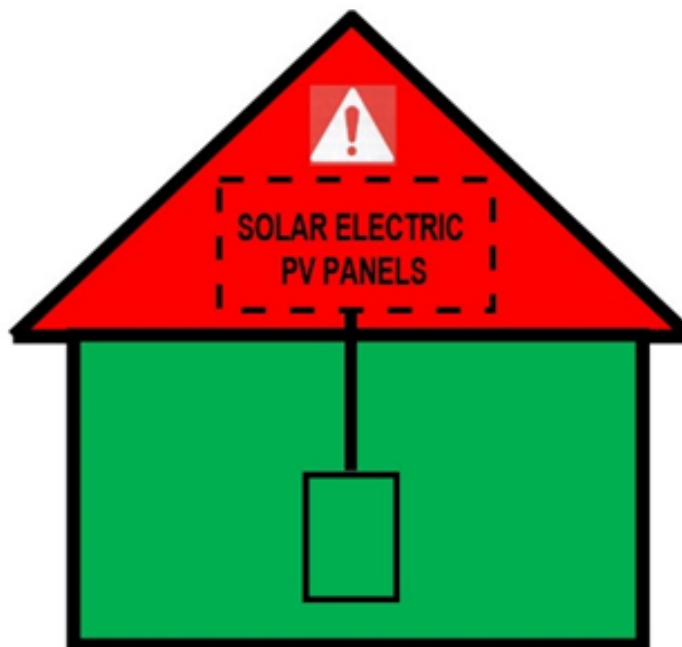
**TURN RAPID
SHUTDOWN SWITCH
TO THE "OFF"
POSITION TO
SHUTDOWN ENTIRE
PV SYSTEM**



For PV systems that only shutdown
conductors leaving the array:

**EMERGENCY RESPONDER
THIS SOLAR PV SYSTEM EQUIPPED
WITH RAPID SHUTDOWN**

**TURN RAPID SHUTDOWN
SWITCH TO THE "OFF"
POSITION.
ONLY CONDUCTORS
INSIDE BUILDING
OR OFF THE ROOF
WILL SHUT DOWN**



INITIATION DEVICE MARKING

**RAPID SHUTDOWN SWITCH
FOR SOLAR PV SYSTEM**