Application Note
Rapid Shutdown – NEC 2017-2023
March 2024

What is rapid shutdown?

Rapid shutdown is a *National Electrical Code* (NEC) requirement for controlled conductors within PV systems on or in buildings. The requirement was first introduced in the 2014 NEC and has evolved in more recent iterations of the Code.

Rapid shutdown has one goal in mind: reducing the shock hazard for first responders in the event of an emergency. As more rooftops are covered with solar, it is imperative that firefighters can quickly de-energize a PV system so they can safely perform their duties inside or atop a building.

As a U.S. market leader in three-phase string inverters for seven of the past eight years, our team at CPS is well versed in rapid shutdown solutions. In this Application Note, we will cover rapid shutdown requirements and applications according to 2017 through 2023 NEC standards.

How is rapid shutdown defined in the NEC?

In the 2017 NEC, the code requirements related to rapid shutdown are described in Section 690.12, which states:

690.12 Rapid Shutdown of PV Systems on Buildings.

PV system circuits installed on or in buildings shall include a rapid shutdown function to reduce shock hazard for emergency responders in accordance with 690.12(A) through (D).

(A) Controlled Conductors. Requirements for controlled conductors shall apply to PV circuits supplied by the PV system.

(B) Controlled Limits. The use of the term, array boundary, in this section is defined as 305 mm (1 ft) from the array in all directions. Controlled conductors outside the array boundary shall comply with 690.12(B)(1) and inside the array boundary shall comply with 690.12(B)(2).

> *(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 30 seconds of rapid shutdown initiation. Voltage shall be measured between any two conductors and between any conductor and ground.
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> *2) Inside the Array Boundary. The PV system shall comply with one of the following:*

(1) The PV array shall be listed or field labeled as a rapid shutdown PV array. Such a PV array shall be installed and used in accordance with the instructions included with the rapid shutdown PV array listing and labeling or field labeling.

(2) 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 shall be limited to not more than 80 volts within 30 seconds of rapid shutdown initiation. Voltage shall be measured between any two conductors and between any conductor and ground.

(3) PV arrays with no exposed wiring methods, no exposed conductive parts, and installed more than 2.5 m (8 ft) from exposed grounded conductive parts or ground shall not be required to comply with 690.12(B)(2).

In summary, to satisfy rapid shutdown requirements, the following conditions must be met:

(1) Controlled conductors outside the 1ft array boundary must be de-energized to less than 30V within 30 seconds of initiation.
(2) Controlled conductors inside the 1ft array boundary must be de-energized to less than 80V within 30 seconds of initiation.

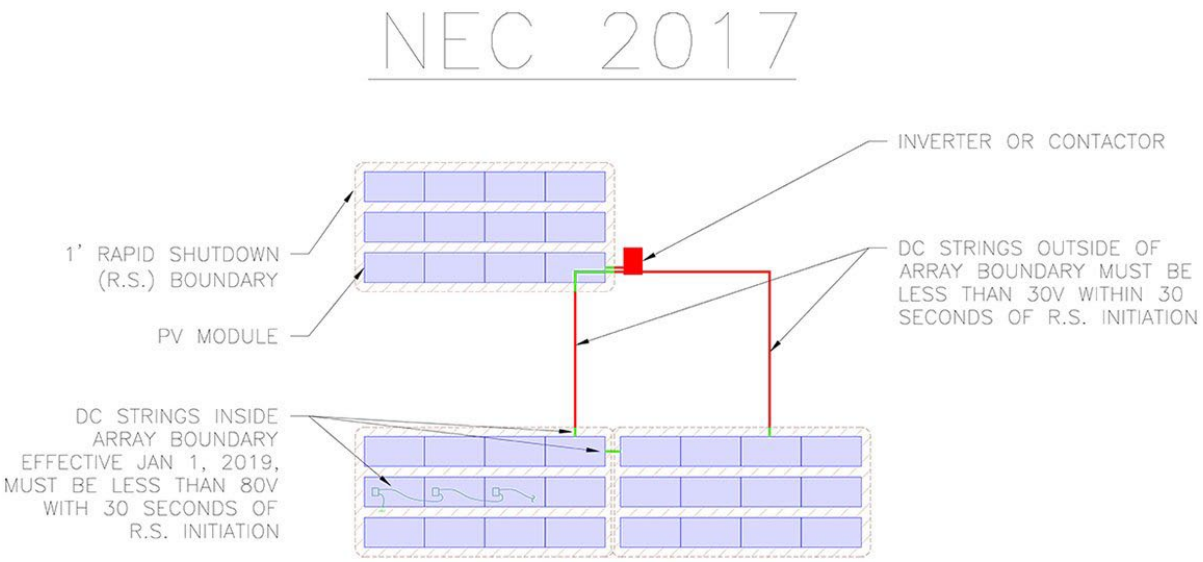


Figure 1: Example of a rapid shutdown-compliant array per NEC 2017 (source: Pure Power Engineering)

It should be noted that we define "controlled conductors" inside the array as the DC conductors and any AC output conductors from inverters located within the array boundary; and "controlled conductors" outside the array as the AC conductors beyond the array boundary and up to the PV system disconnect or 3ft from the point of entry to a building.

Additionally, the term “array boundary” refers to an invisible border extending 1ft from the outermost edge of the array, including the modules and racking. Array boundaries may overlap (e.g., if two subarrays are separated by less than 2ft) to form a single, continuous array as illustrated by the overlapping subarrays in Figure 1.

How is rapid shutdown applied?

Most installers in recent years have been utilizing module-level power electronics (MLPE) to control conductors within the array boundary. CPS has partnered with APsmart (APS) to offer UL certified, system-level rapid shutdown-compliant design solutions.

CPS 1,000Vdc inverter models are PV Rapid Shutdown System (PVRSS) certified with MLPE products from APsmart. PVRSS certification means the inverter, RSS transmitter, and MLPE receiver have all been tested together as a system and will work safely and reliably in the field.

The components of a PVRSS communicate with each other to initiate rapid shutdown. CPS inverters are offered with RSD wire-boxes that include integrated RSS transmitters to send a “keep-alive” signal to the MLPE via power line communication—no separate RSD transmitter box is needed.

When the PV system disconnect is used as the initiation device, the AC conductors on the output side of the inverter are de-energized, and the inverter and RSS transmitter immediately cease operation. The MLPE stop receiving the “keep alive” signal, which automatically triggers rapid shutdown. Thus, rapid shutdown may be initiated from the PV system disconnect using a single switch.

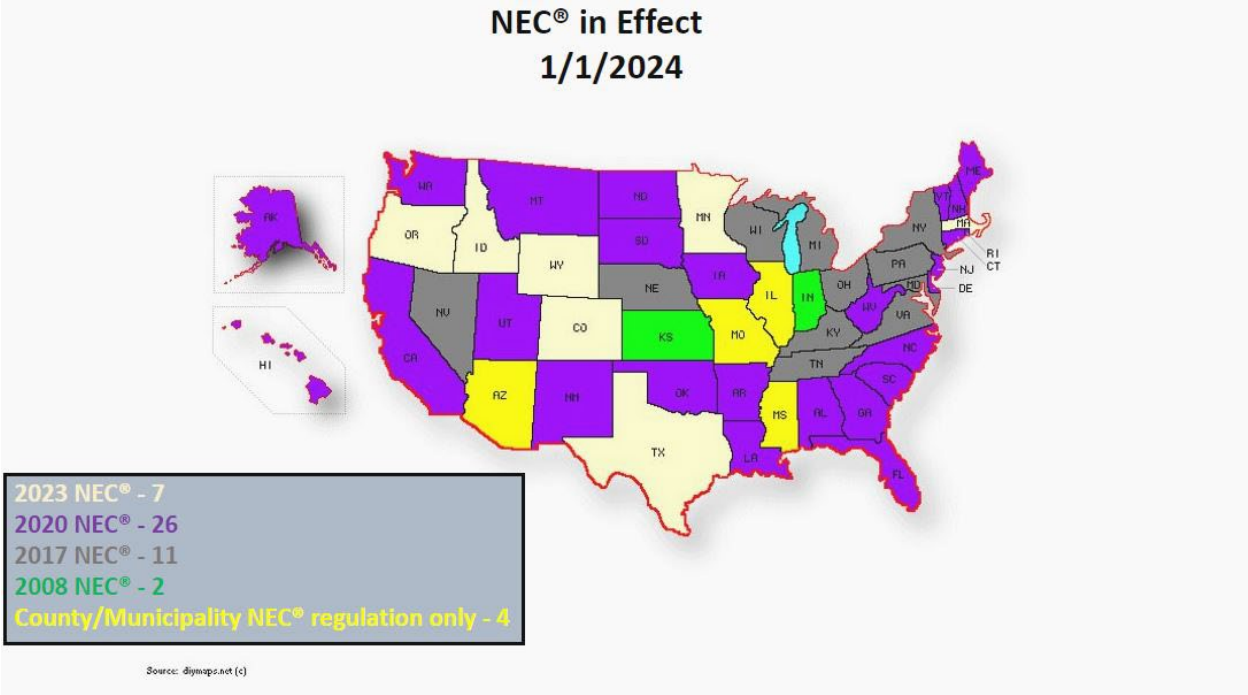
CPS inverters are PVRSS certified with the following MLPE models:

APsmart

- RSD-S-PLC (one per module)
- RSD-D (one per two modules)

What is new in the 2020/2023 NEC?

NEC adoption varies across the U.S., with each state determining its own timeline for Code adoption. A plurality of states currently adhere to 2017 NEC requirements. However, all states will inevitably adopt newer editions of the Code in the coming years.



Source: NFPA

The 2020 NEC introduces a few updates to the rapid shutdown requirements. Most notably, initiation device rules changed from allowing as many as six rapid shutdown switches per PV system to requiring a single switch per system. Up to six switches (e.g., breakers) may still be placed on a single service, but each switch must control an entire PV system. Returning to our definition of a PV array above, that means all contiguous subarrays within 2ft of each other must be controlled by a single rapid shutdown initiation device.

The 2020 NEC also introduces the concept of a UL-listed or field-labeled "PV Hazard Control System" (PVHCS) which is defined by UL 3741 standards. UL 3741 introduces another option by which to comply with rapid shutdown requirements with all major components listed and certified as part of the PV Hazard Control System. More information on UL 3741 listed inverters and compatible racking solutions can be found here.

The 2023 NEC updated the language in section 690.12(B)(2)(1) stating:

The PV system shall provide shock hazard control for firefighters through the use of a PVHCS installed in accordance with the instructions included with the listing or field labeling. Where a PVHCS requires initiation to transition to a controlled state, the rapid shutdown initiation device required in 690.12(C) shall perform this initiation.

Additional technical resources can be found here. For questions on CPS products or applications related to this Application Note, please call the CPS Hotline at: 855-584-7168.