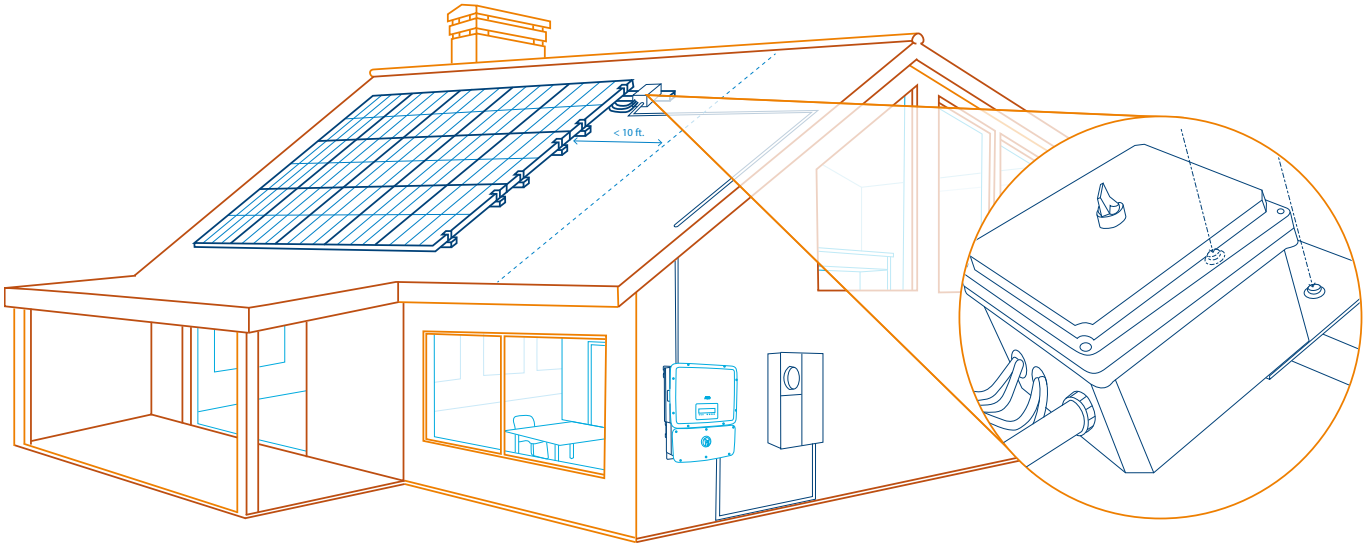
Solar inverters

A guide to rapid shutdown for photovoltaic (PV) systems
Safe and economical compliance using ABB's Rapid Shutdown (RSD) solution



For years, new National Electric Code (NEC) requirements have been challenging for installers and inspectors alike. NEC 2014 Section 690.12 - Rapid Shutdown is no different. It is important to understand not only this section of code, but also use the tools offered throughout the rest of the NEC to build the most efficient and safe rapid shutdown system possible to enable inspections to be passed the first time.

Rapid shutdown (RSD) was added to this code cycle in an effort to help protect first responders and other emergency personnel charged with saving lives and structures where the building at risk has a photovoltaic (PV) energy system installed on its roof.

It is important to understand the requirements of this code section because as adoption of this code progresses, due to the perceived safety hazards, more and more jurisdictions are requiring immediate implementation of the requirements of Section 690.12. In some areas of the country, this 2014 code section has been mandated, even though the jurisdiction may still be on a previous code cycle.

Understanding the code

It is important to understand the intent of the code and how the RSD complies in order to provide safety to firefighters and to pass authorities having jurisdiction (AHJ) inspections.

When considering the design and implementation of the RSD system, it is important to consider the initial tasks of firefighters arriving at a fire scene. An immediate concern for firefighters arriving at a site is how to remove power from the building.

Today, it is common for these first responders to open the building's main disconnect to remove utility power. Because the utility power is disconnected from the home, it is natural to tie the activation of the RSD system to the loss of AC grid.

Most residential structures are connected to the utility grid via a single meter. De-energizing is straightforward — turn off the main breaker/disconnect. Some buildings, however, may include more than one metered service and/or PV system, and the PV system may be provisioned with multiple disconnect switches. In these cases, it could become confusing for first responders, prompting the question, "Which disconnect do I need to open?"

For the single-meter residential building, simply powering the RSD from the grid and using a failsafe[1] design makes sense — it is simple and does not require external switches or special steps by emergency personnel.

For large residences and/or commercial buildings, there is the potential of more than one grid connection; there is the possibility that all service connections may not be switched off. As a result, PV arrays may unknowingly stay energized. In this case, a separate "emergency" switch connected in series to disengage the RSD circuits should be included in the design.

Whichever rapid shutdown initiation method is used, appropriate signage in the form of easy-to-read labels or placards must be placed at key locations. By eliminating the need for an additional disconnect and tying the activation to the presence of the utility grid along with a clearly labeled placard, firefighters are able to quickly and safely act with confidence. In accordance with 690.56(B) and (C), placard locations referencing the fact there is a PV system associated with the building should include a reference to the RSD and its operation. These placards should be placed in readily accessible locations such as the main service disconnect, the building meter or the main PV system disconnect. Contact the local fire department and/or AHJ before installation for any preferences or requirements they may have in the placement of these labels, placards and disconnects. Working directly with these officials will help avoid conflict later during inspection and better assist emergency personnel in the event of a fire.

Using tips within the NEC

Using the NEC to design a safe and compliant PV system is required. A thorough understanding of the NEC provides designers with the tools to design an efficient and cost-effective RSD complaint PV system.

NEC 2014 Section 690.12 requires that the equipment performing rapid shutdown be listed and identified. String inverters commonly have capacitors which are capable of bleeding stored energy onto rapid shutdown-controlled conductors. To meet requirements of a maximum 30 volts and 240 volt-amperes on the controlled conductors, the PV system must intentionally discharge these capacitors to compliant levels after initiation. Because the inverter is involved in the overall performance of the RSD system, it must be included in the testing required for listing the RSD product. The ABB RSD system has been tested and certified for use with ABB's single-phase string inverters.

The ABB inverter is part of the RSD system and the power supply and terminals are listed for use within the ABB string inverter. The rooftop disconnect box must receive power from the power supply mounted inside the inverter. The power supply provides $24V_{DC}$ power. The positive and negative conductors powering the rooftop box are required circuitry for the operation of the PV system and are therefore considered part of the PV system.

NEC 2014 Section 690.31(B) - Identification and Grouping of Wiring Methods requires any conductor that is run in the same conduit as the PV source or PV output conductors be identified by color coding, marking-tape, tagging or other approved means. When including conductors from different circuits in the same raceway, it is required to use an insulation rating equal to at least the maximum circuit voltage for all conductors in the conduit, per NEC 300.3(C)(1). For a $600V_{DC}$ residential system, this means the $24V_{DC}$ circuit must use 600V-rated conductors.

The power supply installed in the inverter wiring box is a Class 2 power source, which would not be permitted to be installed in the same raceway as the PV conductors. However, class 2 circuits are permitted to be reclassified as Class 1 circuits per NEC 725.130(A). By reclassifying this circuit as Class 1, the $24V_{DC}$ conductors may be installed in the same raceway as the PV conductors (inverter power supply conductors) as specified in section 725.48(B)(1) of the NEC. Be sure to follow all Class 1 wiring methods as stated in section 725.49 to ensure compliance.

Pass inspection with the ABB RSD family

There are many elements to consider when designing an RSD device. In addition to complying with NEC requirements, ABB's RSD system was designed to increase the safety of the emergency personnel charged with saving lives and preserving structures. Once the firefighter removes the grid power, the ABB RSD solution is activated and power is shut down within 10 seconds or less.

The ABB RSD kits includes a small $24V_{DC}$ DIN-rail mount power supply that is intended to be located in the inverter wiring box. It draws its power from the AC grid connection on the inverter. The RSD system power supply is powered directly from the inverter AC terminals and draws minimal power — typically less than 5W — from the AC grid. The output from this supply powers the normally-open contactors located in the rooftop RSD box.

[1]A failsafe design implies that when AC utility power is interrupted, the RSD circuits will "fail open", meaning that upon disconnection of AC, the PV circuits automatically open, causing the PV output conductors to de-energize.

When the PV system is disconnected from the grid or the grid is removed, this power supply ceases to supply energy to the rooftop disconnects, thereby opening the circuit. By including the power supply in the inverter and feeding it from the inverter's output circuit, there is no need for additional disconnect switches or buttons. (See the white arrow in Figure 1 below that points to the power supply).

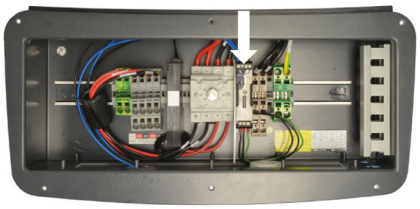


Figure 1 - UNO-7.6/8.6 wiring box with RSD power supply installed

To facilitate cost-optimized designs for all system sizes and configurations, the ABB RSD family consists of three different rooftop box kits (and one rooftop box alone to be used in conjunction with a kit), as shown in Table 1 below.

Model	In/Out	Description
RS2-2PN6-KIT	2/2	Two string in/two independent outputs; no combining
RS2-1CN6-KIT	2/1	Two string in/one output; one 2x1 fuseless string combiner
RS2-1CN6	2/1	Same as RS2-1CN6-KIT, except rooftop box only. For use in systems requiring two RSD boxes.
RS4-2CN6-KIT	4/2	Four string in/two independent outputs; two 2x1 fuseless string combiners

All items designated as KIT contain a rooftop box, power supply and replacement terminal blocks for the inverter wiring box.
When the RS2-1CN6-KIT is used, a second rooftop box may be required and can be powered from a single power supply. All equipment is rated for use in 600V_{DC} PV systems.

Table 1 - ABB's RSD rooftop box kits

The first RSD kit listed in Table 1 (RS2-2PN6-KIT) is a simple two string in/two string out pass through box. The strings remain independent and may be connected to different MPPT channels of the inverter. The next kit and model listed (RS2-1CN6-KIT and RS2-1CN6) combine two strings together to offer the additional cost savings from running fewer conductors to the inverter. Each combiner model includes a manual disconnect switch on the rooftop box (see Figure 2 below) in order to comply with the strictest interpretations of NEC 2014 Section 690.15(C) - Direct-Current Combiner Disconnects. The last combiner configuration listed (RS4-2CN6-KIT) accepts four strings, combining two pairs for two independent PV output circuits for use with dual-MPPT channels, if desired.

Figure 2 - ABB's rooftop RSD box

The ABB RSD system has been designed for use with the ABB single-phase string inverter family. Using an RSD product designed specifically for use with the inverter being installed provides confidence that the system will operate as expected. Testing in the harshest environments has proven the robustness of the ABB RSD solution. Understanding the purpose of the NEC, following the additional code tips, and selecting the right device help ensure a trouble-free inspection and receipt of your system's green tag the first time around.

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