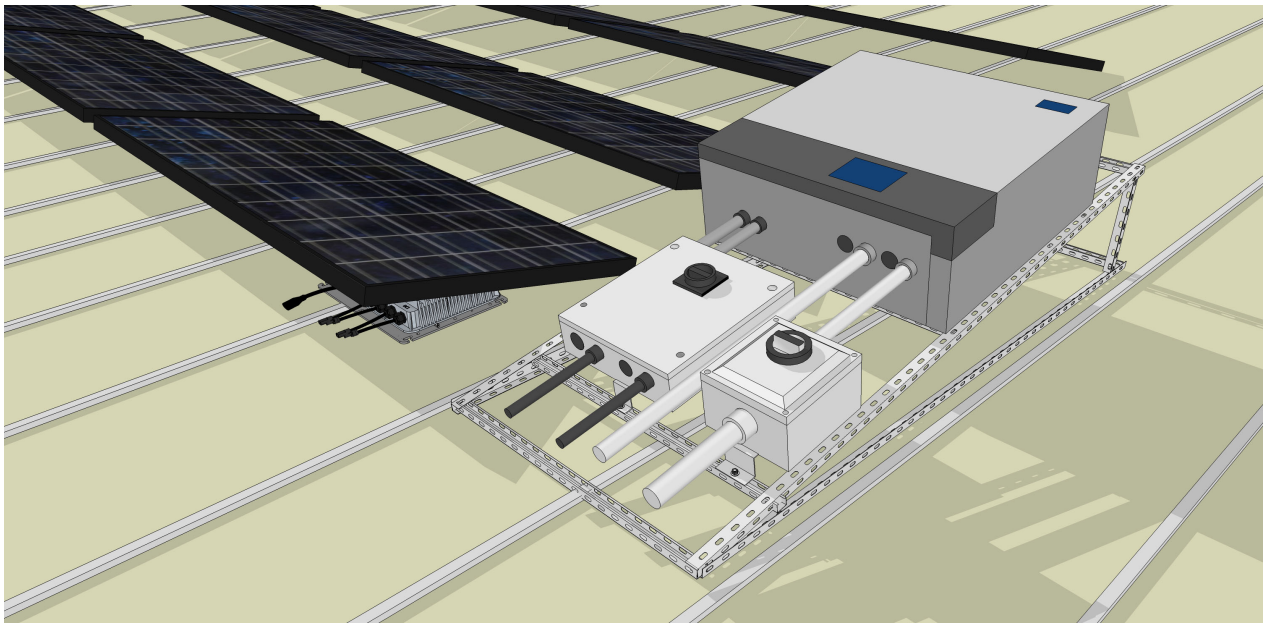
NEC 2014 Rapid Shutdown and HiQ's TrueString Inverters – A Natural Fit



Introduction

As the 2014 edition of the National Electrical Code[1] (NEC) is adopted across the US, compliance with a new requirement called Rapid Shutdown becomes mandatory. This new requirement is contained in paragraph 690.12 of the 2014 NEC. At a high level the requirement is that controlled conductors must be less than 30 volts within 10 seconds of initiation of Rapid Shutdown. Controlled conductors are defined as any conductor more than 10 feet from the PV array.

This article is not intended to be academically thorough or rigorous – an excellent article[2] and the original NEC language are listed at the end for those that need depth. This is a general overview as well as a blatant sales pitch for HiQ products and their compliance with Rapid Shutdown. We focus on 3-phase commercial installations, and this discussion is biased in that direction.

Opening the AC disconnect for a utility-interactive inverter causes it to shut down (UL1741 anti-islanding requirements mandate this for utility-interactive inverters in the US). However, this doesn't ensure that all conductors on the DC side between the inverter and the PV array will become de-energized – the PV modules will still be producing a voltage any time there is sufficient irradiance. Common practice for central and string inverter installations has been to mount them on a wall or down on the ground, and to install long runs of wire up to the PV array. This new Rapid Shutdown requirement complicates this – shutting the inverter off down on the ground doesn't deenergize the DC wires running up to the roof. An obvious next step, then, is to put remote-controlled or auto-sensing DC disconnects within 10 feet of the array, and such products are available for sale. Unfortunately there are several problems with this. Firstly it adds extra cost, install time, and complexity. Secondly, when the DC side of some inverters goes

open-circuit, capacitors inside the inverter keep the voltage high for up to 5 minutes (a maximum time allowed by UL1741.) This is far longer than the 10 seconds required by the 2014 NEC.

The Push for Array Mounting

For the reasons mentioned above it is increasingly common to mount inverters on the roof, within 10 feet of the array. Doing this means that one throw of the AC disconnect shuts the inverters down, and any high DC voltages are within the 10-foot boundary of the array, where they are allowed.

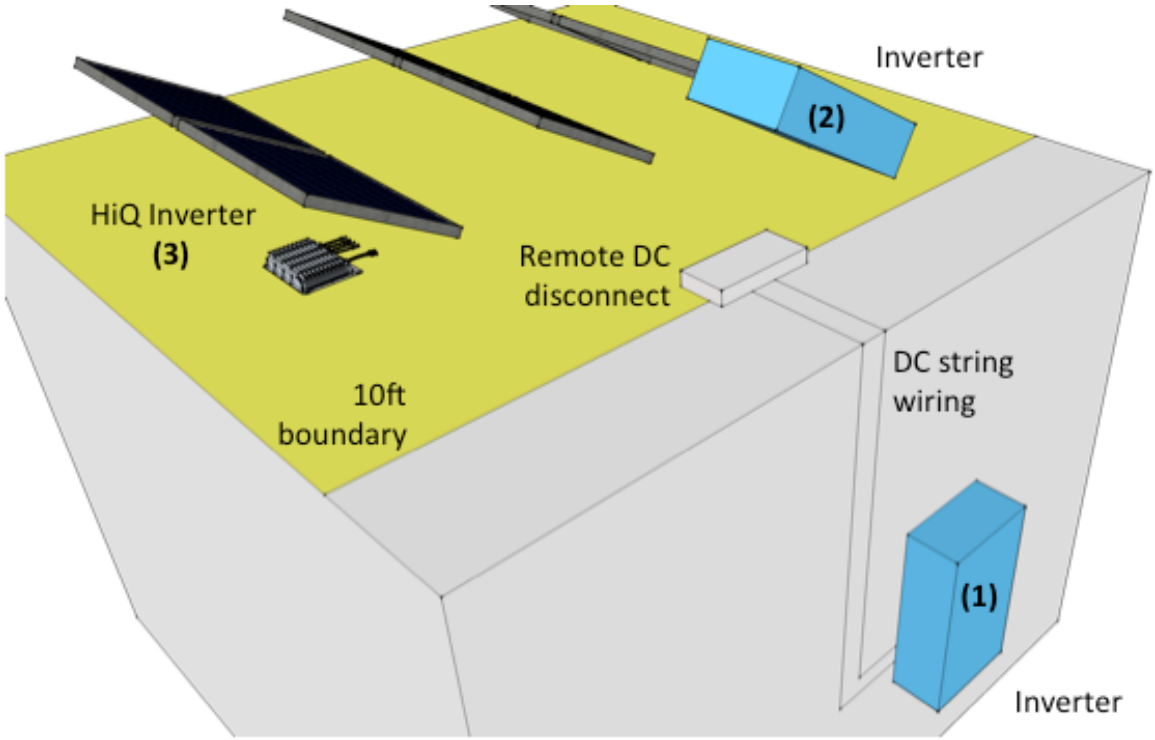


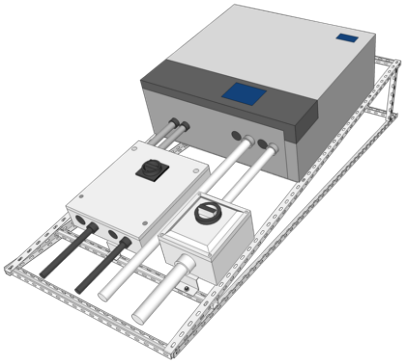
Figure 1: Different approaches to complying with the Rapid Shutdown requirement. (1) Central and wall-mounted string inverters often add an intelligent (i.e. expensive) DC disconnect switch that senses when the inverter has shut down and disconnects the array. Alternatively (2) has the string inverter mounted within 10 feet of the array. (3) The HiQ TrueString inverter tucks naturally under the array and easily fulfills the requirement for Rapid Shutdown

When it comes to array mounting, not all inverters are created equal. If you're a manufacturer of central inverters you are quietly crying at this point, and a maker of micro inverters cheering loudly. However, micro inverters are usually too expensive for commercial rooftops, and central inverters are being used less and less in favor of large 3-phase string inverters. So the problem faced by many installers is that they want to use 3-phase string inverters, but somehow have to comply with the Rapid Shutdown requirement.

Most 3-phase string inverters were designed to be mounted vertically on a wall in a sheltered environment. Usually they cannot lie flat on their backs. They also frequently have LCD screens giving system information, and these are known to need frequent replacement when used in direct sunlight and harsh environments. However, it's not usually practical to build a suitable wall to mount these inverters on, which is why attempts are being made to mount them on angled cradles such as is illustrated in the picture at the start of this discussion. It's obvious that this is no one's idea of a perfect solution.

Cradle Compromises or Purpose-Designed Solution

The HiQ Solar TrueString inverters were designed from the outset to be array-mounted. Below is a quick comparison of our approach with the large 3-phase string inverters that are increasingly common.

		3-phase String on a Cradle 	HiQ TrueString mounted under the array 
1.	Satisfies 2014 NEC 690.12 Rapid Shutdown?	When installed correctly and within 10 feet of the array, yes	When installed correctly and within 10 feet of the array, yes
2.	Ease of designing with	Requires extra wide walkways or takes up space in mandated walkways	Sits under the array, but easy to access unlike micro inverters
3.	Ease of installation	Typically weigh more than 150 lb., hard to lift, requires more than one person. Requires extra effort and cost to buy and assemble the cradle	Weighs 24 lb. Easy to lift, easy to install, easy to carry spares. Easy to install by one person. Connector-based electrical connections.
4.	Reliability	LCDs, fans etc. require maintenance and regular replacement. Often these inverters use electrolytic capacitors. Sits in full sun. Not being used as originally intended	NEMA6, no electrolytics, no display, no fans. Maintenance-free. Robust, single circuit board, automotive grade components. Being used as intended
5.	Ease of replacement later	150 lb.+, hard to get replacement units onto a roof later, requires several people in the crew to do so	Tuck one under your arm, climb a ladder. Unclick the connectors, click in the new one. Easy
6.	Other	Usually strings are paralleled, making poor granularity of monitoring, fault-finding and arc detection	Each string has separate MPPT, monitoring. Single string arc detection, placed next to the modules, makes arc detection reliability better, and reduces occurrence of false-positives

Summary

HiQ's TrueString inverters were designed to be mounted under the PV array, and naturally comply with the requirements of NEC 2014 690.12.

Appendix

The following is taken from the Bill Brooks article listed at the end[2], and gives the exact wording of the Rapid Shutdown requirement in the 2014 code.

"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."

References

1. "NFPA 70®: National Electrical Code® (NEC®), 2014 Edition", by National Fire Protection Association
2. Article in SolarPro magazine by Bill Brooks, January 2015: "Rapid Shutdown for PV Systems: Understanding NEC 690.12"
   http://solarprofessional.com/articles/design-installation/rapid-shutdown-for-pv-systems?v=disable_pagination