

Saving Install Cost by Using Connectors as Means of Disconnect



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Introduction

Additional AC and DC disconnects add cost and complexity to PV systems and introduce several points of potential failure, thus reducing reliability. In the US disconnecting means are mandated by the governing electrical code.

Several cents/Watt can often be saved in installation cost if separate disconnect boxes can be avoided in favor of integrated disconnects used by inverter manufacturers such as HiQ and Enphase. But is this code compliant? This paper addresses the regulatory requirements governing disconnecting means required for the replacement and servicing of PV inverter equipment. Specifically, the use of connectors as the required means of disconnect is detailed. It then shows that HiQ Solar TrueString™ inverters have been tested as part of their certification to allow this.



Code Requirements

All discussions in this document are based on the 2014 NEC¹, which is currently adopted in the majority of US states. This also applies to the 2011 NEC. *Direct quotes from the NEC are in bulleted blue italics.*

The National Electrical Code (NFPA 70) contains specific requirements for Disconnecting Means for PV systems. The NEC, article 690, section III. Disconnecting Means, lays out the basic requirements for AC and DC disconnects.

NEC article 690.13 establishes that a means of disconnecting DC conductors is required.

¹ <http://www.nfpa.org/codes-and-standards/document-information-pages?mode=code&code=70>,
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- *690.13 All Conductors. Means shall be provided to disconnect all current-carrying DC conductors of a photovoltaic system from all other conductors in a building or other structure. [...]*
- *690.14 Additional Provisions. Photovoltaic disconnecting means shall comply with 690.14(A) through (D).*
- *690.14(A) Disconnecting Means. The disconnecting means shall not be required to be suitable as service equipment and shall comply with 690.17.*

While there are many specific requirements in 690.14, a couple of them are particularly applicable for this paper:

690.14(A) states that the disconnection means does NOT have to be rated as service equipment.

(The NEC defines service equipment as; “The necessary equipment, usually consisting of a circuit breaker(s) or switch(es) and fuse(s) and their accessories, connected to the load end of service conductors to a building or other structure, or an otherwise designated area, and intended to constitute the main control and cutoff of the supply.

Per the NEC, service equipment requirements:

1. Must be marked with the maximum available fault current.
2. Surrounding working space must be provided with illumination.
3. Pipes and ducts may not be located in the vicinity of service equipment.
4. May require the installation of an ac electrical outlet nearby
5. Shall be marked as service equipment.
6. Shall be listed as service equipment.
7. Must be installed in a readily accessible location.
8. Means for disconnecting the grounded conductor must be provided.
9. Must have a handle or other operating means.
10. Metallic enclosure must be connected to a GEC

And, there are many more minuscule details, but the above gives an idea.)

690.14(D)(1) mandates that the disconnecting means shall be within sight of or mounted in the inverter.

690.15 says that the inverter shall have a means to be disconnected from all sources. This includes all AC and DC sources.

- *690.15 Disconnection of Photovoltaic Equipment. Means shall be provided to disconnect equipment, such as inverters, batteries, charge controllers, and the like, from all ungrounded conductors of all sources. [...]*

690.17 contains basic switch requirements; readily accessible, externally operable without hazard to the operator, clearly indicate whether in the open or closed position, be properly rated for voltage and current. Notice there is no requirement for the switch to be separate from the inverter.

- *690.17 Switch or Circuit Breaker. The disconnecting means for ungrounded conductors shall consist of a manually operable switch(es) or circuit breaker(s) complying with all of the following requirements:*
 - *Located where readily accessible (1)*
 - *Externally operable without exposing the operator to contact with live parts*
 - *Plainly indicating whether in the open or closed position*
 - *Having an interrupting rating sufficient for the nominal circuit voltage and the current that is available at the line terminals of the equipment*
- [...]

And the exception to 690.17 states that connectors are allowed to be used as disconnects:

- ***Exception: A connector shall be permitted to be used as an AC or a DC disconnecting means, provided that it complies with the requirements of 690.33 and is listed and identified for the use.***

690.33 addresses specific requirements for the use of connectors as the means of disconnect, and outlines 5 basic requirements for the connectors:

- They must be polarized or keyed to prevent misconnection
- They must be touch safe
- They must be latching or locking
- If ground is included in the connector, it must be the first to make and the last to break
- They must be rated for interrupting the system current, OR, they must require the use of a tool to open and must be marked “Do Not Disconnect Under Load”

The NEC requires a disconnecting means for ac and DC circuits of a PV system. The NEC specifically allows the use of connectors for this purpose, and clear requirements are provided for this.

TrueString Inverters

HiQ Solar has performed laboratory testing at a Nationally Recognized Testing Lab to certify that the connectors used on HiQ inverters are suitable for use as the means of disconnect. Both the 208V and 480V TrueString inverters have been through the same rigorous certification process. An excerpt from the test report for the TS480-8k showing the method of evaluation is shown below.

57	Cap Discharge
Input and Output as Disconnect device Construction: NFPA 70 National Electric Code 2014 Edition section 690.13 and 690.33 Testing in accordance to UL 1977	AC and DC -Disconnect and connect 50 times at maximum current 15 A for DC connector and 14.4 A for AC connector measure the resistance after

The test protocol also requires measurement of the insulation between the conductors and the outside, accessible area of the connector after load break cycling.

Conclusion

As shown in detail above, the NEC allows use of connectors as an allowed disconnecting means. HiQ Solar TrueString inverters have been tested and certified as compliant for this use. By using the connectors for load break on an approved inverter, an installer is able to save several cents/Watt in install cost while maintaining a safe and code compliant project.

