Application Note
Three Phase String Inverters NEC 2014
Compliance

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The technical information and cross references of this document are subject to a continuous improvement and the right to change as may be technically or legally required is reserved.

Code compliance for any PV System extends well beyond the specific design features of the inverter. This Application Guide is intended as a guide for our CPS customers, but is not a substitute for the comprehensive design and installation work required to comply with NEC 2014 code.

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This application note describes the major changes in the National Electrical Code going from the 2011 to 2014 code cycle that effect photovoltaic installations and more specifically string inverters. NEC 2014 adoption varies state by state. Massachusetts, Nebraska, Washington, South Dakota, Minnesota, Maine, Kentucky, Idaho and Colorado have adopted 2014 code as of the release date of this Application Note. However, by the end of 2014, 18 more states plan to adopt NEC 2014. The NEC Adoption by state map is shown below as of June 30th ‘2014.

The major changes in NEC 2011 and 2014 that effect photovoltaic installations, and specifically are related to the application and use of inverters, are:

1. Section 690.5 - Ground Fault Protection
2. Section 690.11 - Arc-Fault Circuit Protection
3. Section 690.12 - Rapid Shutdown
4. Section 690.16 - Fuse Servicing

The Application Note evaluates each of these sections with respect to the use of string inverter products, specifically CPS 23kW and CPS 28kW inverters.
1. Section 690.5 - Ground Fault Protection

“690.5 Ground-Fault Protection. Grounded dc PV arrays shall be provided with dc ground-fault protection meeting the requirements of 690.5(A) through (C) to reduce fire hazards. Ungrounded dc PV arrays shall comply with 690.35. Exception: Ground-mounted or pole-mounted PV arrays...”

The changes in this section effect the arrays and inverters in which at least one DC conductor is grounded. CPS three phase string inverters the arrays are floating (ungrounded) and are compliant with 690.35. Section 690.35 requires detection of ground faults via residual current monitoring and requires that the device providing ground fault protection (GFP) should be listed for that purpose. CPS inverters provide GFP and are listed for that function under UL 1741.

2. Section 690.11 - Arc-Fault

“690.11 Arc-Fault Circuit Protection (Direct Current). Photovoltaic systems with dc source circuits, dc output circuits, or both, operating at a PV system maximum system voltage of 80 volts or greater, shall be protected by a listed (dc) arc-fault circuit interrupter, PV type, or other system components listed to provide equivalent protection. The PV arc-fault protection means shall comply with the following requirements:

(1) The system shall detect and interrupt arcing faults resulting from a failure in the intended continuity of a conductor, connection, module, or other system component in the dc PV source and dc PV output circuits.

(2) The system shall require that the disabled or disconnected equipment be manually restarted.

(3) The system shall have an annunciator that provides a visual indication that the circuit interrupter has operated. This indication shall not reset automatically.”

CPS three phase string inverters come with an Arc-Fault Circuit Interrupter (AFCI) device as a standard feature set. This circuit board is located in the inverter wiring box. The AFCI device has been tested and listed to UL 1699B for the 23kW and 28kW inverters. In the event of an arc fault, the inverter will
detect and interrupt the ARC and disconnect from the grid. A visual indication through the error code on the LCD screen and the LED on the front panel is provided. The inverter will not restart until it is manually reset by engaging the inverter AC/DC disconnect switch off and then on again. After being turned on it will check to see if the error has been corrected before it starts exporting power.

3. Section 690.12 - Rapid Shutdown

“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.”

The conditions outlined in this section can be met with string inverters. If the inverters are placed within 10ft of the perimeter of the array, they can support the requirement outlined in 690.12. The ac output conductors become the “controlled conductors” that are subject to the 690.12 requirements.

The CPS 1000Vdc inverters (23kW and 28kW) have a unique ability to be
installed at a low tilt angle (15°) which improves the ability install these units near the array, particularly in a rooftop application. The inverters NEMA 4 rating supports this type of installation. Note, however, that the low tilt installation method is not necessary to comply with the code described above. The inverter can be installed on nearby parapet walls or by any other structural installation means.

When there is a requirement for rapid shutdown the main AC disconnect for the system can be turned off. Doing so will cut off AC power to the inverter forcing it to shutdown in much less than 10 sec. Per the inverters’ UL1741 listing, the inverters are designed to turn off in 2 seconds if AC power is lost for any reason. Removing ac power will eliminate voltage and current on the controlled conductors, leaving only the conductors within the 10 foot array perimeter to remain energized. This feature, when combined with inverter location within 10ft of the perimeter of the array, enables the system to comply with 690.12.(2). To complete the compliance with this section, the installation will need to include labels per 690.56 identifying the rapid shutdown device for the PV system conductors.
**4. Section 690.16 - Fuse Servicing Disconnects**

"690.16 Fuses.

(A) Disconnecting Means. Disconnecting means shall be provided to disconnect a fuse from all sources of supply if the fuse is energized from both directions. Such a fuse in a PV source circuit shall be capable of being disconnected independently of fuses in other PV source circuits.

(B) Fuse Servicing. Disconnecting means shall be installed on PV output circuits where over current devices (fuses) must be serviced that cannot be isolated from energized circuits. The disconnecting means shall be within sight of, and accessible to, the location of the fuse or
integral with fuse holder and shall comply with 690.17. Where the disconnecting means are located more than 1.8 m (6 ft) from the over current device, a directory showing the location of each disconnect shall be installed at the over current device location. Non-load-break-rated disconnecting means shall be marked “Do not open under load.”

The wiring box for 23/28kW inverters are equipped with standard touch safe fuse holders (shipping beginning 10/1/2014, see “Touch Safe Fuse Puller Retrofit Solution” for product received before 10/1/2014) with pre-installed DC fuses and AC and DC disconnects to meet this requirement. The load break rated DC disconnect opens the circuit on the output side of the fuse, between the fuse and the inverter to meet the requirements of 690.16(A). Opening this switch stops all current from flowing from the array into the inverter and places the array into open circuit. There is still voltage present on the terminals but the conductors and fuses are no longer under load. The touch safe fuse holders can safely be used to independently remove the fuse, complying with 690.16(A) and (B). However, the touch safe fuse holders must not be opened under load. They are safely used only after the DC disconnect is turned to the “OFF” position.

An alternate solution is provided by CPS for any customer seeking a touch safe fuse solution for an inverter received prior to October 1st, 2014. The solution
includes a permanently attached fuse holder for each DC fuse in the wire-box (16 total), as shown below. This fuse holder solution can be provided at no charge upon customer request (contact your sales representative).

*Touch Safe Fuse Puller Retrofit Solution

**Summary**

The CPS 23 and 28kW three phase string inverters comply with the NEC2014 code requirements outlined in Sections 690.5 (690.35), 690.11 and 690.16. The inverters include specific design features listed to meet these requirements.

Section 690.12 (Rapid Shutdown) can be met with proper system design and installation techniques. The CPS 23 and 28kW, when placed within 10ft of the array perimeter, can support this requirement as the inverters will disconnect within 2 seconds of AC power loss. However, the system design and installation must follow all requirements of NEC code to support compliance and, as in all cases, should work with local AHJ’s to ensure compliance.

Please contact our Application Engineering staff if you have any questions or need assistance.