
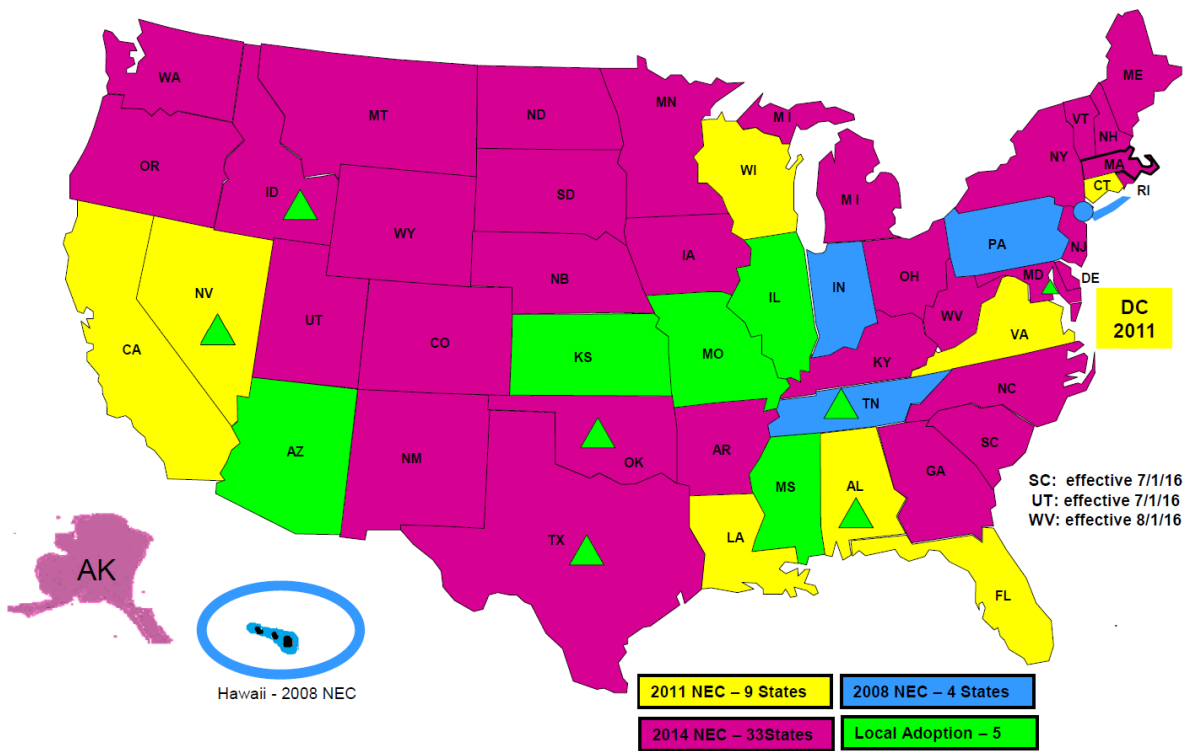


## CPS 3Phs String Inverters NEC 2014 Compliance

This application note describes the major changes within the NFPA 70, National Electric Code, specifically **Article 690 Solar Photovoltaic (PV) Systems** as it transitions from the 2011 edition to 2014 edition code cycle that effect photovoltaic installations, and in particular string inverters. Adoption of the NEC 2014 edition varies from state to state. Massachusetts and Nebraska were early adoptees of the 2014 code, however many more states either have or are in the process of adopting NEC 2014. The NEC Adoption by State map is shown below as of June, 2016.

### NEC Adoption by State

 = Subject to local adoptions



Revised - June 2016

Note: Some local adoption states have earlier than 2008 adoptions in some jurisdictions

The major changes to the 2014 NEC that effect photovoltaic installations are -

1. **Ground-Fault Protection - Article 690.5**
2. **Arc-Fault Circuit Protection (Direct Current) - Article 690.11**
3. **Rapid Shutdown of PV Systems on Buildings - Article 690.12**
4. **Fuses, (A)Disconnecting Means and (B)Fuse Servicing - Article 690.16**

This application note will evaluate each of the above articles to see their effect on CPS 3Phs String Inverter products, specifically the CPS SCA23KTL-DO/US-480, CPS SCA28KTL-DO/US-480, CPS 36KTL-DO/US, CPS SCA50KTL-DO/US-480, and CPS SCA60KTL-DO/US-480 models.

**1. "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 with not more than two paralleled source circuits and with all dc source and dc output circuits isolated from buildings shall be permitted without ground-fault protection."*

The major change to Article 690.5 is that it now requires Ground-Fault Protection for all installations, whereas previously the 2011 version included an additional exception;

*Exception No. 2: Photovoltaic arrays installed at other than dwelling units shall be permitted without ground-fault protection if each equipment grounding conductor is sized in accordance with 690.45.*

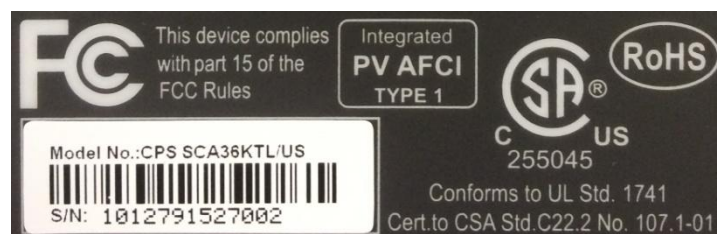
The other changes to Article 690.5 primarily effect PV arrays and inverters in which at least one DC conductor is grounded. Article 690.5(A) now specifies that Ground-Fault Detection and Interruption (1) Be capable of detecting a ground fault in the PV array dc current-carrying conductors and components, including any intentionally grounded conductors, (2) Interrupt the flow of fault current, (3) Provide an indication of the fault, and (4) Be listed for providing PV ground-fault protection

The CPS 3Phs String Inverters are designed to be used with PV arrays that are floating or ungrounded and therefore they must comply with Article 690.35. Article 690.35 has no major changes from the 2011 code cycle with the exception that the ground-fault protection device must be listed for providing PV ground-fault protection. CPS 3Phs String Inverters include Ground-Fault Protection and are listed for that function under the UL 1741 safety standard.

**2. "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."

The CPS 3Phs String Inverters include a Type 1 Photovoltaic (PV) DC Arc-Fault Circuit Interrupter device integrated within the wiring box. This AFCI circuit has been tested and listed to the UL 1699B standard. In the event of a (dc) arc-fault originating on the DC source or output circuits, the inverter will detect and interrupt the arcing faults, and cease operation. A visual indication will then be displayed by means of an error code and brief alarm description on the LCD screen, and the LEDs on the front panel will also illuminate to show that there is an arc-fault condition. The inverter(s) will not restart until the arc-fault has been corrected, and the error/alarm condition has been manually reset.



**3. "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(C).
- (5) Equipment that performs the rapid shutdown shall be listed and identified."

The inclusion of Article 690.12 in the 2014 NEC for PV rapid shutdown requirements of PV systems on buildings were meant to improve electrical and fire safety hazards, namely for first responders. Conductors associated with PV systems often remain energized even after the electrical service disconnect has been opened. To alleviate this risk, the NEC has put in place specific requirements to de-energize conductors extending more than 1.5m (5ft) inside a building, or more than 3m (10ft) from a PV array.

These new requirements outlined in Article 690.12 can be easily met with CPS 3Phs String Inverters. The inverters can be installed at a very low tilt angle from horizontal ( $\geq 15\text{deg}$ ), and making use of this feature allows the inverters to be located directly adjacent to or within the immediate vicinity (3m/10ft) of the PV array on a flat commercial roof. Alternatively, if parapet walls are within a 10ft boundary of the PV array, then the CPS 3Phs String inverters may be mounted there as well.



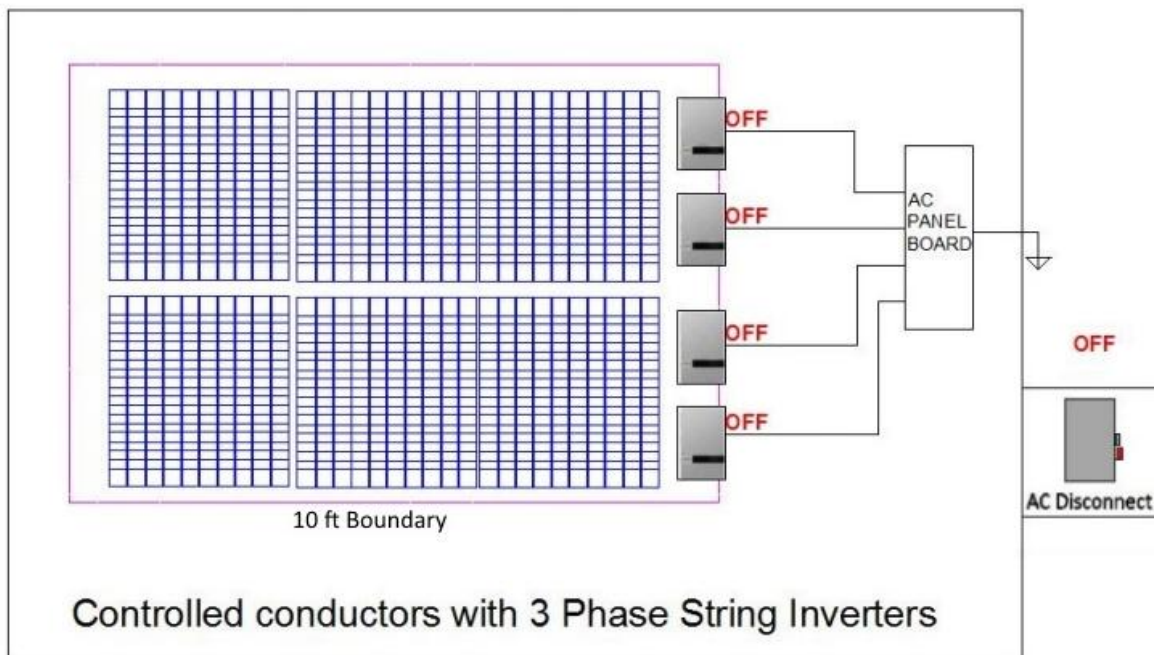
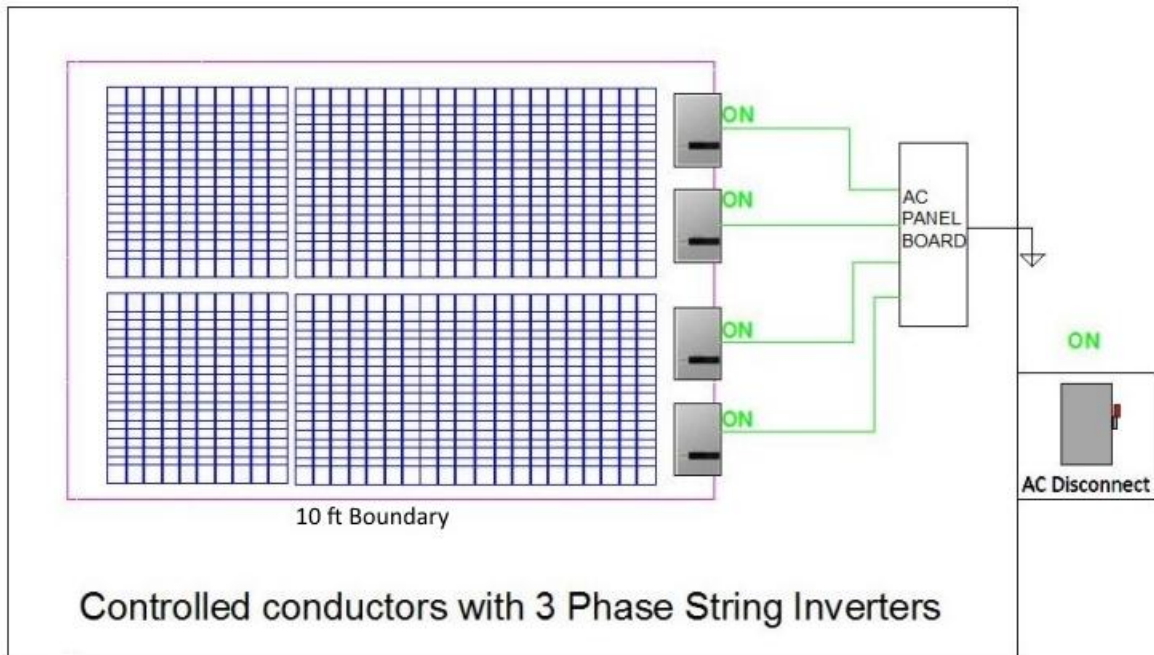
Low tilt angle installation < 10ft boundary



Parapet wall installation < 10ft boundary

### 3. 690.12 Rapid Shutdown of PV Systems on Buildings (cont'd).

When installations on or in buildings dictate the need to meet 690.12, the main AC disconnect for the system shall be opened to comply with the rapid shutdown requirement. Doing so will initiate an immediate cessation of AC power to the inverter forcing it to shutdown in much less than 10 seconds. The inverter is programmed by default to disconnect and cease to energize the Area EPS in less than 2 seconds when it detects a loss of AC power either L-L or L-G, and as such complies with 690.12.(2). The CPS 3Phs String Inverters are listed to the UL1741 safety standard, although proper labeling (permanent plaque or directory) identifying the equipment that performs the rapid shutdown must be done by the installer.

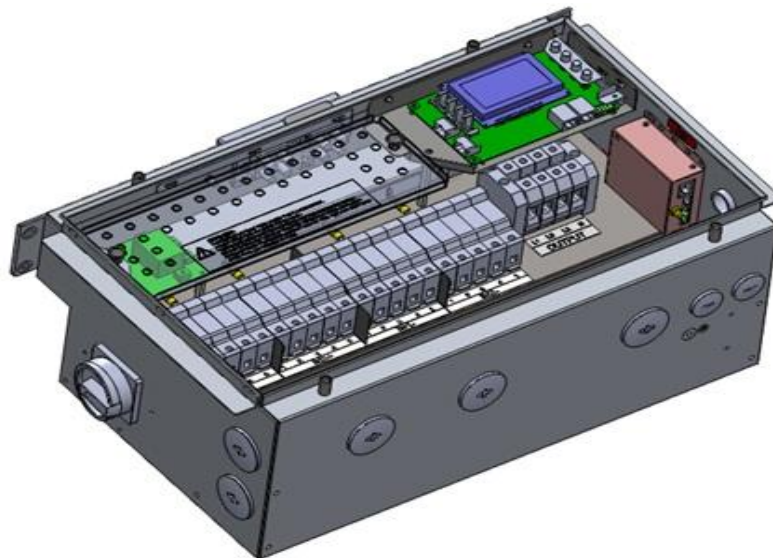


#### 4. "Article 690.16 Fuses

**(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 CPS 3Phs String Inverters all come equipped with touch safe fuse holders, as well as an integrated DC disconnect switch within the wiring box for compliance with Article 690.16. The load-break rated DC disconnect switch can be used to open all ungrounded conductors between the DC fuses and the inverter to meet the requirements of 690.16 (A). Opening the DC disconnect switch will stop all current flow from the PV array into the inverter, and places the DC source circuits into an open circuit state. There will still be DC voltage present on the input side of the touch safe fuse holder terminals, however the conductors and fuses are no longer under load. The touch safe fuse holders are now capable of being disconnected independently and safely to service the fuses, complying with 690.16(A) and (B). The touch safe fuse holders must not be opened under load, and can only be accessed after the DC disconnect is turned to the "OFF" position.



CPS 3Phs String Inverter Wiring Box (typical)

The technical information and cross references within this document are subject to continuous and further development, and therefore CPS reserves the right to any changes as may be technically or legally required.

For further questions:

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