



# **INSTALLATION AND OPERATIONS MANUAL: DC 1500V AFCI COMBINER**

**REV. 0669-00-A**

Innovative Solar Inc.

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## IMPORTANT SAFETY INSTRUCTIONS SAVE THESE INSTRUCTIONS

## INSTRUCTIONS IMPORTANTES CONCERNANT LA SÉCURITÉ

Before installing or using the String Combiner Box, please read all instructions and caution markings in this manual as well as on the string combiner, on the PV modules and PV inverter or Charge Controller.

This manual contains important instructions that shall be followed during installation and operation of String Combiner Boxes. To reduce the risk of electrical shock and to ensure the safe installation and operation of the combiner, the following safety symbols are used to indicate dangerous conditions and important safety instructions.

CONSERVER CES INSTRUCTIONS. CETTE NOTICE CONTIENT DES INSTRUCTIONS IMPORTANTES CONCERNANT LA SÉCURITÉ.



**WARNING**  
Could Injure Personnel or  
Damage Equipment



Instructions for  
Qualified  
Personnel Only



Positive  
Connection Point  
Symbol



Negative  
Connection Point  
Symbol



Ground  
Connection  
Point Symbol



DC Electrical  
Connection  
Point Symbol

All electrical installations, including the wiring method, shall be performed in accordance with all local and national electrical codes, including NFPA 70 and the Canadian Electric Code Part 1.



**WARNING** – The fused string combiner contains no user serviceable parts. For maintenance, please contact Innovative Solar or an authorized installer by visiting [www.innovativesolarinc.com](http://www.innovativesolarinc.com) or by calling +1-888-315-6551.



**WARNING** – Disconnect all PV modules or follow your site specific instructions when connecting the array. PV arrays produce electrical energy when exposed to light and could create a hazardous condition.



**AVERTISSEMENT** – Couper Toutes Les Sources d'alimentation Avant Le Dépannage.



**WARNING** – Connection of the String Combiner Box to PV modules as well as PV inverter to the electric utility grid must be performed only by qualified personnel.

## 1.0 Product Overview

The String Combiner is a disconnecting fused string combiner designed for combining multiple strings of photovoltaic (PV) modules for connection to an inverter. In a large PV array, each string of PV modules must be fused before being paralleled and connected to an inverter. The String Combiners are available with up to 32 source inputs and each source circuit is designed to utilize a fuse that is rated at least 156% of the short circuit current rating of the respective PV string source circuit. The fuse value for any source circuit should not exceed the PV module fuse rating.

### 1.1 Switch Operation

The String Combiner contains a user-operable switch. The switch is 2-poles and interrupts both the positive and negative legs simultaneously. When the switch is in the ON position, the circuit is closed between the source conductors and the output conductors. In the OFF position, the circuit is open between the source conductors and the output conductors. The switch is full load-break rated and can be safely operated under normal operating conditions when installation is per this guide and all warnings and ratings are observed.

### 1.2 AFCI and RSD Versions

In Arc-Fault and Rapid Shutdown versions the user-operable switch can also be tripped electronically. Control power must be available to the combiner box for the switch to be tripped in response to an Arc-Fault. In Rapid Shutdown (RSD) configurations, loss of control power will also trip the switch. When "TRIPPED", the switch handle will move to an intermediate position and both main contacts will open in the same manner as if the switch were turned off manually. Returning control power after an Arc-Fault or Rapid Shutdown will not reset the switch. Whenever tripped, the switch must be reset manually. To do this, turn the switch handle full CCW to the "Reset" position. Only then may it be turned CW to the "ON" position.

### 1.3 Surge Suppression

The combiner box is rated for a maximum voltage of 1500VDC, but can also be used on 1000v systems. In order to better support 1000VDC systems using surge protection, all models can also be ordered with 1000v surge protection.

## 2.0 Ratings Table

Ratings				
Size	Standard Size Enclosure		Over-Size Enclosure	
Operating Voltage Range	0 - 1000 VDC	0 - 1500 VDC	0 - 1000 VDC	0 - 1500 VDC
Max Output Current	400 A			
# of Fused Inputs	6 to 24 (up to 32A)		6 to 32 (up to 32A)	
Fuse Size Range (A)	3 - 32, 40, 50, 63 A (1 leg only, per NEC2017)			
Non-fused leg	Switched (per NEC2017)			
Input Conductor Size	10 - 8 awg (up to 32A)			
# of Output Conductors	1 or 2 (per polarity)			
Output Connection	Dual M12 (1/2") Studs, 1.75" Spacing (Optional Mechanical Lugs)			
Max Output Conductor Size	1000 MCM (dual 600 MCM)			
Ground Connections	(2) 2/0 + (10) 14 - 4 awg			
Ambient Operating Temp	-40°C to +50°C (-40°F to +122°F)			
Ambient Storage Temperature	-40°C to +85°C (-40°F to +185°F)			
Certifications	UL 1741 (2 <sup>nd</sup> Ed.) (R2015) CSA C22.2 No. 290-15			
<b>Enclosure, Fiberglass (Standard)</b>			<b>NEMA 4X</b>	
Dimensions H x W x D	24"x30"x10"		n/a	
Net weight (approx.)	75 lb.		n/a	
<b>Enclosure, Powder coated CRS (Optional)</b>			<b>NEMA 3R/4</b>	
Dimensions H x W x D	24"x30"x10"		30"x30"x10"	
Net weight (approx.)	80 lb.		90 lb.	

Control Power for AFCI and RSD Versions				
Version	Non-AFCI	AFCI	RSD	AFCI & RSD
Control voltage	n/a	120 or 230vac, ±10%, 50-60Hz	24vdc, ±10%	120 or 230vac, ±10%, 50-60Hz
Power consumption	n/a	2 W	1.6 W	4 W
Inrush consumption, <10ms	n/a	170 W	1.6 W	4 W

### 3.0 Installation



**WARNING** – These installation instructions are for use by qualified personnel only. To reduce the risk of electric shock, do not perform any installation unless you are qualified to do so.



**WARNING** – This manual contains important instructions for all String Combiner models that shall be followed during installation of the String Combiner Box.

The necessary steps to installing the String Combiner are unpacking, inspecting, mounting, conduit installation, wiring, testing, and commissioning.

### 3.1 Unpacking and Inspection

The String Combiners are thoroughly inspected and rigorously tested before they are shipped. Even though the units are delivered in cardboard packaging, it is possible that the units may become damaged during shipment. Inspect the combiner thoroughly after it is unpackaged. If damage is noticed, document the damage with digital photos and immediately report the damage to the shipping company. If there is any question about potential shipping damage, contact Innovative Solar. If it is determined that the unit must be returned, an RMA number must be obtained from Innovative Solar prior to returning the unit. Take care not to set the combiner on a gravel surface that might scratch the finish.

### 3.2 Mounting

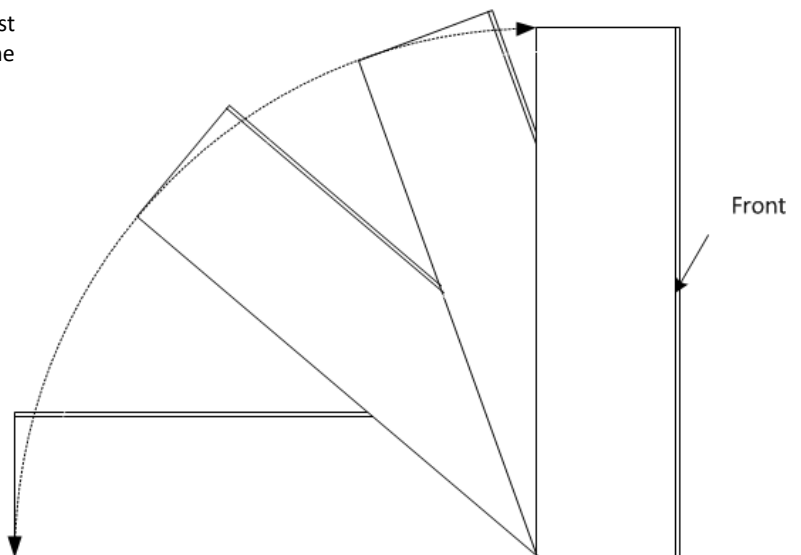
The String Combiner enclosure is Type 4 or 4X rated and will maintain the rating with appropriate installation methods. For personnel safety, the String Combiner box should not be installed with the door angled downward at any angle. See mounting option graphic for further understanding.

Be sure to verify load capacity of the mounting area. Mount the combiner using the mounting holes provided.

Install the combiner in an accessible location following NEC codes for enclosure and switch clearances and proximity to other equipment.

Although not required, the combiner and fuses will stay coolest if the combiner is located in shade or partial shade from the array, equipment vault, or other equipment at the site.

Mounting Options



Vertical, Angled, or Horizontal Mounting

### 3.3 Install Conduits

The use of UL514B or equivalent conduit fittings and UL50 installation methods are required to maintain the Type 4 or 4X rating of the enclosure. Failure to follow these standards may result in water intrusion into the unit through conduit connections and may void the warranty.

Output conduits and source circuit conduits must be installed on the bottom.

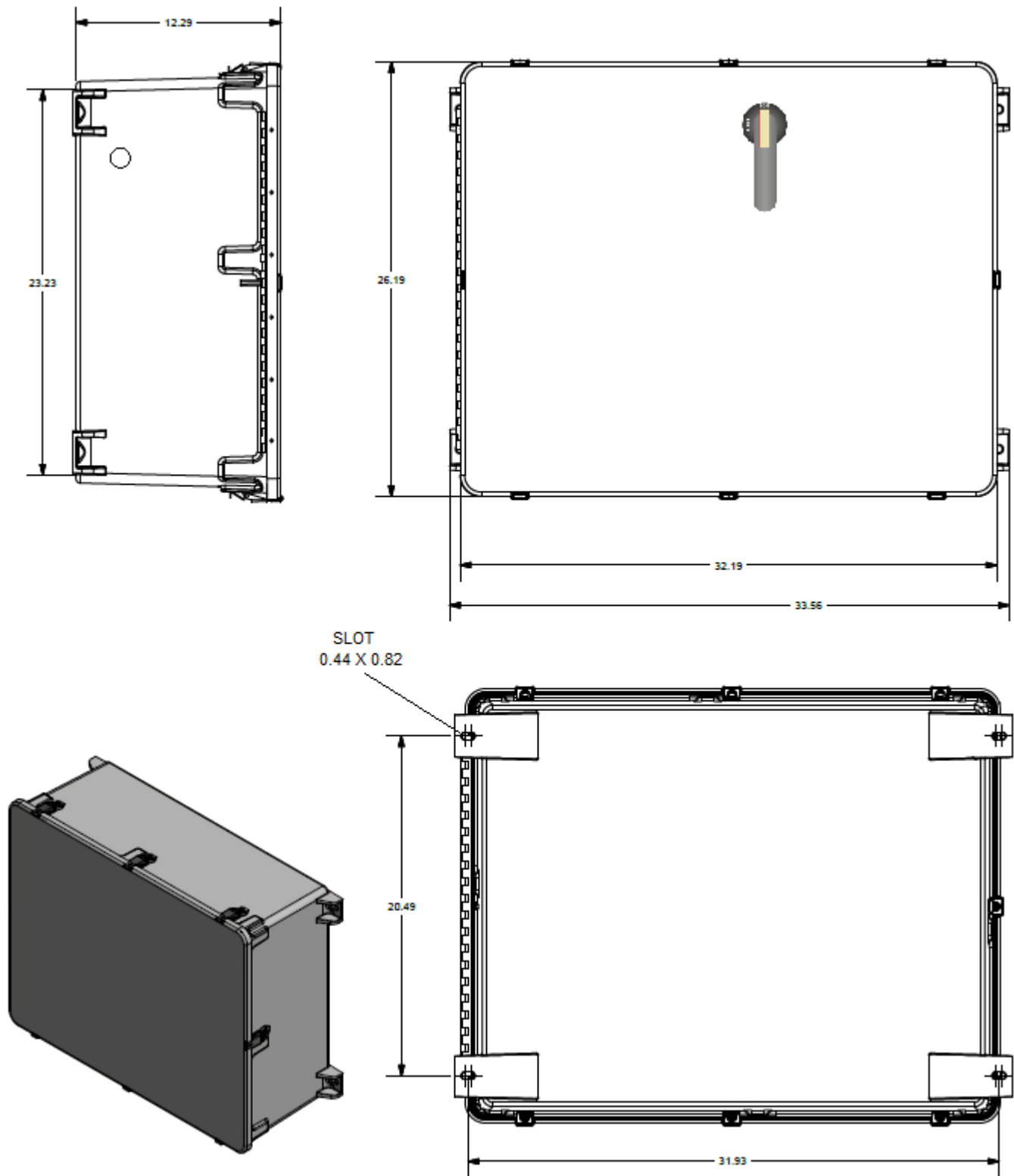
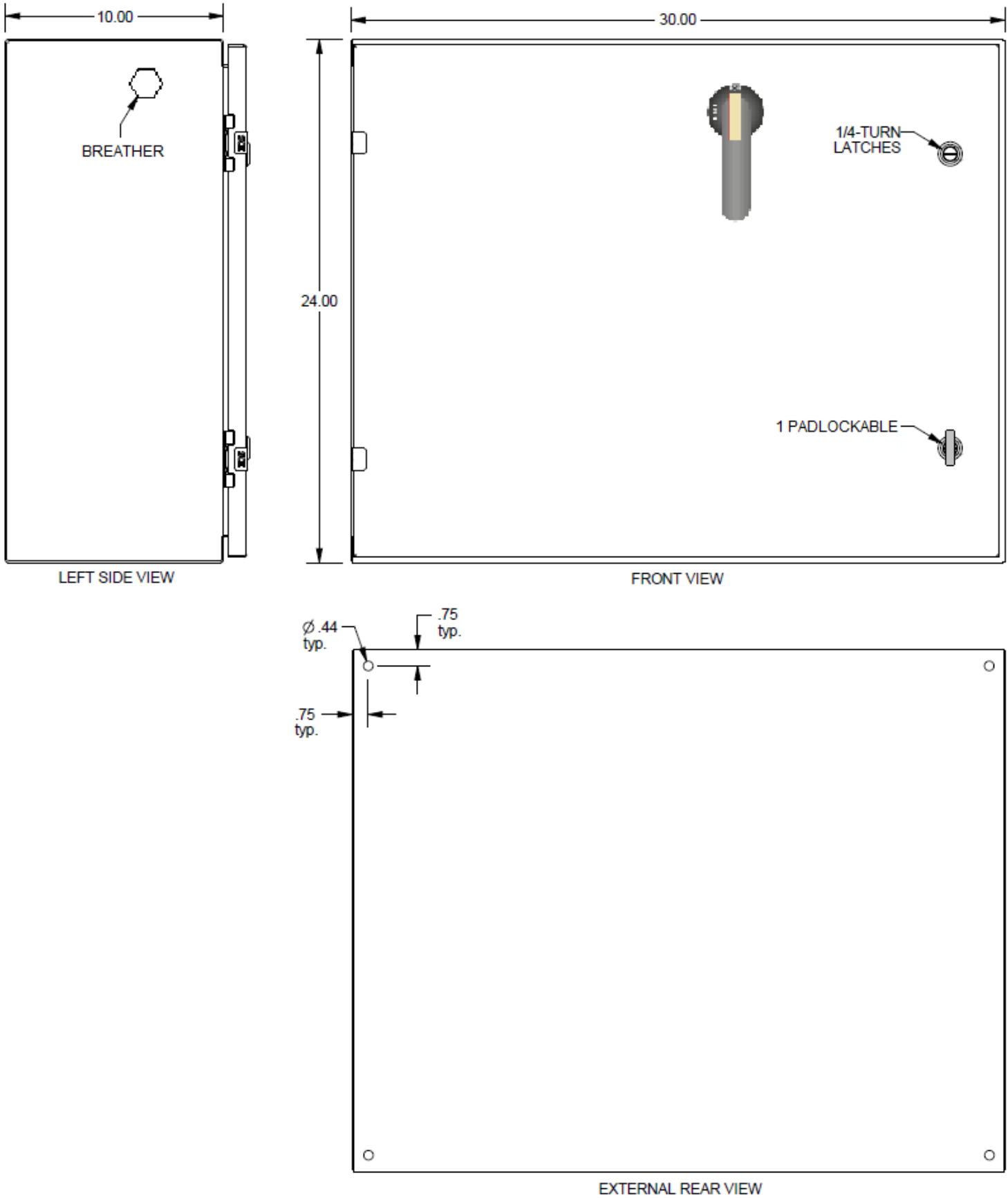


Figure 1 –Dimensions (Fiberglass 24x30)



**Figure 2 –Dimensions (Steel 24x30)**

### 3.4 Wiring

The String Combiner must use copper source circuit conductors only. For the PV output circuit feeders, either copper or aluminum conductors may be used. As with any aluminum wiring, follow best industry practices to ensure a reliable connection; thoroughly clean the conductor just prior to making the electrical connection and use an oxide inhibitor to prevent the formation of aluminum oxide.

All output conductor terminations are rated and have been tested for 90°C wire sizing.

All wiring must be in accordance with local and national electrical codes.

#### 3.4.1 Remove Fuses



**WARNING**– Removing fuses from a live circuit may create dangerous arc-flash and shock hazards.

- 1 Confirm that the switch is in the OFF position.
- 2 Remove each fuse from the touch-safe fuse holder for each source circuit. Store the fuses for later reinstallation.

#### 3.4.2 Shield Removal



**WARNING** – Removing the plastic shield(s) exposes the installer to dangerous voltage and shock hazards.





**WARNING**– Remove all fuses before proceeding with Sections 3.4.3 through 3.4.7.

- 1 Loosen, but do not remove the screw using a screwdriver.
- 2 Gently remove the plastic shield and store for reinstallation.
- 3 Leave the screw in place for reinstallation of the plastic shield.

#### 3.4.3 Grounding

See NEC Article 250 and 690 for grounding requirements. A ground bar has been provided for Equipment Grounding Conductors (EGCs). Torque each EGC accordingly. The String Combiner Box EGC terminal should be used to connect the enclosure to the inverter EGC circuit.

Equipment Grounding Terminals	PV Output Circuit Equipment Grounding Terminals
	
<p>10 positions, 14AWG – 4AWG Torque to 35 in-lb, use slotted driver Cu or Al Conductors</p>	<p>(2) 6AWG – 2/0AWG Torque to 50 in-lb, use 3/16" Allen wrench Cu or Al Conductors</p>

#### 3.4.4 Source Conductors

See NEC Articles 310 and 690 for proper source circuit conductor sizing. Note that the conductor size ranges given here and on the labels in the product are the overall allowed ranges that fit in the terminals but the minimum size conductor that can be used must be determined using NEC and is likely larger than the minimum shown in the ranges.

Acceptable source circuit conductor inputs are restricted to copper for the fused source circuit inputs.

Fused Source Conductors	Non-Fused Source Conductors
(1) 14AWG – 6AWG Torque to 20 in-lb, use #2 Phillips 75°C Terminations, Cu Conductors Only	14AWG – 4AWG Torque to 35 in-lb, use 1/8" Allen 90°C Terminations, Cu or Al Conductors

Connect the fused source circuit conductors to the touch safe fuse holders, one conductor per fuse holder. Route all source circuit conductors such that the installation is neat and orderly.

Connect the Non-Fused source circuit conductors to the negative source circuit terminal block, one conductor per screw terminal; torque each circuit conductor as described above. Route all source circuit conductors such that the installation is neat and orderly.

### 3.4.5 PV Output Circuit Conductors

See NEC Articles 310 and 690 for proper output conductor sizing. Innovative Solar provides dual M12 studs (Nema 1.75" pattern) for compression lugs as standard on utility scale String Combiner Boxes. Combiners can be field configured for mechanical lugs. Simply install the mechanical lug on the lower stud. Mechanical lugs can be purchased as an accessory.

Output terminals on all Innovative Solar combiners are CU/AL compatible and are approved and **tested** for 90C sized wire.

#### A. PV Outputs

For compression lugs 2x M12 Studs per bus Torque to 350 in-lb (29.2 ft-lb) Maximum lug width 2.40"	600 kcmil– 2 awg Torque to 550 in-lb (46 ft-lb) Use 1/2" Allen wrench 90°C Terminations Cu or Al Conductors Strip length 1.4"
	Consult factory for alternate lug sizes

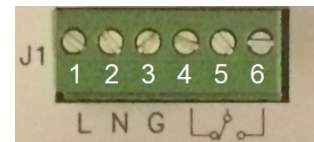


**NOTE:** Only use lugs with aluminum conductors that are explicitly listed for use with aluminum conductors.

### 3.4.6 Control wiring

For AFCI and Rapid Shutdown versions, control power must be provided to the control module. Please see the ratings table for power requirements.

Connect L, N, and GND as indicated by terminal block J1 on the control module. The control module is located in the upper left corner of the enclosure.



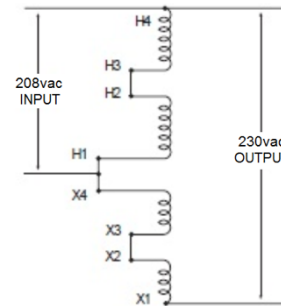
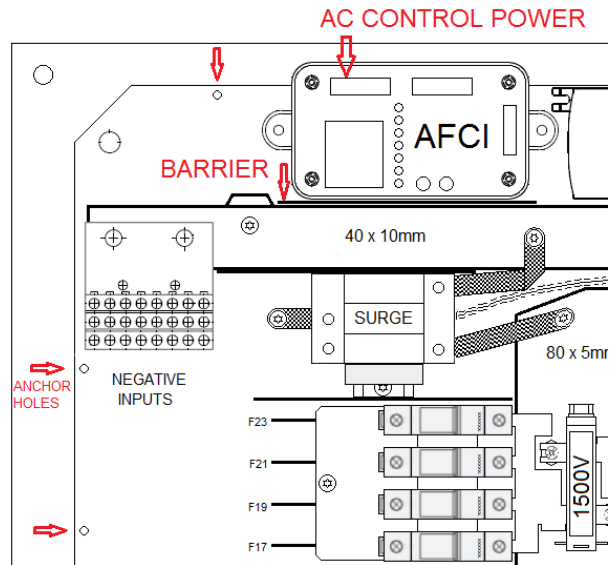
The control module also provides an auxiliary contact. The contacts will be in their normal state any time that the switch is tripped or power is lost.



Code requires that the control conductors be segregated from the PV conductors, if the control conductors are not also rated equal or higher than the PV voltage. To support this segregation, anchor holes have been provided along the left side perimeter of the mounting pan. Non-conductive tubing or conduit may be used on the conductors if an additional barrier is needed. A fixed barrier is provided between the control module and adjacent bus bar.

If desired the need for this segregation can be reduced by having the control conductors enter the enclosure in proximity to the control module.

The trip coil in the disconnect switch requires that only specific voltages be used. For other voltages such as 208vac, a good solution is the use of a buck-boost transformer. These transformers are smaller and easier to implement than isolation transformers.



### 3.4.7 Final Steps



**WARNING**– Verify the proper polarity of each source conductor. Polarity reversal can lead to dangerous arc-flash conditions capable of harming personnel and equipment.



**WARNING**– Check the String Combiner Box for tools and ensure the unit is clean and orderly.

1. Verify all connections meet the requirements of this Installation and Operations Guide.
2. Reinstall the plastic shield.
3. Install all fuses.
4. Close the string combiner door.

## 4.0 Operating Instructions



**WARNING**– Do not operate the switch with the String Combiner Box door open.

The String Combiner contains a user-operable switch. When this switch handle is in the OFF position, the circuit is open between the source conductors and the output conductors. Under normal operation, when the switch is in the ON position, the circuit is closed between the source conductors and the output conductors.

### 4.1 AFCI Operation

The AFCI function continually monitors all input and output conductors for arcing. If any one of the AFCI sensors detects the signature of an arc it will send a signal to the control module. The control module in turn sends the appropriate signal to the switch in order for it to trip in < 1 sec.

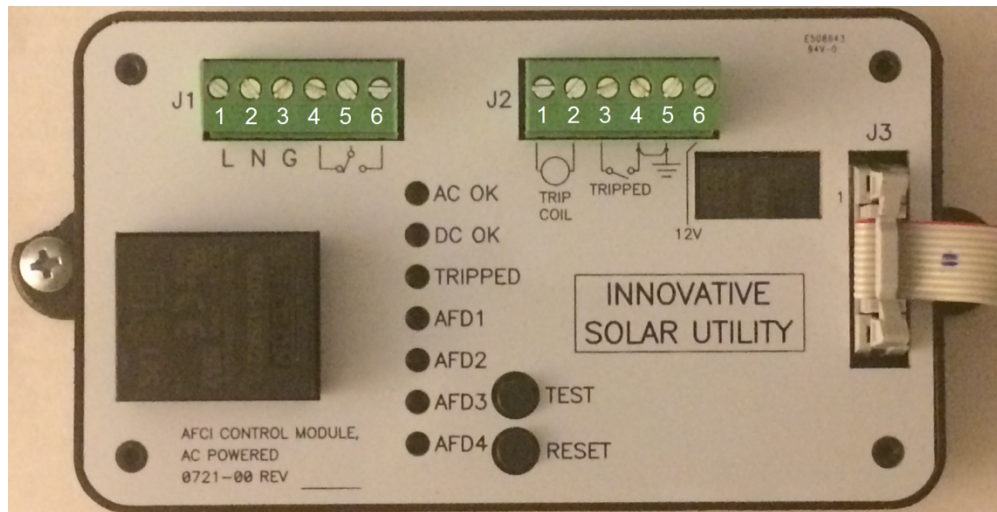
The AFD sensors each have an LED that indicates status: Flashing = normal, Continuous = fault, Off = power loss.

The control module has a bank of LEDs indicating the status of both inputs and outputs. Green LEDs indicate normal status, while red LEDs indicate faults.

If an arc-fault is detected the disconnect switch will open and the disconnect handle will move to an intermediate position indicating that it has been "TRIPPED". At the same time the control module LEDs will identify that it has tripped as well as the source of the trip. The auxiliary contacts will also change state providing for an optional remote indication.

In order to reset after a fault, rotate the disconnect handle to its full CCW momentary position "RESET". This will both recharge the springs in the disconnect and clear the logic in the electronics.

The disconnect switch may then be turned back on when desired.



**AFCI Control Module**

## **6.0 Warranty and RMA Instructions**

For all warranty information, please visit: <http://www.innovativesolarinc.com/>

## **7.0 Appendices**

### **7.1 Appendix A – Datasheet**

Please visit: <http://www.innovativesolarinc.com/>

### **7.2 Appendix B – Contact Information**

Innovative Solar Inc  
224 Airport Parkway  
Suite 190  
San Jose, CA 95110 USA

Tel: 888-315-6551

Sales/General Info: [kevina@innovativesolarinc.com](mailto:kevina@innovativesolarinc.com)  
Customer Support: [service@innovativesolarinc.com](mailto:service@innovativesolarinc.com)  
Website: [www.innovativesolarinc.com](http://www.innovativesolarinc.com)

### **7.3 Appendix C – Authorized Distributors**

See website for complete and updated listing: <http://www.innovativesolarinc.com/>



# Certificate of Compliance

**Certificate:** 70218895

**Master Contract:** 274986

**Project:** 70218895

**Date Issued:** 2019-05-30

**Issued To:** Innovative Solar Inc.  
224 Airport Parkway  
Suite 190  
San Jose, California, 95110  
United States

*The products listed below are eligible to bear the CSA Mark shown with adjacent indicators 'C' and 'US' for Canada and US or with adjacent indicator 'US' for US only or without either indicator for Canada only.*



## **PRODUCTS**

CLASS – 5311 09 - POWER SUPPLIES-Distributed Generation Power Systems Equipment

CLASS – 5311 89 - POWER SUPPLIES - Distributed Generation-Power Systems Equipment - Certified to U.S. Standards

Solar Combiner Box with Optional AFCI. Models: Models CB Series:

## **APPLICABLE REQUIREMENTS**

CSA C22.2 No. 290-15 – Photovoltaic Combiner

UL 1741 (2<sup>nd</sup> Ed.) (R2015) – Inverter, Converters and Controllers and Interconnection System Equipment for Use With Distributed Energy Resources

UL 1741 CRD PV Input Circuit Combiners and PV Combiner Boxes