OutBack POWER™
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FLEXware Integrated Combiner Solution Plus

Owner's Manual

GRIDHybrid™

About OutBack Power Technologies

OutBack Power Technologies is a leader in advanced energy conversion technology. OutBack products include true sine wave inverter/chargers, maximum power point tracking charge controllers, and system communication components, as well as circuit breakers, batteries, accessories, and assembled systems.

Grid/Hybrid™

As a leader in off-grid energy systems designed around energy storage, OutBack Power is an innovator in Grid/Hybrid system technology, providing the best of both worlds: grid-tied system savings during normal or daylight operation, and off-grid independence during peak energy times or in the event of a power outage or an emergency. Grid/Hybrid systems have the intelligence, agility and interoperability to operate in multiple energy modes quickly, efficiently, and seamlessly, in order to deliver clean, continuous and reliable power to residential and commercial users while maintaining grid stability.

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Table of Contents

Important Safety Instructions

READ AND SAVE THESE INSTRUCTIONS!

This manual contains important safety instructions for the Integrated Combiner Solution Plus (ICS Plus) product.

Symbols Used

	**WARNING: Hazard to Human Life** This type of notation indicates that the hazard could be harmful to human life.
	**CAUTION: Hazard to Equipment** This type of notation indicates that the hazard may cause damage to the equipment.
	**IMPORTANT:** This type of notation indicates that the information provided is important to the installation, operation and/or maintenance of the equipment. Failure to follow the recommendations in such a notation could result in voiding the equipment warranty.
	**NOTE:** This type of notation indicates that the information provided is important to understanding the operation and limits of the equipment. Failure to follow the recommendations in such a notation could result in improper or failed operation.

MORE INFORMATION

When this symbol appears next to text, it means that more information is available in other manuals relating to the subject. The most common reference is to the *ICS Plus Quick Start Guide*.

General Safety

	**WARNING: Limitations on Use** This equipment is NOT intended for use with life support equipment or other medical equipment or devices.
	**WARNING: Reduced Protection** If this product is used in a manner not specified by ICS Plus product literature, the product's internal safety protection may be impaired.
	**CAUTION: Equipment Damage** Only use components or accessories recommended or sold by OutBack Power Technologies or its authorized agents.

Introduction

Audience

This manual provides instructions for installation, setup, and operation of the product. These instructions are for use by qualified personnel who meet all local and governmental code requirements for licensing and training for the installation of electrical power systems with AC and DC voltage up to 600 volts. This product is only serviceable by qualified personnel.

Welcome to OutBack Power Technologies

Thank you for purchasing the OutBack Integrated Combiner Solution Plus (ICS Plus). It provides comprehensive PV rapid shutdown and arc fault protection. This product allows a system to meet the 2014 National Electric Code requirements for PV systems.

- NEC 690.11 — Arc fault protection (protects against arc faults due to loose connections, damaged wires, or other DC component failures)
- NEC 690.12 — Rapid shutdown (allows first responders to safely de-energize controlled conductors)
- NEC 690.15 — DC combiner disconnect (opens all ungrounded circuit conductors from all energy sources)

Product Overview

Features

- First end-to-end solution listed to UL1741 with PV rapid shutdown systems (PVRSS)
- Arc fault circuit interrupter (AFCI) listed to UL1699B with local and remote indication
- Type 3R enclosures rated for indoor or outdoor installation
- Flexible design — install the combiner box vertically, horizontally, or at any intermediate angle; mount to racking or under the PV array
- Interoperability with compatible third-party PV rapid shutdown system equipment (PVRSE) with a dry contact input
- Three complete packages simplify the design and ordering process
- Combiner box has removable component panel for ease of wire management and for serviceability
- Combiner box has easy-to-install DIN-mount fuses for bi-directional overcurrent protection
- Lockable disconnects on combiner and rapid shutdown boxes
- Communications use building wire commonly available in the field (THHN/THWN-2)
- Ground lug and grounding terminal bus bar for system and equipment grounding
- Internal factory prewiring to save time during installation

Components

The primary component in the ICS Plus system is the DC combiner box. This combines up to six PV source circuits and provides an overcurrent protective device (OCPD) for each circuit. The AFCI device is located here.

The combiner provides a local disconnecting means. It also provides a contactor for PV rapid shutdown functionality to de-energize PV circuits within 10 feet of the PV array.

Other components include:

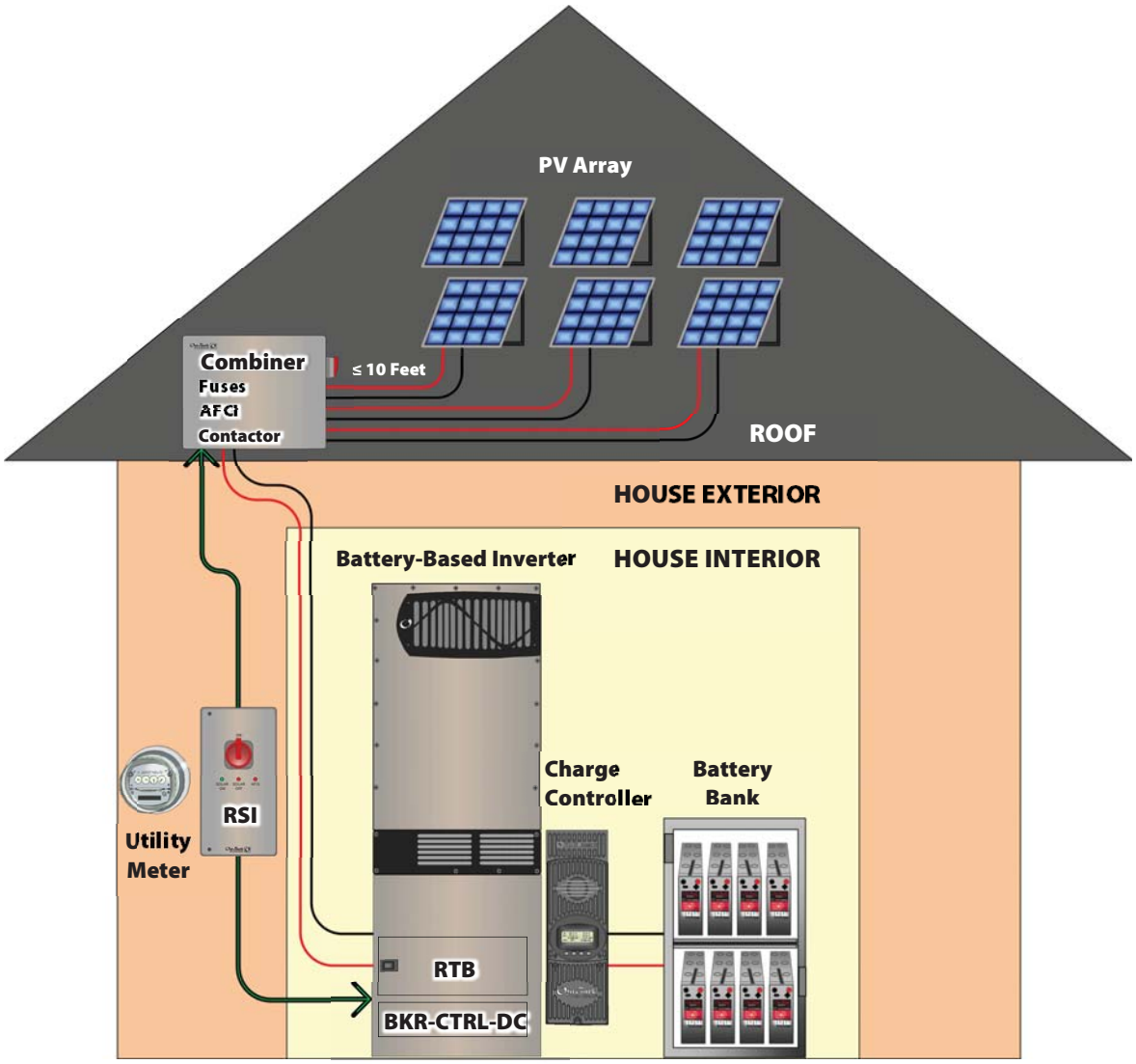
- Rapid Shutdown Initiator (RSI) which works with the combiner box to induce the rapid shutdown function
- Relay-Trip Breaker (RTB) which physically opens the circuits near the charge controller(s)
- Breaker control and power supply (BRK-CTRL-DC) which powers the RSI, RTB, and combiner

Packages

The ICS Plus has three prepackaged solutions for battery-based systems.

Table 1 Packaged Systems

Package	ICSPLUS-1	ICSPLUS-2	ICSPLUS-3
FWPV6-FH600-SDA combiner	1	2	4
Compatibility	6 PV strings 1 charge controller	12 PV strings 2 charge controllers	24 PV strings 4 charge controllers
RSI	Standard		
BKR-CTRL-DC	Standard		
Relay-Trip Breaker	PNL-75-DC-RT	PNL-75D-DC-RT	PNL-75Q-DC-RT



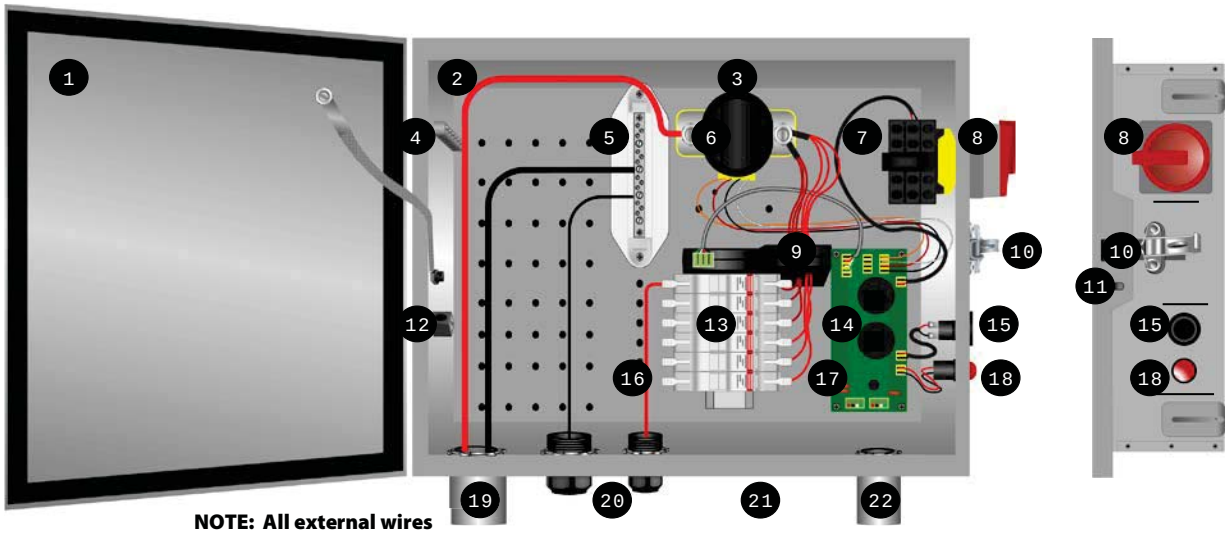
- Combiner Box
  - ~ Contains OCPD, AFCI, main contactor, PV Combiner Disconnect
  - ~ Includes local disconnect to de-energize PV circuits within 10 feet of the array
- Rapid Shutdown Initiator (RSI)
  - ~ Contains control circuit for PVRSS (contactors and relay-trip breakers)
  - ~ Includes PVRSS disconnect switch
  - ~ Includes LED indicators for PV connection, disconnection, or arc fault
- Relay-Trip Breaker (RTB)
  - ~ Removes charge controller(s) from PV circuit
  - ~ Can be integrated into OutBack GSLC or FLEXware enclosures
- Circuit Breaker Control Box (BKR-CTRL-DC)
  - ~ Provides power to combiner, RSI, and RTB

Figure 1 Example of Residence with ICS Plus

Components

NOTE:
This manual depicts the use of a negative-grounded system. For positive grounding, see page 18.

Combiner

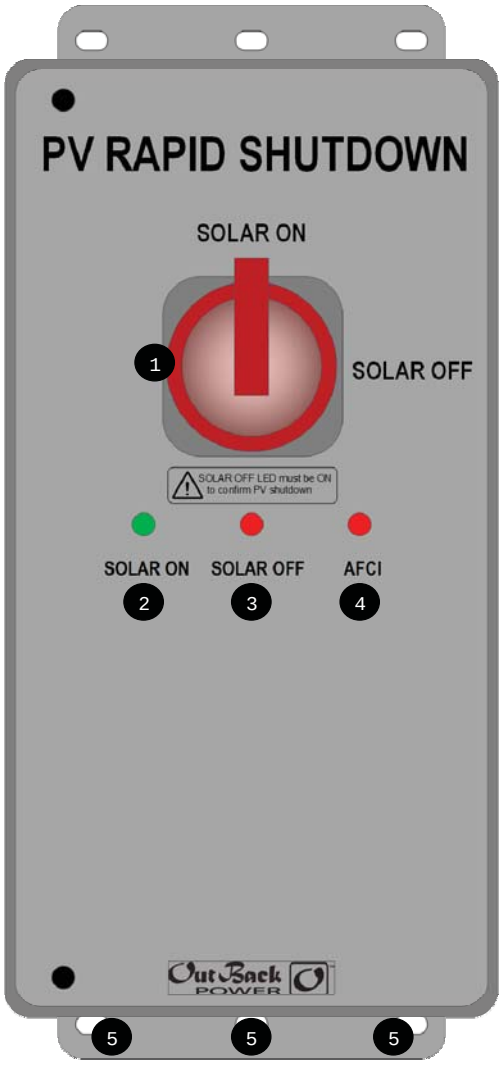


NOTE: All external wires are provided by installer

1	Gasketed Door/ Type 3R Enclosure	Protects from the environment	**12**	Ground Cable Terminal	Provides "lay-in" lug for optional pass-through ground wire
2	Component Panel (Removable)	For ease of wire management and for serviceability	**13**	Fuse Holders	PV source overcurrent protection; fuses provided by user
3	Bidirectional PV Contactor	Opens PV circuits for AFCI and for local or remote disconnect	**14**	Combiner Control Board	Controls all functions within the combiner; commands the contactor
4	Ground Terminal Bus Bar	Provides a means for system and equipment grounding	**15**	Arc Fault Self-Test Button	Allows AFCI to be tested without opening the combiner box
5	Negative Terminal Bus Bar	Combines negative PV source circuits	**16**	PV Input Connections	Connections for positive PV source circuits
6	PV Positive Output Terminal	Connection for PV positive output circuit	**17**	Communications Terminals	Communicates with RSI and additional combiner boxes
7	Internal Prewiring	Factory-installed for ease of installation	**18**	AFCI Annunciator	Illuminates during an arc fault event or test
8	PV Combiner Disconnect	Activates the contactor for disconnection; can be padlocked in the OFF position	**19**	2" EKO (PV Output)	Accommodates conduit and a UL 514-compliant fitting for PV output circuits
9	Arc Fault Detection Device	Detects series DC arc fault events	**20**	Cable Glands (PV Input)	Provide waterproof strain relief for PV source circuits
10	Secure Latch	Fastens door; can be padlocked	**21**	½" EKO (optional)	For installation of a third-party surge protection device (provided by user)
11	Securing Screw	Secures door in place if padlock is not used	**22**	½" and ¾" (2 ea) EKO (Communications)	Accommodate conduit and a UL 514-compliant fitting for communication wires

Figure 2 Components of Combiner Box

RSI



1	Rapid Shutdown switch	Initiates the PVRSS function; disconnects RTB and main contactor in combiner.
2	**SOLAR ON** indicator	Green LED indicator; illuminates when DC voltage is present and Rapid Shutdown switch is in the ON position.
3	**SOLAR OFF** indicator	Red LED indicator. **SOLAR OFF** must be illuminated to confirm PV shutdown. This indicator tells responders that the Rapid Shutdown switch is in the OFF position to create a "safe" condition.
4	**AFCI** indicator	Red LED indicator; illuminates when receiving an "arc fault" signal from the combiner.
5	½" (3) EKO	These accommodate conduit and a UL 514-compliant fitting for communication wires

NOTE:
SOLAR ON does not necessarily indicate that the PV system is active.
See the Troubleshooting section on page 19 .

Figure 3 Components of RSI

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Functions

Arc Fault Circuit Interruption

In a PV system, an electrical arc occurs when current bridges a gap between conductive surfaces. Gaps can occur due to conductor damage, or can be caused by inadequate system connections. An "arc fault" is a safety concern for several reasons:

- Risk of electric shock if the mounting system or other components become electrified.
- Fire hazard due to heat buildup from the current flow.

A series arc occurs across open connections in a single conductor. A parallel arc occurs if the current bridges multiple conductors that were meant to remain separate. The arc fault circuit interrupter (AFCI) in the ICS Plus is intended to protect against series arcs.

Detection

The combiner has a dedicated arc fault detection device. The device operates by detecting the distinct electrical noise created by an arc. The detector has two current transducers, each of which monitors up to three PV circuits. If an arc is detected, the detector sends a signal to the main control board in the combiner box.

- The control board sends a signal to open the combiner's main contactor. The **AFCI Annunciator** turns on.
- The control board also sends a signal to the RSI and turns on the "arc fault detected" indicator.

NOTES:

- This is a simple alarm indicating that an arc fault has occurred somewhere in the system. If multiple combiners are in use, the RSI cannot specify which combiner triggered it.
- Only the combiner with the detected arc will open its contactor. Any other combiners in the system will continue to operate. Relay-trip breakers will continue to operate.

If an arc fault occurs, see the Troubleshooting section on page 19.

Upon an arc fault event, the system is required by NEC 690.11 to be reset manually. The manual reset also resets the RSI **AFCI** indicator and the combiner **AFCI Annunciator**.

Reset

To reset the detector following an arc fault:

1. Turn the PV Combiner Disconnect switch (or the Rapid Shutdown switch) to the OFF position. The **AFCI Annunciator** and **AFCI** indicator should turn off. All combiner box contactors will open.
2. Turn the same switch to the ON position. The **AFCI Annunciator** and **AFCI** indicator should remain off. All combiner box contactors will close.

NOTES:

- The Rapid Shutdown switch can be used to reset all combiners at once from a central location.
- If the Rapid Shutdown switch is used, the relay-trip breakers will turn off at the same time. Make certain to turn them back on when this step is performed.

An arc fault can also be reset by disconnecting all DC power from the system, including the batteries.

The ICS Plus arc fault detector has been evaluated to have a low instance of nuisance tripping. However, installing external DC components in the system may increase the risk of nuisance tripping.

Arc Fault Self-Test

The arc fault function can be manually tested. The arc fault self-test mimics the conditions of an arc fault. The combiner and RSI give the same indications as described on page 11.

To perform the arc fault self-test:

1. Ensure the system is functioning and all indicators are normal.
2. Push the arc fault self-test button as shown in Figure 2 on page 8.
3. Listen for an audible click as the contactor opens.
4. Check the **AFCI Annunciator** on the combiner. It should be illuminated.
5. Optional (if installed): Check the **AFCI** indicator on the RSI. It should be illuminated.

Reset the system by the same method as described on page 11.

Rapid Shutdown

The rapid shutdown requirement is intended for firefighters or first responders. In an emergency, a responder may need to set the PV system in a "safe" (de-energized) state according to NEC 690.12.

For this reason, the RSI is required to be mounted close to the main utility meter. The RSI must be easily visible.

The RSI includes a Rapid Shutdown switch that initiates a disconnection of all elements of the PV system. Opening this switch sends a signal to all combiners to open the main contactor on each.

Opening this switch also sends a signal to all relay-trip breakers, ordering them to open. According to NEC 690.12, the rapid shutdown must reduce the DC circuit to less than 30 Vdc and 240 VA within ten seconds of initiation. Because many charge controllers have capacitors which may not discharge quickly enough, the RTB function removes the controller from the circuit to make it safe.

Rapid Shutdown Self-Test

The rapid shutdown should be tested every six months. This test should be performed as described in the Verification section.

Verification

Turning the Rapid Shutdown switch to the right (clockwise) puts it in the OFF position. The **SOLAR OFF** LED indicator will illuminate upon successful shutdown. If this does not occur, see the Troubleshooting section on page 19.

PV Combiner Disconnect

Each combiner has a PV Combiner Disconnect switch which is used to turn off a particular array. This is used if the array or circuit needs to be serviced. The switch can be padlocked in the OFF position as a "lockout/tagout" procedure to prevent a shock hazard.

Installation

This section assumes the use of the combiner, the RSI, the BKR-CTRL-DC and the RTB. The combiner box is a required part of all ICS Plus systems. All examples in OutBack literature show one or more combiners in use, including the *ICS Plus Quick Start Guide*.

The RSI is required for all ICS Plus systems utilizing the PVRSS function. For examples of systems which may not require the use of the RSI, see page 17. Also see page 17 for examples of systems which may not require the use of the BKR-CTRL-DC or the RTB.

Mounting Information

The ICS Plus combiner box accommodates multiple mounting types.

- It can be mounted horizontally, vertically, or at any intermediate angle.
- It has slotted mounting feet which allow a variety of positions.
- It is capable of being mounted directly under the PV array if necessary.
- It must be mounted at least 36" (91.4 cm) above the ground.
- The combiner box has a latch which should be padlocked to limit internal access.
- The main disconnect can also be padlocked in the OFF position for safety.

NOTE:
If the box is not padlocked, the securing screw must be used to secure the door.
See Figure 2 on page 8.

The RSI has mounting brackets at the top and bottom.

- It should be installed near the service meter.
- It must be mounted vertically and must be at least 36" (91.4 cm) above the ground.
- The Rapid Shutdown switch can be padlocked in the OFF position for safety.

NOTE:
If the structure where the RSI is installed is also equipped with utility service, the structure must have a permanent sign or plaque reading "PHOTOVOLTAIC [or PV] SYSTEM EQUIPPED WITH RAPID SHUTDOWN". This plaque must be reflective, with all letters capitalized and having a minimum height of ⅜" (9.5 mm) in white on red background.

The BKR-CTRL-DC is intended to be installed in the load center in most cases.

- When using the FLEXware 500 or 1000, it is installed in one slot in the DC enclosure.
- When using the FLEXware 250, it is not installed inside the enclosure. It is installed externally using the included bracket. It connects alongside the FLEXnet DC Battery Monitor.
- When using the GSLC, it is installed in one circuit breaker slot on the DC rail.
- If necessary, the slotted holes on the included bracket allow it to be installed in various external locations on the GSLC or the Radian inverter.

The RTB is intended to be installed in the load center.

- Each RTB takes the place of a PV input circuit breaker.
- Note that each RTB assembly requires an additional circuit breaker slot. For example, PNL-75D-DC-RT requires three slots. PNL-75Q-DC-RT requires five slots.

Connection Information

Combiner

The combiner box can take input circuits from up to six PV subarrays. It provides a single PV output which is connected to the load center and one pole of the RTB. See Figure 4 on page 15.

- The combiner's control board receives power from the RSI (**2**). It also sends status information to the RSI (**3**). Both sets of wires must be connected for correct PVRSS operation.
- The communication wires may be run in the same conduit as the PV wire only if the communication wiring is rated for the highest system voltage.
- Up to six combiners can be used in a single system with a single RSI. The control wires must be placed in series ("daisy chained") between combiners.
- Regardless of the number in use, the last combiner must have a jumper placed across its sensing terminals to close the circuit. If only one combiner is present, the jumper must be placed there.

RSI

The RSI communicates with the combiner box (and with any additional combiners connected to it). It also communicates with the Circuit Breaker Control box, BKR-CTRL-DC, and RTB connected to it. See Figure 4 on page 15.

- It receives power (**1**) from the BKR-CTRL-DC or a similar power supply.
- It sends power (**2**) to the combiner(s) control board.
- It receives AFCI (**3**) status information from the combiner(s).
- It receives PVRSS status information from the BKR-CTRL-DC (**4**) and the combiner(s) (**5**).
- It sends RTB disconnect commands (**6**) to the BKR-CTRL-DC.

Both sets of wires must be connected for correct PVRSS operation.

BKR-CTRL-DC

The BKR-CTRL-DC connects to the battery bus in the load center. See Figure 4 on page 15.

- It sends 24-volt power to the RTB (**8**) and the RSI (**1**) (which in turn powers the combiner).
- The positive wire to the load center must be protected with the following fuse type: 3AG Cartridge, 3A slow-blow, 10kA@125VDC.
- This box receives a plug which must be manually wired in advance with the appropriate conductors.

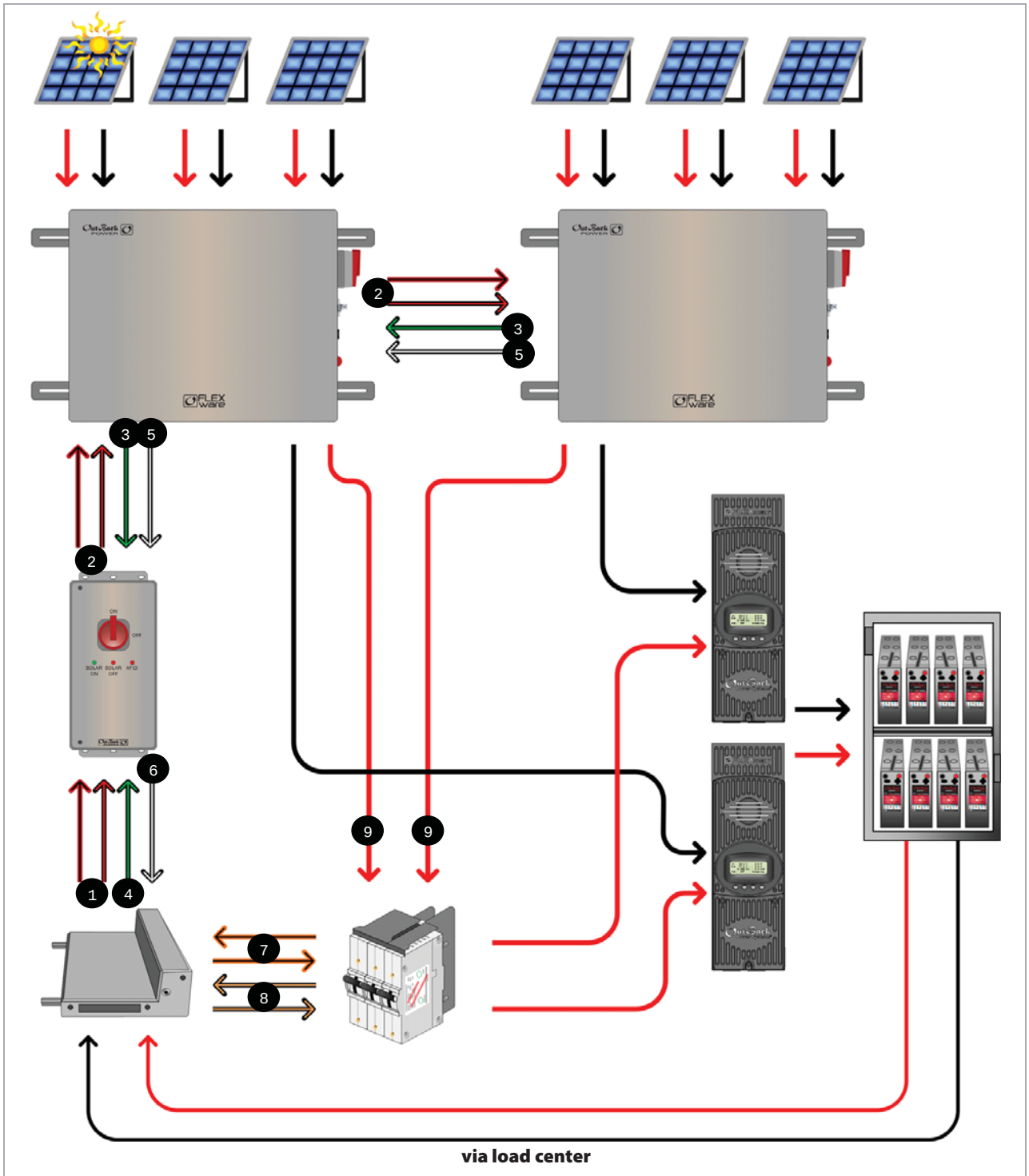
CAUTION: Equipment Damage

The 24-volt conductor is not grounded and is not to be connected to chassis or any other grounding system.

RTB

The remote-trip breaker facilitates part of the PVRSS function by removing the charge controller from the PV circuit. It has connections for the trip sense function (**7**), the breaker-trip coil (**8**), and the PV input (**9**). See Figure 4 on page 15.

- The RTB takes the place of the PV input disconnect which is normally installed in the load center.
- When multiple combiners are in use, multiple RTB poles may be required. PNL-75D-DC-RT has dual poles for two combiners. PNL-75Q-DC-RT has quadruple poles for four combiners.
- When six combiners are in use, PNL-75D-DC-RT and PNL-75Q-DC-RT should both be installed. For this installation, the RTB control and coil connections should be wired in parallel.



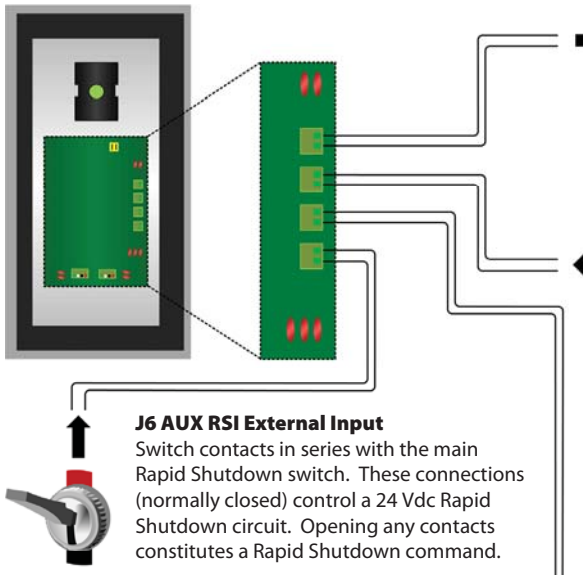
1 24V RSI Supply
2 24V Combiner Supply
3 PV Arc Fault
4 Breaker RSI Safe
5 PV RSI Safe
6 Breaker Trip
7 Trip Sense
8 Breaker-Trip Coil
9 PV to RTB

Figure 4 Block Diagram

Optional Connections

RSI

The RSI has several sets of auxiliary terminals. Terminal **J6** has a factory-installed jumper. **J3**, **J4**, and **J5** do not. The terminals can be wired to alarms or switches to send or receive status messages.



J3: AUX RSI Command/Status Output
Dry contacts which report RSI status. The **J3** contacts can activate a local alarm or send status messages to the Internet or other OutBack devices.

- Open: Rapid Shutdown (**SOLAR OFF**)
- Closed: Normal (**SOLAR ON**)
- 30 Vdc or 15 Vac @ < 2 A

J4: AUX RSI Safe Status Input
Switch contacts in parallel with the Breaker RSI Safe and PV RSI Safe wires from BKR-CTRL-DC. (See page 15.) These connections close a 24 Vdc "Safe" status circuit. An external switch or relay can send a "Safe" signal to **J4** from another location.

- Open (all connections): Not "Safe"
- Closed (any connection): "Safe" (Rapid Shutdown)

J6 AUX RSI External Input
Switch contacts in series with the main Rapid Shutdown switch. These connections (normally closed) control a 24 Vdc Rapid Shutdown circuit. Opening any contacts constitutes a Rapid Shutdown command.

An external switch or relay can serve as another rapid shutdown device if connected to the **J6** contacts from another location.

- Closed (J6 and R.S.): Normal (**SOLAR ON**)
- Open (either J6 or R.S.): Rapid Shutdown (**SOLAR OFF**)

NOTE: The **J6** jumper must remain in place if an external switch is not connected. Leaving these contacts open will cause a continuous shutdown.

IMPORTANT:
If BKR-CTRL-DC or other devices are not installed, a jumper must be installed on **J4**. With no connections, the **SOLAR OFF** ("safe") indicator will not light even if the Rapid Shutdown switch is OFF. (See page 17.)

J5 AUX AFCI Status Output
Dry contacts which report AFCI status. The **J5** contacts can activate a local alarm or send status messages to the Internet or other OutBack devices.

- Open: Normal
- Closed: Arc Fault Event
- 30 Vdc or 15 Vac @ < 2 A

Figure 5 Interface Connections

Surge Protector

An optional surge protection device can be installed in the combiner. A knockout has been provided to accommodate this type of device. Figure 6 shows the underside of the combiner and the location of the knockout.

NOTE:
Any installed devices must be liquid-tight to sustain the combiner's environmental rating.

A. PV Conduit (2")
B. PV Cable Glands
C. Surge Protector (½")
D. Communications Conduits (½" and ¾")

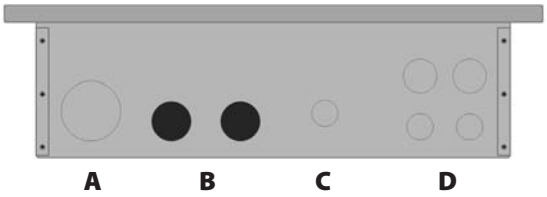


Figure 6 Surge Protector and other Knockout Locations

Other Applications

Alternative System Requirements

The ICS Plus can be used in systems with varying requirements, or with third-party equipment. Some systems may only need certain ICS Plus components, rather than the entire system. This may depend on the applicable codes.

NOTE:
All systems depicted here assume the use of a PV combiner with AFCI protection required.

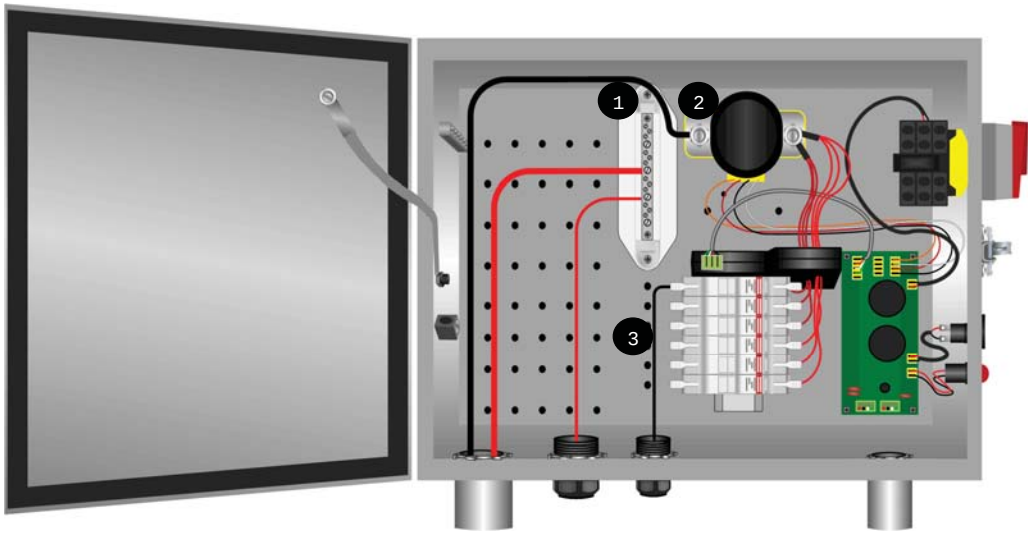
Table 2 Applications

PV Application	Combiner and AFCI	PVRSS Initiator	System Power	Load Center Disconnect
These battery-based applications use OutBack equipment, or equipment which operates in the equivalent voltage range.				
➢ 300 Vdc max array ➢ 24 to 48 Vdc battery bank ➢ PVRSS required	FWPV6-FH600-SDA	RSI	BKR-CTRL-DC	PNL-75*-DC-RT * 75, 75D, or 75Q
➢ 300 Vdc max array ➢ 24 to 48 Vdc battery bank ➢ PVRSS NOT required	FWPV6-FH600-SDA	—	BKR-CTRL-DC	—
These battery-based applications may require third-party equipment which operates in higher voltage ranges.				
➢ 300 to 600 Vdc max array ➢ 24 to 48 Vdc battery bank ➢ PVRSS required	FWPV6-FH600-SDA	RSI	BKR-CTRL-DC	Third-party PVRSE rated for 600Vdc
➢ 300 to 600 Vdc max array ➢ 24 to 48 Vdc battery bank ➢ PVRSS NOT required	FWPV6-FH600-SDA	—	BKR-CTRL-DC	—
These non-battery-based applications may require third-party equipment which operates in higher voltage ranges.				
➢ 600 Vdc max array ➢ Non-battery-based system ➢ PVRSS required	FWPV6-FH600-SDA	RSI	Isolated Class 2 DC supply • Up to 15 Adc • 24 Vdc ± 3% maximum (over operating conditions)	PVRSE rated for 600Vdc
➢ 600 Vdc max array ➢ Non-battery-based system ➢ PVRSS NOT required	FWPV6-FH600-SDA	—		—

IMPORTANT:
When BKR-CTRL-DC is not used and no **J4** input is provided to the RSI, **J4** must have pins 1 and 2 connected together with a jumper. (See page 16.) This provides the RSI Safe signal that otherwise would not be present.

Positive Ground

The ICS Plus can be used in positive-grounded installations. For these solutions, the ungrounded PV negative (–) conductors should be connected to the fuse holders. The grounded PV positive (+) conductors should be connected to the white bus bar. Other connections, such as the combined PV output, should be similarly reversed. The remaining combiner box connections are made as normal.



1	Positive Terminal Bus Bar	Combines grounded (positive [+]) PV source and output circuits
2	PV Negative Output Terminal	Connection for ungrounded (negative [–]) PV output circuit
3	PV Input Connections	Connections for ungrounded (negative [–]) PV source circuits

Figure 7 Positive-Grounded Combiner Box

IMPORTANT:
Some positive-grounded solutions require the disconnection of both the grounded and ungrounded conductors. The ICS Plus product depicted here has only a single contactor. It will not suffice for these applications.

IMPORTANT:
The ICS Plus product depicted here cannot be used in ungrounded systems.

The relay-trip breaker is wired differently from the method in the *ICS Plus Quick Start Guide*.

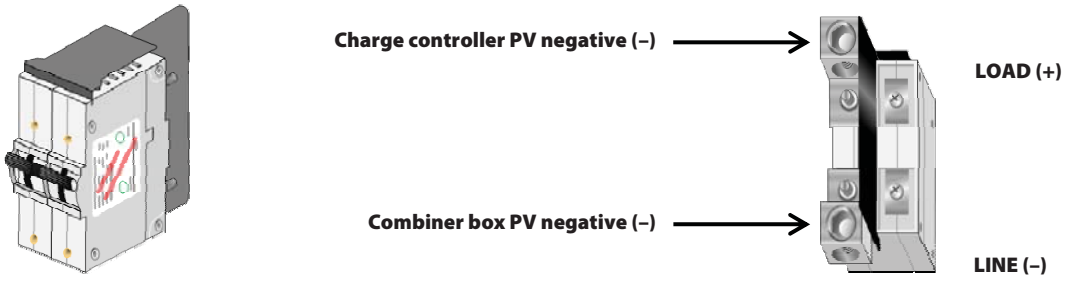


Figure 8 Positive-Grounded RTB

Troubleshooting

LED Indicators

Table 3 LED Table

Box	LED	When Lit	Notes
RSI	**SOLAR ON** (green)	DC voltage present in system, Rapid Shutdown switch ON.	May be lit at the same time as **AFCI**. Despite the label, **SOLAR ON** does not indicate that the PV system is active. It will illuminate even if PV is completely disconnected or if an arc fault is present. The name indicates to responders that this control does not shut down other parts of the electrical system; i.e. it only affects PV-related devices.
RSI	**SOLAR OFF** (red)	System is in "safe" mode. Rapid Shutdown switch OFF. This LED can also illuminate when PV and relay-trip breakers are disconnected.	This indicator should never be lit at the same time as any other.
RSI	**AFCI** (red)	Arc fault condition or deliberate arc fault self-test.	Accompanied by at least one **AFCI Annunciator** (on one or more combiners). May be lit at the same time as **SOLAR ON**.
Combiner	**AFCI Annunciator** (red)	Arc fault condition or deliberate arc fault self-test.	Accompanied by **AFCI** on RSI. Will not be accompanied by **AFCI Annunciator**s in other combiners unless other arc faults are present. May be lit at the same time as **SOLAR ON**.

Basic Troubleshooting

The following table describes known situations which can cause unexpected behavior in the ICS Plus. The table also describes all known situations which will cause the LED indicators to light.

NOTE:

When a true arc fault event occurs, the ICS Plus disconnects the PV by design. ICS Plus troubleshooting is not required. However, it may be necessary to troubleshoot and locate the cause of the problem. Diagnosis of an arc fault is not covered under the scope of this document.

WARNING: Shock Hazard

An arc fault causes the AFCI to disconnect that section of the PV system to prevent fire or shock injuries. These hazards may still exist on the array itself if physical troubleshooting is required. Make certain to cover the PV modules and take any other necessary steps to reduce risk.

See the next page for a table of basic troubleshooting steps.

Table 4 Troubleshooting

Symptom	Possible Cause	Possible Remedy
AFCI indicator and combiner **AFCI Annunciator** lit.	Arc fault event. **NOTE**: The **SOLAR ON** indicator remains lit.	If an arc fault is present, the shutdown of the system constitutes correct operation. The ICS Plus does not need troubleshooting. Investigate any potential causes throughout the PV system.
	Arc fault self-test button was pressed.	Turn combiner disconnect switch or Rapid Disconnect switch off, then on. Reset all RTB devices.
AFCI indicator lit. Combiner **AFCI Annunciator** not lit.	Arc fault in another combiner (multiple combiner system only). **NOTE**: The **SOLAR ON** indicator remains lit.	Check all combiners. An arc fault will activate the **AFCI Annunciator** in that combiner only.
SOLAR OFF indicator lit. RTB cannot be turned on.	Rapid Shutdown switch is in off position. System is in "safe" condition with PV contactors disconnected and RTB forced to the off position.	Turn Rapid Shutdown switch on. Once it is on, turn on the RTB.
SOLAR OFF indicator and another indicator both lit.	RSI miswired.	Check all wiring between RSI and combiner.
SOLAR ON indicator lit, but charge controller does not register PV input.	Combiner disconnect switch turned off.	Turn on combiner disconnect switch.
SOLAR ON indicator lit, but charge controller registers reduced PV input.	Array wiring error or poor connection.	Check all PV wiring to combiner. Use DVM to confirm voltage of each subarray at combiner input terminals.
	Fuses blown in combiner box.	Check all fuses.
No indicators lit. RTB off. Turning RTB on does not enable PV.	Battery or DC source is disconnected. Loss of combiner box control voltage caused the PV contactor to disconnect. System is not in the formal "safe" condition, although PV array is still forced to be off.	Check all DC disconnect devices. Check BKR-CTRL-DC fuse. Use DVM to confirm voltage at BKR-CTRL-DC terminals. **NOTE**: Once voltage is established, RTB must be manually turned on (if not already on).
SOLAR OFF indicator does not light when Rapid Shutdown switch is turned off.	Battery or DC source is disconnected. System is not in the formal "safe" condition, although PV array is still forced to be off.	Check all DC disconnect devices. Check the BKR-CTRL-DC fuse. Use DVM to confirm voltage at BKR-CTRL-DC terminals. **NOTE**: Once voltage is established and RTB is off, **SOLAR OFF** indicator should light. See below.
SOLAR OFF indicator does not light when Rapid Shutdown switch is turned off after DC reconnection.	RTB is turned on. System is not in "safe" condition. Rapid Shutdown switch was not able to turn the RTB off due to DC loss. **NOTE**: This may not be a valid test. Wait at least one minute after DC reconnection.	Turn RTB off if necessary, or wait. Within 30 seconds, the RSI will turn the RTB to the off position automatically to force a "safe" condition. The **SOLAR OFF** indicator should light.

Specifications

Device Specifications

Table 5 Electrical and General Specifications

Device	ICS Plus Combiner Box	Rapid Shutdown Initiator	Circuit Breaker Control	Relay Trip Breakers
Designation	FWPV6-FH600-SDA	RSI	BKR-CTRL-DC	PNL-75-DC-RT PNL-75D-DC-RT PNL-75Q-DC-RT
Description	6-string combiner box with PV rapid shutdown, AFCI, and manual disconnect	Initiates a PV rapid shutdown event; provides indication for PV status and AFCI	DC breaker control and power supply; provides isolated 24 Vdc from batteries	1- to 4-pole breakers that open controlled conductors in a PV rapid shutdown event
Compatibility	Can accommodate 6 PV input strings per combiner	Can control up to 6 combiner boxes and 2 relay-trip breakers	Can power up to 6 combiner boxes and 2 relay-trip breakers	Can control 1 to 4 poles 1 pole: PNL-75-DC-RT 2 poles: PNL-75D-DC-RT 4 poles: PNL-75Q-DC-RT
Terminals:				
Input	#14 to #8 AWG (2.5 to 10 mm^2) (Cable glands)	#24 to #16 AWG (0.25 to 1.5 mm2)	¼" stud	#14 to 2/0 AWG (2.5 to 70 mm^2) (PV input)
Output	#14 to 2/0 AWG			10-32 screw (trip sense)
LED indicators	AFCI Annunciator	• SOLAR ON • SOLAR OFF • AFCI	N/A	N/A
Overcurrent Protection	(6) 600 Vdc DIN rail fuse holders	N/APNL	3AG Cartridge, 3A slow-blow, 10kA@125VDC	N/A
Voltage Rating	600 Vdc	24 Vdc ± 3%	N/A	300 Vdc per pole
Total Current (maximum)	96 Adc	N/A	N/A	75 Adc per pole
DC input	24 Vdc ± 3%	24 Vdc ± 3%	24, 32, 36, 48 Vdc (battery nominal)	Supplied from Circuit Breaker Control box
Normal Operation Power Draw	0.10 Adc	0.06 Adc	0.05 Adc	N/A

Table 6 Mechanical and Environmental Specifications

Device	ICS Plus Combiner Box	Rapid Shutdown Initiator	Circuit Breaker Control	Relay Trip Breakers
Enclosure Material	Powder-coated aluminum			N/A
Enclosure Rating	UL Type 3R	UL Type 3R	UL Type 1 with connector enclosure	UL Open Type RH noncondensing
Operating Temperature	–25 to 60°C	–25 to 60°C	–25 to 50°C	–25 to 50°C
Security	• Lockable • Switch is lockable in OFF position	Switch is lockable in OFF position	N/A	N/A
Mounting	Vertical to horizontal (adjustable feet)	Vertical only (brackets)	Panel slot or bracket	Panel slot(s)

Table 6 Mechanical and Environmental Specifications

Device	ICS Plus Combiner Box	Rapid Shutdown Initiator	Circuit Breaker Control	Relay Trip Breakers
Knockouts	2″, ½″, and ¾″	½″	N/A	N/A
Dimensions (H x W x D)	15.5 × 19.5 × 4.5″ (39.4 × 49.5 × 11.4 cm)	14.1 ×7.3 × 3.75″ (30.5 × 17.8 × 12.7cm)	2.0 × 5.25 × 4.4″ (5.1 × 13.3 × 11.2 cm)	Width only: PNL-75-DC-RT: 1.5″ (3.9 cm) PNL-75D-DC-RT: 2.2″ (5.7 cm) PNL-75Q-DC-RT: 3.8″ (9.6 cm)
Weight	~ 12 lb (5.4 kg)	~ 4 lb (1.8 kg)	0.8 lb (0.36 kg)	PNL-75-DC-RT: 0.7 lb (0.32 kg) PNL-75D-DC-RT: 1.15 lb (0.52 kg) PNL-75Q-DC-RT: 2.05 (0.93 kg)

Regulatory Specifications

Listings

This product carries a listing report by UL. It is listed to the following standards:

- UL 1741 — Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources (2nd Edition, 1/28/2010, with revisions through 3/23/2016) with PV Rapid Shutdown
- UL1699 — Standard for Arc-Fault Circuit Interrupters (2nd Edition, revised 11/08/2013)
- UL1699B — Photovoltaic (PV) DC Arc-Fault Circuit Protection (2nd Edition, 1/14/2014)
- CSA C22.2 — General Use Power Supplies, No. 107.1-3 Issue: 2001/09/01 Ed:3 (R2011) with PV Rapid Shutdown

Compliance

This product has been tested to comply with the following standards:

- FCC Part 15, Class B

FCC Information to the User

This equipment has been tested and found to comply with the limits for a Class B digital device when powered by a DC source, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

~ Reorient or relocate the receiving antenna.

~ Increase the separation between the equipment and the receiver.

~ Consult the dealer or an experienced radio/TV technician for help.

Component Compliance

The following individual components have been tested to comply with the following standards:

Relay-Trip Breakers

- UL1077

Definitions

The following is a list of initials, terms, and definitions used in conjunction with this product.

Table 7 Terms and Definitions

Term	Definition
AFCI	Arc Fault Circuit Interruption
Combiner	An enclosure which combines multiple PV circuits, using individual circuit protection
Controlled conductor	A section of wire between the combiner and either the RTB or the PVRSE device
CSA	Canadian Standards Association; establishes Canadian national standards and the Canadian Electrical Code, including C22.1 and C22.2
Dry contact	A relay contact with no source voltage; switches the continuity to be used by an external device
DVM	Digital Voltmeter
EKO	Electrical Knockout
Grounded Conductor	The DC conductor (negative or positive) which is mechanically bonded to ground in one place
NEC	National Electric Code
PVRSS	Photovoltaic Rapid Shutdown System
PVRSE	Photovoltaic Rapid Shutdown (System) Equipment
RSI	Rapid Shutdown Initiator
RTB	Relay-Trip Breaker
GSLC	GS Load Center; the DC and AC load center for Radian series inverters
UL	Underwriters Laboratories; refers to a set of safety standards governing electrical products

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