AC Combiner Box Application Guide for Circuit Breaker Panelboards

Solar engineers and installers often overlook the utility and convenience of using an AC combiner box when designing a photovoltaic (PV) system. This application guide details the benefits of incorporating a panelboard as an AC combiner box into a solar system and assists engineers in selecting the most suitable combiner box/panelboard options for each PV system.

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The role of AC combiner boxes in solar systems

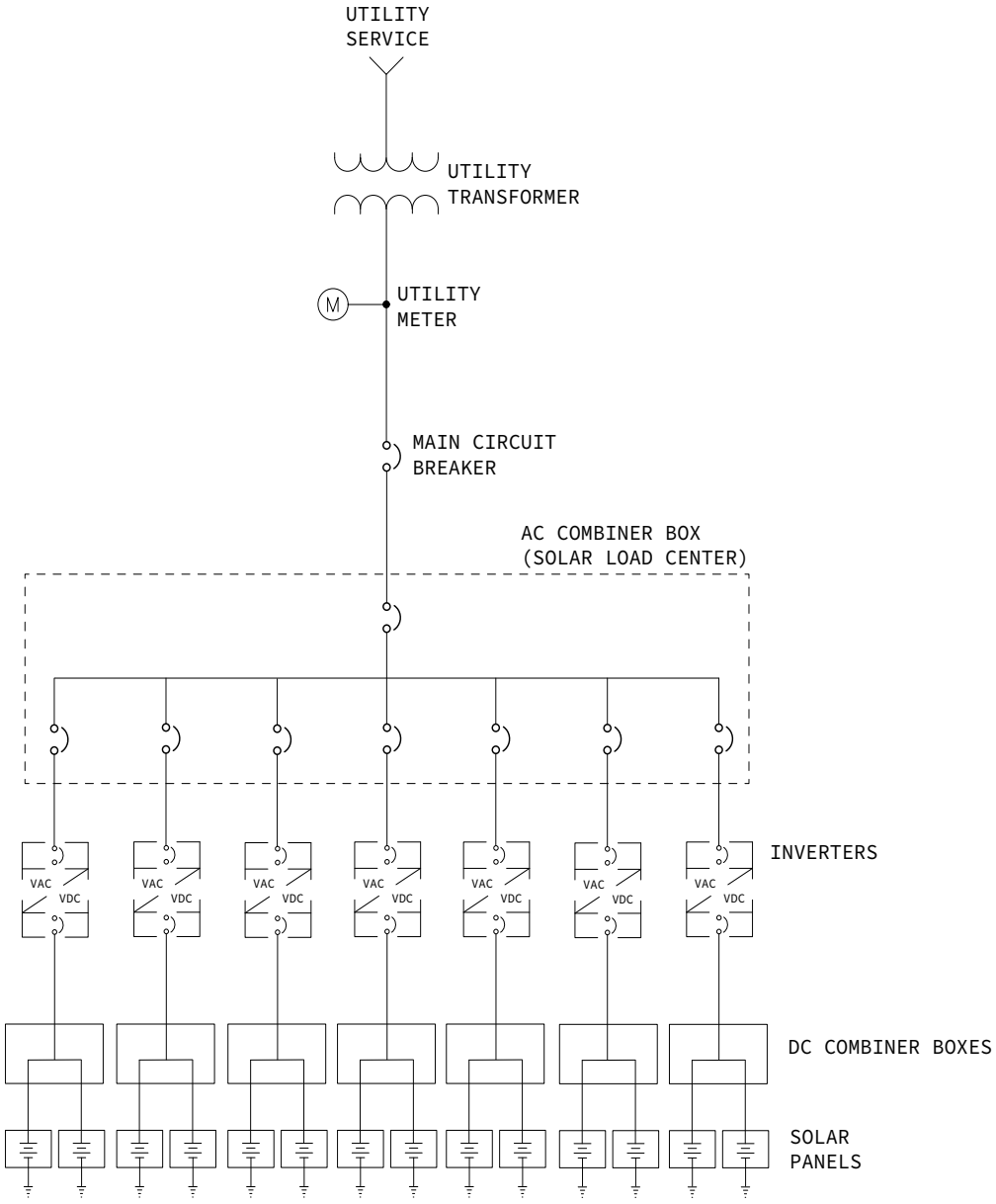
The function of a combiner box is to consolidate the output of multiple string inverters into one main feed, reducing labor and material costs by using less wiring. A combiner box may also provide a disconnecting means to the string inverters that feed them, and overvoltage protection to the electrical equipment they feed.

AC combiner box functions

For solar installations in the Photovoltaic (PV) industry, AC combiner boxes may perform several functions. They can consolidate power from multiple string inverters into a central location and provide overcurrent protection and a disconnecting means for each string inverter input, making the system easier to install, maintain, and operate. They may also incorporate surge protective devices and a main output disconnecting means in one centralized enclosure. For commercial applications, the box maximizes power and saves on material and labor costs by efficiently consolidating and distributing the combined connections, enabling PV power to be sent to the power grid or loads. Choosing the right combiner box can vastly improve the ease of installation, maintenance, and operational efficiency of a solar application.

Square D™ brand panelboards from Schneider Electric may be used as AC combiner boxes. They support voltage systems up to 600 Vac and are more readily available than traditional combiner boxes. Merchandised Square D brand panelboards from Schneider Electric may be purchased Ready-To-Install (RTI) from the inventory of an authorized electrical distributor and assembled at the jobsite. Square D panelboards can house electrical connections and disconnects for multiple inverter output circuits, allowing for maintenance of a single inverter and its strings without suffering power loss of other inverters and PV strings. A single disconnect for the combiner output circuit allows for emergency shutdowns, switching to alternate power sources, and maintenance.

Like standard electrical power systems, PV systems require overcurrent and short-circuit protection for inverters, conductors, and other equipment. Continuous improvements in PV technology have led to increased currents in solar systems, underscoring the need for effective protection. By consolidating the output of multiple string inverters into one AC combiner box, overcurrent protection and disconnects can be coordinated, localizing power disruption to a single inverter and set of PV strings — rather than shutting down the entire system.

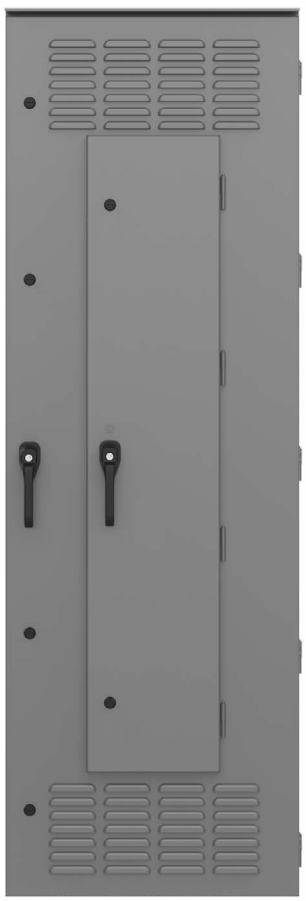


Overcurrent protection in AC combiner boxes

Solar combiner boxes commonly provide overcurrent protection and a disconnecting means for each circuit that feeds them. Historically, fuse boxes/panels were the most popular form of overcurrent protection in home and commercial electrical systems, though they have since been largely eclipsed by circuit breakers. While fuses can provide overcurrent protection, circuit breakers are easier to maintain and provide an integral disconnect switch. Because each fuse protects the circuit by melting, a blown fuse needs to be replaced immediately for the circuit to function again, whereas a circuit breaker “trips” and interrupts the current flow from the power source. To restore power after diagnosing and addressing the reason that a circuit breaker trips, the user merely flips the switch off and on again, instead of needing to replace a fuse.

Square D circuit breaker panelboards provide several inherent benefits over fuses when implemented in a solar system:

1. Square D circuit breakers are 100% factory tested. Fuses, on the other hand, cannot be tested because a blown fuse would need to be replaced.
2. Schneider Electric and Square D have been the brands trusted by electrical contractors and consulting engineers for over 100 years.



NF Panelboards in vented NEMA Type 3R enclosures

Square D brand panelboard advantages

Schneider Electric has been the market leader in circuit breaker panelboards for nearly a century. First developed in the 1960s, the I-Line™ Power Distribution Panelboard features Schneider Electric's unique circuit breaker engagement system and is used to feed NQ and NF Panelboards. I-Line Panelboards are designed to manage currents up to 1200 A and are utilized in nearly every market segment — including solar. NQ Panelboards use QO™ circuit breakers developed in the 1950s, and NF Panelboards were first introduced in 1994, then updated several times as the replacement for previous Square D circuit breaker panelboard ranges dating back to the 1920s. All these technologies have undergone continuous improvements since their inception. PowerPacT™ electronic trip circuit breakers now offer advanced functions such as adjustable long time, short time, instantaneous trip, and ground fault protection that safeguards equipment.

Square D brand circuit breaker panelboards can be purchased ready-to-install from various electrical distributor inventories and assembled at the jobsite. The lead time to deliver factory-assembled panelboards to the jobsite is typically less than two months, supporting a timely setup and installation.

These circuit breaker panelboards are fully customizable to suit a variety of solar projects and systems. Circuit breakers can be back-fed for combiner box inputs (in this case, solar inverters) and support common North American (NAM) AC voltage systems — 3Ø 4W up to 600 Vac and 1Ø 3W up to 600Y/347 Vac. Panelboards are available in NEMA Type 3R/4/4X/5/12 enclosures with lockable handles that provide a degree of protection to personnel against access to hazardous parts and against the ingress of water or solid foreign objects.

Integration of surge protection and metering

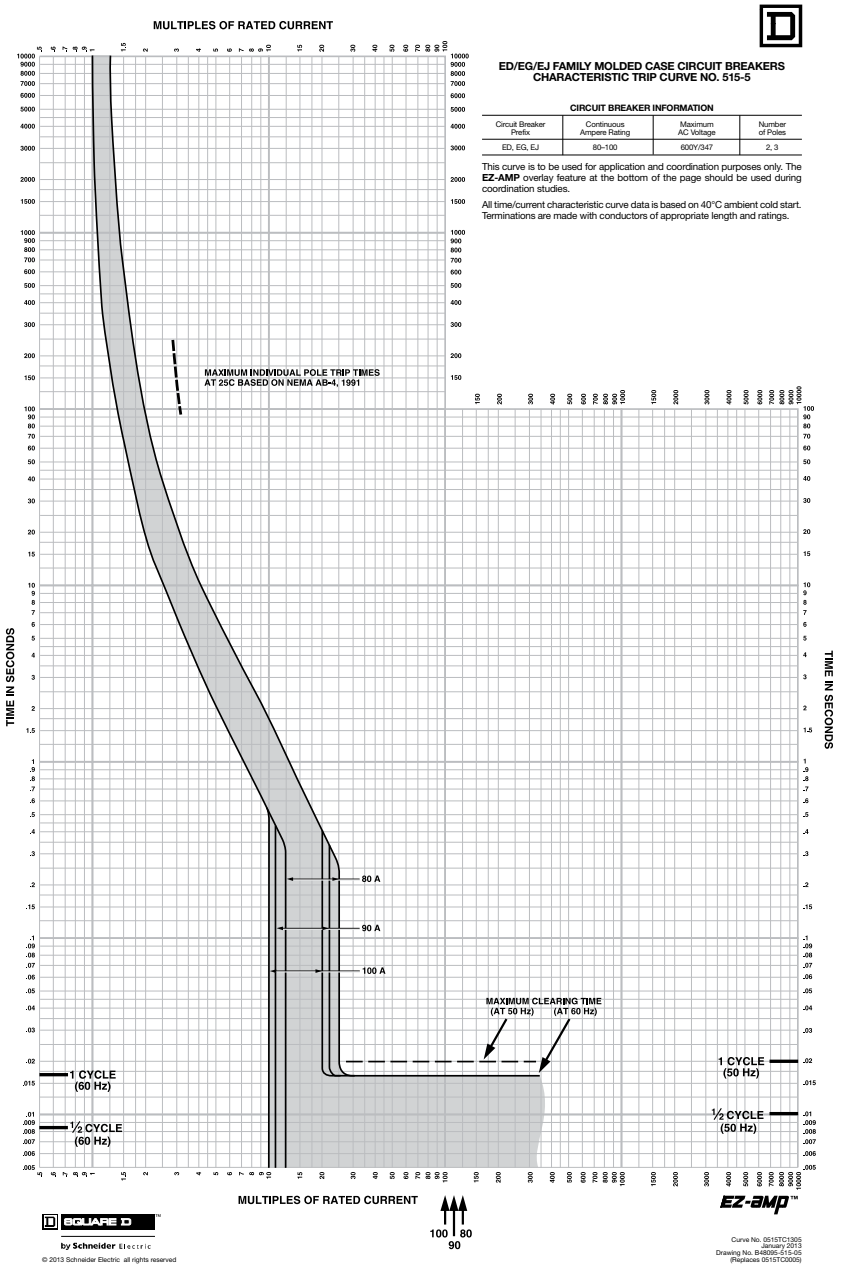
Surge protection devices designed specifically for PV systems can also be installed in the AC combiner box, safeguarding equipment from lightning or other voltage surges. Square D Panelboards may be configured with integral SurgeLogic™ Surge Protection Devices with surge current ratings up to 240 kA.

Power metering may also be installed in Square D brand panelboards to monitor each circuit into and/or out of the panelboard. Branch circuit power monitoring is available for NF and NQ Panelboards, and embedded power metering for feeder circuit breaker trip units and the outgoing circuit are available options in I-Line Panelboards.

For further information on products please go to se.com

Inverter output current vs. circuit breaker trip current

Rated current has a different meaning for solar inverters than for circuit breakers. Inverters may deliver surge power well in excess of their continuous current rating for sustained periods. Circuit breakers may be calibrated to open when continuously operated at as little as 80% of their nominal trip current (or handle rating) at a UL specified ambient temperature of 40°C (104°F).



For this reason, a circuit breaker with a nominal current rating of 100A may open when back-fed continuously with an inverter output current as low as 80 A. Therefore, to avoid nuisance trips, the nominal trip current of a typical circuit breaker should typically be 125% of the continuous output current of the string inverter that feeds it. The trip curve above shows that that the E-frame branch circuit breakers installed in NF Panelboards will operate continuously at >90% of their nominal trip current (at 40 C), making them highly suitable to support the sustained high currents produced by solar string inverters.

Current carrying capacity in extreme conditions

Circuit breakers are sensitive to both current and ambient temperature. When applied at ambient temperatures other than 40°C, at frequencies other than 60 Hz, or in other extreme conditions, circuit breaker performance may be affected. In these cases, it becomes necessary to determine a circuit breaker's actual current carrying capacity under such conditions. By correctly applying an appropriate rerating curve, solar system designers can accurately predict the circuit breaker's real current carrying capacity.[1]

Electronic trip units in Square D PowerPacT circuit breakers are ambient insensitive from -10°C (14°F) to 60°C (140°F).

Schneider Electric recognizes that equipment in solar system applications may endure harsher environmental conditions than governing standards assume and offers several solutions for reliable operation. Additionally, electronic trip units in Square D PowerPacT circuit breakers are ambient insensitive from -10°C (14°F) to 60°C (140°F)[3]. Schneider Electric recommends that outdoor solar array panelboards be configured with remote-mounted main circuit breakers with electronic trip units or remote-mounted switches.

Schneider Electric offers Square D brand panelboards for use in AC combiner boxes

Square D brand I-Line Panelboards are the most capable Schneider Electric circuit breaker panelboards for North American AC Voltage systems — 3Ø 4 W up to 600 Vac and 1Ø 3 W up to 600Y/347 Vac. Molded case circuit breakers (MCCBs) can handle input currents of up to 960 A and back-fed circuit breakers up to 1200 A. For overcurrent protection, thermal magnetic or electronic trip units are fully rated with Short Circuit Current Ratings (SCCR) up to 200 kA at 480Y/277 Vac. The main bus output supports currents up to 1200 A, with a main circuit breaker, main switch, or main lugs, and supports output lugs up to (4) AWG 3/0 - 500 kcmil. For environmental protection, NEMA Type 3R/4/4X/5/12 enclosures are available.

[1] Data Bulletin 0100DB0101
(Determining Current Carrying Capacity in Special Applications)

[2] Data Bulletin 0100DB1901
(Proper Application of Panelboards in Solar Arrays)

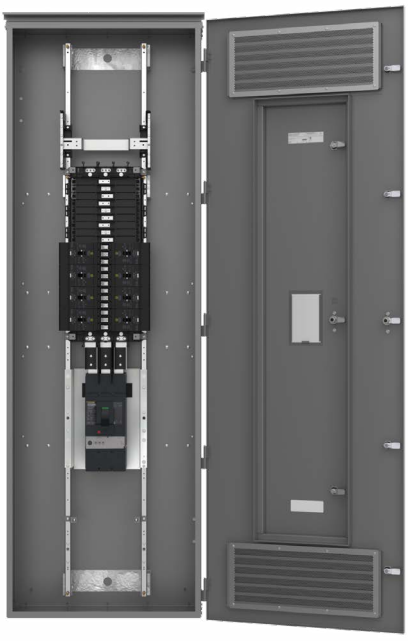
NQ panelboards are suited to solar applications and may be used as low cost combiner boxes for all AC voltage systems up to 240 Vac (Wye or Delta). These panelboards support continuous input currents up to 120 A with back-fed circuit breakers up to 150 A. All circuit breakers feature thermal magnetic overcurrent protection with a fully rated SCCR up to 22 kA, and lugs that accept copper or aluminum wires up to 2/0 AWG. The main bus supports output up to 600 A with main lugs that accept (two) AWG 1/0-750 kcmil cables per phase. An 80% rated main circuit breaker or main switch up to 600A may also be chosen that will accept (two) AWG 2/0-500 kcmil aluminum or copper cables per phase. Neutral lugs are available that will accept up to (four) AWG 1/0-750 kcmil aluminum or copper conductors. Integral surge protective devices, vented NEMA Type 3R enclosures, and electronic trip units for output circuit breakers are available for added protection. NQ panelboards may also be configured for use in 48 Vdc 2 wire voltage systems with a maximum available fault current of 5 kA.

NF panelboards provide another low-cost option for AC combiner box applications for voltage systems up to 600Y/347 Vac. These panelboards support continuous input currents up to 100 A with back-fed circuit breakers rated to 125 A at 480Y/277 Vac, lugs for wires up to 2/0 AWG, thermal magnetic overcurrent protection, and fully rated SCCRs up to 65 kA at 480Y/277. The main bus supports output up to 600 A, with main lugs up to (2) 1/0-750 kcmil main lugs per phase, or an 80% rated main circuit breaker or main switch accepting (2) 2/0-500 kcmil wires per phase. Neutral lugs are available that accept up to (4) AWG 1/0 – 750 kcmil aluminum or copper conductors. Electronic trip units on output circuit breakers, vented NEMA Type 3R enclosures, and surge protective devices are available for added protection.

Back-fed circuit breakers in panelboards used as AC combiner boxes support many North American string inverters. Because thermal magnetic circuit breakers are sensitive to ambient temperature, it may be important to minimize the temperature rise inside their enclosure due to the absorption of incident solar radiation (ISR). ISR absorption in outdoor panelboard applications may be minimized by installing a solar shield, or by painting their enclosure white. To reduce the ambient temperature around each circuit breaker, Schneider Electric recommends leaving blank spaces between circuit breakers in a panelboard.[2] Solar system designers are encouraged to remotely mount the main disconnect switch or circuit breaker for each panelboard to lower the ambient temperature inside its enclosure and enable installation of an internal surge protective device.

Opening the inner door enables access to all circuit breaker handles (and Visi-trip™) indicators).

NF Main Circuit Breaker Panelboards in vented NEMA Type 3R enclosures



Qualified personnel gain access to all electrical connections by opening the outer door (when the panelboard is not energized).

[3] The flow of current combined with ambient temperature increases the temperature of circuit breakers. Please consult the temperature derating table for PowerPacT circuit breakers to avoid reaching their thermal withstand value.

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