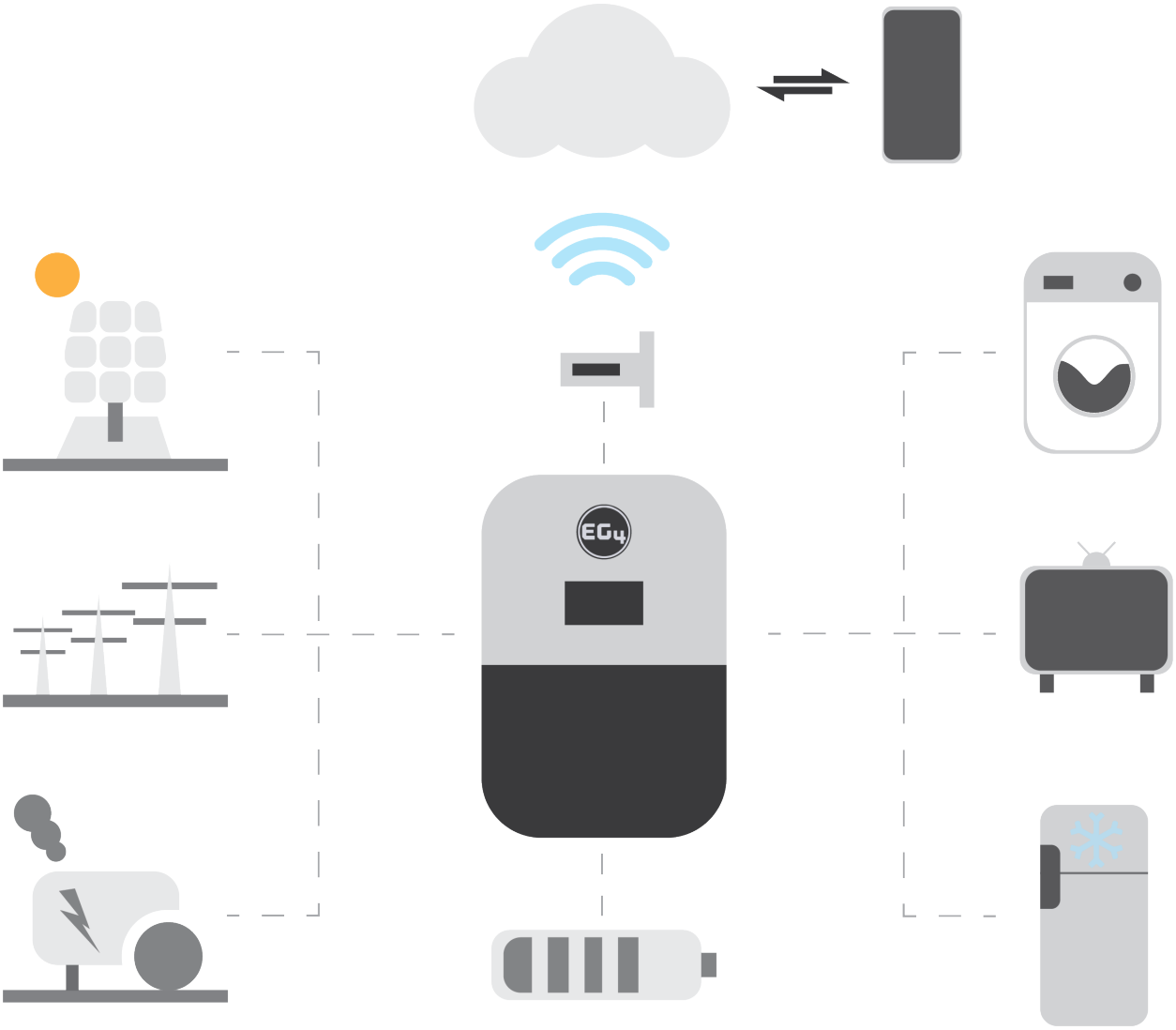
BREAKER SIZING

WHITE PAPER

This guide has been created to give the end-user a guide for properly sizing electrical breakers.



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1. OVERVIEW

The goal of this guide is to provide technical information that will assist end users in determining the proper breaker type and size required to support the installation of inverters, batteries, and solar panels.

2. BREAKER USE CASES

Selecting the right type of breaker within a PV solar system is just like choosing the right tool for any job. Each component, whether it's the PV solar feed, a charge controller, battery bank, or an inverter, requires a tailored solution. Let's look at the key elements:

1. **PV DC Breakers:** These are the gatekeepers of energy flow. They protect the solar panels, ensuring that excess current doesn't flood the system during peak sun hours. Look for breakers with robust capacity and compatibility with direct current (DC) circuits.
2. **Charge Controller DC Breakers:** Charge controllers regulate the battery charging process. Breakers here act to prevent overcharging or excessive discharging. For this application, consider breakers with the ability to handle both AC and DC currents.
3. **Inverter AC Breakers:** Inverters transform DC power from solar panels into usable AC power. Breakers in this realm ensure smooth transitions, prevent overloads, and safeguard against faults. Look for options that align with your inverter's specifications.

3. HOW TO BREAKERS WORK

Circuit breakers, also known as an Over Current Protection Device (OCPD), protect electrical circuits by stopping the flow of electricity when they detect too much current flow on the circuit. This "overcurrent" can be caused by having too many devices plugged in or a sudden surge of electricity known as a short circuit or ground fault.

When a breaker trips, it is known to have stopped the flow of electricity. A breaker can be reset and used again, but only if you resolve the overcurrent situation. If a breaker keeps tripping, investigate the circuit and or the devices plugged into the circuit. If you're not sure what's causing the breaker to trip, call a licensed electrician for help.

The ability to reset a breaker is a significant advantage over fuses, which were common in homes before the introduction of circuit breakers. Fuses can only be used once. If a fuse blows, it must be replaced.

3.1 TRIPPING PRINCIPLES

A circuit breaker has two different tripping principles to protect the circuit. Thermal protection will lead to circuit interruption in case of overheating. Electromagnet protection is designed to interrupt a circuit due to a short circuit.

On the thermal-magnetic side of a circuit breaker, a bimetallic strip heats up with the current. If the circuit's current rises over a certain level, the strip will bend moving the switch linkage breaking its connection to the stationary contact, causing the circuit to break (open).

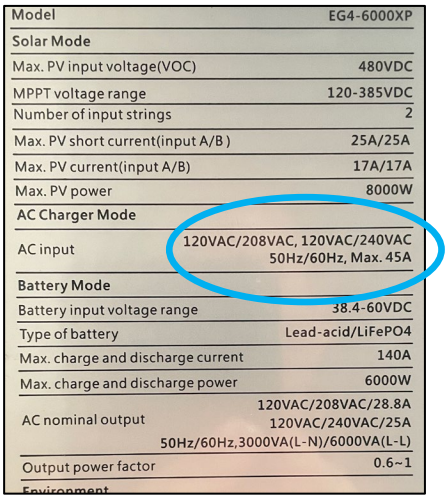
Electromagnetic protection comes from the copper coil. The electromagnet is magnetized when electricity flows through the terminals. The larger the current, the larger the electromagnetic force. When a current reaches unsafe levels while traveling through this coil, the electromagnet becomes strong enough to move a small spool inside it, which will also move the switch linkage, the moving contact, therefore breaking (opening) the circuit.

4. CORRECTLY SIZING BREAKERS

Properly sizing breakers prevent unnecessary tripping or insufficient protection within the electrical system. Sizing breakers too low can result in frequent tripping during normal operation, such as when high-demand appliances like air conditioners or well pumps start. On the other hand, sizing breakers too high may fail to provide adequate protection in case of faults or overcurrent, risking damage to equipment and wiring. One key item to remember, the main job of the breaker is to protect the wire that connects the devices together. When you size a breaker, never install wire that supports less amperage than the installed breaker.

4.1 DEVICE NAMEPLATE RATING

Always check the nameplate rating or the specifications sheet of the device to see what the amperage draw requirement is. The listed amperage rating determines the appropriate wire and breaker size. It is essential to ensure that the wires and breakers are sized correctly. Using an incorrect wire size or breaker can lead to inefficiencies, overheating, and safety hazards. The image below shows the nameplate ratings for the EG4® 6000XP.



Model	EG4-6000XP
Solar Mode	
Max. PV input voltage(VOC)	480VDC
MPPT voltage range	120-385VDC
Number of input strings	2
Max. PV short current(input A/B)	25A/25A
Max. PV current(input A/B)	17A/17A
Max. PV power	8000W
AC Charger Mode	
AC input	120VAC/208VAC, 120VAC/240VAC 50Hz/60Hz, Max. 45A
Battery Mode	
Battery input voltage range	38.4-60VDC
Type of battery	Lead-acid/LiFePO4
Max. charge and discharge current	140A
Max. charge and discharge power	6000W
AC nominal output	120VAC/208VAC/28.8A 120VAC/240VAC/25A 50Hz/60Hz,3000VA(L-N)/6000VA(L-L)
Output power factor	0.6~1
Environment	

4.2 MAKING THE CALCULATIONS

Determining the appropriate size of circuit breaker for single phase supply depends on multiple factors like type of load, cable material and environment temperature etc. The general rule of thumb is that circuit breaker size should be rated 125% of the ampacity of circuit requirements.

For the calculation example, use the 6000XP nameplate sticker listed above. The max AC input is rated at 45A. To properly size the required breaker, take 45A x 1.25 (125%) which equals 56.25A. Since there is not a 56.25A available on the market for purchase, the next sized breaker would be used, a 60A. Also, remember to use properly sized wire rated for 60A.

5. TYPES OF BREAKERS

5.1 MODELS

There are several models of circuit breakers, such as the single-pole, two-pole, three-pole, and even the four-pole circuit breakers. The numbers of poles directly relate to the number of circuits (hot wires) the breaker can support.

A single-pole breaker protects a single circuit in an electrical system. This single circuit might power the lights in your living room or feed receptacles in your kitchen. Single-pole breakers take up one slot in your home's electrical panel and typically protect 15-amp and 20-amp circuits.

Double-pole breakers work the same way as single-pole breakers, but they protect circuits that support more amperage. For example, a 50-amp clothes dryer uses two 120V circuits to deliver enough current for the appliance to operate. Since both circuits need overcurrent protection, a double-pole breaker is used that accepts two wires instead of one. These breakers are larger than single-pole, so they take up two slots in your panel. If a double-pole breaker trips, it has a handle that allows you to reset both hots simultaneously.

Single Pole AC

Two Pole DC

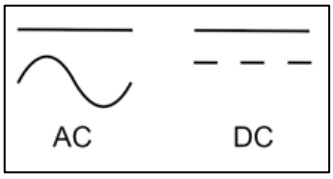
Three Pole AC

5.2 AC AND DC BREAKERS

Understanding the difference between AC and DC breakers is essential in PV solar systems. AC breakers are designed with internal contacts that separate, opening the circuit when too much current flows. But because AC power alternates between positive and negative voltage, there are two points in every cycle where the voltage is zero. When the contacts separate and an arc forms, the arc disappears within 1/120th of a second. AC breakers do not need the arc extinguishing measures that are critical for DC breakers.

DC breakers are very focused, and specific to direct current applications. Because DC voltage constantly flows in one direction, the breaker must have a way to extinguish the arc. These arc extinguishing measures separate a DC breaker from an AC breaker, so it is critical to use DC-rated breakers for DC circuits.

When looking at AC breakers, they are labeled with a gentle tilde (~). The symbol may or may not have a solid line above the tilde. DC breakers are labeled with bold line resting above a dotted line (⎓).



Two Pole DC Breaker

Two Pole AC Breaker

5.3 WIRE CORE MATERIAL

When installing a breaker, ensure it's rated for the wire core material that is connected to the breaker terminals. Breakers are rated for copper wire only, aluminum wire only, or for both. Using the incorrect wire material can cause wire oxidation, overheating of the wire, and possible wire breakage at the wire connection to the breaker. Breakers supporting copper only connections are labeled as "Cu". Breakers supporting only aluminum wire connections are labeled "Al". Breakers that support both are labeled with both, Cu/Al.

5.4 POLARIZED BREAKERS AND INSTALLATION

When installing DC breakers, pay careful attention to the polarity (indicated by a plus and/or minus sign) of each breaker to avoid compromising their protective function. Incorrect installation, such as reversing positive and negative connections, can lead to the loss of protection and potential damage to the system. It is imperative to follow manufacturer instructions, examine markings for polarity, and adhere to specifications to ensure proper installation and functionality of polarized breakers.

6. THERMAL EXPANSION AND MAINTENANCE

Over time, breakers experience thermal expansion due to regular use, leading to the loosening of connections and potential arcing. Proper torquing of clamps during installation and regular maintenance checks are essential to mitigate thermal expansion effects and maintain system stability. Using quality breakers and following recommended maintenance practices contribute to the long-term reliability and safety of PV solar systems.

An Ohm meter is recommended to check for resistance in breakers and assess their performance. Low resistance indicates efficient operation, while high resistance can lead to inefficiencies and overheating. Maintaining low resistance in breakers ensures optimal performance and longevity of the electrical components.

7. CONCLUSION

Sizing breakers accurately and using the correct type for each application is critical to the overall performance and safety of PV solar systems. By understanding the nameplate rating, conducting resistance checks, and following best practices for installation and maintenance, solar manufacturers and end users alike can ensure the efficiency and reliability of their systems while meeting regulatory requirements.

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