How to properly fuse a solar PV system

NOTE: If you are unsure about this area, consult an electrician. Proper use of fuses and breakers are important to maintain safety.

The first thing to know is that fuses and circuit breakers are primarily used to protect the system wiring from getting too hot and catching fire. Secondly, they also are used to protect devices from catching fire or from becoming more seriously damaged if there is a short circuit.

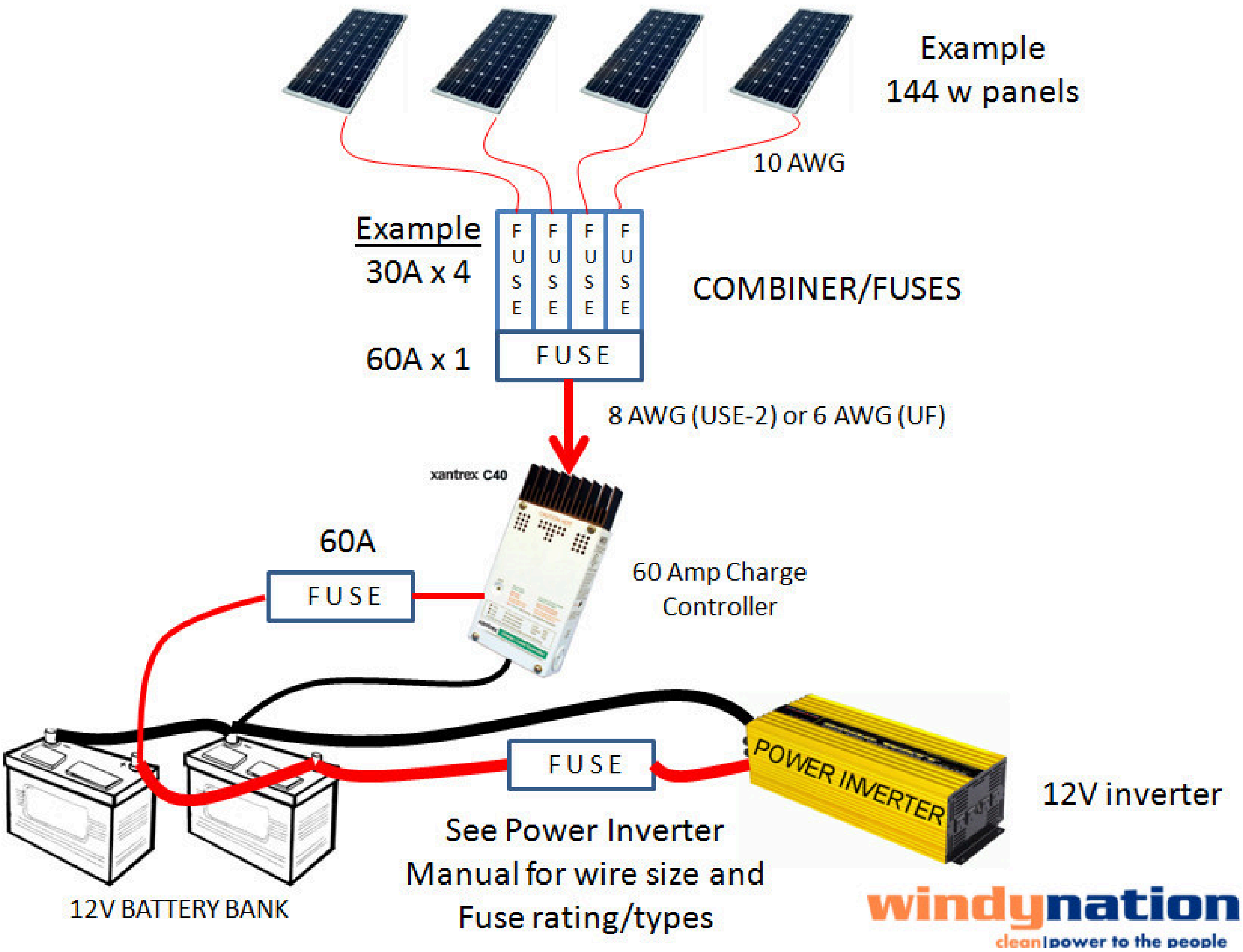
A good example is a 12V lead acid battery. If a short develops in your AC/DC inverter for instance, a fuse between it and the battery will prevent a possible explosion of the battery and it will cut the circuit fast enough to prevent the wires from catching fire or getting dangerously hot. In this case, the battery, wires, and AC/DC inverter will be safely disabled by the fuse.

Solar Panel fusing

Commercially made solar panels over 50 watts have 10 gauge wires capable of handling up to 30 amps of current flow. If you connect these panels in series, there will be no increase in current flow so fusing is not required for this string. This is not the case when you have panels connected in parallel, as when connected in parallel the system current is additive. For instance if you have 4 panels each capable of up to 15 amps, then a short in one panel can draw all 60 amps towards that short-circuited panel. This will cause the wires leading to that panel to far exceed 30 amps causing that wire-pair to potentially catch fire. In the case of panels in parallel, a 30-amp fuse is required for each panel. If your panels are smaller than 50 watts, and use only 12 gauge wires, and 20 amp fuses are required.

Parallel/Combiner Box fusing

In a parallel system a combiner box is used that holds the fuses/breakers to each panel, plus one or more “combined” fuse leading to the charge controller or grid tie inverter (see figure). When sizing this “combined” fuse/breaker, we must first determine the worst case current that will flow based on our specific panels.



If we take the example 144-watt 12V panel from the introduction section, and look at the short circuit current (Isc), we see it is rated at 8.5 amps. This however can be exceeded if the actual installed situation does not match the “standard” test conditions used for solar panel factory ratings. The industry rule is to increase Isc by 25% to cover this possibility, so it now is 10.625 amps in our example.

The National Electrical Code (NEC) also requires that a 25% factor be added if the load is continuous, so the number grows again to 13.28 amps per panel. If there are 4 panels in this parallel set, then the combined current can theoretically be as high as 53.125 amps.

The chart below shows the ampacity for wires in a conduit per the NEC. Note that some wires of the same gauge can handle more amps and higher temperatures. An 8 AWG USE-2 wire set (minimum) from the combiner box to the charge controller in our example will suffice, since it can handle 55 amps. A 60-amp fuse or breaker should be used in this case to protect this wire set. This also aligns with the maximum capacity of the charge controller selected.

Conductor Size (AWG)	60°C (140°F)	75°C (167°F)	90°C (194°F)
	Types UF	Types RHW, THHW, THWN, XHHW, USE	Types RHW-2, THHN, THHW, THWN-2, USE-2, XHHW, XHHW-2
14*	20	20	25
12*	25	25	30
10*	30	35	40
8	40	50	55
6	55	65	75
4	70	85	95
2	95	115	130
1	110	130	150
1/0	125	150	170
2/0	145	175	195
3/0	165	200	225
4/0	195	230	260

*Limits to fuse size for 14, 12, 10 AWG wire [240.4 (D)]: 14 AWG, use max 15 A fuse; 12 AWG, use max 20 A fuse; 10 AWG, use max 30 A fuse.

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Charge controller to Battery Fuse/Breaker

With a Pulse Width Modulated (PWN) charge controller, the worst-case amps flowing to and from the controller are the same, so the fuse and wire size can match. MPPT charge controllers, on the other hand, are able to both lower the voltage and increase the current flowing between the controller and the battery bank, so the exact size wire and fuse size must be recalculated or obtained from the charge controller manual. As an example, Blue Sky recommends a 60-amp fuse/breaker for their Solar Boost 50 (amp) charge controller between the unit and the battery bank. Again, select a wire that is rated appropriately.

Battery Fuse/Breaker to Inverter

The wiring and fusing from the battery to an AC/DC inverter is of critical importance because this is where the most current will likely flow. Similar to the charge controller case, the recommended wire and fusing should be obtained from the inverter manual. It is very likely the invert already has a built in fuse/breaker on the input as well as the output (AC) side of the unit. A typical 1500-watt 12V pure sign wave inverter draws up to 125 amps continuously, a number that increases to 156 amps once we factor in the NEC continuous-use 25% adder. For USE-2 wires, 1/0 AWG is required in this case. For a hobbyist, welding cable is generally used with these general limits:

#4 AWG 150 amps
#2 AWG 200 amps
#1 AWG 250 amps
1/0 AWG 300 amps
2/0 AWG 400 amps

Final Note:

This article was just an introduction. There are important related aspects such as cable length and fuse/breaker types that need to be studied before a design is finalized. There are various free fuse and wire size calculators online that you should use in completing your solar PV system. If your take your time and use the right combination of rated parts, then the system should work well and you'll sleep better knowing you engineered it to be safe and reliable.

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