



Solar Charge Controllers



What is a solar charge controller?

Solar charge controllers are used to regulate the charging of a battery bank. Solar panels produce voltage and current that are variable in nature – meaning they’re a function of the amount and uniformity of solar irradiance (watts per meter squared from sunlight) that a solar panel receives. However, this is not what a battery can use to charge. Battery charging must be done in a highly regulated and specific manner. The amount of voltage and current a battery receives must not vary outside of a small range (too low and no charging will occur; too high and over charging, and possible damage to the battery bank, will occur). The device that regulates the output of a solar panel in order to use the variable power it produces to charge a battery is known as a charge controller. There are two kinds of charge controllers—PWM (pulse-width modulation) and MPPT (maximum power point tracking) charge controllers. Both have a distinct charge regulation method and a similar battery charging algorithm.

What are the pros and cons of PWM solar charge controllers?

PWM charge controllers are a cost-effective alternative to MPPT charge controllers. But they have specific and notable downsides to MPPT charge controllers. The pulse-width modulation process is a process that is commonly used in digital electronics. The duty cycle of a signal is adjusted in order to change the average output of the device, meaning the output power to the battery bank is turned off for part of the time (for example, if turned off half a second every second, this would be a 50% duty cycle). While this is a simple solution for regulating the output voltage of a solar panel, it is not a very efficient one. Solar panels have different nominal voltages, but these are not the actual voltages they output. For instance, a 12V nominal solar panel really outputs anywhere from 17V-21V at maximum power. With a PWM, this extra voltage is lost and the current is simply passed through. For a 19V at maximum power PV module, you are losing about 5V off of the panel, or more than 26% of the output. (Note: this simple example does not consider how panel voltage will react to changes in panel temperature.) For this reason, it is critical that the nominal voltage of the solar panel array matches the nominal voltage of the battery bank in order to minimize charging losses. Losses like this are usually the best-case scenario at max power for PWMs. The MPPT method is significantly more efficient.

What are the pros and cons of MPPT solar charge controllers?

Although they cost more, MPPT charge controllers are almost always worth the additional investment because they provide a significant increase in charge efficiency. This is accomplished in two ways. First, the solar panel’s maximum power voltage point is found and the solar panel’s output voltage is adjusted to this point retroactively by the MPPT charge controller. Secondly, the charge controller internally steps down the voltage and steps up the current on its output. This regulates the voltage going to the battery, but still harvests the extra power produced as current. This process is known as buck converting. In general, losses on an MPPT are below 10%, but in order for the MPPT process to operate successfully, a significant voltage difference is required. For example, you would not want to use a 12V nominal panel in combination with a 12V system and an MPPT charge controller. Generally, a voltage difference of 5 volts or more is required to get the process to begin.

How do I choose a solar charge controller?

When deciding on a charge controller, keep the following in mind:

1. Battery voltage & array voltage

If you are building a system from scratch, it is best to have the array at a higher nominal voltage (24V array for a 12V system for example) and use an MPPT charge controller.

If you are constrained by a lower array voltage and the array voltage is the same as the battery bank’s voltage, a PWM will be the best solution.

2. Array wattage (MPPTs only)

When choosing an MPPT, it is critical to consult the product’s spec sheet in order to find how many amps on its output translates to solar watts coming in. MPPTs can be over-powered in general (in maximum power conditions when an MPPT charge controller is over-powered, the charge controller will track a non-maximum power point to protect itself by forcing the solar panel array to produce less power), but it is imperative to see the manufacturer’s recommendation & commentary on how much they can be over-powered. Over powering an MPPT has the added advantage of increased power output in non-peak production hours, and therefore additional energy produced by the charging system, which is always good.

3. Array short-circuit current (often abbreviated as “Isc”)

A charge controller will never support an array with a short circuit current that is greater than its amperage output. The short circuit current of an array is found by taking the short circuit of each PV module string (group of solar panels connected in series) and adding them all together.

4. Battery chemistry

Solar charge controllers have one main function—battery charging. A solar charge controller must be able to charge the battery it is connected to properly. If the manufacturer is not transparent on the ability to charge a system’s battery, then it should most likely not be used in your system. Also, if you have no way to change charge parameters (for example absorption and float voltages), then you must purchase the appropriate control unit in order to do so. If the charge controller you have or one you’re considering has no such interface, integrated or external, it should be avoided.

5. DC noise requirements

Certain DC-powered devices are particularly noise-sensitive (e.g., HAM radio equipment.) MPPTs have been known to cause noise that interferes with HAM radio equipment and other noise-sensitive devices. Generally speaking, it is better to select a PWM charge controller with noise-sensitive DC communications equipment.

What should I know about controllers for grid-tied and hybrid systems?

Grid-tied inverters all have built-in MPPT charge controllers. Some hybrid inverters do, as well. Generally, these MPPTs are notably different than charge controllers in off-grid scenarios, since they’re often designed for high-voltage input (usually 300 volts or above). When choosing an array for this kind of device, be sure to pay attention to the maximum voltage input, the MPPT voltage range, the maximum input current and maximum array wattage allowed. Consulting manufacturers’ spec sheets is critical to successfully setup a system with these unique devices.

What other features are available in controllers?

Some charge controllers contain additional features, such as built-in Bluetooth capability for monitoring or settings configuration, physical control panels for monitoring or settings configuration, and warranties. When choosing a charge controller, these characteristics should be considered as well.

What safety considerations are there?

When using a solar charge controller, you must always ensure that the input and output overcurrent devices are rated to handle the voltage and current across those respective lines. Refer to our buying guide on wiring and bussing for additional information on this topic.