MORNINGSTAR
World's Leading Solar Controllers & Inverters

Morningstar's TrakStar™ MPPT Technology & Maximum Input Power

Solar module operating specifications have changed rapidly in the last several years. This has been due to new cell configurations becoming available, increases in cell efficiency and the growing demands of the grid connected market on module design. With so many module manufacturers in the market, an extensively broad range of module choices are available to meet the needs of many different global markets. Morningstar's MPPT controllers have a very wide voltage input range with which they can make use of these many modules for charging batteries in the off-grid market. However, finding the best fit and knowing how to correctly size them is sometimes challenging. This document discusses solar module sizing, power ratings and answers some of the more frequently asked questions in order to help make sense of the many options available on the market.

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The FAQs:

Q1. PWM controllers are rated in current only, but MPPT controllers have both an output current rating and a nominal input power rating in watts. How were these ratings determined?

The **output current rating** is a constant value and indicates the maximum charging current, in Amps, for both PWM and MPPT controllers.

- For PWM controllers the input current equals the output current and is not transformed.
- An MPPT controller transforms higher voltage and lower current at the input to a lower battery voltage and higher charging current on the output.

  Varray > Vbat. and Iarray < Ibat.

TrakStar MPPT

Morningstar's Advanced Control Algorithm to Harvest Maximum Power from a Solar Array's Peak Power Point

Morningstar's nominal input PV rating depends on nominal battery voltage. The higher the battery voltage, the greater the nominal input power rating is in Watts. It really indicates a typical maximum charging power, but like nominal battery voltage, the actual maximum charging power is not a constant.

Nominal Maximum Input Power Ratings

Battery Volts	SS-MPPT-15L	TS-MPPT-30	TS-MPPT-45	TS-MPPT-60	TS-MPPT-600V
12V	200W	400W	600W	800W	
24V	400W	800W	1200W	1600W	1600W
48V		1600W	2400W	3200W	3200W

These maximum power ratings are based on a nominal bulk charging voltages of 13.33V for 12V Nominal Battery Voltage. Each Nominal Maximum Power Rating = (Maximum Output Current) x (Nominal Bulk Charging Voltage).

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Q2. Can I exceed the nominal wattage ratings of MPPT controllers? Will it void the warranty?

You can size Morningstar's MPPT controllers well above the Maximum Nominal Solar PV Input rating without damaging the controller and without the charging current exceeding the maximum output current rating. The controller can limit output current and will run at 100% of rated current output and not higher. The controller was designed with this power-shaving capability and when oversized it does not void the warranty.

Q3. Is there a reason I would want to do that?

Yes, there are many benefits to doing this; they are outlined below. Please that note that doing this is partially an economic decision; you can purchase more power than the controller can use and this will contribute to better power availability and lessen the chance of a low voltage disconnect (LVD) & loss of load situation. You just have to consider (at some point) the diminishing return that comes with more power-shaving.

Some of the benefits in exceeding the nominal wattage ratings of an MPPT controller include:

- Effect of maximum charging power limit of a Morningstar TrakStar MPPT controller on an oversized array:
  - Better production early and late in the day.
  - Operates at maximum power rating getting full charging potential of MPPT controller more often.
  - Better production during low solar insolation periods (cloudy weather).
  - Limits the maximum charging current.
- Viable reasons for using an array rated for a wattage greater than the controller maximum:
  - Daily maximum power levels may typically be lower than STC rated power of the solar modules.
    - Tilt, azimuth angle, time of day or year, weather, climate, dust, pollution and other factors reduce output power of the array leaving some unused controller capacity.
  - Energy harvesting during lower power production periods (cloudy weather) is often more valued than during times when the array can operate at full power (sunny weather).
  - Ability to use larger array sizes for more options to better match strings for the array.
  - Using fewer, but high power, modules instead of several smaller ones is more cost effective.
  - The availability and lower cost of 60 cell modules (Vmp~30V) from the Grid connected solar market.
  - More consistent levels of charging current (running controller at maximum levels more consistently).

- Limiting charging current for smaller battery banks without exceeding the maximum charging current.

System details can be examined to determine if operating closer to the MPPT controller's full capacity will be cost effective. For example, a 10% loss for 5% of the time when it is not needed may be more like a 0.5% net charging loss. The ability to oversize the array gives the PV designer more choices.

Q4. Besides STC Power, what array details are important when sizing an MPPT controller?

There are two critical values that must be carefully evaluated.

- The array's temperature compensated minimum Vmp should stay above the battery maximum Vb for consistent charging to occur.
- The array's temperature compensated maximum Voc should never exceed the maximum voltage ratings of the controller (as that will damage the controller).

These minimum and maximum voltage levels are related to the temperature coefficient of the PV cells (Cell temperature can be much higher than the ambient temperature). Morningstar's sizing calculator (http://www.morningstarcorp.com/en/strings/calc.php) can provide minimum and maximum voltage levels for an array based on minimum record low temperature and maximum average high temperatures. Using this sizing tool, with your controller and module of choice, will help to ensure its correct and reliable operation.

Q5. Can I use a 240 Watt (60 Cell / Vmp≅30V) PV module with a SunSaver MPPT™ controller?

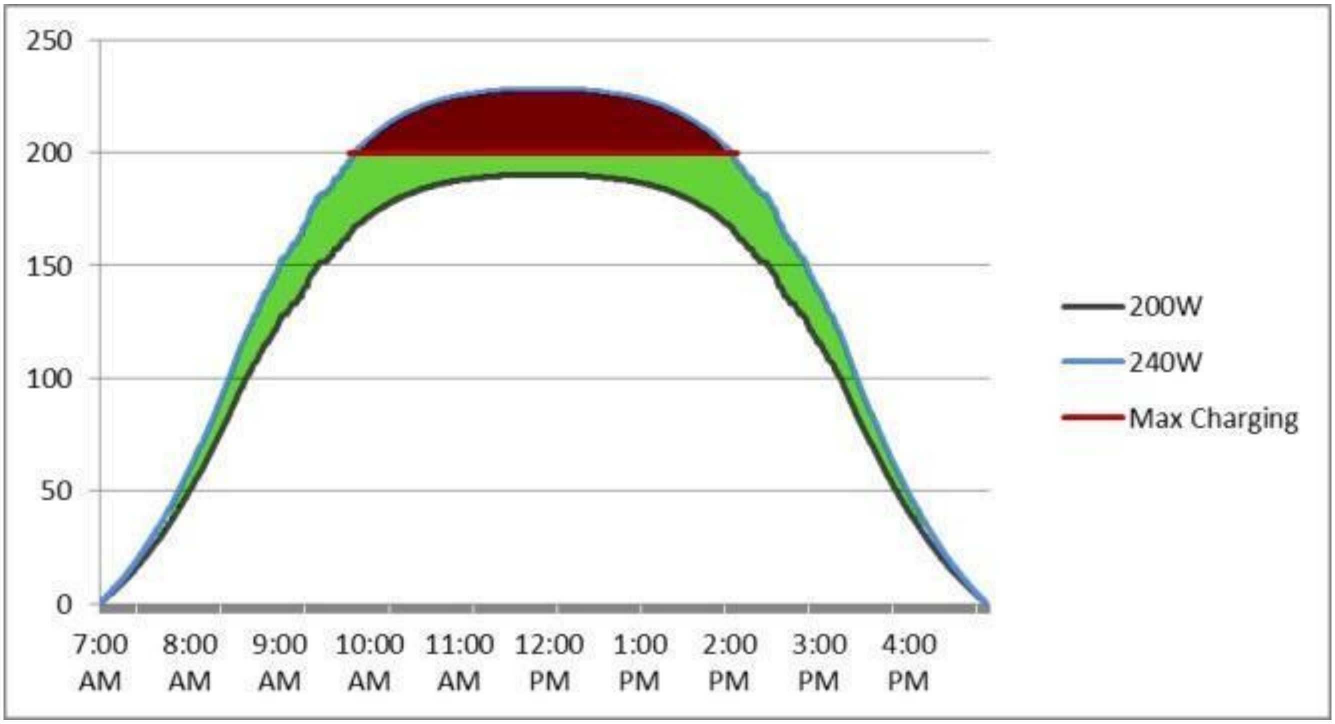
Yes. Even though the SunSaver MPPT™ controller in a 12V system is nominally rated for a 200W PV array, you can use a larger PV module e.g. a 240W PV module.

- For 12V systems the SunSaver MPPT controller is an acceptable option due to its ability to convert the module voltage down and charge a 12V battery very effectively. (Fact: all Morningstar MPPT controllers are buck converters—they can convert voltage down but not up, which is known as a boost converter. For this reason, the Vmp of the module must be above the battery voltage at all times or charging will cease).
- For 24V systems the use of this module with a SunSaver MPPT controller is not an option since the voltage (Vmp≈30V) is too low for a single module to charge correctly (Vmp too low) and Voc is too high for two modules in series—as this would exceed the controllers 75Voc maximum.

This graph illustrates the output power levels of a SunSaver MPPT controller—comparing a 200W module to a 240W module—operating on a clear & sunny day at STC maximum power (Pmp).

- Though the power being delivered to the battery is limited to 200W and the red area at the top of the production curve is lost, the larger module is harvesting more energy, as shown in green.
- The larger module will provide better production with no power-shaving early and late in the day as compared to a smaller module.
- In this case almost twice as much energy is gained (green area) than lost (red area) with 12.5% more energy available to charge the batteries than the 200W module.

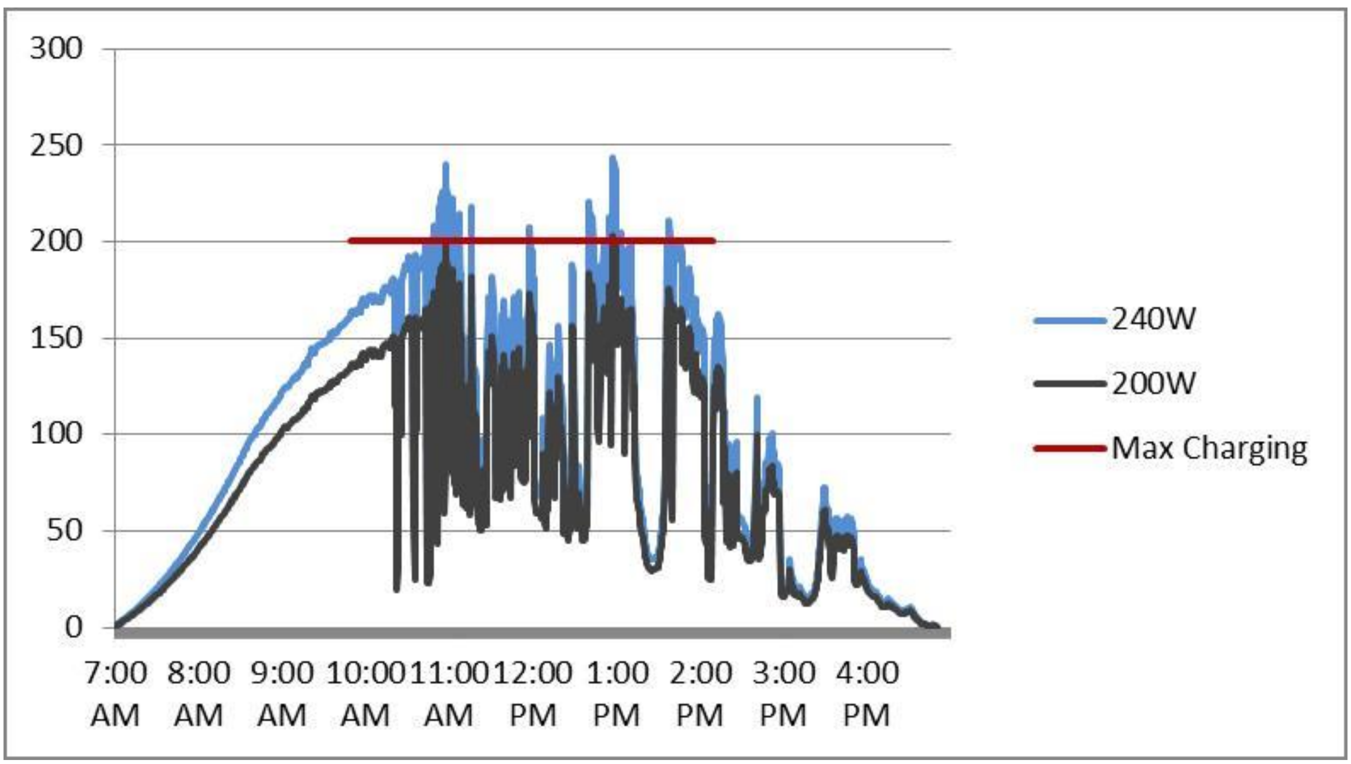
SS-MPPT-15L (240W vs. 200W module) on a Clear Day



On cloudy (or intermittent sunny) days there will be little or no power-shaving and the extra power will serve the battery well with more energy harvest. This graph uses real array data and is scaled to a 200W module and a 240W module.

- On this day there is < 1% loss due to power-shaving (energy above the red line), so more than 95% of the excess power over 200W can be utilized for charging.
- On clear days this loss of power is likely not to be missed so much.
- One exception to note is where the power-shaving energy loss could be more of a factor—in colder climates with winter tilt.
    - In these conditions (shorter days, colder temperatures and okay ≈90° incidence angles) the array will operate above STC Max.
    - Power Levels and the loss of power could have a bigger impact during the time of the year when it is most needed.
- Also, to avoid unnecessary stress on the controller's electronic components, it is recommended that when the controller is installed in a sustained warm temperature climate, the controller not operate at full power, close to its maximum ambient temperature, for prolonged periods of time.

SS-MPPT-15L (240W vs. 200W module) on an Intermittent Day



Q6. Can I oversize other brands of MPPT Controllers?

Morningstar's ***TriStar MPPT™ & SunSaver MPPT controllers are the only controllers*** that will always limit the output current regardless of input power levels. Morningstar's patented TrakStar Technology is capable of limiting the output current, while other manufacturers' MPPT controllers will operate above their maximum current ratings at higher power levels.

Morningstar's MPPT controllers can operate with an oversized array that is several times larger than the maximum Nominal Solar PV ratings, while still limiting the maximum battery current to the controller's maximum current rating. Many other MPPT controllers on the market cannot react quickly enough for fast changes in solar conditions. Even at the published maximum power levels, these controllers are known to exceed their maximum output current ratings and can trip the overcurrent protection fault shutting off the controller during high power conditions.