

**Affected Products:** All Blue Sky Energy charge controllers

**Purpose:** Guidelines for PV Module selection

**Background:**

PV modules are available in a variety of voltage, current and power ratings. For safety, charge controller reliability and proper battery charging, PV modules must be properly matched to the charge controller and battery. This technical bulletin clarifies key PV module specifications and provides guidelines for proper PV module selection. Note that modules must be properly sized for voltage, current and power.



➤ **WARNING:** To reduce the risk of fire or personal injury photovoltaic charge controllers must be installed in accordance with National Electrical Code (NEC), ANSI/NFPA 70. This technical bulletin serves as an application guide only and is not intended to identify all installation and safety requirements for a photovoltaic electric system. For the purpose of PV module selection, use only the PV module manufacturers published specifications conducted at Standard Test Conditions (STC) per ASTM E1036. STC specifies a 25°C cell temperature and illumination of 1kW/m<sup>2</sup> at a spectral distribution of AM 1.5 (ASTM E892 global spectral irradiance).

**PV Modules:**

PV modules are essentially energy converters which convert light into electricity. Because the voltage, current and power produced by a given PV module varies widely based on actual operating conditions, a set of test conditions commonly referred to as **Standard Test Conditions** or **STC** has been developed to rate modules in a meaningful and consistent manner. STC ratings not only provide a fair means to compare one manufacturers modules against another, most importantly STC ratings provide standardized performance data against which actual real world performance can be predicted.

Key PV module specifications;

$P_{MAX}$	Maximum power in watts ( $P_{MAX} = V_{MP} \times I_{MP}$ )
$V_{OC}$	Open circuit voltage (maximum voltage with module output open circuit)
$V_{MP}$	Voltage at which module produces greatest power (also called Operating Voltage)
$I_{MP}$	Current at which module produces greatest power (also called Operating Current)
$I_{SC}$	Short circuit current (maximum current with module output short circuited)

It is important to note that STC ratings are not “maximum” or “optimal” ratings, and that voltage, current and power will be higher or lower based on actual operating conditions. Conditions can be present where  $V_{OC}$  and  $I_{SC}$  can approach 1.25 times STC ratings which is why our recommendations call for 1.25 voltage and current derating. Note that the SC30 calls for a lower 1.12 current derating factor due to its automatic current limit and lack of MPPT current boost. While voltage and current can spike to nearly 1.25 times STC ratings, in typical real world operation  $I_{MP}$  is commonly only about 70 – 80% of  $I_{MP}$  at STC.

Solar Boost MPPT charge controllers will provide the best MPPT current boost performance if all PV modules are identical. If module types are mixed, DO NOT place dissimilar modules in series. Dissimilar modules in parallel should have  $V_{MP}$  values within  $\approx 0.5V$  or better for 12V modules, and be of the same basic cell technology or have a similar temperature coefficient of  $V_{MP}$  so the  $V_{MP}$  of the various modules will tend to track each other as operating conditions change. If module types are very different consider using a separate charge controller for each module type to obtain the best MPPT current boost performance. Multiple controllers on Blue Sky Energy’s IPN Network is an ideal way to obtain the best possible PV performance and battery charge performance from very dissimilar modules.

## PV Module Voltage Sizing:

► **Maximum  $V_{OC}$  Limit:**

Do not connect a total PV  $V_{OC}$  at STC greater than the controller's absolute maximum PV input voltage rating divided by 1.25. This is because real world operating conditions may be present where actual  $V_{OC}$  approaches 1.25 times the published STC rating. Application of PV voltage in excess of the charge controller's absolute maximum PV voltage rating will damage the controller and void the warranty.

► **Minimum  $V_{MP}$  Limit:**

A PV module thought of as a typical 12V nominal module has  $V_{MP}$  and  $V_{OC}$  at STC ratings of about 17.0V and 22.0V respectively. This seemingly high  $V_{MP}$  at STC value is necessary because actual  $V_{MP}$  drops as PV cell temperature rises. The 17V  $V_{MP}$  at STC assures that in hot climates actual  $V_{MP}$  remains sufficiently high enough to properly charge a 12V battery.

To obtain good charge performance a rule of thumb is to not select a PV module with a  $V_{MP}$  of less than 16.5V to charge a 12V battery. 12V PV modules with a somewhat higher  $V_{MP}$  in the range of 17.5V – 18.5V will provide improved MPPT<sup>®</sup> and battery charge performance. However higher voltage is not always better in that some charge controllers can process less PV power if nominal PV voltage is greater than nominal battery voltage as shown on page 3 of this document. These voltage numbers should be multiplied by 2X or 4X for 24V or 48V batteries.

Using the table below for the particular charge controller and battery voltage, select PV modules that have both:  
 1) Total series  $V_{OC}$  at STC not greater than the "Recommended Max. Applied PV  $V_{OC}$  @ STC" value, and  
 2) Total series  $V_{MP}$  value not less than the minimum value shown in "Recommended range of  $V_{MP}$  at STC".



Solar Boost Controller	Battery Voltage	Absolute Max. PV Input Voltage Rating ②	Recommended Maximum PV $V_{OC}$ @ STC	Recommended range of $V_{MP}$ at STC (Typical range of $V_{MP}$ for Nominal PV Voltage Shown)				
				12V Nominal	18V Nominal	24V Nominal	36V Nominal	48V Nominal
SC30	12V	30V	24V	16.5 – 18.5V	X	X	X	X
SB2000E	12V	30V	24V	16.5 – 18.5V	X	X	X	X
SB2512i(X)	12V	35V	28V	16.5 – 18.5V	X	X	X	X
SB2512i(X)-HV	12V	50V	40V	16.5 – 18.5V	23.0 – 31.0V	X	X	X
SB3024i – and – SB3024iL	12V	57V	45.6V	16.5 – 18.5V	23.0 – 31.0V	33.0 – 37.0V	X	X
	24V			X	X	33.0 – 37.0V	X	X
SB1524iX	12V	57V	45.6V	16.5 – 18.5V	23.0 – 31.0V	33.0 – 37.0V	X	X
	24V			X	X	33.0 – 37.0V	X	X
SB50	12V	57V	45.6V	16.5 – 18.5V	23.0 – 31.0V <sup>③</sup>	33.0 – 37.0V	X	X
	24V			X	X	33.0 – 37.0V	X	X
SB3048	24V	140V	112V	X	X	33.0 – 37.0V	46.0 – 62.0V <sup>③</sup>	66.0- 80.0V
	48V			X	X	X	X	66.0- 80.0V

## PV Module Current & Power Sizing:

### ► Maximum PV $I_{SC}$ & Power Limit:

Do not connect total PV module  $I_{SC}$  at STC greater than the controller's maximum output current rating divided by 1.25 for Solar Boost™ charge controllers, or 1.12 for the Sun Charger 30. This is because real world operating conditions may be present where  $I_{SC}$  will exceed the published STC value. The purpose of current derating is to prevent the controller from becoming damaged due to excess PV current or power. These derating values assume that battery voltage and PV voltage are the same nominal value.

If nominal PV voltage is greater than nominal battery voltage it is often easier to use maximum PV power rather than  $I_{SC}$ . Increasing PV voltage does not increase a charge controller's power handling capability. In certain cases as shown below higher PV voltage lowers the maximum power a controller can process. Refer to Technical Bulletin #100210 for more detail regarding  $I_{SC}$  limits at higher PV input voltages.

### ► Minimum PV $I_{MP}$ Limit:

A preferred rule of thumb is that there be at least 3 amps of  $I_{MP}$  per 100 amp-hours of battery capacity for proper battery charging. An absolute minimum  $I_{MP}$  with little or no loads is about 1.5 amps per 100 amp-hours of battery capacity.

Using the table below for the particular charge controller, battery voltage and nominal PV module voltage, select the maximum number PV modules that will not exceed "Maximum Short Circuit Current  $I_{SC}$  at STC" or "Maximum Applied Total PV Power @ STC".



Solar Boost Controller	Nominal Battery voltage	Maximum Applied Total PV Power @ STC	Max. Controller Output Current Rating	Maximum Short Circuit Current $I_{SC}$ at STC (At Nominal PV Voltage Shown)				
				12V Nominal	18V Nominal	24V Nominal	36V Nominal	48V Nominal
SC30	12V	450W	30A	27A	X	X	X	X
SB2000E	12V	340W	25A	20A	X	X	X	X
SB2512i(X)	12V	340W	25A	20A	X	X	X	X
SB2512i(X)-HV	12V	340W ①	25A ①	20A	X	X	X	X
		270W	20A	X	11A	X	X	X
SB3024i	12V	400W	30A	24A	16A	12A	X	X
	24V	800W		X	X	24A	X	X
SB3024iL	12V	540W ②	40A ②	32A ②	X	X	X	X
	12V	400W	30A	X	16A	12A	X	X
	24V	800W		X	X	24A	X	X
SB1524iX	12V	270W ③	20A ③	16A ③	X	X	X	X
	12V	200W	15A	X	8A	6A	X	X
	24V	400W		X	X	12A	X	X
SB50	12V	670W	50A	40A	26.7A	20A	X	X
	24V	1340W		X	X	40A	X	X
SB3048	24V	800W	30A	X	X	24A	16A	12A
	48V	1600W		X	X	X	X	24A

① See "What is MPPT" at [www.blueskyenergyinc.com](http://www.blueskyenergyinc.com).

② The maximum PV input voltage is a hard limit above which the controller will be damaged in a manner that voids the warranty.

③ These modules can be used but a one time special MPPT trim between the high and low ranges is required.

④ Current limit and current rating are higher when charging a 12V battery from 36 cell nominal 12V PV modules. If PV  $V_{oc}$  ever exceeds 30V (i.e., >12V nominal PV modules) current rating and current limit switch to the lower value until the unit reboots.