Application Note

String Sizing with SkyBox

Sizing a solar array is based on many variables. The calculation steps involved are shown below as well as an example using the OutBack SkyBox. Variables not taken into account over these examples include shading coefficients and panel angles.

The traditional method for string sizing with OutBack charge controllers no longer applies to the SkyBox product. The FLEXmax products are centered on the battery, so many calculations include a nominal battery voltage. The SkyBox is not centered on the battery and supports PV strings between 250 Vdc and 600 Vdc, so the calculations presented here are different from those presented in earlier application notes for OutBack products.

Procedure

1. Gather appropriate data
2. Correct for coldest temperature
3. Correct for highest temperature
4. Calculate maximum and minimum panel configurations
5. Calculate maximum power

Step 1: Gather appropriate data

The data required can be found on the specification sheet for the chosen panel (or potential panels) and the inverter specification sheet.

Panel data:

1. Open circuit voltage (V_{oc})
2. Short circuit current (I_{sc})
3. Maximum power voltage (V_{mp})
4. Thermal coefficients (α_{oc}, α_{mp})

SkyBox data:

1. Maximum input voltage
2. Minimum input voltage
3. Maximum input current

Step 2: Correcting for the Coldest Expected Temperature

$$V_{oc,max} = V_{oc,25}\left[1 + \alpha_{T,oc}\Delta T\right] \quad (1)$$

Where:

$$\Delta T = T_{cold}(°C) - 25°C \quad (2)$$

The formula shown above can be used to calculate the maximum voltage experienced by the SkyBox due to cold temperatures. Dependent upon the application, T_{cold} can be the record low temperature, to fail conservatively, or the average low temperature for the area.

All temperatures must be in degrees Celsius. The formula below can be used to convert Fahrenheit to Celsius.

$$T(°\mathrm{C}) = \frac{5}{9}\,[T(°\mathrm{F}) - 32°\mathrm{F}] \tag{3}$$

Step 3: Correcting for the Warmest Expected Temperature

Correcting for the warmest expected temperature ensures the array will not decrease below the minimum operating PV voltage for the SkyBox.

$$V_{mp,min} = V_{mp,25}\left[1 + \alpha_{T,mp}\Delta T\right] \tag{4}$$

Where:

$$\Delta T = T_H(°\mathrm{C}) - 25°\mathrm{C} \tag{5}$$

The formula shown above can be used to calculate the minimum voltage experienced due to warm temperatures. The temperatures used in this formula must be in degrees Celsius.

Step 4: Maximum and Minimum Panels in Series

Once the $V_{oc,\ max}$ and $V_{mp,min}$ values are calculated, the maximum and minimum number of panels in series can be calculated. The maximum inverter input voltage divided by the $V_{oc,\ max}$ gives the maximum number of panels connected in series that will not exceed the inverter voltage rating. If a SkyBox detects it is connected to an array producing more than 600 Vdc, it will keep its PV relay open until the voltage falls into the operating range. Dividing the minimum operating PV voltage by the $V_{mp,\ min}$ will give the minimum panels needed to operate above the lower voltage limit.

Step 5: Maximize Array Power

$$P_{mp} = I_{mp} \times V_{mp} \tag{6}$$

The SkyBox supports any array from 250 to 600 V_{oc} and 20 Adc. It will produce up to 5000 W of DC power from PV. Using this number and the maximum power calculated above, the ideal number of panels can be calculated. More panels can be added to an array in order to increase the available power. However, the SkyBox will only produce up to 5000 W, even if more power is available. Once the optimum number of panels is known, the configuration can be chosen.

$$Ideal\ Number\ of\ Panels = \frac{5000W}{P_{mp}} \tag{7}$$

Example

Step 1: Gather data

Name	Example300
STC Watts	300
V_{oc}	40.0
V_{mp}	31.6
I_{mp}	9.57
$\alpha_{T,oc}$ (°C^{-1})	–0.29%
$\alpha_{T,mp}$(°C^{-1})	–0.39%

Name	SkyBox
Max I_{mp}	20 Adc
Max Input Voltage	600 Vdc
Min Input Voltage	250 Vdc
Maximum DC Power Output	5000 W

Step 2: Correct for Coldest Expected Temperature

Location: Arlington, WA

Extreme Minimum: –9°C

$$\Delta T = -9 - 25 = -34$$

$$V_{oc,max} = 40.0V[1 + (-0.0029/℃)(-34℃)]$$

$$V_{oc,max} = 40V[1 + 0.0986]$$

$$V_{oc,max} = 43.94V$$

Step 3: Correct for Warmest Expected Temperature

2% Average High: 27°C

Equation (5) is used to find the difference between the standard test temperature (25°C) and the local panel temperature. 10°C is added to account for an increase in temperature on the rooftop where panels will be located. Equation (4) is used to find the minimum voltage expected.

$$\Delta T = (27 - 25) + 10 = 12℃$$

$$V_{mp,min} = 31.6V\left[1 + \left(-\frac{0.0039}{°C}\right)(12°C)\right]$$

$$V_{mp,min} = 32.6V[1 - 0.0468]$$

$$V_{mp,min} = 30.12V$$

Step 4: Calculate Maximum and Minimum Panel Configuration

$$\#\ of\ Panels\ in\ Series, max = \frac{600V}{V_{oc,max}}$$

$$\#\ of\ Panels\ in\ Series, max = \frac{600V}{43.94V}$$

$$\#\ of\ Panels\ in\ Series, max = 13.65$$

A system cannot have a fraction of a panel. To avoid exceeding the voltage rating of the SkyBox, a maximum of 13 panels in series may be used.

$$\#\ of\ Panels, min = \frac{250V}{V_{mp,min}}$$

$$\#\ of\ Panels, min = \frac{250V}{30.12V}$$

$$\#\ of\ Panels, min = 8.3$$

To avoid falling below the lower voltage limit, a minimum of nine panels must be used.

Step 5: Maximize array power

$$P_{mp} = I_{mp*}V_{mp}$$

$$P_{mp} = (9.57A)(31.6V)$$

$$P_{mp} = 302.4W$$

$$x = \frac{5000W}{302.4W}$$

$$x = 16.5$$

Solution:

A system in Arlington, WA operating under ideal conditions will produce 5000 W with two strings of nine panels each. The PV array can be oversized in order to compensate for non-ideal conditions. These strings can range anywhere between nine and thirteen panels (the minimum and maximum number calculated above). An array in any of these configurations will not exceed the ratings of the SkyBox MPPT.

Conclusion

In this application note, the procedure was outlined to accurately size PV arrays to the abilities of the SkyBox. These steps differ from the battery-centric method used previously with the FLEXmax charge controllers. After sizing the appropriate battery bank (if applicable), and using the examples above, sizing the PV array with the SkyBox is a simple task.

About OutBack Power Technologies

OutBack Power Technologies is a leader in advanced energy conversion technology. OutBack products include true sine wave inverter/chargers, maximum power point tracking charge controllers, and system communication components, as well as circuit breakers, batteries, accessories, and assembled systems.

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Other

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