Temperature Derating

for **SUNNY BOY, SUNNY MINI CENTRAL, SUNNY TRIPOWER**

Content

During temperature derating, the inverter reduces its power to protect components from overheating. This document explains how temperature is regulated in the inverter, what can cause temperature derating and what measures can be taken to prevent it.

1 What is Temperature Derating?

"Derating" describes the controlled reduction of the power. During normal operation, inverters work at the so-called Maximum Power Point (MPP). At this operating point, the relation between PV voltage and PV current is adjusted to provide maximum power. The actual Maximum Power Point changes constantly depending on the level of solar irradiation and the ambient temperature of the PV modules.

Temperature-dependent derating protects sensitive semiconductor inverter components from overheating. When the monitored components reach the maximum admissible temperature, the device shifts it operating point to a lower power. During this process, power is reduced step-by-step. In the extreme case, the inverter switches off completely. As soon as the temperature of the threatened components falls below the critical value, the inverter returns to the optimal operating point.

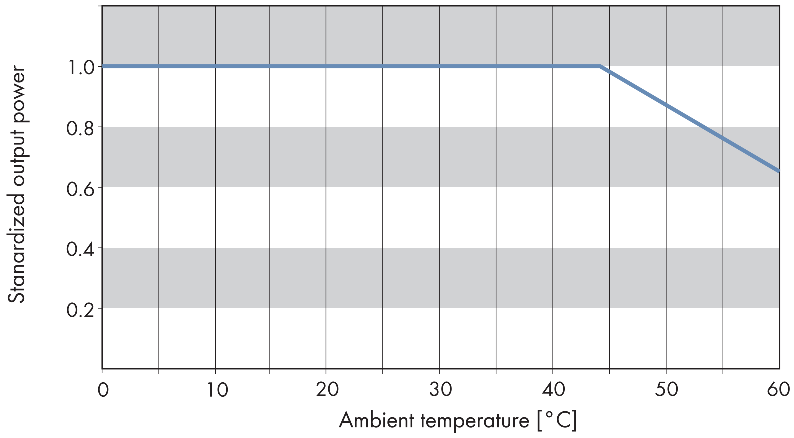

Figure 1: Example of the power curve during temperature derating

Temperature derating can occur for various reasons, e.g. when the PV generator and inverter are not well synchronized or when installation conditions interfere with the inverter's heat dissipation.

Derating does not have a negative effect on the inverter. This operating condition is first shown by the status display LEDs and the inverter display. If it lasts longer than a few minutes, the fault message "Derating" is displayed. This warning is displayed by the inverter until it switches itself off at dusk.

2 Plant Design and Temperature Derating

The correct design of a PV plant must not completely exclude derating. PV plants are optimized in regard to total energy yield. The power available at the inverter output is calculated from the power provided by the PV generator and the efficiency of the inverter. It is therefore crucial that the product of these two factors is as large as possible.

Figure 2 uses the example of Freiburg in Breisgau to show how much energy is available over the course of a year in different areas of the power range of the PV generator. The calculation of the frequency with which each power level occurs is already included in the bar chart in Figure 2. The low power output of the lower partial load ranges contribute significantly to the total system power because they occur very frequently.

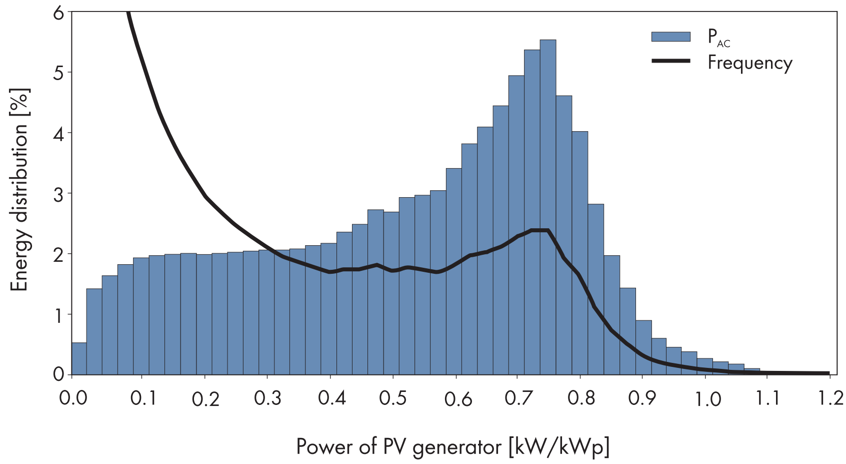

Figure 2: Energy supply related to the power range of the PV generator (example Freiburg in Breisgau, Germany)

The efficiency with which the inverter converts the power provided by the PV generator depends on its efficiency curve.

For a PV plant with optimum orientation towards the sun - in Germany a southern orientation and a PV module angle of 30° to 45° - the following applies: The yield is highest when the nominal power of the inverter is 90 % to 100 % of the generator power. With this power ratio, PV generator power peaks above the nominal power of the inverter trigger derating. On the other hand, the efficiency of the inverter is higher in the partial load range during the frequent periods of low power. That means: With this PV plant tuning, the complete power range is used optimally, with the exception of small yield losses through rarely occurring derating (compare Figure 3).

An inverter with a nominal power greater than 100 % of the generator power can be chosen to prevent derating during PV generator peak power. However, in this case a greater portion of the partial load yields would lie in a range in which the inverter has a relatively low efficiency. The losses in the partial load range would be larger than the gain from completely utilizing periods of peak power (compare Figure 4).

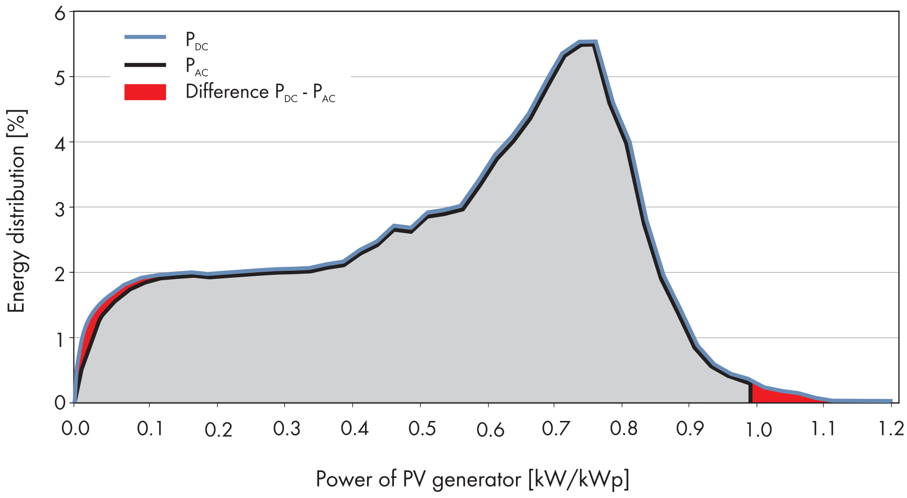

Figure 3: Efficiency and inverter input and output power when the nominal power of the inverter is 90 % to 100 % of the generator power

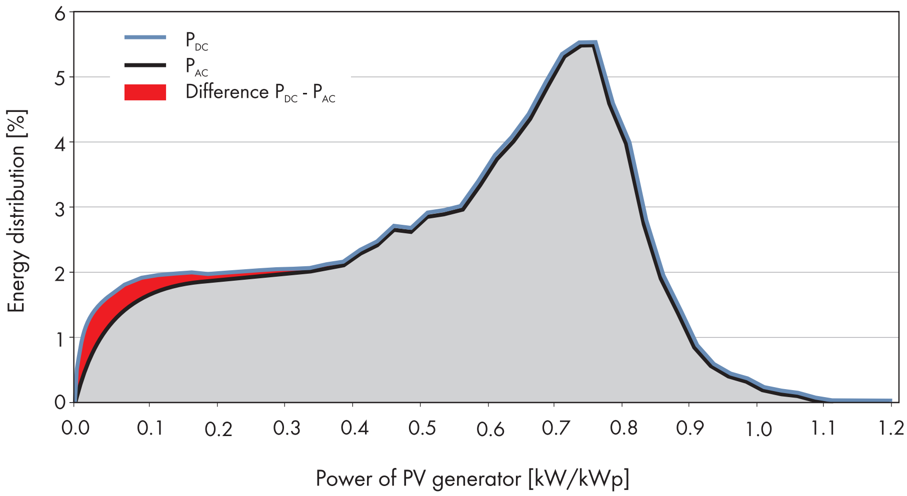

Figure 4: Inverter efficiency and input and output power when the nominal power of the inverter is more than 100 % of the generator power

With optimal PV plant tuning, derating rarely occurs. Frequent derating shows that the selected inverter power is too low compared to the power of the PV generator.

You can determine the ideal design of your PV plant using the "Sunny Design" software. You can download "Sunny Design" free of charge at www.SMA.de/en/SunnyDesign.

3 Inverter Heat Dissipation

SMA inverters have a cooling system adapted to the power and type of the device. Passively cooled inverters dissipate heat to the surrounding air using heat sinks.

Actively cooled devices with the OptiCool system are additionally ventilated. As soon as the device produces more heat than can be dissipated through the enclosure, an internal fan is switched on creating an air flow through the cooling ducts of the enclosure. The fan is RPM controlled, i.e. it increases its speed with increasing temperature. The advantage of active ventilation is that the inverter can continue to feed its maximum power even with increasing temperature. Derating then only occurs when the cooling is no longer sufficient. Actively cooled inverters therefore have additional power reserves in comparison to passively cooled devices.

Ensure sufficient heat dissipation during the installation of inverters to prevent temperature derating.

- Install inverters in cool locations, e.g. in the cellar rather than on the roof.
- Choose locations with sufficient air exchange. Ensure additional ventilation, when necessary.
- Do not expose inverters to direct sunlight. For outdoor installations, use existing shadow or roof over the inverters.
- Maintain the minimum clearance to neighboring inverters or other objects given in the installation guide. Increase the clearance when it is foreseeable that higher temperatures could occur at the installation location.
- Arrange multiple inverters so that they do not draw in the warm air of other inverters. Offset passively cooled inverters to allow the heat from the heat sinks to escape upward.

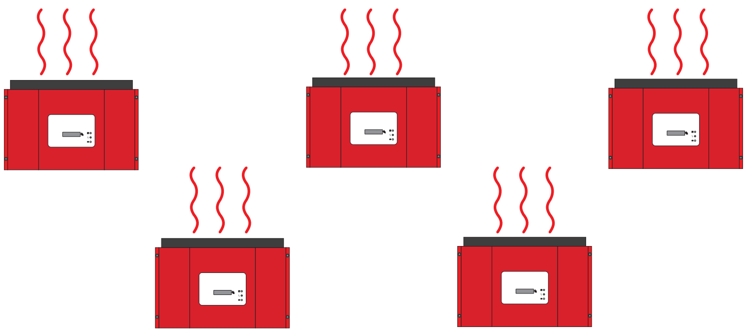

Figure 5: Layout of passively cooled inverters to optimize heat dissipation: Sunny Boy 1200, Sunny Boy 1700, Sunny Boy 2100TL

For actively cooled inverters, the optimal layout depends upon the location of the air inlet and air outlet openings. A number of examples are listed below.

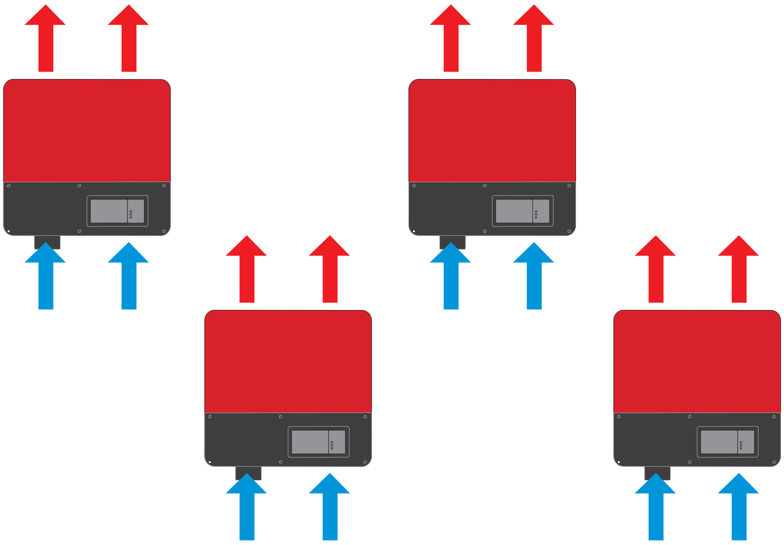

Figure 6: Layout of actively cooled inverters to optimize heat dissipation: Sunny Boy 2000HF, Sunny Boy 2500HF, Sunny Boy 3000HF, Sunny Boy 3000TL, Sunny Boy 4000TL, Sunny Boy 5000TL

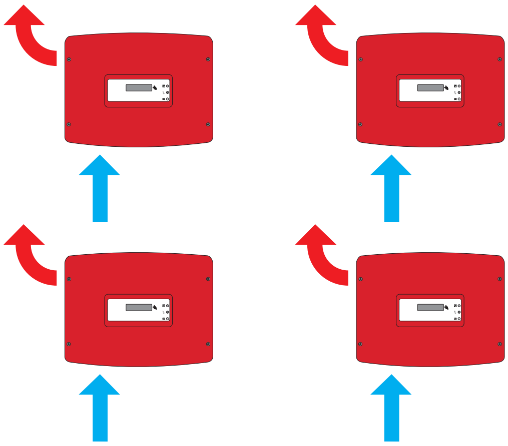

Figure 7: Layout of actively cooled inverters to optimize heat dissipation: Sunny Boy 3300, Sunny Boy 3800

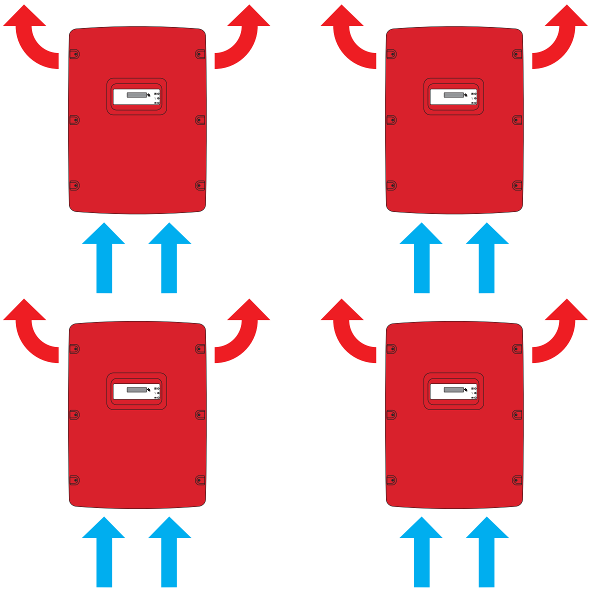

Figure 8: Layout of actively cooled inverters to optimize heat dissipation: Sunny Mini Central

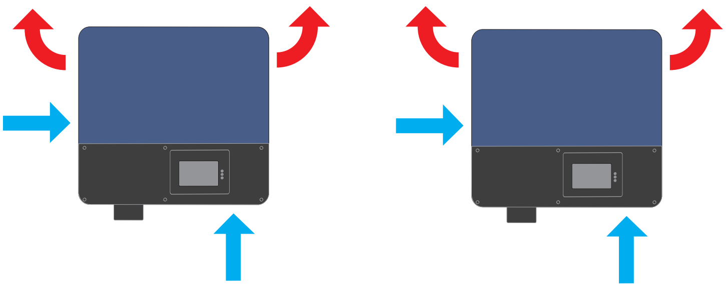

Figure 9: Layout of actively cooled inverters to optimize heat dissipation: Sunny Tripower

As a result of the sophisticated ventilation concept of inverters of the type Sunny Tripower, there is no special recommendation for the layout of multi-row assemblies.

4 Handling Temperature Derating

SMA inverters are built so that the admissible operating temperature will not be exceeded with correct PV plant design and under suitable ambient conditions. If temperature-dependent derating nevertheless occurs, this can have the following causes:

- The inverter cannot dissipate enough heat to the surrounding air because the heat sink or ventilation grid is dirty or fans have failed. Clean the affected parts as described in the respective inverter's installation guide.
- The power of the inverter is too low compared to the power of the PV generator. The input power of the inverter should be 90 % to 100 % of the nominal power of the PV generator. Under extreme climatic conditions, e.g. intense solar irradiation in connection with low PV module temperatures, the power of the PV generator can exceed nominal inverter power even with correct plant design. However, frequent derating is an indication of inappropriate plant design (see section 2 "Plant Design and Temperature Derating" (page 3)). The design of the PV plant should be checked by a specialist.
- The installation environment of the inverter does not provide the required climatic conditions (see section "Technical Data" in the installation guide of the respective inverter). The inverter should be installed by a specialist at a more suitable location. Ensure that minimum clearance between multiple devices is maintained. Increase the clearances in warm installation environments. Install the devices outside the hot air flow of other inverters (see section 3 "Inverter Heat Dissipation" (page 5)). When necessary, provide additional cooling. Ventilate multiple inverters so that the air flow cools all devices equally.