Technical Information

SUNNY BOY / SUNNY TRIPOWER
Temperature derating

ENGLISH

Temp-Derating-TI-en-15 | Version 1.5

1 Introduction

Temperature derating occurs when the inverter reduces its power in order to protect components from overheating. This document explains how inverter temperature is controlled, what causes temperature derating and what can be done to prevent it.

2 What is Temperature Derating?

Derating is the controlled reduction of the inverter power. In normal operation, inverters operate at their maximum power point. At this operating point, the ratio between PV voltage and PV current results in the maximum power. The maximum power point changes constantly depending on solar irradiation levels and PV module temperature.

Temperature derating prevents the sensitive semiconductors in the inverter from overheating. Once the permissible temperature on the monitored components is reached, the inverter shifts its operating point to a reduced power level. The power is reduced in steps. In extreme cases, the inverter will shut down completely. As soon as the temperature of the sensitive components falls below a critical value again, the inverter returns to the optimum operating point.

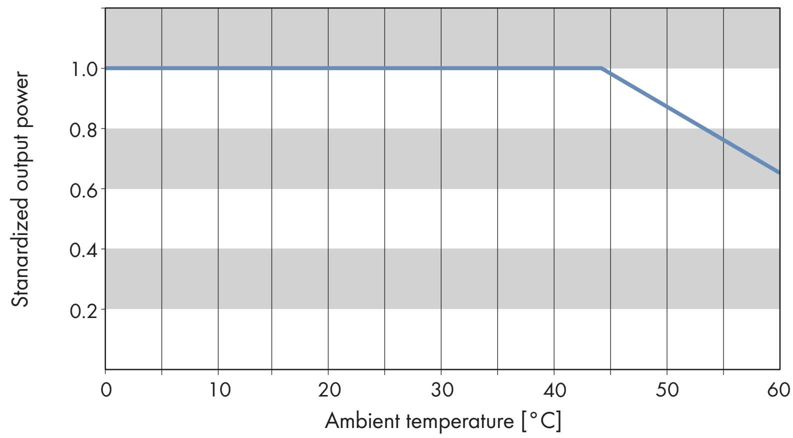

Figure 1: Example of a power curve with temperature derating

Temperature derating occurs for various reasons, including the following:

- The inverter cannot dissipate heat due to unfavorable installation conditions.
- The inverter is operated in direct sunlight or at high ambient temperatures that prevent adequate heat dissipation.
- The PV array and inverter are mismatched (power of the PV array compared to the power of the inverter).
- If the installation site of the inverter is at an unfavorable altitude (e.g. altitudes in the range of the maximum operating altitude or above Mean Sea Level, see Section "Technical Data" in the inverter operating manual). As a result, temperature derating is more likely to occur since the air is less dense at high altitudes and thus less able to cool the components.
- A constantly high DC voltage (V_MPP) is present at the inverter.

Since each DC operating voltage has a considerable influence on the derating behavior of the inverter, it is useful to represent different DC operating voltages in a temperature curve for clarification (see figure 2). Derating as a function of the DC operating voltage of an SMA inverter is shown based on the current requirements specified in the relevant standards (e.g. DIN EN 50524): minimum DC voltage (V_MPP_Min), nominal DC voltage (V_nom) and maximum DC voltage (V_MPP_Max).

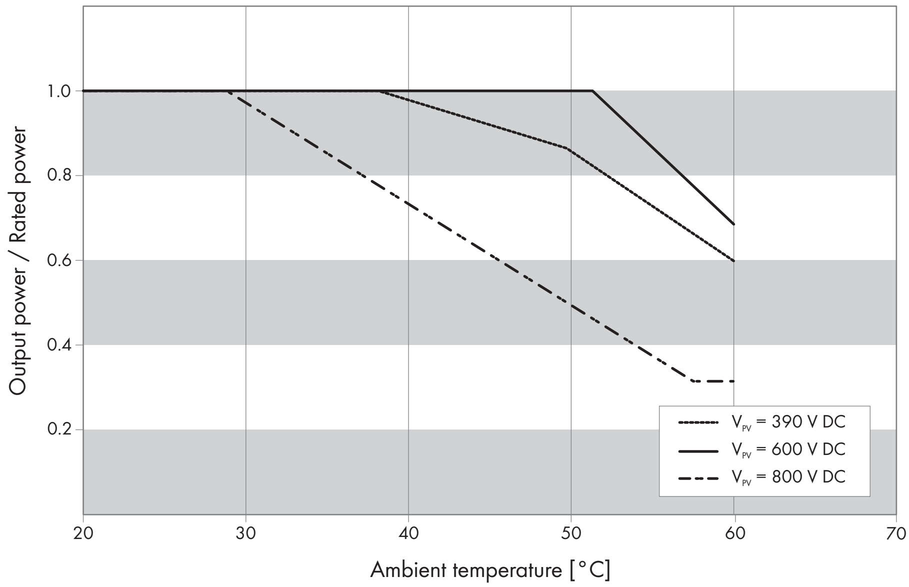

Figure 2: Example for derating behavior of an SMA inverter at various operating voltages

The following figure (figure 3) shows different operating points of a PV system as an example (Australia, Alice Springs; 140% oversizing) depending on the respective ambient temperature and the DC operating voltage that arise in the PV array. The inverter can continuously operate at maximum power as long as it remains in the area on the left of the characteristic curve.

The figure shows that the influence of high DC voltages on the temperature behavior may not be overrated. For instance, the DC operating voltage decreases when the temperature increases: from 800 VDC at 15 °C to 720 VDC at 40 °C. In this case, the maximum DC voltage of the inverter acts more as a technical boundary than a normal operating curve. There is no PV array operating point that requires the inverter to feed in at full power at temperatures above 31 °C (at 800 V).

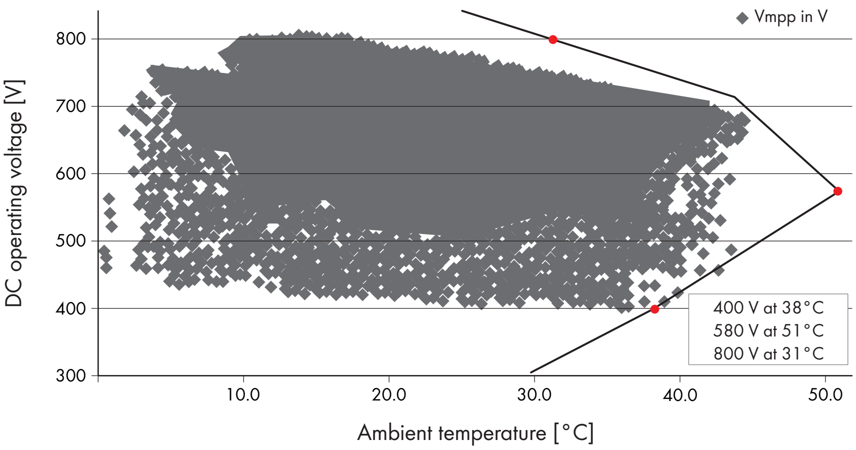

Figure 3: Operating points of a PV system and characteristic curve of the operating range within which the inverter can feed maximum power into the grid (location of the PV system: Australia, Alice Springs; 140% oversizing)

On principle, temperature derating has no negative effects on the inverter. A glowing LED and a warning on the inverter display indicate when the inverter is in the operating state "Derating". The inverter continues to display this warning until shutting down at sunset.

3 System Design and Temperature Derating

Correct PV system design must not necessarily entirely exclude derating. PV systems are optimized in terms of total energy yield. The output power of the inverter is calculated from the PV array power and the inverter efficiency. Therefore it is crucial that the product of these two factors is as large as possible.

Figure 4 shows how much energy is produced in one year by a PV array located in Freiburg im Breisgau, Germany, and how the power output is distributed within the power range of the PV array. The diagram also shows the frequency with which the PV array produces a particular power output. The low power outputs in the lower partial load regions occur very frequently and so account for a significant proportion of total power.

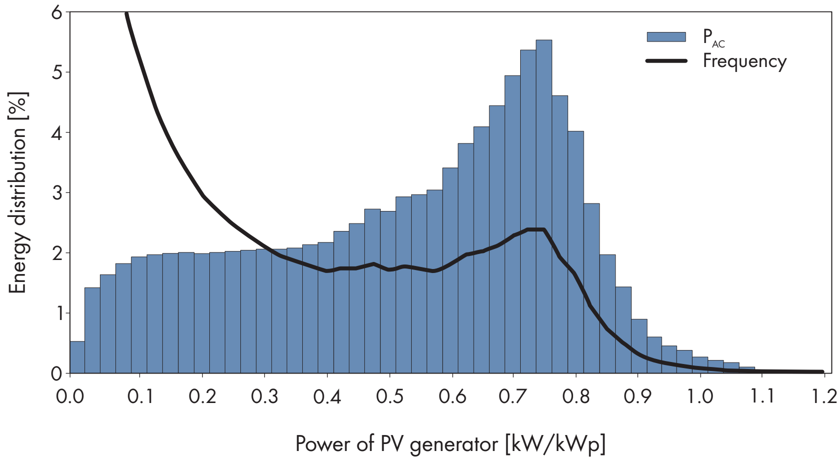

Figure 4: Energy supply relative to the power range of the PV array (example: Freiburg im Breisgau, Germany)

The inverter efficiency curve states how efficiently it can convert the power provided by the PV array.

In order to avoid derating at peak PV array outputs, an inverter with a nominal power of more than 100% of the PV array power could be selected. However, this would shift a larger proportion of partial load yields to a range within which the inverter is relatively inefficient. The losses experienced within this partial load range would exceed the gains obtained by avoiding derating at peak outputs (see figure 6).

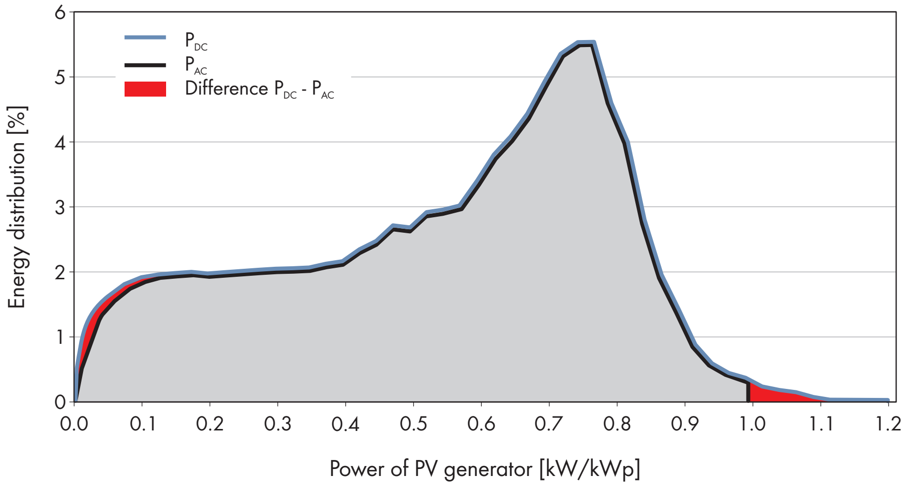

Figure 5: Efficiency, input power and output power of the inverter when the nominal power of the inverter is 90% to 100% of the PV array power.

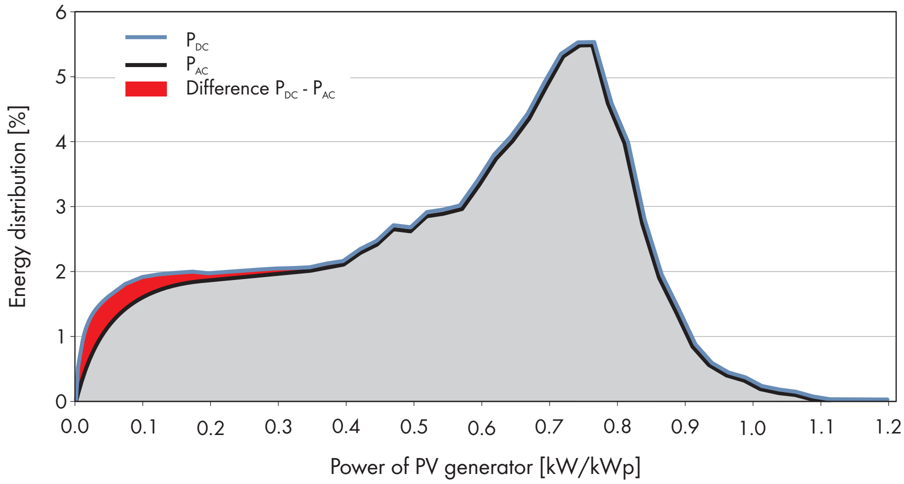

Figure 6: Efficiency, input power and output power of the inverter when the nominal power of the inverter is more than 100% of the PV array power

Derating rarely occurs when the PV system is well matched. Derating is more common when the inverter is undersized relative to the PV array (see Section 2, page 2 for the causes of frequent temperature derating).

You can determine the ideal design for your PV system with the "Sunny Design" software. This design software is available free of charge at www.SMA-Solar.com.

4 Heat dissipation of the inverters

SMA inverters have cooling systems tailored to their power and design. Passively cooled inverters dissipate heat to the atmosphere through heat sinks.

Actively cooled devices with OptiCool systems have supplementary ventilation. As soon as the device generates more heat than its enclosure can dissipate, an internal fan switches on and draws in air through the cooling ducts of the enclosure. The fan is speed-controlled: it turns faster as the temperature rises. The advantage of active cooling is that the inverter can continue to feed in its maximum power as the temperature rises. The inverter is not derated until the cooling system reaches the limits of its capacity. Actively cooled inverters thus have extra power reserves compared to passively cooled devices.

You can avoid temperature derating by installing inverters in such a way that the heat is adequately dissipated:

- Install inverters in cool locations, e.g. basements instead of attics.
- Choose locations with sufficient air circulation. Install additional ventilation if needed.
- Do not expose the inverter to direct solar irradiation. If you install an inverter outdoors, position it in the shade or install a roof overhead.
- Maintain the minimum clearances from adjacent inverters or other objects, as specified in the installation manual. Increase the clearances if high temperatures are likely to occur at the installation site.
- When installing several inverters, arrange them so that they do not draw in the warm exhaust air emitted by other inverters. Passively cooled inverters are offset so the heat from the heat sinks can escape upwards.

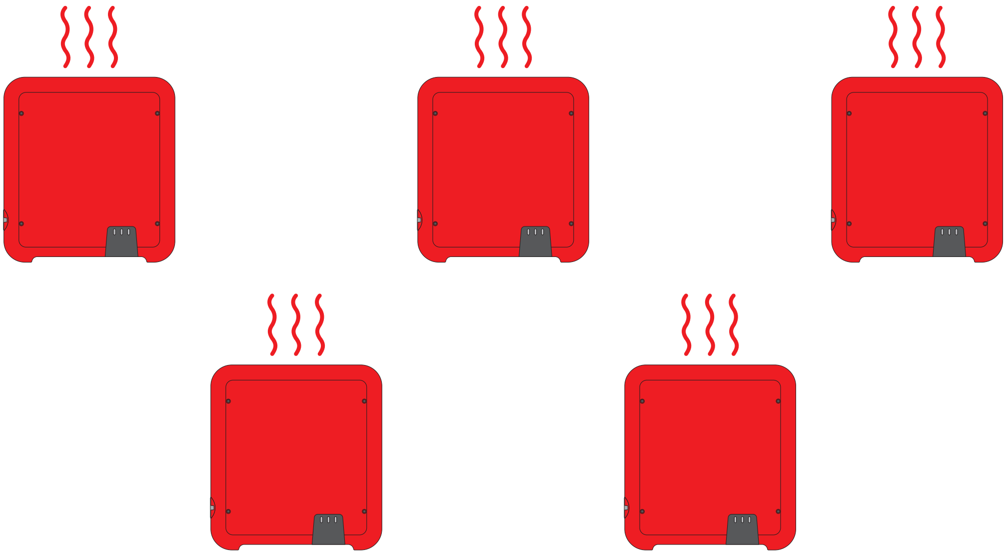

Figure 7: Arrangement of passively cooled inverters to optimize heat dissipation: SBxx-1AV-40

The optimum arrangement for actively cooled inverters depends on the position of the air intake and exhaust openings. Several examples are shown below.

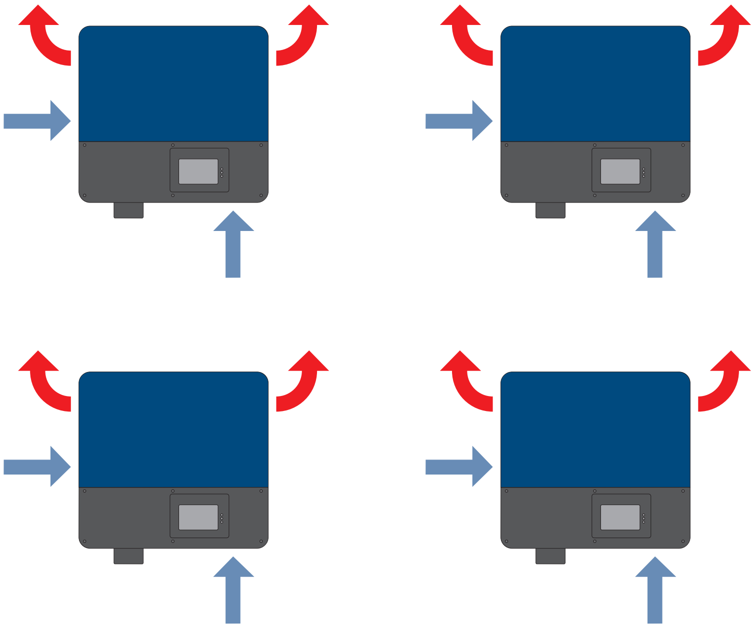

Figure 8: Arrangement of actively cooled inverters to optimize heat dissipation: STP XXXXXTL-30

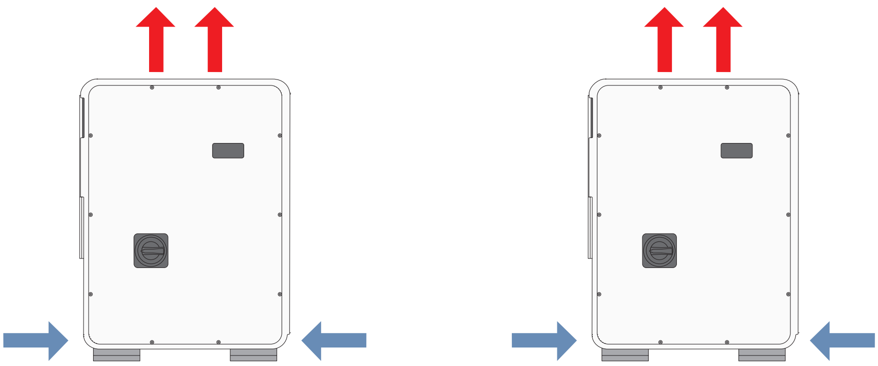

Figure 9: Arrangement of actively cooled inverters to optimize heat dissipation: Sunny Tripower CORE1 / CORE1-JP / CORE1-US

5 Managing Temperature Derating

SMA inverters are designed to stay below the permissible operating temperature as long as the PV system is properly designed and operated in suitable ambient conditions. However, temperature derating may still occur for the following reasons:

- The inverter cannot dissipate enough heat to the atmosphere because the heat sinks or fan guards are clogged or the fans have failed. Clean the affected parts as described in the inverter installation manual.
- The selected inverter power is too low compared to the PV array power. This configuration may make financial sense and is being adopted more and more in the field. Even if the PV system is properly designed, the power of the PV array may still exceed the nominal power of the inverter in extreme climatic conditions, such as high solar irradiation combined with low PV module temperatures.
- The inverter installation site does not have the necessary climatic conditions (see Section "Technical Data" in the inverter manual). In this case, the inverter should be relocated to a more suitable site by a qualified person. Make sure to maintain the recommended clearances between multiple devices. Increase the clearances even more in warm installation environments. Install the devices away from the hot exhaust air streams of other inverters (see Section 4, page 5). Provide additional cooling for the inverter, if necessary. Ventilate multiple inverters in such a way that the airflow cools all devices equally.

ENERGY
THAT
CHANGES

SMA