

# Measurement accuracy

Energy values and efficiency

for PV Inverter Sunny Boy and Sunny Mini Central



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All photovoltaic system operators want to be informed as much as possible about the power and yield of their system. For this purpose, system operators often conduct tests themselves to check the specifications made by the manufacturer and the values displayed by the inverter.

This document highlights two examples within this context:

1. Energy value deviations in the various displays.
2. Determining the efficiency.

# 1 Deviating Displays for Energy Values

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When operating a photovoltaic system, the system operator occasionally discovers that the energy values displayed on the feed-in counter and the inverter or the data logger differ from one another.

The possible reasons for these deviations will be described in this section. In addition, the differences that are normal and those that indicate a malfunction will be explained.

## 1.1 Feed-in Counter Values

The feed-in counter is the only valid reference for a system's yield. However, a calibrated feed-in counter does not take absolutely exact measurements, but rather tolerances are permitted here. Depending on the assigned error class (normally error class 1 or 2), it may have a measuring error of up to  $\pm 2\%$  (class 2) according to DIN EN 62053.

Mechanical electricity meters generally meet the accuracy requirements of class 2. The power consumed by the feed-in counter, which can range between 0.5 and 3 watts depending on the design and model, as well as the losses caused by the starting current are usually negligible when compared to the inverter data. However, this does not apply to small system outputs or at very low daily yield values.

## 1.2 Inverter Measuring Devices

The inverter is equipped with measuring devices that ensure proper system management. The inverter's task is to determine the operating point along with the maximum yield, while a counter is to take a precise energy measurement. Therefore, to achieve maximum energy conversion, it is crucial for the inverter to precisely detect changes in parameters, such as grid current or PV voltage. In this case, high reproducibility is more important than high absolute accuracy.

Compared to the calibrated feed-in counter, the inverter's measuring channels may have a tolerance of up to  $\pm 3\%$  based on the respective final value of the measurement range under nominal conditions. If the feed-in power is low, the relative deviation may therefore also be correspondingly larger. These deviations also then recur proportionately in the derived measurements, such as the feed energy.

In addition, line losses from the AC cabling must also be added. These losses, as recommended in the device documentation, must not exceed approx. 1% at nominal power. In case of doubt, check whether the installed AC cabling matches the cable lengths and the corresponding cable cross-sections recommended in the device documentation.

## 1.3 Deviations and Malfunctions

Taking into account the aforementioned measurement tolerances and influencing factors, the sum of the tolerances of the measuring devices may allow deviations between an inverter display and the feed-in counter to occur. Since the tolerance range for these deviations particularly depends on the present feed-in power, a maximum permissible deviation cannot be specified. However, a deviation of more than 10 % under rated operating conditions indicates a malfunction with one of the measuring devices. In this case, the entire system should be precisely examined.

### **Calculation example in percentage of error information and the absolute value:**

Current sensor measurement range (final scale value):	50 A, permissible error $\pm 2 \%$ (equals absolute value of $\pm 1$ A)
Permissible values for a current of 20 A:	19 A ... 21 A (equals relative value of $\pm 5 \%$ )
Permissible values for a current of 2 A:	1 A ... 3 A (equals relative value of $\pm 50 \%$ )

## 2 Determining the Efficiency

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To verify the performance of their inverters, photovoltaic system operators compare the efficiency specified in the data sheet with an efficiency they themselves have calculated. This efficiency comprises measurement data and other specifications that the inverter displays or provides. However, this procedure has proven to be unsuitable.

This section explains the reasons why an efficiency calculation performed by system operators yields unusable results.

### 2.1 Inverter Measuring Devices

Measuring devices are integrated into the inverter. These devices ensure the proper system management of the inverter. The inverter's task is to determine the operating point along with the maximum yield. Therefore, to achieve maximum energy conversion, it is crucial for the inverter to precisely detect changes in parameters, such as grid current or PV voltage. In this case, high reproducibility is more important than absolute accuracy.

The inverter's measuring devices do not meet the high standards of calibrated measurement equipment.

The inverter's measuring channels may have a tolerance of up to  $\pm 4\%$  for DC measurements and up to  $\pm 3\%$  for AC measurements (based on the respective final value of the measurement range under nominal conditions). As a result, the relative deviation may (also) be correspondingly larger if the feed-in power is low. These deviations have a proportional effect on the derived measurements.

### 2.2 The Efficiency of the Inverter

The efficiency specified for the inverter is determined using a high-precision measuring process and represents the ratio of the output power to the input power during nominal conditions. These specifications are also verified by independent testing institutes. Inverters not operated under nominal conditions, but rather under other conditions, such as with deviating input voltages, under partial load or at an increased ambient temperature produce deviating efficiency values.

### 2.3 Determining the Efficiency by Measuring the Current and Voltage Values

If operators conduct an efficiency calculation themselves by measuring the current and voltage values at the input and output using commercially available measuring devices with larger tolerances, the results yielded cannot be used. The efficiency can only be precisely determined using high-precision and very expensive performance analyzers under laboratory conditions, which allow all input and output values to be measured simultaneously.

## 2.4 Determining the Efficiency by Producing a Ratio

An efficiency calculation that produces a ratio of the input and output values displayed or measured on the inverter also yields invalid results. The reasons for this include the tolerances stated above (see section 2.1) involved in the acquisition of measured values as well as a slight time offset in the internal communication of the inverter or during the transmission to a data logger. As a result of these reasons, the current, voltage and power values for the display and the communication do not match exactly. During inconsistent weather conditions, i.e. if the radiation intensity suddenly changes, this result is also affected by the calculation of a mean value.

## 2.5 The Testing Center at SMA Solar Technology

The aforementioned points clarify why the inverter's actual efficiency can only be determined using highly sophisticated measurement electronics. SMA Solar Technology has its own testing center equipped with state-of-the-art testing equipment. Furthermore, each SMA inverter is subject to a long-term test and its performance is tested before delivery.