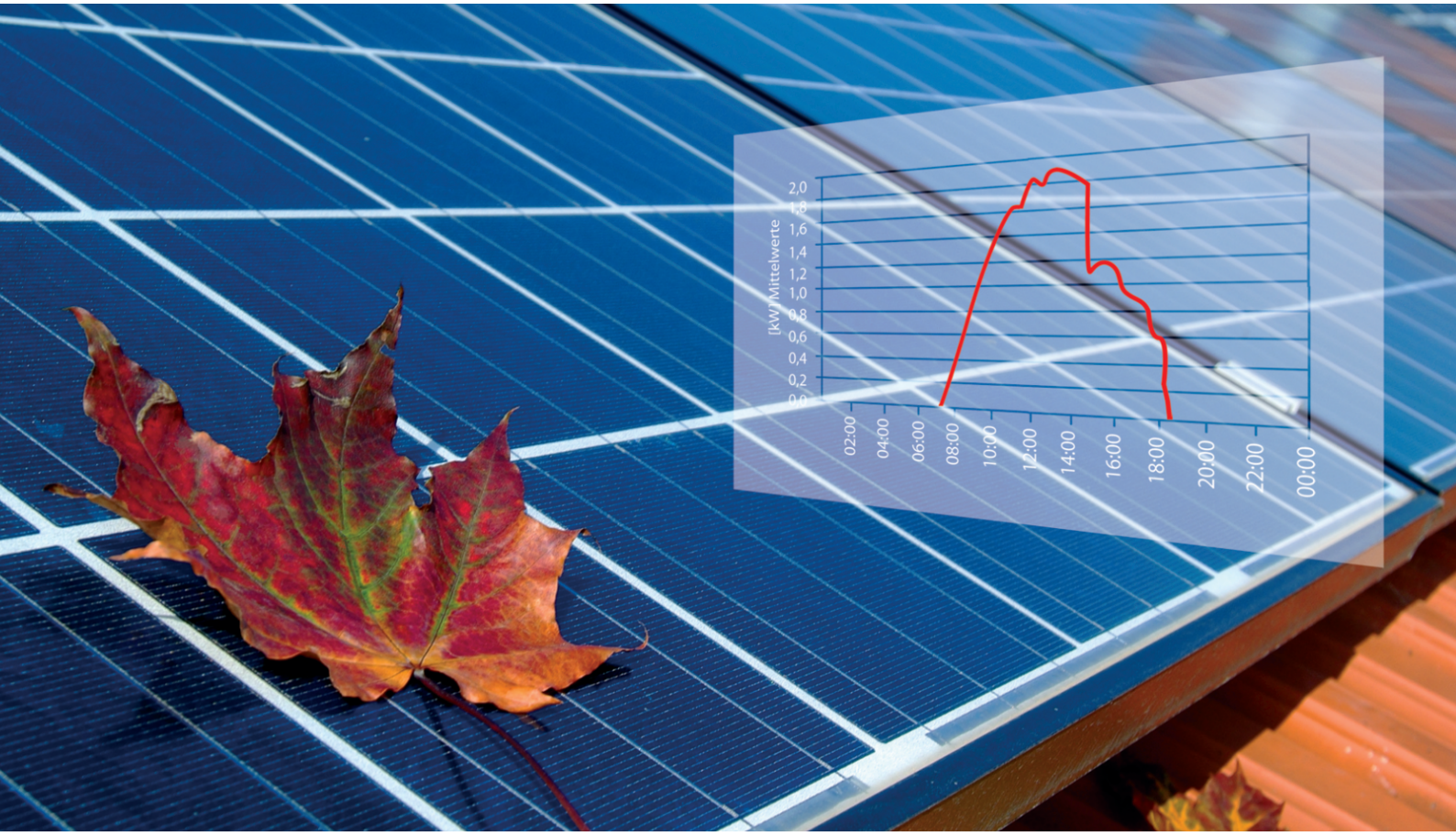
Technical Information



SUNNY BOY 3.0-6.0 / SUNNY BOY SMART ENERGY / SUNNY TRIPOWER 3.0-6.0 / SUNNY TRIPOWER 8.0-10.0 / SUNNY TRIPOWER X / SUNNY TRIPOWER CORE1 / SUNNY TRIPOWER 125

I-V and P-V diagnostics function: Using the inverter to determine the generator's characteristic curve to detect faults in PV modules

Table of Contents

1 Introduction

The inverters covered in this document have a diagnostic function for measuring the current/voltage characteristic curve (I-V characteristic curve) of the connected strings. (see Section 3, page 7).

The measurement results can be visualized both as an I-V characteristic curve and as a power/voltage characteristic curve (P-V characteristic curve). If changes or deviations from the ideal curve occur, faults in the PV modules can be detected and documented at an early stage.

This function can be used during system maintenance or fault diagnosis to extend the service portfolio of the installer through simple measures.

This technical information is for installers, system planners and interested users and describes, in addition to the basic principles, all necessary steps and requirements for using the new I-V diagnostic function.

2 Basic Information

Each PV module and each module string has a typical current and voltage characteristic, which ideally corresponds to the following graphic curve:

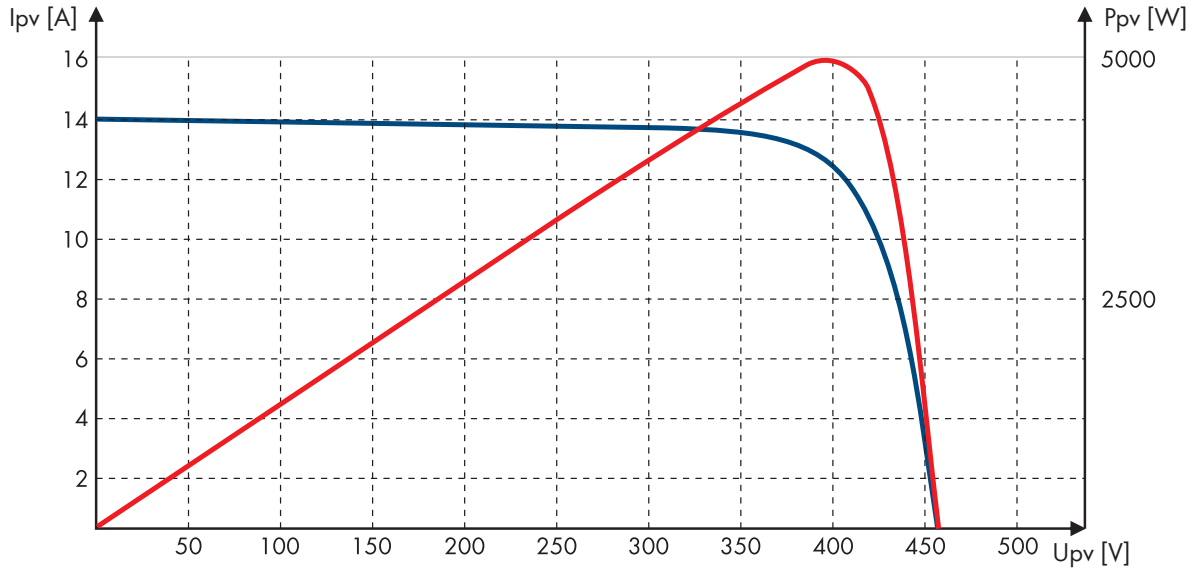


Figure 1: I-V characteristic curve (blue) and P-V characteristic curve (red)

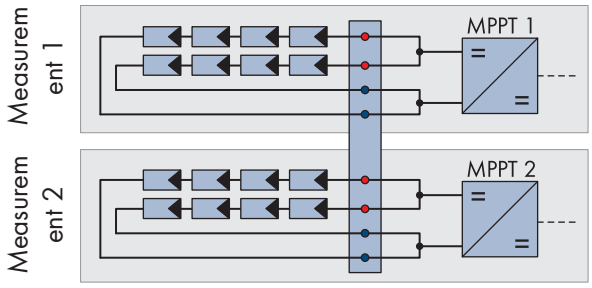
For analysis, the string is operated at different operating points and the resulting current in each case is determined at different voltages.

The characteristic curve is limited by the open-circuit voltage and short-circuit current of the PV string. The respective inverter's MPP tracker (maximum power point tracker) is used to determine the characteristic curve. The MPP tracker already has the capabilities to calculate all the necessary data.

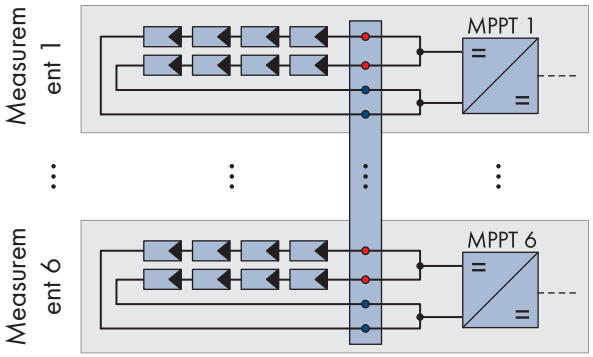
A difference to MPP operation during feed-in is a special measuring mode in which the I-V characteristic curve is measured per MPP tracker. The measurement can be performed via the local inverter user interface. This involves recording the I-V curve of the connected PV modules for each MPP tracker. The result is displayed in the user interface of the inverter as a graph and a table. The results can also be downloaded and saved as a CSV file or PDF file.

Information: The I-V measurements are taken sequentially, each with one MPP tracker respectively. All other MPP trackers will continue to operate as normal. If several strings are connected to one MPP tracker, the characteristic curve of the parallel connection will be determined.

SUNNY BOY 3.0-6.0-1AV-41



SUNNY TRIPOWER CORE1 (STP 50-41)



Based on deviations of the measured I-V curve shape from an ideal current and voltage characteristic curve or the observation of deviations of the I-V curve shape from previous measurements performed under similar ambient conditions, problems can be detected quickly and easily and investigated in more detail. This method is ideally suited for preventive checks during maintenance or fault diagnosis.

In addition to the graphic representation of the measurement results, a table is also displayed containing the most important characteristic data of the measurement.

Value	Description
Vmpp	Voltage at maximum power
Impp	Current at max. power
Pmpp	Maximum power
Voc	Open-circuit voltage
Isc	Short-circuit current
Fill factor	Characteristic value for the curve shape

The fill factor provides information about the shape of the I-V characteristic curve. The higher the fill factor, the more the shape of the characteristic curve approaches a rectangle. For crystalline PV modules, values between 0.75 and 0.82 are reached. A fill factor significantly below this value at nominal conditions indicates potential faults that may result in a yield loss.

In addition to displaying the results on the user interface of the inverter, a PDF export or CSV export can also be generated to log the measurement. At the same time, a choice can be made as to whether the I-V characteristic curve or the P-V characteristic curve is documented.

Diagnosis reports for inverters without user interface powered by ennexOS

I-V GENERATOR DIAGNOSIS REPORT

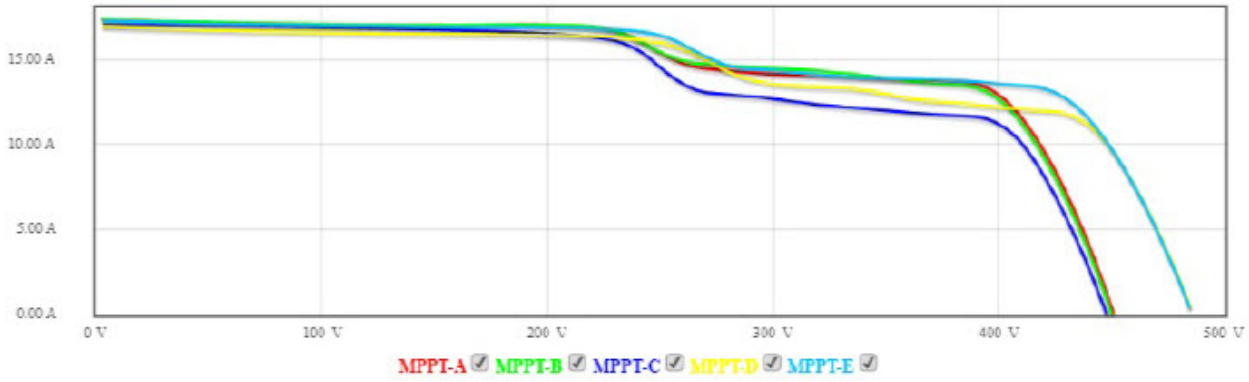
STP50-41

Serial number xxxxxx

Information Inverter

Device type	STP50-41
Device name	STP50-41
Serial number	xxxxx
Ambient temperature	-----
Irradiation	-----
Date	May xx, 2023
Time	2:59:20 PM

Overview



MPPT	Vmpp [V]	Impp [A]	Pmpp [W]	Voc [V]	Isc [A]	FF
MPPT-A	389	13.58	5284	451	17.30	0.68
MPPT-B	389	13.35	5194	450	17.32	0.67
MPPT-C	393	11.55	4539	448	17.01	0.60
MPPT-D	426	11.89	5071	485	16.94	0.62
MPPT-E	418	13.32	5574	484	17.27	0.67

Measurement performed

Company _____

Date: _____ Name _____

Disclaimer

The results of the I-V diagnostics function depend on the ambient conditions of the PV array (e.g., temperature, shading, solar irradiation) as well as the settings and the operating state of all system components. The results may only be used by qualified persons taking this information into consideration to assess the quality and the total power of the PV system.

Figure 2: Example of I-V diagnostic function STP 50-41, light shading

I-V GENERATOR DIAGNOSIS REPORT

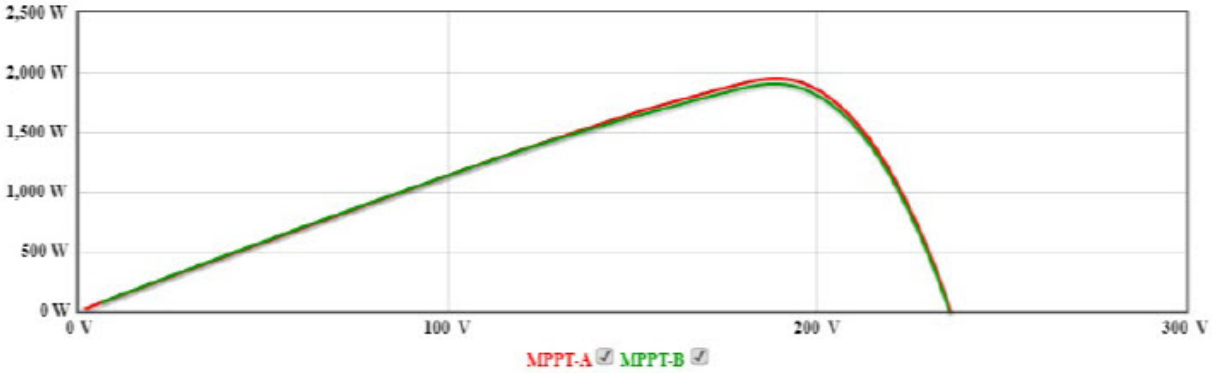
STP6.0-3AV-40

Serial number 1xxxxx

Information Inverter

Device type	SUNNY TRIPOWER 6.0
Device name	SN xxxxxxx
Serial number	xxxxxx
Ambient temperature	-----
Irradiation	-----
Date	May x, xxxx
Time	1:13:34 PM

Overview



MPPT	Vmpp [V]	Impp [A]	Pmpp [W]	Voc [V]	Isc [A]	FF
MPPT-A	189	10.30	1952	236	11.65	0.71
MPPT-B	188	10.12	1903	236	11.97	0.67

Measurement performed

Company _____

Date: _____ Name _____

Disclaimer

The results of the I-V diagnostics function depend on the ambient conditions of the PV array (e.g., temperature, shading, solar irradiation) as well as the settings and the operating state of all system components. The results may only be used by qualified persons taking this information into consideration to assess the quality and the total power of the PV system.

Figure 3: Example of P-V diagnostic function STP6.0-3AV-40

Diagnosis reports for inverters with user interface powered by ennexOS

I/V Generator Dignostic Report

Measurement information

Device name	Sunny Boy Smart Energy 5.0
Device type	SBSE5.0-50
Serial number	3021334947
Measurement time	17.07.2024, 09:49

Measurement performed

Company

Date

Name

Disclaimer

The results of the I/V diagnostic function depend on the ambient conditions of the PV array (e.g. temperature, shading, solar radiation) and the settings and operating status of all system components. The results should only be used by specialists and in consideration of this information to assess the quality and overall performance of the PV system.

I/V Generator Dignostic Report

Device name	Sunny Boy Smart Energy 5.0
Device type	SBSE5.0-50
Serial number	3021334947
Measurement time	17.7.2024, 09:49

Display DC inputs 2 / 2

DC Input A DC Input B

Tracker	Vmpp in V	Impp in A	Pmpp in W	Voc in V	Isc in A	Fill Factor
DC Input A	320	4.18	1337	386	4.49	0.77
DC Input B	352	4.13	1452	423	4.31	0.8

3 Inverter with the diagnostic function

The following table includes an overview of the inverters with the diagnostic functions. SMA Solar Technology AG will inform you about the implementation in further devices in due time.

Inverter	Device type	Firmware version with I-V diagnostic function	Firmware version with P-V diagnostic function	User interface powered by ennexOS
SUNNY BOY 3.0 / 3.6 / 4.0 / 5.0 / 6.0	SB3.0-1AV-41	Starting at 4.00.55.R	Starting at 4.01.15.R	-
	SB3.6-1AV-41			
	SB4.0-1AV-41			
	SB5.0-1AV-41			
	SB6.0-1AV-41			
Sunny Boy Smart Energy 3.6 / 4.0 / 5.0 / 6.0	SBSE3.6-50	Starting at 3.8.12.R	-	✓
	SBSE4.0-50			
	SBSE5.0-50			
	SBSE6.0-50			
Sunny Boy Smart Energy 8.0 / 9.9	SBSE8.0-50	As of production start	-	✓
	SBSE9.9-50			

Inverter	Device type	Firmware version with I-V diagnostic function	Firmware version with P-V diagnostic function	User interface powered by enexOS
Sunny Boy Smart Energy-US 3.8 / 4.8 / 5.8 / 7.7	SBSE3.8-US-50	Starting at 3.8.12.R	-	✓
	SBSE4.8-US-50			
	SBSE5.8-US-50			
	SBSE7.7-US-50			
Sunny Boy Smart Energy-US 9.6 / 11.5	SBSE9.6-US-50	As of production start	-	✓
	SBSE11.5-US-50			
Sunny Tripower 3.0 / 4.0 / 5.0 / 6.0	STP3.0-3AV-40	Starting at 4.00.06.R	Starting at 4.00.54.R	-
	STP4.0-3AV-40			
	STP5.0-3AV-40			
	STP6.0-3AV-40			
Sunny Tripower 8.0 / 10.0	STP8.0-3AV-40	Starting at 4.00.06.R	Starting at 4.00.54.R	-
	STP10.0-3AV-40			
Sunny Tripower X	STP 12-50	Starting at 3.06.15.R	-	✓
	STP 15-50			
	STP 20-50			
	STP 25-50			
Sunny Tripower CORE1	STP 50-41	Starting at 3.12.21.R	> 4.06.08.R	-
Sunny Tripower CORE1-US	STP 33 / 50 / 62-US-41	Starting at 3.12.21.R	> 4.06.08.R	-
Sunny Tripower 125	STP 125-70	Starting at 4.00.48.R	Starting at 4.00.48.R	-

During the measurement, the inverter can briefly interrupt the feed-in or feed in with reduced power. The duration of a measurement is approx. 20 seconds per MPP tracker. To avoid a malfunction and thus yield loss, the measurement can be carried out a maximum of 10 times per day. If more than 10 measurements per day are to be carried out, the inverter must be restarted.

The measuring curve has over 200 measuring points. The display is from 0 V up to the maximum MPP voltage of the inverter. The current is limited by the maximum useable input current of the inverter.

The data is displayed on the user interface and remains there until the next measurement. It is also possible to export the data as a PDF report and in CSV format.

4 Information on measurements

Requirements:

☐ In the case of comparative measurements (e.g. at annual intervals), similar ambient conditions (solar irradiation, shading, temperature) should prevail.

CORE1:

If the Sunny Tripower CORE1 is equipped with the sensor module (optional accessory MD.SEN-40) and the connection of corresponding sensors, the current temperature and solar irradiation are also displayed on the user interface and the report.

Operation with module electronics (MLPE: Module Level Power Electronics):

The measurement is also suitable for operation with so-called SunSpec-compatible module disconnectors (e.g. JMS-F).

However, these systems can only be implemented with special inverters, which have currently been developed exclusively for the US market. For example the STP 33/50/62-US-41. In this application, the inverters are in a special operating mode: **SunSpec Rapid Shutdown**

In this operating mode, the I-V curve is not displayed from 0 V, but only from a device-typical limit voltage. For CORE1, for example, this is 230 V. At lower voltages, there is no measurement or display of the I-V curve.

Operation with optimizers

I-V measurement with so-called optimizers (e.g., module optimizers) is possible, but does not lead to useful measurement results.

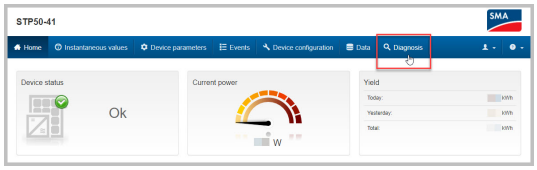
5 Generating characteristic curves

5.1 Inverters without user interface powered by ennexOS

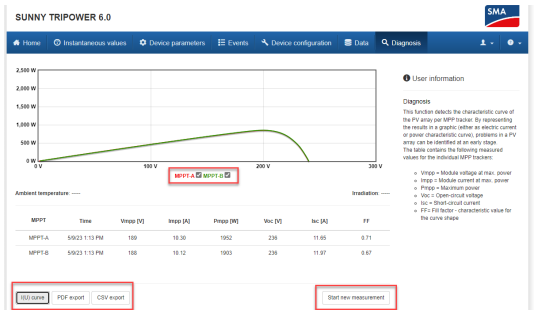
The function for switching between I-V and P-V representation is not available for all inverters.

- Note the firmware version of your inverter.

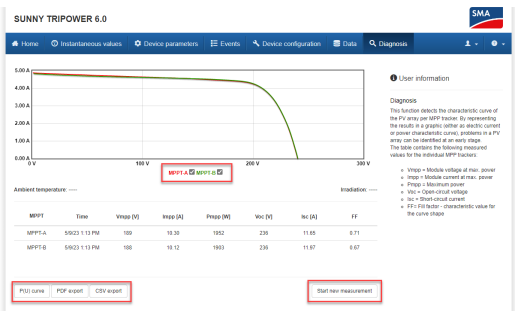
1. Log on to the user interface of the inverter.
2. Click on **[Diagnosis]** in the menu.



3. If necessary, select or deselect the desired MPP tracker.

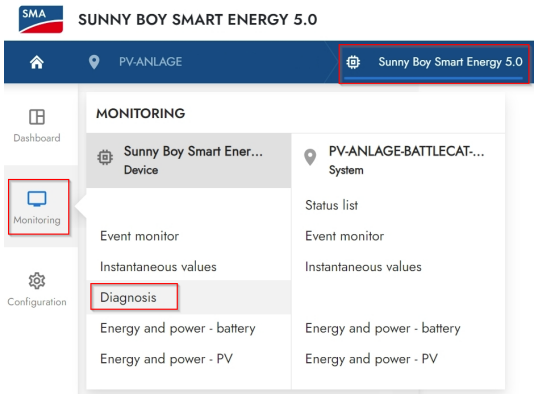


4. Click on **[Start new measurement]**.
5. Click on **[PDF export]** or **[CSV export]** to export the data shown.
6. Alternatively, start the procedure for the P-V characteristic curve.

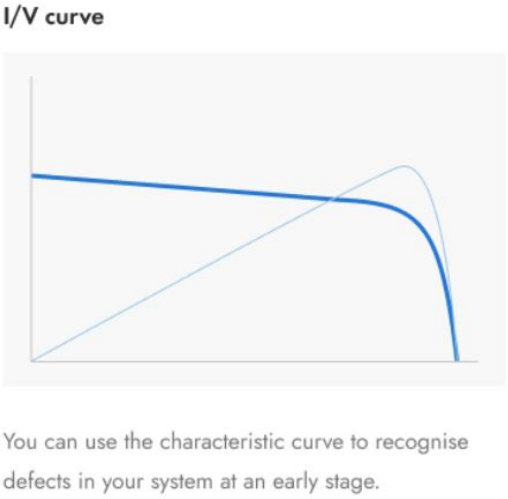


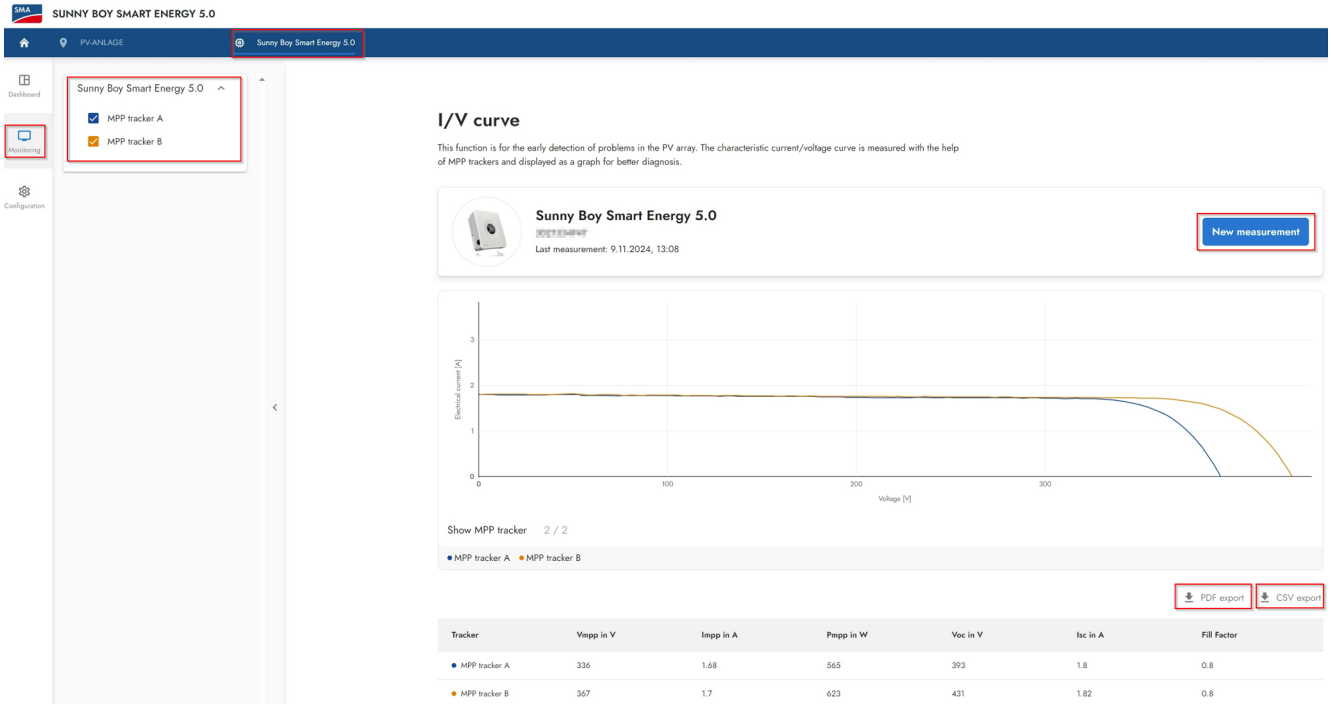
5.2 Inverters with user interface powered by ennexOS

1. Log on to the user interface of the inverter.
2. Select the inverter via the focus navigation.



3. Select the **Monitoring** menu.
4. Select the menu item **Diagnosis**.
5. Select **I-V curve**.

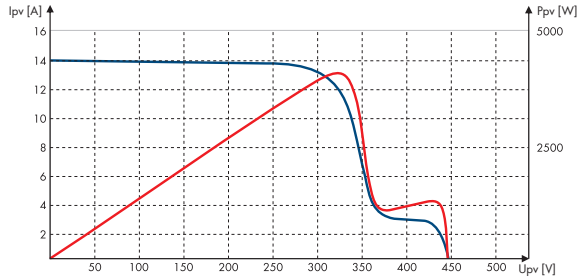
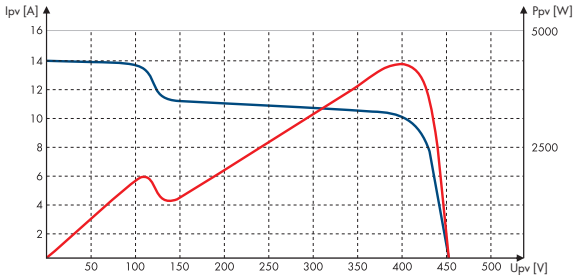
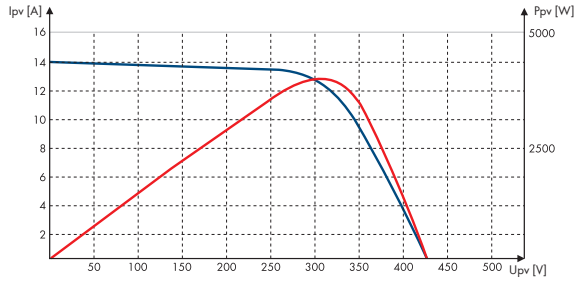
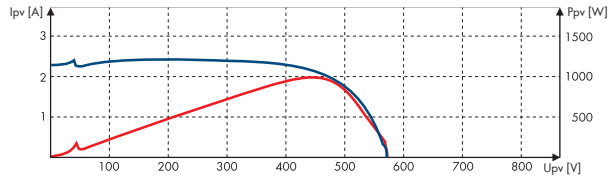




6. Select [**New measurement**].
7. Click on **[PDF export]** or **[CSV export]** to export the data shown.

6 Interpretation of deviations of the characteristic curves

The following graphs show a deviating curve.

Curve shape	Description
	Here, strong shading of a small section of the PV modules may be the cause. The current drops very sharply, the "kink" is at high voltage.
	Here, weak shading of a large section of the PV modules may be the cause. The current drops just a little, the "kink" is at low voltage. This characteristic curve may indicate foliage and dirt on the lower edge of the module.
	The characteristic curve with a flat slope (low fill factor) may indicate a problem with the PV modules (e.g., PID). SMA Solar Technology AG recommends contacting an installer to do a more detailed analysis.
	If the measurement is performed at a power < 50%, inaccuracies may occur at the beginning or at the end of the recorded I-V curve. To avoid these inaccuracies, a measurement should always be carried out at a power > 50%.

7 Event messages

7.1 Event 10102

Display text:

Parameter |In04| set successfully

Description:

This message is issued at the beginning of a measurement.

7.2 Event 10431

Event message:

- **I-V curve measurement was successful**

Explanation:

This message is issued at the end of a measurement.

8 Frequently Asked Questions

8.1 Can the measurement prove the quality of the installation?

The results of the diagnostics functions depend on the ambient conditions of the PV modules (e.g., temperature, shading, solar irradiation) as well as the settings and the operating state of all system components. The results may only be used by qualified persons taking this information into consideration to assess the quality and the total power of the PV system. The results therefore provide only circumstantial evidence.

8.2 Can the measurement be activated with the Data Manager or Sunny Portal?

Currently, the procedure is only supported on the user interface of the inverter. SMA Solar Technology AG is already working on solutions for using the procedure for the Sunny Portal or the data manager.

8.3 What effects does a measurement have on the feed-in?

The feed-in is briefly interrupted at the beginning of the curve measurements per MPP tracker. During the measuring process, the feed-in power is reduced slightly.

8.4 What happens if the power is too low during the measurement?

In this case, the relative fault can become so large that it is no longer possible to make a meaningful interpretation.