Technical Information

SUNNY TRIPOWER CORE1-US (STP 33-US-41 / STP 50-US-41 / STP 62-US-41)

I-V Curve Diagnostic Function

ENGLISH

Table of Contents

1 Introduction

Sunny Tripower CORE1 (STP 33/50/62-US-41) inverters provide a diagnostic function to measure the current and voltage characteristics (I-V characteristic curve) of the connected PV array strings. Results of the I-V curve measurements can be saved to PDF and exported for documentation purposes.

The I-V curve diagnostic function can be used to measure and document I-V curve characteristics during system commissioning or during periodic service and maintenance operations. Deviations or changes in I-V curves can be an indication of installaton errors, faults or damage within the PV array that could adversely affect energy production of the PV system.

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:

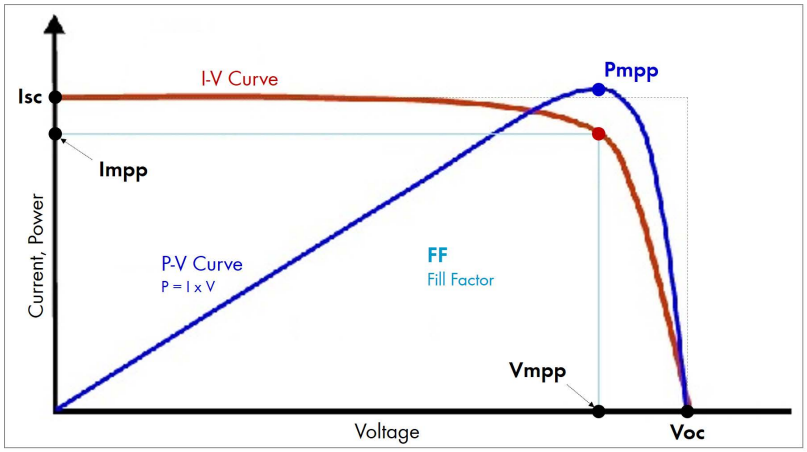


Figure 1: Typical I-V curve (in red) of a PV module or string [Corresponding power curve (in blue) also shown for illustrative purposes.]

During I-V curve measurement the PV string is operated at different voltages and the resulting current is measured. The resulting I-V curve is bounded by the open-circuit voltage and short-circuit current of the PV string.

Taking I-V curve measurements in PV systems has typically been a time consuming and labor intensive process requiring expensive specialized measurement devices. PV inverters perform maximum power point tracking (MPPT) to determine the optimum voltage operating point to maximize energy harvest from the PV array. This MPPT functionality is well suited to taking I-V curve measurements during inverter operation. Using an inverter's inherent MPPT capabilities to perform I-V curve measurements provides several advantages over traditional I-V curve measurement procedures.

Traditional I-V Curve Measurement	Inverter Integrated I-V Curve Measurement
Time consuming and labor intensive	Quick on-demand measurements initiated from inverter user interface
Requires expensive specialized measurement devices	No additonal measurement devices required
Requires partial dis-assembly / re-assembly of PV electrical system	No dis-assembly of PV electrical system required
Significant interruption in system operation and energy production	Minimal interruption of system operation and energy production
Potential introduction of installation errors or faults due to dis-assembly / re-assembly for measurement	Results represent PV array I-V characteristics in a fully assembled and operational condition

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

3 I-V Curve Measurements with Sunny Tripower CORE1

Refer to the following table to determine if the I-V curve diagnostic function is available for your specific SMA inverter model.

Inverter	Type designation	Firmware version
Sunny Tripower CORE1-US	STP 33/50/62-US-41	03.12.21.R or later
Sunny Tripower CORE1-US	STP 50-US-40	Not available

Sunny Tripower CORE1 inverters measure the I-V curve of each MPPT input. If more than one string is connected to an MPPT input, the resulting I-V curve represents the electrical characteristics of those strings connected in parallel.

Measured current is limited to the maximum input current rating per MPPT of the inverter.

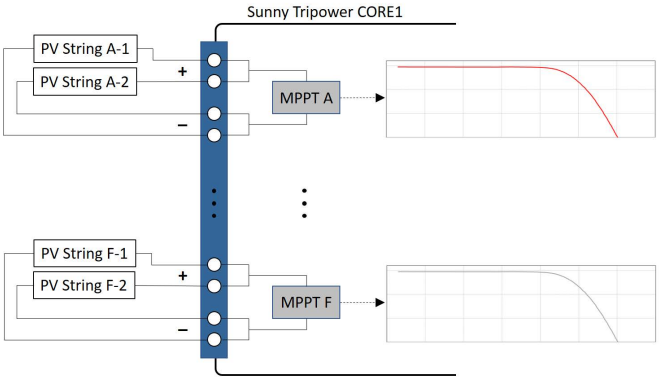


Figure 2: Parallel connection of PV strings per MPPT input

During I-V curve measurement, the inverter will briefly interrupt power production and run with reduced power. The duration to complete measurements is approximately 20 seconds per MPPT input. To avoid misuse of the function and excessive yield loss, I-V curve measurements can be carried out a maximum of 10 times per day. If it is necessary to carry out more than 10 measurements per day, the inverter must be restarted.

The measured I-V curve has over 200 data points for each MPPT input. The data from the most recent measurement is stored in the inverter and displayed on the user interface until the next measurement.

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

Measurement with SunSpec Rapid Shutdown Devices

I-V curve measurements may be taken for PV strings with compatible SunSpec-compliant module-level rapid shutdown devices. A list of compatible rapid shutdown devices is provided in SMA document *SunSpec-Kompatibilitaet-TI*. For operation with these devices the inverter must be set to Rapid Shutdown Mode **SunSpec shutdown**. In this operating mode, I-V measurements are taken starting from a device-typical minimum voltage level of 230 VDC up to open circuit voltage. Below 230 VDC, measurements are not taken and the I-V curve will not be displayed.

Measurement with Module-Level Power Electronics (MLPE)

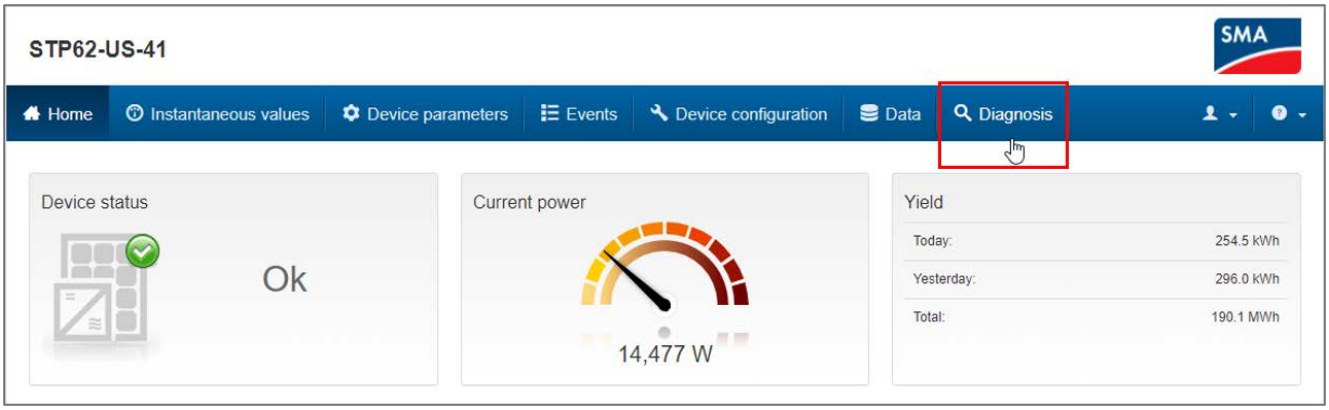
For PV arrays with module-level power electronics (MLPE), such as module optimizers, I-V curve measurements can be initiated but the results will not be meaningful. Contact the MLPE supplier for support on measuring the electrical characteristics of PV strings with their MLPE devices.

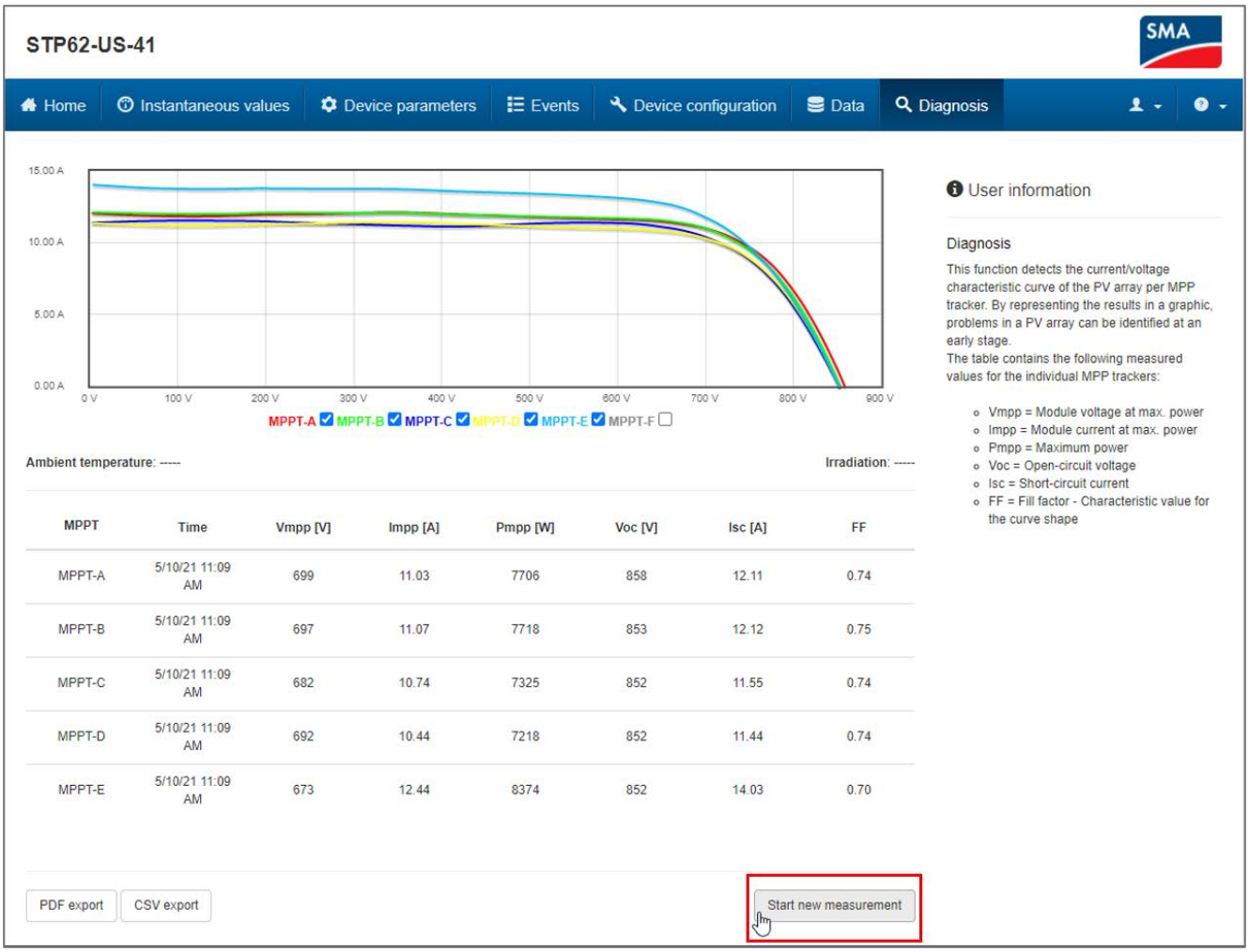
Conditions for I-V curve measurements:

- ☐ To avoid inaccuracies in the measured I-V curves, measurements should be carried out when there is sufficient irradiation such that the PV array is producing at least 50 % of nominal power.
- ☐ For comparative measurements (e.g. at annual intervals), similar ambient conditions (solar irradiation, shading, temperature) should prevail.

Procedure for initiating I-V measurements:

1. Log in to the user interface of the inverter.
2. Click on **Diagnosis** in the menu.
   - The results from the most recent measurement, if any, will be displayed.
3. Click on [**Start new measurement**].
   - The user interface will be paused while the inverter performs the I-V curve measurements.
   - When finished, results from the requested measurement will be shown.
4. With the results displayed, individual MPPT inputs can be selected / de-selected for display. For example, inputs without any PV strings connected can be de-selected.



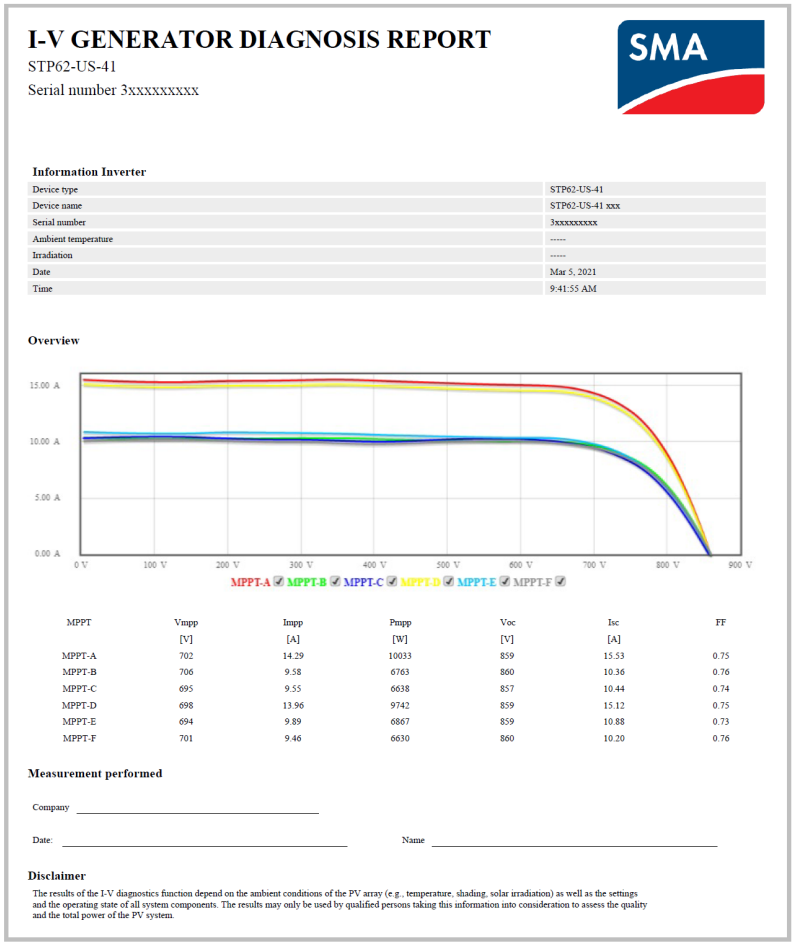


Below the chart displaying the I-V curves, a table is displayed containing the critical data values of the I-V curve for each MPPT input.

Value	Description
Vmpp [V]	Maximum power voltage
Impp [A]	Maximum power current
Pmpp [W]	Maximum power
Voc [V]	Open-circuit voltage
Isc [A]	Short-circuit current
FF - Fill factor	Characteristic value for the curve shape

A PDF report and CSV file can be generated to save the measurement results by clicking on **[PDF export]** or **[CSV export]**.

In addition to the critical data points shown in the user interface and PDF report, the CSV file contains all measured data points for each MPPT input.



I-V GENERATOR DIAGNOSIS REPORT

STP62-US-41

Serial number 3xxxxxxxxx

Information Inverter

Device type	STP62-US-41
Device name	STP62-US-41 xxx
Serial number	3xxxxxxxxx
Ambient temperature	-----
Irradiation	-----
Date	Mar 5, 2021
Time	9:41:55 AM

Overview

MPPT	Vmpp [V]	Impp [A]	Pmpp [W]	Voc [V]	Isc [A]	FF
MPPT-A	702	14.29	10033	859	15.53	0.75
MPPT-B	706	9.58	6763	860	10.36	0.76
MPPT-C	695	9.55	6638	857	10.44	0.74
MPPT-D	698	13.96	9742	859	15.12	0.75
MPPT-E	694	9.89	6867	859	10.88	0.73
MPPT-F	701	9.46	6630	860	10.20	0.76

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.

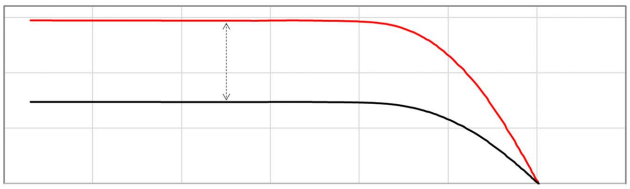
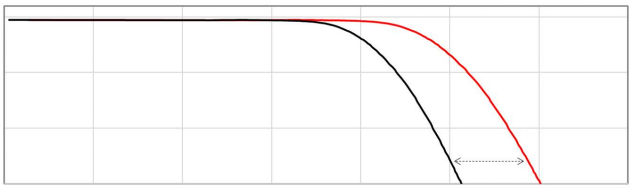
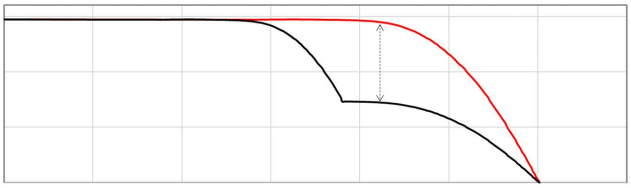
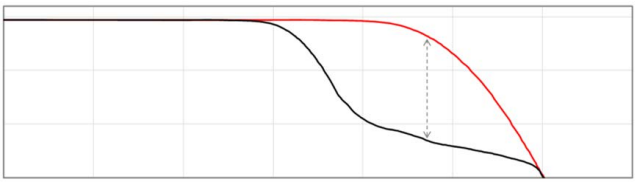
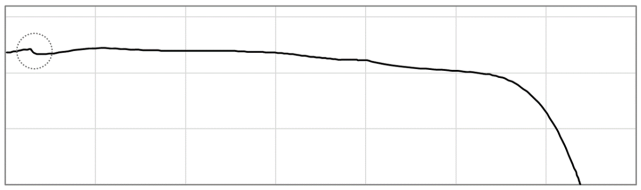
4 Event Messages

The following events can occur during the measurement process:

Event number	Display text	Description
10431	I-V curve measurement successfully carried out	This message is issued at the end of a measurement

5 Interpretation of I-V curve measurement results

The examples below show I-V curves resulting from typical conditions that can affect PV system performance. Since an exact conclusion on the cause of an I-V curve deviation cannot be determined from the I-V curve alone, SMA Solar Technology AG recommends inspection of the PV array by qualified persons in case of deviations in the curve.

Curve shape	Description
	**Different number of strings per MPPT input** I-V curves for MPPT inputs with different number of strings connected to each. This may be as intended according to the system design.
	**Different number of modules per string** I-V curves for MPPT inputs with different number of modules per string. This may be as intended according to the system design.
	**Partial shading** I-V curve of string affected by shading on one or more modules.
	**Damaged module** I-V curve showing the possible affect of one or more modules with broken glass.
	**Measurement at low power** I-V curve showing inaccuracies at low and high end of curve that can occur when measurements are taken at low power (low irradiance).

6 Frequently Asked Questions

Can I-V curve measurements be initiated from the SMA Data Manager M or Sunny Portal?

No. Currently I-V curve measurements can only be initiated from the inverter user interface (WebUI).

What effects does a measurement have on power production?

Power production is briefly interrupted at the beginning of the curve measurements for each MPP tracker. During the measuring process, the power production is reduced slightly. The duration to complete measurements is approximately 20 seconds per MPPT input.

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

At low power (low irradiance) measurement inaccuracies can occur at the lower and upper end of the I-V curve. To avoid inaccuracies in the measured I-V curves, measurements should be carried out when there is sufficient irradiation such that the PV array is producing at least 50 % of nominal power.

Can the measurement prove the quality of the installation?

The results of the I-V curve measurements depend on the ambient conditions of the PV array (e.g. temperature, solar irradiation, shading) as well as the settings and operating state of all system components. The results may be used by qualified persons as an indication of the quality of installation and condition of the PV system. The results by themselves, however, should not be interpreted as conclusive evidence of an installation error or system fault.

What is fill factor (FF)?

Fill factor is a measure of the efficiency of the PV modules in a string. It is calculated as the maximum power divided by open circuit voltage and short circuit current (Pmpp / (Voc * Isc)). The higher the fill factor, the more the shape of the I-V curve approaches a rectangle. The fill factor should be compared to the fill factor specified on the PV module datasheet and to the fill factor measured on other PV strings with the same module type. A fill factor that is significantly below the specification in the PV module datasheet at nominal conditions may indicate faults or other conditions that can lead to yield loss.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