SmartPVMS Smart I-V Curve Diagnosis

User Manual

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About This Document

Purpose

This document describes the Smart I-V Curve Diagnosis function of the Smart PV Management System (SmartPVMS), and provides solutions to common faults.

Intended Audience

This document is intended for photovoltaic (PV) plant operating personnel and qualified electricians.

Symbol Conventions

The symbols that may be found in this document are defined as follows.

Symbol	Remarks
⚠ DANGER	Indicates a hazard with a high level of risk which, if not avoided, will result in death or serious injury.
⚠ WARNING	Indicates a hazard with a medium level of risk which, if not avoided, could result in death or serious injury.
⚠ CAUTION	Indicates a hazard with a low level of risk which, if not avoided, could result in minor or moderate injury.
NOTICE	Indicates a potentially hazardous situation which, if not avoided, could result in equipment damage, data loss, performance deterioration, or unanticipated results. NOTICE is used to address practices not related to personal injury.

Symbol	Remarks
☐ NOTE	Supplements the important information in the main text.
	NOTE is used to address information not related to personal injury, equipment damage, and environment deterioration.

Change History

Changes between document issues are cumulative. The latest document issue contains all updates made in previous issues.

Issue 01 (2021-08-20)

This issue is used for first office application (FOA).

Contents

1 Function Description

Functions

Smart I-V Curve Diagnosis allows Huawei inverters to scan PV strings and generate an I-V curve, which is then analyzed simultaneously in the Smart PV Management System (SmartPVMS) to diagnose PV strings and generate alarms for faulty PV modules.

A large number of PV plant statistics show that PV module quality and faults are important factors that affect energy yields. As the PV industry is becoming mature, how to identify faulty PV modules in a convenient and efficient way and how to take appropriate measures to rectify faults are the key to increasing energy yields and decreasing investment risks, and are also the development trend of operation and maintenance (O&M).

Smart I-V Curve Diagnosis helps scan and diagnose the PV strings connected to an inverter or in an entire PV plant to detect faults and risks and ensure plant safety. In addition, the operation wizard makes O&M easier and faster.

Features

- Promptly detecting faults and risks of PV modules
  - All PV modules in a PV plant are scanned periodically through annual inspection, which helps promptly detect faulty PV modules. Timely processing of faulty PV modules helps improve energy yields and prevents faults from escalating.
  - PV strings are scanned in real time for any output exceptions to detect faults and risks.
  - SmartPVMS analyzes the data simultaneously, which has little impact on energy yields and ensures high reliability.
- Improving the O&M efficiency
  - Wizard-based remote operation is supported.
  - I-V curves are analyzed automatically.
  - Reports are generated automatically.
  - Rectification suggestions are provided for located faults to improve O&M quality and efficiency.

Key Performance Indicator

- Huawei inverter I-V scanning duration (string open circuit to short circuit) < 1s
- Huawei inverter I-V scanning resolution: 128 data points
- Huawei inverter I-V scanning voltage precision: 0.5%
- Huawei inverter I-V scanning current precision: 0.5%
- Scanning of a single inverter does not require the inverter to be shut down, so energy yields will barely be affected.

2 Smart I-V Curve Diagnosis License Management

2.1 License Description

Description

Smart I-V Curve Diagnosis can be used only after a license is purchased. The license file for Smart I-V Curve Diagnosis is stored in a Huawei inverter. The inverter SN uniquely maps to the license.

The license for Smart I-V Curve Diagnosis is a fixed-term license. When the license goes beyond **License Deadline**, the system provides a warning asking the customer to replace it with a new license.

The license can still be used for 60 days (grace period) after the **License Deadline**. After the **Grace period** expires, the Smart I-V Curve Diagnosis function will be disabled.

NOTICE

- The SmartPVMS can be used to manage licenses for all inverters in multiple PV plants.
- The SmartLogger can be used to manage licenses for all inverters in a PV array.
- The FusionSolar app or SUN2000 app can be used to manage the license for a single Huawei commercial inverter.

License Application Procedure

1. The customer exports a license application file and sends it to a technical service engineer.
2. The technical service engineer transfers the obtained license file to the customer.

3. The customer imports and loads the license file to an inverter, thereby obtaining the permission to use the Smart I-V Curve Diagnosis function.

2.2 License Management on the SmartPVMS.

Prerequisites

- You have logged in to the SmartPVMS as an installer.
- You have created a PV plant and added devices to the PV plant. The devices are running properly.

📖 NOTE

The software version corresponding to the user interface (UI) snapshots in this section is SmartPVMS V500R007C00CP1308. The UIs could vary with software versions and are for reference only.

Procedure

Step 1 Choose **Plants** > **Device License Management**.

Figure 2-1 Device license management
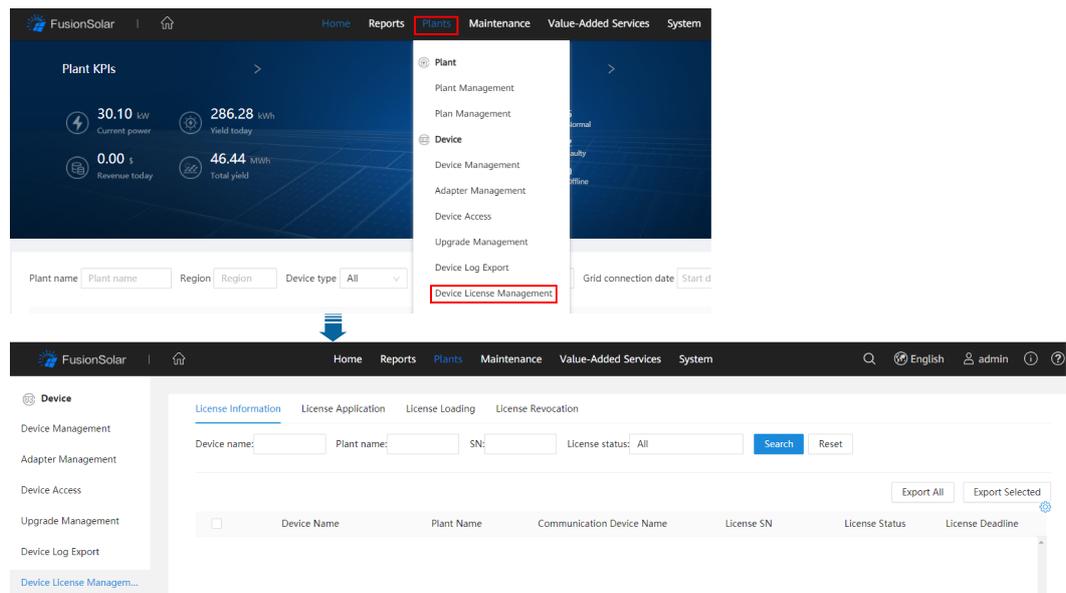
Step 2 Perform operations according to **Table 2-1**.

Table 2-1 Operations related to license management

Task Name	Task Description	Procedure
Viewing license information	For routine O&M, the license validity and function usage are queried routinely to check whether the license is about to expire and solve the problems in a time manner. In this way, the device can function properly.	1. Click **License Information** tab to view the license information about the target device. 2. Click **Export All** or select the target device (multiple devices can be selected) and click **Export Selected**, and save the license information to the PC.
Exporting the license application file	The license application file contains the content required for applying the device license. Export the license application file to apply for a new device license if the license has expired.	1. Click the **License Application** tab and export the license application file. 2. Click **Export All** or select the target device (multiple devices can be selected) and click Export Selected, and save the license information to the PC.
Loading a device license	If the license has not been loaded for the device or the license is about to expire, you need to load a new license file to the device so that the device functions properly.	1. Click the **License Loading** tab. 2. Click **Upload License**. Select the license to be uploaded and click **Upload**. 3. Click **Load All**, or select the target device (multiple devices can be selected) and click **Load Selected** 4. (Optional) To stop license loading, click **Stop Loading** NOTE A license file uniquely maps to a device SN. The license can be successfully loaded only if the license file uniquely maps to the device SN.

Task Name	Task Description	Procedure
Revoking a license	Before a device is replaced, the current device license needs to be revoked so that the revocation code can be generated and used for applying for a new device license. After the device is replaced, you can load the new license file to the device, and then the device functions properly.	1. Select the **License Revocation** tab. 2. Select the target device (multiple devices can be selected) and click **Revoke License** 3. Enter the user password and click **OK**. 4. Click **Export All Revocation Codes** or select the target device (multiple devices can be selected) and click **Export Selected Revocation Code**. **NOTE** If you export revocation codes of devices whose **License Status** is **Normal**, the following message is displayed: The license revocation code cannot be exported because the license is not in revocation state.

----End

2.3 License Management Through the SmartLogger

Prerequisites

- You have logged in to the SmartLogger WebUI.
- Devices have been added to the SmartLogger and operate normally.
- You have logged in as an advanced user, a special user, or the admin user.

  ☐ NOTE

  The software version corresponding to the user interface (UI) snapshots in this section is SmartLogger3000 V300R001C00SPC060. The UIs could vary with software versions and are for reference only.

Procedure

Step 1 Choose **Maintenance** > **License Management** on the main menu.

Figure 2-2 License management
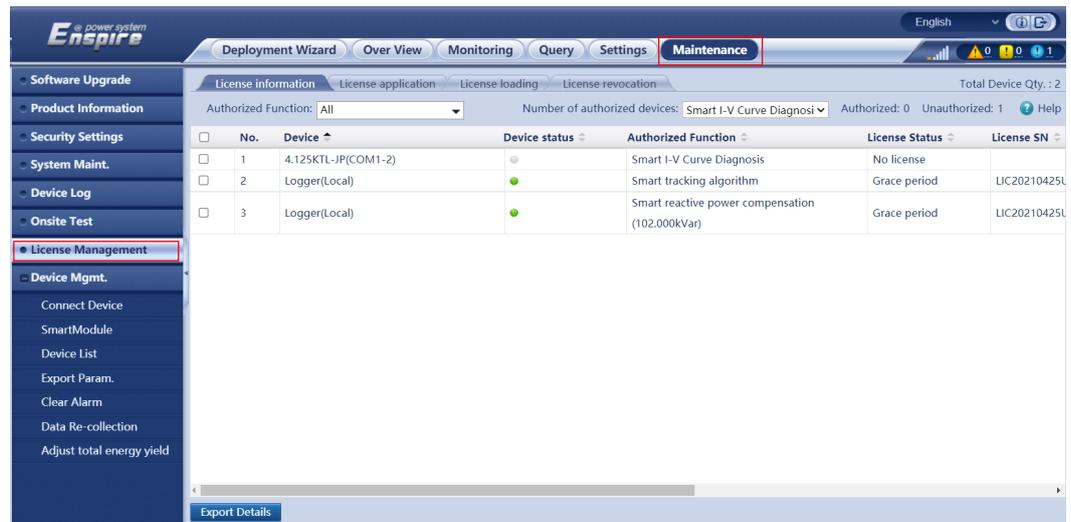
Step 2   Perform operations according to **Table 2-2**.

Table 2-2 Operations related to license management

Task Name	Task Description	Procedure
Querying license information	For routine O&M, the license validity and function usage are queried routinely to check whether the license is about to expire and solve the problems in a time manner. In this way, the device can function properly.	1. Choose **License information** to view the license information about the target device. 2. Select the target device and click **Export Details** to save the license information about the target device to the PC.
Exporting the license application file	The license application file contains the content required for applying the device license. Export the license application file to apply for a new device license if the license has expired.	1. Choose **License application**. 2. Select the target device (multiple devices can be selected) and click **Export License Appli File**.

Task Name	Task Description	Procedure
Loading a device license	If the license has not been imported for the device or the license is about to expire, you need to import the new license file to the device, ensuring that the device functions properly.	1. Choose **License loading**. 2. Click **Upload License** and select the license file to be imported. 3. Select the target device (multiple devices can be selected) and click **Load License** to load the device license. **NOTE** A license file uniquely maps to a device SN. The license can be successfully loaded only if the license file uniquely maps to the device SN.
Revoking a license	Before a device is replaced, the current device license needs to be revoked so that the revocation code can be generated and used for applying for a new device license. After the device is replaced, you can import the new license file to the device, and then the device functions properly.	1. Click **License revocation**. 2. Select the target device (multiple devices can be selected) whose license needs to be revoked. 3. Click **Revoke License**. 4. Enter the user password and click **Submit**. 5. Click **Export Revo Code File**. **NOTE** If you export revocation codes of devices whose **License Status** is **Normal**, the system will prompt you to re-select devices.

----End

2.4 License Management on the FusionSolar App or SUN2000 App

Prerequisites

- The solar inverter has been connected to the mobile phone installed with the FusionSolar app or SUN2000 app.

- You have logged in to the app as an advanced user or an installer user.

- The FusionSolar app or SUN2000 app can be used to manage the license for a single inverter at a time.

☐ NOTE

The software version corresponding to the user interface (UI) snapshots in this section is FusionSolar 5.7.011 and SUN2000 3.2.00.014. The UIs could vary with software versions and are for reference only.

Procedure

Step 1 Choose **Maintenance** > **License management** on the main menu.

Step 2 Tap in the upper right corner of the screen.

Figure 2-3 License management
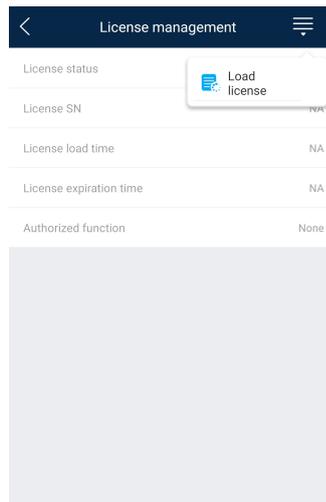
Step 3 Tap **Load license**.

Step 4 Select the license file to be loaded and confirm the loading.

----End

Follow-up Procedure

Before a device is replaced, the current device license needs to be revoked so that the revocation code can be generated and used for applying for a new device license.

Step 1 Tap **Revoke license**.

Figure 2-4 Revoke license
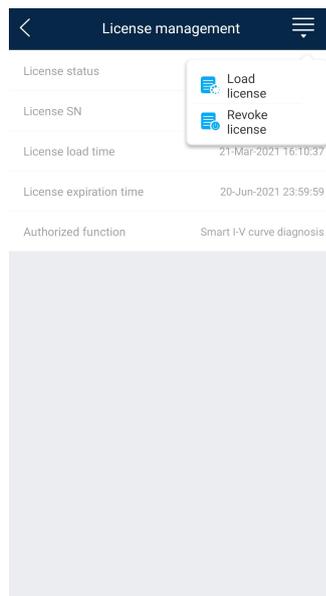
Step 2   Tap **Export revocation code**.

----End

3 Smart I-V Curve Diagnosis

3.1 Smart I-V Curve Diagnosis on the SmartPVMS

Prerequisites

- You have logged in to the SmartPVMS as an installer.
- The Smart I-V Curve Diagnosis license has been loaded and is valid.

  📖 **NOTE**

  The software version corresponding to the user interface (UI) snapshots in this section is SmartPVMS V500R007C00CP1308. The UIs could vary with software versions and are for reference only.

Setting the String Capacity

Step 1 Choose **Maintenance** > **Smart Diagnosis**.

Figure 3-1 Smart diagnosis

Step 2 Choose **I-V Curve** > **Configure Strings**.

Figure 3-2 String management
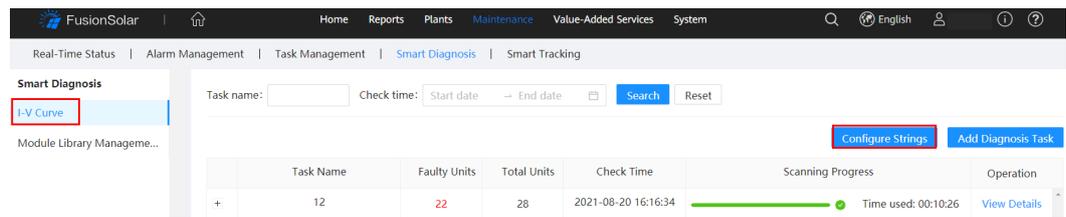
Step 3 (Optional) Set filter criteria such as Task name and Check time, and click **Search**. The device list that meets the search criteria is displayed.

Step 4 Select the target device (multiple devices can be selected) and click **Configure String Details**.

📖 NOTE

You can select and configure devices of the same type in batches. A maximum of 400 devices can be configured at a time.

Figure 3-3 Configure string details
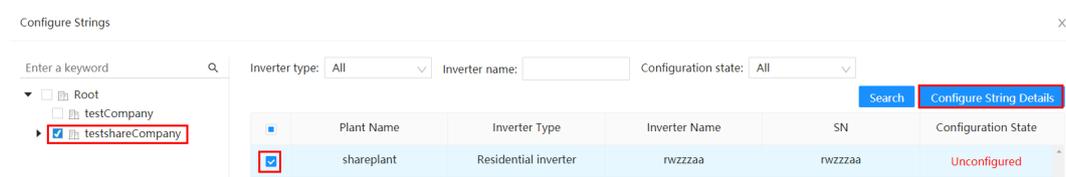
Step 5 Configure the parameters.

📖 NOTE

- String capacity = Rated power of a PV module x Number of PV modules in a PV string
- Click **Parameter Description** to view parameter details.

Figure 3-4 Configuring the parameters
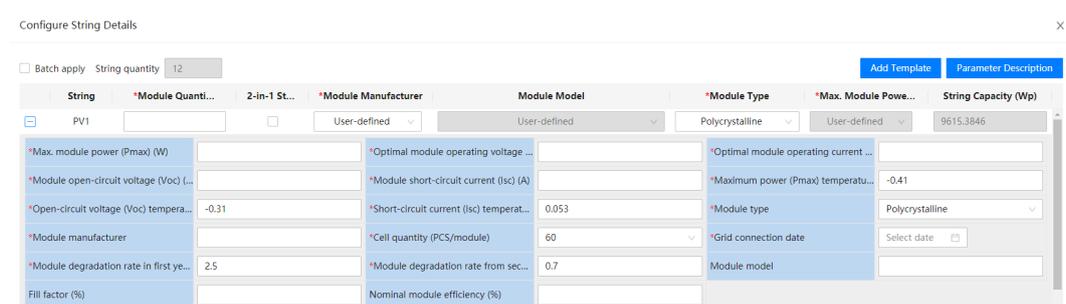
----End

Set the Smart I-V Curve Diagnosis Task.

Step 1 On the **Smart Diagnosis** page, click **Add Diagnosis Task** and set task parameters.

NOTICE

Read the I-V Curve Diagnosis **Operation Suggestions** carefully and ensure that the conditions are met before setting parameters.

Figure 3-5 Setting diagnosis task parameters
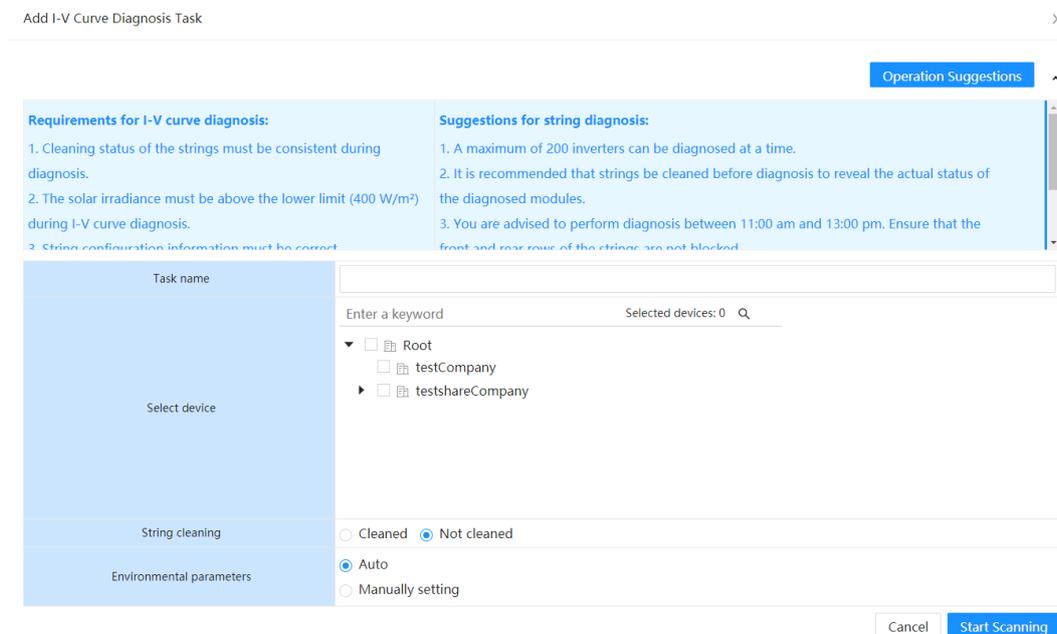
Table 3-1 Diagnosis task parameters

Parameter	Description
Task name	Enter a task name.
Select device	Inverter-Level Health Check: Checks the health status of PV strings connected to the inverter.
String cleaning	Choose **Cleaned** or **Not Cleaned** according to the actual conditions.
Environmental parameters	• Auto: The system automatically calculates **PV module plane** and **Module back surface temperature**. • Manually setting: Manually enter the values of **PV module plane** (The recommended value is greater than or equal to 400 W/㎡) and **Module back surface temperature** (The recommended value is 25°C).

Step 2 Click **Start Scanning**.

📖 **NOTE**

If an error message dialog box is displayed when you attempt to start the diagnosis, rectify the fault and then start the diagnosis.

----End

View Diagnosis Results.

Step 1 On the **Smart Diagnosis** page, locate the target task and click **View Details** in the **Operation** column.

Figure 3-6 Viewing the diagnosis task status
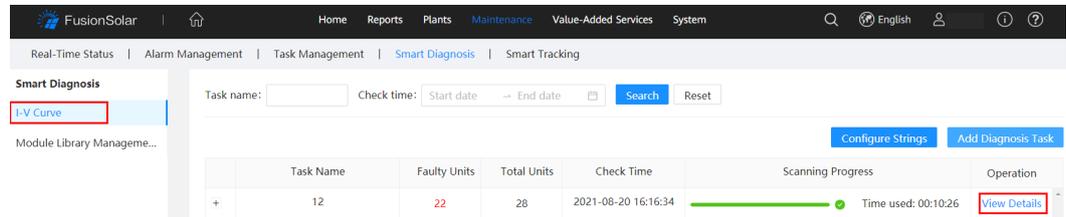
Step 2 Click ➕ before the task to view the **Fault List** and the diagnosis report.

Figure 3-7 Fault list
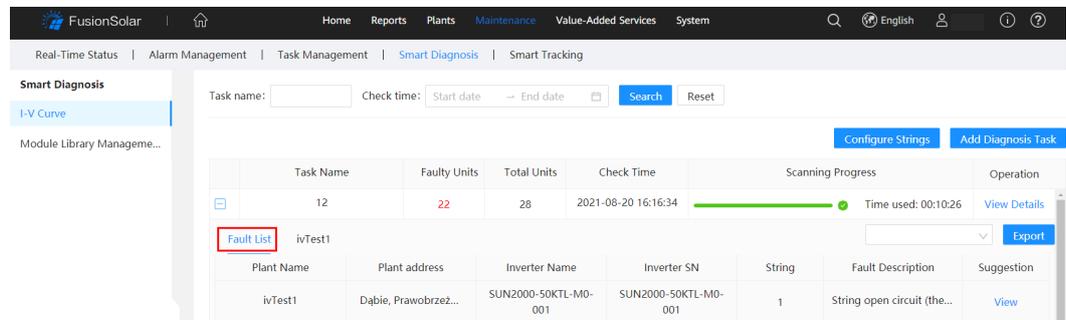
Figure 3-8 Diagnosis report
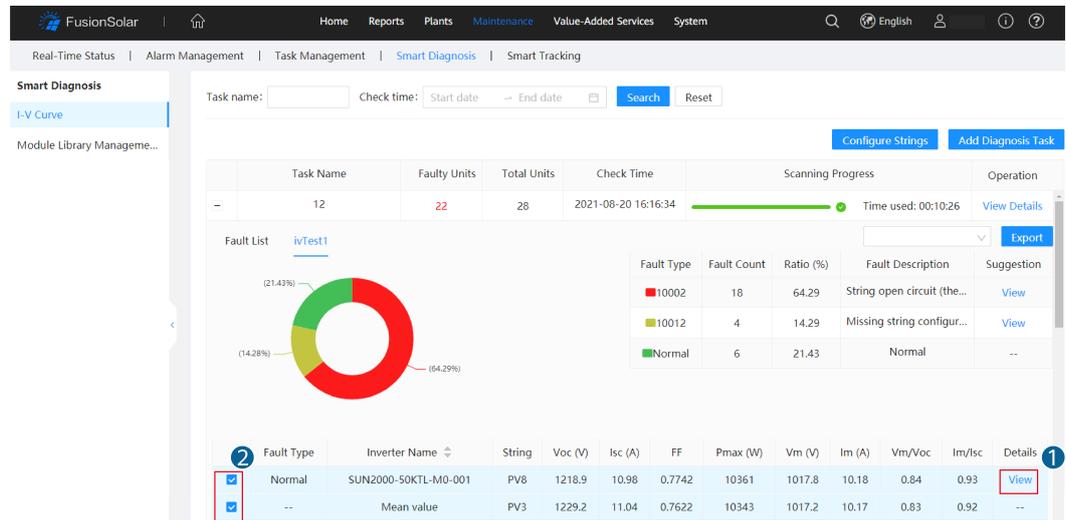
- Click **View** (as shown in **Figure 3-8** ①) to view the I-V curve data of the strings.

Figure 3-9 I-V curve
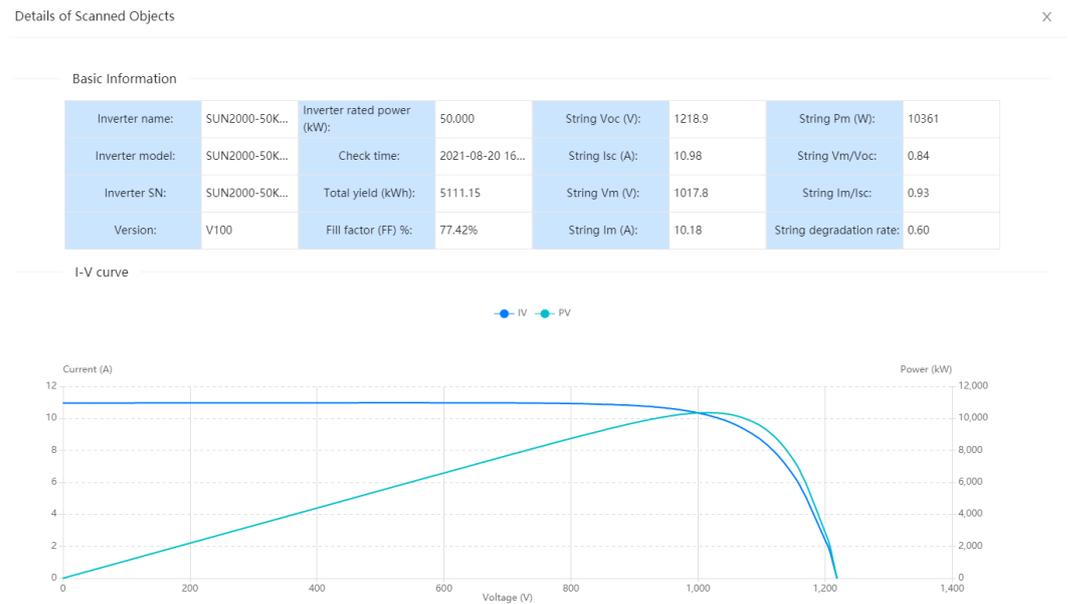
- Select the mean value string and another string (as shown in **Figure 3-8** ②) to view the comparative analysis of the selected strings.

Figure 3-10 I-V curve comparative analysis
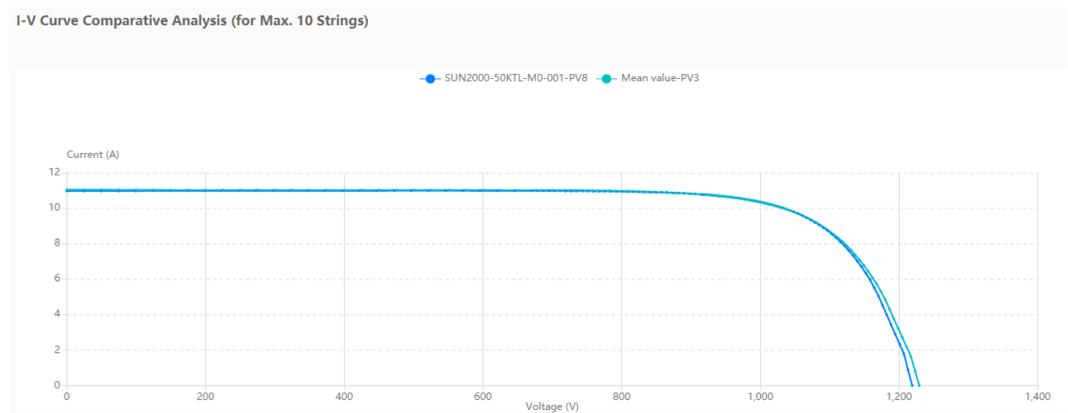
📖 **NOTE**

- Mean value refers to the median power of the strings connected to an inverter. (For example, in the case of 20 W, 30 W, 40 W, 50 W, and 60 W strings, the I-V curve of the 40 W string is the mean value curve.)
- Click **Exported** to export **Fault List** and diagnosis report for viewing or archiving.

----End

3.2 Smart I-V Curve Diagnosis Results and Troubleshooting Suggestions

Fault ID	Fault Type	Troubleshooting Suggestion
10002	String open circuit	1. Check whether the string is correctly connected to the inverter on site. 2. If the string is connected to the inverter, shut down the inverter and remove the cable connectors from the string and the inverter. Then use a multimeter to check the open-circuit voltage of the string. 3. If the open-circuit voltage of the string is normal, check the connectors between the string and the inverter. If they are intact, check the inverter interior for open circuits. 4. If the open-circuit voltage of the string is abnormal, check the string for open circuits. 5. If the open-circuit voltage of the string is normal, use a multimeter to test whether the string current is normal. If the string current is less than 0.5 A, restart the IV scanning when the irradiation meets the requirements.
10003	Incorrect string configuration (incorrect 2In1 flag configuration and/or some 2In1 strings not configured)	1. If 2In1 flag is selected for the current string, check whether this string is connected in 2In1 mode. 2. If 2In1 identity is selected for the current string and this string is connected in 2In1 mode, check whether some 2In1 strings are not configured or the string current is abnormal due to other reasons (such as dust blocking, direction, and aging attenuation). 3. If 2In1 flag is not selected for the current string, check if the current string supports 2In1.
10005	Current mismatch in the string (shade/dust/inconsistent component current)	1. Check to see if scanning was conducted on a sunny day. The fast changes in irradiation may cause current mismatch in the string. 2. Observe the string for shade. If there is shade, eliminate the shade and measure again. 3. If there is no shade, check whether the string has been cleaned. 4. If not, clean it and measure again after the component surface is dry. 5. If the string has been cleaned, test the IV curve of each component to locate the component with low short-circuit current or mixed component.

Fault ID	Fault Type	Troubleshooting Suggestion
10006	Abnormal component current output (due to shading, glass breakage, or hidden cracks)	1. Observe the string for shade on site. If there is shade, eliminate the shade and measure again. 2. If there is no shade, check for foreign matter on the surface of components in the string. If yes, clear the foreign matter and then measure again. 3. If no foreign matter is found, check whether the glass panel of the string component is broken. If yes, replace the component with one of the same model. 4. If no component has a broken glass panel, check whether the string has been cleaned. If not, clean it and measure again after the component surface is dry. 5. If the string has been cleaned, scan the string using an infrared thermal imager to locate the abnormal component. 6. If no abnormal component is found using the infrared thermal imager, test the IV curve for each component on site to locate the component with abnormal output current.
10008	Abnormal string voltage (diode short circuit/ component failure)	1. Check whether the number of components connected to the string is correct. 2. Observe whether there are traces of burning at the interconnection strip, backsheet, and wiring box. If so, replace the component with the same model. 3. Check whether there is a component with diode short circuits or broken interconnection strip by using the infrared thermal image. 4. If no abnormal component is found using the infrared thermal imager, use a voltmeter to test the voltages of the strings (two strings on the same route of MPPT) on site to check whether the string voltage is very low. If so, use a thermometer to check the temperature distribution between components of this string and other normal strings and check whether there is an abnormal temperature.
10009	Low string short-circuit current (abnormal orientation/ dust/component degradation)	1. Check to see if the string direction differs greatly from the direction of other strings. 2. Check whether the string has been cleaned. 3. If not, clean the string and then measure again after the component surface is dry. 4. If yes, check the string area for shade which will greatly decrease the string short-circuit current. 5. If there is no shade, check the string direction. 6. If the string direction is normal, check the string for material deterioration (yellowing).

Fault ID	Fault Type	Troubleshooting Suggestion
10010	Low string power (abnormal orientation/ dust/component degradation)	1. Check to see if the string direction differs greatly from the direction of other strings. 2. Check whether the string has been cleaned. 3. If the string has not been cleaned, clean the string and then measure again after the component surface is dry. 4. Check the string direction. 5. If the direction is correct, check the string for material deterioration (such as yellowing) that causes high component attenuation. 6. If no component has material deterioration, check whether the abnormal string output is caused by high temperature.
10011	String not connected	-
10016	Excessively low string parallel resistance (PID attenuation/ dust/uneven component irradiation)	1. Check to see if scanning was conducted on a sunny day. The fast changes in irradiation may cause abnormal IV curve of the string. 2. Observe the string for shade. If there is shade, eliminate the shade. 3. If there is no shade, check whether the string has been cleaned. 4. If the string has not been cleaned, clean the string and then measure again after the component surface is dry. 5. If the string has been cleaned, test the IV or EL curve for each component on site to locate the component with PID attenuation.
10018	Slight current mismatch in the string (dust/ slight shade)	1. Check to see if scanning was conducted on a sunny day. The fast changes in irradiation may cause slight current mismatch in the string. 2. Observe whether a component is blocked by shade or foreign matter. If so, eliminate the shade or foreign matter. 3. If not, check whether the string has been cleaned. 4. If the string has not been cleaned, clean the string and then measure again after the component surface is dry. 5. If the string has been cleaned, check whether any cell of a component has an abnormal temperature by using an infrared thermal imager. 6. If no abnormal component is found using the infrared thermal imager, test the IV curve for each component on site to locate the component with abnormal output current.
10020	Excessively high string series resistance (high cable resistance/ abnormal internal resistance of the component)	1. Check to see if scanning was conducted on a sunny day. The fast changes in irradiation may cause abnormal IV curve of the string. 2. Scan the string using an infrared thermal imager to locate the abnormal component. 3. If no abnormal component is found using the infrared thermal imager, test the IV curve for each component on site to locate the component with abnormal series resistance.

Fault ID	Fault Type	Troubleshooting Suggestion
10000	Normal	-
11111	Low irradiation during diagnosis	Scan again when the irradiation meets the requirements.
99999	Invalid scanning data (caused by environmental factors)	Scan again when the irradiation meets the requirements.

4 License Fault Management Table

No.	Fault Symptom	Cause Analysis	Troubleshooting Methods
1	**Device License Management** is not displayed on the SmartPVMS WebUI.	The SmartPVMS software version does not support the license management function.	Upgrade the SmartPVMS.
2	Failed to export the license application file from the SmartPVMS.	1. Communication between the SmartPVMS client and server is abnormal. 2. The SmartPVMS server is abnormal.	1. Fix the communication between the SmartPVMS client and server. 2. Fix the SmartPVMS server.
3	The device list in the license application file exported from the SmartPVMS is incorrect.	The target device is incorrectly selected for exporting the license application file.	Select the correct target device and export the license application file again.
4	Failed to upload the license file to the SmartPVMS.	1. Communication between the SmartPVMS client and server is abnormal. 2. The SmartPVMS server is abnormal.	1. Fix the communication between the SmartPVMS client and server. 2. Fix the SmartPVMS server.

No.	Fault Symptom	Cause Analysis	Troubleshooting Methods
5	Failed to load the license file on the SmartPVMS.	1. The communication between the SmartLogger and the inverter is disconnected. 2. The communication between the SmartLogger and the SmartPVMS is disconnected. 3. The license file does not match the inverter SN. 4. The inverter software version does not support the license management function. 5. The SmartLogger software version does not support the license management function.	1. Fix the communication between the SmartLogger and the inverter. 2. Fix the communication between the SmartLogger and the SmartPVMS. 3. Contact the supplier or Huawei customer service center and purchase the Smart I-V Curve Diagnosis function or apply for a license. 4. Upgrade the inverter. 5. Upgrade the SmartLogger.
6	Failed to revoke the license on the SmartPVMS.	1. The communication between the SmartLogger and the inverter is disconnected. 2. The communication between the SmartLogger and the SmartPVMS is disconnected.	1. Fix the communication between the SmartLogger and the inverter. 2. Fix the communication between the SmartLogger and the SmartPVMS.
7	Failed to export the license revocation code file from the SmartPVMS.	1. Communication between the SmartPVMS client and server is abnormal. 2. The SmartPVMS server is abnormal.	1. Fix the communication between the SmartPVMS client and server. 2. Fix the SmartPVMS server.
8	The device list in the license revocation code file exported from the SmartPVMS is incorrect.	The target device is incorrectly selected for exporting the license revocation code file.	Select the correct target device and export the license revocation code file again.
9	Failed to export the license information code file from the SmartPVMS.	1. Communication between the SmartPVMS client and server is abnormal. 2. The SmartPVMS server is abnormal.	1. Fix the communication between the SmartPVMS client and server. 2. Fix the SmartPVMS server.

No.	Fault Symptom	Cause Analysis	Troubleshooting Methods
10	The device list in the license information file exported from the SmartPVMS is incorrect.	The target device is incorrectly selected for exporting the license information file.	Select the correct target device and export the license information file again.
11	**Device License Management** is not displayed on the SmartPVMS WebUI.	The SmartLogger software version does not support the license management function.	Upgrade the SmartLogger.
12	Failed to export the license application file from the SmartLogger.	The SmartLogger is abnormal.	Fix the SmartLogger.
13	The device list in the license application file exported from the SmartLogger is incorrect.	The target device is incorrectly selected for exporting the license application file.	Select the correct target device and export the license application file again.
14	Failed to upload the license file on the SmartLogger.	● The SmartLogger is abnormal. ● The license file (package) name or format is abnormal.	● Fix the SmartLogger. ● Contact the supplier or Huawei customer service center to obtain the license file (package).
15	Failed to load the license file on the SmartLogger.	1. The communication between the SmartLogger and the inverter is disconnected. 2. The license file does not match the inverter SN. 3. The inverter software version does not support the license management function. 4. The SmartLogger software version does not support the license management function.	1. Fix the communication between the SmartLogger and the inverter. 2. Contact the supplier or Huawei customer service center and purchase the Smart I-V Curve Diagnosis function or apply for a license. 3. Upgrade the inverter. 4. Upgrade the SmartLogger.
16	Failed to revoke the license on the SmartLogger.	The communication between the SmartLogger and the inverter is disconnected.	Fix the communication between the SmartLogger and the inverter.
17	Failed to export the license revocation code file from the SmartLogger.	The SmartLogger is abnormal.	Fix the SmartLogger.

No.	Fault Symptom	Cause Analysis	Troubleshooting Methods
18	The device list in the license revocation code file exported from the SmartLogger is incorrect.	The target device is incorrectly selected for exporting the license revocation code file.	Select the correct target device and export the license revocation code file again.
19	Failed to export the license information file from the SmartLogger.	The SmartLogger is abnormal.	Fix the SmartLogger.
20	The device list in the license information file exported from the SmartLogger is incorrect.	The target device is incorrectly selected for exporting the license information file.	Select the correct target device and export the license information file again.
21	Failed to load the license file on the app.	1. The inverter SN does not match the license file. 2. Communication between the app and inverter is disconnected.	1. Load the license file that matches the inverter SN. 2. Fix the communication between the app and inverter.
22	Failed to revoke the license file on the app.	1. The paired inverter is incorrect. 2. Communication between the app and inverter is disconnected.	1. Select the correct inverter for pairing. 2. Fix the communication between the app and inverter.