FusionSolar 6.0 Smart PV Management System
Smart I-V Curve Diagnosis

User Manual

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About This Document

Overview

This document describes the Smart I-V Curve Diagnosis function of FusionSolar 6.0 Smart PV Management System, as well as frequently asked questions and troubleshooting methods.

Intended Audience

This document is intended for photovoltaic (PV) power plant personnel and qualified electrical technicians.

Symbol Conventions

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

Symbol	Description
⚠ DANGER	Indicates an imminently hazardous situation which, if not avoided, will result in death or serious injury.
⚠ WARNING	Indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury.
⚠ CAUTION	Indicates a potentially hazardous situation which, if not avoided, may 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.
📖 NOTE	Calls attention to important information, best practices and tips. 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 the changes made in earlier issues.

Issue 01 (2018-08-29)

This issue is the first official release.

Contents

1 Function Description

Function

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 management system to diagnose PV strings and generate alarms for faulty PV strings.

A large number of PV plant statistics show that PV module quality issues and faults in an early period are important factors for energy yields. 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 trends of operation and maintenance (O&M).

Smart I-V Curve Diagnosis helps scan and diagnose the health of PV strings in a residential PV plant. In this way, potential risks and faults can be detected in a timely manner, thereby increasing the plant quality. The one-click operation facilitates O&M and improves O&M efficiency.

Features

- Promptly detects PV module fault risks
  - All PV modules in a PV plant are scanned periodically (recommended: once every half year), which helps promptly detect faulty PV modules. Timely processing of faulty PV modules helps improve energy yields and prevents faults from escalating.
  - A PV string with an abnormal output can be detected at any time to locate hidden faults promptly.
  - The solar inverter management system analyzes the I-V curve simultaneously, which has little impact on energy yields and ensures high reliability.
- Improves O&M efficiency.
  - Supports remote operations in one-click mode.
  - Automatically analyzes I-V curves.
  - Automatically generates reports automatically.
  - Locates PV string faults according to alarms, which improves O&M quality and efficiency.

Key Performance

- 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 Solution Deployment

Huawei Residential Inverter + Smart PV Management System

Application scenario: residential PV plant

Typical region: China, Europe, Australia

Solution deployment: Huawei residential inverter authorizes Smart I-V Curve Diagnosis through the FusionSolar 6.0 Smart PV Management System. The system and inverter work together to initiate the diagnosis, monitor the process, and display the result.

Version Mapping

Device/Software	Model	Version
Huawei residential inverter	SUN2000L-3KTL-CN	SUN2000L V100R001C00SPC112 and later
	SUN2000L-4KTL-CN	
	SUN2000L-5KTL-CN	
	SUN2000L-2KTL	SUN2000L V100R001C00SPC318 and later
	SUN2000L-3KTL	
	SUN2000L-3.68KTL	
	SUN2000L-4KTL	
	SUN2000L-4.6KTL	
	SUN2000L-5KTL	
Smart PV Management System	FusionSolar 6.0	Smart PV730 V300R006C00SPC220 and later

3 Smart I-V Curve Diagnosis

3.1 Smart I-V Curve Diagnosis on the FusionSolar

Prerequisites

- You have logged in to the FusionSolar 6.0 Smart PV Management System.
- You have the permission for performing the Smart I-V Curve Diagnosis (short as diagnosis).

☐ NOTE

The software version corresponding to the user interface (UI) snapshots in this chapter is Smart PV730 V300R006C00SPC220 of the FusionSolar 6.0 Smart PV Management System. The snapshots vary with software versions and are for reference only.

Suggestions and Restrictions

The following conditions should be met to ensure normal use of the Smart I-V Curve Diagnosis function; otherwise, scanning will fail or be abnormal.

- The day is sunny with stable sunlight. The irradiance is at least 400 W/m^2.
- The cleaning status of PV modules is consistent for a diagnosis task.
- The PV modules are clean and dry. Recommended: start the function after PV modules are cleaned or heavy rain has stopped.
- The PV modules are of the same type and model.
- Currently, the supported type of PV modules is common monocrystalline silicon or common polycrystalline silicon.
- A maximum of 20 PV plants can be diagnosed at a time.

String Settings

Step 1 Click **Intelligent O&M** at the upper right corner of the main menu page of the PV plant monitoring system.

Figure 3-1 Intelligent O&M

Step 2 Click **Intelligent Diagnosis**.

Figure 3-2 Intelligent diagnosis

Step 3 Click **Settings** on the I-V curve page.

Figure 3-3 I-V curve

Figure 3-4 Configuring parameters

Step 4   (Optional) Enter a PV plant name to query the plant.

Figure 3-5 Querying PV plants

Step 5   (Optional) Set the inverter type and name, and click **Search** to screen out the inverters that meet the search criteria.

Figure 3-6 Querying devices

Step 6   Select the PV plant to be configured and click **Configuration**.

Figure 3-7 Configuration

Step 7 Set string parameters.

Figure 3-8 String settings

📖 **NOTE**

PV string capacity = Rated power of a PV module x Number of PV modules in a PV string

* indicates that the parameter is mandatory.

Click **Parameter description** to view the requirements of parameter settings.

Figure 3-9 Parameter description

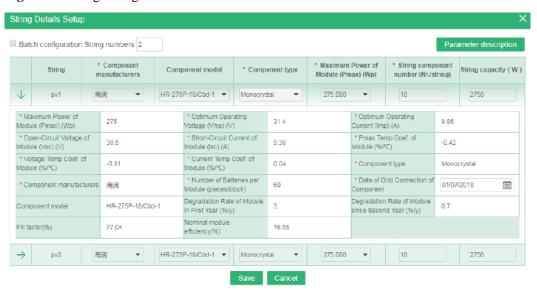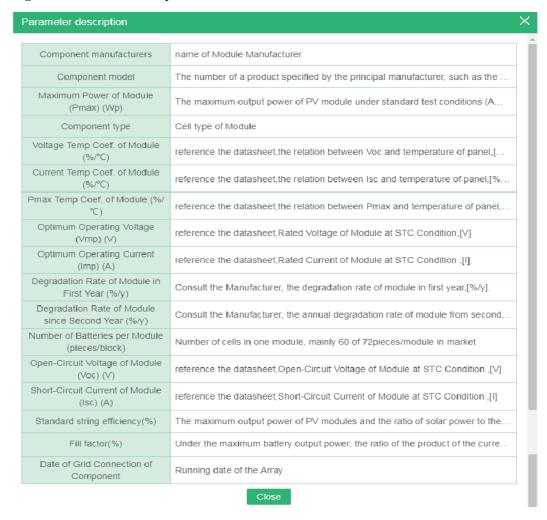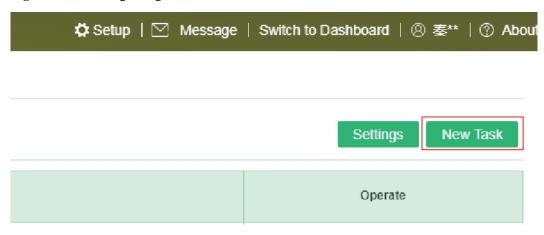| Parameter description		
Component manufacturers	name of Module Manufacturer	
Component model	The number of a product specified by the principal manufacturer, such as the …	
Maximum Power of Module (Pmax) (Wp)	The maximum output power of PV module under standard test conditions (A…	
Component type	Cell type of Module	
Voltage Temp Coef. of Module (%/℃)	reference the datasheet,the relation between Voc and temperature of panel,[…	
Current Temp Coef. of Module (%/℃)	reference the datasheet,the relation between Isc and temperature of panel,[%…	
Pmax Temp Coef. of Module (%/℃)	reference the datasheet,the relation between Pmax and temperature of panel,…	
Optimum Operating Voltage (Vmp) (V)	reference the datasheet,Rated Voltage of Module at STC Condition,[V]	
Optimum Operating Current (Imp) (A)	reference the datasheet,Rated Current of Module at STC Condition ,[I]	
Degradation Rate of Module in First Year (%/y)	Consult the Manufacturer, the degradation rate of module in first year,[%/y].	
Degradation Rate of Module since Second Year (%/y)	Consult the Manufacturer, the annual degradation rate of module from second…	
Number of Batteries per Module (pieces/block)	Number of cells in one module, mainly 60 of 72pieces/module in market	
Open-Circuit Voltage of Module (Voc) (V)	reference the datasheet,Open-Circuit Voltage of Module at STC Condition ,[V]	
Short-Circuit Current of Module (Isc) (A)	reference the datasheet,Short-Circuit Current of Module at STC Condition ,[I]	
Standard string efficiency(%)	The maximum output power of PV modules and the ratio of solar power to the…	
Fill factor(%)	Under the maximum battery output power, the ratio of the product of the curre…	
Date of Grid Connection of Component	Running date of the Array	

Close

----End

Smart I-V Curve Diagnosis

Step 1   Click **New Task** on the I-V curve page.

Figure 3-10 Creating a diagnosis task

Step 2   Click **Start Scanning** to set diagnosis parameters.

⚠ **NOTICE**

Operation suggestions specify the conditions and suggestions for performing the diagnosis.
Read the content carefully and ensure that the conditions are met.

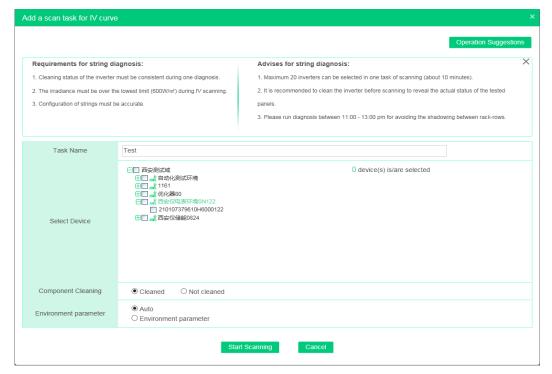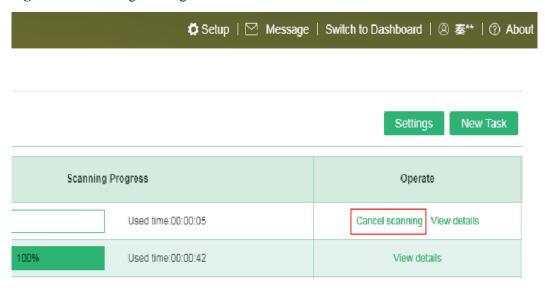**Figure 3-11** Setting diagnosis parameters

Table 3-1 Diagnosis parameter description

Parameter	Description
Task Name	Enter a task name, such as "Test."
Select Device	The selected PV plants are residential ones. A maximum of 20 PV plants can be diagnosed at a time.
Component Cleaning	Specifies the cleaning status of strings. Set a value as required.
Environment parameter	• Automatic mode: The system automatically calculates **Component plane radiation intensity** and **Component backplane surface temperature** ℃. • Environment parameter mode: Manually enter **Component plane radiation intensity** and **Component backplane surface temperature** ℃.

Step 3 (Optional) In the **Operate** area, click **Cancel scanning** to cancel the ongoing diagnosis task.

Figure 3-12 Canceling scanning

Step 4 (Optional) In the **Operate** area, click **View details** to view the details of the scanned object.

Figure 3-13 Scanned object details

No.	Plant Name	Inverter Name	String	Creation Time	End Time	Status
1	SUN2000	0080	PV1	30/07/2018 17:35:51	30/07/2018 17:37:30	Succeeded
2	SUN2000	0080	PV2	30/07/2018 17:35:51	30/07/2018 17:37:30	Succeeded

Per Page: 10 ▼   Total 2 records |< < 1 > >| Page 1 of 1   Turn to Page 1   GO
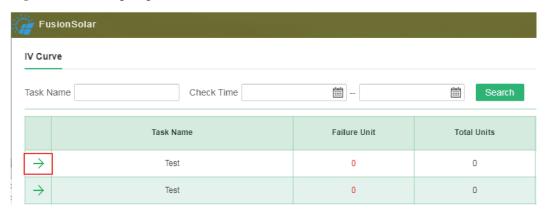
----End

Viewing Diagnosis Results

Step 1   On the I-V curve page, click → on the left of the task name to view diagnosis results.

Figure 3-14 Viewing diagnosis results

	Task Name	Failure Unit	Total Units
→	Test	0	0
→	Test	0	0

Step 2   On the **Fault List** page, you can view the fault results of the I-V curve scanning.

Click **Export**. In the displayed **Prompt** dialog box, click **OK** to save the I-V curve diagnosis report in the format of **.xls**.

Figure 3-15 Fault list

Plant Name	Plant Location	Inverter Name	Inverter SN	String	Fault Description	Handling Advice
SUN2000	Xian	0080	210107380110HB000080	PV1	Current mismatch in the PV string (shade/dust/PV module current...	View
SUN2000	Xian	0080	210107380110HB000080	PV2	Scanning data invalid (Irradiation causes)	View

Per Page: 10 ▼   Total 2 records |< < 1 > >| Page 1 of 1   Turn to Page 1   GO

Step 3   Click **Plant Name** on the right side of **Fault List**. Select a target string and view **Contrast analysis on strings for IV curve**.
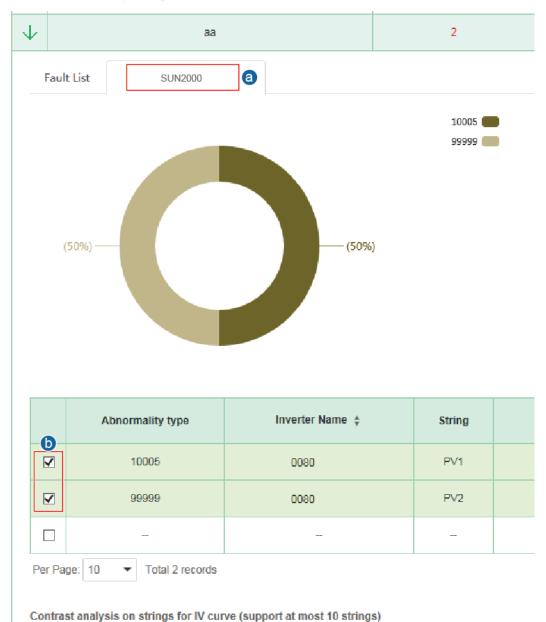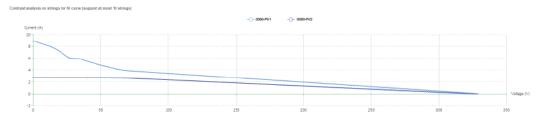
Figure 3-16 Selecting a PV plant

Figure 3-17 String I-V curve comparison

Step 4 Click **View** in the **Detail information** area to view the string details.

Figure 3-18 Details

Im(A)	Vm/Voc	Im/Isc	Detail information
2.421	0.51	0.27	View
	--	--	View
--	--	--	--

|◄ ◄ 1 ► ►| Page 1 of 1   Turn to Page [1] [GO]
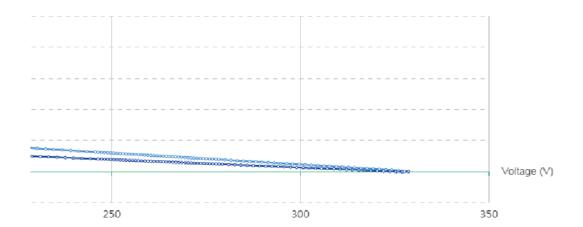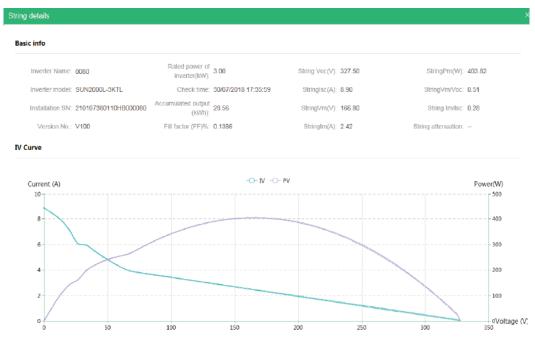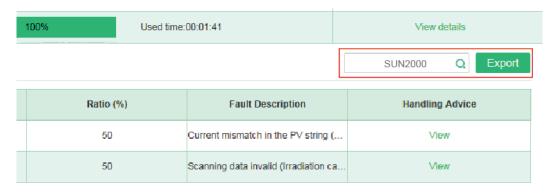
Figure 3-19 String details

Step 5 Click **Export**. In the displayed **Prompt** dialog box, click **OK** to save the I-V curve diagnosis report in the format of **.pdf**.

Figure 3-20 Exporting an I-V curve diagnosis report
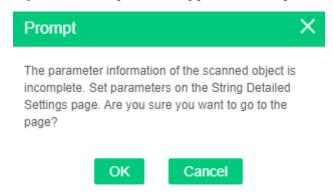

----End

Troubleshooting

📖 **NOTE**

Perform another Smart I-V curve diagnosis scanning at least two minutes after the last scanning. Otherwise, the system will display a message indicating that the scanning fails.

If an error message dialog box is displayed when you attempt to start the diagnosis, rectify the fault and then start the diagnosis.
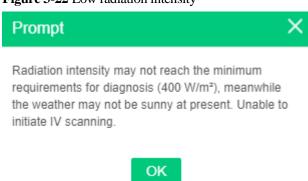
- If the message indicates that the parameters for the scanned object are incomplete, complete the string parameter settings first.

Figure 3-21 Incomplete scanning parameter settings

- If the message indicates that the irradiance is too low, unable to initiate IV scanning and wait until the irradiance meets the requirement.

Figure 3-22 Low radiation intensity

3.2 Smart I-V Curve Diagnosis Results and Troubleshooting Suggestions

Result ID	Result Type	Troubleshooting Suggestion
10000	PV string normal	None.
10002	PV string open circuit (PV string breakage/PV string configured by mistake)	1. Check if the strings are connected correctly, if connections are loose, or not connected. 2. If the strings are connected to inverter,then switch off the inverter and pull off the connector between strings and inverter;then measuer Voc of the strings with a multimeter and check whether the Voc is within correct

Result ID	Result Type	Troubleshooting Suggestion
		parameters. 3. If the Voc is within correct parameters,then check whether the connector between string and inverter is broken,if everthing is ok, then check if there is broken circuit inside of inverter. 4. If the Voc is abnormal,then check if there is broken circuit in strings.
10005	Current mismatch in the PV string (shade/dust/PV module current inconsistent)	1. Please check if the scanning is done at a sunny day, current mismatch may occur when the irradiance changes dramatically. 2. Check if there is shadow, if yes, please measure again after removing the shadow. 3. If no, please check string was cleaned. 4. If the PV string has not been cleaned, clean the PV string and then measure again after the PV module surface is dry. 5. If string was cleaned,please check if there are panels with low Isc or from other power class by IV testing of each panel.
10006	PV module output current abnormal (shade/glass breakage/hidden crack)	1. Observe the PV string for shade. If there is shade, eliminate the shade and measure again. 2. If there is no shadow on panel,check if there are foreign matters or dirt on the surface of the panel,if yes,then measure again after removing the foreign matters. 3. If there is no shadow on the surface of panel,please check if there is broken glass, if yes, please measure again after replacing with same model of PV module. 4. If no PV module has a broken glass panel, check whether the PV string has been cleaned. If not, clean the PV string and then measure again after the PV module surface is dry. 5. If the PV string has been cleaned, scan the PV string using an infrared thermal imager to locate the abnormal PV module. 6. If there is no fault, please identify the module with abnormal current by IV tester.
10008	PV string voltage abnormal (diode short circuit/PV module	1. Check whether the number of PV modules connected to the PV string is correct.

Result ID	Result Type	Troubleshooting Suggestion
	invalid/PV module quantity incorrect)	2. Observe whether there are traces of burning at the interconnection strip, backsheet, and wiring box. If so, replace the PV module with the same model. 3. If none of the above exists, please use IR camera to check if there is short circuited diode or broken ribbon for interconnection. 4. If there is no abnormal found on the module with IR camera, please use voltage meter to check the the voltage of the strings (from same MPPT), to see if it is too low.And if yes, please measure the temperature of panels in string to check whether there is abnormal temperature distribution.
10009	Low PV string short-circuit current (abnormal orientation/dust/PV module degradation)	1. Check whether the string direction differs greatly from the direction of other strings. 2. Please check if the panel was cleaned. 3. If the PV string has not been cleaned, clean the PV string and then measure again after the PV module surface is dry. 4. If yes, please check if there is shadow in the string area, which induces low Isc. 5. If there is no shadow area, please check if the orientation of string is correct. 6. If the orientation is correct, please check if there is 'brown' material in the string.
10010	Low PV string power (abnormal orientation/dust/PV module degradation)	1. Check whether the string direction differs greatly from the direction of other strings. 2. Please check if the panel was cleaned. 3. If the PV string has not been cleaned, clean the PV string and then measure again after the PV module surface is dry. 4. Check the PV string orientation. 5. If the orientation is correct, please check if there is 'brown' modules in the string. 6. If there is no 'brown' modules in the string, please check if there is high temperature of module that induces the low output.
10011	No string connected (normal status)	Connect the PV string.
10012	Missing configurations of PV strings	Check whether the parameter settings are correct.
10016	Excessively low PV	1. Please check if the scan was done in a sunny day, the rapid change of

Result ID	Result Type	Troubleshooting Suggestion
	string parallel resistance (PID degradation/dust/uneven PV module irradiance)	irradiance may induce IV curve become abnormal. 2. Please check if there is shadow in string, if yes please remove it. 3. If there is no shadow, please check if the string was cleaned. 4. If the PV string has not been cleaned, clean the PV string and then measure again after the PV module surface is dry. 5. If the PV string has been cleaned, test the I-V or EL curve on each PV module onsite to locate the PV module with PID.
10018	Slight current mismatch in the PV string (dust/slight shade)	1. Please check if the scan was done in a sunny day, the rapid change of irradiance may induce moderate current mismatch in the string. 2. Please check if there is shadow or dirt on the module, if yes, please remove or clean. 3. If there is no shadow, please check if string was cleaned. 4. If the PV string has not been cleaned, clean the PV string and then measure again after the PV module surface is dry. 5. If the array was cleaned, please use IR camera to check the temperature of modules. 6. If there is no abnormal found through IR camera, please identify the module with abnormal output current with IV tester.
10019	Abnormal curve near MPP in the PV string (hotspot/hidden crack/glass breakage)	1. Please check if the scan was done in a sunny day, the rapid change of irradiance may induce IV curve become abnormal. 2. Please check if the string was cleaned. 3. If the PV string has not been cleaned, clean the PV string and then measure again after the PV module surface is dry. 4. Scan the PV string using an infrared thermal imager to locate the abnormal PV module. 5. If no abnormal temperature was found, please use IV test to identify the module with abnormal output current.
10020	Excessively high PV string series resistance (high cable resistance/abnormal internal resistance of the	1. Please check if the scan was done in a sunny day, the rapid change of irradiance may induce IV curve become abnormal. 2. Scan the PV string using an infrared thermal imager to locate the abnormal

Result ID	Result Type	Troubleshooting Suggestion
	PV module)	PV module. 3. If no abnormal modules is found with IR camera, please inspect the modules with IV test to identify the one with abnormal Rs.
11111	excessively low irradiance	Scan again after the irradiance meets the requirements.
99999	Scanning data invalid (Environmental factors)	Scan again after the irradiance meets the requirements.

A Acronyms and Abbreviations

A

APP   Application

E

EL   Electro Luminescent(EL) Instrument

I

IV   Current-Voltage

M

MPPT   Maximum Power Point Tracking

P

PID   Potential Induced Degradation