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1. SAFETY MEASURES AND PRECAUTIONS

This instrument has been designed to comply with the IEC/EN61010-1 Directive on electronic measurement equipment. Before and during measurement, carefully follow the instructions below and read all the notes preceded by the symbol \triangle

- Do not take voltage or current measurements in humid environments •
- Do not take measurements near explosive gases or materials and fuels, or in dusty • environments
- Avoid contact with the circuit being tested if no measurement is being taken
- Avoid contact with exposed metal parts, unused measurement terminals, circuits, etc.
- Do not take any measurements if you notice any abnormalities in the instrument, such as deformation, breakage, leakage of substances, no reading on the display, etc.
- Only use original HT accessories
- When closing the case, DO NOT LEAVE ANY ACCESSORIES inside in order to not damage the instrument's display



CAUTION

The instrument can only be connected to strings or PV modules. It must not be used in connection with other electrical sources and/or electronic devices to avoid possible damage

The following symbols are used in this manual and on the instrument:



CAUTION: follow the instructions given in this manual; improper use may cause damage to the instrument, its components or dangerous situations for the operator.

High voltage: risk of electric shock



Double insulation



DC voltage or current



This symbol indicates that the equipment, the batteries and its accessories must be collected separately and disposed of in the correct manner

1.1. **PRELIMINARY INSTRUCTIONS**

- The instrument has been designed to be used in the environmental conditions specified in § 10.3. The presence of significantly different environmental conditions can compromise the safety of the instrument and the operator. In any case, before using, wait until the conditions inside the instrument are comparable to the conditions of the environment in which it is operating
- The instrument can be used for VOLTAGE and CURRENT measurements in CAT III 1500VDC with a maximum voltage of 1500VDC between inputs and a maximum current of 40A. Do not work on circuits that exceed the limits specified in § 10.1
- We recommend that you follow normal safety procedures to protect yourself from dangerous currents and to protect the equipment from misuse
- Only the accessories supplied with the instrument guarantee compliance with the safety standards. They must be in good condition and must be replaced, if necessary, with identical models
- Check that the batteries are inserted correctly
- Before connecting the measurement cords to the circuit being tested, check that the desired function has been selected

1.2. DURING USE

Read the following recommendations and instructions carefully:

CAUTION

- Failure to comply with the warnings and/or instructions may result in damage to the equipment and/or its components or personal injury to the operator
- Do not touch any unused test terminal
- Do not disconnect the cords during measurement
- Do not open the battery compartment when the instrument inputs are connected



The symbol "L" indicates that the internal batteries are fully charged. When

the charge level drops to the minimum level, the symbol " \Box " appears on the display. In this case, stop the tests and replace or recharge the batteries as described in § 9.2

- The instrument will not charge the batteries if the temperature is outside the permitted range of them (0°C ÷ 40 °C / 32°F ÷ 104°F)
- The instrument retains data even without batteries

1.3. AFTER USE

When measurements are complete, switch off the instrument by pressing and holding the **ON/OFF** key for some seconds. If the instrument is not to be used for a long period, remove the batteries and follow the instructions in § 3.3.

1.4. DEFINITION OF MEASUREMENT CATEGORY (OVERVOLTAGE)

Standard IEC/EN61010-1: Safety requirements for electrical equipment for measurement, control and laboratory use, Part 1: General requirements", defines what measurement category, commonly called overvoltage category, is. In § 6.7.4: Measuring circuits, it states that:

Circuits are divided into the following measurement categories:

• **Measurement Category IV** is for measurements performed at the source of the low-voltage installation.

Examples are electricity meters and measurements on primary overcurrent protection devices and ripple control units.

- **Measurement Category III** is for measurements performed in the building installation Examples are measurements on distribution boards, circuit breakers, wiring, including cables, bus-bars, junction boxes, switches, socket-outlets in the fixed installation, and equipment for industrial use and some other equipment, for example, stationary motors with permanent connection to fixed installation.
- **Measurement Category II** is for measurements performed on circuits directly connected to the low voltage installation. Examples are measurements on household appliances, portable tools and similar

Examples are measurements on household appliances, portable tools and similar equipment.

• **Measurement Category I** is for measurements performed on circuits not directly connected to MAINS.

Examples are measurements on circuits not derived from MAINS, and specially protected (internal) MAINS-derived circuits. In the latter case, transient stresses are variable; for that reason (OMITTED) the user must know the transient withstand capability of the equipment

2. GENERAL DESCRIPTION

2.1. FOREWORD

The instrument is designed to carry out performance measurements (I-V curve) and quick pre-testing (IVCK) of photovoltaic (PV) modules/strings in accordance with IEC/EN60891 and IEC/EN62446-1.

2.2. INSTRUMENT FUNCTIONS

The instrument can perform tests on Monofacial and Bifacial modules/strings up to 1500VDC, 40ADC.

Measurement of I-V Curve (I-V)

The following functions are available on the instrument:

- Activation of Manual or Automatic measurement (*)
- Measurement of Voltage/Current/Power under operating conditions (@OPC)
- Measurement of Voltage/Current/Power referring to standard conditions (@STC) in accordance with IEC/EN60891
- I-V curve diagram and Power/Voltage under @OPC and @STC condition
- Direct comparison of the @STC values with the nominal values declared by the manufacturer and display of OK/NO result
- Tests also on PV modules with efficiency >19%

Commissioning test measurements (IVCK)

- Open circuit voltage measurement VOC
- Short-circuit current measurement ISC
- Display of results under @OPC and @STC conditions in accordance with IEC/EN62446-1 and IEC/60891
- OK/NO evaluation of results
- Tests also on PV modules with efficiency >19%

General characteristics

- The instrument is supplied in a carrying case with IP67 mechanical protection.
- Safety sliding cover on inputs
- Large graphic colour display (800x480pxl) with capacitive touch-screen
- Internal icon-based menus for intuitive user interface
- Auto power-off (can be disabled) after approx. 5 minutes of inactivity
- HELP function for information on instrument connections
- The instrument is powered by alkaline batteries or NiMH batteries rechargeable via the external power supply unit (provided)
- Measurement of front-side and back-side irradiance and temperature of PV modules via Bluetooth connection with the SOLAR03 remote unit, HT305 reference cell and PT305 temperature probe
- Customisable internal database for managing up to ca 63.000 PV modules
- 32GB memory card (not expandable) for data storage
- USB-C and WiFi interface for data transfer to PC and dedicated APP (*)

(*) The feature may only be available on certain models

3. PREPARATION FOR USE

3.1. INITIAL CHECKS

The electronics and mechanics of the instrument have been carefully checked before shipment. Every precaution has been taken to ensure that the instrument is delivered in perfect condition. In any case, it is advisable to check it for any damage that may have occurred during transport. If any faults are found, please contact your dealer immediately. It is also advisable to check that the packaging contains all the parts listed in § 10.4 . In case of discrepancies, please contact your dealer. Should it be necessary to return the instrument, please follow the instructions given in § 12

3.2. INSTRUMENT POWER SUPPLY

The instrument is powered by 8x1.5V AA-type alkaline batteries or 8x1.2V AA-type NiMH batteries rechargeable via external power supply unit supplied as standard.

For information on battery operations see § 9.2. The symbol "" indicates that the internal batteries are fully charged. When the charge level drops to the minimum level, the symbol

" \Box " appears on the display. In this case, stop the tests and replace the alkaline batteries or recharge the NiMH batteries as described in § 9.2.

CAUTION

- The instrument retains data even without batteries
- The instrument will not charge the batteries if the temperature is outside the permitted range of them (0°C ÷ 40 °C / 32°F ÷ 104°F)

3.3. STORAGE

The instrument has been designed to be used in the environmental conditions specified in § 10.3. The presence of significantly different environmental conditions can compromise the safety of the instrument and the operator and/or not guarantee precise measurements. After a long period of storage and/or in extreme environmental conditions, wait until the conditions inside the instrument are comparable to those in the environment in which it will be used.



CAUTION

The instrument automatically switches on cooling fans in case of overheating

4. DESCRIPTION OF PARTS





CAPTION:

- 1. **C1, P1, C2, P2** inputs
- 2. Front panel
- 3. Touch-screen display
- 4. Key ON/OFF
- 5. **START/STOP** key
- 6. Battery compartment cover
- 7. Battery compartment cover fixing screw
- 8. Input for external power supply unit
- 9. Sliding cover for connections

Fig. 1: Description of the front part of the instrument



CAPTION:

- 1. Front panel
- 2. USB-C connector for PC connection

Fig. 2: Description of the instrument's side



CAPTION:

- Battery compartment with battery polarity indicator
- 2. Slot for memory card
- 3. Memory card

4

4. Position of batteries inside the compartment

Fig. 3: Description of instrument battery compartment



 \wedge

The memory card (see Fig. 3 – part 3), in addition to managing saving data, contains basic information on the internal functions of the instrument and <u>must</u> <u>NOT be removed, modified or replaced</u> unless explicitly requested by the HT service assistance

4.2. DESCRIPTION OF FUNCTION KEYS

The instrument includes the following function keys:

 ON/OFF key → Press the key for at least 2s to switch the instrument on or off. A green light briefly surrounds the key when it is switched on



ON/OFF key → in presence of the external power supply connected, after 30s of inactivity (no action on the keyboard and touch screen, no sending of commands via USB/WiFi, no disconnection of the power supply), the instrument turns off the display and a flashing green light surrounds the button. Double-tap the touch screen or perform any other action to turn the display back on



• ON/OFF key → in absence of an external power supply connected, after 30s of inactivity (no action on the keyboard and touch screen, no sending of commands via USB/WiFi, no disconnection of the input terminals) the instrument turns off the display and a red-light flashing surrounds the button. Double-tap the touch screen or perform any other action to turn the display back on



• **START/STOP** key → Press the key to start a measurement. A green light briefly surrounds the key when it is switched on

4.3. DISPLAY DESCRIPTION



Check that the string cables are not in contact with other voltage sources, if necessary, de-energize these cables/field panels

4.4. INITIAL SCREEN



When switched on, the instrument briefly displays the initial screen before switching to the main menu. It shows:

- The manufacturer's logo
- The instrument's model
- The serial number of the instrument (S/N:)
- The internal firmware (FW) and hardware (HW) versions
- The date of the last calibration carried out on the instrument (Calibration Date:)

4.5. SIDE MENU



Tap on the icon ">" to open/close the side bar/menu shown in the figure on the left. The following icons are available:

- 1. **↑**HOME icon→, used to go back to the main menu from any screen displayed on the instrument
- 3. SOLAR03 icon→, used to access the management section of the SOLAR03 remote unit from any screen displayed on the instrument
- 4. **WHELP** icon→, used to access the 'Help' section from any screen displayed on the instrument

4.6. DESCRIPTION OF THE STATES OF THE SOLAR03 REMOTE UNIT

Depending on how it is used in conjunction with the instrument, the **SOLAR03** remote unit can be in one of the following states, identified by the symbol at the top of the display (see Fig. 4- section 5):



SOLAR03 remote unit connected to the instrument



SOLAR03 remote unit connected to the instrument and recording



SOLAR03 remote unit **NOT connected** to the instrument



SOLAR03 remote unit recording, but out of connection range

4.7. USING INSTRUMENT WHILE IT IS HANGING AND ATTACHED TO A STRAP

For measurements where it is useful to hang the instrument, it is advisable to remove the cover from the case. To do so, proceed as follows:

1. Open the case and turn the two locking pins as shown in Fig. 5



2. Remove the two locking pins by pulling them outwards as shown in Fig. 6



Fig. 6: Removing the cover from the instrument case - Step 2

3. Remove the case cover from its housing as shown in Fig. 7



Fig. 7: Removing the cover from the instrument case - Step 3

4. Connect the **SP-2003** strap (supplied) to the instrument as shown in Fig. 8. In this case, it is useful to rotate the display by 180° by tapping on the **REVERSE** key in the side menu (see § 4.5) or by activating the "**Rotate display**" option (see § 5.2)



Fig. 8: Using the instrument with strap attached and display rotated

5. Repeat steps 3), 2), 1) in reverse order to put back the case cover

5. MAIN MENU



The instrument's main menu contains a series of icons used to access the internal measurements and settings.

The instrument is controlled and programmed using the touchscreen display only, with no external function keys.

The main menu consists of two pages. The first page is always displayed when the instrument is switched on.

Slide your finger up and down the screen to access the second page, as shown in the screen on the side



5.1. HELP

1. Tap on the "**Help**" icon on the main menu. The following screen will be displayed:



Fig. 9: Help screen for connecting to the instrument

- 2. Scroll left to view the help screens for the various measurements performed by the instrument
- 3. Tap on the "**Exit**" key to exit and return to the main menu

5.2. INSTRUMENT SETTINGS

- 1. Switch on the instrument using the ON/OFF key
- 2. Tap on the "Settings" icon on the main menu. The following screen will be displayed

S	ETTINGS		15.	17.05 27/0	07/2023 X 📋
>	Language Min. Irradiance Auto Power Off Contrast Key sound WiFi		English 700 10 20 0N 0FF	W/m2 min. %	
	Rotate display		OFF		
	Reset Database	Date&Time			

Fig. 10: General instrument settings

- 3. <u>Drag</u> each of the 7 thumb wheels to the <u>right or left</u> to set the desired value for each parameter in the "General" section. The following items are available:
 - ➤ Language → system language setting
 - Min. irradiance → to set the minimum irradiance threshold considered by the instrument when measuring the I-V curve and the IVCK in the range: 100 W/m² ÷ 1100W/m² in 100 W/m² increments
 - Auto Power Off → to set the instrument auto-off time between the following values: Omin (No Auto Power Off), 1min to 10min in 1min increments
 - ➤ Contrast → to set the percentage of display contrast in the range: 0% to 99% in 5% increments
 - ➤ Key sound → to enable (ON) or disable (OFF) the key beep each time the touchscreen display is touched
 - WiFi → to enable (ON) or disable (OFF) the WiFi connection that can <u>only</u> be used to connect the instrument to a PC (via a management software HTAgorà) or mobile devices via dedicated APP (*)
 - ➢ Rotate display → to enable (ON) or disable (OFF) the rotation of the display (this function can also be executed from the side menu see § 4.5)
 - ▶ **Reset Database** \rightarrow see the § 6.3.5

(*) The feature shown may only be available on certain models

- 4. Tap on the icon to save the settings and return to the main menu, or on the icon to exit without saving
- 5. Tap on "**Date&Time**" to set the date/time of the system. The following screen will be displayed:



S	ETTINGS		15.17.05 27/07/2023 🗙	1
	Year Month Day Hour Minute Date Format Time Format		2023 7 27 15 17 ddmmyy 24h	
	General	Date&Time		

Fig. 11: Setting the date/time of the system

- 6. <u>Drag</u> each of the 7 thumb wheels to the <u>right or left</u> to set the desired value of each parameter in the "Date/Time" section. The following items are available:
 - > Year \rightarrow to set the current year
 - > Month \rightarrow to set the current month
 - > **Day** \rightarrow to set the current day
 - > Time \rightarrow to set the current time
 - > Minute \rightarrow to set the current minute
 - Date Format
 → to choose the date format from the following options: "ddmmyy" (day/month/year) or "mmddyy" (month/day/year)
 - ➤ Time Format → to choose the time format from the following options: "24h" or "12h" (UK notation - AM/PM)
- 7. Tap on the *icon* to save the settings and return to the main menu, or on the *icon* to exit without saving

5.3. INFORMATION

1. Tap on the "**Information**" icon on the main menu. The following screen appears on the display, showing the internal information of the instrument



Fig. 12: Instrument information

2. Tap on the "**Menu**" key to return to the main menu

6. OPERATING INSTRUCTIONS

6.1. DMM – MULTIMETER FUNCTION

In this function, the instrument displays the DC voltage value between the positive (+) and negative (-) poles of the PV module/string/field being tested, as well as the irradiance and temperature values **when connected to a SOLAR03 remote unit**.

- 1. Switch on the instrument using the ON/OFF key
- 2. Connect the instrument to the PV string being tested as shown below Fig. 13



Fig. 13: Instrument connection for DMM Function

3. Tap on the "**Multimeter**" icon on the second page of the main menu. The value of the DC voltage V P-N is shown on the display as illustrated in Fig. 14. Tap on the "Menu" key to return to the main menu



Fig. 14: DMM function measurement screen (SOLAR03 disconnected)



	CA	UT	0	N
		1		

The results of function DMM cannot be saved in the instrument's memory.

6.2. SOLAR03 - REMOTE UNIT

The SOLAR03 remote unit allows measuring the Irradiance and temperature values of the module, which are indispensable for the evaluation of the I-V curve, as well as the IVCK with values referenced to @STC. In general, the instrument and the SOLAR03 unit can operate in direct connection or synchronous recording.

CAUTION

The maximum direct connection distance between the SOLAR03 unit and the instrument can be depending on the obstacles between the two units and is up to 100m (328ft) in free air conditions



The maximum distance for direct connection is indicative as it is strongly influenced by many uncontrollable external variables. The recommended measurement mode is always that of "synchronous recording" (see § Errore. L'origine riferimento non è stata trovata.) which does not require an active Bluetooth connection during measurements and, regardless of the obstacles present and the extension of the field to be measured, guarantees a reliable measurement in every situation

This section manages all the operations that can be performed on the SOLAR03 remote unit in conjunction with the instrument. It is possible to:

Using the Bluetooth connection, find a SOLAR03 remote unit that can be managed by the instrument by entering it in its internal list

The indicative maximum communication distance via Bluetooth (up to 100m/328ft) refers to an open field, dry environment, 1m (328ft) from the ground, in the absence of obstacles and possible electromagnetic disturbances deriving from other sources close to the instruments

CAUTION

- Select or cancel a remote unit SOLAR03 among those present in the list;
- Pair/unpair a remote unit SOLAR03 to/from the instrument so that it can be automatically recognized upon every connection;
- Display the information of the selected remote unit.
- > Activate/stop recording environmental parameters (temperature/irradiance) on a connected and active remote unit.

For each managed SOLAR03 remote unit, the instrument provides the following information:

- Serial Number
- Active (symbol) or inactive (no symbol) remote unit
- Active remote unit connected to the instrument
- Active and connected unit in recording mode ('Rec.' symbol)

Pairing a Remote Unit

- 1. Switch on the instrument using the **ON/OFF** key
- 2. Tap on the "SOLAR03" icon on the main menu. The following screen will be displayed

SOLAR03		15.17.05 27	7/07/2023 X 📋
>			•
Find	Pair	Delete	Run/Stop
Fig. 15: Pa	iring a SOLA	R03 remote u	nit - Step 1

- 3. <u>Switch on the</u> SOLAR03 <u>remote unit</u> and select the "**PAIRING...**" menu (see the remote unit user manual)
- 4. Tap on the "**Find**" button on the instrument to start searching for the remote unit. The following screen appears on the display:



Fig. 16: Pairing a SOLAR03 remote unit - Step 2

5. Once the remote unit has been recognised, the following screen will appear on the display of the SOLAR03 unit waiting to be connected



Fig. 17: Pairing a SOLAR03 remote unit - Step 3

6. <u>Press ENTER on the SOLAR03 remote unit</u> to complete the operation. After a few moments, the following screen will appear on the display:



Fig. 18: Pairing a SOLAR03 remote unit - Step 4

- 7. From this point on, the two devices are paired and it is not necessary to repeat the above steps. To connect the instrument and the remote unit, simply switch them on, bring them close together and wait for the automatic connection. The following information is available for the paired and connected remote unit:
 - Icon in the top right corner of the display
 - Model and serial number
 - Internal FW and HW version of the unit
 - Status: Idle (the instrument does not query the unit for irradiance/temperature values) or active (unit that provides irradiance/temperature values on measurements stored in the instrument to define values under STC conditions)
 - > Battery charge percentage indicator
 - Indication of the space available in the internal memory for storing recordings in terms of days/hours
 - Number of measurements stored in the instrument that need synchronising with the irradiance/temperature values received from the remote unit. Tap on the icon to synchronise measurements

Recording activation on remote unit

8. To start recording on the connected remote unit, tap on the "**Start/Stop**" key. The following screen will appear:



Fig. 19: Recording Activation on Remote Unit - Step 1



9. Tap on 💽 to confirm or tap on 든 to exit without proceeding. If yes, the following screen will appear:



Fig. 20: Recording Activation on Remote Unit - Step 2

10. The **FEC** icon and the message "**REC**" appear on the display of the remote unit 11. Tap on the "**Run/Stop**" button to end the recording. The following screen will appear:

SOLAR03		15.17.05 2	27/07/2023 📲 📋
SOLAR03 230	070001 Connec	ted Rec.	e
SOLAR03 - SN: 23 FW: 1.00 - HW: 1.0 Status: idle Battery: 53% Free memory: 0day N. of measures to s	070 Do u want to s ys 2hours sync.: 0	top recording?	(
Find	Unpair	Delete	Run/Stop

Fig. 21: End recording on the remote unit

- 12. Tap on the key to confirm. The recording is **automatically** saved in the internal memory of the remote unit (see relevant user manual)
- 13.Tap on the **T** icon to return to the main menu

Removing a remote unit

A remote unit can **only** be deleted from the unit after it has been disconnected. To this end, proceed as follows:

- 14.Switch off the remote unit
- 15.Tap on the "**Unpair**" key to un-pair the remote unit. The message "**Not connected**" will appear on the display
- 16.Tap on the "**Delete**" key. The following screen will appear:





Fig. 22: Deleting a remote unit

17. Tap on the 🛃 key to confirm. The remote unit will be removed from the list; alternatively, tap on the key to exit without proceeding

6.3. DB – PV MODULES DATABASE MANAGEMENT

The instrument allows defining and saving up to approx. 63.000 modules. The parameters related to 1 module and the @STC conditions that can be set are shown in Table 1 below:

Symbol	Description	Meas. Unit	Meas. range	Default
Man.	Module manufacturer	-	-	-
Name	Module name	-	-	-
Pmax	Maximum nominal power of module	W	30 ÷ 1999	400
Voc	Open circuit voltage	V	15.0 ÷ 999.99	45
Vmpp	Voltage on point of maximum power	V	15.0 ÷ 999.99	40
lsc	Short circuit current	A	1.00 ÷ 39.99	10.5
Impp	Current on point of maximum power	A	1.00 ÷ 39.99	10
Toll -	Negative tolerance for Pmax	%	0.00 ÷ 25.00	0
Toll +	Positive tolerance for Pmax	%	0.00 ÷ 25.00	1.25
TC(Isc)	Isc temperature coefficient	%/°C	-0,100 ÷ 0,100	0.03
TC(Voc)	Voc temperature coefficient	%/°C	-0,999 ÷ -0,001	-0.25
Rs	Module series resistance	Ω	0.10 ÷ 10.00	0.0
Perf.@Yr1	Module performance in Year 1	%	0.00 ÷ 100.00	90
Perf.@Yr2	Module performance in Year 2	%	0.00 ÷ 100.00	80
Years@Perf.1	Performance Year 1	Years	0.0 ÷ 50.0	10
Years@Perf.2	Performance Year 2	Years	0.0 ÷ 50.0	25
Туре	Module type: STD (Monofacial) BIFAC. (Bifacial)	-	-	STD
Coef. Bif.	Isc/Pmax bifaciality factor	%	0.00 ÷ 100.00	79.0
PhiTollBi	Isc/Pmax bifaciality factor tolerance	%	0.00 ÷ 100.00	16.0

Table 1: Typical parameters of PV modules

CAUTION

 The parameters "Perf.@Yr1" and "Perf.@Yr2" represent the module performance percentages declared in the manufacturer's data sheet



- The "Years@Perf.1" and "Years@Perf.2" parameters represent the years of operation of the module to which the manufacturer has assigned the performance associated with the "Perf.@Yr1" and "Perf.@Yr2" parameters
- On the basis of these values, the instrument automatically calculates the Years/Performance curve (see Fig. 23) from which to derive the performance loss control value % used to calculate the I-V curve (see § 6.4.5 and § 11.3)



Fig. 23: Example of the Years/Performance curve of a PV module

The initial screen of the Database function is shown in the following Fig. 24:

PV DATABASE		15.17.05 2	7/07/202	3 X 📋
Manufacturer	Pmay	130.0	14/	
TER SOLAR.	r max	130.0		
TOTAL ENERGY	Voc	22.2	V	
TRIENERGIA	lsc	8.28	A	
TRINA SOLAR ENERGY	Vmpp	17.2	V	
TRINA SOLAR ENERGY (U.S) INC	Impp	7.56	А	
Model				
TRS 130 BLUE	Tol.(+)	4	%	
TRS 190 200P	Tol.(-)	0	%	
TRS 200 220M	TC(Isc)	0.050	%/°C	
TRS 200 220P	TC(Voc)	-0.56	%/°C	💙
TRS 210 220M	Perf.@Y	r1 0.0	%	
Find Edit		New	De	lete

Fig. 24: Database function initial screen

in which there are two sections:

Left-hand side

- > The list of PV module manufacturers in alphabetical order, as entered by the user (manually or via the management software HTAgorà) up to that point. A manufacturer is selected
- > The list of PV modules in alphabetical order associated with the selected manufacturer, as entered by the user (manually or via the management software HTAgorà) up to that point

Right-hand side

> List of parameters corresponding to the currently selected module. The list normally comprises several pages -> scroll up/down to view all the parameters

icon to select the currently highlighted PV module and use it for testing, or Tap on the icon to exit and return to the main menu on the

6.3.1. How to define a new PV module

1. Tap on the "**New**" button on the main screen to open the programming screen. The following window will appear on the display:



Fig. 25: Creating a new PV module - Step 1

- 2. Use the alphanumeric virtual keyboard to set the name of the manufacturer and the model. Tap on the *(ENTER)* button on the virtual keyboard to confirm each value and move on to the next item
- 3. Use the virtual numeric keypad to set the parameter values for the module according to the module data sheet, as shown in Fig. 26.
- 4. <u>If certain parameters are unknown</u>, tap on the "Default" key to enter the corresponding default value present in Table 1 (these values may also not be correct for the module being tested, so please contact the PV module manufacturer if necessary
- 5. Use the "**Meas. Unit**" key. to select the measurement unit of the tolerance associated to the power between the "%" or "**W**" options
- Tap on the (ENTER) button on the virtual keyboard to confirm each value and move on to the next item



Fig. 26: Creating a new PV module - Step 2

- 4. Scroll the display up/down to view all the parameters. For the "Type" parameter, <u>scroll</u> the thumb wheel to the <u>right or left</u> to set the PV module type (see Fig. 27). The following options are available:
 - STD → Standard Module (Monofacial)
 - ➢ Bifacial → Bifacial Module



PV DATABASE		15.17.05 27	/07/2023	X	Ü
		Yearsi@Perf.2 = 0.0Y			
Type STD		Type = STD			
N					
					_
Default	Meas. Unit	Save	Exit		

Fig. 27: Creating a new PV module - Step 3

5. Tap on the "**Save**" key to save the defined module and return to the main screen, or tap on the "**Exit**" key to exit the setting without saving

6.3.2. Modification of a PV module

1. Tap on the "Edit" key on the main screen. The following window will appear on the display:

PV DATABASE		15.17.05 27/07/2023 🗙	Ü		
SUNWIN GMBH	YUIOP/ HJKL:;	Manuf. = SUNWIN GMBH Type = SWM-180 54P Pmax = 180.0W Voc = 32.3V Isc = 7.84A Vmpp = 25.4V			
Impp = 7.14A Tol.(-) = 4W Tol.(+) = 4W Tol.(+) = 4W Tol.(+) = 0.038%/°C					
Find	Meas. Unit	Save Exit			

Fig. 28: Modification of an existing module

- 2. Use the virtual alphanumeric keyboard to change the parameters. Tap on the *(ENTER)* button on the virtual keyboard to confirm each value and move on to the next item
- 3. Tap on the "**Save**" key to save the changes and return to the main screen, or tap on the "**Exit**" key to exit the setting without saving



6.3.3. Searching for PV modules in the database



CAUTION

The search performed by the instrument is **positional**, i.e. the string entered will be searched within the lists starting from the first character to the left

1. Tap on the "**Find**" key on the main screen. The following window will appear on the display:

PV DATABASE		1	5.17.05 27	7/07/202	3 X 📋
Manufa	acturer	Zmay	130.0	14/	
TER SOLAR		max	130.0	vv	
TOTAL ENERGY	N	/oc	22.2	V	
TRIENERGIA	1	sc	8.28	A	
TRINA SOLAR ENER	RGY	/mpp	17.2	V	
TRINA SOLAR ENER	RGY (U.S) INC	mpp	7.56	А	
Mo	del	F-1 (+)	Α	0/	K I
TRS 130 BLUE		101.(+)	4	70	
TPS 100 2000	1	Tol.(-)	0	%	
Find module		TC(Isc)	0.050	%/°C	
Find an ender the second	,	FC(Voc)	-0.56	%/°C	
Find manufacturer	F	Perf.@Yr1	0.0	%	
Find	Edit	1	lew	Del	ete

Fig. 29: Searching for a module in the database

2. Tap on the "**Find module**" option to perform a search by module in the database. The following screen will appear on the display:

PV DATABASE				15.	.17	.05	27	/07	/20)23	×	(📋
Manufa	acturer	TR	si									
TER SOLAR												
TOTAL ENERGY												
TRIENERGIA												
TRINA SOLAR ENE	RGY											
TRINA SOLAR ENE	RGY (U.S) INC	_	_	_	_	_	_	_	_	_	_	
Mo	del	Q	w	E	R	т	Y	U		0	Р	1
TRS 130 BLUE			님	님	님	님	님	님	님	님		님
TRS 190 200P		Α	S	D	F	G	н	J	к	L	:	;
TRS 200 220M				z	x	c	v	в	N	м	•	
TRS 200 220P						屵				Ч		-11
TRS 210 220M		12	23	0	Ŋ.						•	-
Find	Edit	New					۵	Delet	e			

Fig. 30: Search by module

- 3. Use the alphanumeric virtual keyboard to enter the desired model name or a keyword and tap on ← (ENTER) on the virtual keyboard to confirm. The searched model (if present) will be highlighted on the display (see Fig. 30)
- 4. Tap on the "**Find manufacturer**" option to perform a search by manufacturer in the database. The following screen will appear on the display:

	PV DATABASE				15	.17	.05	27	/07	/20	23	X	ĺ
	Manufacturer			NINA/I	ы								
	SUNWIN GMBH			NVVI	N								
	SUNWIZE TECHNOLOGIES. INC												
	SUNNY GROUP LTD.												
	SUZHOU SHENGLONG PV-TECH CO.												
	SWAT-INTERNATIONAL				_	_	_	_		_	_	_	
	Model		Q	w	E	R	т	Y	υ	Т	0	Р	1
ľ	SWM-180 54P		⊨	\vdash	<u> </u>	H	님	님	\square	⊢	믬		
	SWM-180 72M		Α	S	D	F	G	н	J	к	L	:	;
	SWM18072MSF				z	x	c	v	в	N	м	•	3
	SWM-185 54P						\vdash						
	SWM-185 72M		12	23	(Ŋ						•	
	Find	Edit	New				Delete						

Fig. 31: Search by manufacturer

5. Use the alphanumeric virtual keyboard to enter the desired manufacturer's name or a keyword and tap on ← (ENTER) on the virtual keyboard to confirm. The searched manufacturer (if present) will be highlighted on the display (see Fig. 31)

6.3.4. Deleting a PV module

1. With the PV module highlighted in the main screen, tap on the "**Delete**" key. The following window will appear on the display:

PV DATABASE		1	5.17.05	27/07/202	3 X 📋					
Manufacture	r	Pmax	130.0	w						
TOTAL ENERGY		Voc	22.2	V						
TRIENERGIA		lsc	8.28	А						
TRINA SOLAR ENERGY			?	V						
TRINA SOLAR ENERGY			•	A						
Model				0/						
TRS 130 BLUE	Deverying	nt to doloto	242	70						
TRS 190 200P	Do you wa	Int to delete	IL ?	%						
TRS 200 220M		TC(Isc)	0.050	%/°C						
TRS 200 220P		TC(Voc)	-0.56	%/°C						
TRS 210 220M		Perf.@Yr1	0.0	%						
Find	Edit	New		Del	lete					
Fig.	Fig. 32: Deleting a PV module									

2. Tap on the key to confirm. The highlighted module will be removed from the database; alternatively, tap on the key to exit without proceeding

6.3.5. Restore PV modules database

If the PV modules database saved on the instrument is corrupt and is no longer accessible due to improper operations by the user or internal damages, it is possible to <u>restore the</u> <u>factory database (default)</u> in order to continue with the measurements To this end, proceed as follows:

- 1. Tap on the "Settings" in the general menu
- 2. Tap on the "Reset Database" key. The following message is shown on the display:

English
700 W/m2 i reset modules database? OFF OFF

Fig. 33: Reset PV modules database

3. Tap on the exit without proceeding

CAUTION The "Reset Database" command <u>permanently deletes</u> all the modules saved in the instrument database The restore of deleted modules could be possible via connection to a PC (see § 8) if the modules had been saved within the HTAgorà management software

6.4. I-V – MEASURING THE I-V CURVE

6.4.1. General information

The instrument allows measuring the I-V curve on PV modules/strings/fields (see § 11.1) in the following modes:

- SOLAR03 remote unit NOT connected → In this case the instrument does not receive any irradiation and temperature measurements and provides ONLY the parameter values at @OPC conditions as a result without any outcome to quickly evaluate only the trend of the curve to understand any situations environmental on the PV field (shading, mismatch, etc.). Any post-processing of the data can be carried out with the HTAgorà management software. See § 6.6.2 for connection methods
- SOLAR03 remote unit connected (recommended test) → In this case the instrument receives the irradiation and temperature measurements and provides the complete numerical results and curves at @STC conditions. Irradiance measurements are performed via one or more HT305 reference cells (in the case of Bifacial modules) connected to the SOLAR03 remote unit



CAUTION

For the irradiation measurements carried out with the **HT305** reference cell(s) <u>it</u> <u>is not necessary</u> to set the relative sensitivity and alpha values which are **automatically** managed by the SOLAR03 after connecting these accessories to this remote unit

The I-V600 instrument can acquire the module temperature value (also **essential** for calculating values under @STC conditions) as follows:

- "Meas.": temperature measured via the PT305 probe connected to SOLAR03
- "Auto": temperature calculated by the instrument on the basis of the measured open circuit voltage Voc and the nominal parameters of the module

In general, the instrument and the SOLAR03 unit can operate in the following modes:

- Instrument used in Bluetooth direct connection with SOLAR03 remote unit without recording of irradiance/temperature values
- Instrument used in direct connection with the SOLAR03 remote unit with prior start of synchronous recording of irradiance/temperature values. If the connection between the instrument and the remote unit is critical (long distance or transmission through walls/obstacles), the irradiance values (and temperature, if selected) will be transmitted at the end of the session by bringing the two units closer together and stopping recording

The Current/Voltage value pairs describing the I-V curve are initially acquired under **OPC conditions (O**perative **C**onditions), i.e. under the actual conditions of the plant. Using the irradiance/temperature values, the instrument then automatically converts these pairs to **STC** conditions (**S**tandard **Test Condition** - Irradiance = $1000W/m^2$, Module Temperature = 25 °C, Spectral Distribution AM=1.5) for comparison with the nominal characteristics declared by the module manufacturer (and stored in the instrument's internal database).

6.4.2. I-V Curve test without remote unit SOLAR03

CAUTION

• The maximum voltage between the P1, C1, P2 and C2 inputs is 1500VDC. Do not measure voltages exceeding the limits given in this manual.



- Do not perform tests on PV modules or strings connected to the DC/AC converter.
- The maximum current measured by the instrument is 40A
 - Standard IEC/EN62446-1 requires that measurements are performed string by string. Even if the instrument is designed to handle inrush current for single strings or strings connected in parallel, we recommend testing one string at a time in accordance with the standard.
- 1. Switch on the instrument by pressing the ON/OFF key
- 2. Note the presence of the "X" in the top right corner of the display to indicate the absence of an active SOLAR03 remote unit connected to the instrument. If not, execute the "**Unpair**" command for the currently active unit (see § 6.2)
- 3. Connect the instrument to the module/string being tested as shown in Fig. 34. In particular, connect the Negative pole of the module/string to the **P2, C2** terminals and the Positive pole from the module/string to the **P1, C1** terminals



Fig. 34: Connection for I-V test without remote unit SOLAR03

- 4. In the case of **Monofacial** modules, the screen of Fig. 35 is shown on the display. The following parameters are indicated:
 - VPN voltage between positive and negative pole of the string
 - > Module temperature with "- -" indication as remote unit not connected
 - Module irradiance with "- -" indication as remote unit not connected
 - Display of currently selected PV module
 - References of C1, P1, C2, P2 terminals connected to the instrument

IV TEST		15.17.05 27	7/07/2023 X 📋
	v	P-N	
	60	5 V	
		Investions	_
	Module Temp.	Irradianc	e
>	°C	V	V/m2
	Module: SP	/355-R60LWMG	
Menu	Settings	Help	Start
	U U		

Fig. 35: Initial I-V test screen without remote unit on Monofacial modules

- 5. In the case of **Bifacial** modules, the screen of Fig. 36 is shown on the display. The following parameters are indicated:
 - > VPN voltage between positive and negative pole of the string
 - > Module temperature with "- -" indication as remote unit not connected
 - > Irradiance of the front with "- -" indication as remote unit not connected
 - > Irradiance of the back with "- -" indication as remote unit not connected
 - Display of currently selected PV module
 - > References of C1, P1, C2, P2 terminals connected to the instrument

IV TEST		15.17.05 27	7/07/2023 🗙 📋						
	V	P-N							
	760	V							
Module Temp	Irradianc	e Rear	Irradiance						
°C	 W /	m2 = =	– – W/m2						
	Module: JKM560N-72HL4-BDV								
Menu	Settings	Help	Start						

Fig. 36: Initial I-V test screen without remote unit on Bifacial modules

- 6. Tap on the "**Settings**" key (Monofacial module reference). The following screen is shown in Fig. 60. The following parameters are given:
 - Reference values of the currently selected module
 - Parameters of the test string to be programmed
 - Icon icon icon to exit without saving

IV	SETTIN	IGS			15.17.0	5 27/07/20	23 X 📋
	PV M	odule					
	SPV355	-R60LWMG		Num. N	lod.	15	
	Tol.(+)	5	%	N. Strin	g. Paral.	1	
	Tol.(-)	5	%	Temp. N	Node	Auto	
)	TC(lsc)	0.050	%/°C	Yrs of s	ervice	5.0	
	TC(Voc)	-0.56	%/°C	IV Debi	pr	OFF	
	Rs	1.0	Ω		3	UFF	
	Perf.@Yr1	0.0	%				
	Туре	STD					
	PV Module				SOLAR03		

Fig. 37: Settings parameters I-V test without remote unit

- 7. Tap on the "**PV Module**" key to change the PV module to be tested. The instrument opens the DB section, where a new module can be selected from the list in the DB section (see § 6.3)
- 8. <u>Drag</u> each of the 5 available thumb wheels to the <u>right or left</u> to set the desired value of the following parameters:
 - > Num. Mod \rightarrow to set the number of modules in the string being tested (max. 60)
 - > N. String Paral. → to set the number of strings in parallel (max. 5). Setting "1" indicates the presence of only one overall string
 - ➤ Temp. Mode → to set the module temperature measurement mode. The following options are available: Auto (temperature calculated by the instrument based on the Voc measurement and the nominal parameters of the module- no probe connected and recommended option), Meas. (temperature measured via PT305 probe connected to the SOLAR03 remote unit)
 - Yrs of service (setting the number of years of operation of the PV system being tested in the range 0.1 ÷ 49.9 years with 0.1-year increments), considering that 0.5 years = 6 months. This information is used by the instrument to determine the I-V curve
 - > IV Debug \rightarrow this function (see § 6.5.1) <u>must only be used in operations with the</u> <u>HT assistance service</u>. The option MUST always be set to **OFF**

CAUTION

• When **START/STOP** (or **Start** on the display) is pressed, the instrument may give various error messages (see § 6.4.6) and, as a result, fail to perform the test. Check and, if possible, eliminate the cause of the problem before proceeding.



- The method used by the instrument meter for output VDC and IDC measurements of PV module/string is the "4-wire". Therefore, it is possible to use also test cables connected to P1, C1, P2, C2 inputs of different length without performing any calibration of cable resistance. For extensions, only use accessories supplied by HT
- 9. Press the START/STOP key (or Start on the display) to activate the tests. If there are no error conditions, the instrument will show the icon "∑ on the display for a few moments together with the message "Measuring..." The test can take up to approximately 20 seconds, depending on the open circuit voltage and module parameters. In the absence of a direct connection to the SOLAR03 unit, the instrument will show <u>only the measured values @OPC without the irradiance and module temperature references</u> (see Fig. 38) and without final result





IV	TEST					15.17.05 2	7/07/20	23 X 📋
	OPC Val	ues						
		Test Para	imeters			Results - OPC	;	
	Nmod	1x	1	In	r		W/m2	
	Year	10)	Pi	max	71.4	W	
	Perform.	0.	0 %	т	Mod.		°C	
				Vo	oc	56.0	V	
				Vi	mpp	46.5	V	
				In	прр	1.54	А	
				ls	с	1.66	А	
			Mod	ule: SP	R-318E	EWHTD		
	Menu Current		t		Help		Start	

Fig. 38: I-V curve measurement result without remote unit

10. Tap on 🛅 to save the measurement (see § 7.1) or the icon 🗲 to exit without saving



6.4.3. I-V Curve test with remote unit SOLAR03 in direct connection

CAUTION

• The maximum voltage between the P1, C1, P2 and C2 inputs is 1500VDC. Do not measure voltages exceeding the limits given in this manual.



- Do not perform tests on PV modules or strings connected to the DC/AC converter.
- The maximum current measured by the instrument is 40A
 - Standard IEC/EN62446-1 requires that measurements are performed string by string. Even if the instrument is designed to handle inrush current for single strings or strings connected in parallel, we recommend testing **one string at a time** in accordance with the standard.
- 1. Switch on the instrument by pressing the **ON/OFF** key
- 2. Switch on the SOLAR03 remote unit, pair it with and connect it to the instrument as described in § 6.2. Note the presence of the "🖥" icon in the top right corner of the display
- 3. Connect the instrument and the SOLAR03 remote unit to the module/string being tested as shown in Fig. 39. In detail:
 - Connect the Negative pole output of the module/string to terminals P2, C2 and the Positive pole output of the module/string to terminals P1, C1
 - ➤ In case of Monofacial modules → position the reference cell HT305 onto the front surface of module (F) and at input "INP1" and possibly temperature probe PT305 at input "INP4" of the remote unit.
 - In case of Bifacial modules ->, position the three HT305 reference cells on the front surface of module (F), on the top back section(BT=BackTop) and on the bottom back section (BB=BackBottom) of the module. Connect the front reference cell (F) to input "INP1", BT reference cell to input "INP2", BB reference cell to input "INP3" and possibly the temperature probe PT305 to input "INP4" of the remote unit.

In accordance with the IEC/EN60904-1-2 standard, the instrument calculates the equivalent front-side Irradiance (Irreq) value, which corresponds to the Irradiance on the front surface only, which produces the same effects as the Irradiance measured on both sides, considering the **bifaciality factor** (ϕ) of the module according to the following relationship:

 $Irr_{Eq} = Irr_F + \varphi \times Irr_R$



Fig. 39: Connection with remote unit SOLAR03 on Monofacial and Bifacial modules



- 4. In the case of **Monofacial** modules, the Fig. 40 screen is present on the display. The following parameters are shown:
 - > VPN voltage between positive and negative pole of the string
 - Module temperature (with PT305 probe connected)
 - Module irradiance measured by reference cell HT305
 - Display of currently selected PV module
 - > References of C1, P1, C2, P2 terminals connected to the instrument

IV TEST		15.17.05 27	7/07/2023	Ü
	VF	P-N		
	605	V		
	Module Temp.		e //m2	
	5.5 0	930.2	//11/2	
	Module: SPV3	55-R60LWMG		
Menu	Settings	Help	Start	

Fig. 40: Initial I-V curve measurement screen on Monofacial modules

- 5. In the case of **Bifacial** modules, the screenFig. 40 is present on the display. The following parameters are shown:
 - > VPN voltage between positive and negative pole of the string
 - Module temperature (with PT305 probe connected)
 - Irradiance of the front side of the module measured by reference cell HT305
 - Irradiance of the back side of the module measured by reference cells HT305



CAUTION

The "**Rear Irradiance**" parameter indicates the **minimum value** between the irradiance measured by the HT305 cells at the bottom back (BB) and top back (BT) of the module

- Display of currently selected PV module
- References of C1, P1, C2, P2 terminals connected to the instrument

IV TEST	C1 P1 C2 P2 0 0 0 0	15.17.05 27	/07/2023 🗄	Ű
	760	2-N V		
) Module Temp. 55.3°C	Irradiance 930.2 W	e Real 1/m2 34	r Irradiance 7.5 W/m2	
Menu	Settings	Help	Start	

Fig. 41: Initial I-V curve measurement screen on Bifacial modules
- 6. Tap on the "**Settings**" key (Monofacial module reference). The following screen is shown in Fig. 42. The following parameters are given:
 - > References of the currently selected module
 - > Parameters of the test string to be programmed
 - Icon 1 to save the settings and return to the main screen, or icon 1 to exit without saving

IV	SETTIN	IGS			15.17.0	05 27/07/20	23 🗄 📋
	PV M	odule					
	SPV355	-R60LWMG		Nur	n. Mod.	15	
	Tol.(+)	5	%	N. 5	String. Paral.	1	
5	Tol.(-) TC(lsc)	5 0.050	% %/°C	Ten	np. Mode	Auto	
	TC(Voc)	-0.56	%/°C	Yrs	of service	5.0	
	Rs	1.0	Ω	IV E	Debug	OFF	
	Perf.@Yr1 Type	0.0 STD	%				
	PV Mod	ule			SOLAR03		

Fig. 42: I-V curve measurement parameter settings

- 7. Tap on the "**PV Module**" key to change the PV module to be tested. The instrument opens the DB section, where a new module can be selected from the list in the DB section (see § 6.3)
- 3. <u>Drag</u> each of the 4 available thumb wheels to the <u>right or left</u> to set the desired value of the following parameters:
 - > Num. Mod \rightarrow to set the number of modules in the string being tested (max. 60)
 - > N. String Paral. \rightarrow to set the number of strings in parallel (max. 5). Setting "1" indicates the presence of only one overall string
 - ➤ Temp. Mode → to set the module temperature measurement mode. The following options are available: Auto (temperature calculated by the instrument based on the Voc measurement and the nominal parameters of the module- no probe connected and recommended option), Meas. (temperature measured via PT305 probe connected to the SOLAR03 remote unit)
 - Yrs of service (setting the number of years of operation of the PV system being tested in the range 0.1 ÷ 49.9 years with 0.1-year increments), considering that 0.5 years = 6 months. This information is used by the instrument to determine the I-V curve
 - > IV Debug \rightarrow this function (see § 6.5.1) <u>must only be used in operations with the</u> <u>HT assistance service</u>. The option MUST always be set to **OFF**
- 8. Tap on the "**SOLAR03**" key to access the control and management section of the SOLAR03 remote unit (see § 6.2). Check that the remote unit is active and connected to the instrument
- 9. Check that the value set in the "Min. Irradiance" section (see § 5.2) is consistent with the measurements to be taken. It is recommended to measure with a threshold of \geq 700 W/m² in accordance with the IEC/EN60891 standard.

10.Assemble the stem onto the disk of the accessory M304 and keep it resting on the module's surface. Check that the shadow of the stem on the disk falls within the internal "limit concentric circle" of the disk itself (see picture). If this is not the case, the angle between the sun's rays and the module surface is high therefore too and the measurements taken by the instrument reliable. are NOT Repeat the operations at other times of the day



CAUTION

- When **START/STOP** (or **Start** on the display) is pressed, the instrument may give various error messages (see § 6.4.6) and, as a result, fail to perform the test. Check and, if possible, eliminate the cause of the problem before proceeding.
- The method used by the instrument meter for output VDC and IDC measurements of PV module/string is the "4-wire". Therefore, it is possible to use also test cables connected to P1, C1, P2, C2 inputs of different length without performing any calibration of cable resistance. For extensions, only use accessories supplied by HT
- 11.Press the **START/STOP** key (or **Start** on the display) to activate the test. If there are no error conditions, the instrument will show the icon " "" on the display for a few moments together with the message "**Measuring**..." The test can take **up to approximately 20 seconds**, depending on the open circuit voltage and module parameters. At the end of the test, **the values related to the @STC conditions**, and the corresponding result are displayed (here below, for convenience, <u>only Monofacial modules are referred to (the results for bifacial modules are similar as they refer to the equivalent front-side Irradiance</u>

IV	TEST					15.17.05 2	7/07/2	023 🗄 📋
	STC Valu	les						
		Nominal V	/alues			Results - STC		
	Pmax	318.	0 w	Pr	nax	319.3	W	
	$\Delta P\%$	-3/+5	5 %	ΔP	%	0.4	%	
	Voc	64.7	v	Vo	С	64.3	V	
/	Vmpp	54.6	v	Vn	прр	52.6	V	
	Impp	5.82	A	Im	рр	6.07	А	
	lsc	6.20	А	Isc	>	6.47	A	
	Module				R-318E	EWHTD		
Menu Settings				Help		Start		

Fig. 43: Example of I-V curve measurement result - STC values

12. The measurement result screen shows the following parameters:

- Nominal values of the module being tested under STC conditions as defined in the internal DB (see § 6.3)
- Measurement results calculated under STC conditions as a function of irradiance values measured by the connected SOLAR03 remote unit
- Indication of the value of the parameter Δp% in compliance with the control conditions shown in § 6.4.5
- Icons , Ico
- 13. The following additional results can be viewed by scrolling left or right. **Results under OPC conditions**: the following screen appears on the display:

IV	/ TEST					15.17.05 2	7/07/20	23 🖥 📋
	OPC Values							
	Te	st Parar	neters			Results - OPC		
	Nmod	1x	1	Irr		252.9	W/m2	
	Year	10)	Pn	nax	71.4	W	
	Perform.	0.0	0 %	ТІ	Mod.	47.1	°C	
)				Vo	C	56.0	V	
				Vn	npp	46.5	V	
				Im	рр	1.54	А	
				lso	2	1.66	А	
			Modul	e: SPF	R-318E	WHTD		
	Menu		Current			Help		Start



- 14. The measurement result screen shows the following parameters:
 - Values of the test parameters set in the main screen (number of modules, number of strings in parallel, years of operation and annual performance percentage)
 - Measurement results of electrical and environmental parameters (irradiance and module temperature) under OPC conditions
- 15. Graphs of I-V and power curves under OPC and STC conditions. Examples of screens are shown in the following figures



Fig. 45: Example of I-V curve measurement result - STC curve



Fig. 46: Example of power measurement result - STC curve



 The instrument refers all the values to <u>one module only</u> under STC condition
 The string voltage obtained at OPC indicates the total measured value. Together with the measured current, the instrument calculates the I-V curve @ OPC which is then translated to the @STC conditions

CAUTION

16.Tap on the 🛅 icon to save the measurement result (see § 7.1) or on the 🗲 icon to exit without saving

6.4.4. I-V Curve test with remote unit SOLAR03 in synchronous recording

Irradiance and temperature measurements (if the instrument is set to temperature measurement mode "Meas.") via SOLAR03 remote unit in synchronous recording are recommended if the distance between the modules and the instrument is significant. On the other hand, since it is impossible for the instrument to obtain the above environmental values immediately, it is necessary to wait for the data to be transmitted from the remote unit to the main unit to have all the available results.

CAUTION

- The maximum voltage between the P1, C1, P2 and C2 inputs is 1500VDC. Do not measure voltages exceeding the limits given in this manual.
- Do not perform tests on PV modules or strings connected to the DC/AC converter.
- $\underline{\mathbb{N}}$
- The maximum current measured by the instrument is 40A
- Standard IEC/EN62446 requires that measurements are performed string by string. Even if the instrument is designed to handle inrush current for single strings or strings connected in parallel, we recommend testing **one string at a time** in accordance with the standard.
- 1. Switch on the instrument by pressing the ON/OFF key
- Connect the instrument to the module/string being tested as shown in Fig. 47 (Monofacial modules) or Fig. 48 (Bifacial modules). In detail, connect the negative pole output of the module/string to terminals P2, C2 and the positive pole output of the module/string to terminals P1, C1



Fig. 47: Connection with SOLAR03 in synchronous recording on Monofacial modules



Fig. 48: Connection with SOLAR03 in synchronous recording on Bifacial modules

<u>Step 1</u>

3. Move the SOLAR03 remote unit close to the instrument as shown in Fig. 47 or Fig. 48 – left side part



- 4. Tap on the "**SOLAR03**" key to access the control and management section of the SOLAR03 remote unit (see § 6.2). Check that **only one** remote unit is active and connected to the instrument
- 5. Tap on the "**Run/Stop**" key to start recording on the connected remote unit; the following screen will be displayed:



6. Tap on 💽 to confirm or tap on 🗲 to exit without proceeding. Recording is performed

Tap on solution to confirm or tap on solution to exit without proceeding. Recording is performed with a **1s non-editable scan** and the message "**REC**" appears on the remote unit display to indicate the operation in progress

S	OLAR03			15	5.17.05	27/07	/2023		Ü
	SOLAR03 2	3070001	Connect	ted	Rec.	V			
	h							4	
1	SOLAR03 - SN: 23070001								
	Status: idle	.02					Г		_
	Battery: 53% Free memory: 0d	lays 2hours						0	
	N. of measures to	o sync.: 0					L	~	
	Find	Ur	npair	De	lete		Run/Sto	р	
F	Fig. 50: Recording Activation on Remote Unit - Step 2								

7. The ⁵ icon and the message "**Rec.**" are shown on the display and the message "REC" is shown on the display of the remote unit

<u>Step 2</u>

- 8. <u>Move the remote unit close to the modules</u> and connect the irradiance and temperature probes (if necessary) as shown in Fig. 47 or Fig. 48 middle side part. In particular:
 - ➤ In case of Monofacial modules → position the reference cell HT305 onto the front surface of module (F) and at input "INP1" and possibly temperature probe PT305 at input "INP4" of the remote unit
 - ▶ In case of Bifacial modules →, position the three HT305 reference cells on the front surface of module (F), on the top back section(BT=BackTop) and on the bottom back section (BB=BackBottom) of the module. Connect the front reference cell (F) to input "INP1", BT reference cell to input "INP2", BB reference cell to input "INP3" and possibly the temperature probe PT305 to input "INP4" of the remote unit. In accordance with the IEC/EN60904-1-2 standard, the instrument calculates the equivalent front-side Irradiance (Irreq) value, which corresponds to the Irradiance on the front surface only, which produces the same effects as the Irradiance measured on both sides, considering the bifaciality factor (ϕ) of the module according to the following relationship:

$$Irr_{Eq} = Irr_F + \varphi \times Irr_R$$

- Since recording has already been activated on remote unit SOLAR03, it is not necessary to maintain the Bluetooth connection anymore. Maintaining the connection will only allow to immediately obtain the outcome of the test without waiting for the measuring campaign to be completed.
- 10.In the case of **Monofacial** modules, the Fig. 51 screen is shown on the display. The following parameters are indicated:
 - > VPN voltage between positive and negative pole of the string
 - > Module temperature with "- -" indication as the remote unit is not connected
 - > Module irradiance with "- -" indication as the remote unit is not connected
 - Display of currently selected PV module
 - > References of C1, P1, C2, P2 terminals connected to the instrument



Fig. 51: I-V curve with SOLAR03 in synchronous recording on Monofacial modules

- 11.In the case of **Bifacial** modules, the screen Fig. 52 is shown on the display. The following parameters are indicated:
 - VPN voltage between positive and negative pole of the string
 - > Module temperature with "- -" indication as the remote unit is not connected
 - > Irradiance of the front side with "- -" indication as the remote unit is not connected
 - > Irradiance of the rear side with "- -" indication as the remote unit is not connected



CAUTION

The "**Rear Irradiance**" parameter indicates the **minimum value** between the irradiance measured by the HT305 cells at the bottom back (BB) and top back (BT) of the module

- > Display of currently selected PV module
- > References of C1, P1, C2, P2 terminals connected to the instrument

IV TEST		15.17.05 27	7/07/2023 🗙 📋
	VI	2-N	
	760	V	
\mathbf{b}			
Module Temp.	Irradianc	e Rear	Irradiance
°C	 W/	′m2 = =	= = W/m2
	Module: JKM56	0N-72HL4-BDV	
Menu	Settings	Help	Start

Fig. 52: I-V curve with SOLAR03 in synchronous recording on Bifacial modules

- 12. Tap on the "**Settings**" key (Monofacial module reference). The following screen is shown in Fig. 42. The following parameters are given:
 - > References of the currently selected module
 - Parameters of the test string to be programmed
 - Icon to save the settings and return to the main screen, or icon to exit without saving

I١	/ SETTIN	IGS			15.17.	05 27	/07/202	23 🔀 📋
	PV M	odule						
	SPV355	-R60LWMG		Num	. Mod.		15	
	Tol.(+)	5	%	N. St	ring. Paral.		1	
	Tol.(-)	5	%	Tem	o. Mode	A	uto	
$\mathbf{>}$	TC(Isc)	0.050	%/°C	Vro	faaniaa		5.0	
ľ	TC(Voc)	-0.56	%/°C	fisc	I Service		5.0	
	Rs	1.0	Ω					\square
	Perf.@Yr1	0.0	%					
	Туре	STD						
	PV Mod	ule			SOLAR0	3		

Fig. 53: I-V curve measurement parameter settings

- 13. Tap on the "**PV Module**" key to change the PV module to be tested. The instrument opens the DB section, where a new module can be selected from the list in the DB section (see § 6.3)
- 14.<u>Drag</u> each of the 5 available thumb wheels to the <u>right or left</u> to set the desired value of the following parameters:
 - > Num. Mod \rightarrow to set the number of modules in the string being tested (max. 60)
 - N. String Paral. → to set the number of strings in parallel (max. 5). Setting "1" indicates the presence of only one overall string
 - ➤ Temp. Mode → to set the module temperature measurement mode. The following options are available: Auto (temperature calculated by the instrument based on the Voc measurement and the nominal parameters of the module- no probe connected and recommended option), Meas. (temperature measured via PT305 probe connected to the SOLAR03 remote unit)
 - Yrs of service (setting the number of years of operation of the PV system being tested in the range 0.1 ÷ 49.9 years with 0.1-year increments), considering that 0.5 years = 6 months. This information is used by the instrument to determine the I-V curve
 - ➢ IV Debug → this function (see § 6.5.1) <u>must only be used in operations with the</u> <u>HT assistance service</u>. The option MUST always be set to OFF
- 15.Assemble the stem onto the disk of the accessory M304 and keep it resting on the module's surface. Check that the shadow of the stem on the disk falls within the internal "limit concentric circle" of the disk itself (see picture). If this is not the case, the angle between the sun's rays and the module surface is too high and therefore the measurements taken by the instrument NOT reliable. Repeat the are operations at other times of the day



CAUTION

 When START/STOP (or Start on the display) is pressed, the instrument may give various error messages (see § 6.4.6) and, as a result, fail to perform the test. Check and, if possible, eliminate the cause of the problem before proceeding.



- The method used by the instrument meter for output VDC and IDC measurements of PV module/string is the "4-wire". Therefore, it is possible to use also test cables connected to P1, C1, P2, C2 inputs of different length without performing any calibration of cable resistance. For extensions, only use accessories supplied by HT
- The settings made on the instrument control parameters can be modified at any time even while recording is in progress



16.Press the **START/STOP** key (or **Start** on the display) to activate the tests. If there are no error conditions, the instrument will show the icon " and the display for a few moments together with the message "**Measuring**..." The test can take **up to approximately 20 seconds**, depending on the open circuit voltage and module parameters.

In the absence of a direct connection to the SOLAR03 unit, the instrument will show <u>only</u> the measured values @OPC without the irradiance and module temperature references (see Fig. 54) and final result.

To obtain the final result (@STC values) of the tests performed, it is necessary to wait for the end of the test session, the stop of the recording and the <u>subsequent</u> <u>synchronisation</u> with the SOLAR03 remote unit.

IV	TEST		000	2 P2 0			15.17.05	27/07/20	23 X 🛍
	OPC Value	es							
	1	lest Para	meters				Results - OP	C	
	Nmod	1x	1		Irr			W/m2	
	Year	10)		Pm	iax	71.4	W	
	Perform.	0.0	0	%	ΤN	lod.		°C	
					Voo	C	56.0	V	
ſ					Vm	рр	46.5	V	
					Imp	ор	1.54	А	
					Isc		1.66	А	
	Module: S			SPR	-318EV	VHTD			
	Menu		С	urrent			Help		Start

Fig. 54: I-V curve measurement result @OPC with synchronous recording

17. Tap on the ticon to save the measurements to the internal memory (see § 7.1) or on the the icon to exit without saving

<u>Step 3</u>

- 18. <u>At the end of the test session</u>, disconnect the SOLAR03 remote unit and move it back close to the instrument (se Fig. 47 or Fig. 48 right side part)
- 19.Tap on the "**SOLAR03**" key to access the control and management section of the SOLAR03 remote unit (see § 6.2) and wait for the automatic reconnection to the instrument. The "**N. of measures to sync.**" parameter indicates the value of the stored measurements waiting for values from the SOLAR03 unit.
- 20. Tap on the "Run/Stop" key to end the recording. The following screen will appear

SOLAR03		15.17	.05 27/	07/2023	
SOLAR03 230)70001 Connec	ted Rec.		2	
SOLAR03 - SN: 23 FW: 1.00 - HW: 1.0 Status: idle Battery: 53% Free memory: 0day N. of measures to s	070 Do u want to st ys 2hours sync.: 0	op recording?			
Find	Unpair	Delete		Run/Sto	р

Fig. 55: Ending recording on the remote unit





- 21. Tap on the 🕑 key to confirm or on the 💻 key to exit without proceeding
- 22. The synchronization of the pending @OPC measurements, the translation of the @STC values and the subsequent saving are performed **automatically** by the instrument. The "**N. of measures to sync**" parameter must take on the value "0" once the operations are completed
- 23. Tap on the 🕑 icon if there are some errors, to reactivate synchronization again
- 24.Access the memory area (see § 7.2) to retrieve the saved measurements

CAUTION

The instrument translates @OPC results to @STC values when the following conditions occur:

14.Voltage Voc > Voc minimum = 15V



- 15.**Frontal** irradiance values (also valid for bifacial modules) detected as greater than the minimum threshold set on the instrument (>100W/m²) and **stable** (variation between the start and end of the measurement campaign **±20 W/m²**)
- 16. Open voltage Voc measured consistent with expected value indicated in the module datasheet
- 17.Module temperature value included in the range: -40°C ÷ 100°C (-40°F ÷ 212°F)
- 18.Short-circuit current value Isc > Iscmin = 0.2A
- 25.See the § 6.4.5 for the meaning of measurement results

6.4.5. Interpretation of measurement results

The parameter measured and calculated by meter have the following meaning:

Parameter	er Description			
Pmax Maximum module power (@STC) measured by the instrument				
△P% Difference % of maximum measured power from nominal power (@ S ⁻				
Voc	Open circuit voltage			
Vmpp	Voltage on point of maximum power			
lsc	Short circuit current			
Impp	Current on point of maximum power			

Table 2: List of parameters measured by the meter

Where:

 $\Delta P\% = \left(\frac{P_{STC}^{Max} - P_{Perf}^{Nom}}{P_{Perf}^{Nom}}\right) * 100 \rightarrow \text{control parameter that defines the final test result}$

$$P_{Perf}^{Nom} = P_{Nom} * \left(1 - \frac{PerfLoss\% * YearService}{100}\right)$$

Rated power with performance loss effect (see § 6.3 and § 11.3)

 P_{Nom} = rated power @STC of the module as declared by the manufacturer *PerfLoss*% = performance loss % calculated based on the data entered in the DB (see § 11.3)

The following final response is gives by the instrument:

Outcome	Condition	Note	Description
~	- (ToI-) + ℇ _{Instrum} ≤ ℇ _{Meas} ≤ (ToI+) - ℇ _{Instrum}	(1)	Test OK
*	Relation (1) is not verified but still applies: - (Tol-) ≤ ᢄ _{Meas} ≤ (Tol+)	(2)	Acceptable test
×	Relations (1) and (2) are not verified, but still apply: - (Tol-) - $\mathcal{E}_{\text{Instrum}} \leq \mathcal{E}_{\text{Meas}} \leq (\text{Tol+}) + \mathcal{E}_{\text{Instrum}}$	(3)	Test not acceptable
8	None of the relations (1), (2) and (3) are verified	(4)	Test NOT OK

where:

Tol- = Tol%(-) * $P_{Nom} \rightarrow$ Negative tolerance of the power declared by manufacturer

Tol+ = Tol%(+) * $P_{Nom} \rightarrow$ Positive tolerance of the power declared by manufacturer

 $\mathcal{E}_{\text{Meas}} = P_{STC}^{Max} - P_{Perf}^{Nom} \rightarrow \text{Control parameter calculated by the instrument}$

NOTE: the value P_{STC}^{Max} is obtained in compliance with **IEC/EN60891**

 $\mathcal{E}_{Strum} \rightarrow Maximum$ instrumental error declared on P(@STC) (see § 10.1)



Application example (measurement with remote unit)

- Module name: JKM575N-72HL4-BDV (JINKO manufacturer)
- Module type: Bifacial
- ➢ Nominal power (@STC): 575W
- Tolerance Power (@STC): -0% / +3%
- Performance loss calculated: 1.3%
- Service year: 1 year
- Measured power (@STC): 547W

Tol+ = Tol%(+) * Pnom = 0.03 * 575V = 17.3W Tol- = Tol%(-) * Pnom = 0W

$$P_{Perf}^{Nom} = 575 * \left(1 - \frac{1.3 * 1}{100}\right) = 567W$$

 $\mathcal{E}_{\text{Instrum}} = \pm (547 * 0.04 + 2) = \pm 23.88W$

 $\mathcal{E}_{\text{Meas}} = 547 - 567 = -20W$

Comparison conditions:

Power \rightarrow 0 +23.88 \leq -20 \leq 17.3 - 23.88 \rightarrow Condition 1 NOT verified Power \rightarrow 0 \leq -20 \leq 17.3 \rightarrow Condition 2 NOT verified Power \rightarrow - 23.88 \leq -20 \leq 17.3 + 23.88 \rightarrow Condition 3 verified \rightarrow **Outcome (*)**

6.4.6. Anomalous situations



If the instrument detects a voltage of **-0.5V≤VPN≤15VDC** at the P-N terminals of the string, it does not perform the test, emits a prolonged audible signal and displays the message shown in the screen alongside. Check the tension on the string



If the instrument detects a voltage <-0.5VDC at the P-N terminals of the string, it does not perform the test, emits a prolonged audible signal and displays the message shown in the screen alongside. Check the connections of the string poles

IV TEST	C1 P1 C2 P2 0 0 0 0	15.17.05 2	7/07/2023 🗙 📋
	v	P-N	
	10	52 V	
>	Module Solaro3	is not connected	V/m2
	Module: SP	/355-R60LWMG	
Menu	Settings	Help	Start

If the SOLAR03 remote unit is active but **not connected and not recording**, the instrument does not perform the test and displays the message shown in the screen alongside. Connect the SOLAR03 remote unit





If, with the remote unit active and connected (even in recording mode), the instrument detects an irradiance value below the threshold (see § 5.2), it stops the test and returns to the main screen. Check the threshold value and carry out the tests at another time of the day with stable irradiation

If, during the execution of an I-V IVCK or measurement. the instrument is unable to determine the @STC values, it displays the message shown in the screen alongside. Check that you have stable irradiation, in addition to the correct exceeding of the minimum threshold and that you have carried out the measurement in accordance with the indications of the M304 accessory (see § 6.4.2 - point 10). Repeat the measurements at other times of the day if necessary

If the instrument detects, at the end of the test, a Voc too much different from the open-circuit voltage measured before starting the test, the message alongside is shown on the display This condition could be due to the execution of tests on poor quality modules and/or too low short circuit current and/or measurements carried out with too low irradiance









In the event of an error within the module database (e.g.: database corruption), the instrument blocks the test and the message alongside is shown on the display.

Restore the default database (see § 6.3.5) to continue with the measures



If a string voltage **greater than 1500V DC** is detected, the instrument stops the test and the message alongside is shown on the display.

Check the characteristics of the module, the number of modules in the string and possibly reduce the number in order to perform the test

6.5. LIST OF ERROR MESSAGES ON THE DISPLAY

Number	Actions on instruments	Result after actions		
1	No possible action	Send instrument to HT support		
2	Turn off/on the instrument and try again the measurements	If error continues after actions, send instrument to HT support		
3	Check the measurement cables, the type of module, the Voc parameters, Voc temperature coefficient,	If error continues after actions, perform Debug		
4	number of modules and irradiation conditions	procedure (see § 0.5.1) and contact TT support		
5	No possible action	Send instrument to HT support		
6, 8, 13, 14, 15	Check the measurement cables, the type of module, the Voc parameters, Voc temperature coefficient, number of modules and irradiation conditions	If error continues after actions, perform Debug procedure (see § 6.5.1) and contact HT support		
16	In "MEAS" mode the temperature probe is not recognized. Check if the PT305 probe is damaged or not properly attached to the module	If error continues after actions, send SOLAR03 and PT305 to HT support		
18	Check the type of module, the Voc parameters, Voc temperature coefficient, and number of modules			
19	Check the type of module, the Voc,Isc, Impp, Vmpp parameters, Voc and Isc temperature coefficients, and number of modules	If error continues after actions, perform Debug procedure (see § 6.5.1) and contact HT support		
20	Check the type of module, the Voc,Isc, Impp, Vmpp parameters, Voc and Isc temperature coefficients, and number of modules and the parallel strings			
21	Check the module type, parameters and number of modules. Turn the instrument off/on again and repeat the measurements more times	If error continues after actions, send instrument to HT support		
22	Check the type of module, the Voc,Isc, Impp, Vmpp parameters, Voc and Isc temperature coefficients, and number of modules and the parallel strings	If error continues after actions, perform Debug procedure (see § 6.5.1) and contact HT support		
23	Turn off/on the instrument and try again the measurements	If error continues after actions, send instrument to HT support		
24	Check the type of module, the parameters Voc, Isc, Vmpp, Impp, temperature coefficients Voc and Isc, number of modules and number of strings in parallel and check that string is disconnected from the inverter	If error continues after actions, perform Debug		
25	Check the type of module, the number of modules and the number of strings in parallel. Check that the string is disconnected from the inverter. If multiple strings are connected in parallel, test them one at a time	procedure (see § 6.5.1) and contact HT support		
27	Unstable irradiance due to the presence of clouds	Repeat tests under stable climatic conditions		
28	Check that the Voc value at the end of the test is not too different from that at the beginning of the test	Check that the modules under test do not have a short-circuit current that is too low and an irradiation value that is too low		
29	Turn off/on the instrument and try again the measurements	If error continues after actions, send instrument to HT support		
30	Check the type of module, the parameters Voc, Isc, Impp, Vmpp, temperature coefficient Voc and Isc, number of modules. In "AUTO" mode, let the HT305 cell stabilize for 10 minutes. In "MEAS" mode, check correct fixing of the PT305 probe to the module	If error continues after actions, perform Debug procedure (see § 6.5.1) and contact HT support		
31	Check the type of module, the parameters Voc, Isc, Impp, Vmpp, temperature coefficient Voc and Isc, number of modules i			
32	No possible action	Perform Debug only with HTAgorà software (see § 6.5.1) and contact HT support		
33		Possible dangerous conditions for the		
34	Avoid further measurements as there are high currents due to strong parasitic capacitances	instrument. Contact HT support		
35	No possible action	Perform Debug only with HTAgorà software		
36				
37	Check the correct connections on C1 and C2 inputs and repeat the test	If error continues after actions, contact HT support		

6.5.1. Description of Debug procedure



 CAUTION

 The Debug procedure must be carried out ONLY for situations in which the instrument shows error messages as indicated in the § 6.5 and in agreement with the HT support service

Operations on the instrument

- 1. Turn on the instrument with the ON/OFF key
- 2. Touch the "I-V Curve" function \rightarrow IV Settings to open the following screen

IV	SETTIN	IGS			15.17.	05 27/07/20	23 X 📋
	PV M	odule					
	SPV355	-R60LWMG		Nur	n. Mod.	15	
	Tol.(+)	5	%	N. 5	String. Paral.	1	3
	Tol.(-)	5	%	Ten	np. Mode	Auto	
)	TC(lsc)	0.050	%/°C	Yrs	of service	5.0	
	TC(Voc)	-0.56	%/°C	IV E	Debug	ON	<u> </u>
	RS Porf @Vr1	1.0	0/				
	Туре	STD	70				
	PV Module				SOLARO	3	

Fig. 56: Activation of Debug function on the instrument

- 3. Select "**ON**" option in the "**IV Debug**" menu and touch the button 😒 to confirm
- 4. DO NOT TURN OFF THE INSTRUMENT
- 5. Connect the instrument to the module/string under test trying to repeat as faithfully as possible the test conditions (use of the remote unit, irradiation and temperature values) which show the error message on the display
- 6. Press the **START/STOP** key to perform **at least two I-V curve measurements** and save the results
- 7. Disconnect the instrument from the module/string under test

Operations on HTAgorà software

- 8. Always update the HTAgorà software to the latest version available from the link: https://download.ht-instruments.com/HTagora/
- 9. Run HTAgorà and select the "Preferences" menu



10.In the "Language" section, activate the "Device debug" option and confirm with OK

~
~
:

11.Turn on the instrument and connect it to the PC by supplied USB-C cable 12.Click on the "**Scan**" button to detect the instrument

🛕 HT Agorà - 1.3.3					_		x
Scan	Dashboard	Data analysis		Preferences	Feedba	තී ack	
Device I-V600		Serial number 24010538	Manufacturer HT		Туре СОМ		
				CC	onnect Di	sconnec	
					Discor	nnected	°°°

13. Select the "I-V600" instrument and click on "**Connect**"

14.In the Dashboard window click on "Debug Options"





15.Click on the " \downarrow " icon to start downloading the Debug package to the PC. Wait a few seconds the end of operation

🛕 Debug data	x
IV Debug	
$\underline{\vee}$	
Download Debug Package	

16.Select the folder on the PC in which to save the Debug file and confirm. The default folder is always the following path: C:\Users\UserName\HTInstruments\Debug\

A Destination directory			x
← → ✓ ↑ 📜 C:\Users\UserName\HTIns	truments\Debug\	マ ひ Search Debug	م
Organise 🝷 New folder			:= • ?
- Ouisk assass	^ Name		Date modified
	=	No items match your search.	
OneDrive			
 OneDrive 			
🧢 This PC			
3D Objects			
Desktop			
Documents			
Downloads Music			
Videos	~ <	III	>
Folder:			
		Select Folder	Cancel

17. The Debug file, with **IVDBG** extension, is saved in the selected folder 18. Send the IVDBG file to HT Support

6.6. IVCK – COMMISSIONING TEST ON PV MODULES AND STRINGS

6.6.1. General information

This function performs the following tests on a PV module/string by measuring only:

- Open-circuit voltage Voc of the PV string/module being tested, measured in OPC condition (OPerative Condition), i.e. in the real conditions in which the installation is, with or without irradiance and temperature measurement.
- Open-circuit voltage lsc of the PV string/module being tested, in compliance with standard IEC/EN62446, measured in OPC condition (OPerative Condition), i.e. in the real conditions in which the installation is, with or without irradiance and temperature measurement

For Voc and Isc measurements **WITHOUT irradiance and temperature measurements** (and therefore without the use of the SOLAR03 remote unit), the instrument displays only the values evaluated under **@OPC (OP**erative Conditions) conditions, that is under the actual conditions of the plant, compares them with the **average values** (rolling average of the last 10 measurements stored) and displays the result for comparison of average values.

For Voc and Isc measurements **WITH Irradiance and Temperature** the data measured under OPC conditions are automatically "translated" by the instrument into **@STC** conditions **(S**tandard Test Condition - Irradiance = $1000W/m^2$, Module Temperature = 25 °C, Spectral Distribution AM=1.5) to make a comparison with the characteristics declared by the module manufacturer. In these conditions it is strictly necessary to use the SOLAR03 remote unit in order to connect the irradiation and temperature probes.

The irradiance and module temperature measurements are performed via one or more **HT305** reference cells (**in the case of Bifacial modules**) and with a **PT305** temperature probe connected to the SOLAR03 remote unit which communicates the data in real time with the instrument **via Bluetooth connection**.

CAUTION

For the irradiation measurements carried out with the **HT305** reference cell(s) <u>it</u> <u>is not necessary</u> to set the relative sensitivity and alpha values which are **automatically** managed by the SOLAR03 after connecting these accessories to this remote unit

In general, the result page will include:

- Description of the module used
- Irradiance and temperature values (if available)
- Average values of Voc and Isc calculated as average of the corresponding values under OPC on the last 10 tests saved in the memory. If the number of tests is < 10, the average is calculated on the number of available tests. The first test will display dashes in the field "average values" as there are no previous tests on which to calculate an average.
- The values of Voc and Isc measured under OPC as well as any partial result (only available if STC values are not available) obtained by comparison with average values.
- The values of Voc and Isc calculated under STC (if available) and any partial result obtained by comparing the values calculated under STC with the nominal ones (inserted in DB modules
- The overall test outcome will be calculated basing on the partial outcomes in STC (if available) or basing on the partial outcomes in OPC (if STC values are not available).
- The instrument will not display any overall outcome if no partial outcome is available



6.6.2. IVCK test without remote unit SOLAR03

- CAUTION
- The maximum voltage between the P1, C1, P2 and C2 inputs is 1500VDC. Do not measure voltages exceeding the limits given in this manual.
- Do not perform tests on PV modules or strings connected to the DC/AC converter.
- The maximum current measured by the instrument is 40A
- Standard IEC/EN62446-1 requires that measurements are performed string by string. Even if the instrument is designed to handle inrush current for single strings or strings connected in parallel, we recommend testing **one string at a time** in accordance with the standard.
- The final result is obtained by comparing the results obtained on each module/string without any correction for irradiance or temperature. <u>It is</u> <u>therefore recommended that this mode is only used in sufficiently stable</u> <u>environmental conditions</u> (clear skies, no reflected irradiance, no shading)
- 1. Switch on the instrument by pressing the **ON/OFF** key
- 2. Note the presence of the "X" in the top right corner of the display to indicate the absence of an active SOLAR03 remote unit connected to the instrument. If not, execute the "**Unpair**" command for the currently active unit (see § 6.2)
- 3. Connect the instrument to the module/string being tested as shown in Fig. 57. In particular, connect the Negative pole of the module/string to the **P2**, **C2** terminals and the Positive pole from the module/string to the **P1**, **C1** terminals



Fig. 57: Connection for IVCK tests without remote unit

- 7. In the case of **Monofacial** modules, the Fig. 58 screen is present on the display. The following parameters are shown:
 - > VPN voltage between positive and negative pole of the string
 - Module temperature with "- -" indication
 - Module irradiance with "- -" indication
 - > Display of currently selected PV module
 - > References of C1, P1, C2, P2 terminals connected to the instrument

IV CHECK	C1 F 0 (15.17.05	27/07/2023	X	Ē
		v	P-N			
		60	5 V			
		_				
	Module	Temp.	Irradia	nce		
>		°C		VV/m2		
1		Module: SPV	/355-R60LWMG			
Menu		Settings	Help	Star	t	
		•				

Fig. 58: Initial IVCK test screen without remote unit on Monofacial modules

- 8. In the case of **Bifacial** modules, the Fig. 59 screen is present on the display. The following parameters are shown:
 - > VPN voltage between positive and negative pole of the string
 - > Module temperature with "- -" indication
 - Irradiance of the front of the module with "- -" indication
 - Irradiance of the back of the module with "- -" indication
 - Display of currently selected PV module
 - > References of C1, P1, C2, P2 terminals connected to the instrument

IV CHECK		15.17.05 27	7/07/2023 X 📋					
	VF	2-N						
	760	V						
\rangle		_						
Module Temp. = = = = °C	Irradianc – – – – W/	e Rear /m2 = =	IrradianceW/m2					
Module: JKM560N-72HL4-BDV								
Menu	Settings	Help	Start					

Fig. 59: Initial IVCK test screen without remote unit on Bifacial modules

- 9. Tap on the "**Settings**" key (Monofacial module reference). The following screen is shown in Fig. 60. The following parameters are given:
 - Voc_avg and lsc_avg values of the currently selected module
 - Parameters of the test string to be programmed
 - Icon icon icon to exit without saving

I۱	CK SETTINGS	6		15.17.	.05 27/07/20	23 X 📋
	PV Modul	е				
	SPV355-R60LV	VMG	Num	. Mod.	15	
	Voc_avg 0.0	V	N. St	ring Paral.	1	
	lsc_avg 0.0	D A	Temp	o. Mode	Auto	
1			Tol. ±	: Voc[%]	5	
			Tol. ±	: Isc [%]	5	
	PV Module	Reset Avg	g.	SOLARO	3	

Fig. 60: IVCK test parameter settings

- 10. Tap on the "**PV Module**" key to change the PV module to be tested. The instrument opens the DB section, where a new module can be selected from the list in the DB section (see § 6.3)
- 11. <u>Drag</u> each of the 5 available thumb wheels to the <u>right or left</u> in order to set the desired value of the following parameters:
 - > Num. Mod \rightarrow to set the number of modules in the string being tested(max. 60)
 - ➤ N. String Paral. → to set the number of strings in parallel (max. 5). Setting "1" indicates the presence of only one string
 - ➤ Temp. Mode → to set the module temperature measurement mode. The following options are available: Auto (temperature calculated by the instrument based on Voc measurement no probe connected and recommended option), Meas. (temperature measured via PT305 probe connected to the SOLAR03 remote unit)
 - ➤ Tol. ± Voc [%] → setting of the percentage tolerance in the measurement of Voc in the range: 1% ÷ 20% (typical 5%)
 - ➤ Tol. ± Isc [%] → setting of the percentage tolerance in the measurement of Isc in the range: 1% ÷ 20% (typical 10%)
- 12. Tap on the "**Reset AVG**" key to reset the average values of the Voc_avg and Isc_avg parameters (average values of Voc and Isc in the 10 previously saved tests) before starting a new measurement. The following screen will appear:

IVCK SET	TINGS				15.17.0	5 27/07/	2023 X 📋
PV M	odule	•					
SPV355	5-R60LWI	MG		Num.	Mod.	15	
Voc_avg	0.0	V				1	
Isc_avg	0.00	A				Auto	
/	Do you v			vant to	clear OPC avg. value	? 5	
				Tol. ±	Isc [%]	5	
PV Mod	lule	Reset Avg			SOLAR03		

Fig. 61: Resetting average Voc and Isc values in the IVCK test

13. Tap on the 🛃 key to confirm or on the 💻 key to exit without proceeding



CAUTION

When **START/STOP** (or **Start** on the display) is pressed, the instrument may give various error messages (see § 6.4.6) and, as a result, fail to perform the test. Check and, if possible, eliminate the cause of the problem before proceeding.

11. Press the **START/STOP** key (or **Start** on the display) to activate the test. If there are no error conditions, the instrument displays for a few moments the icon " together with the message "**Measuring**...". The test can take **up to approximately 20 seconds**, depending on the open circuit voltage and module parameters. At the end of the test, if the result of the test is **positive**, the following screen will appear on the display (<u>Monofacial modules</u> are used for ease of reference):



Fig. 62: Example of a positive IVCK test result - OPC values 12. If the result is **negative**, the following screen is shown:

IV	CHEC	K 🍯			15.17.05	27/07/20	23 X 📋
	Voc Isc Nmod	Test Parameter 60.6 5.12 1x1	s V A	Voc Isc Irr T Mo	Results - OP 62.4 5.64 	C V A W/m2 °C	
			Module	: SPR-	318EWHTD		
	Menu				Help		Start

Fig. 63: Example of a negative IVCK test result - OPC values

13. The following parameters are displayed on the above screens:

- Model of the module being tested
- Average values of Voc and Isc calculated as the average of the corresponding values under OPC on the last 10 tests stored memory. If the number of tests is < 10, the average is calculated on the number of available tests. The first test will show '- - -' in the "average values" field as there are no previous tests from which to calculate the average
- Measurement results calculated under OPC conditions
- > Icons \checkmark , \checkmark , \checkmark , to indicate the outcome of the measurement (see § 6.6.5)
- 11. Tap on 🛅 to save the measurement (see § 7.1) or the icon 🗺 to exit



12. For the meaning of the results see § 6.6.5

6.6.3. IVCK test with remote unit SOLAR03 in direct connection

Irradiance and temperature measurements (if the instrument is set to temperature measurement mode "Meas.") <u>using a SOLAR03 remote unit directed connected to the</u> <u>device via Bluetooth</u> are recommended when irradiance conditions are unstable or when a comparison with the nominal values of the module declared by the manufacturer is required. In this case the instrument directly provides the results of the @STC measurements.

CAUTION

- The maximum voltage between the P1, C1, P2 and C2 inputs is 1500VDC. Do not measure voltages exceeding the limits given in this manual.
- Do not perform tests on PV modules or strings connected to the DC/AC converter.
- The maximum current measured by the instrument is 40A.
- Standard IEC/EN62446-1 requires that measurements are performed string by string. Even if the instrument is designed to handle inrush current for single strings or strings connected in parallel, we recommend testing **one string at a time** in accordance with the standard.
- 1. Switch on the instrument by pressing the **ON/OFF** key
- 2. Switch on the SOLAR03 remote unit, pair it with and connect it to the instrument as described in § 6.2. Note the presence of the "🚽" icon in the top right corner of the display
- 3. Connect the instrument and the SOLAR03 remote unit to the module/string being tested as shown in Fig. 64. In detail:
 - Connect the Negative pole output of the module/string to terminals P2, C2 and the Positive pole output of the module/string to terminals P1, C1
 - In case of Monofacial modules → position the reference cell HT305 onto the front surface of module (F) and at input "INP1" and possibly temperature probe PT305 at input "INP4" of the remote unit.
 - In case of Bifacial modules →, position the three HT305 reference cells on the front surface of module (F), on the top back section (B T=BackTop) and on the bottom back section (BB=BackBottom) of the module. Connect the front reference cell (F) to input "INP1", BT reference cell to input "INP2", BB reference cell to input "INP3" and possibly the temperature probe PT305 to input "INP4" of the remote unit. In accordance with the IEC/EN60904-1-2 standard, the instrument calculates the equivalent front-side Irradiance (Irreq) value, which corresponds to the Irradiance on the front surface only, which produces the same effects as the Irradiance measured on both sides, considering the bifaciality factor (φ) of the module according to the following relationship:

$$Irr_{Eq} = Irr_F + \varphi \times Irr_R$$



Fig. 64: Connection with remote unit SOLAR03 on Monofacial and Bifacial modules



- 4. In the case of **Monofacial** modules, the Fig. 65 screen is present on the display. The following parameters are shown:
 - VPN voltage between positive and negative pole of the string
 - Module temperature (with PT305 probe connected)
 - Module irradiance measured by reference cell HT305
 - Display of currently selected PV module
 - References of C1, P1, C2, P2 terminals connected to the instrument



Fig. 65: Initial IVCK test screen without remote unit on Monofacial modules

- 5. In the case of **Bifacial** modules, the screen of Fig. 66 is present on the display. The following parameters are shown:
 - > VPN voltage between positive and negative pole of the string
 - Module temperature (with PT305 probe connected)
 - Irradiance of the front side of the module measured by reference cell HT305
 - Irradiance of the back side of the module measured by reference cells HT305



CAUTION

The "**Rear Irradiance**" parameter indicates the **minimum value** between the irradiance measured by the HT305 cells at the bottom back (BB) and top back (BT) of the module

- Display of currently selected PV module
- References of C1, P1, C2, P2 terminals connected to the instrument

IV CHECK		15.17.05 27	7/07/2023 🔒	Ü					
	VF	P-N							
	760	V							
>									
Module Temp	. Irradian	ce Rea	ar Irradiance						
°C	930.2	W/m2 34	17.5 W/m2						
	Module: JKM56	0N-72HL4-BDV							
Menu	Settings	Help	Start						

Fig. 66: Initial IVCK test screen without remote unit on Bifacial modules

6. Tap on the "**Settings**" key (Monofacial module reference). The following screen is shown in Fig. 67. The following parameters are given:



- > Voc and Isc (@STC) references of the currently selected module
- Parameters of the test string to be programmed

I١	CK SETTINGS		15.17	.05 27/07/20	23 🗄 📋
	PV Modul	е			
	SPR-318EWHT	D	Num. Mod.	15	
	Voc 64.7	V	N. String. Paral.	1	
	lsc 6.20	A	Temp. Mode	Auto	
1			Tol. ± Voc [%]	5	
			Tol. ± Isc [%]	5	
	PV Module		SOLARO	03	

Fig. 67: I-V curve measurement parameter settings

- 7. Tap on the "**PV Module**" key to change the PV module to be tested. The instrument opens the DB section, where a new module can be selected from the list in the DB section (see § 6.3)
- 8. Scroll each of the 5 available thumb wheels to the right or left in order to set the desired value of the following parameters:
 - > Num. Mod. \rightarrow to set the number of modules in the string being tested(max. 60)
 - ➤ N. String. Paral. → to set the number of strings in parallel (max. 5). Setting "1" indicates the presence of only one overall string
 - ➤ Temp. Mode → to set the module temperature measurement mode. The following options are available: Auto (temperature calculated by the instrument based on Voc measurement no probe connected and recommended option), Meas. (temperature measured via PT305 probe connected to the SOLAR03 remote unit)
 - ➤ Tol. Voc ± [%] → setting of the percentage tolerance in the measurement of Voc in the range: 1% ÷ 20% (typical 5%)
 - ➤ Tol. lsc ± [%] → setting of the percentage tolerance in the measurement of lsc in the range: 1% ÷ 20% (typical 5%)
- 9. Assemble the stem onto the disk of the accessory M304 and keep it resting on the module's surface. Check that the shadow of the stem on the disk falls within the internal "limit concentric circle" of the disk itself (see picture). If this is not the case, the angle between the sun's rays and the module surface is too high and therefore the measurements taken by the instrument reliable. NOT Repeat the are operations at other times of the day



CAUTION

When **START/STOP** (or **Start** on the display) is pressed, the instrument may give various error messages (see § 6.4.6) and, as a result, fail to perform the test. Check and, if possible, eliminate the cause of the problem before proceeding.

10. Press the **START/STOP** key (or **Start** on the display) to activate the test. If there are no error conditions, the instrument will show the icon " a on the display for a few moments together with the message "**Measuring**..." The test can take **up to approximately 20 seconds**, depending on the open circuit voltage and module parameters. The following screen will appear on the display in the event of a **positive test** result (for convenience, reference is made to monofacial modules)



Fig. 68: Example of a positive IVCK test result - STC values

11. If the result is **negative**, the following screen is shown:

IV						15.17.05 27	7/07/20	23 🗄 📋		
	Voc Isc Nmod	Test Parame 64.7 6.20 1x1	v v A	Vo Isc Irr T N	c Mod.	Results - STC 62.4 6.02 931.5 49.2	V A W/m2 °C			
Module: SPR-318EWHTD										
	Menu					Help	Start			

Fig. 69: Example of a negative IVCK test result - STC values

- 12. The following parameters are displayed on the above screens:
 - > Model of the module being tested
 - Nominal values of the module being tested as defined in the internal DB (see § 6.3)
 - Measurement results calculated under STC conditions
 - Icons , B, , Icons , Icons
- 13. Tap on the 🛄 icon to save the measurement (see § 7.1), or tap on the 🔙 icon to exit without saving
- 14. For the meaning of the results see § 6.6.5

6.6.4. IVCK test with remote unit SOLAR03 in synchronous recording

The Irradiation and temperature measurements (if the instrument is set in the "Meas" temperature measurement mode) by using the SOLAR03 remote unit connected in synchronous recording to the instrument are recommended if unstable irradiation conditions are present, in the presence of obstacles that could interrupt the connection Bluetooth, and there is a need for comparison with the nominal values of the module declared by the manufacturer.

In this way, the active SOLAR03 remote unit must be connected via Bluetooth only at the BEGINNING and to the ENDING of the operations and NOT DURING the real irradiation and temperature measurements.

The instrument provides the results of measurements @OPC condition without outcome then performs the automatic and simultaneous @STC condition translation only after the data transfer from the remote unit at the end of the recording and the subsequent reconnection.

CAUTION

- The maximum voltage between inputs P, N, E and C is 1500VDC. Do not measure voltages exceeding the limits given in this manual.
- Do not perform tests on PV modules/strings connected to the DC/AC converter
- The maximum current measured by the instrument is 40A
 - Standard IEC/EN62446 requires that measurements are performed <u>string by</u> <u>string</u>. Even if the instrument is designed to manage inrush current for single strings or strings connected in parallel, it is **recommend** testing **one string at a time** according to the standard's prescriptions.
- 1. Switch on the instrument by pressing the **ON/OFF** key
- Connect the instrument to the module/string being tested as shown in Fig. 70 (Monofacial modules) or Fig. 71 (Bifacial modules). In detail, connect the negative pole output of the module/string to terminals P2, C2 and the positive pole output of the module/string to terminals P1, C1



Fig. 70: Connection with SOLAR03 in synchronous recording on Monofacial modules



Fig. 71: Connection with SOLAR03 in synchronous recording on Bifacial modules



<u>Step 1</u>

- 3. Move the SOLAR03 remote unit close to the instrument as shown in Fig. 70 or Fig. 71 left side part
- 4. Turn on the SOLAR03 remote unit, pair it and connect it to the instrument as indicated in § 6.2. Note the presence of the "
- 5. To start recording on the connected remote unit, tap on the "Start/Stop" key. The following screen will appear:



Fig. 72: Recording Activation on Remote Unit - Step 1

6. Tap on \checkmark to confirm or tap on \checkmark to exit without proceeding. The recording is performed with a non-modifiable 1s scan and the message "REC" appears on the display of the remote unit to indicate the operation in progress:

SO	LAR03			15.17.0)5 27/0	7/2023			
S	OLAR03	23070001	Connect	ed Rec.	•				
S F	SOLAR03 - SN: 23070001								
S B FI N	tatus: idle attery: 53% ree memory: . of measure:	0days 2hours s to sync.: 0					0		
	Find	U	Inpair	Delete		Run/Sto	р		
Fig	73 [.] Re	cording	Activatio	n on Ren	note I	Init - S	Sten 2		

7. The **e** icon and the message "**Rec**" appear on the display

<u>Step 2</u>

- Move the remote unit close to the modules and connect the irradiance and temperature probes (if necessary) as shown in Fig. 70 or Fig. 71 – middle side part. In particular:
 - ➤ In case of Monofacial modules → position the reference cell HT305 onto the front surface of module (F) and at input "INP1" and possibly temperature probe PT305 at input "INP4" of the remote unit
 - ▶ In case of Bifacial modules →, position the three HT305 reference cells on the front surface of module (F), on the top back section(BT=BackTop) and on the bottom back section (BB=BackBottom) of the module. Connect the front reference cell (F) to input "INP1", BT reference cell to input "INP2", BB reference cell to input "INP3" and possibly the temperature probe PT305 to input "INP4" of the remote unit. In accordance with the IEC/EN60904-1-2 standard, the instrument calculates the equivalent front-side Irradiance (Irreq) value, which corresponds to the Irradiance on the front surface only, which produces the same effects as the Irradiance measured on both sides, considering the bifaciality factor (ϕ) of the module according to the following relationship:

$$Irr_{Eq} = Irr_F + \varphi \times Irr_R$$

- Since recording has already been activated on remote unit SOLAR03, it is not necessary to maintain the Bluetooth connection anymore. Maintaining the connection will only allow to immediately obtain the outcome of the test without waiting for the measuring campaign to be completed.
- 10. In the case of **Monofacial** modules, the Fig. 74 screen is shown on the display. The following parameters are indicated:
 - VPN voltage between positive and negative pole of the string
 - > Module temperature with "- -" indication as the remote unit is not connected
 - > Module irradiance with "- -" indication as the remote unit is not connected
 - Display of currently selected PV module
 - > References of C1, P1, C2, P2 terminals connected to the instrument



Fig. 74: IVCK test screen with SOLAR03 in synchronous recording on Monofacial modules



- 10. In the case of **Bifacial** modules, the Fig. 75 screen is shown on the display. The following parameters are indicated:
 - > VPN voltage between positive and negative pole of the string
 - > Module temperature with "- -" indication
 - Irradiance of the front of the module with "- -" indication
 - Irradiance of the back of the module with "- -" indication
 - Display of currently selected PV module
 - > References of C1, P1, C2, P2 terminals connected to the instrument

IV CHECK		15.17.05 27	//07/2023 🗙						
	760	P-N ∨							
Module Temp.	Irradianc	e Rear	Irradiance						
°C	 W/	'm2 = =	= = W/m2						
Module: JKM560N-72HL4-BDV									
Menu	Settings	Help	Start						

Fig. 75: IVCK test screen with SOLAR03 in synchronous recording on Bifacial modules

- 11. Tap on the "**Settings**" key (Monofacial module reference). The following screen is shown in Fig. 60. The following parameters are given:
 - > Voc and Isc (@STC) references of the currently selected module
 - Parameters of the test string to be programmed
 - Icon let to save the settings and return to the main screen, or icon let to exit without saving

I۱	/CK S	ETTINGS			15.17.05 27/07/2023 🗙 📋					
	PV	Module	•							
	SPR	-318EWHTI	C		Num.	Mod.		15		
	Voc	64.7	V		N. Stri	ng. Paral.		1		
	lsc	6.20	A	A Temp. Mode			A	Auto		
					Tol. ±	Voc [%]		5		
					Tol. ± Isc [%]			5		
	PV Module					SOLARC	03			

Fig. 76: IVCK test parameter settings with SOLAR03 in synchronous recording

12. Tap on the "**PV Module**" key to change the PV module to be tested. The instrument opens the DB section, where a new module can be selected from the list in the DB section (see § 6.3)

- 13. <u>Drag</u> each of the 5 available thumb wheels to the <u>right or left</u> in order to set the desired value of the following parameters:
 - > Num. Mod \rightarrow to set the number of modules in the string being tested(max. 60)
 - N. String Paral. → to set the number of strings in parallel (max. 5). Setting "1" indicates the presence of only one string
 - ➤ Temp. Mode → to set the module temperature measurement mode. The following options are available: Auto (temperature calculated by the instrument based on Voc measurement no probe connected and recommended option), Meas. (temperature measured via PT305 probe connected to the SOLAR03 remote unit)
 - ➤ Tol. ± Voc [%] → setting of the percentage tolerance in the measurement of Voc in the range: 1% ÷ 20% (typical 5%)
 - ➤ Tol. ± Isc [%] → setting of the percentage tolerance in the measurement of Isc in the range: 1% ÷ 20% (typical 10%)
- 15. Assemble the stem onto the disk of the accessory M304 and keep it resting on the module's surface. Check that the shadow of the stem on the disk falls within the internal "limit concentric circle" of the disk itself (see picture). If this is not the case, the angle between the sun's rays and the module surface is therefore too high and the measurements taken by the instrument reliable. NOT Repeat the are operations at other times of the day



CAUTION



- When START/STOP (or Start on the display) is pressed, the instrument may give various error messages (see § 6.4.6) and, as a result, fail to perform the test. Check and, if possible, eliminate the cause of the problem before proceeding
- The settings made on the instrument control parameters can be modified at any time even while recording is in progress
- 16. Press the **START/STOP** key (or **Start** on the display) to activate the tests. If there are no error conditions, the instrument will show the icon " [™] [™] [™] on the display for a few moments together with the message "**Measuring**..." The test can take **up to approximately 20 seconds,** depending on the open circuit voltage and module parameters. At the end of the test, the instrument will <u>only</u> display the values <u>measured</u> <u>at OPC without the references of the irradiance and temperature values of the module</u> (see Fig. 77) and it is necessary to wait for the end of the test session and the <u>subsequent synchronisation</u> with the SOLAR03 remote unit to obtain the final result (values @ STC) of the tests performed, as shown here below:



IV	CHEC	K				15.17.05 2	7/07/20	23 X 📋	
	Voc Isc Nmod	Test Parar 60. 5.0 1x ²	neters 6 V 2 A 1	Vo Isc Irr T N	vc ; Mod.	Results - OPC 61.2 5.12 	V A W/m2 °C		
Module: SPR-318EWHTD									
Menu					Help		Start		

Fig. 77: IVCK test result @OPC with synchronous recording

17. Tap on the ticon to save the measurements to the internal memory (see § 7.1), or on the the icon to exit without saving

Step 3

- At the end of the test session, disconnect the SOLAR03 remote unit, place it close to the instrument (see Fig. 70 or Fig. 71 – right side part) and check that it automatically reconnects to the instrument
- 19. Tap on the "**SOLAR03**" button to access the control and management section of the SOLAR03 remote unit (see § 6.2) connected to the instrument
- 20. Tap on the "Start/Stop" key to end the recording. The following screen will appear:



Fig. 78: Ending recording on the remote unit

- 21. Tap on the 🛃 key to confirm or on the 💻 key to exit without proceeding
- 22. The synchronization of the pending @OPC measurements, the translation of the @STC values and the subsequent saving are performed **automatically** by the instrument. The "**N. of measures to sync**" parameter must take on the value "0" once the operations are completed
- 23. Tap on the \bigcirc icon if there are some errors, to reactivate synchronization again
- 24. Access the memory area (see § 7.2) to retrieve the saved measurements
CAUTION The instrument translates @OPC results to @STC values when the following conditions occur: 19.Voltage Voc > Voc minimum = 15V 20.Frontal irradiance values (also valid for bifacial modules) detected as greater than the minimum threshold set on the instrument (>100W/m²) and stable (variation between the start and end of the measurement campaign ±20 W/m²) 21.Open voltage Voc measured consistent with expected value indicated in the module datasheet

22.Module temperature value included in the range: -40°C ÷ 100°C (-40°F ÷ 212°F)

23.Short-circuit current value **Isc > Iscmin = 0.2A**

24.For the meaning of the results see § 6.6.5



6.6.5. Interpretation of measurement results

In general, the result of a test on a Voc and Isc measurement is determined by the following relationships:

Measurements without remote unit (no irradiation and temperature)

Note the following parameters:

VocAve \rightarrow average open voltage value calculated in the last 10 saved measurements IscAve \rightarrow average short circuit current value calculated in the last 10 saved measurements Voc (Tol+) = **Tol%(+)Voc** * **VocAve** \rightarrow Positive tolerance value on Voc Voc (Tol-) = **Tol%(-)Voc** * **VocAve** \rightarrow Negative tolerance value on Voc Isc (Tol+) = **Tol%(+)Isc** * **IscAve** \rightarrow Positive tolerance value on Isc Isc (Tol-) = **Tol%(-)Isc** * **IscAve** \rightarrow Negative tolerance value on Isc

 $\mathcal{E}_{\text{instrum}}$ Voc \rightarrow Maximum instrumental error declared on the Voc @OPC (see § 10.1)

 $\mathcal{E}_{\text{instrum}}$ lsc \rightarrow Maximum instrumental error declared on the lsc @OPC (see § 10.1)

The following check parameters are calculated by the instrument:

 $\mathcal{E}_{\text{Meas}}$ Voc = Voc (@OPC) – VocAve \rightarrow Error on the measurement of Voc @ OPC

E_{Meas}**Isc** = Isc (@OPC) − IscAve \rightarrow Error on the measurement of Isc @ OPC

The following conditions on the measurement outcome are managed by the instrument

Ν	CONDITION	OUTCOME
1	➤ - Voc (ToI-) + E _{Instrum} Voc ≤ E _{Meas} Voc ≤ Voc (ToI+) - E _{Instrum} Voc ➤ - Isc (ToI-) + E _{Instrum} Isc ≤ E _{Meas} Isc ≤ Isc (ToI+) - E _{Instrum} Isc	>
2	 ≻ - Voc (Tol-) ≤ E_{Meas}Voc ≤ Voc (Tol+) ≻ - Isc (Tol-) ≤ E_{Meas}Isc ≤ Isc (Tol+) 	·>
3	 ≻ - Voc (ToI-) - E_{Instrum}Voc ≤ E_{Meas}Voc ≤ Voc (ToI+) + E_{Instrum}Voc ≻ - Isc (ToI-) - E_{instrum}Isc ≤ E_{Meas}Isc ≤ Isc (ToI+) + E_{Instrum}Isc 	×
4	The previous conditions 1, 2 and 3 are not verified	*



Measurements with remote unit (irradiation and temperature)

Note the following parameters:

VocNom → nominal open voltage value of Voc (declared by the manufacturer) IscNom → nominal short circuit current value of Isc (declared by the manufacturer) Voc (Tol+) = **Tol%(+)Voc** * **VocNom** → Positive tolerance value on Voc Voc (Tol-) = **Tol%(-)Voc** * **VocNom** → Negative tolerance value on Voc Isc (Tol+) = **Tol%(+)Isc** * **IscNom** → Positive tolerance value on Isc Isc (Tol-) = **Tol%(-)Isc** * **IscNom** → Negative tolerance value on Isc

 $\mathcal{E}_{\text{Instrum}}$ Voc \rightarrow Maximum instrumental error declared on the Voc @STC (see § 10.1)

 $\mathcal{E}_{\text{Instrum}}$ lsc \rightarrow Maximum instrumental error declared on the lsc @STC (see § 10.1)

The following check parameters are calculated by the instrument:

 $\mathcal{E}_{\text{Meas}}$ Voc = Voc (@STC) – VocNom \rightarrow Error on the measurement of Voc @ STC

E_{Meas}**Isc** = Isc (@STC) − IscNom \rightarrow Error on the measurement of Isc @ STC

NOTE: Voc (@STC) and Isc (@OPC) values are obtained in accordance with IEC/EN60891

The following conditions on the measurement outcome are managed by the instrument:

Ν	CONDITION	OUTCOME
1	➤ - Voc (ToI-) + & Einstrum Voc ≤ & Meas Voc ≤ Voc (ToI+) - & Einstrum Voc	
	> - Isc (ToI-) + $\mathcal{E}_{\text{instrum}}$ Isc ≤ $\mathcal{E}_{\text{Meas}}$ Isc ≤ Isc (ToI+) - $\mathcal{E}_{\text{instrum}}$ Isc	
2	> - Voc (Tol-) ≤ $\mathcal{E}_{\text{Meas}}$ Voc ≤ Voc (Tol+)	*
	> - Isc (ToI-) ≤ \mathcal{E}_{Meas} Isc ≤ Isc (ToI+)	
3	> - Voc (ToI-) - $\mathcal{E}_{\text{Instrum}}$ Voc ≤ $\mathcal{E}_{\text{Meas}}$ Voc ≤ Voc (ToI+) + $\mathcal{E}_{\text{Instrum}}$ Voc	×
	> - Isc (ToI-) - $\mathcal{E}_{instrum}$ Isc ≤ \mathcal{E}_{Meas} Isc ≤ Isc (ToI+) + $\mathcal{E}_{instrum}$ Isc	
4	The previous conditions 1, 2 and 3 are not verified	*



Application example (measurement with remote unit)

- Module name: LR5-54HIH-410M (LONGI manufacturer)
- Module type: Mono-facial
- Declared nominal Voc voltage (@STC): 37.3V
- Declared nominal short circuit current lsc (@ STC): 13.88A
- Tolerance Voc: ±5%
- Tolerance Isc: ±10%
- Frontal irradiance measured: 577 W/m²
- Module temperature (@STC): 25°C
- Voltage Voc calculated by the instrument (@STC): 37.1V
- Short circuit current Isc calculated by the instrument (@STC): 10.53A

Voc (Tol+) = Tol%(+)Voc * VocNom = 0.05 * 37.3V = 1.9VVoc (Tol-) = Tol%(-)Voc * VocNom = 0.05 * 37.3V = 1.9VIsc (Tol+) = Tol%(+)Isc * IscNom → = 0.1 * 13.88 = 1.39AIsc (Tol+) = Tol%(-)Isc * IscNom → = 0.1 * 13.88 = 1.39A

 $\begin{aligned} & \mathcal{E}_{\text{Instrum}} \text{Voc} = \pm (37.1 * 0.04 + 0.2) = \pm 1.7 \text{V} \\ & \mathcal{E}_{\text{Instrum}} \text{Isc} = \pm (10.53 * 0.04 + 0.02) = \pm 0.44 \text{A} \\ & \mathbf{\mathcal{E}}_{\text{Meas}} \text{Voc} = \text{Voc} (@\text{STC}) - \text{VocNom} = 37.1 - 37.3 = -0.2 \text{V} \end{aligned}$

E_{Meas}**Isc** = Isc (@STC) - IscNom = 10.53 - 13.88 = - 3.35A

Comparison conditions:

Voc Voltage → -1.9 + 1.7 ≤ - 0.2 ≤ 1.9 – 1.7 → Verified condition 1 → **Outcome** Isc Current → -1.39 + 0.44 ≤ -3.35 ≤ 1.39 – 0.44 → Condition 1 NOT verified Isc Current → -1.39 ≤ -3.35 ≤ 1.39 → Condition 2 NOT verified Isc Current → -1.39 - 0.44 ≤ -3.35 ≤ 1.39 + 0.44 → Condition 3 NOT verified Isc Current → Verified condition 4 → **Outcome**

7. MEM - STORAGE OF RESULTS

The instrument can store up to **up to 9999** measurement results (I-V curves or IVCK tests). Test results can be organised and grouped in a structure similar to that of the photovoltaic system being tested by associating **up to 3** different **levels of** markers for each of the memory locations used, in order to detail the corresponding location of the measurement. For example, a location tested as 'Plant XX', 'String YY', 'Module ZZ' can be stored and associated with the measurement just taken.

7.1. SAVING MEASURES





2. Tap on the 🛃 key to confirm. The following screen will be displayed:

IV	MEM							15.	17.	05	27	/07	/20	23	X	Ü
	Marker list		PL	AN1	ΓΑΙ											
	PLANT															
	STRUCTURE															
	SYSTEM															
\mathbf{b}	STRING		Q	w	Е	R	Т	Υ	U	I	0	Р	1			_
	MODULE		A	s	D	F	G	н	J	к	L	:	;			
	PANEL				z	X	С	v	в	N	м	•	×			
	USER		12	23	(D						•	_			
	New	C)elet	е												

Fig. 80: Saving Measurement Result - Step 2



IVN	MEM Marker list		15.17.05 27	/07/2023 🗙	Ü
Р	LANT A				
>					
	New	Delete			

Fig. 81: Saving Measurement Result - Step 3

4. <u>With a first-level marker highlighted</u>, tap on the "**New**" key to define a possible name for a **second-level** marker. The following screen will appear:

ľ	V MEM							15.	17.	05	27	/07	/20	23	X	Ü
	Marker list		ST	RIN	G 1											
	PLANT A															
															4	
D	•		Q	w	E	R	Т	Υ	U	Ι	0	Ρ	1			
			A	s	D	F	G	н	J	к	L	:	;			
					z	x	С	v	в	N	м	•	X			
			1:	23	(9						•	-			
	New	C)elet	е												

Fig. 82: Saving Measurement Result - Step 4

Use the virtual alphanumeric keyboard to define the second-level marker (ex: "STRING 1") and touch the *(ENTER)* button to confirm. The name will appear in the list of markers highlighted in blue, as shown in the following figure:

IV	MEM		15.17.05 27/07/2	2023 X 📋
	Marker list			
	PLANT A			
	STRING 1			
	New	Delete		

Fig. 83: Saving Measurement Result - Step 5

6. <u>With the second-level marker highlighted</u>, tap on the "**New**" key to define a possible name for a **third-level** marker. The following screen will be displayed:

I\	/ MEM							15.	17.	05	27	/07	/20	23	X	Ü
	Marker list		мо	DUI	LE X	:										
	PLANT A															
	STRING 1															
															4	
\mathbf{b}			Q	w	E	R	Т	Y	U	I	0	Р	1			
			A	s	D	F	G	н	J	к	L	:	;			
					z	X	С	v	в	N	м		x			
			12	23	(D						•	_			
	New	C)elete	Э												

Fig. 84: Saving Measurement Result - Step 6

Use the virtual alphanumeric keyboard to define the **third**-level marker (ex: "MODULE X") and touch the *(ENTER)* button to confirm. The name will appear in the list of markers highlighted **in blue**, as shown in the following figure:

IV	MEM		15.17.05 27	7/07/2023	Xü
	Marker list				
	PLANT A				
	STRING 1				
	MODULE X				
>					
	New	Delete			

Fig. 85: Saving Measurement Result - Step 7

8. Tap on the icon " to exit the section. The following screen appears on the display

IV MEM	15.17.05 27/07/2023 🗙 📋
Markers	Measure list
└▶ PLANT A	
L→ STRING 1	
MODULE X	
\mathbf{b}	
New	

Fig. 86: Saving the measurement result - End



- 9. Tap on the ficon again to **complete the saving process** of the measurement under the blue highlighted marker (ex: third-level "MODULE X") and return to the main measurement screen
- 10. When a new first-level marker is required, tap on the "**New first level**" key shown on the following screen:

IV MEM				15.17.05	27/0	7/20	23 🗙	(📋
Markers			N	leasure list				
PLANT A								
L→ STRING 1								
	<							
New	New first lev	el						

Fig. 87: Definition of new first-level marker

11. Use the virtual keyboard as described in the previous paragraphs



7.2. DISPLAYING RESULTS

1. Tap on the "**Memory**" icon in the main menu to display the data. The following screen shows an example of displayed data

IV MEM	15.17.05	27/07/2023	XÜ
Markers	Measure list	N. of Measure	es: 765
L→ PLANT A	🥑 211 - IVCurve		
	😕 212 - IVCurve		
└→ MODULE X	L 🖌		
PLANT B	number of meas, per marker		
L SANYO	217 - IVCK		
SPR-X21	218 - IVCurve		
SPR-318E	219 - IVCurve220 - IVCurve		
New			

Fig. 88: Displaying results

- 2. Tap on the desired marker on the left-hand side of the screen. On the right-hand side, the current memory location is shown, along with the measurements stored for that marker.
- 3. The following indications are possible:
 - > \checkmark → I-V curve measurement or IVCK test result: **correct** (Result: OK)
 - > \checkmark -> I-V curve measurement or IVCK test result: incorrect (Result: NOT OK)
 - ✓ ✓ → I-V curve measurement or IVCK test result: correct except in case of instrument error
 - ➤ → I-V measurement or IVCK test result: incorrect except in case of instrument error
 - > $O \rightarrow$ I-V or IVCK curve measurement result **without** @STC values (only @OPC values)
- 4. Select a measurement by highlighting it in blue and tap on the "**View Results**" key to display it. In the case of Fig. 88, the following screen is displayed relative to the I-V curve measurement:

IV	MEM	O				15.17.05 2	7/07/20	23 🗄	Ü
	STC Valu	ues	•••••						
		Nominal Value	S			Results - STC			
	Pmax	318.0	W	Pn	nax	319.3	W		
	ΔΡ%	-3/+5	%	ΔP	%	0.4	%		
	Voc	64.7	V	Vo	С	64.3	V		
1	Vmpp	54.6	V	Vm	прр	52.6	V		
	Impp	5.82	А	Im	рр	6.07	А		
	lsc	6.20	А	Isc	;	6.47	А		
			Module	e: SPF	R-318E	EWHTD			
			Current			Help			

Fig. 89: Retrieving the I-V curve measurement results - Values @STC



5. Tap on the "Current" key to display the I-V @STC curve. The following screen will appear:



Fig. 90: Retrieving the I-V curve measurement results - Current curve @STC

6. Tap on the "**Power**" key to display the I-V @STC power curve as shown in the figure below:



Fig. 91: Retrieving the I-V curve measurement results - Power curve @STC

7. Scroll the screen to the right to display the @OPC values. The following screen will appear:

IV	MEM					15.17.05 2	7/07/20	23 🗄 📋
	OPC Value	S	0000					
	I I	est Parame	ters			Results - OPC		
	Nmod	1x1		Irr		252.9	W/m2	
	Years	10		Pma	ax	71.4	W	
	Perform.	0.0	%	ΤM	lod.	47.1	°C	
)				Voc	2	56.0	V	
				Vmp	рр	46.5	V	
				Imp	p	1.54	А	
				lsc		1.66	А	
	Module			: SPR-	-318EV	VHTD		
			Current			Help		

Fig. 92: Retrieving the I-V curve measurement results - Values @OTC





Fig. 93: Retrieving the I-V curve measurement results - Current curve @OPC

9. Tap on the "**Power**" key to display the @OPC power curve. The following screen will appear:



Fig. 94: Retrieving the I-V curve measurement results - Power curve @OPC

10.Tap on the " icon to return to the main screen 11.<u>When retrieving the IVCK test results</u>, the following screen will appear:

IV	MEM			22		15.17.05 2	7/07/20	23 🗄 📋
>	Voc Isc Nmod	Test Parameters 64.7 6.20 1x1	V A	Vo Isc Irr T N	ic ; Иod.	Results - STC 64.5 6.18 931.5 49.2	V A W/m2 °C	
			Module	: SPF	R-318E	WHTD		
						Help		

Fig. 95: Retrieving the IVCK test results @STC



7.3. DELETING RESULTS

- 1. Tap on the "Memory" icon on the main menu to display the data (see Fig. 88)
- 2. Select (highlight in blue) a test on the screen and tap on the "**Delete**" key. The following message will appear on the display:

IV MEM		15.17.0	5 27/07/2023	X 📋
Markers		Measure list	N. of Measures	s: 246
└▶ PLANT A		211 - IVCurve		
L→ STRING 1		😕 212 - IVCurve		
MODULE X				
PLANT B	De u went			
L► SANYO	Do u want			
└► SPR-X21				
SPR-318E				
Delete	Delete all	Delete Marke	er View Resu	ilts

Fig. 96: Deleting a measurement result

- 3. Tap on the key to confirm the deletion of the measurement or on the key to exit without proceeding
- 4. Tap on the "**Delete all**" key to delete all measurements stored in memory. The following message will appear on the display:

IV MEM		15.17.05 2	7/07/2023 X 📋
Markers	M	easure list	N. of Measures: 246
L► PLANT A	•	211 - IVCurve	
L→ STRING 1		212 - IVCurve	
└→ MODULE X			
PLANT B	Do u want to de	lete all measures?	
L> SANYO	Do u want to de	217 - IVCK	
L► SPR-X21			
└ → SPR-318E			
Delete	Delete all	Delete Marker	View Results

Fig. 97: Deleting an entire internal memory

- 5. Tap on the key to confirm the deletion of the entire internal memory or on the key to exit without proceeding
- 6. Select (highlight in blue) a marker on the screen and tap on the "**Delete Marker**" key. The following message will appear on the display



IV MEM	15.17.	05 27/07/20)23 X 📋
Markers	Measure list	N. of M	easures: 246
└▶ PLANT A	🔗 211 - IVCurve		
STRING 1	🔋 212 - IVCurve		
L→ MODULE X	I 🗸		
PLANT B	slata colocitad marker?		
L SANYO			
SPR-X21			
L→ SPR-318E			
Delete Delete a	II Delete Mar	rker Vie	w Results

Fig. 98: Deleting an internal marker

7. Tap on the **e**key to confirm the deletion of the marker **together with any measurements it contains**, or on the **e**key to exit without proceeding

PLANT A

► PLANT B

L→ STRING 1

└→ MODULE X

L→ SANYO

→ SPR-X21

Delete

7.3.1. Anomalous situations



211 - IVCurve

🙁 212 - IVCurve

Delete Marker

View Results

No marker selected

Delete all

If a highlighted top-level marker containing some measurements is to be removed, the instrument will not proceed and will display the message shown in the figure. Remove **all lower-level markers** first

If an attempt is made to delete a marker with the word "**Markers**" highlighted, the instrument will display the message shown in the figure and will not perform the operation. **Select a valid marker**



When the third-level marker is selected, touching the "**New**" key will display the screens shown in the figure and the instrument will not perform the operation. It is **not possible to define markers beyond the third level**



IV MEM	15.17.05	27/07/2023 X 📋
Markers	Measure list	N. of Measures: 765
L→ PLANT A	🥑 211 - IVCurve	
	🔋 212 - IVCurve	
PLANT B	x number of meas, per marker	
L SANYO		
SPR-X21	218 - IVCurve	
SPR-318E	 219 - IVCurve 220 - IVCurve 	
New		

If, during saving, you try to associate a measurement with a marker in which the maximum number of possible measurements are present (**max 500**), the instrument shows the message shown in the figure on the side and does not carry out the operation. Download the measurements to the PC and delete them before saving again

8. CONNECTING THE INSTRUMENT TO THE PC

The PC is connected to the instrument via the USB-C port (see Fig. 2) using the C2010 cable supplied, or via a WiFi connection. The choice of connection type must be made within the management software HTAgorà



CAUTION

To transfer data to a PC, first install the management software HTAgorà downloadable from the **www.ht-instruments.com** website

Connection via USB-C cable

- 1. Switch on the instrument by pressing the **ON/OFF** key
- 2. Connect the instrument to the PC using the supplied USB-C C2010 cable
- 3. Use the management software HTAgorà controls to activate the transfer

Connecting by WiFi

- 1. Switch on the instrument by pressing the **ON/OFF** key
- 2. Tap on the "**Settings**" icon on the main menu and drag the thumb wheel corresponding to the "**WiFi**" function to "**ON**" as shown in the following screen

00	SETTINGS		15.	17.05 27/0	07/2023 🗙 📋
	Language		English		
	Min. Irradiance		700	W/m2	
	Auto Power Off		10	min.	
	Contrast		20	%	
ľ	Key sound		ON		
	WiFi		ON		
	Rotate display		OFF		
	Reset DataBase	Date&Time			

Fig. 99: WiFi connection activation

- 3. Tap on the icon to save the setting. The icon "?" is shown in the top right corner of the display
- 4. Enable the WiFi connection on the PC (if necessary, it is possible to use a WiFi adaptor). Select and connect the WiFi network which the instrument makes available in "Network connection → Wireless networks" section on the PC
- 5. Use the management software HTAgorà controls to activate the transfer

9. MAINTENANCE

9.1. GENERAL INFORMATION

During use and storage, the recommendations in this manual must be followed to avoid possible damage or danger to the operator. Do not use the instrument in environments characterized by humidity or temperatures outside the environmental conditions indicated in § 10.3. Do not expose to direct sunlight. Always switch off the instrument after using it. If the instrument is to be left unused for a long period of time, remove the batteries to prevent leaking and damage to the internal circuits of the instrument.

9.2. REPLACING OR RECHARGING INTERNAL BATTERIES

When the low battery symbol " appears on the display, replace (if using alkaline batteries) or recharge (if using NiMH rechargeable batteries).

CAUTION

This operation must be carried out by skilled technicians only. Before carrying
out this operation, make sure that all the cables have been removed from the
input terminals



- Only use the supplied HT power supply unit to recharge the batteries in order to avoid possible damage to the instrument
- Replace the exhausted batteries within max 10 minutes. Otherwise, the instrument could lose the internal date/time which should to be restored

Replacing internal batteries

- 1. Switch off the instrument
- 2. Remove the cables from the input terminals
- 3. Unscrew the screw securing the battery cover (see Fig. 1 part 6) and remove it
- 4. Remove all the alkaline batteries and replace them with others of the same type (see § 10.2) making sure the polarity is correct (see Fig. 3)
- 5. Put back the battery compartment cover and fasten it by means of the appropriate screw
- 6. Do not dispose of the used batteries in the environment. For disposal, use appropriate containers

Recharging internal batteries

The complete recharging of the batteries <u>must always be carried out using the external</u> <u>power supply supplied</u>. The external power supply recharges the batteries with the instrument <u>both ON and OFF</u>. <u>Do not recharge alkaline batteries</u>. Proceed as follows:

- 1. Remove the cables from the input terminals
- 2. Move the sliding cover on the inputs to the right (see Fig. 1 part 9) so that the "Ext **P.Supply**" input can be used
- 3. Switch on the instrument
- 4. Plug the external power supply unit into the instrument and connect it to the mains. The symbol "" in the top right corner of the display indicates that the internal batteries are being charged
- 5. Continue recharging until the icon "

9.3. INSTRUMENT CLEANING

Use a dry and soft cloth to clean the instrument. Never use wet cloths, solvents, water, etc.

10. TECHNICAL SPECIFICATIONS

10.1. TECHNICAL CHARACTERISTICS

Accuracy stated as ± [%reading + (num. dgt*resolution)] at 23 °C ± 5 °C, <80%RH

MULTIMETER FUNCTION

DMM – DC Voltage

Range [V]	Resolution [V]	Accuracy
3 ÷ 1500	1	\pm (1.0%reading + 2dgt)

I-V CURVE MEASUREMENTS AND IVCK TESTS

I-V, IVCK: DC Voltage (@ OPC)

Range [V]	Resolution [V]	Accuracy (*)
15.0 ÷ 1500.0	0.1	±(0.2%Voc)

(*) In accordance with IEC/EN60904-1; Measurements start at VDC > 15V and with module capacitance <30 μ F

I-V, IVCK: DC Current (@ OPC)

Range [A]	Resolution [A]	Accuracy (*)
0.20 ÷ 40.00	0.01	±(0.2%lsc)
(*) In a second second (*) IEO/EN(20004.4.1)		

(*) In accordance with IEC/EN60904-1; Iscmin = 0.2A and module capacitance <30 μF

I-V: DC Power (@ OPC) (VDC > 30V)

Range [W]	Resolution [W]	Accuracy
50 ÷ 9999	1	(1.0.) (reading + Cdat)
10.00k ÷ 59.99k	0.01k	\pm (1.0 %reading + 6dgt)

VDC voltage ≥ 30V and module capacitance <30µF

I-V, IVCK: DC Voltage (@ STC)

Range [V]	Resolution [V]	Accuracy
3.0 ÷ 1500.0	0.1	± 4.0 %reading + 2dgt)

I-V, IVCK: DC Current (@ STC)

Range [A]	Resolution [A]	Accuracy
0.20 ÷ 40.00	0.01	\pm 4.0 %reading + 2dgt)

I-V: DC Power @ STC (referred to 1 module)

Range [W]	Resolution [W]	Accuracy
50 ÷ 9999	1	\pm (4.0%reading + 2dgt)

Module capacitance <30µF



CAUTION

The instrument performs I-V Curve measurements and IVCK tests **even on PV** modules with efficiency >19%

10.2. GENERAL CHARACTERISTICS Reference guidelines

Instrument safety: EMC: Technical literature: Safety of measuring accessories: Measurements: PV module temperature (Auto): EMC environment of use: Insulation: Level of pollution: Measurement category:	IEC/EN61010-1, IEC/EN61010-2-030 IEC/EN61326-1 IEC/EN61187 IEC/EN61010-031 IEC/EN60891, IEC/EN60904-1-2 (I-V curves) IEC/EN62446, IEC/EN60904-1-2 (IVCK test) IEC/EN60904-5 portable, Class A, Group 1 double insulation 2 CAT III 1500VDC, max. 1500VDC between inputs
Radio Compliance with RED directive:	ETSI EN300328, ETSIEN301489-1, ETSIEN301489-17
Measurement throughput	6.5MWh/hour (@Voc=1500V,Isc=40A) – approx. 108 tests/hour, no cooling required, regardless ambient temperature
Display, memory and PC interface Type of display: Memory type: Internal database: Saved data:	TFT colour, 7", capacitive touch screen, 800x480pxl Memory card, max. 32GB (non-expandable) ca 63.000 modules can be saved 9999 IVCK tests or I-V curve
PC interface: Interface with SOLAR03:	USB-C and WiFi Bluetooth connection (up to 100m/328Ft free space)
Power supply Internal power supply: External power supply: Consumption: Low battery indication: Charging time: Battery life (@ 0°C ÷ 40°C):	 8x1.5V type AA LR06 alkaline batteries or 8x1.2V type AA rechargeable NiMH batteries 100-415VAC/15VDC, 50/60Hz external power supply CAT IV 300V (use HT power supply only) 8W symbol " is displayed approx. 4 hours 8 hours under the following conditions: > Battery capacity: 2000mAh > PV string voltage: 800V > Work cycles: 80 measurements/hour > Instrument connected for 30s/measurement > Instrument disconnected for 15s/measurement
Auto power off:	1 ÷ 10min selectable (can be disabled)
Mechanical characteristics Dimensions (L x W x H) Weight (batteries included):	336 x 300 x 132mm (13 x 12 x 5in) 5.5 kg (11lv)



10.3. ENVIRONMENTAL CONDITIONS FOR USE

Reference temperature: Working temperature: Permitted relative humidity: Storage temperature: Storage humidity: Max operating altitude: 23° ± 5°C (73°F ± 41°F) -10°C ÷ 50°C (14°F ± 122°F) <80%RH -20°C ÷ 60°C (-4°F ± 140°F) <80%RH 2000m (6562Ft)

This instrument complies with the requirements of the Low Voltage Directive 2014/35/EU (LVD) and the EMC Directive 2014/30/EU and RED Directive 2014/53/EU This instrument satisfies the requirements of 2011/65/EU (RoHS) directive and 2012/19/EU (WEEE) directive

10.4. ACCESSORIES

See the attached packing list



CAUTION

Only the accessories supplied with the instrument guarantee compliance with the safety standards. They must be in good condition and must be replaced, if necessary, with identical models

11. APPENDIX

11.1. THEORETICAL ASPECTS OF THE I-V CURVE MEASUREMENT

The instrument is designed to perform tests and measurements on **PV modules** consisting of a suitable number of **PV cells** in order to determine their I-V (Current-Voltage) characteristic, which identifies them constructively, based on the reference standard IEC/EN60891

Tests can be performed either on individual modules or on a **PV string** (a set of PV modules), the set of which forms what is commonly known as a "PV generator", which is an integral part of a Single-phase or Three-phase PV installation

11.1.1. Theoretical Aspects of I-V Curve measurement

The <u>I-V curve test</u> is performed as described below:

- The meter performs the I-V curve measurement of the PV module connected to it, further to the real time measurement of irradiance and module temperature
- The measurement result is automatically "translated" to the Irradiance Standard Test Condition (STC) equal to 1000W/m² and module temperature equal to 25°C. In order to obtain accurate results in accordance with this manual, it is recommended that the specifications in § 10.1
- The instrument makes a comparison between the maximum rated power, with the percentage tolerance margin declared by the module manufacturer and included in the database for the module type selected on the meter (see § 6.3.1), and the measured value
- If the comparison is within the declared tolerance, the final result of the test will be "OK"; if not, the result will be "NOT OK" and the module will therefore not meet the specifications declared by the manufacturer (see § 6.4.5)

11.2. TYPICAL ERRORS ON I-V CURVES AND TROUBLESHOOTING

Measurement	Event	Troubleshooting
Good measurement 7.0 6.0 5.0 4.0 3.0 2.0 1.0 0.0 1.0 0.0 1.0 0.0 5.0 5.0 5.0 5.0 5.0 5.0 5	The measured curve extrapolated to STC (blue) and the curve as declared by the manufacturer (black) of the modules match.	No error, save data and move to next string to test
Low short circuit current 7.0 6.0 5.0 4.0 3.0 2.0 1.0 0.0 0 10 20 30 40 40	 Irradiance sensor oriented differently than the string under test Reflections on the irradiance sensor Wrong module selection at configuration of PV system Environmental contaminants on modules (soiling, dirt, snow, debris) Far distance obstruction (shading) Aging 	 Orient the irradiance sensor properly Set the instrument properly Clean the modules Remove the obstructions Check the modules for blindness, humidity, etc. Replace affected modules
High short circuit current 7.0 6.0 5.0 4.0 3.0 2.0 1.0 0.0 0.0 1.0 0.0 1.0 0.0 1.0 0.0 0	 Irradiance sensor oriented differently than the string under test Reflections on the irradiance sensor Dirt on the irradiance sensor Wrong module selection at configuration of PV system Irradiance sensor defect 	 Orient the irradiance sensor properly Clean the irradiance sensor Remove the obstructions Check the irradiance sensor for blindness, humidity, etc. Set the instrument properly Replace affected sensor
Low open circuit voltage 7.0 6.0 5.0 4.0 3.0 2.0 1.0 0 0 10 2.0 1.0 0	 Low temperature measurement Wrong numbers of module selection at configuration of PV system Shorted bypass diodes 	 Attach the thermocouple properly to a typical temperature location Select the AUTO mode Set the instrument properly Replace affected modules
Low current ratio Impp/Isc 7.0 6.0 5.0 4.0 3.0 2.0 1.0 0.10 20 30 40 50 60	 Soiling across modules Tapered shades Small current mismatch Degradation of cell shunt resistance 	 Clean the modules Un-shade the modules Check that currents match Replace affected modules

Low voltage ratio Vmpp/Voc 7.0 6.0 5.0 4.0 3.0 2.0 1.0 0.0 0.0 0.0 0.0 0.0 0.0 0	 Voltage drop on cables to PV module string 	 Check cables, connectors, contacts, and string wirings Check cable length and cross section Check modules for bad connections or oxidation Replace affected modules
Steps in the I-V curve 7.0 6.0 5.0 4.0 3.0 2.0 1.0 0.0 0 10 20 1.0 0	 Small or partial shading of one module of the string under test Reflections Random environmental contaminants on modules (soiling, dirt, snow, debris, etc.) Strong current mismatch Cracks of cells or glass 	 Remove the obstructions Remove obstructions Re-test when un-shaded Clean the modules Check that currents match Replace affected modules
Characteristic curve not linear 7.0 6.0 5.0 4.0 3.0 2.0 1.0 0.0 0 10 20 30 40 50 60	 Unsteady irradiation during measurement Leopard spot clouds shading the modules Low irradiation during measurement 	 Re-test when clouds are gone Repeat measurement at an irradiation of minimum 700W/m² (IEC/EN61829)



11.3. CALCULATION OF ANNUAL PERCENTAGE PERFORMANCE LOSS

The manufacturers provide in the technical data sheets of the PV modules, the information on the percentage of **annual performance loss** over a certain number of **years of service**. These indications are normally shown with a linear function like the one shown in Fig. 23 or only as a textual description which must be correctly interpreted to correctly define this condition in the instrument.

Based on this information, with appropriate programming of the internal parameters **Perf.@Yr1**, **Perf@Yr2**, **Years@Perf.1**, **Years@Perf.2** in the DB section (see § 6.3), the instrument takes into account the performance loss effect in the evaluation of the final outcome of the I-V curve measurement as indicated in § 6.4.5.



CAUTION

Pay particular attention to the programming of the parameters **Perf.@Yr1**, **Perf@Yr2**, **Years@Perf.1** and **Years@Perf.2** <u>to avoid possible incorrect</u> <u>negative outcomes</u> in the results of the I-V curve measurements

In general, the performance loss% is calculated by the instrument based on the following relationship:

 $PerfLoss\% = \frac{Perf@Yr1 - Perf@Yr2}{Years@Perf2 - Years@Perf1}$ [1]

The relationship [1] is determined based on the characteristics present in the technical data sheet of the PV module. Some examples are provided below to establish ideas.

Example 1 \rightarrow parameters determined with textual description in the data sheet

A manufacturer's data sheet reads as follows:

(...) with the linear yield guarantee, XXXXXXX guarantees a maximum progressive reduction in yield of **0.7% per year** for **25 years**, a clear added value compared to the standard scalar guarantee in the sector (...)

In this situation the available data are:

- > PerfLoss% year = 0.7%
- > Perf@Yr1 = $100\% 0.7\% = 99.3\% \rightarrow$ Module performance after 1 year of service
- Years@Perf1 = 1
- ➢ Perf@Yr2 = 82.5% → Module performance after 25 years of service obtainable from inverse formule of [1]
- Years@Perf2 = 25

With the data obtainable from the text, the relationship [1] provides the **PerfLoss%** = **0.7%** which will be the value calculated and considered by the instrument

Conclusion \rightarrow the parameters to be set on the instrument are the followed:

Perf@Yr1 = 99.3%Year@Perf1 = 1 Perf@Yr2 = 82.5%Year@Perf2 = 25

Example 2 \rightarrow parameters determined by curve starting from 0 years

The technical data sheet shows the below curve in addition to the following information:

Average annual performance loss less than 0.3% from the 2nd year to the 30th year

Esempio 2 → parametri determinati da curva con partenza da 0 anni



In this situation the available data are:

- PerfLoss% year = 0.3% (declared)
- > Perf@yr1 = $100.0\% \rightarrow$ Module performance at year 0
- Year@Perf1 = 0
- > Perf@Yr2 = $90.3\% \rightarrow$ Module performance after 30 years of service (from graph)
- Year@Perf2 = 30

With the data obtainable from the graph, the relationship [1] provides the **PerfLoss%** = **0.32%** which will be the value calculated and considered by the instrument

Conclusion \rightarrow the parameters to be set on instrument based on the graph are the followed:

Perf@Yr1 = 100.0%Years@Perf1 = 0 Perf@Yr2 = 90.3%Years@Perf2 = 30

Example 3 → parameters determined by curve starting from 1 year

The following technical sheet shows the curve relating to a Bifacial module



In this situation the available data are:

- PerfLoss% year = 0.45% (declared)
- > Perf@Yr1 = 98.0% \rightarrow Module performance after 1 year of service (from graph)
- Year@Perf1 = 1
- > Perf@Yr2 = 84.95% \rightarrow Module performance after 30 years of service (from graph)
- Year@Perf2 = 30

With the data obtainable from the graph, the relationship [1] provides the **PerfLoss%** = **0.45%** which will be the value calculated and considered by the instrument

Conclusion \rightarrow the parameters to be set on instrument based on the graph are the followed:

Perf@Yr1 = 98.0% Years@Perf1 = 1 Perf@Yr2 = 84.95% Years@Perf2 = 30

12. SERVICE

12.1. WARRANTY CONDITIONS

This unit is guaranteed against defects in materials and workmanship in accordance with the General Conditions of Sale. During the warranty period, all defective parts may be replaced and the manufacturer reserves the right to repair or replace the product.

If the instrument is to be returned to the after-sales service or to a dealer transportation costs shall be borne by the Customer. However, shipment must be agreed upon. Any instrument returned must be accompanied by a report stating the reasons for the return. Only the original packaging material can be used to ship the instrument; any damage caused by non-original packaging will be charged to the Customer. The manufacturer declines all responsibility for damage caused to persons and/or property.

The warranty does not appy in the following cases:

- Repair and/or replacement of accessories and battery (not covered by warranty).
- Any repairs that may be required as a result of misuse of the unit or use with incompatible equipment.
- Any repair that may be required as a result of improper packaging.
- Any repair that may be required as a result of servicing by unauthorised personnel.
- Any modification made to the equipment without the manufacturer's authorisation.
- Any use not specified in the specifications of the instrument or in the instruction manual.

The contents of this manual may not be reproduced in any form whatsoever without the authorisation of the manufacturer.

All our products are patented and their trademarks registered. The manufacturer reserves the right to modify the product specifications and prices if this is aimed at technological improvements.

12.2. SERVICE

If the instrument does not operate properly, before contacting the after-sales service check cables as well as test leads and replace them if necessary. If the unit continues to malfunction, check that it is being used correctly and as instructed in this manual. If the instrument is to be returned to the after-sales service or to a dealer, the transport costs shall be borne by the Customer. However, shipment must be agreed upon. Any instrument returned must be accompanied by a report stating the reasons for the return. Use only the original packaging material for shipping; any damage caused by non-original packaging will be charged to the Customer



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