



**W** 

**User** manual

I-V400w - SOLAR I-Vw

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### 1. SAFETY PRECAUTIONS AND PROCEDURES

The word "instrument" in this manual means generically both the model I-V400w and the model SOLAR I-Vw except notation specifically indicated. This instrument has been designed in compliance with directives IEC/EN61010-1 regarding electronic measuring instruments. Before and while measuring, carefully follow the instructions below:

- Do not perform voltage or current measurements in humid environments
- Do not perform measurements near explosive gas or material and fuels or in dusty environments
- Avoid contact with the circuit tested if no measurement is being performed
- Avoid contact with exposed metal parts, test terminals not in use, circuits, etc.
- Do not perform any measurement if instrument anomalies are detected, such as deformations, breaks, leakage of substances, no display reading, etc.
- Only use original HT accessories

In this manual, following symbols are used:



CAUTION: Follow the instructions given in this manual; improper use may damage the instrument, its components or create dangerous situations for the operator



High voltage: risk of electrical shock



Double insulation



DC voltage or current

AC voltage or current



Ground reference

### **1.1. PRELIMINARY INSTRUCTIONS**

- This instrument has been designed for use in the environmental conditions specified in § 10.5. Do not use in different environmental conditions.
- The instrument may be used for measuring of VOLTAGE and CURRENT in CAT II 1000V DC or CAT III 300V to ground. Do not use on systems exceeding the limit values specified in § 10.1 and § 10.2
- We recommend to follow the ordinary safety rules aimed at: your protection against dangerous currents, the instrument's protection against improper use.
- Only the accessories provided with the instrument guarantee compliance with safety standards. They must be in good conditions and must be replaced, if necessary, with identical models.
- Check that batteries are correctly inserted.
- Before connecting the test cables to the circuit being tested, check that the desired function has been selected.

### 1.2. DURING USE

We recommend to carefully read the following recommendations and instructions:

### CAUTION

- Failure to comply with the CAUTIONs and/or instructions may damage the instrument and/or its components or cause dangers to the operator.
- The symbol "**Mathe**" indicates the charge level. When there are five bars, it means that batteries are fully charged; a decrease in the number of bars down to "**Mathematication**" indicates that the batteries are almost low. In this case, interrupt tests and replace the batteries according to the indications given in § 9.2. The instrument is capable of keeping data stored even without batteries.

#### 1.3. AFTER USE

When measuring operations are completed, turn off the instrument by pressing and holding the ON/OFF key for a few seconds. Should the instrument remain unused for a long time, remove batteries and follow the indications given in § 3.4.

### **1.4. OVERVOLTAGE CATEGORIES - DEFINITIONS**

Standard IEC/EN61010-1 (Safety requirements for electrical equipment for measurement, control and laboratory use, Part 1: General requirements) defines what a measurement category (usually called "overvoltage category") is. At § 6.7.4: Measuring circuits it quotes:

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 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, the norm requires that the transient withstand capability of the equipment is made known to the user.

### 2. GENERAL DESCRIPTION

### 2.1. INTRODUCTION

The instrument was designed to perform complete yield test on **single-phase** (and threephase if combined with optional accessory MPP300) PV installations with calculations of efficiencies (only SOLAR I-Vw) and to perform all I-V curve tests on single modules (panels) or complete strings of photovoltaic (PV) plants in order to verify the reference parameters given by the manufacturers. Therefore, the meter is an ideal solution for troubleshooting any PV installation

### 2.2. INSTRUMENT FEATURES

The instrument can perform the following tests:

### Check on Single phase PV installations (EFF - only SOLAR I-Vw)

- DC/AC TRMS voltage and current measurements
- DC/AC power measurement
- Solar irradiation [W/m<sup>2</sup>] measurement by use of reference cell connected to unit SOLAR-02
- Module and environ. temp. measurement by means of probe connect to SOLAR-02
- Use of compensation relationships on PDC measurements
- Immediate evaluation of result OK/NO of a test
- Checks with programmable IP from 5s to 60min

### Testing of single/three-phase PV systems (MPP - only SOLAR I-Vw + opt. acc. MPP300)

- Measurement of 3 DC voltages and currents
- Measurement of DC string power and total DC power
- Measurement of 3 AC TRMS voltages and currents
- Measurement of total AC power
- Measurement of irradiation [W/m<sup>2</sup>] by means of a reference cell connected to unit SOLAR-02
- Module and environ. temp. measurement by means of probe connect to SOLAR-02
- Application of compensation relationships to DC efficiency.
- Immediate evaluation of result OK/NO of a test
- Parameter recording of a PV system with 5s to 60min programmable IP

### I-V Curve measurement

- Voltage, current, power measurement of PV module/string up to 1000V DC, 10 A DC
- PV module/string temperature measurement
- Irradiance measurement [W/m<sup>2</sup>] by using reference cell
- Numerical and graphical results of I-V curve with 4-wire method
- Comparison of results with standard conditions (STC) and OK/NO final response
- Serial resistance measurement of PV module
- Internal customizable database for definition up to 30 PV modules
- Internal memory for saving test and Optical/USB interface for PC connection

### Quick Check (IVCK)

- Fast test on PV modules and strings of voltage and current up to 1000V DC, 15A
- Immediate evaluation (OK/NO) of test results

The instrument has an innovative electronic function selector to simply set operations with internal parameters, a backlit display, the contrast adjustment and a **HELP** key in order to give a valid help to the operator during the meter's connection to the plants. An enable/disable AutoPowerOFF feature is available after about 5 minutes of idleness.

### 3. PREPARATION FOR USE

### 3.1. INITIAL CHECKS

Before shipment, the instrument's electronics and mechanics have been carefully checked. All possible precautions have been taken to have the instrument delivered under optimal conditions. However, we recommend to rapidly check the instrument in order to detect possible damage occurred during transport. Should you detect anomalies, please immediately contact the dealer.

It is also recommended to check that the package contains all parts indicated in § 10.6. In case of discrepancies, please contact the dealer. Should it be necessary to return the instrument, please follow the instructions given in § 12.

### 3.2. INSTRUMENT POWER SUPPLY

The instrument is battery supplied. For battery type and life, see § 10.4.

The symbol "**Matter**" indicates the charge level. When there are five bars next to the battery symbol, it means that batteries are fully charged; a decrease in the number of bars down to "**Matter**" indicates that the batteries are almost low. In this case, interrupt tests and replace the batteries according to the indications given in § 9.2.

### The instrument is capable of keeping data stored even without batteries.

The instrument is provided with advanced algorithms to maximize the batteries' life.

During instrument operation, a further short pressing of the 32 key turns on the display's backlighting (if battery voltage level is high enough). In order to save battery efficiency, backlighting automatically turns off after approx. 30 seconds.

A frequent use of back lighting reduces the batteries' life

#### 3.3. CALIBRATION

The instrument's technical specifications are those described in this manual. Its performance is warranted for one year (12 months) from the date of purchase.

#### 3.4. STORAGE

In order to guarantee precise measurements, after a long period of the instrument's storage under extreme environmental conditions, wait until it recovers its normal conditions (see the environmental specifications listed in § 10.5).

### 4. DESCRIPTION OF PARTS

### 4.1. INSTRUMENT DESCRIPTION







CAPTION:

- Input for irradiance probe (I-V) / DC transducer clamp (EFF – only SOLAR I-Vw)
- Input for auxiliary temperature probe (I-V) / AC transducer clamp (EFF – only SOLAR I-Vw)
- C1, C2 inputs for current measurement (I-V) / voltage measurement (EFF – only SOLAR I-Vw)
- P1, P2 inputs for voltage measurement (I-V) / AC voltage (EFF – only SOLAR I-Vw)





### CAPTION:

1. Connector for opto insulated cable connection

Fig. 3: Description of the instrument's side

### 4.2. KEYBOARD DESCRIPTION

The keyboard includes following keys:



ON/OFF key to switch on/off the instrument

**ESC/MENU** key to exit the selected menu without confirming and to activate menu management



 $\blacktriangleleft \blacktriangleright \lor \lor$  keys to move the cursor through the different screens in order to select the desired programming parameters

**ENTER** key to confirm the modifications and the selected programming parameters and to select the function from the menu



HELI Å **GO/STOP** key to start measurements

**SAVE** key to save the measured values

**HELP** key (long pressure) to display an indicative outline of the connections between the instrument and the system being tested in the function set key (short pressure) to turn on the display's backlighting

### 4.3. DISPLAY DESCRIPTION

The display is a graphic module with a resolution of 128 x 128 15/05/10 15:34:26 dots. The display's first line indicates the system date/hour and the battery charge indicator. In the bottom part the functionality of **ENTER** key and the active mode is displayed The symbol **1** indicates the presence of an active radio connection with the selected remote unit (SOLAR-02 or MPP300).

The flashing symbol **1** indicates that the instrument is currently searching for a radio connection with the selected Selection remote unit (SOLAR-02 or MPP300).

### 4.4. INITIAL SCREEN

When turning on the instrument, the instrument displays the initial screen for a few seconds. It displays the following:

- The instrument's model (I-V400w or SOLAR I-Vw)
- The manufacturer's name
- Internal modules for RF (Radio Frequency) and WiFi connection
- The serial number (SN:) of the instrument
- The firmware version (FW:) in the instrument's memory
- The date of the last calibration (Calibration date:)

Then, the instrument switches to the last function selected.

Selection I-V 1

SOLAR

I-Vw

нт

RF-Wi SN:15345678

FW: 7.02 H4

Calibration date:

09/09/2015

### 5. MAIN MENU

Pressing the **MENU/ESC** key in any allowable condition of the instrument displays the main menu screen, in which the instrument may be set, the saved measures can be displayed and the desired measuring function may be set (item EFF only appears for instrument SOLAR I-Vw).

Select by cursor the desired options and confirm by pressing **ENTER** 

15/05	/10 15:34:26			
1 - V	I_V Test			
1 - V	1 V 1030			
EFF	Yield Test			
SET	SET Settings			
DB	DB Modules			
MEM Data Recall				
PC	PC PC connection			
	ENTER to select.			
	MENU			

### 5.1. SET – INSTRUMENT SETTINGS

Move the cursor to **SET** by means of the arrow keys  $(\blacktriangle, \blacktriangledown)$  and confirm with **ENTER**. Subsequently, the displays shows the screen which provides access to the various instrument's settings.

The settings will remain valid also after switching off the instrument

15/05/10 15:34:26			
General			
Meas. Unit			
Date and Time			
Remote Unit/Solarim.			
Irradiance			
DC Clamp			
ENTER to select.			
SET			

### 5.1.1. General

- Move the cursor to "General" by means of the arrow keys 15/05/10 15
   (▲,▼) and confirm with ENTER
- 2. The displays shows the screen which allows:
  - Setting the instrument language
  - > Setting the enable/disable of auto power off
  - Adjusting the contrast of display
  - > Enabling the acoustic signal when pressing a key.
- By means of the arrow keys (▲,▼) and select the desired option by means of the arrow keys (◄,►)
- Confirm with SAVE and the "Data saved" message is displayed for a while. Press the ESC/MENU key to exit without saving and to go back to the previous screen

15/05/10	15:34:2	26	
Languag	e ik	Engl	isn 🕨
Autopow	eroff	: N O	
Contrast		:10	
Kev Beer	)	:NO	)
,			
SVVE	to etc	vro da	a t a
SAVE			ala
		S	SET

### 5.1.2. Measurement units

This § allows setting the default measurement units of some internal parameters included in the database (DB) for the management of PV modules (§ 5.3)

- Move the cursor to "Meas. Unit" by means of the arrow 15/05/10 15:34:26 keys (▲,▼) and confirm with ENTER.
   Parameter
- The display shows the screen which allows selecting the measurement units of parameters shown by the meter.
- 3. Press **ESC/MENU** to exit without saving any setting.
- ENTER to select

15:34:26

Beta

Gamma

Tolerance

: mV/°C

: W/°C

: %



- The display shows the screen which allows selecting the measurement units of typical parameters of the modules:
  - Alpha → possible selection: "%/°C" and "mA/°C"
  - Beta → possible selection: "%/°C" and "mV/°C"
  - Gamma → possible selection: "%/°C" and "W/°C"
  - Tolerance  $\rightarrow$  possible selection: "%" and "W"
- 6. Set the desired units by means of the arrow keys  $(\blacktriangleleft, \triangleright)$ .
- Confirm with SAVE and the "Saved data" message is displayed for a while. Press ESC/MENU key to exit without saving and to go back to the previous screen.

### 5.1.3. Date/Time

- 1. Move the cursor to "**Date/Time**" by means of the arrow 1 keys (▲,▼) and confirm with **ENTER**
- The display shows the screen which allows setting the system date/time both in the European (EU) or USA (US) format.
- 3. Set the values by means of the arrow keys  $(\blacktriangleleft, \triangleright)$ .
- 4. Confirm with **SAVE** and the "Saved data" message is displayed for a while. Press **ESC/MENU** key to exit without saving and to go back to the previous screen.

		SET
15/05/10	15,24,26	_
15/05/10	15:34:26	
Veer		

Year	: •	● 2009 ▶
Month	i :	06
Day	:	15
Hour	. :	09
Forma	e. at ·	FII
		20
	SAVE to sto	ore data
		SET

### 5.1.4. Remote unit

This section allows selecting the type of remote unit to be used (if available) and setting the values of typical parameters (Sensitivity and Alpha) of the reference irradiance cell supplied with the meter. The values of these parameters, which are printed on the back label of the cell, depend on the type of PV modules on test.

- 1. Move the cursor to "Remote unit" by means of the arrow 15/05/10 15:34:26 keys  $(\blacktriangle, \nabla)$  and confirm with **ENTER** MPP300 Remote U EFF 2. The display shows the screen which allows: Remote U I-V: ▲ NO ▶ : ◀ 31.0 ▶ mV/kW/m2 Sens. Select the type of remote unit to be used for testing PV Alpha : 0.060 %/°C systems (only for SOLAR I-Vw): • **NO**: Remote unit disabled • SOLAR: Use of SOLAR-02 • MPP300: Use of MPP300 (optional) Enable/disable the use of the remote unit SOLAR-02 for SAVE to store data SET
  - Enable/disable the use of the remote unit SOLAR-02 for I-V measurements (opt. for I-V 400). In case the use of the remote unit has not been enabled, it will be possible to set the sensitivity values (sens.) of the reference cell provided, expressed in "mV/kW\*m-2", and of the Alpha parameter.
- 3. Set the value by means of the arrow keys  $(\blacktriangleleft, \blacktriangleright)$
- 4. Confirm with **SAVE** and the "Saved data" message is displayed for a while. Press **ESC/MENU** key to exit without saving and to go back to the previous screen

### CAUTION

- For EFF measurements (testing of PV systems only SOLAR I-Vw), disabling the remote unit **entails**:
- The impossibility of carrying out Irradiation and Temperature measurements by means of unit SOLAR-02
  - The impossibility of using the unit MPP300 (if available)

Consequently, it will be impossible to obtain a result for the test carried out.

#### 5.1.5. Irradiance

- 1. Move the cursor to "Irradiance" by means of the arrow keys  $(\blacktriangle, \triangledown)$  and confirm with **ENTER**.
- 2. The display shows the screen with the options: " Irr min IV" which allows to set the minimum threshold of measured irradiance expressed in W/m<sup>2</sup>, used by meter as reference during the I-V curve measurements and "Irr min EFF" (only SOLAR I-Vw) which allows to set the minimum threshold of measured irradiance expressed in W/m<sup>2</sup>, used by meter as reference during the check PV efficiency measurements
- 3. Set the value by means of the arrow keys  $(\blacktriangleleft, \triangleright)$ . The accuracy indicated in this manual is granted under condition indicated in § 10.1 and § 10.2. In I-V curve measurement the value is set within the  $0 \div 800 \text{ W/m}^2$ interval while  $400 \div 800 \text{ W/m}^2$ for the PV check operations (only SOLAR I-Vw)
- 4. Confirm with SAVE and the "Saved data" message is displayed for a while. Press ESC/MENU key to exit without saving and to go back to the previous screen.

15/05/10 15:34:26			
Irrmin IV :∢0 ► W/m2			
Irr min EFF : ◀ 600 ▶ W/m2			
SAVE to store data			
SET			

The "0 W/m2" setting for parameter "Min Irr IV" allows carrying out I-V measurements without the following conditions being checked: Connection of reference cell to input IRR of the instrument

CAUTION

- Unsteady irradiation values
- Number of modules consistent with the measured open circuit voltage  $\triangleright$

#### 5.1.6. DC Clamp (only SOLAR I-Vw)

This option allows setting a **possible** correction factor K for the DC clamp, in order to improve current measurement. If present, the correction factor is indicated on the rear label of the clamp itself, indicated as:

K = X.xxx

In case no label is present, set k = 1.000

1. Move the cursor to "DC Clamp" by means of the arrow 15/05/10 15:34:26 keys  $(\blacktriangle, \mathbf{\nabla})$  and confirm with **ENTER** DC clamp k : ◀ 1.000 ▶ 2. The item: "DC clamp k" is shown at display to set the corrective factor in a interval within 0.950 and 1.050. Set the value by means of the arrow keys  $(\blacktriangleleft, \triangleright)$ 3. Confirm with SAVE and the "Saved data" message is displayed for a while. Press ESC/MENU key to exit without saving and to go back to the previous screen SAVE to store data SET

### 5.2. EFF – SETTINGS FOR TESTING PV SYSTEMS (ONLY SOLAR I-VW)

Further in this manual, the acronym **MPPT** (Multiple Power Point Tracker) shall indicate the characteristic of the DC/AC converter (inverter), capable of maximizing the DC power which can be taken from the photovoltaic field. See § 11.2 for further details.

### 5.2.1. Settings for PV systems with single-MPPT inverter - single-phase AC output

Check beforehand the settings made in **MENU→SET→Remote Unit** and check that you have selected "**SOLAR**" as setting for parameter "**R. unit**".

### 5.2.1.1. Instrument settings

Press MENU key, move the cursor to "EFF" by means of 15/05/10 15:34:26
 the arrow keys (▲,▼) and confirm with ENTER. The screen with the values of electrical parameters relative to PV generator is displayed

- 2. Press ENTER key. The options Set PV plant and Set 15/05/10 Instrum. are displayed
- 3. By means of the arrow keys (▲,▼) to select **Set Instrum.** and confirm with **ENTER**. The herewith screen is shown:



t	15/05/10	15:34:26	
).	PRp Irr Pnom Tc Te Pdc Vdc Idc ndc	0.000 0.000 0.000 0.000 0.00	W/m2 kW °C °C kW V A
	Set PV pla	ant	
	Set Inst	rum.	
	Select		EFF

- 4. By means of the arrow keys (◀,►) the herewith 15/05, parameters are set:
  - IP (integration period) used by meter during yield test recording. The values I 5s, 10s, 30s, 60s, 120s, 300s, 600s, 900s, 1800s, 3600s are selectable
  - The full scale (FS) of DC clamp used on DC current measurement with selectable value within 1A ÷ 3000A
  - The full scale (FS) of AC clamp used on AC current measurement with selectable value within 1A ÷ 3000A
- 5. Press the **SAVE** key to save the settings made; the message "Data saved" will be displayed for a few seconds. Press the **ESC/MENU** key to exit without saving and go back to the previous screen.

h	15/05/10 15:34:26
	IP · ↓ 5 k s
st	FS DC clamp : 1000 A
,	FS AC clamp : 1000 A
nt	
1	
nt	
	CAV/E to other data
	SAVE to store data
	EFF

### -<del>M</del>HT°

### 5.2.1.2. PV plant parameters

Press MENU key, move the cursor onto EFF by using the arrow keys (▲,▼) and confirm with ENTER. The display shows the values of the output electrical parameters of the photovoltaic generator (DC side).

15/05/10	) 15:34:26	
P R p Irr P n o m T c T e P d c V d c I d c n d c	0.000 0.0 0.0 0.0 0.0	W/m2 kW °C °C kW V A
•		
	GO – start	rec
Select		EFF

- 2. Press the ENTER key. The instrument shows the following options: "Set PV plant" and "Set Instrum".
- 3. Use the arrow keys (▲, ▼) to select "Set PV plant" and confirm with ENTER. The instrument shows the following screen:

15/05/10	15:34:26	
Prp Irr Pnom Tc Te Pdc Vdc Idc ndc Set PV pl	0.000  0.0 0.000 0.000 0.0	W/m2 W/m2 kW °C °C kW V A
Set Inst		
Select	EFF	

- 4. By means arrow keys (◀ , ►) the herewith parameters 15/05/10 are set:

  - ➤ Gamma → coefficient of variation of power with the temperature, standard parameter of PV module (range: -0.3 ÷ -0.5%/°C typical)
  - Noct → nominal working temperature of a PV cell, standard parameter of PV module (range: 42 ÷ 48°C typical)
  - ➤ Te, Tc → set of default values of environmental temperature and PV module temperature. These values are considered by the meter only without the auxiliary probe connected to emote unit SOLAR-02
  - ➤ Corr. Type → set the corrective term Ptpv for DC efficiency calculation and for maximum DC efficiency visualization (see § 5.2.3)

;	15/05/10 15:34:26
,	Pmax : ◀ 3.500 ▶ kW
	Gamma : 0.45 %/°C Noct : 45 °C
è	Te : 40 °C
è	Corr. Type : T. Env
	SAVE to store data
	EFF

#### 5.2.2. Settings for PV with single/multi MPPT inverter – single/three phase AC output

See § 11.2 for further details about the meaning of MPPT. This mode requires unsing the remote unit **MPP300** (optional). Check beforehand the settings made in **MENU** $\rightarrow$ **SET** $\rightarrow$ **Remote Unit** and check that you have selected "**MPP300**" as setting for parameter "**R. unit**".

### 5.2.2.1. Instrument settings

 Press the MENU key, position the cursor onto EFF by using the arrow keys (▲,▼) and confirm with ENTER. The display shows the screen here to the side, which using the global parameters of the system.

y	15/05/1	0 15:34:26	
	PRD		
า	lrr		W / m 2
	Pnom	150.0	k W
	Тс		°C
	Те		°C
	Pdc		k W
	Pac		k W
	ndc		
	nac		
	▼		
		GO - start	Rec
	Select		MPP

15:34:26

150.0

- - -

- - -

\_

Τс

Te Pdc

Рас

ndc nac

Select

MPP300 Status Set PV plant Set Instrum. W/m2

kW

°C

°C

kW

kW

мрр 🕇 🍿

- Press the ENTER key. The instrument shows the 15/05/10 following options: MPP300 status, System Par. and Instrument settings.
   How the arrow keys (▲ ▼) to select "Instrument Pnom
- 3. Use the arrow keys (▲,▼) to select "Instrument settings" and confirm with ENTER. The instrument shows the following screen:

- 4. By using the arrow keys  $(\blacktriangleleft, \blacktriangleright)$  it is possible to set:
  - the integration period (IP) which can be used by the instrument when testing the parameters of a PV system. The following values can be selected: 5s, 10s, 30s, 60s, 120s, 300s, 600s, 900s, 1800s, 3600s
  - The FS of the DC clamp used for measuring DC current with value selectable between 1A ÷ 3000A
  - The FS of the AC clamp used for measuring AC current with value selectable between 1A ÷ 3000A
  - The type of AC clamp used: STD (standard) or FLEX (flexible clamp)
  - The number of DC inputs to be used for measuring: 1, 1+2, 1+2+3
  - > The type of AC electrical system: **SINGLE**, **4 wires**
- 5. Press the **SAVE** key to save the settings made; the message "Data saved" will be displayed for a few seconds. Press the **ESC/MENU** key to exit without saving and go back to the previous screen.



### -WHT°

### 5.2.2.2. PV plant parameters

 Press MENU key, position the cursor onto EFF by using the arrow keys (▲,▼) and confirm with ENTER. The display shows the screen here to the side, which contains the global parameters of the system.

	15/05/10	) 15:34:26	
	PRp Irr Pnom Tc Te Pdc Pac ndc ndc	 150.0    	W/m2 kW °C °C kW kW
	V		
Ì	(	GO - start r	ec.
	Select		MPP

- 2. Press the ENTER key. The instrument shows the following options: MPP300 status, Set PV plant. and Set Instrum.
- 3. Use the arrow keys (▲,▼) to select "Set PV plant" and confirm with ENTER. The instrument shows the following screen:

15/05/10	15:34:26	
PRp Irr Pnom Tc Pdc Vdc Idc ndc MPP300 Set PV pl Set inst	0.000 0.000 0.000 0.00 0.0 status ant rum.	W/m2 kW °C °C kW V A
Select		мрр 护 🥼

- 4. By using the arrow keys ( $\blacktriangleleft$ ,  $\blacktriangleright$ ) it is possible to set:
  - ➤ Pmax → maximum rated power of PV installation expressed in kW
    - ➤ Range → coefficient of power variation with temperature, characteristic parameter of PV modules (typically in range: -0.3 ÷ -0.5%/C)
    - Noct → rated operating temperature of the cell, characteristic parameter of PV modules (typically in range: 42 ÷ 48°C)
    - ➤ Te, Tc → setting of default values of environmental and PV module temperatures. These values are taken into consideration by the instrument only when probe is not connected to unit SOLAR-02
    - ➤ Corr. Type → Setting of the compensation relationship on the calculation of Pdc power and the maximization of DC performance (see § 5.2.3)

15/05/10	15:34:26	
Dmax		
Pmax	: < 3.	500 ▶ KW
Gamma	: 0.4	45 %/°C
Noct	: 45	°C
Те	: 40	°C
Tc	: 45	°C
Corr.Typ	e. : T.	Env
SAV	E to store	data
SAV		uata
		MPP

### -<del>M`HT</del>°

### 5.2.2.3. MPP300 status

If SOLAR I-Vw is near MPP300, the general parameters of MPP300 may be displayed.

Position the cursor onto EFF by using the arrow keys 15
 (▲,▼) and confirm with ENTER. The display shows the screen here to the side, which contains the global parameters of the system.

	Select		мрр 🕂 🕅
	G	0 - start r	ec.
	▼		
	nac		
	ndc		
	Pac		kW
	Pdc		k W
	Te		°C
	Тс		°C
	Pnom	150.0	k W
	lrr		W/m2
,	PRn		
	15/05/10	15:34:26	

- 2. Press the ENTER key. The instrument shows the 15/05/10 15:34:26 following options: MPP300 status, Set PV plant and Set Power supply P.S Battery Intervention of the state o
- 3. Use the arrow keys (▲,▼) to select "**MPP300 status**" and confirm with **ENTER**. The instrument shows the screen here to the side, which indicates the main general parameters of the instrument.

)	15/05/10 15:34:26		
t	Power supply		P.Sup.
	Battery		In use
,	Charge		99%
Ş	SOLAR-02 detected		SI
í	Version		1.01
I	SN 11010030		
	MPP300 status		
	Set PV plant		
	Set instrum.		
	Select	M	enu <b>†</b> M

### 5.2.3. Selection of the compensation relationship of temperature effects

This option allows selecting the relationship to be used to correct the measurements performed according to the modules' temperature. The following correction modes are available:

- T.mod.: Correction factor Rfv2 related to PV module Temp. (Italian guideline CEI-82-25)
  - T.env: Correction factor Rfv2 related to environment Temp. (Italian guideline CEI-82-25)
- ndc: PRp (Performance ratio for active power) corrected by PV module Temp.



-

### CAUTION

If it's performed a test according to Italian guideline it is recommended to select "T.env." correction

Corr. Type	Temperature (Tcel)	PRp calculation	
T.mod.	$Tcel = Tmodule_Meas$	$\int 1 \qquad (if Tcel \le 40^{\circ}C)$	
T.amb.	$Tcel = \left(Tamb + \left(NOCT - 20\right) \times \frac{Irr}{800}\right)$	$Rfv2 = \begin{cases} 1 - (Tcel - 40) \times \frac{ \gamma }{100} & (if Tcel > 40^{\circ}C) \\ - \rightarrow \\ PRp = \frac{P_{ca}}{\left[ Rfv2 \times \frac{G_p}{G_{STC}} \times P_n \right]} \end{cases}$	CEI 82-25
$\eta_{_{dc}}$	Tcel=Tmodule_Meas	$PRp = \frac{G_{STC}}{G_p} \times \left[1 + \frac{ \gamma }{100} \times \left(T_{cel} - 25\right)\right] \times \frac{P_{ca}}{P_n}$	

#### where:

Symbol	Description	Meas. unit
$G_p$	Irradiance on PV module surface	$\left[ W/m^{2} \right]$
$G_{STC}$	Standard Irradiance = 1000	$\left[ W/m^{2} \right]$
$P_n$	Nominal Power = sum of all power module (Pmax ) included in the part of PV plant under test	[kW]
$P_{ca}$	AC Active Power measured	[kW]
Rfv2	Thermal Coefficient factor	
$ \gamma $	Absolute value of Pmax thermal coefficient	[%/°C]
NOCT	Normal Operating Cell Temperature (@ 800W/m <sup>2</sup> , 20°C, AM=1.5, vel. Aria =1m/s).	[%/°C]

For further details see § 11.1

### 5.3. DB - MODULE DATABASE

The meter allows defining **up to 30 different PV modules**, further to a DEFAULT situation (not editable and not erasable) which can be used as reference case when no piece of information about the module under test is available.

The parameters which can be set, **with reference to 1 module**, are described below in Table 1 together with their range, resolution and validity condition.

Symbol	Description	Range	Resolution	Condition	
Nms	Number of modules for string	1 ÷ 50	1		
Pmax	Maximum nominal power of module	50 ÷ 4800W	1W	$\left \frac{P_{\max} - V_{mpp} \cdot I_{mpp}}{P_{\max}}\right  \le 0.01$	
Voc	Open voltage	15.00 ÷ 99.99V 100.0 ÷ 320.0V	0.01V 0.1V	$Voc \ge Vmpp$	
Vmpp	Voltage on point of maximum power	15.00 ÷ 99.99V 100.0 ÷ 320.0V	0.01V 0.1V	$Voc \ge Vmpp$	
lsc	Short circuit current	0.5 ÷ 15.00A	0.01A	$lsc \ge Impp$	
Impp	Current on point of maximum power	0.5 ÷ 15.00A	0.01A	$lsc \ge Impp$	
Таш	oll - Negative tolerance for Pmax provided by the module manufacturer	0% ÷ 25.0%	0.1%		
1011 -		0 ÷ 99W	1	100 101/Priorit< 25	
	Positive tolerance for Pmax provided	0 ÷ 25%	0.1%	100*Tol⁺/Pnom< 25	
1011+	by the module manufacturer	0 ÷ 99W	1		
Alpha	les temperature coefficient	-0.100÷0.100%/°C	0.001%/°C	100* Alpha / laa < 0.1	
Арпа	isc temperature coemcient	-15.00 ÷ 15.00mA/°C	0.01mA/°C	$100^{\circ}$ Alpna / ISC $\leq 0.1$	
Boto		-0.99 ÷ -0.01%/°C	0.01%/°C	100*Data \/aa < 0.000	
Dela	voc temperature coencient	-0.999 ÷ -0.001V/°C	0.001V/°C	$100^{Beta/Voc} \le 0.999$	
Gamma	Pmax temperature coefficient	-0.99 ÷ -0.01%/°C	0.01%/°C		
NOCT	Nominal working temperature of cell	0 ÷ 100°C	1°C		
Tech.	Effects due to PV technology	STD (standard) CAP(capacitive eff.) HIT (hybrid techn.)			
Rs	Internal serial resistance	$0.00 \div 10.00 \Omega$	0.01Ω		

Table 1: Typical parameters of PV modules

### CAUTION



- The "Tech" item is referred to the choose of the technology of the module on test. Select the "STD" option for test on "STANDARD" PV modules, "CAP" option for test on higher capacitive effects PV modules or HIT (modules with HIT/HIP hybrid technology
- A wrong choose of the type of technology can lead to a negative outcome of the final test

EN - 20

### 5.3.1. How to define a new PV module

- 1. Move the cursor to "DB" by means of the arrow keys  $(\blacktriangle, \nabla)$  and confirm with **ENTER**. The display shows the screen with:
  - The type of selected module
  - The parameter associated to the module (see Table 1)
- 2. Select the "DEFAULT" module by means of the arrow keys  $(\blacktriangleleft, \triangleright)$  and confirm with **ENTER**.
- 3. Press ENTER, select the "New" command and confirm 15/05/10 again with ENTER. Use the arrow keys  $(\blacktriangle, \nabla)$  to scroll all internal parameters.

- 4. By using the internal virtual keyboard it is possible to 15/05/10 define the name of the module (ex: SUNPOWER 210) by Type : means the arrow keys  $(\blacktriangle, \bigtriangledown, \triangleleft, \blacklozenge)$ . Press ENTER to digit  $|_{Pmax}^{\bullet}$ the characters of the desired name.
- 5. Press the SAVE key to save the inserted name of the module as defined or ESC/MENU key to exit without ABCDEFGHIJ saving.
- 6. Digit the value of each parameter of the defined module 15/05/10 (see Table 1) based on the manufacturer's data sheet. Move the cursor to the row of the parameter by means of the arrow keys  $(\blacktriangle, \nabla)$  and set the value by means of the arrow keys  $(\blacktriangleleft, \triangleright)$ . Press and hold  $(\blacktriangleleft, \triangleright)$  for a quick setting of values.
- 7. Confirm with SAVE and the displayed for a while. Pres without saving and to go back

	impp	=	0.00	A	l
"Soved data" massage is	Toll-	=	0	%	
Saveu uala messaye is	▼				
s ESC/MENU key to exit					
the theory management of a second second					L
to the previous screen.			DР		L

### CAUTION

- If the value of any parameter is unknown press and hold the **HELP** key for some seconds to set the default values
- After pressing the **SAVE** key, the meter checks all the conditions shown in Table 1 and, if one or more of these conditions do not occur, some error messages are shown by the display (§ 6.5) and the meter does not save the configuration before any error is solved. Solve the error condition before saving.

	15/05/1	0 15:	34:26	
\$	Туре	: • DE	FAULT )	•
	Pmax	=	185	W
	Voc	=	44.5	V
	Vmpp	=	37.5	V
	lsc	=	5.40	A
1	Impp	=	4.95	A 0/
	▼	=	0	70
	•			
	Select		DB	

า	15/05/1	0 15	:34:26	
I	Туре	: • DE	FAULT	,
	▲			
	Pmax	=	185	W
	Voc	=	44.5	V
	Vmpp	=	37.5	V
	lsc	=	5.40	А
	lmpp	=	4.95	A
	Toll-	=	0	%
	▼			
	New			
	Select		DB	



15/05/10	) 15	5:34:	26		
Type :	SU	NΡ	ЭWЕ	R 2	210
Pmax		•	0		W
Voc	=		0.0		V
Vmpp	=		0.0		V
lsc	=		0.00		А
lmpp	=		0.00		А
Toll-	=		0		%
▼					
			DB		

### 5.3.2. How to modify a PV module

- 1. Select the PV module to be modified from the internal database by means of arrow keys  $(\blacktriangleleft, \triangleright)$ .
- 2. Press the ENTER key and select the "Modify" command by means the arrow key  $(\mathbf{\nabla})$ .
- 3. Confirm the selection with ENTER.

15/05/10	1	5:34:26	
Type: ◀	sι	JNPOWER	R210 🕨
<b>A</b>			
Pmax	=	210	W
Voc	=	47.70	V
Vmpp	=	40.00	V
lsc	=	5.75	A
New			
Modify			
Delete			
Del. Al			
Select	-	DB	

15:34:26

185

44 5

R210 ▶

W

V

- 4. By using the internal virtual keyboard it is possible to 15/05/10 define a different name of the module by means of arrow Type: < SUNPOWE keys  $(\blacktriangle, \bigtriangledown, \triangleleft, \triangleleft, \triangleright)$ . Press **ENTER** to digit any character of  $|_{Pmax}^{\bullet}$ the desired name. Voc
- 5. Press the SAVE key to save the new name of the module as defined or to access the new setting of parameters.
- Select the desired parameters to be modified by means of arrow keys  $(\blacktriangle, \nabla)$  and change values by means of arrow keys  $(\blacktriangleleft, \blacktriangleright)$ . Press and hold the  $(\blacktriangleleft, \blacktriangleright)$  for a quick setting of values. If the value of any parameter is unknown, press and hold the HELP key for some seconds to set the default values.
- 7. Confirm with SAVE and the "Saved data" message is displayed for a while. Press ESC/MENU key to exi without saving and to go back to the previous screen.

### 5.3.3. How to delete a PV module

- 1. Select the PV module to be deleted from the internal database by means of arrow keys  $(\blacktriangleleft, \triangleright)$ .
- 2. Press the ENTER key and select "Delete" command by means of arrow key  $(\mathbf{\nabla})$  to delete the selected module.
- 3. Press the ENTER key and select "Del. All" command by means of arrow key  $(\mathbf{\nabla})$  to delete all modules in the database (except for "DEFAULT").
- Confirm the selection with ENTER or press ESC/MENU to exit

	15/05/10	1	5:34:26	
	Type:∢	Sι	INPOWER	₹210 ►
,	<b>A</b>			
	Pmax	=	210	W
	Voc	=	47.70	V
,	Vmpp	=	40.00	V
	lsc	=	5.75	A
)	New			
	Modify			
)	Delete			
	Del. Al			
	Salact		DР	



### CAUTION It is not possible to modify or delete the "DEFAULT" PV module which is the standard reference factory module.

KEYBOARD
SUNPOWER 210
A B C D E F G H I J K L M N O P
Q R S T U V W X Y Z - + 0 1 2 3
456789 SPACE DEL
SAVE/ESC
15/05/10 15:34:26
Type : SUNPOWER 210
Pmax = ◀ 210 ▶ W
$V \circ c = 47.70 V$

s	Voc	=	47.70	V
~	Vmpp	=	40.00	V
e	Isc	=	5.75	A
	Impp	=	5.25	A
	Toii-	=	5	%
s	V		-	
iŧ				
π				
			DB	
			υь	

### 6. HOW TO OPERATE

### 6.1. TESTING PV SYSTEMS (ONLY SOLAR I-VW)

For the sake of simplicity, further in this manual, the word "string" will be used, although often the term "photovoltaic field" would be more correct. From the point of view of the instrument, the management of a single string or of more parallel strings (photovoltaic field) is identical. Furthermore, the acronym **MPPT** (Multiple Power Point Tracker) shall indicate the characteristic of the DC/AC converter (inverter), capable of maximizing the DC power which can be taken from the photovoltaic field (see the § 11.2 for further details), the acronym PRp shall indicated the Performance ratio (evaluated on active powers).

### CAUTION



- For the evaluation of the PRP only, the measurement of the DC (voltage and current) is not strictly necessary
- Conversely it is necessary if you want to evaluate the performance of the photovoltaic section (ndc) and DC / AC conversion (nac)

Simbol	Description	Unit
PRp	Performance Ratio (calculated through Active power)	
Irr	Irradiance	W/m <sup>2</sup>
Pnom	Total Nominal power of the PV section under test.	kW
Тс	Module Temperature	°C
Те	Environment Temperature	°C
Pdc, Pdcx	Total DC power measured, DC power of PV field x (x=1,2,3)	kW
Pac, Pacx	Total AC power measured, AC power of phase x (x=1,2,3,)	kW
ndc	DC efficiency	
nac	AC efficiency	
Vdc, Vdcx	DC Voltage, DC voltage of PV field x (x=1,2,3)	V
ldc, ldcx	DC current, DC current of PV field x (x=1,2,3)	А
Vac, Vacx	AC Voltage, AC voltage of PV field x (x=1,2,3)	V
lac, lacx	AC current, AC current of PV field x (x=1,2,3)	A

Symbols description

### 6.1.1. Testing of PV systems with single-MPPT inverter - single-phase AC output

The SOLAR I-Vw meter (master) can perform check tests of efficiencies on single phase PV installations by using the irradiance and temperature probes which are connected to the remote unit SOLAR-02. This remote unit communicates with the master unit (for the synchronization and download data operations) through a wireless radio-frequency (**RF**) which is active with a maximum distance of about **1m** between units.

### CAUTION

- The maximum voltage between C1, and C2 inputs is 1000V DC and between P1 and P2 inputs is 265V AC rms. Do not measure voltages exceeding the limits prescribed by this manual. Should you exceed the voltage limits you could damage the instrument and/or its components or endanger your safety
- In order to guarantee the operator's safety, while making the connections, disable the system being measured by means of the switches/breakers upstream and downstream of the DC/AC converter (inverter).



Fig. 4: Connection of meter for check on single phase PV installation

- Check and, if necessary, set the sensitivity of the reference cell on SOLAR-02 consistently with the type of PV modules which will be measured (please refer to the User Manual of SOLAR-02)
- 2. We recommend making a preliminary evaluation of the value of irradiation on the surface of the PV modules being tested by means of unit SOLAR-02 (operating independently) and the reference cell
- 3. Switch on SOLAR I-Vw. Check and if necessary modify the basic settings of meter relative to the minimum irradiance threshold, the FS of DC and AC transducer clamps, the IP and the parameters of the PV installation on test (see § 5.1.1, §5.1.5 and §5.2)
- 4. In order to guarantee the operator's safety, disable the system being measured by means of the switches/breakers upstream and downstream of the DC/AC converter (inverter)

- 5. In case of inverters provided with more than one power tracker (MPPT), **only leave the string corresponding to the first MPPT connected**, as shown in Fig. 4. Then, it will be necessary to repeat the operations described below by only leaving the string corresponding to the second MPPT connected, then to the third, etc.
- 6. Bring SOLAR I-Vw and SOLAR-02 nearer (maximum distance of 1m between them). **All instruments must be switched on** (see the User Manual of SOLAR-2 for further details)
- On SOLAR I-Vw, press the MENU key, select the function EFF and press ENTER; wait for the two units to start communicating with each other. This condition is highlighted by the contemporary presence of the following indicators:
  - Symbol **L** steady (not flashing) on the display of SOLAR I-Vw
  - Symbol **±***m* steady (not flashing) on the display of SOLAR-02
- 8. Connect the **C2** and **C1** inputs respectively to the positive and negative polarity of the output string. Connect the **P1** and **P2** inputs to the phase and neutral conductors respecting the colors as shown in Fig. 4
- 9. Connect the output connector of the DC clamp to the **IDC1** input.



CAUTION BEFORE CONNECTING THE DC CLAMPS TO THE CONDUCTORS Switch on the clamp, check the LED indicating the status of the clamp's internal batteries (if present), select the correct range, press the ZERO key on the DC clamp and check on the display of SOLAR I-Vw the actual zeroing of the corresponding Idc value (values up to 0.02A are acceptable).

- 10. Connect the DC current clamp to the positive string output conductor **by respecting the direction of the arrow** on the clamp itself as indicated in Fig. 4. Position the DC clamp in point so far fron the inverter and avoid that the jaws stay close to the negative conductor
- 11. Connect the AC current clamp to the Phase L1 conductor **by respecting the direction of the arrow** on the clamp itself as indicated in Fig. 4. Position the AC clamp as far as possible from the inverter and avoid that the jaws stay close to the neutral conductor. Connect the output of the clamp to the **IAC** input of the instrument
- 12. Power on the system on test

13. The display shows the first screen containing the values of the electrical parameters on the DC side of the inverter.

\$	15/05/10	15:34:26	
-	PRp Irr Pnom Tc Te Pdc Vdc Idc Idc ndc	3.500 45 30 3.125 389 8.01	W/m2 kW °C °C kW V A
	G	0 - start	rec.
	Select		EFF

3.125

389

8.01

3.012

231

3.03

0.96

GO - start rec

kW

V

А °C

kW

EFF 土 🕅

V

А

- 14. By means of arrow key ▼ to access to the second screen 15/05/10 15:34:26 ▲ Pdc with the values of electrical parameters of the AC side of inverter. Before to start the recording: Vdc
  - ldc  $\succ$  Verify the symbol " $\perp M$ " blinking at display which ndc means the search by the meter of RF connection with Pac Vac the remote unit SOLAR-02 lac
  - > Verify that the Pac active power should be a positive nac value. In the opposite case open the AC clamp and rotate of 180 degree on the phase conductor
  - > Verify that the AC efficiency  $\eta ac = Pac / Pdc$  should be Select a consistent value (e.g.: a situation of  $\eta ac > 1$  is not physically possible)
- 15. With remote unit always close to the main unit pr GO/STOP key to start the recording. The "Rec. S waiting..." message is shown at display of main unit and "HOLD" message is shown at display of SOLAR-02 m than the indication of residual time for "00" instance

ss	15/05/10	15:34:26	
rt ne re	A Pdc Vdc Idc ndc Pac Vac Iac nac	3.125 389 8.01  3.012 231 13.03 0.96	kW V A °C kW V A
	Rec.	Start wa	iting
	Select		

is	15/05/10	0 15:35:00	
ly ic ie	▲ Pdc Vdc Idc ndc	3.125 389 8.01	kW V A °C
	Pac Vac Iac nac	3.012 231 13.03 0.96	k W V A
	F	Rec. Runni	ng
	Select		EFF 土 🍿

ress	15/05/10	15:34:26	
itart the nore	A Pdc Vdc Idc ndc Pac Vac Iac nac	3.125 389 8.01  3.012 231 13.03 0.96	kW V A °C kW V A

16. When the "00" instant after the press of **GO/STOP** key reached, the recording starts and the units are correctly synchronized. In these conditions the message "Re running..." is displayed on the main unit and th "Recording..." message is displayed on the SOLAR-02

- 17. At any time it will be possible to analyze the current 15/05/10 15:35:00 recording status by pressing the **MENU** key. The following Start 14/02/00 1
  - starting date and time of recording
  - the value set for the integration period
  - the number of periods elapsed from the beginning of the recording
  - the remaining memory capacity for recording
- Press the ESC key to exit the screen

- NG Start 14/02/00 17:18:00 Period: 5s IP Number 61 Rec. Time 0d 1h Rec. running Select MPP
- 18. Now it is possible to bring the unit SOLAR-02 near the PV strings to measure irradiation and temperature by means of the relevant probes. When the distance between unit SOLAR-02 and SOLAR I-Vw does not allow the RF connection, on the display of SOLAR-02, the symbol "100" flashes for approx. 30s and then disappears, while SOLAR I-Vw continues searching for the connection for approx. 1 minute.
- 19. Position the reference cell onto the surface of the PV modules. Please refer to the relevant User Manual for a correct assembly.
- 20. Put the temperature sensor in contact with the rear side of the module and fasten it with some tape; prevent touching it with your fingers (as this could alter the measure).
- 21. Wait some seconds in order to permit a stable measure by probes and then connect the irradiation and temperature probes respectively to the inputs **PYRA/CELL** and **TEMP** of the SOLAR-02 unit.
- 22. Wait for "**READY**" message displayed on SOLAR-02. This event indicates that the instrument has detected some data with solar irradiation > minimum limit threshold (see § 5.1.5)
- 23. Wait at least 1 minute in order to recording more valid samples
- 24. Disconnect the irradiation and temperature probes from unit SOLAR-02 and bring the unit near SOLAR I-Vw (max distance 1m).
- 25. The main unit SOLAR I-Vw must be in **EFF** mode. If there is no flashing symbol "**±m**)", press key **▲** to activate the RF connection search again.
- 26. Press the ▼ key on SOLAR-02 to active the RF connection. On the main unit the message "RF connection active" is displayed
- 27. To stop testing, press the **GO/STOP** key on instrument 15/05/10 SOLAR I-Vw and confirm with **ENTER** that you want to stop Irr recording.
- 28. The display of SOLAR I-Vw will show the message "DOWNLOAD" to indicate that the data will be transferred to the main unit during its various phases.
- 29. After the automatic data transfer phase, the instrument:
- Do not show any results if do not exist on the PV installation a "stable irradiance" condition more than the Select minimum irradiance threshold.
- Display the best performance values if during the recording, the Irradiance values reached the "stable" condition and its values were higher than the minimum irradiance threshold.
- 30. Press **SAVE** to save the results (see § 7.1) or **ESC** to exit the screen of the results and go back to the initial screen

t	15/05/10	15:35:00	
	▲ Irr Pnom Tc Te Pdc Pac	971 3.500 45.1 30.5 3.125 2.960	W/m2 kW °C °C kW kW
	nac nac	0.86	
'	Ar	nalysis Re	esult
•	Select		EFF 上M

# 6.1.2. Test PV systems with single/multi-MPPT inverter – single/three-phase AC output

The instrument SOLAR I-Vw, used together with remote units SOLAR-02 and MPP300 (optional), allows testing PV systems characterized by 1 or more strings (with the same direction and inclination) and single-phase or three-phase output.

The remote unit MPP300 is capable of communicating with SOLAR I-Vw (to manage synchronization and data download) and with the remote unit SOLAR-02 (for recording irradiation and temperature values) via a wireless radiofrequency (**RF**) connection, which is active up to a maximum distance of **1m** between the units.



Fig. 5: Connection of MPP300 for testing a single-phase PV system



Fig. 6: Connection of MPP300 for testing a three-phase PV system

### CAUTION

When SOLAR I-Vw is set in order to use MPP300 as a remote unit, ALL connections relevant to electrical quantities (voltages and currents) must be carried out on unit MPP300. SOLAR I-Vw must have no voltage nor current connected to its inputs.



- The maximum voltage for the inputs of MPP300 is 1000VDC between inputs VDC1, VDC2, VDC3 and 600VAC between inputs VAC1, VAC2, VAC3. Do not measure voltages exceeding the limits given in this manual. Exceeding these limits could result in electrical shocks to the user and damage to the instrument.
- In order to guarantee the operator's safety, while making the connections, disable the system being measured by means of the switches/breakers upstream and downstream of the DC/AC converter (inverter).
- 1. Check and, if necessary, set the sensitivity of the reference cell on SOLAR-02 consistently with the type of PV modules which will be measured (please refer to the User Manual of SOLAR-02).
- 2. We recommend making a preliminary evaluation of the value of irradiation on the surface of the PV modules being tested by means of unit SOLAR-02 (operating independently) and the reference cell
- 3. Switch on SOLAR I-Vw, check and, if necessary, change the settings relevant to the type of remote unit, to the minimum irradiation threshold, to the full scale of the AC and DC clamps, to the integration period and to the parameters of the system being measured (see § 5.1.4, § 5.1.5, § 5.1.6, § 5.2.2).
- 4. In order to guarantee the operator's safety, disable the system being measured by means of the switches/breakers upstream and downstream of the DC/AC converter (inverter).
- 5. Bring SOLAR I-Vw, SOLAR-02 and unit MPP300 nearer (maximum distance of 1m between them). **All instruments must be switched on** (see the User Manuals of SOLAR-2 and MPP300 for further details).
- 6. On SOLAR I-Vw, press the **MENU** key, select the function **EFF** and press **ENTER**; wait for the three units to start communicating with each other. This condition is highlighted by the contemporary presence of the following indicators:
  - Symbol **1** Steady (not flashing) on the display of SOLAR I-Vw
  - Symbol **L**M steady (not flashing) on the display of SOLAR-02
  - > MASTER and REMOTE LEDs flashing green on unit MPP300
- 7. Connect the VDC1(+) and VDC1(-) inputs of unit MPP300 to the output terminals of the string, respecting the polarities and the colours indicated in Fig. 5 or Fig. 6
- 8. Repeat the operation described in the step above for other possible DC power trackers to be monitored by using the **VDC2** and **VDC3** inputs according to the number of DC inputs set (see § 5.2.1.1).

9. Connect the output connector of the DC clamp to the **IDC1** input of unit MPP300.

### CAUTION



BEFORE CONNECTING THE DC CLAMPS TO THE CONDUCTORS Switch on the clamp, check the LED indicating the status of the clamp's internal batteries (if present), select the correct range, press the ZERO key on the DC clamp and check on the display of SOLAR I-Vw the actual zeroing of the corresponding Idc value (values up to 0.02A are acceptable).

- 10. Insert the DC current clamp onto the positive output conductor of the string, **respecting the direction of the arrow** found on the clamp itself as indicated in Fig. 5 or Fig. 6. Position the clamp toroid as far as possible from the inverter and from the negative output conductor of the string itself.
- 11. Repeat the operations described in the two steps above for other possible DC power trackers to be monitored by using the **IDC2** and **IDC3** inputs according to the number of DC inputs set (see § 5.2.1.1).
- 12. Connect the **VAC1** and **N** inputs of unit **MPP300** to the Phase and Neutral conductors respectively, respecting the polarities and the colors indicated in Fig. 5 or Fig. 6. In case of three-phase systems in which no Neutral conductor is available, connect input **N** to earth.
- 13. In case of inverter with three-phase output (see settings in § 5.2.1.1), repeat the operation described in the step above for the remaining phases by using the **VAC2** and **VAC3** inputs of MPP300.
- 14. Connect the AC clamp to the Phase L1 conductor, **respecting the direction of the arrow** found on the clamp itself as indicated in Fig. 5 or Fig. 6. Position the clamp toroid as far as possible from the inverter and from the Neutral conductor. Connect the clamp output to the **IAC1** input of MPP300.
- 15. In case of inverter with three-phase output (see settings in § 5.2.1.1), repeat the operation described in the step above for the remaining phases by using the **IAC2** and **IAC3** inputs of MPP300.
- 16. Restore the operation of the electrical system being measured.
- 17. The display of SOLAR I-Vw will show the values of the <u>15/05/</u> **general** electrical parameters of the system being PRP measured. In particular, in this screen:
  - Pdc = General DC power (sum of the string powers)
  - Pac = AC power (if single-phase) or sum of the ac powers (if three-phase)

We recommend checking that the values of the electrical parameters (Pnom, Pdc, Pac) and of the ac performance ( $\eta$ ac) are consistent with the system being measured (e.g.:  $\eta$ ac > 1 is not physically acceptable).



- 18.On SOLAR I-Vw, press key (▼) to access the second screen which contains the values of the output DC parameters of the strings according to the number of DC inputs set (see § 5.2.1.1). In particular, in this screen:
  - Vdcx = DC voltage of string x
  - Idcx = DC current of string x
  - > Pdx = DC power of string x.

We recommend checking that the values of the electrical parameters (Vdc, Idc, Pdc) are consistent with the system being measured.

- 19. On SOLAR I-Vw, press key (▼) to access the third screen which contains the values of the electrical parameters on the AC side of the inverter, consistently with the settings made in § 5.2.2 (single-phase, threephase 4 wires). In particular, in this screen:
  - Vacxy = AC voltage between Phase and Neutral (if single-phase) or between Phases x and y (if threephase)
  - Iacx = AC current of phase x
  - Pacx = AC power of phase x

We recommend checking that the values of the electrical parameters (Vac, Iac, Pac) are consistent with the system being measured.

- 20. Keeping the three instruments near each other (max distance approx. 1m), press the **GO/STOP** key on SOLAR I-Vw to start testing. Consequently:
  - The display of SOLAR I-Vw shows the message "rec. start waiting"
  - The display of SOLAR-02 shows the message "HOLD" and the time, expressed in seconds, remaining before the recording is started
  - On MPP300, the STATUS LED turns on green (not flashing)
- 21. Upon reaching the instant "00" after pressing the **GO/STOP** key, the test is started and the three units are synchronized with each other. In these conditions:
  - The display of SOLAR I-Vw shows the message "rec. running"
  - The display of SOLAR-02 shows the message "Recording..."
  - > On MPP300, the STATUS LED flashes green

15/05/1	0 15:34:26	
Vdc1 Vdc2 Vdc3 Idc1 Idc2 Idc3 Pdc1 Pdc2 Pdc3	$\begin{array}{r} 460.1 \\ 461.4 \\ 462.5 \\ 2.25 \\ 2.31 \\ 2.21 \\ 1.035 \\ 1.066 \\ 1.024 \end{array}$	kW V A A A A kW kW kW kW
	GO - start	rec
Select		мрр 📶

4 5 /0 5 /4 0	45 04 00	
15/05/10	15:34:26	
Vac12	401.4	V
Vac23	401.1	V
Vac31	400.1	V
lac1	4.26	Α
lac2	4.26	Α
lac3	4.27	Α
Pac1	987	W
Pac2	986	W
Pac3	985	W
		▼
G	0 - start	rec
Select		мрр 🛨 🕅

Example of a screen for PV systems with threephase output

15/05/10	15:34:26	
PRp Irr Pnom Tc Pdc Pac ndc ndc nac	3.500 3.125 2.960 0.95	W/m 2 k W ° C ° C k W k W
F	Rec. runn	ing
Select		мрр 📶

Select	Rec. runn	
		-
nac	0.95	
ndc	2.900	ĸvv
Pdc	3.125	k W
Ţe		°C
Тс		°C
Pnom	3.500	kW
Irr		W/m2
PRn		
15/05/10	15:35:00	

- 22. At any time it will be possible to analyze the current 15/ recording status by pressing the **MENU** key. The following Statistic formation will be shown:
  - Starting date and time of recording
  - > The value set for the integration period
  - The number of periods elapsed from the beginning of the recording
  - > The remaining memory capacity for recording

Press the **ESC** key to exit the screen

- 23. Now it is possible to bring the unit SOLAR-02 near the PV strings to measure irradiation and temperature by means of the relevant probes. When the distance between unit SOLAR-02 and MPP300 does not allow the RF connection, on the display of SOLAR-02 the symbol "100" flashes for approx. 30s and then disappears. Unit MPP300 steadily searches for the RF connection with unit SOLAR-02.
- 24. Position the reference cell onto the surface of the PV modules. Please refer to the relevant User Manual for a correct assembly.
- 25. Put the temperature sensor in contact with the rear side of the module and fasten it with some tape; prevent touching it with your fingers (as this could alter the measure).
- 26. Wait for a few seconds to allow the probes to reach a steady measure and then connect the irradiation probe to input **PYRA/CELL** and the temperature probe to input **TEMP** of unit SOLAR-02.
- 27. Wait for the message "**READY**" to appear on the display of SOLAR-02 to indicate that the unit has detected the data with solar irradiation > minimum threshold set (see § 5.1.5).
- 28. With the message "READY" shown on the display, wait for approximately 1 minute in order to take a certain number of samples.
- 29. Disconnect the irradiation and temperature probes from unit SOLAR-02 and bring the unit near unit MPP300. Bring the main unit SOLAR I-Vw near MPP300 too. The three units must be near each other (max distance 1m).
- 30. The main unit SOLAR I-Vw must be in **EFF** mode; if no flashing symbol "**±m**" appears, press key **▲** to activate the RF connection search again.
- 31. Press key ▼ on SOLAR-02 to activate the RF connection again. Consequently, the main unit will show the message "active radio connection".

	Select MPP
	Rec. Running
ļ	
	Rec. IIME Ud 1h
	Period: 5s IP Number 61
	14/02/00 17:18:00
ļ	Start
	15/05/10 15:35:00

- 32. To stop testing, press the **GO/STOP** key on instrument 15/05/ SOLAR I-Vw and confirm pressing **ENTER** that you want to stop recording.
- 33. The display of SOLAR I-Vw will show the message "DATA DOWNLOAD" to indicate that the data will be transferred to the main unit during its various phases.
- 34. After the automatic data transfer phase, the instrument:
- Do not show any results if do not exist on the PV installation a "stable irradiance" condition more than the minimum irradiance threshold.
- Display the best performance values if during the recording, the Irradiance values reached the "stable" condition and its values were higher than the minimum irradiance threshold.
- 35. Press **SAVE** to save the results (see § 7.1) or **ESC** to exit the screen of the results and go back to the initial screen.

15/05/10	15:35:00	
▲ PRp Irr Pnom Tc Pdc Pdc Pac ndc nac	$\begin{array}{c} 0.815\\ 971\\ 3.500\\ 45.1\\ 30.5\\ 3.125\\ 2.960\\ 0.806\\ 0.947 \end{array}$	W/m2 kW °C °C kW kW
Ar	alysis Ro	esult
Select		EFF 抗

### 6.2. I-V CURVE MEASUREMENT

The meter can perform I-V curve tests by using one of the herewith modes:

- > I-V curve test with Irr/Temp measurement directly performed by the instrument
- I-V curve test with Irr/Temp measurement performed by use of remote unit SOLAR-02

For theoretical information on measurement see the § 11.1

#### 6.2.1. I-V curve measurement by use of instrument

### CAUTION

- The maximum voltage among P1, P2, C1, and C2 inputs is 1000V DC. Do not measure voltages exceeding the limits prescribed by this manual
- The maximum current measured by the meter is 15A. Do not perform test on strings of PV modules in parallel with them
- Do not perform test on PV modules or strings connected to DC/AC converter
- 1. Turn on the meter by pressing **ON/OFF** key
- 2. Check that option NO relative to the selection of remote unit SOLAR-02 should be set on the instrument (see § 5.1.4)
- 3. Check that the values set on the "Remote unit" section (see § 5.1.4) should be consistent with the reference cell depending on the kind of module/string on test
- 4. Check that the value set on "Irradiance" section (see § 5.1.5) should be consistent with the measurement to perform. It is suggested to perform the measurement with a threshold  $\geq$  700 W/m<sup>2</sup> in compliance to the IEC/EN60891 guideline
- 5. Back to the main menu and select the "I-V" option
- 6. Press ENTER, by means of arrow keys (▲, ▼) select 15/05/10 15:34:26item "Meas. Type ▶" Vdc = 0.0 V
- 7. Using the ► key, select item "I-V Test" and confirm by pressing ENTER

,	vuc	= 0.0 V	
	lrr	= <b>0</b> W/m2	
	Тс	= °C	
	Modul	e: SUNPOWER 210	
		I-V Test	
	Set	RS Test	
	Mea	IV Fast Check	
	Select	I - V	

- one 15/05/10 15:34:26Vdc = 0.0 V ured Irr = - - - W/m2 Tc = Auto Module: PANEL01 Temp: Auto Select I-V
- 8. The instrument displays a screen similar to the one 15/05/10reported here to the side, where: **V d c** =
  - Vdc = DC output voltage from module measured between C1 and C2 inputs of meter
  - Irr = irradiance measured by supplied reference cell
  - Tc = temperature of module cell. The herewith options are available for this field:
  - > AUTO  $\rightarrow$  automatic mode of temperature measurement
  - > Number  $\rightarrow$  MAN or AUX mode of temp. measurement
  - > " - "  $\rightarrow$  AUX mode with no connected probe
  - Module = type of selected module
  - Temp = measurement mode of module temperature

#### I-V400w - SOLAR I-Vw

15:34:26

0.0 V

 $-W/m^{2}$ 

SET

9. Press ENTER key, select the "Settings" item and confirm again with ENTER to access the next screen which allows setting the type of PV module and the number of modules relative to the PV string under test.
 15/05/10
 V d c = Irr =

- 10.By means of arrow keys (◀,►) select the type of PV module included in the database of meter (§ 5.3.1).
- 11.By means of arrow keys (▲,▼) select the item "N. of Mod." and by means of arrow keys (◀,►) set the number of modules of the PV string under test. The maximum number of modules is 50
- 12.By means of arrow keys (▲,▼) select the "Rs" item and by means of arrow keys (◄,►) choose the "Manual" or "Auto" mode for the serial resistance measurement (§ 6.2.4)
- 13.By means of arrow keys (◀,►) select the type of PV module included in the database of meter (§ 5.3.1). By means of arrow keys (▲,▼) select the "Temp" item and by means of arrow keys (◀,►) choose the type of module temperature among the modes listed:
  - ➤ Auto" → automatic measurement performed by the meter depending on the measured value of open voltage of the modules (recommended method)
  - ➤ "Manual" → setting of a module temperature value by the operator on the corresponding "Value" field
  - ➤ "Aux" → setting of temperature of module performed by auxiliary probe
- 14.Confirm with **SAVE** key or press **ESC/MENU** key to exit without saving
- 15. Mount the M304 (inclinometer) supplied accessory, place and hold it on the plane of module. Verify that the sun shadow falls on the disc within the <u>"limit internal circle" on the disc itself (see Fig. 7b)</u>. If this is not the case, the incidence angle between sun rays and the module surface is too high and not complying with the test conditions declared by the module manufacturer. As a consequence the measurements performed by the meter are not ok and all measurements steps shall be repeated at another daytime
- 16. Fix the support of the cell to the module by using the supplied set of screws and mount the reference cell on it possibly with **output terminals downwards with respect to the module**. Rotate the cell upwards to lean it on the small wing of the support so as the cell is perfectly parallel to the plane of module, then fix it with the relevant screws supplied
- 17.Connect the output of reference cell (depending on the type of module under test) of reference cell at the **IRR.** input of meter by using the cable supplied with the cell
- 18.Connect, if used, the auxiliary temperature probe (optional accessory) to the **AUX** input of meter and on the rear of module, fixing it with adhesive tape

			,
Тс	= -	°C	;
Modul	e: PAN	NEL01	
Setti	ngs		
Meas	s. Ty	pe 🕨	
Select		I - V	
15/05/	′ <b>10</b> 1	5:34:26	
Туре	: • Sl	JNPOWER	210 🕨
N.of	Mod.	: 15	
Rs	:	Auto	
Temp	:	Manual	
Value	:	51°C	
Pmax	=	210	
Voc	=	47.70	
Vmpp	=	40.00	
ISC	=	5.75	
Impp	=	5.25	

### ŴHT

19.Connect the meter to the module/string under test as shown in Fig. 7a. In particular, connect the negative output pole of module/string to P1, C1 input terminals and the positive output pole of module/string to P2, C2 input terminals



Fig. 7a: Instrument connection to module/string FV





Select

CAUTION

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. It is recommended to use cables with a  $\S \ge 4mm^2$ 

20.After connection to the plant, the real time values of 15/05/10 15:34:26 parameters are shown by meter: 367 V Vdc = Vdc = DC output voltage of PV module/string Irr = Irradiance value measured by sensor lrr 1045 W/m2 \_ • Tc = Value of module temperature °C Тс 45 = Module: SUNPOWER 210

### CAUTION

At the press of **GO/STOP** key some different error messages can be displayed by the meter (see § 6.4) and, due of this, the test cannot start. Check and remove, if possible, this error message before start the test

21.Press **GO/STOP** key to start the test. If none of the previous error messages are detected, the message **Measuring...**" is shown on the display for some seconds, depending on the level of power during test.

15/05/10	15:34:26
Vdc =	367 V
Irr =	<b>1045</b> W/m2
Tc =	<b>45</b> °C
Module: Sl	JNPOWER 210
Ν	leasuring
Select	I - V

I - V
# -<del>M`HT</del>°

- 22.At the end of test, the values of typical parameters (all referred to a single module in standard conditions STC) are shown by the meter together with the final response (§ 6.2.3) based on the automatic calculation performed and relevant to:
  - Translation of I-V curve to STC condition
  - Verification of tolerance % of the maximum power declared by the manufacturer.

15/05/10	) 15:3	15:34:26		
Voc Vmpp Impp Isc Pmax FF	= = = =	15.2 14.7 4.7 5.2 200 77.1	V V A W %	
DPmax	=	2.1	%	
Results	@ STC	– Respor	nse: OK	
Select		I - V	1	

# CAUTION

The instrument refer all the values of parameters to one only module at the STC condition



- The total voltage of the string, obtained at OPC, is divided for the number of module of it. Considering this "average" value, together with the measured current, the instrument perform the I-V curve @ OPC calculation which is the translated at the STC condition
- 23.Press **ENTER** for the display of measurement results both in numeric and graphical mode referred to STC or OPC conditions (see § 6.2.3).
- 24.Use the arrow key ► for the selection of table or graph visualization.
- 25.Press **SAVE** key to store the result of test (see § 7.2) or **ESC/MENU** key to exit without saving and to go back to the main menu.

15/05/10	15:3	34:26	
Voc	=	15.2	V
Vmpp	=	14.7	V
Impp	=	4.7	А
lsc	=	5.2	A
Pmax	=	200	W
FF	=	77.1	%
DPmax	=	2.1	%
Table			
Graph	•	– Respo	nse: OK
Select		I - N	/

#### 6.2.2. I-V curve measurement by use of remote unit SOLAR-02

The I-V curve test with Irr/Temp measurement by use of remote unit SOLAR-02 can be performed in one of the herewith mode:

- > Remote unit SOLAR-02 in RF connection with main unit
- Remote unit SOLAR-02 in synchro recording (no RF connection with main unit)

#### 6.2.2.1. I-V curve test by remote unit SOLAR-02 in RF connection

This mode is possible ONLY if the distance between the main unit and the remote unit SOLAR-02 can establish always a stable RF connection. This distance limit is influenced by obstacles, air humidity, etc., so it is considered valid about some meters.

# CAUTION

 The maximum voltage among P1, P2, C1, and C2 inputs is 1000V DC. Do not measure voltages exceeding the limits prescribed by this manual



- The maximum current measured by the meter is 15A. Do not perform test on strings of PV modules in parallel with them
- Do not perform test on PV modules or strings connected to DC/AC converter
- 1. Turn on the meter by pressing **ON/OFF** key
- 2. Check that option YES relative to the selection of remote unit SOLAR-02 should be set on the instrument (see § 5.1.4)
- 3. Check that the values set on the "Remote unit" section (see § 5.1.4) should be consistent with the reference cell depending on the kind of module/string on test
- 4. Check that the value set on "Irradiance" section (see § 5.1.5) should be consistent with the measurement to perform. It is suggested to perform the measurement with a threshold  $\geq$  700 W/m<sup>2</sup> in compliance to the IEC/EN60891 guideline
- 5. Back to the main menu and select the "I-V" option
- 6. Press ENTER, by means of arrow keys  $(\blacktriangle, \nabla)$  select 15/05/10 15:34:26 item "Meas. Type  $\blacktriangleright$  "  $\forall dc = 0.0$
- 7. Using the ► key, select item "I-V Test" and confirm by pressing ENTER



8. Switch on the remote unit SOLAR-02 and wait that "Radio connection active" message is displayed

0.0 V

-

°C

= Auto

Irr

Тc

Module: PANEL01

Settings Meas. Type W/m2

I−A **∓**∭

- 9. The instrument displays a screen similar to the one 15/05/10 15:34:26 reported here to the side, where: Vdc =
  - Vdc = DC output voltage from module/string
  - Irr = irradiance measured by supplied reference cell
  - Tc = temperature of module. The herewith options are **Tc** available for this field:
    - Module: PANEL01 > AUTO  $\rightarrow$ automatic mode of temperature Temp: Auto measurement
    - temp. Select Number  $\rightarrow$ MAN or AUX mode of measurement
    - $\succ$  " - "  $\rightarrow$  AUX mode with no connected probe
  - Module = type of selected module
  - Temp = measurement mode of module temperature
  - The symbol "**1** fixed at display means that a stable RF connection is established with the remote unit SOLAR-02
- 10.Press ENTER key, select the "Settings" item and confirm 15/05/10 again with **ENTER** to access the next screen which allows Vdc = setting the type of PV module and the number of modules Irr relative to the PV string under test.

11.By	means	of	arrow	keys	(◀,▶)	select	the	type	of	PV 1	1
mo	dule incl	lude	ed in th	e data	abase of	f meter	(§ 5	.3.1)			I

- 12.By means of arrow keys  $(\blacktriangle, \nabla)$  select the item "N. of Mod." and by means of arrow keys  $(\blacktriangleleft, \triangleright)$  set the number of modules of the PV string under test. The maximum number of modules is 50
- 13.By means of arrow keys  $(\blacktriangle, \nabla)$  select the "Rs" item and by means of arrow keys  $(\blacktriangleleft, \triangleright)$  choose the "Manual" or "Auto" mode for the serial resistance measurement (§ 6.2.4)
- 14.By means of arrow keys  $(\blacktriangleleft, \triangleright)$  select the type of PV module included in the database of meter (§ 5.3.1). By means of arrow keys  $(\blacktriangle, \nabla)$  select the "Temp" item and by means of arrow keys  $(\blacktriangleleft, \triangleright)$  choose the type of module temperature among the modes listed:
  - > Auto"  $\rightarrow$  automatic measurement performed by the meter depending on the measured value of open voltage of modules (recommended method)
  - $\succ$  "Manual"  $\rightarrow$  setting of a module temperature value by the operator on the corresponding "Value" field
  - $\succ$  "Aux"  $\rightarrow$  setting of temperature of module performed by auxiliary probe
- 15.Confirm with SAVE key or press ESC/MENU key to exit without saving

Select		I - V	
15/05/10	1	5:34:26	
Туре : ∢	SL	JNPOWER	210 ►
N.of Mo	d.	: 15	
Rs	:	Auto	
Temp	:	Manual	
Value	:	51°C	
Pmax	=	210	
Voc	=	47.70	
Vmpp	=	40.00	
lsc	=	5.75	
Impp	=	5.25	
			SET

15:34:26

0.0 V

 $= - - W/m^{2}$ 

- °C

# -<del>Ŵ</del>HT°

- 16. Mount the M304 (inclinometer) supplied accessory, place and hold it on the plane of module. Verify that the sun shadow falls on the disc within the <u>"limit internal circle" on the disc itself (see Fig. 8)</u>. If this is not the case, the incidence angle between sun rays and the module surface is too high and not complying with the test conditions declared by the module manufacturer. As a consequence the measurements performed by the meter are not ok and all measurements steps shall be repeated at another daytime
- 17. Fix the support of the cell to the module by using the supplied set of screws and mount the reference cell on it possibly with **output terminals downwards with respect to the module**. Rotate the cell upwards to lean it on the small wing of the support so as the cell is perfectly parallel to the plane of module, then fix it with the relevant screws supplied
- 18.Connect the output of reference cell (depending on the type of module under test) at the **PYRA/CELL** input of remote unit SOLAR-02 by using the supplied cable
- 19.Connect, if used, the auxiliary temperature probe to the **TEMP** input of remote unit SOLAR-02 and on the rear of module, fixing it with adhesive tape
- 20.Connect the meter to the module/string under test as shown in Fig.9. In particular, connect the negative output pole of module/string to P1, C1 input terminals and the positive output pole of module/string to P2, C2 input terminals



Fig. 8: Positioning the M304 inclinometer



Fig. 9: Connection of units to the PV module/string

- 21. The instrument displays a screen similar to the one 15/05/10 15:34:26 reported here to the side, where:
  - Vdc = DC output voltage from module/string.
  - Irr = irradiance measured by supplied reference cell
  - Tc = temperature of module. The herewith options are **Tc** available for this field:
  - $\rightarrow$  AUTO  $\rightarrow$  automatic mode of temperature measurement
  - > Number  $\rightarrow$  MAN or AUX mode of temp. measurement
  - $\succ$  " - "  $\rightarrow$  AUX mode with no connected probe
  - Module = type of selected module
  - Temp = measurement mode of module temperature
  - The symbol "**1 fixed** at display means that a stable RF connection is established with the remote unit SOLAR-02



# CAUTION

At the press of GO/STOP key some different error messages can be displayed by the meter (see § 6.3) and, due of this, the test cannot start. Check and remove, if possible, this error message before start the test

22. Press GO/STOP key to start the test. If none of the previous error messages are detected, the message "Measuring..." is shown on the display for some seconds, depending on the level of power during test.

•	15/05/10	15:34:26
	Vdc =	367 V
	Irr =	<b>1045</b> W/m2
	Tc =	<b>45</b> °C
	Module: Sl	JNPOWER 210
		leasuring
	Salact	I = V

23.At the end of test, the values of typical parameters (all	15/05/10	15:34	4:26	
referred to a single module in standard conditions STC)				
are shown by the meter together with the final response (§	Voc Vmnn	=	15.2	V
6.2.3) based on the automatic calculation performed and	lmpp	=	4.7	V A
relevant to:	lsc	=	5.2	A
<ul> <li>Translation of I-V curve to STC condition</li> </ul>	Pmax FF	=	200	VV %
Verification of tolerance % of the maximum power	DPmax	=	2.1	%
declared by the manufacturer.	Deculto	@ etc	Deene	

Select

•	Translation	of I-V	curve to	STC	condition	
---	-------------	--------	----------	-----	-----------	--

- Verification of tolerance % of the maximum declared by the manufacturer.
- 24. Press ENTER for the visualization of measurement results referred at STC or OPC conditions both in numeric and graphical mode (§ 6.2.3)
- 25.Use the arrow key  $\blacktriangleright$  for the selection of table or graph visualization
- 26.Press SAVE key to store the result of test (see § 7.2) or ESC/MENU key to exit without saving and to go back to the main menu.

15/05/10	15:3	34:26	
Voc	=	15.2	V
Vmpp	=	14.7	V
Impp	=	4.7	А
lsc	=	5.2	A
Pmax	=	200	W
FF	=	77.1	%
DPmax	=	2.1	%
Table	•		
Graph	•	– Respo	nse: OK
Select		I - V	/

I - V

#### Vdc =367 V Irr = **1045** W/m2 45 °C \_ Module: SUNPOWER 210 1−A **∓**ໜ Select

#### 6.2.2.2. I-V curve test by remote unit SOLAR-02 in synchro recording

This mode, which consists in an independent recording of the irradiance and temperature parameters by the remote unit SOLAR-02, permits to perform I-V curve test also with wide distance between the instrument and SOLAR-02 without any connection between them. On the other hand, due to the impossibility for the meter to have immediately the values of irradiance/temperature, it is necessary wait the transfer of data from remote unit SOLAR-02 to main unit in order to have all the available results.

## CAUTION

- The maximum voltage among P1, P2, C1, and C2 inputs is 1000V DC. Do not measure voltages exceeding the limits prescribed by this manual
- The maximum current measured by the meter is 15A. Do not perform test on strings of PV modules in parallel with them
- Do not perform test on PV modules or strings connected to DC/AC converter
- 1. Turn on the meter by pressing **ON/OFF** key
- 2. Check that option YES relative to the selection of remote unit SOLAR-02 should be set on the instrument (see § 5.1.4)
- 3. Check that the value set on "Irradiance" section (see § 5.1.5) should be consistent with the measurement to perform. It is suggested to perform the measurement with a threshold  $\geq$  700 W/m<sup>2</sup> in compliance to the IEC/EN60891 guideline
- 4. Back to the main menu and select the "I-V" measurement mode
- 5. Press ENTER, by means of arrow keys (▲,▼) select 15/05/10 15:34:26 item "Meas. Type ▶"
  C. Using the ▶ keys collect item "IV Teet" and confirm by
- Using the ► key, select item "I-V Test" and confirm by pressing ENTER



- 7. Switch on the remote unit SOLAR-02 and wait that "Radio connection active" message is displayed
- 8. Check the status of internal batteries of SOLAR-02 (the "\_\_\_\_" symbol should be not displayed)
- 9. Check that the values of sensitivity and temperature coefficient set on the SOLAR-02 section should be consistent with the reference cell depending on the kind of module/string on test (see user manual of SOLAR-02)

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- 10. The instrument displays a screen similar to the one 15/05/10 15:34:26 reported here to the side, where: Vdc = 0.0
  - Vdc = DC output voltage from module/string
  - Irr = irradiance measured by supplied reference cell
  - Tc = temperature of module. The herewith options are available for this field:
  - ➢ AUTO → automatic mode of temperature measurement
  - > Number  $\rightarrow$  MAN or AUX mode of temp. measurement
  - > " - " → AUX mode with no connected probe
  - Module = type of selected module
  - Temp = measurement mode of module temperature
  - The symbol "1) fixed at display means that a stable RF connection is established with the remote unit SOLAR-02
- 11.Press ENTER key, select the "Settings" item and confirm<br/>again with ENTER to access the next screen which allows<br/>setting the type of PV module and the number of modules<br/>relative to the PV string under test.15/05/10Vdc =<br/>Irr =



-					
5	Vdc	=	0.0	V	
Ś	lrr	= -		W/ı	m 2
	Тс	= -		°C	
	Module	e: PAN	IEL01		
	Setti	ngs			
	Meas	. Ту	pe 🕨		
	Select		۱-	V	
1	15/05/	10 1	5:34:26		
	Туре	: • SL	JNPOW	ER 2	10 🕨
f	N.of I	Mod.	: 15		
	Rs	:	Auto		
ſ	Temp	:	Manu	al	
۱	Value	:	<u>51°C</u>	1.0	
	Voc	=	47	70	
,	Vmpp	=	40.	00	
1	lsc	=	5.	75	

5.25

SET

15:34:26

- 12.By means of arrow keys (◀,►) select the type of PV module included in the database of meter (§ 5.3.1)
- 13.By means of arrow keys (▲,▼) select the item "N. of Mod." and by means of arrow keys (◀,►) set the number of modules of the PV string under test. The maximum number of modules is 50
- 14.By means of arrow keys (▲,▼) select the "Rs" item and by means of arrow keys (◀,►) choose the "Manual" or "Auto" mode for the serial resistance measurement (§ 6.2.4)
- 15.By means of arrow keys (◀,►) select the type of PV module included in the database of meter (§ 5.3.1). By means of arrow keys (▲,▼) select the "Temp" item and by means of arrow keys (◀,►) choose the type of module temperature among the modes listed:
  - ➤ Auto" → automatic measurement performed by the meter depending on the measured value of open voltage of modules (recommended method)
  - ➤ "Manual" → setting of a module temperature value by the operator on the corresponding "Value" field
  - ➤ "Aux" → setting of temperature of module performed by auxiliary probe
- 16.Confirm with **SAVE** key or press **ESC/MENU** key to exit without saving

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- 17. Mount the M304 (inclinometer) supplied accessory, place and hold it on the plane of module. Verify that the sun shadow falls on the disc within the <u>"limit internal circle" on the disc itself (see Fig. 10)</u>. If this is not the case, the incidence angle between sun rays and the module surface is too high and not complying with the test conditions declared by the module manufacturer. As a consequence the measurements performed by the meter are not ok and all measurements steps shall be repeated at another daytime
- 18. Fix the support of the cell to the module by using the supplied set of screws and mount the reference cell on it possibly with **output terminals downwards with respect to the module**. Rotate the cell upwards to lean it on the small wing of the support so as the cell is perfectly parallel to the plane of module, then fix it with the relevant screws supplied
- 19.Connect the output of reference cell (depending on the type of module under test) at the **PYRA/CELL** input of remote unit SOLAR-02 by using the supplied cable
- 20.Connect, if used, the auxiliary temperature probe to the **TEMP** input of remote unit SOLAR-02 and on the rear of module, fixing it with adhesive tape
- 21.Connect the meter to the module/string under test as shown in Fig.11. In particular, connect the negative output pole of module/string to P1, C1 input terminals and the positive output pole of module/string to P2, C2 input terminals



Fig. 10: Positioning the M304 inclinometer



- 22. The instrument displays a screen similar to the one 15/05/10 15:34:26 reported here to the side, where: **Vdc = 367** 
  - Vdc = DC output voltage from module/string
  - Irr = irradiance measured by supplied reference cell
  - Tc = temperature of module. The herewith options are available for this field:
  - > AUTO  $\rightarrow$  automatic mode of temperature measurement
  - > Number  $\rightarrow$  MAN or AUX mode of temp. measurement
  - > " - "  $\rightarrow$  AUX mode with no connected probe
  - Module = type of selected module
  - Temp = measurement mode of module temperature
  - The symbol "1" fixed at display means that a stable RF connection is established with the remote unit SOLAR-02
- 23.Press ENTER key, select the "Activate Rec." item and confirm with ENTER. The message "Remote unit in recording..." is displayed on the meter. In this condition is possible to start the I-V curve tests always considering that the complete results will be available only after the stop of recording of SOLAR-02 and transfer them from the same remote unit

ł	15/05/10 15:34:	26	
ו	Vdc = 0.	0 V	
3	Irr =	- W/	m2
	Tc =	- °C	
3			
	Activate Rec		
	Settings		
	Meas. Type	•	
	Select	I – V	ŦŴ



## **CAUTION**

At the press of **GO/STOP** key some different error messages can be displayed by the meter (see § 6.4) and, due of this, the test cannot start. Check and remove, if possible, this error message before start the test

24.Press **GO/STOP** key to start the test. If none of the previous error messages are detected, the message "**Measuring...**" is shown on the display for some seconds, depending on the level of power during test.

15/05/10	15:34:26						
Vdc =	367 V						
Irr =	W/m2						
Tc =	Auto °C						
Module: Sl	JNPOWER 210						
Measuring							
Select	I - V						



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25.At the end of test, based on the descriptions of previous 1 points, the message "STC Data available after Stop rec" is displayed and then the results at OPC conditions are displayed

	Select		۱-	V
		Results	@ OP(	)
	Тc	=	Auto	,
	Irr	_		Ŵ/m²
	Pmax FF	=	200	VV 9/-
	lsc	=	5.2	A
	Impp	=	4.7	A
	Vmpp	=	14.7	V
	Voc	=	15.2	V
_	15/05/10	0 15:34	4:26	
Г	4 5 /0 5 /4		1.00	

- 26.Press **ENTER** for the visualization of measurement results 15/05/10 15:34:26 both in numeric and graphical mode (§ 6.2.3)
- 27.Use the arrow key ► for the selection of table or graph visualization
- 28.Press **SAVE** key to store the result of test or **ESC/MENU** key to exit without saving and to go back to the main screen

Voc	=	15.2	V
Vmpp	=	14.7	V
lmpp	=	4.7	А
lsc	=	5.2	А
Pmax	=	200	W
FF	=	77.1	%
lrr	=		W/m²
Table	•		
Graph	•		
Select		I - V	V

- 29.At the end of I-V test, press the ENTER key, select the "Stop recording" item and confirm with ENTER. The messages "Wait..." and then "STC Data available in MEM" are displayed
- 30.In this conditions, for the I-V tests performed with irradiance values over the limit threshold and stable, the correspondent STC results will be available inside memory

15/05/10 1	5:34:26		
Vdc =	0.0	V	
Irr = -		W/r	m 2
Tc = A	Auto '	, C	
Stop Reg	g.		
Settings			
Meas. Ty	ype ▶		
Select		- V	

- 31. The message "**Download data**" is displayed on the instrument and, at the same time, the message "**Send**" is displayed on SOLAR-02 which means the transfer of irradiance values and, if necessary, the module temperature values on the main unit
- 32.At the end of data transfer the instrument **automatically** join the average value of irradiance (detected with IP = 5s) to each I-V test performed and, correspondingly, will calculate the results translated to STC conditions and the Yes/No response for each test. The complete results are recalled at display as described in § 7.3.2. See the § 6.2.3 for the meaning of measurement results

### 6.2.3. Meaning of measurement results

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

Parameter	Description	
Pmax	Maximum power of module measured by the meter	
DPmax	Difference % of maximum measured power from nominal power (@ STC)	
FF	Fill Factor %	
Voc	Open voltage	
Vmpp	Voltage on point of maximum power	
lsc	Short circuit current	
Impp	Current on point of maximum power	

Table 2: List of parameter measured by the meter

Where:

**DPmax** = 100 ABS [(Pmax – Pnom) / Pnom] → check parameter which defines the final response of test

Pnom = nominal power of module

 $FF = 100 \times [(Vmpp \times Impp) / (Voc \times Isc)] = Fill Factor \rightarrow$  represents a kind of "efficiency" of module/string as it is a ratio between the maximum power measured and the open power

The meter gives the following final response:

Response	Condition	Note
ок	- $Tol^{(-)} + \varepsilon^{Meter} \le \varepsilon^{Meas} \le Tol^{(+)} - \varepsilon^{Meter}$	(1)
OK*	The previous relation (1) is not verified but the following is valid: - $Tol^{(-)} \le \varepsilon^{Meas} \le Tol^{(+)}$	(2)
NO OK*	The relations (1) and (2) are not verified but the following is valid: - $Tol^{(-)} - \varepsilon^{Meter} \le \varepsilon^{Meas} \le Tol^{(+)} + \varepsilon^{Meter}$	(3)
NO OK	None of the relations (1), (2) and (3) are verified	(4)

where:

 $Tol^{(-)} = Tol^{(-)}$  (%)\*Pnom  $\rightarrow$  Negative tolerance in absolute value, declared by manufacturer

 $Tol^{(+)} = Tol^{(+)}$  (%)\*Pnom  $\rightarrow$  Positive tolerance in absolute value, declared by manufacturer

 $\varepsilon^{Meas}$  = Pmax – Pnom  $\rightarrow$  DPmax which defines the difference between measured values and declared values

 $\varepsilon^{Meter}$   $\rightarrow$  Absolute error of the measurement chain (meter + transducers in the point of measure) considering the error % and the declared dgt

(1) OK  $\rightarrow$  Positive response of test also considering the error of measurement chain

(2)  $OK^* \rightarrow Response of test positive less than the error of measurement chain$ 

- (3) NO OK\*  $\rightarrow$  Response of test negative less than the error of measurement chain
- (4) NO OK  $\rightarrow$  Negative response of test also considering the error of measurement chain

#### 6.2.4. Serial resistance Rs

The serial resistance Rs is one of the typical elements of PV modules which can affect the I-V curve measurement of the panels themselves. The instrument meter performs the Rs calculation, during the measurement of I-V curve (§ 6.2.1), in the following modes:

- AUTOMATIC mode → the Rs calculation is automatically performed by meter using an approximate evaluation based on the measurement of I-V curve.
- MANUAL mode → the Rs value is given by the internal database where it can be manually input by the operator (§ 5.3.1) or measured (§ 6.2.4.1).

#### 6.2.4.1. Serial resistance Rs measurement

The reference standard IEC/EN60891 defines the Rs value with 2 different consecutive measurements at the following conditions:

- Measurement #1: irradiance > 500 W/m<sup>2</sup>
- Measurement #2: irradiance less respect to the previous measurement #1



## CAUTION

The maximum voltage among P1, P2, C1, and C2 inputs is 1000V DC. Do not measure voltages exceeding the limits prescribed by this manual. Should you exceed the voltage limits you could damage the instrument and/or its components or endanger your safety.

- 1. Turn on the meter by pressing **ON/OFF** key.
- 2. Check the specifications of the reference cell (parameters Alpha and Sens.) on meter depending on the type of module **MONOcrystal** or **MULTIcrystal** under test (§ 5.1.4)
- 3. Check the minimum irradiance threshold set on meter (§ 5.1.5). It is recommended to perform measurements with threshold  $\geq$  **700 W/m**<sup>2</sup> in compliance with IEC/EN60891 standard
- 4. Press **ESC/MENU** key to enter to the herewith main menu
- 5. Select the "I-V" item and press ENTER to access the I-V curve measurement §
- 6. Press the ENTER key, select the "Settings" item and 15/05/10 confirm again with ENTER. Select the type of PV module under test among the available models as described in § 5.3.1.



7. Note the name of the selected module (ex: SUNPOWER 210) in the screen

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- 8. Press ENTER key and by means of arrow keys (▲,▼) 15. select the item "Meas. Type ▶"
- 9. By means of arrow key ► access the internal submenu, select the item "**RS Test**" and confirm with **ENTER** to open the main screen of Rs measurement.



10. The herewith screen is shown on the display, where:

- Rs = serial resistance
- Vdc = DC output voltage from module
- Irr = irradiance measured by supplied reference cell
- Module = active module

-			
15/05/1	0 15	:34:26	
Rs	=		Ω
Vdc	=	0.0	V
Irr	=	0	W/m2
Module: SUNPOWER 210			
Select		RS	Mode

- 11.Mount the M304 (inclinometer) supplied accessory, position and hold it on the plane of module. Verify that the sun shadow falls on the disc within the <u>"limit internal circle"</u> on the disc itself (Fig.12b). If this is not the case the incidence angle between sun rays and the module surface is too high and not complying with the test conditions declared by the module manufacturer. As a consequence the measurements performed by the meter are not ok and all measurements steps shall be repeated at another daytime.
- 12.Connect the MONO or MULTI output (depending on the type of module under test) of reference cell at the **IRR.** input of meter by using the cable supplied with the cell.
- 13.Fix the support of the cell to the module by using the supplied set of screws and mount the reference cell on it possibly with **output terminals downwards with respect to the module**. Rotate the cell upwards to lean it on the small wing of the support to have it perfectly parallel to the module plane, then fix it with the relevant screws supplied.
- 14.Connect the meter to the module/string under test as shown in Fig.12a In particular, connect the negative output pole of module/string to P1, C1 input terminals and the positive output pole of module/string to P2, C2 input terminals



Fig. 12a: Instrument connection to module FV

15.After connection to the panel, the real time values are	15/05/10 15:34:26
shown by meter:	$\mathbf{Rs} = \Omega$
Open voltage of module installation	Vdc = 367 ∨
<ul> <li>Irradiance value on the panel installation, measured by reference cell</li> </ul>	$Irr = 1045 W/m^2$
	111 = 1045 W/m2
	Module: SUNPOWER 210
	Select RS Mode
CAUTION	
After pressing the GO/STOP key, some different h	hessages can be shown by
Check and, if possible, solve this situation before c	arrying on with the test.
16 Press GO/STOP key to start the test of none of the	15/05/10 15:34:26
previous error messages are detected, the message	$\mathbf{Rs} = \Omega$
"Measuring 1 running" is displayed for about 5 s and	Vdc – 367 V
the meter performs the first measurement of Rs with the	
standard conditions of module irradiance (§ 5.1.5).	Irr = 1045 W/m2
	Modulo: SUNDOWED 210
	Measure 1 running
	Select RS Mode
17.After performing the first measurement, the meter enters a	15/05/10 15:34:26
waiting mode before starting the second measurement,	$\mathbf{Rs} = \Omega$
which should be performed with the panel partially obscured and the message "Wait for modifying Irrad "	Vdc = 367 ∨
18.Cover the module under test and the reference cell (e.g.	Irr = 1045 W/m2
by using a white plexiglass sheet) in order to reduce the	
irradiance value measured by a percentage ranging from	
40% up to 70% with respect to the previous test.	Module: SUNPOWER 210
	Wait for modify Irrad.
	Select KS Mode
CAUTION	
<ul> <li>Do not modify the inclination of the module duri</li> </ul>	ng the obscuring operation
/ to avoid possible errors on measurements	

- After pressing the **GO/STOP** key, some different messages can be shown by the meter (§ 6.4) and, in this case, the meter does not perform the test. Check and, if possible, solve this situation before carrying on with the test
- 19.Press **GO/STOP** key to start the second measurement. If none of the previous error messages are detected, the meter gives the definitive value of Rs parameter for the panel under test as combination of two previous measurements
- 20.Press **SAVE** key to save the result and the "Saved data" message is displayed for a while. Press **ESC/MENU** key to exit without saving and to go back to the previous screen.

#### 6.3. QUICK CHECK ON PV MODULES AND STRINGS (IVCK)

#### 6.3.1. General information

This function permits to carry out a quick Test of a panel/string just measuring open circuit voltage and short circuit current in compliance with IEC/EN62446. Consequently both irradiance and temperature module values can be measured (using corresponding probes).

Irradiation measurement can be executed only adopting one of the following modes:

- Irradiance sensor directly connected to I-V400w or SOLAR I-Vw
- Irradiance sensor connected to SOLAR-02 through RF to I-V400w or SOLAR I-Vw

Irradiance measurements are always effected in real time, it is impossible to start a "remote" recording of irradiance values through SOLAR-02

If minimum IV irradiance threshold is set (see § 5.1.5):

- = 0 → the instrument does not control the presence of cell, irradiance changes, number of modules and does not display error messages should it be impossible to calculate Voc and Isc values transposed to Voc and Isc under STC. This mode is suitable to effect a test session on a considerable number of strings as quickly as possible.
- > 0 (suggested > 700) → the instrument carries out all tests provided for I-V, manages all conditions and error messages for I-V test (wrong num. Mod., Temp. out of range, cell presence, Min Irr, etc..) and calculates values of Voc and Isc under STC. This mode is recommended whenever thorough tests are to be effected on modules/strings under test.

In general the result page will include:

- Description of the module
- 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 into 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 average can be calculated.
- The values of Voc and Isc measured under OPC as well as any partial outcome (the latter available only if STC values are not available) obtained through comparison with average values.
- The values of Voc and Isc calculated under STC (if available) and any partial outcome obtained comparing the values calculated under STC with the nominal ones (inserted in DB modules).
- The overall test outcome (OK(NO). The overall result will be calculated based on the partial results.
  - > Based on partial outcome under STC (if these are available)
  - > Based on partial outcome under OPC (if STC values are not available)

The instrument will not display any overall outcome if no partial result is available.

In case of negative outcome it is advisable to effect measurement of I-V feature (see § 6.2) in order to thoroughly analysis of the module/string under test.

## 6.3.2. Preliminary settings

- 1. Turn the instrument on by pressing ON/OFF key.
- 2. Press **ESC/MENU** to display the main menu.
- 3. Select "I-V" and press ENTER to enter the FV module performance measurement section. In general when selecting I-V from main menu the instrument shows automatically the last mode under use (I-V or IVCK).
- 4. In case the current mode is not IVCK, press ENTER, 15/05/10 15:34:26 select "Measurement ▶" by means of arrow keys  $(\blacktriangle, \nabla)$ .Use the arrow key  $\triangleright$  to enter the internal submenu, select "IV Check" and confirm by ENTER to start up the initial screen of rapid test IVCK.

10/00/1	0 10	5.04.20		
Vdc	=	0.0	V	
Irr	=	0	W/m	2
Tc	=		°C	
Module	: SUI	NPOWE	ER 210	
	I-V	Test		
Set	Rs	Test		
Mea	I - V	Fast	Chec	k
Select		I	- V	

5. Press ENTER, select "Settings" and confirm by 15/05/10 pressing ENTER again to enter the following screen Module: where it is possible to set module type and number of Tc (AUTO) modules making the string under test.



Str

=

=

Temp Value

Voc

lsc

Tol Voc

15

Manual 51°C

3%

3%

64.7

6.20

(+4%)

(+4%)

%

%

SETTING

Auto

- 6. Use the arrow keys ( $\triangleleft$ ,  $\blacktriangleright$ ) to select the module type 15/05/10 15:34:26 among the ones stored inside the instrument's database Tipo : < SUNPOWER 210 ▶ Mod. x (see § 5.3.1) Rs
- 7. Use the arrow keys  $(\blacktriangle, \nabla)$ , select "Mod. per Str" and use the arrow keys  $(\blacktriangleleft, \blacktriangleright)$  to enter the number of modules for the string under test. The maximum number Tol Isc of modules to be set is 50
- 8. Use the arrow keys  $(\blacktriangle, \nabla)$ , select "Temp" and use the arrow keys  $(\blacktriangleleft, \blacktriangleright)$  to select the measurement type of the module temperature among the modes:
  - $\succ$  "Auto"  $\rightarrow$  automatic measurement carried out according to the measured open circuit voltage value of modules (recommended method)
  - > Manual  $\rightarrow$  entering the known value for the module temperature in the corresponding field "Value"
  - $\blacktriangleright$  Aux  $\rightarrow$  temperature measurement with probe

Note: Settings for parameter "Rs" are ignored for measurements type IVCK.

- 9. Use the arrow keys  $(\blacktriangle, \nabla)$ , select "Tol Voc" and "Tol Isc" then use the arrow keys  $(\blacktriangleleft, \blacktriangleright)$ to set the tolerance values for open circuit voltage (Voc) and short circuit current (Isc) provided by the module manufacturer (values allowed: +0% .. +25%). Please note that the instrument's uncertainty is indicated in brackets beside the above mentioned values and it will be added to the value entered to get the outcome (OK/NO).
- 10. Press SAVE to store the measurements effected or ESC/MENU to quit without saving.



#### 6.3.3. Fast check IVCK without irradiance measurement



The maximum voltage among inputs P1, P2, C1 and C2 is 1000V DC. Do not measure voltages exceeding the limits expressed in this manual.

CAUTION

- The maximum current allowable for the instrument is 15A. Do not effect tests in parallel on FV module strings.
- Never effect tests on modules or FV strings connected to DC/AC converter.
- 1. Turn on the instrument pressing ON/OFF
- 2. Check that remote unit SOLAR-02 is not selected (see § 5.1.4– setting NO)
- 3. Check that the value of minimum irradiance set in the section "Irradiance" (see §5.1.5) is equal to **0**
- 4. Go back to main MENU and select "I-V"
- 5. Select "I-V" and press ENTER to enter the section of FV module performance measurement. Generally when selecting I-V on general menu the instrument automatically shows the last mode under use (I-V or IVCK).
- 6. In case the current mode is not IVCK, press ENTER, select "Measurement ▶" by means of arrow keys (▲,▼). Use the arrow key ▶ to enter the internal submenu, select "IV Check" and confirm pressing ENTER to start up the initial screen of fast check IVCK.
  15/05/10 15:34:26
  Vdc = 0.0
  Irr = 0
  Tc =--



- 7. Check the preliminary settings based on descriptions of § 6.3.2
- 8. Connect the instrument to the module/string under test as shown in the following picture. In particular connect the negative pole of the module/string to terminals P1, C1 and it positive pole to terminals P2, C2.



### CAPTION:

- P1: Black cable
- P2: Blue cable
- C1: Green cable
- C2: Red cable
- 1: Module or FV string

Fig. 10: Connection to module/FV string for IVCK tests without irradiance measurement

- 9. The initial screen under **IVCK** mode displays the values of:
- Module under use
- > The average values of Voc and Isc under OPC conditions.
- > The value of Voc measured under OPC conditions

15/05/10 15:34	4:26
Module:	SUNPWR210
Irr.	W/m2
Tc (AUTO)	°C
VocMed@OPC	647V
lscMed@OPC	5.43A
Voc@OPC	646V
lsc@OPC	A
Voc@STC	V
lsc@STC	A
Selection	IVCK



# CAUTION

When pressing the **GO/STOP** key the instrument can provide different error messages (see §6.3) and, as direct consequence, not carry out the test. Check and eliminate, if possible, causes of the problems before continuing the test.

- 10. Press **GO/STOP** to start the test. In case of no error conditions, the instrument displays the screen with results as shown sideways. It displays as follows:
  - > The module under use
  - > The average values of Voc and Isc under OPC conditions
  - The values of Voc and Isc measured under OPC and relative partial outcome resulting after comparing the average values. In general:

15/05/10 15:34	:26
Module:	SUNPWR210
Irr	W/m 2
Tc (AUTO)	°C
VocŇed@OPC	647V
lscMed@OPC	5.43A
Voc@OPC	647V OK
lsc@OPC	5.35A OK
Voc@STC	V
lsc@STC	A
OUTCO	ME: OK
Selection	IVCK

$$Outcome Voc_{@OPC} = OK \quad \text{if} \quad 100 \times \left| \frac{VocAvg_{@OPC} - Voc_{@OPC}}{VocAvg_{@OPC}} \right| \le (\text{Tol Voc} + 4\%)$$
$$Outcome Isc_{@OPC} = OK \quad \text{if} \quad 100 \times \left| \frac{IsAvg_{@OPC} - Isc_{@OPC}}{IscAvg_{@OPC}} \right| \le (\text{Tol Isc} + 4\%)$$

- The overall value of outcome:
  - o OK: if all results under OPC are OK,
  - o NO if one of the results under OPC is NO
- 11. Press **SAVE** to store the test result into the instrument's memory (see §7.2) or press **ESC/MENU** to quit without saving and go back to main measurement screen.

### NOTES on displayed AVERAGE VALUES

The average values of Voc and Isc are displayed on the outcome page. Such values include the average values of Voc and Isc under OPC conditions calculated as mean of the last 10 tests previously saved. If the user effected and saved a number of tests <10 or he reset the average values (see 6.3.5) the average value displayed during test N+1 will be calculated on N available values.

## 6.3.4. Fast check IVCK with irradiance measurement



The maximum voltage among inputs P1, P2, C1 and C2 is 1000V DC. Do not measure voltages exceeding the limits expressed in this manual.

CAUTION

- The maximum current allowable for the instrument is 15A. Do not effect tests in parallel on FV module strings.
- Never effect tests on modules or FV strings connected to DC/AC converter.
- 1. Turn on the instrument pressing ON/OFF
- 2. Irradiance measurement can be carried out just through the following modes:
  - Measurement through reference cell directly connected to I-V400w or SOLAR I-Vw
  - $\bullet$  Measurement through reference cell connected to SOLAR-02 under RF to I-V400w or SOLAR I-Vw

Check that the remote unit SOLAR-02 setting is consistent with the type of measurement to be effected (see §5.1.4).

- 3. Check the minimum irradiance value set in the "irradiance" section (see § 5.1.5).
- 4. Go back to main MENU and select "I-V"
- 5. Select "I-V" and press ENTER to enter the FV module performance measurement section. Generally when selecting I-V on general menu the instrument automatically shows the last mode under use (I-V or IVCK).
- 6. In case the current mode is not IVCK, press ENTER, 15 select "Measurement ▶" by means of arrow keys (▲,▼). Use the arrow key ▶ to enter the internal submenu, select "IV Check" and confirm pressing ENTER to start up the initial screen of fast check IVCK



- 7. Check the preliminary settings based on descriptions of § 6.3.2
- 8. Connect the instrument to the module/string under test as shown in the following picture. In particular connect the negative pole of the module/string to terminals P1, C1 and it positive pole to terminals P2, C2.



Fig. 14: Instrument's connection for IVCK tests with direct measurement of Irrad/Temp



Fig. 15: Instrument's connection for IVCK tests with measurement of Irrad/Temp through SOLAR-02

Caption:

- P1: Black cable
- P2: Blue cable
- C1: Green cable
- C2: Red cable
- 1: Module or FV string
- 2: Reference cell
- 3: Temp probe (if required)
- 4 Remote unit SOLAR-02

# -<del>Ŵ</del>HT°

SUNPWR210

980W/m2

--°C

647 V

5.43A

646V

IVCK

- - A

A

SUNPWR210 932W/m2

647V

647V 5.35A

787V

.72 A

OUTCOME: OK

IVCK

OK

ΟK

43A

57°C

Luit

- - - V

15/05/10

15:34:26

Module:

Tc (AUTO) VocMed@OPC

scMed@OPC

Voc@OPC

sc@OPC

Voc@STC

sc@STC

Selection

<u>scMed@</u>OPC

Voc@OPC Isc@OPC

Voc@STC

lsc@STC

lrr.

- 9. Connect irradiance probes and temperature probe (if necessary) according to previous pictures and to effected settings (see § 6.3.2).
- 10. In the initial screen of **IVCK** mode the following values are displayed:
- Module under use
- Irradiance (through direct measurement or SOLAR\_02 under RF connection)
- ➤ The temperature value (if mode MAN or AUX) and corresponding measurement mode. If mode AUTO →"- -"
- > The average values of Voc and Isc under OPC conditions
- The following values acquired in real time are also displayed:
- > Open circuit voltage
- > Any symbol of RF connection with SOLAR-02



When pressing the **GO/STOP** key the instrument can provide different error messages (see §6.3) and, as direct consequence, not carry out the test. Check and eliminate, if possible, causes of the problems before continuing the test.

CAUTION

- 11. Press GO/STOP to start up the test. In case of no error 15/05/10 15:34:26 conditions, the instrument displays the screen with the Module: St following results:
   The module under use
- The module under use
- The irradiance value
- The cell temperature value
- The average values of Voc and Isc under OPC
- The values of Voc and Isc measured under OPC
- The values of Voc and Isc measured under STC and relative selection partial outcome resulting after comparing the rated values. In general:

$$Outcome Voc_{@STC} = OK \quad \text{if} \quad 100 \times \left| \frac{VocNom_{@STC} - Voc_{@STC}}{VocNom_{@STC}} \right| \le (\text{Tol Voc} + 4\%)$$

$$Outcome Isc_{@STC} = OK \quad \text{if} \quad 100 \times \left| \frac{IscNom_{@STC} - Isc_{@STC}}{IscNom_{@STC}} \right| \le (\text{Tol Isc} + 4\%)$$

The rated values of Voc and Isc are the values of the DB built-in modules (see §5.3)

- > The overall value of outcome:
  - o OK: if all results under STC are OK,
  - o NO if one of the results under STC is NO
- 12. Press **SAVE** to store the test result into the instrument's memory (see §7.2) or press **ESC/MENU** to quit without saving and go back to main measurement screen.

IVCK

Settings Measurement

Selection



#### 6.3.5. Reset Media

If irradiance values are measured the instrument provides an outcome comparing the measured values with the average values calculated according to previously saved measurements.

Therefore in this case the average values calculated by the instrument play an important role.

In case you start a new set of measurements with significant variations in irradiance and temperature it is advisable to set the reference average values to zero in order to recalculate based on new measurements.

To reset the average values keep to the following steps:

1. Under mode IVCK, press ENTER key, select "Reset 15/05/10 15:34:26 Media" and confirm by pressing ENTER to zero the Irr SUNPWR210 980W/m2 average values calculated till then. Tc (AUTO) 49°C VocNed@OPC - - - V scMed@OPC - - - A Voc@OPC 646V sc@OPC - - - A Reset Medi

The average values are automatically reset even **modifying and saving** one of the following parameters:

- > FV module type
- Number of modules per string

The average values are not reset if the operator changes working mode (for example he goes to the overall detection of the I-V curve to effect string analysis in deep) and go back to this mode.

## 6.4. LIST OF DISPLAY MESSAGES

MESSAGE	DESCRIPTION		
Voltage too low	Check the voltage between C1 and C2 input terminals		
Vin > 1000	DC output voltage from module/string > 1000V		
Irradiance too low	Irradiance value lower than threshold limit		
NTC Error	Internal NTC damaged. Contact service dpt		
Please wait for cooling	Instrument overheated. Wait before starting the tests again		
Memory full	Internal memory full. Download data to PC		
Pulse width too long	Anomalous condition. Repeat test with more modules		
Current too low	Measured current lower than the minimum detectable		
Vdc wrong connection	Check the voltage between C1 and C2 input terminals		
Negative voltage	Check the polarity of input terminals		
Data base full	The number of modules defined is > 30		
Data @ STC unavailable	The meter does not calculate the date at STC conditions		
Irradiance too high	Irradiance value higher than the maximum range		
Data unavailable	Generic error. Repeat the test		
ISC too high	Output current nigner than maximum range		
Error 1/2/2/4/5: contact Assistance	Contect date/nour on meter		
Error EEDBOM : contact Assistance	Contact service dpt		
Error ELASH: contact Assistance	Contact service dpt		
EITOL FLASH . COllider Assistance	Contact service dpt		
Battery low	Low battery indication. Fit new batteries inside meter		
Error: Vmpp >= Voc	Check the settings of module inside DB		
Frror: Impp >= Isc	Check the settings of module inside DB		
Error: Vmpp * Impp >= Pmax	Check the settings of module inside DB		
Error: alpha too high	Check the settings of module inside DB		
Error: beta too high	Check the settings of module inside DB		
Error: Toll too high	Check the settings of module inside DB		
Error: gamma too high	Check the settings of module inside DB		
Module already present	Name of module just used inside DB		
Delta-Irrad. too high. Retry	Unstable condition on irradiance. Repeat the test		
Voltage not steady	Anomalous condition. Repeat test with more modules		
Unsteady Current	Difference between 2 consec. Instant, values of current is > 0.13A		
Firmware mismatch	Problem with Internal FW. Contact service dpt		
PV module temp over range	Temperature inteasured by reference cell is too high		
Wrong Mod Num Continue?	Setting of number of modules not ok with measured Voc		
Ref. Cell temp not detected (ENTER/ESC)	Measure on the cell of module not performed		
Unable to calculate Rs value	Rs value external to measurement range		
Thermal Instability	The instrument detect unsteady conditions (see § 10.2)		
Error during memory writing	Problem with the access to internal memory		
Error Radio: contact Assistance	Contact service dpt		
Error Radio transmission	Contact service dpt		
Error during download	Contact service dpt		
Recording downloaded	Recording corrected downloaded on the instrument		
Radio connection activated	Corrected RF connection with remote unit SOLAR-02		
	Download data from SOLAR-02 and wait for response		
	Output ourroot lower that the minimum measurable		
CALITION: internal short			
Remote unit not detected Enter/Esc	Unit SOI AR-02 do not RF connected to the instrument		
Rem. Unit in rec	Unit SOLAR-02 in recording parameters Irr/Temp		
STC Data available after Stop rec.	Stop the recording to obtain STC data		
STC Data available in MEM	Data STC condition save on memory		
Verify connect. P1	Check the proper insertion of test cable in the input P1		
Error in data download from SOLAR-02	SOLAR I-Vw set for use with MPP300. Error in download from SOLAR-02.		
SOLAR-02 not detected. Stop Rec.?	SOLAR I-Vw set for use with MPP300. SOLAR-02 not detected when stopping Rec.		
MPP300 not detected	SOLAR I-Vw set for use together with MPP300. MPP300 not detected		
SOLAR-02 not detected.	SOLAR I-Vw set for use together with MPP300. SOLAR-02 not detected.		
MPP300: negative AC power	MPP300 has detected negative AC powers.		
MPP300: inverted AC and DC voltages	MPP300 has detected inverted AC and DC voltages		
No power supply to MPP. Continue? Enter/Esc	MPP300 has not detected the presence of the external power supply.		

# 7. STORING DATA

The meter allows storing 99 results of PV checks (only SOLAR I-Vw) and 249 tests of I-V curve in its internal memory. In the PV check operation it's also possible to save the instantaneous values at display. The saved data can be recalled at display and deleted in each moment, and can be associated (for I-V curve test) to reference numerical markers relevant to the installation name, the PV string and the PV module (max 255 markers).

## 7.1. SAVING TEST RESULTS OF PV CHECKS (ONLY SOLAR I-VW)

- 1. Press **SAVE** key with a measured result shown at display 15/0 or for saving the instantaneous values. The right screen with a virtual keyboard is displayed by the meter
- Use the arrow keys (▲,▼) and (◀, ►) to fit a short description (max 12 chars) relative to the PV check
- 3. Press **SAVE** key to store the result of test or **ESC/MENU** key to exit without saving

# 7.2. SAVING TEST RESULTS OF I-V CURVE TEST

- Press SAVE key with a measured result shown at display. The following screen is displayed where the herewith items are shown:
  - > The first memory location available ("Measurement")
  - > The numerical marker "Installation"
  - The numerical marker "String"
  - > The numerical marker "Module"
  - The field "Comment" where the operator can include a short description (max 14 char) by using virtual keyboard
- 15/05/10
   15:34:26

   S
   Measurement:
   007

   Installation: < 010 >
   String:
   009

   Module:
   004
   Comment:

   KEYBOARD

   ABCDEFGHI

   ABCDEFGHI
   JKLMNOP

   QRSTUVWXYZ-+0123
   456789
   SPACE

   DEL
   SAVE for store data
   Comment

   MEM-IV
   MEM-IV
- 2. Use the arrow keys (▲,▼) to select the items and (◀,►) to set the numeric value of the markers and to use the virtual keyboard. "Comments" field modifications are possible only by changing the number of the "Installation" marker inserting one among the available markers
- 3. Press ENTER to digit any character of the desired name
- 4. Press SAVE key to store the result of test or ESC/MENU key to exit without saving.



## 7.3. MANAGING THE RESULTS

## 7.3.1. Recall data of PV checks at display (solo SOLAR I-Vw)

- 1. Press ESC/MENU key to back to the main menu, select 15/05/10 15:34:26 the "MEM" item and confirm with ENTER to access inside MEM 1 the section od saved data 001 IST 08/0
- Using arrows keys (▲,▼) and the arrow key ► select the 002 item "Recall", the item "Yield Test" and confirm with ENTER for the visualization of PV checks results only
- 3. Using arrow key  $\blacktriangleright$  the herewith labels can be displayed:
  - ► TYPE → means the type of saved data: "REC" for a vie 1-V Test complete PV check, "\*REC" when the values of rradiance/temperature measured by SOLAR-02 are not available for the meter and "IST" for the saving of instantaneous values at display



- > DATA  $\rightarrow$  means the date/hour od saved data on meter
- ➤ Comments → means the description gives by the user during the data saved operation
- 4. Select the "**IST**" data, the item "**View**" and confirm with **ENTER**. The herewith screen is displayed:
- Press the arrow keys (▲, ▼) to access to the two available screens
- 6. Press ESC/MENU to back to previous screen
- Select the "REC" data, the item "View" and confirm wit ENTER. The herewith screen is displayed:

е	15/05/10	15:35:00	
'n	► Pdc Vdc Idc ndc Pac Vac Iac nac	3.125 389 8.01 0.88 3.012 231 13.03 0.96	kW V A °C kW V A
	A	nalysis res	sults
	Select		EFF

- Press the arrow keys (▲, ▼) to access to the two available screens
- 9. The final values of PV check relative to the maximum efficiency condition detected are displayed
- 10. Press **ESC/MENU** to back to previous screen
- 11. Selecting the "\*REC" data, the item "View" and confirm with ENTER the message "Unable to execute analysis" is displayed due to the missed of irradiance/temperature values recorded by SOLAR-02. The partial values of this measurement are only visible after downloading the data onto PC (see § 8)

è	15/05/10	15:35:00	
)	▲ Pdc Vdc Idc ndc Pac Vac Iac nac	$\begin{array}{c} 3.125\\ 389\\ 8.01\\ 0.88\\ 3.012\\ 231\\ 13.03\\ 0.96 \end{array}$	k > A ° k > A ℃ W > A
) F			
	Select		EFF

# -<del>M^H</del>T

## 7.3.2. Recall data of I-V curve tests at display

- Press ESC/MENU key to back to the main menu, select 1 the "MEM" item and confirm with ENTER to access inside the section od saved data
- Using arrows keys (▲,▼) and the arrow key ► select the item "Recall", the item "I-V Test" and confirm with ENTER for the visualization of I-C curve results only
- 3. The "DATA" label means the date/hour od saved data on meter
- 4. Use arrow key ► to select the "Comments" label
- 5. The description gives by the user during the data saved operation (see § 7.2) is displayed
- 6. The symbol "\*" near the number of measure means that the meter have performed the I-V curve test with recording of irradiance/temperature values by use of remote unit SOLAR-02, but this values did not transferred or are not available. For this measurements the translated STC values won't be available

15/05/10	) 15:34:26	
MEM	DA	TA
001	08/04/202	10 10:38
002	13/04/202	10 12:15
Y	ield Test	
Vie	-V Test	
Recal		
Delete	•	
Select	ME	M I - V

15/05/10 15:34:26	
MEM	Comments
001	MODULE # 1
002*	MODULE # 2
Select	MEM I-V

- 7. By means of the arrow key ▶, select the "parameters" label.
- 8. The markers relevant to Installation, String and Module selected by the user during the saving procedure (§ 7.2) are shown on the display.
- 9. Press **ESC/MENU** to exit the screen and to go back to the main menu.

,	15/05/10 15:34:26	) S	I	
	MEM	IMP	STR	MOD
	001	001	001	001
	002	001	001	002
	Select		MEM	– IV

# 7.3.2.1. View data – Numerical screens

- 1. Select a row corresponding to a saved result and press ENTER to access the § for the display of stored data. The herewith screen shows a list of saved tests.
- 2. Select the "View" item and press ENTER to open the section of data visualization in the herewith modes:
  - > Numeric screens of parameters measured at the STC conditions and at the operative conditions (OPC)
  - Graphic screens relative to the I-V curves saved at STC and OPC conditions

s	15/05/10	15:34:	26				
е	MEM	INS		STR	ľ	MOD	
	001	001		001		001	
е	002	001		001		002	
2							
~	View						
ر	Delete						
	Select			MEM	-	IV	

3.	The	first	screen	shows	S	the	valu	les	of	me	easi	ured	15/05/1
	parar	neters	, referre	ed to	1	mod	ule,	trar	nslat	ed	to	the	Voc
	stand	lard co	onditions	(STC) a	aco	cordi	ng to	§ 6.	2.3				Vmpp
4.	Press	s arrov	w key ▶,	select	by	mea	ns of	arro	ow k	eys	; ( 🔺	(▼)	lmpp lsc

4. Pre the option "OPC – Avg" and press ENTER.

	15/05/10	15:34:26	
è	Voc	48.0	V
	Vmpp	39.8	V
	lmpp	5.24	А
	lsc	5.60	Α
	Pmax	208	W
	FF	0.78	%
	DPmax	STC	
		OPC - Avg	
	Data	OPC	
	I-V Grap	h ▶	
	PWR Gra	ph 🕨 -	OK
	Select	I –	V

5.	The meter shows the values measured on a string at the	15/05/10	15:34:26	
	real operating conditions (OPC). The values are averaged	Voc	46.9	V
	on a single module (corresponding to the total values	Vmpp	39.0	V
	chould the string he made of a single module)	Impp	4.85	А
	should the string be made of a single module).	lsc	5.22	A
6.	Press arrow key in the first screen, select the option	Pmax	189	W
•.		FF	0.77	%
	"OPC" by means of arrow keys ( $\blacktriangle$ , $\checkmark$ ) and press ENTER.	lrr	927	W / m 2
		Тс	25.1	°C
		Results	@ OPC	– Avg
		Select		I – V

al	15/05/10	15:34:26	
er JS	Voc Vmpp Impp Isc Pmax FF Irr	46.9 39.0 4.85 5.22 189 0.77 927	V V A A W W/m 2
	R e Select	25.1 sults @	OPC I-V

7. The meter shows the total values measured at the real operating conditions (OPC) relative to the string under test.

8. Press ESC/MENU key to exit and go back to the previou screen.

# 7.3.2.2. View data – Graphic screens of I-V curve

- 1. With screen of numerical values relative to standard 15/05/10 conditions (STC) select the item "I-V Graph" by means of arrow key ▼ and press ENTER or the arrow key ►.
- 2. Select the "STC" option and press ENTER.
- 3. The herewith screen is shown by the meter.
- 4. The graph is the I-V curve relative to the object under test 15/05/10 translated to the standard conditions (STC) and referred to 1 module.
- 5. Press **ESC/MENU** key to exit the screen and to go back to the memory section.
- With screen of numerical values measured by meter 15/05/10 select the item "I-V Graph" by means of arrow key ▼ and press ENTER or the arrow key ►.
- Select the option "OPC Avg" and press ENTER. The I-V curve graph of a string measured at the real operative conditions (OPC) and displayed by the meter is averaged on a single module.
- 8. Press **ESC/MENU** key to exit the screen and to go back to the memory section
- With screen of numerical values measured by meter select the item "IV Graph" by means of arrow key ▼ and press ENTER or the arrow key ►.
- 10. Select the option "**OPC**" and press **ENTER**. The I-V curve graph measured at the real operative conditions (OPC) and displayed by the meter corresponds to the **total value relative to the string under test.**
- 11. Press **ESC/MENU** key to exit from screen and back to the memory §



-V Graph @ OPC

Select

Αv





15:34:26

15:34:26

## 7.3.2.3. View data – Graphic screens of power

- 1. With screen of numerical values measured by the meter select the item "**PWR Graph**" by means of arrow key ▼ and press **ENTER** or the arrow key ▶.
- 2. Select the option "STC" and press **ENTER**.
- 3. The herewith screen is shown by the meter.

r	15/05/10	15:34:26	
7	Voc Vmpp Impp Isc Pmax FF	48.0 39.8 5.24 5.60 208 0.78	V V A W %
	DPmax Data S I-V G C PWR C Select	U.5 TC PV – Avg PC	% 

15:34:26

- 4. The graph shows values of output power from 15/05/10 module/string translated to the standard conditions (STC).
- 5. Press **ESC/MENU** key to exit the screen and to go back to the memory §.



- Select the option "OPC Avg" and press ENTER. The meter shows the graph of output power from a single module of a string measured at the real operative conditions (OPC).
- 8. Press **ESC/MENU** key to exit the screen and to go back to the memory §.
- With screen of numerical values measured by the meter <u>15/05/10</u> select the item "**PWR Graph** " by means of arrow key ▼ and press **ENTER** or the arrow key ►.
- 10. Select the option "OPC" and press ENTER. The meter shows the graph of total output power relevant to the string under test measured at the real operative conditions (OPC).
- 11. Press **ESC/MENU** key to exit the screen and to go back to the memory §.





PWR Graph @ <u>OPC-Avc</u>

Select

### 7.3.3. Delete data

- 1. Press **ENTER** key in the memory § to show the submenu
- 2. Select the "Delete" item and press the arrow key ▶. The options below are shown by the meter:
  - $\succ$  Del. Last  $\rightarrow$  delete the last measurement saved
    - > **Del. All**  $\rightarrow$  delete all data in the memory
- 3. Select the desired option with arrow keys  $(\blacktriangle, \nabla)$  and confirm with **ENTER**
- 4. Press ESC/MENU to exit the screen and go back to main menu

	15/05/10	15:3	4:26	;		
ļ	MEM		D	ΑΤΑ		
	001	$\frac{5}{0}$	5/1 2	0		
		-2.0				
l						
I	View	Del	. L	ast		
	Delete	Del	1.	A11		
	Select			MEM	— I	V

# 8. CONNECTING THE INSTRUMENT TO A PC

#### 8.1. CONNECTING BY OPTICAL/USB CABLE C2006

#### CAUTION

- The connection between instrument and PC is realized by means of cable C2006.
- In order to transfer the data onto a PC it is necessary to install beforehand both the management software Topview and the drivers of cable C2006 on the PC itself.



- Before connecting, it is necessary to select the port to be used and the right baud rate (57600 bps) on the PC. To set these parameters, start the **TopView** software and refer to the program's on-line help.
- The selected port must not be engaged by other devices or applications, e.g. a mouse, a modem, etc.
- Optical port emits invisible LED radiations. Do not bring the beam at eye level. Class 1M LED apparatus according to IEC/EN 60825-1

To transfer the saved data to the PC, follow this procedure:

- 1. Switch on the instrument by pressing the **ON/OFF** key
- 2. Connect the instrument to the PC via the provided optical/USB cable C2006.
- 3. Press **ESC/MENU** key to open the main menu.
- 4. By means of arrow keys (▲,▼) select the item "**PC Connection**" to access the PC mode section and confirm with **ENTER**

15/05/	/10 15:34:26
I - V	I-V Test
EFF	Yield Test
SET	Settings
DB	Modules
MEM	Data Recall
PC	PC Connection
	ENTER to select.
	MENU

5. The herewith screen is shown by the meter:

15/05/10	15:34:26					
とし	- K97	232				
WIFI ON						
		MENU				
		MENU				

6. Use the data management software TopView for transferring the content of the instrument memory to the PC (see on-line help of this software for all details)

#### 8.2. CONNECTING BY WIFI



To transfer the saved data to the PC, follow this procedure:

- 1. Switch on the instrument by pressing the **ON/OFF** key
- 2. Press ESC/MENU key to open the main menu.
- 3. By means of arrow keys (▲,▼) select the item "**PC Connection**" to access the PC mode section and confirm with **ENTER**



4. The herewith screen is shown by the meter:

15/05/10	15:34:26	
РС	– RS	232
	WIFION	
		MENU

- 5. Enable the WiFi connection on the target PC (ex: by using a WiFi key installed and connected to a USB port). Select and connect the WiFi network made available by the instrument inside the "Network connection → Wireless networks" section"
- 6. Use the data management software TopView for transferring the content of the instrument memory to the PC (see on-line help of this software for all details)

# 9. MAINTENANCE

#### 9.1. GENERAL

The instrument you purchased is a precision instrument. When using and storing it, please observe the recommendations listed in this manual in order to prevent any possible damage or danger. Do not use the instrument in environments with high humidity levels or high temperatures. Do not directly expose it to sunlight. Always switch off the instrument after using it. Should the instrument remain unused for a long time, remove batteries in order to prevent liquids from leaking out of them, and the instrument internal circuits from being damaged.

### 9.2. BATTERY REPLACEMENT

When the low battery symbol " appears on the LCD display, or if during a test the meter gives the message "low battery", it is necessary to replace the batteries.



# CAUTION

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

- 1. Switth off the instrument by pressing and holding the **ON/OFF** key.
- 2. Remove the cables from the input leads.
- 3. Unscrew the cover fastening screw from the battery compartment and remove it.
- 4. Remove all the batteries from the battery compartment and replace with new batteries of the same type only (§ 10.4) making sure to respect the indicated polarities.
- 5. Restore the battery compartment cover into place and fasten it by means of the relevant screw.
- 6. Do not dispose of the used batteries into the environment. Use relevant containers for disposal.

### 9.3. INSTRUMENT CLEANING

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

### 9.4. END OF LIFE



**CAUTION**: this symbol indicates that the equipment, the batteries and its accessories must be collected separately and disposed of in the right way.

# **10. TECHNICAL SPECIFICATIONS**

# 10.1. YIELD TEST TECHNICAL FERATURES (ONLY SOLAR I-VW)

Accuracy is calculated as [%reading+(number of dgt) \* resolution] at  $23^{\circ}C \pm 5^{\circ}C$ , <80%HR VDC Voltage

<u></u>					
Range [V]		Reso	lution [V]	Accu	iracy
15.0 ÷ 999.9			0.1	±(0.5%rd	g + 2dgt)
AC TRMS Voltage		•		•	
Range [V]		Reso	lution [V]	Accu	iracy
50.0 ÷ 265.0			0.1	±(0.5%rd	g + 2dgt)
Max crest factor: 1.5	• .			X	0 0
DC Current (by externa	I trans	ducer clamp)	(; r )/7	•	
		Resolu	ution [mV]	ACCU	iracy
-1100 ÷ -5			0.1	$\pm$ (0.5%rdg + 0.6mV)	
D ÷ TTUU The value of current is ALWAYS of	displayed v	with positive sign · The	e value of current transduce		
AC TRMS Current (by e	externa	I transducer cla	amp)		0
Range [mV]		Resolu	ution [mV]	Accu	iracy
1 ÷ 1200			0.1	47.5 ÷	- 63.0
Max crest factor: 2.0 ; The value c	of current t	ransduced in voltage	less then 5mV is zeroed		
FS DC and AC clam	ο [Δ] ο	Reso	lution [A]	Minimum re	ad value [A]
		1.630		DC	AC
1< FS ≤ 10		0	).001	0.05	0.01
10< FS ≤ 100	(		0.01	0.5	0.1
100< FS ≤ 1000			0.1	5A	1
DC Power (Vmis > 150)	/)				
FS clamp [A]	F	Range [W]	Resolution [W]	Accu	iracy
1< FS < 10	0.0	00k ÷ 9.999k	0.001k	+(0.7%rd	a + 3dat)
	10.	00k ÷ 99.99k	0.01k	(Imis < ′	g + 30gt) 10%FS)
10 < FS < 100	0.0	00k ÷ 9.999k	0.001k	(11110) (	
	10.	00k ÷ 99.99k	0.01k	+(0.70	%rda)
100~ FS < 1000	0.0	00k ÷ 99.99k	0.01k	(Imis > 10% FS)	
100<10 3 1000	100	).0k ÷ 999.9k	0.1k	(1110 =	
Vmis = voltage at which power is	measured	; Imis = measured cu	rrent		
$\frac{\text{FS clamp [A]}}{\text{FS clamp [A]}}$	V, FF=1 5	<u>)</u> Range [W]	Resolution [W]	Δοου	Iracy
	0.0	$0.0k \div 9.999k$	0.001k	Aut	indoy
1< FS ≤ 10	10	00k ÷ 99.99k	0.01k	±(0.7%rd	g + 3dgt)
	0.0	00k ÷ 9 999k	0.001k	(Imis < <i>1</i>	10%FS)
10< FS ≤ 100	10.	00k ÷ 99.99k	0.01k		
	0.0	$00k \div 99.99k$	0.01k	±(0.7%rdg)	%rdg)
100< FS ≤ 1000	100	$0.0k \div 999.9k$ 0.1k		(Imis ≥ 10%FS)	
Vmis = voltage at which power is	measured	; Imis = measured cu	rrent		
Frequency					
Range [Hz]		Resol	ution [Hz]	Accu	iracy
47.5 ÷ 63.0			0.1	±(0.2%rd	g + 1dgt)
Irradiance (with referen	nce refe	erence cell)			

In adiance (ii			
Ran	ige [mV]	Resolution [m	V] Accuracy
1.0	÷ 100.0	0.1	±(1.0%rdg + 5dgt)

#### Temperature (with auxiliary probe)

Range [°C]	Resolution [°C]	Accuracy
-20.0 ÷ 100.0	0.1	±(1.0%rdg + 1°C)

#### 10.2. I-V TEST TECHNICAL FEATURES (I-V AND IVCK)

#### I-V: DC Voltage @ OPC

Range [V] (***)	Resolution [V]	Uncertainty (***)
5.0 ÷ 999.9	0.1	±(1.0%rdg + 2dgt)

(\*\*\*) The I-V curve and Rs measurements start for VDC > 15V and the accuracy is defined for VDC > 20V

#### I-V: DC Current @ OPC

Range [A]	Resolution [A]	Uncertainty
0.10 ÷ 15.00	0.01	±(1.0%rdg + 2dgt)

#### I-V: DC Power @ OPC (Vmpp > 30V, Impp > 2A)

Range [W] (*, **)	Resolution [W]	Uncertainty
50 ÷ 9999	1	±(1.0%rdg + 6dgt)

Vmpp = Maximum power voltage, Impp = Maximum Power Current

(\*) Max measurable value of Power must include FF value(~ 0.7) → Pmax = 1000V x 15A x 0.7 = 7000W

(\*\*) Test is stopped and the message "Thermal instability" occurs if the instrument detects Voltage > 700V and Current I >3A, I > - 0.038\*V + 37.24 - 0.5

#### I-V: DC Voltage @ STC, IVCK: DC Voltage @ OPC and @ STC

Range [V]	Resolution [V]	Uncertainty (*,**)
5.0 ÷ 999.9	0.1	±4.0%rdg + 2dgt)

#### I-V: DC Current @ STC, IVCK: DC Current @ OPC and @ STC

Range [A]	Resolution [A]	Uncertainty (**)
0.10 ÷ 15.00	0.01	±(4.0% rdg + 2 dgt)

#### I-V: DC Power @ STC (Vmpp > 30V, Impp > 2A)

50 ÷ 9999	1	±(5.0% rdg + 1 dgt)

Vmpp = Maximum power voltage, Impp = Maximum Power Current

(\*) Measurements start for VDC > 15V and the accuracy is defined for VDC > 20V

(\*\*) Test conditions:

Fest cond.: Steady Irrad.≥700W/m<sup>2</sup>, spectrum AM 1.5,solar incidence vs perpendicular. ≤ ± 25°, Cells Temp. [15..65°C]

Global accuracy include contribute of solar sensor and its measuring circuit

#### Irradiance (with reference cell)

Range [mV]	Resolution [mV]	Accuracy
1.0 ÷ 100.0	0.1	±(1.0%rdg + 5dgt)

#### Temperature (with auxiliary probe)

Range [°C]	Resolution [°C]	Accuracy
-20.0 ÷ 100.0	0.1	±(1.0%rdg + 1°C)

#### **10.3. SAFETY SPECIFICATIONS**

10.3.1. General	
Instrument safety:	IEC/EN61010-1
EMC:	IEC/EN61326-1
Technical literature:	IEC/EN61187
Accessory safety:	IEC / EN61010-031
Measurements:	IEC/EN60891 (I-V curve test)
	IEC/EN 60904-5 (Temperature measurement)
Insulation:	double insulation
Pollution level:	2
Category of measure:	CAT II 1000V DC, CAT III 300V to earth
	Max 1000V among inputs P1, P2, C1, C2

## **10.4. GENERAL CHARACTERISTICS**

**Display and memory** Type of display: Memory capacity: Saved data: PC interface:

LCD custom, 128x128 pxl, backlighted 256kbytes 99 yield tests (SOLAR I-Vw only); 249 I-V, 999IVCK optical/USB and WiFi



1m (3 ft)

## PV Yield Test (only SOLAR I-Vw)

Integration period (IP): Memory authonomy SOLAR-02:

Max distance RF connection: Memory of SOLAR-02 - MPP300:

#### **Power supply**

Battery type: Consumption: Low battery indication: Battery life:

Auto power off:

#### **Mechanical data**

Size: Weight (batteries included): 6 x1.5 V alkaline type AA LR06 1W symbol "\_\_\_\_\_" is displayed approx 120 hours (PV Yield test) >249 I-V curve test, 999 IVCK test after 5 minutes of idleness

5,10,30,60,120,300,600,900,1800,3600s

approx 1.5 hours (@ PI = 5s) approx 8 days (@ PI = 600s)

approx. 1.5 hours (@ PI = 5s) approx. 8 days (@ PI = 600s)

235(L)x165(W)x75(H)mm ; 9(L) x 6(W) x 3(H) in 1.2kg (42 ounces)

### **10.5. ENVIRONMENT CONDITIONS**

Reference temperature: Working temperature: Relative humidity allowed: Storage temperature: Storage humidity: Max height of use: 23° ± 5°C (73°F ± 41°F) 0 ÷ 40°C (32°F ÷ 104°F) <80%RH -10 ÷ 60°C (14°F ÷ 140°F) <80%RH 2000m (6562 ft) (\*)

### CAUTION



(\*) Information about the use of meter at altitude from 2000 to 5000m As for voltage inputs P1, P2, C1, C2 the instrument is to be considered downgraded to overvoltage category CAT I 1000V DC and CAT II 300V to ground, max 1000V among inputs. Markings and symbols indicated on the instrument are to be considered valid when using it at altitude lower than 2000m

This instrument complies with the prescriptions of the European directive on low voltage 2006/95/CE (LVD) and EMC 2004/108/CE This instrument satisfies the requirements of 2011/65/EU (RoHS) directive and 2012/19/EU (WEEE)

#### directive

### **10.6. ACCESSORIES**

See only the standard and optional accessory indicated in the enclosed packing list

# 11. APPENDIX

### 11.1. TESTING PHOTOVOLTAIC SYSTEMS

According to the requirements of the laws in force, the result of the test depends on settings about Temperature effects compensation and **PRp** calculations:

Corr.Typ e	Tcel value	PRp calculation	Guidelin e
Tmod	Tcel = PV Module Temp. measured	Р	CEL
Tamb or Tenv	Tcel = PV module Temp. calculated Tcel = Tamb + $(NOCT - 20) \times \frac{G_p}{800}$	$PRp = \frac{P_{ca}}{\left[Rfv2 \times \frac{G_p}{G_{STC}} \times P_n\right]}$	82-25 (Italian Guideline)
nDC	Tcel = PV Module Temp. <b>measured</b>	$PRp = \frac{G_{STC}}{G_p} \times \left[1 + \frac{ \gamma }{100} \times \left(T_{cel} - 25\right)\right] \times \frac{P_{ca}}{P_n}$	

#### where:

Symbol	Description	Meas. unit
$G_p$	Irradiance on PV module surface	$\left[ W/m^2 \right]$
G <sub>STC</sub>	Standard Irradiance = 1000	$\left[ W/m^2 \right]$
$P_n$	Nominal Power = sum of all power module (Pmax ) included in the part of PV plant under test	[kW]
P <sub>ca</sub>	AC Active Power measured	[kW]
$Rfv2 = \begin{cases} 1 & \text{(if Tcel} \le 40^{\circ}\text{C)} \\ 1 - (\text{Tcel} - 40) \times \frac{ \gamma }{100} & \text{(if Tcel} > 40^{\circ}\text{C)} \end{cases}$	Thermal Corrective factor	
γ	Absolute value of Pmax thermal coefficient	[%/°C]
NOCT	Normal Operating Cell Temperature (@ 800W/m <sup>2</sup> , 20°C, AM=1.5, vel. Aria =1m/s).	[%/°C]

Previous relationship are valid if Irradiance > Min Irraddiance value and the Irradiance values are "steady": if  $IP \le 1min \rightarrow (Irr max - Irr min) < 20W/m^2$ 

The final OUTCOME can be:

- Non-displayable: if the obtained values are inconsistent (e.g. PRp >1.15) or if irradiation has never reached a steady value > minimum threshold set.
- > The maximum performance point (PRp) of the system

The highest performance (maximum value of PRp) is detected according with previous relationships.
### 11.2. NOTES ON MPPT (MAXIMUM POWER POINT TRACKER)

Solar irradiation on a surface such as the surface of a photovoltaic system has extremely variable characteristics, since it depends on the position of the sun with respect to the surface and on atmospheric conditions (typically, on the presence of clouds). A photovoltaic module presents, for different solar irradiation values, and for different temperature values, a range of characteristic curves of the type shown in the following figure. In particular, the figure shows three I-V curves (in bold) which correspond to three values (1000, 800, 600W/m<sup>2</sup>) of solar irradiation.



On each characteristic curve there is one single point in which the power transfer towards a hypothetical charge supplied by the photovoltaic module is maximized. The maximum power point corresponds to the voltage-current pair for which the product V\*I is maximum, where V is the value of voltage at the module's terminals and I is the current which runs in the circuit obtained by closing the module on a hypothetical charge.

With reference to the figure above, the product V<sup>\*</sup>I is represented, for the three solar irradiation values mentioned above, through the three curves in thinner lines.

The figure shows that, as stated above, these curves only have one single maximum point. For example, for  $1000W/m^2$ , the maximum power point corresponds to a voltage value of approx. 36V and to a current value of approx. 5.5A.

Obviously, if the power provided by the system is maximized, it is possible to make the most of the system, both in case the system is connected to mains, and in case it is standalone.

MPPT is an inbuilt device in the inverters. It typically reads the voltage and current values at any instant, calculates their product (i.e. the power in Watts) and, by causing small variations in the conversion parameters (duty cycle), it is capable of determining, by comparison, if the photovoltaic module is working in maximum power conditions or not. According to the result, it operates again on the circuit in order to bring the system to an optimal condition. The reason why MPPTs are used is simple: a photovoltaic system without MPPTs may operate anyway; however, with the same solar irradiation, it provides less energy.

There are inverters with 1, 2 or also 3 inbuilt MPPTs available on the market. Typically, the inverters with more than one MPPT are used in systems where:

- the different photovoltaic systems it consists of "forcibly" have different inclinations or directions. In this way, each single MPPT manages its own photovoltaic field, maximizing its performance for the corresponding irradiation and temperature characteristics (without being influenced by the other photovoltaic fields).
- a greater service continuity is sought. With more MPPTs it is possible to put one single photovoltaic field out of service, while the others continue producing energy towards the remaining MPPTs.

## 11.3. THEORETICAL ASPECTS OF THE 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 results of measurements are automatically "translated" to the standard conditions (STC) of irradiance at **1000 W/m<sup>2</sup>** and module temperature at **25°C.** The accuracy indicated in this manual is granted under condition indicated in § 10.2.
- The meter performs a comparison between the maximum nominal power, with the margin of percentage tolerance declared by the module's manufacturer, which is included in the kind of module selected on the meter from the database (§ 5.3.1), and the measured value
- If the comparison of power is within the declared tolerance, the final response of the meter will be "OK" or will be "NO OK" in the opposite case, and the module will not be complying with the specifications declared by the manufacturer (§ 6.2.3)

### 11.3.1. Theoretical aspects of Rs measurement

The test about <u>serial resistance Rs</u> is used in order to perform an exact measurement in real time of this parameter and then add this value to the definition of the PV module's specifications in the internal database of the meter, in compliance with the IEC/EN60891 standard.

# 12. SERVICE

### **12.1. WARRANTY CONDITIONS**

This instrument is guaranteed against any defect in material and manufacturing in compliance with the general sales terms and conditions. Throughout the period of guarantee 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 are on the customer's behalf. Shipment shall be however agreed upon. A report must always be enclosed to a rejected product stating the reasons of its return. To ship the instrument use only the original packaging material; any damage that may be due to no-original packing shall be charged to the customer. The manufacturer declines any responsibility for damages caused to persons and/or objects.

Warranty is not applied in the following cases:

- Repair and/or replacement of accessories and battery (not covered by warranty)
- Any repair that might be necessary as a consequence of a misuse of the instrument or of its use with no compatible devices.
- Any repair that might be necessary as a consequence of improper packaging.
- Any repair that might be necessary as a consequence of service actions carried out by unauthorized personnel.
- Any modification of the instrument carried out without the authorization of the manufacturer.
- Use not provided for in the instrument's specifications or in the instruction manual.

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

All our products are patented and their trade marks 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. Should the instrument still operate improperly check that the operation procedure is correct and conforms with the instructions given in this manual.

If the instrument is to be returned to the after-sales service or to a dealer, transportation costs are on the customer's behalf. Shipment shall be however agreed upon. A report must always be enclosed to a rejected product stating the reasons of its return. To ship the instrument use only the original packaging material; any damage that may be due to non-original packing shall be charged to the customer.

YAMUM0038HT0



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