ENGLISH

User manual

Version EN 2.00 - xx/xx/2012

Table of contents:

1. PRECAUTIONS AND SAFETY MEASURES 2
1.1. Preliminary instructions 2
1.2. During use 3
1.3. After use 3
1.4. Definition of measurement (overvoltage) category 3
2. GENERAL DESCRIPTION 4
2.1. Introduction 4
2.2. Instrument functions 4
3. PREPARATION FOR USE 5
3.1. Initial checks 5
3.2. Instrument power supply 5
3.3. Calibration 5
3.4. Storage 5
4. OVERVIEW 6
4.1. Instrument description 6
4.2. Description of the indication LEDs 6
4.3. MASTER instrument 6
4.3.1. Displaying the status of MPP300 by means of MASTER instruments of Type 1 7
4.3.2. Displaying the status of MPP300 by means of MASTER instruments of Type 2 7
5. SETTINGS ON MASTER INSTRUMENTS 8
5.1. MASTER instruments OF type 1 - Remote unit settings 8
5.2. MASTER instruments OF type 2 – Remote unit settings 8
6. OPERATING INSTRUCTIONS 9
6.1. PV system testing for instruments of Type 1 (SOLAR I-V) 9
6.1.1. Testing of PV systems with single/multi-MPPT inverter - single/three-phase AC output 9
6.2. PV system testing for instruments of Type 1 (SOLAR 300N) 15
6.2.1. Testing of PV systems with single/multi-MPPT inverter - single/three-phase AC output 15
7. MAINTENANCE 21
7.1. General information 21
7.2. Status of the internal rechargeable batteries 21
7.3. Cleaning the instrument 21
7.4. End of life 21
8. TECHNICAL SPECIFICATIONS 22
8.1. Technical specifications for test on PV systems 22
8.2. Reference standards 23
8.3. General characteristics 23
8.4. Environmental conditions for use 23
8.5. Accessories 23
9. APPENDIX – THEORETICAL OUTLINE 24
9.1. Testing photovoltaic systems 24
9.2. NOTES on MPPT (Maximum Power Point Tracker) 25
10. SERVICE 26
10.1. Warranty conditions 26
10.2. Service 26

1. PRECAUTIONS AND SAFETY MEASURES

The instrument has been designed in compliance with directive IEC/EN61010-1 relevant to electronic measuring instruments. Before and while carrying out measurements, observe the following indications and read all notes preceded by the symbol ⚠ with the utmost attention

CAUTION

In case the instrument is used in a way different from the one described in this user manual, this could result in a failure of the protections the instrument is provided with

- Do not carry out any voltage or current measurement in humid environments
- Do not carry out any measurements in case gas, explosive materials or flammables are present, or in dusty environments
- Avoid contact with the circuit being measured if no measurements are being carried out
- Avoid contact with exposed metal parts, with unused measuring probes, circuits, etc
- Do not carry out any measurement in case you find anomalies in the instrument such as deformation, breaks, substance leaks, absence of display on the screen, etc
- Pay special attention when measuring voltages higher than 20V, since a risk of electrical shock exists
- Only use original accessories

In this manual, and on the instrument, the following symbols are used:

CAUTION: observe the instructions given in this manual; an improper use could damage the instrument or its components

High voltage danger: electrical shock hazard

Double insulation

DC voltage or current

AC voltage or current

Connection to earth

1.1. PRELIMINARY INSTRUCTIONS

- This instrument has been designed for use in an environment with pollution level 2 and in the environmental conditions specified in § 8.4. Do not use in different environmental conditions
- We recommend following the normal safety rules devised to protect the user from dangerous currents and the instrument from an incorrect use
- The instrument may be used for measuring **VOLTAGE** in CAT III 1000V DC or CAT IV 300V AC to earth. Do not use on systems exceeding the limit values specified in § 8
- The instrument may be used for measuring **CURRENT** by means of external clamp transducers
- Only original HT accessories guarantee safety standards. They must be in good conditions and replaced with identical models, when necessary
- Before connecting the measuring cables to the circuit being measured, check that the instrument has been correctly set

1.2. DURING USE

Please carefully read the following recommendations and instructions:

CAUTION

- Failure to comply with the notes and/or instructions may damage the instrument and/or its components or be a source of danger for the operator
- The red flashing "POWER" LED indicates that the internal rechargeable batteries are almost flat. In this case, connect the external power supply as described in § 7.2
- **The IDC1, IDC2, IDC3 input connectors are type 4-pole type. Use only clamps with 4-pin output connector or interpose adapter ACON3F4M between the clamp output connector and the instrument input.**
- The instrument maintains the data stored also in case of flat battery
- The instrument is particularly sensitive to ESD nearby and on the USB port while it is operating; we recommend connecting the cables to the USB port when the instrument is off

1.3. AFTER USE

When measurements are completed, turn off the instrument by pressing and holding the ON/OFF key for some seconds. If the instrument is not to be used for a long time, please follow the instructions given in § 3.4

1.4. DEFINITION OF MEASUREMENT (OVERVOLTAGE) CATEGORY

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

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 on installations inside buildings
  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 standard requires that the transient withstand capability of the equipment is made known to the user

2. GENERAL DESCRIPTION

2.1. INTRODUCTION

Dear Customer, thank you for choosing one of the instruments in our range. If used according to the instructions given in this manual, the instrument you have just purchased will guarantee accurate and reliable measures. The instrument is designed to guarantee maximum safety, thanks to a newly conceived development, which ensures double insulation and enables the instrument to reach overvoltage category CAT III 1000V DC and CAT IV 300V AC (to earth)

The instrument has been designed as an accessory for an instrument, hereafter called the MASTER instrument (see par. 4.3), for the purpose of carrying out testing operations on single-phase and three-phase PV systems.

Together with a MASTER instrument, MPP300 is the ideal solution for testing and analyzing the possible problems linked to possible low efficiency values of photovoltaic systems

2.2. INSTRUMENT FUNCTIONS

The instrument has the following features:

- 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^2] by means of a reference cell connected to unit SOLAR-02
- Measurement of panel and environmental temperature by means of probe PT300N connected to SOLAR-02
- Testing of PV systems with single/multi-MPPT inverter - single/three-phase AC output
- Parameter recording of a PV system with 5s to 60min programmable IP
- Internal memory for data saving
- RF/USB interface for transferring the data to the MASTER instrument

3. PREPARATION FOR USE

3.1. INITIAL CHECKS

Before shipping, the instrument has been checked from an electric as well as mechanical point of view. All possible precautions have been taken so that the instrument is delivered undamaged. However, we recommend checking it to detect any damage possibly suffered during transport. In case anomalies are found, immediately contact the dealer.

We also recommend checking that the packaging contains all components indicated in § 8.5. In case of discrepancy, please contact the Dealer. In case the instrument should be returned, please follow the instructions given in § 10.

3.2. INSTRUMENT POWER SUPPLY

The instrument only operates with a Li-ION rechargeable battery (3.7V, 1900mAh) housed inside the instrument itself. Use the external power supply A0055 provided to recharge the battery. For indications on the status of the battery, please refer to § 7.2

The instrument maintains the data stored also in case of completely flat battery.

3.3. CALIBRATION

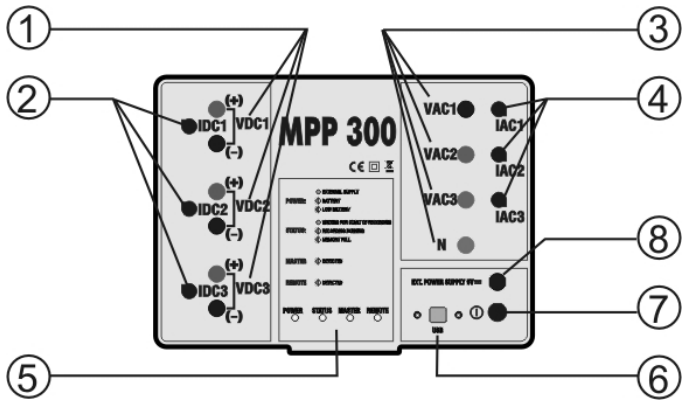
The instrument has the technical specifications described in this manual. Its performance is guaranteed for 12 months from the date of purchase.

3.4. STORAGE

In order to guarantee precise measurement, after a long storage time under extreme environmental conditions, wait for the instrument to come back to normal condition (see the environmental specifications contained in § 8.4).

4. OVERVIEW

4.1. INSTRUMENT DESCRIPTION



CAPTION:

1. DC voltage inputs
2. DC current inputs
3. AC voltage inputs
4. AC current inputs
5. Indication LEDs
6. USB connector (only for MASTER instruments of Type 2, see § 4.3)
7. **ON/OFF** key
8. Connector for external supply

Fig. 1: Description of the instrument's front panel

4.2. DESCRIPTION OF THE INDICATION LEDS

LED name	Status	Description
POWER	GREEN steady GREEN flashing RED flashing	MPP300 supplied by external power supply MPP330 supplied by internal batteries Batteries of MPP300 almost flat
STATUS	GREEN steady GREEN flashing RED flashing RED steady	MPP300 in synchronization phase before starting recording MPP300 in recording phase MPP300 memory full Internal error of MPP300 (see § **4.3.1** and Message table in the User Manual of the MASTER instrument)
MASTER	GREEN flashing OFF	MPP300 is connecting to the MASTER unit MPP300 is NOT connecting to the MASTER unit
REMOTE	GREEN flashing OFF	MPP300 is connecting to unit SOLAR-02 MPP300 is NOT connecting to unit SOLAR-02

Table 1: Description of the indication LEDs on MPP300

4.3. MASTER INSTRUMENT

MPP300 may be controlled **only** by the following MASTER instruments:

MASTER instrument	Instrument type	Firmware	Fw update
SOLAR I-V	1 (RF connection)	5.02 or higher	Can be carried out by the user
SOLAR 300N	2 (USB connection)	1.27 or higher	Can be carried out by the user

Table 2: Characteristics of the MASTER instruments

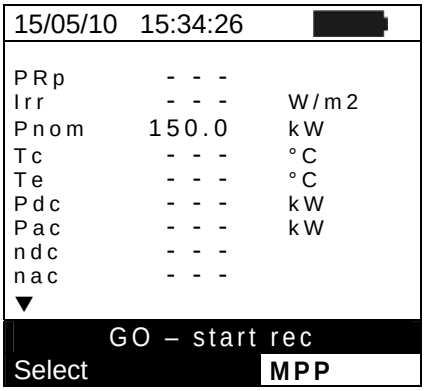
CAUTION

- All controls are sent to the instrument via RF communication (MASTER instrument of Type 1) or via USB port (MASTER instrument Type 2)
- We recommend the user verifies that the software version (Firmware) in the MASTER instrument to which MPP300 should be connected is consistent with the indications given in Table 2. This information is present in the initial screen shown when switching on the MASTER instrument. The results of the measurements carried out by MPP300 are sent to the MASTER instrument to which it is connected and shown on the master instrument's display. All measures stored in the MASTER instrument's memory can be subsequently displayed and can be transferred to a PC

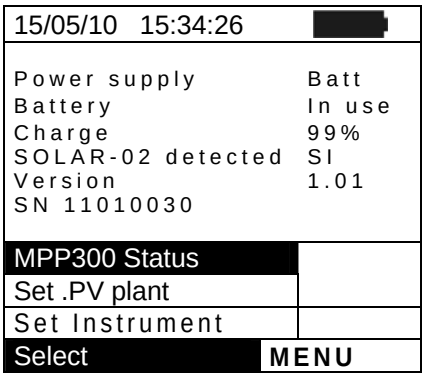
4.3.1. Displaying the status of MPP300 by means of MASTER instruments of Type 1

In case the MASTER instrument is near MPP300, it is possible to display the general parameters and obtain information about a possible error state of MPP300 (STATUS LED red steady). For a description of the error conditions, please refer to the Message table in the User Manual of the MASTER instrument

1. 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



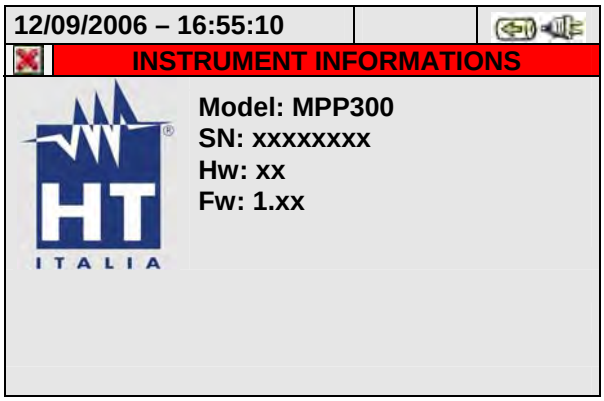
2. Press the **ENTER** key. The instrument shows the following options: **MPP300 status**, **Set PV Plant** and **Set Instrument**
3. Use the arrow keys (▲,▼) to select "**MPP300 status**" and confirm with **ENTER**. The instrument shows the screen here to the side, which indicates the main general parameters of the instrument



4.3.2. Displaying the status of MPP300 by means of MASTER instruments of Type 2

In case the MASTER instrument is connected to MPP300 though USB cable, it is possible to display the general parameters and obtain information about a possible error state of MPP300 (STATUS LED red steady). For a description of the error conditions, please refer to the Message table in the User Manual of the MASTER instrument

In GENERAL MENU select the "Instrument informations" icon and press **ENTER** key. The herewith screen is shown by the instrument:



Press **ESC** key (or smart icon) to back to GENERAL MENU screen.

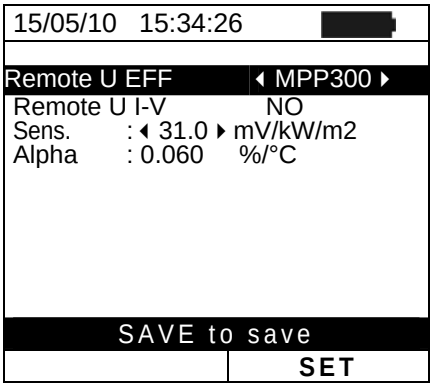
5. SETTINGS ON MASTER INSTRUMENTS

Instructions are given according to the Type of instruments, classified according to Table 2. Further in this manual, a brief description is provided of the settings of the MASTER instrument for use together with MPP300. For an exhaustive description of the controls and functions of the MASTER instrument, please refer to the User Manual of the instrument itself.

5.1. MASTER INSTRUMENTS OF TYPE 1 - REMOTE UNIT SETTINGS

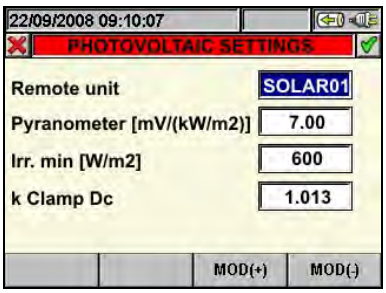
Turn on the instrument, press the **MENU** key, position the cursor onto **SET** by using the arrow keys (▲,▼) and confirm with **ENTER**. The display shows the screen which lists the different settings of the instrument

1. Position the cursor onto **Remote Unit** by using the arrow keys (▲,▼) and confirm with **ENTER**
2. In parameter "**Remote U EFF**", set **MPP300**
3. Press **SAVE** to confirm

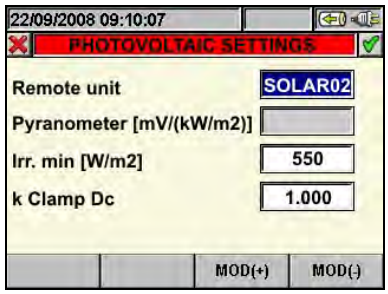


5.2. MASTER INSTRUMENTS OF TYPE 2 – REMOTE UNIT SETTINGS

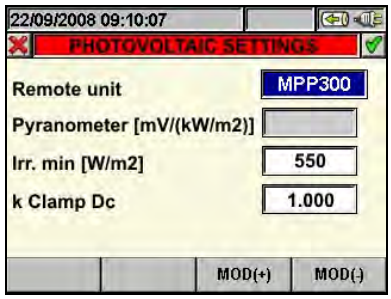
In the GENERAL MENU select ANALYZER SETTINGS, press the **F2** key or touch the "**ADVANCED**" item on the display. The herewith screens are shown by the meter:



Selection of rem. U. SOLAR-01



Selection of rem. U. SOLAR-02



Selection of rem. U. MPP300

1. By means of the **F3** or **F4** key (or items **MOD(+)** or **MOD(-)** on the display), select the desired unit **SOLAR01** or **SOLAR02**, **MPP300**

CAUTION

The selection of remote unit **MPP300** automatically disables the "Pyranometer" field as the sensitivity of the used irradiance probe (pyranometer or reference cell) should be set inside the internal menu of SOLAR-02 (see user manual of SOLAR-02). The selection of the type of system MPP-1 or MPP-3 shall automatically force MPP300 as remote unit type.

2. Press the **SAVE** or **ENTER** key (or the smart icon ✔) to save the selected setting by confirming with "Ok". In this way, the settings made will remain valid also after turning off the instrument.
3. To quit the settings made or to exit without saving, press the **ESC** key (or the smart icon ✖).

6. OPERATING INSTRUCTIONS

Further in this manual, a brief description is provided of the use of MPP300 together with the MASTER instrument. For an exhaustive description of the controls and functions of the MASTER instrument, please refer to the User Manual of the instrument itself.
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, the acronym **PRp** shall indicated the Performance ratio (evaluated on active powers). See § 9.1 for further details

ATTENTION

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)

6.1. PV SYSTEM TESTING FOR INSTRUMENTS OF TYPE 1 (SOLAR I-V)

6.1.1. Testing of PV systems with single/multi-MPPT inverter - single/three-phase AC output

The instrument SOLAR I-V, used together with remote units SOLAR-02 and MPP300, 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-V (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

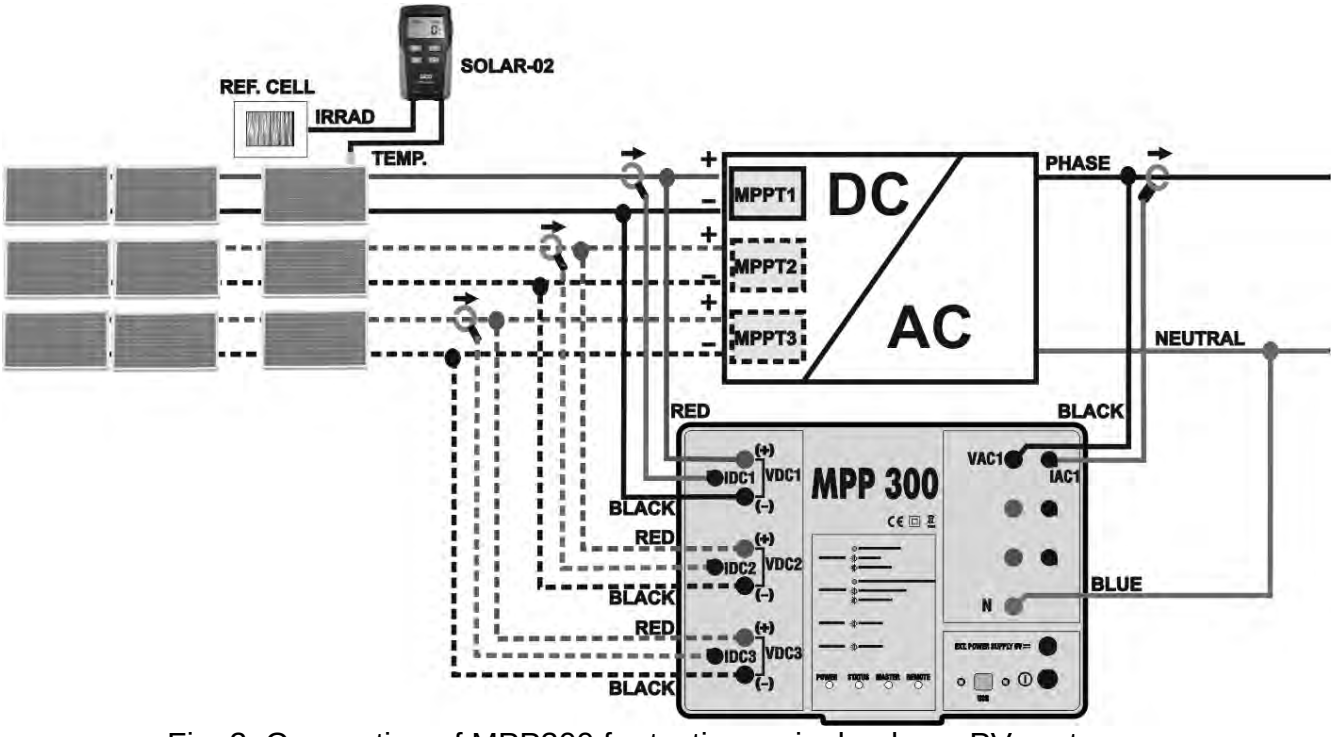


Fig. 2: Connection of MPP300 for testing a single-phase PV system

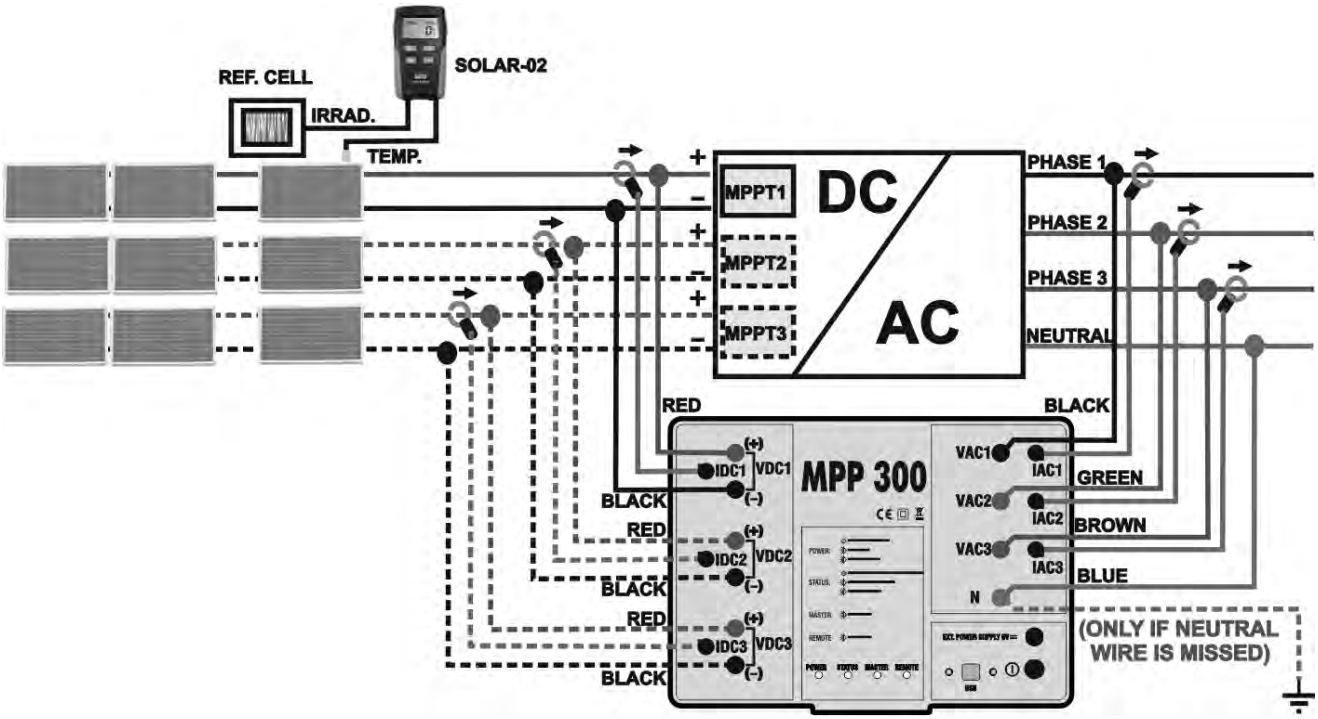


Fig. 3: Connection of MPP300 for testing a three-phase PV system

CAUTION

- When SOLAR I-V 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-V 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-V, 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 the User Manual of SOLAR I-V)

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-V, 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-V, 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 steady (not flashing) on the display of SOLAR I-V
- Symbol steady (not flashing) on the display of SOLAR-02
- MASTER and REMOTE LEDs flashing green on unit MPP300

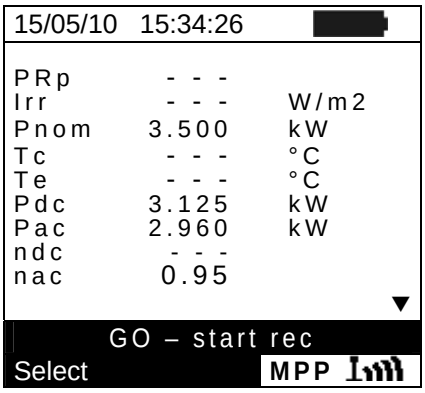
7. Connect the **VDC1(+)** and **VDC1(-)** inputs of unit **MPP300** to the output terminals of the string, respecting the polarities and the colors indicated in Fig. 2 or Fig. 3.
8. Repeat the operation described in the step above for other possible DC power trackers to be monitored by using the **VDC2** and **VDC3** inputs according to the number of DC inputs set (see the user manual of SOLAR I-V)
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-V 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 in Fig. 2 or Fig. 3. 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 the User Manual of SOLAR I-V)
12. Connect the VAC1 and N inputs of unit MPP300 to the Phase and Neutral conductors respectively, respecting the polarities and the colours indicated in Fig. 2 or Fig. 3. 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 the User Manual of SOLAR I-V), 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. 2 or Fig. 3. 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 the User Manual of SOLAR I-V), 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

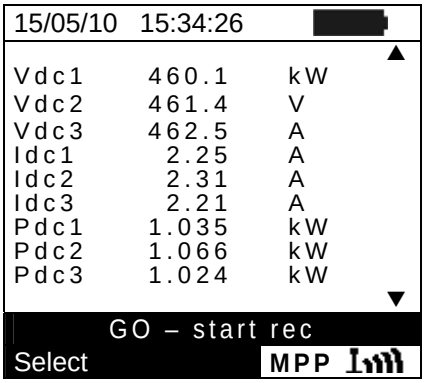
17. The display of SOLAR I-V will show the values of the **general** electrical parameters of the system being measured



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 (**ηac**) are consistent with the system being measured (e.g.: **ηac > 1** is not physically acceptable)

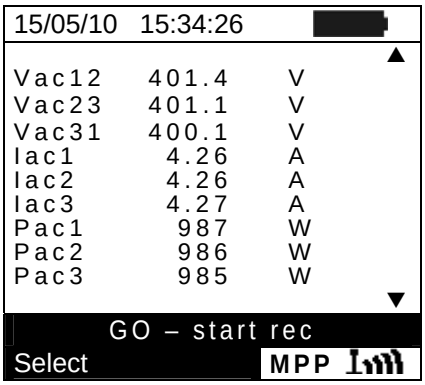
18. On SOLAR I-V, press key (▼) to access the second screen which contains the values of the output DC parameters of the strings according to the number of DC inputs set (see the User Manual of SOLAR I-V)



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-V, 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 (see – SOLAR I-V user's manual, single-phase, three-phase 4 wires).

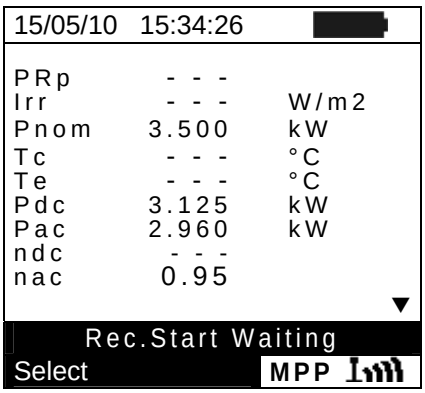


Example of a screen for PV systems with three-phase output

In particular, in this screen:
Vacxy = ac voltage between Phase and Neutral (if single-phase) or between Phases x and y (if three-phase)
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

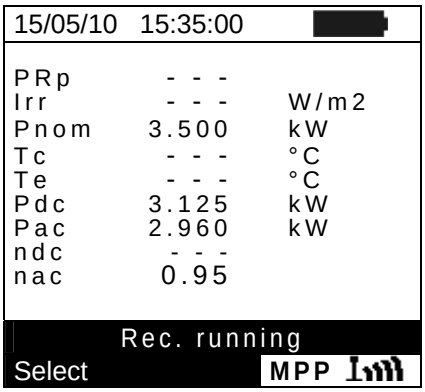
20. Keeping the three instruments near each other (max distance approx. 1m), press the **GO/STOP** key on SOLAR I-V to start testing. Consequently:



- The display of SOLAR I-V 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:

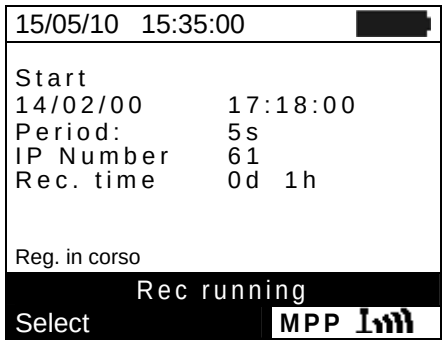
- The display of SOLAR I-V shows the message "**rec. running**"
- The display of SOLAR-02 shows the message "**Recording…**"
- On MPP300, the STATUS LED flashes green



22. At any time it will be possible to analyze the current recording status by pressing the **MENU** key. The following information 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 "" 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 panel 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 the User Manual of SOLAR I-V)

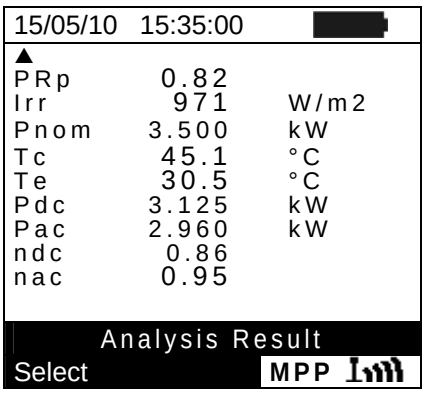
28. **With the message "READY" shown on the display, wait for approximately 1 minute in order to take a certain number of samples**

29. Disconnect the irradiation and temperature probes from unit SOLAR-02 and bring the unit near unit MPP300. Bring the main unit SOLAR I-V near MPP300 too. The three units must be near each other (max distance 1m)

30. The main unit SOLAR I-V must be in **EFF** mode; if no flashing symbol "" 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 "radio connection activated"

32. To stop testing, press the **GO/STOP** key on instrument SOLAR I-V and confirm with **ENTER** that you want to stop recording
33. The display of SOLAR I-V 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 (see see user's manual of MASTER instrument) or all PRp values are not valid (PRp > 1.15).
- 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 (see user's manual of MASTER instrument).

35. Press **SAVE** to save the results or **ESC** to exit the screen of the results and go back to the initial screen

6.2. PV SYSTEM TESTING FOR INSTRUMENTS OF TYPE 1 (SOLAR 300N)

6.2.1. Testing of PV systems with single/multi-MPPT inverter - single/three-phase AC output

The instrument SOLAR300N, used together with remote units SOLAR-02 and MPP300 (optional), allows carrying out long recordings on PV systems characterized by 1 or more PV fields (with the same direction and inclination), each connected to an MPPT of the inverter (see § 9.1) and single-phase or three-phase output. The remote unit MPP300 is capable of communicating with SOLAR300N via USB cable (to manage data synchronization and 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.

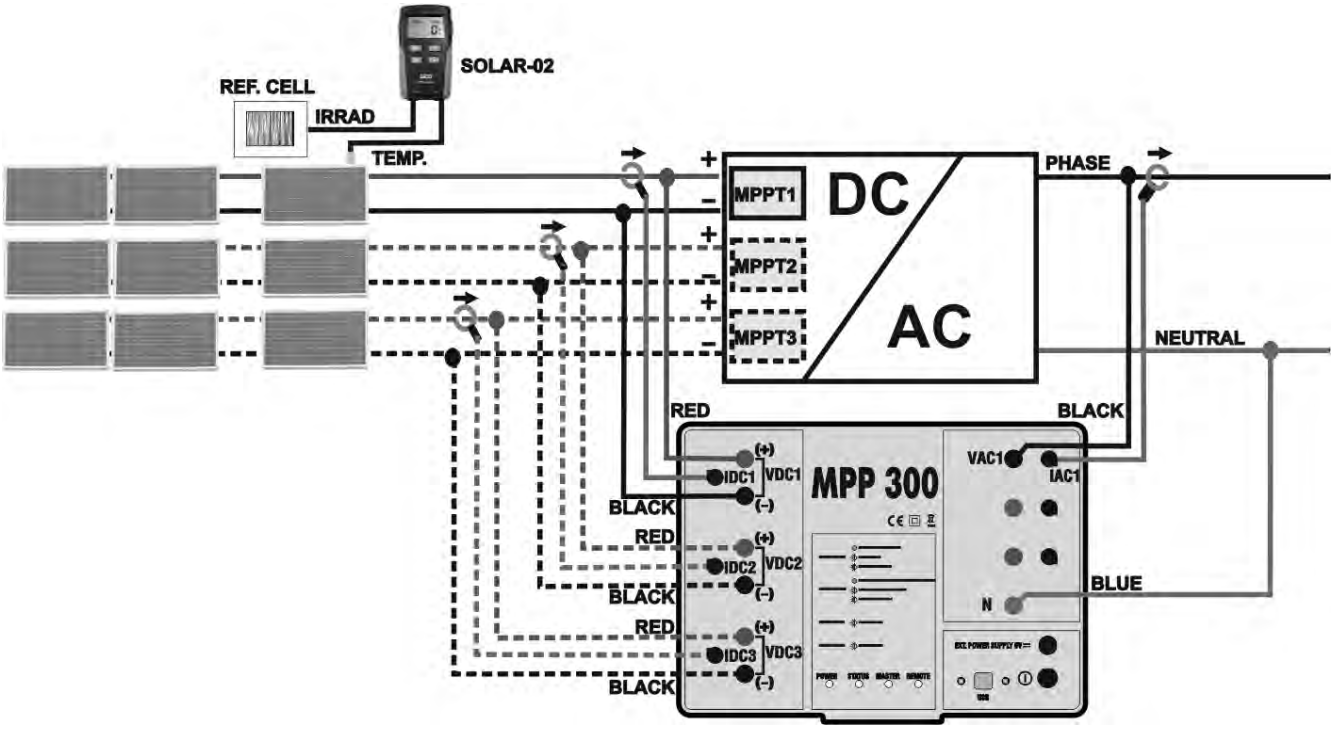


Fig. 4: Connection of MPP300 for testing a single-phase PV system

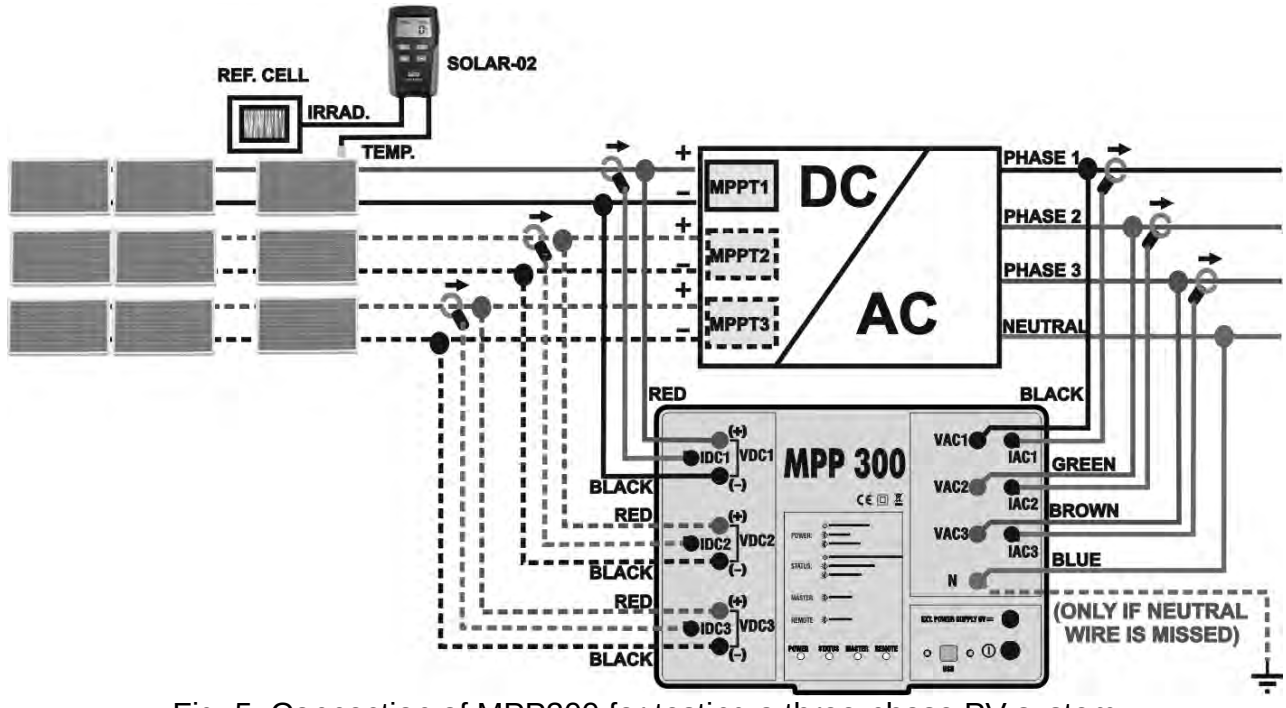


Fig. 5: Connection of MPP300 for testing a three-phase PV system

CAUTION

- When SOLAR300N 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**. SOLAR300N 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 SOLAR300N, 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 parameters of the system being measured and to the value of the integration period (see SOLAR300N user's manual).

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. Connect SOLAR300N to the MPP300 unit via the USB cable and bring SOLAR-02 and MPP300 nearer (max distance approx. 1 m). **All instruments must be switched on** (see the User Manuals of SOLAR-2 and MPP300 for further details). The display of SOLAR300N must show (for 5 seconds) the message "**MPP300 connected**".

6. On SOLAR300N, access the **GENERAL MENU**, select the function **View Measures** 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:
    a. Symbol steady (not flashing) on the display of SOLAR-02
    b. **MASTER** and **REMOTE** LEDs flashing green on unit MPP300

7. Connect the **VDC1(+)** and **VDC1(-)** inputs of the **MPP300** unit to the output terminals of the string, paying attention to the polarity and the colours indicated in Fig. 4 or Fig. 5.

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 SOLAR300N user's manual).

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 SOLAR300N 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. 4 or Fig. 5. 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 SOLAR300N user's manual).

12. Connect the **VAC1** and **N** inputs of unit MPP300 to the Phase and Neutral conductors respectively, respecting the polarities and the colours indicated in in Fig. 4 or Fig. 5. In case of three-phase systems in which no Neutral conductor is available, connect input **N** to earth.

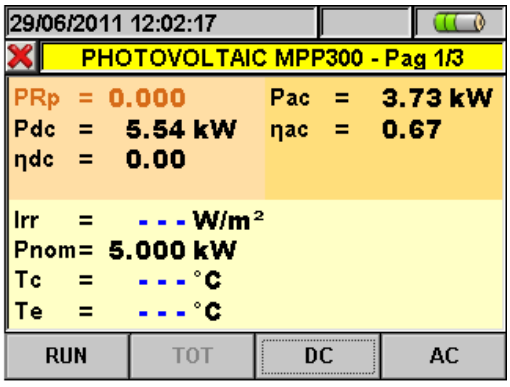
13. In case of inverter with three-phase output (see SOLAR300N user's manual), repeat the operation described in the step above for the remaining phases by using the **VAC2** and **VAC3** inputs of MPP300.

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. 4 or Fig. 5. 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 SOLAR300N user's manual), 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 SOLAR300N will show the values of the **general** electrical parameters of the system being measured.

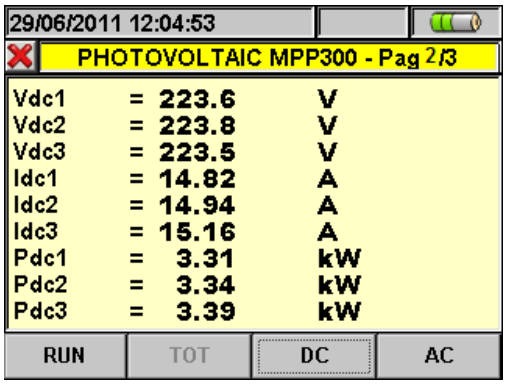


In particular, in this screen:
Pdc = General dc power (sum of the string powers)
Pac = ac power (if single-phase) or sum of the ac powers (if three-phase)

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

18. On SOLAR300N, press key **F3** 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 SOLAR300N user's manual).

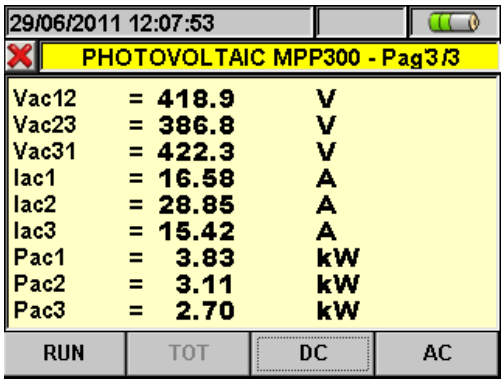
In particular, in this screen:
Vdcx = dc voltage of string x.
Idcx = dc current of string x.
Pdx = dc power of string x.
We recommend checking that the values of the electrical parameters (Vdc, Idc, Pdc) are consistent with the system being measured.



Example of a DC screen for PV systems with 3 MPPTs

19. On SOLAR300N, press key **F4** 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 (see SOLAR300N user's manual - single-phase, three-phase 4 wires).

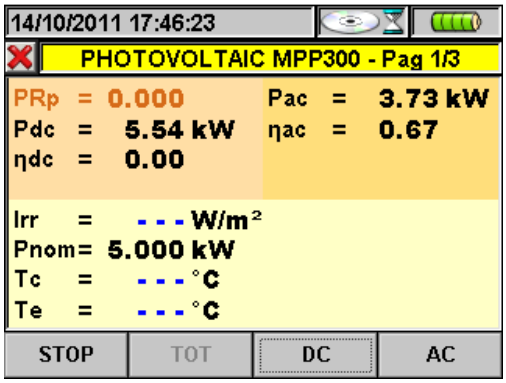
In particular, in this screen:
Vacxy = ac voltage between Phase and Neutral (if single-phase) or between Phases x and y (if three-phase)
Iacx = ac current of phase x
Pacx = ac power of phase x
We recommend checking that the values of the electrical parameters (Vac, Iac, Pac) are consistent with the system being measured.



Example of an AC screen for PV systems with three-phase output

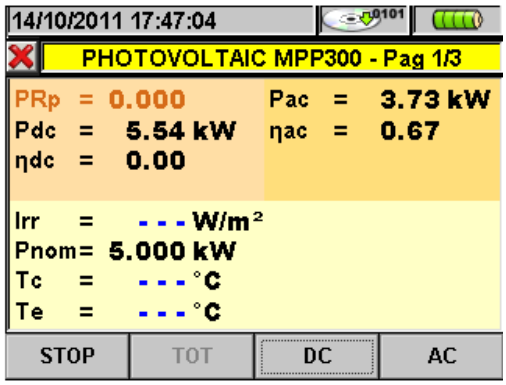
20. Keeping the three instruments connected, press the **F1** key on SOLAR300N **to start recording**. Consequently:

a. The display of SOLAR300N shows the icon  . The display of SOLAR-02 shows the message "**HOLD**" and the time, expressed in seconds, remaining before the recording is started
b. On MPP300, the STATUS LED turns on green (not flashing)

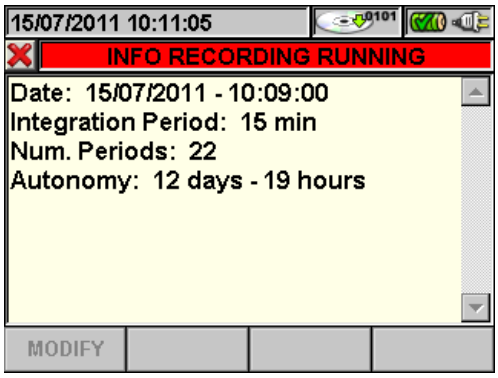


21. Upon reaching the instant "00" after pressing the **F1** key, the test is started and the three units are synchronized with each other. In these conditions:

a. The display of SOLAR300N shows the icon  .
b. The display of SOLAR-02 shows the message "**Recording…**"
c. On MPP300, the STATUS LED flashes green



22. At any time while recording it will be possible to analyze its current status by selecting the button **Saved data management** in the **GENERAL MENU**. The following information will be shown:
    a. starting date and time of recording
    b. the value set for the integration period
    c. the number of periods elapsed from the beginning of the recording
    d. 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 "" 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 SOLAR300N user's manual).

28. With the message "**READY**" shown on the display, wait for a time period at least equal to the set integration period (see SOLAR300N user's manual) in order to take a significant number of samples (>=2).

29. Disconnect the irradiation and temperature probes from unit SOLAR-02 and bring the unit near unit MPP300. The two units must be near each other (max distance 1m).

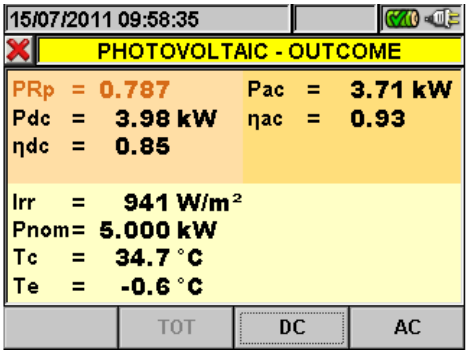
30. Connect (if disconnected) the SOLAR300N unit to the MPP300 unit. The **MASTER** LED must always be flashing to indicate the connection between SOLAR300N and MPP300.

31. Press key ▼ on SOLAR-02 to activate the RF connection again. Consequently, the **REMOTE** LED on unit MPP300 will start flashing.

32. To stop recording, press the **GO/STOP** key on the instrument SOLAR300N and confirm with **ENTER** that you want to stop recording.
33. The display of SOLAR300N will show various messages indicating the different phases of data transfer to the main unit. The transferred data will be saved automatically.
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 (see see user's manual of MASTER instrument) or all PRp values are not valid (PRp > 1.15).
- 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 (see user's manual of MASTER instrument).

35. Press **SAVE** to save the obtained results. Pressing the key will display the virtual keyboard for adding possible comments. Further pressing the **SAVE** key will archive the measure and the added comments and will go back to the initial screen for a new measurement.



Example of a result combined with MPP300

7. MAINTENANCE

7.1. GENERAL INFORMATION

The instrument you purchased is a precision instrument. While using and storing the instrument, carefully observe the recommendations listed in this manual in order to prevent possible damage or danger during use. Do not use the instrument in environments with high humidity levels or high temperatures. Do not expose to direct sunlight. Always switch off the instrument after use.

7.2. STATUS OF THE INTERNAL RECHARGEABLE BATTERIES

The status of the POWER LED provides indications about the operating/charge status of the instrument's internal rechargeable batteries

POWER:	GREEN steady:	MPP300 supplied by external power supply
	GREEN flashing:	MPP330 supplied by internal batteries
	RED flashing:	Batteries of MPP300 almost flat

CAUTION

- In case the LED indicates the condition of almost flat batteries, we recommend connecting the instrument to power supply. It is not necessary to stop possible measurements in progress to connect the power supply
- If the instrument detects a too low battery voltage, it stops possible recordings in progress and switches off
- The instrument maintains the data stored also in case of flat battery

7.3. CLEANING THE INSTRUMENT

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

7.4. END OF LIFE

CAUTION: this symbol indicates that the appliance, its accessories and the internal batteries must be collected separately and correctly disposed of

8. TECHNICAL SPECIFICATIONS

8.1. TECHNICAL SPECIFICATIONS FOR TEST ON PV SYSTEMS

Uncertainty is indicated as [%reading + (no. of digits) * resolution] at 23°C ± 5°C, <80%HR

DC voltage

Range [V]	Resolution [V]	Uncertainty
10.0 ÷ 999.9	0.1	±(0.5%rdg + 2dgt)

Phase-Neutral AC TRMS voltage

Range [V]	Frequency	Resolution [V]	Uncertainty
10.0 ÷ 300.0	42.5 ÷ 69.0Hz	0.1	±(0.5%rdg + 2ddgt)

Max peak factor: 1,5

Phase-Phase AC TRMS voltage

Range [V]	Frequency	Resolution [V]	Uncertainty
50.0 ÷ 594.0	42.5 ÷ 69.0Hz	0.1	±(0.7%rdg + 2dgt)

Max peak factor: 1,5

DC current (by means of external clamp transducer)

Range	Resolution	Uncertainty	Protection against overcharge
5.0mV ÷ 319.9mV	0.1mV	±(0.5%rdg + 0.06%FS)	10V
320.0mV ÷ 999.9mV		±(0.5%rdg)	

Current values corresponding to a voltage < 5mV are zeroed

AC TRMS current (by means of external clamp transducer STD type)

Range	Frequency	Resolution	Uncertainty	Protection against overcharge
5.0mV ÷ 219.9mV	42.5 ÷ 69.0Hz	0.1mV	±(0.5%rdg + 0.06%FS)	10V
220.0mV ÷ 999.9mV			±(0.5%rdg)	

Peak factor <= 1.5 – Current values corresponding to a voltage < 5mV are zeroed.

AC TRMS current (by means of external clamp transducer of FLEX 8.5uV/A – FS 100A type)

Range	Frequency	Resolution	Uncertainty	Protection against overcharge
0.008 ÷ 8.50mV	42.5 ÷ 69.0Hz	0.001mV	± (0.5%rdg + 7dgt)	10V

Peak factor <= 1.5 – Current values < 1A are zeroed.

AC TRMS current (by means of external clamp transducer of FLEX 8.5uV/A – FS 1000A type)

Range	Frequency	Resolution	Uncertainty	Protection against overcharge
0.085 ÷ 85.0mV	42.5 ÷ 69.0Hz	0.01mV	± (0.5%rdg + 15dgt)	10V

Peak factor <= 1.5 – Current values < 5A are zeroed.

DC power (Vmeas > 150V) ; AC power (Vmeas > 200V, PF=1)

Clamp FS [A]	Range [W]	Resolution [W]	Uncertainty
1< FS ≤ 10	0.000k ÷ 9.999k 10.00k ÷ 99.99k	0.001k 0.01k	±(0.7%rdg + 3dgt) (Imeas < 10%FS)
10< FS ≤ 100	0.00k ÷ 99.99k 100.0k ÷ 999.9k	0.01k 0.1k	
100< FS ≤ 1000	0.0k ÷ 999.9k 1000k ÷ 9999k	0.1k 1k	±(0.7%rdg) (Imeas ≥ 10%FS)

Vmeas = voltage at which power is measured; Imeas = measured current

8.2. REFERENCE STANDARDS

Instrument safety:	IEC/EN61010-1
Safety of measuring accessories:	IEC/EN61010-031
Technical documentation:	IEC/EN61187
Insulation:	double insulation
Mechanical protection:	IP 40
Pollution level:	2
Measurement category:	CAT III 1000V DC, Max 1000V between DC inputs CAT IV 300V AC to earth, max 600V between AC inputs

8.3. GENERAL CHARACTERISTICS

Memory

Memory capacity:	2 MBytes
Integration Period:	5,10,30,60,120,300,600,900,1800,3600s
Battery duration (with SOLAR-02):	approx. 1.5 hours (@ PI = 5s) approx. 8 days (@ PI = 600s)

Characteristics of radio module

Frequency range:	2.400 ÷ 2.4835GHz
R&TTE category:	Class 1
Max transmission power:	30μW
Max RF connection distance:	1m (39in)

Power supply

Internal power supply:	Internal rechargeable Li-ION battery (3.7V, 1900mAh) Battery duration >3 hours
External power supply:	AC/DC power supply 100÷240VAC/50-60Hz – 5VDC

Mechanical characteristics

Dimensions (L x W x H):	300 x 265 x 140mm ; (12 x 10 x 6in)
Weight (batteries included):	1.2kg (2lv)

8.4. ENVIRONMENTAL CONDITIONS FOR USE

Reference temperature:	23° ± 5°C (73° ± 41°F)
Operating temperature:	0 ÷ 40°C (32 ÷ 104°F)
Allowable relative humidity:	<80%HR
Storage temperature:	-10 ÷ 60°C (14 ÷ 140°F)
Storage humidity:	<80%HR
Max operating altitude:	2000m (*) (6562ft)

CAUTION

(*) Prescriptions for the use of the instrument at altitudes between 2000 and 5000m
As regards inputs, the instrument must be considered as downgraded to overvoltage category CAT II 1000V DC and CAT III 300V to earth max 1000V between inputs. The marks and symbols found on the instrument are valid only when the instrument is used at altitudes <2000m

This instrument satisfies the requirements of Low Voltage Directive 2006/95/EC (LVD) and of EMC Directive 2004/108/EC

8.5. ACCESSORIES

See the attached packing list

9. APPENDIX – THEORETICAL OUTLINE

9.1. 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 (see MASTER instrument settings):

Corr.Type	Tcel value	PRp calculation	Guideline
Tmod	Tcel = PV Module Temp. measured	$PRp = \frac{P_{ca}}{\left[Rfv2 \times \frac{G_p}{G_{STC}} \times P_n \right]}$	CEI 82-25 (Italian Guideline)
Tamb or Tenv	Tcel = PV module Temp. calculated $\mathrm{Tcel} = \mathrm{Tamb} + (NOCT - 20) \times \frac{\mathrm{G_p}}{800}$		
nDC	Tcel = PV Module Temp. measured	$PRp = \frac{G_{STC}}{G_p} \times \left[1 + \frac{\lvert\gamma\rvert}{100} \times (T_{cel} - 25) \right] \times \frac{P_{ca}}{P_n}$	- - -

where:

Symbol	Description	Meas. unit
G_p	Irradiance on PV module surface	$[\mathrm{W/m^2}]$
G_{STC}	Standard Irradiance = 1000	$[\mathrm{W/m^2}]$
P_n	Nominal Power = sum of all power module (Pmax) included in the part of PV plant under test	$[\mathrm{kW}]$
P_{ca}	AC Active Power measured	$[\mathrm{kW}]$
$Rfv2 = \begin{cases} 1 & (\text{if Tcel} \le 40°\mathrm{C}) \\ 1 - (\mathrm{Tcel} - 40) \times \frac{\lvert\gamma\rvert}{100} & (\text{if Tcel} > 40°\mathrm{C}) \end{cases}$	Thermal Corrective factor	
$\lvert\gamma\rvert$	Absolute value of Pmax thermal coefficient	$[\%/°\mathrm{C}]$
NOCT	Normal Operating Cell Temperature (@ 800W/m², 20°C, AM=1.5, vel. Aria =1m/s).	$[\%/°\mathrm{C}]$

- Previous relationship are valid if **Irradiance > Min Irraddiance value** (see user manual of the MASTER instrument) and the Irradiance values are "steady": if **IP ≤ 1min →(Irr max – Irr min) < 20W/m²**

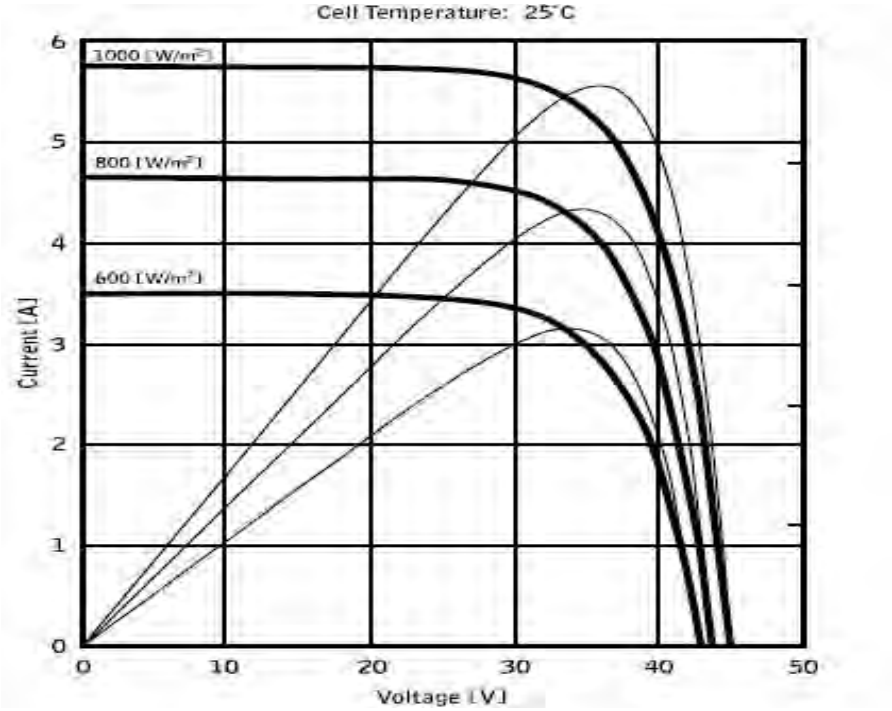
The final OUTCOME can be:

- **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 (see user's manual of MASTER instrument).
- The maximum performance point (PRp) of the system

The highest performance (maximum value of PRp) is detected according with previous relationships.

9.2. 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^2) 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*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 stand-alone

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.

10. SERVICE

10.1. WARRANTY CONDITIONS

This instrument is warranted against any material or manufacturing defect, in compliance with the general sales conditions. During the warranty period, defective parts may be replaced. However, the manufacturer reserves the right to repair or replace the product

Should the instrument be returned to the After-sales Service or to a Dealer, transport will be at the Customer's charge. However, shipment will be agreed in advance. A report will always be enclosed to a shipment, stating the reasons for the product's return. Only use original packaging for shipment; any damage due to the use of non-original packaging material will be charged to the Customer. The manufacturer declines any responsibility for injury to people or damage to property

The warranty shall not apply in the following cases:

- Repair and/or replacement of accessories (not covered by warranty)
- Repairs that may become necessary as a consequence of an incorrect use of the instrument or due to its use together with non-compatible appliances
- Repairs that may become necessary as a consequence of improper packaging
- Repairs which may become necessary as a consequence of interventions performed by unauthorized personnel
- Modifications to the instrument performed without the manufacturer's explicit authorization
- Use not provided for in the instrument's specifications or in the instruction manual

10.2. SERVICE

If the instrument does not operate properly, before contacting the After-sales Service, please check the conditions of the battery and of the cables. Should the instrument still operate improperly, check that the product is operated according to the instructions given in this manual

Should the instrument be returned to the After-sales Service or to a Dealer, transport will be at the Customer's charge. However, shipment will be agreed in advance. A report will always be enclosed to a shipment, stating the reasons for the product's return. Only use original packaging for shipment; any damage due to the use of non-original packaging material will be charged to the Customer