

I-V characteristic tester for photovoltaic modules

I-V TRACER FTV200



ENGLISH

User's manual

1. WARNINGS

Thank you for purchasing an **FTV200 I-V TRACER**. For best results from your instrument:

- **read** these operating instructions carefully,
- **comply with** the precautions for use.

Meanings of the symbols on the instrument:

 WARNING, risk of DANGER! The operator must refer to these instructions whenever this danger symbol appears.

 The CE marking indicates conformity with European directives, in particular LVD and EMC.

 Equipment protected by double insulation.

 The rubbish bin with a line through it indicates that, in the European Union, the product must undergo selective disposal in compliance with Directive WEEE 2002/96/EC. This equipment must not be treated as household waste.

 USB port.



WARNING! TEST POINT ADAPTER USE:

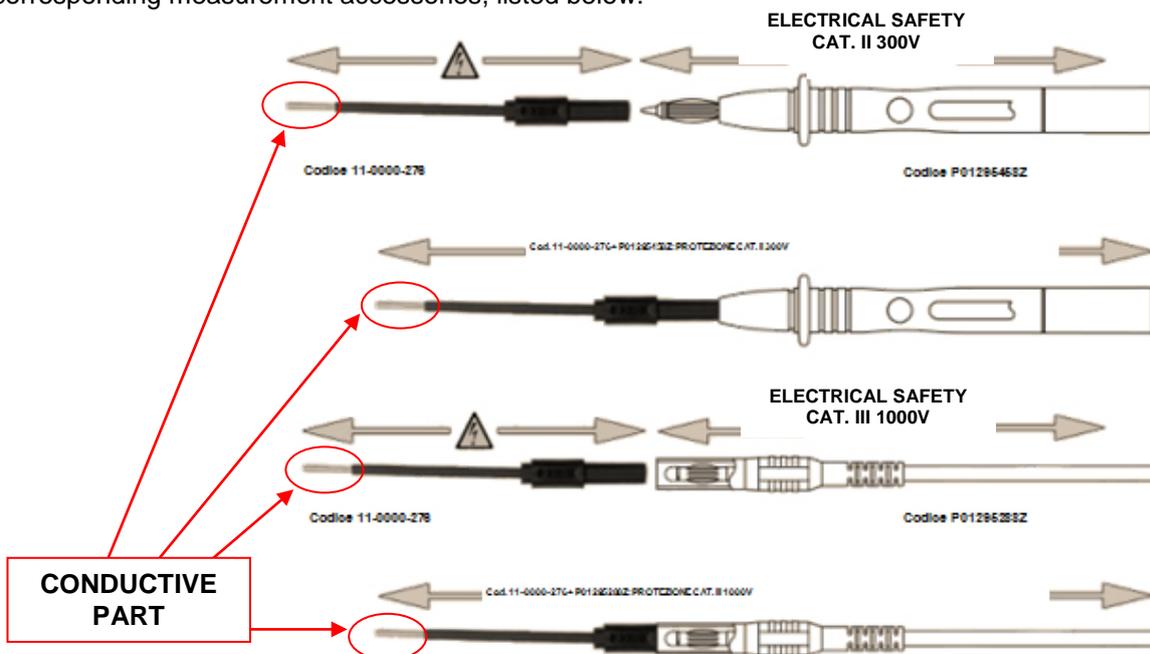
1

PLEASE VERIFY AND MAKE SURE THAT THE INSTALLATION OR THE CIRCUIT IS NOT POWERED WHILE YOU ARE CONNECTING THE TEST POINT.

NO CONDUCTIVE PART SHOULD REMAIN REACHABLE WHEN THE INSTALLATION IS SWITCHED BACK ON.
Connect the test probes to the installation or the electrical circuit only after making sure there is no current.

2

Connect the test probes to the installation or the electrical circuit only after they have been connected to the corresponding measurement accessories, listed below:



2. PRECAUTIONS FOR USE

This instrument and its accessories comply with safety standards IEC 61010-1, IEC 61010-031, and IEC 61010-2-032 for voltages of 600V in category III, or 1000V in category II, at an altitude of less than 2000m, indoors, with a degree of pollution of not more than 2.

Failure to observe the safety instructions may result in electric shock, fire, explosion, and destruction of the instrument and of the installations.

- The operator and/or the responsible authority must carefully read and clearly understand the various precautions to be taken in use. Sound knowledge and a keen awareness of electrical hazards are essential when using this instrument.
- If you use this instrument other than as specified, the protection it provides may be compromised, thereby endangering you.
- The safety of any system incorporating this instrument is the responsibility of the person who assembles the integrated system.
- For your safety, use only the cables and accessories supplied with the instrument: they comply with IEC 61010-031 (2002). When the sensors or accessories used are of a lower category than the instrument, the lower rating must be applied to the entire system.
- Before each use, make sure that the cables, junction boxes, and accessories are in perfect working condition. Any cable, sensor, or accessory of which the insulation is damaged (even partially) must be set aside for repair or eliminated.
- Do not use mains power when making measurements. Mains power may be used only to recharge the internal batteries, with the instrument switched off.
- Respect the environmental conditions.
- Use personal protection equipment systematically.
- Never use it on systems of which the voltage or category is higher than that indicated.
- For replacement of the internal battery, contact an authorised service centre only. These components have specific safety devices; using non-original spare parts could cause serious damage to persons or property.
- Respect the limits of the physical protections of the accessories and sensors. Do not place your hands on unused terminals.
- All troubleshooting and metrological checks must be performed by competent and accredited personnel.

- The maximum voltage between the inputs is $1000V_{DC}$. Do not measure voltage exceeding the limits in this manual.
- The maximum current the instrument tolerates is $10A_{DC}$. Do not carry out tests on FV module strings connected in parallel.
- Never test FV modules or strings connected to the DC/AC converter.

3. NOTES CONCERNING THIS MANUAL

- The information in this manual is subject to change without prior notice;
- Although this manual has been written with the utmost care, please contact the manufacturer should you have any comments, opinions or product-related questions;
- Make sure you fully understand the pre-requisites for use of the product, such as its technical characteristics and hardware and the software limitations affecting its use. We decline all responsibility for damage resulting from improper use of the product;
- Reproduction of this manual, in full or in part, without written permission from our company, is prohibited.

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4. INTRODUCTION

The FTV200 I-V TRACER is a measuring instrument designed and built to meet the needs of technicians doing troubleshooting or maintenance work on the photovoltaic generator or module in conformity to the IEC/EN 60891 standard.

Photovoltaic systems are in two main parts:

A photovoltaic generator comprising one or more strings of photovoltaic panels that generate a direct current.

An inverter that converts the direct current generated by the panel into alternating current so it can be used in the grid.

The FTV200 I-V TRACER has two measurement inputs, one for measuring voltage (V_{DC}) and one for measuring current (I-DC). Measurements can be made on a single panel or on a string of panels (the latter measure is not provided for in the standard).

There are also inputs for a pyranometer sensor and a temperature probe.

The temperature probe input accepts both the ambient temperature probe and the contact probe used to measure the temperature of the photovoltaic panels.

All the electrical data measured in OPC operating conditions are "transferred" to radiation STC standard conditions equal to 1000W/m² and module temperature of 25°C applying the calculation formulas in conformity to the IEC/EN 60891 standard.

The user may request the comparison (DPmax) between the maximum power (Pmax) stated by the manufacturer and the maximum power measured during the test (OPC), transferred to the STC standard conditions (as stipulated in the IEC/EN 60891 standard).

If the comparison value is within the manufacturer's stated tolerance, the test result is "OK"; otherwise, it is "NO".

N.B.: the IEC/EN 60891 standard indicates the procedures for transferring the values measured under real OPC operating conditions to the reference standard STC conditions for a single module. Consequently, a negative result for a measurement test on one string of modules could mean that every single module has to be measured in order to identify the defective module or modules in the string.

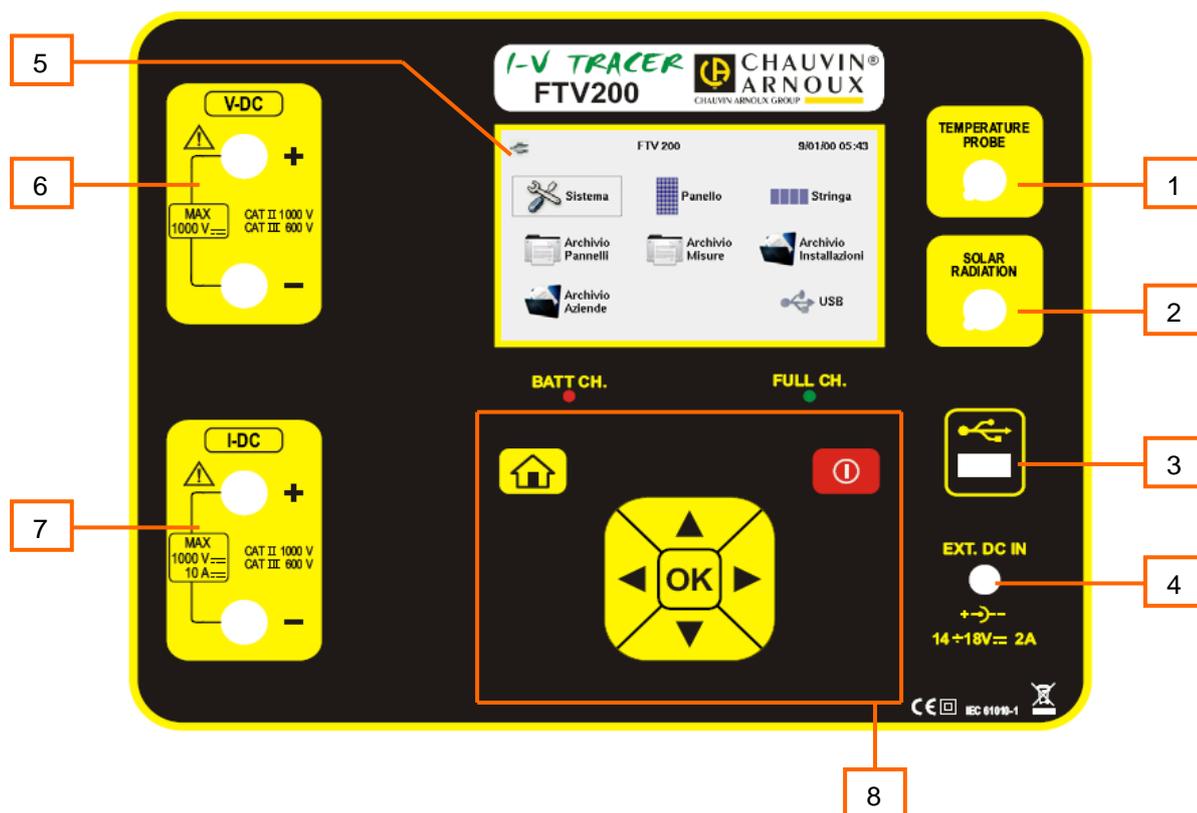
The FTV200 I-V TRACER instrument also lets you enter a percentage of "degradation" and the age (years) of the PV module or of the PV string, further improving the accuracy of the test results.

To make the instrument easier to use in difficult conditions, an FTV100 REMOTE UNIT accessory is available to allow wireless connection of the pyranometer sensor and the temperature probe; the sensor measurements are transmitted to the instrument by BLUETOOTH, via a pair of adapters connected to the respective communication ports.

The main measurements made are:

- ⇒ measurement of solar radiation by pyranometer (up to 2000W/m²)
- ⇒ measurement of the ambient temperature or panel temperature by Pt100 sensor (up to 120°C)
- ⇒ possibility of measuring both single panels and strings of panels
- ⇒ measurement of the no-load voltage and the MPP voltage (up to 1000 V_{DC})
- ⇒ measurement of the short-circuit current and the MPP current (up to 10 A_{DC})
- ⇒ graphic representation of the I-V curve with marker at the MPP.
- ⇒ graphic representation of the power curve with marker at the MPP.
- ⇒ comparison of the measurements with the panel nameplate data and indication of the result:
OK/NO
- ⇒ calculation of the efficiency of the solar panels and display of the difference between the nominal value and the measured value
- ⇒ measurement of the series resistance, R_s , in compliance with the requirements of standard EN60891

5. DESCRIPTION OF CONNECTIONS AND CONTROLS



- 1) Temperature probe input
- 2) Pyranometer input
- 3) USB 2.0 port
- 4) External power supply input (15V DC; maximum current consumption 2A)
- 5) 4.3" colour "touch-screen" LCD Monitor
- 6) Input for voltage measurements
- 7) Input for current measurements
- 8) Multi-function keypad including the following keys:

▲ : "up" arrow key

▶ : "right" arrow key

OK: button to confirm selection

◀ : "left" arrow key

▼ : "down" arrow key



On/off key



Return to main menu key

BATT Ch LED (active only with external power supply connected)

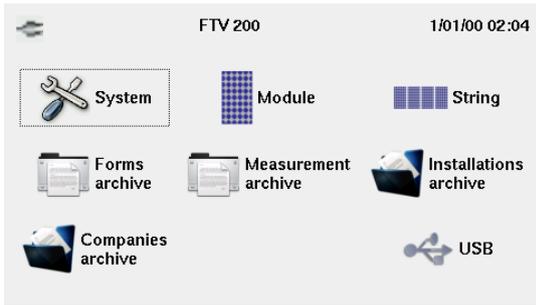
lit while battery is charging, which takes place **ONLY** when the instrument is Off

FULL CH LED INDICATOR (active only with external power supply connected)

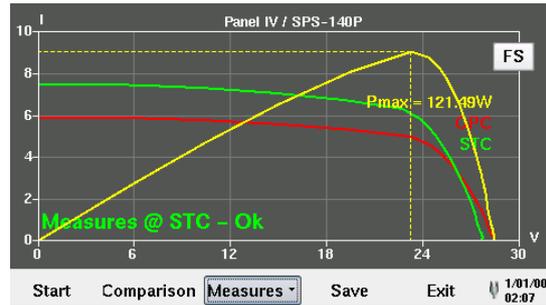
lit when the internal batteries have reached full charge

6. DISPLAY UNIT

The FTV200 I-V TRACER has a 4.3" colour touch-screen LCD display that displays function access icons, menus, and graphs of the I-V curves of the panel or string of panels measured.



Main screen



Graph Screen

7. POWER SUPPLY

7.1. Battery life

The battery icon in the lower right part of the display indicates the battery's charge status. The number of bars in the icon is proportional to the charge level.

-  Battery fully charged. Remaining life approx. 12 hours
-  Battery semi-charged. Remaining life approx. 50 minutes
-  Battery low (blinking symbol). Remaining life approx. 10 minutes

7.2. Charging the batteries

The battery is charged with the INSTRUMENT OFF, using the power supply unit supplied with the instrument, which is connected to the dedicated jack.

It is recommended that only the power supply unit provided with the instrument be used. This type of power supply unit is specific to the instrument and ensures electrical safety.

If the battery is fully discharged, the charging time is approx. 5 hours.

7.3. Mains power supply unit

The mains power unit accepts voltages ranging from 90V to 260V-50Hz. The protecting fuses are inside the mains power unit and are not accessible.

NOTE: If the fuses blow, do not replace them, but send the power supply unit to the service centre for inspection.

ATTENTION: use only the mains power unit to charge the internal batteries.

Before using the instrument to make measurements, make sure that the mains power unit is disconnected.

8. ON/OFF SWITCH

To switch the instrument On, press the  button and hold it down for approx. 3 seconds

NOTE: If, when the key is released after starting up, the instrument switches itself off, the batteries are not sufficiently charged. Charge the batteries before use.

To switch the instrument Off, press the  button and hold it down for approx. 3 seconds

9. IMPORTANT NOTE FOR USE

To enter alphanumeric characters in one of the fields listed in the menus or in specific functions, use the keypad, opened by touching the screen that corresponds to the desired field.

To switch the keypad from numeric to alphabetical mode, press the (ABC) key in the lower left corner.

To switch the keypad from alphabetical to numeric mode, press the (.?123) key in the lower left corner.



Keypad in numeric mode



Keypad in alphabetical mode

When it is impossible to use the TOUCH-SCREEN, the keypad on the front panel can be used to select icons and control keys. Use the arrow keys to select the desired icon or control key, then confirm by pressing the OK key.

10. DESCRIPTION OF THE MENUS

10.1. System

If this icon is selected, a window containing the instructions and system settings opens as described below. Before browsing this menu, please wait a few seconds until the Power Version Number is displayed.



Serial number: indication of the instrument's serial number.

SW Version: indication of the instrument's firmware version (upgradable through the "USB" menu)

Power Version: indicates the version of the instrument's measuring software.

Display: The date and time can be displayed at all times in the top bar of the display; pressing the  key opens a window in which you can select one of the following conditions:

Local: the date and time are not displayed.

Date-Time: the current date and time are displayed simultaneously.

Date: only the current date is displayed.

Time: only the current time is displayed.

Setting the date and time: the current date and time are displayed in their respective fields; to edit the date/time, select the value to be changed using the  or  key.

Press the "Apply" button to confirm the new settings and exit from the menu.

Temperature probe: press the  key to open probe type selection window:

Module: the measurements are made with allowance for the temperature of the photovoltaic module.

Ambient temperature: the measurements are made with allowance for the ambient temperature.

Sens. Pyra (mV/kW/m²): the pyranometer sensitivity value is displayed in the corresponding window. Because of a change of unit, this value is 1,000 times the value marked on the pyranometer (i.e. 0.01490mV/Wm⁻² x 1.000 = 14.90mV/kW/m²). If the assigned does not correspond to the pyranometer used or if the pyranometer is replaced, select this window and enter a new value using the keypad displayed. Then press "Apply" followed by "Invio" ("Enter") to confirm the new setting and close the function.

If the value set does not match that of the pyranometer being used, or if the pyranometer is replaced, select the window on the screen, use the instrument's keypad to configure the new value, and when the change has been made click on "ENTER" to confirm the setting and exit from the field.

Minimum radiation: can be used to set the minimum solar radiation value in W/m², adjustable from 1 to 1,000W/m², used as reference by the instrument during a measurement.

Please always check that the value set is consistent with the measurement you want to make.

We recommend making measurements with a solar radiation value $\geq 700\text{W/m}^2$ in compliance with standard IEC/EN60981.

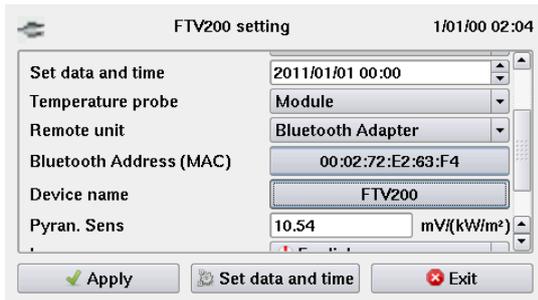
Remote Unit: If the ▼ button is pressed, the remote unit activation window opens for selection of the type of connection between the remote unit and the FTV200. Possible choices are:

Local, the probes are connected without the use of a remote unit.

RS-232 Serial Adapter, the BLUETOOTH module is connected to the instrument's USB port by an RS232-USB adapter.

Bluetooth Adapter, the connection is via a USB-BLUETOOTH adapter module. When this item is selected, the following two fields are activated for the following settings:

Bluetooth Address (MAC), if the corresponding field is selected, a keypad opens for entry of the "MAC" number of the Bluetooth adapter used on the remote unit with which you want to communicate.



NOTE: For the Bluetooth devices of the instrument and the remote unit to be able to communicate, the MAC number of the Bluetooth adapter used on the instrument must be set in the Bluetooth device used on the remote unit.

The PIN code setting of this device must not be activated.

To configure the device used on the remote unit, follow the instructions provided in the remote unit's manual.

Device name: this can be used to enter a name for the Bluetooth adapter used for the instrument; this is optional.

Brightness: click on the associated numeric value to modify it if necessary

Language: press the ▼ key to open the language selection window. Touch the desired language on the screen to confirm the selection and exit.

Memory used: this displays the percentage of the instrument's memory occupied by the data entered and the stored measurements.

Note that the available memory of the instrument is 84 MBytes.

10.2. Module Archive

Selecting this icon opens a window with the following functions:

New Module: Selecting this icon activates a function allowing entry of the model and plate data of a panel not present in the pre-loaded list. If a new brand must be entered, exit by selecting "Exit", then select the "Edit Brand" icon.

Edit Brand: Selecting this icon opens a window containing a list of the brands present; select the "enter new brand" line if you want to add a brand not present in the list. Select the window below the list to enter the new name, then click on "SAVE" to confirm, or "Exit" to cancel the operation.

Working in the same way as described above, you can select and then edit the name of a brand already present.

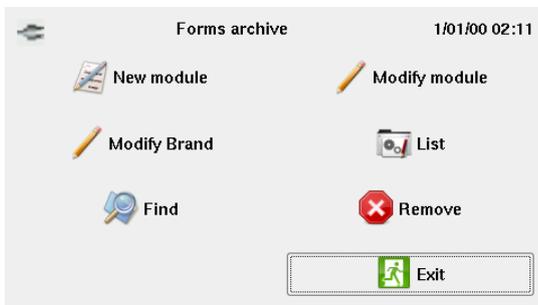
Find: selecting this icon opens a window that lets you search the list of panels in memory according to a selection criterion based on their electrical characteristics. Completing one or more of the fields for the main electrical characteristics of the panels and pressing the "Search" button displays a list of panels matching the values entered. This function can be used, for example, for a quick check of the brand and model of panels that have the selected characteristics.

Edit Module: when this function is used – once the brand has been selected – it is possible to edit and update the model and electrical characteristics of the listed panels

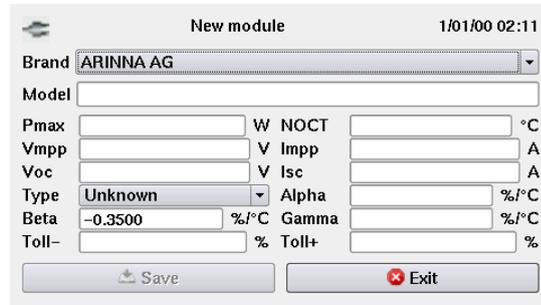
List: Selecting this icon opens a window displaying a list of the panels and their respective characteristics.

Delete: This function can be used to delete a brand from the list, or all panels that correspond to it, or a single panel. To delete, select the brand and possibly the model; press "Delete Model" if you want to delete only the selected model, "Delete Brand" to delete the brand and all of its contents.

Press the "Exit" button to return to the previous menu.



Module Archive menu window



New Module data entry window

The table below indicates ranges of values for the characteristic parameters of the panels that are entered when a New Module record is created in the database.

Symbol	Description	Measurement unit	Range
P_{max}	Maximum power of the module	(W)	1.00 to 1000.0
V_{mpp}	Voltage at maximum power point	(V)	1.00 to 200.0
V_{oc}	No-load voltage	(V)	1.00 to 200.0
Type	Type of silicone in the cells		Monocrystalline Polycrystalline Thin Film Amorphous Micromorph
Beta	Voc temperature coefficient	(%/°C)	-1.00 to -0.0001
Toll –	Negative tolerance of P_{max} stated by the PV module manufacturer	(%)	0 to -50
NOCT	Nominal operating temperature of the cell	(°C)	0 to 100
I_{mpp}	Current at maximum power point	(A)	0.2 to 10.00
I_{sc}	Short-circuit current	(A)	0.2 to 10.00
Alpha	I_{sc} temperature coefficient	(%/°C)	-0.200 to + 0.200
Gamma	P_{max} temperature coefficient	(%/°C)	-1.00 to -0.01
Toll +	Positive tolerance of P_{max} stated by the PV module manufacturer	(%)	0 to +50

10.3. Company Archive

Select this icon to access the client record management, look-up, and deletion functions via the following menus:

New: select this icon to enter a new record. Click in the desired field to open the keypad; when you have finished typing, confirm your entry by pressing "ENTER".

Note: the Tax code field must be filled in.

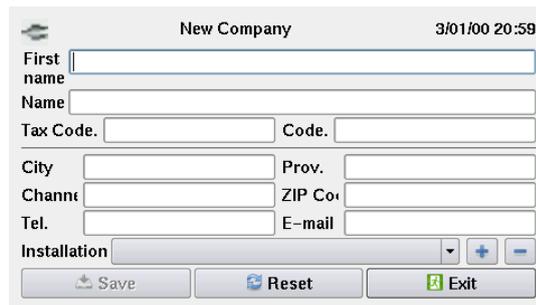
List: press this icon to open the list of all stored records; to view the details of a record, click on the corresponding line and press "Open". To view the characteristics of the installations associated with the record, select the installations and press "Display".

Edit: click on this icon to access the Edit record function; to make a change, select the desired record in the "Surname - Company Name" field(s) and press the "Edit" button. Select the field to be edited, enter the changes, and confirm by pressing "ENTER".

Delete: select this icon to open a list of stored records. Select the record you want to delete by highlighting it in the "First name - Name" field and click on the "Delete" button to delete it from the memory.



Company Archive Windows



Menu Window Company Details Window

10.4. Measurements Archive

Press this icon to access all measurement archive management windows. The available functions are:

Modules: click on this icon, then on "List", to display the records of all measurements made on individual panels.

Strings: click on this icon, then on "List", to display the records of all measurements made on strings.

To view the graph of a measurement, for both modules and strings, select the desired measurement in the list by touching the desired item on the screen, then select the "Graph" button. When viewing the graph, you can use the "FS" command in the top right corner to switch to full screen graph display mode or to display both the graph and the command bar at the bottom of the screen, with the following items:

Module or String: displays the electrical data measured.

Environment: displays the ambient temperature and radiation measurements.

Power: displays the OPC or STC power curve on the graph, depending on the selection made.

Exit: return to previous menu.

Delete: click on this icon after selecting "Panels" or "Strings" to enter Delete measurement record mode. To delete a record, select the desired line and press "Delete"



Measurements Archive Windows

10.5. Installations Archive

Press this icon to access the installations archive in order to create, manage and if necessary delete measurement records. The available functions are:

New: select this icon to enter the new installation entry window.

When the field of an item is selected, the data entry keypad opens; when you have finished entering the data, confirm by pressing the "ENTER" key. Repeat the same steps for each field to be completed.

List: press this icon to open the list of all stored installations; to view the details of an installation, click on the corresponding line, then press "Open". To view the data of a plant associated with the installation, select the plant and press "Display".

Edit: click on this icon to access the Edit installation function; to make a change, select the desired installation in the "ID" field and press the "Edit" button. A keypad opens when the field to be edited is selected; enter the changes, then confirm by pressing "ENTER".

Delete: selecting this icon opens a window from which the list of stored installations is accessed. Select the installation you want to delete, highlighting it in the "ID" field, then click on the "Delete" button.

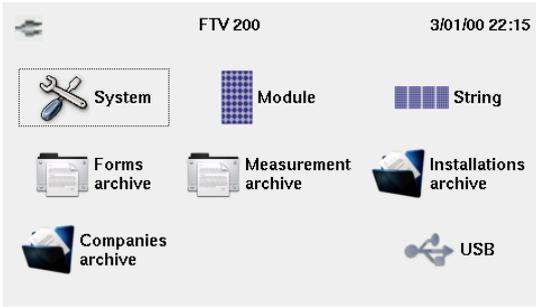


Installation Archive Menu

Window Installation Data Entry Window

10.6. USB

Select this icon to access the USB port management menu and its controls.



Main screen



USB menu screen

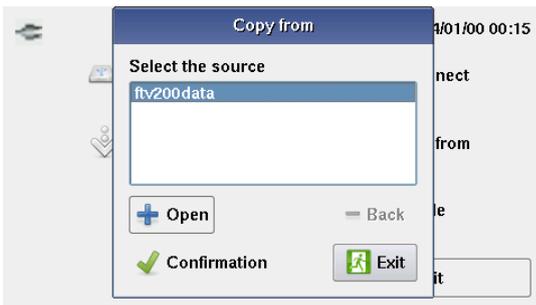
The USB port can be used to control the following devices.

10.6.1. USB-bluetooth adapter

this device allows the instrument to communicate with the "FTV100 Remote Unit" to obtain the measurements from the atmospheric probes. The instructions for adjusting the USB-BLUETOOTH ADAPTER are given in Chapter 10.1, "System".

10.6.2. USB pen drive

USB memory is used to transfer archives (measurements or settings) from the instrument to the PC and vice versa. This is done by selecting the "Copy to..." or "Copy from..." command; a window then appears on the screen for the selection of the destination folder or the "source" folder.



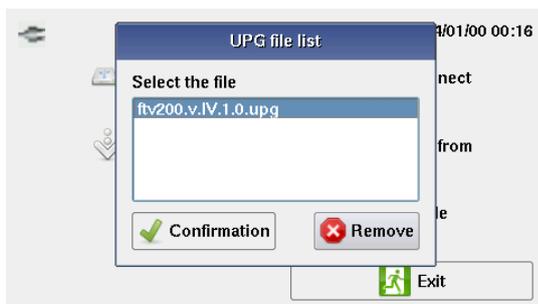
"Copy from..." message box



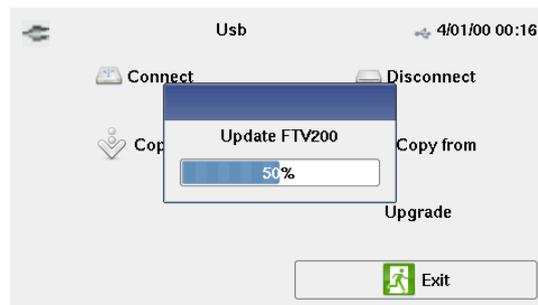
"Copy to..." message box

The "Copy to..." command corresponds to a transfer from the instrument onto the USB pen drive. The "Copy from..." command corresponds to a transfer from the USB pen drive to the instrument.

The pen drive is also used to update the instrument's firmware. To carry out the update, make sure you have copied the file with the ".upg." extension to the USB key. Once the USB key connection is established, select "Upgrade" in the menu; a window in which to select the update file appears on the monitor. Select the file to be loaded, then click on "Confirm". The progress bar displays the progress of the update; when it is complete, you are prompted to restart the instrument. Press OK to finish the procedure.



File selection window



Update progress bar window



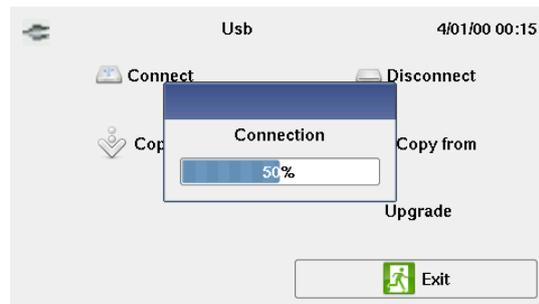
Restart command window

IMPORTANT NOTE: To ensure the correct operation of the USB devices, execute the following commands once the USB key to be used has been inserted in the connector:

Connect: clicking on this command opens a window for confirmation of the connection between the instrument and the device inserted in the port, USB-BLUETOOTH ADAPTER or USB PEN DRIVE. During the connection of the inserted device, a connection progress indicator appears on the monitor.



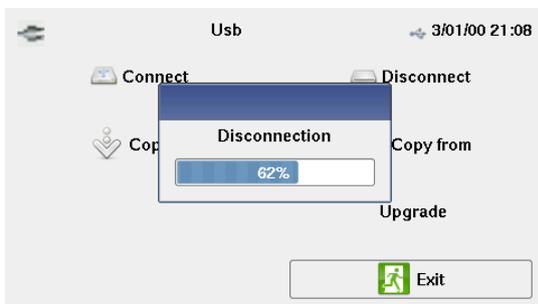
Connection message box



Connection progress window

Disconnect: select this command to start the "safe" disconnection of the connected device.

The disconnection progress bar appears on the monitor; once disconnection is complete, it is possible to disconnect the device in use from the connector.



Disconnection progress window



Disconnection complete message box

11. MAKING MEASUREMENTS

Before making measurements, make sure that the pyranometer and the temperature probe have been connected, as follows:

PYRANOMETER: the pyranometer must be placed on the same level as the modules to be tested; also make sure that there are no shadows.

Attach the pyranometer directly to the PV module frame or to the main structure using the metallic accessory supplied with the pyranometer (take care to avoid further shade by improper positioning of the pyranometer).

Make sure the angle between the sun's ray and the module's surface is as close as possible to 90°, the ideal angle for obtaining excellent reliable results. If need be repeat the measurements at other times of the day.

Plug the connector directly into the instrument or the Remote Unit (if used).

AMBIENT TEMPERATURE PROBE: the temperature probe must be placed in a shaded area that is adequately ventilated and near the modules.

Plug the connector directly into the instrument or the Remote Unit (if used).

PANEL TEMPERATURE PROBE: the temperature probe must be positioned on the back of the panel aligned to a cell; if you are measuring a string of panels, place the probe on a panel in the middle of the string.

Plug the connector directly into the instrument or the Remote Unit (if used).

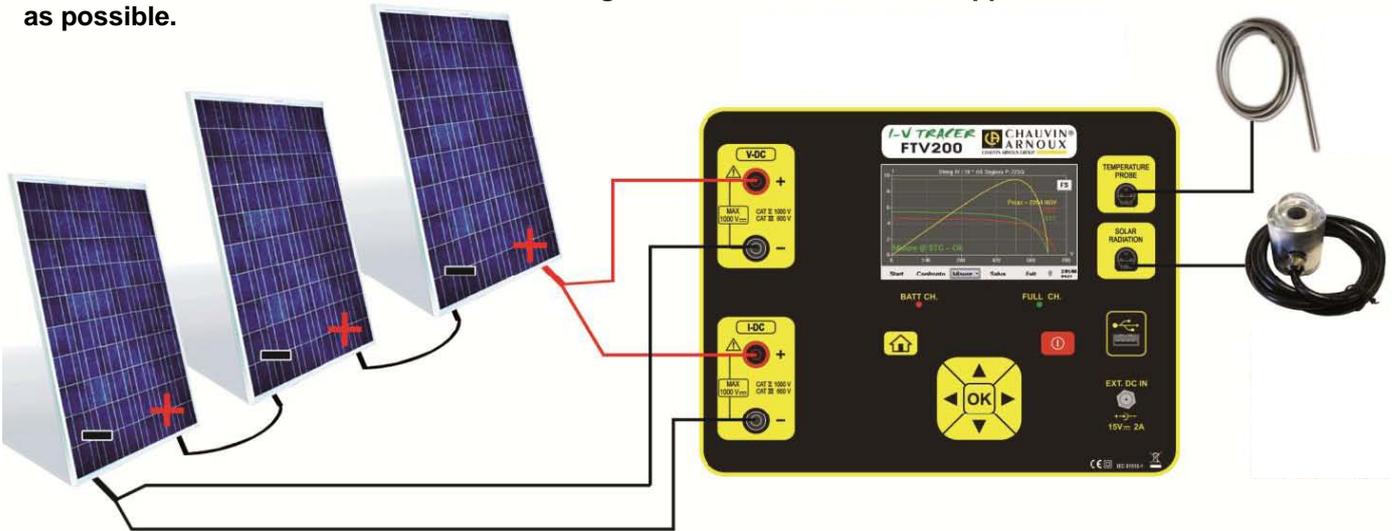
11.1. Electrical connections:

The inputs for the V-DC voltage and I-DC current measurements are on the front panel.

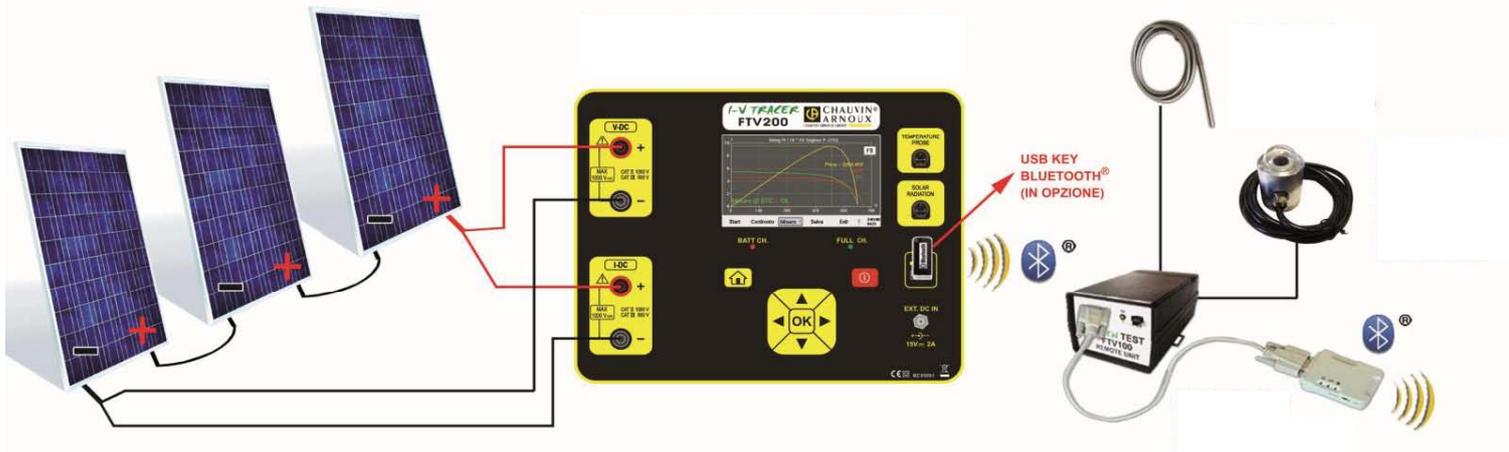
Connect cables in parallel from the positive terminals of the instrument to the positive terminal of the panel or string and from the negative terminals of the instrument to the negative terminal of the panel or string. This 4-wire connection makes the voltage and current measurements of the panel or string independent and more accurate.

ATTENTION: use only the cables supplied for the electrical connections or, possibly, cables with suitable characteristics and certifications.

If the measurement connection is made using cables other than those supplied, use cables that are as short as possible.



Example of electrical connections without remote unit



Example of electrical connections with remote unit

11.2. Remote Unit

The size of the plant may force you to place the instrument in a location far from the photovoltaic panels (for example, an integrated plant on the roof with no possibility of making the electrical connections on the same level as the modules or strings).

The FTV 100 remote unit (optional) can be installed next to the photovoltaic panels, thereby making it possible to transmit the radiation, ambient temperature, and panel temperature measurements to the instrument in REAL TIME (using the Bluetooth kit). This will make your testing very simple and accurate, and also let you view and store the measurements.

How to make measurements using the remote unit:

- Place the remote unit next to the panels.
- Use the included RS232 cable to connect the module or environment temperature probe and the parallel pyranometer to the Bluetooth adapter.
- Switch the remote unit ON (green LED ON). The green power LED of the Bluetooth adapter will light (if not, set the selector on its side to "PoRI").

The remote unit now is ready to transmit measurements to the FTV200 I-V TRACER instrument.

How to program the FTV200 I-V TRACER instrument for use with the remote unit:

- Turn the instrument On and open the "System" menu.
- Choose the Remote Unit - Bluetooth Adapter option.
- In the Bluetooth Address (MAC) option, enter the MAC number marked on the BLUETOOTH-RS232 adapter connected to the remote unit.
- Click on "Apply" to confirm.
- Insert the USB-BLUETOOTH adapter into the USB port.

The instrument is now ready to receive measurements from the remote unit.

The LED on the USB-BLUETOOTH adapter will light only when measurements are activated from the "MODULE" or "STRING" menu.

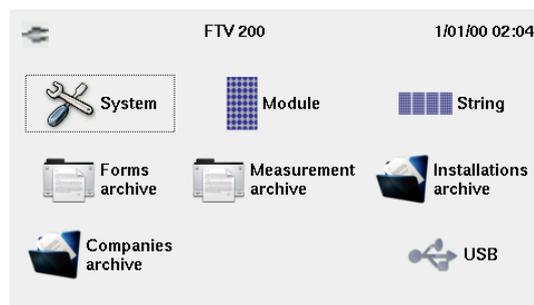
11.3. Module or String

- The maximum voltage between the inputs is 1000VDC. Do not measure voltage exceeding the limits in this manual.
- The maximum current the instrument tolerates is 10A DC. Do not carry out tests on FV module strings connected in parallel.
- Never test FV modules or strings connected to the DC/AC converter.

The measurement functions are as follows:

Module: to measure a single panel, select the "Module" icon in the main menu,

String: to measure a string of panels, select the "String" icon in the main menu,



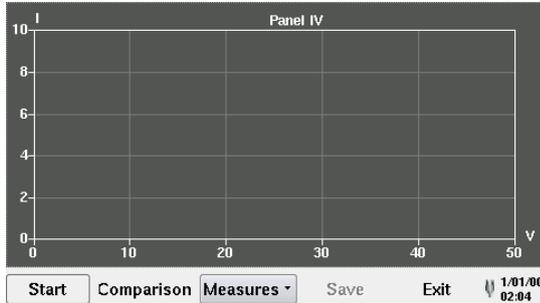
Main menu

Selecting the Module or String icon in the main menu displays the connection diagram on the screen; pressing "Continue" displays the graph. This is how the choice of measurement of a single panel or of a string of panels is activated (the type of measurement selected is displayed at the top centre of the screen). Independently of the selection made, the control buttons under the graph let you control the measurements as described below:

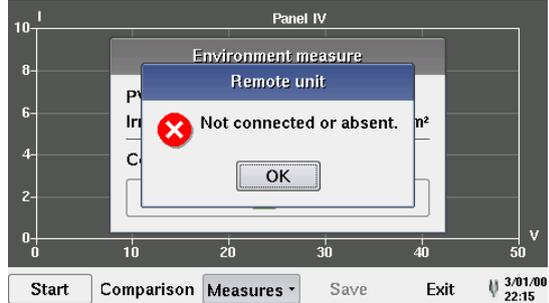
Start:

Pressing this button starts the measurement session; when the session is over, a graph showing the "I-V" curve in red is created.

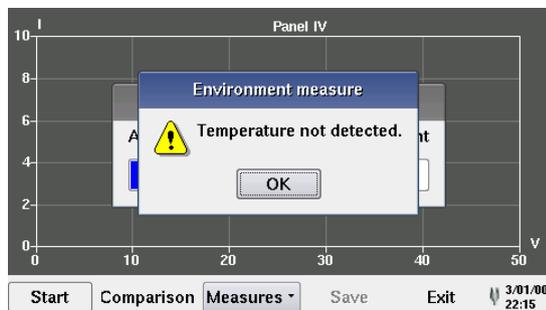
NOTE: Before the measurements are made, a test is run to verify the presence and correct operation of the ambient or module temperature probe and the solar radiation (pyranometer) probe. If an error is found in the probe measurements or the remote connection (if active), the measurement session is aborted. An error message appears on the screen; check the connection and correct operation of the probe or the connection to the remote unit.



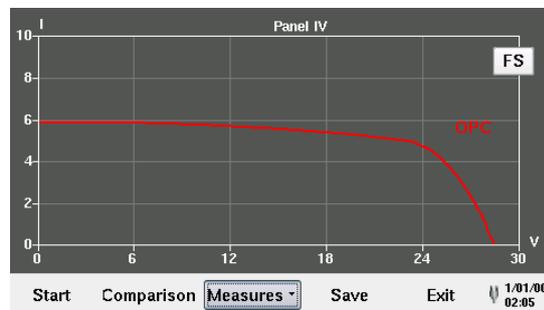
Single panel measurement window



Error message box

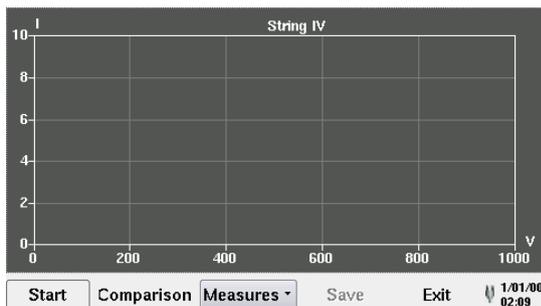


Error message box

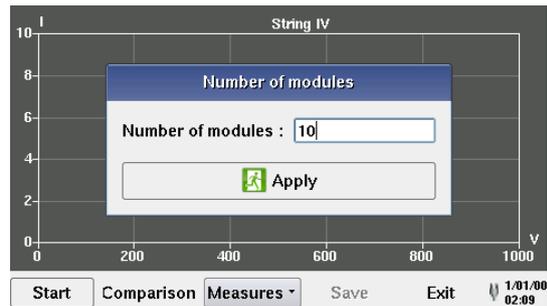


Panel measurement graph

When "STRING" measurement is selected, a dialog box opens; the number of panels in the string to be tested must be entered before the measurements are made.

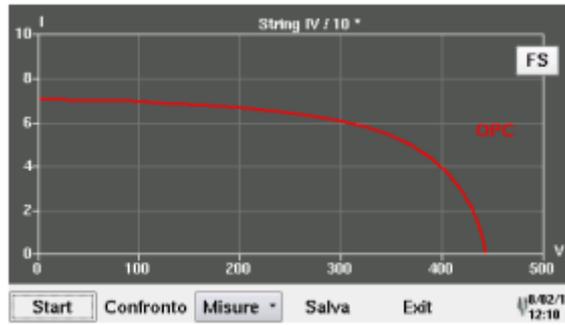


String of panels measurement window



Number of panels entry window

At the end of the test the instrument provides the characteristic I-V measured under real OPC conditions (red colour) concerning the single module or string tested, as shown in the screen below



Characteristic I-V curve under real OPC conditions

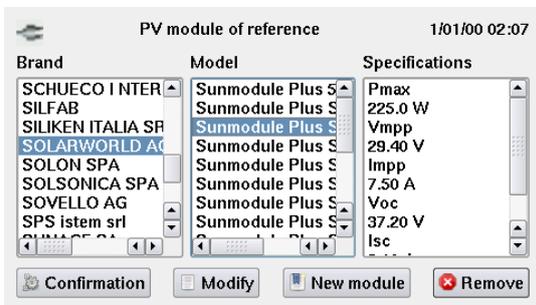
The comparison between the I-V curve measured under real OPC conditions and that characteristic of the producer under STC conditions (green colour) can be requested.

Using the command COMPARISON the MODULES ARCHIVE menu is displayed: select the brand and module model tested to be used in the comparison.

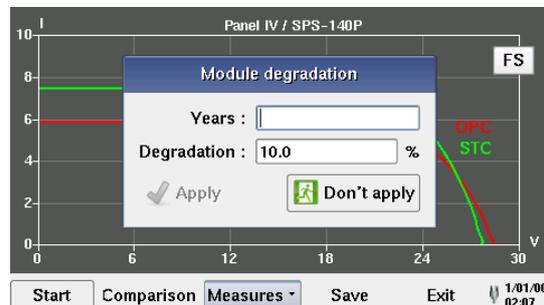
When clicking on Valid the parameters inserted in the modules archive (corresponding to those stated by the producer of the modules) are used and the values measured by the instrument under real OPC conditions are recorded to the STC reference standard conditions.

Comparison:

Pressing this button opens a window for entry of the brand and model of the panel measured, in order to compare the measurements with the nameplate data; the measured values will appear alongside the nominal characteristics of the panel. For a more accurate comparison, the age and corresponding presumed percentage of panel performance degradation are requested; if you do not want to enter these data, press the "Do not apply" button.



Reference panel selection window

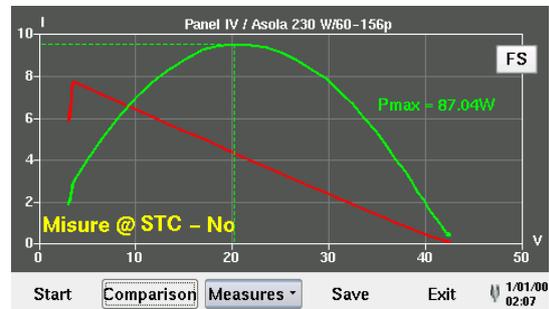
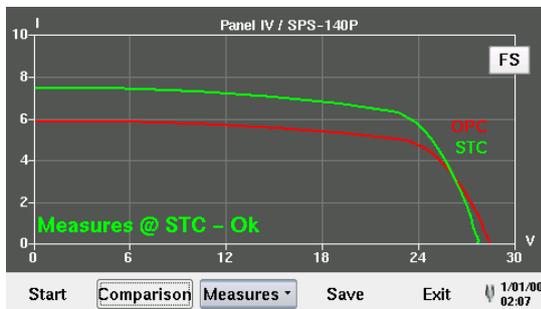


Ageing values entry box

When the panel settings have been chosen, the results of the comparison are displayed in the bottom left corner of the graph as follows:

Measurements @ STD – NO
 For the case in which the verification of the manufacturer declared tolerance of maximum power % does not fall within the range of values measured on the panel (or string).

Measurements @ STD – OK
 For the case in which the verification of the manufacturer declared tolerance of maximum power % does not fall within the range of values measured on the panel (or string).



Measurement graphs with comparison results

NOTE: the IEC/EN 60891 standard indicates the procedures for transferring the values measured under real OPC conditions to the reference standard STC conditions for a single module. Consequently, a negative result for a measurement test on one string of modules could mean that every single module has to be measured in order to identify the defective module or modules in the string.

Measurements:

Press the "Measurements" button on the command bar below the graph to access the menu for the following functions:

Rs: use this command to activate the **Series Resistance** measurement function.

The RS series resistance is one of the main features of PV modules and significantly influences their I-V characteristics.

The series resistance is measured **only on individual modules** and, as stipulated in standard IEC/EN 60891, it is measured in two stages, under different solar radiation conditions.

The first measurement must be made with a solar radiation value greater than 500W/mq. The second measurement must be made with a solar radiation value that is at least 50 W/mq lower. The conditions necessary to ensure that the measurements are correct are checked automatically by the instrument. The measurements made will later be saved along with the measurements of the I-V curve in the panel tab, following the procedure described in the **Save** (bold) section.

To make this measurement, proceed as follows:

When the **Rs** function is selected, two commands are proposed:

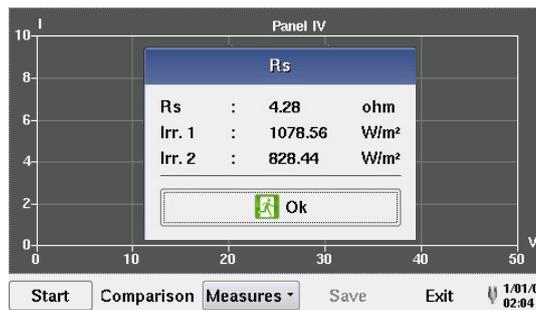
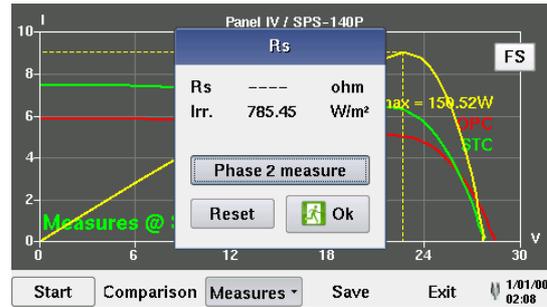
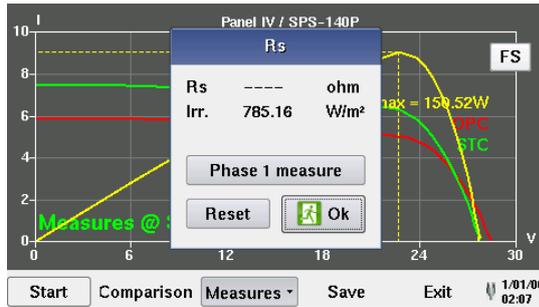
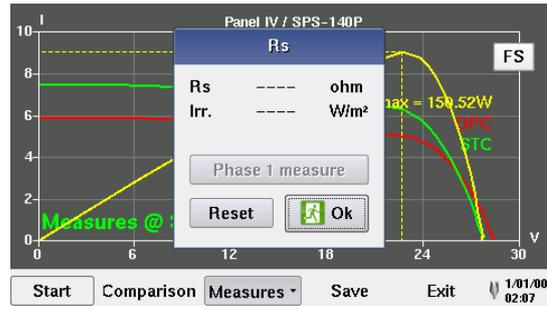
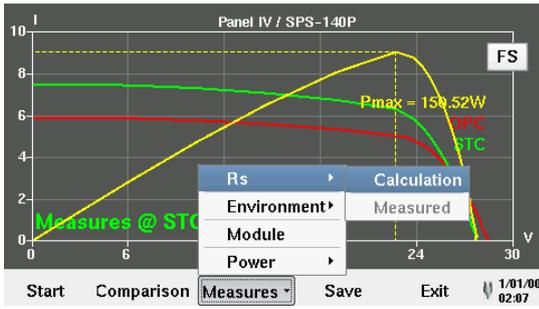
Calculation: pressing this button starts phase 1 of the measurements; a window opens on the monitor, highlighting the measured radiation value I_{rr} (W/m²) and the "**Phase 1 Measurement**" button. Press this button to make the measurements. If the solar radiation value is not correct, a warning message appears on the screen.

When the phase 1 measurements have been made, a window with a "**Phase 2 Measurement**" button appears.

If the solar radiation condition is correct, pressing this button starts the second measurement session; otherwise, a warning message appears on the screen. In this case you must wait until the solar radiation conditions are within the proper range as described previously. When these conditions are correct, the second measurement phase can begin.

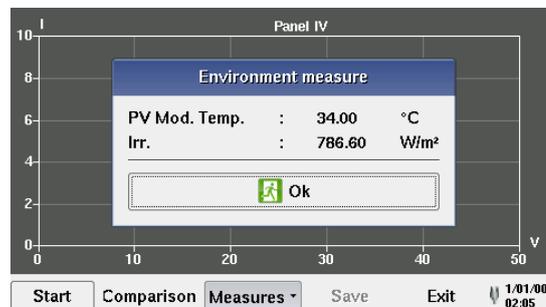
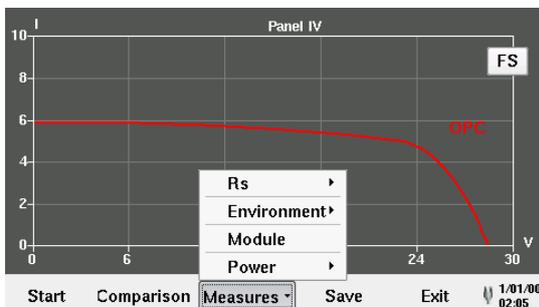
NOTE: To make the **Phase 2** measurement without waiting for the natural atmospheric variation of the solar radiation, a screen, for example a sheet of polycarbonate like those used in shop windows, can be placed over the panel being tested and the pyranometer measuring the radiation to filter the sun's rays and so create the right conditions for the measurement.

Below is a series of Rs measurement screens



Measured: clicking on the Measured button on the screen opens a window displaying the measurement made. The window displays the Rs value and the two solar radiation test values.

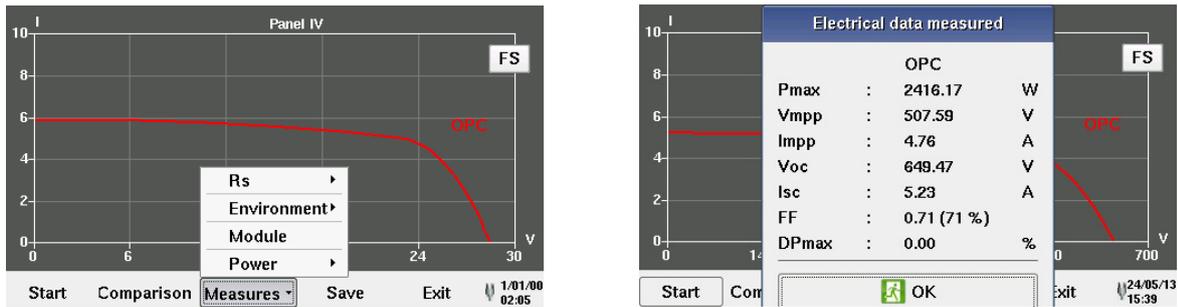
Ambient measurements: Selecting this command displays the temperature and solar radiation measurements. The Mod. Temp. and Amb. Temp. options are available for the reference. Indicates whether the measurements are being made using the module temperature probe or the ambient temperature probe (previously selected). The Remote Connection... message is present whenever the probes are connected via the remote unit.



Images of the Environment Measure Windows

Module (or String):

Module (or String): on selecting one of these commands the "Electrical Data Measured" table is displayed (OPC conditions and STC reference standard if comparison previously requested).



Electrical Data Measured window.

Power:

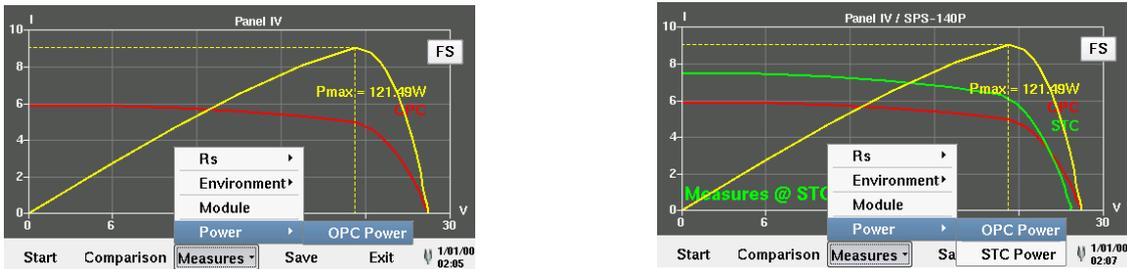
This command displays on the I-V curve graph of the panel or string the power curve (yellow colour) as well.

The window this command opens lets you choose between two options for the power curve to be displayed:

OPC: the instrument shows the trend for power output from the module/string under real OPC conditions (calculated with the measured values).

STC: the instrument shows the trend for power output from the module/string under STC standard conditions (calculated by transferring the values measured under STC standard conditions in compliance with IEC/EN 60891 standard).

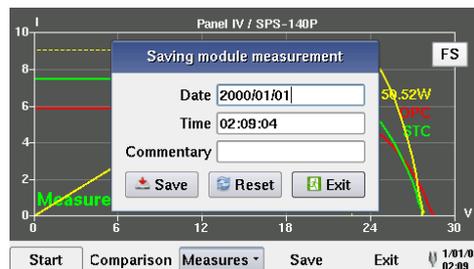
NOTE: the STC selection button is present only when the brand and model of the comparison panel have been entered.



Representations of the OPC and STC power curves

Save: press the Save button to access the Saving module measurement function. The window that opens for this function lets you enter a comment, which is saved in the measurements tab. Press the Save button in the dialog box to save the measurements and the comment.

The saved measurements can be displayed using the "Measurements Archive" Menu, accessed from the main menu (page 9 of the "MEASUREMENTS ARCHIVE" chapter).



Dialog box for saving the measurements

11.2.1 Interpreting the measurement results

The parameters measured by the instrument are described below

Parameter	Description
P_{max}	Maximum Power of the PV module/string measured by the instrument
V_{mpp}	Voltage at maximum power point
I_{mpp}	Current at maximum power point
V_{oc}	Open-Circuit Voltage
I_{sc}	Short-Circuit Voltage
FF	Fill Factor %
DP_{max}	Difference between the maximum power measured by the instrument, referred to STC, and the maximum power declared by the manufacturer, P_{nom} (@ STC)
DPmaxAvg	Available only for measurements on strings: indicates the DPmax on only one module. This value ought not to be considered reliable for the test's purposes.

Result of the measurements

Result	Conditions	Note
OK	$Tol^{(-)} * P_{nom} \leq (P_{max} - P_{nom}) \leq Tol^{(+)} * P_{nom}$	DEGRADATION NOT TAKEN INTO ACCOUNT
	$Tol^{(-)} * P_{nom1} \leq (P_{max} - P_{nom1}) \leq Tol^{(+)} * P_{nom1}$	DEGRADATION TAKEN INTO ACCOUNT
NO (requirements not satisfied)	$Tol^{(-)} * P_{nom} \leq (P_{max} - P_{nom}) \leq Tol^{(+)} * P_{nom}$	DEGRADATION NOT TAKEN INTO ACCOUNT
	$Tol^{(-)} * P_{nom1} \leq (P_{max} - P_{nom1}) \leq Tol^{(+)} * P_{nom1}$	DEGRADATION TAKEN INTO ACCOUNT

Where:

$P_{max} - P_{nom} \rightarrow DP_{max}$ (degradation not taken into account)

$(P_{max} - P_{nom1}) \rightarrow DP_{max}$ (degradation applied)

$Tol^{(-)} (\%) * P_{nom} =$ Negative tolerance declared by the manufacturer (degradation not taken into account)

$Tol^{(-)} (\%) * P_{nom1} =$ Negative tolerance declared by the manufacturer (degradation taken into account)

$Tol^{(+)} (\%) * P_{nom} =$ Positive tolerance declared by the manufacturer (degradation not taken into account)

$Tol^{(+)} (\%) * P_{nom1} =$ Positive tolerance declared by the manufacturer (degradation taken into account)

DPmax:

$$DP_{max} = 100 * \left(\frac{P_{max} - P_{nom1}}{P_{nom1}} \right) \text{ Control parameter that defines the test result (degradation taken into account)}$$

Control parameter **with** degradation (defines the test result for the measurements on module)

$$DP_{max} = 100 * \left(\frac{P_{max} - P_{nom}}{P_{nom}} \right) \text{ Control parameter that defines the test result (degradation not taken into account)}$$

Control parameter **without** degradation (defines the test result for the measurements on module)

DPmaxAvg: (only displayed for measurements on strings)

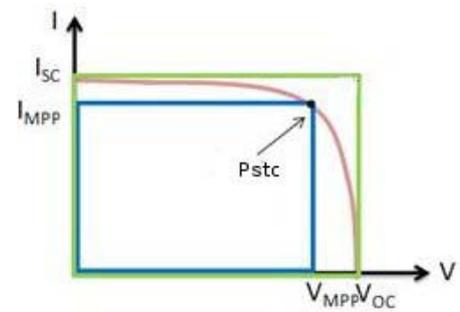
$$DP_{max\ Avg} = \left(\frac{DP_{max}}{\text{numero moduli}} \right)$$

Control parameter that defining the test result for the measurements on the string

Fill Factor:

$$FF = 100 * [(V_{mpp} * I_{mpp}) / (V_{oc} * I_{sc})]$$

This indicates the presumed efficiency of the PV module/string as determined by the ratio of the maximum measured power to the product of the short-circuit current and the open-circuit voltage.



KEY:

$P_{nom1} = P_{nom} * (1 - Deg * Age) = PV \text{ module nominal power calculated with degradation (if taken into account)}$

$P_{nom} = PV \text{ module nominal power (@ STC)}$

$Deg. = \text{Degradation (\%)}$

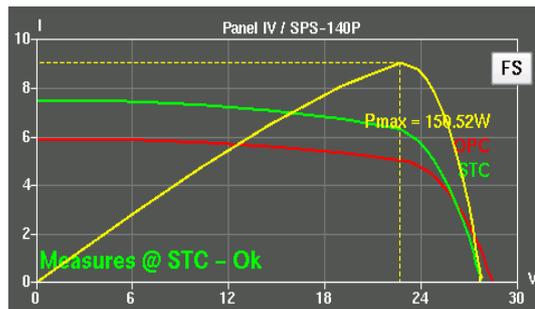
$Age = PV \text{ module age (years)}$

If $Deg = 0$ or $Age = 0$ then $P_{nom1} = P_{nom}$

11.4. Other functions

11.4.1. "FS" (full scale) function

When the graphs are displayed, use the FS button in the upper right of the monitor to switch to full-screen mode. The increased height of the graph gives a better view. To return to the normal viewing mode, press the FS button again.



Full-screen view

11.4.2. Zoom Function

The zoom function can be used to enlarge a portion of the graph and allow a more detailed analysis of a given part of the curve shown.

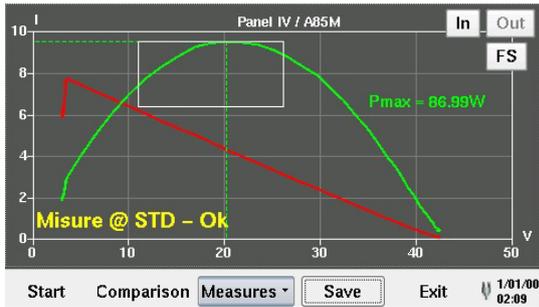
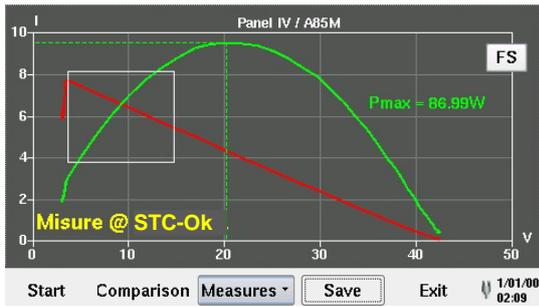
To use the zoom function, touch the screen with the stylus and drag to highlight the portion of the graph you want to enlarge. During this operation, a white rectangle is drawn on the screen to help you define the area you want to enlarge.

When the stylus is removed from the screen, the zoom mode is automatically activated and the area defined is displayed in full-screen mode.

In the top right corner of the screen, above the Full Screen (FS) function button, there are two command buttons to control the zoom function. These buttons are:

In: each time this button is pressed, the magnification increases.

Out: each time this button is pressed, the magnification decreases, until the "normal" display is restored.



12. TECHNICAL CHARACTERISTICS

12.1. Reference conditions

Influence quantities	Reference values
Temperature	20 ± 3 °C
Relative humidity	45 to 55 % RH
Supply voltage	Internal battery
Electric field	< 1 V/m
Magnetic field	< 40 A/m

12.2. Specifications

DISPLAY	4.3" COLOUR GRAPHIC LCD WITH BACKLIGHT AND TOUCH-SCREEN RESOLUTION 480 x 272 BRIGHTNESS 500 cd/mq CONTRAST 400:1			
MEASUREMENTS	METHOD	RANGE	ACCURACY	RESOLUTION
SOLAR RADIATION	THERMOPILE PYRANOMETER	from 0 to 2000W/m ²	<3%	1W/m ²
AMBIENT TEMP.	PT100 PROBE	-20 to +100°C	< 2% ± 1°C	0.1°C
MODULE TEMP.	PT100 PROBE	-20 to +100°C	< 2% ± 1°C	0.1°C
VOLTAGE	DC VOLTMETER	10 to 1000 V;	± 1%	0.1 V
CURRENT	DC AMMETER	0.1 to 10 A;	± 1%	0.01 A
POWER	I-V MEASUREMENT	10 W to 10 KW	± 1%	0.1 W
SERIES RESISTANCE	I-V MEASUREMENT	0.1 Ω to 100 Ω	< 2% ± 0.1 Ω	0.01 Ω
I-V GRAPH	I-V CURVE OF THE PANEL or STRING OF PANELS			
MPP GRAPH	POWER CURVE WITH MARKER ON MPP POINT			
DATA LOGGER	RECORD STORAGE INCLUDING: CLIENT DETAILS, PLANT CHARACTERISTICS, GRAPHS. INTERNAL MEMORY CAPACITY 80 MB FOR A TOTAL OF 10,000 RECORDS. POSSIBILITY OF USING "USB" EXTERNAL MEMORIES			
COMMUNICATION PORT	USB 2.0			
INTERNAL POWER	Li-Ion BATTERY PACK, 16V 4.5Ah MAX CONSUMPTION IN USE 0.6A			
MAINS POWER SUPPLY	EXTERNAL POWER SUPPLY 220-V AC 50Hz with 3-pole mains cord and SHUKO plug OUTPUT 16V 3.8A DC MAX CONSUMPTION IN BATTERY CHARGE MODE 2A			

12.3. Environmental conditions

Use indoors or outdoors.

Range of use	- 5 to +40 °C	80 % RH max.
Storage (without battery)	- 10 to +60 °C	80 % RH max.
Degree of pollution:	2	
Altitude	< 2000 m	

12.4. Construction specifications

Dimensions of the instrument (L x W x H): 270 x 250 x 130 mm

Weight: approximately 2.5 kg (battery included)

12.5. Electromagnetic compatibility

Emissions and immunity in an industrial setting compliant with IEC 61326-1.

12.6. Mechanical protection

IP 54 per IEC 60529 (with lid closed)

IK 04 per IEC 50102

13. FTV200 PC SOFTWARE

13.1 General information

The FTV200 PC SOFTWARE is an application package installed on the PC to let you manage the same archives as are present on the instrument.

This application can be used to import the records of the measurements and their respective graphs so they can be printed or used according to the user's requirements.

In addition, it is possible to prepare the "Installation" records and the "Company" records, edit or update the Database of modules, then transfer the new data to the instrument.

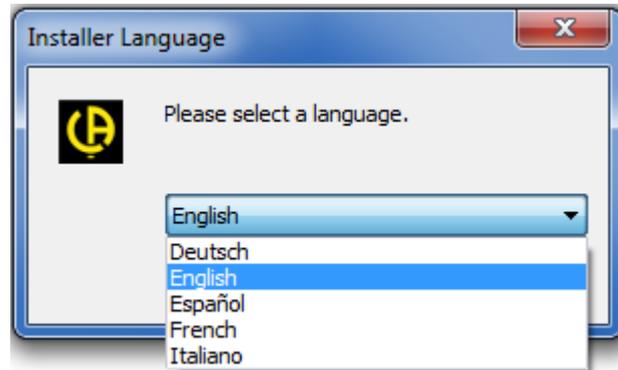
13.2 Installation

The software is automatically installed when the CD supplied is inserted.

If your PC is not set up to start the CD automatically, click on My Computer in the Start menu, then right-click on "CD ROM Unit" and select Open by left-clicking; this opens the window displaying the contents of the CD.

Double-click on the "FTV200_SETUP" icon to start the installation.

Language selection is prompted first. Select the desired language and press OK to continue.



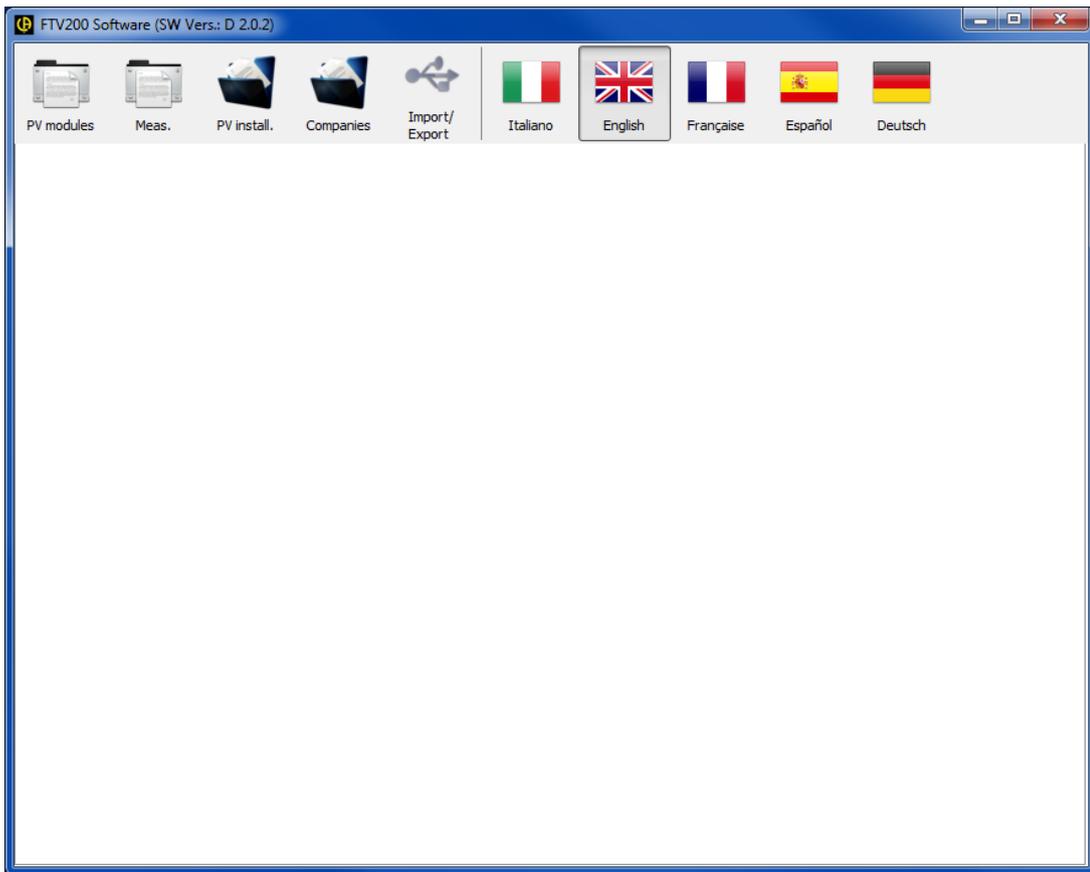
Follow the instructions that appear on screen until the installation procedure is complete; the program icon will then be available on the desktop.



Desktop Icon

13.3 Using the program

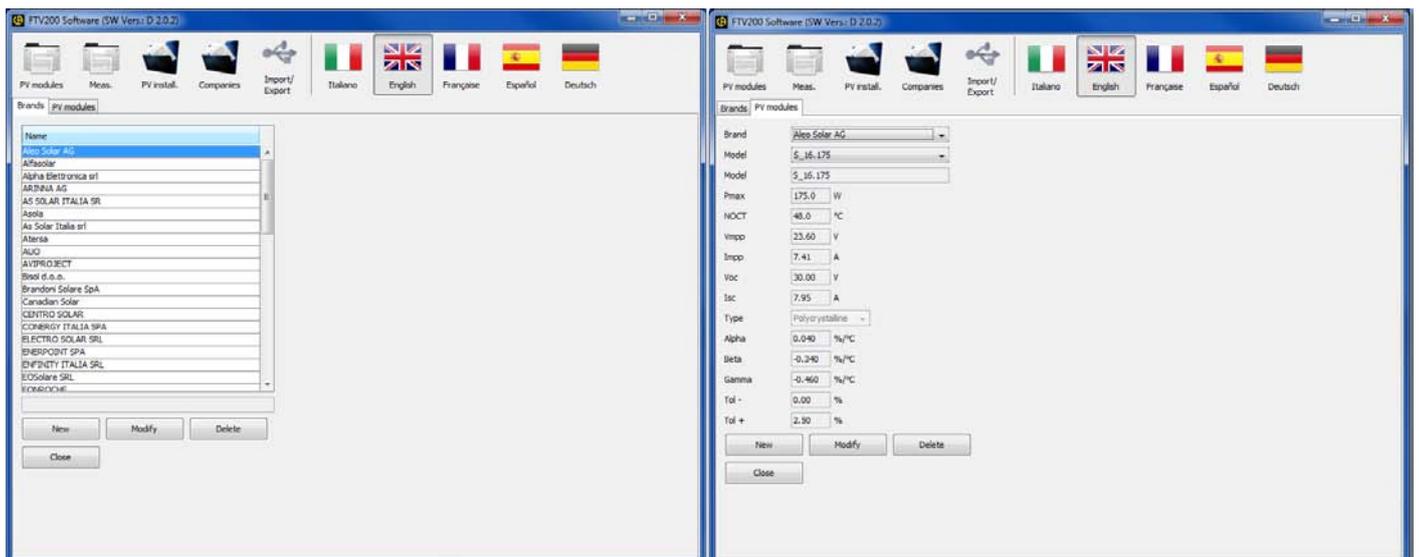
When the program is started, the main window appears as shown below.



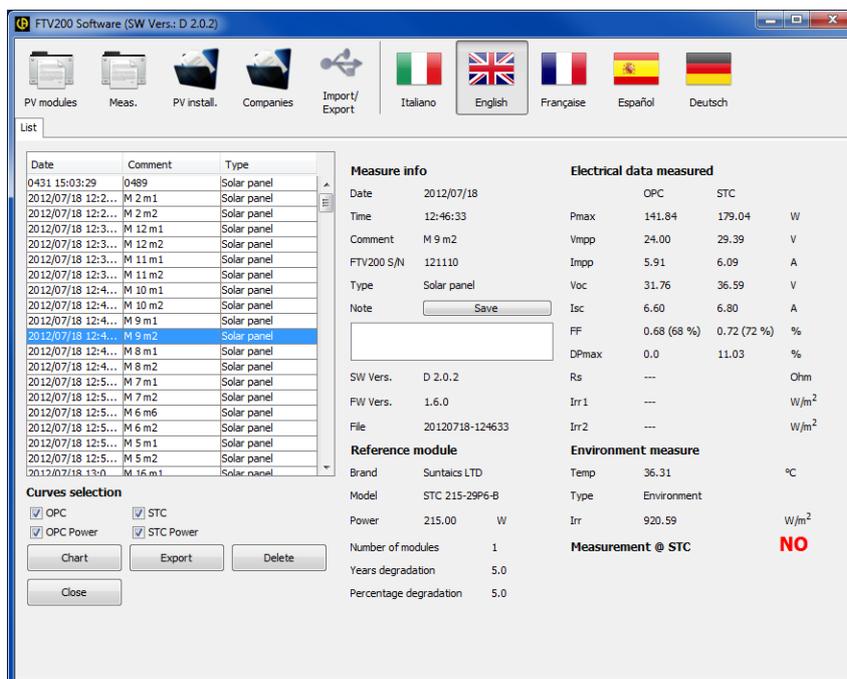
The command bar in the upper left part of the window includes buttons for the following functions:

PV modules: press this button to access the archive where the Brand and Module folders are stored. Selecting the Brand folder lets you enter a new brand, edit a brand in the list, or delete a module brand and all models associated with it.

When you select the module folder, you can enter, edit, and delete data for a selected single panel. Press close to return to the main menu.



Meas.: if this button is pressed the measurements archive folder opens as shown in the following image.



This window displays a list of stored measurements; select a measurement on the right to display the "Electrical Data Measured", the "Ambient Measurements" recorded when the electrical measurements were made, and the results of the comparison between the measurements made and the standard characteristics of the module (or string).

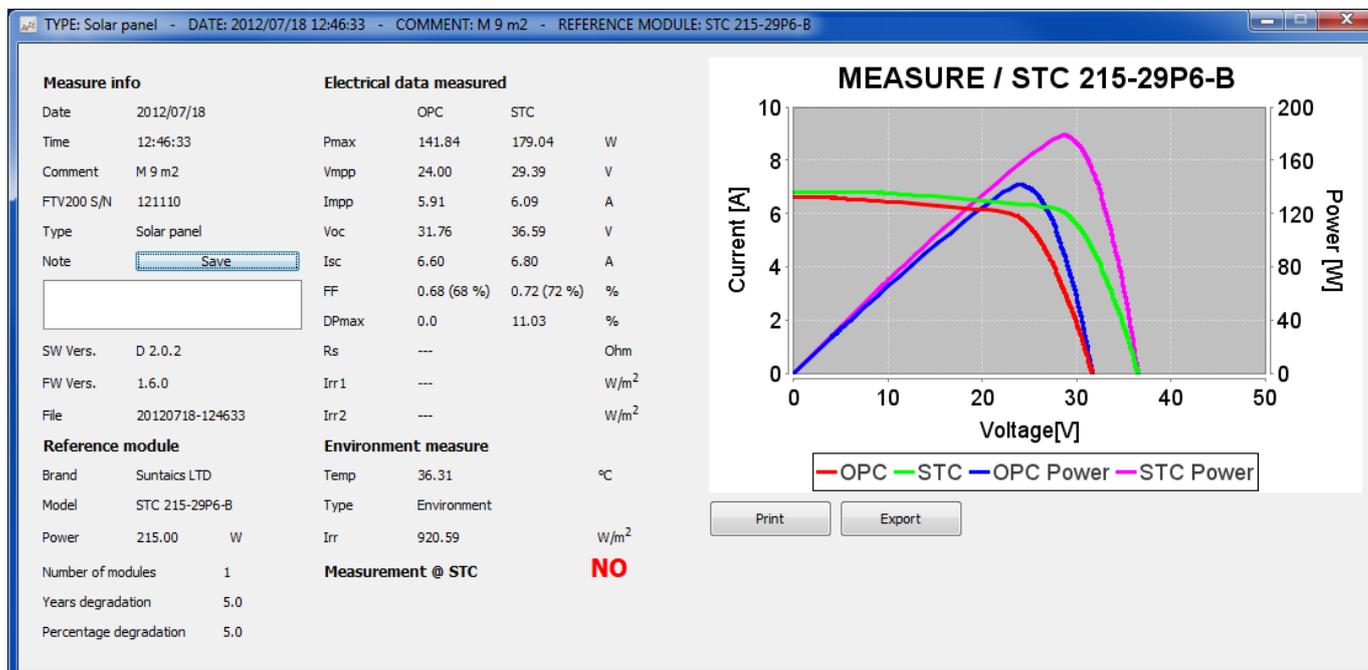
The commands located under "Curve Selection" let you select the curves you want to display by checking the corresponding box(es).

After making your selection, press the "Graph" button on the screen to open the graph window.

Right-click with the mouse on the desired area of the graph; a menu pops up to let you print the graph or perform other authorized operations.

Chart: press this button to view the electrical measurement data and corresponding graph.

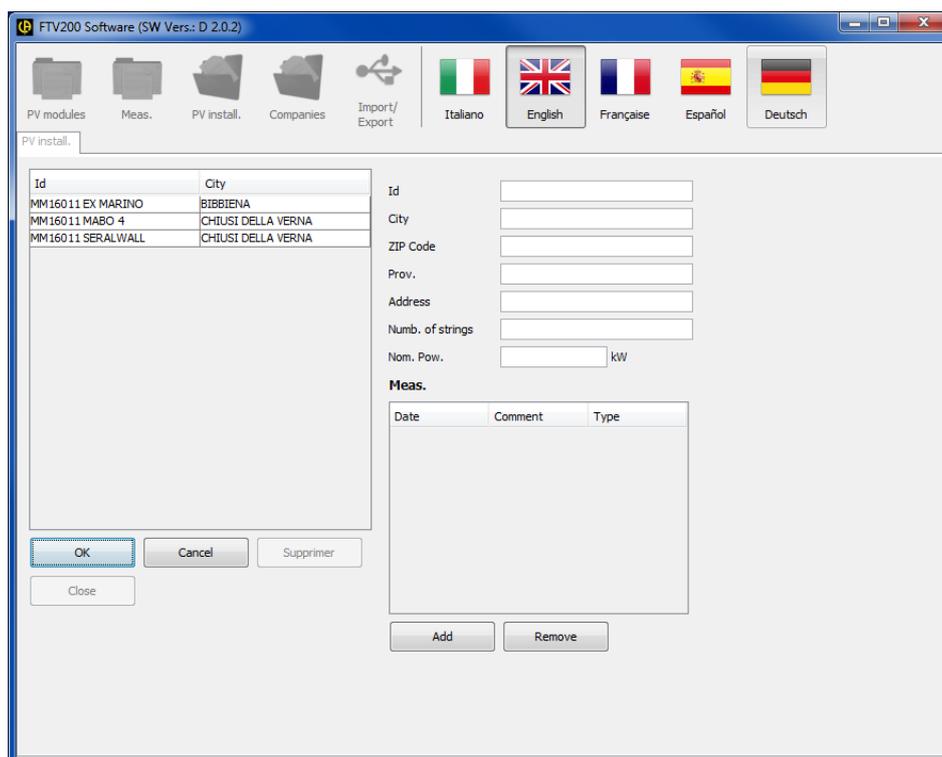
The "Export" button let you export the data in PDF format.



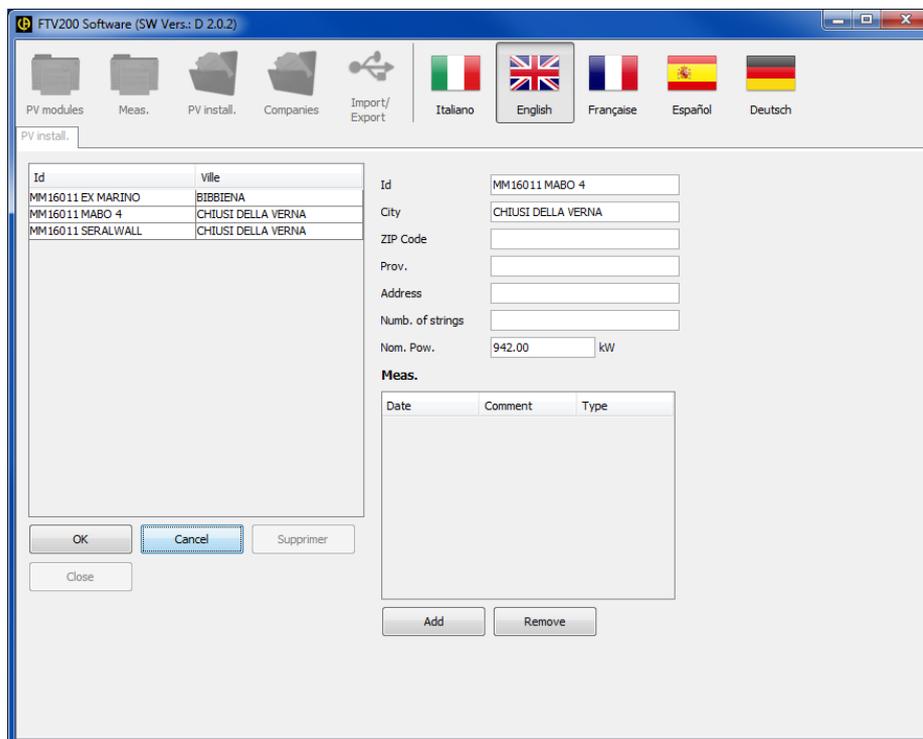
Export: clicking on this button saves the selected measurement and corresponding graph in Excel format. Follow the PC's operating system instructions to finish saving the file.

The commands below the installations list let you perform the following operations:

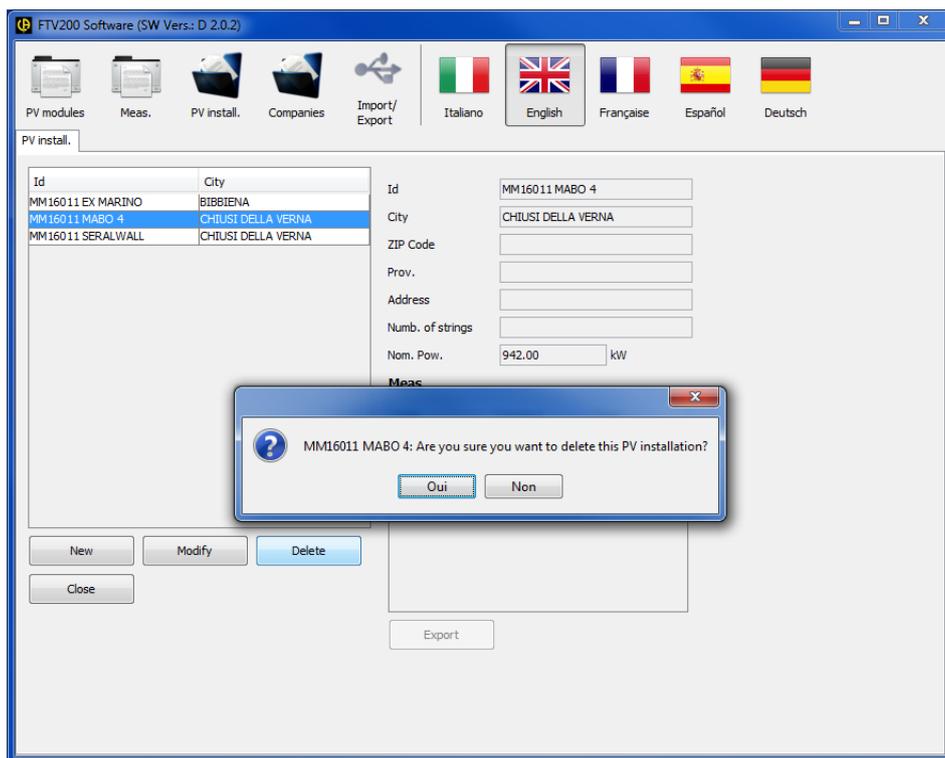
New: this command is used to enter a new installation and corresponding record in the archive. When the button is pressed, the fields are cleared and can be completed. When you have finished, click on OK to save the new record or Cancel to exit without saving.



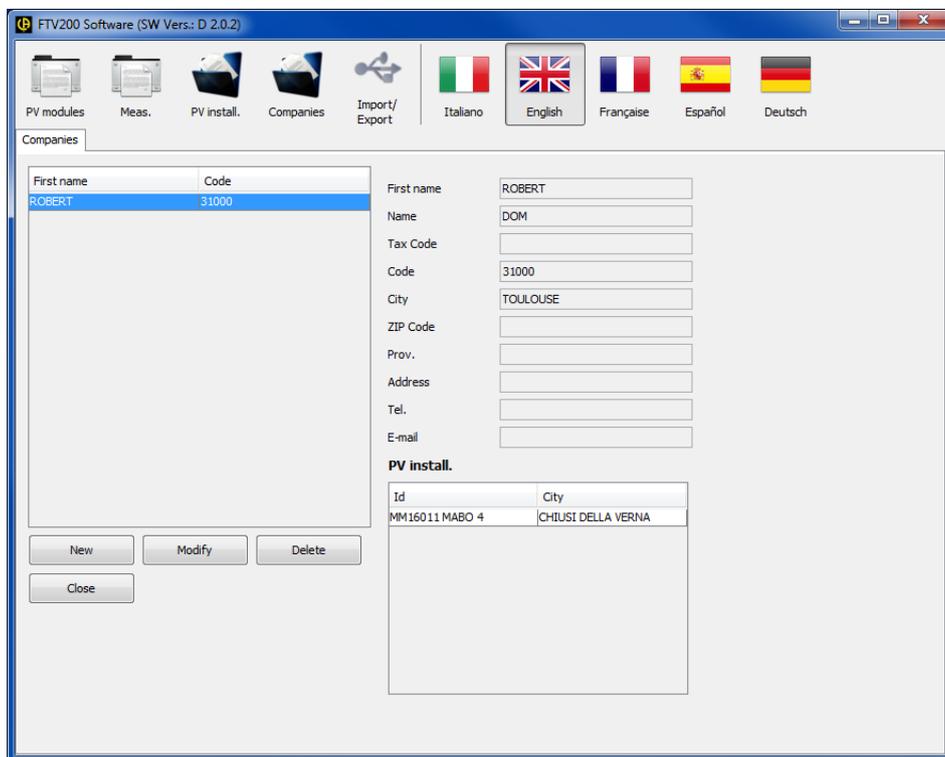
Modify: this command is used to edit the record of the selected tab. When the button is pressed, the record fields are made available so the desired changes can be made. Mouse-click in the field to be edited and type the changes. When finished, press the OK button to save the changes, or Cancel to exit from the edit function without saving.



Delete: use this command after selecting a specific installation from the list in order to delete it from the database. When the button is pressed, a dialog box opens and prompts you to confirm or cancel the operation. Select YES to delete the installation or NO to cancel the operation.



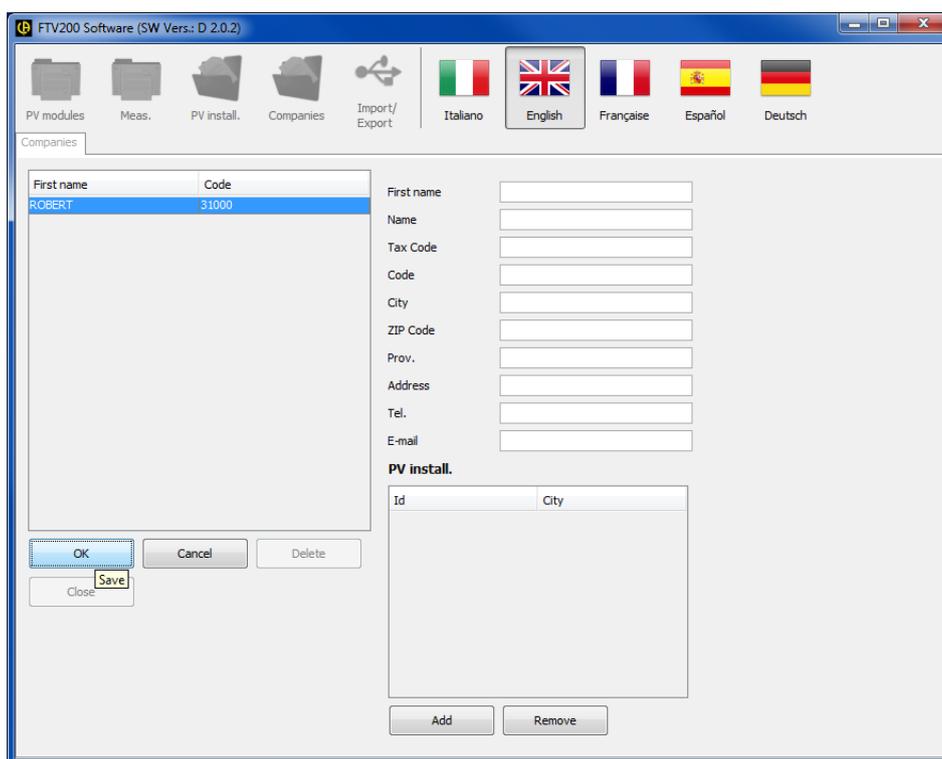
Companies: press this button to access the companies tab, which displays a list of the companies stored in the database. The right side of the tab displays the complete record of the selected company; below this, in the "Installations" section, is a list of the installations belonging to this record.



The Companies tab

The command buttons below the list of companies let you perform the following operations:

New: this command is used to enter a new company and corresponding record in the archive. When the button is pressed the fields are cleared and can be completed. When you have finished, click on OK to save the new record or Cancel to exit without saving.

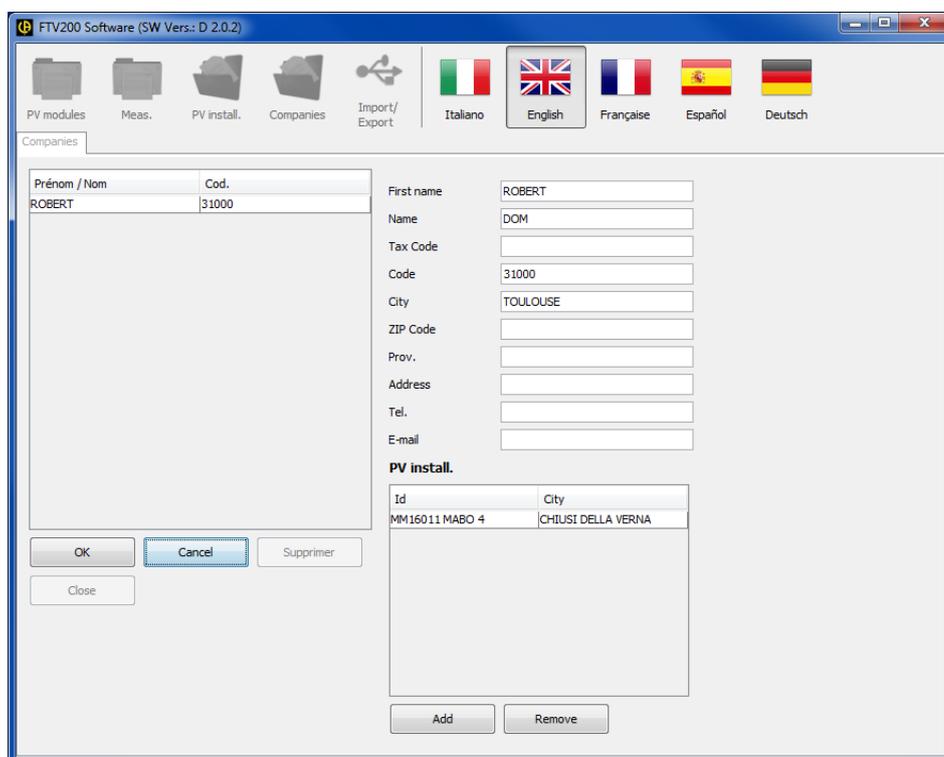


Modify: this command is used to edit the record of the selected company.

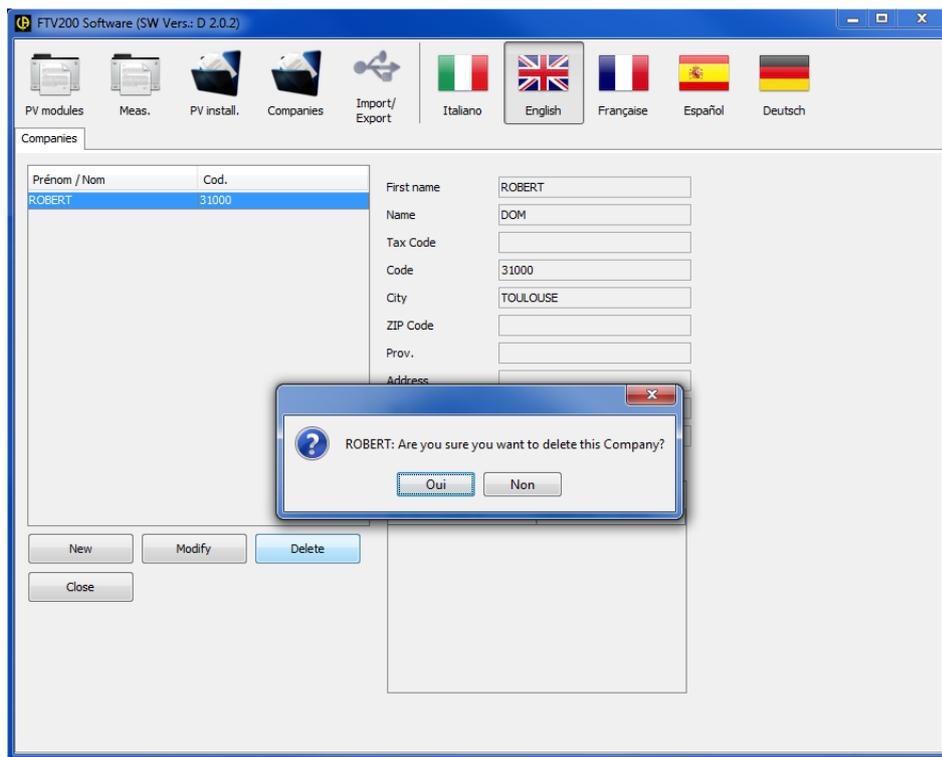
Clicking on the command makes the record fields available for the desired changes to be made.

Mouse-click in the field to be edited and type the changes.

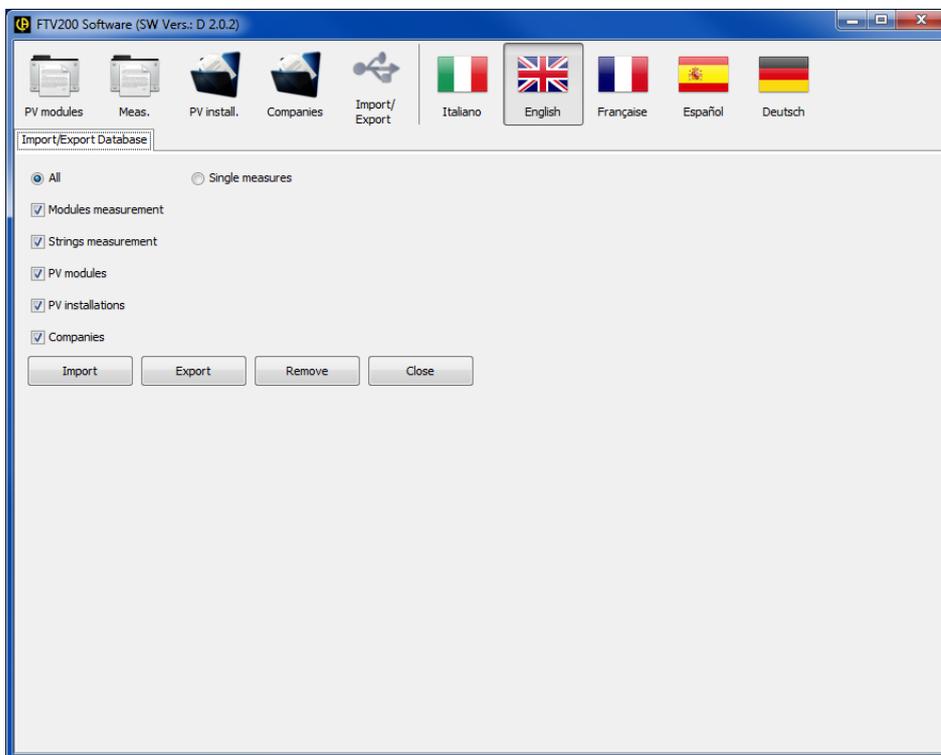
When finished, press the OK button to save the changes, or Cancel to exit from the edit function without saving.



Delete: use this command after selecting a specific company in the list, in order to delete it from the database. When the button is pressed, a dialog box opens and prompts you to confirm or cancel the operation. Select YES to delete the installation or NO to cancel the operation.



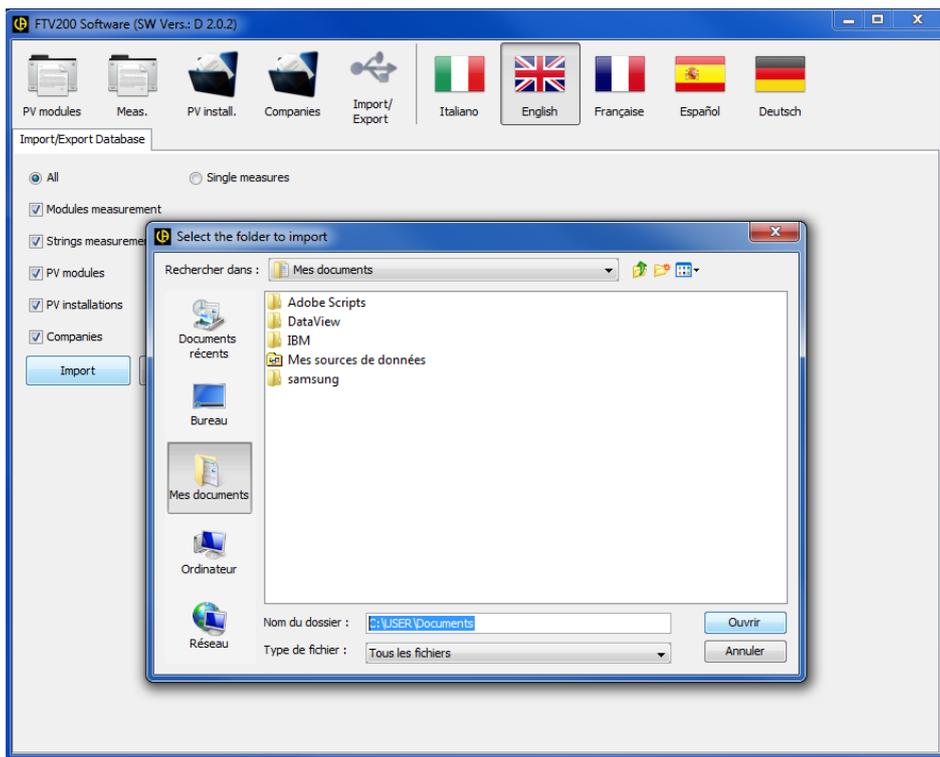
Import/Export: this function is used to manage the transfer of the entire database, or part of it, from the PC to a pen drive or vice versa. This procedure can be used to transfer the new settings of the various tabs from the PC to the instrument. The same procedure is used to transfer the measurement archives from the instrument to the PC. When the function button is pressed, the window shown below opens.



The tab shows 5 database sections: Module measurements, String measurements, Modules, Installations, Companies. Next to each section is a check box which lets you choose the part of the database you want to manage; a check indicates that the corresponding item has been activated.

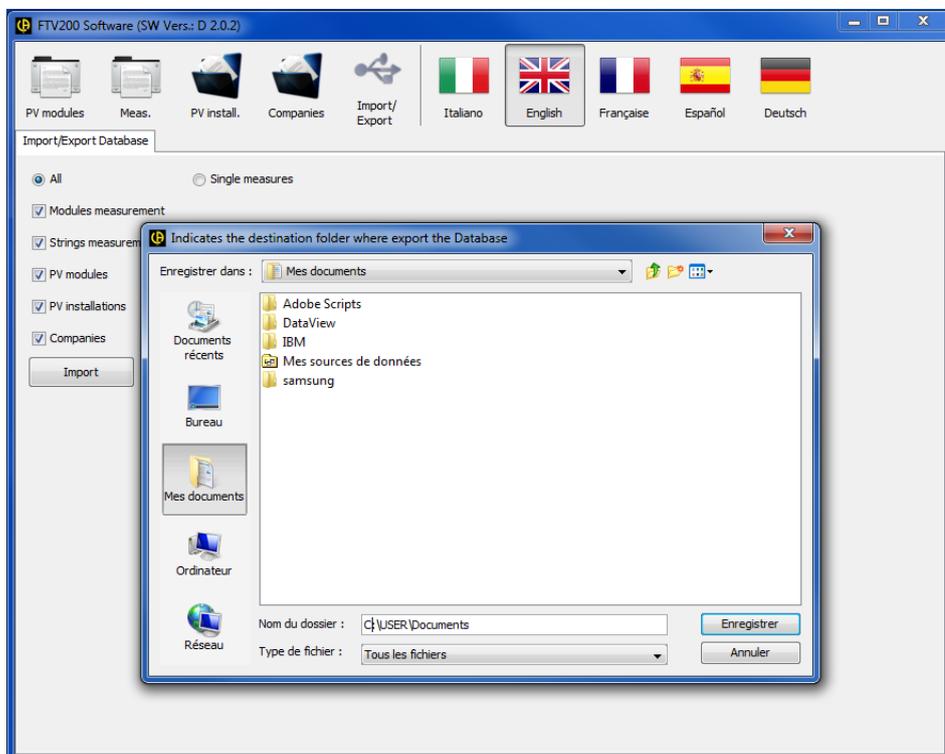
The database management commands are:

Import: this command opens a dialog box in which you can select the path of the folder to be imported. See the example in the figure below.



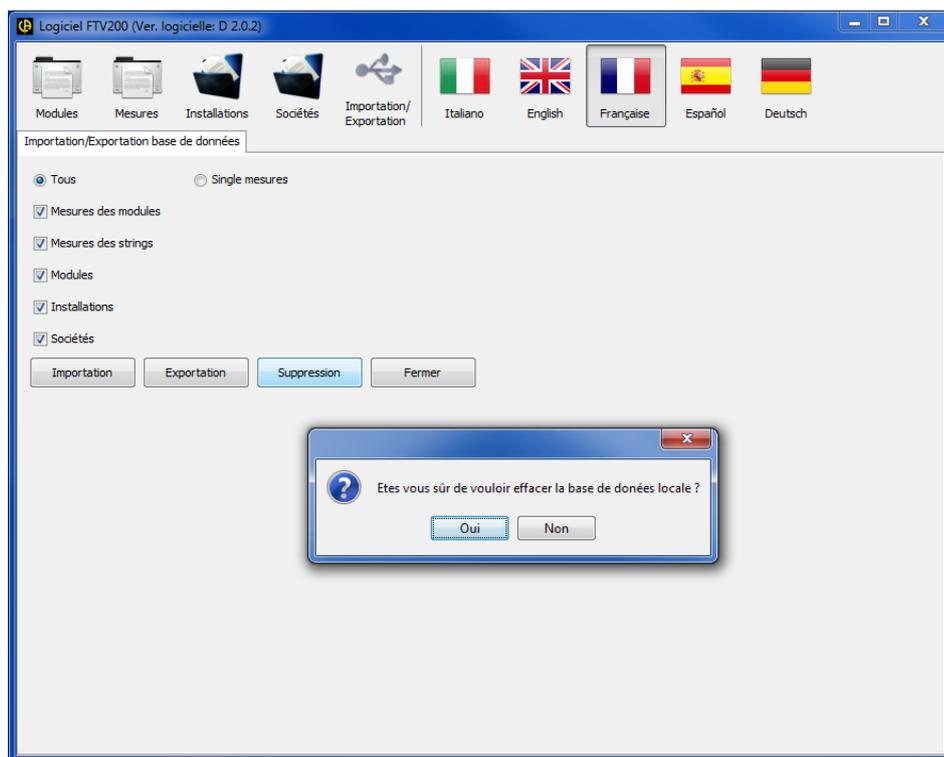
When you have selected the folder to be imported, click on Open. To finish the procedure, follow the instructions provided on screen.

Export: selecting this command opens a dialog box in which you can select the path of the folder to be exported. See the example in the figure below.



Select the destination and click on Save. To finish the procedure, follow the instructions provided on screen.

Remove: this command lets you delete selected items in the database.
Clicking on the command opens a Confirm cancellation window.
Click on YES to confirm or NO to cancel.



13. Maintenance

 The instrument contains no parts that can be replaced by personnel who have not been specially trained and accredited. Any unauthorized repair or replacement of a part by an "equivalent" may gravely impair safety.

13.1. Cleaning

Disconnect the unit completely and turn the instrument OFF.

Use a soft cloth, dampened with soapy water. Rinse with a damp cloth and dry rapidly with a dry cloth or forced air. Do not use alcohol, solvents, or hydrocarbons.

13.2. Metrological check

 Like all measuring or testing devices, the instrument must be checked regularly.

This instrument should be checked at least once a year. For checking and calibration, contact one of our accredited metrology laboratories (information and contact details available on request), at our Chauvin Arnoux subsidiary or the branch in your country.

13.3. Repair

For all repairs before or after expiry of warranty, please return the device to your distributor.

14. WARRANTY

Except as otherwise stated, our warranty is valid for **twelve months** starting from the date on which the equipment was sold. Extract from our General Conditions of Sale provided on request.

The warranty does not apply in the following cases:

- Inappropriate use of the equipment or use with incompatible equipment;
- Modifications made to the equipment without the explicit permission of the manufacturer's technical staff;
- Work done on the device by a person not approved by the manufacturer;
- Adaptation to a particular application not anticipated in the definition of the equipment or not indicated in the user's manual;
- Damage caused by shocks, falls, or floods.

15. TO ORDER

FTV 200 I-V TRACER..... P01160740

The instrument is supplied in a hard carrying case:

- 3m cable set (R/N) with MC4 compatible connectors
- 1 magnetic touch-screen stylus
- 1 set of 2 flexible test probes (1R/1N), to be used only with the cables supplied
- 1 pyranometer for solar radiation + 5m connection cable
- 1 Pt100 ambient temperature probe, 3m
- 1 Li-Ion battery + mains power unit
- Data transfer software and user manual in USB key
- Certificate of conformity
- Carrying case for accessories
- Instruction manual in Italian

FTV 200 I-V TRACE P01160745

The instrument is supplied in a hard carrying case:

- 3m cable set (R/N) with MC4 compatible connectors
- 1 magnetic touch-screen stylus
- 1 set of 2 test probes (1R/1N) Flex, to be used only with the cables supplied
- 1 Li-Ion battery + mains power unit
- Data transfer software and user manual in USB key
- Certificate of conformity
- Carrying case for accessories
- Instruction manual in Italian

15.1. Optional accessories

FTV100 remote unit + 2 male/male RS232 connectors.....	P01160736
Bluetooth communication kit (transmitter/receiver – already programmed).....	P01160739
1 Pt100 probe for panel temperature.....	P01160732

15.2. Spare parts

1 pyranometer for solar radiation + connection cable.....	P01160730
1 Pt100 probe for ambient temperature.....	P01160731
1 Pt100 probe for panel temperature.....	P01160732
Li-Ion battery, 14.8V 4.5Ah.....	P01160735
Magnetic stylus.....	X02934A00
Carrying case for accessories.....	P01298066

16. LIST OF POP-UP DISPLAY MESSAGES

The screenshot shows a software interface for 'Panel IV' with a graph of current (I) on the y-axis (0 to 10) and voltage (V) on the x-axis (0 to 50). A pop-up window titled 'Power Device' is displayed in the center, containing a yellow warning icon and the text 'Excessive current value.' Below the text is an 'OK' button. The interface includes a menu bar with 'Start', 'Comparison', 'Measured', 'Save', and 'Exit', and a timestamp '23/07/12 17:07'.

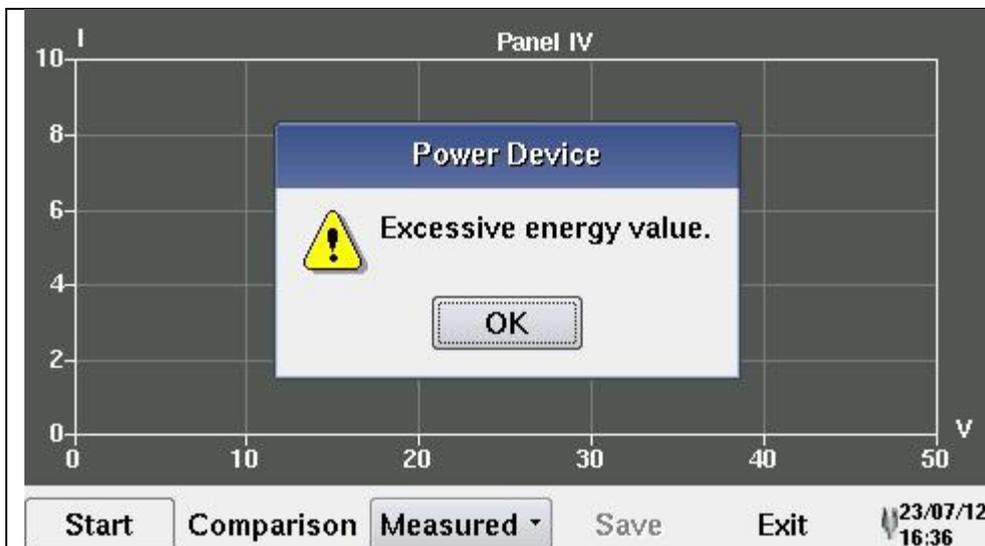
The measured current value exceeds the maximum range value supported by the instrument.

The screenshot shows a software interface for 'Panel IV' with a graph of current (I) on the y-axis (0 to 10) and voltage (V) on the x-axis (0 to 50). A pop-up window titled 'Power Device' is displayed in the center, containing a yellow warning icon and the text 'Current too low.' Below the text is an 'OK' button. The interface includes a menu bar with 'Start', 'Comparison', 'Measured', 'Save', and 'Exit', and a timestamp '23/07/12 17:08'.

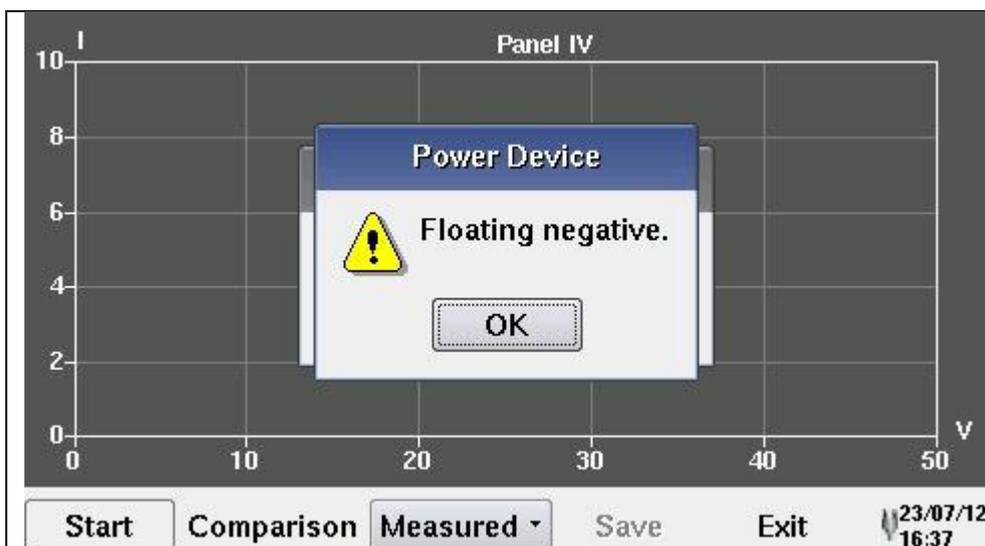
The measured current value is too low. The instrument can't detect the current value. Check if the cables are correctly connected.

The screenshot shows a software interface for 'Panel IV' with a graph of current (I) on the y-axis (0 to 10) and voltage (V) on the x-axis (0 to 50). A pop-up window titled 'Highly variable solar radiation' is displayed in the center, containing a yellow warning icon and the text 'STC values are not available. Repeat.' Below the text is an 'OK' button. The interface includes a menu bar with 'Start', 'Comparison', 'Measured', 'Save', and 'Exit', and a timestamp '23/07/12 16:35'. There are also labels 'FS' and 'OPC' on the graph.

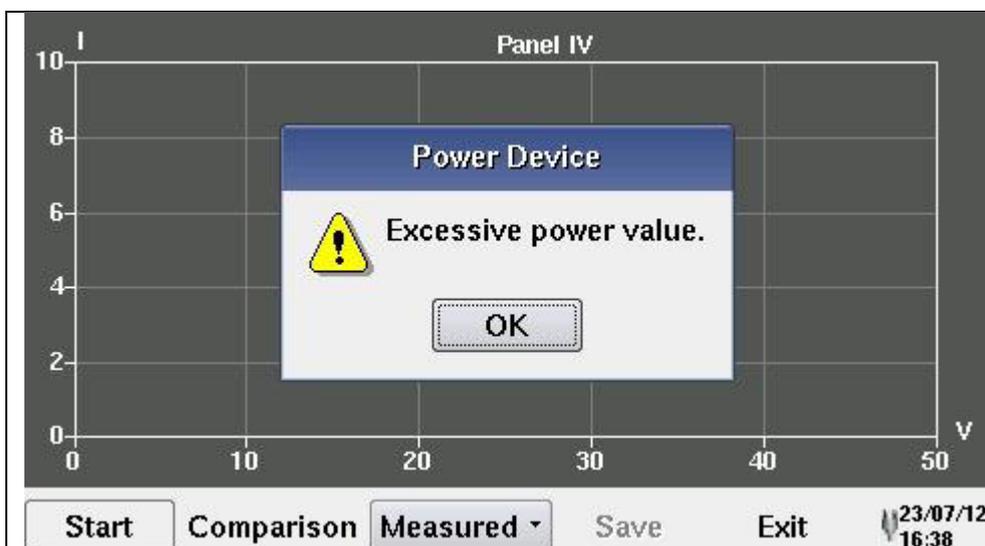
The solar radiation value is not steady during the measure.



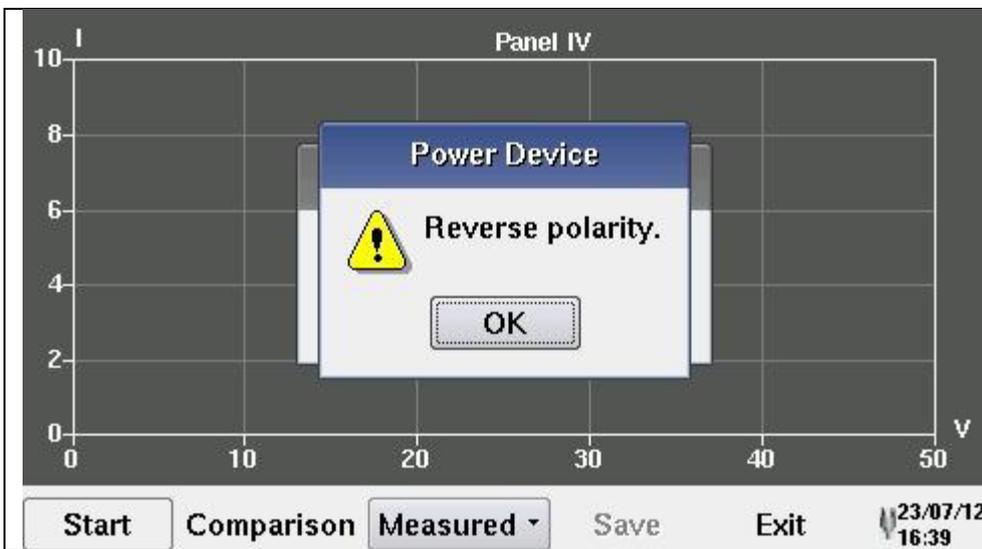
The measured energy value exceeds the maximum range value supported by the instrument.



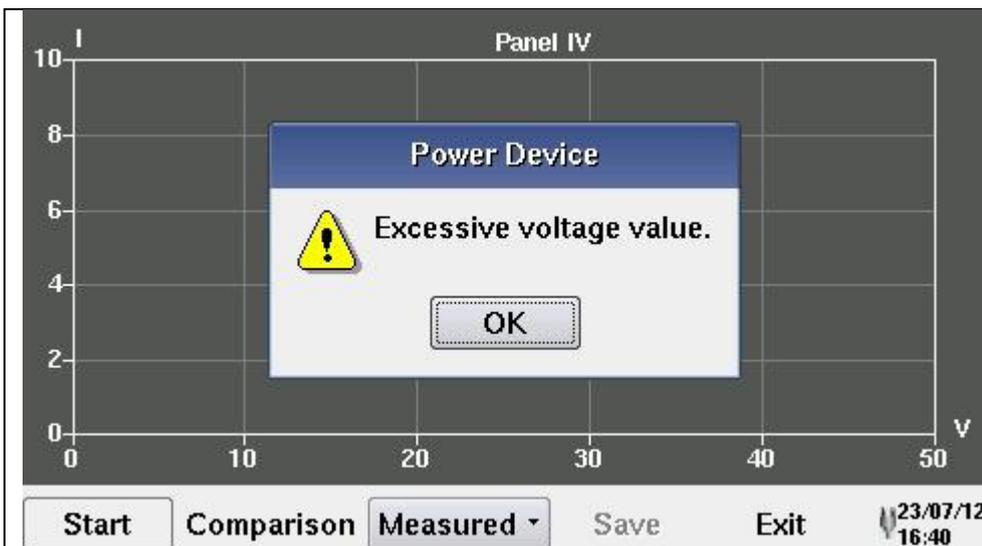
One or more cables are not connected. Check the electrical connections.



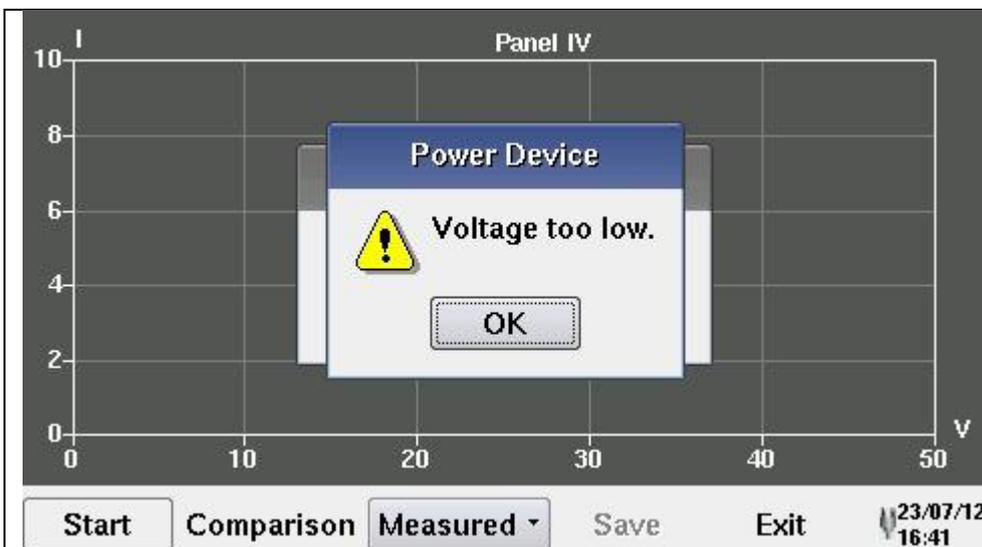
The measured power value exceeds the maximum range value supported by the instrument.



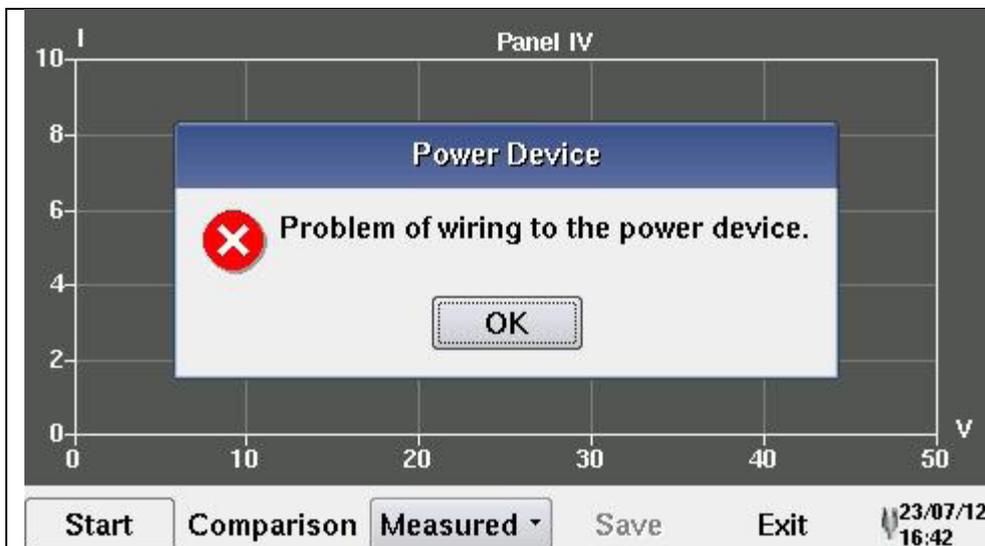
Wrong electrical connections.



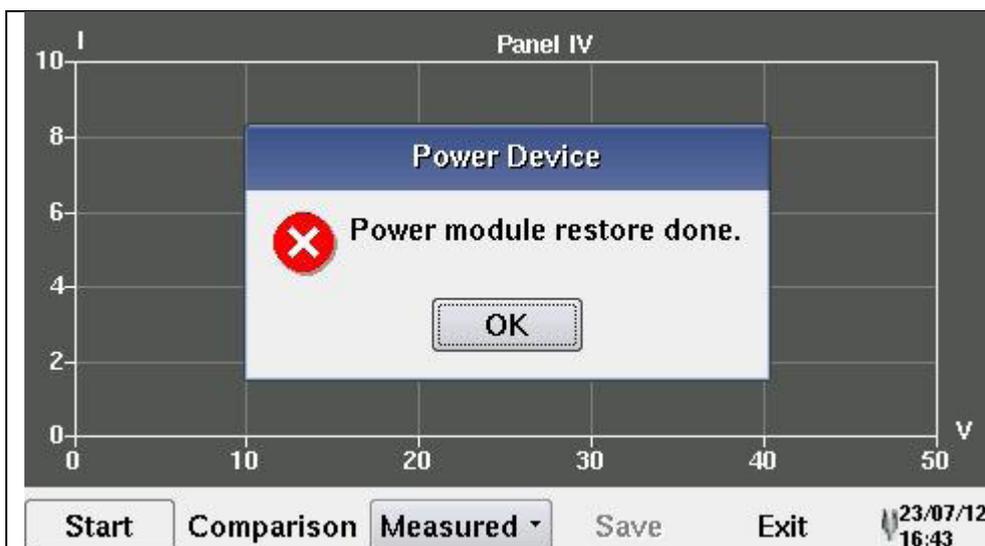
The measured voltage value exceeds the maximum range value supported by the instrument.



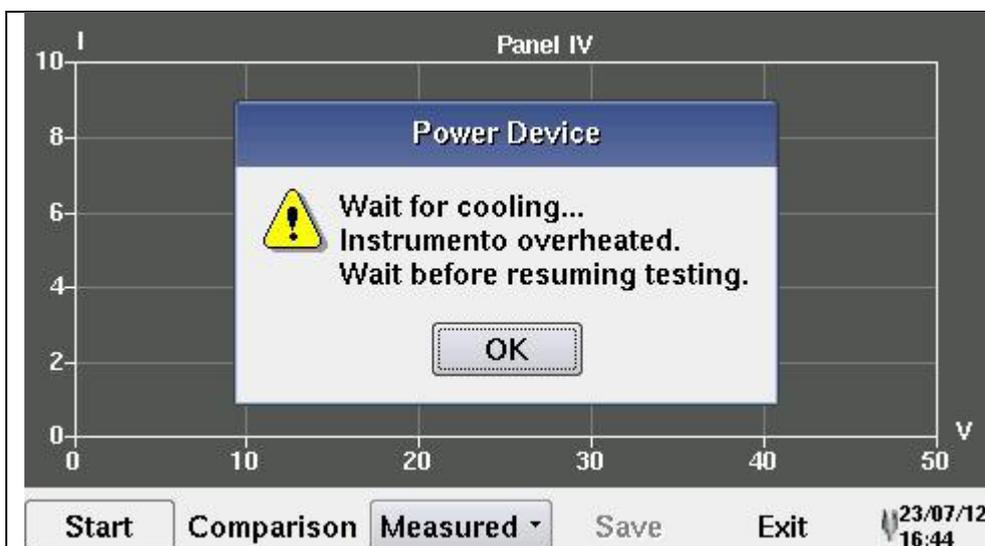
The measured voltage value is too low.
The instrument can't detect the voltage value.
Check if the cables are correctly connected.



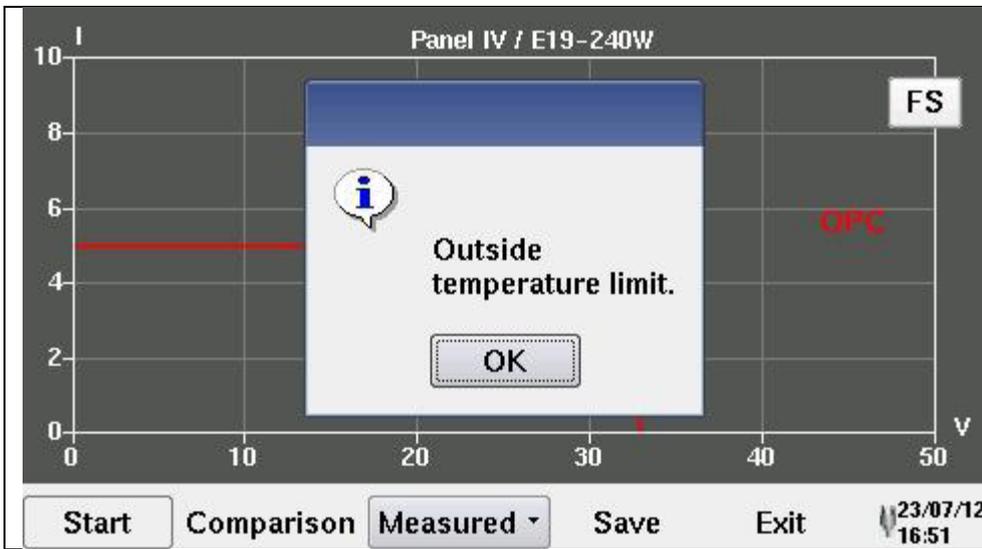
Communication error during the measure.
Possible causes: internal instrument failure or wrong instrument update procedure.
Turn off and then turn on instrument.
If the problem persists please contact our after sales service.



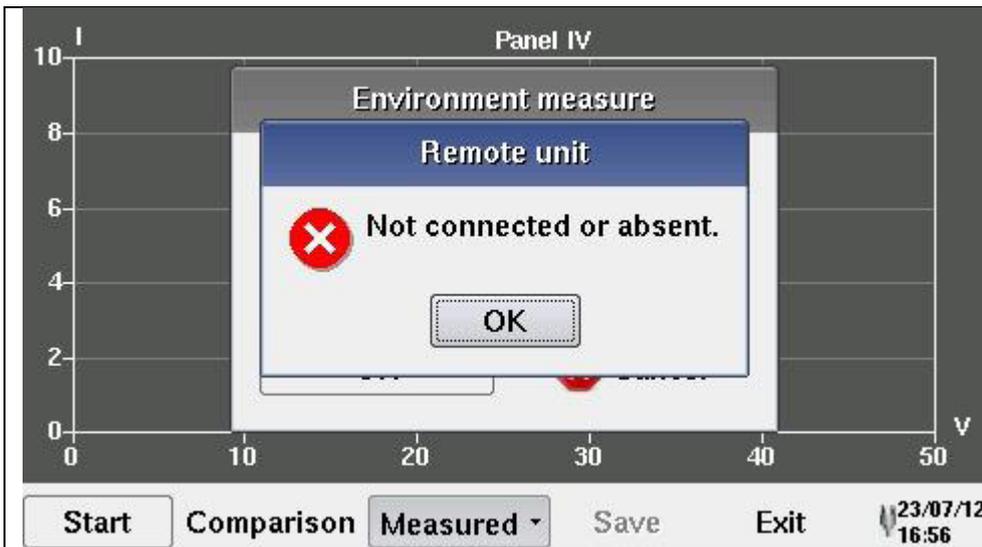
Communication error during the measure.
The instrument tried to reset the internal part of the instrument unsuccessfully.
Turn off and then turn on the instrument.
If the problem persists please contact our after sales service.



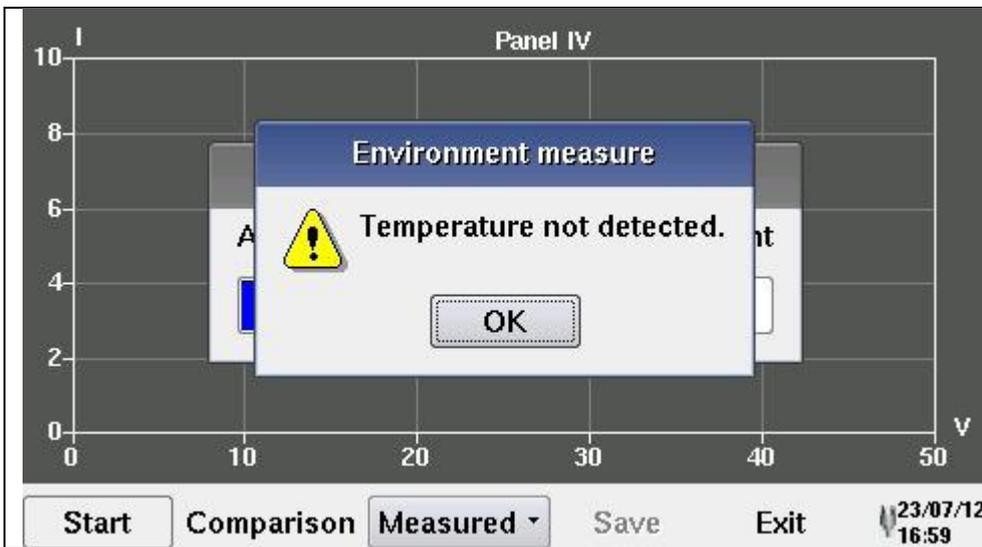
The instrument's internal temperature is too high. Wait for the cooling before perform other tests.



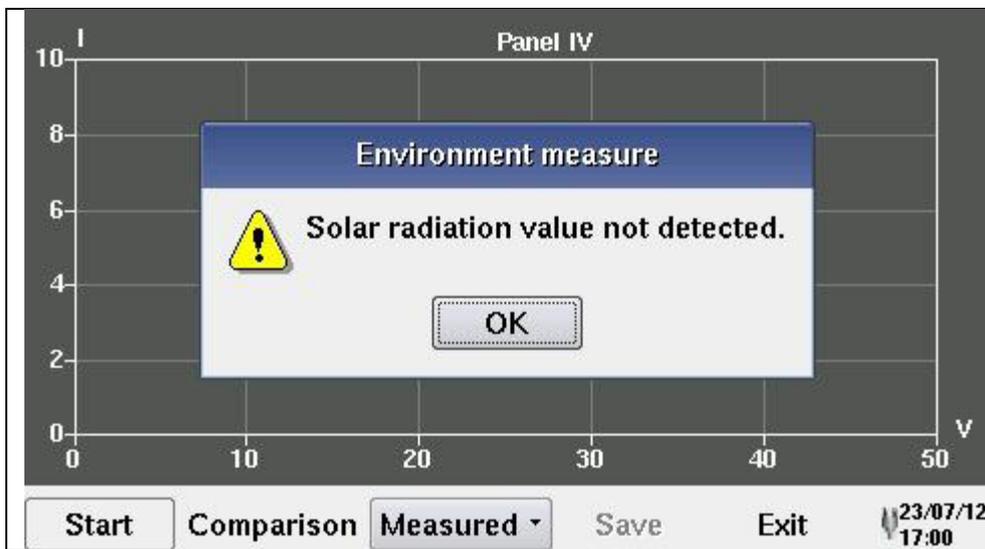
The calculation of the equivalent ETC photovoltaic cell temperature compliant the standard CEI EN 60904-5 is over limit.



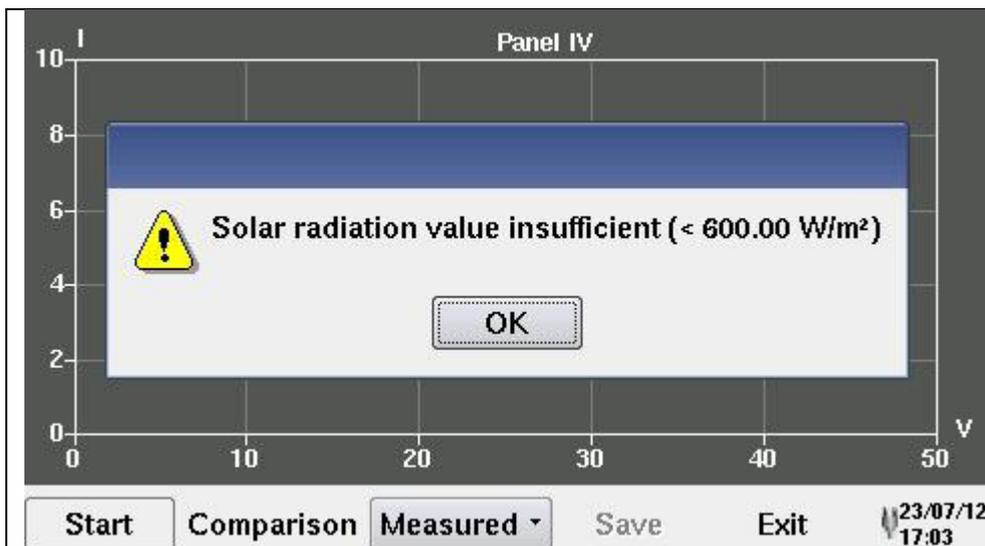
The remote unit not connected or turned off.



The instrument is not able to detect the temperature of the probe. Check the insertion of the temperature probe.



The instrument is not able to detect the solar radiation. Check the insertion of the pyranometer or any shade of the same.



The detected solar radiation value is less than the minimum set in the "system" menu.



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