



# **SOLAR-4000**

## **Solar-Analyser**

**Peak performance and  
I-V characteristic curve  
analyzer for PV systems**

**instruction manual**









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# 1. Safety information

Measurements of the electrical safety on electrical systems or photovoltaic systems should only be carried out by properly trained and competent electricians!

Carefully read the safety information before using the Solar-Analyzer SOLAR-4000.

References marked on the instrument or in this instruction manual:

	Warning of a potential danger, comply with instruction manual.
	Reference, please pay utmost attention.
	Continuous double or reinforced insulation (protection class II)
	Caution, dangerous voltage. Danger of electrical shock.
	Symbol for marking of electrical and electronic equipment (WEEE Directive).
	Conformity symbol, the instrument complies with the valid directives. It complies with the EMC Directive and the Low Voltage Directive.

## **WARNING**

The instruction manual contains information and references necessary for safe operation and maintenance of the instrument. Prior to using the instrument (commissioning / assembly) the user is kindly requested to thoroughly read the instruction manual and comply with it in all sections. Failure to read the instruction manual or to comply with the warnings and references contained herein can result in serious bodily injury or instrument damage.

The Solar-Analyzer SOLAR-4000 may used only for measurements on photovoltaic systems. The instrument is designed for limited maximum currents and voltages. Please refer to technical data on page 33-34.

Solar modules exposed to sunlight produce voltage and current. The connectors and other live parts may pose a risk of high voltage even under cloudy conditions and diffuse irradiation! When working on photovoltaic systems, it is mandatory that the following safety measures are observed! Power or voltage sources other than solar modules may irreparably damage the instrument.

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All the technical data and mentioned standards in this manual are up-to-date at the time of going to print and have been determined to the best of our knowledge, nevertheless this data may be subject to errors and printing errors. Therefore no legal responsibility or any other liability can be accepted for incorrect information or the consequences of this information. The respective regulations, provisions and standards are the authorities defining the procedures to be followed when conducting tests.

## 2. Introduction

You have purchased a high-quality measurement instrument manufactured by AMPROBE, which will enable you to perform repeatable measurements for a very long period of time. The product was calibrated during production process by defined standard test procedures.

### Model and type designation

The type sticker is located on the rear of the instrument. Below the rubber holster there is the serial No. sticker. When questions arise regarding the instrument, please always quote product designation and serial number.

## Product description

### Portable measurement instrument (SOLAR-4000 ANALYZER)

The new SOLAR-4000 is capable of determining current characteristic values not just from individual PV modules, but also from module strings. The I-V characteristic curve, the short circuit current, open circuit voltage, power, irradiance, temperature and inclination angle are recorded by a 16-bit processor. For each measurement the SOLAR-4000 determines the optimal range and sampling rate. The instrument is simple and intuitive to operate via a menu-driven colour touch screen. The characteristic curve measured by the SOLAR-4000 will be extrapolated to standard test conditions (STC\*) by using the measured values of the sensor and then displayed. In addition, the manufacturer's STC ideal characteristic curve can be displayed as well using the integrated module database.

#### \* *STC - Standard Test Conditions:*

Irradiation = 1000 W/m<sup>2</sup>, spectrum/air mass AM = 1.5, module temperature +25 °C

### Wireless sensor (SOLAR-4000 SENSOR)

The wireless sensor measures the cell temperature without direct contact, as well as the inclination angle and the irradiation in the solar module level. The measurement values are transmitted directly to the main instrument by radio signal. To measure the irradiation, the instrument switches the reference cell automatically from a mono crystalline to a polycrystalline cell.

### Evaluation software

The module data measured can be evaluated, managed and stored on a PC using the software. The performance data is computed and can be compared with STC values. In just a few steps, the measurement data is stored by using a wizard in the respective customer folder or plant folder as part of a tree-type file structure. Further measurements from the same plant can be added with date stamp at will and compared with the software.

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## The SOLAR-4000 is characterised by the following features:

- Quick and precise measurement - approx. 15...30 s
- Simple identification of errors and defects affecting PV plants and modules
- Very light and easy-to-handle measurement instrument
- Wireless communication between ANALYZER and SENSOR
- Contactless temperature measurement
- Measurement of mono crystalline and polycrystalline cells (measurement of thin-layer modules on request, without STC computation)
- Easy menu guidance via colour touch screen
- Large measurement range: 1.0...1000 V and 0.1...15.0 A
- Reporting: plant and maintenance certificates
- Performance comparison for a plant over several years
- Built-in battery allows measurement over several hours
- Measurement instrument and software includes over 5000 module data items
- Regularly available module data updates free of charge
- Quick and easy sensor assembly using quick fix mounting (in scope of supply) directly to solar module
- Evaluation software included in scope of supply





### **Scope of Supply**

1 pc. SOLAR-4000 ANALYZER

1 pc. SOLAR-4000 SENSOR

1 pc. Hard case with foam inlay,

6 pc. PV test lead sets (MC3, MC4, Huber+Suhner, Tyco, SunClix as well as without PV connectors)

1 pc. Sensor (quick-fix) mounting

1 pc. SD card (PC software with manual)

1 pc. USB SD/SDHC card reader

2 pc. charging devices

2 pc. user manuals

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**The PC software can be found on the supplied SD card. The file is located in the directory SOL-4000/Update and can be installed in the computer from there.**

### **System requirements:**

The following are minimum requirements for optimal use of the PC software:

- Microsoft® Windows XP/ Vista/7
- Pentium processor with at least 600 MHz or equivalent
- at least 256 MB of RAM or higher
- VGA graphics card with at least 16 bit colour setting (High colour) and a resolution of 1024 x 768 pixels
- at least 500 MB of free hard disc space
- keyboard; mouse
- USB interface

### **Note:**

- Windows is a registered trademark of the Microsoft Corporation.
- Pentium is a registered trademark of the International Business Machines Inc.

### **Transport and storage**

Please keep the original packaging for potential later transport, e.g. for calibration. Any transport damage due to faulty packaging will be excluded from warranty claims. Instruments must be stored in dry and closed areas. In case of an instrument being transported in extreme temperatures, a recovery time of minimum 2 hours is required prior to instrument operation.

## **3. Safety measures**

The instrument has been built and tested in compliance with the valid safety regulations and left the factory in safe and perfect condition. In order to maintain this condition and to ensure safe instrument operation, the user must pay attention to the references and warnings contained within this instruction manual.



The respective accident prevention regulations established by the national health & safety board for electrical systems and equipment must be strictly met at all times



- In order to avoid electrical shock, the valid safety and national regulations regarding excessive contact voltages must receive utmost attention when working with voltages exceeding 120 V DC or 50 V RMS AC.
- Measurements in dangerous proximity of electrical installations are only to be executed when instructed by a responsible electrical specialist, and never alone.
- Prior to any operation, ensure that the instrument, test leads used and accessories are in perfect condition.



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- The instrument must not be used if one or more function fail or the instrument does not show functionality.
  - The test leads and the measurement accessories may only be touched at the handle section provided.
  - Direct contact of measurement connectors or test probes must be avoided at any time.
  - Do not disconnect the test leads during measurements! The resulting electric arcs may cause serious injury and irreparably damage of the plug connectors and the measuring instrument.
  - If the operator's safety is no longer guaranteed, the instrument is to be put out of service and protected against use. The safety can no longer be guaranteed if the instrument (or test leads):
    - shows obvious damage
    - does not carry out the desired measurements
    - has been stored for too long under unfavourable conditions
    - has been subjected to mechanical stress during transport.
  - The instrument may only be used within the operating ranges as specified in the technical data.
  - Avoid any heating up of the instrument by direct sunlight to ensure perfect functioning and long instrument life.
  - Do not open the instrument housing, as dangerous voltage is present
  - The instrument does not include any service parts for the user
  - Do not use the instrument for measurements near combustible gases and dust or other flammable materials.  
Risk of explosion!
  - Before taking a measurement, disconnect all loads (e.g. inverters, etc.) from the photovoltaic system.
  - For measurements of strings switched in parallel and modules switched in series, the maximum measuring range of the instrument must be observed.
  - When using the instrument on a roof make sure to comply with all safety regulations relating to roof work as well as with the requirements for working on electrical equipment!

## 4. Appropriate usage

- The instrument may only be used under those conditions and for those purposes for which it was built. For this reason, in particular the safety references, the technical data including environmental conditions and the usage in dry environments must be followed.
- When modifying or changing the instrument, the operational safety is no longer guaranteed.
- Any maintenance and calibration tasks may only be carried out by authorized repair or service staff.
- If the instrument is subjected to an extremely high electro-magnetic field, its functioning ability may be impaired.
- To ensure a safe measurement only use original test leads and accessories. Please especially observe the measurement category.

## 5. Operation Elements and connectors

Explanation of the connectors, operating elements and display



### ANALYZER

1. Touch screen to operate the SOLAR-4000 ANALYZER
2. On/Off button to switch on/off the SOLAR-4000 ANALYZERS
3. Test lead connector (+ positive)
4. Test lead connector (-, negative)
5. Memory card slot for SD card
6. Socket for charging device

### SENSOR

7. Button „°C“ to measure the temperature
8. LC-Display to display the measured values of the sensor
9. Reference cell (poly crystalline)
10. Reference cell (mono crystalline)
11. On/Off button to switch on/off the SOLAR-4000 SENSORS
12. Sensor for contactless temperature measurement
13. Socket for charging device

## 6. First Steps

### Changing the language setting of SOLAR-4000



Press the On/Off button (2) to switch on the SOLAR-4000



Touch the button „Settings“



Touch the button „Display“



By (multiple) touching of the selection field „Language“ the preferred language can be selected.



Return to the main menu by pressing the button „Settings“ (cog wheel) and the button „Back“ (Home).

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## 7. Measurement and analysis requirements on PV systems

The weather conditions must remain constant throughout the measuring process. Significant changes in the weather will produce unreliable results of the characteristic curve measurement. The standard EN 61829 (on-site measurement of I/U characteristics) specifies a minimum irradiation of 700 W/m<sup>2</sup> for reliable results. The higher the irradiation, the more accurate the characteristic curve measurement.

The module temperature is measured at various points rather than in a fixed place for a whole solar system. Where there are several rows of solar modules, the temperature between the upper and lower rows varies quite considerably. The environment of the solar modules can have a significant influence on the temperature. Several temperature measurements on the modules of the string to be measured produce the most reliable average.

The SOLAR-4000 SENSOR is placed in the quick-fix mounting and fitted to the module frame. It must face in the same direction and have the same inclination as the solar modules to be measured. Even small deviations can lead to significant errors in measurement and so distort the results. To ensure optimal system analysis, it is advisable to repeat the measurements. The evaluation software allows several measurements for the same string. In order to produce reliable measuring results, it is advisable to expose the SOLAR-4000 SENSOR to the measuring conditions over a longer period.

## 8. Instrument preparation and operation

### Unpacking the instrument

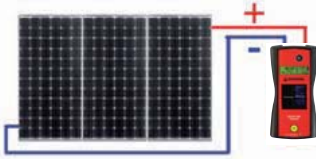
All instruments and components required for measurements are stored in the transport case. It protects them from transport damage and thus ensures the long life of the instrument and components. To perform a measurement, all used instrument must be removed from the transport case. Before each use, the instrument must be visually inspected for any sustained damage. In case of visible damage to the housing or components, such as test leads or connectors, the instrument must not be used due to safety reasons. To transport the instruments after the measurements, it must be returned to the transport case.

### Charging the accumulators

Both the SOLAR-4000 ANALYZER and the SOLAR-4000 SENSOR integrate a powerful lithium polymer accumulator (LiPo). It is recharged using the charging devices provided for uncomplicated working without inconvenient cables. The socket to connect the charging devices is located on the underside of each instrument. The status of the battery is shown on the instrument screen. Further instrument information on the current battery voltage is provided in the menu under "Settings – Info". The charging time of the SOLAR-4000 ANALYZER and the SOLAR-4000 SENSOR can be several hours, depending on charge conditions. The measuring instruments have an internal charge controller with overload and deep discharge protection.

### Inserting the memory card

The data between the solar analyser SOLAR-4000 ANALYZER and the PC software are communicated via the SD memory card. This is included in the scope of supply and needs to be inserted before the SOLAR-4000 ANALYZER is switched on. The memory card slot is found on the underside of the measuring instrument.



## Connecting the SOLAR-4000 ANALYZER

When measurements are taken with the SOLAR-4000 ANALYZER, the solar modules must only be connected to the measuring instrument. Other loads such as inverters, chargers, etc., must be disconnected from the solar modules. Failure to do so may result in irreparable damage to the measuring instrument!

The prescribed order for separating the loads must be observed! Make sure to connect the test leads correctly to the modules. Reverse polarity may damage the instrument. The measuring cables must be fully inserted into the connectors. Excessive contact resistance will falsify the results of the measurement and cause hazardous arcs and burns.



Damaged test leads must be replaced immediately. A repair of the test leads is not permitted.



## Connecting the SOLAR-4000 SENSOR to the solar module

The SOLAR-4000 SENSOR is placed into the quick-fix mounting and fitted to the module frame of an edge module of the photovoltaic system. The mounting is slotted onto the side of the module frame. The two clamps are positioned on the frame by turning the fixing screw and then clamped down by tilting the lever. The quick-fix mounting is now securely fitted to the module and the SOLAR-4000 SENSOR can be placed into the quick-fix mounting.



## Switching on the instruments

The instruments are switched on using the On/Off button. After switched on the display of the ANALYZER shows "AMPROBE...Reading SD card". The SENSOR signals readiness for operation with a short beep.

Before the instruments are switched on, make sure that the battery has been charged. For the ANALYZER it is also important to remember that the SD memory card must first be inserted. The SD card stores the measured data. The customer and module database is also kept on the SD card.



The instruments are switched off again by pressing the On/Off button.

## 9. Taking a measurement



Measuring the module temperature at several points of the module/string.



Fitting SOLAR-4000 SENSOR by the quick-fix mounting the in the same level as the module/string to be measured and measuring the irradiation.



Using the SOLAR-4000 ANALYZER to measure the open-circuit voltage (UOC) and the short-circuit current (ISC) and determine the systems current/voltage characteristic curve.



Again measuring the module temperature of the module/string.



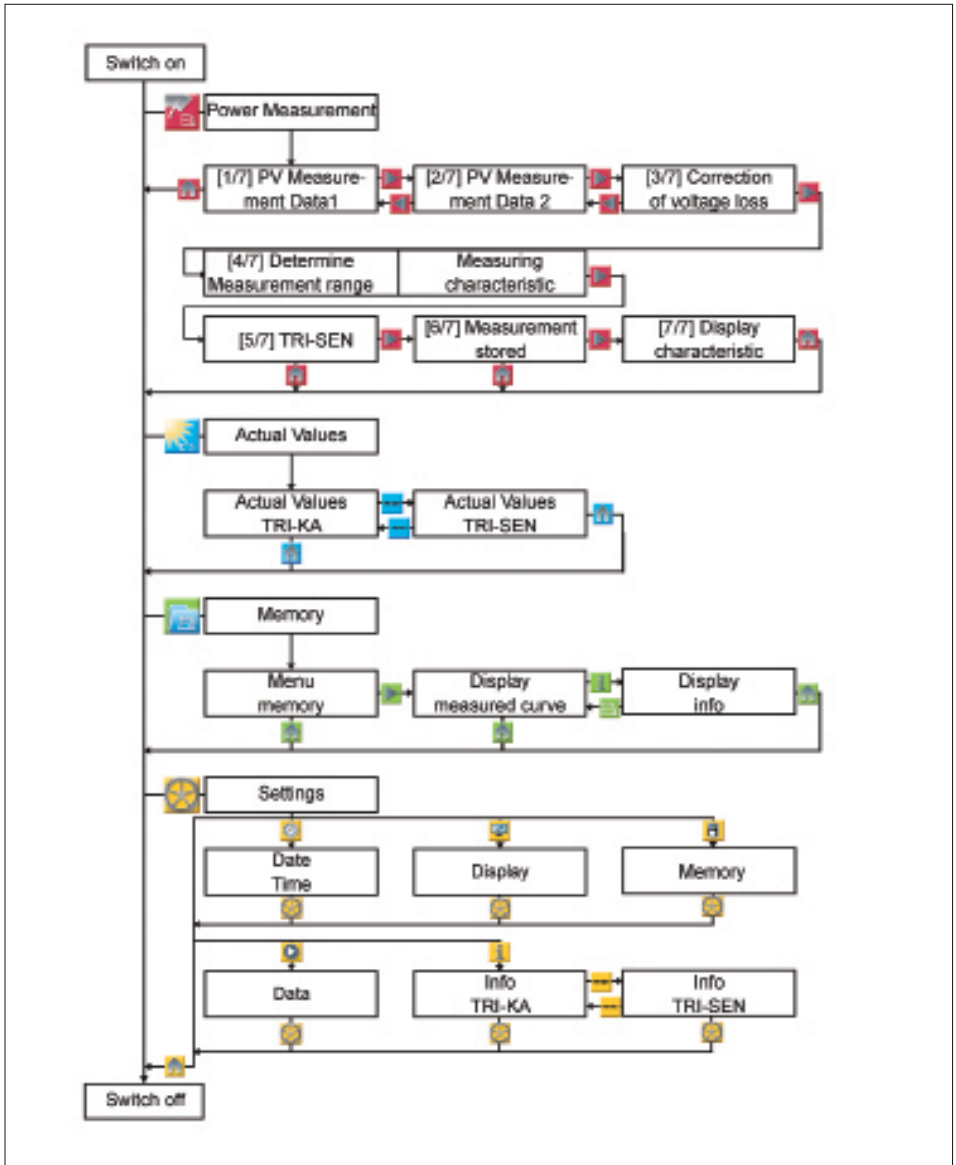
Wireless transfer of the measured data from the SENSOR to the ANALYZER.

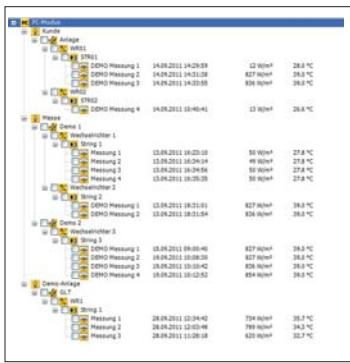


Importing the measured results via SD card from the ANALYZER into the PC and evaluating them using the PC software.

# 10. Programme structure, functions and operating of SOLAR-4000 ANALYZER

The following chart provides an overview of the programme and operating structure of the SOLAR-4000 ANALYZER.

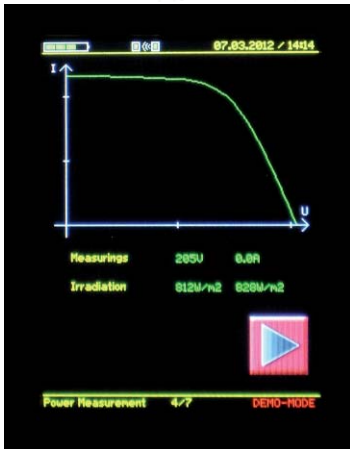




1 2 3 4

## 10.1 Layout of the customer and system structure

The measured data are stored on the SD card and hierarchically managed in the SOLAR-4000 ANALYZER and the PC software. To each hierarchy level can be added any number of further levels. The levels can be given any name. The measured data are saved in the relevant strings. The hierarchy levels can be created in the PC software and then selected in the SOLAR-4000 ANALYZER or directly entered in the SOLAR-4000 ANALYZER.



5 6

## 10.2 Touch screen display

General information about the measuring instrument and the currently open window is shown at the top and bottom of the screen:

### 1. Charging status

shows the remaining accumulator charge

### 2. Wireless connection

shows whether a wireless connection to the SOLAR-4000 SENSOR exists

### 3. Progress indicator

shows instrument activity and progress

### 4. Date/ Time

shows the date and time set for the instrument

### 5. Navigation indicator

shows which SOLAR-4000 ANALYZER window is open. In the Home screen, it shows the instrument's serial number.

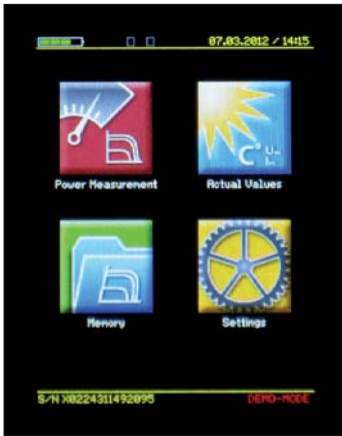
### 6. Firmware version

shown in the Home screen



### 10.3 Functions, power measurement

Press the button "Power Measurement" to start measuring the current /voltage characteristic curve. The process progress is shown in the bottom part of the screen. The two arrow keys allow navigation to the previous and the next step. The button "Home" takes you back to the main menu.



### 10.4 PV data 1

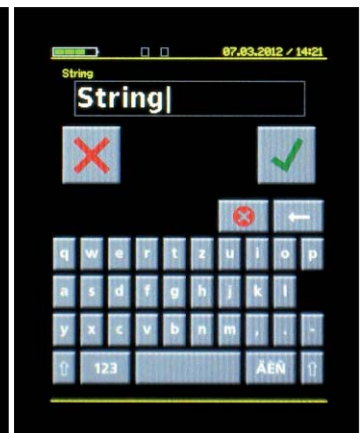
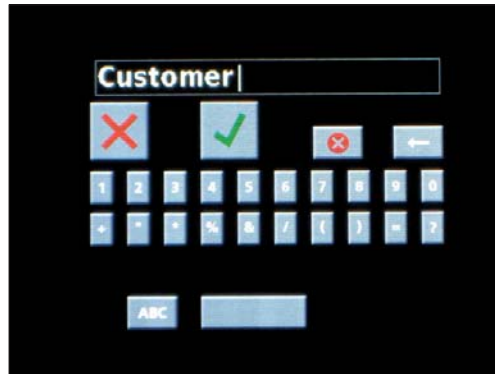
Selection or entry of customer and system data on the photovoltaic system to be measured. You can immediately start the characteristic curve measurement using the button in the middle. The default data will be used for the characteristic curve measurement.

Selecting a text field opens a window in which existing data or details previously created using the PC software and stored on the memory card can be selected.



To enter new data, press the button "+" next to the text field. Turn SOLAR-4000 ANALYZER by 90° to enter the data comfortably.

Depending on the entry field, a window opens with the appropriate entry options for customer, system, inverter and string. To change from full keyboard mode to numerical keypad, click on the numeric symbol "123". To enter special characters click on the symbol "ÄË". The entry is confirmed by clicking on the tick symbol. The instrument automatically returns to the previous menu function.



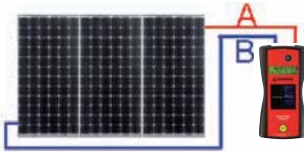


## 10.5 PV data 2

Selection or entry of module data of the photovoltaic system to be measured. If a module cannot be found in the module database, the characteristic curve can be measured using the dummy module ? [STANDARD]? . The missing module can later be added to the module database. Modules added later are saved under [Custom] in the PC software.

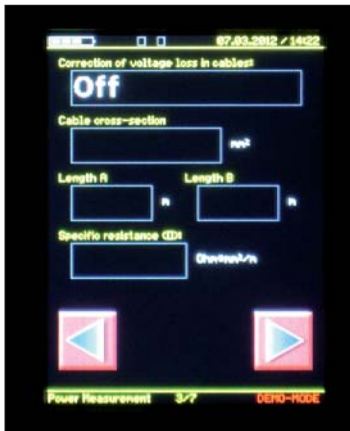
- **Manufacturer/Type:** Selection of the PV module to be measured from the module database.
- **Number of modules serial:** Number of PV modules connected in series of the system to be measured.
- **Number of strings parallel:** Number of strings connected in parallel of the system to be measured.

To move to the next window after the customer and system data have been entered, click on the right arrow at the bottom of the screen.



## 10.6 Correction of voltage loss in cables

Correction of the measuring result with the voltage drop in the PV cable between the modules and the measuring instrument. The correction is activated and deactivated in the first line. The data to calculate the cable voltage drop are entered in the following fields.



### Cable cross-section:

Cross-section of the PV cableg

### Length A:

Length of the cable between the measuring instrument and the first module of the string

### Length B:

Length of the cable between the measuring instrument and the last module of the string

### Specific resistance:

Specific resistance of the cable used. Exact data are available on the data sheet of the manufacturer.

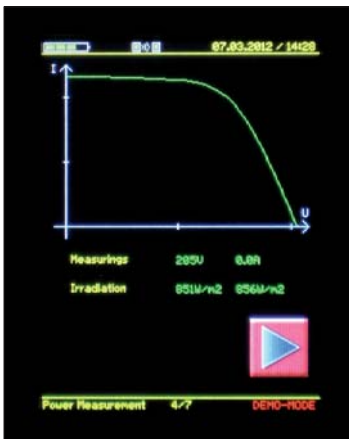
### Standard values

- Copper:  $0.01786 \Omega \cdot \text{mm}^2/\text{m}$
- Aluminium:  $0.02857 \Omega \cdot \text{mm}^2/\text{m}$



## 10.7 Measurement of the current/voltage characteristic curve

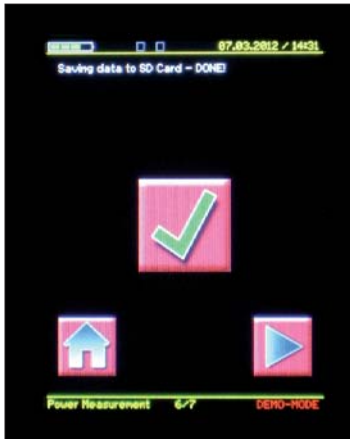
Before the characteristic curve is measured, the measuring range is determined. While the characteristic curve is measured, the current and voltage values currently measured are shown on the screen and the characteristic curve is drawn. The screen also shows the irradiation measured by the SOLAR-4000 SENSOR. The right value is the average irradiation established; this is used for STC extrapolation. If no wireless connection can be established between SOLAR-4000 ANALYZER and SOLAR-4000 SENSOR during measurement of the characteristic curve, the data are temporarily stored in the SOLAR-4000 SENSOR. After the measurement(s), the data stored in the SOLAR-4000 SENSOR must be synchronised with the SOLAR-4000 ANALYZER (refer to chapter 12.4).





### 10.8 SOLAR-4000 SENSOR data

At this point, the module temperature once again can be measured with the SOLAR-4000 SENSOR. If no wireless connection can be established ANALYZER and -4000 SENSOR during measurement of the characteristic curve, the data are temporarily stored in the SENSOR. After the measurement(s), the data stored in the SOLAR-4000 SENSOR must be synchronised with the SOLAR-4000 ANALYZER (refer to chapter 24).



### 10.9 Save measurement

The measured data are saved on the inserted SD card. Once successfully saved, click on the tick symbol or the right arrow to open the next window.



### 10.10 Display of the I-V characteristic curve

The diagram shows the characteristic curve previously measured (green) and extrapolated to STC (red) along with the ideal characteristic curve of the manufacturer (blue). If no module was selected under the module data (window 2 / 7), the ideal characteristic curve of the manufacturer (blue) is not shown. If no SOLAR-4000 SENSOR data could be stored, the measured characteristic curve extrapolated to STC is not shown. Click on the button "Home" to complete the measurement and return to the main menu.

## 11. Measurement of actual values

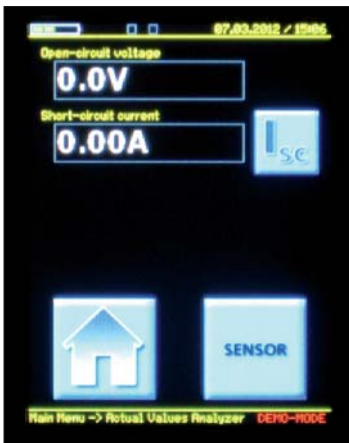
Click the button "Actual Values" to see the actual values of the SOLAR-4000 ANALYZER and SOLAR-4000 SENSOR.



### 11.1 Actual values – SOLAR-4000 ANALYZER

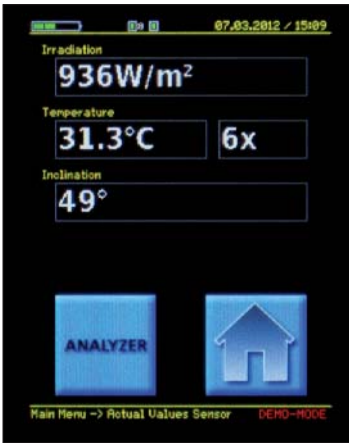
This shows details of the open-circuit voltage and short-circuit current. Click to the button "ISC" on the screen to measure the short-circuit current. Use the button "SENSOR" or "ANALYZER" to change from the actual values of SOLAR-4000 ANALYZER to SOLAR-4000 SENSOR or vice versa.

Click the button "Home" to return to the main menu.



## 11.2 Actual values – SOLAR-4000 SENSOR

Shows the current irradiation, the average module temperature measured along with the number of temperature measurements taken and the angle of inclination of the SOLAR-4000 SENSOR.



## 12. Memory

Measurements stored on the SD card can be accessed using the button "Memory".





## 12.1 Open saved data

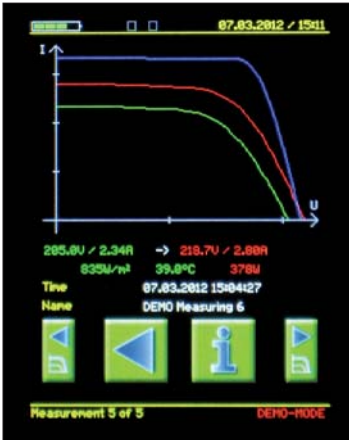
Select the customer, the system, the inverter or the name of the string to retrieve the data stored.



## 12.2 Switch between saved measurements

Use the arrow keys to change between further measurements stored in the selected string. To display the graph as big as possible the SOLAR-4000 can be rotated by 90°. At rotated display by touching the left or right side of the screen (next to the characteristic curve) will also let you browse through the stored measurements in the selected string. Press the button "Info" to see further information on the selected measurement.

Click the button "Home" to return to the main menu.



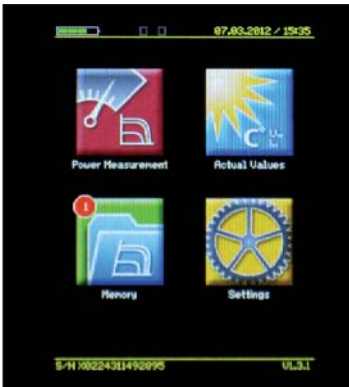
### 12.3 Show more data

The info screen provides further data on the selected measurement. Click the button "Home" to return to the start screen. To see a graphic display of the selected measurement click the button "Graph" in the middle. The button "Delete" deletes the measurement data. This step must be confirmed in the next step.



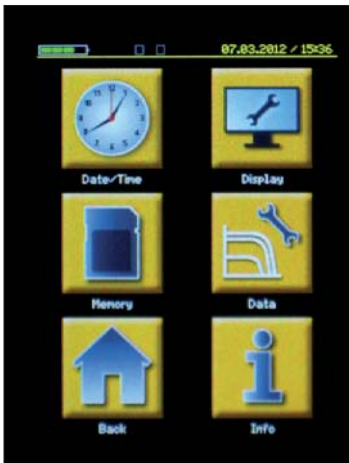
### 12.4 Add missing data

Missing SOLAR-4000 SENSOR data in saved measurements are indicated by the number of missing data shown in a red circle at the top left edge of the button "Memory". Click on the button "SENSOR" to synchronise the SOLAR-4000 SENSOR data with the SOLAR-4000 ANALYZER.



## 13. Settings

The basic settings of the SOLAR-4000 ANALYZER can be changed by menu "Settings".





### 13.1 Settings - Time and date

Click on the button "Date/Time" to set both the time and the date of the instrument. The time and date are changed in the appropriate input fields using the numerical keypad.



### 13.2 Settings - Display

#### Language and display

Display and instrument settings are made by clicking on the button "Display". This is also where the SOLAR-4000 ANALYZER language can be changed.

#### Backlight

The brightness of the display backlight can be set in four steps.

#### Auto power -off function

Automatically switches the instrument off after the set time. Switch-off times range from 1 to 15 minutes. This function is deactivated with the Off button.

#### Automatic screen orientation

With this function the automatic screen rotation can be switched on or off.

#### Display background

Use the right button at the bottom of the screen to change between a black and white background.

Press the button „Settings“ (cog wheel) to return to the Settings menu.



### 13.3 Settings - Memory

#### Show memory space and format SD card

Click on the button "Memory" to view the free memory available on the inserted SD card. The memory card will be formatted by using the button at the low end corner on the display. During formatting all necessary directories are setup and all data on the memory card is deleted. Before execution this must be confirmed again.

**Attention!** Before formatting we recommend to save all data on the SD card. Beside the measurement data also the module data base and the PC software are also stored on the SD card.



### 13.4 Settings - Data

#### Minimum irradiation and irradiation tolerance

The lower limit value for the solar irradiation at power measurement can be set in this submenu. If the actual level of irradiation falls below the set value, the measurement is aborted resulting in an error message.



#### Irradiation tolerance

Maximum permitted variation for irradiation (as a percentage) during measurement of the characteristic curve. If the irradiation exceeds the tolerance value, the measurement is aborted resulting in an error message.

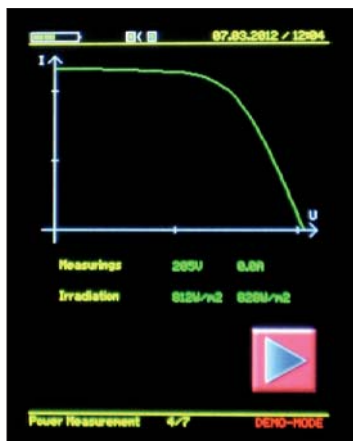


## 13.5 Settings - Info

### Instrument information and firmware update, connection mode ANALYZER-SENSOR "Pairing"

Press the button "Info" to check the serial number, the software version and the accumulator status of the SOLAR-4000 ANALYZER and SOLAR-4000 SENSOR.

If the button "Firmware Update" is highlighted in yellow, a new firmware version for the SOLAR-4000 ANALYZER is available on the SD card. Click the button "Firmware Update" to install the new firmware for the ANALYZER. The firmware for the SENSOR can only be updated by manufacturer's service. Use the buttons "SOLAR-4000 SENSOR / SOLAR-4000 ANALYZER" to change between SOLAR-4000 SENSOR and SOLAR-4000 ANALYZER data.



### Connection mode ANALYZER-SENSOR (Pairing).

If the button SENSOR is pressed to receive data from Sensor, the button "ANALYZER SENSOR" appears close to the field "Firmware".

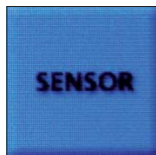
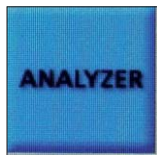
This button is used to connect both SOLAR-4000 ANALYZER and SOLAR-4000 SENSOR, and setup to the same wireless channel. This is only required in case ANALYZER and SENSOR have been changed.

To activate this function switch off SENSOR first and then click on the ANALYZER the button "ANALYZER SENSOR". Now following is displayed: „Sensor Pairing: Turn on Sensor in Pairing-Mode. Searching for Sensor ...“

Now press the two keys „°C“ and “On/Off “ on the SENSOR together for 5 seconds. The display of the SENSOR shows „Pairing“, after approx. 5 seconds the sensor will be detected, and the ANALYZER displays „Paired with sensor switch off/on sensor“.

Now SENSOR and ANALYZER are connected and measurement can be performed.

Press the button "Settings" (cog wheel) to return to the settings menu.



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## 14. Functions and operating of SOLAR-4000 SENSOR

The wireless sensor measures the cell temperature without direct contact, as well as the inclination angle and the irradiation in the solar module level. The measurement values are transmitted directly to the main instrument by radio signal. To measure the irradiation, the instrument switches the reference cell automatically from a mono crystalline to a polycrystalline cell.

### 14.1 Measuring the cell temperature

When switched on, the SOLAR-4000 SENSOR signals its readiness for operation with a short beep. The SOLAR-4000 SENSOR has an infrared temperature sensor at the top end for contactless measurement of the cell temperature.

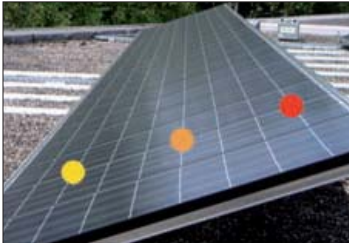
The sensor must be held directly onto a solar cell. Press the button "°C" for temperature measurement at least one second until you hear a beep indicating that the instrument has measured the temperature. The actual measured temperature is shown on the LC-DISPLAY while the button "°C" is pressed. When the temperature button is released, the LC-DISPLAY changes to the average temperature of all the measurements taken. The number of measurements is shown in brackets. It is recommended to measure the temperature at least 3 times before measuring the characteristic curve and at least 3 times after. The average temperature is included when the measured characteristic curves are extrapolated to the STC characteristic curves. The temperature should be measured at various points of the module surface. The average temperature is updated with each new measurement.

It is recommended to measure the lower, middle and upper solar cells because of the temperature difference between the upper and lower solar cells. The average temperature reading is stored until the SOLAR-4000 SENSOR is switched off. To delete the measurement values the SOLAR-4000 SENSOR must be switched off.

Warning: Switching the SOLAR-4000 SENSOR will delete all measured data!

### 14.2 Measuring the irradiation

Once the SOLAR-4000 SENSOR is switched on, the integrated solar cells measure the irradiation. After the temperature measurement, the SOLAR-4000 SENSOR is placed in the quick-fix mounting which is fitted in the same level as the module/string to be measured (refer to chapter 8, page 11). The position of the SOLAR-4000 SENSOR at module level is crucial for the accuracy and reliability of the STC evaluation! The irradiation is measured continuously, stored at intervals in the memory and transferred to the SOLAR-4000 ANALYZER. The actual irradiation is shown in the top left-hand corner of the LC-DISPLAY.



### 14.3 Measuring the angle of inclination

Once switched on, the SOLAR-4000 SENSOR continuously measures the angle of inclination, shown in the top right-hand corner of the screen. For a reliable measuring result, the SOLAR-4000 SENSOR should be placed in the quick-fix mounting fitted to the module frame (refer to chapter 8, page 11).

## 15. Processing measurement data

The data measured by the SOLAR-4000 SENSOR are wirelessly transferred to the SOLAR-4000 ANALYZER. A wireless connection is automatically established once both instruments are switched on. The connection is shown at the top of the screen (picture). If the wireless connection is disrupted, the data are stored in the SOLAR-4000 SENSOR until they are synchronised. This allows measurement even without a wireless connection. The disruption of the data connection is signalled by a message popping up on the SOLAR-4000 ANALYZER screen. The SOLAR-4000 SENSOR should not be switched off before the data have been transferred, as otherwise all values will be lost and the measurement is no longer reliable.

### 15.1 Transfer of SOLAR-4000 ANALYZER measurement values to the PC

Once saved, all measured values are automatically stored on the SD card of the SOLAR-4000 ANALYZER. The data are uploaded using the PC software and inserting the memory card into the computer or the supplied card reader. More details on how to upload the data are provided in the manual for the PC software on the SD card.

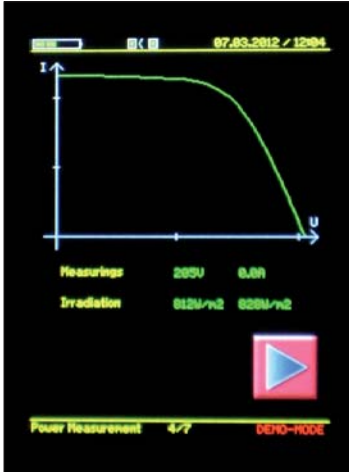
The software is saved on the SD card of the SOLAR-4000 ANALYZER in the directory `...\SOL-4000\UPDATE` "; it can also be downloaded at "[www.amprobe.eu/de\\_DE/content/Patches-Updates/](http://www.amprobe.eu/de_DE/content/Patches-Updates/)".

### 15.2 Evaluation of the measuring results

The current/voltage characteristic curve (I/V characteristic curve) of a photovoltaic system is used to identify and analyse different features and problems of a generator. It helps detect partial shading of the generator field, defective bypass diodes, excessive serial module resistance, soiling of the modules and problems with individual cells in the PV modules. Interpreting characteristic curves requires some experience and basic knowledge of semiconductor technology. To facilitate the interpretation, examples of characteristic curves from the evaluation software are listed on the following page or available under [www.amprobe.eu](http://www.amprobe.eu).

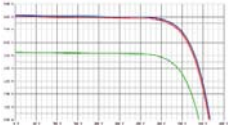
**Explanation for the colours of the diagrams on page 31:**

- GREEN** Measured characteristic curve
- RED** Measured characteristic curve extrapolated to standard test conditions (STC)
- BLUE** manufacturer's STC ideal characteristic curve





## 15.3 Typical I-V characteristic curves and troubleshooting

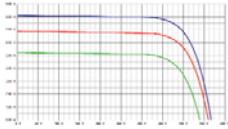


### Good measurement

- The measured characteristic curve (green) and the curve extrapolated to STC (red) are almost congruent with the manufacturer's STC ideal characteristic curve (blue)

### Error/troubleshooting:

- No error

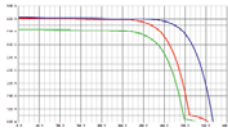


### Short circuit current too low

- Modules are contaminated
- Far distance obstruction (shading)
- Ageing
- Production defects

### Error/troubleshooting:

- Cleaning of modules
- Remove obstruction
- Check lamination, cells and cover material for blindness, humidity etc.
- Contact manufacturer

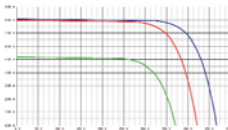


### Incorrect I-V characteristic curve

- One module has low irradiation (small shading, partial shading)
- Irregular contamination
- Individual production defects
- Sample variance at modules

### Error/troubleshooting:

- Search for optical obstruction (antenna, chimney, adjoining building, power line etc.)
- Cleaning of modules
- Check part of the PV string
- Contact manufacturer

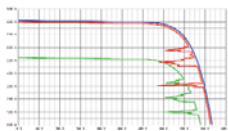


### Open voltage too low

- Incorrect temperature measurement
- Short circuit of individual solar cells
- Wrong entry "numbers of module serial" at configuration of PV system

### Error/troubleshooting:

- Repeat temperature measurement on different test points
- Check part of the PV string
- Check configuration of PV system

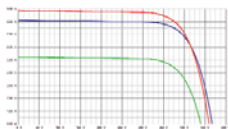


### Incorrect I-V characteristic curve

- A part of the PV string was completely shaded for a short time

### Error/troubleshooting:

- Repeat measurement and ensure that the PV string is not shaded.

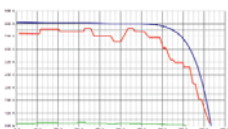


### Short circuit current too high

- Incorrect irradiation measurement
- Wrong module selection at configuration of PV system.

### Error/troubleshooting:

- Place irradiation sensor at module level
- Check irradiation sensor for shading
- Check module selection at configuration of PV system

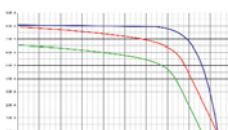


### Characteristic curve not linear

- Irradiation too low during measurement
- Unsettled irradiation during measurement

### Error/troubleshooting:

- Repeat measurement at an irradiation of minimum 700W/m<sup>2</sup> (EN 61829)



### Incorrect I-V characteristic curve

- Additional serial resistance in PV system
- Voltage drop on cables to PV module string.

### Error/troubleshooting:

- Check cables contacts connector etc.
- Enter cable length, cross section and spec. resistance in ANALYZER, and activate function "Correction of voltage loss in cables", repeat measurement

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## **16. Maintenance, Cleaning, Calibration interval, fuse replacement**

### **16.1 Maintenance**

When using the instrument in compliance with the instruction manual, no special maintenance is required. Should operational problems occur during daily use, our after sales service will repair your instrument without delay.

Both instruments should always be transported and stored in the hard case. The buttons and screens are designed for manual operation and are not resistant to metal or other hard objects. Always use a soft cloth to clean the measuring instrument. Harsh abrasives or aggressive cleaning agents will irreparably damage the screen and buttons. To prevent damage to the LiPo accumulator during longer storage times of the measuring instrument, the accumulator should be charged to approx. 50%, and should be recharged every 4-6 months.

### **16.2 Cleaning**

If the instrument is dirty after daily usage, it is advised to clean it by using a damp cloth and a mild household detergent. Prior to cleaning, ensure that the instrument is switched off and disconnected from all external voltage supplies. Never use acid detergents or dissolvants for cleaning. Do not use the instrument after cleaning until it has completely dried off.

### **16.3 Calibration interval**

To ensure the accuracy of the measurements it is recommended that the SOLAR-4000 is calibrated regularly by our after sales service. We suggest a calibration interval of one year. If the instrument is used very often or if it is used under rough conditions we recommend shorter intervals. If the instrument is used few times only the calibration interval can be extended on to 3 years.

### **16.4 Fuse replacement**

If, due to overload or improper operation the internal fuse has blown the instrument must be returned to our service department for a full check.

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## 17. Technical data, warranty, service

### 17.1 Technical data SOLAR-4000 ANALYZER

Display	3.2 inch colour LCD, touch screen (240 x 320 pixel, RGB)
Measurement functions	current – voltage -diagram, (I-V characteristic curve), short circuit current, open voltage, power, MPP current, MPP voltage
Voltage measurement range	1.0... 1000 V Open voltage (Uoc) >5 V
Resolution	0.1 V
Accuracy	±1%
Current measurement range	0.1... 15.0 A
Resolution	0.01 A
Accuracy	±1%
Characteristic curve measurement duration	approx. 15...30 seconds
Number of measurement points	max. 100
Calculated values:	STC values (short circuit current, open voltage, MPP current, MPP voltage), MPP power, fill factor, manufacturer's ideal characteristic curve
Measurement connectors	Standard-4 mm test leads to PV-Module, or PV system
Memory	dependent on SD memory card size (> 1000 measurement curves per GB)
Recommended SD memory cards	1 GB to 4 GB
Power supply	Lithium polymer accumulator (LiPo) 3.7 V, 2 Ah
Charging device	100...240 V, 50...60 Hz, 0.2 A 12 V, 0.42 A (DC)
Auto-Power-Off	adjustable 1... 15 minutes
Fuse (internal)	6A, 1000 V DC, 38 x 10 mm
Interface	SD/SDHC- memory card to PC wireless (ZigBee) to SOLAR-4000 SENSOR
Operating range	max. 100 m outside in free field, (operating range depends on local and physical conditions in the field)
Ambient temperature	0...+50°C
Relative humidity (operating)	<80 % RH
Storage temperature	0...+50 °C
Relative humidity (storage)	<80 % RH
Protection degree	IP 20
Protection class	II, continuous double or reinforced insulation
Safety according to	EN 61010-1, EN 61010-31
Measurement category	CAT II / 1000 V, CAT III / 600 V
Operating Altitude	2000 m above sea level
Dimensions	210 x 105 x 41 mm
Weight	approx. 0.5 kg

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## 17.2 Technical data SOLAR-4000 SENSOR

Display	LC display (2 lines, 16 characters) B/W
Measurement functions	Global irradiation, module temperature, inclination angle
Measurement range irradiation	100...1200 W/m <sup>2</sup>
Resolution	1 W/m <sup>2</sup>
Accuracy	±5 %
Reference cell	1x mono crystalline cell, 1x polycrystalline cell
Measurement range temperature	0...+100 °C,
Measurement principle	infrared, contactless
Resolution	0.1 °C
Accuracy	± 3 % (with reference to a black body)
Measurement range inclination angle	0...90 °
Resolution	1°
Accuracy	±5 %
Memory	ca. 1 hour (volatile)
Power supply	Lithium polymer accumulator (LiPo) 3.7 V, 1 Ah
Charging device	100...240 V, 50...60 Hz, 0.2 A 12 V, 0.4 A (DC)
Interface	wireless (ZigBee) to SOLAR-4000 ANALYZER
Operating range	max. 100 m outside in free field, (operating range depends on local and physical conditions in the field)
Ambient temperature	0...+60°C
Relative humidity (operating)	<80 % RH
Storage temperature	0...+50 °C
Relative humidity (storage)	<80 % RH
Protection degree	IP 20
Operating Altitude	2000 m above sea level
Dimensions	160 x 82 x 41 mm
Weight	approx. 0.2 kg

## 17.3 Limited warranty and limitation of liability

It is guaranteed that this AMPROBE product is free of material and manufacturing damages for the time period of 24 months starting from the date of purchase. This warranty does not include fuse malfunctions, as well as damages caused by accidents, negligence, misuse, unauthorised modifications, abnormal operating conditions or improper handling. The sales offices do not have the right to extend the warranty on behalf of AMPROBE.

## 17.4 Service

All instruments that are sent in for repair or calibration within or beyond the warranty period, must contain the following data: Name of the client, name of the company, address, contact telephone number and a proof of purchase. Please enclose also the test leads and a short description (or a service form) of the problem detected or of desired maintenance.

## 18. Error messages and possible solutions

Error Message Display/Problem	Root cause	Troubleshooting
Please insert the SD card!	There is no SD card inserted into the measuring instrument SOLAR-4000 ANALYZER.	Insert SD card
	Inserted SD card is corrupted and cannot be read.	Replace SD card
Error: Old MMC card! Initialise SD card!	A MMC card has been inserted into the SOLAR-4000 ANALYZER.	Replace MMC card with SD card
Overvoltage > 1000 V! Switch off!	Test leads are connected to a	Switch off the instrument immediately! Check the measuring setup!
Over current > 15A Switch off!	Measuring cables carry a current higher than 15A!	Switch off the instrument immediately! Check the measuring setup!
Internal error!	Internal error in measuring instrument	Contact AMPROBE !
Error: Communication of measurement	Internal error in measuring instrument	Contact AMPROBE !
Error: Open-circuit voltage (xxV) < 5 V!	Test leads are connected a voltage lower than 5 V.	Connect a module or string to the measuring instrument, Check the measuring setup! Observe the polarity of the test leads.
Error: Irradiation too low	Irradiation measured by the SOLAR-4000 SENSOR is lower than the pre-set limit value for the solar irradiation, refer to the submenu "Settings – Data"	Repeat the measurement with higher irradiation! Check the position of the SOLAR-4000 SENSOR!
Error: Irradiation too low	Irradiation measured by the SOLAR-4000 SENSOR is lower than the pre-set limit value for the solar irradiation, refer to the submenu "Settings – Data"	Repeat the measurement with higher irradiation! Check the position of the SOLAR-4000 SENSOR!
STC impossible	Type of the tested module is a thin-layer module.	STC extrapolation is not performed with thin-layer modules!
SOLAR-4000 SENSOR data missing! Measuring curve must later be adjusted manually.	Characteristics analysis was performed without radio connection between SOLAR-4000 SENSOR and SOLAR-4000 ANALYZER. The measured data of SOLAR-4000 SENSOR must later be synchronised with the SOLAR-4000 ANALYZER.	Synchronise measured SOLAR-4000 SENSOR data under menu item "Memory".
No data for measuring curve	SOLAR-4000 ANALYZER cannot find measured data for the respective measurement during the later synchronisation of the SOLAR-4000 SENSOR data. SOLAR-4000 SENSOR has been switched off before synchronisation.	Repeat measurement.

Error Message Display/Problem	Root cause	Troubleshooting
Data synchronisation failed	The later synchronisation of measured SOLAR-4000 ANALYZER and SOLAR-4000 SENSOR data has failed.	Position SOLAR-4000 d ANALYSER and SOLAR-4000 SENSOR within radio range, Repeat measurement.
Measurement not found	During synchronisation, no measured sensor data could be allocated to a SOLAR-4000 measurement. SOLAR-4000 measurement file was deleted before synchronisation.	Repeat measurement.
No data or files could be read!	SOLAR-4000 ANALYZER cannot load saved measurement file.	Perform Firmware update on measuring instrument
	Measurement file corrupted	Delete measurement file in PC software
Verification failed!	Data format of measurement file does not correspond to data format of measuring instrument.	Perform Firmware update on measuring instrument
	Measurement file was manually manipulated!	Delete file
Error: Battery voltage too low/ instrument fails to activate	Capacity of LiPo accumulator too low	Charge measuring instruments using the supplied charging device
No firmware file found!	Could not perform firmware update. File could not be found.	Firmware file Vx_x_x.TFW must be in directory x:\SOL-4000\UPDATE.
Firmware file could not be opened!	Firmware file cannot be opened. File corrupted	Copy new Firmware file Vx_x_x.TFW into directory x:\SOL-4000\UPDATE
Error formatting!	Incorrect type of memory card inserted into SOLAR-4000 ANALYZER	Insert SD/SDHC card into the SOLAR-4000 ANALYSER
	SD card cannot be formatted.	Use new SD/SDHC card
Module to be tested missing from module database	Module does not exist in module database.	Perform measurement using the dummy module "STANDARD" and add missing module type to the PC software in the module databasen Install new module database by PC software. Check homepage <a href="http://www.amprobe.eu">www.amprobe.eu</a> for update of module database.
At power on the two symbols "Power Measurement" and "Memory" are shown in grey. No measurements can be performed,	The memory card was deleted completely or formatted in a PC.	First format the memory card in the SOLAR-4000 ANALYZER by using menu "Settings – Memory". Then install module database by PC software to memory card.



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