TRITEC

TRI-KA

Characteristics Analyser

Hardware Operating Instructions

Contents

1 Introduction

The photovoltaic market is a highly active and brisk market. For end users, the annual energy yield of photovoltaic installations is ultimately decisive. Previously, the quality control of installed PV generators has only been possible with very expensive and unmanageable measuring systems. The combined "TRI-KA" and "TRI-SEN" measuring system enters the market with easy-to-handle mobile instruments of an excellent price/performance ratio offering any installer the possibility for the quality control and the documentation of PV installations.

"TRI-KA" and "TRI-SEN" are an intelligent measuring and documentation system which is indispensable for the professional installation and maintenance of PV installations. It facilitates the proper assembly of a PV installation and provides comprehensive documentation of the quality of the same.

The system performs the following measurements and analyses:

- Open-circuit voltage
- Short-circuit current
- I-U characteristics
- Module plane irradiation
- Cell temperature
- STC characteristics

The quality of a photovoltaic installation may be assessed by current-voltage characteristics. The TRI-KA takes this measurement starting at a voltage of 50 V. In addition, the TRI-KA calculates the output of the PV installation under STC conditions based on the measured values.

The measuring system is based on two portable instruments: the TRI-KA and the TRI-SEN. The TRI-SEN measures the cell temperature and irradiation. The TRI-KA records current-voltage characteristics and can display short-circuit current and open-circuit voltage at the push of a button. For the conversion of the characteristics into standard test conditions, the measured data is transferred from the TRI-SEN to the TRI-KA via an infrared interface. This data transfer procedure enables the synchronous measurement of characteristics and solar irradiation irrespective of the location.

The TRI-KA shows the output on an LC display which is able to provide graphic representation. The measurement may be taken without any profound skills in measuring technology. The menu navigation is logically structured and easy to understand.

2 Contents of the case

1. TRI-KA characteristics analyser with infrared interface
2. TRI-SEN
   Irradiation and temperature sensor with memory and 2 interfaces (infrared and USB-PC interface)
3. 2 measuring cables:
   1 red positive cable
   1 black negative cable
4. 1 USB cable
5. Batteries for the TRI-KA:
   4 x LR6 / Mignon / AA
6. Battery for the TRI-SEN:
   1 x 6LR61 / E-block / 9 V
7. 1 CD with PC software (not shown)

The CD provided in the case contains a help file for the PC software.

System requirements:
Windows 2000® or Windows XP®
USB interface 1.0 or higher
Recommended: min. resolution of 1024 x 768 pixel, colour printer

3 Warnings – Please mind!

3.1 TRI-KA

The TRI-KA may only be used for photovoltaic generators of maximum 1000 Volt and 10 Ampère direct current. Solar modules generate current and voltage as soon as they are exposed to light. This means that also in overcast rainy weather, plugs and other voltage-carrying items represent a danger! Therefore, all safety regulations must be strictly complied with while working on photovoltaic generators.
Improper handling is considerably prone to accidents and might cause severe injuries. Sources of current and voltage other than solar modules can destroy the measuring instrument.

3.2 Cables

The connecting cables must NEVER be detached during measurement. The resulting arcs might cause severe injuries and would destroy the contacts of the plugs.

3.3 Location

Measurements must not be performed in the vicinity of combustible gases and dusts or other flammable materials. – EXPLOSION HAZARD !

The TRI-KA must not be used in rain or a wet or very moist environment because of the danger of an electric shock. Liquid must not penetrate the device. Wetness and moisture destroy the device. The tolerable TRI-KA temperature ranges between 5 and 50 °C. The TRI-KA should not be exposed to direct sunlight for extended periods.

3.4 Measurements

Measurements may only be performed by skilled electricians. Read the user manual completely prior to first commissioning of the device in any case. Store the manual together with the instrument.

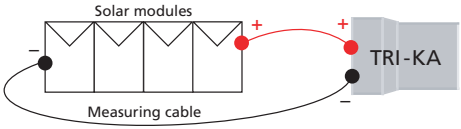
The device may only be opened and repaired by authorised and trained persons. Disconnect all connections to the solar generator and switch off the instruments prior to any opening of the device (e.g. to change the battery).

All loads (e.g. inverters) must be disconnected from the solar energy installation prior to any measurement. For measurements on a roof, all safety regulations concerning work on a roof and on electric installations must be respected.

Safety first!

4 Step by step to the measurement result

The step-by-step instruction from the measurement to the PC:

	Step	Explanations
1.	Disconnect loads from the solar modules	All loads like inverters or batteries must be disconnected from the solar modules prior to measurement!
2.	Measure the cell temperature using the TRI-SEN	See 6 TRI-SEN, 6.1 Measurement of the cell temperature
3.	Measure the irradiation using the TRI-SEN	See 6 TRI-SEN, 6.2 Irradiation measurement
4.	Connect the TRI-KA to solar modules	 See 5 Connection of the photovoltaic generator

5. Read open-circuit voltage and short-circuit current if required

See 7 TRI-KA, 7.1 Uoc

6. Measure output

See 7 TRI-KA, 7.2 P Measur

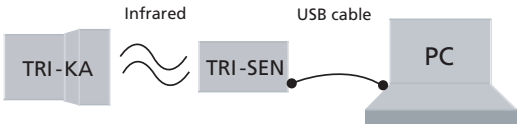
7. Measure the cell temperature again (optional)

This step is recommended to receive an average temperature value; see 6 TRI-SEN, 6.1 Measurement of the cell temperature

8. Transfer measured values from the TRI-SEN to the TRI-KA via infrared interface

See 7 TRI-KA, 7.3 Sensor, 7.3.2 Add

9. Transfer of measured values from the TRI-KA via the TRI-SEN to the PC



See 7 TRI-KA, 7.3 Sensor, 7.3.3 PC

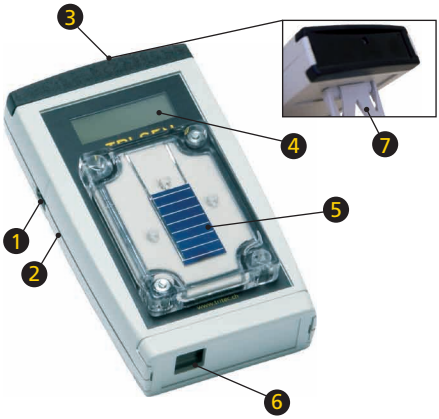
5 Connection of the photovoltaic generator

For a significant informational value of the measurement it is crucial that no solar module connected in parallel be measured. This would lead to difficulties in the evaluation of the measurement results. The individual strings can subsequently be added together by means of the software.

During the measurement, the solar modules may only be connected to the TRI-KA. Other loads like inverters or batteries must be disconnected from the solar modules! Please ensure the correct connection of the poles. Reverse polarity might lead to errors and damage. The measuring lines must be completely inserted into the sockets. Excessive junction resistance falsifies the measurement result and can cause dangerous arcs and burns. Damaged measuring cables must be replaced immediately. The repair of cables is not permitted.

6 TRI-SEN

The TRI-SEN is used to record the cell temperature and irradiation. After the characteristics measurement by the TRI-KA these values may be transferred from the TRI-SEN to the TRI-KA and used for the conversion into STC values (Standard Test Conditions: Irradiation 1000 W/m², spectrum AM = 1.5 and module temperature 25 °C).
For a simple measurement of open-circuit voltage and/or short-circuit current the irradiation and the cell temperature are not required.



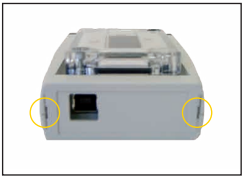
1. Slide switch for start-up
2. Key for temperature measurement
3. Temperature sensor and infrared interface
4. LC display
5. Solar cell for irradiation measurement
6. USB-PC connection
7. Hinged back

TRI-SEN data

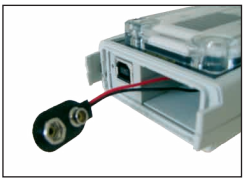
Measurement	Cell temperature and irradiation
Temperature measuring range	10 – 60 °C ± 3 %
Irradiation measuring range	100 – 1000 W/m² ± 3 %
Measuring connection	Non-contact
Memory	Up to approx. 8 hours (volatile)
LC display	8 characters, 5 x 7 pixels each
Power supply	Battery operation (1 x 9 V) or USB interface
Interface	Infrared to the TRI-KA, USB to PC
Operation	Key
Evaluation	Transfer to the TRI-KA
Dimensions	130 x 75 x 40 mm
Weight	0.15 kg

The TRI-SEN is powered by a 9 V battery. If the device is stored for a longer period of time, it is advisable to remove the battery from the device. If the TRI-SEN is operated in connection with a PC, the power is supplied via the USB interface.

TRI-SEN change of battery



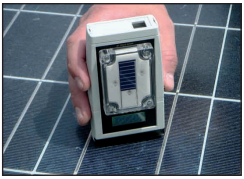
1. Remove protective cover (in case of a USB connection) pressing both lateral buttons (e.g. with a pen).



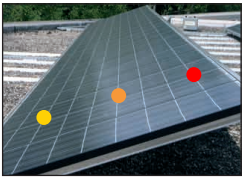
2. Take out terminal connections and connect them to the battery (6LR61 / E-block / 9 V).

3. Insert battery (terminals are pointing outwards) and close protective cover.

6.1 Cell temperature measurement



The TRI-SEN is switched on using the slide switch on the left-hand side of the device. A short beep and flashing of the irradiation value in the LCD confirm that the device is available for operation. The upper end of the TRI-SEN is equipped with a temperature sensor for non-contact measurement. The sensor is pointed directly to a solar cell. As soon as the temperature measurement key is pressed a beep is sounded and the instrument acquires the temperature. Simultaneously, the currently measured temperature **Ta** appears on the LCD. This measurement should be repeated at different points of the solar area. With every new measurement a new average temperature **Tm** is calculated. If the key is continuously pressed, the average temperature value **Tm** appears on the display. **Tm** is included in the conversion of the measured characteristics into STC characteristics (see 7.3.2).



It is recommended to measure the lower, centre and upper solar cells since a temperature difference between the upper and lower solar cells exists. The average measured temperature value remains in the memory until the device is switched off.

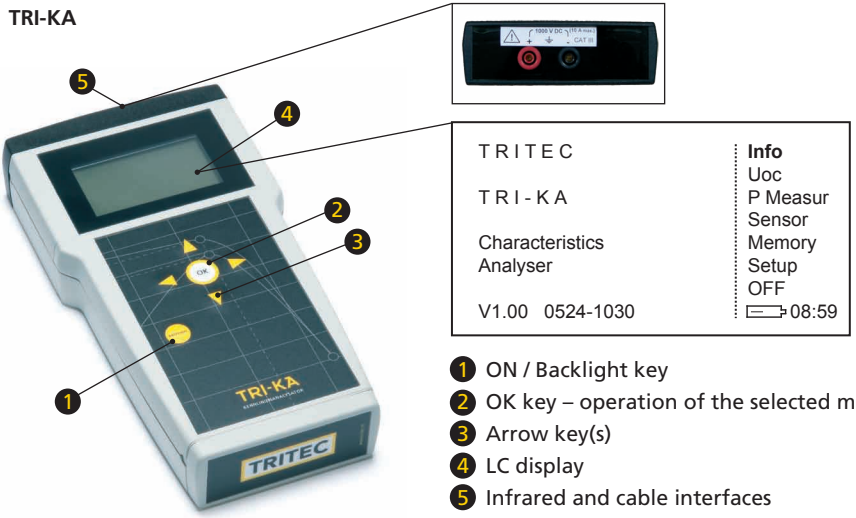
Once the TRI-SEN is switched off, all measured values are deleted!

6.2 Irradiation measurement

As soon as the TRI-SEN has been switched on by the slide switch, the irradiation is measured via the integrated solar cell. After temperature measurement, the solar cell of the TRI-SEN is positioned in the module plane (i.e. at the same angle of inclination and parallel to the solar module) using the hinged back. This positioning is decisive for the accuracy of the STC evaluation.

Irradiation is continually measured and stored in the memory in intervals. The device runs out of memory after 8 hours. The data has to be transferred to the TRI-KA after measurement (see 7 TRI-KA, 7.3 Sensor) since it will be lost as soon as the TRI-SEN is switched off!

7 TRI-KA



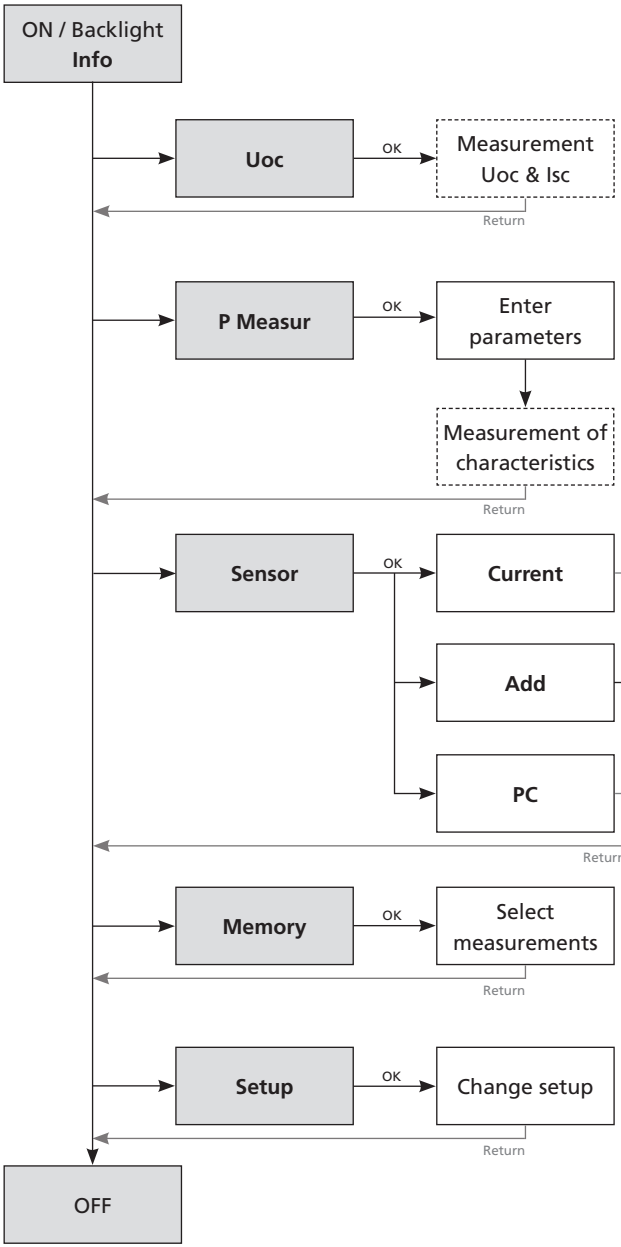
1. ON / Backlight key
2. OK key – operation of the selected menu
3. Arrow key(s)
4. LC display
5. Infrared and cable interfaces

TRI-KA data

Measurement	Current-voltage curve (output, short-circuit current and open-circuit voltage)
Voltage measuring range	50 – 1000 V ± 2 %
Current measuring range	0.1 – 10.0 A ± 2 %
Measuring connection	Aligator clip (different adaptor cables as options)
Memory	Up to 125 measured curves (not volatile)
LC display	Graphic representation, 128 x 64 pixel, backlight via key
Power supply	Battery operation (4 x 1.5 V)
Interface	Infrared to the TRI-SEN, 2 measuring cables to PV string
Operation	Menu driven via membrane keyboard
Evaluation	PC software (Windows 2000 and XP)
Dimensions	236 x 125 x 42 mm
Weight	0.5 kg
Options	Adapter cable for MC3, MC4, Huber & Suhner and Tyco plug

The autonomous power supply and easy handling properties make the TRI-KA a fully portable instrument which can be taken anywhere. If the device is stored for a longer period of time, it is advisable to remove the batteries from the device.
The instrument has a red input for the positive cable and a black input for the negative cable of a solar module series connection. An infrared interface for non-contact communication with the TRI-SEN has been arranged at the top of the device.

TRI-KA navigation



Measurement of open-circuit voltage and short-circuit current at the connecting terminals – see 7.1

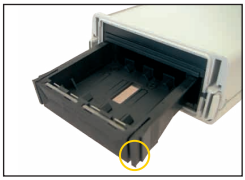
Measurement of I-U characteristics – see 7.2

Connection to the TRI-SEN and the PC – see 7.3

Display of stored measured data – see 7.4

Setting of instrument parameters – see 7.5

TRI-KA change of battery



CAUTION: Prior to any battery change the cables must be removed from the TRI-KA and the device must be switched off (see Warnings)!

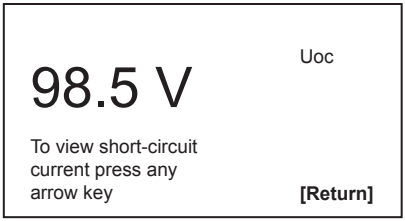
1. Remove protective cover (see picture) pressing both lateral buttons (e.g. with a pen).
2. Take out the black battery compartment pulling the side elements together.
3. Place the four batteries (LR6 / Mignon / AA) in the battery compartment.
4. Push the battery compartment (opening points to the rear side of the TRI-KA) back into the TRI-KA until it engages and replace the protective cover.

7.1 Uoc – measurement of open-circuit voltage and short-circuit current

The TRI-KA can measure and display the current open-circuit voltage (Uoc). The present closed-circuit current (Isc) can be measured in the same menu item, if required. These values can neither be stored nor recorded. If required, these values must be written down. Both measurements serve the fast evaluation of the photovoltaic generator in the field. The instructions concerning the connection of the solar modules must be respected.

Measurement of open-circuit voltage and short-circuit current:

1. Ensure that the TRI-KA has been correctly connected to the photovoltaic generator to be measured.
2. Switch on the TRI-KA by pressing the ON / Backlight key.
3. Select the **Uoc** menu item using the arrow keys.
4. Press the OK key to open the **Uoc** menu.
5. Read open-circuit voltage.
6. If required, press any arrow key to read the closed-circuit current.

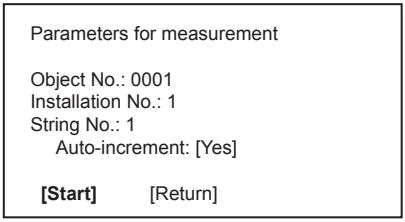


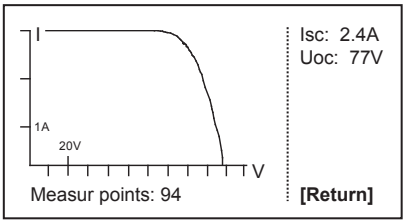
7.2 P Measur – characteristics measurement

For characteristics measurement the cell temperature must be measured first and the TRI-SEN must be placed in the module plane for the irradiation measurement. Subsequently, the curve can be recorded in the **P Measur** menu.

For a complete characteristics measurement proceed as follows:

1. Ensure that the TRI-KA has been correctly connected to the photovoltaic generator to be measured.
2. Switch on TRI-KA pressing the ON / Backlight key.
3. Select the **P Measur** menu item using the arrow keys.
4. Press the OK key to get into the **P Measur** menu.
5. Define object number, installation number, string number for unambiguous recognition. Parameter settings may be changed using the arrow keys. (The increment function is helpful for the measurement of large installations. The string number is increased by 1 after each measurement.)
6. Select the Start menu level and trigger the measurement using the OK key.
7. Measurement is performed.
8. The measured curve is recorded and simultaneously displayed.
9. Leave the illustration using the OK key.





If the voltage is too low, a measurement cannot be performed. Please check the messages on the display. The measurements are stored in the memory under a running number. 125 curves can be stored.

7.3 Sensor – communication with the TRI-SEN

The **Sensor** menu item is used to transfer measured values from TRI-SEN to TRI-KA and for the communication between TRI-KA and the PC.

7.3.1 Current – display of the current irradiation and temperature values

The TRI-SEN can display the currently measured values for the verification of irradiation and temperature:

1. Navigate to **Current** in the **Sensor** menu.
2. Point the upper ends of both devices against each other so that the infrared communication can take place.
3. Read measured values.

Current values:	**Current** Add PC
Temp.: 19°C Sun: 1003W/m2 Batt. V.: 7.5V USB V.: 0.0V Unit No.: 0524-1006	[Return]

7.3.2 Add – transfer of recorded irradiation and temperature values

After the characteristics measurement the irradiation and temperature values may be transferred from the TRI-SEN to the TRI-KA in the **Add** menu point. This can be done automatically (time-dependent) or manually (independent allocation of values). The measured characteristics are converted into STC characteristics using the sensor data. The same can immediately be seen on the display or analysed by the PC software.

1. Select the **Add** menu item.
2. Select **Autom.** for an automatic transfer of measured values.
3. Point the upper ends of both devices against each other so that the infrared communication can take place.

If the automatic transfer does not work or is not desired, the values for irradiation and temperature may be entered in the **Manual** menu using the arrow keys. Characteristics may also be acquired without recording the irradiation and temperature, however, this will not guarantee a correct analysis.

7.3.3 PC – transfer of measured values from the TRI-KA to the PC

1. Switch on the TRI-KA and the TRI-SEN and start the TRI-KA software.
2. Point the upper ends of the TRI-KA and the TRI-SEN against each other so that the infra-

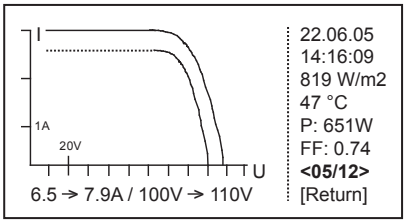
red communication can take place.

3. Connect the TRI-SEN with the PC using the provided USB cable.
4. Select the **Sensor** menu item.
5. Select the **PC** menu item.
6. Download the measured values to the PC (see operating help software on the CD).

7.4 Memory – display of stored curves

All of the stored curves may be displayed in the **Memory** menu item. All relevant values can be seen on the right-hand side of the display:

- Date and time of the measurement
- Irradiation and temperature
- Peak output at STC (i.e. nominal output converted into STC)
- Filling Factor (FF) refers to the quotient of the maximum output of a solar cell at the maximum power point and the product of open-circuit voltage and closed-circuit current
- Measurement number (the left and right arrow keys select the next or previous measurement; <05/12> means that this is the 5th of 12 measurements)
- Closed-circuit current measured and extrapolated to STC
- Open-circuit voltage measured and extrapolated to STC



7.5 Setup – TRI-KA parameters

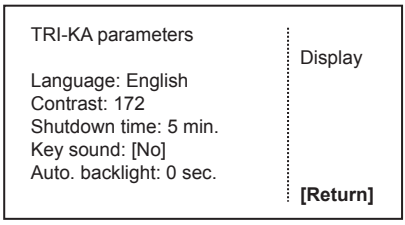
The following TRI-KA parameters may be adjusted in Setup:

Time

- Time
- Date

Display

- Language: English, French, German, Italian or Spanish may be selected
- Contrast
- Shutdown time for automatic shutdown



- Key sounds for the confirmation of an operation
- Auto. Backlight

Memory

- Delete all?: If the memory is deleted, all data and curves are irretrievably deleted!

7.6 Storage / maintenance TRI-KA

The TRI-KA must be transported and stored its case. The instrument must not be exposed to direct sun irradiation in prolonged measuring. The membrane keyboard must not come in contact with pointed or sharp objects. The keys are intended for manual operation and not resistant against metals or other hard materials. The instrument may only be cleaned with a soft cloth. Abrasives or aggressive cleaning agents destroy the glass of the LCD and the membrane keyboard.

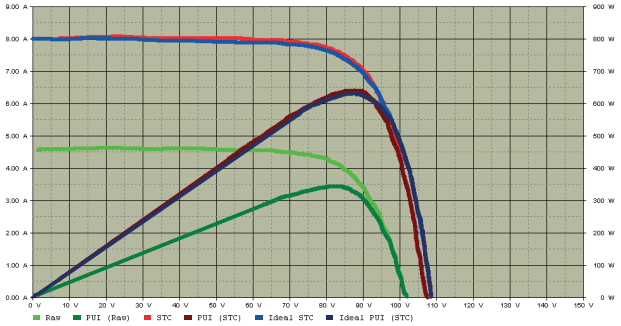
8 Requirements for measurement and analysis

Weather conditions should be constant during measurement. Measurements taken under strongly fluctuating weather conditions will be insignificant. The stronger the irradiation, the more accurate the measurement will be. From approx. 400 W/m^2 onwards a measurement is significant. An irradiation of more than 500 W/m^2 is however recommended. The temperature measurement is selective and inconsistent for an entire solar installation. When using several strings, the temperature difference between the lower and the upper string will be substantial. The environment of the solar modules may have a strong influence on the temperature. Try to collect an average value as significant as possible.
Make sure that the TRI-SEN is lying in the module plane (same alignment and same inclination as the solar modules). Even small deviations will result in substantial measuring errors.
Measurements may be repeated for an improved evaluation. The evaluation software allows several measurements for the same serial connection.

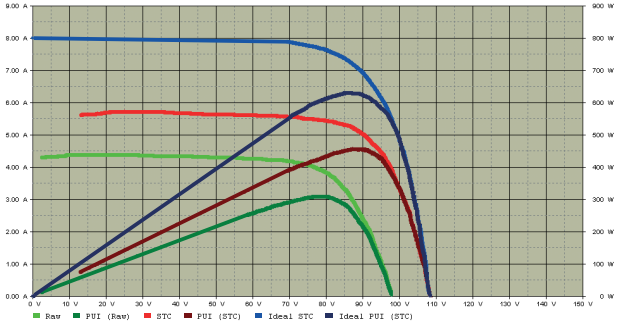
9 Evaluation of the measurement results

Using the current-voltage characteristics (I-U characteristics) of a PV generator, different properties and problems of the generator can be recognised and analysed. Partial shading of the generator field, defect bypass diodes, delamination of individual PV modules, excessive serial resistance of the modules, dirty modules and problems of individual cells can be recognised in this way. The interpretation of the characteristics requires some experience and a basic knowledge of semiconductor engineering. To facilitate the interpretation, some examples of characteristics taken from the evaluation software are subsequently listed.

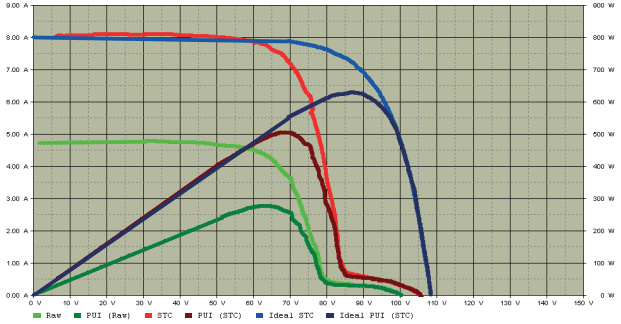
- Good string



- Partial shading of the entire string



- Covered cells of a module



Generally, it is true to say that the temperature influences the width (Uoc) and the irradiation influences the height (Isc) during the conversion of the I-U characteristics into the STC characteristics.

Using the I-U characteristics, the solar irradiation and the module temperature, the TRI-KA calculates the electric values of the PV generator under STC conditions. STC = Standard Test Conditions = Conditions under which PV modules reach their values stated on the rating plate (standard test conditions: irradiation 1000 W/m^2, spectrum AM = 1.5 and module temperature 25 °C). Using the calculated peak performance at STC the actual output can be compared with the output stated on the data sheets of the modules. The installation of the PV generator and the condition of PV modules can be evaluated by a comparison of the actual peak output at STC and the output according to the data sheet. In case of unclear characteristics or insufficient peak output at STC, please contact the manufacturer of the components concerned to obtain further information in relation to the components and possible errors.

The software is included in the delivery of the TRI-KA. Furthermore, it can be downloaded from www.tritec-energy.com.

10 Declaration of conformity

EU/UE
KONFORMITÄTSERKLÄRUNG
DECLARATION OF CONFORMITY
DÉCLARATION DE CONFORMITÉ

Wir
We **TRITEC AG**
Nous

(Name des Anbieters) (supplier's name) (nom du fournisseur)

Herrenweg 60 **CH – 4123 Allschwil**

(Anschrift) (address) (adresse)

erklären in alleiniger Verantwortung, dass das Produkt
declare under our sole responsibility that the product
déclarons sous notre seule responsabilité que le produit

Photovoltaik-Kennlinienmesssystem bestehend aus zwei Messgeräten
TRI-KA und TRI-SEN mit Zubehör

(Bezeichnung, Typ oder Modell, Los-, Chargen- oder Seriennummer, möglichst Herkunft und Stückzahl)
(name, type or model, lot, batch or serial number, possibly sources and numbers of items)
(nom, type ou modèle, nom de lot, d'échantillon ou de série, éventuellement sources et nombres d'exemplaires))

auf das sich diese Erklärung bezieht, mit der / den folgenden Norm(en) oder normativen Dokument(en) übereinstimmt.
to which this declaration relates is in conformity with the following standard(s) or other normative document(s)
auquel se réfère cette déclaration est conforme à la (aux) norme(s) ou autre(s) document(s) normatif(s)

Sicherheit: **EN 61010-1 (2001)D + 61010-031 (2002)**
EMV: **EN 61326 (1997) + A1 (1998) + A2 (2001) + A3 (2003)**

(Titel und/oder Nummer sowie Ausgabedatum der Norm(en) oder der anderen normativen Dokument(e)
(title and/or number and date of issue of the standard(s) or other normative document(s)
(titre et/ou no. et date de publication de la (des) norme(s) ou autre(s) documents) normatif(s)

Gemäss den Bestimmungen der Richtlinie(n); following the provisions of directive(s); conformément aux disposition de(s) directive(s)
(falls zutreffend) (if applicable) (le cas échéant)

73 / 23 / EEC + 89 / 336 / EEC + 93 / 68 / EEC

Jahr der Anbringung der CE-Kennzeichnung:

2005

Allschwil, 15. Juli 2005 Giorgio Hefti

(Ort und Datum der Ausstellung)
(Place and date of issue)
(Lieu et date)

(Name und rechtsgültige Unterschrift)
(name and legally valid signature)
(nom et signature valide)

11 General terms and conditions of warranty for TRITEC products

TRITEC products are of top quality and exclusively available via specialised retail outlets. TRITEC warrants unobjectionable functioning and faultlessness of its devices in the EU at the time of delivery. If our products are used correctly, the warranty period shall be two years after their purchase. The delivery note or original invoice shall be the proof of dispatch or delivery.

However, should problems or deficiencies occur, we recommend the following procedure:

- Visit our website. You will find a repair form as well as the current addresses of our branches world-wide under Service & Support.
- Contact your outlet or the next TRITEC branch.

TRITEC is very concerned about warranting product quality and will provide any support and expert advice to you to this end.

Warranty

- TRITEC warrants that its products will function properly for a period of two years after purchase if operated correctly.
- The warranty covers the costs of repair, replacement devices and/or the replacement of damaged parts. Any costs relating to the assembly, the dispatch or travels of technicians are not included and shall be charged in accordance with the expenditure incurred.
- The warranty shall lapse in case of improper use of TRITEC products, e.g. improper installation or maintenance, replacement or changes which were not authorised by TRITEC.
- In case of delivery by TRITEC, the goods shall be checked immediately after receipt. Transport damage shall be reported within 5 days.
- For transport damage as well as any other damage caused after the passage of risks any liability shall be excluded.

Notice

Because of the large available number of different module types and brands and the dynamic technical development, TRITEC cannot guarantee that all modules, which are available at the market place, can be measured. Off course we do our utmost to keep fully on track with all developments to achieve a full market coverage a.s.a.p.

Returns for repair purposes

All of the returns shall be co-ordinated by your TRITEC representation/branch in your vicinity. Please contact your customer consultant.

All returns shall be subject to the following conditions:

- A registration number (RMA number) which entitles you to return the materials. RMA numbers may be applied for at your branch.
- You shall bear the postage fees for all returns.

Your TRITEC branch will be at your disposal for any queries you might have. Report first to this branch.

The exclusive place of jurisdiction for all disputes with TRITEC arising from the contract, illicit action or any other legal reason shall be Basel, Switzerland, in the absence of contradictory, written understandings and as far as legally permitted.

Your notes