



**PROFITEST** | **PV**  
PHOTOVOLTAIC | TESTER

Peak Power Measurement and  
Characteristic Curve Tracing

# As Clear as Daylight: Maximum Precision for Photovoltaics

## High-Tech Metrology for the Energy of the Future

Sustainably ecological, ever increasing efficiency for the energy balance and economically convincing: PV systems for generating electrical power are rapidly gaining extraordinary significance. Already today, they're considered the energy source of the future. Absolute precision is required in order to exploit solar energy to the greatest possible extent, and with maximum yield.

This results in highly demanding requirements for the utilized measuring technology – during all stages of operation: Already during the planning phase for the PV system, determining factors must be accurately ascertained and incorporated into the system concept. During

initial start-up and periodic testing, a report must be prepared which includes the measured electrical values and system data specified in the standards. And the quality and performance of a PV installation can be verifiably documented with photovoltaic system certification. Quality assurance retains essential significance for the entire service life of the system – after all, system owners want reliable, decisive yield monitoring in order to secure long-term profitability.

The PROFITEST PV was developed to meet these demanding criteria. The instrument makes it possible to perform measurements accurately, as well as efficiently. Its design concept: maximized precision – minimized effort. Read your results while others are still entering data!

## Testing in Compliance with DIN EN 62446 - VDE 0126-23



Utmost precision thanks to steady measurement of characteristic IU curves at the capacitive load at PV modules and strings



Patented calculation process for evaluating PV generators without knowledge of the manufacturer's specifications



Patented calculation process for determining the generator's internal series resistance based solely on a single measured characteristic IU curve



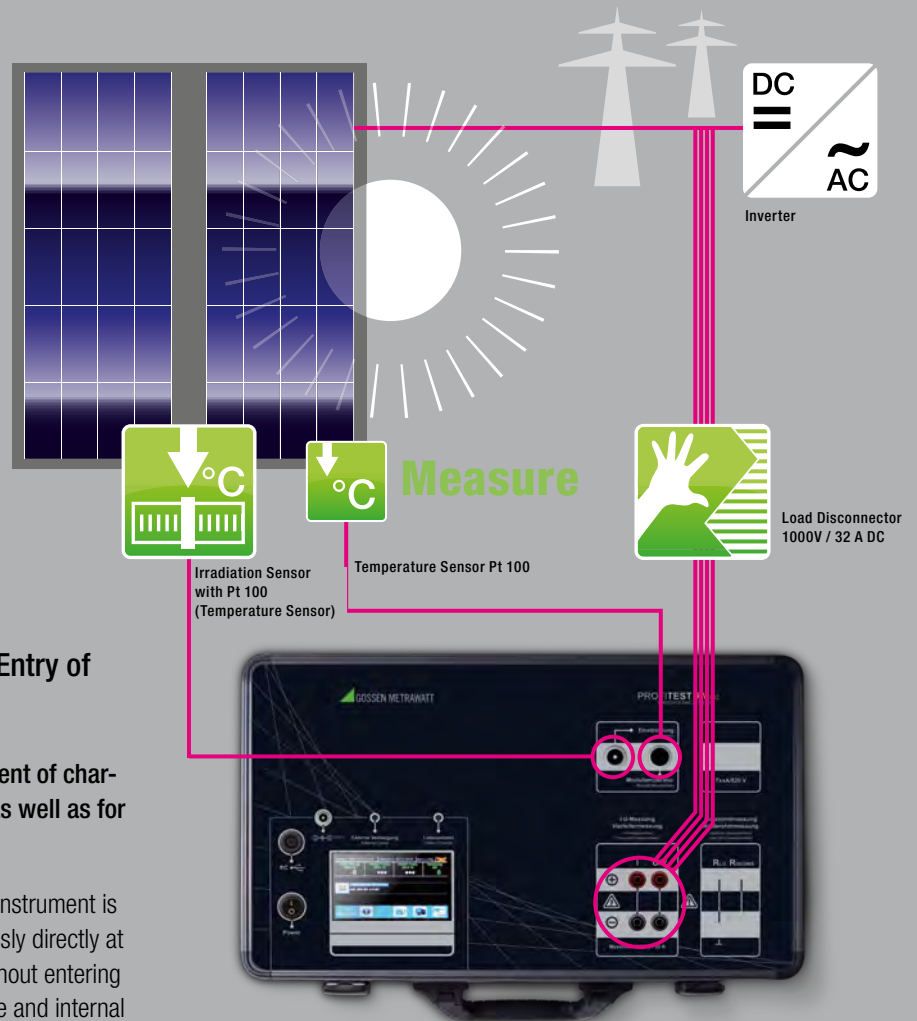
High level of intrinsic safety thanks to included load disconnecter (1000 V/32 A DC) for all-pole disconnection of the measuring instrument from the PV generator



Calibrated irradiation sensor in accordance with IEC / EN 60904-2, VDE 0126-4-2 with integrated Pt1000 temperature sensor

# PROFITEST PV: Connect, Switch On, Measure, Done!

Peak Power Measuring Instrument and Characteristic Curve Tracer for Photovoltaic Systems with Auto-Ranging up to 1000 V / 20 A



## Measurement Without Time-Consuming Entry of Module Data

The PROFITEST PV allows for reliable ascertainment of characteristic IU curves – for photovoltaic modules as well as for strings.

- Thanks to a patented process, this innovative test instrument is capable of ascertaining several values simultaneously directly at the installation with one single measurement – without entering module data: peak power, internal series resistance and internal parallel resistance.
- Troubleshooting and quality documentation can thus be completed quickly, simply and reliably as well
- Measured values are easy to read. They appear at a high resolution, graphic compatible color touch-screen which is suitable for use in sunlight.

This newfound efficiency for measuring procedures saves a great deal of time for the installation technician – during initial start-up as well as for periodic testing. And the customer can rest assured that the system is always in top condition, and that energy yield is on the bright side.

## Broad Measuring Spectrum Included

The broad range of integrated measuring methods makes the PROFITEST PV a universal measuring instrument for applied solar technology: For example, measured peak power can also be used to determine performance ratio. Beyond this, acquired characteristic curves provide accurate insight into the electrical attributes of the measured module or string. Consequently, the tester is also extremely well suited for use as a precision measuring instrument in research and development.

## Internal Series Resistance $R_s$ : a Single Measurement Suffices

Until recently, at least two characteristic curves traced under defined conditions were necessary for the measurement of internal series resistance  $R_s$  at crystalline as well as thin-film modules – a time-consuming, difficult test procedure.

**This measurement is much faster and easier with the PROFITEST PV:**

- The instrument only needs to acquire a single characteristic IU curve, after which it immediately calculates  $R_s$ , peak power  $P_{pk}$  and parallel resistance  $R_p$  automatically.
- Included PV Analyzer software even makes it possible to compare values acquired by the test instrument with those expected from the system. In this way, for example, signs of breakage, corrosion and cable connection errors are made apparent and energy harvesting losses can be reduced.

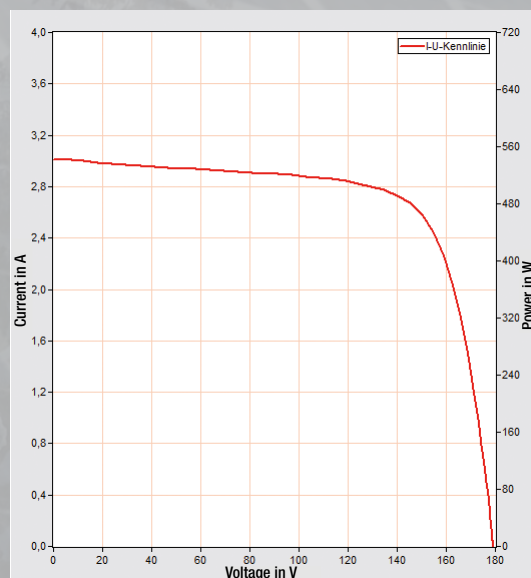
# Enhanced Precision with Intelligent Measuring Technology

The PROFITEST PV is setting new standards for quality and safety with a comprehensive scope of measurements, as well as operating and documentation functions which are targeted at actual practice and outstanding ergonomics.

- Measurement of short-circuit current  $I_{SC}$ , and open-circuit voltage  $U_{OC}$ , instantaneous peak power of a solar cell  $P_{max}$ , series resistance  $R_S$  and internal parallel resistance  $R_p$ ,
- Displayed (calculated) values: peak power  $P_{pk}$ , internal series resistance  $R_S$ , internal parallel resistance  $R_p$ , instantaneous values:  $U_{pmax}$ ,  $I_{pmax}$ ,  $P_{max}$ ,  $U_{OC}$ ,  $I_{SC}$ , FF,  $T_{mod}$ ,  $T_{ref}$ ,  $E_{eff}$ , characteristic IU curve diagram
- Automatic conversion of momentary measured values to STC \*1
- Generator voltage up to 1000 V DC, current up to 20 A DC, power up to 20 kW
- Power and temperature measurement via 4-wire cable for error-free results
- Analog connection of sensors for irradiation and temperature via a rugged data transmission line

\*1 STC – Standard Test Conditions

In order to be able to compare different PV modules and cells with each other, standard test conditions have been established worldwide by means of which the characteristic curves of the solar cells are determined. The STCs make reference to the IEC 60904 and DIN EN 60904 standards. Essentially, the characteristic curve is defined by the MPP value, short-circuit current and open-circuit voltage.



IU characteristic curve

- Real-time irradiation measurement, reliable detection of fluctuation even in the millisecond range
- Internal data memory for several thousand measurements
- Continuous display of momentary irradiation and temperatures
- Separate measurement of temperatures at the irradiation sensor and the back of the module (Pt100) for increased measuring accuracy
- Universal input for use with commercially available or modified irradiation reference sensors; sensor replacement is possible at any time on-site
- Operation via a PC with direct import of measurement results is also possible, e.g. for long-term measurements
- External power pack with broad-range input for charging the batteries, and for continuous operation
- Open interfaces allow for operation of the instrument in special applications
- Integrated module, customer and equipment database with bidirectional connection to the PROFITEST PV

## Capacitive Measuring Method: the Accurate Solution

One of the decisive advantages of the PROFITEST PV is its ability to test a great variety of module types by means of the capacitive measuring method. This assures highly accurate results for all PV measurements – regardless of changing solar irradiation.

- As opposed to conventional measuring methods, the instrument acquires characteristic IU curves with great accuracy by means of steady measurement at the capacitive load.
- With common measuring methods used to date, one measurement takes relatively long with durations ranging from 10 to 30 seconds. Even in the millisecond range, irradiation typically changes by up to several hundred  $W/m^2$  – and thus results become blurred to some extent over the duration of the measurement.

## Pure Characteristic Curve – Without Interference

Convincing technical arguments speak in favor of measurement with capacitive load, which is now made possible by the PROFITEST PV:

- On the one hand, tracing of characteristic curves for PV generators such as modules, strings and arrays must not be conducted too quickly, because the capacitive or inductive characteristics of the generator may themselves influence the results. On the other hand, excessively long measurement may lead to reduced accuracy due to irradiation fluctuations under unfavorable circumstances.
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With the capacitive measuring method used by the PROFITEST PV, all of these system-specific variables are eliminated – and continuously accurate measurements are assured

# Perfectly Matched Accessories

Perfectly matched accessories make it possible to conveniently take advantage of the measuring diversity offered by the PROFITEST PV for a great variety of testing tasks at photovoltaic systems. The instrument and its accessories can be comfortably transported in the rugged case system.

## Accessories



Case system for the PROFITEST PV and accessories



Calibrated, monocrystalline irradiation sensor in accordance with IEC/EN 60904-2 with integrated Pt1000 temperature sensor, 10 m connector cable



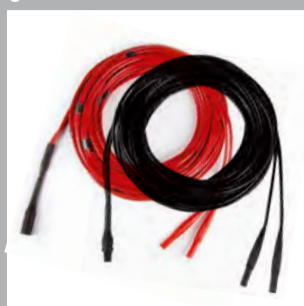
External load disconnecter (1000 V / 32 A) with outstanding intrinsic safety for all-pole disconnection of the measuring instrument from the PV generator



External power pack (16 V DC 2.5 A) for charging batteries and for power supply, with integrated charge controller



External Pt100 temperature sensor for separate measurement of temperatures at the irradiation sensor and the back of the module for increased measuring accuracy



4-wire measurement cable for connecting the load disconnecter and the PV generator, 10 meters



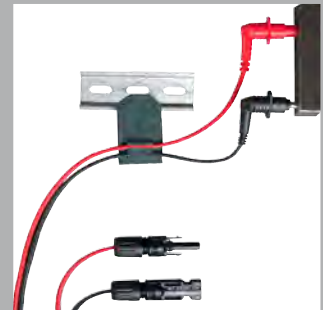
## Optional



PV adapter set  
SUNCLIX-MC4 (Z360H)



PV adapter set  
MC3-MC4 (Z360K)



Magnetic measuring probes  
with MC4 plug (Z502Y)



PV adapter set  
TYCO-MC4 (Z360J)



4-wire measurement cable set  
25 m connection cable (Z360L)



Trolley (502V)  
for case system

# Documented Quality: E-CHECK – PV Tests and Standards Compliant Tests

Certification in accordance with the standards issued on the basis of defined criteria which confirms system performance, economy and functionality is of great significance for owners of photovoltaic systems. The PROFITEST PV is equipped with all of the functions required in order to reliably document the quality of your work in accordance with applicable directives:

## E-Check for PV systems

Photovoltaic systems (PV systems) and associated equipment serve to produce, transmit and apply electric power. They are subject to ageing and wear and tear caused by environmental impacts and special operating conditions. Consequently, defects may occur in the course of time which have a decisive influence on the safety in private households and industry. For this reason, periodic tests in the form of E-CHECK testing as is mandatory in the industrial sector should be performed for PV systems in all other sectors as well.

E-CHECK helps to discover defects in PV systems and associated equipment which involve hazards for persons, animals and material. At the same time, the electrician should act as a consultant for the plant operator by providing them with useful advice for the efficient application of power. The operator is responsible for the correct functioning of the PV system and/or the associated equipment.

On the basis of the E-CHECK guidelines, the condition of the PV system or the associated equipment is to be examined with regard to:

- usability and functionality,
- proper condition in terms of safety requirements,
- protection against electric shock,
- protection against fire caused by short circuit in the electrical system,
- lightning and overvoltage protection measures,
- energy saving potential and
- profitability of the PV system

After completion of the E-CHECK for PV systems and remedying the established defects, the required safety for persons, animals and material is restored.

The generally accepted codes of practice valid at the time of mounting the electrical system or equipment must be taken into account when performing the periodic tests. All relevant data and measured values are included in the final documentation. (Source: ZVEH)

## Service and operation of grid-connected photovoltaic systems

PV systems must be set up and installed in accordance with existing IEC, DIN EN and VDE requirements. The safety requirements specified in the following standards must be complied with:

- IEC 60364-1 (VDE 0100-100 Low-voltage electrical installations – Part 1: Fundamental principles),
  - IEC 60364-6 (VDE 0100-600 Low-voltage electrical installations – Part 6: Verification),
  - DIN EN 50110-1 (VDE 0105-100 Operation of electrical installations)
  - DIN EN 62305-3 (VDE 0185-3 Protection against lightning – Part 3: Physical damage to structures and life hazard)
- The following standard deals in particular with the installation of PV systems:  
IEC 60364-7-712 (VDE 0100-712: Requirements for special installations or locations – Photovoltaic (PV) power systems)



## Standards Compliant Testing of Grid-Connected PV Systems

In addition to the items which have to be included in system documentation, DIN EN 62446 (VDE 0126-23: Grid connected photovoltaic systems – Minimum requirements for system documentation, commissioning tests and inspection) also describes tests and measurements which must be conducted for initial start-up, as well as periodic tests and measurements for legally secure operation.

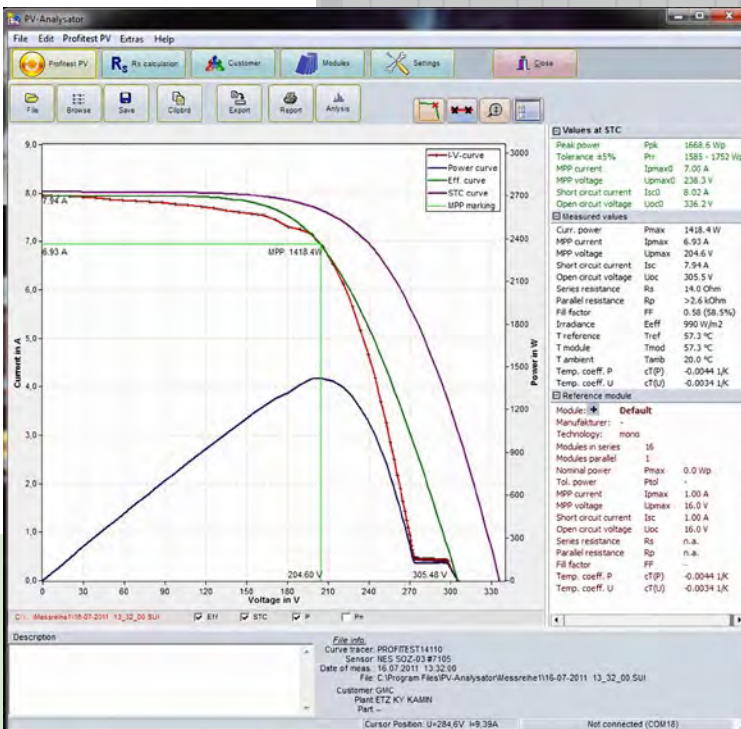


# PV Analyzer Including Software

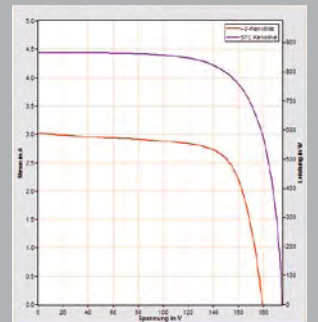
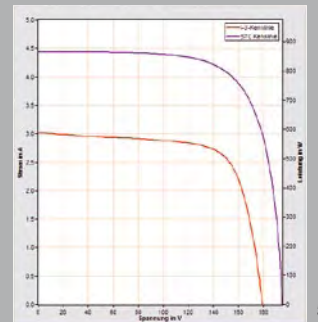
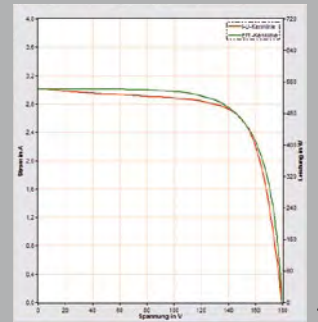
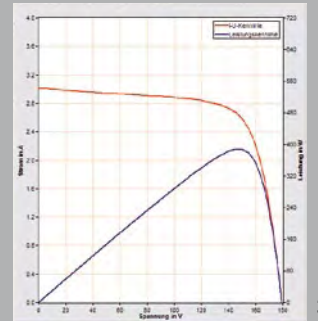
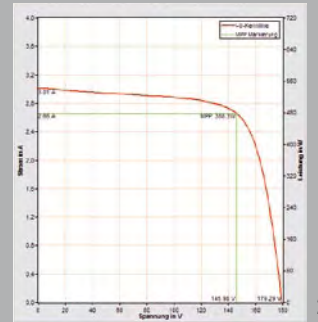
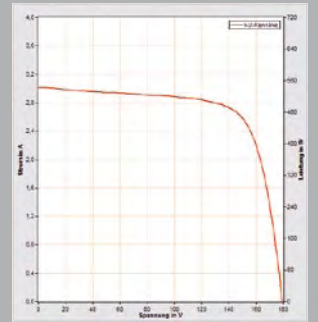
Included PV Analyzer software provides you with effective support for testing and documentation. The software has been specially developed for use in the field of photovoltaics and allows for graphic representation of measurement results, as well as precise evaluation and reliable documentation with an integrated database.

**PV Analyzer includes the following functions and more:**

- Read-in measured characteristic curve values from the PROFITEST PV
- Export of measured values or results (e.g. to an XLS file)
- Test report generation (e.g. as a PDF file)
- Online measurement – graphic representation of the characteristics curve and measured values (also suitable for continuous measurement)
- Online access to the database / data management in the PROFITEST PV
- Representation of measured and calculated values under STC
- Overview of characteristic IU curves for a given test series in the browser window
- Compatible with MS Windows® NT, 2000, XP, Vista, Windows 7
- Module database (30,000 modules)
- Analysis function: evaluation of measured values in comparison with STC measured values (interpretation of defects).



- 1 Graphic representation of the characteristic IU curve
- 2 With calculated MPP – maximum power point ( $P_{max}$ )
- 3 In comparison with the characteristic power curve
- 4 In comparison with the TRMS curve
- 5 In comparison with the STC curve
- 6 Characteristic IU curve with display of measuring points
- 7 Representation of measured values and calculated values under STC



# Measuring and Test Instruments for Photovoltaic Measurements (PV)

**GOSSEN METRAWATT** stands for outstanding quality and reliability around the world – first choice for maximum measuring and test precision. Comprehensive equipment offerings are available for use in photovoltaic systems and their peripheries, which perfectly cover all measuring tasks.

## PROFITEST PVsun

The test instrument is suited for testing PV modules and strings up to 1,000 V / 20 A. In addition to insulation measurement, polarity check and earth fault tests, it is also possible to test the continuity of the protective conductor (1).

## PROFITEST MTECH

Instrument for testing the effectiveness of protective measures in electrical systems per IEC 60364-6 / VDE 0100 – 600 / VDE 0105 – 100. (2)

## METRISO G500 / METRISO G1000

METRISO G500/ G1000 insulation and resistance measuring instruments for quick, streamlined testing of protective measures per IEC 60364 / VDE 0100. (3)

## MAVOWATT 20

This energy and power analyzer is a high performance measuring instrument for comprehensive energy and power analysis at single and 3-phase energy systems (e.g. ascertainment of the efficiency of photovoltaic inverters). (4)

## METRAHIT ISO

Multimeter and insulation tester for service applications with adjustable test voltage (50, 100, 250, 500, 1000 V DC) for insulation resistance measurement. (5)

## METRACLIP 41

Current clamp meter for precise contactless measurement of alternating and direct current, as well as complex current waveforms with TRMS value display and automatic zero balancing. (6)



1



2



3



4



5



6

## Technical Data

### Measurements

- Short-circuit current  $I_{SC}$
- Open circuit voltage  $U_{OC}$
- Instantaneous peak power of a solar cell  $P_{max}$
- Internal parallel resistance  $R_p$
- Internal series resistance  $R_s$

### Displayed calculated values

- Peak power  $P_{PK}$
- Internal series resistance  $R_s$
- Internal parallel resistance  $R_p$
- Instantaneous values:  $U_{pmax}$ ,  $I_{pmax}$ ,  $P_{max}$ ,  $U_{OC}$ ,  $I_{SC}$ ,  $FF$ ,  $T_{mod}$ ,  $T_{ref}$ ,  $E_{TRMS}$ , characteristic IU curve diagram

### Features

- Automatic conversion of momentary measured values to STC
- Generator voltage up to 1000 V DC
- Current up to 20 A DC
- Power up to 20 kW
- Power and temperature measurement via 4-wire cable for error-free results

### Memory

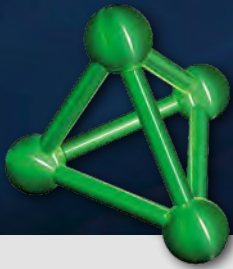
- Internal data memory for up to several thousand measurements
- Integrated module database, bidirectional data exchange with PV Analyzer software (approx. 1000 module types)

### Operation

- Operation via a PC with direct import of measurements is also possible (e.g. for long-term measurements)
- External power pack with broad-range input for charging the batteries / continuous operation of the measuring instrument
- Open interfaces allow for operation of the instrument in special applications as well



Further information regarding the issues of planning, directives, financing, standards, system certification etc. is included in our "PV Guidelines" (3-337-281-03).



# GOSSEN METRAWATT

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