



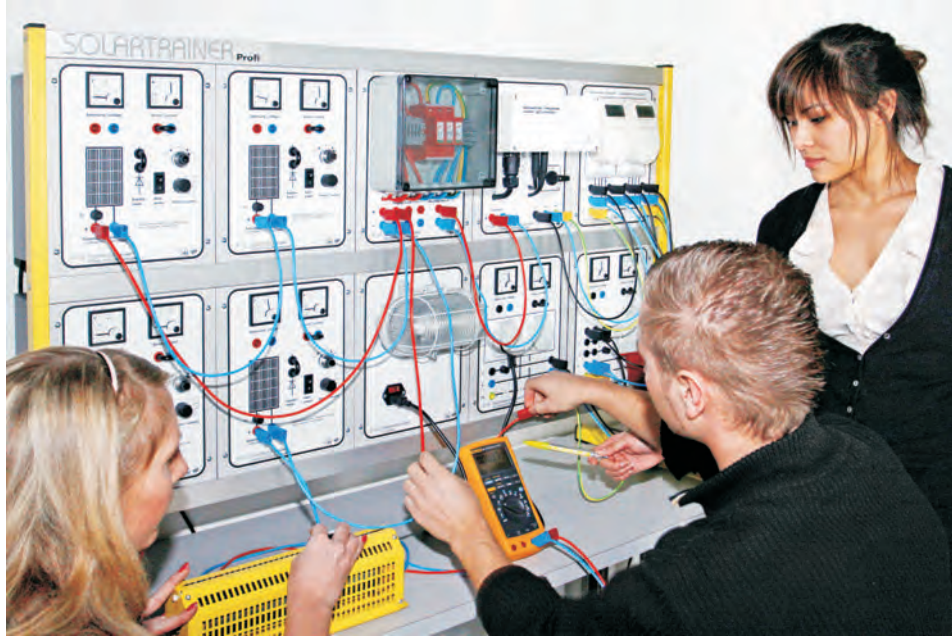
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Photovoltaic – Trainingsystem for vocational and advanced training

The Solar branch is one of the important growth markets of the future. The number of jobs grows, the demand of specialists and executive staffs increases continuously. For this reason worldwide the vocational and advanced training in the field of photovoltaic will become more and more important.



Development

In cooperation with the ISET - Institut für Solare Energieversorgungstechnik e. V. (now: Fraunhofer Institut für Windenergie und Energiesystemtechnik IWES) in Kassel the company IKS Photovoltaik developed the Photovoltaic-Trainingsystem Solartrainer profi.

Application

The PV-Trainingsystem is suited for the instruction at schools, vocational training Schools, training centres, evening classes and universities. Supported learning objectives can be electrical and system engineering, construction, mode of operation, connecting and installation of PV-plants. It can be used both to the supplementary demonstration of lessons and courses as well as for the use in practical training.

Construction

The system consists of individual plugin units each with components for different experimental arrangements. The plugin units are put in the rackside and connected according to the demand. The conception of the system allows indoor and outdoor experiments. Indoor experiments are easily possible among others because of the system included PV-module

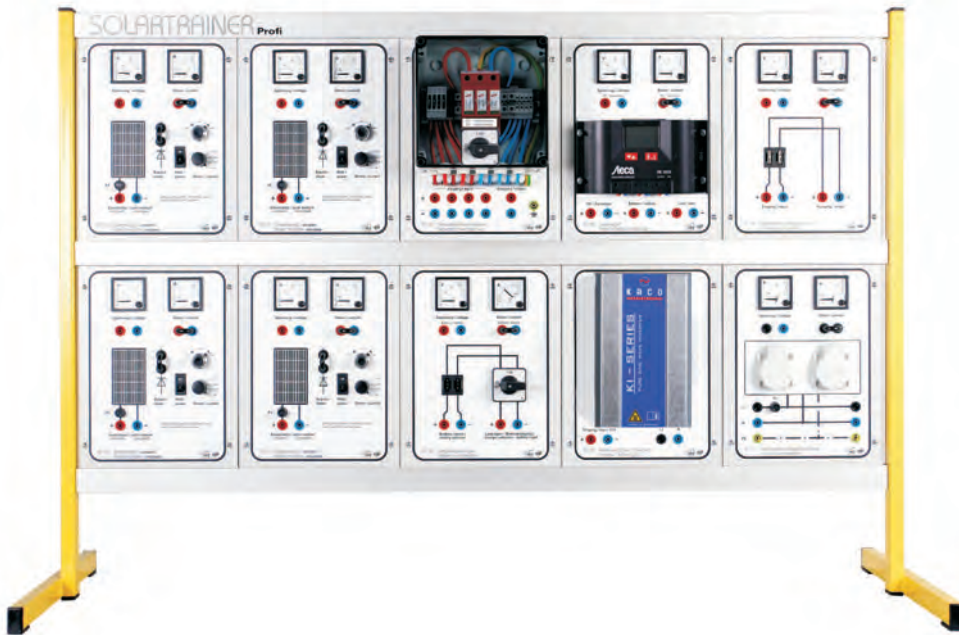
plus module stand. Using a dimmable spotlight which is vertically as well as horizontally movable fixed to an outrigger, seasonal daily curves can easily be simulated.

Additional options are the change of slope angle and the simulation of the influence of irradiation and temperature on the characteristic curve of a PV-module.

To ensure a reproducibility of measurements and not to depend on the weather, a PV-module simulator was developed, which exactly simulates the behaviour of a PV-module. The short circuit current can be adjusted.



What a pupil or trainee can work out on his own in practice oriented lab-scale experiments, is transferable to real systems without problems.



Flexible

The modular conception of the system allows the selection of the plug-in units and components for the different training objectives.

The at any time possible enlargement and integration of new technology assure a system that is always state-of-the-art.

Instructional materials

An experimental instruction as well as two developed training sessions are available.

German
English
Spanish
French

Experiments

The basic principles of photovoltaics considering the influence of different parameters can also be imparted as the application of direct connected small systems, the mains behaviour of stand alone systems and the especially for craftsmen very important line powered operation mode:

- Characteristic curve of a diode, respectively a diode series
- Characteristic curve of a solar module (I/U) and (U/P), MPP
- Characteristic curve of a solar module (I/U) depending on irradiation
- Characteristic curve of a solar module (I/U) depending on temperature
- Power output of a solar module depending On the angle of incidence of the light
- Simulation: Power output of a solar module depending on the position of the sun (morning to evening / winter- and summertime)
- Series connection of solar modules
- Parallel connection of solar modules
- Series connection of solar modules and shadowing without bypass-diode
- Series connection of solar modules and shadowing with bypass-diode
- Grid parallel operation mode
Different operation modes and directions of electric energy power flow. Calculation of the efficiency (inverter)
- Stand alone systems DC and AC. Different operation modes
- Integration of outdoor solar module



The listing does not contain all experiments which are possible to carry out. The possibility of carrying out the experiments is depending on the equipment. Technical changes reserved 2014-06



ST 01
Solar Module
Connection Indoor

For connecting the solar module of "ST 14 module stand" to the socket on the front. The two front sockets of the schematically shown solar module can be connected to a variable load (e.g. ST 20 B). Measuring of voltage and current.



ST 05 O / ST 05 D
Inverter Grid Connection

Transforms direct current into sinusoidal alternating current, single-phase feed-in, line-commutated. Input 28 - 50 V DC, MPP-tracking AC power approx. 110 W
Available versions:
230 V / 50 Hz (ST 05 O / ST 05 D)
230 V / 60 Hz (ST 05 D)
115 V / 60 Hz (ST 05 D)



ST 02
Solar Module Simulated

Solar module simulator for the exact simulation of a solar module.
Short circuit current can be adjusted in steps or variably. Parallel and series connection possible
Switchable bypass diode.
Mains connection 230 V / 50-60 Hz.
Open circuit voltage 23.1 V, short circuit current 0 -1.5 A, rated power 24 Wp



ST 06 R
Inverter Island Grid

Transforms direct current into rectangular alternating current for operation of an island grid system. Input 12 V DC/8 A, output 230 V / 50 Hz.
AC power approx. 100 W



ST 03
Generator Terminal Box

For the parallel connection of 4 solar modules/ simulators each via one diode onto one output. Overvoltage protection
Without function. Max. current per input 24 V/3 A DC-disconnector.



ST 06 S
Inverter Island Grid

Transforms direct current into sinusoidal alternating current for operation of an island grid system.
Input 12 V DC/8 A
AC power approx. 100 W
Available versions:
230 V / 50 Hz
230 V / 60 Hz
115 V / 60 Hz



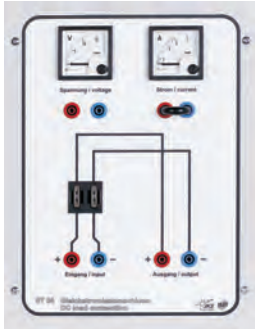
ST 04
Solar Charge Controller

For monitoring of the state of charge state of the battery. Controls the loading process and the connection and disconnection of loads (low voltage disconnection). Operation status on LCD display.
Rated voltage 12 V/max 8 A



ST 07
AC Load Connection

For connection to the mains (via "ST 13 Mains connection) or to an inverter island grid ("ST 06 / ST 06 A") and operation of alternating current loads of max. 450 W
Available versions:
230 V / 50-60 Hz
115 V / 60 Hz



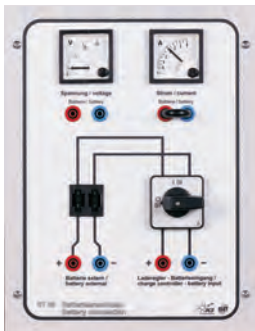
ST 08 DC Load Connection

For connection to "ST 04 solar charge controller" and operation of direct current loads 12 V / max. 8 A



ST 12 Automatic Insulation Unit

For monitoring single-phase power feeding systems. It prevents uncontrolled island effects following failure or shutdown of the public electricity supply. Operating voltage 230 V / 50 Hz



ST 09 Battery Connection

For the connection of "ST 21 solar-battery" to "ST 04 charge controller"



ST 13 Mains Connection

Three-phase AC connection for connection of the public grid via a 5-pole CEE coupling 16 A to the training system. Adapter cable for single-phase available.



ST 10 Electric Meter

Single-phase electronic AC meter for measuring of the generated solar energy. Display of current power, kWh, measurement duration, inputting of tariff possible. Available versions:
230 V / 50 Hz
230 V / 60 Hz
115 V / 60 Hz



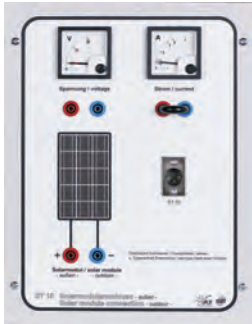
ST 11 Input /Supply Meter

Single-phase electronic AC meters for measuring of the solar energy fed into the grid and for measuring of the energy drawn from the grid. Display same as ST 10. Available versions:
230 V / 50 Hz
230 V / 60 Hz
115 V / 60 Hz



ST 14 Module Stand

For the illumination of a 10 W solar module by means of a 400 W dimmable halogen spotlight. The inclination of the solar module and the height and distance of the spotlight to the solar module are Adjustable. The inclination of the spotlight can also be altered by fine adjustment. The solar module can be swung to simulate the sun's path during the day. Power supply 230 V / 50-60 Hz.



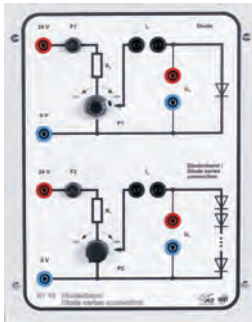
ST 15
Solar Module
Connection Outdoor

For connection of the module "ST 22 Solar Module Outdoor " or similar to the socket on the front. The solar module is connects to the two front sockets of the schematically shown solar module.



ST 19
Set of Safety Test Leads
with movable laboratory stand

Highly flexible safety-test leads with 4 mm plugs. Contacts gold-plated brass/hard copper, inclusive movable laboratory stand with 2 brackets supplied with total 42 holding fingers. Lockable wheels, height 1.45 m



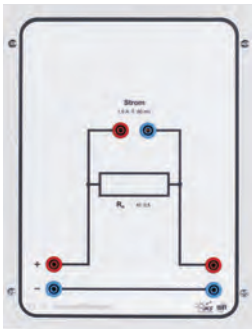
ST 16
Diode Series Connection

To perform the basic experiments "Characteristic curve of a diode" and "Characteristic curve of a diode series connection". Power supply external 24 V DC by "ST 27 Power Supply".



ST 20 AC
AC Load

Panel 1
60 W bulb
Standard plug socket with switch.
Available versions:
230 V / 50-60 Hz
115 V / 60 Hz



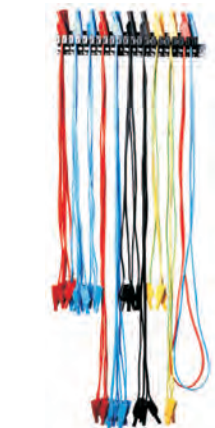
ST 17
Shunt

For measuring current up to 1.5 A as voltage drop at the shunt resistance. E.g. for measurements in grid parallel operation circuits using an oscilloscope.



ST 20 AC
AC Load

Panel 2
60 W bulb.
Standard plug socket with switch.
Available versions:
230 V / 50-60 Hz
115 V / 60 Hz



ST 18
Set of Safety Test Leads

Highly flexible safety-test leads with 4 mm plugs. Contacts gold-plated brass/hard copper, inclusive wall bracket with 21 holding fingers.



ST 20 AC
AC Load

Panel 3
9 W Energy-saving lamp.
Standard plug socket with switch.
Available versions:
230 V / 50-60 Hz
115 V / 60 Hz (15 W)

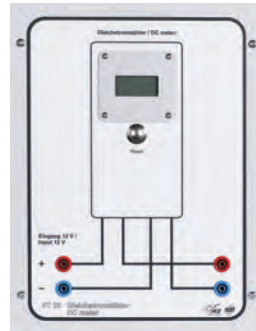
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**ST 20 DC
DC Load**

Panel 4
50 W halogen lamp,
with switch, 12 V.



**ST 23
DC Meter**

Electronic DC meter for
measuring direct current loads.
Using in load circuits.
Display of current power and
Wh, reset button.



**ST 20 RW
Set of electrical loads**

Four variable resistors:
15 Ohm / 5,5 A
170 Ohm / 1,7 A
325 Ohm / 1,2 A
15,8 K.Ohm / 0,17 A



**ST 24
Set Multimeter**

Particularly robust.
Automatic range selection,
large display.
DC / AC max. 1000 V,
max. 10 A



**ST 21
Solar Battery**

Closed lead-gel battery
especially for storing solar
energy. Connected via
"ST 09 battery connection"
to "ST 04 solar charge
controller" for operation of
an island grid with storage.
12 V / 27 Ah C100.



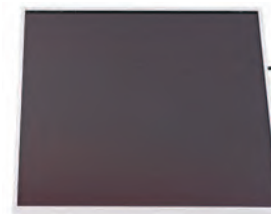
**ST 27
Power Supply**

For the power supply of
"ST 16 diode series connection"
Control range 0 - 30 V DC / 0-2 A
Power supply:
115-230 V / 50-60 Hz.



**ST 22
Solar Module Outdoor**

Solar module for outdoor
experiments. Angle of
inclination adjustable,
can be read off on a large
degree scale
Power 55 Wp
Operation with "ST 15
Solar module connection
outdoor".



**ST 28 Solar Module polycrystalline
ST 28 Solar Module amorphous**

Alternatively additional
solar module for
"ST 14 module
Frame". Quick
change holder.
Power:
Polycrystalline ca. 10 W
Amorphous ca. 5 W

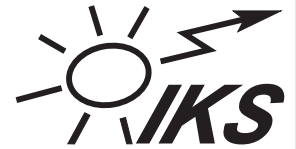


**ST 30
Fuse Box**

Fuse box with 4-pole FI-
circuit breaker, CEE plug
and 1.5 m feed cable with
CEE plug.
400 V / 50 Hz.

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ST 95 Transformer

For the adaption of ST 02 and ST 14 in 115 V-gridss. Inclusive outlet strip 230 V
Transformer 115 V AC to 230 VAC / 500 W



ST 96 Laboratory Table

Laboratory table , lockable wheels.
Serves as a support for "ST 99 take-up frame", incl. fastening screws.
Tabletop 1.25 x 0.62 m, height 0.74 m



ST 99 15 panels Holding Frame

Take-up frame for 15 instruction panels.



ST 99 10 panels Holding Frame

Take-up frame for 10 instruction panels.



ST 97 Basic Photovoltaic Laboratory

Detailed experimental instructions on 12 themes, with solutions. Available in German English Spanish French



ST 98 Instruction Manual

Instructions for all components.
Available in German English Spanish French

Technical changes reserved 2014-06

Reseller

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Training systems
Measurement engineering
Special developments

Some user report on practical experiences:

Technikerschule Butzbach

„Solartrainer Profi has been in use for 15 years completely error-free and without repairs”



Handwerkskammer Münster

Already the prototype won over -
Solartrainer Profi in successful operation since 1997”



Landesstelle Hessen für gewerbliche Berufsförderung in Entwicklungsländern

„Solartrainer Prof for multiplier training”



Bildungsinstitut Pscherer

“Fit for the job: basic and continuing vocational
training with the Solartrainer Profi”



BZ Bildungszentrum Kassel

„Since 1997 more than 500 participants were trained with the Solartrainer Profi”



University of Nairobi

Institute of Nuclear Science and Technology



One device - double benefit: Innovative PV measurement equipment for use at the training system and at real PV plants



The PV training system Solartrainer Profi for vocational education and training was expanded with an innovative Photovoltaic measurement equipment

The background: Today PV plants are working very reliable. Nevertheless they often generate only a part of the maximum possible power. The causes are multiple and it is not rare that they can be traced back before the period of the actual installation. Because even on the way to the installation site micro cracks can arise because of incorrect storage or as a result of incautious transport. The micro cracks cannot be seen with the naked eye, however the consequences have far reaching implications: If water has penetrated or soldered bonds were interrupted the efficiency of solar modules can be noticeably reduced. The financial losses for private operators as well as investors in large solar systems may be substantial. In practice the possibility of monitoring the characteristic curves of single solar modules, strings and the test of complete photovoltaic installations becomes more and more important.

PV vocational education and training

However, this also means that this subject has to be an integral part of the vocational education and training in the field of photovoltaic. A development, that was taken up with our latest product innovation. The well-known PV training system Solartrainer Profi was expanded with a measurement equipment, consisting of an innovative multifunction instrument, remote datalogger with radio transmission, transducer clamps and an ISET Sensor irradiation sensor with dimmable halogen spot for setting of irradiation values, as well as practice-oriented didactic materials.

Double benefit

The particular feature: The newly into the PV training system integrated Photovoltaic measurement equipment can be used afterwards for measurements and tests at real photovoltaic installations. A system with double benefit. Because as always before we have focused on a high practical relevance when selecting the components.

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Profi



Scope of delivery PV measurement equipment

■ Multifunction instrument with tool pocket

Measuring range performance analysis:

Voltage DC: 15,0 V - 999,9 V

Voltage AC: 50,0 V - 265,0 V

Current DC (über Stromzange): 50 mA - 1100 A

Current AC (über Stromzange): 10 mA - 1200 A

Power DC: 1 W - 999,9 kW

Power AC: 1 W - 999,9 kW

Measuring range I-U curve measurement:

Voltage DC: 5,0 V - 999,9 V

Current DC: 0,1 A - 10,0 A

Power DC: 50 W - 999,9 W / 1.000 kW - 9.999 kW

Irradiance (with ST 36) 1,0 mV - 100,0 mV

■ Remote datalogger with radio transmission for irradiance and temperature

■ Transd. clamp DC 10 A / 100 A

■ Transd. clamp AC 5 A / 100 A

■ Training panel

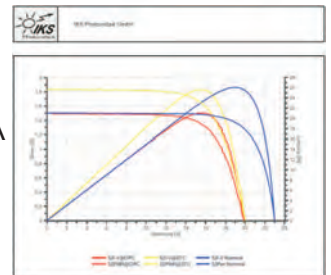
■ ST 36 Solar radiation sensor (sensor removable)

■ Module temperature sensor and ambient temperature sensor -20 bis 100 °C

■ Measuring cables and adapter plugs

■ Data transfer software and evaluation software

■ Experimental instructions



Experiments

■ I-U curve recording of different solar modules

■ I-U curve recording of different solar modules at different irradiation intensities

■ Temperature influence on the I-U curve of different solar modules

■ I-U curve recording of a series connection of solar modules

■ I-U curve recording of a parallel connection of solar modules

■ Shading of a series connection of solar modules without bypass diode, I-U curve recording

■ Shading of a series connection of solar modules with bypass diode, I-U curve recording

■ Photovoltaic plant mains parallel operation, measuring of the inverter efficiency

■ Test of a photovoltaic plant mains parallel operation, measuring also the irradiation and temperature. Measuring of the inverter efficiency, solar modules efficiency and the overall efficiency (performance ratio) and issue of a test report

■ Test of a photovoltaic plant mains parallel operation. Simulation of system failures: PV power too low / irradiation sensor failure / Irradiation value too low for evaluation

■ I-U curve recording and evaluation of a solar module (solar module simulated) also measuring the irradiation and temperature. Detection of underperformance

■ I-U curve recording and evaluation of a string (solar module simulated) also measuring the irradiation and temperature. Detection of underperformance

■ I-U curve recording and evaluation of a solar module (solar module outdoor) also measuring the irradiation and temperature and considering the position of the sun. Detection of underperformance

■ Rapid test on solar modules and strings with and without measuring the irradiation and temperature

■ Measuring the internal resistance of a solar module

■ Reading out and processing of the data with a PC

Subject to technical modifications. Stand: June 2014

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Training systems
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