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SOLARTRAINER **Profi**

ISET

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# Photovoltaic – Trainingsystem for vocational and advanced training

Considering the potential of roof and facade surfaces usable for PV-modules, photovoltaics, particularly for the craft, hold new working areas. The electric and roofer craft will play a decisive role in the dissemination and realisation of this technology. For this reason, particular attention should be given to the school and professional education as well as to the further qualifying training in the field of renewable energies.

## Development

Therefore, in the past years extensive work documents were compiled by the ISET in Kassel and numerous workshops for craftsmen were carried out. These experiences and particularly the wish for more practiceorientation were the reason for the decision to develop a PVtrainigsystem. A prototype was developed as part of academic works at the ISET. In cooperation with the engineering company IKS Kunsch & Schröder GbR as licencee for manufacturing and marketing, a preproduction model was improved and revised for series production.

## Application

The PV-Trainingsystem is suited for the instruction in 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 were put in the rackside and connected according to the demand. The conception of the system allows indoorand outdoor experiments.
Indoor experiments are easily possible among others because of the system included PV-module plus module stand. Using a dimable spotlight, which is vertical as well as horizontal 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.
High attention was paid to use highgrade components and materials like the crafts man would use for real PV plants.

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

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**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 assur a system that is always state of the art.

**Instructional materials**
An experimental instruction as well as two developed training sessions are available.
(at the time only in German language)

**Contents of the 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 crafts men 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 modul 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
- Line powered operation mode: solor energy is fed via inverter (changes solar DC into sinusodial AC, singlephase) to the mains. Different constellations of power flowing in the system. Calculation of efficiency (inverter)
- Stand alone systems DC and AC. Solar charging controler, battery, stand-alone inverter, DC and AC loads. Different constellations of power flowing in the system
- Integration of outdoor solar module
- Measurement with PC, data storage

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.

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**ST 01**
**PV-module connection indoor**

For connecting the solar module from "ST 14".
Analogous voltmeter, ammeter

**ST 02**
**PV-module simulator**

For exact imitation of a PV-module, mains-fed 230 V AC.
Output DC:
Voc = 23,1 V
Isc = 0 - 1,5 A
Pmax = 24 W.
Short circuit current can be adjusted in three steps or continuously. Switchable bypass-diode.
Analogous voltmeter, ammeter

**ST 03**
**PV-module terminal box**

For parallel connection of 4 solar modules / simulators over diodes to one output.
Excess voltage protection not operable.

Power rating 24 V/ 3 A each input

**ST 04**
**Solar charging controler**
Controls the charging of the battery “ST 21” and loads, deep discharge control, visualisation of operating status and key values.
Nominal voltage 12 V DC, max. current 8 A DC.
Analogous voltmeter, ammeter

**ST 05**
**DC / AC inverter / mains parallel operation**

Changes DC into sinusodial AC, singlephase feeding, linecommutated.
input = 24- 35 VDC / 3A
output = 230 V AC
Pmax = 110 W

**ST 06**
**DC / AC inverter / stand-alone operation**

Changes DC into rectangular AC to create a stand alone mains.
input = 12V DC / 3A
output 230V AC
Pmax = 100 W.
Analogous voltmeter, ammeter

**ST 06A**
**DC / AC inverter / stand-alone operation**

Changes DC into sinusodial AC to create a stand alone mains.
input 12V DC / 3 A
output 230V AC
Pmax = 100 W.
Analogous voltmeter, ammeter

**ST 07**
**AC load connection**

For connecting with the mains via "ST 13”, two 230 V AC sockets for AC loads, max. 450 W.
Analogous voltmeter, ammeter

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**ST 08**
**DC load connection**

For connecting DC loads in stand alone systems, two 12 V DC sockets for DC loads, max. 100 W

**ST 13**
**Mains connection**

Threephase AC -grid connection to connect the trainingsystem with the mains.
Five-pin plug CEE 16 A
Fuse 2 A. Analogous voltmeter, ammeter

**ST 09**
**Battery connection**

For connecting a solar batter
“ST 21” with "St04”.
The battery can be switched
Analogous voltmeter, ammet
bidirectional

**ST 14**
**PV-module stand**

The halogen lamp 500 W (mains connection 230 V AC) with dimmer switch is vertical as well as horizontal movable fixed to an outrigger and irridiates the PV-module. Adjustable angle of inclination of the PV-module.
PV-module
Pmax = 10 W, monocrystalline.
Stand with 4 rolls with stop-function

**ST 10**
**Electronic AC electricity mete**
**1x input, 1x output**

For measuring the via inverter generated solar energy.
Measuring kWh, W, time, different tariffs can be selected

**ST 11**
**Electronic AC electricity meter, 2x input, 2x output**

For measuring the via inverter fed solor energy to the mains and the supplied energy from the mains.
Measuring kWh, W, time, different tariffs can be selected

**ST 15**
**PV-module connection outdoor**

For connecting the solar module from "ST 22”.
Analogous voltmeter, ammeter

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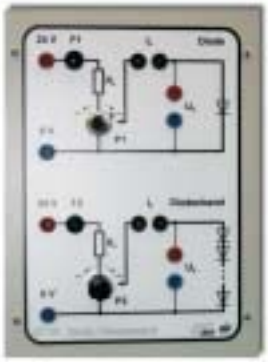

**ST 16**
**Diode / diode series**

For recording the characteristic curve of a diode, respectively a diode series.
Input 24 V DC, max. 1 A (power supply ST 27)

**ST 17**
**Shunt**

Max. current 1,5 A

For measuring with “ST 05” mains parallel operation / connecting with an oscilloscope

**ST 18**
**Set of safety connecting / measuring cords**

Highly flexible safety cords, 4 mm. Contacts brass / hard copper gold plated.
Bracket with 21 consoles for wall mounting

**ST 19**
**Movable laboratory stand and set of safety connecting / measuring cords**

Highly flexible safety cords, 4 mm. Contacts brass / hard copper gold plated.
Bracket with 21 consoles mounted, 4 rolls with stop-function

**ST 20**
**Set of electrical loads, consisting of:**

1 x variable resistor 378 Ohm / 1,3 A
1 x variable resistor 148 Ohm / 1,6 A
1 x variable resistor 12,8 K.Ohm / 0,16 A
1 x variable resistor 13,1 Ohm / 6 A

**ST 20**
plug-in units
2 x AC load 230 V, 60 W lamp
1 x AC load 230 V, 11 W energy saving lamp
1 x DC load 12 V, 50 W halogenlamp

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**ST 21**
**Solar battery**

Closed lead-gel battery specific for storage of solar energy.
Connecting with "ST 09" and "ST 04" to build a stand-alone system

**ST 22**
**PV-module outdoor**

For outdoor experiments.
Adjustable angle of inclination of the PV-module, mounted on a frame with two wheels.
Output DC:
Voc = 20,8 V
Isc = 3,6 A
Pmax = 56 W
Type polycrystalline

**ST 23**
**Electronic DC electricity meter, 1x input, 1x output**

For measuring energy in DC mains (one direction)
Measuring W

**ST 27**
**Power supply**

Mains connection 230 V AC, output 0 - 30 V / 0 - 2 A DC, for use with "ST 16 "

**ST 28**
**PV- module polycrystalline**

10 W, with alternate mounting system (for Pos. 14), incl. connection cord and plug

**ST 29**
**PV- module amorphous**

5 W, with alternate mounting system (for Pos. 14), incl. connection cord and plug

**ST 30**
**Safety box**

with false current cut - out ( 4 - pole ), CEE five-pin plug and 1,5 m connecting cord.
With CEE five-pin socket.
For connecting with mains and “St13”

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**ST 34**
**Solar integrator + counter**

for connecting with a solar irradiation sensor (ISET-Sensor), LCD - display, recording of irradiation, temperature, current ( shunt ), ampere - hours, operation as stand - alone device ( data - logger ) or via RS 232 port and PC

**ST 35**
**Software**

for the graphic representation of the measured values, ST 34, incl. RS 232 cord

**ST 97**
**Experimental introduction**

At the time only in German language

**ST 98**
**Instruction manual**

At the time only in German language

Subject to alteration. State: 08/2006

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# SOLARTRAINER junior

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## Photovoltaic - Experimental kit for teaching in schools

The available experimental materials allow the carrying out of all basic experiments in the field of photovoltaics.
Cause the experiments were built up modularly the adaption to the actual teaching is possible according to the requirement.

The materials are arranged clearly and optically attractive in a specific yellow suitcase. Everything is always completely at hand, extra material is not necessary.
The experiments can be fast built up and removed.
The pupils are able to carry out the experiments by themselves with help of of the easily understandable experimentation instruction.
The teacher gets further informations to solve the exercises and to understand the physics.


Supported financially by the German Federal Ministry for education, science, research and technology.
Identification-number 0329841C

**With the set of equipment supplied, the following experiments are possible:**

- Measuring of the irradiance of different light sources
- Solar cell as a energy converter
- Solar cell as a energy converter and diode function
- Open circuit voltage of a solar cell at different shadowing conditions
- Short circuit current of a solar cell at different shadowing conditions
- Open circuit voltage and short circuit current of a solar cell at different irradiance
- Short circuit current of a solar cell depending from angle of incidence of the light
- Series connection of solar cells / different shadowing conditions
- Parallel connection of solar cells / different shadowing conditions
- Characteristic curve of a solar cell (I/U) / different irradiance
- Characteristic curve of a solar cell (U/P), MPP, figur out of the efficiency
- Simulation: Short circuit current of a solar cell depending from position of the sun (sunrise to sunset)
- Charging a GoldCap / accumulator with solar cells
- Discharging a GoldCap / accumulator with electric motor and light bulb
- Build up of a stand alone operation net

**With extension kit - measurement with PC:**

- Characteristic curve of a solar cell (I/U) / different irradiance
- Demonstration of an inverter (sinwave / rectangular)
- Charging a GoldCap / accumulator with solar cells, discharging a GoldCap / accumulator with electric motor and light bulb

# SOLARTRAINER *junior*

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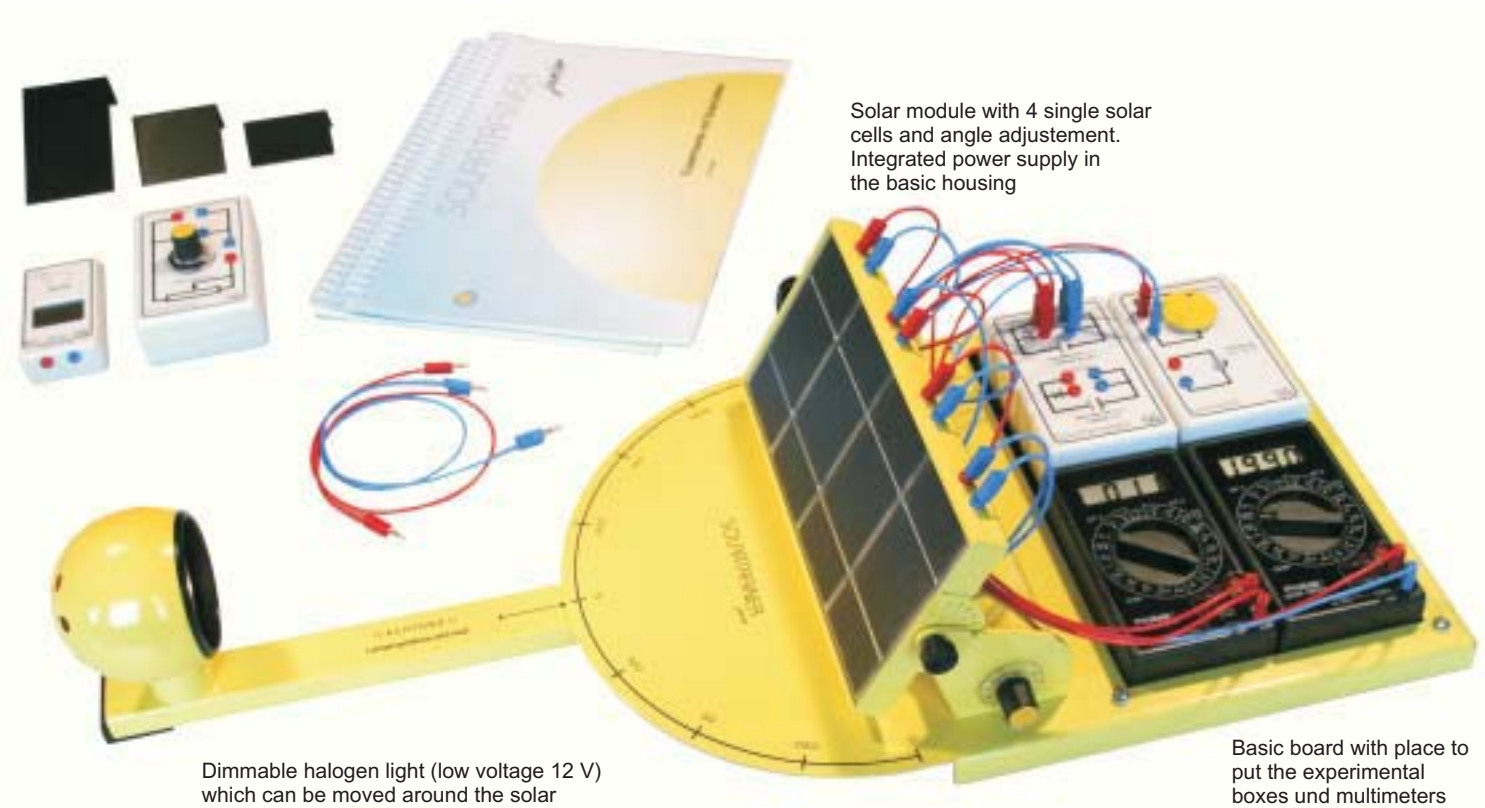

Solar module with 4 single solar cells and angle adjustement. Integrated power supply in the basic housing

Dimmable halogen light (low voltage 12 V) which can be moved around the solar module in a semicircle, disconnectable for experiments with sun light

Basic board with place to put the experimental boxes und multimeters

**Set of equipment supplied:**

- Specific yellow suitcase with shaped part made of foam plastic
- Basic board with place to put the experimental boxes und multimeters
- Low voltage (12 V ) halogen lamp
- Power supply with dimmer switch, power cable (mains fed, input 230 V AC 50 Hz, output 12 V AC)
- Solar module with 4 single cells and angle adjustement
- 2 multimeters with 2 mm connectors
- Sensor box for measuring irradiance
- Load box with electric motor and light bulb
- Storage box with NC accumulator and GoldCap and blocking diode
- Measuring box with variable resistor
- Connecting cords, high flexible, contacts brass / hard copper gold plated
- Experimental instruction / documentation for teacher

**Optional extension kit:**

- PC measuring box
  Inverter box
  Interface cable
  Software (running under WINDOWS)

Subjekt to alteration. Pictures partially with optional extra.
State: 08/2006

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# WINDTRAINER junior

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## Windenergy - Experimental kit for teaching in schools

The available experimental materials allow the carrying out of all basic experiments in the field of windenergy.
Cause the experiments were built up modularly the adaption to the actual teaching is possible according to the requirement.

The materials are arranged clearly and optically attractive in a specific white suitcase. Everything is always completely at hand, extra material is not necessary.
The experiments can be fast built up and removed.
The pupils are able to carry out the experiments by themselves with help of of the easily understandable experimentation instruction.
The teacher gets further informations to solve the exercises and to understand the physics.


**With the set of equipment supplied, the following experiments are possible:**

- Measuring of the wind force in the vicinity of the school
- Measuring of the wind force of the wind machine dending from the adjustement of the control knob
- Power output of the generator depending from the shape of the wing (even / curved)
- Power output of the generator depending from the number of wings (2, 3 , 4)
- Power output of the generator depending from the position (angle) of the wing
- Characteristic curve of a generator (U/) at constant speed
- Characteristic curve of a generator (U/). Measuring the resistance- and buoyancy rotor at constant wind force
- Power output of the generator depending from the wind force
- Charge of an akku/Gold Cap with the generator
- Discharge an akku/Gold Cap with different loads
- Build up of a stand alone operation net

**With extension kit savonius rotor:**

- Characteristic curve of a savonius rotor(U/) at constant speed
- Power output of the savonius rotor operating with and without aperture

# WINDTRAINER *junior*

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**Set of equipment supplied:**

- Specific white suitcase with shaped part made of foam plastic
- Basic board with place to put the experimental boxes und multimeters
- Wind machine with controllable power supply
- Wind power plant with with axial rotor, generator without gear, with tacho generator, hub for mounting 2, 3, and 4 wings, angle of the wings adjustable
- 4 wings even, 4 wings curved
- Pprotection cover, wind shield, tool
- 2 multimeters with 2 mm connectors
- Anemometer
- Load box with electric motor and light bulb
- Storage box with NC accumulator and GoldCap and blocking diode
- Measuring box with variable resistor
- Experimental instruction / documentation for teachert

**Optional extension kit:**

- Savonius-Rotor

Subjekt to alteration. Pictures partially with optional extra.
State: 08/2006

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# $H_2$-TRAINER junior

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## Hydrogen - Fuel Cell Experimental kit for teaching in schools

The available experimental materials allow the carrying out of all basic experiments in the field of Hydrogen - Fuel Cell technology.
Cause the experiments were built up modularly the adaption to the actual teaching is possible according to the requirement.

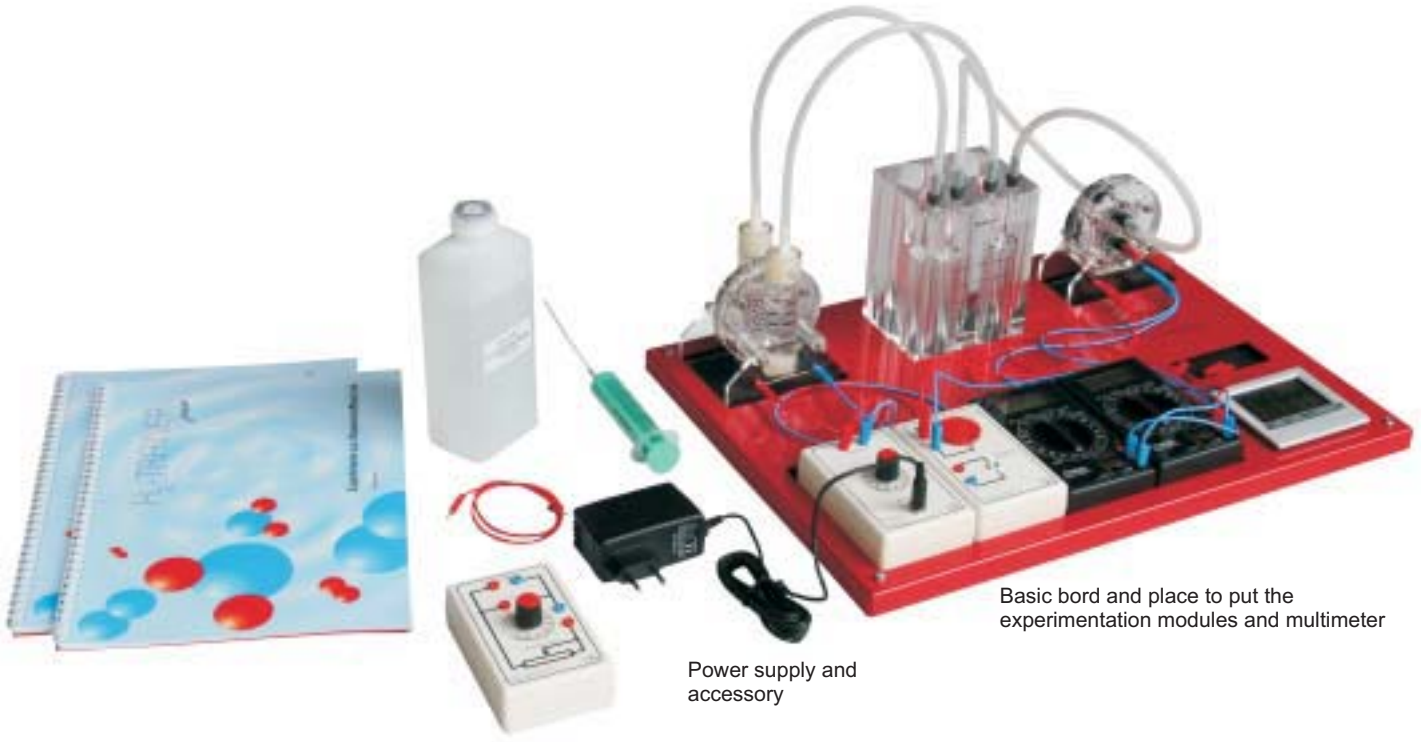
The materials are arranged clearly and optically attractive in a specific red suitcase. Everything is always completely at hand, extra material is not necessary.
The experiments can be fast built up and removed.
The pupils are able to carry out the experiments by themselves with help of of the easily understandable experimentation instruction.
The teacher gets further informations to solve the exercises and to understand the physics.


**With the set of equipment supplied, the following experiments are possible:**

- Measuring of the volume ratio of the generated gases
- Measuring of the generated volumes of the gases per unit of time depending from the current
- Determination of the power effiency and the Farady efficiency of the elektrolyser
- Determination of the U/I- characteristic of the elektrolyser
- Determination of the power effiency and the Farady efficiency of the fuel cell
- Determination of the U/I- characteristic of the fuel cell
- Build up of a stand alone operation net
- In combination with the Solartrainer junior: Operation of the elektrolyser with solar cells
- In combination with the Windtrainer junior: Operation of the elektrolyser with windenergy
- In combination with the Solartrainer junior and the Windtrainer junior: Operation of the elektrolyser with solar cells and windenergy as a hybrid system

# $H_2$-TRAINER *junior*

Elektrolyser, gas storage and fuel cell



Basic bord and place to put the experimentation modules and multimeter

Power supply and accessory

**Set of equipment supplied:**

- Specific red suitcase with shaped part made of foam plasticl
- Basic board with place to put the experimental boxes und multimeters
- Elektrolyser
- Power supply
- Current control box
- Gas storage
- Fuel cell
- 2 multimeters with 2 mm connectors
- Load box with electric motor and light bulb
- Measuring box with variable resistor
- Connecting cords, high flexible,contacts brass/ hard copper gold plated
- Connecting hoses / caps
- Destilled water
- Syringe
- Experimental instruction / documentation for teachert

Subjekt to alteration. State: 09/2006

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# ComBox

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## Hardware / software system for PC - based measuring and controling

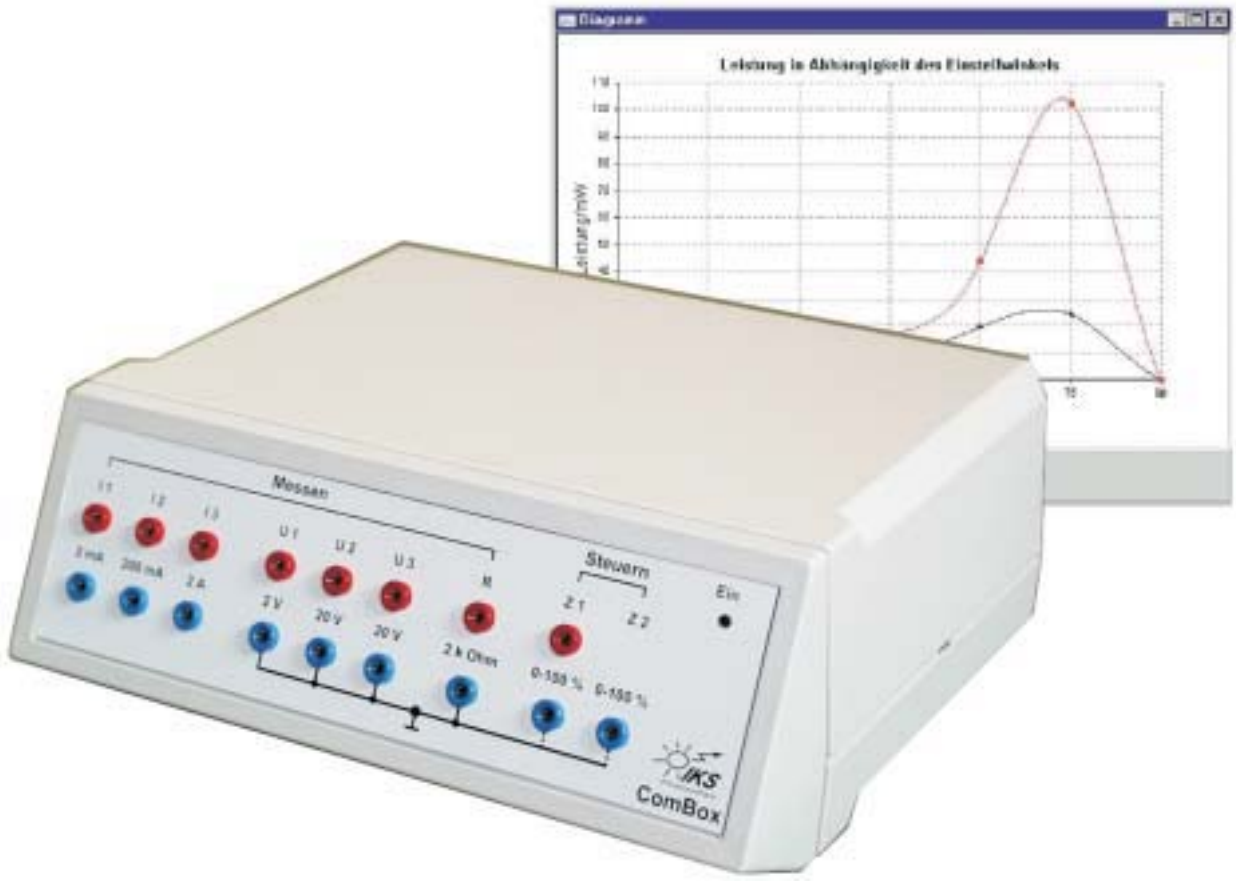
The **ComBox** is ideal for easy data recording and evaluation of experiments of the experimental-kits SOLARTRAINER junior, WINDTRAINER junior and $H_2$-TRAINER junior.

For the experiments there are templates and it is of course possible to create own templates.


The **ComBox** , software-CD, interface cable as well as test- and adapter cables and the operating manual are kept in a special case.

The material is always completely at hand, extra material is not necessary.

# ComBox




**Scope of delivery:**

- Specific black suitcase with an inset of shaped Foam material
- ComBox with power supply inside,
  RS 232- interface.
  Input current: 2 mA / 200 mA / 2 A
  Input voltage: 2 V / 20 V / 20 V
  Resistance: 0 - 2000 Ohm
  Control output:
  Z1: controllable power source 0 - 12 V DC / 25 W
  Z2: controllable resistance
- Power cable
- Connecting cable, high flexible, contacts brass / hard copper gold plated
- Adapter cable for WINDTRAINER junior
- Software
- Manual

Subjekt to alteration. State: 07/2006

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# Energie Check
**Profi**

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## Measurement equipment

For energy consultants, caretakers, consulting engineers and environment issues manager the ideal tool for building diagnostics and room air analyses.
Furthermore there can be made analyses in the field of water consumption, lighting and energy consumption of electrical appliances.

The measurement devices are arranged clearly and optically attractive in a specific green suitcase. Everything is always completely at hand, extra material is not necessary.
With the set of equipment supplied, the following measurements are possible:

**Room air quality**

With the high-class multi measuring device and a multible sensor the $CO_2$-concentration, relative air humidity, indoor temperature and the absolute air pressure can be measured contemporaneously.
The values were displayed on a big LCD-display and can be logged optionally.
With the relative air humidity and the indoor temperatur it is possible to determine the dew point temperatur tabularly.

**Surface temperatur**

With the infrared thermometer it is possible to measure surface temperatures contactless.
The wall temperatur can be inspected of critical dew point temperatures (mildew potential).

**Illuminance level**

With the lux meter living areas and workplaces can be inspected of adequate and evenly distributed illuminance level - which is prerequisite for a non fatigue seeing.

This way it is possible to detect deficiencies and wasteful illumination can be avoided.

**Water consuption**

With the flow rate meter the water consumption at every spigot can be determined.

**Energy consumption of electrical appliances**

With the energy meter the energy consumption of electrical appliances can be determined as well as the energy costs.

**Room dimensions**

Longitudes, areas and volumes can be measured comfortable and contactless with the electronic distance meter.

# Energie Check
**Profi**

Content:

1 Lux meter digital
Effective range 0 - 50.000 Lux, value-hold-function, sensor external with spiral cable.
Metering precision +/- 5% + 2 digits

2 Enery cost meter digital
Measuring of energy, power (Effective, apparent and idle power), voltage, current, power factor, frequency, measuring duration, duty cycle, costs, min. / max. values, cost prognosis and more features

1 Flow rate meter
Effective range 1 to 25 l/min, actual value can be read off directly on the scale

1 Infrared digital themometer
Contactless measuring with two point laser targeting, diplay of measuring spot size, Effective range -30 ...+400 C°, Emission factor adjustable 0,2 ... 1,00, lighted display, value hold function

1 Electronic distance meter digital
Effective range 0,6 ... 20 m, with laser pointer, Measuring of longitudes, aereas and volumes, memory, adding up function,
Metering precision +/- 0,5%

1 Multi measuring device
With multible sensor (IAQ sensor) for measuring of
$CO_2$- concentration 0 .. + 10.000 ppm
Temperatur 0 .. + 50° C
Relative air humidity 0 .. + 100 %
Absolute air pressure + 600 .. 1.150 hPa
Big digital LCD display,
With data logger,
Set up of up to 99 measuring localities

1 Power supplyl

1 USB interface cable

1 Software

1 Set of short instructions

Subjekt to alteration. State: 09/2006

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# Energie Check *junior*

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## Measurement equipment

For projects in schools the ideal measurement equipment to deal with energy-saving, room-air condition, water consumption, room lighting and energy consumption of electrical appliances.

The measurement devices are arranged clearly and optically attractive in a specific green suitcase. Everything is always completely at hand, extra material is not necessary.
With the set of equipment supplied, the following measurements are possible:

**Room air quality**

With the two digital temperature-humidity-meters the relative air humidity and the air temperature can be measured.
The measured values were displayed on a LCD-display, also it is possible to log the datas.
With the relative air humidity and the air temperature it is possible to determine the dew point temperature.
The data can be read out by the RS-232 -interface with the enclosed software.

**Surface temperature**

With the digital precision temperature meter it is possible to measure surface temperatures, water and air temperatures.
The wall temperature can be inspected of critical dew point temperatures (mildew potential).

**Indoor and outdoor temperatur**

With the two digital temperature meters the indoor and outdoor temperature can be measured just as the min. and max. values.

With the two analog temperature meters the air temperature and the min. and max. values can be measured.

**Illuminance level**

With the lux meter class-rooms and laboratory areas can be inspected of adequate and evenly distributed illuminance level - which is prerequisite for a non fatigue seeing.
This way it is possible to detect deficiencies and wasteful illumination can be avoided.

**Water consuption**

With the flow rate meter the water consumption at every spigot can be determined.

**Energy consumption of electrical appliances**

With the energy meter the energy consumption of electrical appliances can be determined as well as the energy costs.

# Energie Check *junior*

Content:

1 Lux meter digital
Effective range 0 - 50.000 Lux, value-hold-function, sensor external with spiral cable.
Metering precision +/- 5% + 2 digits

1 Precision digital thermometer
External sensor for measuring of surface, water and air temperatures
Effective range -199,9 ...+199,9 C°,
Resolution 0,1° C
Precision 0...100° C: 0,1°C +/- 1 digit

2 Enery cost meter digital
Measuring of energy, power (Effective power), voltage, measuring duration, duty cycle, costs, min. / max. values, cost prognosis and more features

1 Flow rate meter
Effective range 1 to 25 l/min, actual value can be read off directly on the scale

2 Temperatur humidity meter digital
Effective range temperatur: 0 .. + 59,9° C,
Metering precision +/- 0,5 °C
Effective range relative air humidity: 1 .. 99 %
Metering precision +/- 3%
Time (DCF-77 signal)
Min.-/ Max.- values
Preset of alarm values possible
Average values
Dew point temperatur
Big digital-LCD-display,
Data logger, up to 3.000 values,
memory, time interval selectable
RS 232 - interface
Foot to put up

2 Interface cable

1 Software to read out, data export and processing with other software possible

2 Indoor - outdoor temperatur meter digital
External sensor for measuring of the outdoor temperature,
Cable length 3 m
Effective range indoor temp. -10 ...+60° C
Effective range outdoor temp. -50 ...+70° C
Min- / Max. - values
Big digital-LCD-display

2 Indoor temperatur meter analog
Effective range -35 ...+50° C
Min- / Max. - values, reset

1 Set of short form instructions

Subjekt to alteration. State: 09/2006

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# Energie Check
## home

## Measurement equipment

The containing measurement devices are for analyses in the field of room air condition, water consumption of washing machines, dishwashers as well as the energy consumption of these and other household applicances.
Also the hardness of water can be specified.

Inhalt:

2 Enery costs - meter
1 Water meter for spigots
1 Open-end wrench for water meter
1 Digital-temperatur-humidity-meter
1 Receptacle with 100 test strips for specifiying the hardnes of water
1 Set of short instructions

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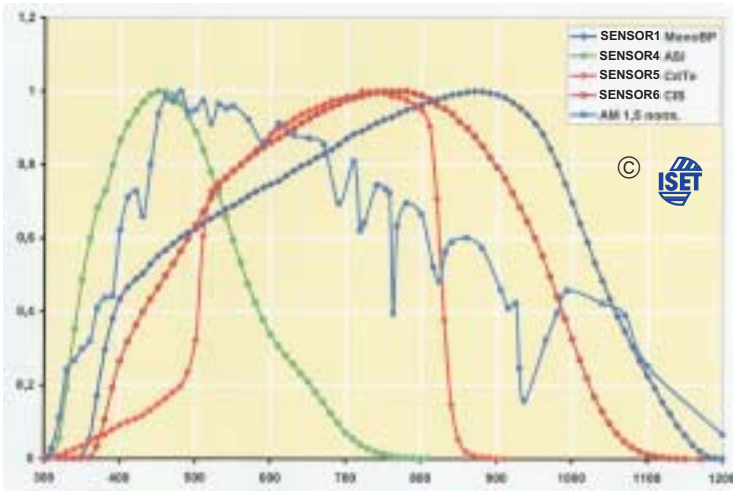
# ISET *Sensor*

## Solar radiation sensor ISET *Sensor* - high-quality technique of measurement for the mass market

### The new ISET *Sensor*

Photovoltaic plant system operators want to have simple, quick and dependable information about the function of their PV-plant . Thermoelectric radiation sensors are not to compare without further ado with a real PV-generator with respect to the "energy yield" because of their different spectral sensitiveness as well their different reflection- and temperature characteristics.
In addition you have the relatively high acquisition cost.
In the contrast to this, the radiation sensors of the lower price category do not fulfill the long-term accuracy requirements and may find because of their "low-cost equipment ", in particular in the field of buildings, low or no acceptance.
The solar cell sensor **ISET *Sensor*** eliminates these deficits. It fits well to the physical characteristics of the solar generator . The simple and compact but nevertheless precise construction predestine it for use in field instrumentation.
With the new housing design it gains the necessary acceptance in the technical services for facilities as well as in the general field of architecture.




Wavelength [nm]

Spectral sensitivity of different **ISET *Sensor*** sensors under AM 1,5 (normalized).

### Technical features of the ISET *Sensor*

The solar radiation is converted into a proportional current by an exact defined solar cell . Via a specific shunt resistance which is coupled thermally to the compact aluminum housing, the measured voltage is determined.
The almost identical geometrical construction of the test cell comparable with PV modules as well as the specifically formed housing with possibilities of outside temperature link-up and high weather resistance assure repeatable results of measurement.
A Pt 1000 - temperature sensor registers the cell temperature over a two-wire data line with high measuring accuracy.
The calibration of every **ISET Sensor** occurs with a reference element constructed in an identical fashion from an accredited test laboratory in W/m² and is documented on a quality assurance calibrating certificate.

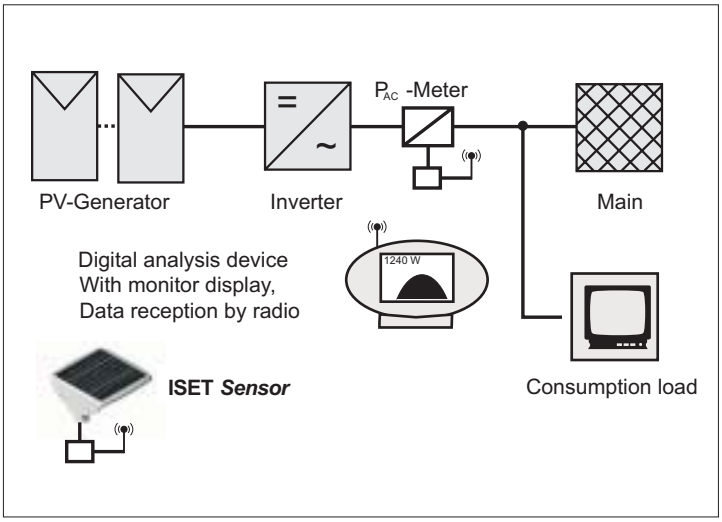
It is explicit visible and derivable that for the energetical rating and monitoring of a PV-plant should only be used the same technology of the sensor and the PV-plant because of the different spectral sensitivity of the different technologies.
Further there are the same physical characteristics regarding temperature, reflection and degradation.

With the **ISET *Sensor*** for each photovoltaic technology the suitable radiation sensor is deliverable.

# ISET *Sensor*

## Monitoring concept

Using the **ISET *Sensor*** in a new Monitoring concept, that is also examined in the ISET test laboratory, the received radiation power measured on the PV generator level is compared with the output (AC) generated by the PV system. The comparison quotient represents a functional and quality parameter for the PV -plant in simplest way.
By the implementated evaluation logic, solar module manufacturers, traders and even electricians for the first time receive via the cumulated energy output an insight into a simplified "course of life documentation" of their products. In this way, questions about a "guaranteed" energy output are discussed more reasonable, the energy output will be provable.




**ISET *Sensor*** monitoringsystem (in preparation)

## Technical data ISET *Sensor*

### Housing
- Aluminum, powder coating in facade quality, color is silvery grey *
- Mounting with two nuts M 5 backside
- Housing pressure balance by means of a special membran.

### Connecting cable
AWG 26, shielded, black, length 3m *
Plug connected

### Available solar cell sensors *
- monocristalline
- polycrystalline
- EFG
- amorphously
- CdTe**
- CIS**

Embedded under clear glass hardened thermally or embedded like solar module

### Measuring voltage
- about 100 mV (cal.val.) /1000 W/m², 25°C
- Specific shunt resistance coupled thermally to the case.

### Calibration
The calibration of every **ISET *Sensor*** occurs with a reference element (quality grade A, constructed in an identical fashion) from an accredited test laborator in W/m² by ISET / Kassel.
A calibrating printout according to EN 45001 documents the product specific parameters.

The relative measurement uncertainty is ±4% (cryst.mat.) / ±5% (am. mat.) The measurement uncertainty refer to a confidence level of 1-alpha =95%.

### Temperature sensor
Pt 1000, embedded or bond axially under the cell

### Operating temperature range
-25° to + 80° C

* other versions according to customer preference (minimum quantity)
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# VisiKid

Fachhochschule Münster University of Applied Sciences

IKS Photovoltaik

## Child oriented readout system for visualization of energy yields from photovoltaic plants

### Photovoltaic plants as shining examples on the roofs of kindergartens and schools

The possibility to convert sunlight with solar cells directly into electric power, makes the photovoltaic to one of the popularest renewable energies.
It is for this reason that photovoltaic plants were installed enhanced on kindergartens and schools.
Apart from the aspirated example function the kids should familiarized with renewable energies.

### Visualization not as yet child oriented

For visualization of the energy yields of photovoltaic plants typically the “standard solution” is used:
A large sized digital display to display the actual power and the total fed electric power to the mains.
But by and by the display gets tieded to the most of the kids also beause it is not really plain.

### New concept of a visualization

On that score from the University of Applied sciences Münster a new concept of a visualization was created within the scope of a diploma thesis.
The preproduction model was developed by the company IKS Photovoltaik as a licence partner.


**The actual electric power** is displayed analoguesly by means of 24 symbolic incandescent lamps (inside LED), because kids know electricity above all from incandescent lamps in their everyday life.
The higher the actual output of the photovoltaic plant is the more lamps are in operation.

**The monthly fed in energy is displayed** analoguesly by red balls, which were transported by the sun wheel into the catch tank. The number of balls transported depends on the energy fed into the mains. At the end of the month the balls were filled back into the above storage tank and the digital display for the monthly energy yield is set to zero.

**Digital displays** for the actual power, the monthly and the total energy yield are there additionally.

The system is preferably for wallmounting in public areas of entryways.

Awarded with the „Special prize for the most interesting exhibit“ by the conference jury of the 20th symposium of photovoltaic solarenergy 2005 in Staffelstein / Germany.

# VisiKid

Fachhochschule Münster University of Applied Sciences

IKS Photovoltaik

## Kinder sehen, wie der Strom vom Himmel fließt

FH-Professor erhält Preis Visualisierung der „Stromernte" / Vermarktung

Burgsteinfurt. Wenn die Sonne kräftig scheint, laufen alle 24 Lämpchen auf der Schautafel und eine Sonnenuhr schaufelt für jede gewonnene Kilowattstunde der Solaranlage zwei Holzperlen in eine „Batterie". So soll die „Stromernte" der Solaranlage auf dem Dach auch schon für Kindergartenkinder begreifbar werden.

Entwickelt worden ist die so genannte VisiKid-Anlage unter Leitung von Prof. Dr.-Ing. Konrad Mertens am Fachbereich Elektrotechnik und Informatik der Fachhochschule in Burgsteinfurt. Der Hochschullehrer hat die Anlage jetzt auf einer Photovoltaik-Konferenz in Bamberg vorgestellt und ist mit einem Sonderpreis für das interessanteste Exponat durch die Konferenz-Jury ausgezeichnet worden. Zudem konnte sich der Wissenschaftler vor Nachfragen und Bestellwünschen kaum retten.

„Nun stellte sich uns die Frage, wie wir mit dem offensichtlich hohen Vermarktungspotenzial umgehen sollten", betont Mertens. Da sich der Wissenschaftler aber in der Rolle des Ideengebers als in der des Produzenten sieht, lag es nahe, die Anlage durch einen Lizenznehmer produzieren und vermarkten zu lassen. Mertens hat nun mit dem Unternehmen IKS-Photovoltaik in Kassel einen Lizenzvertrag für die Produktion von VisiKid abgeschlossen.

Angefangen hatte die Entwicklung mit der Bitte eines Emsdettener Kindergartens. Dort sollte die Stromerzeugung der Solarstromanlage auf dem Dach für die Kinder erlebbar werden. Der Hochschullehrer und Leiter des Labors für Optoelektronik und Sensorik nahm sich der Sache an und entwickelte das Konzept „VisiKid – Kindgemäße Visualisierung von Solarstromerträgen".

Ein erster Prototyp, der seitdem den Emsdettener Kindern die Solarenergie erklärt, ist während einer Diplomarbeit entstanden. Die jeweilige elektrische Leistung der Anlage signalisieren bis zu 24 Energie sparenden Leuchtdioden. Gleichzeitig zeigen Holzkugeln, die durch ein mittels Mikrocomputer gesteuertes Zahnrad in einem Behälter befördert werden, die erzeugten Kilowattstunden an. IKS-Geschäftsführer Holger Kunsch gibt sich optimistisch: „Das Konzept ist bereits eine gute Grundlage für unsere Weiterentwicklung. Wir gehen davon aus, dass wir schon in Kürze mit der Serienproduktion beginnen können." Auch Prof. Mertens freut sich, „dass diese Entwicklung auf ein solches Interesse stößt." Darüber hinaus könnte über die Lizenznahmen die Ausstattung im Labor verbessert werden.

Die Geschäftsführer von IKS Photovoltaik Holger Kunsch und Michael Schröder sowie Prof. Dr.-Ing. Konrad Mertens von der FH (v.l.) besiegelten per Händedruck den Lizenzvertrag.

**Technical specifications:**

- Dimensions: 1036 x 836 x 146 mm
- Weight: 12 kg
- Power supply 230 V / 50 Hz / 12 V DC
- Digitale LCD display
  -Actual power
  -Monthly energy yield (with reset function)
  -Total energy yield
- Analogue display of the actual power by 24 symbolic “incandescent lamps” (LED inside)
- Analogue display of the monthly energy yield by red balls (360 pieces), which were transported by the sun wheel from the storage tank into the catch tank depending from the energy fed into the mains
- Removable catch tank, secured by lock
- Low power requirement (max. 6,5 W)
- Inputs:
  -Power supply
  -6x analogous for current and voltage sensors
  -1x impulse for meter (in preparation)
  -RS 232 interface
  -Ethernet (in preparation)
- Current and voltage sensors for mounting in the meter board, meter with impulse output as accessory deliverable
- Factor according to the photovoltaic plant size freely programmable:
  -One LED (of 24) = x W
  -One ball = x kWh
- Individual lettering possible

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# Photovoltaic - simulators

## Model line PV - DS 24 bis PV - DS 10.000

For the development and research of photovoltaic system components experiments on photovoltaics generators are absolutely essential.
Since real PV generators depend on temporal and meteorological influence factors they are unsuitable for a continuous laboratory operation with reproducible conditions needed.
That's why for tests and certifeing of different devices PV-hardware-simulators are used. They have the one advantage of beeing cheap and easy in construction, even for high demanding relating to the dynamics.

Up to now in cooperation with the ISET model lines with a performance of 24 W and 1.200 W up to 10.000 W were developed. Through the specially modular structure we are able to deliver versions corresponding to our customer preferences (range of voltage, range of current, voltage steps, ...).

Suitable power supplies with different options, also with pc interface are deliverable, too.

Using an external or integrated power source, the characteristic curve of an in wide performance range variable PV generator analogeous to the equivalent circuit diagram is replicated.

The level of direct current of the power source simulates the irradiance.
There are voltage and current measuring instruments (digital) and indications for the different operating states existing.

The simulation process is controled by electric and thermic safety devices.

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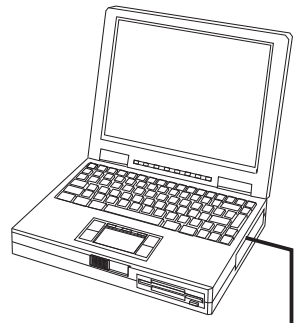
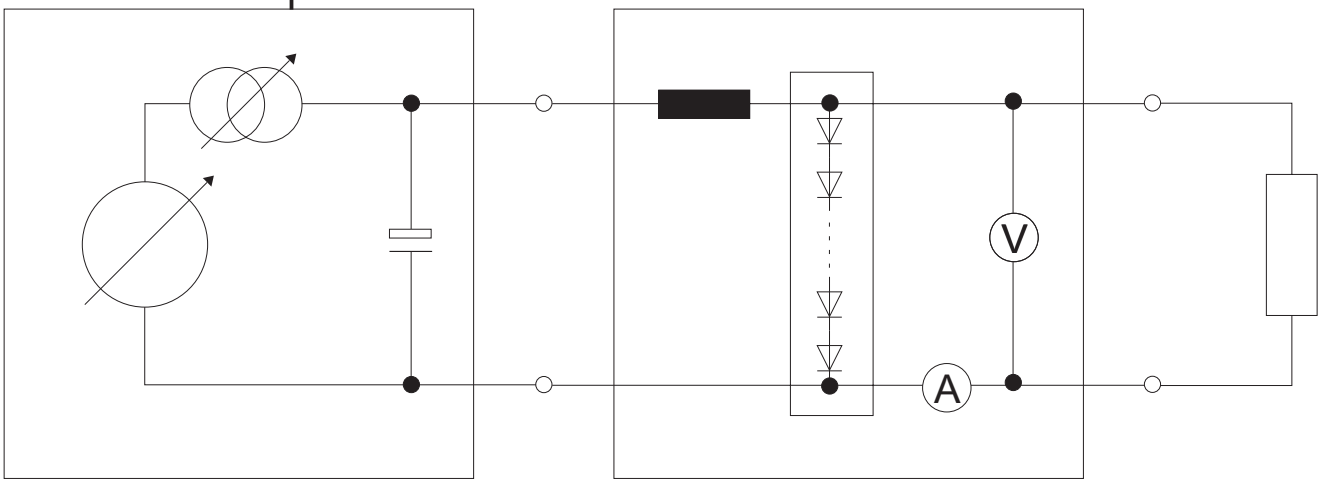
# Photovoltaic - simulators

## Equivalent circuit diagram



interface IEEE 488,
programming and read-out
of voltage and current as well
as on / off-operation,
status message




Power supply PV - Simulator Load