MATRIX | RENEWABLES

Advanced Smart Grid Systems

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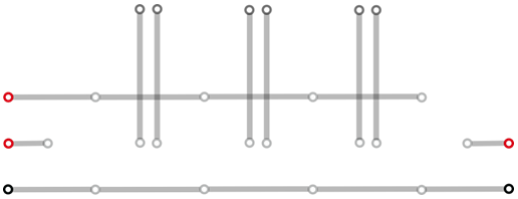
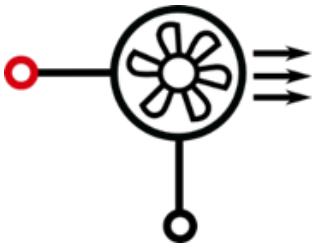
Contents

Base unit Professional 1400-13



The base unit is a breadboard where up to 4 components can be plugged in a series and parallel connection. The current flows along the wires on the bottom side. At the head there are bypass slots to connect the components in the desired way.

Wind machine 1400-19

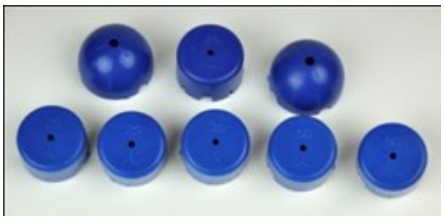


The wind machine is used to control the wind conditions during an experiment with the wind turbine. For those experiments the wind machine has to be connected to the PowerModule (voltage source). For this the negative (positive) pole of the PowerModule has to be connected to the black (red) connection. Towards the connections there is also a seperate on/off-switch. The wind direction is marked with arrows on the upside. The use of the wind machine is only permitted with the PowerModule or a stabilized voltage source. Misuse leads to termination of warranty.

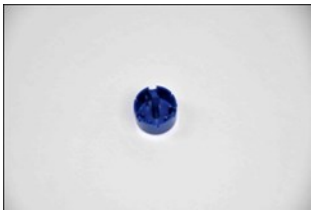
Specifications:

Maximum voltage: 12 V DC (stabilized)
Wind speed: 0 – 7 m/s

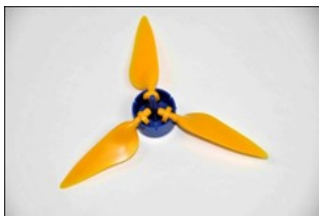
Wind rotor set 1400-12



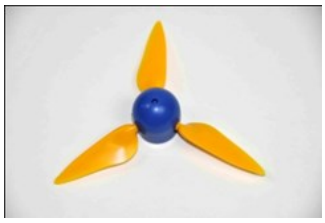
With the available components, rotors with 2, 3 or 4 blades and with a flat or an optimized profile can be created. There is a hub for 4 blades with a pitch angle of 25° and hubs for 3 blades with pitch angles of 20°, 25°, 30°, 50° and 90°. To assemble you should proceed in the following way:



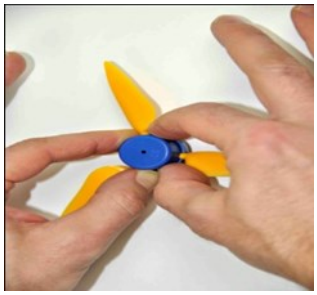
First, a hub with the desired rotor blade pitch and the number of blades should be selected. (The hubs are labelled on the back.) The Two-blade rotor and the Four-blade rotor can both be constructed with the Four-blade hub.



After that, the rotor blades are installed. During the insertion of the blades, make sure that they are installed with the rounded side up.

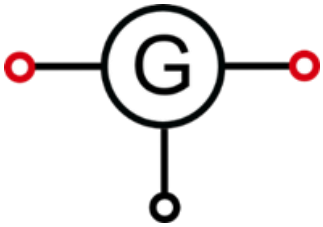


After installation of the rotor blades, the hub-cap will be mounted and lightly pressed against the hub.



To replace the blades, a small nose is located on the head of the hub. If the nose is pressed lightly on a hard surface, the hub-cap can be removed easily.

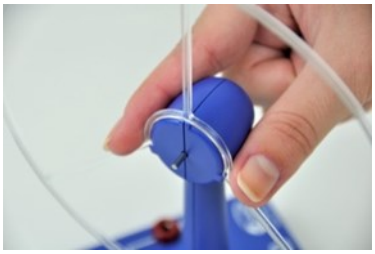
Wind turbine module 1118-03



At first the blue wind turbine has to be plugged into the module. The rotor has to be racked at the generator shaft to get a model of a wind turbine. The rotor must not touch the casing to avoid friction, which would considerably impede its rotation. The generator produces a direct current, with its polarity marked on the module. Additionally an angle scale is printed on the module, so it is possible to adjust a certain wind angle.
It is not allowed to touch the rotor during movement due to risk of injury. The rotor may only be touched, when it does not turn!

Handling of the fingerguard:

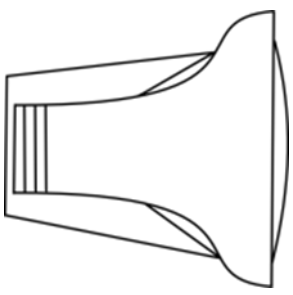
The wind turbine has three small retainer to fix the fingerguard.



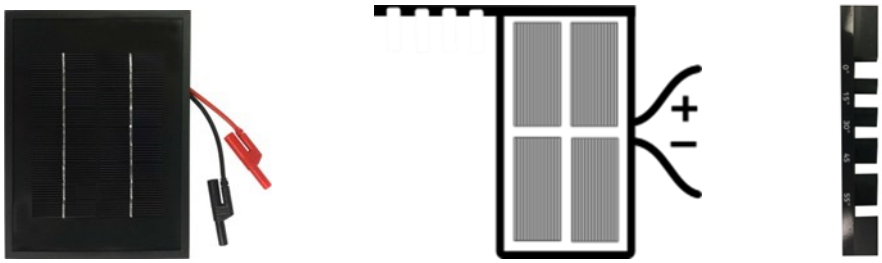
The fingerguard will be attached at the top of the wind turbine and pressed firmly at the lower retainers.

Afterwards, the wind rotor will be fixed at the wind turbine.

Lamp housing (L2-04-080) with illuminant 120W (L2-04-116)



Solar module 5,22V, 380mA (1100-04) with base (1118-17)

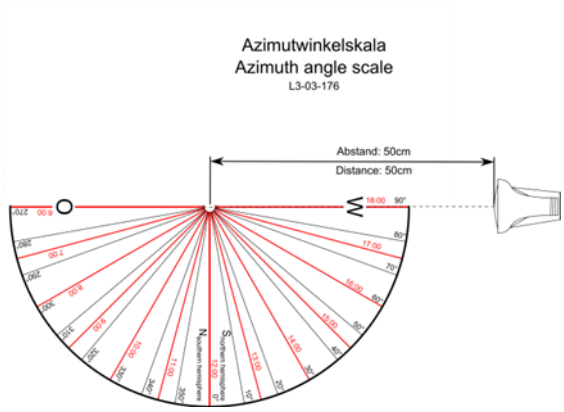


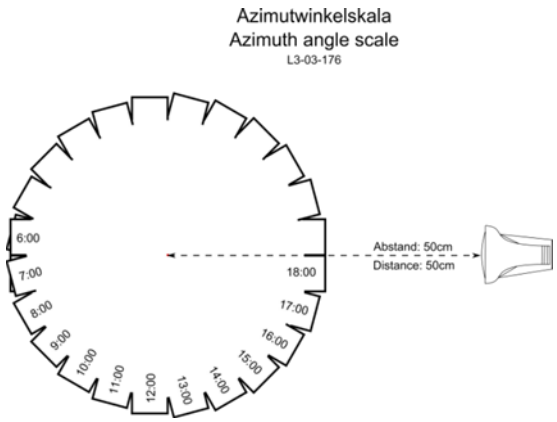
During every experiment there has to be a minimum distance of 50 cm between the solar module and the lamp. The solar module warms up due to the illumination and can be damaged irreparably, when the distance is lower. The lamp must only be switched on during experiments and must not be directed at another person. Due to heat build-up during operation, a cooling time has to be observed before touching and repackaging the lamp. During an experiment there should be no objects or persons in or near the light path. Otherwise there will be reflections, which could falsify the measured values.

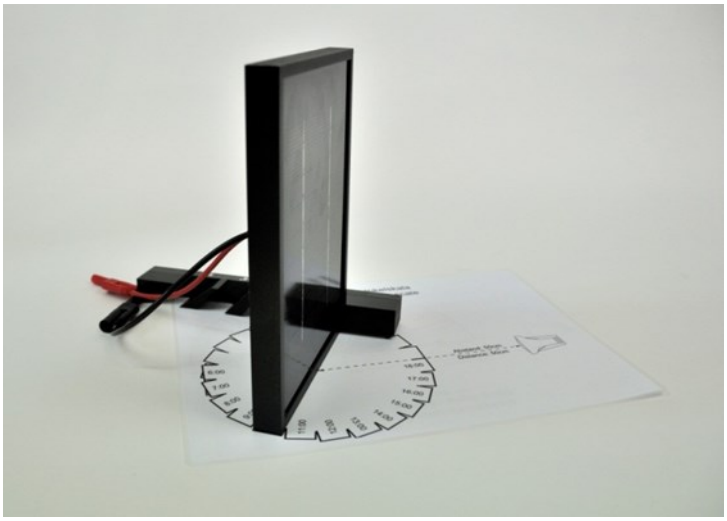
Specifications:
Lamp: 120 W PAR-Lamp

Solar module:
- 4,5 V open circuit voltage
- 840 mA short circuit current
- 3,75 Wp peak power

Azimuth angle scale L3-03-176

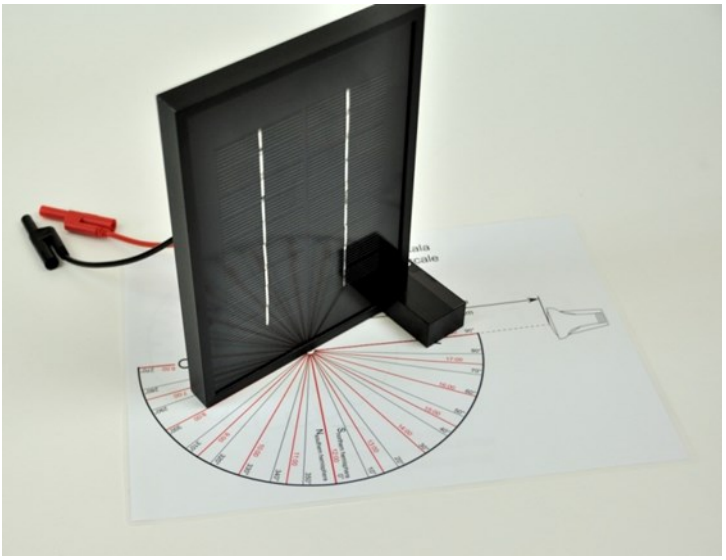






With the azimuth angle scale it is possible to set up the azimuth angle between the solar module and the lamp. On one page there are rectangles arranged in a circle and labelled with corresponding times of day. If the solar module is placed in a certain rectangle, the azimuth angle is set up for the chosen time of day. For example, in the alongside figure the solar module is arranged in the 10 o'clock position.

Solar module in 10 o'clock position

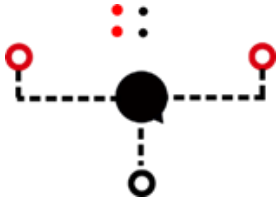


The second page can be used for a more exact configuration of a specific azimuth angle. The angle is set up, when the leading edge of the solar module is located at the corresponding line.
In the alongside figure the solar module is arranged in an azimuth angle of 300°. On both scales the position of the lamp is marked. The distance between the lamp and the center of the solar module has to amount to at least 50 cm.
The center of the solar module has to be located at the center of the angle scale.

Solar module in 8 o'clock position

Advice: The azimuth angle scale does not name the deviation angle of the solar module concerning the south, but name the azimuth angle of the sun in the astronomic meaning! In the experiment is assumed that the solar module is aligned to south (optimal direction). Therefore the used azimuth angle is not the term used in solar engineering, where 0° describe an aligned solar module to the south (-90° to the east, +90° to the west).

MPP-Tracker 1118-13



When connecting an arbitrary consumer to the solar module, it will commonly not operate at the MPP (Maximum Power Point) of the module. Therefore, often a part of the solar cell power is lost because of not using the possible maximum power. An MPP-Tracker is a so called DC/DC inverter which can increase or decrease the input voltage. The power as the product of voltage and current remains constant but the operating point can be adapted to a more convenient part of the I-V-characteristic. The leXsolar MPP-Tracker module has two operation modes that can be chosen with pushbuttons. When choosing the “automatic mode” the output voltage is varied in a broad range (LED is blinking) and the operating point with the maximum output power is automatically selected (LED shines continuously). Afterwards, the operating point is slightly shifted, to ensure that the consumer always extracts the maximum power from the solar module (dissipation power is disregarded). When using the “manual mode”, the ratio between output and input voltage can be adjusted manually with the potentiometer and a manual tracking is possible. To reduce the power dissipation of the MPP-Tracker module, it is only possible to reduce the output voltage against the input voltage. This is an advantage when the consumer has a lower internal resistance than the solar module .

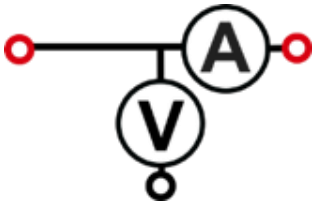
PowerModule 9100-05

Specifications:

- Output voltage: 0-12 V
- Output power: max. 24 W
- Adjustable in 0.5 V steps
- Overcurrent detection >2 A and automatic shutoff
- Input voltage: 110-230 V, 50-60 Hz (with enclosed power adapter)

The PowerModule is a compact and intuitively usable voltage source. First, the attached power adapter has to be connected to a power outlet and to the top right input jack. The voltage can be chosen with the „+“- and „-“ -buttons and will be displayed by LEDs. When the desired voltage is chosen, the voltage will be applied by using the yellow on/off- button. In case of a short circuit or currents greater than 2 A the PowerModule will switch off immediately.
In the Smart Grid experiments the PowerModule is on the one hand used as voltage source for the wind machine or the electrolyzer or on the other hand as a simulation of a power plant or a transformer station .

AV-Module 9100-03



The AV-Module is a combined voltage and current meter. It holds 3 buttons, whose features are described in the display respectively. By pushing a random button the module will switch on. When the display does not show anything or the word „Bat“ is shown, it is necessary to change the batteries in the back (2 x AA batteries 1.2 to 1.5V; Take care of the polarity marked on the bottom of the battery case! Do not touch the button while inserting the batteries).

With the top right button the measuring mode can be switched between voltage mode, current mode or combined voltage-current mode. Both measurement mode and required cable connection will be indicated by the circuit symbols on the display. Take care that in voltage mode no current is applied to the right jack. In the combined mode the voltage can be measured with the right jack as well as with the left one. The influence of the internal resistance of the current measurement is compensated internally. The measured values are signed. When the positive pole is connected to a red jack and the negative pole is connected to the black jack, the value of the voltage will be positive. When current is applied from the left to the right, the current value will be positive, as well. The other way around, the algebraic sign changes.

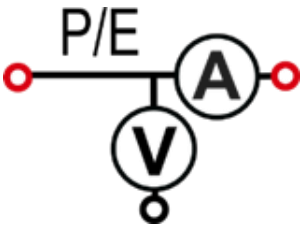
After 30 min without pushing a button or after 10 min of measuring a constant value, the module will switch off automatically. It can measure voltages up to 12 V and currents up to 2 A. In case of exceeding one of the values, the module interrupts the current flow and shows “overcurrent“ or “overvoltage”. This error message can be confirmed by touching a button. The module will resumes measuring, when the values attain acceptable values.

Specifications:

Voltage metering:
- range: 0...12 V
- accuracy: 1 mV
- automatic shutoff in case of overvoltage >12 V

Current metering:
- range: 0...2 A
- accuracy: 0,1 mA (0...199 mA) and 1mA (200 mA...1 A)
- automatic shutoff in case of overcurrent >2 A
- internal resistance <0,5 Ohm (0...200 mA); <0,2 Ohm (200 mA...2 A)

SmartMeter 9100-04

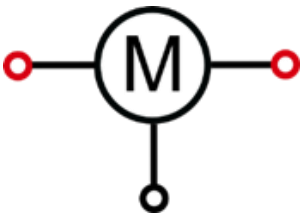


The SmartMeter is a power and energy meter with a switch function. In the SmartGrid experiments it acts as an electric meter.
The SmartMeter measures the voltage and the current at the positions as denoted on the imprint. With the measured values, power and energy are calculated and displayed. The energy meter can be reset by pushing the button on the right.
The current flow can be interrupted with the switch button at any time. For all measurements the usual polarity definitions are valid (red jack positive pole, black jack negative pole). Therefore it is possible to measure negative power values, which will reduce the energy value.
Information about the maximum voltage and current, error messages and advice concerning the battery are identical with the AV-Module and can be found in the description of the AV-Module.

Specifications:

Voltage and current metering correspond to the AV-Module
Power metering 0-24 W
Maximum energy count: 0-200 mWh

Motor module (1118-02) with yellow propeller (L2-02-017)

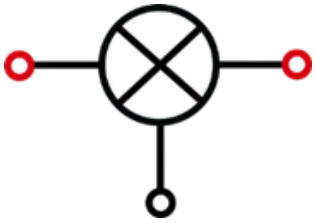


The motor module acts as a consumer in SmartGrid experiments.

Potentiometer module 1100-62

The potentiometer module holds a 0-10-Ω-potentiometer and a 0-100-Ω-potentiometer. Both are serially connected, so that the potentiometer can attain resistances between 0 Ω bis 110 Ω. The measuring error amounts to 0.5 Ω for the small resistor and 5 Ω at other one .

Light bulb module 1118-01

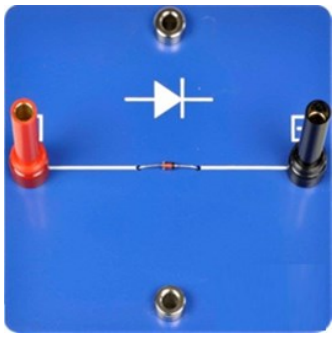


The light bulb module acts as a consumer in SmartGrid experiments.

Specifications:

Light bulb P_{typ} = 200 mW (at 3.5 V)
Fuses work up to maximum voltage of 6 V

Diode module 1100-21

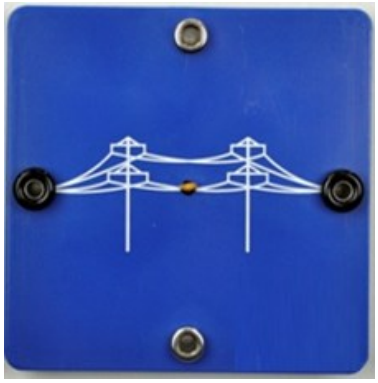


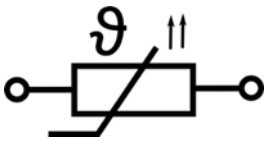
The diode module is used to avoid a return current to the wind turbine in SmartGrid experiments with many voltages sources. Without the diode the turbine could act as a motor.

Specifications:

Schottky diode
$U_{forward}$ = 0.33 V
Maximum current: 200 mA (500 mA Peak <1 s)

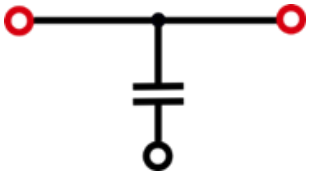
Grid module 1607-01





The grid module is used as a simulation of a power line and consists of a positive temperature coefficient (PTC) fuse. The PTC-fuse is a resistor, which attains a resistance of 3-5 Ω, up to a current of 190mA. In the process it reaches temperatures of up to 50°C. In the experiments it illustrates the power drain due to thermal energy. Up to the stated current the relation between temperature and resistance is, as with metals, approximately linear.
If the current is higher than 190mA, it cannot be used as a simulation because the resistance increases enormously and the current gets lower. This is not the behavior of a real power line.
The measuring of the temperature is just possible by using a temperature sensor, because the released thermal energy is too low for thermometers.

Capacitor module 1118-11

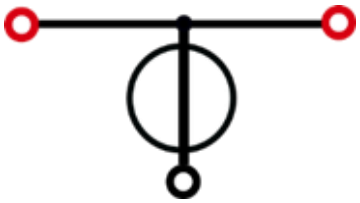


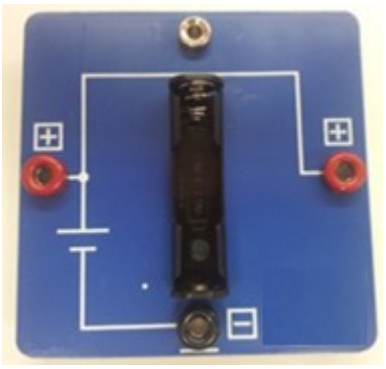
The capacitor module consists of 2 series-connected capacitors. The maximum voltage of the capacitor amounts to 5.4 V. Charging voltages for the capacitor should not exceed 5 V. It is possible to short-circuit the capacitor to discharge, because there are fuses to avoid damages.
For quick charging, it is also possible to connect the capacitor directly to a power supply. The voltage source should be switched on at a voltage of 0.5 V and can be increased by 0.5 V every 10 s. The capacitor should be charged with the final voltage for 30 s.

Specifications:

Capacitance: 5 F
Maximum voltage: 5,4 V

LiFePo-battery AAA (1801-06) with holder (1800-08)

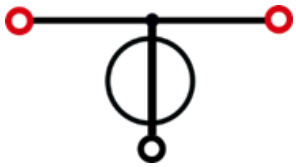




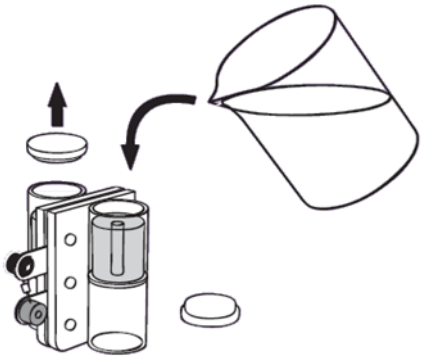
Specifications:

U= 3.2 V… 3.3 V
End-of-discharge voltage: 2,5 V…2,8 V
Maximum charging voltage: 3,6 V

Reversible fuel cell (L2-06-067) with holder (1800-12)



The reversible fuel cell consists of an electrolyzer and a fuel cell. To fill the reversible fuel cell you should proceed in the following way:



1. Fill the rev. fuel cell with distilled water as shown in the alongside figure.
2. Fill both storage cylinders up to the top of the tubules, which are inside the cylinders.
3. Knock the rev. fuel cell slightly on the table.
4. Continue filling in water until it flows through the tubules.
5. Close the storage cylinders with the plugs and turn over the rev. fuel cell. (the plugs must be on the bottom)

To charge the reversible fuel cell the applied voltage should not exceed 1.5 V. Otherwise the resulting current could exceed 1 A, which would damage the fuel cell.

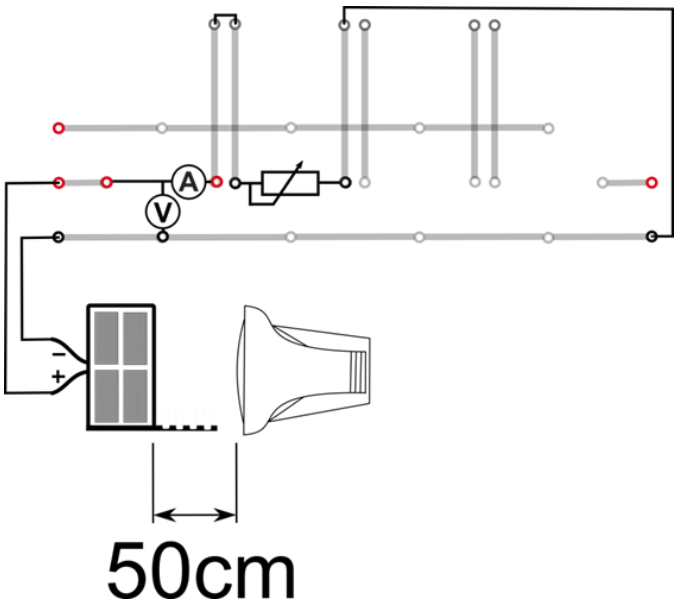
Worksheet

The I-V characteristic of a solar module

Task

Measure the I-V-characteristic of the solar module.

Setup



Required Equipment

Base unit
Lamp
Solar module
AV-Module
Potentiometer
Cables and short circuit plugs

Procedure

1. Set up the experiment according to the circuit diagram. Set the maximum resistance on the potentiometer. Arrange the solar module vertically in front of the lamp in a distance of 50 cm so that it will be illuminated entirely. The lamp should be aligned horizontally.
2. Switch on the lamp and measure voltage and current. Decrease the resistance of the potentiometer and measure further voltage and current values. You will measure useful values, if you note the values after a variation of 20 mA of current or a variation of 0.5 V of voltage. Measure the open circuit voltage and the short circuit current as well.
3. Calculate the power of the module for each measuring point.

Worksheet

The I-V characteristic of a solar module

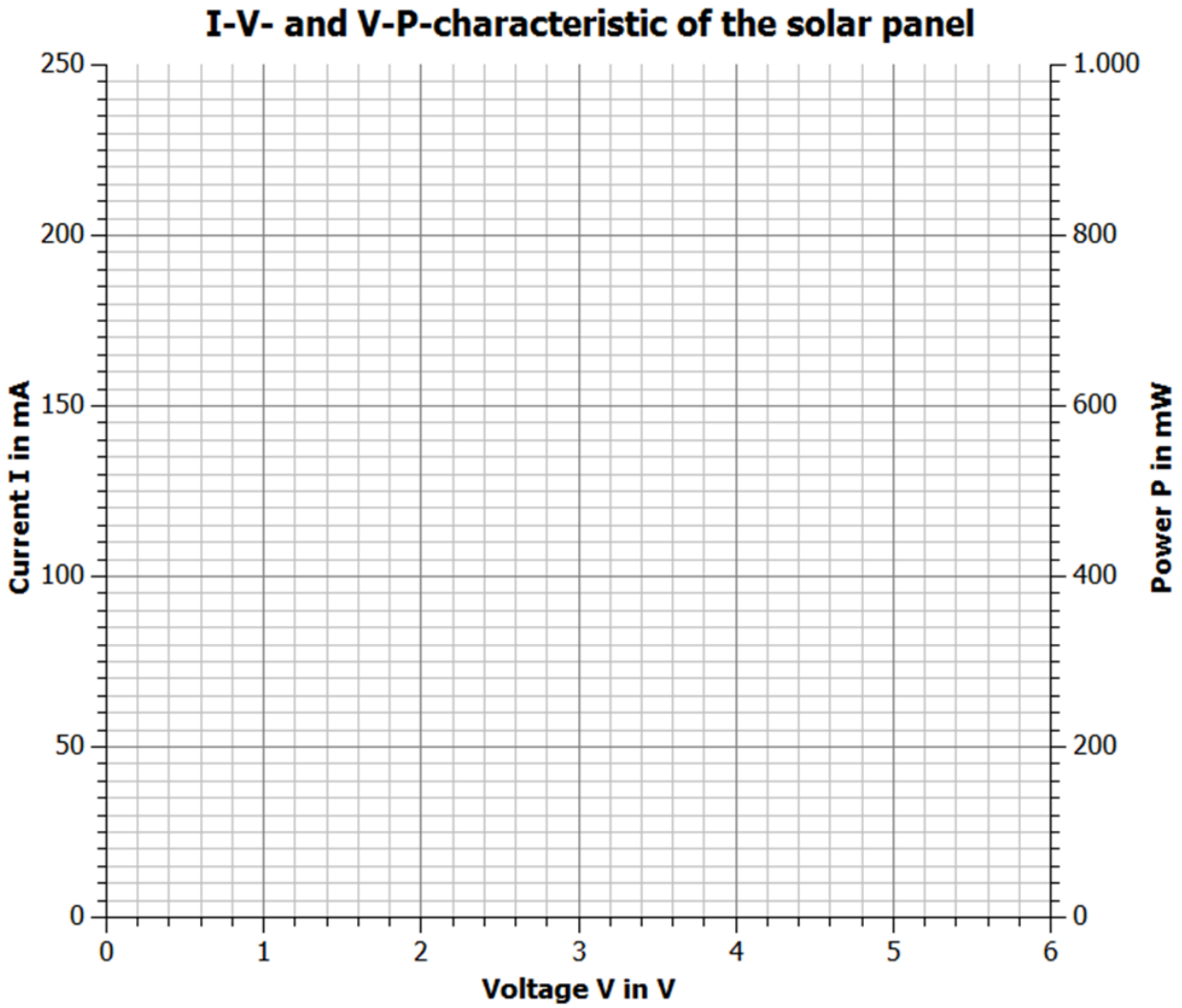
Measured value

V in V										
I in mA										
P in mW										

V in V										
I in mA										
P in mW										

Evaluation

Plot your measuring points in the I-V- and V-P-diagram and draw the according curves.



2. Describe the behavior of the curves.

3. Draw the I-V-characteristic of a 10 Ω- and a 100 Ω-resistance into your diagram. Explain the meaning of the intersection points between the characteristic curves of the solar module and the resistances.

4. Evaluate the voltage and energy output of the solar module depending on the connection of a certain consumer

5. Calculate the resistance, which generates the highest power of the solar module .

The full version of this curriculum is available upon purchase of the kit.

Please see contents for a full list of experiments from the full version.