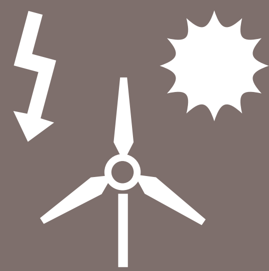
leXsolar-SmartGrid Ready-to-go



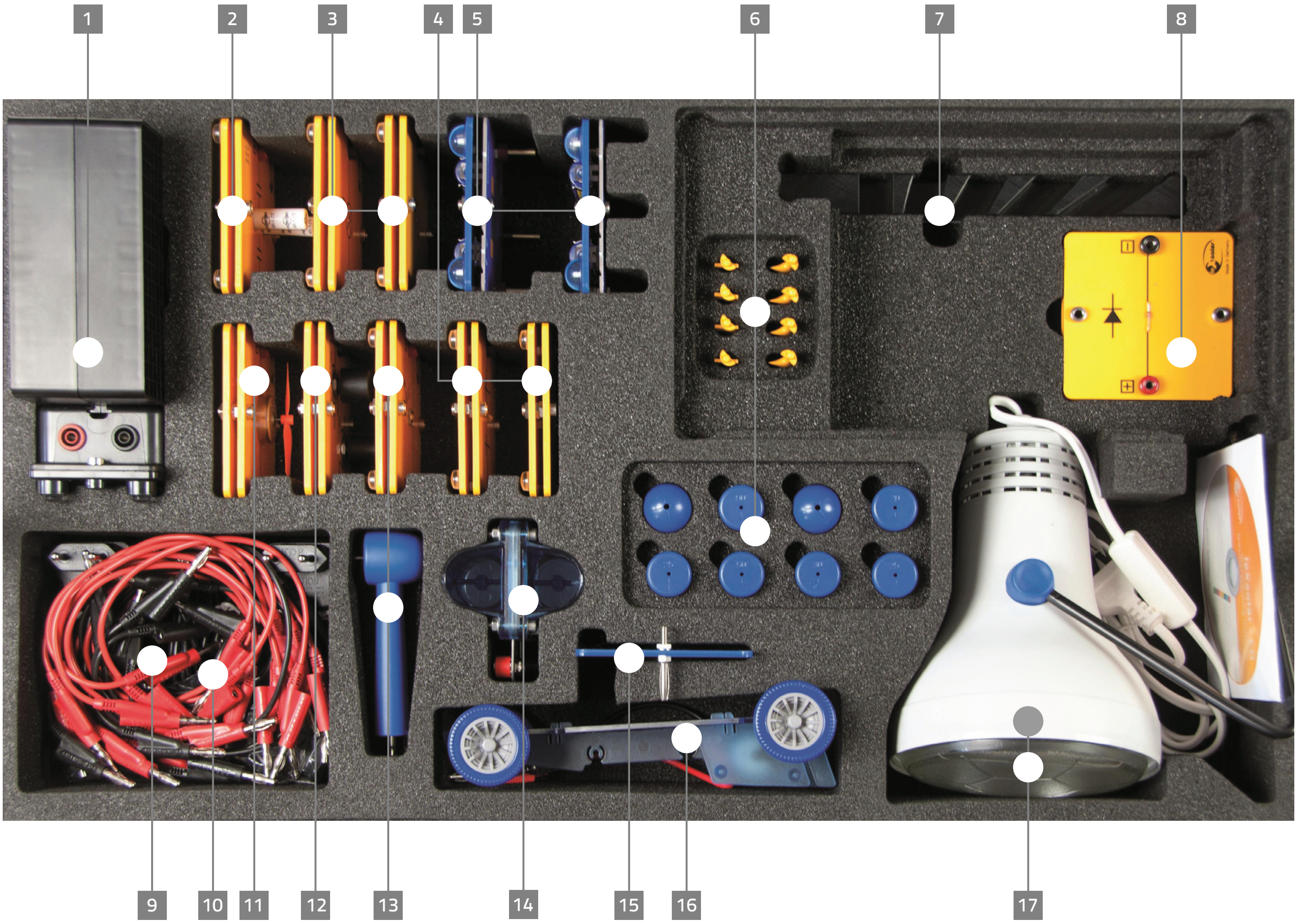
Instructions Manual

Layout diagram leXsolar-SmartGrid Ready-to-go

Item-No.1605

Bestückungsplan leXsolar-SmartGrid Ready-to-go

Art.-Nr.1605



1	1400-19 leXsolar-Wind machine 1400-19 leXsolar-Winderzeuger
2	1600-02 Capacitor module 5.0F/5.4V 1600-02 Kondensatormodul 5.0F/5.4V
3	2x1100-26 Light bulb module 2x1100-26 Glühlampenmodul
4	2x1600-01 Power grid module 2x1600-01 Stromnetzmodul
5	2x9100-04 SmartMeter 2x9100-04 SmartMeter
6	1400-12 leXsolar-Wind rotor set (8 blades, 6 hubs, 2 capes) 1400-12 leXsolar-Windrotoren (8 Flugel, 6 Naben, 2 Kapen)
7	1118-17 Base for solar panel 1118-17 Standfuß Solarmodul
8	1100-21 Diode module 1100-21 Diodenmodul
9	3xL2-06-014 Test leads black 50 cm 3xL2-06-015 Test leads red 50 cm 3xL2-06-014 Messleitung schw. 50 cm 3xL2-06-015 Messleitung rot 50 cm
10	4xL2-06-012 Test leads black 25 cm 7xL2-06-013 Test leads red 25 cm 4xL2-06-012 Messleitung schw. 25 cm 7xL2-06-013 Messleitung rot 25 cm
11	1100-27 Motor module 1100-27 Motor module L2-02-017 Yellow propeller L2-02-017 Luftschraube (Propeller) gelb
12	1100-61 Potentiometer module 110 Ohm 1100-61 Potentiometermodul 110 Ohm
13	1400-22 Wind turbine module 1400-22 Windturbinenmodul
14	L2-06-067 Reversible Fuel cell Pro L2-06-067 Reversible Brennstoffzelle Pro
15	Battery adapter for 16 Akku-Adapter für 16
16	1801-02 Electric model car with 15 1801-02 Elektro-Modellfahrzeug mit 15
17	L2-04-116 Illuminant 120W with L2-04-080 Lamp housing L2-04-116 Leuchtmittel 120W mit L2-04-080 Lampengehäuse

Version number
Versionsnummer

III-01.24_L3-03-169_24.05.2017

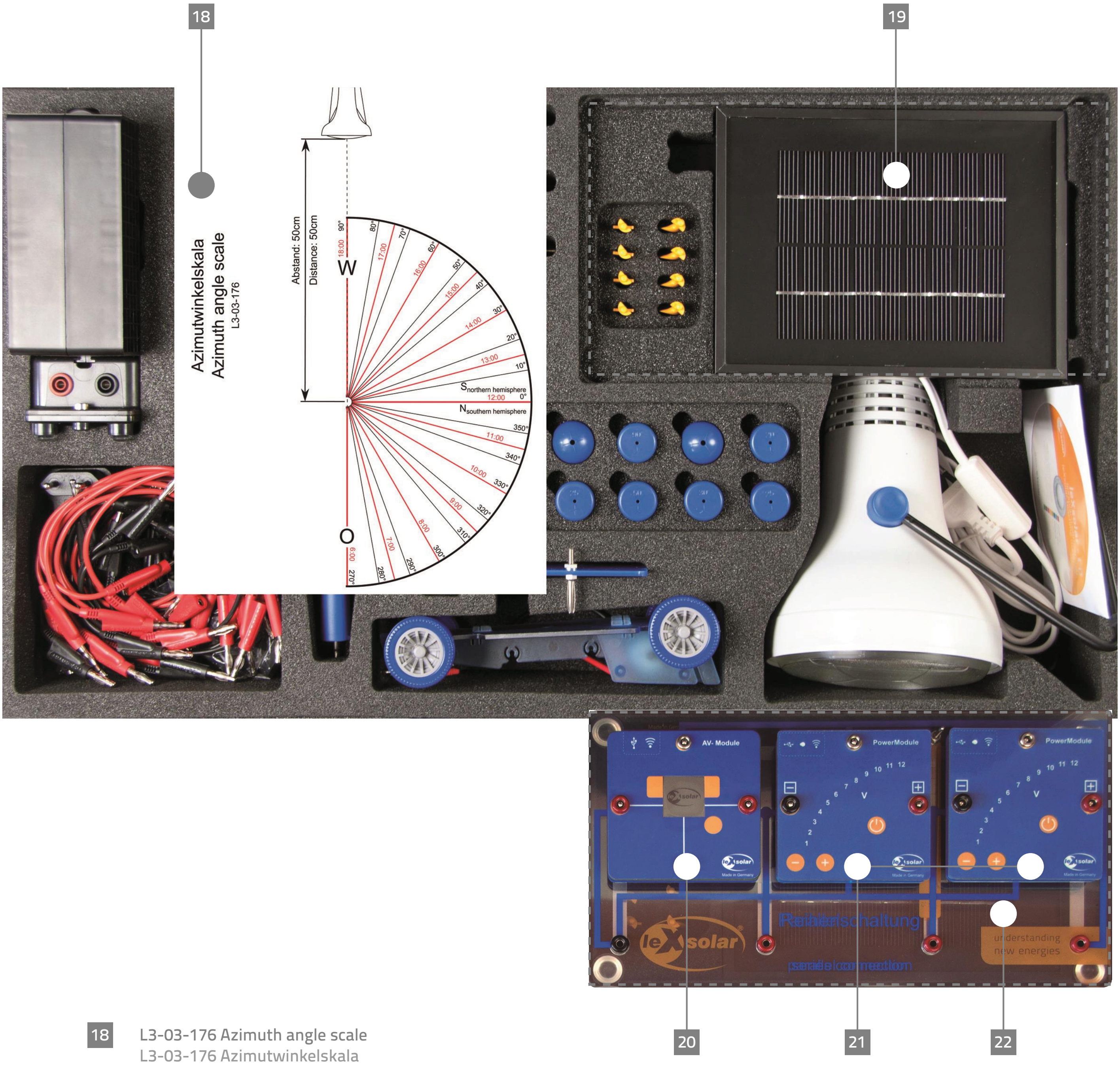
CE RoHS2

Layout diagram leXsolar-SmartGrid Ready-to-go

Item-No.1605

Bestückungsplan leXsolar-SmartGrid Ready-to-go

Art.-Nr.1605



18	L3-03-176 Azimuth angle scale L3-03-176 Azimutwinkelskala
19	1100-53 Solar panel 5.22 V, 380 mA 1100-53 Solarmodul 5.22 V, 380 mA
20	9100-03 AV-Module 9100-03 AV-Modul
21	2x9100-05 PowerModule 2x9100-05 PowerModul
22	1100-19 leXsolar-Base unit 1100-19 leXsolar-Grundeinheit groß

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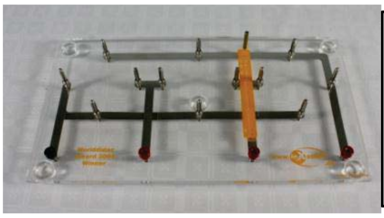
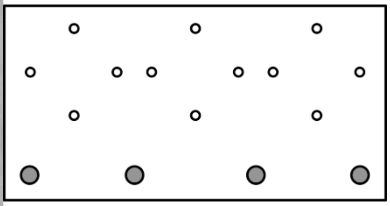
Chapter 1: Description of the experimental components of leXsolar-SmartGrid Ready-to-go

In the following schedule every component of the leXsolar-SmartGrid Ready-to-go is listed. For every component there is the name with article number, a picture, the pictogram for the circuit diagram and operating instructions. With the aid of the article number it is possible to reorder a specific component.

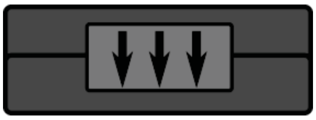
Base unit 1100-19





The base unit is a breadboard where up to 3 components can be plugged in a series and parallel connection. The current flows along the wires on the bottom side. To connect the components on the base unit with other components, there are 4 terminals at the lower end.
The printed circuit diagrams show the connections in a series and parallel connection. To change between series and parallel connection, the modules have to be turned by 90°.

Wind machine 1400-19

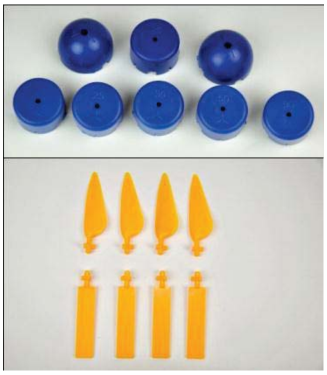


The wind machine is used to control the wind conditions during an experiment with the wind turbine. For those experiments the wind machine has to be connected to the PowerModule (voltage source). For this the negative (positive) pole of the PowerModule has to be connected to the black (red) connection. 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. Furthermore, the wind machine has to be protected from intense hits. Otherwise, the rotor blade within the device could break. Misuse leads to termination of warranty.

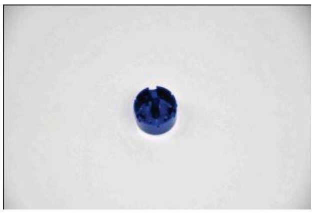
<ins>Specifications:</ins>

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

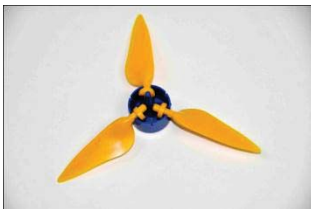
Wind rotor set 1400-12



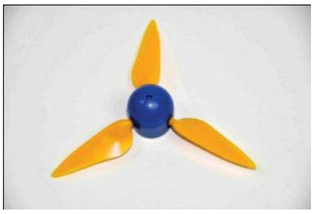
With the available components, rotors with 2, 3 or 4 blades and with a flat or an optimized profile can be created. There is a hub for 4 blades with a pitch angle of 25° and hubs for 3 blades with pitch angles of 20°, 25°, 30°, 50° and 90°. To assemble you should proceed in the following way:



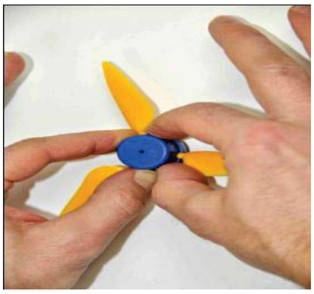
First, a hub with the desired rotor blade pitch and the number of blades should be selected. (The hubs are labelled on the back.) The Two-blade rotor and the Four-blade rotor can both be constructed with the Four-blade hub.



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

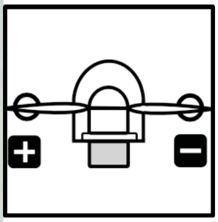


After installation of the rotor blades, the hub-cap will be mounted and lightly pressed against the hub.



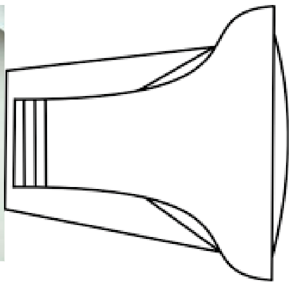
To replace the blades, a small nose is located on the head of the hub. If the nose is pressed lightly on a hard surface, the hub-cap can be removed easily.

Wind turbine module 1400-22

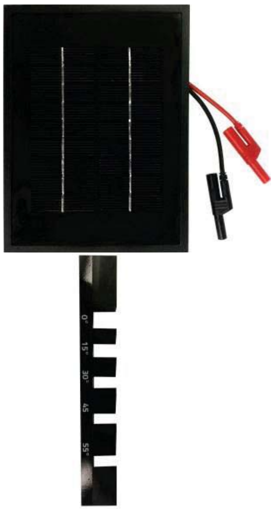


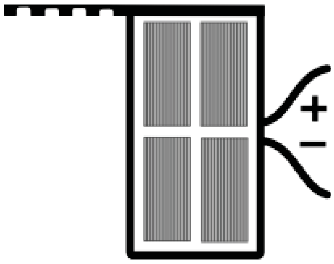
At first the blue wind turbine has to be plugged into the module. The rotor has to be racked at the generator shaft to get a model of a wind turbine. The rotor must not touch the casing to avoid friction, which would considerably impede its rotation. The generator produces a direct current, with its 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!

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



Solar module 5.22V, 380mA (1100-04) with base (1118-17)





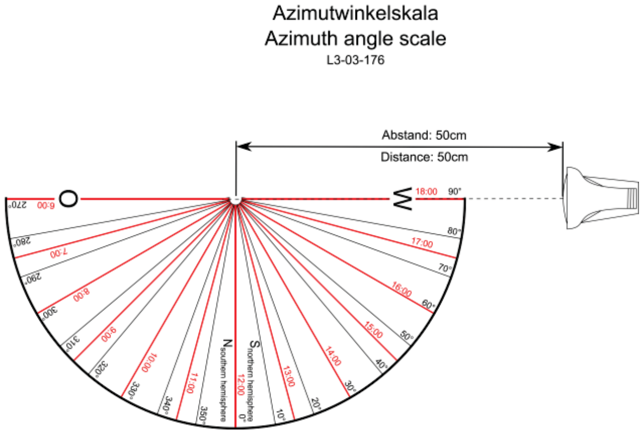
During every experiment there has to be a minimum distance of 50 cm between the solar module and the lamp. The solar module warms up due to the illumination and can be damaged irreparably, when the distance is lower. The lamp must only be switched on during experiments and must not be directed at another 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.

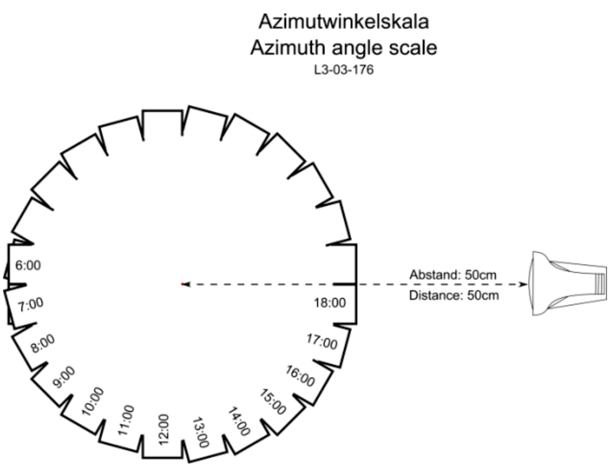
<u>Specifications:</u>
Lamp: 120 W PAR-Lamp

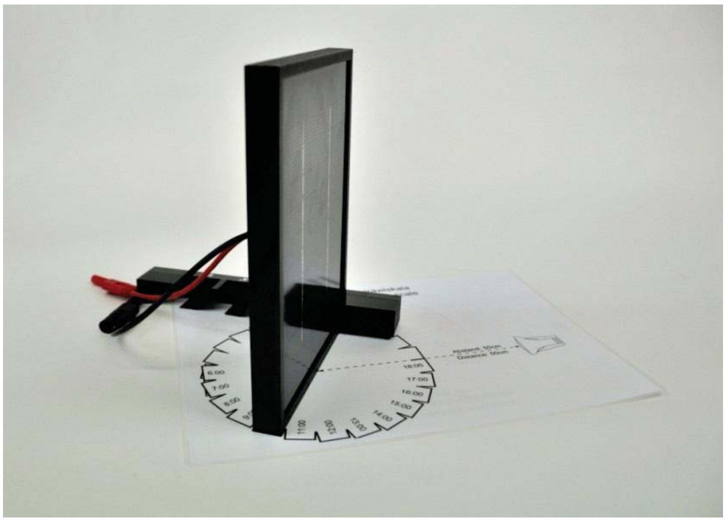
Solar module:

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

Azimuth angle scale L3-03-176

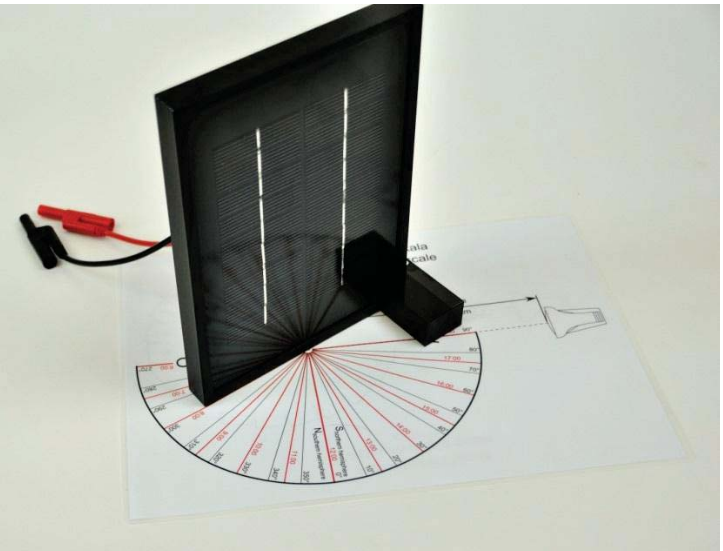






Solar module in 10 o'clock position

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.

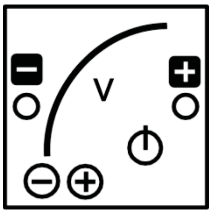


Solar module in 8 o'clock position

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.

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).

PowerModule 9100-05

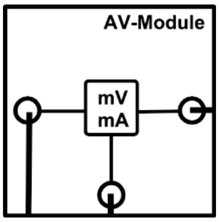


The PowerModule is a compact and intuitively usable voltage source. First, the attached power adapter has to be connected to a power outlet and to the top right input jack. The voltage can be chosen with the „+“- and „-“ -buttons and will be displayed by LEDs. When the desired voltage is chosen, the 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.

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)

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. In the disabled state the display shows the leXsolar emblem. 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.

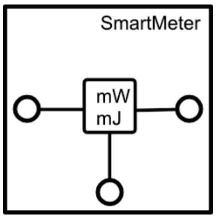
After 30 min without pushing a button or after 10 min of measuring a constant value, the module will switch off automatically. It can measure voltages up to 12 V and currents up to 2 A. In case of exceeding one of the values, the module interrupts the current flow and shows “overcurrent“ or “overvoltage”. 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

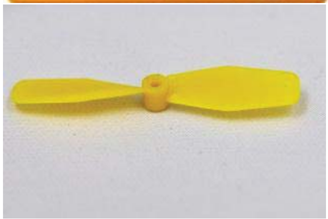


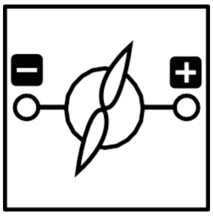
The SmartMeter is a power and energy meter with a switch function. In the SmartGrid experiments it acts as an electric meter.
The SmartMeter measures the voltage and the current at the positions as denoted on the imprint. With the measured values, power and energy are calculated and displayed. The energy 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

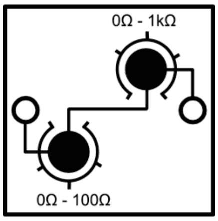
Motor module (1100-27) with yellow propeller (L2-02-017)





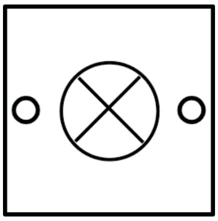
The motor module acts as a consumer in SmartGrid experiments.

Potentiometer module 1100-61



The potentiometer module holds a 0-10-Ω-potentiometer and a 0-100-Ω-potentiometer. Both are serially conneted, 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 1100-26

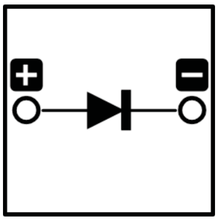


The light bulb module acts as a consumer in SmartGrid experiments.

<u>Specifications:</u>

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

Diode module 1100-21

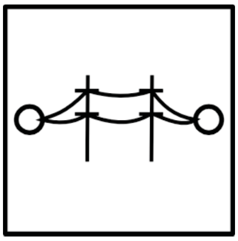


The diode module is used to avoid a return current to the wind turbine in SmartGrid experiments with many voltages sources. Without the diode the turbine could act as a motor.

Specifications:

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

Grid module 1600-01



The grid module is used as a simulation of a power line.
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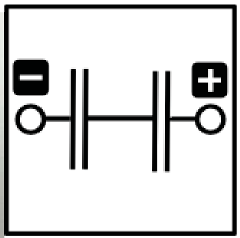
Capacitor module 1600-02

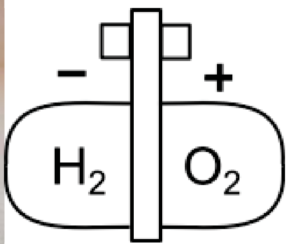


The capacitor module consists of 2 series-connected capacitors. The maximum voltage of the capacitor amounts to 5.4 V. Charging voltages for the capacitor should not exceed 5 V. It is possible to short-circuit the capacitor to discharge, because there are fuses to avoid damages. For quick charging, it 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.

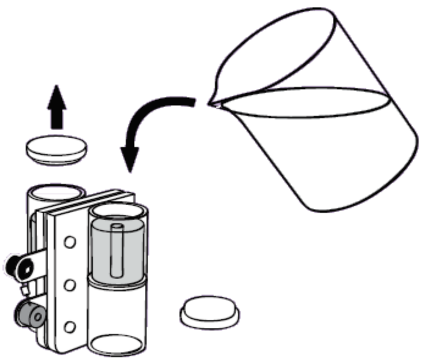
<u>Specifications:</u>

Capacitance: 5 F
Maximum voltage: 5,4 V

Reversible fuel cell L2-06-067

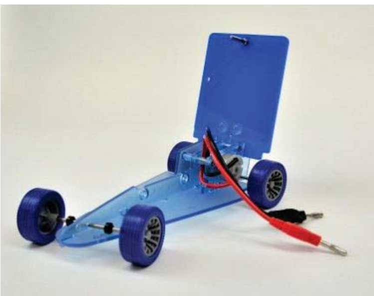
The reversible fuel cell consists of an electrolyzer and a fuel cell. To fill the reversible fuel cell you should proceed in the following way:



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.

Electric model car with battery adapter 1801-02



The electric model car can be used with the reversible fuel cell or the capacitor module. The fuel cell can be plugged directly in the car. The capacitor can be plugged with the adapter in the car. The car will move when both cables are connected with the voltage source. There will be a short circuit when the wires are held during the short circuit.

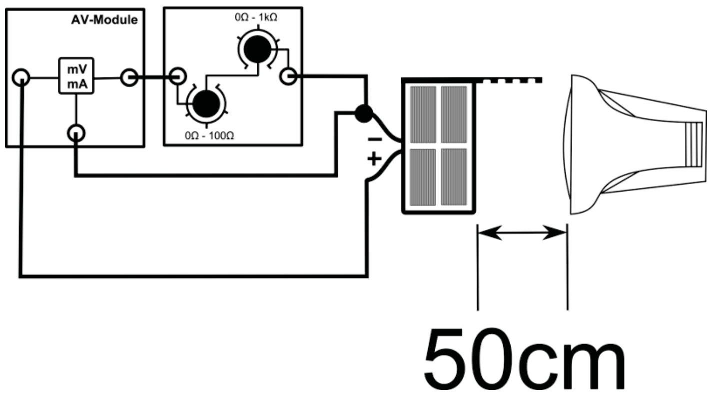
Chapter 2: Protocols

1.1 The I-V-characteristic of a solar module

Task

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

Setup



Equipment

- Lamp
- Solar module
- AV-Module
- Potentiometer module
- cables

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. Ensure that every component is connected in series and that the voltage of the solar module is measured in a parallel connection.
3. Switch on the lamp and decrease the resistance of the potentiometer. Always measure voltage and current to a given resistance. 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. Do not try to set certain values of current or voltage because the accuracy of the potentiometer will not be sufficient. Measure the open circuit voltage and the short circuit current as well.
4. Calculate the power of the module for each measuring point.

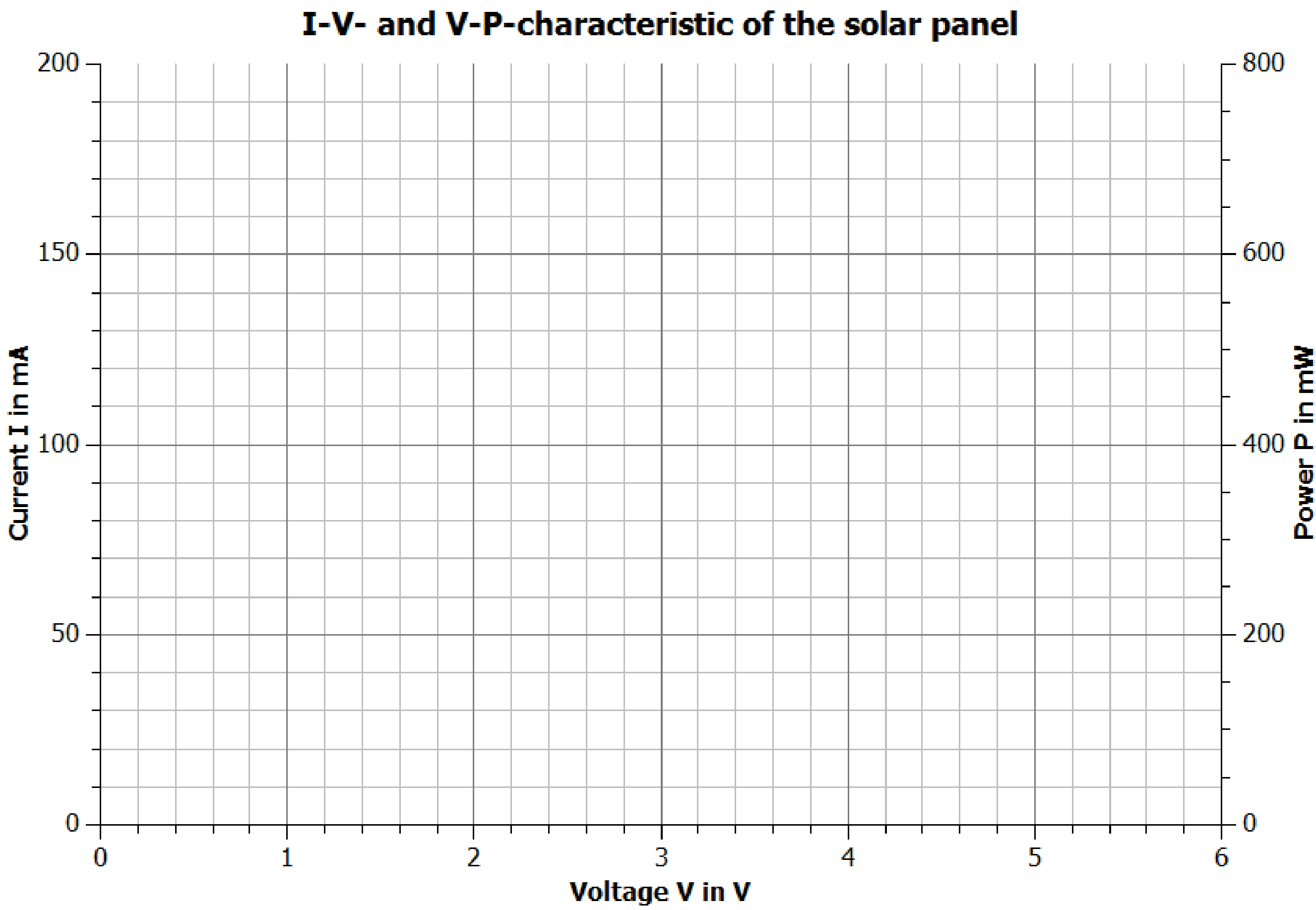
Measured values

V in V										
I in mA										
P in mW										

V in V										
I in mA										
P in mW										

Evaluation

1. 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.

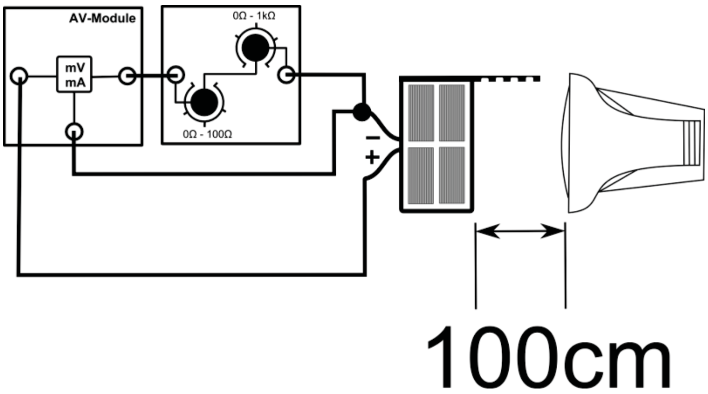
5. Calculate the resistance, which generates the highest power of the solar module.

1.2 The I-V-characteristic of a solar module depending on the illuminance

Task

Measure the I-V-characteristic of the solar module with a lower illuminance as in experiment 1.1.

Setup



Equipment

- Lamp
- Solar module
- AV-Module
- Potentiometer module
- cables

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 100 cm so that it will be illuminated entirely. The lamp should be aligned horizontally.
2. Ensure that every component is connected in series and that the voltage of the solar module is measured in a parallel connection.
3. Switch on the lamp and decrease the resistance of the potentiometer. Always measure voltage and current to a given resistance. 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. Do not try to set certain values of current or voltage because the accuracy of the potentiometer will not be sufficient. Measure the open circuit voltage and the short circuit current as well.
4. Calculate the power of the module for each measuring point.

Measured values

V in V								
I in mA								
P in mW								

V in V								
I in mA								
P in mW								