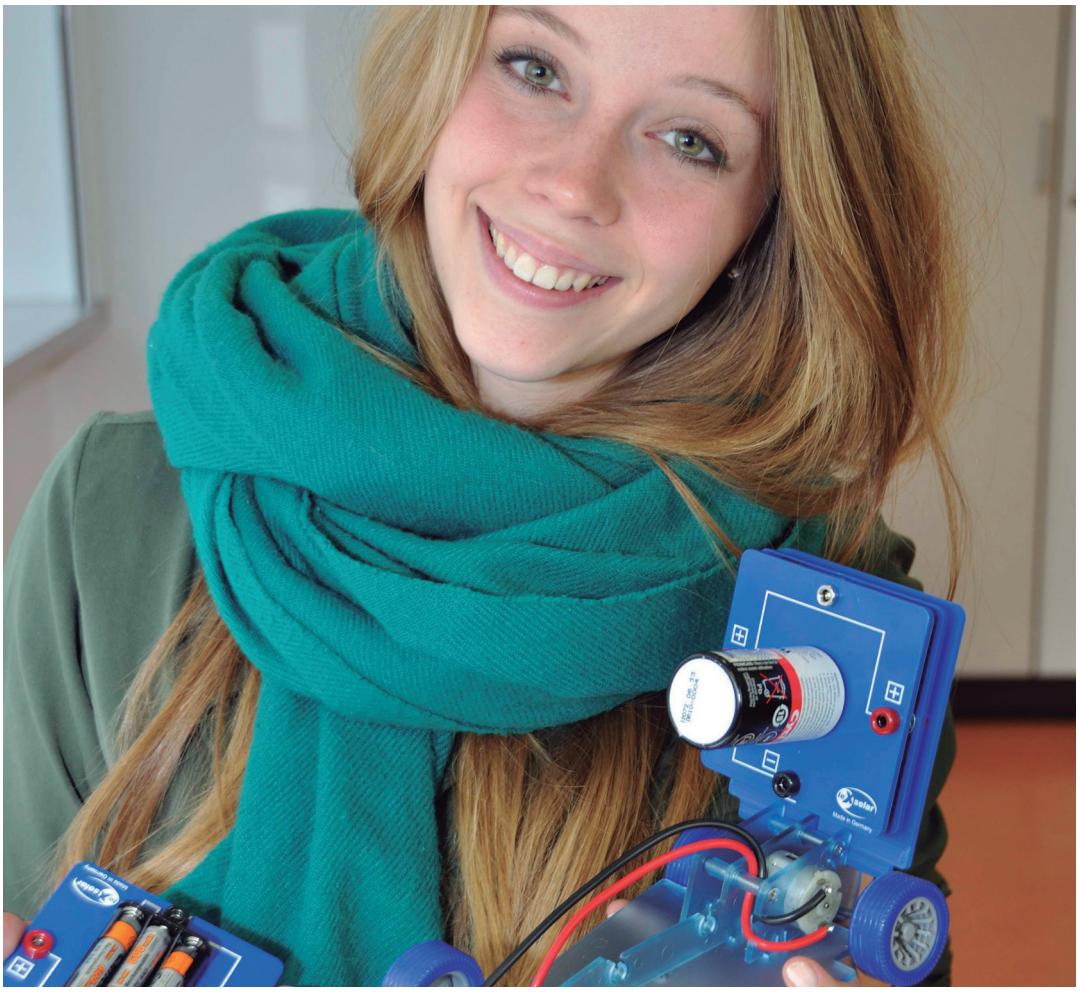
leXsolar-EStore Professional



Experimental handbook

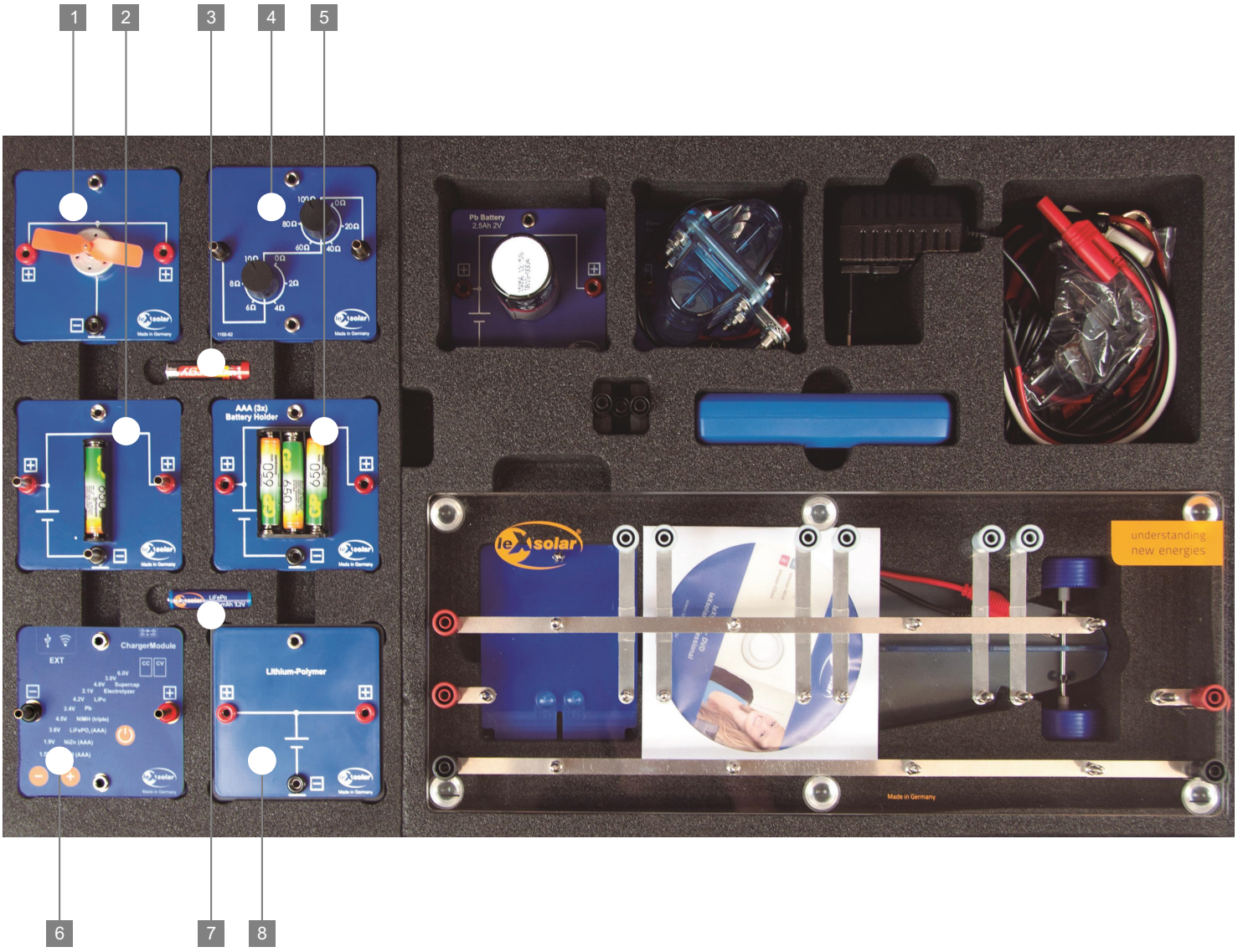
www.lexsolar.de/feedback

Layout diagram leXsolar-EMobility Professional

Item-No.1801

Bestückungsplan leXsolar-EMobility Professional

Art.-Nr.1801



1 1118-02 Motor module Pro with L2-02-017 Propeller
1118-02 Motormodul Pro mit L2-02-017 Propeller

2 1800-08 Battery module holder 1xAAA Pro with L2-04-021 NiMH battery AAA
1800-08 Akkuhalterungsmodul 1xAAA Pro mit L2-04-021 NiMH-Akku AAA

3 L2-04-102 NiZn-battery AAA
L2-04-102 NiZn-Akku AAA

4 1100-62 Potentiometer module 110 Ohm Pro
1100-62 Potentiometermodul 110 Ohm Pro

5 1118-09 Battery module NiMH 3xAAA Pro
1118-09 Akkumodul NiMH 3xAAA Pro

6 9100-13 ChargerModul with 16
9100-13 ChargerModul mit 16

7 1801-06 LiFePo-battery AAA
1801-06 LiFePo-Akku AAA

8 1800-07 Lithium-Polymer battery module Pro
1800-07 Lithium-Polymer-Akkumodul Pro

Version number
Versionsnummer

III-01.24_L3-03-165_18.10.2017

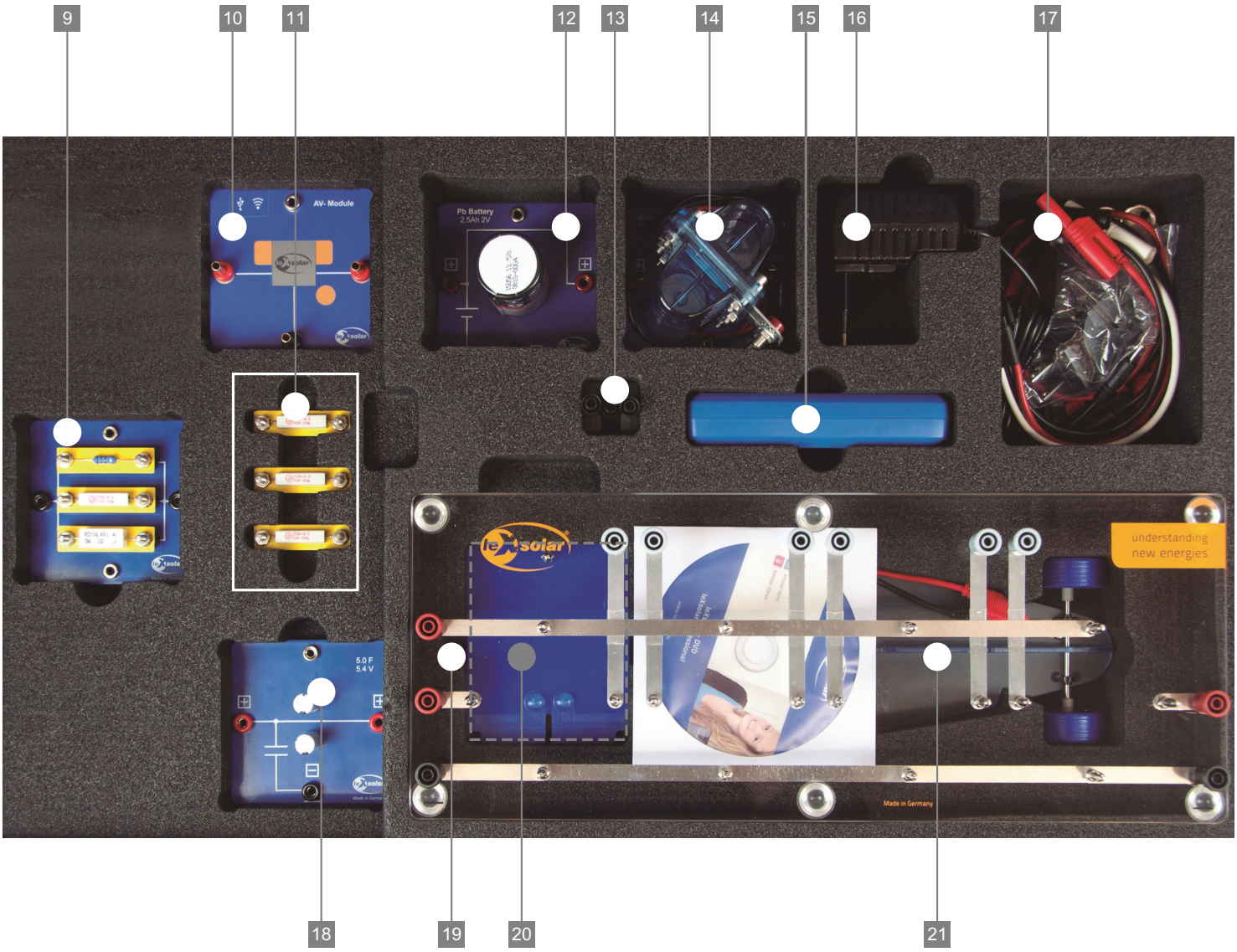
CE RoHS 2

Layout diagram leXsolar-EMobility Professional

Item-No.1801

Bestückungsplan leXsolar-EMobility Professional

Art.-Nr.1801



9 1800-01 Resistor module (triple) Pro with
1800-03 Plug element 1 Ohm
1800-04 Plug element 100 Ohm
1800-06 Plug element 33 Ohm
1800-01 Widerstandsmodul 3-fach Pro mit
1800-03 Widerstands-Steckelement 1 Ohm
1800-04 Widerstands-Steckelement 100 Ohm
1800-06 Widerstands-Steckelement 33 Ohm

10 9100-03 AV-Modul
9100-03 AV-Modul

11 3x1800-05 Plug element 10 Ohm
3x1800-05 Widerstands-Steckelement 10 Ohm

12 1800-13 Lead battery module Pro
1800-13 Blei-Akkumodul Pro

13 3xL2-05-068 Short circuit plugs
3xL2-05-068 Sicherheits-Kurzschlussstecker

14 L2-06-067 Reversible fuel cell Pro with
1800-12 Fuel cell holder Pro
L2-06-067 Reversible Brennstoffzelle Pro mit
1800-12 Halterung Brennstoffzelle reversibel Pro

15 L2-06-011 Digital multimeter
L2-06-011 Digitalmultimeter

16 Universal power supply for 6
Stromversorgungsgerät für 6

17 L2-04-059 Safety test lead 50 cm, red
L2-04-059 Sicherheitsmessleitung 50 cm, rot
L2-04-060 Safety test lead 50 cm, black
L2-04-060 Sicherheitsmessleitung 50 cm, schw.
L2-04-066 Safety test lead 25 cm, red
L2-04-066 Sicherheitsmessleitung 25 cm, rot
L2-04-067 Safety test lead 25 cm, black
L2-04-067 Sicherheitsmessleitung 25 cm, schw.
1800-09 Battery adapter cable
1800-09 Akku-Adapterkabel

18 1118-11 Capacitor module Pro
1118-11 Kondensatormodul Pro

19 1400-13 leXsolar-Base unit Pro
1400-13 leXsolar-Grundeinheit Pro

20 Battery adapter for 21
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mit 20

CE RoHS 2

leXsolar-EStore Professional

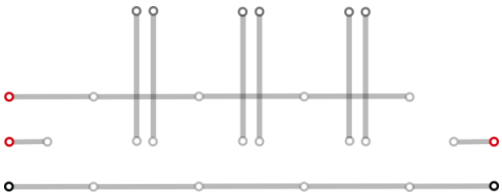
Experimental handbook

Content

Identification and handling of experimental equipment

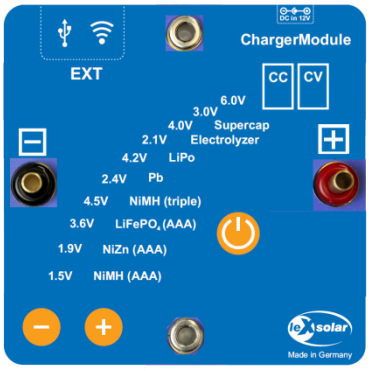
In the following schedule every component of the leXsolar-EStore Professional case is listed. For every component there is the name with article number, a picture, the pictogram for the circuit diagram and operating instructions. With the aid of the article number it is possible to reorder a specific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

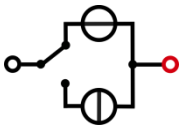
Base unit Professional 1400-13



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.

ChargerModule 9100-13





The ChargerModule is a universal battery charger for all batteries, the capacitor and the reversible fuel cell included in leXsolar-EStore Professional. With the additional fixed-voltage outputs constant voltage of 3V or 6V can be applied. To operate the ChargerModule first the power adapter must be plugged in and connected to the input jack on the top right of the module. The charging program is selected by the "+" and “-“ button and is displayed by the LEDs. The Power button is used to switch on the ChargerModule. During the charging process, the Power Enable LED flashes once per second and all keys are locked. Pressing the Power Enable button for 0.5s cancels the selected program. When the charging process is complete, there occurs an acoustic signal (3 loud "medium high" beeps, a total of about 2 seconds) and the Power Enable LED is continuously lit.

The ChargerModul provides a constant voltage (cv-mode) or constant current (cc-mode) depending on the charge program. For most battery modules a combined cc/cv-mode is applied. The top LEDs (CC/CV) indicate the applied charging mode.

For open-circuit (for example no battery module is connected to the charger) five high beeps occur and the charging program is terminated immediately. If the voltage of the connected battery module is higher than the maximum charging voltage (for example, if an incorrect battery is connected) or below the specified end-of-discharge voltage the charging program is also terminated. Independent of the connected module the charger switches off after 1 hour to prevent accidental overloading of the battery module.

The following charging programs can be selected:

NiMH (AAA):

- Only cc-mode (charge current I= 250 mA) without cv-process
- Upper voltage limit: 1.6V
- Lower voltage limit: 1V

NiZn (AAA):

- Starts with cc-mode (I=250mA) up to a switching voltage V=1.8V
- After reaching the threshold voltage switch to cv-mode, switch-off at a current of 100mA
- Upper voltage limit: 2V
- Lower voltage limit: 1.3V

LiFePo (AAA):

- Starts with cc-mode (I=200mA) up to a switching voltage V=3.6V
- After reaching the threshold voltage switch to cv-mode, switch-off at a current of 100mA
- Upper voltage limit: 3.7V
- Lower voltage limit: 2.8V

NiMH (triple):

- Only cc-mode (charge current I= 250 mA) without cv-process
- Upper voltage limit: 4.8V
- Lower voltage limit: 3V

Pb:

- Starts with cc-mode (I=500mA) up to a switching voltage V=2.35V
- After reaching the threshold voltage switch to cv-mode, switch-off at a current of 200mA
- Upper voltage limit: 2.45V
- Lower voltage limit: 1.8V

LiPo:

- Starts with cc-mode (I=500mA) up to a switching voltage V=4.1V
- After reaching the threshold voltage switch to cv-mode, switch-off at a current of 200mA
- Upper voltage limit: 4.3V
- Lower voltage limit: 3V

Electrolyzer:

- Only cv-mode (V=2.1V)

Supercap:

- Only cv-mode (V=2.1V), switch-off at a current of 50mA
- Upper current limit: 2A
- Switch-off after 10min, independent of current

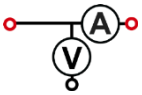
3V:

- Constant voltage of 3V

6V:

- Constant voltage of 6V

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.

<u>Specifications:</u>

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)

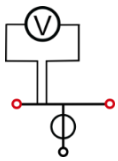
Digital multimeter L2-06-011 with safety test lead and safety short-circuit plugs



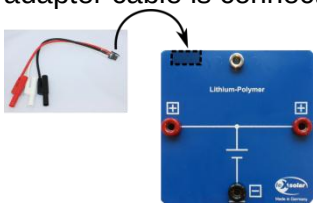
The digital multimeter is used, depending on the test for the evaluation of voltage, current or resistance. In case of accidental overload the fuse of the device can be replaced to restore the functionality of the current measurement again. However, it is recommended that in the experiments of the current measurement to use the 10A measuring range (Warning: Then use the third socket on the bottom right)
The following test leads are included in the experimental system:

1x Safety test lead, 50cm, red	L2-04-059
1x Safety test lead, 50cm, black	L2-04-060
1x Safety test lead, 25cm, red	L2-04-066
1x Safety test lead, 25cm, black	L2-04-067

Battery adapter cable 1800-09

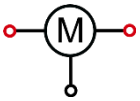



All battery modules are equipped with an additional connection for the four-point measurement. The adapter cable is connected with the black connector to this port:



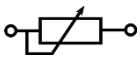
To measure the voltage, the red and the black cable are connected with the measurement device. For measuring the resistance the white cable instead of the red is used.

Motor module 1118-02 with propeller L2-02-017



The motor module acts as a consumer in the EStore experiments.

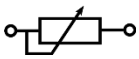
Resistor module, triple 1800-01 with resistor plug elements



By means of the resistor module parallel connections of different resistor plug-in elements can be realized. The following resistor plug elements are included in the experimental system:

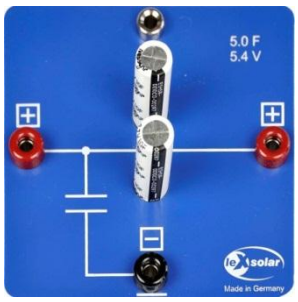
1 x R=1Ω	1800-03
3 x R=10Ω	1800-05
1 x R=33Ω	1800-06
1 x R=100Ω	1800-04

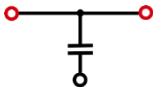
Potentiometer module 1118-04



The potentiometer module consists of a 0-10Ω rotational resistance and a 0-100Ω resistance. Both are connected in series, so that the potentiometer module can realize resistances between 0Ω to 110Ω. The measurement accuracy when setting a resistor is 0.5Ω at the smaller and about 5Ω at the 100Ω-rotational resistance.

Capacitor module 1118-11

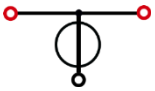




The capacitor module consists of two series-connected capacitors. The maximum voltage of the capacitor module is 5.4 V. When charging no higher voltage should be applied as 5V. To discharge the capacitor may be shorted as fuses in the module prevent it from too high amperage. For fast charging the capacitor can be connected directly to the charger module. In the experiment the capacitor can be charged in the constant voltage mode.

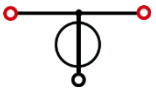
Specifications:
Capacity: 5 F
Voltage: 5.4 V

Lead battery module 1800-13



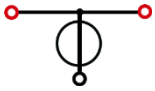
Specifications:
V=1.9V…2.15V
End-of-discharge voltage: 1.9V
Maximum charging voltage: 2.35V

LiFePo battery module AAA 1801-06 with mount 1800-08



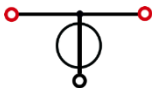
Specifications:
V=3.2V… 3.4V
End-of-discharge voltage: 2.8 V
Maximum charging voltage: 3.6 V

Lithium-Polymer (LiPo) battery module 1800-07



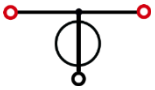
Specifications:
V=3V… 4.2V
End-of-discharge voltage: 3 V
Maximum charging voltage: 4.2 V

NiMH battery module, single



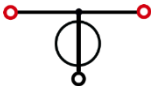
Specifications:
V=1.0V...1.35V
End-of-discharge voltage: 1V
Maximum charging voltage: 1.6V

NiMH battery module. triple 1118-09



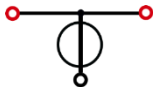
Specifications:
V=3V…4.05V
End-of-discharge voltage: 3V
Maximum charging voltage: 4.8V

NiZn battery module L2-04-102

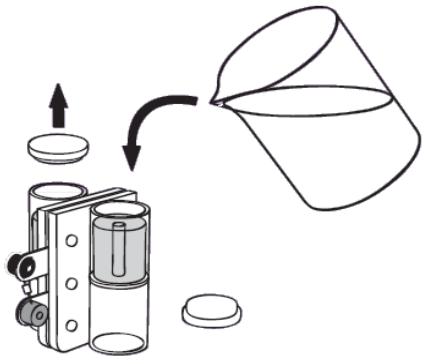


Specifications:
V=1.3V…1.8V
End-of-discharge voltage: 1.3V
Maximum charging voltage: 1.9V

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



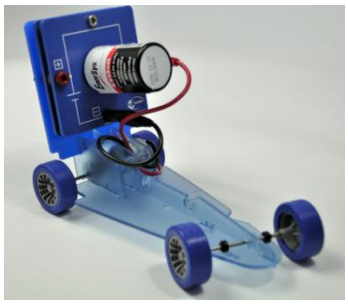
The reversible fuel cell consists of an electrolyzer and a fuel cell. To fill the reversible fuel cell you should proceed in the following way:



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 1.5V. Otherwise the resulting current could exceed 1A, 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, the battery modules or the capacitor module. The fuel cell can be plugged directly in the car. The capacitor and the batteries can be plugged with the adapter in the car.

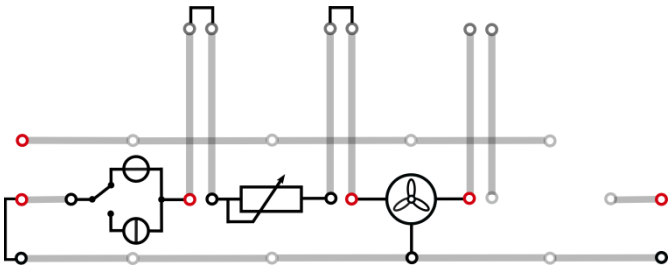
The car will move when both cables are connected with the voltage source. There will be a short circuit when the wires are held during the short circuit.

1.1 Setup of a simple circuit

Task

Set up a simple electrical circuit.

Setup



Required devices

- base unit
- 1 ChargerModule
- 1 Potentiometer module
- 1 Motor module
- 2 Short circuit plugs
- cables

Execution

1. Set up the experiment according to the circuit diagram. Use the ChargerModule with constant voltage mode at 3V. For handling instructions see page 6.
2. Open and close the electrical circuit by:
   a) Plug in/plug off a cable.
   b) Plug in/plug off the potentiometer.
   c) Switch on/switch off the ChargerModule.
3. Vary the resistance at the potentiometer module. Note your observations.

Observation

The motor stops turning when the electrical circuit is interrupted. It is not an issue in which way the circuit is broken.

The motor turns faster at lower resistances.

Evaluation

1. Formulate reasons for the behavior of the motor.

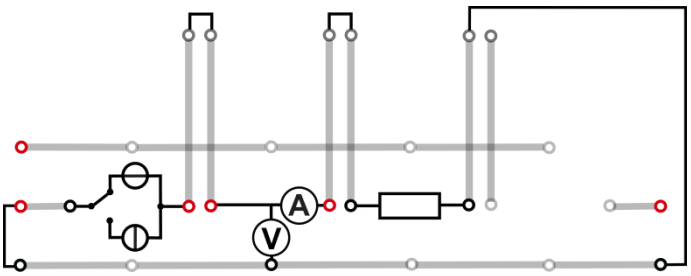
The motor needs a certain voltage and current to turn. When the circuit is interrupted no current is flowing and therefore the motor stops turning. By increasing the resistance of the potentiometer the current and hence the power at the motor is decreasing. The motor is turning accordingly slower.

1.2 Ohm`s law

Task

Investigate Ohm`s law with several resistors.

Setup



Required devices

- base unit
- 1 ChargerModule
- 1 resistor module, triple
- 3 resistor plug elements
  (R=100Ω, R=33 Ω, R=10 Ω)
- 1 AV-Module
- 2 Short circuit plugs
- cables

Execution

1. Set up the experiment according to the circuit diagram. Use the ChargerModule with constant voltage mode at 6V. For handling instructions see page 6.
2. Measure voltage and current for various resistances. Use the AV-Module in voltage-current-mode.
   - R=100Ω
   - R=33Ω
   - R=10Ω
3. Note your measured data in the table and calculate each the ratio V/I.

Measurements

R (Ω)	100	33	10
V (V)	6.0	6.0	5.8
I (mA)	60.9	180.6	532.7
V/I (Ω)	98.5	33.2	10.9

Evaluation

1. Deduce a connection between resistance R and ratio V/I. Which lawfulness can be derived?

The resistance R is matching the ratio V/I. Therefore the equation of Ohm`s law can be deduced:

R=V/I

1.3 Series connection of ohmic resistances

Evaluation

1. Calculate each the ratio $R_{tot}=V_{tot}/I$ and note your values in the table above.
2. Calculate each the sum of the single voltages ($V_1 + V_2$) and compare it the voltage over both resistances (V_{tot}).
3. What is the influence of the resistance on the current I and the voltages $V_1 + V_2$, respectively V_{tot}?
4. What is the connection between the total resistance R_{tot} and the single resistances?
5. Formulate a law for the calculation of the total resistance in a series connection of resistances.

2.

	$V_1 + V_2$	V_{tot}
R_{Pot} =100Ω / R_S =100Ω	5.96	5.98
R_{Pot} =100Ω / R_S =33Ω	5.96	5.97
R_{Pot} =100Ω / R_S =10Ω	5.96	5.96
R_{Pot} =100Ω / R_S =1Ω	5.96	5.96

→ $V_{tot}= V_1+V_2$

3.

The higher the resistance, the lower the current.

The higher the sum of the resistances, the lower the current.

If both resistances are equal, the voltage over the resistances is also equal.

If one resistance is higher, a higher voltage can be measured at the higher resistance.

The total voltage remains constant.

4. + 5.

The total resistance is nearly matching the sum of the single resistances.

Therefore the equation for the total resistance in a series connection can be written as:

$R_{tot}= R_1+ R_2+…+R_n$ (n… number of resistances)

7.2 Operation of the electric car with the reversible fuel cell

Evaluation

1. Compare the operation of the electric car with the fuel cell to the operation with conventional accumulators like in the prior experiment.
2. Inform yourself about the application of fuel cells in the automotive industry. Which forms of storage of hydrogen are in use?

Measurements

	4 rounds	8 rounds	12 rounds	16 rounds	20 rounds	Observation after 5min (resp.when the car stops)
Fuel cell: V_0 = 1.4 V						
time in s	34	72	112	154	198	continuous decrease of speed
time for 4 rounds	34	38	40	42	44	stops after ca. 3:40 min

Evaluation

1.

Obviously much slower than with other accumulators (due to lower operational voltage).

Lower storage capacity

Current is produced by reaction with hydrogen

2.

Used as hybrid drive in electric cars (for ex. in combination with battery regeneration techniques).

compressed gaseous hydrogen storage, metal hydride hydrogen storage.

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