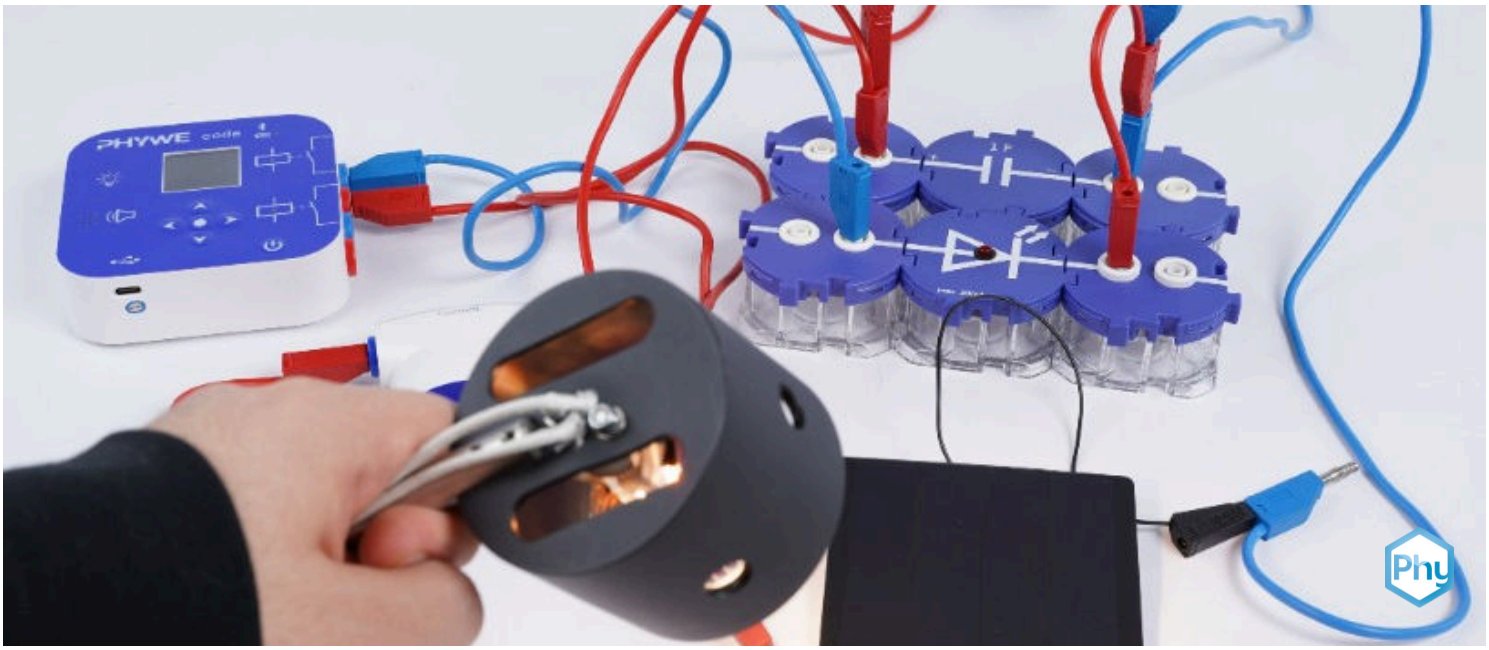
Storage of the electric energy from a solar cell in a capacitor



In this experiment, the students learn how a capacitor works, which is charged by a solar cell. They will also be familiarised with the simple programming of a device for voltage and current monitoring and the switching of relays.

Physics	Energy	Energy forms, conversion & conservation
Physics	Energy	Renewable energies: Sun
Physics	Energy	Energy storage

Difficulty level	Group size	Preparation time	Execution time
easy	1	10 minutes	10 minutes

This content can also be found online at:

https://www.curriculab.de/c/685d3050d0b4740002bf1f22

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Teacher information

Application

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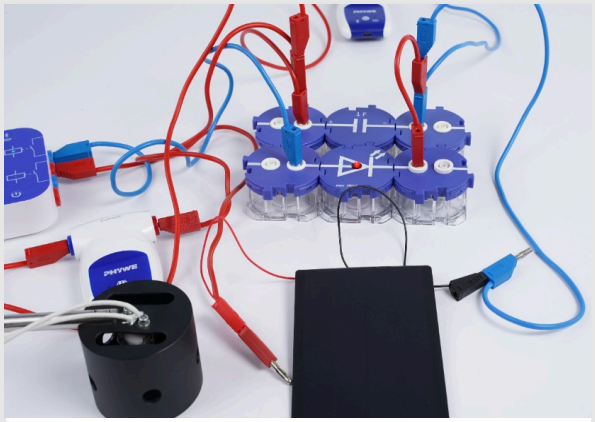

Experimental setup

A capacitor is a passive electrical component with the ability to store electrical charge and the associated energy.

Among other things, the circuit can be supplied with voltage from the capacitor in order to equalise and smooth out voltage drops if the primary voltage source has excessively long response times.

Due to their wide range of applications, capacitors can be found in almost all modern circuits.

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Other teacher information (1/3)

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Prior knowledge

The students should have experience in using a student network device and it is advisable to have some experience with the measureAPP beforehand.

Principle

In this experiment, students will observe how a capacitor works by charging it and then using it as a voltage source.

Other teacher information (2/3)

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Learning objective

In this experiment, the students learn how a capacitor works, which is charged by a solar cell. They will also be familiarised with the simple programming of a device for voltage and current monitoring and the switching of relays.

Tasks

The students programme the code actuator to use it as an automatic switch. They try to store the energy generated by a solar battery in a capacitor and then use this voltage to light up an LED.

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Other teacher information (3/3)

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Notes on structure and implementation

The capacitor is similar in function to an electrolytic capacitor.

It is therefore important to ensure that the positive pole of the capacitor is always connected to a red connection cable.

Incorrect polarity destroys the dielectric and thus the capacitor.

In addition: The threshold current set here was determined empirically. If the lighting conditions or the condition of the solar cell or lamp change drastically, a new threshold value may need to be selected.

Safety instructions

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The general instructions for safe experimentation in science lessons apply to this experiment.

Furthermore, caution is advised with these sources of danger:

- The light bulb and its holder heat up during operation. You should therefore not touch them once they have been switched on.
- The cables to which the lamp is connected have exposed ends that are live.

  These should not be touched and should not be brought into contact with conductive materials under normal conditions.

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Student information

Motivation

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A heap of capacitors

Capacitors make it possible to store energy in the form of separate electrical charges and the associated voltage.

As the stored charge quantities are not particularly large, capacitors, unlike sockets, batteries or rechargeable batteries, do not serve as primary voltage sources for electrical circuits. Their main function is rather to store excess charge and release it again at a later point in time.

This allows the voltage to be kept constant in a circuit, for example, as possible voltage drops are compensated for by the capacitor.

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Tasks

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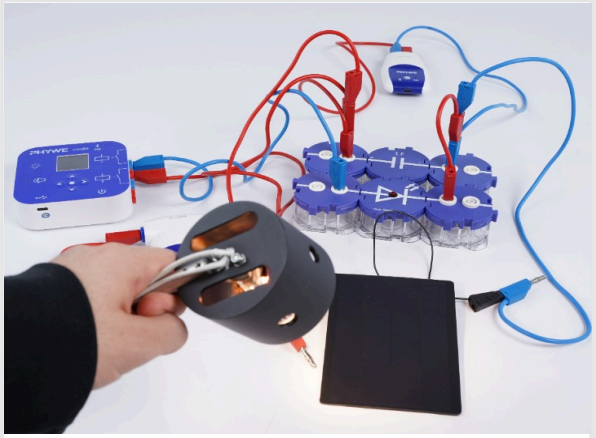

Experimental setup

1. Programme the code actuator to use it as an automatic switch.
2. Store the energy generated by a solar battery in a capacitor.
3. Use the voltage of the capacitor to light up the LED.

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Equipment

Position	Material	Item No.	Quantity
1	Cobra SMARTsense Code - Output device for switching relays, LEDs, display	12953-00	1
2	Cobra SMARTsense Voltage - Sensor for measuring electrical voltage ± 30 V (Bluetooth + USB)	12901-01	1
3	Cobra SMARTsense Current - Sensor for measuring electrical current ± 1 A (Bluetooth + USB)	12902-01	1
4	Solar battery, 4 cells, with cable and connectors	06752-22	1
5	Interrupted connector module with sockets, SB	05601-04	4
6	Halogen lamp with reflector, 12V / 20W	05780-00	1
7	Mount for halogen lamp with reflector	05781-00	1
8	PHYWE Power supply, 230 V,DC: 0...12 V, 2 A / AC: 6 V, 12 V, 5 A	13506-93	1
9	Capacitor (gold cap), 1F, SB	05650-10	1
10	Light emitting diode module red , SB	05654-00	1
11	Connecting cord, 32 A, 250 mm, red	07360-01	5
12	Connecting cord, 32 A, 250 mm, blue	07360-04	4

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Setup (1/6)

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Cobra SMARTsense Code

In this experiment, you will use the Cobra SMARTsense code. This is a control unit that can output specific signals. Possible signal forms are, for example: Illumination of an LED, display indication or sound. In this experiment, we use the relay control of the Cobra SMARTsense Code. In this case, a relay is nothing more than a switch. It can be used to open and close circuits in a targeted manner.

Setup (2/6)

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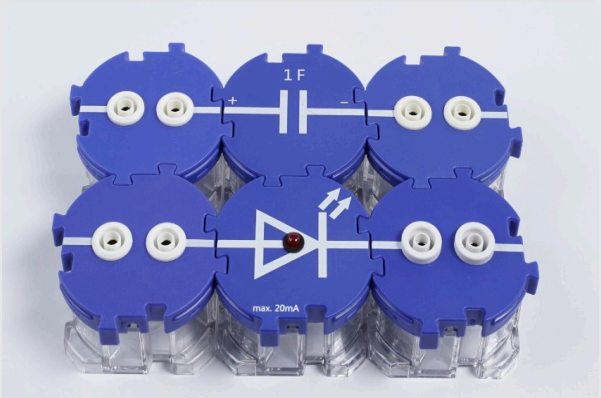
- Plug the cable components together as shown in the picture.
- Pay attention to the correct polarities and the correct direction of the diode.



Module arrangement for this experiment

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Setup (3/6)

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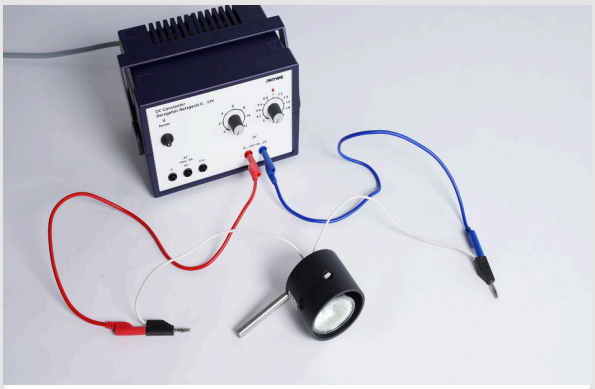
- Connect the lamp to the power supply unit and two cables.
- Set up the power supply unit $10\ \mathrm{V}$ and $1{,}8\ \mathrm{A}$ and do not switch it on yet.



Power supply unit with connected lamp

Setup (4/6)

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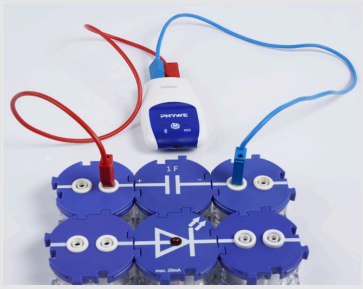

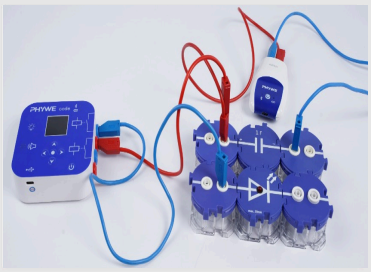

- Now connect the Cobra SMARTsense Voltage Sensor in parallel to the capacitor.
- Connect the Cobra SMARTsense code actuator as a bridge between the capacitor and the diode via relay 1 (top) of the code actuator.

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Setup (5/6)

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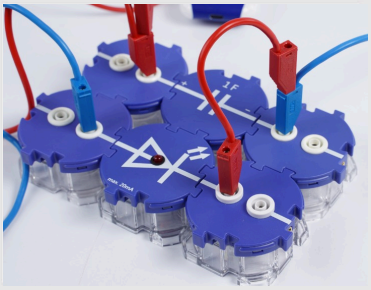

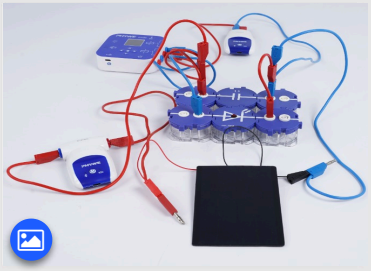

- Connect the other side of the circuits directly with a cable.
- Connect the negative end of the solar cell (blue) to the cable component that leads to the negative side of the capacitor.
- Lead the other end of the solar cell (red) through the Cobra SMARTsense Current sensor to the positive side of the capacitor.

Setup (6/6)

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To measure with the **Cobra SMARTsense sensors**, the **PHYWE measureAPP** is required. The app can be downloaded free of charge from the respective app store (QR codes below). Please check that **Bluetooth is enabled** on your device (smartphone, tablet, desktop PC) before starting the app.

measureAPP for Android operating systems

measureAPP for iOS operating systems

measureAPP for tablets / PCs with Windows 10

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Realisation (1/4)

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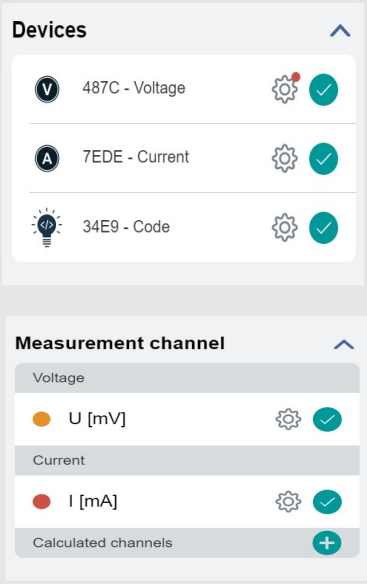

- Activate the Cobra SMARTsense sensors and the Cobra SMARTsense code by pressing and holding the power button for a few seconds until the Bluetooth symbol starts flashing.
- Open the measureApp and connect the three devices by clicking on the white circle next to the sensor at the top of the app under Sensors.
- Click under **Measuring channel** for the voltage under Voltage $U\,[\mathrm{V}]$ on the cogwheel to open the settings. There you set the unit to $[\mathrm{mV}]$ in. Now do the same with the Current measuring channel $I\,[\mathrm{A}]$ to $[\mathrm{mA}]$ to receive.

Realisation (2/4)

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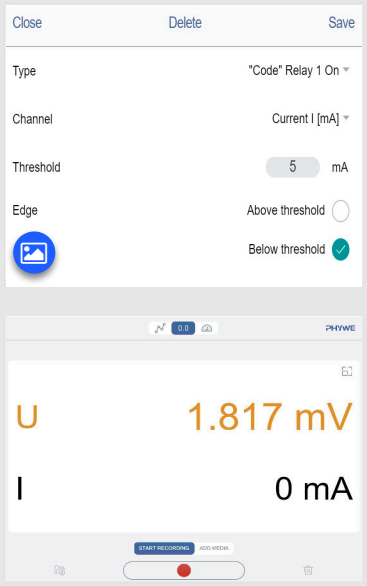

- In the measureAPP, click on Trigger at the bottom left, then on Select action and then select **"Code" Relay 1 On** and click on Save in the top right-hand corner.
- Place in the new window as **Measuring channel** the current $I\,[\mathrm{mA}]$ as **Threshold value** 5mA and as trigger the **below the threshold value** and click Save again.
- Click on the 0.0 symbol at the top of the measureAPP to change the display mode from graph to digital display. You can now see the voltage and current values of the solar cell.

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Realisation (3/4)

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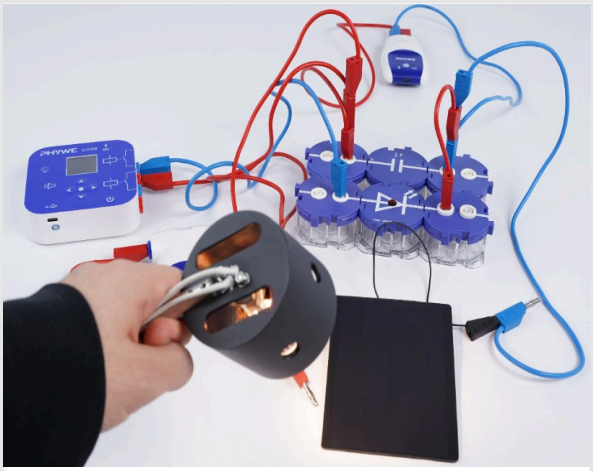
- Activate the lamp by switching on the power supply unit and direct the light from the lamp onto the solar cell.
- Start the measurement in the measureAPP by pressing the button:

- Switch off the lamp or swivel it away from the solar cell as soon as you see that the current to the capacitor has fallen below approx. $20\ \mathrm{mA}$ falls.



Charging the capacitor

Procedure (4/4)

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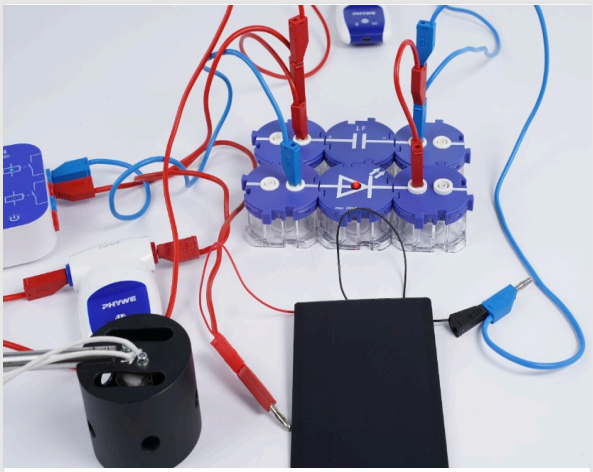
- Observe the behaviour of the LED after switching off the lamp.



Luminous LED

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Report

Task 1

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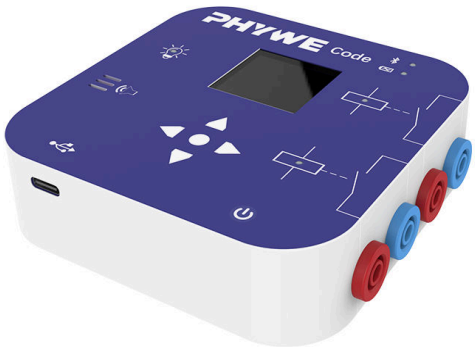
What do we use the Cobra SMARTsense for?
Code in the experiment?

- To act as a switch.
- To measure the voltage.
- To measure the current.



Cobra SMARTsense code

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Task 2

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Drag the words into the correct boxes!

When the solar cell is illuminated, the current flowing to the capacitor _____. This is because the capacitor is _____. As a result, it _____ electrical energy. This is used to light up the LED. Storing solar energy can be useful if more energy is produced during the day when the sun is shining than is _____ by households. This energy can then be used at _____, as households typically consume more at this time because more people are _____ and use electrical energy for lighting or _____ mobile phones, laptops or electric cars, for example.

- charged
- charging
- at home
- night
- consumed
- drops
- stores

Check

Task 3

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Assign the SI unit to the physical quantities.

- Coulomb (C)
- Farad (F)
- Ampere (A)
- Volt (V)

Capacity	Amperage	Tension	Charge

Check

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Slide	Score / Total
Slide 22: Function of the sensors and actuators	0/3
Slide 23: Storing electrical energy in the capacitor	0/7
Slide 24: The physical SI units	0/4

Total amount 0 / 14

Solutions Repeat

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