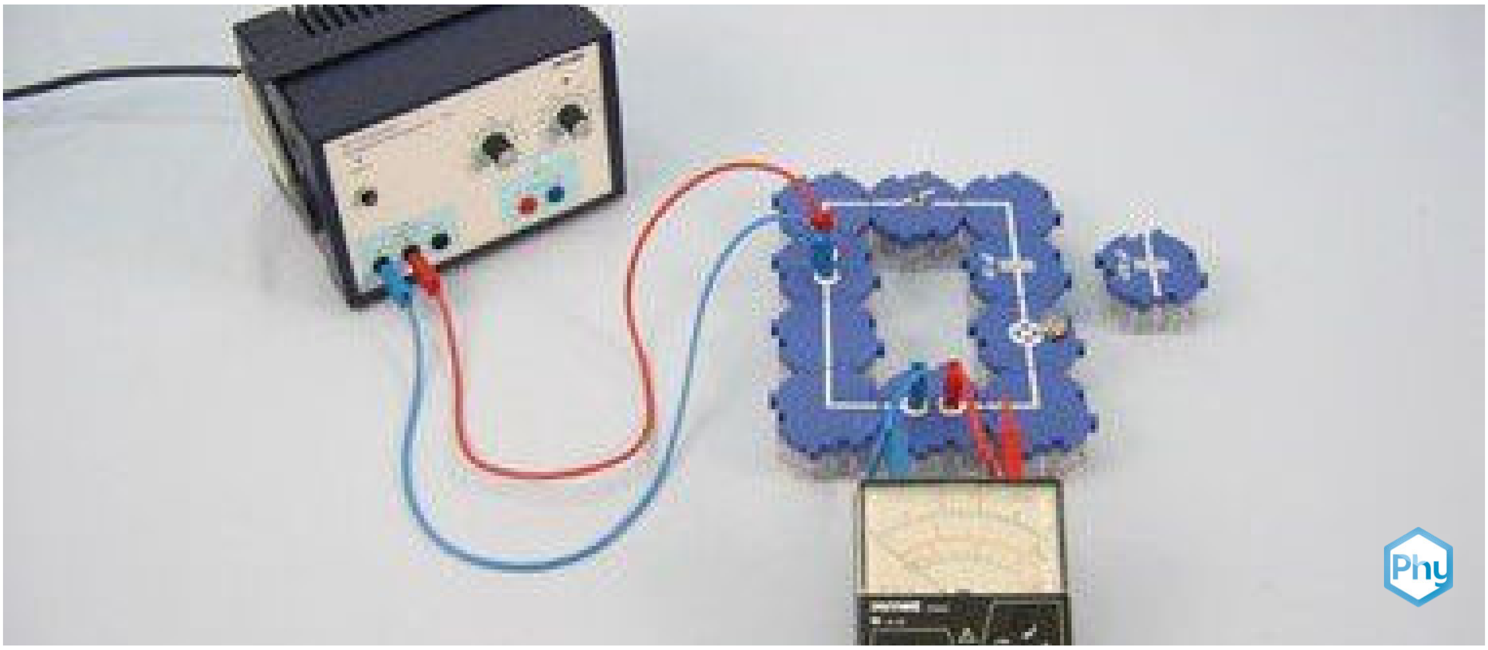
Capacitors in alternating current circuits



Physics | Electricity & Magnetism | Simple circuits, resistors & capacitors

Difficulty level	Group size	Preparation time	Execution time
medium	2	10 minutes	10 minutes

This content can also be found online at:

http://localhost:1337/c/63147200971a9300037ff6ea

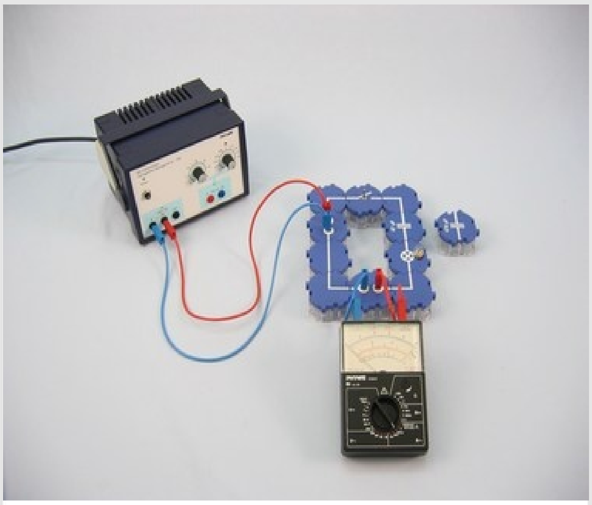
Robert-Bosch-Breite 10
37079 Göttingen

Tel.: 0551 604 - 0
Fax: 0551 604 - 107

info@phywe.de
www.phywe.de

Teacher information

Application



Experimental setup

A capacitor is a standard electrical component. When DC voltage is applied, charge and thus energy is stored in the capacitor, the stored energy being present in the form of the resulting internal electric field. The amount of charge a capacitor can hold depends on its design and the applied voltage and is referred to as its capacitance: $C = Q/U$.

This experiment is about the properties of a capacitor in an alternating current circuit. Here the capacitor acts as a finite resistor for which the following applies $X_C = 1/\omega C = 1/2\pi f C$.

Robert-Bosch-Breite 10
37079 Göttingen
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info@phywe.de
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Other teacher information (1/2)

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Prior knowledge

Students should be able to construct a simple circuit and understand the principles of current, voltage and resistance. Ideally, the students have already been theoretically introduced to the concept of impedance.

Principle

In the first section of the experiment, measurements are used to recognise that a capacitor acts as a resistor in an alternating current circuit. For this purpose, the current intensity is measured when two different capacitors are inserted. Simultaneously, an installed light bulb is observed.

In the second section of the experiment, an alternating current is generated by manually actuating the changeover switch at direct voltage. Here, the dependence of the resistance on the frequency is to be detected.

Other teacher information (2/2)

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Learning objective

Students should understand the behaviour of a capacitor in an AC circuit by investigating and interpreting it.

Task

A capacitor in an alternating current circuit presents a large resistance. This is due to the fact that when the polarity of a capacitor is reversed (or charged and discharged), charges and thus an electric current flow for a short time. How many charges flow depends on the capacitance of the capacitor.

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37079 Göttingen

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Fax: 0551 604 - 107

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Safety instructions

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

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Student information

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Robert-Bosch-Breite 10
37079 Göttingen
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Fax: 0551 604 - 107
info@phywe.de
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Motivation

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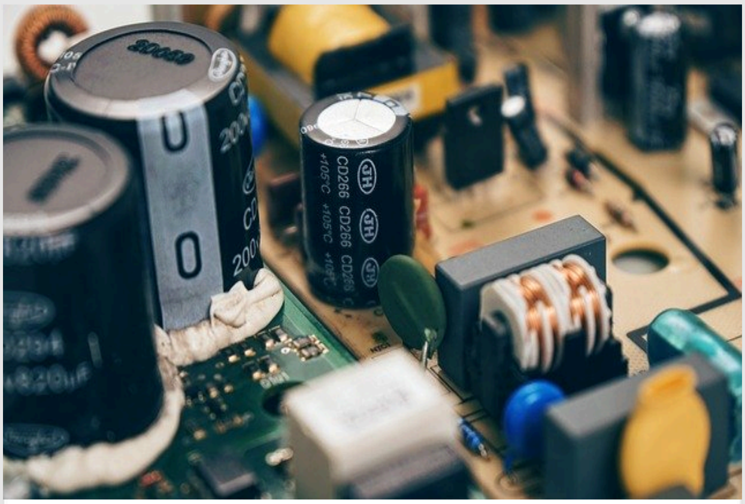
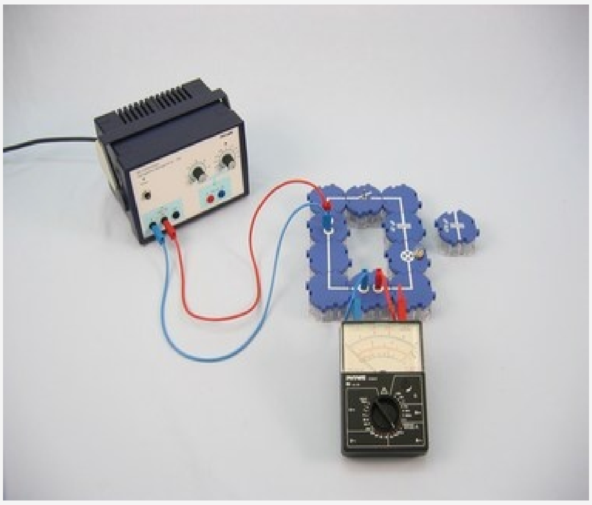


Capacitors on a plate

Capacitors are built into virtually all electrical devices, including computers, smartphones and tablets, because they have special useful properties. These include, in particular, the property of storing charge. Capacitors come in various forms. The simplest form is the so-called plate capacitor, while cylindrical capacitors are usually used on circuit boards.

In this experiment, you will investigate the properties of a capacitor in an alternating current circuit (especially when it is switched on and off).

Tasks



Experimental setup

How does a capacitor behave in an AC circuit?

Demonstrate that a capacitor does not break an AC circuit and investigate what the current depends on when a capacitor is built into the AC circuit.

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Equipment

Position	Material	Item No.	Quantity
1	Straight connector module, SB	05601-01	4
2	Angled connector module, SB	05601-02	4
3	T-shaped connector module, SB	05601-03	1
4	Interrupted connector module with sockets, SB	05601-04	2
5	Junction module, SB	05601-10	2
6	On-off switch module, SB	05602-01	1
7	Change-over switch module, SB	05602-02	1
8	Socket module for incandescent lamp E10, SB	05604-00	2
9	Capacitor module 47 µF non-polar electrolytic, SB	05645-47	1
10	Capacitor module 470 µF non-polar electrolytic, SB	05646-47	1
11	Connecting cord, 32 A, 250 mm, red	07360-01	1
12	Connecting cord, 32 A, 250 mm, blue	07360-04	1
13	Connecting cord, 32 A, 500 mm, red	07361-01	1
14	Connecting cord, 32 A, 500 mm, blue	07361-04	1
15	Filament lamp 6 V/3 W, E10, 10 pcs.	35673-03	1
16	Filament lamps 4V/0.04A, E10, 10	06154-03	1
17	PHYWE Analog multimeter, 600V AC/DC, 10A AC/DC, 2 MΩ, overload protection	07021-11	1
18	PHYWE Power supply, 230 V, DC: 0...12 V, 2 A / AC: 6 V, 12 V, 5 A	13506-93	1

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11	Connecting cord, 32 A, 250 mm, red	07360-01	1
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Set-up

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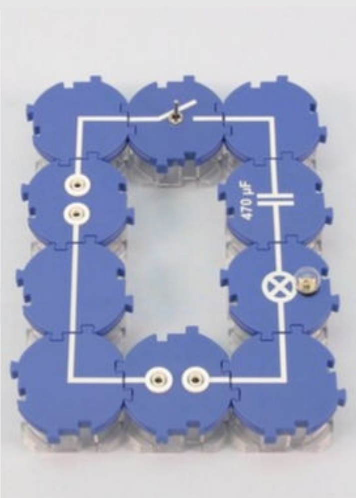

Figure 1

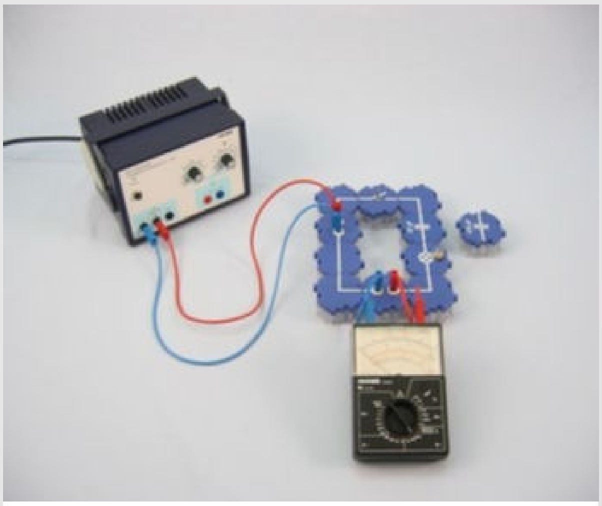

Figure 2

- Set up the experiment according to the illustrations opposite, but first use the $47\ \mu F$ Capacitor.
- First open the switch, connect it to the AC voltage source. $6\ V$~ here.
- Select the measuring range $300\ mA$~ for the multimeter.

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Procedure (1/2)

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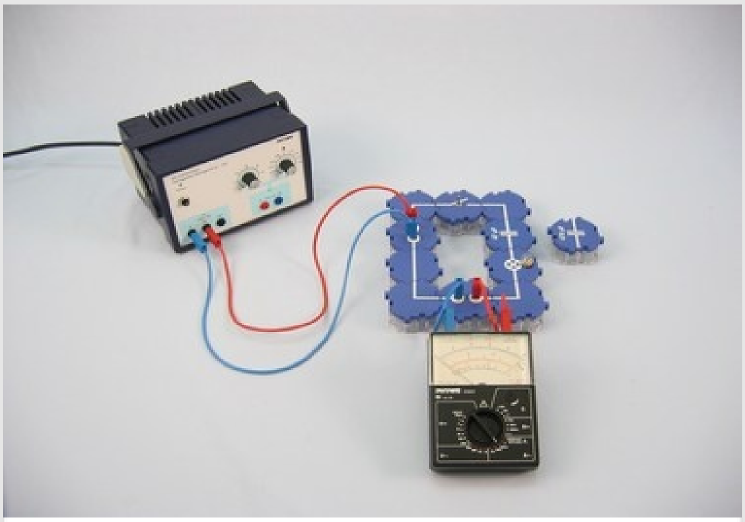

Experimental setup

Task 1: Close the AC circuit, measure the current and observe the brightness of the light bulb. Enter your observations in the table in the report.

Set the measuring range to $3\ A$~.

Task 2: Replace the $47\ \mu F$ Capacitor through the capacitor with $470\ \mu F$. Measure the current and note it in the table.

Task 3: Replace the capacitor with a conductive component, measure the current and note the results in the table.

Switch off the power supply unit.

Procedure (2/2)

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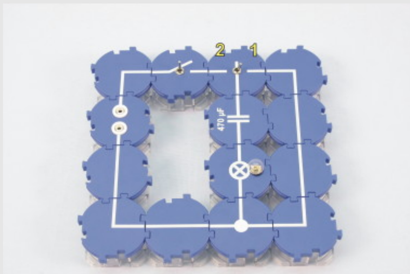
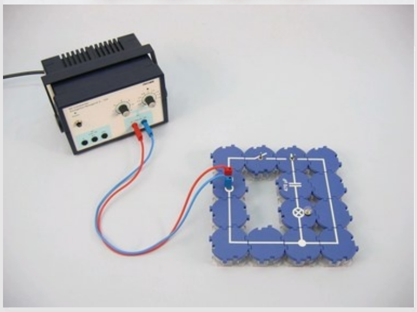
Rebuild the experiment according to the figures on the right. The circuit breaker is initially open again. Set the changeover switch to position 1 and $10\ V$ **DC voltage** on the power supply unit, discharge the capacitor by short-circuiting it before installing it in the circuit.

Task 4: Switch on the power supply, close the circuit and observe the light bulb, write down your observations in the report.

Task 5: Replace the $470\ \mu F$ Capacitor with the $47\ \mu F$ capacitor. Actuate the changeover switch slowly at first, then in increasingly rapid succession (with increasing switching frequency), while observing the bulb and noting your observations in the report.

Finally, switch off the power supply unit.





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37079 Göttingen

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Fax: 0551 604 - 107

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Report

Table 1

Enter your measurements and observations about the condition of the light bulb in the table.

Capacitor	Condition of bulb	$I\,[mA]$
$C = 47\,\mu F$		
$C = 470\,\mu F$		
Without		

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37079 Göttingen
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Task 1

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What is to be observed in the 4th and 5th tasks of the procedure?

- ☐ The faster the switch is pressed, the lower the light bulb glows.
- ☐ The faster the switch is pressed, the brighter the light bulb shines.
- ☐ The switching speed has no effect on the brightness of the bulb.
- ☐ After closing the circuit, the light bulb does not light up.
- ☐ When the circuit is closed, the light bulb lights up briefly.

Check

Task 2

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In the DC circuit, a capacitor means an infinitely large resistance because it interrupts the circuit. What follows from the results of the 1st experiment noted in Table 1 for the AC circuit?

- The smaller the capacity, the greater the resistance.
- The greater the capacity, the greater the resistance.
- The brighter the bulb shines, the greater the resistance.
- No correlation can be deduced from the table.

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Task 3

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Which statement about the relationship between the resistance of a capacitor in an alternating current circuit and the frequency results from the observations of the 5th task?

- The higher the frequency, the greater the resistance.
- The higher the frequency, the lower the resistance.
- The smaller the frequency, the smaller the resistance.
- There is no correlation between the frequency of the alternating current and the resistance of the capacitor.

Task 4

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Drag the words into the correct boxes!

It can be summarised that the so-called capacitive ______ of a capacitor depends on both the capacitance C with ______ as well as from the frequency f with ______ of the alternating current. Explicitly, this relationship can be expressed as ______ .

- resistance
- $R_C = 1/(2\pi f C)$
- $R_C \propto 1/f$
- $R_C \propto 1/C$

Check

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