Filter Networks (Item No.: P1378400)

Curricular Relevance

Area of Expertise:	Education Level:	Topic:	Subtopic:	Experiment:
Physik	Klasse 10-13	Elektrizitätslehre	Elektronik	Die Siebkette

Difficulty	Preparation Time	Execution Time	Recommended Group Size
Intermediate	10 Minutes	10 Minutes	2 Students

Additional Requirements:

Experiment Variations:

Keywords:

Task and equipment

Information for teachers

Additional information

In this experiment, the students should examine the effect filter capacitors and filter sections have on the direct and alternating current portions of a pulsating direct current. Since oscilloscopes are generally not used in student experiments, the students must note the brightness of the filament lamp used as a load resistor to determine how large the direct voltage portion is. They can compare hum voltage based on the volume of the humming in the headphones. Furthermore, they can measure with the meter how much of it is alternating voltage. A capacitor is connected in front of the meter to filter out the direct voltage. Since the minimum alternating voltage measurement range of 10 V is too insensitive, we suggest to use a more sensitive alternating current measurement range of 30 mA.

Notes on setup and procedure

Advise the students regarding the correct connections for the meter.
The 47 µF capacitor C_3 must be connected in front of the meter. Otherwise, the average of the pulsating direct voltage would also be displayed in the measurement range for alternating voltage.
Selecting the measurement range for the current instead of the measurement range for the voltage might be a bit confusing for the students, but the measured change in current can be used to surmise the change in hum voltage. The actual figures are not so important anyway.

Remarks

The pulsating direct voltage produced by rectification can be interpreted as a superposition of the average direct voltage with alternating voltage, i.e. the hum voltage. Since this would interfere with transmission in many electronic devices, it must be reduced as much as possible and/or necessary. Electronic regulation circuits, which are available as integrated circuits, are the most common solution to this problem. A combination of a filter capacitor connected in front of a filter section, however, can also be used to solve the problem.
The equation listed under question 3 is only approximately true because, in deriving it, we neglected the fact that there is a residual hum voltage U_{Hm2} across the parallel connection of the load resistor and capacitor.

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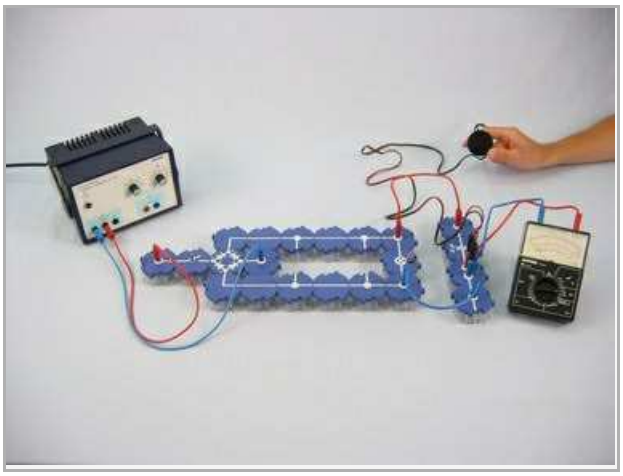
Task and equipment

Task

How can pulsating direct current be transformed into smooth direct current?

Using capacitors and coils, try to reduce the ripple of a pulsating direct current produced by rectification as much as possible.



Equipment

Position No.	Material	Order No.	Quantity
1	Straight connector module, SB	05601-01	4
2	Angled connector module, SB	05601-02	2
3	T-shaped connector module, SB	05601-03	4
4	Interrupted connector module, SB	05601-04	2
5	Junction module, SB	05601-10	2
6	Straight connector module with socket, SB	05601-11	2
7	Angled connector module with socket, SB	05601-12	2
8	On-off switch module, SB	05602-01	1
9	Socket module for incandescent lamp E10, SB	05604-00	1
10	Capacitor module 47 µF non-polar electrolytic, SB	05645-47	1
11	Capacitor module 100 µF non-polar electrolytic, SB	05646-10	1
12	Capacitor module 470 µF non-polar electrolytic, SB	05646-47	1
13	Bridge rectifier module, SB	05655-00	1
14	Earphones, 2kOhm,with 4mm-plugs	06811-00	1
15	Coil, 400 turns	07829-01	1
16	U-core	07832-00	1
17	Yoke	07833-00	1
18	Tightening screw	07834-00	1
19	Connecting cord, 32 A, 250 mm, red	07360-01	2
20	Connecting cord, 32 A, 250 mm, blue	07360-04	2
21	Connecting cord, 32 A, 500 mm, red	07361-01	2
22	Connecting cord, 32 A, 500 mm, blue	07361-04	2
23	Filament lamps 12V/0.1A, E10, 10	07505-03	1 piece
24	PHYWE power supply DC: 0...12 V, 2 A / AC: 6 V, 12 V, 5 A	13506-93	1
25	Multi-range meter, analogue	07028-01	1

Set-up and procedure

Set-up

Set up the experiment as shown in Fig. 1 and Fig. 2 with the following exceptions. Leave the 470 µF capacitors C_1 and C_2 out of the circuit to start and plug a connector building block into the circuit instead of the coil.
Note: The 47 µF capacitor transmits only hum voltage to the headphones and the meter, but blocks the direct voltage part.

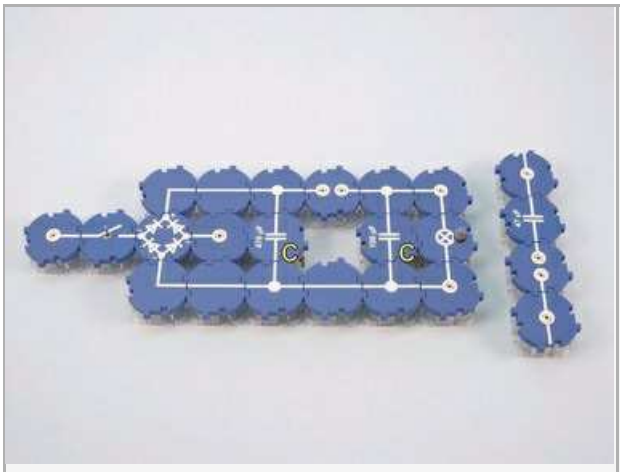


Fig. 1

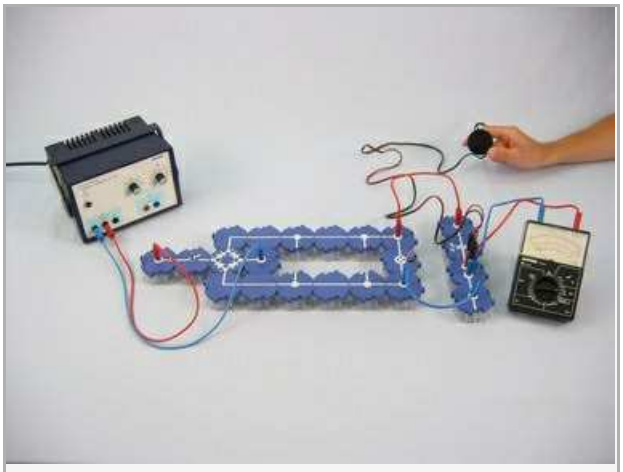


Fig. 2

Procedure

- Select a measurement range of 30 mA. Switch on the power supply unit and set the alternating voltage to 6 V~.
- Measure the current and enter the value in Table 1 in the report. Keep the volume of the humming in the headphones in mind.
- Add capacitor C_1 to the circuit, as shown in Fig. 3. Note the volume in headphones and the brightness of the filament lamp.
- Measure the current. Note your observations and measurements.
- Add one coil with 400 turns to the circuit as shown in Fig. 4. Note the volume in the headphones and measure the current once again. Note the results.
- Place the U-core in the coil, lay the I-core on top, and secure it with the tightening screw, as shown in Fig. 5. Repeat observations and measurements.
- Add the capacitor C_2 to the circuit (Fig. 6). Repeat the observations and the measurements.
- Switch off the power supply unit.

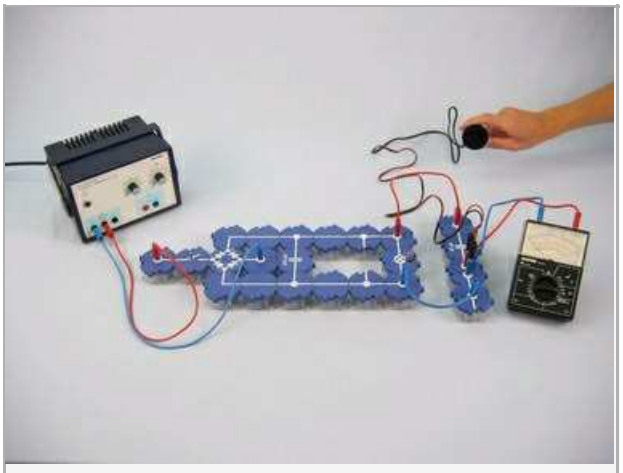


Fig. 3

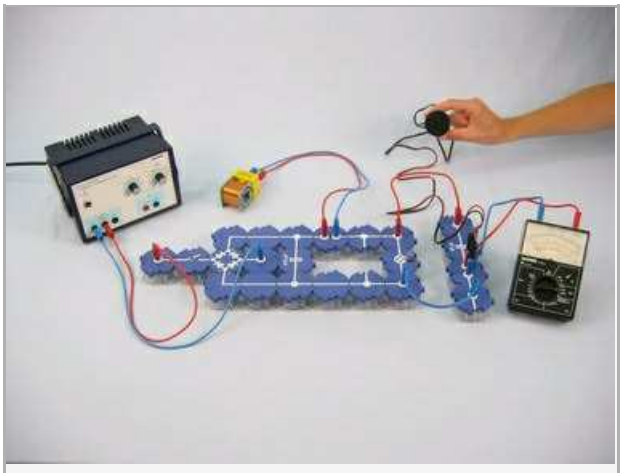


Fig. 4

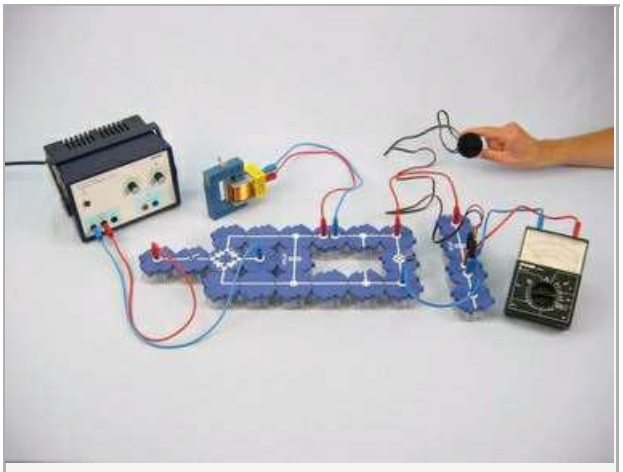


Fig. 5

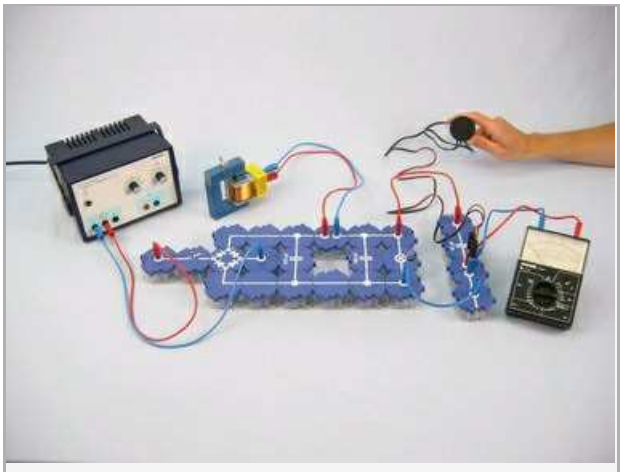


Fig. 6

Report: Filter Networks

Result - Table 1

Note your observations and measured values.

	Humming		I in mA
without capacitor and without coil	loud		1 ± 0
with C_1 and without coil	less loud	1	1 ± 0
with C_1 and coil without iron core	hardly any change	1	1 ± 0
with C_1 and coil with iron core	even lower	1	1 ± 0
with C_1 and C_2 and coil with iron core	not longer audible	1	1 ± 0

Result - Observations

Note your observation of the filament lamp when C_1 is added to the circuit.

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Evaluation - Question 1

The capacitor C_1 is referred to as a filter capacitor. The series connection composed of the coil and capacitor C_2 is called the filter section. Answer the question posed in the header under "Task" using these terms!

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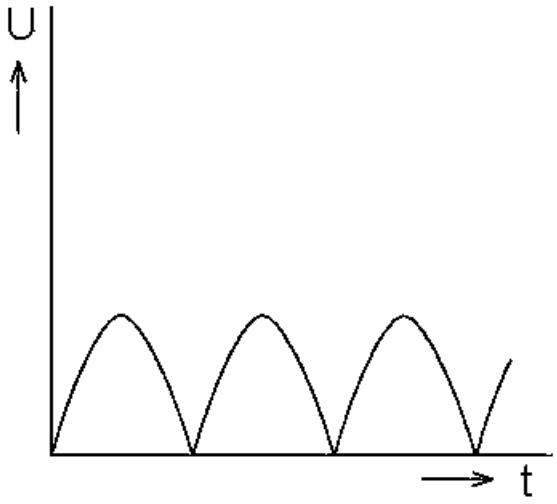
Evaluation - Question 2

The scribble field shows the voltage curve at the filament lamp without the filter capacitor. Using a different color on the same graph, draw in the voltage curve after the filter capacitor is added to the circuit. Note that the voltage source charges the capacitor to the maximum value of the pulsating direct voltage in each half period but can only discharge via the load resistor.



Evaluation - Question 3

Using the previous graph, explain why direct voltage increases (indicated by the brightness of the lamp) when the filter capacitor is added to the circuit.

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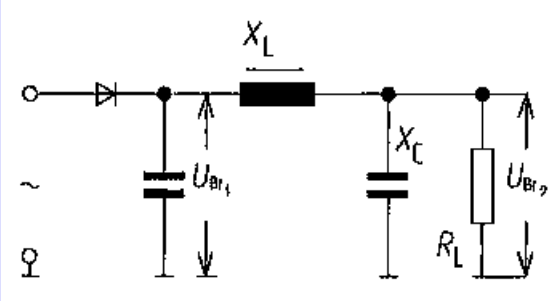
Evaluation - Question 4

Why does the filter section reduce the hum voltage connected to the filament lamp?

Note that the filament lamp used as a load resistor is connected in parallel to the filter capacitor C_2 and that this capacitor together with the coil forms a voltage divider for the alternating voltage. Use the figure below to answer this question.



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Evaluation - Question 5

List some practical applications for a rectifier circuit where hum voltage would otherwise interfere with operation.

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