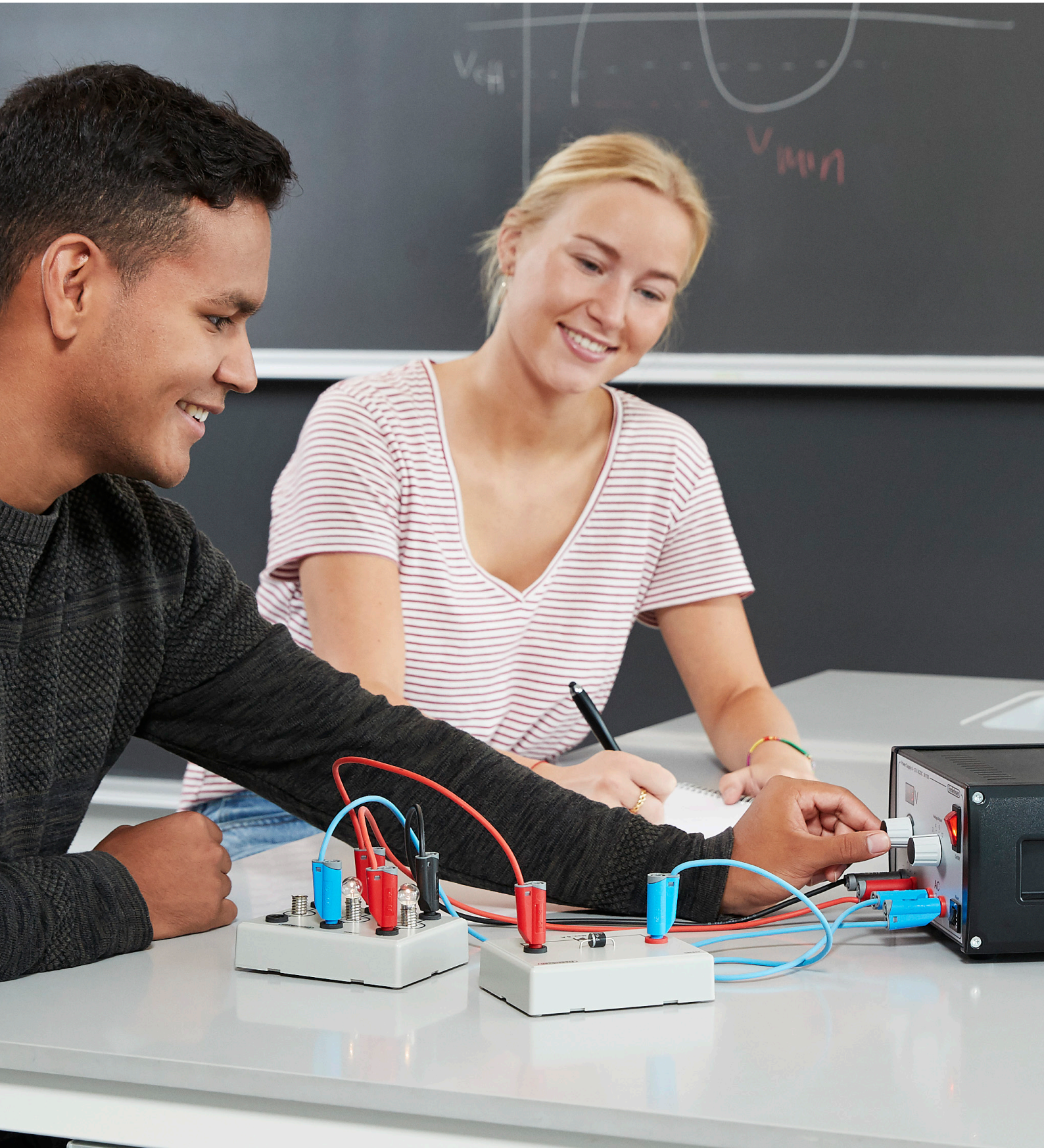
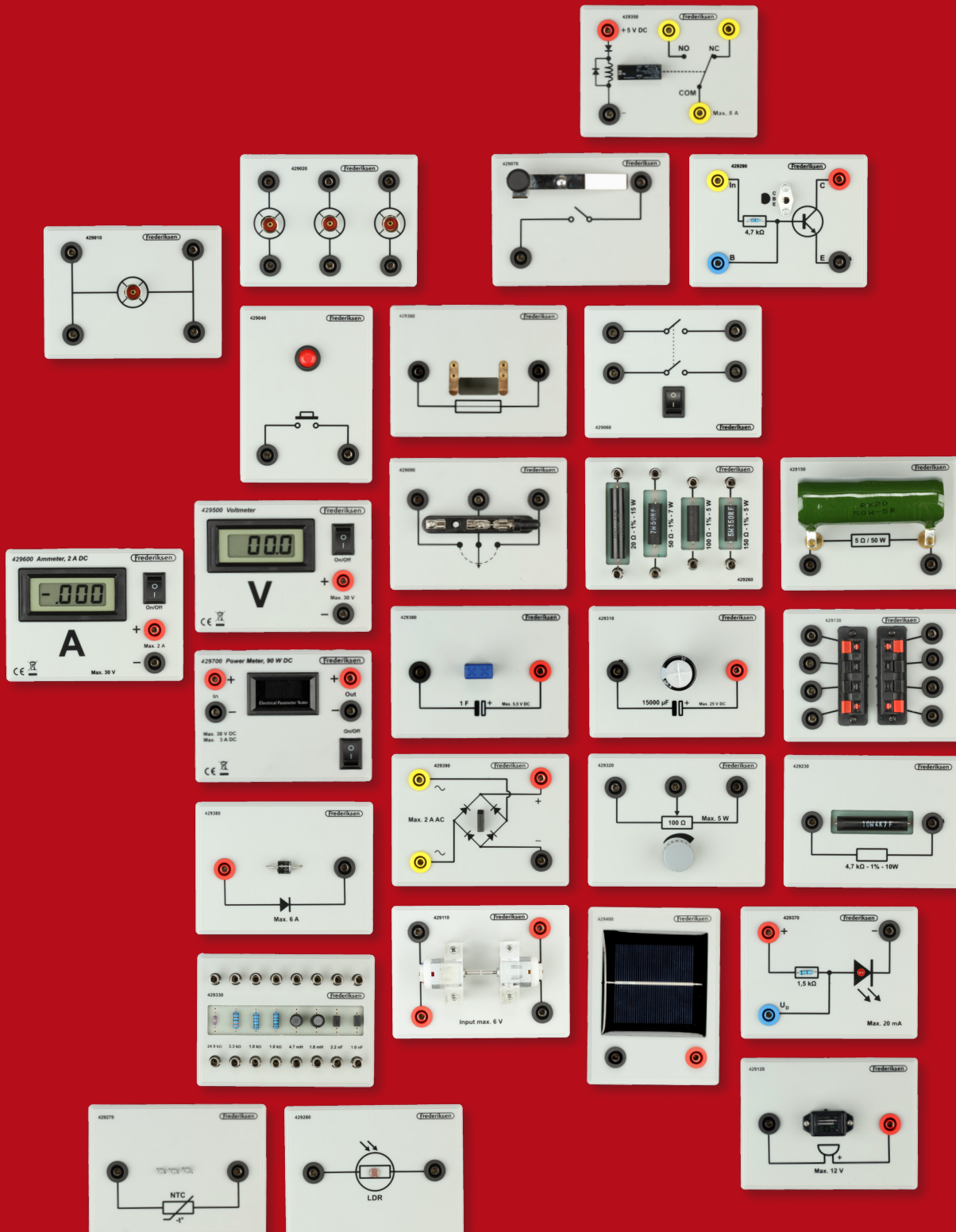


ELECTRICAL COMPONENTS



Frederiksen Scientific is proud to present this series of high-quality equipment for teaching purposes

- Clear and stable setups - the equipment does not tip over when wires are connected
- Conservatively dimensioned components – typical small mishaps will not damage the equipment
- Robust plastic base plate (120 x 90 mm)
- All sockets fit both standard 4 mm banana plugs and shrouded safety plugs



Frederiksen's high-quality products: The best platform, you can build your teaching on – now and in the future.

In this brochure you will find about 50 devices for electricity and magnetism. "Everything else" – power supplies, wires, bulbs, coils, UI cores, multimeters, rod magnets, tone generators, oscilloscopes, etc. – can be found at www.frederiksen.eu.

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MEASURING INSTRUMENTS

Voltmeter, digital, DC

A student friendly digital DC voltmeter with a 3½ digits LCD display. Connects through one red and one black 4 mm safety socket (red is plus).

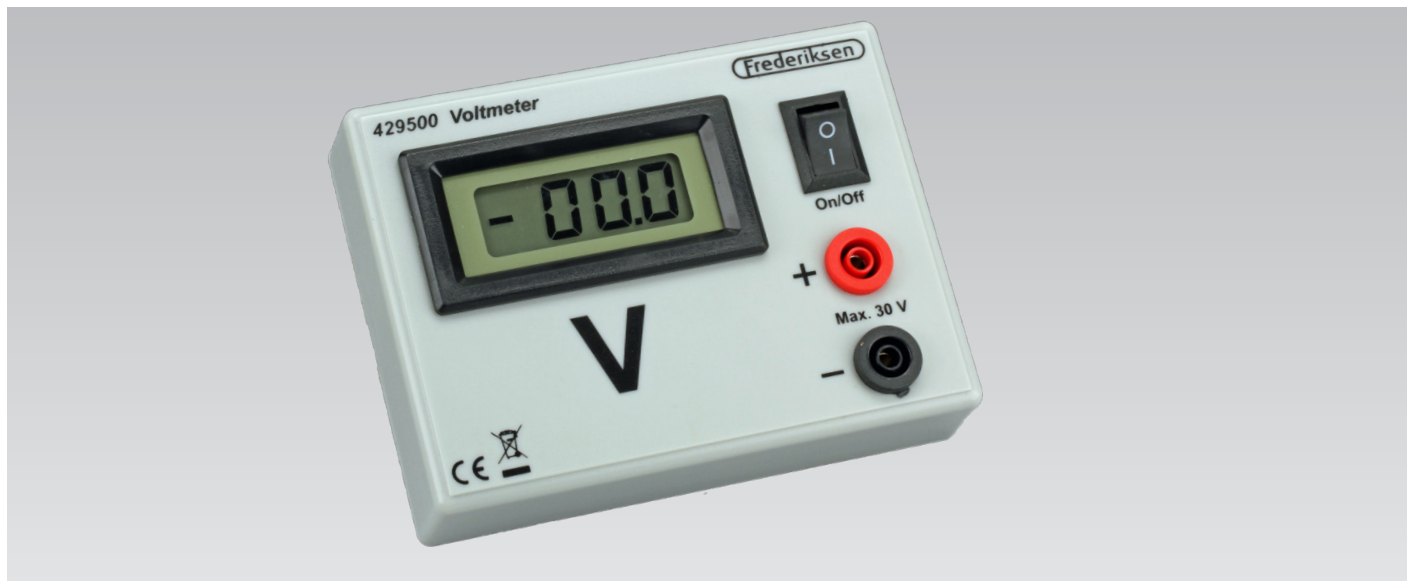
- The instrument provides one fixed measurement range with a resolution of 0.1 V.
- Precision (@ 23°C ± 5°C): ± 1 % ± 1 digit
- Input resistance: ≥ 10 MΩ

Used for example in these experiments:

136035 Resistors in series and parallel (see p. 9)

136230 Capacitor – Charging and discharging (see p. 7)

Item no. 429500



Ammeter, digital, 2 A DC

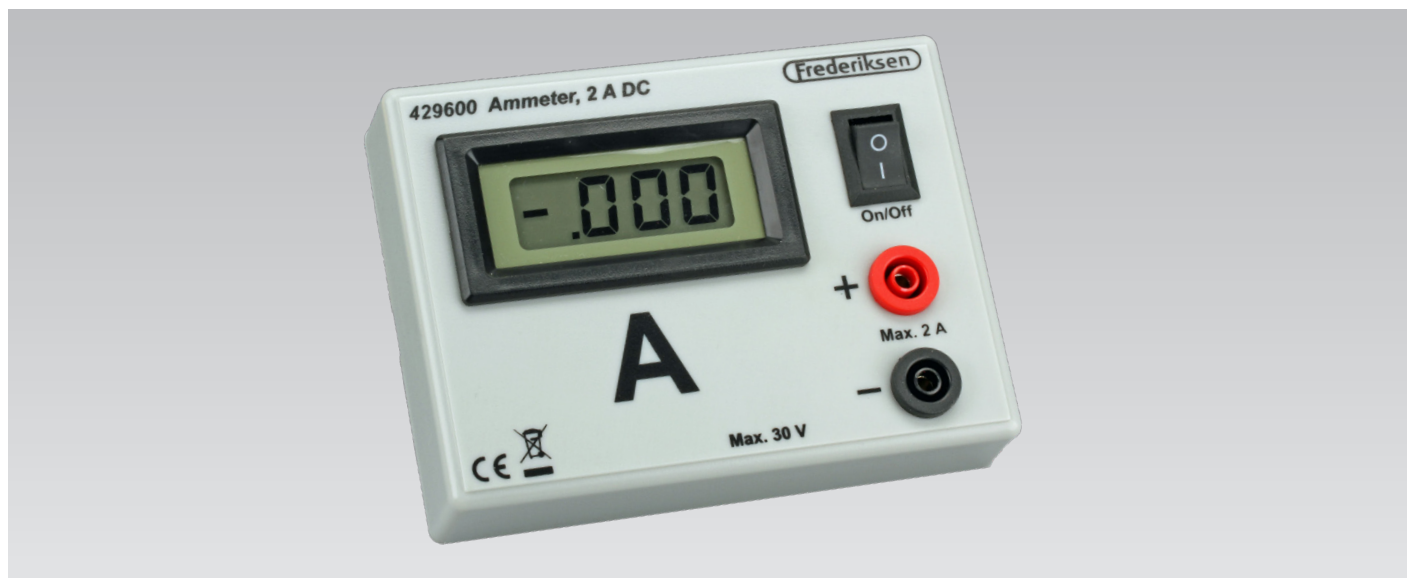
A student friendly digital DC ammeter with a 3½ digits LCD display. Connects through one red and one black 4 mm safety socket (red is plus). The instrument tolerates short term overloads (up to 15 A in 5 seconds).

- The instrument provides one fixed measurement range (0 to 1.999 A) with a resolution of 0.001 A.
- Precision (@ 23°C ± 5°C): ± 2 % ± 1 digit
- Maximum voltage drop: 250 mV (at 2 A)

Used for example in experiment:

133065 Resistors in series and parallel (see p. 9)

Item no. 429600



MEASURING INSTRUMENTS

Ammeter, digital, 20 A DC

A DC ammeter like 429600 but with a 20 A range. For large currents or where low series resistance is important. Connects through one red and one black 4 mm safety socket (red is plus). The instrument tolerates short term overloads (up to 45 A in 5 seconds).

- The instrument provides one fixed measurement range (0 to 19.99 A) with a resolution of 0.01 A.
- Precision (@ 23°C ± 5°C): ± 2 % ± 1 digit
- Maximum voltage drop: 350 mV (at 20 A)

Item no. 429610



Wattmeter, digital, 90 W

Digital DC instrument, measuring voltage, current, power and energy. The two 4 mm safety sockets marked **In** connect to the power providing equipment (solar panel, power supply etc.). The two safety sockets marked **Out** connect to the power consuming equipment (light bulb, load resistor, motor, etc.). The instrument also contains a built-in, rather inaccurate thermometer.

Specifications:

Voltage

- Measuring range 0 – 30.00 V
- Accuracy ± 0.3 % + 2 digits

Current

- Measuring range 0 – 3.000 A
- Accuracy ± 0.8 % + 3 digits
- Voltage drop < 200 mV (typ.)

Power: 0 - 90.00 W

Energy: 0 - 999.99 Wh

Time: 00:00 - 99:59

Item no. 429700



The four instruments shown each run from a single 9 V E-block battery, placed in a battery compartment (i.e. the battery can be changed without disassembling the instrument).

SOCKETS FOR INCANDESCENT LAMPS

Lamp holder E10, 2 connectors

E10 lamp holder (for pygmy bulbs) mounted on a solid base with two 4 mm safety sockets.

Item no. 429000



Lamp holder 3 x E10, 6 connectors

Three E10 lamp holders (for pygmy bulbs) mounted on a solid base with six 4 mm safety sockets. The three bulbs can be connected in series, parallel, or a combination of these.

Item no. 429020



Lamp holder E10, 4 connectors

E10 lamp holder (for pygmy bulbs) mounted on a solid base with four 4 mm safety sockets, connected two by two. Especially suited for parallel coupling of light bulbs.

Item no. 429010



Lamp holder E27, 2 safety sockets

E27 lamp holder (for incandescent light bulbs) mounted on a solid base with two 4 mm safety sockets. (**Not** for UV bulb 286000 or spectral lamps 283650 – 293675.)

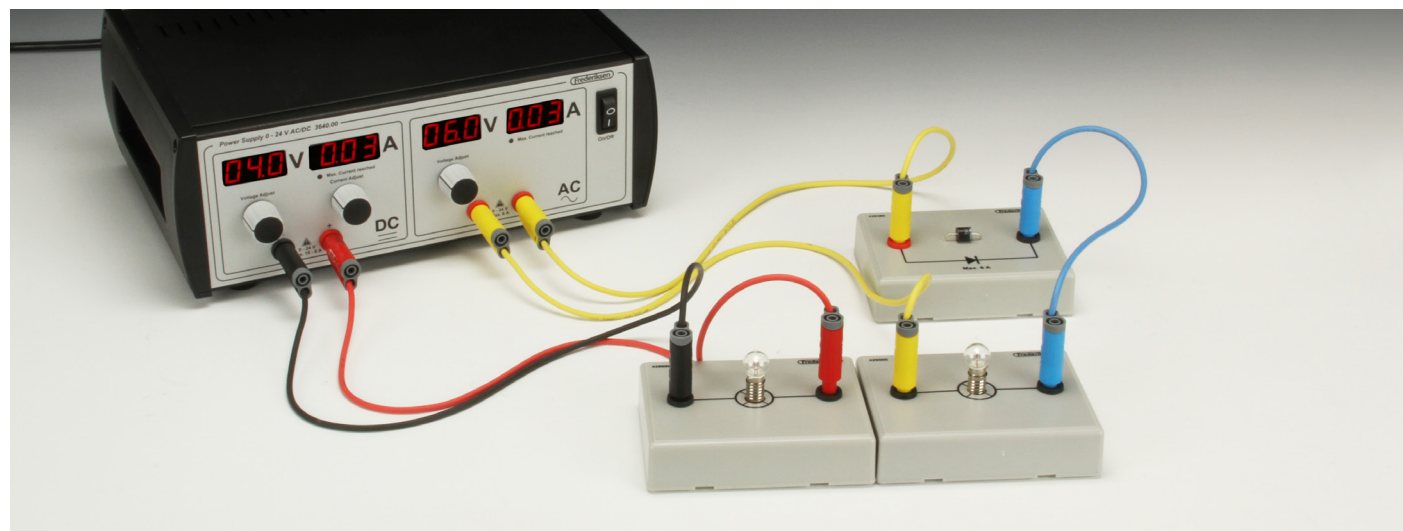
Item no. 429030



Experiment: Effective voltage (136220)

The effective (RMS) value of different voltage waveforms are found by comparing the light yield from to bulbs – one connected to a known DC voltage, one connected to the voltage to investigate. When the bulbs shine equally bright, the effective value of the unknown voltage is the same as the DC voltage. All the E10 lamp holders shown can be used. With 429020 you only need one.

Lab manual and detailed equipment list at www.frederiksen.eu



SWITCHES

Pushbutton

Momentary switch (pushbutton). "Push-to-make": turns ON as long as it is pressed.

- Breaking capacity: 3 A

Item no. 429040



On/off switch, single-pole

Single pole single throw rocker switch with on and off markings.

- Breaking capacity: 10 A AC

Item no. 429050



Knife switch, one-way

Single pole single throw switch, shaped as a knife switch.

Used for example in experiment:

136230 Capacitor, charging and discharging

Item no. 429080



Telegrafnøgle

Momentary switch (pushbutton), shaped like an old-fashioned telegraph key.

Item no. 429070



On/off switch, double-pole

Double pole single throw rocker switch with on and off markings.

- Breaking capacity: 10 A AC

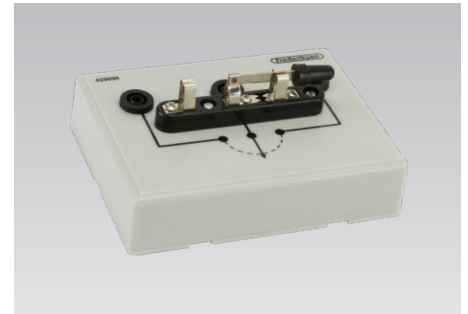
Item no. 429060



Knife switch, two-way

Single pole double throw switch, shaped as a knife switch.

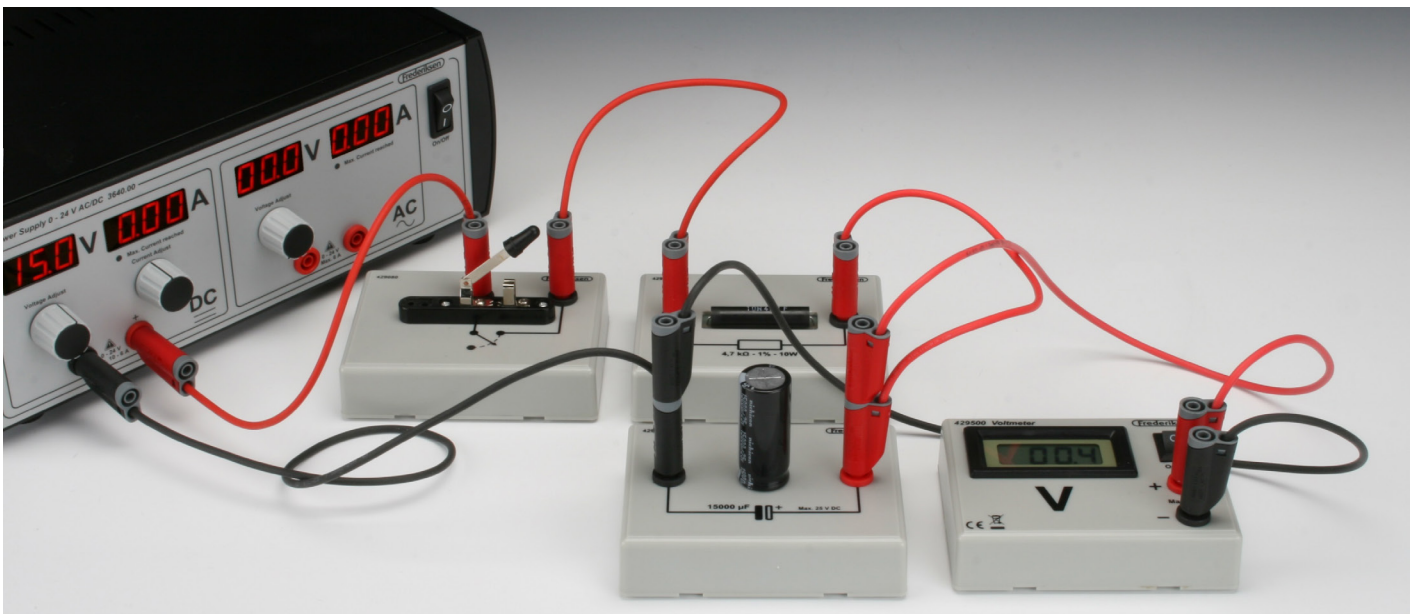
Item no. 429090



Experiment: Capacitor, charging and discharging (136230)

With the components used, the voltage changes can be followed with a stopwatch and a voltmeter. The results are plotted in a spreadsheet and from a trend line the capacitance can be found. The knife switch 429080 (or 429090) clearly shows if the switch is on or off.

Lab manual and detailed equipment list at www.frederiksen.eu

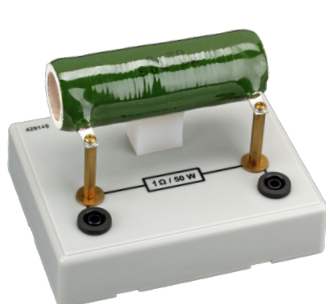


POWER RESISTORS, 50 W

Power resistors

These heavy-duty wire-wound resistors tolerate up to 50 W. Their resistance tolerance is 5%. The resistors will accept short term overloads without harm. When running near maximum power for a prolonged period the resistors will get very hot.

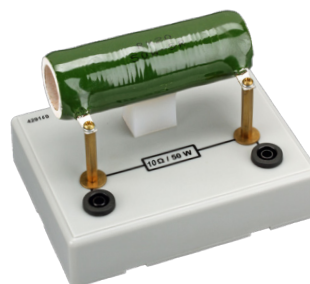
| Item no. | Resistance | Max sustained voltage | Max sustained current |
|----------|-------------|-----------------------|-----------------------|
| 429140 | 1 Ω | 7 V | 7 A |
| 429150 | 5 Ω | 16 V | 3.2 A |
| 429160 | 10 Ω | 22 V | 2.2 A |



Item no. 429140



Item no. 429150

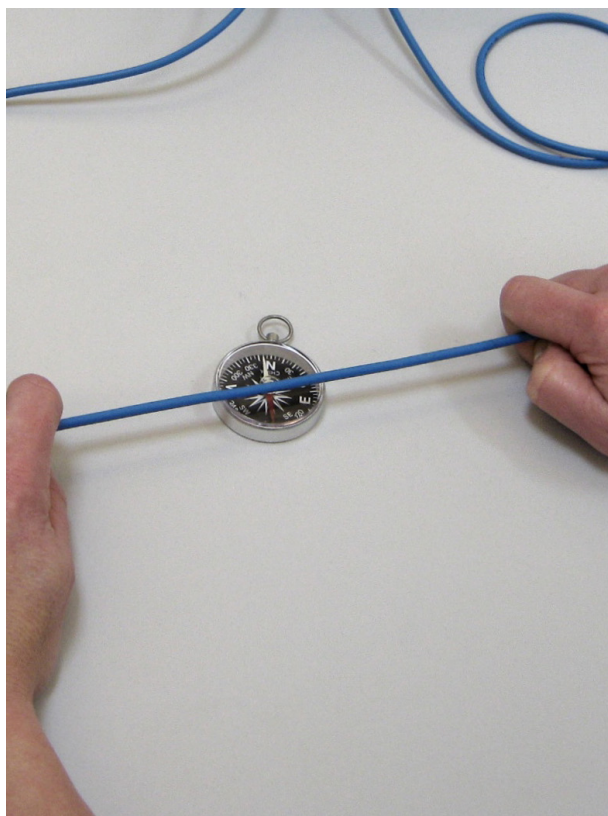
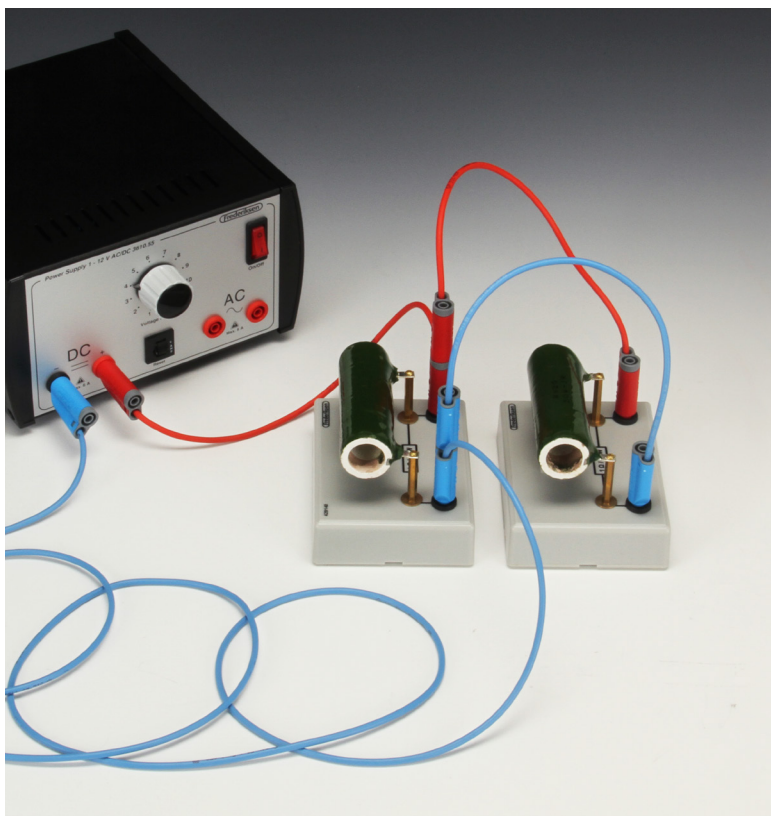


Item no. 429160

Experiment: Oersted's experiment (137110)

We study the magnetic field around a current carrying wire. The direction of the magnetic field at a given position can be found with a small compass. The north pole of the compass needle points in the direction of the field. In fact, the wire constitutes a short circuit. If you want to perform this experiment with a power supply without a variable current limiter, you must insert a couple of power resistors 429140, coupled in parallel.

Lab manual and detailed equipment list at www.frederiksen.eu



POWER RESISTORS, 10 W

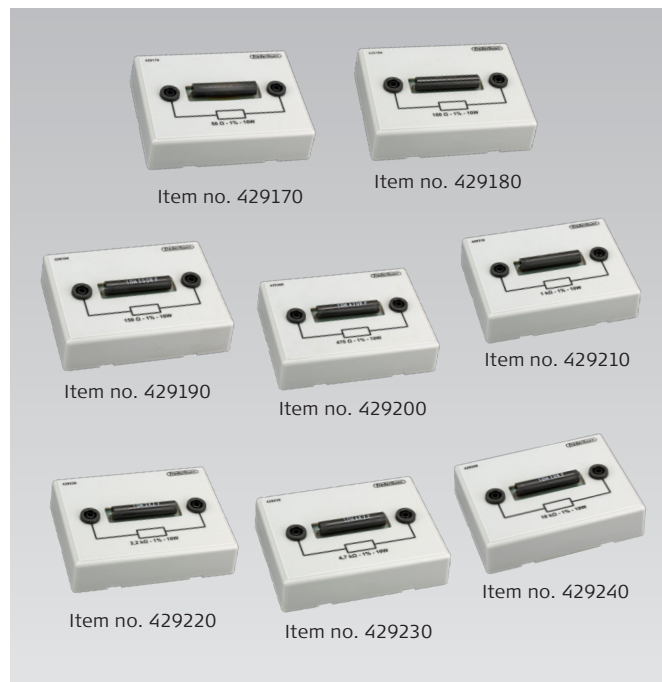
Power resistors

Uncompromising quality for your teaching. These are not just powerful 10 W power resistors - they are 1% precision resistors.

We have selected a number of resistance values that cover most situations. Combine this range with the 50 W series for the smallest resistance values and you will have a good assortment.

The minimum value of the 10 W series (the 50 Ω resistor) can be permanently connected to a voltage of up to 22 V (where it draws 0.45 A). The other resistors simply cannot be destroyed with a regular 0-24 V power supply.

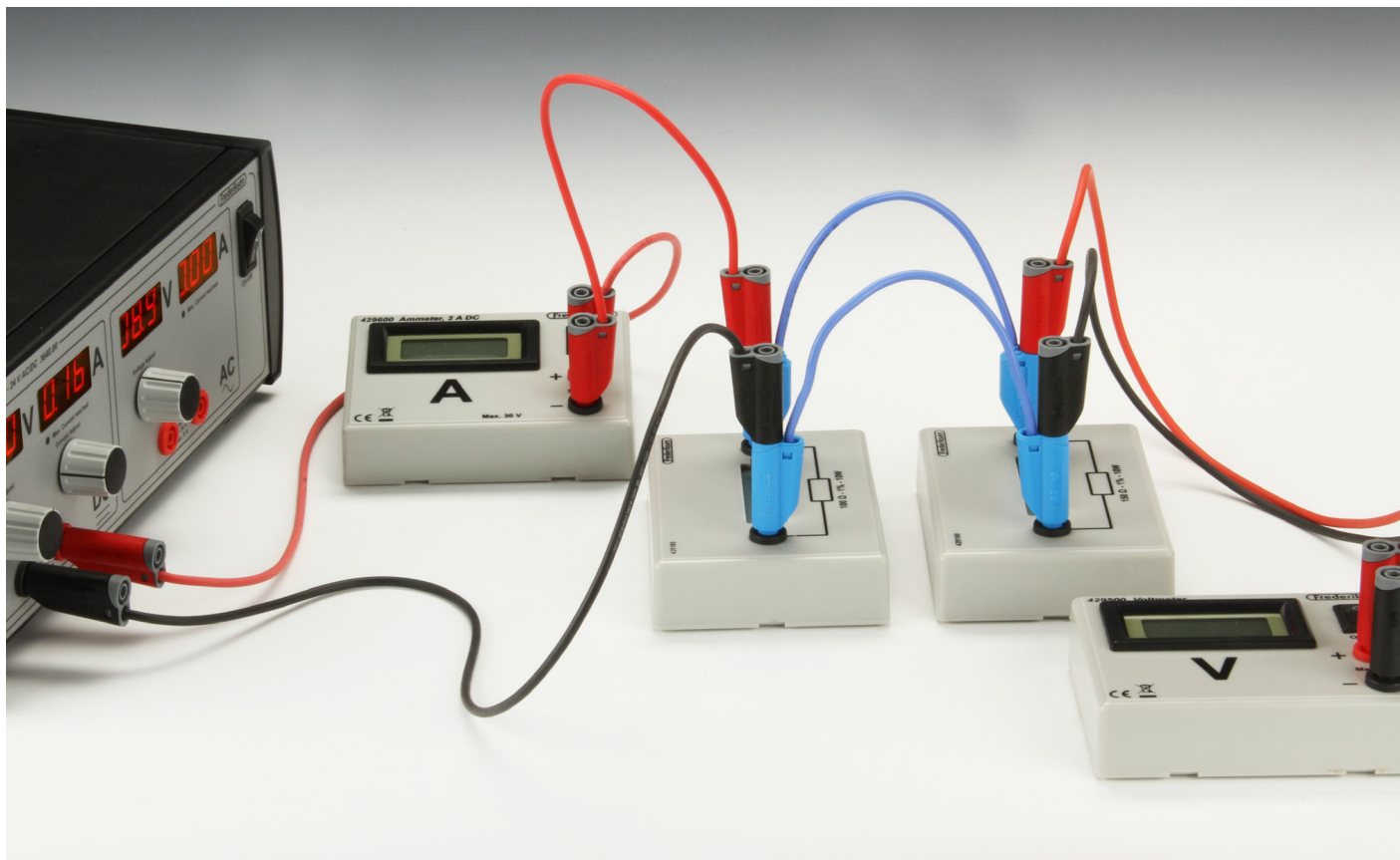
| Item no. | Resistans |
|----------|----------------|
| 429170 | 50 Ω |
| 429180 | 100 Ω |
| 429190 | 150 Ω |
| 429200 | 470 Ω |
| 429210 | 1 k Ω |
| 429220 | 2.2 k Ω |
| 429230 | 4.7 k Ω |
| 429240 | 10 k Ω |



Experiment: Resistors in series and parallel (136035)

We study how current, voltage and resistance behaves in series and parallel coupled resistors. The formulae for the resulting resistances are verified. Current and voltage are measured. Ohm's law is applied to find the resistance – both for the individual resistors and for the series and parallel connections.

Lab manual and detailed equipment list at www.frederiksen.eu

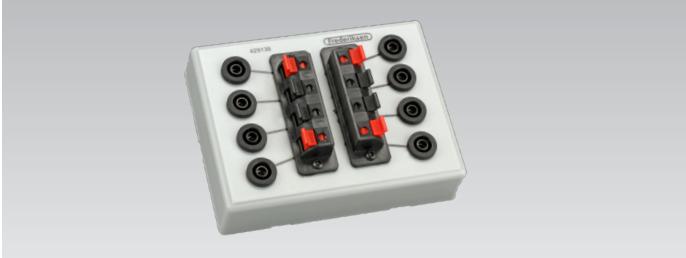


RESISTOR COUPLINGS

Resistor holder

Up to four resistors (or other components) can be mounted in the spring loaded terminals, each connected to a 4 mm safety socket. Used when non-mounted components are included in a circuit with ordinary lab leads.

Item no. 429130



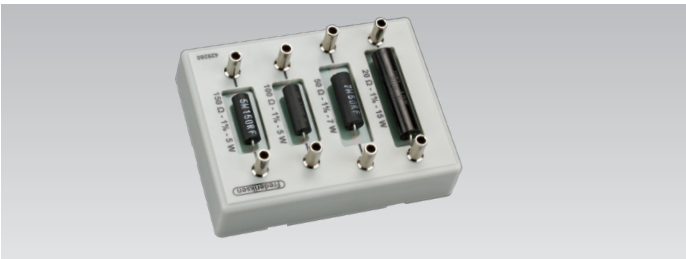
Resistors, 20, 50, 100, 150 Ω

Four precision resistors connected to 4 mm safety sockets. The resistors can be combined in series and parallel connections in countless ways.

| Resistance | 20 Ω | 50 Ω | 100 Ω | 150 Ω |
|------------|-------------|-------------|--------------|--------------|
| Tolerance | 1 % | 1 % | 1 % | 1 % |
| Max. power | 15 W | 7 W | 5 W | 5 W |

Rule of thumb: However you combine these four resistors, they cannot be destroyed using voltages of 17 V or less.

Item no. 429260



Resistors, 2 x 470 Ω , 5 W

Two 470 Ω resistors simulate the resistance in long power lines. Each resistor is connected to two 4 mm safety sockets. Used to demonstrate the necessity of transforming the voltage up when electric energy is transferred through long cables. See experiment below.

Item no. 429250



Potentiometer, 100 Ω

Wire-wound power potentiometer (5 W). Provided with a knob. The potentiometer is mounted on a solid base with three 4 mm safety sockets. Excellent as a variable load resistor, e.g. for smaller solar cells. Withstands up to 220 mA regardless of the setting.

As the potentiometer, the two **outermost** sockets can be connected to 0 V and e.g. 12 V (abs. max. 22 V). The centre socket then gets a continuously variable voltage.

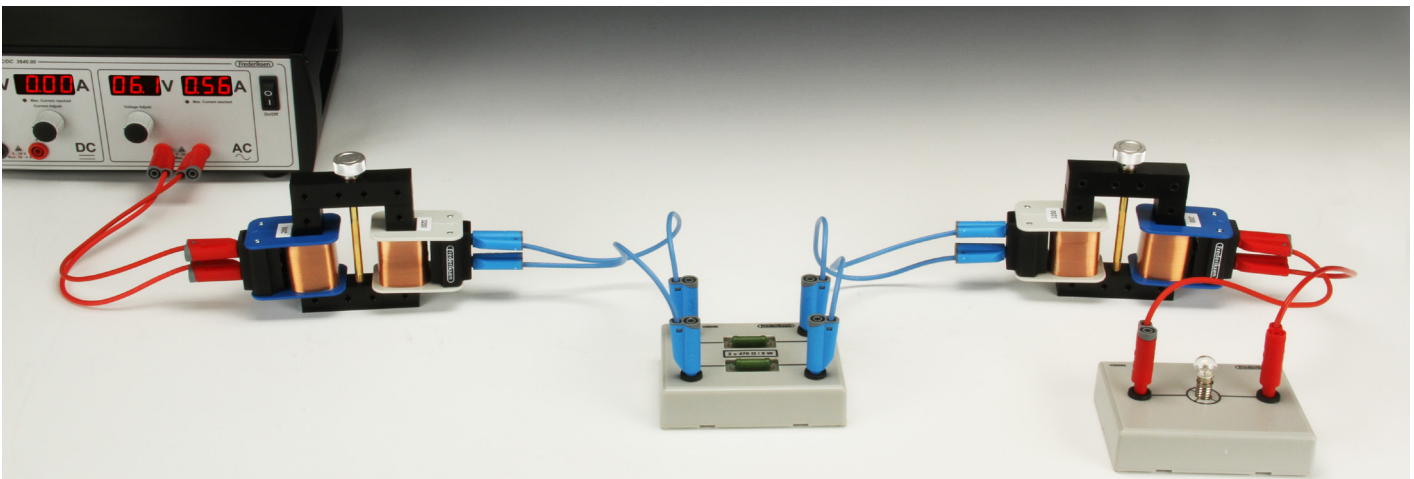
Item no. 429320



Experiment: High voltage power lines (136090)

We study how wire resistance affects the power transmission, using both high and low voltages. A small light bulb connects to a power supply, first directly, then through resistors simulating long wires. Finally, two transformers are added, so the resistance lies in the high voltage part of the transmission line.

Lab manual and detailed equipment list at www.frederiksen.eu



MISCELLANEOUS CIRCUITS

NTC Resistor on base

The resistance of a NTC resistor decreases with temperature. NTC resistors can therefore be used for temperature measurements. Another application is "soft start" circuits where the NTC resistor changes from high to low resistance as it gradually heats up from the dissipated power. Here, three NTC resistors are coupled in parallel to increase the maximum power. Place it in series with e.g. a 6 V 0.5 A incandescent lamp (pygmy bulb). Connect the series connection to 9 V. Observe, how the current increases while the NTC resistor gets hot. (Caution: Watch your fingers – the components get very hot.)

Item no. 429270



Resistor on base

Light dependent resistor, mounted with 4 mm safety sockets. In darkness the resistance exceeds 1 M Ω , in normal indoor light it drops to a few k Ω .

Item no. 429280



LCR Circuit

Used for experiments with resonant circuits and filters. The components are selected to illustrate the different characteristics as clearly as possible. For example, the components can be connected to make LCR low-pass filters which are overdamped, underdamped, critically damped or have the flattest possible frequency response.

The equipment consists of:

- Resistors: 24.9 k Ω / 3.3 k Ω / 1.0 k Ω / 1.0 k Ω (1%)
- Inductors (coils): 4.7 mH / 1.8 mH (5%)
- Capacitors: 2.2 nF / 1.0 nF (1 %)

Used for example in the following experiments:

- 136310 RC Low-pass filters
- 136320 RC High-pass filters
- 136330 Resonant circuits – measuring inductance
- 136340 LCR Band-pass and band-stop filters
- 136350 LCR Low-pass filters

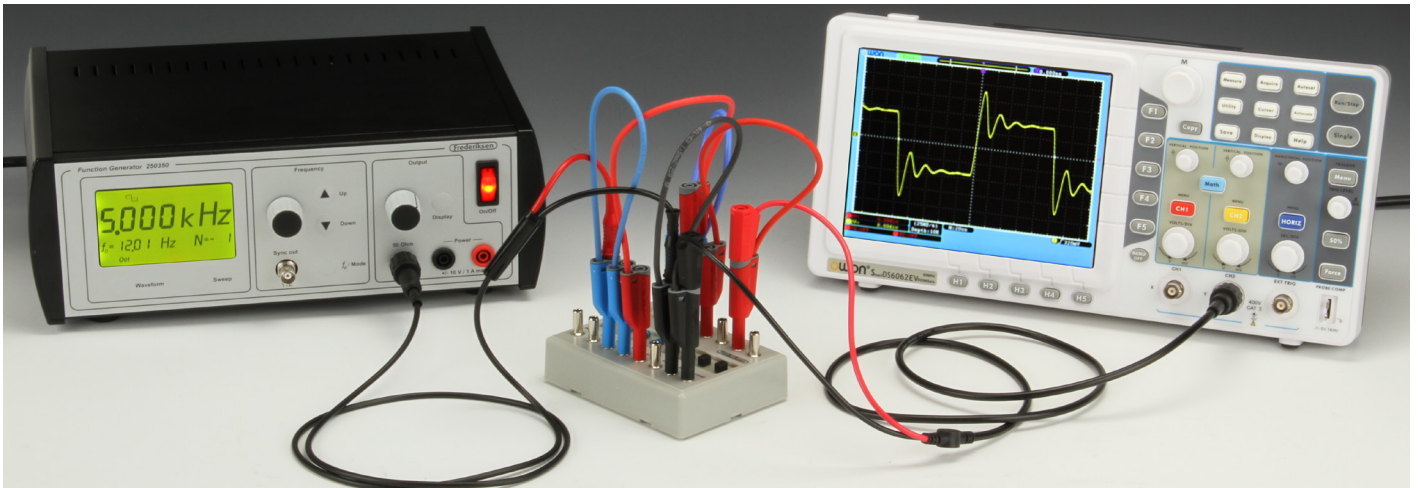
Item no. 429330



Experiment: LCR low-pass filters (136350)

The behaviour of LCR low-pass filters are studied by measuring frequency response and step response for a set of filters. The cut-off frequency (the phase resonance frequency) is found using an oscilloscope in x-y mode. The amplitude of a sine wave signal is measured before and after the filter at different frequencies. The step response is found by sending a square wave into the filter, studying the output signal on the oscilloscope.

Lab manual and detailed equipment list at www.frederiksen.eu



RECTIFICATION AND SMOOTHING

Rectifying diode

Silicon diode, rated for currents up to 6 A.

Used for example in experiment:

136210 Rectifier circuits.

Item no. 429380



Bridge rectifier on base

Silicon bridge rectifier, rated for currents up to 2 A AC.

Used for example in experiment:

136210 Rectifier circuits

Item no. 429390



Capacitor, 15000 μF

Electrolytic capacitor, useful in experiments with charging and discharging, smoothing in a rectifier circuit and as an illustration of electrostatic energy storage (more than 9 J).

Specifications:

- Capacitance: 15.000 μF
- Tolerance: $\pm 20\%$
- Voltage, max.: 25 V

Used for example in experiment:

136210 Rectifier circuits

Item no. 429310



Capacitor, 1 F

A "SuperCap" capacitor. Illustrates electrostatic energy storage (more than 30 J).

Specifications:

- Capacitance: 1 F (dvs. 1.000.000 μF)
- Tolerance: -10 / +30 %
- Voltage, max.: 5.5 V

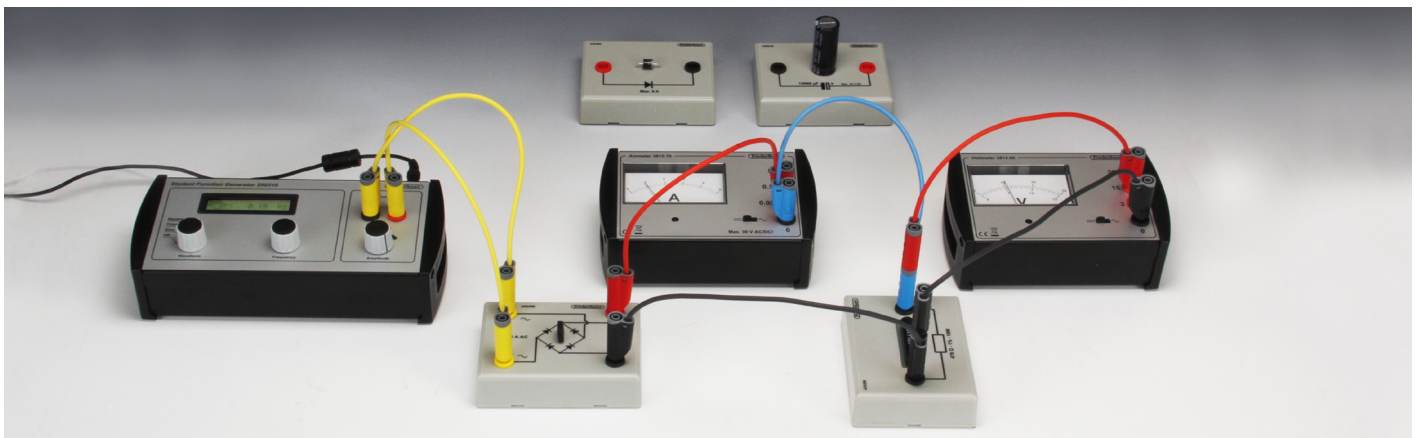
Item no. 429300



Experiment: Rectifier circuits (136210)

We investigate how a diode and a bridge rectifier converts AC voltage to a pulsating DC voltage. We also see how a capacitor smooths the pulsating voltage. In order to follow the variations of voltage and current, we don't use 50 Hz AC, but instead a function generator running at e.g. 0.1 Hz. With this "slow motion AC", the variations can be followed using ordinary analog instruments (Frederiksen's Voltmeter 381560 and Ammeter 381570).

Lab manual and detailed equipment list at www.frederiksen.eu



INDICATORS

Buzzer, 2 – 13 V

The buzzer is used as a voltage controlled acoustic indicator. The large voltage interval makes it easy to use the buzzer in many different setups.

Item no. 429120



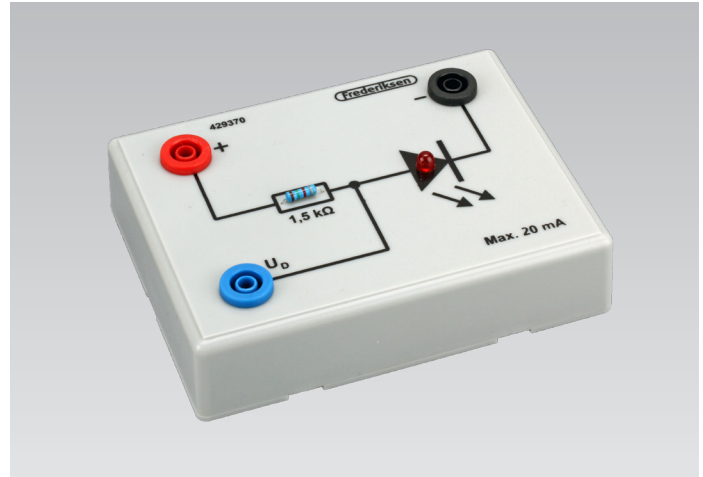
LED on base, red

A red LED with a series resistor, mounted with two 4 mm safety sockets, red (plus) and black (minus). A third safety socket (blue) is bypassing the series resistor to allow for measurements of the voltage drop across the diode alone. (Don't connect the blue socket directly to a power supply.)

Used for example in experiment:

136160 Characteristic curves

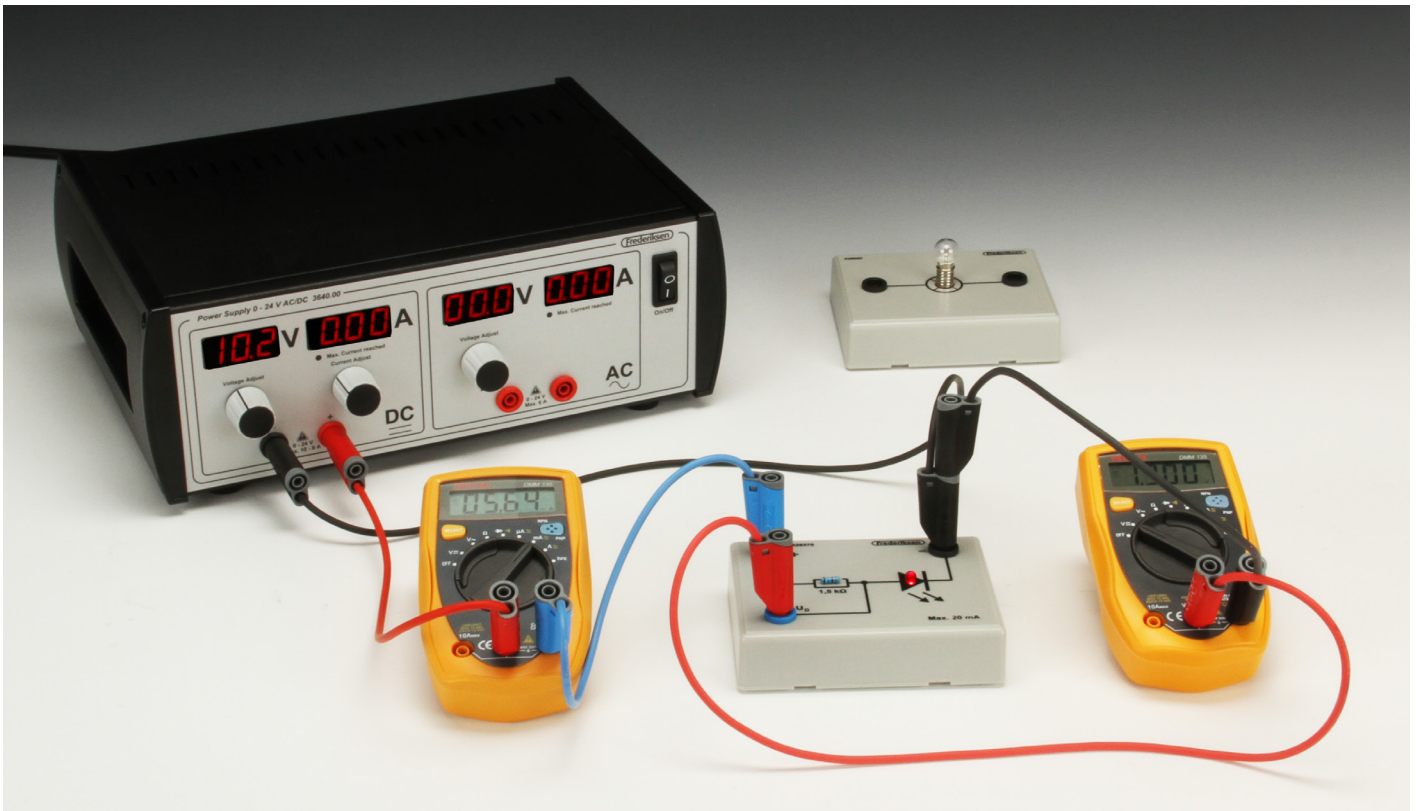
Item no. 429370



Experiment: Characteristic curves (136160)

The characteristic curve for an electrical component is a graph showing the relationship between current and voltage. We will vary the voltage and measure the resulting current for an incandescent lamp and an LED.

Lab manual and detailed equipment list at www.frederiksen.eu



ELECTRONICS AND CONTROL

Relay on base

5 V single pole double throw relay. The contact tolerates up to 8 A. The relay coil is connected internally to protective diodes, enabling the relay to be driven from a transistor circuit without the risk of blowing up the transistor by voltage transients. The coil resistance is at least 100 Ω . Maximum current is therefore 50 mA when driven by 5 V.

Item no. 429350



NPN transistor on base

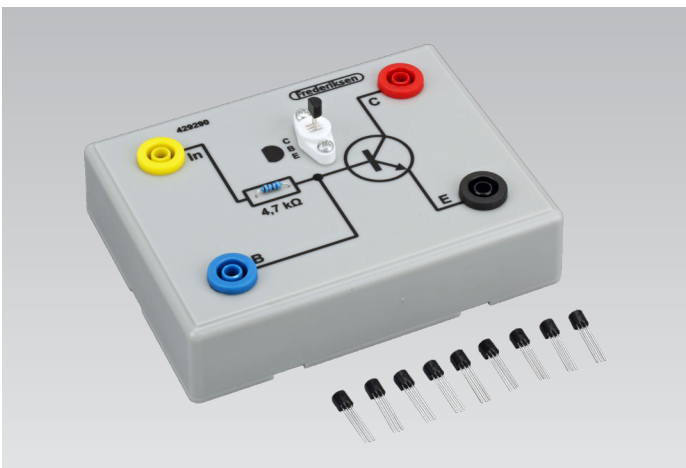
Transistor socket, connected to 4 mm safety sockets. 10 pc. BC547 transistors are included but the socket can be used with any normal small signal transistor. Three safety sockets – marked *C*, *B* and *E* – are directly connected to the three pins of the transistor (Collector, Base and Emitter).

The base is also connected through a resistor to a fourth safety socket, marked *In*. This socket can be used as a digital voltage input: In a circuit where the emitter is connected to 0 V, an input voltage of 0 V will shut off the transistor while a voltage of 5 V will turn it on. This can be shown by connecting an LED with a series resistor (see e.g. 429370) between +12 V and the collector of the transistor. (Don't connect the blue socket directly to a power supply.)

Data for BC547

- Voltage, collector-emitter, max.: 45 V
- Collector current, max.: 100 mA
- Power, max.: 500 mW

Item no. 429290



MISCELLANEOUS

Solar cell on base

Single solar cell that delivers approx. 0.5 V / 800 mA in clear sunshine.

Item no. 429400



Holder for fuse wire

Used in circuits where you want to demonstrate how a fuse works. Used with fuse wire 410000 which is pushed into the clips of the fuse holder. The clips are connected to the two safety sockets.

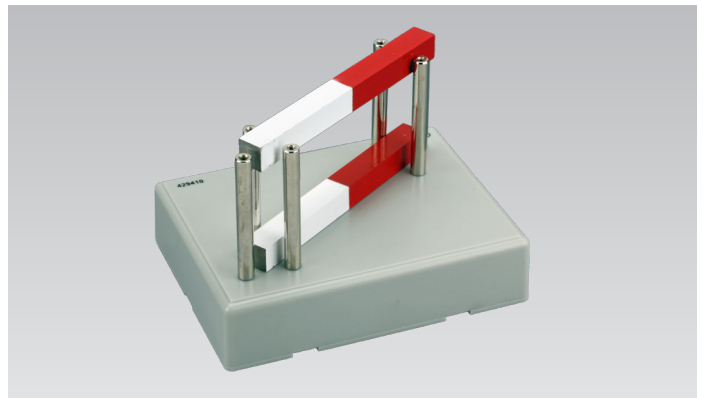
Item no. 429360



Magnet holder on base

Holder for two bar magnets. Steers the upper magnet to make it levitate above the lower. (The magnet poles must be oriented the same way.) Works with bar magnets 10 x 10 x 100 mm (330510) – not included. (Round magnets $\varnothing 10$ mm x 100 mm can also be used.)

Item no. 429410



MOTOR AND GENERATOR

Motor on base

2-6 V DC electric motor. The motor can also be used as a generator. Driving a 1.5 V, 90 mA incandescent light bulb requires around 2500 RPM. The motor is provided with a Ø16 mm pulley.

Item no. 429100



Connected motors on base

Two identical electric motors are used to demonstrate the energy conversion between electrical and mechanical energy. One motor turns the other which acts as a generator. The motors are identical to the one used in 429100.

Item no. 429110



CIRCUIT CHALLENGES

Secret circuit boxes

Eight different hidden circuits with switches and incandescent lamps (bulbs). The circuits can be investigated by pushing the switch buttons and by screwing the bulbs out or in. The students are challenged to determine the configuration of the circuits and to draw the schematics diagrams for each of them. Each box is powered by a 4.5 V battery or a power supply (not included).

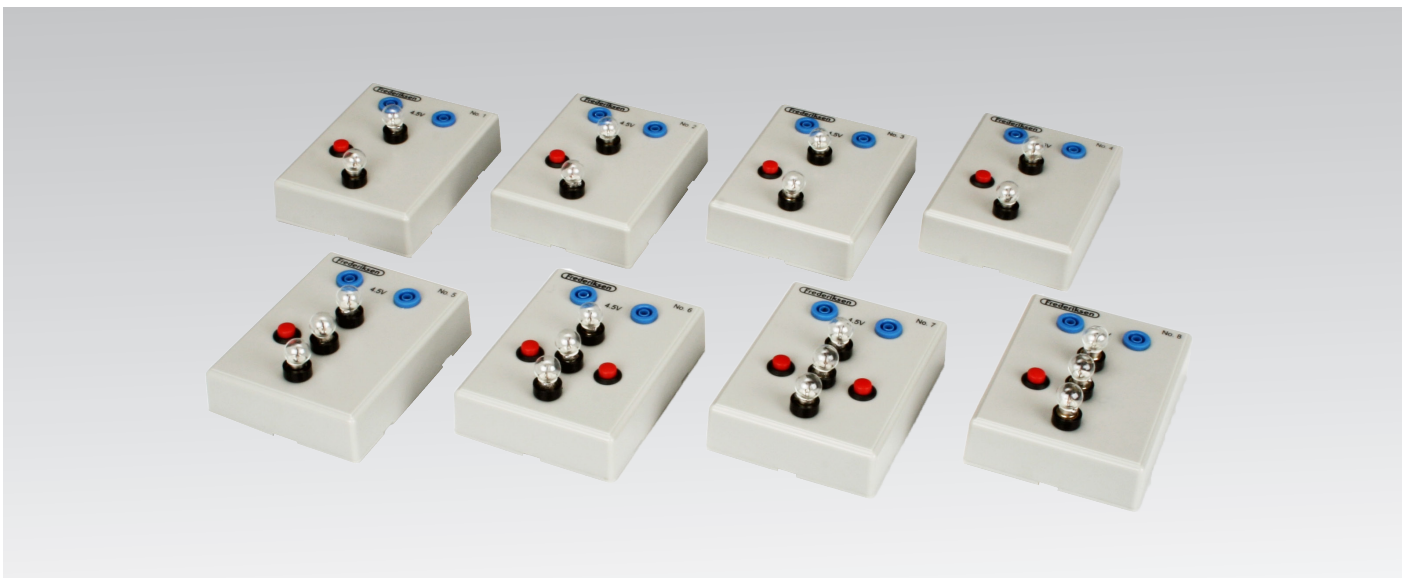
A *lab manual for the students* is included with the product and can also be downloaded from our web site (described below). The secret circuit boxes also includes a *product manual* which can be downloaded as well. Finally, a teacher's guide with answers to the exercises is included – this **cannot** be downloaded from our web site.

Item no. 429800

Experiment: Secret circuit boxes (136040)

Bulbs are observed with the switches on (pressed down) and off. If there are multiple switches, all combinations must be tried. One or more bulbs can be unscrewed - all possible combinations of bulbs and switches are tested. Work with one box at a time, and draw the schematics diagram of the circuit inside.

Lab manual and detailed equipment list at www.frederiksen.eu





Frederiksen Scientific A/S · Viaduktvej 35 · DK-6870 Ølgod · Tel. +45 7524 4966 · info@frederiksen.eu · www.frederiksen.eu