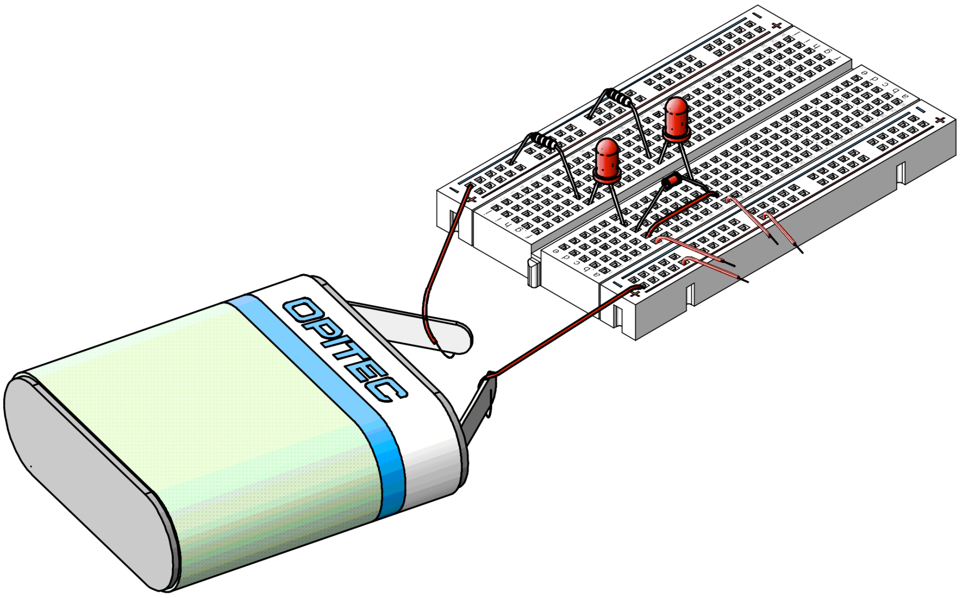
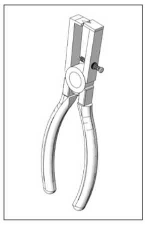
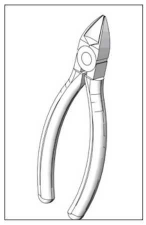
118.392

Electronics Assembly Learning Programme with Breadboard



Tools Required:


Stripper


Side Cutters

Please Note!
The Opitec Range of projects is not intended as play toys for young children. They are teaching aids for young people learning the skills of craft, design and technology. These projects should only be undertaken and operated with the guidance of a fully qualified adult. The finished projects are not suitable to give to children under 3 years old. Some parts can be swallowed. Danger of suffocation!

Article List	Quantity	Size (mm)	Designation	Part No.
plug-in board/ breadboard	1	83x55	plug-in board	1
blade receptacle	2	6,3	connection to the battery	2
resistor 1,8 kOhm	1		resistor	3
resistor 6,8 kOhm	2		resistor	4
resistor 18 kOhm	2		resistor	5
resistor 130 Ohm	2		resistor	6
transistor BC 548 or BC 547	2		transistor	7
elko 22 µF	2		capacitor	8
elko 1000 µF	1		capacitor	9
LED red	2	ø 5	LED	10
LED green	1	ø 5	LED	11
diode	1		diode	12
trimmer 1 kOhm	1		trimmer	13
jumper wire, red	1	500	jumper wire	14
jumper wire, black	1	500	jumper wire	15

OPITEC

Instruction 118.392
Electronics Assembly Learning Programme with Breadboard

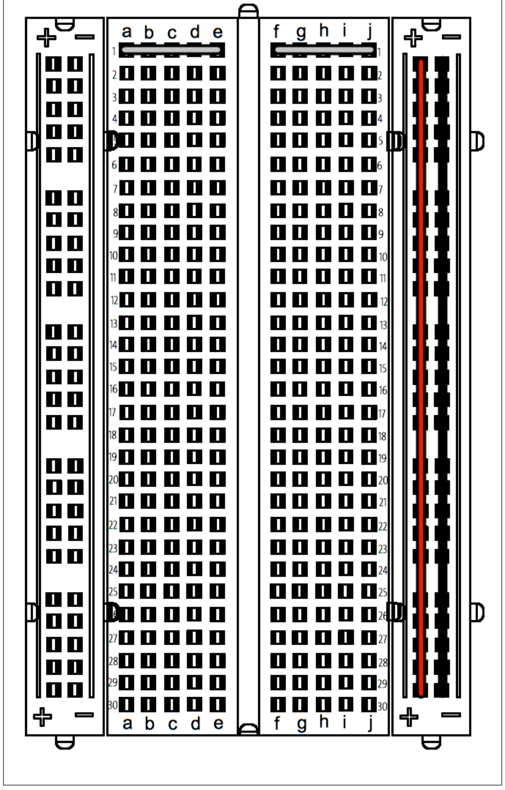
General:

How does a breadboard work?

The breadboard also called plug-in board - makes experimenting with electronic parts immensely easier. The components can simply be plugged into the breadboard without soldering them.
Circuits can be plugged directly onto the breadboard.
Because the production of a complete circuit board is very expensive, a breadboard is a quick and easy alternative.

Originally, the English term came from the first circuits, which were simply nailed to a wooden board. These wooden boards reminded of breakfast boards and thus the plug-in board was called breadboard.

The trick with the breadboard is that some of the holes on the breadboard are conductively connected to each other. In the representation of the breadboard on the right these connections are marked with lines. In the outer supply part these run in two parallel strips (+ and -) from top to bottom, while in the middle of the breadboard each 5 holes are combined horizontally to form a column.



Between the rows a-e + f-g is a large gap. At this point, DIP-IC's can be plugged onto the board.
Other components such as resistors, capacitors or transistors etc. can be installed anywhere within the blocks. To connect them to each other, you can either put one leg of the components in a common row or work with wire bridges.

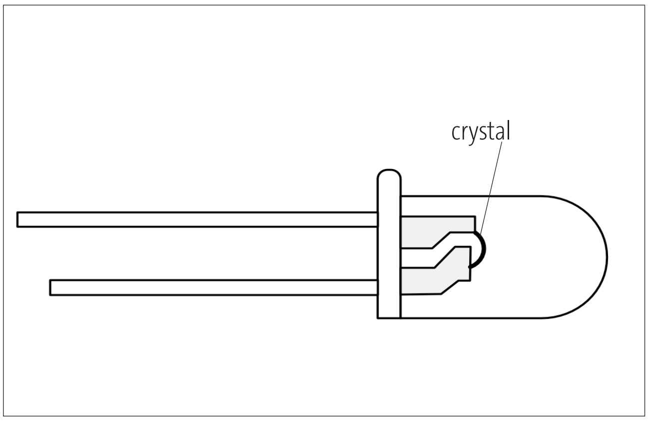
Most breadboards have a lateral power supply. Often, plus is marked red and minus by black.

Breadboards are a great way to quickly build new circuits. Though, there are some limitations:

- SMD components can not be used without additional adapters.
- Breadboards are not suitable for high voltages and currents.
- At a certain size, the circuits become confusing.
- Breadboards are only conditionally suitable for circuits with high frequencies.

The Light-emitting Diode LED

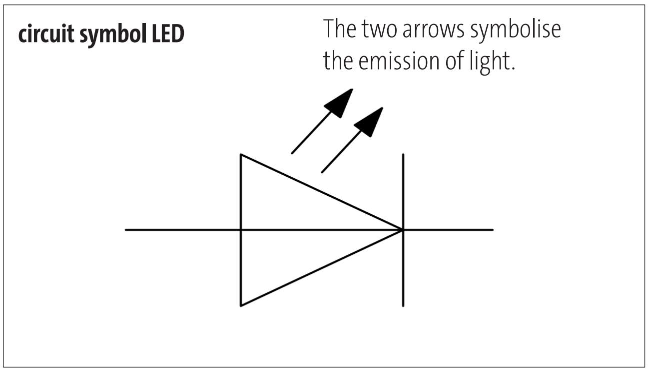
The Light Emitting Diode is not a lamp or bulb.
The light of a light-emitting diode is created by a small crystal, which emits electromagnetic waves, that we can see.
If you hold a light-emitting diode against a light source (lamp, window) you can see the crystal inside.



This lighting is very bright today, so that light diodes are used as flashlights, room lamps and in the car industry.
In most modern devices, LEDs are used as function display and function control, e.g. in MP3 players, computers, digital clocks, hi-fi systems and televisions.

Everywhere where small "lights" light up and show something, are light-emitting diodes. They are available in the colours white, red, yellow, green, blue and with colour change (RGB-Rainbow). The most common form is round, but light-emitting diodes are also used in quadrangular and triangular form.
The advantages of LEDs over small bulbs are:
- low power consumption
- vibration-proof
- unbreakable
- very long service life
- low space requirement

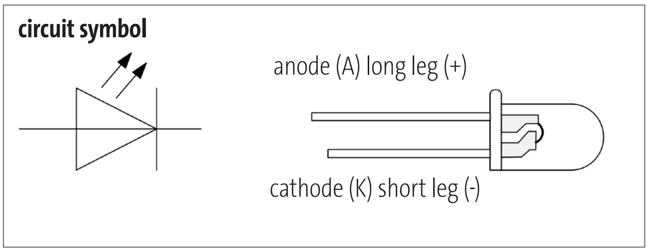
It's called LED because of light-emitting-diode.
This abbreviation is used by electronics technician. Like all electronic components, the light-emitting diode also has a circuit symbol.



Caution:

If you want to make a LED shine, you must note following points:

1. The light-emitting diode must be connected with the correct polarity, otherwise it will not light up. For this purpose, the connections have been labeled ANODE (A +) and CATHODE (K-). The LED is too small to print the terms on it, so it can be seen on the connection legs, which wire is the anode and cathode.



The anode gets connected positive (+), the cathode minus (-).

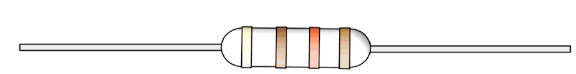
2. A commercially available light-emitting diode must never be connected to a voltage source with more than approx. 1.6 volts (today there are LED's with different voltage values which can be taken from the technical data sheets of the manufacturer), they would immediately "burn out". However, because a higher voltage than 1.6 volts is used in most devices and circuits, the voltage must be reduced to 1.6 volts via another electronic component. The required component is the RESISTOR.

Here is a list of the most common power sources and the necessary resistor values.

voltage	resistor
4,5 Volt	130 Ohm
6 Volt	180 Ohm
9 Volt	390 Ohm
12 Volt	510 Ohm
24 Volt	1,2 kOhm

The Resistor

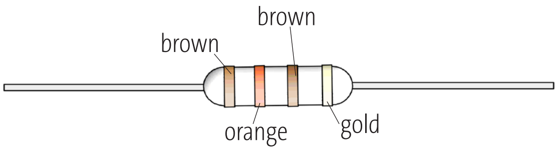
The resistor is an electronic component which restricts the current flow.
The most common resistors are made of carbon film on a ceramic tube (carbon is a poor conductor). At the beginning and end of the tube are connecting wires.



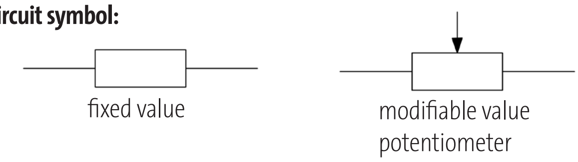
Coloured rings on the resistor show the resistance value.
This value is given in ohms (Ω) and indicates whether the resistor allows a large or small current flow.
A high ohmic resistor, e.g. 1.8kΩ (1800Ω) allows less current flow than a resistor of smaller ohmic value, e.g. 130 Ω.
With the help of the following table, it is easy to find out which ohm value the used resistors have.

ring colour	1. ring	2. ring	3.ring/ multiplier	4. ring/ tolerance
black	0	0	1	1 %
brown	1	1	10	2 %
red	2	2	100	-
orange	3	3	1000	-
yellow	4	4	10000	-
green	5	5	100000	-
blue	6	6	1000000	-
purple	7	7		-
grey	8	8		-
white	9	9		
gold			0,1	5 %
silver			0,01	10 %
				without ring 20%

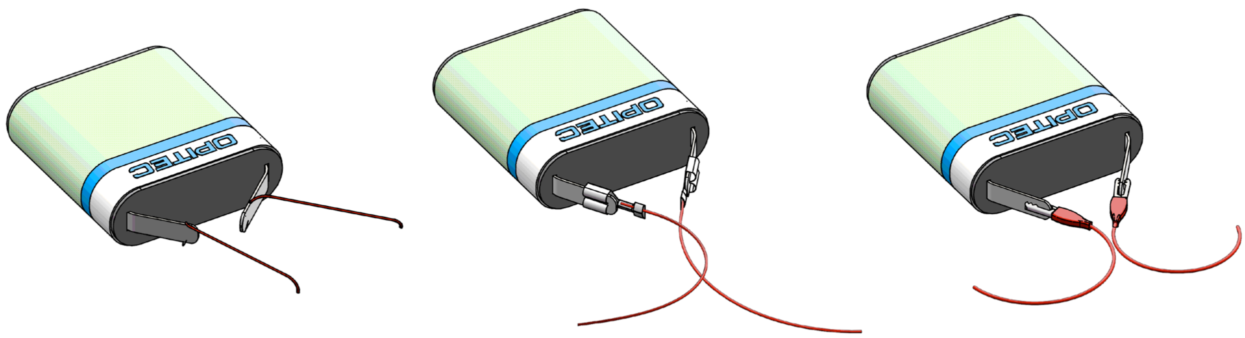
Example: 130 ohm with 5% tolerance



circuit symbol:



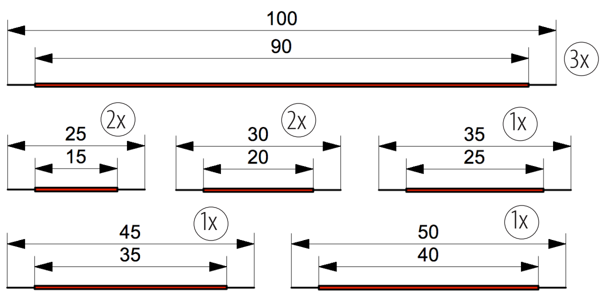
Possibilities for connecting breadboard and battery:



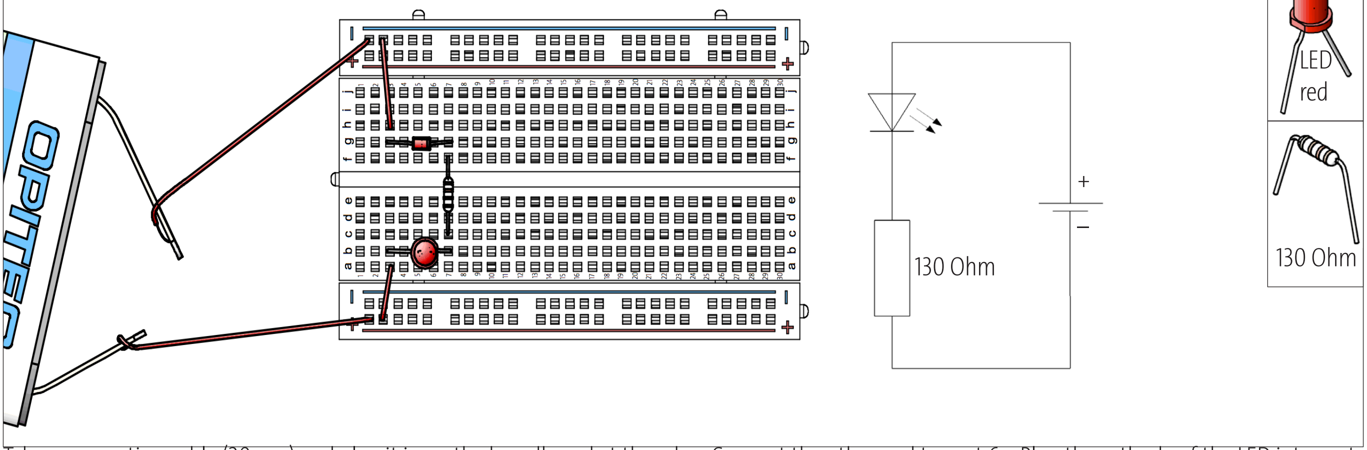
There are several ways to connect the breadboard to the battery. Separate two pieces from the jumper wire (approx. 110mm) and strip them on both sides. The wire ends can simply be attached to the battery by wrapping the - and + pole. Likewise, the wire ends can be enclosed to the attached blade receptacles (2) and then pushed onto the poles. Another option is to connect the wires with crocodile clips. The free wire ends are inserted in the breadboard in the respective bar for the + or - pole.

Cutting the cables for connections and bridges:

To build different circuits cable pieces are needed as connections and bridges. Cut them off the remaining jumper wire as shown and strip them on both sides.



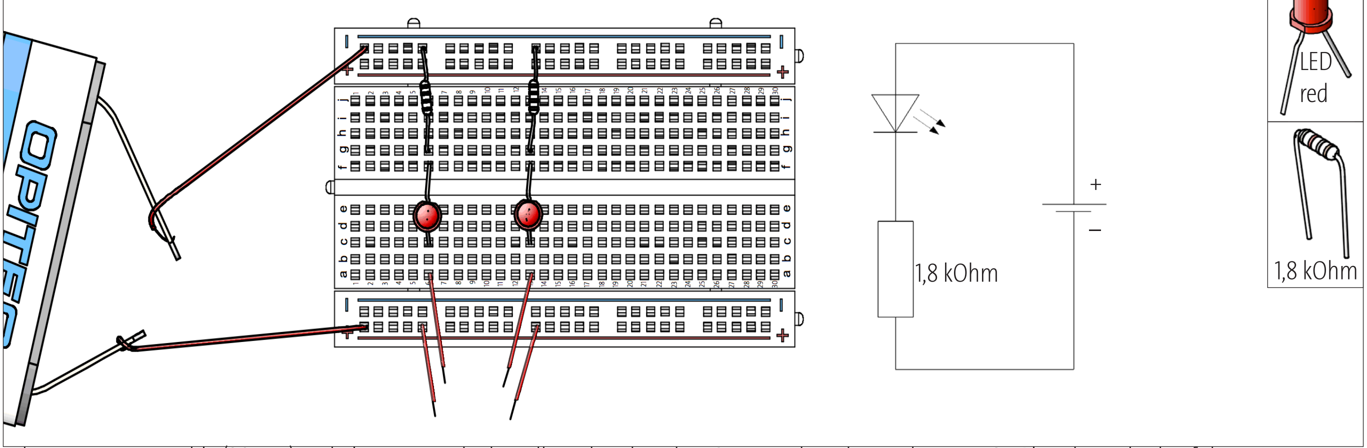
experiment 1



Take a connection cable (20mm) and plug it in on the breadboard at the +-bar. Connect the other end to port 6a. Plug the cathode of the LED into port 2b and insert the anode of the LED into port 6b. Insert the resistor (130 Ohm) at 2c and 2f. Insert a 30mm long piece of jumper wire (stripped on both sides) at 2g and the -bar. Connect the battery as described on page 3.

Result: LED shines bright!

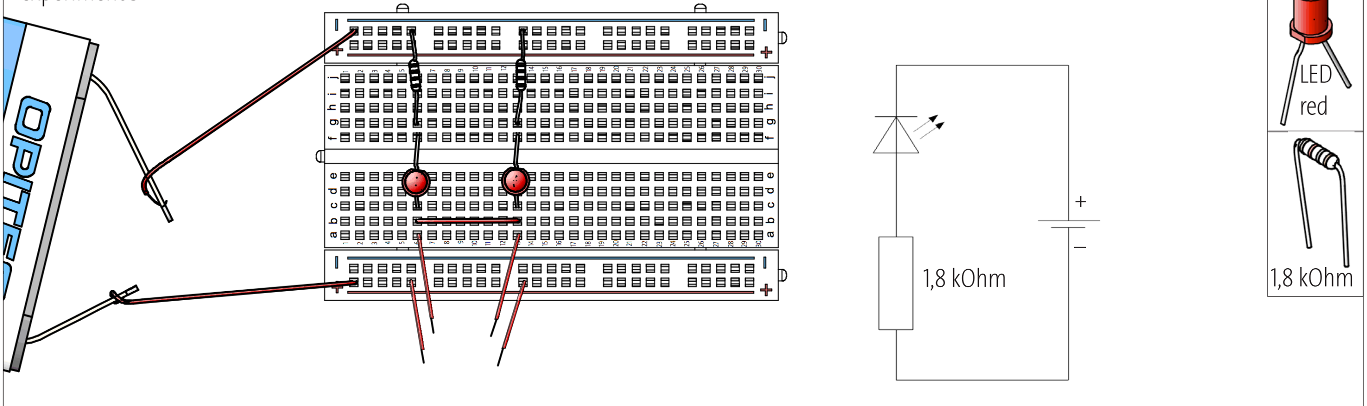
experiment 2



Take a connection cable (20mm) and plug it in on the breadboard at the +-bar. Connect the other end to port 6a. Plug the cathode of the LED into port 2b and insert the anode of the LED into port 6b. Insert the resistor (1,8 kOhm) at 2c and 2f. Insert a 30mm long piece of jumper wire (stripped on both sides) at 2g and the -bar. Connect the battery as described on page 3.

Now the LED shines: ______________________ **Why? Because the resistor:** ______________________

experiment 3



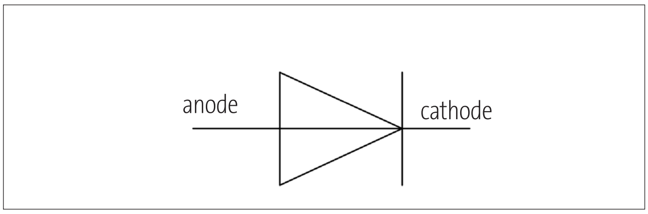
Remove the LED, swap the connections and insert it again.

Now the LED shines: ______________________

Why? The answer is obtained in the following experiments with a diode.

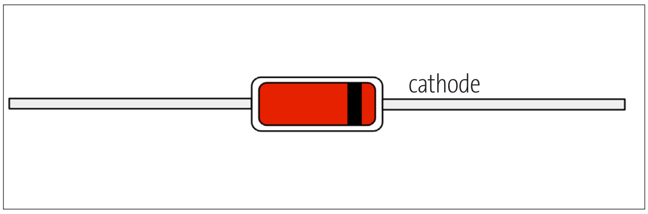
The Diode

A diode is also a component widely used in electronics. It is a so-called semiconductor. For example, if you take copper as a good conductor, plastic as a bad conductor and in between the semiconductors made of silicon, you get a diode.
Now this "semiconductor diode" has a strange characteristic:



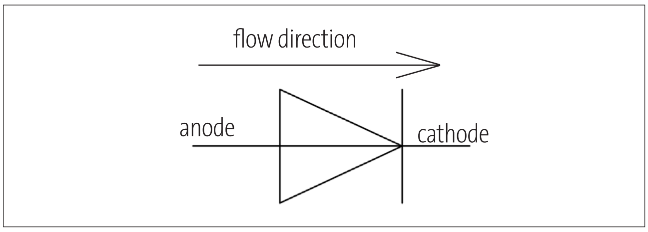
It conducts the current only in one direction, just as a valve on the bicycle tyre only allows air to flow into the tyres.
Accordingly, a distinction is made between flow direction and reverse direction.

This valve effect of the diode is used, for example, to generate a voltage with constant direction (DC) from a voltage with alternating direction (AC).
The diode is also used for "shutting off" unwanted current flows. This becomes clear in our experiments.
In order to recognize how a diode is installed (flow or blocking direction) without experiments, the diode has a symbol.
When using the circuit symbol, the connections A = Anode (+) and K = Cathode (-) must be observed!

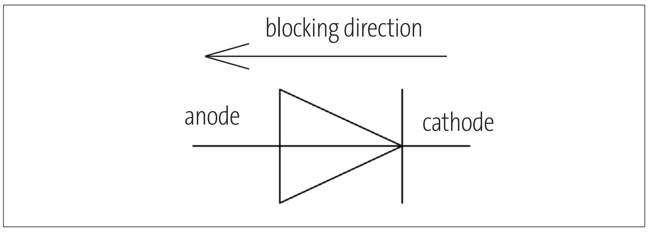


Diodes are very small and cannot be labeled with a lot of data. The cathode is identified by a wide cathode ring.

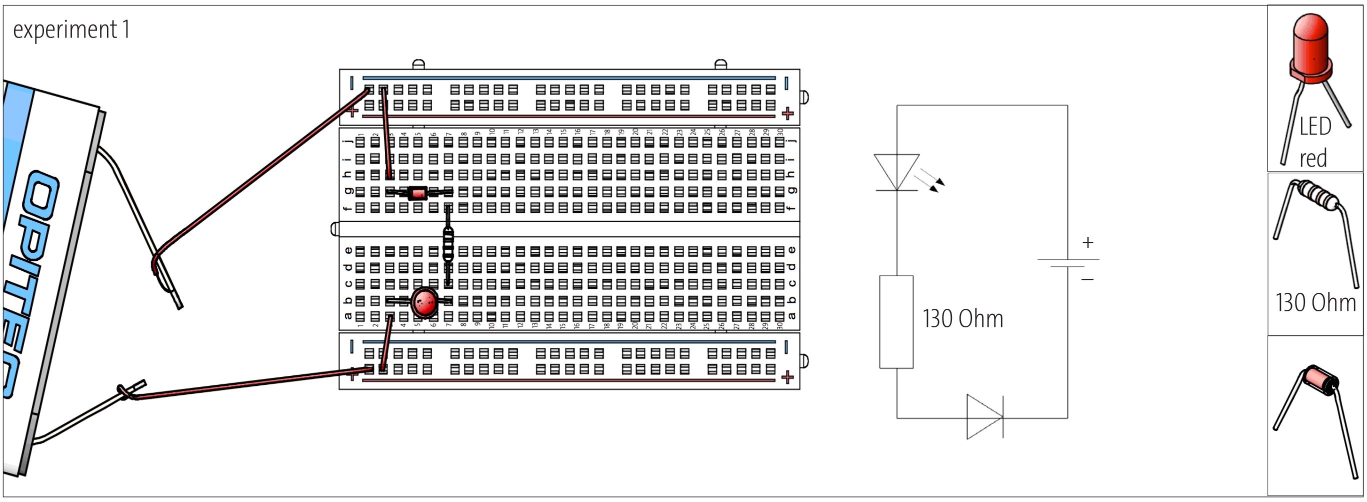
A diode is switched in flow direction when the anode is connected to (+) and the cathode to (-).



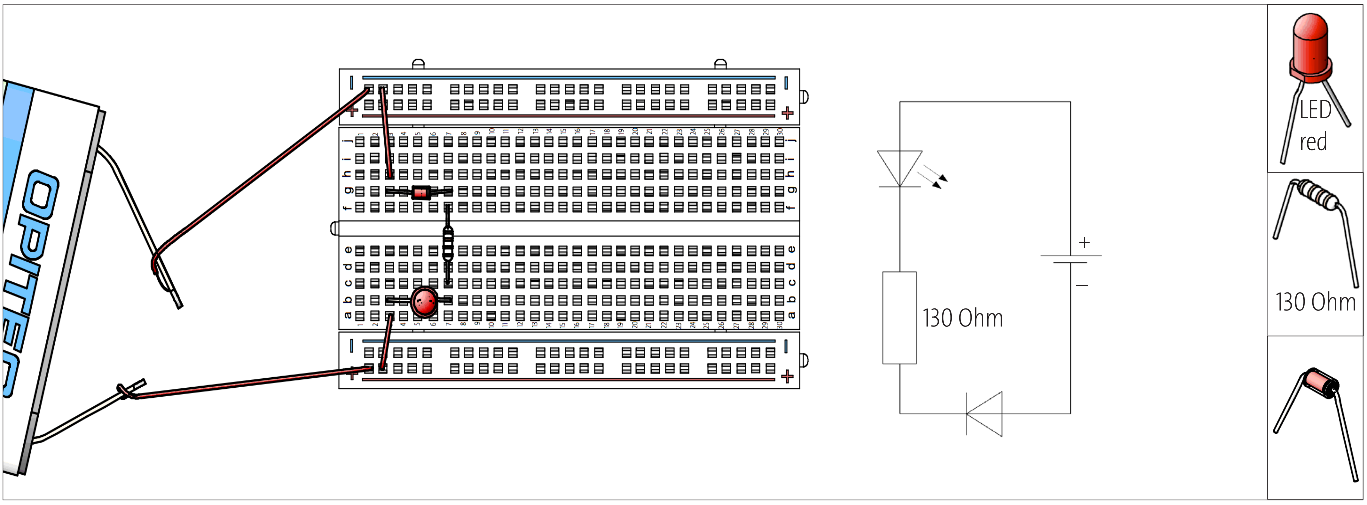
A diode is switched in the blocking direction when the poles are connected in reverse.



Experiment with the diode:



Take a connection cable (20mm) and plug it in on the breadboard at the +-bar. Connect the other end to port 3a. Plug the cathode of the LED into port 7b and insert the anode of the LED into port 3b. Insert the resistor (130 Ohm) at 7c and 7f. Insert the anode of the diode at 7g and the cathode at 3g. Insert a 30mm long piece of jumper wire (stripped on both sides) at 3h and the -bar. Connect the battery as described on page 3.**Result:**The LED lights up!



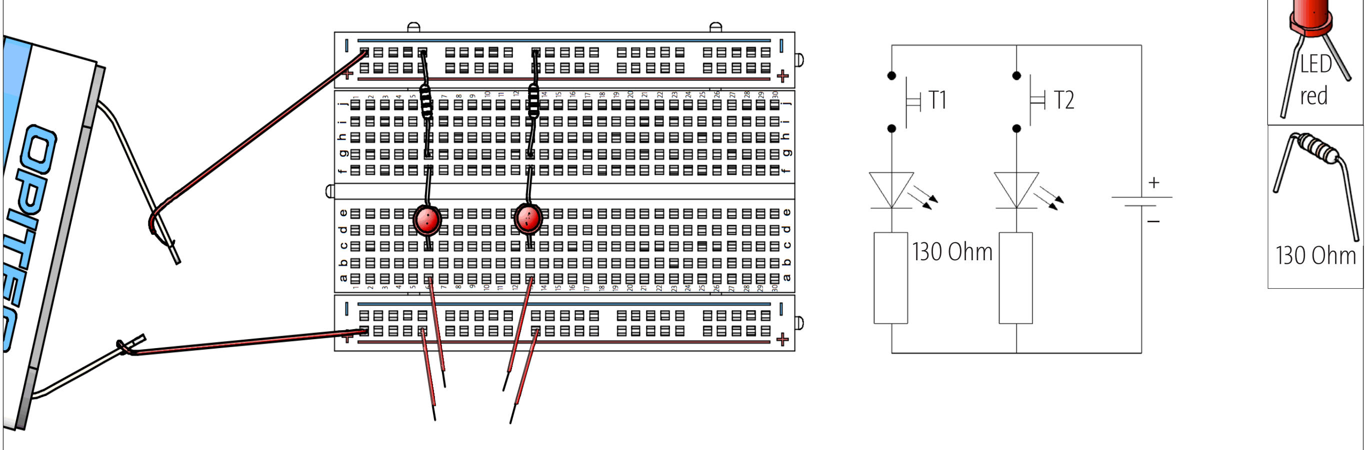
Reverse the connections of the diode (removing the diode and installing it in reverse).

The LED lights up _______________________________ Why? The diode is installed in _________________________________.
If the circuit is to work, the diode must be installed in _____________________________________.

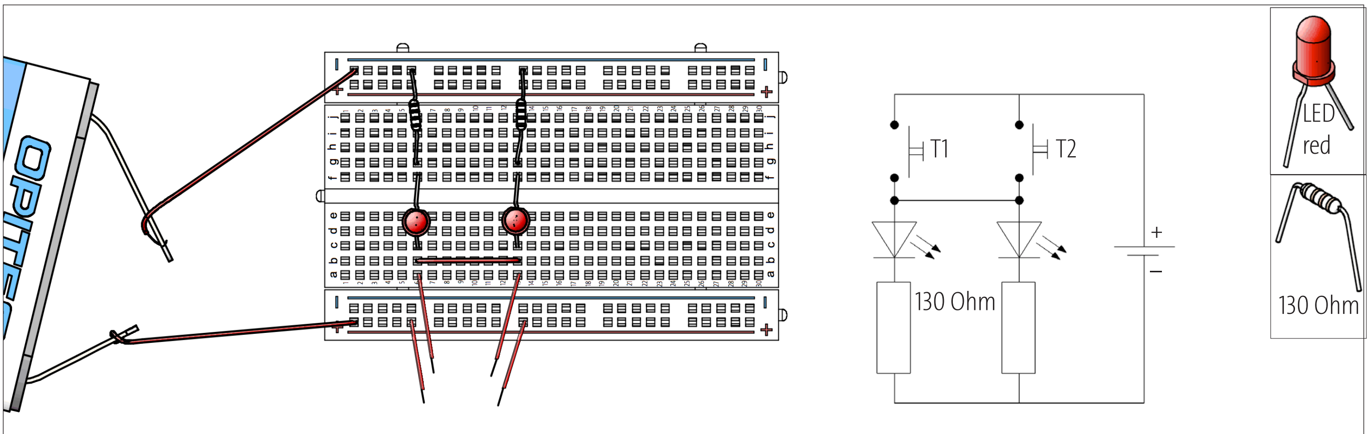
Light emitting diodes also have a flow and blocking direction!

Examples for using a diode.
Set up the circuit as follows. It represents an optical call system (e.g. in a waiting room!)

experiment 1



Plug in the resistor R1 between - and the port 6g. Plug in the anode (A+) of the LED at 6c and the cathode (K-) at 6f. Then Plug in the resistor R2 between - and port 11g. Plug in the anode (A+) of the second LED at 13c and the cathode (K-) at 13f. Furthermore plug in a cable connection (25mm) at 6a and a second cable connection (20mm) at + (5) = T1. Plug in a cable connection (25mm) at 13a and a second cable connection (20mm) at + (14). = T2.

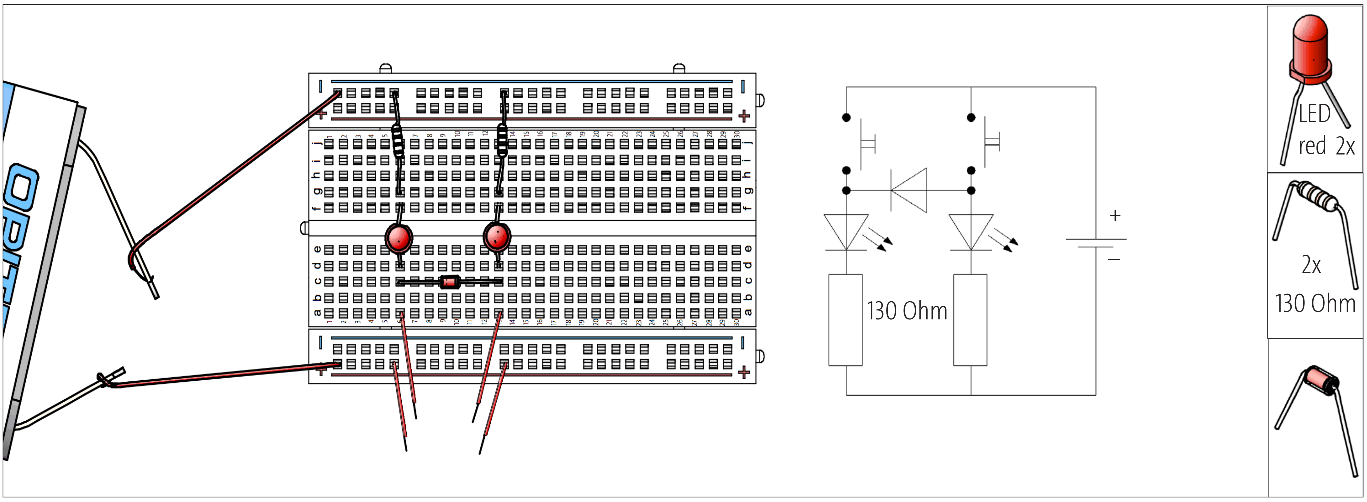


A jumper (cable connection 25 mm between 6b and 13b) is attached to both switches. Now press switch 1, then press switch 2.

The circuit should now be extended so that switch 1 switches on one LED and switch 2 switches on both LEDs:

Switch 1 is used to switch only the left LED. This means that the current must not flow to the right LED. When pushing switch 2 the current should flow to both LEDs.
So what needs to be changed here? Use a diode for problem solving.
The circuit diagram (item 8) serves as an aid for the conversion of the circuit, if necessary the modification can be compared with the drawing on the title page.

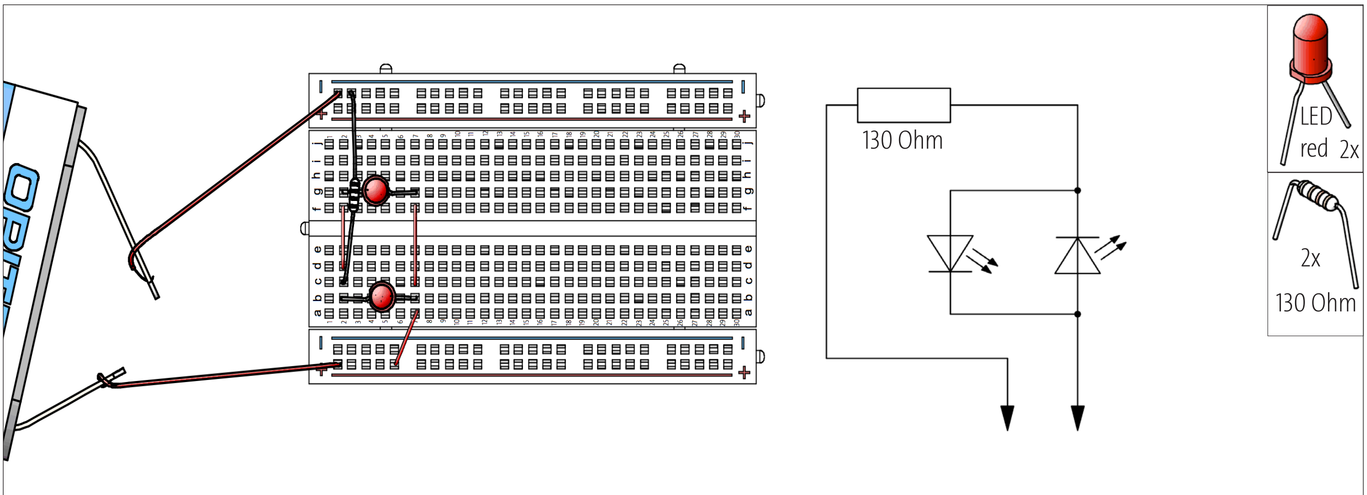
Set up the circuit as follows:



Insert the resistor R1 between the -bar and the terminal 6g. Plug in the anode (A+) of the LED at 6d and the cathode (K-) at 6f. Insert the resistor R2 between the -bar and the connector 13g. Plug in the anode (A+) of the second LED at 13d and the cathode (K-) at 13f. Insert a cable connection (25mm) at 6a. Insert a second cable connection (20mm) at +bar (5) = T1. Insert one cable connection (25mm) at 13a. Insert a second cable connection (20mm) at +bar (14). = T2. Place the diode between 6c (A) and 13 c (K).

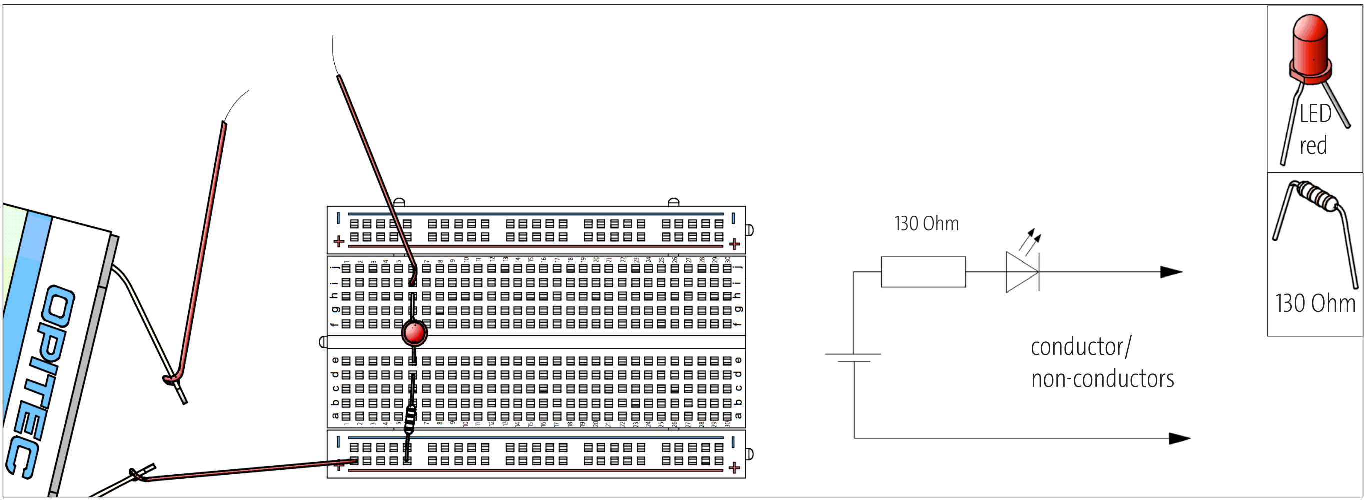
Assembly of the components to a device with practical application.
The following suggestions are useful circuits with the components you have got to know. Select a suggestion for your purposes!

Polarity Checker



Take a connection cable (20mm) and plug in one end on the breadboard at the +-bar. Connect the other end to port 7a. LED 1: Plug in cathode at 2b and anode at 7b. Insert the wire connection (20mm) between 2d and 2f. Insert another wire connection between 7c and 7f. LED 2: Connect anode at 2g and cathode at 7g. Plug in the resistor R (130 Ohm) into terminal 2c and connect it to the - pole.
Function: 1 If the + pole is connected to the positive pole of the battery and the - pole is connected to the negative pole of the battery, the + LED (right LED) lights up. If the polarity is reversed, the - LED lights up. This polarity tester can be used to check the correct current direction of current in a DC circuit.

continuity tester

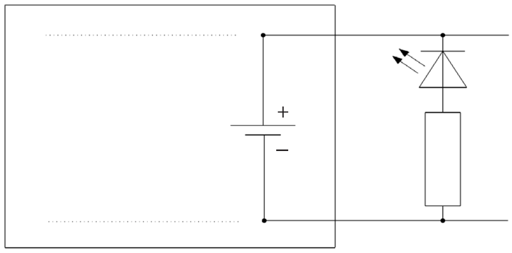


Plug in resistor (130 Ohm) at 6d and at +pole. LED: Insert cathode at 6h and anode at 6e. Plug in the wire connection at 6i and leave the other end free. Connect a second wire to the -pole of the battery and leave the other end free. Function: To check the continuity of a connection, connect both terminals. The circuitry should be de-energized. The LED lights up when it goes through.

Equip the breadboard according to the circuit diagram.
Note 1: The size of the resistor depends on the battery used.

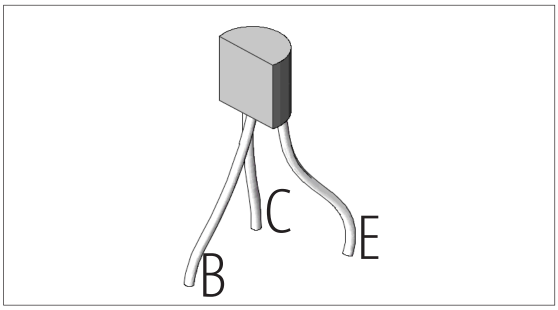
Function:
The LED only lights up when the battery is inserted with reversed polarity, indicating through this that the polarity is reversed.

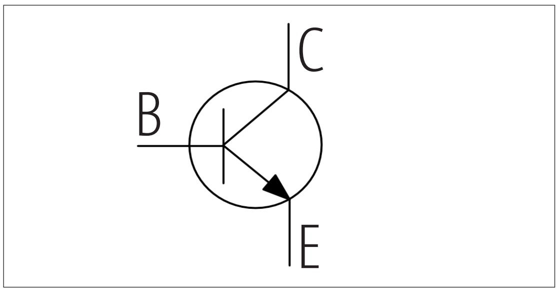
proposal 3 - reverse polarity protection



The Transistor

The transistor is the most versatile component of the previously discussed electronics.
Resistors limit the current flow. LEDs and diodes allow the current to flow in one direction only.
A transistor, like a diode, allows the current to flow in one direction and also decide whether a current should actually flow and how strong it should be.
The current can be turned on and off, as well as weaken or amplify. The transistor can be used as a switch and amplifier.
Only about 30 years ago you had to switch and amplify only tubes in the electronics devices (see old radios). Tubes are much larger than transistors and considerably more expensive, they also need a power-hungry heater for operation. Only the transistor made it possible to produce radios small and cheap.
In 1956, three Americans received the Nobel Prize for the development of the transistor.
All known devices, such as Walkman, recorder, calculator, digital clock, computer could not be produced without transistors. The transistor has miniaturized the electronics devices.
It is very small in its construction. If you pick up a transistor, you first notice that it has three connections and is flattened on one side. On the flattened side the type designation is printed. There is no indication of marking of the connections.
One must use the symbol to help distinguish the three terminals.



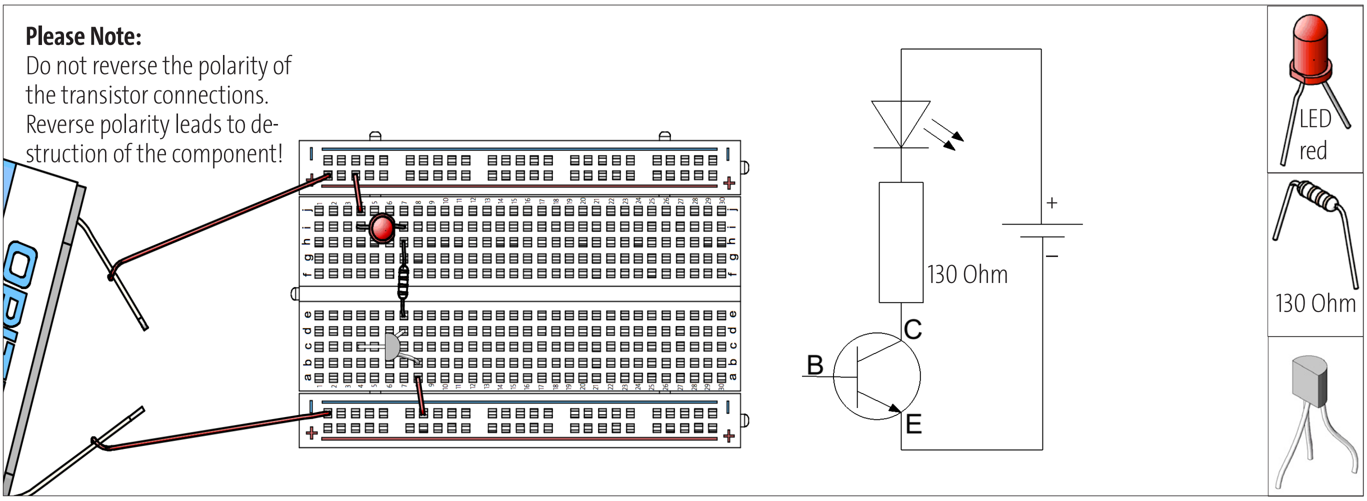


E = emitter (sends electrons)
B = base (controls the flow of the electrons)
C = collector (collects electrons)

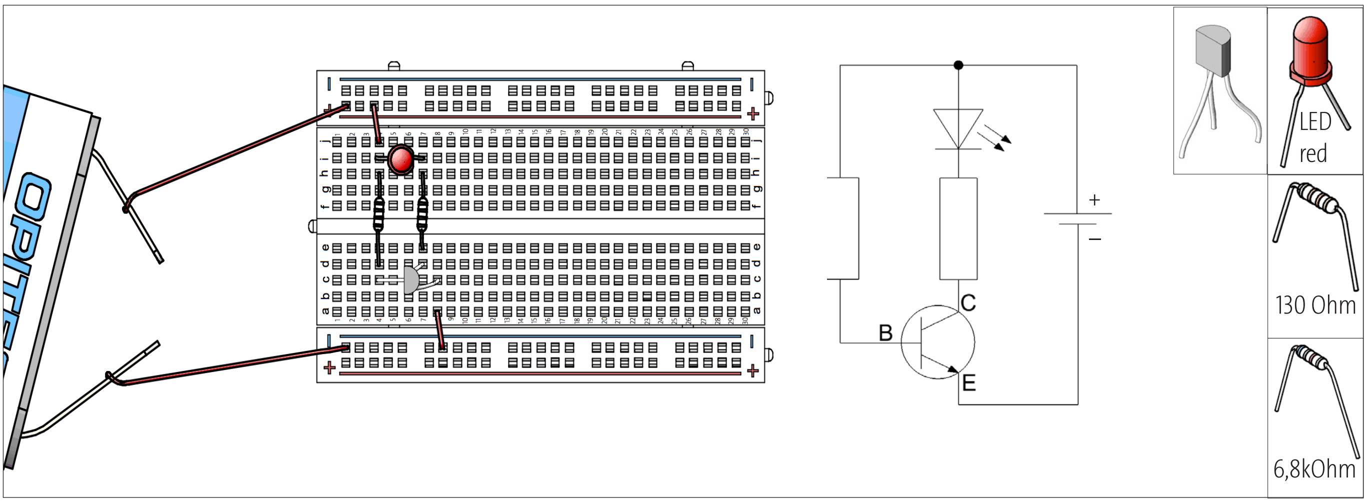
It can be seen that the electrons from the emitter (E) flow through the transistor to the collector (C). The base (B) controls this electron flow. The base decides if the transistor is blocking or passing.

This is demonstrated by the following experiments:

Please Note:
Do not reverse the polarity of the transistor connections. Reverse polarity leads to destruction of the component!



Take a piece of switching wire (20mm). Plug in one end on the breadboard at the -bar an the other end at port 8a. Insert the transistor as follows: Base (4c), collector (7d), emitter (8b). Connect the resistor (130 Ohm) between 7e and 7h. Insert the anode of the LED at 4i and the cathode at 7i. Insert a wire connection at 4j and the + bar.
The base of the transistor is not connected yet, therefore the transistor blocks and the LED does not light up.



In order for the transistor to switch through, a positive voltage of approx. 0.7 volts must be connected to the base. With a 6,8 kOhm resistor, the voltage is limited to 0,7 V. Insert the resistor according to the connection description.
Take a piece of switching wire (20mm). Plug in one end on the breadboard at the -bar an the other end at port 8a. Insert the transistor as follows: Base (4c), collector (7d), emitter (8b). Connect the resistor (130 Ohm) between 7e and 7h. Connect the resistor (6,8 kOhm) between 4d and 4h. Insert the anode of the LED at 4i and the cathode at 7i. Insert a wire connection at 4j and the + bar.

The LED lights up 1, because a current flows over the base and the emitter and the transistor is switched through.

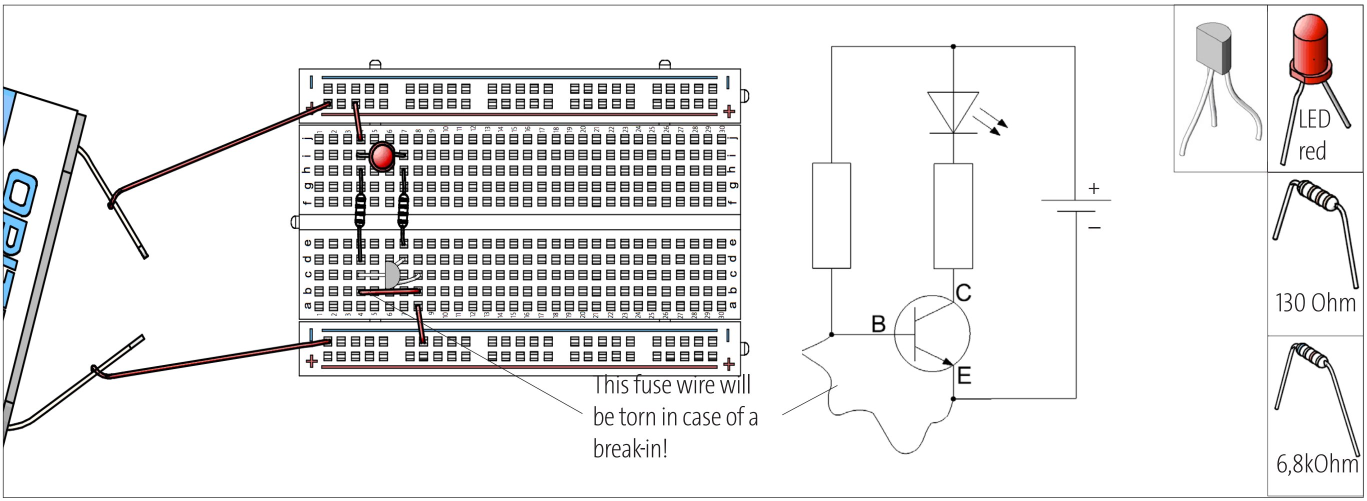
Such a circuit is called emitter circuit. It is one of the three basic circuits of transistors. All further experiments are based on this basic circuit.

Why grounded emitter circuit?
If you follow the current flow from the positive terminal of the battery via the 6.8 kOhm resistor to the base of the transistor, you can see that the current must flow from the base to the emitter in order to reach the negative terminal of the battery.

Therefore grounded emitter circuit!
In this case, the basic emitter circuit is named control circuit and the collector-emitter circuit is called controlled circuit or working circuit.

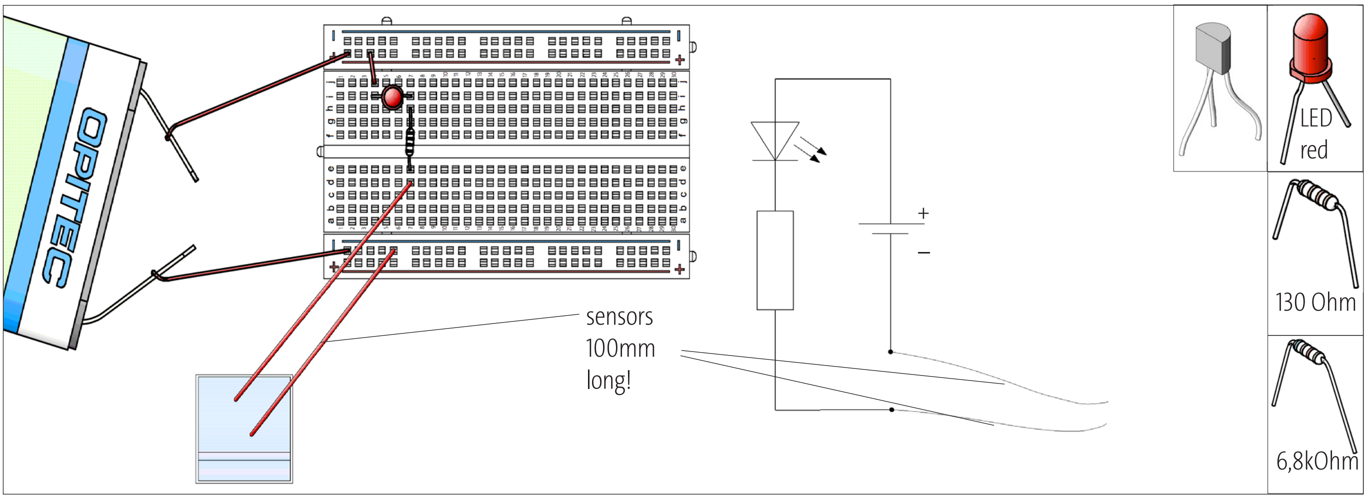
After this short excursion into theory, several circuits are built up to get to know further functions of the transistor.

Expansion of the emitter basic circuit to an alarm system



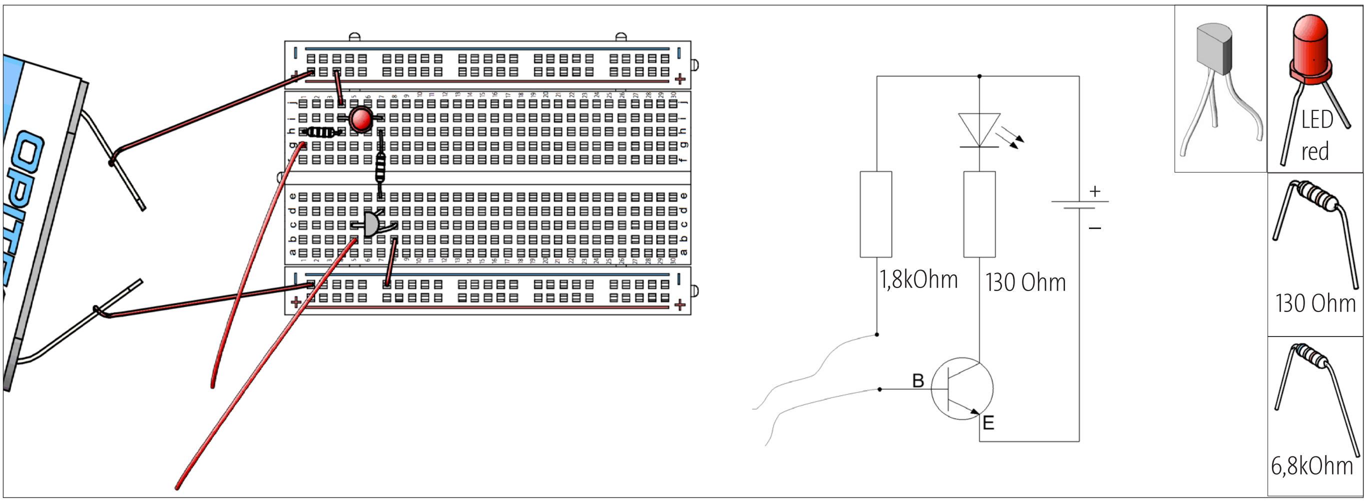
Take a piece of switching wire (20mm). Plug in one end on the breadboard at the - bar an the other end at port 8a. Insert the transistor as follows: Base (4c), collector (7d), emitter (8c). Connect the resistor (130 Ohm) between 7e and 7h. Connect the resistor (6,8 kOhm) between 4d and 4h. Insert the anode of the LED at 4i and the cathode at 7i. Insert a wire connection at 4j and the + bar. Plug in a connecting wire (safety wire!) between 4b and 8b.
When is the alarm triggered? And why? In this alarm system, the LED serves as an alarm indicator.
The transistor was used as a switch in the alarm system. In the next experiment we want to use the transistor as an amplifier.

Humidity Sensor
This circuit makes clear that the transistor can amplify a very weak current in such a way that the LED lights up.



Take a piece of switching wire (20mm). Insert one end on the breadboard at the - bar and the other end is put into the water later. Insert another piece of switching wire into connection 7d and the free end is also put into the water later. Plug in the resistor (130 Ohm) between 7e and 7h. Insert the cathode of the LED at 7i and the anode at 4i. Plug in a wire between 4j and + pole.
The two wires must not touch each other. They are immersed in water with a distance of approx. 10mm or placed on the tongue.

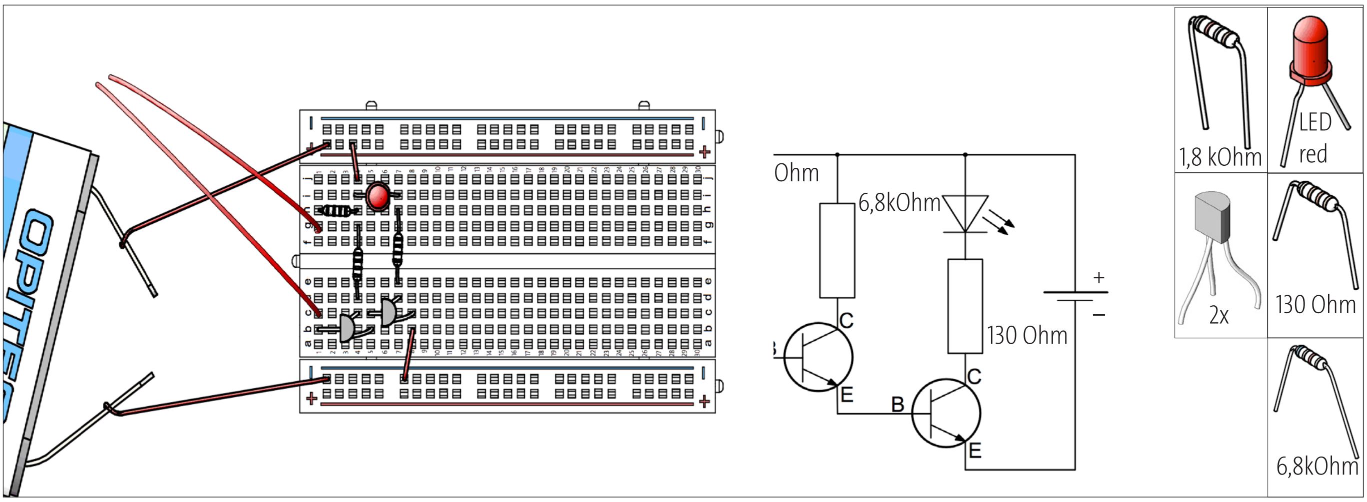
Does the LED shine?
The LED does not light up because the humidity is a great resistance and therefore only a relatively weak current flows. Therefore his weak current must be amplified.
For this purpose, a transistor is built into the circuit as an amplifier. The resistor of 1,8 kOhm protects the transistor in case the two wires accidentally touch each other.



Take a piece of jumper wire (20mm). Insert one end on the breadboard at the - bar and the other end at port 8b. Insert the transistor as follows: Base (5c), collector (7d), emitter (8c). Plug in the resistor (130 Ohm) between 7e and 7h. Plug in the resistor (1,8 kOhm) between 4h and 4e. Insert the anode of the LED at 4i and the cathode at 7i. Plug in a jumper wire connection at 4j and the + bar. Insert a wire section at connection 4d and keep the other end free. Insert another wire section at 5b and the other end remains free.
The circuit "humidity sensor" can be used for plant monitoring. Both wires are pushed deep into a flowerpot. If the LED does not light up, the flower must be watered. The moisture detector is also suitable as a level indicator for a bath tub.
This circuit offers space for even more practical applications.

Sensor Key

Can the amplification of the transistor be further increased?
When experimenting with the circuit "humidity sensor" the transistor was loaded with only one LED. If you want to connect a light bulb or a relay, the load is too high and the transistor would be destroyed. Here, a second transistor is added, which further increases the amplification and both transistors share the load. At the same time, the current at the base of the first transistor can be even lower than with the humidity sensor. Simply touching with your finger will light up the LED.

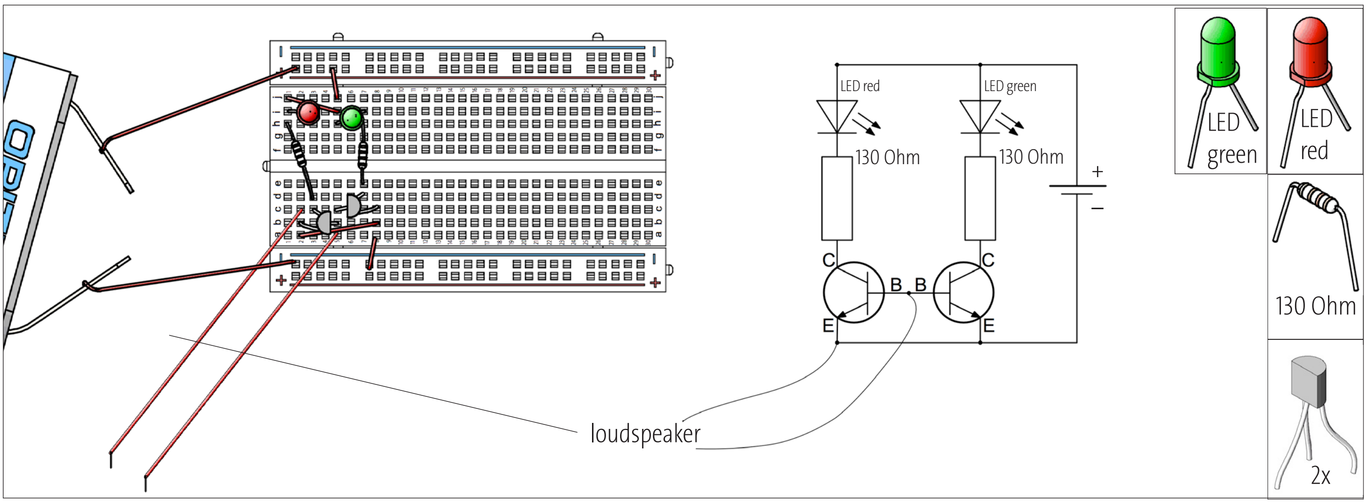


The combination of two transistors for amplification is called Darlington circuitry.
In our example, such a Darlington circuit serves as a sensor key. This sensor key reacts to the extremely weak current flowing through the finger. Sensor keys can be found on the television, for example. One saves a mechanical switch and facilitates the handling.

Take a piece of connecting wire (20mm) and plug one end into the - bar. Plug in the other end into terminal 8b. Plug in transistor 1 as follows: Base (5c), Collector (7d), Emitter (5b). Plug in transistor 2 as follows: Base (1b), collector (4c), emitter (5b). Insert a resistor (130 Ohm) between 4d and 4g. Insert a resistor (1.8 kOhm) between 4h and 1h. Plug in the anode of the LED at 4i and the cathode at 7i. Insert a resistor (6.8 kOhm) between 7e and 7h. Insert a piece of connecting wire (20mm) between 4i and +bar. Insert an approx. 60mm long piece of wire at 1c. The other end remains free. Insert another approx. 60mm long piece of wire at 1g. Also here the other end remains free.

Mini Colour Organ

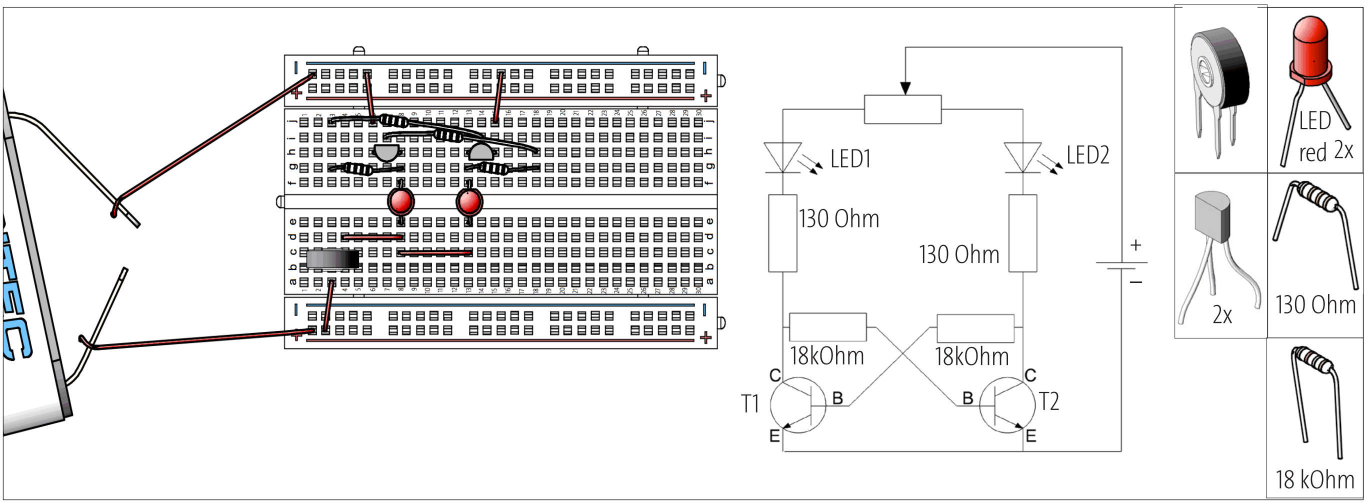
A transistor switches and amplifies current. Can he do this at high speed, i. e. several times a second?
In the following circuit, two transistors are controlled depending on speech or music. This creates a mini light organ. Speech and music consist of a multitude of vibrations. In humans, these vibrations are generated by the vocal chords or the membrane of a loudspeaker. So that the loudspeaker can vibrate, it receives signals from the electronics, e. g. a radio. These signals are tapped and thus the transistors are controlled, which in turn switch both LEDs on and off at the rhythm of speech/music. The transistors have to switch the LEDs with high speed.
The two wires are connected to a loudspeaker box. The polarity must not be observed.



Take a piece of jumper wire (20mm). Insert one end on the breadboard at the - bar and the other end at port 8a. Insert a wire connection between 8b and 2a. Connect the 1st transistor as follows: Base (5b), collector (2c), emitter (3c). Insert the 2nd transistor as follows: Base (5c), Collector (7d), Emitter (8c). Plug in the resistor (130 Ohm) between 7e and 7h. Plug in the 2nd resistor (130 Ohm) between 3d and 1h. LED 1 (green): Insert the anode at 5h and the cathode at 7i. LED2 (red): Insert the anode at 1i and cathode at 3i. Insert a wire connection between 5i and 1j. Insert a wire connection between 5j and +. Insert switch wire piece (approx. 100 mm) to the loudspeaker at 5a. Connect another 100mm switch wire piece also as a connection to the loudspeaker at 3c.
The circuit can be connected to any loudspeaker. If it is installed in a radio or in a loudspeaker box (Opitec MP3 speakers), you have an optical control indicator.

Quiz

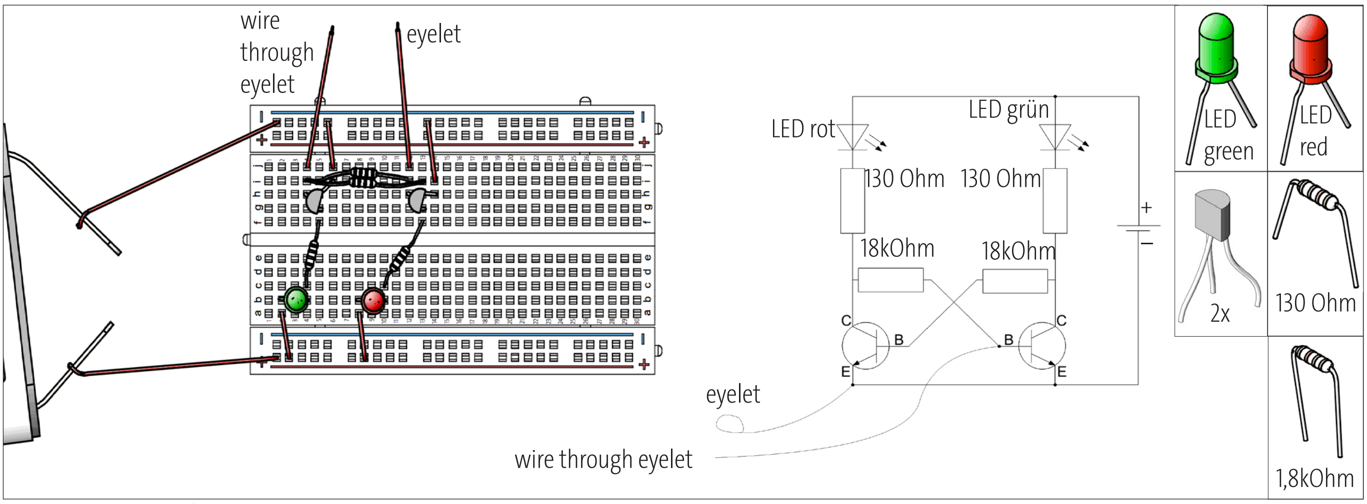
This circuit is a so-called random generator. It can be used as a guessing game or as a game of luck (like head or tails with a coin). If you put the circuit into a small box, you have an interesting game equipment.
If the battery is connected, one of the two transistors switches "its" LED on. The players should guess beforehand which one it will be. Let's assume that the battery is connected and a positive current (+) reaches the base of transistor 2 via LED1, the transistor switches through and LED 2 lights up. There is now a negative current (minus) at the collector of transistor 2 and thus also at the base of transistor 1, which therefore cannot switch through, so LED 1 remains dark. The variable resistor (trimmer) determines into which LED a stronger current flows, the other one is then switched on by the transistor. So you can adjust the circuit so that both LEDs light up randomly alternately, or one of them lights up more often than the other.
Note: Make sure that the transistors are correctly connected! Use two light emitting diodes of the same colour!
Such random generators are installed in slot machines, for example. Surely you know an electronic cube, the numbers appear randomly, controlled by a random generator.



Insert a piece of connecting wire between +bar and 3a. Insert the trimmer at 3b, 2c and 4c. Insert a wire connection between 4d and 8d. Insert a wire connection between 8c and 13c. LED1: Place anode at 8e and cathode at 8f. LED2: Place anode at 13e and cathode at 13f. Insert a resistor (130 Ohm) between 3g and 8g. Insert a resistor (130 Ohm) between 13g and 18g. Place a resistor (18 kOhm) between 18h and 7h. Place a resistor (18 kOhm) between 14i and 3j. Insert a wire connection between the -bar and 6j. Insert a wire connection between -bar and 15j. Place transistor 1 as follows: Plug in the base at 14h, the collector at 13h and the emitter at 15h. Place transistor 2 as follows: Insert the base at 7h, the collector at 6h and the emitter at 8h.

Flip-Flop

Starting from the circuit "random generator" you can now build up an electronic memory. This circuit is a basic circuit from computer technology. It can store a short signal (pulse). Computers need thousands of such memory circuits. For example, if you type in a calculator 16 * 8, you first enter the number 16, then the x-symbol and then the number 8. What's happening? The 16 disappears and the 8 appears. The computer invisibly stores the number 16 and our memory can store the information on/off. It moves back and forth between two states LED on or off. The electronics engineers therefore call such a circuit a bistable flip-flop or flip-flop circuit. The flip-flop can memorize an impulse and is therefore excellently suited to control the following skill game. In this game, the player should put a wire through the eyelet of a feather. If it only touches the eyelet for a short time, the flip-flop stores this impulse and the LED always lights up. So you can't cheat. What the eye does not see, the electronics notices it and stores it in its memory.
If you build the circuit in a small box, you have an interesting game to train your concentration.



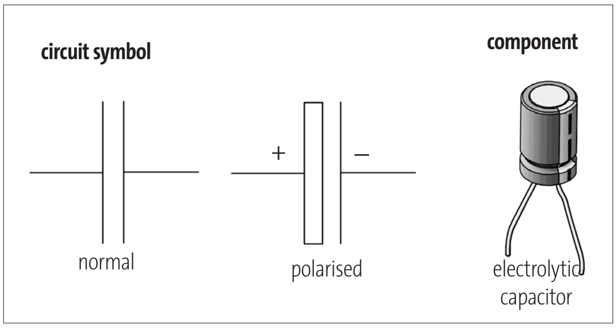
Plug a 15mm piece of connecting wire into the + bar on the breadboard. Plug in the other end at terminal 2a. Insert another connecting wire piece between +bar and 8a. Plug in the anode of the green LED at 2b and the cathode at 4b. Plug in the anode of the red LED at 8b and the cathode at 10b. Insert the 1st resistor (130 Ohm) between 4c and 5f. Insert the 2nd resistor (130 Ohm) between 10c and 13f. Place transistor 1 as follows: Insert the base at 4h, the collector at 5g and the emitter at 6i. Place transistor 2 as follows: Insert the base at 12h, the collector at 13g and the emitter at 14h. Insert the 1st resistor (18 kOhm) between 4i and 13i. Insert the 2nd resistor (18 kOhm) between 5i and 12i. Insert a piece of wire between -bar and 6j. Insert a piece of wire between -bar and 14i. Insert a cable at 12j and a cable at 4j. Leave the ends of these two cables free.

How does the flip-flop remember the impulse?

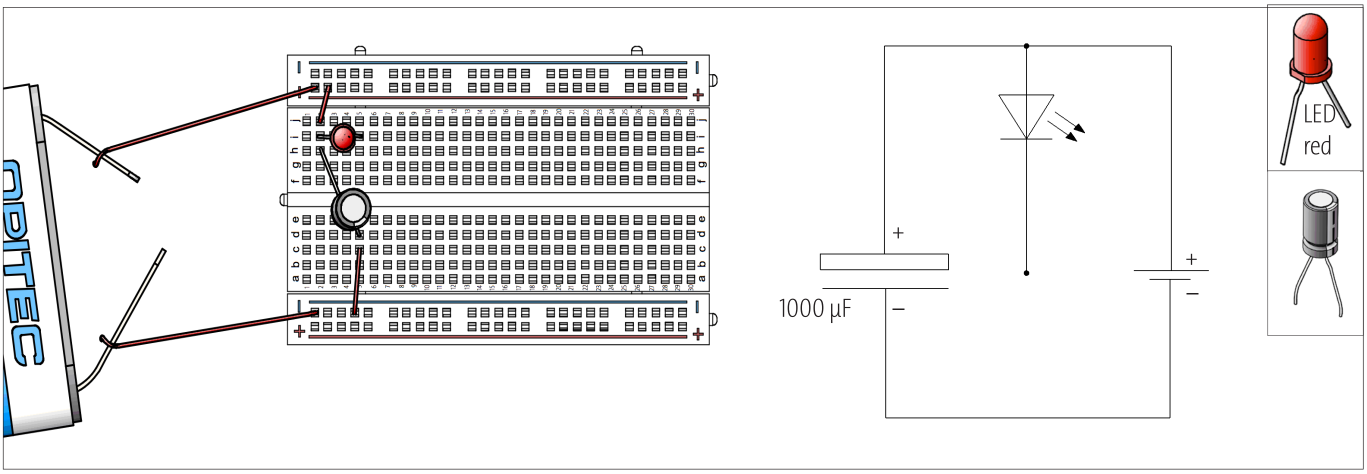
When the battery is connected, positive potential flows to the base of transistor 2 via the red LED, the transistor switches through and the green LED lights up. If a conductor is touched with the wire, negative potential reaches the base of transistor 2, the transistor blocks. Via the green LED, a positive current now reaches the base of transistor 1 and the red LED lights up continuously. The red LED only goes out when the battery is disconnected. The green LED lights up again when the battery is reconnected.

The Capacitor

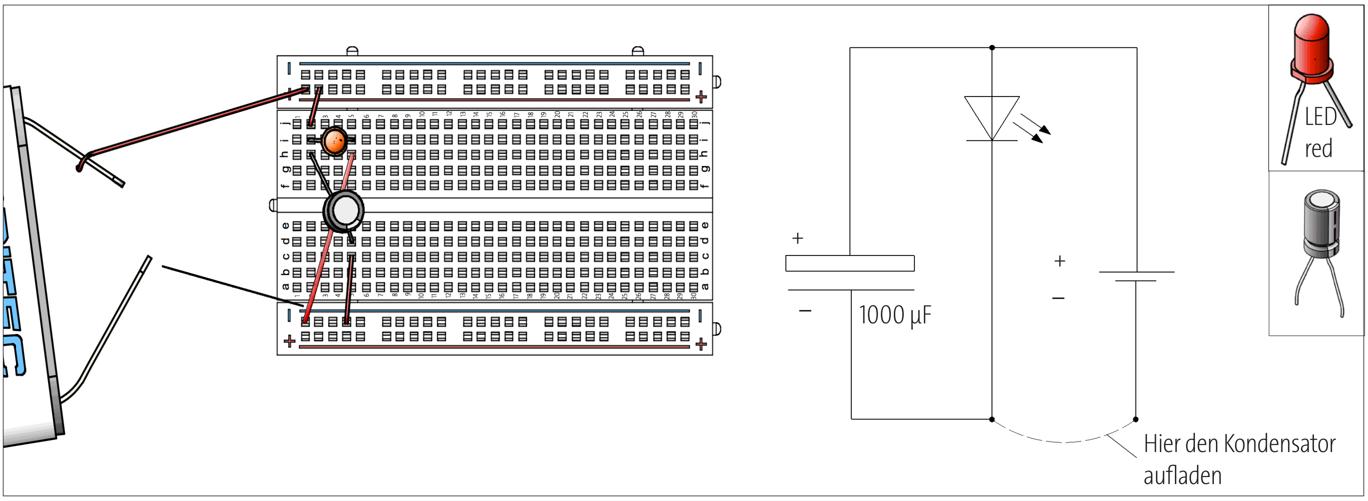
Batteries or rechargeable batteries are known. In them, chemical energy is converted into electricity. Now there are certain circuits where you have to store a stream for a short time. Batteries or even rechargeable batteries would be too big and too expensive. Therefore, one uses a component which can store current for a short time, the 1 capacitor..
The circuit diagram illustrates the structure of a capacitor. It consists of two separate plates. Between these plates he can store an electric charge. For reasons of space, the plates are rolled up in the case of large capacitors. Such a capacitor then has a cylindrical shape.



Experiments to charge and discharge a capacitor

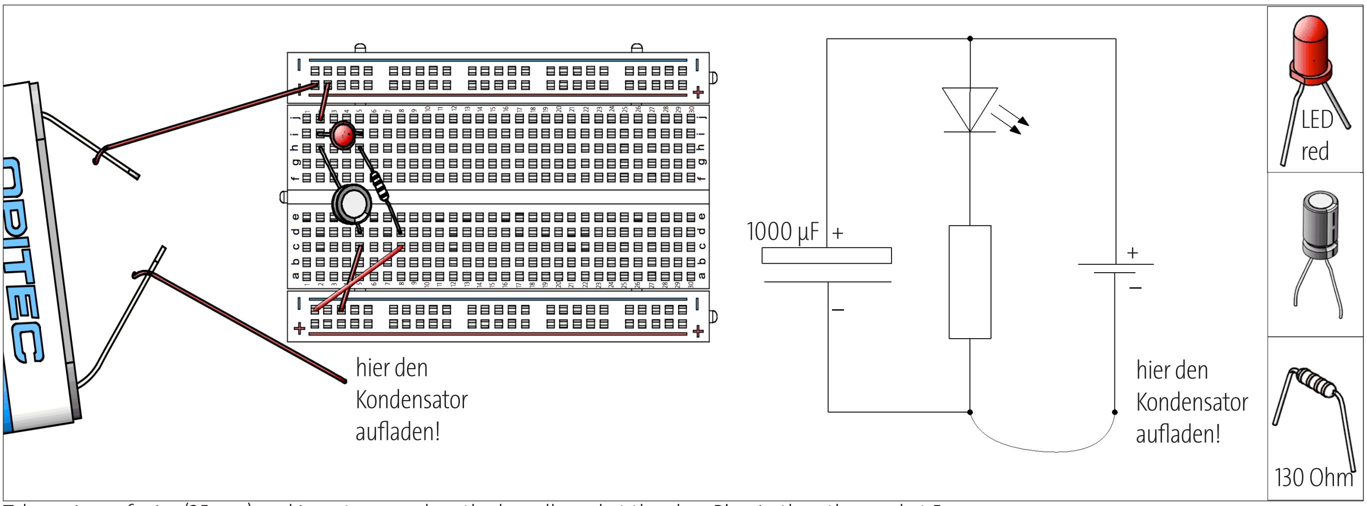


Take a wire connection (25mm) and plug in one end on the breadboard at the - bar. Insert the other end at 5c. Plug in the + pole of the capacitor at 5h and the - pole at 5d. Insert the cathode of the LED at 5i and the anode at 2i. Insert a wire connection between + pole and 2j.



Take a piece of wire (20mm) and insert one end on the breadboard at the - bar. Plug in the other end at 5c.
Plug in the + pole of the capacitor at 2h and the - pole at 5d. Insert the cathode of the LED at 5i and the anode at 2i. Insert a wire connection between + pole and 2j. After connecting to the battery, disconnect the wire connection at the - pole of the battery and insert in port 5h.
The LED flashes because the capacitor discharges quickly and discharges its stored charge.
Note: The current for flashing the LED does not come from the battery, but only from the capacitor.
For example photoflashes and warning lamps work according to this principle.
Now there are circuits where this fast discharge of the capacitor is not desirable. The capacitor should discharge more slowly. Do you know an electronic component that could delay discharge? This component would have to attenuate the discharge current.
Use the 130 Ohm resistor and extend the circuit.

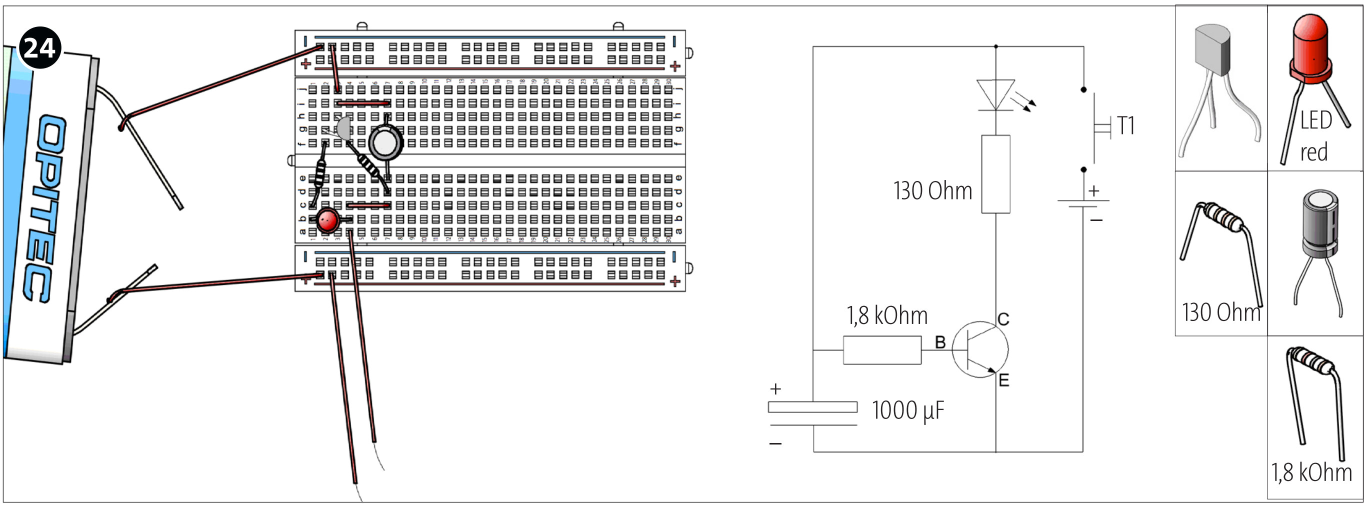
Timer



Take a piece of wire (25mm) and insert one end on the breadboard at the - bar. Plug in the other end at 5c.
Insert a wire connection between - pole and 8c. Plug in the + pole of the capacitor at 2h and the - pole at 5d. Insert the cathode of the LED at 5i and the anode at 2i. Plug in the resistor between 8d and 5h. Insert a wire connection between + pole and 2j.

Charge the capacitor by holding the terminal briefly to the negative pole of the battery. Then hold the terminal to the resistor!
What happens?
The LED lights up longer because the capacitor discharges more slowly via the resistor. Delayed discharge of a capacitor caused by a resistor is used, for example, in time circuits.

The next setup represents such a time switch in principle. A time delay up to approx. 20 seconds can be achieved with it. The transistor receives only a small current via the 1.8 kOhm resistor at its base, thus the charge stored in the capacitor lasts longer. The LED lights up for a correspondingly long time. To charge the capacitor, the push-button is pressed only briefly.



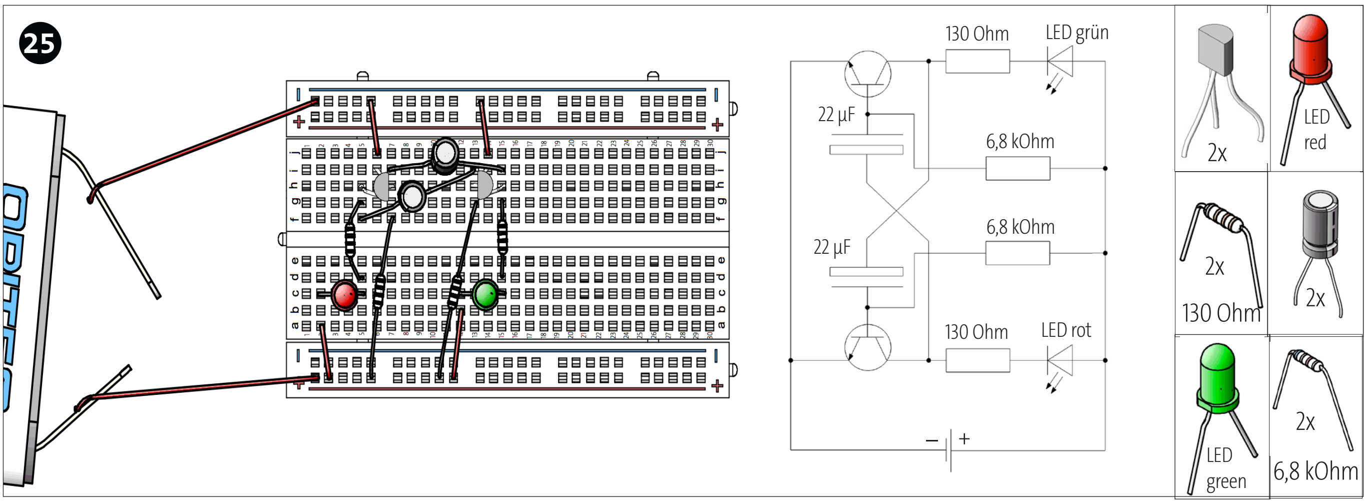
Take a piece of wire (100mm) and insert one end on the breadboard at the + bar. Plug in a second piece of switching wire (100mm) into terminal 4a. These two wires serve as switches.
Insert a wire connection between 7c and 4c. Plug in the anode of the LED at 4b and the cathode at 1b. Insert the resistor (130 Ohm) between 1c and 2f. Insert the resistor (1.8 kOhm) between 7d and 4f. Connect the base of the transistor with 4g, the emitter with 3h and the collector with 2g. Plug in the + pole of the capacitor at 7e and the - pole at 7i. Plug a wire connection from the - pole to 3j and between 7j and 3i.

If you replace the 1.8 kOhm resistor against the 6.8 kOhm or 18 kOhm resistor, the time is increased many times over. If you place the circuit in a small box, you have a timer for games. For example, in chess the character should be pulled within the flashing time of the LED. A timer can also be used to limit the thinking time in guessing games.

If you extend the circuit so that the capacitor is automatically recharged again, you have a system that switches the LED on and off again and again. You need a second transistor for this purpose, it should switch on the capacitor after discharging and recharge it again. However, the second transistor may only switch on the capacitor for charging, so it must be switched on and off by another capacitor.

Both capacitors thus constantly change their charging and discharging rhythm. The LEDs flash alternately in the circuit, an alternating indicator. Of course, the circuit can be changed so that only one LED flashes. To do this, you only need to remove one LED and connect the 130 Ohm resistor to the positive terminal.
You can also exchange one of the two capacitors for the large 1000 µF capacitor. The rhythm then slows down.

This is how the circuit is constructed:



Insert a piece of the connecting wire between +bar and 2a. Insert a wire piece between +bar and 12b. Plug in the anode of the red LED at terminal 2c and the cathode at terminal 5c. Plug in the anode of the green LED at connection 12c and the cathode at 15c. Place the resistor 1 (130 Ohm) between 5d and 5g. Place the resistor 2 (130 Ohm) between 15d and 15g. Plug the resistor 1 (6.8 kOhm) into the +bar and terminal 7f. Insert resistor 2 (6.8 kOhm) between +bar and 13g. Plug in the +pole of capacitor 1 at 13i and the -pole at 5f. Plug in the + pole of capacitor 2 at 15i and the - pole at 7i. Plug in transistor 1 as follows: Plug in the base at 7h, the collector at 5h and the emitter at 6i . Plug in transistor 2 as follows: Plug in the base at 13h, the collector at 15h and the emitter at 14i. Insert a wire connection between -bar and 14j. Insert a wire connection between -bar and 6j.

For example alternating indicators can be used on a model railway at the level crossing. A flashing light can be installed in a model car or used as a warning light.

Finally the functional description of the interplay of the two LEDs:
When the battery is connected, the green LED lights up first. Via the red LED a current flows into capacitor 1, which charges itself and then blocks transistor 1. the green LED therefore goes off and the red LED lights up. Now capacitor 2 can charges itself and then blocks transistor 2. During this time, capacitor 1 has already discharged again, which means that transistor 1 switches through again, the green LED switches on and capacitor 1 recharges itself again. This process is constantly repeated.