

**MAKER
FACTORY**

The logo for 'MAKER FACTORY' features the words in a bold, dark blue, sans-serif font. The word 'MAKER' is on the top line and 'FACTORY' is on the bottom line. A stylized volcano is integrated into the text, positioned behind the 'A' in 'MAKER' and the 'F' in 'FACTORY'. The volcano has a grey body, a yellow lava flow at the top, and a grey smoke plume rising from the top. The base of the volcano is a dark grey, rounded shape.

Content

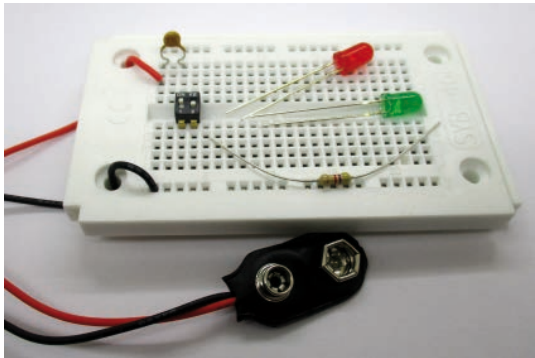
1 The components	3
2 The first LED lamp.....	4
3 More light!	7
4 Switchable brightness	10
5 series connection with two LEDs	13
6 Parallel connection.....	14
7 Flashing Morse code device	16
8 Green signals.....	18
9 An electric tester	19
10 red and green light.....	21
11 A colour switcher	23
12 A yellow-green switch	25
13 Adjustable brightness	26
14 red - green - white.....	28
15 Setting from green to red	30
16 Automatic flashing light.....	31
17 flashing lights - red and green	33
18 alternating flash lights	34
19 One change indicator with four LEDs.....	37
20 Alarm system with flashing indicator	38
21 A game of skill.....	39

22 An automatic colour-changing LED	41
23 White flashing light	44
24 Green flashing light	45
25 Flickering and flashing with six LEDs.....	47

1 The components

This package contains exciting projects with LEDs and other electronic components. In addition, there are info boxes all around that explain why the experiments work the way they do. Of course, you can also just perform the actual experiments. After a while, the technical connections will become clear on their own!

The package contains the following components to build and connect: a plug-in board to assemble all the tests, a 9 V battery clip to connect the battery, a dual four-port switch, a two-wire fuse, and five cables to plug into the plug-in board.



The battery cable must be fixed as stable as possible, so that it does not come loose during the following experiments. The bare tips of the red and black cables should be plugged into

exactly the right contact sockets of the plug-in board. You should first prick small holes in the protective foil at the back of the board using a needle and insert the cables from below. This way, they will no longer easily slip. The switch and fuse should be placed exactly in the position shown. This applies to all other experiments. This will prevent big mistakes from occurring.

There are also seven light emitting diodes (LEDs), including five colourful red, yellow, green, blue, and pink LEDs, a red flashing LED that has a clearer casing to recognise it, an extra small chip, and a red LED automatic colour-changing LED in a clear housing.

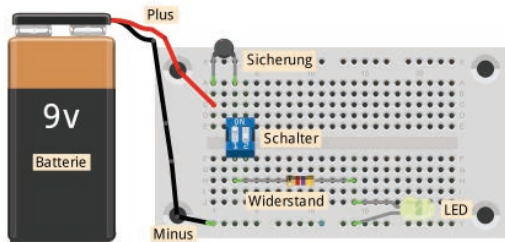
Caution: The LEDs must never be connected directly to a 9 V battery! You must always use a resistor to reduce the electrical current. There are twelve different resistances, which can be distinguished by their coloured rings.

A push button and an adjustable resistor (potentiometer) provide even more variety in the experiments. With these you can turn on the power or adjust the brightness of an LED.

2 The first LED lamp

For the first experiment, you need the plug-in board, battery clip, switch, fuse, an LED and a resistor. The result is a simple circuit with an LED. It's not bright, but there's a switch and all the important components that will also be used in the following experiments. In the picture you can clearly see in

which holes of the plug-in board, the components have to be plugged.



Fit the components onto the plug-in board using small flat-nose pliers. Carefully insert the wires from the top. The correct position of the connections is important.



When installing LEDs, it is important to note the mounting direction. The shorter wire is the negative pole (the cathode K); the longer wire is the positive pole (the anode A). The larger holder for the LED crystal is visible from the cathode side. The K-connector also has a small flattened area on the casing. This is also the case with coloured LEDs. The white LED also has a yellowish fluorescent colour that covers the LED crystal. There are LEDs that look almost identical from the outside. But looking through the lens from the front helps to recognise the white LED even when it is off.

The resistor may be installed in any direction. It is marked by coloured rings (yellow, violet, red and gold), which represent a numerical value. In this case, the rings indicate that the resistance is 4700 ohms (4700 Ω).

The battery clip should only be plugged into the battery when everything has been set up and properly checked. Then you shift switch 1 to the ON position. The LED should now shine white. If it does not work, the LED may have been installed the wrong way around. You should also check all other connections and compare everything exactly with the drawing.

Attention!

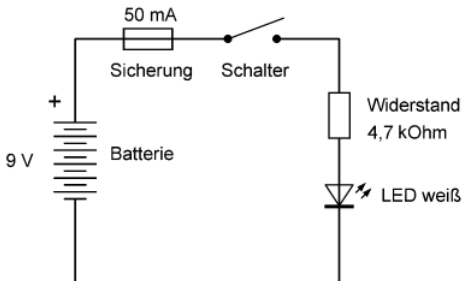
You absolutely must avoid short circuiting the battery, as it will result in a current of several amperes. The battery will then quickly become unusable. In extreme cases, it could even explode, or wires could become red hot.

Diagrams

A circuit diagram portray the connections of the components in a simplified form. In the beginning, it may seem a bit confusing because the real components look different. But once you get used to it, a diagram will clarify how everything fits together.

The battery consists of six 1.5 V battery cells. The long dash indicates the positive pole. The fuse is indicated as a box with a wire. The switch indicates an open connection, so it is currently in the off position. The resistor is displayed as a box

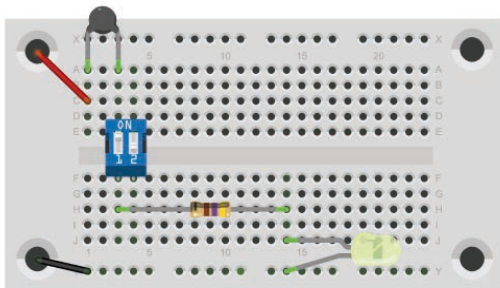
and the LED contains an arrow showing the current direction. Two small arrows represent the generated light.



Here you'll see all components form a complete path, i.e. a closed circuit. Only at one point is the circuit interrupted: where the switch has just opened.

3 More light!

The LED was not very bright in the first experiment. Here another resistor is installed. The first resistance was 4.7k Ω (4,700 ohms, yellow, violet, red), this has only 0.47k Ω (470 Ohm, yellow, purple, brown). It therefore allows significantly more current through. This makes the LED shine much brighter.

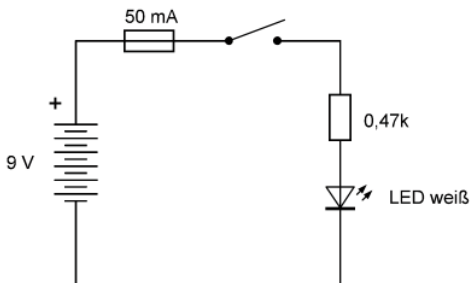


Resistors and their coloured rings

The coloured rings on the resistors represent numbers. They are read starting with the ring closer to the edge of the resistor. The first two rings stand for two numbers, the third for added zeros. Together they denote the resistance in ohms. A fourth ring indicates the accuracy. All resistors have a golden ring. This means that the specified value can be 5% larger or smaller than indicated by the coloured rings.

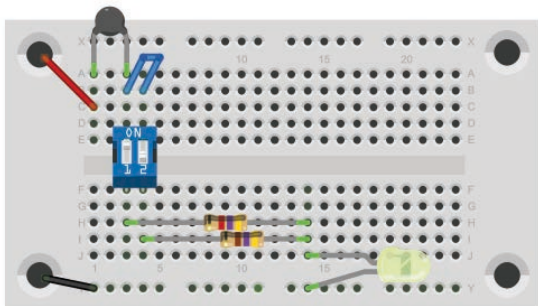
The resistor colour code

Colour	Ring 1 1. Code	Ring 2 2. Code	Ring 3 Multiplier	Ring 4 Tolerance
Black		0	1	
Brown	1	1	10	1 %
Red	2	2	100	2 %
Orange	3	3	1000	
Yellow	4	4	10000	
Green	5	5	100000	0.5 %
Blue	6	6	1000000	
Purple	7	7	10000000	
Grey	8	8		
White	9	9		
Gold			0.1	5 %
Silver			0.01	10 %



4 Switchable brightness

More brightness is sometimes an advantage, but also has a disadvantage. It makes the battery run down faster. It is more practical if you can choose whether you need a lot of light or just a little. That's where the second switch comes in, which is connected via a cable to two thin connectors. When in the ON position, more current flows through and the LED shines brighter. Switch 1 is for when you require less brightness. And the special LED light with two brightness levels is done!



Actually, there are three brightness levels. Switch 1 is for simple brightness and switch 2 for tenfold brightness. But if both switches are on, the result is eleven times the brightness. You can easily test it: Turn on switch 2 and turn switch 1 on and off alternately. The difference is, however, very insignificant and hardly recognisable.

Voltage, resistance and current

As is known, the electrical voltage is measured in volts (V). The battery is 9 V. And a resistance is measured in ohms (Ω) or kilo ohms ($k\Omega = 1,000\Omega$). But there is another very important measure: the electrical current, which is measured in amperes (A) or at low currents in milliamps ($mA = 1/1000A$).

Using a suitable meter, you could measure how much current flows through the LED. But you can also work out how strong the voltage, at the moment, the battery is and what the voltage is at the LED. If the battery is still new, it will have a voltage of 9 V. The LED needs about 3 V, which leaves another 6 V for the resistor. You can calculate the low brightness like this:

Current = voltage/resistance

Current = 6 V/4700 Ω

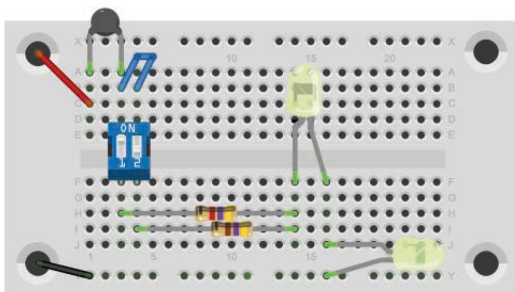
Current = 0.0013 A = 1.3 mA

That's not very much, only 1.3 mA are flowing, although the LED can tolerate a current of 20 mA. But the battery will last long! It usually has a capacity of 500 milliamps (500 mAh), so could deliver 500 mA for one hour or 1 mA for 500 hours. Or the lamp will glow for about 400 hours at 1.3 mA; that is, for more than two weeks.

For the higher brightness you get about ten times the current (13 mA) and then you are closer to the allowed limit of 20 mA. But the battery only manages to do this for around 40 hours, which is just under two days.

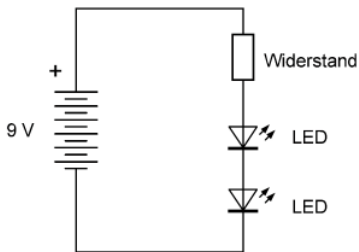
5 series connection with two LEDs

Here we use a second white LED in the circuit. The light will be a little brighter. The brightness is enough to read at night. And once again, there are two brightness levels. Depending on the situation, you can decide how much light is needed.



Series connection

In series connection, the same current flows through two or more consumers. It is an “unbranched circuit” because there is only one way the current can flow. This means that the current is the same at each point.

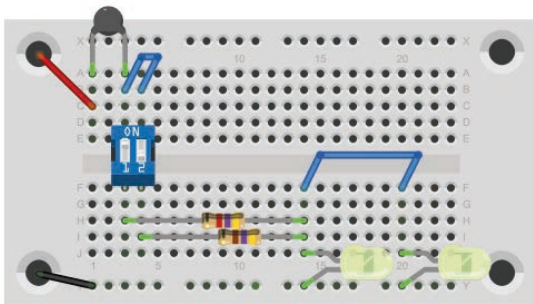


Simplified circuit diagram of a series connection

The voltage is divided among the consumers in the circuit. In this case, there are two LEDs and a resistor. Each white LED needs about 3V. So, two LEDs have a voltage drop of 6V. And because the battery has 9V, there is a 3V voltage drop across the resistor. In this case, therefore, the battery voltage is divided equally between three consumers. The same applies to the energy consumption. The resistor does generate a little useless heat, but the LEDs provide the desired light. Because this time only one third of the voltage is at the resistor, only one third of the energy is "wasted". The circuit with two LEDs in series is therefore better than that with only one LED, since only two thirds of the voltage are lost.

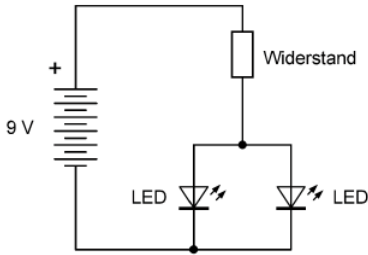
6 Parallel connection

This time, the LEDs should be connected in parallel. For this purpose, a second cable is required. At first glance, both LEDs light up as in the last experiment. But actually, they are a little less bright now.



Parallel connection

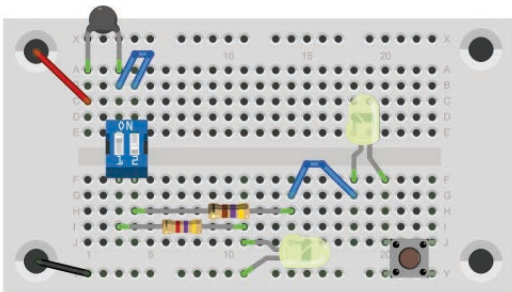
The parallel connection is also called "branched circuit". The current through the resistor is divided by two LEDs. Half the current flows through one LED, the other half through the other LED. A small test can prove this: If you remove the cable between both LEDs, one LED goes out, but the other one shines brighter. All the current then flows through that LED.

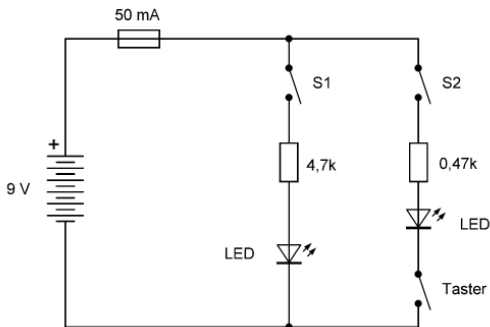


Parallel connection
with two LEDs

7 Flashing Morse code device

A push button switches the signal LED on and off in this experiment. This creates a simple Morse code device. The signal LED uses high brightness. In addition, there is a LED with lower steady light, which can be switched on via switch 1.





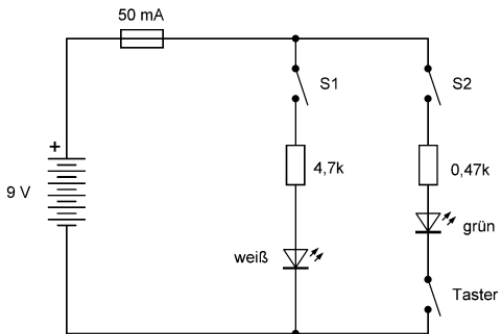
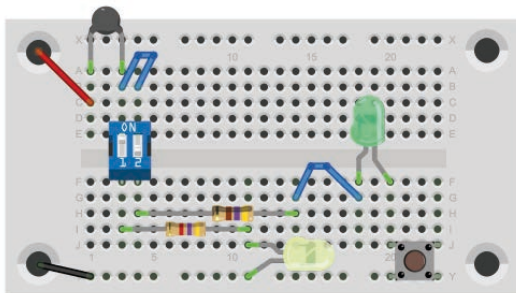
Info Morse code

Morse Code

A	• —	M	— • —	Y	— • • —	6	— • • • •
B	— • • •	N	— • •	Z	— • • •	7	— • • • •
C	— • • —	O	— • —	A	• • • —	8	— • • • •
D	— • •	P	• • — •	Q	— • • •	9	— • • • •
E	•	Q	— • • —	U	• • —	.	• • • • •
F	• • • •	R	• • •	Ch	— • — —	,	— • • • —
G	— • •	S	• • •	0	— • — — —	?	• • • • •
H	• • • •	T	—	1	• — • — —	!	• • • • •
I	• •	U	• • —	2	• • • — —	:	— • • • •
J	• — • — —	V	• • • —	3	• • • —	"	• • • • •
K	— • • —	W	• • — •	4	• • • •	'	• • • • •
L	• • • •	X	— • • •	5	• • • •	-	— • • • •

8 Green signals

Here, a green LED is installed instead of the white signal LED. The light of this LED can be seen over even greater distances. This allows you to exchange messages with friends who are in sight.

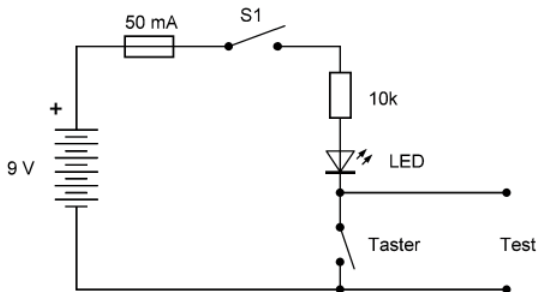
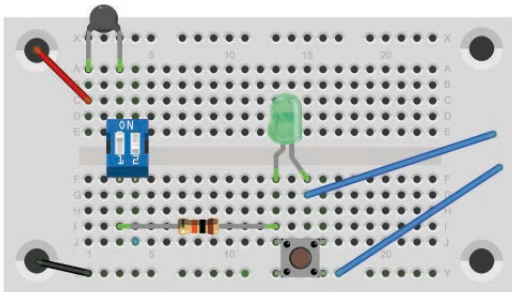


9 An electric tester

In this experiment, a test device is built to check which things conduct electricity. The resistance of 10k Ω (brown, black, orange) should further reduce the current through the LED, as great brightness is not required here. There are two cables with test tips. You can use these to touch any object. When the LED lights up, you know that electricity is flowing through it. All metals conduct electricity, but also other things such as pencil lead.

Even weak conductors are detected. If you touch both wires with your fingers, you will see a very dim light. So, the skin does conduct some electricity. If you moisten your fingers with water, even more electricity will be conducted. This is harmless because the battery only has a voltage of 9 V. However, high voltages over 48 V can be dangerous. The mains voltage of 230 V is life-threatening! You may touch wires only if you know for certain that the voltage is no more than 12V.

In addition to a test object, the push button switch can also close the circuit. This helps to distinguish whether the object being examined is a good or bad conductor. When the test cables touch an object, the LED will light up. Then press on the button. Does the LED shine even brighter? In this case, it is a weak conductor. But if you examine a metal object or a wire, there will be no difference, because all metals are good conductors.



Additional experiment

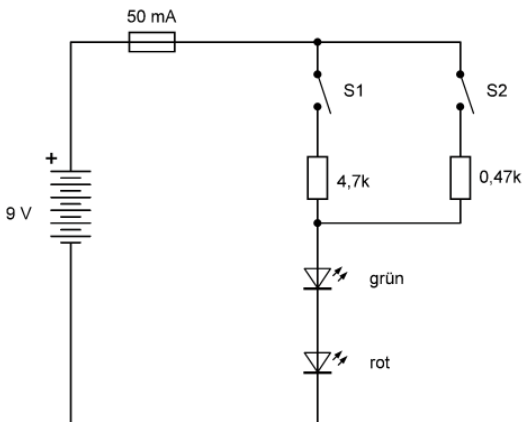
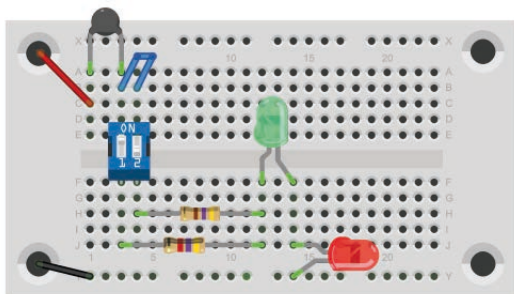
The test device is also suitable for testing electrical components. The resistors in the package conduct the current to different degrees. An LED will only conduct in one direction. And you can check if a light bulb is still working or has already burned out.

10 red and green light

The aim of this experiment is to compare the brightness of different coloured LEDs. A red LED should be connected in series to the green LED. The same current flows through both, as in Experiment 5, when two white LEDs were connected in series. But which seem brighter, the red or the green LED? You can once again choose the brightness levels by turning on S1 or S2.

Additional experiment

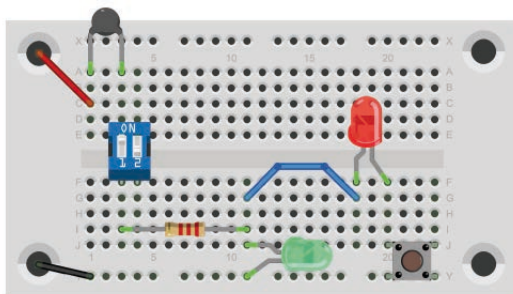
Both LEDs should shine on white paper. At the points where the coloured circles overlap, the mixed colour should appear yellow.

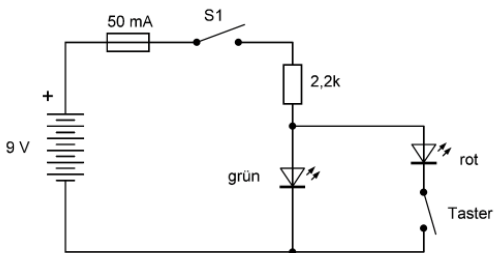


11 A colour switcher

With a resistance of $2.2\text{k}\ \Omega$ (red, red, red) and two LEDs, a very special circuit is built - a green-red switch. Every time you press the button, the red LED goes on, but the green LED goes off.

When the switch contact is closed, it is actually a normal parallel connection like in Experiment 6. But in that experiment similar LEDs were used; this time they are different. The green LED needs a higher voltage than the red LED. When the red LED is turned on, the voltage drops so low that the green LED can no longer shine. This is how changing colours is created.





The PTC fuse

All experiments use a fuse that kicks in when an error occurs. If you accidentally cause a short circuit, a wire could become red hot, or the battery could overheat and in the worst case even explode. But the fuse can prevent this from happening.

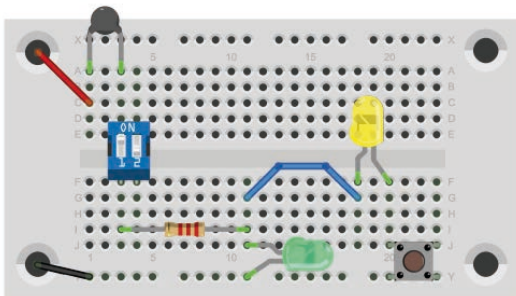


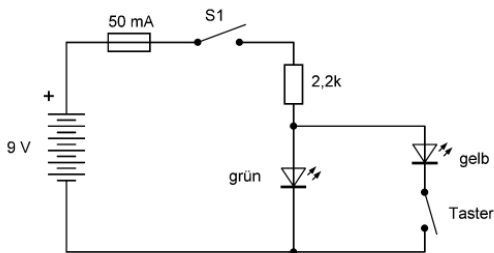
Many fuses burn out easily when a short circuit occurs. But this special fuse is different. It is a self-resetting fuse called PTC fuse. If too much current flows in the event of a short circuit, the PTC fuse becomes hot and allows very little cur-

rent to pass through, as its resistance rises sharply. Hence the name. PTC stands for “Positive Temperature Coefficient” and means that the resistance increases as the temperature rises. At a voltage of 9 V, a temperature of about 60 degrees is reached. If you turn off the power and eliminate the error, the fuse cools down and works like new again.

12 A yellow-green switch

This time, the colour switch must be tested with a yellow LED. You can use them just like for the other colours. But the question arises, how the yellow LED would behave together with the green LED. And indeed, the green-yellow switch works.

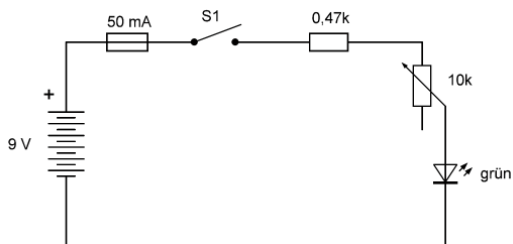
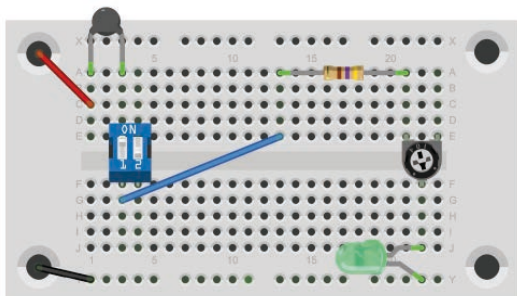




13 Adjustable brightness

The potentiometer (pot for short) is a three-terminal adjustable resistor. Such components are also used as volume controls in radios. But in this case, it is used to set the brightness of a green LED.

The further you turn the knob to the right, the brighter the LED will shine. So far, different resistances between $0.47\text{k}\Omega$ and $10\text{k}\Omega$ have been used. The pot can be set between $0\text{k}\Omega$ and $10\text{k}\Omega$. But, because a series resistor of 0Ω is not allowed and could overload the LED, a resistor with $0.47\text{k}\Omega$ is connected in series. The total resistance is then adjustable between $0.47\text{k}\Omega$ and $10.47\text{k}\Omega$.

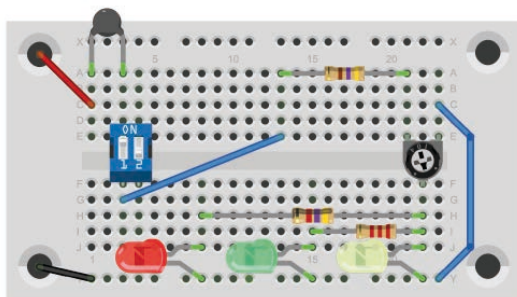


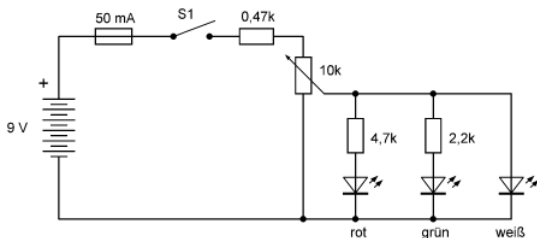
The opened pot

14 red - green - white

Another cable can be used to connect the third port of the potentiometer. This allows you to adjust the electrical voltage in the circuit. There are three LEDs connected to the slider of the potentiometer. The red and green LEDs have their own series resistor. Although the white LED is connected directly, at full brightness, the resistance is $470\ \Omega$.

If you turn the knob all the way to the left, all LEDs go out. By turning slowly to the right, first the red LED will turn on, then the green one and finally the white LED. In other words: The red LED needs the least voltage; the white LED the most. You can also test the yellow LED once and use it instead of the red or the green LED.

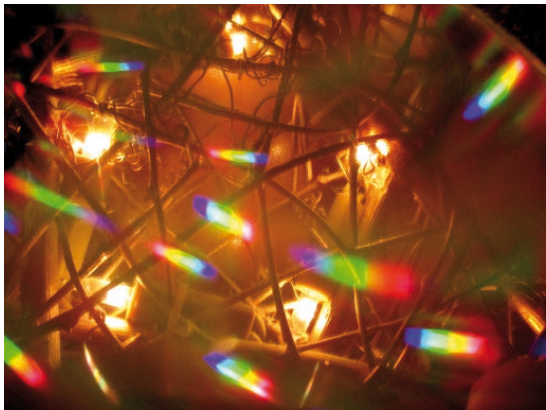




Additional studies: Spectral colours

A CD can be used as a mirror to look at the three LEDs. By changing the angle to the correct position, the white LED will be visible as stripes in all colours of the rainbow. The light spectrum is pulled apart because the CD has narrow lines that cause interference of the light waves. The lines of the red and green LEDs are also pulled apart slightly, but contain only a small part of the light spectrum.

The white LED is actually a blue LED. But apart from the LED crystal there is fluorescent material, which activates the blue light to radiate all other colours too. When the LED is off, you can see the yellowish fluorescent material inside. The material is similar to what is found in fluorescent tubes and energy-saving lamps.

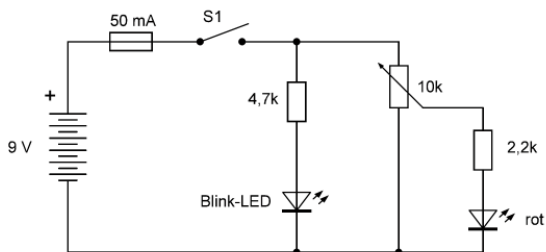
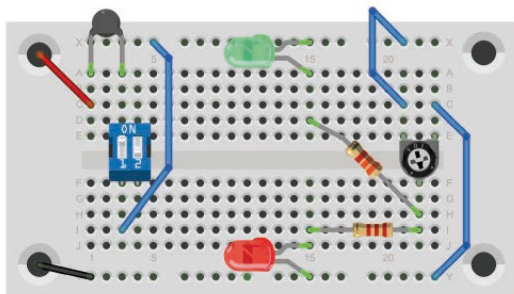


15 Setting from green to red

In this experiment, we create an LED with adjustable colour. It shines either red or green or in both colours. With the potentiometer you can adjust the brightness of both LEDs. If the green LED shines brighter when turning to the left, the red LED will shine dimmer. And if you turn the potentiometer more to the right, the red LED will shine brighter while the green LED will be dimmer.

If you shine the LEDs on a piece of paper and align them so that they create a single spot of light, the red and green light will together shine yellow. You can adjust all colours using

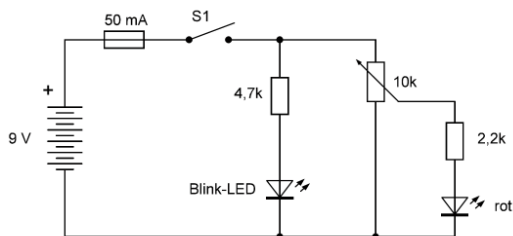
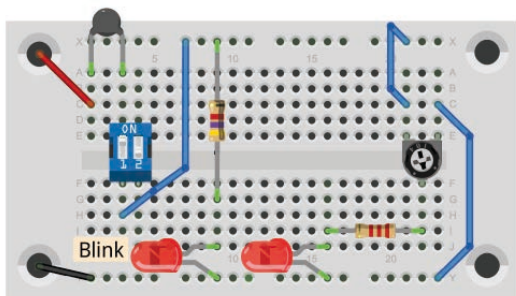
the potentiometer and all intermediate tones in the range red - yellow - green.



16 Automatic flashing light

The red flashing LED is a special LED with additional internal electronics. If you install it like a normal LED with a series

resistor, it turns on and off again and again. For comparison, the red LED with adjustable brightness should be placed next to it.



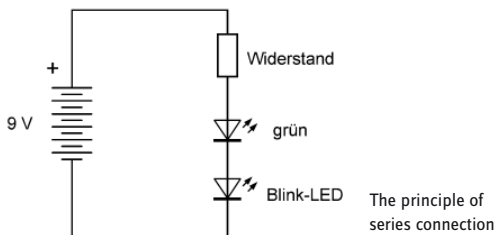
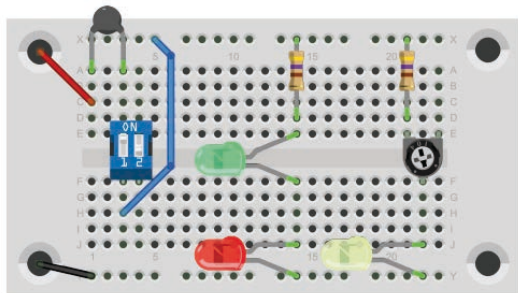
The flashing LED

The flashing LED contains a transistor as an electronic switch. In addition, other transistors and other components are required, which together form a complex circuit and control the exact timing. Everything is constructed on a small piece of silicon, which is installed next to the LED crystal.

17 flashing lights - red and green

Now the flashing lights should be extended so that two LEDs flash at the same time. For this, the green LED is switched in series to the red flashing LED. In addition, there is a white, LED the brightness of which can be adjusted with the potentiometer.

This causes both LEDs to flash at the same rate. But if you look closely, you realise that the green LED never goes out completely. So even when it's off, some power will flow through the blinking LED. The controller in the flashing LED continues to run and measures the time until the red LED should be switched on again.



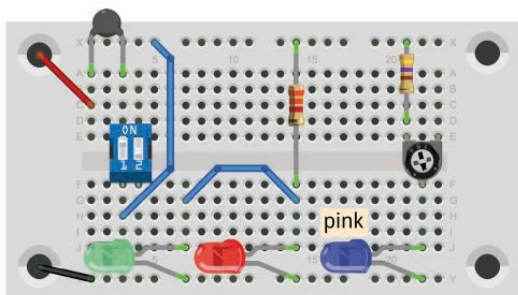
18 alternating flash lights

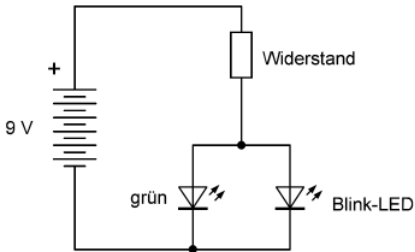
How the changing colours work, has already been tested in Experiment 11. But there a push-button was used to turn on a red LED. This time it is the automatic switch built into the flashing LED, the LED controller. Here, the flashing red LED and the green LED are connected in parallel. And because the

green LED needs more voltage than a red LED, it only lights up during the pauses.

In addition, the LED with the colour pink is now used. It should first be tested with adjustable brightness.

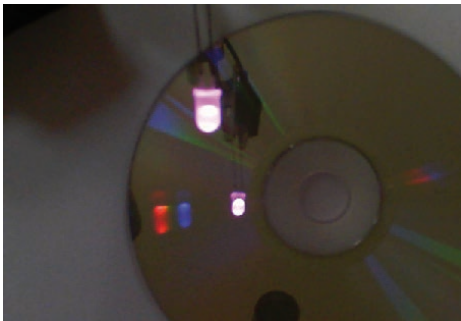
If you swap the green and the pink LEDs, the pink LED will flash and the green will show even brightness with adjustable brightness. This proves that even a pink LED needs more voltage than a red LED.





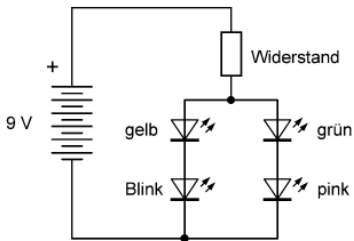
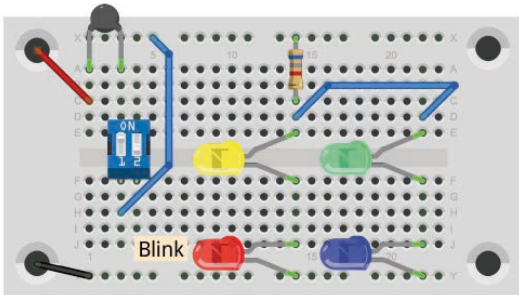
Structure of the pink LED

The pink LED is similar to the white LED. The actual LED crystal emits blue light. But it is covered with a fluorescent material that captures part of the blue light and emits it as red light. So, it happens that the pink LED actually has two colours: red and blue. Looking at a CD reveals this ...



19 One change indicator with four LEDs

Now we're building flasher with four colours. A yellow LED is in series with the flashing LED and therefore flashes in the same cycle. Parallel to this is a series connection of a green and a pink LED. These two LEDs require more power and shine whenever red and yellow are off.



Simplified circuit diagram

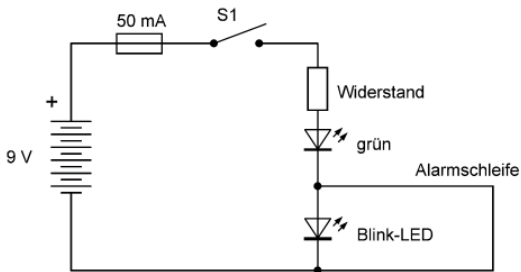
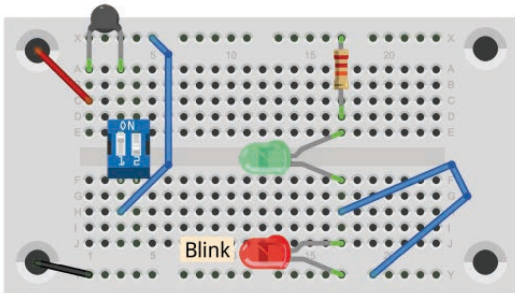
Additional experiments:

Different series resistors are tested in the circuit. The smaller the resistance, the greater the brightness. But does the switch still work with the slightest resistance?

20 Alarm system with flashing indicator

You can build a simple alarm system with two LEDs. The green LED lights up permanently, the red one not at first, because the cable short-circuits it. Green means: Everything's ok! You can tie a piece of string to the cable and attach it to the door. When someone enters the room, he will pull the cable out. The red and green LEDs will start to flash. The alarm is triggered.

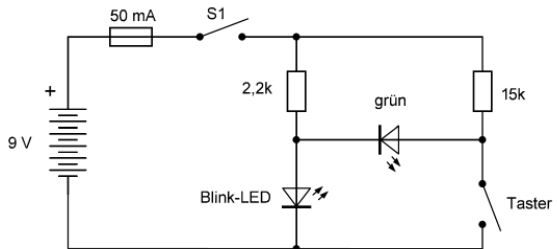
For this alarm system a large resistor with $22\text{k } \Omega$ (red, red, orange) is used. An alarm system must be in operation for a long time. That is why it is crucial that the current flow is very little. Here it is about 0.3 mA . A new 500 mAh battery could run the system for about 1,500 hours - more than two months. Real alarm systems are usually connected to the power grid. But when it comes to pieces of great value in a museum, a battery or a backup battery is used in addition to the power grid in case of a power failure.



21 A game of skill

For this game you have to try to press the button exactly in time with the flashing red LED. If you press the button, the green LED remains off. When you let go, it flashes at the same rate as the flashing red LED. The resistance for the green LED is $15\text{k}\Omega$ (brown, green, orange) and therefore allows only a

The button must be pressed again and again only releasing it briefly released once the flashing LED goes out. If you miss the point in time, the green LED will flash. It all depends on a fast reaction! How often can you press the switch without the LED flashing?



Bridge circuit

A bridge circuit consists of two series connections and one component between the two. On the left, the series connection contains a resistor and the flashing LED. On the right, there is a resistor and a switch. An LED is located between the resistor and switch forming the bridge. The question arises: Is the tension higher on the left or on the right? The green LED can only shine once the flashing LED on the left is shining and the switch on the right is off. Only then is the voltage on the right greater than on the left, allowing current to flow through the green LED.

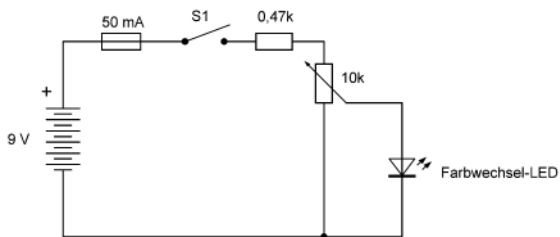
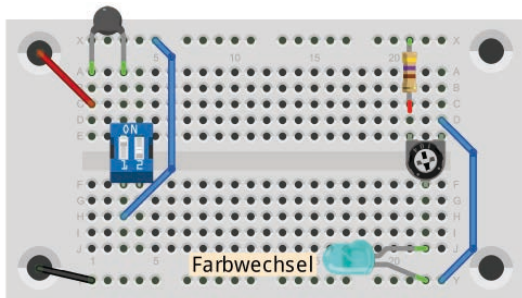
22 An automatic colour-changing LED

The automatic colour-changing LED contains three LEDs in red, green and blue. Because it has a clear housing, you can use the front rounding as a magnifying glass and view everything in the off state in high magnification. The silicon chip with complicated structures and the thin wires to the three LED crystals are clearly recognisable. The colour-changing controller turns the three LEDs on and off in rapid succession.



Caution: Never look directly into the LED when it is switched on. The blue light especially can damage the retina. Because the eye is less sensitive to blue light, the blue LED appears less bright, but is still very dangerous to the eyes.

The colour-changing LED is operated in this experiment using adjustable brightness. You can try another experiment. The potentiometer is connected as a voltage divider, so that even very small voltages from as low as 0 V can be set. If you turn the knob slowly to the right and thus increase the voltage, at first only the red LED will flash. Then the green will start flashing. And only at significantly higher voltage, the blue LED will start to flash. So, the voltage range of the LED colours also apply here. The shorter the wavelength of the light, the more voltage is required by the LED.

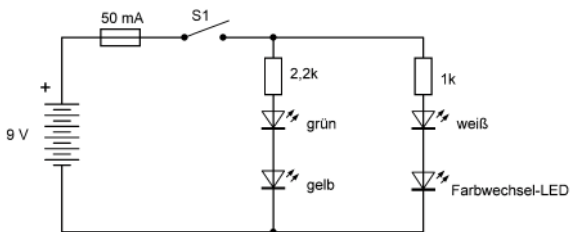
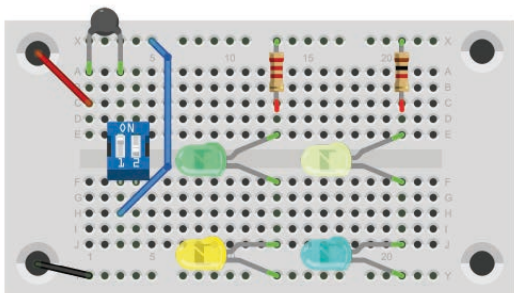


Pulse width modulation

The individual LEDs are not only switched on and off, but also appear lighter or darker. Sometimes the brightness increases evenly. Therefore, you might suspect that some kind of potentiometer is installed to change the current. But, actually the LEDs are turned on and off in quick succession. If you move the entire structure back and forth quickly, you can see light strokes of different lengths. The length of the pulses is changed and therefore the average duty cycle. The change (modulation) of the pulse length gives the impression of a change in brightness. This is called pulse width modulation (PWM).

23 White flashing light

The colour-change LED should now flash a white LED in sync. To achieve a high level of brightness, a relatively small resistance with $1k\ \Omega$ (brown, black, red) is required. The colour-changing LED is intended to modulate the current through the white LED. It has to be connected in series. Sometimes the brightness of the white LED is adjusted in steps and sometimes seamlessly. Two other LEDs are also connected in series for comparison, but shine with the same brightness.



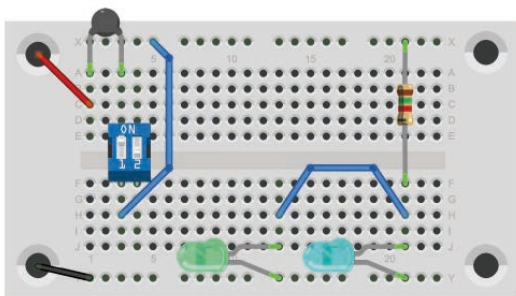
24 Green flashing light

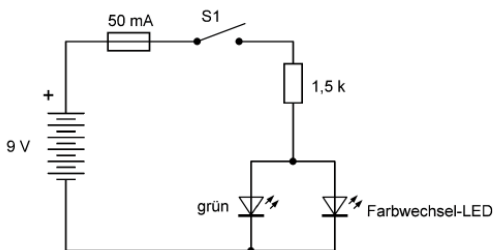
This time, the green LED should light up in the opposite direction of the colour-changing LED. It must be connected in parallel. The suitable resistance is $1.5\text{k}\ \Omega$ (brown, green, red). Whenever the colour change controller turns on the red LED, the green LED goes off. This creates an interesting flickering

of the green LED. And you can sometimes even see seamless changes in brightness in the green LED.

Additional experiment

One can test many different resistances between $470\ \Omega$ and $22\text{k}\ \Omega$ in this circuit. This makes it possible to set many different brightness levels. The goal may be more brightness (lower resistance) or longer battery life (greater resistance).

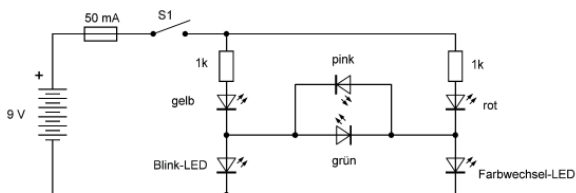
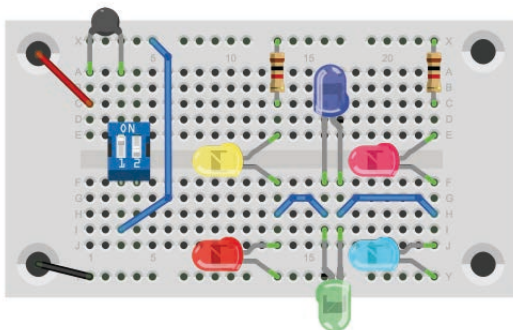




25 Flickering and flashing with six LEDs

With a total of six LEDs and two identical resistors of $1\text{ k } \Omega$ (brown, black, red), we are going to create a colourful and varied LED light at the end, in which all LEDs flash or flicker. Actually, the package contains only two LEDs with a built-in controller. But there are some circuit tricks with which other LEDs can blink or flicker.

The circuit consists of two LED series circuits and a bridge circuit with two oppositely poled LEDs. Note the installation direction of each LED. If something does not work, it could be because an LED was installed the wrong way around.



Six LEDs are now installed, but two white LEDs have no assigned purpose yet. It can be fun to add them. There are many different possibilities. Suggestions lead to the presented experiments. Overall, countless new circuits can be developed using existing components.

Imprint

Dear Customers,



This product has been manufactured in accordance with the applicable European directives and therefore bears the CE mark. The intended use is described in the enclosed instructions.

For any other use or modification of the product, you are responsible to comply with applicable rules. Therefore, install the circuits exactly as described in the instructions. The product may only be distributed along with this manual.



The symbol of the crossed-out wheeled bin means that this product must be sent for recycling separately from household waste as electronic waste. Consult with your local authority to find the nearest free collection point.

© 2018 Franzis Verlag GmbH, 85540 Haar

Author: Burkhard Kainka

GTIN 4019631150196

Produced on behalf of Conrad Electronic SE, Klaus-Conrad-Str. 1, 92240 Hirschau

All rights reserved, including those of photomechanical reproduction and storage in electronic media. The production and distribution of copies on paper, on data media or on the Internet, in particular as PDF, is permitted only with the express permission of the publisher and will otherwise lead to prosecution.

Most product designations of hardware and software as well as company names and logos mentioned in this work are usually also registered trademarks and should be considered as such. The publisher essentially follows the spellings of the manufacturers in terms of the product names.

All circuits and programs presented in this book have been developed, tried and tested with the utmost care. Nevertheless, errors in the book and software cannot be ruled out completely. The publisher and author are liable in cases of intent or gross negligence in accordance with statutory provisions. Moreover, the publisher and author shall only be held liable under the Product Liability Act for injury of life, body or health or for a culpable violation of essential contractual obligations. However, the claim for damages for the infringement of essential contractual obligations shall be limited to foreseeable contract-specific damages, unless a case of mandatory liability in terms of the Product Liability Act 2 exists.

Electrical and electronic devices may not be disposed of with domestic waste. Dispose of an unserviceable device in accordance with the relevant statutory regulations. Collection points have been set up, where you can return electrical appliances for free. Your municipality will inform you where such collection points are located. This product complies with the relevant CE directives, to the extent that you use it according to the enclosed instructions. The description forms part of the product and must be provided when you pass it on.