Adventskalender Elektronik 21

Translation into English. I saw this documentation on Burkhard's website.
Unfortunately, only available in German. So a quick translation.
Such a great kit should be helpful everywhere. Enjoy – Juergen Pintaske

https://www.elektronik-labor.de/Lernpakete/Kalender21/Franzis21.htm

Elektronik-Labor Literatur Projekte Lernpakete Kalender

www.franzis.de/adventskalender/technik-adventskalender/adventskalender-elektronik-kalender
www.amazon.de/FRANZIS-67400-Adventskalender-Experimente-Steckplatine/dp/B095C2ZD6T

Videos:	**The videos are unfortunately in German**
Example 1-2:	**https://youtu.be/FwCrwLQnQSw**
Example 3- 6:	**https://youtu.be/ce8L6b4E9nU**
Example 8- 12:	**https://youtu.be/jfeos98uVdo**
Example 13- 24:	**https://youtu.be/7Pp9i2leKwk**
Additional Example: wire finder:	**https://youtu.be/ptq6dj3L7x0**

Introduction

This electronics advent calendar contains 24 experiments on the subject of transistors and LEDs. Here you will find the two main types of transistors, namely bipolar transistors and field effect transistors. This allows numerous exciting circuits to be set up.

There is a layout diagram and a circuit diagram for each experiment. Compact information on the structure and function is followed by brief information on the technical background. It's all about trying and fun. But if you want to know more about it, you will find the key keywords that enable you to search for more detailed information.

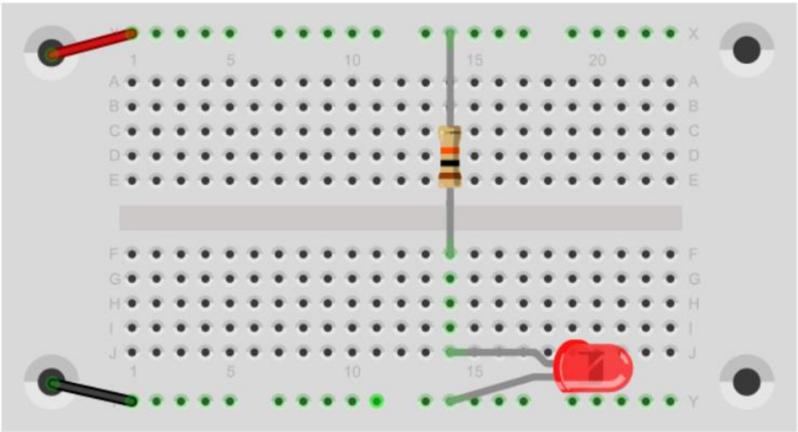
The calendar is aimed at interested people of all ages. It is ideal if you set up and try out the circuits with your family or together with friends. In this way, experiences and knowledge are exchanged and new ideas can arise.

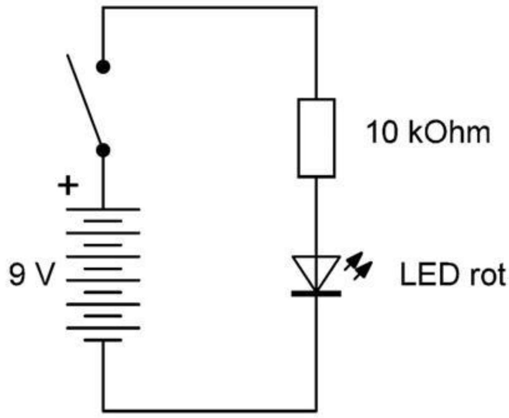
This calendar contains a lot of components, so that you can test these different circuits at any time. It is important that you keep all the parts carefully stored away right from the start, because they are used several times. And in the end you have enough material to implement your own ideas.

with your experimenting!

1 - Please switch it on and off **2 resistors 10 kΩ, 1 red LED**

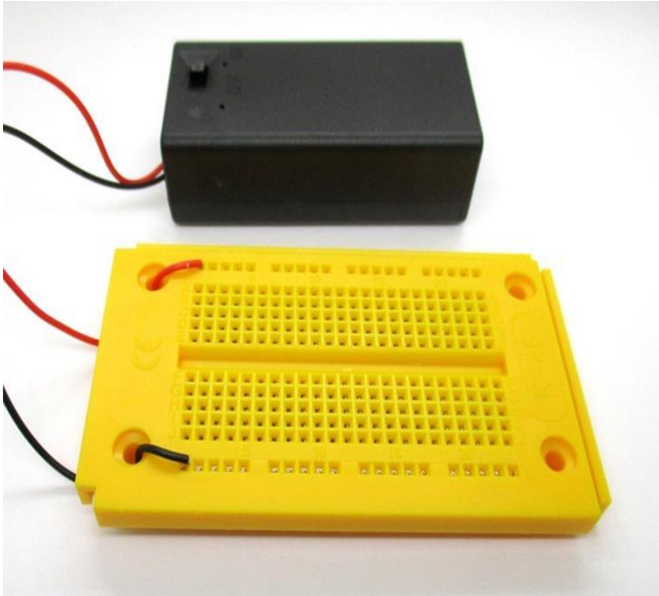
Behind the first door of the calendar there is a battery compartment with a switch, a breadboard, a red light-emitting diode (LED) and two resistors with 10 kiloohms. If all the components have been put together according to the assembly diagram and a 9 V battery is inserted into the battery compartment, our first circuit is created. The LED can now be switched on and off by using the battery compartment switch.





The patch panel has 230 contacts in the central area, each of which is conductively connected by vertical strips with 5 contacts. In addition, there are 40 contacts for the power supply on the edge, which consist of two horizontal contact spring strips with 20 contacts each. The patch panel thus has two independent supply rails, which are used here for the positive pole (top) and the negative pole (bottom) of the battery.

Inserting components requires a relatively large amount of force. The connection wires are therefore easily kinked. It is important that the wires are inserted exactly vertically from above. A pair of tweezers or small pliers will help. A wire is grabbed as short as possible above the breadboard and pressed vertically down. In this way, even sensitive connecting wires such as the tinned ends of the battery clip can be used without kinking. Sometimes it also helps to widen the contacts a little with a needle first.



The battery compartment has tinned wires at the end, that could easily wear out if you keep plugging them into the board. In order for these cables to remain stable for all experiments, they should be fed through the mounting holes. To do this, you have to pierce the foil with a needle.

It is very important to install the LED the correct way around. The shorter wire is the negative terminal (the cathode) and the long wire is the positive terminal (the anode).
And just as important: an LED is never installed without a resistor in series . This series resistor prevents the LED from being overloaded by limiting the current via this resistor.

The resistor has the color rings **brown** (1), **black** (0), **orange** (000). A final, golden ring indicates that these 10,000 ohms (10 kΩ) are manufactured with a tolerance of 5%. The second resistance must be kept safe for the following examples. A current of around 0.7 mA flows in this circuit.
Let's calculate the current:
9 Volt from the battery, the LED roughly uses 2Volt gives 9V – 2V = 7V
Current I = Volt (U) / Resistance (R) gives 7V divided by 10k (10 000 Ohm) =
about 7000 mV / 10 000 Ohms = 0.7 mA.

For comparison: The LED can handle currents up to about 20 mA.

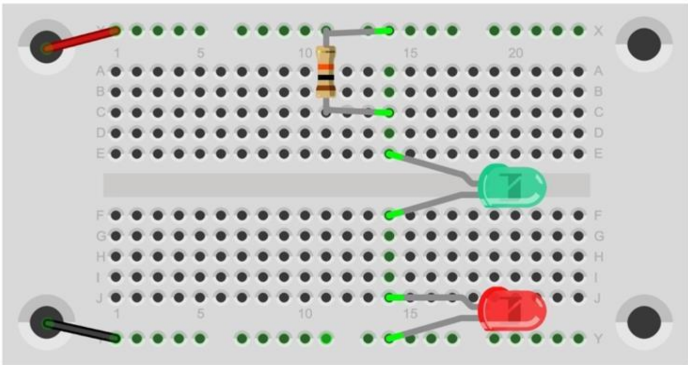
Let us calculate this resistor then to achieve these 20 mA current:
Resistor (R) = Voltage (U) / Current (I) = 7000 mV / 20 mA = 350 Ohm

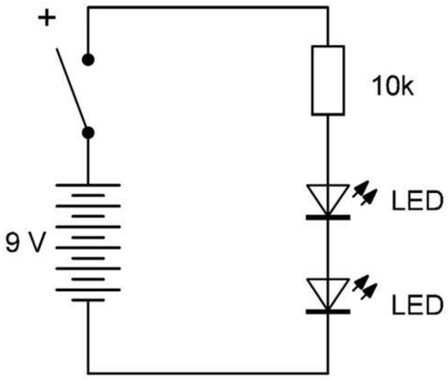
A quick cross check:
7V / 1kOhm = 7mA. So a third of this resistor would give 3x the current, so 1K / 3 of 1K is about right – so 350 Ohm.

2 - More color

2 green LEDs

The second compartment contains two green LEDs. One of them should now be installed in series with the red LED. You now get red and green light at the same time. If you let both light cones shine on a white sheet of paper, the mixed color yellow is created in the area covered by both colors.



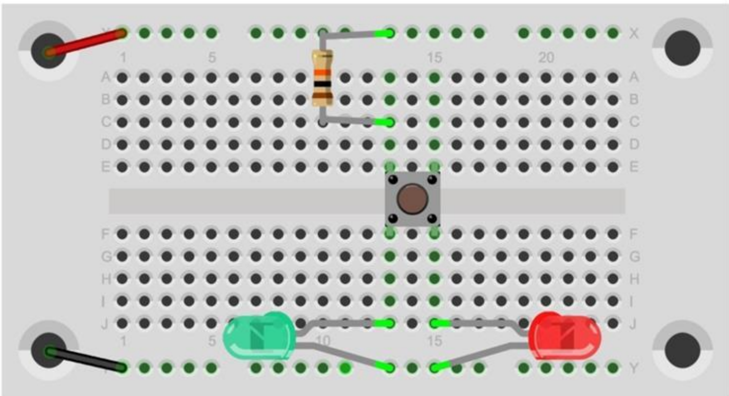


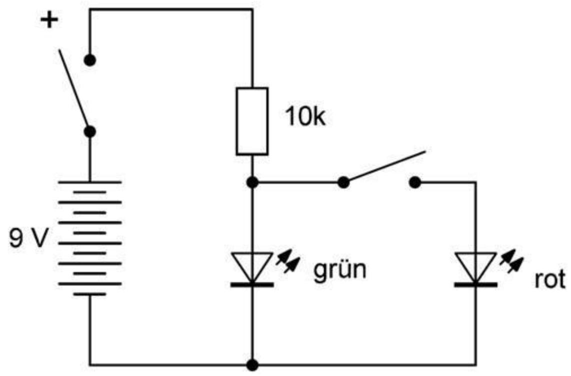
A current of the same strength flows at every point of this series circuit. A simple test provides the proof: swap both LEDs and you will find the same brightness as before. Incidentally, the current is lower than in the first example od day 1. Each LED needs around 2 V. That leaves 5 V for the resistor. From this, the current of 0.5 mA can be calculated (5 V / 10 kΩ = 0.5 mA). If you already understand it all, you can also test how three LEDs and the resistor behave in a series connection. The current would then be about 0.3 mA, and that should give enough light. And the attempt becomes even more economical if you also connect both resistors in series.

3 - Green or Red

2 pushbuttons

There is already a switch in the battery compartment. Two more are now added. There are 2 pushbutton switches whose installation direction must be carefully observed. Two of the four contacts each are connected inside. In between, there is a switching contact that connects both sides. With one of these switches, a parallel connection of the two LEDs is now formed. At first, only the green LED lights up. When you press the switch, the red LED switches on, very clear. But what is a bit surprising is that the green LED switches off out at the same moment. The push button acts like a switch: Green on.   Red on,   Green on,   Red.on .





The explanation can be found in the different specification of the two LEDs. As with any diode, the current only increases steeply with increasing voltage above a certain voltage. This voltage is higher for the green LED than it is for the red one. So, when the current limited by the resistor flows through the red LED, the voltage drops so much that this voltage is no longer sufficient for the green LED. A test with two green LEDs shows it: Both will light up in parallel.

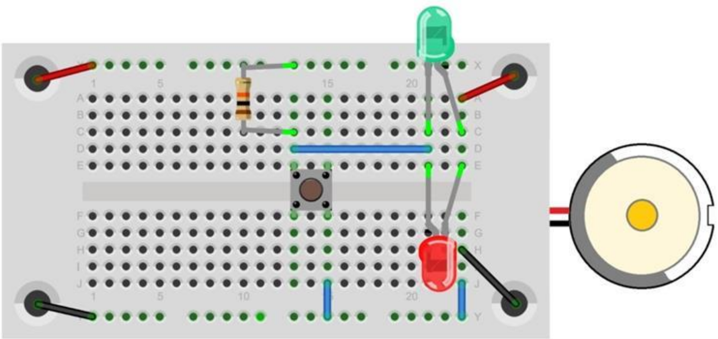
4 - Switching pulses and noise

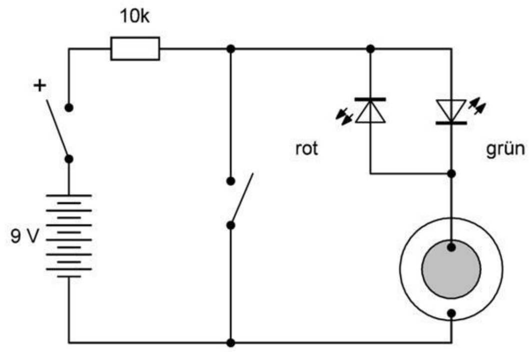
Piezo sound transducer and wire

Behind door number 4, some wire and a piezo-ceramic sound transducer appear, which can be used like a small loudspeaker. Its connection cables are also very sensitive and should be routed through holes in the breadboard and then plugged in appropriately for all subsequent experiments. Even if the component is not used for a test, the connections should remain plugged in.

The insulated jumper wire is needed for connections on the breadboard. Use pliers or old scissors to cut off suitable pieces and remove the insulation at the ends of a length of 5 mm. The insulation can be pulled off with your fingernails. A knife can help to lightly score the insulation, but not too deep so that you do not cut into the copper wire.

Attention: the experiment of this day only succeeds with sharpened senses. It should be very quiet where you are and not too bright. When you first turn the experiment on, you might hear a faint click from the speaker. When you press the button, the red LED lights up briefly; when you release it, a faint green flash of light appears. And both events produce a click from the speaker that's easy to miss because the switch itself also makes a sound.
You can hear it more clearly if you silently bridge the switch with a wire.





Let’s get on, we can do even better! Turn off the battery and keep the button open. If you then lightly tap the membrane of the piezo speaker, flashes of light are created. The piezo transducer now works as a microphone or a generator.

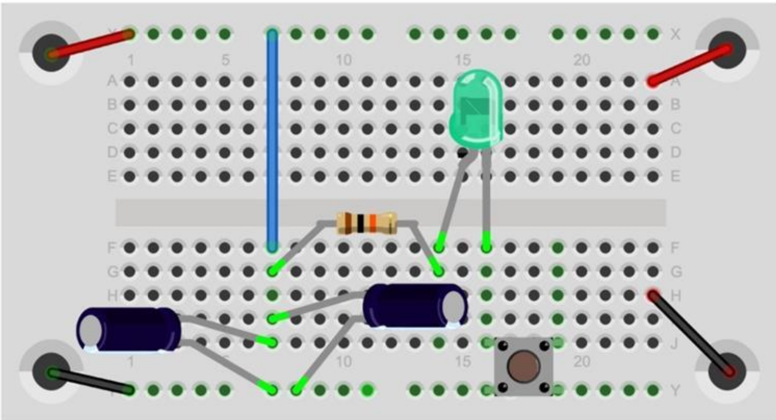
And there is more to try: The battery is switched off, and keep the pushbutton switch open Touching the piezo disc with your finger now, should heat it up a little. Then you press the button and you get a flash of light. After cooling down for a few minutes, pressing the button again brings a flash of light of the other color via the other LED.

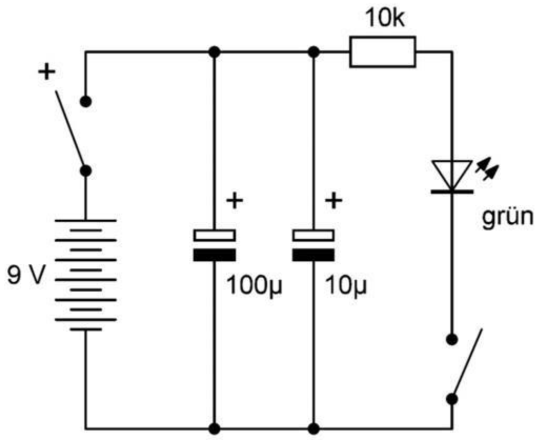
As explanation: The piezo disc is constructed like a capacitor with two metal surfaces and an insulator in between. There is an electrical force field inside the ceramic disc. Every change of the electrical voltage deforms the disc through electrical forces, which creates a noise. Conversely, any deformation caused by mechanical forces or temperature changes also changes the charge, so that electrical energy is generated.

5 -
Stored energy

2 electrolytic capacitors - 100 µF and 10 µF

Now two electrolytic capacitors (Elkos) come into play; the larger one with 100 µF and a smaller one with 10 µF. When installing, you have to pay attention to the direction. The negative pole is marked on the housing with a white line and has the shorter wire.
Warning: incorrect polarity can destroy an electrolytic capacitor and, in extreme cases, even cause it to burst. The piezo sounder from the last experiment may remain installed, but is not connected.





The electrolytic capacitors are used here for energy storage. If you close the switch on the battery compartment, they will be charged. Then you disconnect the battery and press the button switch. The LED lights up for up to 10 seconds and slowly fades away. You can see how the stored energy is consumed.

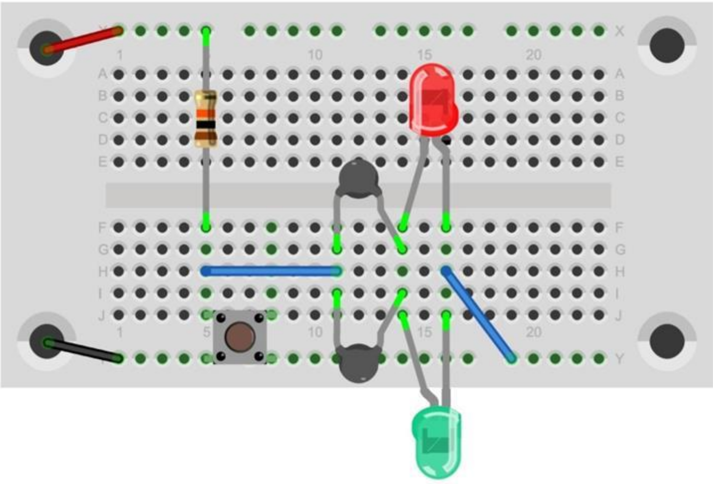
It is actually not possible to state when the LED is completely off, because this depends on the sensitivity of the eye. In the dark, the LED seems to glow longer. Anyone who recognizes the most stars in the night sky also sees the light of the LED the longest.

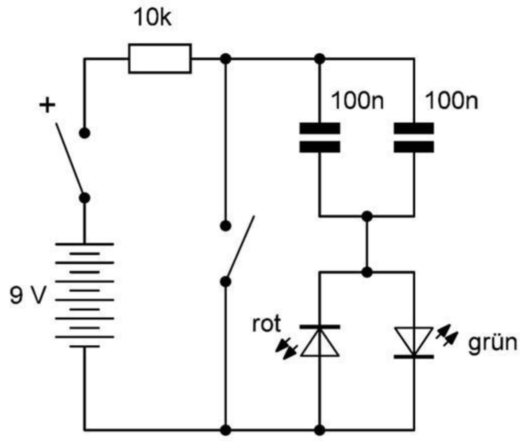
You can repeat the experiment as often as you like. Unlike a rechargeable battery, a capacitor does not wear out even after many charging cycles. It is also interesting to know, how long an electrolytic capacitor can store this charge. Is it still fully charged after an hour? And you can examine what changes if you remove one of the two electrolytic capacitors from the circuit. With the smaller electrolytic capacitor of 10 µF, the LED lights up for a much shorter time.
An electrolytic capacitor contains two aluminum foils and a conductive liquid. The actual insulating layer is a very thin layer of aluminum oxide. The thinner the layer, the stronger the electric field and the greater the capacitance, which is measured in farads. Smaller capacitances are given in microfarads (µF), nanoafarads (nF) and picofarads (pF).

6 - Colored mini flashes

2 capacitors 100 nF

Two very different capacitors appear behind compartment number 6. These are 2 ceramic disc capacitors. They are more similar in structure to the piezo disc and have two metal surfaces on a thin ceramic disc. The capacitance is only 100 nanofarads (100 nF) and is indicated by the imprint 104 (for 100 000 pF). The capacitance is 1000 times smaller than that of the 100 µF electrolytic capacitor from the last compartment.





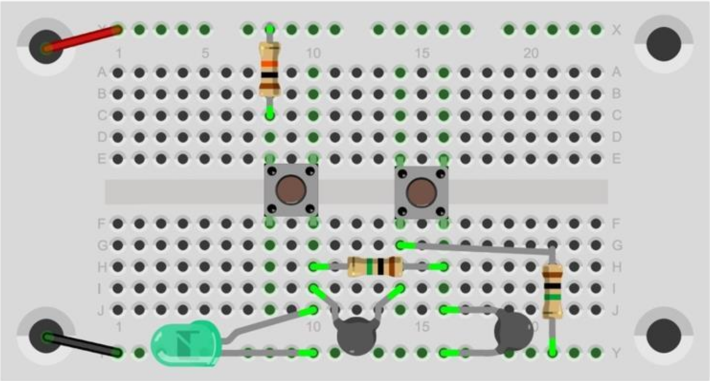
The experiment shows how these capacitors are charged and discharged in very short moments. It shouldn't be too bright in the room. When you press the button, the red LED flashes because the capacitors are being discharged. If you release the button, the capacitors are charged again, and the green LED lights up briefly. Taking out a capacitor gives weaker flashes. Two 100 nF capacitors in parallel behave like one 200 nF capacitor.

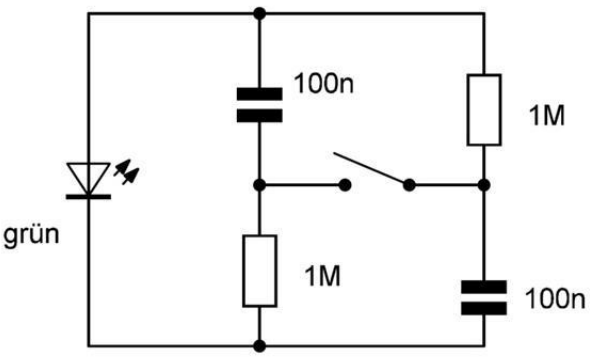
A slightly different approach: you turn the battery on to charge the capacitor and then turn it off again. After a few minutes you press the button. The charge was still there, it flashes red. Then turn the battery back on, and you'll see a flash of green light. However, repeated switching off and on of the battery does not produce a new flash of light because the capacitor is already charged.

7 - Collected solar energy

2 resistors 1 MΩ

Previously there were only resistors with 10 kΩ. But now two resistors with a megohm (1 MΩ = 1000 kΩ, brown, black, green) are added. They are built into a circuit that works entirely without a battery. The battery therefore remains switched off. This time the green LED should work like a small solar cell and generate the energy for its own operation. When enough energy has been collected, you press the button and a small flash of light appears.





For a first test there is the left button and an additional resistor. Both of them are not part of the actual experiment and are therefore not included in the circuit diagram. But you can briefly press the left button to quickly charge the capacitors. Then you press the right button and you get the flash of light you're looking for. This makes it clear as a test, that everything was set up correctly.

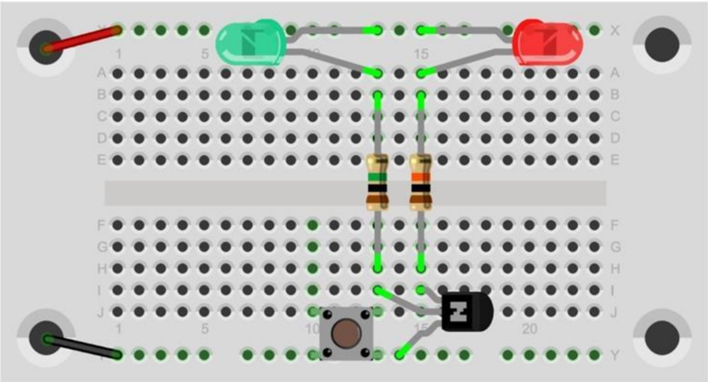
If possible, place the circuit in as bright sunlight as possible for a few minutes. During summer you only need a charging time of a few seconds, but in the dark season the sun's energy is scarce. You can therefore place the circuit under a bright lamp for a few minutes to an hour. After charging, you first have to go to a place with very low light and and have to get used to the lower light for a few minutes. Then the flash of light can be clearly seen. It's not very bright, but at least it runs on self-generated energy.

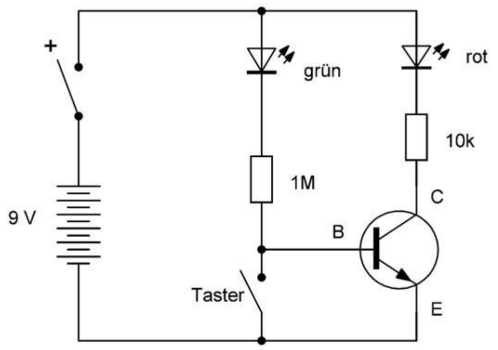
Each LED can also work like a small photocell. In full sunlight, a green LED can produce a voltage of up to 2V. Therefore both capacitors are charged up to more than 1 V even with weaker light. But that is not enough voltage to operate the LED as a light source. Both capacitors are therefore connected in series with the push button. For a brief moment, they deliver twice the voltage and this is sufficient for the flash of light. Compared to a medium-sized solar cell, the LED has a million times smaller active area. It therefore only supplies a very small charging current. But slowly and surely it charges the capacitors. You just have to be a little more patient. Or as we say in German: The squirrel has a hard time for feeding.

8 - Boosted current

2 transistors BC547C

Two BC547 type transistors appear behind the eighth door. They have three terminals labeled Emitter (E), Base (B) and Collector (C). Looking at the writing from the front, the emitter is on the right, the base is in the middle, and the collector is on the left. A transistor works like an amplifier. When a small current flows through the base, a much larger current flows through the collector. In our first attempt, this is tested with two LEDs. The green LED is only dimly lit, because the large 1 MΩ resistor keeps the base current very small. The red LED shows the amplified current and shines much brighter.





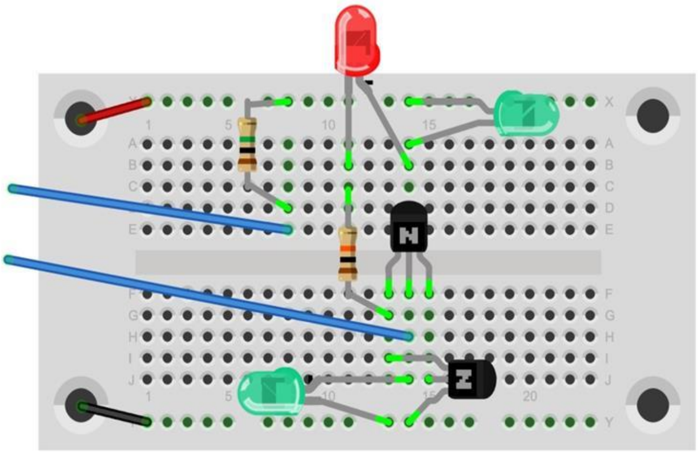
If you now press the button, the green LED stays on, but the red LED goes out. The control current is going to ground when the switch is closed, i.e. the base current is switched off, so that no more collector current flows. But as soon as you release the button, the red LED switches on again.
The transistor used can amplify the current about 300 times. A base current is of around 7 µA = 0.007 mA and flows in this circuit. The collector current could now increase by a factor of about 300, i.e. reach 2.1 mA. However, the collector resistance of 10k limits it to 0.7 mA. The transistor is therefore fully switched on and fulfills its task as a switch.

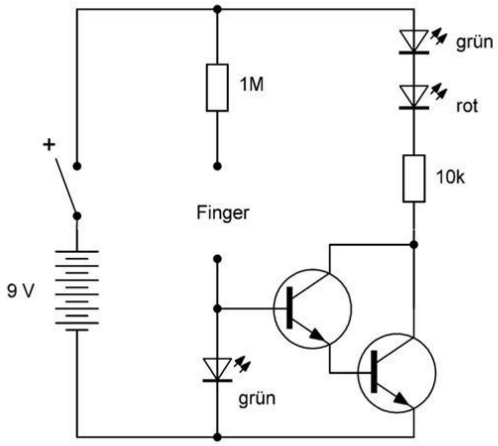
The BC547 transistors are NPN transistors, i.e. they consist of three semiconductor layers with different polarity, **n**egative, **p**ositive and **n**egative again. They are therefore also called bipolar transistors. In addition to NPN transistors, there are also PNP transistors, but they are not used in this calendar.

9 - Light and Touch sensor

2 cables

Today the calendar includes two soft ables with connectors at each end. Now it is a bit easier to build more complicated circuits. Here they are used as cables to the outside and as touch contacts. This time we want to use two transistors together to get even more gain. This makes it possible to use even the extremely small current that an LED can supply as a photo element. To do this, you have to irradiate the left green LED with a lamp. If more or less light falls on this LED, the other two LEDs light up to a greater or lesser extent.





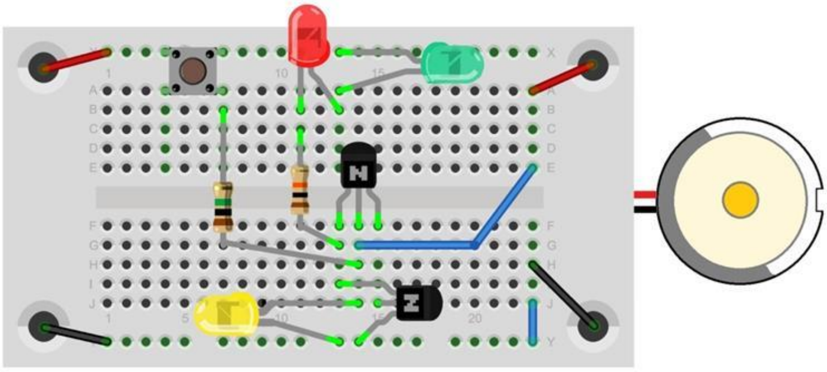
The circuit has another function as well. If you touch the two free cables with your finger, the LEDs also switches on. A very small, imperceptible current then flows through the fingers, which the transistors amplify to such an extent that the LEDs are switched on. For use as a touch switch, the left green LED is not required and could be removed.

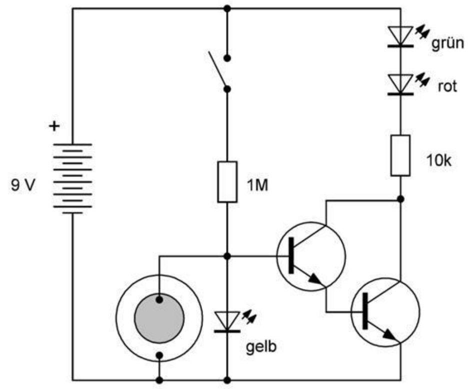
This circuit with two transistors connected together is called a Darlington circuit. The current amplified by the first transistor is amplified again by the second transistor. Overall, this achieves a current gain of around 300 * 300 = 90,000.

10 - The proximity sensor

2 yellow LEDs

Two yellow LEDs appear in the tenth compartment. They are also suitable as photodiodes. But the actual experiment revolves around the piezo converter, which is to be used here as an infrared sensor. Again, two transistors provide the necessary amplification. The yellow LED provides a very small base current for the amplifier. You first have to wait until the two LEDs reach a medium level of brightness. Then you hold your hand at a distance of 2 cm from the sensor. The brightness will then change. The thermal radiation of the hand is detected.





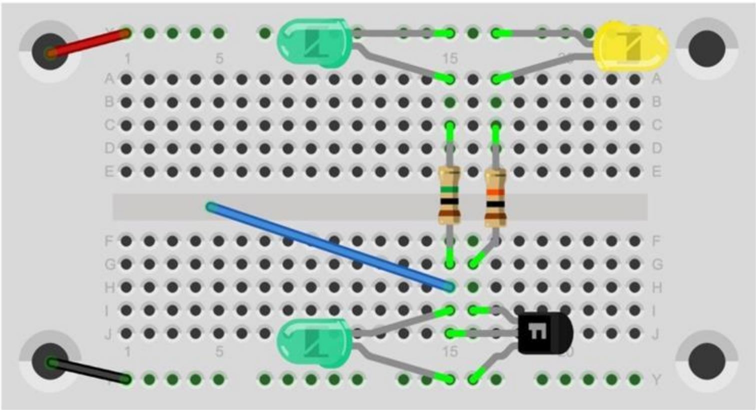
The piezo transducer is also at the same time a capacitor, so it takes some time before the correct voltage is set at which the transistors just start conducting. So that it doesn't take too long, there is the pushbutton switch and the resistor with 1 MΩ. A short press on the button charges the converter far enough, so that the LEDs light up. You may then have to wait a little longer until the average brightness is low enough. The sensitivity of the heat sensor increases significantly when very little current flows. Therefore, you can also set the best working point by changing the ambient brightness.

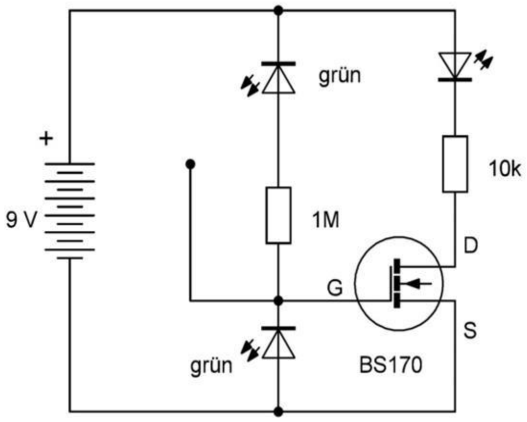
The effect of the sensor can be further improved by blackening the silver surface of the converter with a soft pencil. The heat radiation from the hand is absorbed on this surface and leads to a slight temperature change in the sensor, which then generates a small voltage. The transistors do the rest.

11 - Photosensitive switch

2 transistors BS107

Behind the eleventh door there are two completely different transistors of the type BS170. They are field effect transistors (FETs), more precisely MOSFETs (metal oxide semiconductor). Their connections are called Source (S), Gate (G) and Drain (D) and are comparable to the E, B and C connections of an NPN transistor. The key difference is that an NPN transistor is controlled by a current, but the MOSFET is controlled by a voltage.





In this experiment, two LEDs are connected to the gate as reverse-biased photodiodes. If you only light the upper one, the transistor will conduct and turn on the yellow LED. If only the bottom one is lit, the yellow LED goes out. So the circuit works like a switch that is controlled by light and shadow.

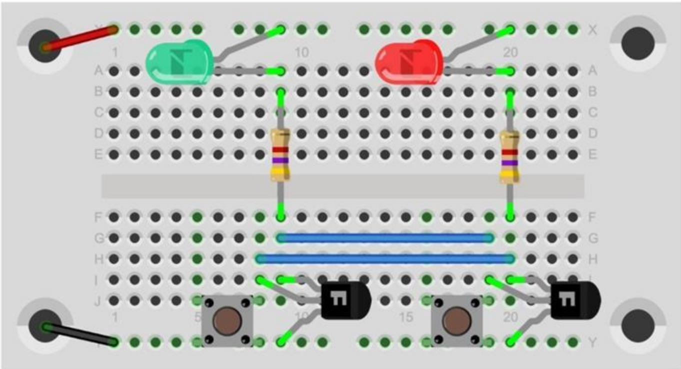
In addition, a cable is connected to the gate like an antenna. When a person has become electrically charged, it usually goes unnoticed. However, if he puts his hand near the wire, the brightness of the yellow LED changes. One can also hold the hand at a distance of 2 cm and lift one foot off the floor. The voltage then usually changes as well. Or you pick up the entire circuit and walk around the room with it. Depending on the floor covering, a clear flashing can then be observed in step with the footsteps.

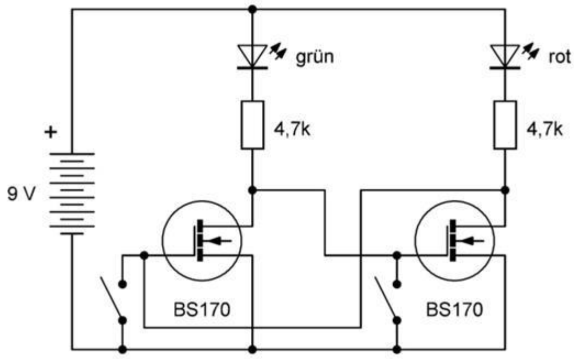
The MOSFET consists of an N-type semiconductor covered with an insulating oxide layer. There is a metal layer on top of it, the gate. The structure is reminiscent of a capacitor, and in fact the gate can charge and retain its charge for a long time. A voltage between the gate and source creates an electric field that controls the flow of current through the semiconductor. With the BS170, current begins to flow when the gate-source voltage exceeds around 2V. But you have to be very careful not to apply too high a voltage, as this would destroy the transistor. The two LEDs protect the gate from high voltage if someone is heavily charged and touches the wire. In their function as photodiodes, they slowly charge or discharge the gate, depending on which LED is more illuminated.

12 - A storage memory

2 resistors 4.7 kΩ

The resistors we have could use some variety too, so there are now two 4.7 kΩ resistors. This time two BS170s are used, which switch each other on and off. Only one transistor is conducting at a time, but you can switch the state with the buttons. Red or green, yes or no, 1 or 0, the respective status is stored indefinitely as long as there is power.



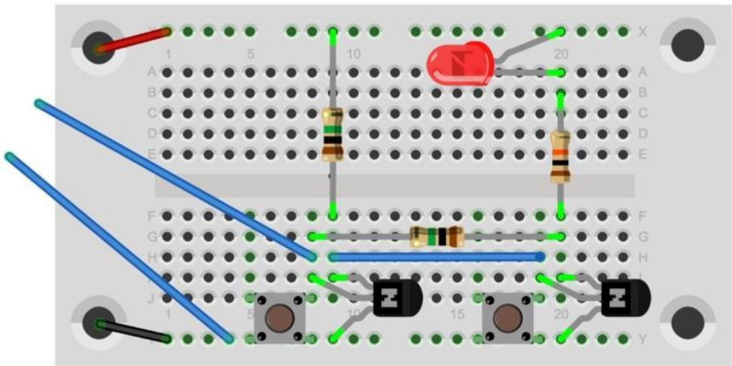


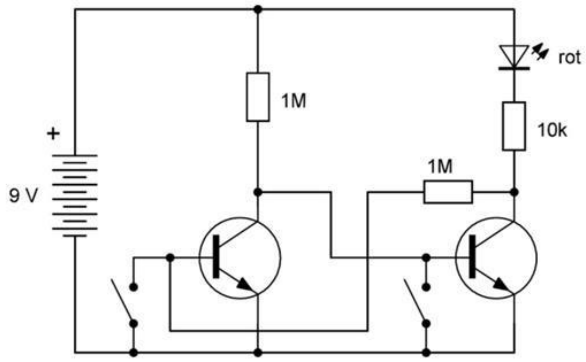
This circuit is also called a multivibrator or flip-flop because the state always flips to one side. In this case it is an RS flip-flop, which stands for the two states reset and set. This circuit shows how a data memory is structured in a computer. However, only one bit is stored here. Larger memories contain a lot of MOSFETs.

13 - On-off button

2 cables

Two more cables appear behind door no. 13. Today's circuit is again an RS flip-flop, but this time it's built with bipolar transistors. The red LED is either on or off. The status can be changed with the two buttons. In addition, two cables are connected, which can also be used to force the on state. Such a circuit can be used like a fire alarm with several alarm buttons. Anyone of those can raise an alarm, but only the fireman can turn it off. Only he has the key to the control cabinet and can then press the right button.



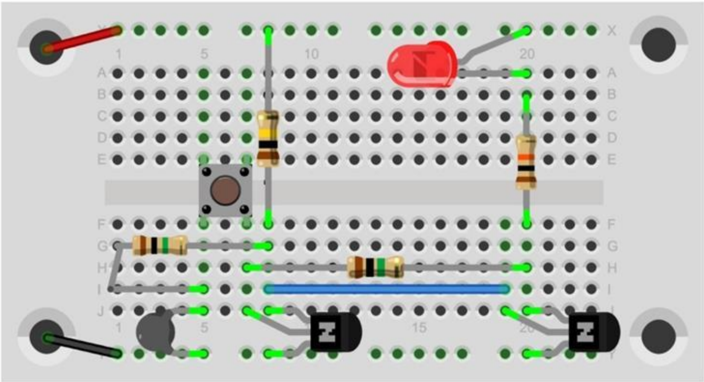


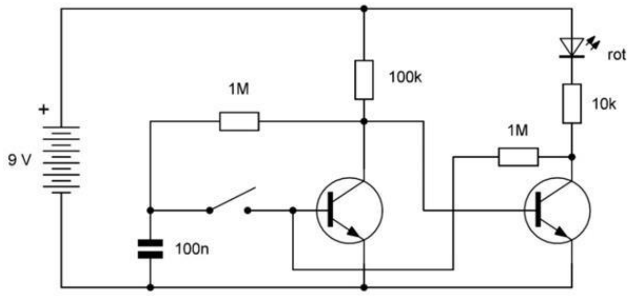
If you look closely, you will see a weak residual light in the off state. Then still the low base current of the left transistor flows through the LED. In the comparable circuit with field effect transistors, on the other hand, the LED was completely off. Here you can see the crucial difference again: Bipolar transistors are controlled by a current, while unipolar transistors are controlled by a voltage.

14 - Toggle switch

2 resistors 100 kΩ

Today, two 100 kΩ resistors (brown, black, yellow) are added to the collection of components. The circuit of the day is also an on/off switch again, but this time with only one tactile switch. Each actuation changes the state: on, off, on, off and so on.



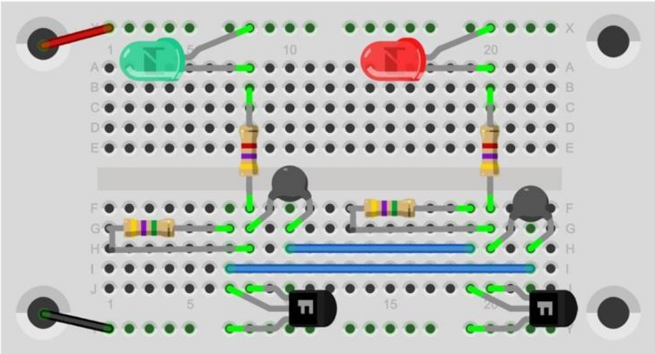


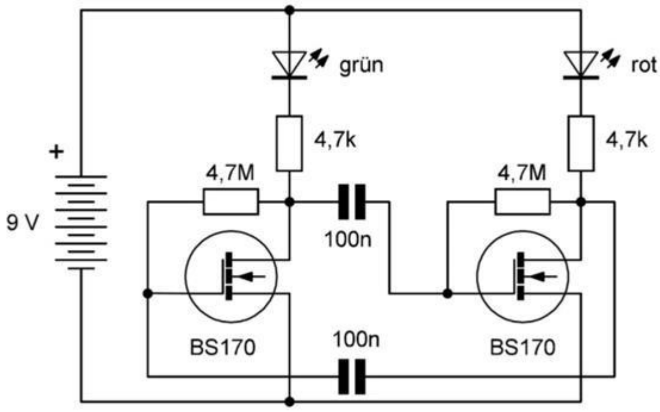
You can see the similarity to the RS flip-flop. But this time there is a capacitor that charges up to the voltage at the collector of the left transistor with a small delay. When the base voltage is high, the collector voltage is low and vice versa. Therefore, when the contact closes, a change of state is forced. Such a circuit is called a toggle flip-flop. It is also a frequency divider. If you press the button ten times, the LED only lights up five times.

15 - The red-green alternating flasher

2 resistors 4.7 MΩ

The two largest resistances of this calendar are in compartment no. 15 with 4.7 MΩ (yellow, violet, green). They are used for an alternating indicator with two BS170 field effect transistors. The two LEDs alternate constantly: red, green, red, green ....





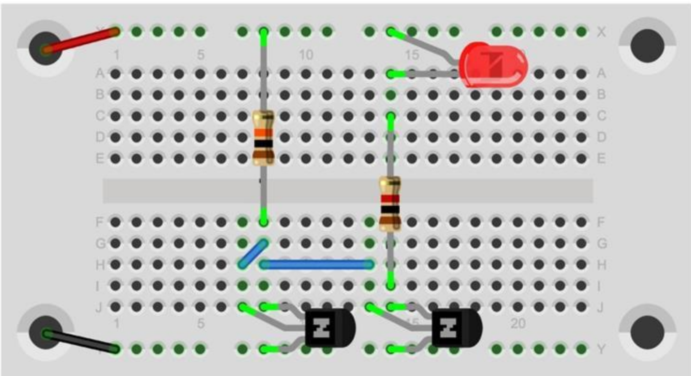
This circuit is called an astable flip-flop. It also knows two stable states, but only for the relatively short time in which the capacitors recharge to the new state. The 4.7 MΩ resistors were chosen to be large enough so that the relatively small 100 nF capacitors are charged sufficiently slowly.

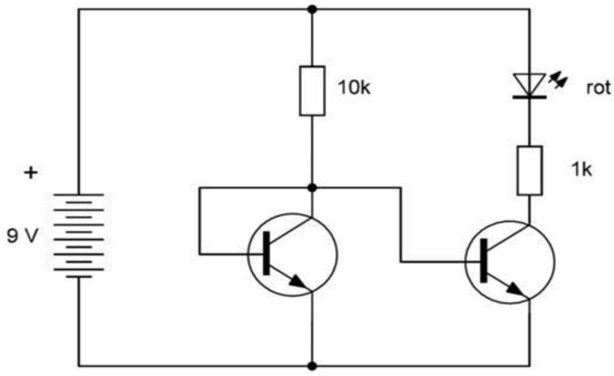
Incidentally, with this circuit there is the rare case where the field effect transistors can be replaced by bipolar transistors without further changes. The alternating flasher still works, but with a much higher flashing frequency.

16 - Temperature sensor

2 resistors 1 kΩ

Today two resistors with 1 kΩ (brown, black, red) appear. With a series resistor of only 1 kΩ, one might expect the LED to shine particularly brightly. In fact, however, the brightness is determined by the left resistance of 10 kΩ. And the LED current is also affected by the temperature difference between both transistors. This can be easily tested with a touch, because the finger temperature is usually well above room temperature. If you touch the left transistor, the LED gets darker, if you touch the right transistor, it gets brighter. The difference becomes even clearer when you hold an ice cube or a heated spoon up to the transistors.





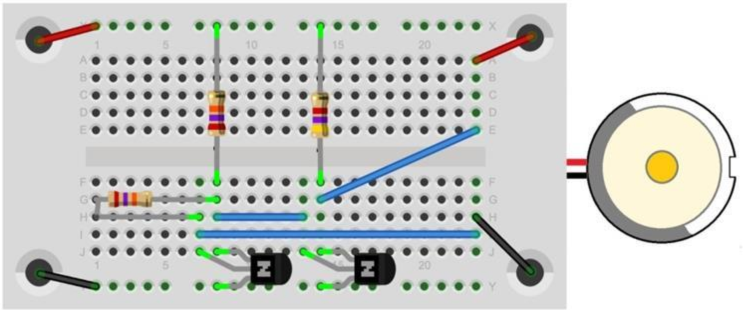
In this circuit, the base and collector of the left transistor are directly connected to the base of the right transistor. That means the same base voltage, and with exactly the same transistors, the same collector current. The collector current of the left transistor is determined by its collector resistance of 10 kΩ. The same current then appears “mirrored” at the right transistor. This circuit is therefore also called a current mirror.

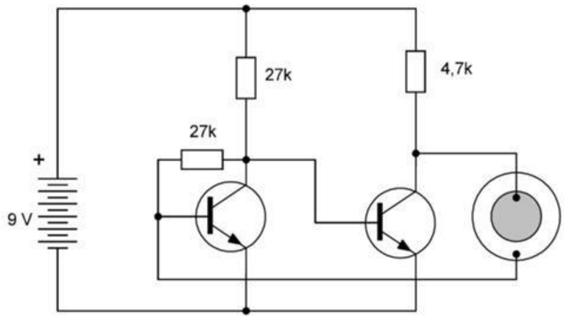
However, bipolar transistors are also temperature-dependent. With the same base voltage, the collector current increases with temperature. Conversely, as the left transistor heats up, the base voltage drops because its collector current is limited by the 10 kΩ resistor. On the other hand, a much larger current can flow through the right-hand collector and the LEDs. The LED current is only limited by the 1 kΩ resistor at maximum brightness.

17 - Sound signals

2 resistors 27 kΩ

Two resistors with 27 kΩ (red, violet, orange) are available for the circuit of this day. The result is a tone generator whose tones can be influenced. If you hold the buzzer with its sound hole more or less close to a hard surface, touch it with your finger or cover the sound hole, the frequency will change.



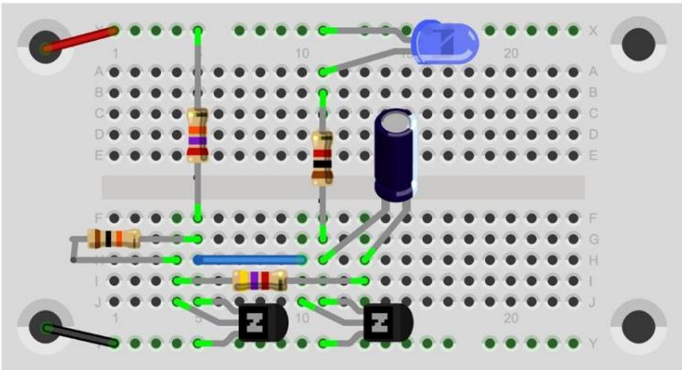


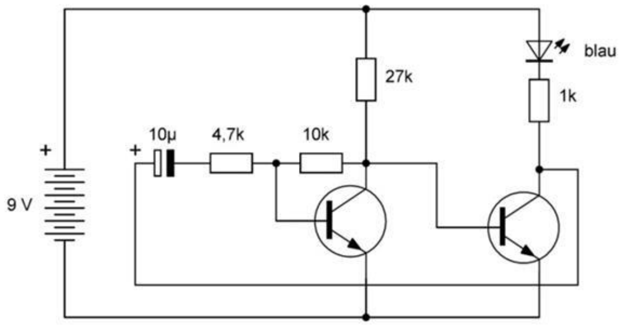
The circuit with two bipolar transistors forms an astable flip-flop. The piezo speaker is also the frequency-determining capacitor. In addition, the frequency is influenced by the loudspeaker's own resonance, which can be changed by reflections on a hard surface or by touching it.

18 - Blue light

blue LED

Today a blue LED appears. It is now to be used in a flashing light. With the 10 µF electrolytic capacitor and slightly different resistors, the previous tone generator can quickly be converted into a blinker. The blinking is reminiscent of the fire brigade in action. You'd rather see it on the breadboard than in front of your own house.



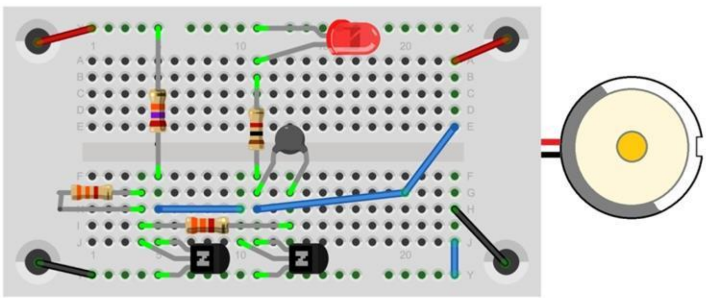


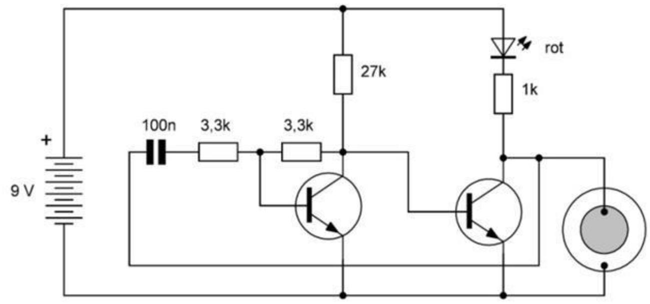
A particularly small series resistor of 1 kΩ was used in this circuit in order to achieve high brightness. At the same time, however, this also means greater consumption. You can therefore also test resistances up to 10 kΩ so that the battery lasts longer. And the capacitor can also be changed. With an electrolytic capacitor of 100 µF, the flashing becomes ten times slower.

19 - An acoustic temperature sensor

2 resistors 3.3 kΩ

Two 3.3 kΩ resistors (orange, orange, red) are required for today's experiment. The circuit is similar to the flasher of the previous experiment. The smaller capacitor turns it into a tone generator. You hear a deep tone. But if you touch the capacitor, the sound gets higher. With this experiment you can quickly determine who has the warmest fingers.





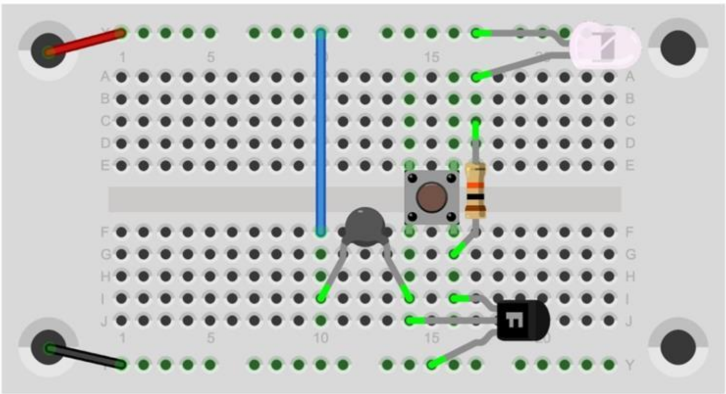
The LED appears to glow evenly and constant, but it actually turns on and off about 300 times in a second. If you let your eyes wander quickly over the experiment or move the entire structure, you can see that the glow dissolves into individual lines.

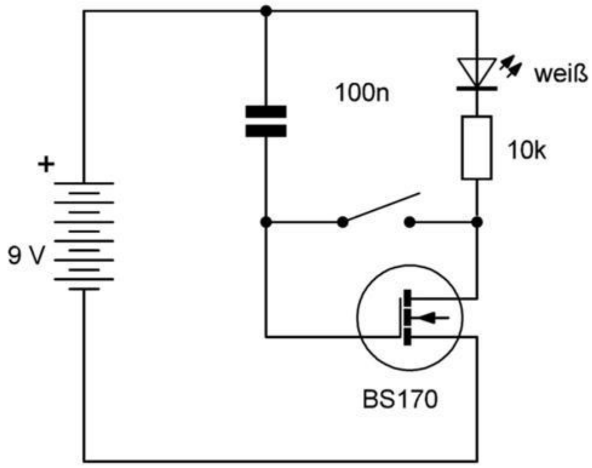
The frequency of the generator can be changed by changing the temperature of the capacitor. If you touch it with your finger, its temperature increases, while the capacity decreases slightly. Therefore the frequency increases audibly.

20 - Cold fingers?

white LEDs

A white LED was still missing. It should now display the result of a simple temperature test. The actual temperature sensor is again the ceramic capacitor. First you press the button briefly and you get a medium brightness. If you then touch the capacitor, the light usually becomes weaker. This indicates that the finger temperature is above room temperature. On the other hand, if someone comes out of the winter cold and has perhaps even just built a snowman, then the LED gets brighter.



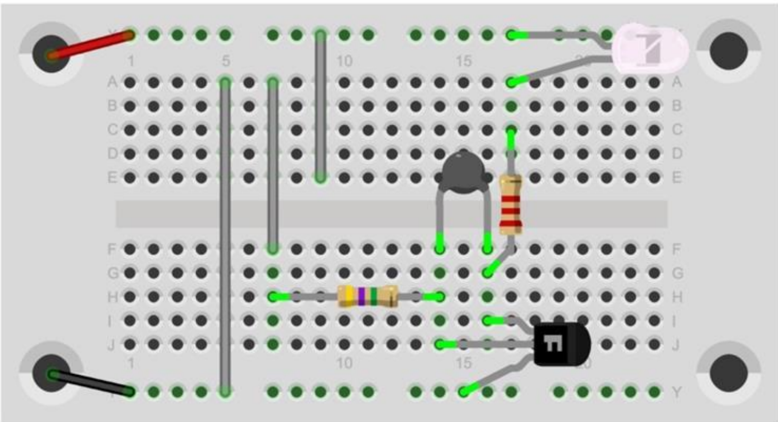


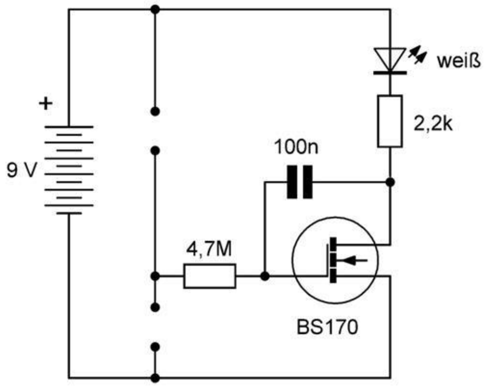
The capacitor decreases its capacitance as the temperature increases. After it has been charged to an average voltage of around 7 V by pressing a button, this voltage increases with temperature because no current flows and the electrical charge therefore remains constant. At the same time, the voltage between the gate and source drops, so that the LED current decreases. Conversely, cooling leads to larger capacitance, smaller capacitor voltage and more LED current. This experiment shows the strengths of the field effect transistor, which requires no control current.

21 - The touch dimmer

2 resistors 2.2 kΩ

Today two resistors with 2.2 kΩ are added to the collection. Less resistance means more current and more brightness of the LED. It is all the more important that the brightness can also be reduced. For this purpose the dimmer was invented. The touch dimmer is controlled by touching contacts made of bare wires. To do this, you have to remove the insulation from the jumper wire. If you hold your finger on the middle and the right wire, it gets brighter. With the middle and the left contact, the LED is dimmed.



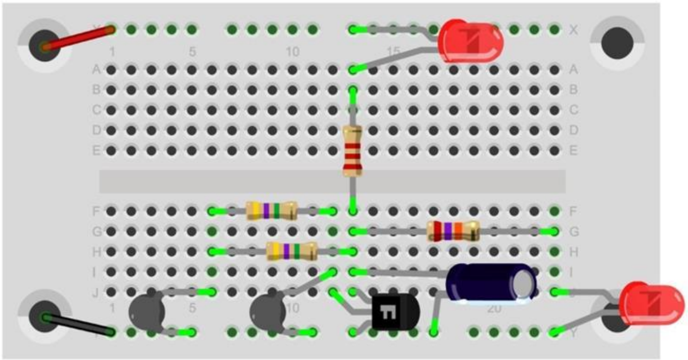


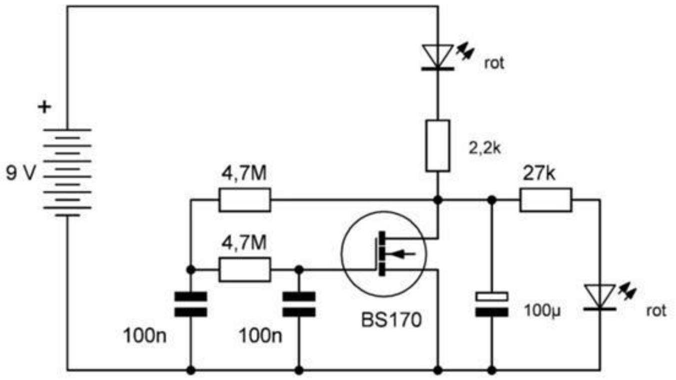
Wenn der obere Kontakt berührt wird, steigt die Spannung am Gate des BS170, und es fließt mehr Strom durch die LED. Gleichzeitig sinkt aber die Spannung am Drain, sodass der Kondensator zwischen Gate und Drain der Änderung entgegenwirkt. Die Veränderung der Helligkeit wird dadurch verlangsamt. Zugleich sorgt der Kondensator dafür, dass die eingestellte Helligkeit sehr lange unverändert erhalten bleibt.

22 - The red heart

red LED

The red LED from compartment number 22 is supposed to represent a beating heart today. For this you need a soft blinker, more precisely a sine wave generator. A single FET can do the job when backed up by a few capacitors and resistors. The second red LED flashes in opposition and is intended to show the function of the right ventricle. You'd have to ask a cardiologist if that's realistic.



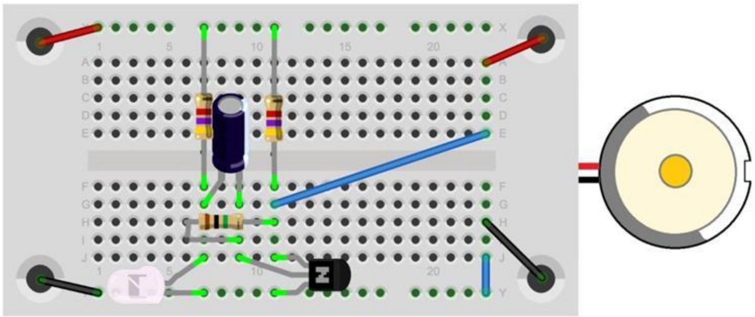


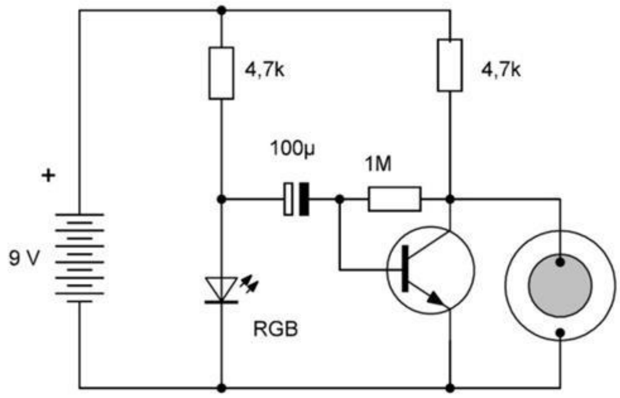
If everything has been set up correctly, the heart beats quite quickly and vigorously. That's because of the excitement just before Christmas. But if you swap the 2.2 kΩ resistor for a 10 kΩ resistor, the heartbeat slows down and weakens, like a hibernating bear. Clearly, bears don't celebrate Christmas.

This circuit is a phase shift oscillator. Previous oscillator circuits required two transistors because each transistor inverts the phase and therefore two inversions ensure the correct phase of the feedback. In a phase shift oscillator, three capacitors and associated resistors provide a total phase shift of 180 degrees, i.e. the necessary phase reversal.

23 - Color changing LED

Today a very special LED appears that changes color automatically. The color-changing LED in the transparent housing actually contains three LEDs with the colors red, green and blue. If you look closely (when switched off! For eye protection!), you can see the three crystals. You can also see an LED controller and some fine connecting wires. Otherwise, this LED is connected like any other one with a series resistor. You can then see slow color changes with smooth transitions.





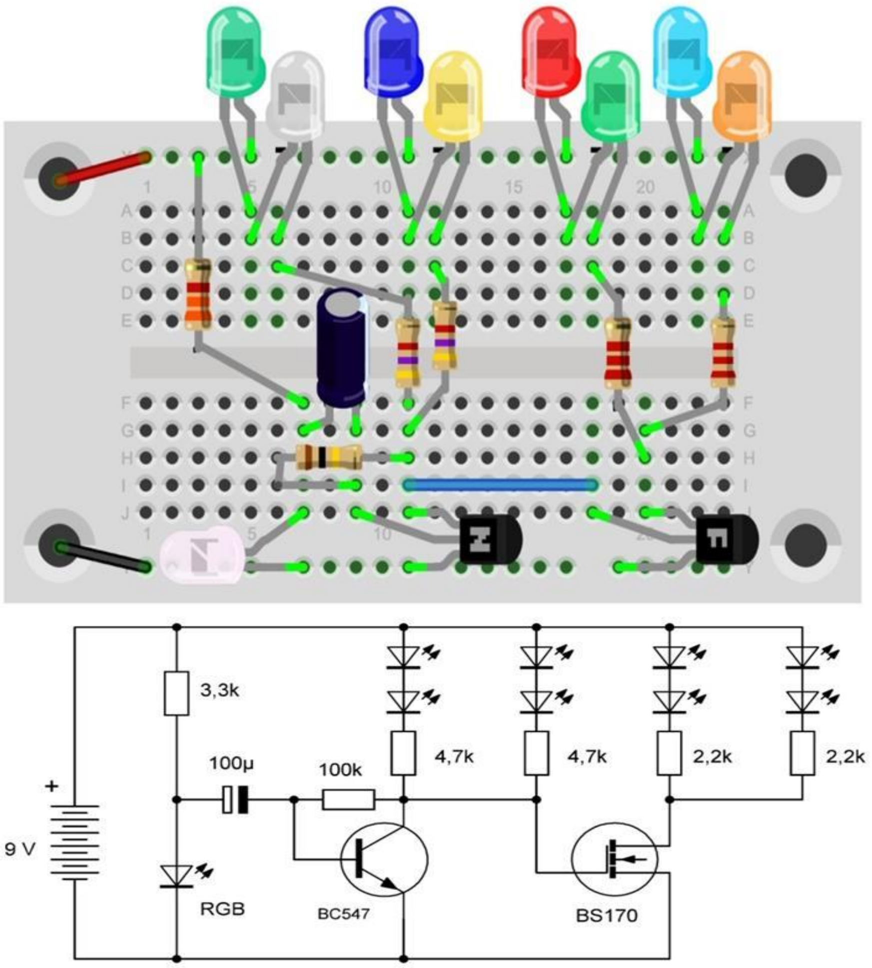
In addition, this circuit has a transistor amplifier and a piezo speaker. You can always hear tones from the speaker when there is a transition from one color to another, resulting in mixed colors.

The tones give an indication of how the controller is working. Unlike the analog circuits in the last example, the controller turns each LED on and off in quick succession. The respective pulse length determines the brightness. This technique is called pulse width modulation (PWM) and is widely used in digital electronics. The frequency of the PWM signal is around 500 Hz, so it is easily audible. The eye, on the other hand, is too slow and sees only average brightness.

24 - Christmas light

2 LEDs Pink, Orange

On the last day of Advent, two LEDs with special colors appear, orange and pink. The goal is to get almost all of the LEDs to have a happy glow and flicker. First and foremost is the automatic color change LED, which sets the pace. All other LEDs can be used as you wish. And you can swap out the 2.2kΩ, 3.3kΩ, and 4.7kΩ resistors to make some LEDs a little brighter and others a little dimmer.



The LEDs can be artfully arranged like a bouquet of flowers so that their colors harmonize well. If the result is convincing, the entire breadboard can be hung on to the Christmas tree or light up the dark night through the window.

The color-changing LED creates small voltage fluctuations that the NPN transistor amplifies. The pulses control the brightness of the LEDs in the collector circuit. Whenever the bipolar transistor is not conducting, its collector voltage increases. This turns the FET on. The right group of LEDs is therefore controlled in opposition to the left.

Anyone who has carefully carried out the experiments in this calendar now knows the function of bipolar and unipolar transistors. This means that it is no longer difficult to change circuits and adapt them for other purposes. And completely new circuits can also be developed. There are enough components available, there are no limits to creativity!

Content of the different compartments:

Day
1. 2 x 10 k, LED rot, Battery Box with Switch, Breadboard
2. 2 x LED green
3. 2 x Push Button
4. Piezo + Wire
5. 100 µF + 10 µF
6. 2 x 100 nF
7. 2 x 1 M
8. 2 x BC547B
9. 2 x Cable
10. 2 x LED yellow
11. 2 x BS107
12. 2 x 4,7 k
13. 2 x Cable
14. 2 x 100 k
15. 2 x 4,7 M
16. 2 x 1k
17. 2 x 27 k
18. LED blue
19. 2 x 3,3 k
20. LED white
21. 2 x 2,2 k
22. LED red
23. colour changing LED
24. LED pink, LED orange

Or the same listed differently:

Breadboard Battery Box with Switch 2 Push Buttons Piezo Speaker Wire

Resistors: 1k 1k 2k2 2k2 3k3 3k3 4k7 4k7 10k 10k 27k 27k 100k 100k 1M 1M 4M7 4M7

Capacitors: 100nF 100nF 10 uF 100 uF

LEDs: red red green green yellow yellow blue white pink orange color change

Transistors: BC547 BC547

FETs: BS107 BS107 ####