118.381

17 Electronics Assembly Basic Expe-riments with Breadboard



Tools Reauired:

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
Loudspeaker	1		Loudspeaker	2
Blade receptacle	2		Connection battery	3
Resistor 120 Ohm	2		Resistor	4
Resistor 470 Ohm	1		Resistor	5
Resistor 1 kOhm	1		Resistor	6
Resistor 2,7 kOhm	1		Resistor	7
Resistor 4,7 kOhm	1		Resistor	8
Resistor 22 kOhm	1		Resistor	9
Resistor 39 kOhm	1		Resistor	10
Resistor 56 kOhm	1		Resistor	11
Resistor 1 MOhm	1		Resistor	12
Photoconductive cell	1		Photoconductive cell	13
Transistor BC 517	2		Transistor	14
Transistor BC 548	2		Transistor	15
Transistor BC 557	1		Transistor	16
Capacitor 4,7 μF	1		Capacitor	17
Elko 22µF	2		Elko	18
elko 470μF	1		Elko	19
LED red	1		LED	20
LED green	1		LED	21
Jumper wire, red	1	2000	Jumper Wire	22



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 is marked 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 flash-lights, 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 lightemitting 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-resistant
- 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.



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. $1.8k\Omega$ (1800Ω) allows less current flow than a resistor of smaller ohmic value, e.g. 130Ω .

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	100000	-
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



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.



The Resistor

The following resistors are needed:

120 Ohm(brown-red-brown)1 kOhm(brown-black-red)4,7 kOhm(yellow-violet-red)1 MOhm(brown-black-green)

470 Ohm (yellow-violet-brown) 2,7 kOhm (red-violet-red) 22 kOhm (red-red-orange) 56 kOhm (grenn-blue-orange)

Now you can begin:



Pick up a connecting cable (20mm) and insert it on the breadboard on the + -bar. Insert the other end at port 2a. Insert the anode of the LED into port 2b and plug in the cathode of the LED at 6b. Insert the resistor (variable) between 6c and - bar.

After connecting the battery, the current flows from the positive pole through the LED and the respective resistor to the negative pole. Result:

The 120-Ohm resistor is small and lets a lot of current through, so the LED lights will be very bright. The higher the resistance, the less current flows which results in the LED lights being very weak or in some casees do not light up at all.

The Light-emitting Diode LED

Because we do not need normal diodes in our experiments, we use here a light emitting diode (LED) which can show us however the function of a normal diode.



Take a connection cable (20mm) and plug it into the +bar on the breadboard. Plug in the other end at connection 2a. Plug in the anode (+) of the green LED at 2b and the cathode (-) at 6b. Insert the resistor (120 Ohm) between 6c and 6i. Plug in the red LED at 6j and the -bar.

Connect the battery. Both LEDs are lit. Plug the red LED in the opposite direction. Soft return Result: Both LEDs light up only when pointing in the same direction. The reason is simple. Diodes cause current in the current, which causes the valve in the bicycle hose in the air, they are permeable only in one direction.

Diodes and light emitting diodes must never be connected directly to plus and minus, the current would be so large that the diode would be destroyed, and in the test circuit this is prevented by the 120 ohm resistor, which serves as a protective resistor in almost all experiments



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.

About 50 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.



Pick up a connecting cable (20mm) and insert it on the breadboard on the + -bar. Insert the other end at port 2a. Insert the cathode (-) of the LED into port 6b and the anode (+) at 2b. Insert the resistor (120 ohms) at 6c and 6f. Place the transistor as follows: Insert the base at 8i, the collector at 6g, and the emitter at 5i. Insert a connection cable (15mm) between 5j and -. Insert a connection cable (25mm) between 8d and +.

Above the LED and the 120 ohm resistor is (+) the collector (C), the emitter (E) is (-). Nevertheless, the LED does not light, indicating that no current is flowing. The transistor is said to be "blocking". 1 Place the second resistor (2.7 Kohms, 22 Kohms, 1 Mohms) between 8e and 8 hours.

The LED lights up brightly; the transistor conducts. You can see that a small current from (+) through the base (B) to the emitter (E) to (-) is sufficient to make the transistor between collector (C) and emitter (E) conductive. Perform the same experiment with the 22KOhm resistor (rt-rt-or). The current through the base is now much smaller, but it is enough to make the transistor conductive (the LED is bright). From experiment 1 you know that through the 22 KOhm resistor only very little current flows, because there the LED was dark with this resistance. Try it now with the 1 Mohm resistor (1 000 000 ohms). The LED should still be on, albeit very dimly. The current through the base here is only about 4 millionths of an ampere; but it is enough to make the transistor (slightly) conductive.

Remember: 1 the transistor can do two things:

1. It can switch by passing or blocking the current through the collector.

2. It can amplify, because a very small current through the base is sufficient to control a much larger current through the collector.



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.

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Pick up a connecting cable (20mm) and insert it on the breadboard on the + -bar. Insert the other end at port 2a. Insert the cathode (-) of the LED into port 5b and the anode (+) into 2b. Insert the resistor (120 ohms) at 5c and 8a. Place the transistor as follows: Insert the base at 10f, the collector at 8e, and the emitter at 7f. Insert the resistor (4.7 kOhm) between 9b and 10g. Insert the capacitor between 8b or 9a (+) and 7g (-). A cable connection (25mm) from 7i to the bar.

Connect the battery. The minus connection of the Elko is permanently connected to minus. Change the + connection of the capacitor between 8b and 9a and observe.

when plugged into 8b, the electrolytic capacitor will receive current from (+) through the LED and the 120 ohm resistor and will charge. The brief flash of the LED shows that only a short time current flows. The condenser will be full, no electricity will flow and the LED will stay dark. When plugged into 9a, the previously charged current flows (slowly) through the 4.7 KOhm resistor and the base to the (-) and makes the transistor conductive for some time, the LED lights up. The capacitor (Elko) is discharged.

Discharging takes longer because the 4.7K ohm resistor is much larger than the 120 ohm resistor.

Note: 1 A capacitor can pick up (charge) and recharge (discharge) power.

The experiment was completed with the largest capacitor in your kit; it has a capacity of 470 micro farads. Repeat the experiment with a 22 microfarad Elko. You'll find that charging and discharging is much faster because this capacitor has a much smaller capacity. With the normal capacitors you can save yourself trying. Although they carry large numbers (1000 and 4700), but the unit of measurement (pF = picofarad), which was omitted, because the expert knows anyway, is millions of times smaller. This means that these capacitors are charged or discharged in fractions of a second. Of course you can not see that anymore, but hear what later experiments will show. 12 The type of capacitor needed in a circuit can be easily recognized by the symbol (symbol).



For interest only:

The basic unit 'Farad' was eventually determined and (stupidly) chosen very large. A standard capacitor with a capacity of 1 Farad would fill a larger room completely. It is therefore not surprising that much smaller capacities are used in practice. The largest capacitor (Elko) in your kit has a capacity of 470 μ F (micro Farad). The micro-farad unit is the millionth part of the basic unit.

The smallest (normal) capacitor in the kit has a capacity of 1000 pF (pico-farad). A piko farad is the millionth part of a micro farad and thus the trillionth part of the basic unit, in numbers:

1/1000000000000

Experiment: Optical Sensors

Photoconductive cell (LDR)		= "Light dependent resistor"
Photodiode (LDD)	=	light dependent diode "
Phototransistor (LDT)	=	light dependent transistor "

Optical sensors are components that react to light. Unfortunately, such components are quite expensive. Therefore, you will find in your kit only one of these components. This has no negative impact on the experiments, because they work in the same way with each of these components. Handle the components with care and never bend the leads directly on the housing.



Insert the resistor (120 Ohm) between the +bar and terminal 5b. Plug in the anode of the green LED at 5c and the cathode at 9c. Insert the resistor (4, 7 kOhm) between 11d and 13d. Insert the LDR between +bar and 13c. Place the transistor as follows: Plug in the base at (11e), the collector at (9e) and the emitter at 9g. Insert a cable connection between 9i and -bar.

Connect the battery.

When light falls on the sensor, it provides little resistance to the current. Therefore, the transistor conducts and the LED lights up. Now cover the sensor with your hand. If the sensor is not lit, it provides a lot of resistance to the current. The transistor will not conduct and the LED will not light. It may very well be that the attempt does not seem to work because the LED does not go dark. In this case, it is very likely that the sensor is still receiving too much light from the side, because it is too bright and you can not darken it enough by hand. Repeat the experiment in a darker room or otherwise make sure that the sensor is dimmed properly. Photoresistor (LDR) is mainly used for measuring (for example in exposure meters). Photodiodes (LDDs) and phototransistors (LDTs) are used for switching (e.g., in photointerrupters). One can do so with e.g. switch on lighting systems in the dark and switch them off again during the day or open doors or count on things on conveyor belts and much more. A corresponding experiment (photocell) will follow later.

Important instructions:

The first five attempts have shown you the function of the components. In the following experiments, the various components should work together meaningfully. In order to understand the circuits and the interaction of the components, it is of course necessary to know the function of the individual parts. If you feel the function of a component is unclear, you can not understand the whole circuit. In this case, you should first repeat the experiment that explains the corresponding component.

In the following experiments with larger structures, it often happens that cross over lines. Make sure that the wires are not touching. Otherwise it can easily lead to a short circuit and the destruction of components.



Preparations for further experiments:

The basic circuit:



Plug in the anode of the green LED in the +bar and the cathode at terminal 3b. Plug in the anode of the red LED in the +bar and the cathode at terminal 14b. Place the resistor 1 (120 Ohm) between 14c and 14f. Place resistor 2 (120 Ohm) between 3c and 3f. Place transistor 1 as follows: Insert the base at 5g, the collector at 3g and the emitter at 4i. Place transistor 2 as follows: Insert the base at 15i, the collector at 14g and the emitter at 13i. Plug in a cable connection between 13j and the -bar. Insert a cable connection between 4j and the -bar.

Experiment: "Stromklau"

Change the circuit and build it up as follows. Connect the battery. The green LED is lit!



Plug in the anode of the green LED in the +bar and the cathode at terminal 3b. Plug in the anode of the red LED in the +bar and the cathode at terminal 14b. Place resistor 1 (120 Ohm) between 14c and 14f. Place resistor 2 (120 Ohm) between 3c and 3f. Place transistor 1 as follows: Insert the base at 5g, the collector at 3g and the emitter at 4i. Place transistor 2 as follows: Insert the base at 15i, the collector at 14g and the emitter at 13i. Plug in a cable connection between 13j and the -bar. Insert a cable connection between the 4j and the -bar. Insert a resistor (22 kOhm) between 5i and 14i. Insert a resistor (R1) between 15f and the +bar.

The resistor R1 serves as a switch. To turn the leg of the resistor on and off at 11h. If the connection is disconnected, the first transistor does not receive a base current and blocks. From + via the red LED and R3 current flows. From there it can only continue via R2 to the base of T2 and through the transistor after -. The power is so low that the red LED is not lit. As T2 receives base current, it conducts and the green LED lights up. Now insert the resistance leg at 11h. Now the red LED is lit and the green is dark. Why?

When the switch is closed, T1 receives R1 current over R1 and conducts. Therefore, the red LED lights up. When T1 conducts, the current no longer flows through R2 to the base of T2 but directly to T1 -. T1 leads yes (between the collector and emitter) and provides the current almost no resistance. Therefore, T2 does not receive a base current and locks. The green LED remains dark. One can say T1 clues T2 the base current. The principle that one transistor "steals" the other current occurs again and again in the following circuits.



Experiment "Klau as Klau can"



Plug in the anode of the green LED in the +bar and the cathode at terminal 3b. Plug in the anode of the red LED in the +bar and the cathode at terminal 14b. Place resistor 1 (120 Ohm) between 14c and 14f. Place resistor 2 (120 Ohm) between 3c and 3f. Place transistor 1 as follows: Insert the base at 5g, the collector at 3g and the emitter at 4i. Place transistor 2 as follows: Insert the base at 15i, the collector at 14g and the emitter at 13i. Plug in a cable connection between 13j and the -bar. Insert a cable connection between 4j and the -bar. Insert a resistor R1 (56 kOhm) between 3i and 15j. Insert a resistor R2 (22kOhm) between 14h and 5f.



Change the circuit or build it up as the picture shows. In order to clarify the equality of the two transistors, the circuit diagram is drawn symmetrically, i. It consists of two (almost) mirror-like halves. Otherwise, not much has changed. Only the resistor R1 has been replaced by one of 56 kilo-ohms. Compare exactly with the diagram of experiment 6.

Turn the power on and off several times.

The green LED is always lit and the red remains dark. Why is that when both circuit halves are almost the same?

They are not completely the same! The larger resistance R1 flows less current than the smaller resistance R2 and this has consequences.

To understand that, we need to think about what happens at power up:

First, both transistors are blocking, because they need base current to conduct. There is some current flowing through both LEDs. The current through the red LED flows through R3 and R2 to the base of T2. The current through the green LED flows through R4 and R1 to the base of T1. But because R2 is smaller than R1, T2 gets more base current and becomes more conductive.

When T2 conducts, it "steals" T1's base current, and T1 has no chance to become conductive.

Since nothing changes in the circumstances, the "game" is the same every time you turn on:

R2 lets more electricity through. T2 "claws" T1 the base current. T1 blocks. - The green LED lights up and the red stays dark.



Experiment: The flip-flop



Plug in the anode of the green LED in the +bar and the cathode at terminal 3b. Plug in the anode of the red LED in the +bar and the cathode at terminal 14b. Place resistor 1 (120 Ohm between 14c and 14 f). Place resistor 2 (120 Ohm) between 3c and 3f. Place transistor 1 as follows: Insert the base at 5g, the collector at 3g and the emitter at 4i. Place transistor 2 as follows: Insert the base at 15i, the collector at 14g and the emitter at 13i. Plug in a cable connection between 13j and the -bar. Insert a cable connection between the 4j and the -bar. Insert a resistor R1 (56 kOhm) between 3i and 15j. Insert a resistor R2 (22kOhm) between 5f and 14h. Plug in a cable connection at connection 5i - the other end remains free at first.



As can be seen from the picture, nothing has changed at the circuit. Only a short piece of wire for this experiment. So that the red LED also lights up, we now want to forcibly block T2. Touch the minus pole with the 10c wire. The red LED lights up; the green is dark. With the wire we have "stolen" the base of T2 by simply shorting it.

If T2 does not receive a base current, it locks.

-When T2 locks, T1 receives over R1 base current and conducts. When T1 conducts, it "steals" T2's base current.

As a result, the red LED remains bright and the green is dark. If you want the green LED to light up again, you just have to forcibly lock T1 only by shorting its base current to the minus of the wire from terminal 11i.

By itself nothing changes at the respective state. The circuit has two stable states and can only be forcibly tipped into the other state. This circuit is therefore also called bistable flip-flop (bi means two). Because this circuit can store the last switched-on state indefinitely, it is used e.g. in calculators and computers as electronic memory. You can use them the same way:

Attach one long wire to each of terminals 11i and 10c and bend their ends to a contact, e.g. closed by a door. The circuit then remembers if the door has been opened. After switching on, the green LED lights up. With a loose wire you connect briefly terminal 10c and minus, so that the red LED lights up. Then you can safely remove yourself. If somebody uses the "locked" door in your absence, he inevitably switches to green. Also, by interrupting the current can not be switched back to red, because when you turn on so always the green LED. Only those who know exactly how the circuit, the red LED can bring to light. Of course, if you want to control a door with this circuit, you must remember to install the circuit outside.



Experiment : The quiz clock



Plug in the anode of the green LED in the +bar and the cathode at terminal 3b. Plug in the anode of the red LED in the +bar and the cathode at terminal 14b. Place resistor 1 (120 Ohm between 14c and 14 f). Place resistor 2 (120 Ohm) between 3c and 3f. Place transistor 1 as follows: Insert the base at 5g, the collector at 3h and the emitter at 4i. Place transistor 2 as follows: Insert the base at 15i, the collector at 14h and the emitter at 13i. Plug in a cable connection between 13j and the -bar. Insert a cable connection between the 4j and the -bar. Insert a resistor (22 kOhm) between 12d and 14g. Insert a resistor (22kOhm) between the +bar and 7c. Place the capacitor as follows: +pole at 3g and -pole at 7d. Insert a cable connection between 12e and 5h. Insert a cable connection between 15j and 7e. Insert a resistor (4, 7 kOhm) between the +bar and 12c (optional).



One leg of resistor R2 should not be plugged in yet. Use a wire or screwdriver to touch both terminals of the electrolytic capacitor at the same time to discharge it. Then turn on the power and watch closely.

The green LED lights up very briefly. Then the red LED lights up and the green stays dark.

Explanation: 1 When switching on, both transistors are initially disabled and the electrolytic capacitor is discharged.

T2 could receive base current via the red LED, R1 and R5, but T1 receives its base current directly from (+) via R3 and therefore "makes the race". When T1 conducts, it "steals" T2's base current. As a result, the red LED lights up and the green remains dark. Nothing will change that by itself.

Why did the green LED light up in the beginning? -

Please remember experiment 4. There you learned that a capacitor can charge current.

On the basis of T1 is the negative terminal of the electrolytic capacitor (-) The current of (+) over R3 does not change anything, because it flows over T1 to (-). The positive connection of the electrolytic capacitor is connected to terminal 8b. Since T2 blocks, a charging current can flow into the Elko via the green LED and R4. The green LED lights up briefly due to this charging current. Once the Elko is loaded, and that's very fast. no electricity flows and the green LED remains dark.

If you switch the power off and on again, only the red LED will light up. The green can not shine, because the Elko is still loaded. Now insert the free end of the 4.7 KOhm resistor and observe for a while.

The green LED lights up and the red one goes dark. - After a while, the green will turn dark again, and the red will glow as before.

Statement:

When R2 gets connected to (+), so much current flows to the base of T2 through this 4.7 KOhm resistor that this transistor becomes conductive. Although T1 continues to conduct a fraction of a second, it can not "steal" the base current from T2, because R5 is in between and forms an excessive obstacle with 22 KOhm. - So T2 will definitely be on top.



When T2 conducts, the positive terminal of the electrolytic capacitor is connected to (-) by T2, and the electrolytic capacitor is discharged. When discharging the electrolytic power can not just flow out of the positive terminal, but it must flow at the same time as much power at the negative terminal. This current can only come from R3. Thus, when discharging T1, the electrolytic capacitor deprives the base current and causes T1 to block. As long as T1 locks, T2 gets its base current through R5. The green LED continues to light even if the contact between R2 and terminal 2f has already been released. Since only a small amount of current flows through the (large) 22 KOhm resistor R3, T2 does not conduct very well. Consequently, the Elko can only discharge relatively slowly.

However, when the electrolytic capacitor is discharged, T1 again receives base current, becomes conductive, and T2 steals the base current. T2 locks again, and the electrolytic capacitor is charged again. Therefore, the green LED will continue to light briefly when the red is already lit again. Now the stable initial state is reached again.

This circuit therefore only has a stable state and is therefore called a monostable multivibrator (mono means on).

Please Note:

You probably will not have understood everything right away, the thing is a bit tricky. Read the description carefully several times and keep looking at the circuit diagram.

Experiment: The double turn signal



Plug in the anode of the green LED in the +bar and the cathode at terminal 3b. Plug in the anode of the red LED in the +bar and the cathode at terminal 14b. Place the resistor 1 (120 Ohm) between 14c and 14 f. Place the resistor 2 (120 Ohm) between 3c and 3f. Place transistor 1 as follows: Insert the base at 5g, the collector at 3h and the emitter at 4i. Place transistor 2 as follows: Insert the base at 15i, the collector at 14h and the emitter at 13i. Plug in a resistor (22 kOhm) at the +bar and terminal 7c. Plug in a resistor (22 kOhm) at the +bar and terminal 12c. Place capacitor 1 between 7d (-pole) and 3g (+pole). Place capacitor 2 between 12d (-pole) and 14g (+pole). Insert a cable connection between 12e and 5h. Insert a cable connection between 15j and the -bar.

The red and green LEDs light up alternately.

The explanation is simple if you understood the previous experiment correctly:

When one of the transistors conducts, it "claws" the other by discharging its capacitor and blocks it. Its electrolytic capacitor is then charged. As soon as one of the capacitors is discharged, the other transistor becomes conductive again and discharges its electrolytic capacitor, which then "steals" the base current again to the other transistor - and so on.

How long the discharge of the electrolytic capacitors takes (and thus the blinking) depends on the capacitance of the electrolytic capacitors and on the resistors R2 and R3. Smaller resistances and / or capacities shorten the time. Larger values increase the time.

Repeat the experiment and replace one of the two electrics with the one with 470 micro Farad.

Natürlich kannst Du den Versuch auch mit anderen Widerständen durchführen. But please note: R2 and R3 must never be smaller than 2.7 KOhm!



Experiment: The metronome

Change the circuit or build it up as the picture shows:



Plug in the anode of the red LED in the +bar and the cathode at terminal 14b. Insert the resistor 1 (22 kOhm) between +bar and 12c. Insert resistor 2 (22 kOhm) between +bar and 7c. Insert resistor 1 (120 kOhm) between 14c and 14f. Insert resistor 2 (120 kOhm) between 3c and 3f. Insert capacitor 1 between 7d (-pole) and 3g (+pole). Insert capacitor 2 between 12d (-pole) and 14g (+pole). Place transistor 1 as follows: Insert the base at 15i, the collector at 14h and the emitter at 13i. Place transistor 2 as follows: Insert the base at 5g, the collector at 3h and the emitter at 4j. Plug in a cable connection between 7e and 15j. Insert a cable connection between 12e and 5h. Plug in a cable connection between 13j and the -bar. Insert the -pole at 3c and +pole at +bar.



The difference to the previous circuit is only slight: the green LED is replaced by the loudspeaker. Schalte den Strom ein und hör e genau hin!

The red LED flashes again and the speaker crackles softly. Each time T2 conducts, the diaphragm of the speaker is torn or torn. Touch the membrane gently with your fingers, then you can feel it too. Of course, the speaker in this circuit does not honor his name, but that should not bother us, because this is initially only about the principle.

We come later to a great circuit that uses the speaker properly and makes neat noise.

But for this circuit we need special transistors, and we want to get to know the next attempts, which are certainly not uninteresting, first of all.



Experiment: The Darlington circuit

For this experiment we need the two normal transistors of type 'BC 548 B'. Build the circuit as shown in the picture:



Insert a cable connection between +bar and 3g. Connect the transistor 1 as follows: Plug in the base at 5g, the collector at 3h, the emitter at 4i. Connect transistor 2 as follows: Plug in the base at 15i, the collector at 14h and the emitter at 13i. Insert the resistor (120 Ohm) between 4j and 7h. Plug in the anode of the green LED at 7i and the cathode in the -bar. Plug in a cable connection between 5h and 13j. Insert a resistor (22 kOhm or 1 MOhm optional) between +bar and 5f. Insert a resistor (22 kOhm or 1 MOhm optional) between +bar and 15j. Insert a resistor (22 kOhm) between +bar and 14g.

Turn on the power. Now insert a 22K resistor (A) into + and 4c. The LED shines bright because T2 receives enough base current. (T1 is not playing here yet).

Now replace the resistor by the 1 MOhm. The LED now shines only weakly because the base of T2 receives very little power. The faint glow, however, shows that the transistor, after all, becomes a little bit conductive. Now insert the 1 Mohm resistor (B) into + and 13a. The LED is now bright and showing that T2 is getting plenty of base current.

Explanation: As you have seen before, the low current through the 1 Mohm resistor is enough to make a transistor a bit conductive. That's exactly what is happening at T1. However, the much larger collector current of T1 now becomes the base current of T2. Consequently, T2 gets enough base current to become properly conductive.

Since Darlington circuits are often needed, special transistors such as the BC 517 have been developed, which looks and is used externally as a normal transistor, but inside consists of two transistors in Darlington circuits.

Experiment: The "electroscope"



Insert a cable connection between +bar and 3g. Place the transistor T1 (BC548) as follows: insert the base at 5g, the collector at 3h and the emitter at 4i. Insert the resistor (120 Ohm) between 4j and 7h. Insert the anode of the red LED at 7j and the cathode in the -bar. Plug in a cable connection between 5f and 11f. Place the transistor 2 (BC517) as follows: plug in the base at 12h, the collector at 13g and the emitter at 11g. Place the transistor 3 as follows: insert the base at 15i, the collector at 14h and the emitter at 12i. Plug in a cable connection between 13f and +bar. Insert a cable connection between 14g and the +bar. Insert a cable connection (probe) at 15j - the other end remains free.



From the circuit diagram it can be seen that the two Darlington transistors and the normal transistor are connected to a five-stage Darlington circuit. You can safely imagine that this circuit will be incredibly sensitive to very low currents.

ATTENTION!

The probe wire of terminal 12c may come in contact with a live part. The transistors would not survive this with absolute certainty! The probe wire should therefore be in any case (except for the end that is in terminal 12c)

s o l i e r t 1. Turn on the power. Now take a piece of plastic (such as a geo-triangle), rub it briefly on the clothing, bring it closer to the probe wire, and then remove it suddenly. - You will notice that the LED lights up each time the plastic is removed from the probe. How is this possible, even though the probe has no connection at all? It is clear that the LED only lights up when the first transistor receives base current. - Consequently, current must flow in the probe.

When you rubbed the Geo triangle on your clothes, it released a lot of electrons to the fabric on the surface and became electrically positively charged. When approaching the probe wire, therefore, the electrons of the wire are attracted. If the plastic part is then suddenly removed, they move back in the wire, which means that a current is flowing in the probe wire. Although this power is unimaginably small, it is sufficient in this five-stage Darlington circuit, but ultimately to let the LED light up.

Experiment: The "squeak box"



Insert the 1st resistor (120 Ohm) between +bar and 4a. Insert the 2nd resistor (120 Ohm) between +bar and 4b. Insert a cable connection between 4c and the + pole of the loudspeaker. Insert a cable connection between 7c and the - pole of the loudspeaker. Insert the 3rd resistor (1 MOhm) between +bar and 9f. Insert a cable connection (20mm) at the +bar. The other end of the cable remains free. Insert a cable connection at 16a. The other end of the cable remains free. Insert a cable connection at 16a. The other end of the cable remains free. Plug in the 4th resistor (39 kOhm) at 16b and 16f. Insert the 5th resistor (22 kOhm) between the +bar and 19g. Place capacitor C1 (1000pF) between 7h and 9g. Place capacitor C2 (4700pF) between 16h and 19h. Place the transistor T2 as follows: Insert the base at 6h, the collector at 7g and the emitter at 5g. Place the transistor T1 as follows: Insert the base at 17j, the collector at 19i and the emitter at 18i. Plug in a cable connection between 9h and 17i. Insert a cable connection between -bar and 5h. Plug in a cable connection between -bar and 18j. Plug in the anode of the red LED at 7d and the cathode at 7f.

First, look at the circuit diagram and compare it with that of experiment 10. You will surely recognize the great similarity to the double turn signal. As in experiment 11 here the speaker is used as an acoustic display.

The capacitors are much smaller here. That's why the circuit will go back and forth a lot faster, a few thousand times a second. The consequence of this is that the diaphragm of the speaker is just as quickly torn. You no longer hear single crackling sounds, but a sound. Since the LED is traversed by the same current, it also lights up a few thousand times a second and just as often gets dark again. Since our eye is not working so fast, we do not notice anything more than that the LED is lit.

So that the "squeak box" squeaks, you have to connect only the "entrance" with plus. You can do that with a wire. It is also sufficient to touch the entrance with one hand and the other (+) with one hand.

Note: 1 The two 120 ohm resistors are connected in parallel and function like a 60 ohm resistor.



Experiment: The "squeak box"



Insert a cable connection between +bar and 6a. Place the transistor T3 (BC557) as follows: Plug in the base at 7c, the collector at 6b and the emitter at 5c. Insert a cable connection between 5d and the + pole of the loudspeaker. Insert a cable connection between 3f and the -pole of the loudspeaker. Plug in the anode of the first LED at 3g and the cathode at the -bar. Insert the anode of the second LED at 3h and the cathode at the -bar. Insert a cable connection between 5h and the -bar. Place the transistor T2 (BC517) as follows: insert the base at 6h, the collector at 7g and the emitter at 5g. Place the transistor T1 (BC517) as follows: insert the base at 17j, the collector at 19i and the emitter at 18i. Insert the capacitor C1 (1000pF) between 7h and 9g. Insert capacitor C2 (4700pF) between 16h and 19h. Insert a cable connection between 17i and 9h, between 6i and 16g and between 18j and the -bar. Insert a resistor R4 (470 Ohm) between 7d and 7f. Insert a resistor R3 (1MOhm) between +bar and 9f. Insert a resistor R2 (39 kOhm) between 16b and 16f. Insert a resistor R1 (22kOhm) between +bar and 19g.



As you can see in the schematic, another transistor of type BC 558/557 B has been added. In contrast to the other NPN transistors, this is a PNP type, that is to say it is constructed in the reverse layer sequence. Therefore, its emitter in the diagram does not show minus, but more plus. Otherwise, it works quite normal.

The task of this additional transistor is to get the speaker with the largest possible current to a corresponding volume. Therefore, apart from the transistor, only the two LEDs and the loudspeaker are between plus and minus. Since one LED (in this case) provides too much resistance to the current, the same "trick" was used here with the parallel connection, as you can see in the previous circuit with the two 120 ohm resistors. - Two parallel LEDs provide only half as much resistance to the current as one. Incidentally, the LEDs cope with this "horse cure" without protective resistance only because they are not constantly traversed by the stream, but in between, even if only for fractions of a second, always "catch" so to speak. In the normal squeak box circuit you can see that there is also "a" protective resistor of 60 ohms in front of the collector of T2 except for the speaker and the LED. This is for a simple reason: if the resistor were too small or too large, the flip-flop would not work properly.

For the same reason, the 470 ohm resistor is located in the super squeak box. As a collector resistor it is just small enough for the toggle to work properly, and as a base resistor just big enough to prevent T3 from getting too much base current.

What makes the Super Squeakbox so awesome?

1. The circuit needs in retirement (so if it makes no noise) very little power and thus spares the battery.

2. The circuit is super-sensitive, because it does not hurt if the input is connected directly to plus.

3. The circuit is super-sensitive, because a current of less than a ten millionth of an ampere (with normal means no longer measurable) at the entrance is sufficient to achieve a clearly audible effect.

4. The circuit is universally applicable, because you can use it with countless other circuits as optical and acoustic signal generator combine.



What can you do with the "Super Quietschbox"?

Put on as many classmates as you can muster in a large circle; the first handles the positive connection, the last the entrance. As soon as everyone has their hands full, the Super Squeakbox will unmistakably show that. But as soon as only one person interrupts the circle, the "box" will become unmistakably quiet as well. The experiment was already done with 60 students, more were just not "tangible", but it would have to work with twice as many. - Try it!

Experiment: The "light barrier"

This circuit alone is hardly usable. It needs the "Super Quietschbox" of trial 15 as an additional display.



The construction of experiment 15 (Super Squeak Box) is now extended as follows:

Plug in a cable connection at 23 d. Connect the other end with terminal 16a of the Super Squeak Box. Insert the anode of the red LED in the +bar and the cathode in terminal 22a. Place the transistor (T1) as follows: the base at 24b, the collector at 22b and the emitter at 23c. Insert the resistor R5 (1 kOhm) between 23e and 23h. Insert the resistor R2 (22 kOhm) between +bar and 24a. Place the LDR between +bar and 27b. Insert the resistor R1 (2.7 kOhm) between 27c and 26f. Insert the resistor R3 (4.7 kOhm) between 26h and the -bar. Insert the resistor R4 (120 Ohm) between 23i and the -bar. Place the transistor T2 as follows: plug in the base at 26g, the collector at 24e and the emitter at 23g..



Build the circuit in addition to the squeak box or super squeak box on the other clip strip. Then connect each plus and minus of the two circuits so that they are powered by a battery and also connect the output of the photocell to the input of the "box".

From experiment 5 you know that the sensor also reacts to incident light. This is completely undesirable here. Therefore, you should now take appropriate precautions. - Obtain an opaque (eg black) tube from an empty felt-tip pen or old ballpoint pen, which is slightly thicker inside than the sensor, and then cut (saw off) an approx. 5 cm long piece. Cut a small stopper out of a cork or eraser that just fits into the tube. Then slide the sensor about 1.5 to 2 cm into the tube and close this end with the plug so that the two connections of the sensor do not touch each other. The photosensitive surface of the sensor can now (hopefully) only be reached by the light that falls through the other, open end of the tube.

When you try the photocell, align the whole circuit or sensor so that the opening of the tube points to a window or lamp and gets plenty of light. If you now pass with splayed fingers close to the opening of the tube, the "box" with every interruption of the light sends a signal.



Instruction 118.381

17 Electronics Assembly Basic Experiments with Breadboard

The circuit of the light barrier has some peculiarities compared to the previous circuits, but you should already understand quite easily: If the sensor is illuminated, it provides only little resistance to the current. The current from (+) across the sensor and R1 flows only to a minor extent via R3 to (-), because R3 is relatively large. The larger part flows through the base of T1 and R4 to (-) because R4 is relatively small. T1 is therefore conductive. Consequently, the current from (+) via R2 does not flow across the base of T2, because the emitter is followed by the 1-KOhm resistor R5. The way over T1 and R4 offers much less resistance. Since T2 does not receive a base current, it is disabled, and no current flows at the output.

If the sensor is not illuminated, it provides a lot of resistance to the current. The very low current, which then passes through the sensor and R1, is also attenuated by R3; yes derives a part to (-). As a result, the base of T1 does not receive enough power and T1 locks. However, when T1 locks, the current from R2 can only flow across the base of T2. So T2 becomes conductive.

When T2 is conducting, the output is almost directly connected to (+). The input of the following "box" receives full voltage, and the "box" indicates this accordingly. Surely you have already noticed that the emitters of the two transistors are not directly connected to (-) as usual. This is because when T1 conducts, the current from its emitter does not flow directly to (-), but must first overcome resistor R4. Therefore, there is a "traffic jam" before R4. Now, if T2 is to become conductive, it must not only receive base current, but this current must also overcome the "jam" R4. The consequence of this is that the circuit does not respond to any slight variation in illuminance, but exhibits great stability and immunity to interference. Conversely, when T2 conducts, its emitter current provides a "jam" before R4. Therefore, T1 can not become conductive with every slight increase in illuminance, and even in this state, the circuit exhibits high stability and noise immunity. - In both cases, a certain threshold must first be exceeded before the circuit tilts to the other state. Therefore, this circuit is also called threshold circuit or trigger. - If you want to set up the light barrier and control the function, put the LED on (but it will only light up). If the light barrier works and is connected to the "box", you can replace the LED with a simple wire

Experiment: The Water Guard

The circuit is the trigger circuit from Experiment 16 (see there or below). As a display device is again the "box". Instead of the optical sensor, two simple wires with bare ends are used, one each in terminal + and 30a.

If you put the circuit into operation, it will squeak, because between terminal + and 30a no current flows. If you connect the two wires, the squeaking of the "box" stops. Now put the two bare wire ends in a glass with water, a freshly poured flower pot or a pot with hydroponic culture. Make sure the wire ends are close together, but not touching. The water now conducts the electricity and ensures that the "box" remains calm. - But as soon as the water level drops, the "box" gives an alarm.

If your water monitor is working the other way around and alerting you to rising water levels, it's even easier. All you need is the "box": Put the wires of (+) and 'Entrance' close to each other into the open, and you will know immediately when it rains, or put them in the basement, then the box announces a 'burst pipe'.



The structure of this experiment corresponds to that of experiment 16, only the LDR is removed. Two approx. 100 mm long pieces of wire get stripped off at both ends. Insert one wire at the +bar and insert the other wire at terminal 27b. The ends are placed in a bowl filled with water.



This diagram shows you how to connect the light barrier circuit or other circuits with the "Super Quietschbox".

You already know some applications of the light barrier. It opens with e.g. automatically doors, counts items on conveyor belts, ensures passageways and machines, such as. Presses and scissors in which one should not reach into it. The same circuit is also used to switch on the street lighting at night and off again during the day.

Other applications:

The same trigger circuit as in Experiment 16 and 17 can still be used for many other purposes when replacing the optical sensor with others. - You tried another application in experiment 17 yourself. If one uses e.g. a thermoresistor that changes its resistance value with temperature gives you a fire alarm or an alarm to indicate when the temperature in the cabinet is rising too high, or vice versa a frost detector. - Unfortunately, such thermore-sistors are quite expensive. That's why you will not find one in your kit. In addition, real fire or frost detectors must of course work a bit more accurately than our 'craft' circuits.

Ending:

Hopefully you have enjoyed these experiments and learned a lot about electronics. To carry out experiments.

Please Note:

If you want to connect other circuits with the "box", follow the example above. In the other circuits no "output" is marked. But you can easily find it: with all other circuits you can just use the collector connection of a transistor as an output. - Breaking can not do anything.

Try it, for example, with the double turn signal, then the "box" will squeak in the rhythm of the turn signal.

Try other combinations.

Should you wish to carry out further experiments with other components, for example from an old radio or similar items, make sure that the component is not defective. Check the components individually in a circuit. It is important to follow the instructions in the experiments, so that your circuits will not be harmed.

