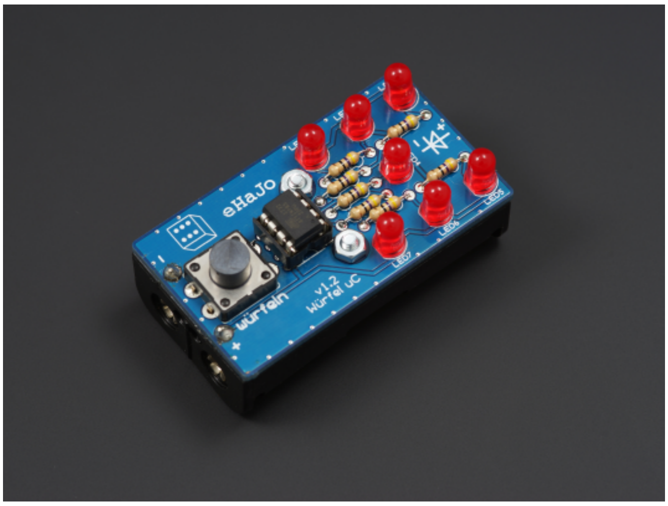
eHaJo
Elektronische Bausätze

Dice SMD



Instructions

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1 Basics

1.1 Soldering

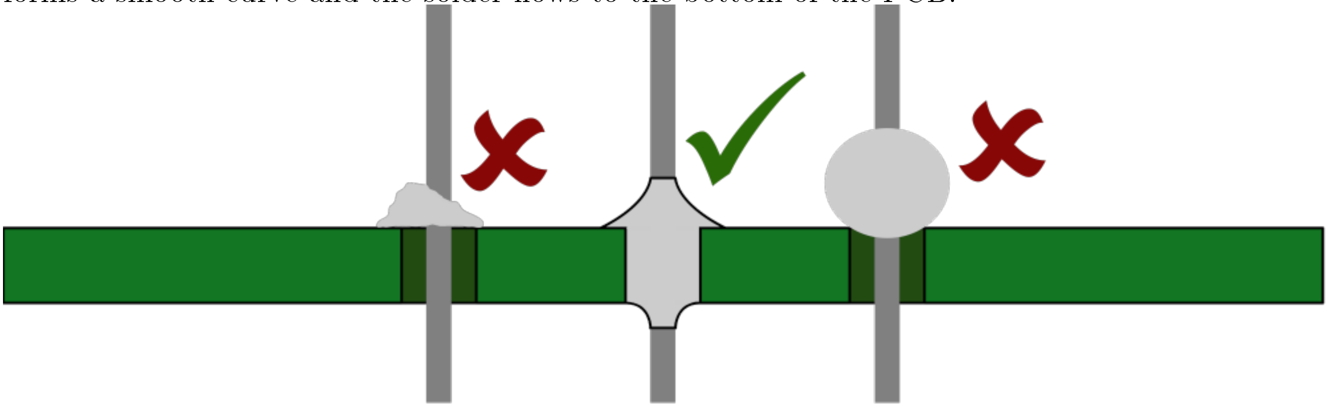
Our soldering exercises are designed to teach you the basics of soldering step by step. Don't worry, no one becomes an expert overnight! Just like in many things, *"practice makes perfect."*

You can find a helpful video about common soldering mistakes on our YouTube channel:
`https://youtu.be/CPXZM8r8xFw`

Here are some important points in brief:

- The ideal **temperature** for the soldering iron should be around **350°C**. It is recommended to use lead-free solder.
- The choice of soldering tip should match the size of the component. A **1.6 mm chisel tip** is ideal for most solder joints – it works for SMD components of size 0805 and wires up to 1.5 mm².
- To protect yourself from solder splashes or flying wires when cutting, it's recommended to wear **safety glasses**.
- Use a **heat-resistant surface** to avoid burn marks on your table.

The right amount of solder is crucial. Make sure the solder covers both the component and the PCB. The soldering iron must touch both the **component** and the **PCB** at the same time so that both are heated properly.
The following image shows typical solder joints: On the left, too little solder was used, while on the right, a ball forms – this happens when only the wire is heated. A perfect solder joint (middle) forms a smooth curve and the solder flows to the bottom of the PCB.



1.2 SMD Soldering

Once you've mastered the basics of soldering through-hole components, you can move on to the **next level**: SMD soldering!
Although the components are **very small**, there is **no need to worry**. With the right techniques, it will become **easy** after a bit of practice.

> ⚠ A common mistake is thinking that you need a particularly small soldering tip for SMD soldering. This is only partially true. Very small tips often have poor heat transfer. Therefore, always use a soldering tip that fits your **components**. In most cases, a 1.6mm wide tip works perfectly for 0805 components and many ICs!

The size of resistors and capacitors is indicated in formats like **1206** or **0805**. Always pronounce the numbers individually: Zero-Eight-Zero-Five.

I explain the basic steps of SMD soldering in this video:
`https://youtu.be/tvVbB6LRx-U`
You can find the most common mistakes here:
`https://youtu.be/4GrQNH8OoDY`

Here are some important points in short:

- Do not use a soldering tip that is too small
- The temperature should be about 350°C
- First, tin one pad of the component
- Melt the solder on the pad and place the component with tweezers into the molten solder. Remove the soldering iron and hold the component in place until the solder cools.
- Now solder the second side
- Reheat the first side briefly to avoid cold solder joints

In SMD soldering, "**more is better**," especially when it comes to flux. Without additional flux, SMD soldering is much more difficult!

1.3 Resistors

Resistors are found in almost every circuit and are one of the three basic **passive components**, along with inductors and capacitors.
The job of a resistor is to **limit** the flow of current. The unit of resistance is the Ohm[1] (Ω). The relationship between current, voltage, and resistance is described by the well-known **Ohm's Law**:

$$U = R \cdot I$$
$$R = \frac{U}{I}$$

The **resistance value** of a component can be read differently depending on its type: For SMD[2] components, the value is printed as a code, while for through-hole resistors, it's shown by color bands.
SMD resistors usually have a three-digit number like 471. The first two digits give the value, and the last digit shows the number of zeros. So, 471 means 47 followed by one zero, or 470Ω. A code like 683 means 68 followed by three zeros, or 68000Ω (68kΩ).
For through-hole resistors, the value is read using color bands. The following image shows how this works:

[1] Named after the German physicist Georg Simon Ohm, born in 1789
[2] Surface Mount Device

Farbe	1. Stelle	2. Stelle	(3. Stelle)	Multiplikator	Toleranz
Silber				x0,01	±10%
Gold				x0,1	±5%
Schwarz	0	0	0	x1	
Braun	1	1	1	x10	±1%
Rot	2	2	2	x100	±2%
Orange	3	3	3	x1.000	
Gelb	4	4	4	x10.000	
Grün	5	5	5	x100.000	±0,5%
Blau	6	6	6	x1.000.000	±0,25%
Violett	7	7	7	x10.000.000	±0,1%
Grau	8	8	8	x100.000.000	±0,05%
Weiß	9	9	9	X1.000.000.000	

4	7	x100	±5%	= 4k7Ω	
6	8	0	x1	±0,1%	= 680Ω

Don't worry about damaging resistors when soldering—they are very heat-resistant and unlikely to get damaged. Also, it doesn't matter which way you solder them because resistors have no polarity. For the perfectionists: It looks neater if all the color bands face the same direction.

1.3.1 Exercises

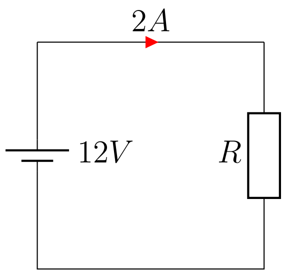
A resistor can limit the flow of current, which is often useful when you don't want the current to go over a certain value.
The following two examples show how to calculate the resistance using Ohm's law. Ohm's law is:

$$U = R \cdot I \quad \text{or} \quad R = \frac{U}{I}$$

Example 1:
Let's say we have a circuit with a voltage of $U = 12V$ and a current of $I = 2A$. To calculate the resistance, we put the values into the formula:

$$R = \frac{U}{I} = \frac{12V}{2A} = 6\,\Omega$$

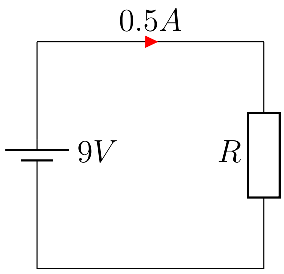
So, the resistance in this circuit is $6\,\Omega$.



Example 2:
In another example, the voltage is $U = 9V$ and the current is $I = 0.5A$. The resistance is calculated as:

$$R = \frac{U}{I} = \frac{9V}{0.5A} = 18\,\Omega$$

So, the resistance in this circuit is $18\,\Omega$.



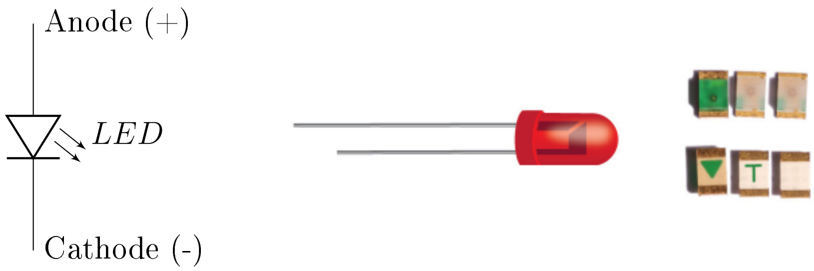
As you can see, it's easy to calculate the resistance when you know the voltage and current.

Calculation examples:

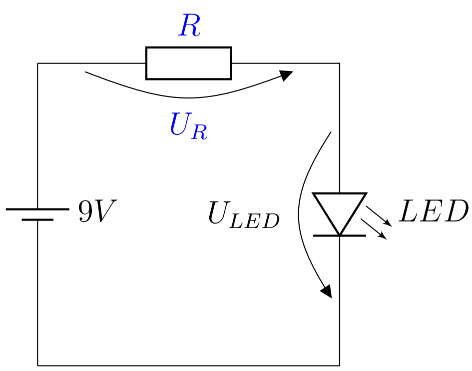
- A resistor with $R = 470\Omega$ is connected to a 5V power source. What is the maximum current? (Answer: $10.6mA$)
- A power supply of 24V should deliver a maximum current of $200mA$. What resistor do you need? (Answer: 120Ω)
- What is the voltage of a power supply if it provides a current of about 7mA through a 470Ω resistor? (Answer: $3.3V$)

1.4 Soldering LEDs

A light-emitting diode (LED) is an electronic component that emits **light** when current flows through it.
The correct **polarity** of the LED is crucial. If it is soldered onto the board the wrong way, it will not light up and might even be damaged.
The LED has two terminals: the **anode** (positive, +) and the **cathode** (negative, -). You can distinguish between them by the length of the legs. An easy way to remember is: *"Minus is always shorter"* – the shorter leg marks the cathode. For SMD LEDs, the cathode is often marked with a colored dot on the top or a diode symbol on the bottom.



An LED should never be operated without a **current-limiting resistor**. This resistor limits the maximum current flowing through the LED and protects it from overloading and potential damage. Always check the LED's datasheet to determine the correct values.
Example for calculating a current-limiting resistor:



Let's say we have an LED that lights up at a voltage of $U_{LED} = 2V$ and requires a maximum current of $I_{LED} = 20mA$. The supply voltage is $U_S = 9V$.
Since $2V$ are dropped across the LED, the remaining $7V$ are left for the resistor, as calculated by Kirchhoff's voltage law:

$$U_R = U_S - U_{LED} = 9V - 2V = 7V$$

The current flowing through the LED is the same as the current through the resistor. So, we can calculate the resistor's value using Ohm's law:

$$R = \frac{U_R}{I_{LED}} = \frac{7V}{0.02A} = 350\,\Omega$$

Thus, the required resistor is $350\,\Omega$. Since resistors come in standard values (called E-series), you often need to round up. The closest available value would be $360\,\Omega$.
You can also find a video on how to calculate the current-limiting resistor for LEDs on our YouTube channel:
`https://youtu.be/p0dt-6F-EZg`

1.4.1 Exercises

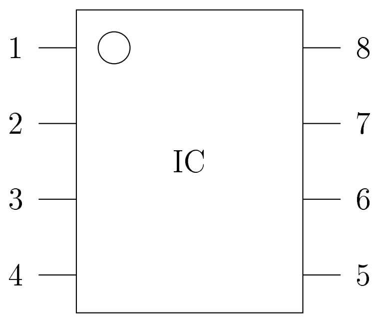
The answers are rounded to standard E-series resistor values!

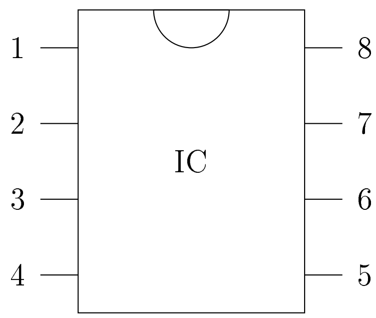
- You have a low-current LED running at $I = 2mA$ and requiring a voltage of $2.5V$. You want to power it with $5V$. What current-limiting resistor do you need? (Answer: 1300Ω)
- A blue LED requires $4V$ and a current of $17mA$. What resistor should you use to power it with $12V$? (Answer: 470Ω)

1.5 IC

Integrated Circuits (ICs) are compact components that come in many different types, ranging from simple logic gates to operational amplifiers and complex microcontrollers. Typically, they are small, black components with pins, either in through-hole or SMD technology.

An important thing to remember when handling ICs is the **polarity**, which is marked by a small dot or a notch on the case. This marking always indicates the position of **Pin 1**. When placing the IC on a circuit board, be sure to check the **correct orientation** of the polarity, as placing it incorrectly can damage the component.





You will also find a marking for Pin 1 on the circuit board, making it easier to correctly align the chip when soldering it.

2 Dice SMD

2.1 Bill of Materials

The following components are needed for assembly:

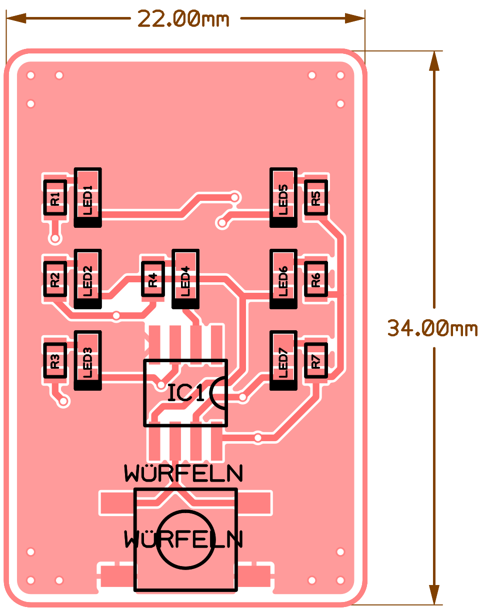
- PCB
- 7x Resistor 0805
- IC (Attiny13A, pre-programmed)
- SMD Button
- 7x Red LED
- Battery holder

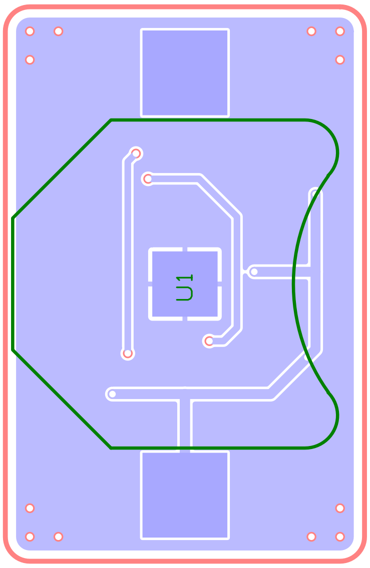
> The battery holder on the bottom should be soldered in last. Otherwise, the PCB will not lie flat on the work table, making soldering harder.

The critical components in this kit are the LEDs and the IC. Please pay close attention to their polarity before soldering them. This is explained in the basic chapters.

Before soldering in the battery holder, you must tin the middle pad with some solder; otherwise, the battery will not make contact. The battery you need is a CR2032.

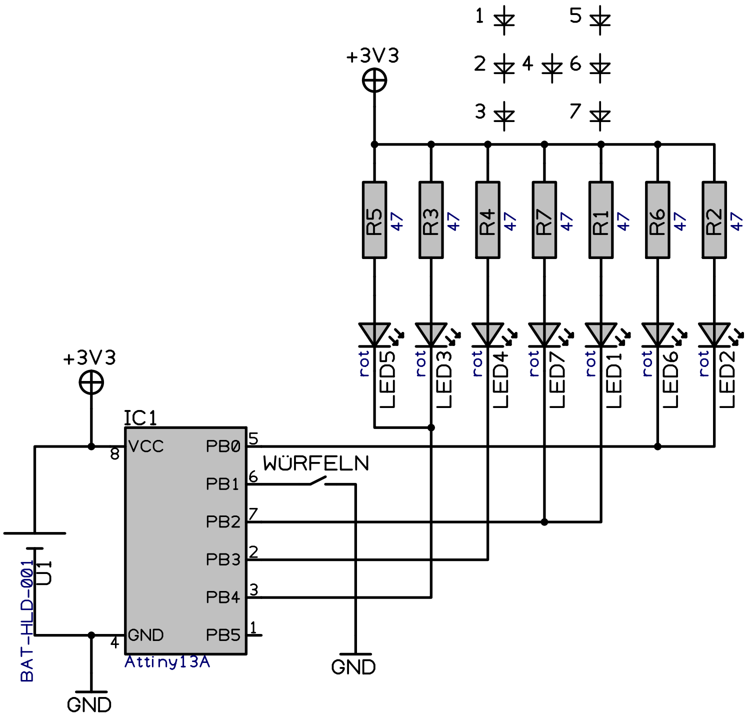
You can find a simple video about assembling the cube on our YouTube channel:
`https://youtu.be/pJ-d1wIgMUY`





2.2 Circuit Diagram

The circuit diagram for the kit is on the next page to ensure correct scaling. You can use the empty space for notes!



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