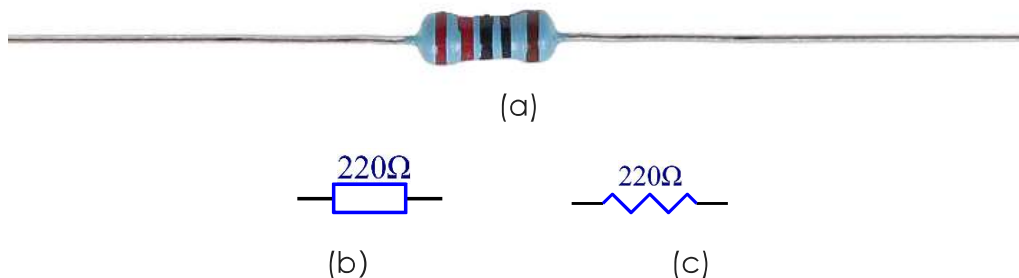


Components Introduction

Resistor

Resistor is an electronic element that can limit the branch current. A fixed resistor is one whose resistance cannot be changed, when that of a potentiometer or variable resistor can be adjusted.

The resistors in this kit are fixed ones. It is essential in the circuit to protect the connected components. Figure (a) below shows a 220Ω resistor. Ω is the unit of resistance and the larger includes $K\Omega$, $M\Omega$, etc. Their relationship can be shown as follows: $1 M\Omega = 1000 K\Omega$, $1 K\Omega = 1000 \Omega$, which means $1 M\Omega = 1000,000 \Omega = 10^6 \Omega$. Figure (b) and (c) show two generally used circuit symbols for resistor. Normally, the resistance is marked on it. So if you see these symbols in a circuit, it stands for a resistor.



The resistance can be marked directly, in color code, and by character. The resistors offered in this kit are marked by different colors. Namely, the bands on the resistor indicate the resistance.

When using a resistor, we need to know its resistance first. Here are two methods: you can observe the bands on the resistor, or use a multimeter to measure the resistance. You are recommended to use the first method as it is more convenient and faster. If you are not sure about the value, use the multimeter.

In the kit, a Resistor Color Code Calculator card is provided as shown below:

4-Band-Code

2%, 5%, 10% 560kΩ ± 5%

Color	1st Band	2nd Band	3rd Band	Multiplier	Tolerance
Black	0	0	0	1Ω	
Brown	1	1	1	10Ω	± 1% (F)
Red	2	2	2	100Ω	± 2% (G)
Orange	3	3	3	1KΩ	
Yellow	4	4	4	10KΩ	
Green	5	5	5	100KΩ	± 0.5% (D)
Blue	6	6	6	1MΩ	± 0.25% (C)
Violet	7	7	7	10MΩ	± 0.10% (B)
Grey	8	8	8		± 0.05%
White	9	9	9		
Gold				0.1	± 5% (J)
Silver				0.01	± 10% (K)

5-Band-Code

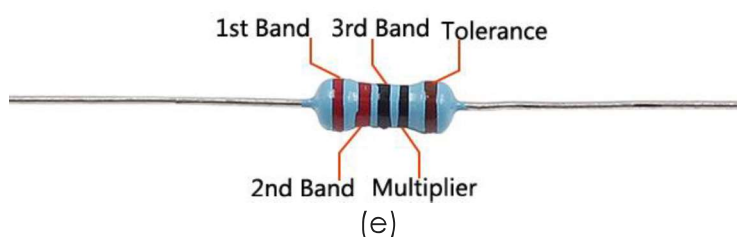
0.1%, 0.25%, 0.5%, 1% 237Ω ± 1%

(d)

As shown in the card, each color stands for a number.

Black	Brown	Red	Orange	Yellow	Green	Blue	Violet	Grey	White	Gold	Silver
0	1	2	3	4	5	6	7	8	9	0.1	0.01

The 4- and 5-band resistors are frequently used, on which there are 4 and 5 chromatic bands. Let's see how to read the resistance value of a 5-band resistor as shown below. Normally, when you get a resistor, you may find it hard to decide which end to start for reading the color. The tip is that the gap between the 4th and 5th band will be comparatively larger. Therefore, you can observe the gap between the two chromatic bands at one end of the resistor; if it's larger than any other band gaps, then you can read from the opposite side.

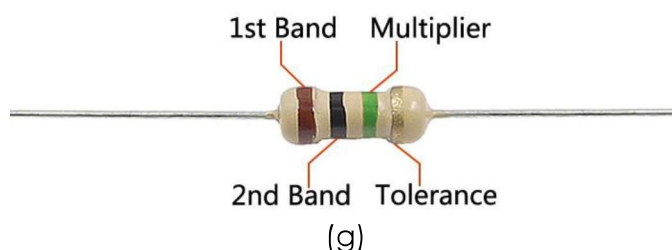


So for this resistor, the resistance should be read from left to right. The value should be in this format: 1st Band 2nd Band 3rd Band $\times 10^{\text{Multiplier}}$ (Ω) and the permissible error is \pm Tolerance%. So the resistance value of this resistor is 2(red) 2(red) 0(black) $\times 10^0$ (black) $\Omega = 220 \Omega$, and the permissible error is $\pm 1\%$ (brown).

One more example. The resistance of the resistor below should be 1(brown) 0(black) 0(black) $\times 10^1$ (brown) $\Omega = 100 \times 10 \Omega = 1000 \Omega = 1\text{K}\Omega$, and the permissible error is $\pm 1\%$ (brown). Now try it by yourself!



Now let's try a 4-band resistor. There are two 4-band resistors in the kit: a $1\text{M}\Omega$ one and a $5.1\text{M}\Omega$ one. You may not use such a large resistor in the experiments of the kit but you can use them in other projects. Unlike 5-band resistors, the third band of a 4-band one is not the 3rd band but the multiplier; its fourth band is Tolerance. So the resistance value of a 4-band resistor should be 1st band 2nd band $\times 10^{\text{Multiplier}}$ (Ω), and the permissible error is \pm Tolerance%.



Read the resistance of the above resistor from left to right. The value is 1 (brown) 0 (black) $\times 10^5$ (green) = $10 \times 10^5 \Omega = 10^6 \Omega = 1 \text{ M}\Omega$ and the permissible error is $\pm 5\%$ (gold)

The resistance value of the resistor below is 5 (green) 1 (brown) $\times 10^5$ (green) = $51 \times 10^5 \Omega = 5.1 \times 10^6 \Omega = 5.1 \text{ M}\Omega$, and the permissible value is $\pm 5\%$ (gold).

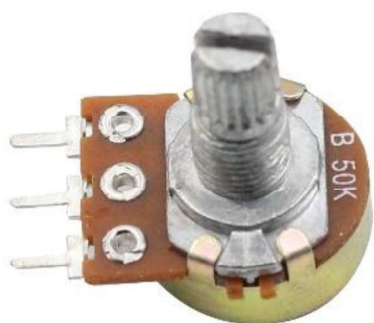


(h)

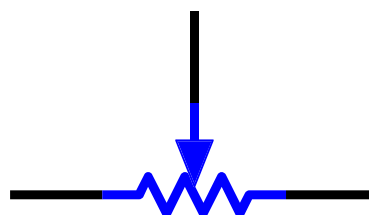
You can also use a multimeter to measure the resistance value of these resistors to double check whether you've read it correctly or not.

Potentiometer

Potentiometer is also a resistance component with 3 terminals and its resistance value can be adjusted according to some regular variation. Potentiometer usually consists of resistor and movable brush. When the brush is moving along the resistor, there is a certain resistance or voltage output depending on the displacement. Figure (i) is the potentiometer and figure (j) is the corresponding circuit symbol. The middle pin in figure (i), represented by the arrow in Fig. (j) is the movable brush.



(i)



(j)

The functions of the potentiometer in the circuit are as follows:

1. Serving as a voltage divider

Potentiometer is a continuously adjustable resistor. When you adjust the shaft or sliding handle of the potentiometer, the movable contact will slide on the resistor. At this point, a voltage can be output depending on the voltage applied onto the potentiometer and the angle the movable arm has rotated to or the travel it has made.

2. Serving as a rheostat

3. When the potentiometer is used as a rheostat, connect the middle pin and one of the other 2 pins in the circuit. Thus you can get a smoothly and continuously changed resistance value within the travel of the moving contact.

4. Serving as a current controller

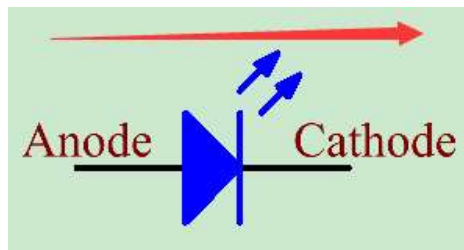
When the potentiometer acts as a current controller, the sliding contact terminal must be connected as one of the output terminals.

LED

Semiconductor light-emitting diode is a type of component which can turn electric energy into light energy via PN junctions. By wavelength, it can be categorized into laser diode, infrared light-emitting diode and visible light-emitting diode which is usually known as light-emitting diode (LED).



(k)



(l)

See LED in figure (k). Figure (l) is the circuit symbol. Diode has unidirectional conductivity, so the current flow will be as the arrow indicates in figure (l). You can only provide the anode with a positive power and the cathode with a negative. Thus the LED will light up.

In this kit, LEDs of red, green, yellow and white are provided. An LED has two pins. The longer one is the anode, and shorter one, the cathode. Pay attention not to connect them inversely. There is fixed forward voltage drop in the LED, so it cannot be connected with the circuit directly because the supply voltage can outweigh this drop and cause the LED to be burnt. The forward voltage of the red, yellow, and green LED is 1.8 V and that of the white one is 2.6 V. Most LEDs can withstand a maximum current of 20 mA, so we need to connect a current limiting resistor in series.

The formula of the resistance value is as follows:

$$R = (V_{\text{supply}} - V_D) / I$$

R stands for the resistance value of the current limiting resistor, V_{supply} for voltage supply, V_D for voltage drop and I for the working current of the LED.

If we provide 5 voltage for the red LED, the minimum resistance of the current limiting resistor should be: $(5V - 1.8V) / 20mA = 160\Omega$. Therefore, you need a 160Ω or larger resistor to protect the LED. You are recommended to use the 220Ω resistor offered in the kit.

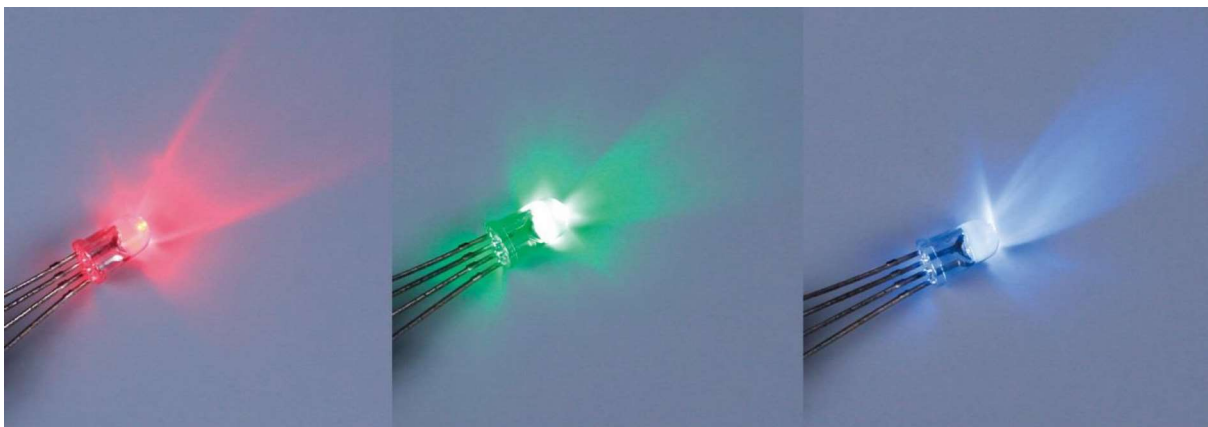
RGB LED

An RGB LED is provided in this kit. RGB LEDs emit light in various colors. An RGB LED packages three LEDs of red, green, and blue into a transparent or semitransparent plastic shell. It can display various colors by changing the input voltage of the three pins and superimpose them, which, according to statistics, can create 16,777,216 different colors.

RGB LEDs can be categorized into common anode and common cathode ones. In this experiment, the latter is used. The common cathode, or CC, means to connect the cathodes of the three LEDs. After you connect it with GND and plug in the three pins, the LED will flash the corresponding color. Its circuit symbol is shown as figure (n).



An RGB LED has 4 pins: the longest one is GND; the others are Red, Green and Blue. Touch its plastic shell and you will find a cut. The pin closest to the cut is the first pin, marked as Red, then GND, Green and Blue in turn.



(o)

Or you can distinguish them in another way. As GND is the longest one and can be defined directly, you just need to confirm the other three pins. You can test it by giving them a small voltage. The forward voltage drop from the three pins to the GND are respectively 1.8V (red), 2.5V (blue), and 2.3V (green). Thus, when you connect the same current limiting resistor with the three pins and supply them with the same voltage, the red one is the brightest, and then

comes the green and the blue one. Therefore, you may need to add a current limiting resistor with different resistances to the three pins for these colors.

Jumper Wires

Wires that connect two terminals are called jumper wires. There are various kinds of jumper wires. Here we focus on those used in breadboard. Among others, they are used to transfer electrical signals from anywhere on the breadboard to the input/output pins of a microcontroller.

Jumper wires are fitted by inserting their "end connectors" into the slots provided in the breadboard, beneath whose surface there are a few sets of parallel plates that connect the slots in groups of rows or columns depending on the area. The "end connectors" are inserted into the breadboard, without soldering, in the particular slots that need to be connected in the specific prototype.

There are three types of jumper wire: Female-to-Female, Male-to-Male, and Male-to-Female. The reason we call it Male-to-Female is because it has the outstanding tip in one end as well as a sunk female end. Male-to-Male means both side are male and Female-to-Female means both ends are female.



Male-to-Female

(p)



Male-to-Male

(q)



Female-to-Female

(r)

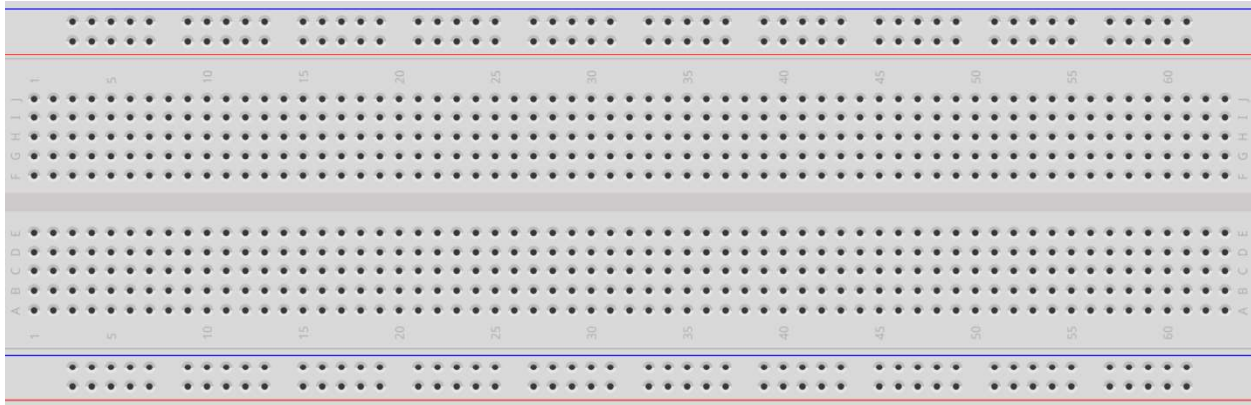
More than one type of them may be used in a project. The colors of the jumper wires are different but it doesn't mean their functions are different accordingly; it's just designed so to better identify the connection between each circuit. The Male-to-Male and Male-to-Female jumper wires are included in the kit. But actually only some Male-to-Male ones will be used in the experiments. You can use the Male-to-Female wires in other experiments.

Breadboard

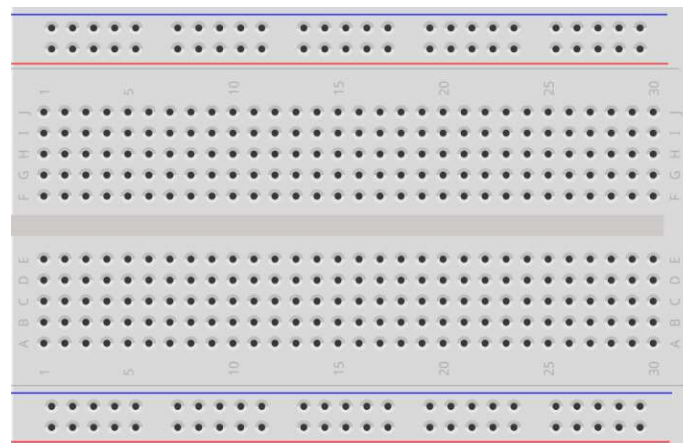
A breadboard is a construction base for prototyping of electronics. It is used to build and test circuits quickly before finalizing any circuit design. And it has many holes into which components like ICs and resistors as well as jumper wires mentioned above can be inserted. The breadboard allows you to easily plug in and remove components. If there is going to be many changes or if you just want to make a circuit quickly, it will be much quicker than

soldering up your circuit. Therefore, in lots of experiments, it is often used as a hub to connect two or more devices.

Normally, there are two types of breadboard: full+ and half+. You can tell their difference from the names. A half+ breadboard is half the size of a full+ one and their functions are the same. Here take the full+ breadboard.

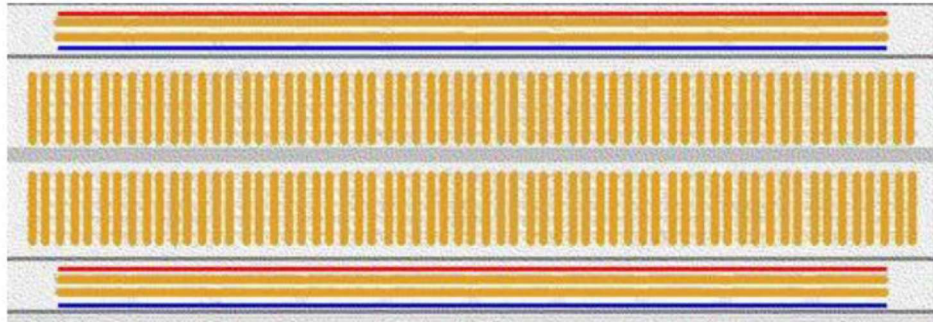


(s) Full+



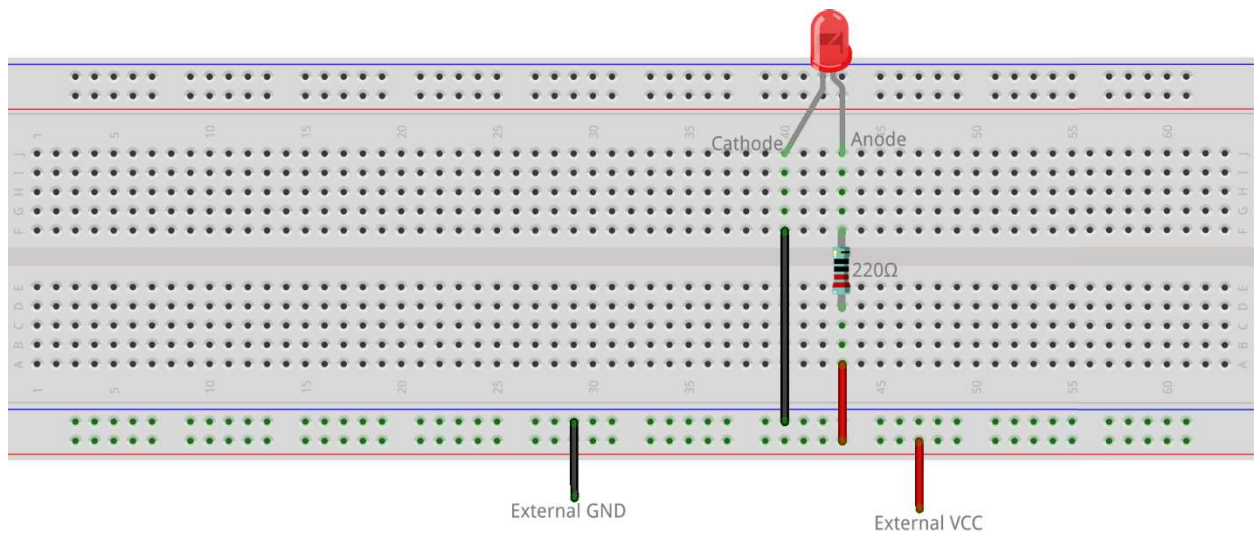
(t) Half+

This is the internal structure of a full+ breadboard. Although there are holes on the breadboard, internally some of them are connected with metal strips. Those holes are to insert pins of devices or wires. As shown in the fig. (t) below, there are four long metal strips on the long sides; the blue and red lines are marked just for clear observation. But you can take the blue line as the GND and red one as VCC for convenience. Every five holes in the middle are vertically connected with metal strips internally which don't connect with each other. You can connect them horizontally with wires or components. A groove is made in the middle on the breadboard for IC chips.



(u) Internal structure of the full+

Now let's make some simple experiment with the breadboard. Turn on an LED as shown in the figure below. You can have a try and the LED will light up. The breadboard makes it possible for you to plug and pull components at any time without welding, which is very convenient for tests.



(v)