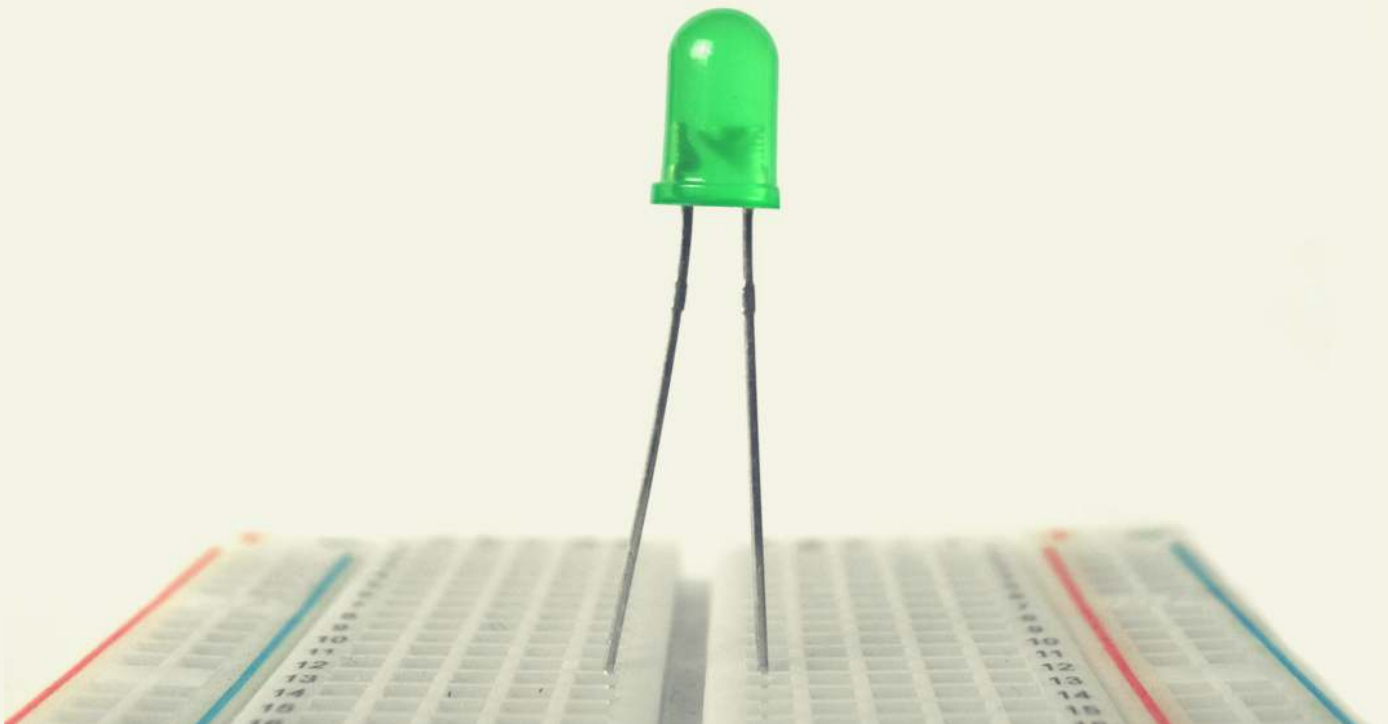


# BASIC ELECTRONIC COMPONENTS

A SIMPLE INTRODUCTION TO THE MOST COMMON COMPONENTS  
USED IN ELECTRONICS



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# Light-Emitting Diode (LED)

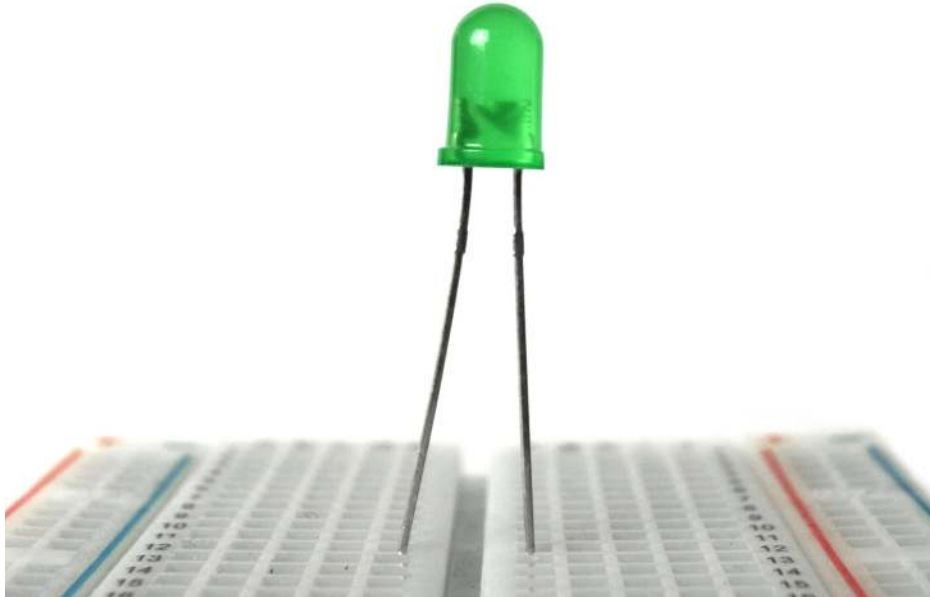


Figure 1: A Light-Emitting Diode (LED)

A Light Emitting Diode – or LED for short – is a small component that lights up when current flows through it.

Sometimes you use it for simple tasks like indicating that your circuit has power, that the circuit is working or that the circuit has failed.

But you can also combine several LEDs to create simple 7-segment displays that can display numbers or use them to make cool light decorations. If you combine enough LEDs in a square, you can even use them to show images.

The LED exist in many different colors; Red, green, blue and many more.

There is also a special type of LED called RGB. This is an LED where a red, green and blue LED has been combined into one package. The colors mix, so by controlling the intensity of each of the three colors you can create a wide spectrum of different colors.

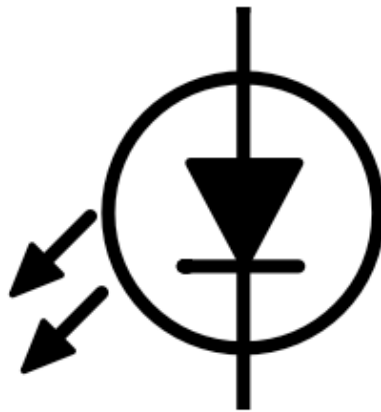


Figure 2: The symbol used in circuit diagrams for a Light-Emitting Diode (LED)

## Example

To use an LED, you need to connect it in a circuit with a resistor, as shown in Figure 3.

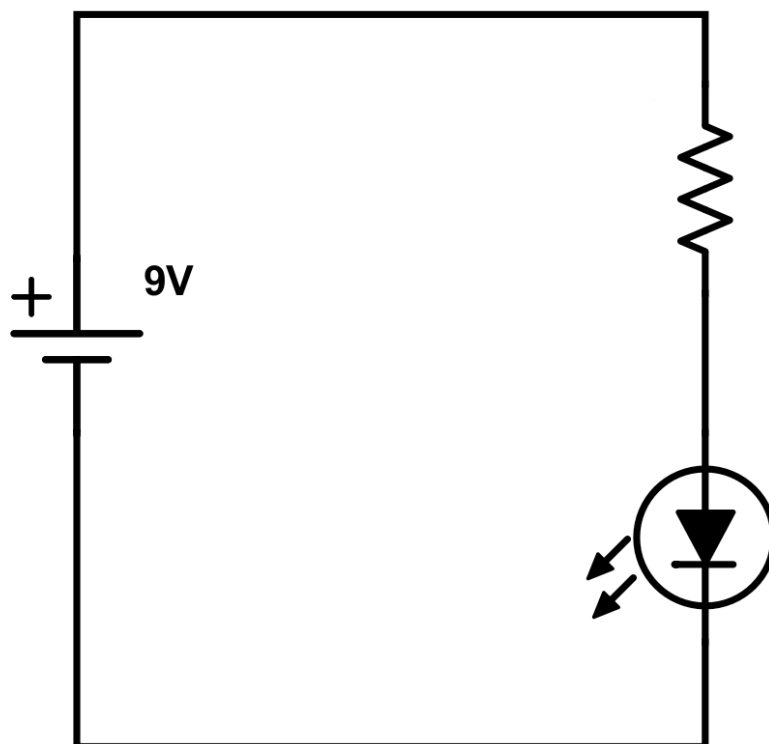


Figure 3: A simple LED circuit

The reason you need the resistor is to make sure the LED does not burn up. A common LED can only handle a very low current. If you don't use a resistor to control the current, your LED will quickly die and become unusable.

But what is a resistor?

That's next. Jump on over to the next page to learn what a resistor is.

# The Resistor

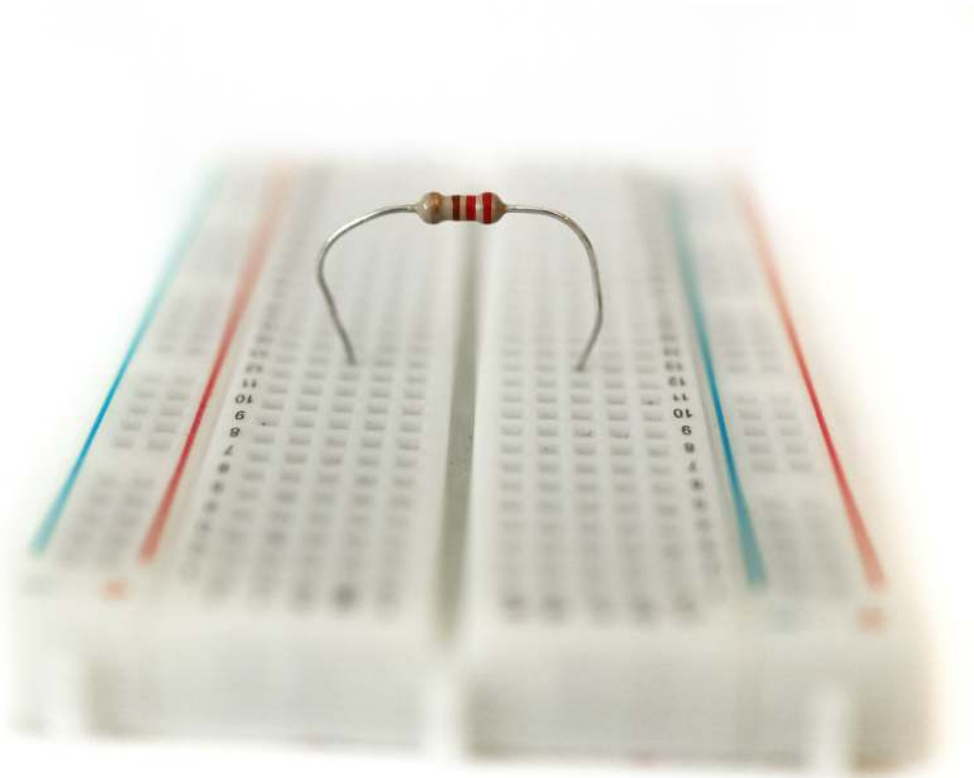


Figure 4: The LED in a circuit

I didn't understand the resistor in the beginning. It seemed like it didn't do anything! It was just there, consuming power.

But eventually, I learned that the resistor is actually extremely useful.

You'll see resistors everywhere. And as the name suggests, they resist the current. But you are probably wondering:

"What do I use it for?"

You use the resistor to control the voltages and the currents in your circuit.

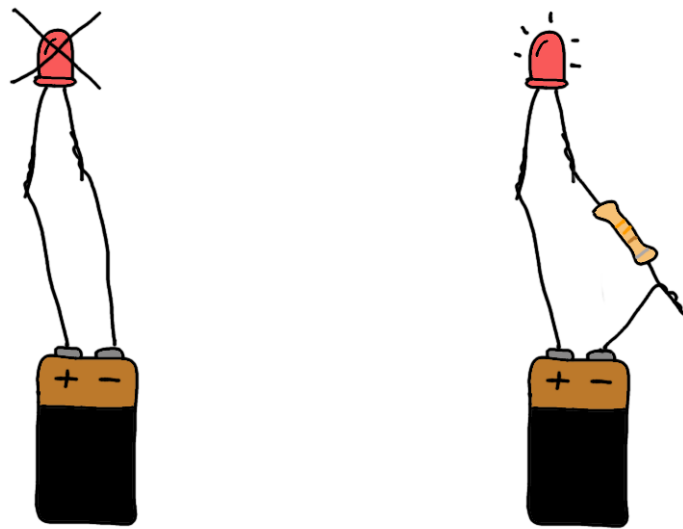


Figure 5: You always need a resistor with the LED

Let's say you have a 9V battery and you want to turn on an LED. If you connect the battery directly to the LED, LOTS of current will flow through the LED! Much more than the LED can handle. So the LED will become very hot and burn out after a short amount of time.

But – if you put a resistor in series with the LED, you can control how much current is going through the LED.

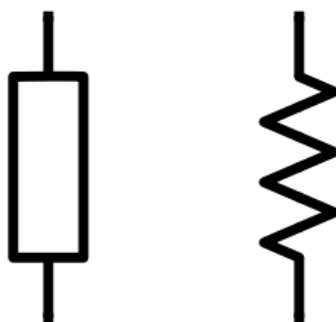


Figure 6: A rectangle or a zigzag line is used as a symbol for the resistor

## Example

In Figure 7 you can see a common example of how a resistor is used to control the current for protecting the LED.

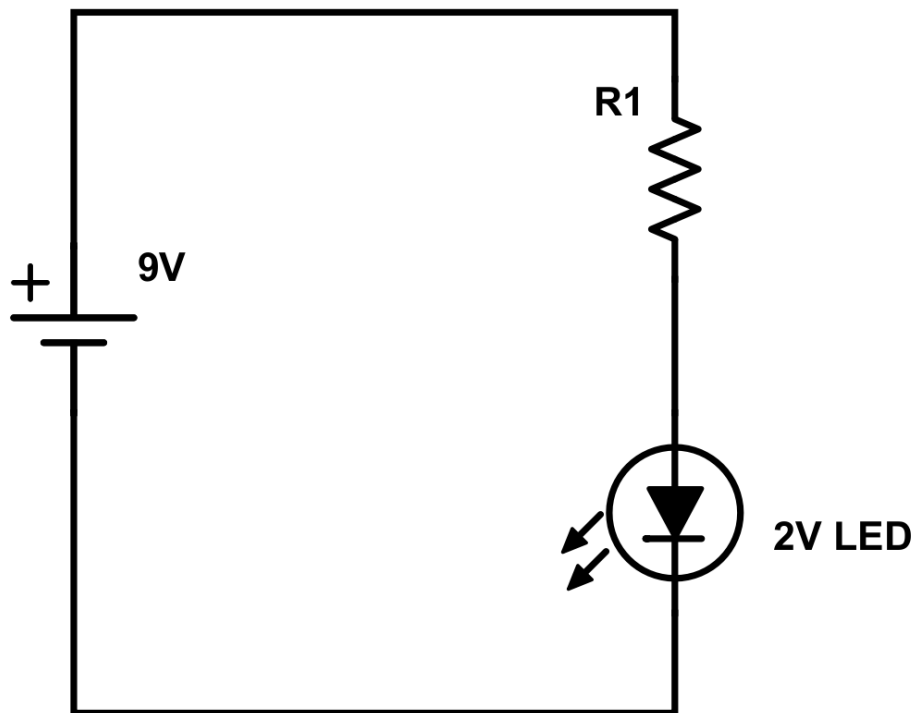


Figure 7: A common way to use resistors is to control the current for an LED

A standard LED can only handle up to around 20-30 mA. If the current is much bigger than that, the LED will quickly die.

Let's say the LED in the circuit above needs 15 mA to give a good light, and it has a voltage drop of 2 volts. (These values should be specified by the supplier when you buy an LED.)

If you have a 9 V battery that you would like to power it with, which resistor value do you need?

The voltage specified for the LED is the voltage drop the LED will have under normal conditions. That means you know you will have 2V over the LED.

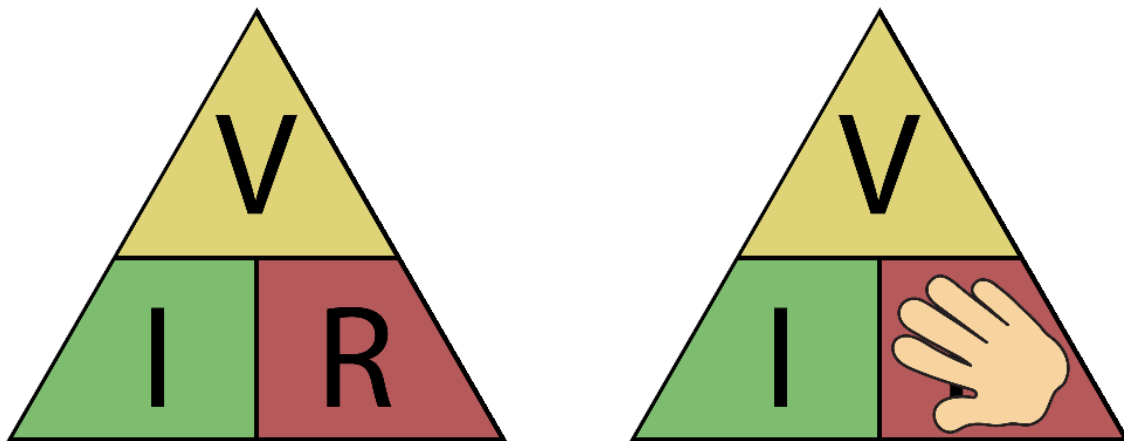


To find the resistor value, we start by finding the voltage drop over the resistor.

Since there is a 2-volt drop over the LED, there will be a 7V drop over the resistor (9V - 2V equals 7V).

You have 7V over the resistor, and whatever amount of current flows through it will also flow through the LED. So by setting the resistor value to a value that gives you 15 mA, you'll also get 15 mA through the LED.

To find the necessary resistor value we use Ohm's law.



By placing your hand over the R in the Ohm's law triangle, you get that Resistance (R) equals voltage (V) divided by current (I). This means you get:

$$R = 7V / 0.015 A = 467\Omega$$

470Ω is a standard value close enough, so by choosing this resistor value you decide that the current flowing in your circuit is 15 mA.

# The Switch

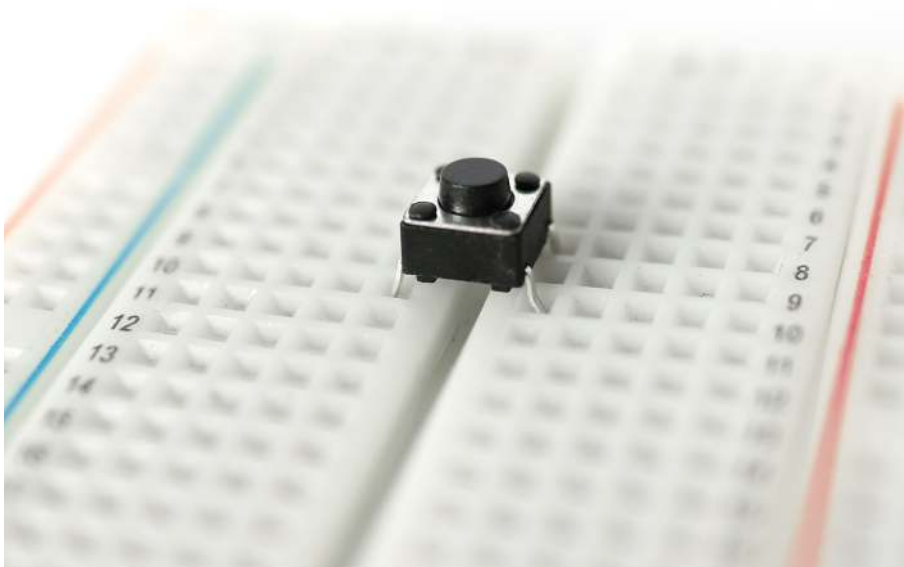


Figure 8: The push-button is a popular switch

The switch is a component that connects one pin to another. For current to flow through a circuit, there needs to be a path from the plus of the battery to the minus of the battery.

If you build a simple circuit with an LED and a resistor and connect this to a battery, your LED will light up. If you disconnect the plus of the battery from the circuit, the LED turns off.

The switch is nothing more than a way to connect and disconnect two or more things. For example to make a light-switch. Or a keyboard.



Figure 9: The switch symbol comes in many forms. This is the pushbutton switch.

## Example

In Figure 10, you can see how you can use a switch to turn on and off an LED.

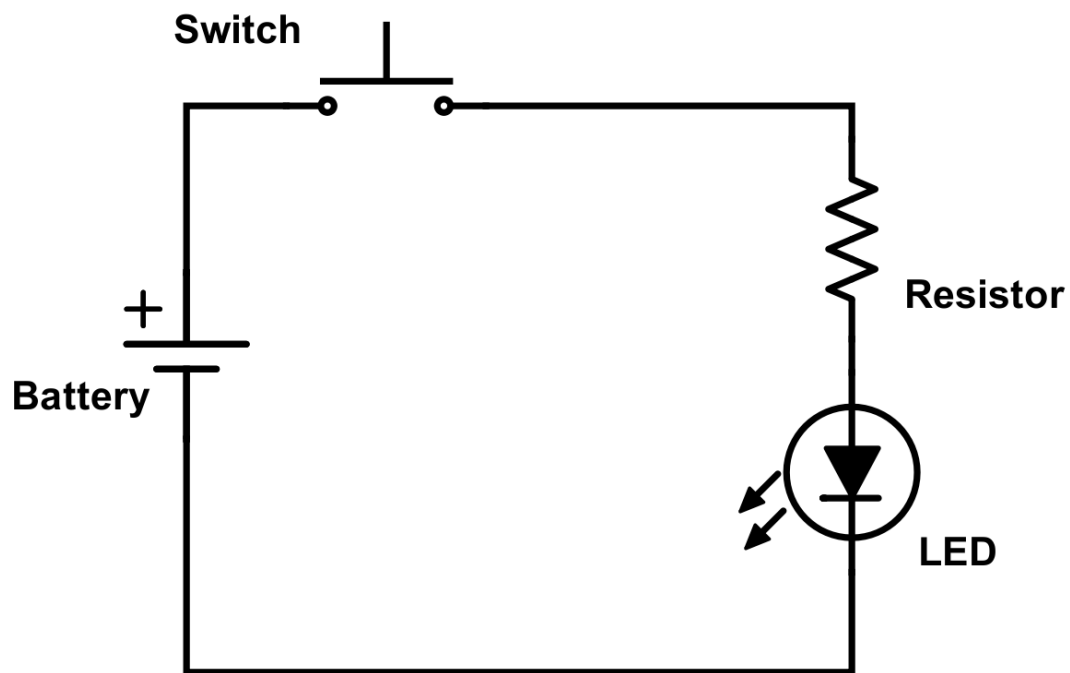


Figure 10: In this circuit, the switch turns on the LED when pushed down

# The Capacitor

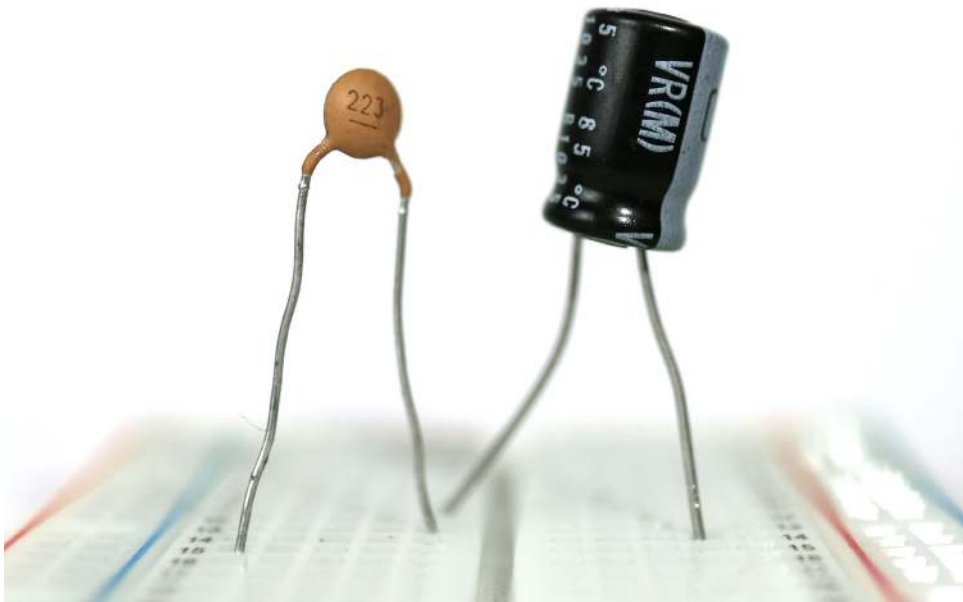


Figure 11: Two capacitors (Non-polarized on left and polarized on right)

You can think of a capacitor as a battery with very low capacity. You can charge and discharge it, just like a battery.

The capacitor is often used to introduce a time-delay in a circuit. For example to blink a light (check out the example in the Integrated Circuit section). But it's also useful for removing noise in an audio signal, or make the power supply of a circuit more stable.

Capacitors come as *polarized* and *non-polarized* capacitors. The biggest difference is that with the polarized capacitor, you have a positive and a negative pin and you need to make sure to connect them correctly. You can connect non-polarized capacitors any way you want.

So which one to choose?

You never *need* your capacitor to be polarized. But for larger values, the capacitors are made with a material that makes them polarized. So, sometimes you don't have any choice but to use a polarized one.

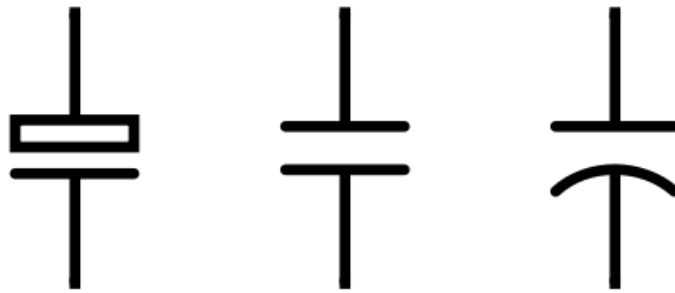


Figure 12: Three different variations of the capacitor symbol. If a plus is shown, it means it's a polarized capacitor.

## Example

By connecting a capacitor in parallel with a resistor and an LED, the capacitor can store energy and use the energy after the battery is disconnected. This creates a “fading out”-effect of the LED.

In Figure 13 you can see such a circuit. To build this circuit, you'll need a capacitor of at least 1000 $\mu$ F to see the effect.

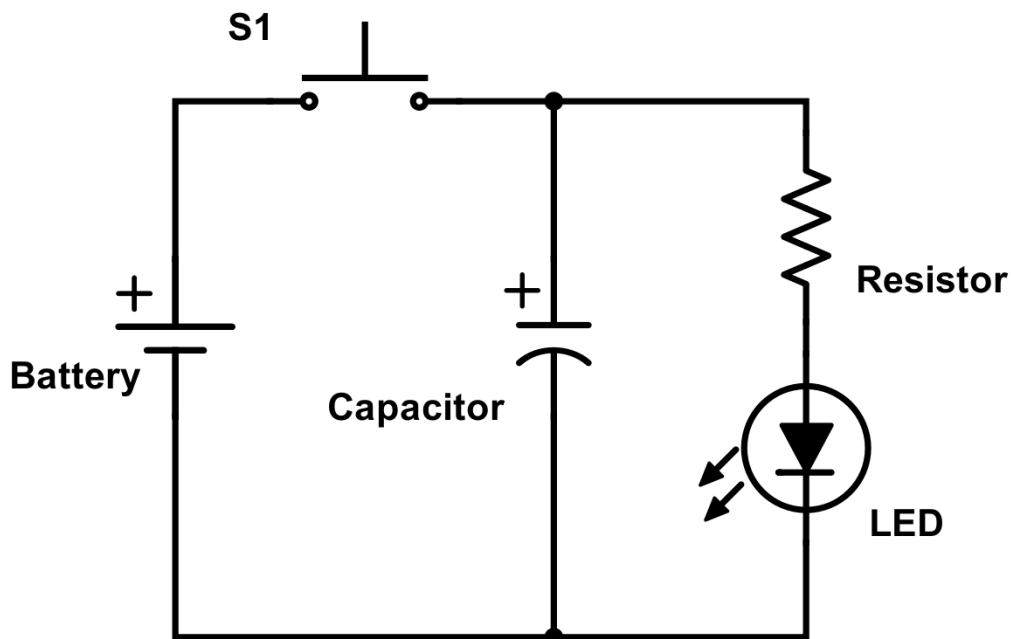


Figure 13: A circuit where the LED fades out because of the energy stored in the capacitor

# The Transistor

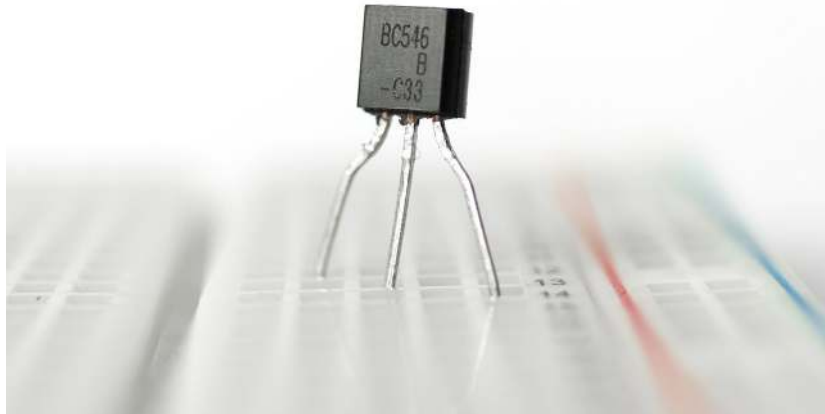


Figure 14: A transistor placed onto a breadboard

This is the component that seems to be the hardest to understand when starting out. At least it was for me.

But don't worry, it's not that hard.

A transistor is like a switch that is controlled by an electrical signal.

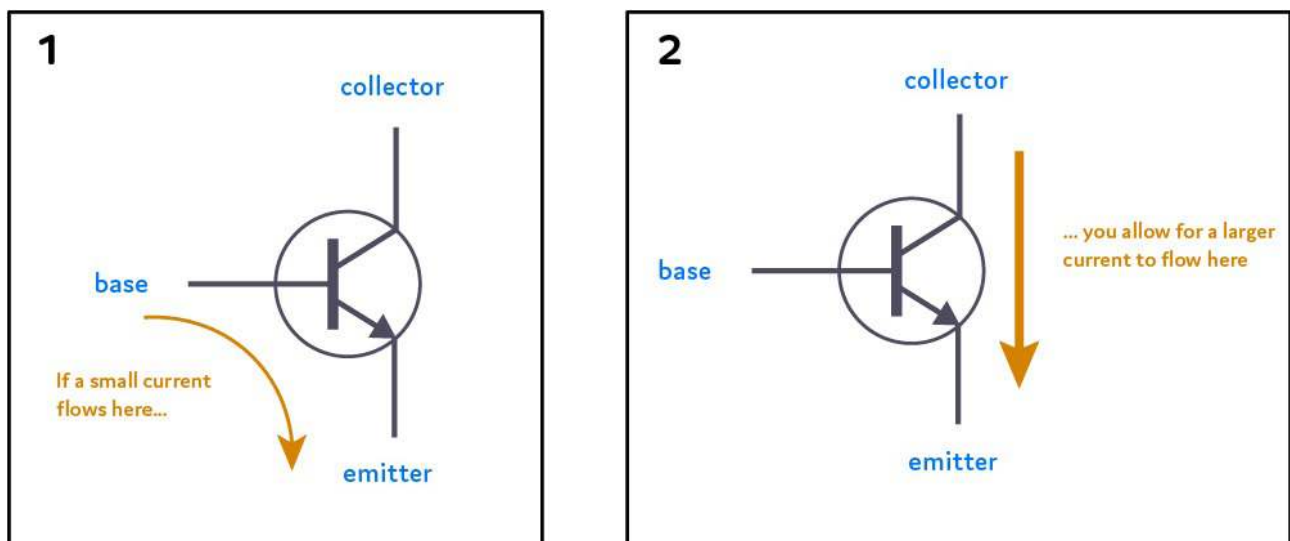


Figure 15: A little bit of current flowing through the base of the transistor turns it ON

In Figure 15, you can see an illustration of how the transistor works:

It has three pins named base, collector, and emitter. If you have a small current flowing from base to emitter, you turn it on. With no current, it is off. To get current flowing you need about 0.7V from base to emitter (for this type of transistor).

Unlike a normal switch that only has two states (ON or OFF), the transistor can also be “partly on” by controlling the current that goes through its base. A bit of current on the base produces a current of maybe 100 times more (depending on the transistor) through the Collector and Emitter. You can use this effect to build an amplifier.



Figure 16: The transistor symbol for a NPN transistor

## Example

A simple example of using a transistor is for building a touch-sensor, like in Figure 17.

In this example, the transistor does not let any current flow through the LED and resistor if there is no current flowing through the base. That means there is no light in the LED.

When you touch your finger to the touch-pad (for example two metal pins), your finger acts as a resistor, and lets a little bit of current flow down through the base of the transistor. The transistor “opens its gate” and lets about 100 times the amount of current flow through the LED and resistor, which makes the LED light up.

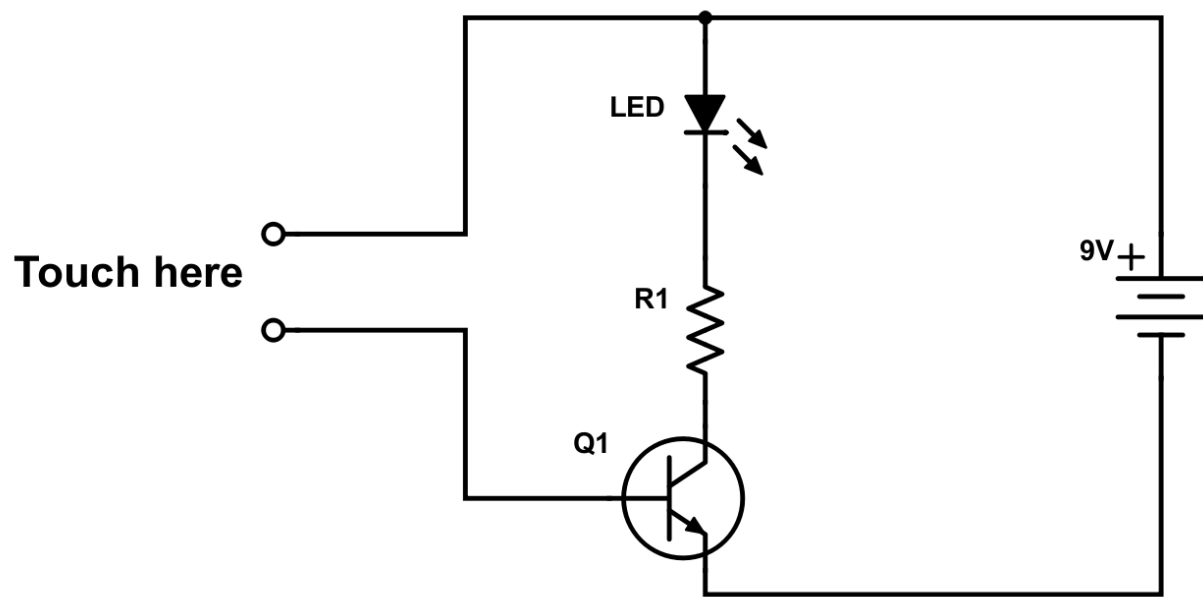


Figure 17: A touch-sensor that turns on a light when you touch it.



# The Inductor



Figure 18: An inductor on a small circuit board

An inductor is just a coil of wire. If you take a wire and wind it up into a coil, you have created an inductor. When you apply a current through the coil, a magnetic field is created around it, and this field stores energy.

When the current through the inductor stays the same, the inductor does nothing. It just lets the current pass through, just like it was a normal wire.

But when the current through the inductor changes, the built-up energy in the magnetic field will resist this change by changing the resistance of the inductor. Resistance to change is a good thing for example to create a filter to reduce noise.



Figure 19: The symbol used in circuit diagrams for an inductor

If the wire is wound around a magnetic core (for example iron), the magnetic field becomes much stronger. A *transformer* is a component made up of two inductors wound around the same magnetic core.

The transformer is a classical component used to reduce the voltage in power supplies. If you constantly change the current through one inductor (the input), the change in magnetic field is picked up by the other inductor (the output).

If the input inductor has 1000 windings, and the other inductor has only 100, then the resulting voltage on the output inductor is ten times less than the input voltage.

## Example

Inductors are often used in filters and oscillators, for example in radio equipment. But it's hard to find a practical circuit example that is both simple and really demonstrates how an inductor works, without going into mathematical explanations.

Instead, a fun example to demonstrate the magnetism that is created in an inductor is to create an electromagnet!



Figure 20: A homemade electromagnet

Here's how to do it:

1. Take some insulated wire.
2. Wind it around an iron screw, maybe about 50 times.
3. Connect a big 1.5 V flashlight battery (You can try a higher voltage, but then be very careful as it gets hot really fast.)'
4. Place it over some small metallic objects to test it.

*Note: Not all metals are magnetic. For example, copper coins won't be attracted to the magnet.*

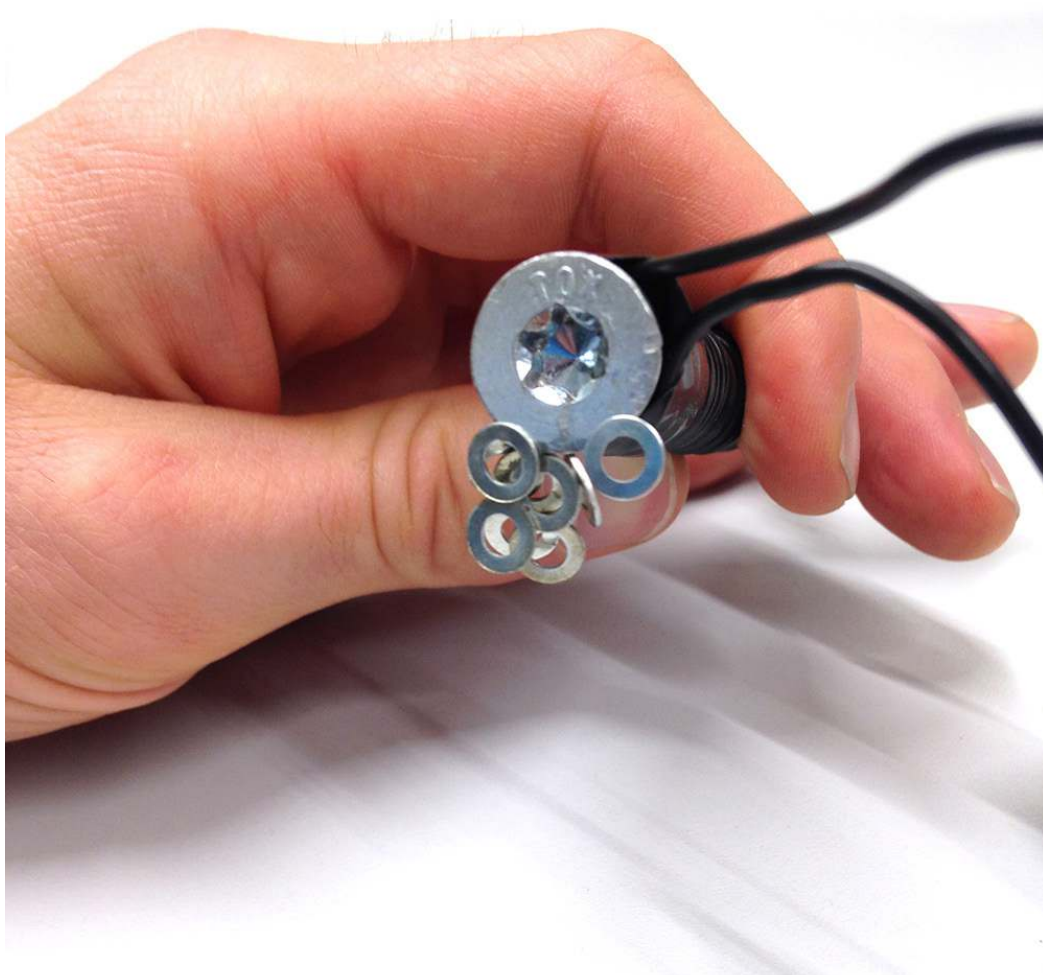


Figure 21: The electromagnet pulling some metallic objects

# The Integrated Circuit

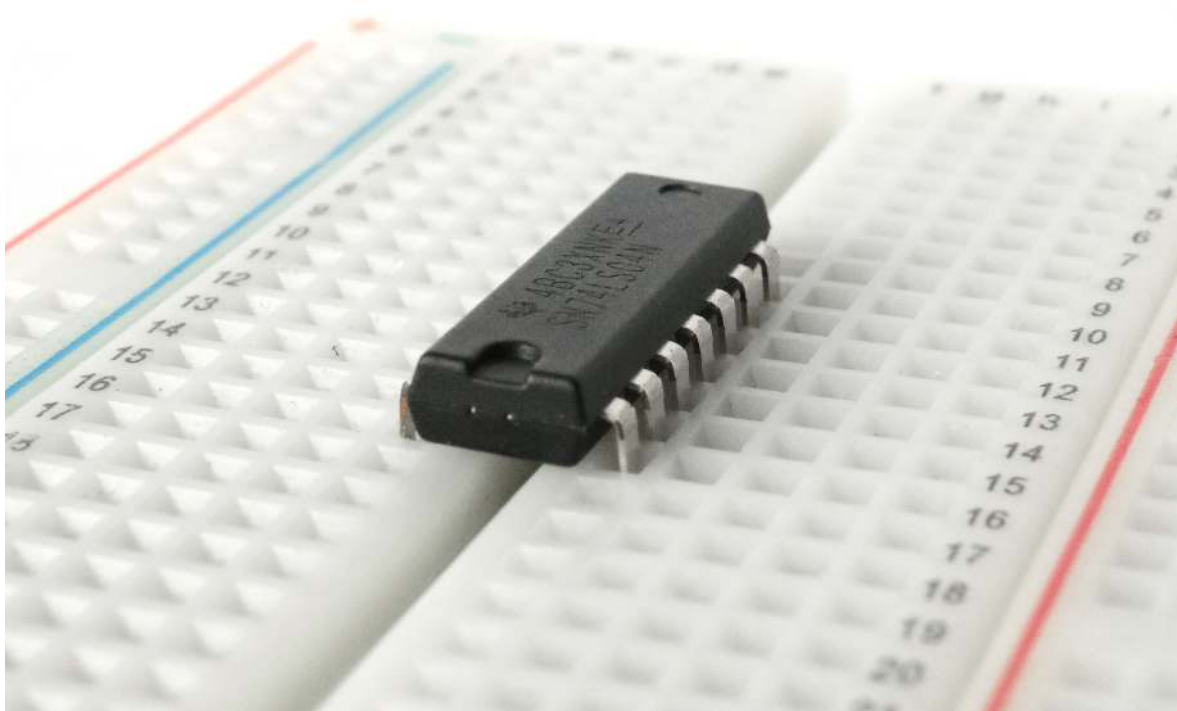


Figure 22: An Integrated Circuit (IC) connected on a breadboard

An integrated circuit is any kind of circuit that is integrated onto a chip. It can be a radio transmitter, a microcontroller, an audio amplifier or any other circuit you can think of.

By making a circuit on a small chip, it's much easier to make advanced projects. Let's say you want to make a tracking device for your car. You can find a GPS chip for positioning, a GSM chip to send text messages, and a microcontroller chip to control everything.

To figure out exactly what a specific IC does, you need to check its datasheet. The datasheet is a document that comes with every IC. You can find the datasheet for almost any IC by just searching for the chip name + "datasheet" in Google.

The datasheet explains what each of the pins does, how much voltage it needs, and often contains an example circuit to show you how to connect it.

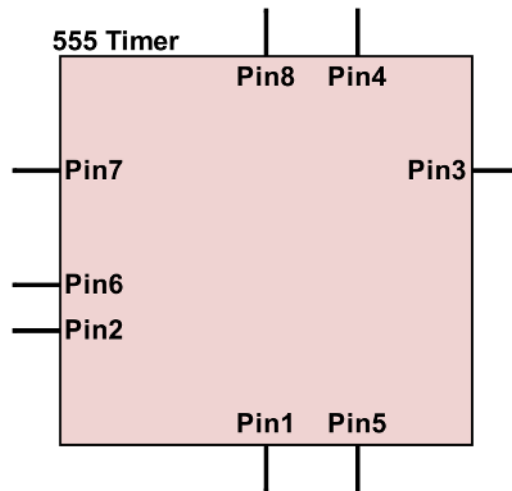


Figure 23: The symbol for an IC is often a box with pins. But it can also be the symbol of the function of the IC (like a logic gate or an operational amplifier).

## Example

The 555 timer is a very useful and popular Integrated Circuit. You can use it to blink a light, to create sound, to create a clock signal, add a countdown timer and a lot of other things.

A simple example is to blink an LED. By carefully selecting the values of the capacitor and resistors on the input side, you can control how fast the light should blink.

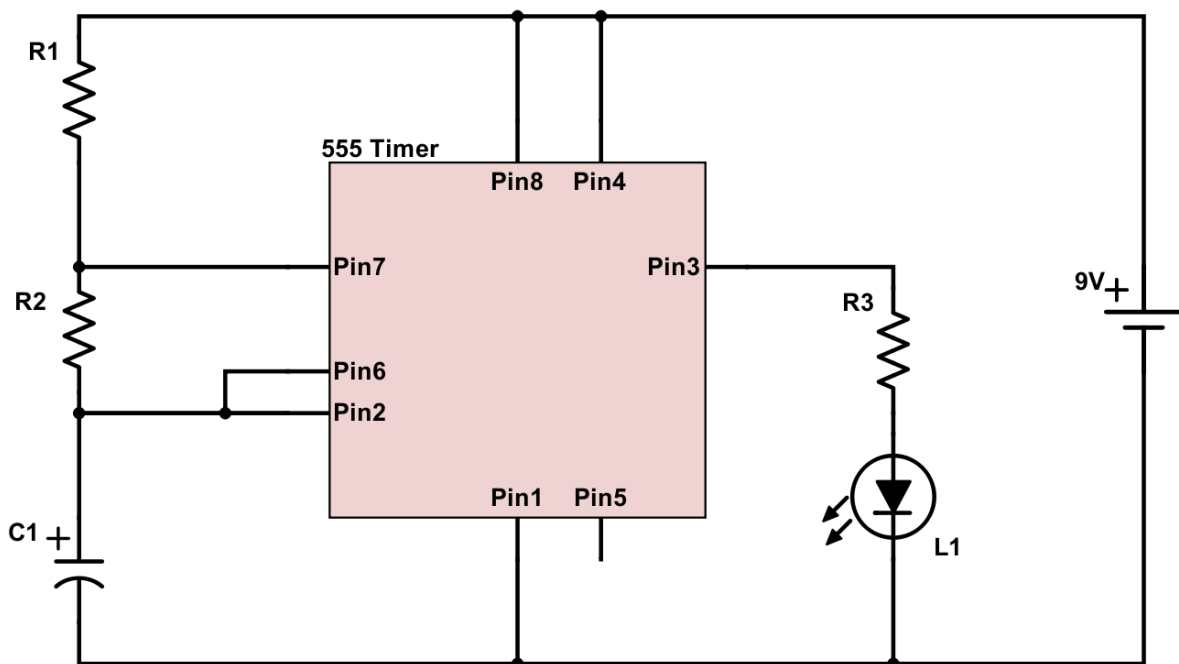


Figure 24: This circuit will make the LED blink

The circuit shown in Figure 24 will blink an LED about once per second.

The resistors R1 and R2, together with the capacitor C1, set the output frequency of the output pin. The frequency is the number of times the output goes high per second. So an output frequency of 5 Hz would mean the output goes high 5 times per second.

You can find the output frequency of your circuit by using the following formula:

$$frequency = \frac{1.44}{(R1 + R2 + R2) \times C1}$$

To find the frequency, just replace R1, R2, and C1 with the values you use, and put it all into a calculator.

Let's say you have a circuit with the following component values:

R1 = 100 kΩ

R2 = 10 kΩ

C1 = 10 μF

The resistor values are in ohms, and the capacitance is in farads. That means R1 = 100 000Ω, R2 = 10 000Ω, and C1 = 0.00001 F.

Frequency = 1.44 / ((100 000Ω + 10 000Ω + 10 000Ω) \* 0.00001 F)

Frequency = 1.44 / ((120 000Ω) \* 0.00001 F)

Frequency = 1.2 Hz

According to this calculation, the output should turn on and off 1.2 times per second with those values.

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