

Introduction to electronics

This workshop will introduce you to a number of electrical components and prototyping techniques with the aim of building a small sound producing circuit.

As a hackers/hobbyists I tend to follow a flow when producing electrical circuits. Like all good things, I start with an idea about what I want to do. This may be making some lights blink, maybe I want to generate power using a bicycle, or a want to share a 12 volt power supply with components with different electrical needs.

In order to get to the final outcome of say having my own custom printed circuit boards made, I first need to prototype my design to make sure it works (and doesn't explode, catch fire etc). Then once I'm happy with my prototype I'll be able to move onto the next stage and design my circuit board, then have them printed.

In this workshop we're going to focus on the prototyping phase, because this is where most of the fun can be had, by experimenting with ideas and learning through mistakes.

Electricity

When we think about electricity, we should think about how it's defined. In the same way that a tree is made up of a trunk, branches and leaves, electricity among other things is defined by its of *Voltage*, *Resistance* and *Current*.

Each of these elements can be measured, and have terms to describe the units of measure.

- For resistance we use the measure **Ohms**
- For voltage we use the measure **Volts**
- And finally for current we measure this in **Amps**

Each of these units operates together to provide an electrical charge to our electronics equipment, whether that's the white goods in our home or the gadgets in our lives.

Also, knowing about these values is important when applying Ohms Law to calculate the voltage, resistance or amperage requirements for your circuits. We're not going to cover Ohms Law in this workshop, but you can read more about it here http://www.allaboutcircuits.com/vol_1/chpt_2/1.html

Resistance

If we take our garden hose and turn the water on, water flows freely through the hose. However, if we apply pressure to the hose wall we prevent water from flowing freely and we end up a much slower flow of water.

Electrical resistance is like the water flowing through a hose, except instead of water we restrict the flow of electrons.

Different materials have different resistance properties. All materials have some sort of resistance, some resist the flow of electrons more than others. For example metals like copper, brass and silver have low resistance. They're so good at conducting the flow of electricity they're used all the time. Other materials like water, glass and semi-conductors (materials that contain various conducting and non-conducting/insulating materials) have different resistance properties.

- **Experiment 1:** Electrical resistance of water
- **Experiment 2:** Electrical resistance of an apple
- **Experiment 3:** Electrical resistance of a rubber eraser

In electronics if we want to restrict electrons flowing through our circuit we use a resistor. We'll get to these in a moment.

Voltage

Voltage is the force behind the flow of electrons. This force is a little like a dam wall: the bigger the wall, the more force to push the electrons along. Likewise, the more voltage, the greater the pressure and the more potential the electrical circuit has to complete its task.

In our day-to-day activities we use different voltages, in a variety of electronics devices. At home we use 240 volts for our white goods, like the washing machine, refrigerator and air conditioning units. While our mobile phones use 5 volts, remote controls use 3 volts and digital scales use 1.5 volts.

We have different voltage requirements because some electronic components are able to function with different power needs.

Experiment 4: Powering a light bulb with 3 volts and 9 volts.

Current

Current is the rate of the electrical charge passing through a point on a circuit, measured as a quantity over time.

Using the water analogy again, we may say that water is being pumped at 5 liters per second. In electrical circuits we would say how many amps are being consumed.

Another aspect we often hear of when referring to current is *Direct Current* and *Alternating Current*. Technically Direct Current travels from the positive side to the negative side of a power source, as it does in a battery. In Alternating Current as the electrons flow through the circuit they change from positive to negative really quickly – 60 times per second.

AC + DC is really about how the power is produced. Huge generators at coal fired or hydroelectric power stations produce our household power. Inside these generators is a shaft with magnets that spin. This causes the magnetic field to fluctuate from North to South and so on.

Tightly coiled wires on the outside of the generator capture this magnetic change and produce an electrical charge. This process is called inductance.

Different electrical equipment uses DC and AC. For example, at home our refrigerator, household lights, water pump, microwave and air conditioner use AC. While items that use batteries such as watches, iPods, car radio's, laptops and desktop computers use DC. However, even though we plug some of these items into mains power, the current is first transformed from AC to DC using a transformer.

Why there is both AC and DC played out a little like the Blue Ray versus HD DVD wars. If you're interested read about the Current Wars here http://en.wikipedia.org/wiki/War_of_Currents

Experiment 4: Power generation via a stepper motor and multi meter

For our circuits we're only interested in using DC power sources.

Electric circuit

"An electric circuit is formed when a conductive path is created to allow free electrons to continuously move. This continuous movement of free electrons through the conductors of a circuit is called a current, and it is often referred to in terms of "flow," just like the flow of a liquid through a hollow pipe.

The force motivating electrons to "flow" in a circuit is called voltage.

Free electrons tend to move through conductors with some degree of friction, or opposition to motion. This opposition to motion is more properly called resistance. The amount of current in a circuit depends on the amount

of voltage available to motivate the electrons, and also the amount of resistance in the circuit to oppose electron flow.”

What’s in our pack?

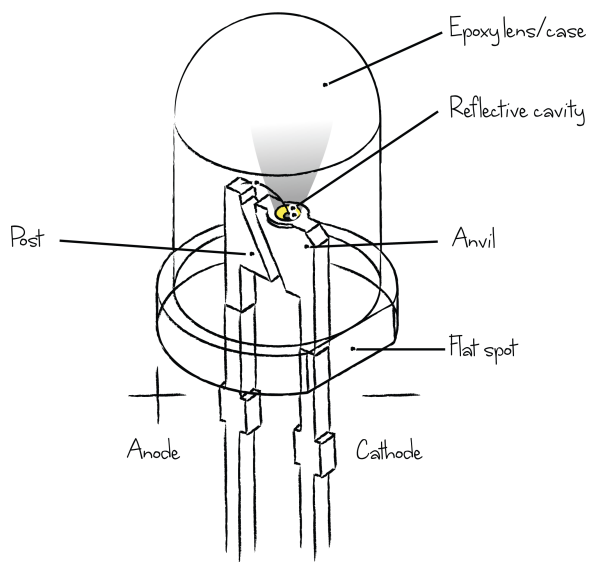
- **Breadboard.** Breadboards are used as a way of prototyping our circuits. They have holes that let us temporarily plug in components for testing.
- Two **resistors**, one yellow with four coloured bands, and one blue with five coloured bands. These colours indicate their resistance values. Remember when we spoke about resistance before? Well, these resistors are made of different materials, the yellow one is carbon and the blue one is metal film. Different materials also have different accuracy, metal film being more accurate than carbon.

The yellow one has the bands: brown, black, red, gold ($1k\Omega$)

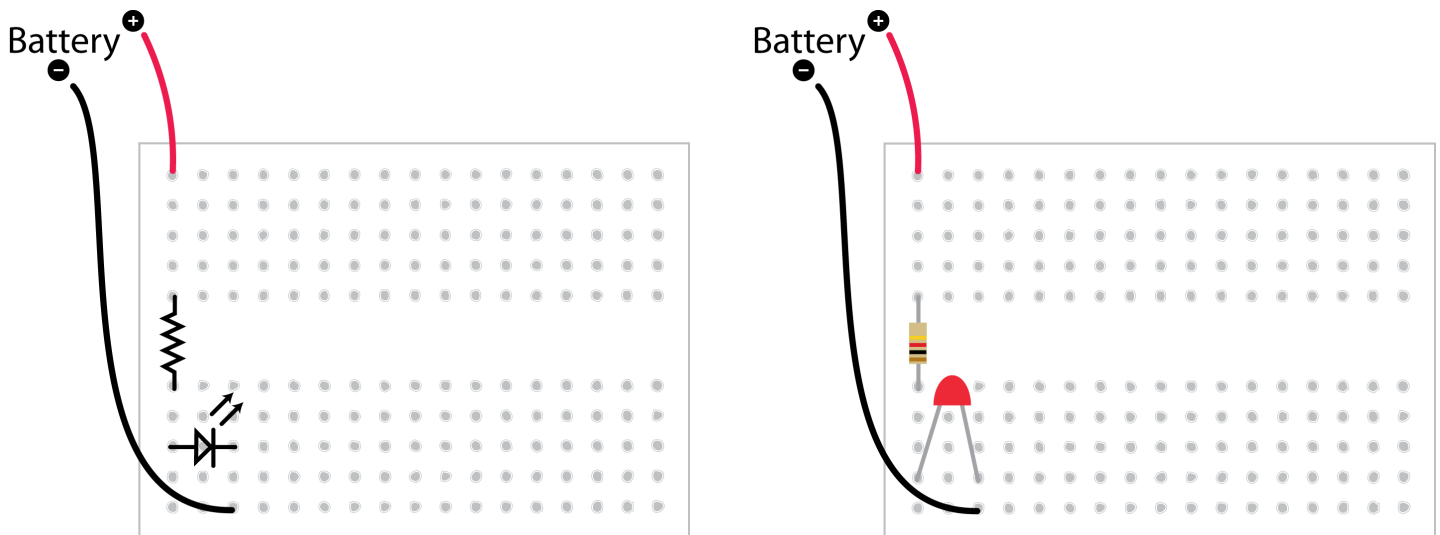
The blue one has the bands: brown, black, black, purple, red (270Ω)

To calculate the value you can use an online calculator like the one here <http://www.hobby-hour.com/electronics/resistorcalculator.php> or read more about resistors here http://www.allaboutcircuits.com/vol_1/chpt_2/5.html

- **LED** or Light Emitting Diode is a type of Diode. Diodes only let an electric charge travel from the positive side to the negative side. They will not work if they are around the wrong way. This is also true for a LED. You can tell which is the positive and negative side of an LED by looking at the legs: the longer leg is the positive and the short the negative. The other way is looking inside the LED. One side has an anvil (like Bugs Bunny and the Coyote): this is the negative side. The smaller side, “the post” is the positive.



- **Exercise 1: On your breadboard connect a resistor and an LED light together using the schematic below.**



- Potentiometer / trim pot, is another type of resistor, except the resistance changes as you turn the knob. They're often used in stereos to change the volume for example.

The potentiometer has three legs: the middle is the wiper and is a bit like a windscreen wiper on the inside. We want to use the charge from this leg. The other two legs are used to bring the charge in, and the left over charge out.

Experiment 5: Show the potentiometer change the brightness of an LED light.

- Capacitor. The capacitor is like a small temporary battery. It's used in circuits to help filter fluctuations in the charge. For example the power boards we use at home have capacitors in them to help protect our electrical items if there is a short gap in the power supply. Likewise they're used to filter out unwanted noise in audio circuits.

Capacitors store electrical energy in an electrostatic field, which is measured in farads: or simply the ratio of the electric charge.

Capacitors come in a variety of types and some even have a polarity – that is a positive and negative side. The capacitors we're using have a positive and negative side

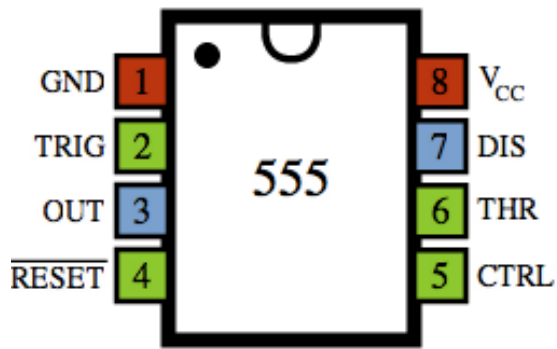
Experiment 6: Show the capacitor charging and lighting a LED light

You can read more about capacitors here http://www.allaboutcircuits.com/vol_1/chpt_13/index.html

- 555 Timer. The 555 timer is an integrated circuit. Inside there are lots of tiny resistors and transistors that together let us keep time, oscillate or trigger a one off event. They're used to say turn off the light in your car a few seconds after you lock the doors, used to turn Christmas lights on and off and for us to produce a square wave to make a noise.

The circuit has eight pins (or legs), with each pin used for different purpose.

Just a quick note on some terminology. In digital electronics we say things like HIGH and LOW. What this essentially means is when something is HIGH an electrical charge is being applied (or flowing), when something is LOW, no charge is being applied (or flowing).



Pin 1: Ground (the negative side of our power source)

Pin 2: Trigger: when LOW this will trigger pin 3 to HIGH

Pin 3: Output: You connect something you want turned on or off to this pin. For example a light or in our case a speaker.

Pin 4: Reset. This pin is held HIGH to start the timer

Pin 5: CTRL. Used to control the output voltage (we're not going to use this pin)

Pin 6: THR: The interval ends when the voltage at THR is greater than CTRL.

Pin 7: Discharge. The open collector output, which is in phase with the output (that if the output is HIGH, the discharge is LOW).

For more specific information about the 555 you can download a copy of the data sheet here

<https://www.national.com/ds/LM/LM555.pdf> or read more about the modes and uses of the 555 here

<http://www.kpsec.freeuk.com/555timer.htm>

There are also plenty of experiments and projects you can use the 555 in here

<http://blog.makezine.com/tag/555-week/>

- **Speaker.** A speaker is a type of inductor, so it has a magnet and coils of wire. When a charge is applied to the coils of wire a magnetic field is created, forcing the magnet to move the speaker cone. This results in a change of air pressure, which we hear as sound.

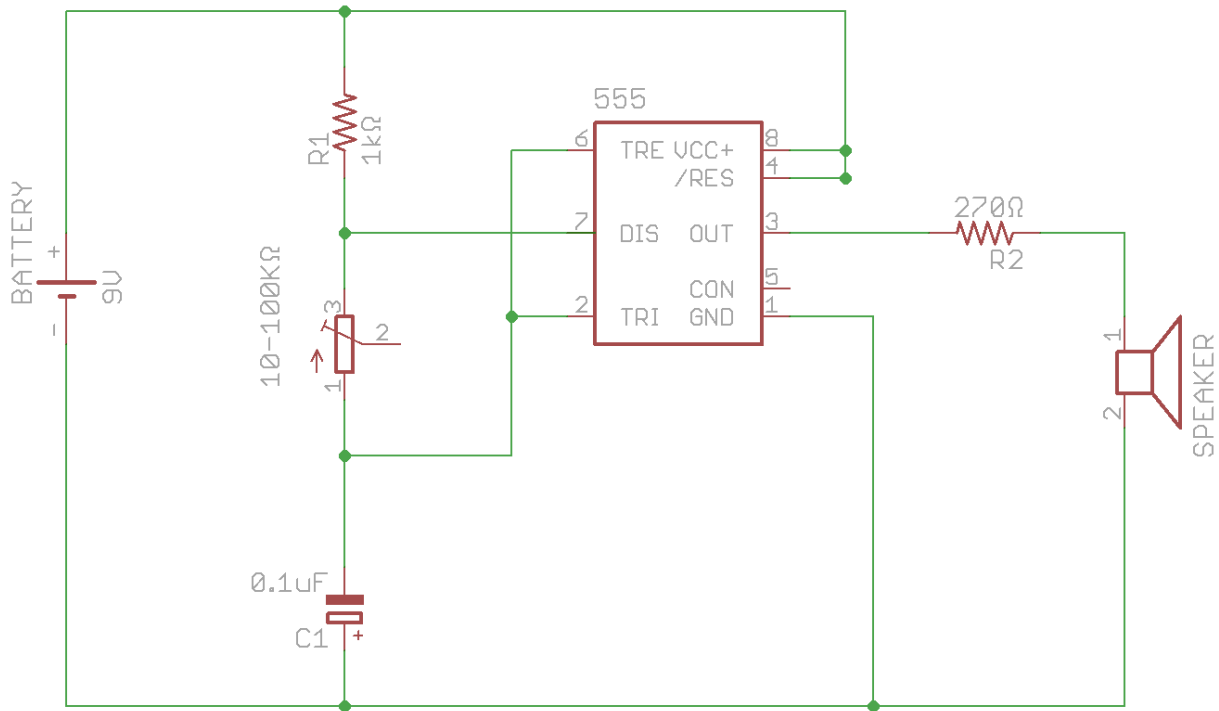
What are we building?

We're building a circuit that produces a square wave to produce a sound. In the circuit we will use a potentiometer to adjust the timing or frequency of the square wave output.

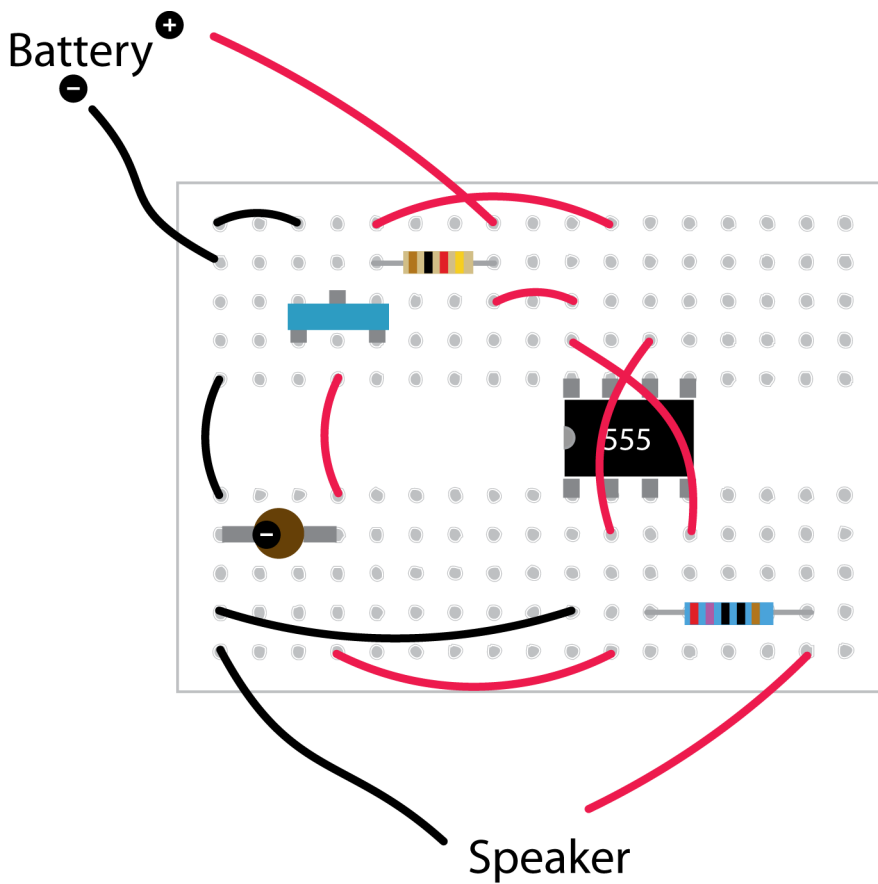
Experiment 7: Show an example of square wave audio file.

Experiment 8: Show the java

Exercise 2: Follow either the schematic or the wiring diagram to complete your circuit.



Schematic



Wiring diagram