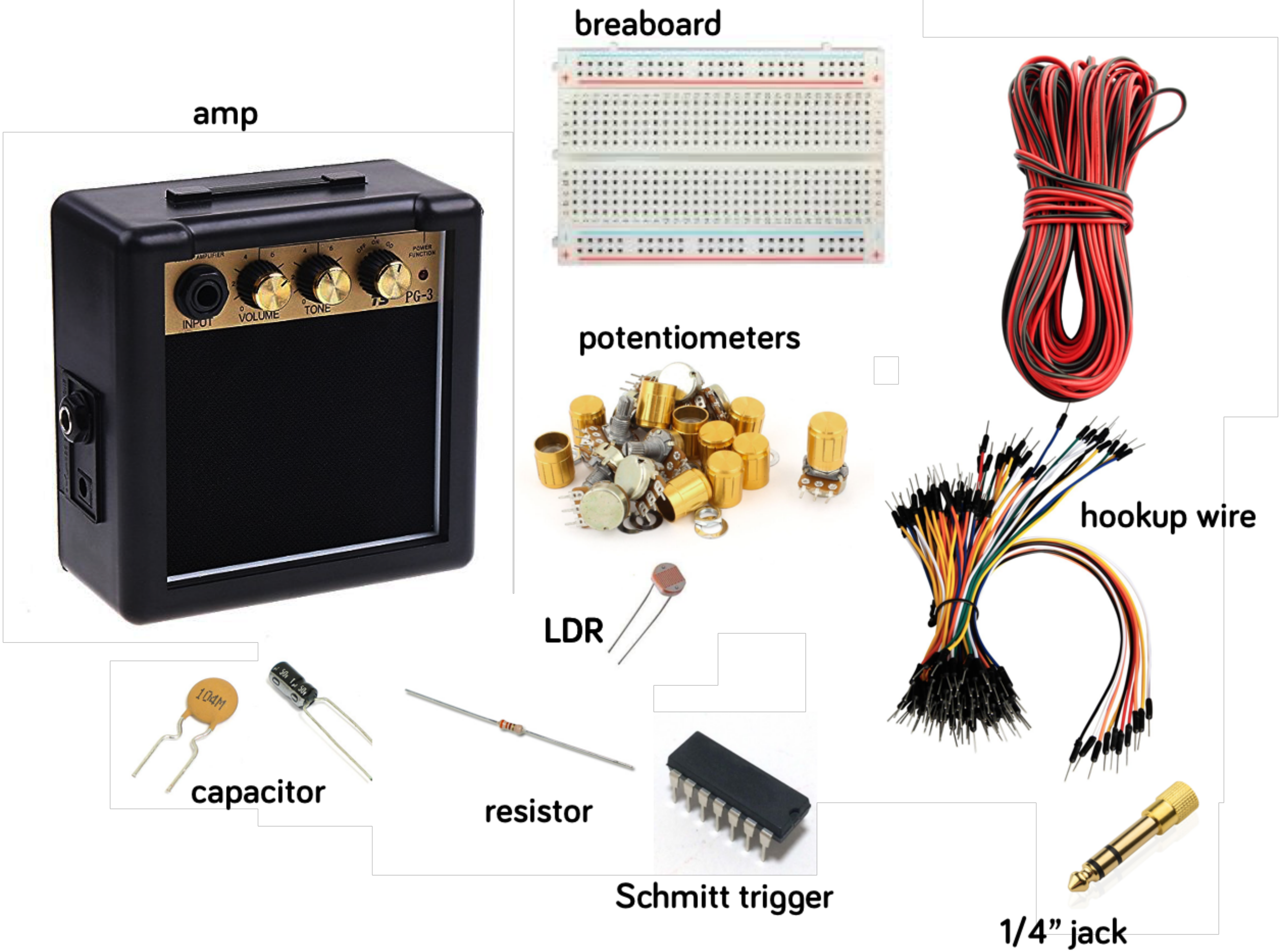
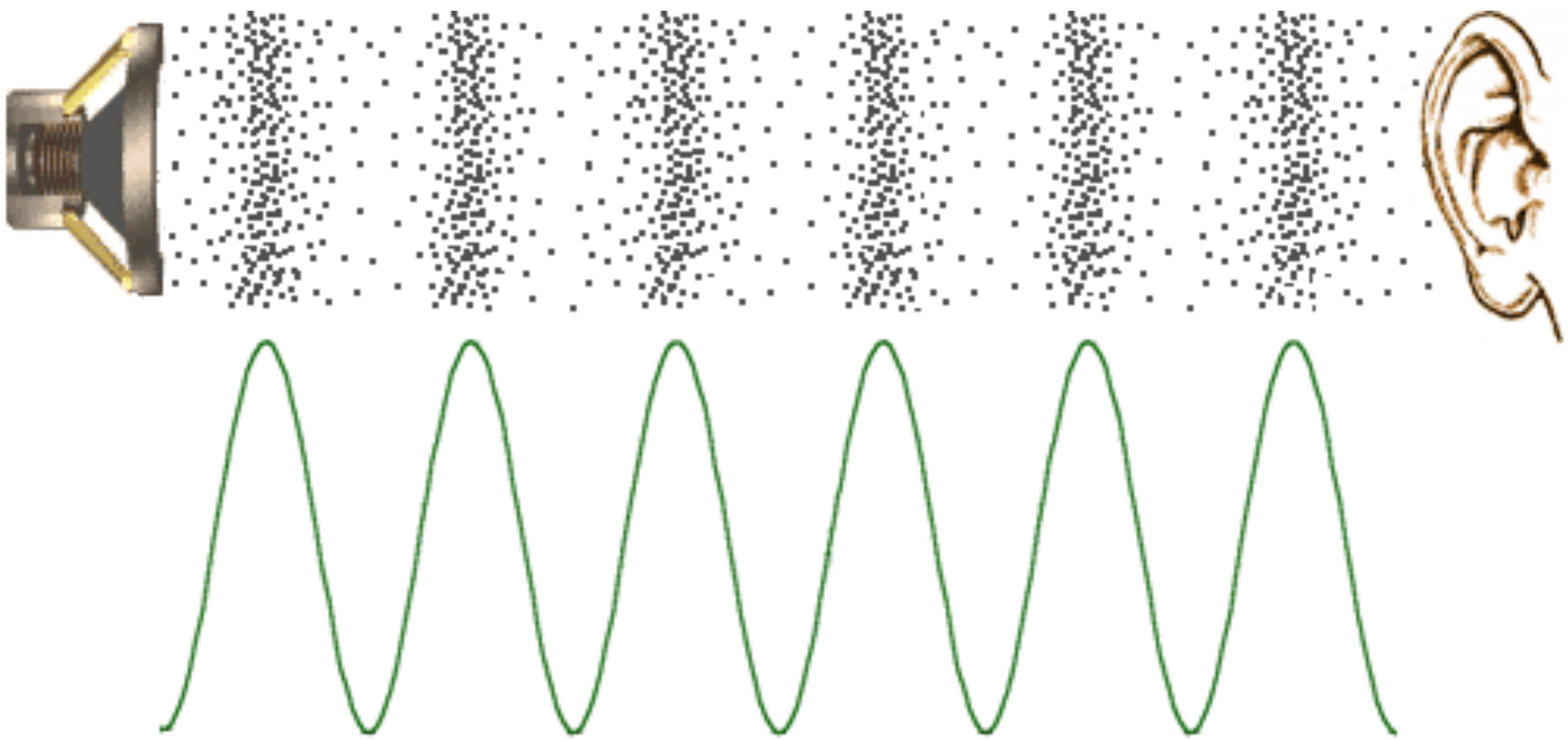

from: cats on synthesizers in space


breaboard
amp
INPUT
VOLUME
TONE
PG-3
potentiometers
hookup wire
LDR
104M
capacitor
resistor
Schmitt trigger
1/4” jack

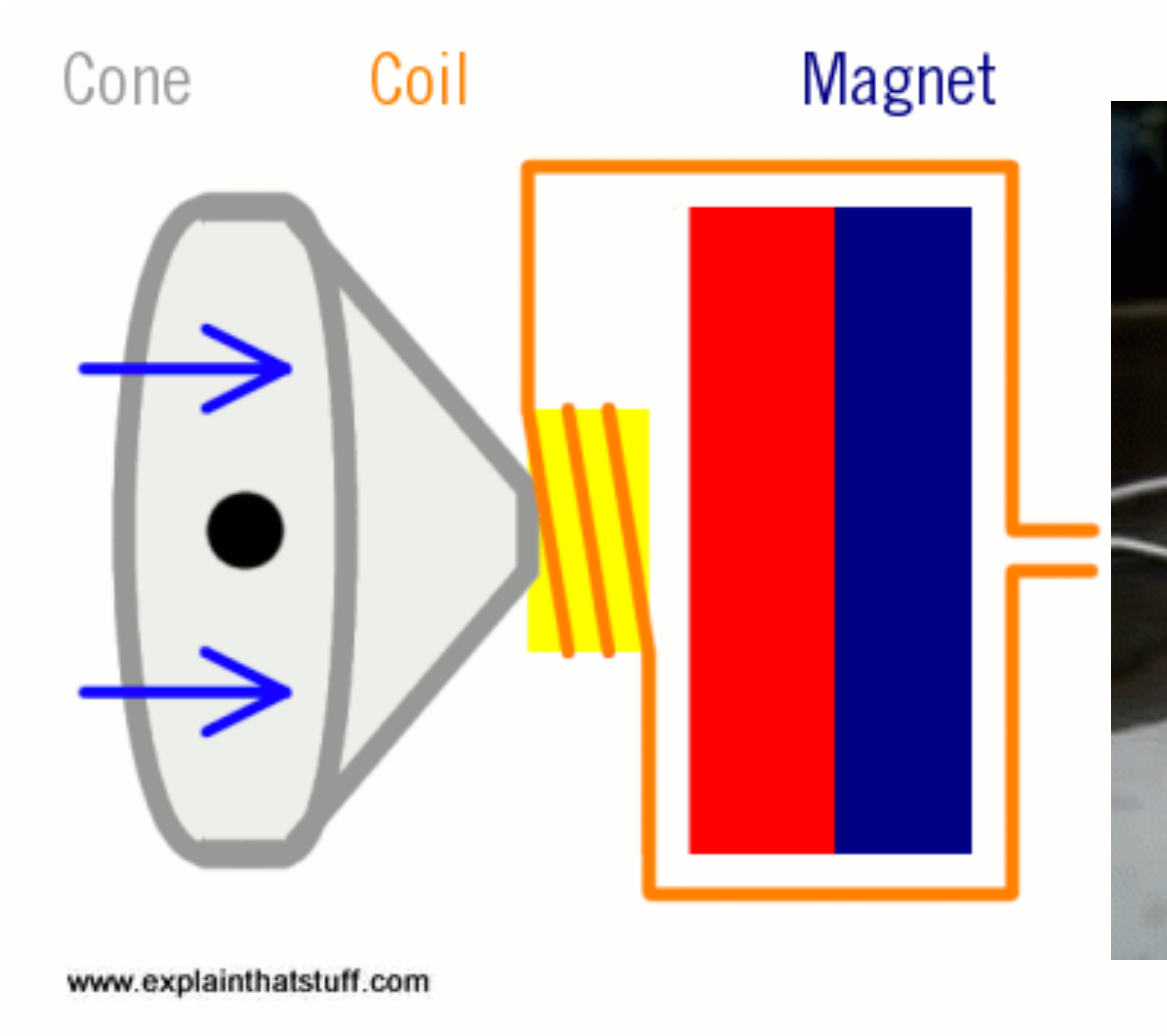
how does a speaker work?

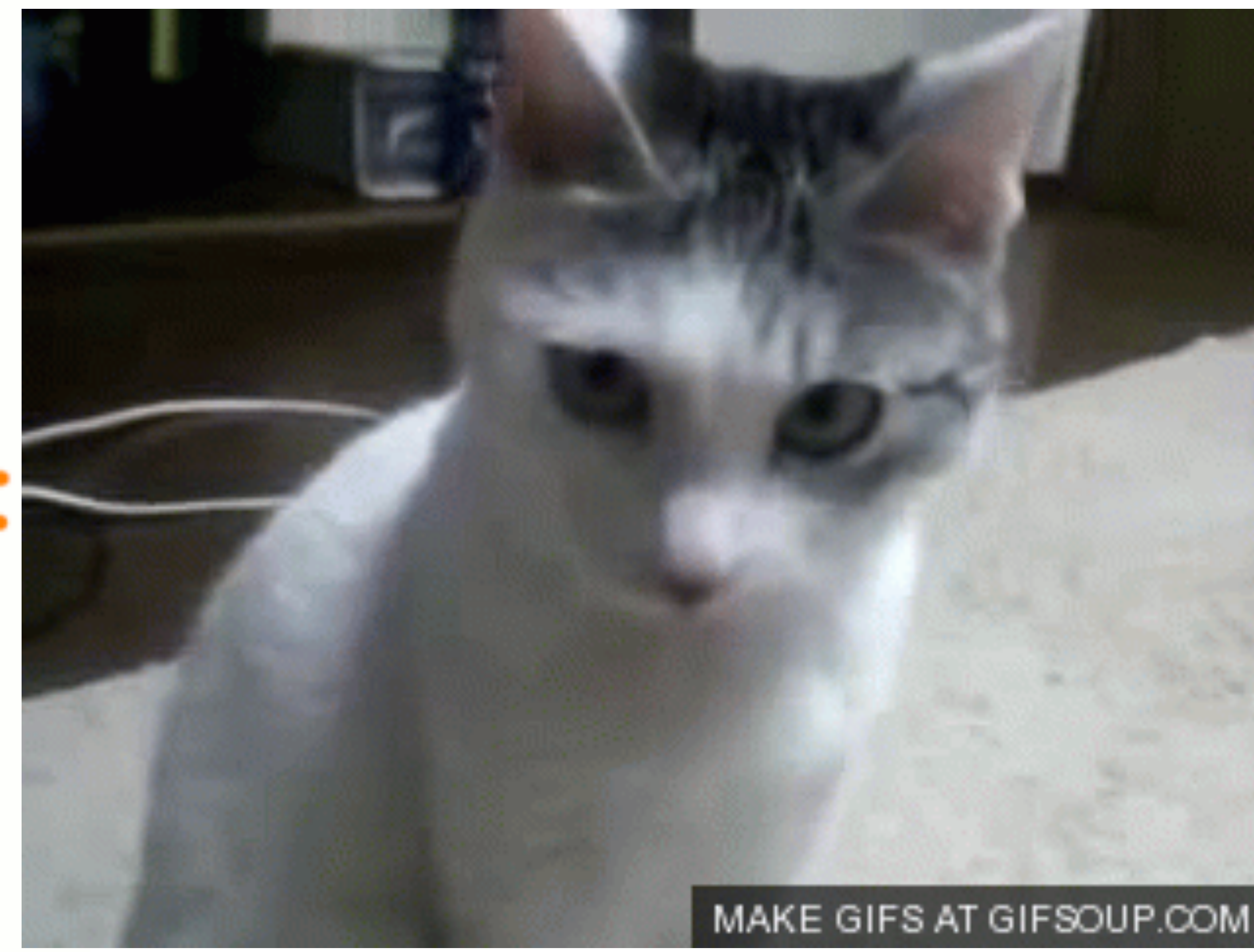
If you separate a coil and a magnet, they’ll pull together when you apply current and snap out when you stop the current. This will push the air outward with a velocity.

We can hear that - we call it sound.



In this way we can control how fast the magnet contracts in and out using voltage. This lets us hear voltage as **sound**.

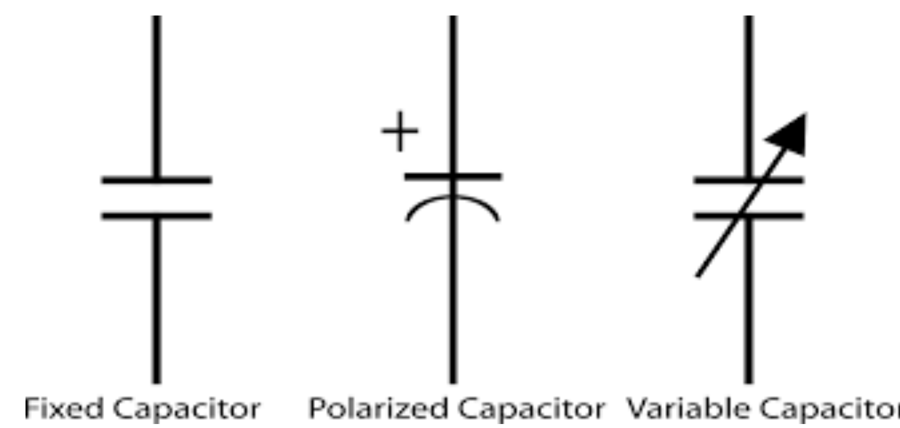




Capacitor

stores electronic current for use later.

Often used to smooth power spikes in a circuit. If it wasn't for capacitors, in your car when your speakers boomed, the car lights would dim. In our circuit, they'll smooth out the on / off square waves our oscillator makes.



Capacitors measure charge they store in farads

Pico Farads (pF)	Nano Farads (nF)	Micro Farads (µF)
1	0.001	0.000001
10	0.01	0.00001
100	0.1	0.0001
1000	1	0.001
10000	10	0.01
100000	100	0.1
1000000	1000	1
10000000	10000	10
100000000	100000	100

http://mechatrotutor.blogspot.com/

easy converter chart
http://www.convertunits.com/from/microfarad/to/picofarad

Capacitors II

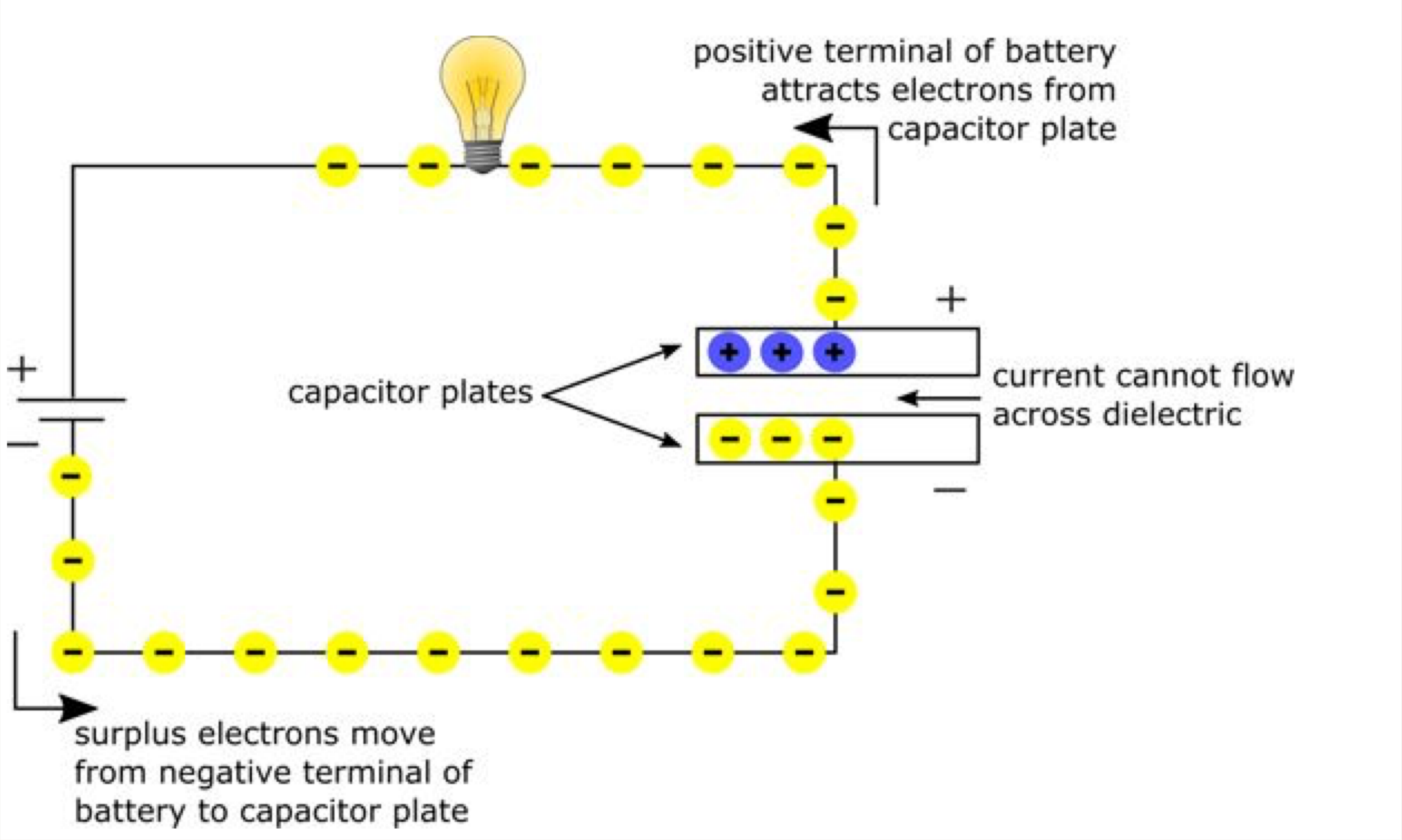
You can get energy from the source like a battery or generator
Or from a device like a capacitor that stores it

If you remove the voltage and isolate a capacitor, it will hang onto the electrical current inside it

A capacitor is made from two metal plates separated by an insulator, which is known as a dielectric.

When the voltage drop across the plates is equal to the battery voltage, the capacitor is said to be fully charged.

Capacitors II



Capacitors II

When the voltage drop across the plates is equal to the battery voltage, the capacitor is said to be fully charged.

The power source keeps pushing electrons onto one plate (and pulling electrons off the other plate) until the voltage drop across the capacitor plates is equal to the battery voltage.

At this equilibrium point, there is no voltage differential between the battery and the capacitor, so there’s no push for electrons to flow from the battery to the capacitor. The capacitor stops charging, and electrons stop moving through the circuit.

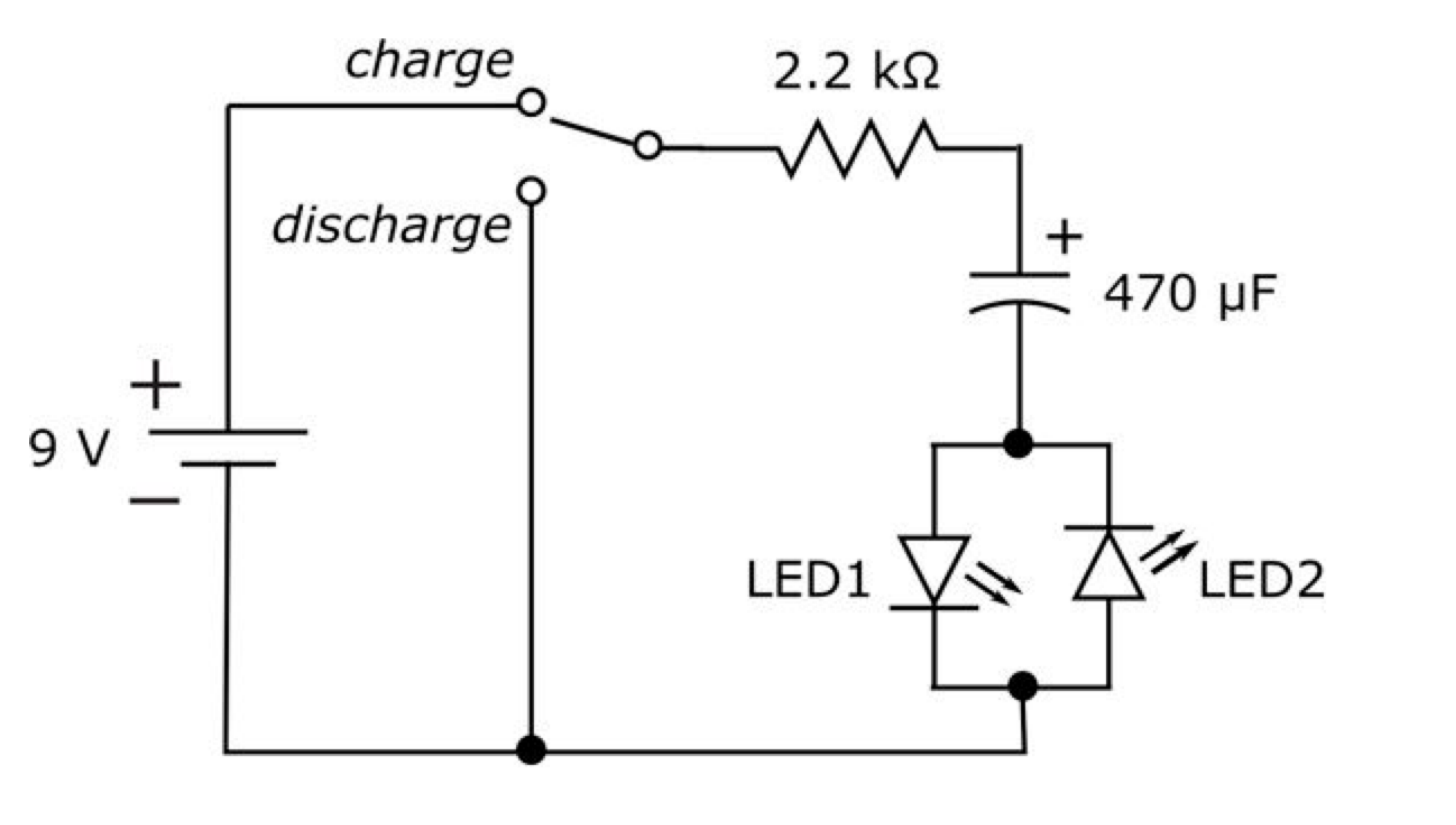
AKA Capacitors can effectively block DC current

Capacitors II

Think of a capacitor like a car at a red light. It takes time to slow and time to reach it’s original velocity again just like a capacitor.

Common uses
A flash in a camera
A car stereo - if it wasn’t for the capacitor every time there was a large base beat the lights would dim because of the voltage change
Capacitors are often used in timing circuits to create ticks and tocks when the voltage rises above or falls below a certain level in a circuit (synths).
Because they filter voltage, they are also used to tune radios

Simple charging and discharging circuit



Capacitors and AC

So far in the class we've only worked with DC, such a current from a battery
However, capacitors are often used to smooth current in AC circuits

Whereas a capacitor can block current in a DC circuit it can make current level out and pass in an AC circuit

As the AC source voltage rises from 0 volts to its peak voltage, the capacitor charges

When the AC supply reaches it's max voltage the capacitor might or might not be a peak charge

At some point, when the power supply goes from peak back to 0v the voltage in the capacitor will become less than the capacitor voltage. At this point, the capacitor starts to discharge.

(imagine being in a circuit as an atom)

Capacitors and AC

The charge is building up on the capacitors plates themselves and not jumping across the dielectric.

The plate that previously held more negative charges now holds positive charges, and the plate that previously held more positive charges now holds more negative charges.

As the source voltage rises from its negative peak, the capacitor again discharges through the AC source, but in the direction opposite to that of its original discharge, and the cycle repeats.

If you add a light bulb to your capacitor circuit powered by an AC voltage source, the bulb will light and will stay lit as long as the AC source is connected.

Although no current ever passes through the capacitor, the charging/ discharging action of the capacitor creates the effect of current flowing back and forth through the circuit.

Capacitance

Capacitance is the capability of a body to store an electric charge. The same term — capacitance — is used to describe just how much charge a capacitor can store on either one of its plates. The higher the capacitance, the more charge the capacitor can store.

Depends on

* surface area of metal plates
* thickness of the dielectric
* the type of material the dielectric is make out of

Units of measure

Capacitance is measured in units called **farads**. One farad (abbreviated **F**) is defined as the capacitance needed to get one amp of current to flow when the voltage changes at a rate of one volt per second.

Most common are microfarad (μF) or picofarad (pF) range.
A microfarad is a millionth of a farad, or 0.000001 farad,
A picofarad is a millionth of a millionth of a farad, or 0.000000000001 farad.

Here are some examples:
A 10 μF capacitor is 10 millionths of a farad.
A 1 μF capacitor is 1 millionth of a farad.
A 100 pF capacitor is 100 millionths of a millionth of a farad, or you could say it is 100 millionths of a microfarad.

Just like resistors, capacitors have a variance

Table 7-1 Capacitor Characteristics

Type	*Typical Range*	*Application*
Ceramic	1 pF to 2.2 µF	Filtering, bypass
Mica	1 pF to 1 µF	Timing, oscillator, precision circuits
Metalized foil	0.01 to 100 µF	DC blocking, power supply, filtering
Polyester (Mylar)	0.001 to 100 µF	Coupling, bypass
Polypropylene	100 pF to 50 µF	Switching power supply
Polystyrene	10 pF to 10 µF	Timing, tuning circuits
Tantalum (electrolytic)	0.001 to 1,000 µF	Bypass, coupling, DC blocking
Aluminum electrolytic	10 to 220,000 µF	Filtering, coupling, bypass, smoothing

Working voltage

The working voltage, sometimes abbreviated as **WV**, is the highest voltage that the manufacturer recommends placing across a capacitor safely.

Capacitors designed for DC circuits are typically rated for a WV of no more than 16 V to 35 V.

If you build circuits that use higher voltages, be sure to select a capacitor that has a WV of at least 10% to 15% more than the supply voltage in your

Dielectric material application

Electrolytic capacitors can handle large currents but perform reliably only for signal frequencies of less than 100 kHz

Commonly used in ***audio amplifiers*** and power supply circuits.

Mica capacitors, however, exhibit exceptional frequency characteristics and are ***often used in radio frequency (RF) transmitter circuits***.

You need to match your capacitor to the one suggested in your diagram. The most common dielectric materials are aluminum electrolytic, **tantalum electrolytic**, **ceramic**, **mica**, **polypropylene**, **polyester** (or Mylar), and **polystyrene**.

Capacitor polarity

Some larger-value electrolytic capacitors (1 μF and up) are ***polarized*** — meaning that the positive terminal must be kept at a higher voltage than the negative terminal, so it matters which way you insert the capacitor into your circuit.

Polarized capacitors are designed for use in DC circuits.

Many polarized capacitors sport a minus (–) sign or a large arrow pointing toward the negative terminal. For radial capacitors, the negative lead is often shorter than the positive lead.

WATCH!

If you reverse your polarity in a polarized circuit - kiss your components good bye.

The capacitor might even explode

Reading values

Some capacitors have the values printed on them -
Some use a numbering system, like 103 or 104 (particularly smaller one)

The system is based on **picofarads**, not **microfarads**.
A number using this marking system, such as 103, means 10, followed by three zeros, as in 10,000, for a total of 10,000 picofarads.

For instance, a value of 22 means 22 picofarads. No third digit means no zeros to tag on to the end.

Reading values

For values over 1,000 picofarads, your parts supplier will most likely list the capacitor in microfarads, even if the markings on it indicate picofarads.

To convert the picofarad value on the capacitor into microfarads, just move the decimal point ***six places to the left***. So a capacitor marked with a 103 has a value of 10,000 pF or 0.01 μF.

Note there are other systems but for the sake of time we're not covering here.

Varying capacitors

These capacitors allow you to adjust the capacitance to suit your needs

The most common type of variable capacitor is the ***air dielectric***, which is found frequently in the tuning controls of AM radios.

Smaller-variable capacitors are often used in radio receivers and transmitters, and they work in circuits that use quartz crystals to provide an accurate reference signal. The value of such variable capacitors typically falls in the 5 pF to 500 pF range.

These can also be mechanically controlled by moving the plates

There are special diodes that act as a variable capacitor; such devices are known as varactors or varicaps —

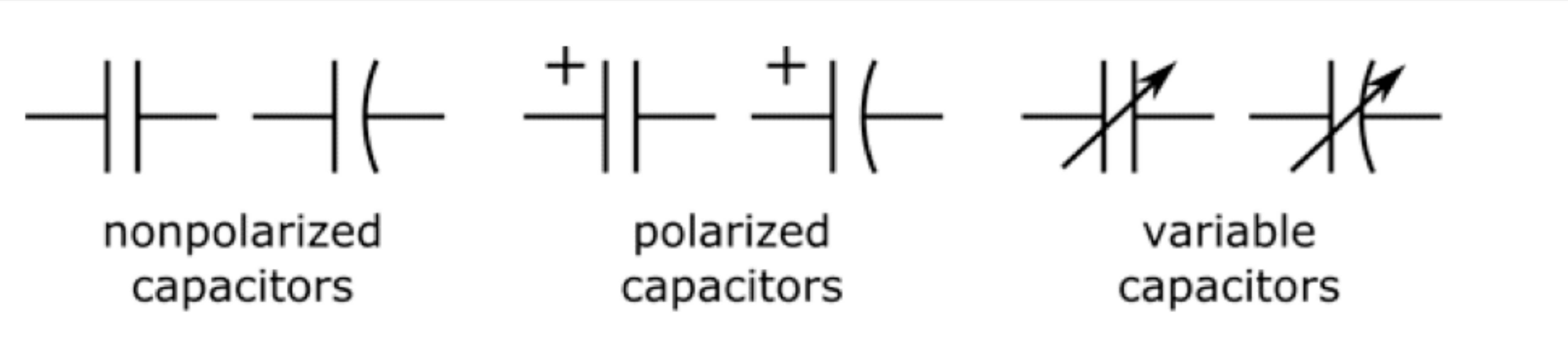
Microphones

These are very common
They are in all smart phones and touch devices

Condensers microphones uses a variable capacitor to convert sound into electrical signals, with the diaphragm of the mic acting as a movable capacitor plate.

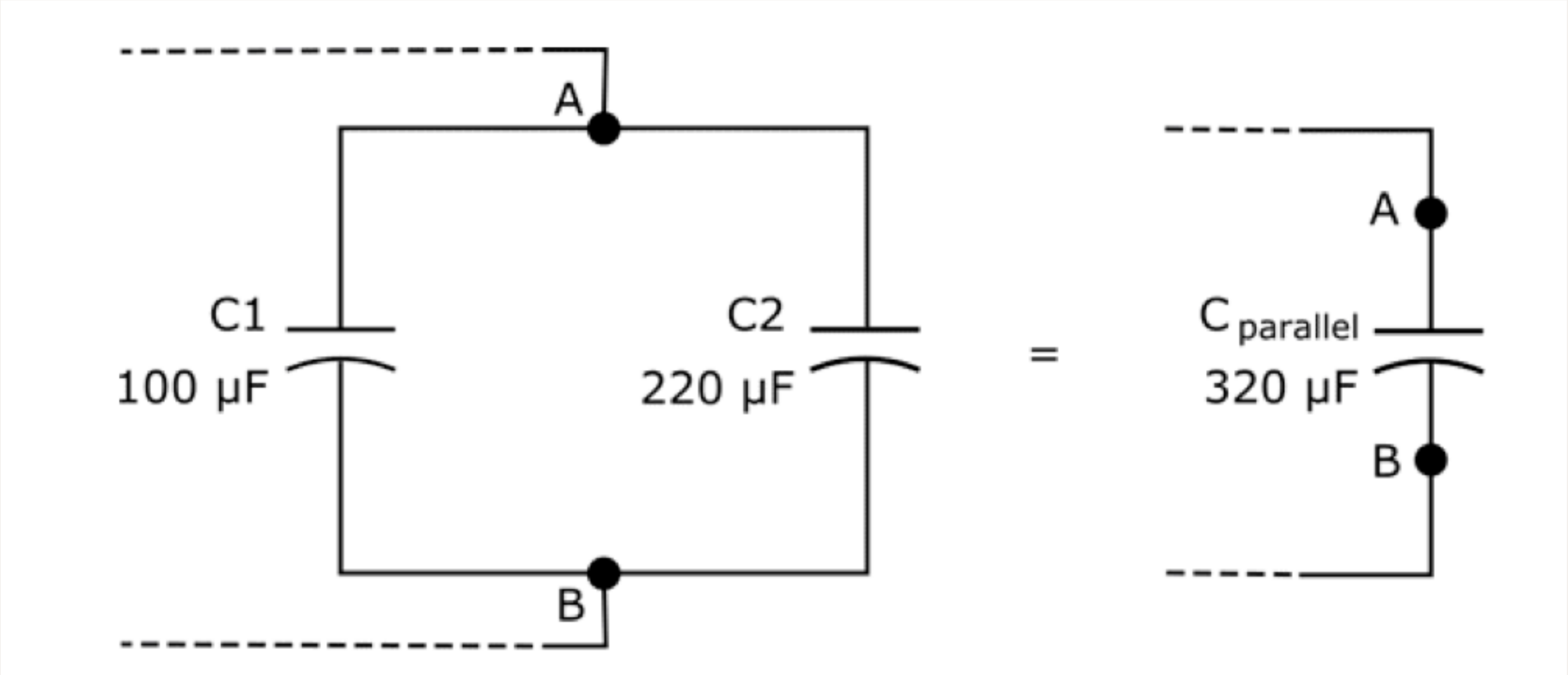
Sound fluctuations make the diaphragm vibrate, which varies the capacitance, producing voltage fluctuations.

Capacitor diagrams



Capacitor in parallel

Cparallel= C1+ C2 + C3 ……



Capacitor in series

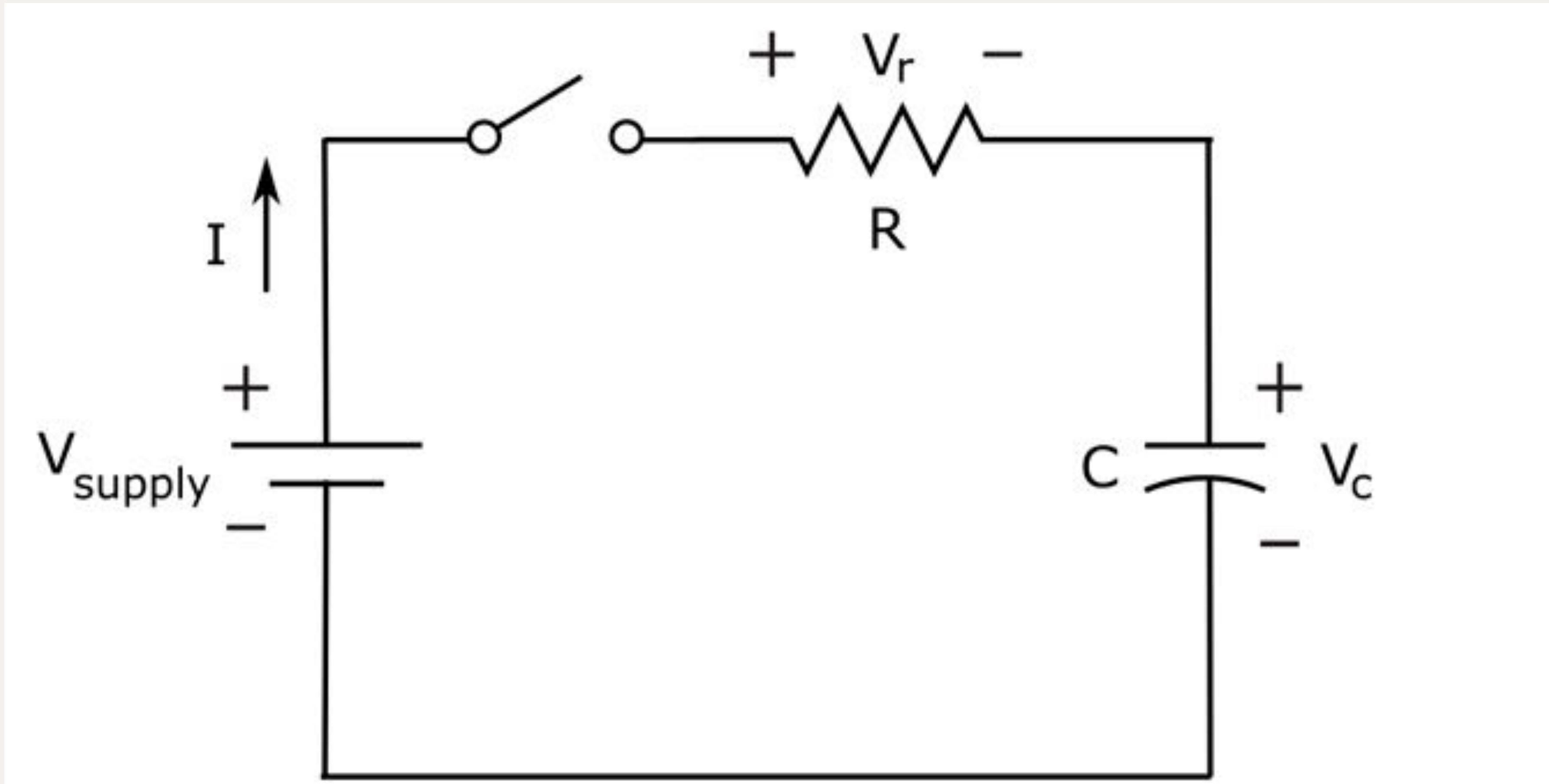
$$C_{series} = \frac{C1 \times C2}{C1 + C2}$$

Teaming up with resistors

This is where the magic happens

Capacitors are often found working hand in hand with resistors in electronic circuits, combining their talent for storing electrical energy with a resistor's control of electron flow.

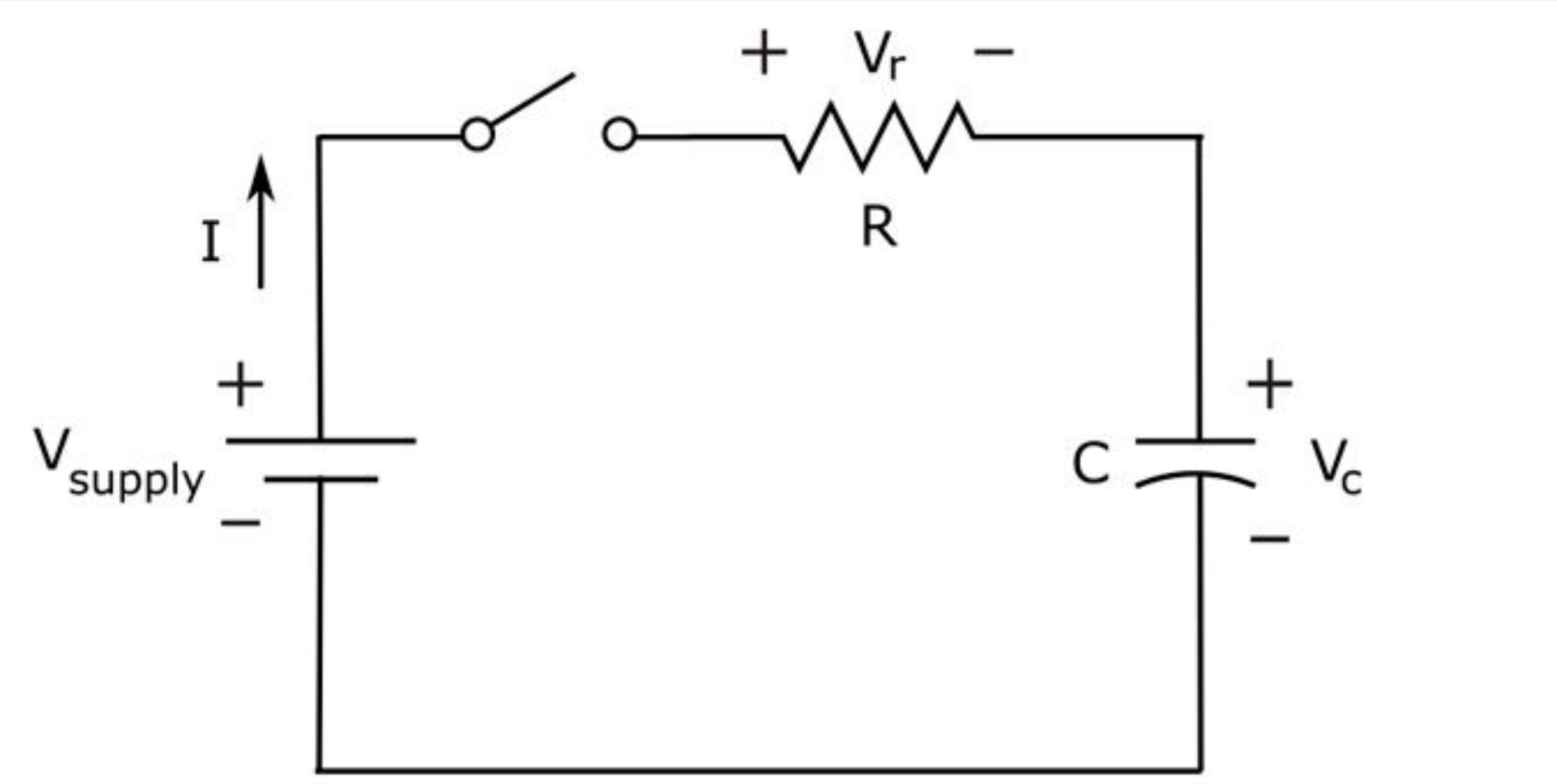
Put these two capabilities together and you can control how fast electrons fill (or charge) a capacitor — and how fast those electrons empty out (or discharge) from a capacitor. This dynamic duo is so popular that circuits containing both resistors and capacitors are known by a handy nickname: ***RC circuits.***



When you close the switch, current starts to flow and charges start to build up on the capacitor plates.

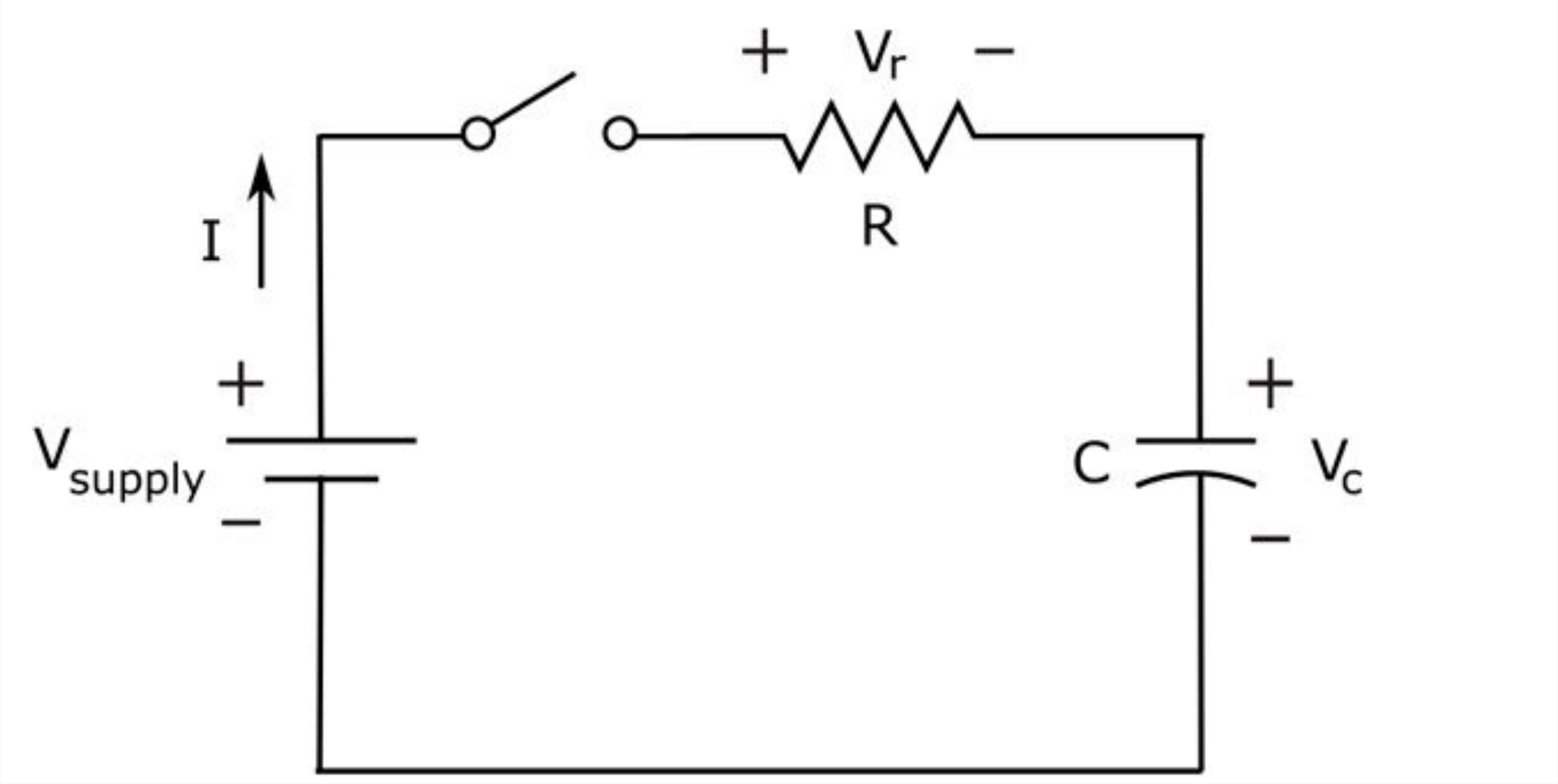
Ohm's Law tells you that the charging current, I, is determined by the voltage across the resistor, V_r, and the value of the resistor, R.

$I = V_r /r$



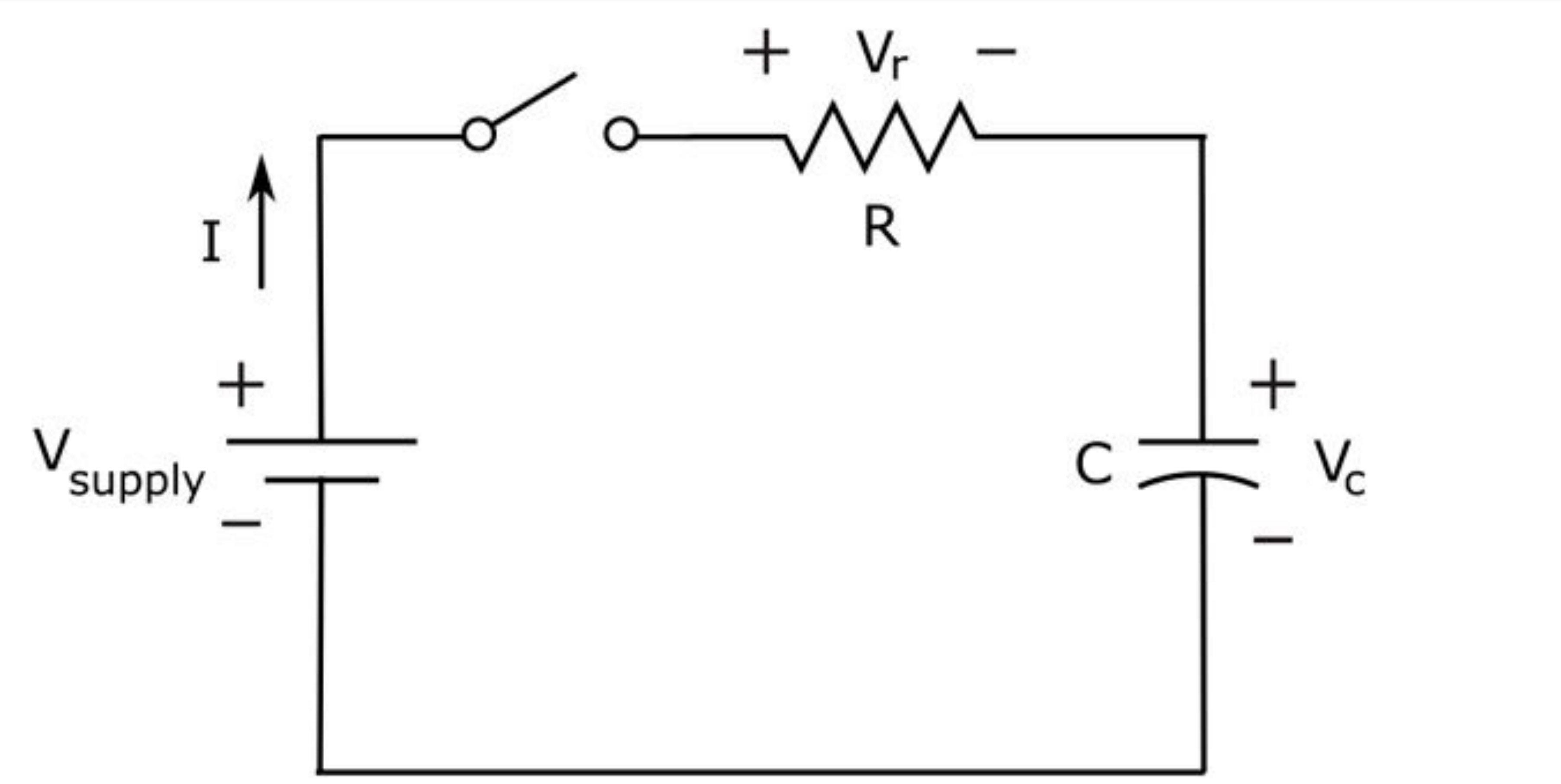
And because the voltage drops equal the voltage rises around the circuit, you know that the resistor voltage is the difference between the supply voltage, Vsupply, and the capacitor voltage, Vc

$$V_r = V_{supply} - V_c$$



And because the voltage drops equal the voltage rises around the circuit, you know that the resistor voltage is the difference between the supply voltage, Vsupply, and the capacitor voltage, Vc

$$V_r = V_{supply} - V_c$$



Initially: Because the capacitor voltage is initially zero, the resistor voltage is initially equal to the supply voltage.

Charging: As the capacitor begins to charge, it develops a voltage, so the resistor voltage begins to fall, which in turn reduces the charging current. The capacitor continues to charge, but at a slower rate because the charging current has decreased. As Vc continues to increase, Vr continues to decrease, so the current continues to decrease.

Fully charged: When the capacitor is fully charged, current stops flowing, the voltage drop across the resistor is zero, and the voltage drop across the capacitor is equal to the supply voltage.

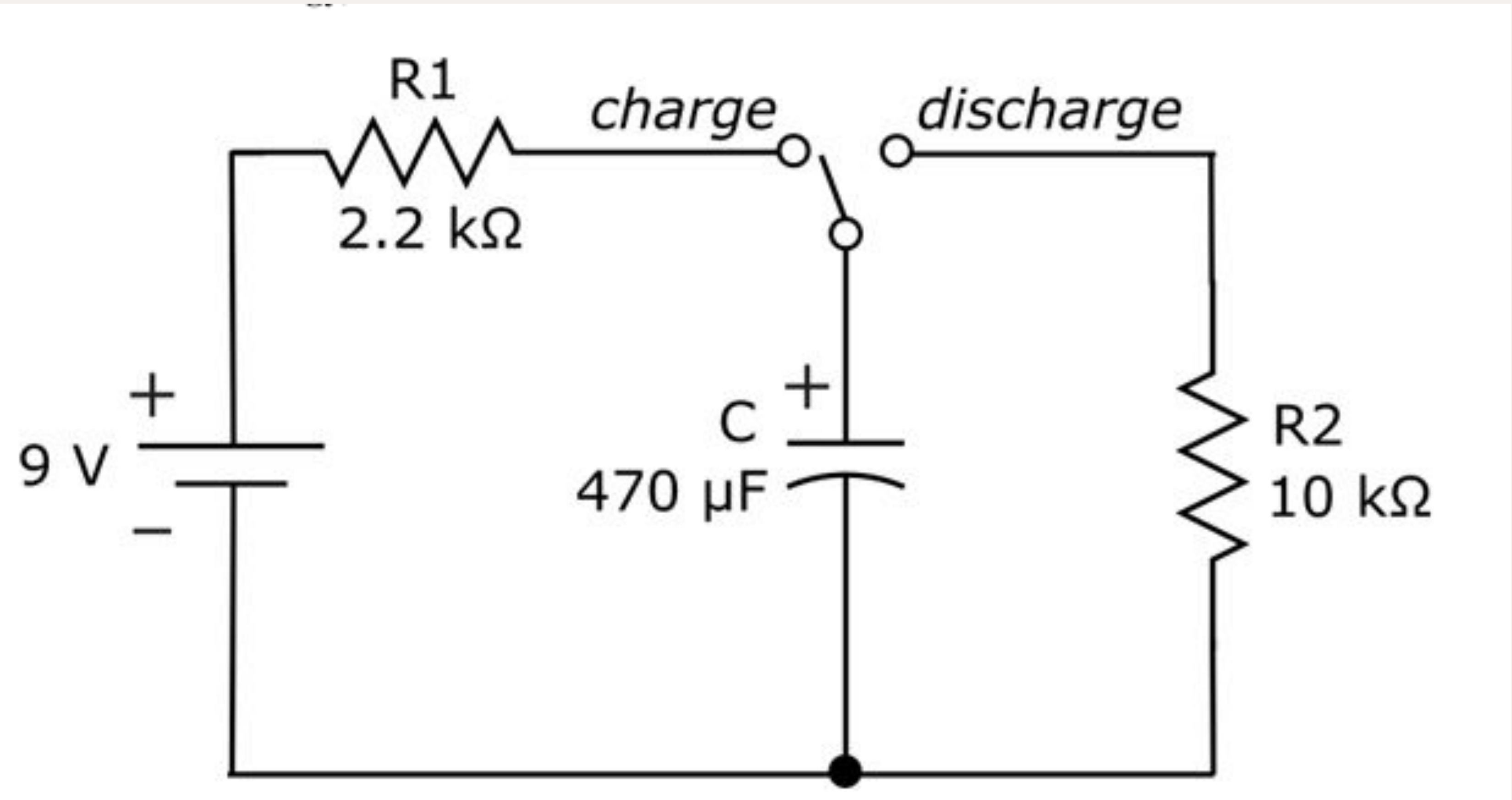
How fast the capacitor charges (and discharges) depends on the resistance and capacitance of the RC circuit.

Larger the resistance,the slower it takes the capacitor to charge

A smaller resistance the faster the capacitor charges.

To calculate the time it takes for the capacitor to charge:

$T = R \times C$

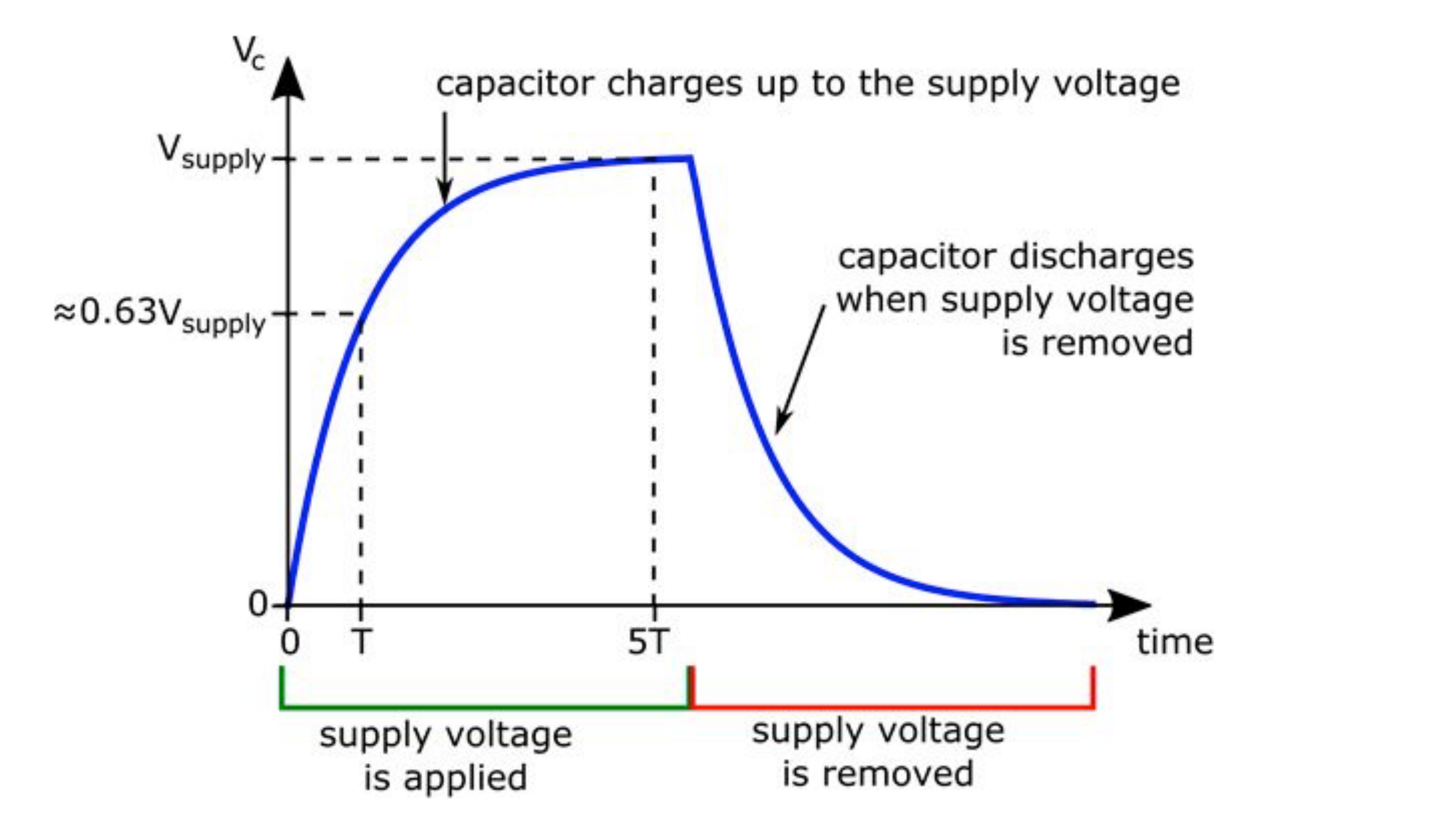


if you replace the power supply with a wire by pressing a button, as in this circuit, it will discharge it’s charge!

Initially: Because the capacitor is fully charged, its voltage is initially Vsupply. Because , the resistor voltage is initially Vsupply, so the current jumps up immediately to Vsupply /R. This means the capacitor is shuffling charges from one plate to the other pretty quickly.

Discharging: As charges begin to flow from one capacitor plate to the other, the capacitor voltage (and so Vr) starts to drop, resulting in a lower current. The capacitor continues to discharge, but at a slower rate. As Vc (and so Vr) continues to decrease, so does the current.

Fully discharged: When the capacitor is fully discharged, current stops flowing, and no voltage is dropped across either the resistor or the capacitor.



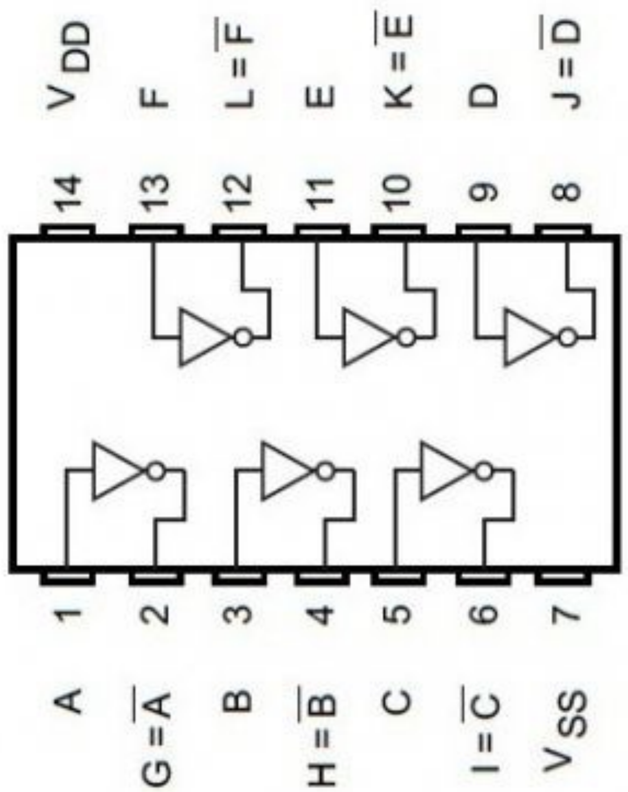
V_c
capacitor charges up to the supply voltage
V_{supply}
$\approx 0.63V_{supply}$
capacitor discharges
when supply voltage
is removed
0
0
T
5T
time
supply voltage
is applied
supply voltage
is removed

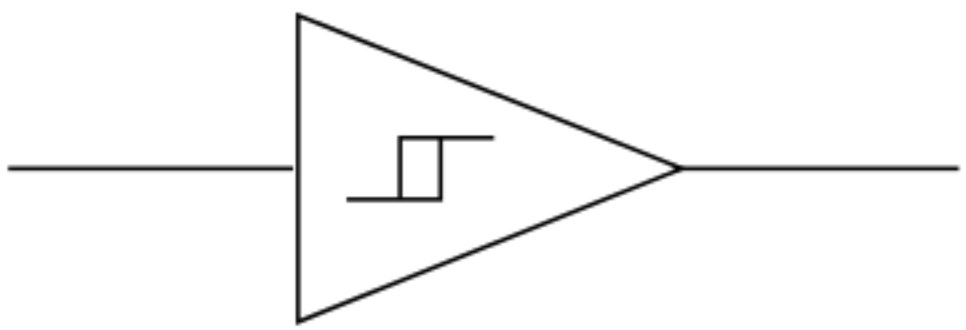
Note: much of the description of this process is covered from Shamieh, Cathleen (2015-07-16). Electronics For Dummies.Wiley. Kindle Edition.

I love this book. I encourage folks to buy it. In fact, you can consider this half of the slide deck slides for her chapter on Capacitors.

An Oscillator (Schmitt Trigger CD40106)

Basically when you apply voltage above a certain threshold, it flips state from off to on.





TRUTH TABLE

INPUTS	OUTPUTS
A, B, C, D,E, F	G, H, I, J, K, L
L	H
H	L

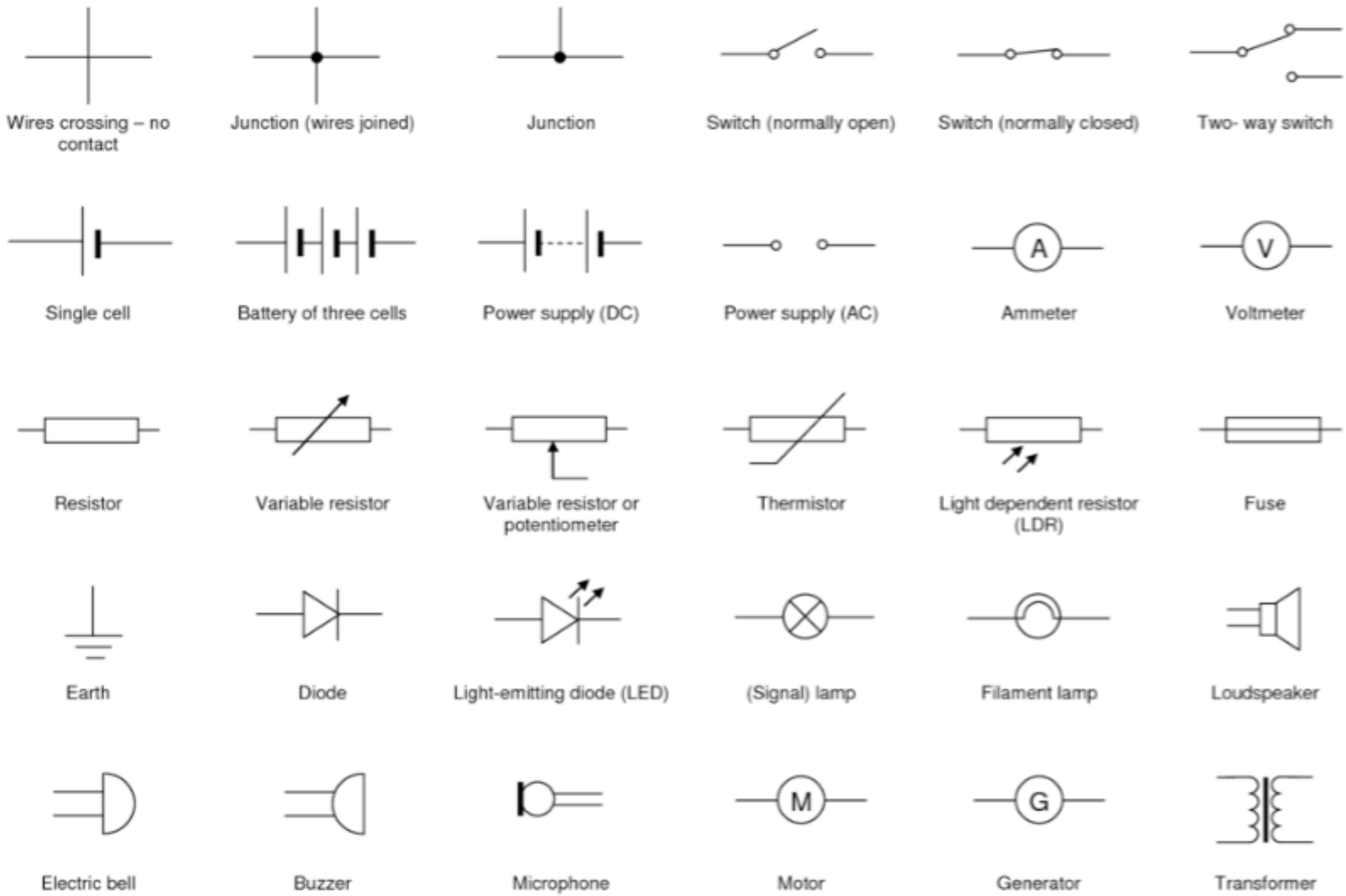
How does this make sound?

The frequency of the oscillator is controlled by the capacitor and resistor.
The **capacitor** sets the **pitch range**
The **resistor** changes the **frequency** within that range

Ranges

.1uf = high frequency
1uf = mid frequency
10uf = low frequency

Symbols for Components



NOW SOUND!

MUSIC

"Nicolas Collins wants to tear apart your CD player."
—***WIRED*** magazine

"Nic Collins' book passes the torch of home-brew electronics to the next generation of musical experimentalists. Providing practical and fun recipes for sonic adventures, it simultaneously introduces the reader to the past and present field of electronic sound art."
—**CHRIS BROWN**, Mills College Center for Contemporary Music

"This is a terrific, unique, and much needed book; I wish I had it fifteen years ago."
—**DAN TRUEMAN**, Princeton Laptop Orchestra, Princeton University

"The most radical music book I've read so far this year. This jargon-free text offers a fresh alternative to the usual instruments prized by the music business."
—**CHRISTOPHER DELAURENTI**, *The Stranger*, Seattle

Handmade Electronic Music: The Art of Hardware Hacking provides a long-needed, practical, and engaging introduction to the craft of making—as well as creatively cannibalizing—electronic circuits for artistic purposes. With a sense of adventure and no prior knowledge, the reader can subvert the intentions designed into devices such as radios and toys to discover a new sonic world. At a time when computers dominate music production, this book offers a rare glimpse into the core technology of early live electronic music, as well as more recent developments at the hands of emerging artists. In addition to advice on hacking found electronics, the reader learns how to make contact microphones, pickups for electromagnetic fields, oscillators, distortion boxes, and unusual signal processors cheaply and quickly.

This revised and expanded second edition is extensively illustrated and includes a DVD featuring 87 video clips and 20 audio tracks by over 100 hackers, benders, musicians, artists, and inventors from around the world, as well as 13 video tutorials demonstrating projects in the book. Further enhancements include additional projects, photographs, diagrams, and illustrations.

Nicolas Collins, an active composer and performer of electronic music, and has worked with John Cage, Alvin Lucier, David Tudor, and many other masters of modern music. Dr. Collins is Professor of Sound at The School of the Art Institute of Chicago, and has led hacking workshops around the world. He has been Visiting Artistic Director of STEIM (Amsterdam) and a DAAD composer-in-residence in Berlin. Since 1997 he has been editor-in-chief of Leonardo Music Journal.

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Cover design: Salamander Hill Design
Cover photo: Three of 42 circuits from "Crash and Bloom," Douglas Irving Repetto. © Douglas Irving Repetto. Used by Permission.

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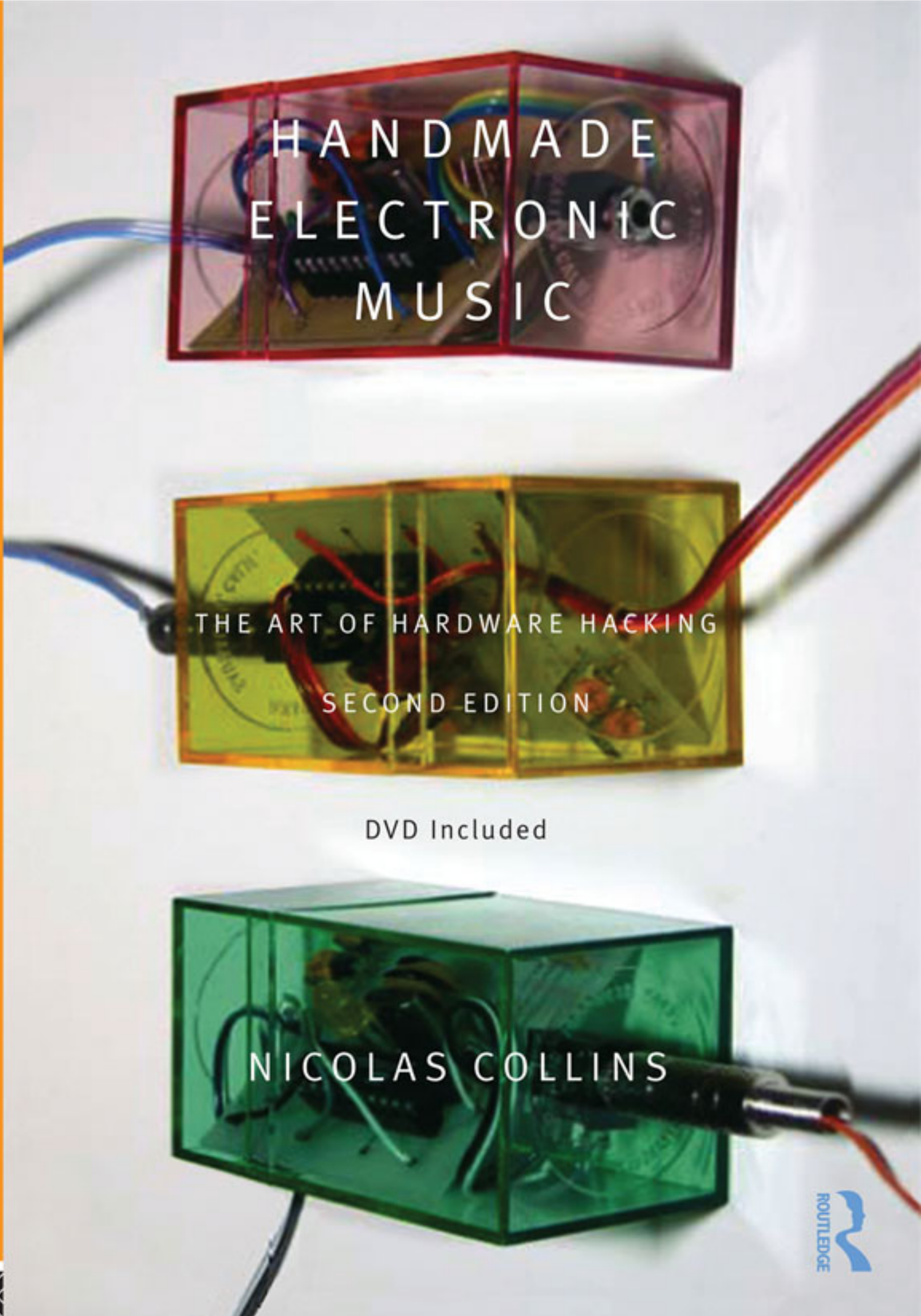
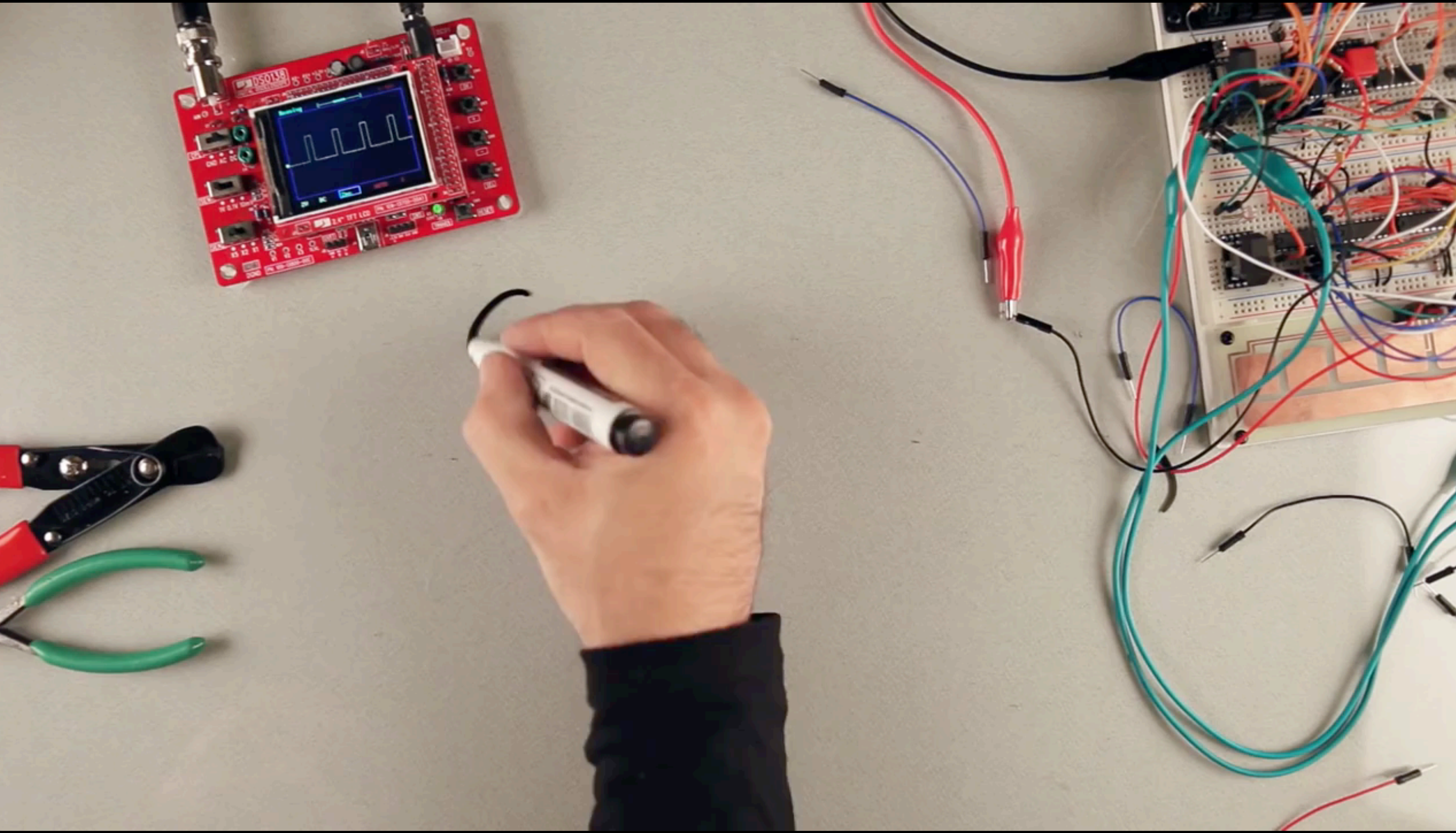
COLLINS HANDMADE ELECTRONIC MUSIC SECOND EDITION Routledge





https://www.youtube.com/watch?v=FaoJaLmZaL4

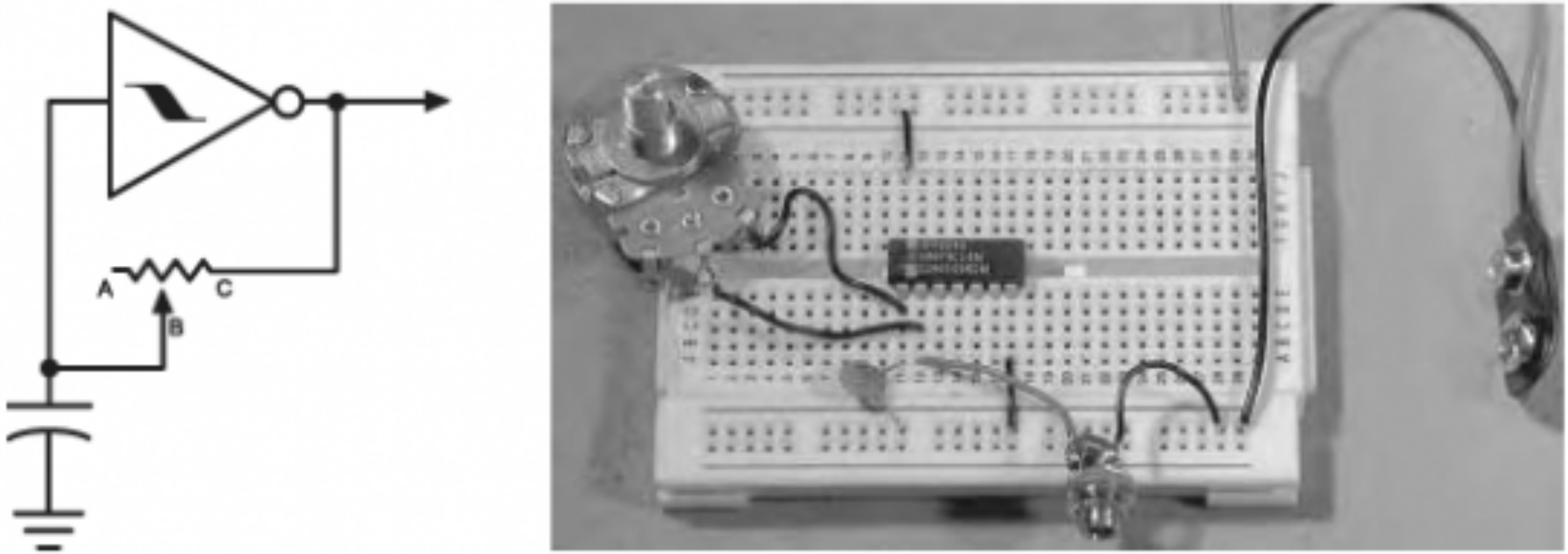
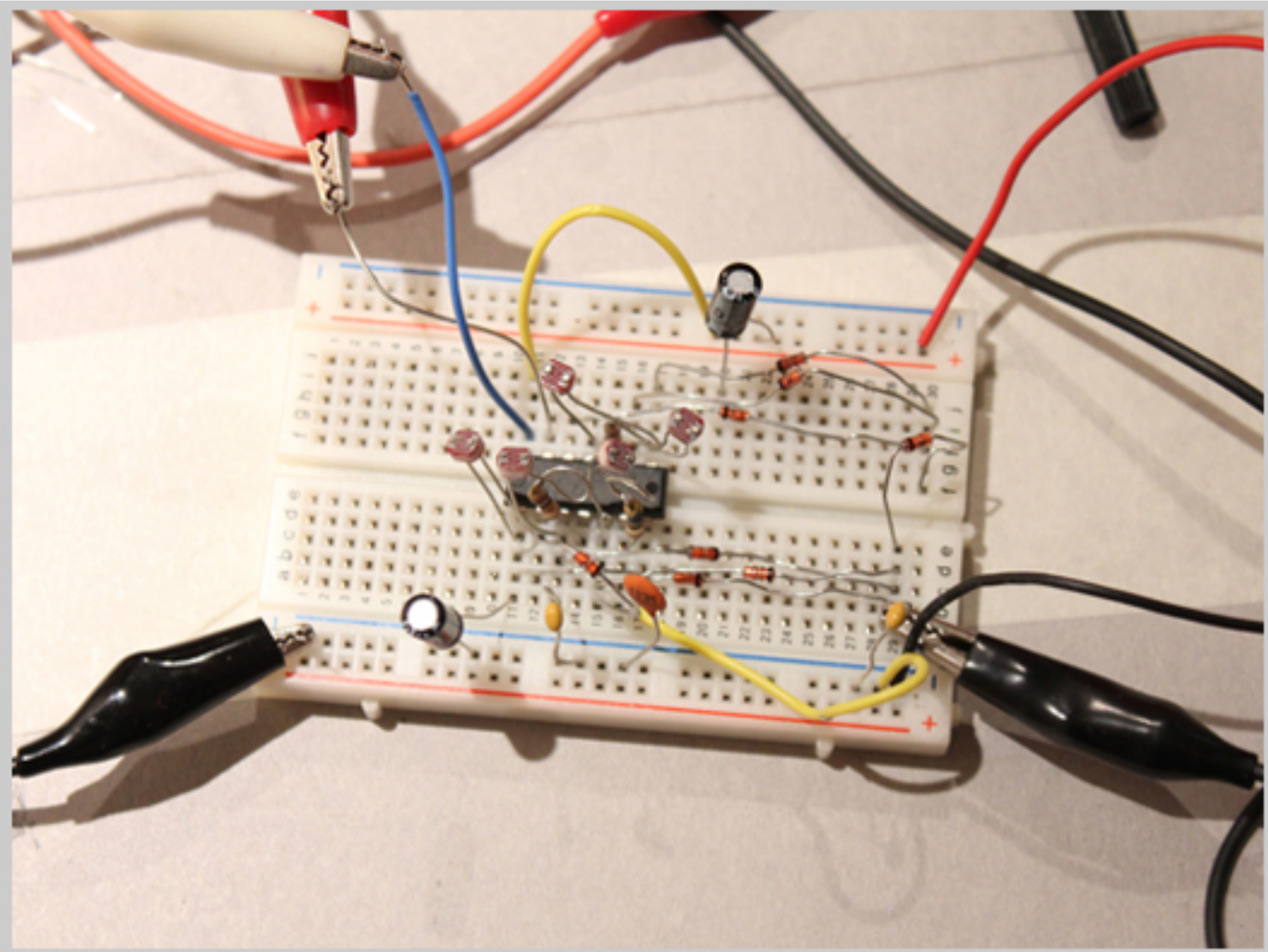
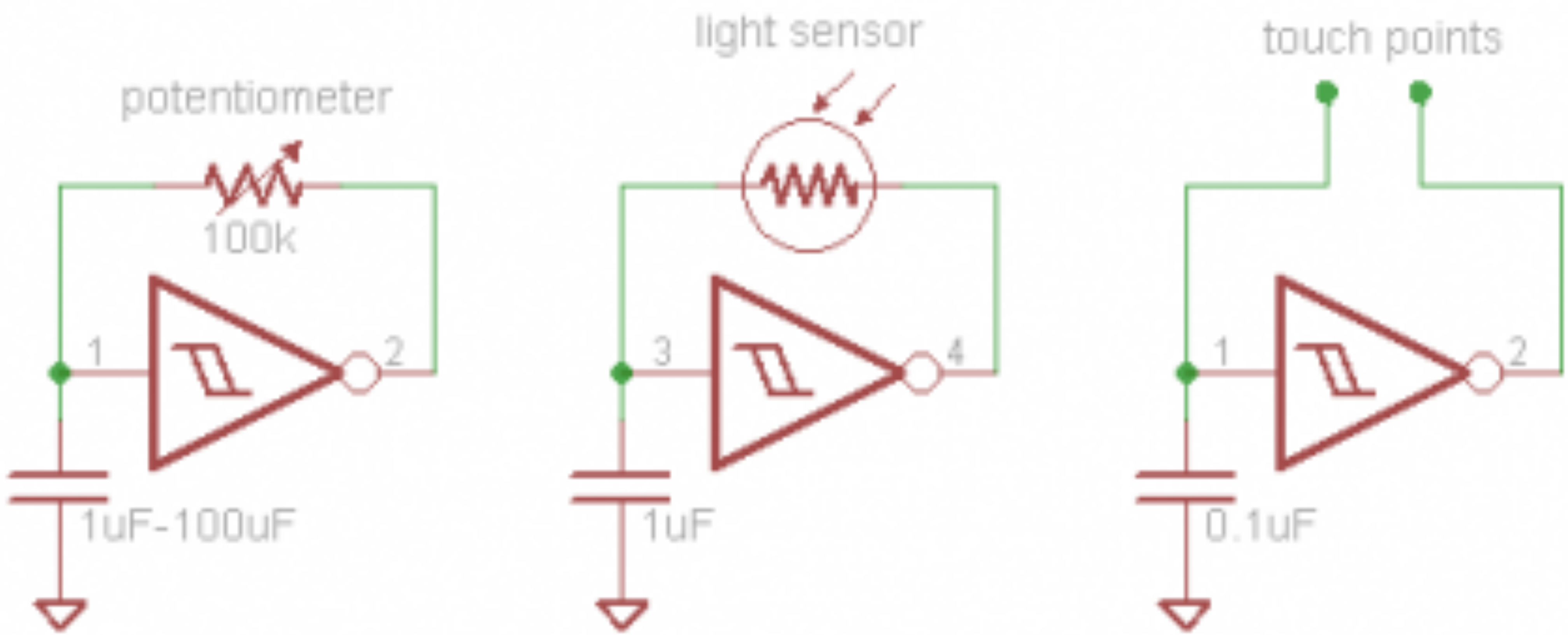


Figure 18.9 Potentiometer-controlled oscillator: schematic and photo.

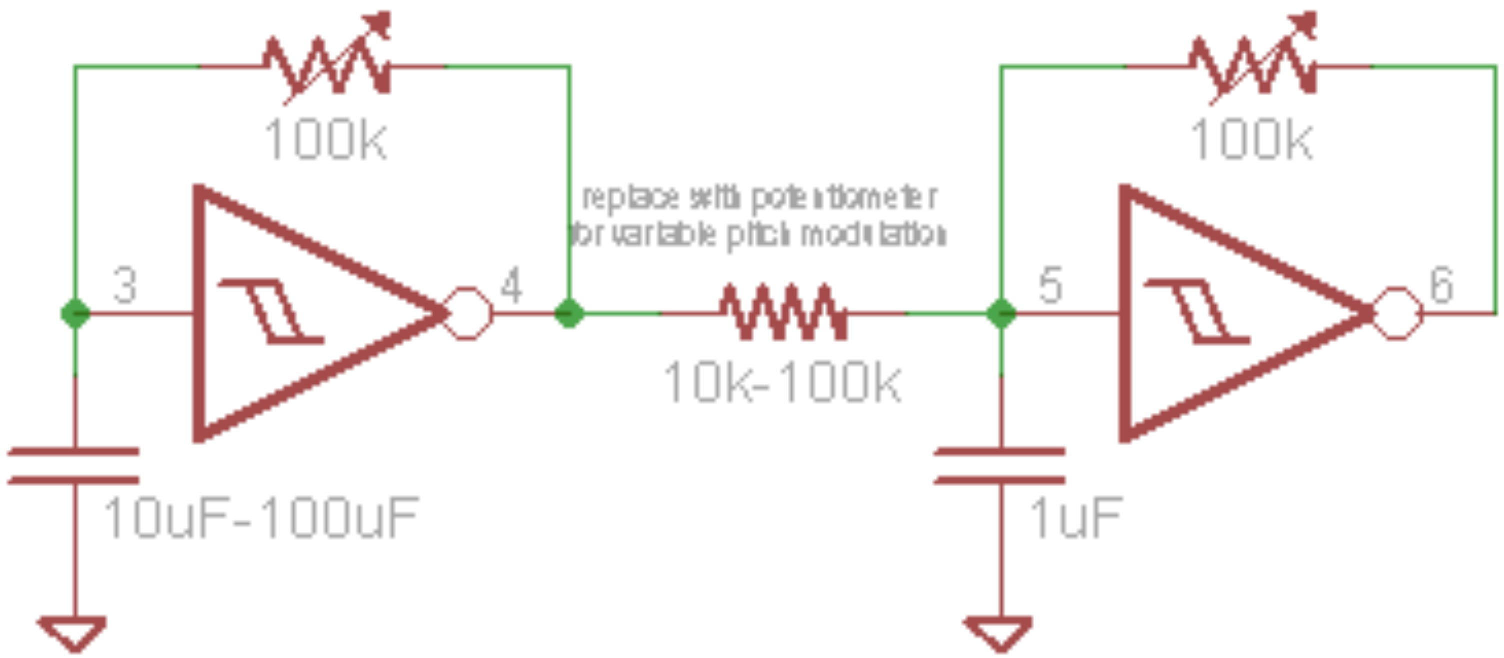


3 possible circuits

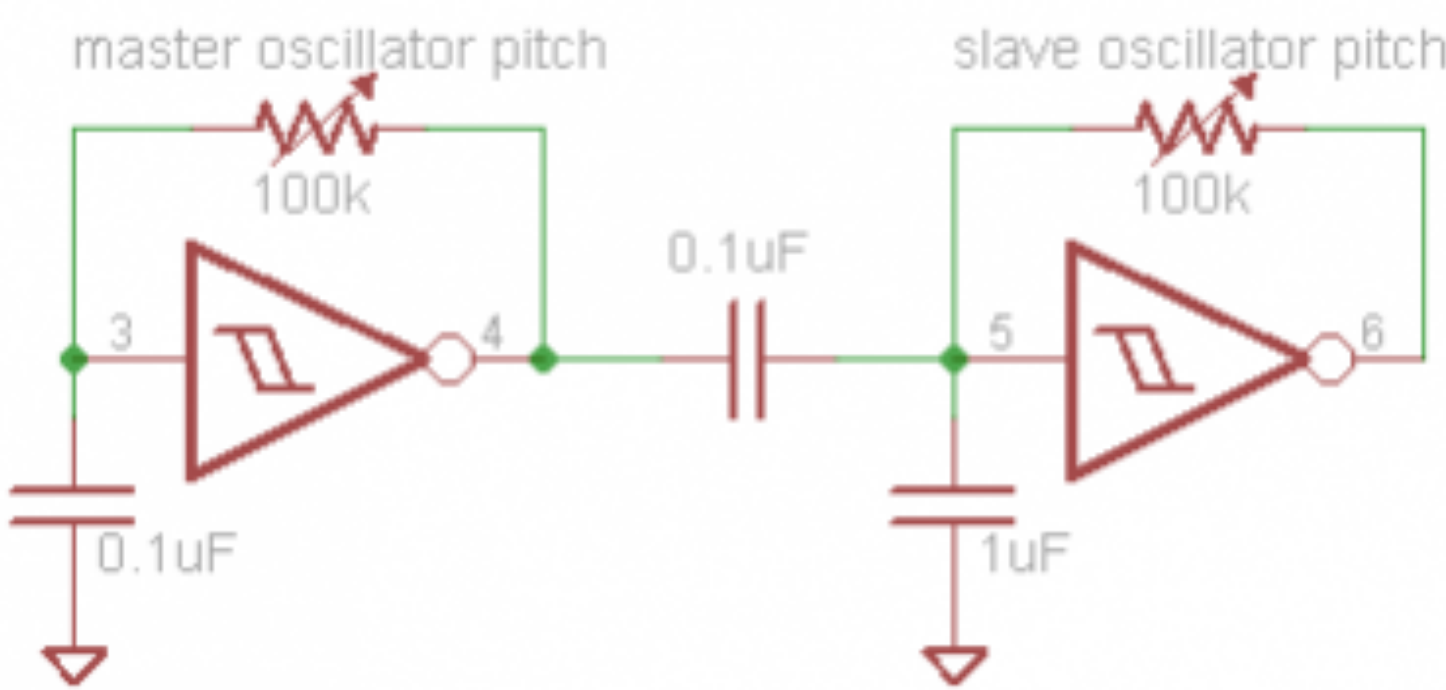


Circuits via Nicolas Collins & Casper Electronics

SIMPLE PITCH MODULATION



SYNCING OSCILLATORS



next steps

http://casperelectronics.com/finished-pieces/omsynth-minilab/omsynth-video-tutorials/video-1-oscillators/