Circuits & Schematics

August 28, 2018

Reminders

Bring something to hack on Thursday

You should have a class buddy

Circuits

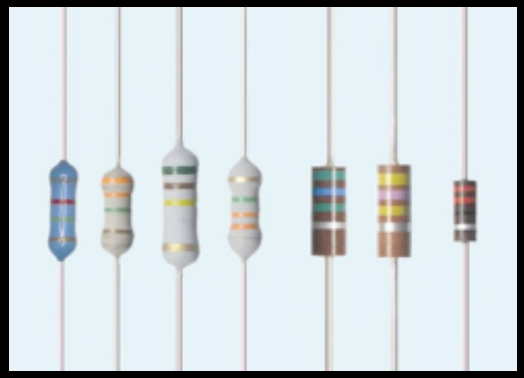
Common Components | Voltage | Current | Resistance

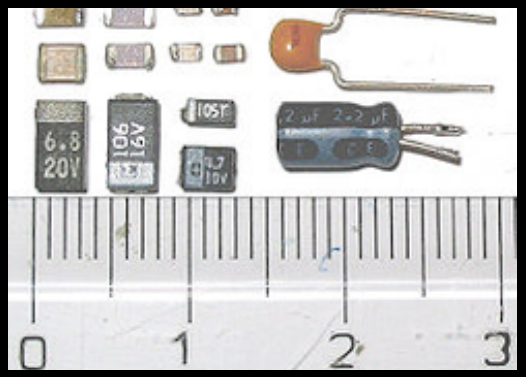
Ohms Law | Watt's Law | Series and Parallel Circuits

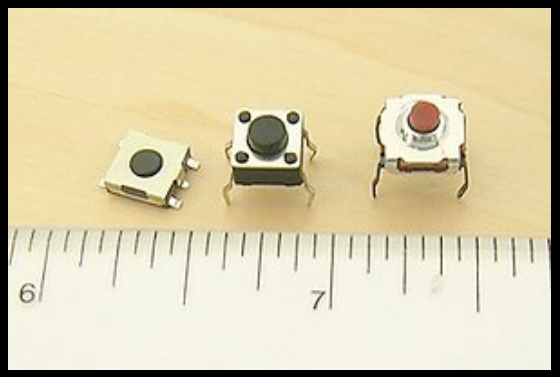
Voltage Divider | Pull-up and Pull-down circuits

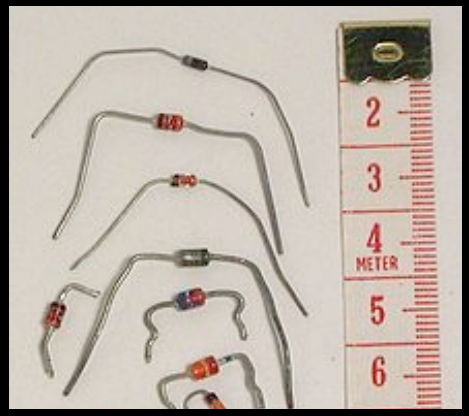
Electrical circuits are networks of electrical elements that contain a closed loop which allows electrons to flow through the elements.

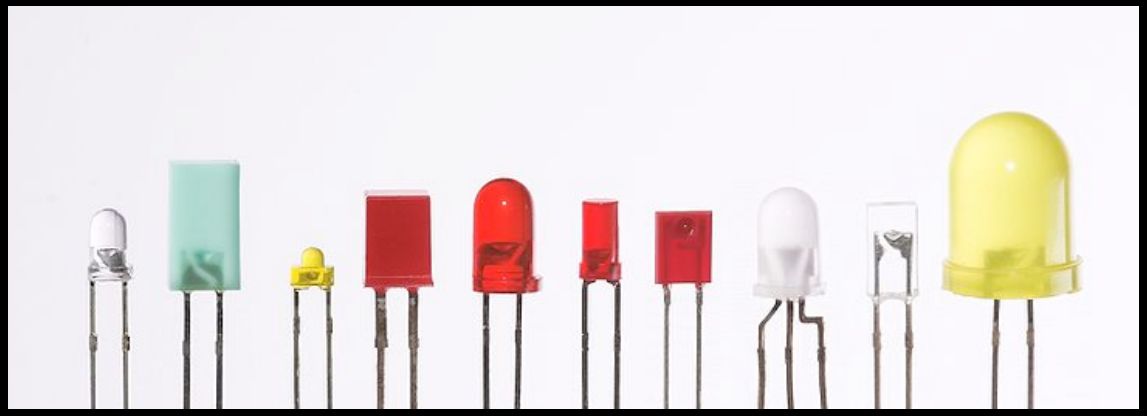
Examples of Electrical Components











images from Wikipedia

Current (measured in Amperes or Amps) is the quantity of electrons passing through a point in a circuit. I

Voltage (measured in Volts) is the potential difference in electrical charge between two points in a circuit.V

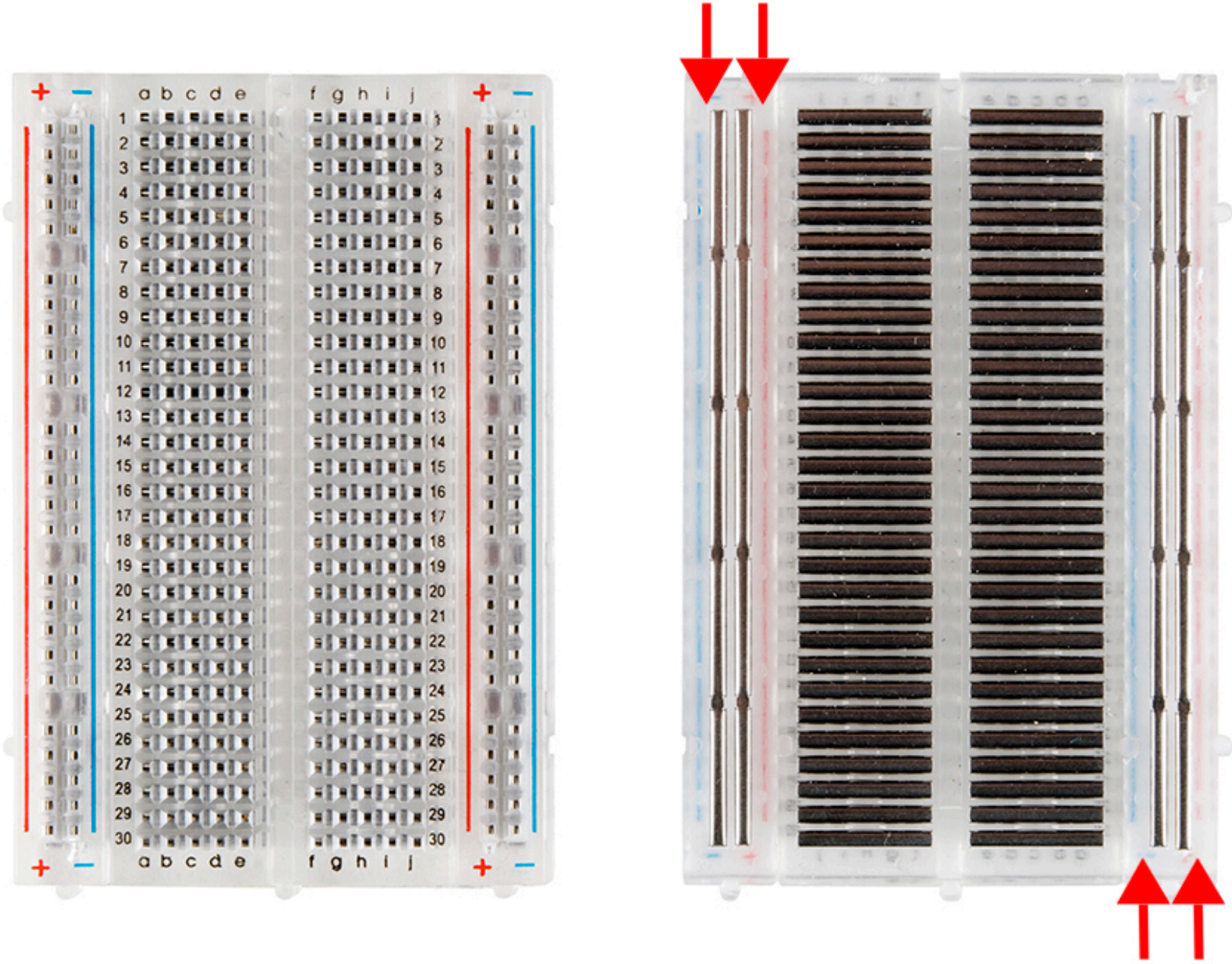
Resistance (measured in Ohms - Ω) is the capacity of a circuit element to impede the flow of electrons in an electrical circuit. R

Current flows with almost no resistance in metal, and so things that are connected by direct metal-on-metal contact share the same voltage.

Sketching in Hardware

image from https://learn.sparkfun.com/tutorials/how-to-use-a-breadboard

originally from http://www.instructables.com/id/Use-a-real-Bread-Board-for-prototyping-your-circui/



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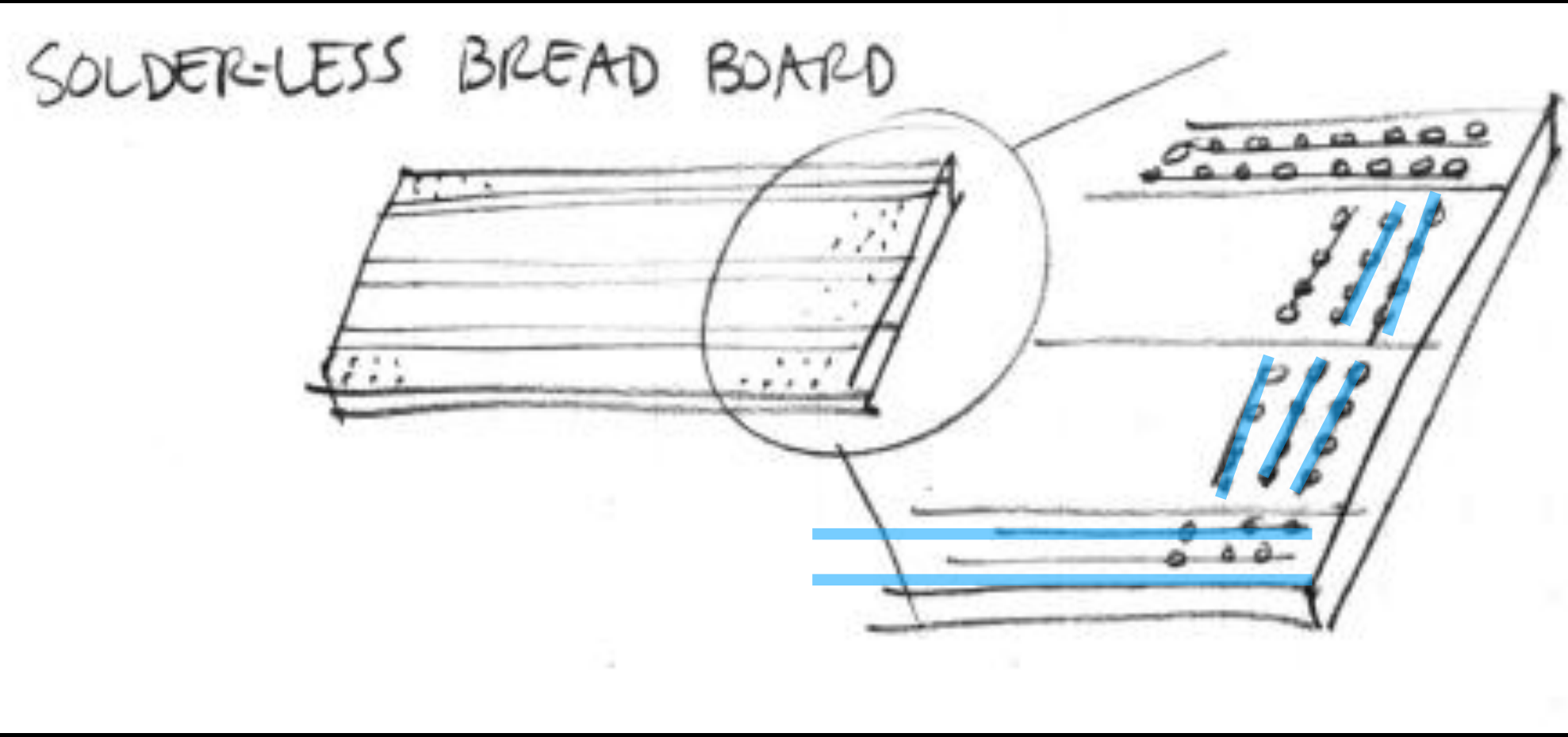
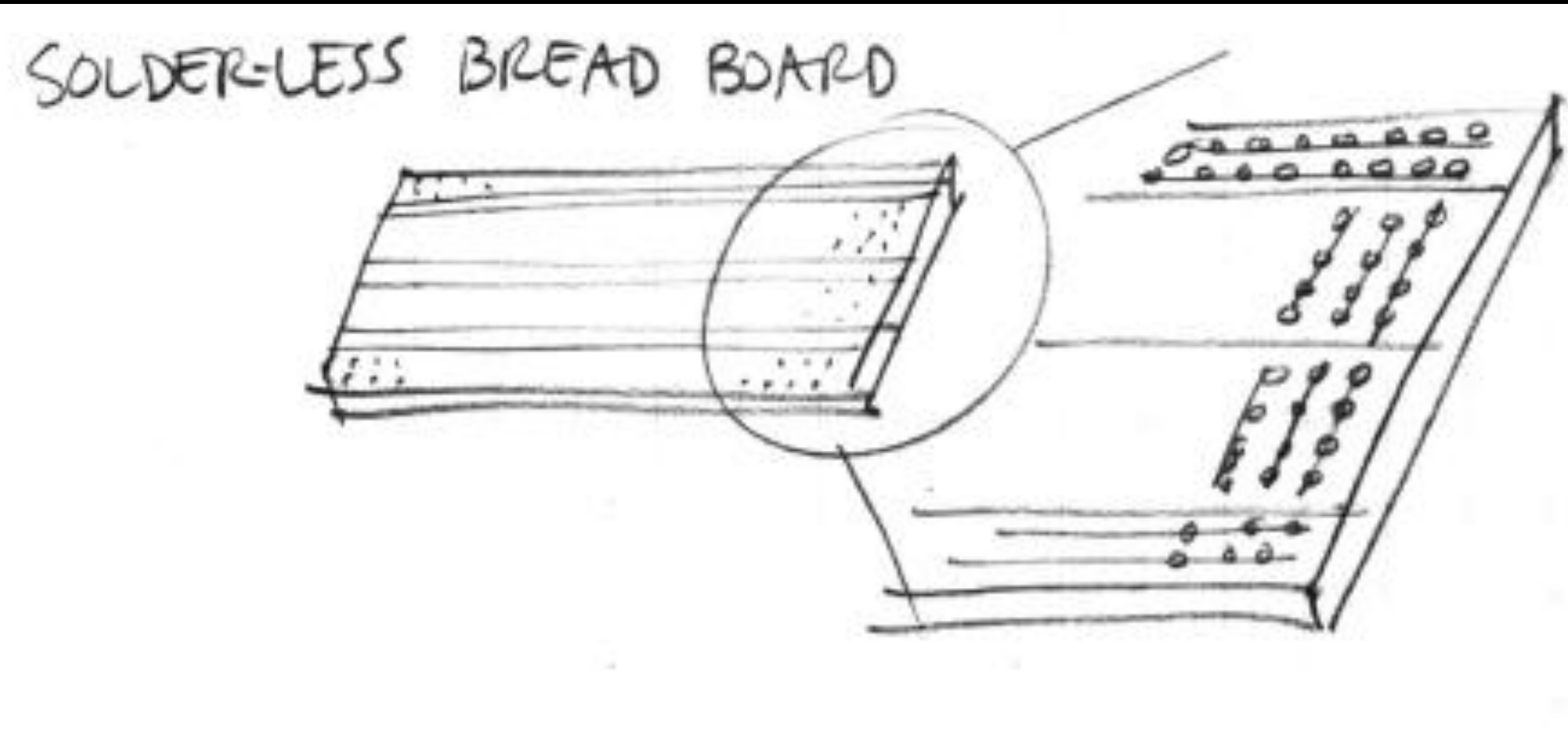
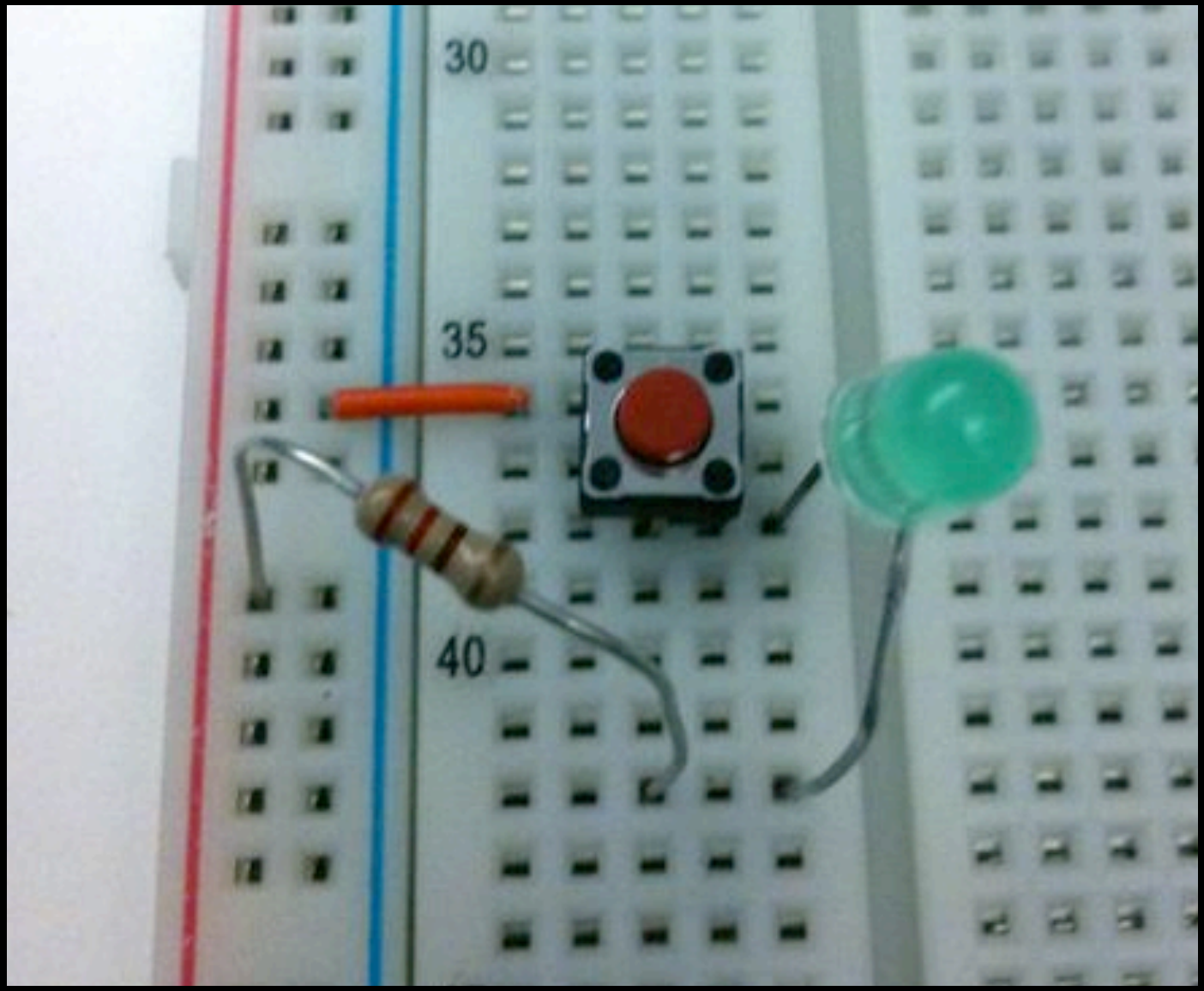


sketch by Bill Verplank



sketch by Bill Verplank

Pushbutton LED circuit



Pushbutton LED circuit breadboard drawing

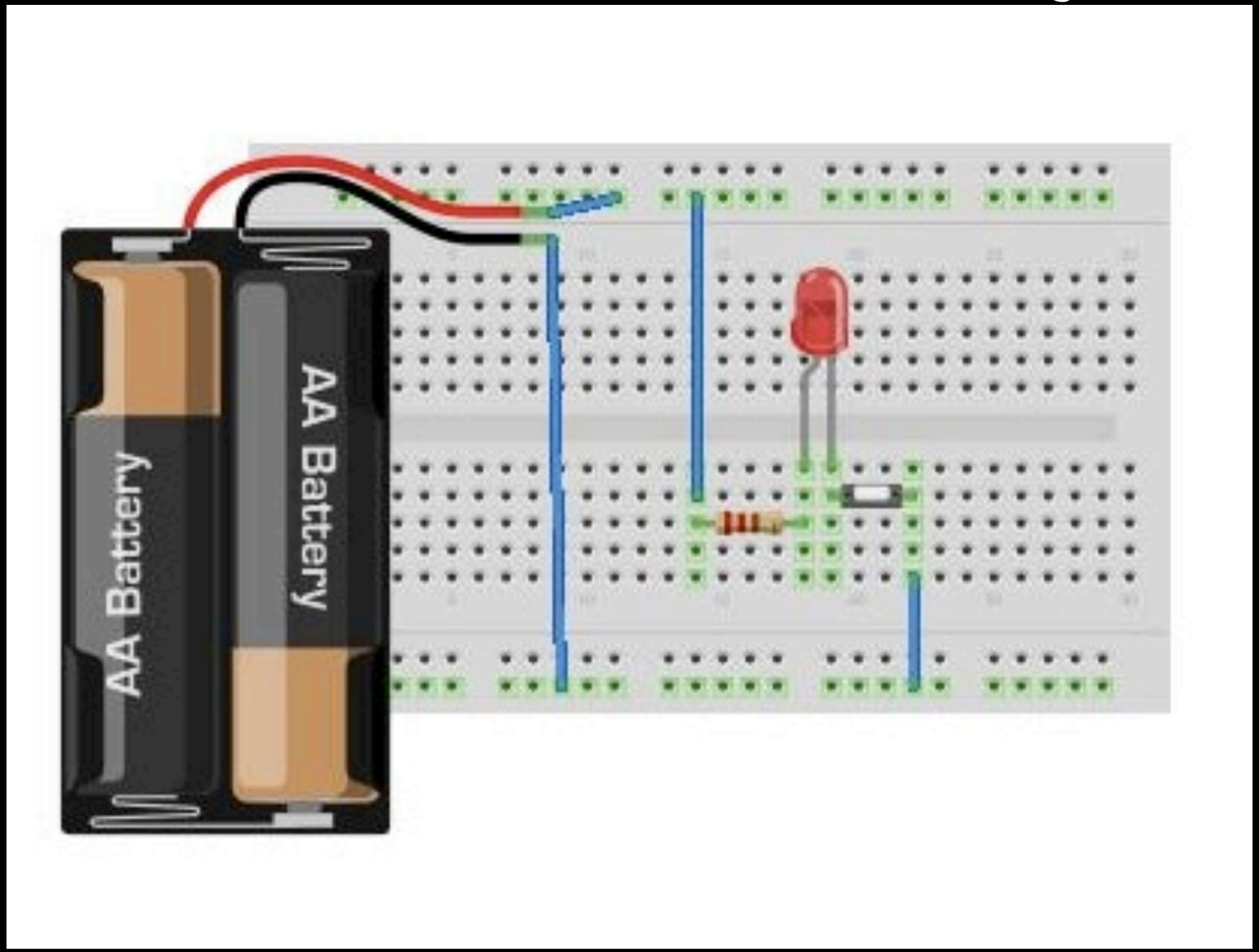
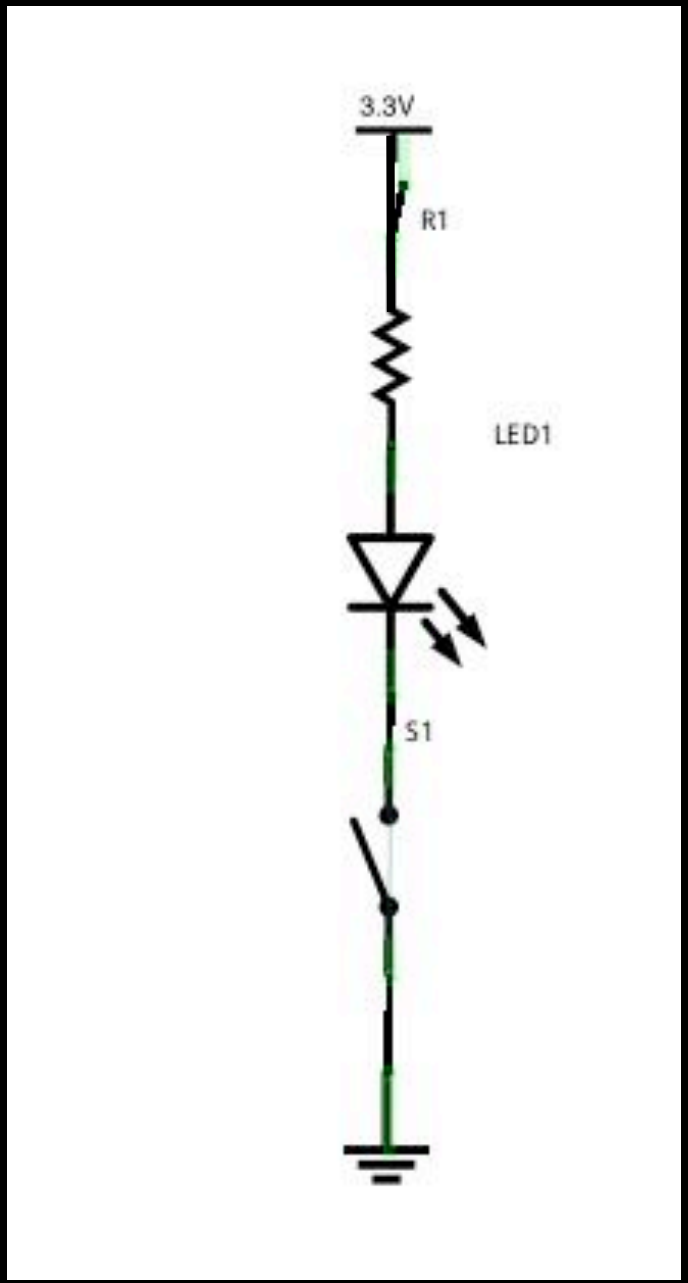
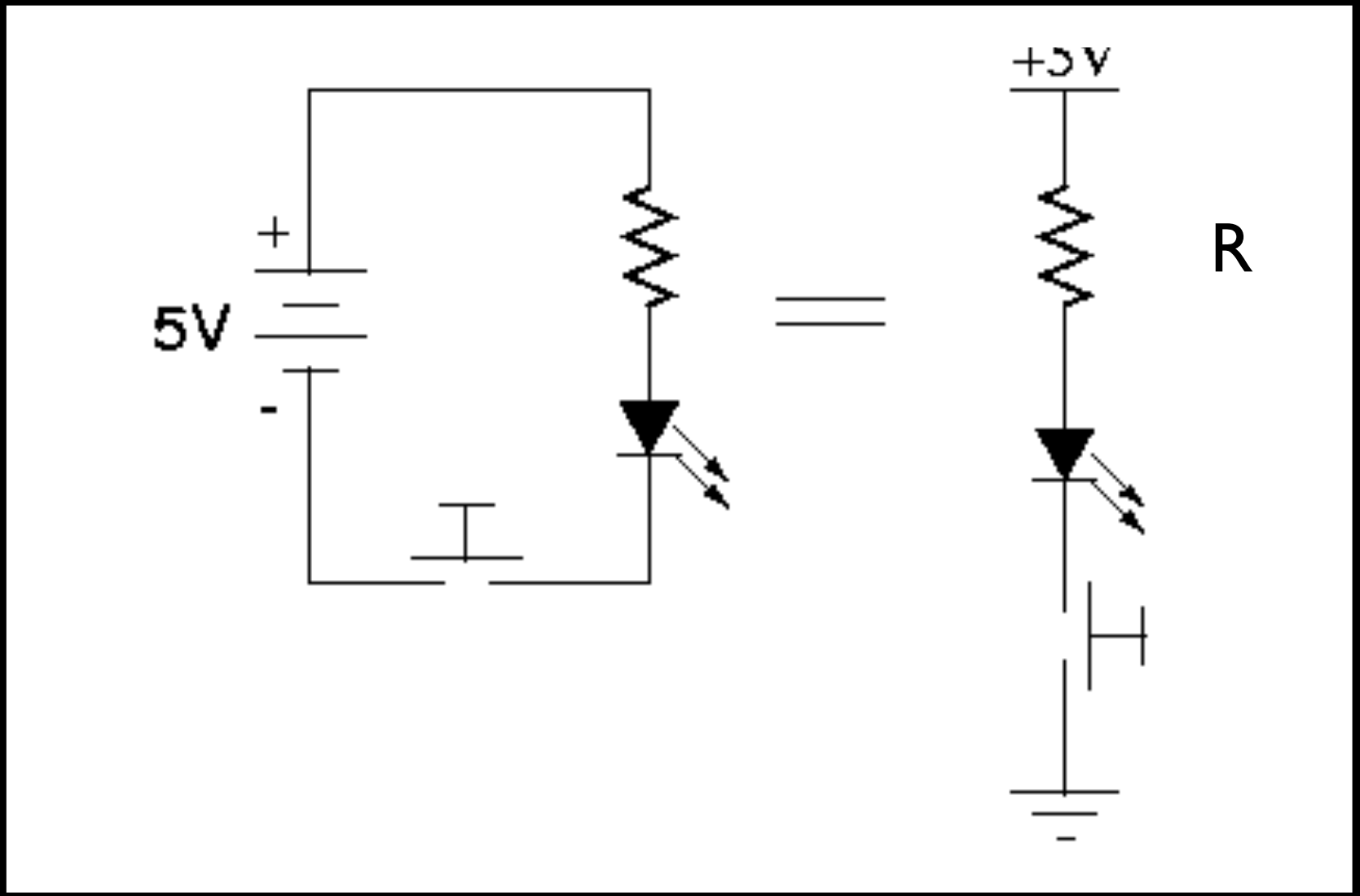


diagram made in Fritzing

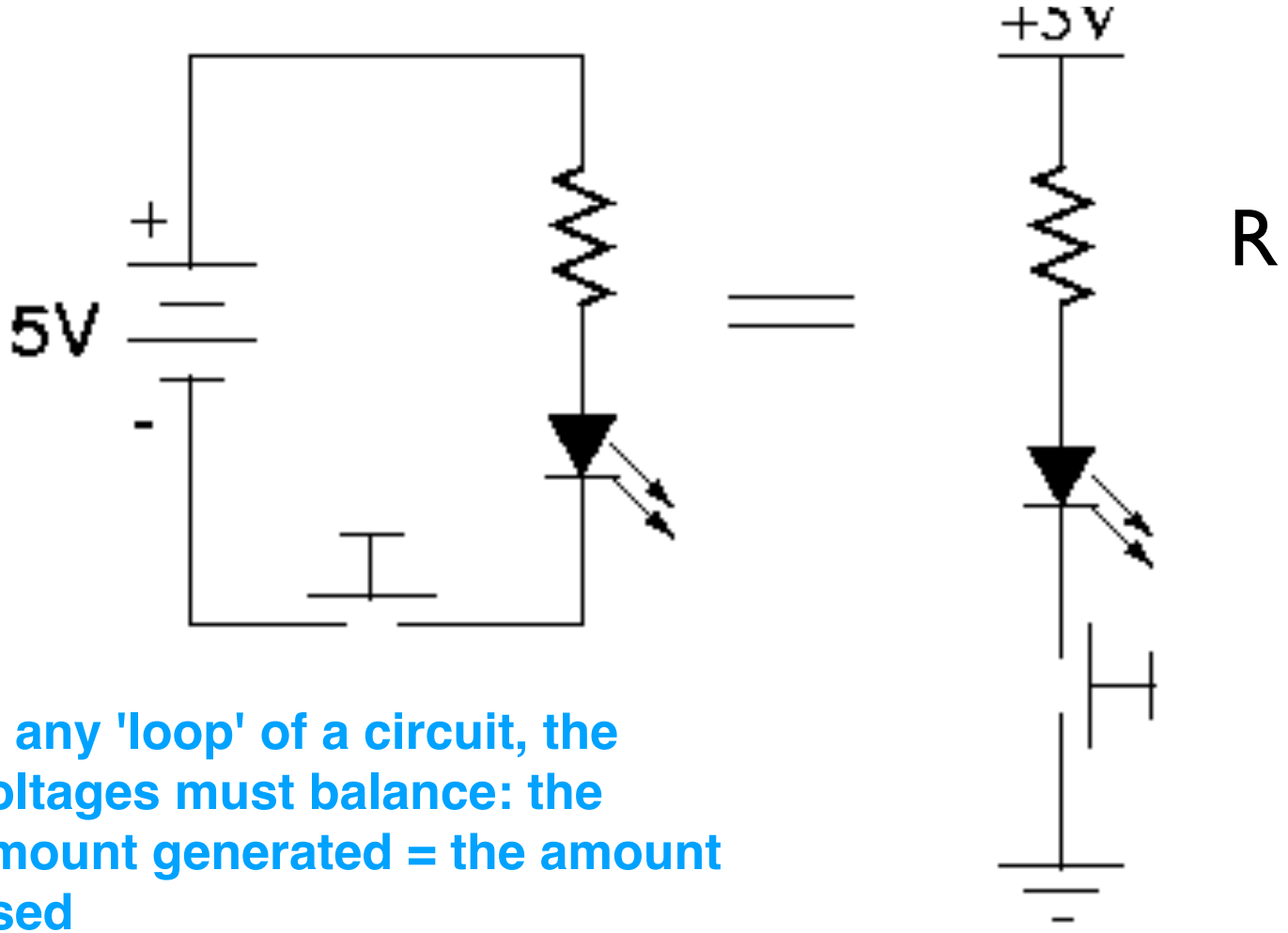
Pushbutton LED circuit schematic



Power in the Pushbutton LED circuit



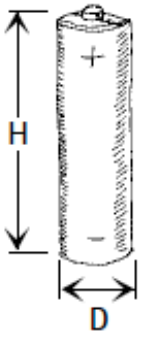
KIRCHOFF'S LAW in the Pushbutton LED circuit



In any 'loop' of a circuit, the voltages must balance: the amount generated = the amount used

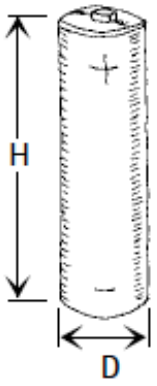
Common Alkaline and Carbon Zinc Cells

1.5V "AAA"



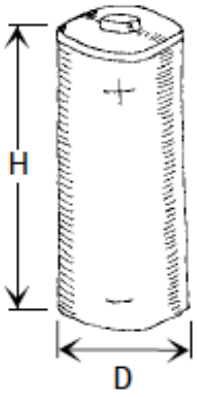
D	H
0.41"	1.75"
$\left(\frac{13}{32}"\right)$	$\left(1\frac{31}{32}"\right)$

1.5V "AA"



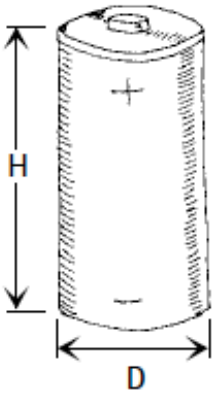
D	H
0.56"	1.97"
$\left(\frac{9}{16}"\right)$	$\left(1\frac{31}{32}"\right)$

1.5V "C"



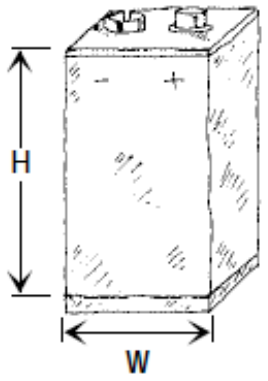
D	H
1.02"	1.97"
$\left(1\frac{1}{64}"\right)$	$\left(1\frac{31}{32}"\right)$

1.5V "D"



D	H
1.32"	2.39"
$\left(\frac{11}{32}"\right)$	$\left(2\frac{27}{64}"\right)$

"9V"



W	L	H
1.03"	0.65"	1.91"
$\left(\frac{13}{32}"\right)$	$\left(\frac{11}{16}"\right)$	$\left(1\frac{15}{16}"\right)$

Lithium

Voltage:
1.55 to 6V
Diameter:
0.460 t0 0.965"
Thicknesses:
0.079" to 0.990"
mAh:
60 to 250 mAh
Label:
Given in I.E.C. number (e.g., CRXXXX or BRXXXX)

Zinc air

Voltage:
1.15 to 1.4V
mAh:
70 to 600 mAh
Labels:
ZAXXX

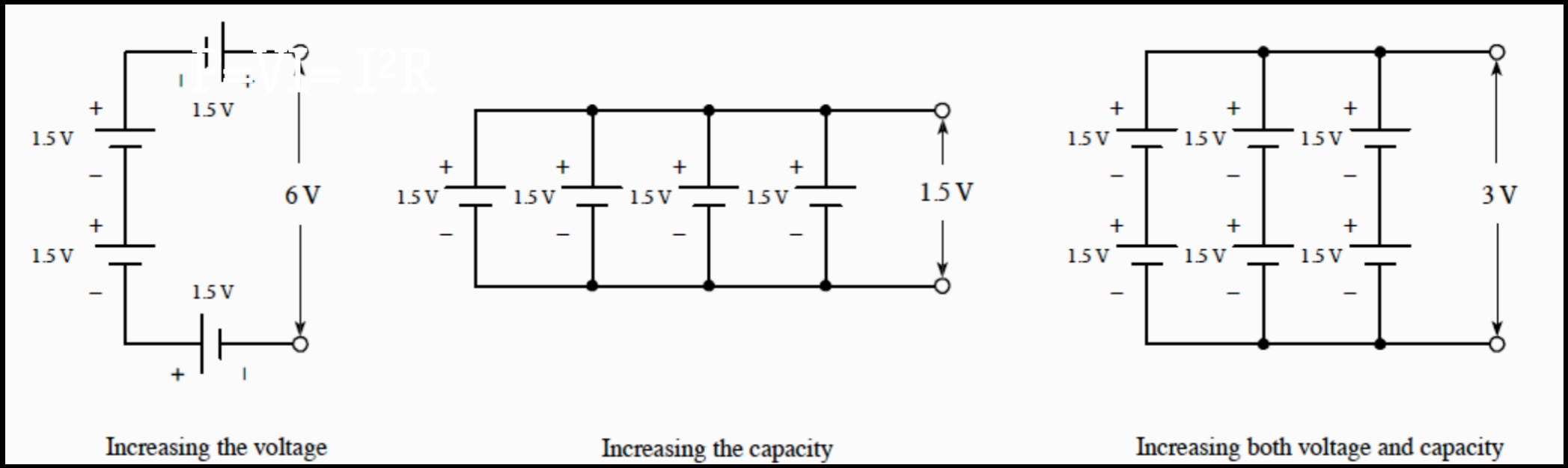
Mercury

Voltage:
1.35 to 5.6V
Diameter:
0.5 to 0.695"
Thicknesses:
0.135" to 0.845"
mAh:
80 to 1000 mAh

Silver oxide

Voltage:
1.55V
Diameter:
0.267 to 0.610"
Thicknesses:
0.81" to 0.210"
mAh:
15 to 250 mAh
Label:
Given in I.E.C. number (e.g., SRXX)

Power can come from supplies or batteries.



Increasing the voltage

Increasing the capacity

Increasing both voltage and capacity

Power Supply

5V DC to DC Step Up - 1xAA

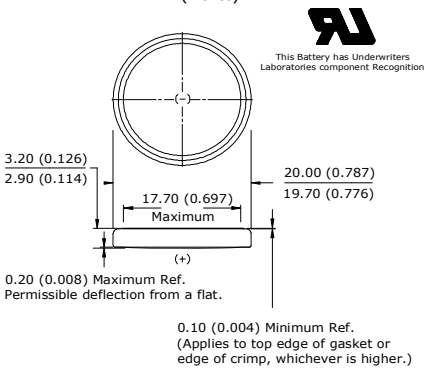
Energizer
1-800-383-7323 USA/CAN
www.energizer.com

ENERGIZER CR2032

Lithium Coin

Industry Standard Dimensions

mm (inches)



Specifications

Classification:	"Lithium Coin"
Chemical System:	Lithium / Manganese Dioxide (Li/MnO_2)
Designation:	ANSI / NEDA-5004LC, IEC-CR2032
Nominal Voltage:	3.0 Volts
Typical Capacity:	240 mAh (to 2.0 volts) (Rated at 15K ohms at 21°C)
Typical Weight:	3.0 grams (0.10 oz.)
Typical Volume:	1.0 cubic centimeters (0.06 cubic inch)
Typical IR:	10,000 - 40,000 mΩ
Max Rev Charge:	1 microampere
Energy Density:	198 milliwatt hr/g, 653 milliwatt hr/cc
Typical Li Content:	0.109 grams (0.0038 oz.)
UL Listed:	MH12454
Shipping:	For complete details, please reference:
Global (except US):	Special Provision A45 of the International Air Transport Association Dangerous Goods Regulations
United States:	49 CFR 173.185

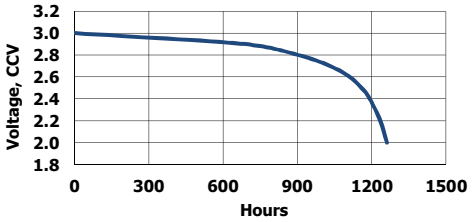
Safety: **⚠ WARNING**

(1) KEEP OUT OF REACH OF CHILDREN. Swallowing may lead to serious injury or death in as little as 2 hours due to chemical burns and potential perforation of the esophagus. **Immediately see doctor; have doctor phone (202) 625-3333.**

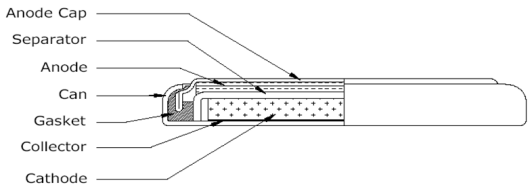
(2) Battery compartment design. To prevent children from removing batteries, battery compartments should be designed with one of the following methods: a) a tool such as screwdriver or coin is required to open battery compartment or b) the battery compartment door/cover requires the application of a minimum of two independent and simultaneous movements of the securing mechanism to open by hand. Screws should remain captive with the battery door or cover.

Continuous Discharge Characteristics

Load: 15K ohms - continuous 21°C (70°F)
Typical Drain @ 2.9V: 0.19 mA



Cross Section



Simulated Application test

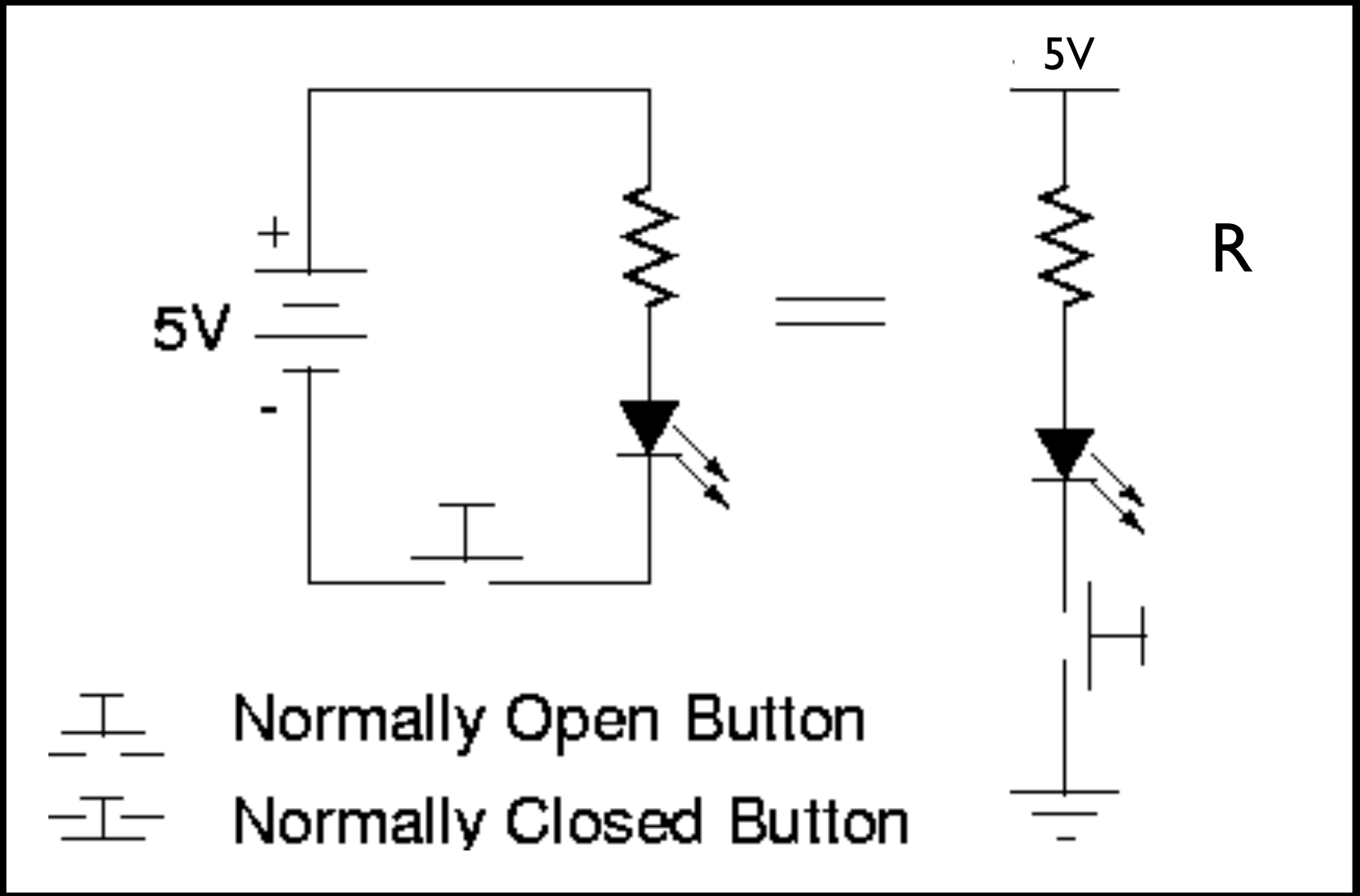
Typical Performance at 21°C (70°F)

Schedule:	Typical Drains: at 2.9V (mA)	Load (ohms)	Cutoff 2.0V (hours)
Continuous	0.043	68,000	721

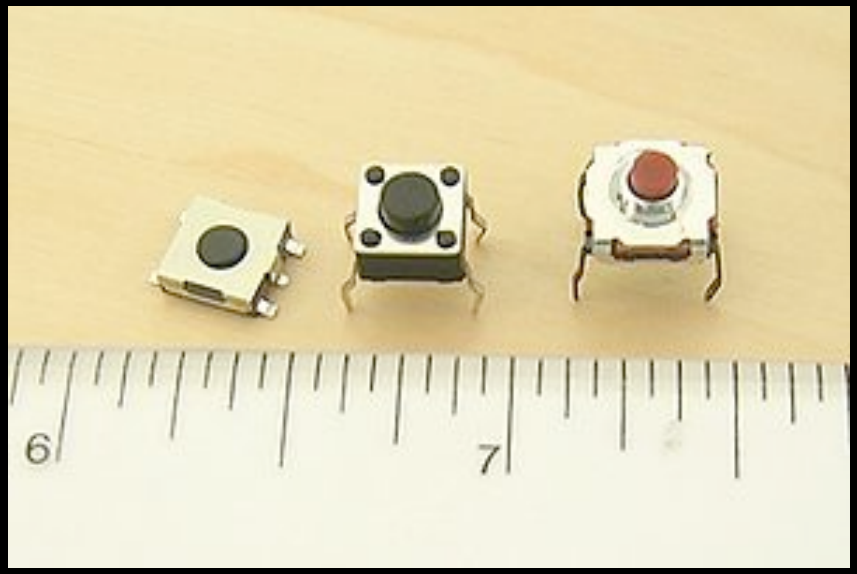
Important Notice

This datasheet contains typical information specific to products manufactured at the time of its publication.

Input in the Pushbutton LED circuit

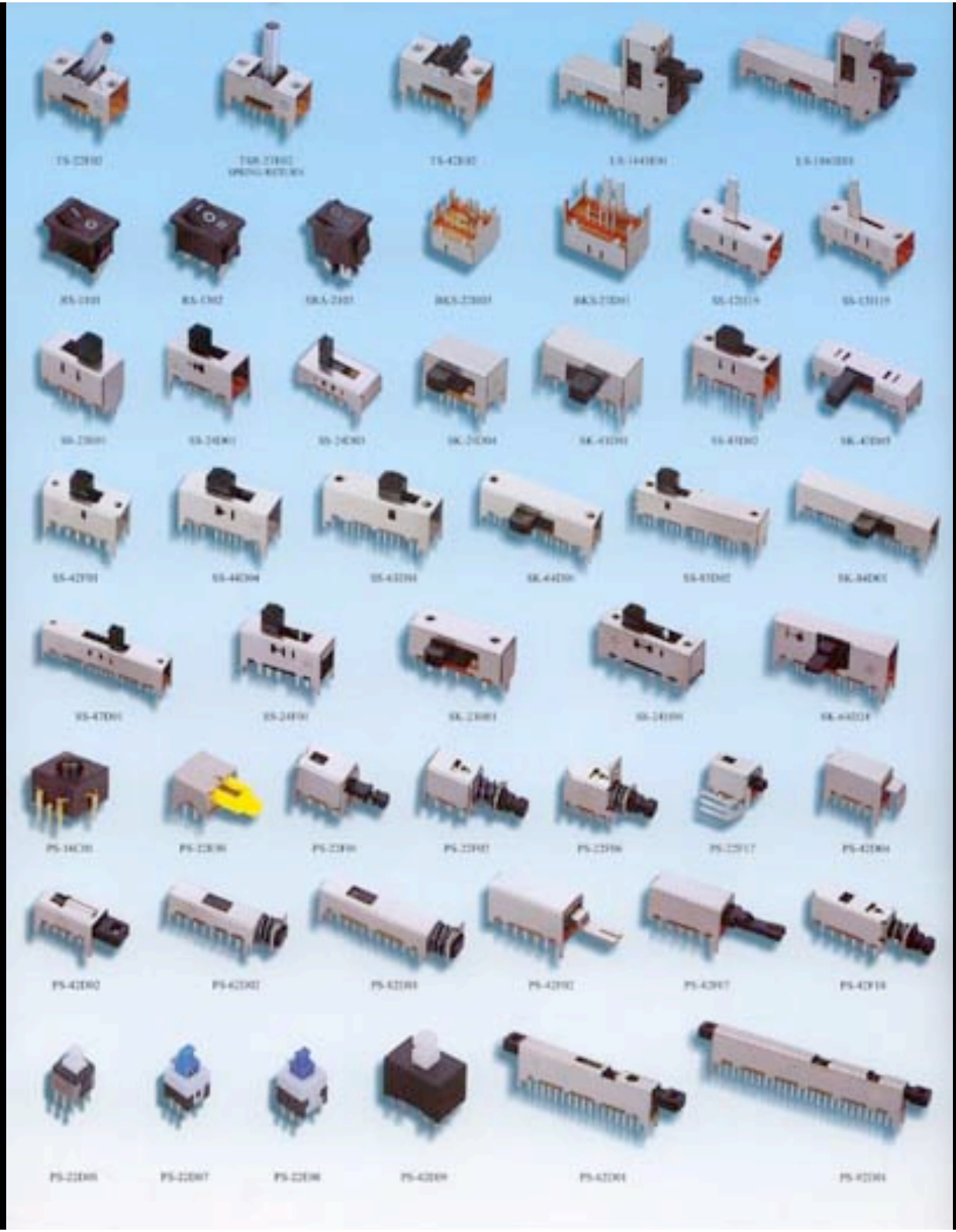


Switches/Buttons

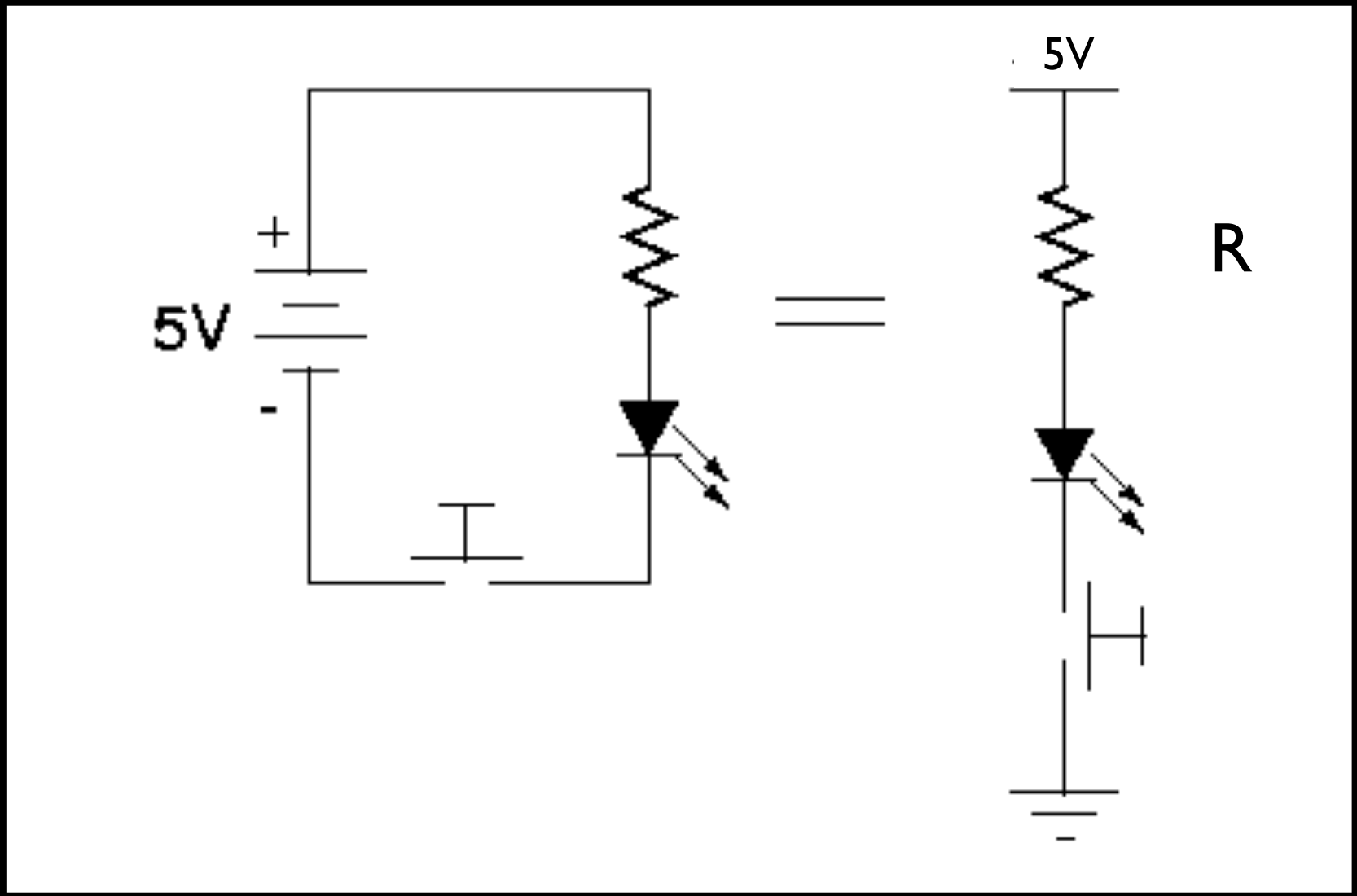


images from Wikipedia

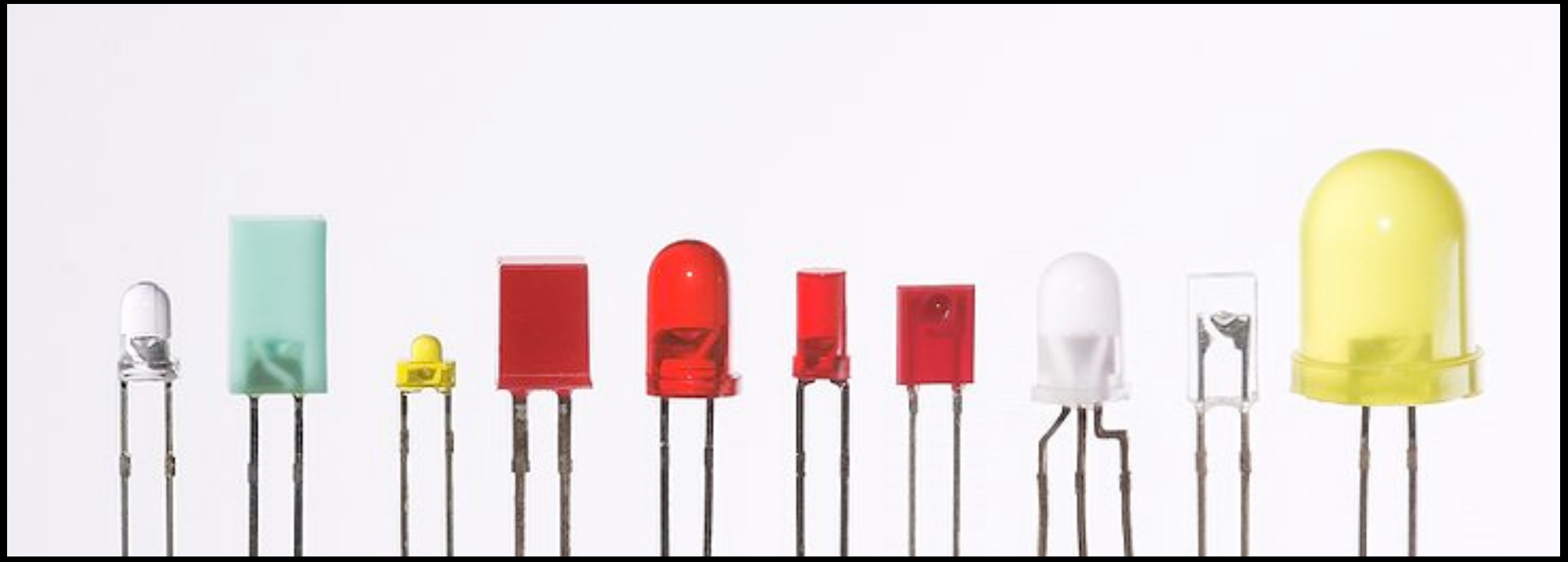
Switches/Buttons



Output in the Pushbutton LED circuit



LEDs



images from Wikipedia

LED datasheet

https://learn.adafruit.com/all-about-leds/the-led-datasheet

Kingbright

T-1 3/4 (5mm) SOLID STATE LAMP

Part Number: WP7113SRD/D Super Bright Red

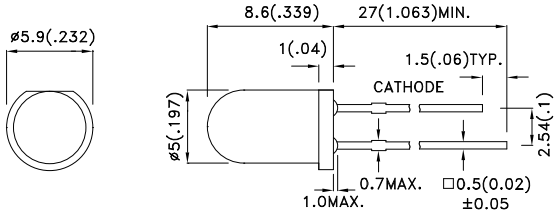
Features

- LOW POWER CONSUMPTION.
- POPULAR T-1 3/4 DIAMETER PACKAGE.
- GENERAL PURPOSE LEADS.
- RELIABLE AND RUGGED.
- LONG LIFE - SOLID STATE RELIABILITY.
- AVAILABLE ON TAPE AND REEL.
- RoHS COMPLIANT.

Description

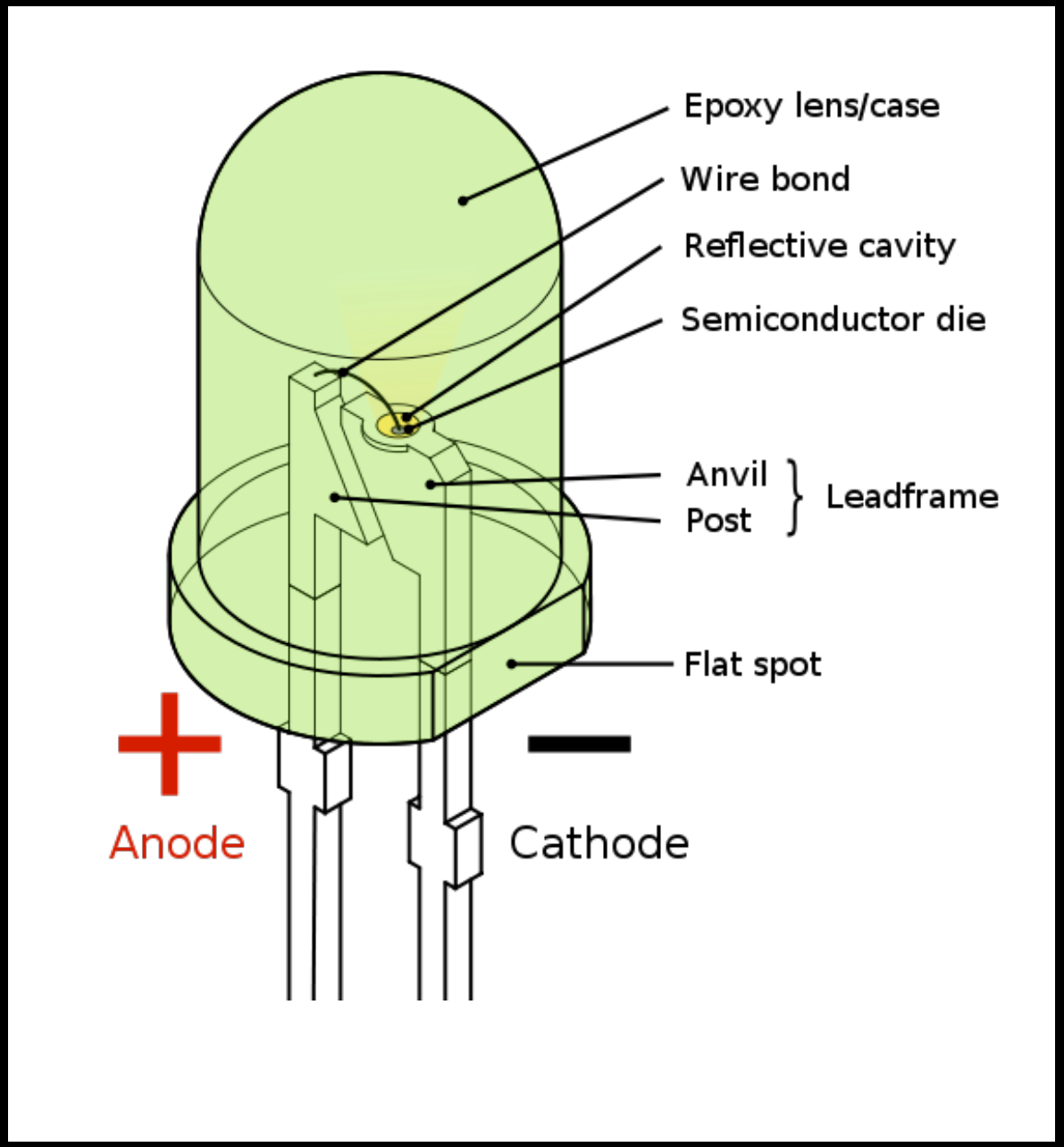
The Super Bright Red source color devices are made with Gallium Aluminum Arsenide Red Light Emitting Diode.

Package Dimensions

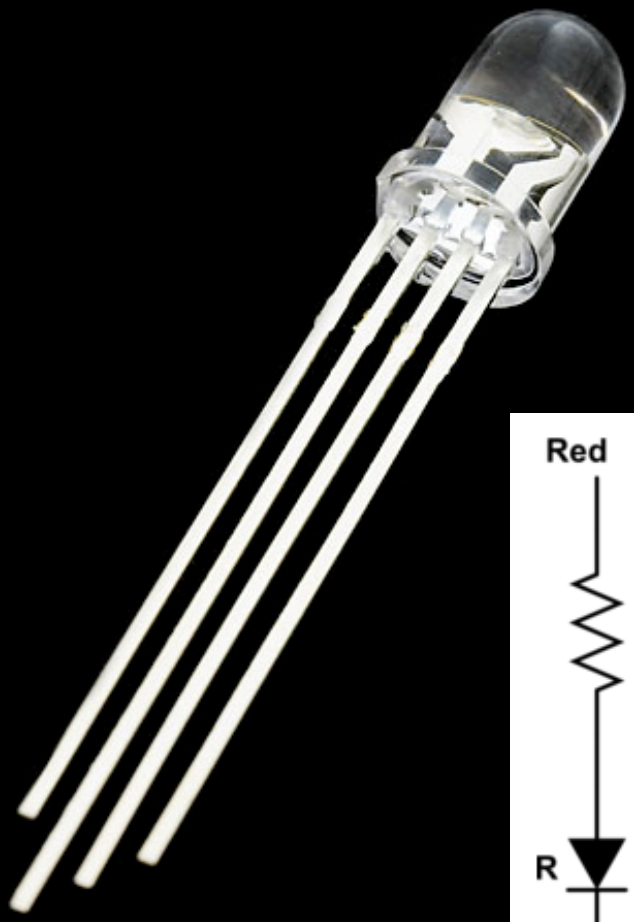


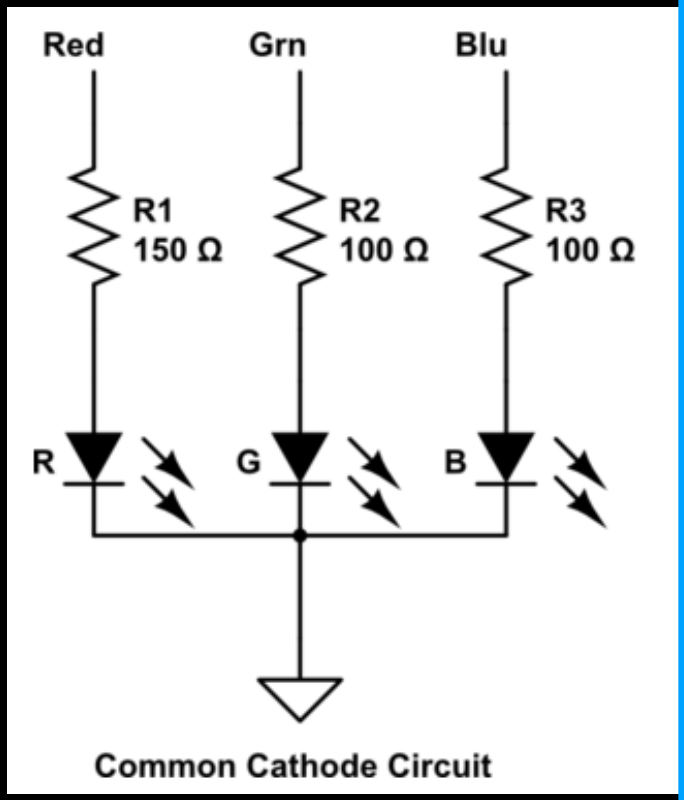
Notes:
1. All dimensions are in millimeters (inches).
2. Tolerance is ±0.25(0.01") unless otherwise noted.
3. Lead spacing is measured where the leads emerge from the package.
4. Specifications are subject to change without notice.

Inside LEDs

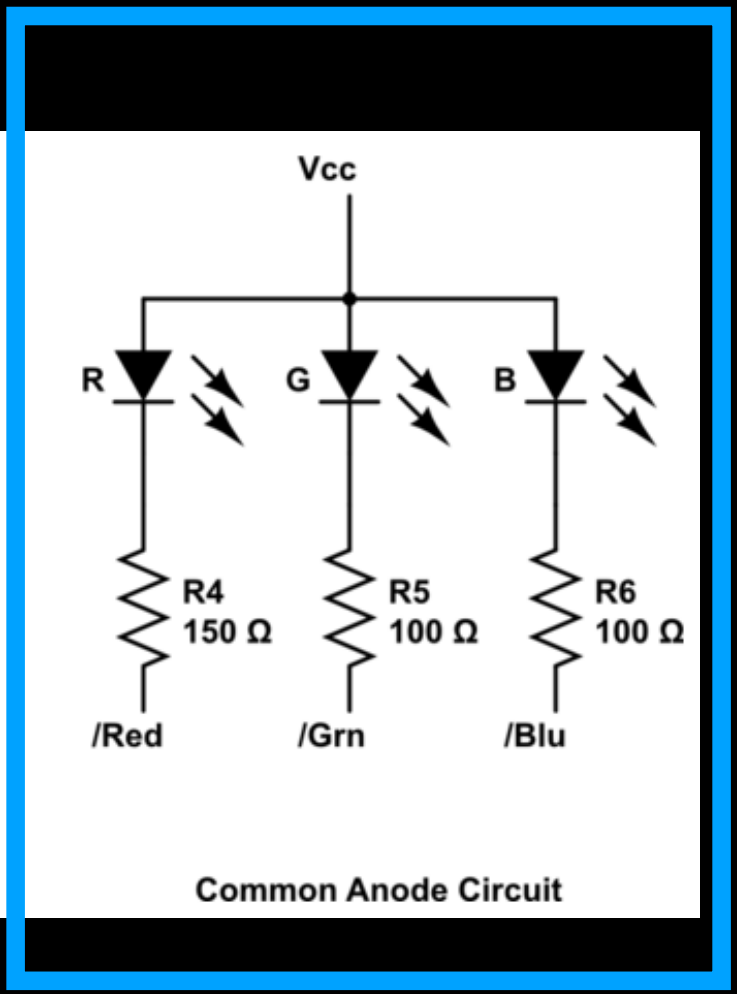

Epoxy lens/case
Wire bond
Reflective cavity
Semiconductor die
Anvil
Post
Leadframe
Flat spot
Anode
Cathode

RGB LEDs



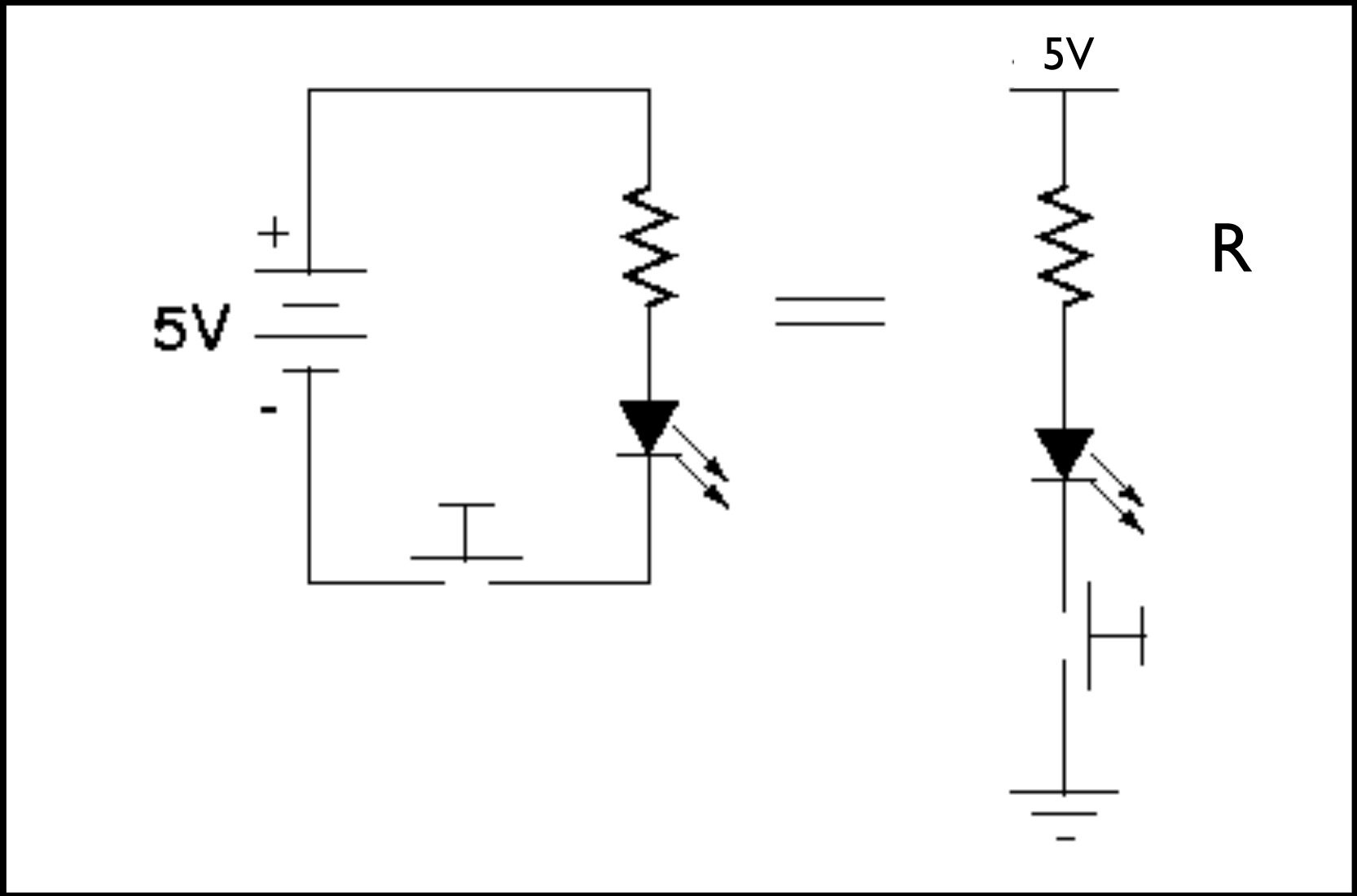


Common Cathode Circuit



Common Anode Circuit

Current regulation in the Pushbutton LED circuit



Ohm's Law states that Voltage = Current X Resistance

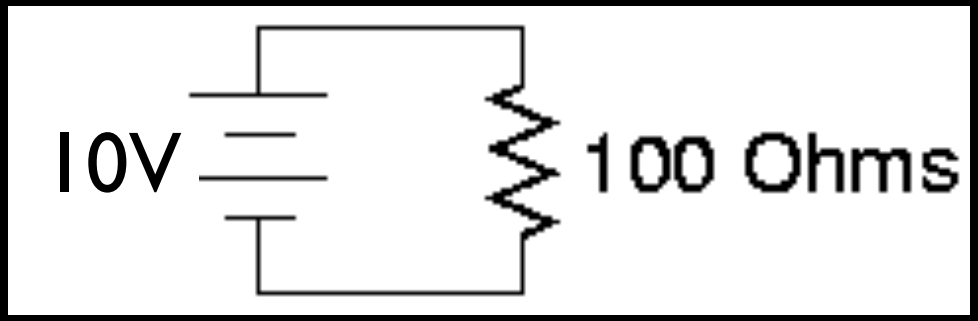
$$V=IR$$

Watt's Law states that Power = Voltage x Current

$$P=VI= I^2R$$

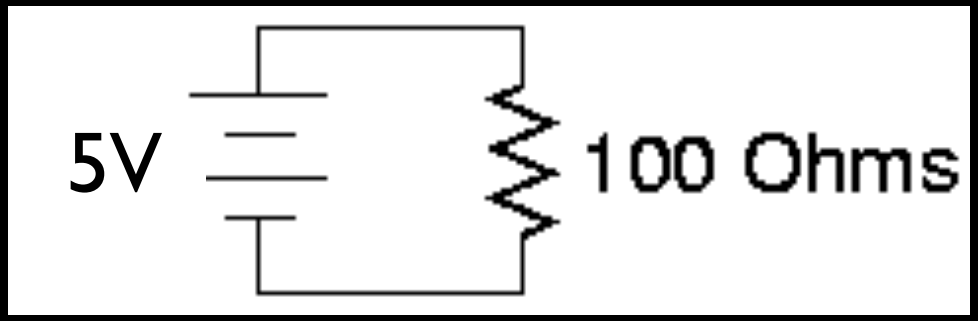
Ohm's Law states that Voltage = Current X Resistance

$V=IR$

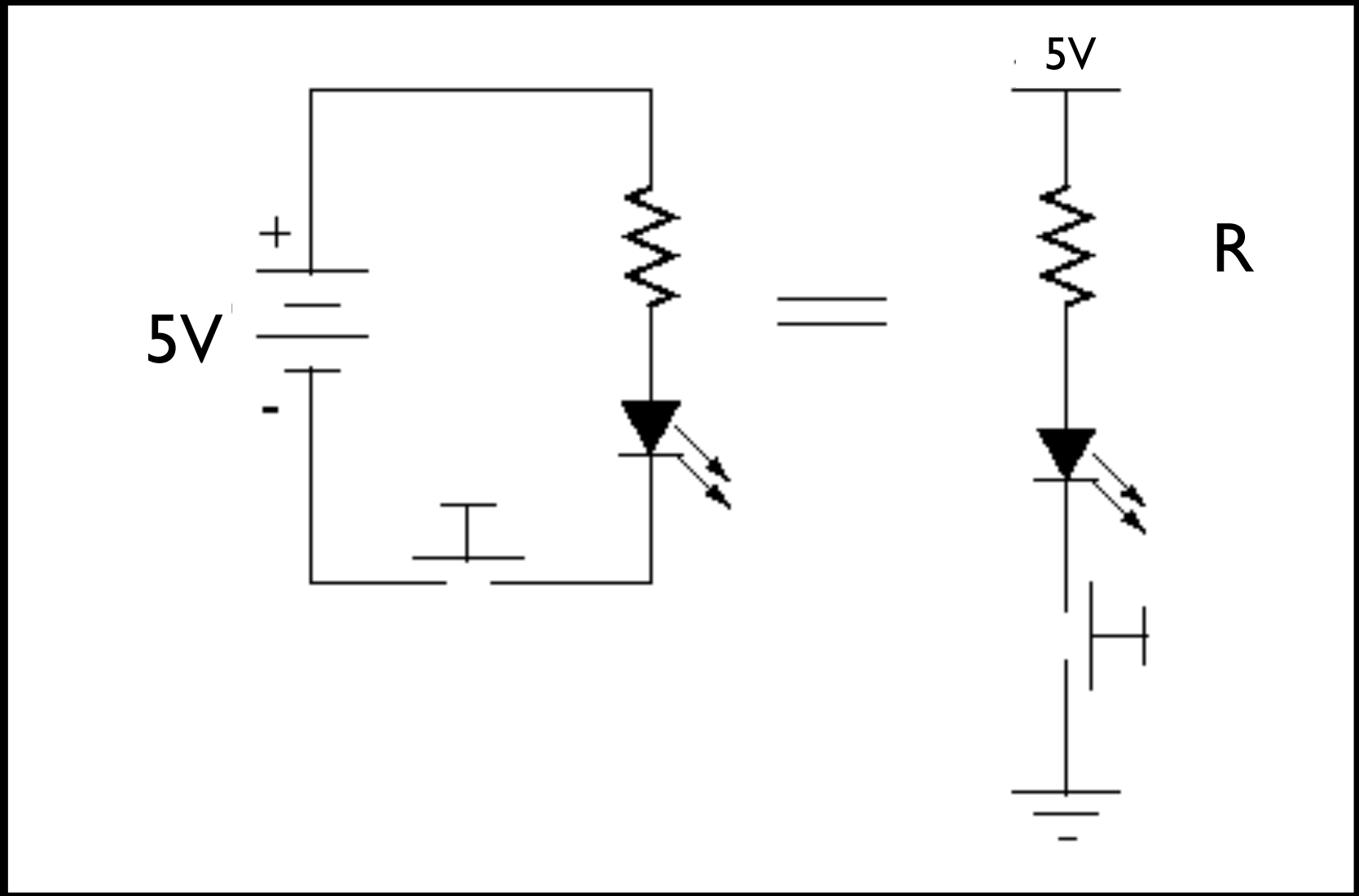


Ohm's Law states that Voltage = Current X Resistance

$$V=IR$$



Equivalent Pushbutton LED circuit



DON’T SHORT POWER TO GROUND

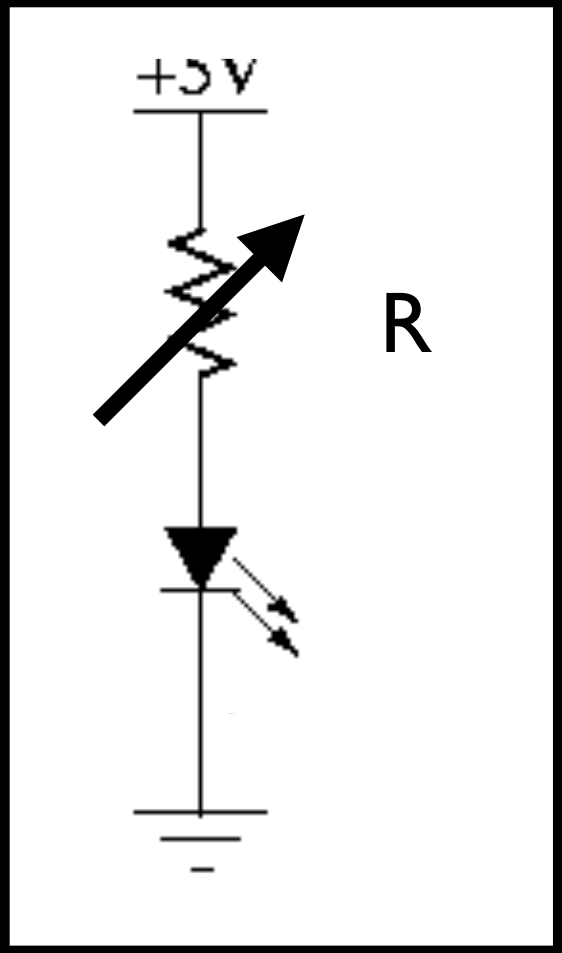
$$V=IR$$

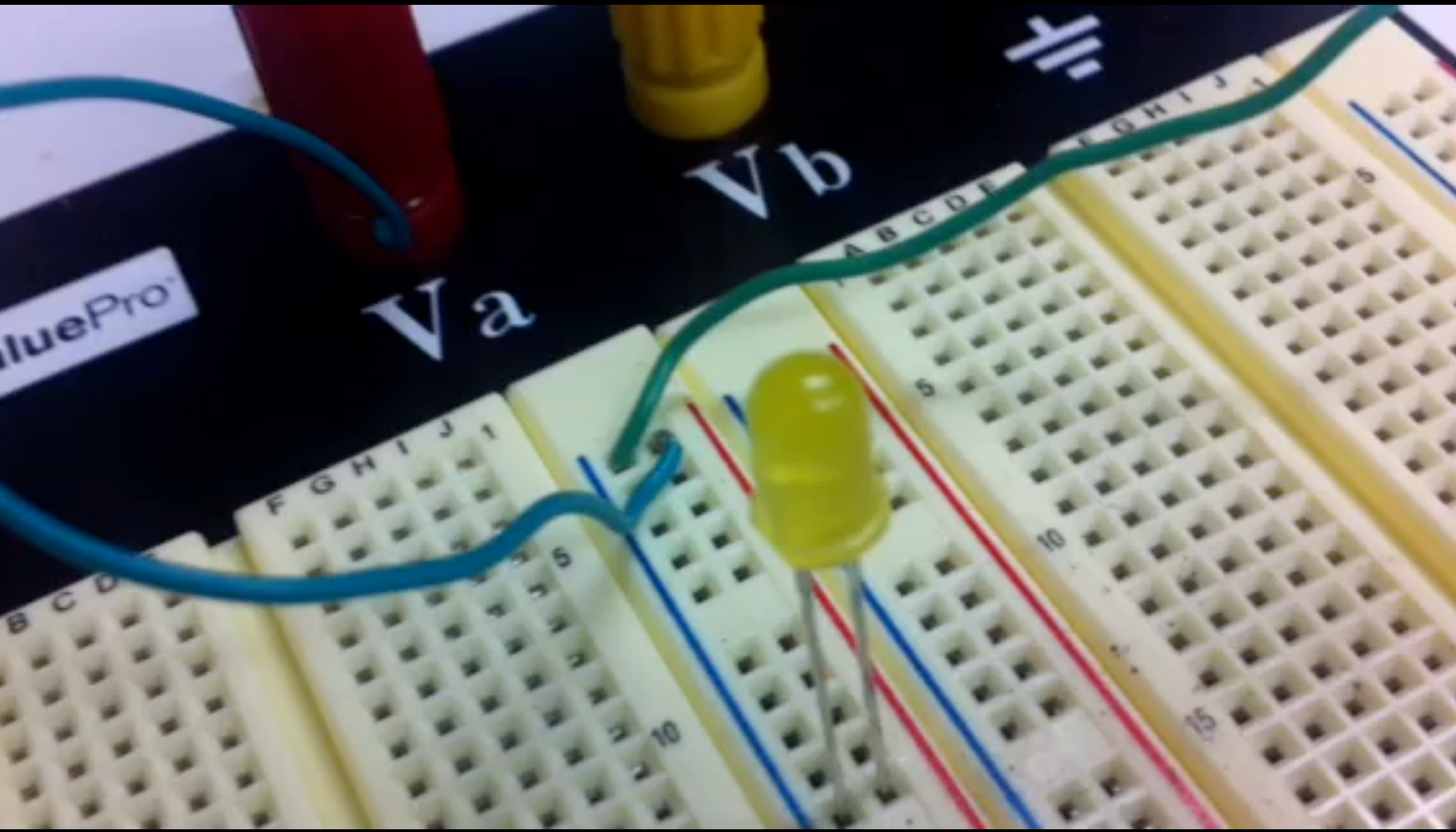
$$I=V/R$$

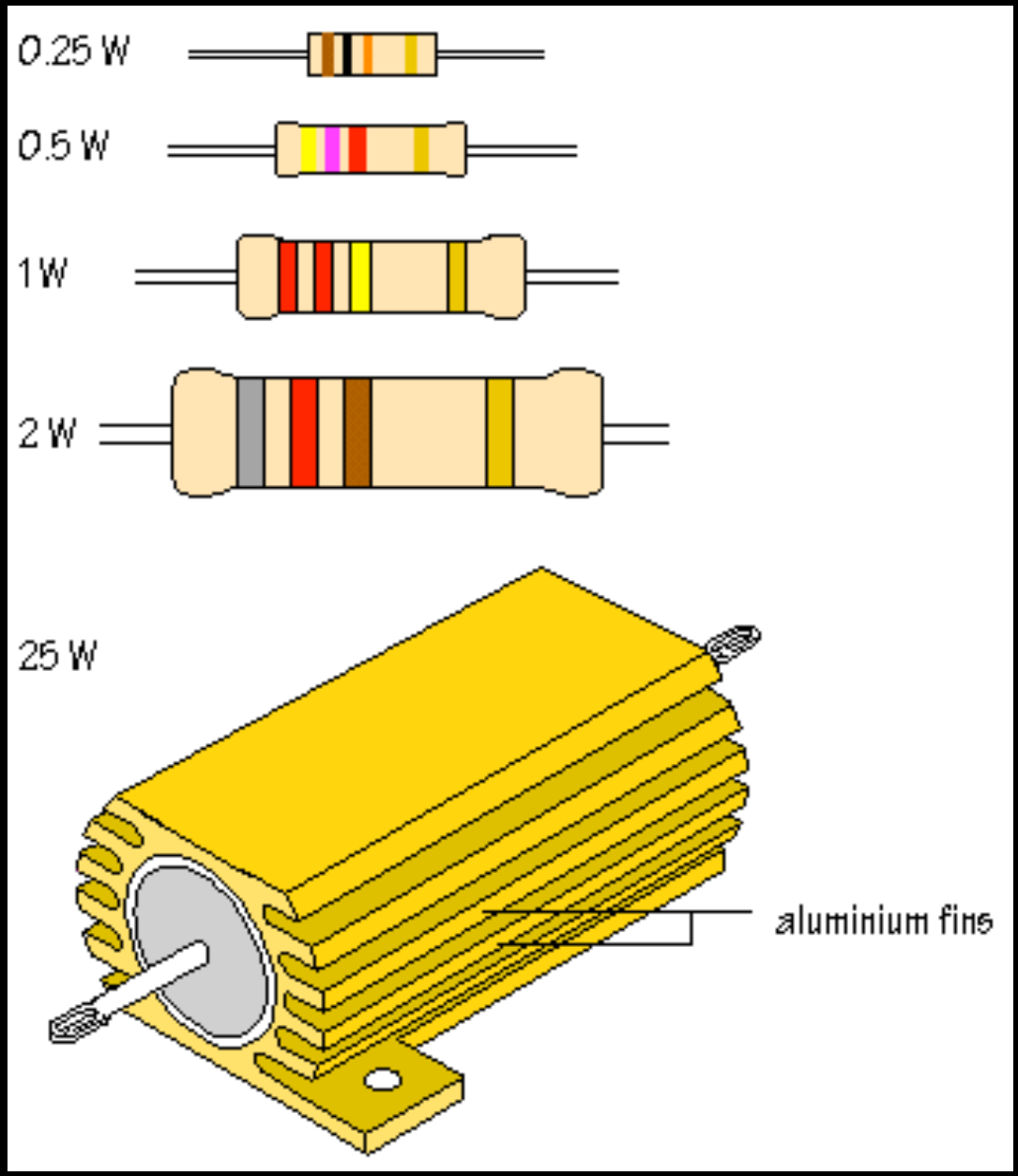
$$\text{If } R=0, I=\infty$$

A little excitement

Why is this a BAD circuit?

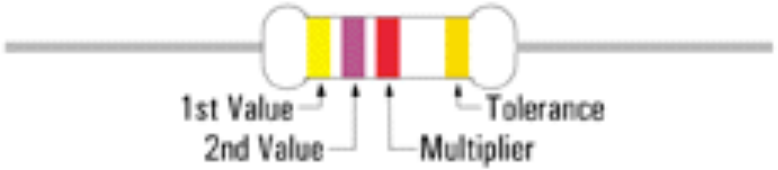



Va
Vb



images from www.steiniche.dk/.../resistors-filer

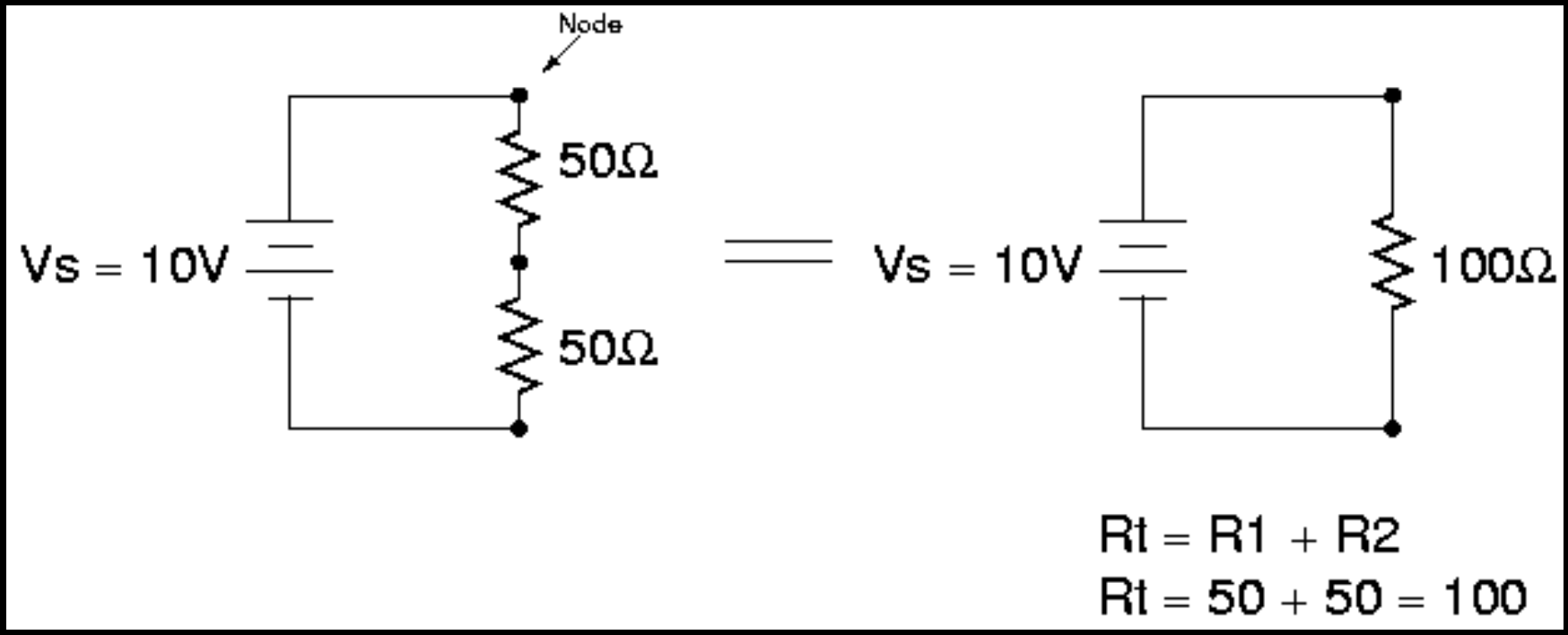
READING RESISTANCE VALUES



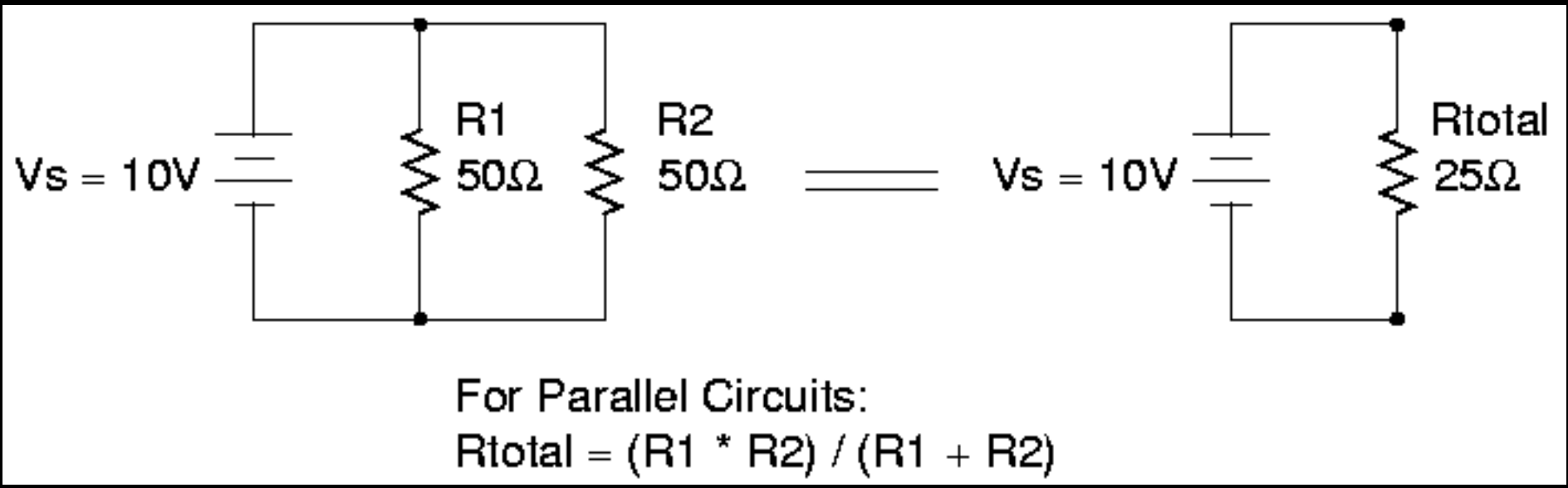
Example: 4 7 x100 –5%
4700Ω–5%

COLOR	VALUE	MULTIPLIER	TOLERANCE
Black	0	1	·
Brown	1	10	–1%
Red	2	100	–2%
Orange	3	1K	·
Yellow	4	10K	·
Green	5	100K	–.5%
Blue	6	1M	–.25%
Violet	7	10M	–.1%
Gray	8	100M	–.05%
White	9	1000M	·
Gold	·	1/10	–5%
Silver	·	1/100	–10%
None	·	·	–20%

Resistors in series ADD



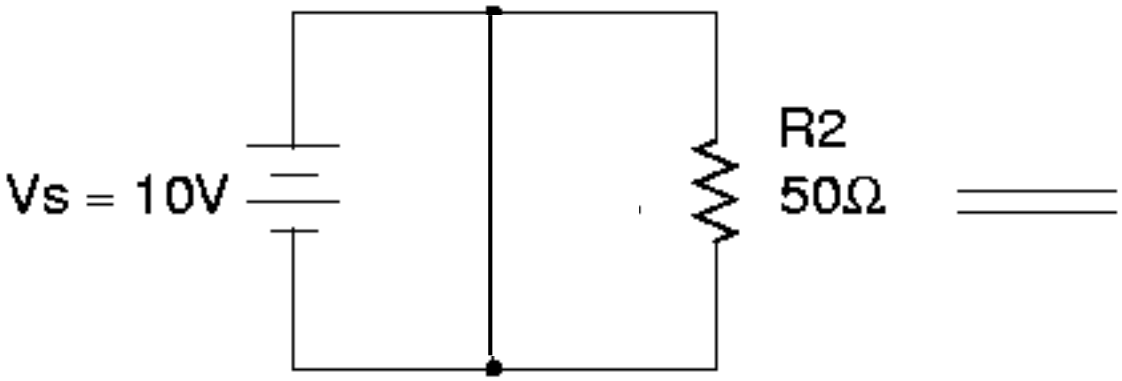
Resistors in parallel DIVIDE



For Parallel Circuits:

Rtotal = (R1 * R2) / (R1 + R2)

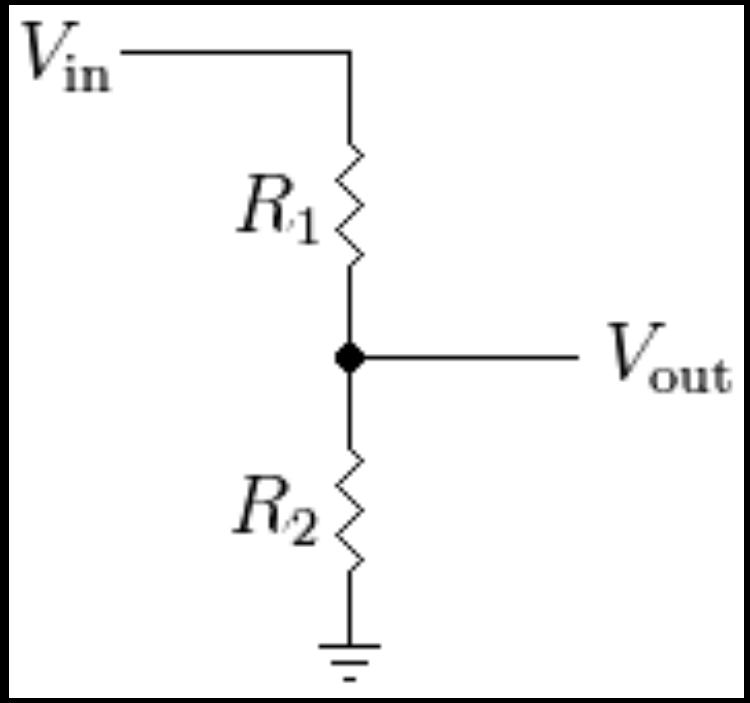
What is a SHORT CIRCUIT??? Why is this bad?



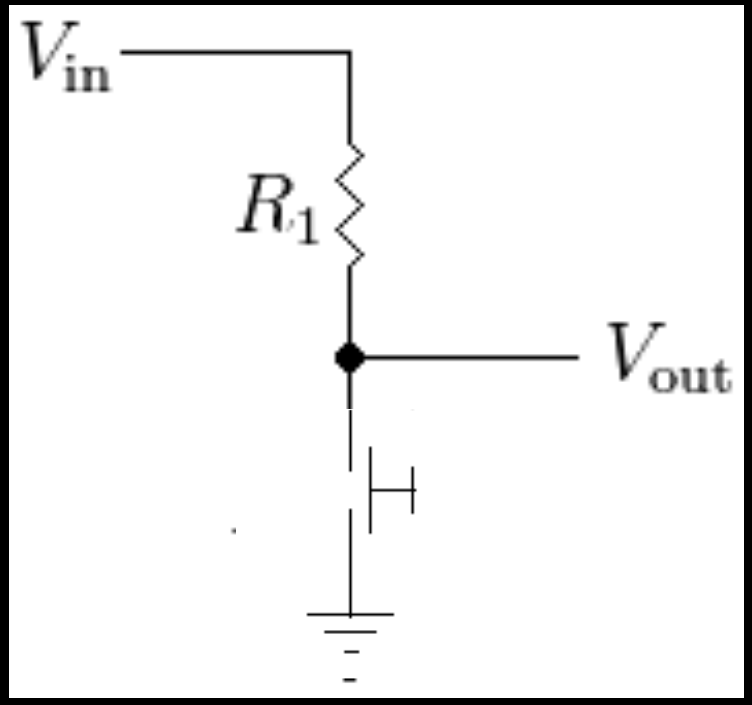
For Parallel Circuits:

Rtotal = (R1 * R2) / (R1 + R2)

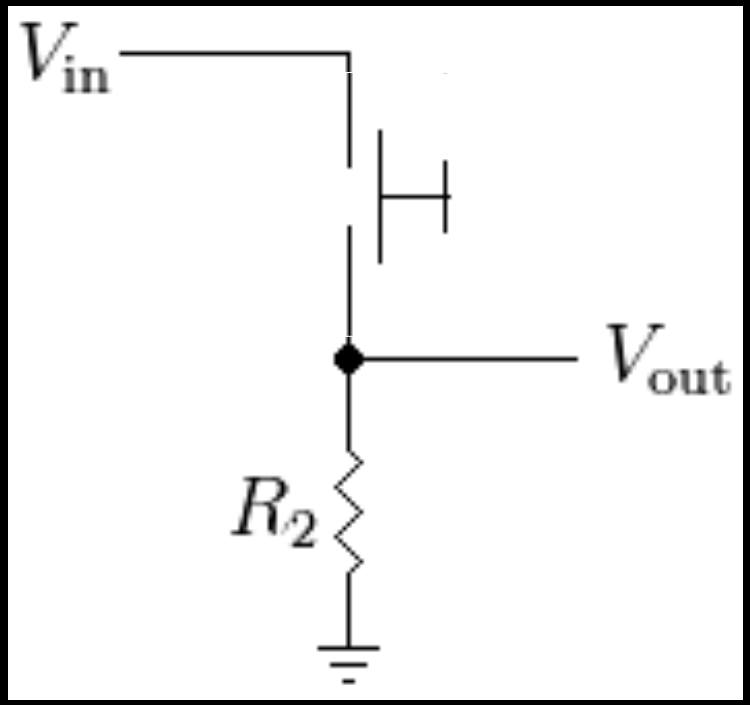
VOLTAGE DIVIDER CIRCUIT



PULL UP RESISTOR



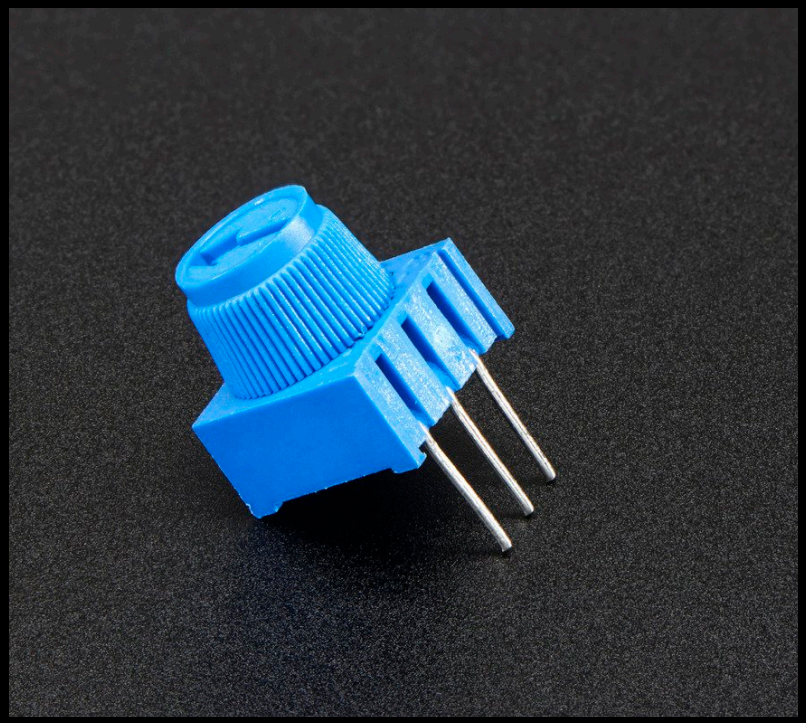
PULL DOWN RESISTOR

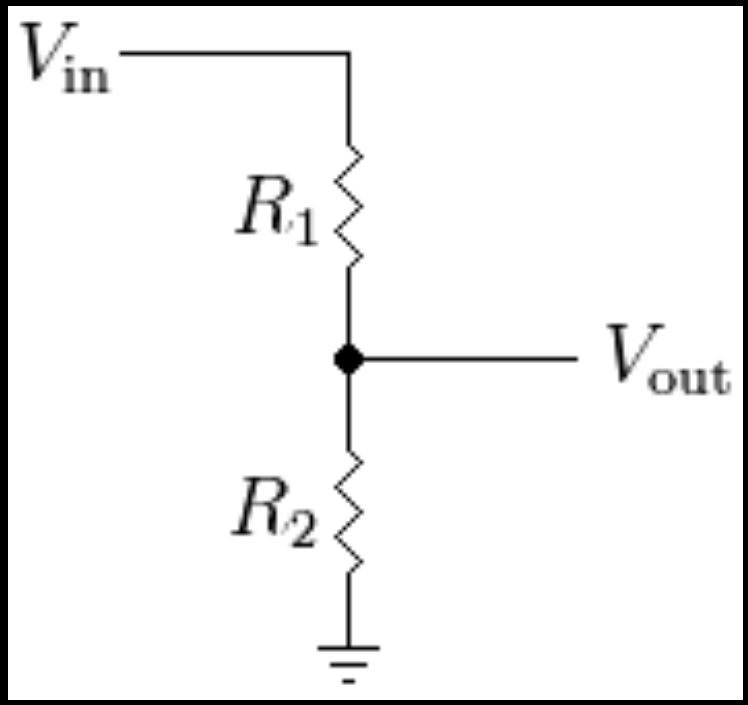


Adjusting the brightness of your LEDs

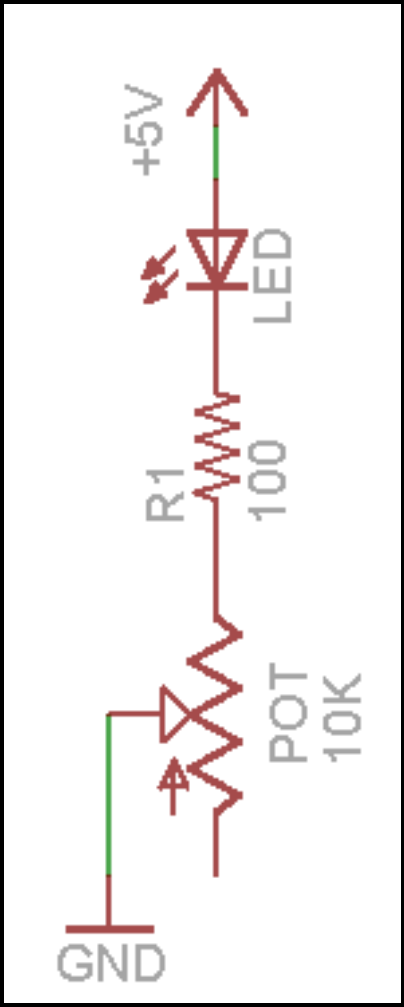
A potentiometer is a variable resistor,

a voltage divider in a package.





Adjusting the brightness of your LEDs



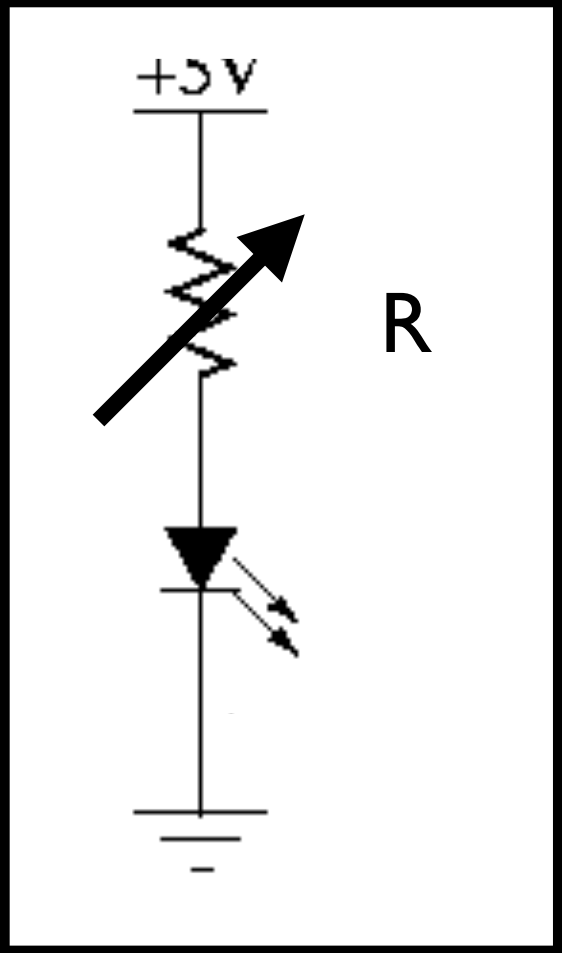
The LED is a diode, with a fixed voltage drop.

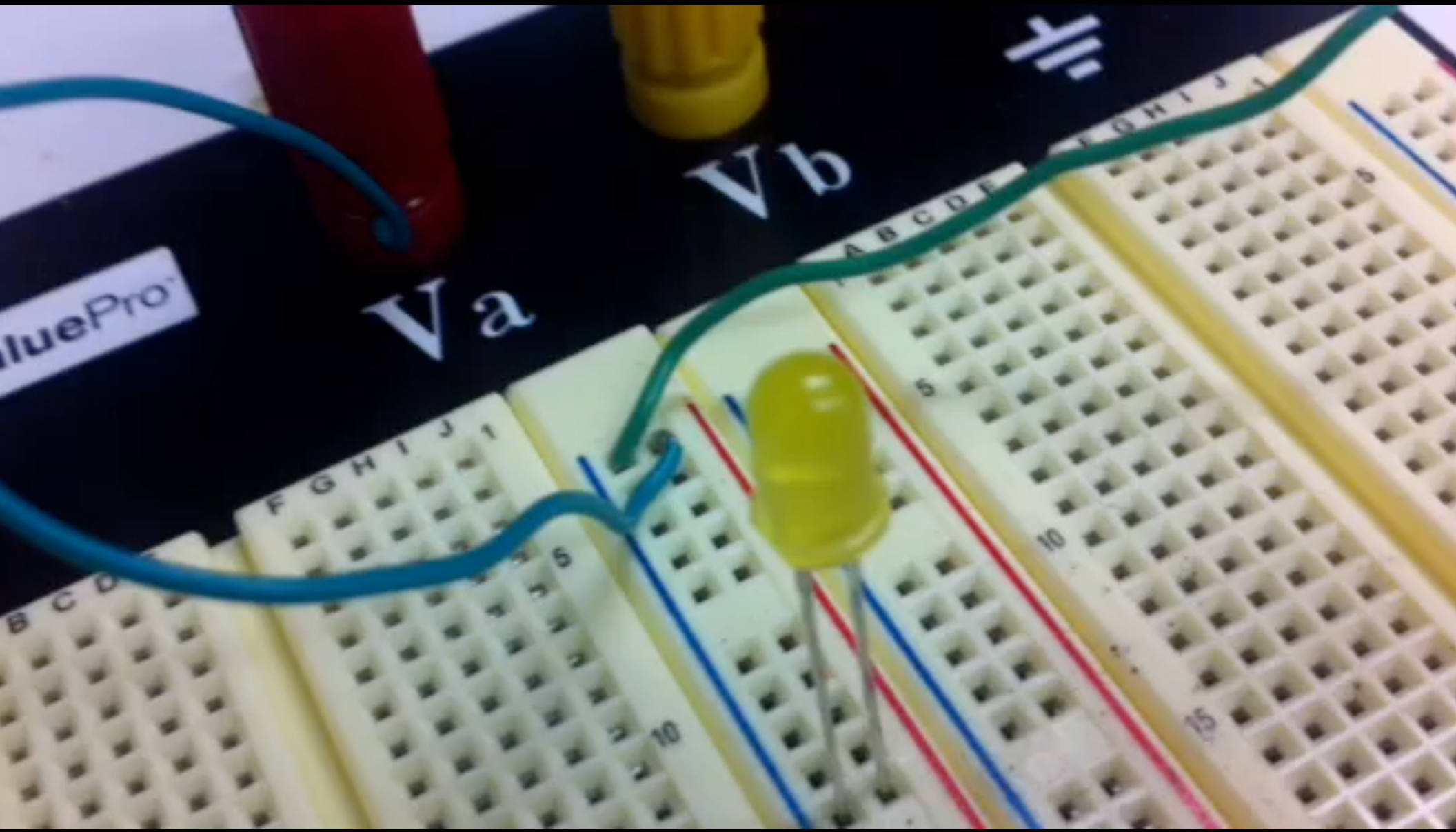
The Current is set by the series resistor

The brightness of the LED is a function of the current, created by the resistance.

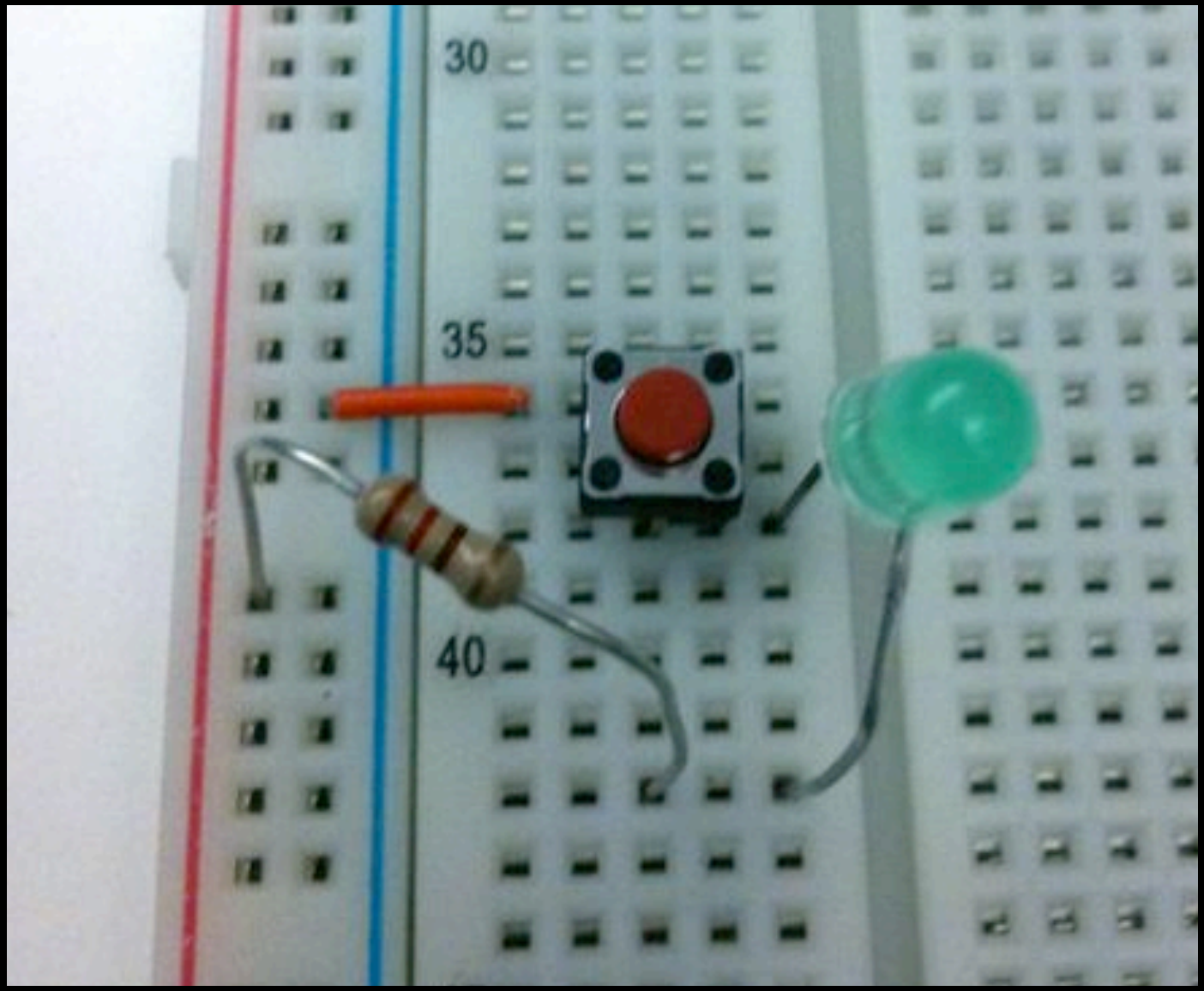
I= V/R

Why is this a BAD circuit?




Va
Vb

Pushbutton LED circuit



Pushbutton LED circuit breadboard drawing

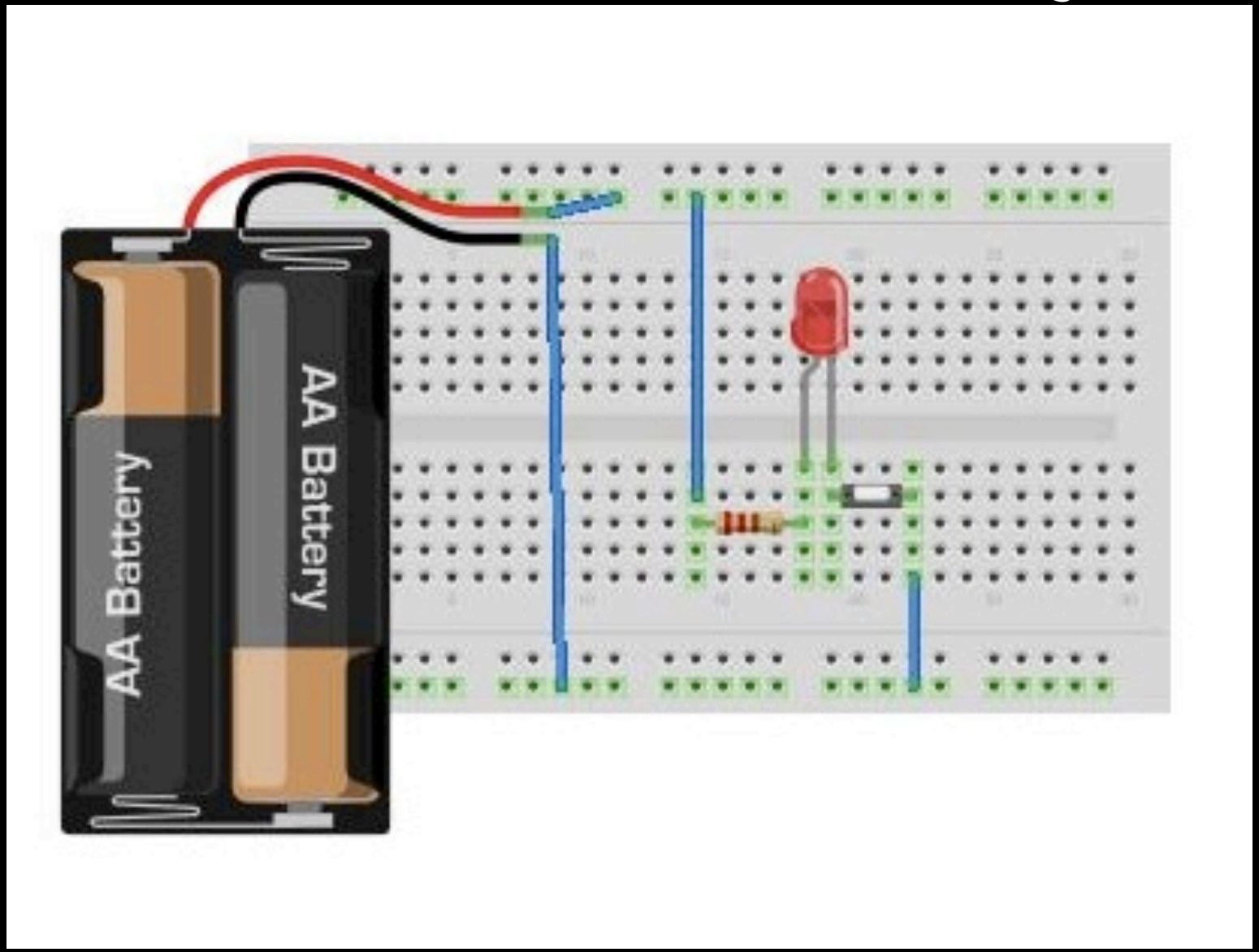


diagram made in Fritzing

Pushbutton LED circuit schematic