

Circuits & Schematics

August 28, 2018

Reminders

Bring something to hack on Thursday

You should have a class buddy

Circuits

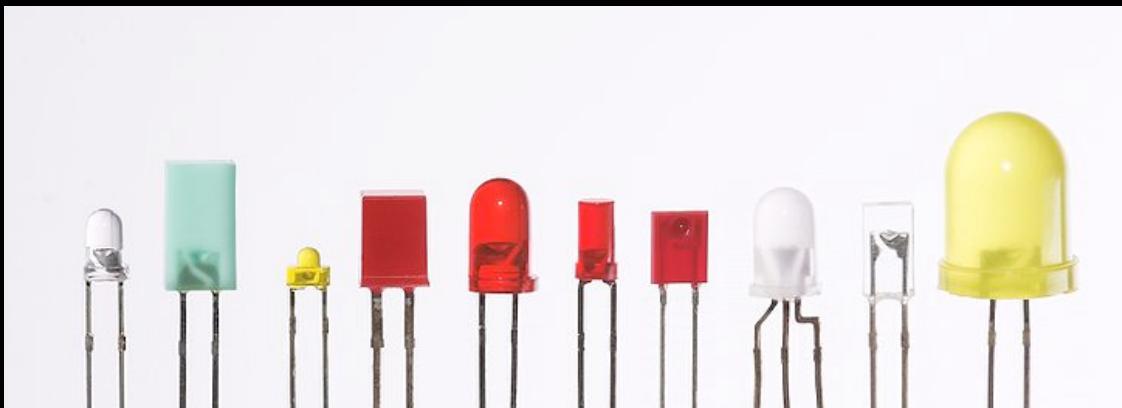
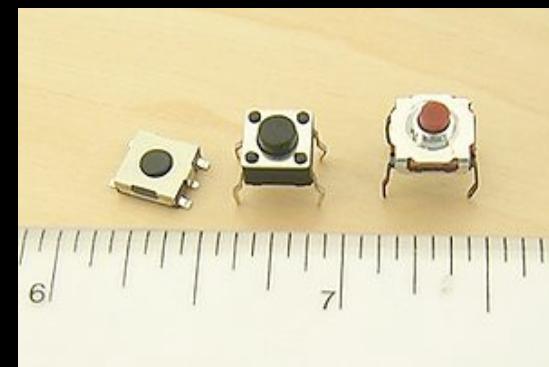
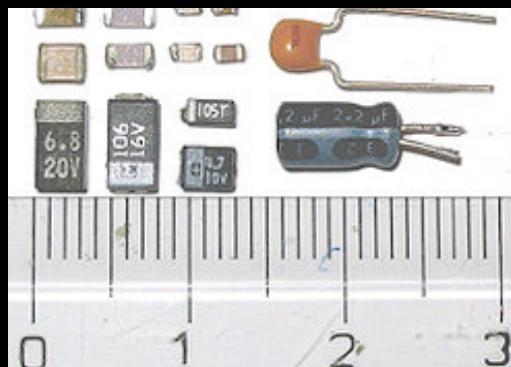
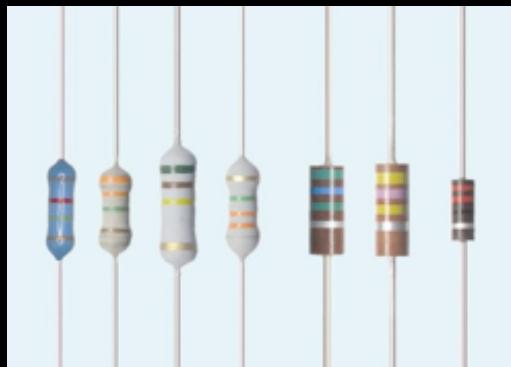
Common Components | Voltage | Current | Resistance

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.

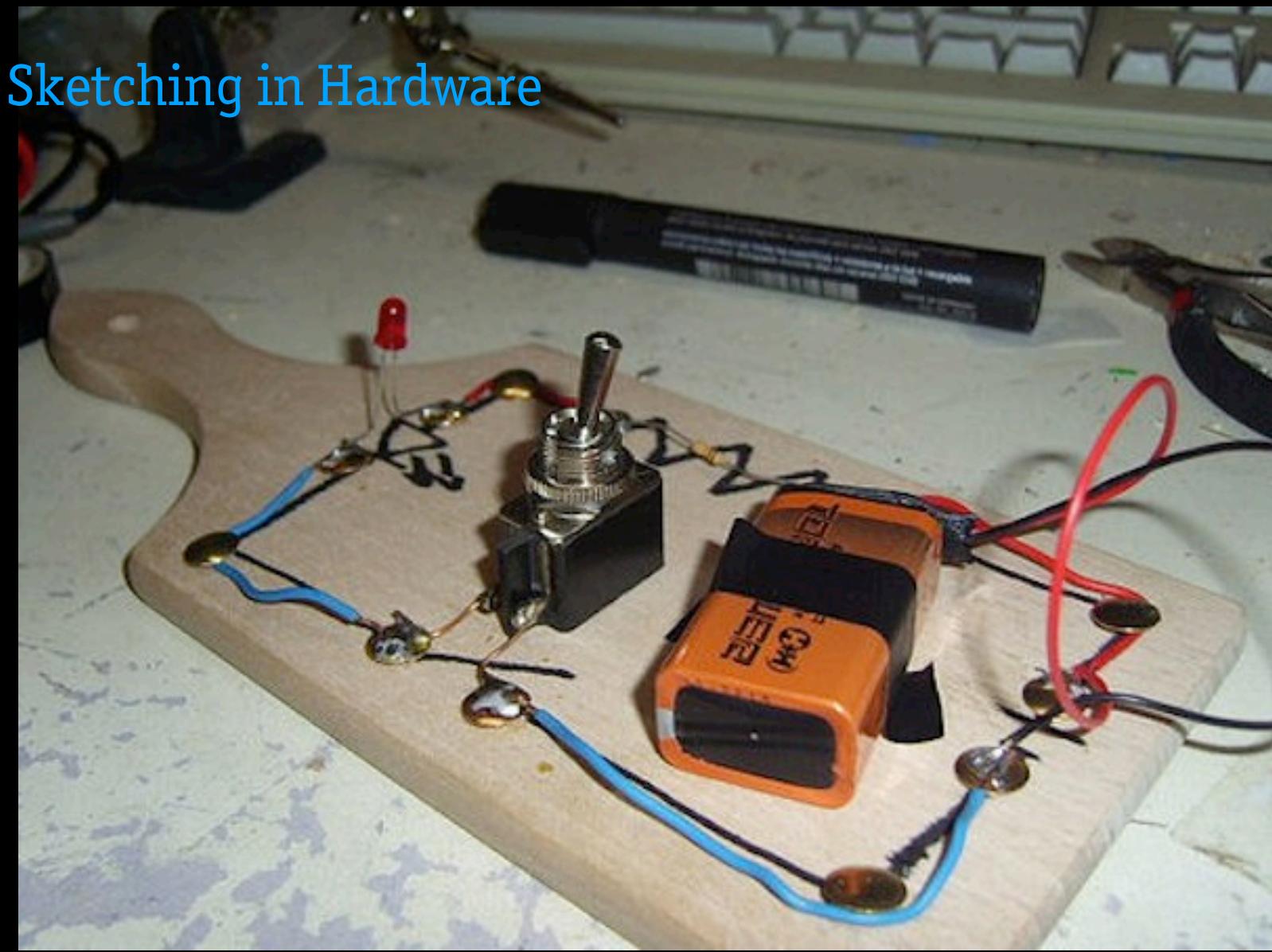


image from <https://learn.sparkfun.com/tutorials/how-to-use-a-breadboard>

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

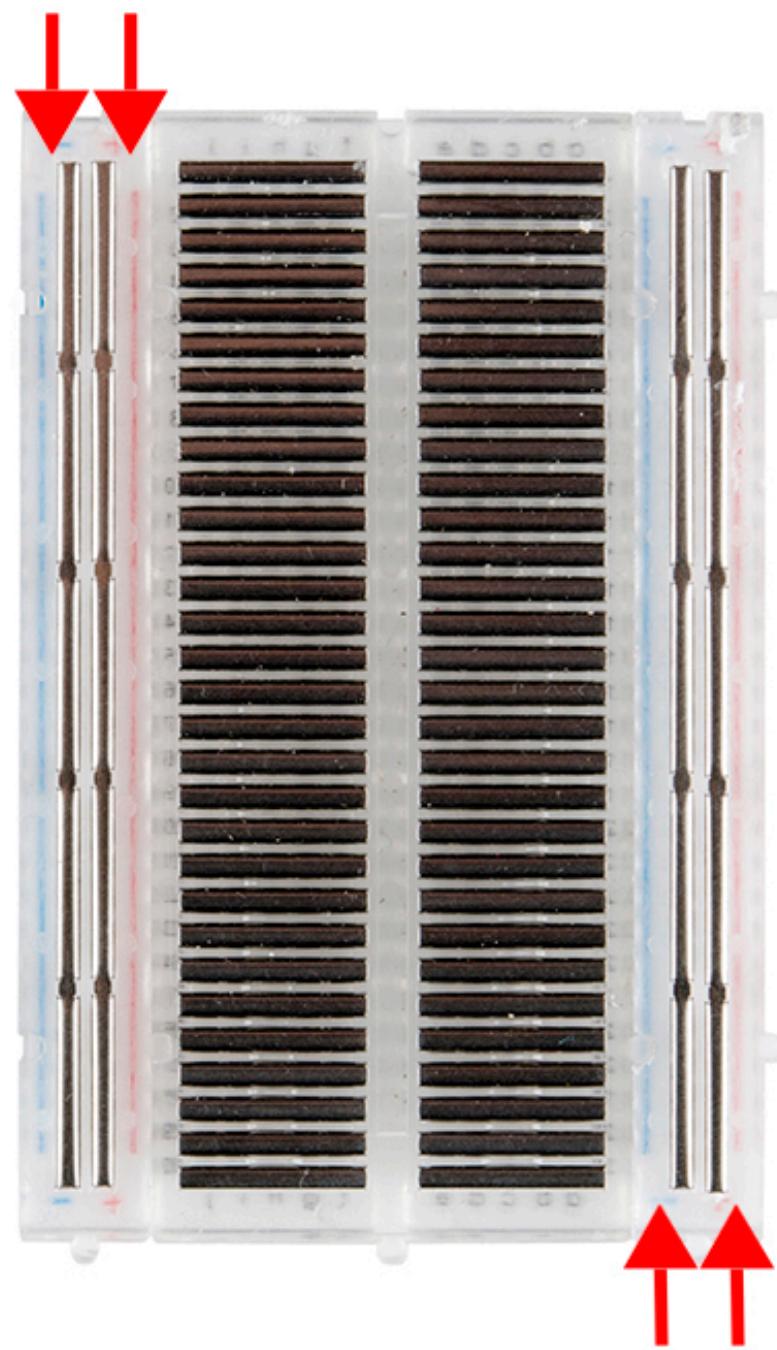
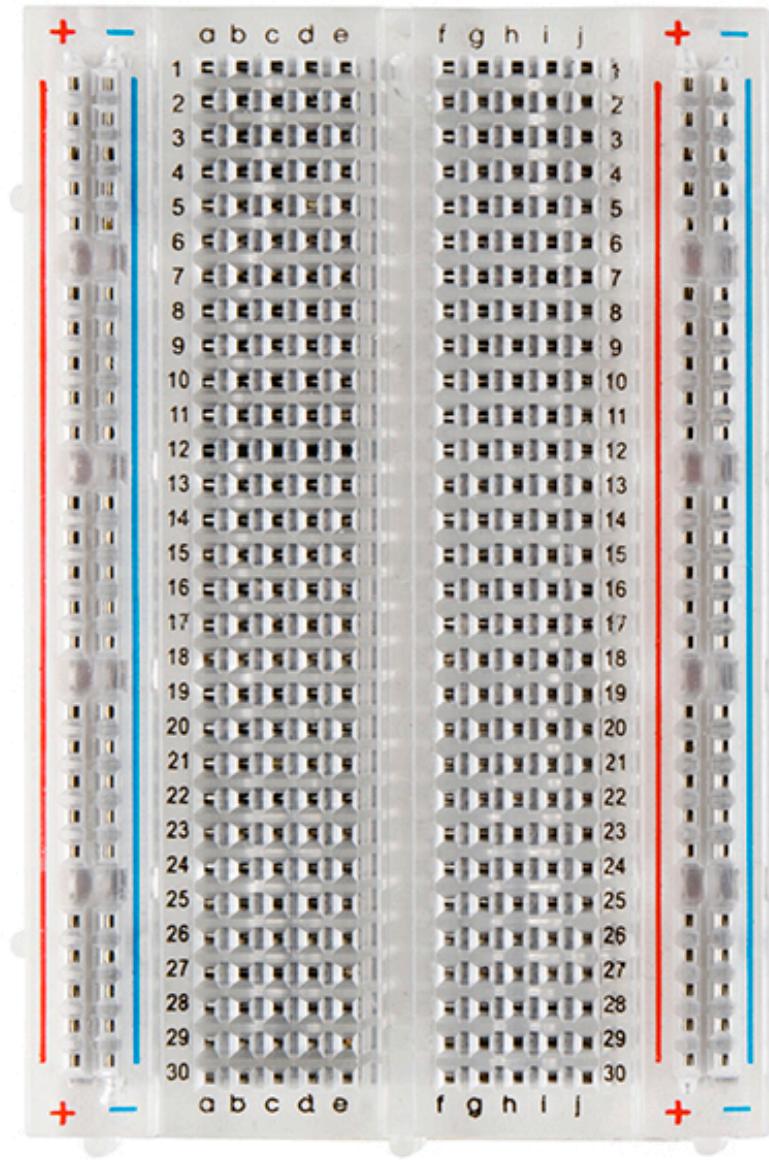
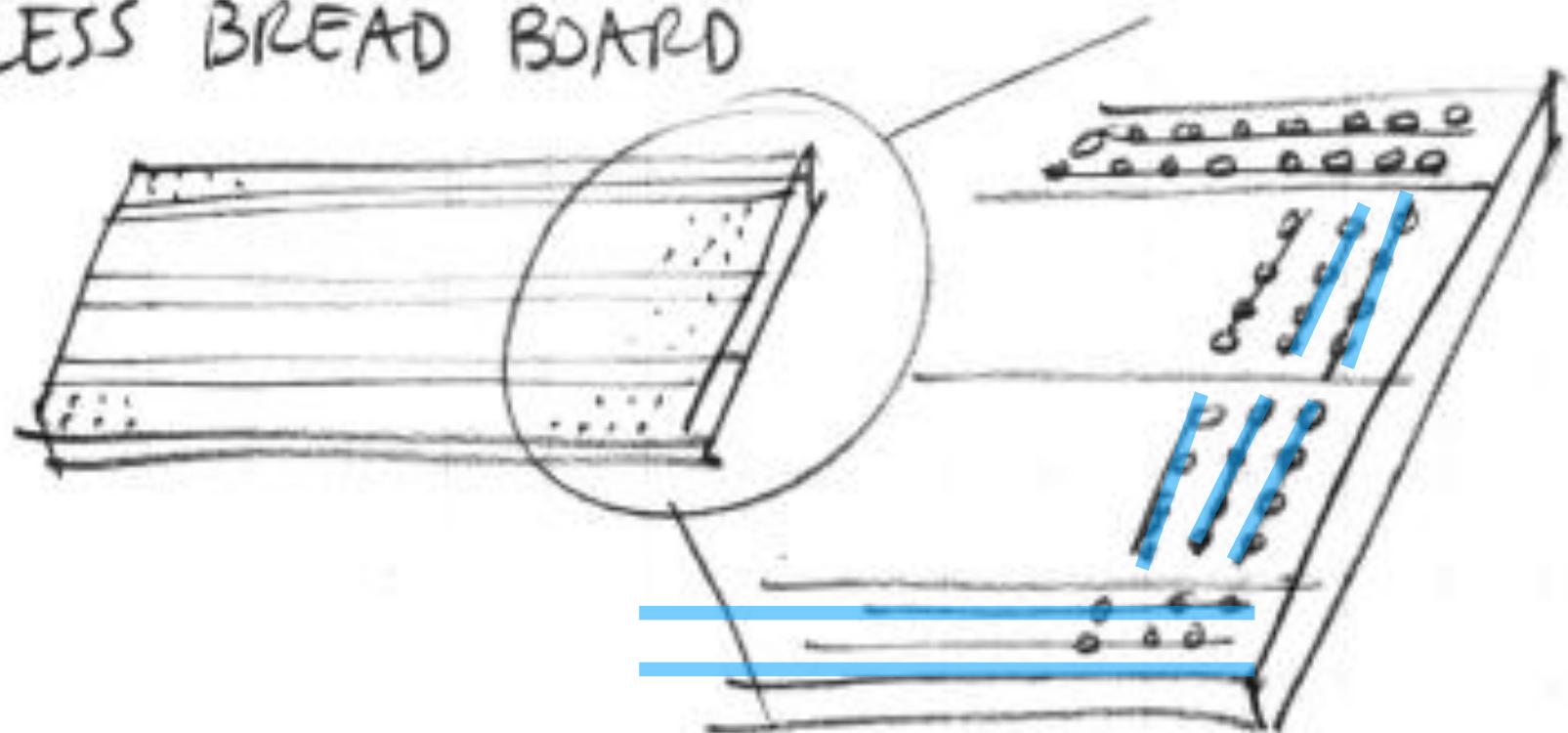


image from <https://learn.sparkfun.com/tutorials/how-to-use-a-breadboard>



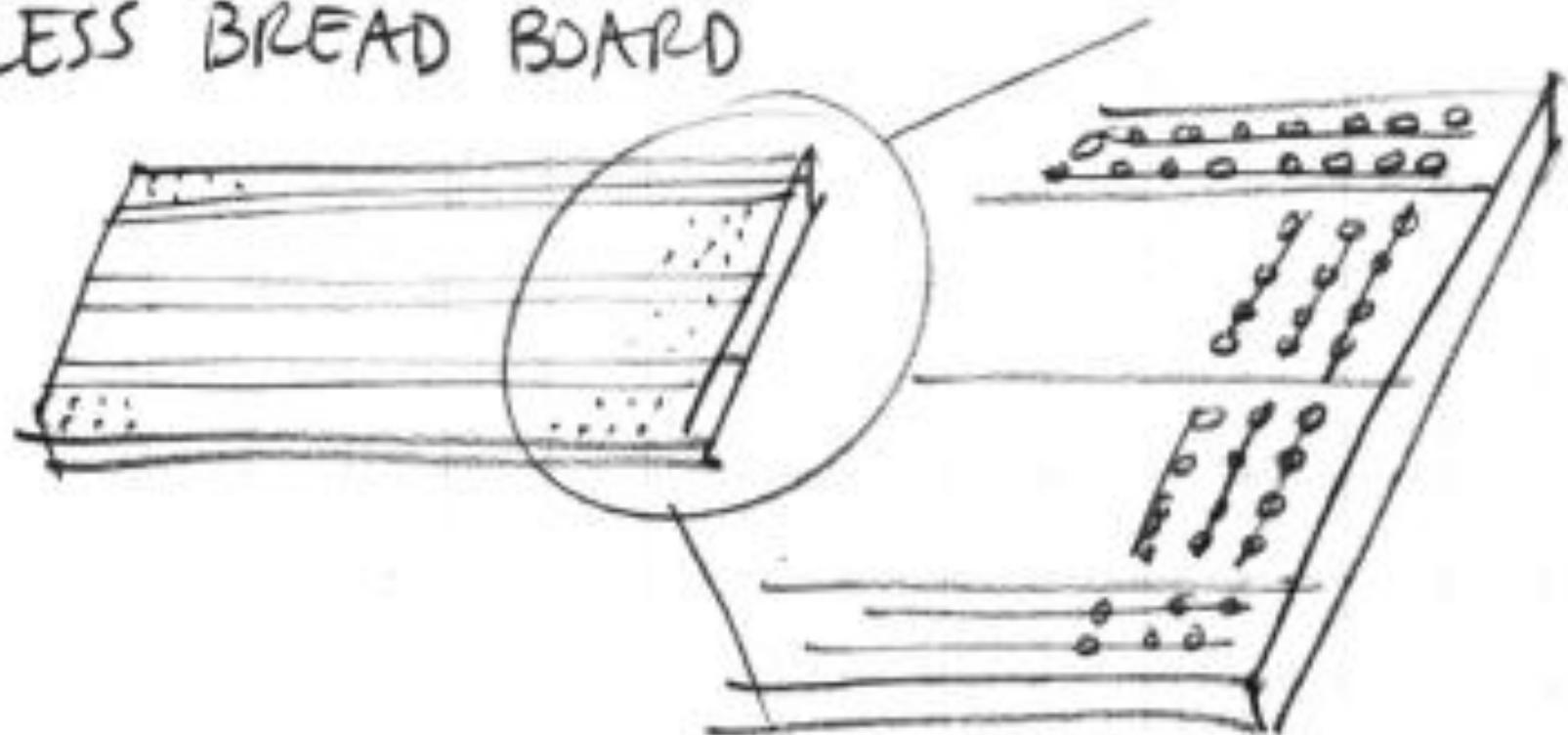
image from <https://learn.sparkfun.com/tutorials/how-to-use-a-breadboard>

SOLDER-LESS BREAD BOARD



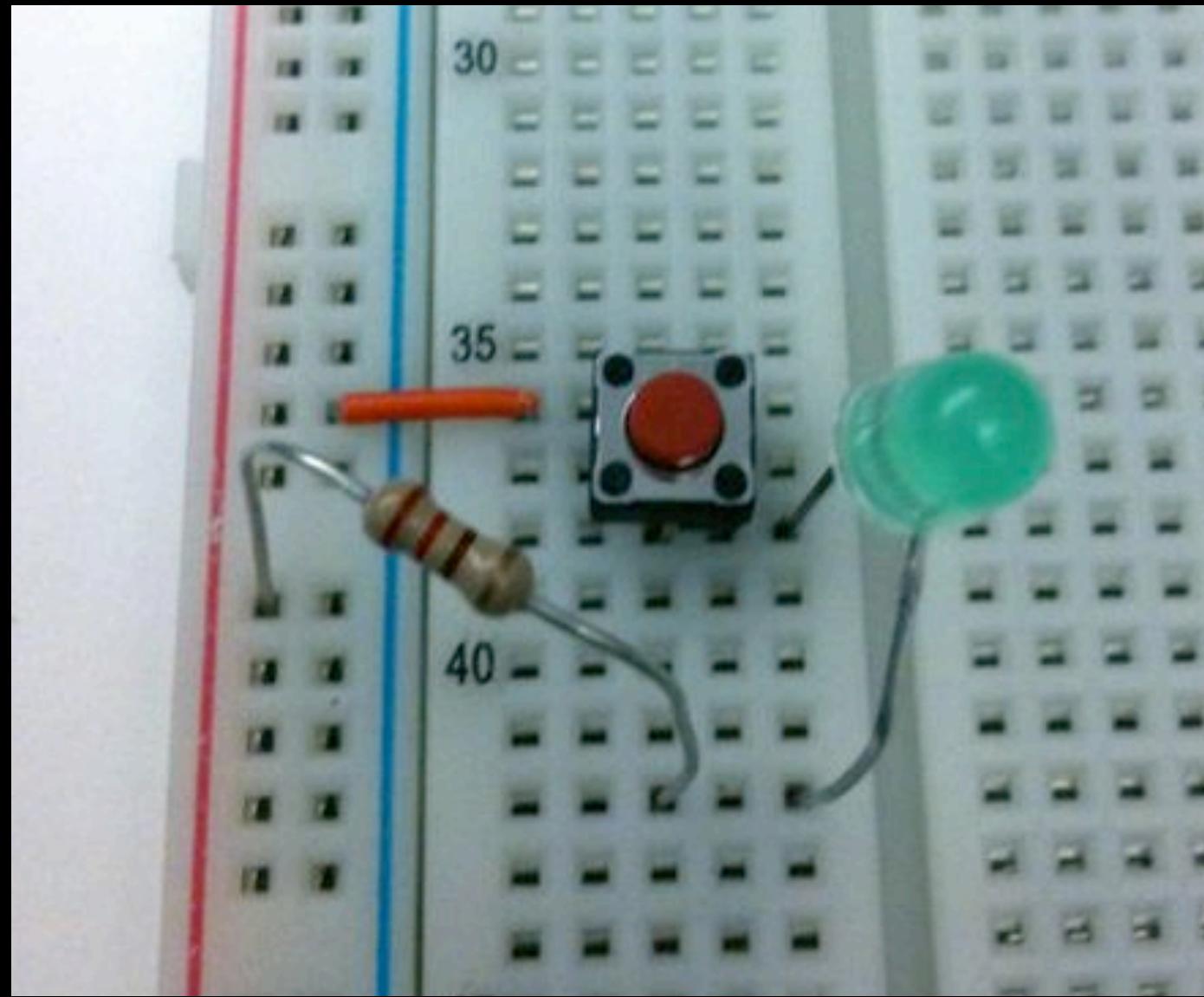
sketch by Bill Verplank

SOLDER-LESS BREAD BOARD



sketch by Bill Verplank

Pushbutton LED circuit



Pushbutton LED circuit breadboard drawing

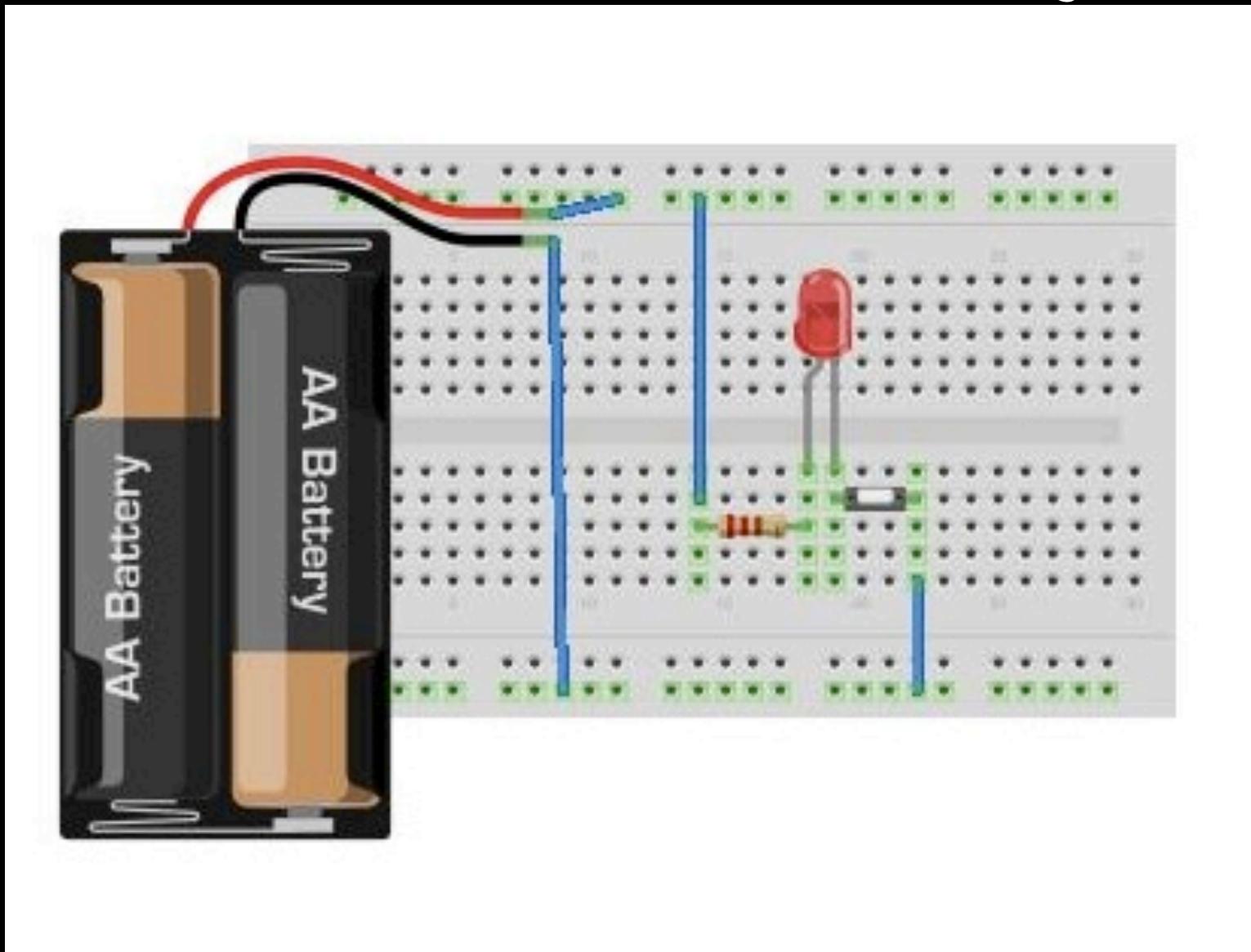
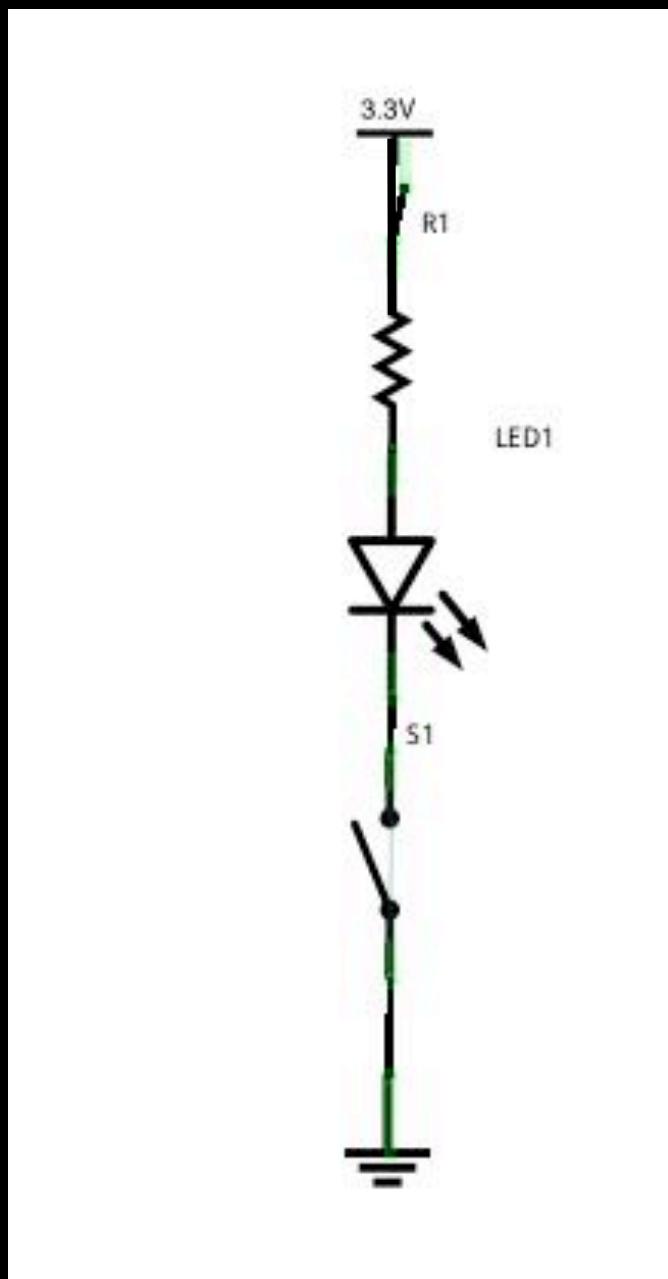
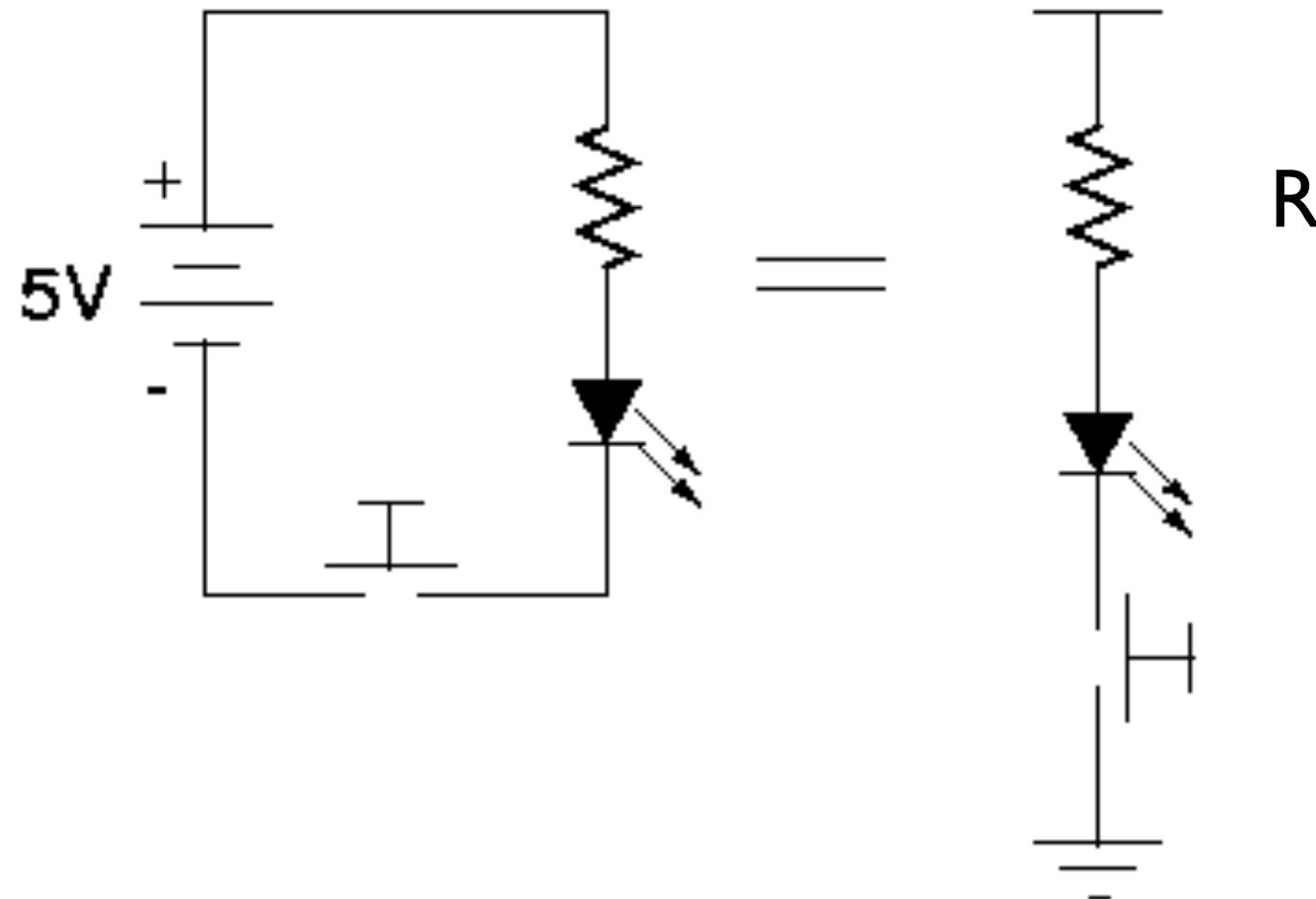


diagram made in Fritzing

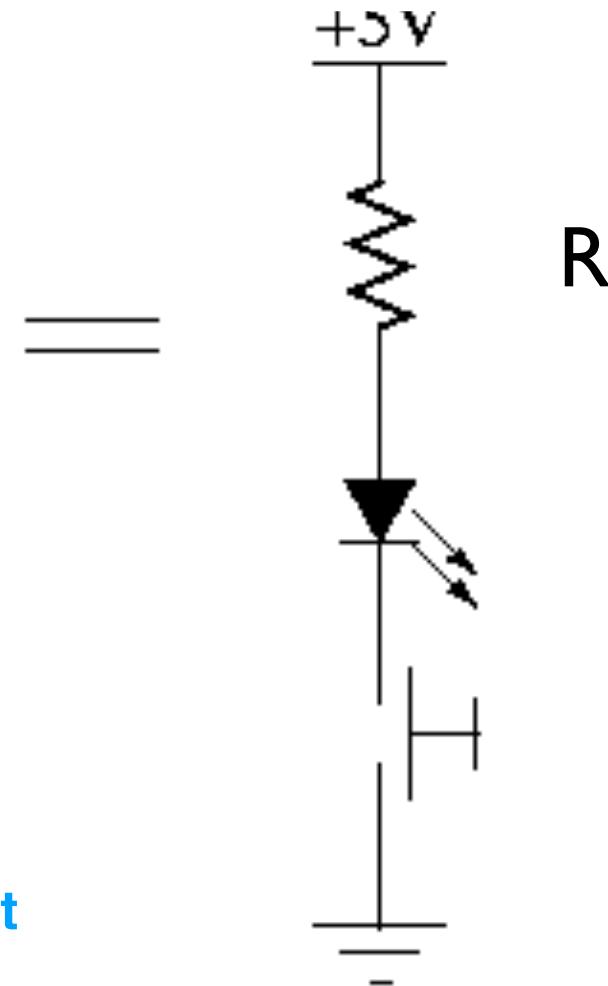
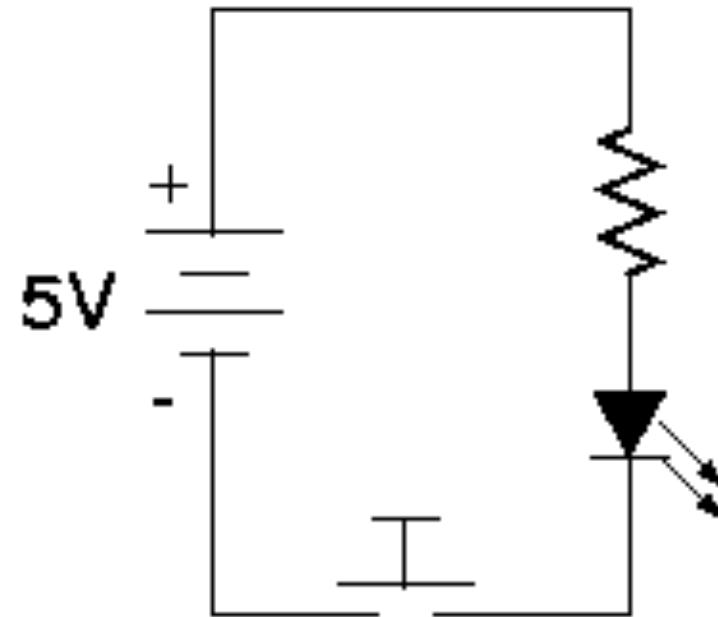
Pushbutton LED circuit schematic



Power in the Pushbutton LED circuit



KIRCHHOFF'S LAW in the Pushbutton LED circuit



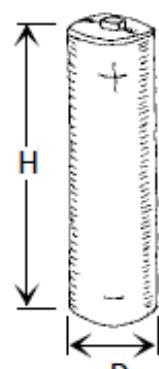
In any 'loop' of a circuit, the voltages must balance: the amount generated = the amount used

Common Alkaline and Carbon Zinc Cells

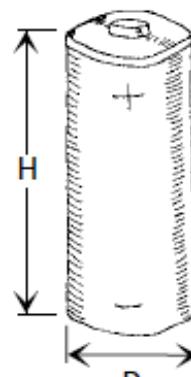
1.5V
"AAA"



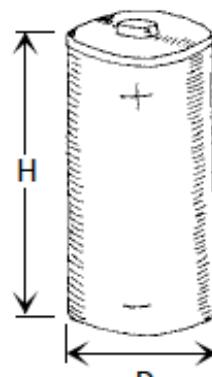
1.5V
"AA"



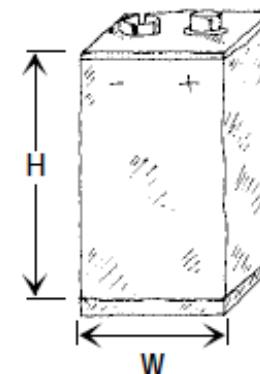
1.5V
"C"



1.5V
"D"



"9V"



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

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

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

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

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 to 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



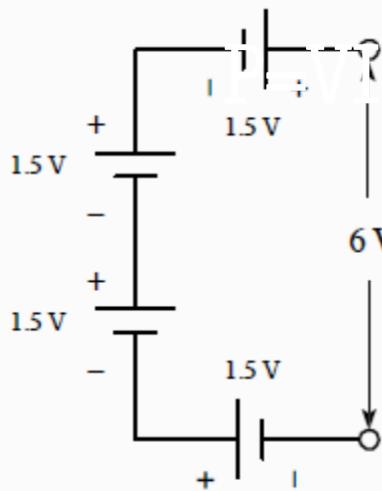
Voltage:
1.35 to 5.6V
Diameter:
0.5 to 0.695"
Thicknesses:
0.135" to 0.845"
mAh:
80 to 1000 mAh

Silver oxide

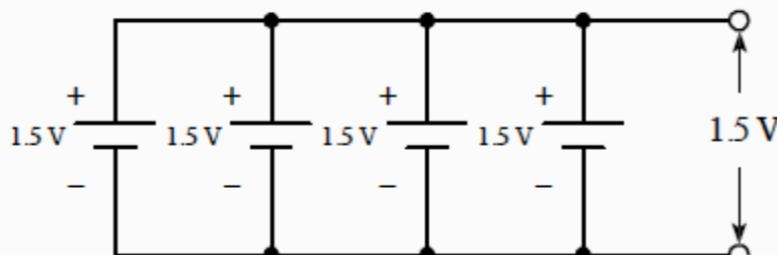


Voltage:
1.55V
Diameter:
0.267 to 0.610"
Thicknesses:
0.81" to 0.210"
mAh:
15 to 250 mAh
Label:
Given in I.E.C.
number (e.g., SRXX)

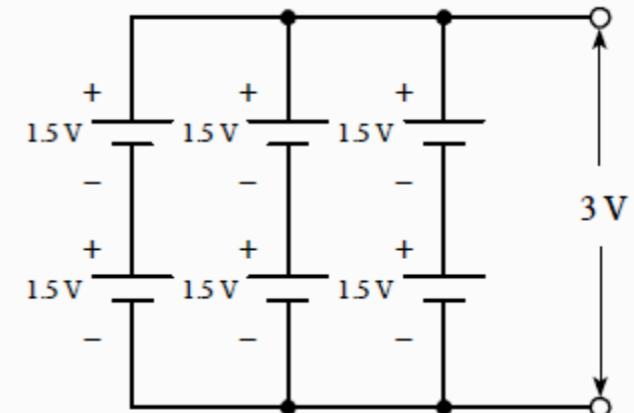
Power can come from supplies or batteries.



Increasing the voltage



Increasing the capacity

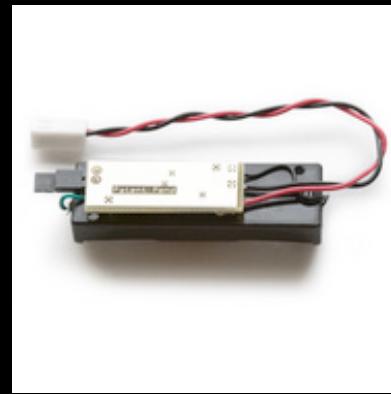


Increasing both voltage and capacity

Power Supply

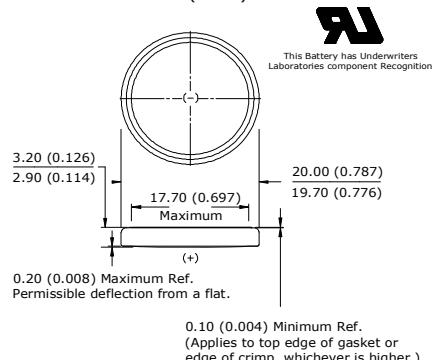
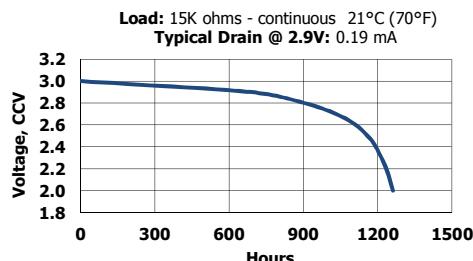


5V DC to DC Step Up - 1xAA



ENERGIZER CR2032**Industry Standard Dimensions**

mm (inches)

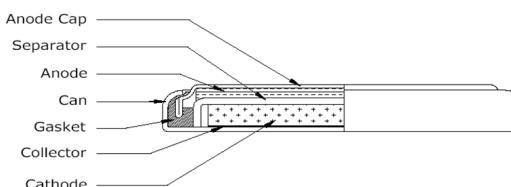
**Continuous Discharge Characteristics****Lithium Coin****Specifications**

Classification: "Lithium Coin"
Chemical System: Lithium / Manganese Dioxide (Li/MnO₂)
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

A 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.

Cross Section**Simulated Application test**

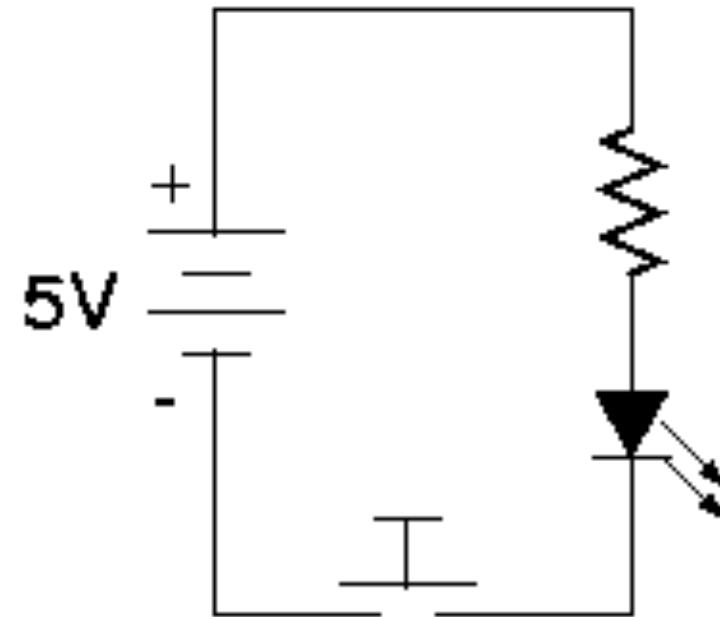
Typical Performance at 21°C (70°F)

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

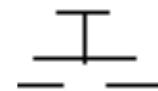
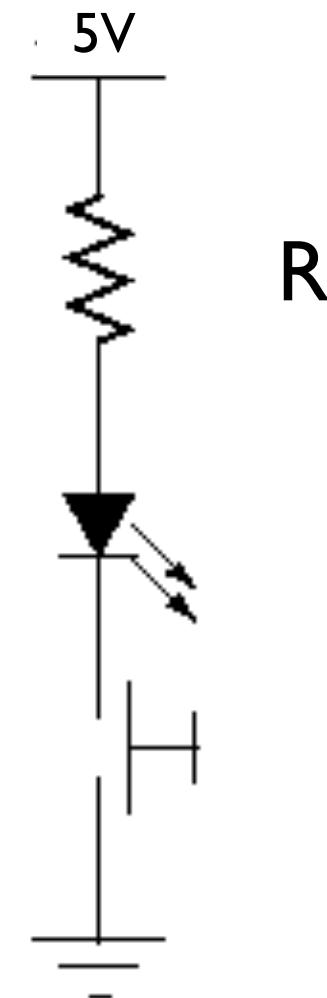
Important Notice

This datasheet contains typical information specific to products manufactured at the time of its publication.
©Energizer Holdings, Inc. - Contents herein do not constitute a warranty.

Input in the Pushbutton LED circuit



=

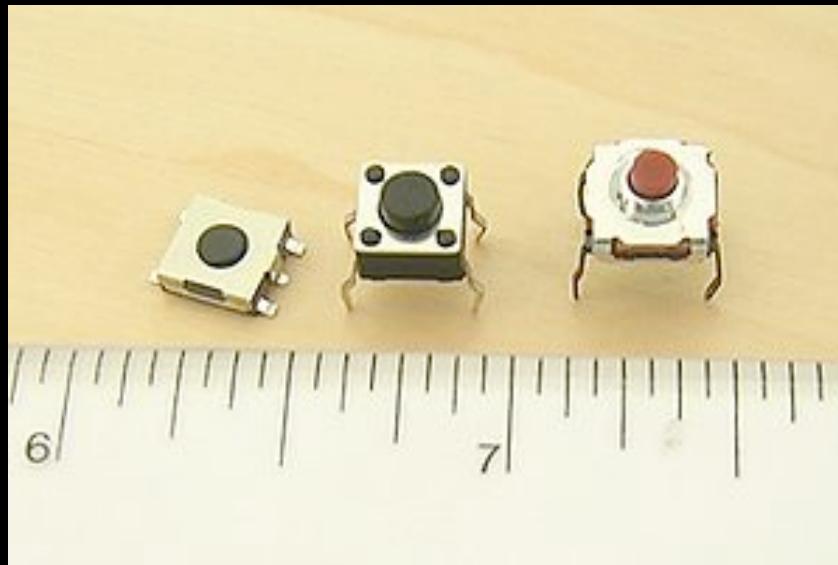


Normally Open Button



Normally Closed Button

Switches/Buttons

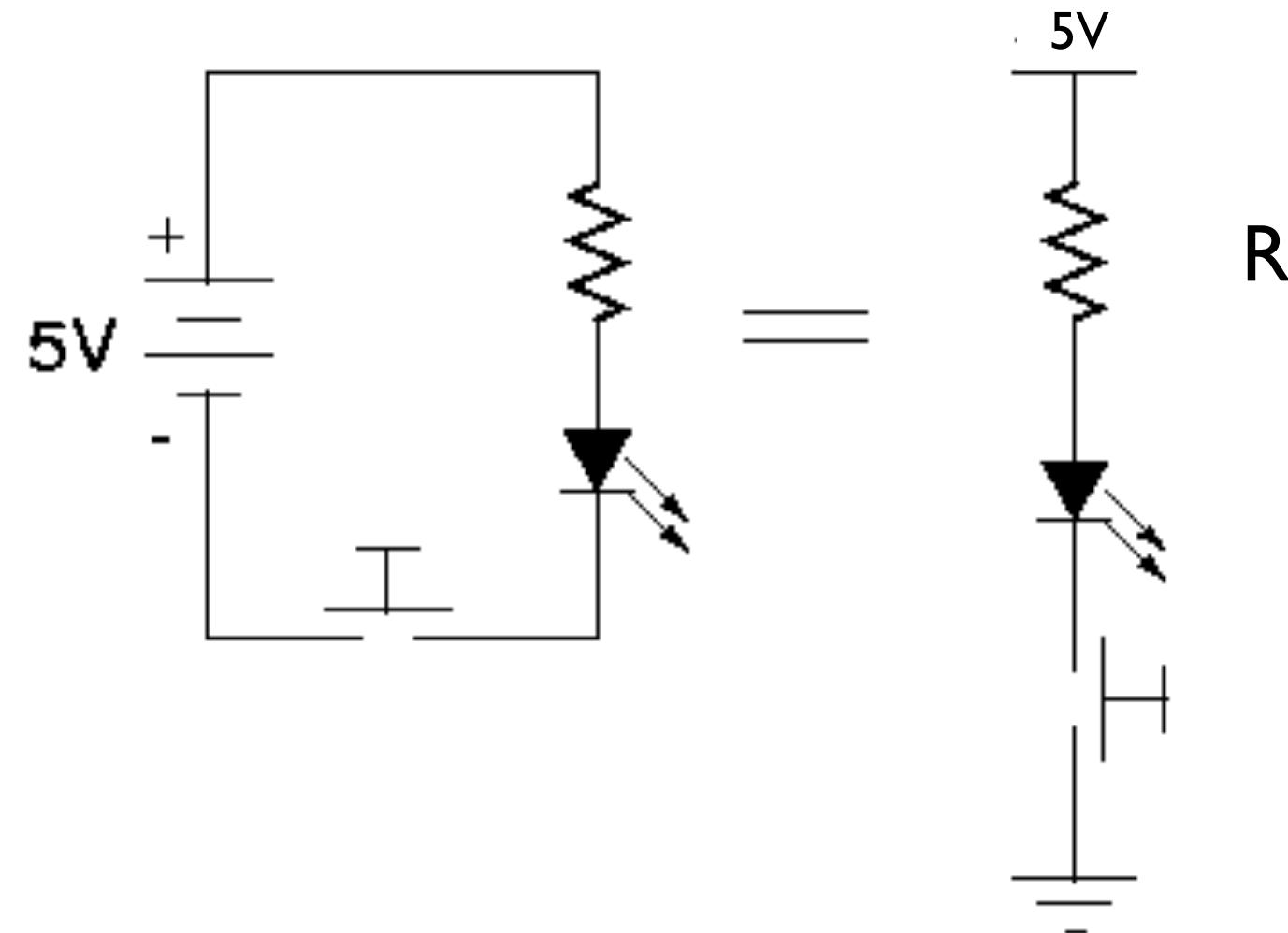


images from Wikipedia

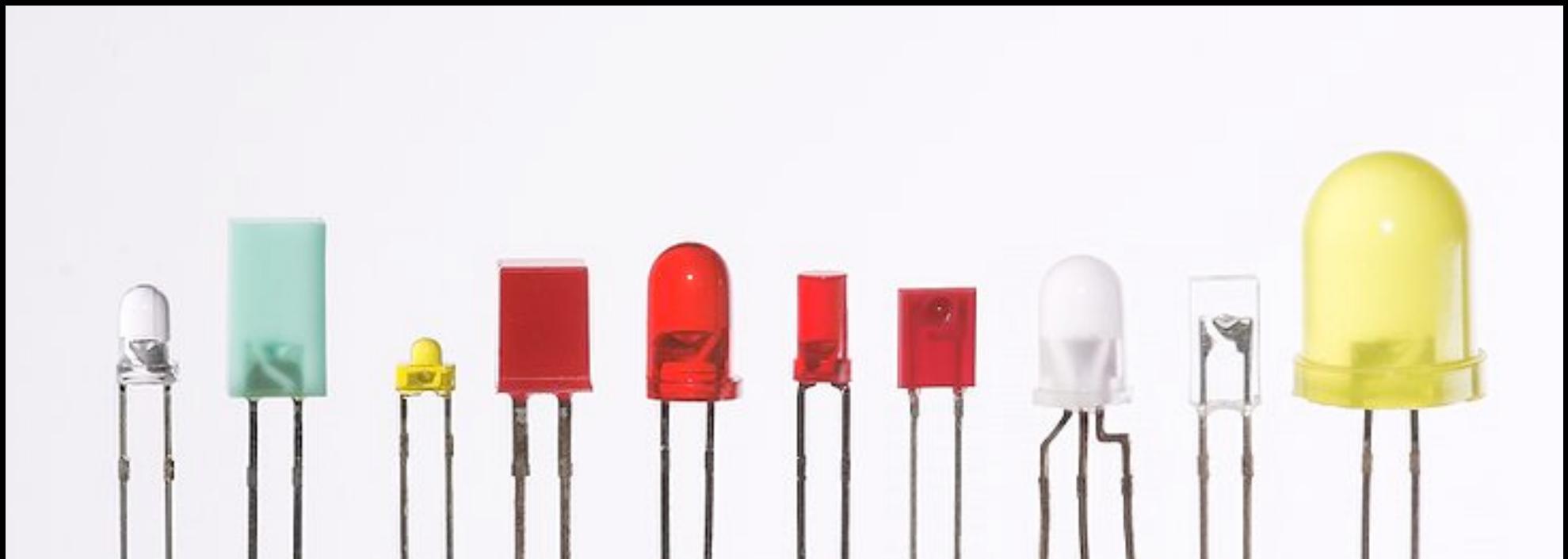
Switches/Buttons



Output in the Pushbutton LED circuit



LEDs



images from Wikipedia

LED datasheet

Kingbright

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

Part Number: WP7113SRD/D Super Bright Red

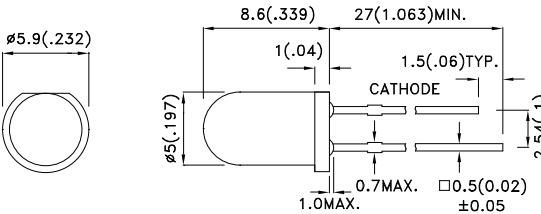
Features

- 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.



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

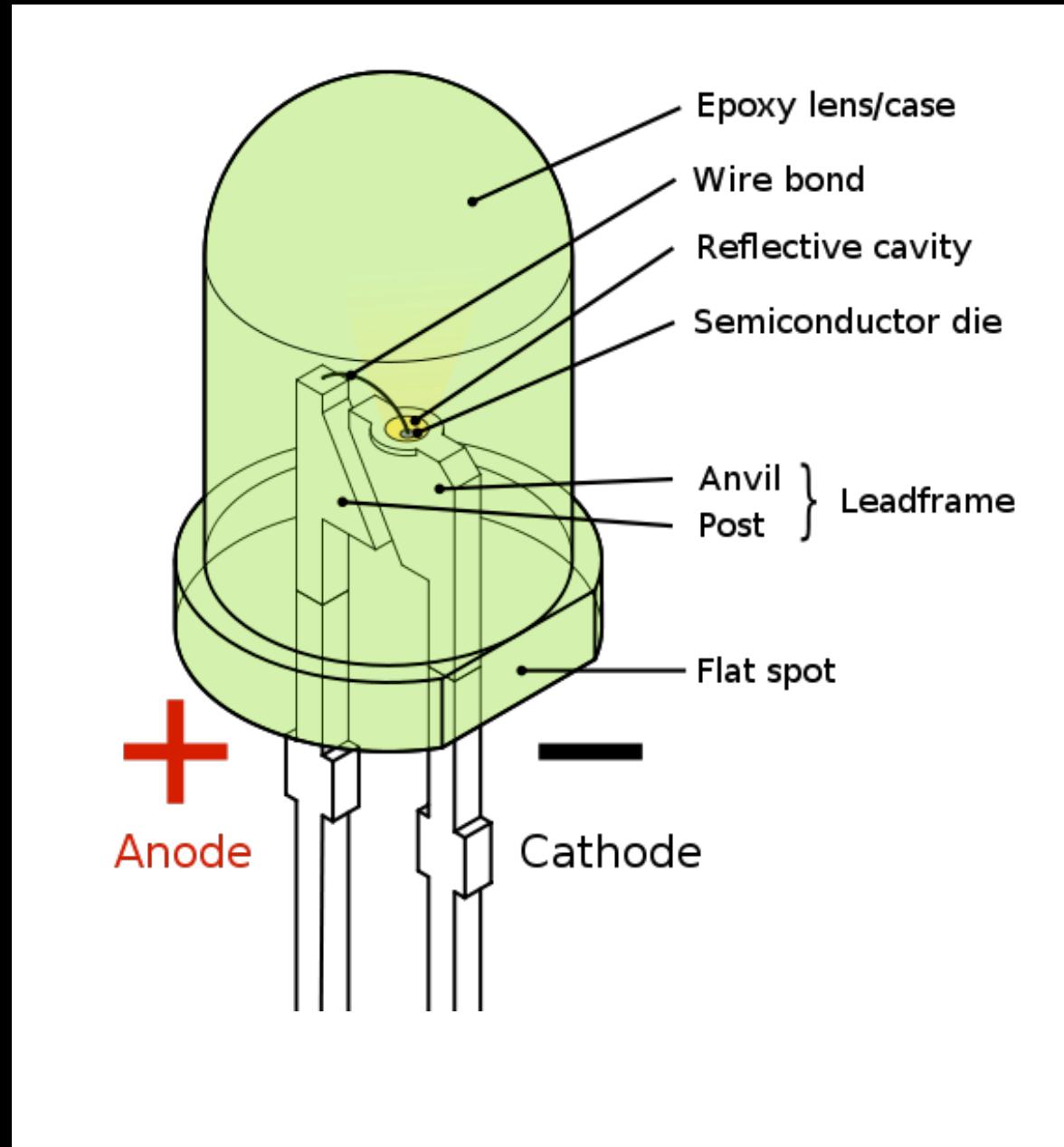
SPEC NO: DSAF2433
APPROVED: WYNEC

REV NO: V.2
CHECKED: Allen Liu

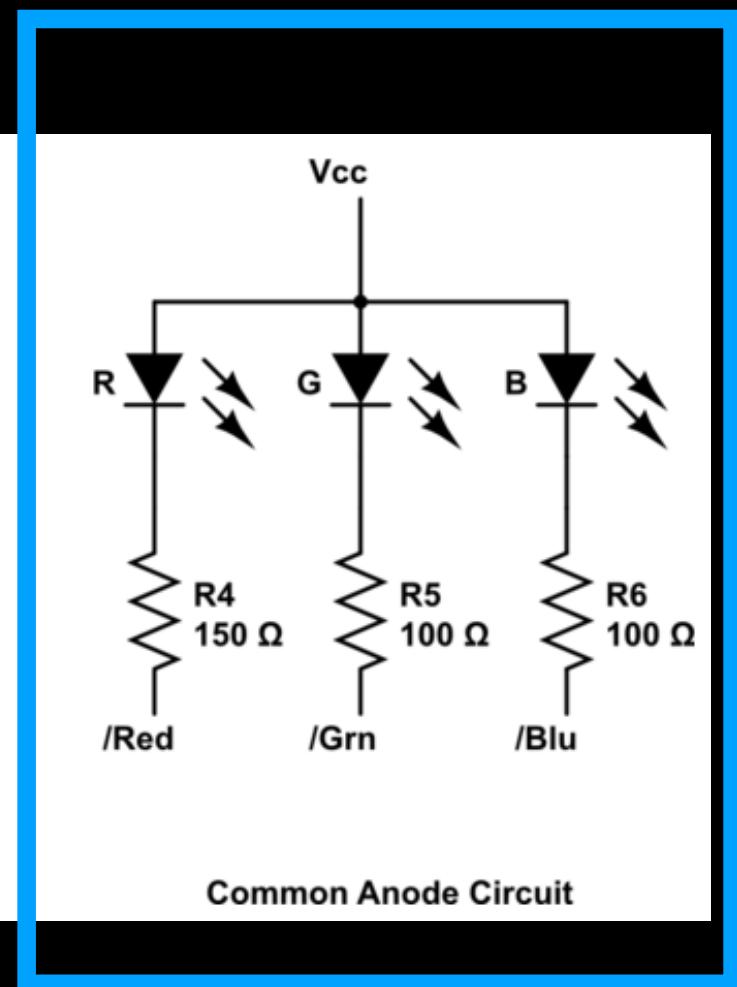
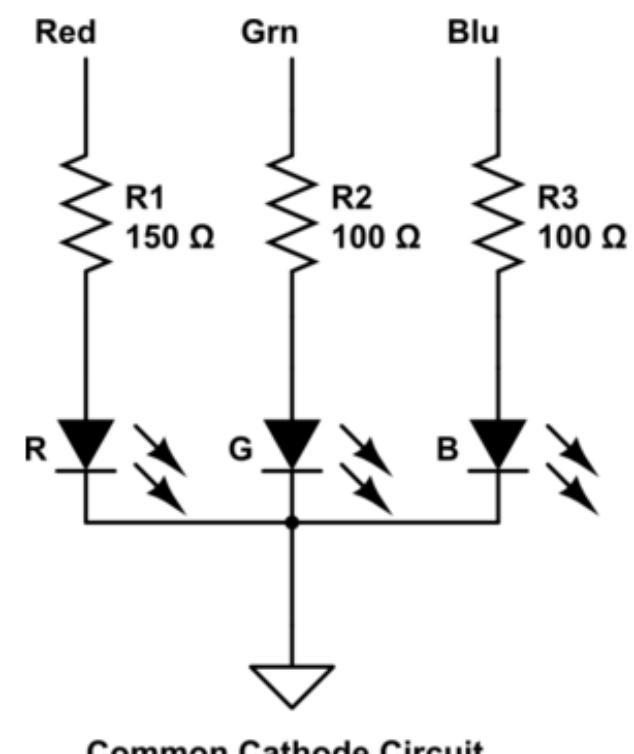
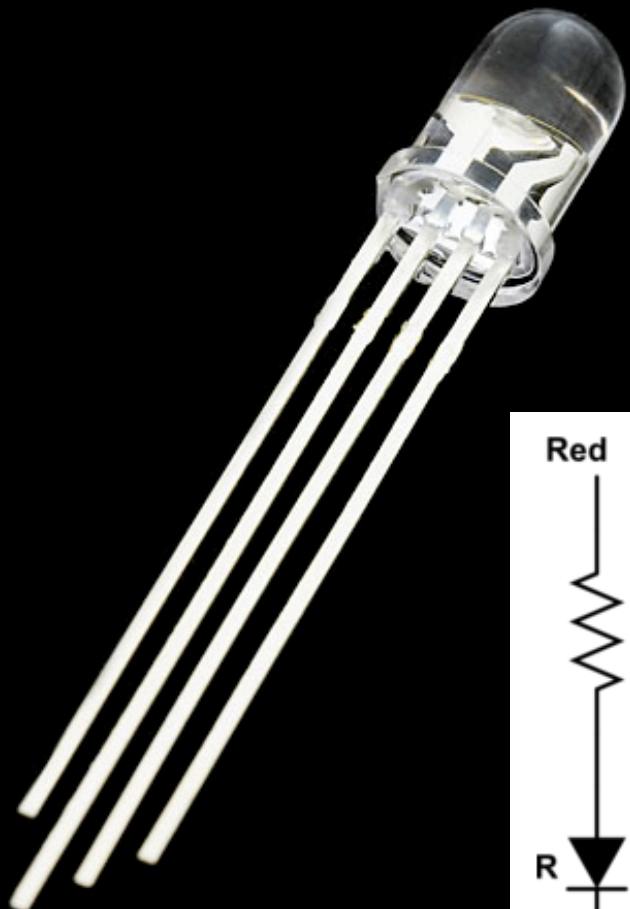
DATE: MAY/11/2007
DRAWN: Y.L.LI

PAGE: 1 OF 6
ERP: 1101005271-02

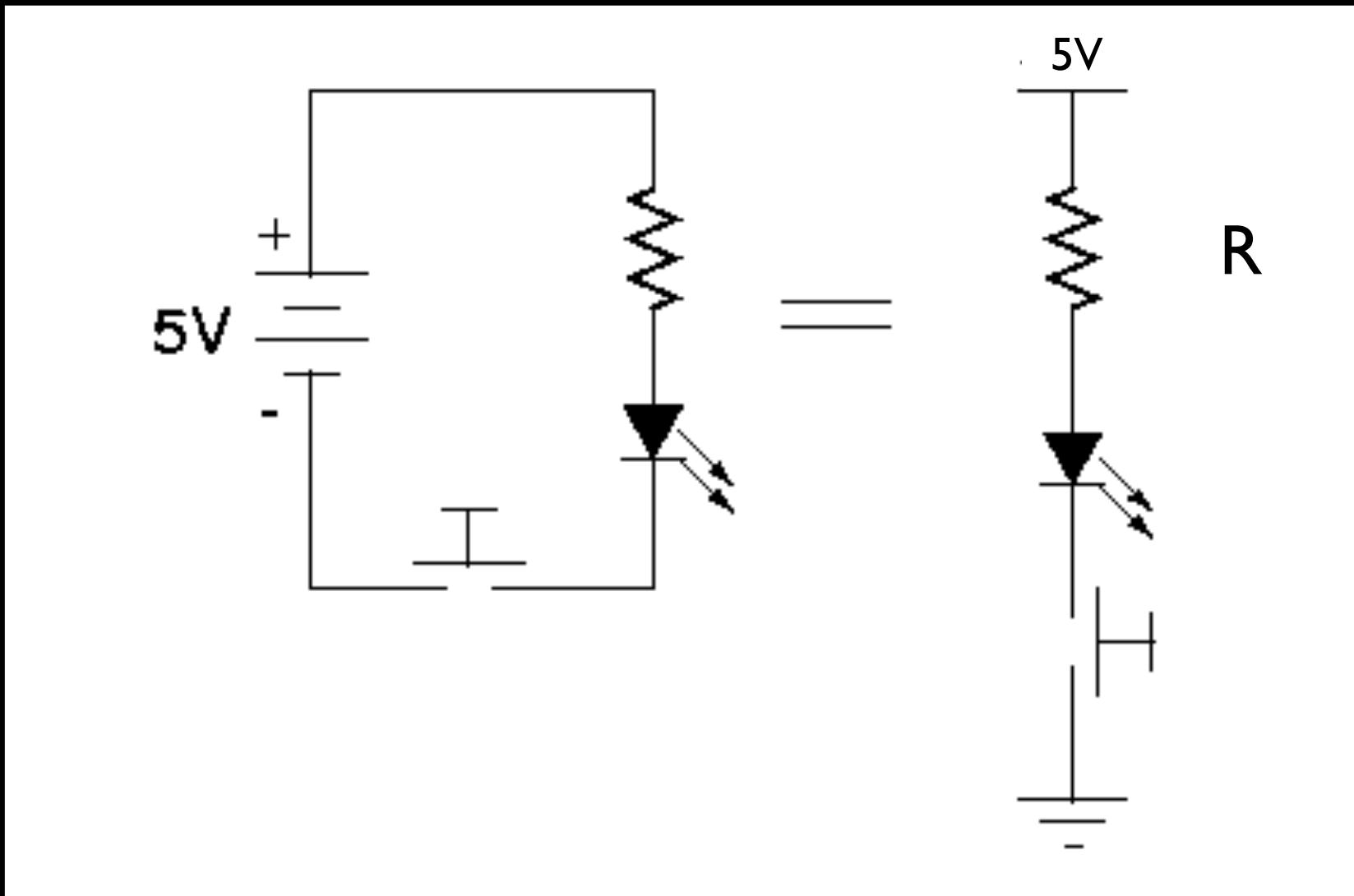
Inside LEDs



RGB LEDs



Current regulation in the Pushbutton LED circuit



Ohm's Law states that Voltage = Current X Resistance

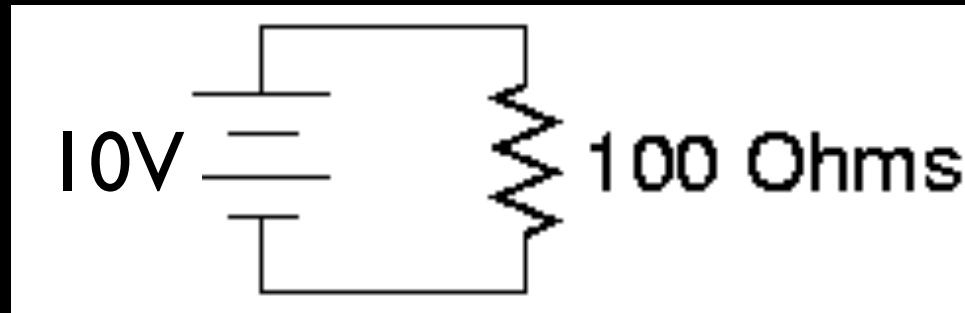
$$V=IR$$

Watt's Law states that Power = Voltage x Current

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

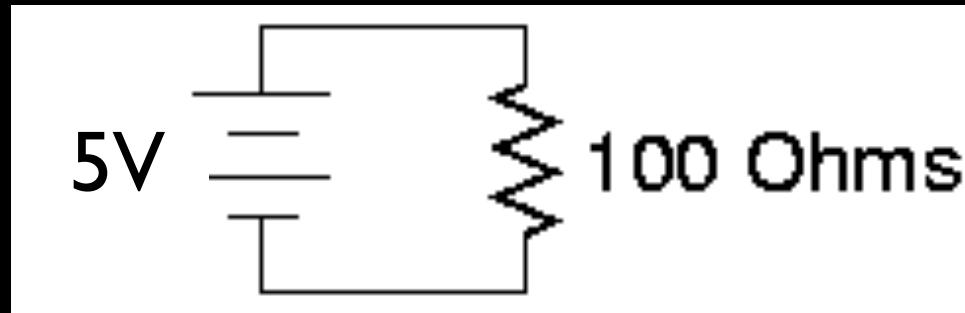
Ohm's Law states that Voltage = Current X Resistance

$$V=IR$$

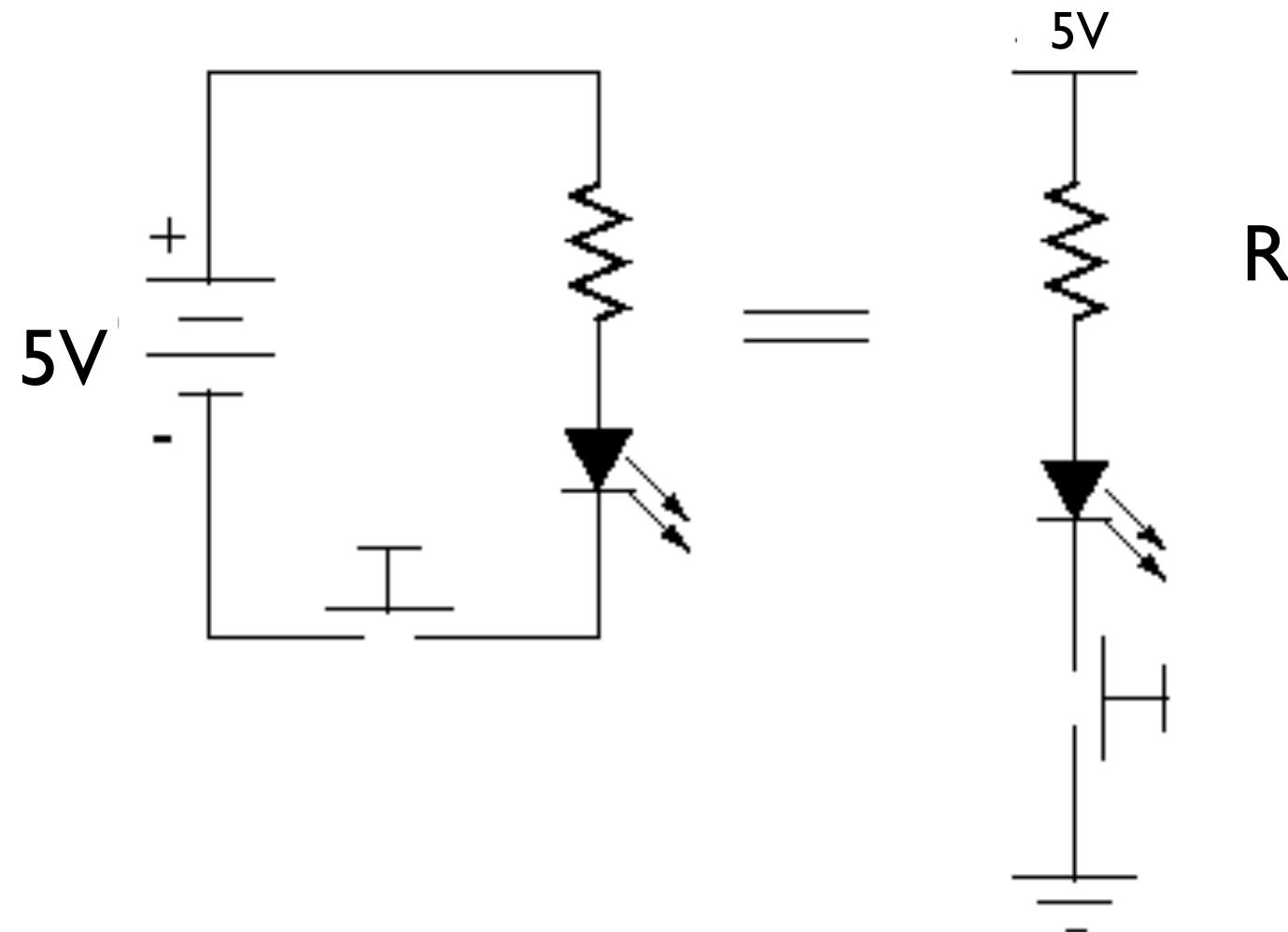


Ohm's Law states that Voltage = Current X Resistance

$$V=IR$$



Equivalent Pushbutton LED circuit



DON'T SHORT POWER TO GROUND

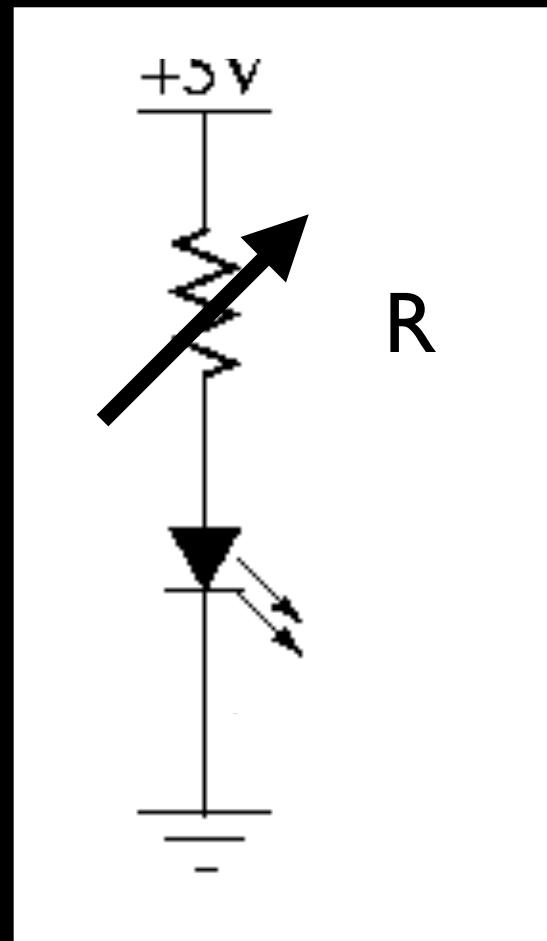
$$V=IR$$

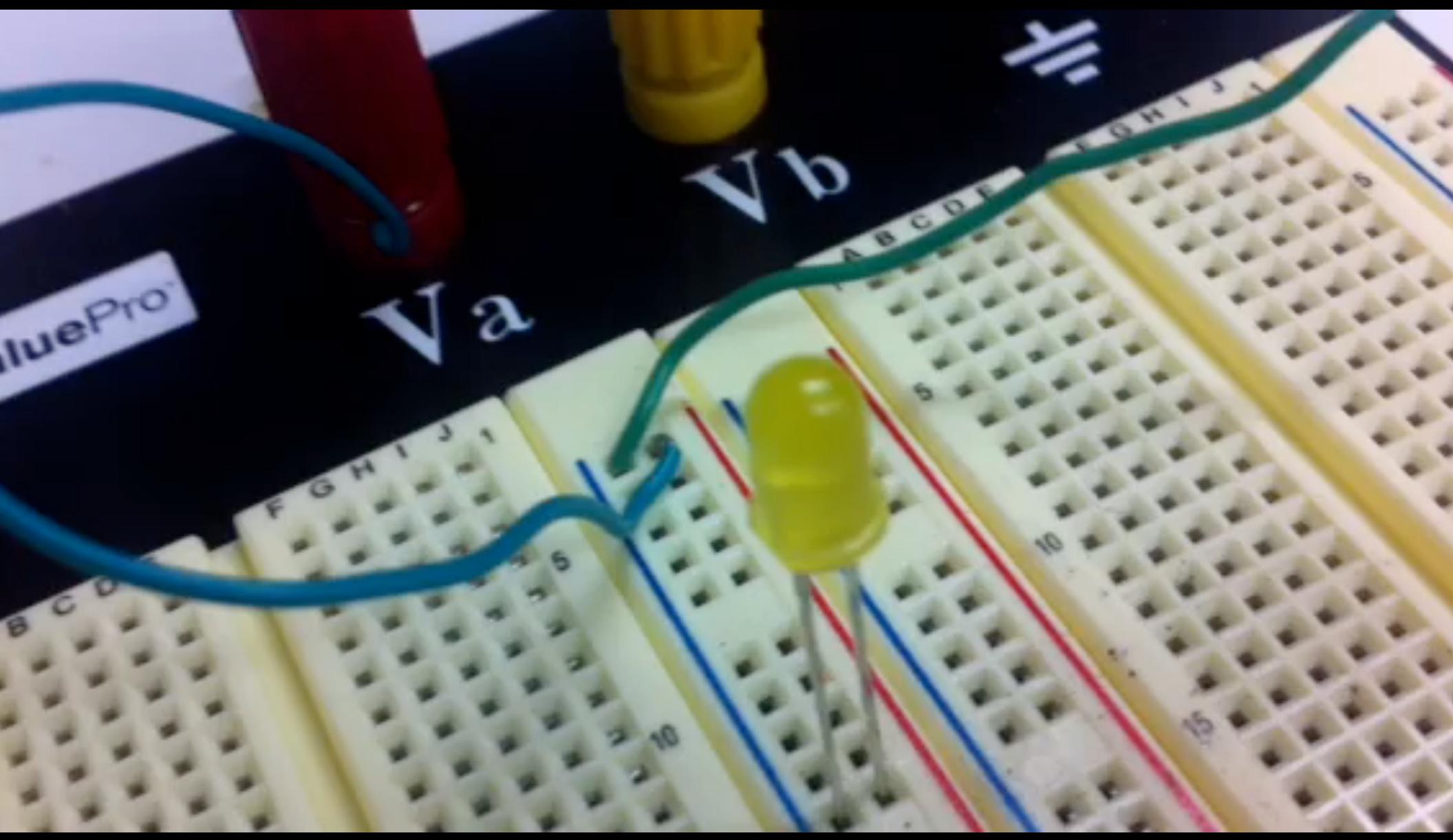
$$I=V/R$$

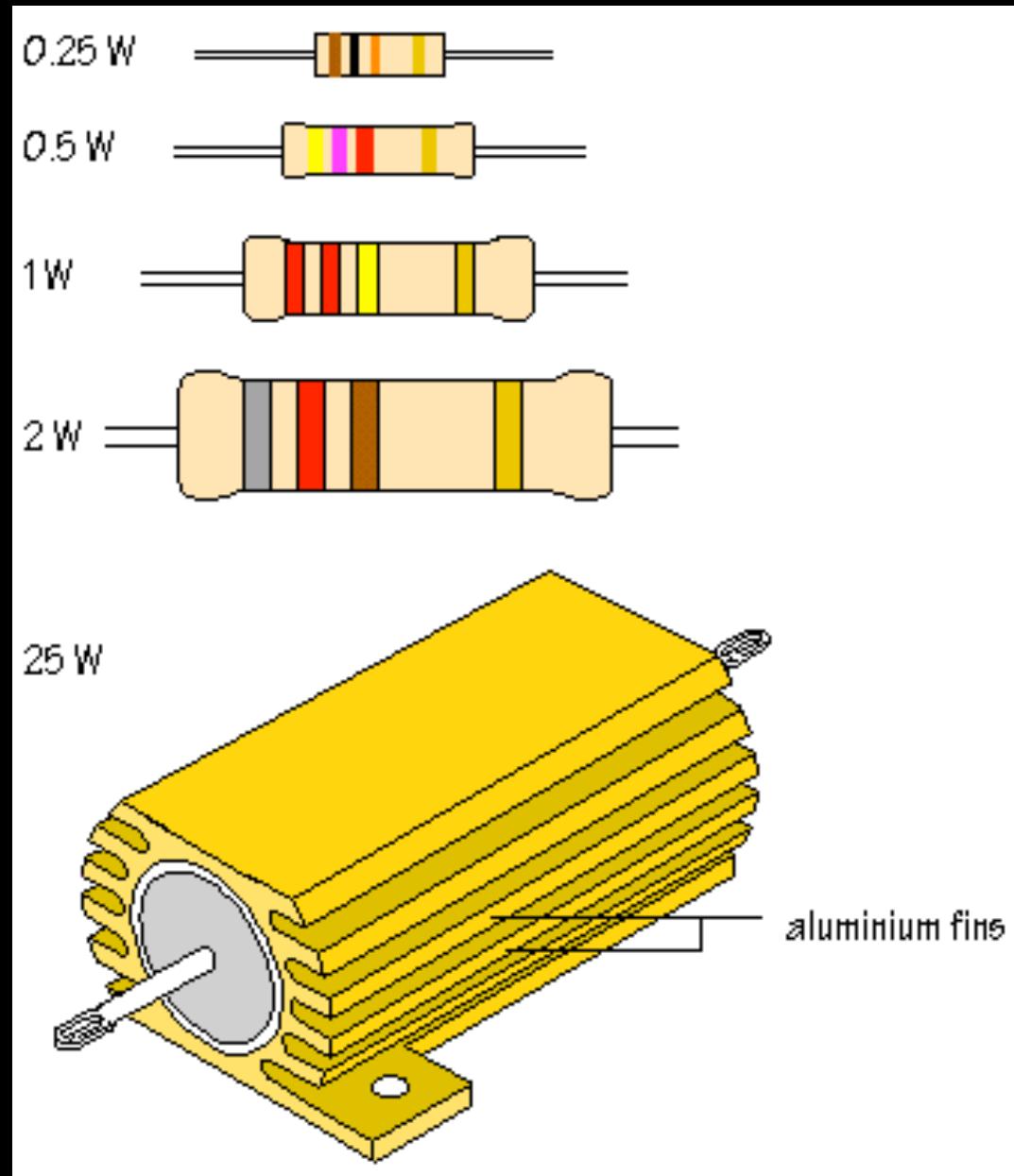
If $R=0$, $I = \infty$

A little excitement

Why is this a **BAD** circuit?

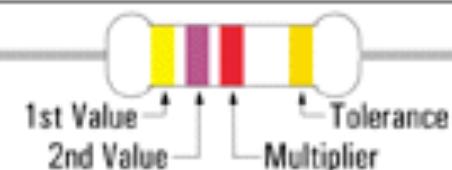






images from www.steiniche.dk/.../resistors-filer

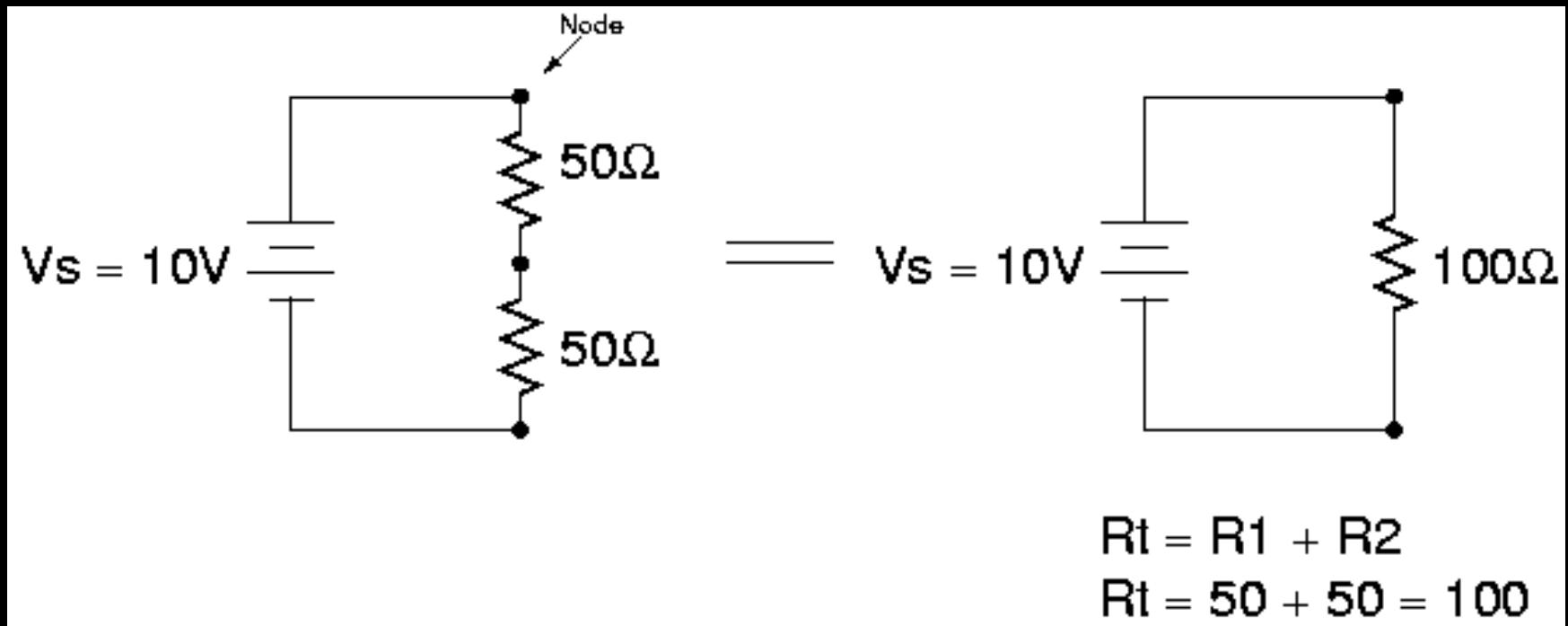
READING RESISTANCE VALUES



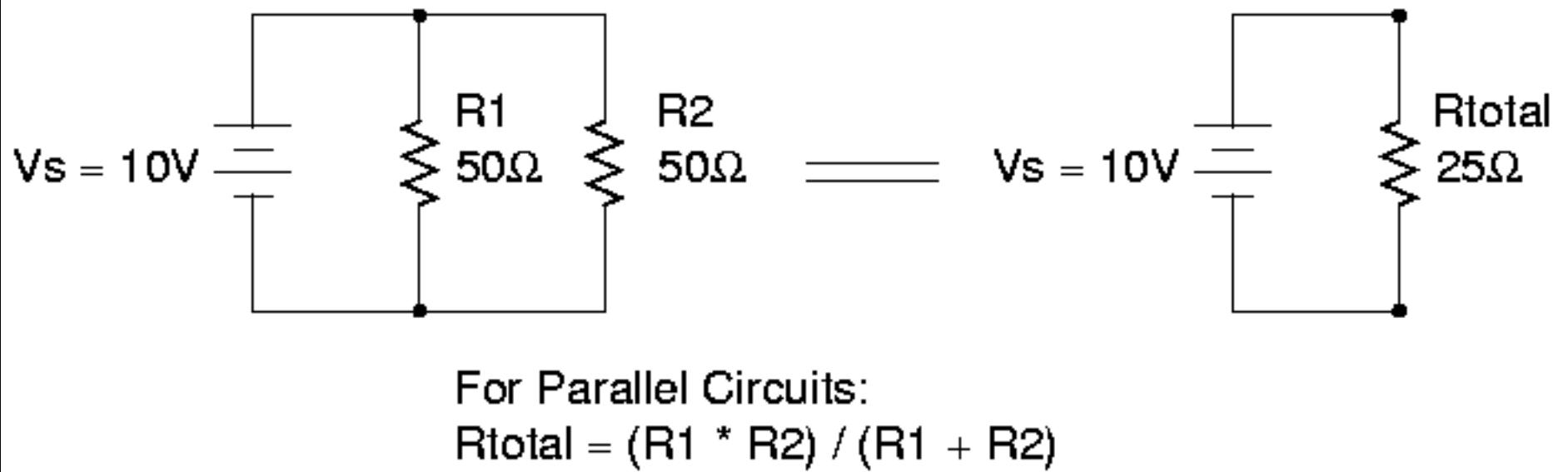
Example: 4 7 x100 -5%
4700Ω-5%

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%

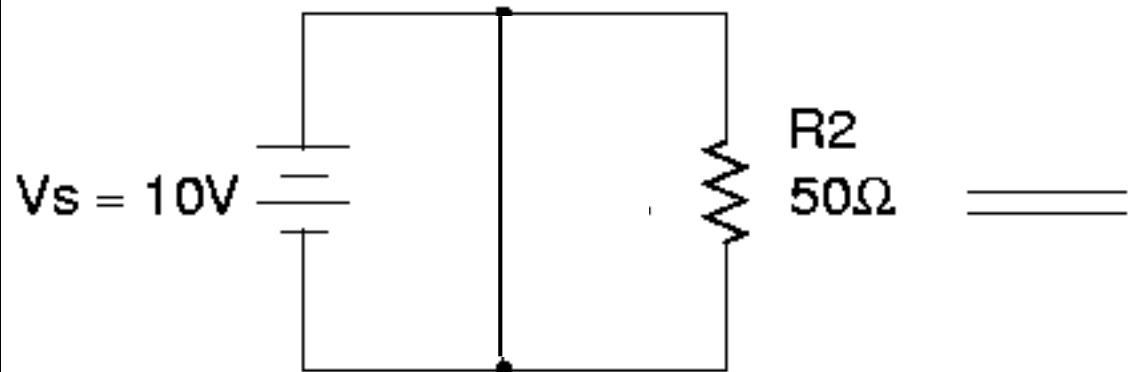
Resistors in series ADD



Resistors in parallel **DIVIDE**



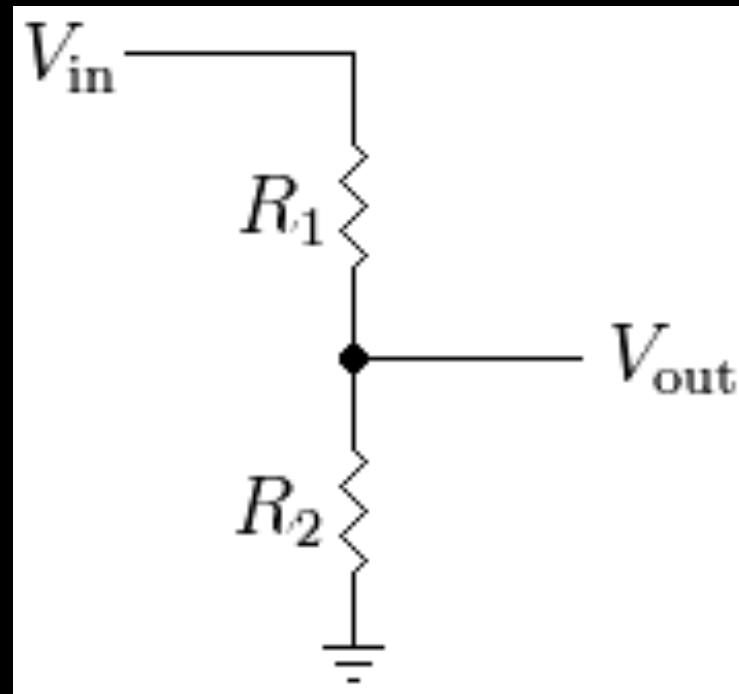
What is a **SHORT CIRCUIT???** Why is this bad?



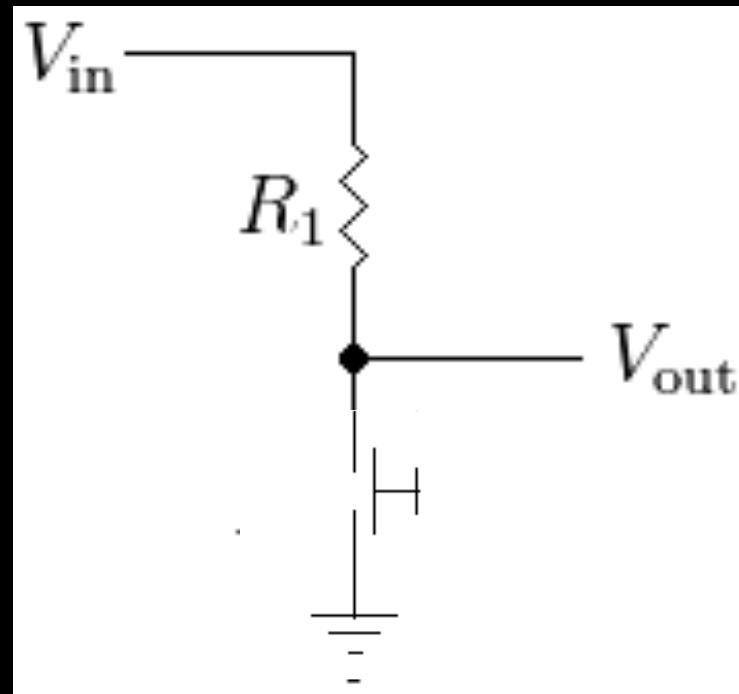
For Parallel Circuits:

$$R_{total} = (R_1 * R_2) / (R_1 + R_2)$$

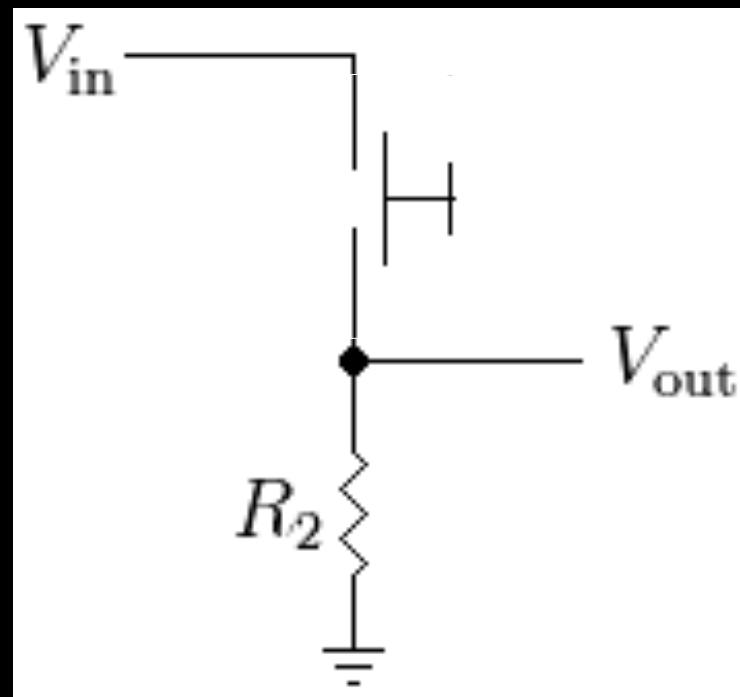
VOLTAGE DIVIDER CIRCUIT



PULL UP RESISTOR



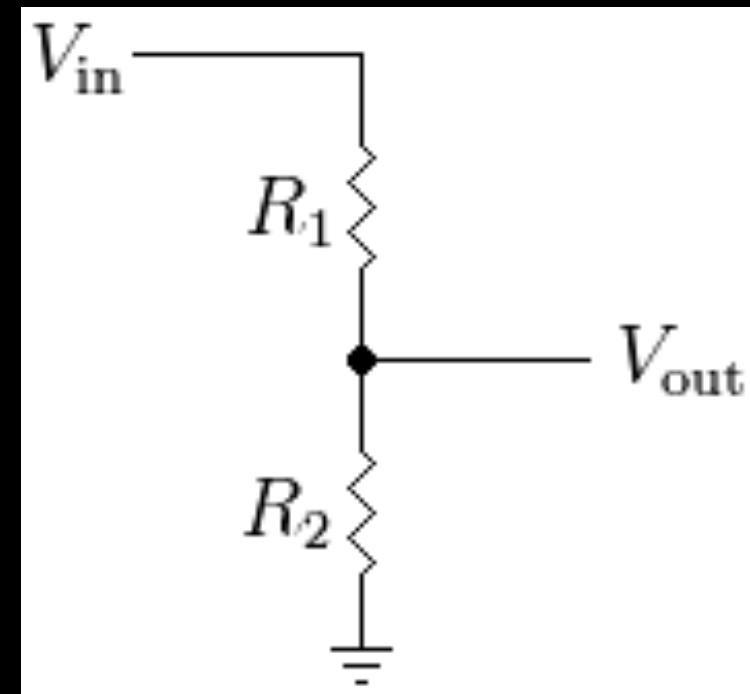
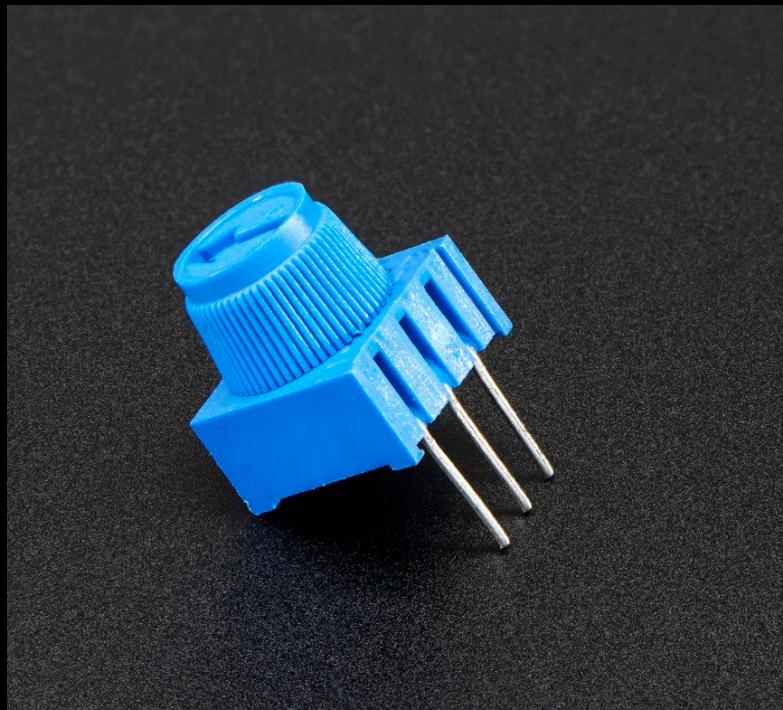
PULL DOWN RESISTOR



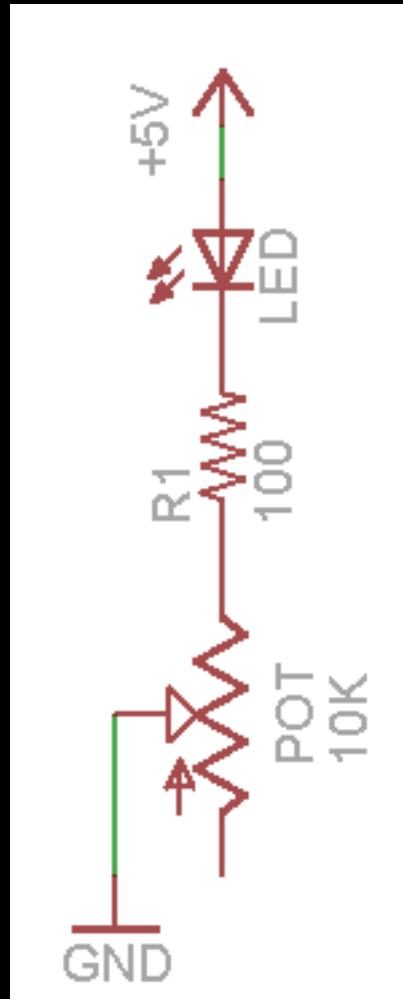
Adjusting the brightness of your LEDs

A **potentiometer** is a variable resistor,

a voltage divider in a package.



Adjusting the brightness of your LEDs



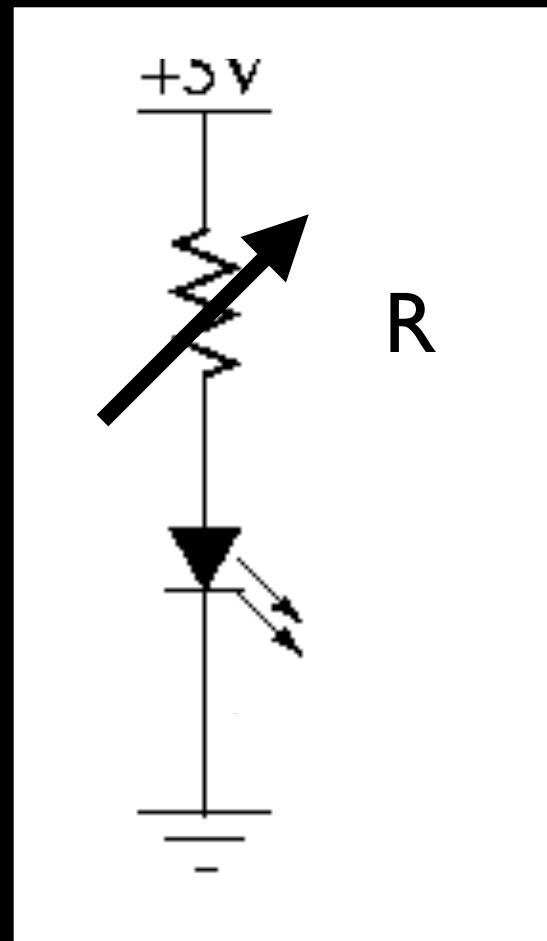
The LED is a diode, with a fixed voltage drop.

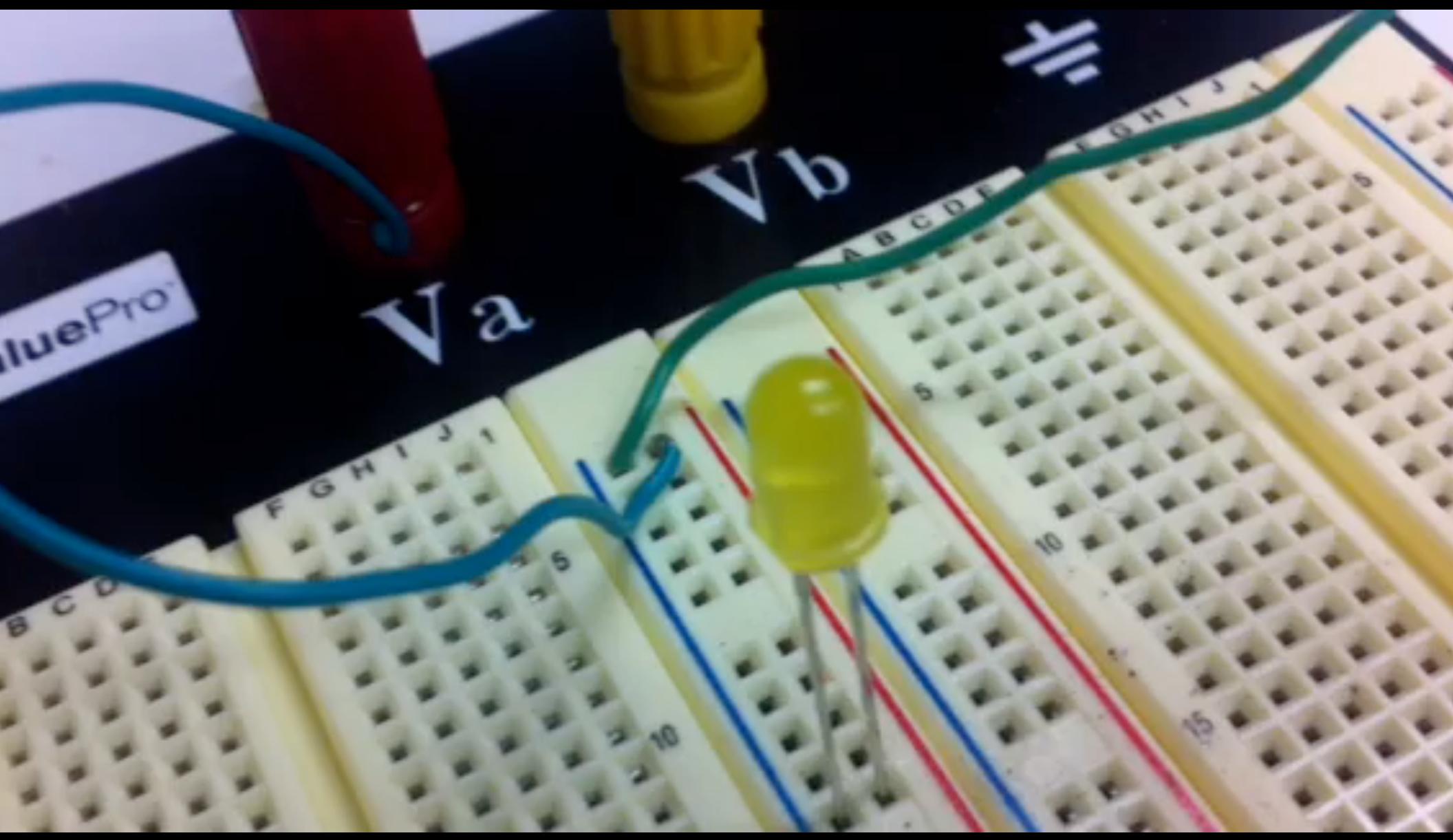
The Current is set by the series resistor

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

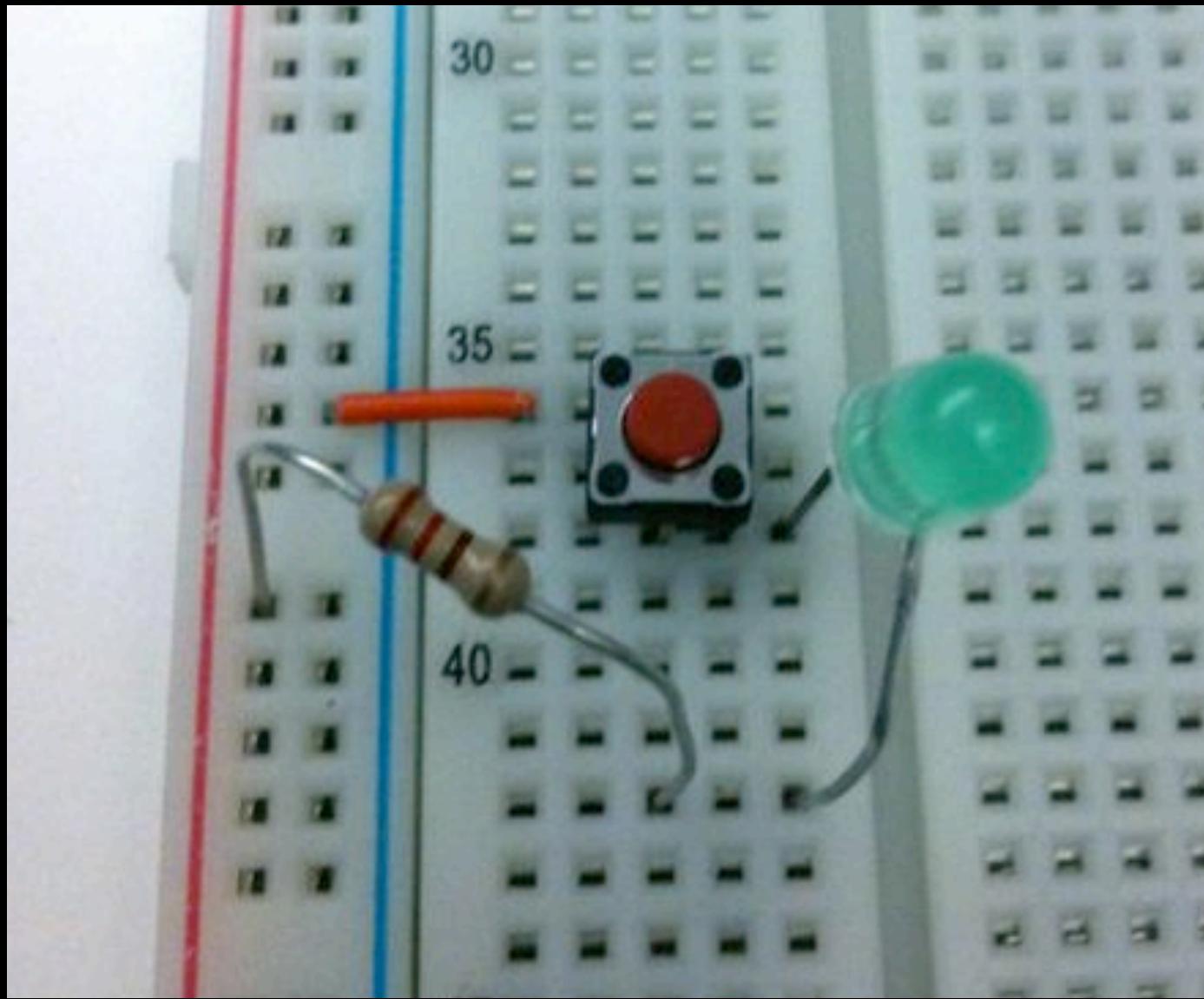
$$I = V/R$$

Why is this a **BAD** circuit?





Pushbutton LED circuit



Pushbutton LED circuit breadboard drawing

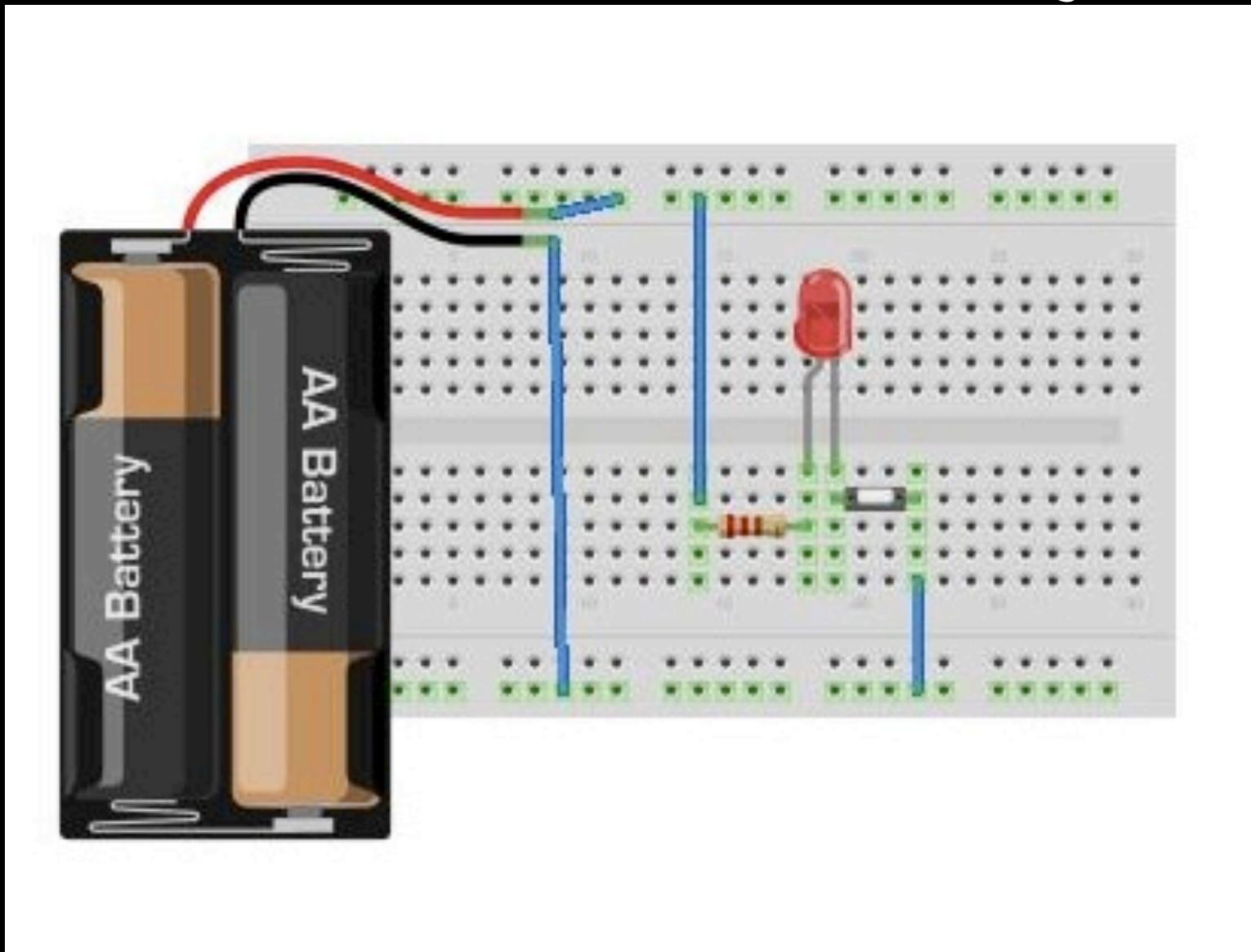
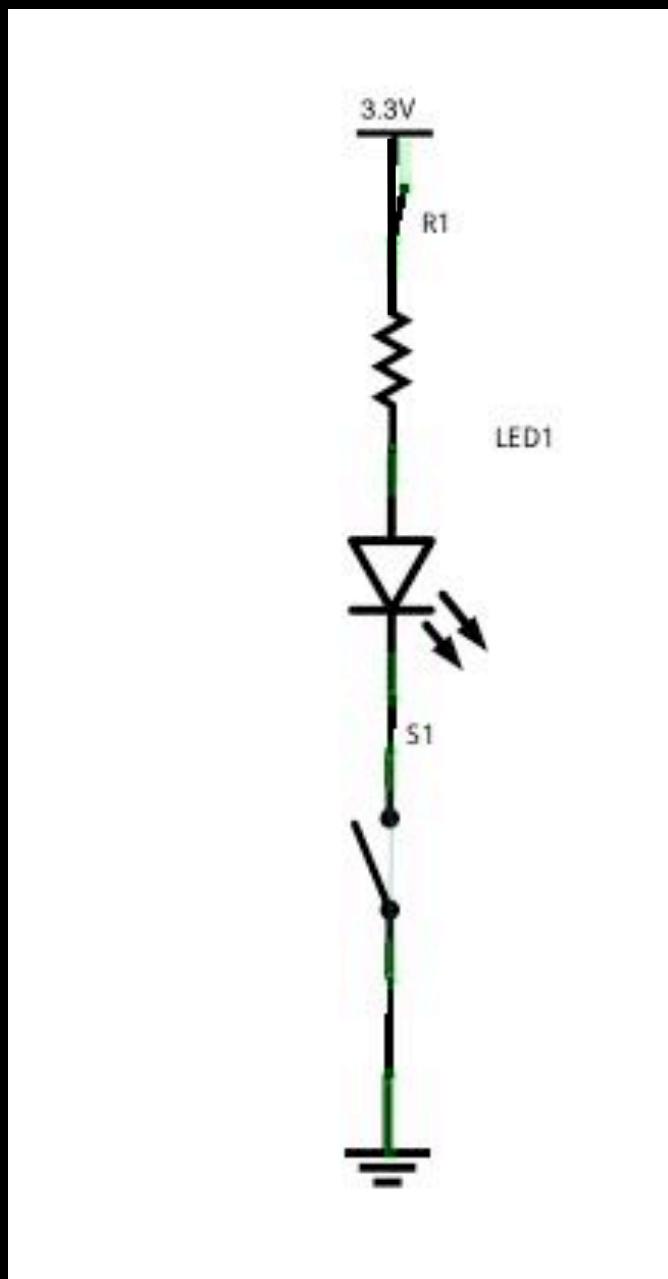
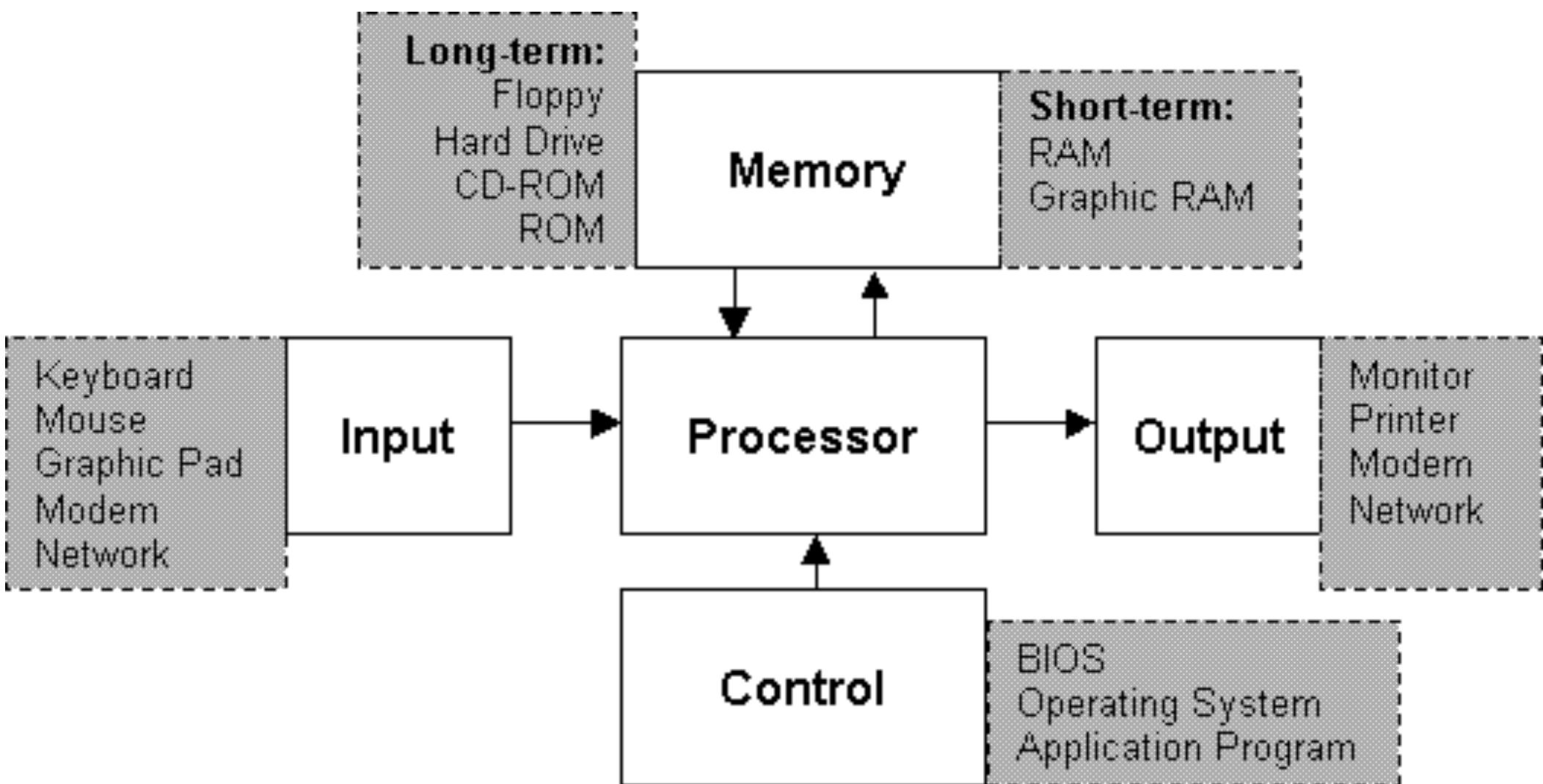


diagram made in Fritzing

Pushbutton LED circuit schematic



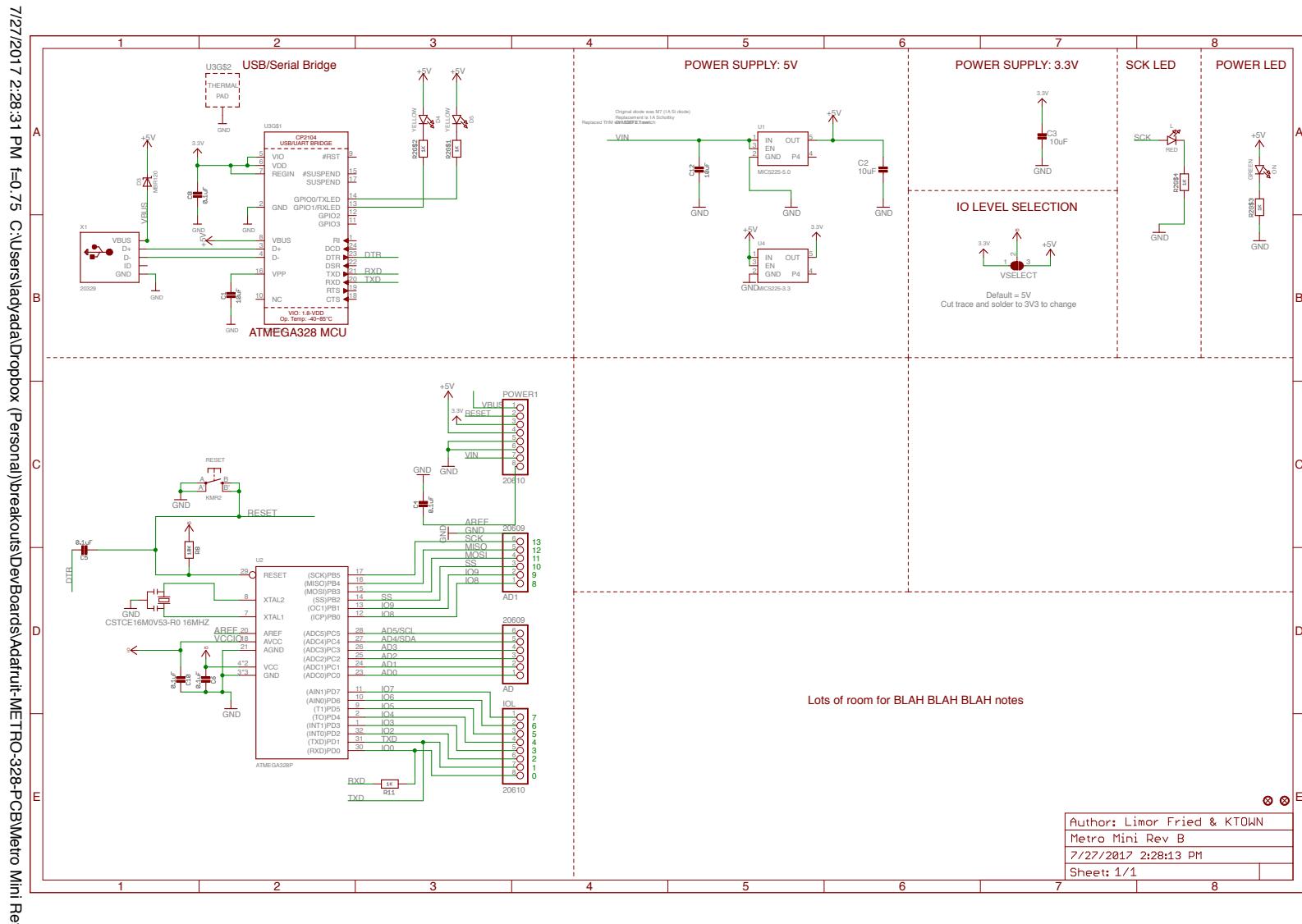
Microcontrollers are
very small computers



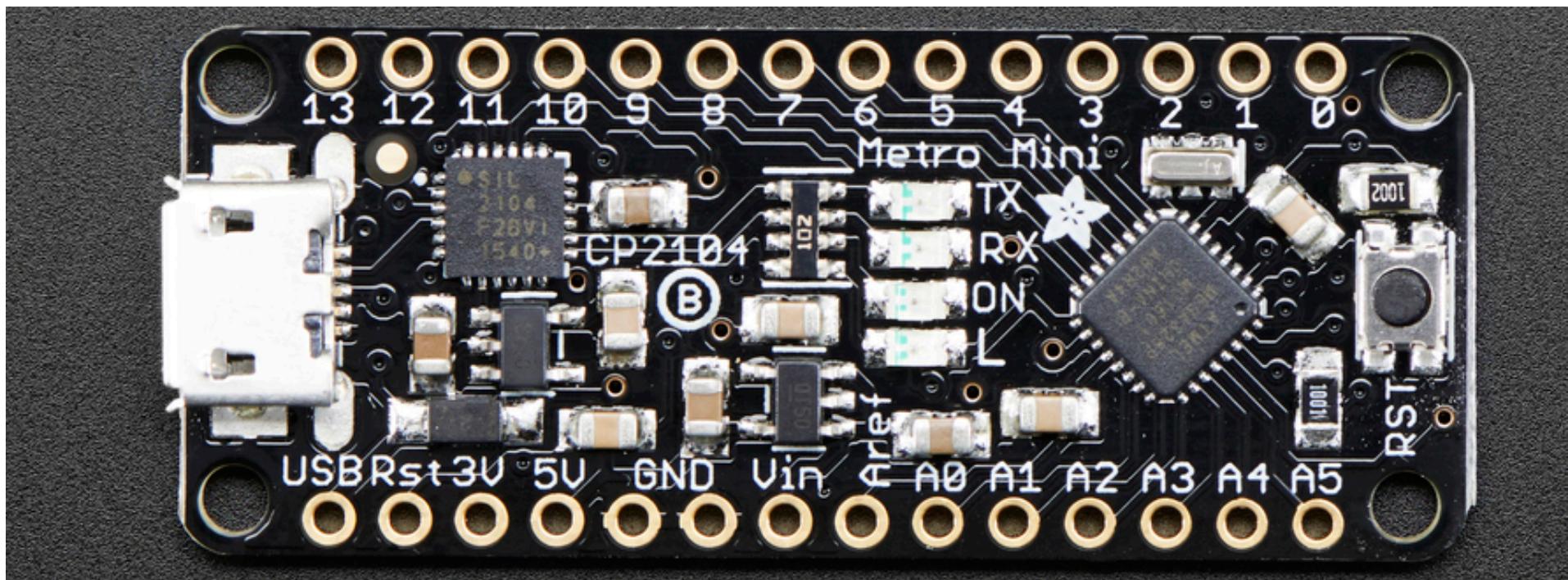
We are using Arduino.

This is a family of
microcontroller boards and an
associated integrated
development environment
(IDE)

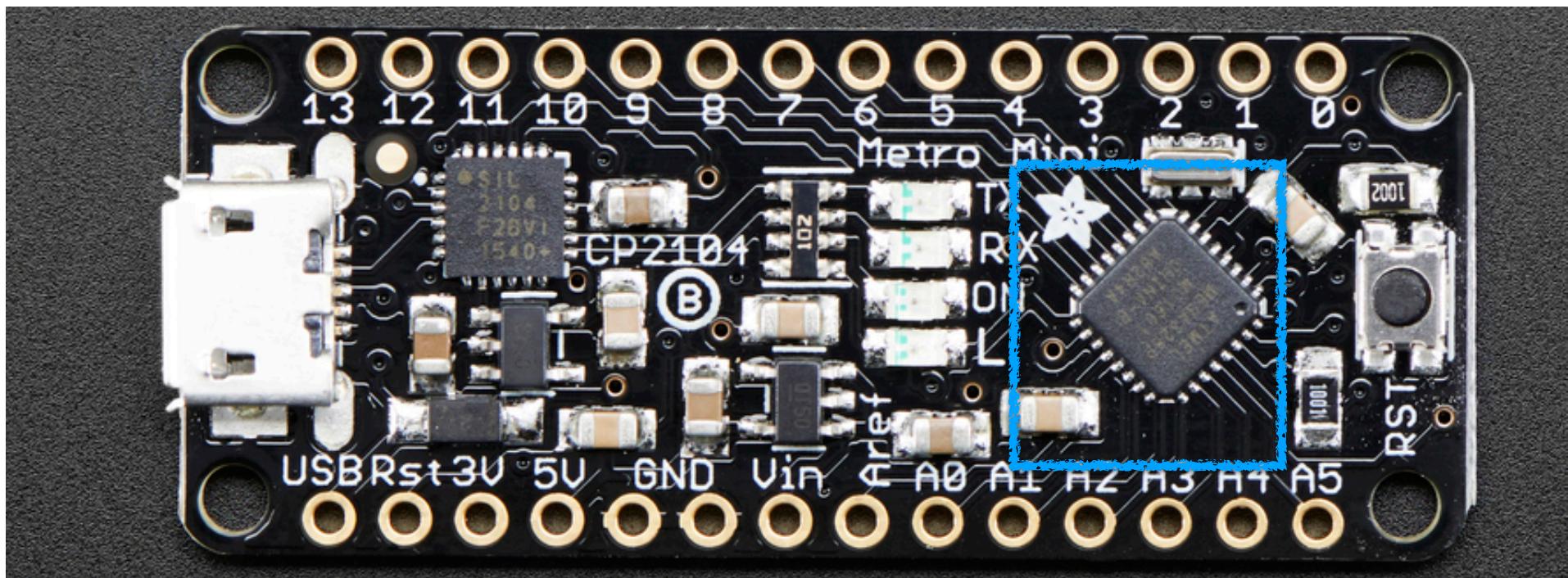
Schematic

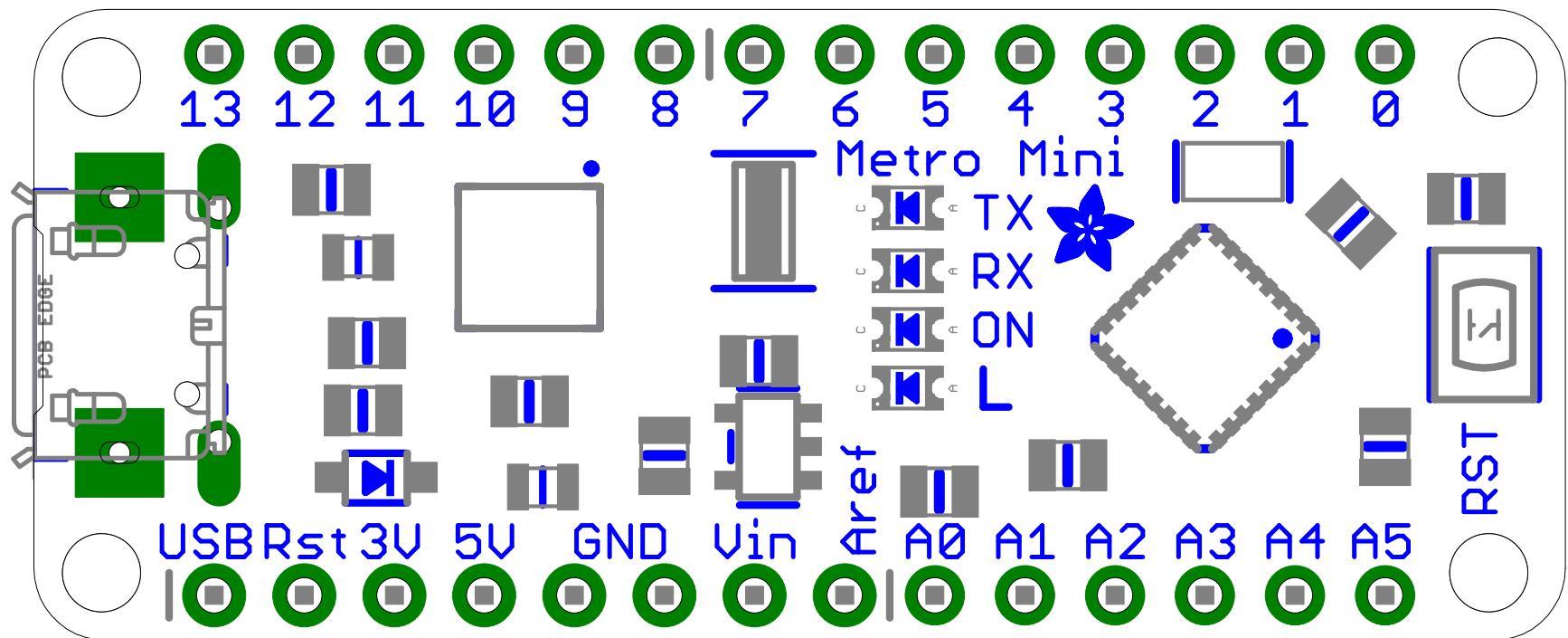


Physical Hardware



Microcontroller



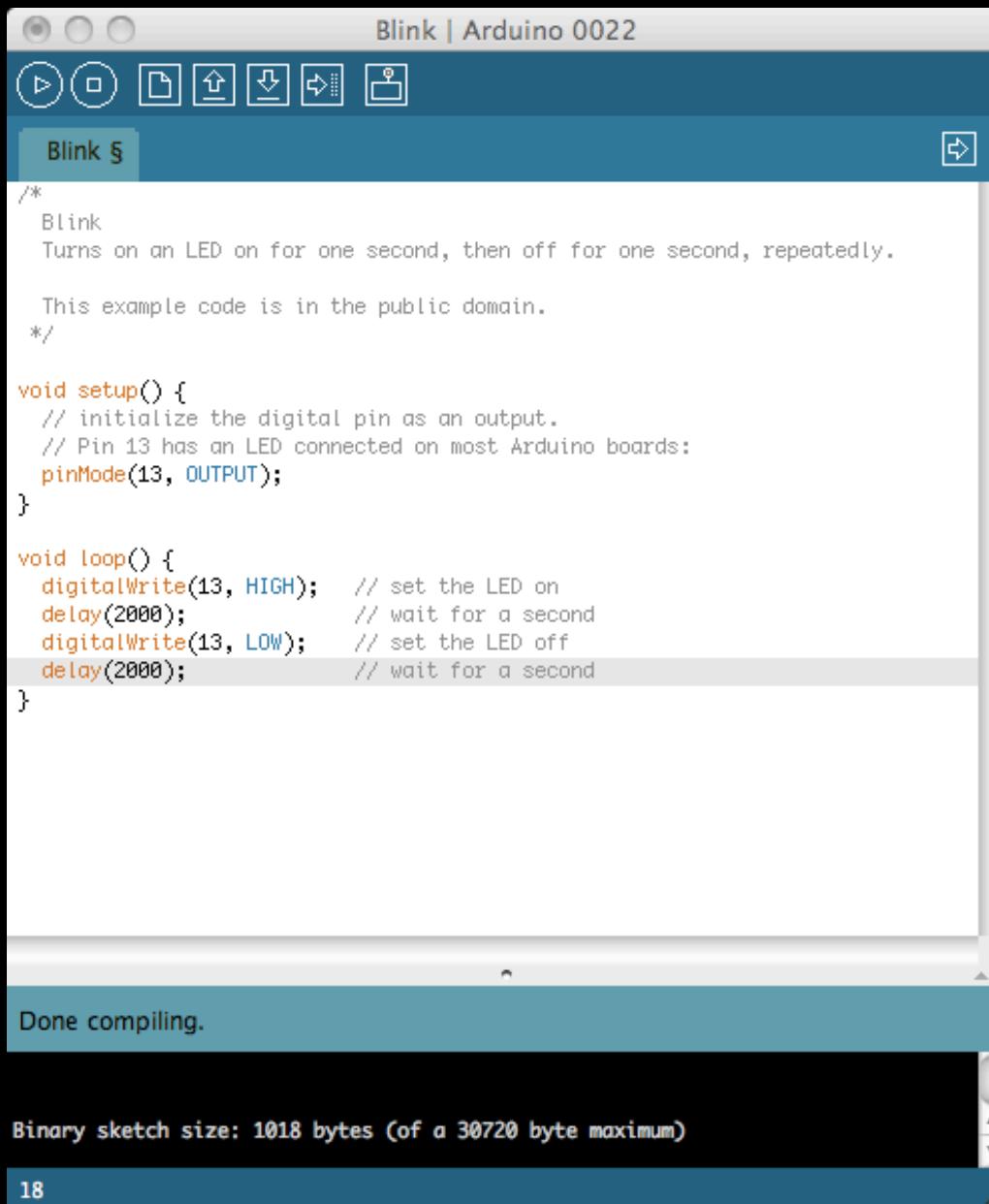


Arduino Software Environment

IDE | Structure of Arduino programs |

Flashing programs

Sketch



The screenshot shows the Arduino IDE interface with the following details:

- Title Bar:** Blink | Arduino 0022
- Toolbar:** Includes icons for play, stop, upload, download, and other common functions.
- Sketch Name:** Blink §
- Code Area:** Displays the `Blink` sketch. The code is as follows:

```
/*
Blink
Turns on an LED on for one second, then off for one second, repeatedly.

This example code is in the public domain.
*/
void setup() {
    // initialize the digital pin as an output.
    // Pin 13 has an LED connected on most Arduino boards:
    pinMode(13, OUTPUT);
}

void loop() {
    digitalWrite(13, HIGH);      // set the LED on
    delay(2000);                // wait for a second
    digitalWrite(13, LOW);       // set the LED off
    delay(2000);                // wait for a second
}
```

- Status Bar:** Shows "Done compiling."
- Bottom Status:** Binary sketch size: 1018 bytes (of a 30720 byte maximum)
- Page Number:** 18

Sketch

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```

```
Blink
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```

What happens when we flash code?

1. Code from libraries (if any) are included (linked).
2. Code is checked for errors (verified).
3. Code is “cross-compiled” into machine code (a.k.a machine code or hex code) using avr-gcc.
4. Code is written to the program memory of the Arduino over USB using avrdude.

Flash Demonstration