IoT Product Design and Coding Bootcamp

Brian Rashap, Ph.D.

24-Feb-2020

Table of contents

IoT Fun


I THINK MY NEST SMOKE ALARM IS GOING OFF. GOOGLE ADWORDS JUST PITCHED ME A FIRE EXTINGUISHER AND AN OFFER FOR TEMPORARY HOUSING.
TOM FISH BURNE
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Brian Rashap, Ph.D.

- Proud husband of Krista and father of Shelby (21) and Ethan (18)
- Electrical Engineer with 25 years industrial experience
- High School track coach
- Hobbies: running, cycling, reading, spending time with family

Introductions

INTRODUCTIONS

Class Rules

- Respect Each Other, Help Each Other
- Ask Questions
- Be On Time (let's us know via Slack if you won't be here)
- Keep Your Workspace and the Classroom Neat and Tidy
- If you are struggling, let myself, Susan, or Esteban know. We are here to HELP!

Grading

1. In class assignments - 30
2. Individual smart device 20
3. Capstone 40
4. Assessments 10

More information later today on how assignments are turned in

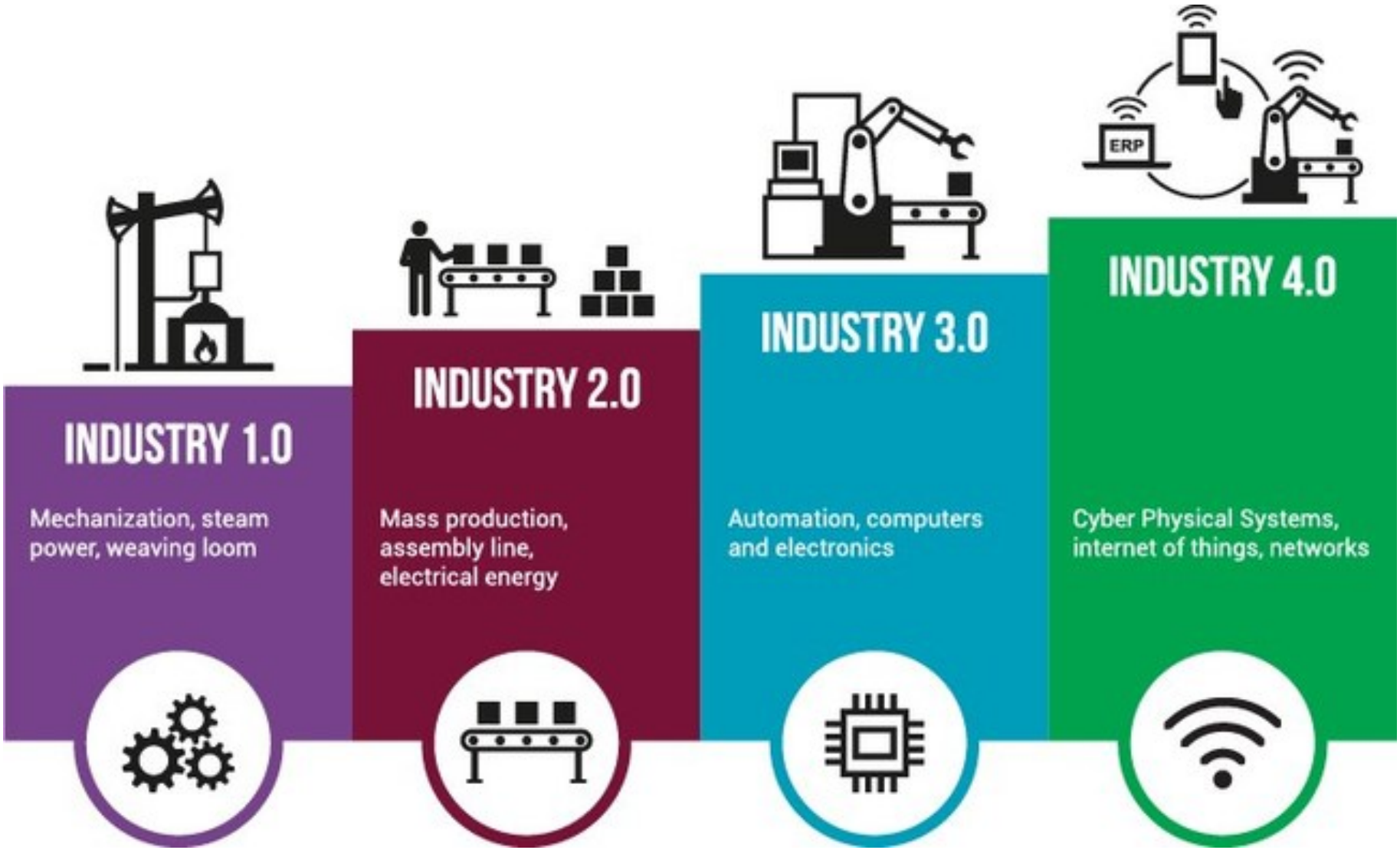
GITHUB Simplified

```
// In Powershell go to ./Documents/<yourname>
// Get a repository that already exists and pull
   it into your local machine
  git clone <URL of repository>

// From the repository directory, get updates
  git pull

// Send your changes up to the repository
  git add .
  git commit -m "<comment>"
  git push

// You may get asked to enter your GIT username
git config --global user.email "you@example.com"
```

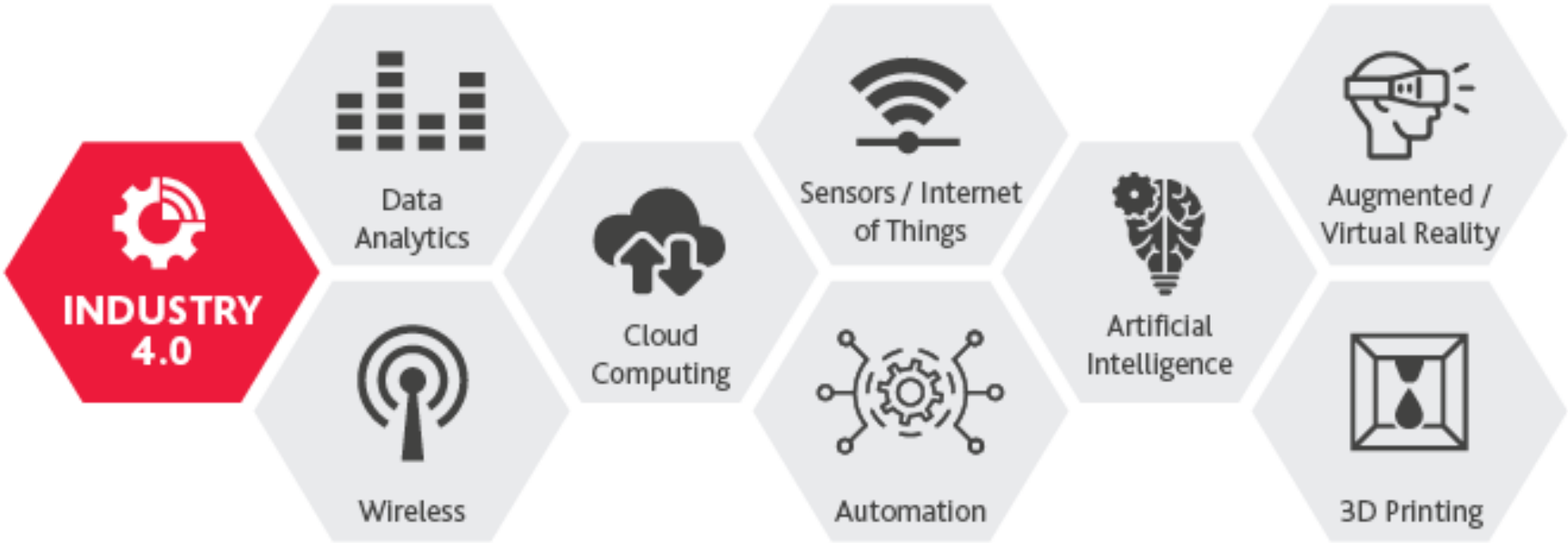
Powershell Commands Simplified

```
mkdir <directory name>  //make a directory
rmdir <directory name> //remove directory
ls //list contents of current directory
pwd //print path of current directory
cd <directory name> // change directory
cd .. //change directory to the directory above
new-item <file name> //create a file
cp <file name> <new file name> //copy file
mv <file name> <directory> //move file to new dir
rm <file name> //delete file
cat <file name> //display contents of file
```

Evolution of Industry

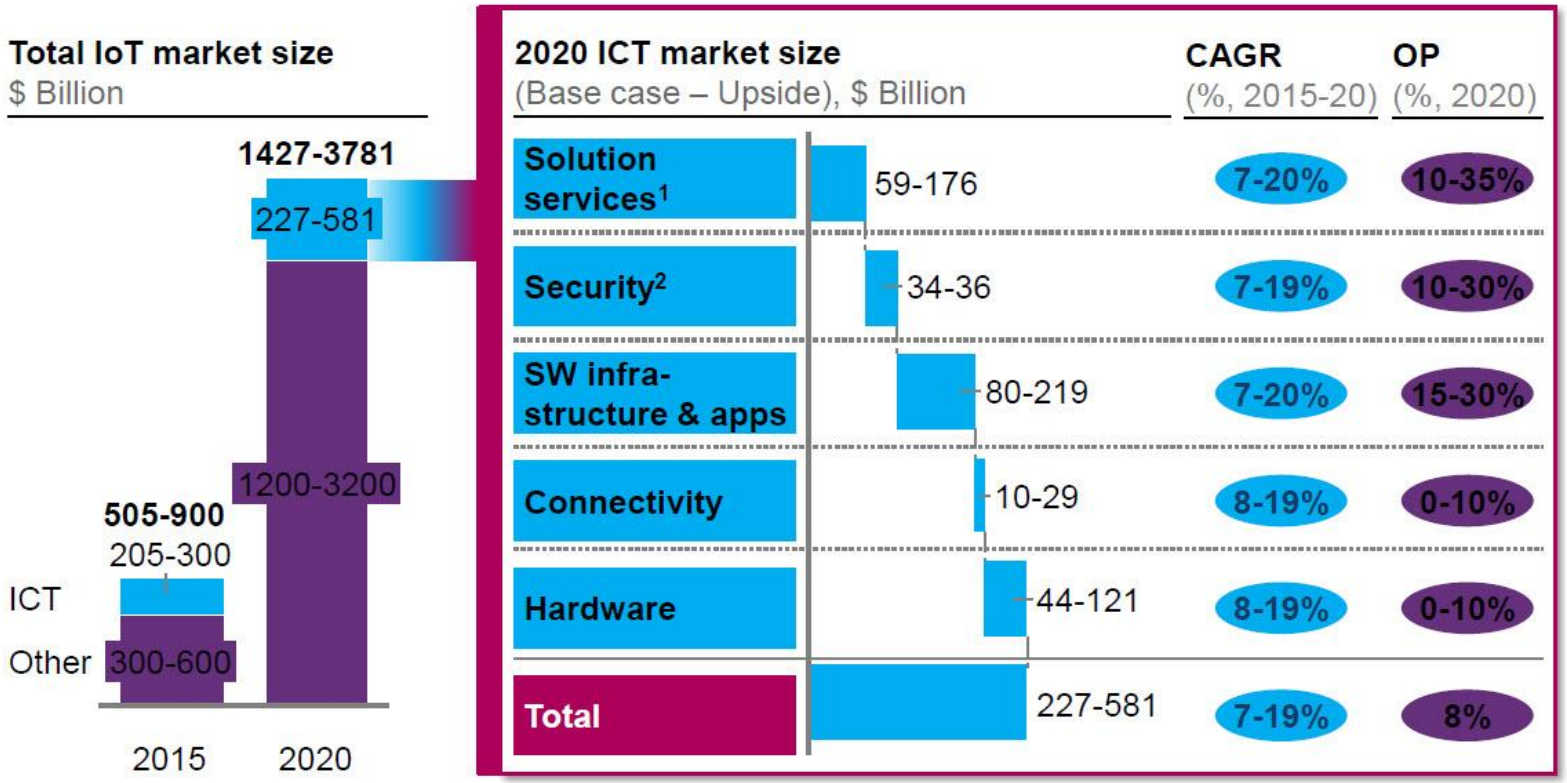


Components of Industry 4.0



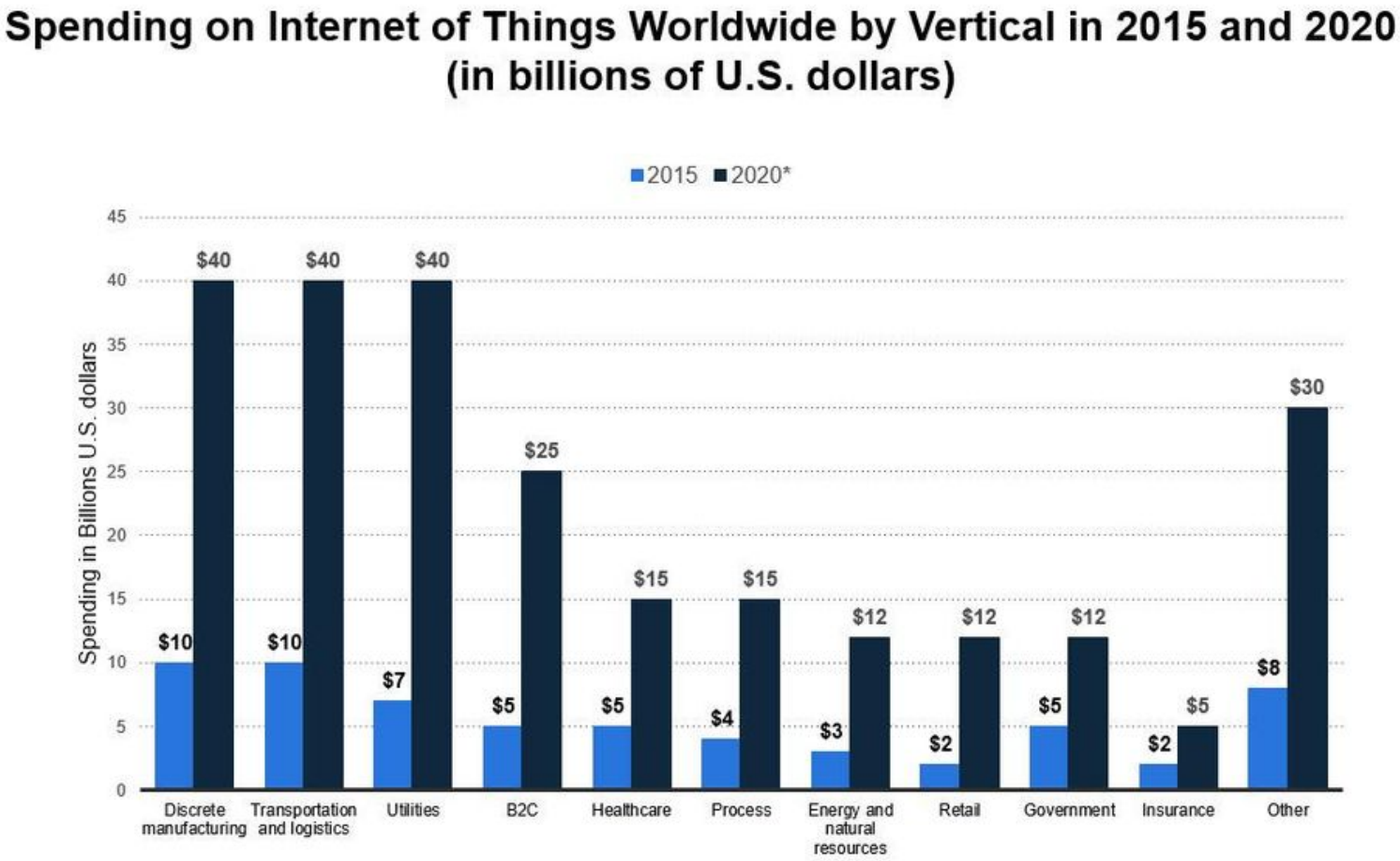
IoT Market Size

Resulting in a large IoT market size, of which a significant component is ICT

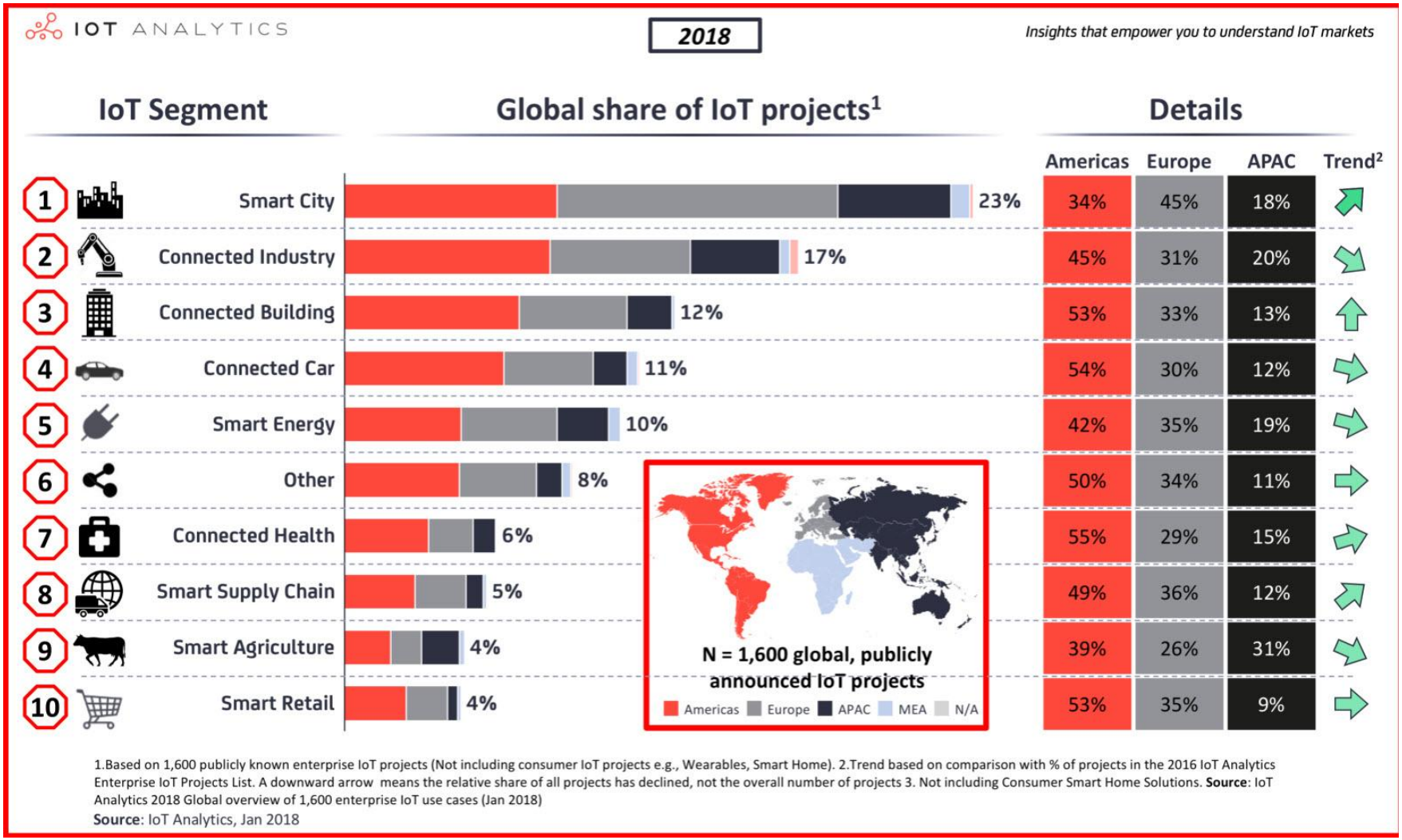


1 Solution services not considered technical products
2 $3-$6B is IoT security and $25-$35B is for mobile security

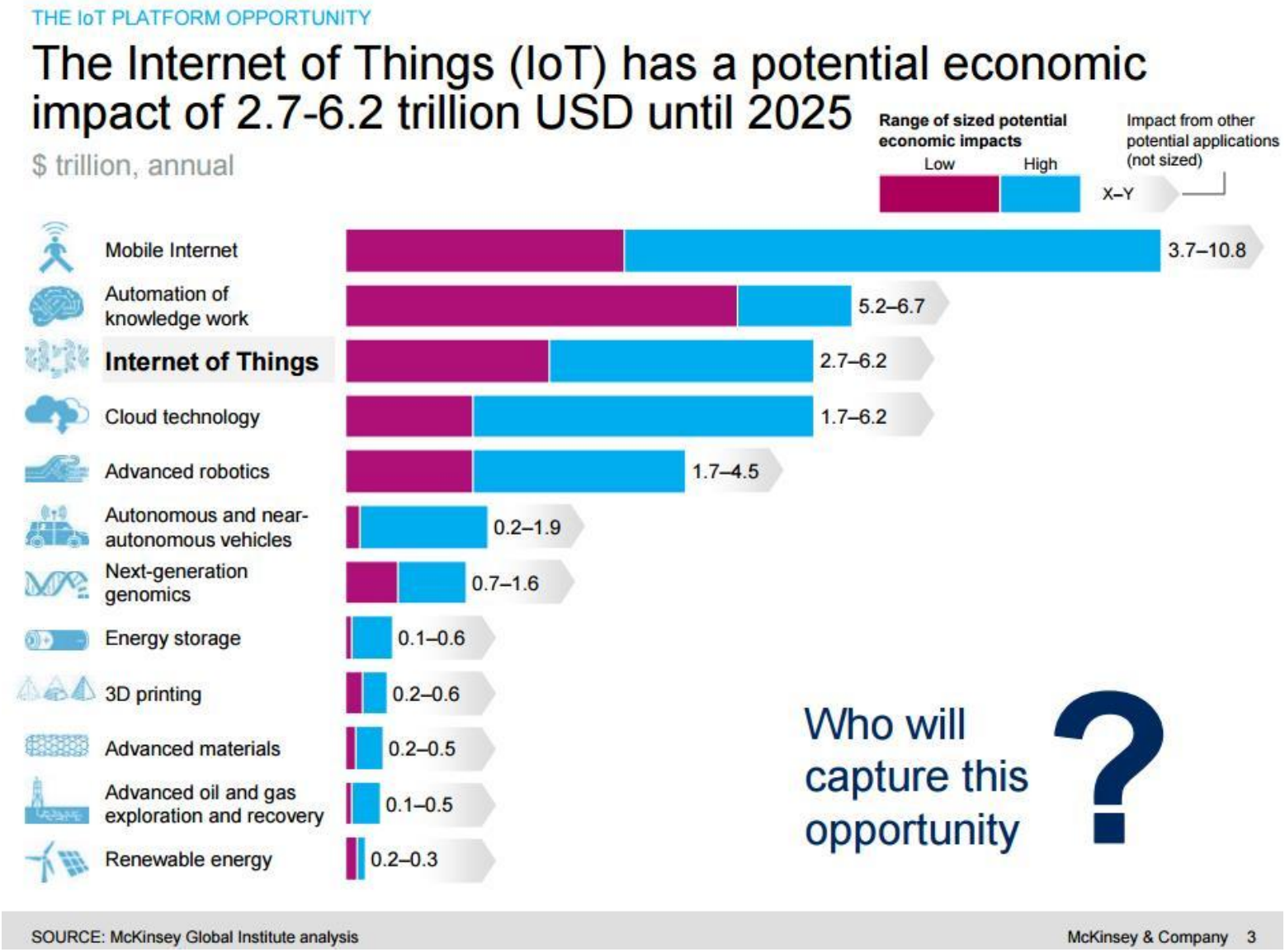
Spending by IoT Vertical



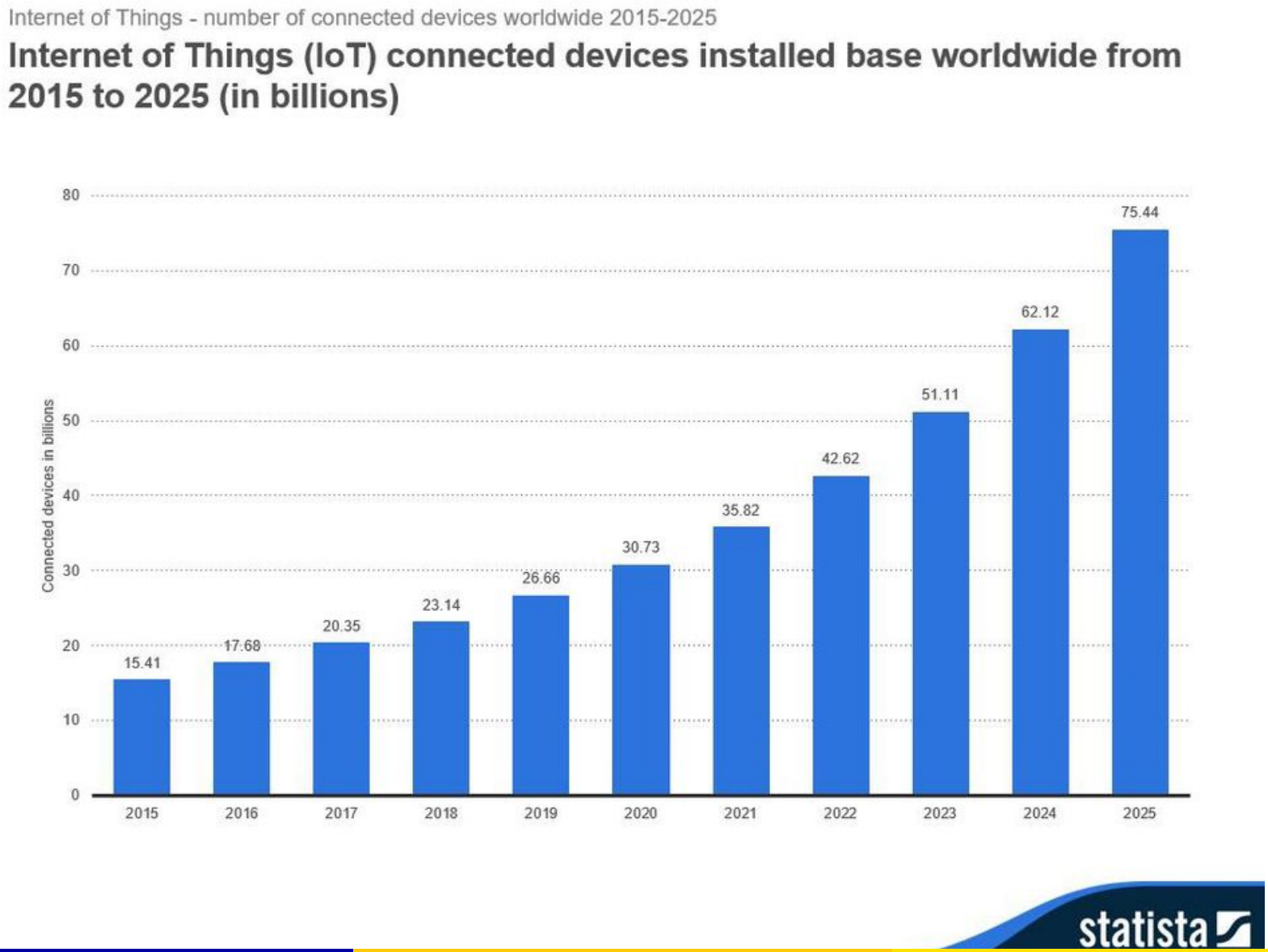
IoT Segments



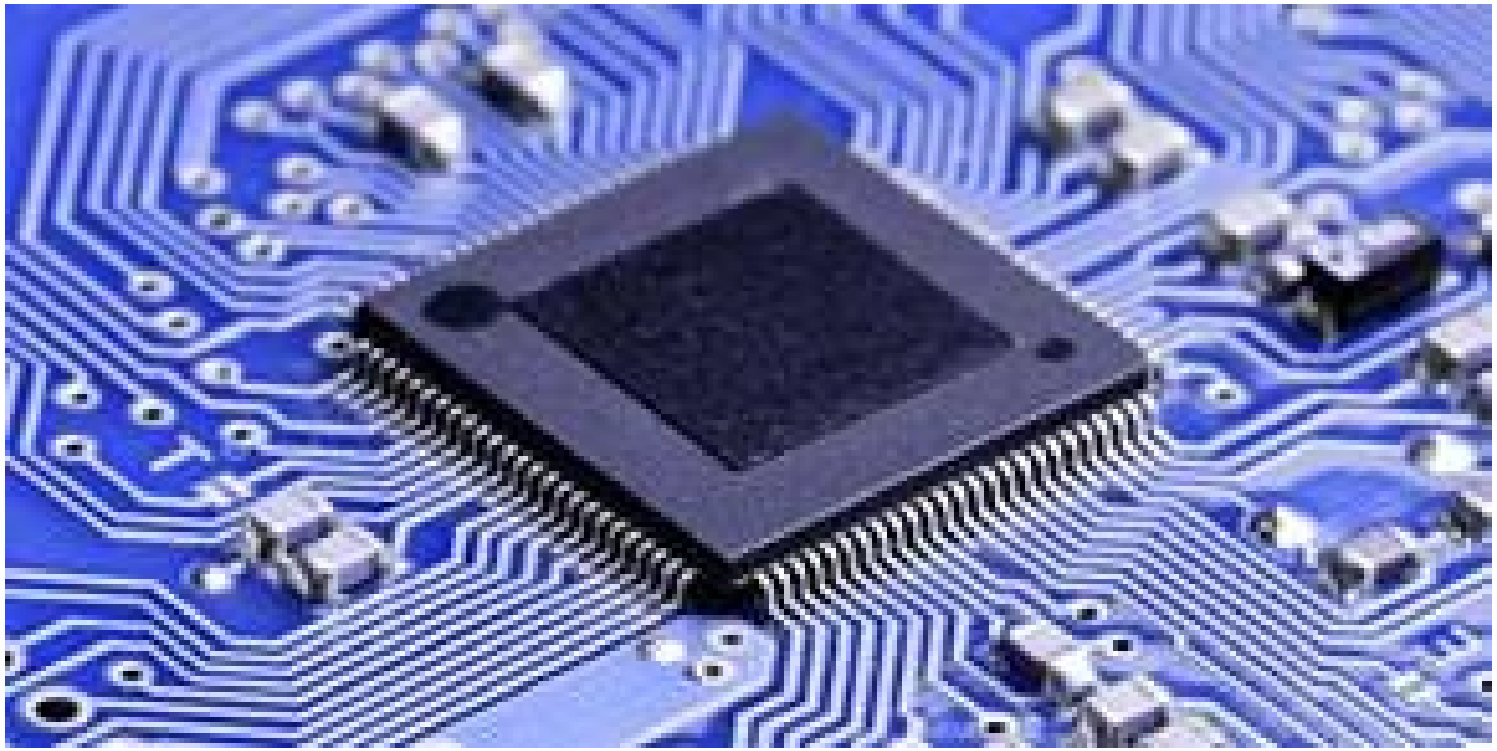
IoT Potential Economic Impact



IoT Growth

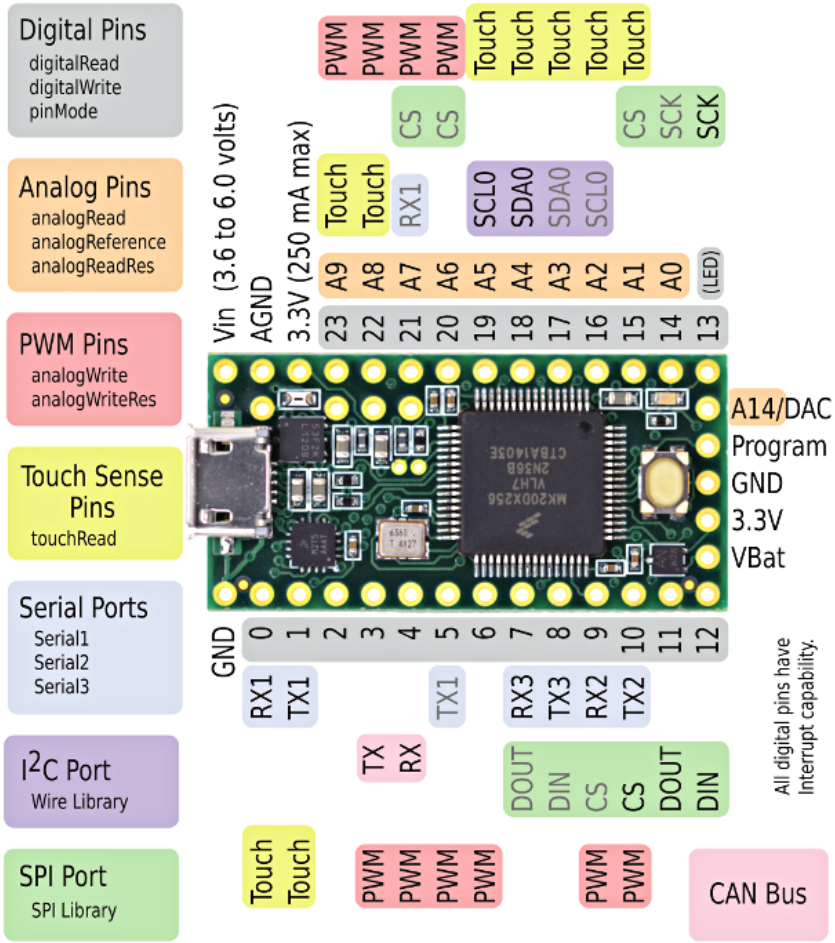

Internet of Things - number of connected devices worldwide 2015-2025
Internet of Things (IoT) connected devices installed base worldwide from 2015 to 2025 (in billions)
Connected devices in billions
0
10
20
30
40
50
60
70
80
15.41
17.68
20.35
23.14
26.66
30.73
35.82
42.62
51.11
62.12
75.44
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025
statista

Our First Microcontroller



Teensy 3.2

- Cortex-M4 72MHz (overclocked to 96 MHz)
- 34 GPIO pins
- 3.3V and 5.0V operating voltages
- 500mA of available power with USB



Arduino IDE for Teensy

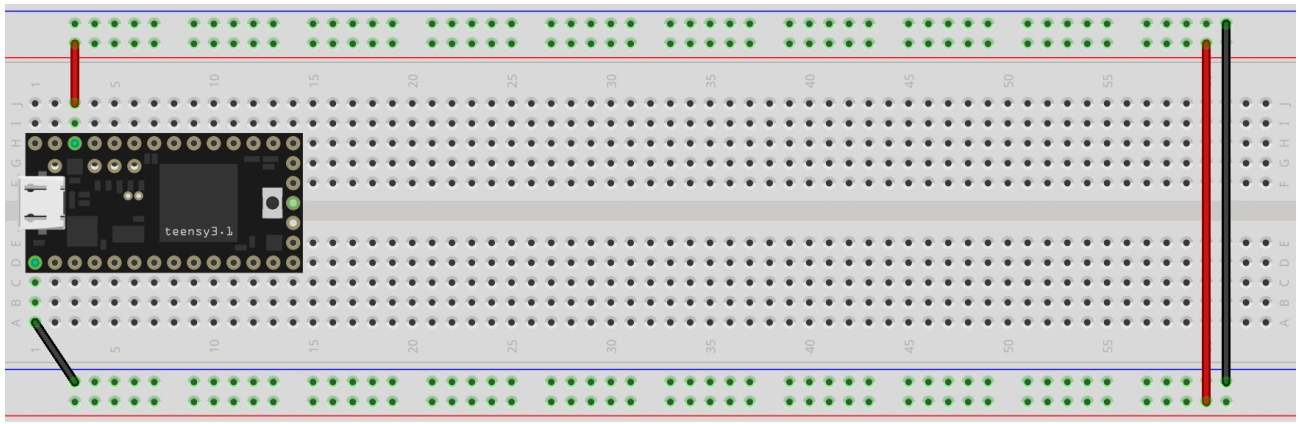
We are going to start off using the Arduino IDE[1]. The Arduino IDE is programmed essentailly using C++ code, but make the compiling and loading onto the microcontroller simplier.

We begin by installing the Arduino IDE:
https : *//www.arduino.cc/en/main/software*

Then, we install the Teensyduino add-on:
https : *//www.pjrc.com/teensy/td_download.html*

[1] An IDE, or Integrated Development Environment, enables programmers to consolidate the different aspects of writing a computer program.

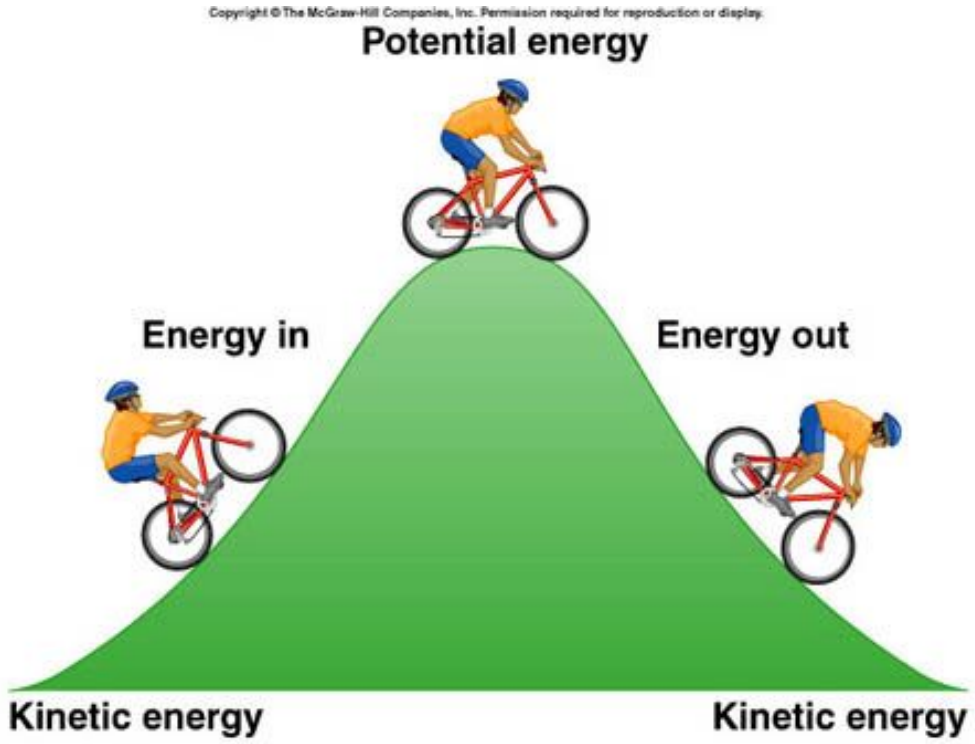
Teensy on Breadboard



Basic Structure of Arduino Sketch

```
// the "header" is used for GLOBALS
#include <library.h> // library files
int class_size;      // declare global variables
Adafruit_BME280 bme; // name object in class

void setup() {
  oled.init();              // initialize objects
  bme.begin(0x76)           // begin processes
  arraySize = sizeof(array)4; // set variables
}

void loop() {
  // functionality of your code
  // this loops indefinately
}
```

Energy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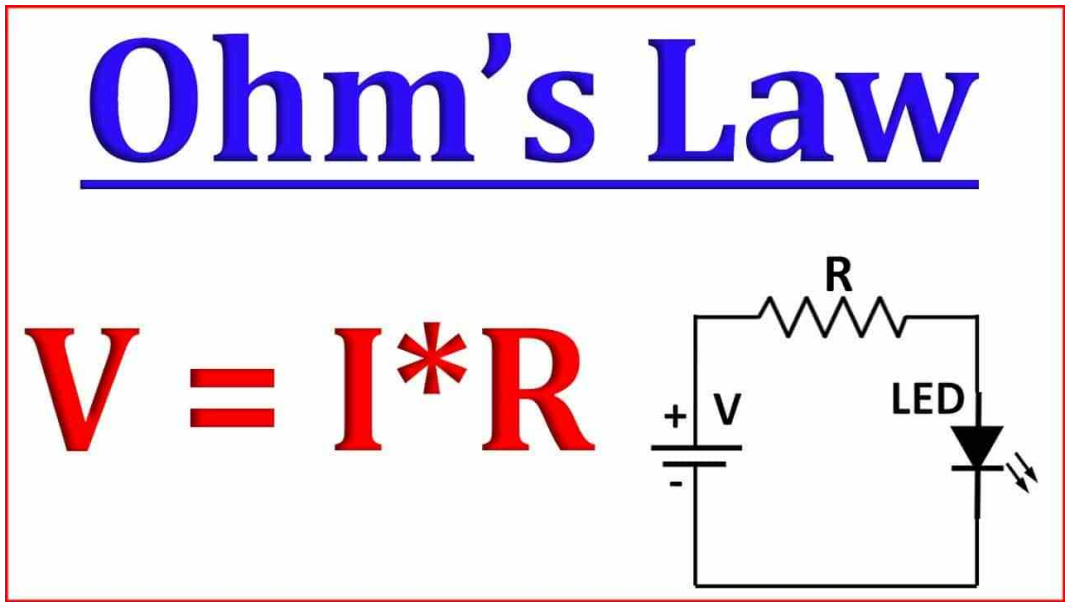
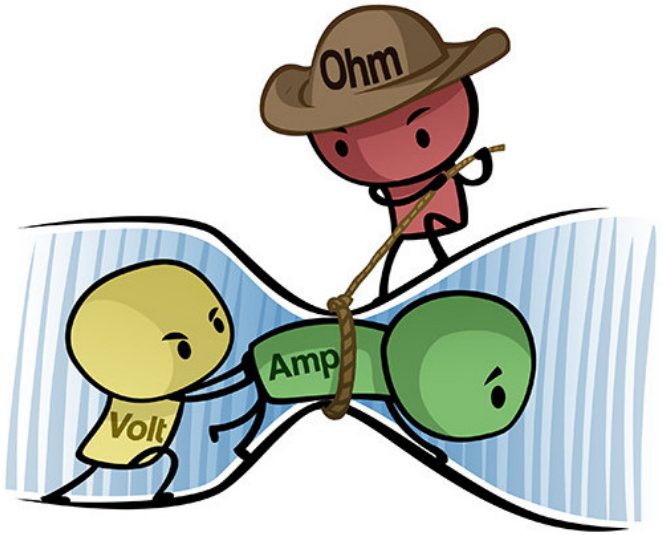
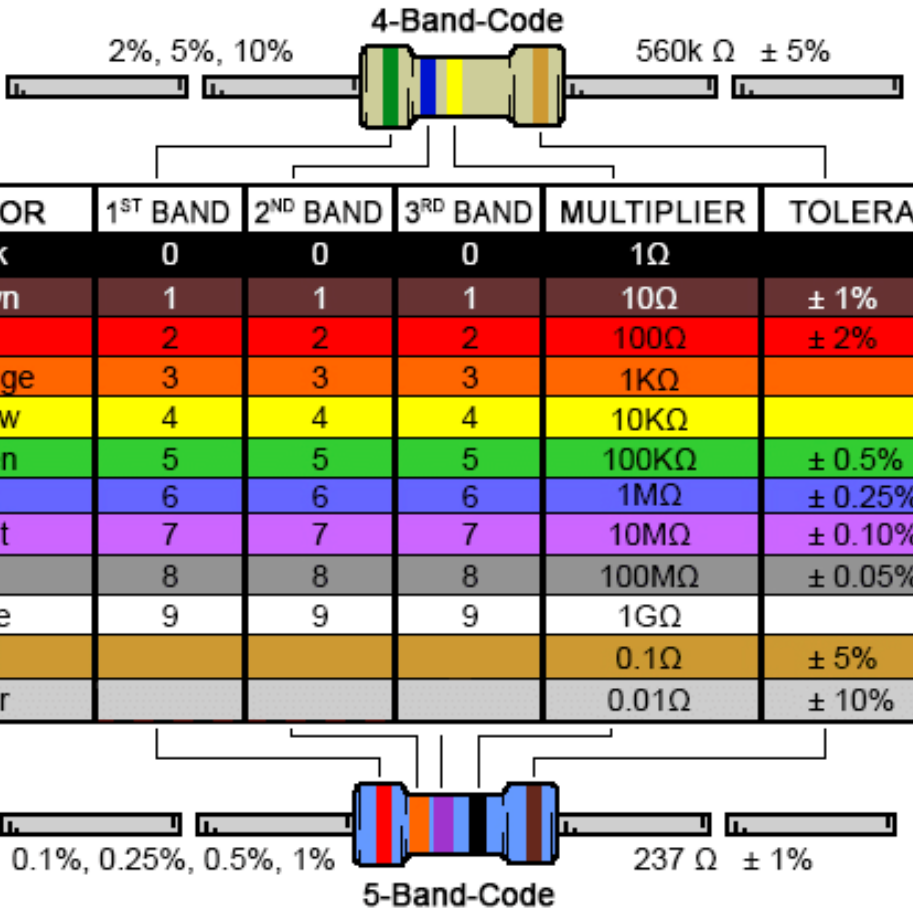
Potential energy
Energy in
Energy out
Kinetic energy
Kinetic energy

Ohm's Law



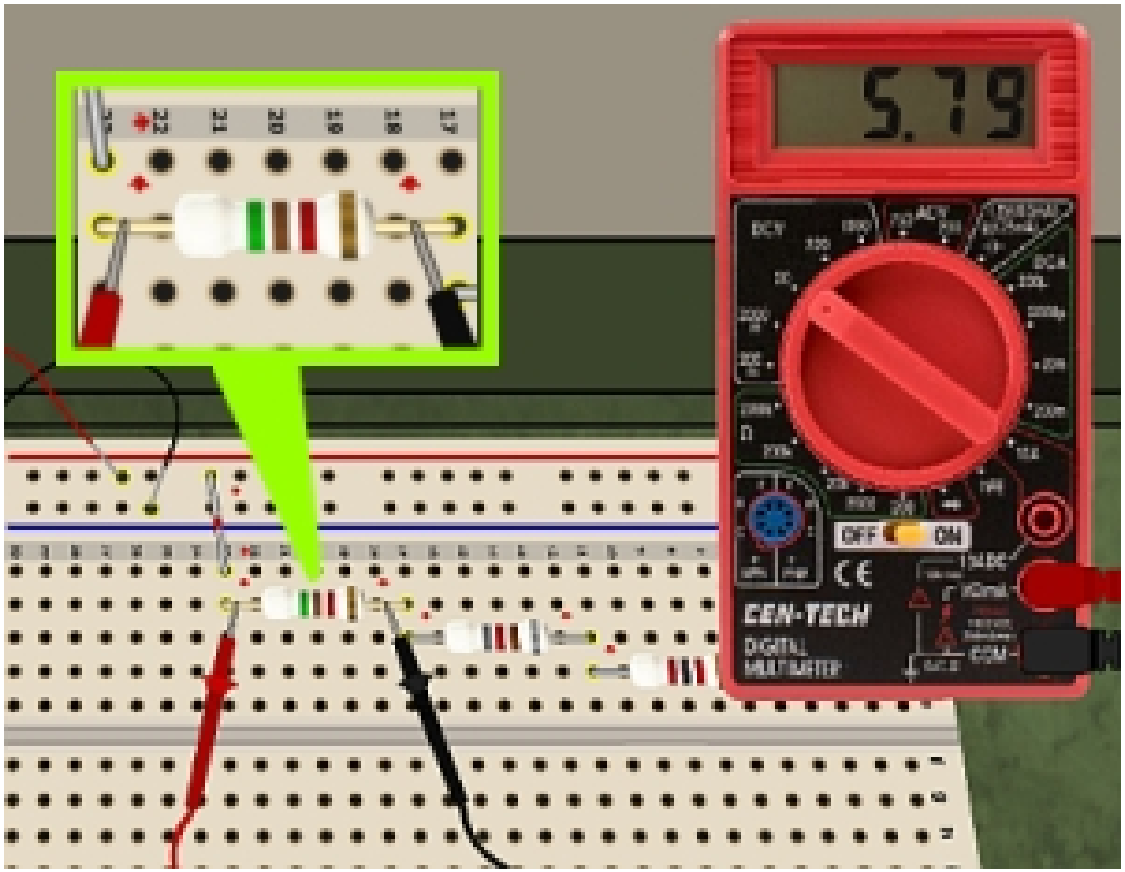


Resistor Color Bands

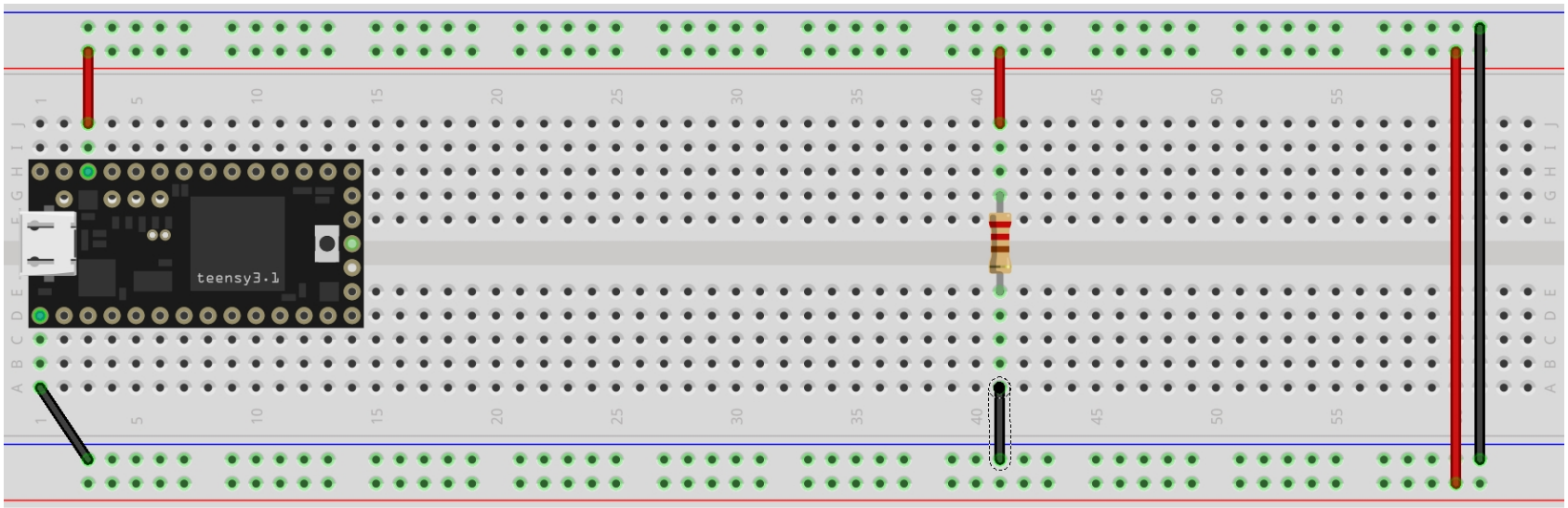


COLOR	1ST BAND	2ND BAND	3RD BAND	MULTIPLIER	TOLERANCE
Black	0	0	0	1Ω	
Brown	1	1	1	10Ω	± 1% (F)
Red	2	2	2	100Ω	± 2% (G)
Orange	3	3	3	1KΩ	
Yellow	4	4	4	10KΩ	
Green	5	5	5	100KΩ	± 0.5% (D)
Blue	6	6	6	1MΩ	± 0.25% (C)
Violet	7	7	7	10MΩ	± 0.10% (B)
Grey	8	8	8	100MΩ	± 0.05%
White	9	9	9	1GΩ	
Gold				0.1Ω	± 5% (J)
Silver				0.01Ω	± 10% (K)

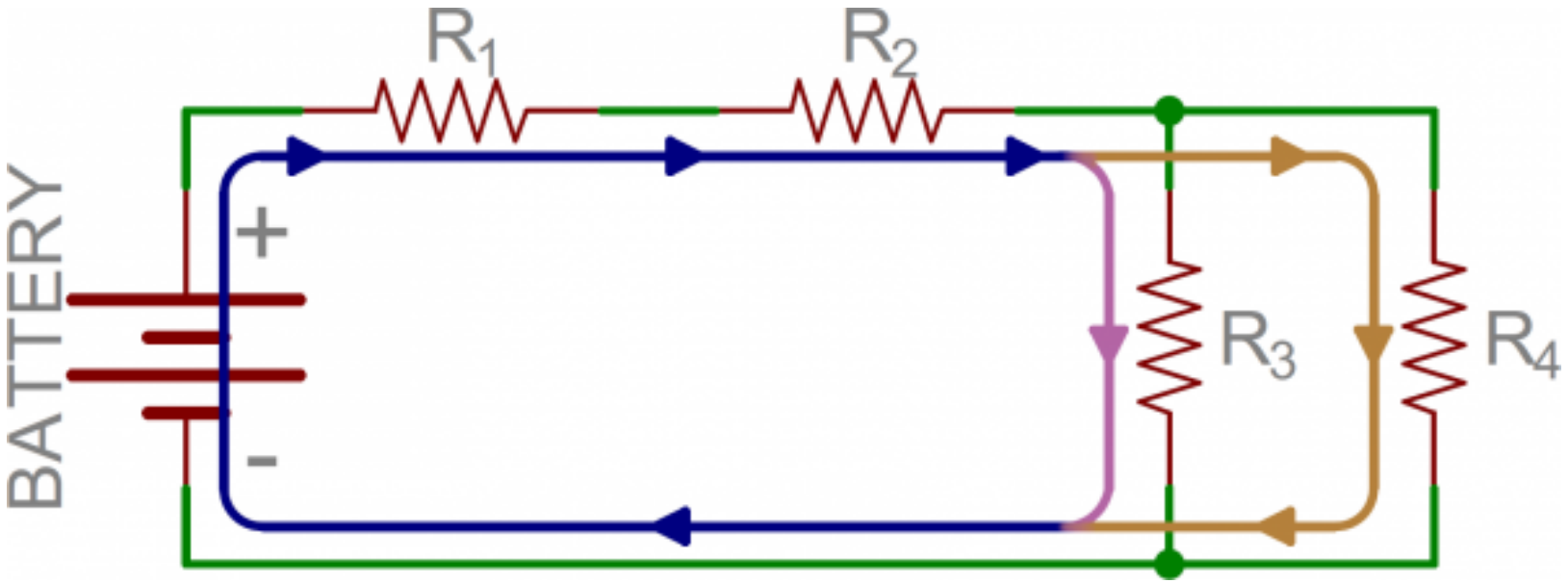
Measuring Voltage, Current, and Resistance



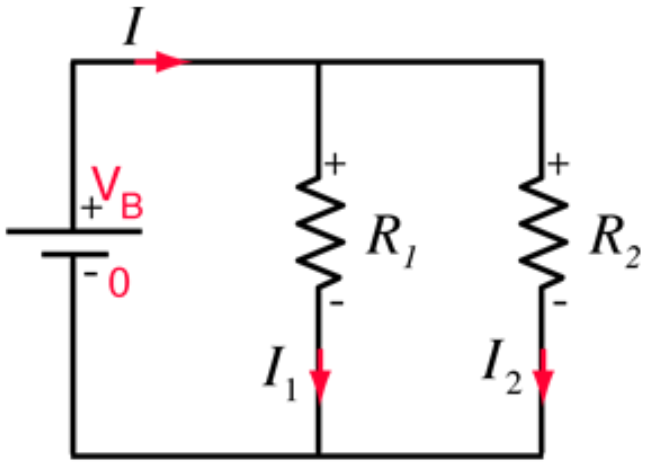
One Resistor



Resistors in Series and Parallel

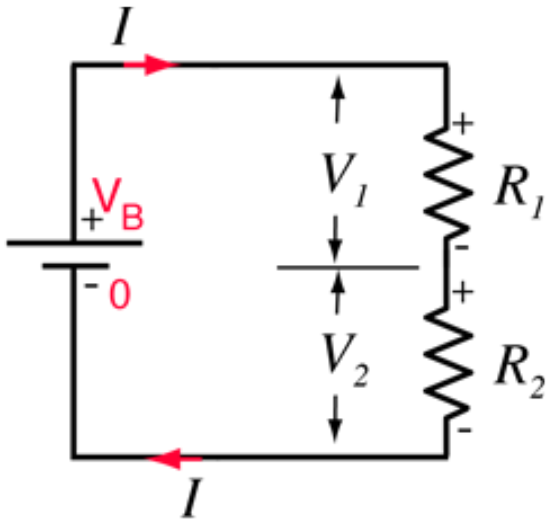


Resistors in Series and Parallel



Parallel resistors

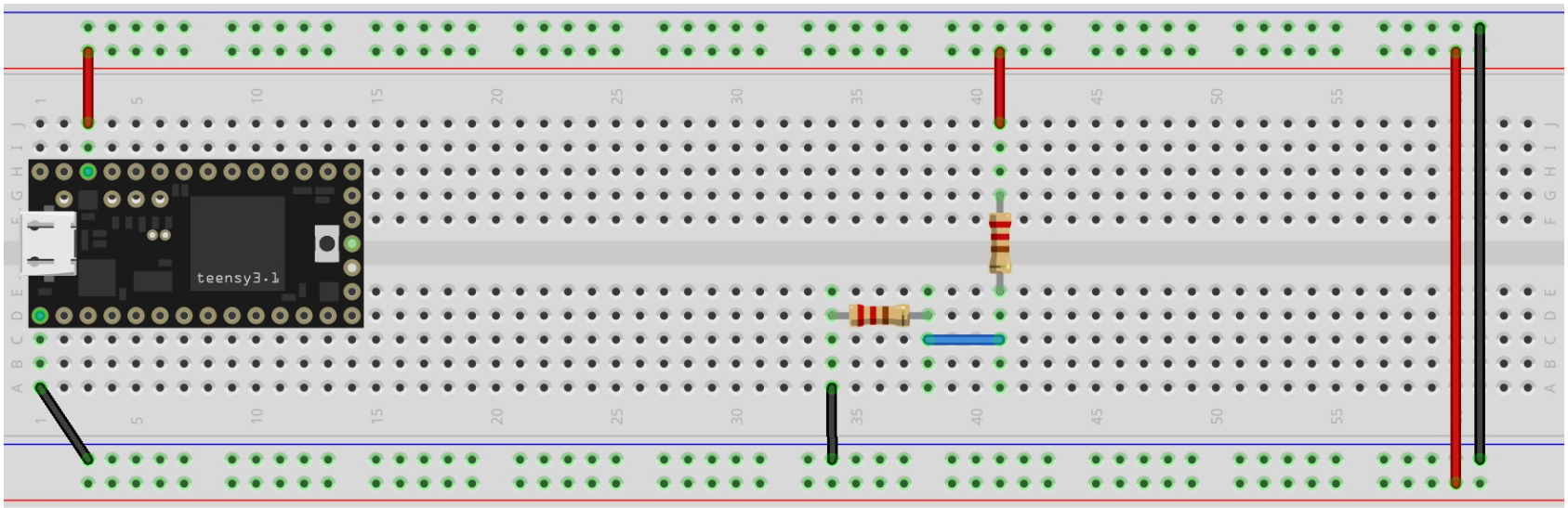
$$\frac{1}{R_{equivalent}} = \frac{1}{R_1} + \frac{1}{R_2}$$



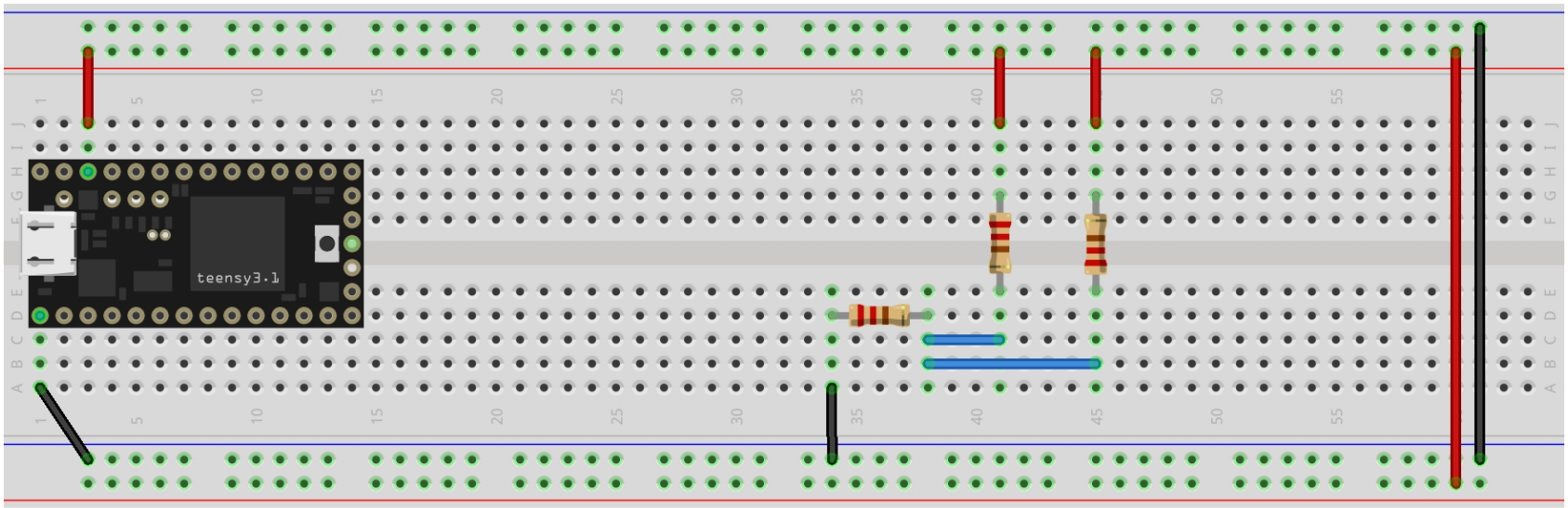
Series resistors

$$R_{equivalent} = R_1 + R_2$$

Resistors in Series

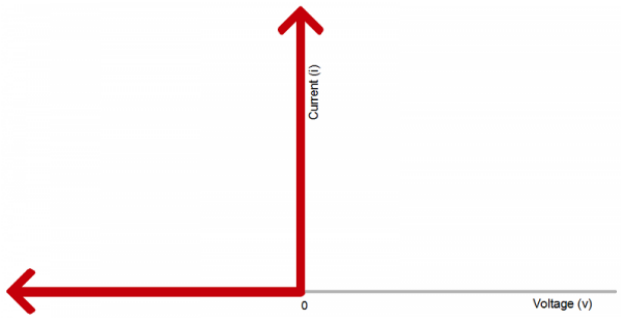


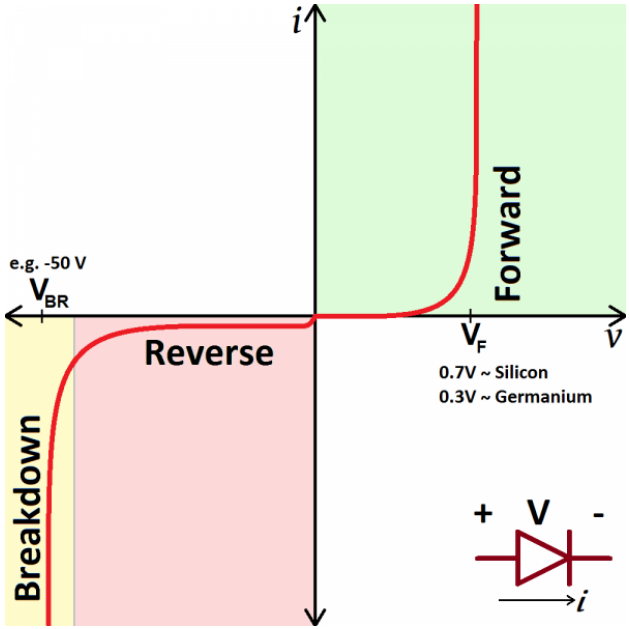
Resistors in Series and Parallel



Diodes

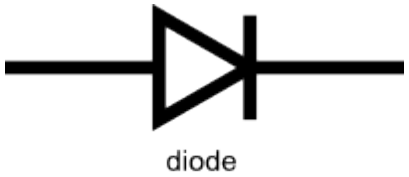
The key function of an diode is to control the direction of current-flow. Current passing through a diode can only go in one direction, called the forward direction. Current trying to flow the reverse direction is blocked.





Light Emitting Diodes

LEDs (that's "ell-ee-dees") are a particular type of diode that convert electrical energy into light.



diode

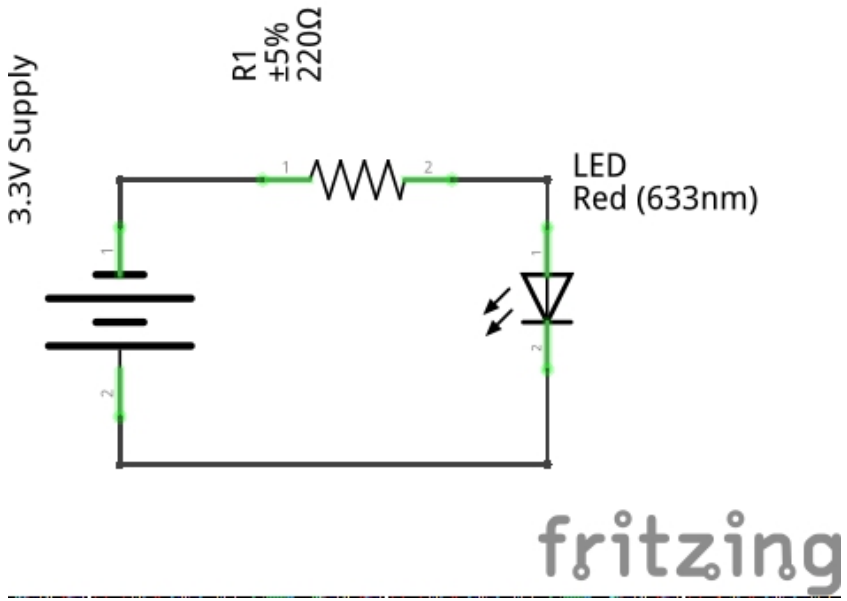
light emitting diode

Current Limiting Resistors

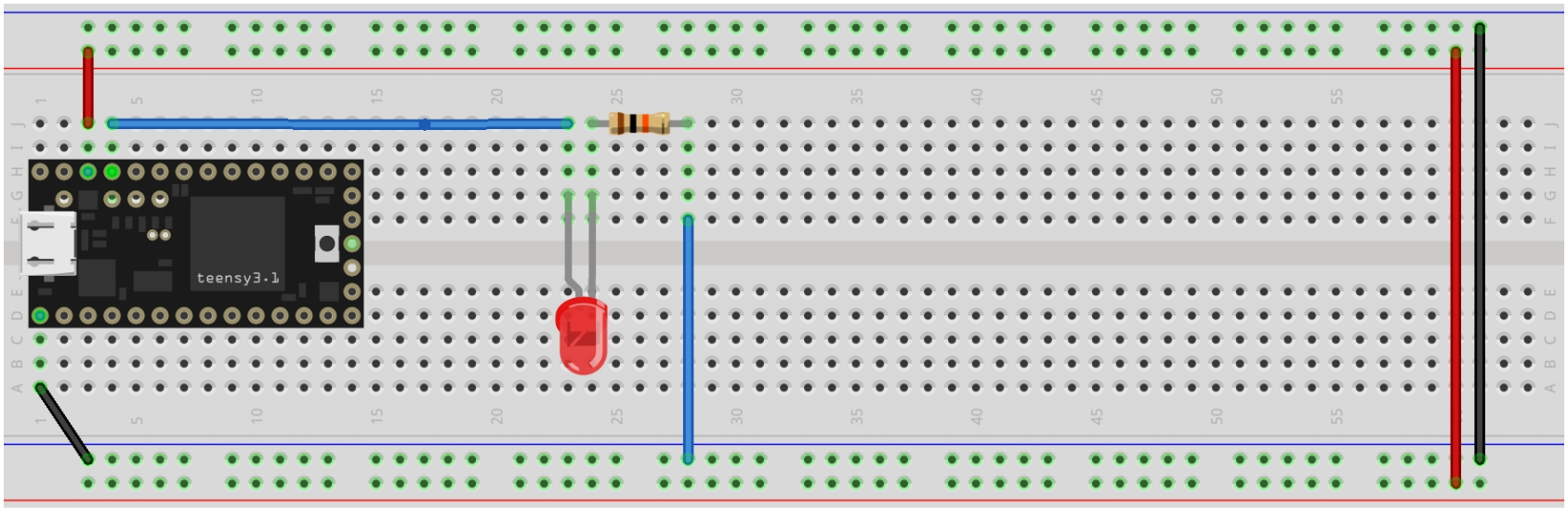
As a LED has very little resistance, when it is connected directly to a power supply, the current draw will exceed its specs and it will burn out.

$$V_{pp} - V_{LED} = IR \Longrightarrow R >= \frac{V_{pp} - V_{LED}}{I_{max}}$$

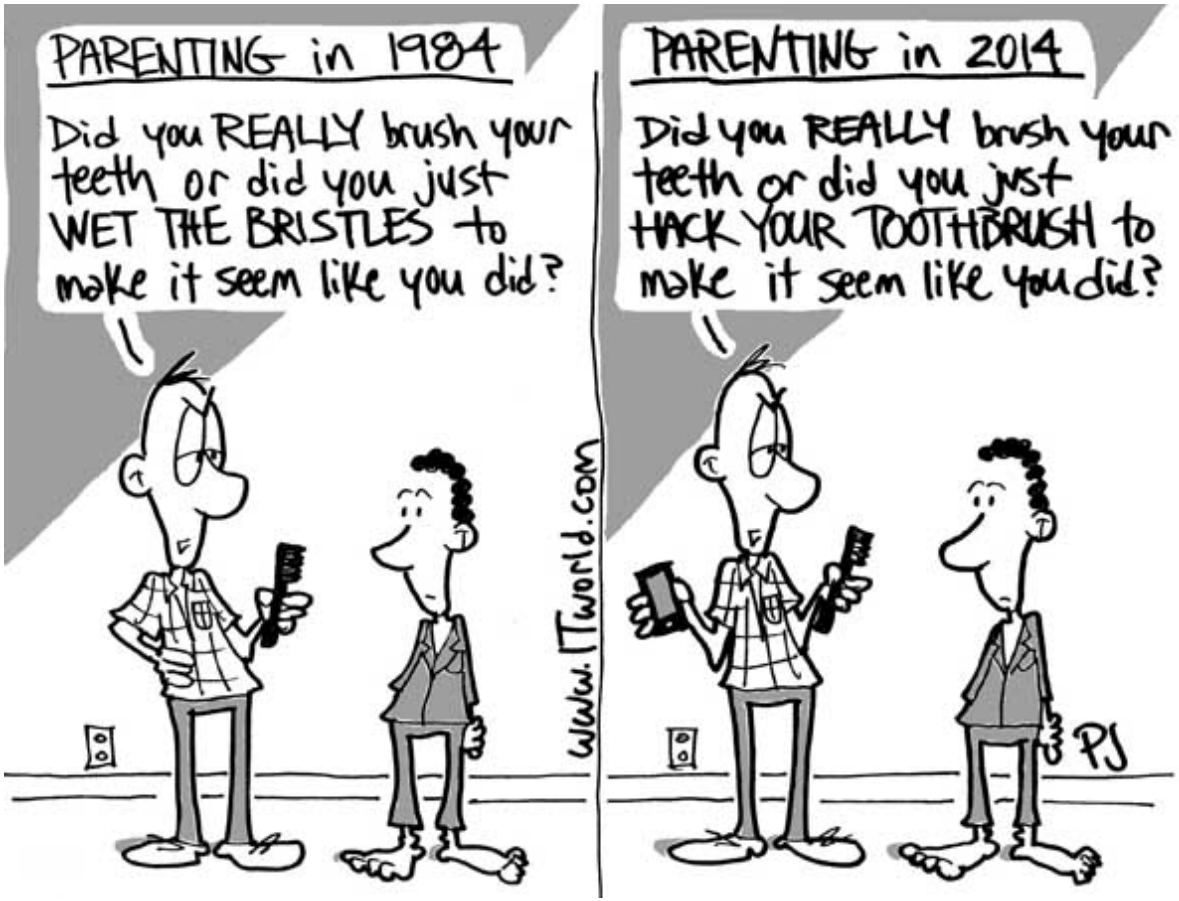
For a 3.3V power supply, a 0.43V across the LED, and a max current of 100mA, the resistor needs to be greater than 29Ω.



Hello LED



IoT Fun


PARENTING in 1984
Did you REALLY brush your teeth or did you just WET THE BRISTLES to make it seem like you did?
www.ITworld.com
PARENTING in 2014
Did you REALLY brush your teeth or did you just HACK YOUR TOOTHBRUSH to make it seem like you did?
PJ

REVIEW: For Loops

```
// FOR loop syntax
for (initialization; condition; increment) {
  // statement(s);
}

// EXAMPLE
for (j=0; j <= 255, j++) {
  analogWrite(ledPin, j);
  }
```

While loops

```
1  // WHILE loop syntax
2  while (condition) {
3    // statement(s)
4  }
5
6
7  // EXAMPLE
8  while (button == HIGH) {
9    digitalWrite(ledPin, HIGH);
10 } //continue this loop until button is released
```

For vs While Loops

For vs While Loop

Comparison Chart

For Loop	While Loop
The for loop is used for definite loops when the number of iterations is known.	The while loop is used when the number of iterations is not known.
For loops can have their counter variables declared in the declaration itself.	There is no built-in loop control variable with a while loop.
This is preferable when we know exactly how many times the loop will be repeated.	The while loop will continue to run infinite number of times until the condition is met.
The loop iterates infinite number of times if the condition is not specified.	If the condition is not specified, it shows a compilation error.

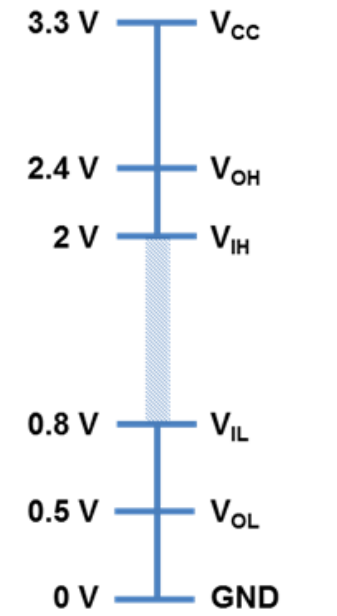
DB Difference Between.net

Serial Monitor

```
1  void setup() {
2
3  // Enable Serial Monitor
4    Serial.begin (9600);
5    while (!Serial);  // wait for Serial monitor
6    Serial.println ("Ready to Go");
7  }
8
9  void loop() {
10   for (i=0; i <=13; i++)
11   Serial.print(i);
12   delay(ledDelay);
13 }
```

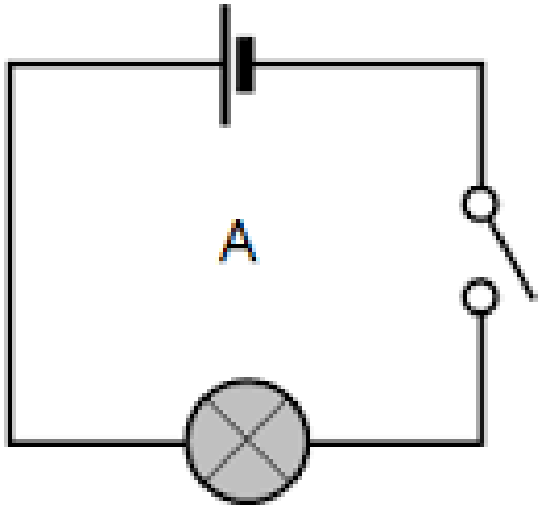
Digital Output

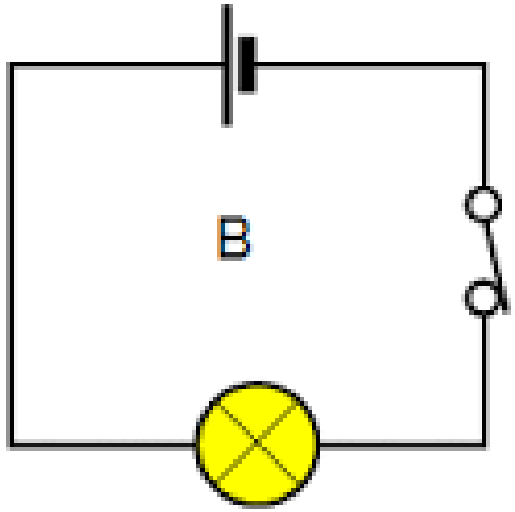
Digital electronics rely on binary logic to store, process, and transmit data or information. Binary Logic refers to one of two states – ON or OFF. This is commonly translated as a binary 1 or binary 0. A binary 1 is also referred to as a HIGH signal and a binary 0 is referred to as a LOW signal.



3.3 V Logic Families
(based on 74LVT04 Hex Inverter)

Switches





Types of Switches

SPST

Single-Pole
Single-Throw
Single-Break

SPST

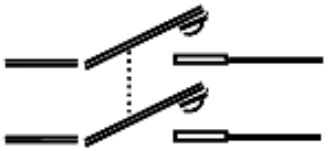
Single-Pole
Single-Throw
Double-Break

SPDT

Single-Pole
Double-Throw
Single-Break

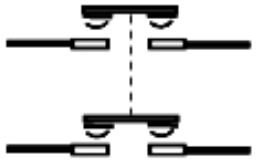
SPDT

Single-Pole
Double-Throw
Double-Break



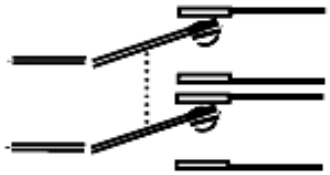
DPST

Double-Pole
Single-Throw
Single-Break



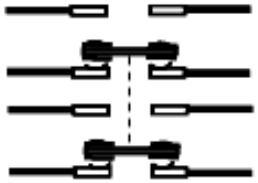
DPST

Double-Pole
Single-Throw
Double-Break



DPDT

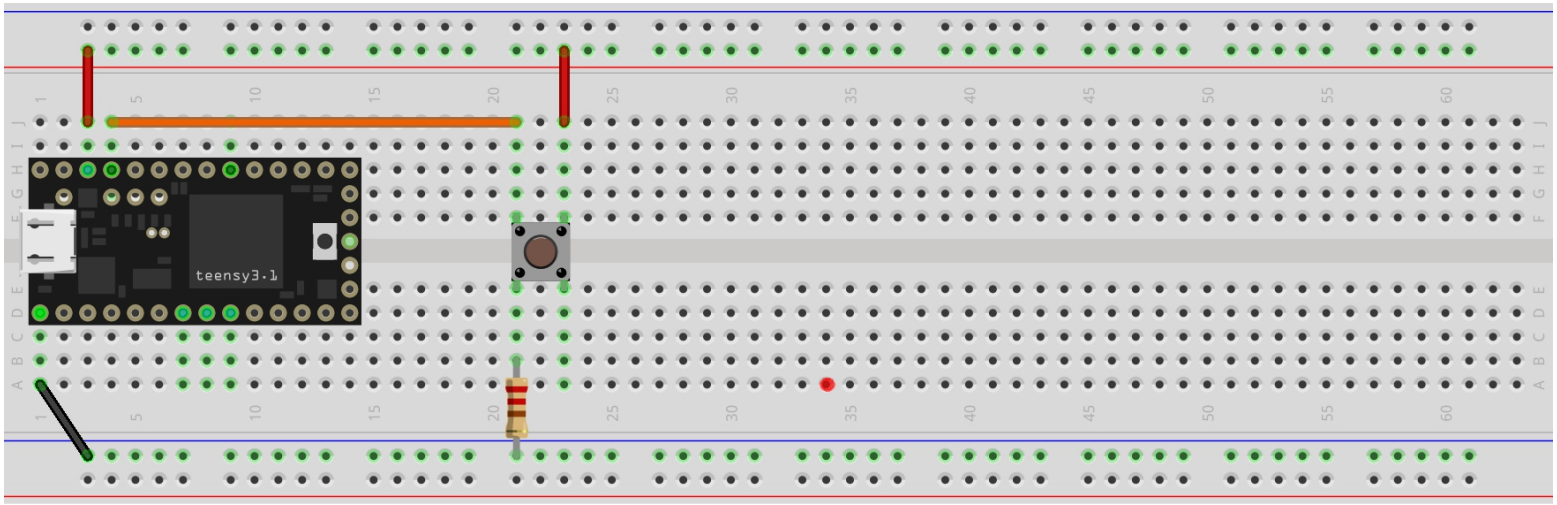
Double-Pole
Double-Throw
Single-Break



DPDT

Double-Pole
Double-Throw
Double-Break

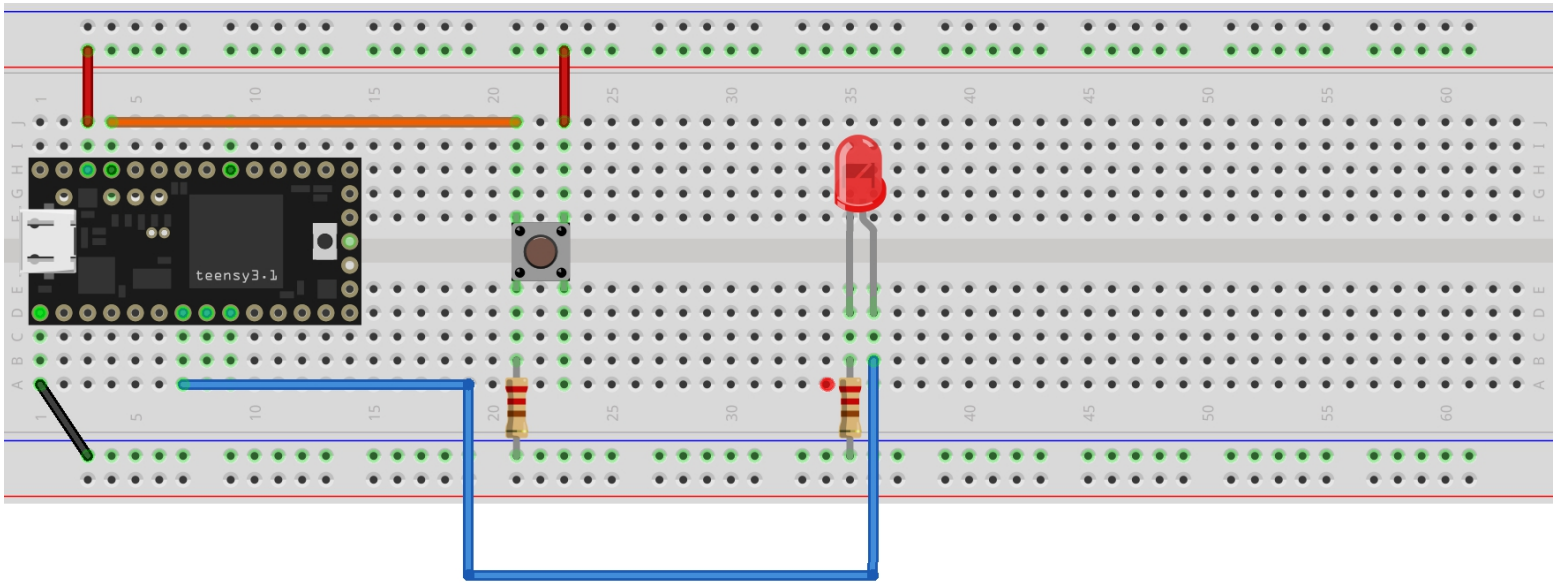
Our First Button



If Statements

```
// IF statement SYNTAX
if (condition) {
  //statement(s)
}

// EXAMPLE
if (button == HIGH) {
  digitalWrite(ledPin, HIGH);
  }
```

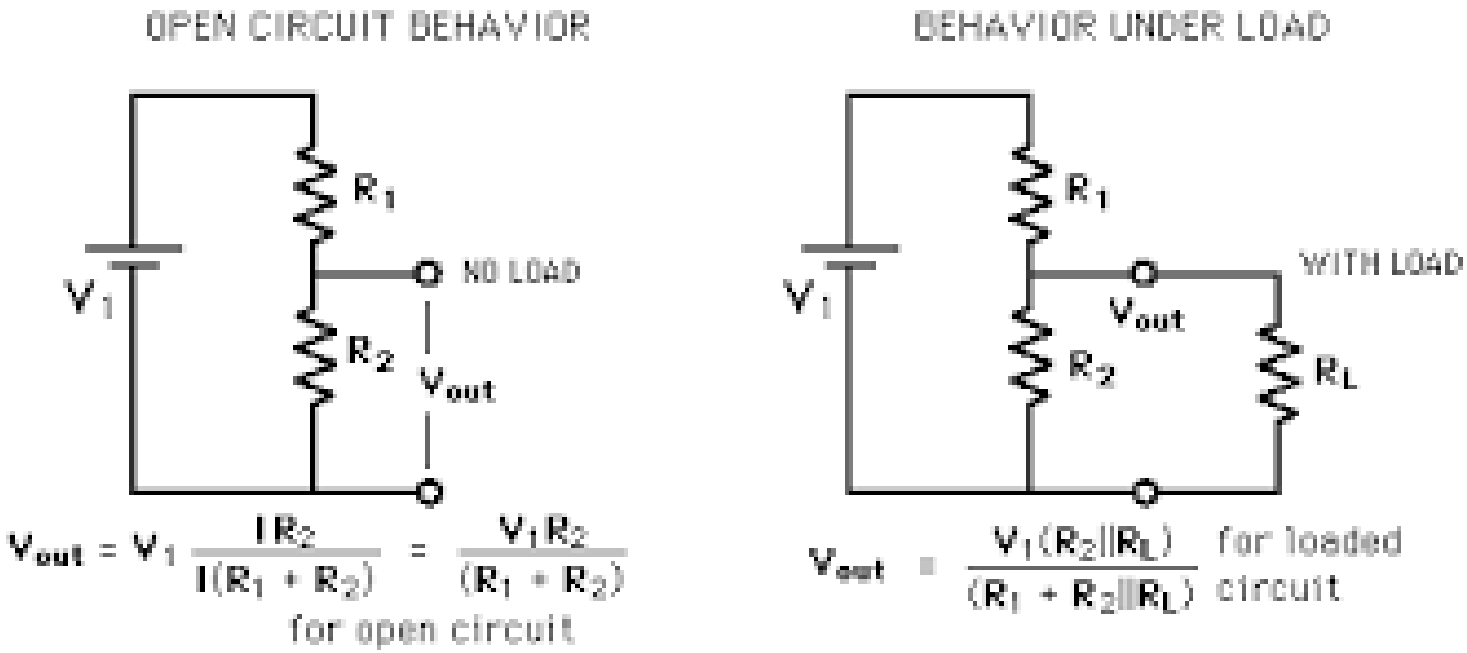
Button and LED



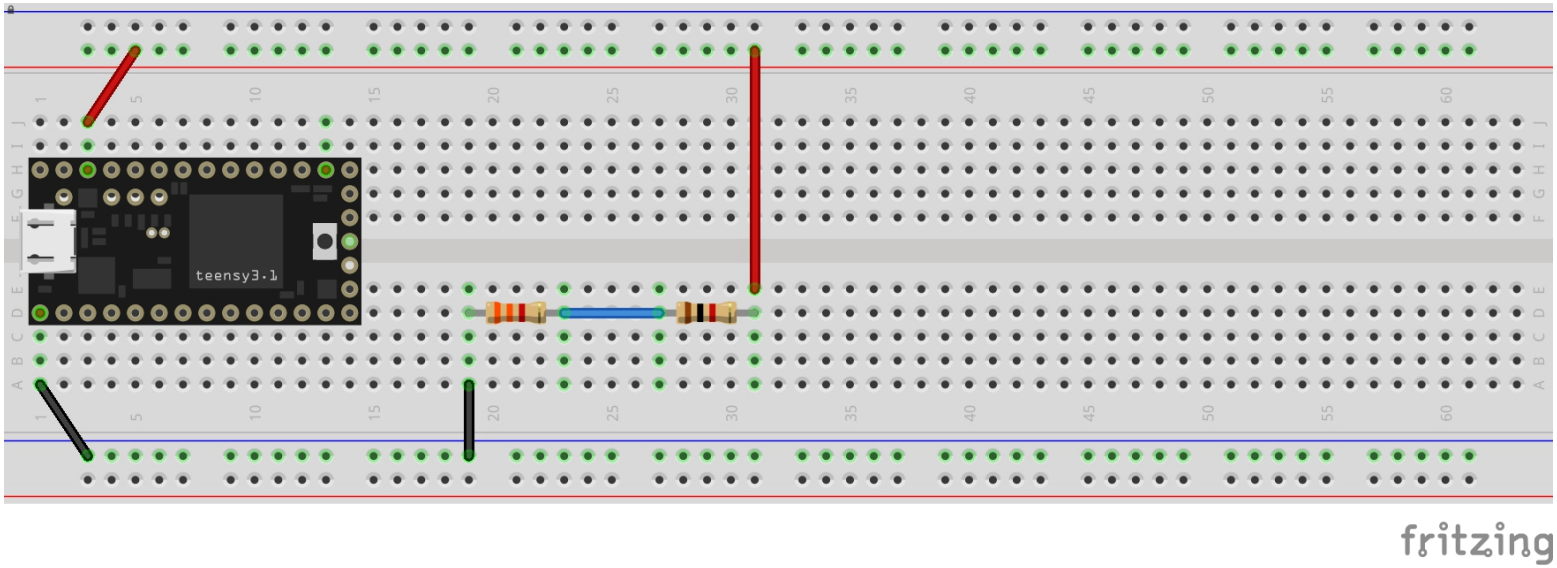
IoT Humor

"I remember when you could only lose a chess game to a supercomputer."

Voltage Divider

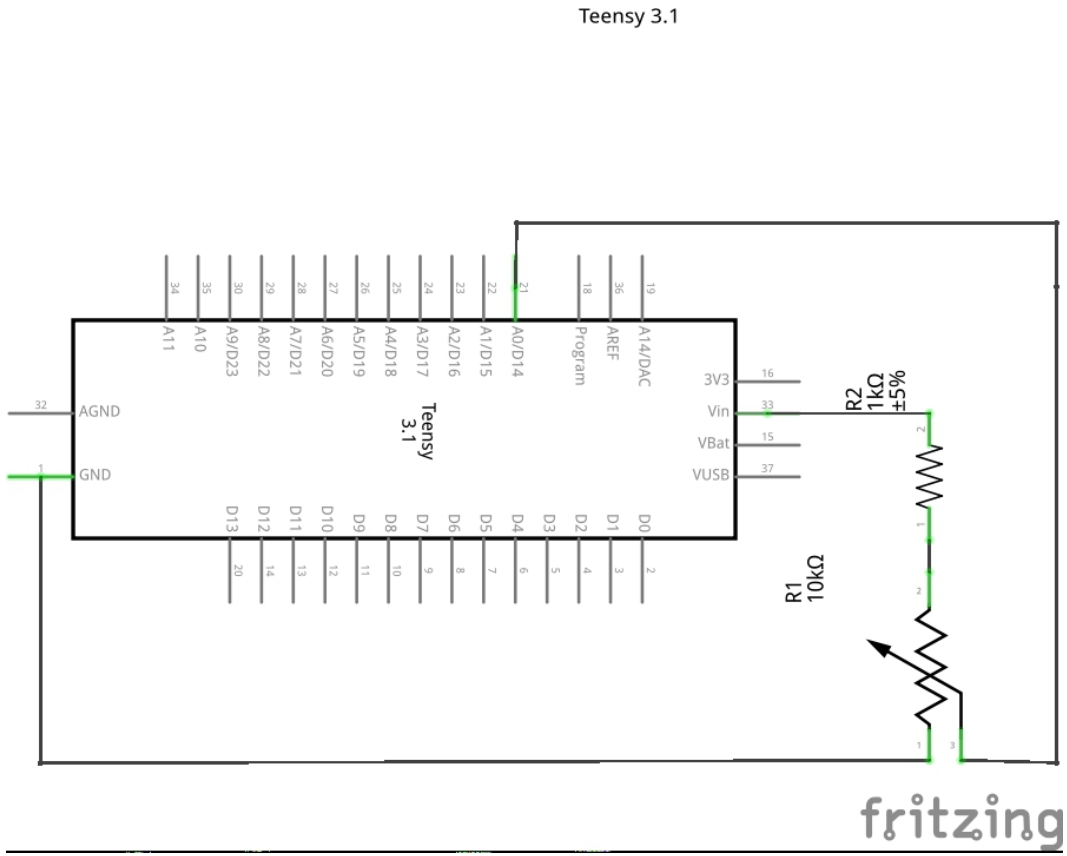


Voltage Dividing



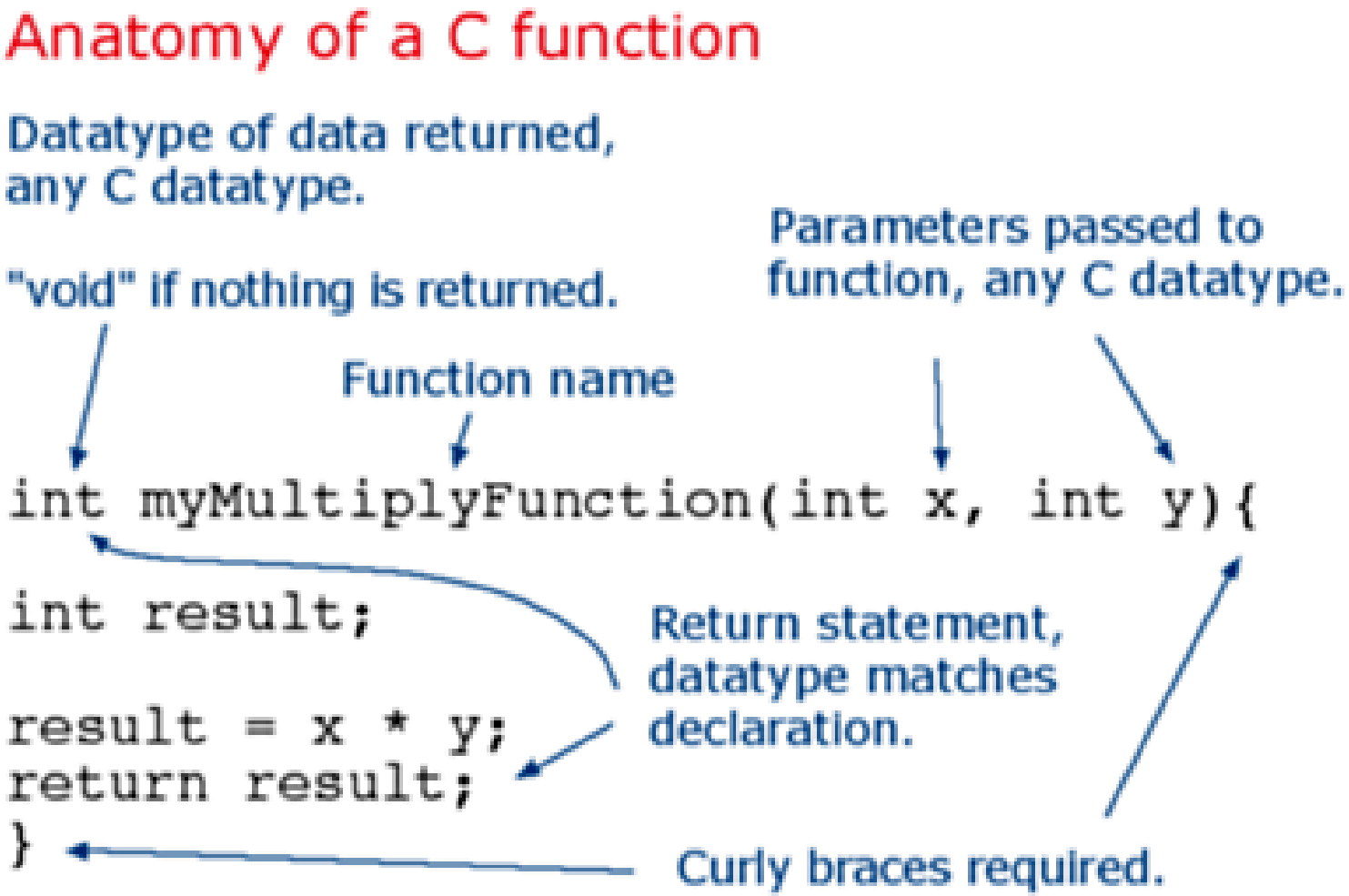
We are just using the Teensy to provide Power and GND.
The right resistor should be 1kΩ
The left resistor between 2.2kΩ and 6.8kΩ

Analog Input Schematic

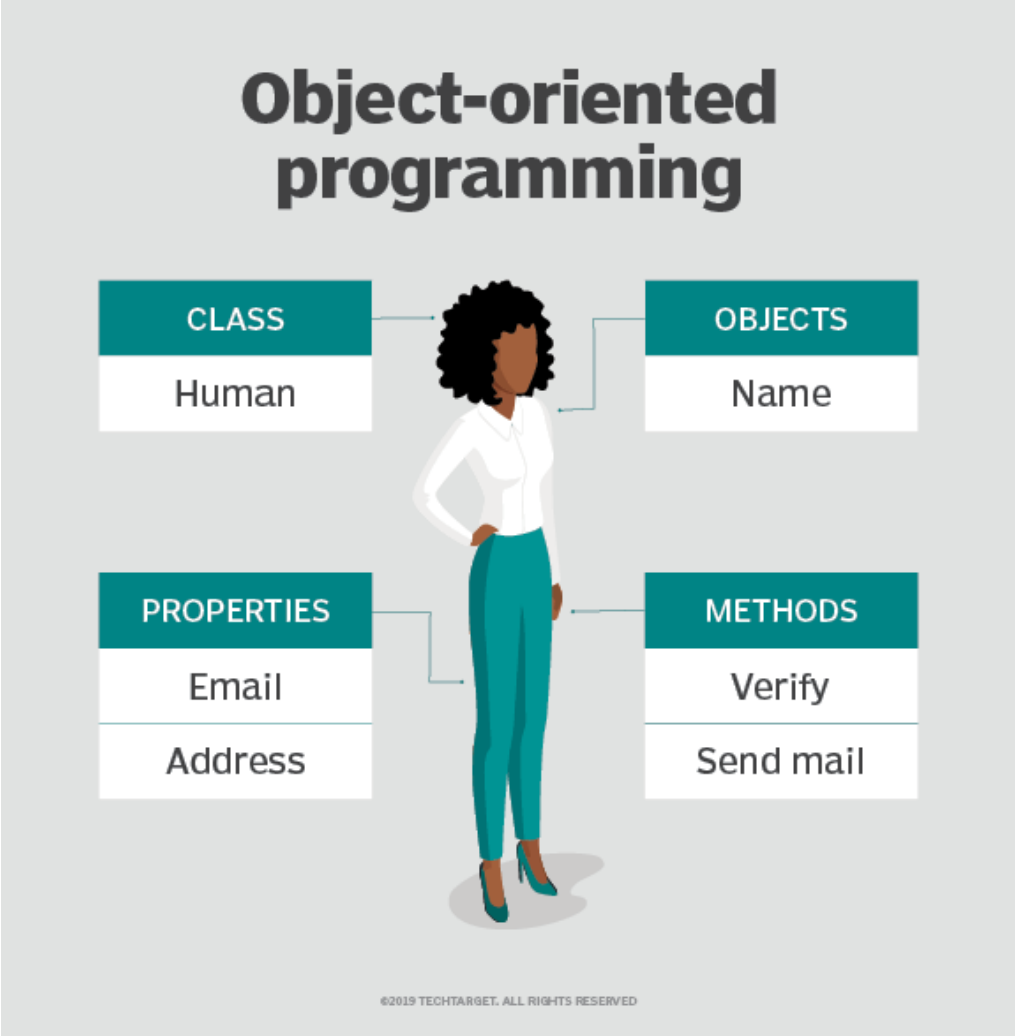


Feel free to use any PIN you would like to measure the voltage.

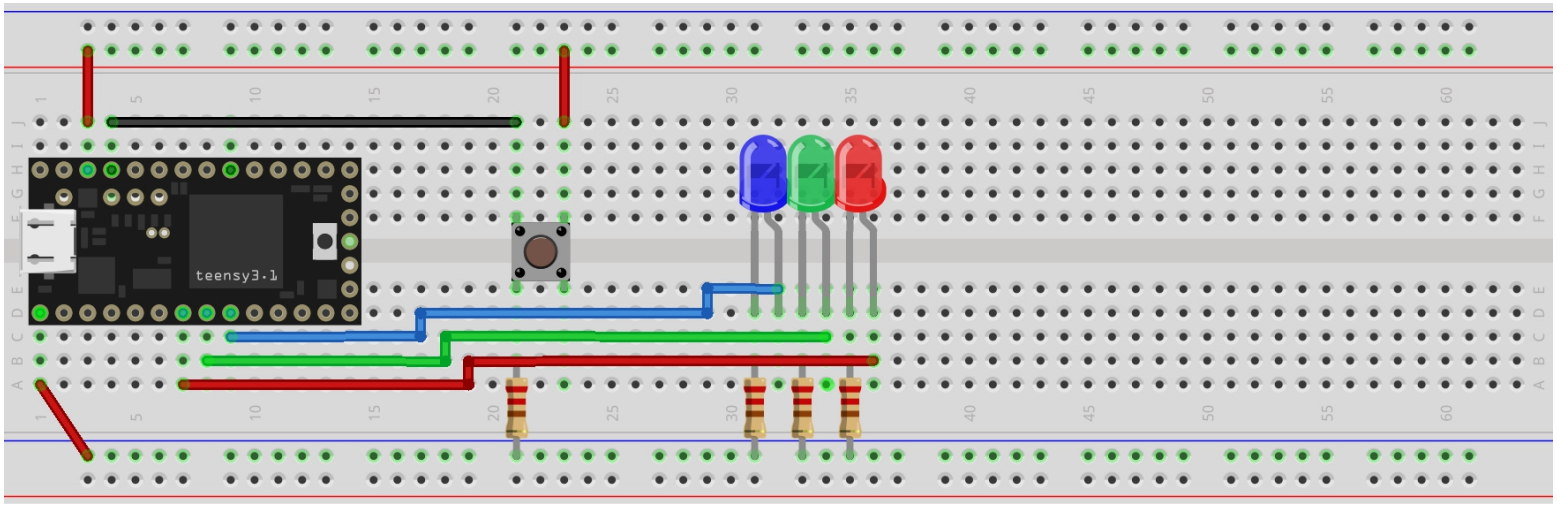
Anatomy of a Function



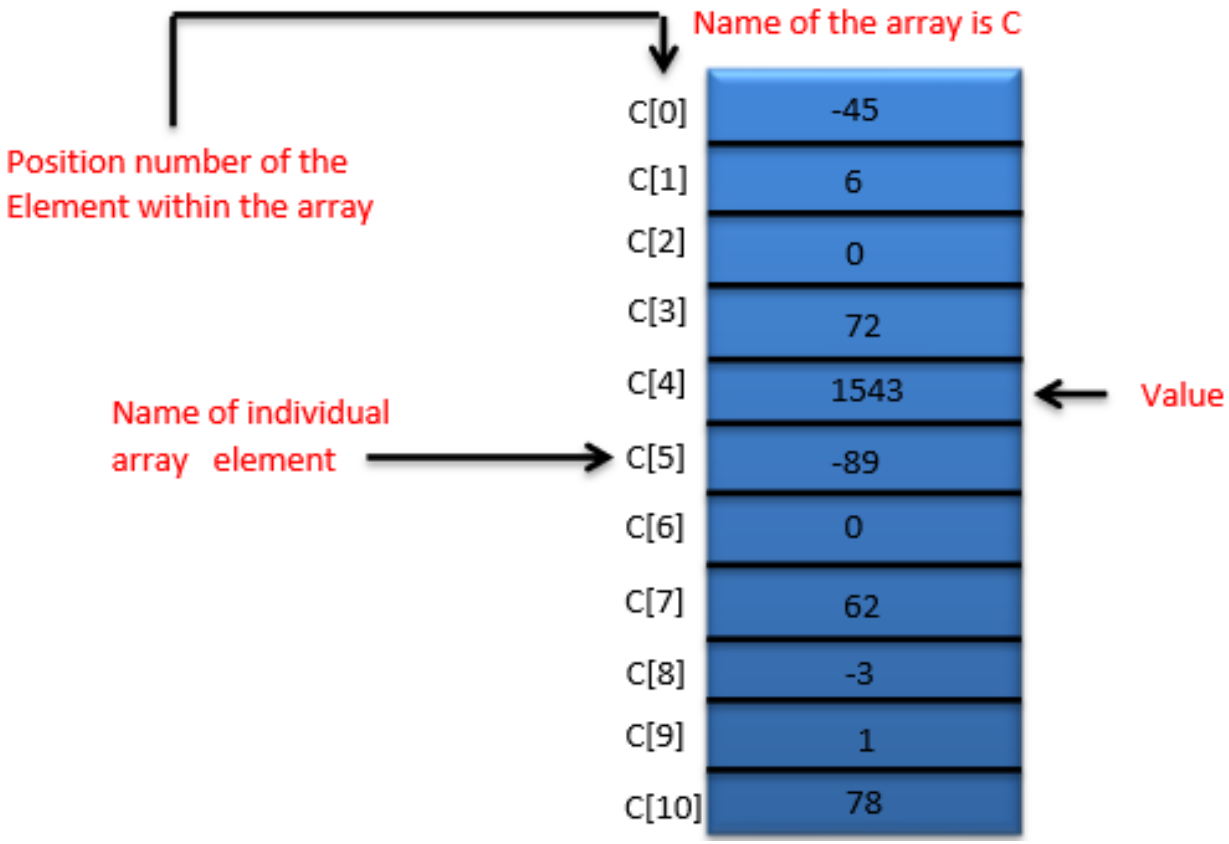
Objects


Object-oriented programming
CLASS
Human
OBJECTS
Name
PROPERTIES
Email
Address
METHODS
Verify
Send mail
©2019 TECHTARGET. ALL RIGHTS RESERVED

oneButton LED



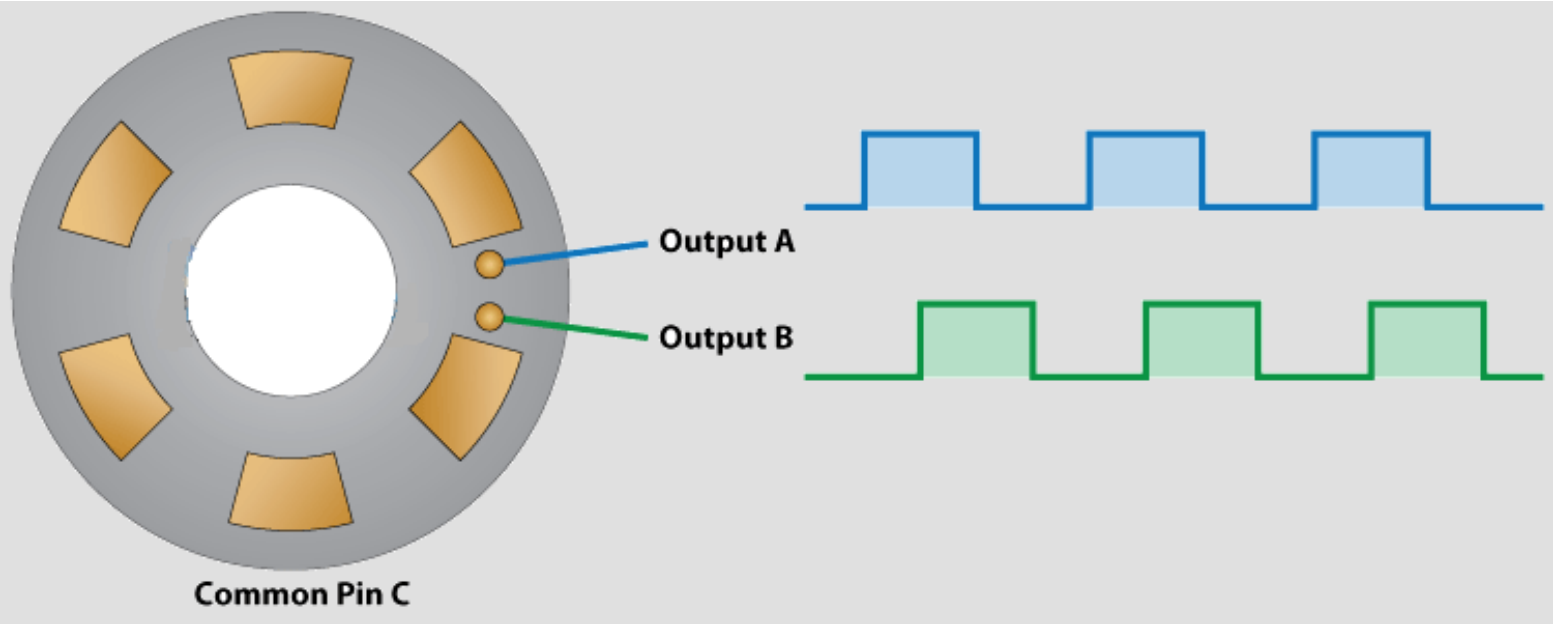
Arrays


Name of the array is C
Position number of the
Element within the array
C[0]
C[1]
C[2]
C[3]
C[4]
C[5]
C[6]
C[7]
C[8]
C[9]
C[10]
-45
6
0
72
1543
-89
0
62
-3
1
78
Value
Name of individual
array element

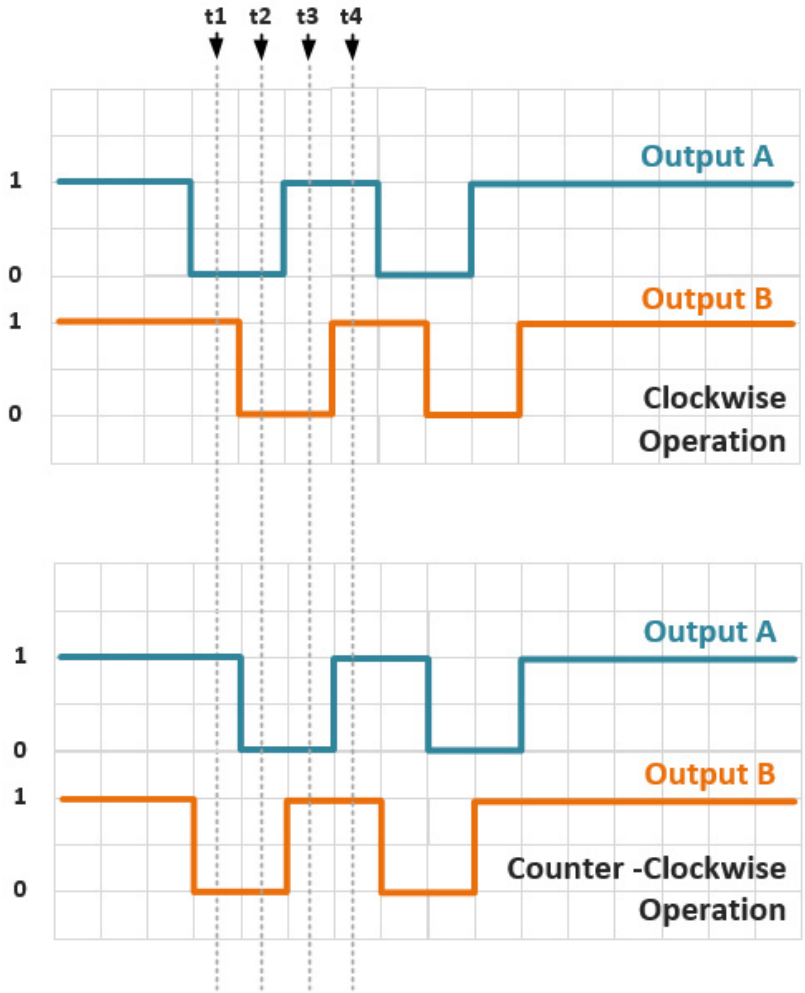
IoT Humor


"WE HAVE TO GO OUT FOR DINNER. THE REFRIGERATOR ISN'T SPEAKING TO THE STOVE."

Encoders



Encoders



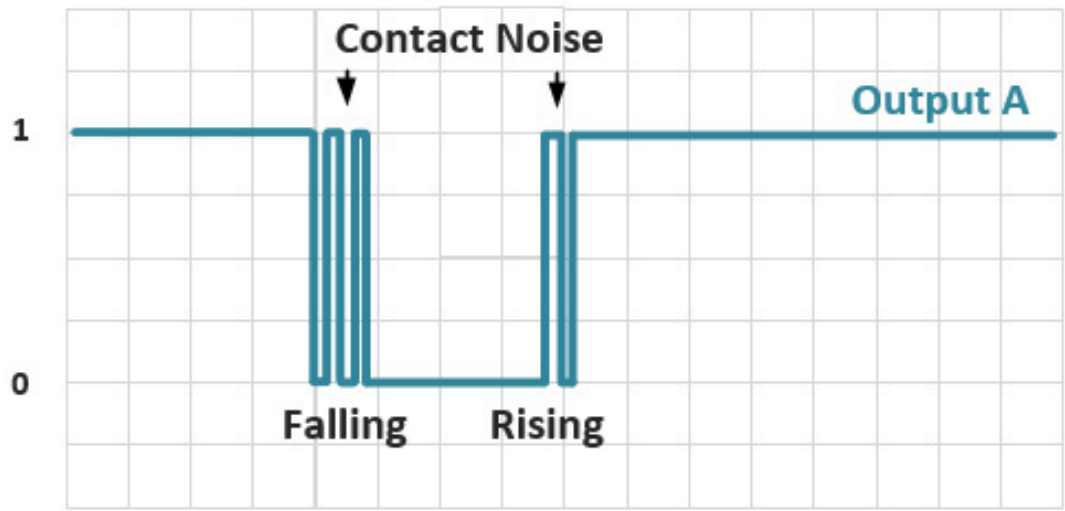
Clockwise Sequence

	A	B
t1	0	1
t2	0	0
t3	1	0
t4	1	1

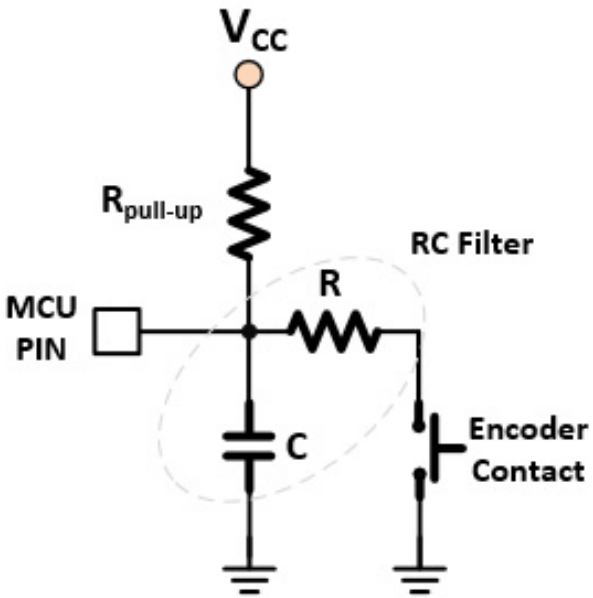
Counter-Clockwise Sequence

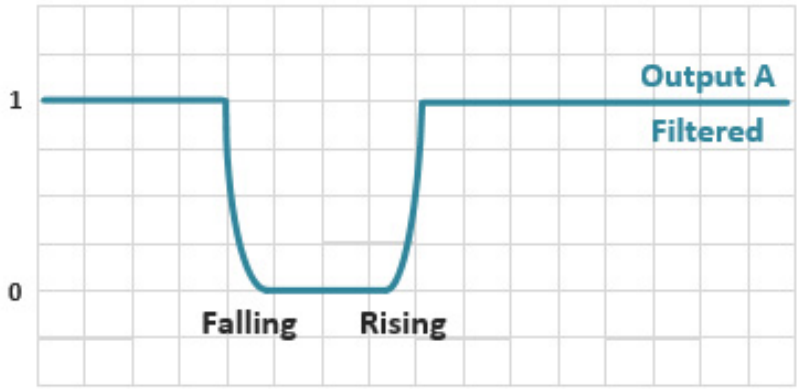
	A	B
t1	1	0
t2	0	0
t3	0	1
t4	1	1

Encoders

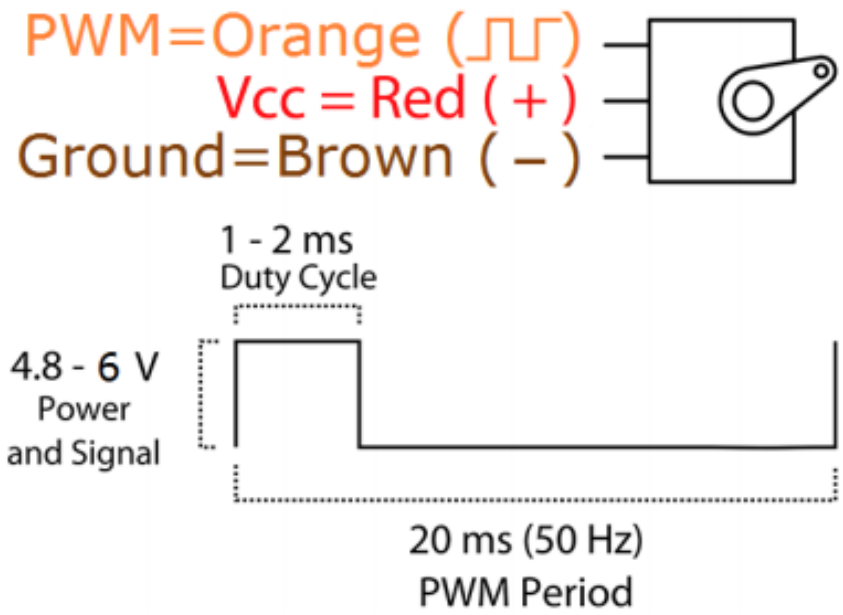


Encoders

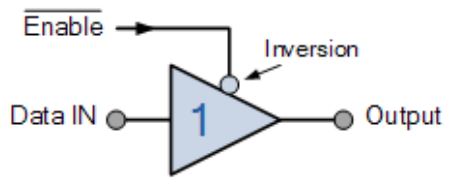

V_{CC}
$R_{pull-up}$
RC Filter
R
MCU
PIN
C
Encoder
Contact


1
0
Output A
Filtered
Falling
Rising

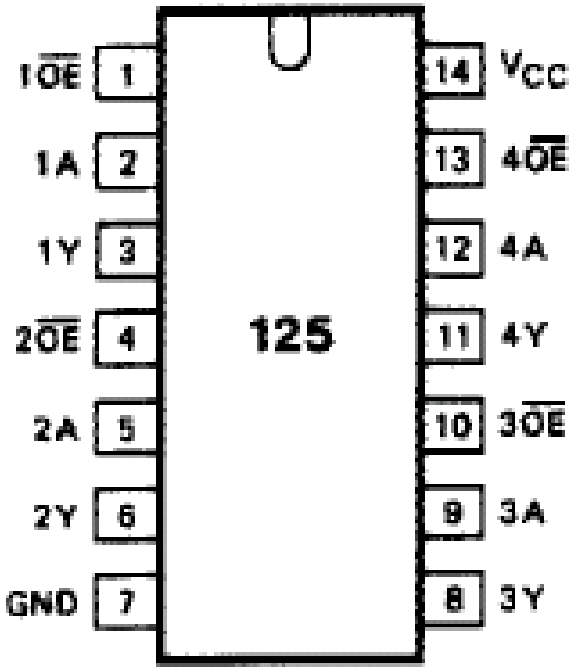
Servo Motors



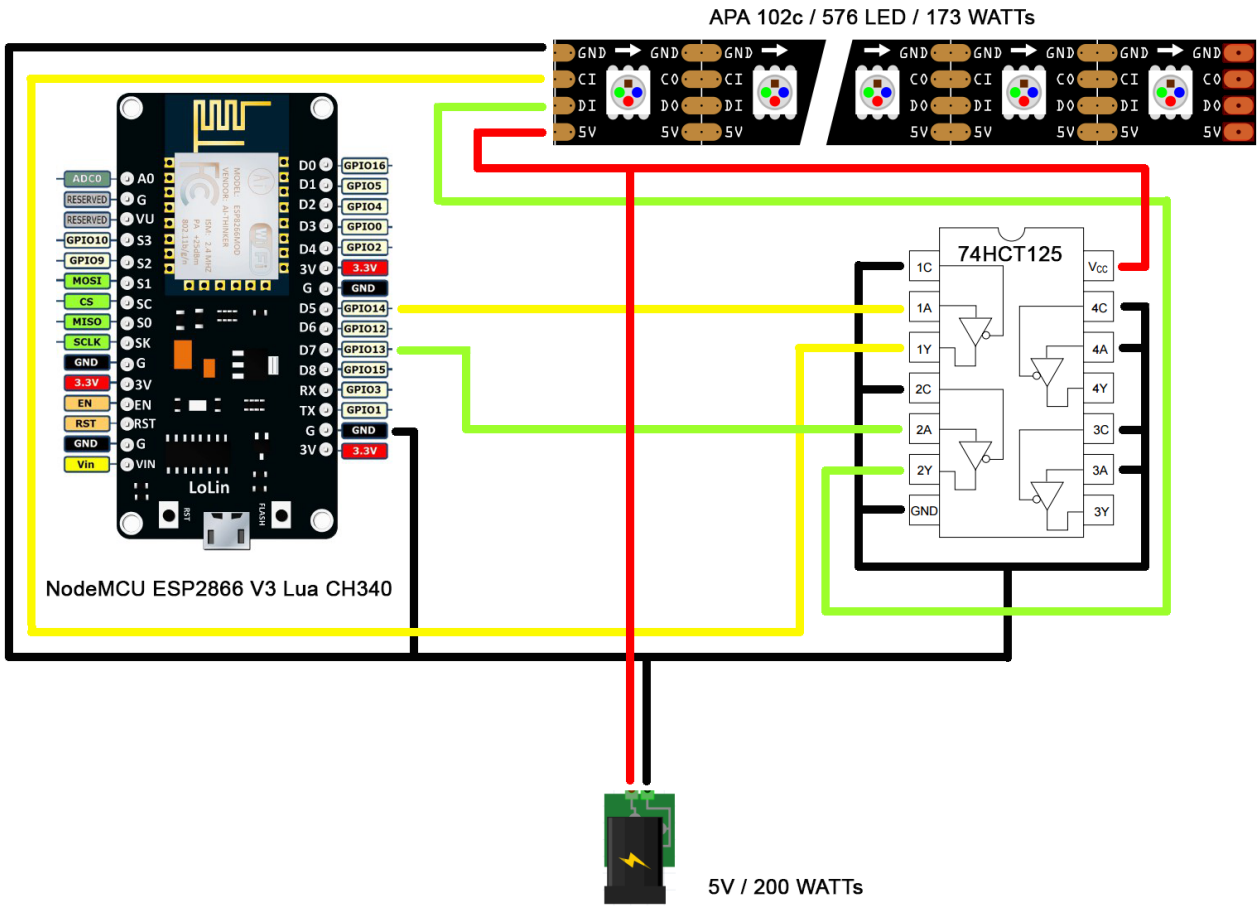
TriState Buffer

Symbol	Truth Table		
	Enable	IN	OUT
	0	0	0
	0	1	1
	1	0	Hi-Z
	1	1	Hi-Z
Read as Output = Input if Enable is **NOT** equal to "1"			

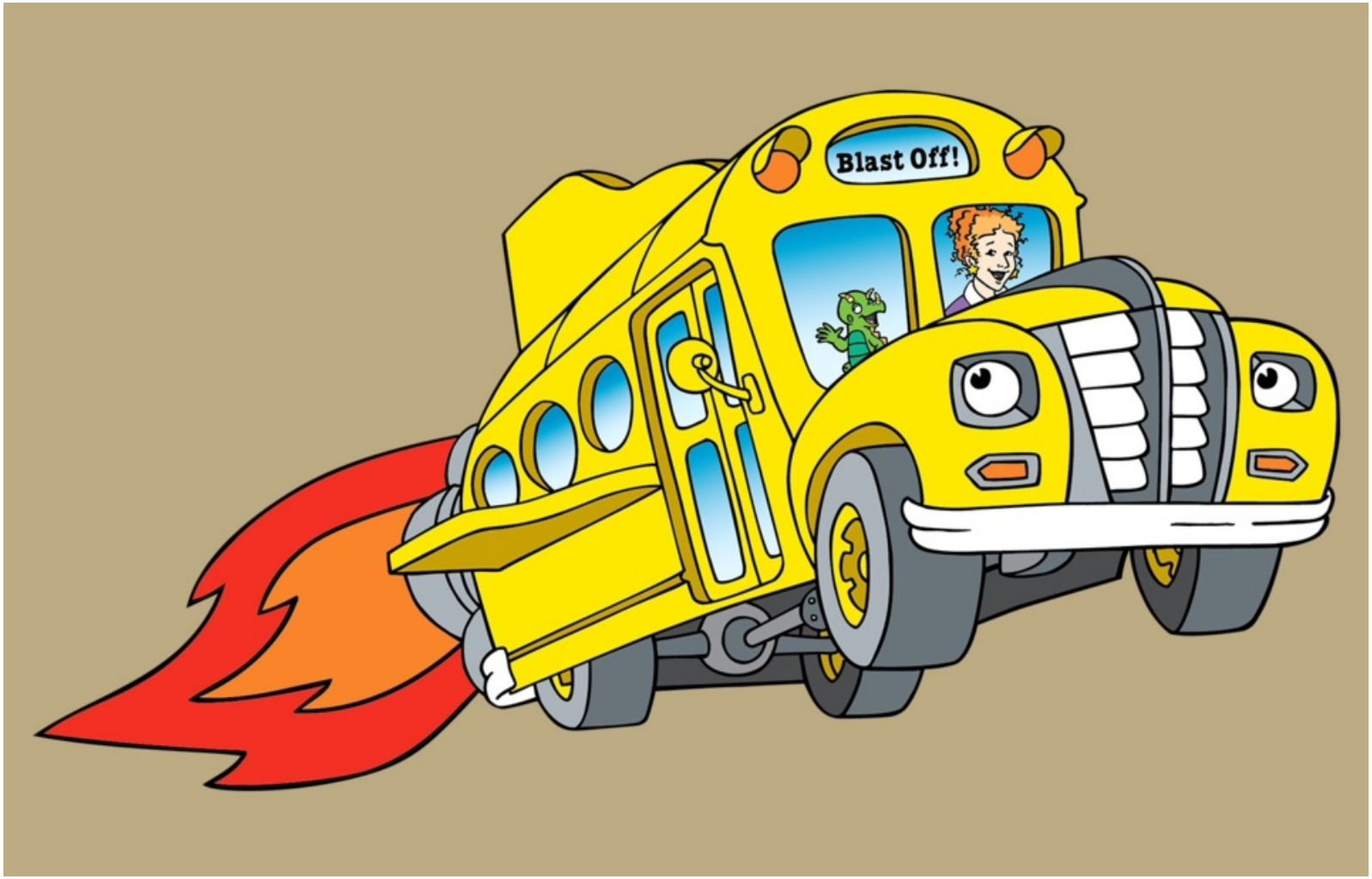
Tri-state Buffer



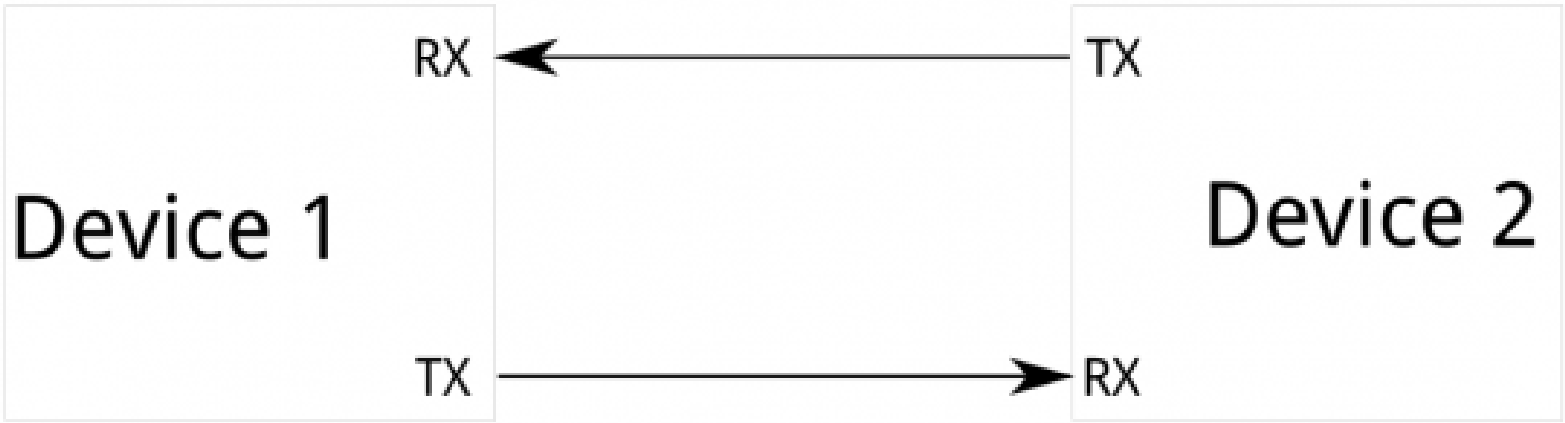
TriState Buffer



Buses and Interfaces

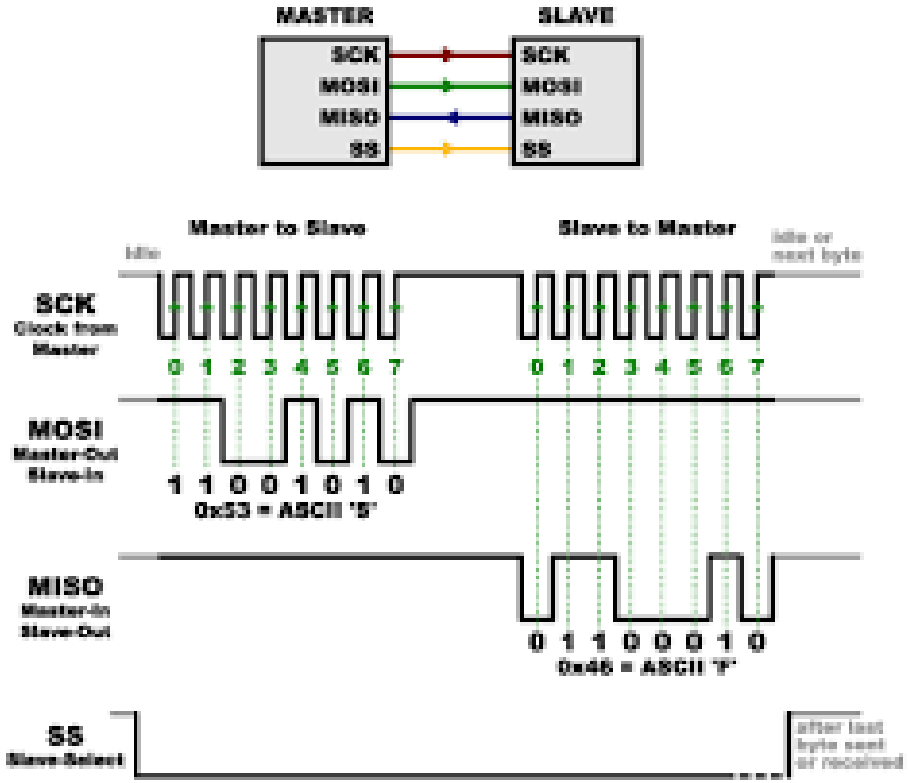


UART

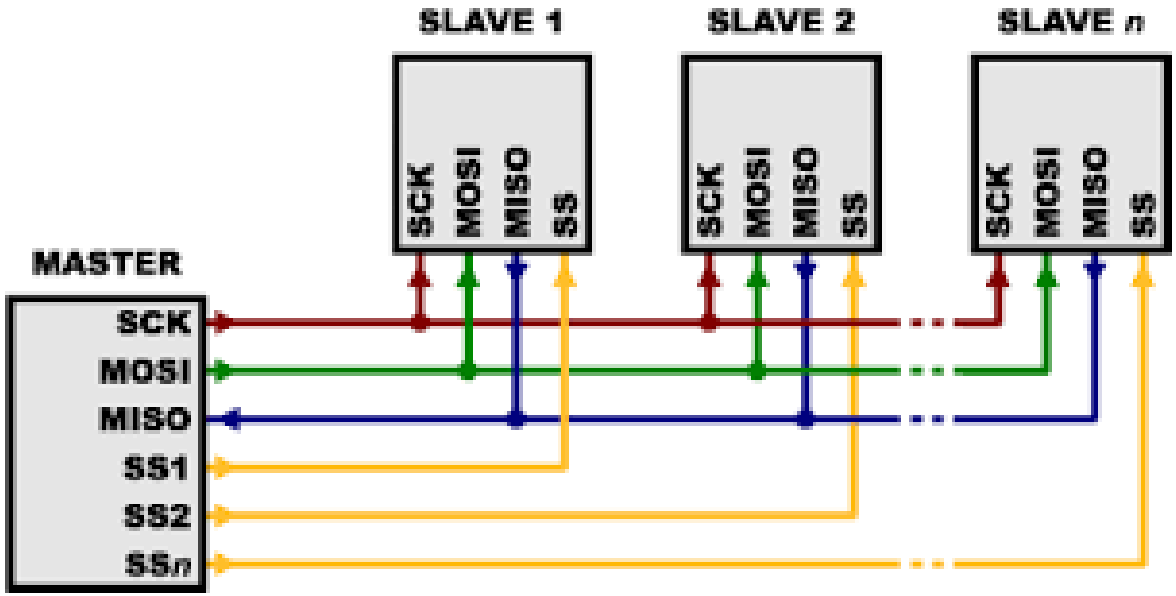


Universal Asynchronous Receiver/Transmitter

Serial Peripheral Interface

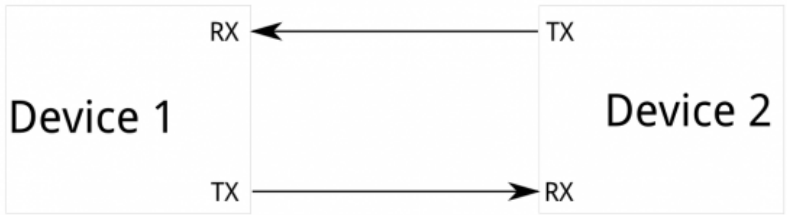


Serial Peripheral Interface

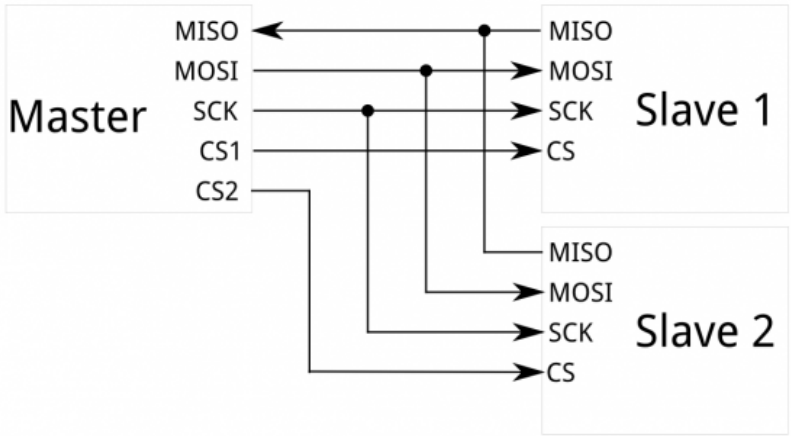


Serial +/−

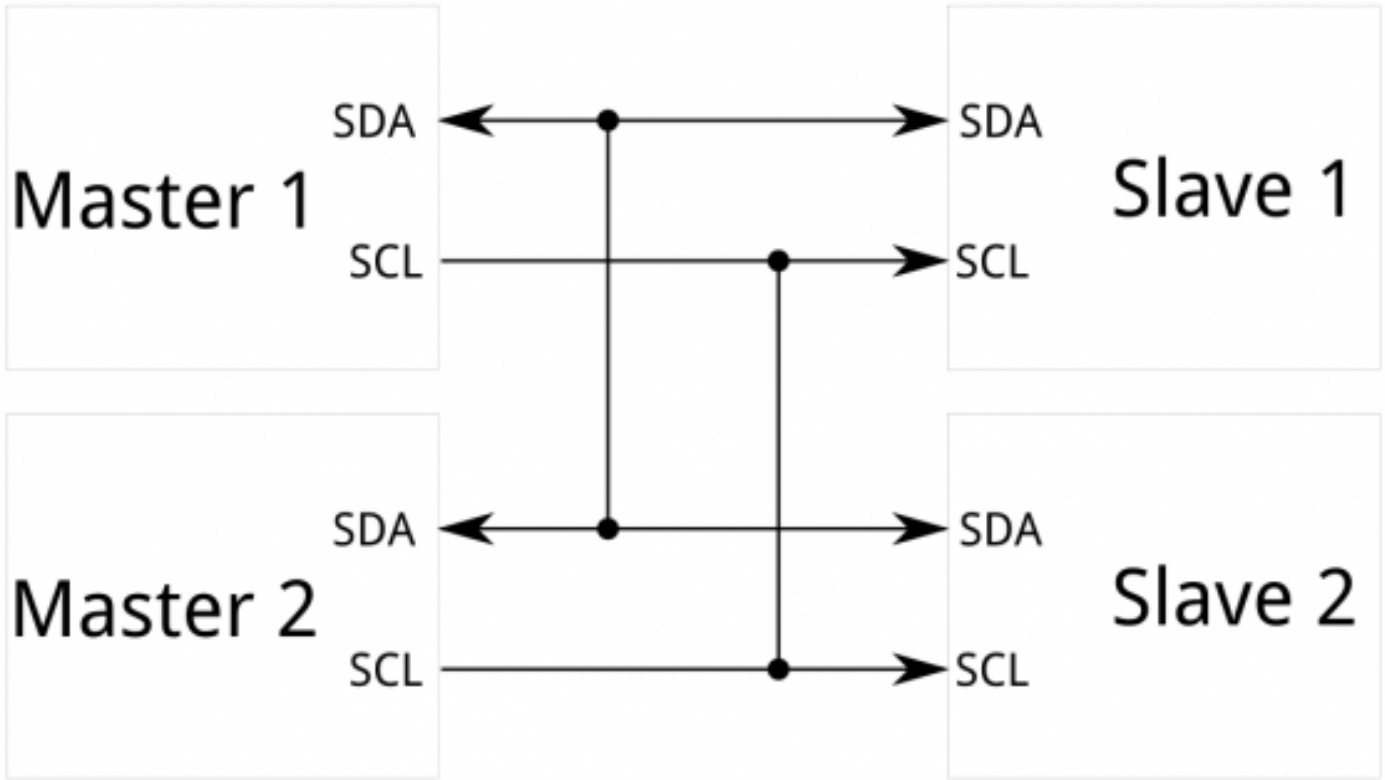
UART



SPI



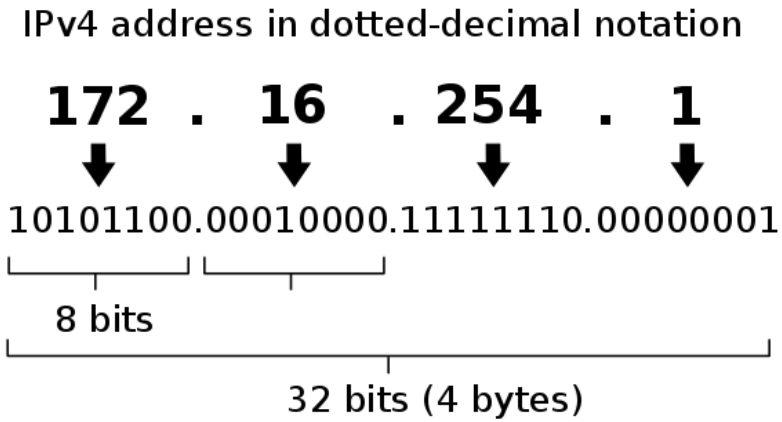
Inter-integrated Circuit (I^2C)



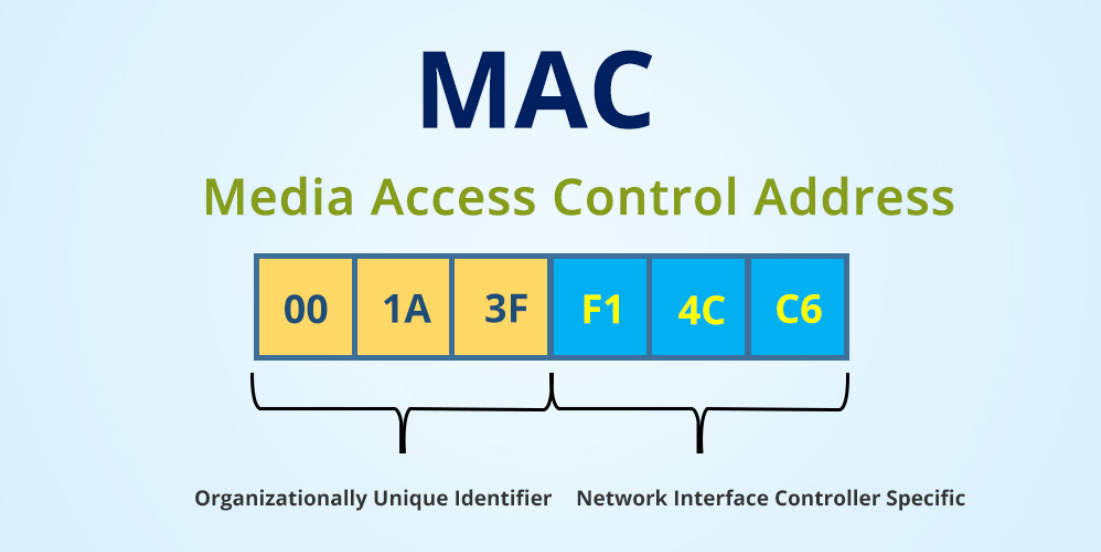
The Internet

IP Addresses

- When a device joins the network it is given an internet address.
  - static or dynamic
- IPv4 (32-bit) - 4.2 billion
- IPv6 (128-bit) - 340 quadrilliard
- In Powershell, try: *ipconfig /all*
- In Terminal (MAC), try: ipconfig getifaddr en0

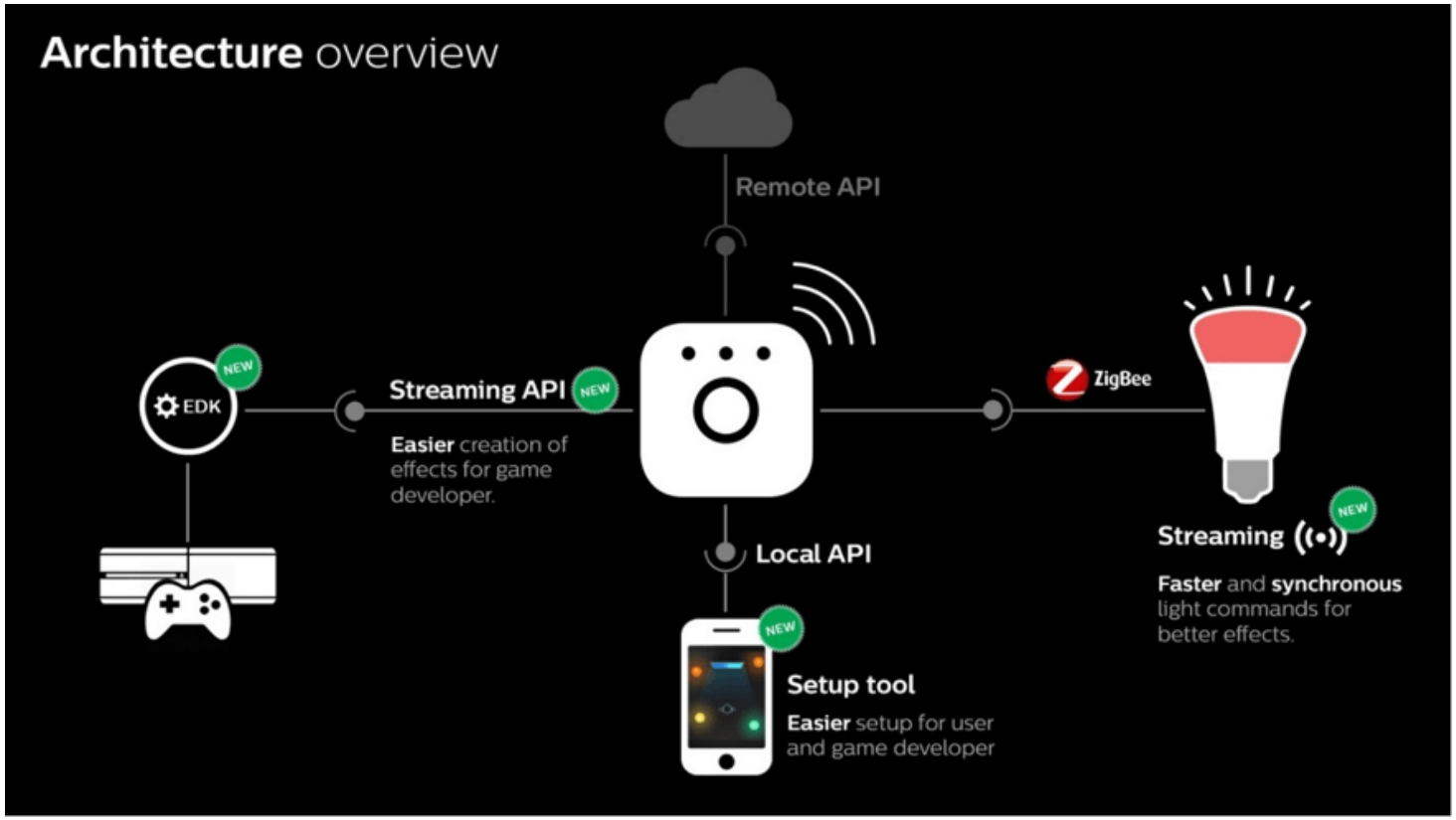


MAC Address



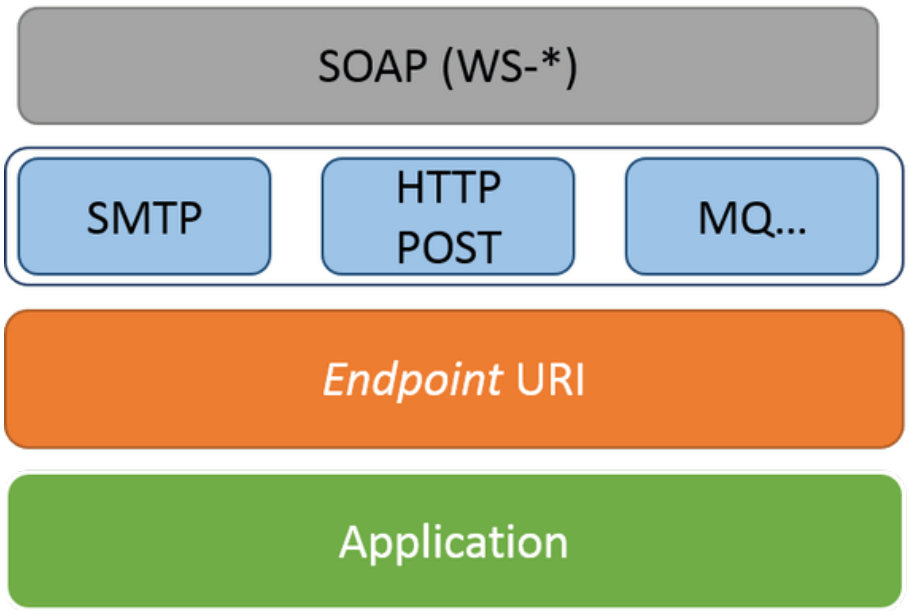
A MAC Address is a unique 6-byte (48-bit) address that is usually permanently burned into a network interface card (NIC) or other physical-layer networking device and that uniquely identifies the device on an Ethernet-based network. The uniqueness of MAC addresses is ensured by the Institute of Electrical and Electronics Engineers (IEEE),

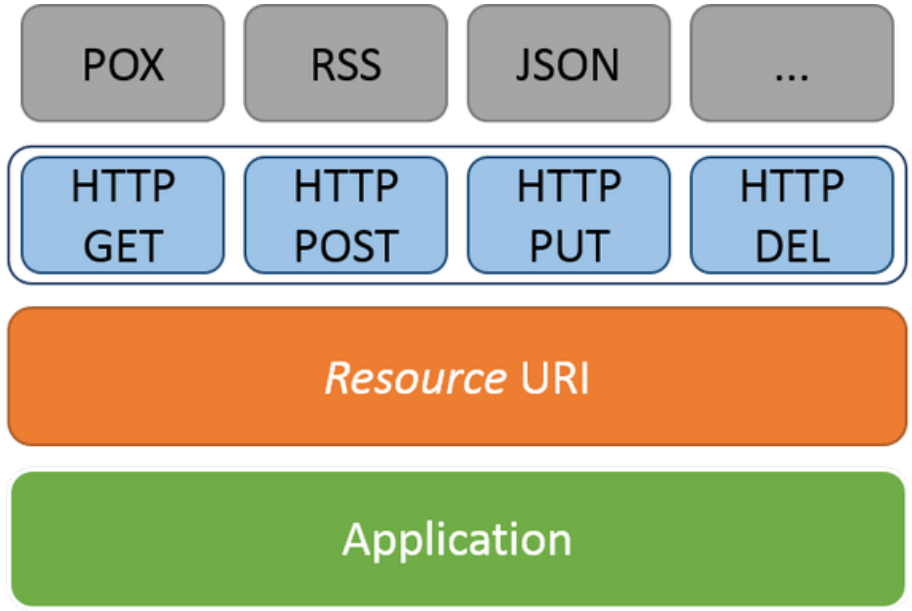
Phillips Hue API



Application Programming Interface: a set of functions and procedures allowing the creation of applications that access the features or data of an operating system, application, or other service.

SOAP vs REST

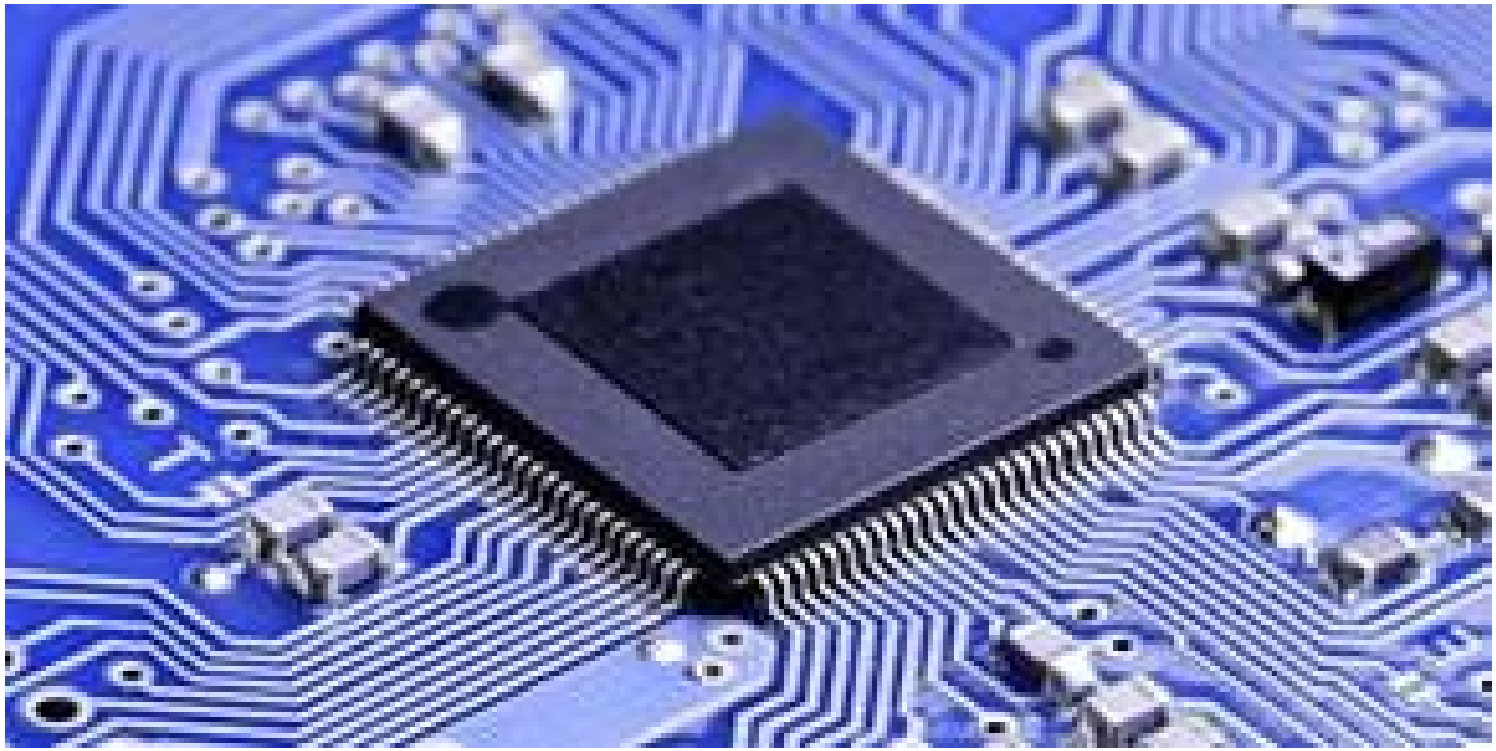

SOAP (WS-*)
SMTP
HTTP POST
MQ...
Endpoint URI
Application
SOAP


POX
RSS
JSON
...
HTTP GET
HTTP POST
HTTP PUT
HTTP DEL
Resource URI
Application
REST

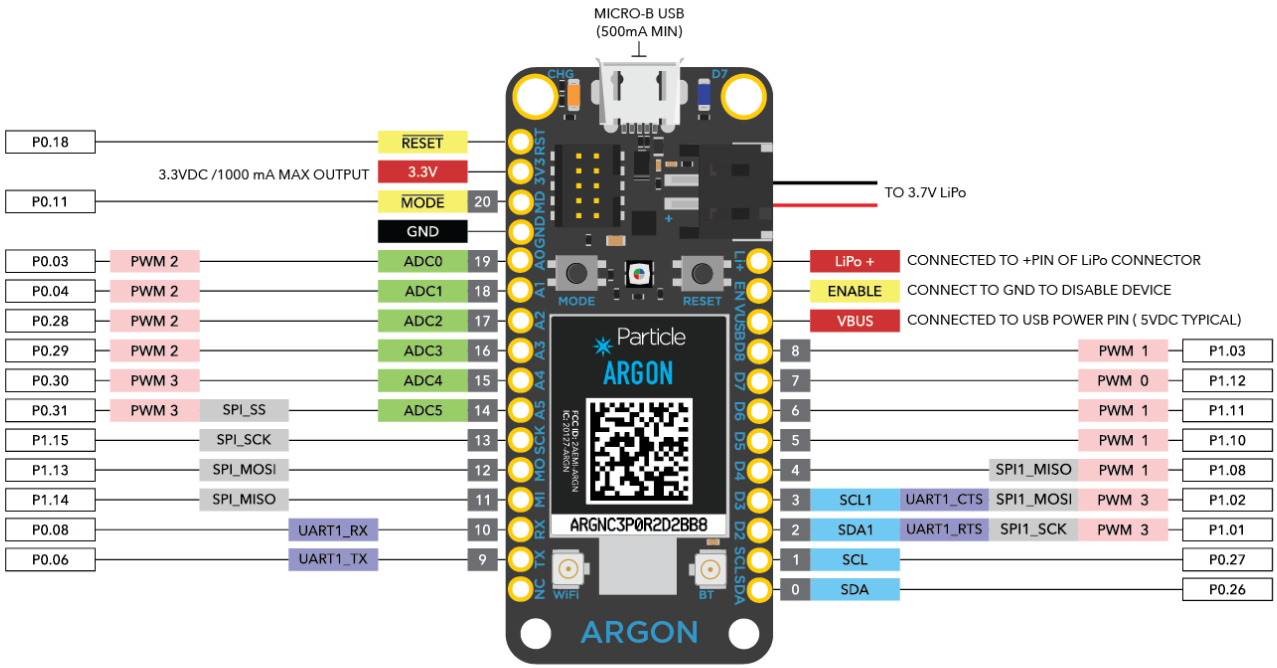
GITHUB Simplified

```
// In Powershell go to ./Documents/<yourname>
// Get a repository that already exists and pull
   it into your local machine
  git clone <URL of repository>

// From the repository directory, get updates
  git pull

// Send your changes up to the repository
  git add .
  git commit -m "<comment>"
  git push

// You may get asked to enter your GIT username
git config --global user.email "you@example.com"
```

Our Second Microcontroller



Particle Argon Pin Layout



v1.0