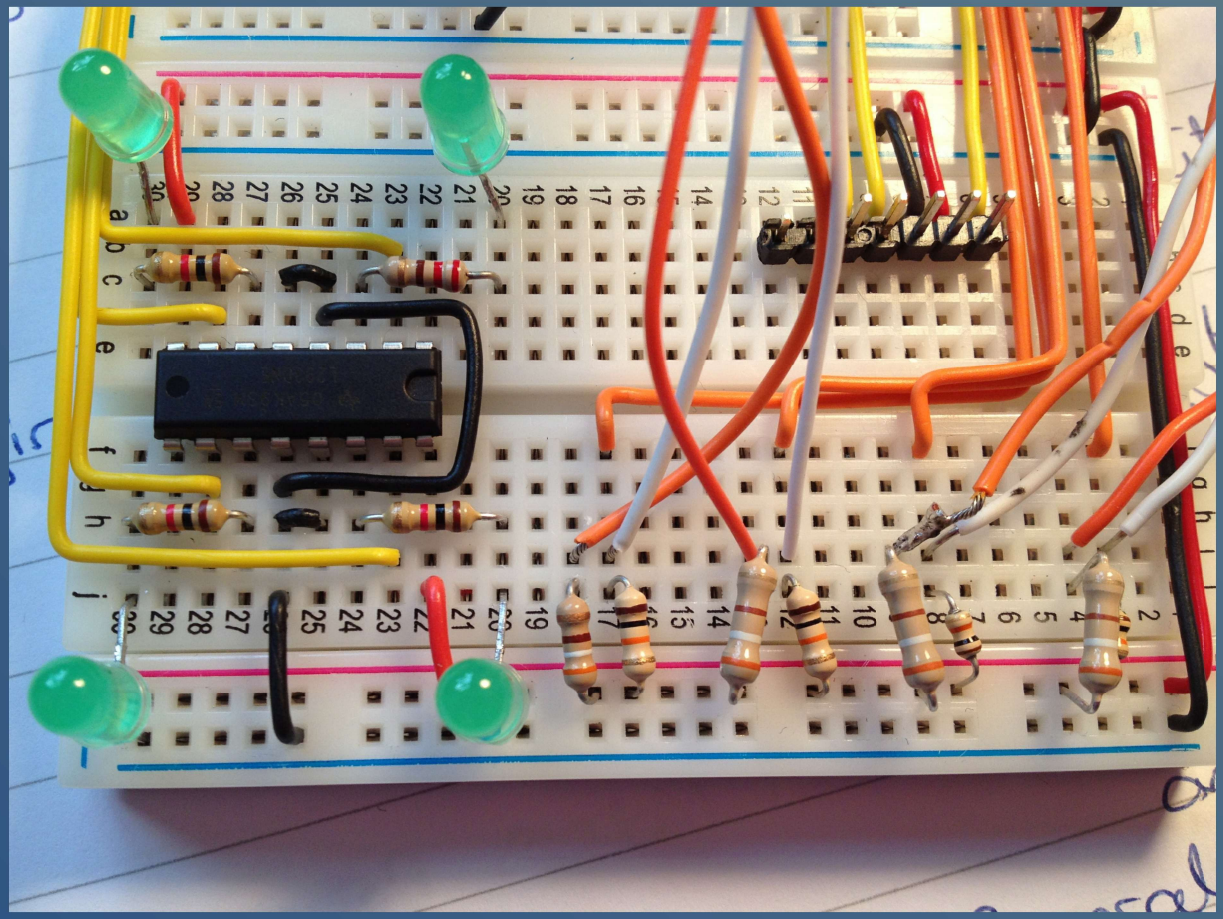
Intro to Electronics

(Greatly abberivated)

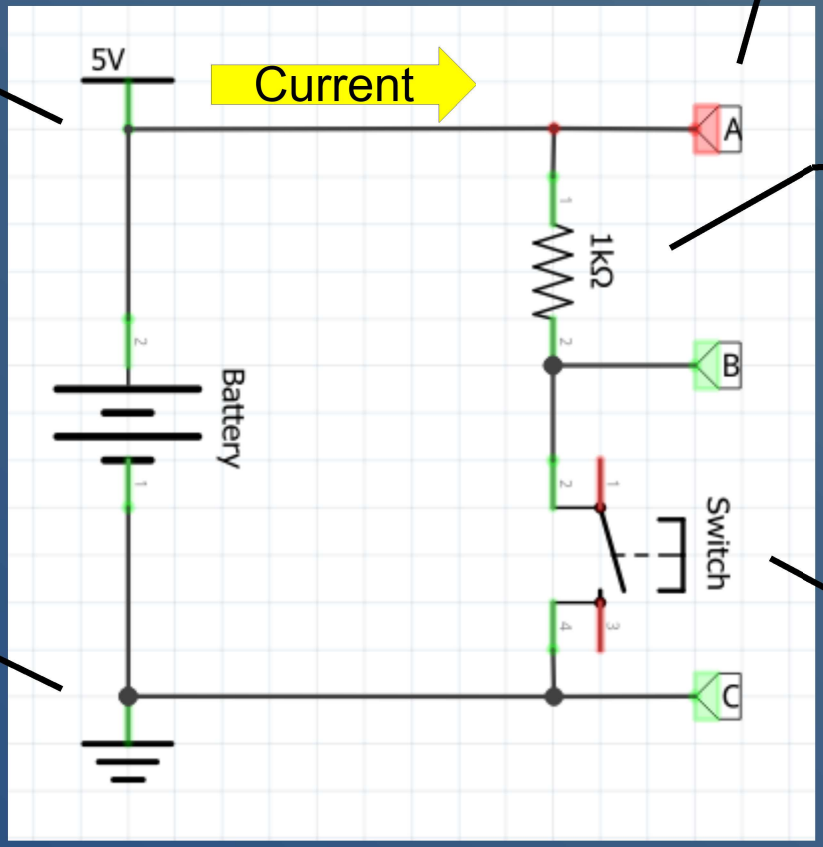


Units

- Mega: 1,000,000
  - Mega-ohms: 1,000,000Ω = 1MΩ
- Kilo: 1,000
  - Kilo-ohms: 1,000Ω = 1kΩ
- Milli: 1/1,000
  - Milliamps: 0.001A = 1 mA
  - Millivolts: 0.100 V = 100 mV
- Micro: 1/1,000,000
  - Microamps: 1A = 1,000,000 µA
  - Microvolts: 1V = 1,000,000 µV

Circuits

Sample Circuit



Power:
VDD or VCC

Ground:
GND or

GPIO connections
to CPU for reading
• Current ~0A in/out of
CPU when reading V

Resistor
• Coloured bands tell ohms
• Not directional

Switch
Open: ∞Ω
Closed: 0Ω

Solving Circuits

- Each components in circuit

  ..

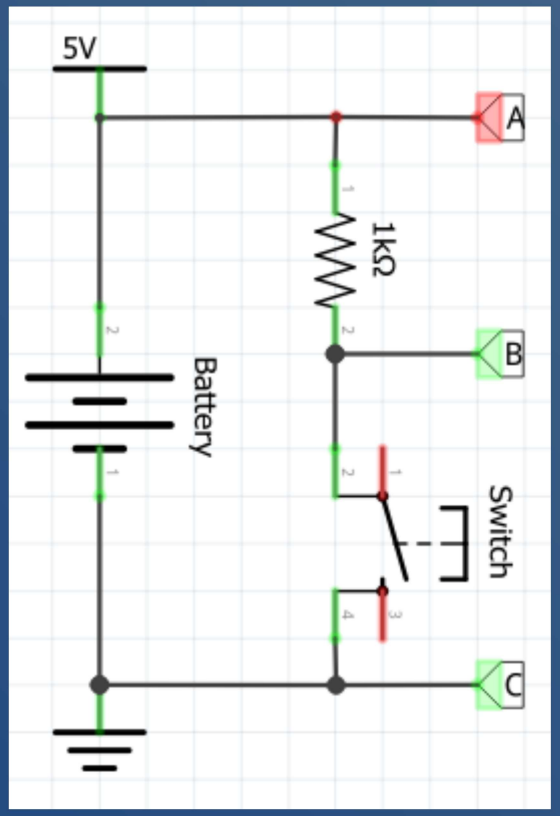
  - Wires assumed to be 0Ω
  - Sum of all voltages lost in circuit =..
  -

- Usual approach to solving a single path circuit

  1. Find the voltage of the source
  2. Find resistance of the circuit
     = sum resistances of each series component
  3. Solve current

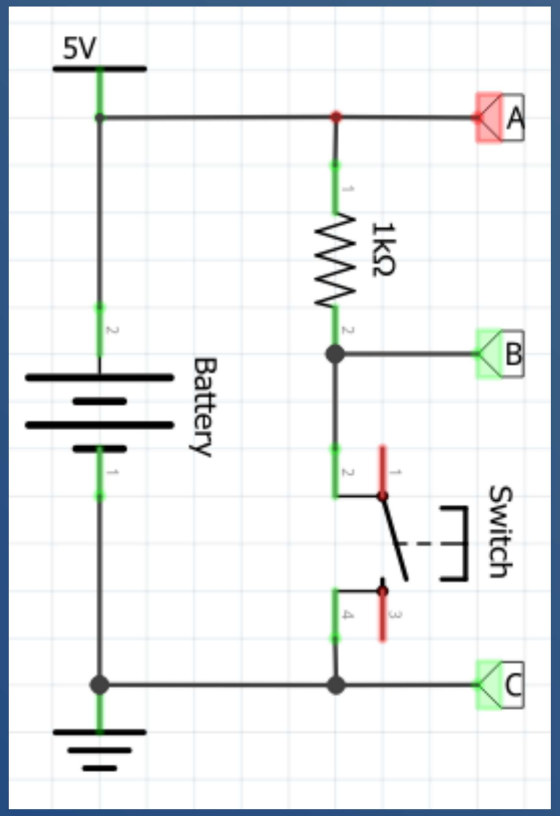
Solving Circuits Examples

- With switch open (not connected), solve:
  - Resistance of circuit
  - Current through switch
  - Current through resistor
  - A’s voltage
  - B’s voltage
  - C’s voltage

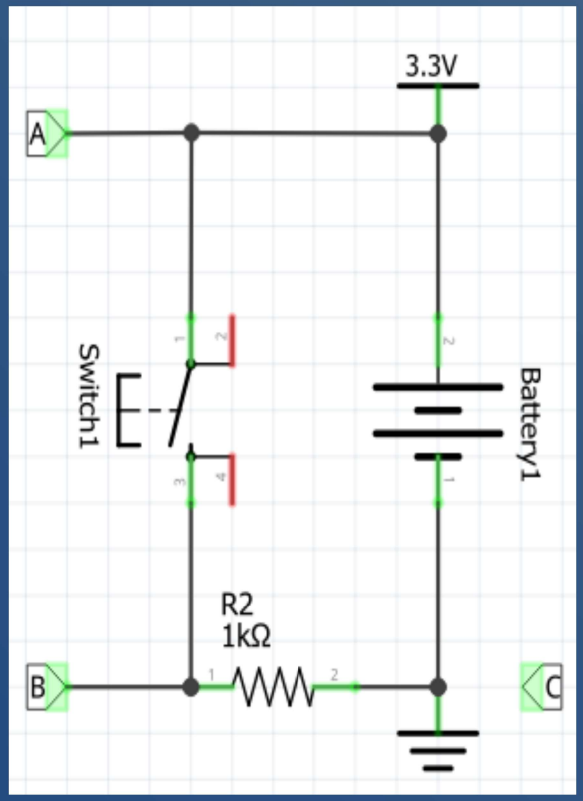


Solving Circuits Examples (cont)

- With switch closed (connected), solve:
  - Resistance of circuit
  - Current (through resistor or switch)
  - A's voltage
  - B's voltage
  - C's voltage

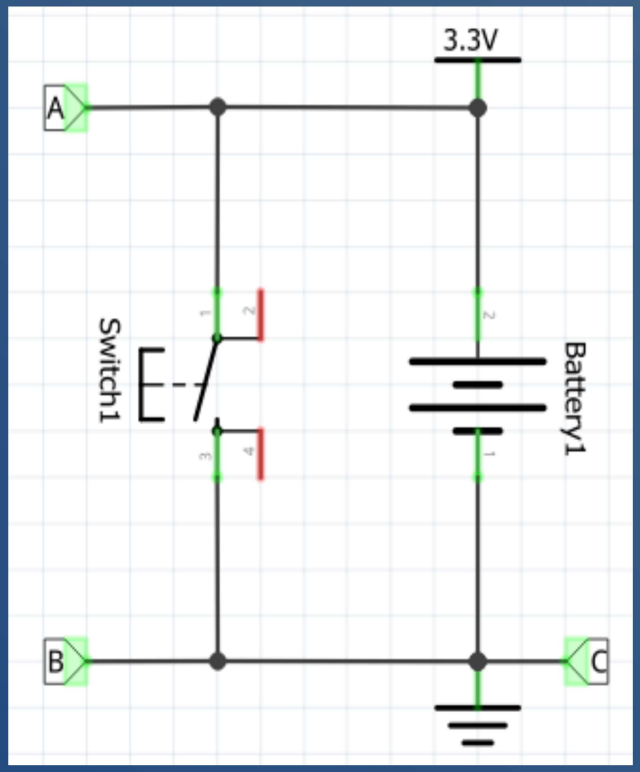


Exercise #1



	Switch Closed	Switch Open
I through Resistor	3.3V / 1k = 3.3mA	0A
I through Switch	3.3mA	0A
V at ‘A’	3.3V	3.3V
V at ‘B’	3.3V 0V + Vr = 0V + Ir * Rr = 0 + 3.3mA *1000 = 3.3V	0V
V at ‘C’	0V	0V

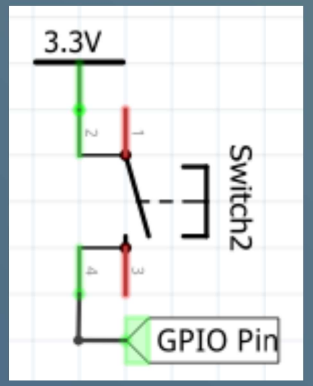
Exercise #2



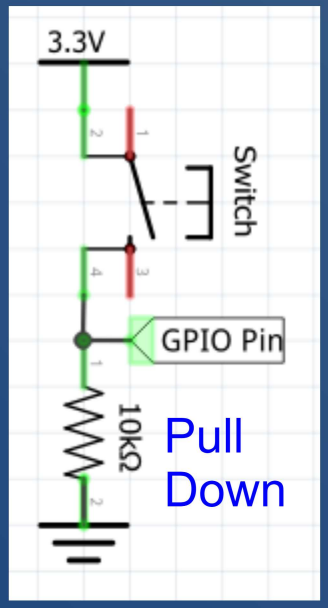
	Switch Closed	Switch Open
I through Switch		
V at ‘A’		
V at ‘B’		
V at ‘C’		

Pull-up / Pull-down

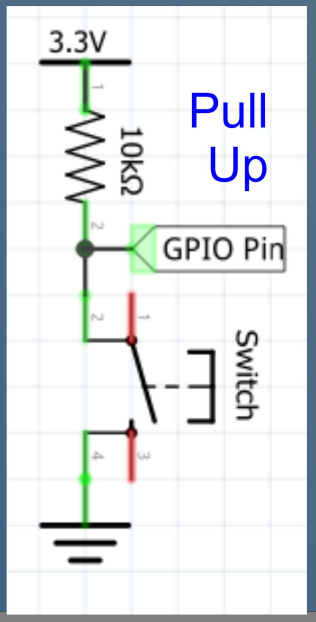
- What does ‘GPIO Pin’ read when:
  - switch closed? ..
  - switch open? ..



- Solution



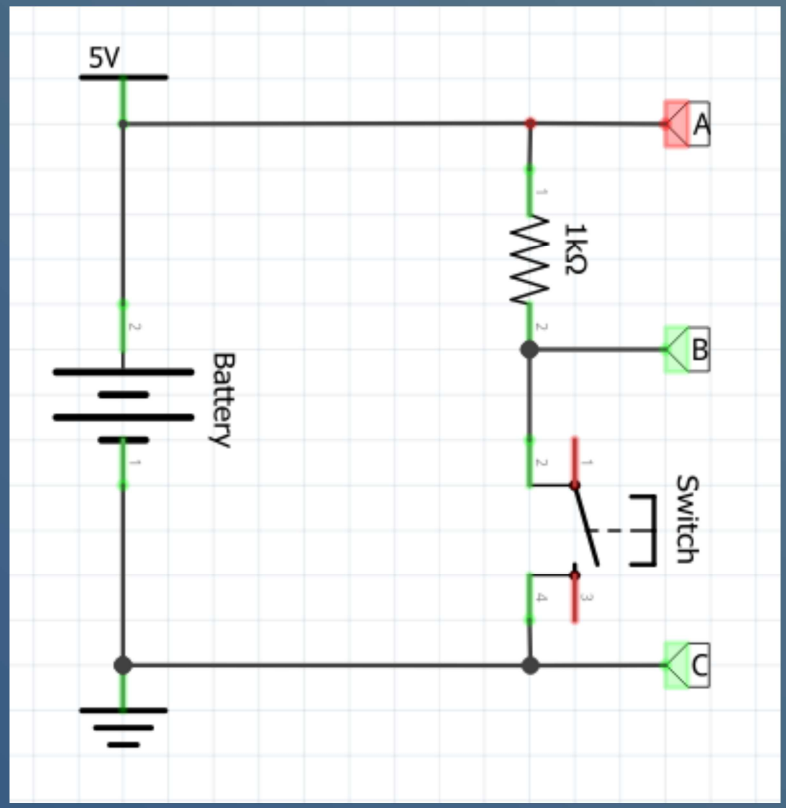
- Pull-down resistor: ..
- Pull-up resistor:
  add large value resistor to 3.3v



ABCD: Button

- Where should we connect the GPIO to read the switch?

a) Read A: 1 when pressed, 0 when open
b) Read A: 0 when pressed, 1 when open
c) Read B: 1 when pressed, 0 when open
d) Read B: 0 when pressed, 1 when open

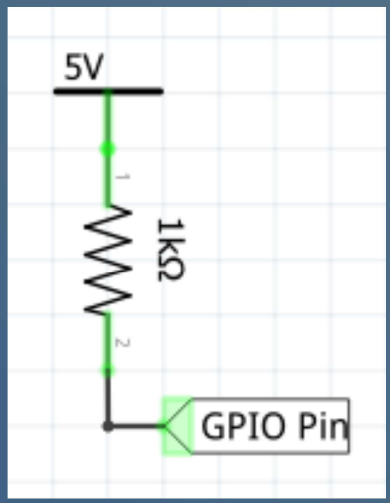


Exercise: Smoke

- If GPIO Pin is an input pin on the BYAI, what does this circuit do?
  - Assume 0A current into input GPIO

..

..



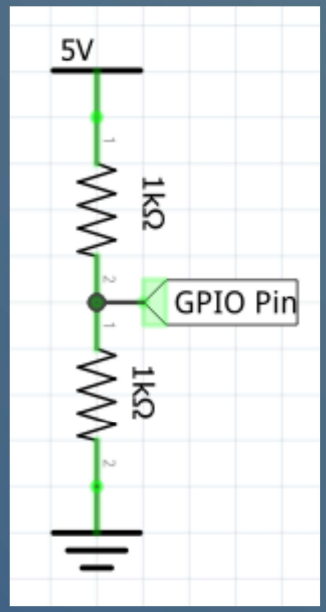
Exercise: Divider

- What does GPIO Pin read?

  ..

  ..

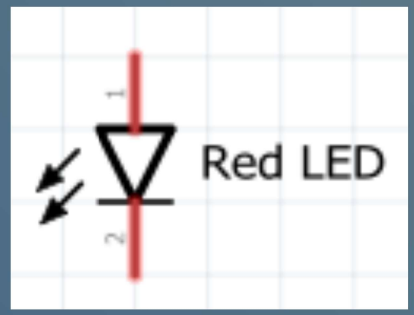
  Intuition: ..



LEDs and Breadboards

LED

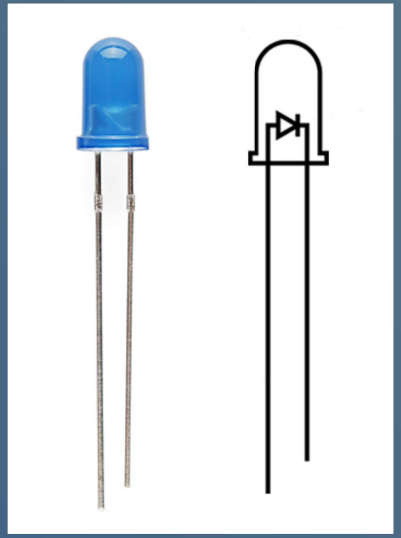
- LED = Light Emitting Diode
  - LEDs require a current to turn on: the more current, the bright.
  - Too much current: damage it.

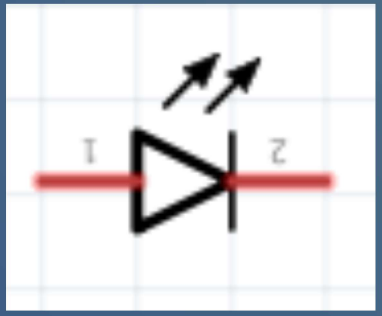


- Details
  - Diodes only allow current to flow one way: in direction of arrow.
  - Don’t wire an LED in backwards.
  - We’ll treat LEDs as a current device, not affecting V (LEDs have a voltage drop across them of ~2V)

LED wiring

- LEDs must be wired in correct direction to turn on
  - Longer lead (wire) is + side (Anode)
  - Shorter lead (wire) is – side (Cathode)
- In reverse, they block all current
  until voltage exceeds their maximum reverse voltage, at which point the LED could be damaged.

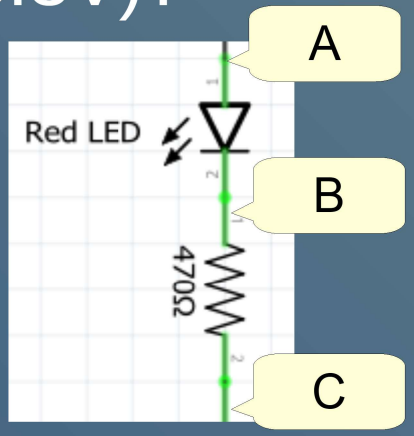




ABCD: LEDs

- What should be connected to make the LED turn on when the GPIO pin is a **1** (3.3V)?

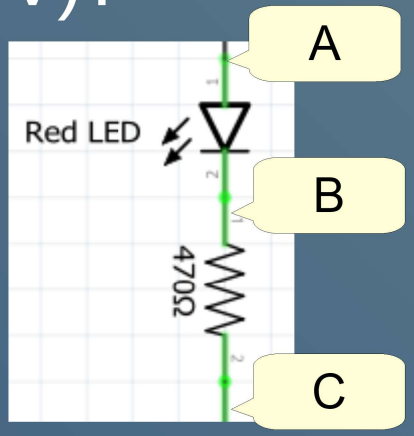
a) GPIO to A, GND to C
b) GND to A, GPIO to C
c) 3.3V to A, GND to C
d) GPIO to A, GND to B



ABCD: LEDs

- What should be connected to make the LED turn on when the GPIO pin is a **0** (0V)?

a) GPIO to A, GND to C
b) GND to A, GPIO to C
c) 3.3V to A, GND to C
d) GPIO to A, GND to B



3.3V at A
GPIO at C

Review Questions

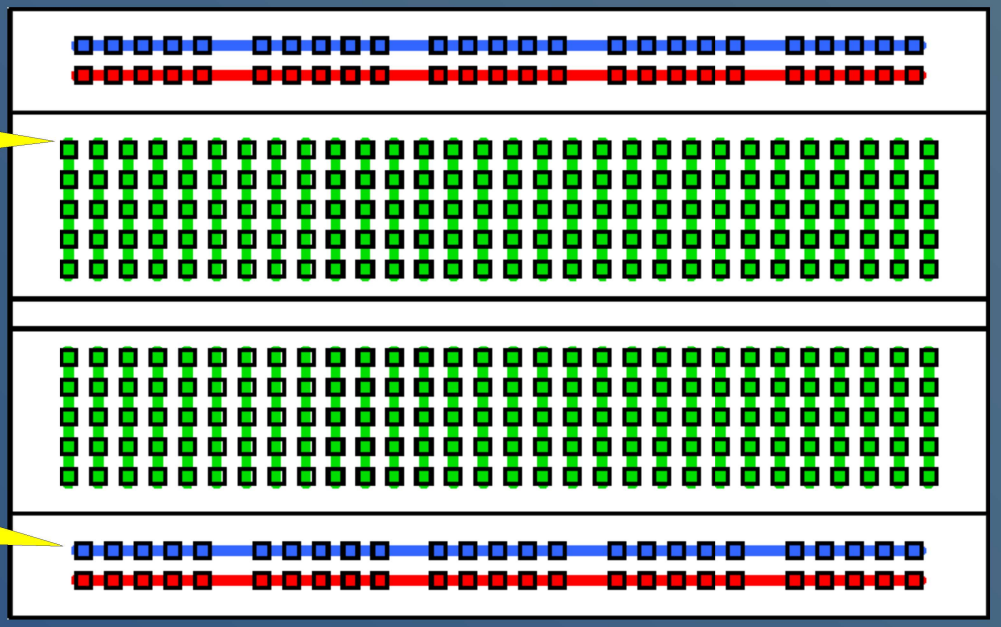
- Suggested circuit drawing questions
  (try on your own time)
  - Draw a circuit which turns on an LED when you press a button.
  - Draw a circuit which turns on an LED when you set a GPIO pin to high.
  - Draw a circuit which turns on an LED when you set a GPIO pin to low.

Breadboard

- Breadboard used to wire circuits without soldering
  - + and - bars on both top and bottom
  - Columns of 5 slots all connected.
  - Columns on top half not connected to columns on bottom half.

All 5 slots in this column are connected.

All 25 slots in this bar are connected. (not connected to top one)



Reading Button

```
brian@BeagleBone:~$ gpiofind GPIO4
gpiochip1 38
brian@BeagleBone:~$ gpioget gpiochip1 38
0
brian@BeagleBone:~$ gpioget gpiochip1 38
1
```

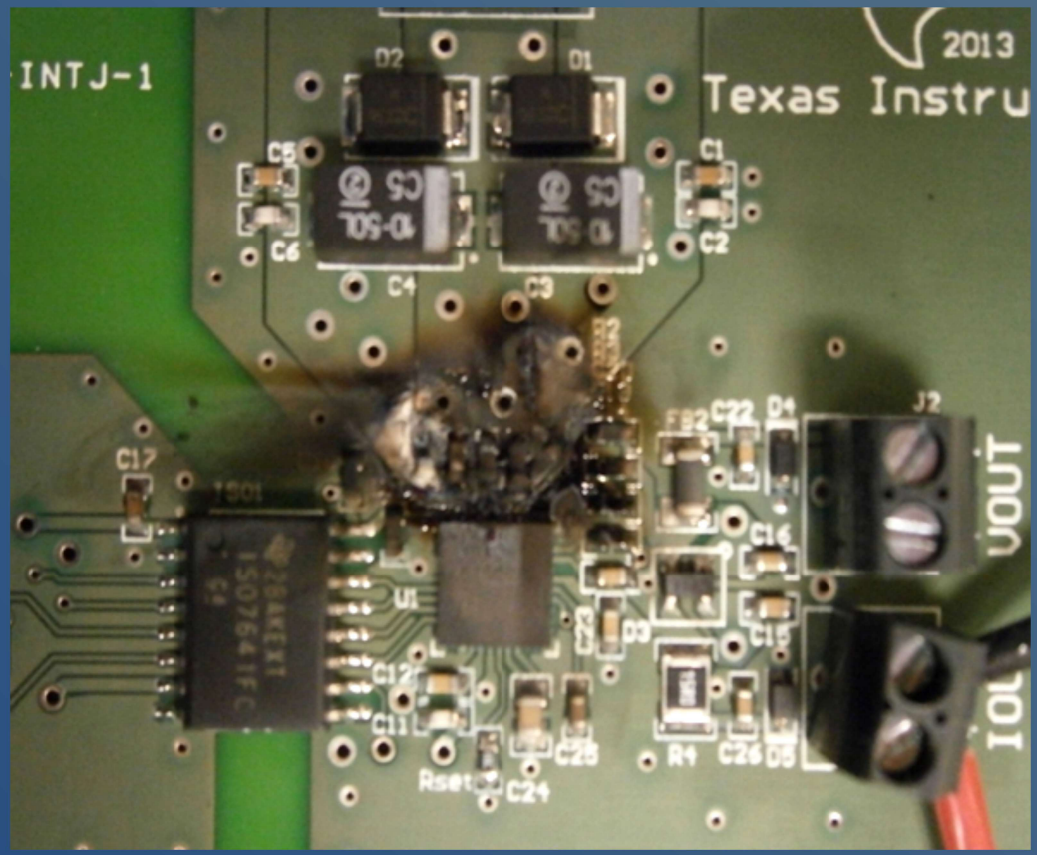
Not pressed

Pressed

Power

- GPIO pins give +3.3V
  - Can source 9mA (as “Output” at 3.3V = on)
  - Can sink 5mA (as “Output” at 0V = off; current in)
- USB gives +5V
  - VDD_IN_5V is powered from USB directly
  - Note: You likely want to use the +3.3V pins for most things instead of the +5V

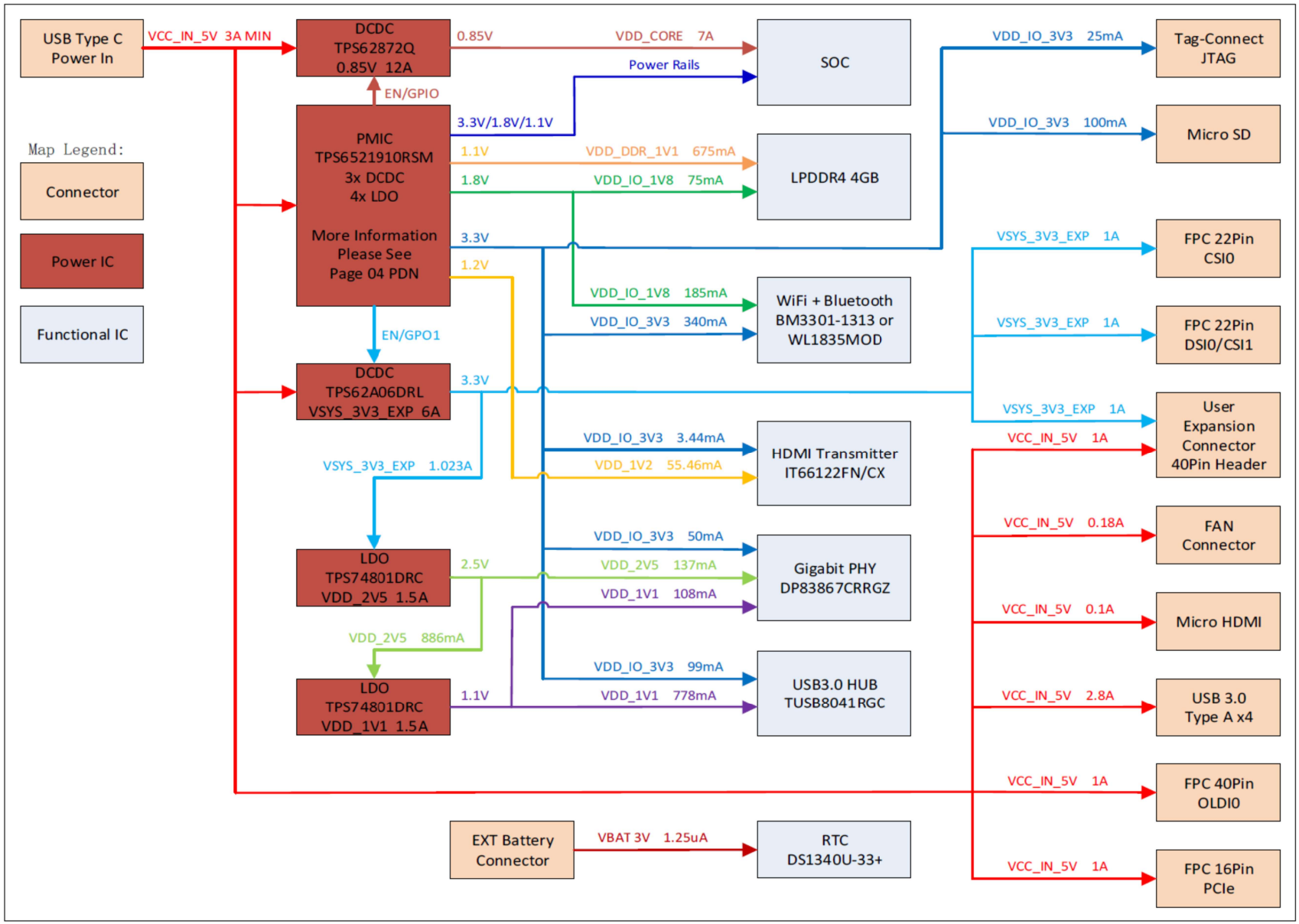
How to damage your board



How to fry your BeagleY-AI

- Draw too much current on header
  - total current from 3.3V >= 1000 mA
    total current from 5.0V >= 1000 mA
  - short circuit to ground anything with power
    (damage voltage regulator)
- Over-current GPIO pins
  - Can source 9mA (current out of pin when output at 3.3V)
  - Can sink 5mA (current into pin when output at 0V)
- Apply too much voltage to CPU pin
  - GPIO [tollerates 0v - 3.3v]
  - A2D [tollerates -0.3v - 3.6v]
- BeagleY-AI USB-C
  - Can use (draw) up to 3A from USB-C to power board.

POWER FLOW DIAGRAM



seeed studio https://www.seeedstudio.com

Title: BeagleY-AI

Size: C | Document Number: 03 POWER FLOW DIAGRAM | Rev: A

Other Systems

- Raspberry Pi
  - may tolerate higher voltages if current is low; not so with BYAI
  - Don't let GPIO go > 3.3V, even at low current
- Arduinos run at 5V
  - Many Arduino peripherals need level shifters to work with BYAI's 3.3V GPIO
- 12V Fans
  - It's 12V! Be careful! Use a relay to turn on/off
- Motors
  - Need a motor driver chip to turn drive the motor

Tips

1) Draw out your circuit on paper before wiring it.
2) Wire your circuit with the power off.
3) Double check wiring before powering on!
   - Not as easy as “recompile” to fix HW errors.
4) If it does not work, don’t just try things till it works.

Summary

- Ohm's Law: `V = I * R`
  - Solve a circuit by finding resistance across a voltage to solve the current.
- Components
  - Switches: Open or closed
  - LED: current turns on
  - Resistor
- Be mindful of HW limits:
  don't fry your board!