

Final Projects

Form teams this week (2-3 people best)

Project proposal ideas and hints

<https://cs107e.github.io/assignments/project/>

\$20 parts budget per person; need to submit receipts

Fill out form with teammates (due midnight Thursday Nov. 15th)

Discuss scope and feasibility with staff and teammates in lab

Submit proposal (due midnight Thursday Nov 29th)

Have progress to show the following week during lab

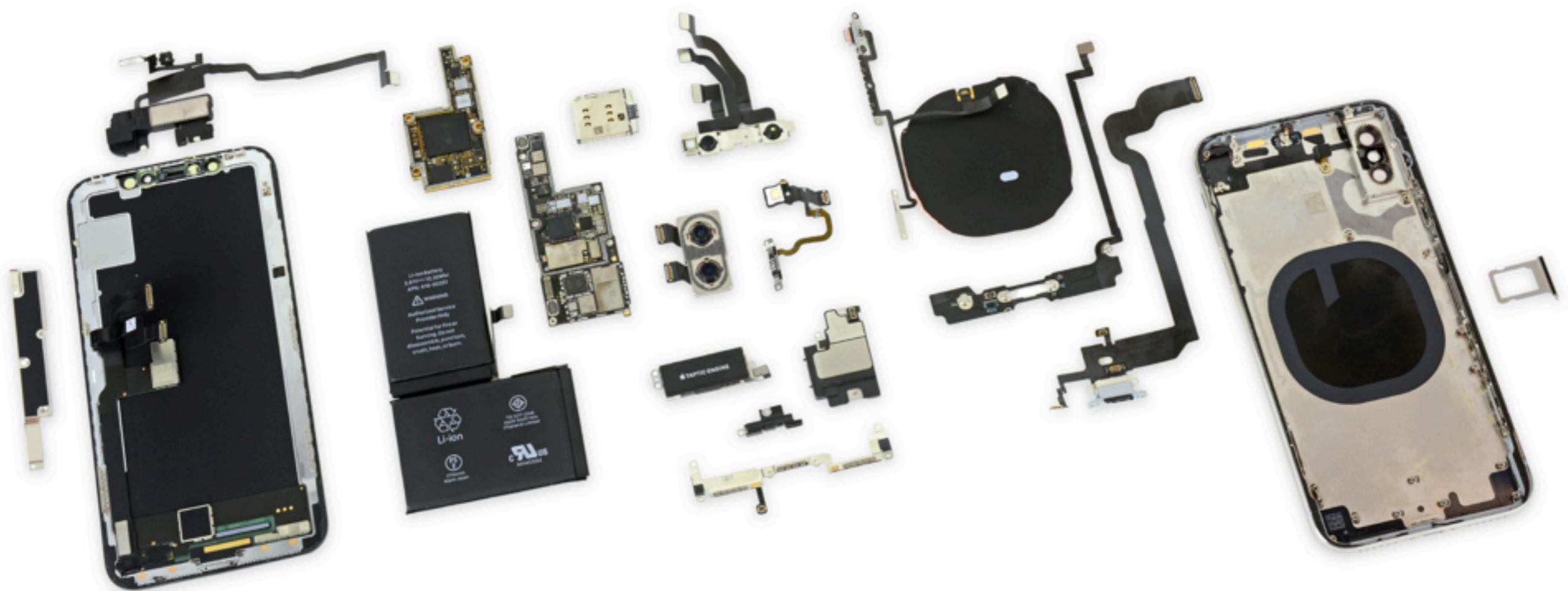
Class demos (8:30-11:30 am Friday, Nov 14th)

Final code and writeup submission (due 8:30am, Nov 14th)

CS107e

Sensors, etc.

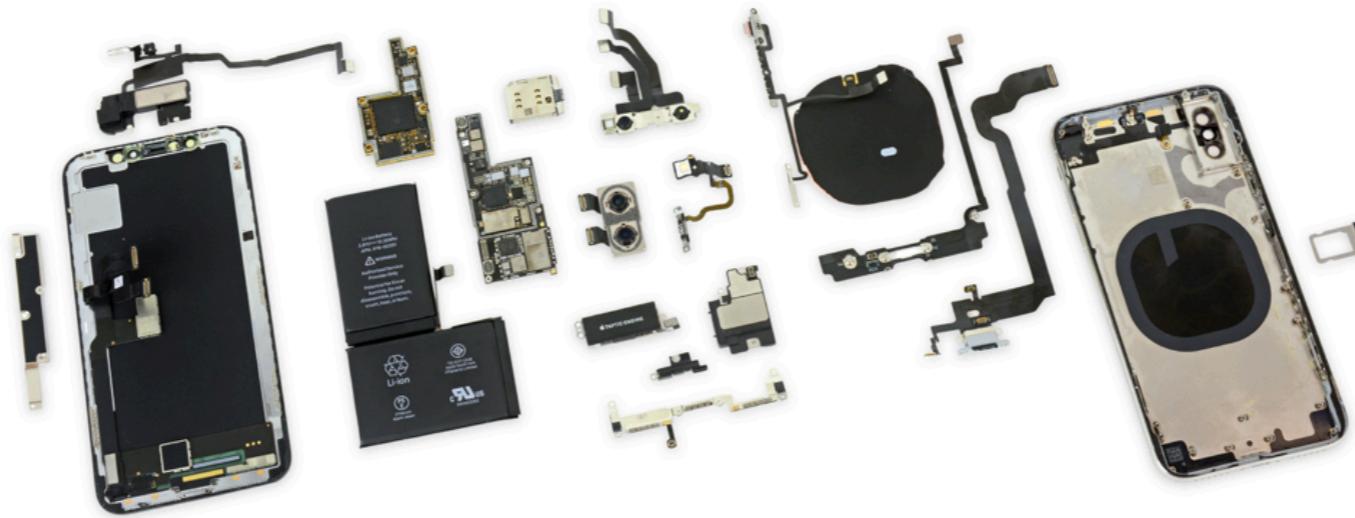
iPhoneX teardown



How many sensors?



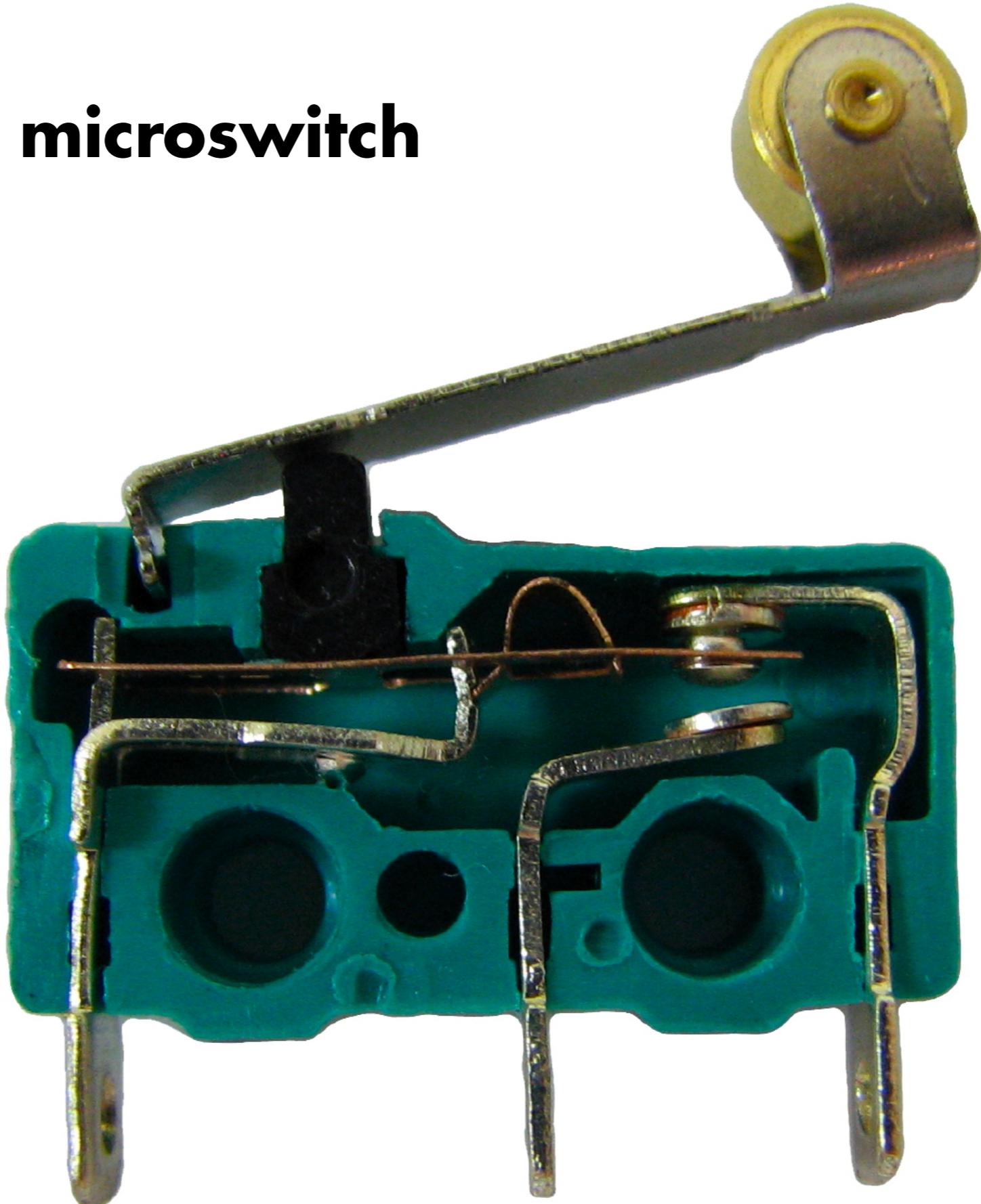
iPhoneX teardown



How many sensors? At least 10

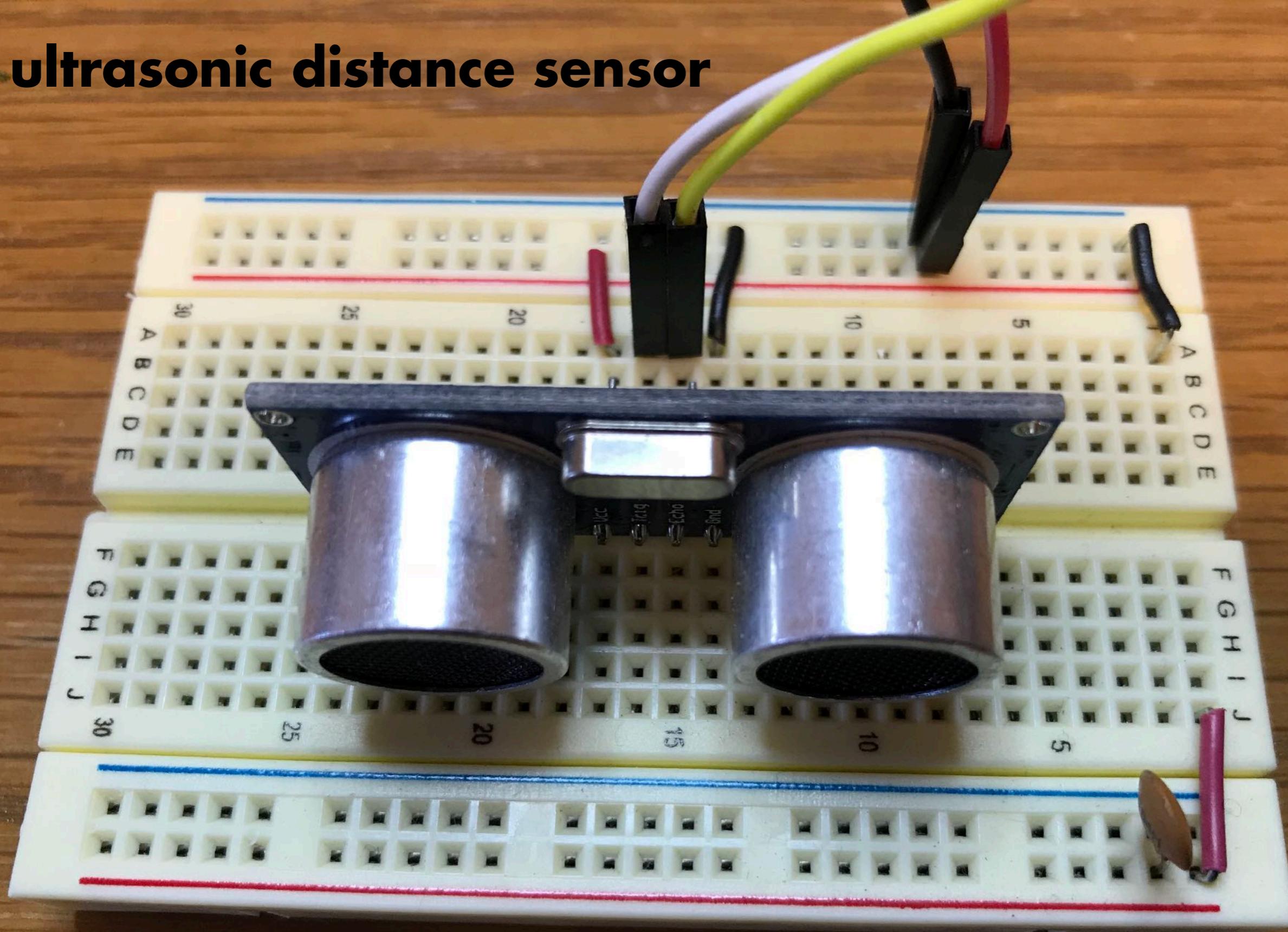
Proximity sensor
Ambient light sensor
Visible Light Camera
Infrared Camera (for face recognition)
Accelerometer
Gyroscope
Compass (Magnetometer)
Barometer
NFC for Apple Pay
Touch ID fingerprint scanner
Pressure sensitive display

snap-action microswitch

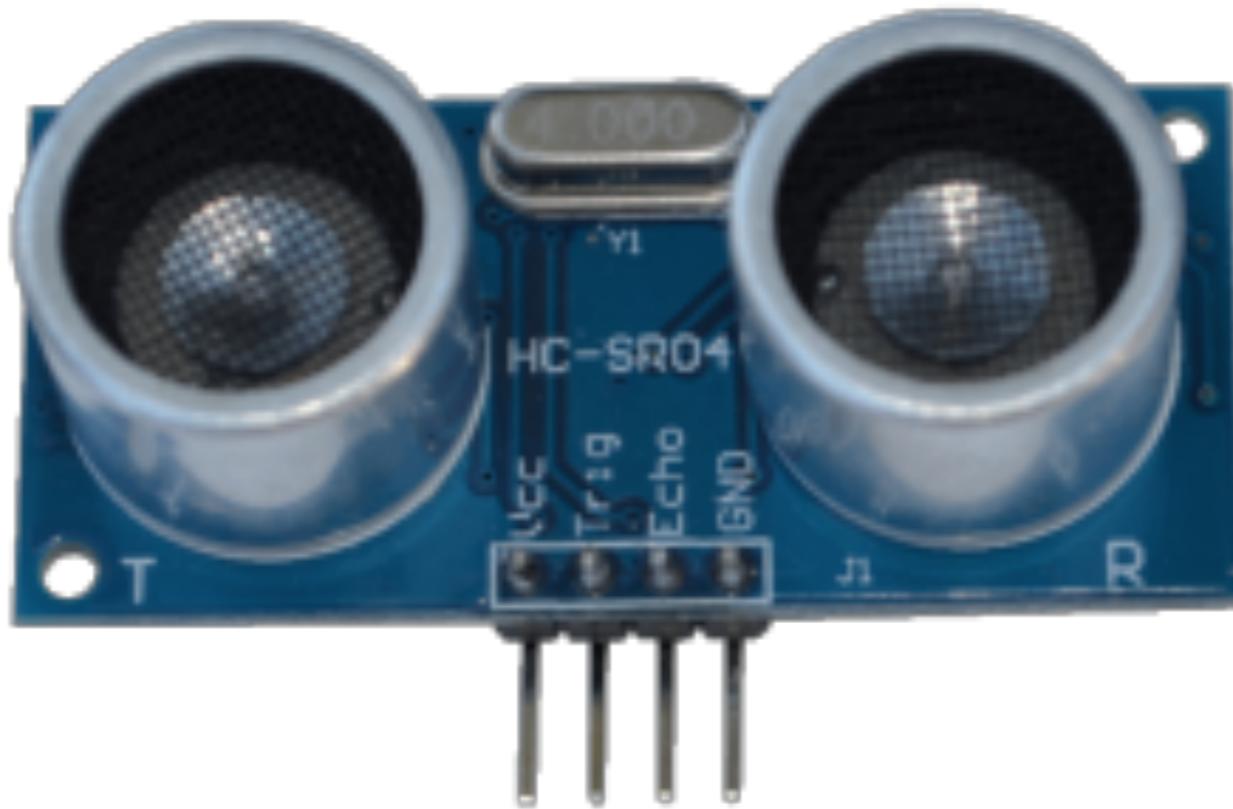


https://en.wikipedia.org/wiki/Miniature_snap-action_switch

ultrasonic distance sensor



ultrasonic distance sensor



How do we figure out how to use it?

ultrasonic distance sensor

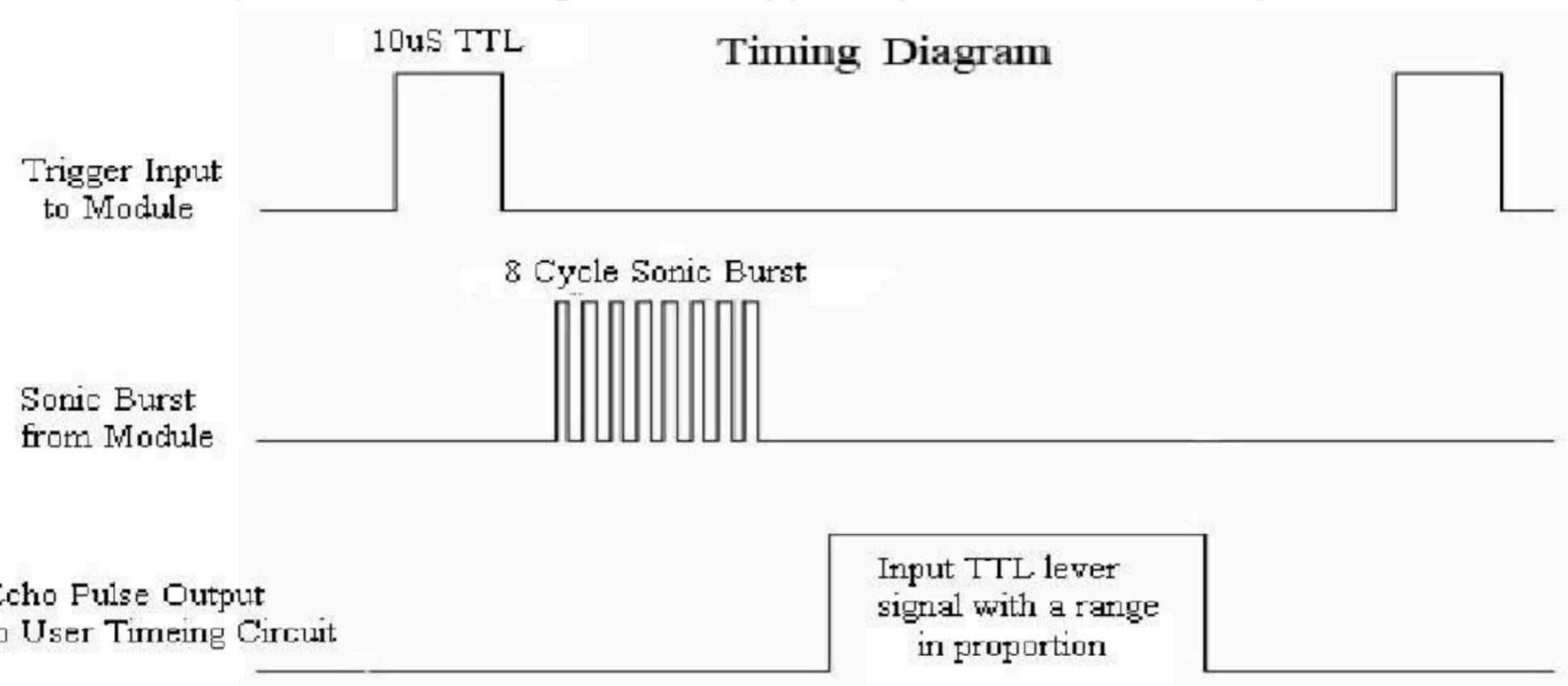


How do we figure out how to use it?

We find the part number (often written on the part), and we read the data sheet!

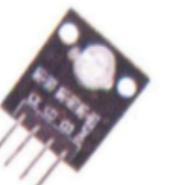
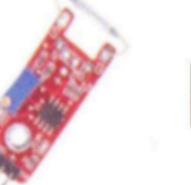
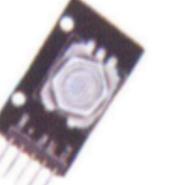
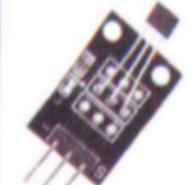
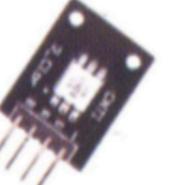
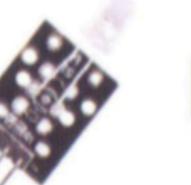
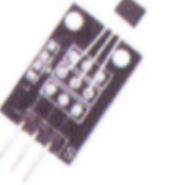
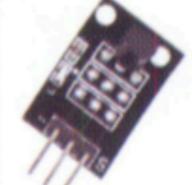
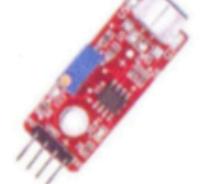
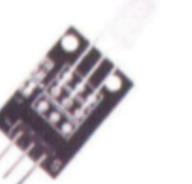
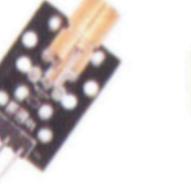
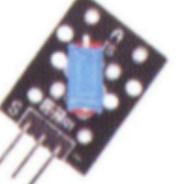
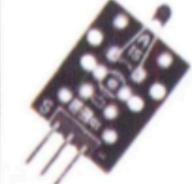
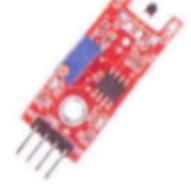
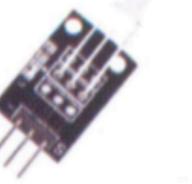
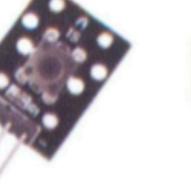
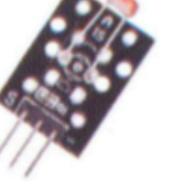
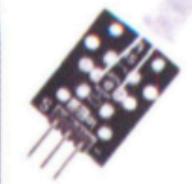
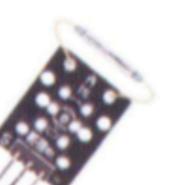
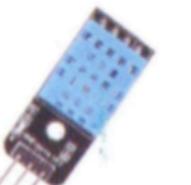
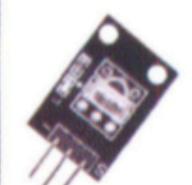
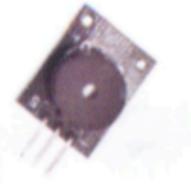
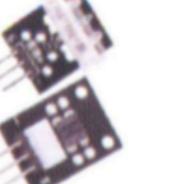
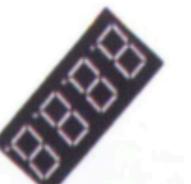
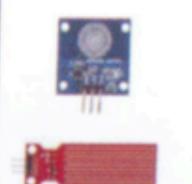


The Timing diagram is shown below. You only need to supply a short 10uS pulse to the trigger input to start the ranging, and then the module will send out an 8 cycle burst of ultrasound at 40 kHz and raise its echo. The Echo is a distance object that is pulse width and the range in proportion .You can calculate the range through the time interval between sending trigger signal and receiving echo signal. Formula: $uS / 58 = \text{centimeters}$ or $uS / 148 = \text{inch}$; or: the range = high level time * velocity (340M/S) / 2; we suggest to use over 60ms measurement cycle, in order to prevent trigger signal to the echo signal.



What other sensors are available?

sensor kit

joystick



How do we figure out how to use it?

We find the part number (often written on the part), and we read the data sheet!

joystick



How do we figure out how to use it?

We find the part number (often written on the part), and we read the data sheet!

**Uh-oh. This part doesn't have a number.
So...we Google the pins.**

joystick



Specifications

	Joystick Module
Switch Protocol	Digital
X,Y Protocol	Analog
Operating Voltage	3VDC - 5VDC
Dimensions	47(L) x 25(W) x 32(H)

Pinout

Module	Duinotech	Function
GND	GND	Ground Connection
+5V	5V	Power
VRX	A0	X Output
VRY	A1	Y Output
SW	D7	Push Button Output

joystick



Specifications

	Joystick Module
Switch Protocol	Digital
X,Y Protocol	Analog
Operating Voltage	3VDC - 5VDC
Dimensions	47(L) x 25(W) x 32(H)

what's this all about?

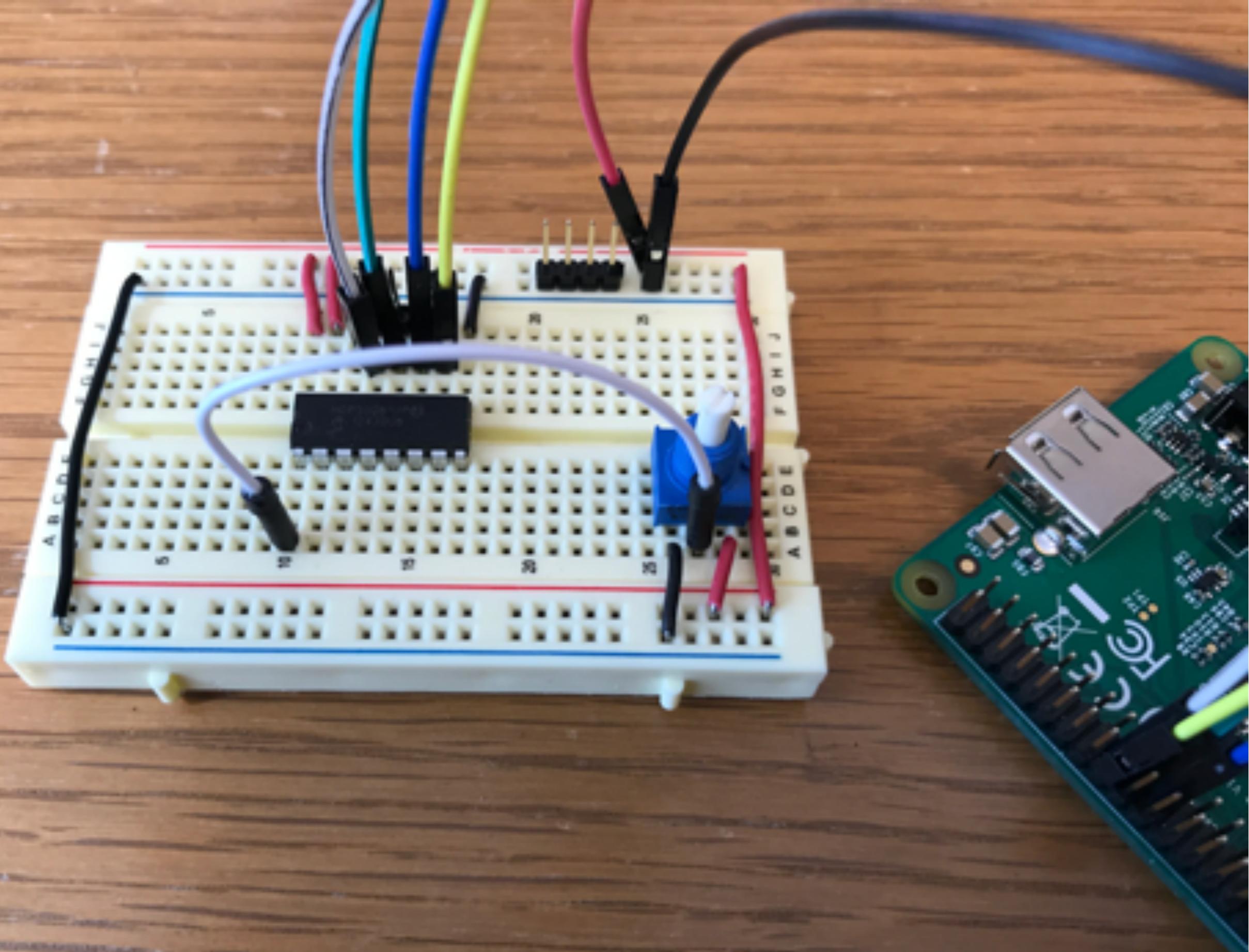
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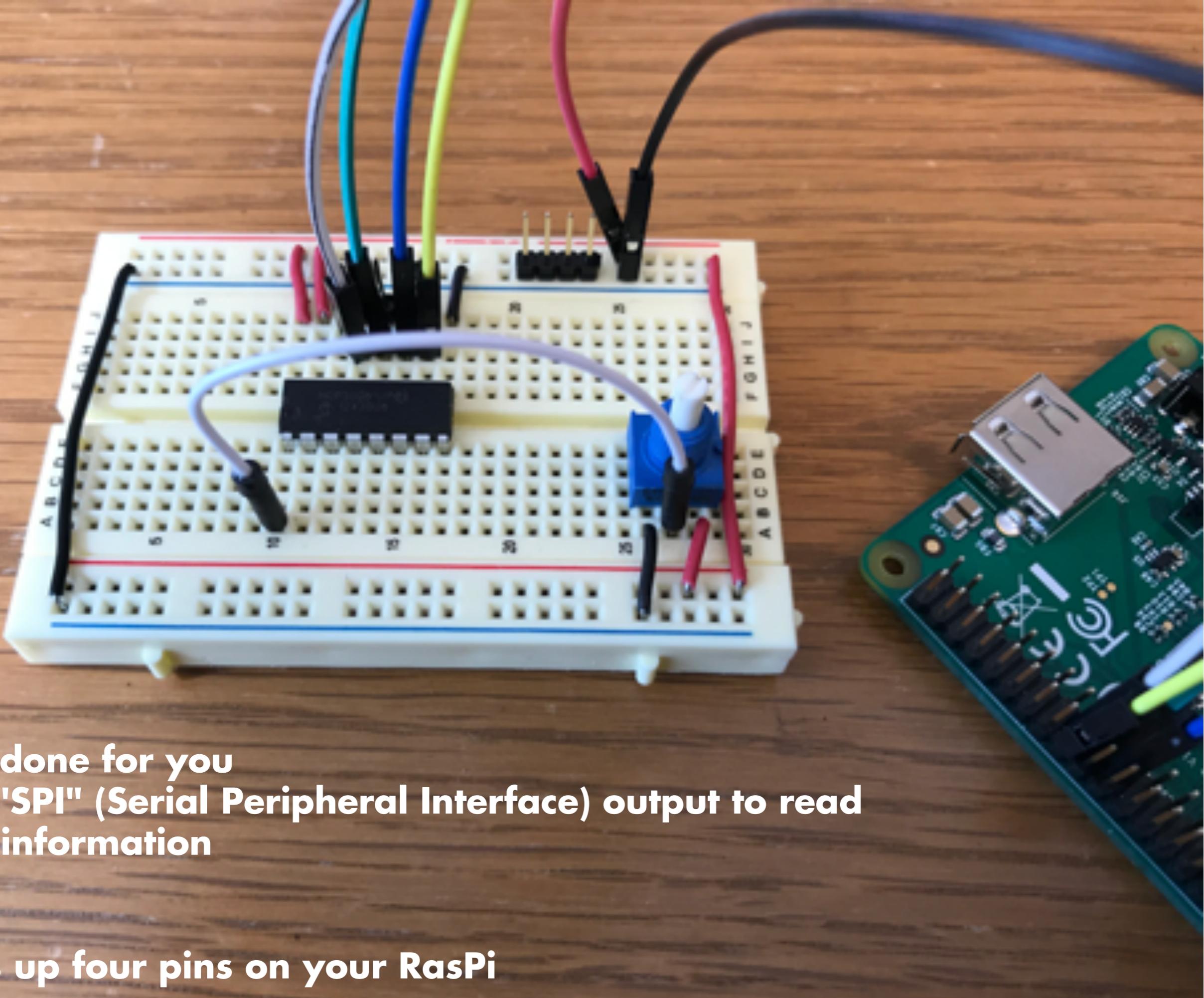
**The Raspberry Pi GPIO pins are all digital, but this joystick
is analog!**

We have some options:

- 1. We can get a dedicated "analog to digital converter"
(ADC) chip**
- 2. We can build our own ADC**



SPI MCP3008 analog to digital converter (ADC)



Pros:

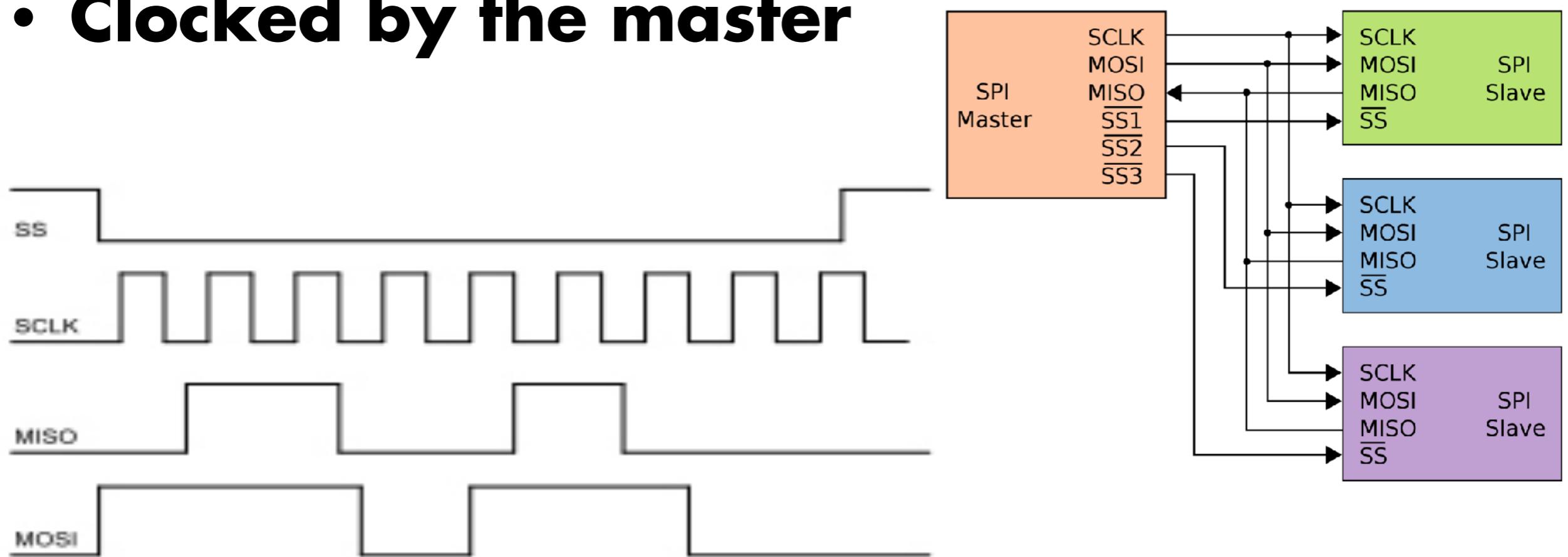
- ADC done for you
- Has "SPI" (Serial Peripheral Interface) output to read digital information

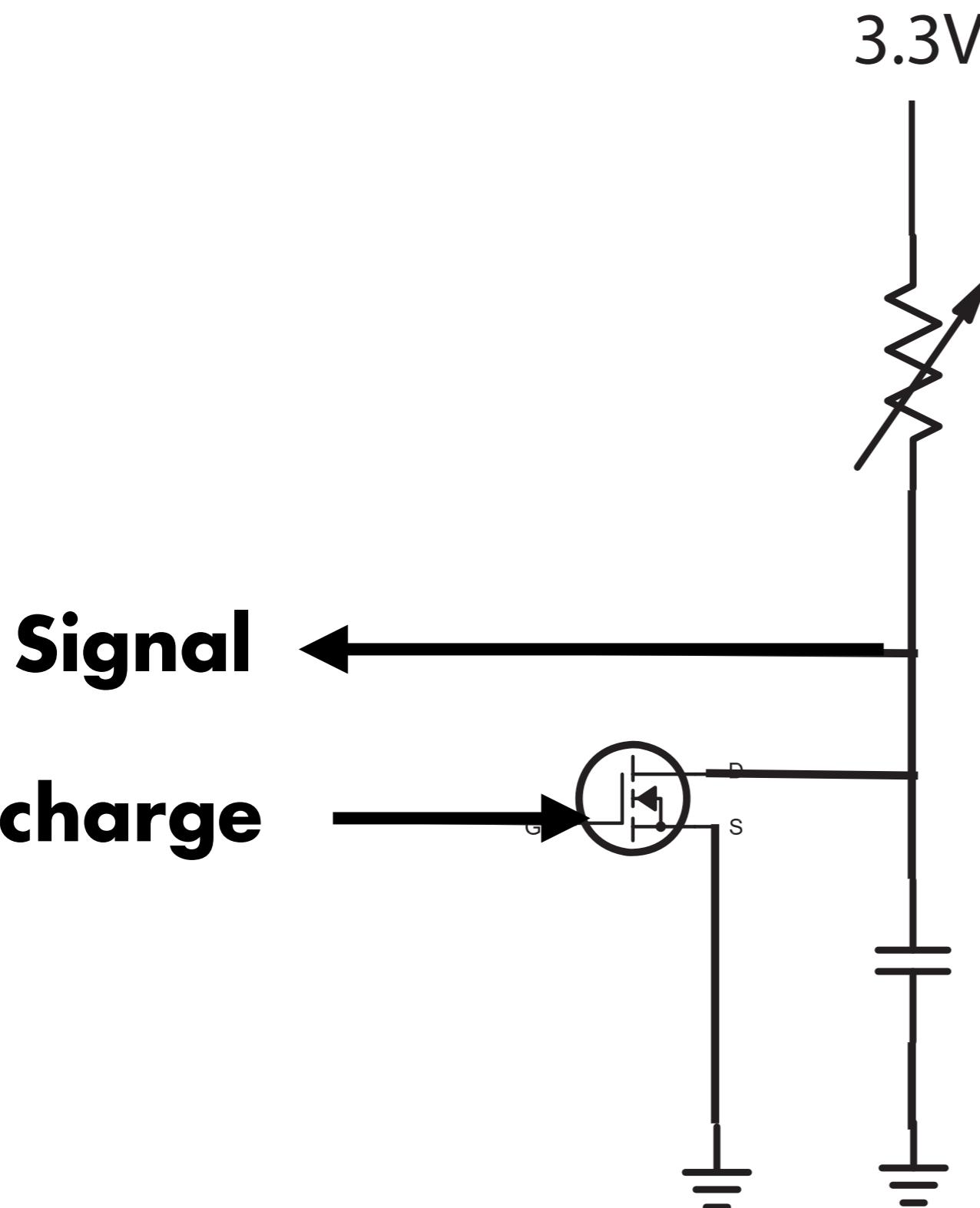
Cons:

- Takes up four pins on your RasPi

SPI

- Shared CLK, MOSI, MISO lines
- Active low slave select (SS) lines to specify which peripheral is active
- Clocked by the master





Build Our own ADC option

Pros:

- Pretty simple circuit! (uses a capacitor and a transistor, and two RasPi pins)

Cons:

- We do have to set up the circuit and write some timing code

Timing Circuit

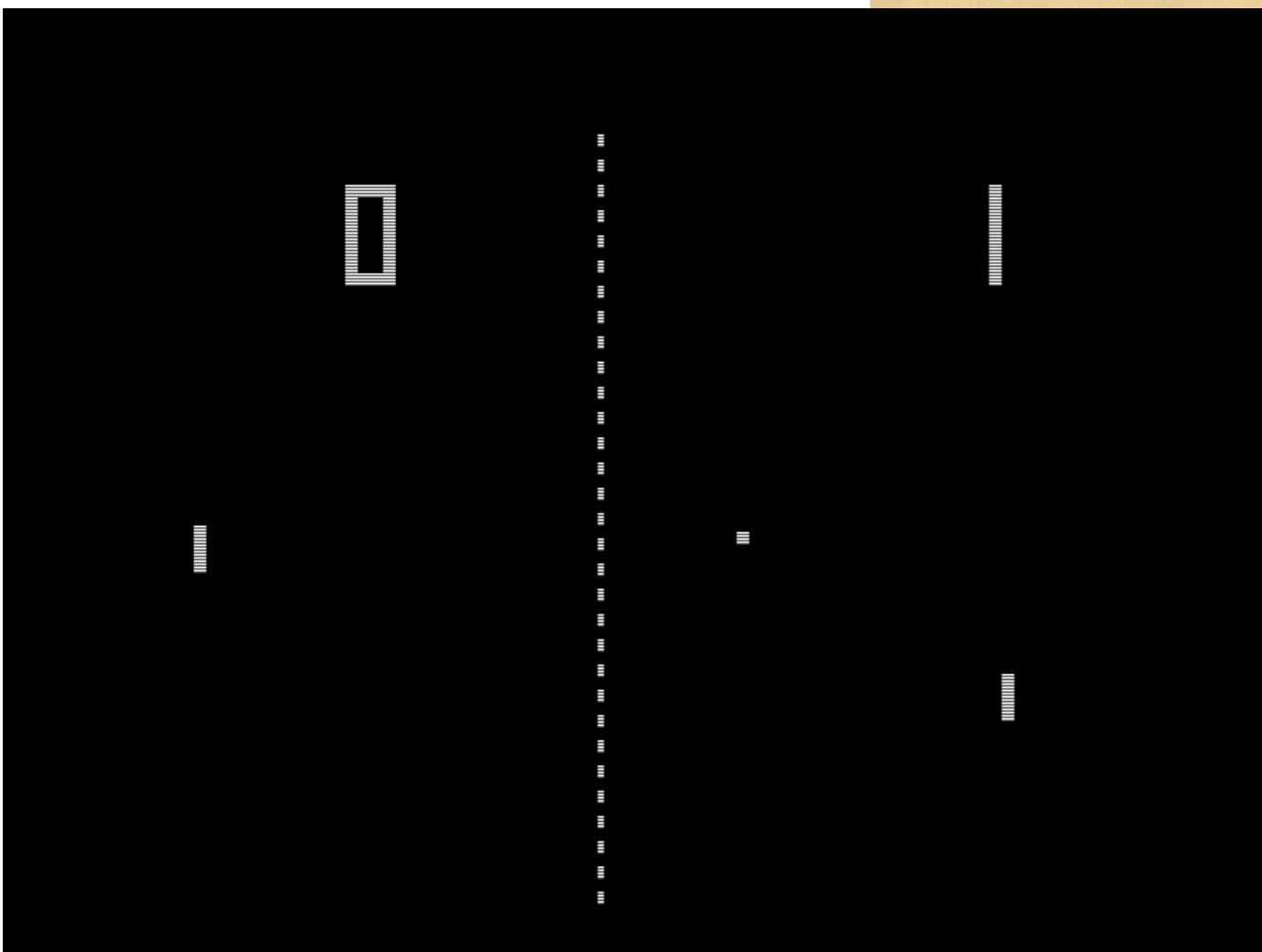


THE NEWEST 2 PLAYER
VIDEO SKILL GAME

PONG

from ATARI CORPORATION
SYZYGY ENGINEERED

The Team That Pioneered Video Technology



tract Mode
matically
of Ball
ng Paddle
te Controls
TE TV and
Long,

MPUTER

ROFITS
• Location
Suitable
d Locations

FROM YOUR LOCAL DISTRIBUTOR

Maximum Dimensions:

WIDTH -26"

HEIGHT - 50"

DEPTH - 24"

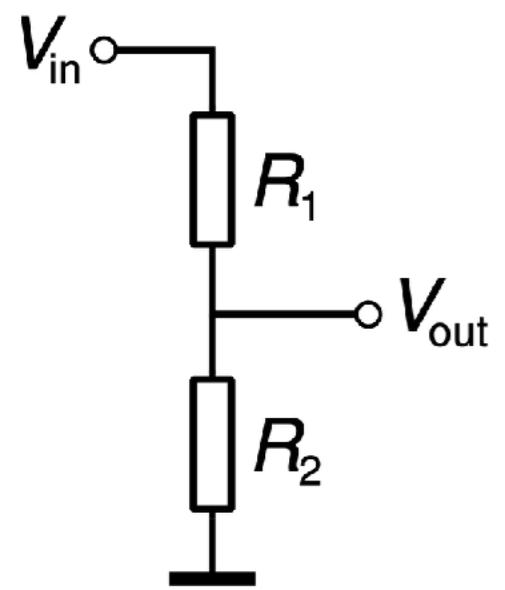
SHIPPING WEIGHT:

150 Lb.

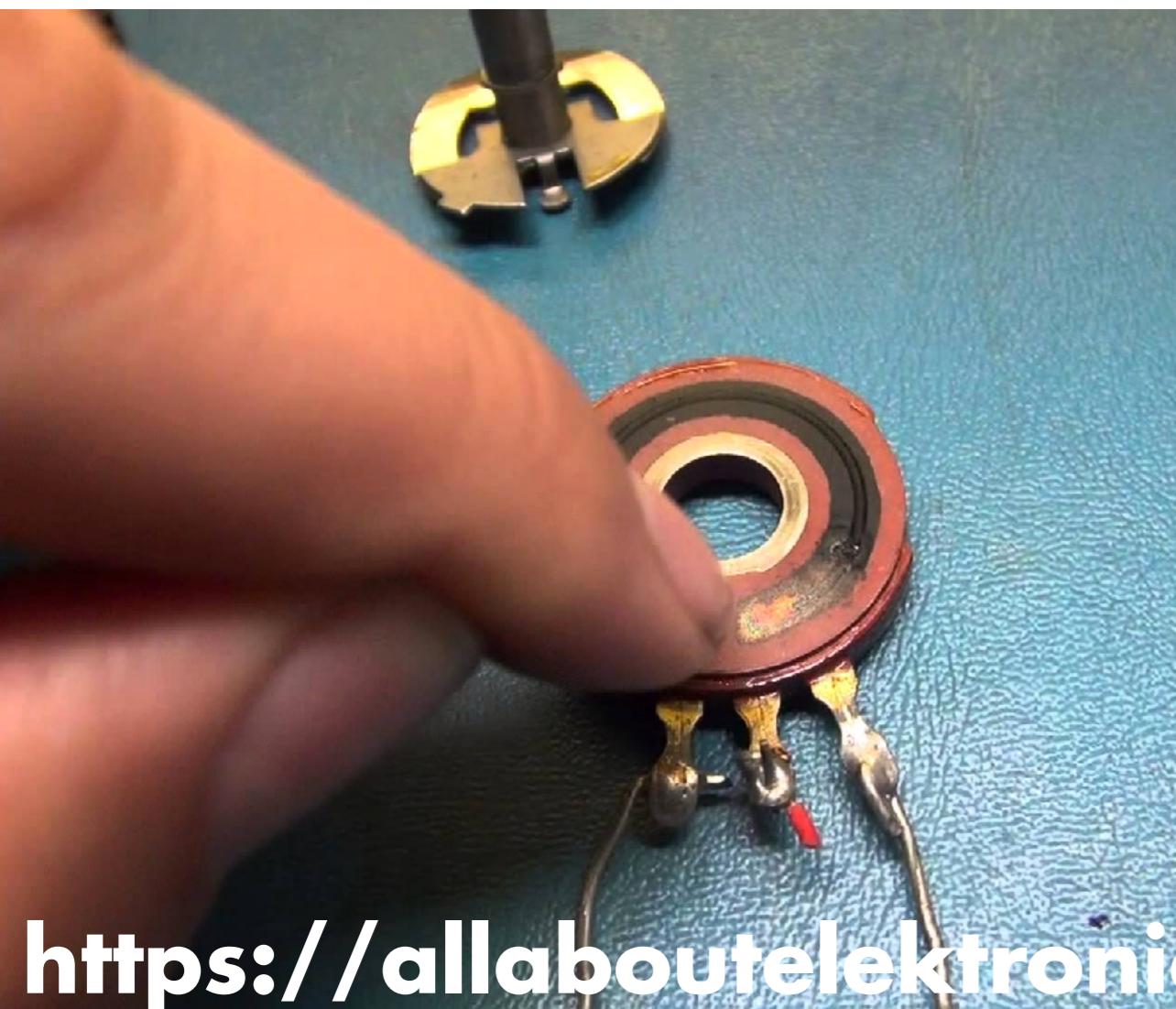
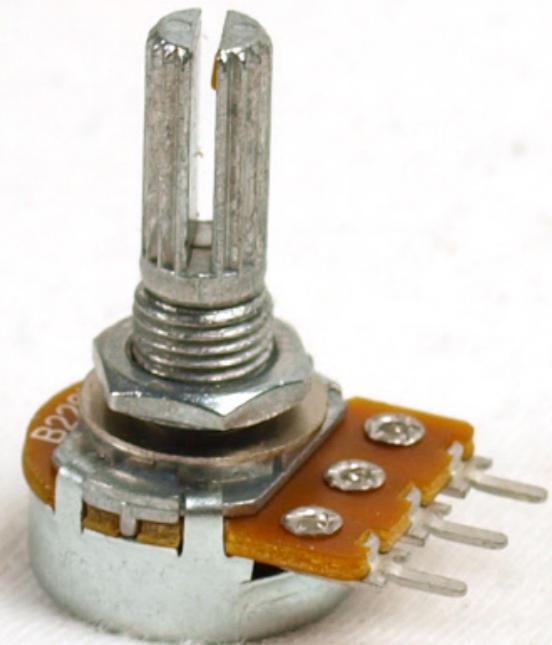




Image © Avon Fox
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$$V_{out} = \frac{R_2}{R_1 + R_2} V_{in}$$



```
unsigned int get_charge_time(void)
{
    // discharge the capacitor
    gpiowrite(discharge, 1);
    timer_delay_ms(10);
    gpiowrite(discharge, 0);

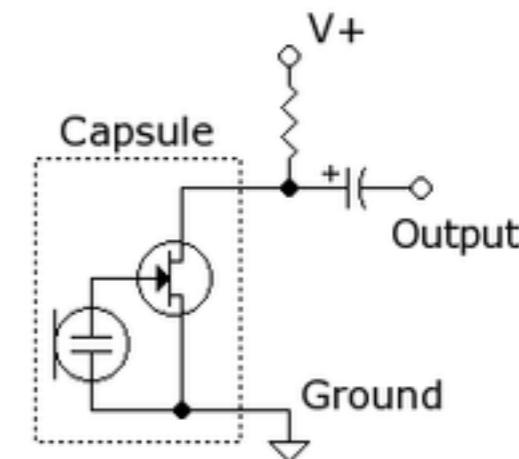
    // time the capacitor charging
    unsigned int start = timer_get_ticks();
    while(!gpioread(signal))
        ;
    unsigned int end = timer_get_time();

    return (end - start);
}
```

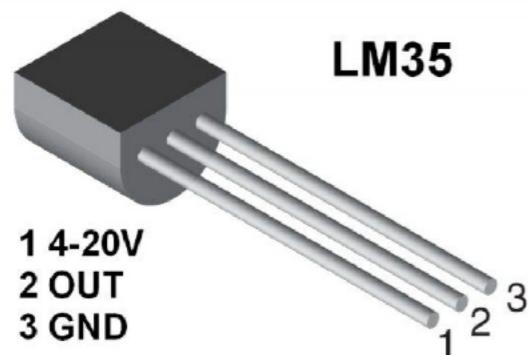
Other Analog Sensors



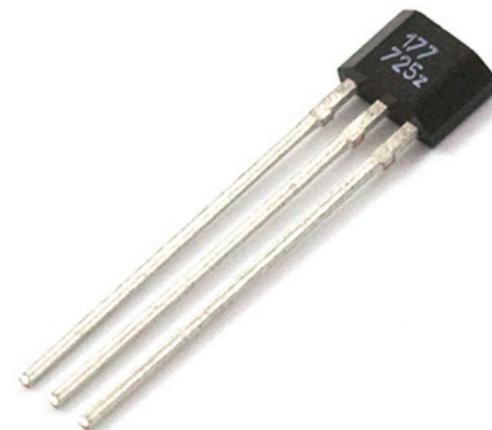
**Phototransistor
(light)**



**Electret Microphone
(pressure)**



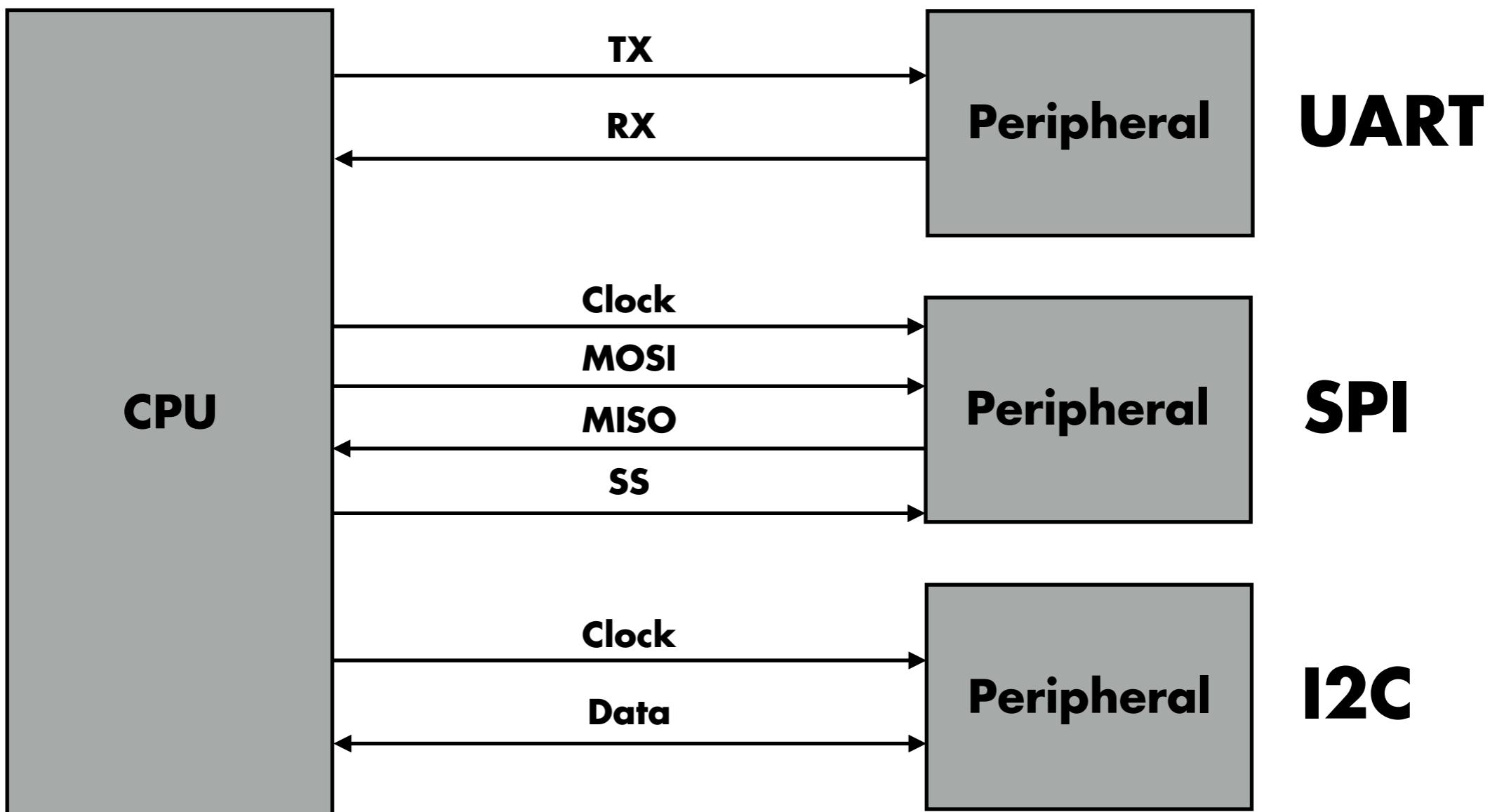
(temperature)

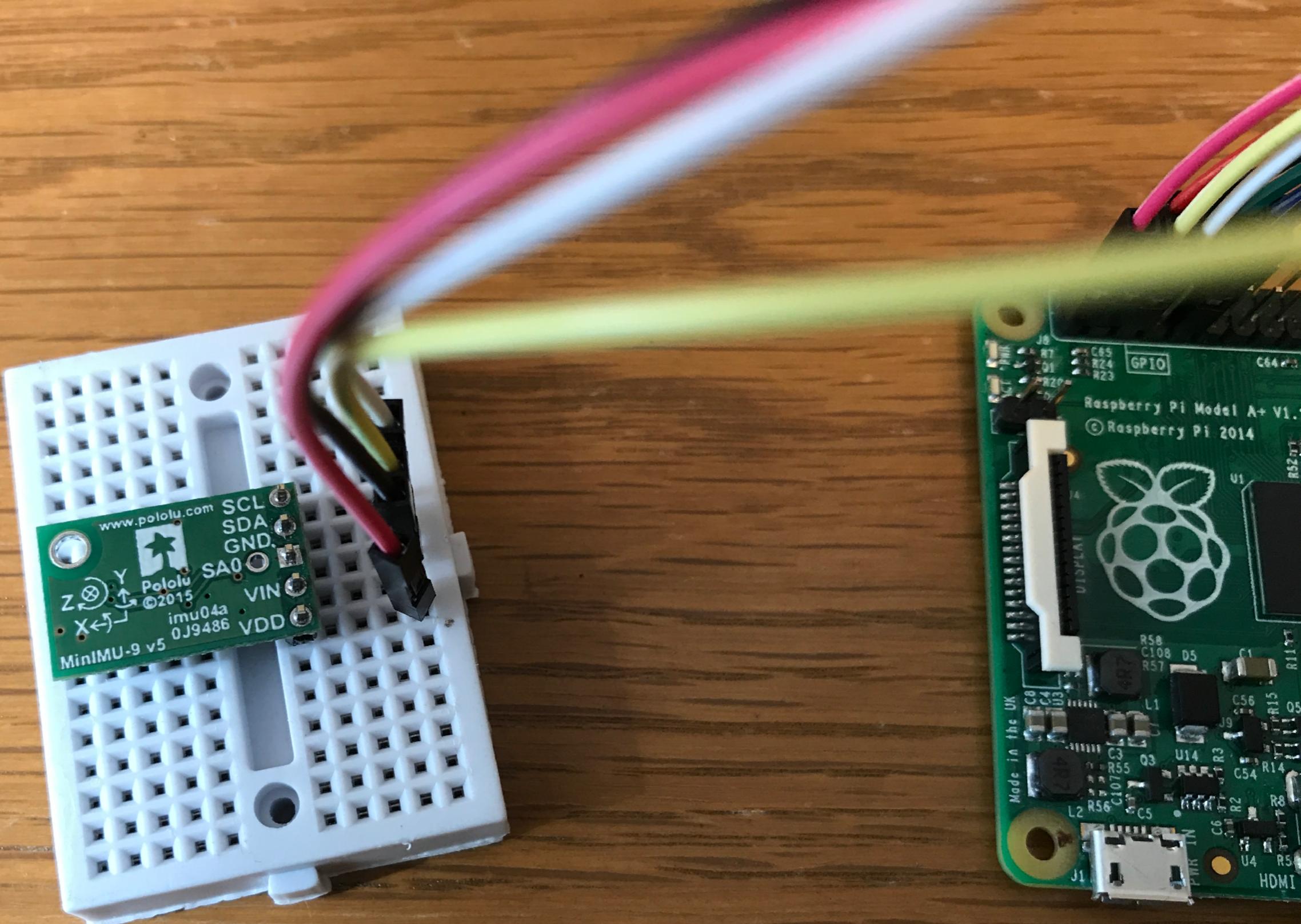


**Hall Effect
(magnetic field)**

Smart Sensors

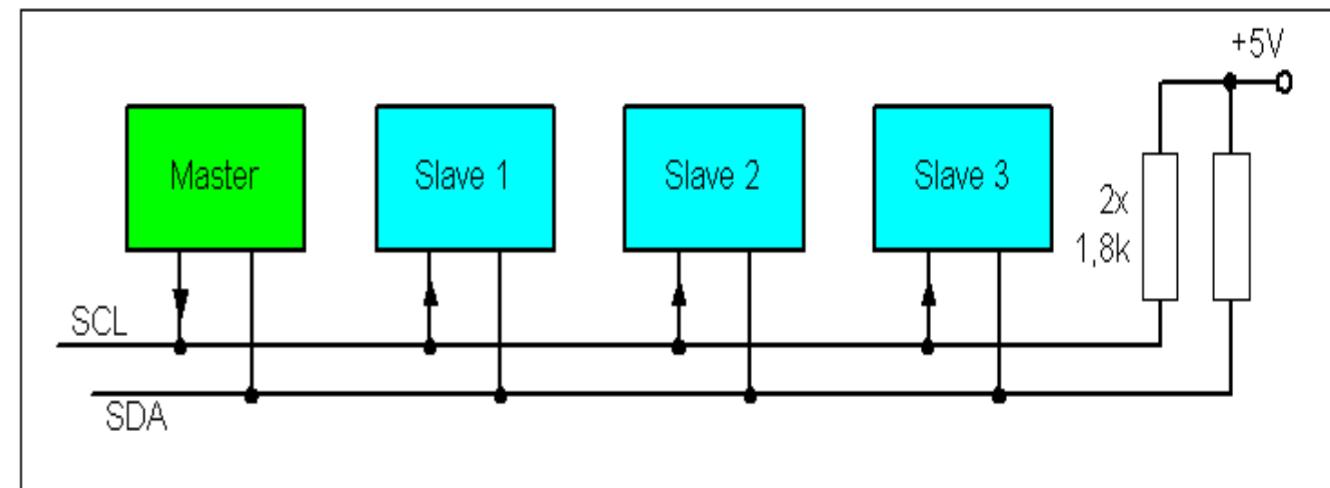
Bus Protocols



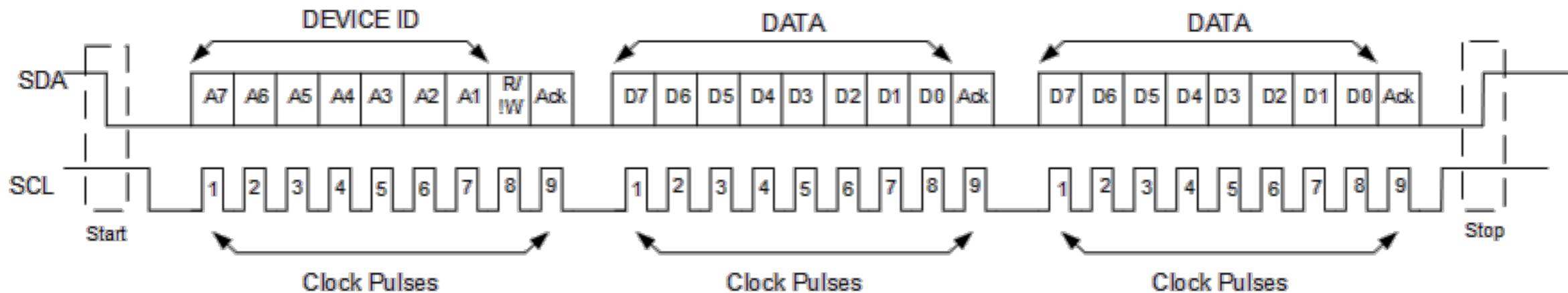


I2C IMU (orientation, gyroscope, compass)

I2C

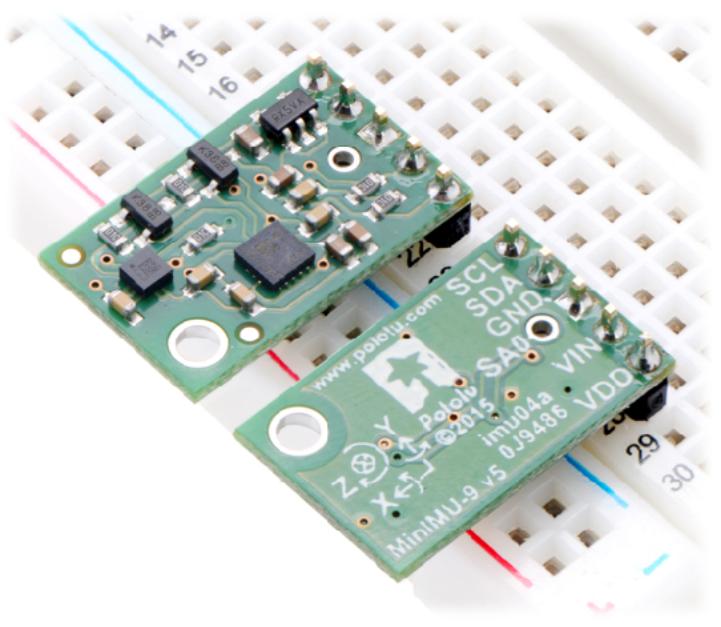


- Only CLK & DATA lines
- Clocked by master, sides alternate who sends data
- Shared bus, slave identified by 7 (or 10) bit address

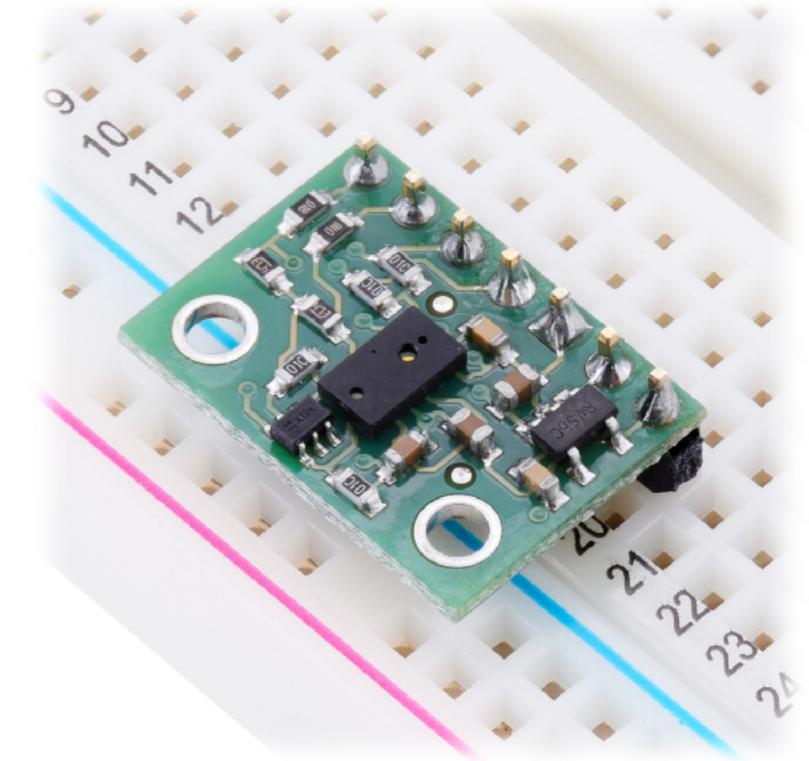


Figures from <http://www.cs.fsu.edu/~baker/devices/notes/graphics/i2cbus3.gif> (top)
https://learn.digilentinc.com/Documents/chipKIT/chipKITPro/P08/Fig_1_Waveform.png (bottom)

I2C Sensors



**Accelerometer
Gyroscope
Magnetometer**



VCSEL Time of Flight



**Temperature,
Humidity,
Pressure**

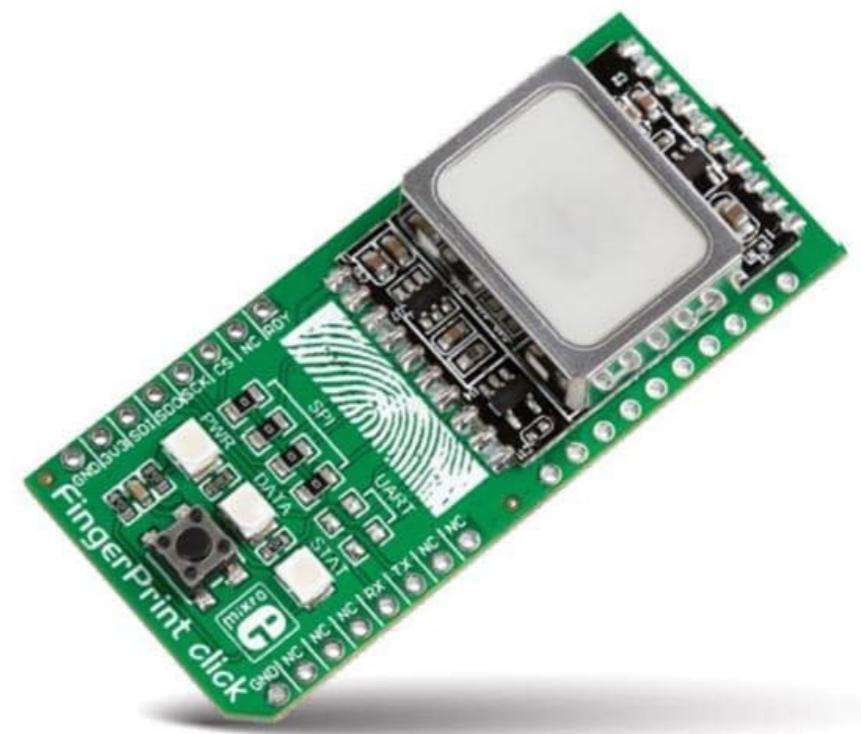


Arducam (SPI and I2C)

SPI Sensors



Mfrc-522 RFID Reader



Fingerprint Sensor

Sound

We talked about sound earlier in the quarter, but there are other options...

e.g.,

BY8301-16P

Sensing the World

Resistance (conduction, impedance, capacitance)-

Light (phototranistor, lidar)

Sound/pressure/deformation (piezo, electret, strain gauge)

Temperature (heat), humidity, pressure

Electromagnetic fields (hall effect, compass, antenna)

Acceleration (force direction)

Orientation (gyroscope)