

Final Projects

Project proposal ideas and hints (<http://cs107e.github.io/project/>)

Form project teams ASAP - highly recommend 2 (1-3 people ok)

- **Submit team members/team request by midnight Sat Mar 4**
- **Will be using a shared GitHub repo for the project**

Project proposal due 11:59 pm Thursday March 9th

- **Answer questions in Proposal.md in team repo**
- **Order parts! \$20 parts budget per person; need to submit receipts**

Two labs - teams should go on the same day

- **1st - refine project ideas, enumerate milestones, and edit proposal**
- **2nd - evaluate milestones and mid-course correction**

Class demos (9-11am Fri Mar 24)

Final code and writeup submission (due 11:59pm on Fri, Mar. 24th)

System Bonus

Assignment 7 - ps2read using interrupts

- **Submit as usual by Tue (on-time) Thu (in grace)**
- **Only 3 tests on ps2 module (two P1, one P2)**

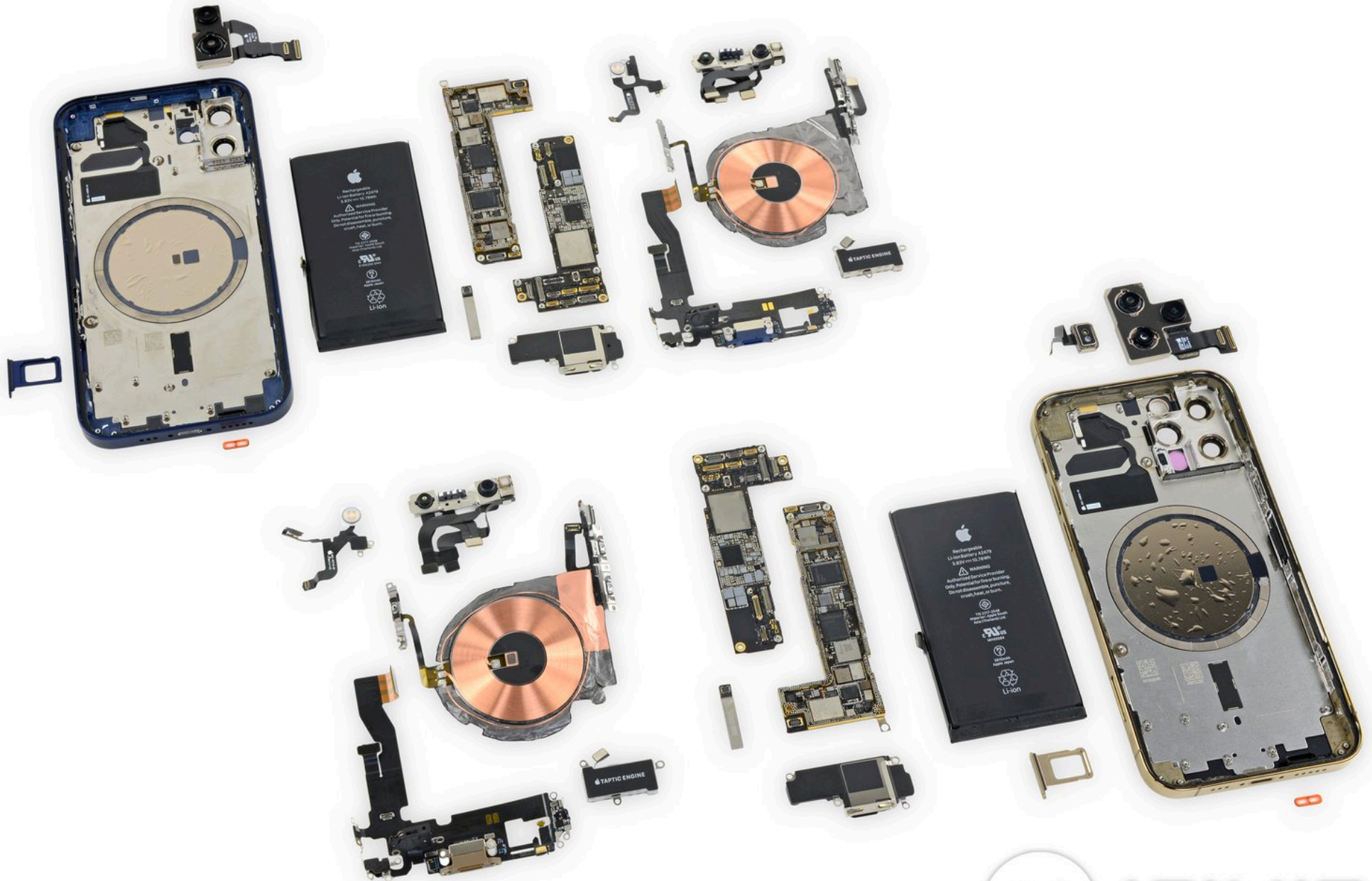
System bonus

- **Run console shell using all your modules**
- **Modules pass all P1 tests, all P1 issues closed**
- **We will accept bug fixes until 5pm Sun Mar 12**

CS107e

Sensors

Apple iPhone 12 Teardown



How many sensors?



3 12MP Ultra wide, wide, and telephoto cameras

LIDAR TrueDepth camera

12MP front TrueDepth camera with FaceID

HapticTouch multi-touch vibrating display

Microphones (2 at top, 2 at bottom)

Proximity sensor

Ambient light sensor

Accelerometer

Gyroscope

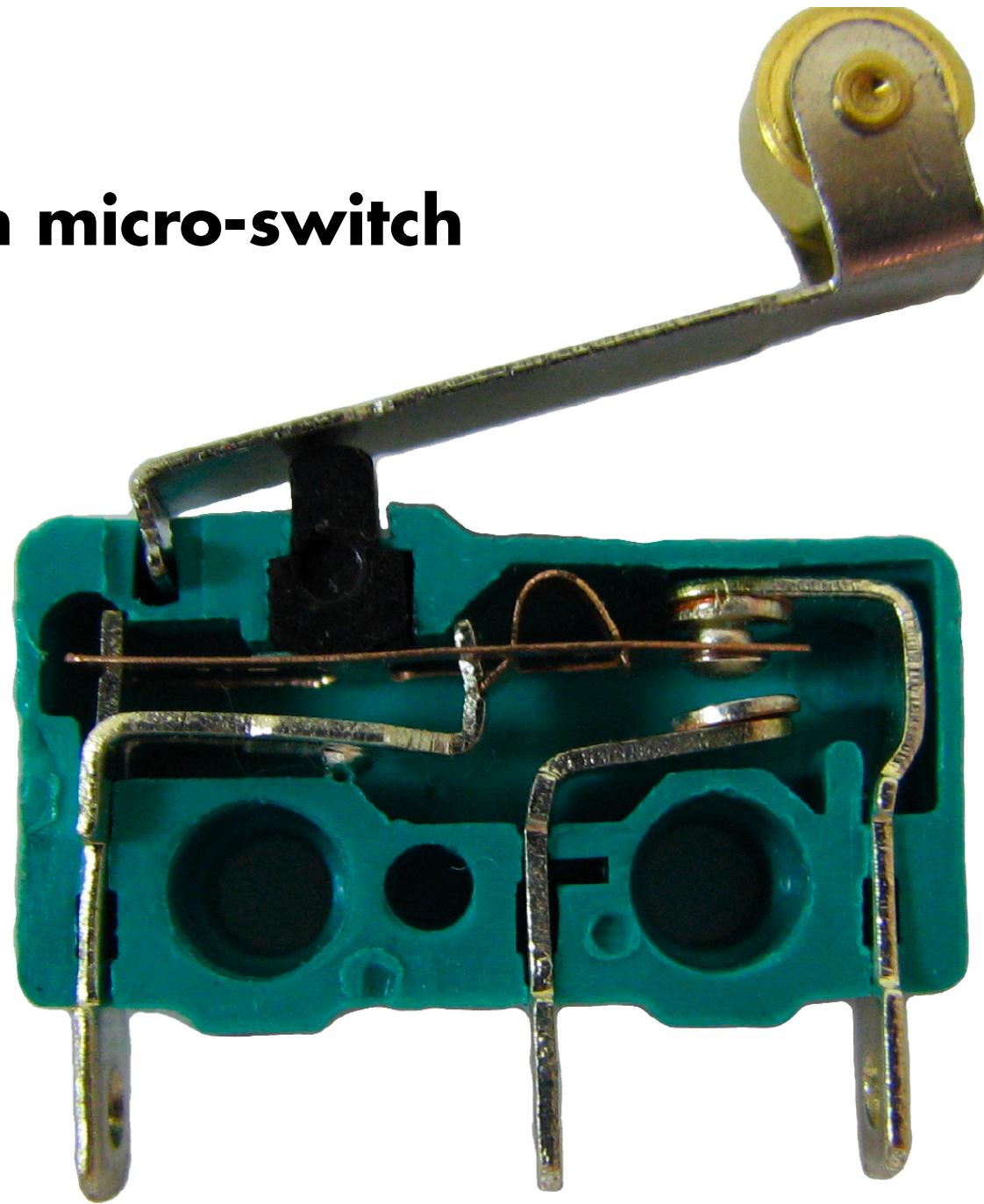
Compass (magnetometer)

Barometer (altimeter)

Moisture

Radios (wifi, bluetooth, cellular, gps, NFC)

Snap-action micro-switch



Common

NO

NC

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



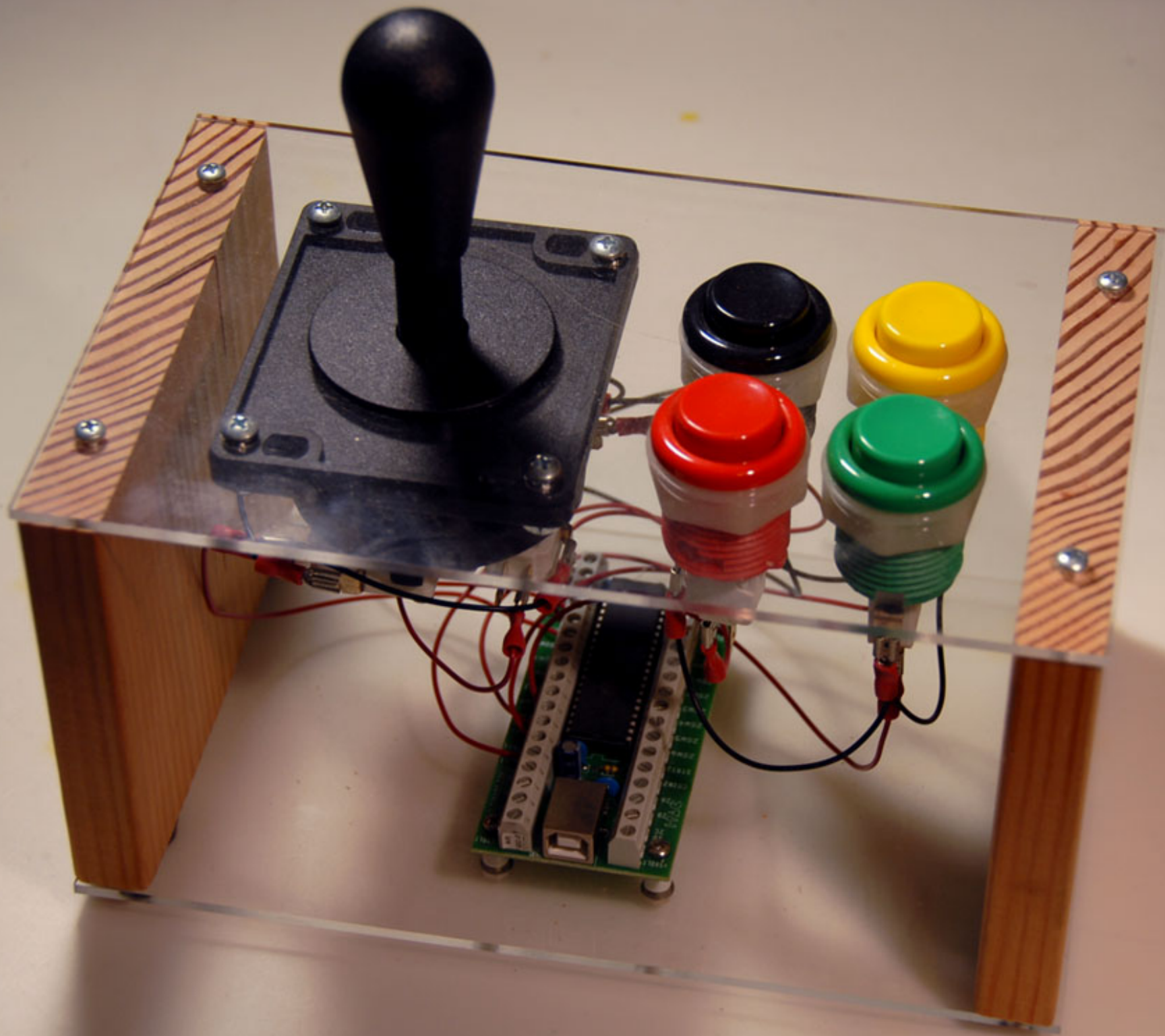
Tim Hunkin's Secret Life of Components - Switches

Happ Pushbutton

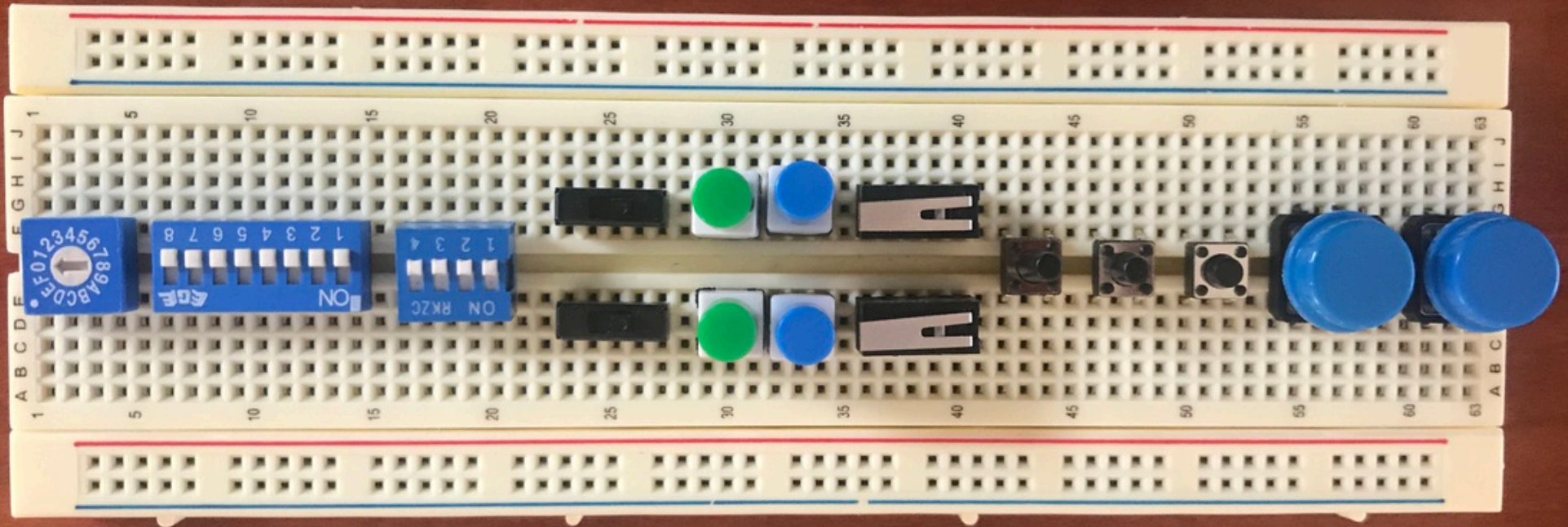


Happ Joystick





Buttons and Switches

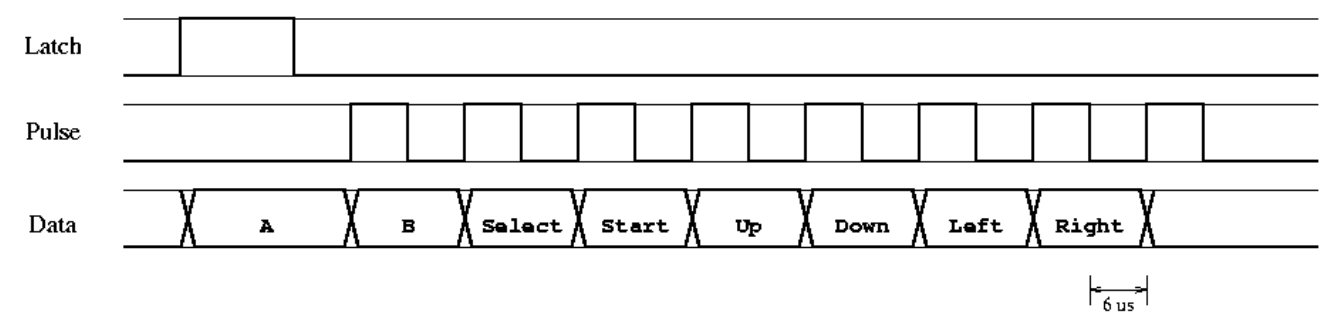
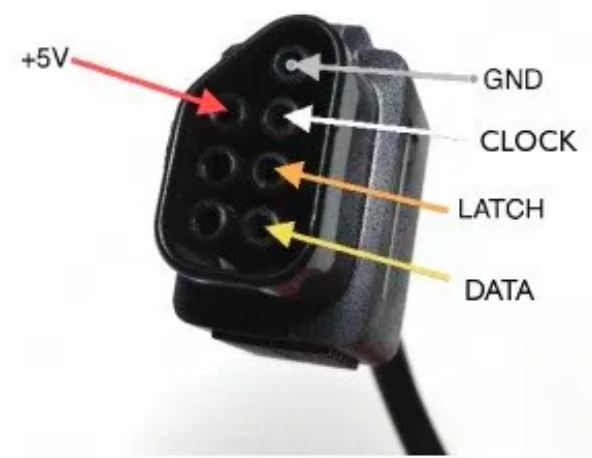




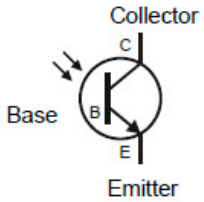
Famicon D-pad



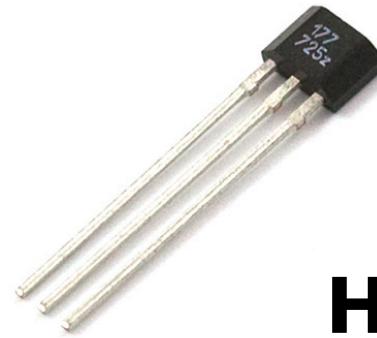
NES D-pad



Transistor Sensors



**Phototransistor
(light)**



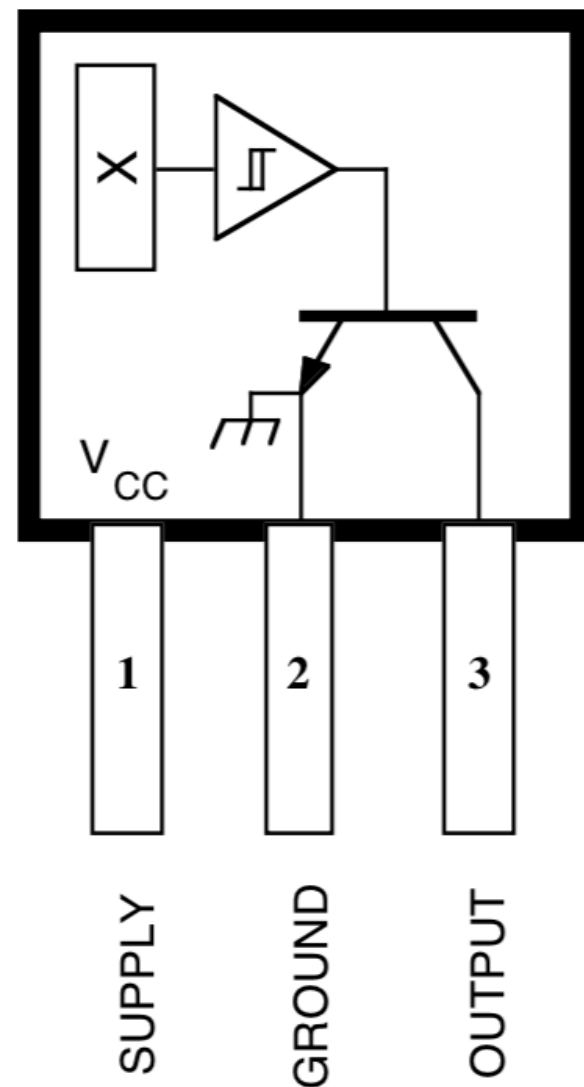
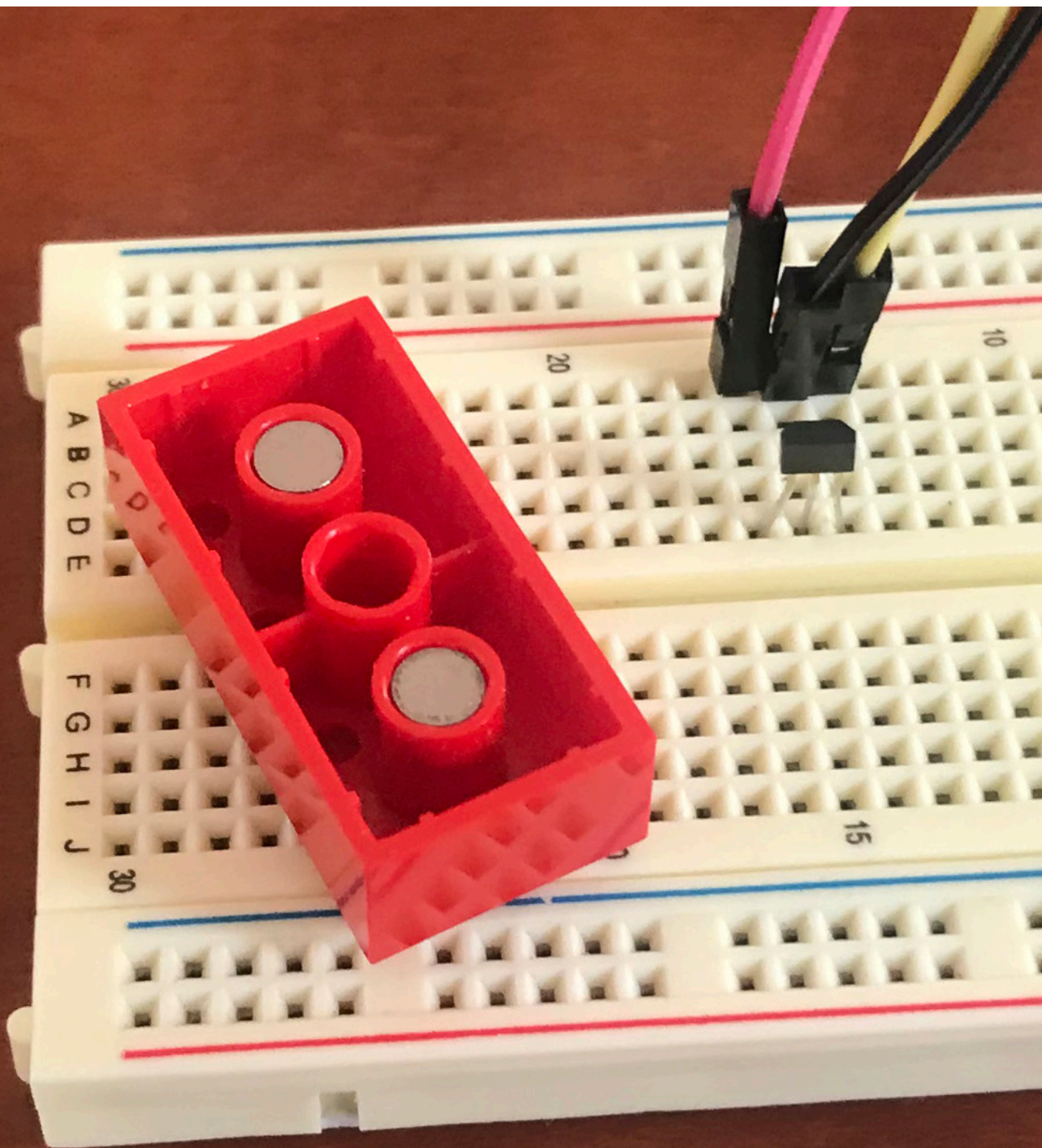
**Hall Effect
(magnetic field)**



38 KHz IR Receiver



Passive infrared (PIR)



3144 Hall Effect Sensor and Magnet



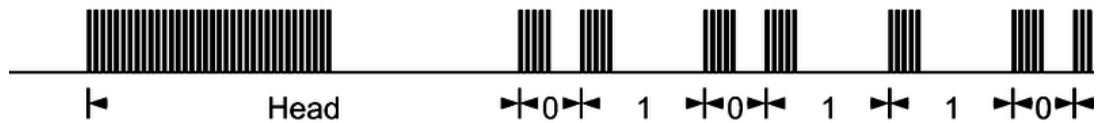
Apple Remote

Protocol

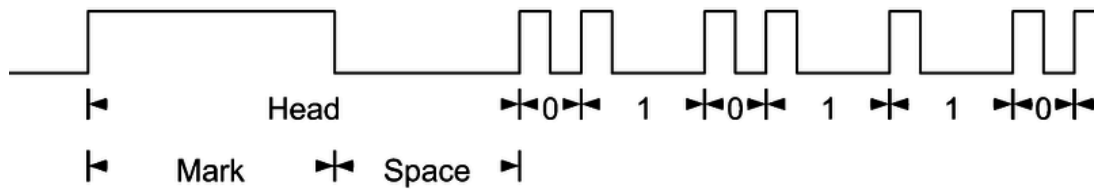


38 KHz IR Receiver

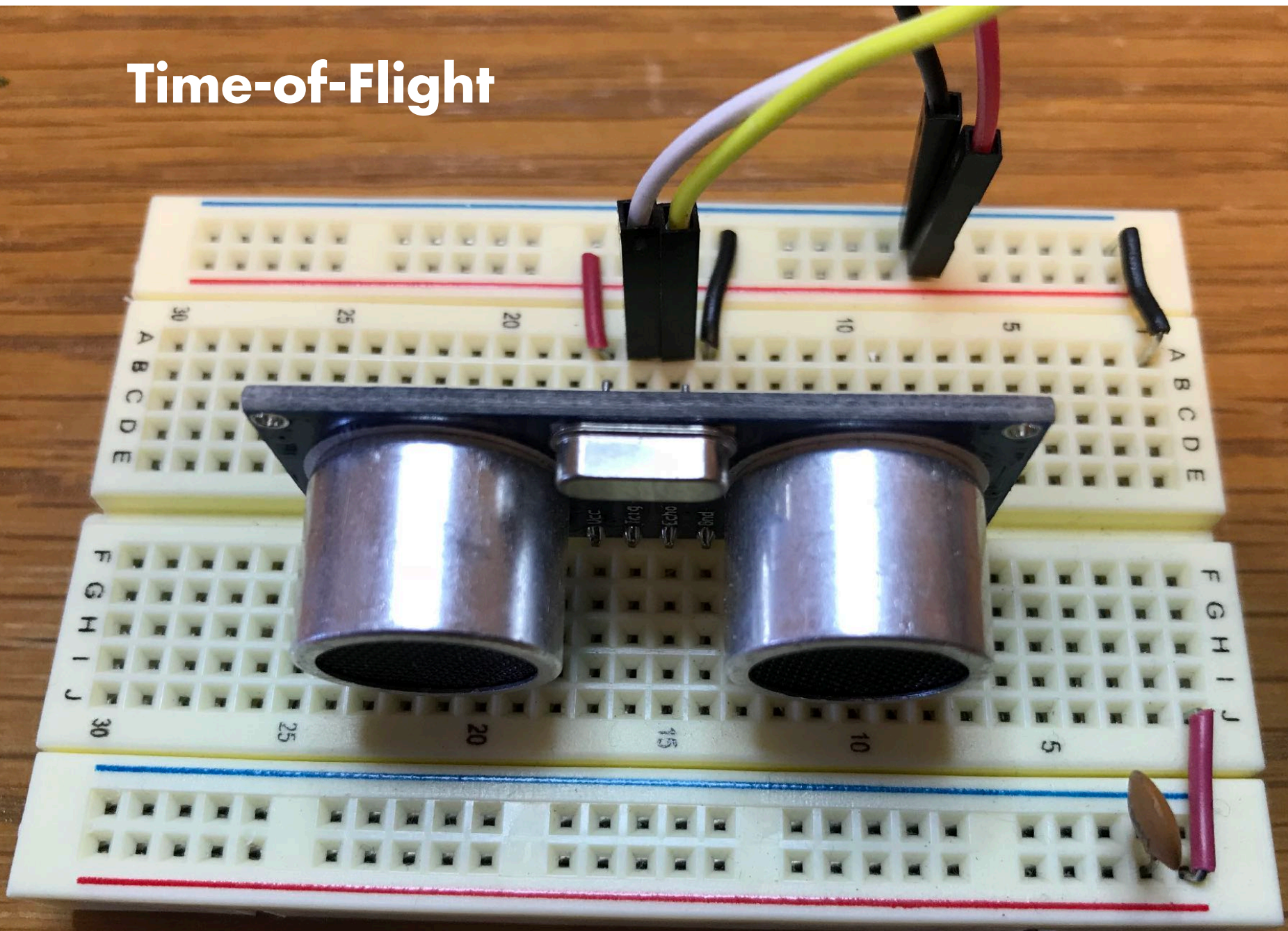
Modulated IR signal



De-Modulated IR signal



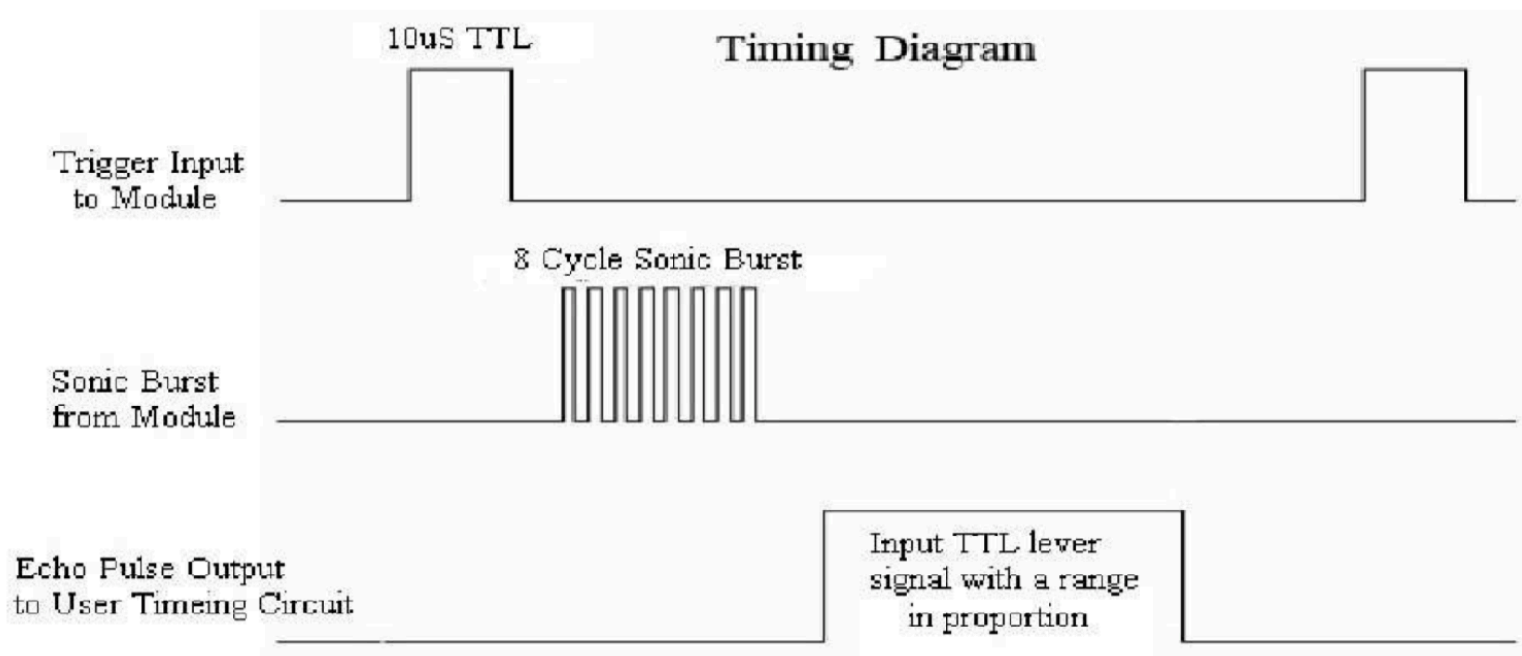
Time-of-Flight



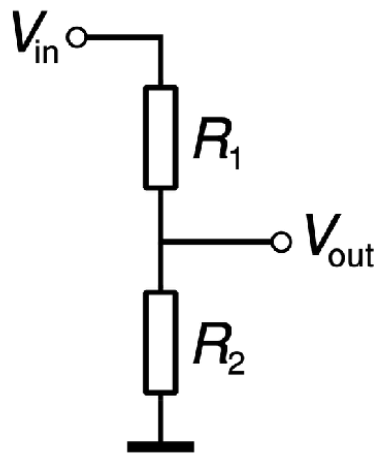
HC04 Ultrasonic Sonar



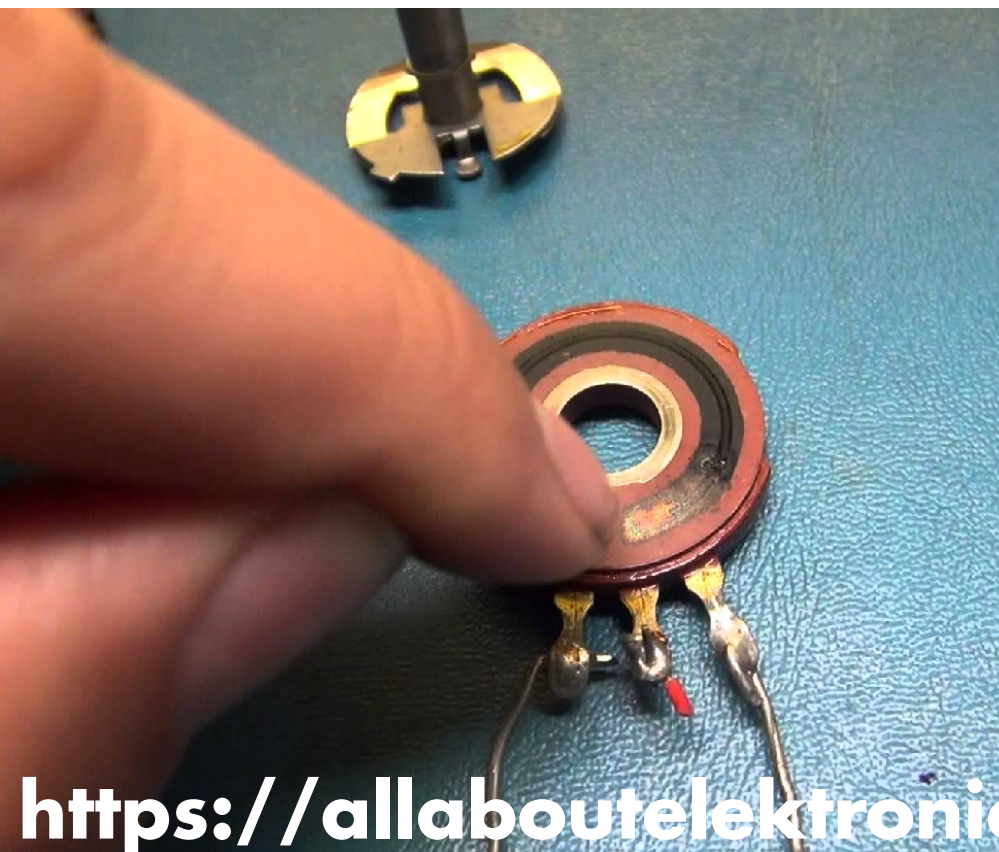
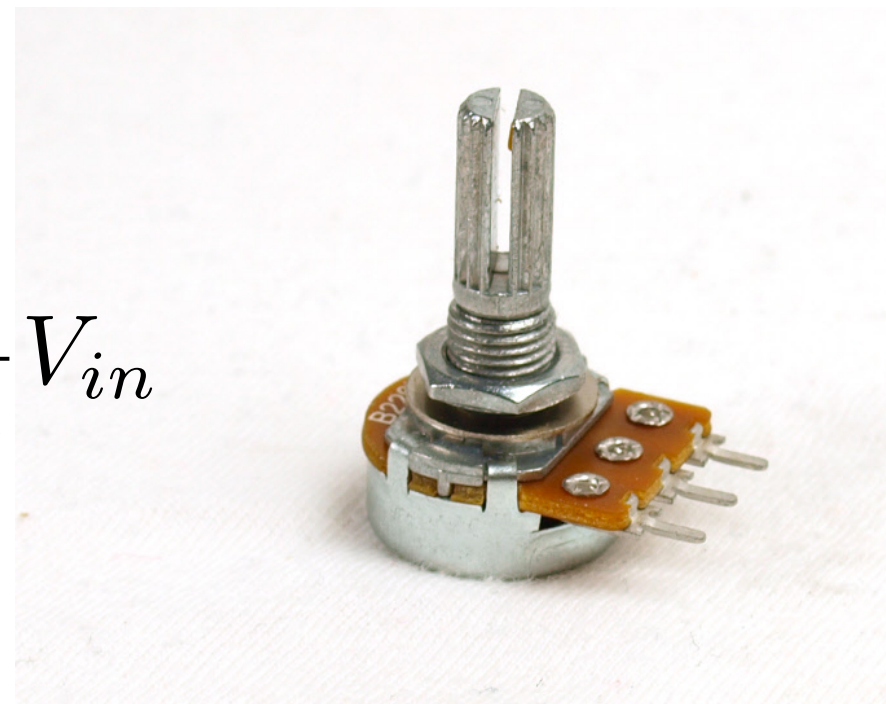
The Timing diagram is shown below. You only need to supply a short 10uS pulse to the trigger input to start the ranging, and then the module will send out an 8 cycle burst of ultrasound at 40 kHz and raise its echo. The Echo is a distance object that is pulse width and the range in proportion .You can calculate the range through the time interval between sending trigger signal and receiving echo signal. Formula: $\mu\text{S} / 58 = \text{centimeters}$ or $\mu\text{S} / 148 = \text{inch}$; 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.

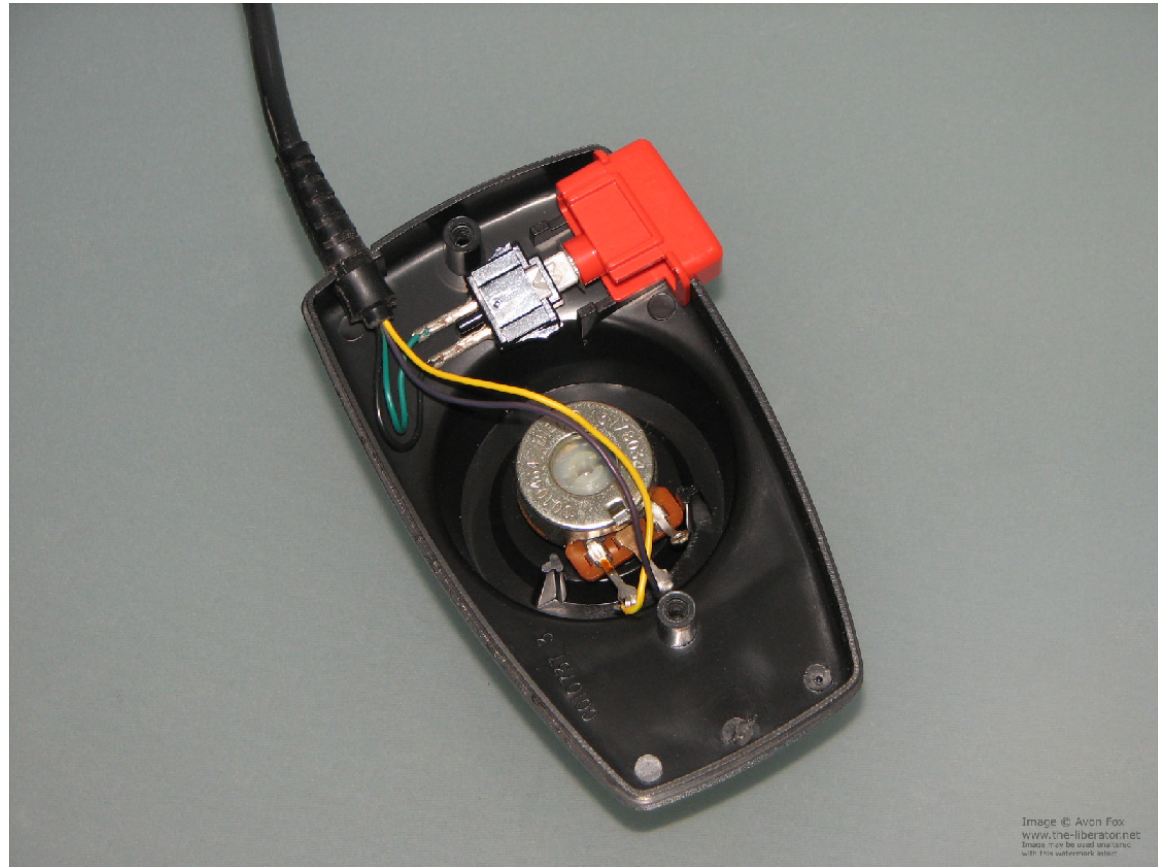


Analog to Digital (ADC)



$$V_{out} = \frac{R_2}{R_1 + R_2} V_{in}$$





Atari 2600 Paddle

How would you measure the voltage?



THE NEWEST 2 PLAYER
VIDEO SKILL GAME

PONG

from ATARI CORPORATION
SYZYGY ENGINEERED

The Team That Pioneered Video Technology



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

MPUTER

ROFITS

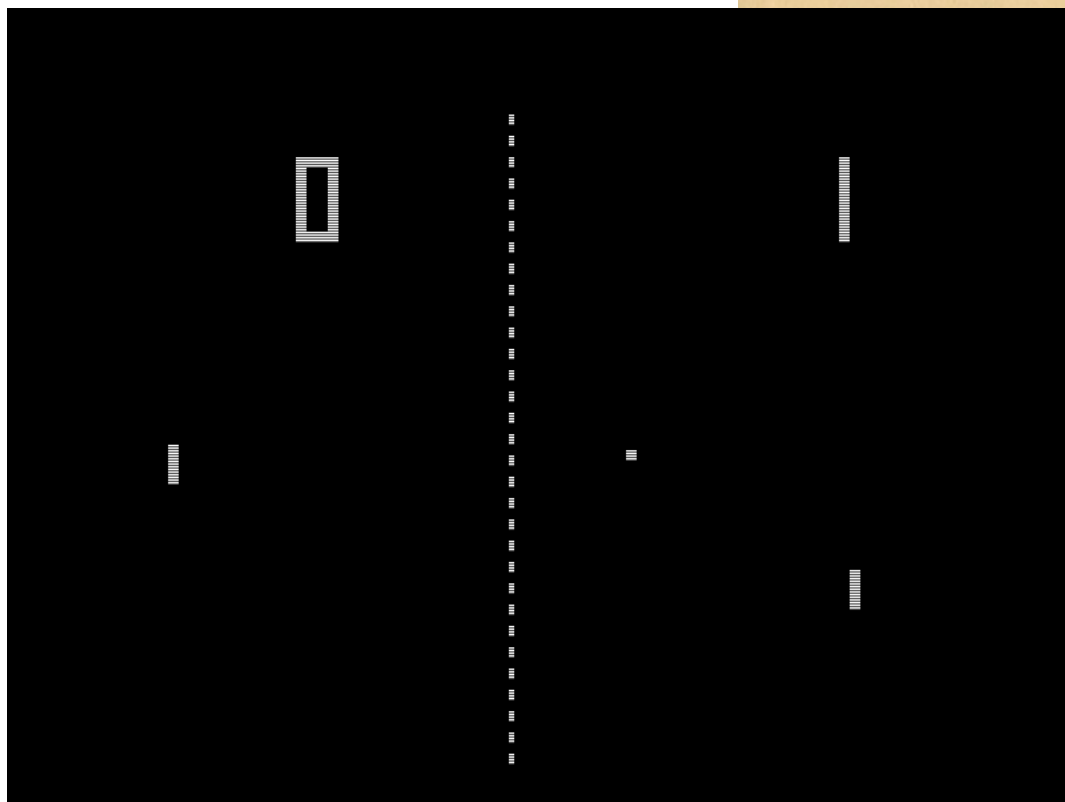
Location

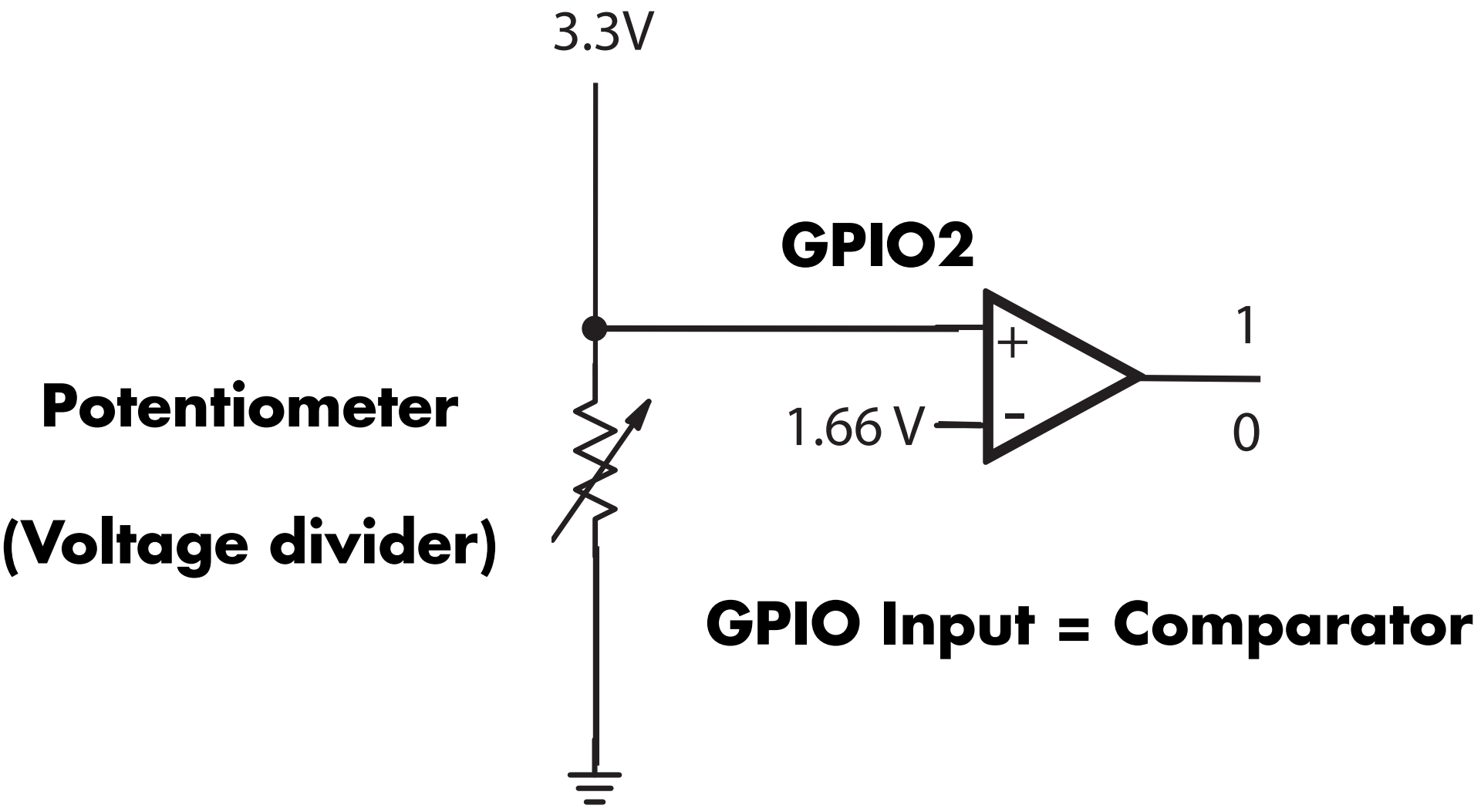
Suitable

Locations

FROM YOUR LOCAL DISTRIBUTOR

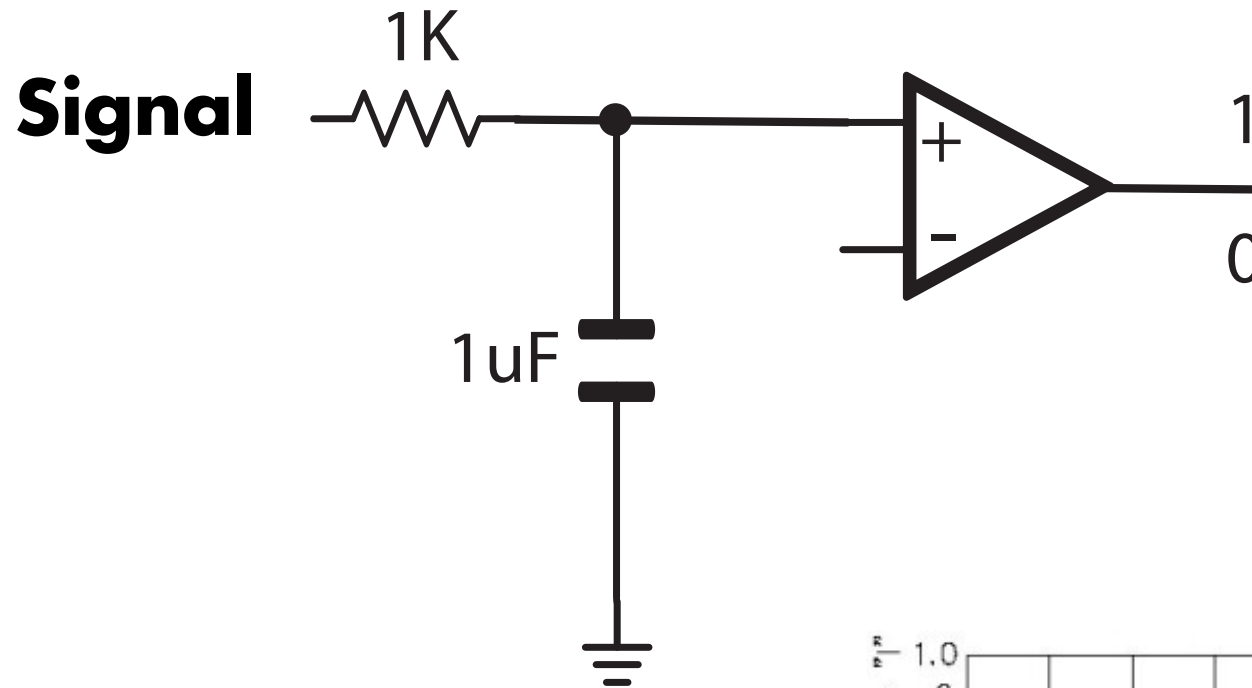
Maximum Dimensions:
 WIDTH - 26"
 HEIGHT - 50"
 DEPTH - 24"
 SHIPPING WEIGHT:
 150 Lb.



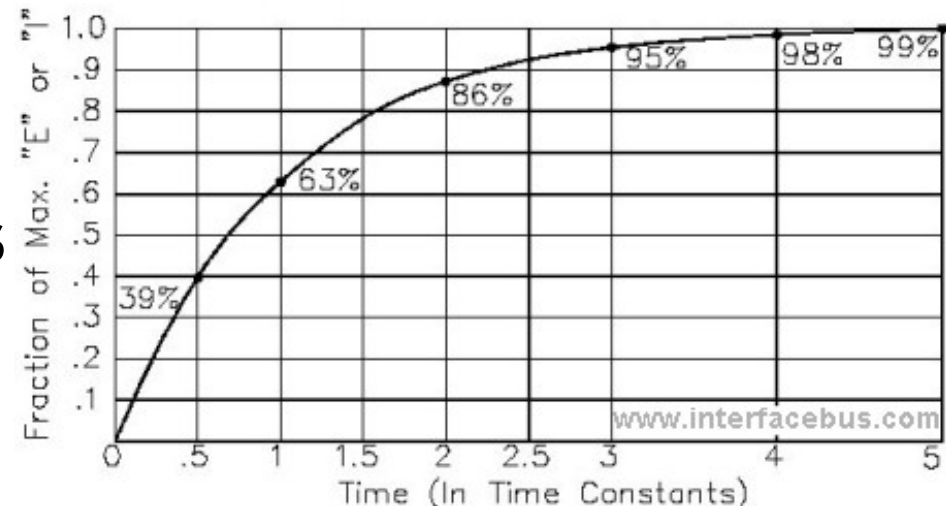


Charging Circuit

The time to fire depends on the input signal voltage

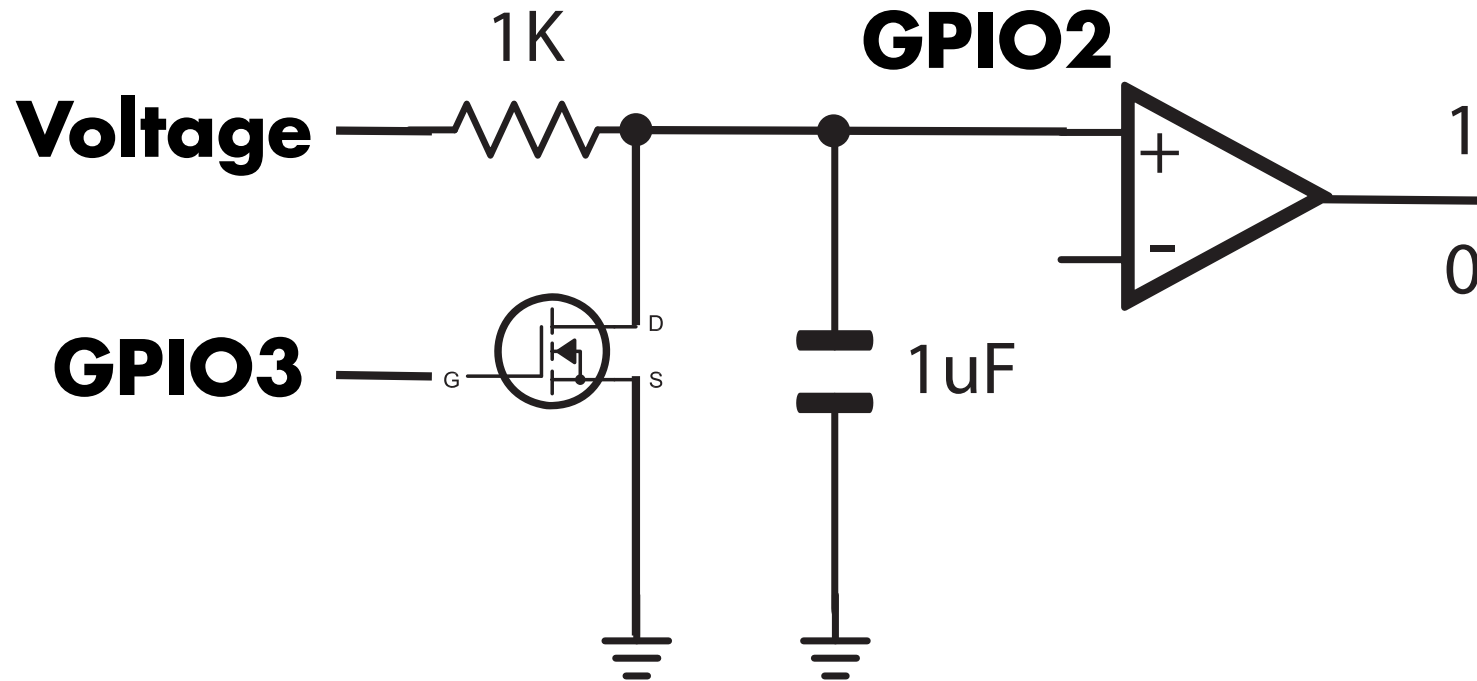


$$RC = 10^3 \times 10^{-6} = 1000\mu\text{secs}$$

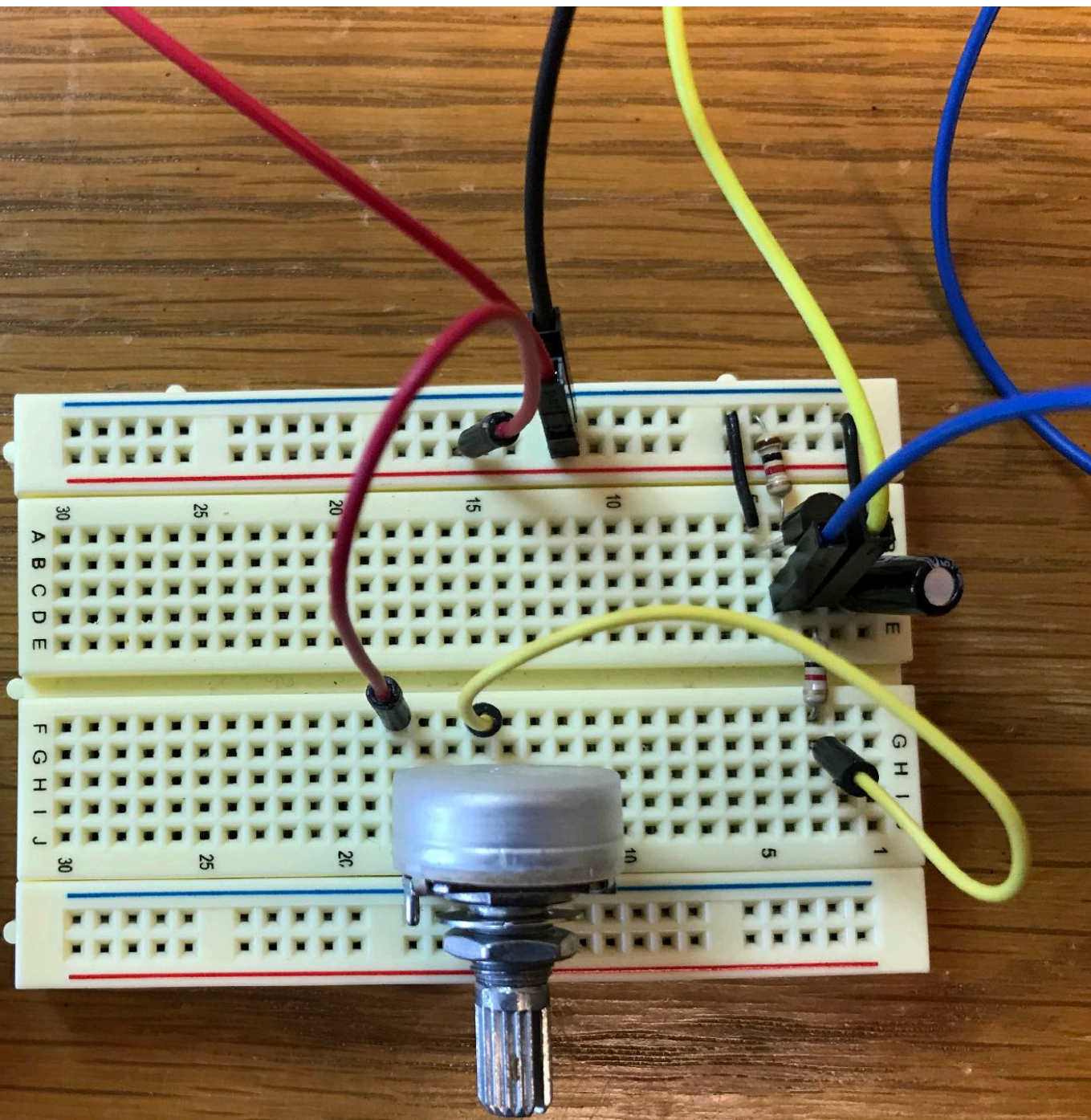


ADC

1. Turn on transistor, discharge capacitor
2. Turn off transistor, charge capacitor



$$RC = 1000 \text{ usecs}$$

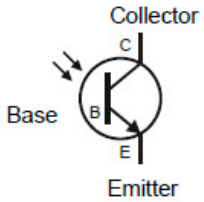



```
unsigned int get_charge_time(void)
{
    // discharge the capacitor
    gpio_write(discharge, 1);
    timer_delay_ms(10);
    gpio_write(discharge, 0);

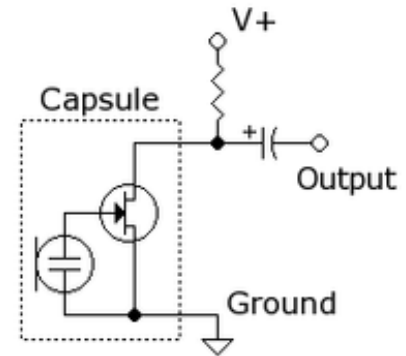
    // time the capacitor charging
    unsigned int start = timer_get_ticks();
    while(!gpio_read(signal))
        ;
    unsigned int end = timer_get_time();

    return (end - start);
}
```

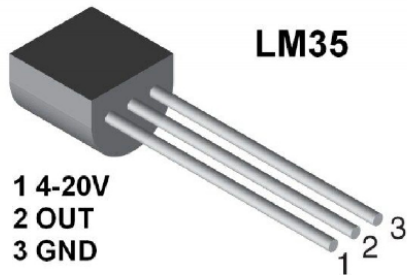
Analog Sensors



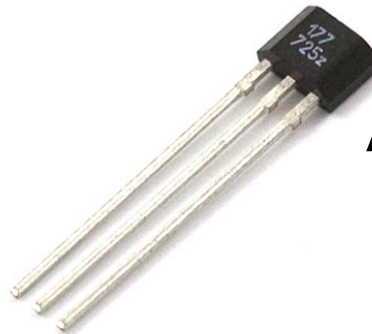
**Phototransistor
(light)**



**Electret Microphone
(pressure)**



(temperature)



**Analog Hall Effect
(magnetic field)**

Digital to Analog (DAC)

Pulse-Width Modulation (PWM)

50% duty cycle



75% duty cycle

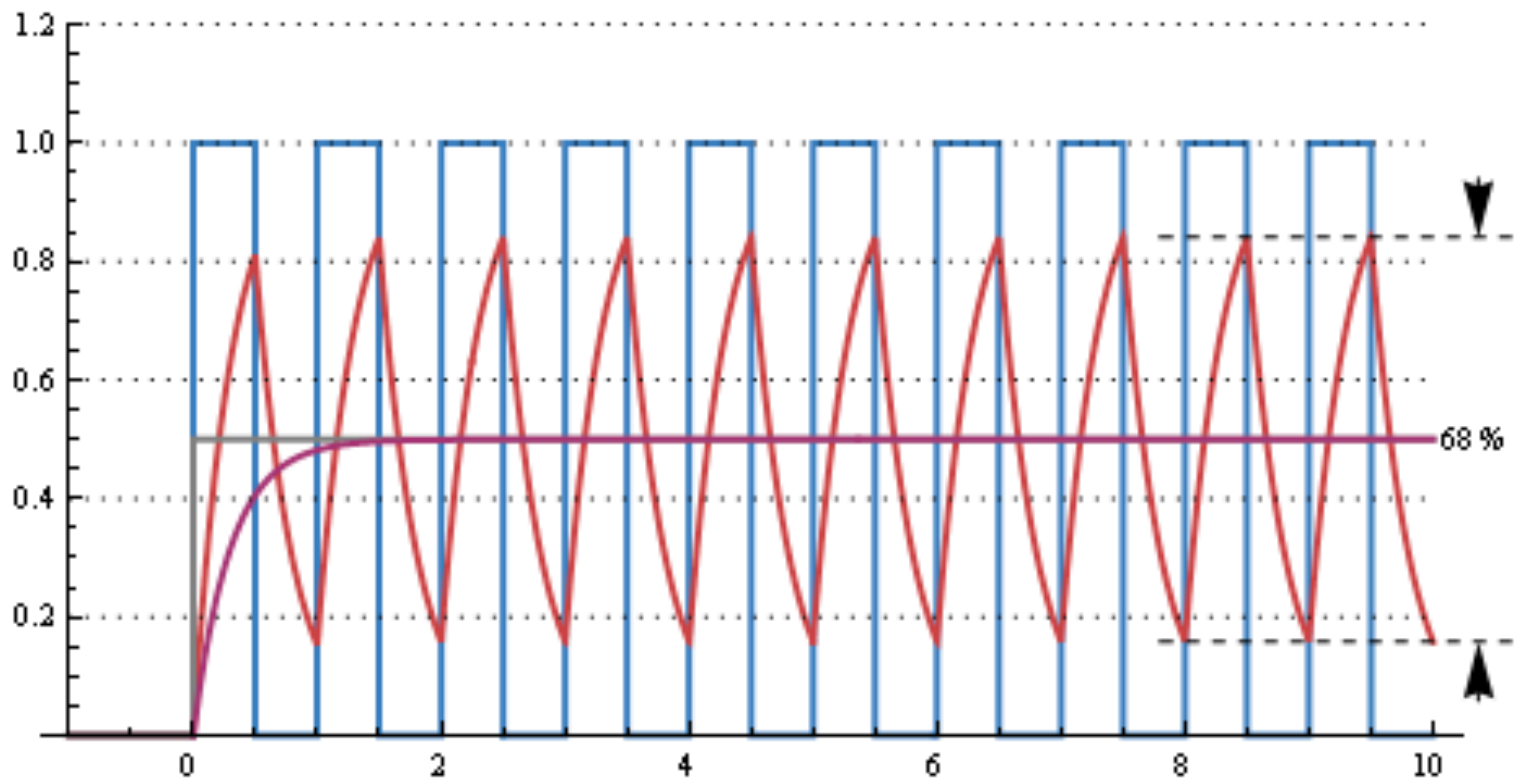
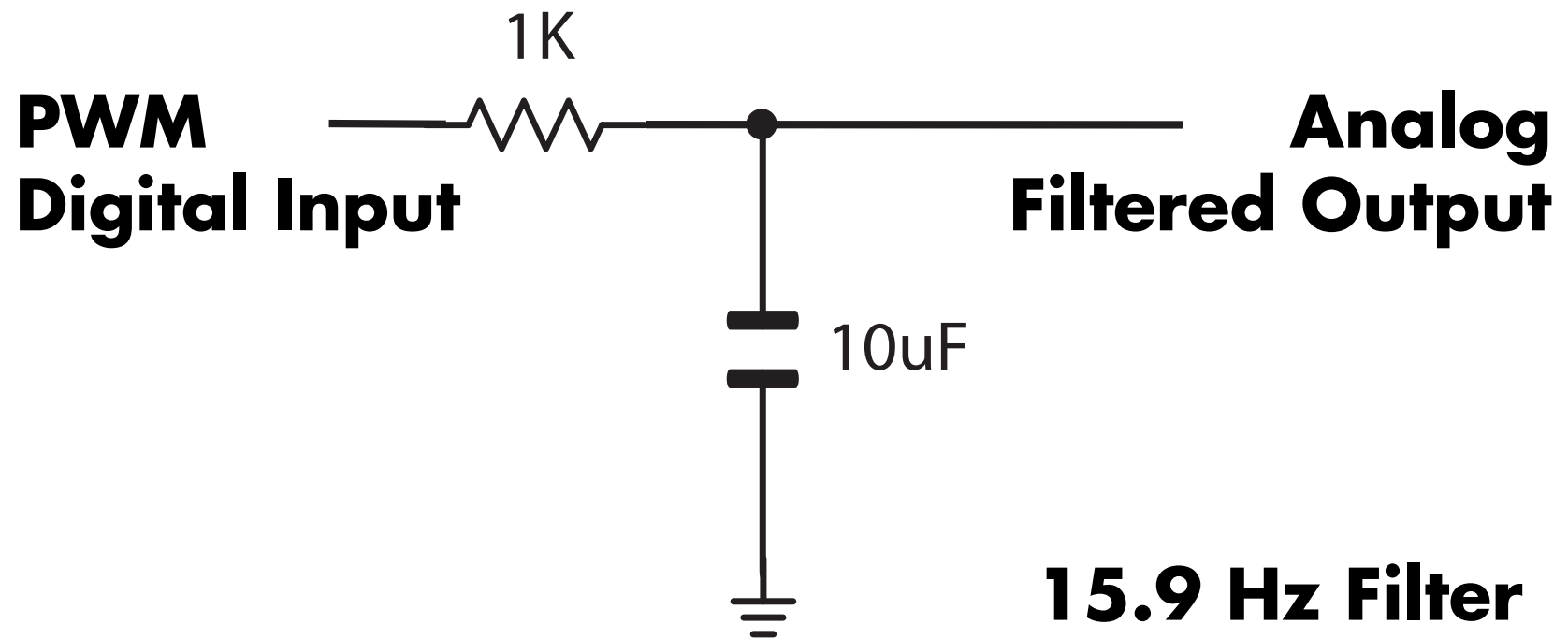


25% duty cycle

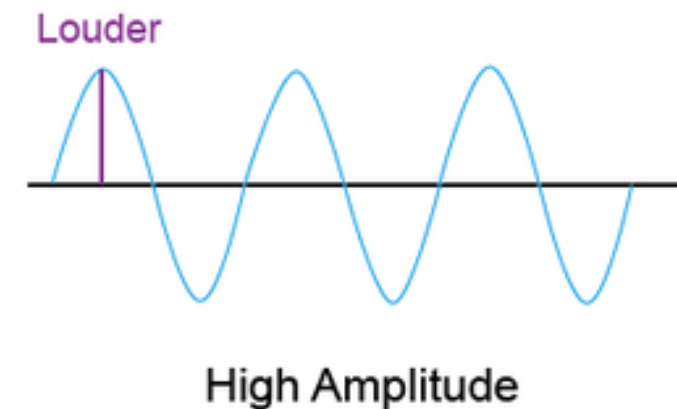
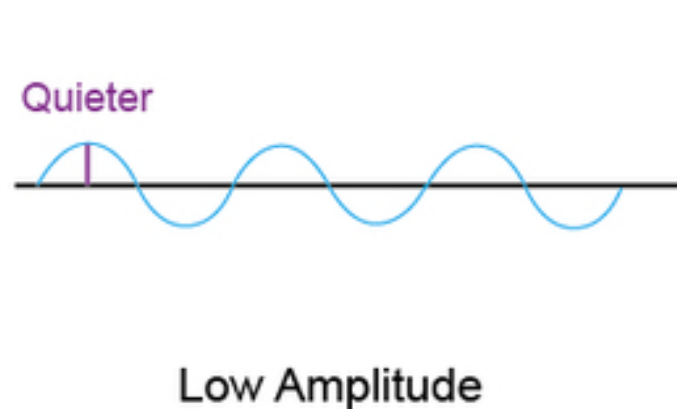
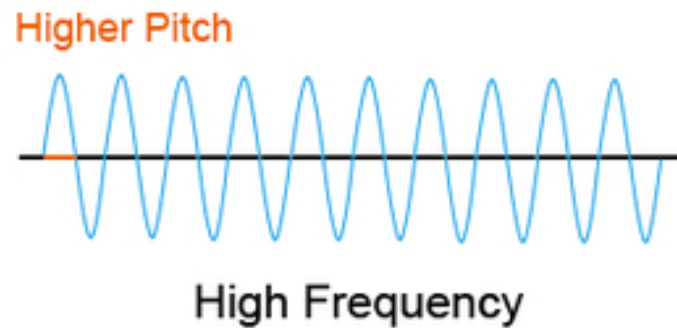
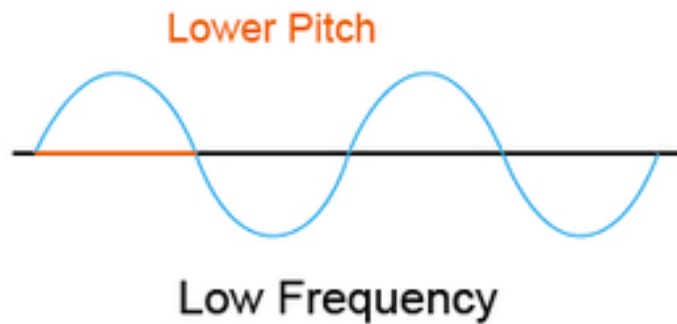


`pwm_clock, pwm_range, pwm_width`

`pwm.c`

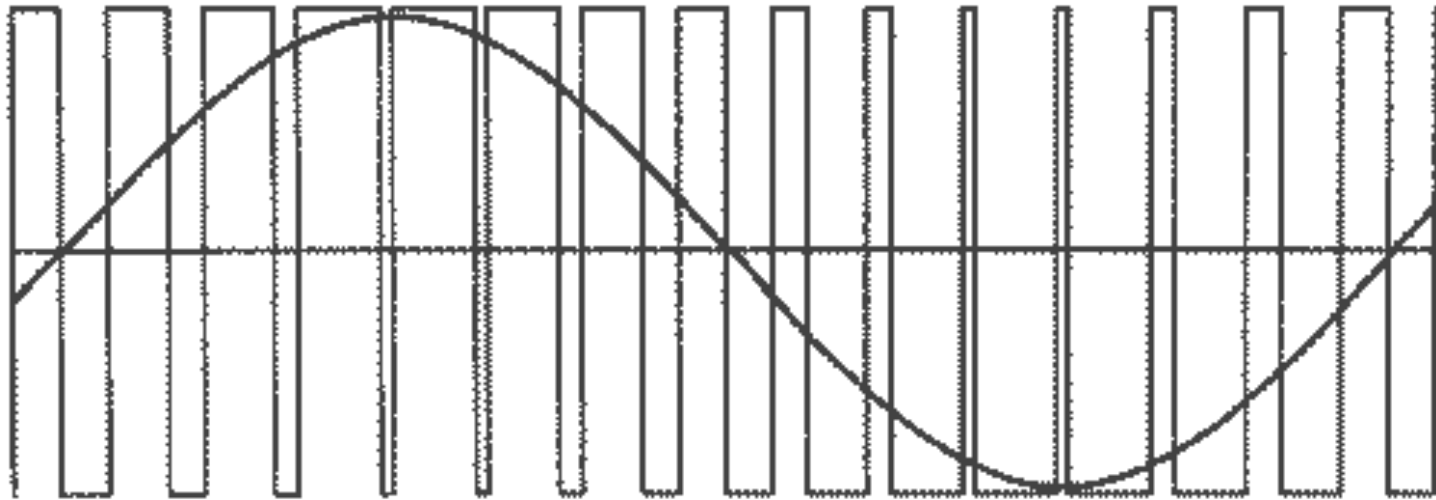


Sound Waves



Continuous Values

Can produce continuous values by filtering out the high frequencies in the PWM signal



111

PWM 1



Raspberry Pi			
Project Code: RPI00021		Title: Raspberry Pi HDMI, SD Card,	
Scale: NTS	Sheet: 02 of 05		File Name:
	Drawn By: PBL		Issue/PMF

Low-pass Filter

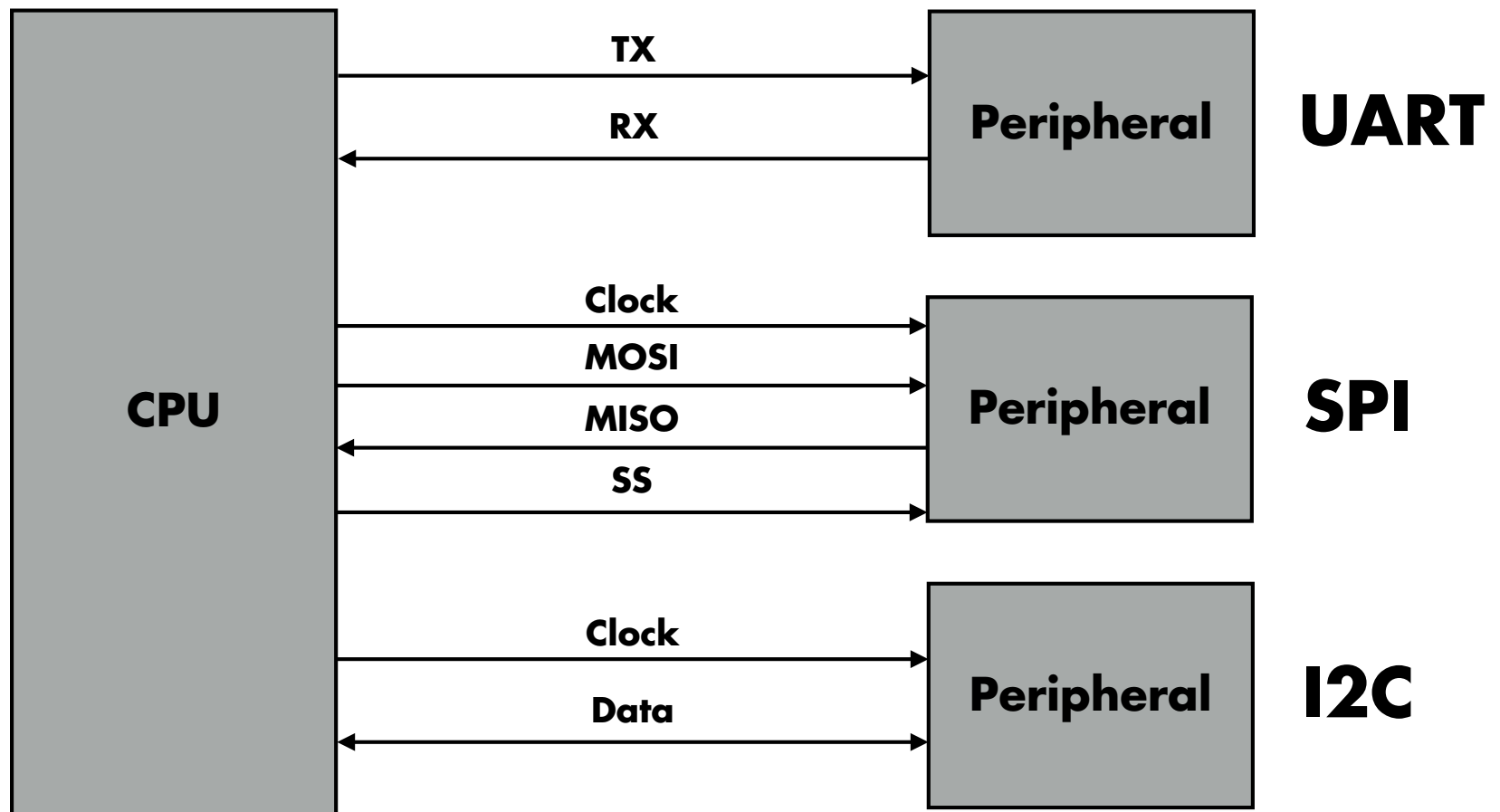
	PWM0	PWM1
GPIO 12	Alt Fun 0	-
GPIO 13	-	Alt Fun 0
GPIO 18	Alt Fun 5	-
GPIO 19	-	Alt Fun 5
GPIO 40	Alt Fun 0	-
GPIO 41	-	Alt Fun 0
GPIO 45	-	Alt Fun 0
GPIO 52	Alt Fun 1	-
GPIO 53	-	Alt Fun 1

**Stereo Jack connected to
GPIO_PIN40 and GPIO_PIN45**

tone.c
melody.c
audio.c

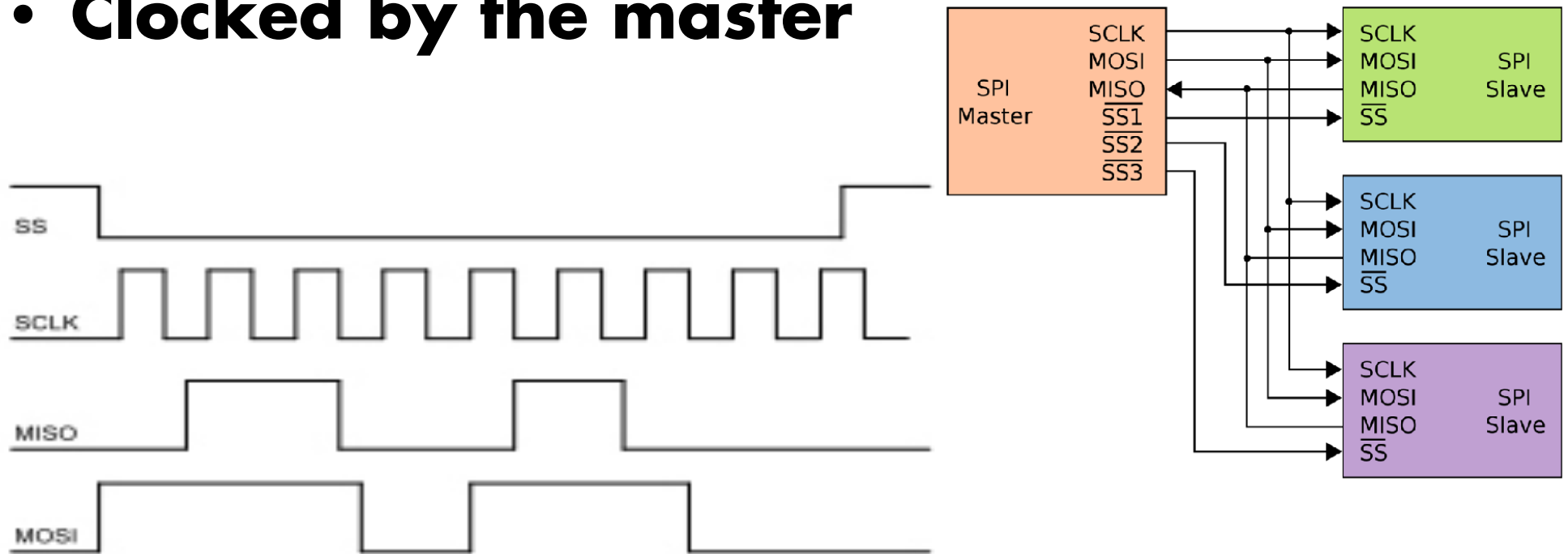
Smart Sensors

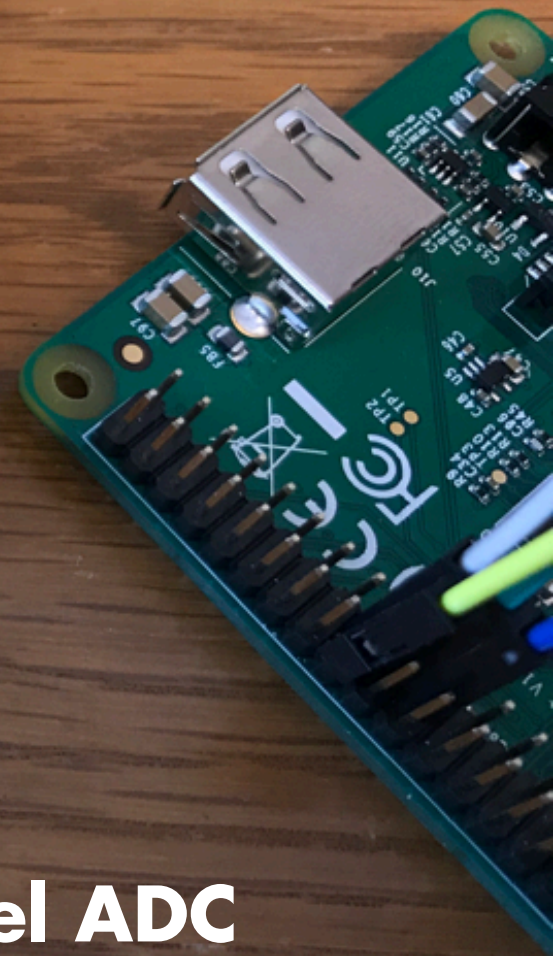
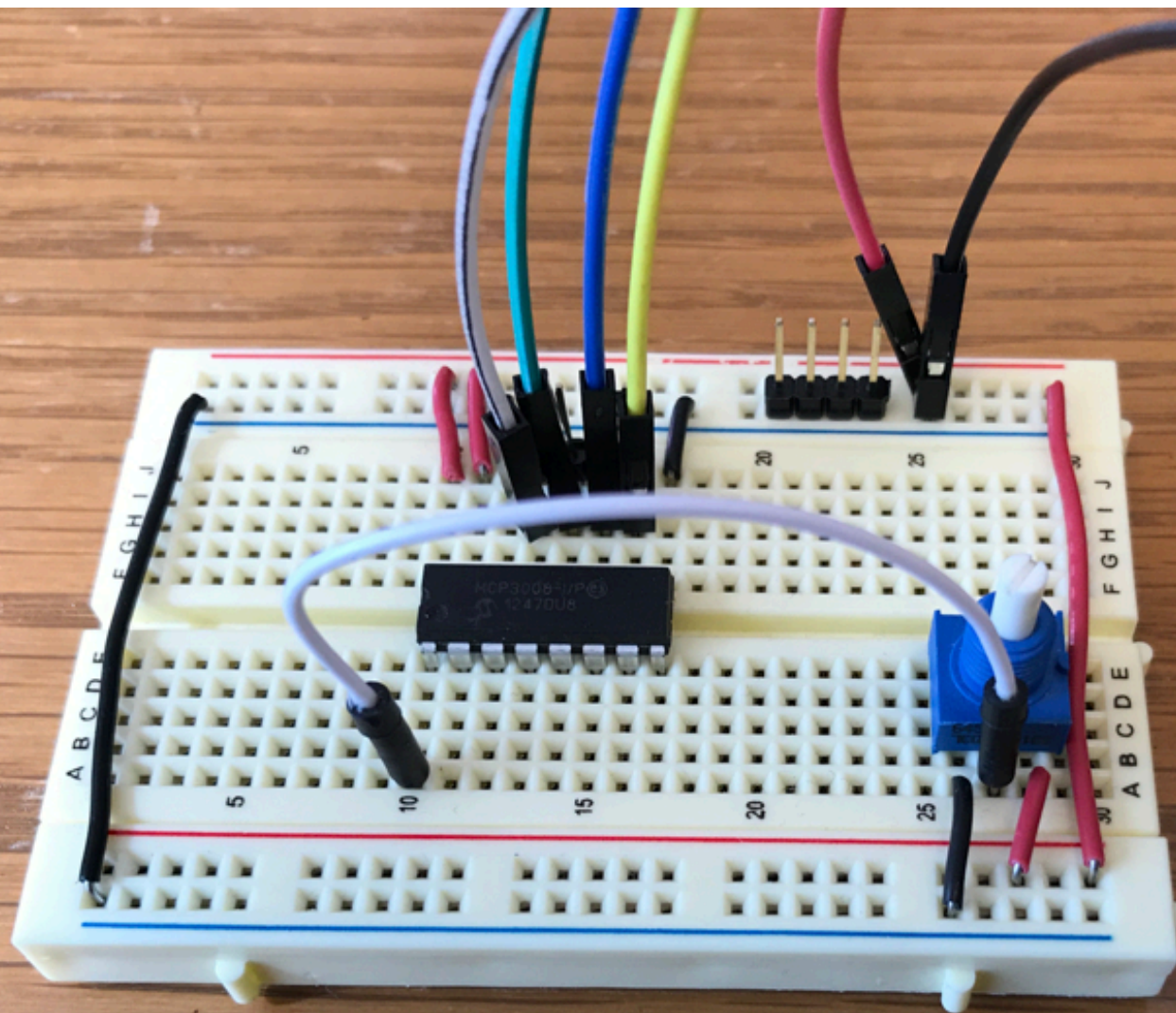
Bus Protocols



SPI

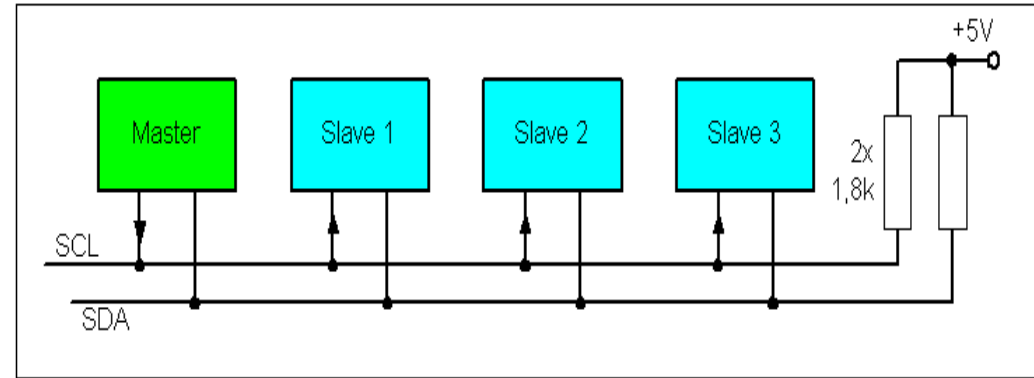
- **Shared CLK, MOSI, MISO lines**
- **Active low slave select (SS) lines to specify which peripheral is active**
- **Clocked by the master**



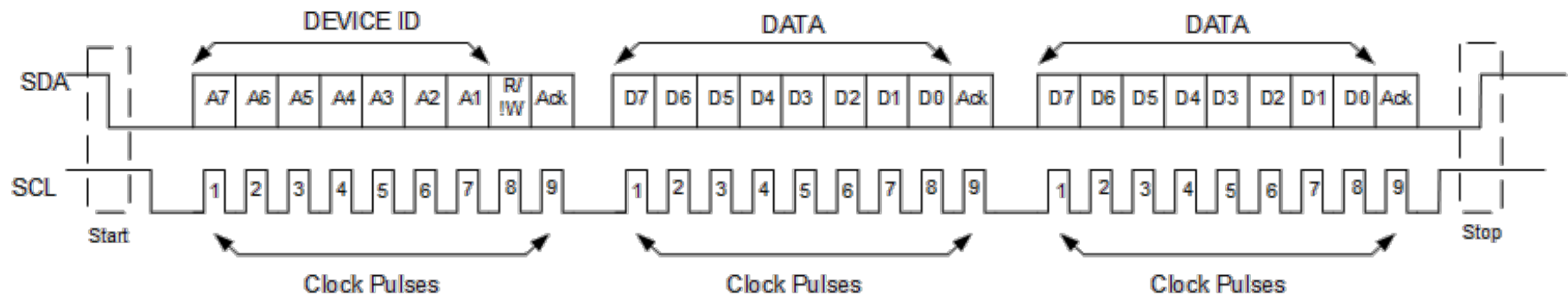


MCP3008 SPI 8-channel ADC

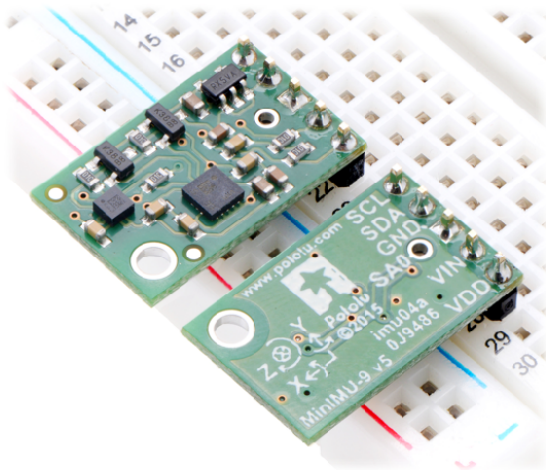
I2C



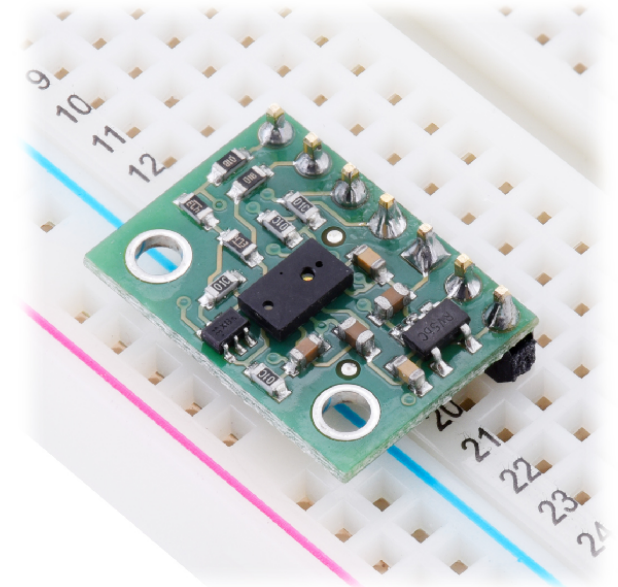
- **CLK & DATA lines (with pull-ups)**
- **Clocked by master, both master and slave and send data**
- **Shared bus, slave identified by 7 (or 10) bit address**



I2C Sensors

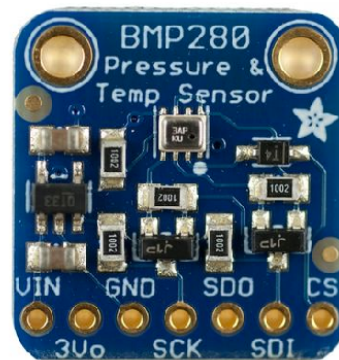


**Accelerometer
Gyroscope
Magnetometer**

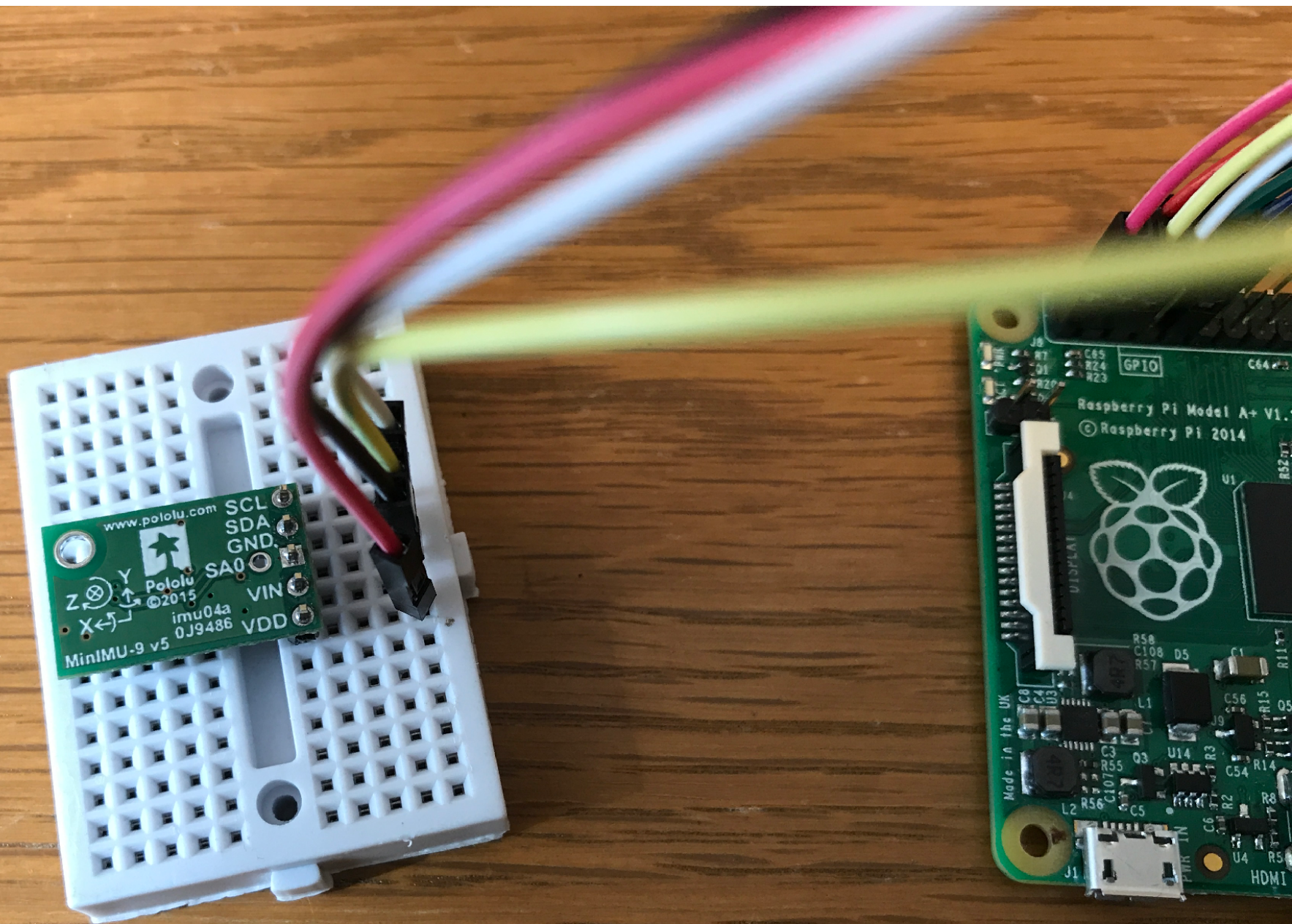


VCSEL Time of Flight

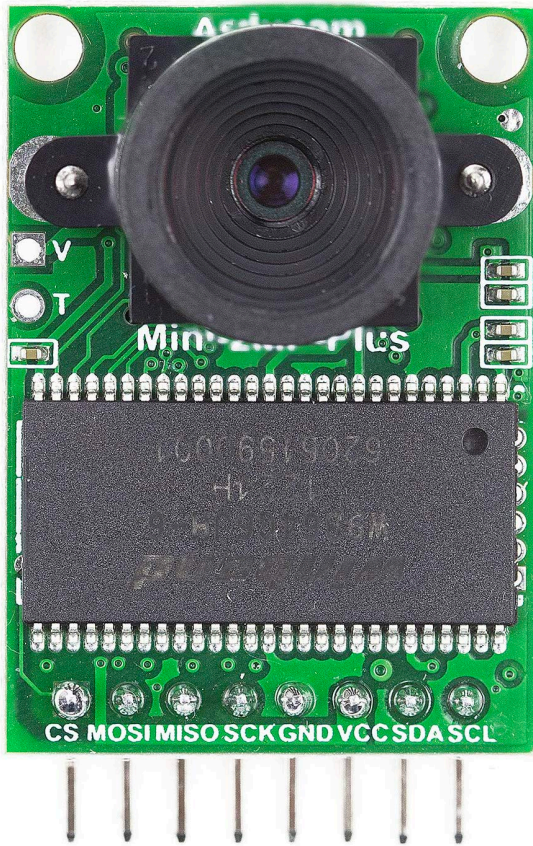
**Temperature,
Humidity,
Pressure**



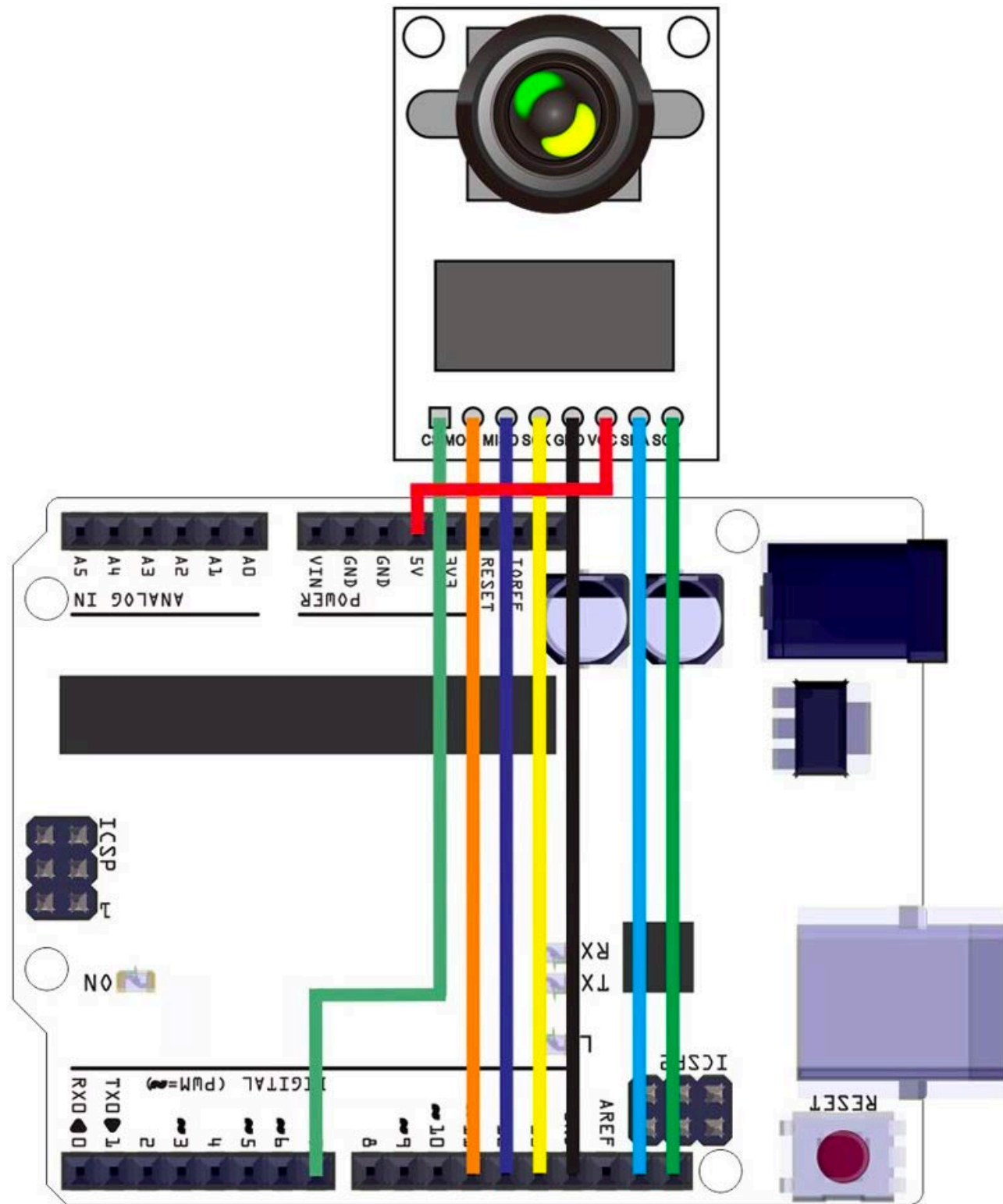
Arducam (SPI and I2C)



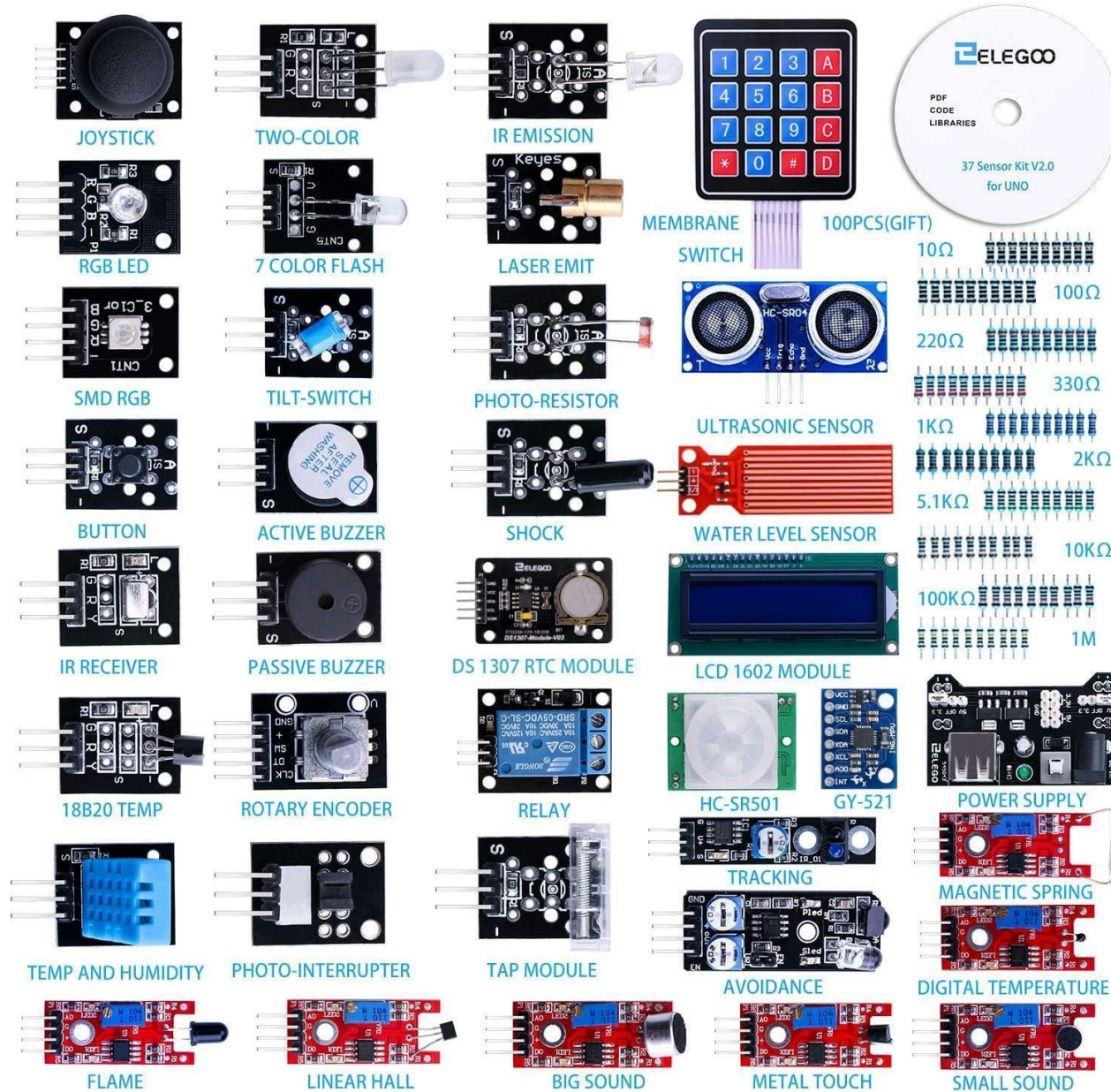
I2C IMU (accelerometer, gyroscope, compass)



Arducam SPI + I2C



ELEGOO Sensor Kit



Download code: <https://www.elegoo.com/blogs/arduino-projects/elegoo-37-in-1-sensor-modules-kit-tutorial>

Sensing the World

Resistance (light dependent resistance, capacitance)-

Convert energy to voltage/current

- **Light (phototransistor)**
- **Sound/pressure/deformation (microphone, piezo, electret, strain gauge, pressure gauge)**
- **Temperature (infrared, humidity, pressure)**
- **Electromagnetic fields (hall effect, compass, coil, antenna)**

Smart sensors (sensor with a digital interface)

- **Acceleration/Gyroscope/Magnetic**
- **Camera, IMU (inertial management unit), ...**