Final Projects

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

Form project teams NOW - 1-3 people (2 best)

Google form due 11:59 pm Thursday November 18th

- **Include teammates for shared git repo**
- **Includes short project proposal**

Two labs

- **1st - refine project ideas and solid milestones**
- **2nd - finish milestones and final push**

Class demos (12:15pm Thurs Dec 9)

Final code and writeup submission (due Noon on Thursday, Dec. 9th)

$20 parts budget per person; need to submit receipts

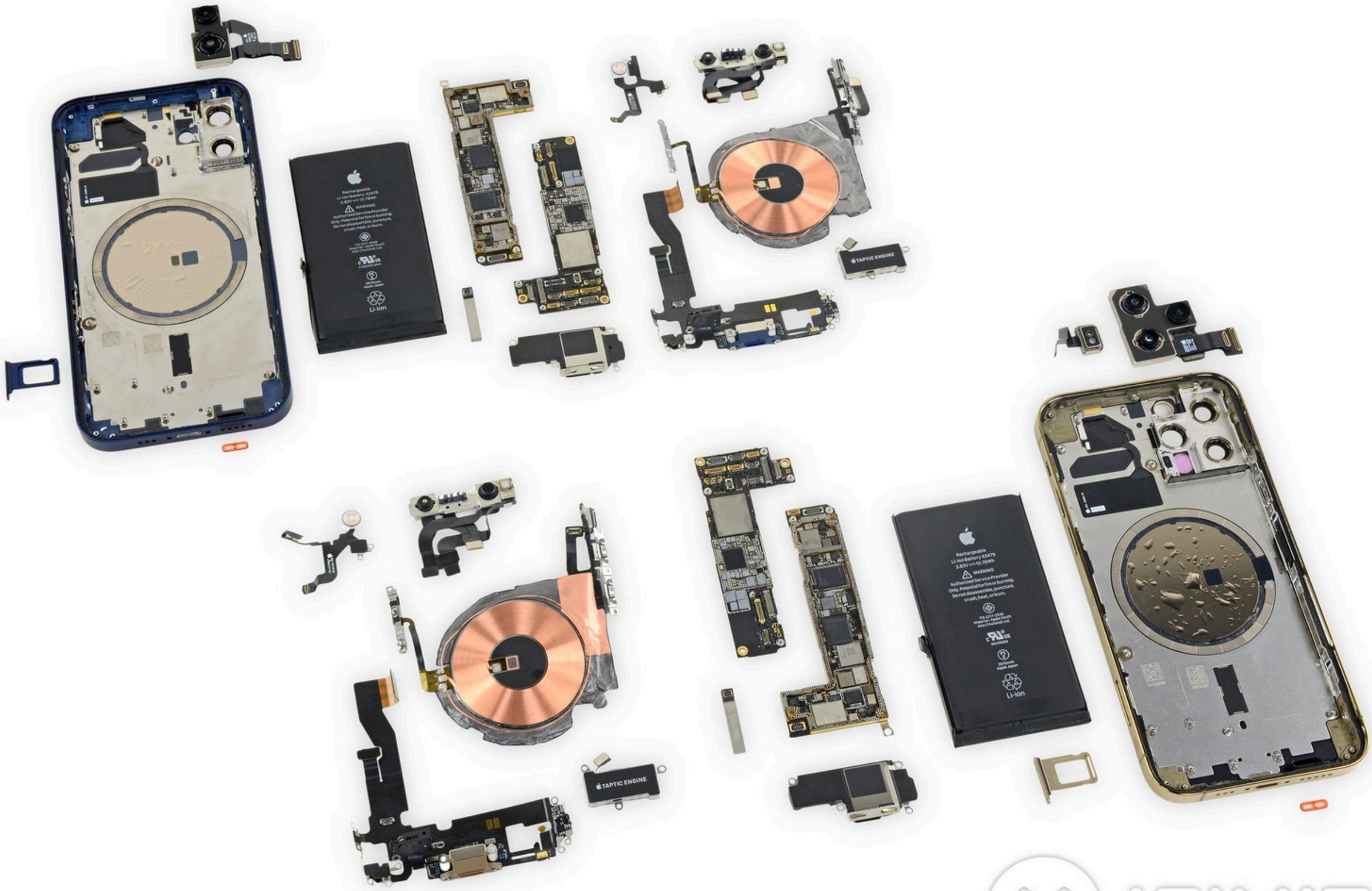
Extensions

After some consideration, we are extending the extensions deadline from the original Assignment 7 due date to *Tuesday, November 23rd*. This is during Thanksgiving break, but before Thanksgiving itself. :)

CS107e

Sensors

Apple iPhone 12 Teardown



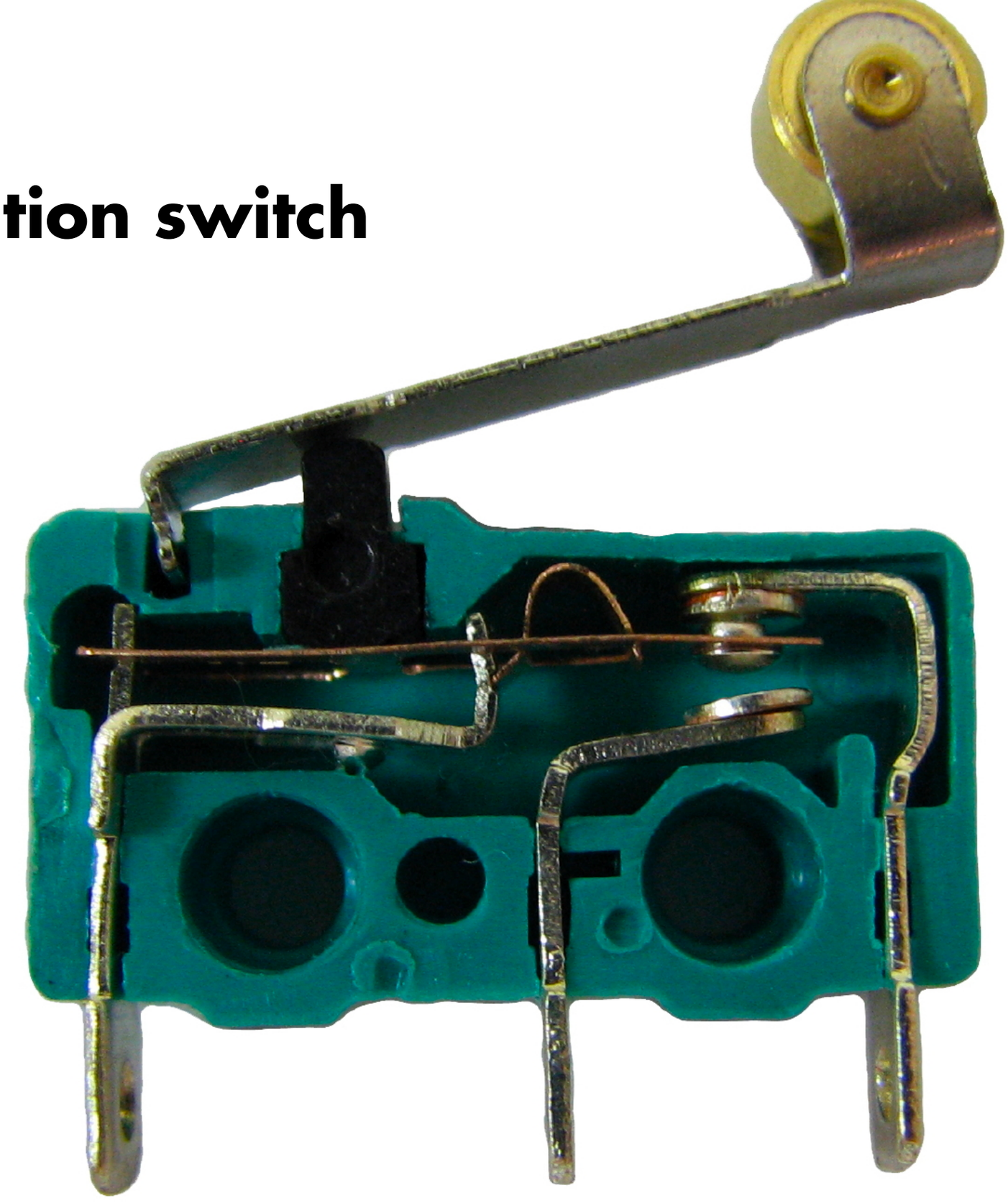
How many sensors?

Apple iPhone 12

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)

Snap-action switch



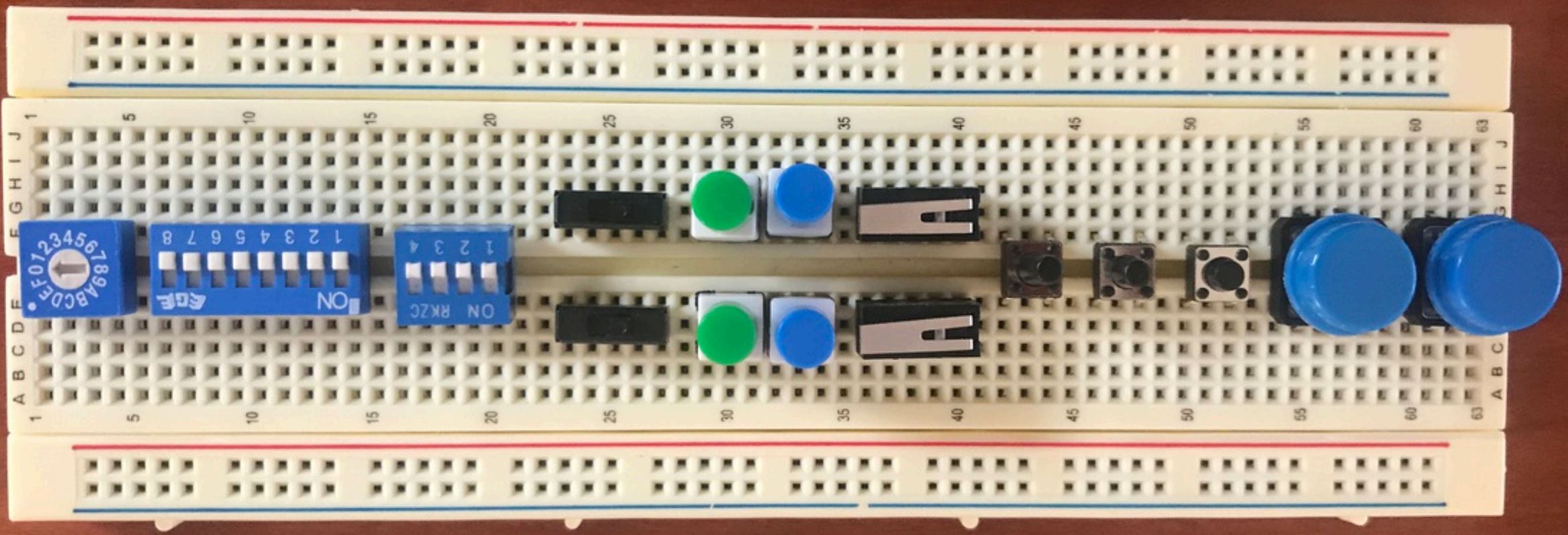
Common **NO** **NC**

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

Happ Pushbutton

Happ Joystick

Buttons and Switches

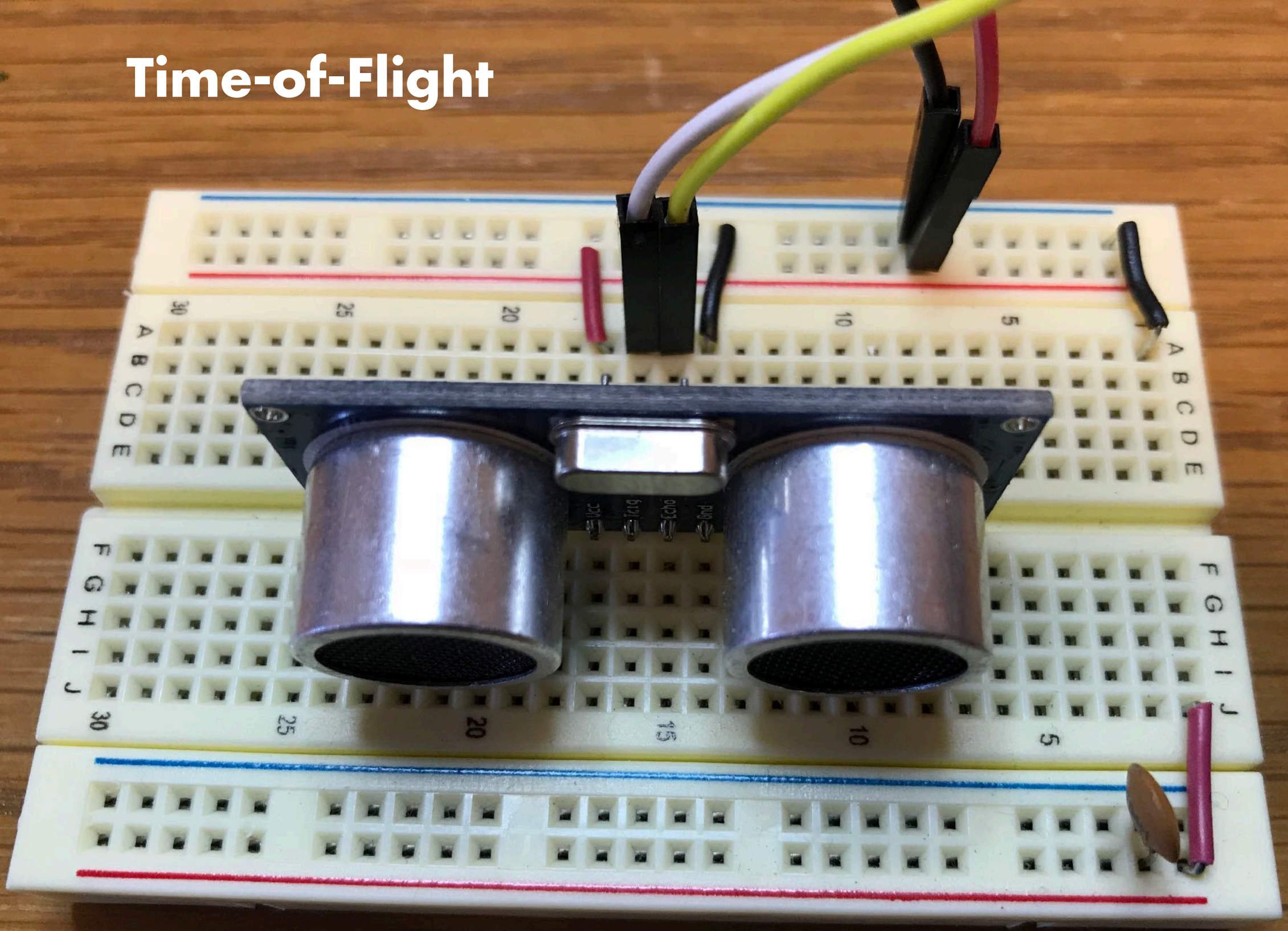


Rotary Encoder

- **A rotary encoder has a knob that turns, and "clicks" after small rotations.**
- **You can programmatically determine which direction the rotation occurred**
- **Pushing down on the knob clicks a button**
- **https://lastminuteengineers.com/rotary-encoder-arduino-tutorial/**

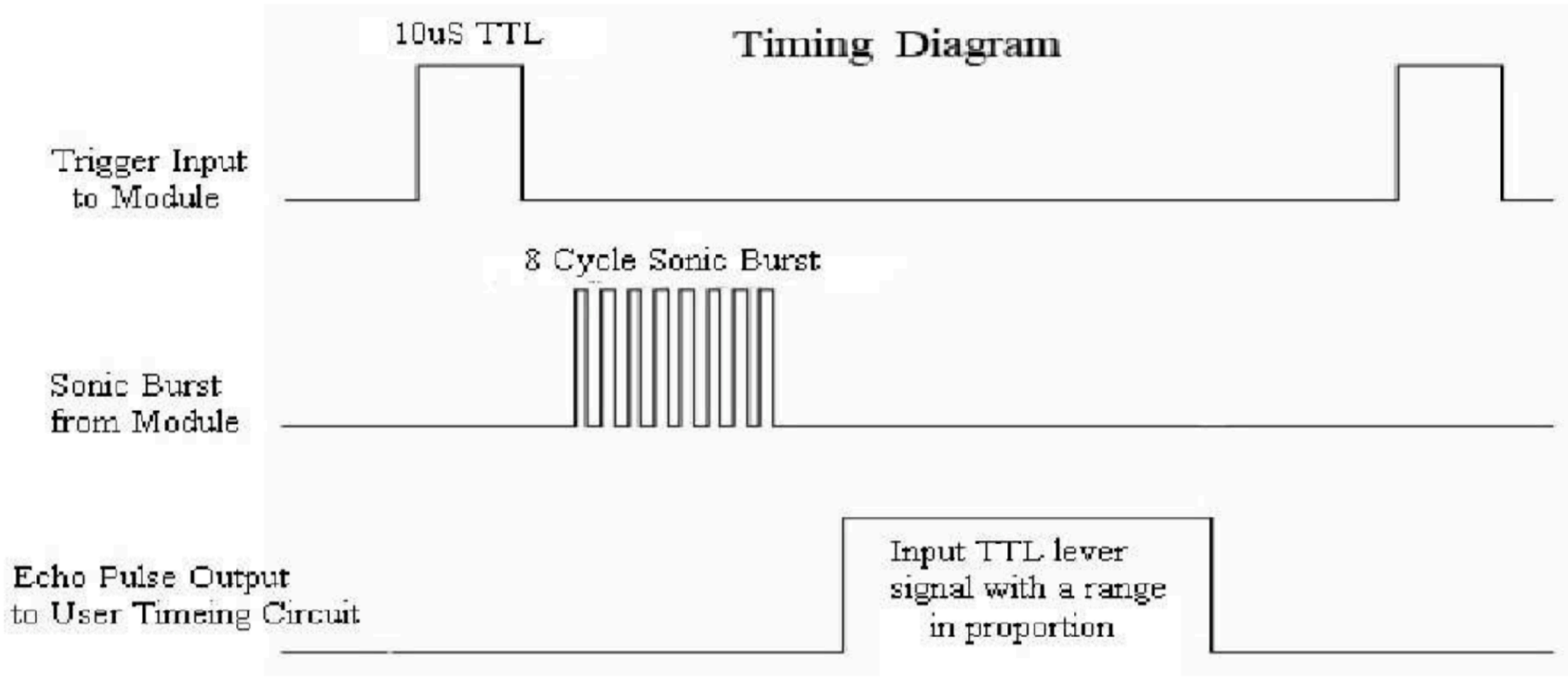
Data Sheet and example code: https://www.handsontec.com/dataspecs/module/Rotary%20Encoder.pdf

Time-of-Flight

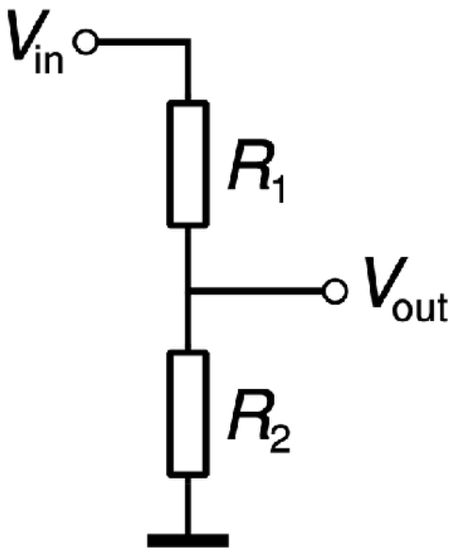


HC04 Ultrasonic Sonar

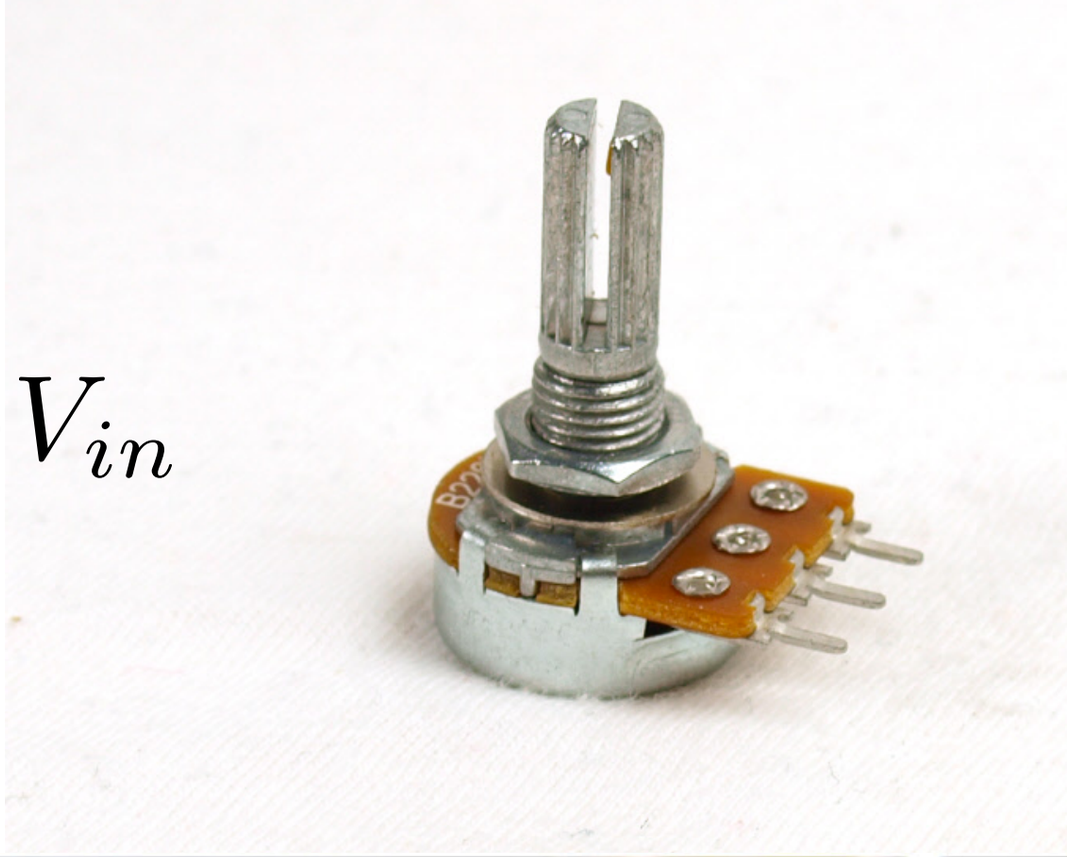
The Timing diagram is shown below. You only need to supply a short 10uS pulse to the trigger input to start the ranging, and then the module will send out an 8 cycle burst of ultrasound at 40 kHz and raise its echo. The Echo is a distance object that is pulse width and the range in proportion .You can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

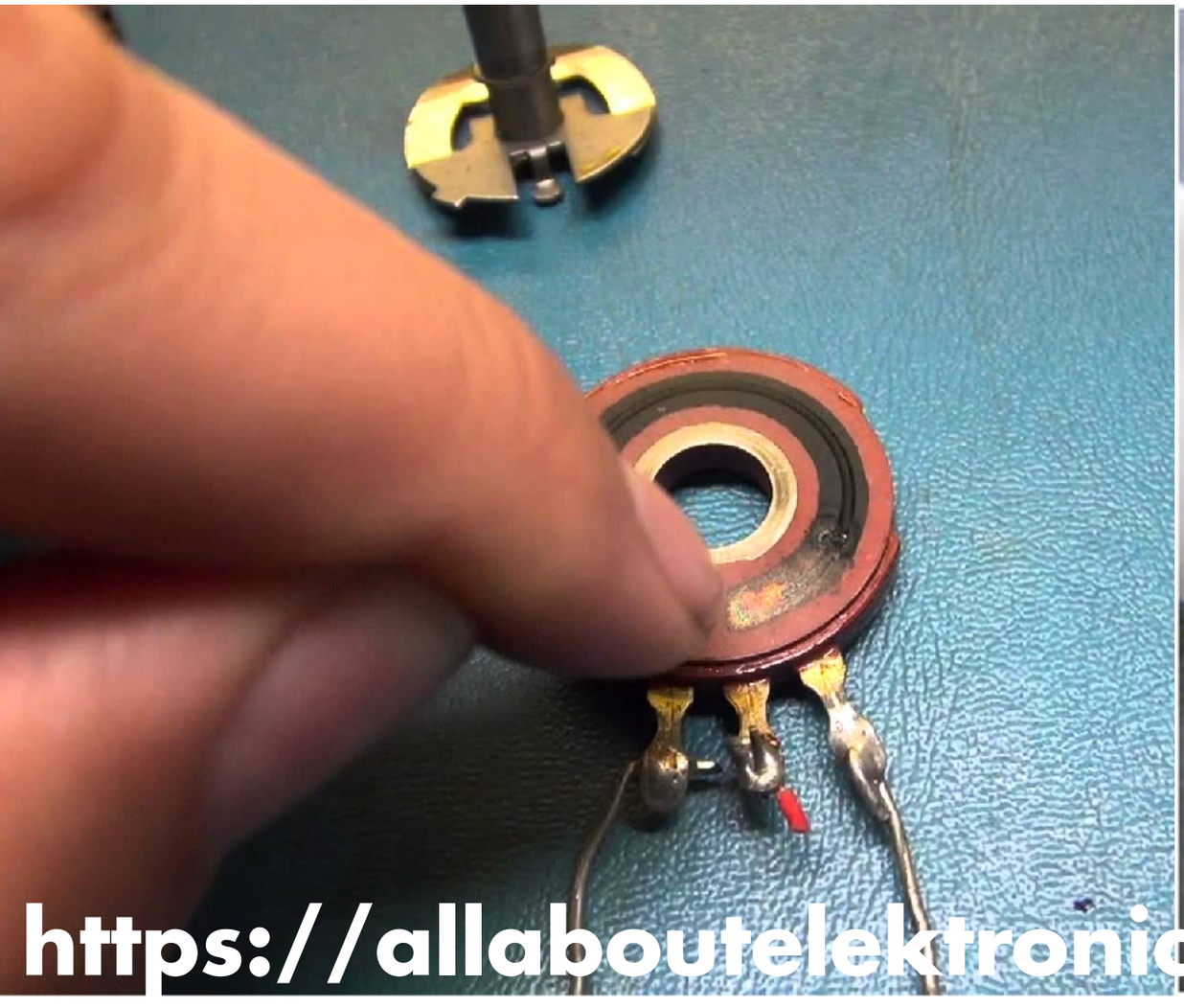


Analog to Digital (ADC)

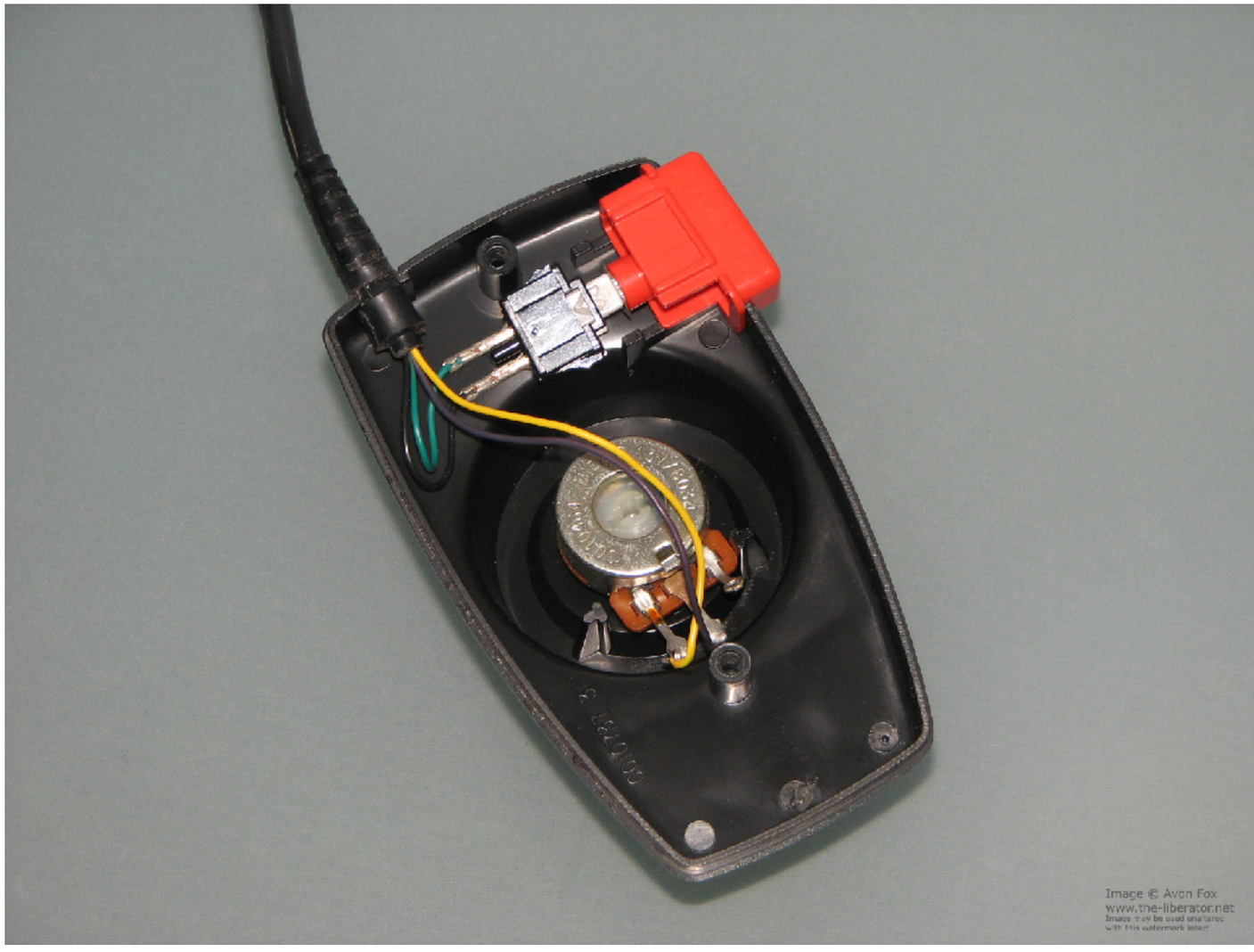


$$V_{out} = \frac{R_2}{R_1 + R_2} V_{in}$$



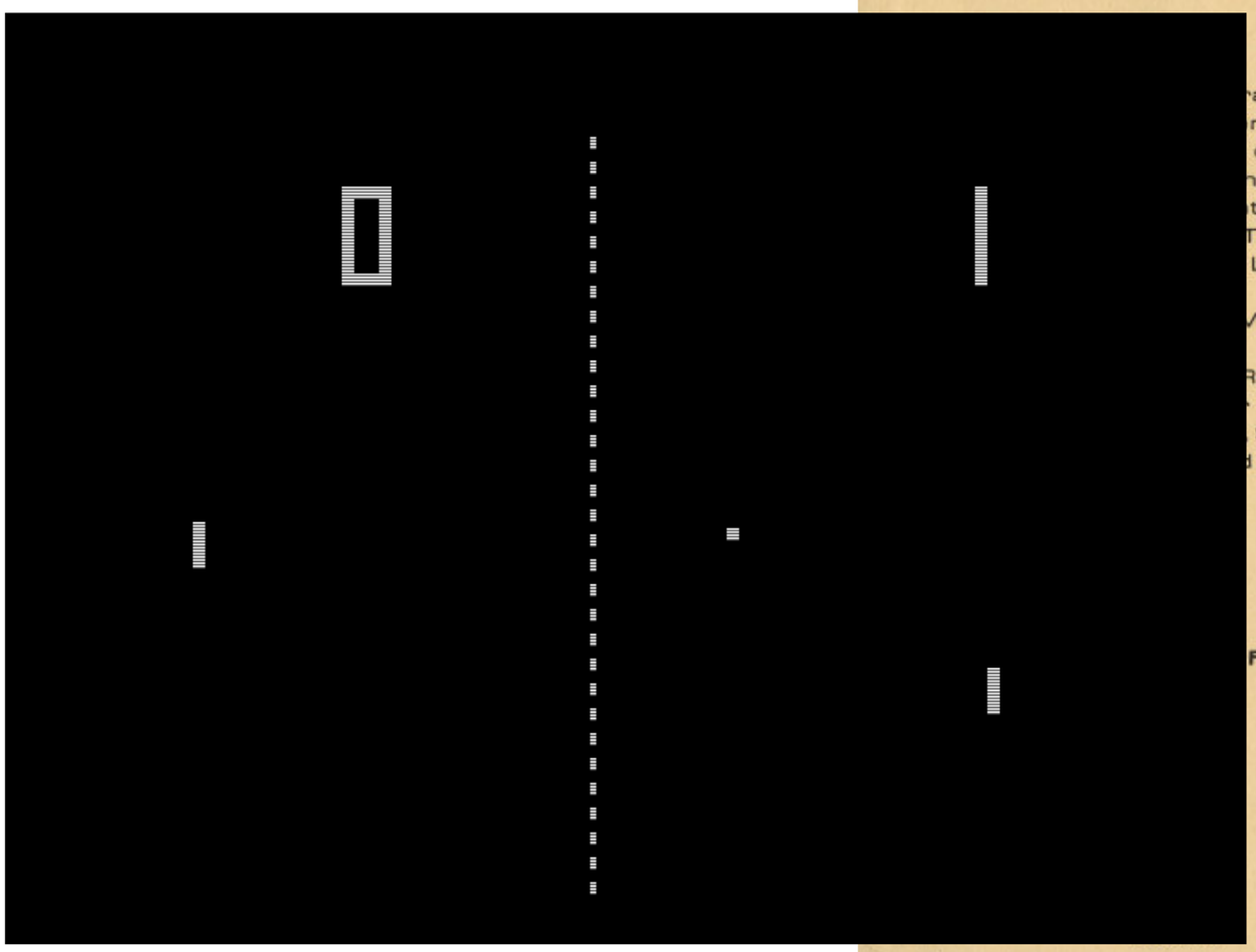


https://allaboutelektronics.wordpress.com/resistors/



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

ract Mode
matically
of Ball
ng Paddle
te Controls
TE TV and
Long.

MPUTER

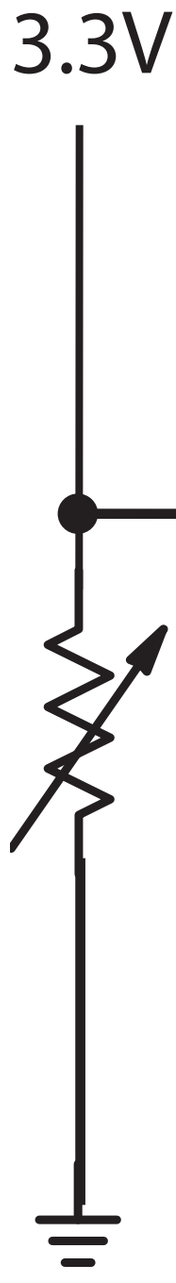
ROFITS
Location
Suitable
d Locations

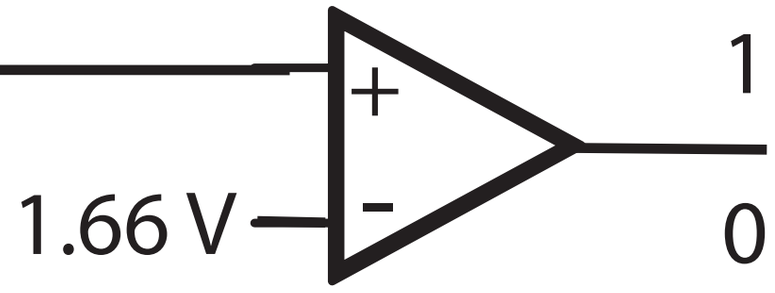
FROM YOUR LOCAL DISTRIBUTOR

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

Potentiometer

(Voltage divider)

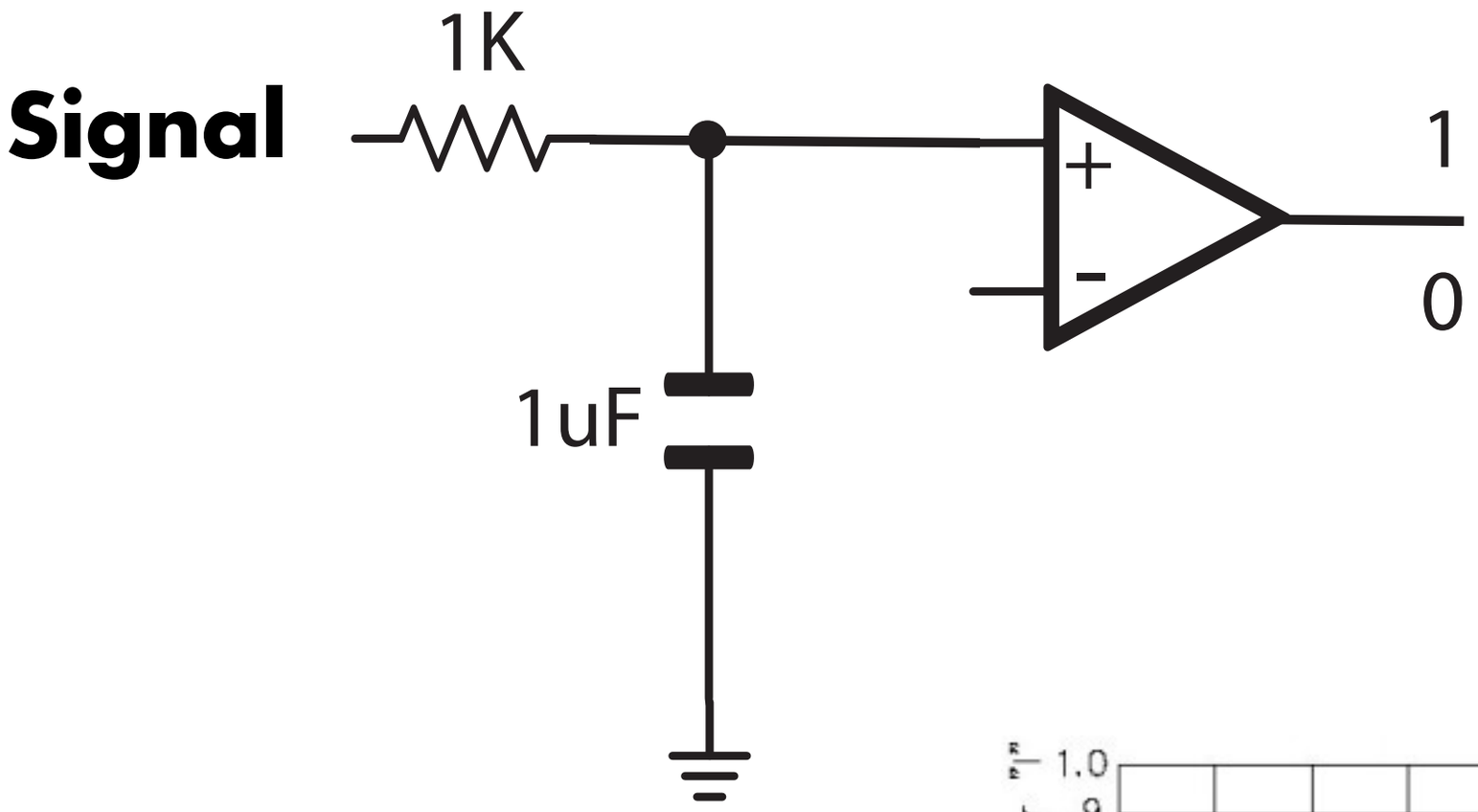




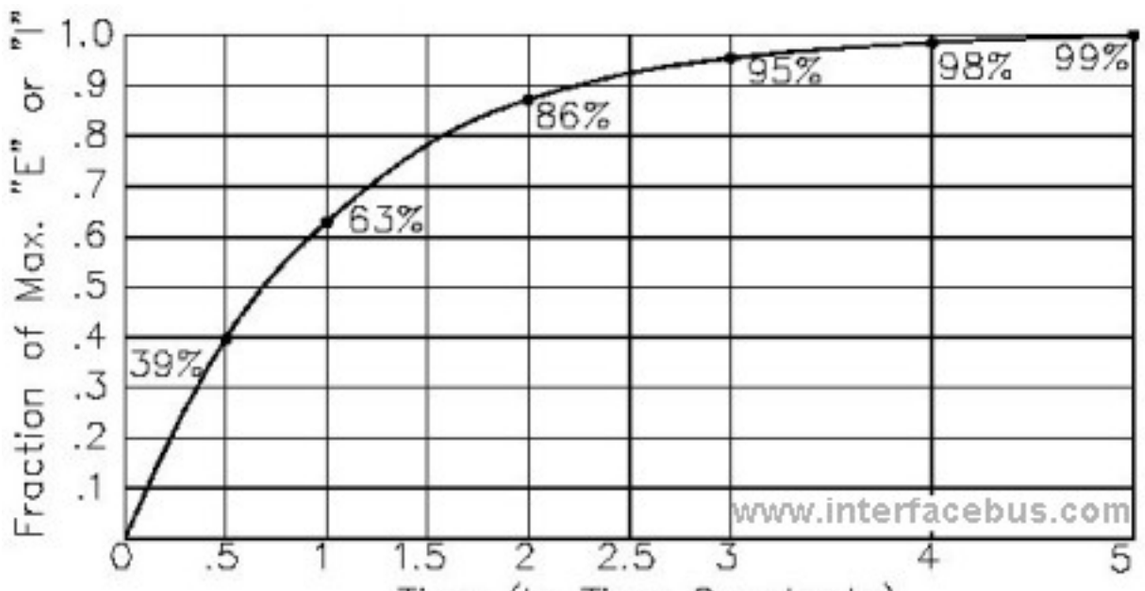
GPIO Input = Comparator

Charging Circuit

The time to fire depends on the input signal voltage

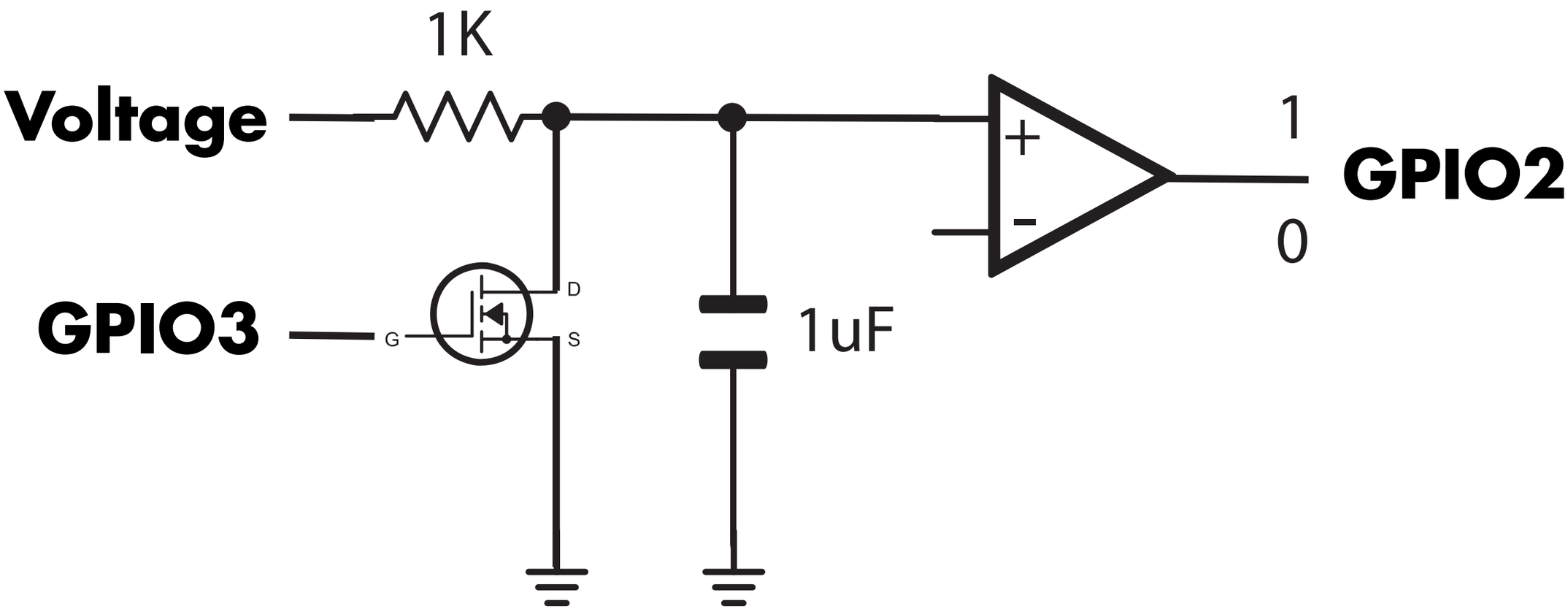


$RC = 10^3 \times 10^{-6} = 1000usecs$



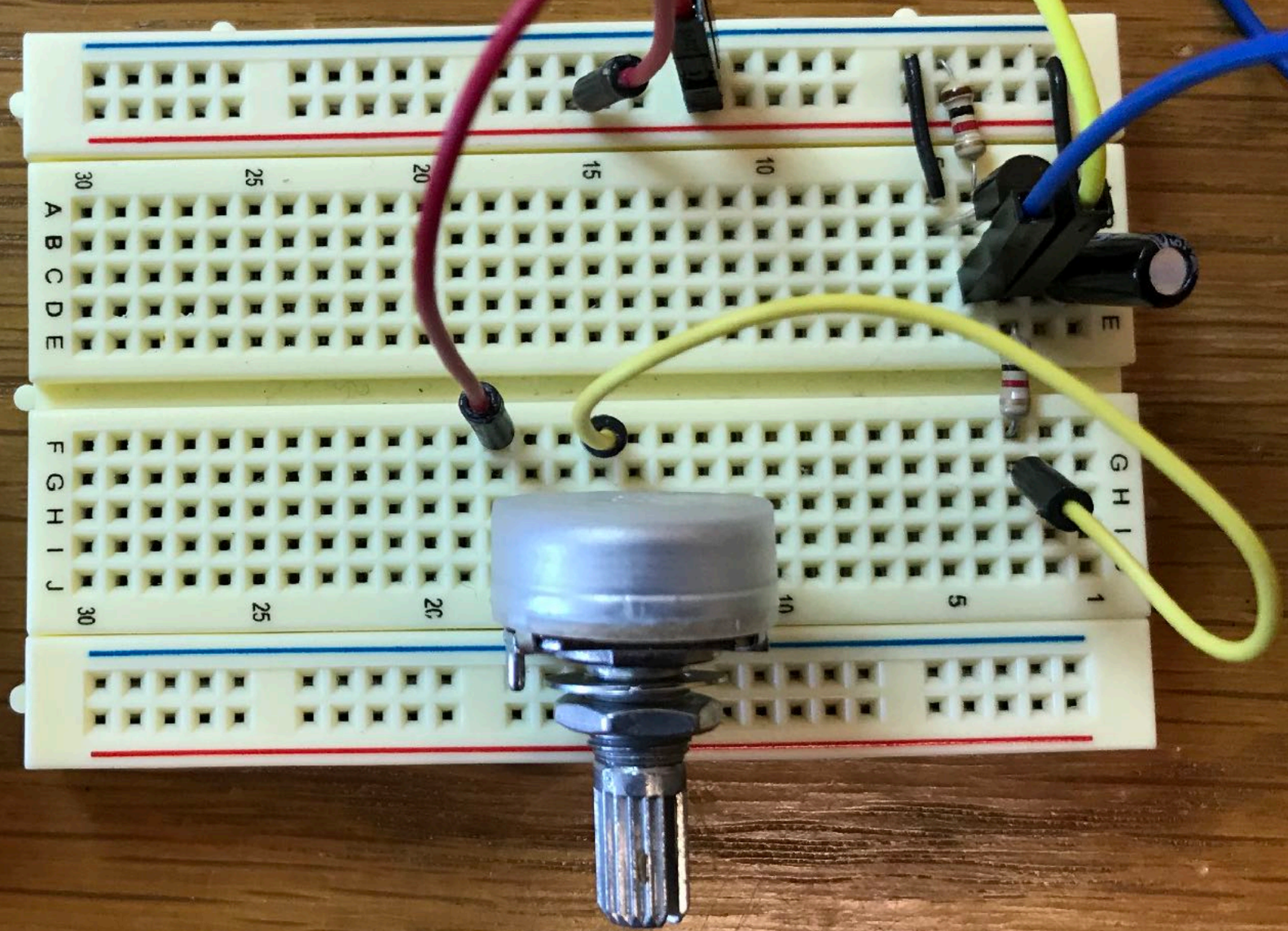
ADC

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



RC = 1000 usecs


U/D+
L/R
U/D
GND


A B C D E
F G H I J
30
25
20
15
10
5
1

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)

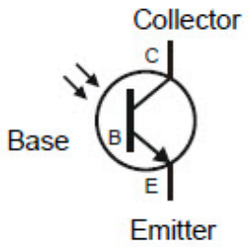
Here we go again with an analog circuit!

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

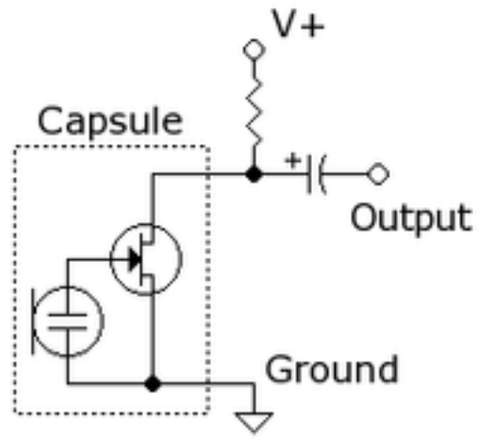
The Raspberry Pi GPIO pins are all digital, but this joystick is analog!

We can use our code from the potentiometer demo!

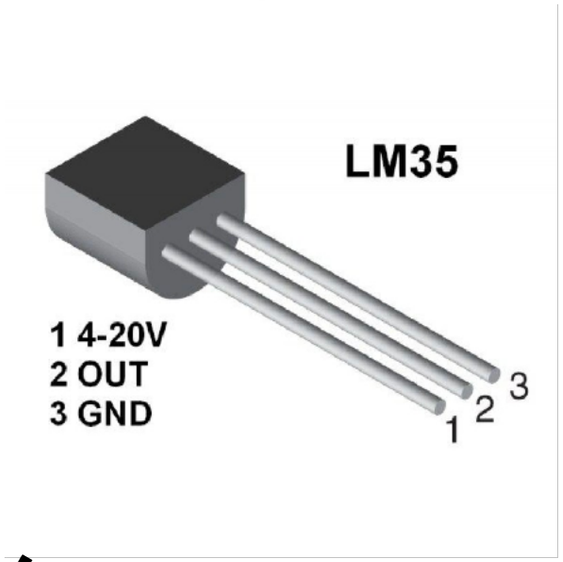
Analog Sensors



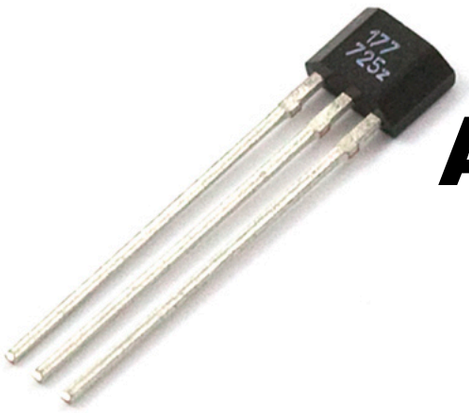
Phototransistor (light)



Electret Microphone (pressure)



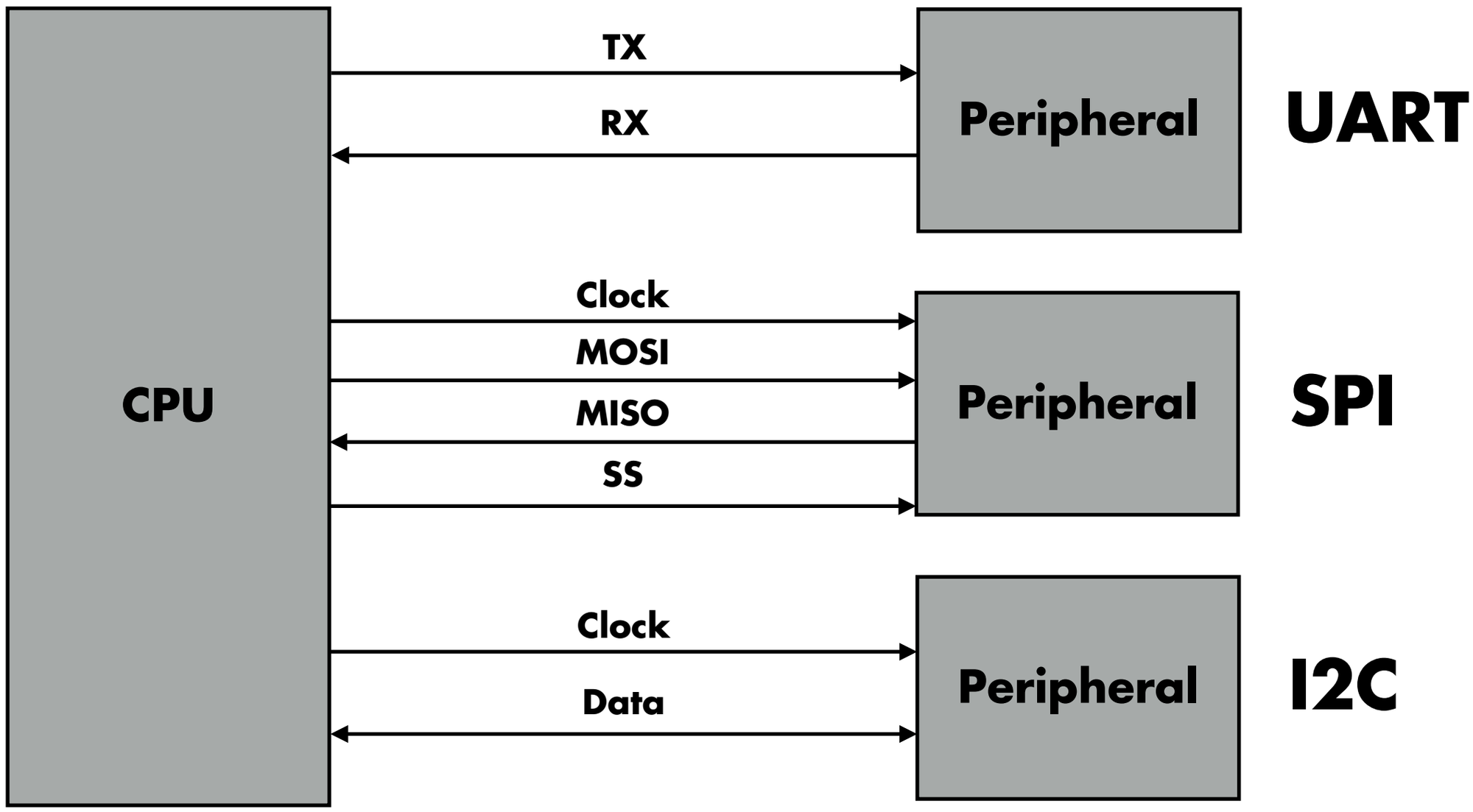
(temperature)



Analog Hall Effect (magnetic field)

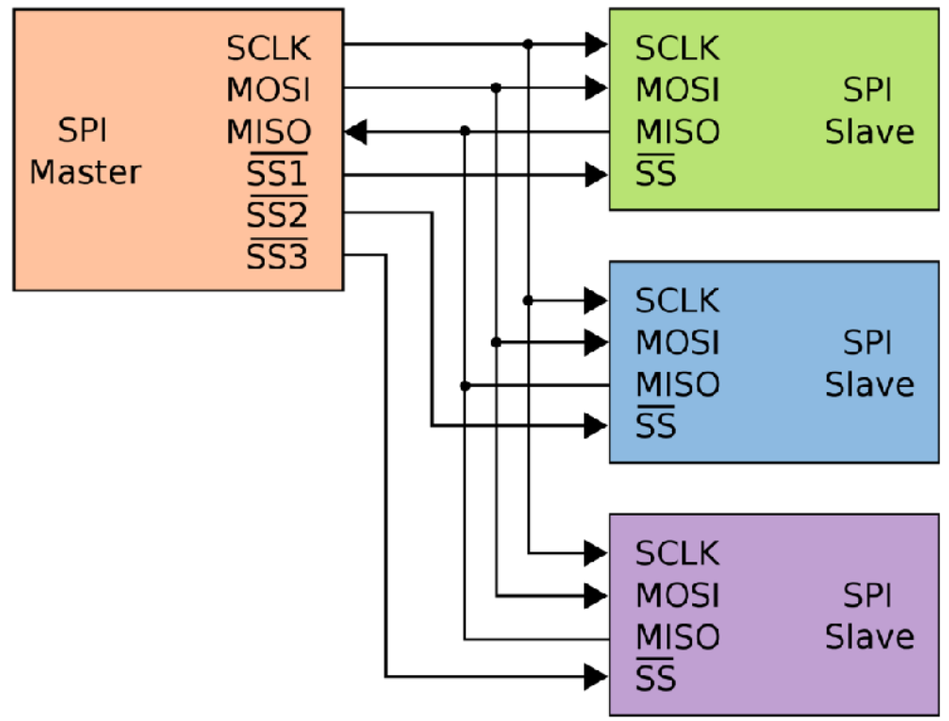
Smart Sensors

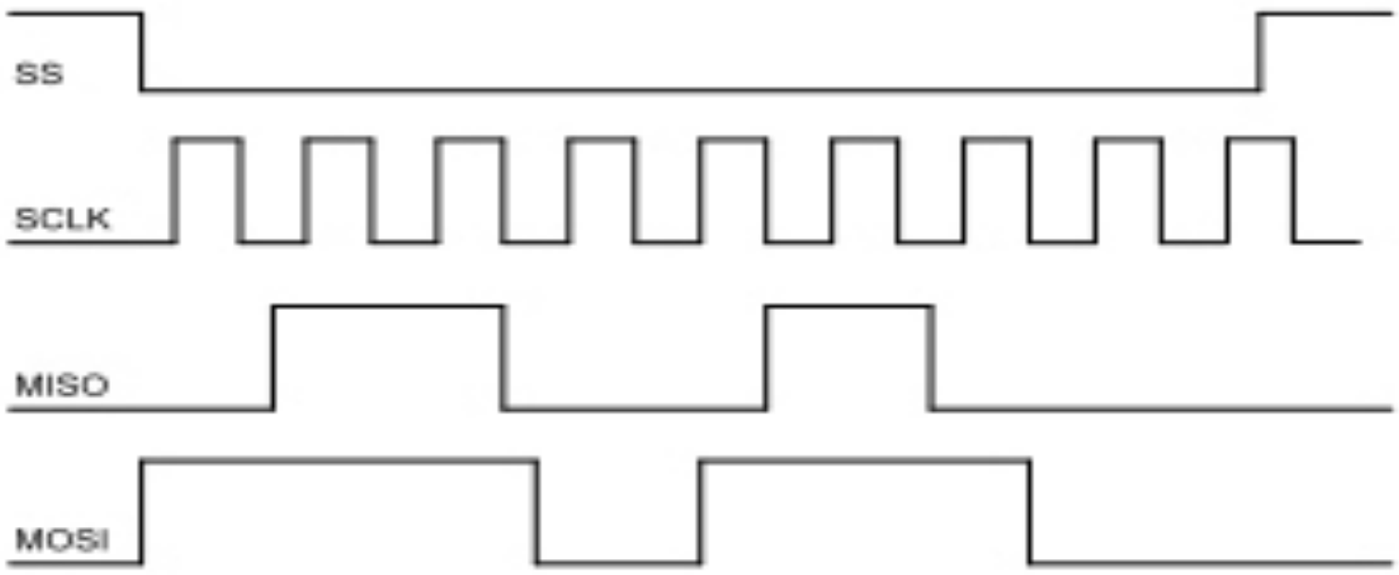
Bus Protocols



SPI

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

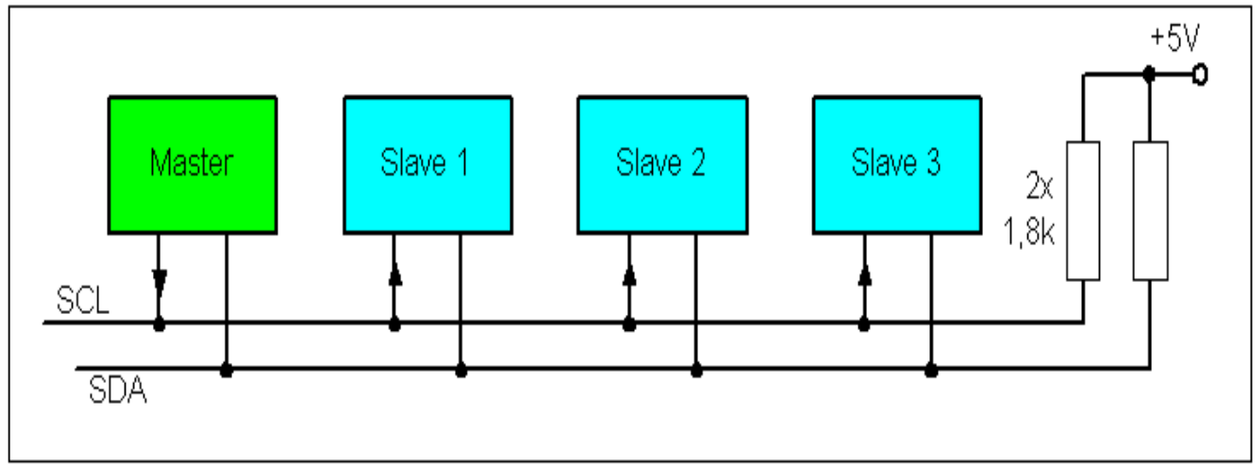




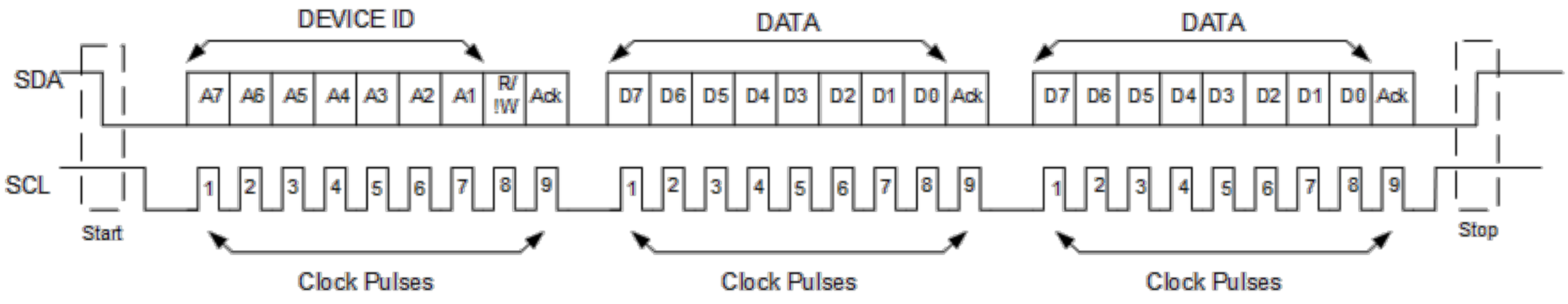
Figures from https://upload.wikimedia.org/wikipedia/commons/thumb/f/fc/SPI_three_slaves.svg/2000px-SPI_three_slaves.svg.png (top), http://www.tequipment.net/RigolSD-SPI-DS4.html (bottom)

MCP3008 SPI 8-channel ADC

I2C

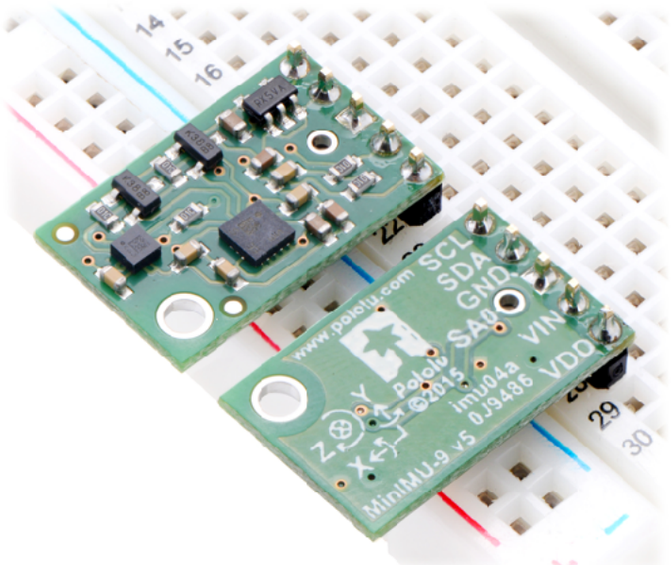


- **CLK & DATA lines (with pull-ups)**
- **Clocked by master, both master and slave and send data**
- **Shared bus, slave identified by 7 (or 10) bit address**

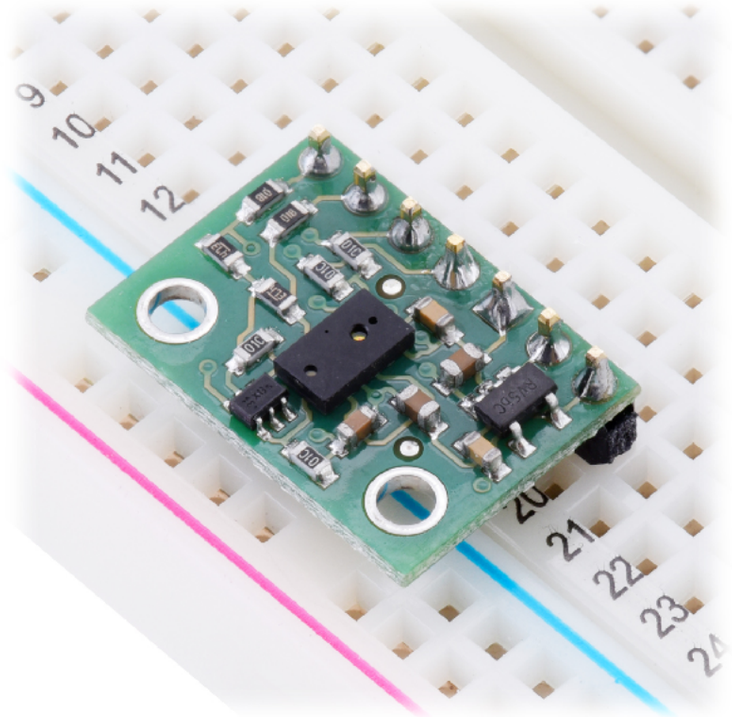


Figures from http://www.cs.fsu.edu/~baker/devices/notes/graphics/i2cbus3.gif (top)
https://learn.digilentinc.com/Documents/chipKIT/chipKITPro/P08/Fig_1_Waveform.png (bottom)

I2C Sensors

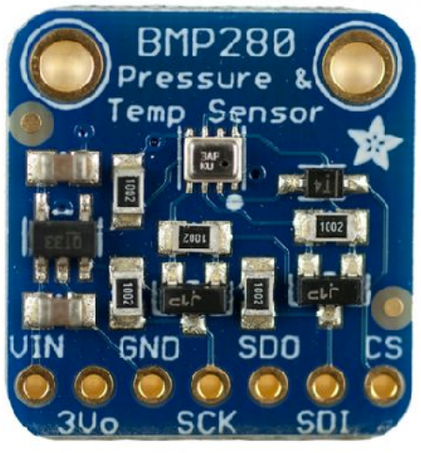


Accelerometer
Gyroscope
Magnetometer

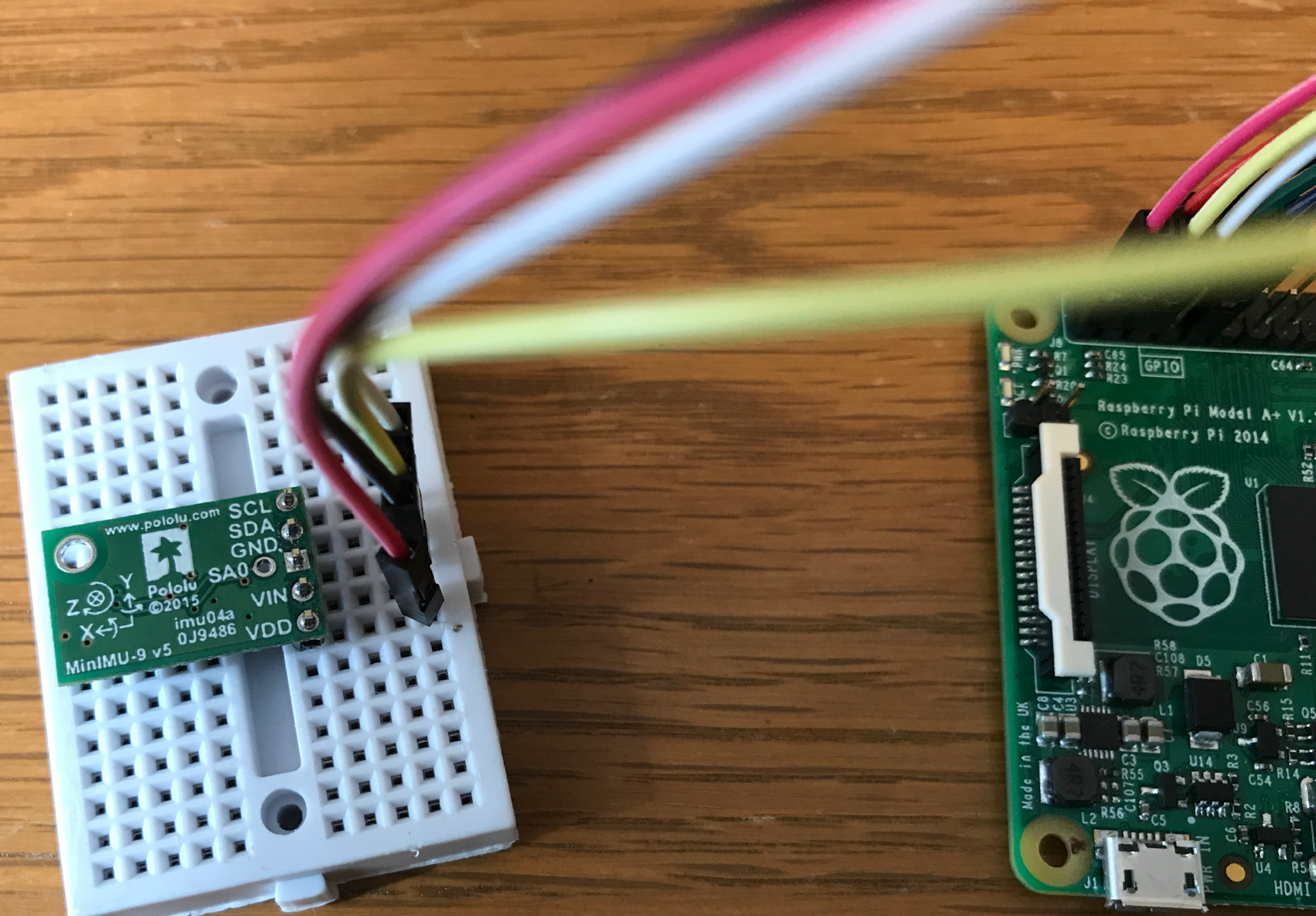


VCSEL Time of Flight

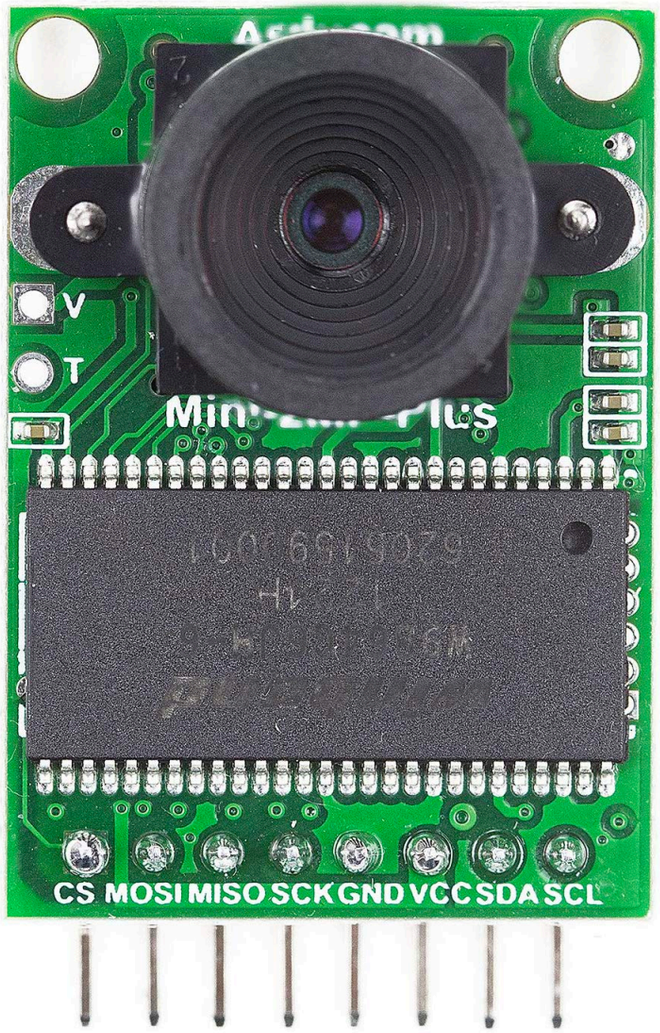
Temperature,
Humidity,
Pressure



Arducam (SPI and I2C)

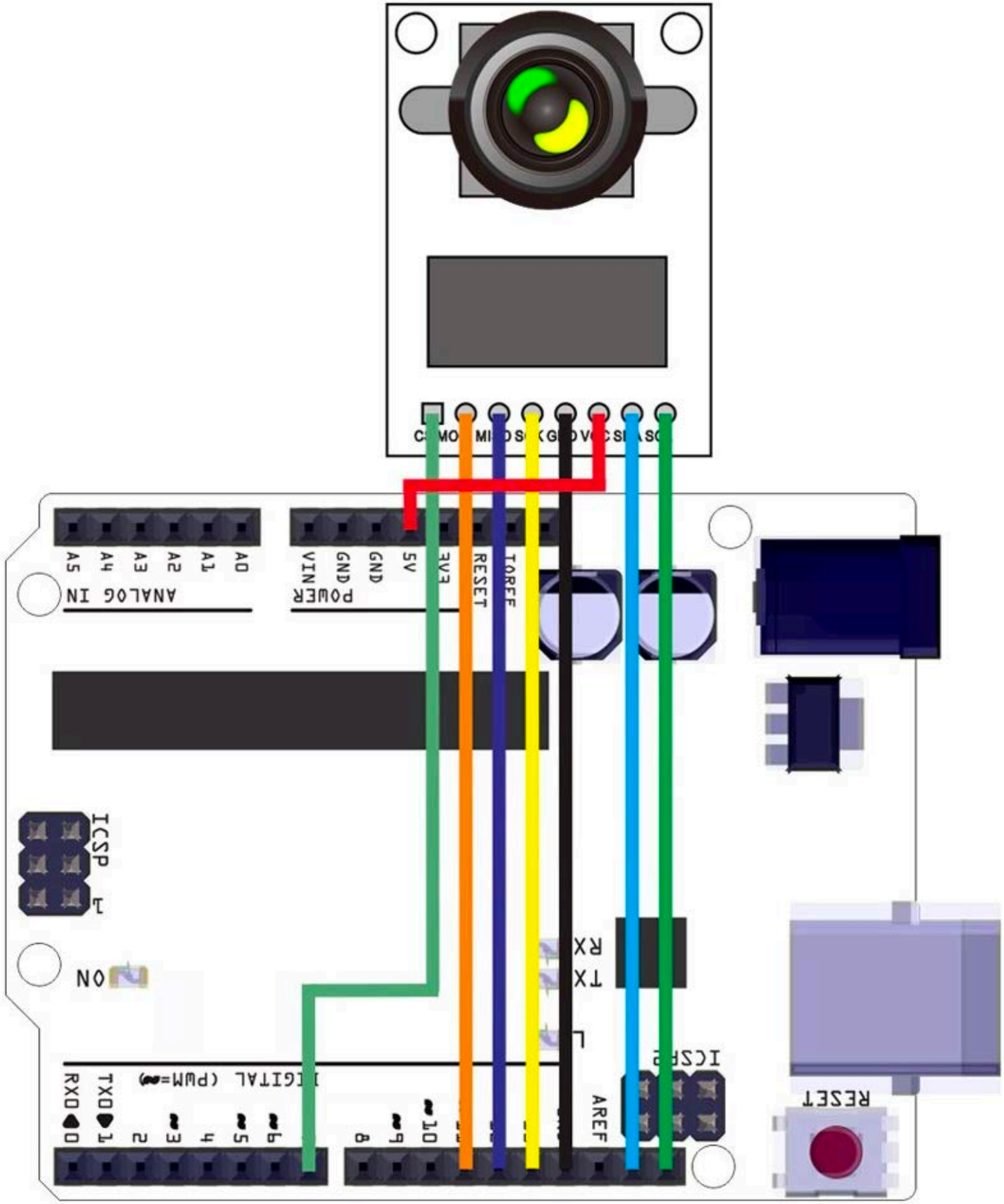


I2C IMU (accelerameter, gyroscope, compass)

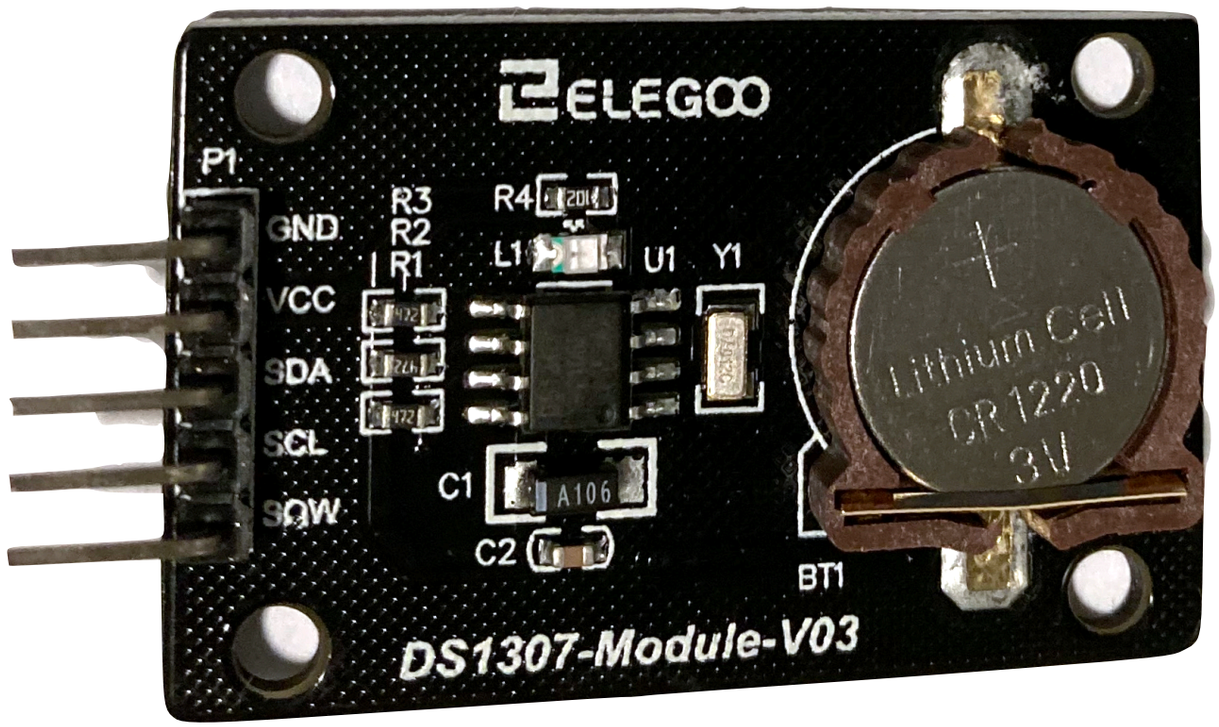


Arducam

SPI + I2C

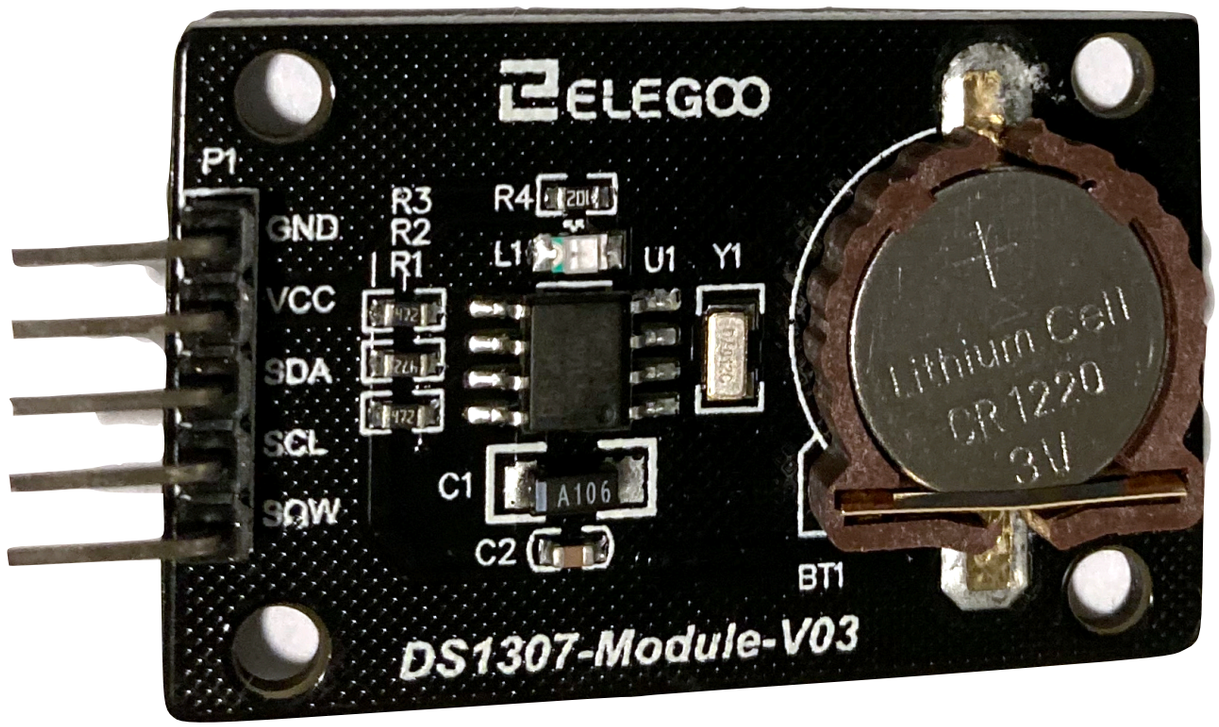


I2C Example: DS1307 Real Time Clock Module



- Five pins: VCC/GND, SDA, SCL, SQW
  - SQW is a "square wave," which we won't demonstrate here. The other pins are for I2C
- Battery — keeps the time going when power is off!
- Has 56 bytes of RAM that you can also use!

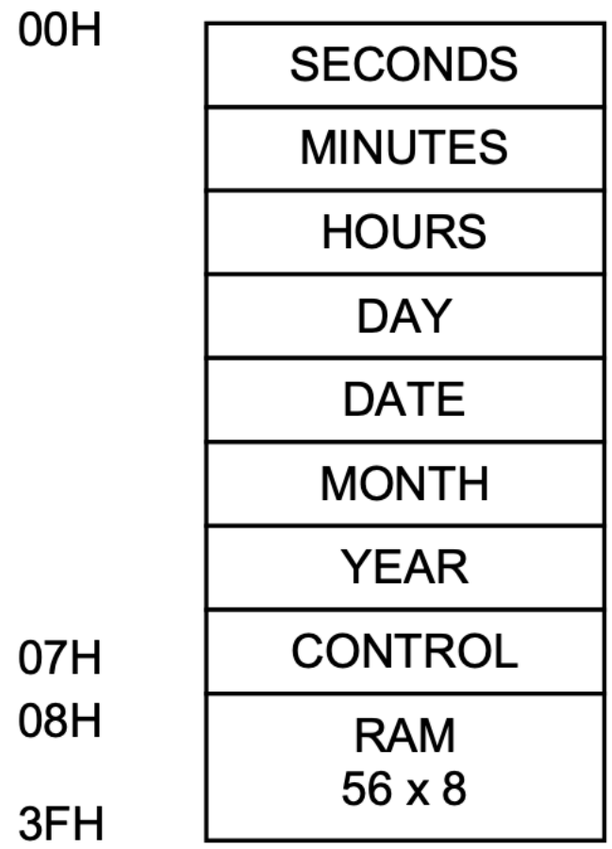
I2C Example: DS1307 Real Time Clock Module



- We need to read the data sheet to figure it out…
- https://www.sparkfun.com/datasheets/Components/DS1307.pdf

I2C Example: DS1307 Real Time Clock Module

DS1307 ADDRESS MAP Figure 2



- We send an I2C write with the address we want to read. If we send 0, we can read all 64 bytes

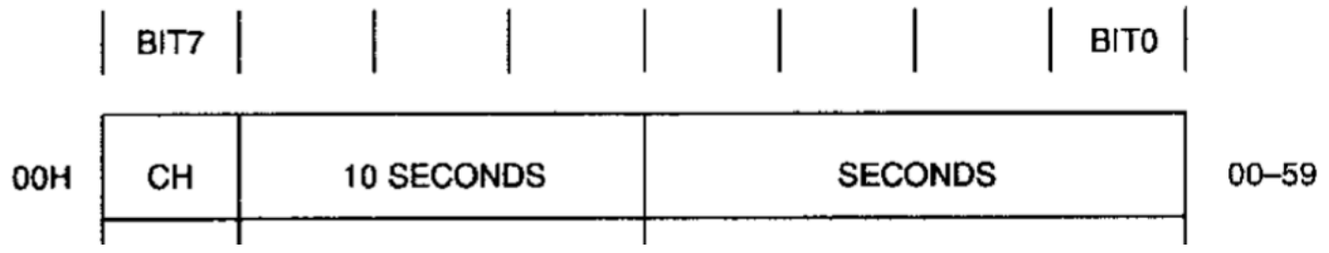
I2C Example: DS1307 Real Time Clock Module

DS1307 TIMEKEEPER REGISTERS Figure 3

- This looks confusing…let's see if we can figure it out (this sometimes takes trial and error!)
- The year is only two digits! (Y2K problem…)
- What would 0b01110011 at address 0 mean?

	BIT7							BIT0	
00H	CH	10 SECONDS			SECONDS				00–59
	0	10 MINUTES			MINUTES				00–59
	0	12 / 24	10 HR / A/P	10 HR	HOURS				01–12 00–23
	0	0	0	0	0	DAY			1–7
	0	0	10 DATE		DATE				01–28/29 01–30 01–31
	0	0	0	10 MONTH	MONTH				01–12
	10 YEAR				YEAR				00–99
07H	OUT	0	0	SQWE	0	0	RS1	RS0	

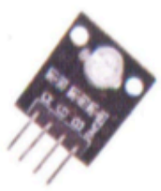
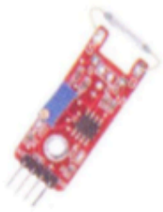
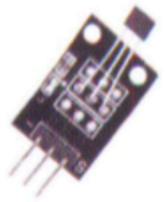
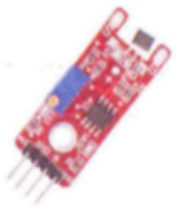
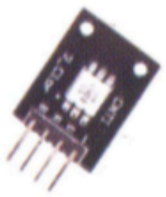
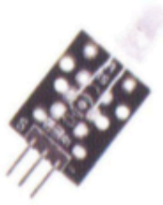
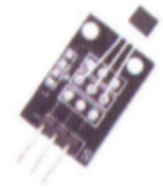
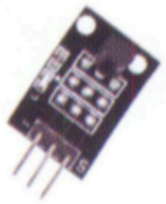
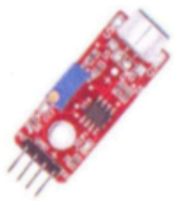
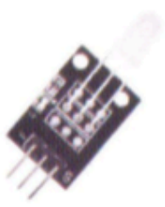
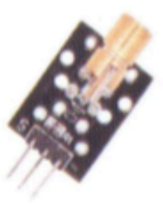
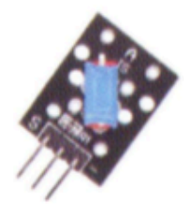
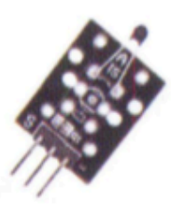
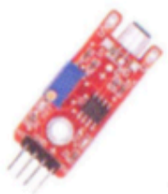
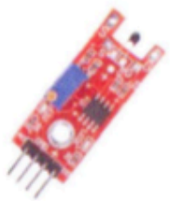
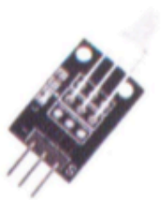
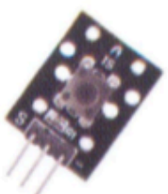
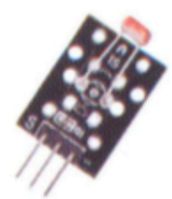
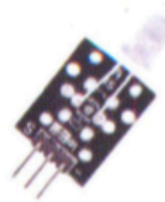
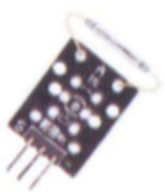
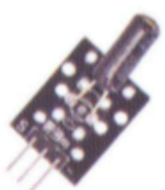
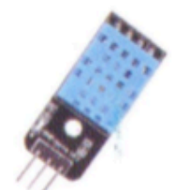
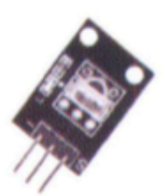
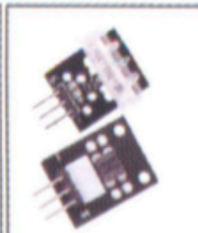
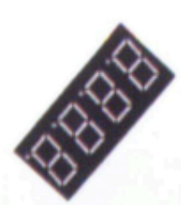
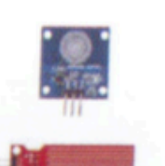
I2C Example: DS1307 Real Time Clock Module



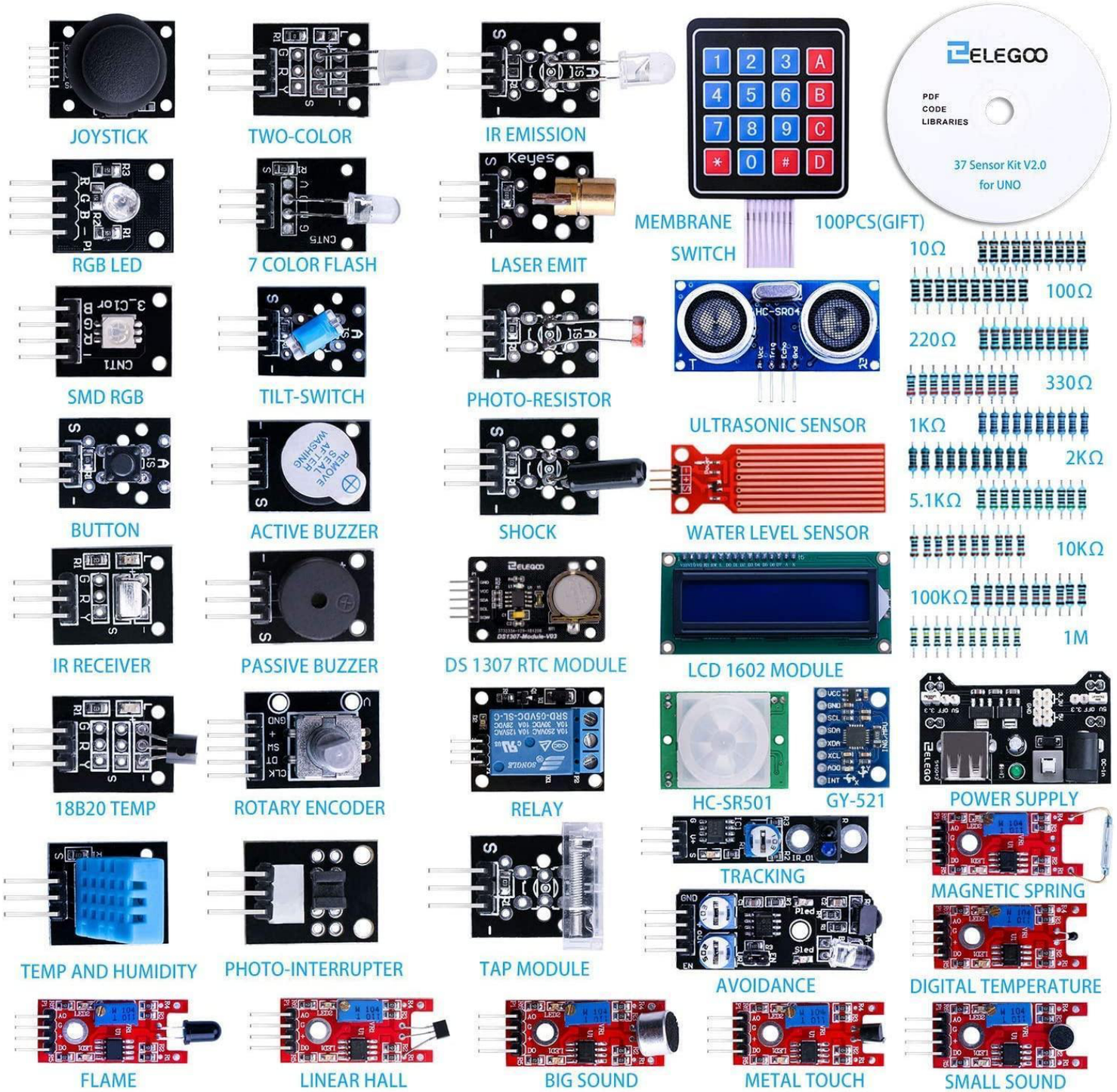
- What would 0b01010011 at address 0 mean?
  - Bit 7: ignore (sets the oscillator on/off). Will be 0 when the oscillator is going (e.g., when it is telling time).
- Bits 6-4 are the "tens" digit. In this case, 0b101 is 5, or "50"
- Bits 3-0 are the "ones" digit. In this case, 0b0011 is 3
- Therefore, the seconds is 53.
  - Why isn't it just the actual numerical 53?
    - Who knows?
      - Possibly because the hex value will actually represent a decimal value…e.g., 0b01010011 = 0x53. Weird.

What other sensors are available?

sensor kit

 joystick	 Flame	 RGB LED	 Reed Switch	 Rotary encoders	 Hall magnatic
 Relay	 Linear Hall	 SMD RGB	 7color flash	 Analog Hall	 TEMP18B20
 Big sound	 Touch	 TWO-color LED	 Laser emit	 Ball switch	 Analog temp
 Small sound	 Digital temp	 Two-color	 Button	 Photoresisor	 IR emission
 Tracking	 Buzzer	 Mini Reed	 Shock	 Temp and humidity	 IR receiver
 Avoid	 Passive Buzzer	 Tap module Light blocking	 7segment	 4 7segment	 Touch Water

sensor kit #2
ELEGOO sensor kit
Download code: https://www.elegoo.com/blogs/arduino-projects/elegoo-37-in-1-sensor-modules-kit-tutorial



Sensing the World

Resistance (conduction, capacitance)-

Convert energy to voltage/current

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

Smart sensors (sensor with a digital interface)

- **Acceleration/Orientation/Magnetic (force direction)**
- **Camera, IMU (inertial management unit), ...**