CS107e

Sensors

Pat Hanrahan

Final Projects

Project proposal ideas and hints

- **https://cs107e.github.io/assignments/project/**

Form teams this week (2 people best)

- **Fill out form with teammates (due 6pm Mon Mar 4)**

Discuss scope and feasibility with staff and teammates in lab next week

Submit project proposal with midpoint milestone (due 6pm Fri Mar 8)

Show progress on milestones during lab the following week

Class demos (9:00-11:30 am Fri Mar 22)

Final code and writeup submission (due 9:00 am Fri Mar 22)

$20 parts budget per person; need to submit receipts

Apple iPhone 7 teardown

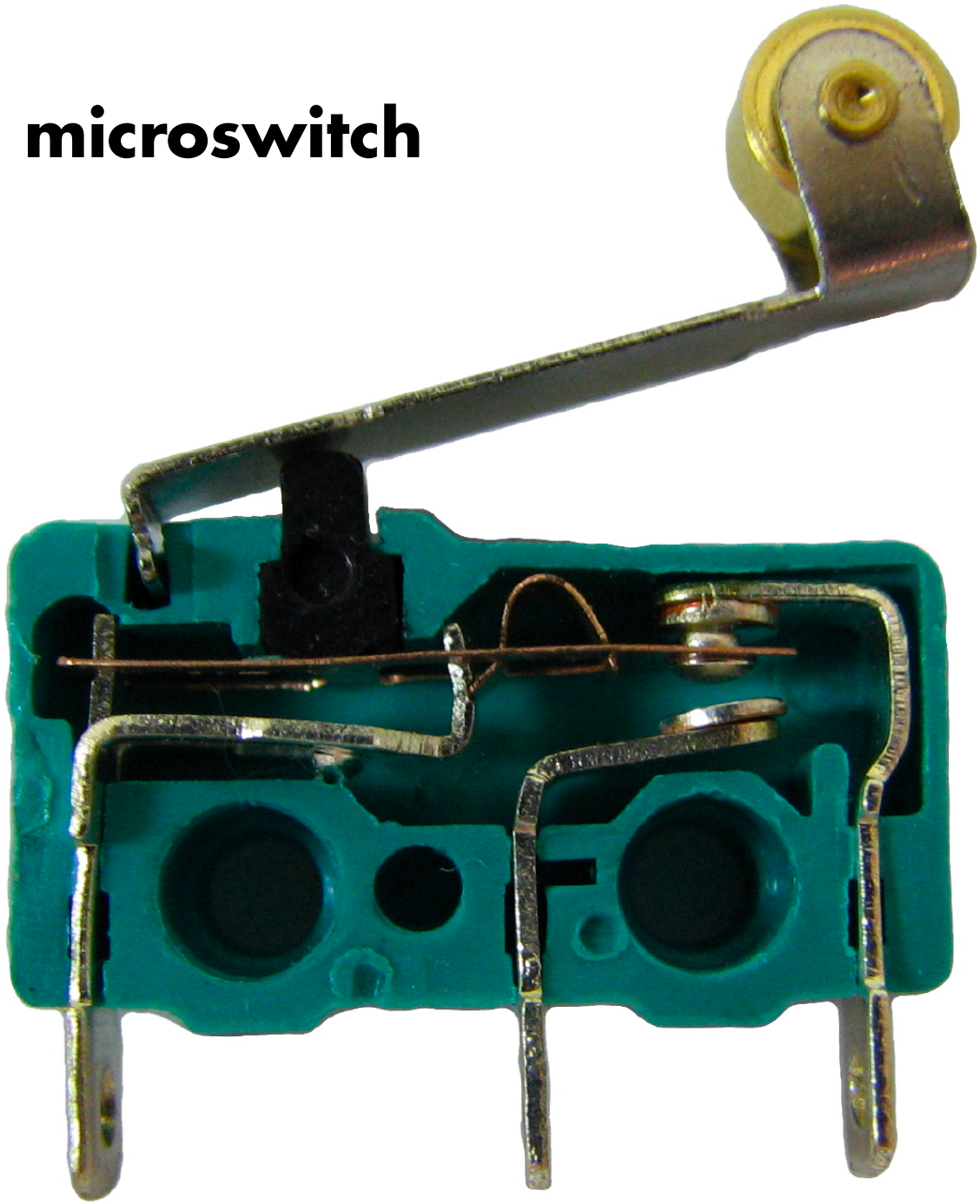
How many sensors?

Apple iPhone 7

How many sensors? At least 10

Dual 12MP wide-angle and telephoto cameras
Facetime camera
Infrared camera (for face recognition)
Microphones
Proximity sensor
Ambient light sensor
Accelerometer
Gyroscope
Compass (magnetometer)
Barometer
Touch ID fingerprint scanner
Pressure sensitive 3D multi-touch display

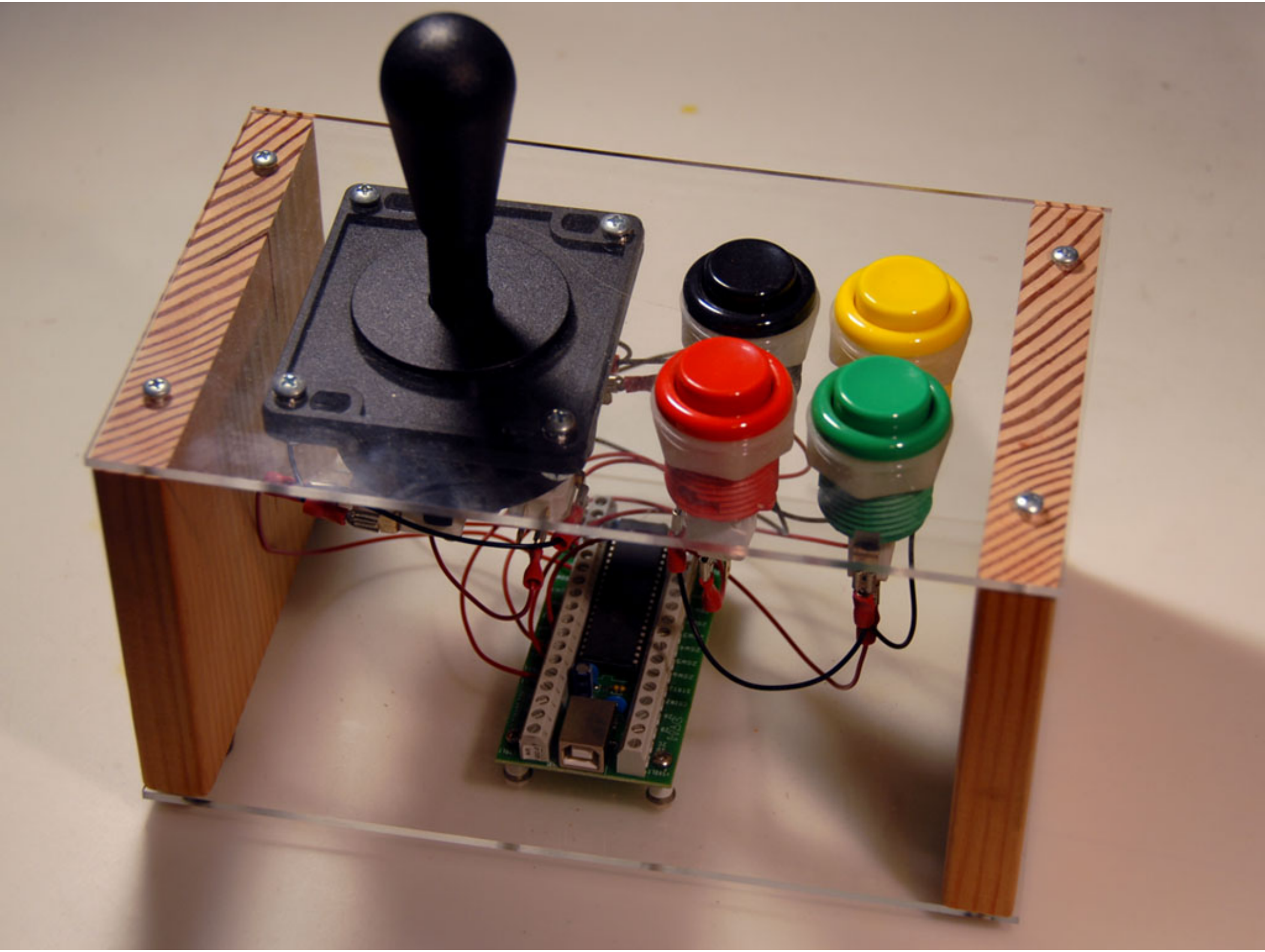
Snap-action microswitch



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

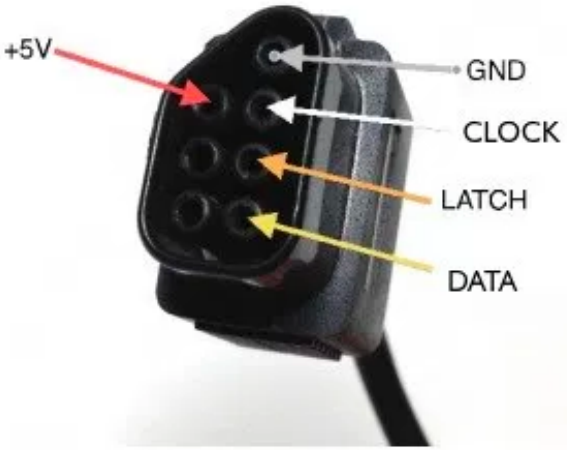
Happ Pushbutton

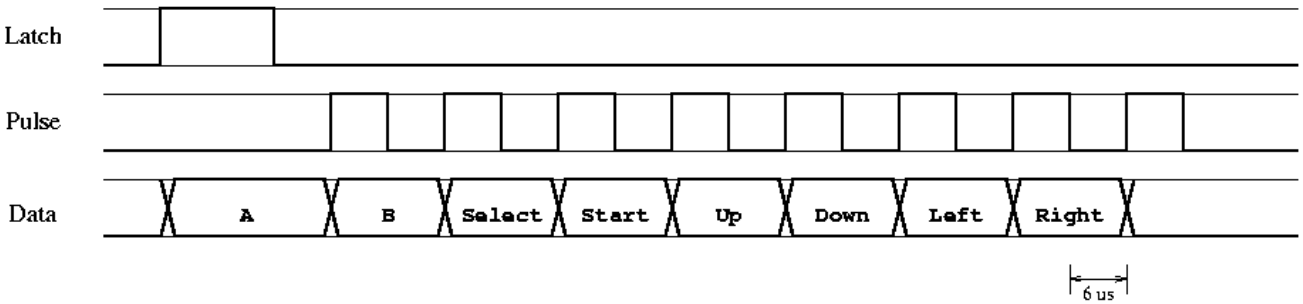
Happ Joystick

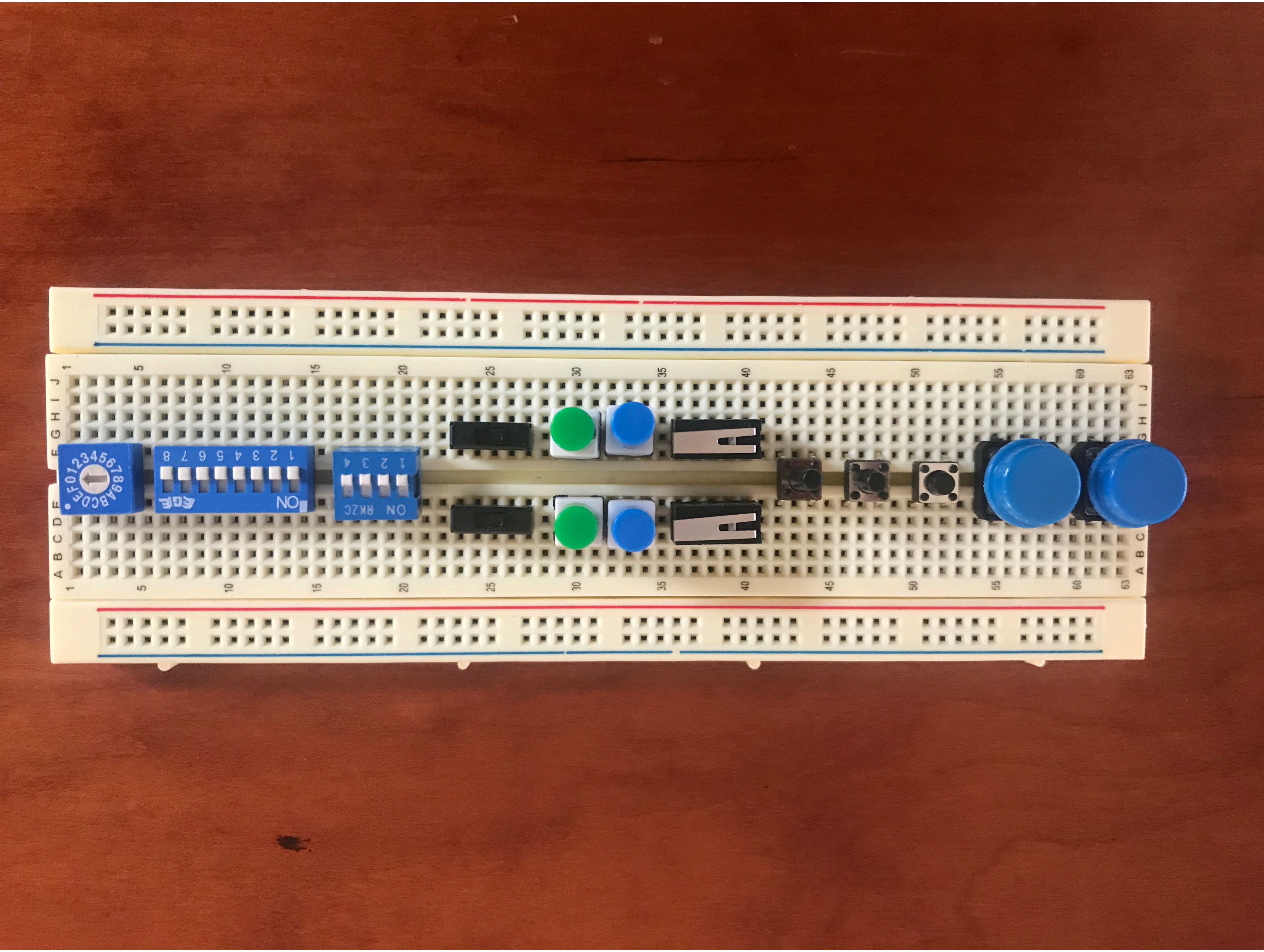


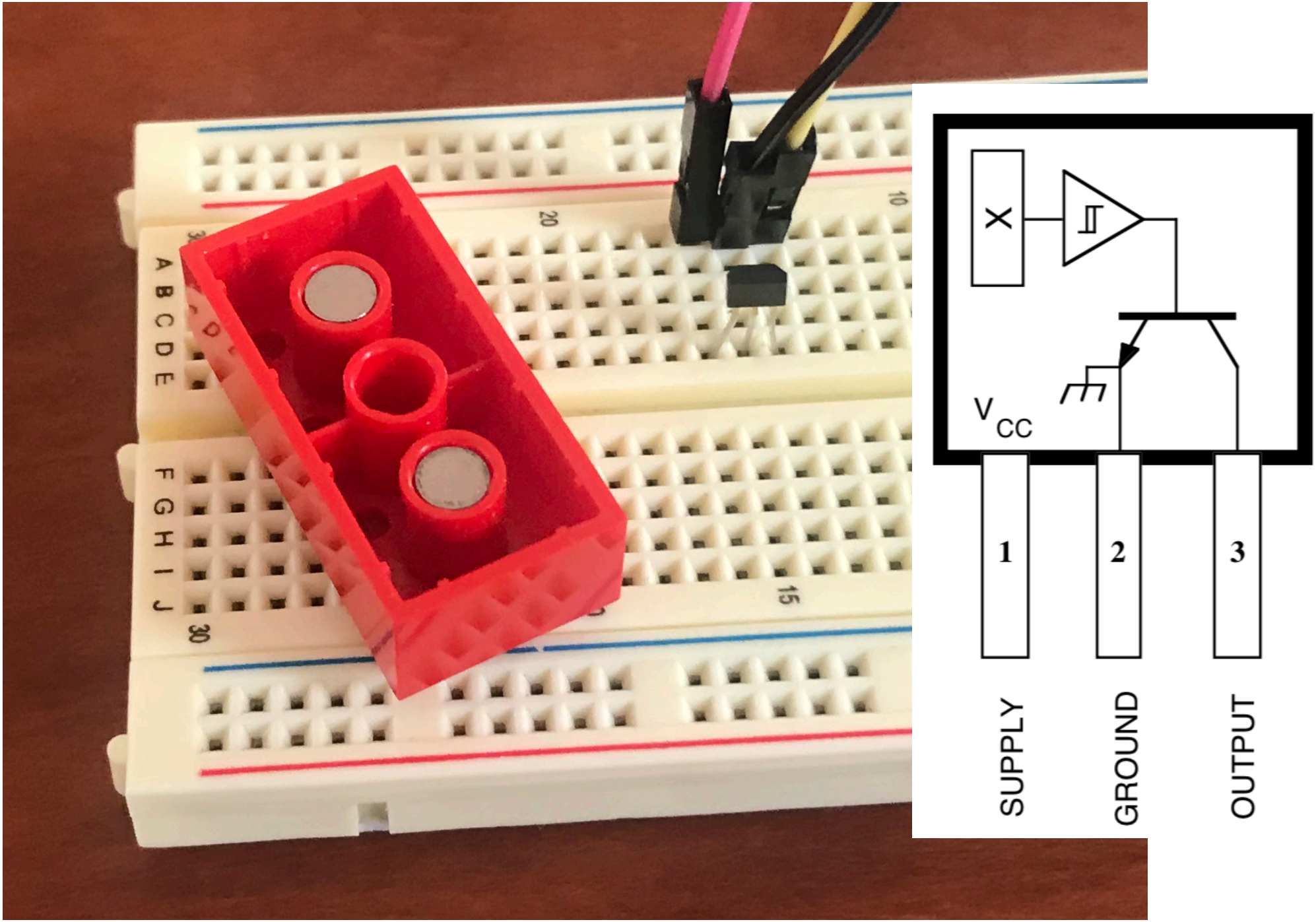
Famicon D-pad

NES D-pad

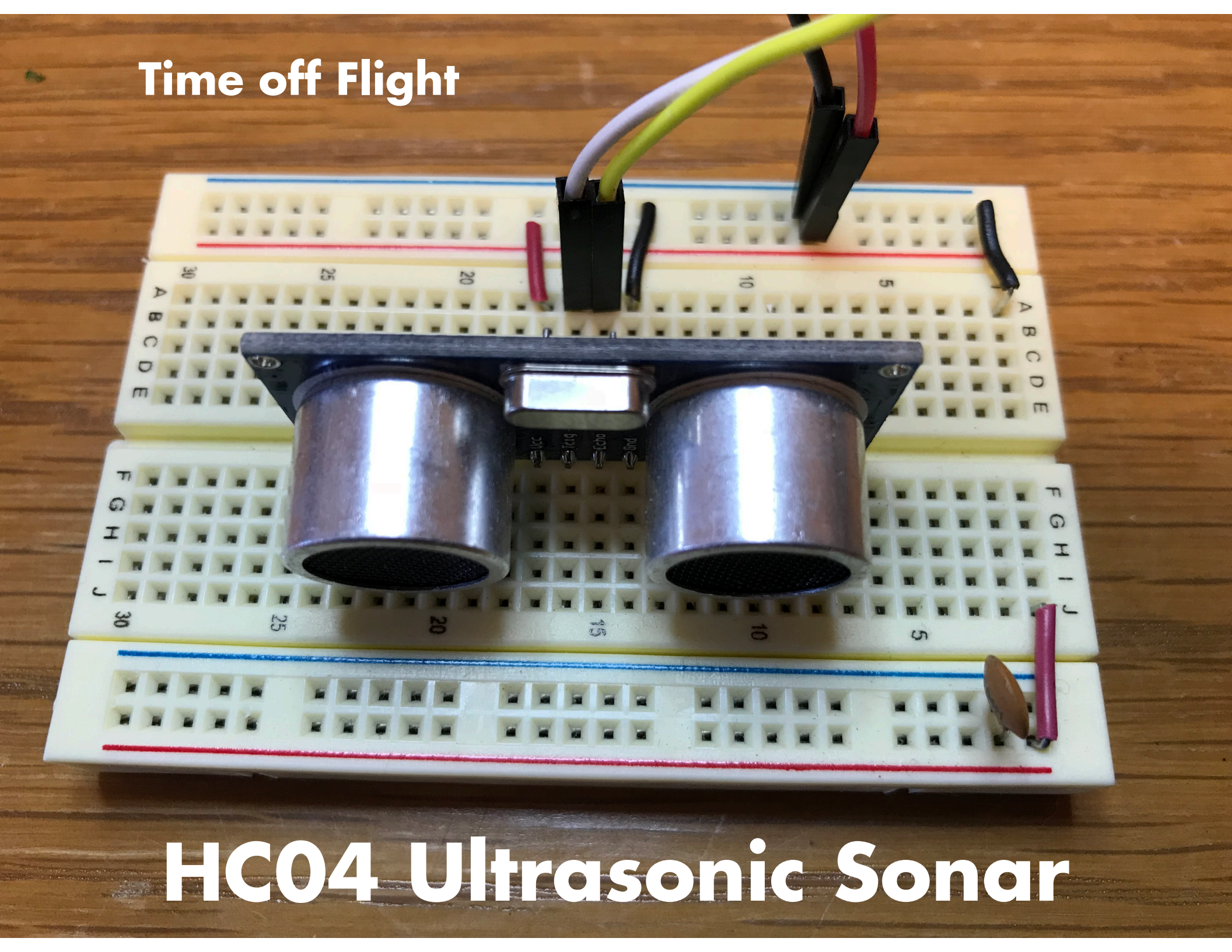




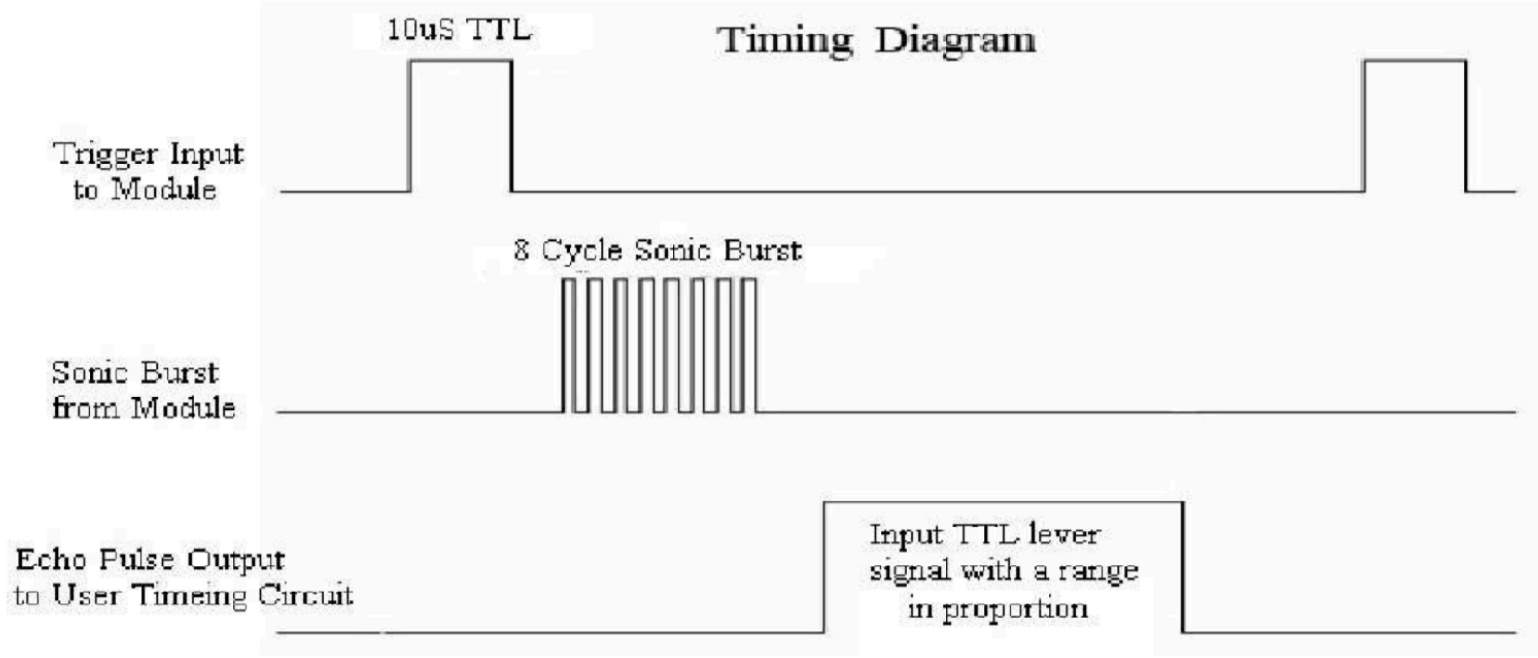




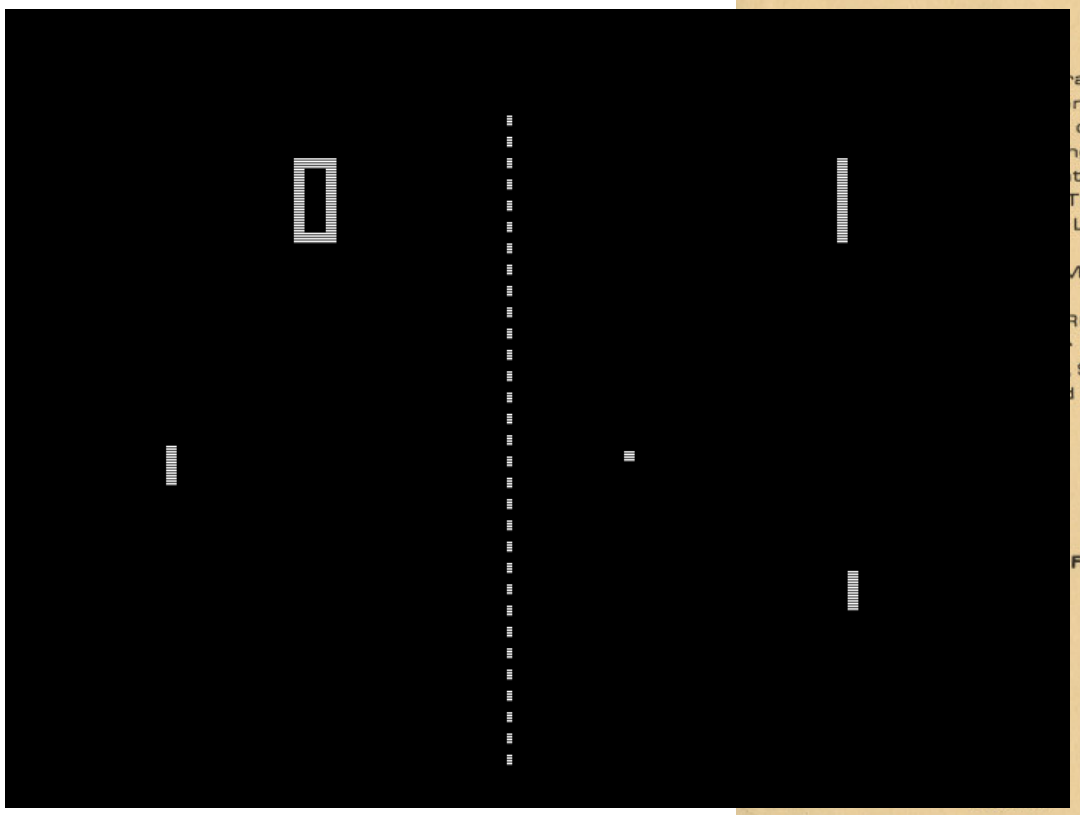
3144 Hall Effect Sensor and Magnet


Time off 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)



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
Locations

FROM YOUR LOCAL DISTRIBUTOR

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


paddle

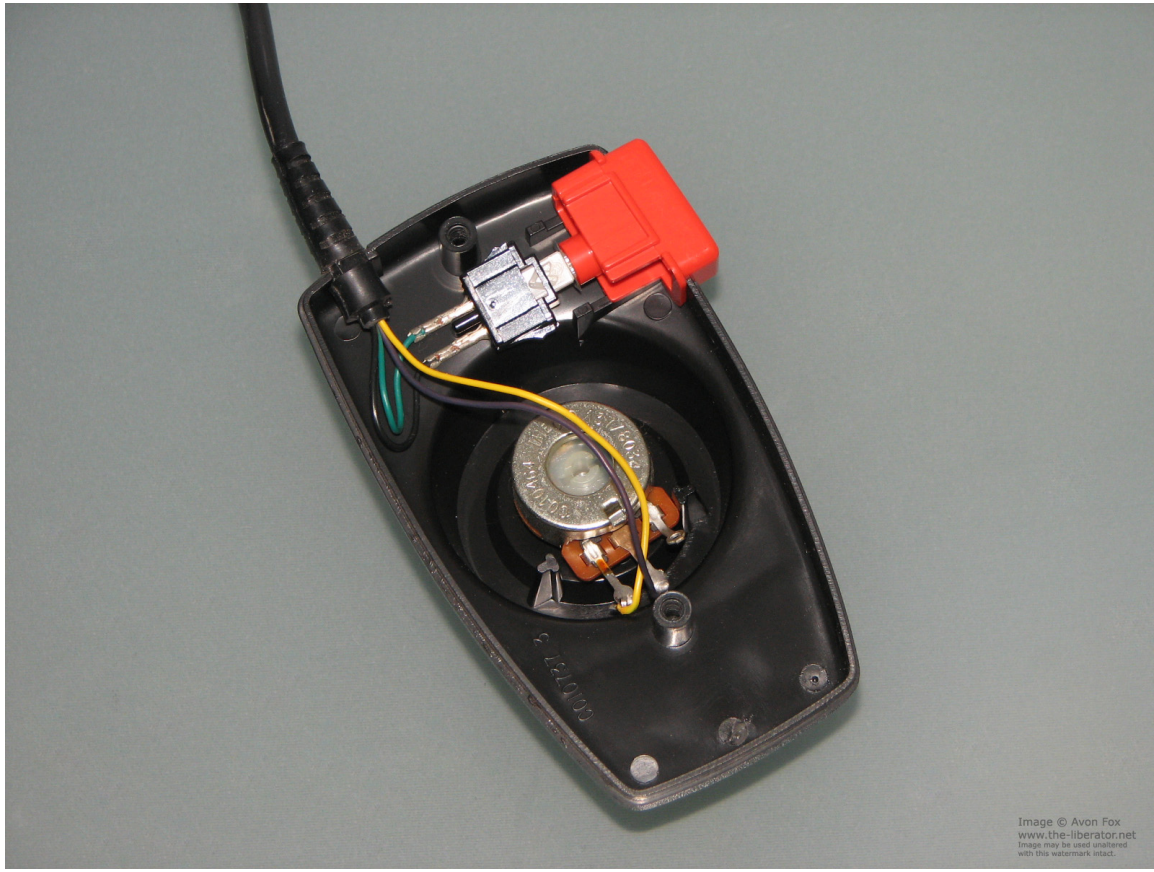
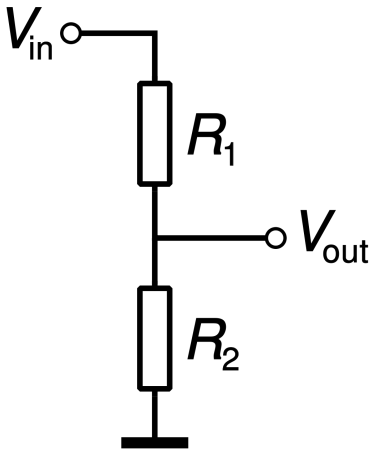
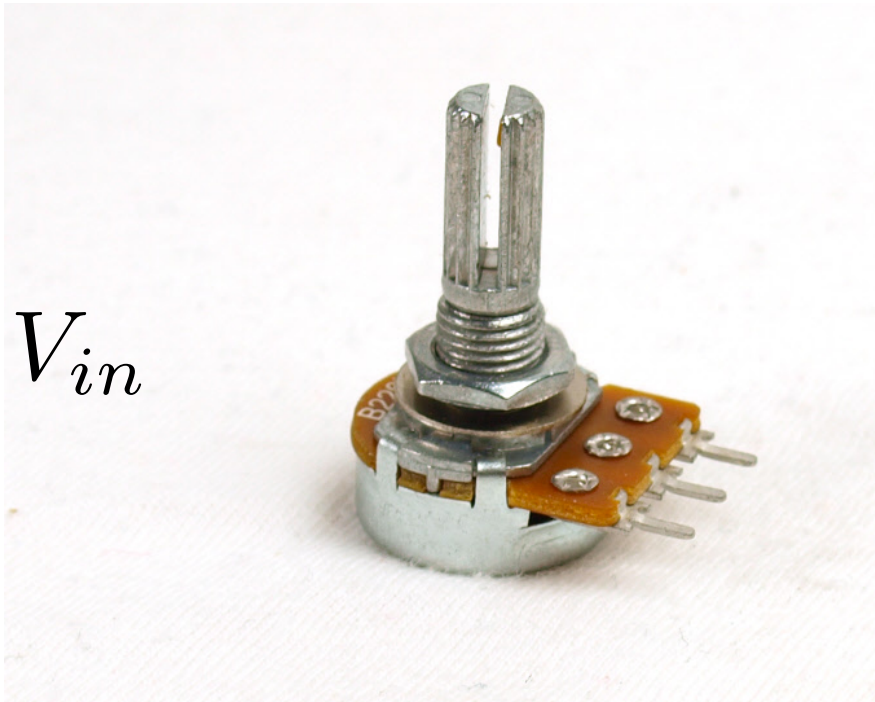
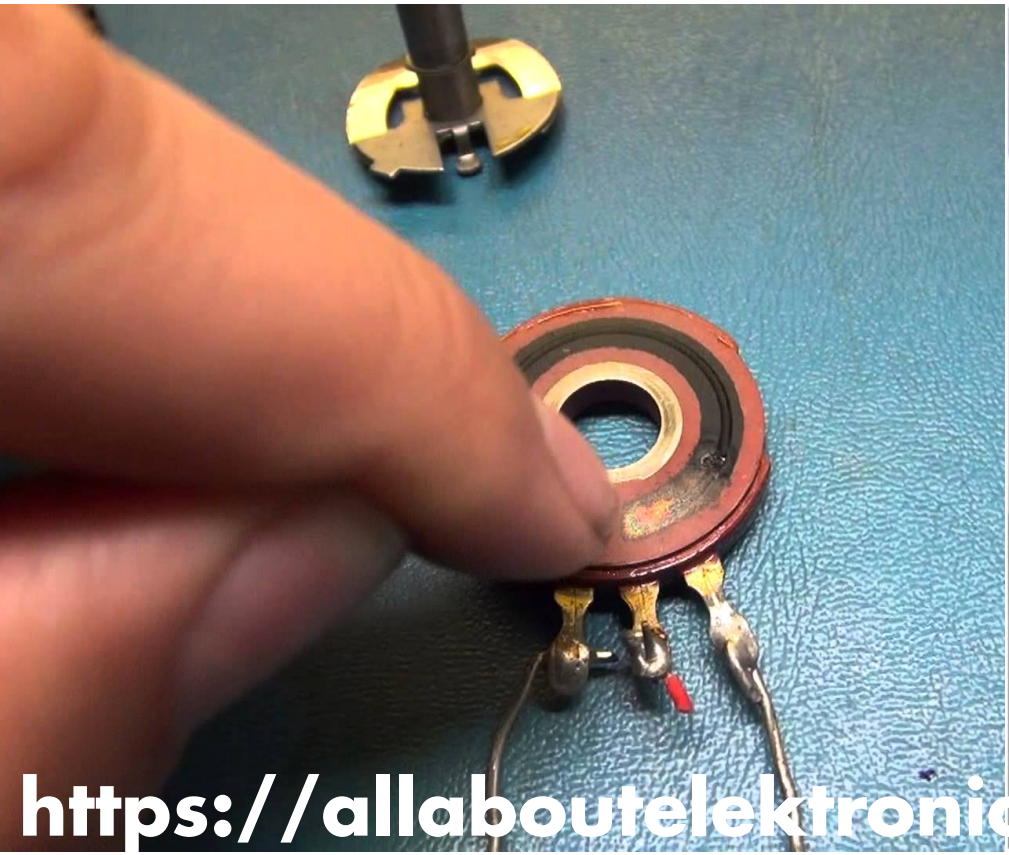


Image © Avon Fox
www.the-liberator.net
Image may be used unaltered
with this watermark intact.



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



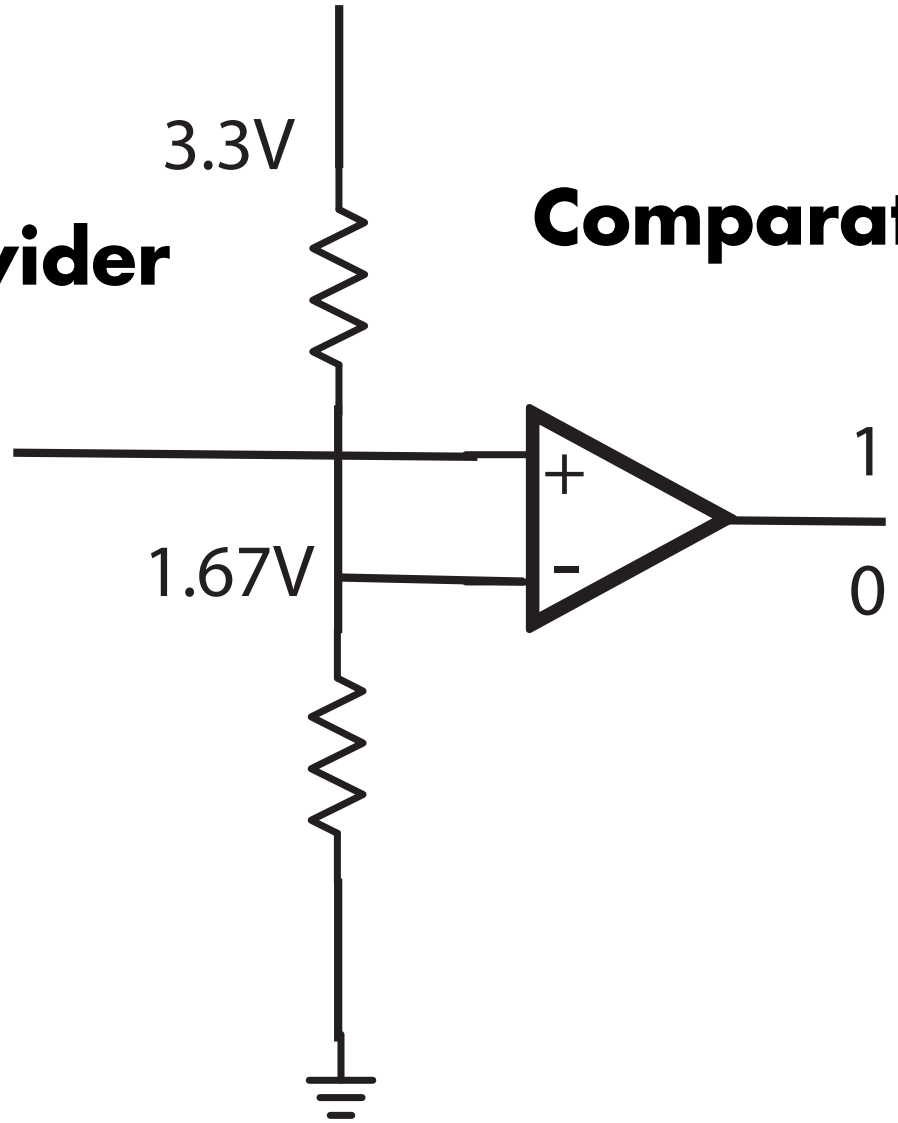


https://allaboutelektronics.wordpress.com/resistors/

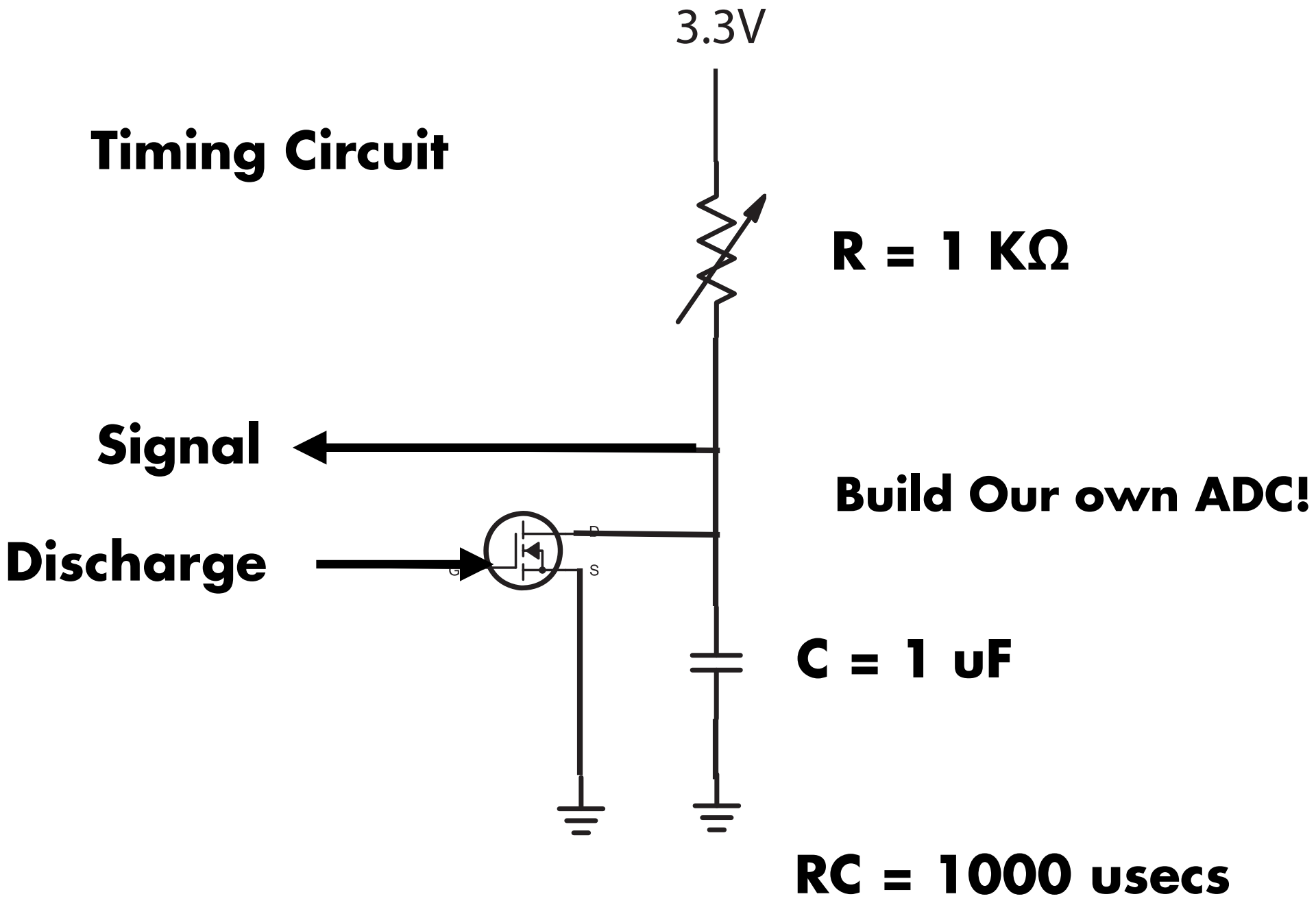
How would you measure the voltage?

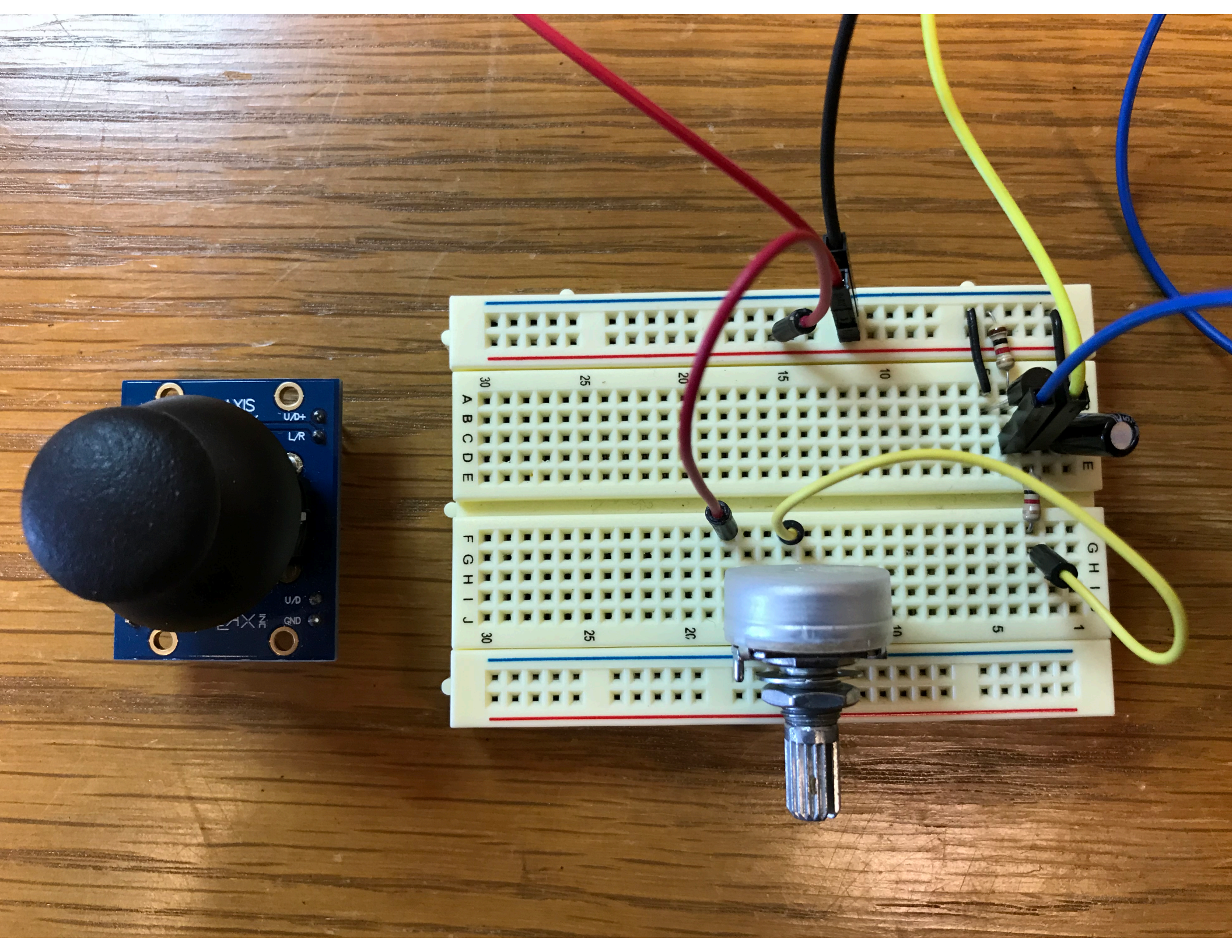
Voltage divider

Comparator



Analog to Digital

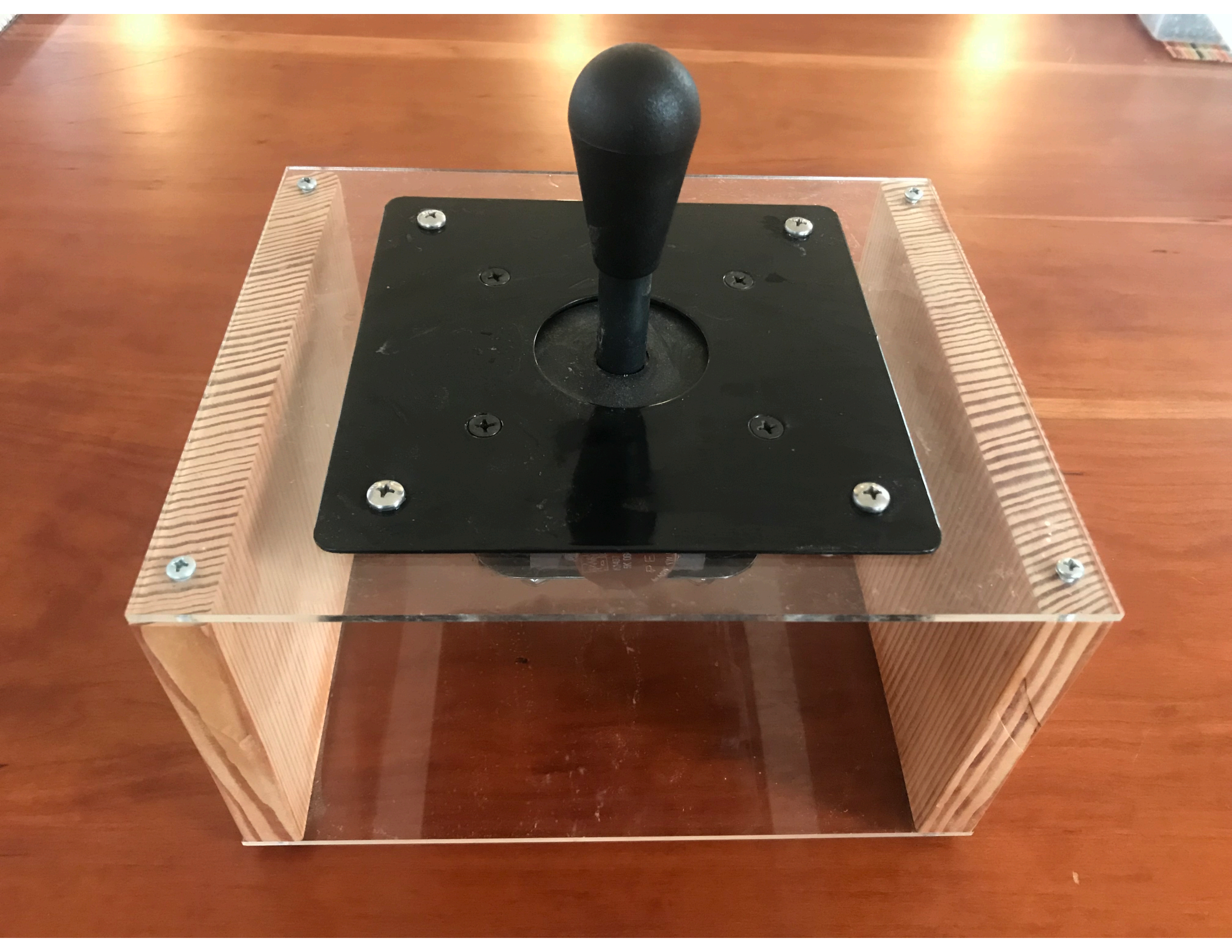

Timing Circuit
3.3V
R = 1 KΩ
Signal
Build Our own ADC!
Discharge
D
G
S
C = 1 uF
RC = 1000 usecs


U/D+
L/R
U/D
GND
A B C D E
F G H I J
30
25
20
15
10
5
1

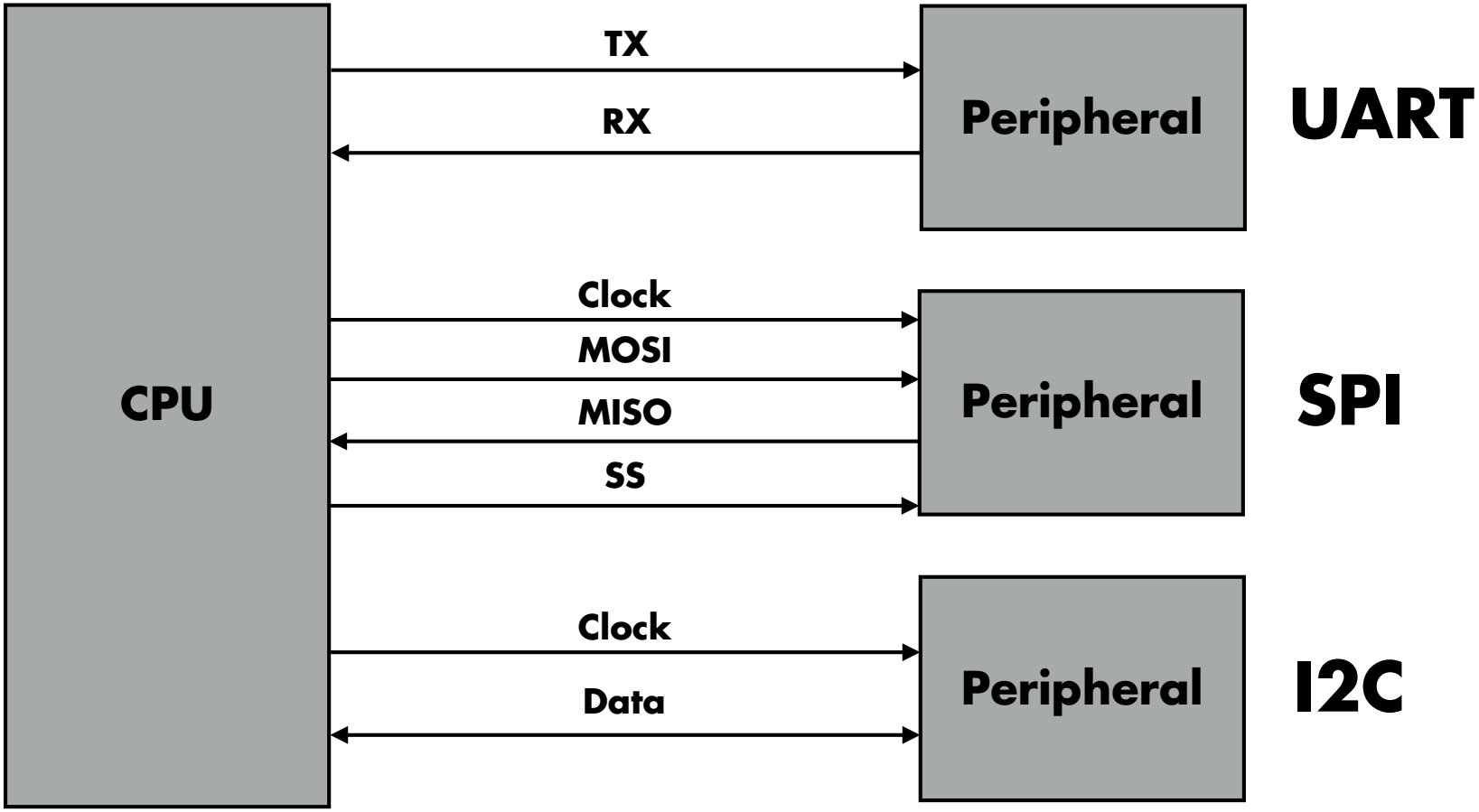
```
unsigned int get_charge_time(void)
{
  // discharge the capacitor
  gpio_write(discharge, 1);
  timer_delay_ms(10);
  gpio_write(discharge, 0);

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

  return (end - start);
}
```

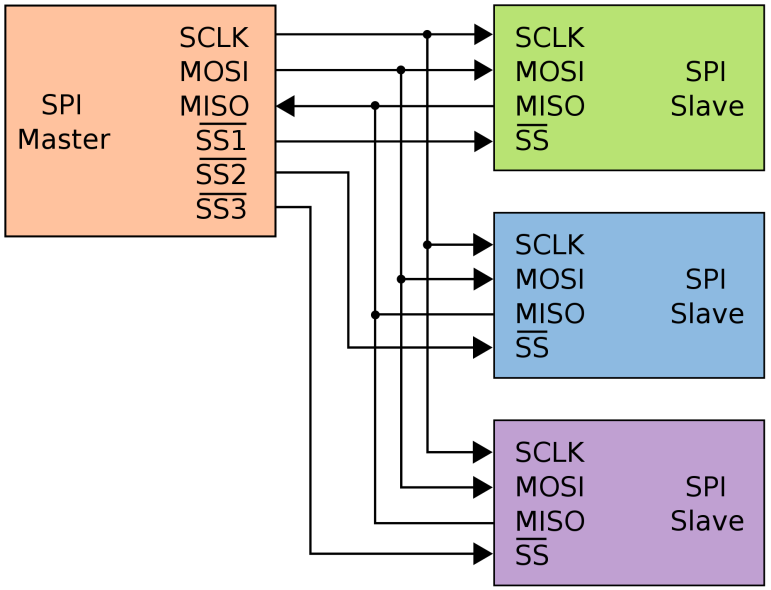


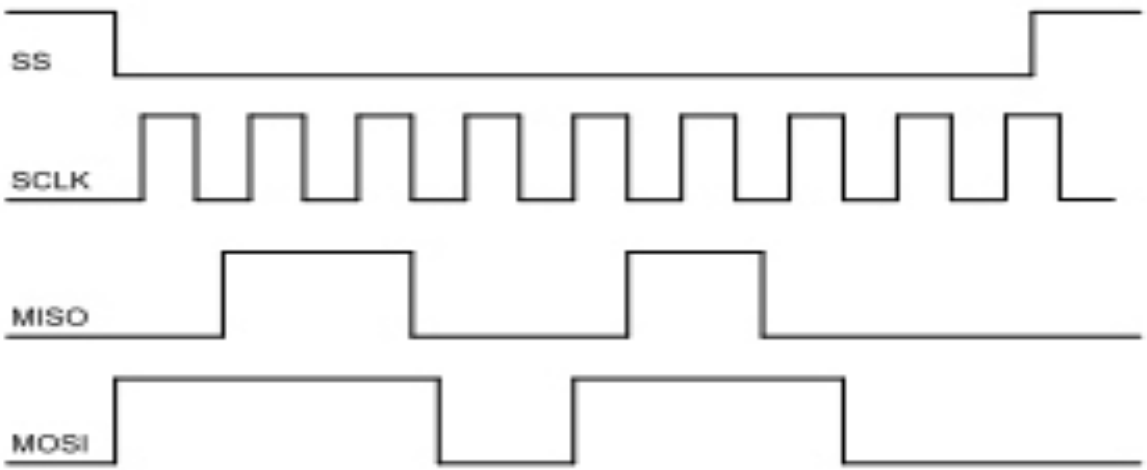
Bus Protocols



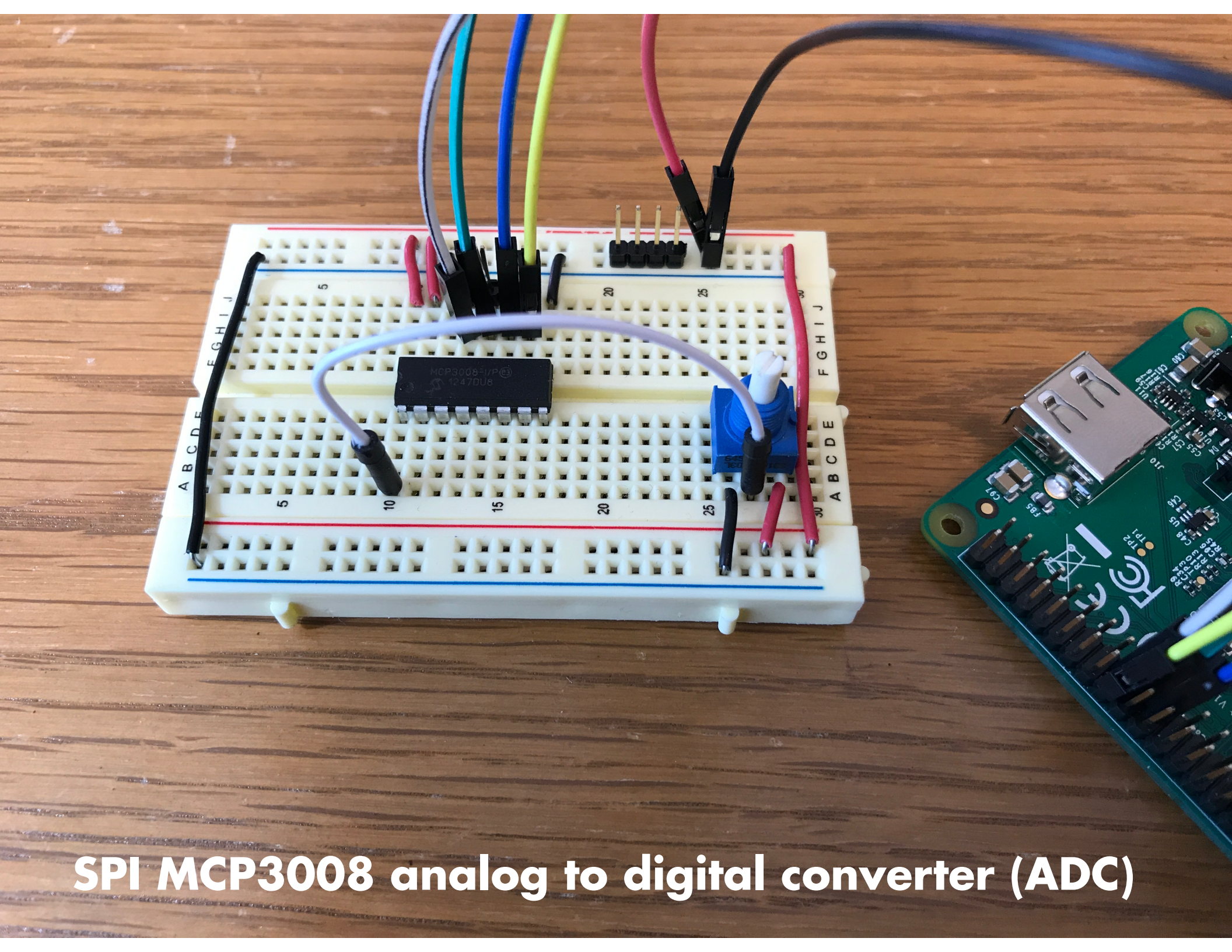
SPI

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

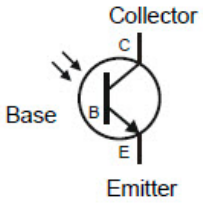




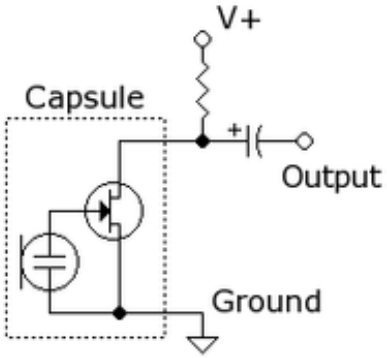
Figures from https://upload.wikimedia.org/wikipedia/commons/thumb/f/fc/SPI_three_slaves.svg/2000px-SPI_three_slaves.svg.png (top), http://www.tequipment.net/RigolSD-SPI-DS4.html (bottom)


SPI MCP3008 analog to digital converter (ADC)

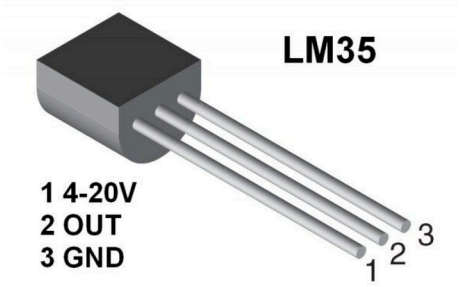
Analog Sensors



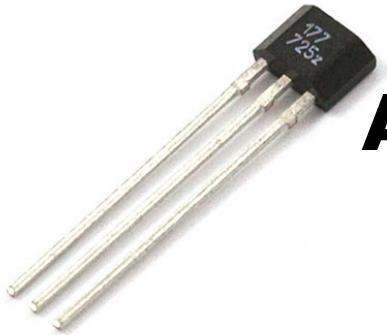
Phototransistor (light)



Electret Microphone (pressure)

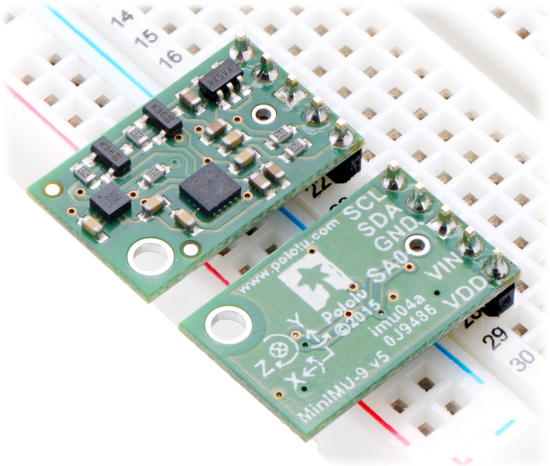


(temperature)

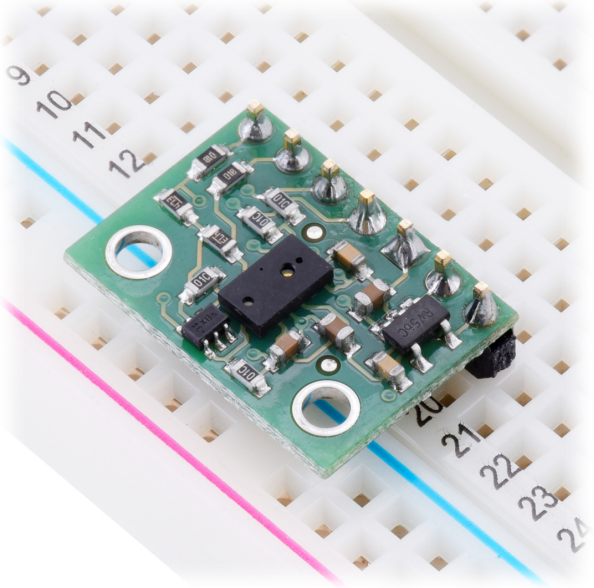


Analog Hall Effect (magnetic field)

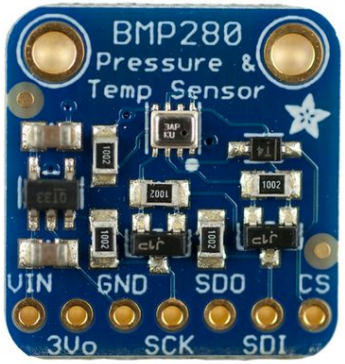
I2C Sensors



Accelerometer
Gyroscope
Magnetometer



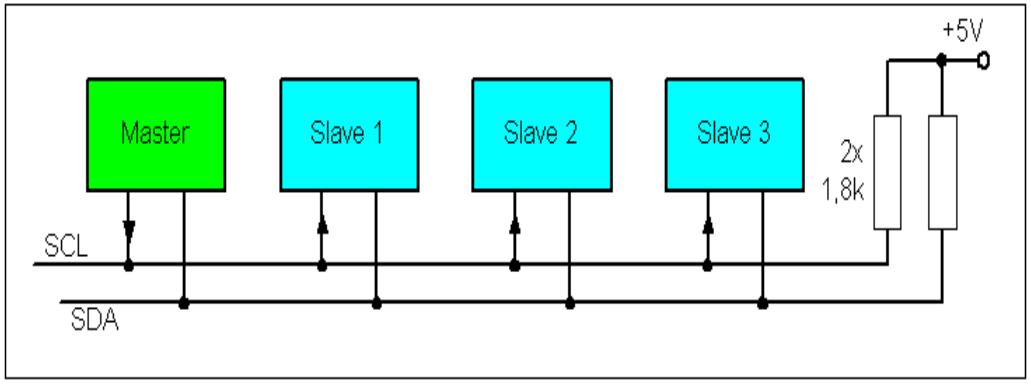
VCSEL Time of Flight



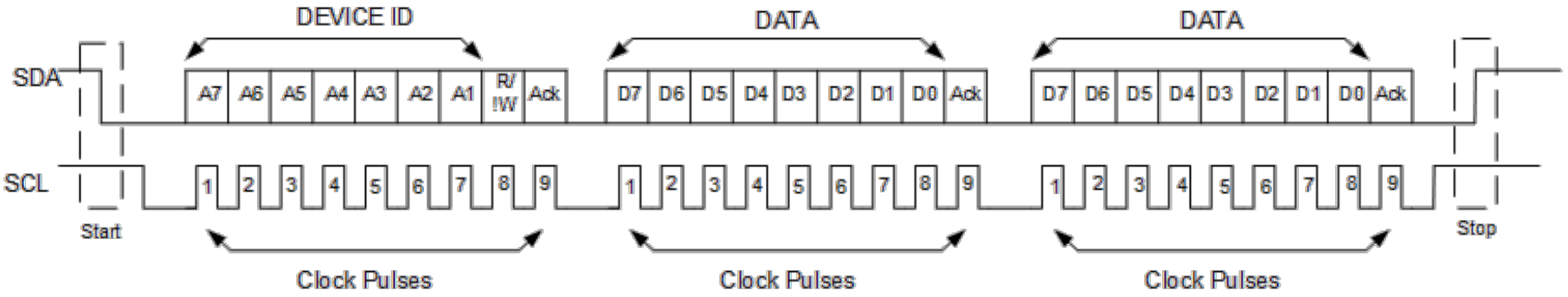
Temperature,
Humidity,
Pressure

Arducam (SPI and I2C)

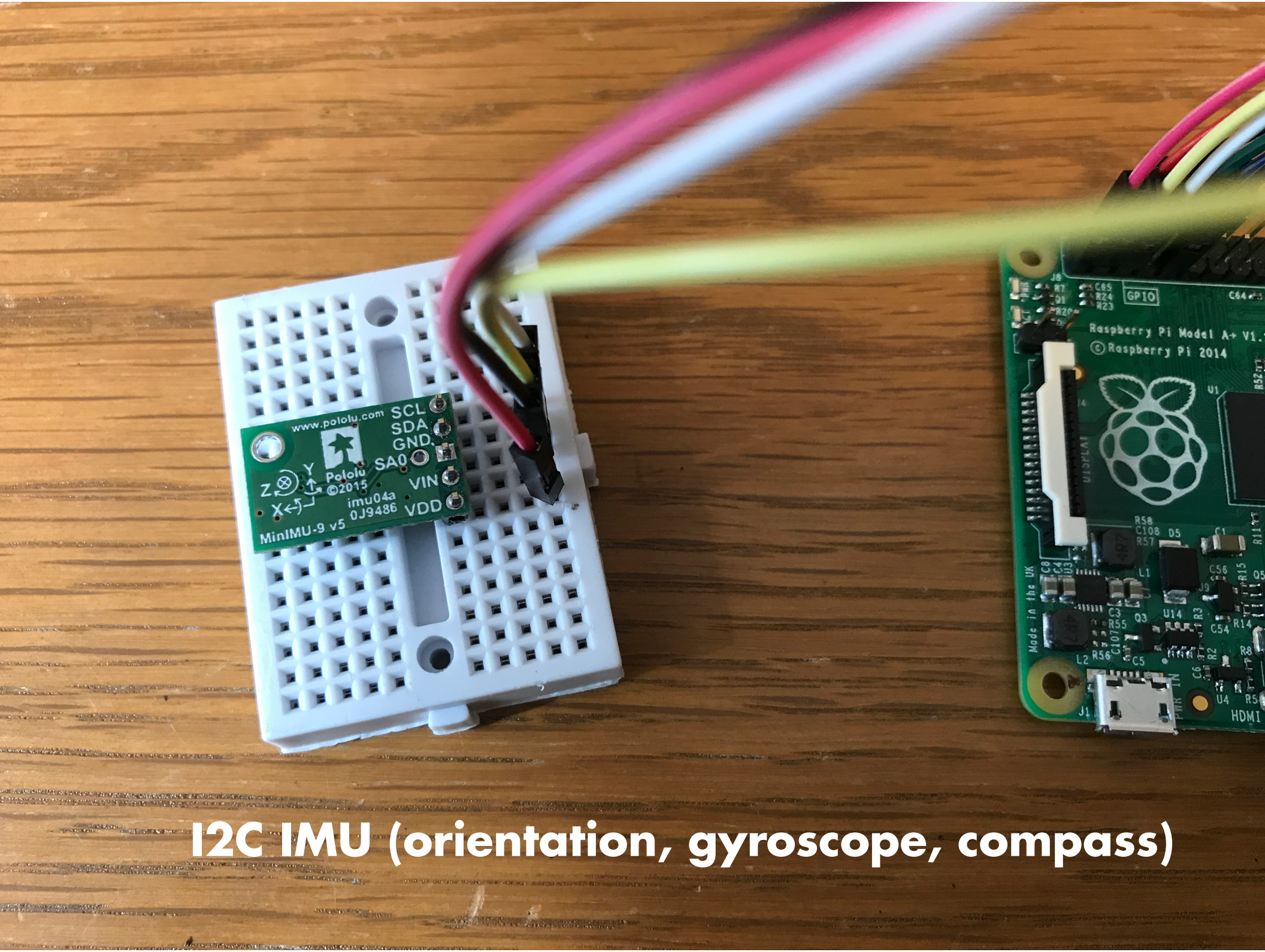
I2C



- **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 IMU (orientation, gyroscope, compass)

Sensing the World

Resistance (conduction, impedance, capacitance)-

Light (phototranistor, lidar)

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

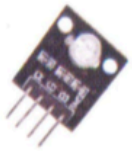
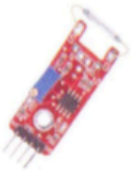
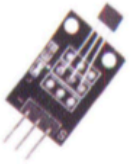
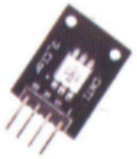
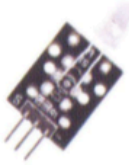
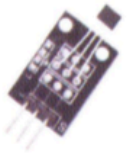
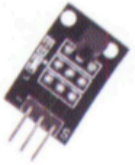
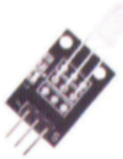
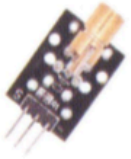
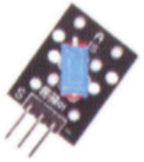
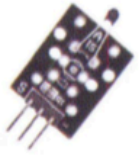
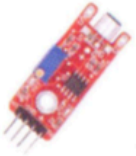
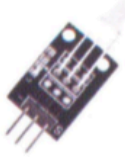
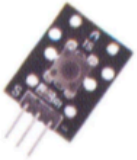
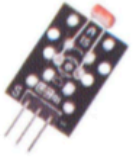
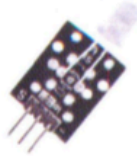
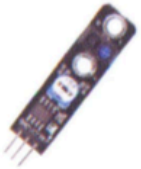
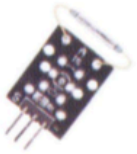
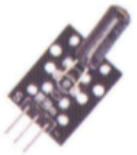
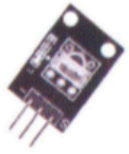
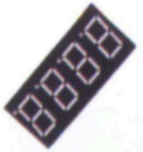
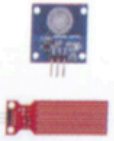
Temperature (heat), humidity, pressure

Electromagnetic fields (hall effect, compass, antenna)

Acceleration (force direction)

Orientation (gyroscope)

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

Sound