Adafruit I2S MEMS Microphone Breakout

Created by lady ada

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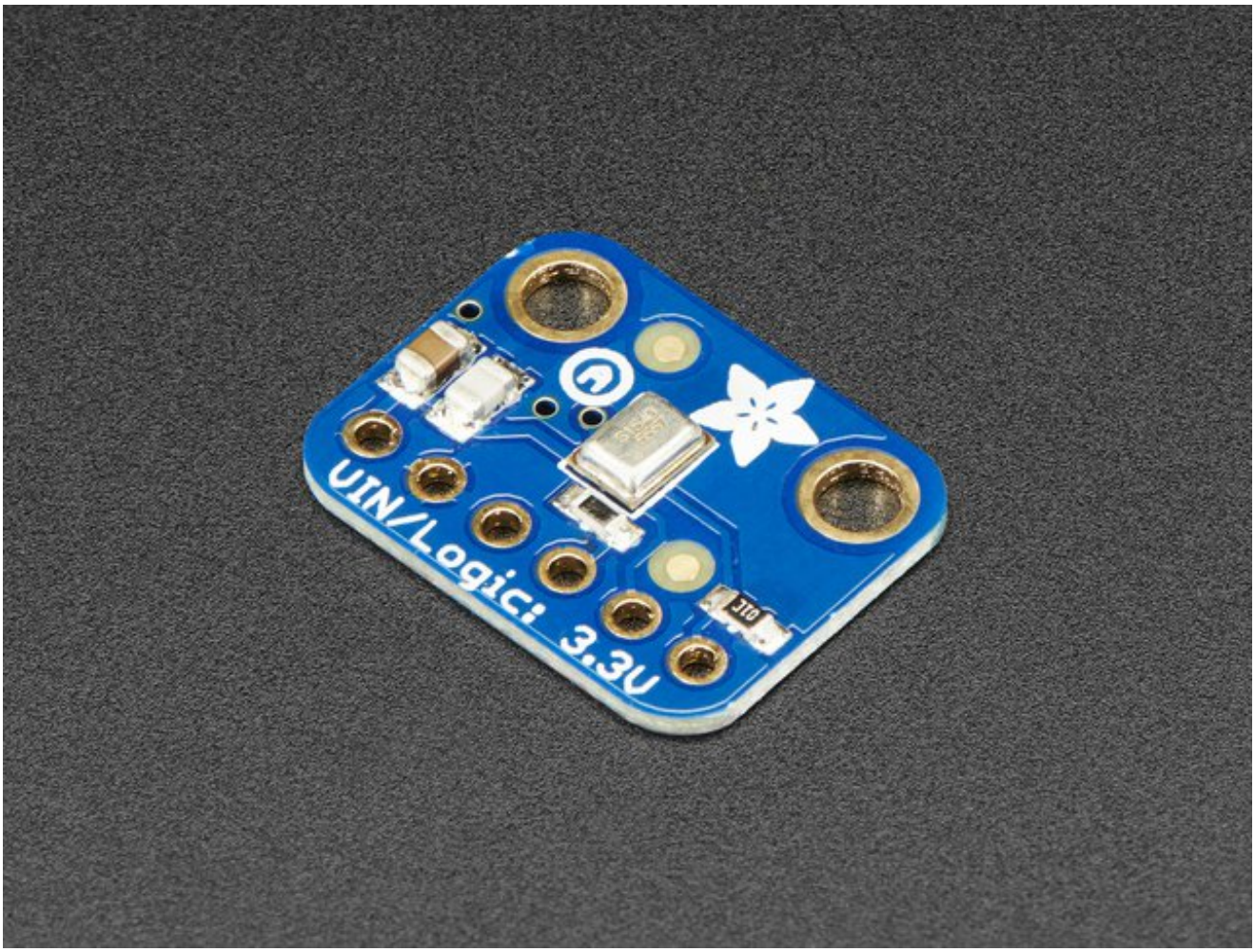
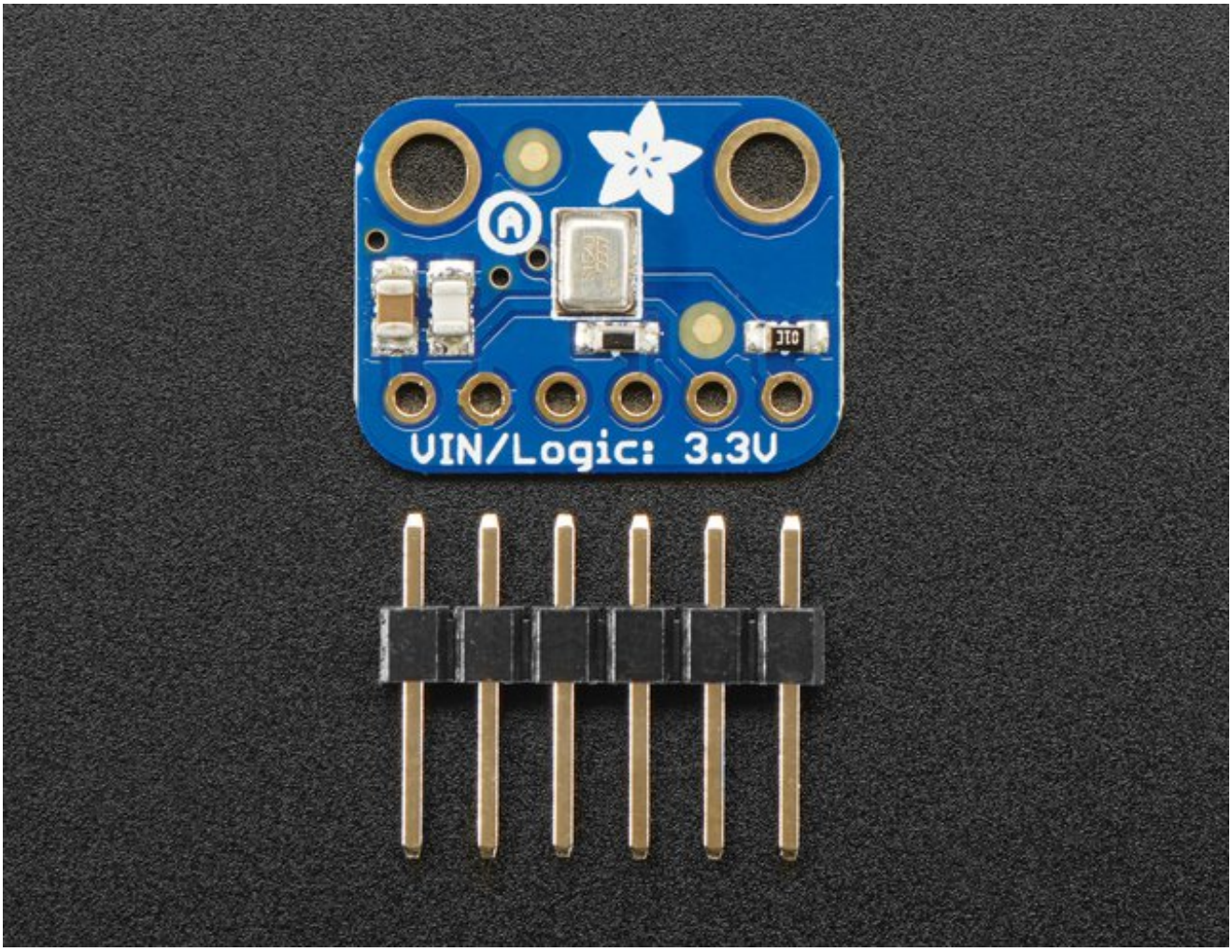
Guide Contents

Overview

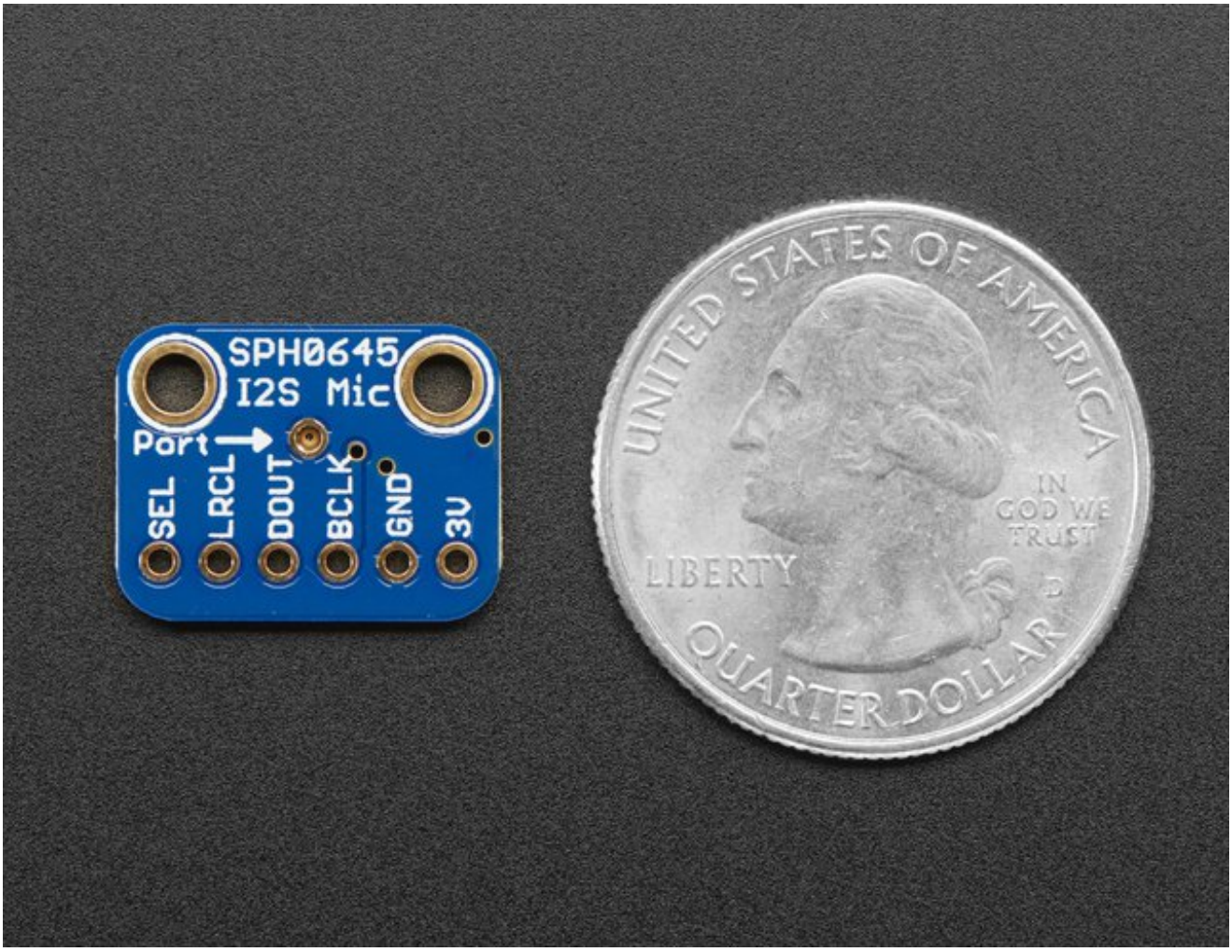


For many microcontrollers, adding audio input is easy with one of our analog microphone breakouts (http://adafru.it/1063). But as you get to bigger and better microcontrollers and microcomputers, you'll find that you don't always have an analog input, or maybe you want to avoid the noise that can seep in with an analog mic system. Once you get past 8-bit micros, you will often find an **I2S** peripheral, that can take *digital audio data* in! That's where this **I2S Microphone Breakout** comes in.

Instead of an analog output, there are three digital pins: Clock, Data and Word-Select. When connected to your microcontroller/computer, the 'I2S Master' will drive the clock and word-select pins at a high frequency and read out the data from the microphone. No analog conversion required!



The microphone is a single mono element. You can select whether you want it to be on the Left or Right channel by connecting the Select pin to power or ground. If you have two microphones, you can set them up to be stereo by sharing the Clock, WS and Data lines but having one with Select to ground, and one with Select to high voltage.

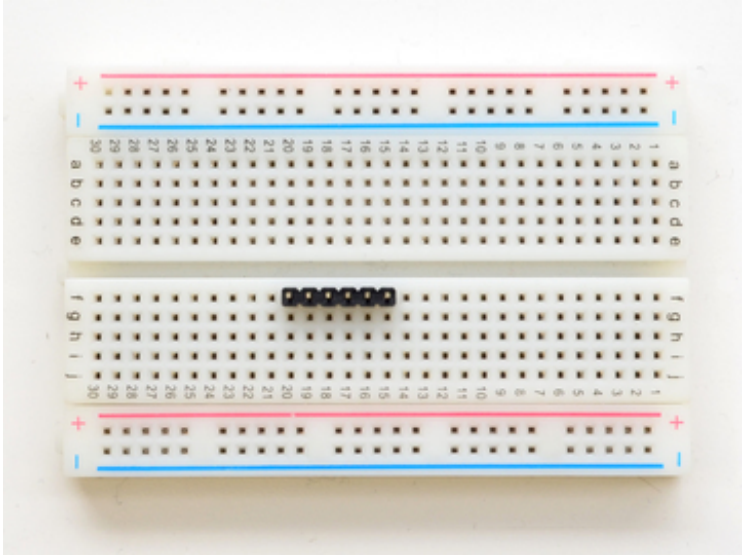


This I2S MEMS microphone is bottom ported, so make sure you have the hole in the bottom facing out towards the sounds you want to read. It's a 1.6-3.3V device only, so not for use with 5V logic (its really unlikely you'd have a 5V-logic device with I2S anyways). Many beginner microcontroller boards *don't* have I2S, so make sure its a supported interface before you try to wire it up! This microphone is best used with Cortex M-series chips like the Arduino Zero, Feather M0, or single-board computers like the Raspberry Pi.

Assembly

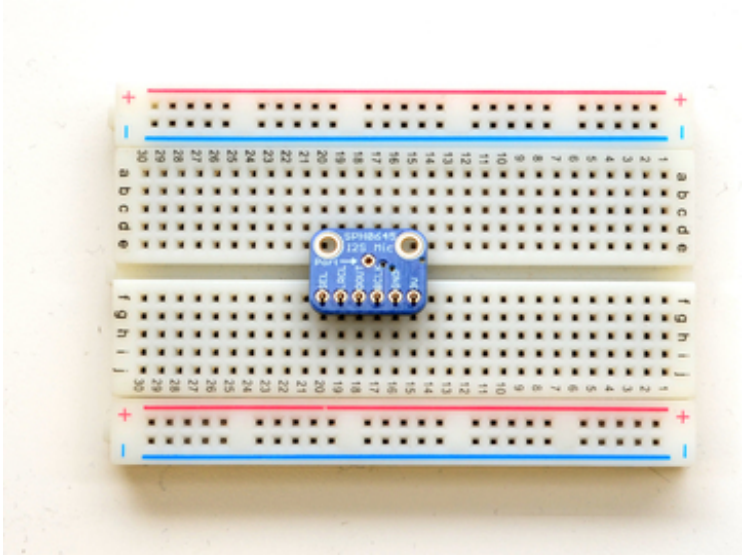
Assembly is really easy, you can use straight or 'right-angle' style headers to attach to the PCB. We'll be using the plain straight headers included

The board comes with all surface-mount components pre-soldered. The included header strip can be soldered on for convenient use on a breadboard or with 0.1" connectors. You can also skip this step and solder on wires.

- 

Prepare the header strip:

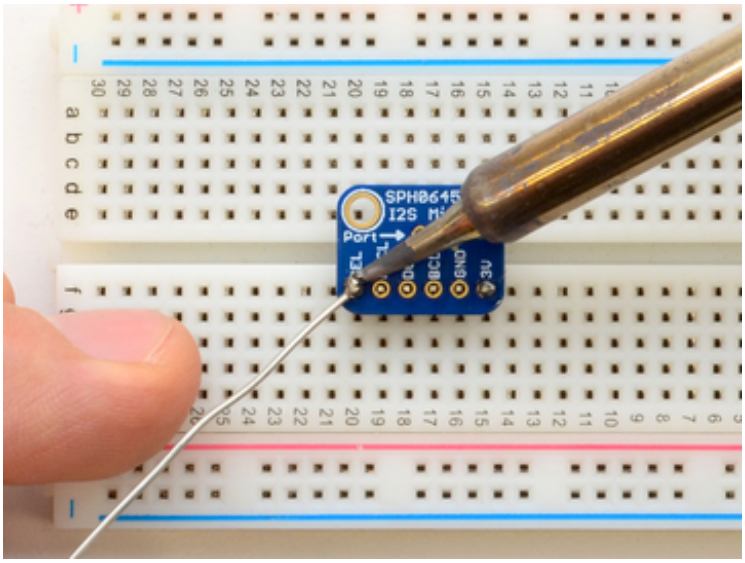
Cut the strip to length if necessary. It will be easier to solder if you insert it into a breadboard - **long pins down**

- 

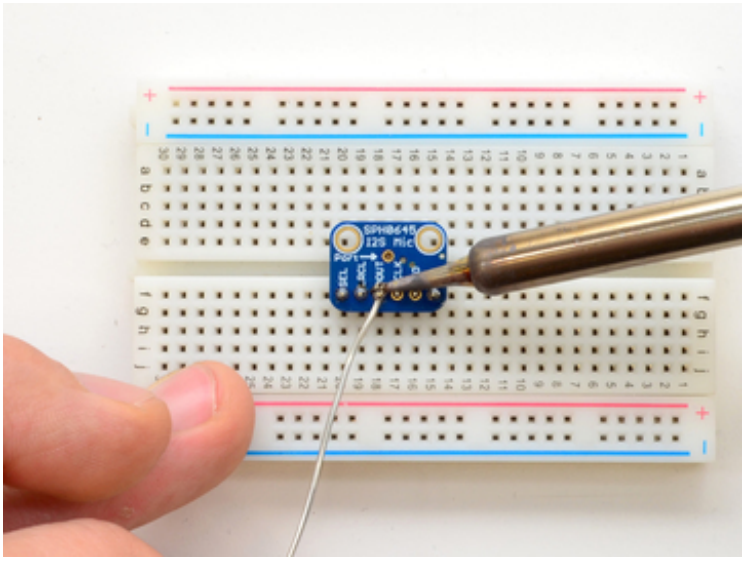
Add the breakout board:

Place the breakout board over the pins so that the short pins poke through the breakout pads

Make sure the side with the components is face down, as shown in the photos in this guide!

- 

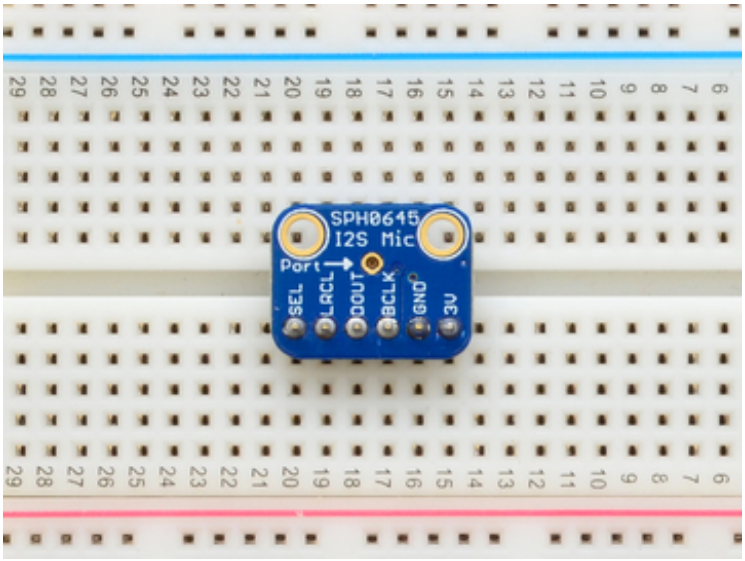
And Solder!

- 

Be sure to solder all 5 pins for reliable electrical contact.

(For tips on soldering, be sure to check out our [Guide to Excellent Soldering](http://adafru.it/aTk)).

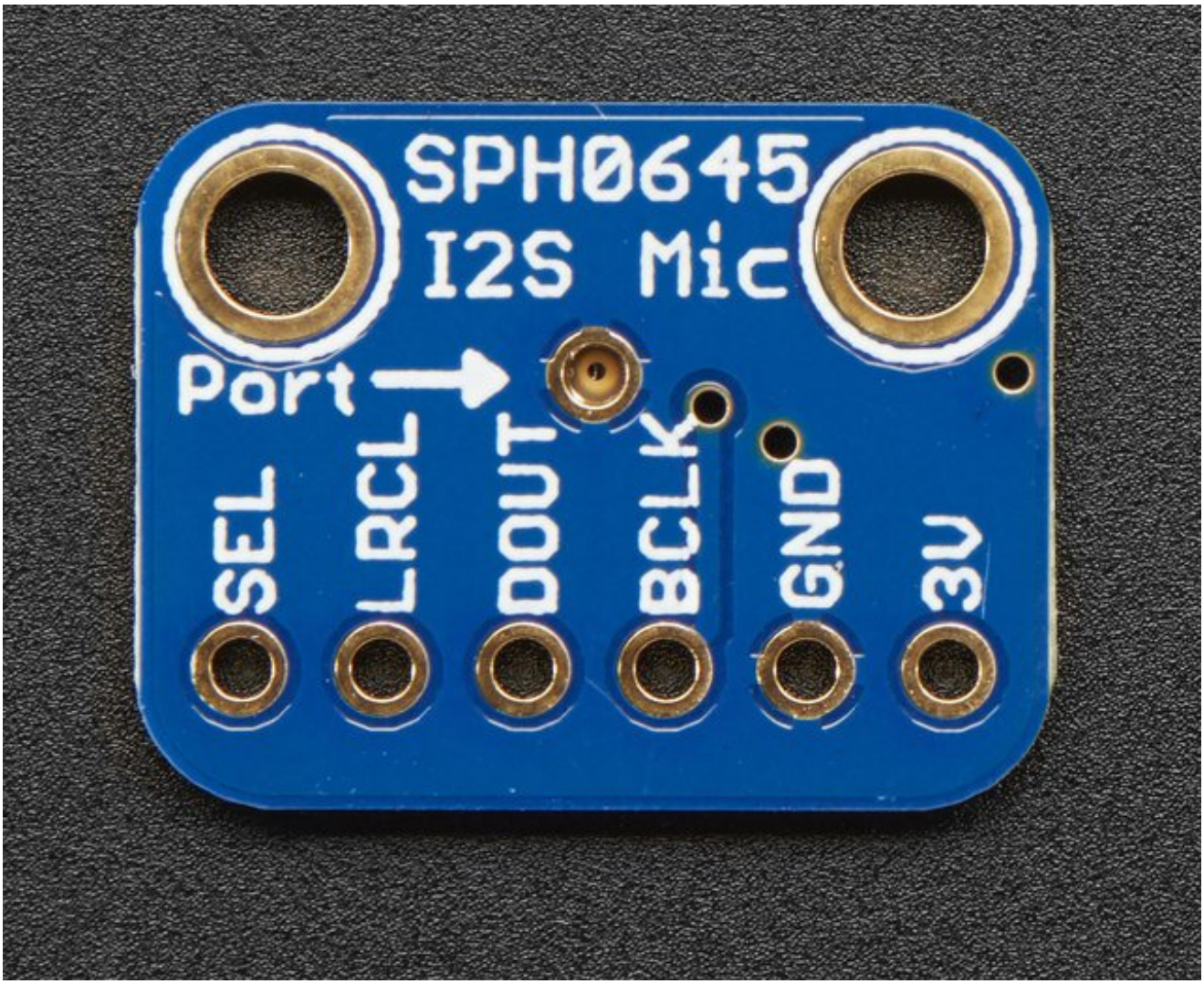
You're done! Check your solder

- 

joints visually and continue onto the next steps

Pinouts

Unlike most of our breakouts, this sensor has the detection element on the**bottom** of the PCB, so we expect you to solder it 'upside down' with the sensor package on the bottom and the port on top!



Power Pins

- **3V** - this is the power in pin. Technically it can be powered from as low as 1.6V to 3.6V but you'll need to make sure your logic level matches!
- **GND** - power and data ground

I2S Data Pins

- **BCLK** - the bit clock, also known as the data clock or just 'clock' - comes from the I2S master to tell the microphone its time to transmit data. This should run at 2-4 MHz but we've found you can often run it a little slower and it'll work fine
- **DOUT** - the data output from the mic!
- **LRCLK** - the left/right clock, also known as**WS** (word select), this tells the mic when to start transmitting. When the **LRCLK** is low, the left channel will transmit. When LRCLK is high, the right channel will transmit.
- **SEL** - the channel select pin. By default this pin is low, so that it will transmit on the left channel mono. If you connect this to high logic voltage, the microphone will instantly start transmitting on the right channel.

Arduino Wiring & Test

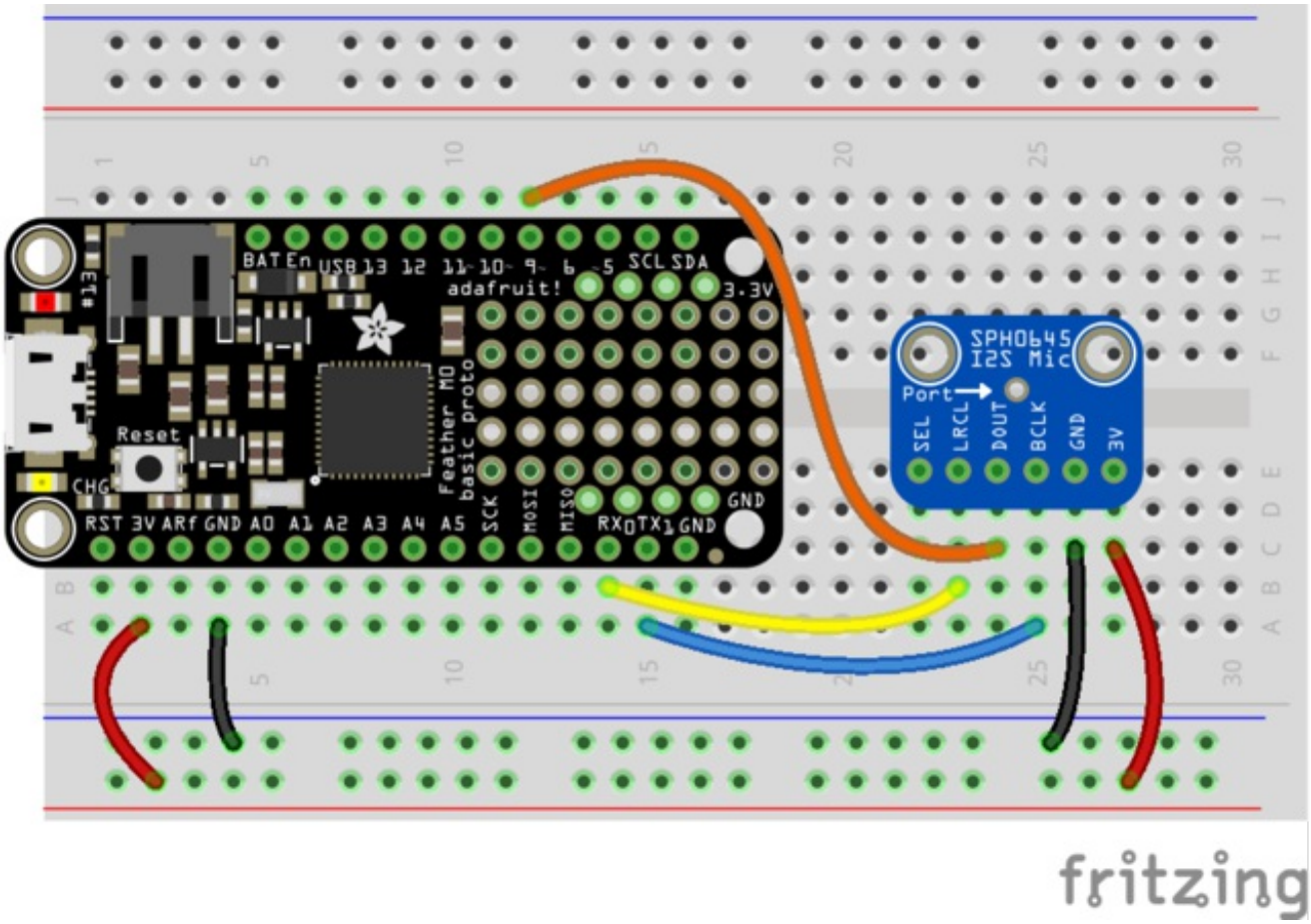
Remember, the I2S microphone requires an I2S peripheral and won't work with chips that *don't* support it in hardware! For this example we'll use a Feather M0, but you can also use an Arduino Zero.

Wiring

For Feather M0, Ardruino Zero and friends, use the following wiring:

- **GND** connected GND
- **3.3V** connected 3.3V (Feather, Zero) or VCC (MKR1000, MKRZero)
- **LRCLK** / WS connected to pin 0 (Feather, Zero) or pin 3 (MKR1000, MKRZero)
- **BCLK** connected to pin 1 (Feather, Zero) or pin 2 (MKR1000, MKRZero)
- **Data** /SD connected to pin 9 (Zero) or pin A6 (MKR1000, MKRZero

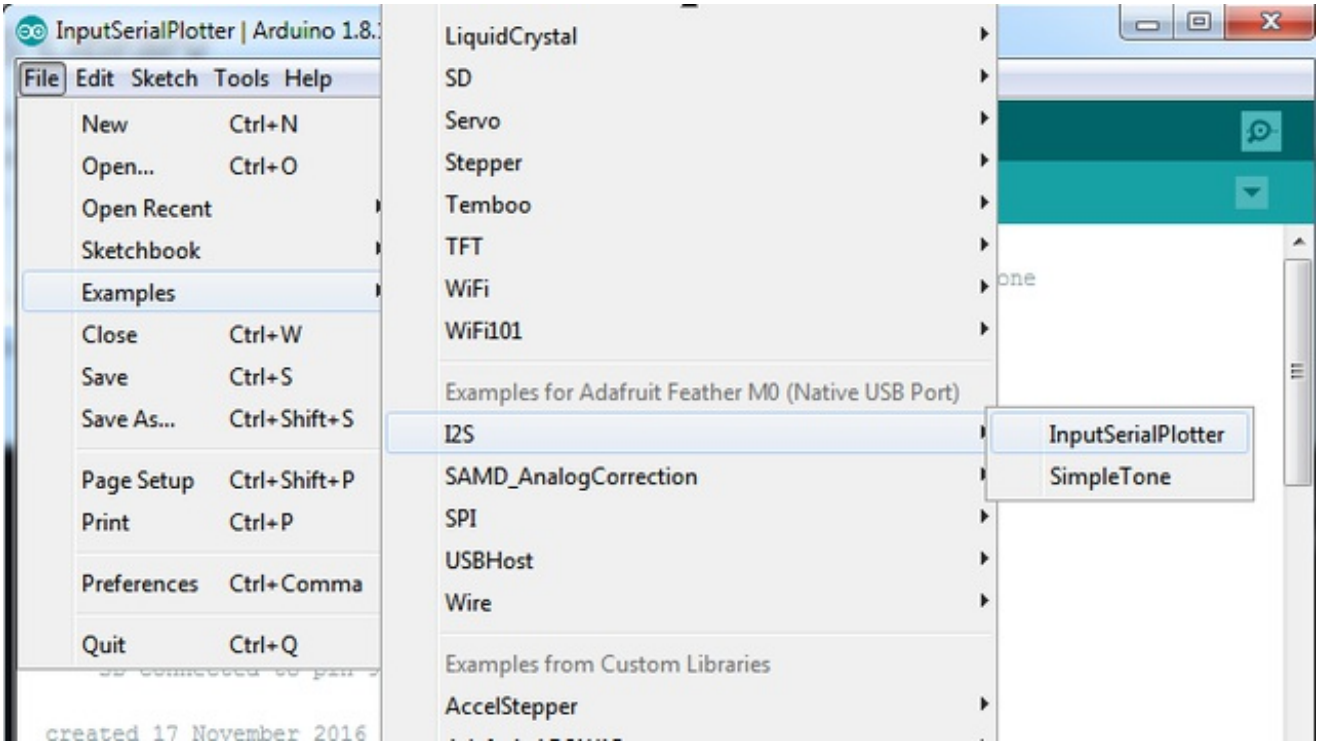
You can leave **Select** disconnected



i2sfeatherm0.fzz
http://adafru.it/uya

I2S Library

Luckily, there's a nice little I2S library already written for Arduinos based on the SAMD processor. Make sure you have the most recent Arduino IDE and SAMD core. Then select the board you're using (e.g. Adafruit Feather M0) and you'll see the **I2S** library examples show up in the pulldown menu

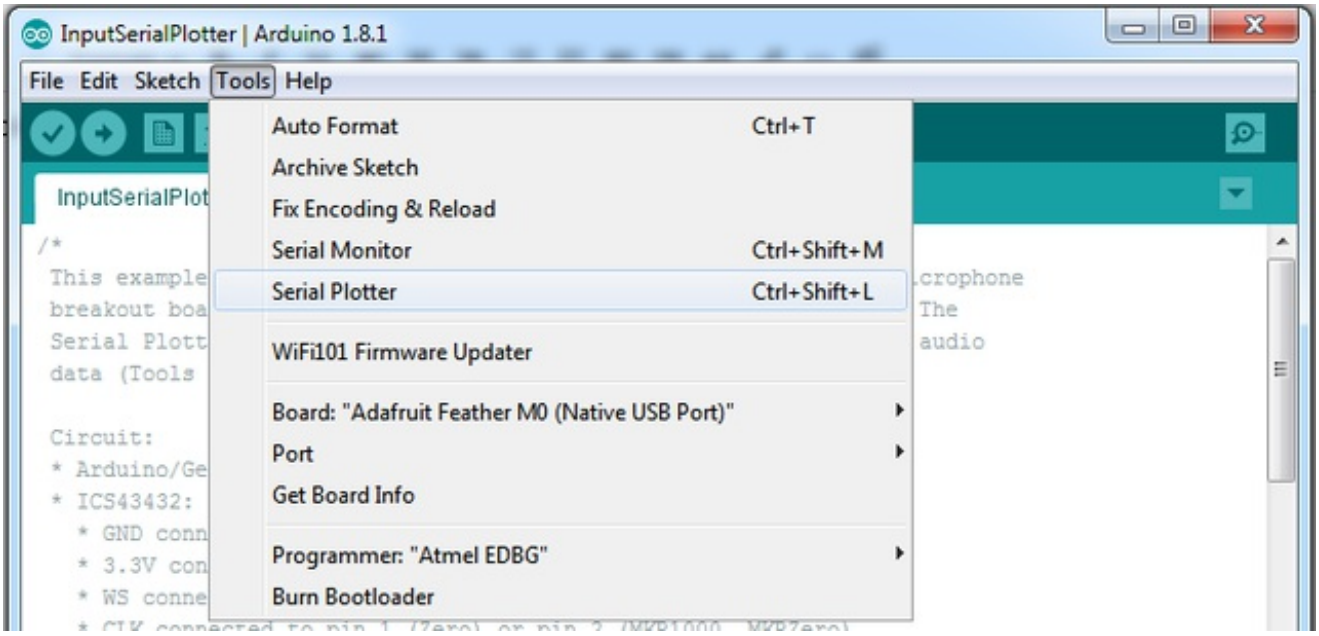


You could try the InputPlotter demo but this code is higher resolution:

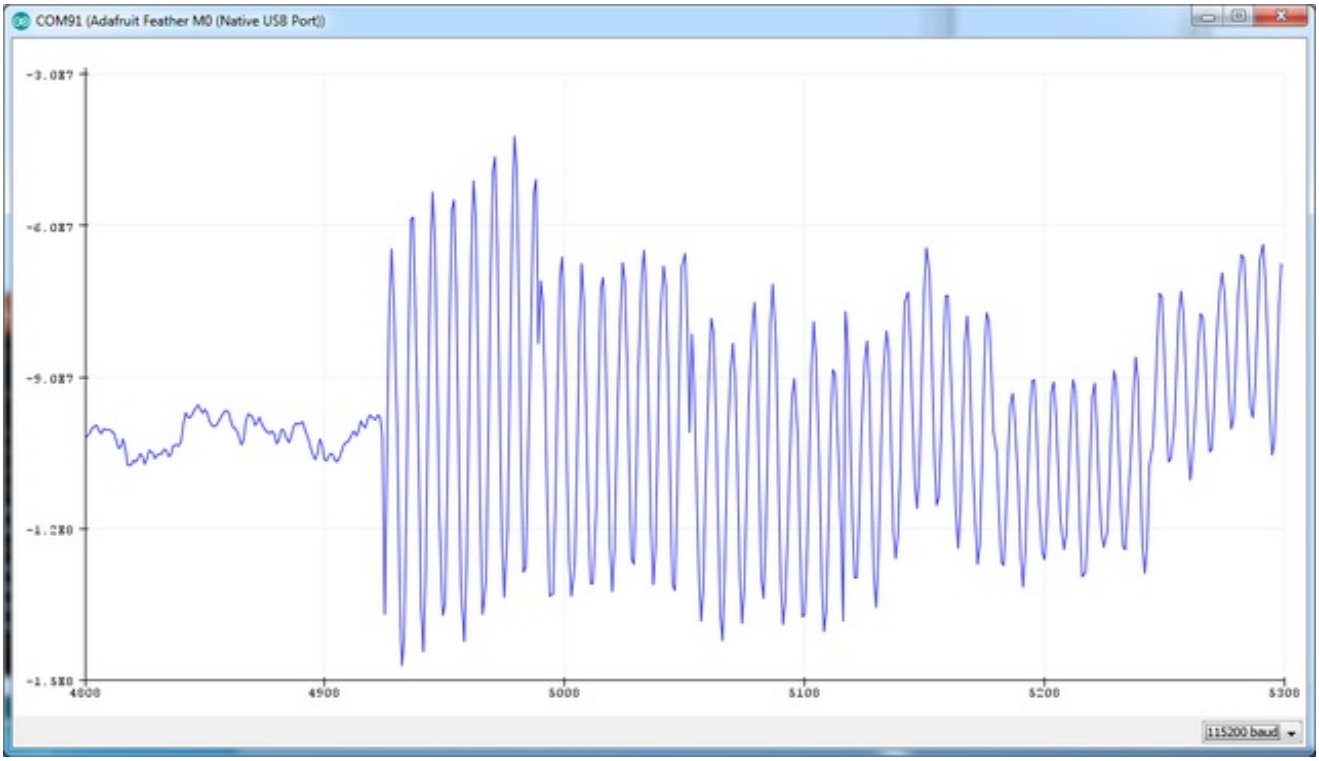
```
/*
 This example reads audio data from an I2S microphone
 breakout board, and prints out the samples to the Serial console. The
 Serial Plotter built into the Arduino IDE can be used to plot the audio
 data (Tools -> Serial Plotter)

 Circuit:
* Arduino/Genuino Zero, MKRZero or MKR1000 board
  * GND connected GND
  * 3.3V connected 3.3V (Zero) or VCC (MKR1000, MKRZero)
  * WS connected to pin 0 (Zero) or pin 3 (MKR1000, MKRZero)
  * CLK connected to pin 1 (Zero) or pin 2 (MKR1000, MKRZero)
  * SD connected to pin 9 (Zero) or pin A6 (MKR1000, MKRZero)

 created 17 November 2016
 by Sandeep Mistry
 */

#include <I2S.h>

void setup() {
  // Open serial communications and wait for port to open:
  // A baud rate of 115200 is used instead of 9600 for a faster data rate
  // on non-native USB ports
  Serial.begin(115200);
  while (!Serial) {
    ; // wait for serial port to connect. Needed for native USB port only
```

```
  }

  // start I2S at 16 kHz with 32-bits per sample
  if (!I2S.begin(I2S_PHILIPS_MODE, 16000, 32)) {
    Serial.println("Failed to initialize I2S!");
    while (1); // do nothing
  }
}

void loop() {
  // read a sample
  int sample = I2S.read();

  if ((sample == 0) || (sample == -1) ) {
    return;
  }
  // convert to 18 bit signed
  sample >>= 14;

  // if it's non-zero print value to serial
  Serial.println(sample);
}
```

Upload to your Arduino Zero/Feather wired up as above, and open up the**Serial Plotter**



Try blowing or whistling at the sensor to see response in real time



VU Meter Demo

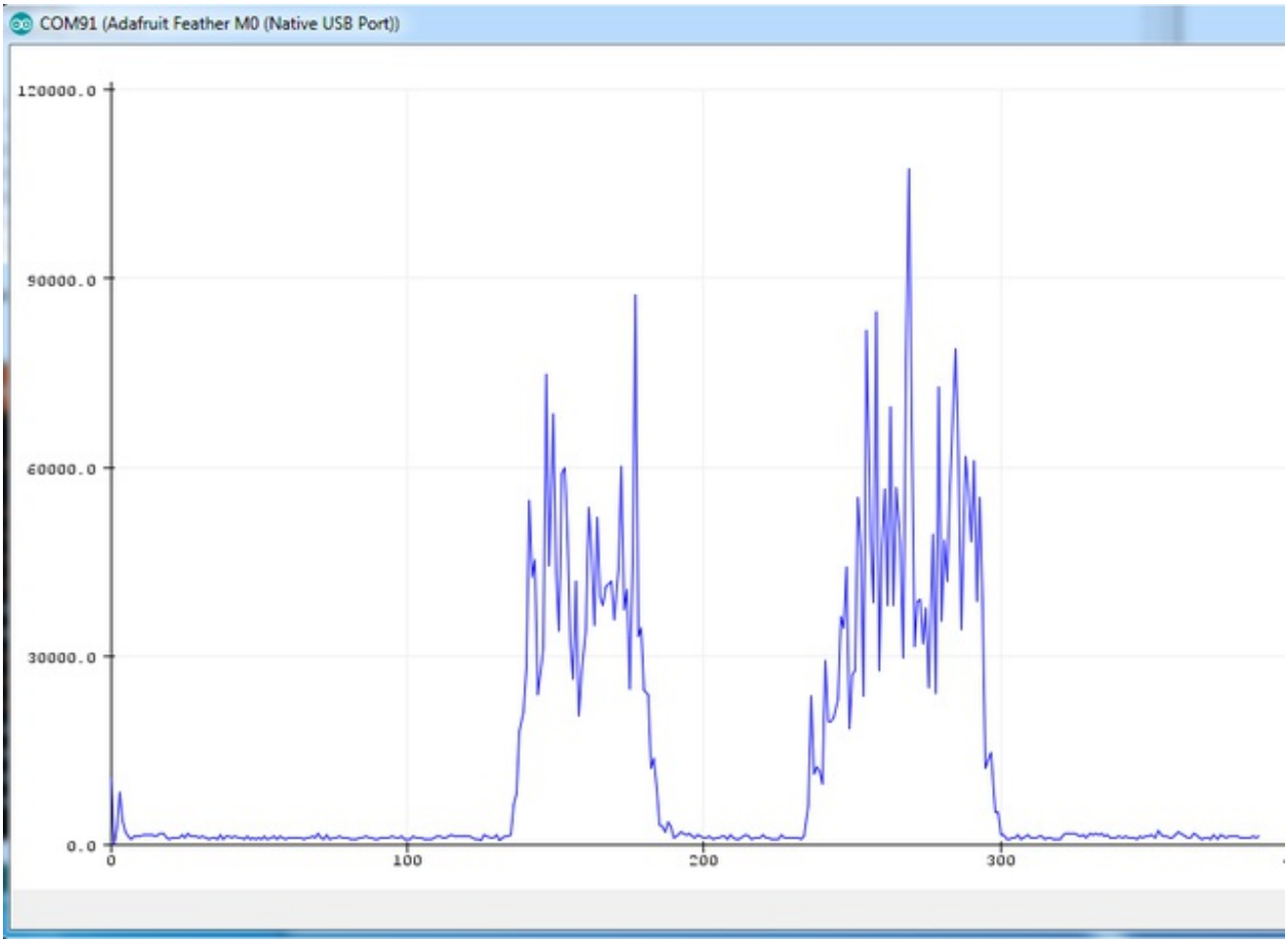
Often times you don't want the actual audio data but the overall "sound pressure level". This example will take a bunch of samples, normalize the data to be around 0, then give you the maximum difference between the waveforms for a 'volume graph'

```
/*
 This example reads audio data from an Invensense's ICS43432 I2S microphone
 breakout board, and prints out the samples to the Serial console. The
 Serial Plotter built into the Arduino IDE can be used to plot the audio
 data (Tools -> Serial Plotter)

 Circuit:
* Arduino/Genuino Zero, MKRZero or MKR1000 board
* ICS43432:
  * GND connected GND
  * 3.3V connected 3.3V (Zero) or VCC (MKR1000, MKRZero)
  * WS connected to pin 0 (Zero) or pin 3 (MKR1000, MKRZero)
  * CLK connected to pin 1 (Zero) or pin 2 (MKR1000, MKRZero)
  * SD connected to pin 9 (Zero) or pin A6 (MKR1000, MKRZero)

 created 17 November 2016
 by Sandeep Mistry
 */

#include <I2S.h>
```

```
void setup() {
  // Open serial communications and wait for port to open:
  // A baud rate of 115200 is used instead of 9600 for a faster data rate
  // on non-native USB ports
  Serial.begin(115200);
  while (!Serial) {
    ; // wait for serial port to connect. Needed for native USB port only
  }

  // start I2S at 16 kHz with 32-bits per sample
  if (!I2S.begin(I2S_PHILIPS_MODE, 16000, 32)) {
    Serial.println("Failed to initialize I2S!");
    while (1); // do nothing
  }
}

#define SAMPLES 128 // make it a power of two for best DMA performance

void loop() {
  // read a bunch of samples:
  int samples[SAMPLES];

  for (int i=0; i<SAMPLES; i++) {
    int sample = 0;
    while ((sample == 0) || (sample == -1) ) {
      sample = I2S.read();
    }
    // convert to 18 bit signed
    sample >>= 14;
    samples[i] = sample;
  }

  // ok we hvae the samples, get the mean (avg)
  float meanval = 0;
  for (int i=0; i<SAMPLES; i++) {
    meanval += samples[i];
  }
  meanval /= SAMPLES;
  //Serial.print("# average: " ); Serial.println(meanval);

  // subtract it from all sapmles to get a 'normalized' output
  for (int i=0; i<SAMPLES; i++) {
    samples[i] -= meanval;
    //Serial.println(samples[i]);
  }

  // find the 'peak to peak' max
  float maxsample, minsample;
  minsample = 100000;
  maxsample = -100000;
```

```
  for (int i=0; i<SAMPLES; i++) {
    minsample = min(minsample, samples[i]);
    maxsample = max(maxsample, samples[i]);
  }
  Serial.println(maxsample - minsample);
}
```

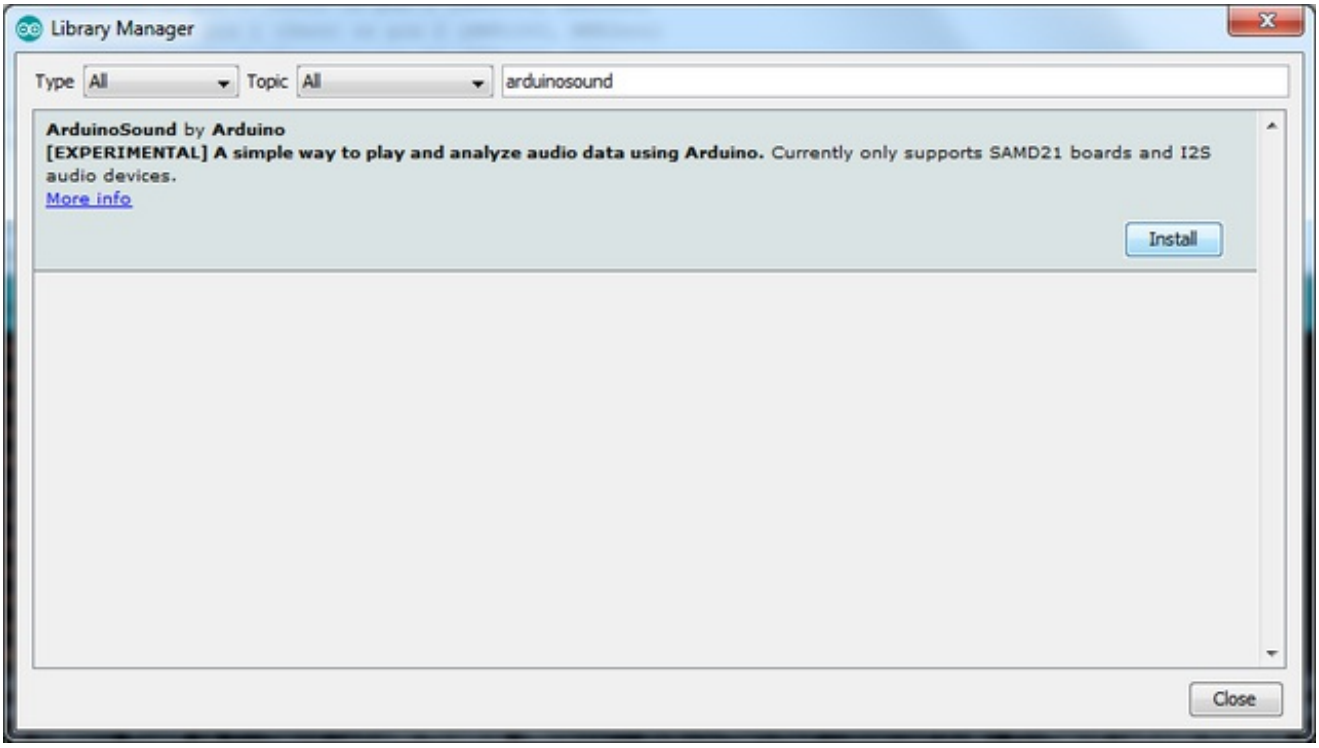
Open up the serial plotter to see how making noises will create peaks!



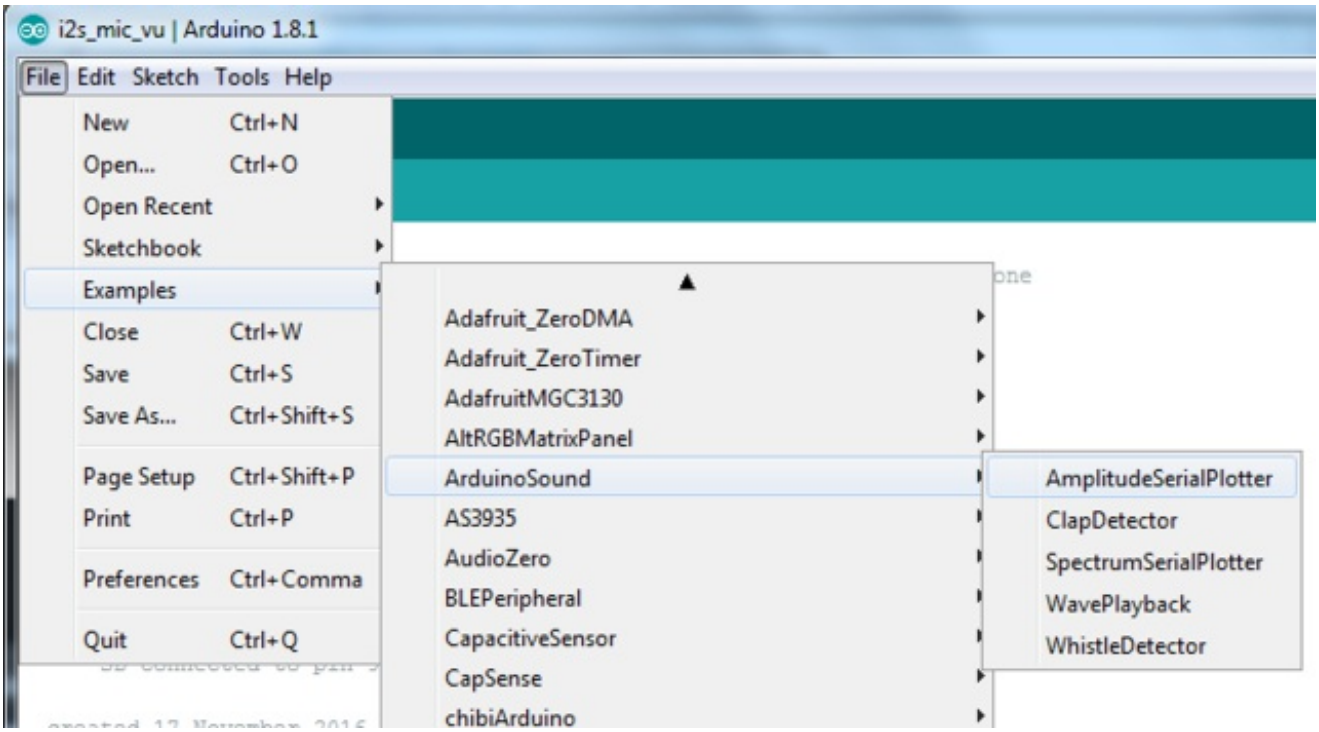
ArduinoSound Library

For most uses, its better to have a higher-level library for managing sound. The ArduinoSound library works with I2S mics and can do filtering, amplitude detection, etc!

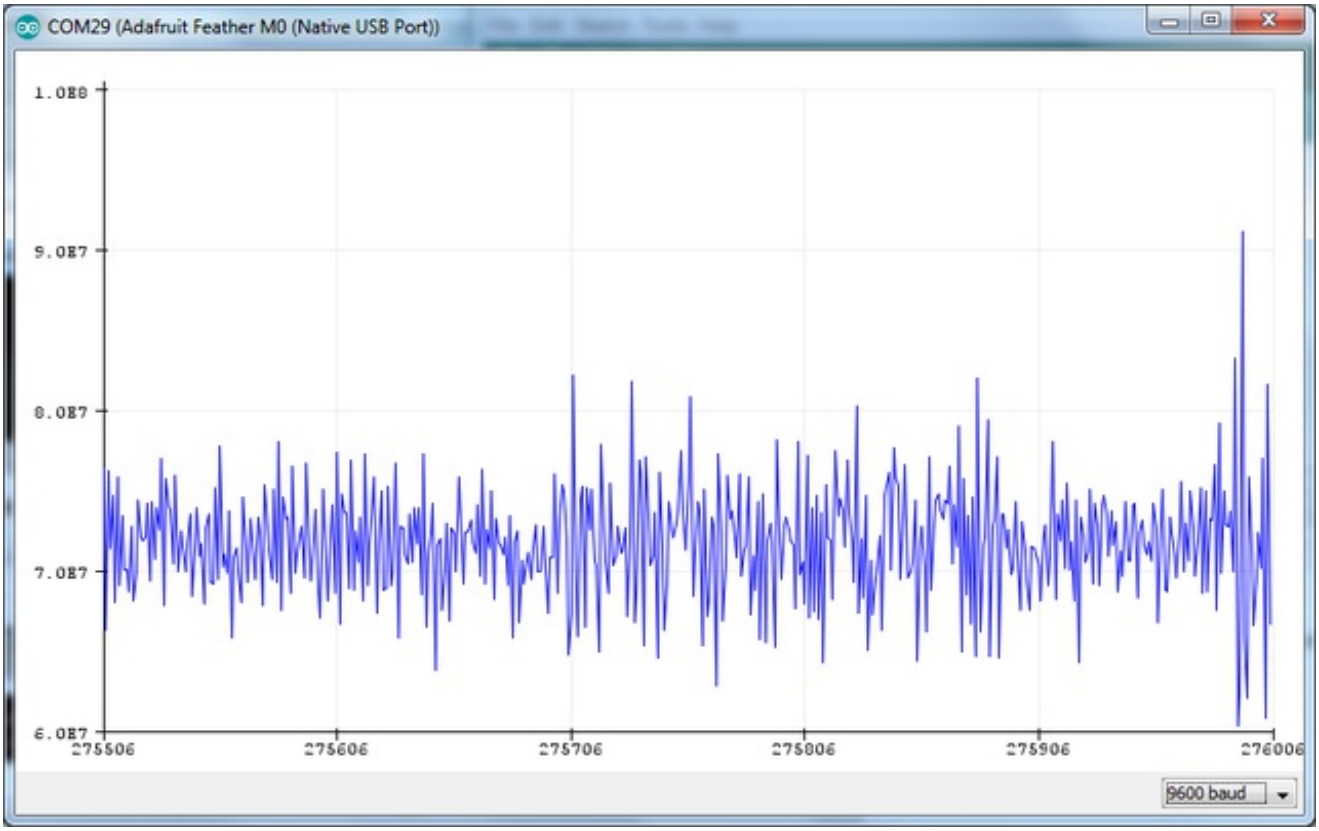
Install it using the Arduino library manager



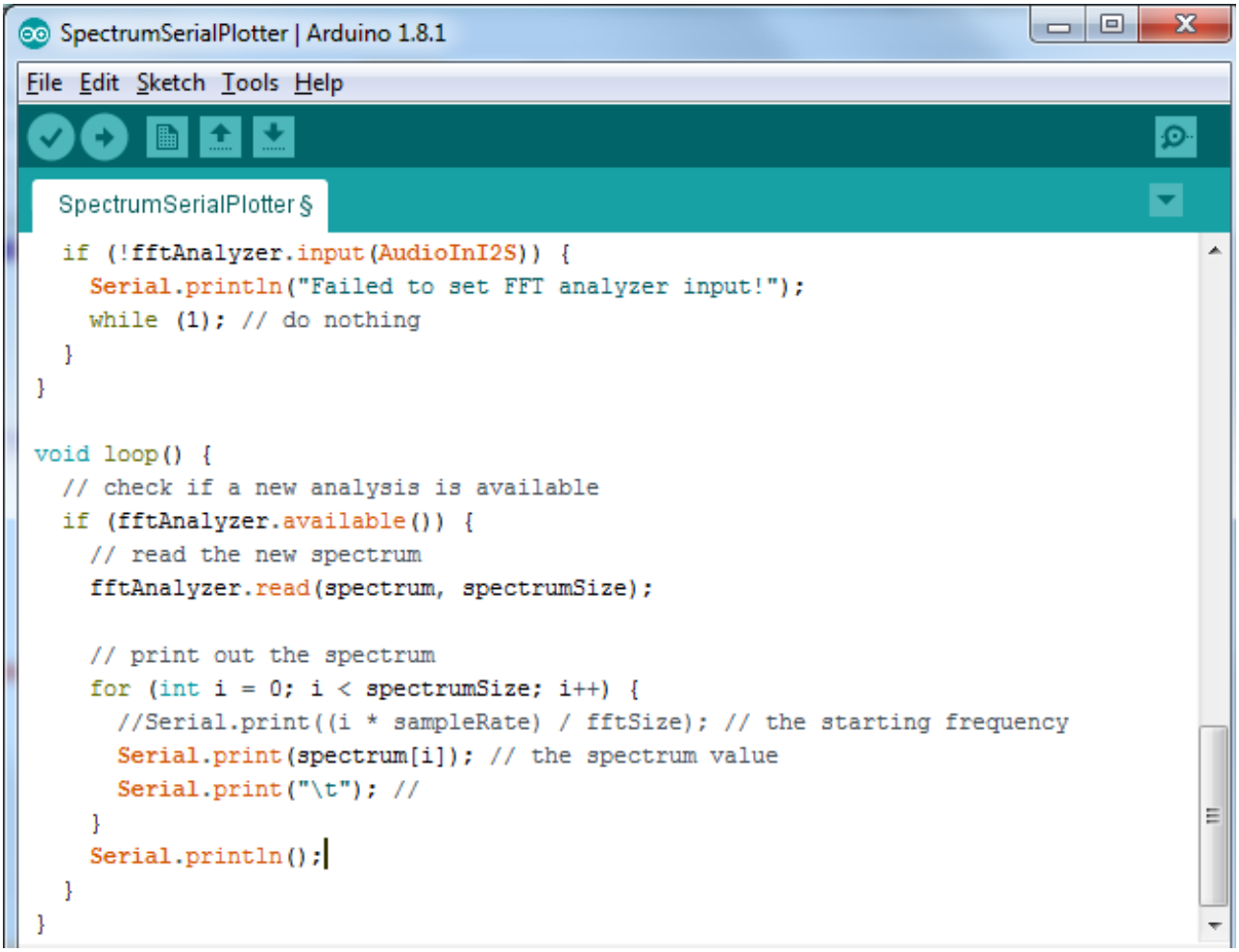
Various examples come with the library, check them out in the File->Examples->ArduinoSound sub menu

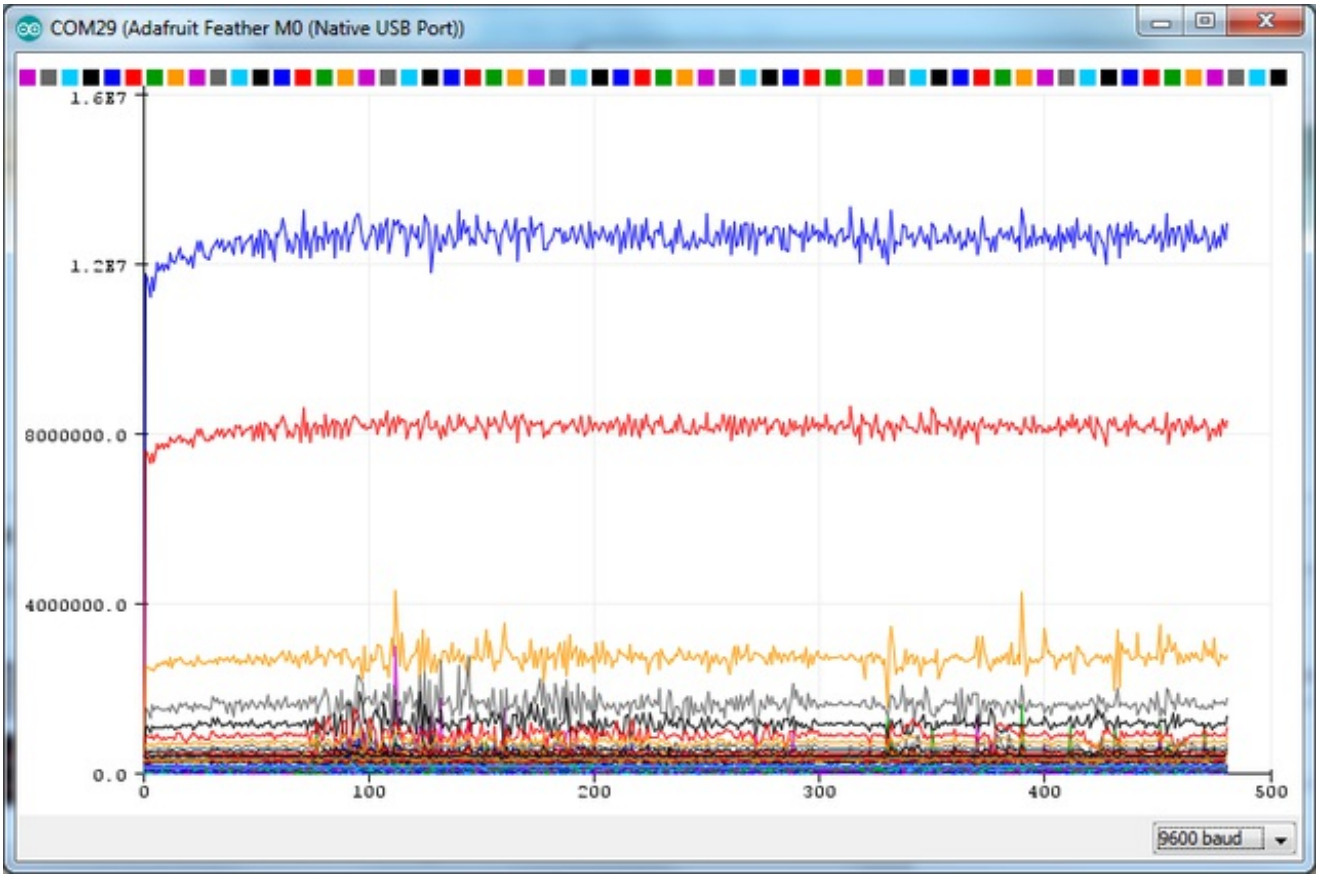


For example, amplitude Serial plotter will do basic amplitude plotting:



You can also do FFT spectral diagramming using SpectrumSerialPlotter. We made a small change to the example so that all 128 bins are plotted:


SpectrumSerialPlotter | Arduino 1.8.1
File Edit Sketch Tools Help
SpectrumSerialPlotter §
if (!fftAnalyzer.input(AudioInI2S)) {
Serial.println("Failed to set FFT analyzer input!");
while (1); // do nothing
}
}
void loop() {
// check if a new analysis is available
if (fftAnalyzer.available()) {
// read the new spectrum
fftAnalyzer.read(spectrum, spectrumSize);
// print out the spectrum
for (int i = 0; i < spectrumSize; i++) {
//Serial.print((i * sampleRate) / fftSize); // the starting frequency
Serial.print(spectrum[i]); // the spectrum value
Serial.print("\t"); //
}
Serial.println();
}
}


COM29 (Adafruit Feather M0 (Native USB Port))
1.6E7
1.2E7
8000000.0
4000000.0
0.0
0
100
200
300
400
500
9600 baud

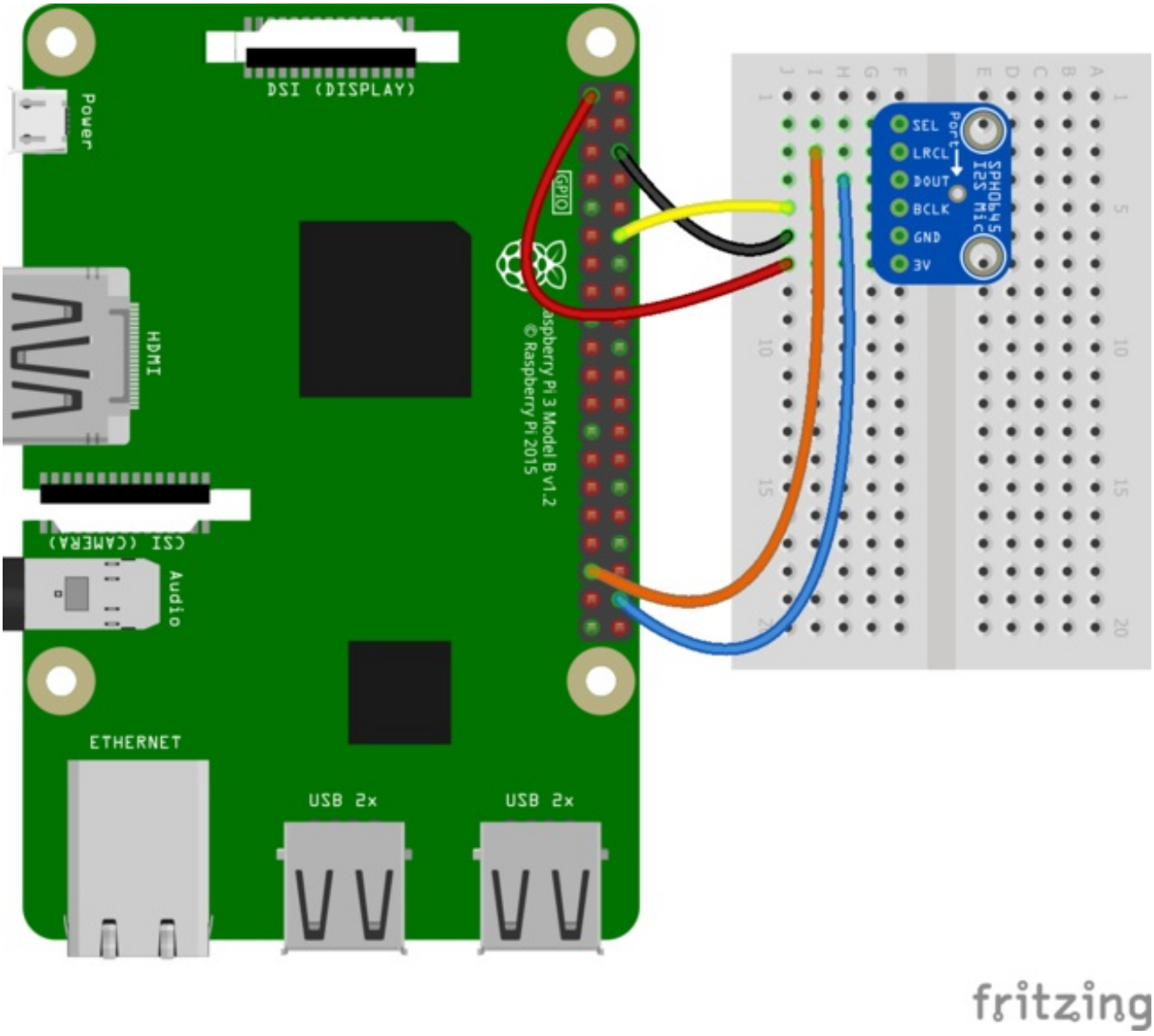
Raspberry Pi Wiring & Test

You can add mono or stereo I2S microphones to your Raspberry Pi, too!

This will work with Raspberry Pi B+, 2, 3, Zero and any other 2x20-connector-Pi

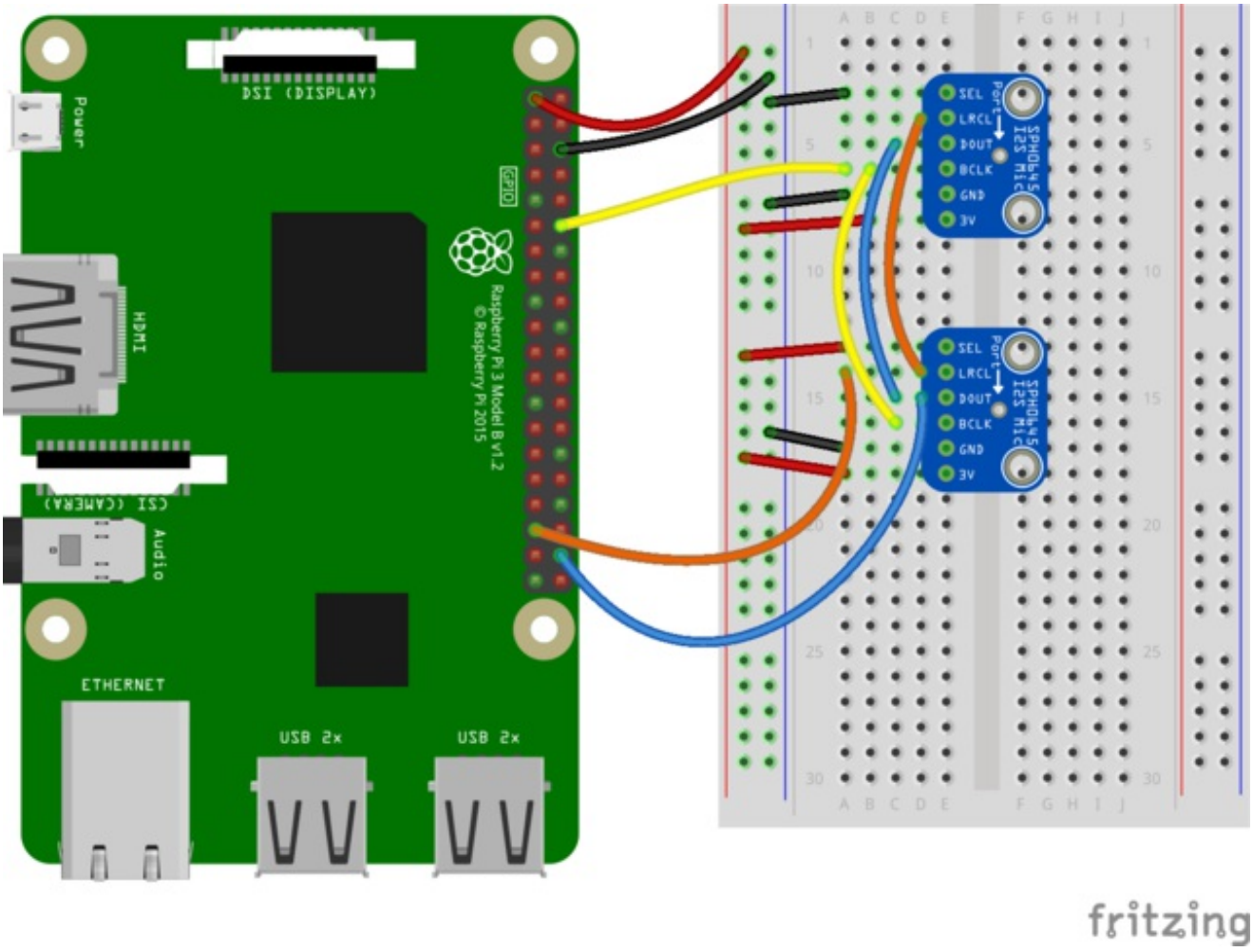
This guide is largely based on this great git repo https://github.com/nejohnson2/rpi-i2s (http://adafru.it/vka)

Wiring For Mono Mic



[Pi i2s Mono Fritzing File](http://adafru.it/vkb)

Wiring For Stereo Mic



[Pi i2s Stereo Fritzing File](http://adafru.it/vkc)

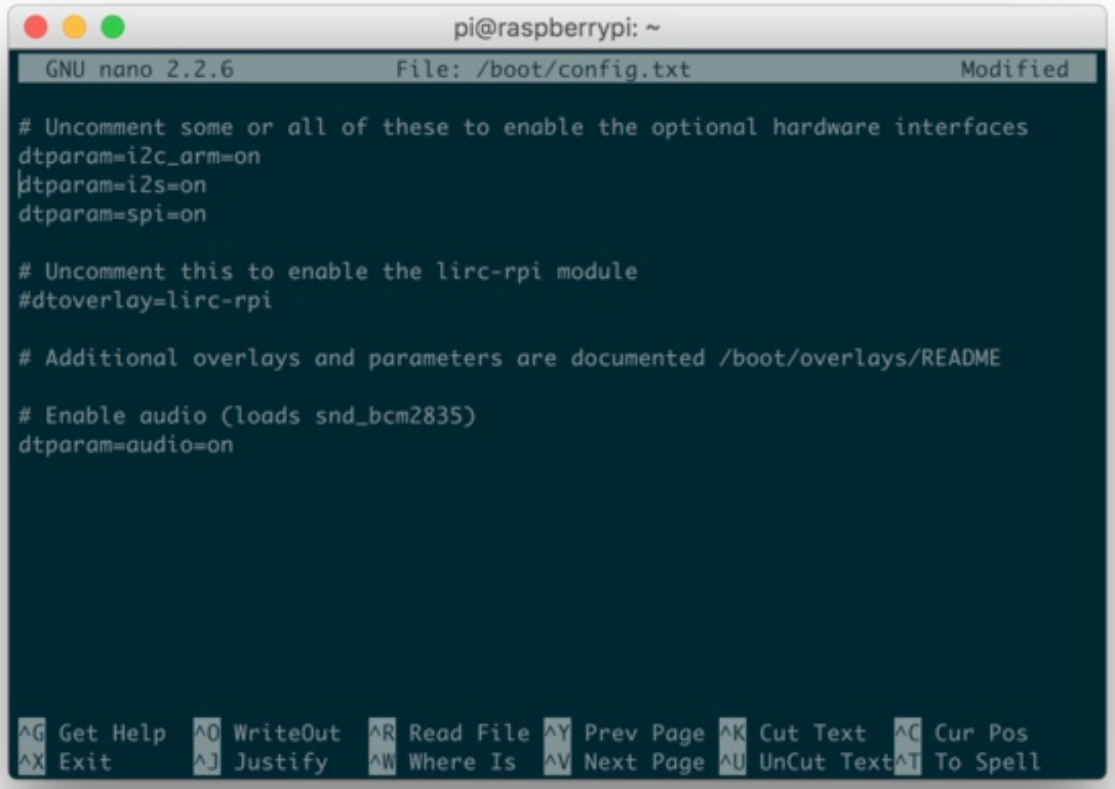
Raspberry Pi i2s Configuration

Start by logging into your Raspberry Pi via a terminal, we recommend ssh so you can copy + paste the many commands.

Turn on **i2s** support by editing **/boot/config.txt** with:

```
sudo nano /boot/config.txt
```

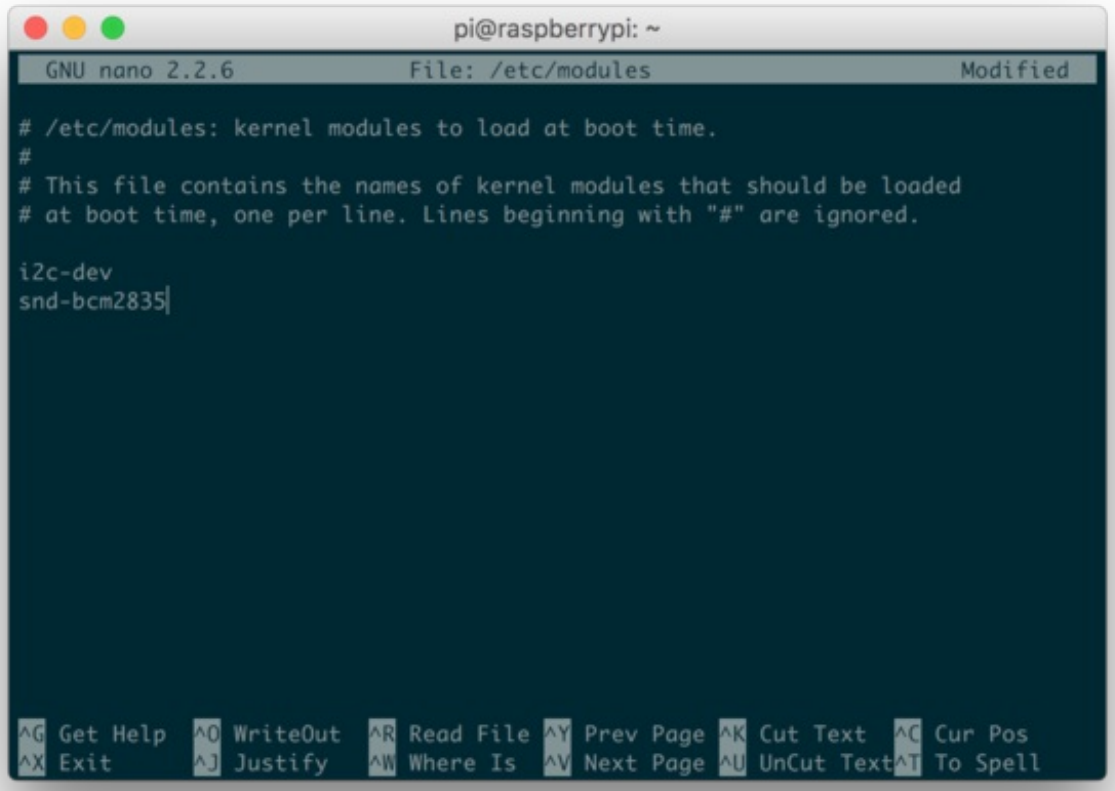
Uncomment #dtparam=i2s=on



Next, we'll make sure sound support is enabled in the kernel with:

sudo nano /etc/modules

Add snd-bcm2835 on its own line, to the modules file as shown below



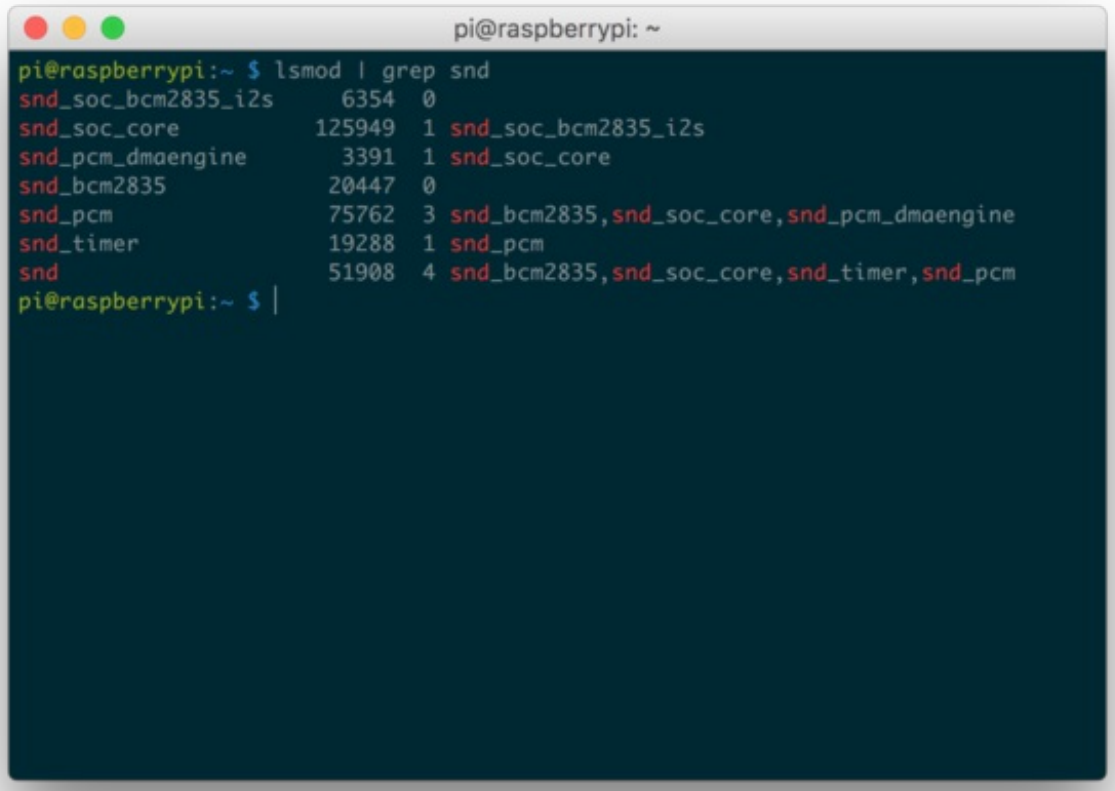
Now reboot your pi with:

```
sudo reboot
```

Once rebooted, re-log in.

Enter the following to confirm the modules are loaded

```
lsmod | grep snd
```



Kernel Compiling

Ok now its time for the *fun* part! You'll manually compile in i2s support.

Start by updating your Pi:

```
sudo apt-get update
sudo apt-get install rpi-update
sudo rpi-update
```

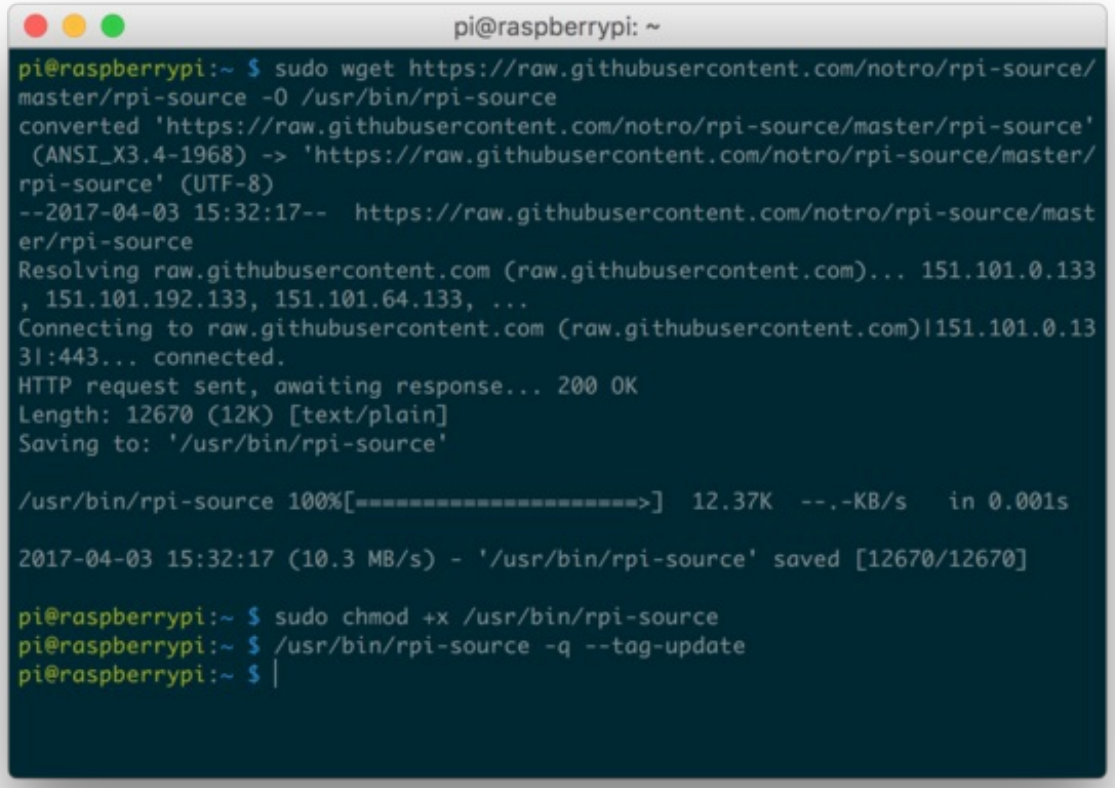
Install the compilation dependencies:

```
sudo apt-get install bc libncurses5-dev
```

Download kernel source & compile:

```
sudo wget https://raw.githubusercontent.com/notro/rpi-source/master/rpi-source -O /usr/bin/rpi-source
sudo chmod +x /usr/bin/rpi-source
/usr/bin/rpi-source -q --tag-update
rpi-source
```

On a Pi 3 this will take many many minutes, so don't worry if its taking 15 minutes. On a Pi Zero it can take an hour or longer!



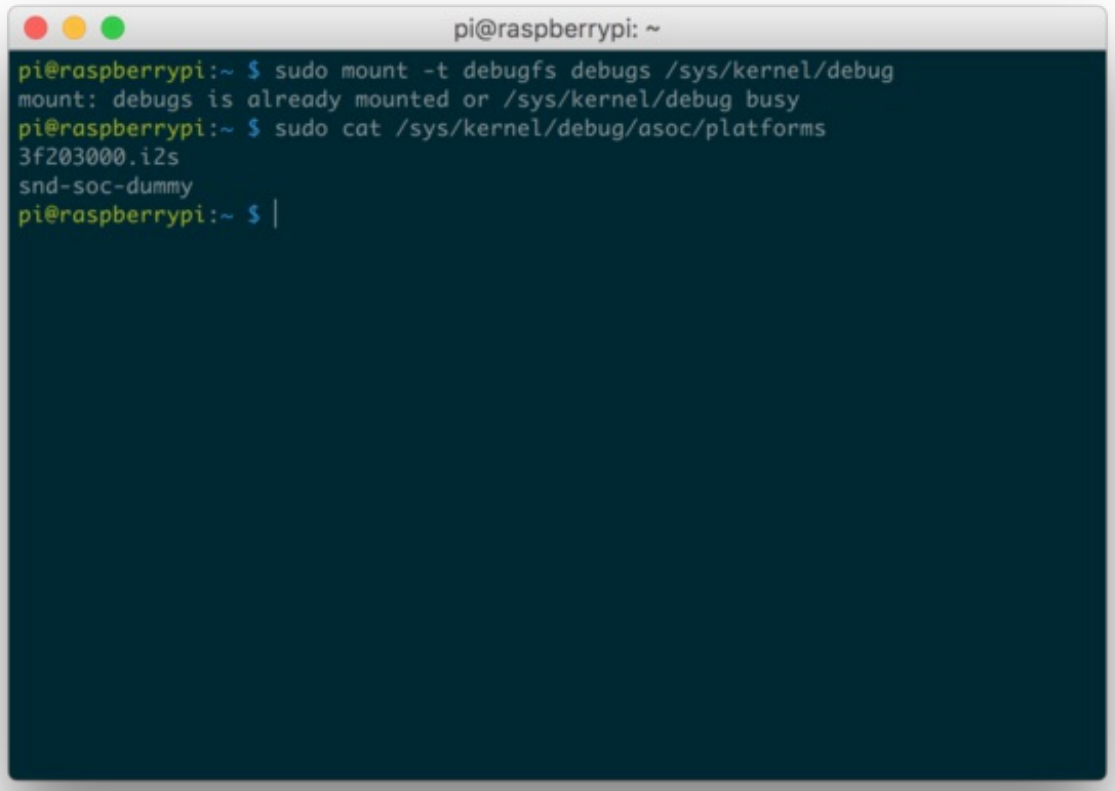
Prepare to Compile the i2s module

Now you're ready to compile i2s support:

sudo mount -t debugfs debugs /sys/kernel/debug

Make sure the module name is 3f203000.i2s

sudo cat /sys/kernel/debug/asoc/platforms

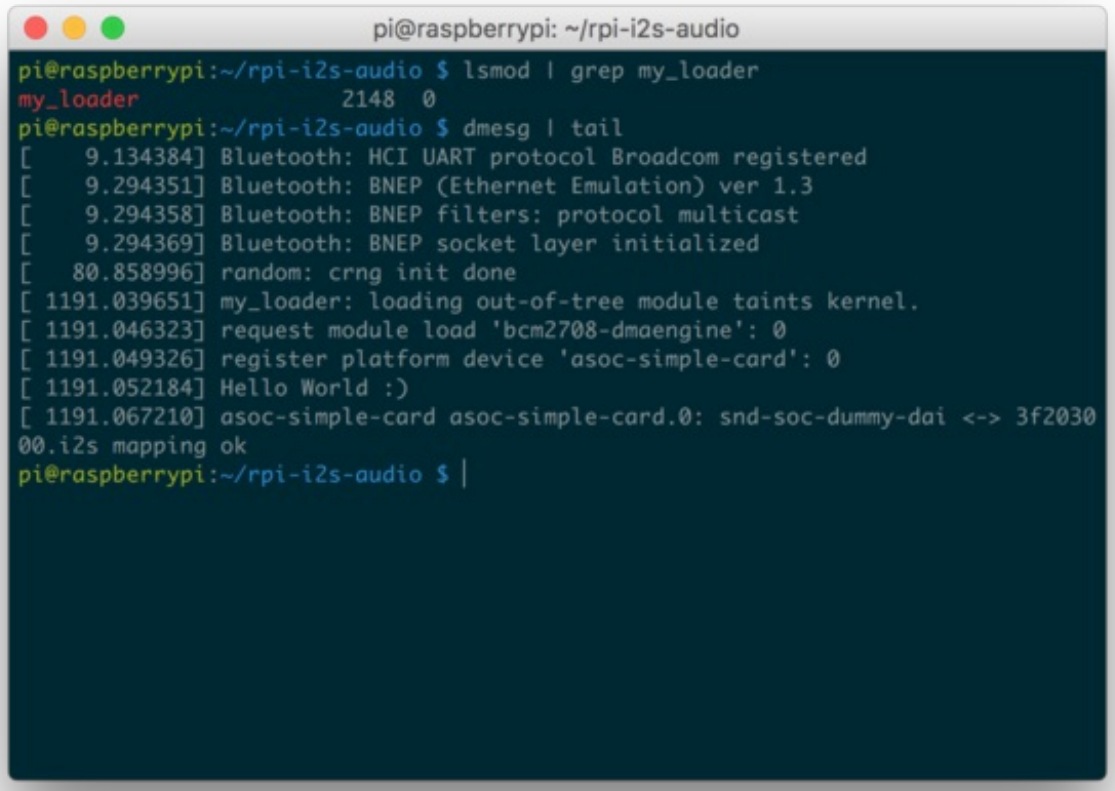


Download the module, written by Paul Creaser (http://adafru.it/vkd)

```
git clone https://github.com/PaulCreaser/rpi-i2s-audio
cd rpi-i2s-audio
make -C /lib/modules/$(uname -r )/build M=$(pwd) modules
sudo insmod my_loader.ko
```

Verify that the module was loaded:

```
lsmod | grep my_loader
dmesg | tail
```



Auto-load the module on startup

Now you can set it up so the module is loaded every time you boot the Pi

```
sudo cp my_loader.ko /lib/modules/$(uname -r)
echo 'my_loader' | sudo tee --append /etc/modules > /dev/null
sudo depmod -a
sudo modprobe my_loader
```

And reboot!

```
sudo reboot
```

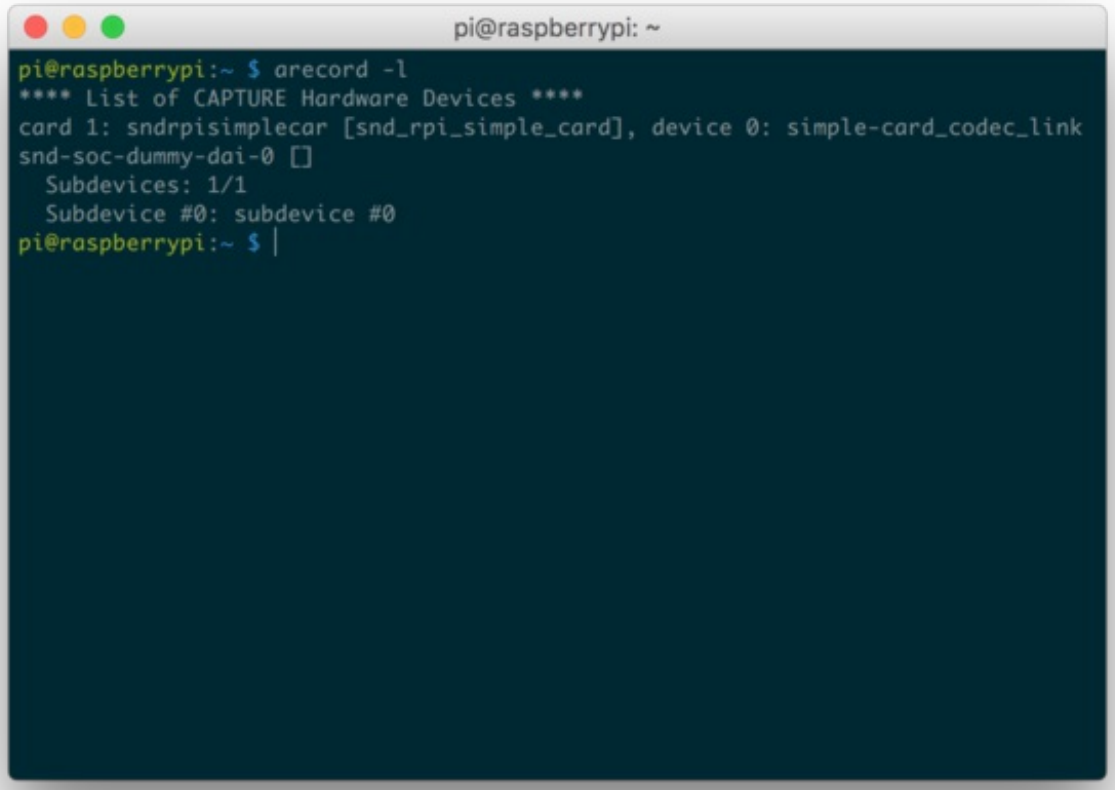
Test & Record!

OK that was a lot of effort but now you are ready to rock!

Use the following command to list the available input devices:

```
arecord -l
```

you should see a **snd_rpi_simple_card**



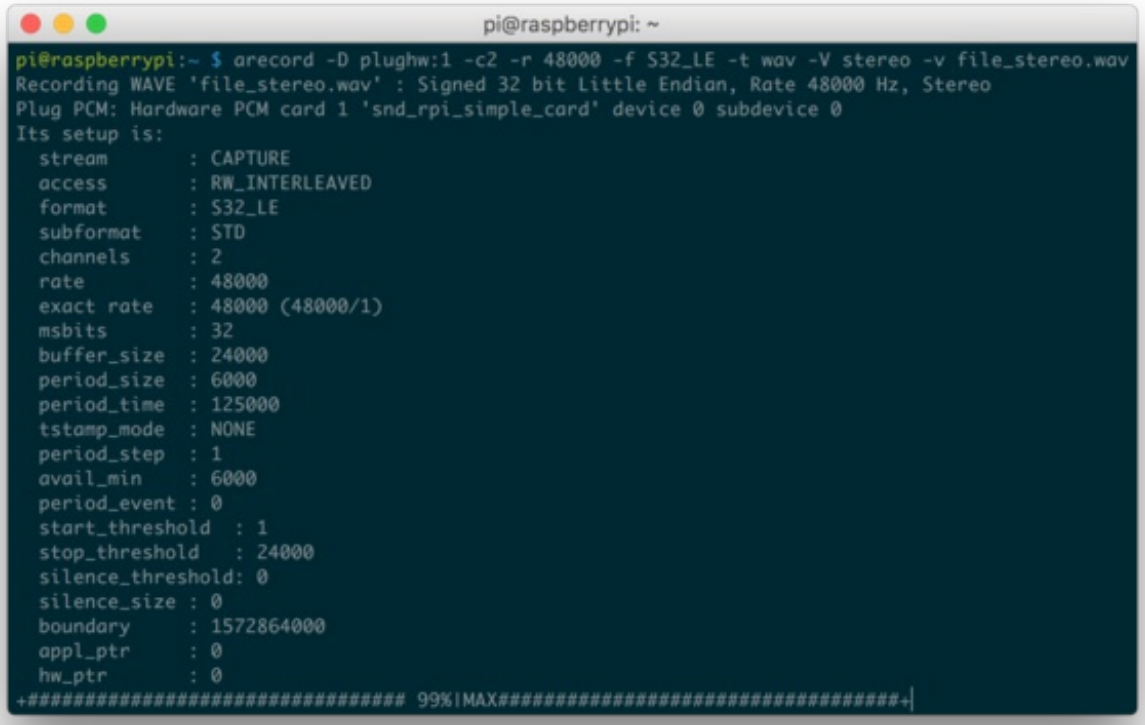
You can record a wav file in mono with this command:

```
arecord -D plughw:1 -c1 -r 48000 -f S32_LE -t wav -V mono -v file.wav
```

Or, if you have two i2s mics installed, record in stereo with this command:

```
arecord -D plughw:1 -c2 -r 48000 -f S32_LE -t wav -V stereo -v file_stereo.wav
```

If all is working correctly, you should see the VU meter react at the bottom of the terminal window



Test Playback

If you have speakers hooked up to the Pi, you can play the file back directly on the device:

aplay file.wav

Or, you can copy it over to your computer for playback :), just insert your Pi's IP address below:

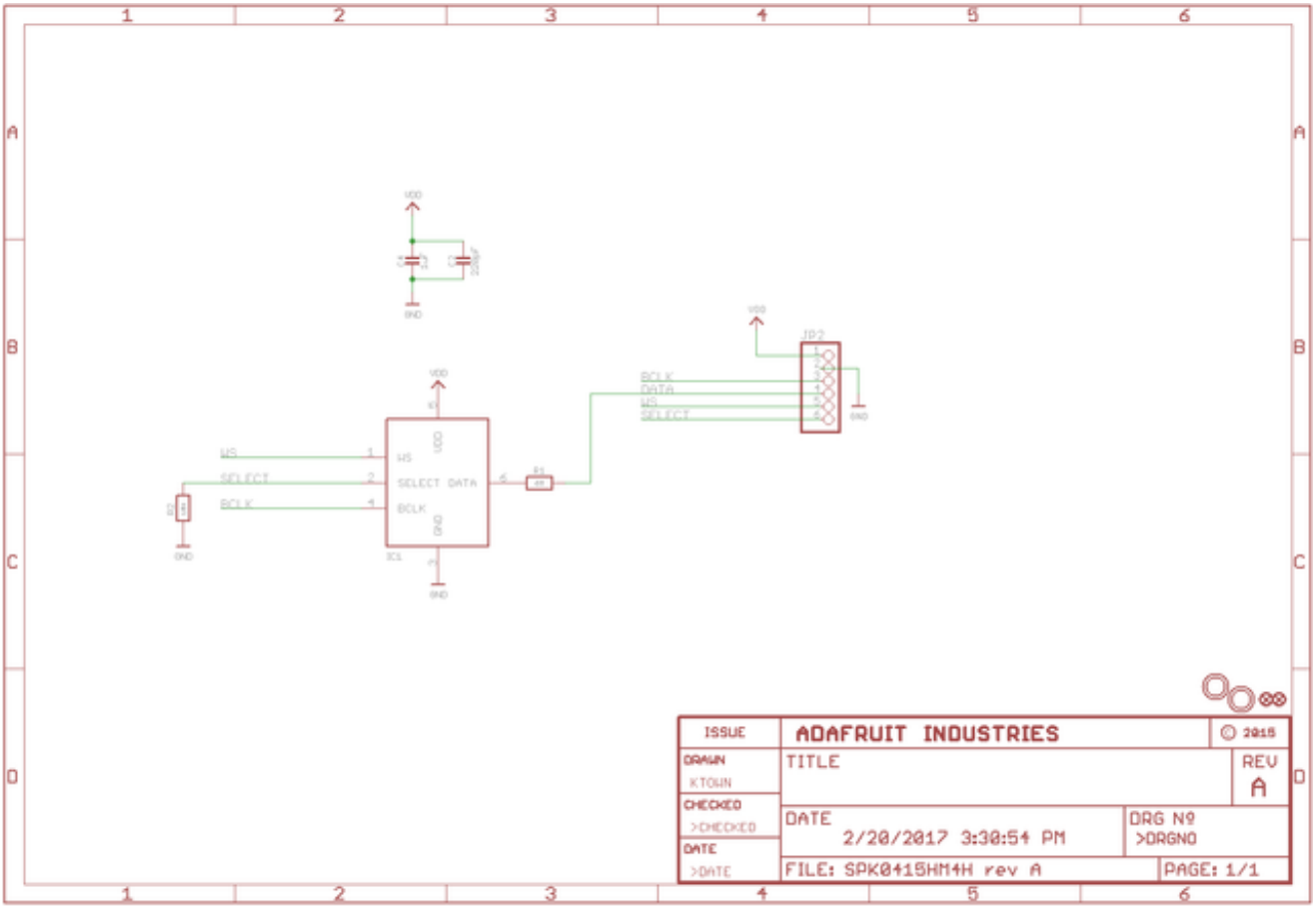
scp pi@<local-ip>:/home/pi/file.wav ~/Desktop/file.wav

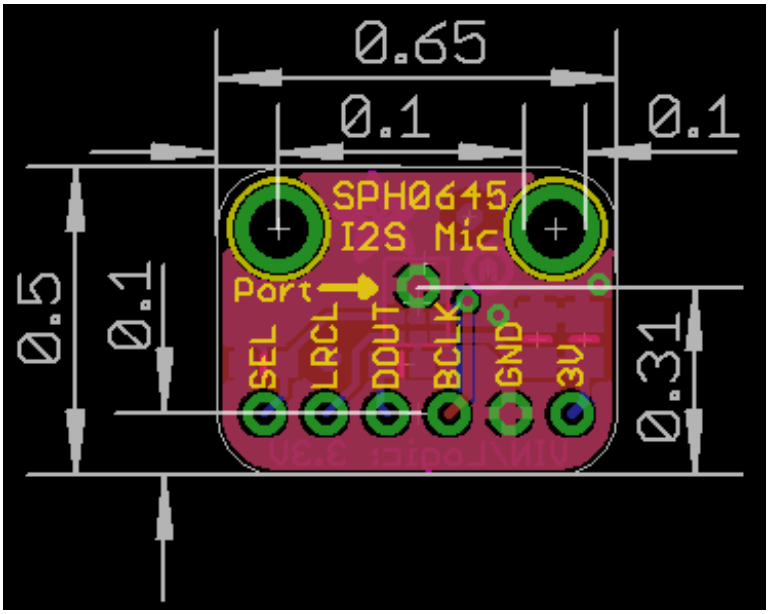
Downloads

Files

- EagleCAD PCB Files on GitHub (http://adafru.it/uyb)
- Fritzing object in the Adafruit Fritzing library (http://adafru.it/aP3)

Schematic & Fab Print




0.65
0.1
0.1
SPH0645
I2S Mic
Port
SEL
LRCL
DOUT
BCLK
GND
3V
0.5
0.1
0.31