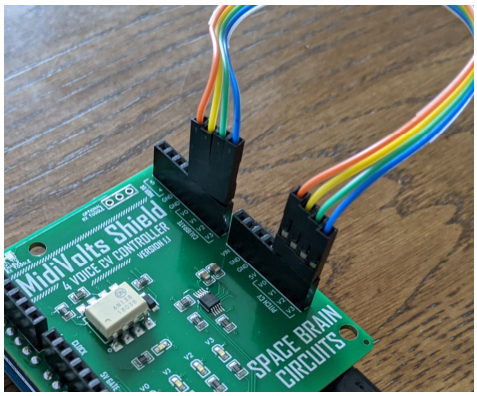
# MidiVolts Arduino Uno Shield Calibration Guide

Pitch CV increments 0.083 Volts per note. The MCP4728 has very accurate voltage scaling, however, there are discrepancies due to internal opamps. This is called Offset and Gain error. These values can be adjusted to properly calibrate the Pitch CV scaling by slightly adjusting these values in code. Please see README for Pitch CV theory and methodology for calibrating your MidiVolts shield using a multimeter. Multimeter calibration is most accurate method but also the most time consuming. The method in this document will be the fastest, however further adjustments may be necessary for perfect scaling.

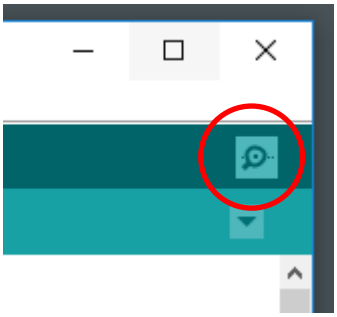
## First Step: Upload MidiVoltsCalibration

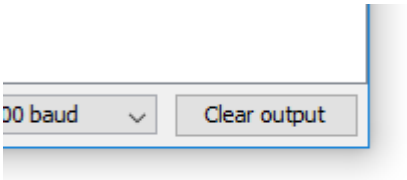
With the MidiVolts shield off, please upload the MidiVoltsCalibration Arduino Sketch to your Arduino Uno. Once finished, place MidiVolts shield onto Arduino Uno, and match the jumpers from Pitch CV to Calibration CV as shown below. Please verify the pins are connected properly.



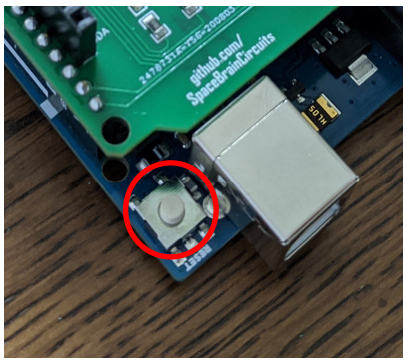

## Second Step: Open Serial Terminal

Open Serial Monitor and press clear output.



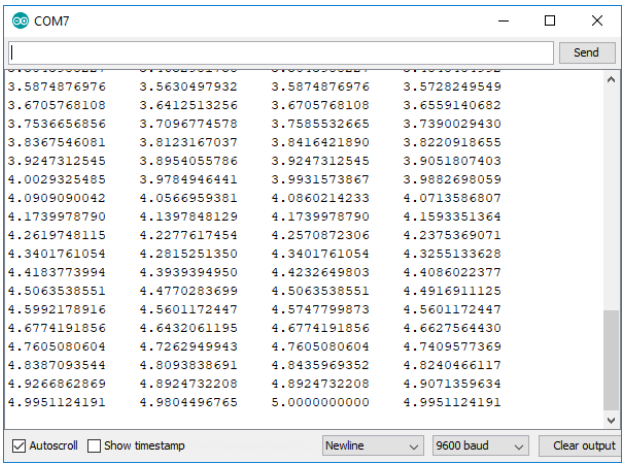



Once Serial Monitor is blank, press the Arduino reset momentary button and wait for the script to finish running.



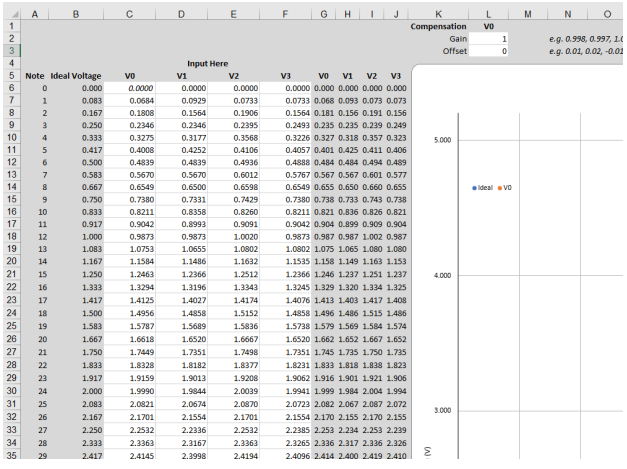

## Third Step: Copy Results

Copy the results from the Serial Monitor window, by pressing Cntrl A (Cmd A for Mac) and Control C (Cmd C for Mac) for copy.




## Fourth Step: Calibration Sheet

Paste values into the Calibration Spreadsheet in cell C6 as shown below.



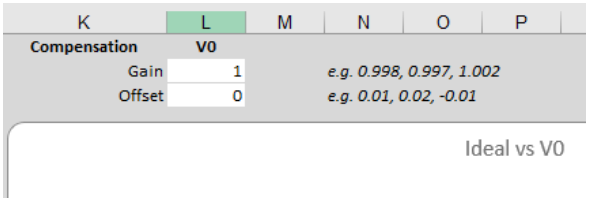
| | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | | | | | | | | | | Compensation | V0 | | | |
| 2 | | | | | | | | | | | Gain | 1 | | e.g. 0.998, 0.997, 1.0 | |
| 3 | | | | | | | | | | | Offset | 0 | | e.g. 0.01, 0.02, -0.01 | |
| 4 | | | | Input Here | | | | | | | | | | | |
| 5 | Note | Ideal Voltage | V0 | V1 | V2 | V3 | V0 | V1 | V2 | V3 | | | | | |
| 6 | 0 | 0.000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.000 | 0.000 | 0.000 | 0.000 | | | | | |
| 7 | 1 | 0.083 | 0.0684 | 0.0929 | 0.0733 | 0.0733 | 0.068 | 0.093 | 0.073 | 0.073 | | | | | |
| 8 | 2 | 0.167 | 0.1808 | 0.1564 | 0.1906 | 0.1564 | 0.181 | 0.156 | 0.191 | 0.156 | | | | | |
| 9 | 3 | 0.250 | 0.2346 | 0.2346 | 0.2395 | 0.2493 | 0.235 | 0.235 | 0.239 | 0.249 | | | | | |
| 10 | 4 | 0.333 | 0.3275 | 0.3177 | 0.3568 | 0.3226 | 0.327 | 0.318 | 0.357 | 0.323 | | | | | |
| 11 | 5 | 0.417 | 0.4008 | 0.4252 | 0.4106 | 0.4057 | 0.401 | 0.425 | 0.411 | 0.406 | | | | | |
| 12 | 6 | 0.500 | 0.4839 | 0.4839 | 0.4936 | 0.4888 | 0.484 | 0.484 | 0.494 | 0.489 | | | | | |
| 13 | 7 | 0.583 | 0.5670 | 0.5670 | 0.6012 | 0.5767 | 0.567 | 0.567 | 0.601 | 0.577 | | | | | |
| 14 | 8 | 0.667 | 0.6549 | 0.6500 | 0.6598 | 0.6549 | 0.655 | 0.650 | 0.660 | 0.655 | | | | | |
| 15 | 9 | 0.750 | 0.7380 | 0.7331 | 0.7429 | 0.7380 | 0.738 | 0.733 | 0.743 | 0.738 | | | | | |
| 16 | 10 | 0.833 | 0.8211 | 0.8358 | 0.8260 | 0.8211 | 0.821 | 0.836 | 0.826 | 0.821 | | | | | |
| 17 | 11 | 0.917 | 0.9042 | 0.8993 | 0.9091 | 0.9042 | 0.904 | 0.899 | 0.909 | 0.904 | | | | | |
| 18 | 12 | 1.000 | 0.9873 | 0.9873 | 1.0020 | 0.9873 | 0.987 | 0.987 | 1.002 | 0.987 | | | | | |
| 19 | 13 | 1.083 | 1.0753 | 1.0655 | 1.0802 | 1.0802 | 1.075 | 1.065 | 1.080 | 1.080 | | | | | |
| 20 | 14 | 1.167 | 1.1584 | 1.1486 | 1.1632 | 1.1535 | 1.158 | 1.149 | 1.163 | 1.153 | | | | | |
| 21 | 15 | 1.250 | 1.2463 | 1.2366 | 1.2512 | 1.2366 | 1.246 | 1.237 | 1.251 | 1.237 | | | | | |
| 22 | 16 | 1.333 | 1.3294 | 1.3196 | 1.3343 | 1.3245 | 1.329 | 1.320 | 1.334 | 1.325 | | | | | |
| 23 | 17 | 1.417 | 1.4125 | 1.4027 | 1.4174 | 1.4076 | 1.413 | 1.403 | 1.417 | 1.408 | | | | | |
| 24 | 18 | 1.500 | 1.4956 | 1.4858 | 1.5152 | 1.4858 | 1.496 | 1.486 | 1.515 | 1.486 | | | | | |
| 25 | 19 | 1.583 | 1.5787 | 1.5689 | 1.5836 | 1.5738 | 1.579 | 1.569 | 1.584 | 1.574 | | | | | |
| 26 | 20 | 1.667 | 1.6618 | 1.6520 | 1.6667 | 1.6520 | 1.662 | 1.652 | 1.667 | 1.652 | | | | | |
| 27 | 21 | 1.750 | 1.7449 | 1.7351 | 1.7498 | 1.7351 | 1.745 | 1.735 | 1.750 | 1.735 | | | | | |
| 28 | 22 | 1.833 | 1.8328 | 1.8182 | 1.8377 | 1.8231 | 1.833 | 1.818 | 1.838 | 1.823 | | | | | |
| 29 | 23 | 1.917 | 1.9159 | 1.9013 | 1.9208 | 1.9062 | 1.916 | 1.901 | 1.921 | 1.906 | | | | | |
| 30 | 24 | 2.000 | 1.9990 | 1.9844 | 2.0039 | 1.9941 | 1.999 | 1.984 | 2.004 | 1.994 | | | | | |
| 31 | 25 | 2.083 | 2.0821 | 2.0674 | 2.0870 | 2.0723 | 2.082 | 2.067 | 2.087 | 2.072 | | | | | |
| 32 | 26 | 2.167 | 2.1701 | 2.1554 | 2.1701 | 2.1554 | 2.170 | 2.155 | 2.170 | 2.155 | | | | | |
| 33 | 27 | 2.250 | 2.2532 | 2.2336 | 2.2532 | 2.2385 | 2.253 | 2.234 | 2.253 | 2.239 | | | | | |
| 34 | 28 | 2.333 | 2.3363 | 2.3167 | 2.3363 | 2.3265 | 2.336 | 2.317 | 2.336 | 2.326 | | | | | |
| 35 | 29 | 2.417 | 2.4145 | 2.3998 | 2.4194 | 2.4096 | 2.414 | 2.400 | 2.419 | 2.410 | | | | | |



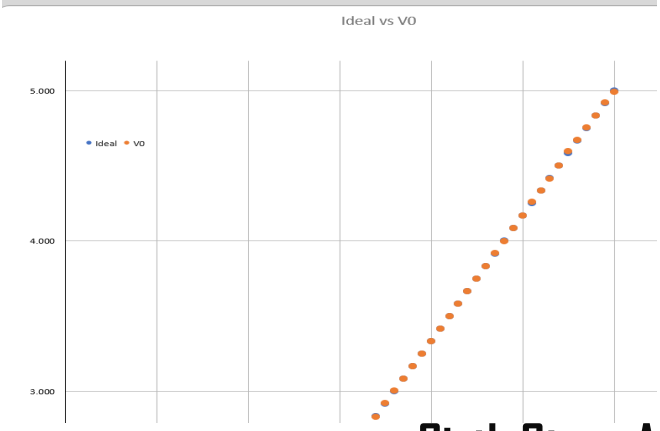
**Please email spacebraincircuits@gmail.com for any questions or issues! I am more than happy to help!**

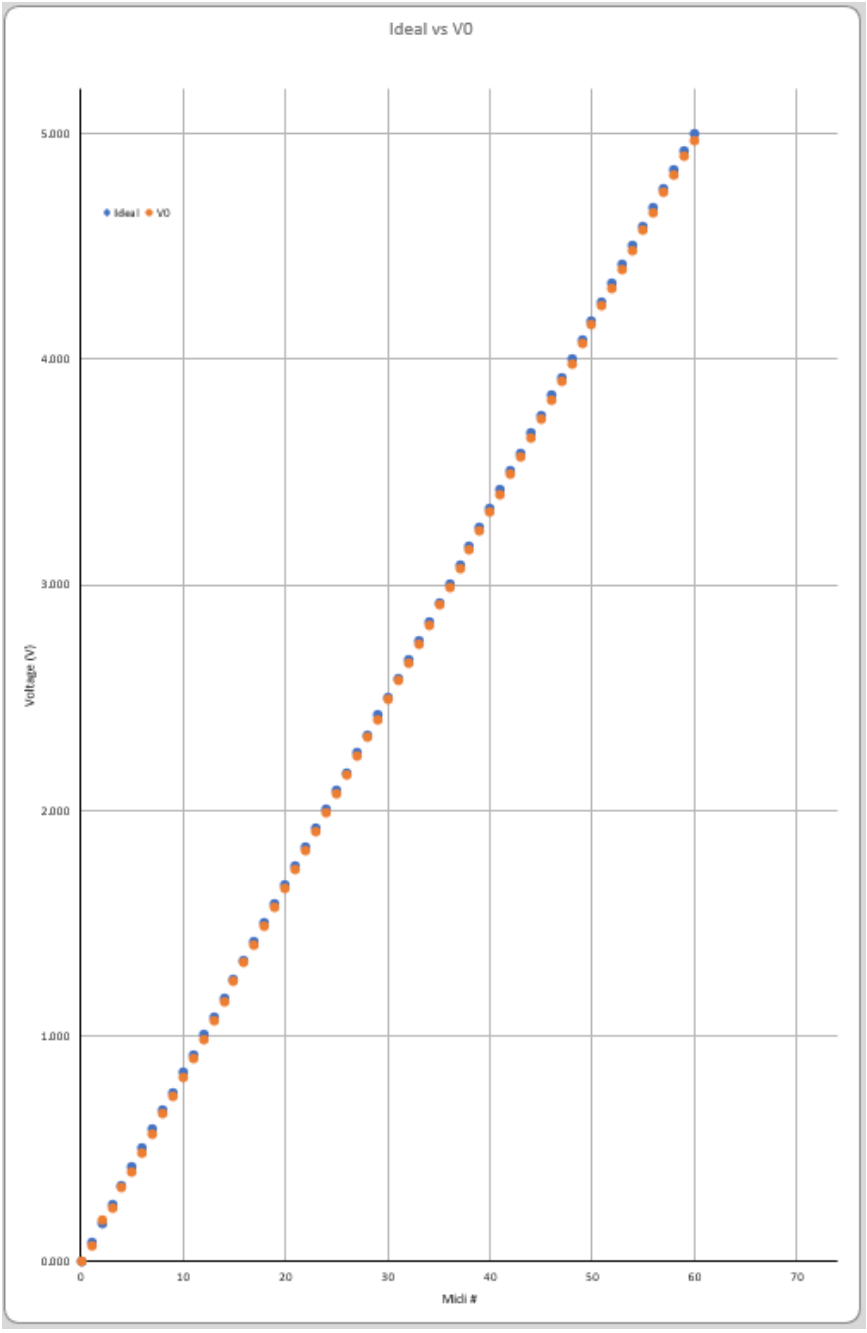
# Fifth Step: Analysis

Based on data that was inserted into spreadsheet, the graphs can be used to calibrate the DAC to scale much more accurately by adjusting the Gain and Offset error. The blue data signifies perfect pitch to CV scaling. The orange is data that came from the MidiVoltsCalibration script. The goal is to match the orange and blue data as much as possible using the Gain and Offset compensation at the top of the spreadsheet.




Adjust these values very minimally to see the effect. In most cases, a range of 1.002 or 0.998 is appropriate for gain adjustment. See numbers to the right as a starter point. Do this process for each Voice (V0-V3).




# Sixth Step: Assign Values to MidiVolts

Place this data in the setup method on the MidiVolts sketch as shown below.

```
void setup() {

  // for fine tune calibration, please see Calibration Guide
  // sample code for calibration
  voice[0].Gain = 0.999;
  voice[0].Offset = 0;
  voice[1].Gain = 1.008;
  voice[1].Offset = 0;
  voice[2].Gain = 1;
  voice[2].Offset = 0;
  voice[3].Gain = 1.004;
  voice[3].Offset = 0.003;
```