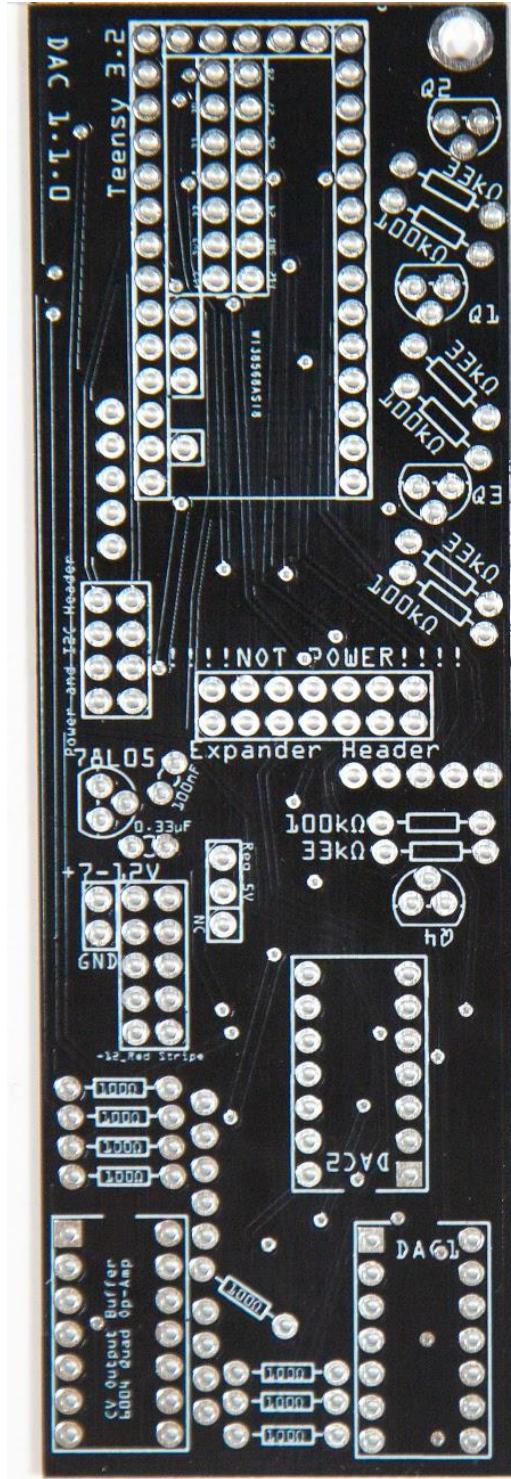


Original Betweener Kit, 2018

# BUILDING A BETWEENER



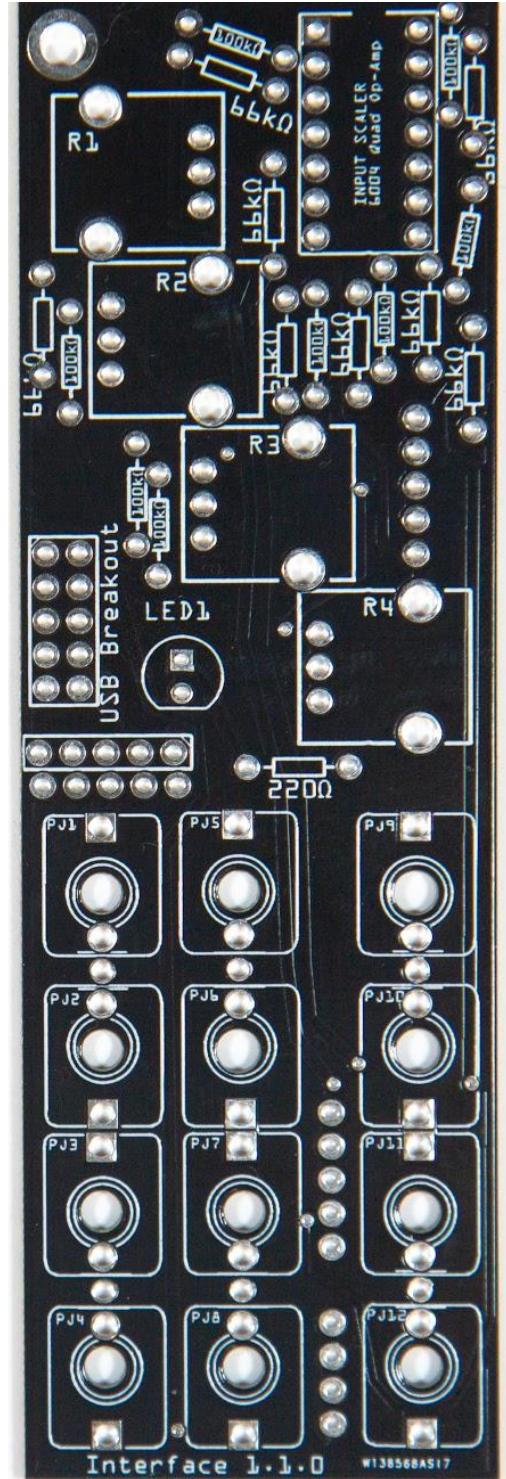
DAC BOARD

There are two main PCBs in the Betweenner kit, plus the Teensy 3.2 microcontroller, micro USB breakout, and PCB faceplate.

Most, but not all components will be soldered on the side of the boards shown here, matching the silkscreen outlines and part values.

An excellent and detailed tutorial on Soldering can be found here:

<https://learn.adafruit.com/adafruit-guide-excellent-soldering/tools>



INTERFACE BOARD

# Betweener Build Overview

This document describes the process of building the Betweener.

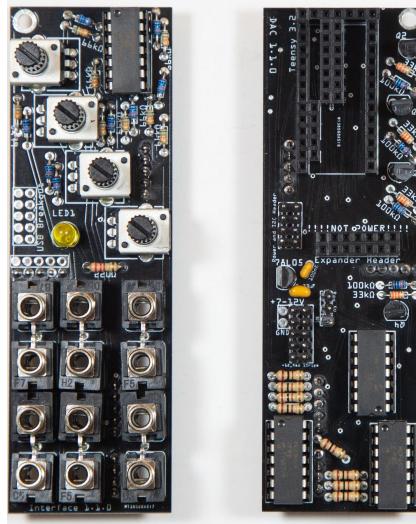
Photos by Misha Khokhlov except where noted.

Document Created by Joseph Kramer.

Last updated 2018.11.20

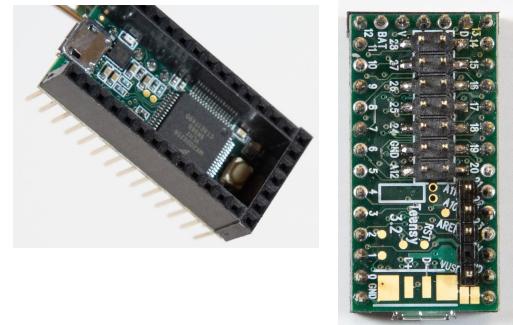
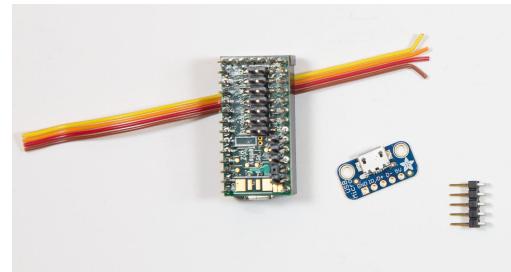
## MAIN PCBs

1. Basic Components
  - a. 33 x Resistors
  - b. 4 x Chip Sockets
  - c. 4 x Transistors
2. 5V regulator (Optional)
  - a. 2 x Capacitors
  - b. 1 x 78105 regulator IC
3. Pin Headers
  - a. The Teensy 3.2 Socket
  - b. The Male and Female Power and Expansion Headers on the front of the DAC BOARD
  - c. The pin headers on the BACK of both boards - used to connect the 2 PCBs back-to-back
4. Jacks and Knobs
5. The IC Chips



## TEENSY 3.2 + EXPANSIONS

1. Set up the Micro USB Breakout (Optional)
  - a. Connect the breakout to the Betweener
  - b. Wire the Breakout to the Teensy 3.2
2. Solder the Header Kit to the Teensy 3.2
3. Test Hardware for Major Problems
4. Complete Assembly
5. Teensy Audio Shield (Optional)



# RESISTORS

1. The **33 kΩ** are a great place to start. There are 4 on the DAC BOARD.

These are part of the four Trigger Input circuits.

2. Add the **100 Ω** resistors.

These eight resistors are part of the CV inputs and outputs. \*\*\*NOTE: these are 100 ohms, NOT  $100^*k^*$  ohms

3. Now add the **100 kΩ** resistors. There are 4 on the DAC BOARD. They are part of the Trigger Input circuits.

4. There are 8 more **100 kΩ** resistors on the

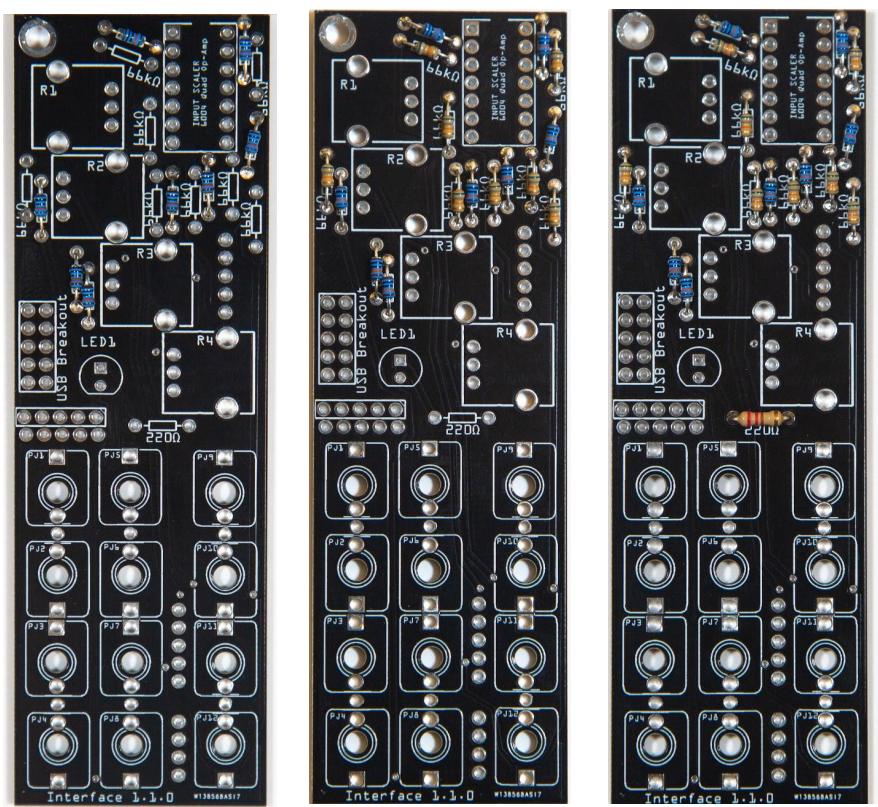
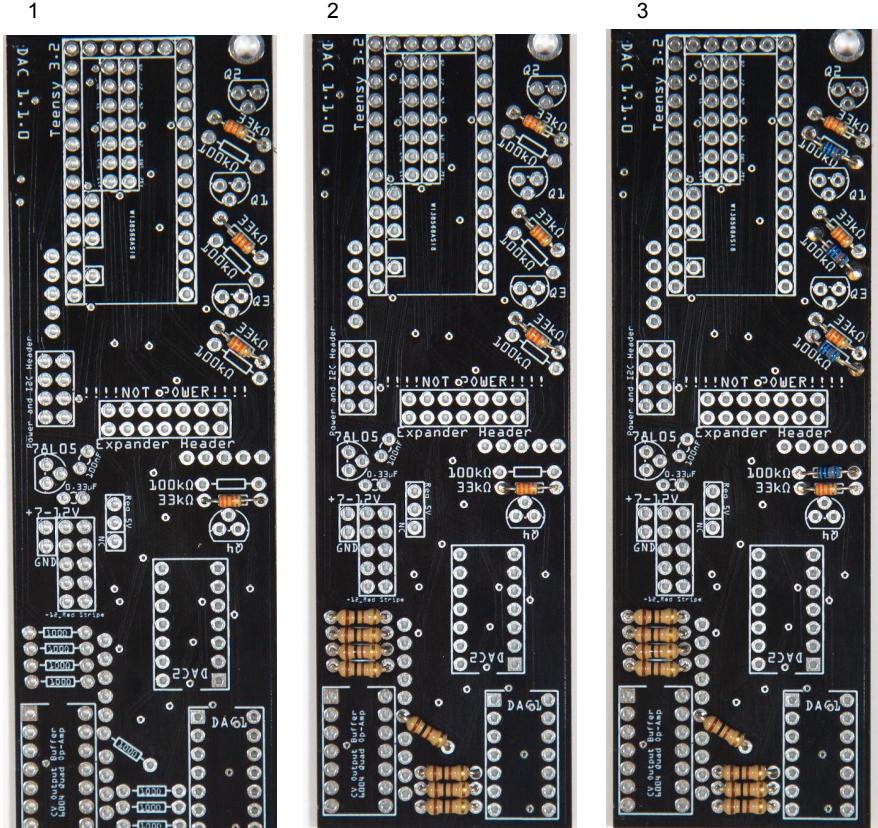
**INTERFACE BOARD**. So switch to the other board and add them

**NOW**. These are part of the input scaling circuit. The scale CV inputs from a range of 0v - 5v down to a range of 0v - 3.3v for the Teensy to safely read.

5. Add the **68 kΩ** resistors.

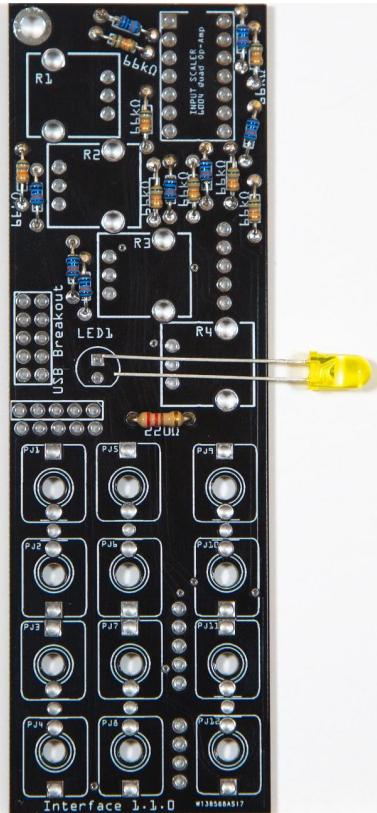
There are 8 of these on the **INTERFACE BOARD**. These go in the spots marked  $68k\Omega$ .

6. Finally, add the **220 Ω** resistor for the LED. This is attached to Teensy Pin D8.



# LED

Add the Led, with its long leg in the square hole and its short leg close to the flat side of the screen printed outline.



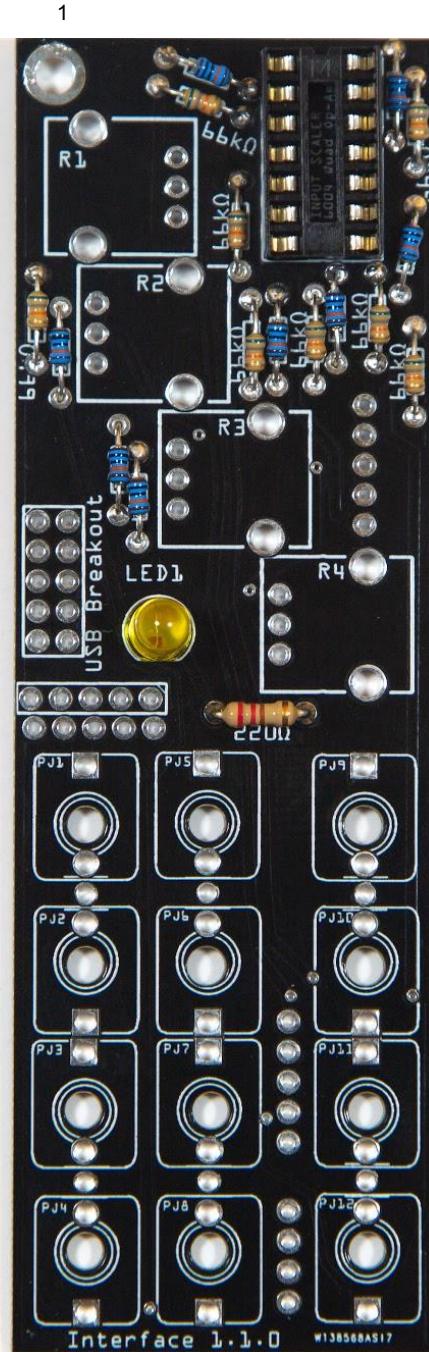
# CHIP SOCKETS

NOTE: These are NOT the chips. Do not place any chips until after you have finished with the soldering, but before you attach the front panel.

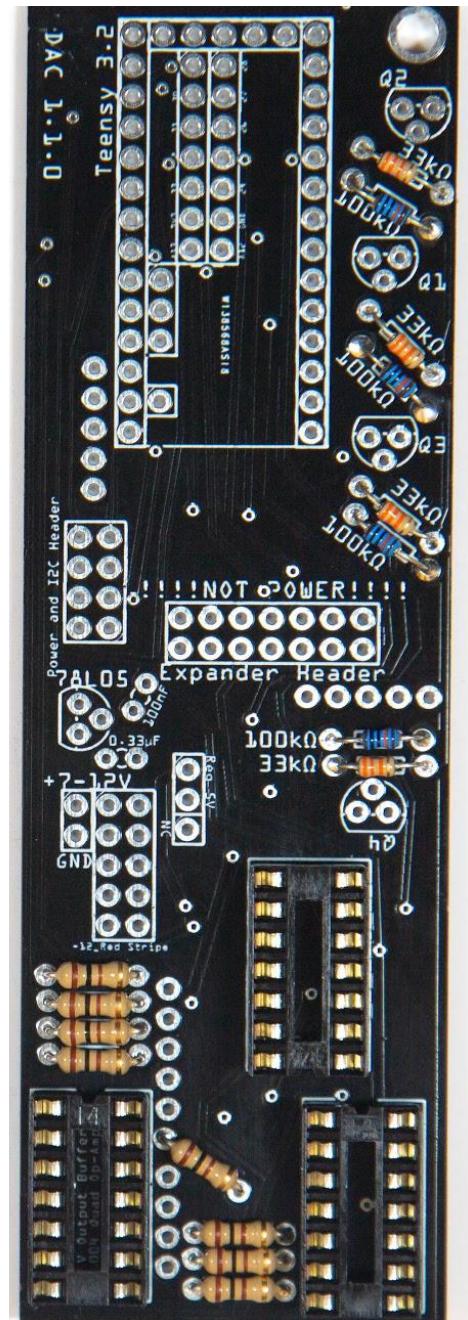
When placing the chip sockets, please be careful to orient them so that the notch in the socket matches the notch on the silk screen outline.

Mistakes will not affect the function of the part, but keeping things oriented correctly here will help make it easier to place the chips in the correct orientation later.

1. There is ONE 14-PIN IC Chip Socket on the INTERFACE BOARD.
2. There are THREE IC Chip Sockets on the DAC BOARD.



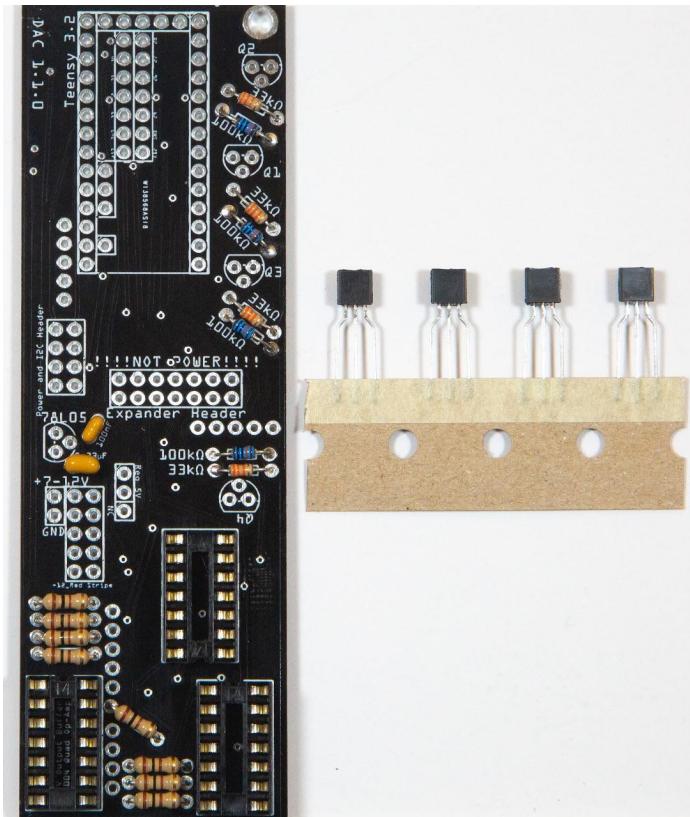
INTERFACE BOARD



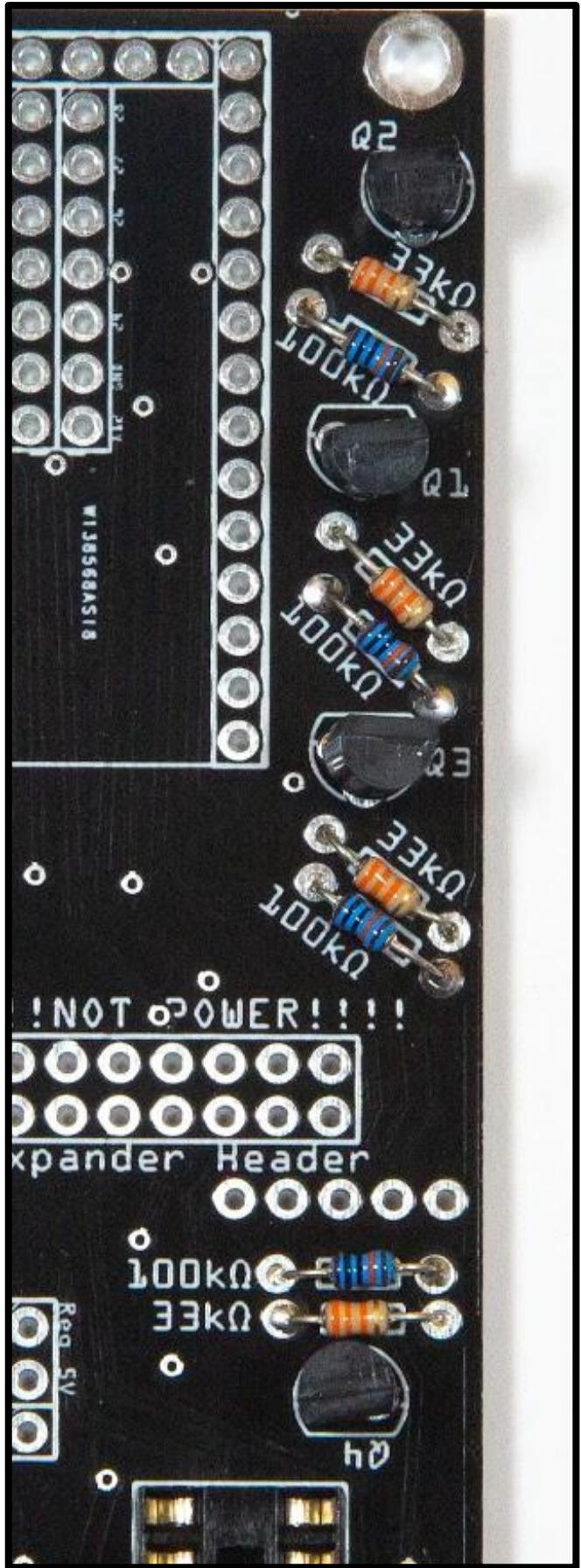
DAC BOARD

# TRANSISTORS

1. There are FOUR transistors. These are 2n2222 or 3904 NPN type.
2. They are Q1 - Q4 and should be placed on the right side of DAC BOARD.
3. The orientation of each part should match the outline shape on the silkscreen image.



**WARNING** - The 78L05 Voltage Regulator looks just like the transistors. Make sure you don't mix these up.



If you plan to power the Betweenener only via USB, you can skip this page.



# VOLTAGE REGULATOR (OPTIONAL)

If you want to power the Betweenener using a supply other than the built-in USB, you can install the voltage regulator, capacitors, and jumper. To use this you must also modify the Teensy.

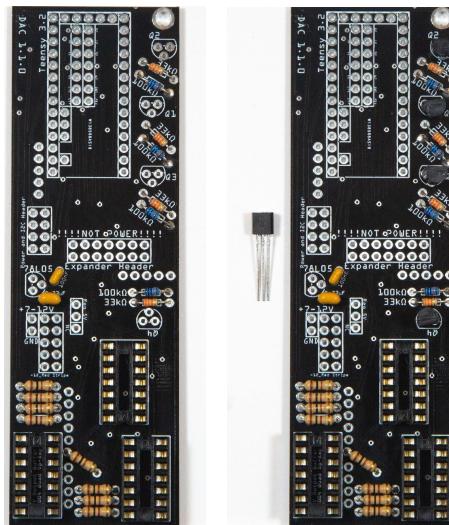
1. Add the 2 Capacitors
  - a. 100nF (104)
  - b. 0.33μF (334)
2. Add the 78L05 (this looks just like the transistors, but it is not one).
3. READ THE REST OF THIS PAGE-----then decide if you want to to on-----
4. Cut the trace on the back of the Teensy.
5. Install the jumper in the top position of the 3-pin header.

## NOTES

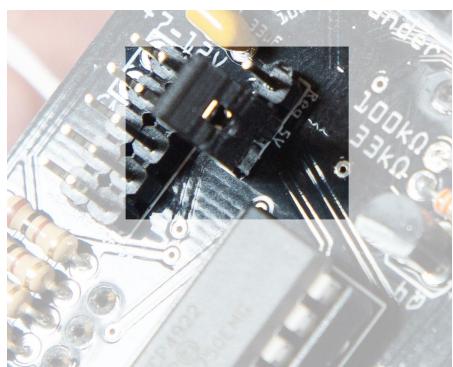
1. This regulator connects to a 10-pin header that is compatible with Eurorack power supplies. It will take power from the +12v rail.
2. The regulator can also be powered by a different type of supply, such a 9V battery, by connecting to the leads to the "+7 - 12v" and "GND" pads located next to the 10-pin header.
3. Do not connect a battery AND Eurorack power supply at the same time!
4. Current consumption will vary based on programming and configuration.

## CAUTION:

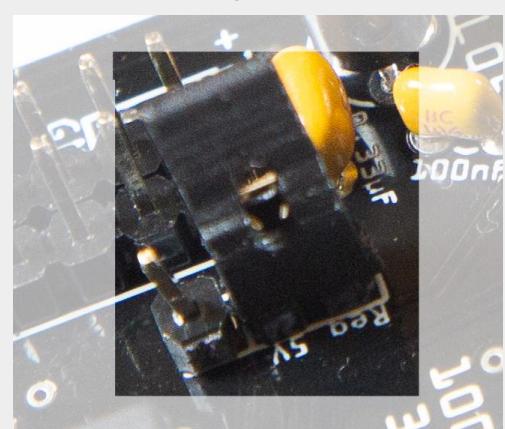
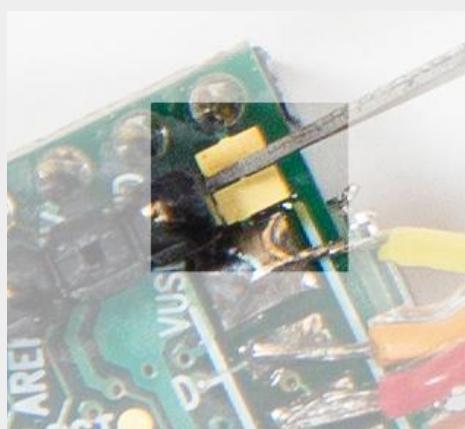
1. To use the 78L05 to power the Betweenener, the VUSB power trace MUST be cut on the back of the Teensy.
2. The 78L05 can become overheated in some cases. It can only supply 100mA to the system. Please make sure you have not configured your system in a way that will cause it to draw more current than the regulator is designed to provide.
3. If you intend to use the 5V regulator, you must cut the trace on the Teensy 3.2 and connect the two top pins of the 3-pin header (found on the DAC BOARD). The Teensy will still be programmable via USB, but can no longer receive power through the USB connection.



When the jumper is in the bottom position the voltage regulator's output is not connected to the Betweenener.



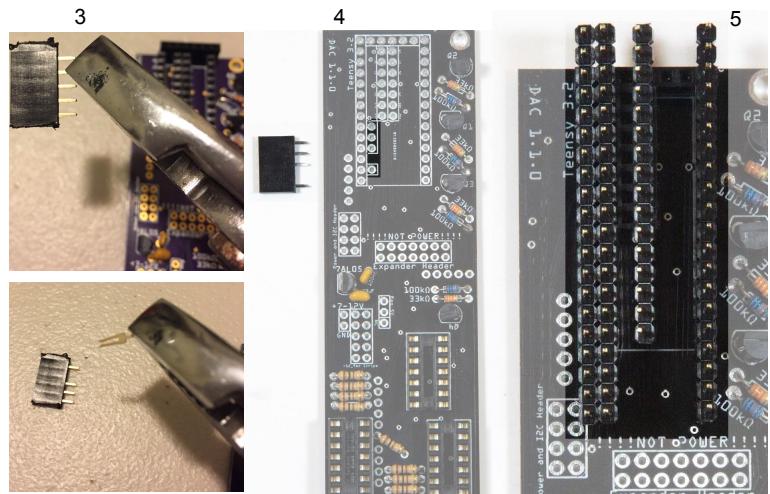
## Trace Cut and Jumper Position for Regulator Use



It is advisable to **WAIT** to cut the trace and move the jumper until the rest of the build is completed and the software has been installed and tested. After the Betweenener has been proven to work, then remove the Teensy from the Betweenener Socket to cut the trace. Before re-inserting it, install the new power supply. Before installing the jumper, check that the "Reg" pin (shown above) is providing 5V by measuring this point with a multimeter. If it checks out, then power everything down, install the jumper in the top position, reinsert the Teensy, and power everything back on.

# HEADERS:

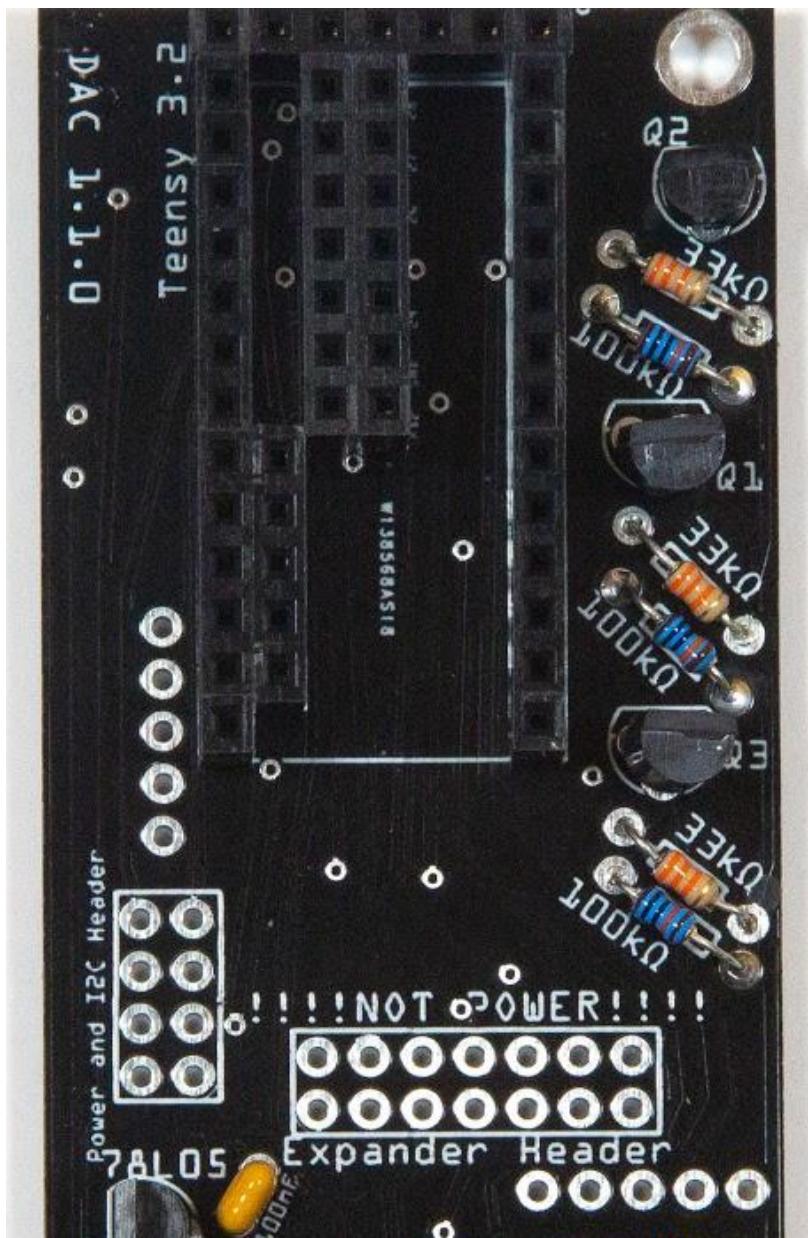
## TEENSY SOCKET



To assemble the Teensy Socket place the six female headers onto the front of the DAC BOARD. Note, the headers will not exactly match the screen printed outline.

1. Place the two 13-Pin headers.
2. Place the three 7-Pin headers.
3. Modify a 5-Pin female header using a pair of pliers to pull one pin out of the second position of a 5-pin header.
4. Place the single, modified 5-Pin header.
5. Use strips of male pin headers to align all the rows of pin headers and keep them straight while soldering.
6. Solder the pin headers that make up the Teensy Socket.

Caution, there are 4 female headers that go on the BACK on the DAC BOARD. These connect with male headers on the BACK of the INTERFACE BOARD. Make sure you are aware of them and don't solder them to the front.



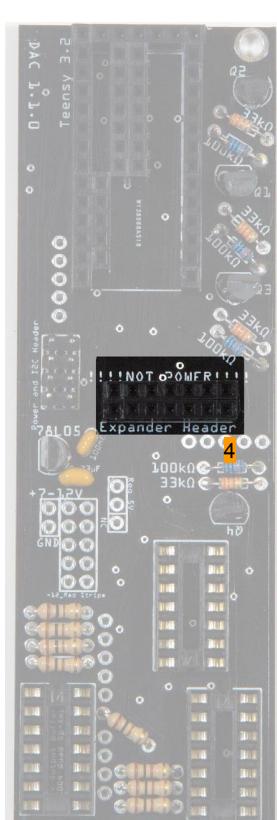
# HEADERS:

## (OPTIONAL) I2C, POWER, and EXPANSION

All headers can be populated with male or female headers, depending on the needs of the builder. Current kit versions come with male pin headers for the I2C and Eurorack Power connections, and female headers for the "Expander Header".

Populating any of these headers is completely optional. The following instructions are for installing the provided components.

1. Populate the vertical 2x4 I2C pads with male pin headers.
2. Populate the 2x5 Eurorack power header with male pin headers (this will allow the connection of an IDC ribbon cable to a Eurorack power supply, red stripe down).
3. Populate the three vertical pads with male pin headers for an optional jumper for the connection of regulated 5v power to the Betweener.
4. Populate the horizontal 2x7 pads with female pin headers for connections to experimental circuitry via jumper wires.



PIN#	GND	PIN7	+5V	PIN6	+3.3V	PIN5	D29/A18 (SCL1)
PIN1	GND	PIN2	+5VNC	PIN3	+5V	PIN4	D30/A19 (SDA1)



These expansion headers can be used like basic Arduino or Teensy pins. The pin numbers can be seen in the charts on this page or viewed in the github repo here:  
[https://github.com/jkrame1/Betweener/blob/master/hardware\\_design/Expander%20Teensy%20Pin%20Reference.pdf](https://github.com/jkrame1/Betweener/blob/master/hardware_design/Expander%20Teensy%20Pin%20Reference.pdf)

# HEADERS:

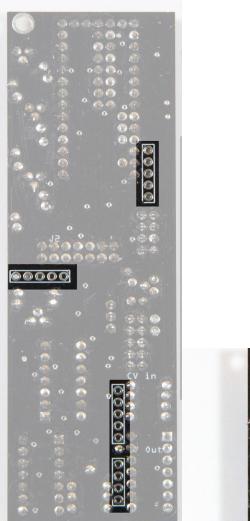
## DAC BACK + INTERFACE BACK



4

There are four headers located on the back of each PCB. These are used to connect the INTERFACE BOARD to the DAC BOARD.

1. Place the long part of the male headers into the female headers.
2. Insert the female headers into the back of the DAC BOARD.
3. Insert the male part of the headers into the INTERFACE BOARD to keep everything straight.
4. Solder the headers onto the **Component Sides** of the two boards.



1



3

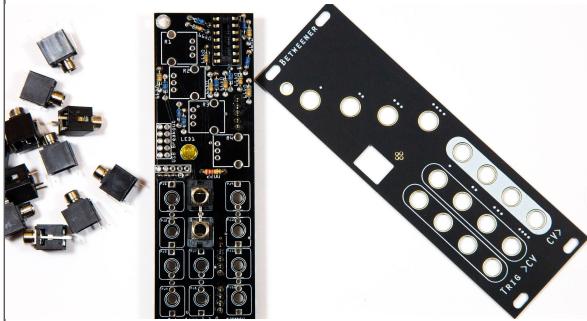


2



4

# JACKS and KNOBS



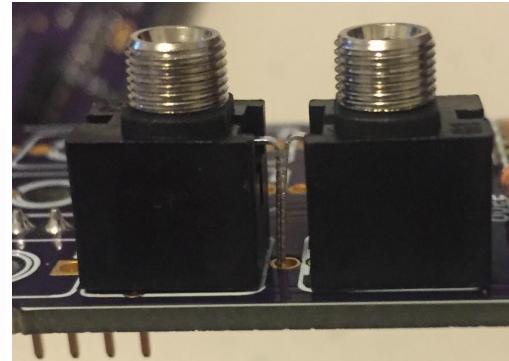
NOTE: DO NOT SOLDER until you have placed all knobs and jacks and used the faceplate to align all parts.

1. Insert all twelve  $\frac{1}{8}$ " jacks.  
Please note that pairs of jacks *share* ground holes.  
See photos on this page.
2. Place the four knobs.
3. Place PCB faceplate and use it to keep all parts aligned as you solder the knobs and jacks.

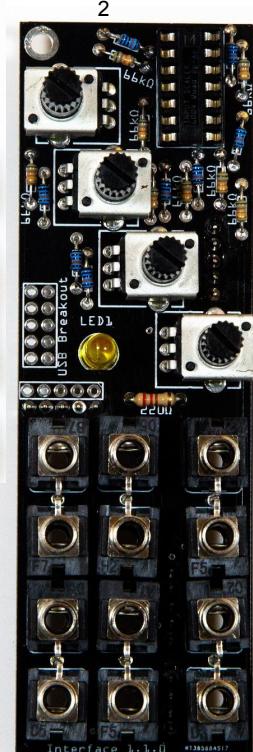
NOTE: You may want to use a couple of the  $\frac{1}{8}$ " nuts to hold the faceplate in place while soldering. It may also be a good idea to use the standoff and screw to get the spacing just right. But do not screw on all twelve nuts at this time. You will need to remove the faceplate in order to complete the project.



1



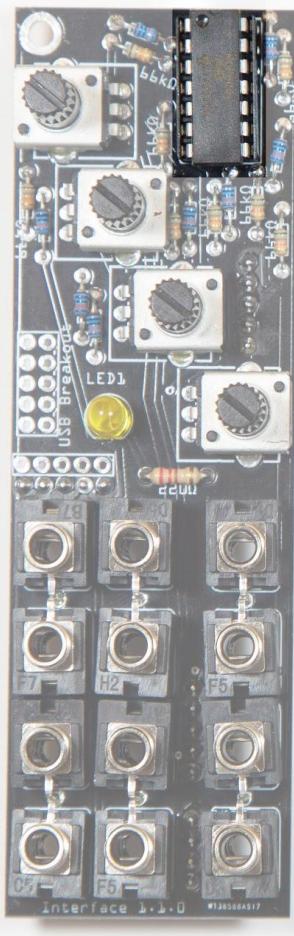
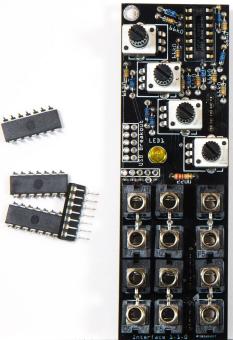
2



3



# INSERT CHIPS



Insert the four Integrated Circuit (IC) chips into the sockets.

Pay careful attention to which chip goes into which socket.

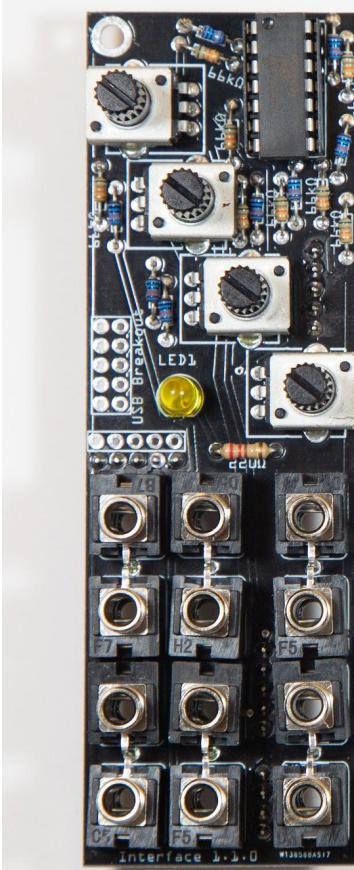
Make sure you align the indentation on the top of the chip with the notch on the silkscreen part outline (and the corresponding notch on the chip socket).

1. One **MCP6004** Quad Op Amp chip goes on the INTERFACE BOARD. It is oriented with pin one (indicated by an indentation on the chip) facing up.
2. One **MCP6004** is on the DAC BOARD. It is in the bottom left corner and also has pin one facing up.
3. Two **MCP4922** Dual DAC chips are located in the bottom right on the DAC BOARD. They are oriented with their pin ones facing each other. See image for details.

1

2

3



# PREPARE THE TEENSY 3.2



The following sections deal with preparing the Teensy to work in the Betweenner. The two main sections are connecting a USB breakout to the faceplate and soldering the headers that will go into the Teensy Socket.



**USB BREAKOUT:** There are many options for power and programming on the Betweenner. If you intend to mount the Teensy in a Eurorack case, then you may choose to wire a USB breakout that can be accessed via the front panel.

**HEADERS:** The Teensy 3.2 has many IO pins located in places that are not Breadboard-friendly.

The small bag from Sparkfun called the “Teensy Header Kit” will allow access to all of the possible IO for both the basic Betweenner function as well as the optional expansions.

This set of headers can be found here:  
<https://www.sparkfun.com/products/13925>



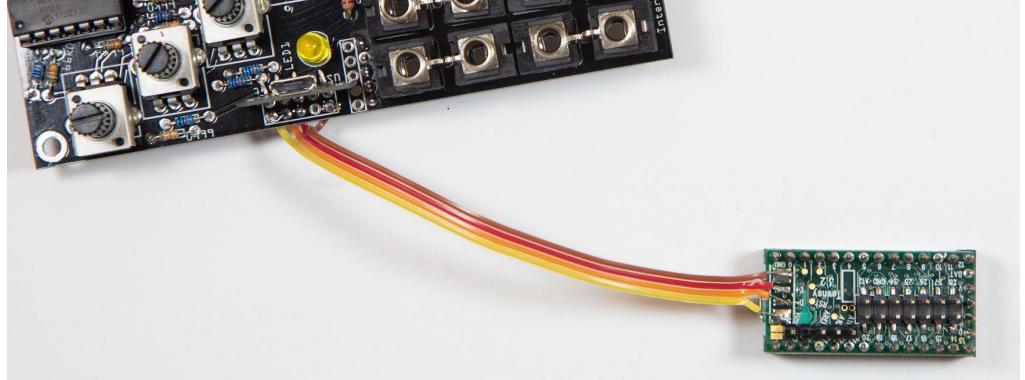
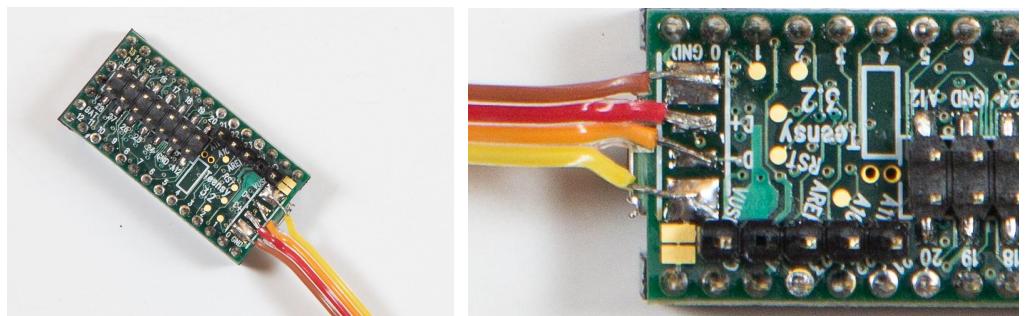
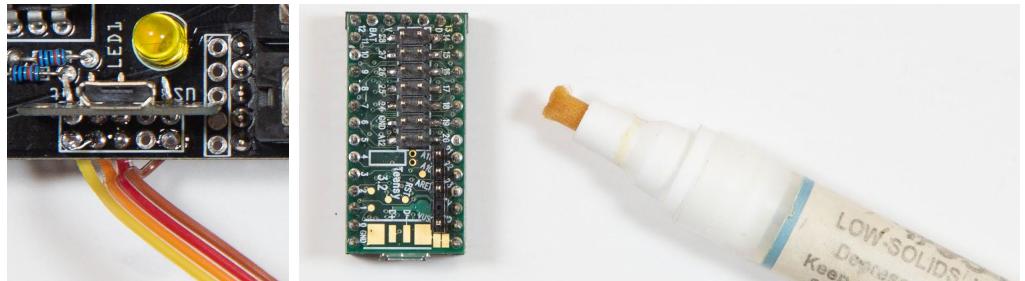
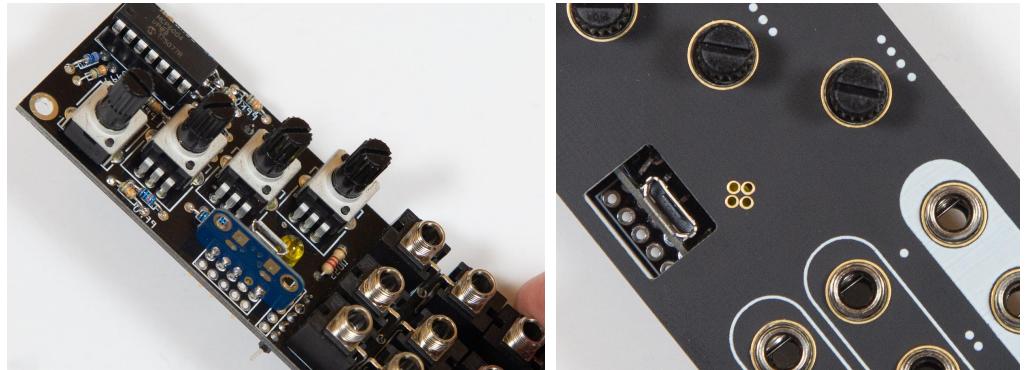
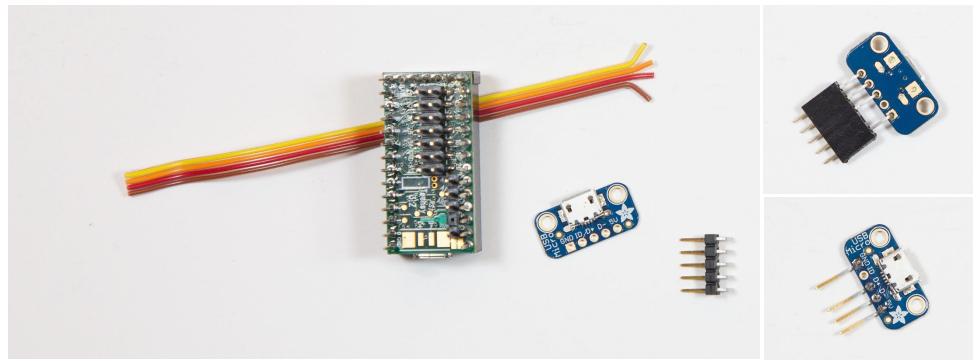
# TEENSY 3.2 + **(OPTIONAL)** MICRO USB BREAKOUT

The Eurorack PCB Faceplate design allows programming to be done through a micro USB cable attached directly to the front of the unit, making it unnecessary to get into the back of the Eurorack case or make any case modifications for power or programming of the module.

The Micro USB breakout allows programming and connects USB power to the Betweenner (unless you modify your Teensy by cutting a trace and connect the power jumper on the back of the Betweener).

It will need to be wired in place. Sorry, I couldn't make it work with pin headers.

If making a custom enclosure or modified Eurorack Case, you may want to consider using a different type of USB connection. See some examples in the Project Gallery of the Wiki:  
[https://github.com/jkrame1/Betweener/wiki/05\\_Project-Gallery](https://github.com/jkrame1/Betweener/wiki/05_Project-Gallery)

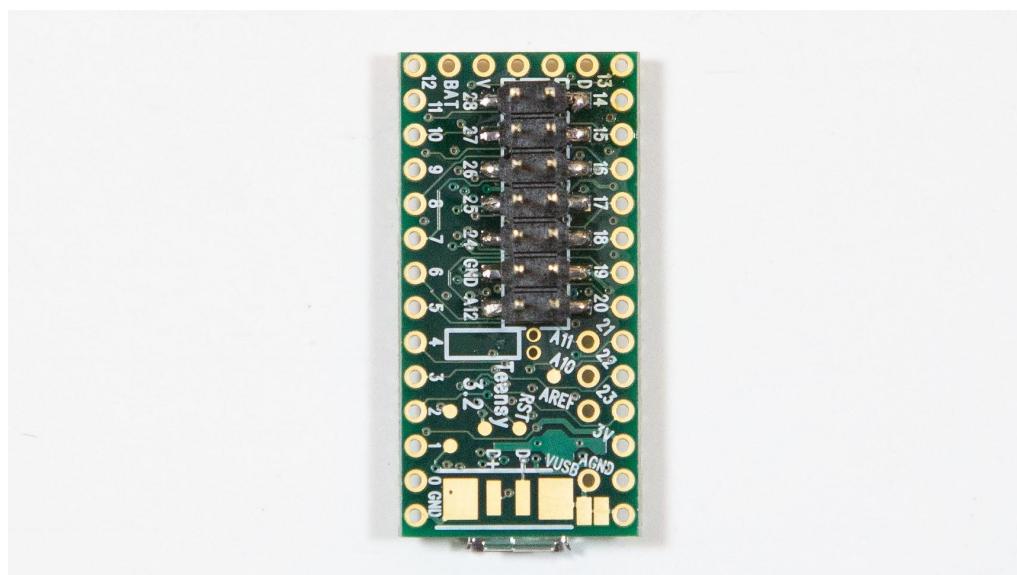
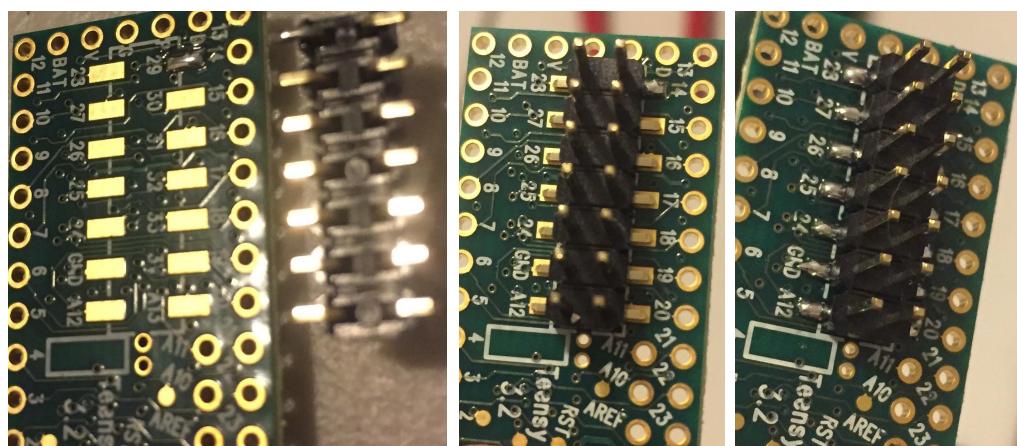
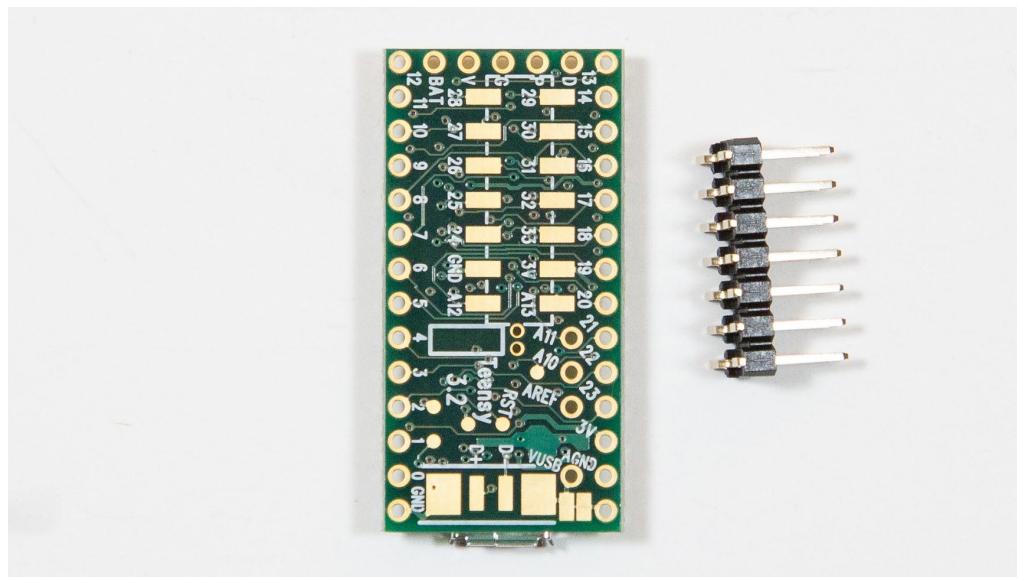


# TEENSY 3.2

## SURFACE-MOUNT HEADER

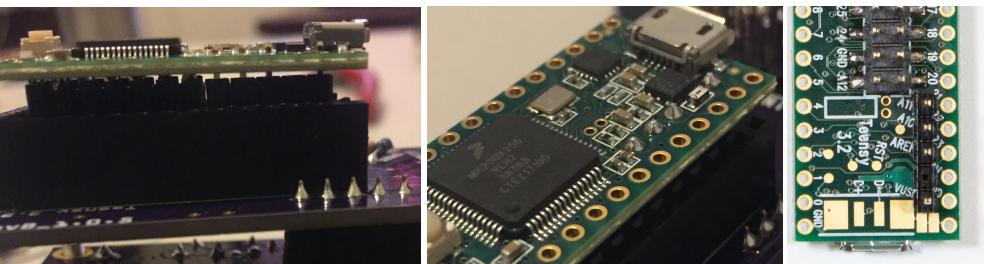
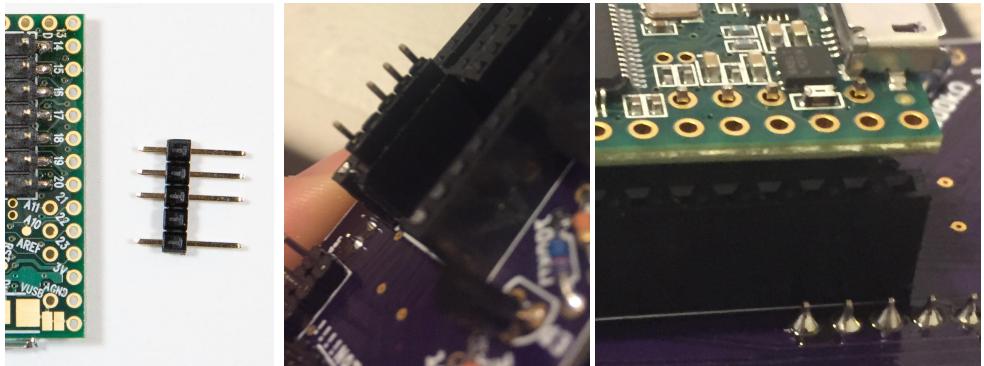
Do the Surface Mount Header FIRST. It will be nearly impossible to do after the other Teensy header pins are soldered in place.

1. Apply solder to one corner pad.
2. Align the header so it fits perfectly on all the pads.
3. Heat the prepared corner while holding the header from the opposite corner.
4. Repeat step 3 until the header is perfectly aligned.
5. Solder the remaining pins, starting at the side opposite from the one soldered pad.



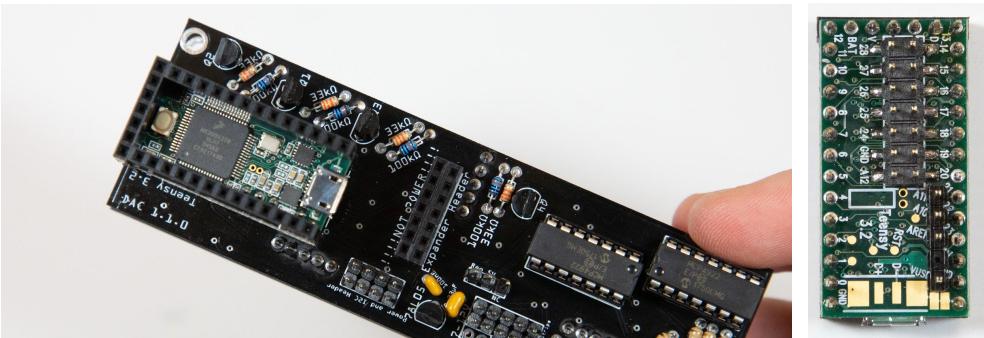
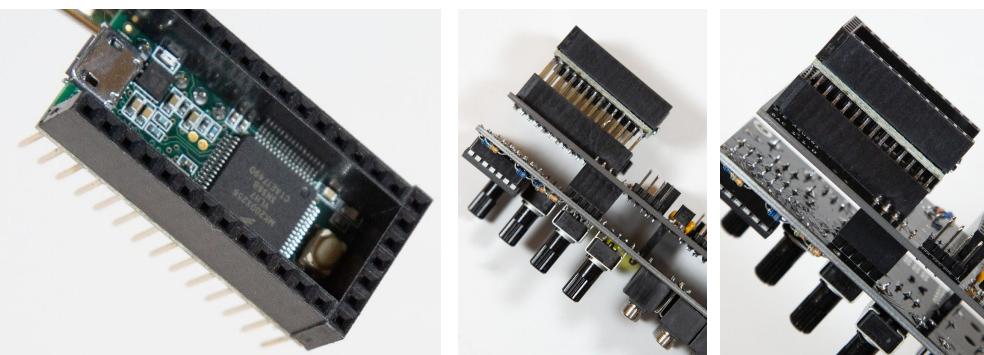
# TEENSY 3.2

## 4-PIN HEADER and STACKING HEADERS



Place the special 4-Pin header from the Teensy Header Kit into the Teensy Socket on the Betweener. Place the Teensy on top of the header and solder the pins from the top.

Insert the three stacking headers through the Teensy and into the Teensy Socket on the Betweener. With the Teensy inserted, solder two pins from each header row. Remove the Teensy and solder the remaining pins.

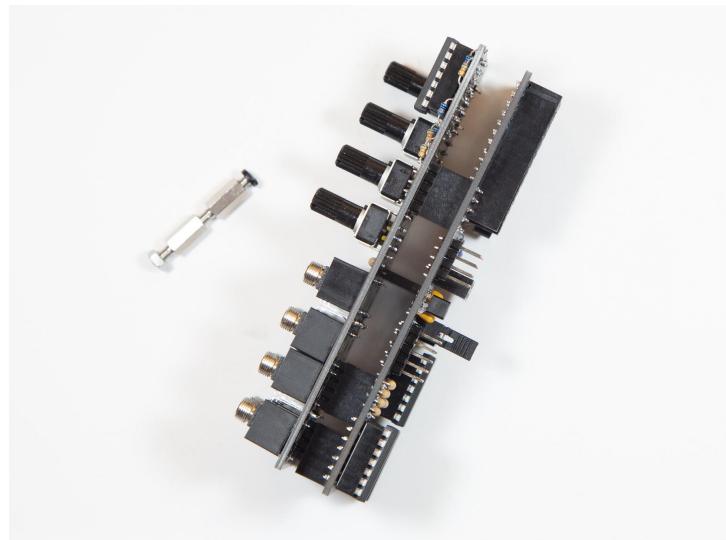
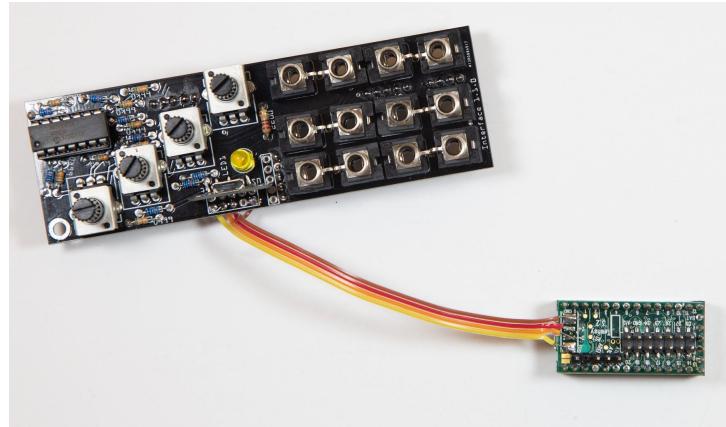


## TESTING HARDWARE

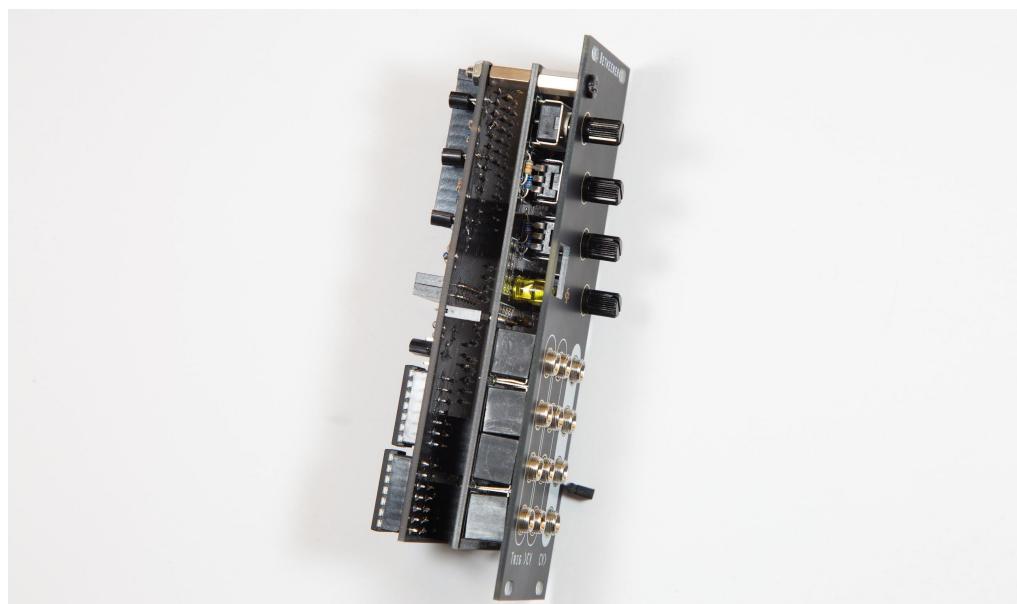
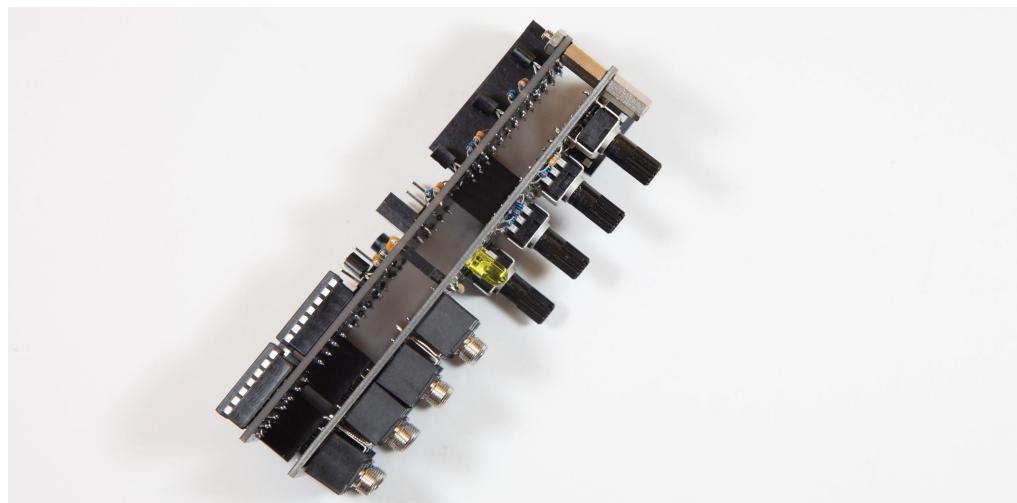
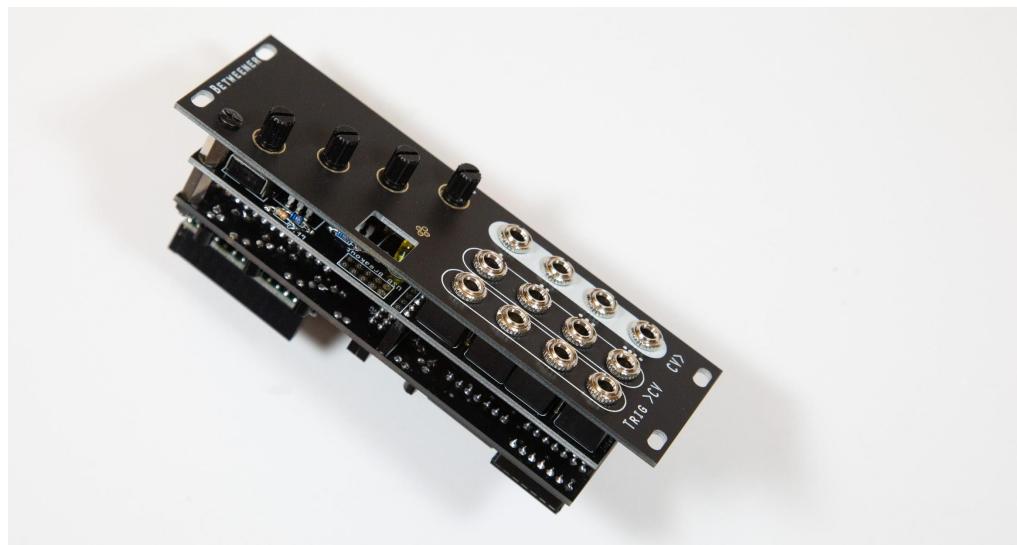
+

## FINISHING

1. Test the hardware.
  - a. Remove the Teensy from the Betweenner socket and plug in the USB. It should blink an LED on the Teensy.
  - b. Disconnect the Teensy from power, insert it back into the Betweenner and plug it back in. You should see blinking again. If not, unplug immediately and check all soldering for errors.
  - c. If everything looks fine, move on.
2. Install the standoffs, nut and screw.
3. Tighten the screws and nuts and move on to installing the software.  
[https://github.com/jkrame1/Betweenner/wiki/02\\_Software-Installation](https://github.com/jkrame1/Betweenner/wiki/02_Software-Installation)



# The ASSEMBLED BETWEENER



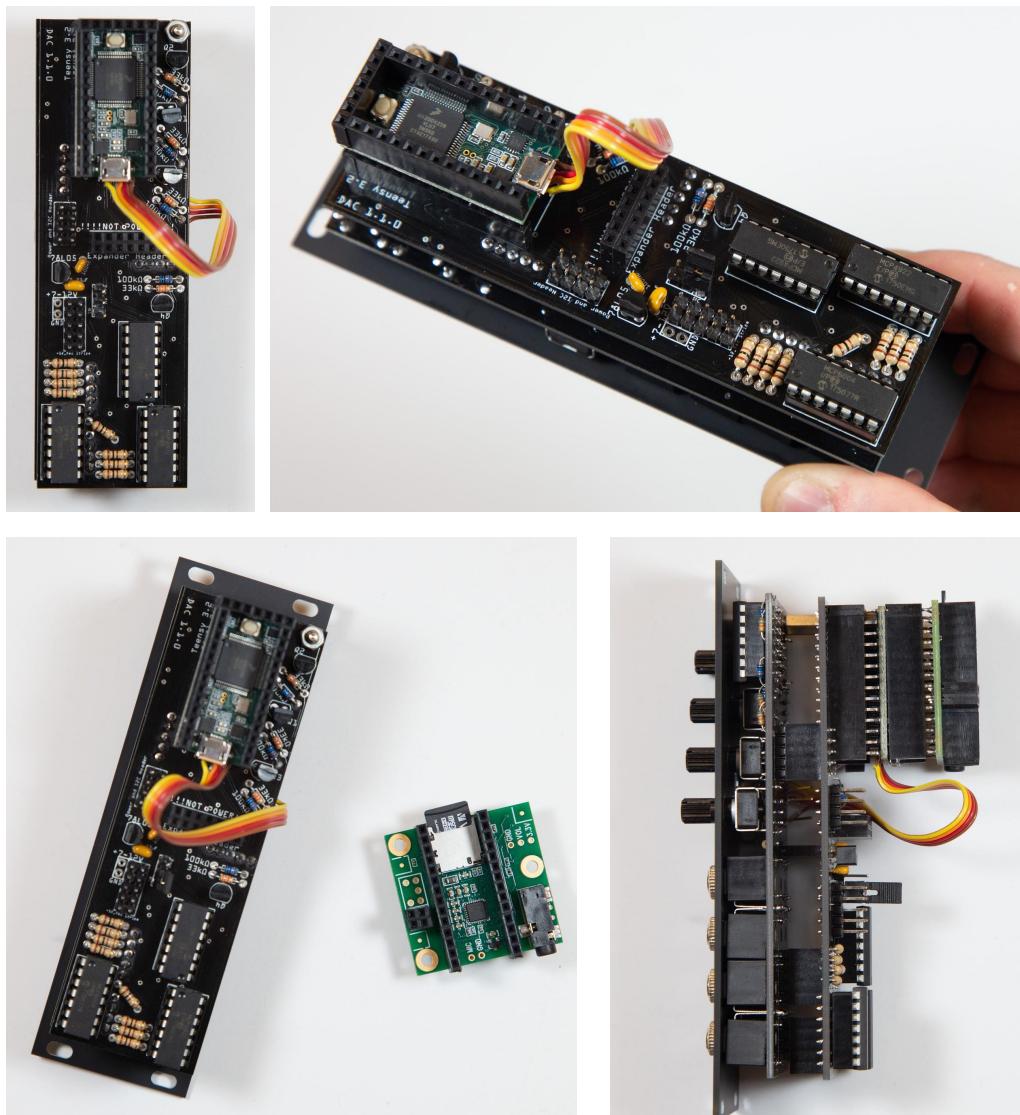
# BETWEENER + TEENSY AUDIO SHIELD

The Betweener has been designed to be compatible with the Teensy Audio Shield. This add-on allows stereo audio input and output at 44.1kHz and 16 bits.

The Teensy Audio Shield is also supported by an audio library with a web-based GUI design tool to aide in audio system design.

More information can be found here:

[https://www.pjrc.com/teensy/td\\_labs\\_Audio.html](https://www.pjrc.com/teensy/td_labs_Audio.html)



Audio System Design Tool for Teensy Audio Library

Export Import

treeverb  
freeverb  
envelope  
multiply  
delay  
delayExt  
bitcrusher  
midside  
waweshape  
granular  
combine  
filter  
biquad  
fir  
filter  
analyze  
filter

i2s1 playSdWav1 mixer1 delay1 i2s2  
wavetable1 mixer2 mixer3 filter1  
drum1 sine1 sine2 waveformMod1  
sine3

info  
Type AudioFilterStateVariable  
ID filter1  
Properties name filter1

Summary  
A State Variable (Chamberlin) Filter with 12 dB/octave roll-off, adjustable resonance, and optional signal control corner frequency.

Audio Connections

Port	Purpose
In 0	Signal to Filter
In 1	Frequency Control
Out 0	Low Pass Output
Out 1	Band Pass Output
Out 2	High Pass Output

Functions

frequency(freq): Set the filter's corner frequency. When a signal is connected to the control input, the filter will implement this frequency when the signal is zero.

resonance(Q): Set the filter's resonance. Q ranges from 0.2 to 5.0. Resonance greater than 0.707 will amplify the signal near the corner frequency. You must attenuate the signal before input to this filter, to prevent clipping.

Search