EAE DIY

Beholder

Builder's Guide

Version 1
September 27, 2021
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Revision History

Version	Changes
1	Initial release. R15 updated from 47K to 10K. Added bias mod to list.
0	Draft Copy

Contents

1 Introduction

This document contains a guide for assembling the **Beholder** Aberrant Reverberator by Electronic Audio Experiments. This pedal (or at least, this implementation of the pedal) is no longer in production, so we have released it as a DIY project for your continued enjoyment.

1.1 Background and Operation

The Beholder is a fuzzed-out, droning reverb pedal inspired by experiments with modifying other reverb pedals and running signal chains in the "wrong" order. Conventional pedalboard wisdom mandates that reverb be placed after distortion (or fuzz or overdrive), but the Beholder does exactly the opposite. Instead, a mostly wet reverb circuit goes into a dark, high-gain fuzz circuit. The combination is greater than the sum of its parts: the sustain and harmonics become an instrument of their own.

The controls are as follows:

Level Master volume of the pedal

Fuzz sets the gain of the fuzz circuit

Filter passive tilt control; morphs from dark low pass to bright high pass

Dwell drives the input of the reverb circuit

Feedback routes the reverb signal back to the input, to increase sustain or achieve self-oscillation/infinite decay

Drone Footswitch increases the feedback loop gain for greater sustain or chaotic noise; ramp intensity is adjustable via internal trimpot labeled DRONETRIM

Dry Mix (trimpot) blends in some dry input signal "around" the reverberation circuit, to preserve pick attack or other transient information going into the fuzz

There is no correct place to put the Beholder in your pedal chain. I like to think of it as a fuzz circuit which completely changes the way you play. If you so choose, it can be further altered by other effects (e.g. modulation, reverb, delay) downstream. Placed at the end of your pedal chain, it will mangle whatever is fed into it. You can also use it to completely alter the character of other sound sources, especially synthesizers and drum machines.

1.2 Before You Start

This board is recommended for moderate level to experienced builders. This guide assumes you have some familiarity with:

- Sourcing your own parts via Mouser, Digikey, etc. using a bill of materials
- Soldering a PCB from a parts list
- Drilling your own enclosure using a provided template
- Pedal assembly using PCB-mounted 16mm potentiometers
- Soldering jacks and switches with off-board wiring

This document includes a bill of materials (BOM), schematic, and drill drawing. It also includes a broad analysis of the circuit and some suggested modifications. For convenience, you may also access an excel BOM. For generic assembly instructions, please refer to the Appendix.

1.3 Disclaimers and Licensing

> ⚠**Caution:** EAE is not responsible for the outcome of your build and cannot offer direct support or troubleshooting beyond this document.

2 Parts List

For a spreadsheet with suggested part numbers, please see the Excel spreadsheet included with this document.

Resistors, Potentiometers, Trimpots

Qty	Value	Ref #s	Description
2	100kΩ	R8, R9	Metal film resistor, 1/4W 1%
7	10kΩ	R3, R4, R5, R13, R15, R16, R26	Metal film resistor, 1/4W 1%
4	1kΩ	R6, R7, R18, R24	Metal film resistor, 1/4W 1%
4	1MΩ	R1, R2, R17, R25	Metal film resistor, 1/4W 1%
3	22kΩ	R10, R11, R27	Metal film resistor, 1/4W 1%
3	4.7kΩ	CLR, R14, R19	Metal film resistor, 1/4W 1% (NOTE: Select CLR for desired LED intensity.)
1	470Ω	R12	Metal film resistor, 1/4W 1%
1	47kΩ	R20	Metal film resistor, 1/4W 1%
1	68kΩ	R22	Metal film resistor, 1/4W 1%
2	100kΩ Trim	DRONETRIM, DRYMIX	Bourns 3362P-1-104LF or equivalent
3	100kΩ Audio	Dwell, Feedback, Volume	16mm potentiometer, PCB mount right angle
1	50kΩ Linear	Tone	16mm potentiometer, PCB mount right angle
1	1MΩ Reverse Audio	Fuzz	16mm potentiometer, PCB mount right angle

Capacitors

Qty	Value	Ref #s	Description
6	100nF	C2, C3, C4, C5, C8, C15	Capacitor, box film 5mm lead spacing
2	100μF	C1, C11	Capacitor, electrolytic 25V
3	10nF	C10, C14, C16	Capacitor, box film 5mm lead spacing
5	1μF	C9, C18, C22, C23, C24	Capacitor, box film 5mm lead spacing
1	470pF	C7	Capacitor, MLCC NP0/C0G 5mm lead spacing
1	47μF	C13	Capacitor, electrolytic 25V

Semiconductors

Qty	Value	Ref #s	Description
2	TL072	IC1, IC2	Op Amp, JFET Input
1	BTDR-2H	IC3	Belton Brick (medium decay preferred, long also works)
1	1N5817	D1	Shottky Diode
2	2N2222	Q1, Q2	NPN BJT
1	2N3904	Q3	NPN BJT
2	1N4148	D4, D5	Silicon diode
1	78L05	REG1	5V regulator
1	LED	LED	5MM LED

Off-Board Parts

Qty	Value	Ref #s	Description
1	Enclosure	N/A	1590BBM equivalent
2	1/4” Mono Jack	IN, OUT	Switchcraft 111x or equivalent
1	DC Jack	9V	2.1mm barrel connector
1	3PDT	BYP	3PDT Footswitch, solder lug
1	SPST	DRONE	SPST Footswitch, momentary, normally open
5	Knob	N/A	1/4” shaft w/ set screw

3 Wiring

The wiring diagram is shown in Figure 1. For overall assembly instructions please refer to the Appendix. Wire pads on the board are listed in Table 1. For convenience, pads make connections to hardware located in close proximity. Note that the LED is mounted on the reverse side of the PCB. The flat side of the led should point down. If you are using the included 3PDT daughterboard, a 6-pin ribbon cable may be used. If you are not using a daughterboard, refer to Figure 2. You may use another scheme provided the input is grounded in bypass.

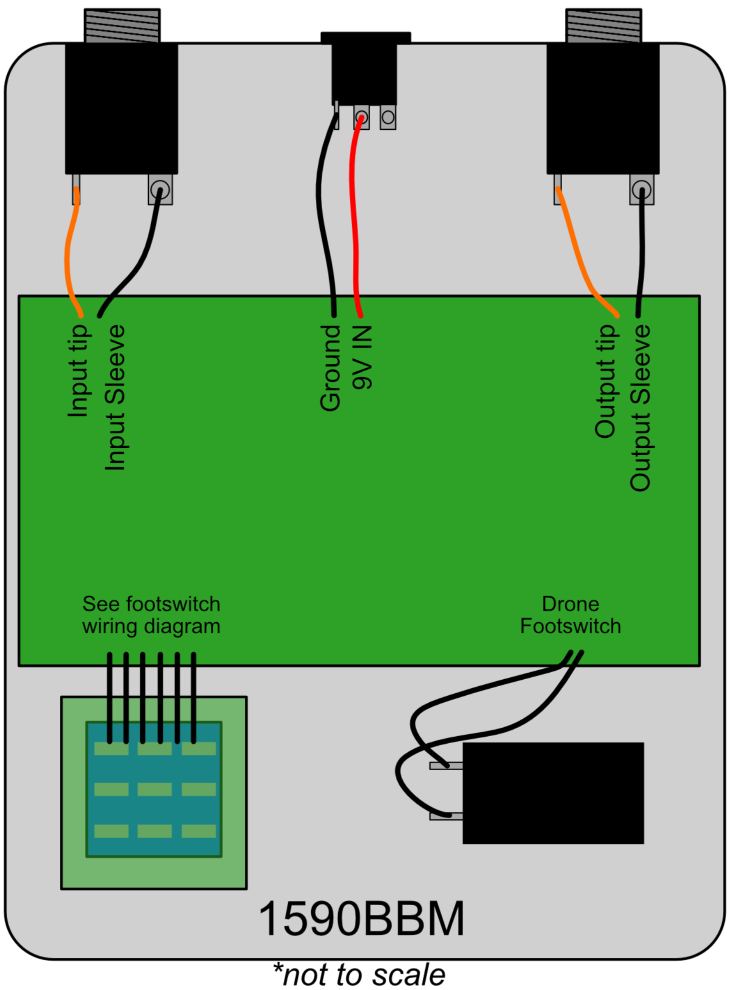


Figure 1: Wiring diagram. This view is looking into the enclosure from below. Note that this figure is for illustrative purposes only and is not drawn to scale. **If there is a discrepancy between the wiring diagram and the PCB, use the labels on the PCB.**

Pad	Function
I	Input Jack Tip
O	Output Jack Tip
G1, G2	Jack Sleeve Connections (Ground)
[+]	9V input (DC jack)
[-]	DC jack ground
JI	Bypass footswitch connection to input jack
L+	LED + to footswitch
L-	LED/Footswitch ground
S	Send/Input to effect
R	Return from effect
JO	Bypass footswitch connection to output jack
Drone (pair)	Momentary drone footswitch

Table 1: List of wire pads and functions.

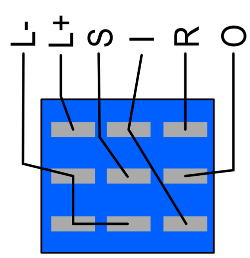
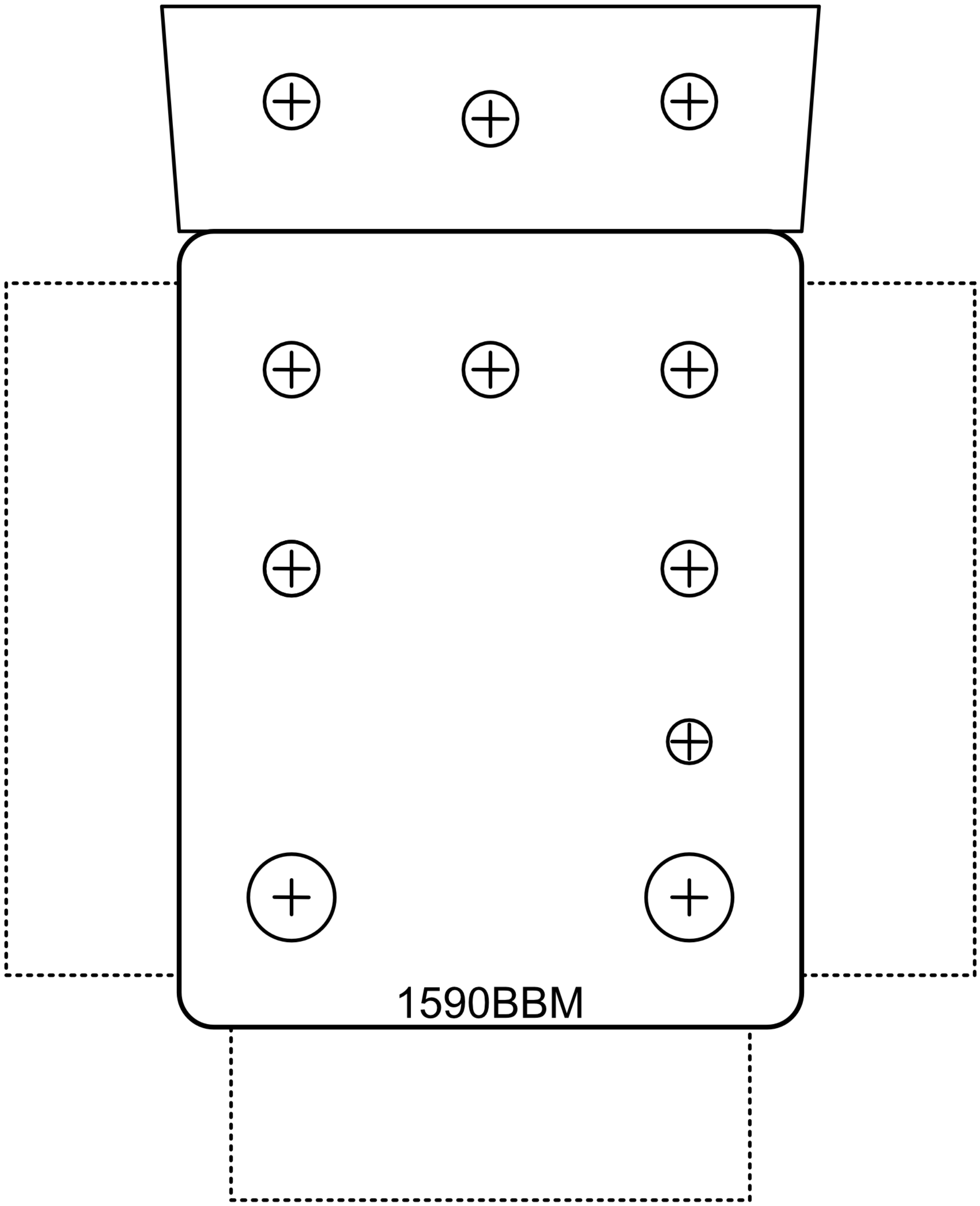


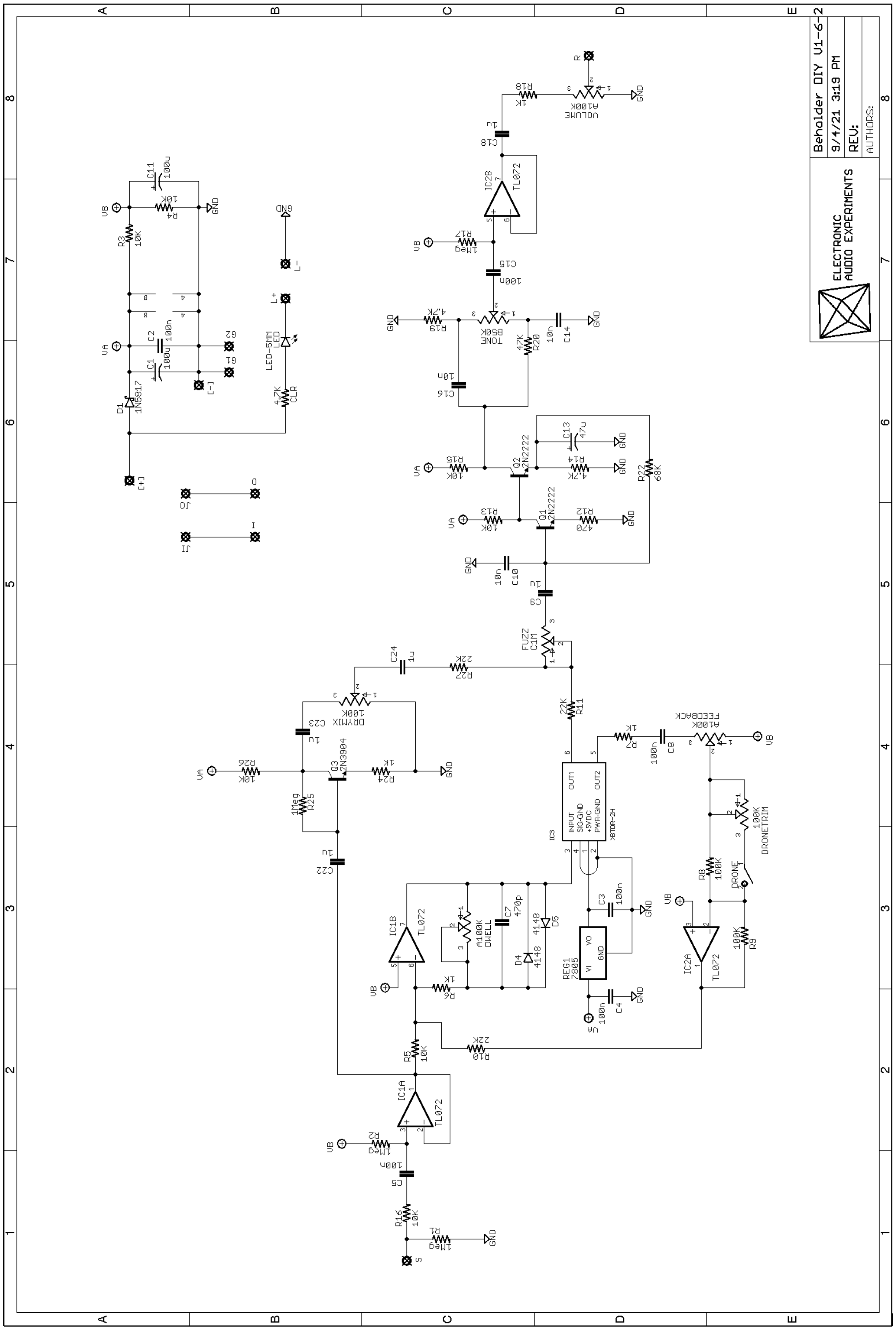
Figure 2: 3PDT Wiring Diagram. Note horizontal orientation of solder lugs.

4 Drill Template

Print this page out using 1:1 settings on your printer and fold to form the drill template. We recommend drilling pilot holes first to check alignment.



5 Schematic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6 Circuit Description

This circuit consists of two major sections: a reverb, and a fuzz circuit. The reverb portion was influenced by a survey of several Belton Brick reverb schematics available online. All share the same basic elements: i) a preamp or buffer, ii) a feedback circuit to increase dwell time, iii) the brick itself, and iv) a mixer for the dry and effected signals. However, none were optimized for use with fuzz, and none could be as pushed into sufficiently noisy territory via feedback.

The Beholder's preamplifier is built around the dual op amp IC1. IC1A provides a standard input buffer with a nominal input impedance of 500KΩ[1] to provide a high-impedance load for guitar pickups. It also provides a low impedance signal for the circuitry downstream, in order to properly split the signal to the reverb and non-reverb paths. IC1B is an inverting op amp gain stage with variable gain (ranging from -20dB to about +20dB) and feedback clipping. This configuration has a few useful properties. First, it actually allows for attenuation, reducing the overall sensitivity of the fuzz to clean-ish settings if desired. Second, at higher amplitude and/or gain settings, the feedback diodes prevent the signal from overhwelming the digital reverb brick[2] when hot signals are present. And third, IC1B serves as a summing amplifier for the reverb feedback path.

The reverb "brick" itself is a Belton BTDR-2H, implemented in a fairly standard fashion. The signal enters at pin 3, and reverberated signals emerge at pins 5 and 6. Since this is not a stereo effect, one pin functions as a dedicated feedback path and the other serves as the output to the fuzz.

To provision for the drone switch, which is intended to produce sustaining feedback at any setting, we added the inverting amplifier IC2A. When the drone switch is closed, it amplifies the signal present at the wiper of the Feedback pot. The amount of amplification depends on the value of the internal DRONETRIM pot as well as the Feedback pot itself. which produces intense feedback swells that ramp up immediately at nearly any setting.

Notice that the reverb does not have a traditional mix control. I wanted the signal to be completely washed out, but the BTDR-2H has a prominent pre-delay which made playing less intuitive. To circumvent this, some of the input signal is sent "around" the reverb brick. To do this we used a simple common emitter amplifier (Q3). A transistor was chosen instead of an op amp because it adds a little bit of grit to the otherwise dry signal, and because the higher output impedance of the common emitter amplifier sounded better with the fuzz circuit.

The fuzz circuit itself is a modification of the classic fuzz face circuit with an input gain control. I tried more complex fuzz circuits at the time, but that classic two transistor arrangement gets the job done—there's a ton of sustain and second-order harmonic content, and it never gets too harsh on its own. The most significant differ-

[1] 1MΩ is often cited as standard, but for extremely high gain circuits it helps to trim this value down to reduce sensitivity to external high frequency noise.

[2] The Belton Brick's signal path consists of three PT2399 delay chips, which are not known for their high headroom or graceful clipping characteristics. I considered this angle, but ultimately wanted to let the fuzz circuit do the heavy lifting.

ence is that, instead of grounding the first emitter (Q1) I added an emitter resistor. The inclusion of an emitter resistor keeps the transistor bias more consistent, at the expense of some gain. There's already so much gain here that it's not a problem. Notice that Q1 is also used as a summing node for the reverb and "clean" paths, by way of R11 and R27.

After the fuzz is a simple passive tilt EQ (the ubiquitous Big Muff tone stack) with a buffer on the output to ensure that the tone control does not interact with the passive output volume control.

7 Modifications

> ⚠**Caution:** Modifications should not be attempted unless you have the means to troubleshoot changes beyond the base configuration.

7.1 Clean Blend

I understand not everyone is trying to conjure up a raging wall of noise every time they turn on their reverb pedal, so if you want to add a simple unity gain clean blend you can perform the following steps. This mod takes a signal from the input buffer and routes it to a blend pot at the output. The only extra part required is a B10K or B25K pot. **Note that this mod disables the internal "dry path".**

1. Do not install the following parts: R25, R26, R24, Q3, C23, DRYMIX trim, C24, R27
2. Solder a wire from the middle pin of Q3 (at least, where Q3 would have been) to Lug 1 of the blend pot.
3. Solder a wire from the R pad (normally reserved for the bypass footswitch) to Lug 3 of the pot
4. Solder a wire from Lug 2 of the pot to the return pin on the footswitch where the effect output normally would be.

The pot should now pan from the buffered clean input signal to the fully wet signal of the Beholder. You can use the Volume control to match levels.

7.2 Tone Stack

Since this is such a common tone stack configuration, feel free to build it with your favorite values. Earlier Beholder units were more heavily scooped, and later ones had a flatter response.

7.3 Op Amp Selection

IC1 and IC2 work great using the humble TL072. We built some units with the TLC2272, which has rail to rail output (meaning the output can go within about 0.2V of both the positive and negative supply voltages). The signal present at the output buffer is enough to clip it at certain settings, which does add some extra hash to the sound. But the selection is not critical. Feel free to experiment!

7.4 Transistor Selection and Biasing

Socketing the fuzz transistors Q1 and Q2 is recommended. We had a box of old stock 2N2222s which worked well here. Other low to medium gain transistors, like the 2N3904 and 2N4401, are also great. Q3 selection is not critical, any decent NPN silicon part will work here. For a greater variety of fuzz sounds, including more starved/gated tones, R15 can be made adjustable. Try a 50KΩ trimpot with a 4.7KΩ resistor in series. Experimentation is welcome.

A Generic Assembly Guide

This is a fully general pedal assembly procedure that applies to all EAE open source projects. Note that minor details can vary between PCBs. But this will serve as a quick reference for those already familiar with this type of assembly.

1. Populate and solder the PCB per the parts list. Do not solder in enclosure-mounted components such as pots, indicator LEDs, and/or toggle switches. Ensure that all leads are trimmed to 0.1" or less.

2. Drill the enclosure per the template. Use a center punch first to mark holes for accuracy. If you have one, a stepper bit is very convenient here. If you are unsure about any hole sizes, check using the appropriate hardware.

3. Solder pots and toggle switches (if present) to the PCB using the enclosure as a jig to hold the hardware in place. We recommend using potentiometers with dust covers. If the pots are not insulated, ensure they are not making contact with the back of the PCB.

4. Install PCB mounted LED on the reverse side of the board. Gently bend the legs to hold it in place, but do not solder yet.

5. Install flying wires on the board. These go to the jacks and footswitch(es).

6. Insert PCB into enclosure and tighten all hardware. Fit LED(s) into place, solder, and trim the leads.

7. Solder flying wires to the appropriate pads. Refer to the wiring diagram or table for the specific pedal in question.

8. Pedal is ready for testing!