PROJECT NAME

DEIMOS

aion
DIY GUITAR EFFECTS

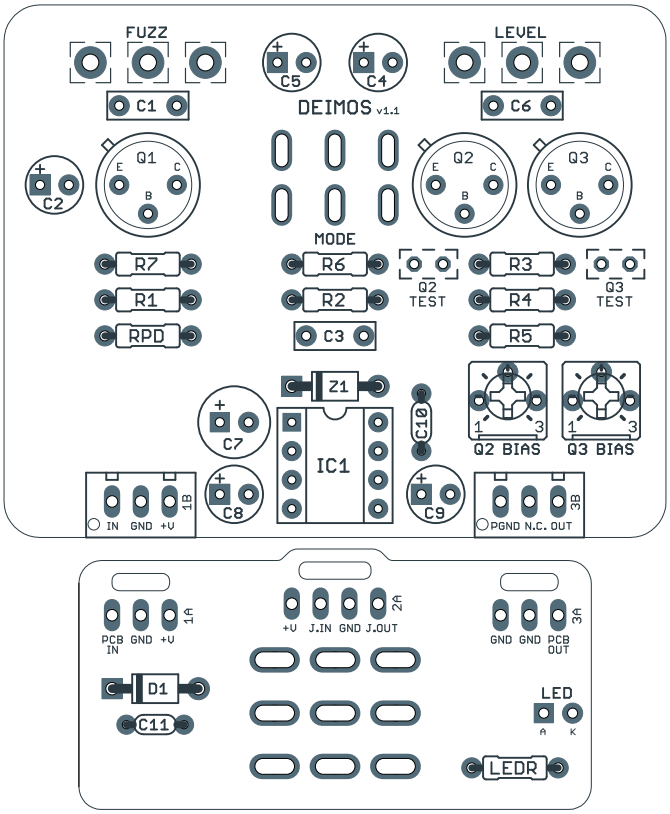
BASED ON
Tone Bender Mk. II Professional

BUILD DIFFICULTY
▮▮▯▯▯ Easy

EFFECT TYPE
Germanium fuzz

DOCUMENT VERSION
1.0.1 (2023-05-15)

PROJECT SUMMARY
The second (and most famous) version of the legendary fuzz pedals from Macaris in London that changed the music world forever.



Actual size is 2.3” x 1.86” (main board) and 2.3” x 0.86” (bypass board).

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INTRODUCTION

The Deimos Germanium Fuzz is a clone of the Sola Sound Tone Bender Mk. II (two-knob) that was produced and sold by Macaris in London beginning in late 1966. It was one of the pioneers of guitar effects pedals, hugely influential both musically and electronically to everything that followed.

While the previous version of the Tonebender was essentially the same circuit as the Fuzz Face, the Mark II version added a single-transistor boost/buffer stage in front of it, increasing the drive level but also making it play nicer with effects that come before it.

The Deimos project is a faithful reproduction of the Tone Bender Professional Mk. II with one big enhancement: a voltage inverter has been added which allows it to be powered with a standard center-negative adapter while maintaining the positive-ground operation of the original. The PCB also includes trim pots so you can dial in a perfect bias without having to swap out resistors.

In addition, the 125B update of the Deimos adds a toggle switch allowing you to bypass the first transistor stage to convert it into the previous version of the Tone Bender, often referred to as the “1.5”. (There is one other capacitor that had a different value in the 1.5 circuit, but it has very little impact on the sound.)

USAGE

The Deimos has two controls and one toggle:

- **Fuzz** controls the amount of gain from the third transistor where the clipping occurs.
- **Volume** is the output volume of the effect.
- **Mode** is a toggle switch that optionally bypasses the first transistor for a lower-gain mode. This mode is equivalent to the Tone Bender Mk. 1.5 and very similar to the Fuzz Face.

PARTS LIST

This parts list is also available in a spreadsheet format which can be imported directly into Mouser for easy parts ordering. Mouser doesn't carry all the parts—notably potentiometers—so the second tab lists all the non-Mouser parts as well as sources for each.

View parts list spreadsheet →

PART	VALUE	TYPE	NOTES
R1	100k	Metal film resistor, 1/4W	Some versions use 10k here, but 100k works best for most germanium transistors. See build notes.
R2	10k	Metal film resistor, 1/4W	
R3	47k	Metal film resistor, 1/4W	
R4	8k2	Metal film resistor, 1/4W	
R5	470R	Metal film resistor, 1/4W	
R6	100k	Metal film resistor, 1/4W	
R7	JUMPER	Metal film resistor, 1/4W	Optional gain-limiting resistor, found in some versions. Use 100R to 470R, or jumper for stock.
RPD	1M	Metal film resistor, 1/4W	Input pulldown resistor.
LEDR	4k7	Metal film resistor, 1/4W	LED current-limiting resistor. Adjust value to change LED brightness.
C1	10n	Film capacitor, 7.2 x 2.5mm	This is 15n in some versions and omitted entirely in others.
C2	4.7uF	Electrolytic capacitor, 4mm	
C3	100n	Film capacitor, 7.2 x 2.5mm	
C4	4.7uF	Electrolytic capacitor, 4mm	
C5	4.7uF	Electrolytic capacitor, 4mm	
C6	10n	Film capacitor, 7.2 x 2.5mm	This is 15n in some versions.
C7	100uF	Electrolytic capacitor, 6.3mm	
C8	10uF	Electrolytic capacitor, 5mm	
C9	47uF	Electrolytic capacitor, 5mm	
C10	470n	MLCC capacitor, X7R	
C11	100n	MLCC capacitor, X7R	
Z1	1N4742A	Zener diode, 12V, DO-41	
D1	1N5817	Schottky diode, DO-41	
Q1	Germanium	Germanium transistor, PNP	Recommended to buy a selected Tone Bender set. See build notes.
Q1-S	TO-5 socket	Transistor socket, TO-5	
Q2	Germanium	Germanium transistor, PNP	Recommended to buy a selected Tone Bender set. See build notes.
Q2-S	TO-5 socket	Transistor socket, TO-5	
Q3	Germanium	Germanium transistor, PNP	Recommended to buy a selected Tone Bender set. See build notes.
Q3-S	TO-5 socket	Transistor socket, TO-5	

PARTS LIST, CONT.

PART	VALUE	TYPE	NOTES
IC1	TC1044SCPA	Voltage inverter, DIP8	
IC1-S	DIP-8 socket	IC socket, DIP-8	
Q2BIAS	100k trimmer	Trimmer, 10%, 1/4"	
Q3BIAS	10k trimmer	Trimmer, 10%, 1/4"	
FUZZ	1kC	16mm right-angle PCB mount pot	Original uses linear (B) taper, but reverse (C) gives better control range.
LEVEL	100kA	16mm right-angle PCB mount pot	
MODE	DPDT	Toggle switch, DPDT on-on	
LED	5mm	LED, 5mm, red diffused	
IN	1/4" stereo	1/4" phone jack, closed frame	Switchcraft 112BX or equivalent.
OUT	1/4" mono	1/4" phone jack, closed frame	Switchcraft 111X or equivalent.
DC	2.1mm	DC jack, 2.1mm panel mount	Mouser 163-4302-E or equivalent.
BATT	Battery snap	9V battery snap	Optional. Use the soft plastic type—the hard-shell type will not fit.
FSW	3PDT	Stomp switch, 3PDT	
ENC	125B	Enclosure, die-cast aluminum	Can also use a Hammond 1590N1.

BUILD NOTES

Transistors

For this circuit, as with other vintage fuzzes, it's not so much the part number of the germanium transistor as it is the properties—specifically, gain (hFE) and leakage.

The Tone Bender Mk. II is particularly finicky about its transistors, so you can save a lot of time by just buying a matched set from Small Bear Electronics or somewhere else. However, if you don't have access to pre-matched transistors or you just want to sort your own, here's what to look for.

Characteristics

This is just a general guideline. There are some transistors that meet these characteristics that won't sound right, and others that are outside this nominal range that will work just fine.

- **Q1:** hFE 50 to 80, high leakage (100-300µA)
- **Q2:** hFE 50 to 80, low to medium leakage (50-200µA)
- **Q3:** hFE 95 to 120, low to high leakage (50-300µA)

Biasing

The Deimos is set up to allow for easy biasing of the Q2 and Q3 transistors via trim pots without having to swap out resistors.

Note that the Q2 bias trimmer adjusts the bias of Q3 as well, while the Q3 trimmer only adjusts Q3. Always bias Q3 using the Q2 trimmer first, and only use Q3's bias trimmer if you need to fine-tune it.

To start, turn the Q2 bias trimmer to around 3:00 and Q3 to around 8:00. Then, with a multimeter, touch the black and red leads to the two pads marked "Q3 TEST". Turn the Q2 trimmer until the Q3 test pad reads between -8V and -8.5V. This voltage may be positive if the test leads are reversed, but we only care about the absolute value.

Then, with the black lead touching ground, measure each leg on all three of the transistors. You're looking for something near these voltages.

- **Q1:** Collector -8.5 to -9.5V, Base -0.05V, Emitter 0V
- **Q2:** Collector -0.15V to -0.25V, Base -0.07V, Emitter 0V
- **Q3:** Collector -8V to -8.5V, Base -0.15 to -0.35V, Emitter -0.1V

After biasing, if Q2's collector voltage is outside the range, you may need to bias Q3 independently. Re-adjust the Q2 trimmer until Q2C looks right, then adjust the Q3 trimmer to get Q3C in range.

Q1 and Q3's collector voltages are also relative to the supply voltage, which is typically 9.6V to 10V for a wall wart, but often exactly 9V for many pedalboard supplies such as the Voodoo Lab PP2+.

The voltages don't need to be anywhere near exact, this is just a rough benchmark. In the end, let your ears be the judge and don't worry much about the voltages if it sounds good to you.

Temperature considerations

The MkII circuit is particularly sensitive to leakage, especially in the Q1 position. The circuit is designed in such a way that Q1 must have a certain minimum amount of leakage in order to function properly. If there's not enough leakage, there will be considerably higher background noise.

Germanium transistors are notorious for being extremely temperature-sensitive, and as the ambient conditions change, gain and leakage can vary drastically. We've seen transistors that measured at 150µA leakage on a warm day that dropped below 50 on a cooler day. While 150 is more than enough, 50 is typically not going to work.

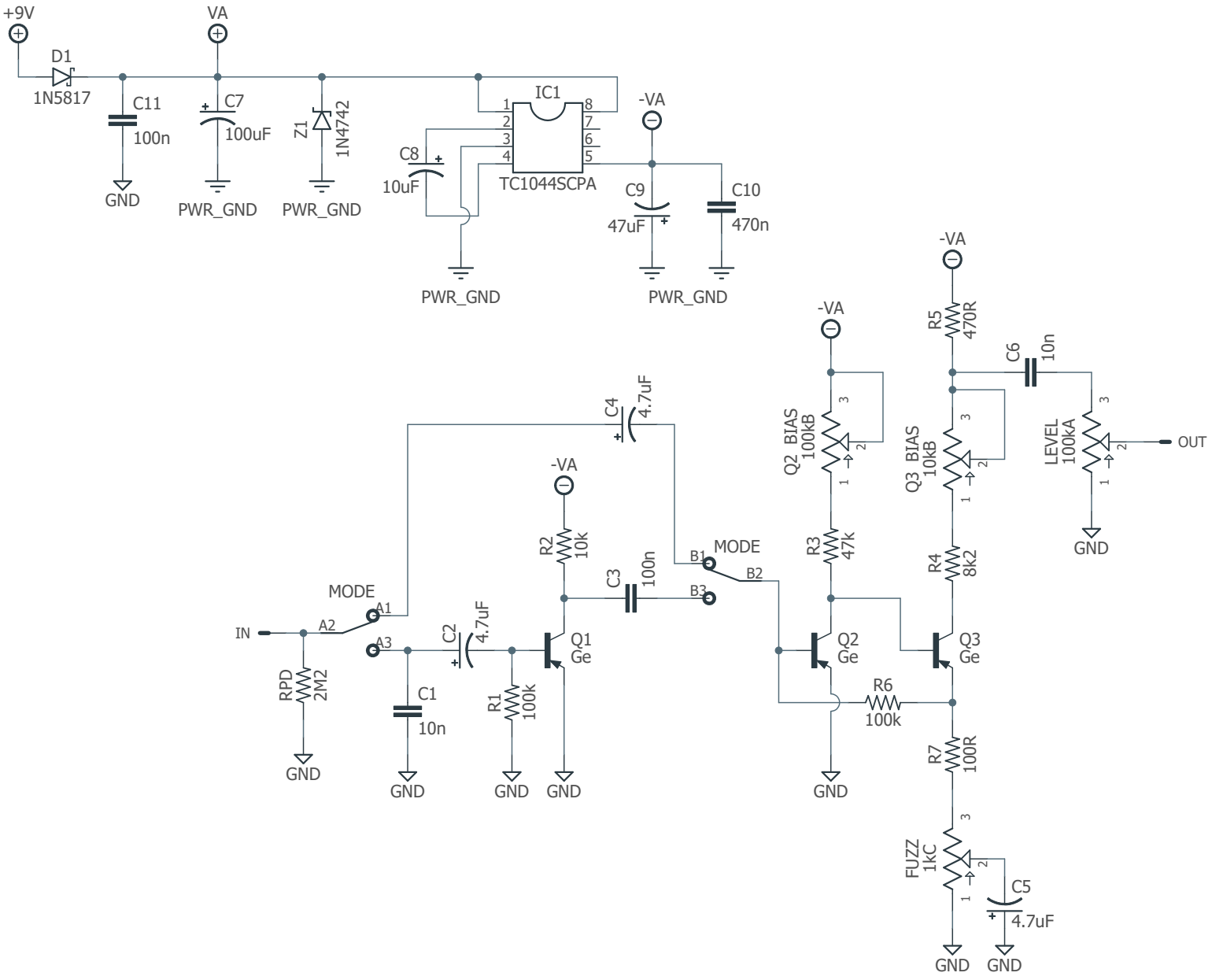
So, if you notice the unit get noisier as the seasons get colder, it's probably because Q1 is not consistently leaky enough. If you can't change the ambient conditions then you might need to change the transistor for one that has an even higher leakage.

R1 resistor value

The very first Tone Bender MkII units used OC75 transistors and a 10k base resistor for Q1 (R1 in the Deimos). Later, they switched to OC81D which is a much less leaky type, and along with this they changed the base resistor to 100k. The two configurations are said to be indistinguishable, so it's purely a difference in biasing arrangement and neither circuit is more desirable unless you're a collector.

Today, it's pretty hard to find transistors that are as leaky as OC75s, and most of what is available is more like the OC81D. Therefore, it's recommended to use 100k for R1 in nearly every instance. But if you do have particularly leaky transistor—and especially if you manage to find original OC75s—then you'll want to use 10k for R1 instead.

SCHEMATIC


+9V
VA
D1
1N5817
C11
100n
C7
100uF
Z1
1N4742
GND
PWR_GND
PWR_GND
C8
10uF
IC1
TC1044SCPA
-VA
C9
47uF
C10
470n
PWR_GND
PWR_GND
C4
4.7uF
-VA
R2
10k
C3
100n
MODE
B1
B2
B3
MODE
A1
A2
A3
IN
C2
4.7uF
Q1
Ge
RPD
2M2
C1
10n
R1
100k
GND
GND
GND
GND
-VA
Q2 BIAS
100kB
R3
47k
Q2
Ge
R6
100k
GND
-VA
R5
470R
C6
10n
Q3 BIAS
10kB
R4
8k2
Q3
Ge
LEVEL
100kA
OUT
GND
R7
100R
FUZZ
1kC
C5
4.7uF
GND
GND

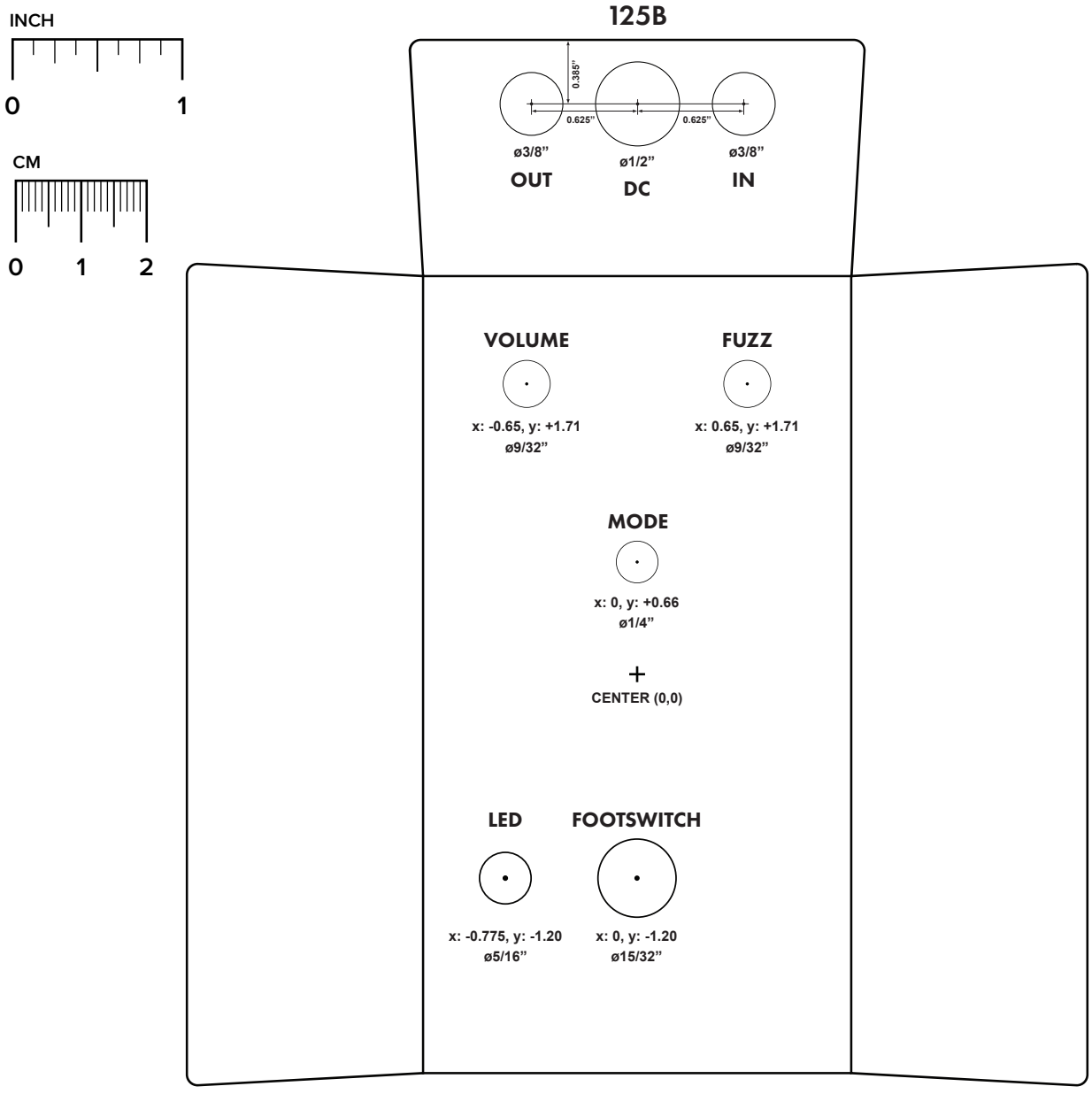
DRILL TEMPLATE

Cut out this drill template, fold the edges and tape it to the enclosure. Before drilling, it's recommended to first use a center punch for each of the holes to help guide the drill bit.

Ensure that this template is printed at 100% or "Actual Size". You can double-check this by measuring the scale on the printed page.

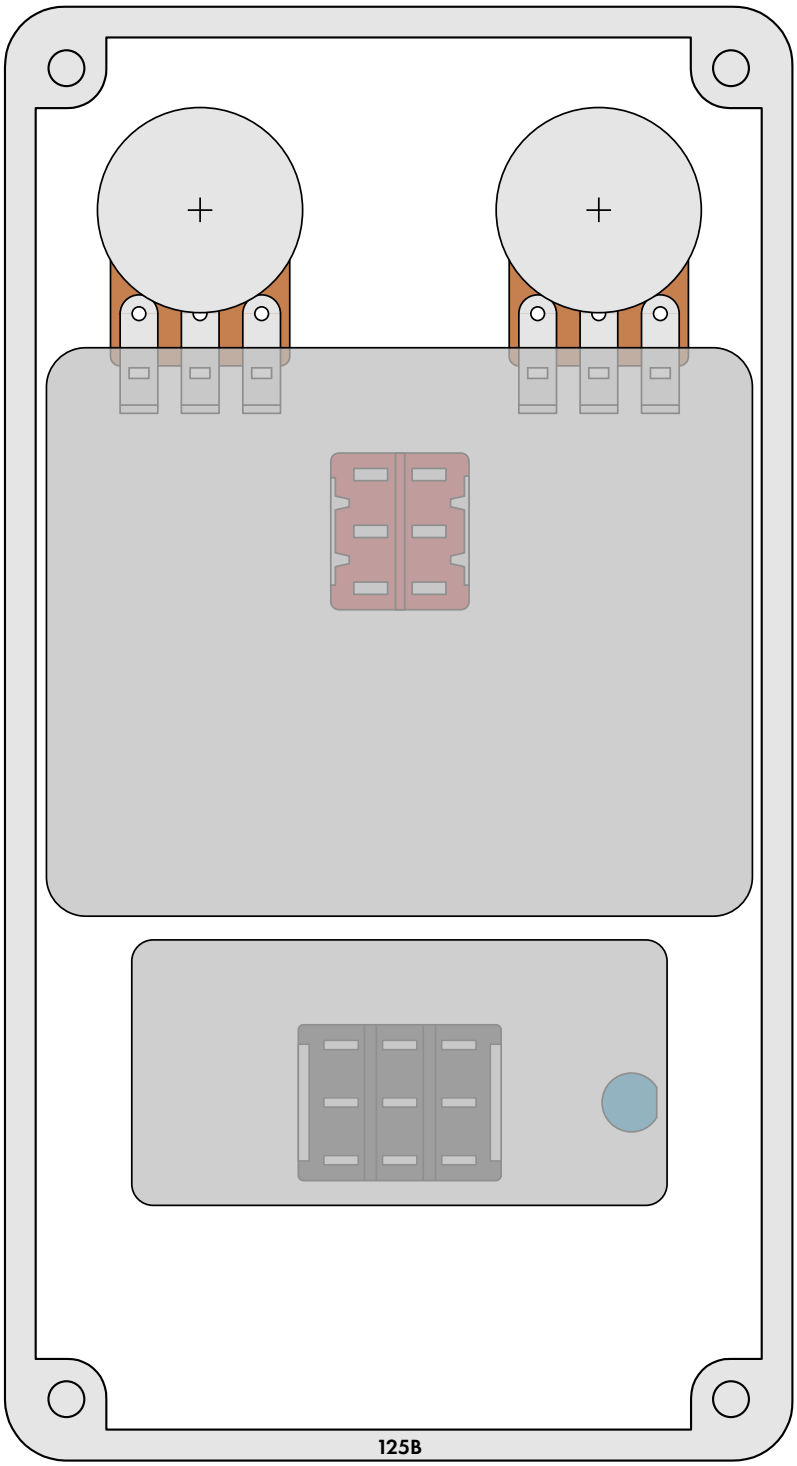
Top jack layout assumes the use of closed-frame jacks like the Switchcraft 111X. If you'd rather use open-frame jacks, please refer to the Open-Frame Jack Drill Template for the top side.

LED hole drill size assumes the use of a 5mm LED bezel, available from several parts suppliers. Adjust size accordingly if using something different, such as a 3mm bezel, a plastic bezel, or just a plain LED.

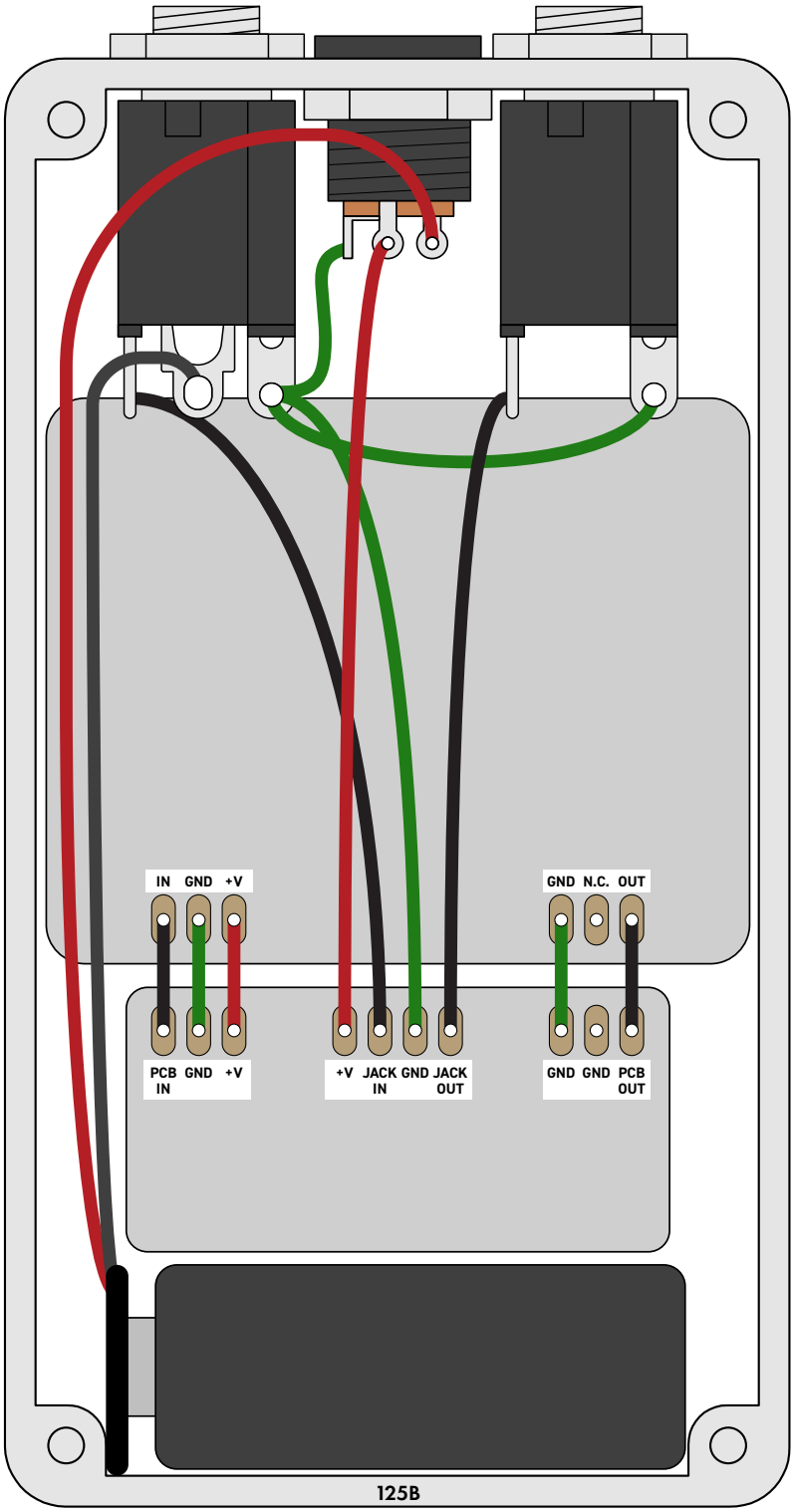


ENCLOSURE LAYOUT

Enclosure is shown without jacks. See next page for jack layout and wiring.



WIRING DIAGRAM



Shown with optional 9V battery. If battery is omitted, both jacks can be mono rather than one being stereo. Leave the far-right lug of the DC jack unconnected.

LICENSE & USAGE

No direct support is offered for these projects beyond the provided documentation. It's assumed that you have at least some experience building pedals before starting one of these. Replacements and refunds cannotbe offered unless it can be shown that the circuit or documentation are in error.

All of these circuits have been tested in good faith in their base configurations. However, not all the modifications or variations have necessarily been tested. These are offered only as suggestions based on the experience and opinions of others.

Projects may be used for commercial endeavors in any quantity unless specifically noted. No attribution is necessary, though a link back is always greatly appreciated. The only usage restrictions are that **(1) you cannot resell the PCB as part of a kit without prior arrangement**, and **(2) you cannot "goop" the circuit, scratch off the screenprint, or otherwise obfuscate the circuit to disguise its source**. (In other words: you don't have to go out of your way to advertise the fact that you use these PCBs, but please don't go out of your way to hide it. The guitar effects industry needs more transparency, not less!)

DOCUMENT REVISIONS

1.1.0 (2023-05-15)
Minor PCB revision reorienting the toggle switch to left-right instead of up-down. Some components shifted. No schematic or parts changes.

1.0.1 (2022-10-20)
Added more information to the build notes regarding biasing and transistor selection.

1.0.0 (2020-07-03)
Initial release.