PROJECT NAME

DYNAMO

aion DIY GUITAR EFFECTS

BASED ON
Bixonic Expandora

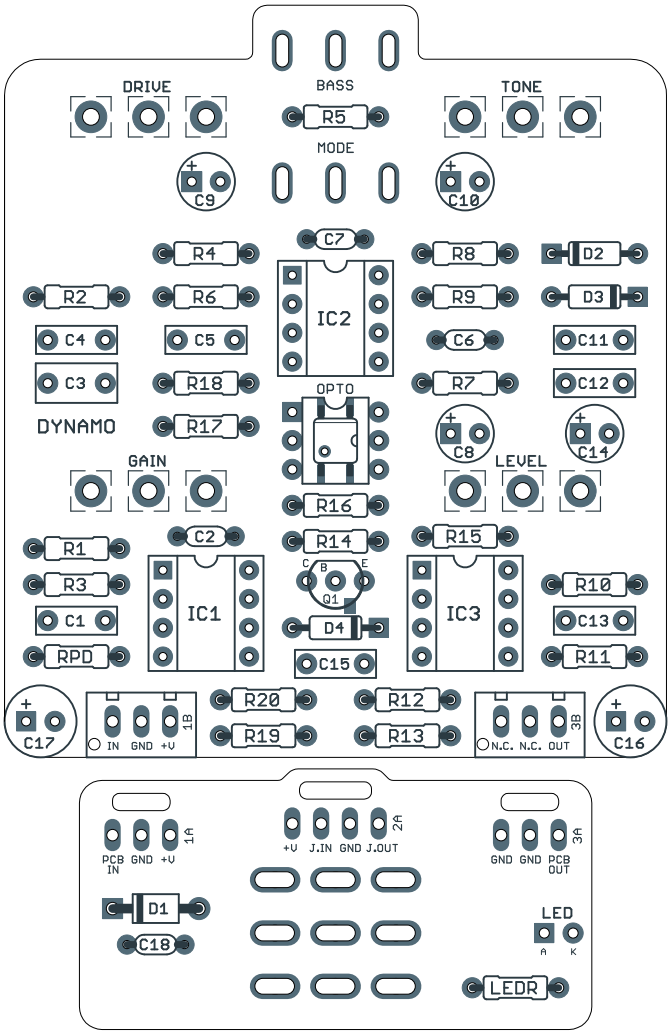
BUILD DIFFICULTY
Intermediate

EFFECT TYPE
Envelope-controlled distortion

DOCUMENT VERSION
1.0.0 (2023-07-04)

PROJECT SUMMARY

Loosely based on the RAT, but with an optocoupler that dynamically sets the gain based on the input signal level, making for a highly unique and often untamed drive effect.



Actual size is 2.3” x 2.61” (main board) and 1.78” x 0.90” (bypass board).

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INTRODUCTION

The Dynamo Reactive Distortion is an adaptation of the Bixonic Expandora, a Japanese boutique pedal first released in 1995. The Expandora was a favorite of Billy Gibbons (ZZ Top) and Stu G (Delirious?), and has also been seen on the pedalboards of Thom Yorke and St. Vincent.

Looking at the schematic, it's clear that the Expandora circuit originated from an experiment in putting two RAT Distortion pedals in series, which you can see in the two cascaded LM308 gain stages. The twist is how the drive level is controlled. A side-chain envelope detector engages an opto-FET (which in this application is essentially the same as an optocoupler or vactrol) that serves as the op-amp's gain control, meaning the gain itself varies with the signal strength. The result is a very touch-sensitive distortion that shares some characteristics with the RAT but is really its own unique creature.

The Expandora had four major versions during its original Bixonic production. The Dynamo is most similar to the third version (called "2000R"), including the Bass/Guitar switch, but with a few tweaks from other versions for added versatility. Inspired by V4, the two separate gain toggles have been condensed into a potentiometer called "Drive" which covers the full range of resistance of the toggles. "Forbidden" mode its own toggle, disengaging the series resistance in the feedback loop.

The JHS Kilt is the most notable commercial clone of the Expandora, designed in collaboration with Stu G. We haven't traced one of these, but based on the control layout and product description, the Dynamo is likely identical except for the potentiometer mod. The Flat/Bass Cut switch is the same as the Bass/Guitar switch from the 2000R version of the Expandora.

USAGE

The Dynamo has four knobs and two toggles:

- **Gain** is a standard gain control in the first op-amp stage.
- **Drive** sets the gain ratio of the envelope-controlled optocoupler.
- **Tone** is a passive treble-cut control that follows the clipping section.
- **Level** is an output volume control.
- **Bass** (toggle) sets the amount of bass at the output. The higher-bass mode is designed for bass guitar, while the standard mode is equivalent to the earlier guitar-only Expandora.
- **Mode** (toggle) disconnects the Drive pot and enables "Forbidden Mode", which is an extremely high-gain untamed fuzz.

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	
R2	2M2	Metal film resistor, 1/4W	
R3	2M2	Metal film resistor, 1/4W	
R4	43k	Metal film resistor, 1/4W	
R5	240R	Metal film resistor, 1/4W	
R6	47R	Metal film resistor, 1/4W	
R7	560R	Metal film resistor, 1/4W	
R8	1k1	Metal film resistor, 1/4W	
R9	1k5	Metal film resistor, 1/4W	
R10	1M	Metal film resistor, 1/4W	
R11	11k	Metal film resistor, 1/4W	
R12	100k	Metal film resistor, 1/4W	
R13	51k	Metal film resistor, 1/4W	
R14	820k	Metal film resistor, 1/4W	
R15	4k7	Metal film resistor, 1/4W	
R16	47k	Metal film resistor, 1/4W	
R17	4k7	Metal film resistor, 1/4W	
R18	47R	Metal film resistor, 1/4W	
R19	10k	Metal film resistor, 1/4W	
R20	10k	Metal film resistor, 1/4W	
RPD	2M2	Metal film resistor, 1/4W	Input pull-down resistor.
LEDR	10k	Metal film resistor, 1/4W	LED current-limiting resistor. Adjust value to change LED brightness.
C1	100n	Film capacitor, 7.2 x 2.5mm	
C2	OMIT		IC1 compensation capacitor, only used for LM308.
C3	1uF	Film capacitor, 7.2 x 3.5mm	
C4	22n	Film capacitor, 7.2 x 2.5mm	
C5	1n	Film capacitor, 7.2 x 2.5mm	
C6	100pF	MLCC capacitor, NP0/C0G	
C7	OMIT		IC2 compensation capacitor, only used for LM308.
C8	4.7uF	Electrolytic capacitor, 4mm	
C9	2.2uF	Electrolytic capacitor, 4mm	
C10	4.7uF	Electrolytic capacitor, 4mm	

PARTS LIST, CONT.

PART	VALUE	TYPE	NOTES
C11	3n3	Film capacitor, 7.2 x 2.5mm	
C12	100n	Film capacitor, 7.2 x 2.5mm	
C13	100n	Film capacitor, 7.2 x 2.5mm	
C14	10uF	Electrolytic capacitor, 5mm	
C15	100n	Film capacitor, 7.2 x 2.5mm	
C16	100uF	Electrolytic capacitor, 6.3mm	Reference voltage filter capacitor.
C17	220uF	Electrolytic capacitor, 6.3mm	Power supply filter capacitor.
C18	100n	MLCC capacitor, X7R	Power supply filter capacitor.
D1	1N5817	Schottky diode, DO-41	
D2	1N914	Fast-switching diode, DO-35	
D3	1N914	Fast-switching diode, DO-35	
D4	1N914	Fast-switching diode, DO-35	
Q1	2N3906	BJT transistor, PNP, TO-92	
OPTO	H11F1	Optocoupler, photoFET, DIP6	See build notes for information on optocoupler selection.
OPTO-S	DIP-6 socket	IC socket, DIP-6	
IC1	OP07	Operational amplifier, single, DIP8	
IC1-S	DIP-8 socket	IC socket, DIP-8	
IC2	OP07	Operational amplifier, single, DIP8	
IC2-S	DIP-8 socket	IC socket, DIP-8	
IC3	JRC4558D	Operational amplifier, DIP8	
IC3-S	DIP-8 socket	IC socket, DIP-8	
GAIN	1MB	16mm right-angle PCB mount pot	
DRIVE	1kB	16mm right-angle PCB mount pot	
TONE	100kC	16mm right-angle PCB mount pot	
LEVEL	1MB	16mm right-angle PCB mount pot	
BASS	SPDT	Toggle switch, SPDT on-on	
MODE	SPDT	Toggle switch, SPDT on-on	
LED	5mm	LED, 5mm, red diffused	
IN	1/4" mono	1/4" phone jack, closed frame	Switchcraft 111X 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.
FSW	3PDT	Stomp switch, 3PDT	
ENC	125B	Enclosure, die-cast aluminum	Can also use a Hammond 1590N1.

BUILD NOTES

LM308 and OP07

The Expandora was based on the Pro Co RAT, and like the RAT, it originally used the LM308—an early op-amp with a very low slew rate compared to modern alternatives. The slew rate is critical to the unique sound of the RAT, and likely the Expandora as well by extension.

In the mid-1990s, the LM308 supply began to dry up, so after some research & experimentation, Pro Co changed over to the OP07. Bixonic followed suit in later versions of the Expandora.

The RAT is plagued with decades of heated debates about whether the LM308 sounds better than the OP07. However, it's been shown on more than one occasion (both by the DIY community and more thoroughly by JHS) that the OP07 performs and sounds identical when used in the same circuit with the same settings.

The LM308 has been obsolete for a long time, and most of what's available today on eBay and component distributors in Asia are relabeled fakes, so it's not recommended to risk using one. Let the article from JHS convince you the LM308 is not special, and use the OP07 with a clear conscience!

C2 and C7 compensation capacitors

The OP07 has an internal slew-rate compensation capacitor while the LM308 does not. C2 and C7 (both 33pF) should be omitted when using the OP07, but they're required for the LM308 to work properly.

Optocoupler selection

The original Expandora used a Sharp PC419 photo-FET optocoupler. They're now obsolete, but not terribly hard to find (e.g. from Small Bear Electronics). However, they were only available in SMD format. The H11F1M is an exact substitute with the same current-to-resistance curves, and it's available in through-hole format, so it's a better choice all around. Note that it's a DIP-6 package, so if you can't source a 6-pin socket, you'll need to cut down an 8-pin socket or use two SIP snap-apart strips.

The JHS Kilt uses the H11F3, which is similar to the F1 but with slightly higher resistance at the same currents. We haven't traced a Kilt to know whether there are any other circuit changes, but if you want to experiment, you can try this optocoupler as an alternate to see if you like it any better.

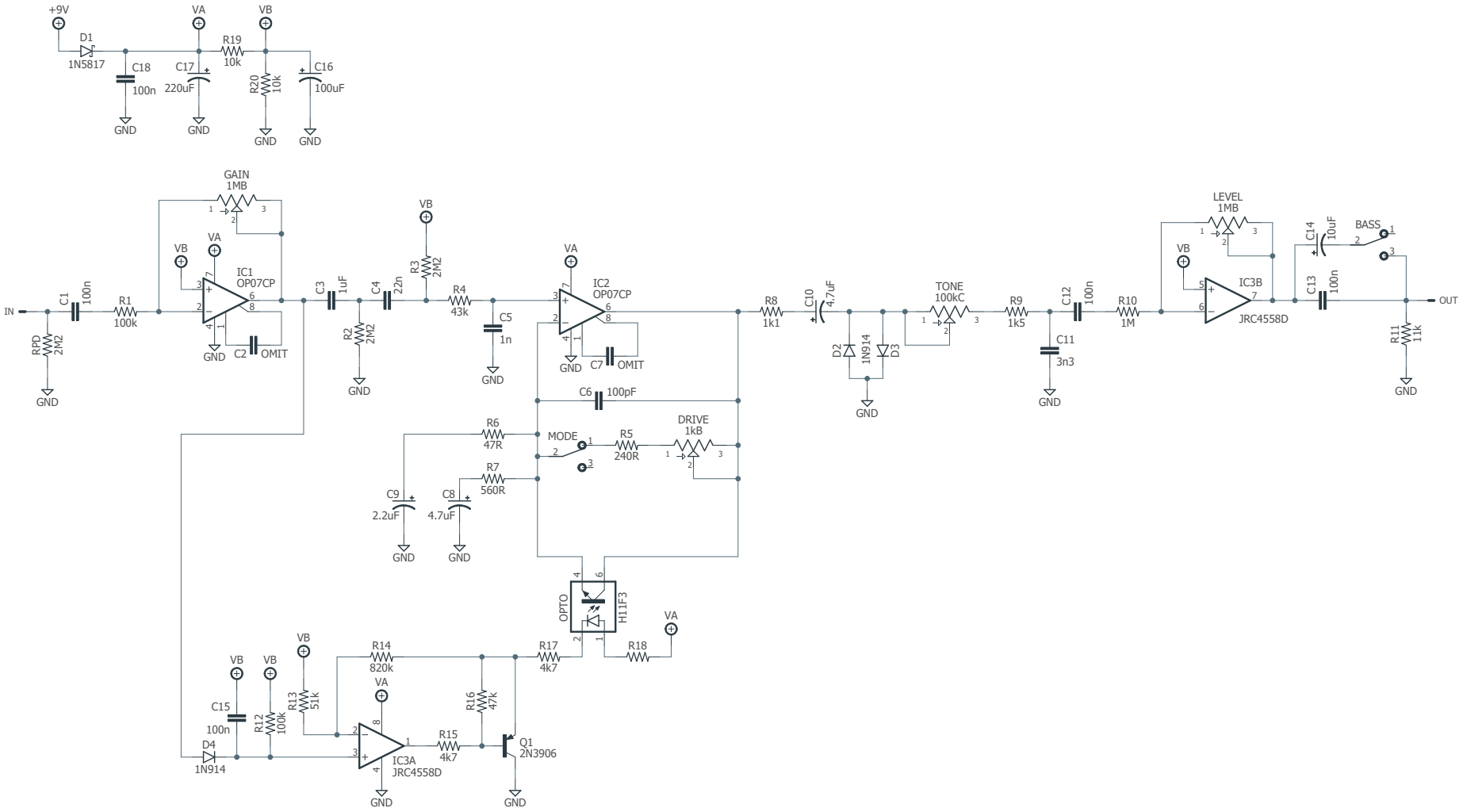
Drive knob

The original Expandora had a set of DIP switches that selected between three different fixed resistances in parallel with the optocoupler, plus a fourth to engage "Forbidden mode" by removing the parallel resistors and using the optocoupler to control the gain directly.

In version 4, this was converted into a potentiometer called "Drive" along with a minimum-value resistor. This is a significant improvement in usability, so we've back-ported this change to our version of the circuit, which is otherwise largely based on V3.

Using 240R for R5 (the minimum-value resistor) and a 1kB pot for the Drive control, the original three settings can be found at approximately 13% rotation (371 ohms), 32% rotation (560 ohms), and 86% rotation (1100 ohms). It can go slightly lower and higher than the stock range, as well as having all the in-between settings that were otherwise unavailable.

SCHEMATIC


+9V
D1
1N5817
C18
100n
GND
VA
C17
220uF
GND
R19
10k
VB
R20
10k
GND
C16
100uF
GND
GAIN
1MB
VB
VA
IC1
OP07CP
C2
OMIT
GND
IN
C1
100n
R1
100k
RPD
2M2
GND
C3
1uF
C4
22n
R2
2M2
GND
VB
R3
2M2
R4
43k
C5
1n
GND
VA
IC2
OP07CP
C7
OMIT
GND
C6
100pF
R6
47R
MODE
R5
240R
DRIVE
1kB
R7
560R
C9
2.2uF
GND
C8
4.7uF
GND
OPTO
H11F3
VA
R8
1k1
C10
4.7uF
D2
1N914
D3
GND
TONE
100kC
R9
1k5
C11
3n3
GND
C12
100n
R10
1M
LEVEL
1MB
VB
IC3B
JRC4558D
C14
10uF
BASS
C13
100n
R11
11k
GND
OUT
VB
VB
VB
C15
100n
R12
100k
R13
51k
D4
1N914
VA
IC3A
JRC4558D
GND
R14
820k
R17
4k7
R18
R16
47k
R15
4k7
Q1
2N3906
GND

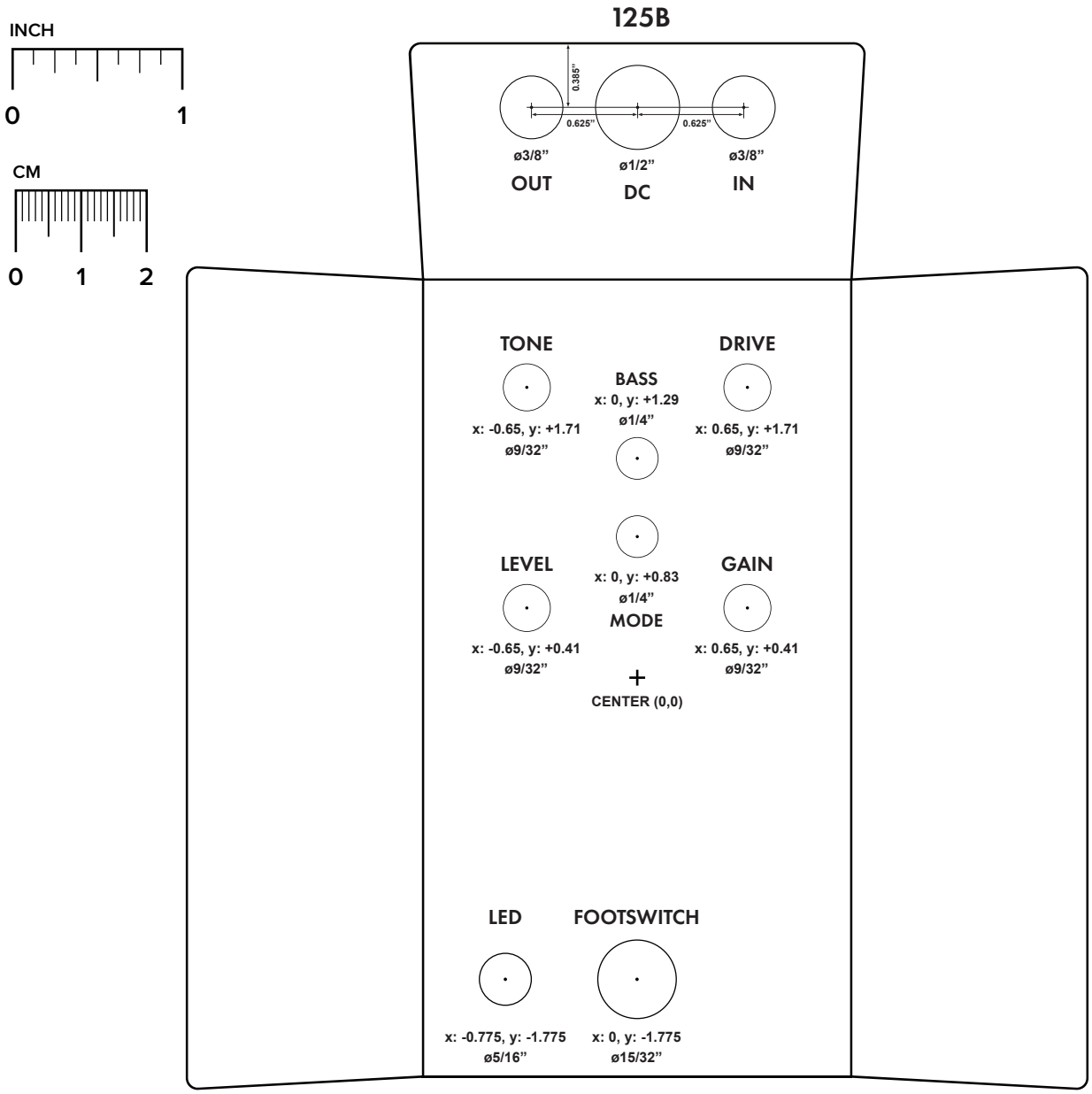
DRILL TEMPLATE

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.

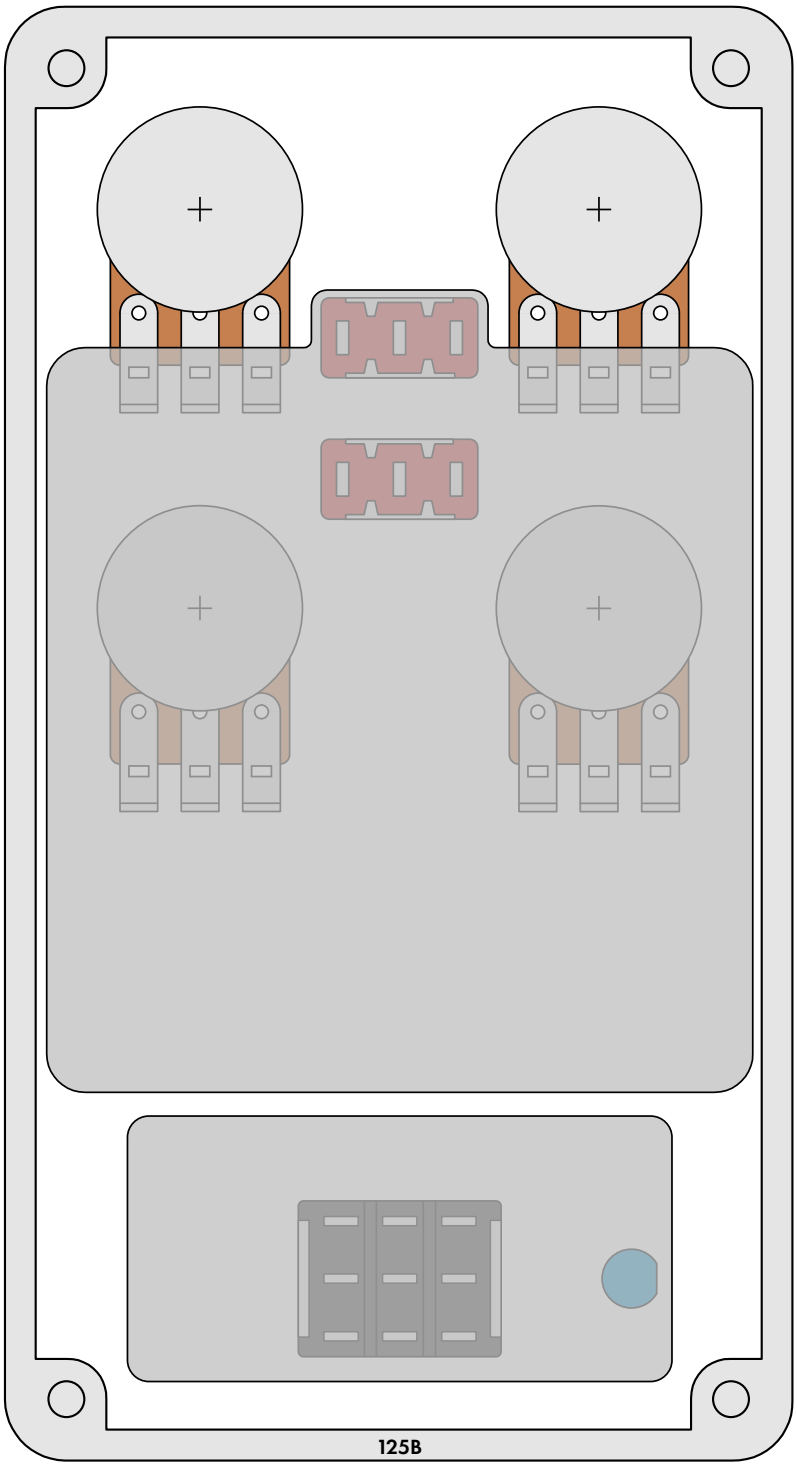
Top jack layout assumes the use of closed-frame jacks like the Switchcraft 111X. If you'd rather use open-frame jacks, please refer to the Open-Frame Jack Drill Template for the top side.

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.

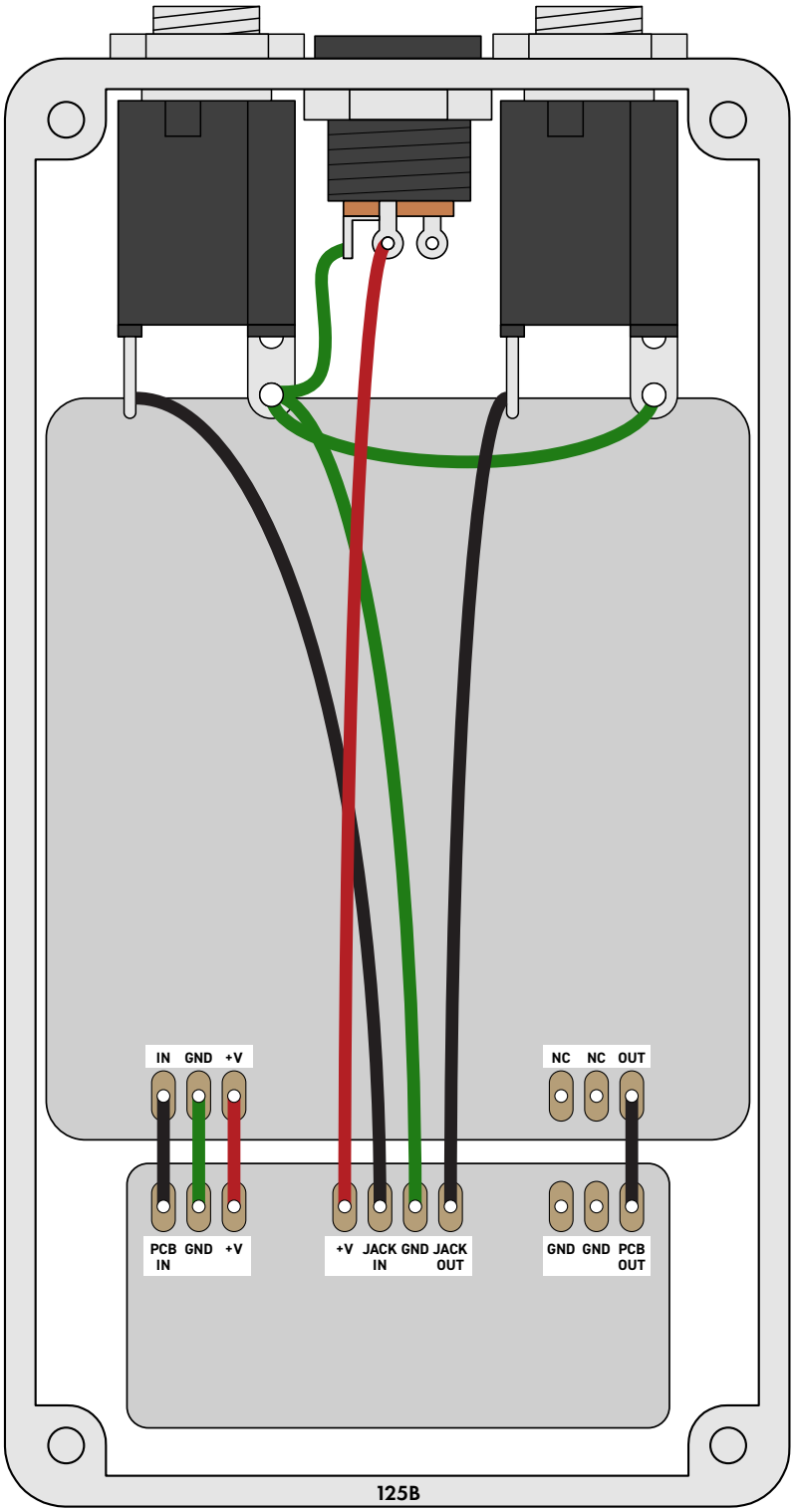


ENCLOSURE LAYOUT

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



WIRING DIAGRAM



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

1.0.0 (2023-07-04)
Initial release.