PROJECT NAME

LITHIUM

aion DIY GUITAR EFFECTS

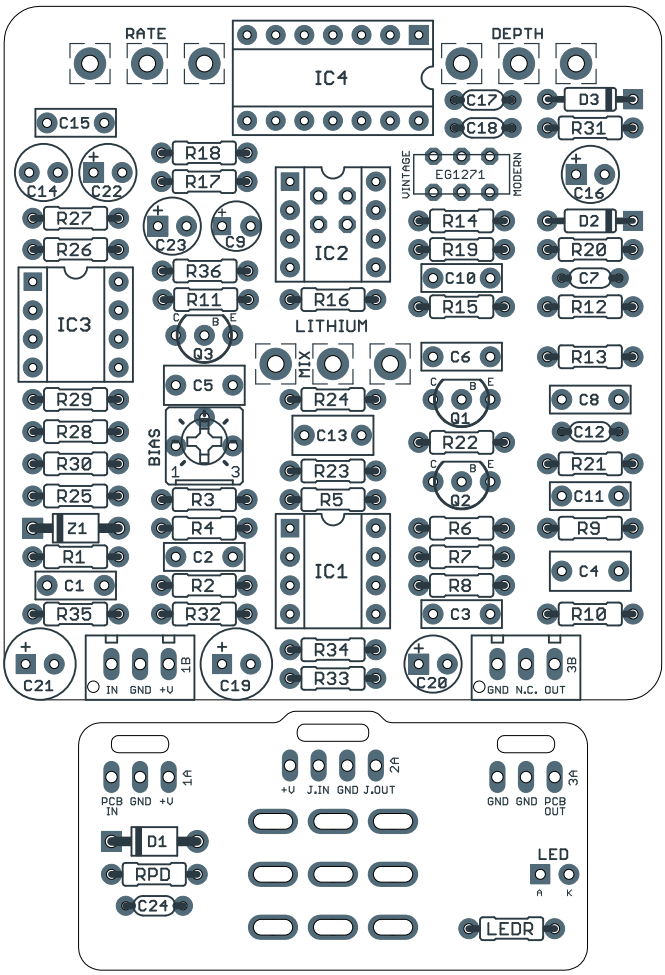
BASED ON
Electro-Harmonix® Small Clone

BUILD DIFFICULTY
Intermediate

EFFECT TYPE
Chorus

DOCUMENT VERSION
1.0.1 (2022-10-21)

PROJECT SUMMARY
An early BBD-based analog chorus most notably used by Kurt Cobain for much of *Nevermind*.



Actual size is 2.3” x 2.42” (main board) and 1.78” x 0.86” (bypass board).

TABLE OF CONTENTS

INTRODUCTION

The Lithium Analog Chorus is an adaptation of the Electro-Harmonix Small Stone chorus pedal, originally released in 1979 and produced up until Electro-Harmonix closed down in 1983. It was a more compact alternative to the Clone Theory, in the same way that the Small Stone was a reduced-footprint successor to the Bad Stone.

The Small Clone was most famously used by Kurt Cobain on "Come As You Are" as well as several other tracks on *Nevermind*. It has also been used by Jonny Greenwood, The Edge and several others.

The Small Clone had two different variants, one using the extremely rare SAD1024 and the other using the MN3007. It's commonly thought that the SAD1024 version came first and the MN3007 replaced it—and the factory schematic would seem to support this, showing SAD1024 as the default and then including the MN3007 changes as a modification. However, based on date codes of production units, the SAD1024 wasn't seen until 1981 or possibly late 1980, while the MN3007 was used throughout the whole production run. Whatever the case, the MN3007 variant is far more common.

While it's often said that Kurt used the SAD1024 version, there is no definitive proof of this that we have seen . It's statistically much more likely that his was the MN3007 one.

The Small Clone was reissued in the early 2000s, still using the MN3007 BBD but with a few small circuit changes that cause it to sound different. The overall schematic is pretty well identical, though, so the reissues can be easily modified to vintage specs.

The Lithium is an expanded adaptation of the MN3007 Small Clone, with the addition of a Depth control (converted from a switch) and a Mix control. If you want to read more on the changes, the build notes are extensive, so there are plenty of details for the curious.

USAGE

The Lithium has three controls:

- **Rate** sets the speed of the chorus effect.
- **Depth** sets the intensity of the chorus effect. This was a 2-position slide switch on the original, but the potentiometer allows for much more flexibility.
- **Mix** sets the volume level of the wet signal, allowing it to be dialed back for a milder effect. The dry signal is unaffected and always unity gain.

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	220k	Metal film resistor, 1/4W	
R2	1k	Metal film resistor, 1/4W	
R3	33k	Metal film resistor, 1/4W	
R4	6k8	Metal film resistor, 1/4W	
R5	22k	Metal film resistor, 1/4W	
R6	10k	Metal film resistor, 1/4W	
R7	33k	Metal film resistor, 1/4W	
R8	6k8	Metal film resistor, 1/4W	
R9	1k	Metal film resistor, 1/4W	
R10	100k	Metal film resistor, 1/4W	
R11	3k3	Metal film resistor, 1/4W	
R12	10k	Metal film resistor, 1/4W	
R13	10k	Metal film resistor, 1/4W	
R14	12k	Metal film resistor, 1/4W	
R15	33k	Metal film resistor, 1/4W	
R16	JUMPER	Metal film resistor, 1/4W	Use 1k for MN3207 version. See build notes.
R17	OMIT	Metal film resistor, 1/4W	Use 14k for MN3207 version. See build notes.
R18	39k	Metal film resistor, 1/4W	
R19	10k	Metal film resistor, 1/4W	
R20	39k	Metal film resistor, 1/4W	
R21	39k	Metal film resistor, 1/4W	
R22	10k	Metal film resistor, 1/4W	
R23	220k	Metal film resistor, 1/4W	
R24	20k	Metal film resistor, 1/4W	
R25	180k	Metal film resistor, 1/4W	
R26	47k	Metal film resistor, 1/4W	
R27	120k	Metal film resistor, 1/4W	
R28	470k	Metal film resistor, 1/4W	
R29	68k	Metal film resistor, 1/4W	
R30	82k	Metal film resistor, 1/4W	
R31	39k	Metal film resistor, 1/4W	
R32	47R	Metal film resistor, 1/4W	

PARTS LIST, CONT.

PART	VALUE	TYPE	NOTES
R33	56k	Metal film resistor, 1/4W	
R34	56k	Metal film resistor, 1/4W	
R35	47R	Metal film resistor, 1/4W	
R36	10k	Metal film resistor, 1/4W	
RPD	2M2	Metal film resistor, 1/4W	Input pull-down resistor. Can be as low as 1M.
LEDR	4k7	Metal film resistor, 1/4W	LED current-limiting resistor. Adjust value to change LED brightness.
C1	33n	Film capacitor, 7.2 x 2.5mm	
C2	10n	Film capacitor, 7.2 x 2.5mm	
C3	10n	Film capacitor, 7.2 x 2.5mm	
C4	1uF	Film capacitor, 7.2 x 3.5mm	
C5	1uF	Film capacitor, 7.2 x 3.5mm	
C6	3n3	Film capacitor, 7.2 x 2.5mm	
C7	470pF	MLCC capacitor, NP0/C0G	
C8	15n	Film capacitor, 7.2 x 2.5mm	
C9	OMIT		Use 4.7uF tantalum for MN3207 version. See build notes.
C10	4n7	Film capacitor, 7.2 x 2.5mm	
C11	2n7	Film capacitor, 7.2 x 2.5mm	
C12	180pF	MLCC capacitor, NP0/C0G	
C13	1uF	Film capacitor, 7.2 x 3.5mm	
C14	2.2uF bipolar	Electrolytic capacitor, 5mm	See build notes for other options.
C15	47n	Film capacitor, 7.2 x 2.5mm	
C16	10uF	Electrolytic capacitor, 5mm	
C17	100pF	MLCC capacitor, NP0/C0G	
C18	47pF	MLCC capacitor, NP0/C0G	
C19	220uF	Electrolytic capacitor, 6.3mm	
C20	47uF	Electrolytic capacitor, 5mm	
C21	220uF	Electrolytic capacitor, 6.3mm	
C22	10uF	Electrolytic capacitor, 5mm	
C23	10uF	Electrolytic capacitor, 5mm	
C24	100n	MLCC capacitor, X7R	
D1	1N5817	Schottky diode, DO-41	
D2	1N914	Fast-switching diode, DO-35	
D3	1N914	Fast-switching diode, DO-35	
Q1	2N5087	BJT transistor, PNP, TO-92	
Q2	2N5088	BJT transistor, NPN, TO-92	
Q3	2N5088	BJT transistor, NPN, TO-92	

PARTS LIST, CONT.

PART	VALUE	TYPE	NOTES
Z1	OMIT		Use 1N4739A if building MN3207 version. See build notes.
IC1	RC4558P	Operational amplifier, DIP-8	
IC1-S	DIP-8 socket	IC socket, DIP-8	
IC2	MN3007	BBD, 1024-stage, DIP-8	
IC2-S	DIP-8 socket	IC socket, DIP-8	
IC3	LM358N	Operational amplifier, DIP-8	
IC3-S	DIP-8 socket	IC socket, DIP-8	
IC4	CD4047BE	CMOS multivibrator, DIP-14	
IC4-S	DIP-14 socket	IC socket, DIP-14	
SW1	DPDT slide, micro	Slide switch, DPDT	E-Switch EG1271
BIAS	100k trimmer	Trimmer, 10%, 1/4"	Bourns 3362P
RATE	1MC	16mm right-angle PCB mount pot	
DEPTH	10kB	16mm right-angle PCB mount pot	
MIX	250kC	16mm right-angle PCB mount pot	
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

Setting the bias trimmer

As with other BBD choruses, the bias trimmer can be set by ear with no special equipment. Start in the center position, and adjust to the left or to the right until you hear a modulated chorus signal. Then, fine-tune it while listening for distortion or other audible artifacts and adjust the trimmer until these are eliminated or minimized.

You can also connect an oscilloscope to pin 7 or 8 of the BBD and use the scope reading to adjust for a symmetrical waveform with equal clipping on the top and bottom. Use a signal generator to send an 8kHz sine wave at 2V p-p as a test signal. This is far higher in amplitude than what the BBD would see in normal operation, but the heavy clipping allows for optimal adjustment.

MN3007 and MN3207 usage

The original Small Clone uses the MN3007 BBD. This BBD is long out of production, but the Xvive reissues sound just as good and are highly recommended.

The MN3207 replaced the MN3007 in the late 1980s, optimized for lower voltages down to 5V but with a maximum voltage of 10V. Today, old-stock 3207s are significantly cheaper than old-stock MN3007s, and the Coolaudio reissues (v3207) are also significantly cheaper than the Xvive MN3007 reissues, so it's an attractive option.

Importantly, though, the 3207 runs on opposite polarity, so in order for the MN3207 to replace the MN3007, the supply voltage and ground need to be reversed for the chip.

Some choruses such as the Boss CE-2 can be easily converted to using the MN3207 by setting a few jumpers to invert the polarity, as in our Azure project. We have experimentally included the same standard MN3007/MN3207 conversion jumpers on the Lithium PCB, although it should be stressed that **we have not tested this** and it may be wildly deficient for this circuit. It's possible that the input biasing network (bias trimmer through R14) would need additional changes in order to work properly.

Therefore, **only attempt a MN3207 conversion if you know what you're doing**. If we hear reports of success, then we'll revise the build notes with more confident advice, but for now we are adding a strong disclaimer to any deviation from the base MN3007 circuit.

Setting the jumpers

Underneath IC2, there are four jumper pads arranged in a square pattern. The MN3007 and MN3207 have their positive and negative supply pins inverted from each other, so the jumpers need to be set to route the supply voltages to the correct pins.

The underside of the PCB has a legend on the silkscreen showing which way the jumpers should be soldered. If using a MN3007, both jumpers should be installed horizontally. If using a MN3207 or v3207, the jumpers should go vertically. If you don't solder these jumpers, there will be no wet signal at all.

If using a MN3207, make sure to use 1N4739A (9.1V zener) for Z1 to limit the BBD's supply voltage to 9V. If using a MN3007, this zener can be omitted since the maximum supply voltage is 15V.

V_{GG} voltage

BBDs typically require pin 4 (V_{GG}) to be supplied with a voltage that is 14/15ths of the supply voltage (V_{DD}) for best performance. This V_{GG} voltage is intended to be supplied by the MN300X series' companion clock chip, the MN3101.

The Small Clone does not use the MN3101, but instead uses a CD4047 to generate the clock signal. Electro-Harmonix did not implement an external 14/15 voltage divider, instead connecting the V_{GG} pin to the V_{DD} supply voltage, and the circuit seems to perform just fine without it.

However, we've heard anecdotally that the MN3207 is more sensitive to the 14/15 voltage than the MN3007, so it may be the case that the MN3207 requires this 14/15 network where the MN3007 does not. It may also be the case that the performance of the MN3007 in the stock circuit could be improved with this network, so you could try using it even with the MN3007—though whether it will affect the character of the effect, we don't know.

Either way, if you want to use the 14/15 V_{GG} network, use **1k** for R16, **14k** for R17, and a **4.7uF** or **10uF** tantalum capacitor for C9.

To build the stock circuit, **omit C9 and R17** (in other words, leave them empty) and **jumper R16**.

Mix knob

The original Small Clone had a fixed proportion of dry and wet signals mixed in the last op-amp stage. We've added a Mix knob that allows the wet signal to be dialed back.

The vintage Small Clone used a 27k resistor for R24, while the 2002 reissue reduced this to 20k, resulting in a more prominent wet mix. Due to the addition of the Mix knob, it's recommended to always use the modern value of 20k since the mix knob directly adds to this fixed resistance value. Therefore, to get the "vintage" value of 27k, just turn the mix knob down about 10-15%. With the mix knob at full rotation, it's equivalent to the "modern" value of 20k.

Depth knob

The original Small Clone only had a 2-position depth switch to change the intensity of the chorus sound. We've converted this to a potentiometer that allows fine-tuning the depth across the whole range and beyond, instead of being stuck with two presets.

Vintage/Modern slide switch

The original Small Clone used a 100pF timing capacitor for the clock, while the reissue uses 150pF. This changes the delay range somewhat, but even adjusting the rate to compensate, the tone is a little different. We've included the vintage 100pf capacitor as the default, as well as a 47pF capacitor that can be switched in parallel using an on-board slide switch. If you don't care to have the modern value available, you can omit C18 and the slide switch (no jumpers needed) and just use C17.

Note that the modern Small Clones also change R8 to 9k1 to add back some of the brightness that is lost by the capacitor change. This is sort of a hack on EHX's part since it puts the pre/de-emphasis filters

out of balance, but if you prefer the modern mode and find that it lacks some brightness, you could try changing out this resistor.

Thanks to Dana for detailed insight into the differences between the vintage and modern versions.

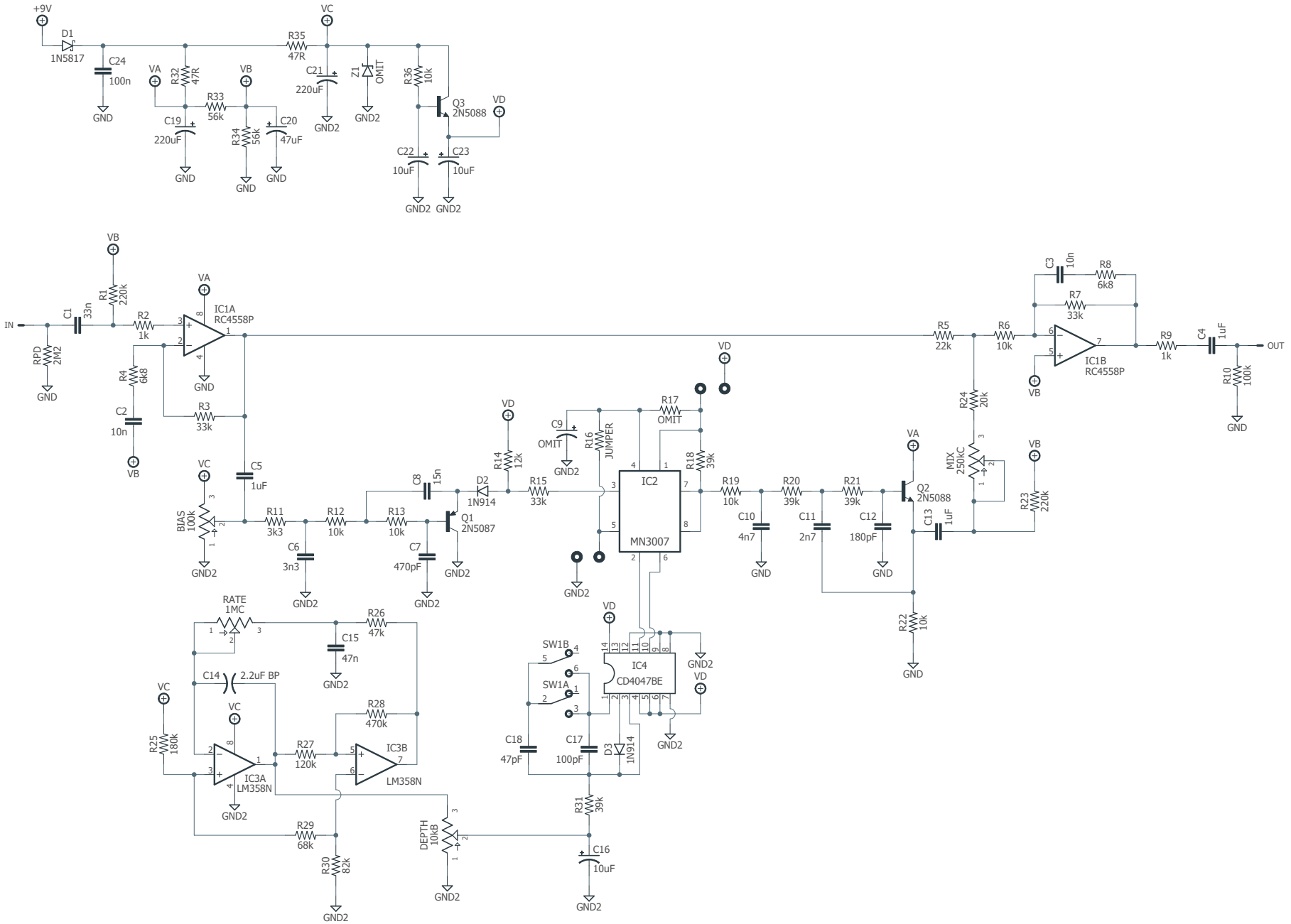
C14 bipolar capacitor

In the original Small Clone, C14 (the LFO timing capacitor) is a polarized 2.2uF tantalum capacitor. Theoretically, this type of capacitor should be bipolar since the voltages are not reliably higher or lower on either side, so we've specified a bipolar type in the parts list.

If you can't find one, you can follow EHX's lead and just use a polarized electrolytic with the positive side going to the left pad (the same orientation as C22 next to it). There are 40-year-old Small Clones that are still working just fine, so it can't be too critical of an issue.

You can also use two 4.7uF electrolytic capacitors wired in series, with the negative legs going to the pads of C14 and the positive legs tied together. This will give an effective capacitance of 2.35uF, which is well within tolerance.

SCHEMATIC


+9V
D1
1N5817
C24
100n
GND
VA
R32
47R
R33
56k
C19
220uF
VB
R34
56k
C20
47uF
VC
R35
47R
C21
220uF
GND2
Z1
OMIT
R36
10k
Q3
2N5088
VD
C22
10uF
C23
10uF
IN
C1
33n
R1
220k
R2
1k
RPD
2M2
R4
6k8
C2
10n
R3
33k
IC1A
RC4558P
C5
1uF
BIAS
100k
R11
3k3
R12
10k
R13
10k
C6
3n3
C7
470pF
C8
15n
D2
1N914
Q1
2N5087
R14
12k
R15
33k
C9
OMIT
R16
JUMPER
R17
OMIT
R18
39k
IC2
MN3007
R19
10k
C10
4n7
R20
39k
C11
2n7
R21
39k
C12
180pF
Q2
2N5088
C13
1uF
MIX
250kC
R23
220k
R24
20k
R5
22k
R6
10k
C3
10n
R8
6k8
R7
33k
IC1B
RC4558P
R9
1k
C4
1uF
OUT
R10
100k
R22
10k
RATE
1MC
R26
47k
C15
47n
C14
2.2uF BP
R28
470k
R25
180k
R27
120k
IC3A
LM358N
IC3B
LM358N
R29
68k
R30
82k
DEPTH
10kB
R31
39k
C16
10uF
SW1B
SW1A
IC4
CD4047BE
C18
47pF
C17
100pF
D3
1N914

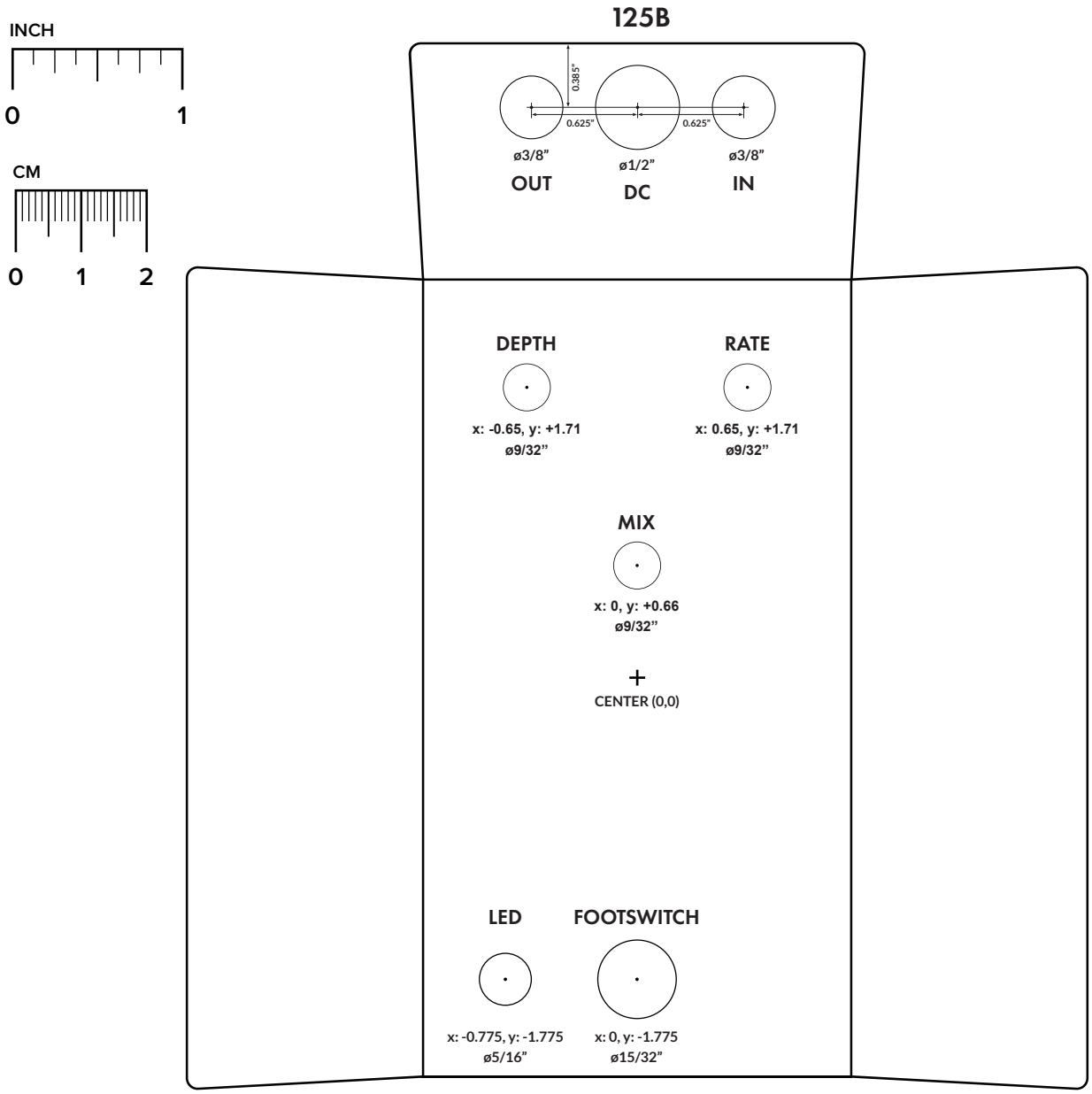
DRILL TEMPLATE

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.

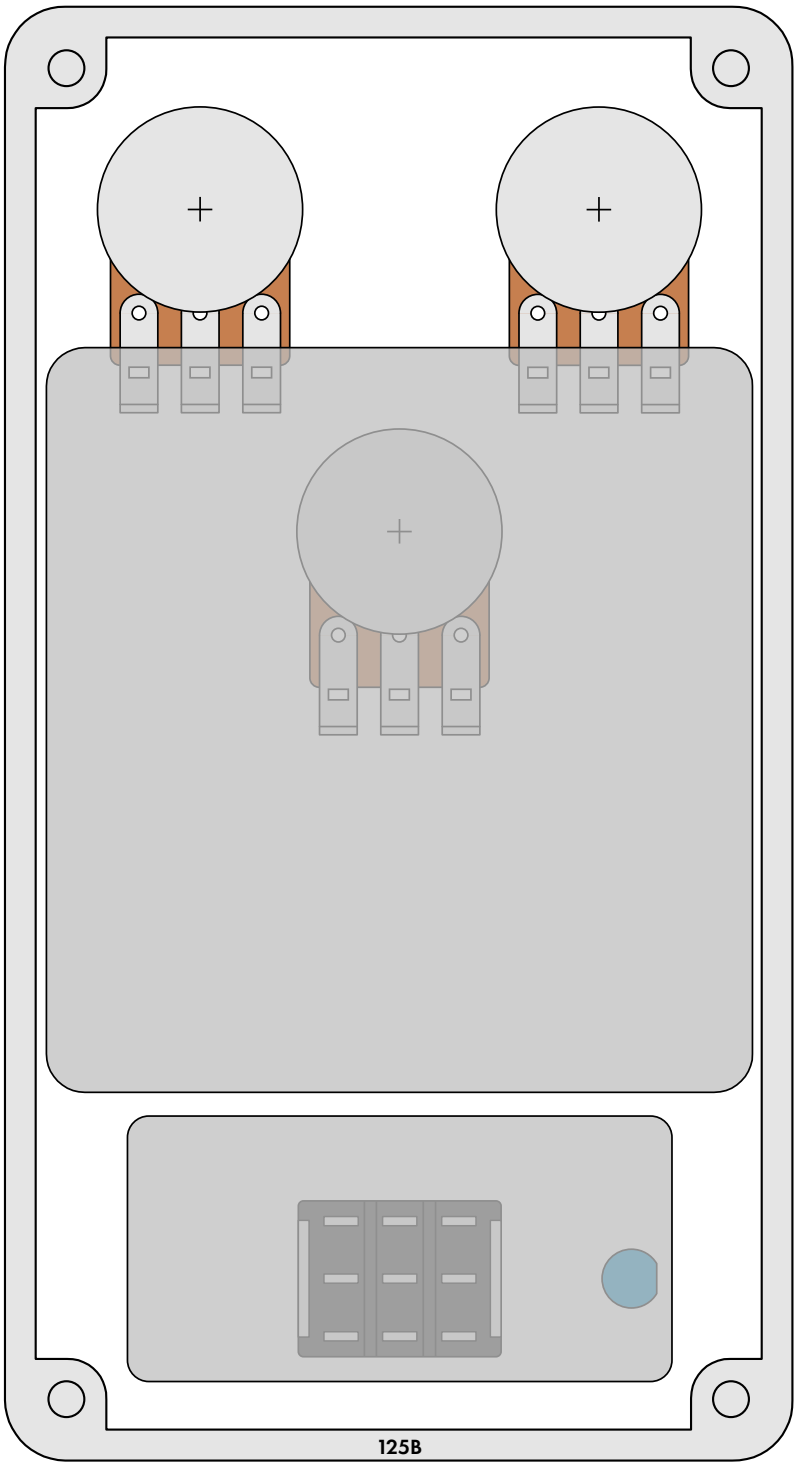
Top jack layout assumes the use of closed-frame jacks like the Switchcraft 111X. If you'd rather use open-frame jacks, please refer to the Open-Frame Jack Drill Template for the top side.

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.

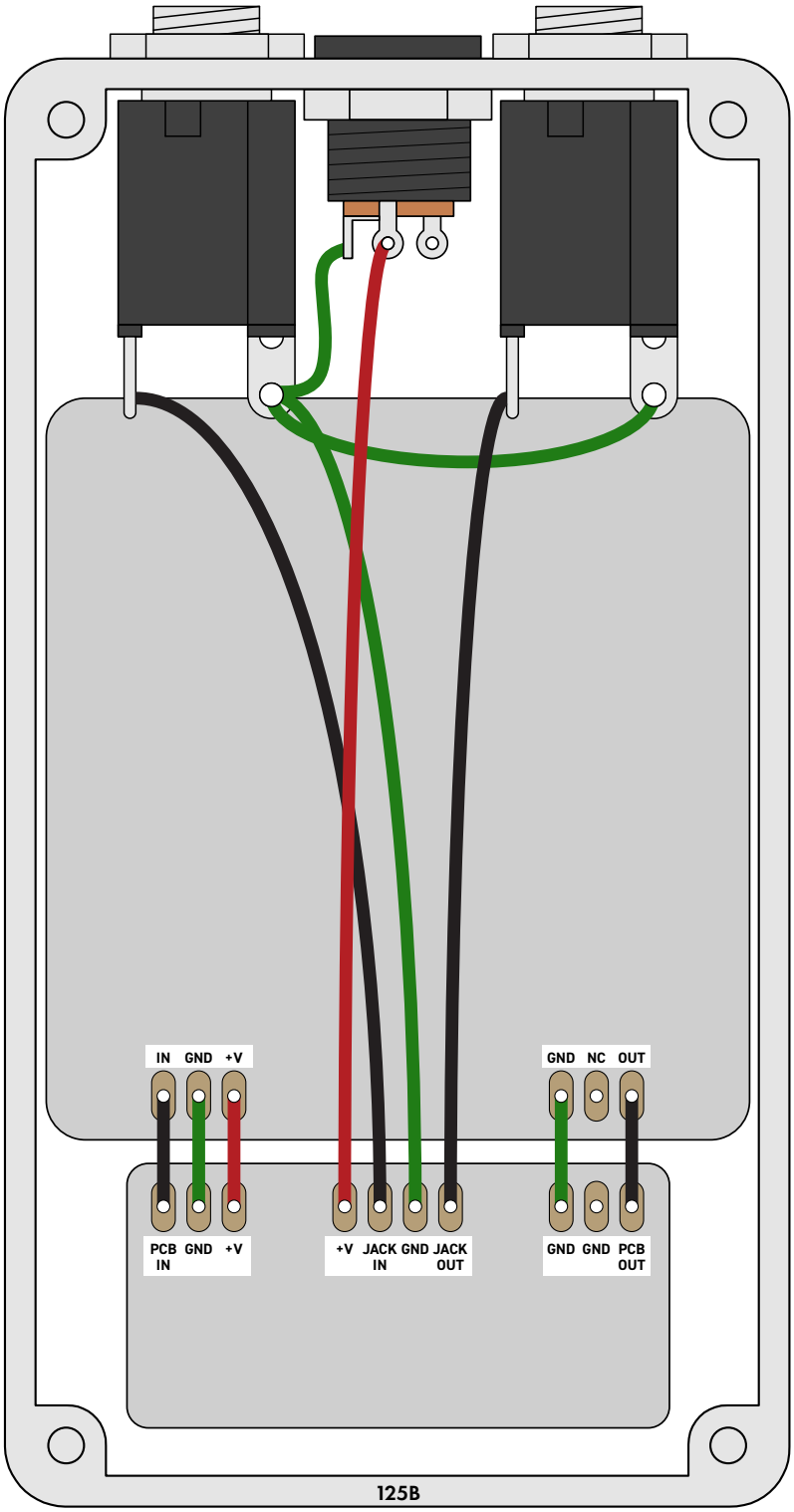


ENCLOSURE LAYOUT

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

1.0.1 (2022-10-21)
Changed recommendation for IC3 to LM358 as used in the original. The TL022 is usually an upgrade for LFOs, but in this circuit it seems to sometimes cause issues with the travel of the Depth pot.

1.0.0 (2022-09-24)
Initial release—and incidentally, the 31st anniversary of the release of *Nevermind*.