

PROJECT NAME

# L5 PREAMP CLEAN CHANNEL



BASED ON

Lab Series® L5 (Channel 1)

BUILD DIFFICULTY



EFFECT TYPE

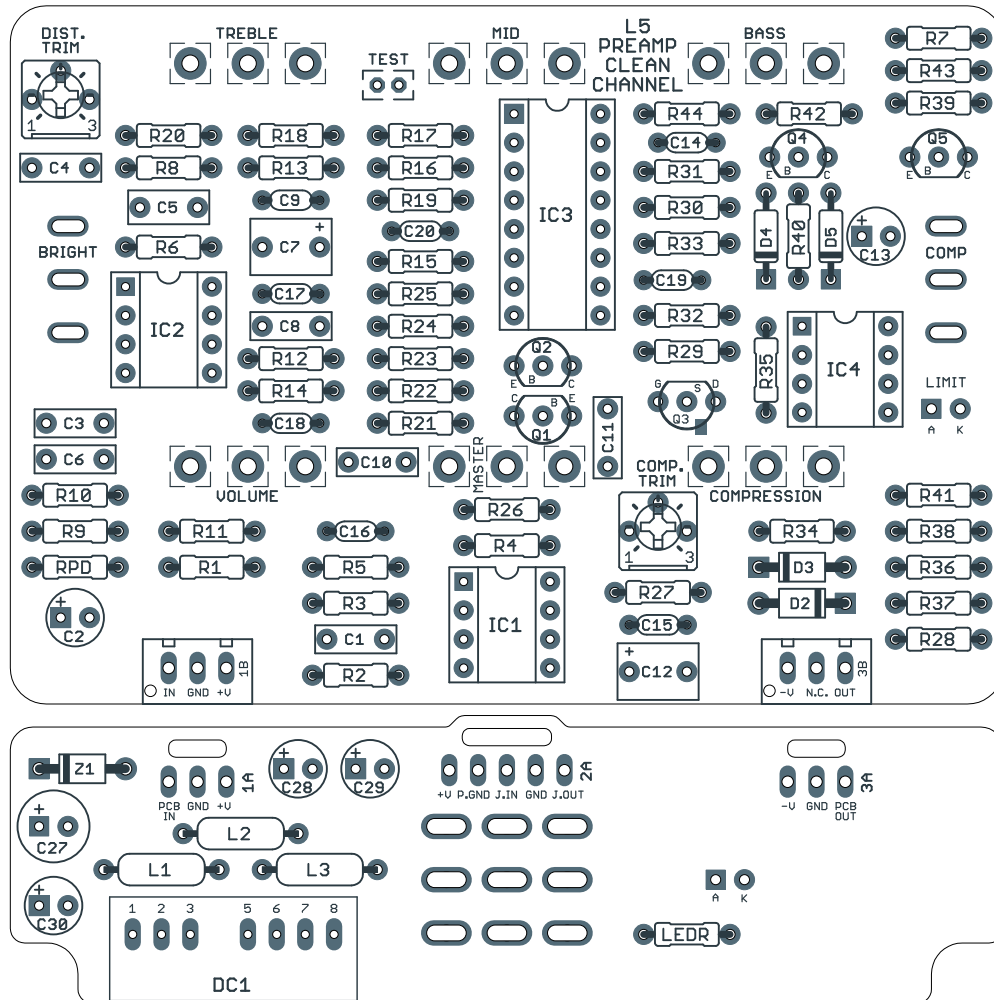
Preamp & overdrive

DOCUMENT VERSION

1.0.0 (2022-11-25)

## PROJECT SUMMARY

A pedal adaptation of the first channel of the Lab Series® L5 amplifier from the late 1970s, often considered to be the best solid-state amp ever designed.



Actual size is 3.44" x 2.42" (main board) and 3.44" x 0.97" (bypass board).

# TABLE OF CONTENTS

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1	Project Overview	12	Drill Template
2	Introduction	13	Enclosure Layout
3	Usage & Circuit Design Notes	14	Wiring Diagram
4-7	Parts List	15	Licensing
8-10	Build Notes	15	Document Revisions
11	Schematic		

## INTRODUCTION

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The L5 Preamp Drive Channel is an adaptation of the second channel of the Lab Series® L5 amplifier, originally released in 1976 and discontinued in 1981.

The Lab Series L5 amp was designed to compete with the Fender Twin Reverb, and the first channel was specifically designed to be Fender-inspired. The passive tone stack is lifted directly from Fender, though with values scaled to match the lower impedance.

Players often refer to this first channel of the amp as the clean channel, and we've adopted this terminology, but it's more than capable of its own drive tones when cranked. We've included some optional modifications to extend the drive range and make it easier to get good overdriven tones, but it also responds really well to a boosted input signal, especially in conjunction with the built-in compressor to level out the dynamics at the tail end of the circuit.

Perhaps the most famous user of the L5's clean channel was BB King. (Ty Tabor also used these amps on the first four Kings X albums, but only the drive channel, for which we have a [different project](#).)

This project recreates the entire preamp signal path of the clean channel, including the OTA overdrive, compressor and master volume, and runs on the same +/-15V voltage as the original unit. The only change we've made is to convert the input stage from inverting to non-inverting. This reduces the noise, but the input impedance and frequency response are exactly the same as the original amp's "Lo" input (the higher-gain mode designed for guitar).

The drive channel is available as a separate project, and like this one, it recreates the entire signal path of the second channel. The full [L5 Preamp pedal](#) is still available.

## USAGE

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The L5 Preamp Clean Channel has the following controls:

- **Volume** controls the amount of gain in the first stage, before the EQ and drive section. **Bright** adds a treble-bleed capacitor to the volume control, which keeps it from getting dull at lower volumes.
- **Treble, Mid** and **Bass** form a standard Fender-style 3-band passive EQ.
- **Master** sets the output volume after the drive section of the preamp.
- **Comp Level** sets the threshold of the compressor at the end of the circuit. This compressor can be disengaged using the **Comp** toggle switch.

## CIRCUIT DESIGN NOTES

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### Power supply design

Like most solid-state preamplifiers of the era, the L5 operated on a bipolar +/-15V supply. This voltage can't be supplied by an external adapter, and the current draw of the circuit is too high to use a charge pump.

When developing the original [Lab Series L5 Preamp](#), we adapted a supply scheme from Alesis rack units in the early 1990s that involved a 9VAC adapter and an AC voltage tripler. This was then rectified to bipolar +/-19V DC and regulated down to 15V on each rail.

This solution used cheap and readily-available parts, and it has worked very well for several years since the L5 Preamp was first developed. But the power adapter requirement has always been the major flaw. A 9VAC adapter will destroy most other pedals if it's plugged in, and if you own one, there's an infinitely higher chance that it'll be mistaken for a 9VDC adapter and plugged into the wrong pedal at some point.

Because of this, when developing the [IVP Preamp](#) project in 2021, we set out to find a reliable way to supply +/-15V from a standard DC adapter. Fortunately, there are a few more options available today than there were in 2015 when the L5 Preamp was originally developed, and a high-quality DC-DC converter module will give us exactly what we need. They're not cheap (USD\$9-15 each), but once you account for the fact that you no longer need a specialized power adapter, the total cost is about the same. We have begun using these DC converters in all of our preamp projects going forward, including this new variant of the L5 that started it all.

See the build notes on page 8 for more information on the specific DC-DC converters that are recommended for use in this project.

## 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 (most 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	10k	Metal film resistor, 1/4W	
R2	220k	Metal film resistor, 1/4W	
R3	2k2	Metal film resistor, 1/4W	
R4	47k	Metal film resistor, 1/4W	
R5	1k	Metal film resistor, 1/4W	
R6	22k	Metal film resistor, 1/4W	
R7	5k1	Metal film resistor, 1/4W	Pot taper resistor. Omit if using a true 2.5kA for Mid. See build notes.
R8	220k	Metal film resistor, 1/4W	
R9	47k	Metal film resistor, 1/4W	Original value 18k. See build notes.
R10	10k	Metal film resistor, 1/4W	
R11	2k7	Metal film resistor, 1/4W	Pot taper resistor. Omit if using a true 2.5kA for Volume.
R12	1k	Metal film resistor, 1/4W	Pot taper resistor. Omit if using a true 2.5kA for Volume.
R13	6k8	Metal film resistor, 1/4W	
R14	10k	Metal film resistor, 1/4W	
R15	15k	Metal film resistor, 1/4W	
R16	1k	Metal film resistor, 1/4W	
R17	6k8	Metal film resistor, 1/4W	
R18	33k	Metal film resistor, 1/4W	
R19	220R	Metal film resistor, 1/4W	
R20	10k	Metal film resistor, 1/4W	
R21	470k	Metal film resistor, 1/4W	
R22	2k	Metal film resistor, 1/4W	
R23	47k	Metal film resistor, 1/4W	
R24	3k3	Metal film resistor, 1/4W	
R25	330R	Metal film resistor, 1/4W	
R26	100k	Metal film resistor, 1/4W	
R27	6k8	Metal film resistor, 1/4W	
R28	2k7	Metal film resistor, 1/4W	
R29	15k	Metal film resistor, 1/4W	
R30	220R	Metal film resistor, 1/4W	

## PARTS LIST, CONT.

PART	VALUE	TYPE	NOTES
R31	220R	Metal film resistor, 1/4W	
R32	10M	Metal film resistor, 1/4W	
R33	820R	Metal film resistor, 1/4W	
R34	3k3	Metal film resistor, 1/4W	
R35	22k	Metal film resistor, 1/4W	
R36	33k	Metal film resistor, 1/4W	
R37	10k	Metal film resistor, 1/4W	
R38	10k	Metal film resistor, 1/4W	
R39	47k	Metal film resistor, 1/4W	
R40	47k	Film capacitor, 7.2 x 2.5mm	
R41	10k	MLCC capacitor, NP0/C0G	
R42	100k	Film capacitor, 7.2 x 2.5mm	
R43	100k	Film capacitor, 7.2 x 5mm	
R44	22k	Film capacitor, 7.2 x 2.5mm	
RPD	2M2	Film capacitor, 7.2 x 2.5mm	Input pulldown resistor. Can be as low as 1M.
LEDR	10k	Film capacitor, 7.2 x 5.5mm	LED current-limiting resistor. Adjust value to change LED brightness.
C1	8n2	Film capacitor, 7.2 x 2.5mm	
C2	22uF	Electrolytic capacitor, 5mm	
C3	10n	Film capacitor, 7.2 x 2.5mm	
C4	1n2	Film capacitor, 7.2 x 2.5mm	
C5	220n	Film capacitor, 7.2 x 2.5mm	
C6	47n	Film capacitor, 7.2 x 2.5mm	
C7	2.2uF	Film capacitor, 7.2 x 5mm	
C8	10n	Film capacitor, 7.2 x 2.5mm	
C9	220pF	MLCC capacitor, NP0/C0G	
C10	330n	Film capacitor, 7.2 x 2.5mm	
C11	68n	Film capacitor, 7.2 x 2.5mm	
C12	2.2uF	Film capacitor, 7.2 x 5mm	
C13	10uF	Electrolytic capacitor, 5mm	
C14	100pF	MLCC capacitor, NP0/C0G	
C15	10n	MLCC capacitor, X7R	Power supply filter capacitor.
C16	10n	MLCC capacitor, X7R	Power supply filter capacitor.
C17	10n	MLCC capacitor, X7R	Power supply filter capacitor.
C18	10n	MLCC capacitor, X7R	Power supply filter capacitor.
C19	10n	MLCC capacitor, X7R	Power supply filter capacitor.

## PARTS LIST, CONT.

PART	VALUE	TYPE	NOTES
C20	10n	MLCC capacitor, X7R	Power supply filter capacitor.
C21	100uF	Electrolytic capacitor, 6.3mm	Power supply filter capacitor.
C22	10uF	Electrolytic capacitor, 5mm	Power supply filter capacitor.
C23	10uF	Electrolytic capacitor, 5mm	Power supply filter capacitor.
C24	47uF	Electrolytic capacitor, 5mm	Power supply filter capacitor.
Z1	1N4743A	Zener diode, 13V, DO-41	
D2	1N4004	Rectifier diode, DO-41	
D3	1N4004	Rectifier diode, DO-41	
D4	1N914	Fast-switching diode, DO-35	
D5	1N914	Fast-switching diode, DO-35	
Q1	2N3904	BJT transistor, NPN, TO-92	
Q2	2N3904	BJT transistor, NPN, TO-92	
Q3	2N5457	JFET, N-channel, TO-92	Substitute. Original uses 2N4303 (PN4303).
Q4	2N3906	BJT transistor, PNP, TO-92	
Q5	MPSA13	Darlington BJT, NPN, TO-92	
L1	10uH	Inductor, 10uH	Bourns 78F100J-RC
L2	10uH	Inductor, 10uH	Bourns 78F100J-RC
L3	10uH	Inductor, 10uH	Bourns 78F100J-RC
DC1	TEC 3-0923	DC-DC converter, +9V to +/-15V	See build notes for alternatives.
IC1	LF356N	Operational amplifier, DIP8	
IC1-S	DIP-8 socket	IC socket, DIP-8	
IC2	RC4558P	Operational amplifier, DIP8	
IC2-S	DIP-8 socket	IC socket, DIP-8	
IC3	LM13700N	Transconductance amplifier, dual, DIP16	
IC3-S	DIP-8 socket	IC socket, DIP-8	
IC4	RC4558P	Operational amplifier, DIP8	
IC4-S	DIP-8 socket	IC socket, DIP-8	
COMP. TRIM	20k trimmer	Trimmer, 10%, 1/4"	
DIST. TRIM	20k trimmer	Trimmer, 10%, 1/4"	

## PARTS LIST, CONT.

PART	VALUE	TYPE	NOTES
VOLUME	10kB	16mm pot, right angle	Original value is 2.5kA. See build notes.
TREBLE	25kB	16mm pot, right angle	
MID	5kA	16mm pot, right angle	Original value is 2.5kA. See build notes.
BASS	25kB	16mm dual pot, right angle	
MASTER	25kA	16mm pot, right angle	
COMP. LEVEL	50kC	16mm pot, right angle	
BRIGHT	SPDT	Toggle switch, SPDT on-on	
COMP	SPDT	Toggle switch, SPDT on-on	
LED	5mm	LED, 5mm, red diffused	
LIMIT	3mm	LED, 3mm, red diffused	
DC	2.1mm	DC jack, 2.1mm panel mount	Mouser 163-4302-E or equivalent.
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.
BYPASS	3PDT	Stomp switch, 3PDT	
ENCLOSURE	1590BBS	Enclosure, die-cast aluminum	

## BUILD NOTES

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### DC converter selection

There are several brands and models available, all with the same pinout and similar specifications. Here are the DC converters we've found that will work in this circuit.

BRAND	PART #	MOUSER #	SUPPLY	NOTES
Traco	TEC 2-0923	495-TEC2-0923	4.5-13.2V	Preferred option. More sources on <a href="#">Octopart</a> .
CUI	PQMC3-D12-D15-S	490-PQMC3-D12-D15-S	9-18V	
XP Power	IZ1215S	209-IZ1215S	9-18V	
Recom	RS-1215D	919-RS-1215D	9-18V	
Recom	RS3-1215D	919-RS3-1215D	9-18V	
Mornsun	WRA1215S-3WR2	N/A	9-18V	NAC Semi: <a href="https://aionfx.com/link/mornsun/">https://aionfx.com/link/mornsun/</a>

The Traco TEC 2-0923 is preferred for this circuit because its supply voltage range (4.5V to 13.2V) is perfectly suited for any type of pedal power supply. The TEC 3-0923 can also be used if you can't find the 2-0923. It has higher current handling, more than necessary for this circuit, and as a result it is more expensive, but it's otherwise identical.

The other brands all have a minimum supply voltage of 9V. Most nominally 9VDC adapters put out around 9.6V, which is more than enough—but one very notable exception is the Voodoo Labs Pedal Power series (and likely other similar pedalboard supplies) which regulate to exactly 9.00V.

These DC converter modules are usually specced very conservatively, so it's very unlikely that there would be any issues even if the supply voltage was slightly lower than 9V. However, operating on the extreme lower end of a spec is not ideal from an engineering standpoint, so if we're going to point you to a specific module, it's going to be the one that works reliably in all use cases.

If you are using a standard wall-wart supply that puts out more than 9V, then all this is immaterial and any of the five units listed above will work the same. All significant specifications are the same aside from this input voltage range. We haven't tried all of them directly, but their datasheets indicate they will perform identically and they have the same pinout and physical dimensions.

This is fortunate, because most suppliers don't stock more than 20 or 30 of each type at a time. So while we recommend the Traco TEC 2-0923 as the best overall, it will likely not always be in stock, especially as we release more preamp projects with converters and more people are using them.

If you're having a hard time finding any that will work, try searching [Octopart](#) for the part number shown in the Part # column. Most of these brands are also carried by Digi-Key, Newark, and several other suppliers, and this engine will search all of the major distributors at once for easier sourcing.

The Mornsun unit is not available from Mouser, but it's included here because it's cheaper than the others (USD\$8.22 as of the time of this writing) with the exact same specs. If you need more than one, it quickly becomes much more cost-effective than the other options.



## BUILD NOTES, CONT.

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### Calibration

The L5 Preamp has two different calibration trimmers. To set these, all you will need is a multimeter and a signal generator (which can be a computer or smartphone).

Note that all voltages are taken in AC, not DC, since we are dealing with audio signal levels. The voltages are also all RMS rather than p-p, so confirm that your multimeter measures RMS if you're not sure. Before you start, turn both trimmers all the way down.

### Distortion trimmer

The distortion trimmer should be set first. This sets the level at which the overdrive kicks in. The procedure calls for a 1kHz 30mV sine wave to be inserted onto pin 4 of IC3, and for the trimmer to be adjusted until you measure **4.4V** on pin 5 of IC3.

For convenience, there is a pair of pads marked "TEST" right underneath the "Frequency" potentiometer's pads where you can insert your signal. The "+" pad connects to pin 4 of IC3 and the other is connected to ground. It's recommended to solder short pins to these pads (about 3/4" in length) to act as 'posts' for alligator clips to attach to. (The clipped leads from a 1N4004 diode work well for this since they are more rigid than normal component leads.)

If you don't have a signal generator, look for a smartphone or Mac/PC app that allows selection of wave type, frequency and gain level. These come and go, so we can't recommend anything specific, but there are several free ones available at any given time and they all do the same basic thing.

From here, hook up a 3.5mm male-to-male headphone cable and turned up the phone or computer volume to maximum, then set the frequency to 1kHz and the wave type to sine. Using a multimeter set to AC millivolt mode, adjust the volume in the app until you read 30mV. (Don't rely on the app to tell you the output signal level; they have no way of knowing the actual real-world level.)

Now, use alligator clips to connect the sleeve and the tip of the headphone cable to the two wires coming from the test pad. Since it's AC, the polarity does not matter. This will insert the signal to pin 4 of IC3 so you can adjust the trimmer as specified earlier, targeting 4.4V on pin 5.

Once you know the correct factory setting, feel free to adjust the trimmer up or down and see if you prefer it in any other position (but consider first marking the trimmer with a Sharpie so you can get back to the calibrated setting). Since this is a pedal adaptation, you may find it worthwhile to adjust the distortion so it comes on earlier than it did in the original amps.

### Compressor/limiter trimmer

With the 30mV sine wave signal still inserted into pin 4 of IC3, turn the master volume up all the way and turn the compressor on (switch in the "up" position). Then turn the compressor knob up to about 2:00 (2/3 of the way up) and touch your probe to the "PCB OUT" pad on the right side of the footswitch board. Turn the trimmer until you measure **1.17VAC**.

This will get you in the range of the original amps. If you're using the L5 primarily as a pedal, you may want to set this lower so it's more sensitive to lower-level signals.

## BUILD NOTES, CONT.

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### Gain boost tweaks

On the original L5 amps, the two channels are somewhat unbalanced with each other. The amp had no built-in channel switching, so you wouldn't notice this in normal usage—but when adapting the circuit to a pedal, it's very apparent that the maximum volume coming out of the first channel is a great deal lower than the second channel, meaning it has much less potential for overdriving the OTA.

We recommend increasing the value of R9 to **47k** (originally 18k) which will triple the gain of the recovery stage after the passive tone stack.

### Potentiometer values

The clean channel of the L5 Preamp uses two 2.5kA potentiometers, which are nearly impossible to find these days. For the Mid pot, we can easily drop down from a more common 5kA potentiometer using a resistor in parallel. R7 has been included for this purpose and should be 5k1 if using a 5kA pot.

If you can't find a 5kA pot, you can also use a more common 10kA pot along with a 3.3k resistor for R7 to get the same result, though the taper will be a little steeper.

The Volume pot, on the other hand, is wired as a true potentiometer, which means that we have to use two tapering resistors to get the same effect. R11 and R12 have been included for this purpose, and with the provided values, they will simulate an audio taper while also dropping the effective value to 2.5k.

R7, R11 and R12 can be omitted if using true 2.5kA potentiometers for Mid and Volume.

### LM13700 vs. CA3080

The original L5 Preamp used CA3080s as in the original amp. These have been discontinued for a long time, and while they have been reissued and are not terribly hard to find, they are expensive.

The LM13700 is essentially a dual version of the CA3080/CA3094 and is still readily available. Since the L5 circuit uses two CA3080s, it seemed like a good opportunity to replace them with a single LM13700.

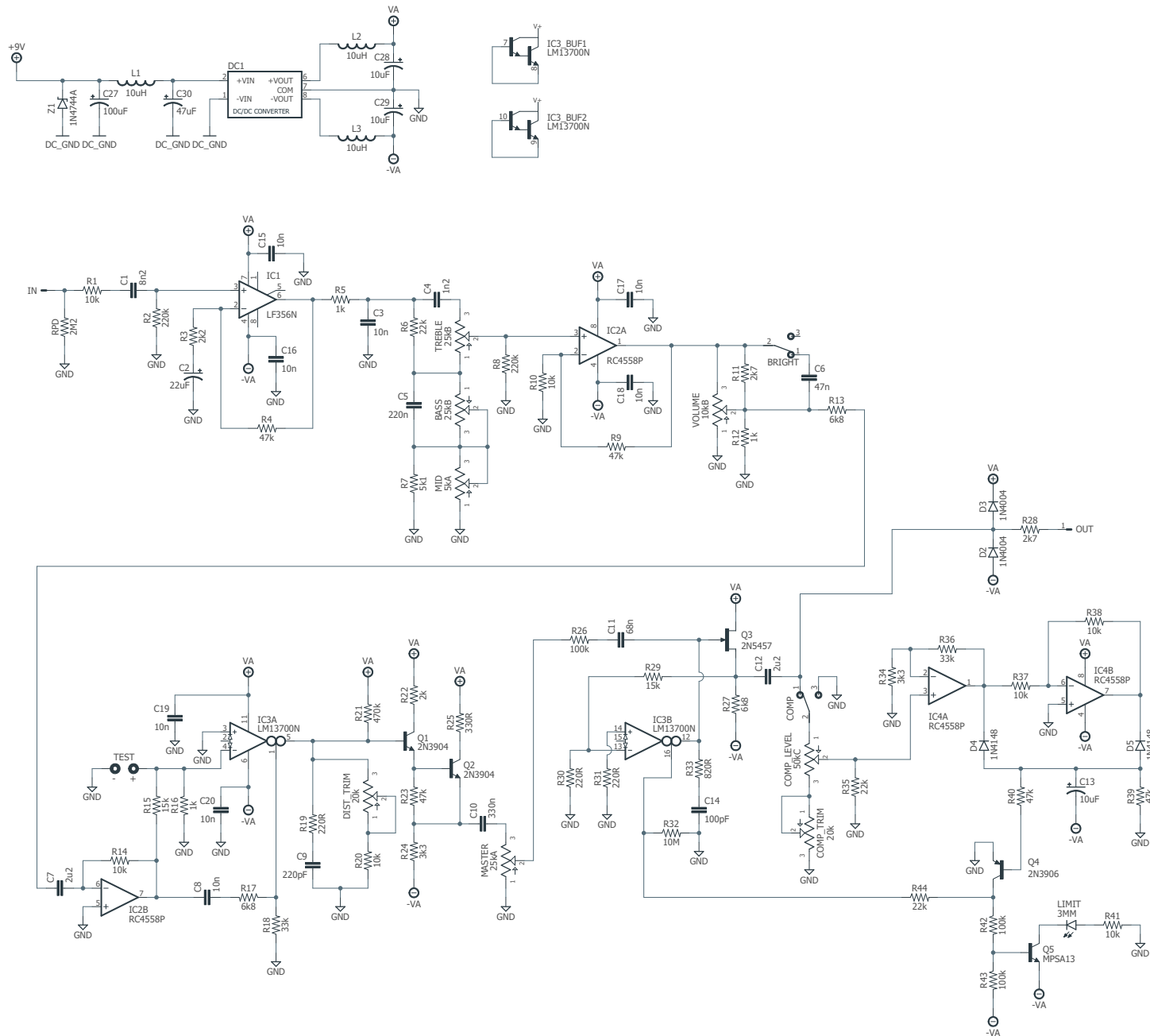
The only change that this required was to add a second 100k resistor (R43) to cut the compressor LED's voltage in half, since the LM13700's I<sub>ABC</sub> pin sits at twice the voltage of the CA3080's pin. This extra resistor prevents the LED from staying on all the time, which was the only side-effect of substituting the LM13700 in place of the CA3080.

### Enclosure size

This project was designed for the **Hammond 1590BBS** enclosure, which has the same height as the 125B or 1590N1. If you don't use the Hammond brand, be careful—not all 1590BBS enclosures are the same. For example, Love My Switches sells two different types, and the [CNC Pro](#) version is correct while the standard one is too short.

The 1590BB2 seems like a close equivalent, but it's about 4mm shorter. It may be possible to fit this circuit in a 1590BB2, but we have not tested it, so you're on your own. Another alternative is the 1590C (also available from Tayda and Love My Switches). It's about 10mm taller than necessary, but if that's all you can find then it will definitely work.

# SCHEMATIC

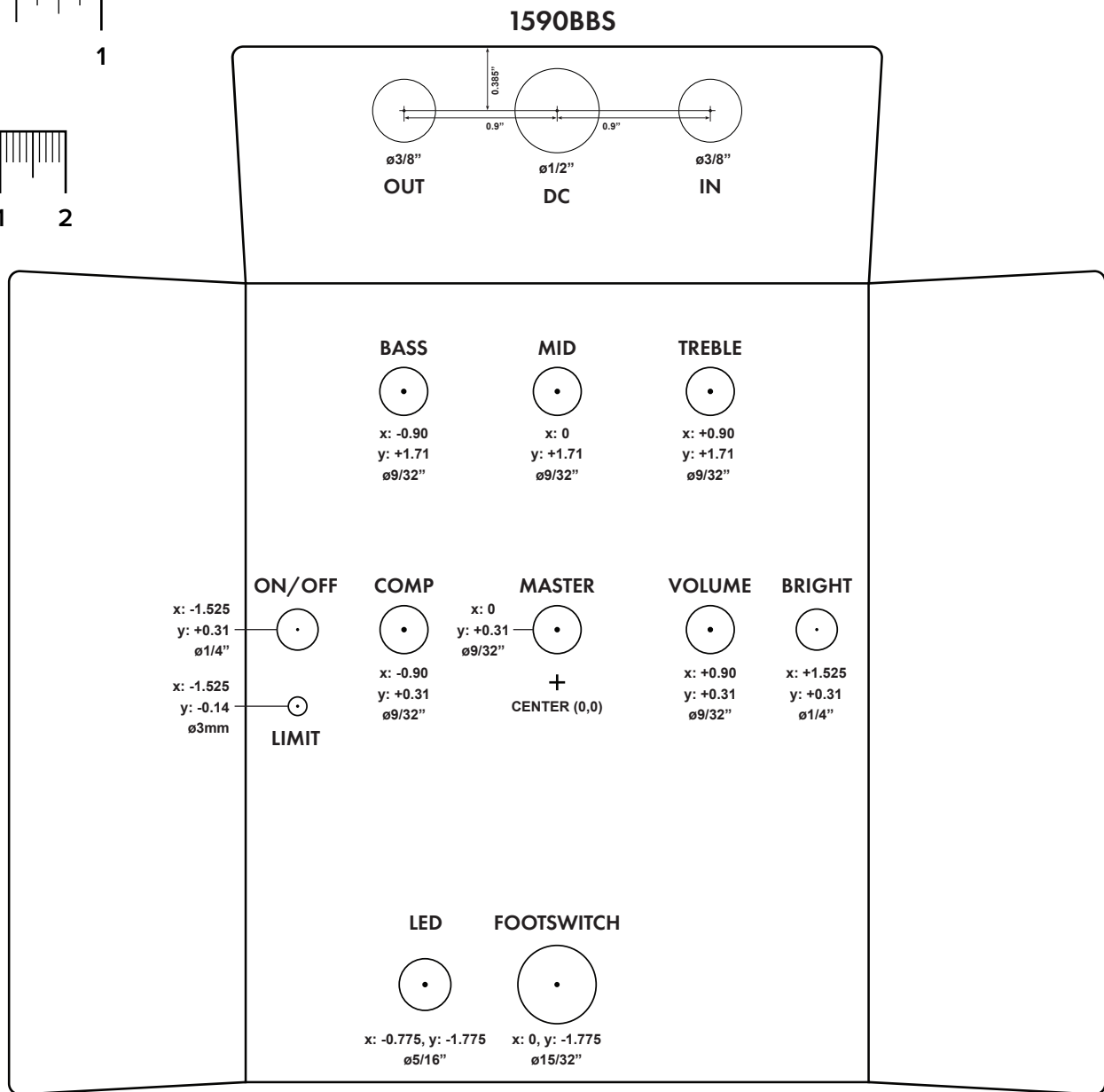
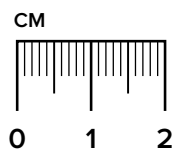
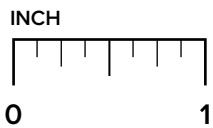


# DRILL TEMPLATE

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.

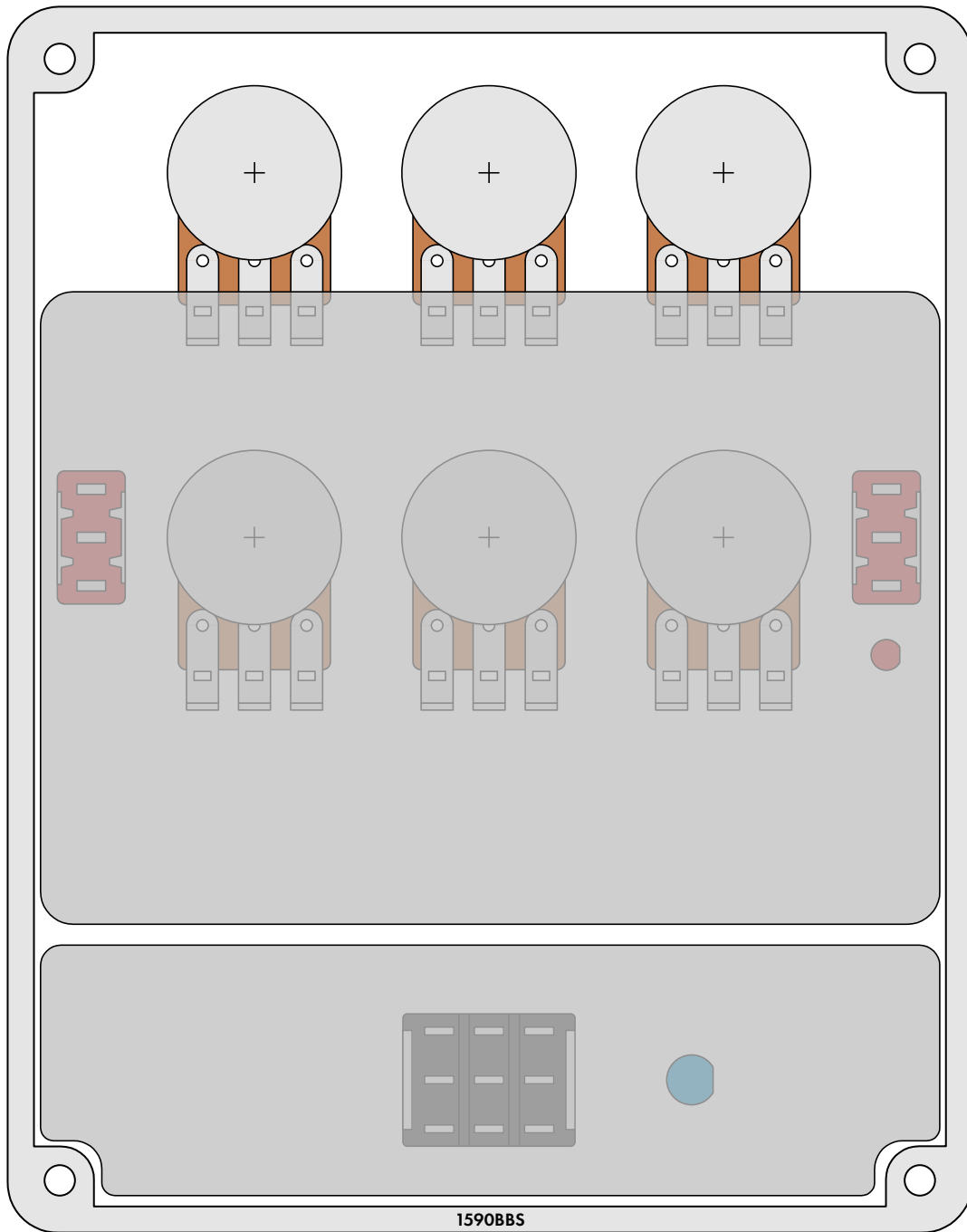
Ensure that this template is printed at 100% or "Actual Size". You can double-check this by measuring the scale on the printed page.

**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.

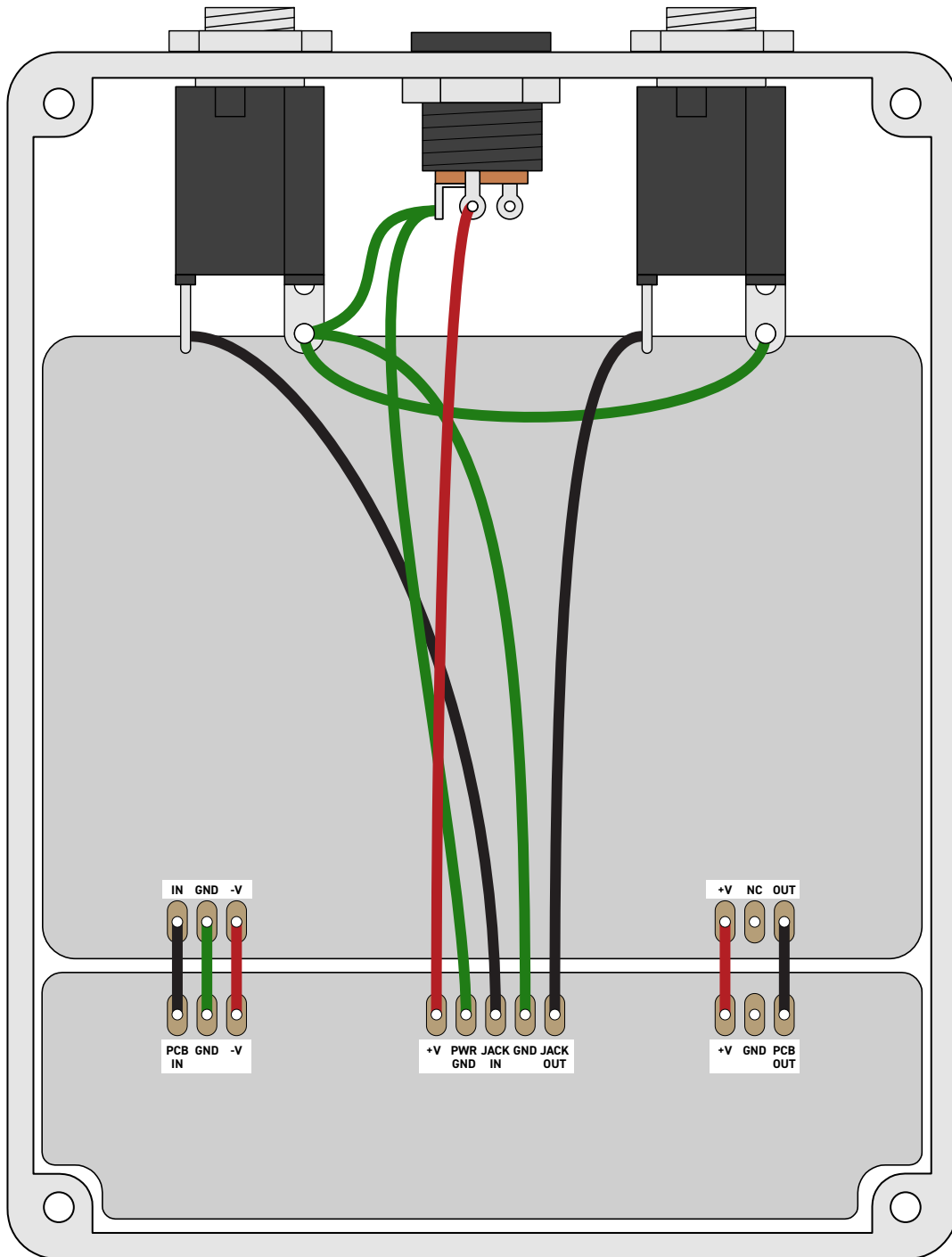


# ENCLOSURE LAYOUT

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



# WIRING DIAGRAM



## LICENSE & USAGE

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**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 cannot be 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

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### 1.0.0 (2022-11-25)

Initial release.