PROJECT NAME

AURUM

aion
DIY GUITAR EFFECTS

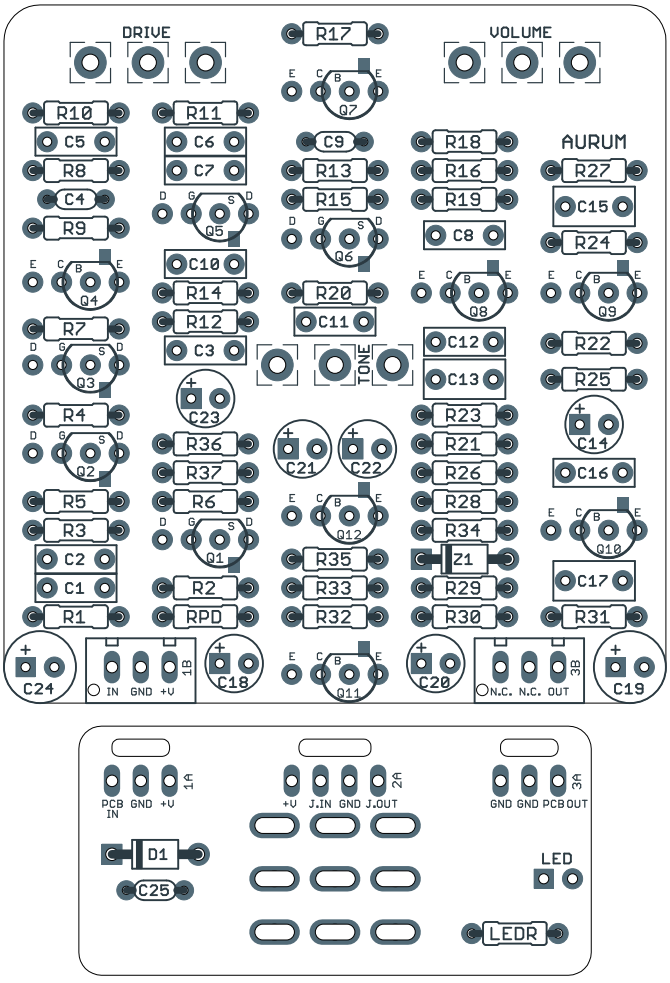
BASED ON
BOSS® OD-2 Turbo Overdrive

BUILD DIFFICULTY
Intermediate

EFFECT TYPE
JFET overdrive

DOCUMENT VERSION
1.0.0 (2021-11-26)

PROJECT SUMMARY
The first in a series of legendary pedals using BOSS's "discrete op-amp" topology that overdrives more like an amplifier than traditional diode-clipping circuits.



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

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INTRODUCTION

The Aurum Amp Overdrive is based BOSS® OD-2 Turbo Overdrive, notable as the first appearance of Boss's "discrete op-amp" circuit topology which uses two JFETs and a PNP transistor to create a variable gain stage that can be controlled like an op-amp but clips gracefully when overdriven. As a bit of trivia, the OD-2 is also one of only three fully discrete circuits ever made by BOSS (no op-amps), alongside the FZ-3 Fuzz and the DS-2 Turbo Distortion.

The OD-2 was first released in 1985 as the successor to the OD-1. In 1994, it was replaced by the OD-2r. The "r" in this case stands for "remote", since it allowed an external footswitch to change between the two channels on the fly. However, the OD-2r also corrected one one of the most persistent flaws of the original unit, which is that it could barely get to unity gain at the highest volume setting.

The Aurum is more specifically based on the "Turbo" mode of the circuit, adapting the OD-2r version of the circuit with the gain recovery stage and a couple of other minor tweaks. The non-"Turbo" mode is a completely separate drive circuit within the pedal, and generally speaking it's unremarkable when compared to the Turbo mode.

The OD-2 was officially succeeded by the OD-3 in 1997, although the BD-2 Blues Driver can be seen as a "rebranded" in-between member of the same series since it shares much of the same circuitry as both the OD-2 and OD-3. However, all three circuits sound pretty different, and they each bring their own character to the table.

The original OD-2 uses the 2SK117-GR JFET, a low-cutoff type similar to J201, but no longer made in through-hole format. 2SK209-GR is the SMD version that is still in production and will perform exactly the same as the originals. Each of the JFETs have extra pads for soldering SMD parts, but if you don't feel confident in your SMD skills, Aion FX sells 2SK209-GR pre-soldered to adapter boards to be used in through-hole applications.

USAGE

The Aurum has three controls:

- **Drive** increases the gain of the first discrete op-amp stage, which overloads the second stage and pushes it into clipping.
- **Tone** is a passive treble cut after the second gain stage.
- **Volume** sets the overall output of the effect signal.

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	10k	Metal film resistor, 1/4W	
R2	1M	Metal film resistor, 1/4W	
R3	10k	Metal film resistor, 1/4W	
R4	100k	Metal film resistor, 1/4W	
R5	4k7	Metal film resistor, 1/4W	
R6	2k2	Metal film resistor, 1/4W	
R7	4k7	Metal film resistor, 1/4W	
R8	4k7	Metal film resistor, 1/4W	Not present in original OD-2. Use a jumper if building that version.
R9	2k2	Metal film resistor, 1/4W	
R10	100k	Metal film resistor, 1/4W	
R11	10k	Metal film resistor, 1/4W	
R12	100k	Metal film resistor, 1/4W	
R13	4k7	Metal film resistor, 1/4W	
R14	2k2	Metal film resistor, 1/4W	
R15	4k7	Metal film resistor, 1/4W	
R16	270k	Metal film resistor, 1/4W	
R17	1k8	Metal film resistor, 1/4W	
R18	820R	Metal film resistor, 1/4W	
R19	10k	Metal film resistor, 1/4W	
R20	4k7	Metal film resistor, 1/4W	
R21	100k	Metal film resistor, 1/4W	
R22	4k7	Metal film resistor, 1/4W	
R23	4k7	Metal film resistor, 1/4W	
R24	4k7	Metal film resistor, 1/4W	
R25	4k7	Metal film resistor, 1/4W	
R26	680R	Metal film resistor, 1/4W	
R27	47k	Metal film resistor, 1/4W	
R28	470k	Metal film resistor, 1/4W	
R29	10k	Metal film resistor, 1/4W	
R30	100k	Metal film resistor, 1/4W	
R31	1k	Metal film resistor, 1/4W	
R32	4k7	Metal film resistor, 1/4W	

PARTS LIST, CONT.

PART	VALUE	TYPE	NOTES
R33	4k7	Metal film resistor, 1/4W	
R34	4k7	Metal film resistor, 1/4W	
R35	4k7	Metal film resistor, 1/4W	
R36	10k	Metal film resistor, 1/4W	Use 16k for original OD-2.
R37	10k	Metal film resistor, 1/4W	Use 14k for original OD-2.
RPD	2M2	Metal film resistor, 1/4W	Input pulldown 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	22n	Film capacitor, 7.2 x 2.5mm	
C2	18n	Film capacitor, 7.2 x 2.5mm	
C3	100n	Film capacitor, 7.2 x 2.5mm	
C4	100pF	MLCC capacitor, NP0/C0G	
C5	22n	Film capacitor, 7.2 x 2.5mm	
C6	6n8	Film capacitor, 7.2 x 2.5mm	
C7	10n	Film capacitor, 7.2 x 2.5mm	
C8	150n	Film capacitor, 7.2 x 2.5mm	
C9	100pF	MLCC capacitor, NP0/C0G	
C10	10n	Film capacitor, 7.2 x 2.5mm	
C11	18n	Film capacitor, 7.2 x 2.5mm	
C12	27n	Film capacitor, 7.2 x 2.5mm	Original OD-2 uses 22n. See build notes.
C13	1uF	Film capacitor, 7.2 x 3.5mm	
C14	10uF	Electrolytic capacitor, 5mm	
C15	1uF	Film capacitor, 7.2 x 3.5mm	
C16	22n	Film capacitor, 7.2 x 2.5mm	
C17	1uF	Film capacitor, 7.2 x 3.5mm	
C18	10uF	Electrolytic capacitor, 5mm	Power supply filter capacitor.
C19	100uF	Electrolytic capacitor, 6.3mm	Power supply filter capacitor.
C20	47uF	Electrolytic capacitor, 5mm	Reference voltage filter capacitor.
C21	10uF	Electrolytic capacitor, 5mm	Power supply filter capacitor.
C22	10uF	Electrolytic capacitor, 5mm	Power supply filter capacitor.
C23	47uF	Electrolytic capacitor, 5mm	Reference voltage filter capacitor.
C24	100uF	Electrolytic capacitor, 6.3mm	Power supply filter capacitor.
C25	100n	MLCC capacitor, X7R	Power supply filter capacitor.
Z1	1N4738A	Zener diode, 8.2V, DO-41	Original OD-2 uses 6.2V zener, e.g. 1N4735A. See build notes.
D1	1N5817	Schottky diode, DO-41	
Q1	2SK209-GR	JFET, N-channel, SOT-23	Both originals use 2SK117-GR. 2SK209-GR is the SMD equivalent.
Q2	2SK209-GR	JFET, N-channel, SOT-23	Both originals use 2SK117-GR. 2SK209-GR is the SMD equivalent.
Q3	2SK209-GR	JFET, N-channel, SOT-23	Both originals use 2SK117-GR. 2SK209-GR is the SMD equivalent.

PARTS LIST, CONT.

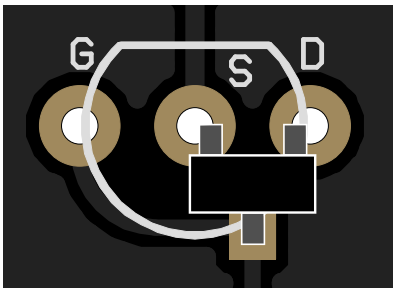
PART	VALUE	TYPE	NOTES
Q4	2N3906	BJT transistor, PNP, TO-92	Substitute. Original uses 2SA970-GR.
Q5	2SK209-GR	JFET, N-channel, SOT-23	Both originals use 2SK117-GR. 2SK209-GR is the SMD equivalent.
Q6	2SK209-GR	JFET, N-channel, SOT-23	Both originals use 2SK117-GR. 2SK209-GR is the SMD equivalent.
Q7	2N3906	BJT transistor, PNP, TO-92	Substitute. Original uses 2SA970-GR.
Q8	2N5088	BJT transistor, NPN, TO-92	Substitute. Original uses 2SC3378-GR.
Q9	2N3906	BJT transistor, PNP, TO-92	Substitute. Original uses 2SA1335-GR.
Q10	2N5088	BJT transistor, NPN, TO-92	Substitute. Original uses 2SC2458-GR.
Q11	2N5088	BJT transistor, NPN, TO-92	Substitute. Original uses 2SC2458-GR.
Q12	2N5088	BJT transistor, NPN, TO-92	Substitute. Original uses 2SC2458-GR.
DRIVE	250kA	16mm right-angle PCB mount pot	
TONE	10kB	16mm right-angle PCB mount pot	
VOLUME	50kA	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

Using SMD JFETs

The 2SK117-GR JFET is no longer available in through-hole format. This PCB uses a hybrid through-hole/SMD outline for each JFET. An extra “G” (gate) pad is included to accommodate surface-mount devices without the need for adapters.

SMD JFETs should be oriented as follows:



All surface-mount JFETs use the same pinout, so this configuration will fit any type that we’re aware of. However, always check the datasheet if you’re uncertain—they’re difficult to desolder.

Using through-hole adapters

If you’re not confident in your ability to work with surface-mount parts, Aion FX offers 2SK209-GR JFETs (the SMD version of 2SK117-GR and 2SK184-GR) that come pre-soldered to adapters for use in through-hole designs. These are from the same manufacturer as the ones used in the original BOSS pedals and will perform identically.

Using old-stock transistors

Toshiba has not manufacturered through-hole transistors and JFETs in many years, but it’s still possible to find the 2SK117-GR as well as the four types of BJT transistors used in the original. However, be aware that these follow the Japanese pinout conventions, whereas the PCB layout is set up for USA conventions since there are a lot more widely-available substitutes in this format.

For those using original Toshiba through-hole JFETs or BJTs, an extra pad has been added to the left of the transistor outline (drain for JFETs, emitter for BJTs) so that the Japanese pinout can be easily used without needing to twist the legs around. In both cases, the transistor should be rotated 180 degrees from the silkscreen and shifted by one pad, as shown:

OD-2 / OD-2r differences

The OD-2r is an updated version of the OD-2 that was released in 1994, nine years after the original OD-2. The major feature was the addition of the "remote" jack allowing the channel to be changed with an external footswitch. While BOSS did not mention any other changes when marketing the new unit, they did sneak in a few updates internally and the two units do not sound exactly the same.

First, there's an added two-transistor **volume recovery stage** so that the unit has more volume available. The original OD-2 barely got to unity gain at max volume—a persistent complaint from users—but the added volume recovery solves this issue entirely.

Second, the **tone control capacitor** has been increased from 22n to 27n. This allows for slightly more treble cut at the minimum setting, but with the treble control set high, it makes essentially no difference.

Third, a **minimum drive resistor** has been added in series with the drive control. This is largely responsible for the OD-2r's perception of having slightly more gain than the original, although it really just impacts the knob positions and the gain itself is not increased.

Fourth, the **supply voltage** for the Turbo stage has been increased from 5.6V to 7.6V by changing the Z1 zener from 6.2V to 8.2V.

Lastly, the **bias voltage** is different. While the original OD-2 had a trimmer for the Turbo mode's bias voltage, the OD-2r omits this and just uses fixed resistors. It's not known what parameters they used in the OD-2 to determine where to set the trimmer in the factory, but the nominal 2.6V bias voltage in the schematic is less than half of the 5.6V supply, so it's may have been as simple as setting the trimmer to 2.6V. However, if it was performance-based with 2.6V being just a rough target, then we don't have enough information. We only know this trimmed voltage wasn't important enough to keep in the OD-2r.

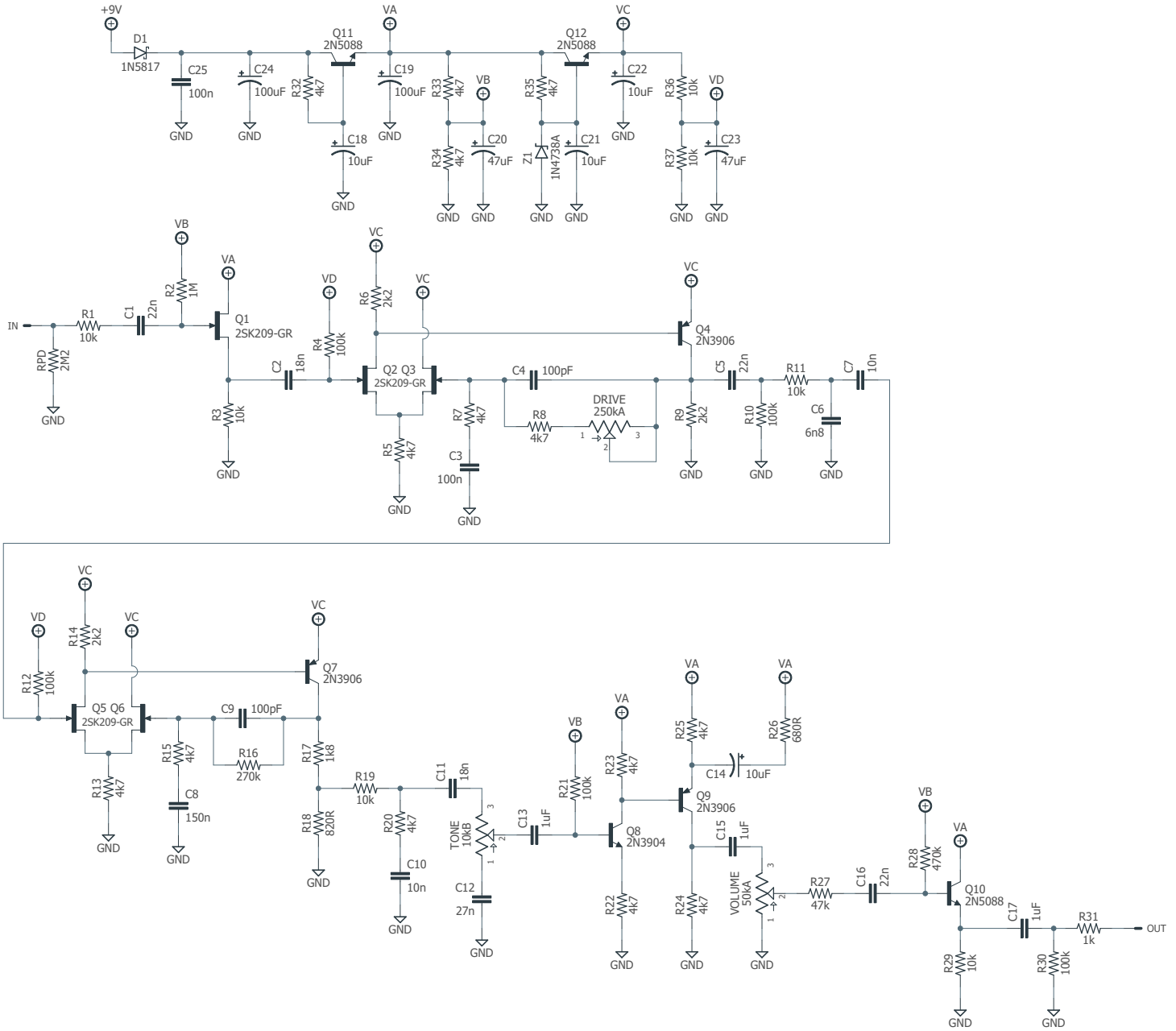
The improvements in the OD-2r make it the definitive version of the circuit, and it's recommended to build the Aurum to OD-2r specs, which is the default configuration in the parts list.

Building the original OD-2

If you want to build a straight OD-2, make the following changes.

1. Use **22n** for C12 instead of 27n.
2. Jumper R8 instead of using a 4k7 resistor.
3. Use **1N4735A** for Z1 (6.2V zener) instead of 1N4738A.
4. Use **16k** for R36 and **14k** for R37, which will give 2.6V bias from a 5.6V source.
5. Run a wire from the middle pin of the Tone control to pin 3 of the Volume control, and omit all of the components in between: C13-C15, R21-26, and Q8-9. No traces need to be cut, just leave the spaces empty.

This list is provided for completion's sake, but since the volume recovery stage fixes a severe shortcoming and does not color the tone, it's recommended to skip #5 and keep this added stage in an OD-2 build.


+9V
D1
1N5817
C25
100n
C24
100uF
Q11
2N5088
R32
4k7
C18
10uF
VA
C19
100uF
R33
4k7
VB
R34
4k7
C20
47uF
Q12
2N5088
R35
4k7
Z1
1N4738A
C21
10uF
VC
C22
10uF
R36
10k
VD
R37
10k
C23
47uF
GND
IN
RPD
2M2
R1
10k
C1
22n
R2
1M
Q1
2SK209-GR
R3
10k
C2
18n
R4
100k
R6
2k2
Q2 Q3
2SK209-GR
R5
4k7
R7
4k7
C3
100n
C4
100pF
R8
4k7
DRIVE
250kA
Q4
2N3906
R9
2k2
C5
22n
R10
100k
R11
10k
C6
6n8
C7
10n
R12
100k
R14
2k2
Q5 Q6
2SK209-GR
Q7
2N3906
C9
100pF
R13
4k7
R15
4k7
C8
150n
R16
270k
R17
1k8
R18
820R
R19
10k
R20
4k7
C10
10n
C11
18n
TONE
10kB
C12
27n
C13
1uF
R21
100k
Q8
2N3904
R22
4k7
R23
4k7
R24
4k7
R25
4k7
R26
680R
C14
10uF
Q9
2N3906
C15
1uF
VOLUME
50kA
R27
47k
C16
22n
R28
470k
Q10
2N5088
R29
10k
R30
100k
C17
1uF
R31
1k
OUT

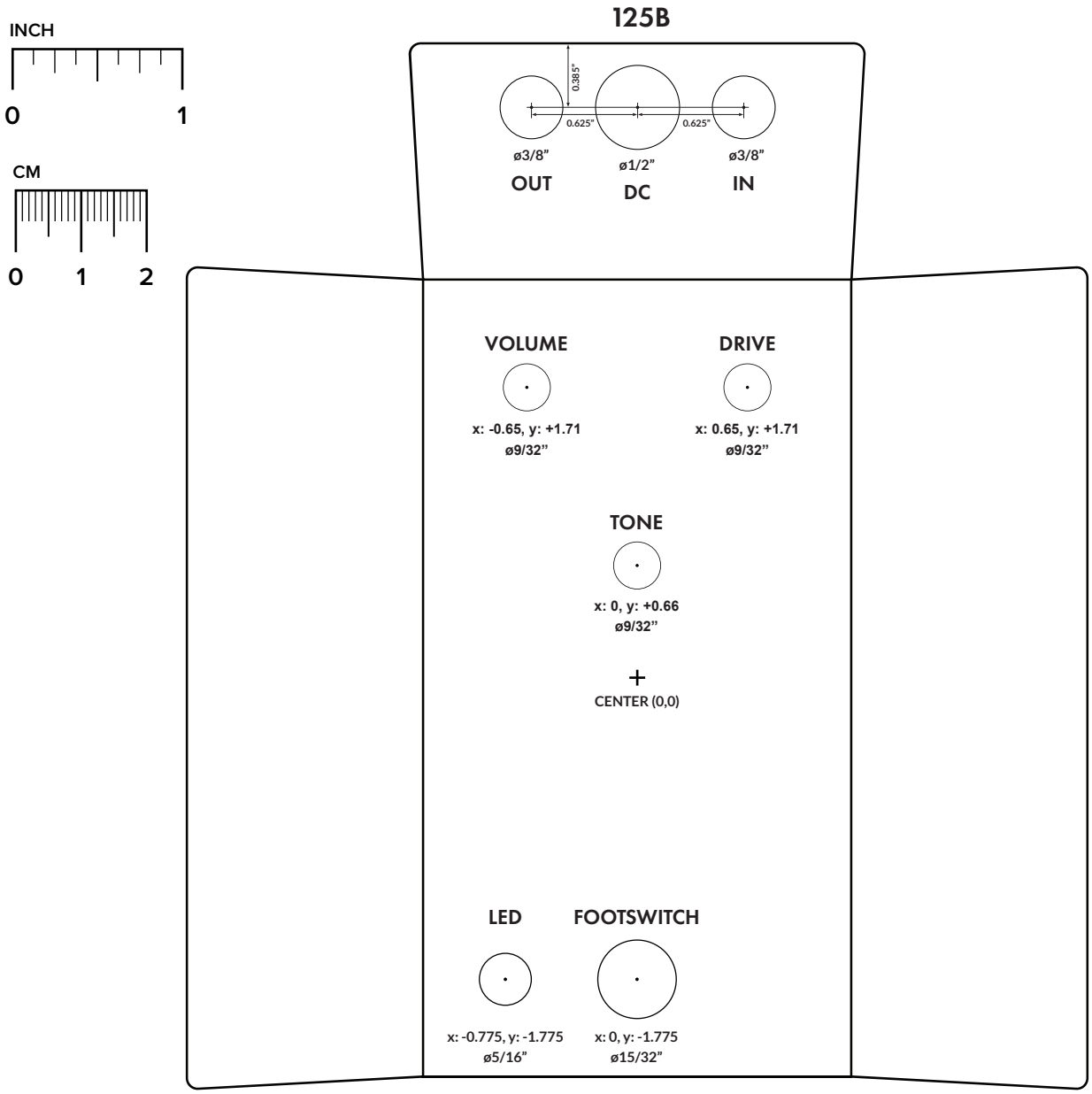
DRILL TEMPLATE

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.

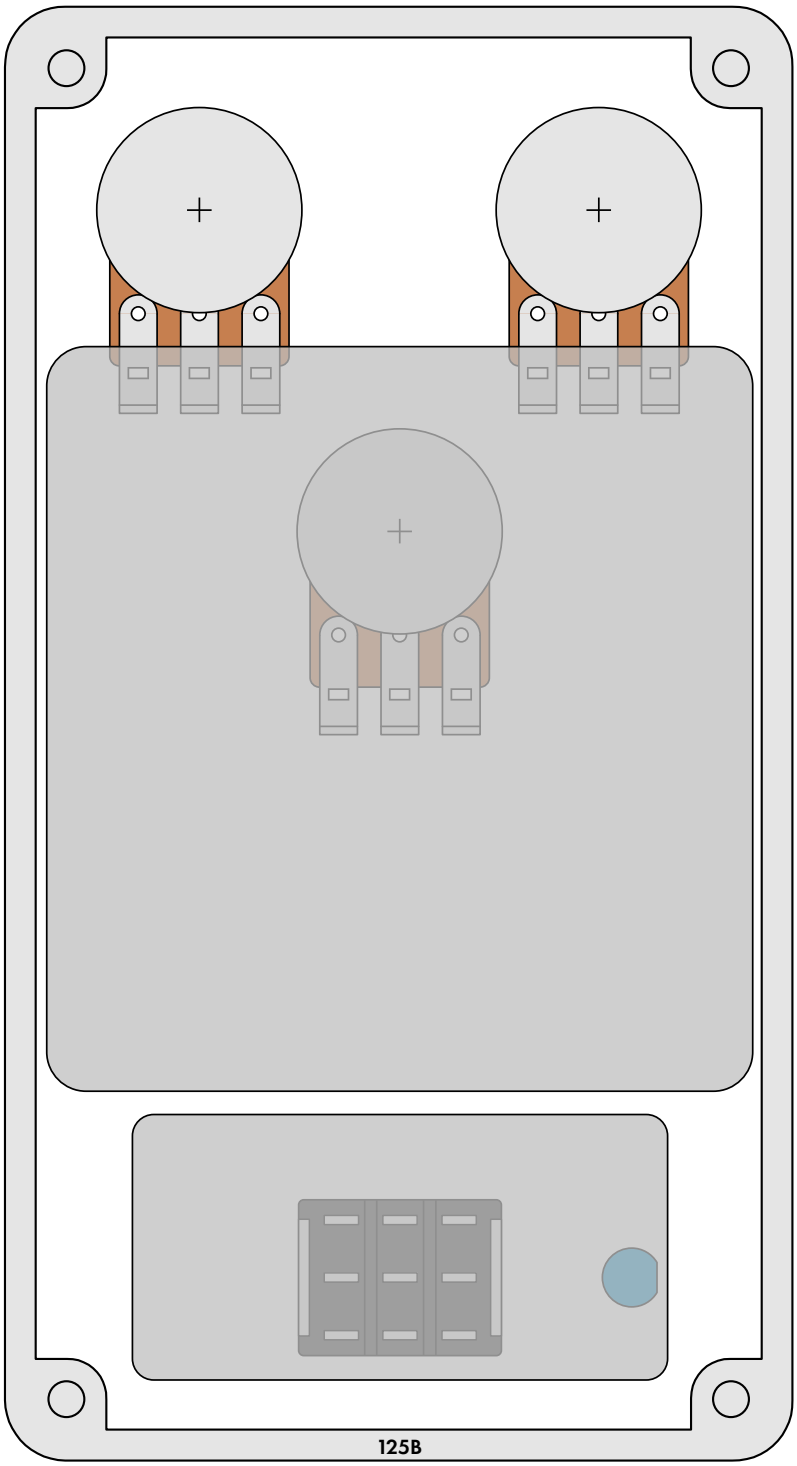
Top jack layout assumes the use of closed-frame jacks like the Switchcraft 111X. If you'd rather use open-frame jacks, please refer to the Open-Frame Jack Drill Template for the top side.

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.

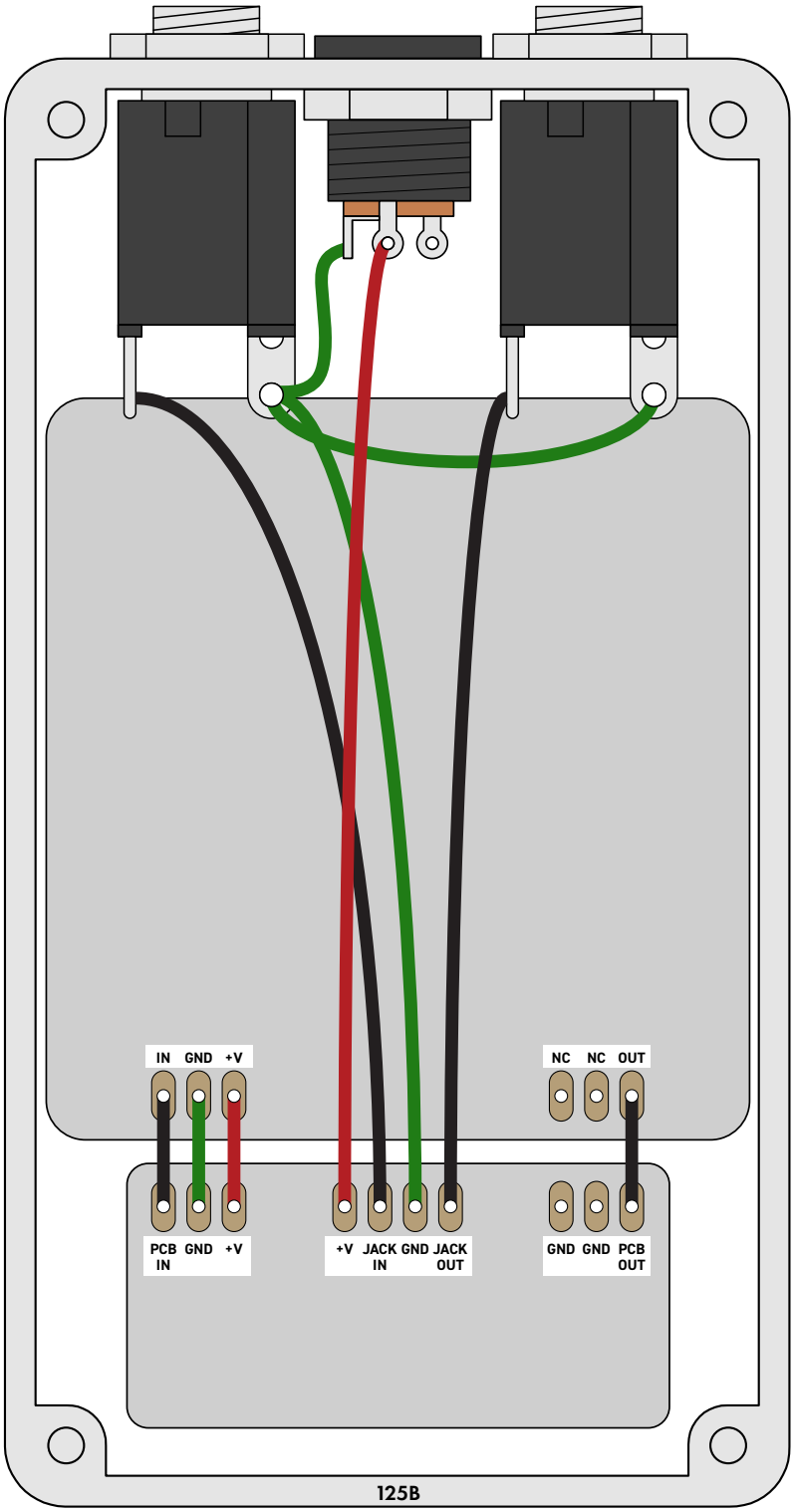


ENCLOSURE LAYOUT

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 (2021-11-26)
Initial release.