PROJECT NAME

GRAVITON

aion DIY GUITAR EFFECTS

BASED ON

BOSS® HM-2 Heavy Metal

BUILD DIFFICULTY

Intermediate

EFFECT TYPE

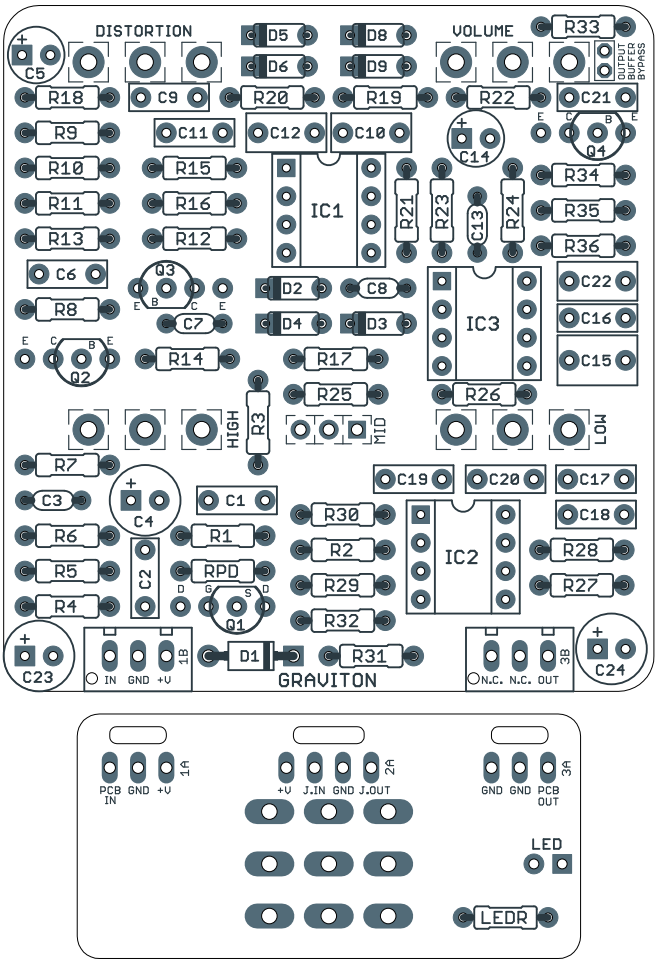
Metal Distortion

DOCUMENT VERSION

1.0.0 (2018-07-04)

PROJECT SUMMARY

A unique distortion effect favored by extreme metal guitarists for its characteristic “buzzsaw” sound. It also works very well as a versatile high-gain effect in other styles of music.



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

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INTRODUCTION

The Graviton Metal Distortion is a clone of the BOSS® HM-2 Heavy Metal, first released in 1983 and discontinued in 1991. The HM-2 was largely overlooked while it was in production, but in the mid-1990s it got the attention of a few bands in the Swedish death metal scene who developed something of a signature guitar tone by turning all the knobs to 10, often running it into a cheap solid state amp. Here is the video that first exposed this technique:

Daniel Ekeroth Demonstrates Swedish Death Metal Guitar Sound

Despite the reputation it enjoys in the extreme metal community, it is far from a one-trick pony. It's a very flexible pedal with a balanced high-gain distortion tone that works well in many styles of music.

This circuit also made an appearance as the DOD FX-56 American Metal, released in 1984. While the pedals don't really sound the same, the American Metal has almost the exact same circuit layout, just with different parts values and with the two tone knobs combined into one. You can build the American Metal with the Graviton PCB.

USAGE

The HM-2 is notoriously difficult to dial in. The Distortion control seems to only have two settings, "on" and "off", with a large dead zone in the middle. The tone controls have a wide range of effect (+/-20dB at approximately 88 Hz and 1000 Hz), but these can also be a bit finicky. There are really good sounds inside this pedal, but you may need to spend some quality time with it to tease them out.

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	22k	Metal film resistor, 1/4W	
R5	100k	Metal film resistor, 1/4W	
R6	470k	Metal film resistor, 1/4W	
R7	10k	Metal film resistor, 1/4W	
R8	22R	Metal film resistor, 1/4W	
R9	150R	Metal film resistor, 1/4W	
R10	22k	Metal film resistor, 1/4W	
R11	100k	Metal film resistor, 1/4W	
R12	470k	Metal film resistor, 1/4W	
R13	120R	Metal film resistor, 1/4W	
R14	1k	Metal film resistor, 1/4W	
R15	10k	Metal film resistor, 1/4W	
R16	68k	Metal film resistor, 1/4W	
R17	220k	Metal film resistor, 1/4W	
R18	47k	Metal film resistor, 1/4W	
R19	10k	Metal film resistor, 1/4W	
R20	10k	Metal film resistor, 1/4W	
R21	68k	Metal film resistor, 1/4W	
R22	3k3	Metal film resistor, 1/4W	
R23	3k3	Metal film resistor, 1/4W	
R24	10k	Metal film resistor, 1/4W	
R25	100k	Metal film resistor, 1/4W	
R26	330R	Metal film resistor, 1/4W	
R27	82k	Metal film resistor, 1/4W	
R28	330R	Metal film resistor, 1/4W	
R29	100k	Metal film resistor, 1/4W	
R30	330R	Metal film resistor, 1/4W	

PARTS LIST, CONT.

PART	VALUE	TYPE	NOTES
R31	10k	Metal film resistor, 1/4W	
R32	10k	Metal film resistor, 1/4W	
R33	470k	Metal film resistor, 1/4W	
R34	10k	Metal film resistor, 1/4W	
R35	1k	Metal film resistor, 1/4W	
R36	100k	Metal film resistor, 1/4W	
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	47n	Film capacitor, 7.2 x 2.5mm	
C2	47n	Film capacitor, 7.2 x 2.5mm	
C3	100pF	MLCC capacitor, NP0/C0G	
C4	47uF	Electrolytic capacitor, 5mm	
C5	10uF	Electrolytic capacitor, 5mm	
C6	47n	Film capacitor, 7.2 x 2.5mm	
C7	100pF	MLCC capacitor, NP0/C0G	
C8	100pF	MLCC capacitor, NP0/C0G	
C9	47n	Film capacitor, 7.2 x 2.5mm	
C10	1uF	Film capacitor, 7.2 x 3.5mm	
C11	1n	Film capacitor, 7.2 x 2.5mm	
C12	1uF	Film capacitor, 7.2 x 3.5mm	
C13	470pF	MLCC capacitor, NP0/C0G	
C14	10uF	Electrolytic capacitor, 5mm	
C15	1.5uF	Film capacitor, 7.2 x 4.5mm	
C16	68n	Film capacitor, 7.2 x 2.5mm	
C17	150n	Film capacitor, 7.2 x 2.5mm	
C18	6n8	Film capacitor, 7.2 x 2.5mm	
C19	100n	Film capacitor, 7.2 x 2.5mm	
C20	4n7	Film capacitor, 7.2 x 2.5mm	
C21	47n	Film capacitor, 7.2 x 2.5mm	
C22	1uF	Film capacitor, 7.2 x 3.5mm	
C23	100uF	Electrolytic capacitor, 6.3mm	Power supply filter capacitor.
C24	47uF	Electrolytic capacitor, 5mm	Voltage reference filter capacitor.
D1	1N5817	Schottky diode, DO-41	Polarity protection diode with low voltage drop (~0.2V).
D2	1N914	Fast-switching diode, DO-35	
D3	1N914	Fast-switching diode, DO-35	

PARTS LIST, CONT.

PART	VALUE	TYPE	NOTES
D4	1N914	Fast-switching diode, DO-35	
D5	BAT46	Schottky diode, DO-35	The HM-2 uses Ge diodes here, but Schottky is a better modern replacement. They only set the gate threshold and do not affect tone.
D6	BAT46	Schottky diode, DO-35	
D8	1N914	Fast-switching diode, DO-35	
D9	1N914	Fast-switching diode, DO-35	
Q1	2N5457	JFET, N-channel, TO-92	The HM-2 uses 2SK30A-Y (a Japanese equivalent).
Q2	2N5088	BJT transistor, NPN, TO-92	The HM-2 uses 2SC2240-GR (a Japanese equivalent).
Q3	2N5087	BJT transistor, PNP, TO-92	The HM-2 uses 2SA970-GR (a Japanese equivalent).
Q4	2N5088	BJT transistor, NPN, TO-92	The HM-2 uses 2SC732TM-GR (a Japanese equivalent).
IC1	JRC4558D	Operational amplifier, DIP8	It's recommended to use a DIP-8 socket for each IC.
IC2	JRC4558D	Operational amplifier, DIP8	It's recommended to use a DIP-8 socket for each IC.
IC3	JRC4558D	Operational amplifier, DIP8	It's recommended to use a DIP-8 socket for each IC.
LED	5mm	LED, 5mm	Adjust LEDR resistor to set brightness depending on the LED used.
VOL	10kA	Potentiometer, 16mm right-angle	Audio (log) taper.
DIST	250kA	Potentiometer, 16mm right-angle	Audio (log) taper. The HM-2 uses D-taper which is similar to A.
HIGH	10kA	Potentiometer, 16mm right-angle	Audio (log) taper. The HM-2 uses G-taper which is similar to A.
LOW	10kA	Potentiometer, 16mm right-angle	Audio (log) taper. The HM-2 uses G-taper which is similar to A.
IN	1/4" mono	1/4" phone jack, closed frame	Switchcraft 111X or equivalent. Open-frame types can be used instead, but the top side drill template is different. See drill template for details.
OUT	1/4" mono	1/4" phone jack, closed frame	
DC	2.1mm	DC jack, 2.1mm panel mount	Mouser 163-4302-E or equivalent.
FSW	3PDT	3PDT stomp switch	
ENC	125B	Enclosure, die-cast aluminum	Can also use a Hammond 1590N1.

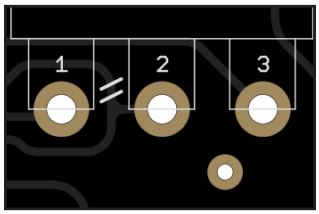
BUILD NOTES

A Word on the "Midrange" Control Modification

Many people who have looked at the schematic of the HM-2 have noticed that there are three distinct EQ poles (technically op-amp gyrators), but two of them are tied together to make the High control. As a result, a common modification is to split out this EQ pole into its own knob, which is mistakenly called a midrange knob because it controls a slightly lower frequency than the high control. People start to think they are unlocking some super-secret control that was hidden by the government or something.

While the Graviton project does support splitting out this 3rd EQ pole into its own control, I'm going to try to dissuade you from it. The reason is that the two EQ poles are centered very closely together around **1kHz** and **1.2kHz**, and they overlap in such a way as to form a single filter that is just broader than normal. By breaking out control over 1k but leaving 1.2k intact, you end up with a really weird notch effect that isn't very useful, while also changing the core tone of the HM-2.

With that said, getting to the point: To use the midrange pot, you will need to cut a trace on the PCB. On the back of the PCB, between lugs 1 & 2 of the "High" pot, you'll see two diagonal marks:



If you cut the trace at exactly this spot, taking care to avoid all surrounding traces, you can solder a 10kA pot to the "MID" pads in the middle. I recommend using an Alpha right-angle 9mm pot as shown to the right, but with the side mounting pins clipped off.

Adjusting the EQ filters

If you want to experiment and don't care about maintaining the stock HM-2 tone, you can turn this filter into a truly useful midrange control. By changing some part values in the "mid" EQ pole, you can lower the gyrator frequency into something that would be worth splitting out.

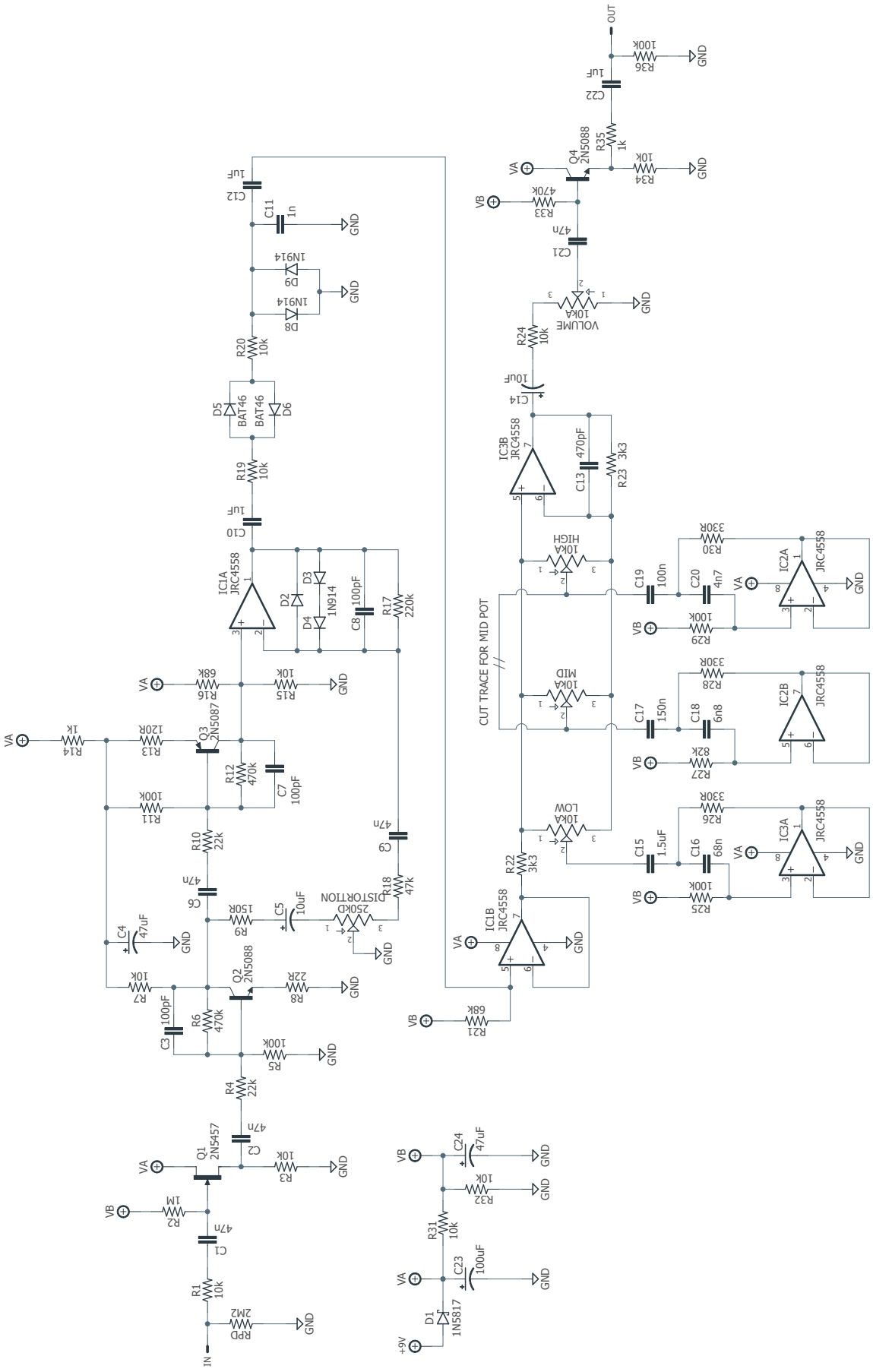
For instance, if you put it down into the 720Hz range, you'd have control over the classic Tube Screamer mid frequency, which also happens to be right between the 86 Hz frequency of the Low knob and the 1.2k frequency of the High knob. To do this, you'd change **R27** to **100k** and **C18** to **10n**.

For further experimentation, I recommend using AMZ's Bandpass EQ calculator.

Bypassing the output buffer

The output of the HM-2 is already well-buffered, but there is a second transistor-based buffer added to the end to support the JFET switching. To be as true to the original as possible, this second buffer has been included in the Graviton even though the JFET switching is omitted. Jumper pads are provided in the upper-right corner of the PCB to bypass this last buffer if desired. If you do use the jumper, you can omit **C21**, **C22**, **R33**, **R34**, **R35**, and **Q4**.

SCHEMATIC


OUT
R36 100K
GND
C22 1uF
Q4 2N5088
R35 1k
R34 10K
VA
VB
R33 470K
C21 47n
VOLUME 10KA
R24 10k
C14 10uF
IC3B JRC4558
C13 470pF
R23 3k3
HIGH 10KA
MID 10KA
LOW 10KA
CUT TRACE FOR MID POT
C19 100n
C20 4n7
R30 330R
IC2A JRC4558
R29 100K
C17 150n
C18 6n8
R28 330R
IC2B JRC4558
R27 82K
C15 1.5uF
C16 68n
R26 330R
IC3A JRC4558
R25 100K
IC1B JRC4558
R21 68K
C12 1uF
C11 u1
D9 IN914
D8 IN914
R20 10k
D5 BAT46
D6 BAT46
R19 10k
C10 1uF
IC1A JRC4558
D2
D3
D4
1N914
C8 100pF
R17 220k
R16 68K
R15 10K
R14 1K
Q3 2N5087
R13 120R
R12 470k
C7 100pF
R11 100K
R10 22k
C9 47n
C6 47n
R18 47k
DISTORTION 250KD
C5 10uF
R9 150R
C4 47uF
Q2 2N5088
R7 10K
R8 22R
C3 100pF
R6 470k
R5 100K
R4 22k
C2 47n
Q1 2N5457
R3 10K
R2 1M
C1 47n
R1 10k
RPD 2M2
IN
C24 47uF
R32 10K
R31 10k
C23 100uF
D1 1N5817
+9V

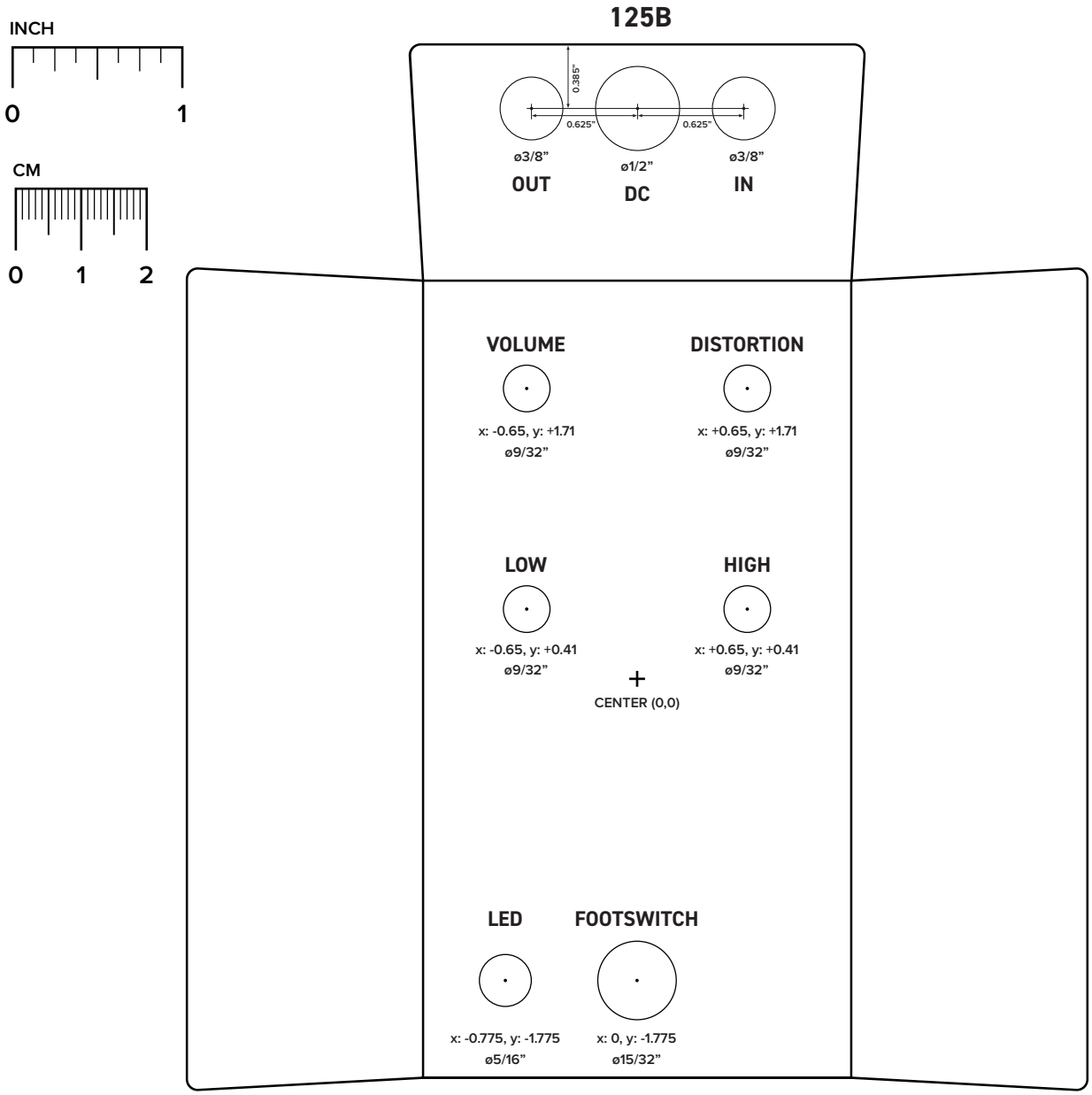
DRILL TEMPLATE

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.

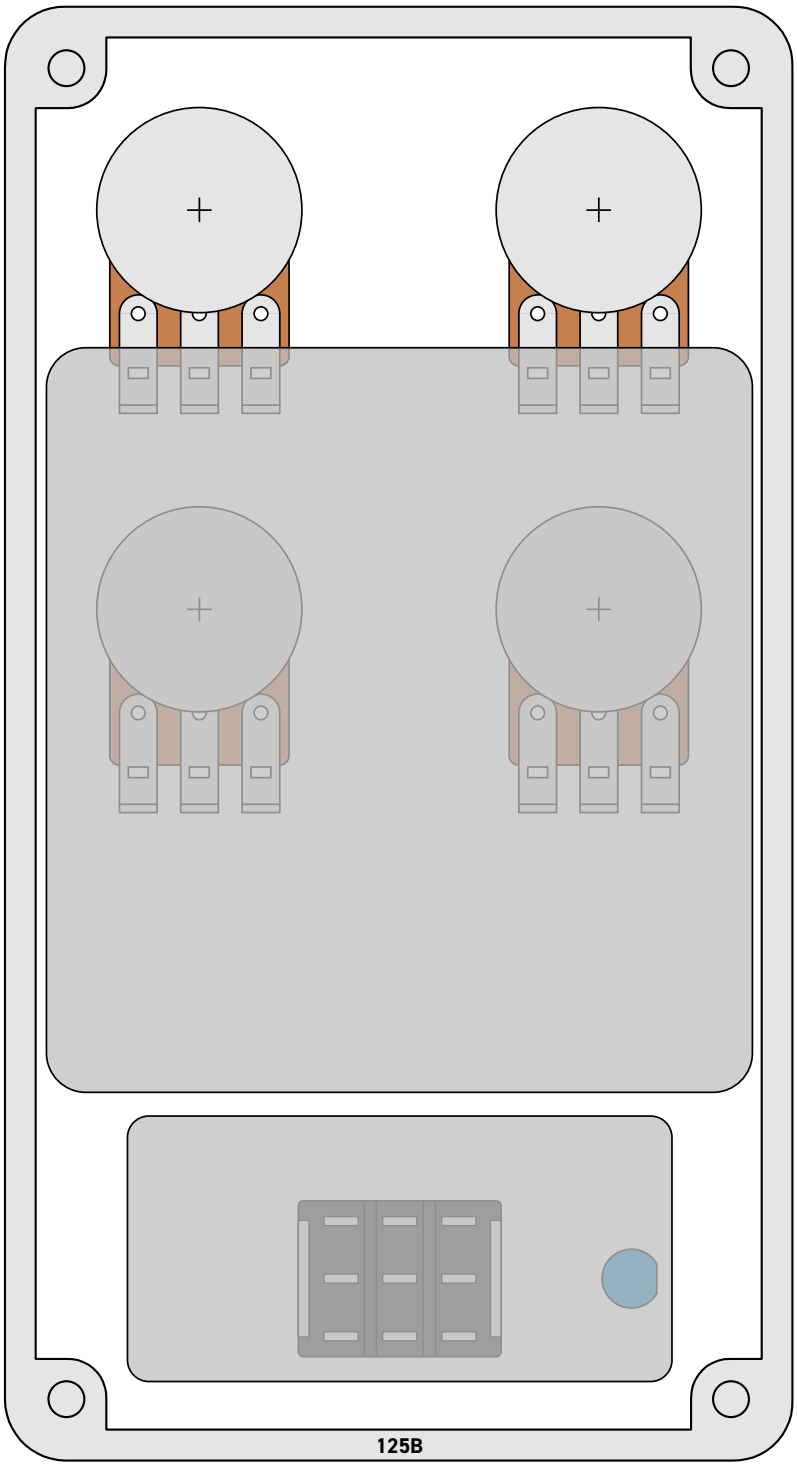
Top jack layout assumes the use of closed-frame jacks like the Switchcraft 111X. If you'd rather use open-frame jacks, please refer to the Open-Frame Jack Drill Template for the top side.

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.

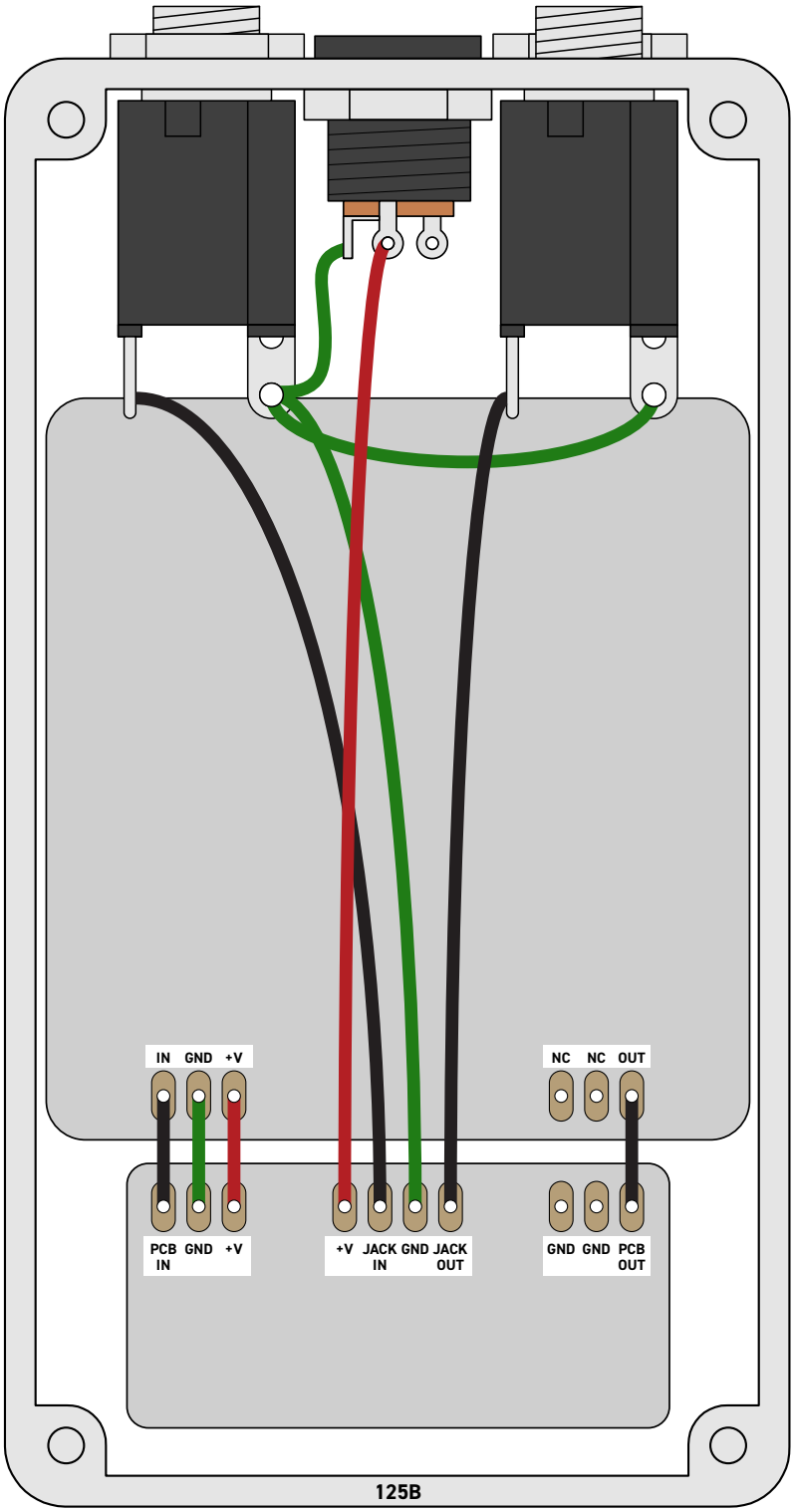


ENCLOSURE LAYOUT

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



WIRING DIAGRAM



"N.C." means "No Connection". These pads are only present to provide design uniformity with other PCB projects in this series.

TECHNICAL DATA

Current Draw: 10mA
Input Impedance: 1M

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 will not 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

1.0.0 (2018-07-04)
Initial release