

PROJECT NAME

SENTINEL



BASED ON

Ibanez SM-9 Super Metal

BUILD DIFFICULTY



EFFECT TYPE

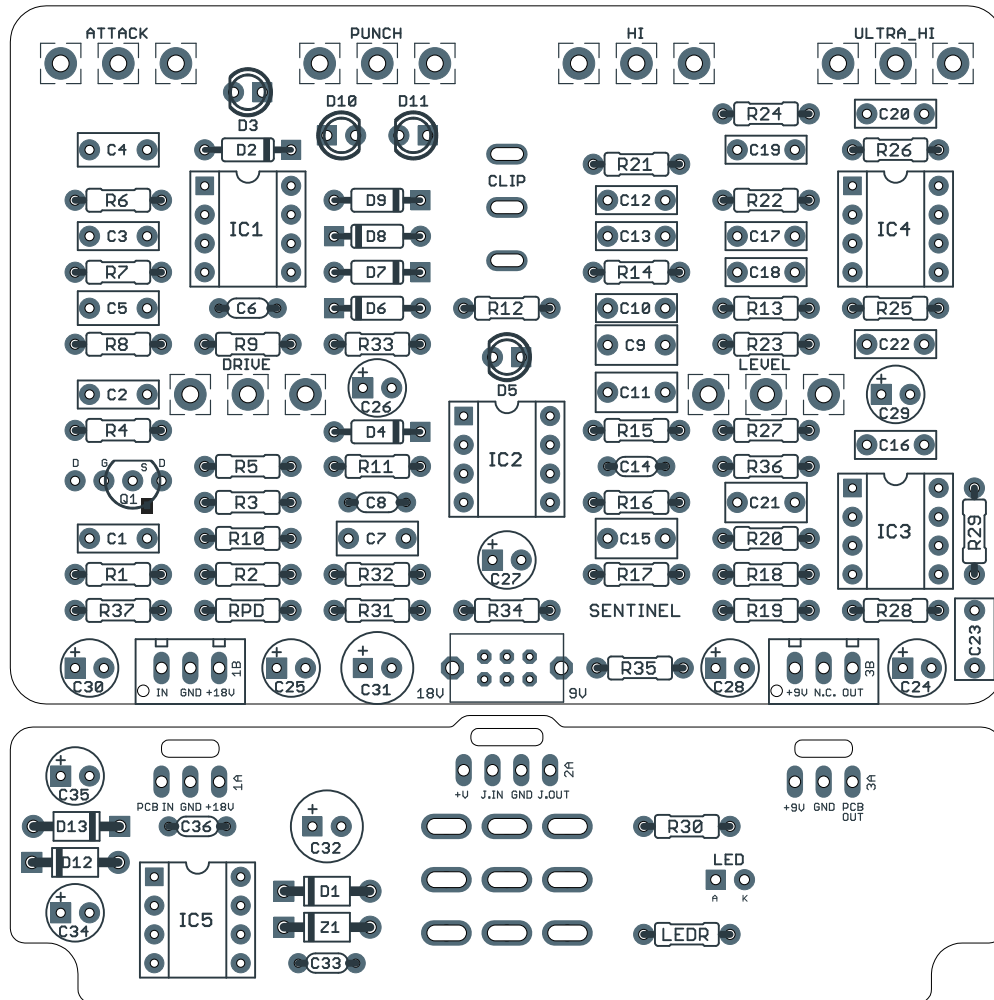
Distortion

DOCUMENT VERSION

1.0.0 (2022-11-25)

PROJECT SUMMARY

One of the earliest distortion pedals designed specifically for metal tones, this effect features cascaded gain stages for a very amp-like topology.



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

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INTRODUCTION

The Sentinel Metal Distortion is based on the Ibanez SM-9 Super Metal, a short-lived entry to the “9” series that was first released in 1983 and discontinued in 1984.

The SM-9 is a very early example (perhaps the first) of a modern amp-like topology in a pedal: multi-stage clipping with tone-shaping before and after. Many solid-state preamps such as the [Ampeg VH-140](#) and [Diezel VH-4](#) employ similar concepts, as well as the [Friedman Dirty Shirley](#) and the lead channel of the [BOSS® SD-2 Dual Overdrive](#).

The Super Metal circuit was re-released three more times throughout the 1980s as the MS-10 Metal Charger, SM-L Super Metal, and SM-01 Super Metal, the latter of which was only in Japan under the Maxon brand name. All four of these are the same pedal internally. (The “reissue” Maxon SM-9 Pro+ from 2010 has not been traced, but just based on the exterior of the pedal, we can tell it has some major differences and is not an exact clone.)

The Sentinel is an exact clone of the SM-9, with two differences. First, the “Edge” control is normally a single knob that controls two gyrators at ~1.2kHz and ~2.3kHz. This is similar to the [BOSS® HM-2](#), but unlike the HM-2 these two frequency bands don’t have much overlap—so we split them out into two knobs allowing both bands to be controlled independently. If they’re set in identical positions, it’ll be the same as the original SM-9, but this way you can fine-tune the high EQ a little more easily and get some expanded tones not found in the stock circuit. You can also lower the frequency of one of the bands if you want to experiment with creating a true midrange control.

The second difference is the addition of a charge pump for 18V operation. This increased voltage is switchable, so you can also run it at the stock 9V if you want, and even hard-wire it if you don’t care about the 18V option.

USAGE

The Sentinel Metal Distortion has the following controls:

- **Attack** is a Tube Screamer-style tone control that comes before the drive section, which has the greatest impact on the initial attack of the note and less on the overall tone.
- **Punch** is a Baxandall-style active bass control that either boosts or cuts bass frequencies, with the middle being flat.
- **Hi** is a gyrator tone control that boosts or cuts frequencies at approximately 1.2kHz.
- **Ultra Hi** is a gyrator tone control that boosts or cuts frequencies at approximately 2.3kHz.
- **Gain** sets the drive level.
- **Level** sets the output volume of the effect.
- **Clip** (toggle) switches between 3 different sets of clipping diodes.

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	1M	Metal film resistor, 1/4W	
R3	10k	Metal film resistor, 1/4W	
R4	1k	Metal film resistor, 1/4W	
R5	10k	Metal film resistor, 1/4W	
R6	1k	Metal film resistor, 1/4W	
R7	220R	Metal film resistor, 1/4W	
R8	4k7	Metal film resistor, 1/4W	
R9	4k7	Metal film resistor, 1/4W	
R10	4k7	Metal film resistor, 1/4W	
R11	220k	Metal film resistor, 1/4W	
R12	10k	Metal film resistor, 1/4W	
R13	100k	Metal film resistor, 1/4W	
R14	10k	Metal film resistor, 1/4W	
R15	10k	Metal film resistor, 1/4W	
R16	15k	Metal film resistor, 1/4W	
R17	10k	Metal film resistor, 1/4W	
R18	4k7	Metal film resistor, 1/4W	
R19	100k	Metal film resistor, 1/4W	Original uses 4.7k here. See build notes.
R20	4k7	Metal film resistor, 1/4W	
R21	220R	Metal film resistor, 1/4W	
R22	1k5	Metal film resistor, 1/4W	
R23	100k	Metal film resistor, 1/4W	
R24	220R	Metal film resistor, 1/4W	
R25	100k	Metal film resistor, 1/4W	
R26	820R	Metal film resistor, 1/4W	
R27	JUMPER	Metal film resistor, 1/4W	Original uses 10k here. See build notes.
R28	510k	Metal film resistor, 1/4W	
R29	470R	Metal film resistor, 1/4W	
R30	100k	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	100R	Metal film resistor, 1/4W	
R34	100R	Metal film resistor, 1/4W	
R35	100R	Metal film resistor, 1/4W	
R36	100R	Metal film resistor, 1/4W	
R37	100R	Metal film resistor, 1/4W	
RPD	2M2	Metal film resistor, 1/4W	Input pulldown resistor.
LEDR	10k	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	100n	Film capacitor, 7.2 x 2.5mm	
C3	33n	Film capacitor, 7.2 x 2.5mm	
C4	220n	Film capacitor, 7.2 x 2.5mm	
C5	220n	Film capacitor, 7.2 x 2.5mm	
C6	100pF	MLCC capacitor, NP0/C0G	
C7	220n	Film capacitor, 7.2 x 2.5mm	
C8	100pF	MLCC capacitor, NP0/C0G	
C9	1uF	Film capacitor, 7.2 x 3.5mm	
C10	1n	Film capacitor, 7.2 x 2.5mm	
C11	1uF	Film capacitor, 7.2 x 3.5mm	
C12	10n	Film capacitor, 7.2 x 2.5mm	
C13	10n	Film capacitor, 7.2 x 2.5mm	
C14	33pF	MLCC capacitor, NP0/C0G	
C15	1uF	Film capacitor, 7.2 x 3.5mm	
C16	5n6	Film capacitor, 7.2 x 2.5mm	
C17	56n	Film capacitor, 7.2 x 2.5mm	
C18	2n2	Film capacitor, 7.2 x 2.5mm	
C19	47n	Film capacitor, 7.2 x 2.5mm	
C20	1n2	Film capacitor, 7.2 x 2.5mm	
C21	1uF	Film capacitor, 7.2 x 3.5mm	
C22	100n	Film capacitor, 7.2 x 2.5mm	
C23	1uF	Film capacitor, 7.2 x 3.5mm	
C24	10uF	Electrolytic capacitor, 5mm	
C25	47uF	Electrolytic capacitor, 5mm	
C26	10uF	Electrolytic capacitor, 5mm	

PARTS LIST, CONT.

PART	VALUE	TYPE	NOTES
C27	10uF	Electrolytic capacitor, 5mm	
C28	10uF	Electrolytic capacitor, 5mm	
C29	10uF	Electrolytic capacitor, 5mm	
C30	10uF	Electrolytic capacitor, 5mm	
C31	100uF	Electrolytic capacitor, 6.3mm	
C32	100uF	Electrolytic capacitor, 6.3mm	
C33	470n	MLCC capacitor, X7R	
C34	10uF	Electrolytic capacitor, 5mm	
C35	10uF	Electrolytic capacitor, 5mm	
C36	470n	MLCC capacitor, X7R	
Z1	1N4742A	Zener diode, 12V, DO-41	
D1	1N5817	Schottky diode, DO-41	
D2	1N914	Fast-switching diode, DO-35	
D3	3mm LED	LED, 3mm, red diffused	
D4	1N914	Fast-switching diode, DO-35	
D5	3mm LED	LED, 3mm, red diffused	
D6	1N914	Fast-switching diode, DO-35	
D7	1N914	Fast-switching diode, DO-35	
D8	1N914	Fast-switching diode, DO-35	
D9	1N914	Fast-switching diode, DO-35	
D10	3mm LED	LED, 3mm, red diffused	
D11	3mm LED	LED, 3mm, red diffused	
D12	1N5817	Schottky diode, DO-41	
D13	1N5817	Schottky diode, DO-41	
Q1	2N5457	JFET, N-channel, TO-92	
IC1	JRC4558D	Operational amplifier, DIP8	
IC1-S	DIP-8 socket	IC socket, DIP-8	
IC2	JRC4558D	Operational amplifier, DIP8	
IC2-S	DIP-8 socket	IC socket, DIP-8	
IC3	JRC4558D	Operational amplifier, DIP8	
IC3-S	DIP-8 socket	IC socket, DIP-8	
IC4	JRC4558D	Operational amplifier, DIP8	
IC4-S	DIP-8 socket	IC socket, DIP-8	
IC5	LT1054CP	Charge pump / voltage converter, DIP8	
IC5-S	DIP-8 socket	IC socket, DIP-8	

PARTS LIST, CONT.

PART	VALUE	TYPE	NOTES
VOLTAGE	DPDT slide	Slide switch, DPDT	E-Switch EG2207
DRIVE	100kB	16mm right-angle PCB mount pot	
ATTACK	20kW	16mm right-angle PCB mount pot	
PUNCH	100kB	16mm right-angle PCB mount pot	
HI	20kW	16mm right-angle PCB mount pot	
ULTRA HI	20kW	16mm right-angle PCB mount pot	
LEVEL	10kA	16mm right-angle PCB mount pot	
CLIP	SPDT cntr off	Toggle switch, SPDT on-off-on	
LED	5mm	LED, 5mm, 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

Increased volume

The stock SM-9 is known for having low volume. There are two confusing and easily-remedied design decisions causing this.

- R19, the 4.7k bias resistor for IC3A, cuts the signal in half when combined with R18.
- R27, the 10k resistor in series with the volume control, halves the maximum volume again.

We have corrected both of these in the default parts list for this project, raising R19 to 100k and recommending to jumper R27. With these two changes, the maximum volume is comparable to other distortion effects.

Hi and Ultra Hi controls

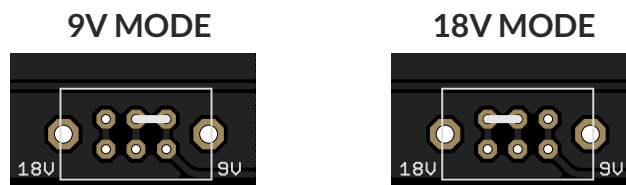
The original SM-9 only has five knobs, with the Hi and Ultra Hi combined into one control called “Edge” that boosts or cuts frequencies at both 1.2kHz and 2.3kHz.

The [BOSS HM-2](#) has a very similar tone control that also combines two gyrator bands into one knob. However, unlike the HM-2, the bands in the SM-9 do not overlap, so there is utility in splitting them out into two separate controls. To make it function like the original pedal, you just have to set these two knobs to the same position.

Since the SM-9 doesn’t have a true midrange control, you may find it worthwhile to modify the “Hi” gyrator to drop the frequency. For instance, C17 = 100n, C18 = 3n3 and R22 = 1.2k would lower the frequency to around 800 Hz. Check out the [AMZ gyrator calculator](#) if you want to experiment more.

9V/18V operation

The Ember Distortion includes a charge pump for 18V operation as well as an internal slide switch to go between 9V and 18V mode. If you want to hard-wire it at either 9V or 18V, you can omit the switch by jumpering the pads as shown:



If you do decide to hardwire it to 9V mode, you can leave out IC5, D12-13, and C34-35. They can just be omitted entirely—nothing else needs to be jumpered except the slide switch pads.

BUILD NOTES, CONT.

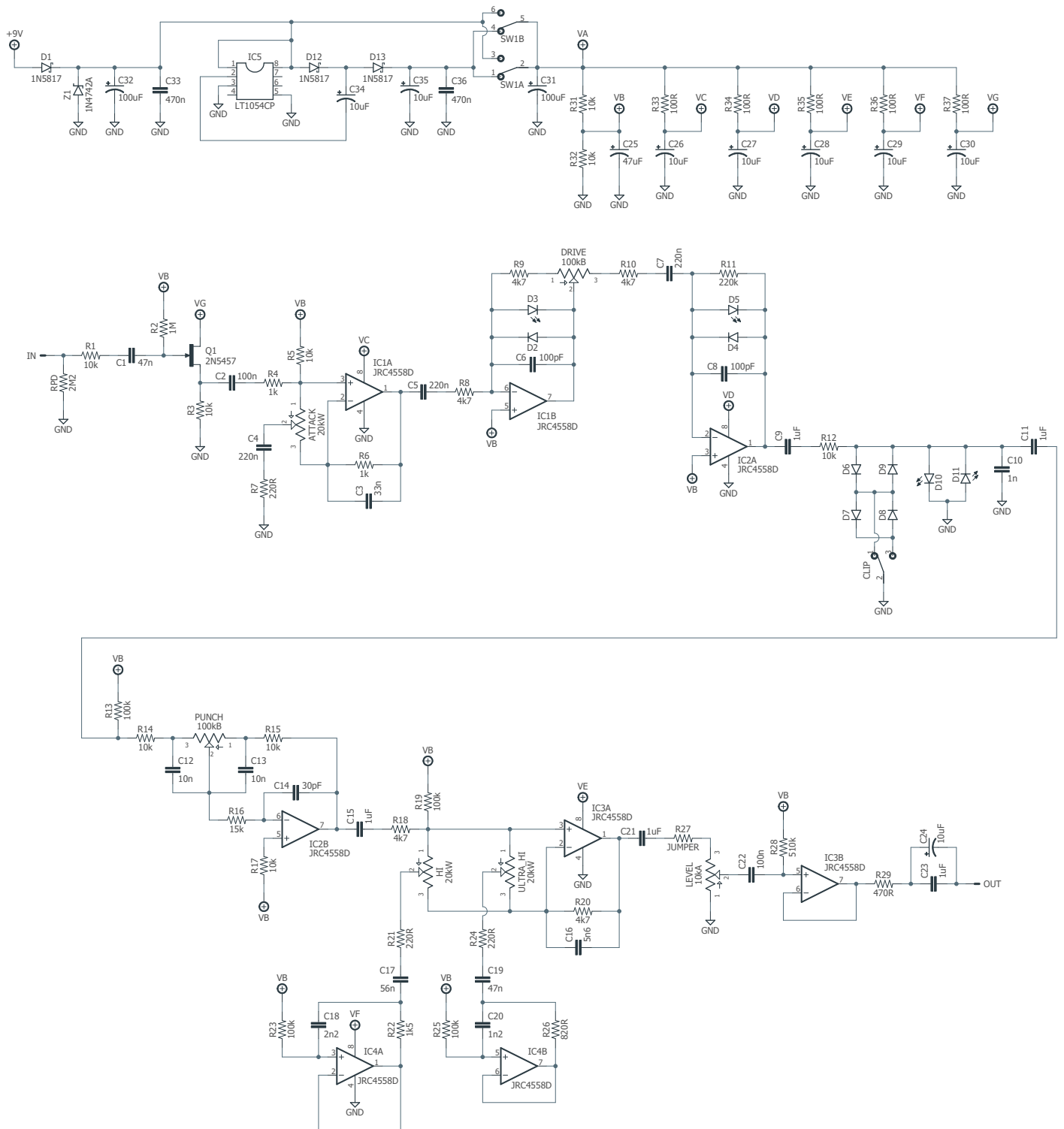
Enclosure size

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

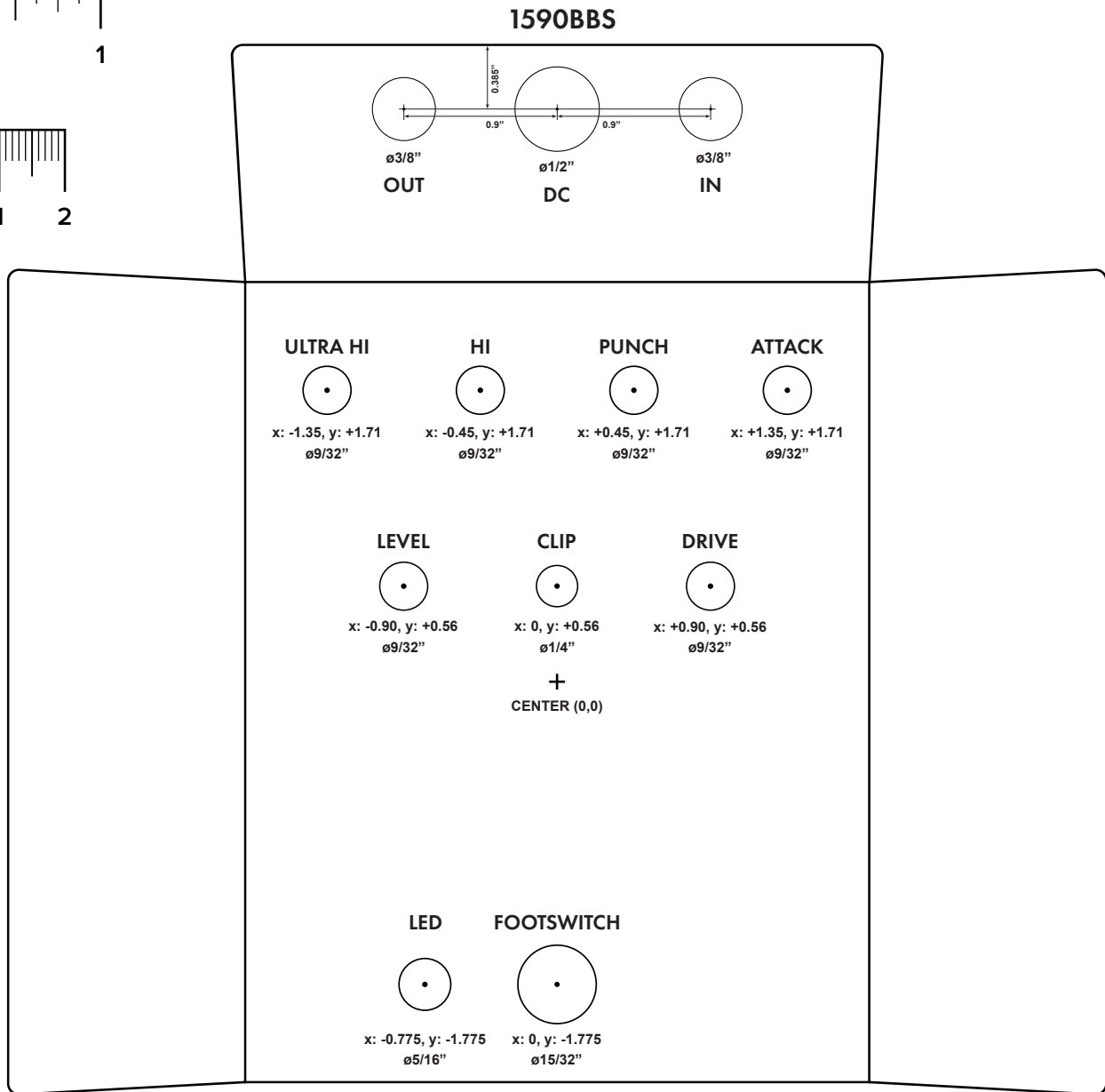
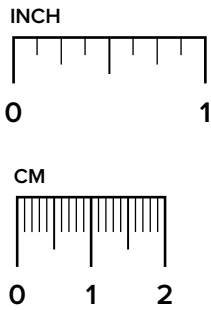


DRILL TEMPLATE

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.

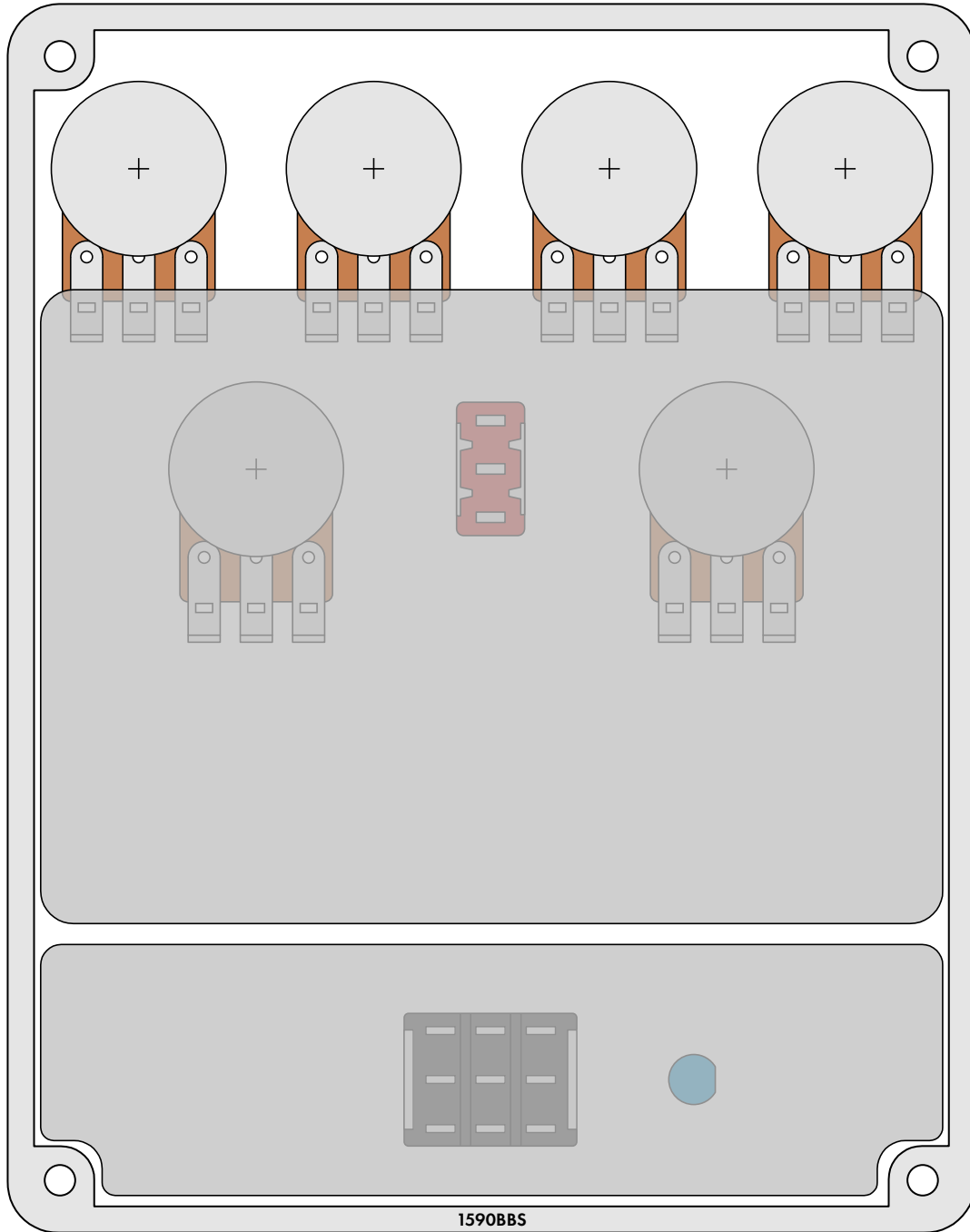
Ensure that this template is printed at 100% or "Actual Size". You can double-check this by measuring the scale on the printed page.

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.

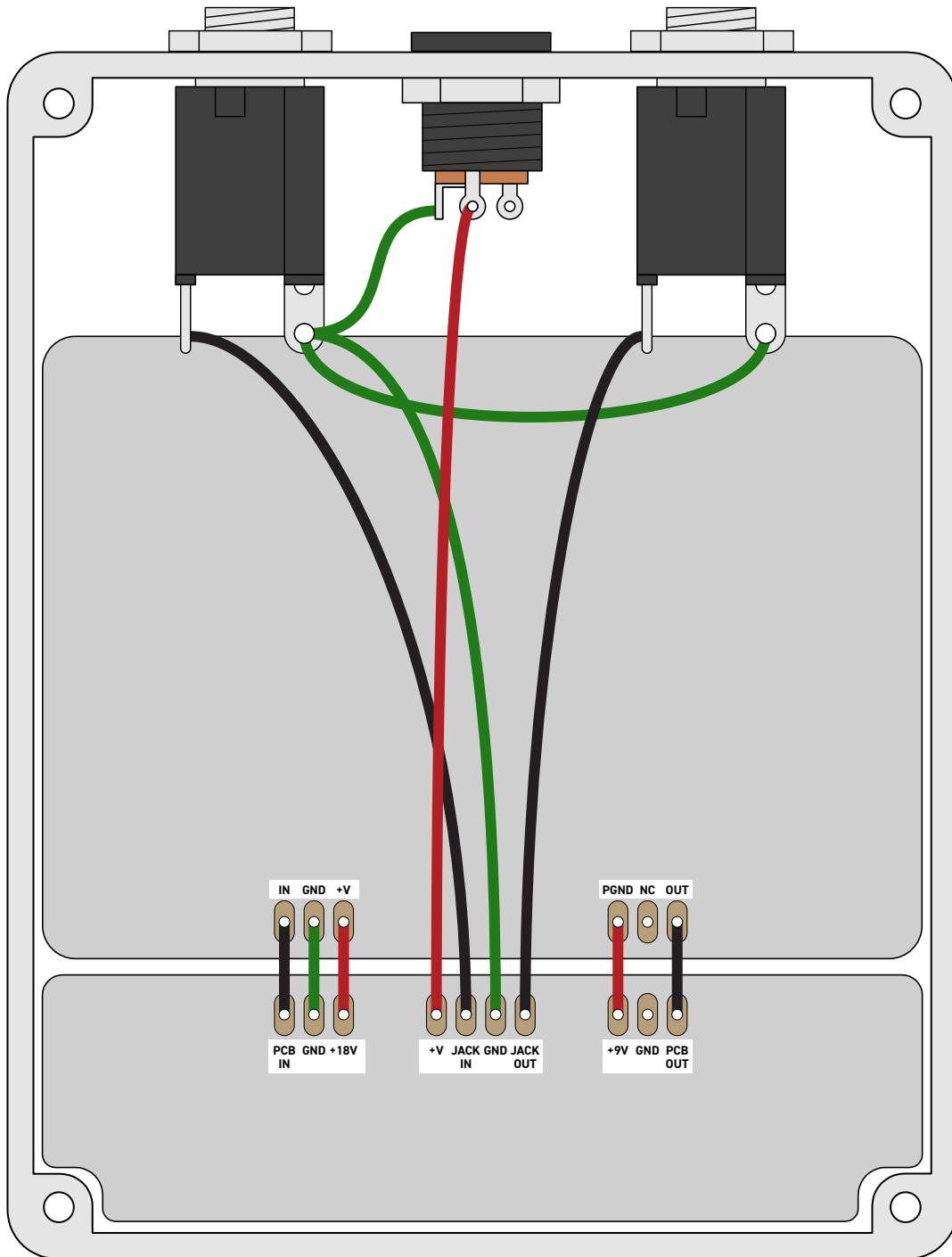


ENCLOSURE LAYOUT

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



WIRING DIAGRAM



LICENSE & USAGE

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

1.0.0 (2022-11-25)

Initial release.