PROJECT NAME

QUARTZ

aion DIY GUITAR EFFECTS

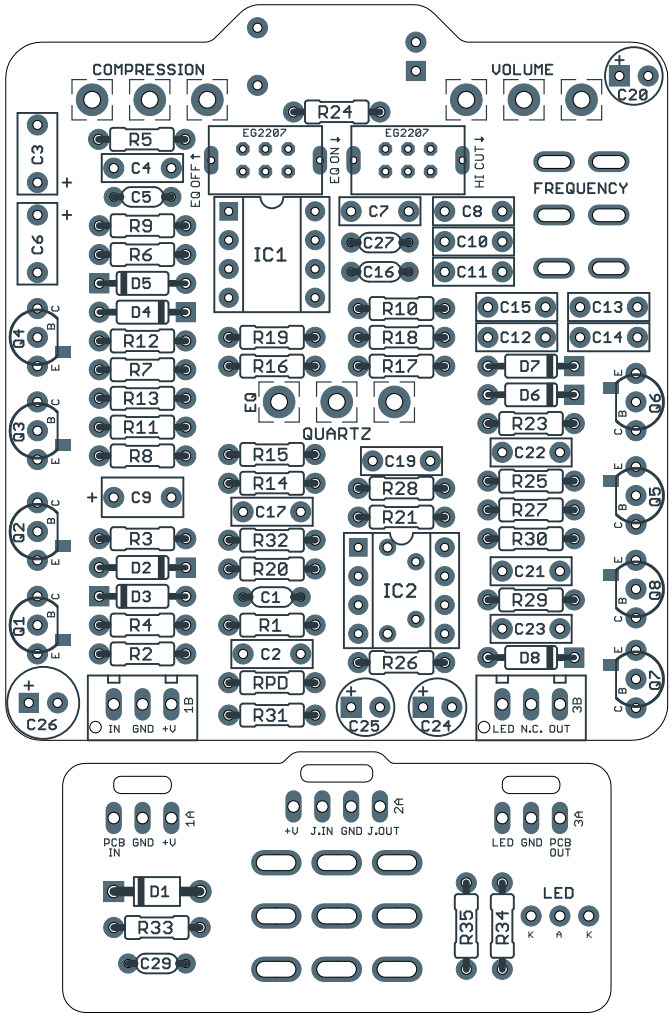
BASED ON
Diamond Compressor

BUILD DIFFICULTY
Intermediate

EFFECT TYPE
Optical compressor

DOCUMENT VERSION
1.0.0 (2024-04-19)

PROJECT SUMMARY
A vintage-inspired optical compressor with an EQ adapted from hi-fi consoles of the 1970s and 80s.



Actual size is 2.3” x 2.55” (main board) and 1.78” x 0.91” (bypass board).

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INTRODUCTION

The Quartz Optical Compressor is based on the Diamond CPR-1 Compressor and BCP-1 Bass Compressor, two vintage-inspired optical compressor pedals that share the same overall schematic.

The original Diamond Compressor was released in 2005. Like other optical compressors, it used an optocoupler for dynamic gain reduction. But the tone control was something never seen before in a pedal: an adaptation of the "Tilt" control from the Quad Model 34 hi-fi preamps of the 1980s, which is similar in usage to the bass/treble pivot of the Big Muff tone control, but refined so that it has a truly flat frequency response in the middle.

The Bass Compressor followed in 2009 after many requests for a bass-specific variant. While the original compressor worked fine on bass, the tone control's pivot frequency was not optimized for the bass guitar's sweet spots. A toggle switch was added to switch between 900 Hz (the value of the original Diamond Compressor) and 250 Hz. The envelope detector circuit was also made more sensitive so it reacts better to bass-specific styles of playing.

In 2020, Diamond Pedals ceased operations and all pedals were discontinued. The brand was later sold to SolidGoldFX, who relaunched new compact versions of Diamond's most popular circuits in 2023. These have been very well received, but are not identical circuits to the original versions.

The Quartz is an adaptation of the original Diamond circuits that allows either the standard or bass version to be built. Our version also adds a third position to the frequency selector, which is a feature in the 2023 compact pedals but not the originals.

USAGE

The Quartz has three knobs and one switch, as well as two internal slide switches.

- **Compression** sets the amount of compression that is applied to the signal.
- **EQ** is a "tilt" control that pans between a low-emphasis/hi-cut on one side and a high-emphasis/low-cut on the other.
- **Volume** is the output volume of the effect.
- **Frequency** (toggle) selects between three different center frequencies for the EQ control.
- **EQ Defeat** (slide switch) allows the EQ to be fully bypassed.
- **Hi Cut** (slide switch) adds a treble-cut filter at 4.8kHz, which reduces noise particularly when followed by overdrive or distortion.

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	475k	Metal film resistor, 1/4W	
R2	100R	Metal film resistor, 1/4W	
R3	22k1	Metal film resistor, 1/4W	
R4	475R	Metal film resistor, 1/4W	
R5	100k	Metal film resistor, 1/4W	
R6	1k	Metal film resistor, 1/4W	
R7	475k	Metal film resistor, 1/4W	
R8	6k81	Metal film resistor, 1/4W	
R9	3k32	Metal film resistor, 1/4W	
R10	10k	Metal film resistor, 1/4W	
R11	100R	Metal film resistor, 1/4W	
R12	22k1	Metal film resistor, 1/4W	
R13	475R	Metal film resistor, 1/4W	
R14	95.3k	Metal film resistor, 1/4W	
R15	47k5	Metal film resistor, 1/4W	
R16	47k5	Metal film resistor, 1/4W	
R17	15k	Metal film resistor, 1/4W	
R18	15k	Metal film resistor, 1/4W	
R19	475k	Metal film resistor, 1/4W	
R20	475k	Metal film resistor, 1/4W	
R21	(jumper)	Metal film resistor, 1/4W	Jumper for guitar version. 47k5 for bass.
R22	(omit)	Metal film resistor, 1/4W	Leave empty (no jumper) for guitar version. 100k for bass.
R23	221k	Metal film resistor, 1/4W	
R24	3k32	Metal film resistor, 1/4W	
R25	100k	Metal film resistor, 1/4W	
R26	475k	Metal film resistor, 1/4W	
R27	100k	Metal film resistor, 1/4W	150k for bass version.
R28	221k	Metal film resistor, 1/4W	470k for bass version.
R29	10k	Metal film resistor, 1/4W	
R30	221k	Metal film resistor, 1/4W	
R31	10k	Metal film resistor, 1/4W	
R32	10k	Metal film resistor, 1/4W	

PARTS LIST, CONT.

PART	VALUE	TYPE	NOTES
R33	47R	Metal film resistor, 1/4W	Power supply filter resistor.
R34	1k5	Metal film resistor, 1/4W	Envelope detector LED resistor. Value depends on LED used.
R35	3k32	Metal film resistor, 1/4W	Bypass LED resistor. Value depends on LED used.
RPD	1M	Metal film resistor, 1/4W	Input pull-down resistor.
C1	100pF	MLCC capacitor, NP0/C0G	
C2	100n	Film capacitor, 7.2 x 2.5mm	
C3	330n	Film capacitor, 7.2 x 2.5mm	Bass version uses 4.7uF. 1uF is OK.
C4	100n	Film capacitor, 7.2 x 2.5mm	
C5	100pF	MLCC capacitor, NP0/C0G	
C6	1uF	Film capacitor, 7.2 x 3.5mm	2.2uF for bass version.
C7	100n	Film capacitor, 7.2 x 2.5mm	
C8	3n3	Film capacitor, 7.2 x 2.5mm	
C9	330n	Film capacitor, 7.2 x 2.5mm	Bass version uses 4.7uF. 1uF is OK.
C10	5n6	Film capacitor, 7.2 x 2.5mm	
C11	5n6	Film capacitor, 7.2 x 2.5mm	
C12	2n7	Film capacitor, 7.2 x 2.5mm	15n for bass version.
C13	5n6	Film capacitor, 7.2 x 2.5mm	
C14	5n6	Film capacitor, 7.2 x 2.5mm	
C15	2n7	Film capacitor, 7.2 x 2.5mm	15n for bass version.
C16	100pF	MLCC capacitor, NP0/C0G	
C17	3n3	Film capacitor, 7.2 x 2.5mm	
C18	(omit)	Film capacitor, 7.2 x 2.5mm	Leave empty (no jumper) for guitar version. 100n for bass.
C19	10n	Film capacitor, 7.2 x 2.5mm	
C20	2.2uF	Electrolytic capacitor, 4mm	
C21	15n	Film capacitor, 7.2 x 2.5mm	
C22	10n	Film capacitor, 7.2 x 2.5mm	
C23	10n	Film capacitor, 7.2 x 2.5mm	
C24	4.7uF	Electrolytic capacitor, 4mm	
C25	47uF	Electrolytic capacitor, 5mm	Power supply filter capacitor.
C26	220uF	Electrolytic capacitor, 6.3mm	Power supply filter capacitor.
C27	100n	MLCC capacitor, X7R	Power supply filter capacitor.
C29	100n	MLCC capacitor, X7R	Power supply filter capacitor.
D1	1N5817	Schottky diode, DO-41	
D2	1N914	Fast-switching diode, DO-35	
D3	1N914	Fast-switching diode, DO-35	
D4	1N914	Fast-switching diode, DO-35	
D5	1N914	Fast-switching diode, DO-35	

PARTS LIST, CONT.

PART	VALUE	TYPE	NOTES
D6	1N914	Fast-switching diode, DO-35	
D7	1N914	Fast-switching diode, DO-35	
D8	1N914	Fast-switching diode, DO-35	
Q1	MPSA18	BJT transistor, NPN, TO-92	
Q2	2N5088	BJT transistor, NPN, TO-92	
Q3	MPSA18	BJT transistor, NPN, TO-92	
Q4	2N5088	BJT transistor, NPN, TO-92	
Q5	2N4401	BJT transistor, NPN, TO-92	
Q6	2N4401	BJT transistor, NPN, TO-92	
Q7	2N5088	BJT transistor, NPN, TO-92	
Q8	2N4401	BJT transistor, NPN, TO-92	
IC1	OP275	Operational amplifier, dual, DIP8	
IC1-S	DIP-8 socket	IC socket, DIP-8	
IC2	LM358	Operational amplifier, dual, DIP8	
IC2-S	DIP-8 socket	IC socket, DIP-8	
EQ DEFEAT	DPDT slide, mini	Slide switch, DPDT, E-Switch EG2207	
HI CUT	DPDT slide, mini	Slide switch, DPDT, E-Switch EG2207	
VACTROL	VTL5C3	Vactrol, fast on/fast off	Available from Aion FX. See build notes.
COMP	100kB	16mm right-angle PCB mount pot	
EQ	50kB	16mm right-angle PCB mount pot	
VOLUME	100kA	16mm right-angle PCB mount pot	
FREQUENCY	DPDT on-off-on	Toggle switch, DPDT center off	
LED	5mm BC-RG-CA	LED, 5mm, bi-color red/green, common anode	Kingbright WP59EGW/CA or Bivar 5BC-3-CA-F
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

Optocoupler selection

The original Diamond Compressor used the VTL5C3 optocoupler (vactrol). These were discontinued by the manufacturer in the early 2010s, but the Xvive reissues perform the same as the originals. They are available from Aion FX as well as several other suppliers.

You can also roll your own optocoupler using an LED and LDR, but many people who have tried this say they weren't able to get it to sound quite right. It's strongly recommended to stick with the VTL5C3.

Note that the optocoupler is installed on the underside of the PCB in order to make room for the I/O jack wiring. It's recommended to install it after all of the other components have been soldered, particularly since R24's pads are pretty close to the underside of the optocoupler and you risk damaging it when soldering the resistor afterward.

Modifying the EQ frequencies

The Quartz has a toggle switch to change between three different center frequency pivot points for the EQ. If you use the suggested values, the center position is stock for the guitar version, which is around 890 Hz. The "down" position reduces it to 600 Hz and the "up" position drops it to 445 Hz.

If you want to modify the center frequency options, C11/C14 and C12/C15 can be changed to different values. There is a fantastic Tilt EQ calculator that lets you plug in different capacitor values to see how it changes the frequency.

For the bass version, we recommend using 15n for one of the capacitor pairs since the original unit had options for 900 Hz and 250 Hz. For the third position, the recommended values in the parts list will get you 445 Hz, but by using the calculator you can modify it as you see fit, even going lower than 250 Hz with capacitors larger than 15n.

Resistor values

The Diamond pedal uses high-precision E96 resistor values such as 3.32k and 47.5k rather than the more common E12 values that we see in most other circuit designs. For this project, we've kept all of these parts the same in the default parts list, and if you're using our Mouser parts list to order parts, you may as well stick with the original values since they all cost the same.

But, if you're building one with parts on hand already, the nearest E12 value will perform the same at any position in the circuit. For example, you can substitute 22k for 22.1k, or 470k for 475k.

Op-amp selection

The OP275 is a very high-quality op-amp, but it comes at a steep price, over USD$6 at the time of this writing. The OPA2134 has almost identical specifications, but it is the same price.

In this circuit, a workhorse op-amp like the TL072 will still perform just fine, so if you'd rather save a few bucks, you probably won't notice an appreciable difference.

For IC2, you will want to use an LM358, no substitutes. This IC is responsible for the envelope detection, and the LM358 is particularly well-suited for this type of application.

Bi-color LED

The original Diamond pedal uses a bi-color LED that is green to show the pedal's active state and adds red when the compressor is active. Bi-color LEDs come in two configurations: common anode (one input, two outputs) and common cathode (two inputs, one output).

The Diamond pedal uses a common-anode LED. The anode receives power from a single source, and then one cathode controls the green color, which is the effect indicator, while the other controls the red color, which indicates compression is happening. We kept the LED functionality the same in this project.

It is not known what brand of LED was used in the original pedal. The Kingbright WP59EGW/CA and Bivar 5BC-3-CA-F seem to be a close match, but in our testing, both colors were overly dim and did not match the original pedal, even when reducing R34 to 1k and R35 to 100R.

It's likely that the original Diamond pedal used a different brand of LED with a higher brightness rating, but we weren't able to find any bi-color LEDs that were brighter than the Kingbright and Bivar, so this is still an open issue that you should be aware of before building the project.

You're welcome to experiment if you want to try to solve it, or see the next section if you want to skip the compression indicator entirely. The main compressor part of the circuit still sounds great, and it's pretty obvious when it is compressing, so it's not strictly necessary to have the LED.

Using a standard bypass LED

If you want to omit the compression indicator, you can use a standard LED. Only the left-most two pads should be used (the "K" pad closest to R34), and the cathode or flat side of the LED should be facing inward toward the footswitch. You can also omit Q7-8, R29-30, R34, D8 and C24.

Bass variant

The bass version shares the same overall schematic, but with several part value changes and a couple of added components. Here are the exact differences:

- C3: 330n → 4.7µF (1µF is OK)
- C6: 1µF → 2.2µF
- C9: 330n → 4.7µF (1µF is OK)
- C12: 2n7 → 15n
- C15: 2n7 → 15n
- C18: omit → 100n
- R21: jumper → 47.5k
- R22: omit → 100k
- R27: 100k → 150k
- R28: 221k → 470k
- R34: 1k5 → 100R
- R35: 3.32k → 6.81k

(continued on next page)

Note that C18 and R22 are located on the underside of the PCB, overlapping IC2. **Make sure to install them before soldering the IC2 socket!**

For C6, there is enough space to use a WIMA 2.2uF film capacitor instead of an electrolytic. For C3 and C9, the 4.7uF value needs to be electrolytic, but you can substitute 1uF film with no change to the tone.

For C3, C6 and C9, the PCB includes polarity markings so that electrolytic capacitors can be used instead of film. Otherwise, the polarity markings should be ignored since film caps are non-polar.

R34 and R35 are the LED resistors, and so they may still require adjustment as mentioned earlier depending on the bi-color LED being used. Presumably R35 was doubled because the bass version is intended to be run at 18V so the LED current remains the same. R34 at 100R is a good idea since the LED doesn't light up much at 1.5k as it is.

18V operation

The bass version of the pedal came with an 18V adapter. According to the user manual for the bass version the pedal works best at this voltage, though it will still operate at 9V. The Quartz project supports the same external 18V provided that C26 (the main filter capacitor) is at least 25V.

Tilt EQ phase response

The Tilt-style EQ is flat in the center position, so theoretically if the knob is at 12:00 there should be no real difference between the EQ defeated (bypassed) or engaged going back and forth on the slide switch. Due to component tolerances, particularly imbalances between the capacitors on each side, there may be some slight measurable differences, but overall it should be indistinguishable.

However, the defeat switch does have one other potentially useful effect. The EQ section inverts the signal, so if the EQ is bypassed, then then pedal is in-phase from input to output. Otherwise, with the EQ engaged, the output is out of phase with the input.

This only makes a difference when using the pedal in a parallel loop with other effects. But since it doesn't have its own clean blend, this is a more likely use case than it would be with most other effects.

Hi cut switch

The hi-cut switch is intended to cut down on white noise by shelving frequencies above 4.8kHz, which is particularly noticeable when using high gain later in the signal chain. It does not have much of an audible difference in the normal audio spectrum. But, if you don't see yourself using it, you can omit the slide switch entirely with no jumpers needed. You can also omit C8 from the PCB in this case.

DESIGN NOTES

The Diamond Compressor sounds truly excellent, but the schematic is a frequent target for criticism from those who have seen the schematic. The designer incorporated several hi-fi audio design practices that do not make any difference at the low voltages and audio levels of a guitar pedal, though they do add significantly to the component cost.

In particular, these choices get the most criticism:

High-end polypropylene capacitors

If you've ever seen a gut shot of an original, you haven't forgotten the massive film capacitors. These are polypropylene, 2% tolerance, and are most often seen in high-end audio equipment.

However, in low-voltage pedal operation, it has been demonstrated time and time again that there is no measurable difference between most good-quality capacitors. (We wrote an article about this if you want to read more.)

Because of this, the PCB layout for our project uses standard 5mm box film capacitors. Don't fall for the trap of thinking the huge polypropylene capacitors are going to make it sound better!

Parallel 820pF capacitors

All of the signal path coupling capacitors (C2, C3, C4, C7 and C9) have 820pF capacitors in parallel. In high-end designs, small-value capacitors are often paired with larger electrolytic capacitors in order to make up for the weaknesses of electrolytics. But when using an MLCC in parallel with a film capacitor, it does nothing more than turn 100nF into 100.82nF.

We omitted these parallel capacitors from the PCB layout, but you can always solder them offboard.

Transistor buffer current sources

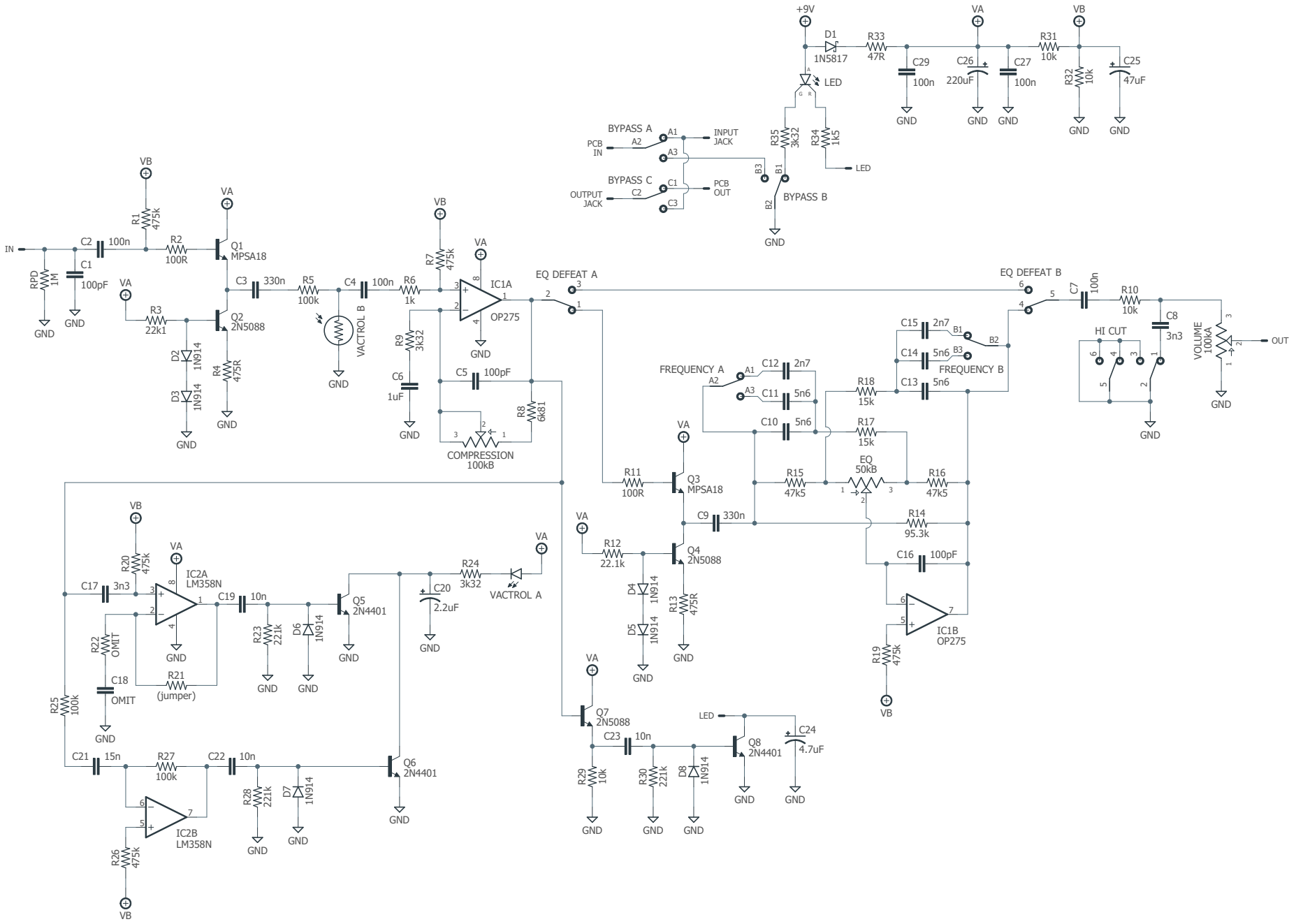
The two transistor buffer stages (Q1 and Q3) use active current sources (Q2 and Q4) in place of standard emitter resistors. This does reduce distortion, but it's reduced from around 0.01% to something like 0.001%. This may be noticeable in an expensive hi-fi stereo, but it's entirely unnecessary for guitar work, since the signal path will almost always have intentional distortion at some point between the guitar and the speakers. Nevertheless, we left these in place for the Quartz project.

Tilt EQ resistors

The tilt EQ control has two "vestigial" resistors bridging the two sides of the EQ pot. This indicates that it was copied part-for-part from the Quad stereo schematics without much analysis. In the original, the junction of these two resistors was connected to a switch, which allowed the EQ to be defeated by essentially switching to a second potentiometer that was fixed to exactly 50%.

The combined resistance does have an impact since it is always in parallel with the EQ control, but it can be replaced with a single resistor if the junction is not connected to anything. We collapsed the two 47.5k resistors into a single 95.3k for this project.

SCHEMATIC


+9V
D1
1N5817
R33
47R
C29
100n
C26
220uF
C27
100n
R31
10k
R32
10k
C25
47uF
LED
VA
VB
GND
BYPASS A
BYPASS C
PCB IN
OUTPUT JACK
INPUT JACK
PCB OUT
BYPASS B
R35
3k32
R34
1k5
IN
C2
100n
C1
100pF
RPD
1M
R1
475k
R2
100R
Q1
MPSA18
R3
22k1
Q2
2N5088
D2
1N914
D3
1N914
R4
475R
C3
330n
R5
100k
VACTROL B
C4
100n
R6
1k
R7
475k
IC1A
OP275
R9
3k32
C6
1uF
C5
100pF
R8
6k81
COMPRESSION
100kB
EQ DEFEAT A
EQ DEFEAT B
C7
100n
R10
10k
C8
3n3
HI CUT
VOLUME
100kA
OUT
C15
2n7
C14
5n6
C13
5n6
FREQUENCY A
FREQUENCY B
C12
2n7
C11
5n6
C10
5n6
R18
15k
R17
15k
EQ
50kB
R15
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R16
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R11
100R
Q3
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C9
330n
R14
95.3k
R12
22.1k
Q4
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D4
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D5
1N914
R13
475R
C16
100pF
IC1B
OP275
R19
475k
C17
3n3
R20
475k
IC2A
LM358N
C19
10n
R23
221k
D6
1N914
Q5
2N4401
R24
3k32
VACTROL A
C20
2.2uF
R22
OMIT
C18
OMIT
R21
(jumper)
R25
100k
C21
15n
R27
100k
C22
10n
R28
221k
D7
1N914
Q6
2N4401
IC2B
LM358N
R26
475k
Q7
2N5088
C23
10n
R29
10k
R30
221k
D8
1N914
Q8
2N4401
C24
4.7uF

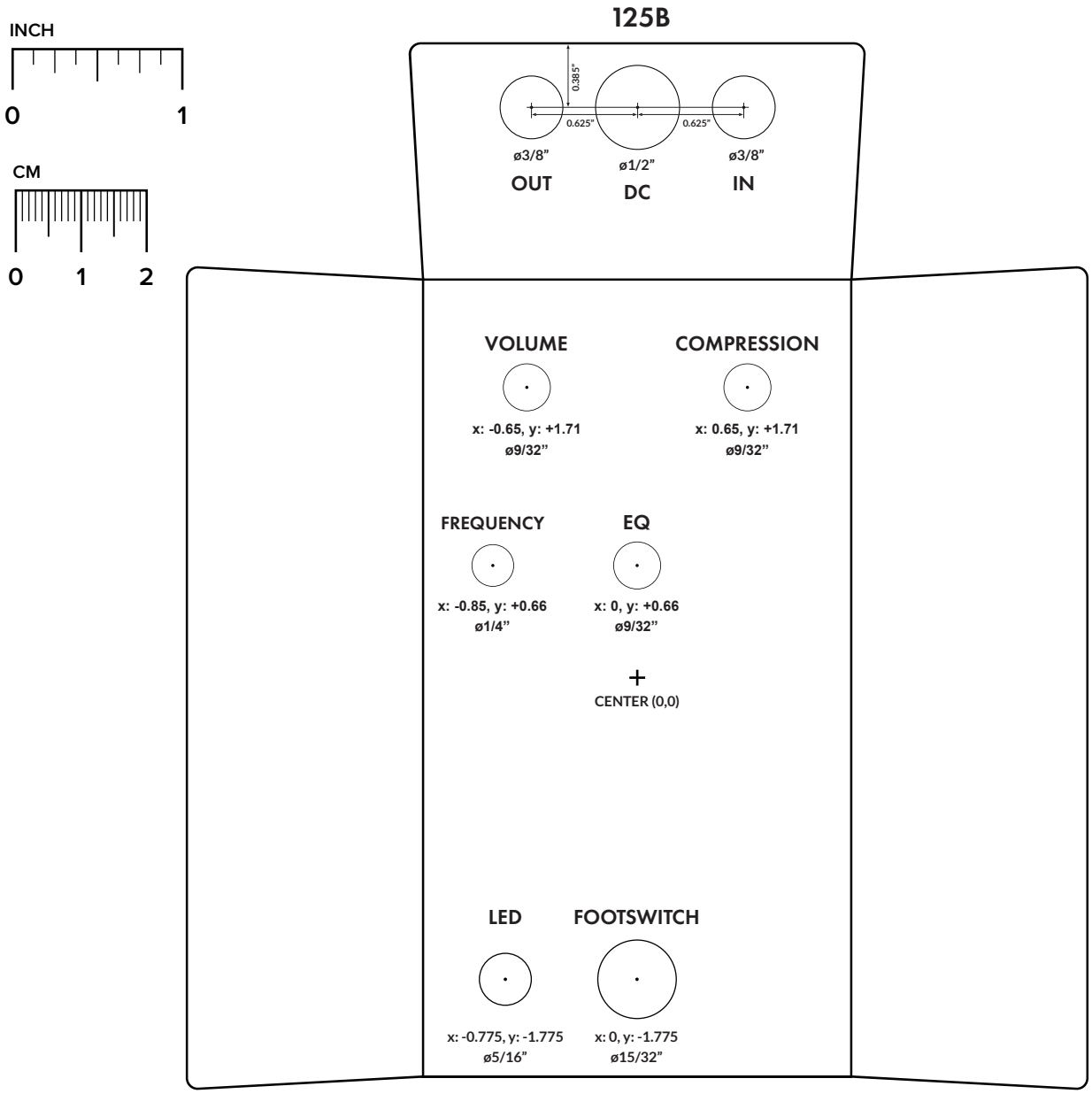
DRILL TEMPLATE

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.

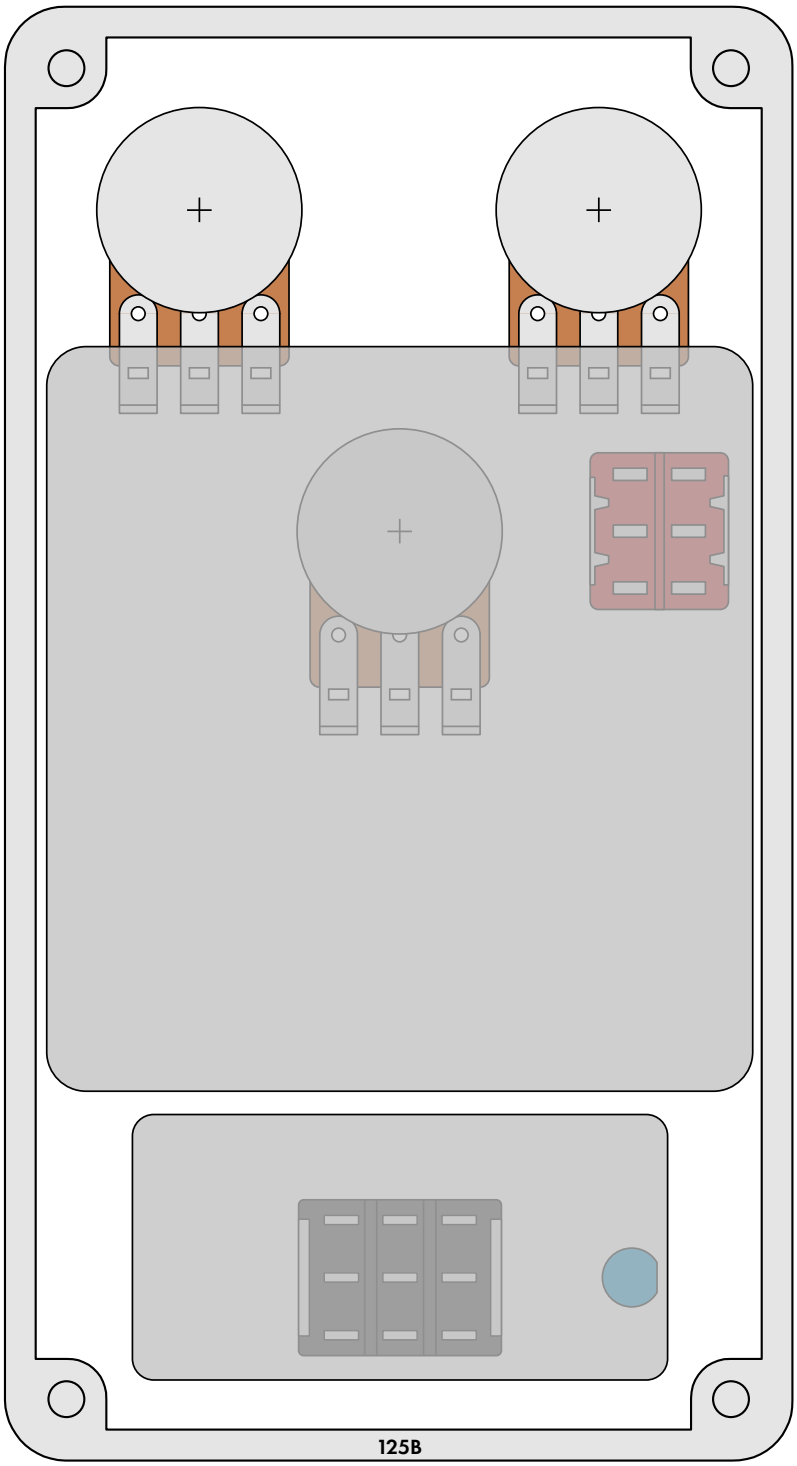
Top jack layout assumes the use of closed-frame jacks like the Switchcraft 111X. If you'd rather use open-frame jacks, please refer to the Open-Frame Jack Drill Template for the top side.

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.

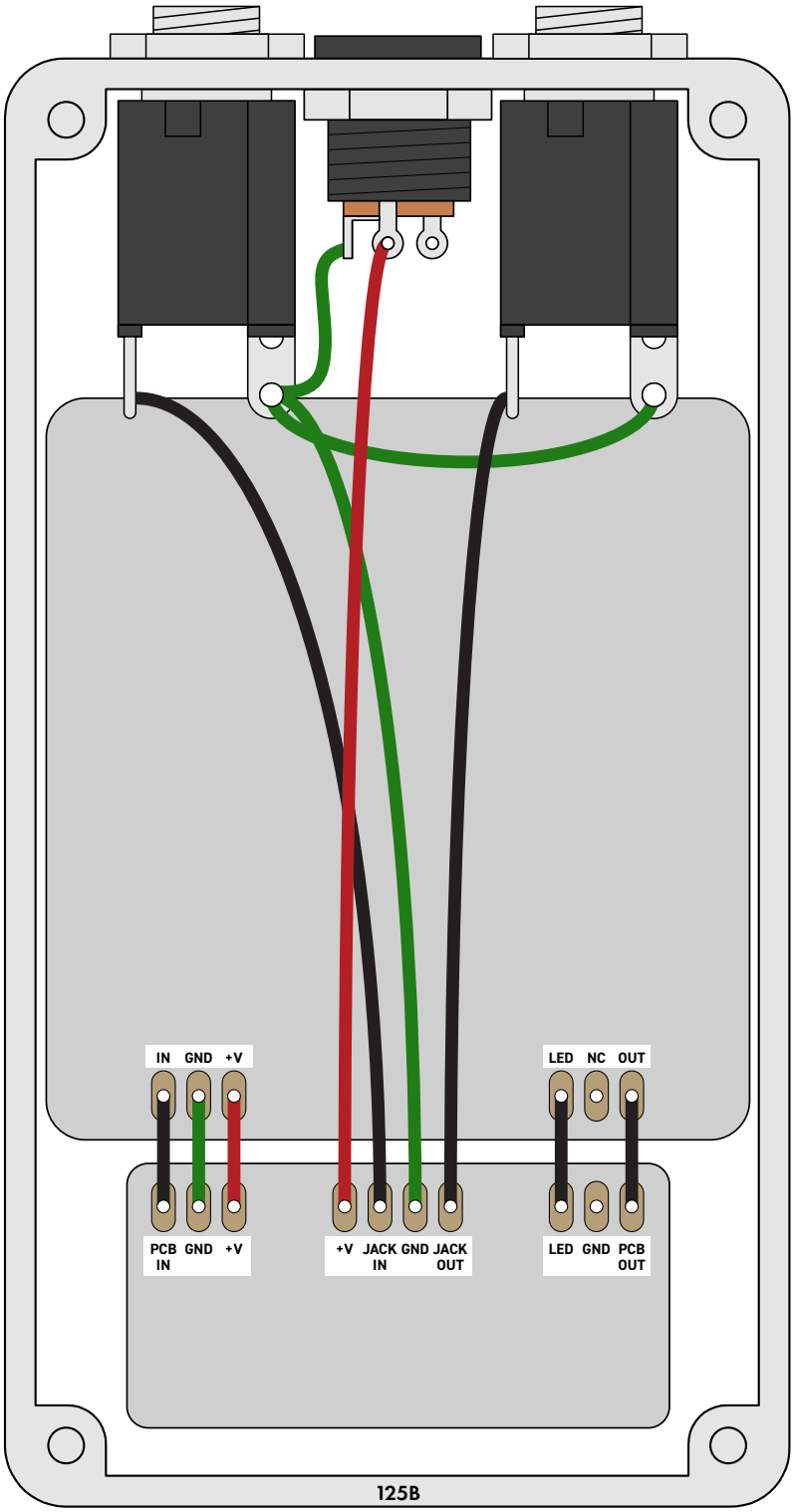


ENCLOSURE LAYOUT

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 (2024-04-19)
Initial release.