



Distortion pedal

12-12-2021

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Version 0.1 DRAFT

I. Version history

Version	Changes
1.0	First version

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1. Product description

The distortion pedal is a guitar effect used to create a distortion effect. It is based on the ProCo Rat distortion pedal from the late 1970s. A pedal analysis reference [1] by Electrosplash is used as a design guideline. A general brief explanation on clipping diodes by Guitarpedalx.com [2] is also used as an information reference.

A custom PCB is designed for the effect. The design consists of 4 stages.

The power stage accepts the standard 9 volts for guitar pedals. It is fused via a PTC 100mA fuse and protected against reverse polarity via a diode. The power stage contains a low pass filter to filter out noise. A voltage divider is used to create 4.5 volts used as a virtual ground for the opamp in the distortion stage.

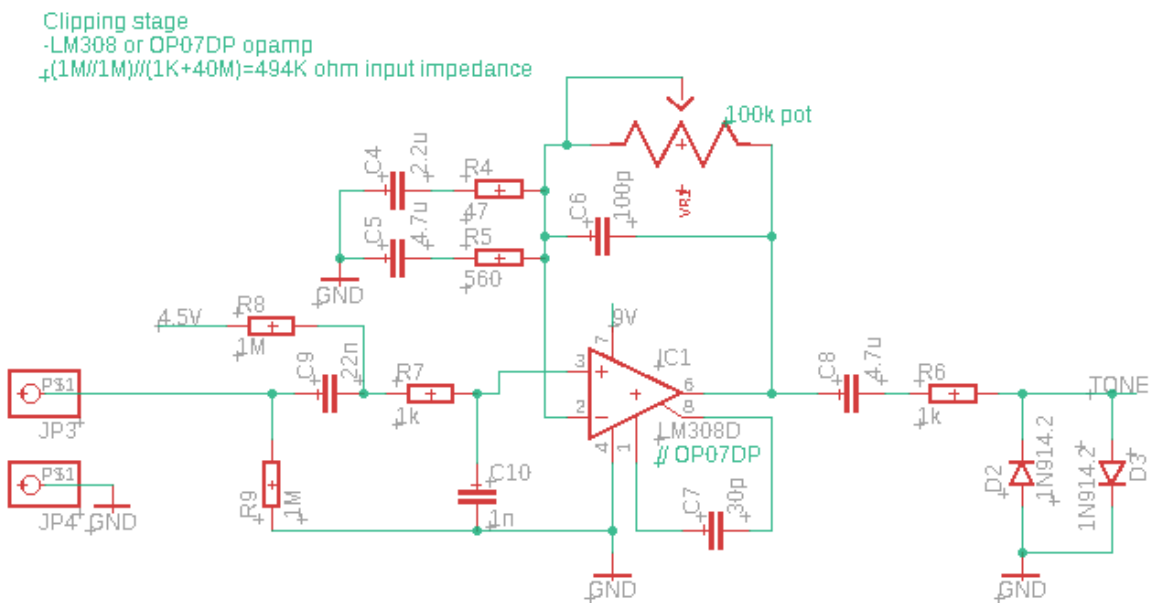
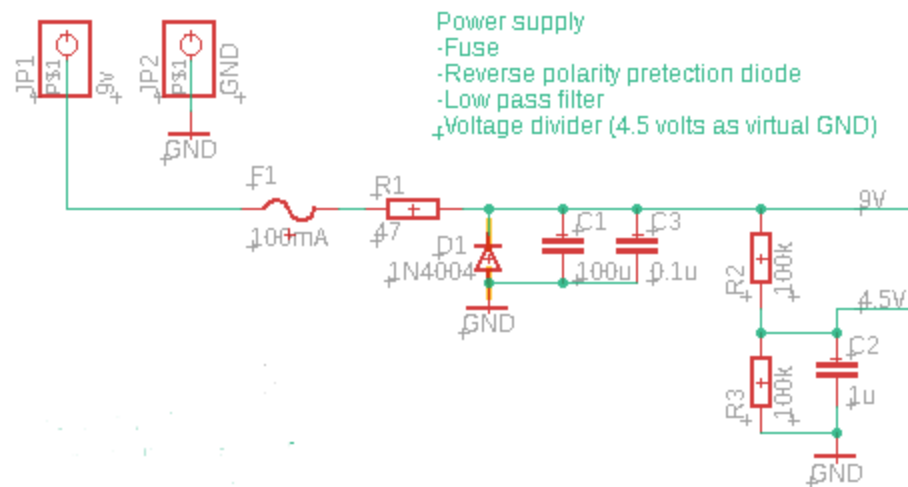
The distortion stage uses a LM308 or OP07D opamp. Clipping diodes are used to create the distorted sounds. A potentiometer can be used to adjust the amount of distortion

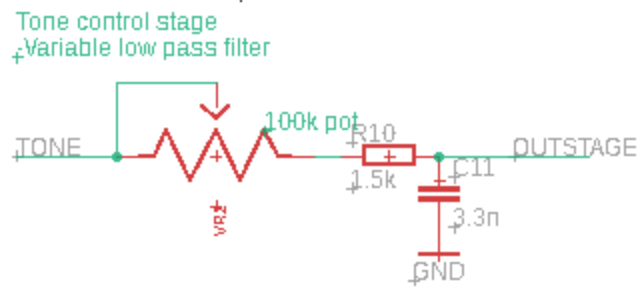
A filter stage consists of a simple low pass filter controlled by the second potentiometer. This potentiometer adjusts the R component in the filter to set the cut off point between about 32KHz and 475Hz. Higher harmonics are filtered out by this stage to differ the tone.

An output power stage is used to create a low output impedance and a volume control that is not affected by the distortion and tone controls. The volume can be adjusted by the third potentiometer.

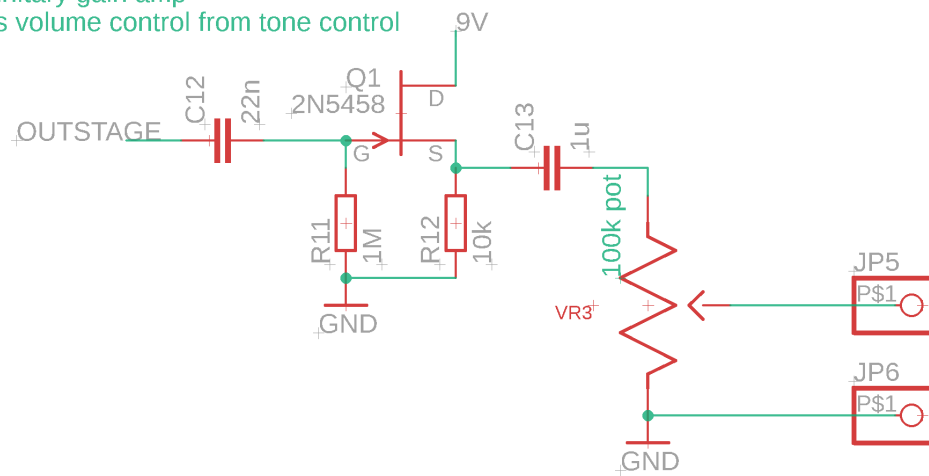
The effect is housed in an aluminum pedal housing. Power can be supplied via a DC 9v barrel jack (center negative). For the audio in- and output 6.35mm mono audio jacks are used. A stomp switch is used to create a true bypass. This is wired according to the schematic "True bypass with LED" by Stinkfoot.se [3].

2. Schematics

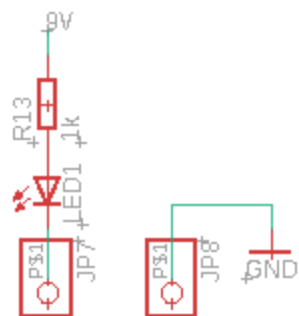




Output stage
-low output impedance
-JFET unitary gain amp
-isolates volume control from tone control



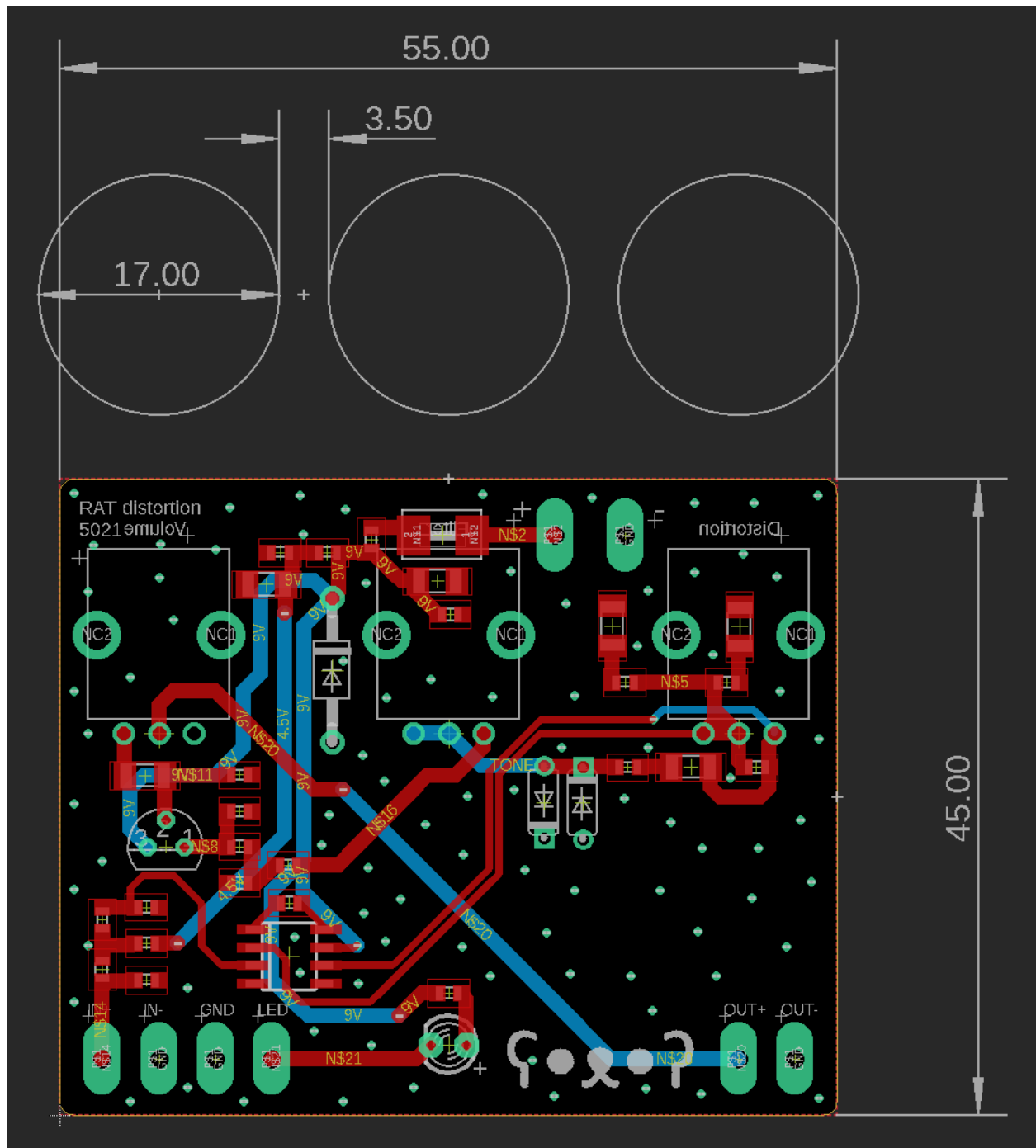
Effect on LED



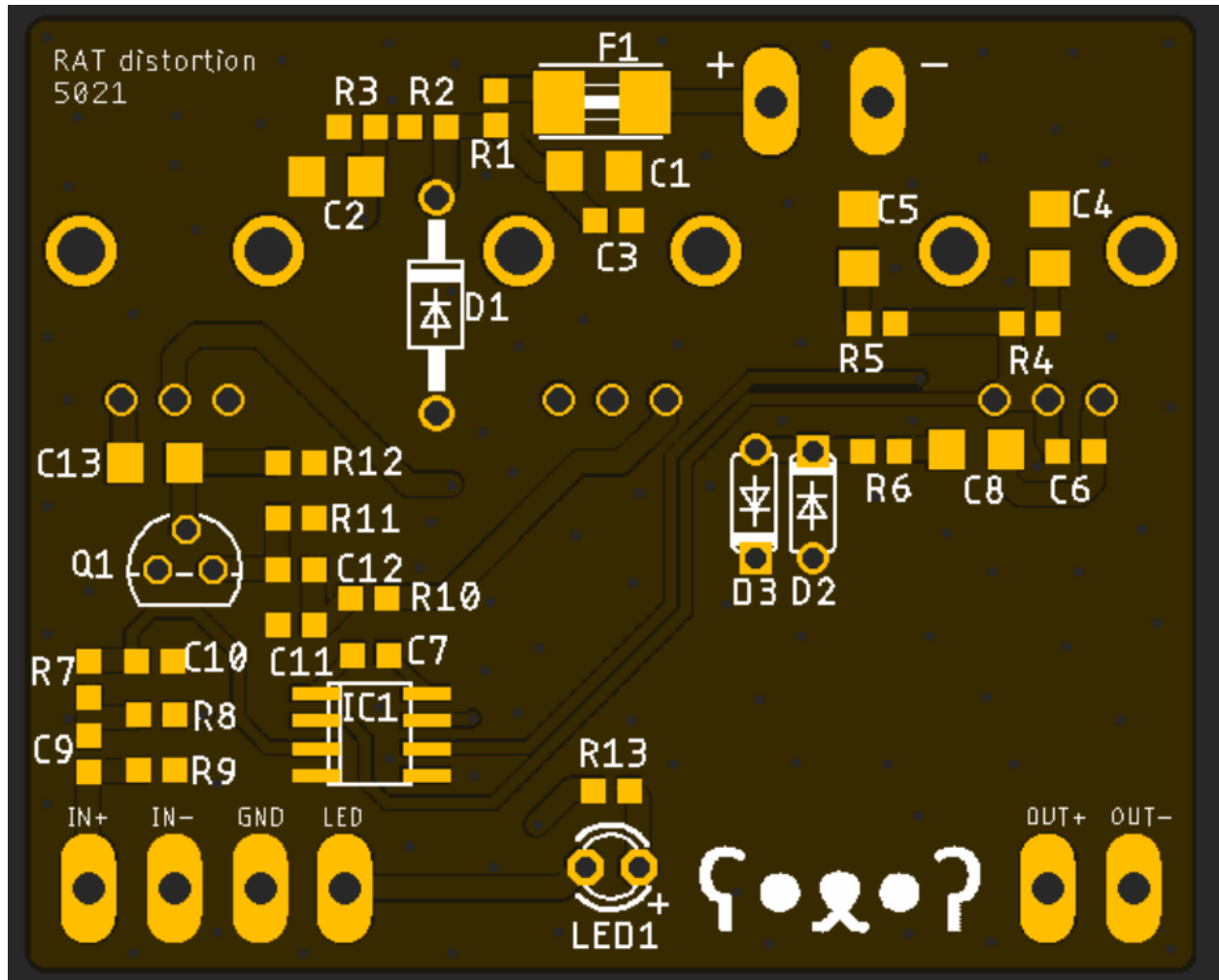
Schema wiring

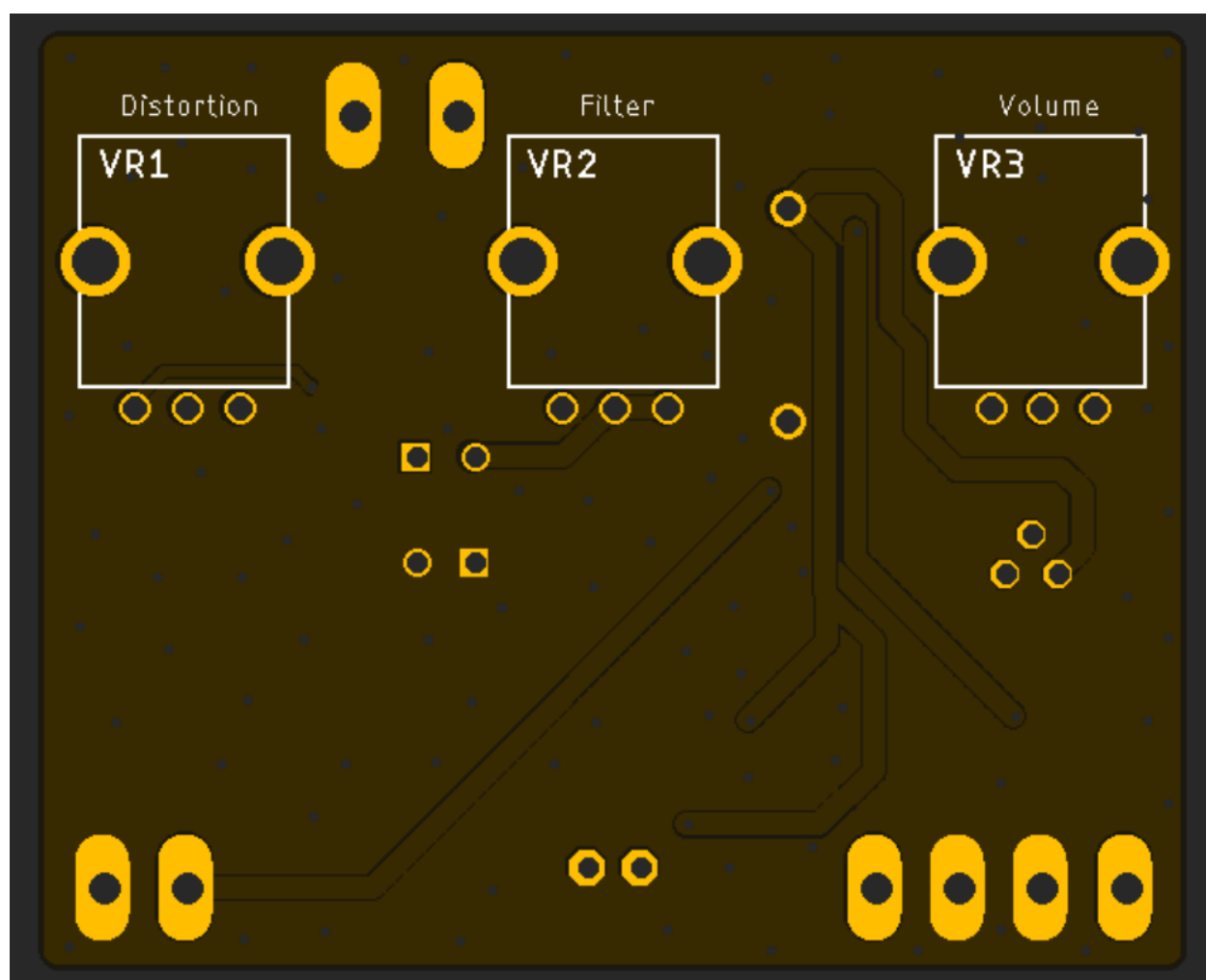
3. PCB layout

The PCB design is as shown in the picture below. The dimensions of the PCB are also shown in the drawing. The circles shown in the dimensions are there to show the space between the potentiometer knobs.



Note: Component number not visible on real PCB



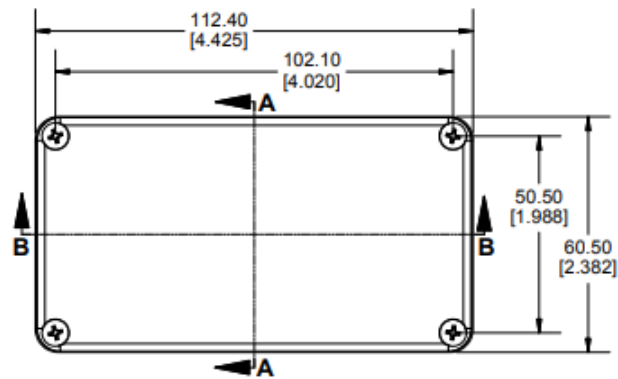


4. Bill of materials

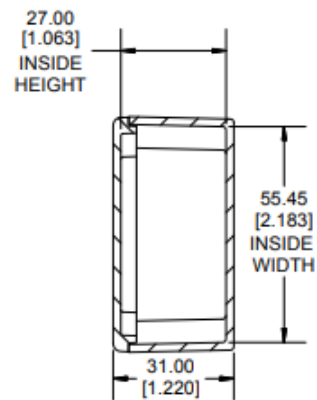
Part number	Device	Footprint	Type / value	Total parts
C1	Capacitor	1206	100uF	1
C2, C13	Capacitor	1206	1uF	2
C3	Capacitor	0603	0.1uF	1
C4	Capacitor	1206	2.2uF	1
C5, C8	Capacitor	1206	4.7uF	2
C6	Capacitor	0603	100pF	1
C7	Capacitor	0603	30pF	1
C9, C12	Capacitor	0603	22nF	2
C10	Capacitor	0603	1nF	1
C11	Capacitor	0603	3.3nF	1
D1	Diode	DO41	1N4004	1
D2, D3	Diode	DO35	1N914	2
F1	PTC fuse	1812	100mA	1
IC1	Opamp	SOP8	LM308d OP07CDR (alternative)	1
Q1	JFET	T092	2N5458	1
LED1	LED	3mm trough hole	3mm LED	1
R1, R4	Resistor	0603	47 ohm	2
R2, R3	Resistor	0603	100k ohm	2
R5	Resistor	0603	560 ohm	1
R6, R7, R13	Resistor	0603	1k ohm	3

R8, R9, R11	Resistor	0603	1M ohm	3
R10	Resistor	0603	1.5k ohm	1
R12	Resistor	0603	10k ohm	1
VR1, VR2, VR3	Potentiometer	PTV09 RK09N (alternative)	100k ohm A (log)	3
Foot switch	Stomp switch	3PDT	3PDT	1
DC in	DC power jack	DC-022	DC-022	1
Audio in, Audio out	Audio jack	6.35mm	6.35mm	2
Housing	Housing	1590B	1590B	1
Pot knobs	Knobs	6mm pot knob	17X13 for 6mm shaft with teeth	3
Wiring	Wire	0.2 mm ²	0.2 mm ²	-
PCB	PCB	45mmx55mm	-	1
Solder paste	Solder	Bi57Sn42Ag1	Bi57Sn42Ag1	-
Solder wire	Solder	Sn60Pb39Cu1	Sn60Pb39Cu1	-
Heatshrink	Heatshrink	-	-	-

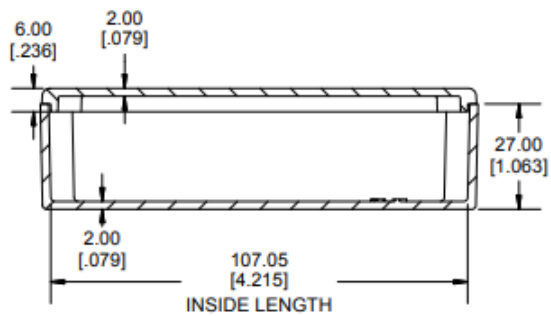
5. Housing dimensions



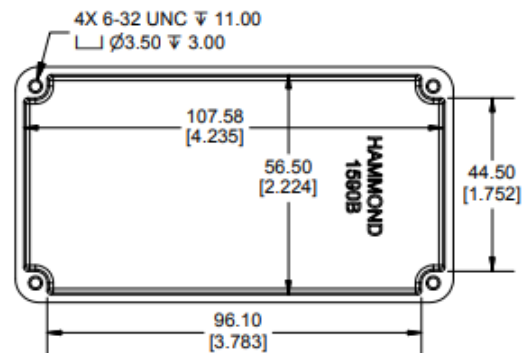
TOP VIEW



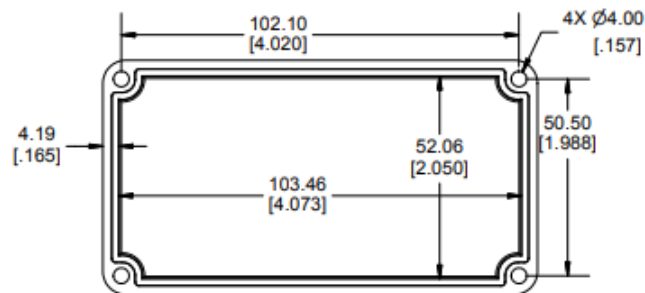
SECTION A-A
END VIEW



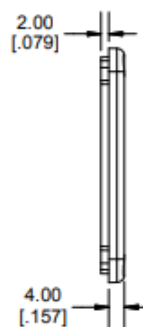
SECTION B-B
SIDE VIEW



INSIDE BOX



INSIDE LID



Dimensions:
mm
[inches]

6. Drill template

7. Development costs

Only the material costs are included in the development costs.

Part number	Device	Type / value	Total parts ordered	Total parts price (€)	Shipping price (€)	Total price incl shipping (€)	Total price per piece (€)	Link (at time of order)	Remark
C1	Capacitor	100uF	-	-	-	-	-	Digikey	From stock
C2, C13	Capacitor	1uF	100	1,03	0,53	1,56	0,02	Aliexpress	
C3	Capacitor	0.1uF	-	-	-	-	-	Digikey	From stock
C4	Capacitor	2.2uF	100	1,19	0,53	1,72	0,02	Aliexpress	
C5, C8	Capacitor	4.7uF	100	1,19	0,53	1,72	0,02	Aliexpress	
C6	Capacitor	100pF	100	0,83	0,53	1,36	0,01	Aliexpress	
C7	Capacitor	30pF	100	0,83	0,53	1,36	0,01	Aliexpress	
C9, C12	Capacitor	22nF	100	0,83	0,53	1,36	0,01	Aliexpress	
C10	Capacitor	1nF	100	0,83	0,53	1,36	0,01	Aliexpress	
C11	Capacitor	3.3nF	100	0,83	0,53	1,36	0,01	Aliexpress	
D1	Diode	1N4004	100	1,17	0,53	1,70	0,02	Aliexpress	
D2, D3	Diode	1N914	50	0,44	2,05	2,49	0,05	Aliexpress	
F1	PTC fuse	100mA	20	0,67	2,11	2,78	0,14	Aliexpress	
IC1	Opamp	OP07CDR	10	1,10	2,31	3,41	0,34	Aliexpress	
Q1	JFET	2N5458	10	2,38	1,93	4,31	0,43	Aliexpress	
LED1	LED	3mm LED	-	-	-	-	-	NA	From stock
R1, R4	Resistor	47 ohm	-	-	-	-	-	Aliexpress	From stock
R2, R3	Resistor	100k ohm	-	-	-	-	-	Aliexpress	From stock
R5	Resistor	560 ohm	-	-	-	-	-	Aliexpress	From stock

R6, R7, R13	Resistor	1k ohm	-	-	-	-	-	Aliexpress	From stock
R8, R9, R11	Resistor	1M ohm	-	-	-	-	-	Aliexpress	From stock
R10	Resistor	1.5k ohm	-	-	-	-	-	Aliexpress	From stock
R12	Resistor	10k ohm	-	-	-	-	-	Aliexpress	From stock
VR1, VR2, VR3	Potentiometer	100k ohm A (log) RK097N	10	7,65	0,00	7,65	0,77	Aliexpress	RK097N with 6mm shaft with teeth, other types may fit
Foot switch	Stomp switch	3PDT	3	2,88	3,13	6,01	2,00	Aliexpress	
DC in	DC power jack	DC-022	10	2,09	1,44	3,53	0,35	Aliexpress	
Audio in, Audio out	Audio jack	6,35mm	10	4,89	0,00	4,89	0,49	Aliexpress	
Housing	Housing	1590B	2	14,36	1,71	16,07	8,04	Aliexpress	
Pot knobs	Knobs	17x13mm for 6mm shaft with teeth	6	3,81	3,86	7,67	1,28	Aliexpress	
Wiring	Wire	0.2 mm ²	-	-	-	-	-	Conrad	From stock
PCB	PCB	2 layer	5	11,75	14,27	26,02	5,20	JLCPCB	Custom ordered
SMD Stencil	SMD Stencil	-	1	-	-	-	-	JLCPCB	Custom ordered, included in PCB costs
Solder paste	Solder	Bi57Sn42-Ag1	-	-	-	-	-	Digikey	From stock
Solder wire	Solder	Sn60Pb39-Cu1	-	-	-	-	-	NA	From stock

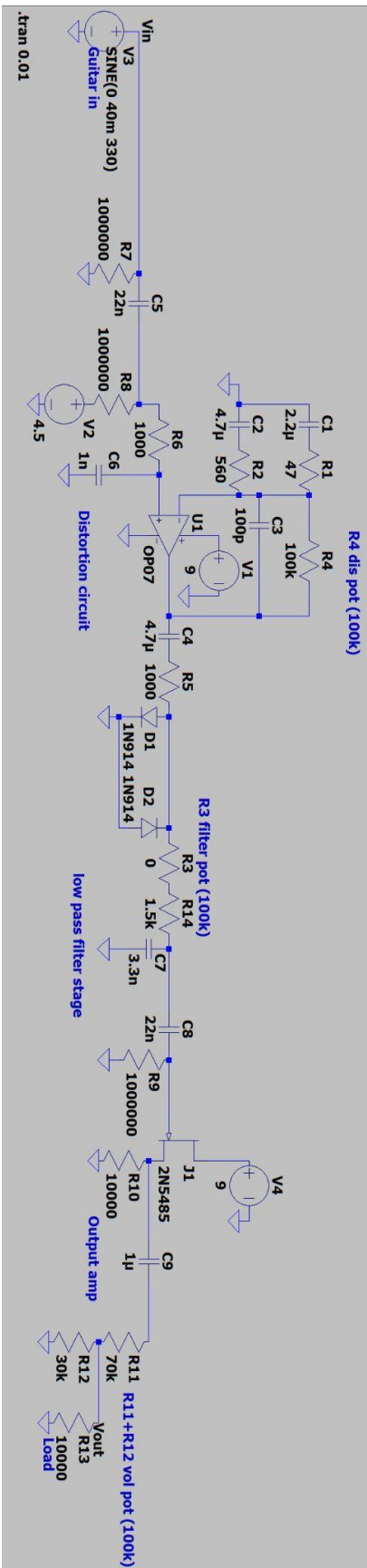
Heat-shrink	Heat-shrink	-	-	-	-	-	-	Aliexpress	From stock
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Total development parts costs including shipping is €98,33 excluding items from stock.

8. Tests

The effect is simulated in LTspice XVII (see drawing on next page) to confirm the correct behavior from the pedal. The opamp used in the simulation is the OP07. The output JFET is replaced with a 2N5485. This should not impact the results.

The tests are done with a 40mV sine wave at 80Hz and 300Hz frequencies. A 10k ohm resistor is used as a load in both the simulation and real tests.



- 8.1. Low distortion 80Hz
- 8.2. High distortion 80Hz
- 8.3. Low distortion 300Hz
- 8.4. High distortion 300Hz
- 8.5. Volume 0%
- 8.6. Volume 50%
- 8.7. Volume 100%
- 8.8. Tone control low
- 8.9. Tone control high

9. Used sources

[1] Electrosmash.com. 2013. *ElectroSmash - ProCo Rat Analysis*. [online] Available at: <<https://www.electrosmash.com/proco-rat>> [Accessed 10 December 2021].

[2] Karlsson, S., 2020. *A Brief Hobbyist Primer on Clipping Diodes*. [online] Guitarpedalx.com. Available at: <<https://www.guitarpedalx.com/news/news/a-brief-hobbyist-primer-on-clipping-diodes>> [Accessed 15 December 2021].

[3] Stinkfoot.se. 2014. *True bypass wiring schemes*. [online] Available at: <<https://stinkfoot.se/archives/2233>> [Accessed 10 December 2021].