Distortion pedal

12-12-2021

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Version 0.1 DRAFT

I. Version history

Version	Changes
1.0	First version

II. Table of contents

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 Electrosmash is used as a design guideline.

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.

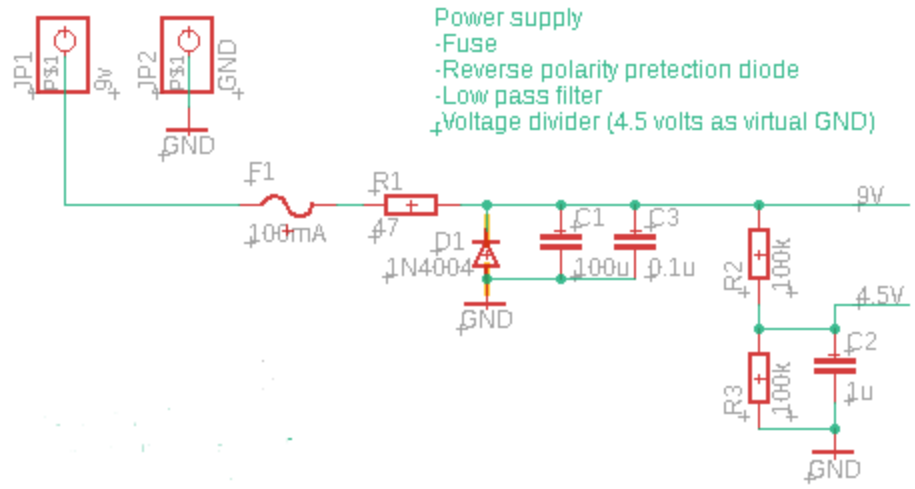
The distortion stage uses a LM308 or OP07D opamp. Clipping diodes are used to create the distorted sounds. A potentiometer can be used to adjust the amount of distortion

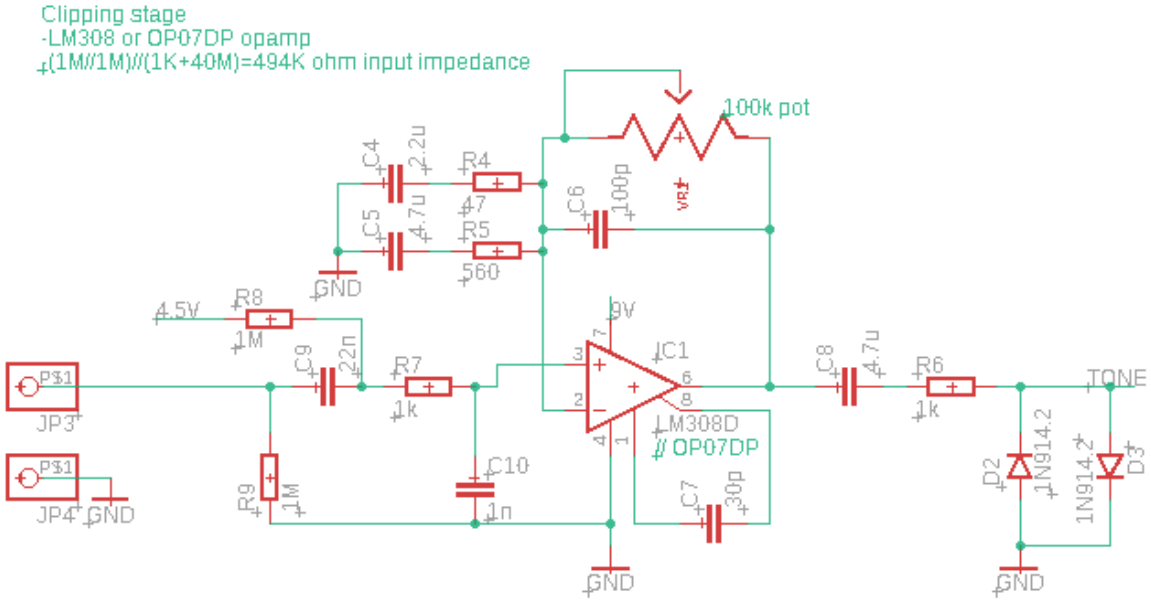
A filter stage consists of a simple low pass filter controlled by the potentiometer to set the cut off point between about 32KHz and 475Hz. Higher harmonics are filtered by this stage to differ the tone.

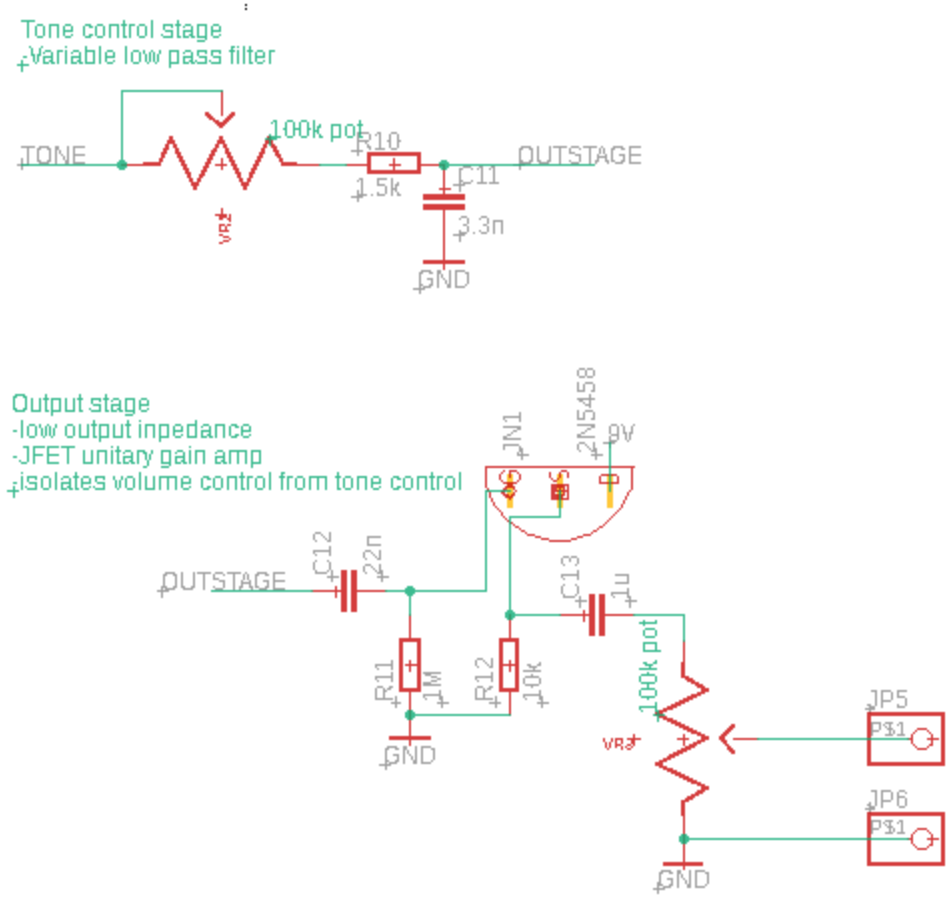
An output power stage is used to create a low output impedance and a volume control that is not affected by the distortion and tone controls. The volume can be adjusted by the third potentiometer.

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 [2].

2. Schematics







Schema wiring

3. PCB layout

PCB ontwerp

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.

PCB front met nummers

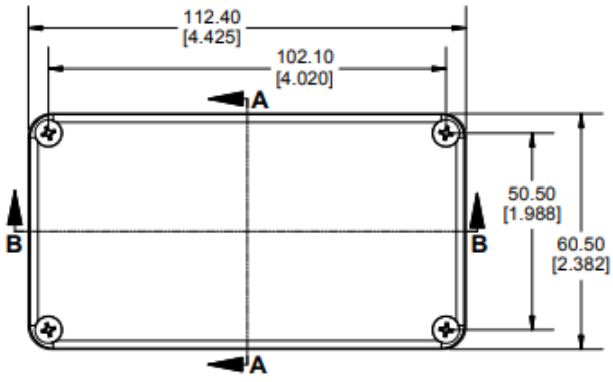
PCB back met nummers

4. Bill of materials

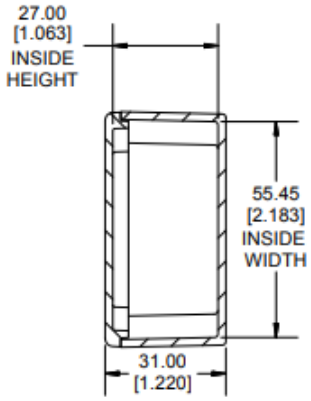
Part number	Device	Footprint	Type / value	Total parts
C1	Capacitor	1206	100uF	1
C2, C13	Capacitor	1206	1uF	2
C3	Capacitor	0603	0.1uF	1
C4	Capacitor	1206	2.2uF	1
C5, C8	Capacitor	1206	4.7uF	2
C6	Capacitor	0603	100pF	1
C7	Capacitor	0603	30pF	1
C9, C12	Capacitor	0603	22nF	2
C10	Capacitor	0603	1nF	1
C11	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
JN1	JFET	TO92	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	-	1
DC in	DC power jack	Barrel jack	-	1
Audio in, Audio out	Audio jack	6.35mm	-	2
Housing	Housing	1590B	1590B	1
Pot knobs	Knobs	6mm pot knob	-	3
Wiring	Wire	Wire	Some wire	-
PCB	PCB	45mmx55mm	-	1

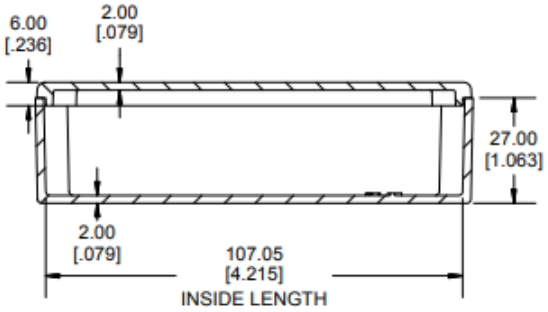
5. Housing dimensions



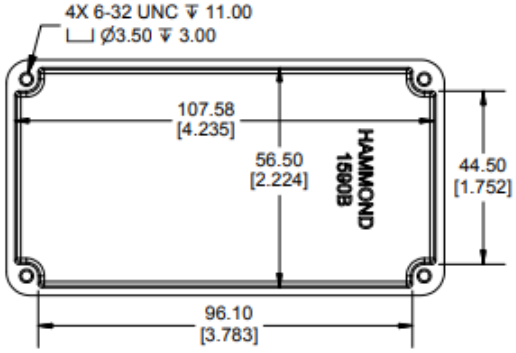
TOP VIEW



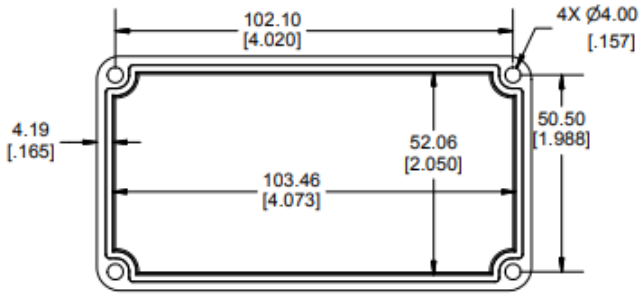
SECTION A-A
END VIEW



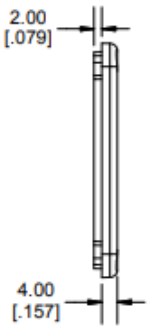
SECTION B-B
SIDE VIEW



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	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	
JN1	JFET	2N5458	10	2,38	1,93	4,31	0,43	Aliexpress	
LED1	LED	3mm LED	-	-	-	-	-	-	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

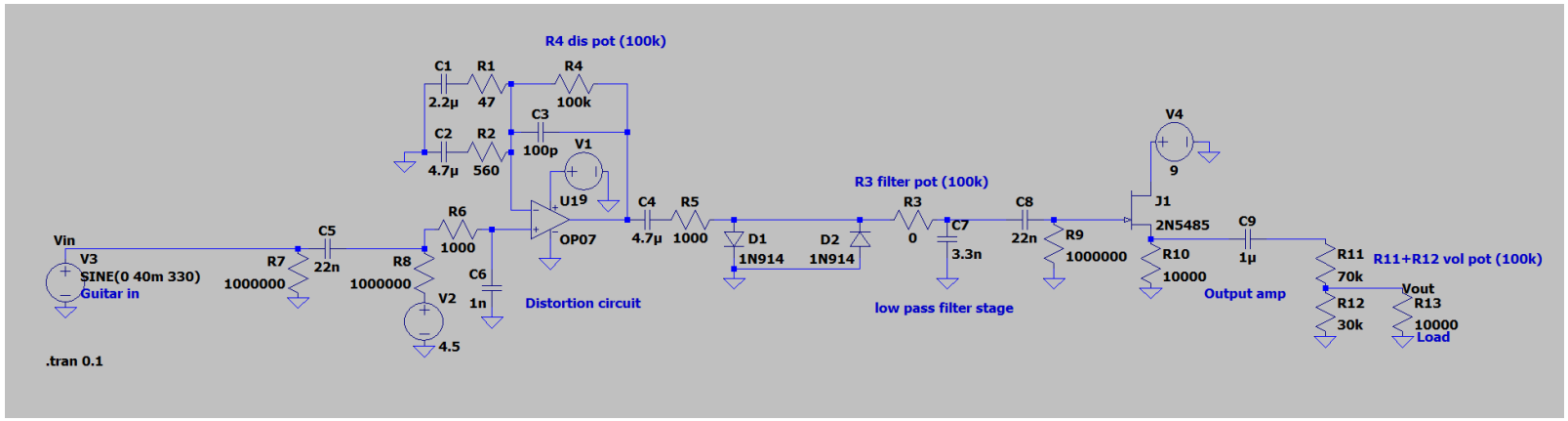
R6, R7, R13	Resistor	1k ohm	-	-	-	-	-	Aliexpress	From stock
R8, R9, R11	Resistor	1M ohm	-	-	-	-	-	Aliexpress	From stock
R10	Resistor	1.5k ohm	-	-	-	-	-	Aliexpress	From stock
R12	Resistor	10k ohm	-	-	-	-	-	Aliexpress	From stock
VR1, VR2, VR3	Potentio meter	100k ohm A (log)	10	7,65	0,00	7,65	0,77	Aliexpress	
Foot switch	Stomp switch	-	3	2,88	3,13	6,01	2,00	Aliexpress	
DC in	DC power jack	-	10	2,09	1,44	3,53	0,35	Aliexpress	
Audio in, Audio out	Audio jack	-	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	-	6	3,81	3,86	7,67	1,28	Aliexpress	
Wiring	Wire	Some wire	-	-	-	-	-	-	From stock
PCB	PCB	2 layer						PCBWay	Custom ordered
SMD Stencil	SMD Stencil	-						PCBWay	Custom ordered

Total development parts costs including shipping is €68,97 excluding items from stock.

8. Tests

The effect is simulated in LTspice XVII 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.


R4 dis pot (100k)
C1
2.2µ
R1
47
R4
100k
C3
100p
C2
4.7µ
R2
560
V1
U19
OP07
R6
1000
C4
4.7µ
R5
1000
R3 filter pot (100k)
R3
0
C7
3.3n
C8
22n
V4
9
J1
2N5485
R9
1000000
R10
10000
C9
1µ
R11
70k
R12
30k
R11+R12 vol pot (100k)
Vout
R13
10000
Load
Vin
V3
SINE(0 40m 330)
Guitar in
R7
1000000
C5
22n
R8
1000000
C6
1n
V2
4.5
D1
1N914
D2
1N914
Distortion circuit
low pass filter stage
Output amp
.tran 0.1

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

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