



# RAT distortion pedal

29-01-2022

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Version 1.0

## 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 Electrosmash 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.

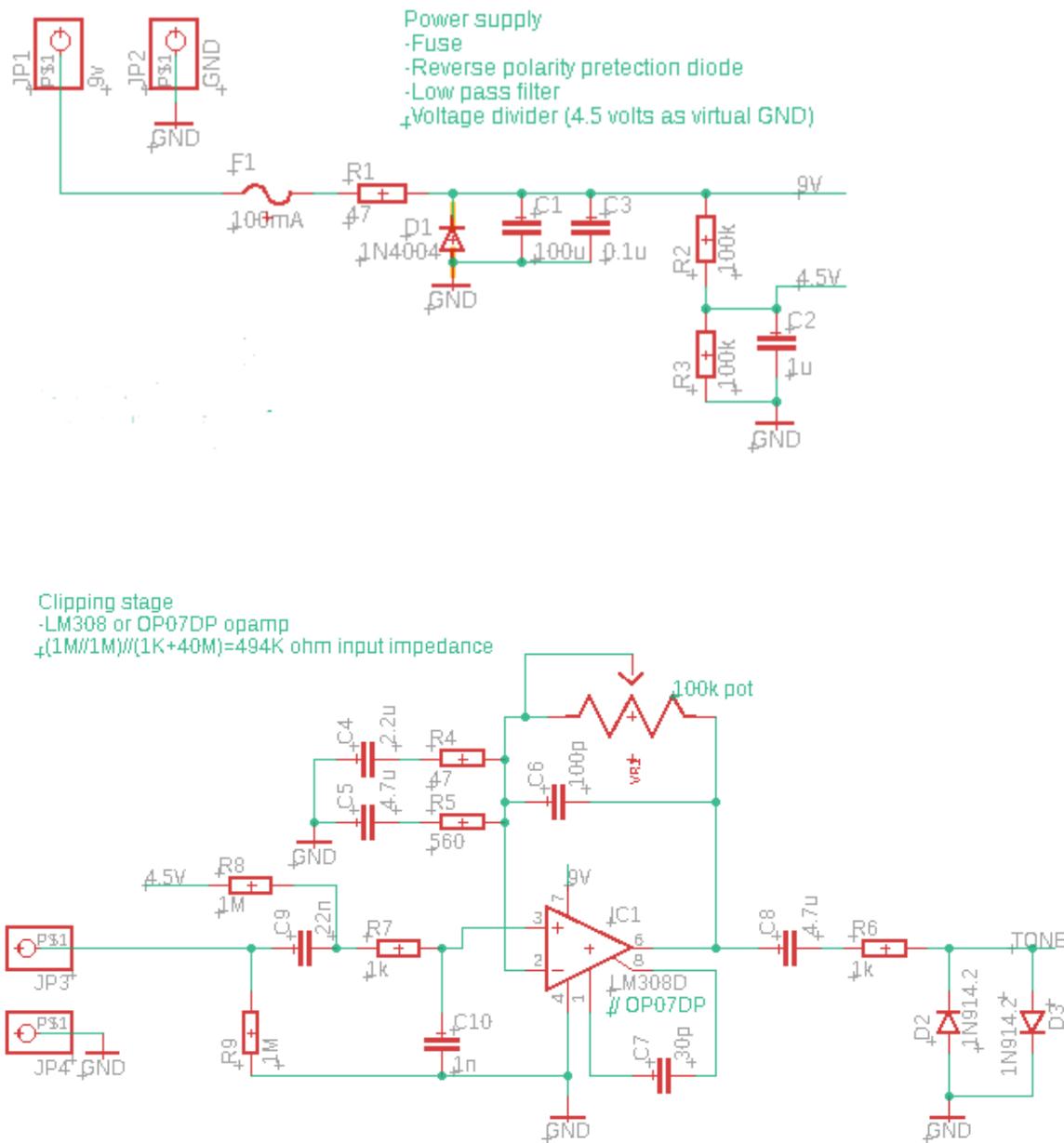
The distortion stage uses a LM308 or OP07D opamp. Clipping diodes are used to create the distorted sounds. A potentiometer can be used to adjust the amount of distortion

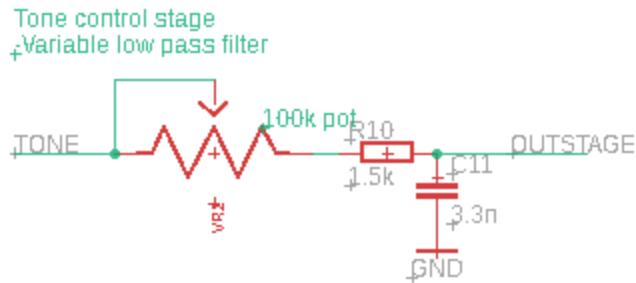
A filter stage consists of a simple low pass filter controlled by the second potentiometer. This potentiometer adjusts the R component in the filter to set the cut off point between about 32KHz and 475Hz. Higher harmonics are filtered out by this stage to differ the tone.

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.

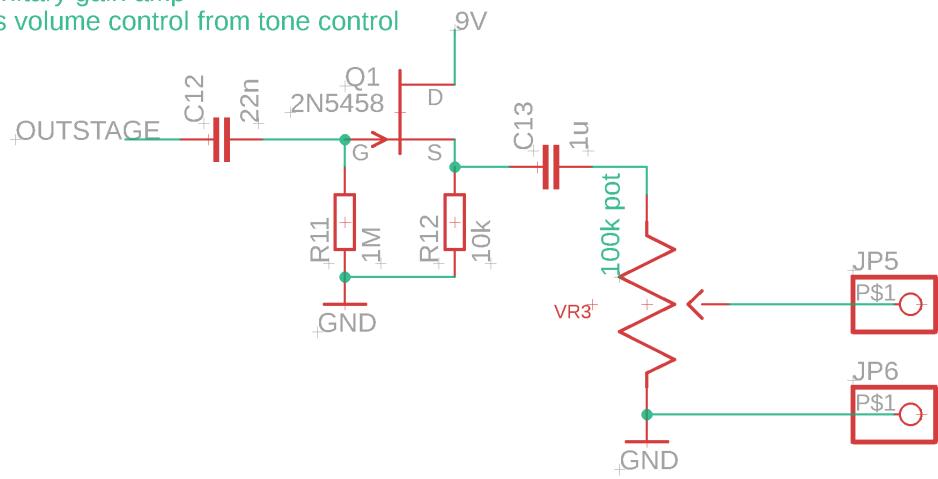
The effect is housed in an aluminum pedal housing. Power can be supplied via a DC 9v barrel jack (center negative). For the audio in- and output 6.35mm mono audio jacks are used. A stomp switch is used to create a true bypass. This is wired according to the schematic "True bypass with LED" by Stinkfoot.se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

## 2. Schematics

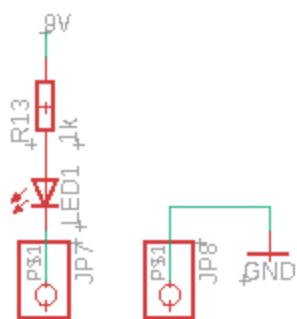


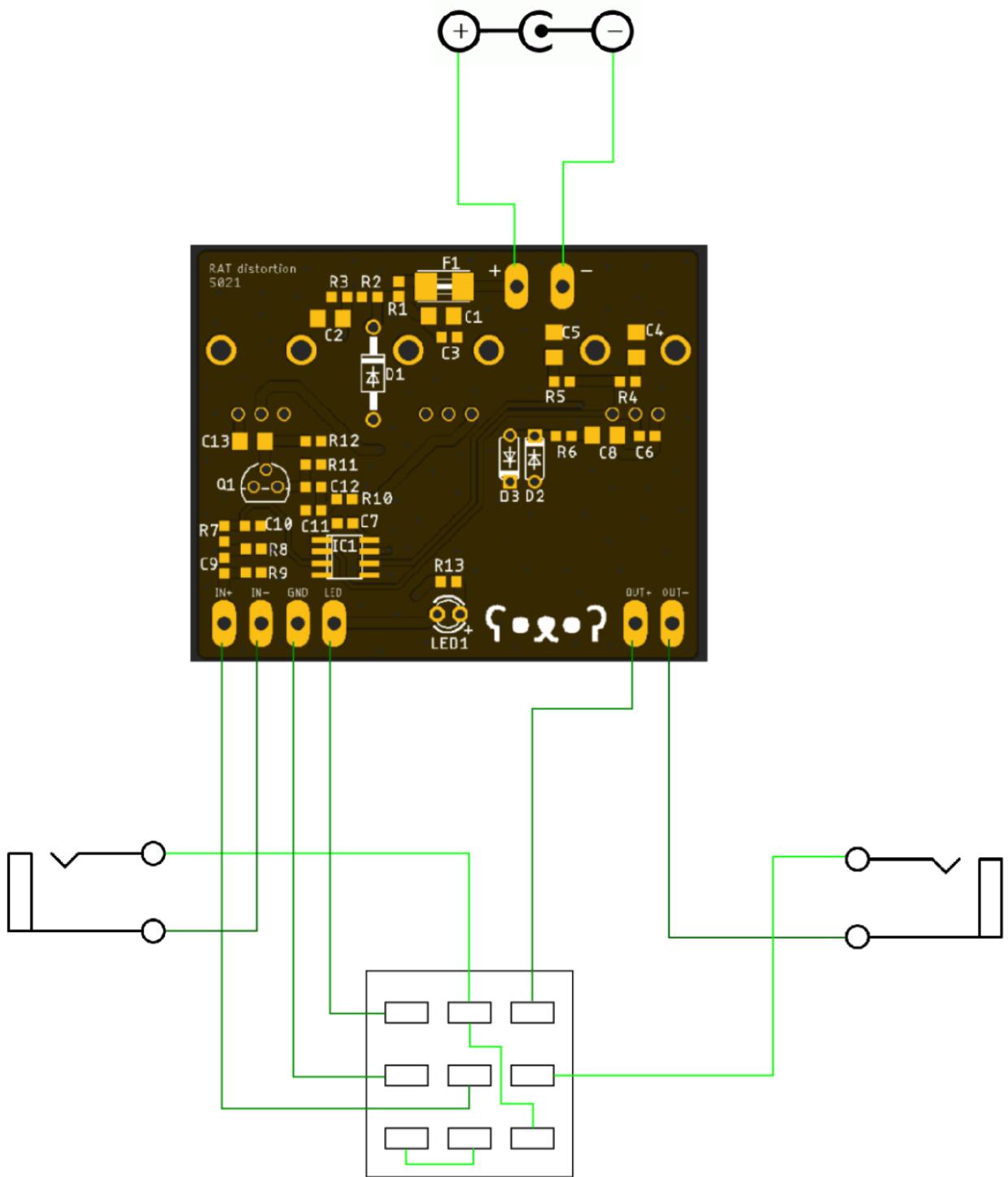


Output stage  
-low output impedance  
-JFET unitary gain amp  
↳ isolates volume control from tone control



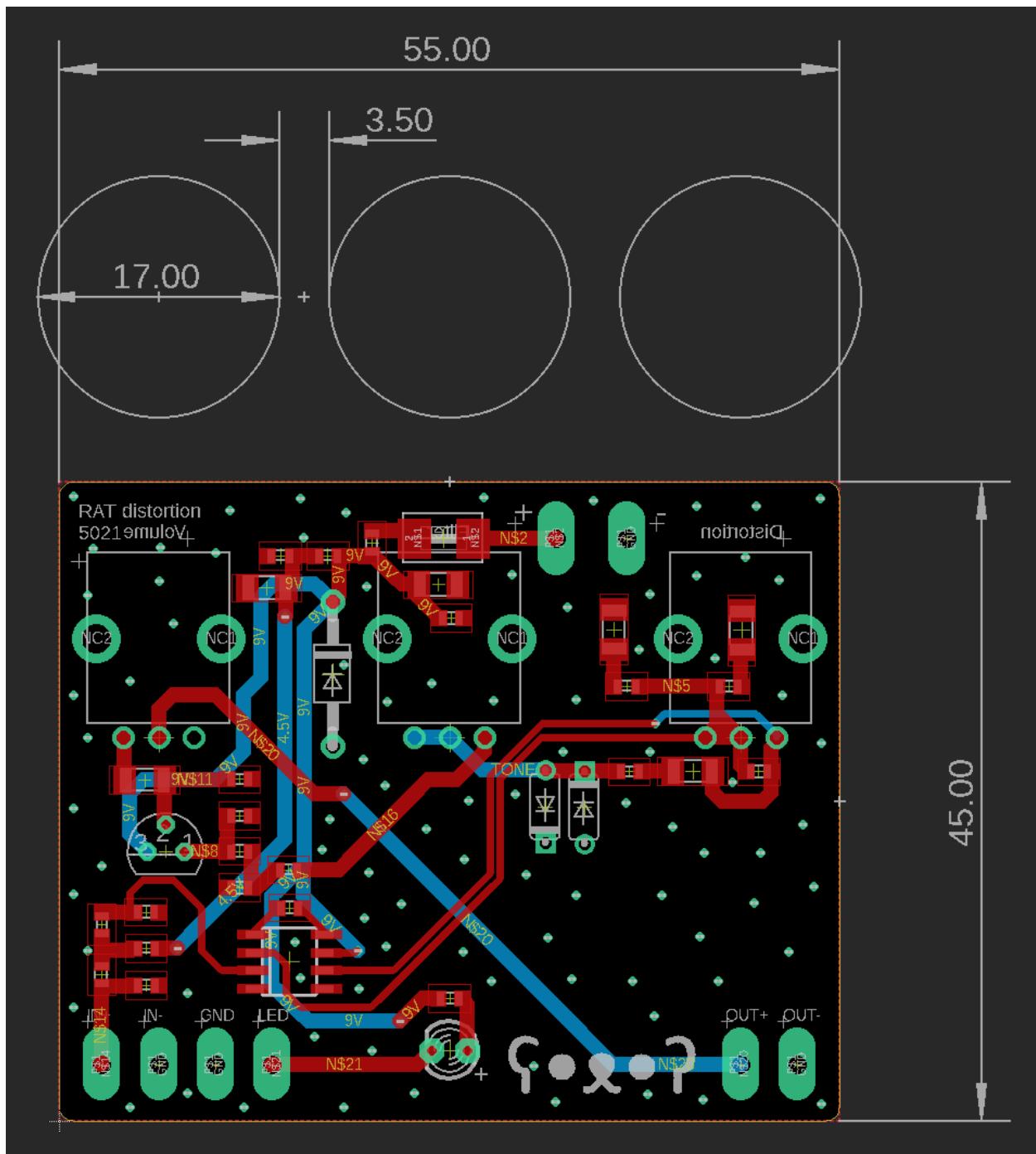
Effect on LED



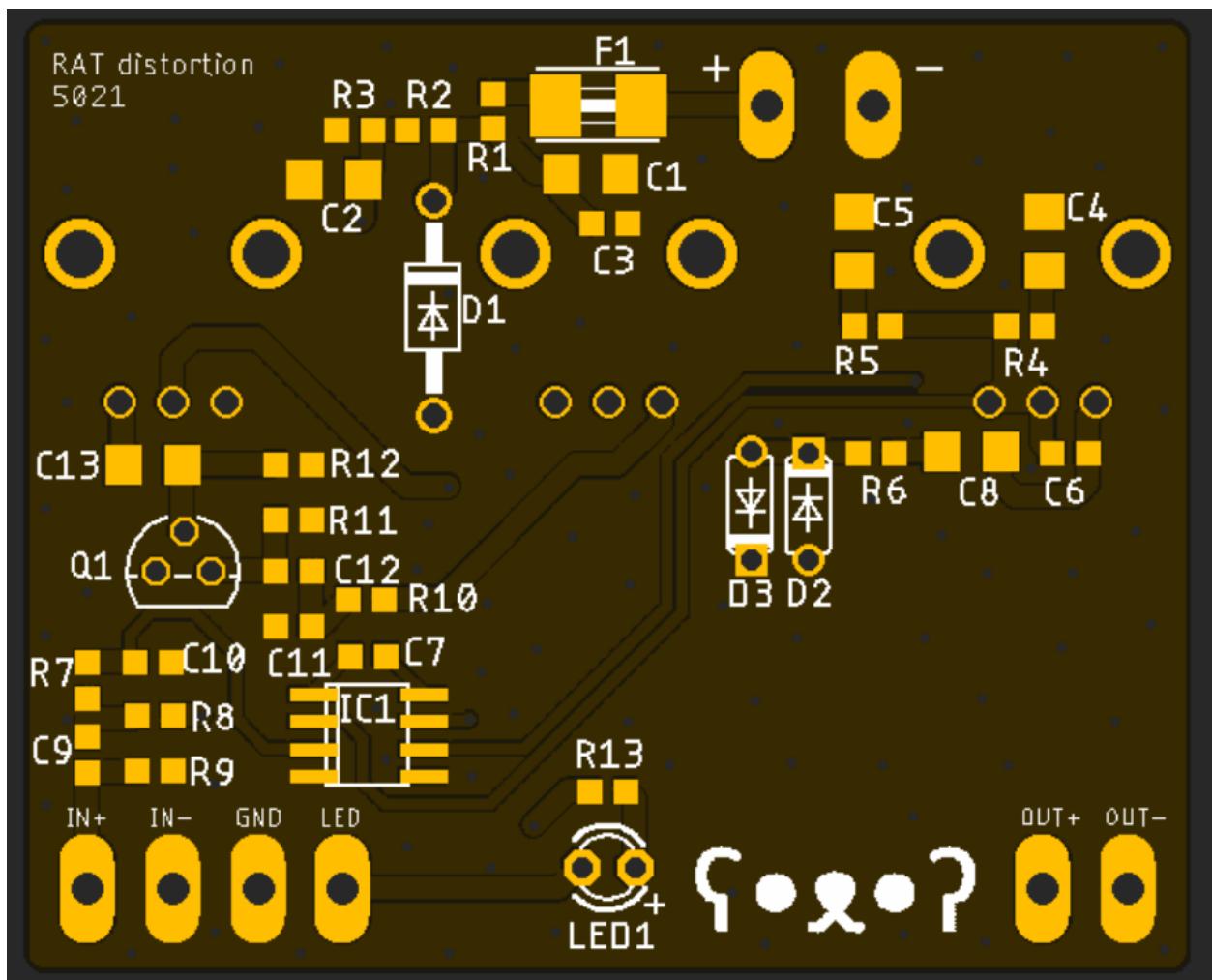


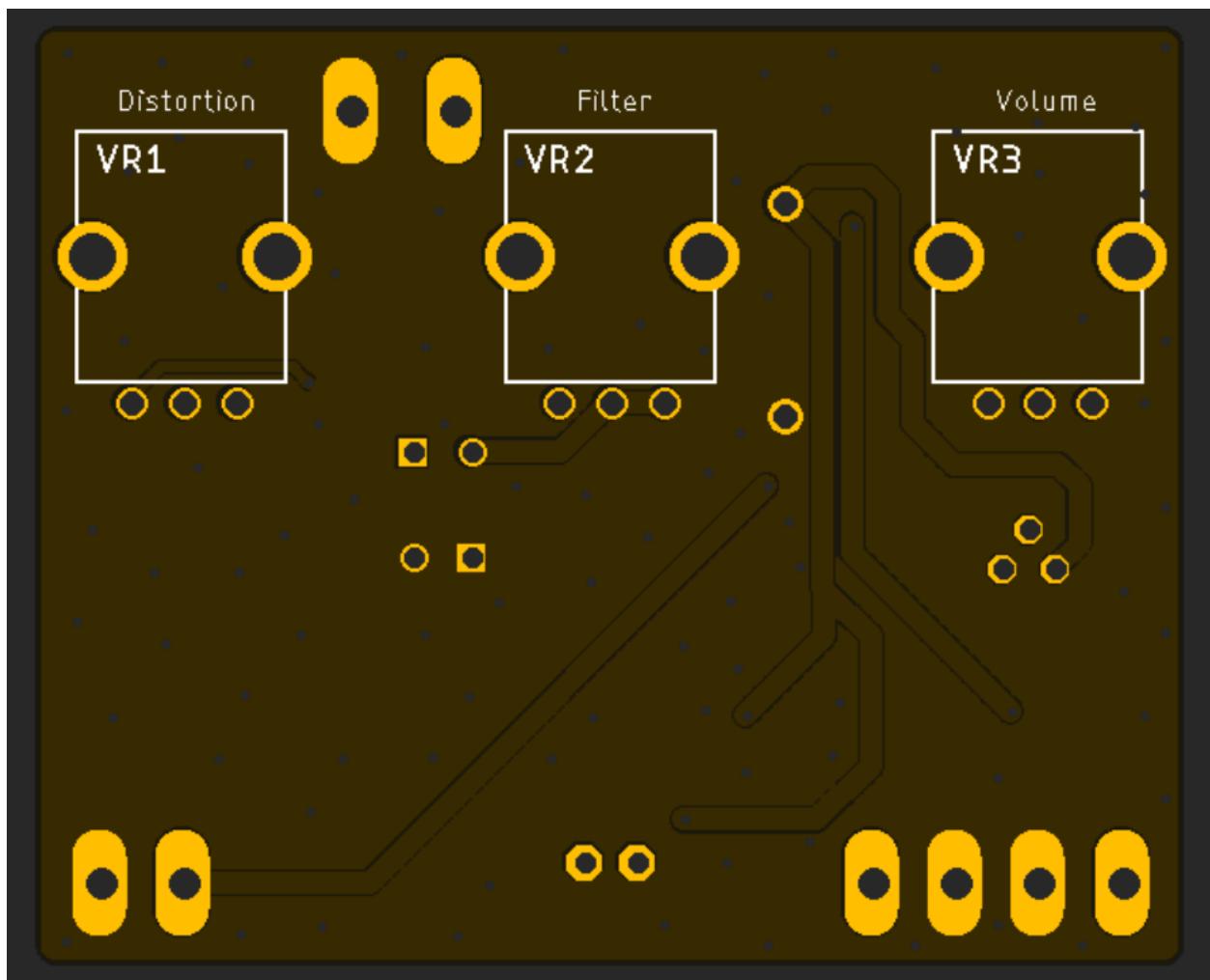
## 3. PCB layout

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*



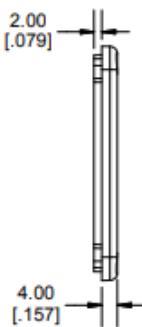
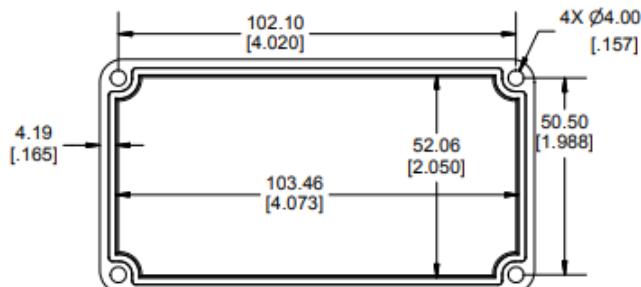
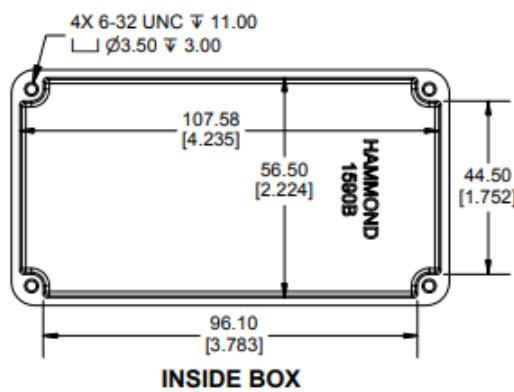
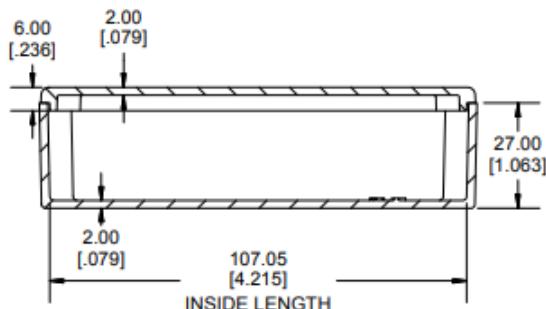
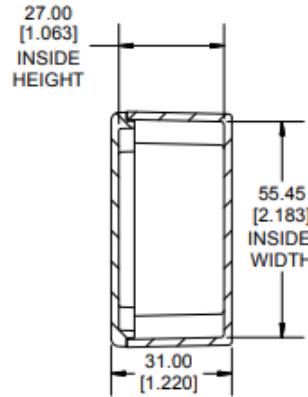
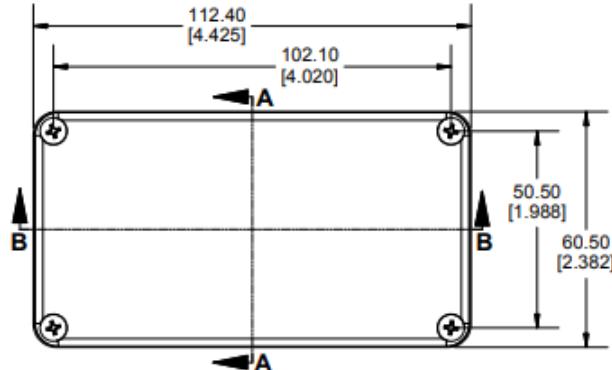


## 4. Bill of materials

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	D041	1N4004	1
D2, D3	Diode	D035	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

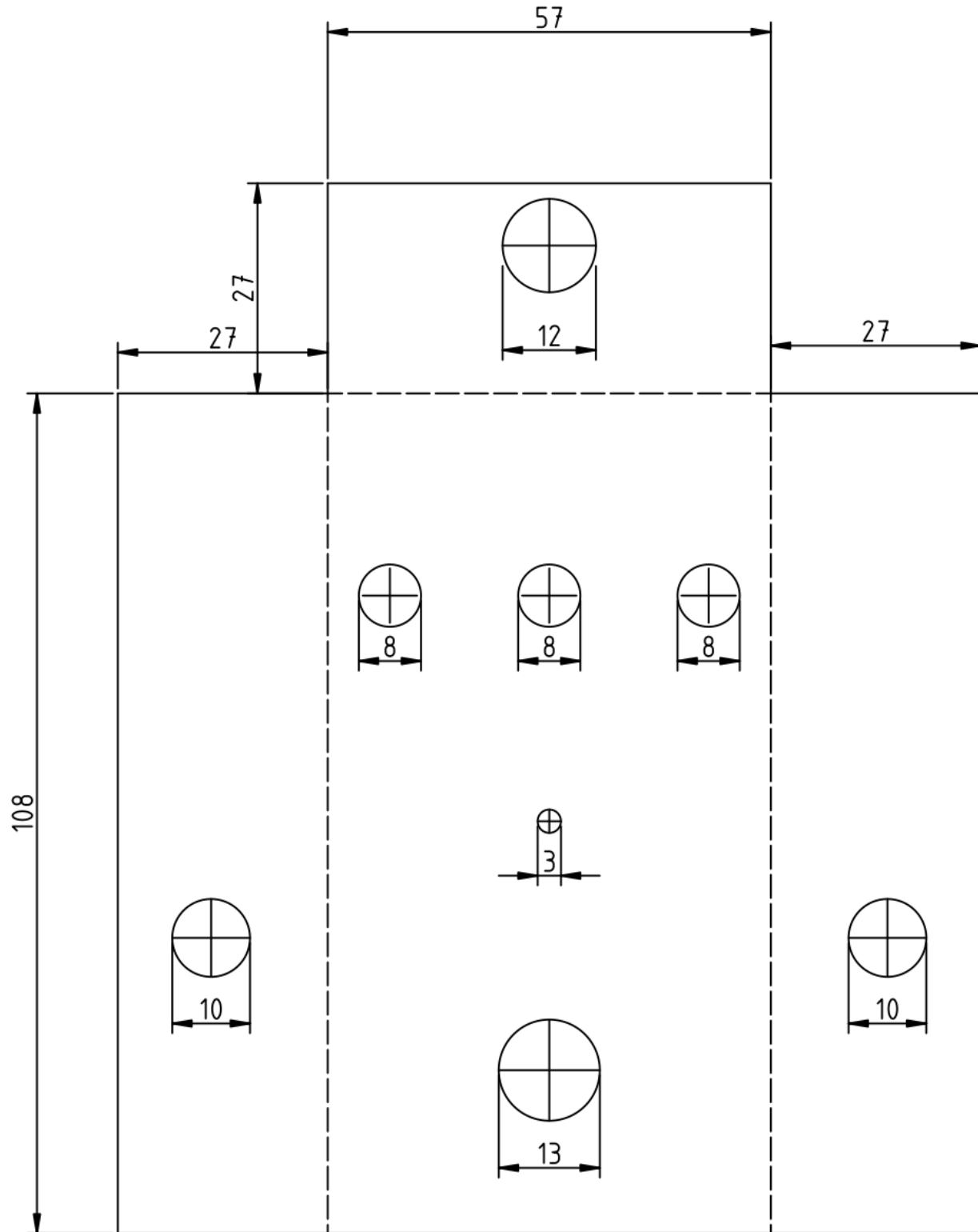
R10	Resistor	0603	1.5k ohm	1
R12	Resistor	0603	10k ohm	1
VR1,VR2,VR3	Potentiometer	PTV09 RK09N (alternative)	100k ohm A (log)	3
Foot switch	Stomp switch	3PDT	3PDT	1
DC in	DC power jack	DC-022	DC-022	1
Audio in, Audio out	Audio jack	6.35mm	6.35mm	2
Housing	Housing	1590B	1590B	1
Pot knobs	Knobs	6mm pot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

## 5. Housing dimensions



Dimensions:  
mm  
[inches]

## 6. Drill template



See "RAT distortion drill template.pdf" and "RAT distortion drill template.dxf". Make sure to print the template on 100% scaling.

## 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	-	-	-	-	-	<a href="#">Digikey</a>	From stock
C2, C13	Capacitor	1uF	100	1,03	0,53	1,56	0,02	<a href="#">Aliexpress</a>	
C3	Capacitor	0.1uF	-	-	-	-	-	<a href="#">Digikey</a>	From stock
C4	Capacitor	2.2uF	100	1,19	0,53	1,72	0,02	<a href="#">Aliexpress</a>	
C5, C8	Capacitor	4.7uF	100	1,19	0,53	1,72	0,02	<a href="#">Aliexpress</a>	
C6	Capacitor	100pF	100	0,83	0,53	1,36	0,01	<a href="#">Aliexpress</a>	
C7	Capacitor	30pF	100	0,83	0,53	1,36	0,01	<a href="#">Aliexpress</a>	
C9, C12	Capacitor	22nF	100	0,83	0,53	1,36	0,01	<a href="#">Aliexpress</a>	
C10	Capacitor	1nF	100	0,83	0,53	1,36	0,01	<a href="#">Aliexpress</a>	
C11	Capacitor	3.3nF	100	0,83	0,53	1,36	0,01	<a href="#">Aliexpress</a>	
D1	Diode	1N4004	100	1,17	0,53	1,70	0,02	<a href="#">Aliexpress</a>	
D2, D3	Diode	1N914	50	0,44	2,05	2,49	0,05	<a href="#">Aliexpress</a>	
F1	PTC fuse	100mA	20	0,67	2,11	2,78	0,14	<a href="#">Aliexpress</a>	
IC1	Opamp	OP07CDR	10	1,10	2,31	3,41	0,34	<a href="#">Aliexpress</a>	
Q1	JFET	2N5458	10	2,38	1,93	4,31	0,43	<a href="#">Aliexpress</a>	Seems to be fake, measures as a NPN transistor
Q1	JFET	2N5458	5	5,45	0,00	5,45	1,09	<a href="#">Mouser</a>	
Q1	JFET	J111	10	3,12	0,00	3,12	0,31	<a href="#">Mouser</a>	Orderd to try, not used

LED1	LED	3mm LED	-	-	-	-	-	NA	From stock
R1, R4	Resistor	47 ohm	-	-	-	-	-	<a href="#">Aliexpress</a>	From stock
R2, R3	Resistor	100k ohm	-	-	-	-	-	<a href="#">Aliexpress</a>	From stock
R5	Resistor	560 ohm	-	-	-	-	-	<a href="#">Aliexpress</a>	From stock
R6, R7, R13	Resistor	1k ohm	-	-	-	-	-	<a href="#">Aliexpress</a>	From stock
R8, R9, R11	Resistor	1M ohm	-	-	-	-	-	<a href="#">Aliexpress</a>	From stock
R10	Resistor	1.5k ohm	-	-	-	-	-	<a href="#">Aliexpress</a>	From stock
R12	Resistor	10k ohm	-	-	-	-	-	<a href="#">Aliexpress</a>	From stock
VR1, VR2, VR3	Potentio- meter	100k ohm A (log) RK097N	10	7,65	0,00	7,65	0,77	<a href="#">Aliexpress</a>	RK097N with 6mm shaft with teeth, other types may fit
Foot switch	Stomp switch	3PDT	3	2,88	3,13	6,01	2,00	<a href="#">Aliexpress</a>	
DC in	DC power jack	DC-022	10	2,09	1,44	3,53	0,35	<a href="#">Aliexpress</a>	
Audio in, Audio out	Audio jack	6,35mm	10	4,89	0,00	4,89	0,49	<a href="#">Aliexpress</a>	
Housing	Housing	1590B	2	14,36	1,71	16,07	8,04	<a href="#">Aliexpress</a>	
Pot knobs	Knobs	17x13mm for 6mm shaft with teeth	6	3,81	3,86	7,67	1,28	<a href="#">Aliexpress</a>	
Wiring	Wire	0.2 mm <sup>2</sup>	-	-	-	-	-	<a href="#">Conrad</a>	From stock
PCB	PCB	2 layer	5	11,75	14,27	26,02	5,20	<a href="#">JLCPCB</a>	Custom ordered
SMD Stencil	SMD Stencil	-	1	-	-	-	-	<a href="#">JLCPCB</a>	Custom ordered,

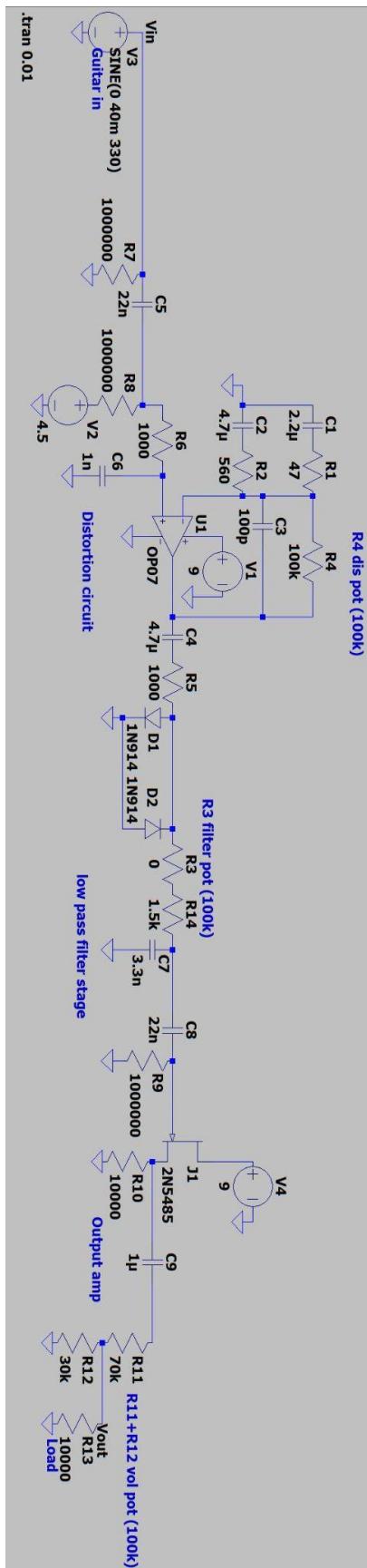
									included in PCB costs
Solder paste	Solder	Bi57Sn42- Ag1	-	-	-	-	-	<a href="#">Digikey</a>	From stock
Solder wire	Solder	Sn60Pb39- Cu1	-	-	-	-	-	NA	From stock
Heat- shrink	Heat- shrink	-	-	-	-	-	-	<a href="#">Aliexpress</a>	From stock

Total development costs including shipping is €106,90. Time and parts already in house are not included in this calculation.

## **8. Tests**

The effect is simulated in LTspice XVII (see drawing on next page) to confirm the correct behavior of the effect. The opamp used in the simulation is the OP07.

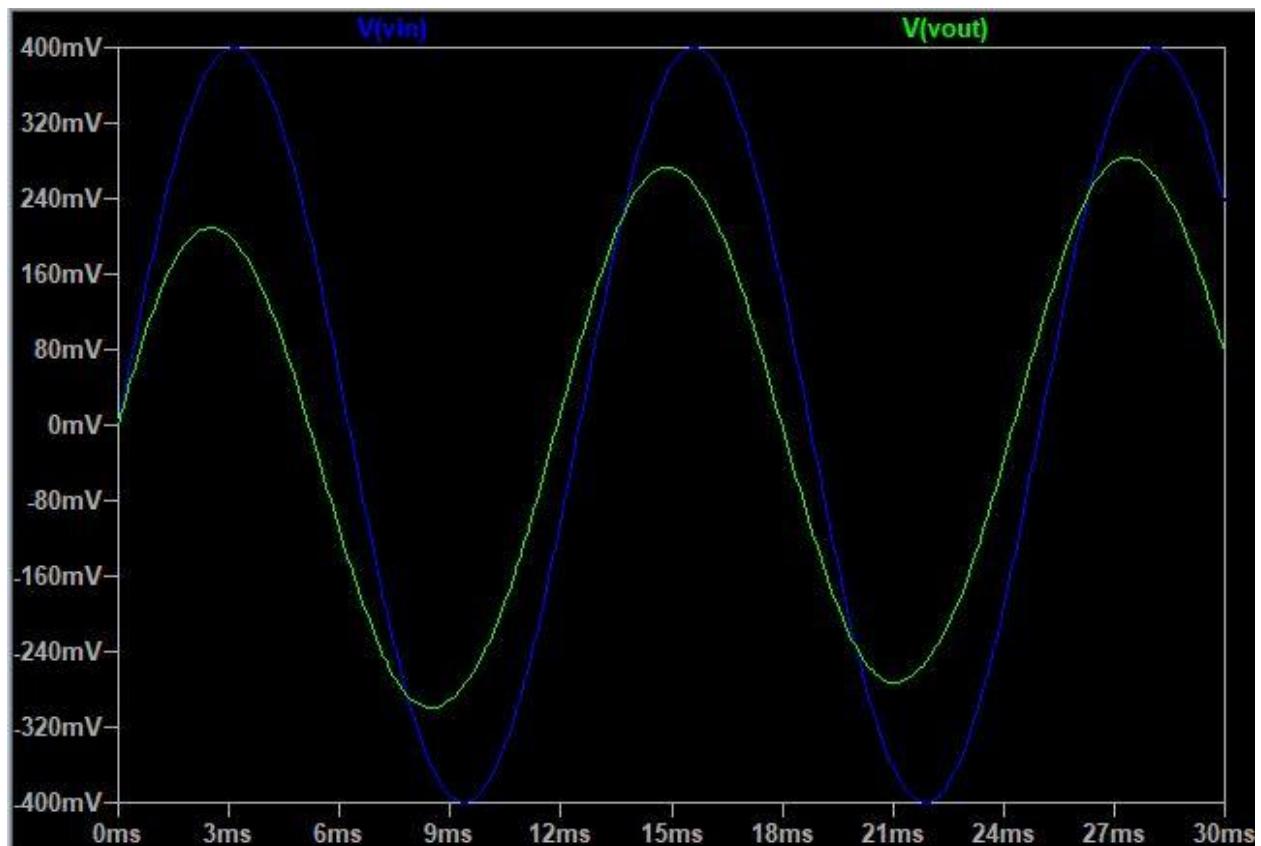
The tests are done with a 800mVpp sine wave at 80Hz and 330Hz frequencies. A 10k ohm resistor is used as a load in both the simulation and real tests.

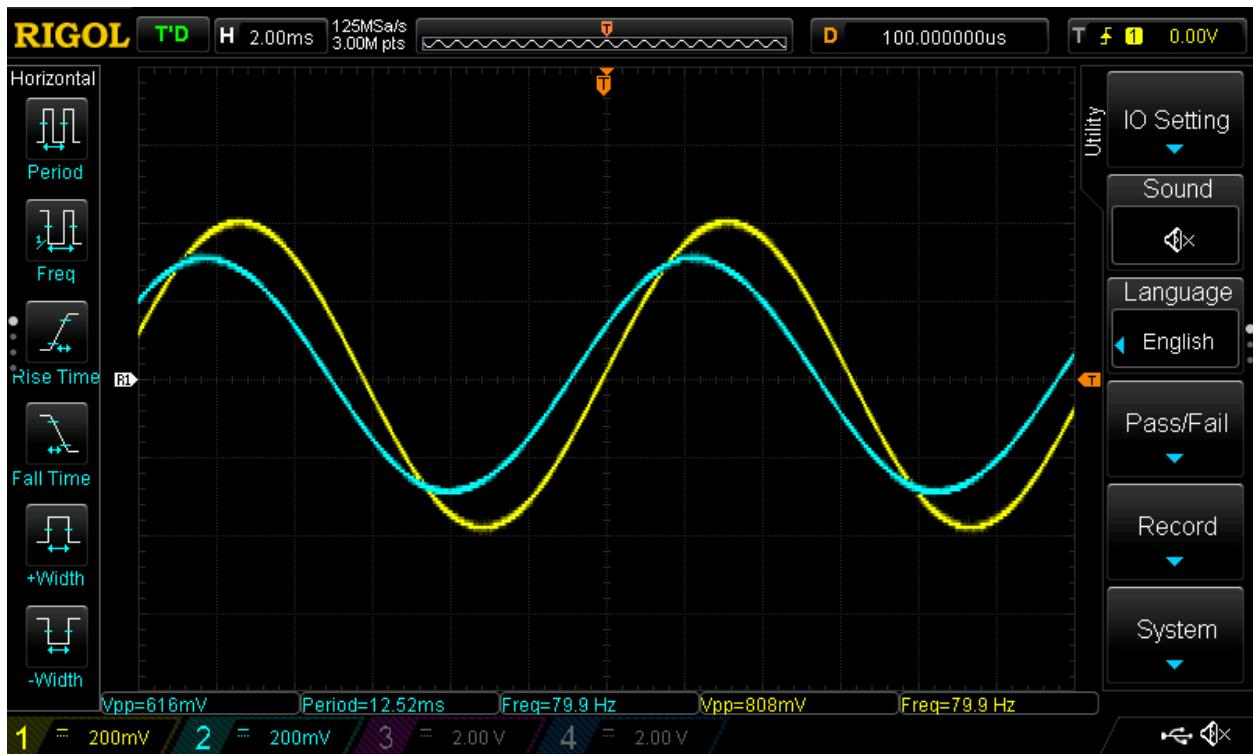


## 8.1. Low distortion 80Hz

Settings:

- Distortion 0%
- Filter 0%
- Volume 100%
- 80Hz input sine wave





### 8.3. Low distortion 300Hz

Settings:

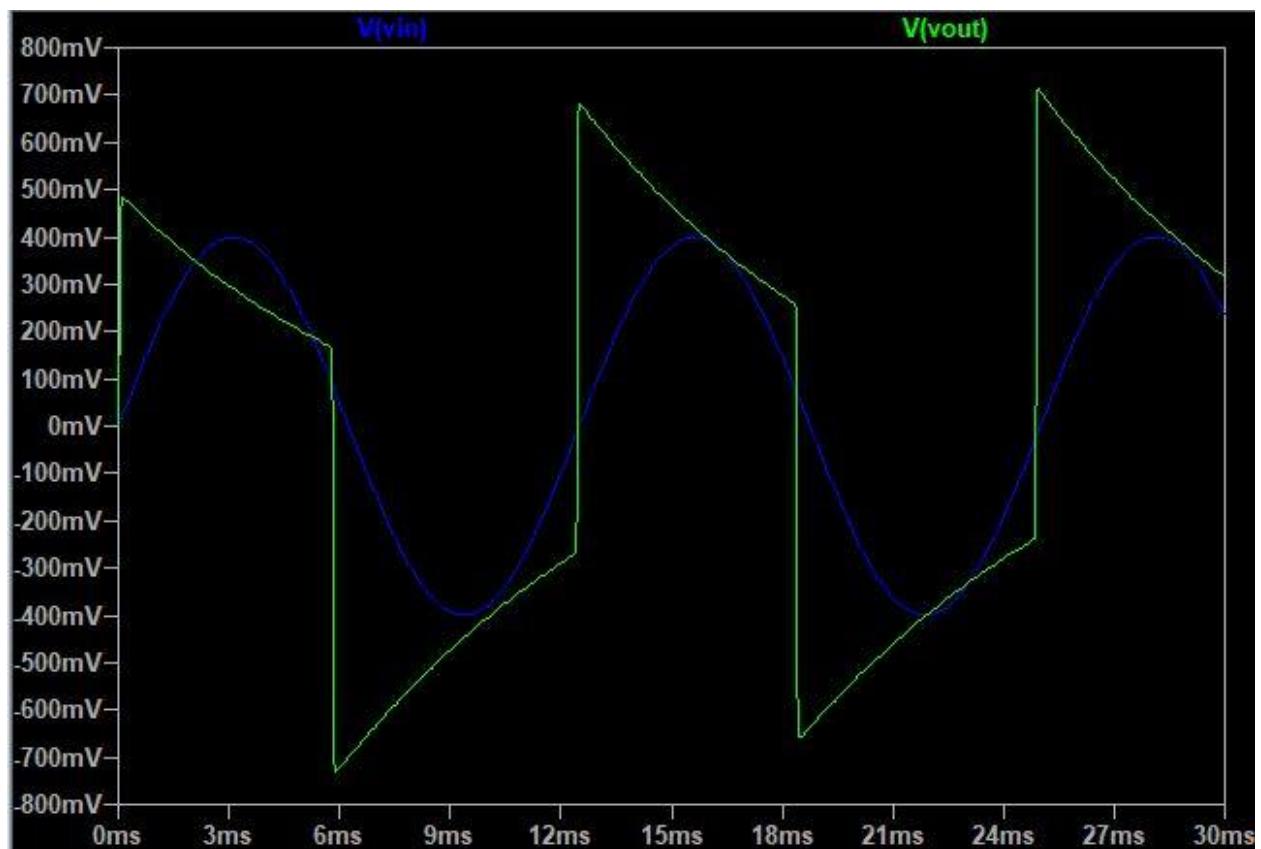
- Distortion 0%
- Filter 0%
- Volume 100%
- 300Hz input sine wave

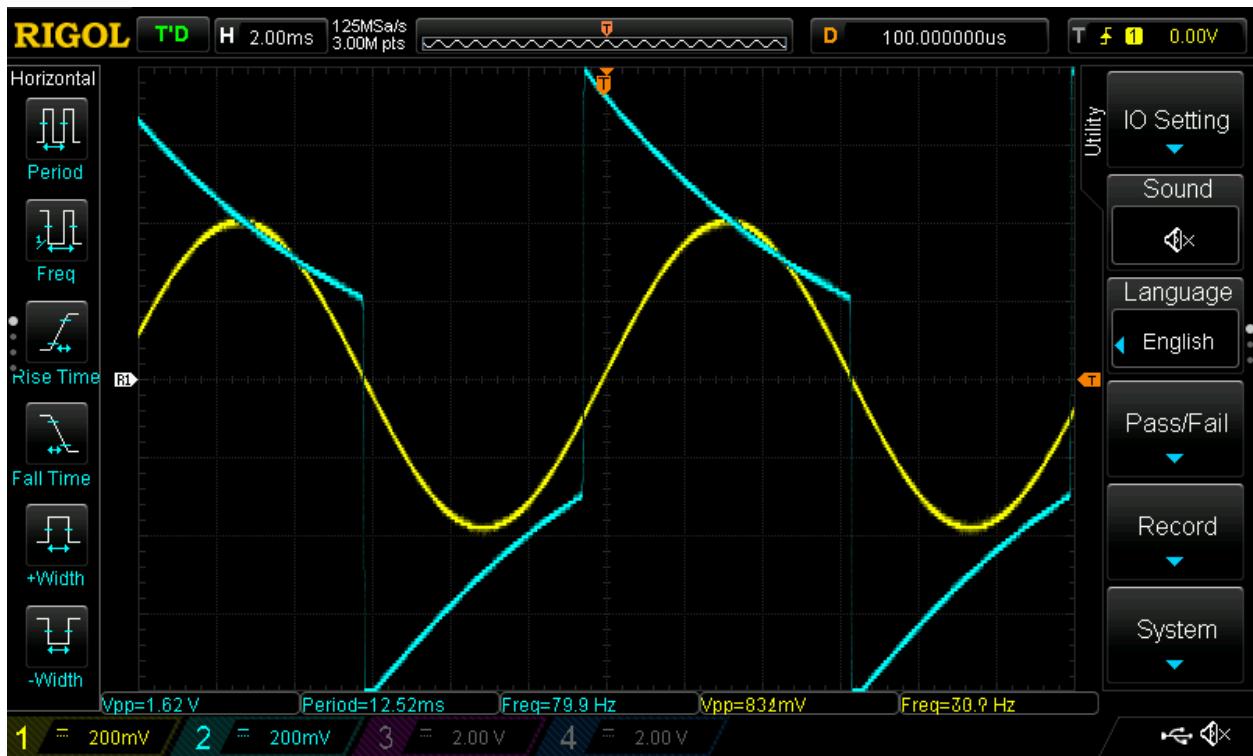


## 8.2. High distortion 80Hz

Settings:

- Distortion 100%
- Filter 0%
- Volume 100%
- 80Hz input sine wave

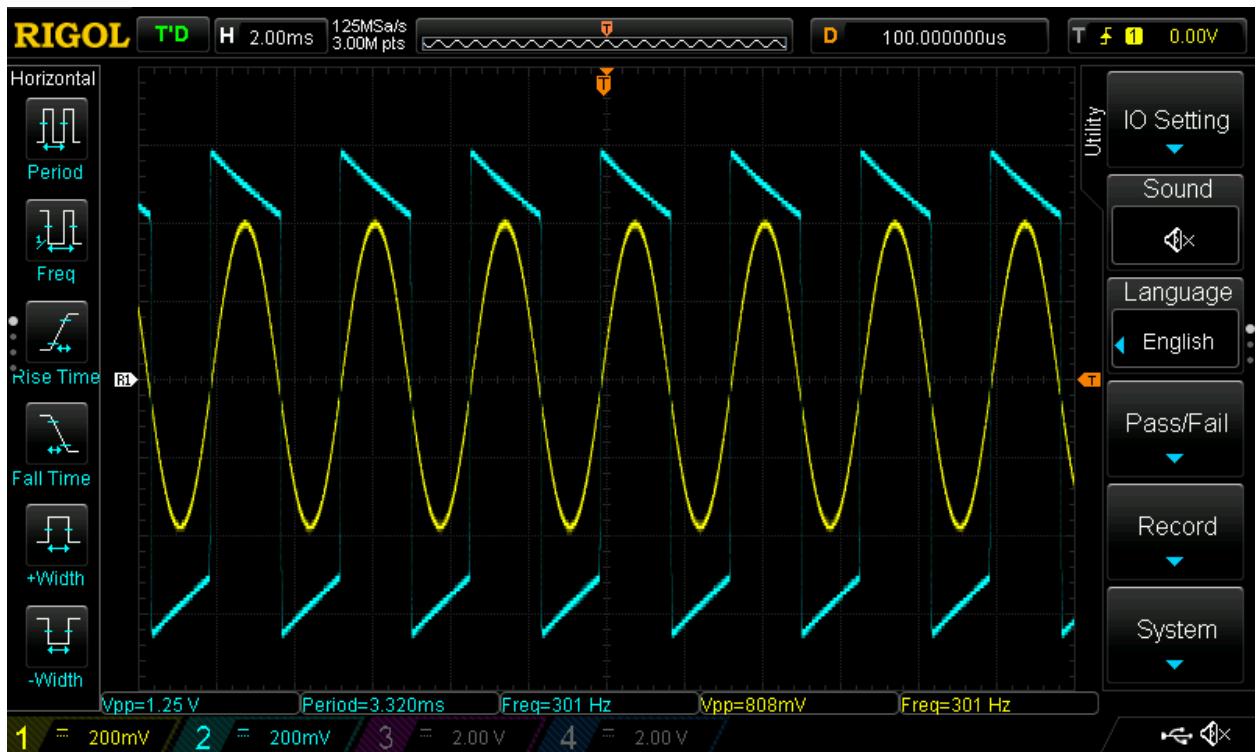
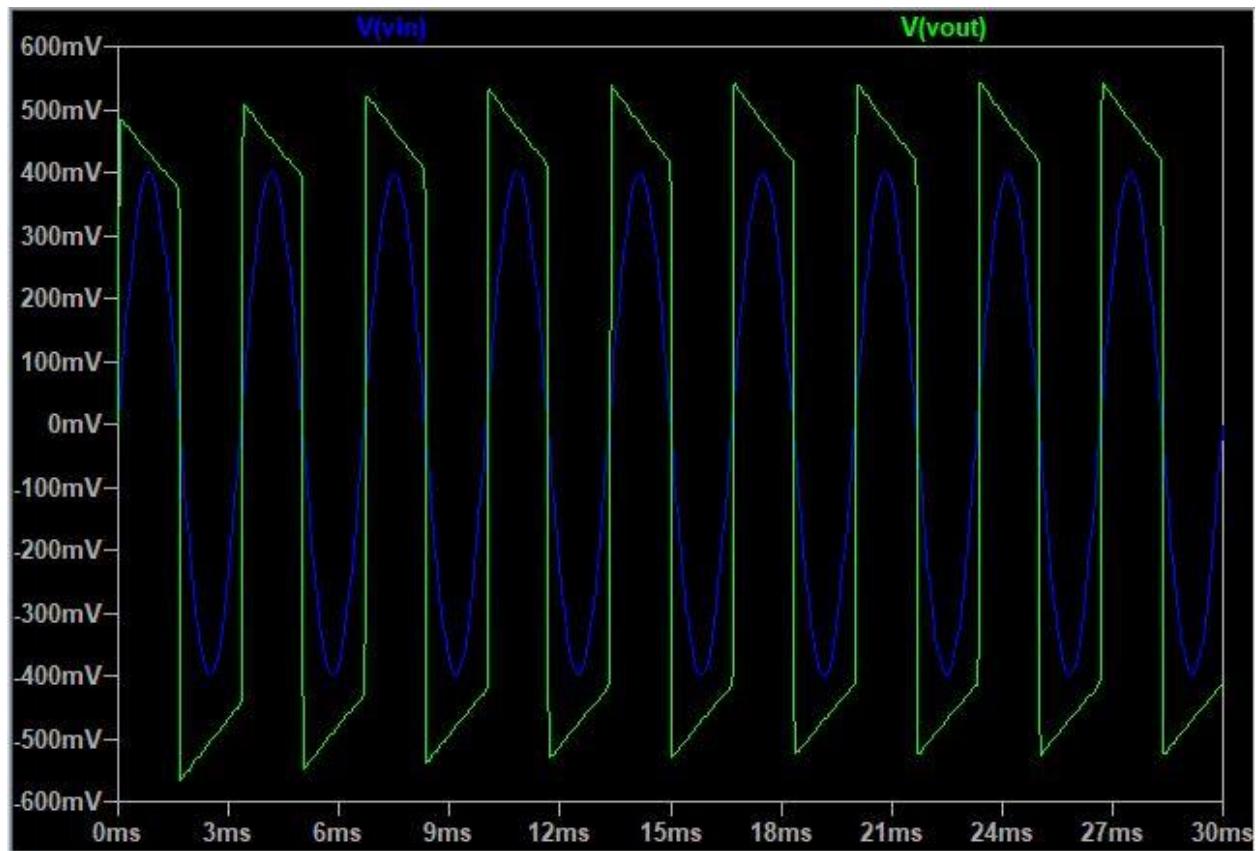




## 8.4. High distortion 300Hz

Settings:

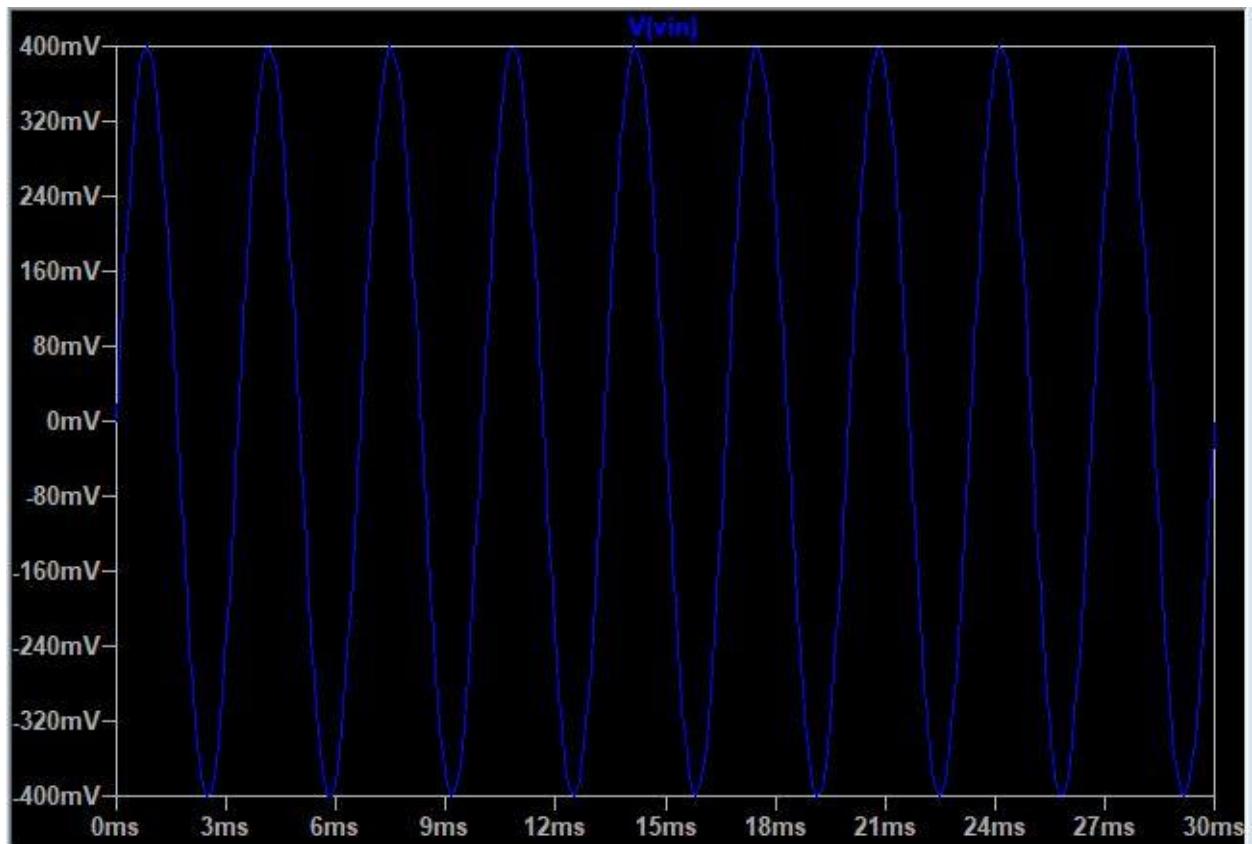
- Distortion 100%
- Filter 0%
- Volume 100%
- 300Hz input sine wave

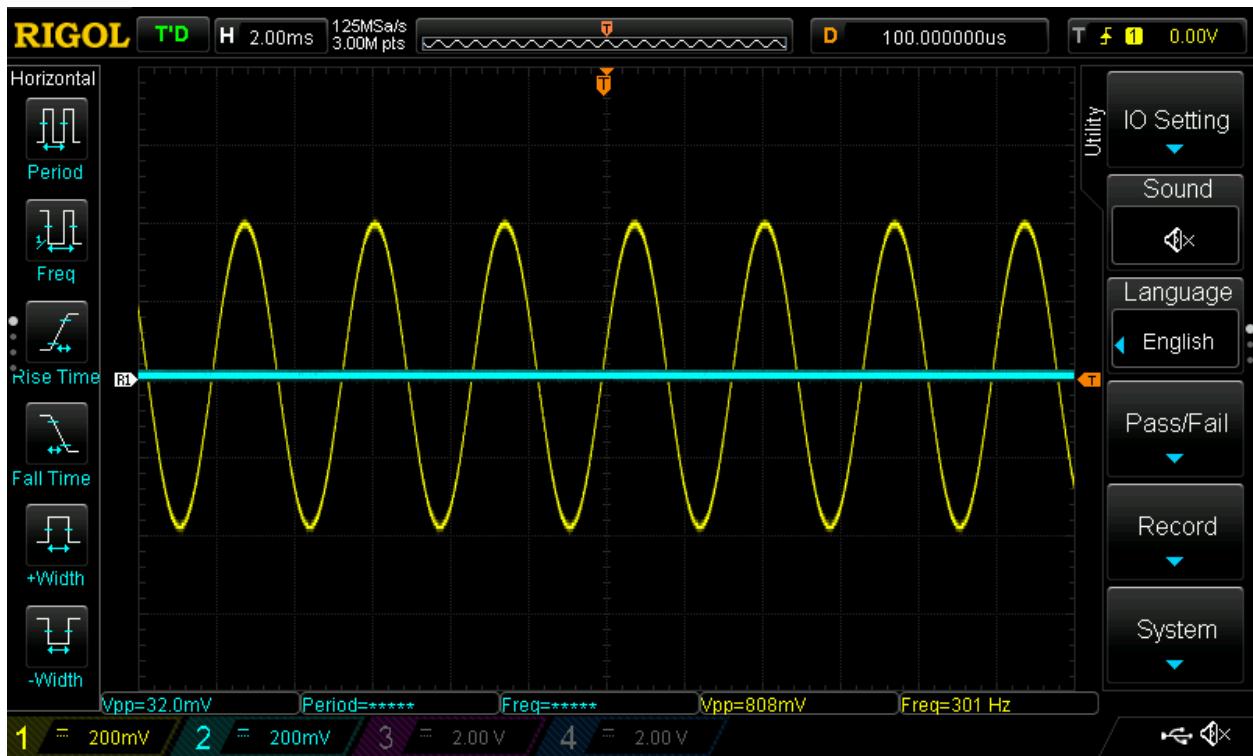


## 8.5. Volume 0%

Settings:

- Distortion 100%
- Filter 0%
- Volume 0%
- 300Hz input sine wave

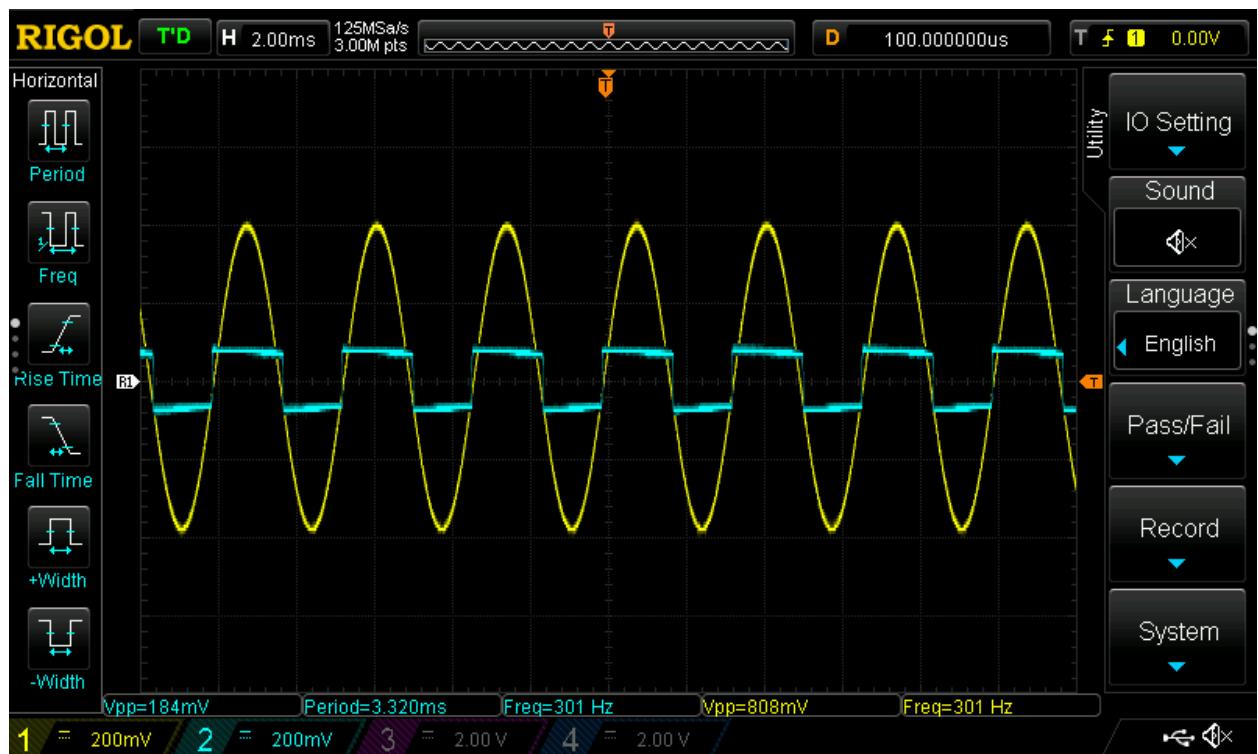
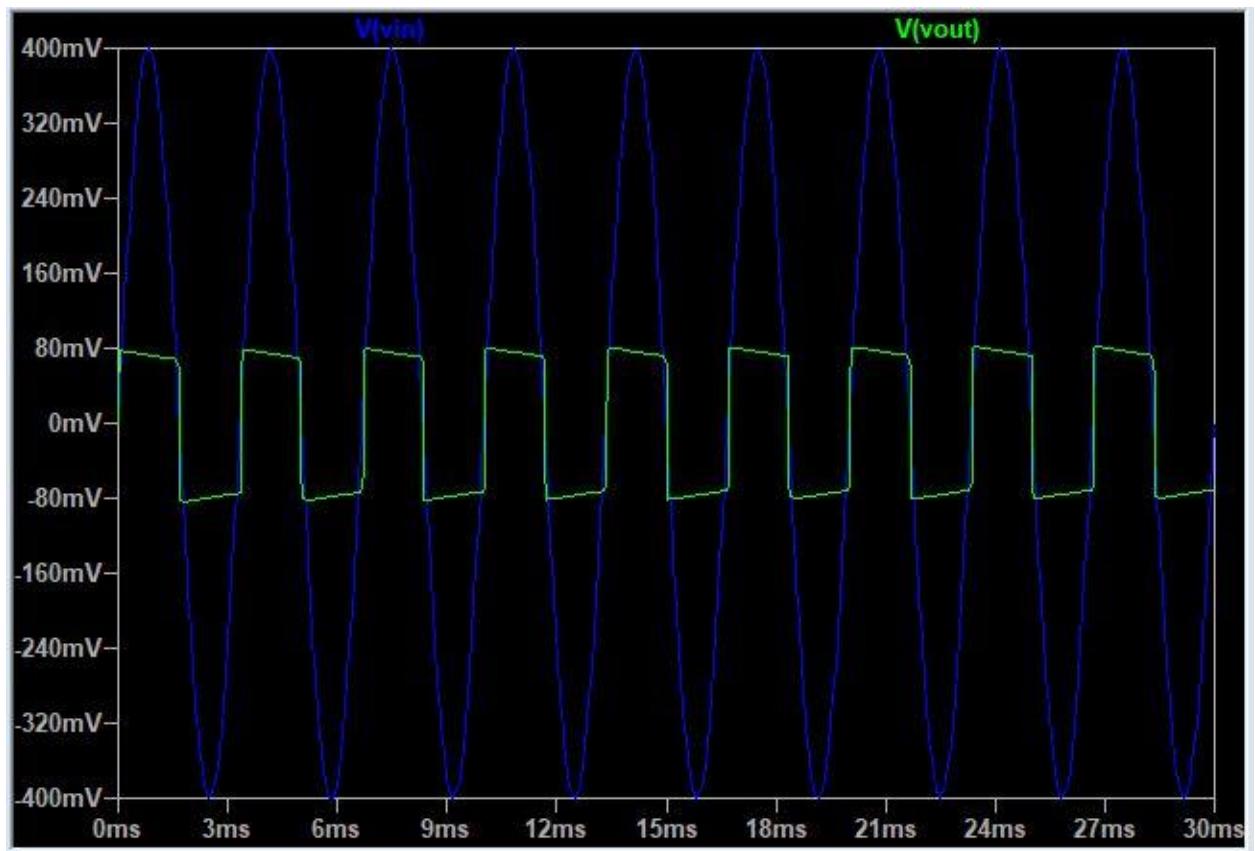




## 8.6. Volume 50%

Settings:

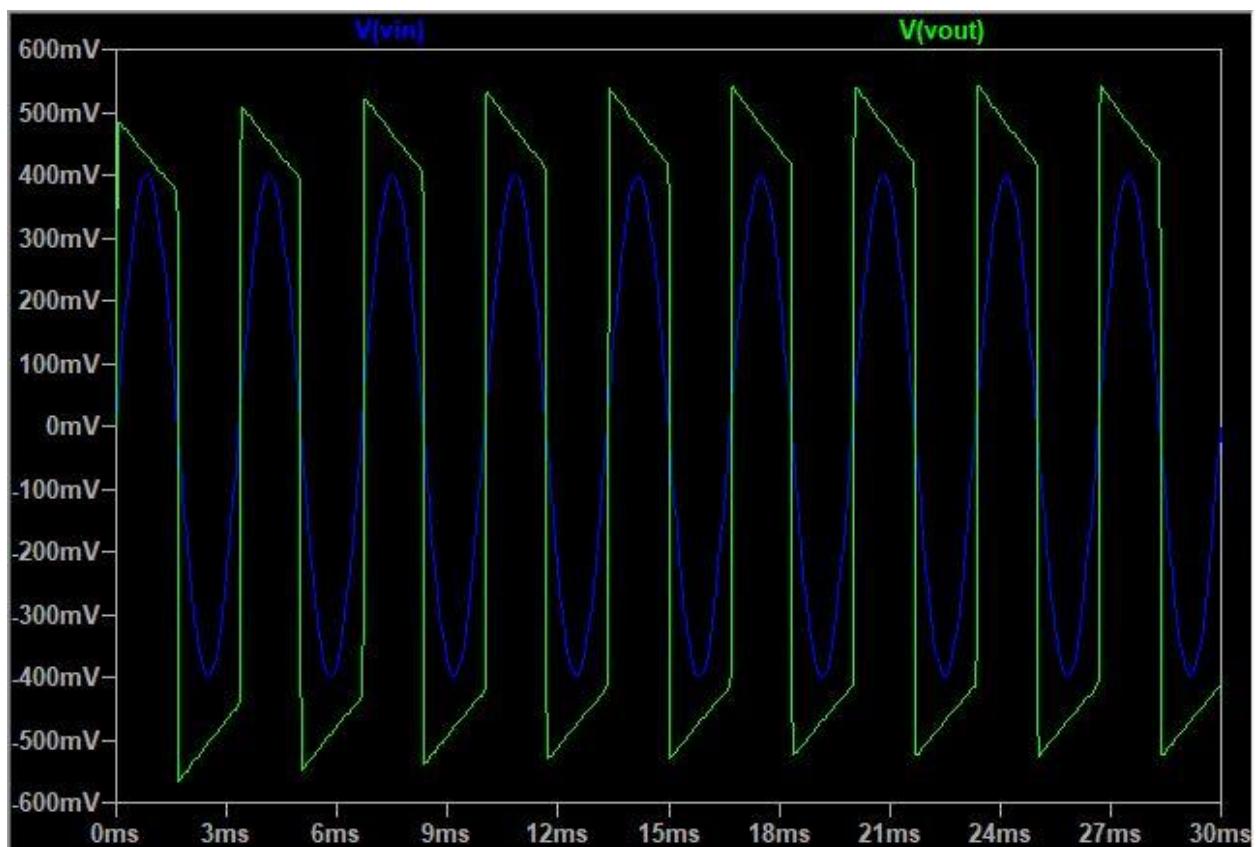
- Distortion 100%
- Filter 0%
- Volume 50%
- 300Hz input sine wave

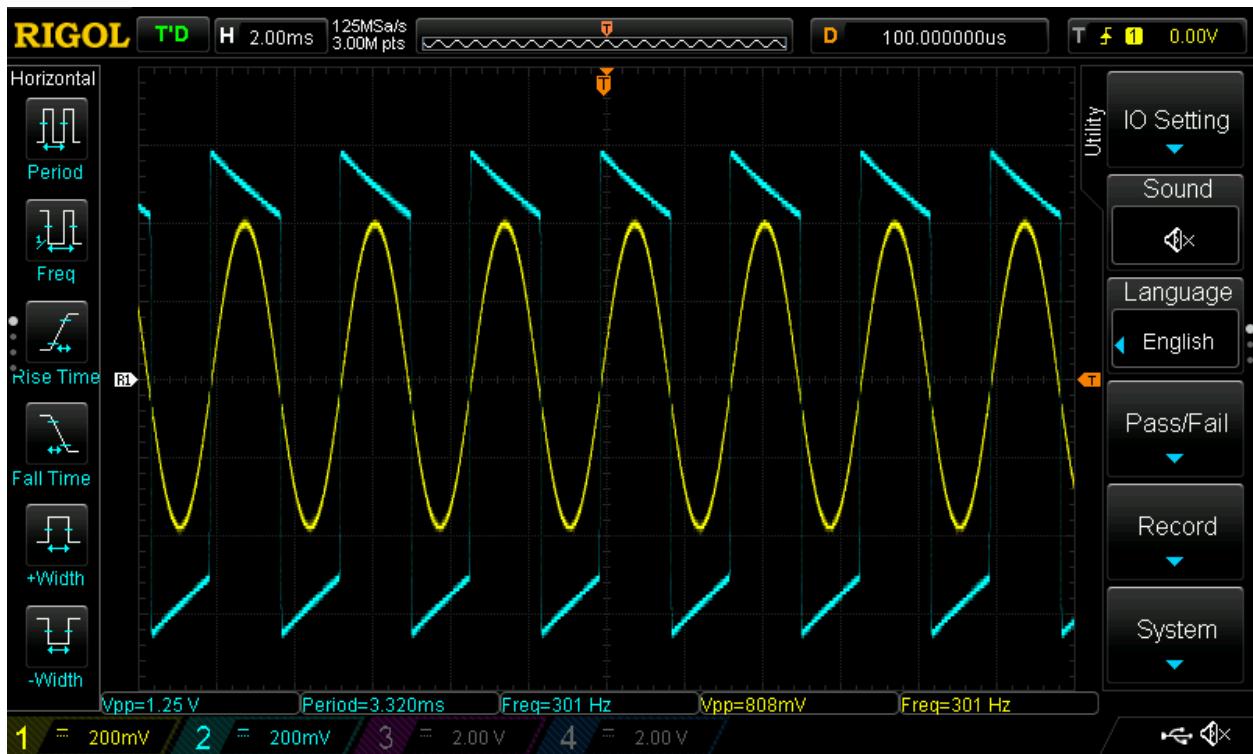


## 8.7. Volume 100%

Settings:

- Distortion 100%
- Filter 0%
- Volume 100%
- 300Hz input sine wave

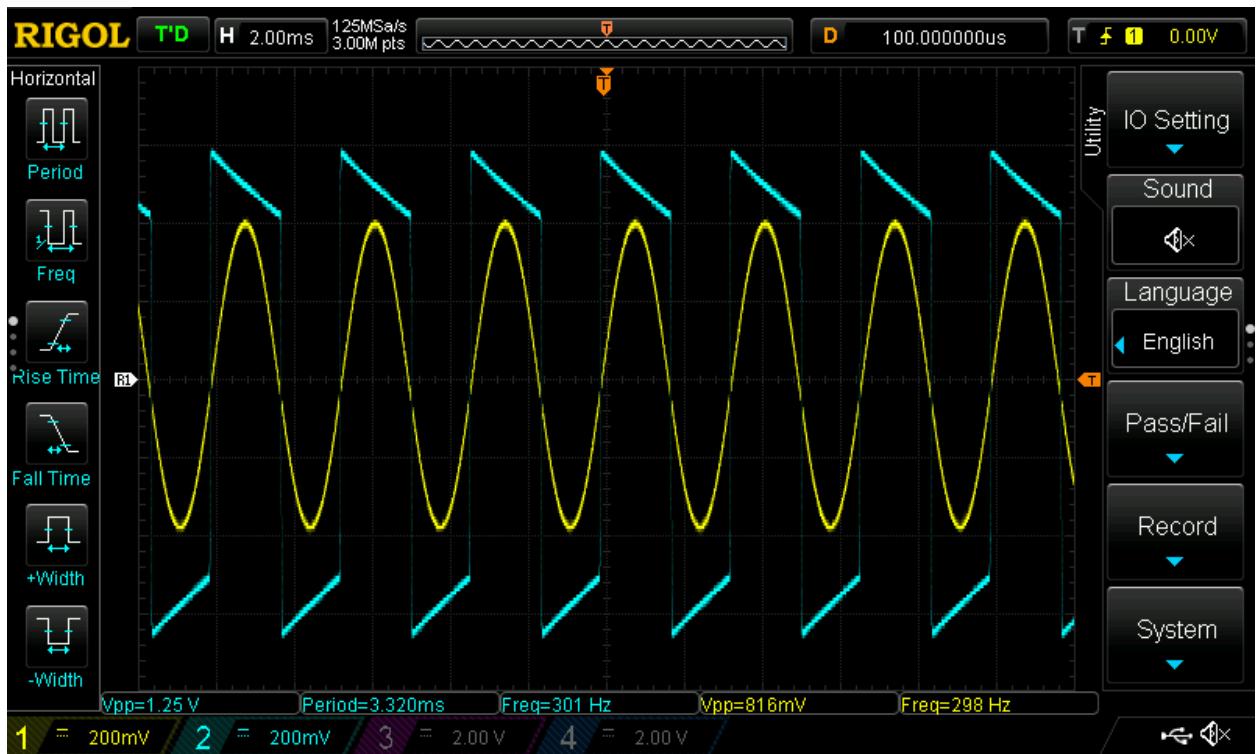
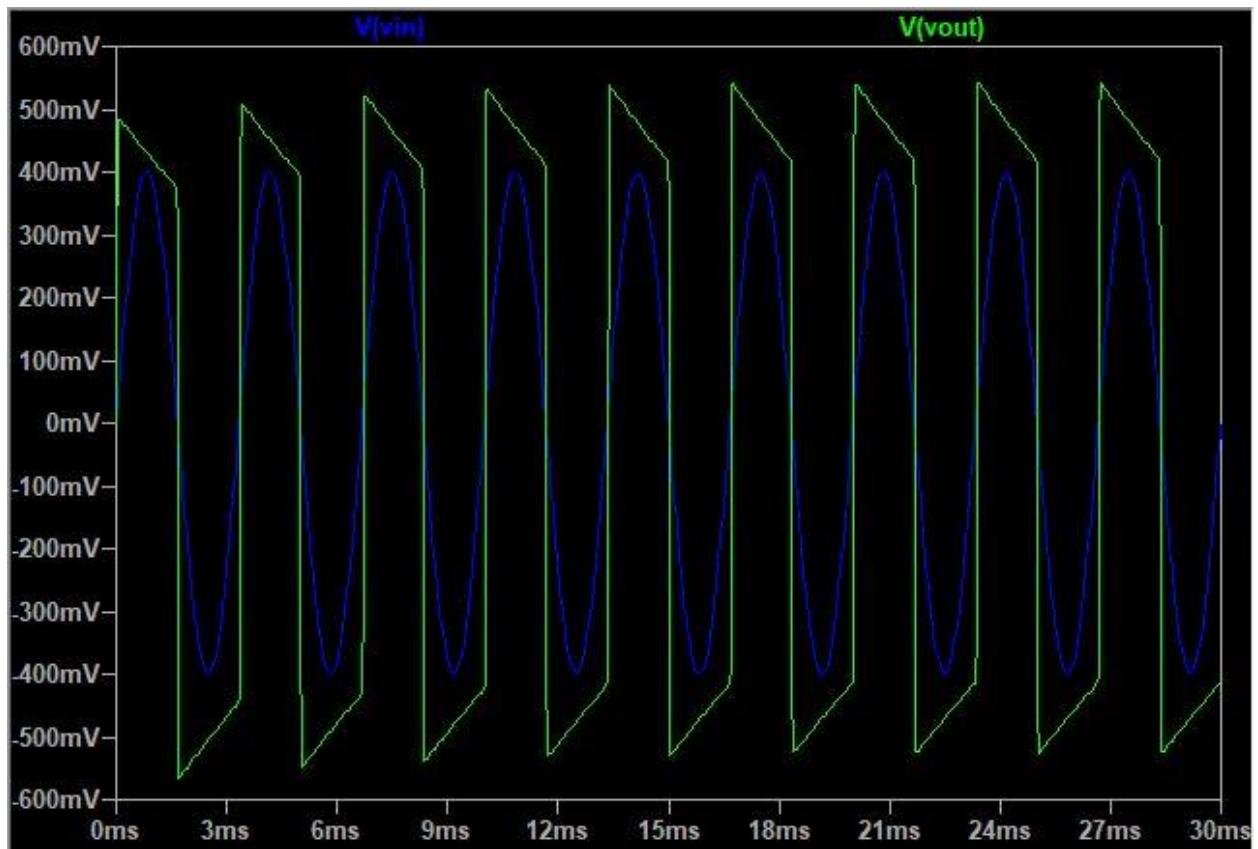




## 8.8. Tone control 0%

Settings:

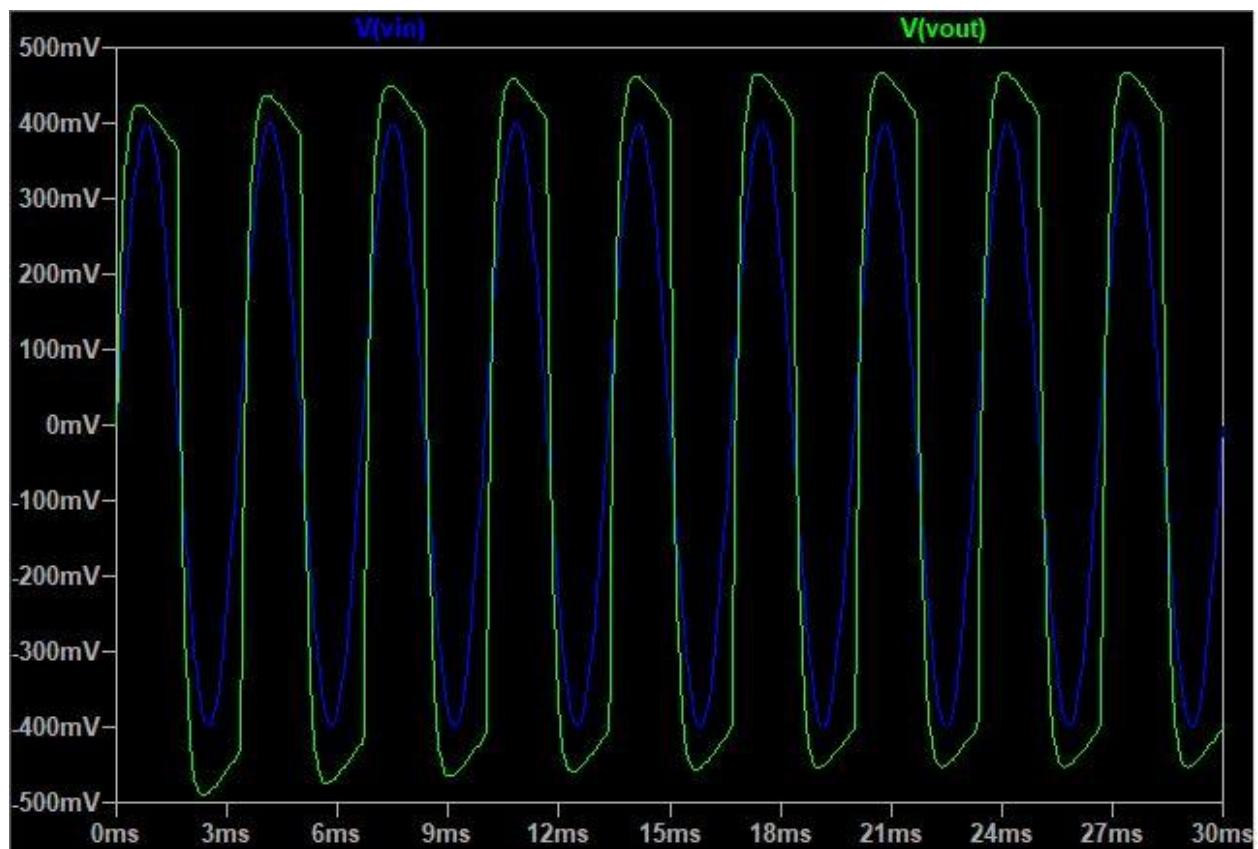
- Distortion 100%
- Filter 0%
- Volume 100%
- 300Hz input sine wave



## 8.8. Tone control 50%

Settings:

- Distortion 100%
- Filter 50%
- Volume 100%
- 300Hz input sine wave

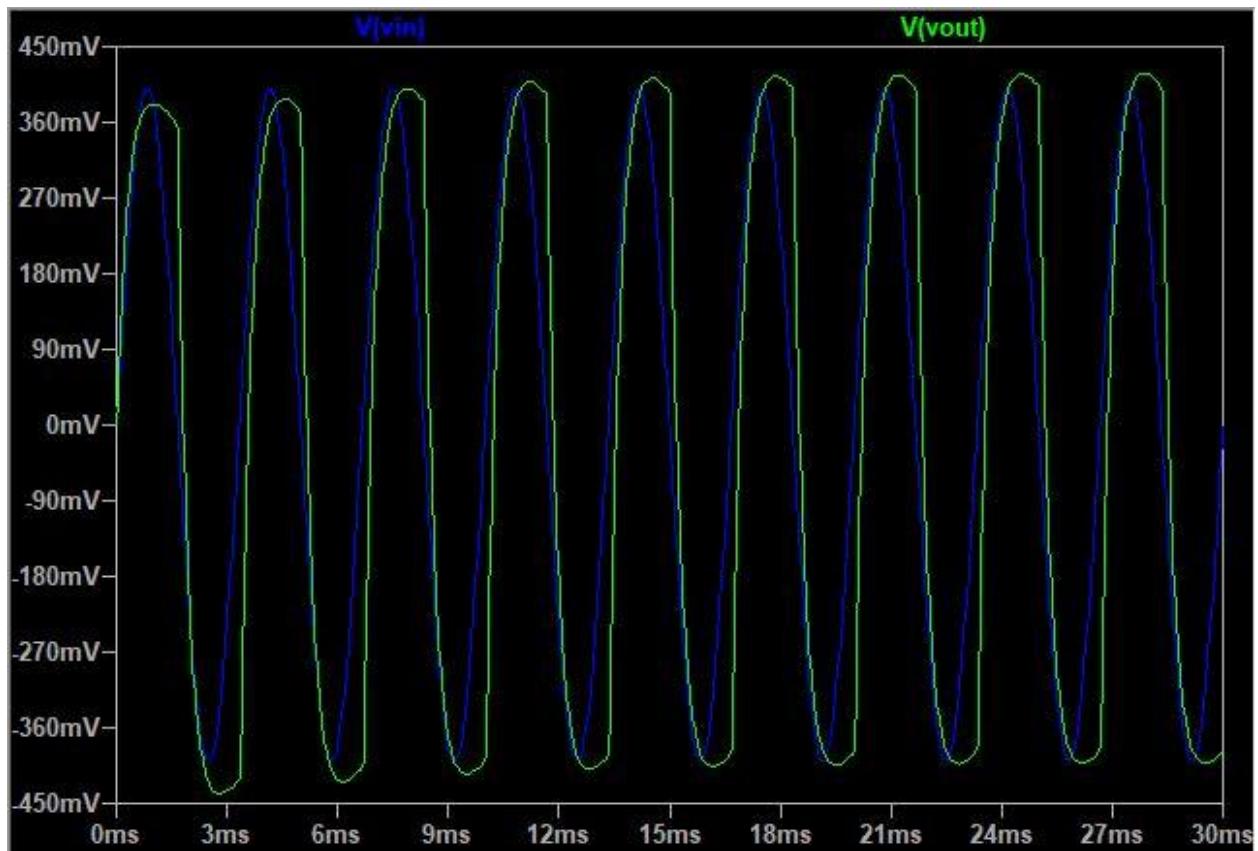




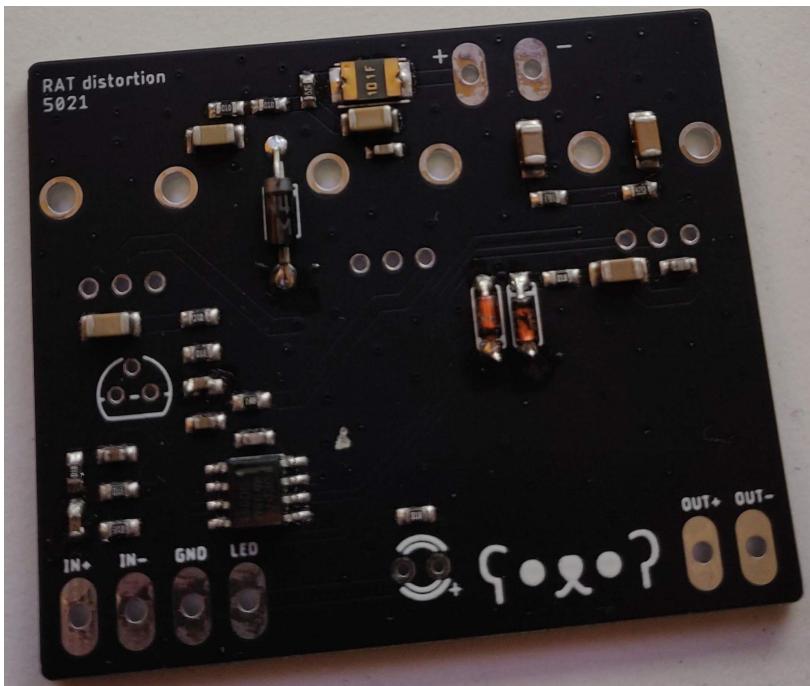
## 8.9. Tone control 100%

Settings:

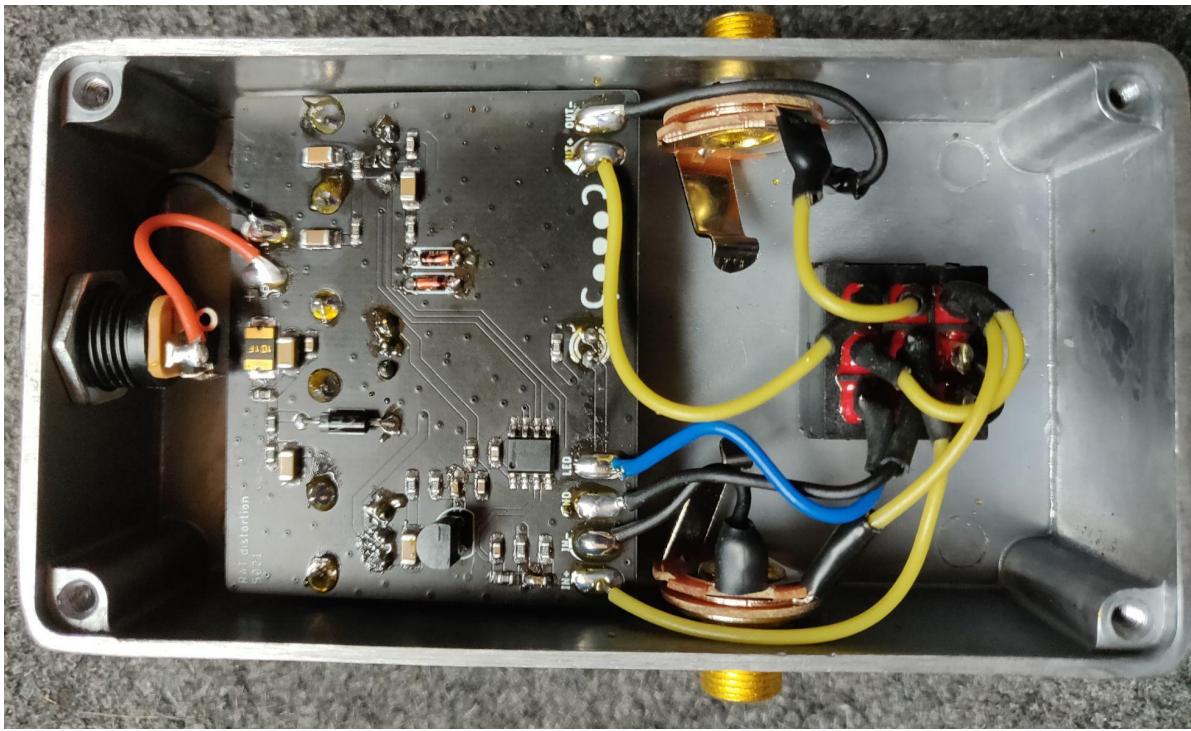
- Distortion 100%
- Filter 100%
- Volume 100%
- 300Hz input sine wave



## 9. Pictures













## 10. 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].