Last change-Date 21.06.2013 V 1.3 and V 1.31
TO-LAD-4tr V 1.3 and V 1.31 Filter for Shruthi-1 from Mutable Instruments

DIY instructions

Attention, if you use the TubeOhm complete Kit the orientation of the pots is valid ! If you use other parts, it can be that the orientation is mirrored. >>> clockwise/anticlockwise.

What you need:
1:) cutter
2:) digital multimeter
3:) soldering iron 30 W
4:) desoldering pump
5:) (better) an oscilloscope
6:) (better) frequency counter
7:) skills in soldering and electronics
8:) time

About the TO-LAD-4tr:

The TO-LAD-4tr is a ladder Filter specially designed for Shruthi from Mutable Instruments.
It contains the complete power supply +5V/-5V, a VCA, the filter unit and the Filter-FM feedback unit.
After soldering you must connect the Filter board to the Shruthi motherboard and do the adjustments.
Adjustment is very important and means that you must:

*1) new in V 1.31 output vol pot 5
1:) setup the volume with POT3 to maximum !
2:) setup the Filter feedback with POT2
3:) setup the Filter linearity with POT 1
4:) setup the external input volume with POT4. This if you use the filter as a filter box.

Attention. Warning, this Filter can produce a signal from 20 HZ up to 40 KHZ .
TubeOhm is not responsible for damage to your loudspeaker, soundcard, Shruthi Motherboard and/or amplifier.
This is a DIY kit, if you solder the parts correctly, it will work. But TubeOhm can't give any guaranty to your work.
So, take a little time, look and check the parts, and measure the resistors before you solder !!

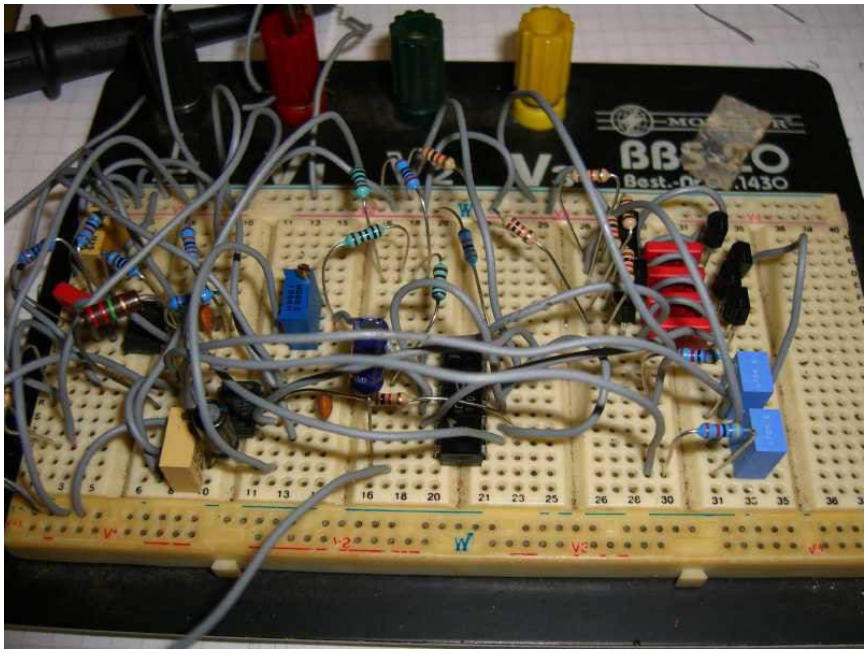
License for building theTO-LAD-4tr:
You can use the schematics to build the Filter on Veroboard on or your own made PCB.
This is only for private use. Sure you can make professional Music without restrictions.

But it is not allowed to sell a Filter with the schematics (especially the filter FM circuit) and your own made PCB. If you want to sell complete Filter boards you had to order and buy the PCB's from TubeOhm.com.
Guys, be fair, we spent a lot of time and money to design the schematics and the PCB's. We live from this and the minimum you can do to help us, also for future projects is order the PCB's from us. It puts food in our mouths.

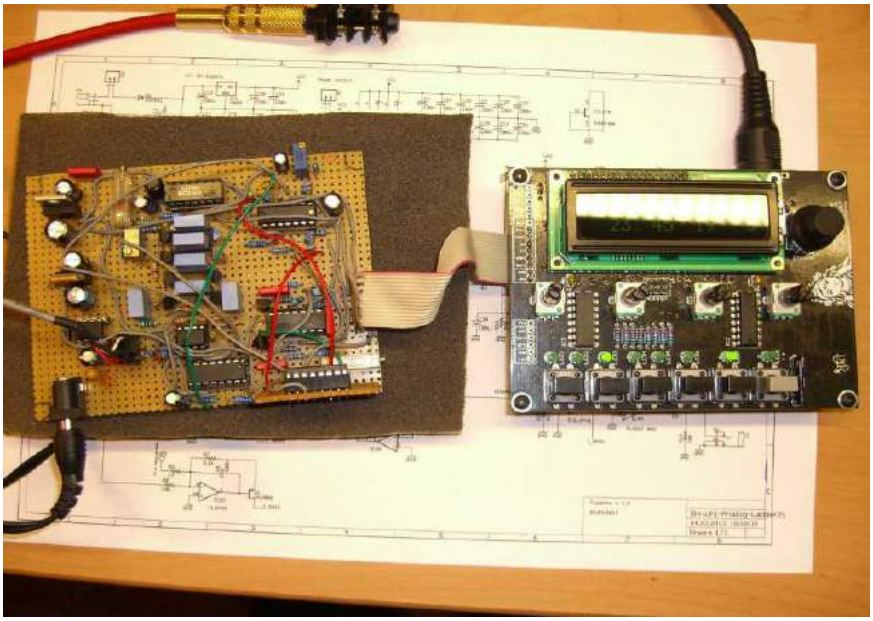
Thanks

Andre'
TubeOhm
History:

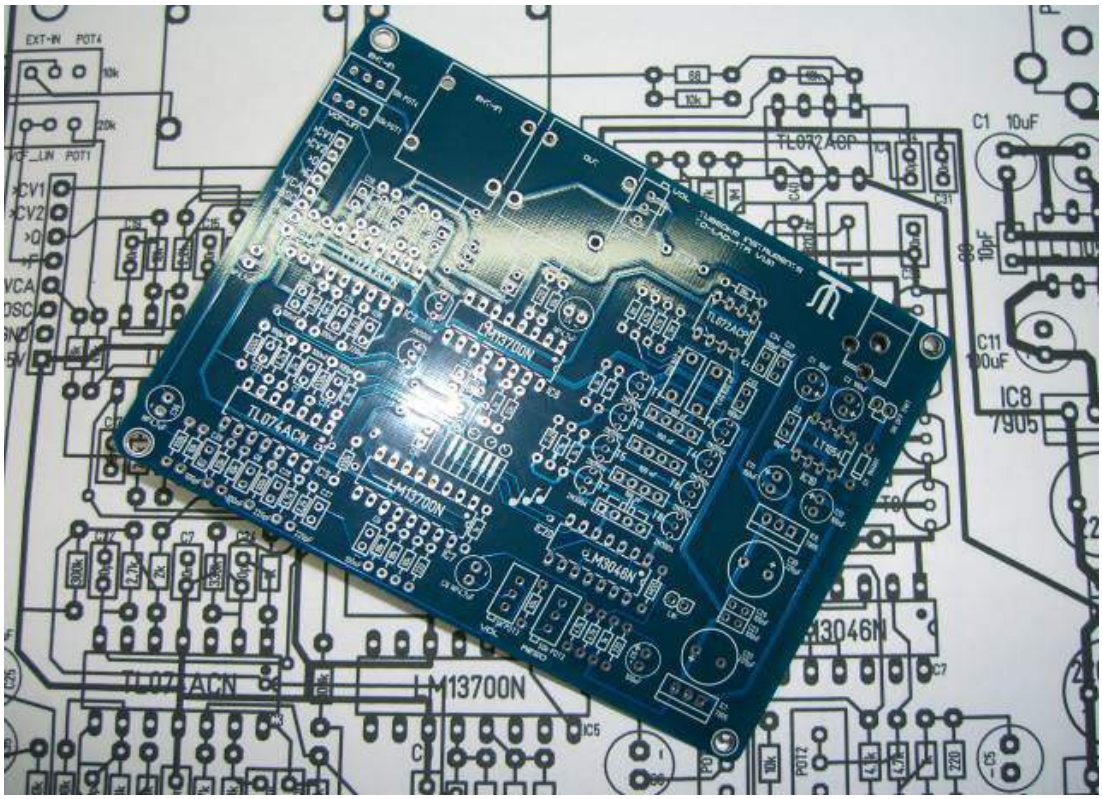
First Prototype:



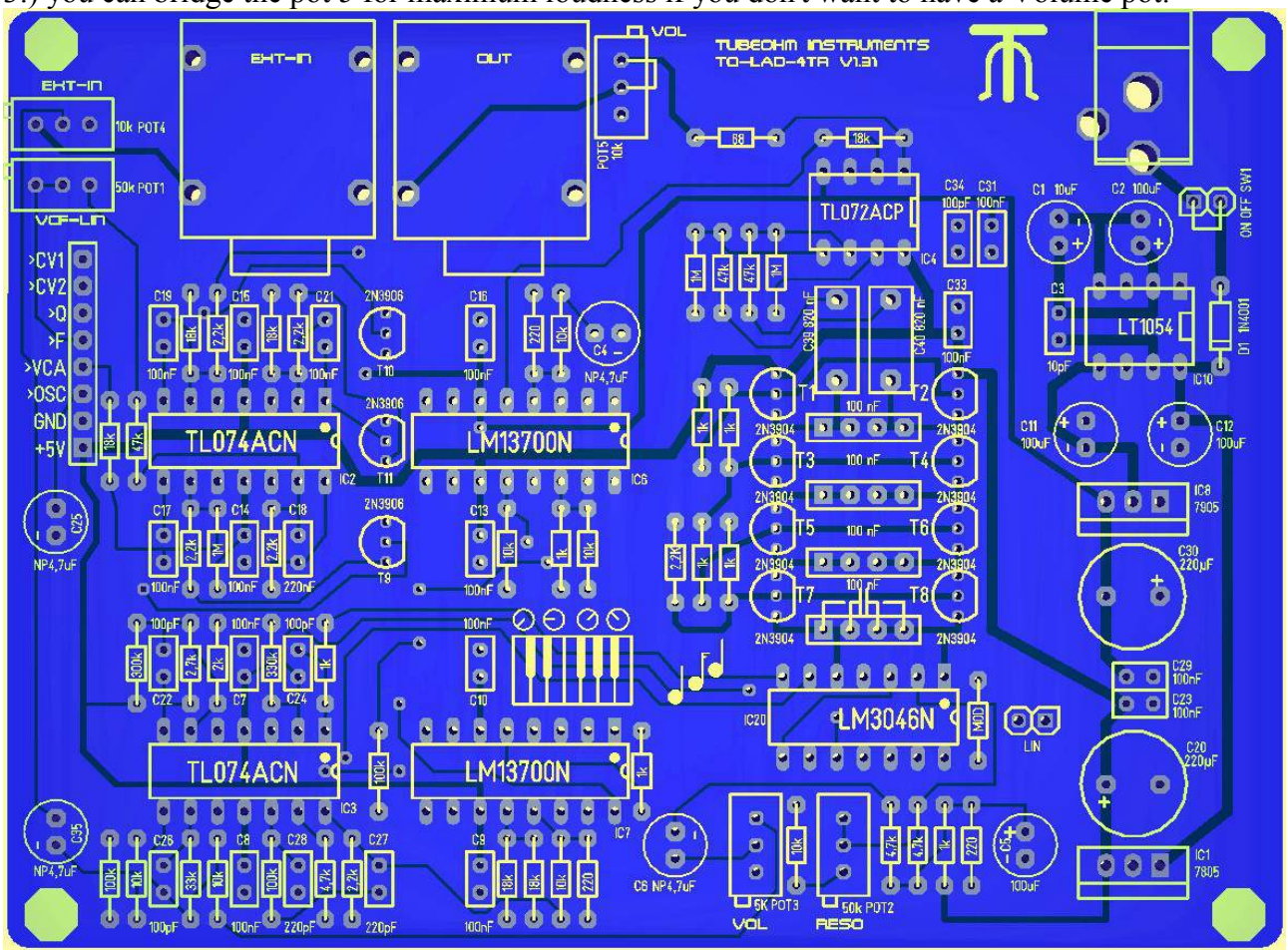
Second Prototype:

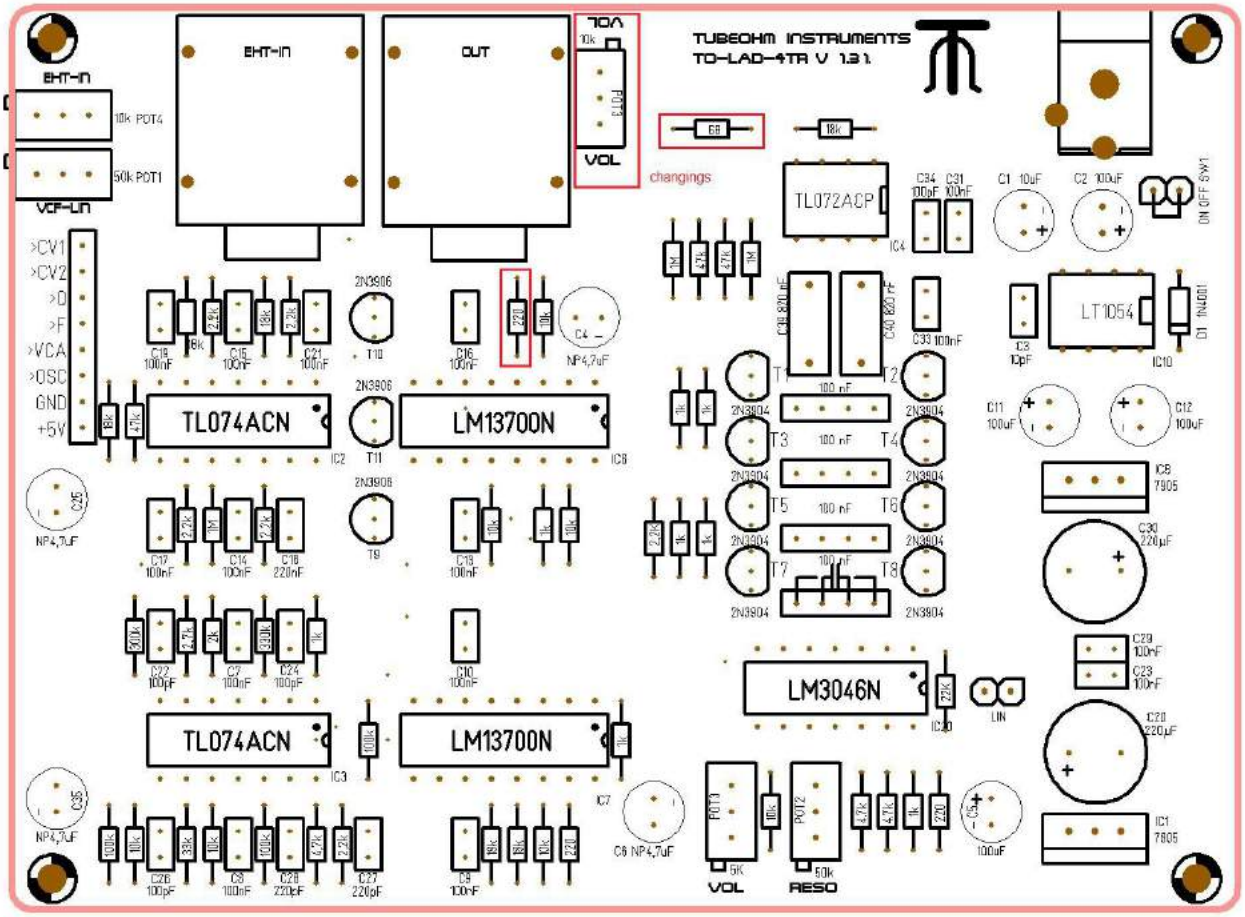


New in Version V 1.31:

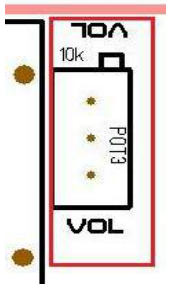


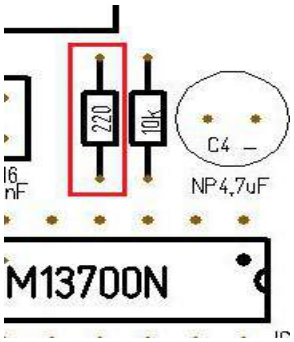
1:) now all Values are good readable.
2:) we have implement a new pot for output volume. Now you can adjust the loudness , or
3:) you can bridge the pot 5 for maximum loudness if you don't want to have a Volume pot.





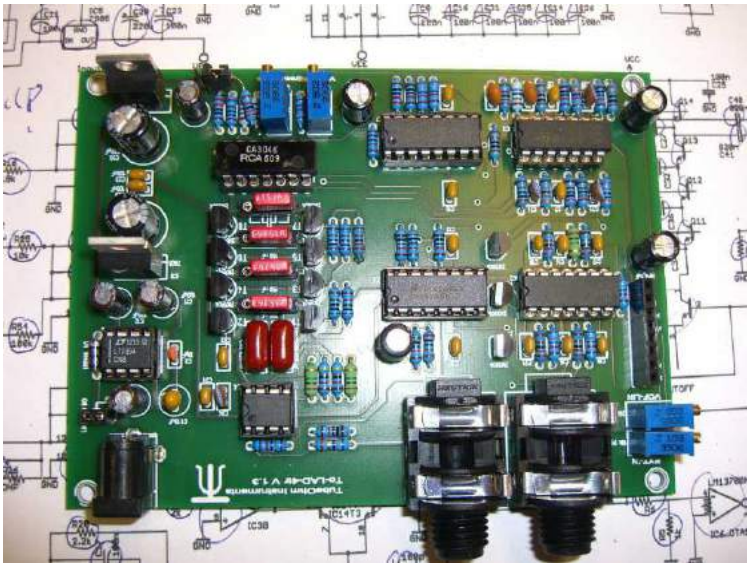
The solder instrucktion V 1.31 is nearly the same like in V 1.3 but with three changes.
First, there is a 10K vol pot, second, we removed one 10 K resistor and third, we replace a 1K ohm against a 220 ohm, so we reduce the output volume.





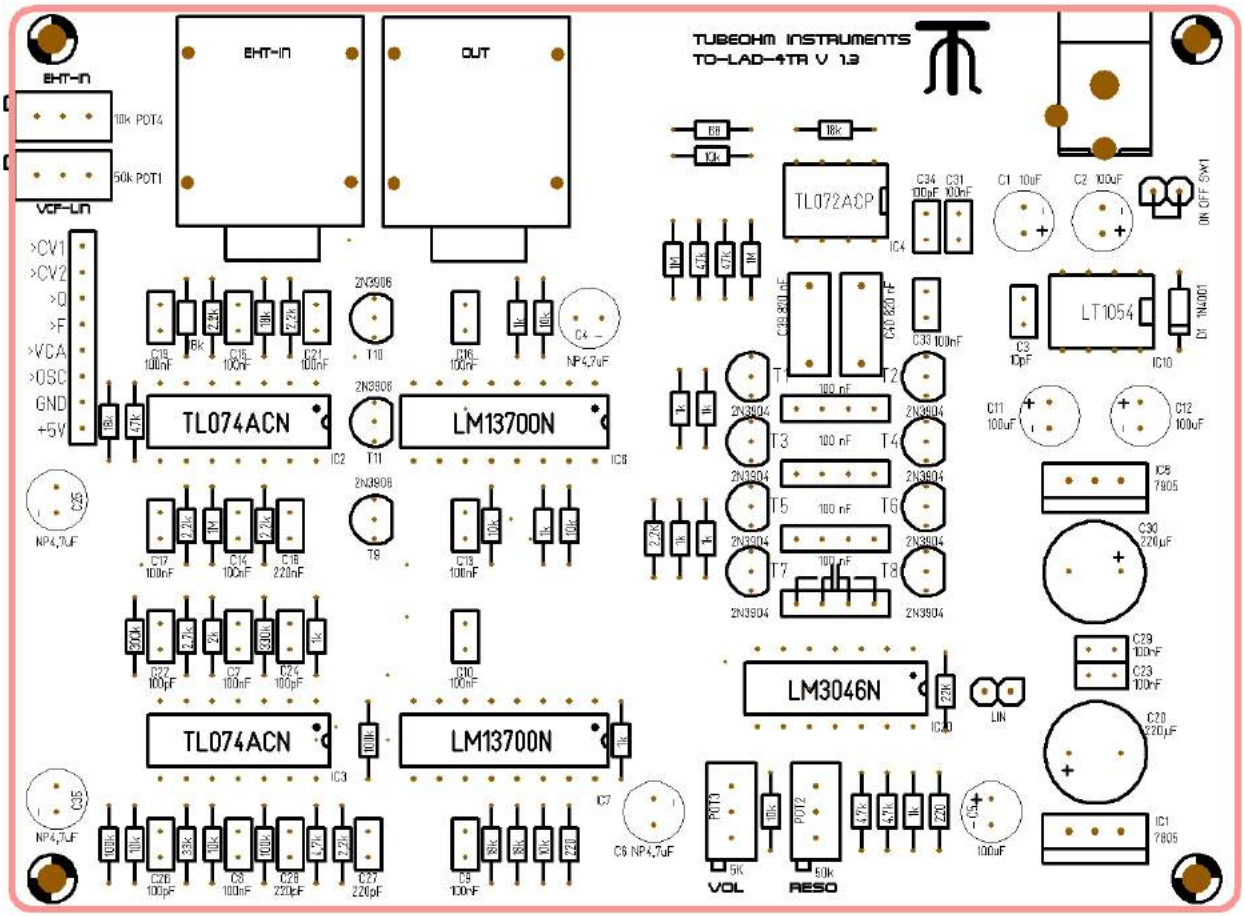
The rest is unchanged.

older Version V 1.3



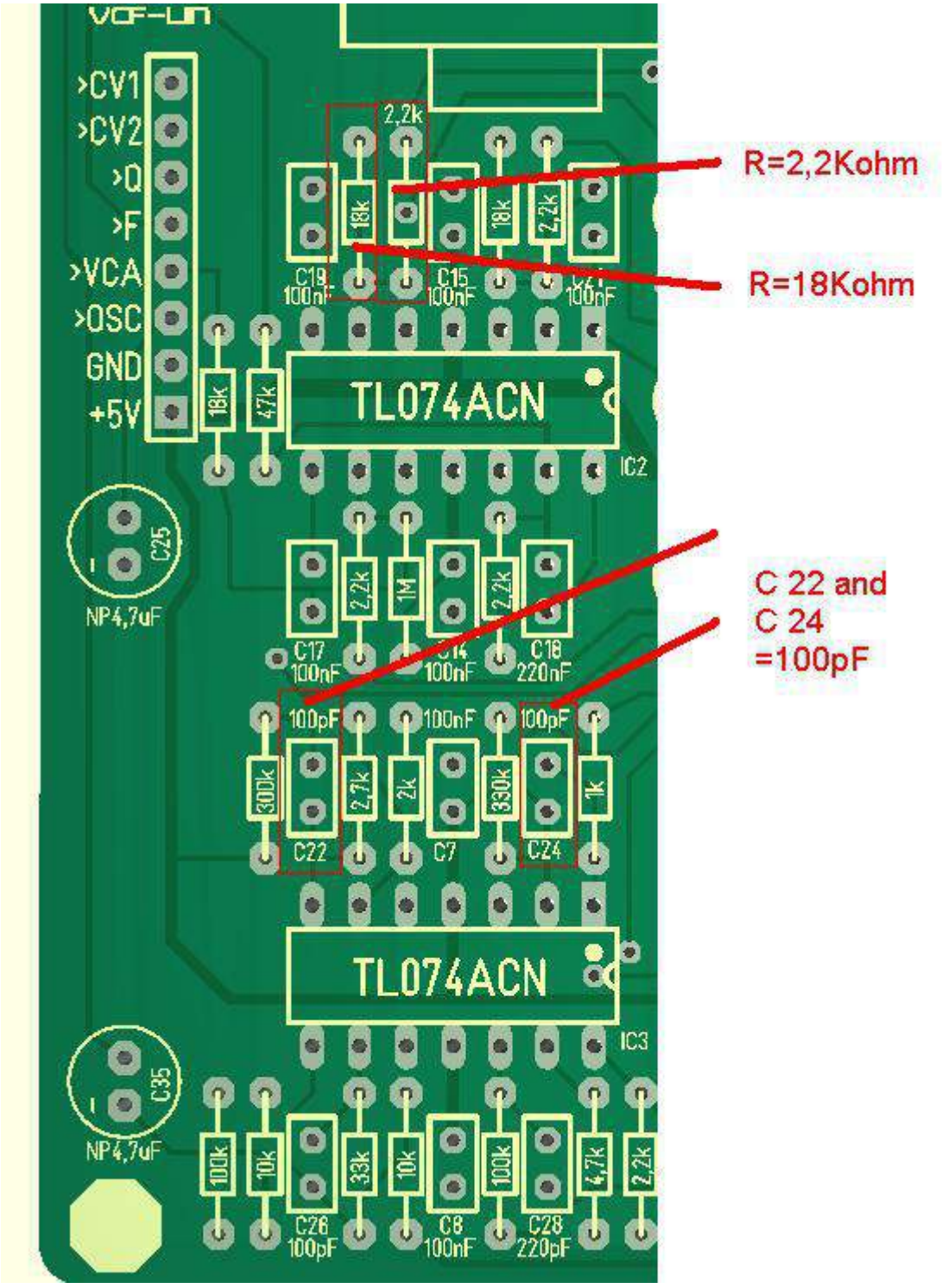
We hope this manual is nearly bugfree, but, double-check all PART VALUES with the 'BOARD FROM THE TOP, if you are unsure you have solder the right parts.
The part values in the Layout 'BOARD FROM THE TOP' are 100% tested and works !!

here is the board from the top view (ZOOM IT)



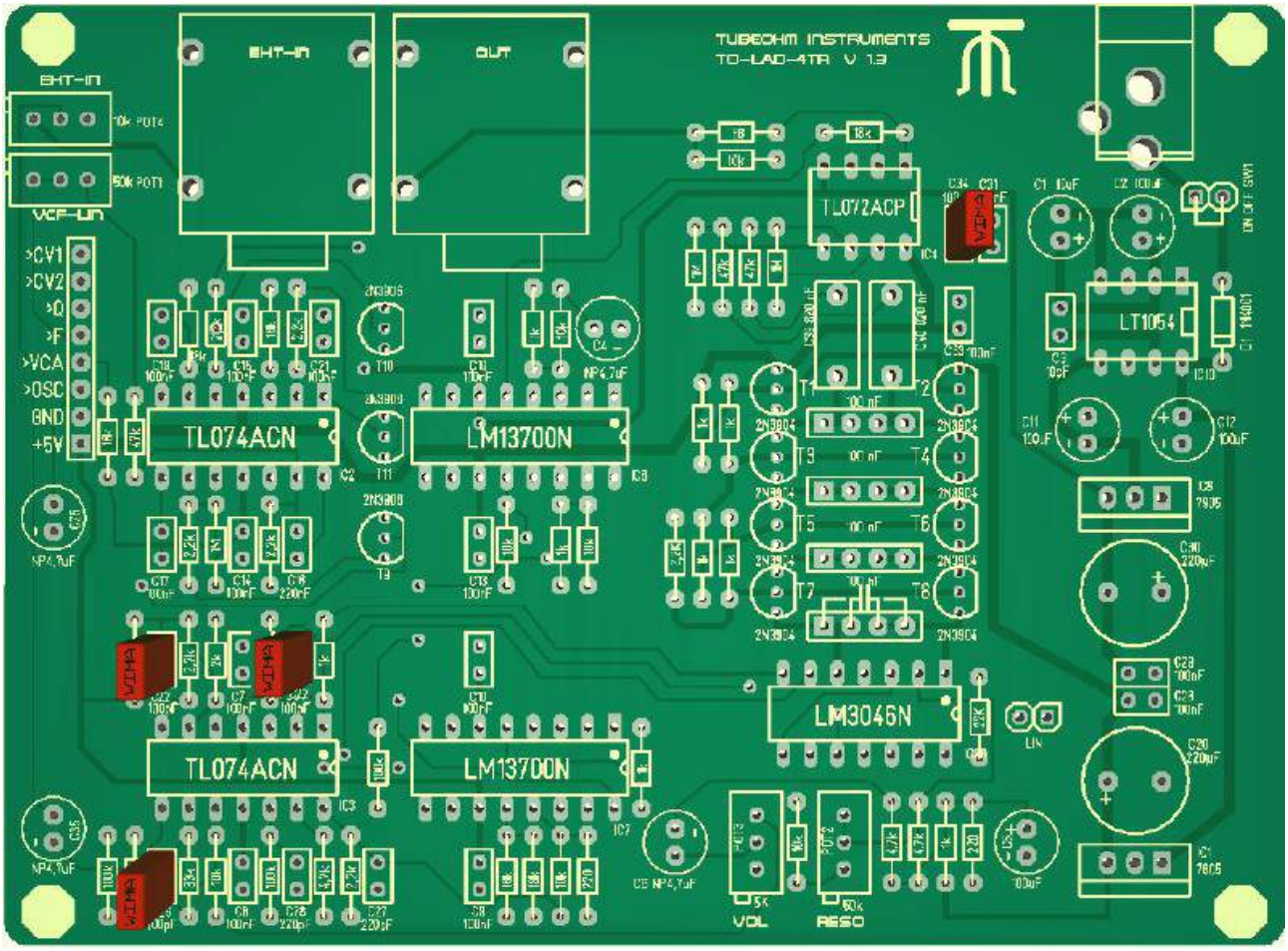
Attention

On the PCB V1.3 there are some part lables unreadable.
This happens with a 18 kOhm resistor, a 2,2kOhm resistor and C22 =100pF and C 24 =100pF.
Here is the picture. Contol that you solder the correct parts !!

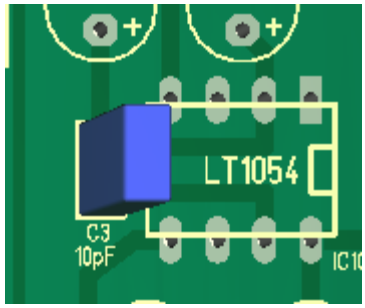


Solder the different capacitors .

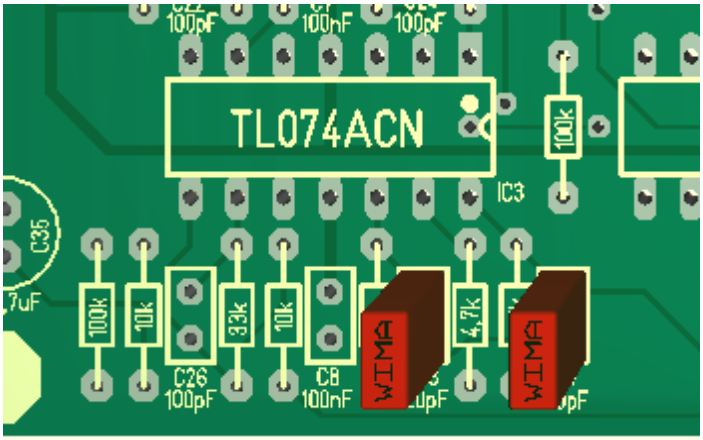
First 4 x 100 pF Capacitors.



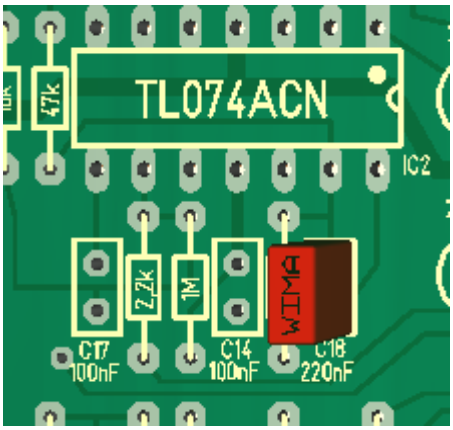
Then one 10 pF capacitor in the power supply



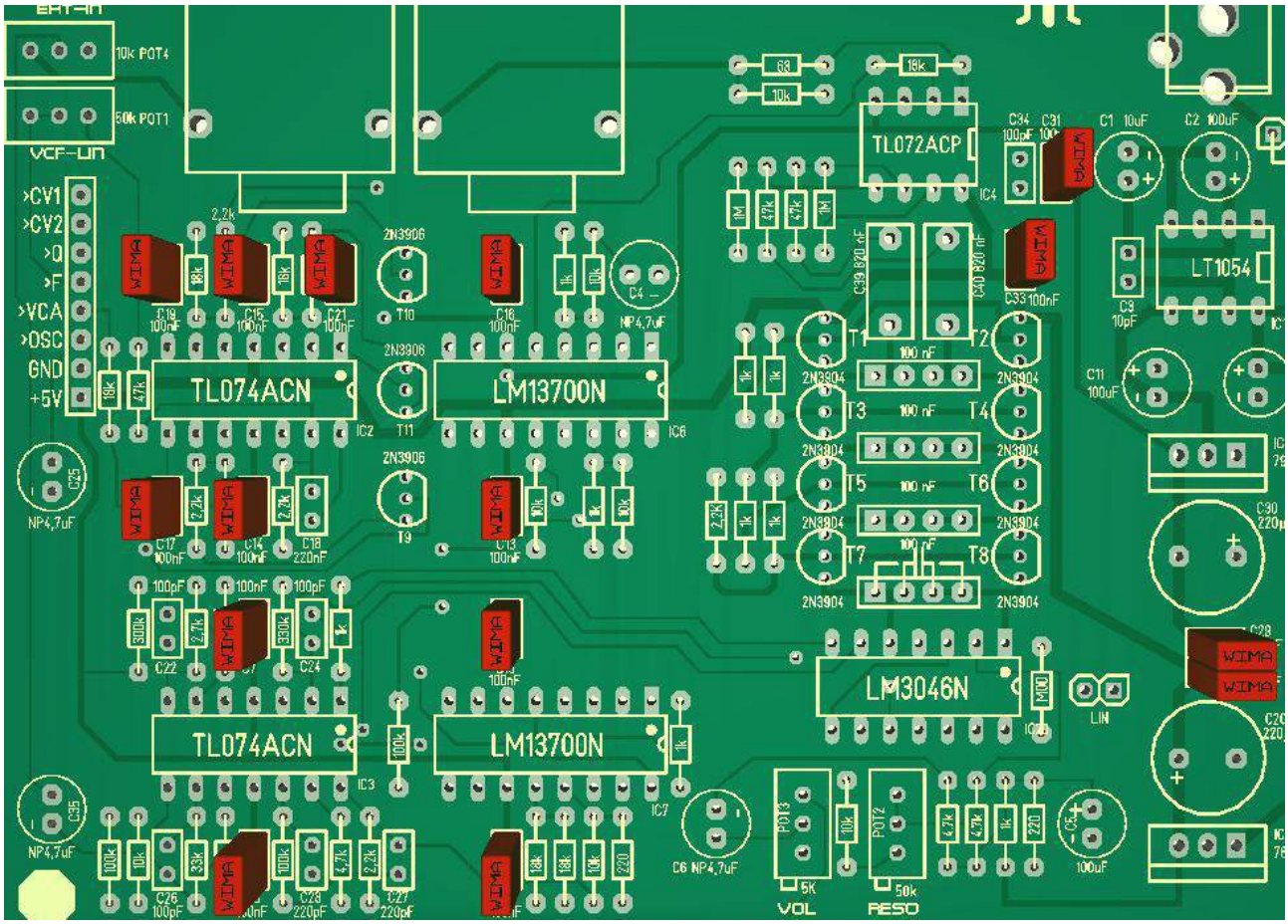
Two 220 **pF** capacitors here near IC 3: **pico Farad**



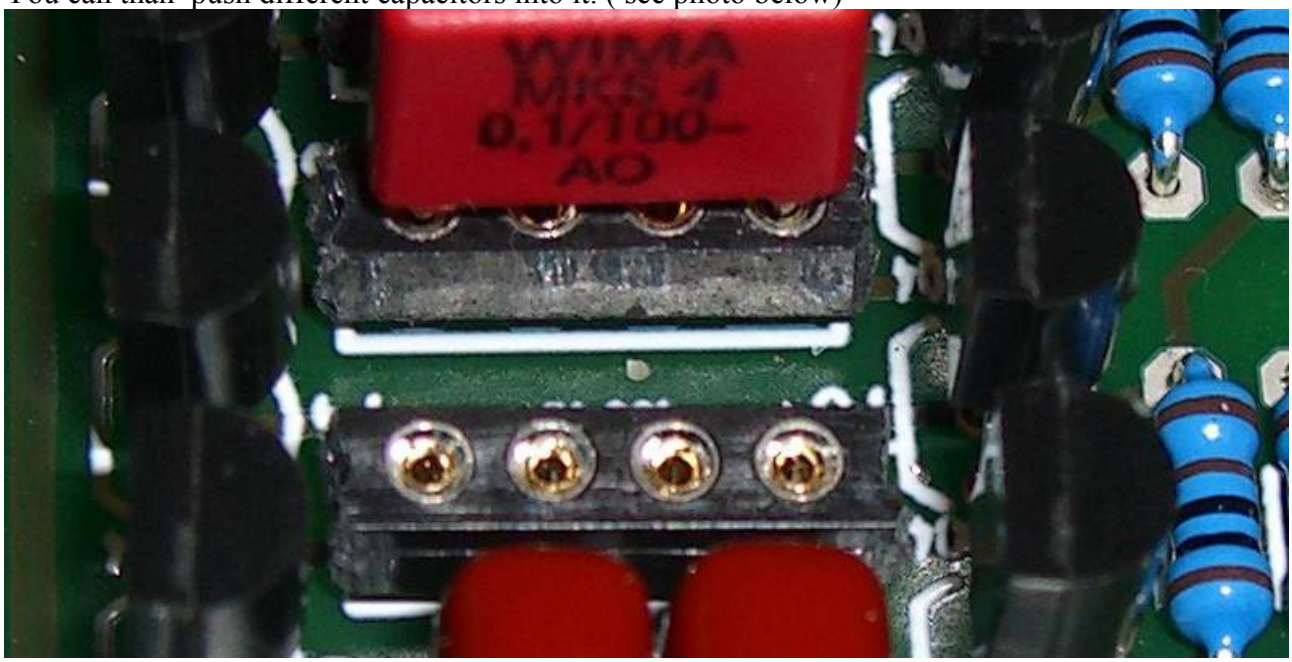
One 220 **nF** capacitor here near IC 2: **nano Farad**



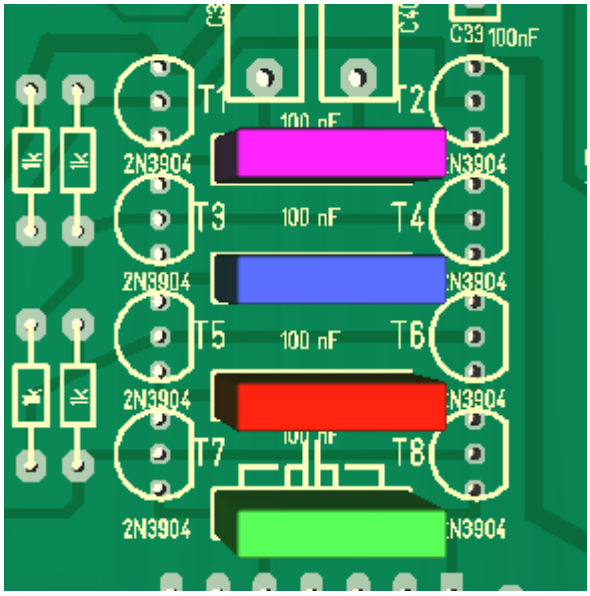
Now 15 x the **100 nF** capacitors for the IC peak blocking.



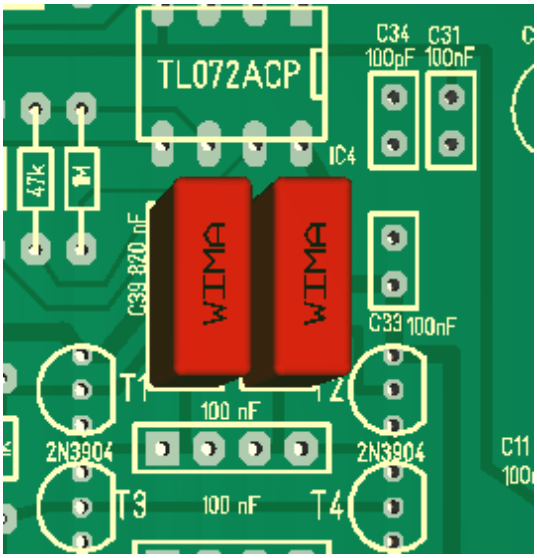
Than the ladder capacitors. We recommend 4x 100 nF for a wide frequency range.
But you can change the value to 150 nF or 120 nF. If you wish to experiment, we suggest that you build in 4 sockets for the capacitors. Simply use a precision IC socket and cut 4 connectors. You can than push different capacitors into it. (see photo below)



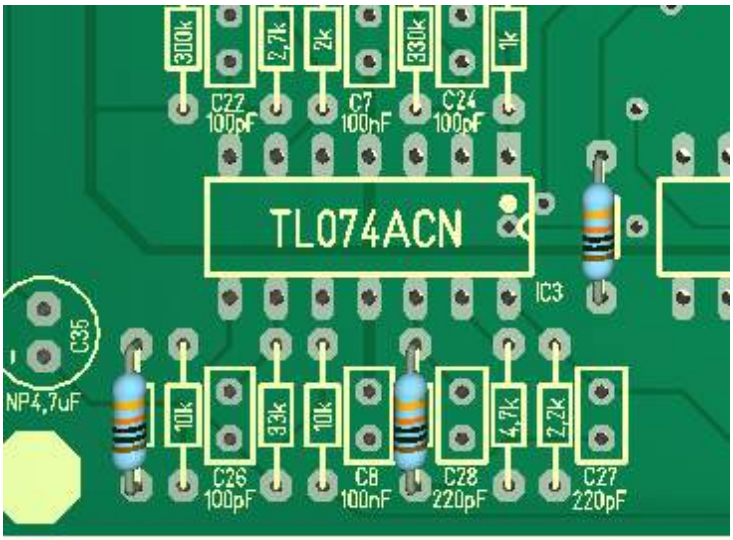
The sockets for the capacitors is a 'CAN do' not a ' MUST do '! You can simply solder 4 x 100 nF capacitors !



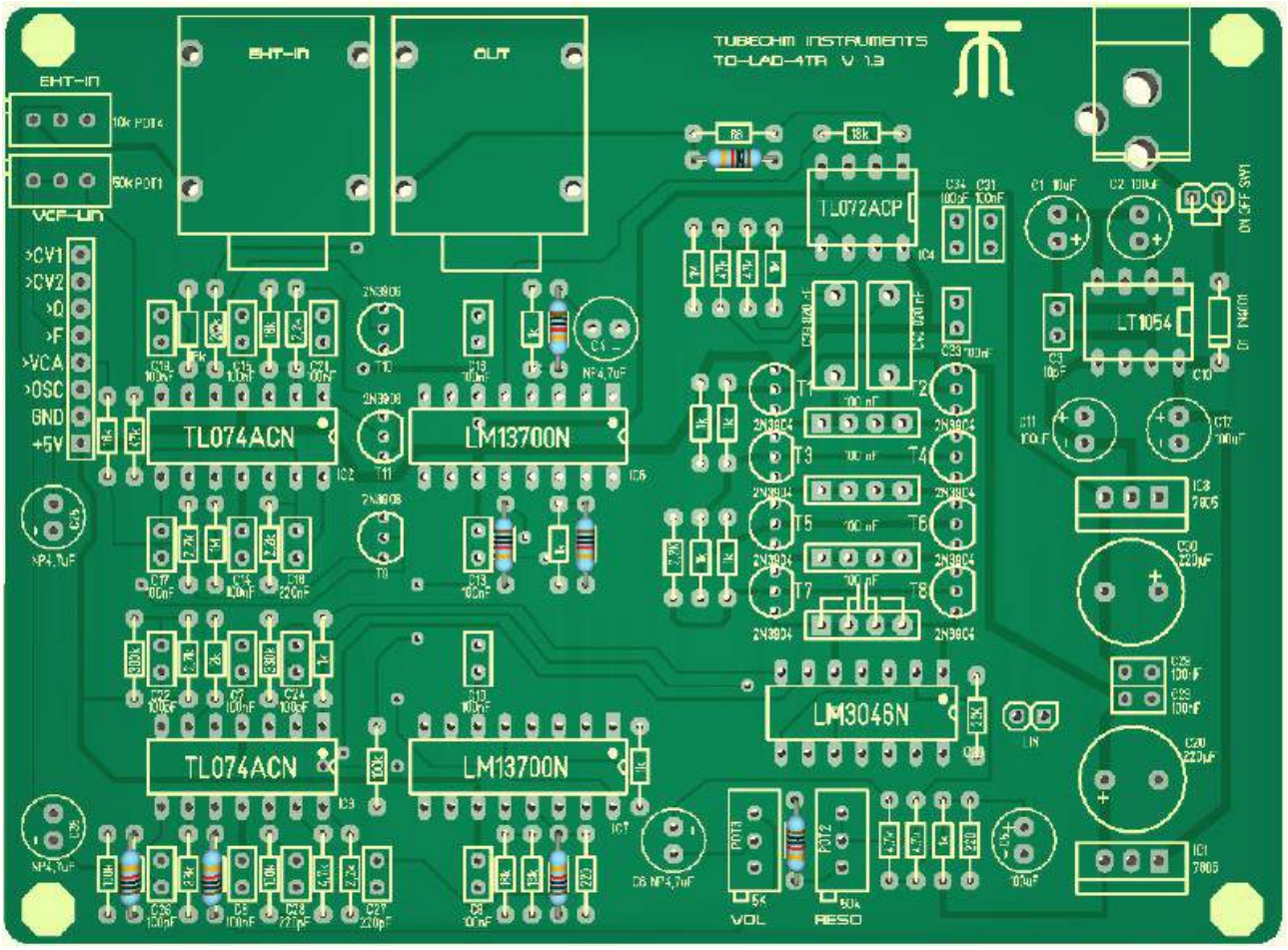
And here the couple capacitors 820 nF



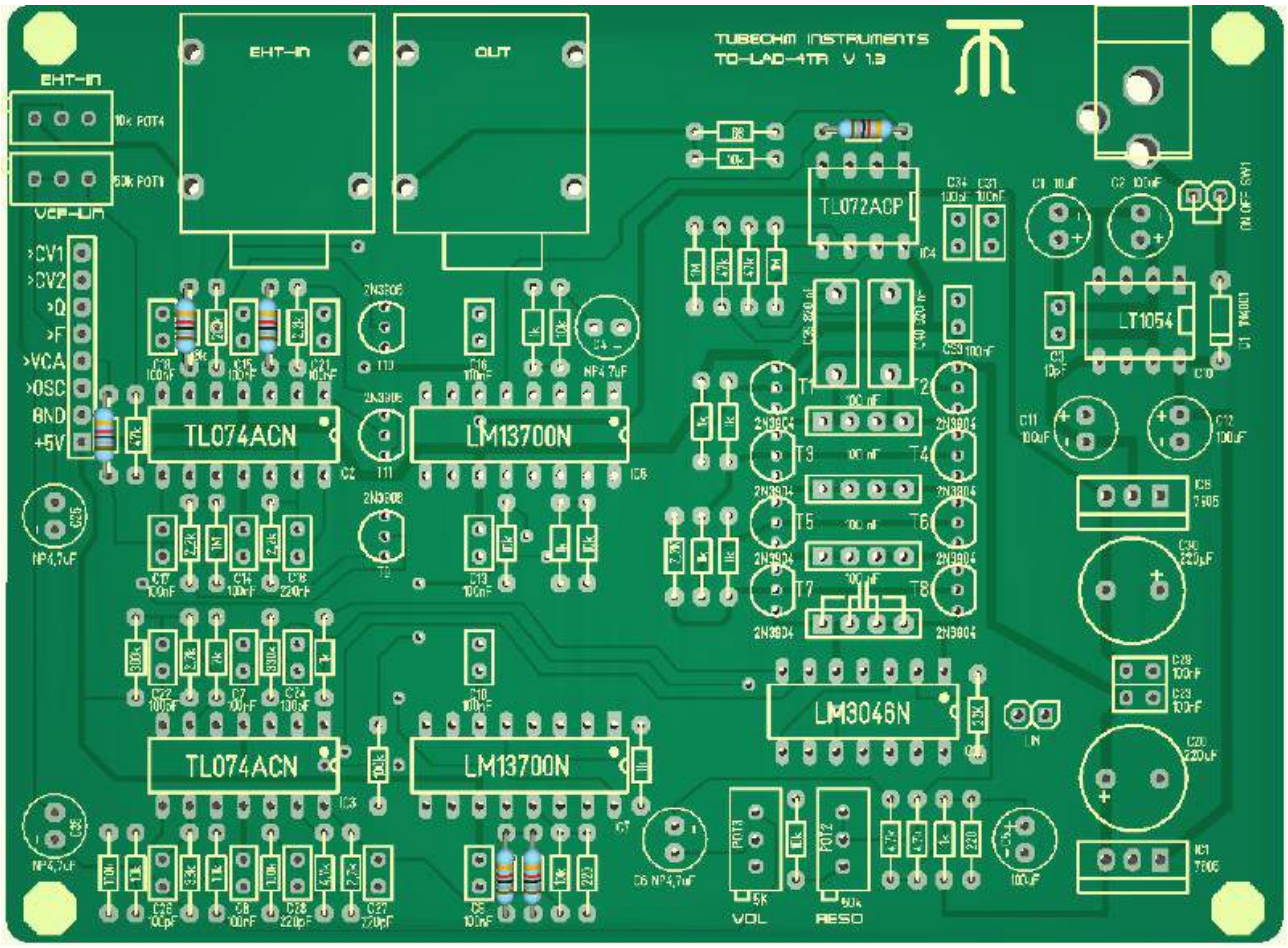
Now the resistors ! 3 x 100 K Ohm metall 1% code: brown, black, black, orange, brown



Now 8 x 10 K resistors 1%, code: brown, black, black, red, brown

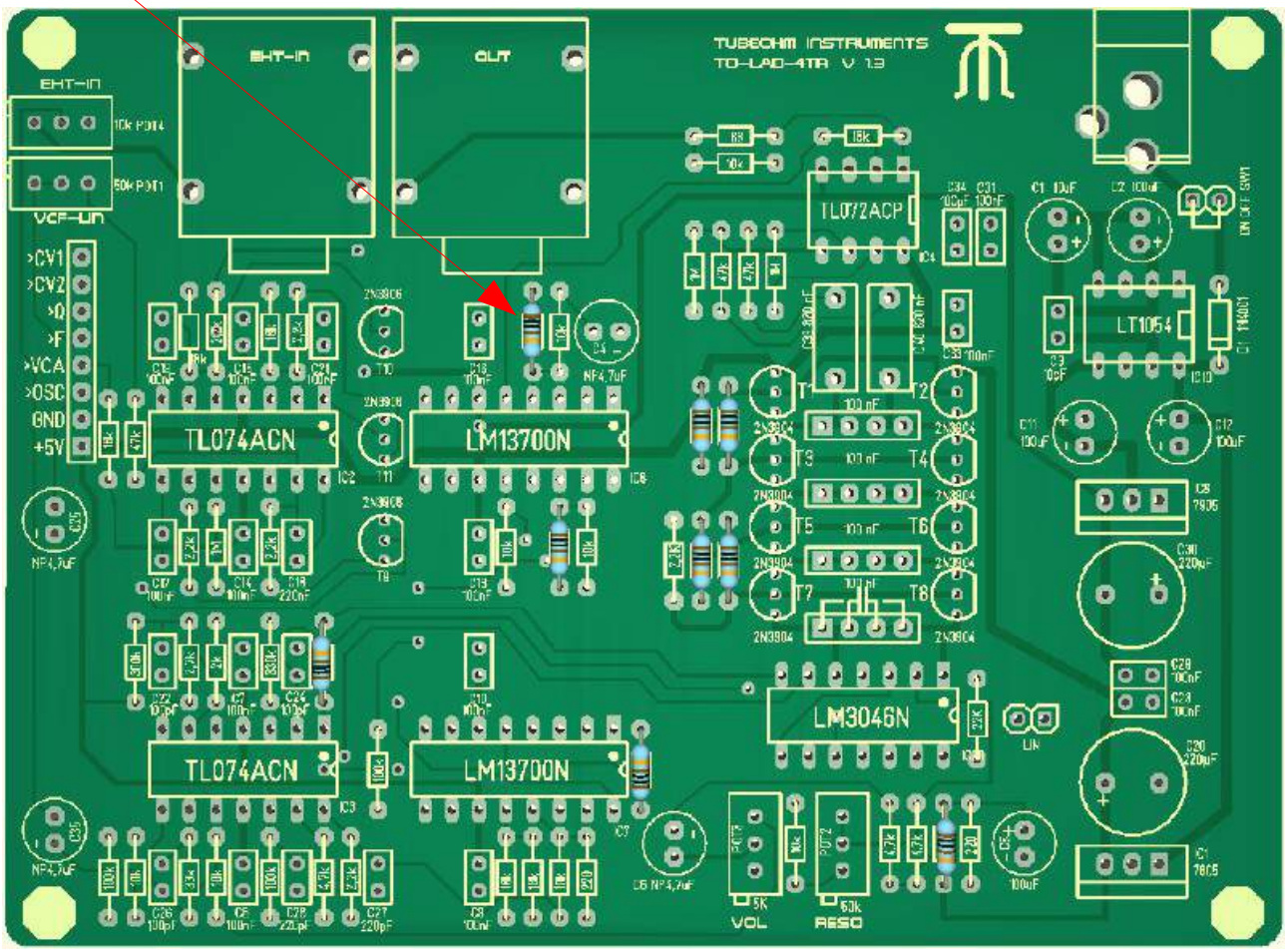


Solder six x 18 k Ohm here , code: brown , gray, black, red , brown

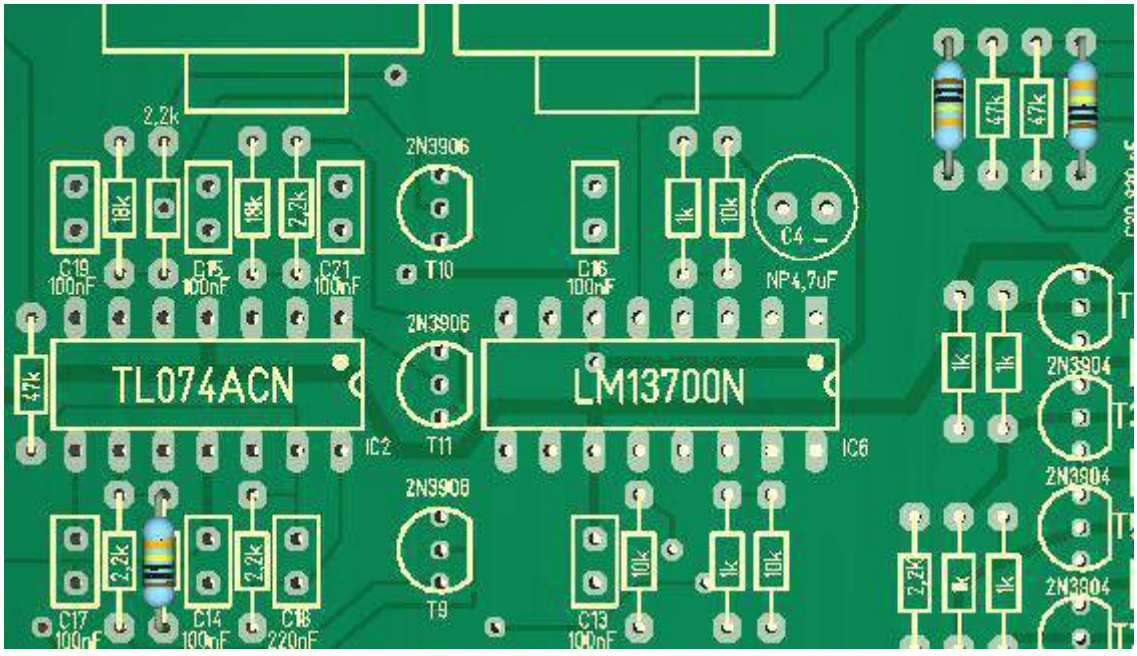


Here 9 x 1 K resistors 1% , code brown, black, black, brown, brown

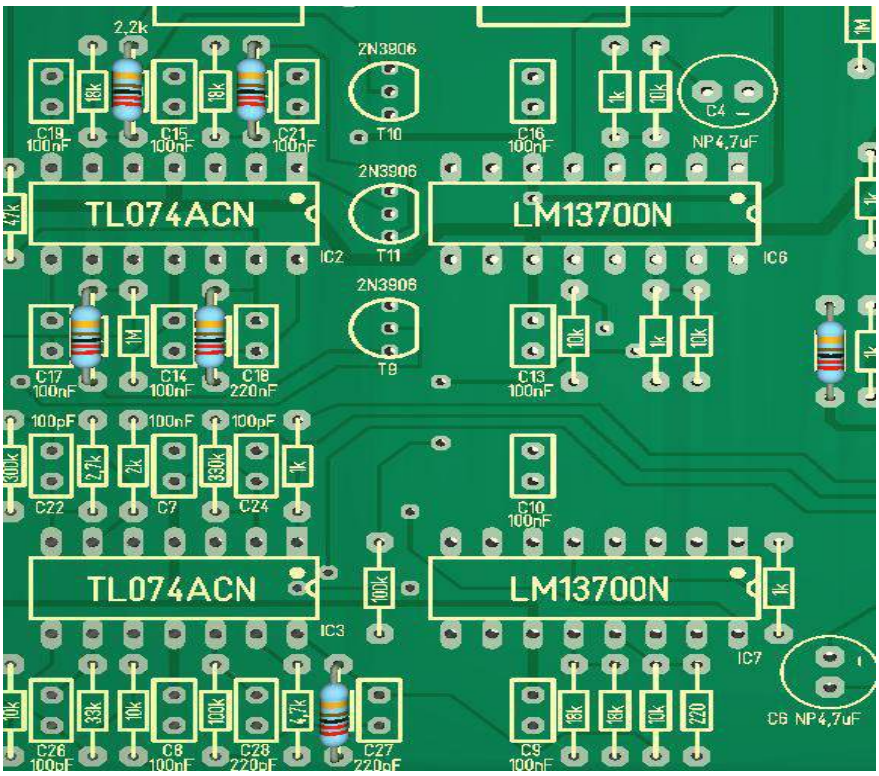
To decrease the output volume from 2 v peak to peak to 1 v peak to peak, reduce R5 from 1 K to 220 R. With 1 K your soundcard direct in can be overload.



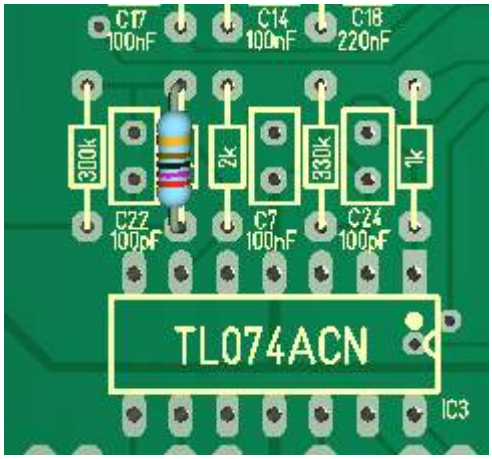
3 x 1M Ohm 1 % resistors here, code brown, black, green, gold



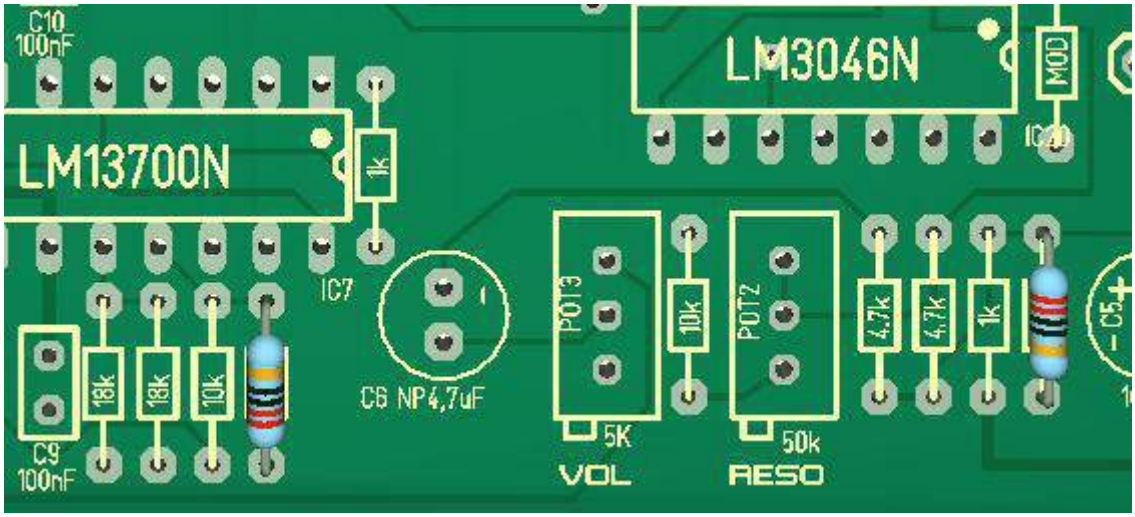
6 x 2,2K Ohm resistors here, code: red, red , black, brown, brown



1 x 2,7 K ohm here, code: red , purple, black, brown, brown

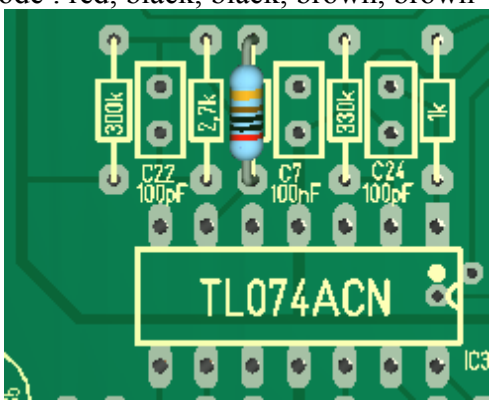


2 x 220 OHM here: code red, red, black, black, brown

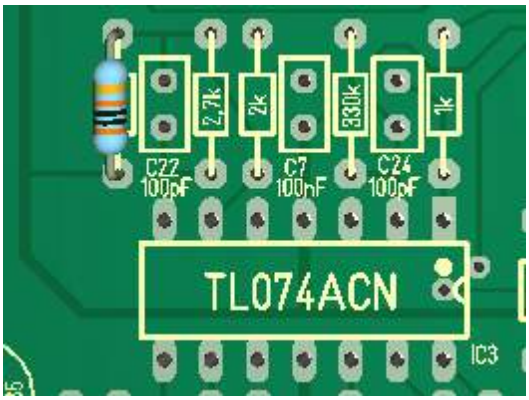


optional 1 x 22...47 K Ohm. This is for modding. If you don't want to mod the Filter, don't solder it. And leave the space free.

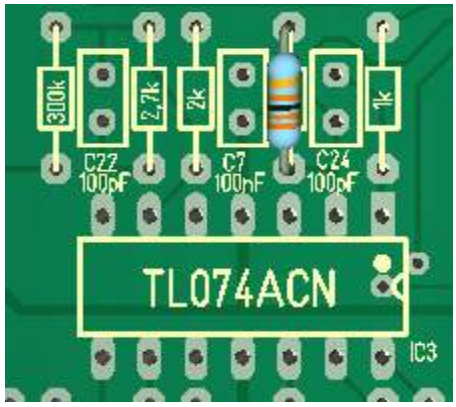
One 2 K Ohm resistor here. Code : red, black, black, brown, brown



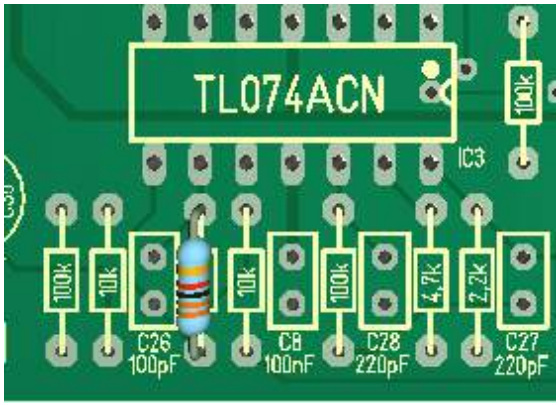
One 300 K Ohm here: code orange, black, black, orange, brown



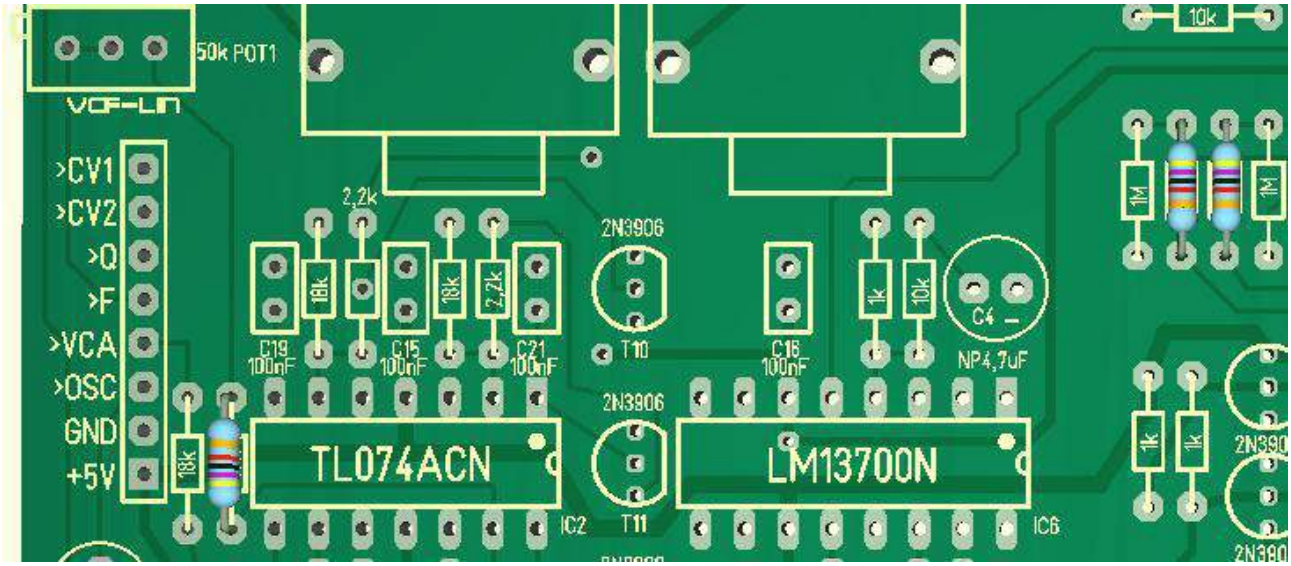
One 330 K Ohm here: code: orange, orange, black , orange, brown



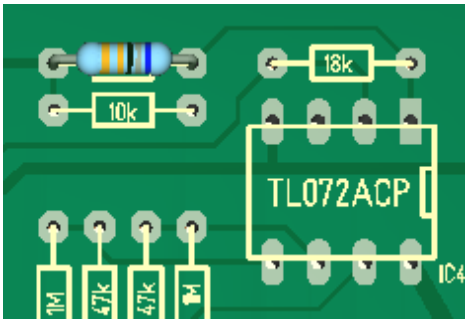
One 33 K Ohm here: code: orange, orange, black, red , brown



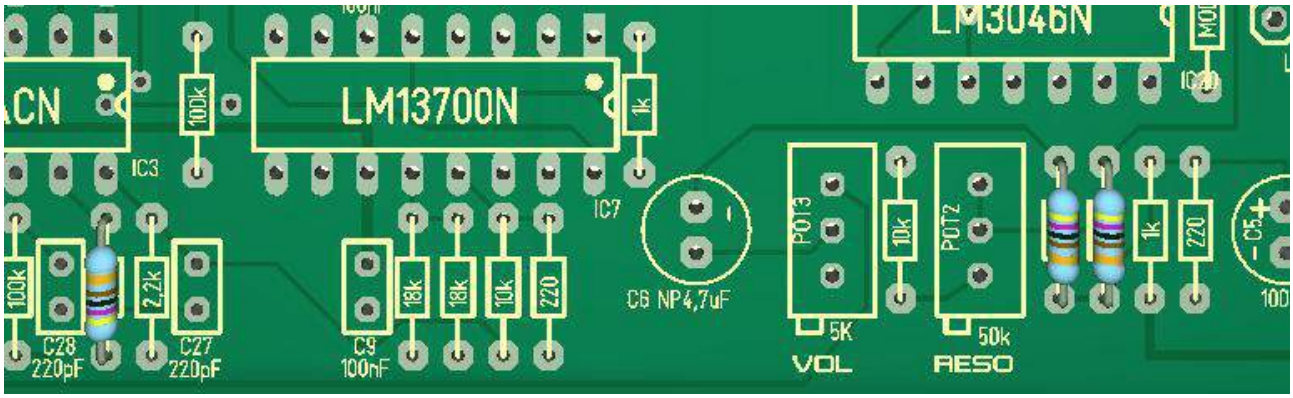
3 x 47 K Ohm here: code: yellow, purple, black, red, brown,



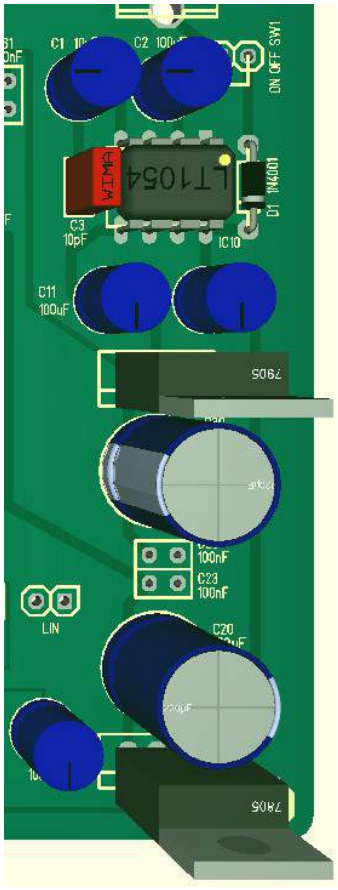
1 x 68 Ohm here: code: blue,gray, black, gold brown



3 x 4,7 K here: code,yellow, purple, black, brown, brown

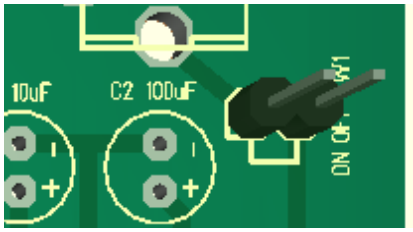


The power supply:



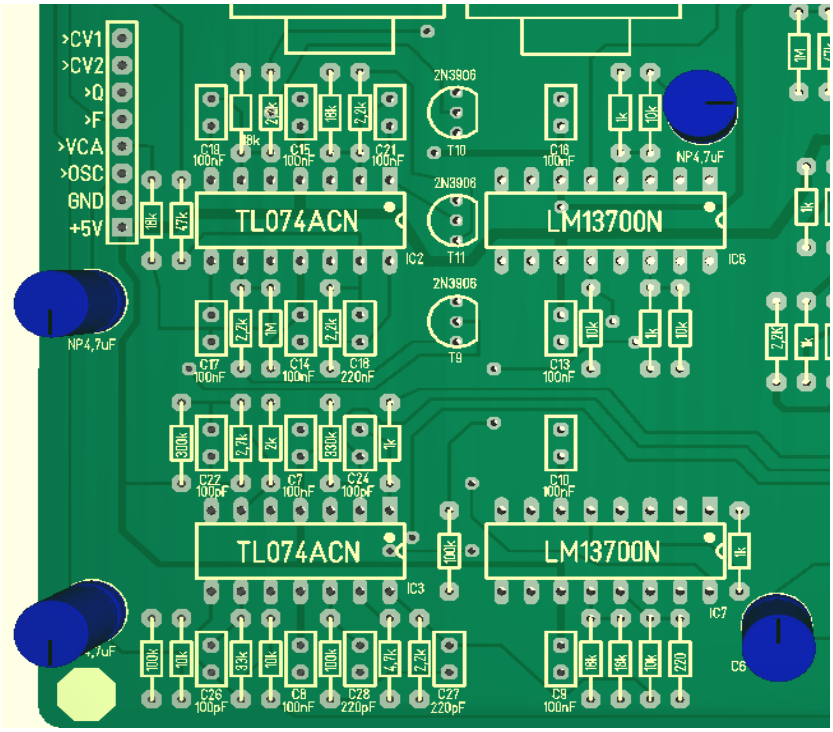
For the power supply you need:
1:) C1, a 10 uF tantalum capacitor, attention ,check the Polarity, PLUS and MINUS
2:) C2,C5,C11, C12, 100 uF Elko, attention check the Polarity, PLUS and MINUS
3:) C30, C20 ELKO 220 uF 25..35 Volt, attention ,check the Polarity, PLUS and MINUS
4:) D1, 1N4001, attention, check the Polarity, PLUS and MINUS
5:) C3 is 10 pF
6:) IC8 =7905, IC 1 = 7805, IC 10 is LT 1054

Power switch here:

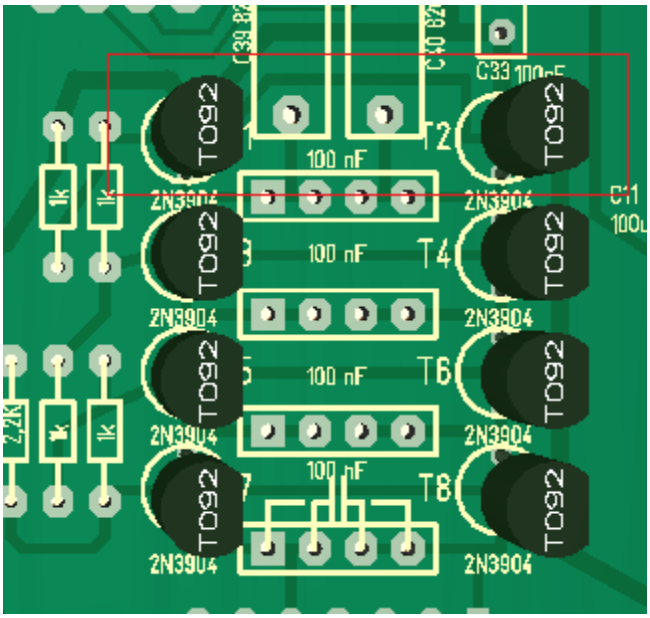


Both pins are for a POWER ON/OFF switch. If you don't want to connect a power switch, just bridge it.

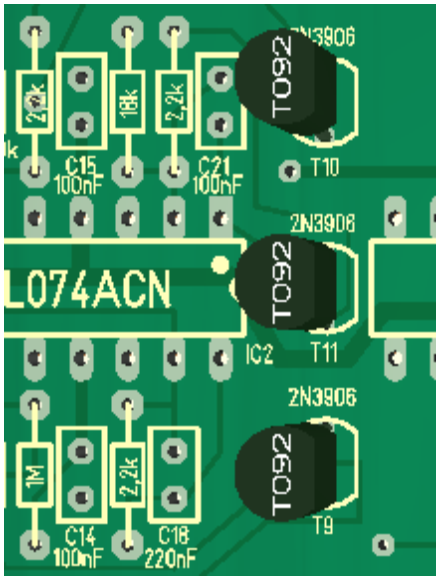
4 non polarised capacitors 4,7 uF here: (No plus or minus worries).



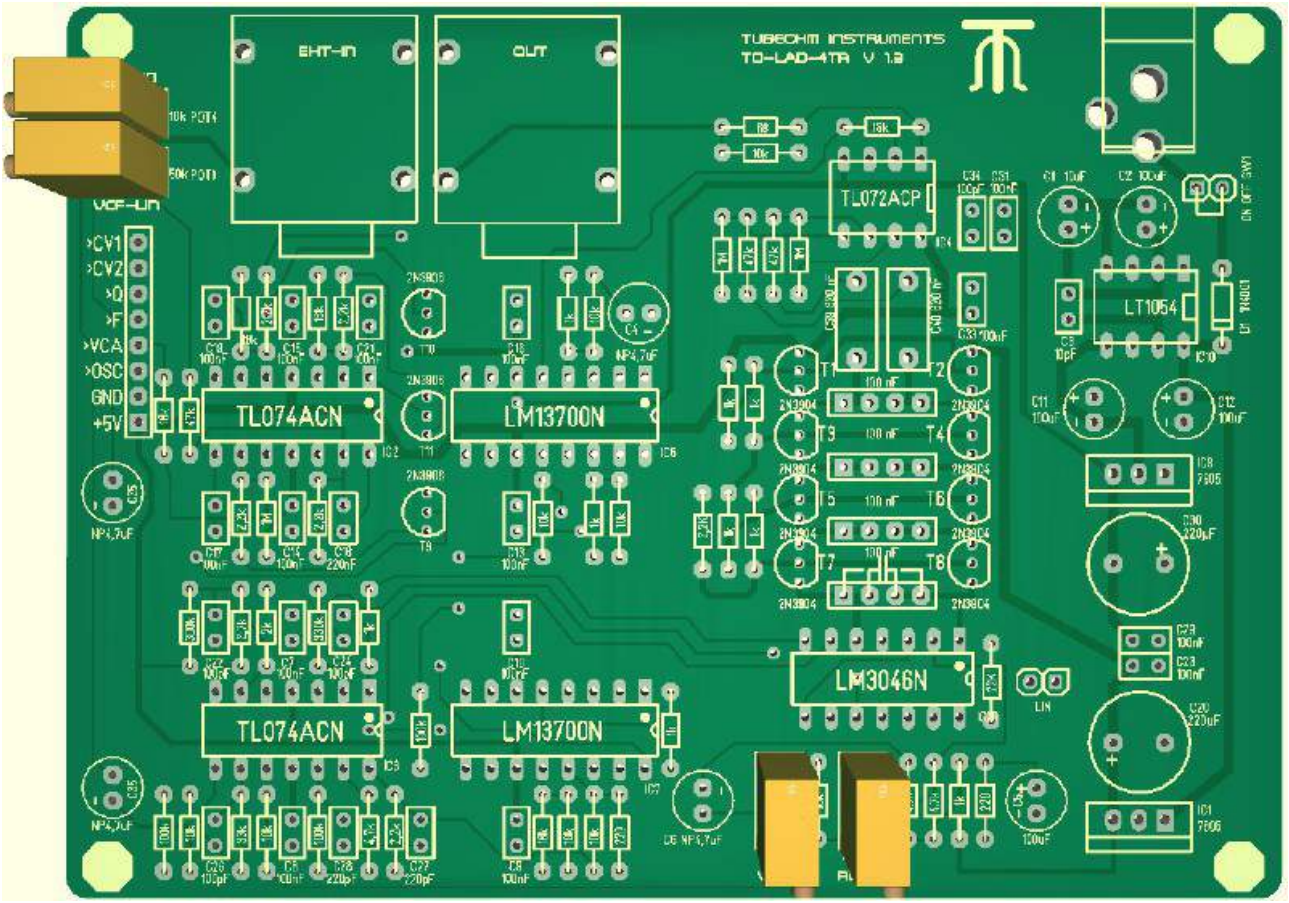
8 x 2N3904 NPN matched Transistors for the ladder here.
We deliver 4 pairs of matched selected Transistors.
Pair 1 is T1 and T2
Pair 2 is T3 and T4
Pair 3 is T5 and T6
Pair 4 is T7 and T8



Three Transistors 2N3906 PNP here:

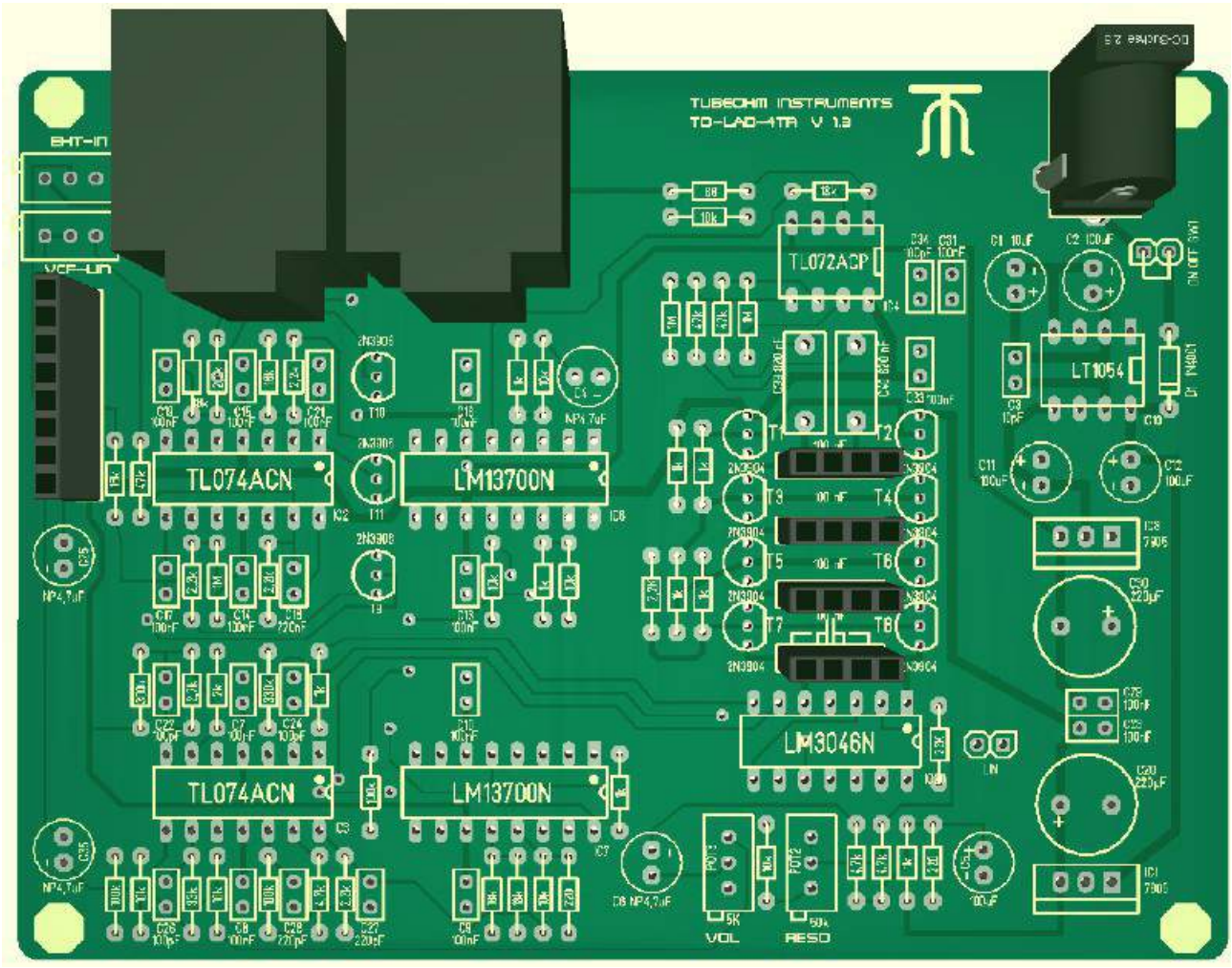


Trim Pots here:
You need 1x 5K, 2x 50 K(47K), 1 x 10 K pot

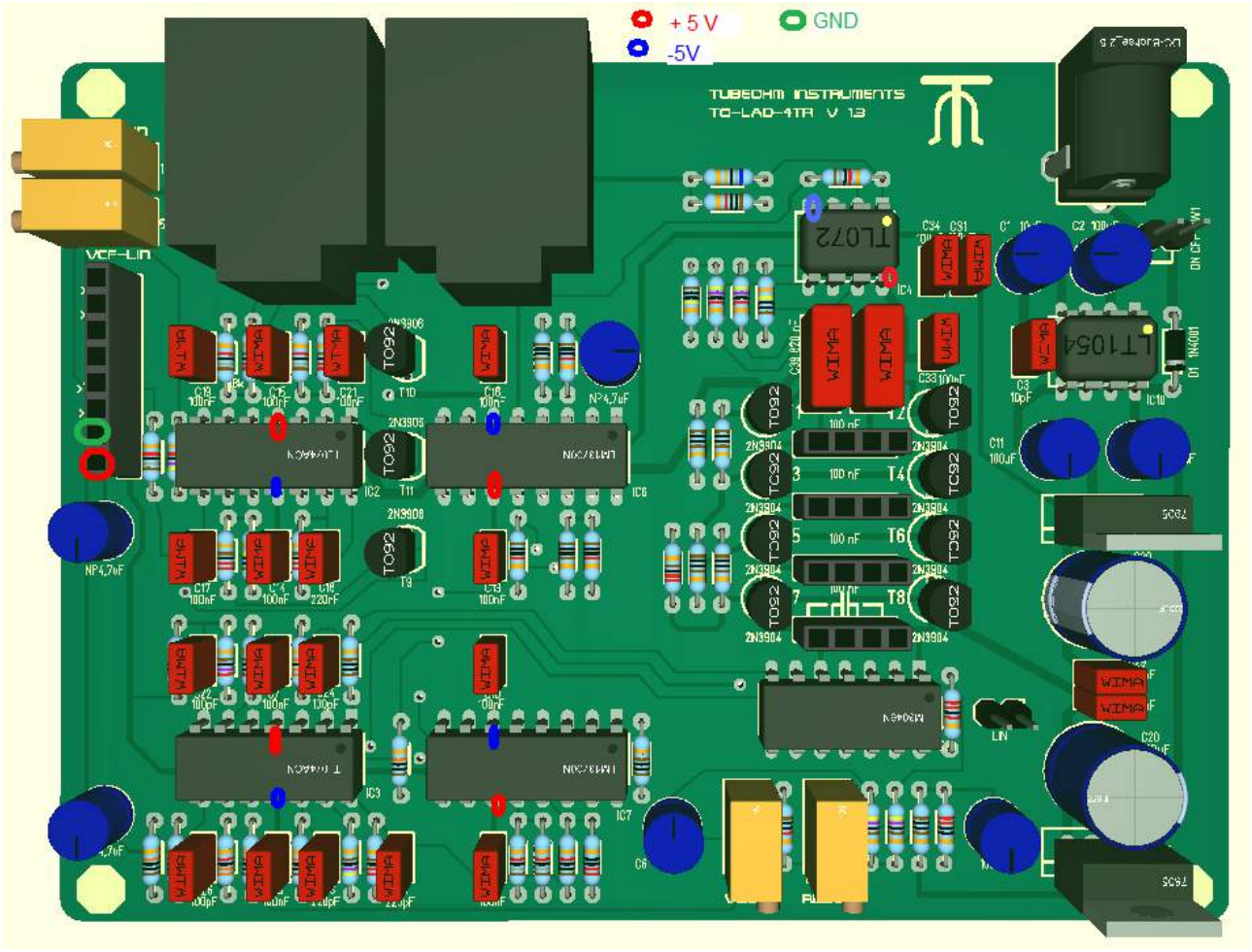


Connectors here:

You need
2 Neutrik 6,3 Audio
1x8 Pin header
1 x power supply connector (DC jack)
4 x 4 pin sockets (optional)



Ok, I think that's about it. Before you connect all IC's firstly let's do a power test.
Insert just the LT 1054 into the socket. No other IC's. Then test with a Multimeter that the power supply works !!!
Set the Multimeter to DC 10..20 V. Connect the filter to the 9V DC power supply WITHOUT the Shruthi motherboard.

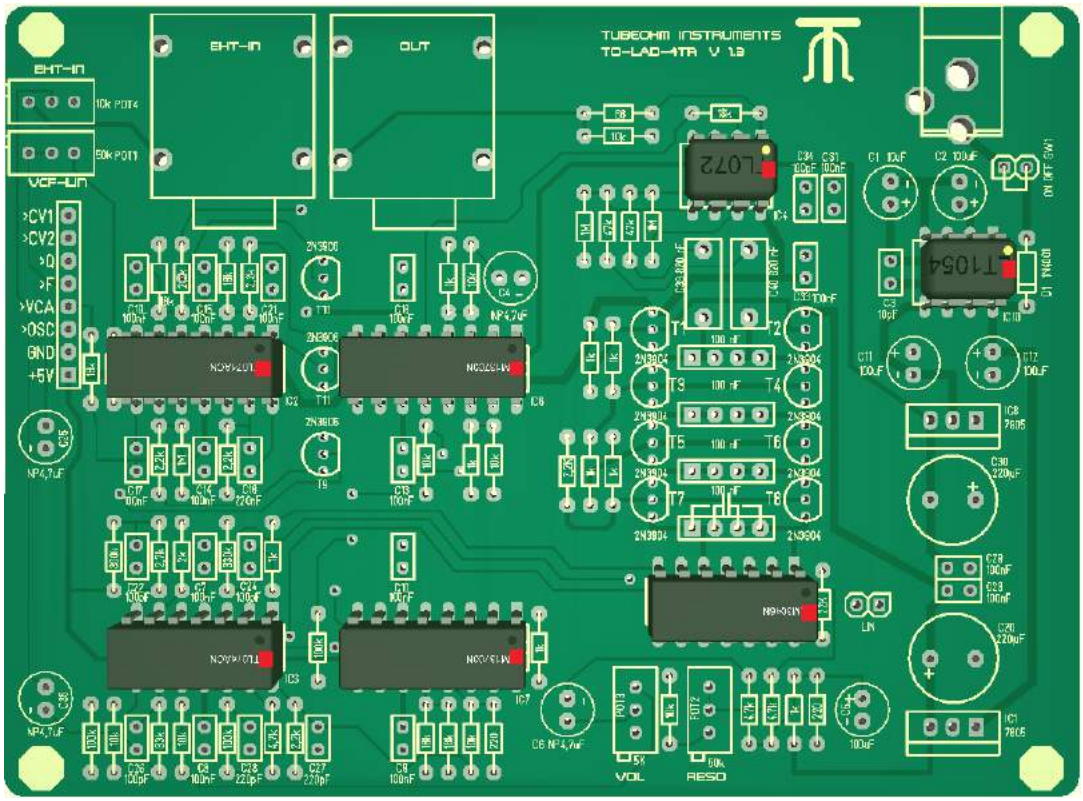


Check the points shown here, red= +5V, blue = - 5V, green is ground.
Tipp: some 7805 have only 4,82... 4,93 V
This is not a great Problem.

Now the IC placement. We suggest you to take sockets for the IC's.
You need

2 x LM 13700N	16 pin
2 x TL074	14 pin
1 x CA 3046	14 pin
1 x TL 072	8 pin
1 x LT 1054 (Power supply)	8 pin

Important, check the orientation !!!



All in the same orientation ??? Sure.....??????

Congratulations, you have built the TO-LAD-4tr.

Now we have come to the most important stage, adjusting the filter.
FIY. if the oscillator input too high, the filter loses its resonance. Be aware as this can be very important in regard to external signals

Why set up the linearity ? This is very important for the complete sound.
Example. If the cut frequency is fixed to 200 Hz, all Notes above 200 Hz are filtered more and more.. One octave higher, you get the half volume, 2 Octave higher it can be that you hear nothing.
The linearity adjustment let the filter move in its frequency like a normal oscillator.
In fact you can use the Filter as an oscillator (High resonance, no oscillator signal) to play notes.
But this only , if the filter doubles its frequency from one octave to the next.
The ladder filter should be linear from 40 Hz up to 5..6 KHz. The sound forming happens between 40 and 5..6 KHZ. On 10..20 KHz you don't hear much changing.

Some words to the adjustment. While design the schematics and building the filter I noticed that the resonance volume is lower if the Oscillator volume is higher.
If the input signal is too loud, you become no filter effect. For this I have built in the Volume pot.
But default setting is : Volume POT 3 to Maximum !! So that you hear the sound with resonancy =0.

Using external signals. Filter BOX.
As I said, if you use external signals, adjust the EXT in Pot 4 in this way that you hear the signal and also the resonance. If the EXT input signal is too loud, the filter is overdriven and you get no filter effect.
This is the normal behavior from a ladder filter.

Now we bring the filter alive.

Step 1: Connect the ladder Filter to the Shruthi Motherboard
Step 2: turn the pot 'POT 5' and 'POT 3' to the maximum loudness until you hear the pot click.
Now you should here a sound if you power on and play the Shruthi.

Step 3: Resonance adjustment.

Switch off both oscillators in Shruthi. Also the sub oscillator.
Set the Filter ADSR/LFO to zero.
Set Q on Shruthi (resonance) to 63.
Set CUT to 30
Adjust the pot POT2 so that you hear a feedback oscillation
Set CUT so, that the oscillation is nearly 100 Hz.(96..105 HZ).
Is the Q oscillation still there ??
If yes, decrease Q in Shruthi to the value 51.
Adjust the POT2 in this way, that on 100HZ the oszillation begins
with the Shruthi Q-Value 51
The oszillation must stop on Q-Value 50

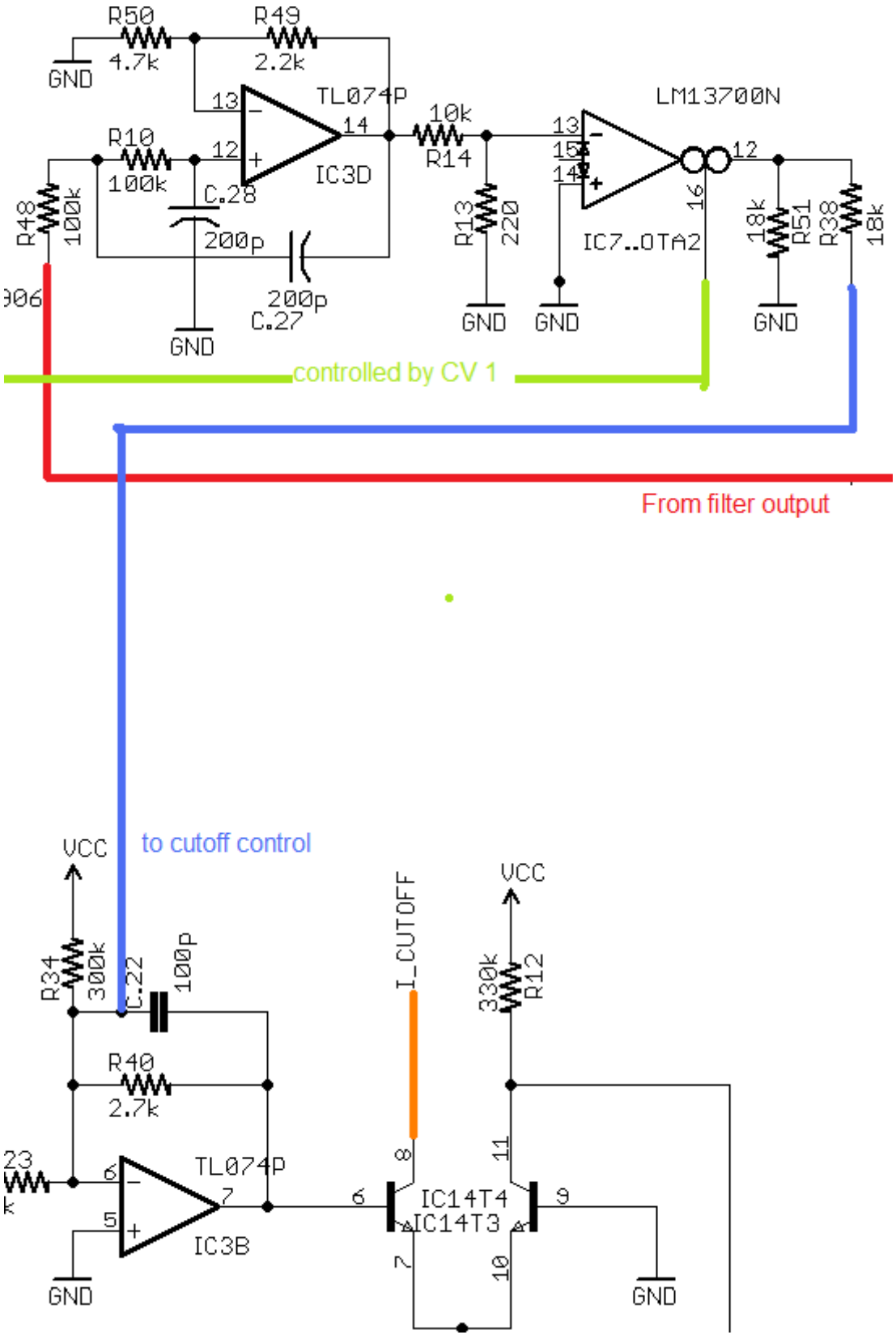
Step 4: Linearity.

Use POT 1 for Cutoff linearity. Resonance to 63, Osc 1 and 2 and Sub to off.
Filter ADSR/LFO to 0.
Play C3 on the keyboard. Use a frequency counter or an oscilloscope.
Measure the frequency . it should be around 100 Hz. Than play C4 and measure the frequency again. Should be 200 HZ +/- a few Hz. If not, adjust the POT1, so that you become the double frequency from C3 to C4.
Tune the Cut-off a little higher . Play C 3 now with 400 Hz and C 4 should be 800 Hz +/- a few Hz. This is very important for the Filter FM. Do it as accurately as you can.
Or use our free Filter calibrator from the TubeOhm website. (WIN PC only)

Step 5: Using the filter FM

Filter FM, what does it mean ??

The output from the filter controls its own cut-off frequency.
OFS is a DC value
CV 1 is the FM- destination
AMT controls how deep the Filter-FM is, in fact it controls the feedback strange from the output to the Cut-off.


R50
4.7k
GND
R49
2.2k
TL074P
IC3D
R10
100k
C.28
200p
200p
C.27
GND
R48
100k
10k
R14
R13
220
GND
GND
LM13700N
IC7..OTA2
16
12
18k
R51
R38
18k
GND
controlled by CV 1
From filter output
to cutoff control
VCC
R34
300k
C.22
100p
R40
2.7k
TL074P
IC3B
GND
I_CUTOFF
IC14T4
IC14T3
VCC
330k
R12
GND

A special feature is the Filter FM. The Filter output controls the Cut-off frequency.

TIP: Resonance, FM, Cutoff and the oscillator signal work together.

Firstly try this. Take only one oscillator, cut-off to 30, no resonance.
Use in the Modulations Matrix – OFFSET- AMOUNT -CV1
CV1 us the control channel. Offset is a DC. The DC controls with AMOUNT the feedback of the FM.
If you now increase the AMOUNT Range 0..63 (negative values don't work !!), you add overtones in the spectrum of the oscillator. Works best if cut-off is not full open.
Now add Resonance , the sound changes from more overtones to hard distortions.
Sometimes less is more.

**** why negative values don't work on offset ?? CV 1 gives out a PWM signal.
The pwm signal is adjustable from 0 to 63 ,0 = pwm 0/0 %, 63 is PWM 100 %
negative values direct in offset gives no effect. It works only from 0..63.
But if you use a LFO for example, and additional a second modulator with offset, then negative values work, because this was calculated in the Shruthi CPU.

Second try, resonance is 0, both oscillators on, no oscillator detune. Both oscillators in phase. Move OFSETT- AMOUNT-CV1 a little. Than detune one oscillator a little.
You will hear a very significant phasing, This because both oscillators are detuned and the detune is couple back to the Filter Cut-off . Play a little with more or less resonance and more or less detune and more or less cut-off. Too much gives a distort sound, fine adjusting let the filter live.
Now I hope you understand, why it is so important to calibrate the linearity. The Resonance must follow the key pitch. This in combination with FM generates new overtones.
If the adjustment isn't good,/accurate from the start you have intermodulation between Q, FM and the Oscillator signal.

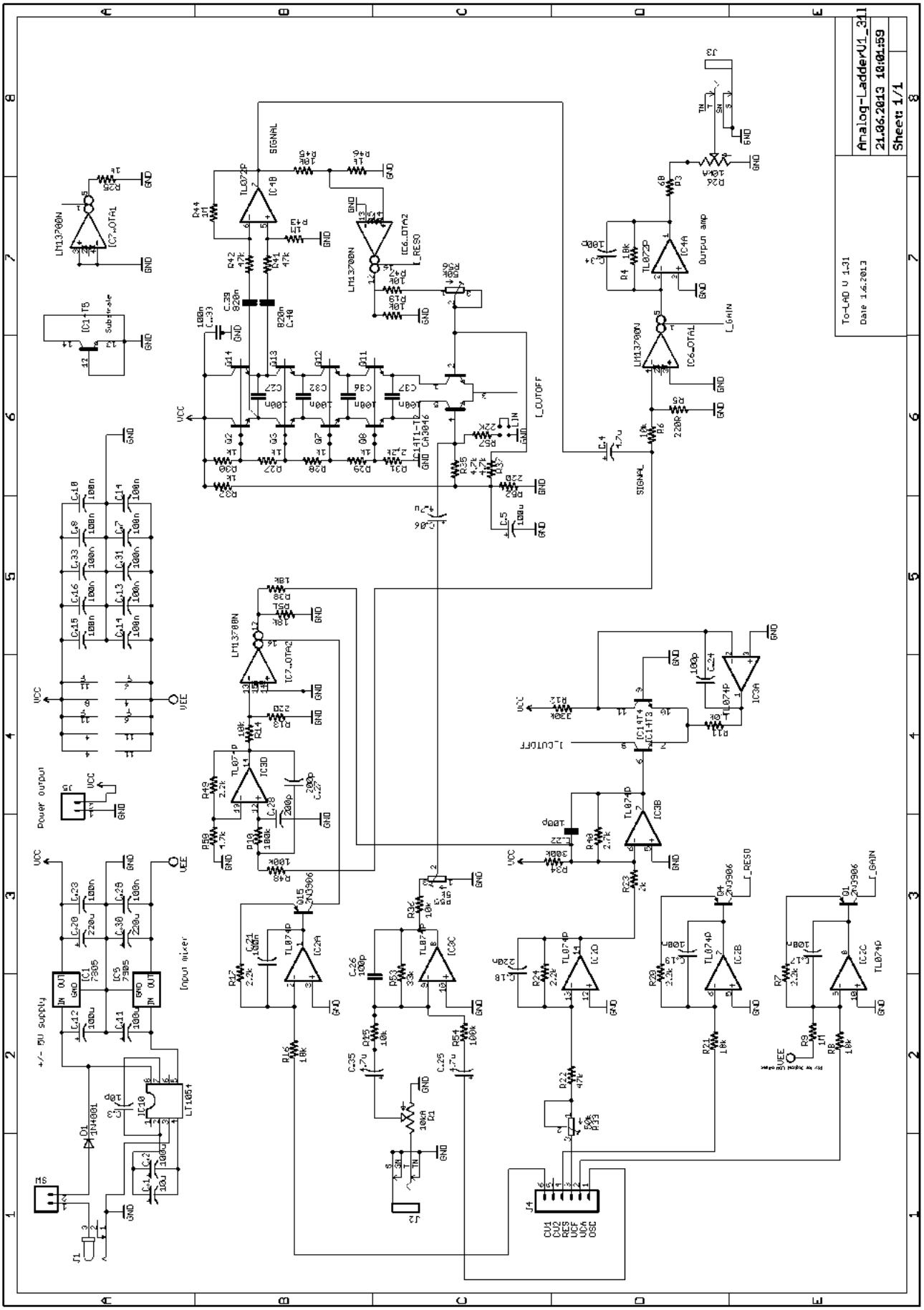
And the best of all, you can modulate the FM with the LFO's and ENV's.
Instead OFFSET simply use an LFO or ENV and adjust with AMOUNT to CV 1.

Have fun with the Filter
TubeOhm
21.06.2013

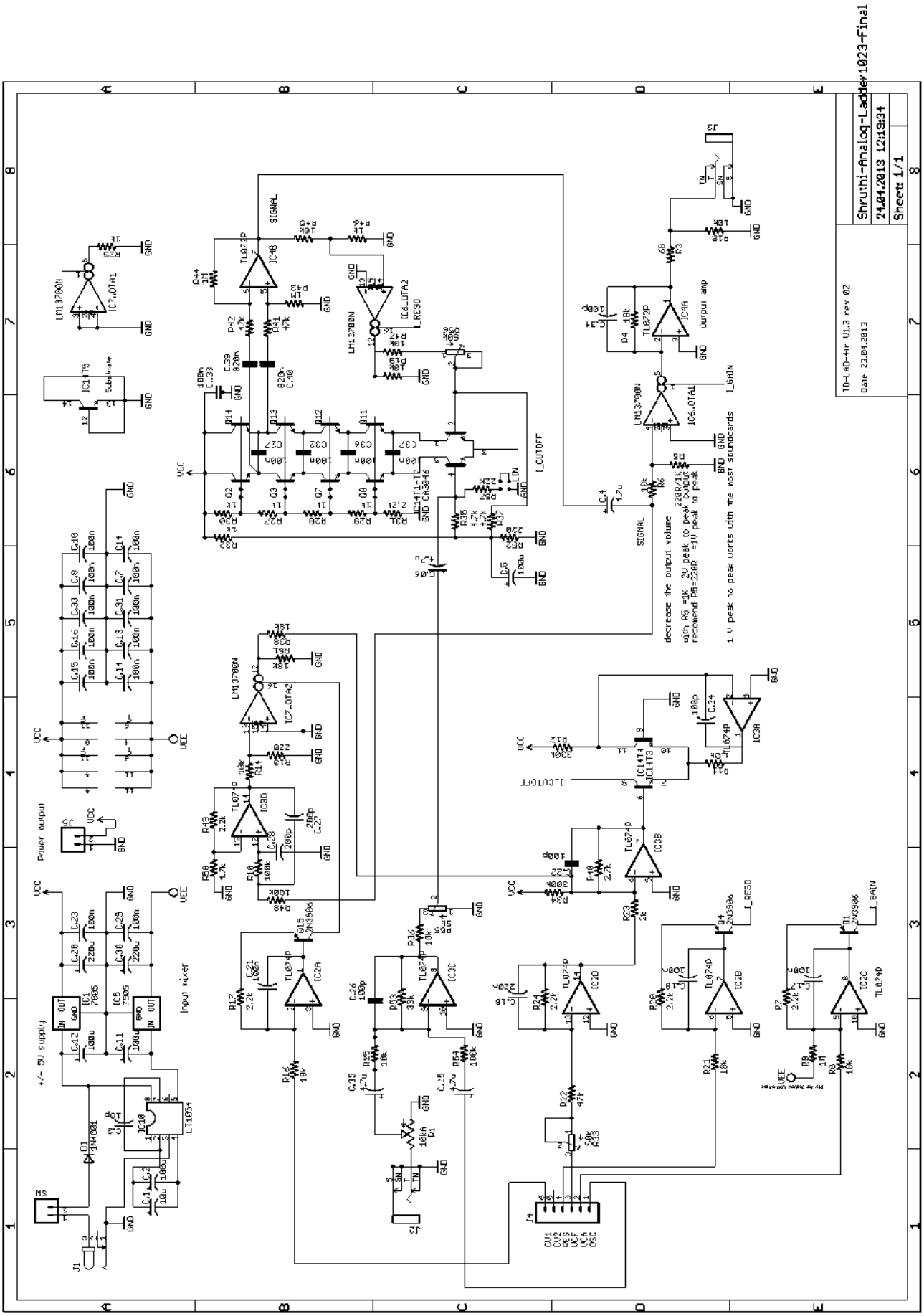
BOM - Date 23.04.2013 rev 2

Ladder Filter	TubeOhm			
Part	Description	Menge	Farnell	Reichelt
1N4001	D1	1		1N4001
Buchse 9 V		1		HEBW 21
7805	Spannungsregler	1		Ua 7805
7905	Spannungsregler	1		Ua 7905
LT1054	Spannungswandler	1		LT 1054 CN8
10 uF	tantal	1		Tantal 10/25
100 uF	Elko	4		Rad 100/16
10 pf	keramik	1		Kerko 10 p
220 uf	Elko	2		Rad 220/35
100 nF	C	15		X7R-2,5 100N
100 nF	C	4		MKS-2-5 100 N
820 nF	C	2	185-4862	MKS-4 680N **
220nF	C	1		Kerko 220nF
220 pF	C keramisch	2		Kerko 220 p
4,7 uF	Elko NP	4	1236689	Ton 4,7/63
100 pF	C keramisch	4		Kerko 100 p
1 k	R	9		Metall 1k
2 k	R	1		Metall 2K
18 k	R	6		Metall 18,0k
4,7 k	R	3		Metall 4,70K
220	R	3		Metall 220
2,2 k	R	6		Metall2,20k
47 k	R	3		MPR 47,0k
1 M	R	3		MPR 1,00M
2,7 k	R	1		Metall 2,70k
68	R	1		Metall 68,0
10 k	R	8		Metall 10,0K
33 k	R	1		Metall 33,0K
100 k	R	3		Metall 100 K
330 k	R	1		Metall 330 k
300 k	R	1		Metall 300 k
T 3906	Transistor	3		2N 3906
T 3904	Transistor mached	8		2N3904
5 k	Poti	1		64Z-5,0k
50 K	Poti	2		64Z-50k
10 k	Poti	1		64Z-10K
NF buchse	Neutric	2	4169244	
Dil 14	Sockel	3	MC-2227-14-03-F1	GS 14
Dil 16	Sockel	2		GS 16
Sockel 8 pol	IC sockel	2		GS 8
TL 074	IC	2		TL 074 DIL
TL 072	IC	1		TL 072 DIP
LM 13700	IC	2		LM 13700 DIL
CA3046	IC	1		
8 Pol Buchse	Pfostenbuchse	1		MPE 094-1-008
PCB TO-LAD-4tr	TubeOhm	1		

Schematics To-LAD-4tr V 1.31



Schematics To-LAD-4tr V 1.3



Modding:
Filter standalone 5 V without Shruthi motherboard and special 1Volt/OCT 0..10 V