

Lampizator Tutorial 2.0

DIY instruction manual

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DISCLAIMER

I do not write in a smallprint, this is a big print disclaimer:

If you try to mess with your CD player you will probably damage it.

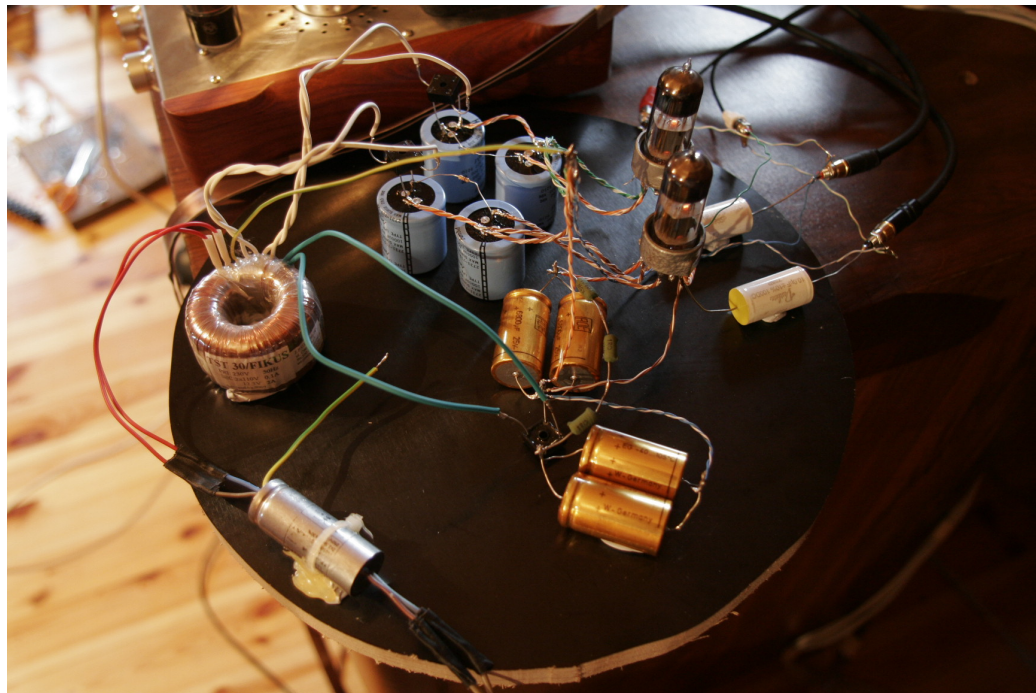
If you apply high voltage to the mother PCB - you will fry it dead.

If you touch 200 V DC - it can hurt, or in some 1% of cases it can be lethal.

If you do not like the sound - please blame yourself for being so naive.

If you do not understand this manual - it means this task is not for you, it is for advanced electricians. Please ask someone who understands it completely - for help.

I reserve the right not to help via email, although I will try.



Pic 1 - bird-nest lampizator in full glory (and working) Photo and job – Arturo Pawlowski

The Purpose

The purpose of lampization is simply to squeeze better sound from existing CD, and not by a mere tuning, but by a radical change, taking the sound quality level to the best achievable. We will reach a quality so high, that we will never need or want to buy a better CD player.

The "quality" coming out of a DAC converter chip is very good, but it is being damaged by badly designed analog output stage. We eliminate this stage altogether and replace it with one simple triode. The improvement is not because this is a tube, tubes are not "magical sound improvers" but simply because we simplify the circuit from hundreds of elements to a dozen or so. SIMPLICITY and POWER are the key words. Tube output is the simplest possible, and on top of that - very powerful. In hi fi terms - tube is able to "drive" the amplifier better.

The resulting improvement is not subtle, it is easy to hear: bass becomes deeper and better, mids are magical, pure and rich, and trebles become open, airy, detailed and strong. The soundstage becomes twice as wide and twice as deep, and the pleasure of listening increases significantly.

Other reading:

<http://www.lampizator.eu/LAMPIZATOR/whytubes/whytubes.html>

<http://www.lampizator.eu/LAMPIZATOR/Types/types.html>

<http://www.lampizator.eu/LAMPIZATOR/investment/investment.html>

**[http://www.lampizator.eu/LAMPIZATOR/Measurements/lampizator
%20measurements.html](http://www.lampizator.eu/LAMPIZATOR/Measurements/lampizator%20measurements.html)**

The Tools

Before starting we must have, beg borrow or steal the following necessary tools:

Soldering iron with sharp tip (not the one for loudspeaker cables) and with temperature controll. I use a cheap chinese station for 50 Euro and it works just fine.

Thin solder with flux

Snips

long nose pliers or a pincette

DMM meter

Drill machine and 3,5 mm bit, 10 mm bit and possibly a crown 24 mm bit.

Solder suction pump



The parts

The parts selection is not critical. I do not believe in premium parts. Decent electronic parts which hold the specs should do. I also urge everyone to substitute parts for near values.

If you see a 47 μF capacitor in the schematics, do not spend days shopping for it if you happen to have a larger one in your drawer. A bigger capacitor is 9 out of 10 times a better capacitor. Bigger voltage ratings are always better. And so on. use rational reason to choose similar parts. Resistors can be connected in series or parallel to get right value. A $\pm 25\%$ value will always do, no matter what circuit.



Lampizator part selection

QTY	PART	description	substitute
1	power transformer	the transformer is the only non- standard part We need two secondaries: 6-7 V AC or 12-13 V AC for heaters, and for anode: 100-200 V AC I use 12 V and 110 V.	The core must be between 20 and 50 VA. Toroid or EI or C. I use toroid
2	Tube sockets	noval or octal, depending on our tube choice.	Octal choice leads to madness of buying NOS and we end up buying red bases for \$260 a pair. I prefer novals for both sonics, availability, reliability and price.
2	Tubes	Any pair of double triodes with amplification factor between 10 and 100. I use 6H6P and 6H1P For Current output DACs Iout - I also recommend the ECC81, E81CC, ECC801S, 6SN7GT, but mostly - 6H2P (6N2P)	E88CC, ECC88, 6DJ8 6SN7GT, ECC182 and 100 others
2	RCA sockets		XLR male for balanced operation

Anode power supply

QTY	PART	description	substitute
1	diode rectifier bridge for anode	1A/400 V	Any bridge, current and voltage can exceed these values, 4 diodes are okay too.
3	electrolytic capacitors for anode	100uF/200 V	Higher ratings are OK, 105C is a good quality indicator,
2	resistors	1K / 1/4 W	metal film type. Higher power is OK, value between 800-1,2K

Heaters Power Supply

QTY	PART	description	substitute
1	diode rectifier bridge	4A/400 V	Any bridge, current and voltage can exceed these values, 4 diodes are okay too.
2	electrolytic capacitors	10 000 uF / 16V	Higher ratings are OK, 105C is a good quality indicator,
1	resistor	1 - 10 Ohm 5 W, depending on transformer and tube heating current.	ceramic type. Higher power is OK, value between 0,5-10 Ohms, value depends on many factors. We choose values untill one tube gets 6,3 V

Tube circuit parts

QTY	PART	description	substitute
4	cathode resistors	100-300 Ohm 1/4 W for 6H6 tube, -100-500 Ohms, for 6H1, and for 6922, E88CC, ECC81, 12AT7 : 400-1K, 150-250 Ohms for 6H2P	metal film type. Higher power is OK,
2	output capacitors	1uF/160V Higher voltage is OK.	metallized polypropylene MKP or better metal foil polypropylene or better paper in oil minimum 470nF optimal 2 uF. Up to 10 uF is good.
2	Input capacitors	for voltage output DACS = 220nF / 63V For current output DAC's - omit - not used	Higher value and higher rating are ok.
2	input resistors - grid to ground	For TDA1541 and 1540 = 90 Ohm For paralell TDA= 50 Ohm PCM1702 = 50 Ohm PCM1704=500 Ohm PCM63K = 100 Ohm For other current output DACs = 500 Ohm AD1862 - 250-500 Ohm For voltage output DACs = 250K	1/8W is enough.

Misc parts

QTY	PART	description	substitute
10	heatshrink insulation	10 pieces of 0,5 cm.	no tape please. it lasts only 2 years.
2	earth star lug	with a M3 nut and bolt	
4	tube socket "legs"	20-30 mm with M3 threads	so called PCB support legs
8	Tube legs bolts	M3/5mm	
1	transformer holding bolt and nut		M4 / 50 mm
	wires	various	

OPTIONAL PARTS

QTY	PART	description	substitute
2	XLR sockets	male	
5	bypass capacitors	100nF / 200 V MKP (poly) for first electrolyte of anode supply, for output caps and for tube sockets between anode power and ground.	styroflex or better teflon

Location and planning

Tubes

Tubes can be mounted anywhere, in any position - vertical, horizontal or skewed. It makes no difference. However I would keep away from the transformer zone, at least 10 cm to avoid possible hum.

The tubes can be mounted fully inside, or partly sticking out from the top, or partly sticking out from the back plate. It is advisable to keep the distance between DAC chip, tubes and RCA as short as possible.

Transformer

The transformer should be mounted securely, because it is heavy and it mustn't break loose inside the player. The best location is on the left of the player, near the rear left corner. It should be in proximity of the power switch where we can steal some 230 AC for our needs.

The transformer can be a toroid, a double-C, a E-I, any type really. The anode voltage secondary winding can be from 100 V AC to 220 V AC. The circuit is very tolerant. I use 110 VAC because after rectification gives 170 V DC, safe value below a capacitor rating value of 200V. And 110 V is easy to find for the reason of USA voltage being adopted in many products.

Power supplies

Two power supplies can be mounted anywhere, and when choosing the location - I would advise to transport DC current from AFTER the power supply on long distance, and keep the AC short (before the power supply) because AC propagates electromagnetic field which can lead to humming. So keep the capacitors close to transformer and if necessary - extend the DC supply wires leading to tubes.

Capacitors in P-S can be of any value, slightly smaller to much bigger than given. For example, I suggest 3 x 100uF for anode supply, but the first one can be much smaller, from 20 uF to as much as 200 uF. The second one can be between 47uF to 200 uF. To make things better, all of them can be parallelly bypassed by a 0,22 uF - 1 uF MKP foil cap.

cables

The cables are not meant to be visually pleasing. We are not a swiss apotheker here. Do not try to make everything neat, straight, and bent at 90 degrees. Bundling of wires is no good either. The wires should be as separate as possible and as short as possible but not any shorter. Messy look is OK by me.

Do not use thick wires - we are only transmitting single milliamps on a short distance. Probably the longest wire has only 20 cm. So PLEASE do not use thick silver cables.

Sockets - "RCA"

RCA sockets should be added, and the existing ones - removed. The RCA sockets should NOT touch the chassis, the hole is insulated by a special washer. The RCA with nut screw fit very well in the old holes after the PCB mounted RCA's have been removed. If we need the new holes - they require a 10 mm drill, but be careful - this drill is a monster and easily gets out of control.

Use a wooden support block and firmly drill against wood. Drilling "in the air" almost surely leads to a disaster, not to mention triangle shaped holes. I advise to drill 3-4 mm first, then 6-7, and only then - 10 mm. Not 10 from the start.

Power input point

All original circuit breakers which I saw inside players, were positively coping with the extra load of added lampizator. We are using only circa 100 mA/230V of additional current, and that fits below the safety margin of most fuses.

Should it trip however, please replace it with one step higher value, like 700 mA instead of 500 mA.

The tubes can be kept permanently on, in this case steal the AC from "before the switch", or find a point after the switch. This makes no difference except a very small increase in electricity bill.

Finding a DAC

DAC is an integrated circuit where the magical transformation of digital information into music takes place. IC chips are black and have many legs, usually 16, 20 or 28.

If you can't find your DAC, better abandon the project, it may be not for you.

There can be numerous chips - sometimes one, sometimes two, or even 4 or 8. How they play together - can not be explained here. Usually however they either play in parallel (same signal) or in differential mode - mirrored signal.

Most DACs out there offer the option to have balanced output and by using 4 tubes - we can get XLR outputs as well as RCA's.

If you can't find the DAC datasheet in the www.alldatasheet.com - you can find the legs (V out only) by using a small speaker and a wire with sharp tips. Touch the ground with one wire and poke the PCB with the second wire until you find the output legs of the DAC. The speaker will sound when V out leg is touched.

Understanding the DAC

The DAC converts digits into electrical pulses - "music". The pulses go out via a special output called "current" which means it has very high impedance. Unlike 99 % of different electrical outputs, current outputs are not afraid of a short, they are afraid of being open. They are most "happy" playing into a dead short to ground. But this flow does not produce any usable signal to control the tubes (grids). To do this we need VOLTAGE signal (more conventional). Now the tricky part is to use some way of creating voltage signal from DAC current output.

This is usually done by:

- using op-amp
- using a transistor circuit
- using a passive resistor

Many DACs seem to avoid all this and they have simply voltage output readily available. Which simply means, that they have option 1 - op-amp - built inside. This is no good - this opamp is cheap and of bad quality. We should rather use current DACs and if necessary - a separate external dedicated op-amp. But if that is the necessity - of course it is very convenient to lampize DACs with voltage outputs.

Some DACs like TDA1547, or BB PCM56 or AD1856 have BOTH types of outputs. These DACs are ALWAYS used as voltage output, but for lampization we convert them to current output types and cut off all the voltage circuitry. This gives far superior results. (I wish I knew this before selling my Revox 426 with TDA1547 !!!)

DRILLING

For transformer we need a 5 mm drillbit, for the RCA - 10 mm, for the tube socket legs - 3,5 or 4 mm drillbit, holes separated by 28 mm apart. For the XLR sockets we need 24 mm "crown" type of bit, the same as for tube openings for exposed mounting.

Star grounding

As it was explained elsewhere, all the grounds must be connected together in a star fashion, to avoid humming and ground loop problems. The star ground lug should be located near the lampizator circuitry on a metal surface and secured by the screw and with lacquer scratched off. The wires which must be connected to the star are:

- RCA ground left and right
- tube socket leg 9 - right and left
- anode supply minus
- heater supply minus
- PCB ground from the point closest to the DAC
- if screened cable is used from DAC to the tube input - the screen must be connected to earth too.
- if the transformer has screen winding - it must be connected as well.

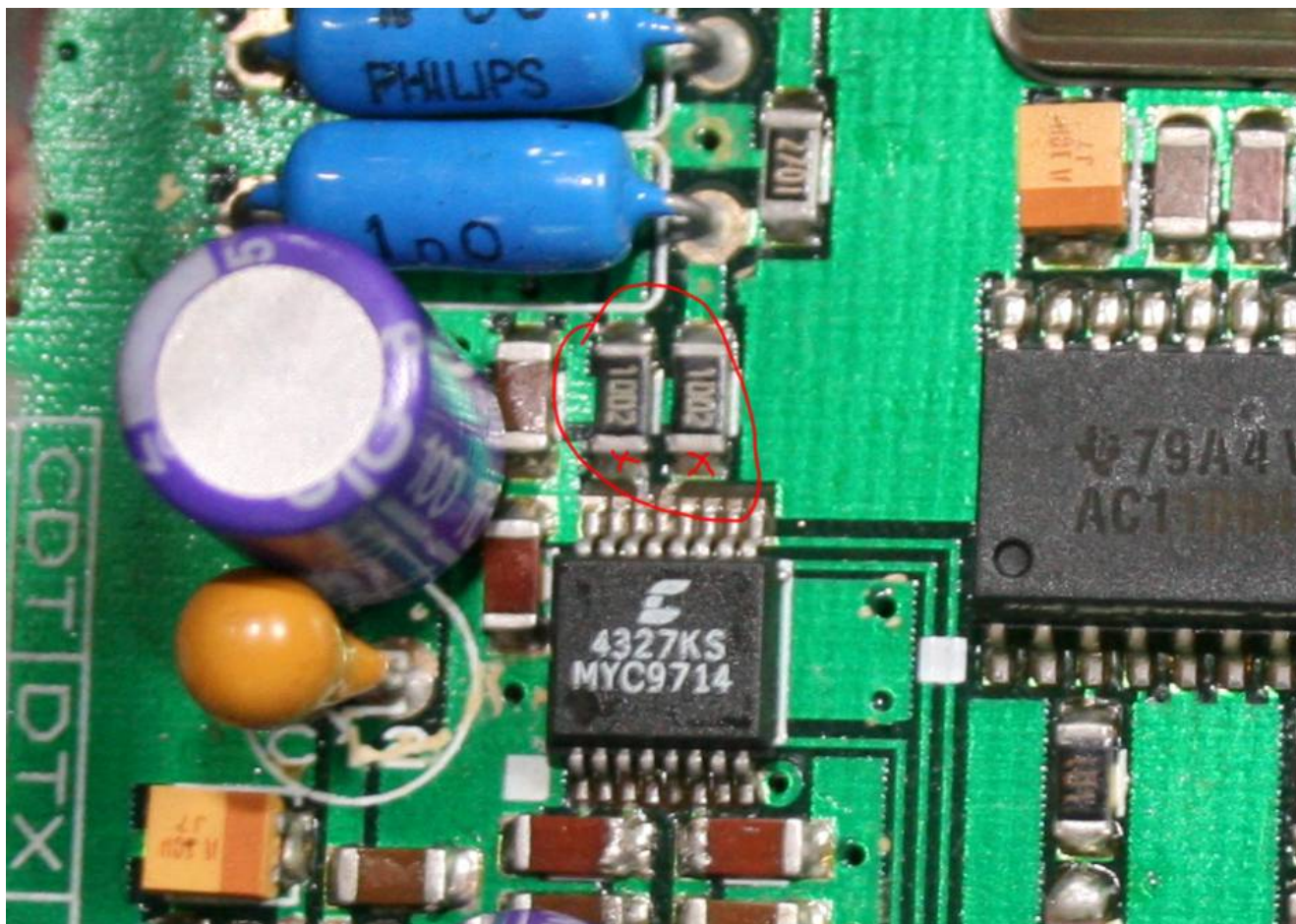
Heat issue

The heat is generally not an issue, it should not bother you. The most heat generating tube of all is the 6H6P, so if it is mounted in very tight space and in un-ventillated box, it will be OK as long as the DAC chip is some 5 cm or more away from the tube. Some DACs are hot and do not tolerate extra heat from the outside (like TDA1541A). All other tubes have negligible heat dissipation (contrary to popular belief).

Signal stealing

In case of voltage output DACs (V_{outR} and V_{outL}) the signal should be stolen from the first soldering point after the leg V_{out} . Do not solder directly to legs - they are fragile. So if the PCB track leads to say -

a resistor, solder your wire from that point. You may leave the circuit intact, to compare results - RCA of lampizator versus old ones. If you like the result of your job, it is good practice to cut off the signal AFTER stealing point. So all juice flows only to lampizator.



Pic 2 Example of soldering points for signal stealing in Cambridge CD4 DAC. The two black "thingies" marked 1002 are resistors after voltage outputs of this Cirrus DAC 4327.

Possible problems:

Humming

The humming can be a result of:

- a forgotten ground connection - see above.
- a tube too close to transformer
- the input wire not screened (usually unnecessary)
- earth point mounted without lacquer scratched off.
- RCA sockets touching the chassis (use washer insulators)

Noise

Noise is usually a result of digital artifacts (oversampled) to frequencies mostly above hearing) not filtered well after DAC chip. To filter them out, add a RCR filter after a DAC (of voltage DAC type). From DAC Vout put a series resistor - maybe 2K, then cap to ground and then another series resistor of 2K or similar. Size of cap must be around 1-10 nF. A nanofarad is 1/1000 of a microfarad. Ceramics are the best.

High distortions of sound

This can be a result of:

current type of lampizator seeing too large resistor. TDA1541 tolerates maximum of 100 Ohms, BB56 tolerates 1 K, PCM1702 tolerates 50 Ohm, and so on. try for yourself the right one. Too small resistor and the sound will be anemic.

Tuning and testing:

The Russian tubes 6H6P and 6H1P which I recommend do have a heater current higher than normal - around 600 mA for 6H1 and 750 mA for 6H6. Their heaters are 6,3 V Dc nominal.

The transformer with 6,3 V AC connects to the heaters via rectified power supply in parallel - two tubes, and the optional transformer of 12- 13 V AC (from halogen lights) In this case left and right tube will connect heaters in series. The voltage on the power supply output must be 12,6 V DC. These voltages get adjusted by the 5 Watt resistor from heater rectifier PLUS to the second capacitor plus (heater output).

Usually values between 0,5 Ohm and 5 Ohm will do.

So called "underheated" tube will sound weak, and overheated - will have significantly shorter life expectancy (months not years)

A momentary overheat like 7 V for 5 minutes is harmless.

The anode supply has a CRC filter with 0,25 Watt resistor of 1 K Ohm. The output has 140-160 V DC for 110 V AC secondaries of transformer. It is convenient to measure anode current on the 1 K resistor - 1 V "drop"

measured across resistor with DMM set to Volts DC - equals 1 mA of anode current.

On the anode of the second tube half, (and on the output before capacitor) there should be exactly 1/2 of anode voltage, this is an indicator of proper functioning.

SCHEMATICS

Lampizator is an anode follower single ended triode in pure class A with a dynamic active load. It is called SRPP circuit or totem pole. It is well known for it's high tolerance to supply voltage and supply variations, it does not require regulated stabilized supply. It „regulates itself" by means of the first triode half. It gives a pure, dynamic and powerful sound from almost any supply voltage. If turned upside down, SRPP can work on negative DC supply, like -50 V in transistor amps.

The Lampizator is self biasing (automatically) by means of a second cathode resistor and grid being grounded by R2.

Alternative circuits

Amplification of DAC signal can be done by many alternative circuits. My favourite SRPP is the best, but the other offer very good sound from simpler solutions.

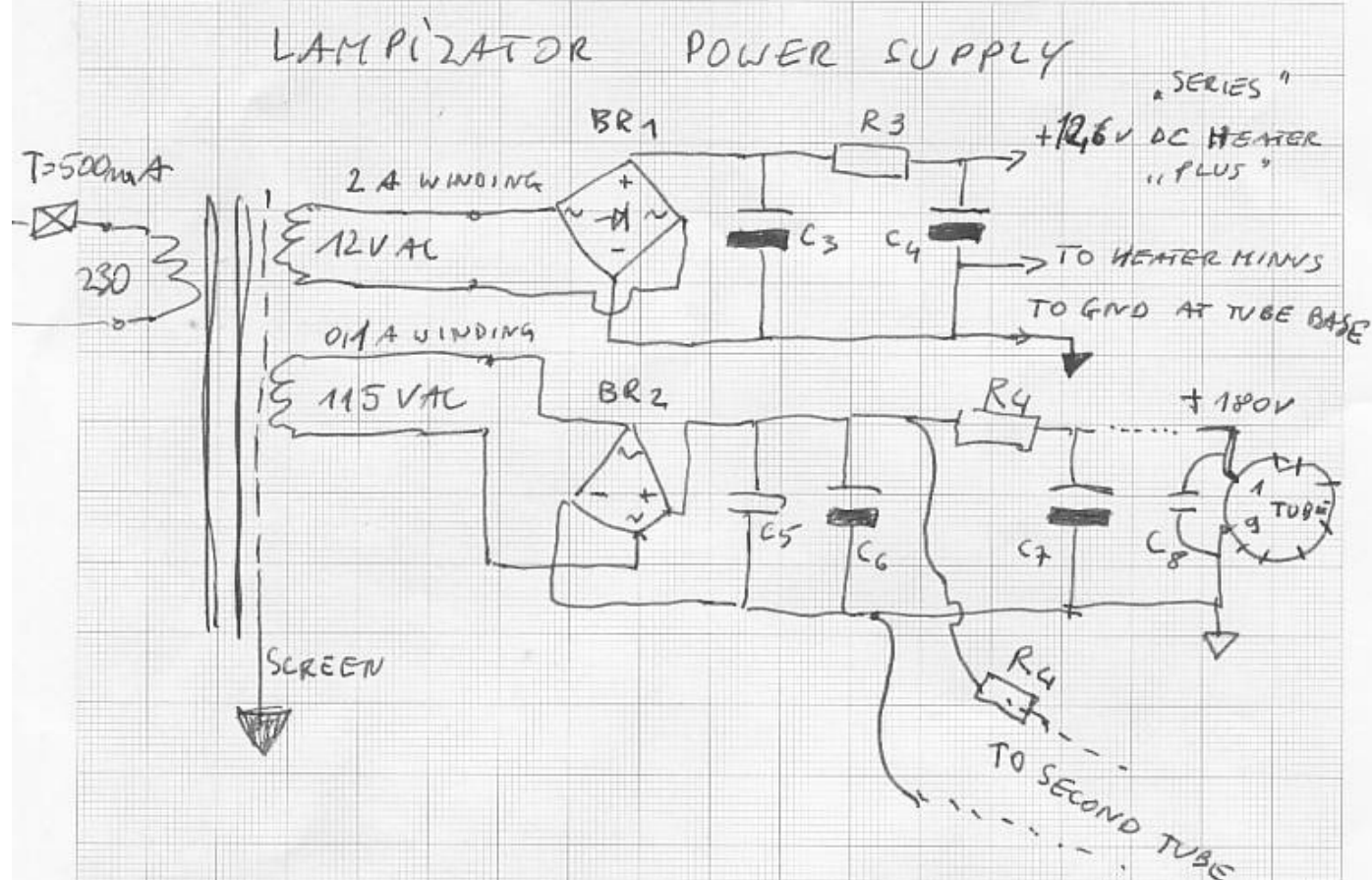
Anode follower triode: This allows to use one half of tube per channel. So stereo lampizator can have just one tube. The sound is very good and pure. The heater must be 6,3V DC because there is one tube and one heater. We choose the anode resistor which gives a half of anode supply drop at the nominal current.

If we choose 10 mA current and supply of 150 V, we want to drop 75 V. So the resistor will be 7,5 K Ohm. Power is $75 \times 10\text{m} = 750\text{ mW}$. A 1 Watt is okay.

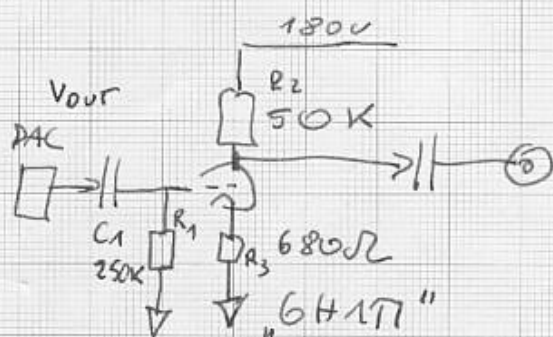
CATHODE FOLLOWER

This circuit gives superb sound at the 1:1 amplification. If the DAC is V out type with nominal output voltage already high enough (2V) we build one tube cathode follower schema.

The anode is connected to the supply voltage of 150 Ohms. Cathode resistor sets the current to be nominal. I times the R cathode gives U grid which sets the current.



ALTERNATIVE SCHEMATICS OF LAMPIZATOR — ANODE FOLLOWER WITH ONE STEREO TUBE



FOR I_{OUT} DAC

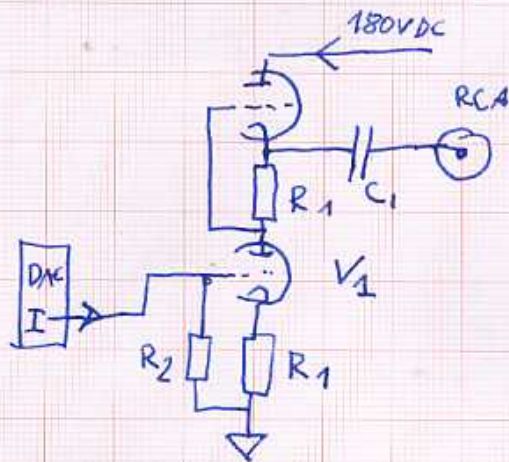
OMIT C₁

REPLACE R₁ WITH 100Ω

Octal tube - the famous 6sn7GT can be directly substituted here.
Anode resistor can be as low as 30 K and the cathode resistor in that case will be 800 Ohm.

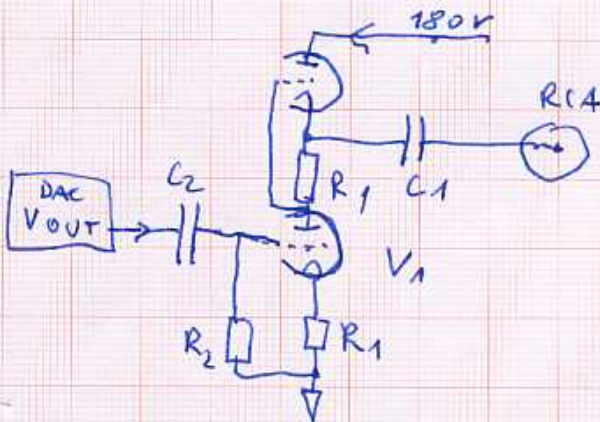
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LAMPIZATOR SCHEMATICS FOR CURRENT OUTPUT
DAC'S LIKE TDA 1541, AD1856, BB PCM 1702
BB PCM 63, PCM 56, AD1865, PCM 58



RECOMMENDED TUBE
 $V_1 \rightarrow 6H1P (6H19T)$

SCHEMATICS FOR VOLTAGE OUTPUT DAC'S
WITH V_{OUT} (OP-AMP BUILT-IN)



RECOMMENDED 6H6P
DIFFERENCE:
ADDITION OF C_2
DIFFERENT VALUE R_2
DIFFERENT V_1

Two variants of Lampizator depending on the DAC type

Comment to the schematics:(example for TDA 1541A DAC chip)

Part	minimum	design center value	maximum
R1 (6H6) (6H1) (ecc81, 12AT7, 6922)	100 200 300	200 300 300	500 800 1K
R2	50	90	100
C1	220n	2uF	10uF
SUPPLY VOLTAGE		170 DC (+/-30V)	
For voltage output DAC			
R2	200K	250K	500K
C2	100n	470 nF	2uF

Power supply:

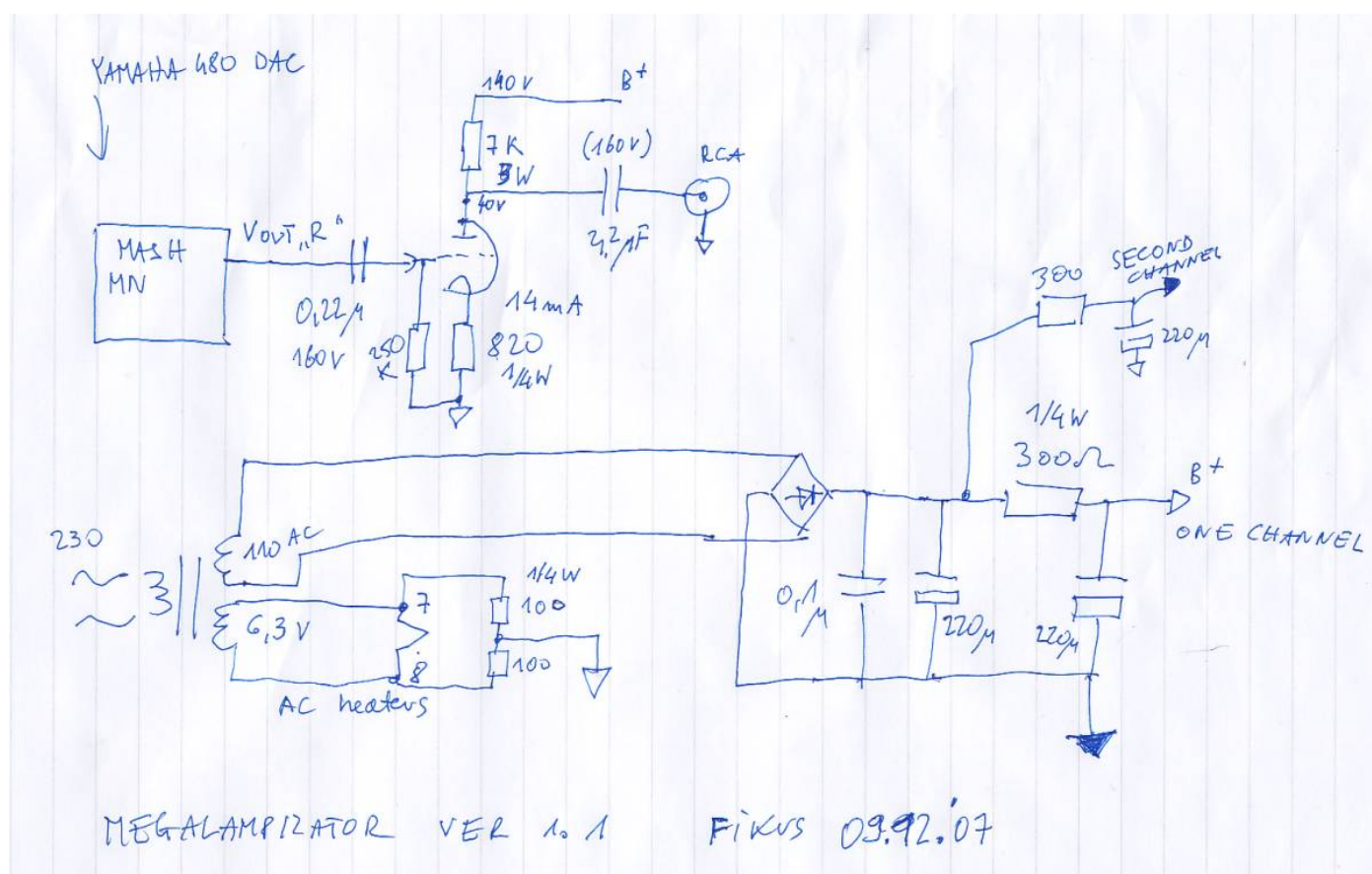
Part	minimum	design center value	maximum
Fuse T1	300mA	500mA	1A
BR2	1A/200V	2A/400V	8A/400V
BR1	2A	4A	8A
SUPPLY VOLTAGE - HEATERS TRANSFORMER WINDING	6 AC (parallell tubes)	12 AC (series tubes)	12,6 AC
C3 = C4	6800 uF / 16V	10 000 uF / 16	-
R3	0,5 Ohm / 5W (parallell heaters)	3,9 Ohm / 5W (series heaters)	-
C5 (optional)	10n	220nF	1uF
c6	20 uF/250V	100 uF/250	220 uF/250
R4	500/0,25	1k / 0,25W	2K / 0,5W
C7	47 uF/200	100 uF/200	220 uF/200 V
C8	220nF/200 MKP	1uF/200 MKP	10 uF/200 MKP

R2 choice (in Ohm) for **I/U conversion** in current output dacs
(given values are usually optimal, with tolerances like this: +10%
-50%)

TDA1541A	TDA1547	AD185X	AD1862	PCM56/58	PCM63
90	?	500	500	500	100

PCM170X	2x1541A	4x1541A	2 x PCM170X	AD1864	Other ?
100	60	28	55	250	

MEGALAMPIZATOR using 6N13S tubes (6H13C)



Alternatively, in the same socket fits the 6sn7GT (6N8, 6H8)
in this case change R anode to 20-30K. I should not exceed 3 mA.
Otherwise increase Rcathode to 1K.

Tips:

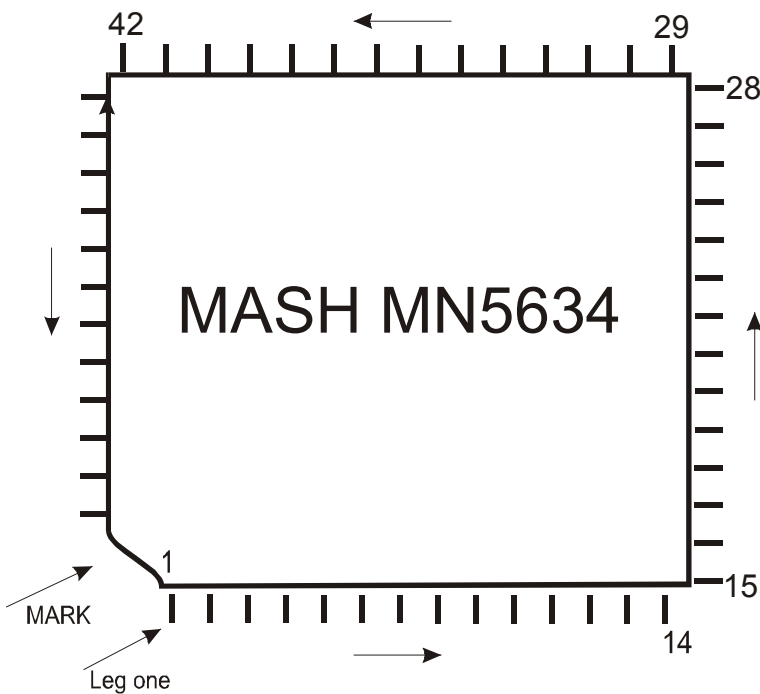
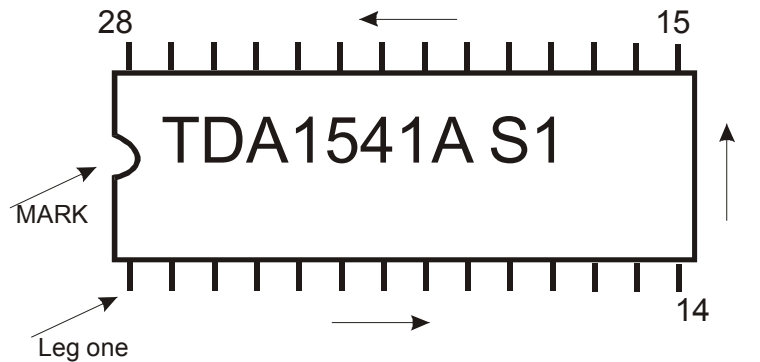
where to find DAC data?
www.alldatasheet.com

Where to find DAC / CD player reference list?
<http://www.vasiltech.nm.ru/files/cd-players/CD-Player-DAC-Transport.htm>

How to determin which leg is which?

in any IC the legs are numbered (looking from top) counterclockwise. The number one is the one at the bottom left corner when the chip code reads properly and the dot or any other mark shows number one.

EXAMPLE: LEG COUNTING IN TWO TYPES OF IC's



Tuning of the CD main PCB.

The lampizator will expose the signal quality so the better the signal from the DAC, the better.

What can be done:

1. Power supply improvement
2. ground improvement
3. clock
4. transformer
5. vibrations

1.1 The power can be improved by better caps.

1.2 level 1: we replace the caps which supply all chips – DAC, digital filter and demodulator and processor. Best is Black Gate, second is OS-CON, third is Tantalum, fourth is low ESR electrolyte.