HiBu

Halfgeleider in Buizen uit

(Semiconductor in Tubes out)

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Construction period	Nov 2023 – May 2024
Adjustment of tubes	May 2024
Final presentation	25 May 2024 in Lemmer, final day of TubeSociety 2024
Measuring and report	June 2024
Costs	Electronics € 837 Casing and materials € 130 Total € 967

Note: translated from Dutch to English

Semiconductor in Tubes out: the HiBu

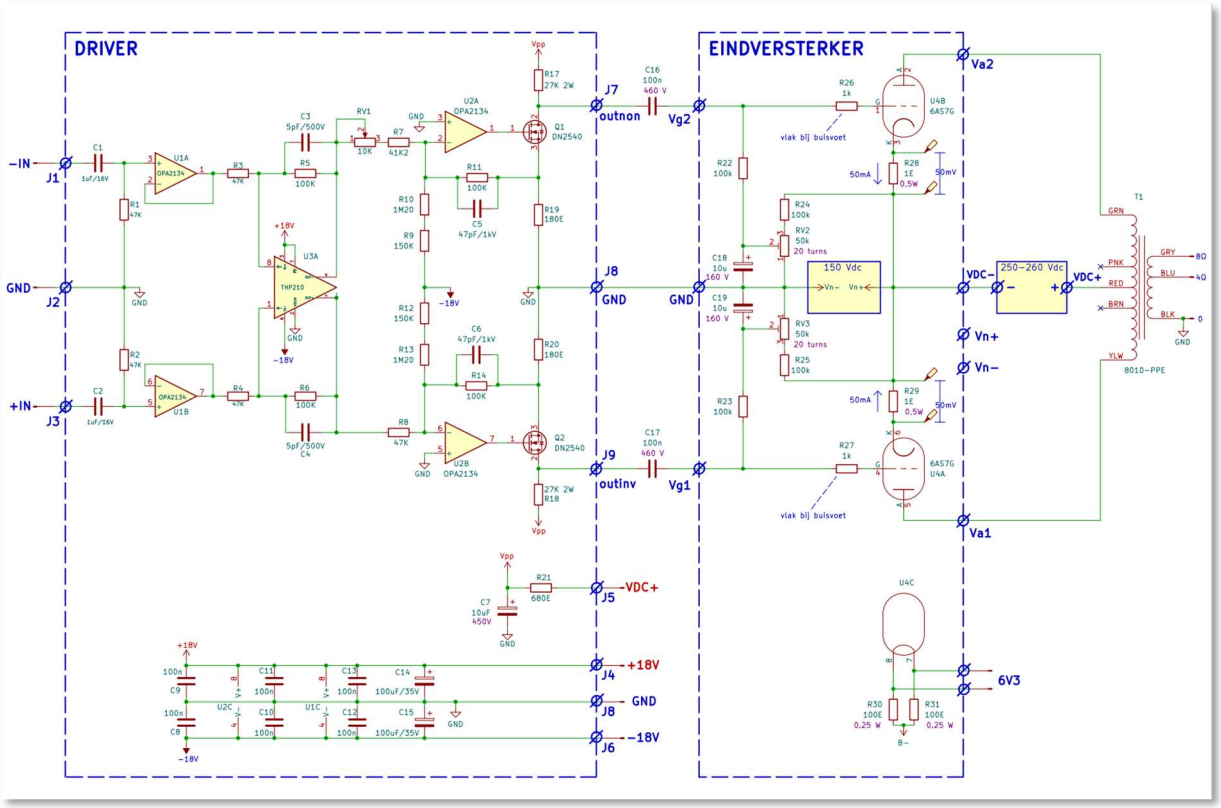
The why?

People sometimes ask me why I am building another amplifier, because I already built a beautiful amplifier last year. There are two reasons for this:

- I wanted to understand and consequently build a push-pull tube amplifier.
- I wanted to learn how to measure an amplifier using my own equipment.

Tubesociety is a beautiful expert group of audio enthusiasts who, under the guidance of Menno van der Veen, build and test quality amplifiers at a high level together with teachers Sep and Joost. It is *the* place in the Netherlands where those two goals of mine are made possible. I enjoy the people within the club, the place inspires me and gives me a good challenge. And it resulted in a beautiful HiBu amplifier in May 2024.

The diagram and a brief explanation



From left to right: The input can be connected symmetrically, or trough RCA by connecting the -IN to GND. The first OPA2134 is configured for a 1x amplification. (ratio of R1 and R3 is equal) The input stage, the driver, is very sensitive, and because of this, the first opamps are used to decouple the driver from the source.

The phase shift (separation of positive and negative signal) is provided by the TMP210. Then follows a second OPA2134, which is configured for a 2x amplification (R7 and R11 ratio is 1:2) which in turn drives a DN2540 mosfet. The ratio R17 and R19 = 27000/180 = 150 times. This scales the audio signal to 130 Volt. The OPA2134 together with the mosfet amplifies 152 times.

Trough C16 and C17 we decouple the driver (voltage amplification) from the second amplification where the tubes take a prominent place. This part provides current amplification, and it increases signal strength by 1.5 - 2 times.

The tube used is a NOS from China: the 6N5P. This is a double high energy triode tube. That is why one tube is enough for one audio channel. One triode for the positive signal and one triode for the negative signal, together in one tube. The 6AS7 is a compatible replacement.

The grid voltage must be quite low, ~130 Volt with reference to the Cathode. That is the remarkable aspect of this tube. The voltage on Vak is 250V. And to drive this tube with the high voltage of +130 and -130 Volts, the driver must provide an extremely large amplitude. This can easily be done using these mosfets, who can actually handle up to 200V. Between R17 and R19 is a potential of 400V, so be careful when measuring!

Back to the tube and it's configuration. The 1 Ohm Cathode resistors R28 and R29 both have a voltage over them of 50mV. This means that trough these resistors flows 50mA. This can be adjusted using the trimmers RV2 and RV3. That is why at rest there is a flow of 50mA. The adjustment of the 50mA is a task that requires a bit of patience and time. If you adjust the voltage, the temperature of the tube also changes, which influences the adjustment. That is why you need to take time adjusting this setting.

The triodes receive or the positive or the negative part of the signal. The positive signal pulls the audio signal trough the output transformer, and the negative signal also pulls the audio signal trough the transformer. This creates a fluctuating magnetic field in the output transformer. Hence the push-pull principle of the amplifier. And a push-pull delivers more power than a single ended amplifier. Regardless, the fluctuations on the primary windings happen under a very high voltage, which delivers a very high output current on the secondary windings that have a lower voltage. Enough to drive a pair of speakers. Using this method, there is no need for an output capacitor. The output transformer must be driven using a low resistance. This 6N5P tube does that.

In the middle of the primary windings is the power supply connected, which in that way can power both the positive and negative part of the amplifier trough the transformer.

The output transformers, number 8010, provided by Menno van der Veen, has a 4 and 8 Ohm output. With this, you can drive 4 Ohm speakers as well. You can also use the 8020 output transformer, this has a bigger core and works more cleanly in the frequency spectrum, but is also almost 2 times as expensive.

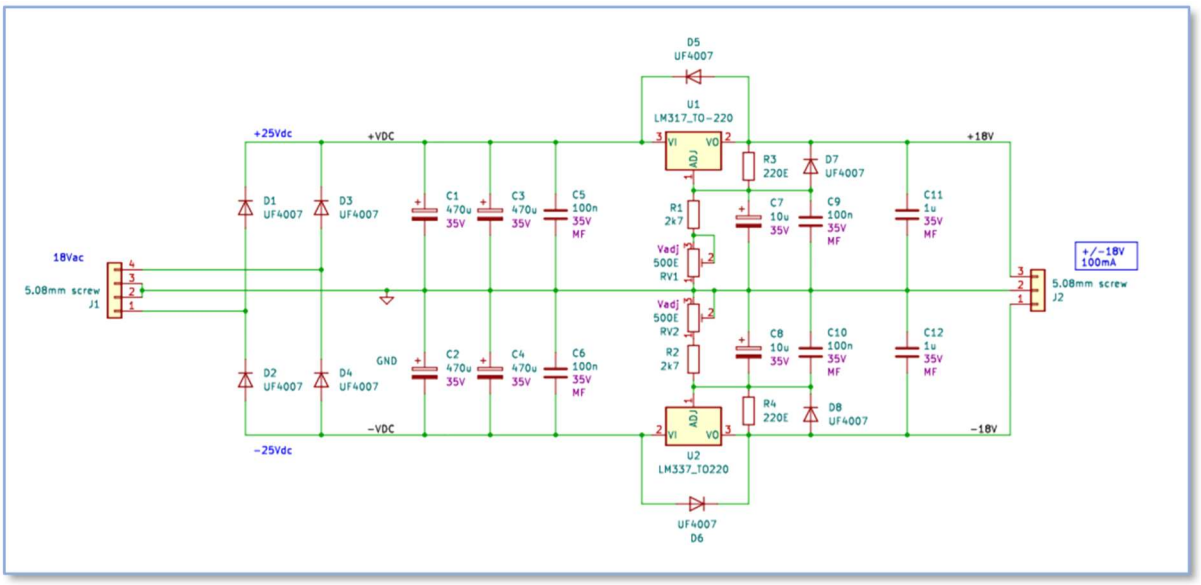
The adjustment of the amplifier

Here in short the adjustment procedure of the amplifier:

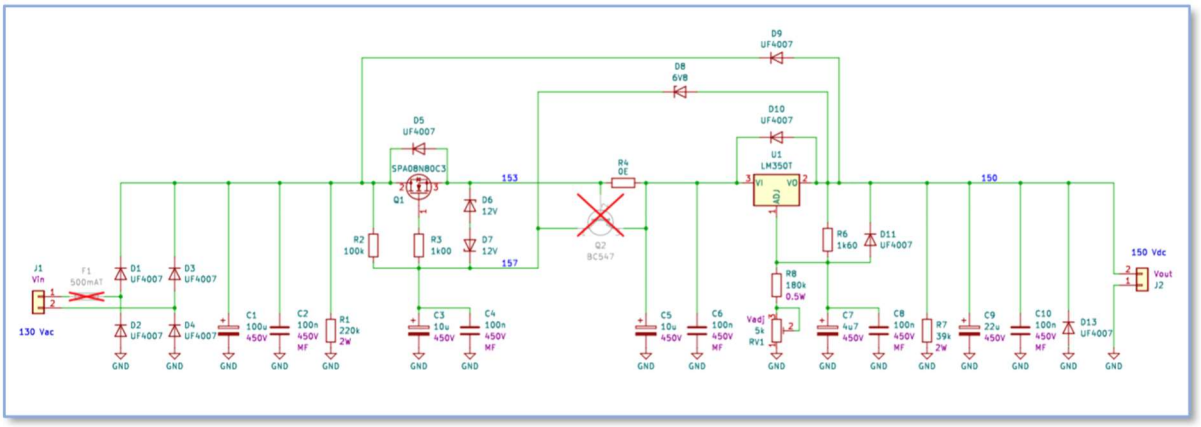
- Measuring the output using Arta while under a 4 Ohm load.
-
- 1 kHz sinus with Vuit = + 6 dBV: adjusted using Arta, not with the amplifier volume knob.
- Observe the 1 kHz spectrum
- Trim RV1 (balance) for least second harmonic deformation (2 kHz at least)
- Adjust Arta-generator for 40 Hz
- 40 Hz sinus with Vuit = + 6 dBV in 4 Ohm
- Observe 40 Hz spectrum
- Trim RV2 (or RV3) (current at rest) until the second harmonics (80 Hz) are minimal.

The trimming of RV2 (or RV3) is a fine adjustment of the equality of the currents at rest. This adjustment is slow and requires a lot of patience due to the temperature fluctuations in the tube caused by the adjustment itself. A little bit of drift is allowed.

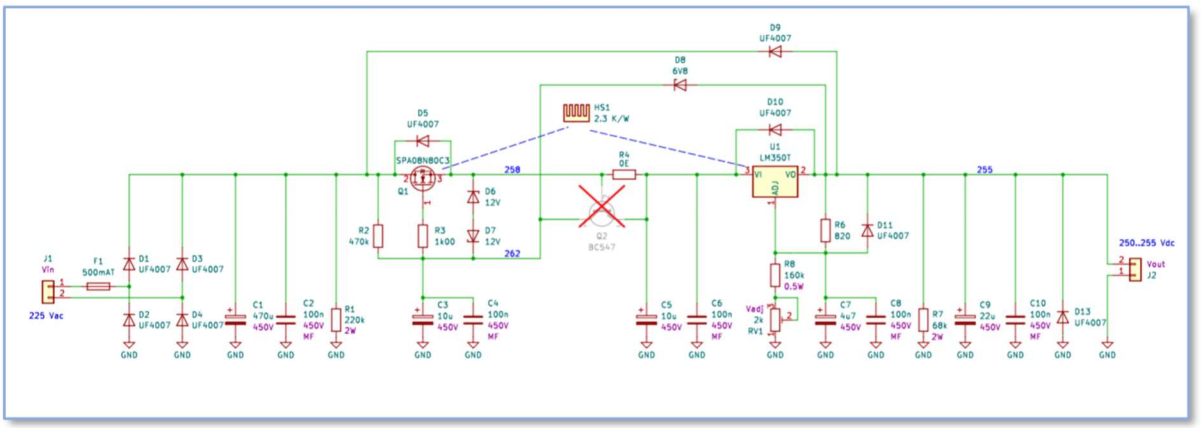
The power supplies



The 18V power supply for the opamps, designed by Erwin

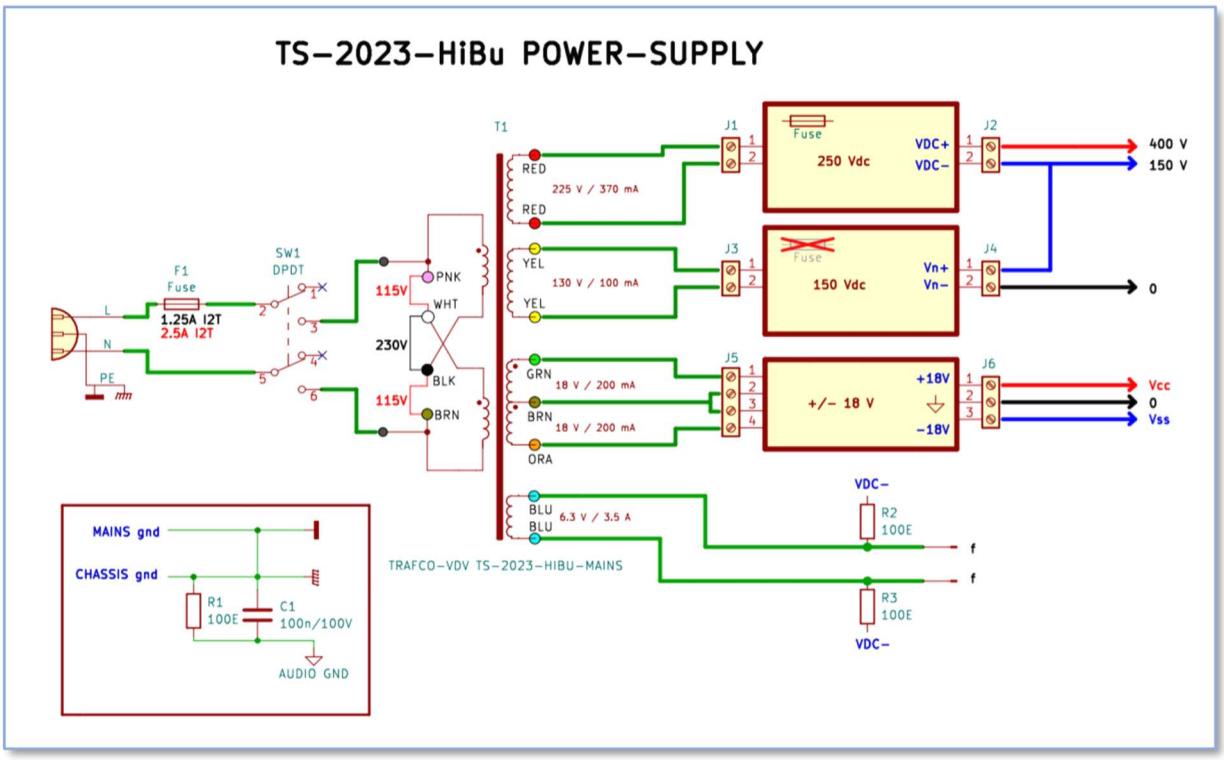


The 150V power supply, designed by Joost



The 250V power supply, designed by Joost

The connection diagram



The interesting part is that the + of the 150 Vdc is connected to the – of the 250 Vdc. This creates a potential of 400 volt between the 150 Vdc ground and 250V positive. This power is required to power each of the driver mosfets with 200 Volts.

The Appearance

I have set the following requirements:

- The appearance of the amplifier must be a neat and tidy appearance in the living room
- The casing must have a common dimension for audio devices.
- A remote for the volume knob
- Volume knob must have a red LED
- 3 audio inputs
- Good airflow around the tubes
- The dark tube socket must not be visible.
- Wooden casing using Limba wood.

Because the wood, delivered by Massave fine wood trade in Zwolle, is easy to work with for me, the first requirement was easy to comply with.

The casing is made using one slab of 1.5 meter by 40cm with a thickness of 4cm. The board is cut into two parts using a band saw. The nice part is that by splitting the board, nice orange colours become visible. Those just had to be put on the front of the case. I cut the two planks at length at home.

You can see the amplifier at work above.

- Two Chinese 6N5P tubes
- In the middle a knob to select one of the 3 channels.
- A volume knob with a 2mm red LED
- A double pole on/off switch

On the top side is a beautiful 8mm aluminium cooling element, made using CNC machinery by Bas Brussen. Without him the amplifier wouldn't have been this beautiful. The glimmering top side, containing my name, the amplifier name and the date, give the amplifier a nice luxury appearance.

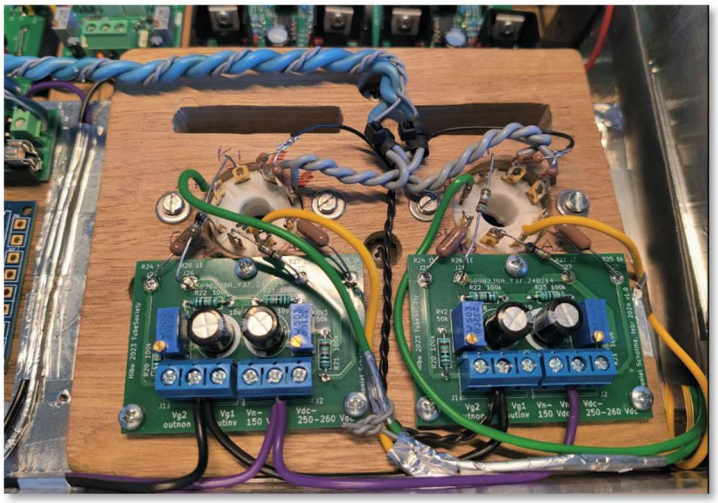
The cooling element is used to cool the mosfet and power regulator of the 250V power supply.

The biggest challenge was the mounting of the tube sockets, with which the airflow should be maximized. I think there's about 8 hours of work into getting this solved. But I succeeded.

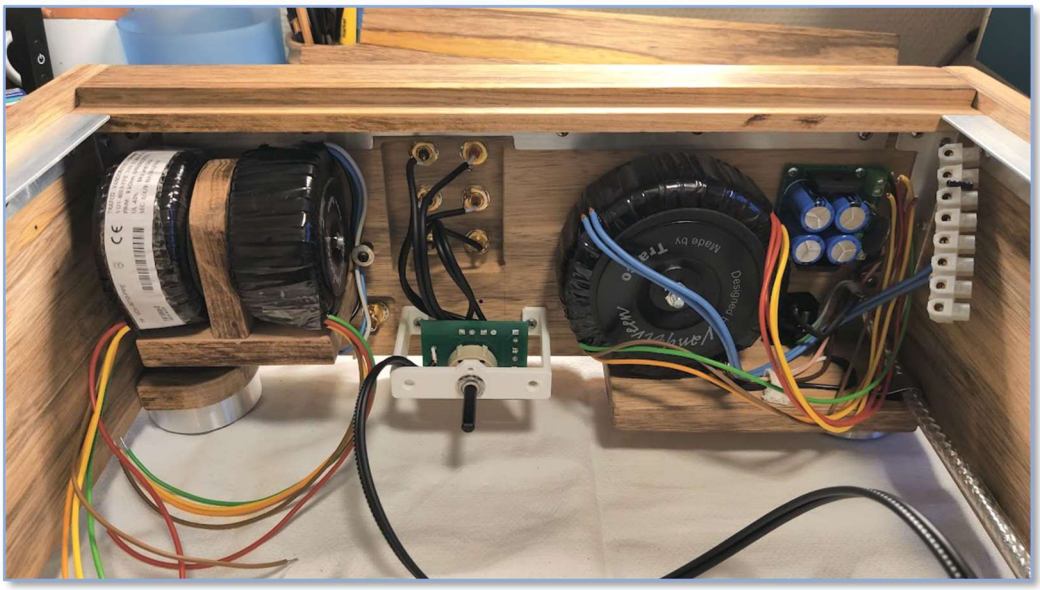
First give the tube sockets a place

This is the solution: the inside of the the tube socket holder. The tube circuit boards are mounted on the bottom side.

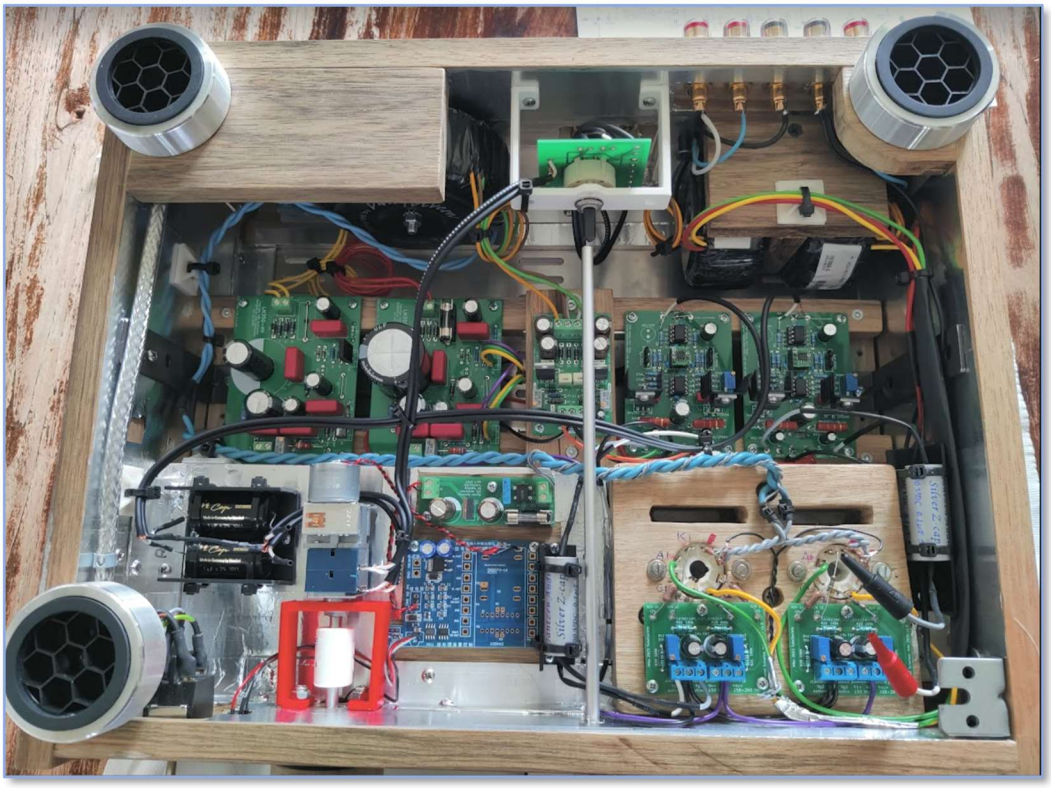
The connection of the tubes. The small circuit boards are designed by myself, obviously subjected to a strict quality check by Menno.



The inside of the casing:



Above you can see at the left two output transformers. At the right you can see the power supply transformer and my selfmade DC blocker with NTC. This prevents current pulses during activation and suppresses the annoying hum of the transformer caused by the pollution of the power grid.

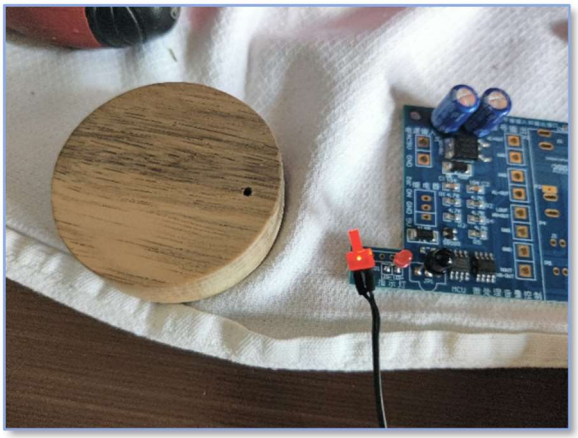


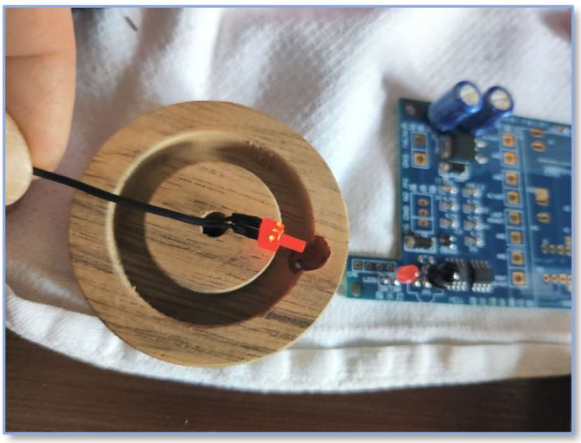
Above you can see the complete construction of the amplifier.

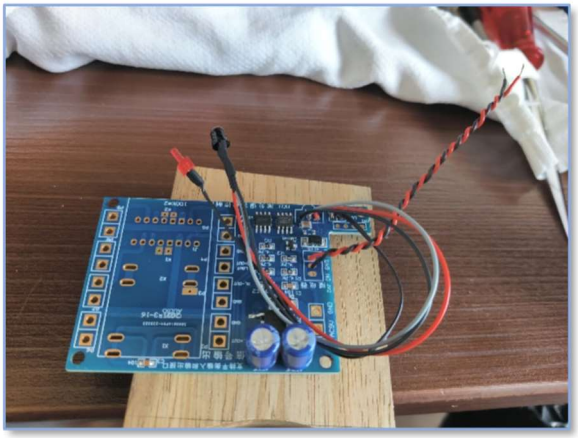
In the end it still became a filled case again where it is quite complex to cleanly lay everything out with 3 channels, a remote control and decently large capacitators.

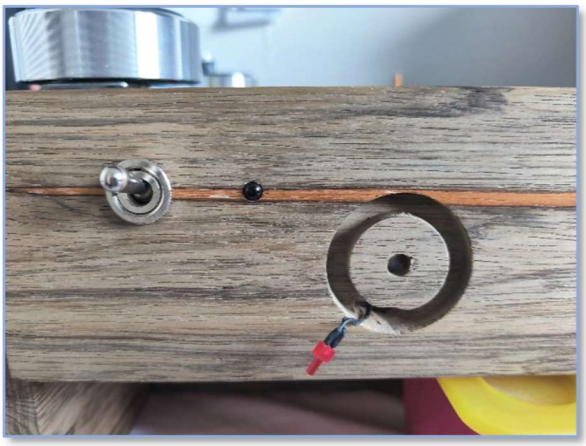
The volume knob is something I have made before. Below you can see how it is done. Using a Makita edge milling cutter I first made a circular guiding hole for the cable before cutting out the volume knob.

The receiver of the remote has a red LED that serves as an indication of the power state. This is replaced by a 2mm round flat LED inside the volume knob. Whenever I power on the amplifier, this LED will start glowing.







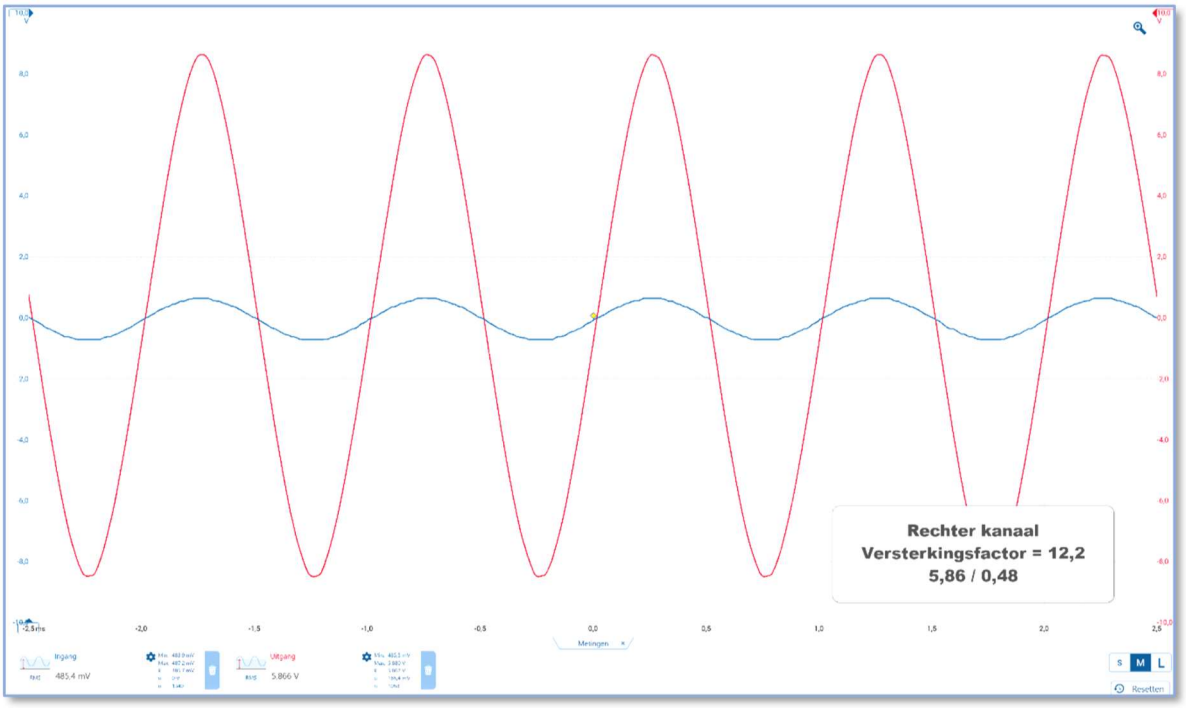


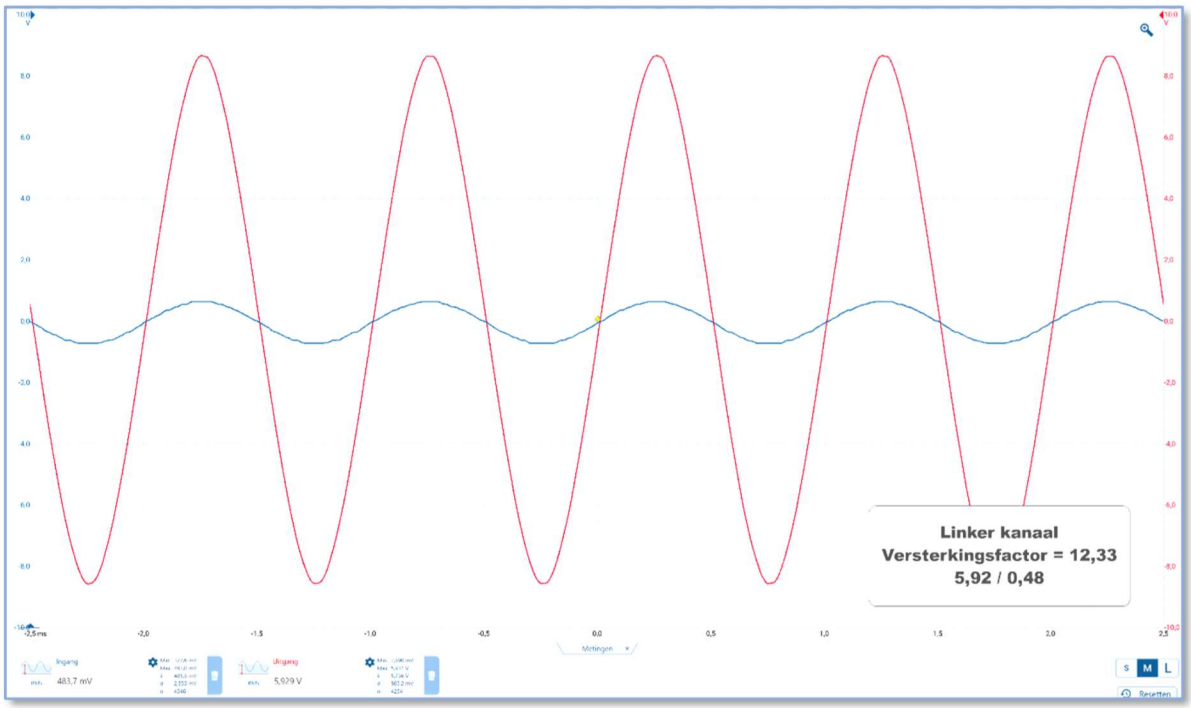
Measurements

In May and June 2024, I put quite a lot of time into measuring the amplifier. Specifications below:

- Measuring at 1 Watt and 4 Ohm, unless noted differently.
- Measuring at the left and right channel
- Frequency range: f-3Low = 15 Hz; f-3High = just beyond 20 kHz

Measuring the amplification factor using the Picoscope: 12,2 and 12,3



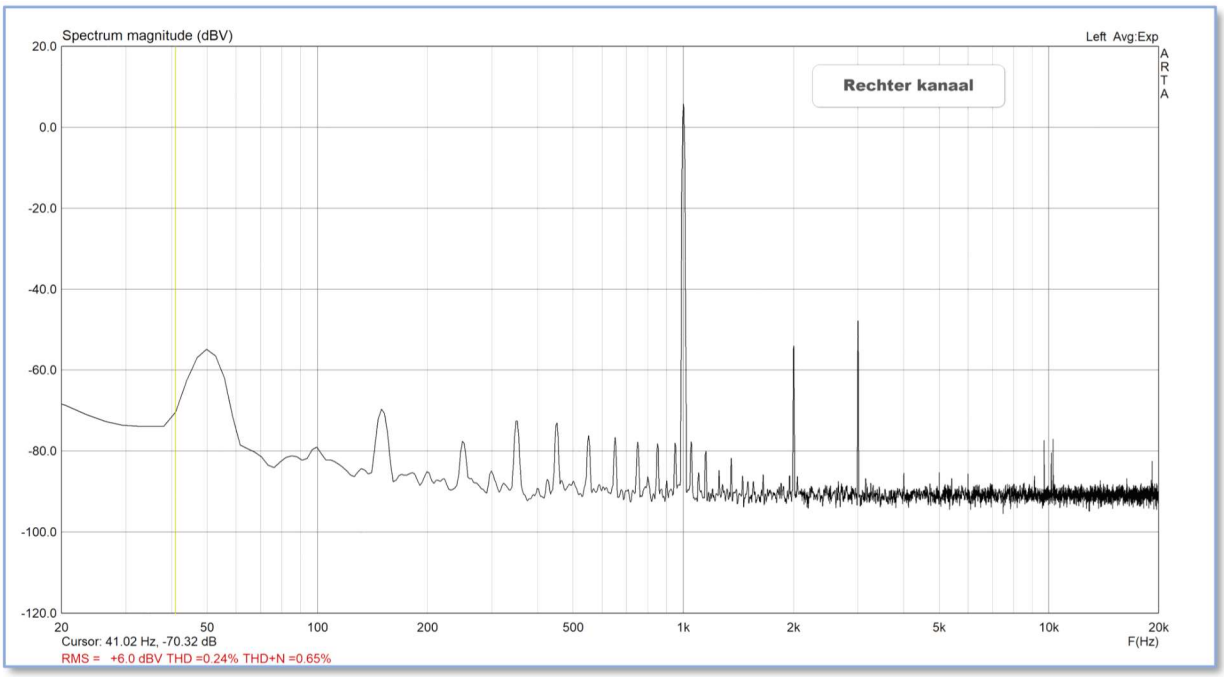


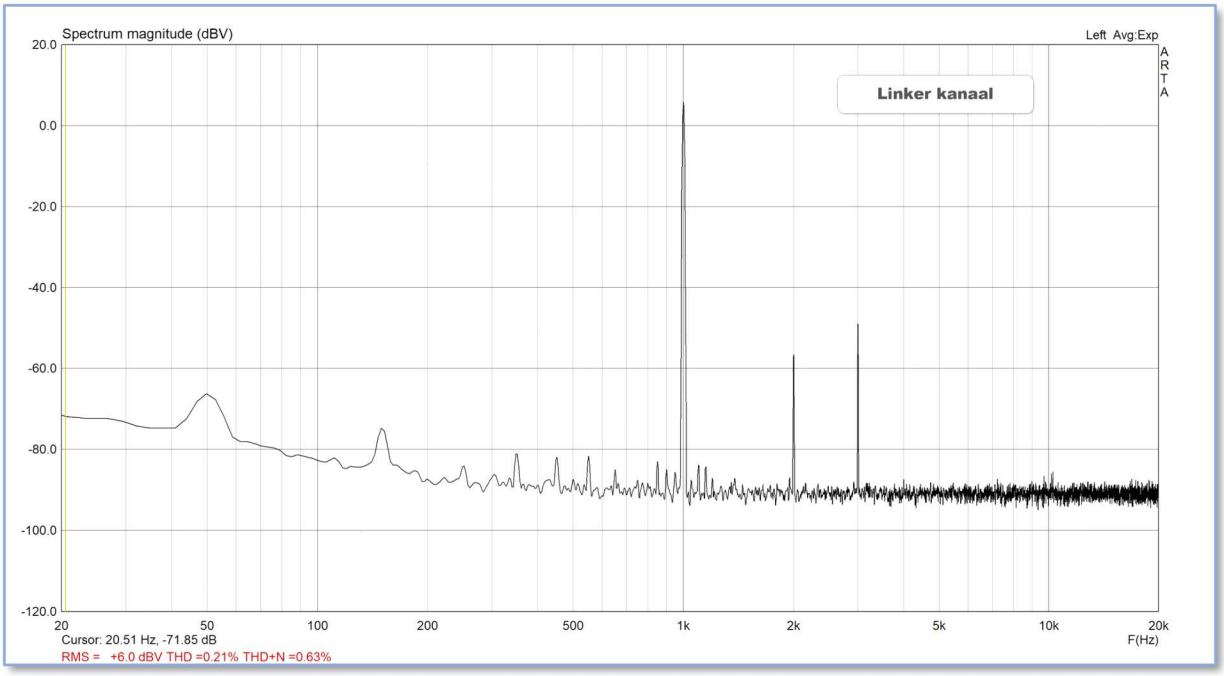
Arta configuration:

- Two ac/dc switches on DC
- Left switch Off
- Right switch On
- Left gain on 0.1
- Right gain on 1
- Using the Arta volumeknob the 1 kHz signal adjusted on 6 dbV, that is 1 Watt of power at 4 Ohm

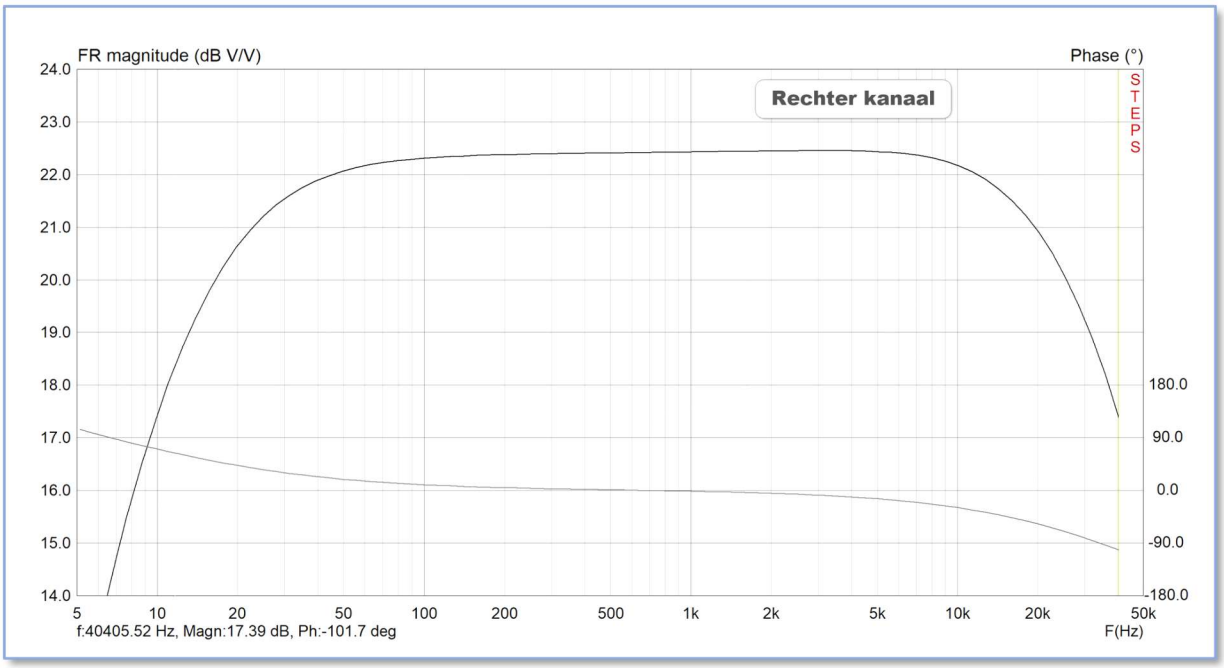
Amplifier volume:

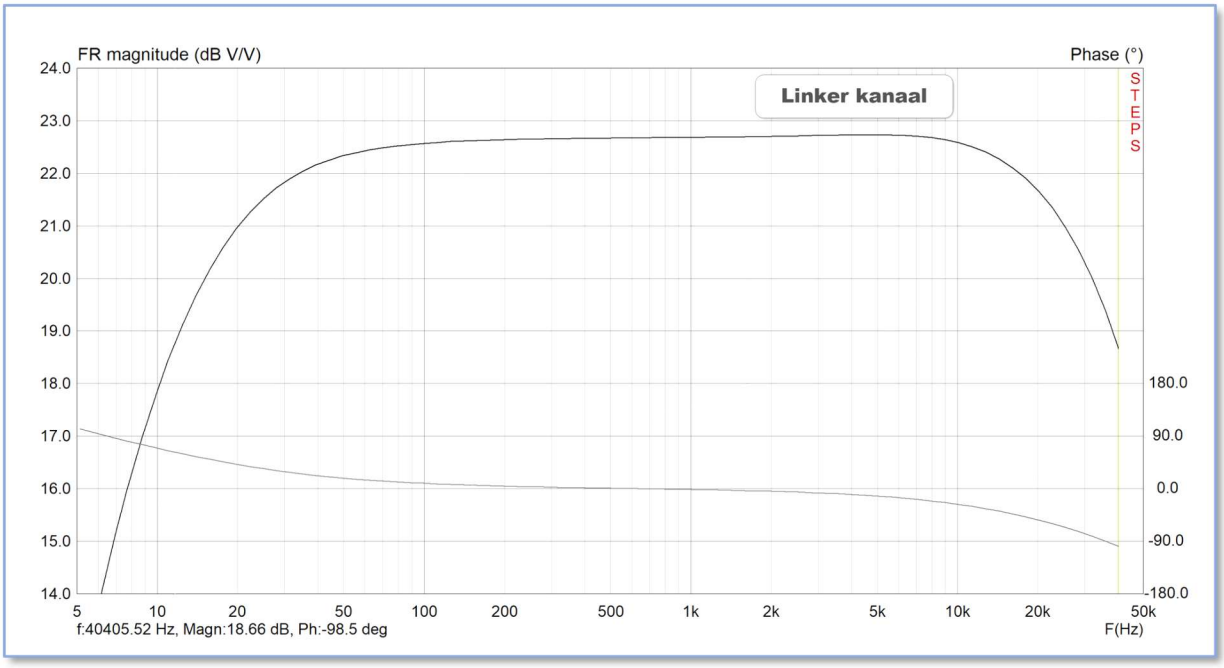
- Volumeknob amplifier set to the maximum



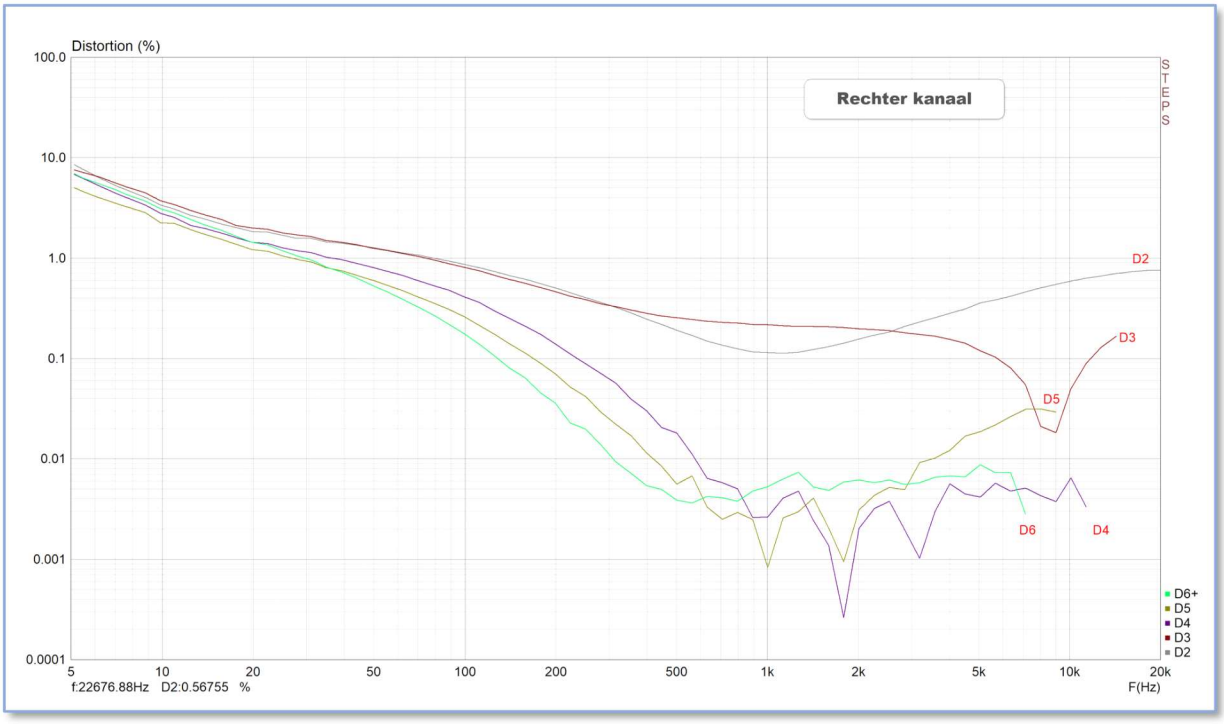


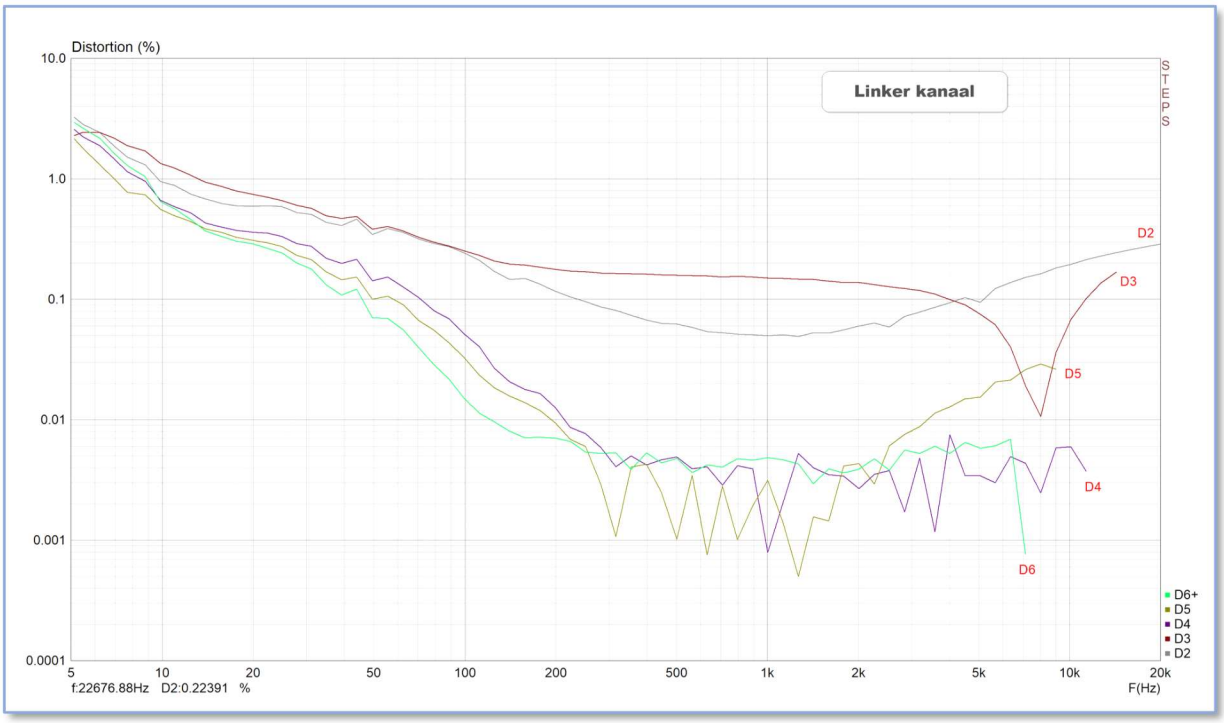
What stands out at both channels: the low distortion: 0,24% and 0,21%.



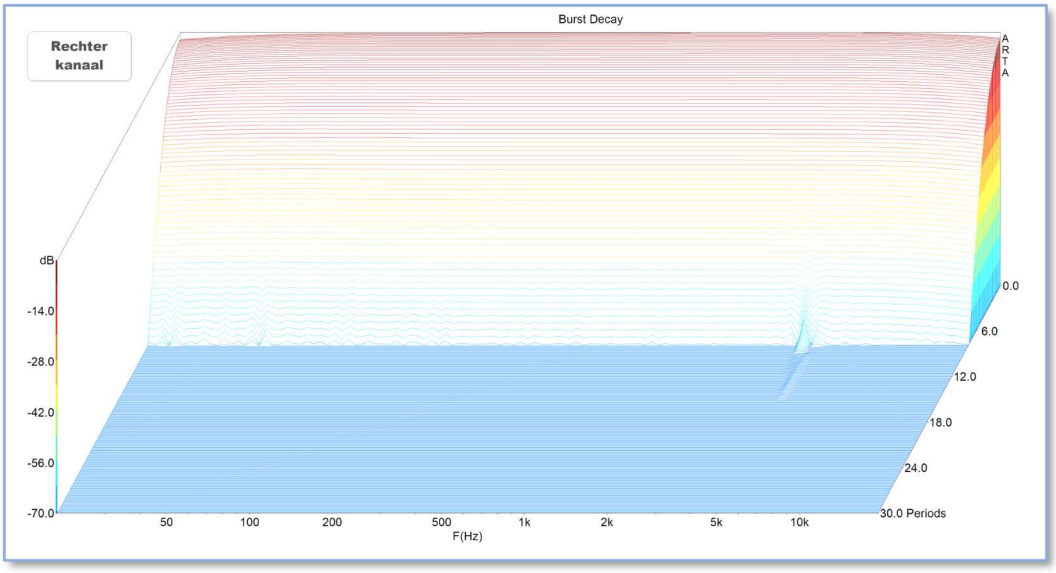


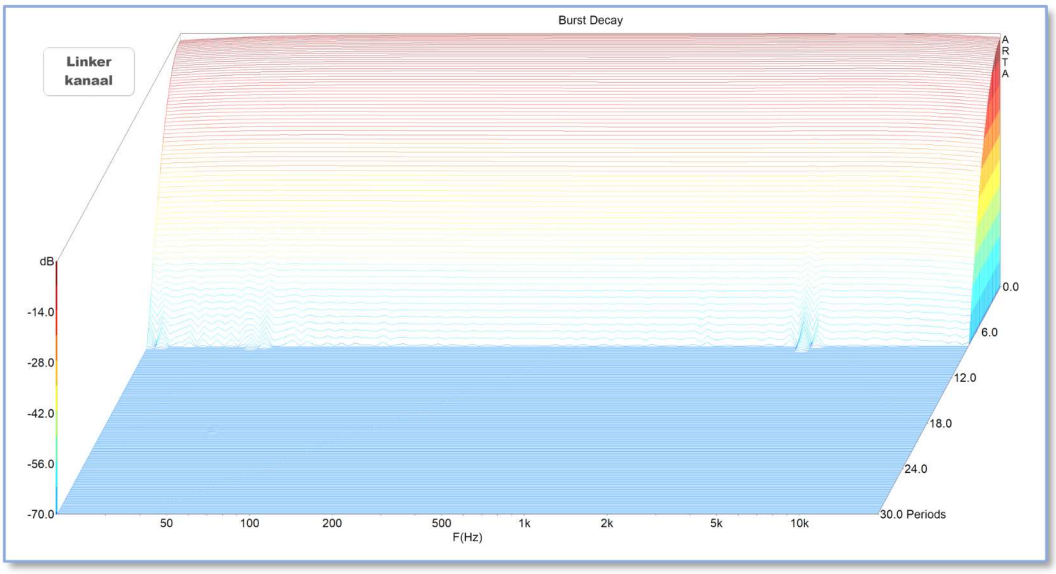
What stands out to me here: the left channel has a slightly higher dB V/V value compared to the right channel, something that was visible in the first measurement as well.





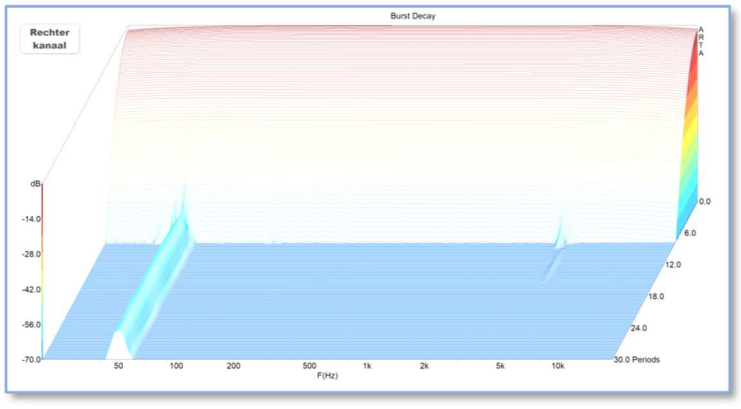
What stands out here is that the right channel starts with a higher value: 4 – 10 % at 5 Hz, and add 100 Hz it is lower than 1 %. The left channel is add 15 Hz lower than 1% distortion. Experimenting with replacing the signal kabel makes a difference: the distortion drops a bit.





Using the measurement **below**, i verified for myself that the hum is easily picked up. This is shown in the image below. If the signal cables are placed too close to the 6.3VAC of the tubes, which contain 50Hz, then you get the measurement below

It's interresting to learn how sensitive shielded signal cables are.
That's the lesson i learned from this measurement.



If i build another amplifier, I would focus more on better cable routing.

Unfortunately, I couldn't get the output impedance measurement working.

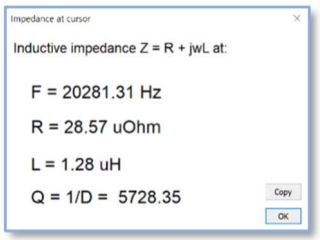
Arta configuration:

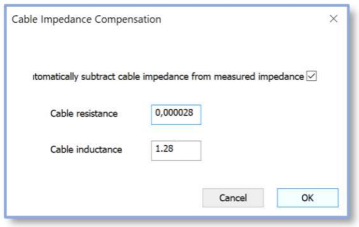
- Both connect switches AC/DC on DC
- Both switches on ON.
- Both gain turnknobs at 1
- Volume Arta on Cal.

Amplifier:

- No dummy load.
- No input connected
- Volume at 0.

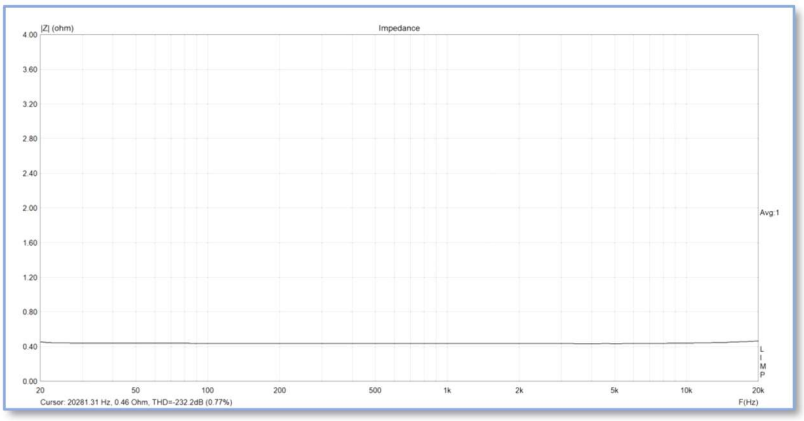
Limp calibrated: first cable resistance measured; 28 uOhm, noted and checked remember cable resistance.





(It matters whether you use a semicolon or dot! It must be a dot.)

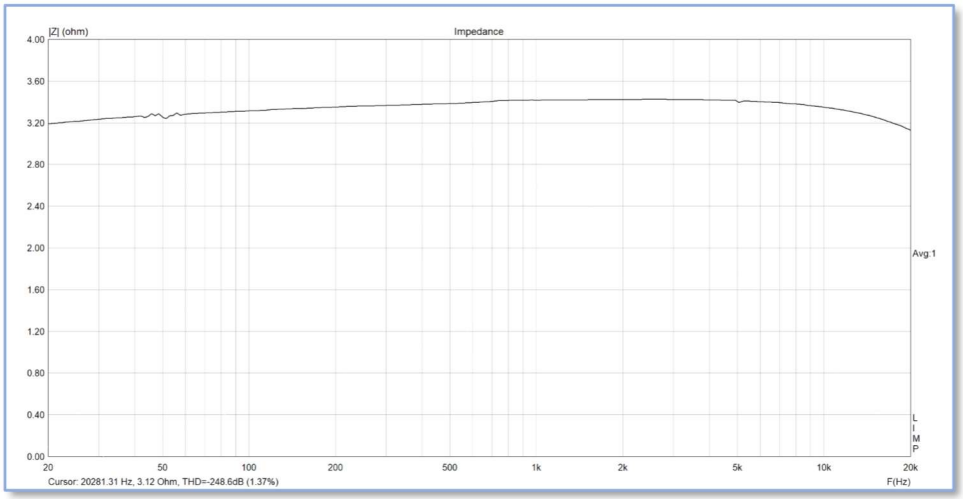
That results in this image:



This image left here is okay.

This image right isn't right. After multiple attempts:

I let it go.



And what do I think about the amplifier?

Detail! Much more detail in the high and low. I will compare this with the OTL-2022 amplifier of the previous season, read my report here..

Is this amplifier better than the OTL? No, it is different: the emotion that the OTL presents, I experience it less with the HiBu. But the "freshness" and accuracy is very pleasant and rich, which I am missing from the OTL. Exactly because the HiBu has a richer detail is it that my wife has become attached to it. If it's up to her, the OTL would leave the living room. Reason: she is partially hearing impaired; she is missing about 30% in the middle and high frequencies. Using the HiBu she can better hear the vocals, hear the words of the music, something that with the OTL is only partially possible for her. I can very much empathize with her choice. But still, I will regularly replace the HiBU with the OTL. Because they are both top notch amplifiers which I am proud of.

And what did this course year bring?

- It brought me new knowledge about the process of adjusting a push-pull amplifier.
- And because I built Arta and with that could measure on my own amplifier, I have gained more insight and understanding of what happens with such devices. This has been achieved by working long at a good spectrum magnitude, the FR magnitude and other measurements. This has given me insight and that was my goal to learn this season.
- Being able to measure has been a tough job of which I needed the help of the TS-members. Because there are so many settings to control. But exactly by making mistakes, sharing this with the TS-members and study the answers, have I succeeded in finishing the most important measurements.