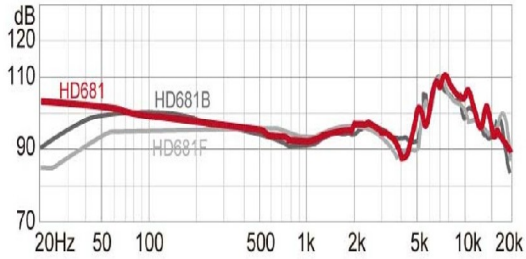
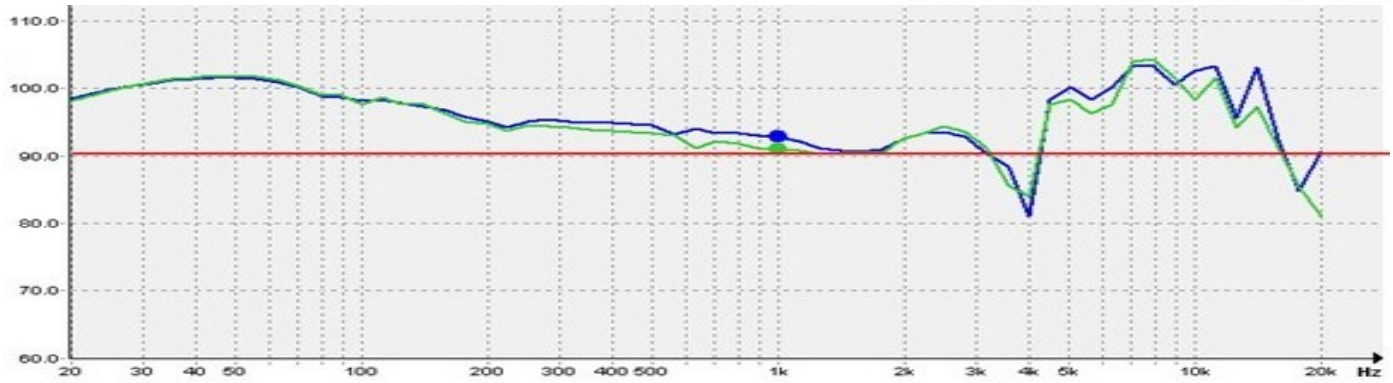
Superlux HD681..... revisited

My previous filters were all based on graphs supplied by Superlux (like the one below) and also based on what I heard. Owning a headphone measurement rig seemed a good reason to have a closer look at the HD681 again. In the old modification guide I made earlier the disassembly procedure is shown. This article is intended for modifications to the HD681 (the red version). A link to it is found on the last page. The HD681-B (**B**alanced) is mechanically the same but has less bass and thus the bass reduction part present in the HD681 filter is changed.
The HD681-B version has grey trimming.

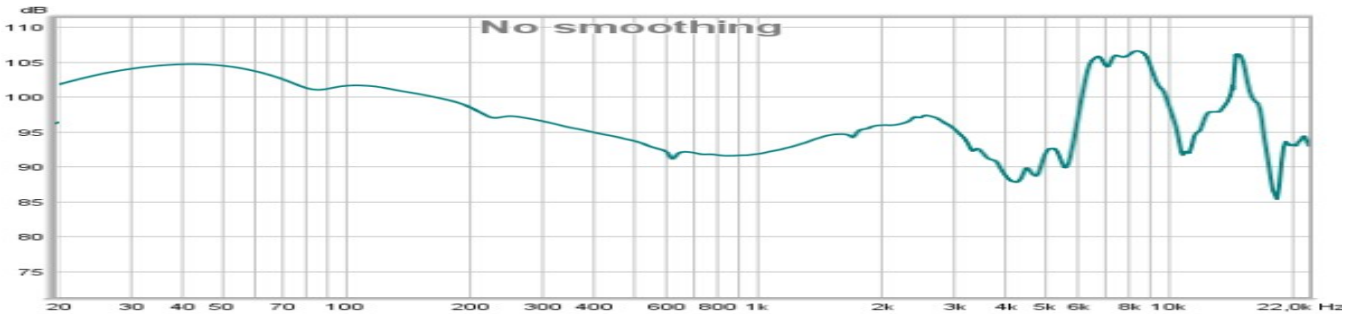


The HD681-F (**F**lat or **F**ront-row) needs the lows filter parts completely removed. The -F version has white trimming.
The differences (according to Superlux) are shown on the right.

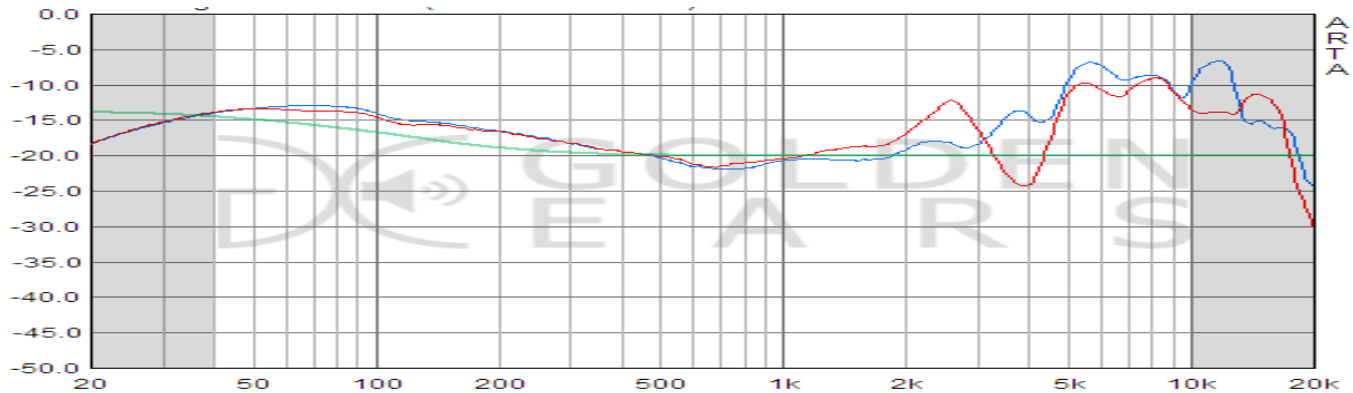


(Frequency plot above is from Superlux techsupport)

below the frequency plot I measured in resized so they have similar scales.

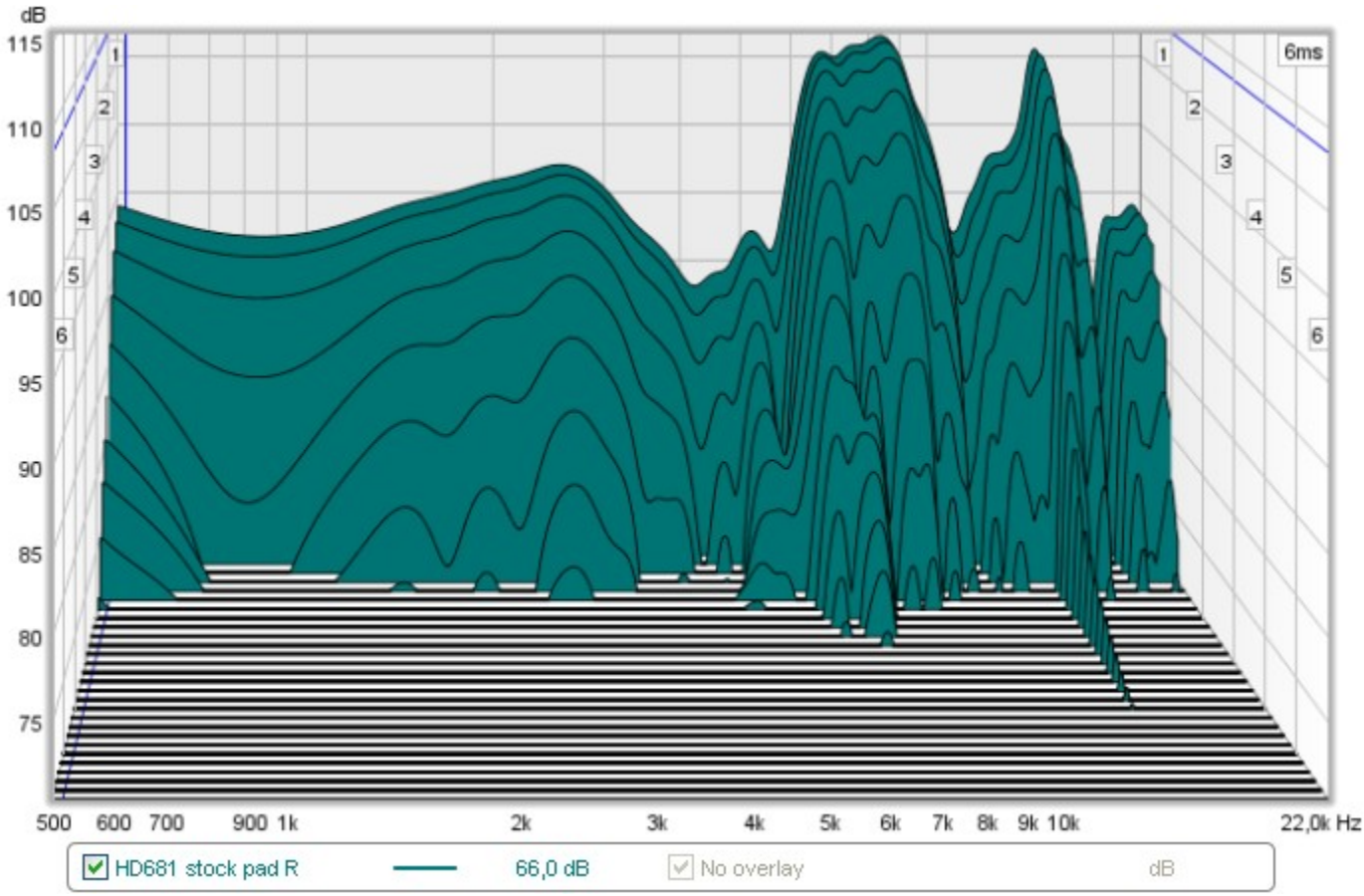


Below the graph from Golden Ears also resized to reach a similar scale.



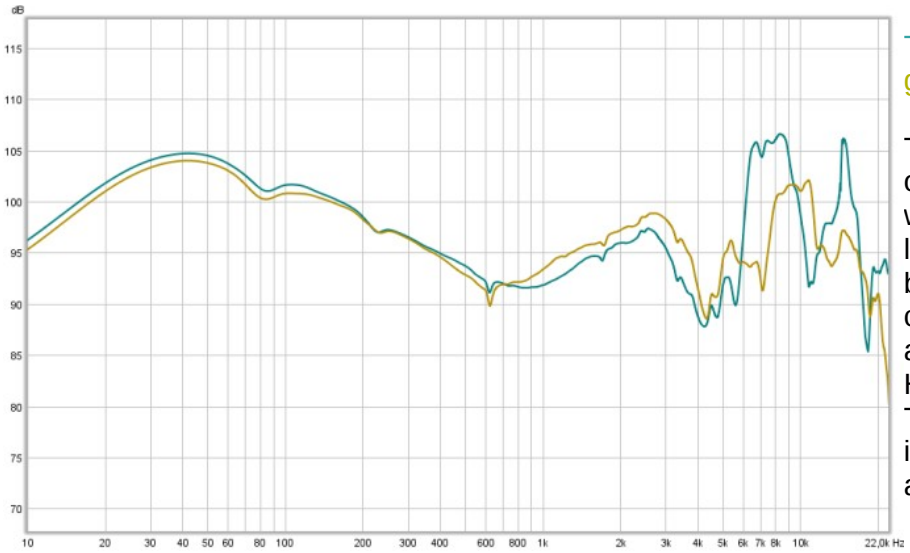
The same frequency plot as above but with a 'stretched' dB scale.

Below the CSD (Cumulative Spectral Decay) plots of the stock HD681 also known as Waterfall diagram. This says something about how fast the driver stops moving when the signal is suddenly stopped. The steeper the waterfall the better it performs.



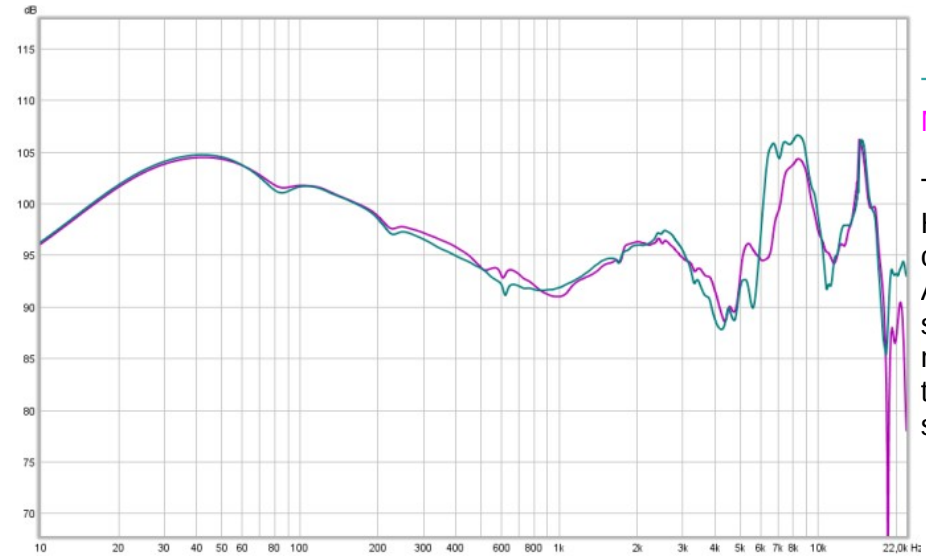
The Waterfall plot shows some 'ringing' around 6kHz and a sharp one around 16kHz. It shows the HD681 is lacking the ability to show the finer nuances and sounds 'sharp'.

Having a few headphone ear-pads (cushions) lying around I wanted to know how these pads compare when used with a stock HD681. The following pads were used as they are an exact fit.
Stock pads (= the original pads), AKG K240 velour pads, Shure SRH-840 pads and Fostex T50RP pads. In the graphs below the original pads are compared with these 3 other pads.



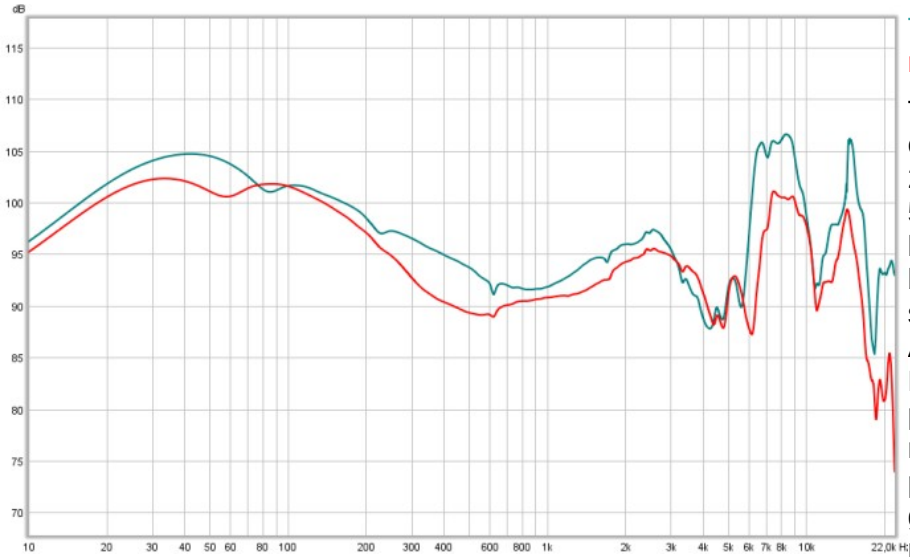
Teal = stock pads
greenish = T50RP pads

These T50RP pads less thick than the original pads which means your ears will/could be touching the drivers. The lows are exactly the same but because the amount of air in the 'ear-chamber' is smaller the higher mids are emphasized by a few dB.
Highs are lowered by a good 5dB.
The lift in the 3kHz area will be higher in real life situations and this is audible in a negative way.



Teal = stock pads
Magenta = K240 velour pads

These are my pads of choice for the HD681 as they are much more comfortable and not as 'sweaty'.
As can be seen on the plots the sonic signature didn't change that much opposite the original pads. A tad less energy around 7kHz, but still way too much to sound pleasant.

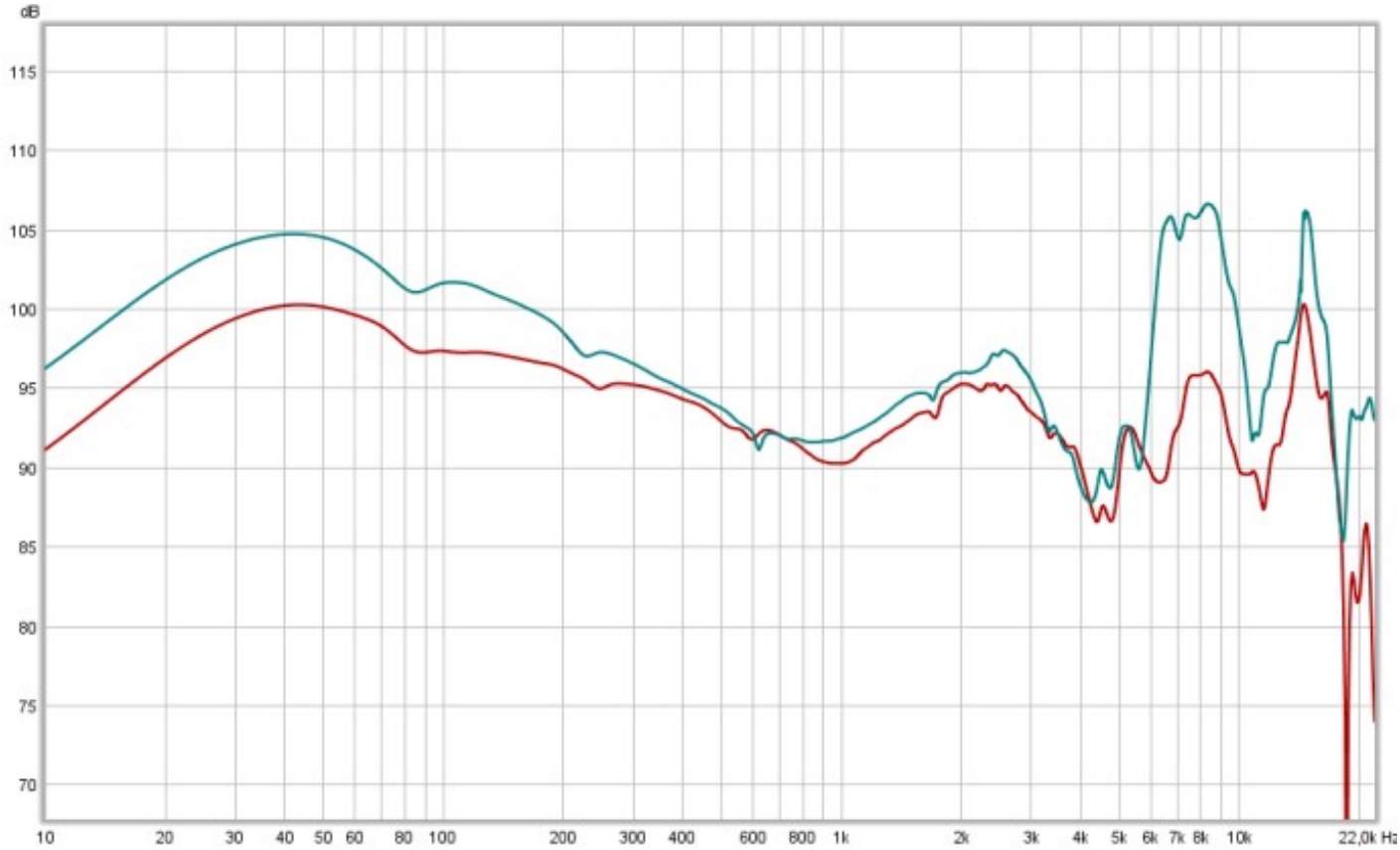


Teal = stock pads
red = Shure SRH-840 pads

The SRH-840 pads lower the efficiency of the headphone by about 2dB and lower the treble peak by 5dB. Overall the highs are thus only lowered by 3dB which is noticeable but still not enough to get rid of the sibilant nature of the HD681.
An audible improvement though.
Because my SRH940 pads were not present at the time these measurements were made these plots aren't included. An educated guess is that the bass area will be reduced slightly more.

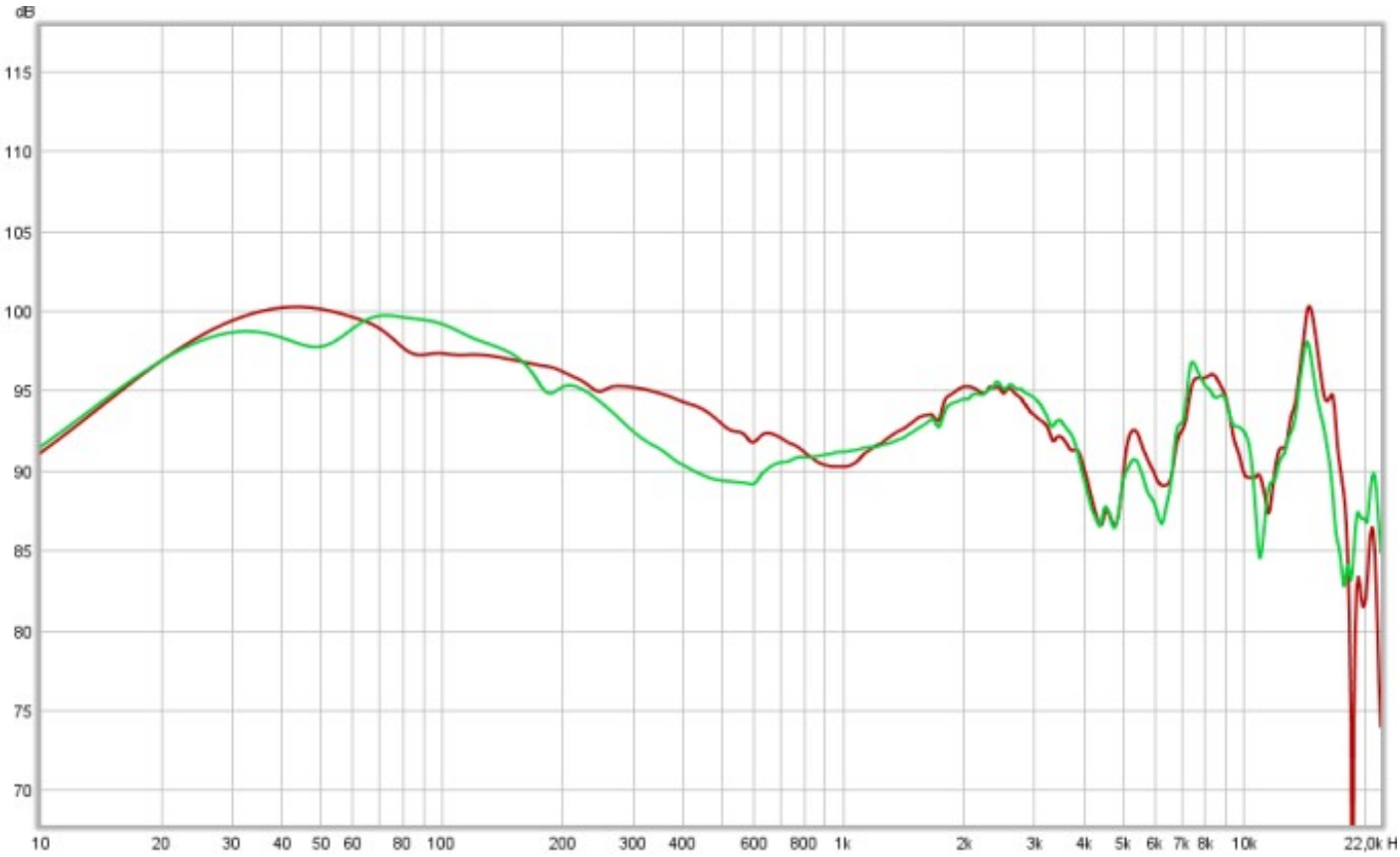
The HD681 is a 'fun' and entertaining headphone with a huge, but not overly distracting, amount of bass. The peak in the treble area raises a false perception of being a highly detailed headphone, where in reality this is where it falls short when compared to better headphones. The CSD plot corroborates this as well. The V shaped frequency behavior is part of this 'fun but not accurate' sonic signature. My previous filter already gave good sonic improvements but were based on the published FR plot of Superlux. This shows only one peak at 7.5kHz and is what the previous filter(s) were based on. In reality it appears that there are more peaks or more accurate an area between 6kHz and 18kHz that is emphasized by 10dB (a doubling in perceived 'loudness'. When the filters center-frequency is shifted a bit towards 10kHz this 'plateau' is lowered in a slightly better (more accurate) way.
Because the headphone has much less treble energy when filtered it will sound much darker as the treble is no longer masking the lack of mids. Bass levels thus need to be lowered as well if the headphone is to sound more balanced, which is the goal.
The filter circuit is therefore revised based on newer insights and measurements and can say that there is a small, but note worthy, improvement in sound quality over the older filter design.

The FR plot below shows the differences between a stock HD681 (no filter, stock pads) and the same headphone but fitted with the filter circuit and K240 velour pads.



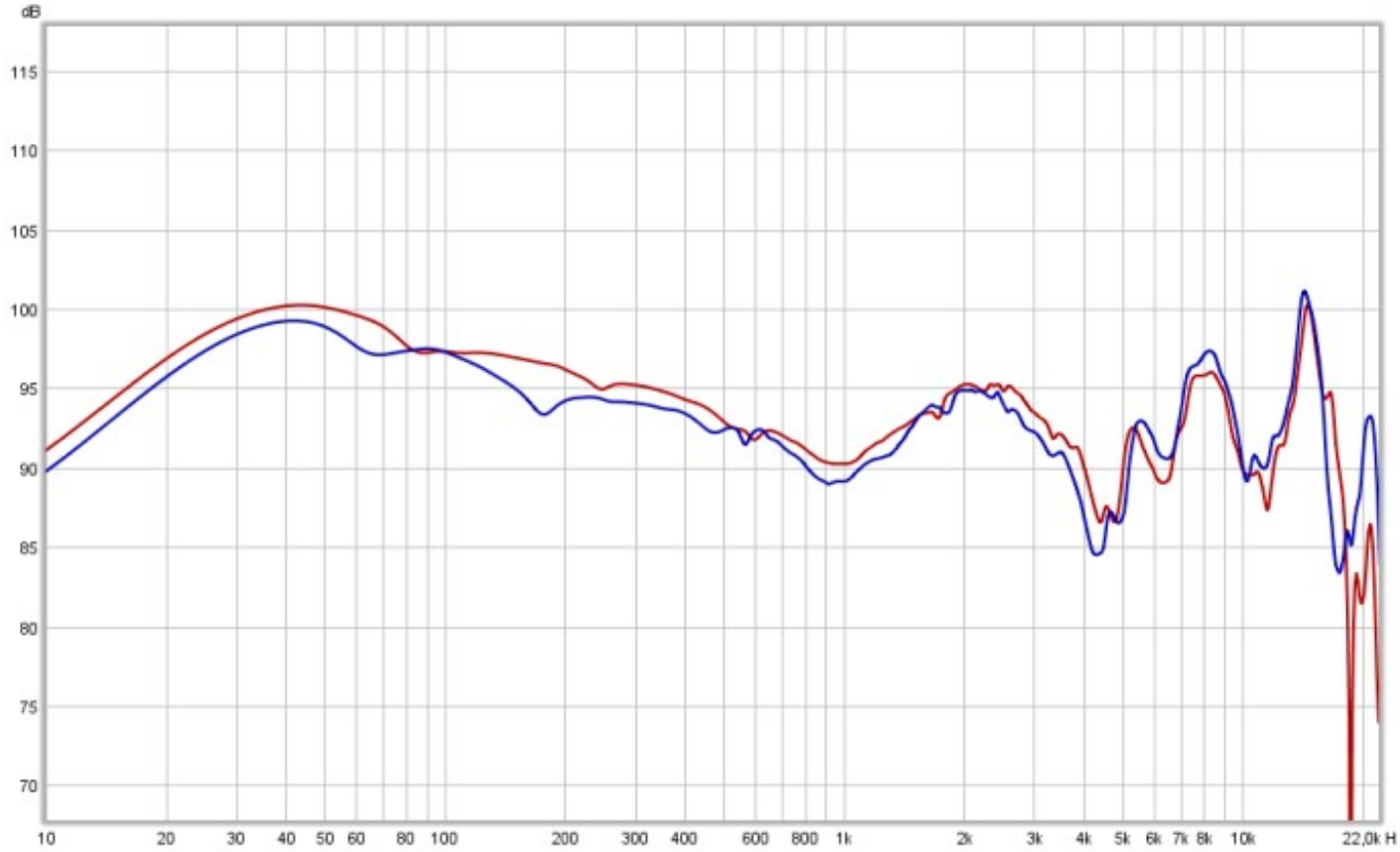
The lows are lowered by about 5dB yet still reach 10Hz with the same amplitude as the mids. The bass is still a good 7dB louder than the mids and thus the 'fun' character of the HD681 remains. The bass is much more 'balanced' though and not over powering.
The treble peak around 7.5kHz is gone and only a small peak remains at 16kHz albeit lower in amplitude. The sibilance, which is in the 3-9kHz region (see http://diyaudioheaven.wordpress.com/tutorials/how-to-interpret-graphs/), however, is lowered by 10dB and is now completely absent.
The lowered amount of bass and treble makes the headphone much more realistic sounding without the negative traits it has in stock form.
The sonic improvements are more than just subtle and transform the HD681 in a very enjoyable and fun headphone with excellent sonic properties that can only be rivaled by MUCH more expensive headphones. It still has a slightly exaggerated but NOT annoying amount of bass and is 'tightened' as well because the level differences between fundamental notes and their respective harmonics is smaller. The highs are no longer sibilant and are on a more realistic level. Listening fatigue is also greatly reduced and even dare to say is completely gone.

The plot below shows the differences between a filtered HD681 with K240 pads and a filtered HD681 with Shure SRH-840 pads.



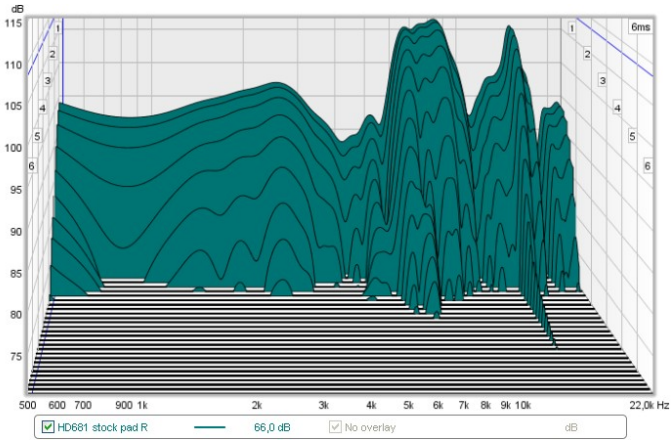
Only some slight differences around the 400Hz region.

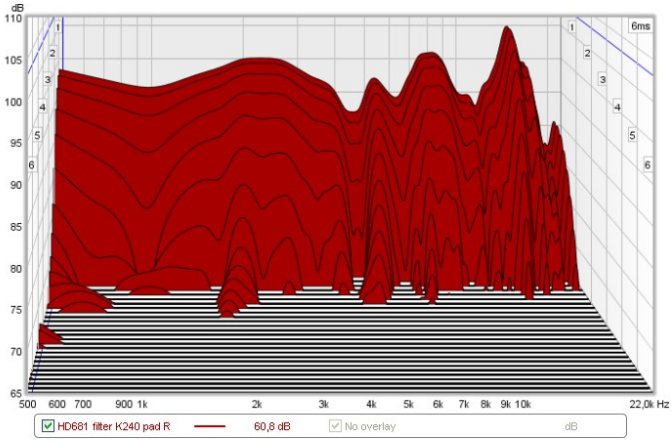
As most headphones tend to have differences between the left and right driver, that sometimes even become noticeable the frequency plot of both channels is shown below.



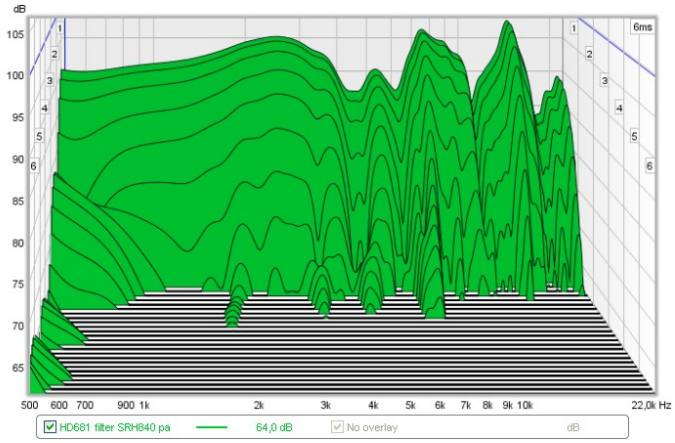
Only very small differences between left and right of less than 1dB in general.

CSD plots of the stock HD681 (left) versus filtered HD681 with K240 velour pads (right):





The filter and pads also clean up the CSD. The ringing at 7kHz and 16kHz is improved noticeably.

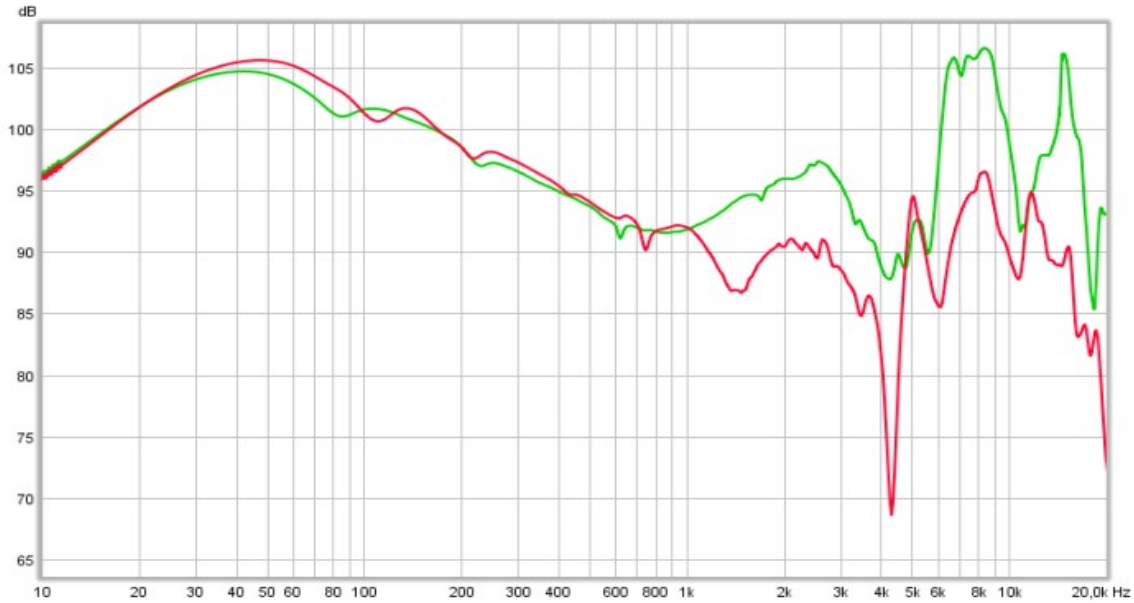


For a more complete picture the CSD plot of the filtered HD681 with Shure SRH840 pads. There is slightly more ringing at 7kHz compared to the K240 pads but not a disturbingly big difference.

The observant reader might think why there are no T50RP plots. The reason is there was a 2dB increase in the higher mids which was too prominent and the pads being flatter than the original ones made the HD681 less comfortable.
Both the SRH840 as the K240 pads improve the comfort greatly.

Cables: Another thing many people attempt to alter the sonic presentation is to change the cable. This won't result in measurable differences in FR so they are pointless to measure. However, stereo image can be affected when a relatively high resistance common return wire is used. The explanation can be found in the article '***impedance, resistance and other issues***' here: http://diyaudioheaven.wordpress.com/tutorials/
The long headphone cable supplied with the HD681 exhibits a larger than usual cable resistance of 0.45Ω. With a nominal impedance of 32Ω this is a rather high value. A replacement cable is therefore advised and suggest to use a 4 wire cable where the return wires are connected in the headphone plug.

Superlux has a newer version, a completely revamped one, of the HD681 next to the original HD681 line-up. This one is called **HD681-EVO** and has a noticeably smaller amount of highs and does not show the sibilance the HD681 series has. Below the differences between a stock HD681 and stock HD681-EVO



The HD681-EVO modifications are covered in its own article. It can be viewed/downloaded here: http://diyaudioheaven.wordpress.com/schematics/headphone/ (scroll down to **Superlux HD681 EVO**)

Of course highs could also be lowered by placing felt or other materials in front of the driver BUT would most likely also affect parts of the frequency range you do not want to be affected.
Another problem is duplicating the results might be difficult as the needed materials might not be available in some (even a lot of ?) countries.
Bass levels can also be lowered by blocking the round holes and or by stuffing the cups with wool or other damping materials. The problem is here that this will be very difficult to reproduce. The right amount and type of materials used are a big hurdle. Another problem is that it will be difficult to 'tune' the headphone by ear unless one has experience with this and a known reference which it can be compared to. Having a measurement setup can help of course but not many people have this.

These problems are not present when electronic filtering is used for the simple reason that the electronic filter only addresses the areas that need correction. Another big advantage is repeatability is very high meaning others who apply this filter will end up with very similar results as those published here.

Of course it is also possible to use active compensation for this headphone using the filter PCB which can be found here: http://diyaudioheaven.wordpress.com/schematics/headphone/ but the costs of making this kind of filter will be higher than those of the headphone including pads and kind of defeats the purpose of the HD681 which is **V**alue **F**or **M**oney. The electronic parts needed for this passive filter are much lower.

The 3 different versions of the HD681 all need a different form of compensation. For the filters where the bass is lowered (HD681, HD681-B) there is a small downside to usability of this filter. For the filter to work correctly an amplifier (or output of a portable device) MUST be low Ohmic. Anything with an output resistance below 10Ω is low resistance enough, it doesn't have to be a near 0Ω output resistance.
For more information about output resistances see the articles '***impedance, resistance and other issues***' and '***headphone power and amplifiers***' found here: http://diyaudioheaven.wordpress.com/tutorials/ .
Most portable equipment is and a lot of desktop amps are as well but certainly not all desktop amplifiers have low enough output resistances. This output resistance value can be rarely be found in the spec sheet of the amplifier/device and is NOT the same as the often mentioned 'impedances' of the headphones that can be used with it.
If unsure about this feel free to contact me via the forum (http://diyah.boards.net/index.cgi) or directly by email: solderdude4u@gmail.com .

For this reason there are different schematics for different circumstances and HD681 types.
These schematics can be found on the following pages.

The most complicated filter for the 'red' HD681 is intended for headphones that are used or might be used on amplifiers where the output resistance is unknown. When this circuit is used the high frequency correction will always be 'correct' regardless of the output impedance of the amplifier. The bass levels are affected though. The higher the output resistance of the amplifier the higher the amount of lows and the 'warmer' it will sound.

When the output resistance of the used equipment is known to be low (< 10Ω) a simpler circuit can be used where components R1,C1,L1,R2,C2,L2 are omitted. This can be used for the 'red' HD681.

The third schematic is for the HD681-B (grey trimming) in case the output resistance of the used equipment is known to be low (< 10Ω). Basically the circuit is the same as for the HD681 but the value of R5 and R6 is different (15Ω instead of 27Ω). When the output resistance of the amplifier is unknown the components R1, C1, L1, R2, C2 and L2 need to be added similar to the first schematic for the 'red' HD681.

The fourth schematic is for the HD681-F (white trimming) which does not need the bass lowered at all. In fact I find this one to be on the bas-shy side which can be improved VERY slightly by driving this headphone from high output resistance sources (between 100Ω and 120Ω). For this reason the components R1,C1,L1,R2,C2,L2 are needed.

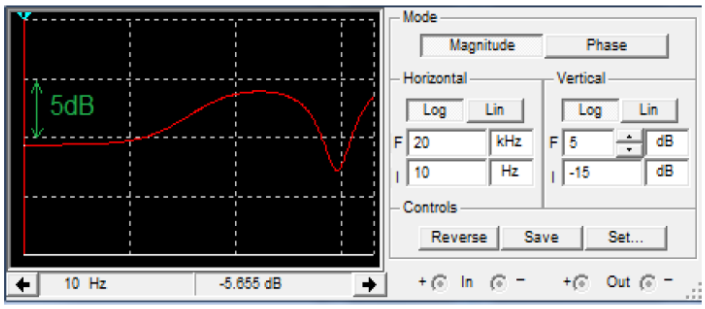
A brief circuit explanation: L3,C3,R3 and L4,C4,R4 form a notch section that lowers the high frequencies to the desired level (near 'flat') and is the 'active' part of the filter circuit. For low output resistance amplifiers R1,C1,L1 and R2,C2,L2 do nothing and can be left out. R1,C1,L1,R2,C2,L2 ARE needed when the HD681 is used on amplifiers with a high output resistance and make sure the filter still works as intended in this case by equalizing the impedance the amplifier 'sees'. When in doubt about the output resistance of the amplifier keep those parts in there.
C5,R5,C6,R6 are the parts that filter the lows and ONLY work when used with a low output resistance amplifier. When used on a higher output resistance amplifier only the lows filter section looses its function.

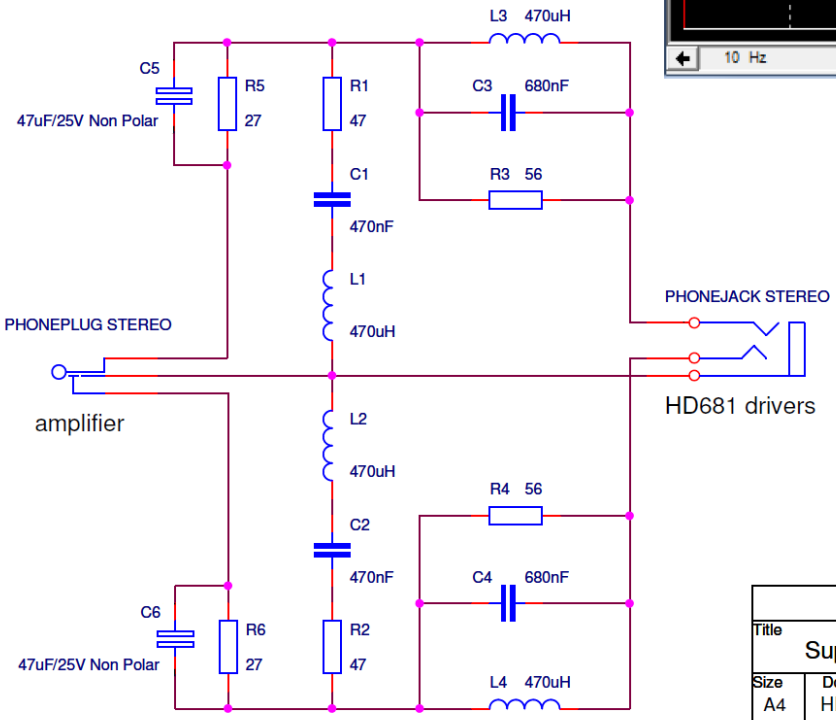
HD681 disassembly procedures are found here (scroll down the the HD681 section, step by step guide):
http://diyaudioheaven.wordpress.com/schematics/headphone/

Schematics for the 'red' HD681 and when using the headphone on equipment of which the output resistance is not known or when used on different amplifiers/players.

This filter ONLY works correctly when driven from players/amplifiers with low Ohmic output resistances.

An amplifier output resistance of 10 Ohm or lower is recommended. When amplifiers are used with higher output resistances the bass reduction will be less and the sound will 'warm' up.





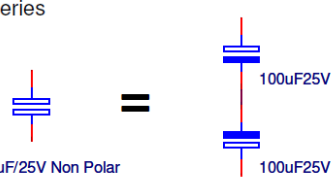
Component properties:

L1 - L4: Rdc < 2.6 Ohms, Current > 0.4A

R1 - R6: metalfilm rated between 0.4W & 0.6W

C1 - C4: Ceramic multilayer NP0/C0G or X7R or film type. Do NOT use electrolytic, ceramic disc or tantalum capacitors.

C5 - C6: 47uF/25V NonPolar (Bipolar) electrolytic or 2x100uF/25V Polar electrolytic in anti-series



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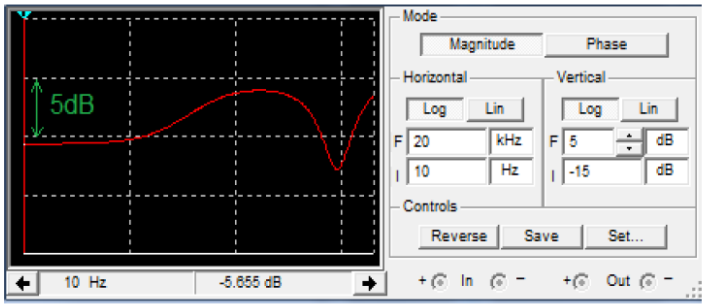
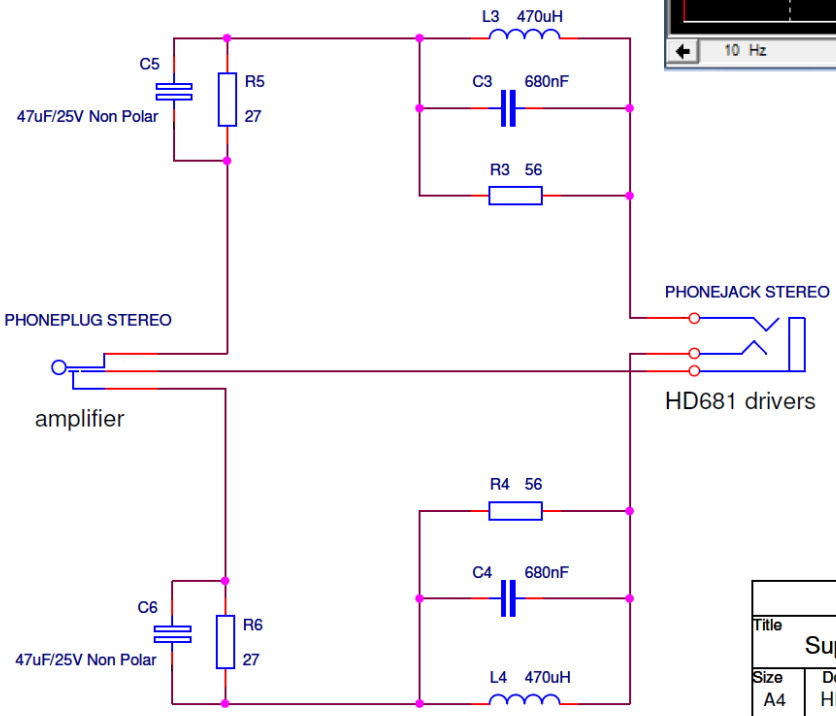
Simplified version that can be used when the HD681 will always be used with low output resistance equipment:

This filter ONLY works correctly when driven from players/amplifiers with low Ohmic output resistances.

An amplifier output resistance of max. 10 Ohm is required. When amplifiers with higher output resistances are used the filter action will differ and become less accurate.

When this headphone is used from a high output resistance amplifier use the HD681-F circuit.





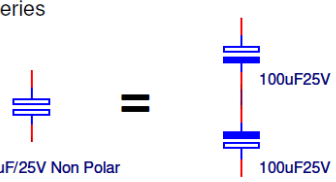
Component properties:

L3 - L4: Rdc < 2.6 Ohms, Current > 0.4A

R3 - R6: metalfilm rated between 0.4W & 0.6W

C3 - C4: Ceramic multilayer NP0/C0G or X7R or film type. Do NOT use electrolytic, ceramic disc or tantalum capacitors.

C5 - C6: 47uF/25V NonPolar (Bipolar) electrolytic or 2x100uF/25V Polar electrolytic in anti-series



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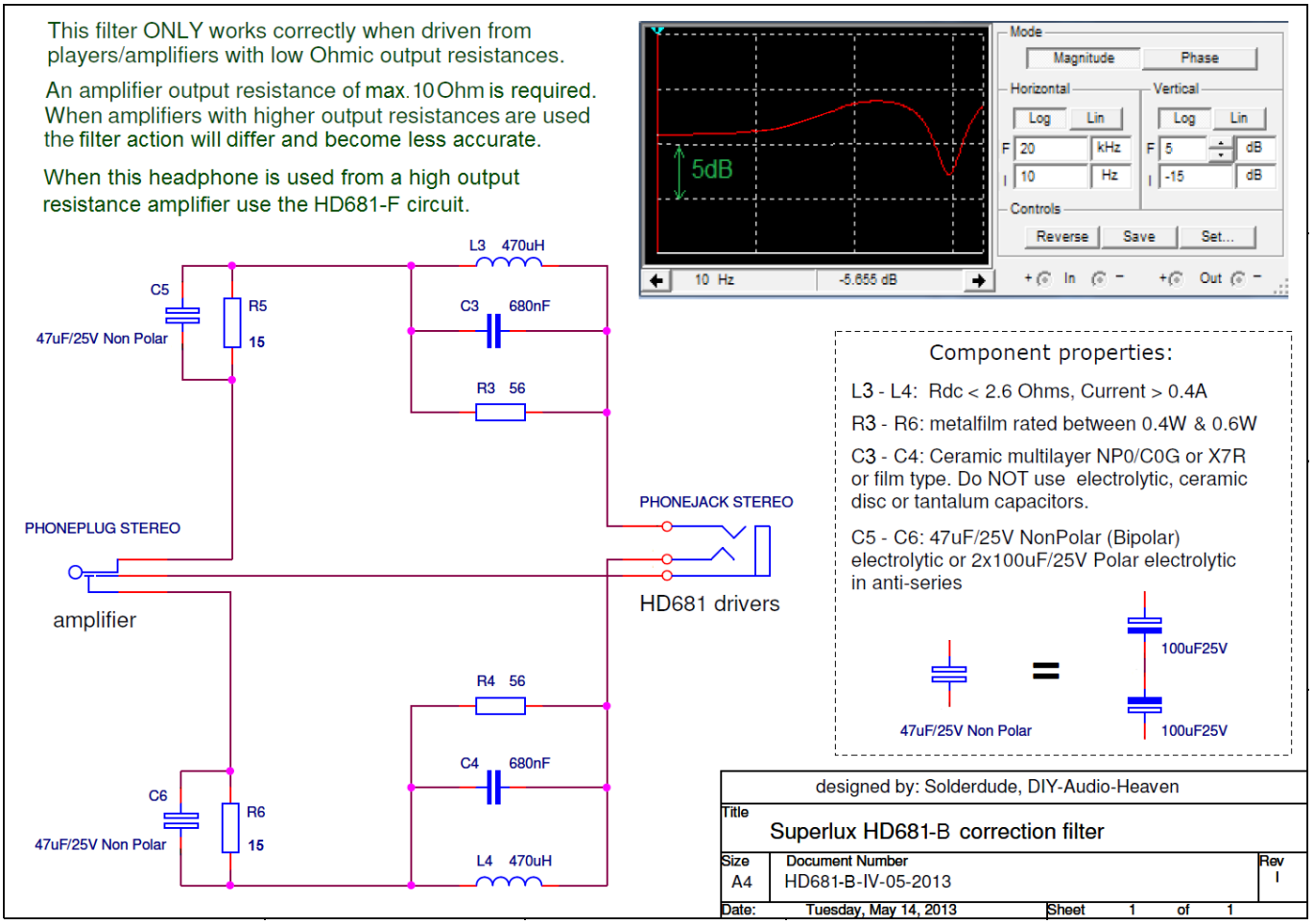
Schematics for the HD681-B when using the headphone on equipment with an output resistance <10Ω :



Schematics for the HD681-F (white trimming):