TubeSociety-2016-300B-SE Amplifiers

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This report describes five 300B-SE amplifier designs, designed by Menno van der Veen, as part of the TubeSociety 2016 project (1). The first 4 designs are described shortly, their concepts are explained and subjectively evaluated. Objective measurements show the advantages and disadvantages of these design. The last conclusive design is described in more detail.

Introduction:
As director/teacher, with many TubeSociety students around me, I had to guide my students into the right direction, to design and construct their own perfect 2A3-300B-SE amplifier for our 2016 TubeSociety project. To make design and construction feasible in about 5 month (which is a short period), I advised my students to use so called "standard components". A student support group (Hessel, Erwin, Gilbert) organized availability of these components plus a nice pre-drilled aluminum case. I made some design-papers (2) to deliver a good start for their design.

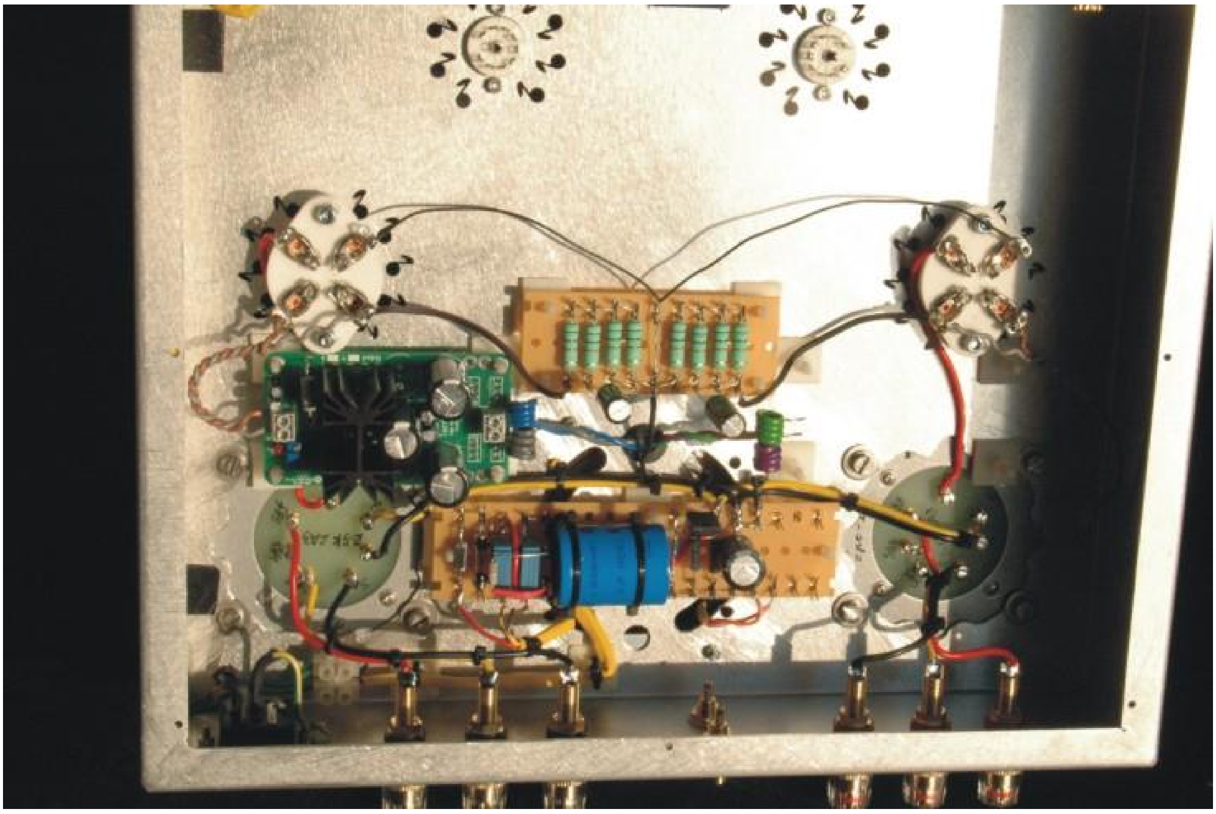
For my personal contribution, I organized some free research time to look into many directions of these special 300B-SE amplifiers. When a new Menno-amp functioned and was measured, I directly shared the result with my students to support and encourage them in their work. I showed the amps, listened with my students and many comments were given. I also invited the famous Dutch designer Peter van Willenswaard (3) to give a tutorial to my students, to share his precious experience. Personally it took me some month to discover the objectives for my contribution to this challenging project. It was a quick learning curve, and my conclusive final word is not said yet. I know, there is more to discover, to try to come somewhat closer to the holy Grail: the perfect 300B-SE-amplifier.

After finishing and demonstration of the student amps, I asked them to write their personal report, mainly based on Arta-2 measurements (4) with the excellent Arta computer programs of Ivo Mateljan (5). For details of the applied Arta-2 measuring unit, see (6). You find the student reports elsewhere in this section. Because we all shared our ideas during lessons and discussions, I asked my students to mention in their reports where they applied ideas of fellow students or from me. By doing so, we were building on each other's shoulders, we progressed quickly and the atmosphere in the group was supportive and challenging.

Looking back to this TS-2016-project, I think it was a little too difficult, too challenging, too demanding. Remember, some of my students started from scratch, others were more experienced. A 300B-SE amp may look simple, but it is not. In it are all the "difficulties" of science, good design and building practice, safety issues, experience in subjective listening evaluation, making reliable measurements and drawing acceptable conclusions. Therefore I consider the excellent final results as a "miracle", a blessing. In spite of all the constraints: we did it!

Preconditions and Standard Components:
To get highest quality components, we asked for support of the Dutch company Amplimo (7). We selected VDV-2512-SEE toroidal output transformers (8); 4N1885 power transformer (9); Tentlabs-current-source-filament supplies (10) or Meanwell AC/DC 5V/20W converters (11). All other components like tubes (300B or 2A3 and 6SN7 or 6SL7 or ECC81) and resistors and capacitors and

diodes and tube sockets also came from Amplimo. In my Menno-designs I applied a special SE-transformer, designed by my Chinese student Zhou Ke, meant for 2A3 application (Vak=250V; Za=2k5; Io=60mA). Some students bought their output transformers from Hammond or Audio Note.



AMPLIFIER-1: FET driver stage plus 300B in 2A3 configuration

The concept of the audio-signal stage is given in figure-1. All considering the power supply section is discussed in detail after amplifier-5. To enable a quick start, I applied BSP135 fets in a very simple driver stage plus source follower (to compensate for the effective grid capacitance of the 300B). Because of the Zhou-Ke OPT, the 300B was put in a 2A3 configuration with Vak=250V and Io=60mA as operating point. This certainly is not optimal for the 300B, but I needed this to evaluate the OPT.

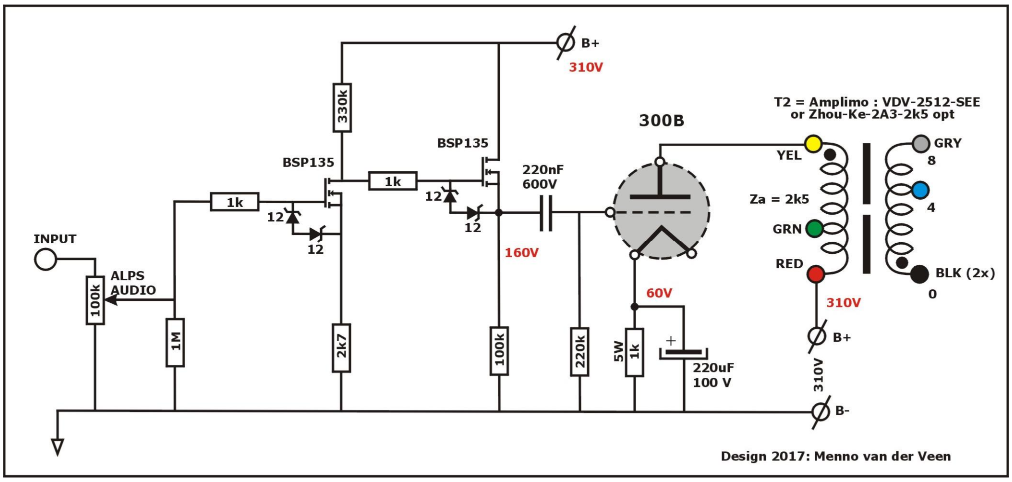


Figure-1 : audio-section Amplifier-1

At each fet the two 12V zener diodes between source and gate protect at start-up of the circuit. The amplification from input to source follower output is 41dBV/V (112 x). The THD of only the driver section is 0,8 % at 1 kHz at 60 V output amplitude to the grid of the 300B. Maximum power output was 4 Watt, as expected. The most important measurement results are shown below.

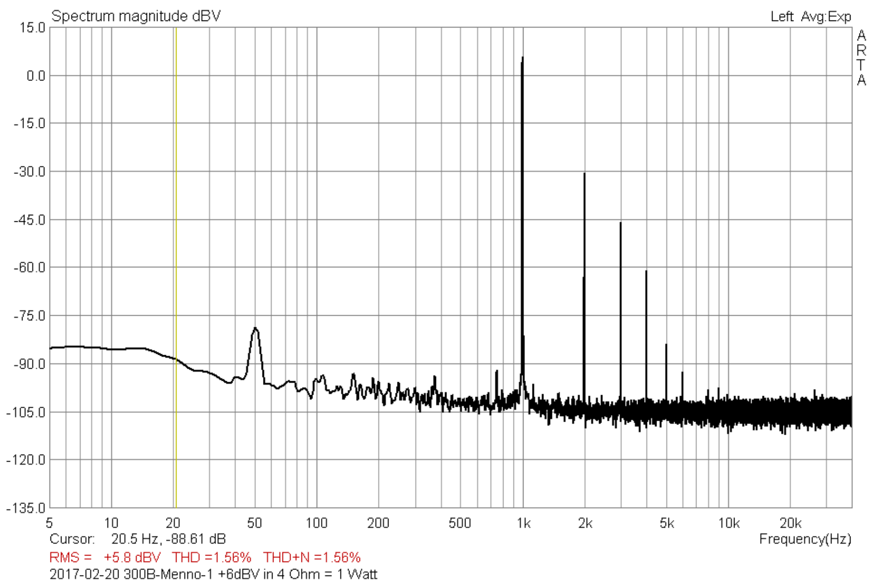


Figure-2: 1 kHz spectrum at 1 W in 4 Ohm

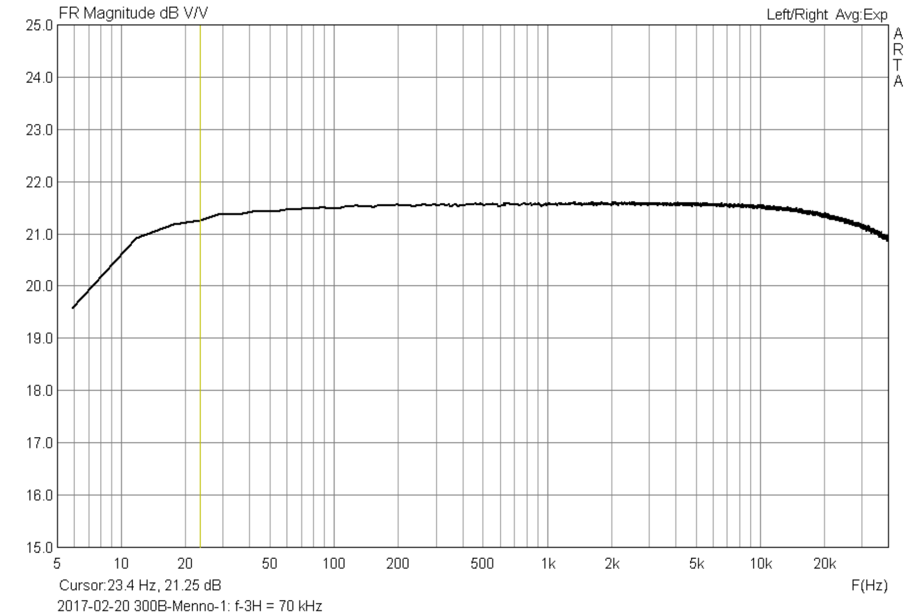


Figure-3: gain and f-range at 1 W in 4 Ohm

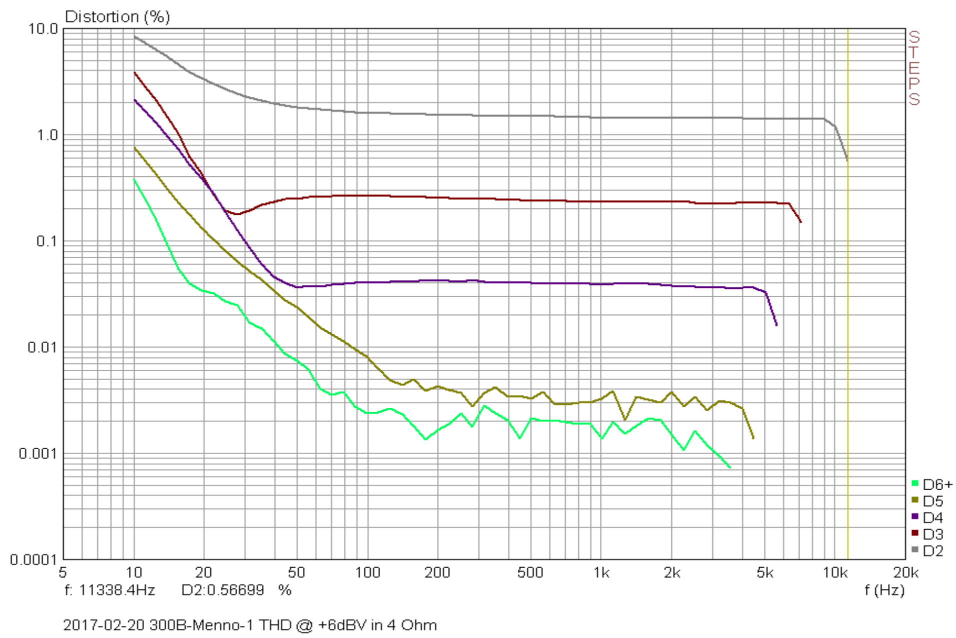


Figure-4: harmonics at 1 W in 4 Ohm

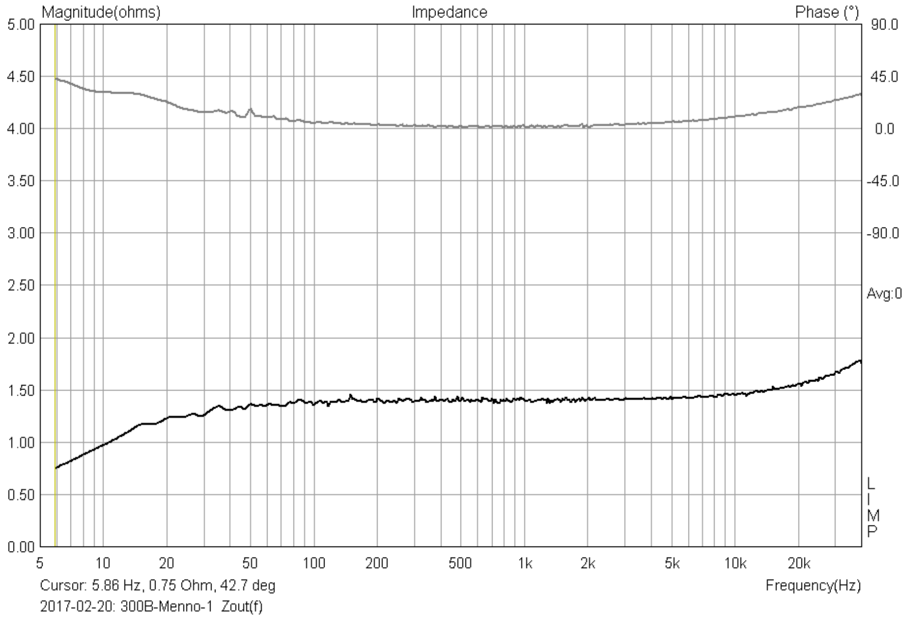


Figure-5: output impedance (lower curve) at 4 Ohm tap.
Upper curve is the phase of the impedance (right hand scale).

Remarks:
Why do I mostly measure at 1 Watt in 4 Ohm? I use horn speakers (made by Giuseppe Maino in Rome) with a sensitivity of 97 dBspl/1W,1m. With 1 Watt power I already have a loudness of 97 dBspl, which is loud. Mostly I will listen below this level. So, I measure at the level where I am listening, not at super output powers. The harmonic spectrum (figure-4) nicely follows the masking curve of our ear. The frequency range extends without any resonance to -3dB at 70 kHz. The OPT alone, driven by a 800 Ohm voltage source, extends to -3dB at 100 kHz without any ringing, which is excellent. Figure-5 shows at lowest frequency the starting shrinking impedance of the primary inductance Lp (12), while at highest frequencies the onset of the influence of the leakage inductance Lsp is just visible. (Remark: you do not see Cip here, because that would cause a Z-out decline).

Subjective comment:
The amp sounded embracing friendly warm, however with too many second harmonics, preventing micro details from being noticed. This sound character did not impress me. Too much fine details got lost. But it functioned; not that bad for a first try.

AMPLIFIER-2: FET driver stage, 300B in 2A3 configuration, focus on the Coupling Capacitor

Amplifier-1 and -2 are exactly the same. The only change was the type of u22/630V coupling capacitor. The students and I listened to the following types: 1) Jensen Silver foil; 2) Jensen Copper foil; 3) Mundorf Mcap Silver/Gold/Oil; 4) Russian Pio K40Y:9; 5) Koweg; 6) LCR PCHVSWF; 7) Lcap KPSd; 9) Siemens MKP; 10) Wima-red MKP10 and several other unmarked brands.

The results were striking. The sequence of this list shows our appreciation, with 1) as absolute winner; 2) somewhat less compared to 1); and 3) as next on the declining scale and so on.
The observations were as follows: nothing was changed in volume, only the capacitors interchanged, followed by an almost blind listening test (because no one knew what to expect). With capacitor 1) the soundstage was open, fluent, deep, no sharp character, friendly and warm, highly attractive human-like sound character. Going higher in number, these good observations declined, until the sound character was not attractive at all.

After this I performed standard measurements of the distortions (see figure 4 at amp-1) and I noticed no differences between the various capacitors.

Consequently I am forced to a rather stringent reformulation of my conclusions of amp-1: "The subjective quality of the amp is mainly influenced by only one component: the coupling capacitor".

It was impossible to measure any effect with my standard measurements. They seem to be non-valid in judging subjective sound quality. (Let me be cautious here: the measurements are valid in showing good design, but that is not the topic of this discussion).
I am very well aware of the influence of construction and materials in coupling capacitors. I even wrote an AES-paper (13) about some of those remarkable effects. That is not my problem. It is that conclusions drawn from standard accepted measurements seem to be non-valid when you wish to say something about appreciation of the sound of an amp. Therefore I shall use my standard measurements only to say something about how healthy the design is. I will hardly derive conclusions from them about observed subjective sound character.

A last small remark: when the coupling capacitor has such a huge influence, why not the same for resistors or transformer core steel or …… Now I understand that people are willing to spend thousands of euros to get the sound character they want, to approach the holy Grail. Is this the way to proceed for me or my students? I decided not to continue on this expensive trail, but to use sound thinking. Let's see what this brings us.

AMPLIFIER-3: FET driver stage, remove Coupling Capacitor and protecting zener diodes

If the coupling capacitor has such a huge influence, why not remove it by changing the circuit into direct coupling? Secondly, I noticed that the protecting 12V zener diodes had a leakage current in the micro Ampère range, creating rather much distortion. So, away with them. See the next schematic of the audio-section below.

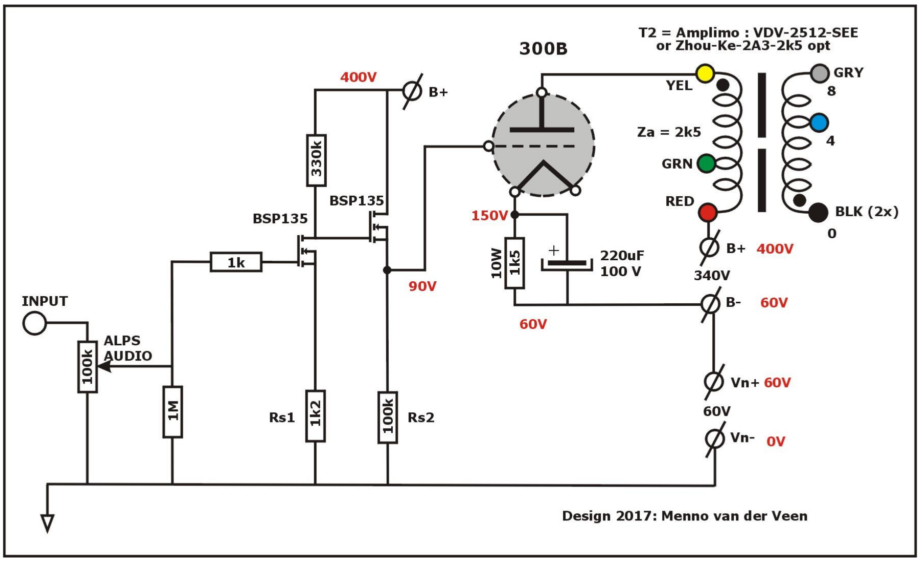


Figure-6: Amplifier-3

Two voltage sources are applied (see after amplifier-5 for description). The B+ supply delivers 340 V and sends 60 mA current through the primary of the OPT, through the 300B, through its cathode resistor of 1k5, back to the B- side of the supply. However, the B- side is NOT grounded, but lifted 60 V above ground by means of the second supply Vn. Consequently, the filament-cathode of the 300B is at (60 + 60mA·1k5) = 150 V above ground. The fet source follower should have its output +90 V above ground, which can be trimmed with Rs1. Under this condition the grid of the 300B is 60 V lower in potential than the filament-cathode. This corresponds with an operating point of Vak=250V and Io=60mA of the 300B. Drifting in time or by changes in Vmains is counteracted by the rather large cathode resistor Rk = 1k5. As you see, the coupling capacitor and protecting zener diodes are not present anymore. Also note that the current capabilities of the B-supply are large (about 120 mA for stereo in this set up), while the very "clean" Vn only has to deliver a few mA.

See next the most important measurement results:

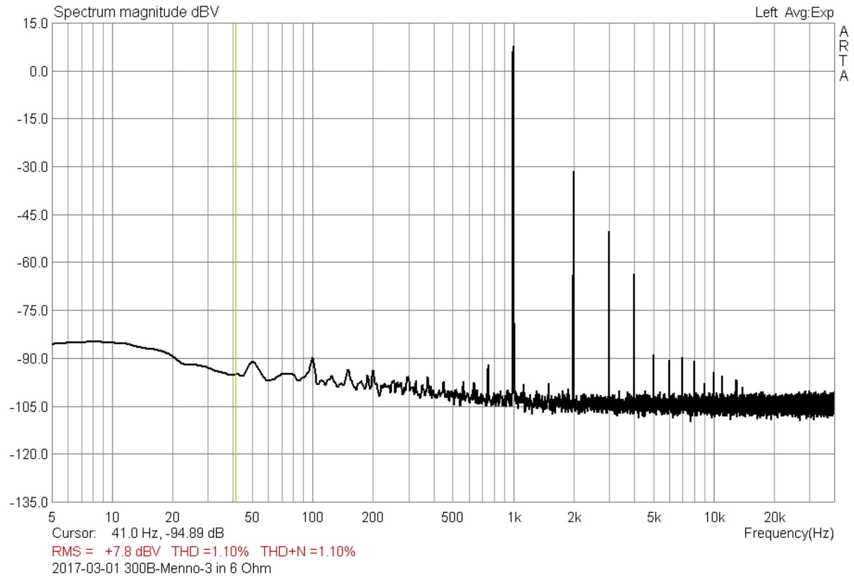


Figure-7: 1kHz harmonic spectrum amp-3

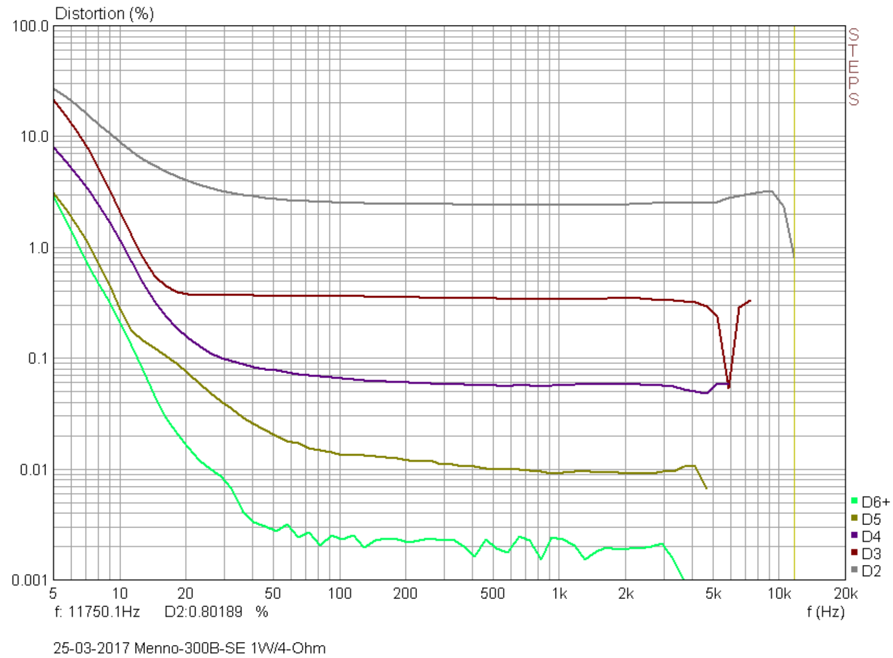


Figure-8: Harmonics at 1 W

In figure-7 the higher harmonics 5,6,7,8 are less suppressed. The harmonic 2,3,4 levels are a little smaller than in amp-1 and -2, but the difference is not very convincing.

How does this amp sound? The sound character is close to amp-2 with the Jensen Copper foil capacitor. Lots of space and depth, but not all details are totally clear, I still observe a curtain (= second harmonic), but lesser than in amp-1. My wife Annemieke said: “the sound character is a little too bright”. See measurement figure-7, which illustrates this observation given the measured level of higher harmonics above 4.

Conclusive: not all is optimal yet, removing C-coupling seems to be a promising route. Let me continue this in amp-4 to improve further.

AMPLIFIER-4: Now you will start to hate me … or … introducing 300B-TRANS

As you might know I have written a book about valve amplifiers with Transconductance. It describes a study where voltage controlled current sources and valves are combined, resulting in a special low impedance drive of the output transformers. See 14-1/2/3 for more details.
My idea was as follows: suppose I change the first fet into a voltage controlled current source. The second fet can stay in place because it is a mandatory source follower to suppress the influence of the gate-capacitance of the 300B. Only one connection needs to be changed. At the first fet the 330 kOhm resistor from drain to B+ shall now be connected to the anode of the 300B. See the next schematic.

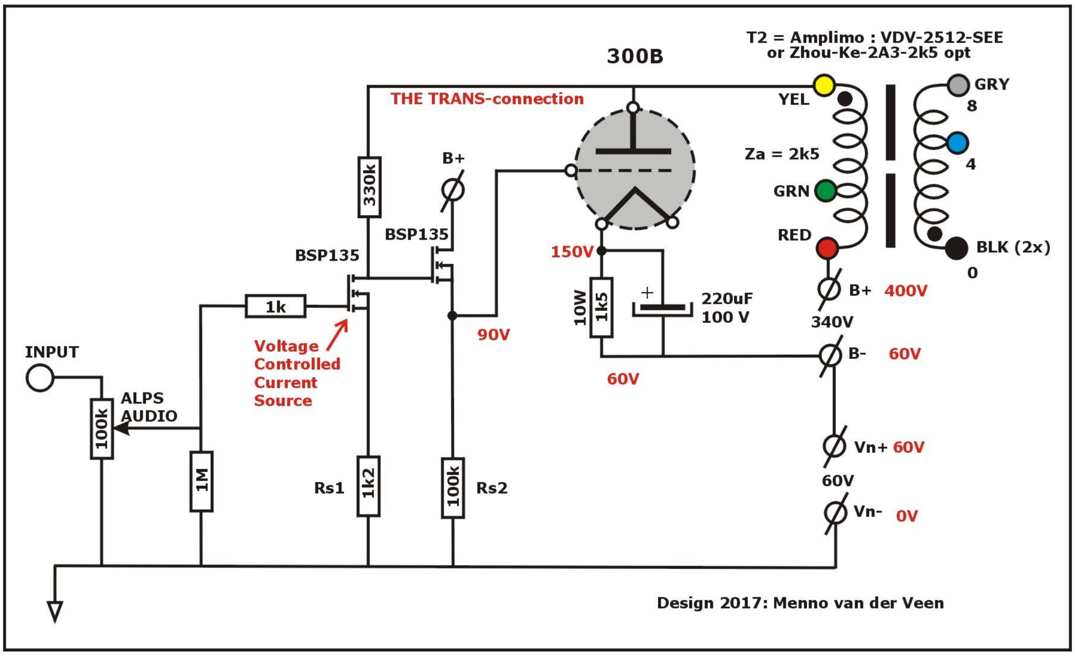


Figure-9: Amplifier-4 with Trans

The more I apply this schematic, the better it pleases me. You can linearize this circuit even further by measuring the AC-music-voltage over Rs1 and compare it with the input signal, by means of a differential opamp circuit. That did produce better measurements but subjectively I noticed no important improvements.

Before studying the measurement results, I would like to pay some attention to the strange title of this chapter. Why should you start to “hate” me when I apply Trans-circuitry on a 300B? Let me be honest. The 300B is a legend, the best creation ever. Now comes Menno, he applies Trans, and this technique creates negative feedback over this famous tube. Has he gone crazy. He will be killing all the specialties of the 300B by applying feedback !

I know, I humbly bend my head. But maybe you allow me some defense. It really was not my goal to feedback the 300B, because Trans works optimal when you NOT use the 300B but a good pentode instead. However, the 300B was already on the chassis and the current source was there, as the source follower. The challenge was irresistible; I couldn’t stop myself from doing this. See the measurement results below:

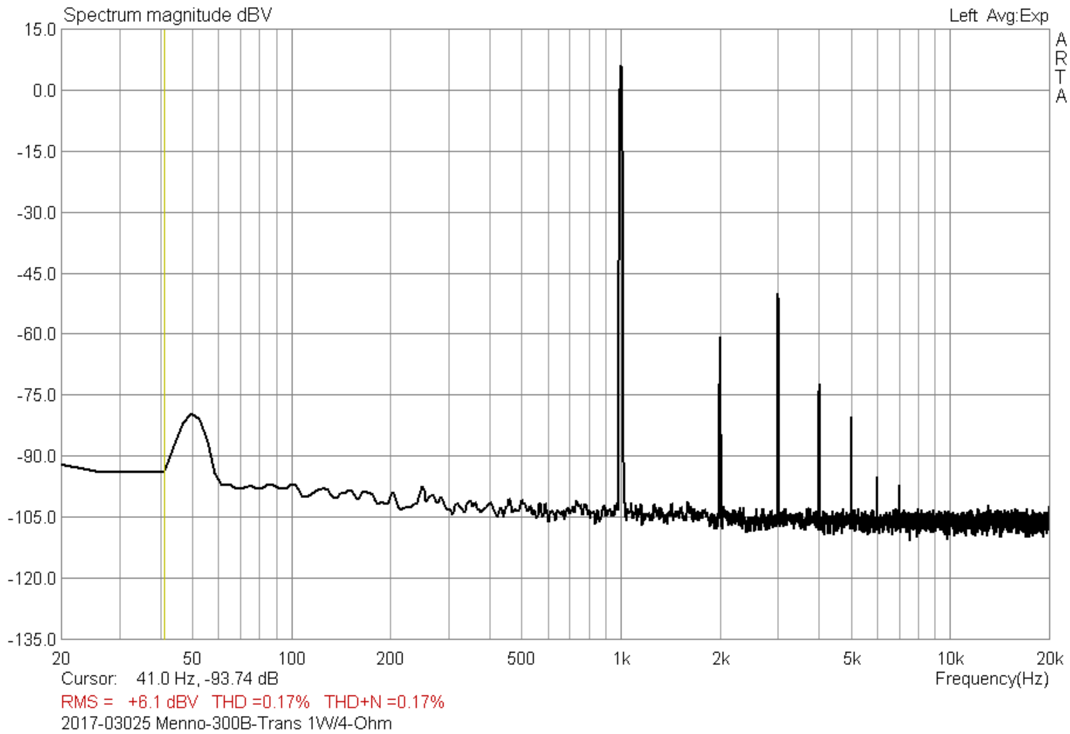


Figure-10: 300B-Trans 1 kHz spectrum

Figure-10 clearly shows that the second harmonic is largely suppressed. Now we don’t see the regular harmonic decline under the masking curve. Understanding this is not difficult: the 300B-Trans is internally fedbacked, creating almost equal distance and slopes of the more vertical gridlines of the Ia-Vak-Vgk characteristics.

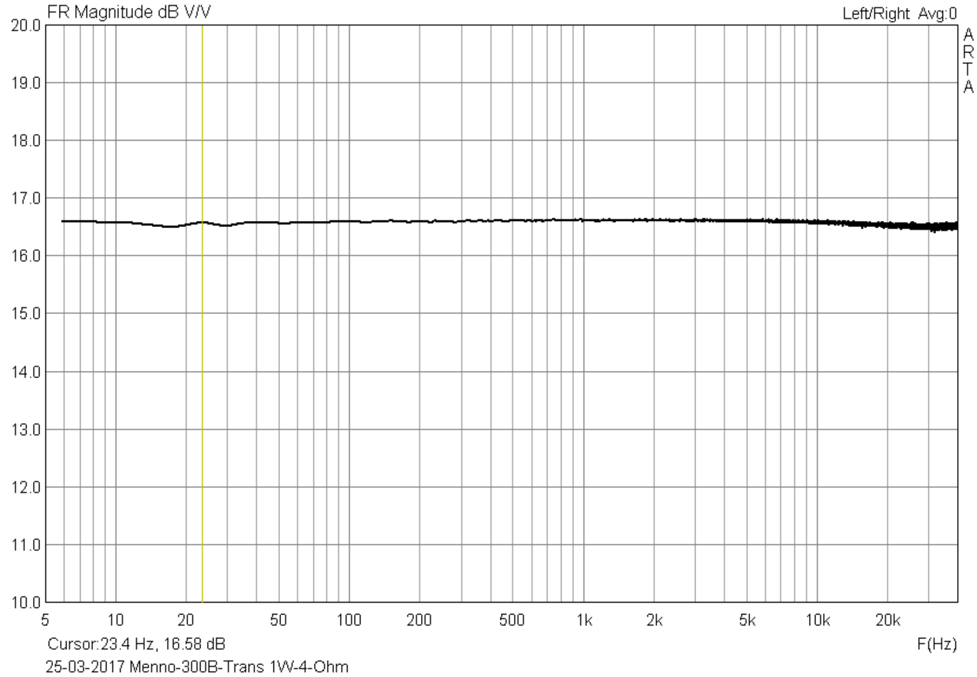


Figure-11: 300-Trans frequency range

Figure-11 shows that the frequency range is almost flat, because of the lower internal effective plate resistance of the 300B-Trans configuration, suppressing the influence of Lp and Cip and Lsp of the OPT.

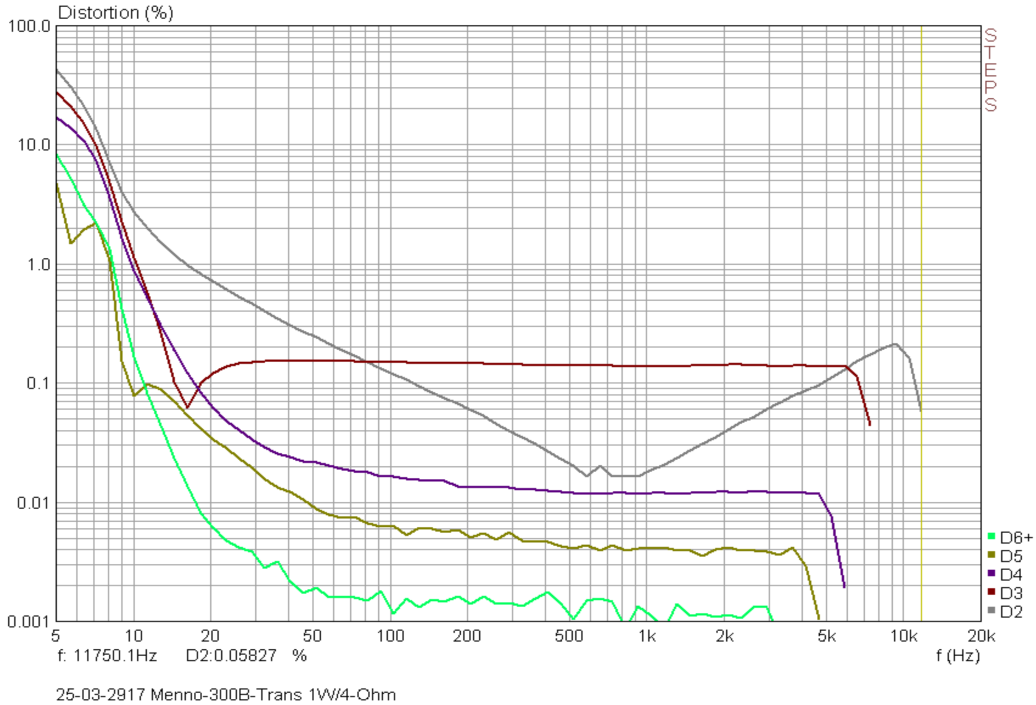


Figure 12: 300B-Trans distortions

Figure-12 shows many interesting items. At very low frequencies (below 20 Hz) the OPT-steel-core distortions are dominant. Going from 20 Hz to 1 kHz, the second harmonic decline is caused by the lesser influence of the primary inductance Lp of the OPT on the effective load line (less oval). Above 1 kHz and higher you see in the second harmonic increasing again because of de decreasing impedance of the effective primary capacitor Cip inside the OPT, making the load line oval again. The third and higher harmonics are smaller than in earlier trials, suppressed to a lesser extent than the second, which can be understood from the famous research by Baxandall (15).

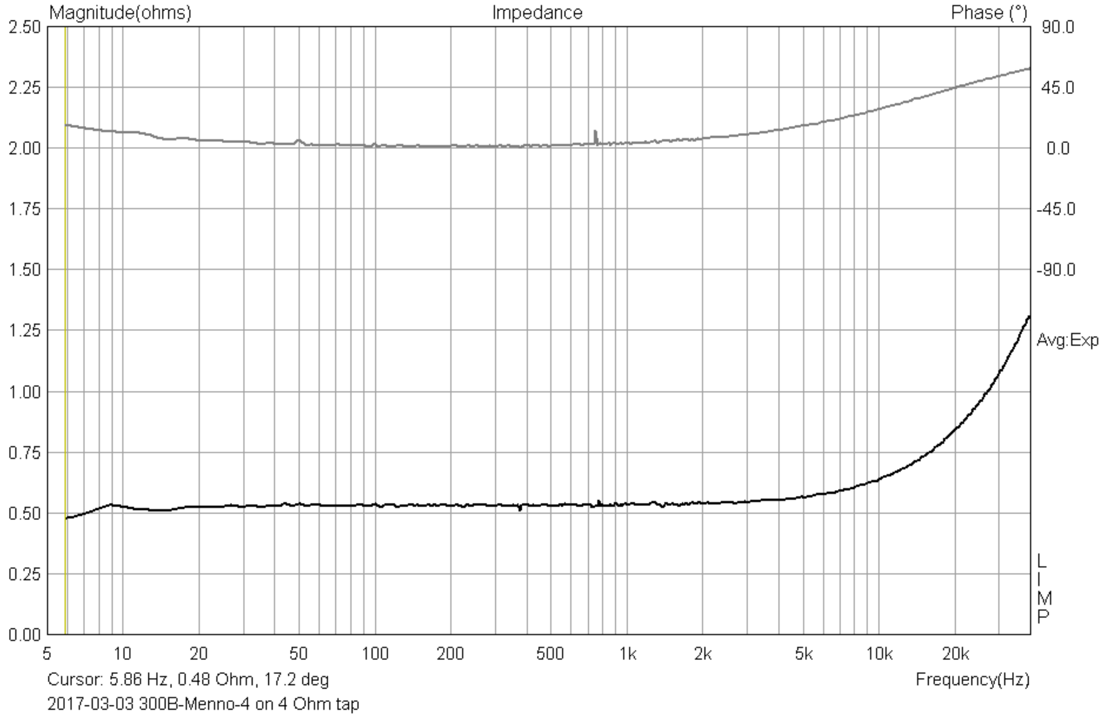


Figure-13: 300B-Trans output impedance (lower curve) at 4 Ohm tap.
Upper curve is the phase of the impedance (right hand scale).

Figure-13 clearly shows the internal Trans-feedback on the 300B. The output impedance is almost (mu – 1) times smaller than in earlier trials. At highest frequencies the influence of the leakage inductance Lsp of the OPT becomes visible (not Cip).

In general: rather drastic changes compared to earlier amps are observed. Fortunately these changes are fully described in 14). The “power” of Trans is large; don’t underestimate this technique because:

1) You can use pentode power tubes with their 50 % efficiency (instead of 25% with triodes)
2) You get better linearity than with triodes (smaller THD)
3) The effective plate resistance (around 300 Ohm) is smaller than with good triodes (around 800 Ohm)
4) Consequently the magnetic distortions in the OPT are at least a factor 2 to 3 less
5) The local Trans feedback is only around the power pentode and does not include the fog and smear creating hysteresis of the core of the OPT.

Subjective observations:
Yep, there we go!!! Lots of details and embracement, depth picture is excellent. None curtain anymore. This is how I like the natural open sound character. Let’s have a bottle of wine and listen for hours into the late night.
I have had this experience before, joy and gratitude and happiness. But usually the next day, with some headache, the pleasure is not that large anymore. Even worse, after three days the amp had been shifted aside and replaced by one of my earlier PP-designs.
However, with this amp-4, my appreciation remained, even grew and friends were invited. In my opinion, I approached the holy grail a little bit.

Till misfortune stroke me. Flash, a spark rain, severe hum, smoke and other bad things. Blown surges, red 300B anodes, broken 300B filament ……. That is the nasty result when you remove safety precautions like the protecting 12 V zener diodes and apply DC-coupling. A burnt amplifier. See 4) for a more detailed description of this nasty event. What should I do next? See amplifier-5.

AMPLIFIER-5: Use a Tube driver, decent 300B operating point

Blown amplifier-4 taught me that DC-coupling can be very nasty, and should not be used at this moment. Back to coupling capacitors. Also, I observed a certain tonal character in the fet-circuitry. The best I could do was to remove these items and to apply high quality driver tubes instead. I did many experiments, mu-stage and the like, but these circuits did not fully satisfy me.

Suppose I use real current sources instead of cathode and anode resistors, would that be the right way to go? See the resulting schematics in figure-14. I also changed the operation point of the 300B. My earlier experiments had shown that the 2A3 setting might be great for the 2A3, but not for the 300B. Now I use Vak = 340 V, Io = 90 mA, Vgk = -70 V and Za = 3k5 primary impedance of the OPT by loading the 4 Ohm secondary tap with an almost 6 Ohm speaker. Remember $Za/Zs = (Np/Ns)^2$.

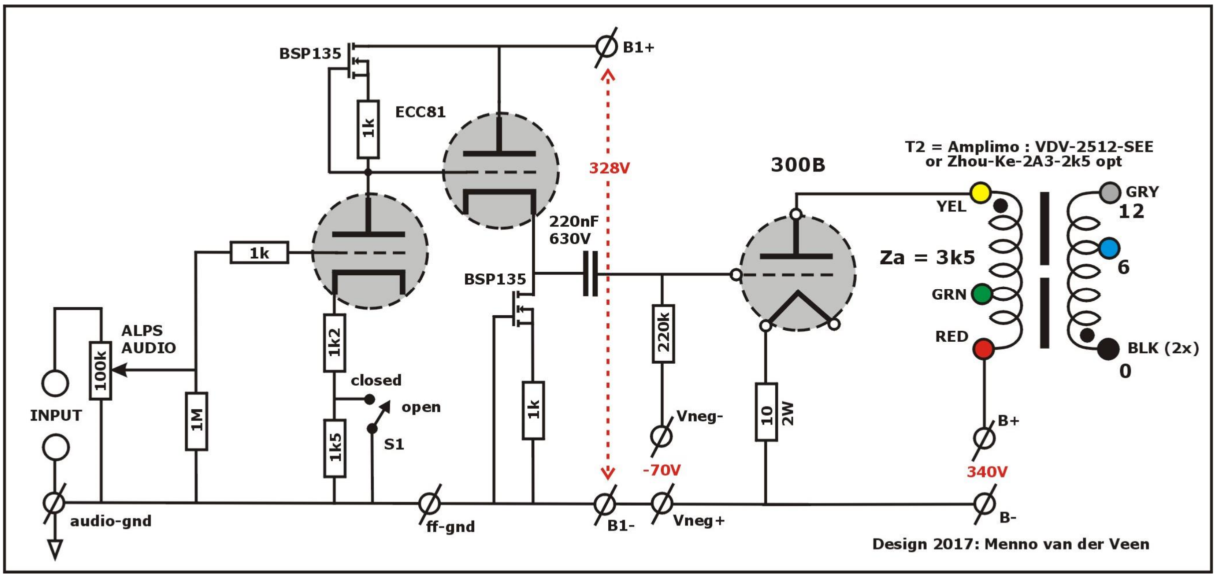


Figure-14: amplifier-5

The current source (1,2 mA) in the first anode creates an almost horizontal load line, thus lowering the distortion of the first amplifier stage. The second tube-section acts as a cathode follower. Its distortions are minimized by the second current source (also 1,2 mA). The operating point (anode voltage) of the first triode can be changed by closing S1. With open S1 the cathode follower output is at 190 V above ground; with closed S1 the output is at 120 V. The circuit is able to drive the 220 kOhm grid resistor of the 300B. I know that 50 kOhm is prescribed for setting the operation point with negative grid voltage. However 50 kOhm would be a too heavy load for this driver section. With my Svetlana 300B the operation point stays stable with Rg = 220 kOhm. To explain the functionality of S1, I will discuss this amp with S1 = open and with S1 = closed.

S1 = open, measured at 1 Watt in 6 Ohm load:

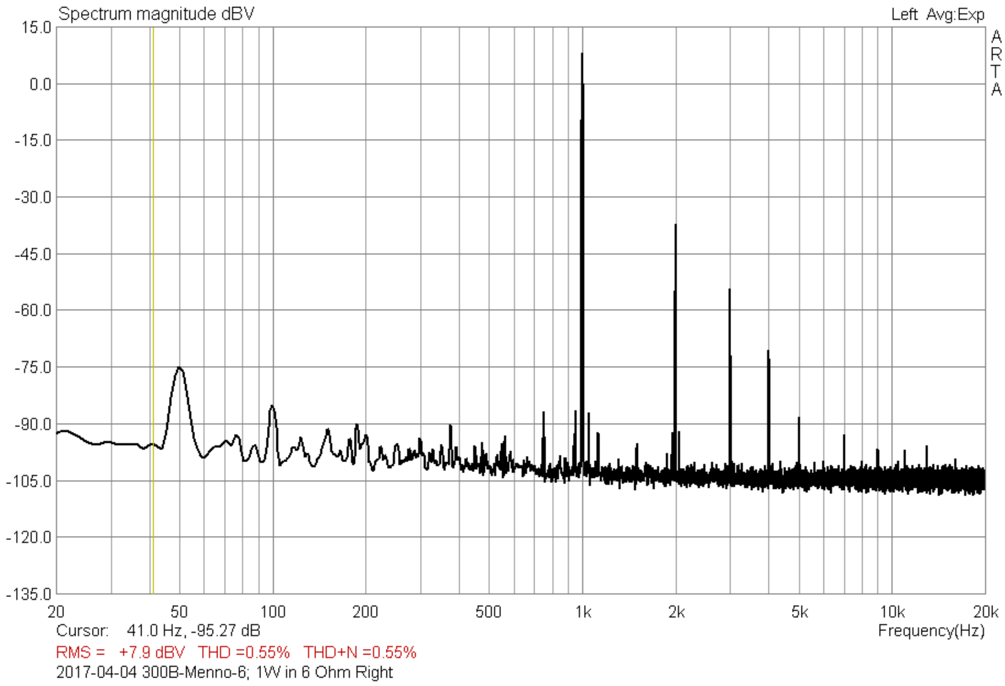


Figure-15: amp-5, S1=open, 1W in 6 Ohm

When you compare figure-15 with measurement figure-7, you see that the THD has gone down by a factor of two. This is caused by the improved driver design and by the improved operating point of the 300B.

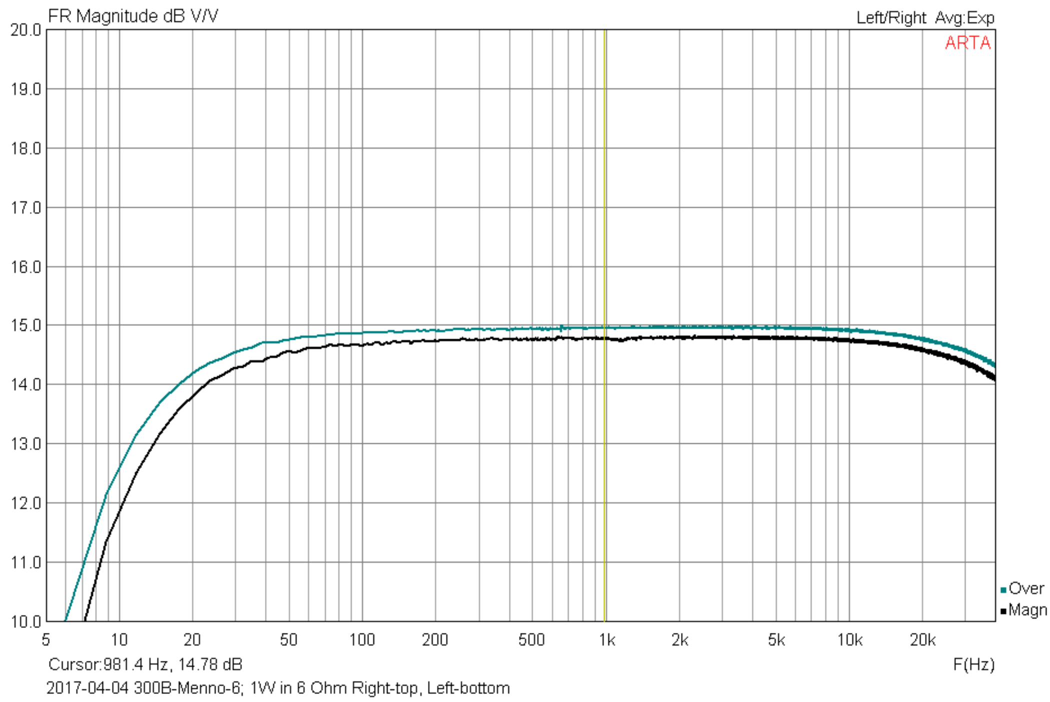


Figure-16: amp-5, S1=open, L and R channels

The frequency range in figure-16 is as wide as before (see figure-3) and gives no reason for concern. However, I should not forget to mention this: also measure f-range at full power, to check if no slew limiting (that happens when dV/dt is too small) occurs in the audio range up to at least 20 kHz. I checked this and there is no reason for concern in amp-5.

The reason why I mention this, is that I noticed with some amps a strange low-mid frequency blur when playing a CD with a nightingale recording. Much loud high frequency information is present there. If dV/dt is too small, the amp can't handle those signals, resulting in the blur mentioned. It took me a while to discover its cause, that's why I share my experience now.

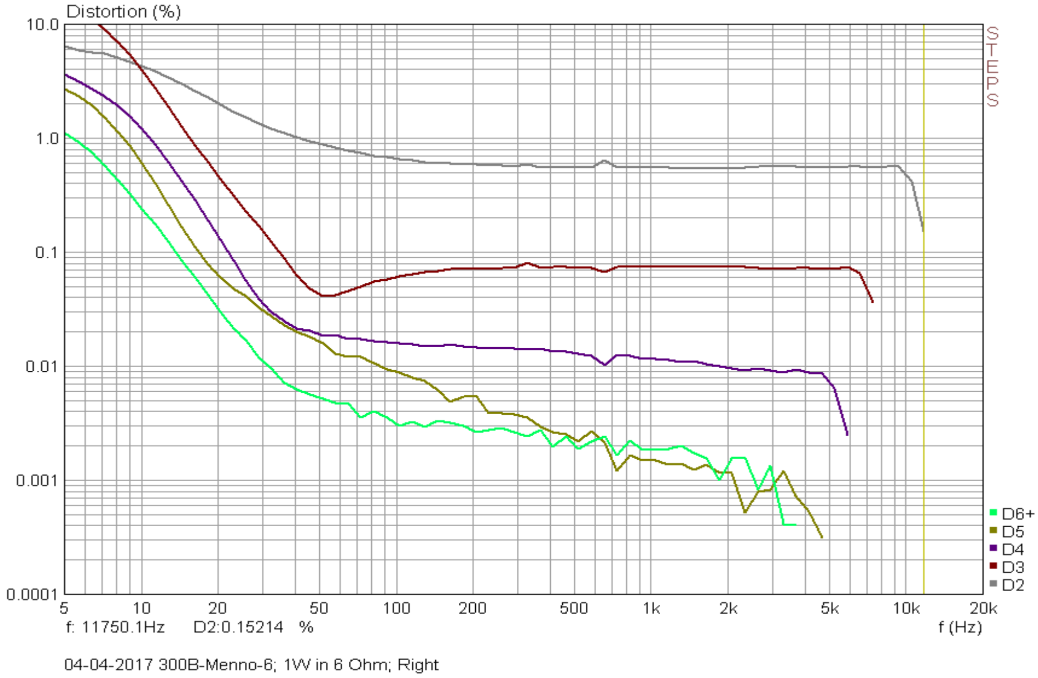


Figure-17: amp-5 distortions at 1W in 6 Ohm

Harmonics as function of frequency are shown in figure-17. Rather standard behavior. We have seen this before.

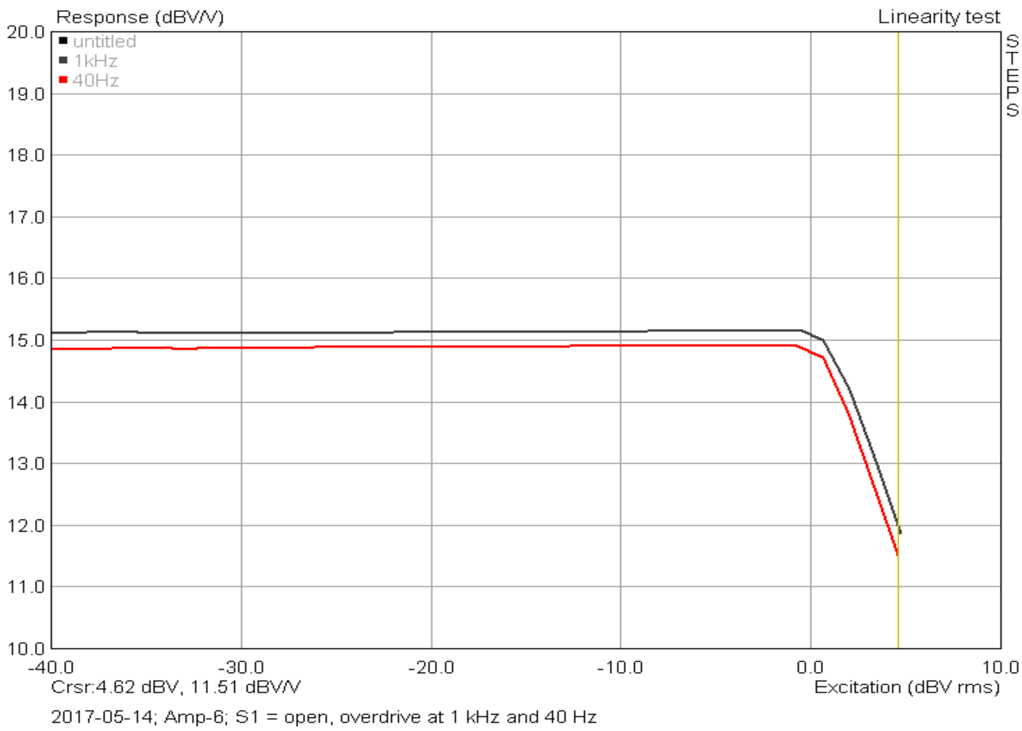


Figure-18: amp-5, linearity at 1 kHz and 40 Hz (red)

Figure-18 shows the linearity (= 20.log[Vout/Vin] as function of Vin, expressed in dBV/V) for 1 kHz and 40 Hz. Overdrive occurs around Vin = 0 dBV (= 1Vrms). The overdrive knee is rather soft (also sounds “soft”), and no core saturation is detected at 40 Hz.

This is a healthy 300B design, 7 Watt output power (at 10% THD) and output impedance of 1,5 Ohm at the 6 Ohm tap. Also a nice decline in harmonics which stay under the 1 kHz masking curve plus a wide enough frequency range.

Subjective comment:
Warm, embracing open sound stage, easy to listen to, but a little curtain caused by the second harmonic. I have heard better, especially with Trans. So, let us now close S1.

S1 = closed, measured at 1 Watt in 6 Ohm load:

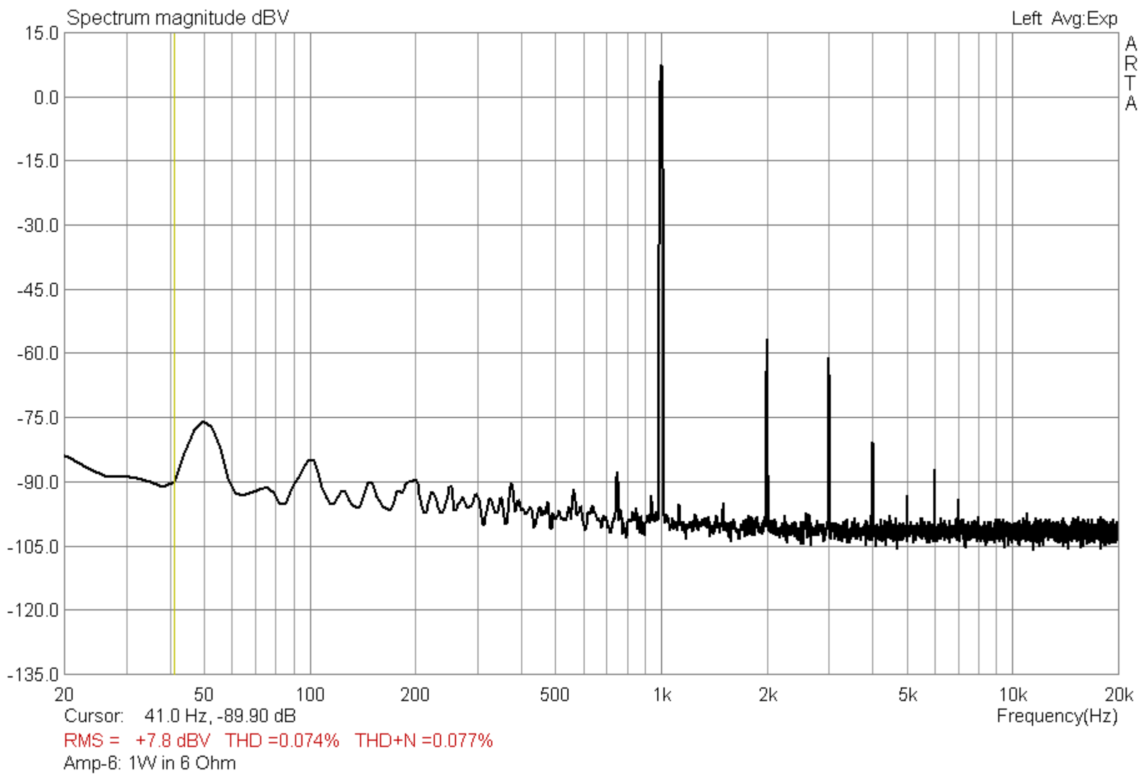


Figure-19: amp-5, S1=closed at 1 W in 6 Ohm

Figure-19 already shows that the harmonics are largely suppressed. With the help of figure-21 I will comment on this in detail.

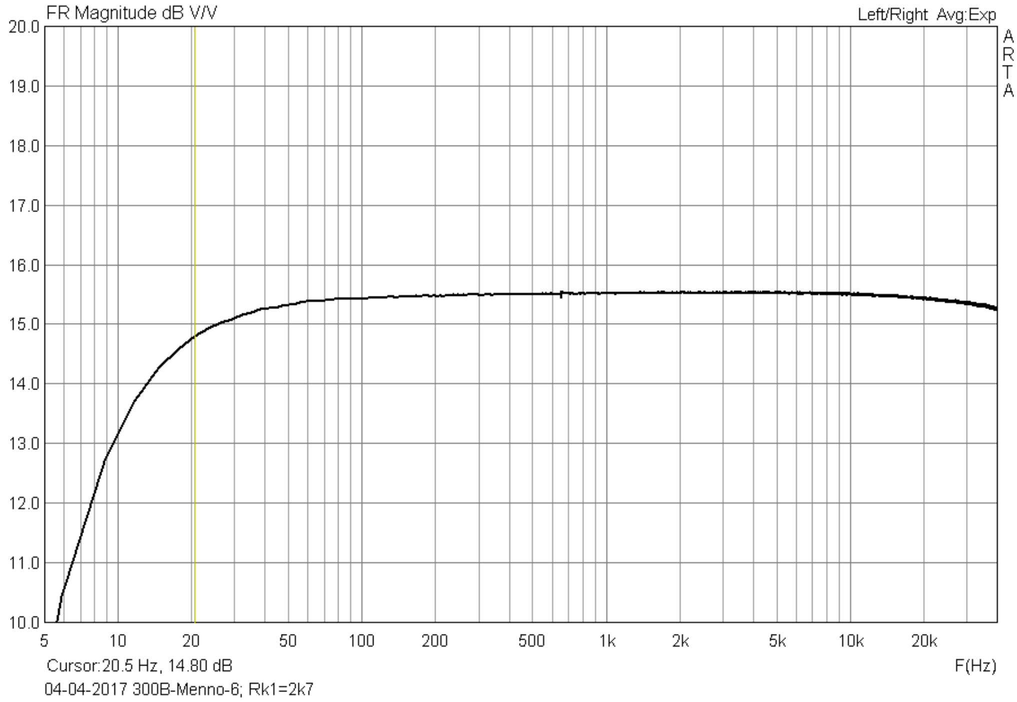


Figure-20: amp-5, f-range

The frequency range and amplification in figure-20 are almost the same as with S2 = open (compare to figure-16). This is as expected because the first triode has a current source at the anode. The amplification is not influenced by how large R-cathode is and almost equal to the mu-factor of the first triode.

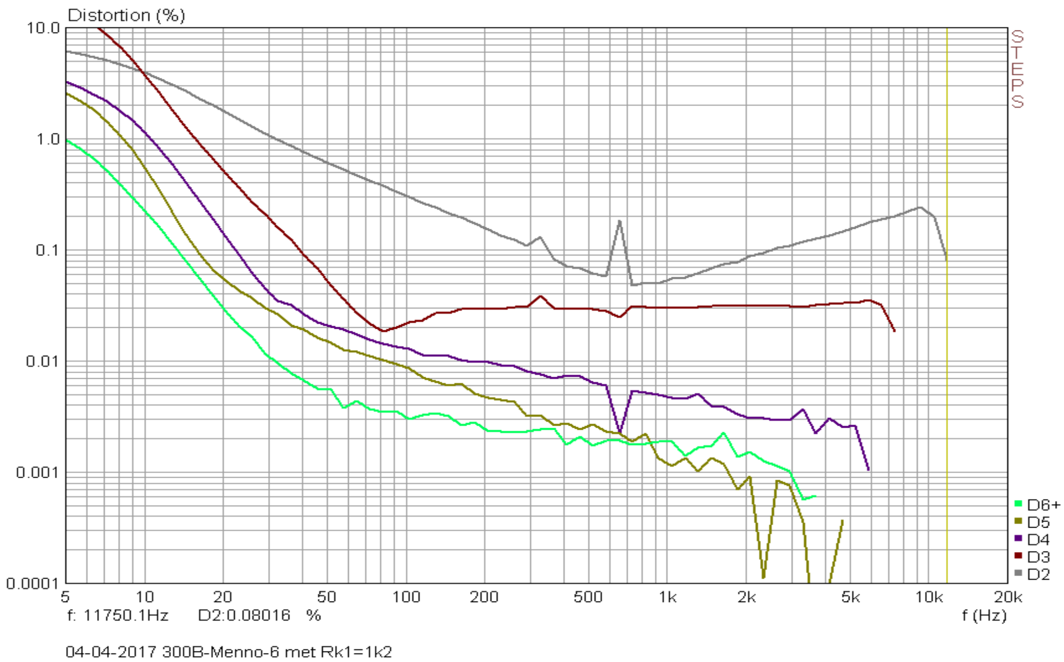


Figure-21: amp-5, distortions at 1W in 6 Ohm

Figure-21 shows in full detail what is happening. The harmonics 2, 3 and 4 are smaller than with S2 = open (compare to figure-17). This behavior is almost equal to what Trans is doing, although we do not apply any negative feedback. What happens is that the driver section pre-distorts in an inverse manner the signal to the grid of the 300B. The driver and 300B distortions together compensate each other, resulting in very small effective total distortion. Again we see below 20 Hz the dominant core distortion. From 20 Hz to 1 kHz we see in the second harmonic the oval load line effect of Lp. Above 1 kHz to 20 kHz we see the oval load line effect of Cip. This is a very effective way to suppress the distortion of the complete amp.

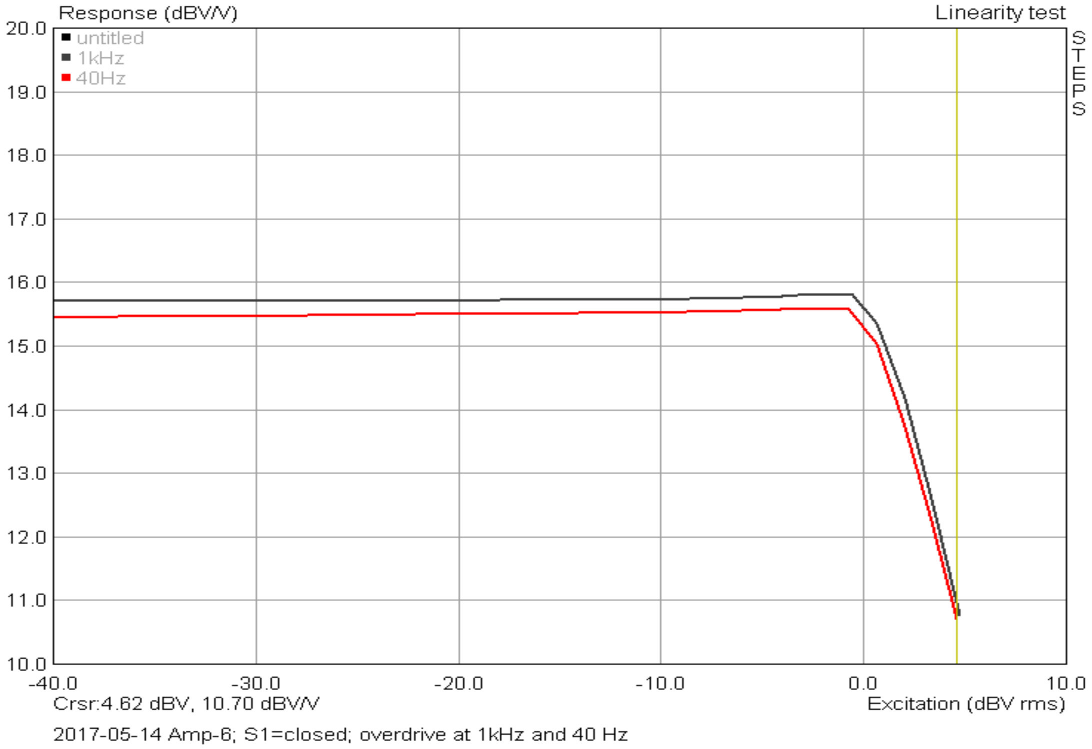


Figure-22: amp-5, linearity at 1 kHz and 40 Hz

Figure-22 shows the linearity; compare to figure-18. Now the overdrive-knee is more abrupt. The tonal character of overdrive sounds “sharper” than with all other amps from this article. In my opinion this is the only disadvantage.

Subjective comment:
Many fine details, no curtain anymore, wide and deep open soundstage, embracing, excellent tonal balance, comparable to all the goodies of the Trans-amp-4. Even after late hours listening into the night and the next days, this character stays convincing. Now, without a burnt amplifier, with classical tube driver section and modern current sources, I am closer to my goal than ever. This soundstage is honest, usable for critical evaluation of a recording up to enjoyable listening with total focus on the music. This design makes me glad and pleases me. For now, my job is done. When time allows, more research later. (All evaluations are with the Jensen-copper-foil coupling capacitor).

CONCLUSIONS

Based on my long experience with push-pull valve amps, plus the findings of this SE research, I would like to draw some conclusions.

1) If your goal is to hear as much details as possible, then the THD of the amp should be lowest as possible. You can apply massive negative feedback (Bruno Putzeys route), or local feedback (as in Trans-amp-4) or pre-distortion compensation (as in amp 5 with S1 = closed). My personal experience with push pull amps is: do not apply moderate negative feedback from the secondary winding of the OPT. The character of the magnetic distortions in the OPT-core, combined with NFB, creates a fog and a dead sounding amp.

2) If you wish the music to embrace you, then THD may be present, especially the second harmonic, but details get lost. Also see conclusion 7).

3) Coupling capacitor brand and construction are of the utmost importance to hear the embracing and details in a non-feedback design. Exactly the same can be said about the quality of resistors and OPT-core material. In this research I did not proof it by own measurements. In the literature there is abundant highest quality proof available (see for instance 16) and 17)) to show low level defects, caused by components. The ear can detect them.

4) Combining 1) and 2) and 3): designing a fine amp (“fine” is a subjective property) is an art.

5) The general understanding is that (in SE-amplifiers) local feedback or pre-distortion weakens the second harmonic and hardly the third. This research has proven that the third can be attenuated as well, although not as much as the second. Baxandall’s research (15) shows the harmonics above 2 to rise in level with the amount of feedback. However, that was measured on a jfet. In tube circuitry apparently things are a little different. It is not the first time that I notice the third and higher harmonics to decline directly with the amount of negative feedback.

6) There is a general understanding that the harmonics in a fine amp should decline regularly with their number. They all should stay under the masking curve of a continues tone. My research does not support that rule. Lowering the second harmonic (as in amps 4 and 5) below the level of the third improves the hearing of details without effecting the embracing character of the sound. I surely agree that higher harmonics (above the third) should decline regularly. I consider the second harmonic as a “curtain” creator.

7) More and more I give my amplifiers a damping factor below 10. Higher values by means of current feedback or overall negative feedback, tend to give the amp a “dead” character. Then the sound stays close to the speakers and does not vibrate everywhere in the listening room.

8) Testing your amp at 1 Watt level and below is a sensible thing to do. But please don’t forget to measure the power bandwidth up to the highest frequencies to detect presence of slew rate limiting induced distortion. Full power bandwidth up to 20 kHz stays mandatory.

APPENDIX: POWER SUPPLIES

B+ and B1+ supplies:

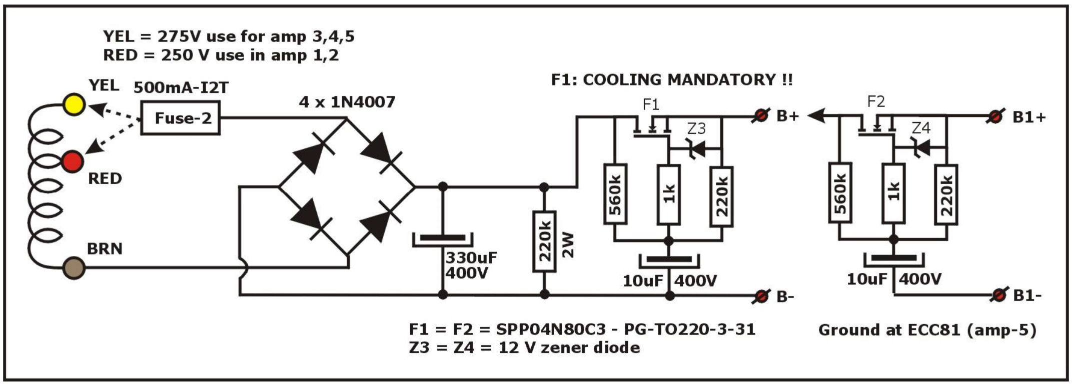


Figure-23: High voltage supplies B and B1 for amp-5

The high voltage winding (250 or 275 V) is rectified, buffered by 330 uF/400V and fed into the special TO220-isolated power fet SPP04N80C3. The capacitor at the gate of 10 uF/400V is slowly loaded by the drain-resistor of 560 kOhm. This creates a very slow start-up of the high voltage B+. The first fet after rectification should be cooled on the chassis. It dissipates a maximum heat of 2 x 90 mA times 12 V between drain and source. The heat equals 2,2 Watt which asks for the extra cooling. The B1+ supply repeats the circuit of the first fet, but dissipates almost no heat: some mA times 12 V is 0,1 Watt; no cooling mandatory. The output impedance of both fet-circuits is 2,5 Ohm at frequencies above 20 Hz. Therefore no further electrolytic caps between B+ and B- are needed. The ripple voltage at the B+ output is smaller than 1 mVrms.

300B-5V Filament supply:

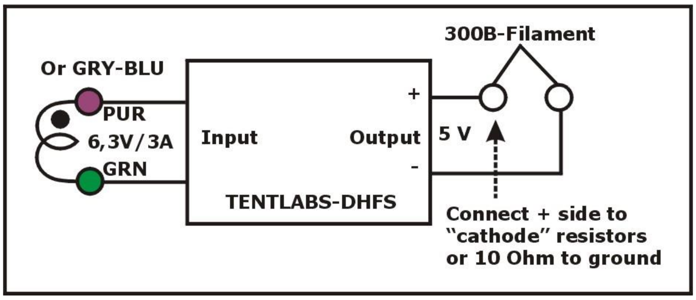


Figure-24: 300B-5V-filament supply (2 times)

On the power transformer are two 6,3V secondary windings. Per 300B, a winding is used and fed into a Tentlabs Direct Heated Filament Supply (see 10)). The output is trimmed for 5,00 V and connected to the 300B filament. "Ground" the + side of the output, meaning that the + side should be connected to the cathode resistors or to the 10 Ohm grounding-resistor, as indicated in the amp-schematics. The TDHFS is dead-silent, acts as a current source, preventing audio currents to enter the supply circuit. I am impressed by its silence and resulting clear sound.
Remember: each 300B has its own 6,3 V secondary winding and its own TDHFS. There are no interconnections between the two independent 300B-filament circuits.

ECC81-ff-supply:

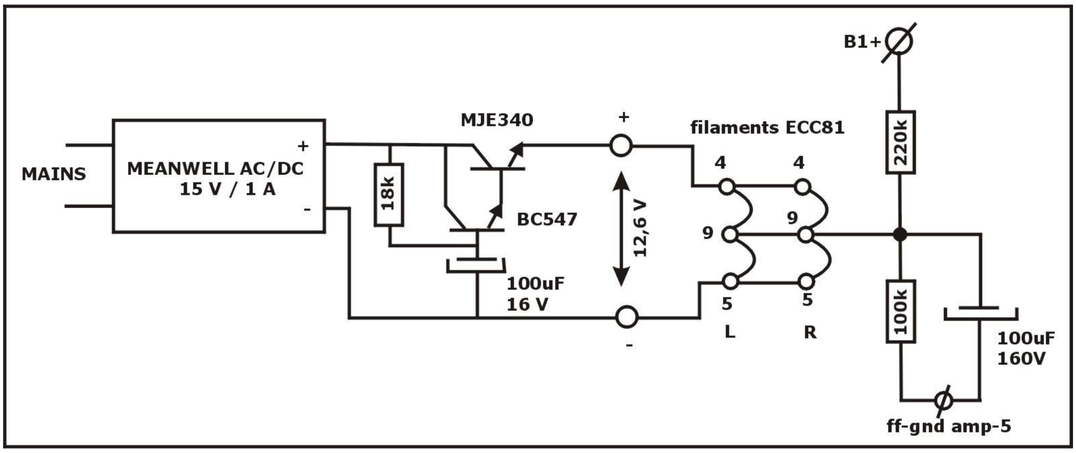


Figure-25: ECC81-ff-supply

The filament of the two ECC81 tubes in amp-5 can NOT be connected to the existing 6,3 V windings, because these winding are only meant for the 300B and should stay completely free of any other connection or use. Therefore I applied a Meanwell AC/DC converter which converts 230V mains into a DC-voltage of 15 V. Its output got a slow start circuit (no flash-on in filaments) around MJE340 plus BC547. Some cooling is necessary for the MJE340 because the total heat is 0,6 A times (15-12,6) V = 1,44 Watt. The filament output is lifted to B1+/3 Volt to prevent too large voltages between filaments and cathodes. this circuit also is extremely silent and no influence on the amplifiers output is detected.

Vn and Vneg supplies:

In amplifiers 3 and 4 the extra clean voltage Vn is applied to lift the B+ supply 60 V above ground. See the schematic of the Vn-supply below. The 50 V winding on the power transformer is used.

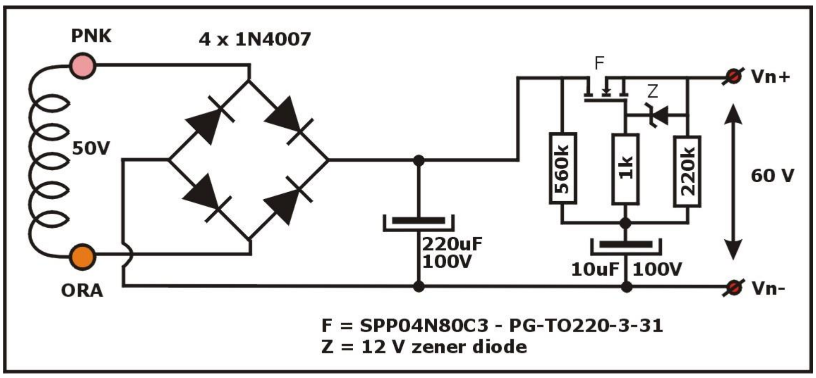


Figure-26: Vn = 60 V supply

In amplifier 5 a simpler version of Vn is applied, called Vneg. See figure-27. Negligible current is asked from this supply. That is why this circuit is very simple. Never try to improve this circuit by means of zener diode clamping or DC-stabilization. If mains voltage rises, so will B+ and so will Vn, thus compensating drift of the operation point through changes in V-mains.

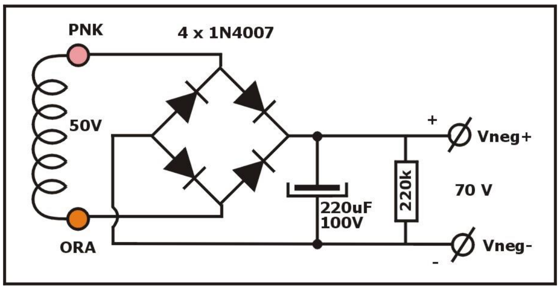


Figure-27: Vneg = -70 V supply

Also note that in the Vn and Vneg supplies no surges have been used. These two supplies always should function, otherwise the 2A3 or 300B valves will certainly see their life shortened because their anode currents will surpass their maximum limits due to the possible absence of Vn or Vneg.

ON-OFF-mains and chassis- and audio-grounding:

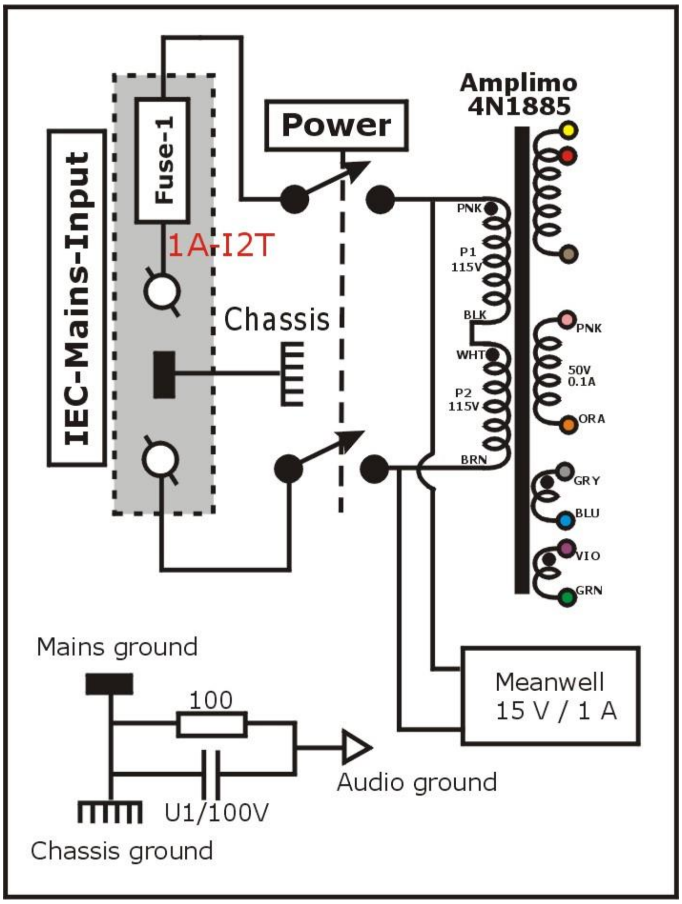


Figure-28: Primary mains connections and grounding

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