You Can DIY!

Build an 18 W Single-Ended Valve Amplifier with Trans Technology

This article shows an easy to build 18 W single-ended valve amplifier using Trans-technology with pentodes, current sources, and toroidal transformers (see **Photo 1**). The amplifier was created by the author to support his TubeSociety students in the Netherlands.

Photo 1: This is the top view of the Vanderveen Trans-SE18 amplifier.

By
Menno van der Veen
(The Netherlands)

Years ago I rediscovered a special technology, called "Transconductance," first published around 1940. I wrote a book[1] and *audioXpress* articles[2],[3] about it, where I explained the technology, which I termed "Trans." Please refer to the publications listed in Resources to learn what Trans implies in more detail.

For now: Trans is local feedback only around the output power tube. Preferably this tube is a pentode. Trans converts the tube into a new Trans-tube with little harmonic distortion and low plate resistance, which minimizes transient distortions inside the output transformer. Consequently the Trans-tube and OPT marriage distorts minimally. An extra bonus is the conservation of pentode output power, which is twice the power of a triode.

About 12 years ago, I started my TubeSociety academy where I try to teach my TubeSociety students to become the best designers and constructors of tube amplifiers. For the TubeSociety students' 2018 project, I shared the design steps of the Trans-SE18 (see **Photo 2**). The design project can also be found on my website (www.mennovanderveen.nl) where I shared information with my students about their TS2018-project.[4]

To apply Trans, a new voltage controlled current source (VCCS) is introduced, called the "Menno-cell." An extra Menno-cell is used to linearize this VCCS. Inside the Menno-cell there are some field-effect transducers (FETs), which perform the current source function and linearization. For those who dislike semiconductors inside tube amps, please study my all-tube kit, Trans-SE10.[5] In this article, I continue with the Menno-cell solution.

The Audio Section

Figure 1 shows the schematic of the SE18 design. On the left, you will find the inputs, their selector, and a volume control. In the middle, you will find two Menno-cells. The first cell-1 functions as a preamplifier and linearizes cell-2. The combination of cell-1 and cell-2 makes this second cell an ideal VCCS with negligible distortion. The current output of cell-2 drives the power tube. The resistor R** (220 kΩ) creates the essential local Trans-feedback.

The diode D1 prevents the voltage between control-grid and cathode to become positive and protects the power tube at start-up.

The 22 turns trimpot P1 sets the quiescent current through the power tube at 115 mA. You can measure this with a DC voltmeter over R11. Its reading should be 115 mV. The trimming of P1 is a little sensitive; you might have to repeat it several times. Take notice of the "cw" indication in the schematics. Turning P1 to "cw" means more quiescent current.

Photo 2: Menno van der Veen addresses his students during one of the bi-weekly meetings of his TubeSociety school in the Netherlands.

The Power Supplies

Figure 2 shows the power supply section of the stereo amplifier. The special power transformer can be ordered from my website. The application of two power supplies—Vn = 120 V and B = 360 V—is essential. The power tube only uses the 360 V supply. A quiescent current of 115 mA flows per channel. For stereo, the total current is 230 mA.

The complete power tube section is lifted 120 V above ground with the Vn supply. Normally, this lifting is done with a cathode resistor plus a paralleled capacitor. However, to create 120 V with 115 mA current requires a resistor of about 1 kΩ with a heat dissipation of 14 W (28 W in stereo). That is a lot of heat! A simple Vn supply does this task much better with negligible heat production.

The two Menno-cells use about 5 mA supply-current per channel. So, 10 mA for the complete stereo amplifier. This small current is delivered by the Vn supply. I applied a very effective voltage doubler circuit[6], not often seen in the audio amplifier literature.

The circuits with Fp1 and Fp2 are not voltage stabilizers, but rather floating active buffers that react slowly on variations of load or mains. They have a residual ripple voltage below 1 mVrms and an output impedance of approximately 1.5 Ω. If you try to get such good specs with tubes, you will need a very complex tube circuit. Every time I apply my version of these super-C-source-followers, I am amazed by their excellent qualities. Don't forget to place Fp1 directly on the chassis for cooling, because it generates approximately 2.8 W of heat. Solder R23 as close as possible to the Fp1 gate to prevent oscillation. The same for R26 and the gate of Fp2.

The audio section also needs 200 V and 300 V supplies. These last two voltages are created with the Zener diodes Z1 and Z2. Because they power the input and VCCS sections, extra low ripple is essential. The Zeners also function as constant load supplies, which sounds superior in preamp sections.

An extra remark about grounding: The mains-ground is directly connected to the chassis for optimal

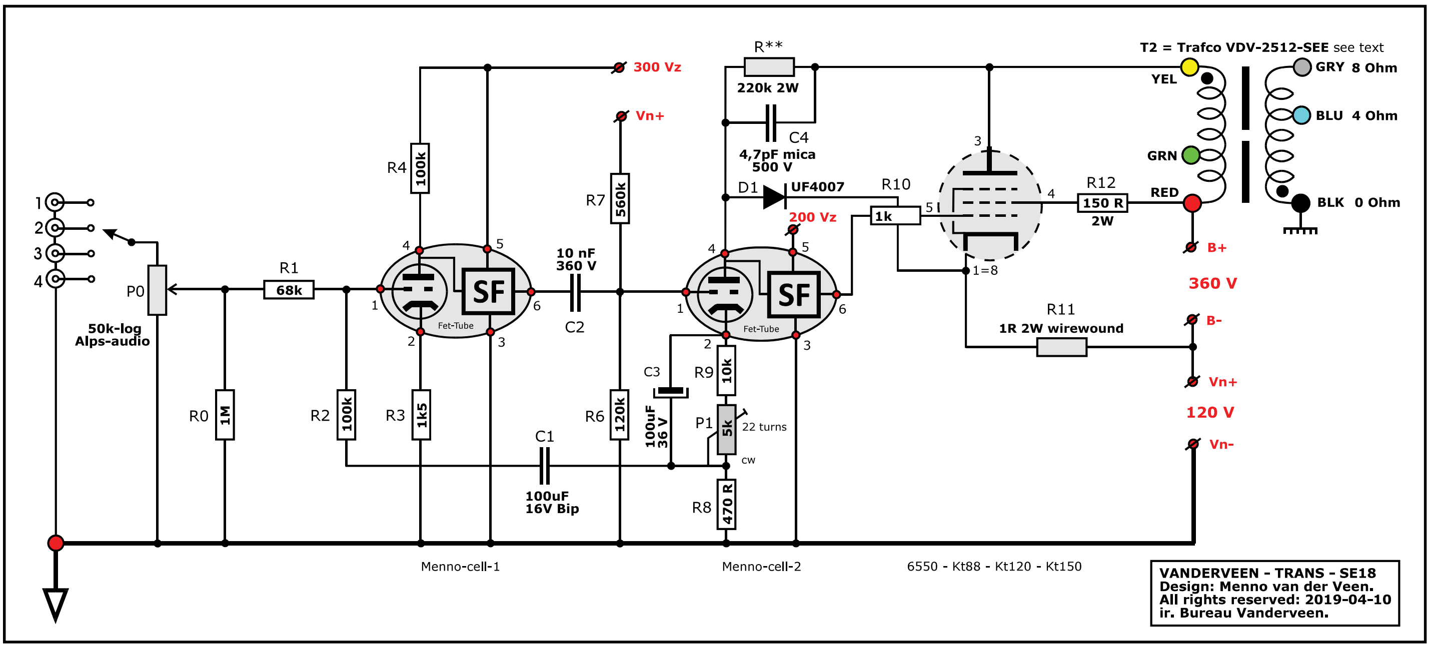

Figure 1: This is the schematic of the audio section of the Vanderveen-Trans-SE18.

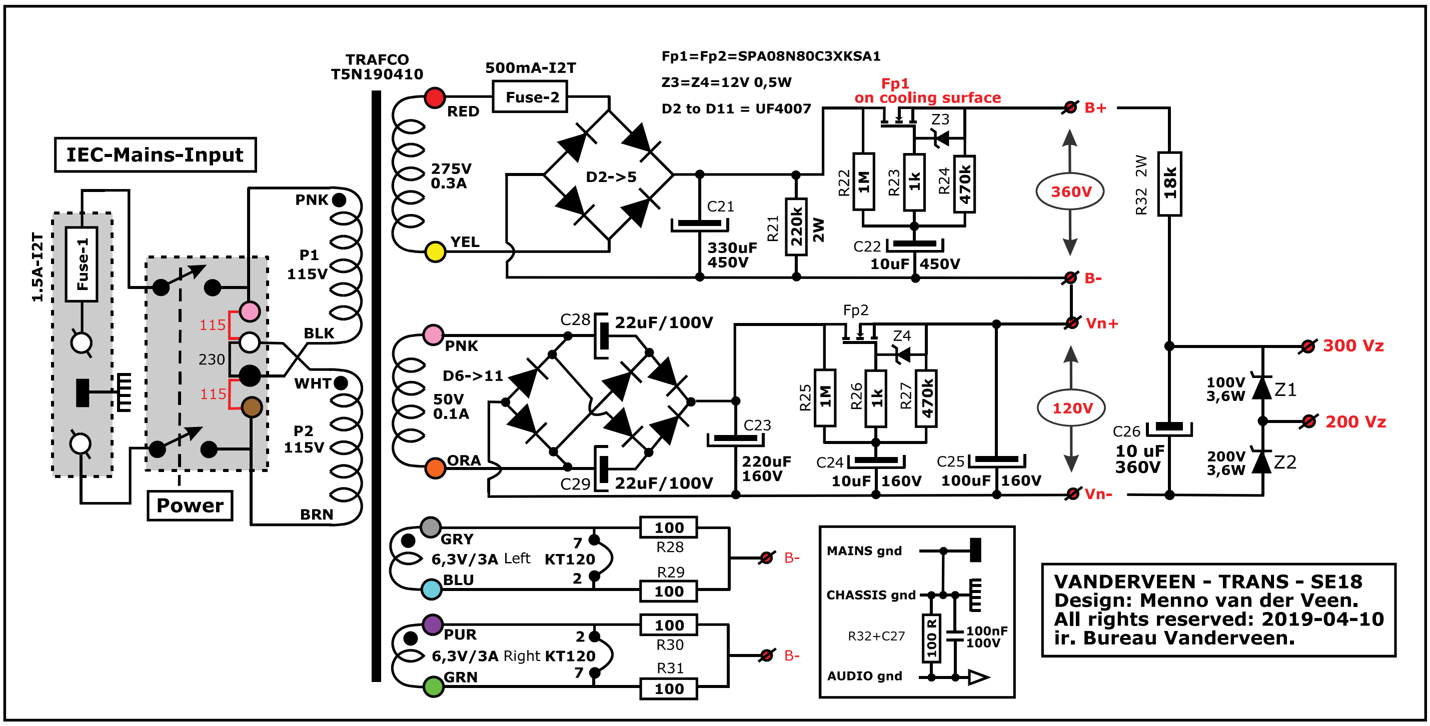

Figure 2: Here is the schematic for the stereo power supply section.

safety. The audio-ground goes to the chassis through R32//C27. This circuitry prevents grounding hum between mains-grounded equipment. Be aware that no connection is made between audio-ground and the chassis at any other spot inside the amplifier. There is only one place for R32//C27: closest to the input sockets!

The Menno-Cell and the Transformers

Figure 3 shows the schematic of the Menno-Cell. The circuit has three FETs (BSP135). The first FET F1 is an amplifier with very large output impedance (almost an ideal current source); F2 is a source follower; and F3 is a current source that linearizes F2. The resistors R1 and R2 at the gates prevent oscillation, while the Zener diodes protect at start-up. The resistor R3 sets the F3 current source at approximately 1.2 mA. My

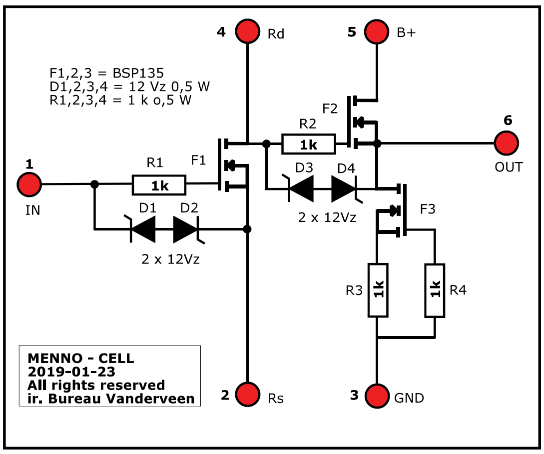

Figure 3: Schematics of the Menno-cell

student Erwin Reins designed a clever PCB shown in **Figure 4**, which is available for free Gerbers download from my website.[4]

There are two toroidal output transformers for this Trans-SE18 amp. The 2512-SEE has a maximum power of 12 W at 22 Hz. It easily can handle the power of the amplifier, but not at the lowest bass frequencies. I can measure such bass saturation, but in practice I don't hear it. The other OPT is the 3025-SE, which can handle 17 W at 22 Hz. See my website[7] for both specifications. The best of both is the 3025-SE, with biggest core (and price).

The Construction

If you look at Photo 1, you can see the power transformer is in the middle. The transformers are protected with black Mylar. I spray painted the mounting discs. The left front switch is power and the right one is free for any application. I gave it a function of 10 dB gain-reduction by switching 150 kΩ in series with R1. Such a function is handy when there is a phone call or for non-disturbing listening. The case was also designed by Reins and its dimensions are 35 cm × 29.5 cm × 8 cm.

The volume knob has a built-in two color LED, connected to a small circuit that measures the left and right cathode currents (measured over R11). When the current is below 60 mA per power tube, the LED glows red. This indicates that mains power is ON. When both quiescent currents are above 60 mA, the LED switches to yellow. This indicates that the amplifier is (almost) ready for listening. I leave the decision of this quiescent current sensor circuit up to you. It is based on a TL072, operating as a comparator. Its supply voltages are taken from a 6.3 VAC filament winding, with rectifying (2 × 1N4007) and buffering (2 × 100 µF/16 V), delivering +8 VDC and -8 VDC to feed the op-amp and the bicolor LED. **Photo 3** (on the right side) shows the realization of this circuit. The inside view of the amp (Photo 3) shows the strip at the bottom, which is the power supply section. Enlarge, and you will find all the details.

In my test amplifier, I did not apply an input selector plus four inputs. One stereo input was enough for all the measurements and listening tests.

I placed the two Menno-cells close to the power tube socket. Please use the shortest connections between the power tube and these cells. If you don't do that, nasty oscillation can occur, resulting in unpredictable quiescent currents.

To measure possible oscillation: connect a 10 MHz (or better) oscilloscope to the output terminals. If you measure 50 mV high-frequency signals, then your amp is heavily oscillating. You can cure it by means of shortest and smartest layout of the interconnections. Enlarge Photo 3 to see how I did it.

For the First Start-Up

So, you've built your version of the Trans-SE18 and checked everything at least a hundred times. So, let's switch on the mains and start enjoying music or producing nasty smoke. Allow me to make some helpful remarks for your first time switch-on.

- Check that P1 is turned to minimum resistance (turned counter-cw)
- Measure the power supply voltages Vn and B without the power tube; see **Figure 5**.
- Measure the voltage at the tube socket point 5. It should be less than 70 VDC, see Figure 5.
- Plug in the power tube, switch-on mains while measuring the voltage over R11 (= 1 Ω). It should read almost zero
- Slowly turn P1 clockwise until the voltage over R11 rises and bring it to 60 mVDC
- Do the same procedure for the other channel
- Now continue to turn P1 clockwise to bring the voltage over R11 to 115 mVDC; do the same for the other channel
- If all of this does not function, you probably have oscillation. Check the layout of wires and change.
- If all functions, check the voltages indicated in Figure 5. Your readings should be close to the given data. The correct reading of 115 mV over R11 is essential.
- Now it is time to enjoy the music.

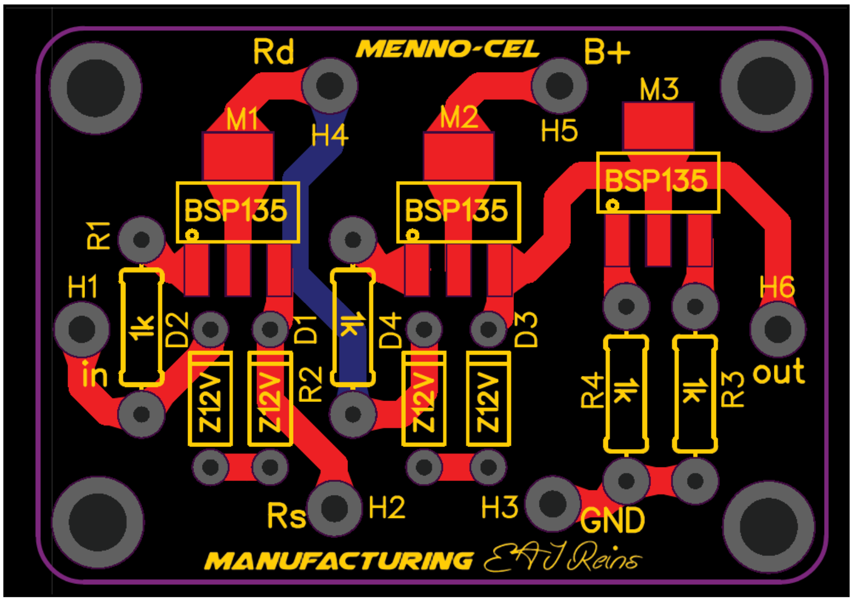

Figure 4: Erwin Reins designed a clever PCB, which is available for a free Gerbers download from my website.

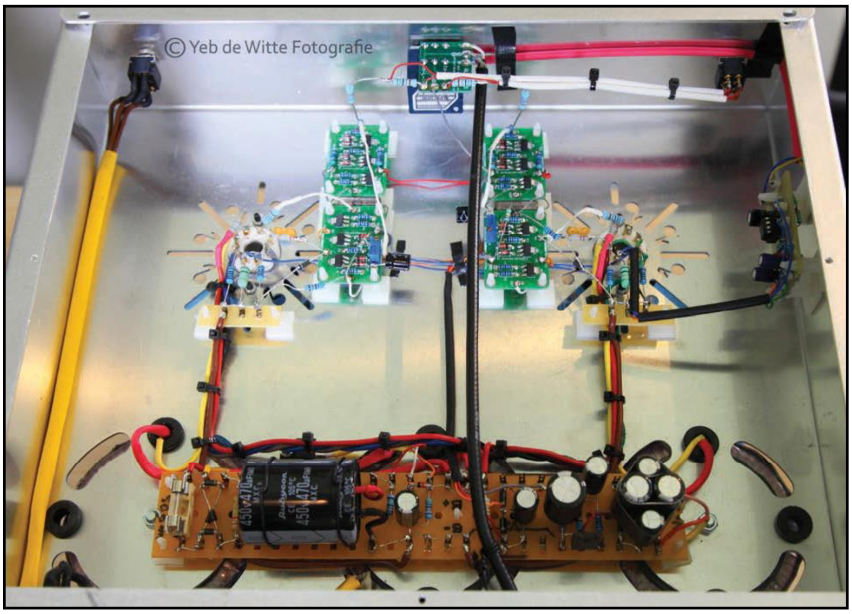

Photo 3: The interior view of the Vanderveen Trans-SE18 amplifier is shown here.

About the Author

Menno van der Veen studied engineering physics at the university. He taught physics at an upper secondary school and teacher trainings college. At the age of 40, he founded his engineering firm, which focues on tube amplifiers and toroidal output transformers. He wrote many articles and books about these subjects. About 12 years ago, he also founded his TubeSociety academy. Tube-amps and toroidal transformer research, consultancy, design, teaching, and playing the guitar are the main activities of his present work.

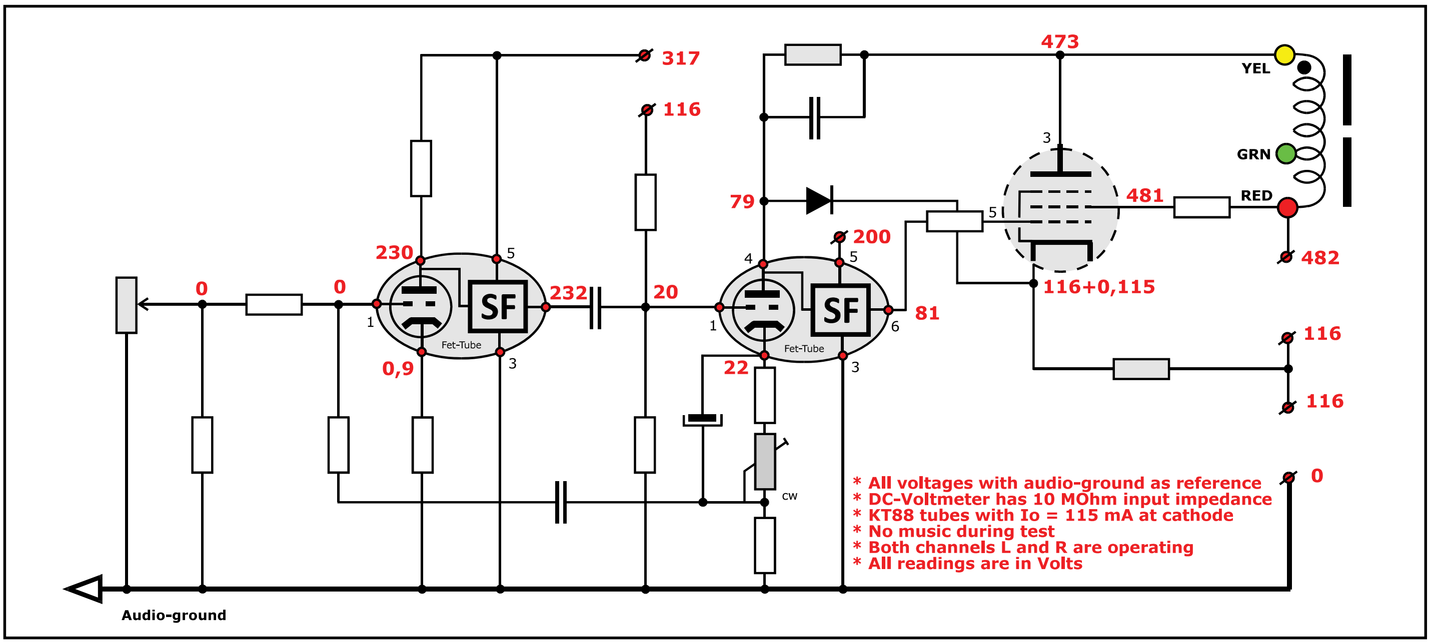

Figure 5: Your voltages should correspond to all the voltages shown here inside the amplifier.

I measured important DC voltages inside the amplifier, enabling you to check correct operation. See Figure 5. All measurements are with a digital voltmeter with audio-ground as reference.

After switching ON, the amplifier takes about 20 seconds to heat up. If you would listen to music during start-up, you clearly will notice that the amp moves towards its optimal operating point.

Measurements

Figure 6 shows the frequency characteristic from 5 Hz to 40 kHz. The -3 dB frequencies are at 7 Hz and 43 kHz, without any higher resonances.

Figure 7 shows the harmonic distortions. From 20 Hz to 1 kHz, you see a clear decline in distortion of all harmonics. However, the third (H3) and higher harmonics decline more than the second (H2) harmonic. See my book for more explanation about this typical Trans-effect, which mainly is caused by local Trans-feedback in combination with the primary inductance Lp of the OPT.

Above 1 kHz, H2 inclines again a little. The Trans-corrected power tube starts to interact with the interwinding capacitance Cip of the OPT. Around 1 kHz, we get the lowest total harmonic distortion (THD) of 0.04 %, where H2 is not dominant. Especially this last result removes the "curtain" before the soundstage, as explained and discussed in my previous *audioXpress* articles (see Resources).

The last measurement (**Figure 8**) shows the output impedance of the amplifier. At the highest frequencies a rise in output impedance is visible, caused by the leakage inductance Lsp of the output transformer. Below say 2 kHz the output impedance is 0.67 Ω, which is a typical result of the Trans principle.

The maximum output power of the amp is 18 W, measured at the onset of soft symmetrical clipping. The voltage amplification is 27 dBV/V = 22.4 x. With reference to 18 W in a 4 Ω load, the input sensitivity of the amplifier is 380 mV. The input impedance is 29 kΩ, equal to the 50 kΩ of the volume control in parallel with R1 = 68 kΩ and R0 = 1 MΩ.

In summary: It all looks sound and understandable. This amplifier follows the typical Trans-rules. What is special are the low harmonic distortion with H2 equal or below H3 in the mid-range of hearing. Also the good speaker damping is striking. But how does it sound?

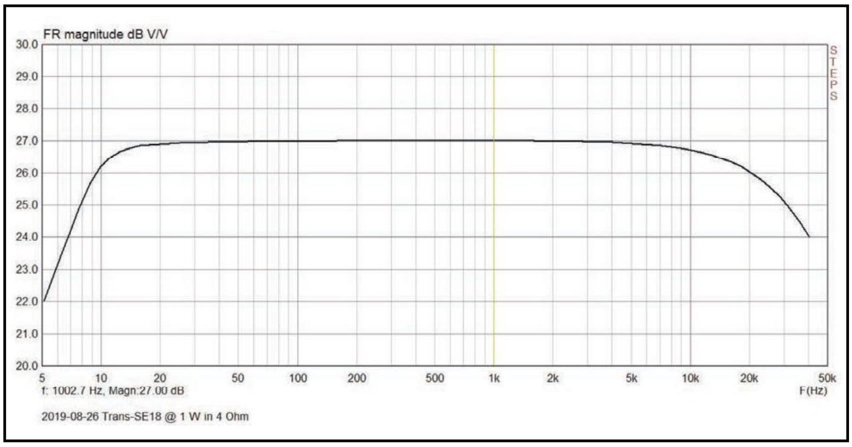

Figure 6: Frequency characteristics shown at 1 W in 4 Ω

Subjective Evaluation of the Trans-SE18

The amplifiers sound open with many details in the soundstage, from left to right and in depth and height and front stages. I know that the lowest H2 causes this detailed character. The bass reproduction is quick, as a result of the low output impedance, which creates good speaker damping. Also, the Trans-technique minimizes the magnetic transient distortions in the core of the OPT. Music consists of transients and Trans transfers those much cleaner. All these facts explain the good detail and space reproduction.

Next, the ease and fluency of listening. These are totally comparable with the standard 300B-SE. However, what is really striking is that the Trans-SE18 shows so many more details, without disturbing the joy of listening. After many years of tube amps design and evaluation, my preference clearly shifts to such details. I am not the only one reporting such observations; see others opinions.[8,9] Last, I would like to remark that the 18 W output power gives you impressive dynamics, especially with my 100 dB/Wm horn speakers.[10]

Summary

With Trans and pentodes and modern semiconductors and toroidal transformers, you can make an amplifier with remarkably low distortion, clean transient reproduction, and pleasant dynamics. Its sound character is very close to the famous 300B-SE amplifier. However, the bonus with Trans are the clean details. General opinion says declining H2-H3-H4-H5- sounds the best. My research says for optimal details ask for lowest THD with minimal H2 and largely reduced magnetic transient distortions.

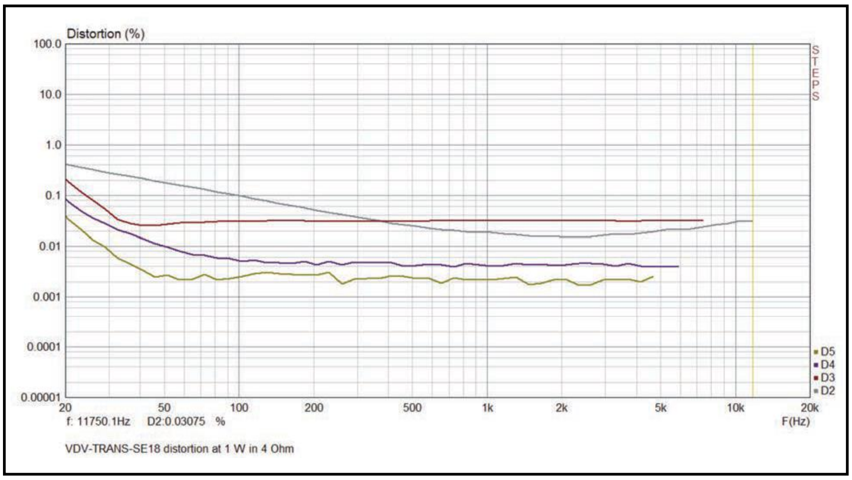

Figure 7: The harmonic distortions shown at 1 W in a 4 Ω load.

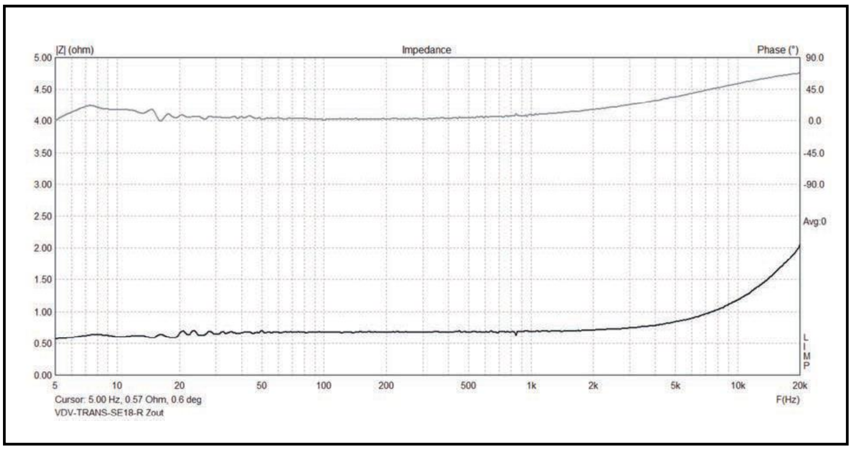

Figure 8: The upper curve is the phase, see the right hand scale. The lowest curve is the output impedance, see the left hand scale.

Resources

[1] M. van der Veen, *Vanderveen-Trans-Tube-Amplifiers*-e-book, www.elektor.com

[2] M. van der Veen, "TubeSociety 2A3-300B-SE Amplifier Project (Part 1)," *audioXpress*, April 2018.

[3] M. van der Veen, "TubeSociety 2A3-300B-SE Amplifier Project (Part 2)," *audioXpress*, May 2018.

[4] Vanderveen ir. Bureau and TubeSociety, www.mennovanderveen.nl | TubeSociety | project-2018

[5] Vanderveen ir. Bureau and TubeSociety, www.mennovanderveen.nl | Products | Kits | Trans-SE10

[6] Eidgenössische Technische Hochschule Zürich; *Elektroniker*, July 1989, pp.83..84

[7] Vanderveen ir. Bureau and TubeSociety, www.mennovanderveen.nl | Products | Transformers | SE-transformers

[8] P. Millet, "A Single-Ended 'E-Linear' Power Amplifier," *audioXpress*, April 2005, http://www.audioxpress.com/article/a-single-ended-e-linear-power-amplifier

[9] F. Blöhbaum, "Multiplied Transconductance Amplifiers (Parts 1 and 2), *Linear Audio* 6 and *Linear Audio* 8, www.linearaudio.net.

[10] Quintafila Niagara MSR: www.facebook.com/quintafila.it