The VDV-6AS7 (The Maurits)

by Ir. Menno van der Veen

Introduction

The 6AS7 is a series regulation triode for power supplies – not your first choice for an audio application. What would it sound like? – after all, this is a real triode, not a pentode mimicking one. Would it be hard to drive or to bias? This article tells it all.

Description of the audio circuit

Figure 1 shows the circuit diagram of the amplifier. This is only the left channel. The stereo version utilizes three dual-triodes for drivers and one 6AS7 power tube per channel, so five tubes in all. The Svetlana 6AS7 is a large, sturdy tube, somewhat similar to a 300B. At first glance the amplifier seems to be Single-Ended, but a closer look reveals the double structure inside the bulb of the 6AS7; so, a balance amplifier after all. Output power estimates about 7 Watts per channel; efficient loudspeakers are therefore recommended – at least 90 dB/W,m.

For the drivers and the phase-splitter type 6N1P (equivalent E88CC, see later) has been chosen; This tube is a steep dual-triode with low internal resistance, allowing a high output voltage swing – all highly desirable in this design. The first stage consists of a single tube whose two triodes serve as pre-amplifiers for both channels; B1a for the left, and B1b for the right. This is a standard triode stage in which the cathode has been decoupled with C1, featuring both high amplification and low internal resistance. The values of C1 and C2 are strongly related. The node between the small resistor R3 and the combination R2||C1 serves as an injection-point for external feedback through RT. Notice that this resistor is not decoupled.

The network around the phase-splitter is relatively complex. Capacitor C2 injects the amplified signal into the grid of tube B2a, the cathode of which has been decoupled with C3. After amplification, the signal passes through R13 and C4 to the grid of tube B2b. Phase inversion can be exactly balanced by comparing the signal on the anode of B2b with that on the anode of B2a – the pathway goes through R13, R14 and trimpot P2. When properly adjusted, both halves of the 6AS7 will receive identical signals – in anti-phase, of course – thus minimizing harmonic distortion.

P2 is marked with the abbreviation 'AC-BAL,' which is pretty self-explanatory. Adjustment is best done with a distortion meter. Apply a 1 kHz sinewave as input, adjust output power to 5 Watts in a 5 W load, then adjust P2 to minimal distortion at the output.

But there is more going on in this phase-splitter. Grid currents will occur in the power tubes, when driven above a certain voltage, creating an extra load on their driver. Should output impedance be high, then this will result in 'collapse' of the output voltage of the phase-splitter, and asymmetries of the splitter halves will result in pretty coarse distortion.

If we leave R5 and R6 out of the circuit, the output impedance of B2a will be about 4 kΩ, whereas the impedance of B2b will be only 200 Ω. Trouble is straight ahead with a discrepancy of more than one order of magnitude: The positive halve of the signal is bound to collapse much sooner than the negative halve, when B2b takes over.

There are two easy methods to lower the output impedance of the upper triode; the first one is depicted in the diagram. Feedback is introduced in tube B2a through resistors R5 and R6, lowering output impedance to about 800 W – still some difference between the two halves, but less dramatically so, therefore the phase-splitter should function flawlessly under normal circumstances.

The second solution – which has not been drawn – is to add a cathode follower behind B2a, which implies; another halve of a dual-triode, so a stereo amplifier will need an entire extra 6N1P. Such a modification results in higher input sensitivity, which may be useful for the amplification of low-level signals, such as older tuners and tape-recorders. On the other hand, the circuit from diagram 1 will accomodate larger signals – around 2 Veff – as generated by present day CD players.

Now on to the power tube section. The common cathode resistor circuit came out as favourite during listening tests. Capacitor C7 decouples the AC voltage over R19, which dissipates 12 to 14 Watts, a hefty device. While testing several 6AS7 tubes, it became clear that none of their triode halves are exactly identical. Therefore, there will always be differences in quiescent current, resulting in hum. In order to compensate for this, the network around trimpot P3 has been added. A fraction of the supply voltage is fed into the grids of the power doublet through R15 and R18. Turning P3 away from its centre position results in an INcrease in one grid voltage, and a simultaneous DEcrease in the other, and vice versa. This way, the quiescent current of both triode halves can be made identical, thereby annihilating hum. The adjustment is simple – no input signal; one ear close to the loudspeaker, while turning P3. At a certain point hum decreases, and becomes inaudible in most cases. Reader, Beware!! Trimpot P3 must be of IMPECCABLE quality. If it ever would break down, the entire power supply voltage will blast into the grids of the 6AS7, which will result in instantaneous destruction of the tube. So do not save pennies on an inferior trimpot; trimpot wise-tube foolish, one might say.

When in operation, the effective voltage over cathode resistor R19 will be about 140 Volts. This voltage causes a current of 140 / 1500 = 93.3 mA to flow through the resistor. The current is distributed evenly between the two tube halves, so quiescent current equals 47mA. With a supply voltage of 385 Volts, there is a voltage drop of 245 V over the tube. Close to the edge, as the maximum allowed Vak = 250 Volts for an 6AS7; we are just within limits. The power dissipated by the tube is 245 * .047 = 11.4 Watts, maximum anode dissipation for the 6AS7 is 13 W, a pretty wide margin.

Next comes the estimation of power efficiency. The total anode power equals 2 * 11.4 = 22.8 Watts, whereas output power amounts to 7 Watts, yielding an efficiency of 31 %. This somewhat unflattering value is intrinsic to the circuit, unfortunately. The grid to anode amplification factor of the 6AS7 is effectively 1.3 in this configuration. Given the characteristics of the output transformer used – which has a primary impedance of 8 kS – then 7 Watts correspond to a primary voltage of 335 Vpp. Every triode bears the halve of this voltage, thus 167 Volts. The phase-splitter needs to deliver 167 / 1.3 = 129 Volts, due to the amplification factor of 1.3. But do not start cheering yet, because this is only halve of the total peak to peak voltage, so the total output voltage of the phase-splitter needs to be 2 * 129 = 258 Vpp. And this brings us to the bottleneck in the circuit: The present topology simply can not build up this output voltage over the load, due to the grid currents of the power triodes. If we had chosen the alternative circuit with the extra cathode follower, then B2a would deliver a higher output voltage, and output power would even rise above 10 Watts. However, due to the simplicity of the setup, and the specific sound which it achieves, quality has prevailed over quantity. The phase-splitter is the limiting factor in this amplifier, and not the power tubes; they are never driven to their maximum power.

And now I will literally close the loop – with an external feedback resistor. Apparently, as listening-tests pointed out, this circuit benefits from slight feedback through RT . Just a little bit seems to give the finishing touch; more detail, without 'collapse' of the auditory image at large – unlike what will happen, if the resistance is lowered too much. The user is free to alter the value of RT , or to leave it out entirely – your ears will tell you what to do.

Some details of the power supply

There are some interesting 'extras' in the power supply of figure 2, that deserve some elaboration.

Starting from the mains side, we see a fuse Z1 and a switch – DPST, just to be safe. Mains earth must be connected to the metal enclosure. Nothing unusual here. The toroidal power transformer has two primary and two secondary sections; the primary can be connected in parallel or in series, depending on the mains voltage available. As indicated in the diagram, the value of the fuse and the series connection fit mains voltages of about 230 Volts.

All filaments are connected in parallel, and will be fed with 6.3 Volts. Resistors R25 and R26 eliminate hum by connecting the filament winding to earth; they act as a 'center tap.' In the unlikely case, that hum is still noticeable – the design is not particularly 'buzzy' – they can be replaced by a single 1 kW trimpot with its wiper connected to earth. If the filament wiring is kept close to the enclosure and far away from the sensitive parts of the circuit – B1 and B2 – shielding should not be necessary; just twisting the wires will suffice.

Now for the interesting part; the high-voltage supply. It all looks pretty run of the mill – rectifier, reservoir capacitors, series resistors R23, R24, also fuse Z2 and the stand-by switch – but what about resistors R21, R22, and capacitors C8 and C9? A power transformer has a wide bandwidth, and will pass a gamut of signals besides the desired 50 c.q. 60 Hz mains voltage. Spurious signals enter through two separate pathways. Before all, capacitive coupling between primary and secondary will cause so-called 'common-mode' noise, which can be eliminated through static shielding in the transformer or the network around R21, R22 and C8, C9. The second form, 'differential' noise, is caused by the all-too-wide frequency response of the power transformer. These noise voltages appear between the red and yellow connections of the secondary. Again, the filter network will deal with them. And, the transformer can be blamed for much, but not everything; the third noise source is the rectifier bridge D1-D4. While these diodes act as fast switches, they will generate sharp transients during zero crossings, which are dampened by C8, C9 and C10.

In summary, this modest little circuit acts as a highly effective interference suppressor. It is well known that a vacuum diode, like the GZ34, sounds smoother than its solid state counterpart, when used as a rectifier. There are two reasons for this; its relatively high internal resistance has a similar effect as resistors R21 and R22. Furthermore, the gentle switching of vacuum diodes is not prone to generating transients. So the network around R21, R22, C8 and C9, does its very best to mimick vacuum rectifier behaviour, and with good effect, as the mild sound of this amplifier proves.

Subjective properties

Listening to the first version of this amplifier was not exactly an overwhelming experience, let me suffice that the amplifier worked – nothing more. In the months thereafter, improvements were made one by one, until the excellent final result came to be. What did I do to get there?

First, the addition of R5 and R6 proved essential; without them, reproduction became messy at high levels. Their presence virtually eliminates distortion – way below the 0.7% of a plain vanilla sine wave generator – so that the effect of adjusting P2 becomes clearly noticeable.

The dehumming network around P3 was the second vital extension of the basic circuit. It suppresses hum effectively, and more important, the meticulous balancing of the power triodes drastically improves output transformer behaviour. Not only does silence reign, but sound becomes effortless, too.

A further essential addition was the introduction of the rectifier network – R21, R22, C8 and C9. This burnished the last sharp edges off the auditory image.

After all this, I tweaked the various driver tubes. It is paramount to have the right tube at the right place; Svetlana 6N1P and Sovtek's

6922 performed fine as a phase-splitter, whereas model 6N1P of Svetlana gave supurbly pre-amplification. Paying attention to the choice of driver tubes is rewarded with better reproduction of details and ‘atmosphere.’

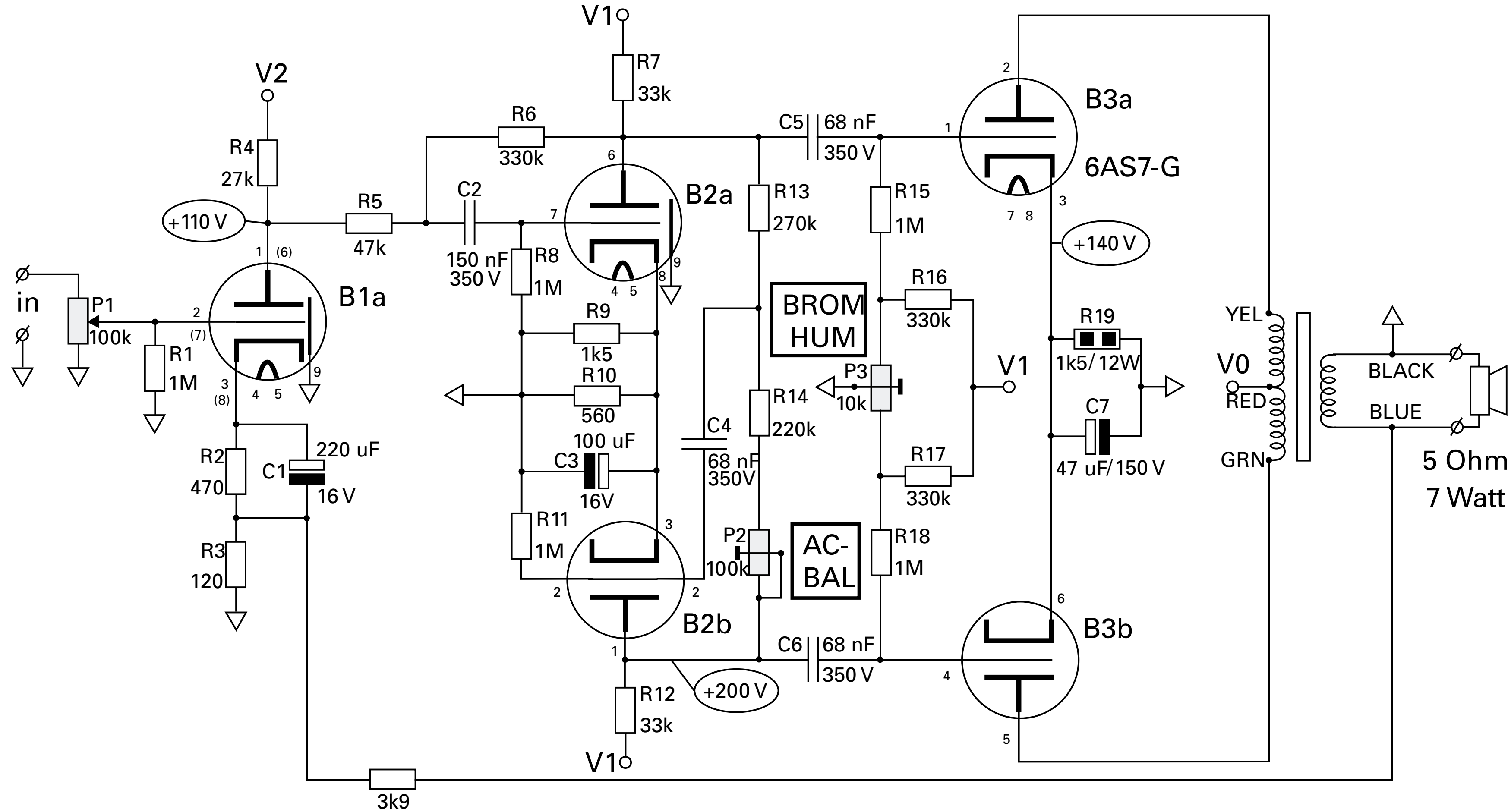
Next on the list were the coupling capacitors. I recommend that you try any type that tickles your fancy, only: Do use the recommended values of 68 nF and 150 nF and nothing else – changing the values may cause momentary imbalance of the 6AS7 triodes during power-up, which may fuse them. They are somewhat prone to this, but should be fine in the exact given configuration.

Final parameter that I massaged to the full was the amount of feedback.

The auditory image can be pushed in every direction – from bare via lively to positively glowing. I found 3k9 for RT the optimum, but let everybody decide for themselves.

Those that are looking for measurements and other technical mumbo-jumbo in this article have come to the wrong place! Evidently, tons of measurements have been done during this project, but I did not want to bore the reader with that. The emphasis here is on experimentation and modification – just having the guts to do something different – listening, and above all; enjoyment. Good luck!

[This manuscript is an abstract of chapter 20 from the book "Modern High-End Amplifiers, based on Toroidal Output Transformers", written by Ir. Menno van der Veen.]



All resistors are 1 Watt Beyschlag resistors, unless otherwise noted

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FIGURE 1: audio circuit diagram of the 6AS7 amplifier code 6as7-1.cdr

Plitron Manufacturing Inc. 8 – 601 Magnetic Dr. Toronto, Ontario, Canada M3J 3J3 1-800-PLITRON (1-800-754-8766) Tel. 416-667-9914 FAX 416-667-8928

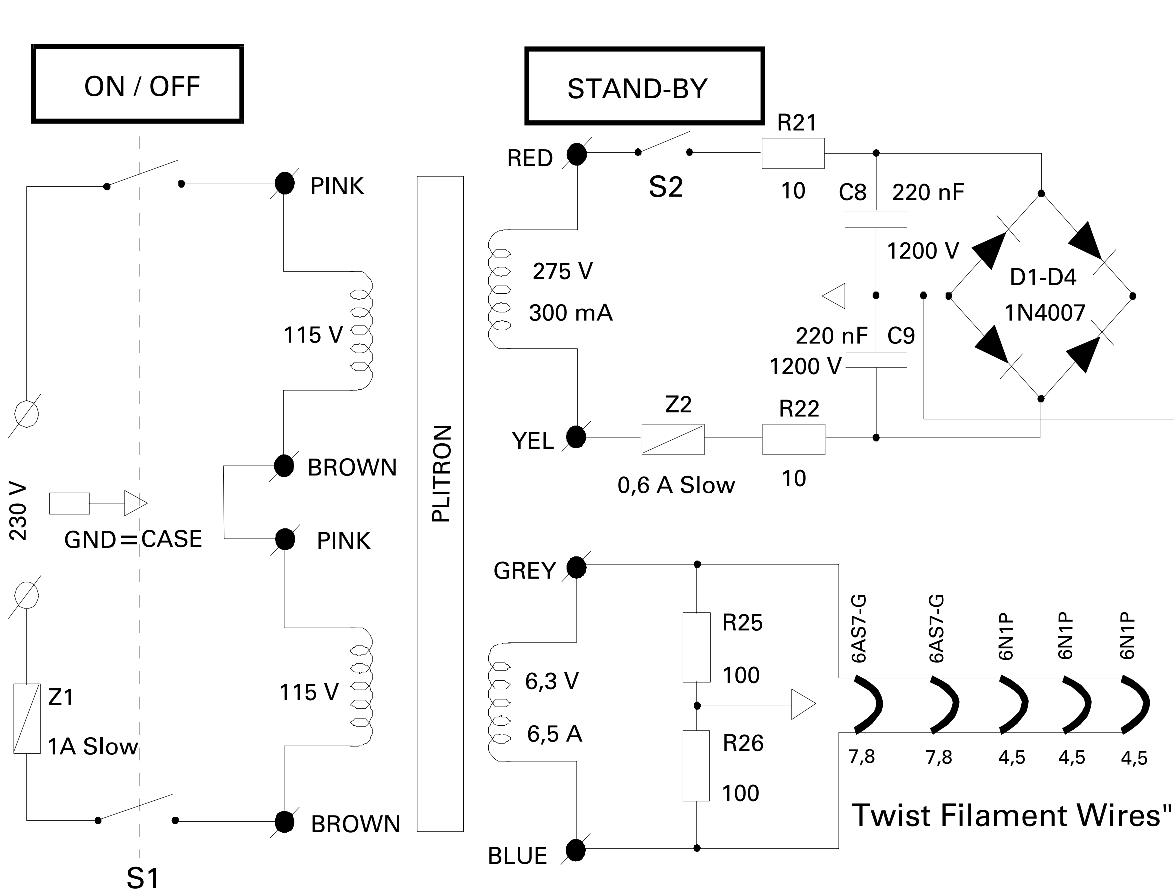

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FIGURE 2: The power supply circuit. Transformer is Plitron part number____ with 115/230VAC primary winding. code 6as7-2.cdr