

VANDERVEEN E-CHOKE: THE SMART ELECTRONIC CHOKE

Introduction

In the early days of valve amplifiers they used chokes in the high voltage plate supplies. With good reasons: hum was rejected and high frequency radio interference was rejected as well. High quality chokes were built, with separate winding chambers to make the capacitance between in and output as small as possible. Nowadays these chokes are also available and widely used in high quality valve amplifiers. The core has a gap to handle the DC-currents of the power tubes. One would say: these chokes are The blessing for us. But as always, there are some minor disadvantages. Like a bulky piece of iron with huge magnetic stray fields, caused by the gap, which might cause considerable interference with sensitive electronic circuits. And what to say about the mechanical hum of the core, caused by movements of the gap? These disadvantages were enough for me not to apply these fantastic chokes. I thought that another route might be better. Why not to create an electronic choke? No mechanical hum, no stray fields, small capacitance between in and output? Not only became this a wish, I did it and designed the electronic choke which I will discuss following. I had one extra demand: this new fantastic choke should fit in my UL40-S2 amplifier, where space is small. So, the circuit should be small, which is possible with nowadays modern electronics. I designed the now called VDV E-CHOKE and Tentlabs manufactured it. Isn't that a good cooperation?

Background of the VDV E-CHOKE

In my UL40 valve amplifier, the plate voltage comes from a high voltage secondary winding on the power transformer. After rectification the voltage is buffered in a large capacitor of 330uF/450V. The resulting high voltage has a ripple of about 14Vpp when the total current demand equals 4 x 80mA. This ripple might cause hum in the loudspeaker. Because the valve amp operates push pull, this ripple is rejected when both power valves have exactly the same plate resistance. That's why I introduced the Super Triode circuit, which enables us to trim the effective plate resistances to exactly the same value. Combine this with my auto bias circuit which takes care of exactly equal quiescent currents and with the balance trim pot in the phase splitter which gives both halves exactly the same amplification. With these adjustments the power valves can be made exactly equal on three important parameters. This resulted in very low distortion and also very low hum, combined with good and open reproduction of micro details in the soundstage. So, my conclusion was: I even don't need a choke!

This was true until recently. I performed measurements on my fantastic amp and saw something that really stroke me. Look at figure 1. There a 1kHz signal is fed through the amp and the spectrum of the loudspeaker

signal is measured. What we see is the 1kHz, but also the higher harmonics at 2 and 3kHz. However, what to say about the intensive intermodulation products of 1kHz and 100Hz multiples of the rectified mains voltage?

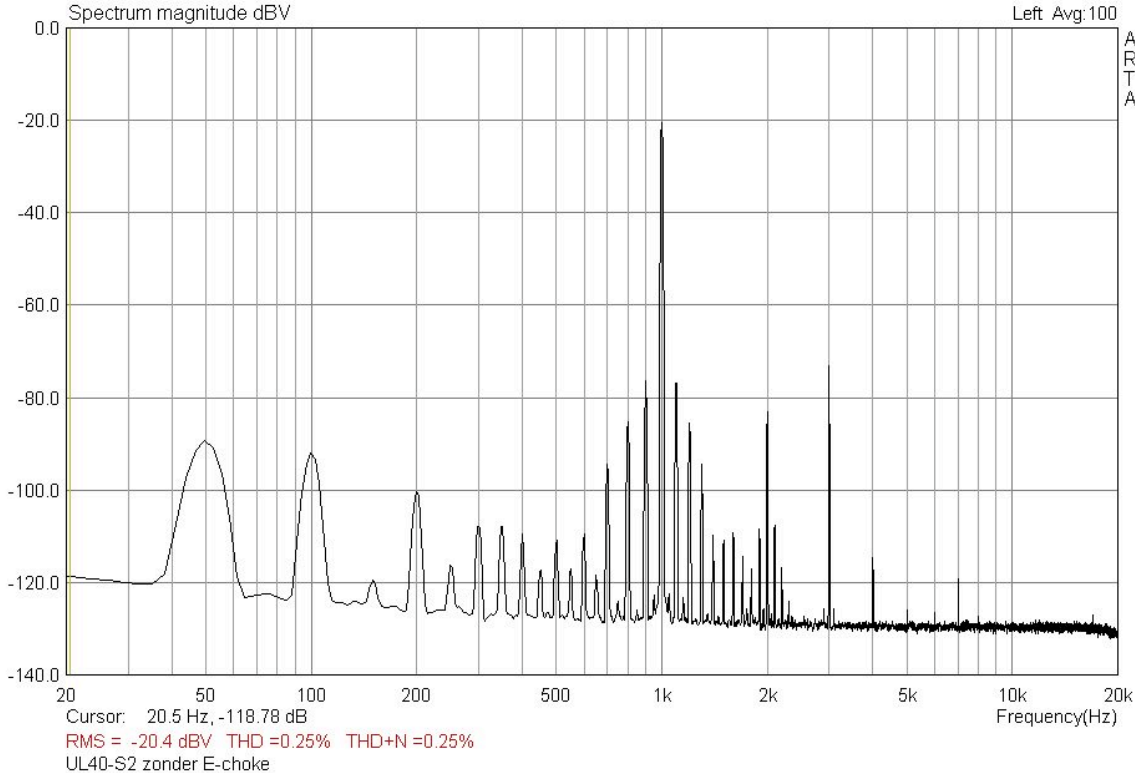
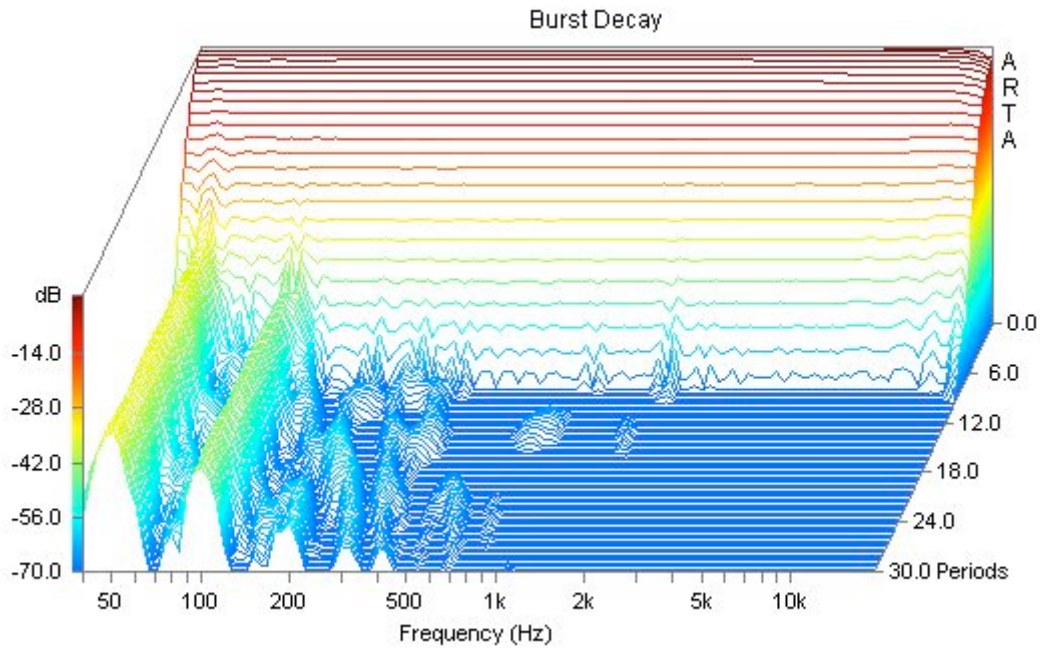


Fig-1: Spectrum UL40 with 1kHz, 8Vtt in 4 Ohm, without a choke

I can't hear the intermodulation products around 1kHz, because they are masked by the stronger 1kHz signal. What I might hear is the residual 50 en 100Hz hum components, because they are above the masking level. Why then to care about this mesh of disturbance when you don't hear it. This was my thinking, and I was wrong. Study the following figure 2. Here we study the behavior of the UL40 in the time domain, after a sudden wide bandwidth burst signal. Look at the mesh after the burst has stopped. The does not look healthy at all.



UL40-S2 zonder E-choke

Fig-2: UL40 without choke, mark the mesh in the signal floor

I can tell you, this is what we can hear. Where we should notice silence, we now hear rubbish and noise and We do not only have to deal with the masking of our ear in the frequency domain, we also have to study any disturbance in the time domain, in order to understand what is going on. My wish was to recreate silence in the signal floor.

Lets suppose we can solve that with a standard choke. Next figure 3 shows the results. I applied a 10H choke after the rectification and buffering, plus an extra capacitor of 330uF, all in the very well known pi circuit. The results are striking.

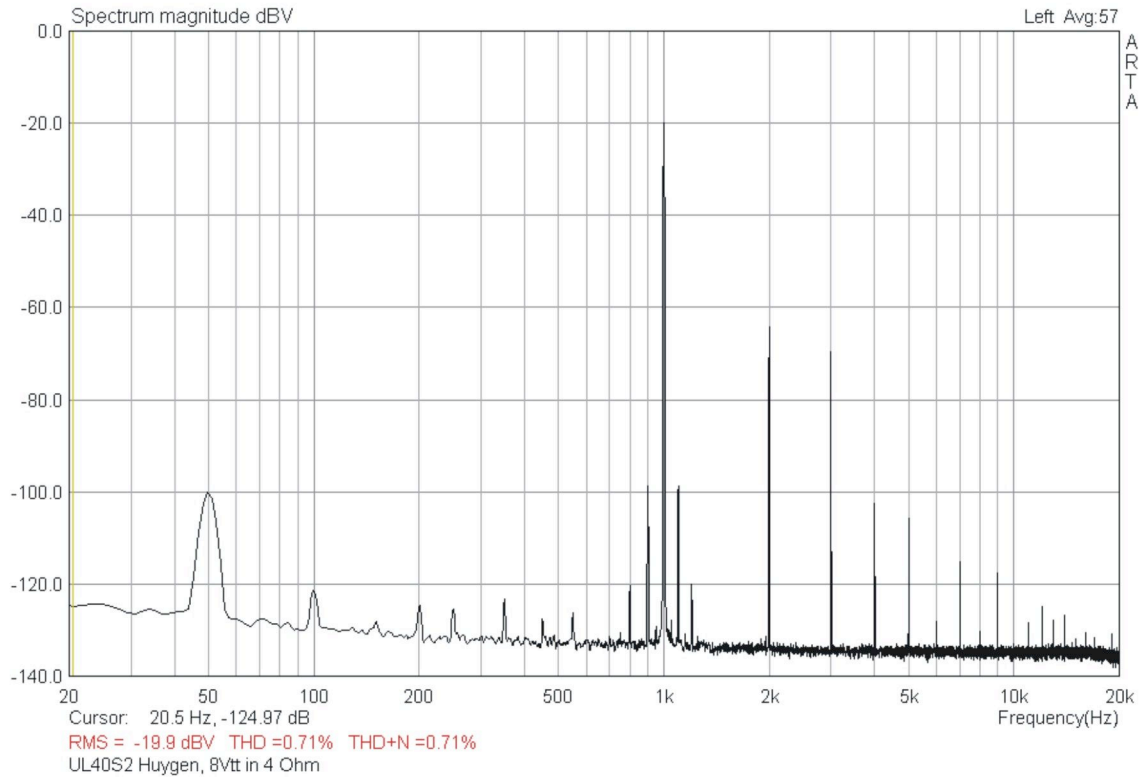
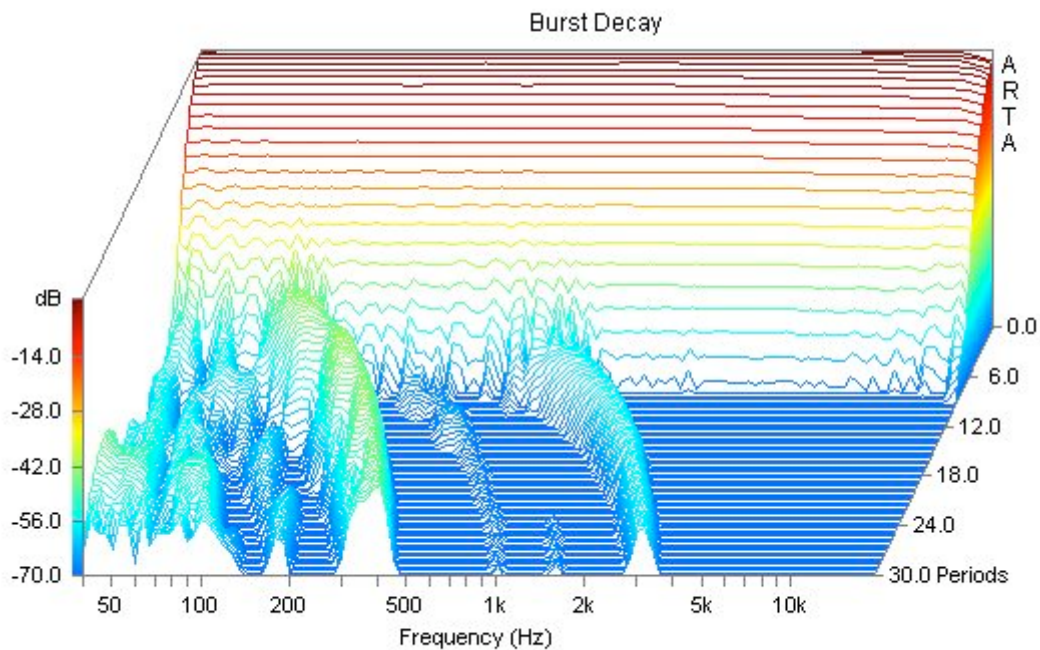


Fig-3: UL40 with 10H choke and extra 330uF/450V capacitor

The 100Hz intermodulation products are almost gone. This looks much cleaner. Before we studied the results also in the time domain. Let us repeat that now, and study figure 4.



UL40-S2 Huygen impuls

Fig-4: UL40 with 10H choke and extra 330uF capacitor

This does not look healthy at all! Look at the residual signals at the signal floor. The 50 and 100Hz components are smaller, but time wise they swing and oscillate over a decent amount of time. I know that 10H plus the capacitors of 330 uF each are not tuned optimally, but this example helps us to find out where to focus at.

The next figure shows the results when I apply my new VDV E-CHOKE in the UL40-S2 with an extra 330uF capacitor directly after the rectifiers. The other capacitor of 330uF is already on the PCB of the UL40. This new choke has two time settings (see later for more info). In this case the time is set OFF

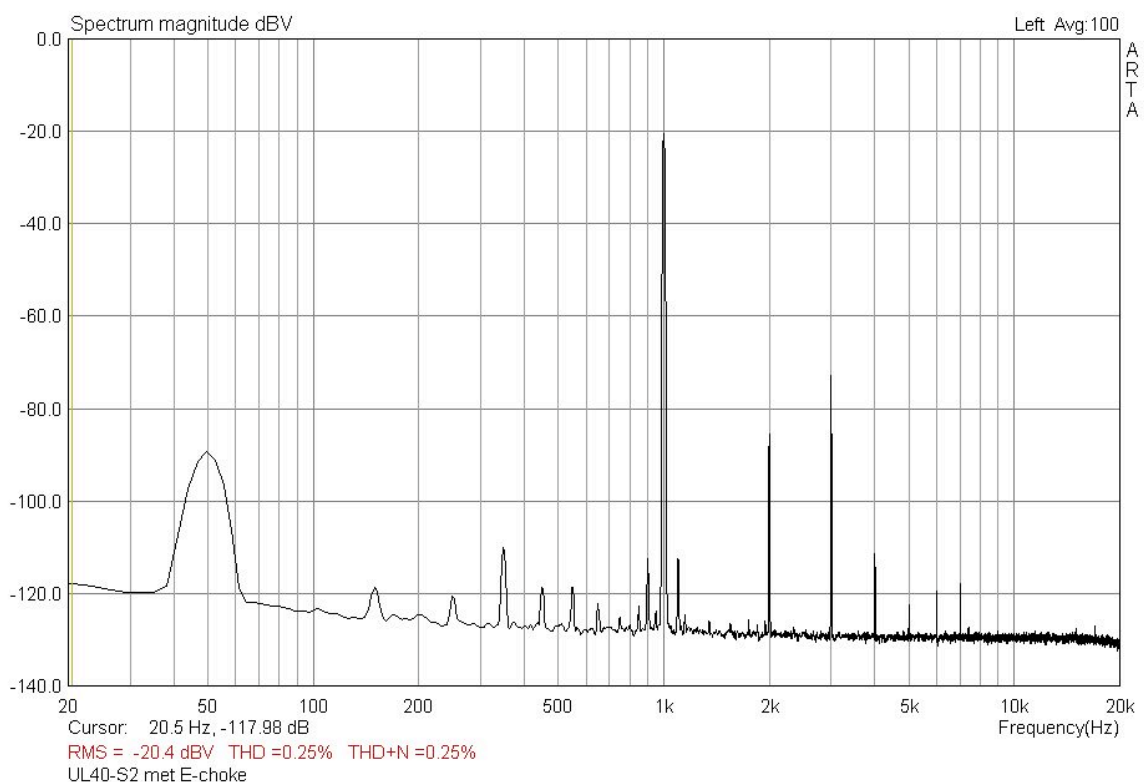
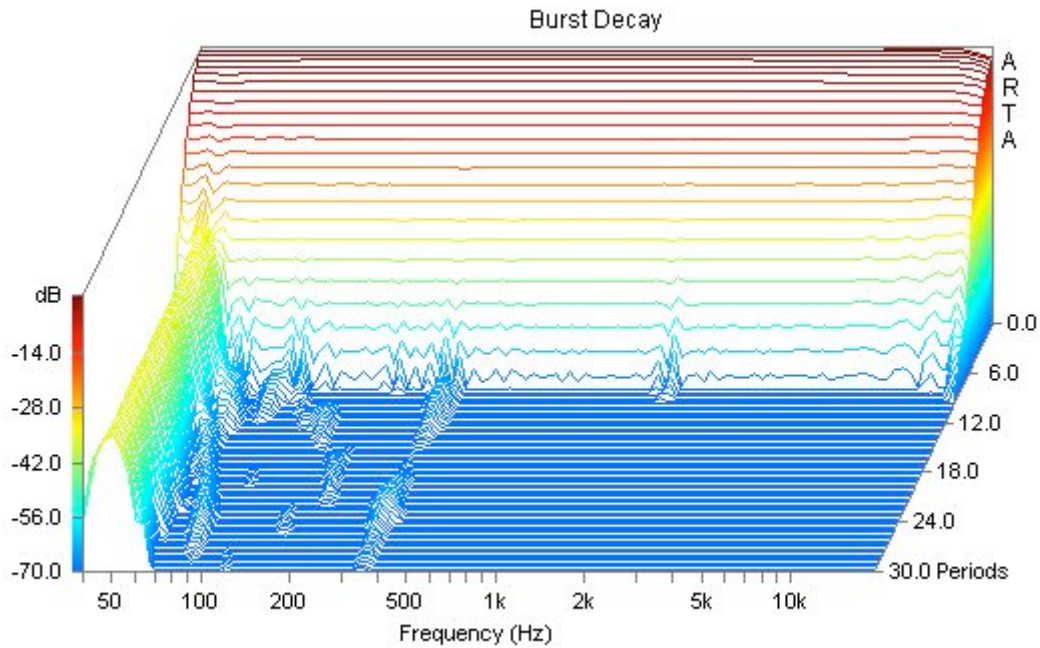


Fig-5: UL40 with VDV E-CHOKE, time modus at OFF.

What we see now is an even stronger rejection of 100Hz intermodulation products. Later I will say something about the 50Hz component, which seems not to change at all. These results are remarkably better than a standard huge iron 10H choke. The question now is: how does this choke behave in the time domain? See the next figure.



UL40-S2 met E-choke

Fig-6: UL40 with VDV E-CHOKE, time modus at OFF

Apart from the 50Hz component (see later) the signal floor is almost completely clean. Only a tiny 50Hz resonance is visible, which has disappeared after 40 ms. In this time modus the new choke reacts very fast and this setting is meant for class AB amplifiers where the current demand can change rapidly.

But I can even do better. When I switch the time modus to ON, there is an extra improvement of intermodulation rejection. See the next figure.

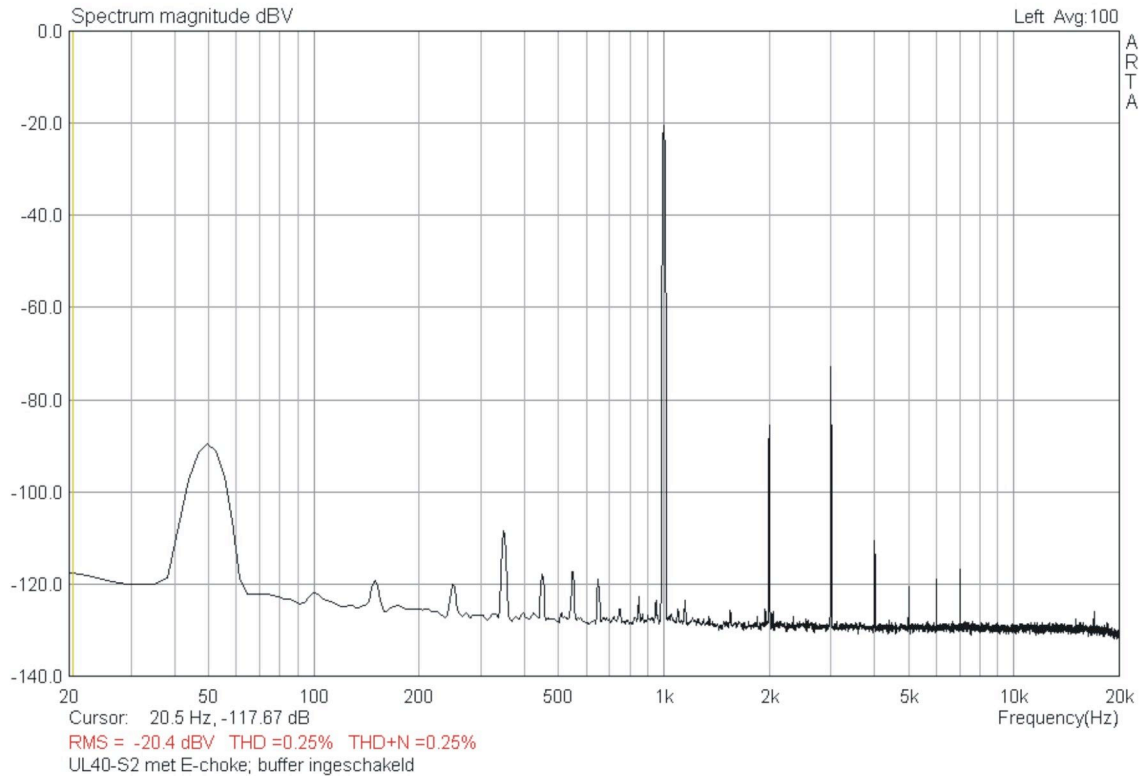
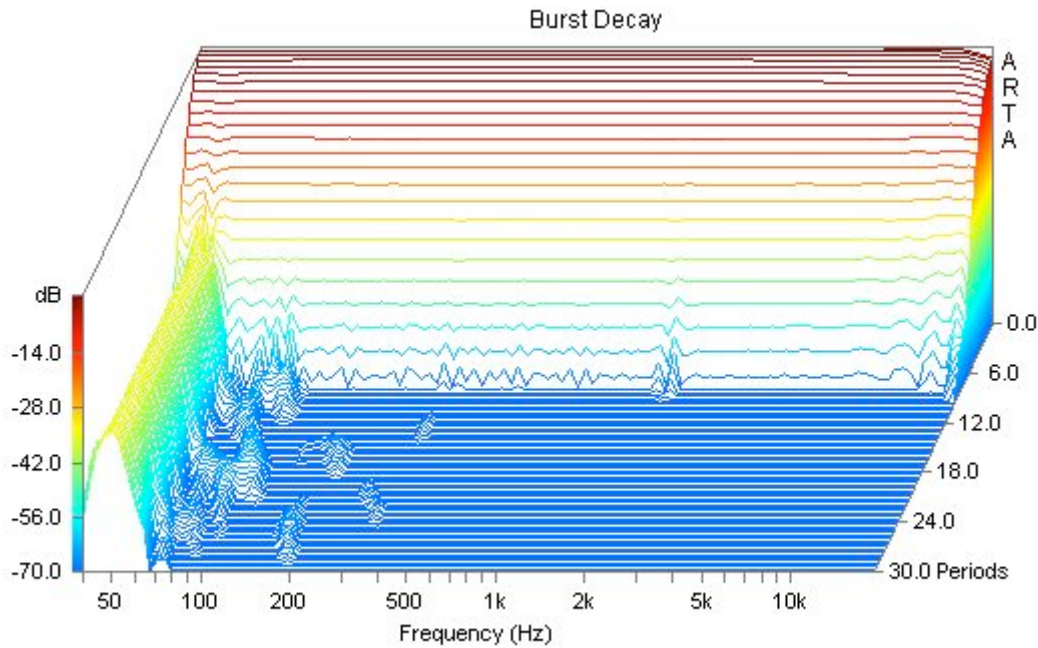


Fig-7: UL40 with VDV E-CHOKE, time modus at ON

A normal bulky iron choke has no time modus switch. That's a new invention of me, intended for class A amplifiers with a constant current demand. Then large changes in current demand seldom occur and therefore you can tune the time behavior of the E-CHOKE very precise, without any concern about the currents drawn. This must be visible in the time domain. See the next figure.



UL40-S2 met E-choke buffer ingeschakeld

Fig-8: UL40 with VDV E-CHOKE, time modus at ON.

As expected any resonance of mains components has disappeared. The signal floor is optimal clean in the time domain. For those who like to measure: after a current change the mains voltage recovers in 10ms in a critical damped manner.

Conclusive: the VDV E-choke does not only remove hum components and intermodulation products in the frequency domain. It also makes the signal floor optimal clean after a signal burst. Now silence becomes silence, and this is what we can hear!

I would like to make a small remarks about these measurements. It looks as if the 50Hz component does not change at all, as if 50Hz is not influenced by the E-CHOKE. Closer research, including oscilloscope measurements, showed that the 50Hz component is weakened in reality. What is visible in the figures is caused by the computer measurement setup, where 50Hz is an internal leakage signal in the computer.

With oscilloscope measurements the following results were shown. The amplifier was drawing a quiescent current of $4 \times 60\text{mA}$. The ripple voltage over C-in was 7Vpp. After the E-CHOKE with time modus at off the residual ripple was 50mVpp, equal to more than 40dB suppression. With the time modus set at on, the residual ripple was 3mVpp, more than 60dB suppression.

VDV E-CHOKE specifications

PCB : 72 by 50 mm, height 50 mm (C-in)

I_{max} : 500mA
 V_{max} : 450V
 V_{ripple max} : 15V_{pp}
 C_{-in} : 330uF/450V (on E-CHOKE PCB)
 C_{-out} : 330uF/450V (external, directly after E-CHOKE)
 Losses : maximum 17V between in and output at 500mA
 Dissipation : maximum 5W on grounded heat sink
 Suppression : >40dB, time at OFF
 : >60dB, time at ON
 : with C_{-out} is 330uF/450V
 reaction time : 40ms with time at OFF
 : 10ms with time at ON (critical damped)
 Protection : none
 Application : class AB amps with time at OFF
 : class A amps with time at ON

Application in the UL40-S2

The next figures show the original UL40 power supply section. Following I will pay closer attention to the plate supply section.

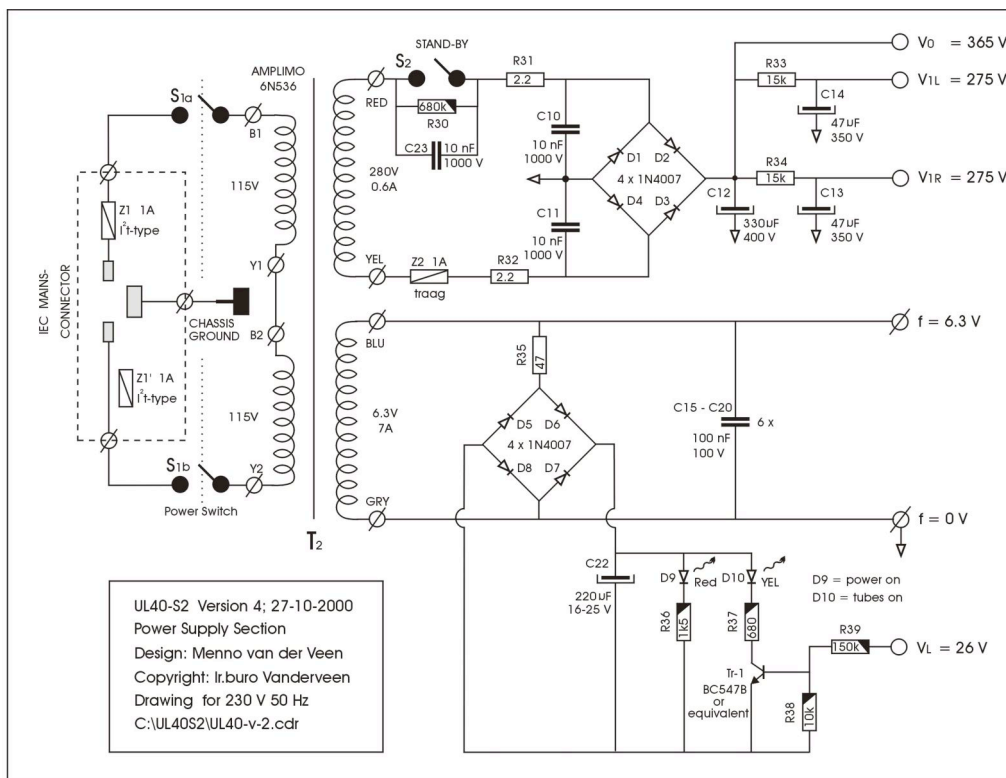


Fig-9: Power supply of the UL40-S2

In the next figure the application of the E-CHOKE is shown.

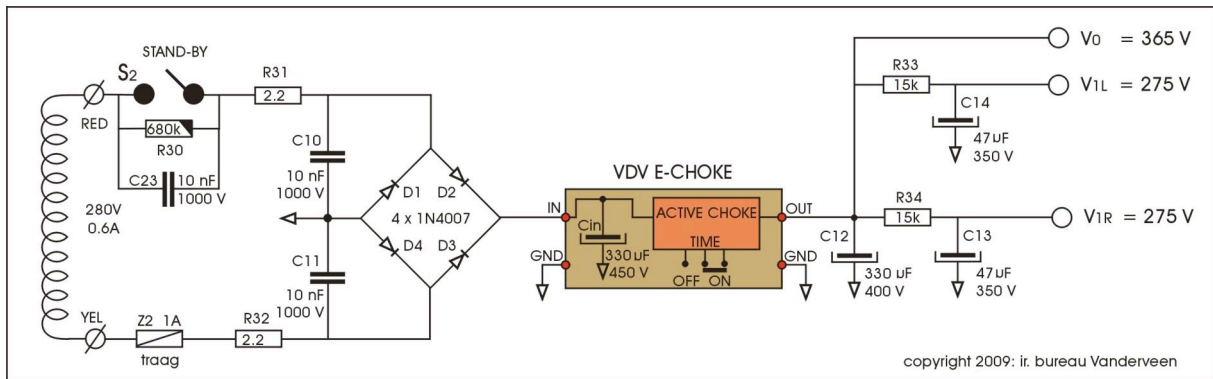


Fig-10: UL40-S2 with VDV E-CHOKE

This figure shows that the plate voltage, after rectification by D1-4, directly goes into the input of the E-CHOKE where it is buffered by the input capacitor C-in = 330uF/450V. The E-CHOKE effectively is placed between D1-4 and the capacitor C12 = C-out = 330uF/450V, which is already present on the UL40 PCB.

How to place and wire the E-CHOKE is very simple, see the following figure.

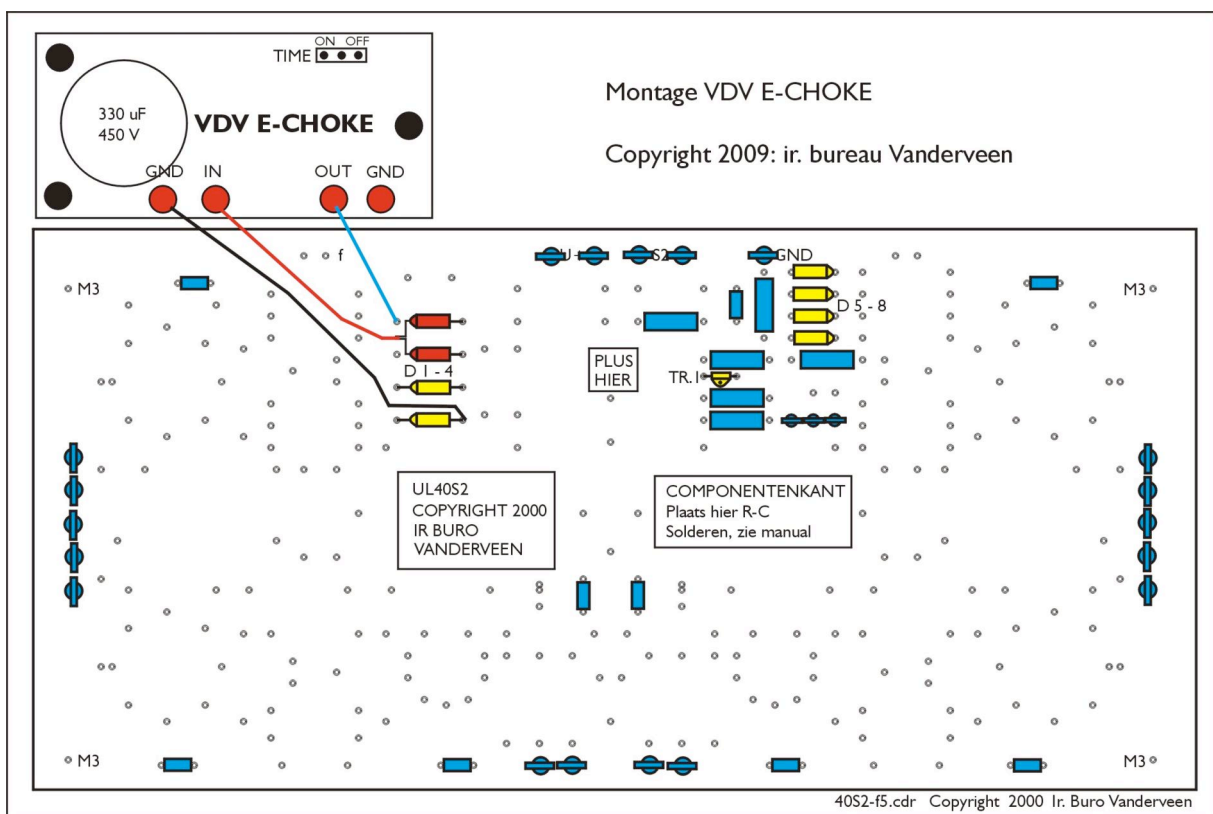


Fig-11: Wiring E-CHOKE in UL40-S2

1) Place the E-CHOKE at the left side above the UL40 PCB. Use three glue spacers and not four, because the right upper hole is just above the mounting screw of the OPT. Therefore use the right middle hole. I always

use extra silicon glue for the spacers. It deals well with the roughness of the metal case and can withstand the heat of the valves.

The axis of the input selector should be removed first for easy placement. When you replace this axis again quickly the glue has not dried yet and there is some time available to shift the PCB a little bit, because the axis should touch nothing of the PCB. Let the glue dry for about at least an hour before continuing the wiring.

2) Unsolder the left sides (the cathodes) of the two upper diodes. Reconnect these left sides (in the air) and connect that joint to a red wire. Isolate this connection with heat shrinking tube. Solder this red wire to the IN-connection of the E-CHOKE.

3) Solder a wire (black) from GND on the E-CHOKE to the anode side (right side) of the lowest fourth diode.

4) Solder a wire (blue) from OUT on the E-CHOKE to the earlier PCB connection of the left side of the upper two diodes (where they were unsoldered in step 2).

That's it. Please check your work carefully.

Trimming

The E-CHOKE needs no trimming. Only the time behavior is adjustable, as mentioned before. I now will discuss the optimal settings of this time modus with the connection bridge between the three time pins at the right upper side of the E-CHOKE.

a) TIME-bridge at OFF: UL40 in its original mode, with cathode resistor and cathode capacitor; UL40 in super triode mode; UL40 with the auto bias module for quiescent currents smaller than 60mA per tube.

b) TIME-bridge at ON: UL40 in all configurations with auto bias with quiescent current larger than 60mA per tube. There the amplifier almost completely operates in class A.

I have some hesitation writing down the following. I really hope that you will read it with the utmost attention, else you might destroy the E-CHOKE and that certainly is not my goal.

When you have your UL40 in the super triode mode, you need to trim P5 (50kOhm trim pot, in series with 47 or 68 kOhm, just before the control grid of the upper power valve) to adjust the plate resistances of the power tubes to equal value. In order to do this, you need hum on the plate voltage. With the ear close to the speaker (or verifying the scope signal) you can trim P5 for minimal hum. The E-CHOKE removes the hum. So, this procedure will not function anymore. Consequently, on timely basis we need to reintroduce hum to do this adjustment.

- 1) Switch the amplifier OFF and wait some minutes for total discharge of the large 330uF capacitors.
- 2) Place the bridge at the TIME setting on the OFF position !!!!
- 3) On timely basis, connect a wire on the E-CHOKE between IN and OUT. Now the E-CHOKE is in shortcut mode and does nothing anymore; we have hum available.
- 4) Switch the amplifier on.
- 5) Trim P5 for minimal hum on the scope or from the loudspeakers. The plate resistances of the power valves are now trimmed for equal value.
- 6) Switch the amplifier off and wait some minutes for discharge of the large 330uF capacitors.
- 6) Remove the wire between IN and OUT of the E-CHOKE.
- 7) The super triode mode is now in its optimal setting and the E-CHOKE removes the last residuals of any hum to an unhearable level.

Suppose one has a different opinion about this procedure. Lets assume that the time was at ON. Or suppose you timely connected IN or OUT to GND. Well, you will end up with a dead E-CHOKE. This explains my hesitation. I have done my utmost to clearly tell you what to do, so mistakes are excluded. Is that true? Experience has taught me that (For your info: when I was doing electronics in my youth at the university, they give me a nick name: "Menno blow-up", because I was an expert in destroying electronics. I must have learned through the years, because now I seldom make these kind of mistakes).

Subjective evaluation

The E-CHOKE is not only marvelous in removing hum. The real thing is that I can listen deeper into the details of the soundstage. The space between instruments and sounds is more silent and cleaner. I have explained this behavior with my measurements in the time domain. When a signal suddenly stops, there is no disturbance noticeable in the plate voltage. Therefore you hear silence and when this silence contains micro information you are able to notice that. When you have a good well tuned old fashioned choke in your plate voltage supply, you get the same good result. That is why people like chokes. The same fine result I have with my E-CHOKE without the disadvantages of stray fields and hum in the gap and large dimensions and heavy weight. Conclusive: the winning item of my E-CHOKE is that the thing enables you to hear much more micro details.

How to apply the E-CHOKE in other valve amps?

Of course the E-CHOKE is an universal device which can be placed in other valve amps. You must have a plate voltage below 450V and the current should be smaller than 500mA. Just the same as in the UL40, place the E-CHOKE directly after the rectifier, and following connect its output to the buffer capacitor that is already present in your valve amp.

However, it might be necessary that you consider the rectifiers of your tube amp. When it contains silicon diodes, there will be no problem. When you use valve rectification, then please check you valve data to see if your valve rectifiers can handle a 330uF capacitor. I guess that the valve books will prescribe 47 or 100uF maximum. How to proceed then?

Unsolder the 330uF capacitor C-in. Place a capacitor of the prescribed value on the E-CHOKE PCB. The condition that you should meet is: the ripple voltage at C-in should be less than 15 V peak to peak, else the E-CHOKE will not function properly. There is an easy way of calculating the optimal value of C-in. Suppose the current demand of your amp equals 50mA. Than C-in should have the value: $C_{in} = 50\text{mA} / 500\text{mA} * 330\text{uF} = 33\text{uF}$ (select 47uF). In other words: C-in is proportional with the current demand of the amp. In all applications C-out inside your amp should equal 330uF, because the time behavior of the E-CHOKE is optimized for this C-out. The E-CHOKE will function as a kind of buffer between the valve rectifiers and C-out. This value of C-out will not harm your valve rectifiers.

Availability

Go to "order" on this website.