CRYSTAL SOLID

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The article presents a diagram and description of the operation of a corrector for MM cartridges, implemented on MOP transistors. As well as recommendations for its repetition.

The problem of lamp flicker noise prompted me to take up the design of this device. Although in properly designed equalizers, it does not seem to have a significant effect on the sound quality, but the constant small chaotic shifts of the operating point (especially in circuits with direct connections between cascades) - I was somewhat strained. As if obvious methods of struggle: the use of capacitive or transformer interstage connections - I didn't really like it, and it's not very effective either. Additional components in the signal circuit and sound do not ozonize,

and the cost is not reduced.

In principle, a standard set of tasks was set during the design: to obtain a high linearity without the use of common feedback circuits, a minimum path length, a high overload capacity, and a minimum noise level. Looking ahead a little, I want to say that, in general, we managed to implement the tasks set (something completely, something partially), and this device is perhaps the best of the entire line of correctors, both in terms of objective parameters and subjective assessments.

We can say that the corrector circuitry is inspired by lamp devices. And probably to many, especially those who are more accustomed to dealing with transistor devices, it will seem strange and not optimal. But since there were no restrictions on power consumption and power supply, a number of issues were resolved head-on. And this gave its positive result in the form of a decrease in the number of active elements (which to some extent have an additional effect on the signal), a decrease in the noise level, and an increase in the stability of the circuit without additional circuits.

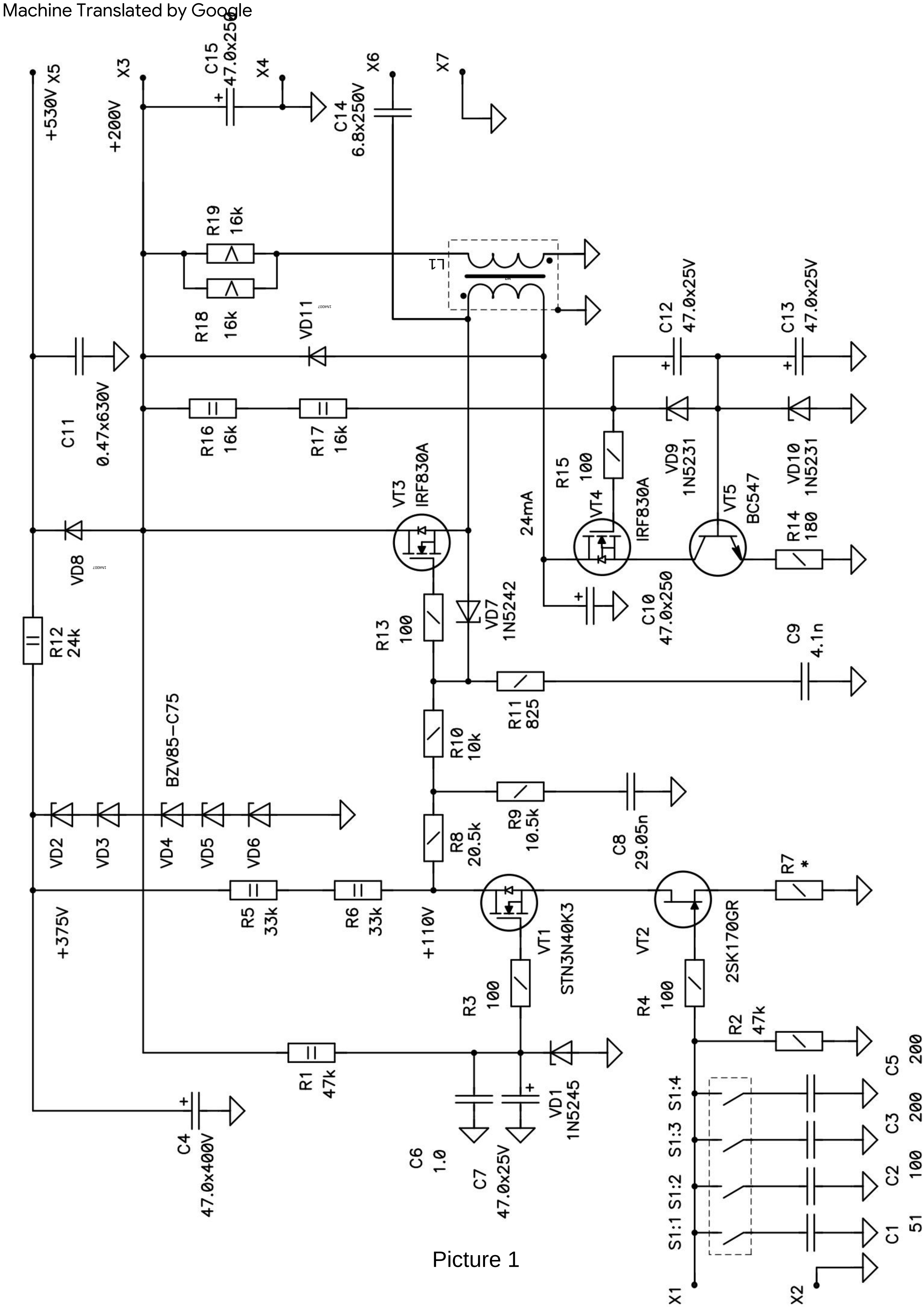
Corrector scheme.

The scheme of one channel of the corrector is shown in Figure 1. The corrector has the following main options:

Gain (1kHz) Input impedance Input	ÿ100
capacitance (adjustable)	47kÿ±0.1%
	51÷560pF
THD (1kHz, Uout=1Vrms) Noise	0.05%
level (not weighted) Overload capacity	-80dB
Maximum output voltage	+32dB
	40Vrms
THD (1kHz, Uout=40Vrms) Output	1.9%
impedance Load impedance	ÿ0.5ÿ
Correction characteristic Characteristic	>10kÿ
error (20Hz - 20 kHz)	eRIAA
	±0.15dB

If we talk only about the basic amplifier (with disabled correction circuits), then with a gain of about 61dB, the amplifier band is limited in the range of 3Hz÷80kHz, and the noise level reduced to the input does not exceed 23nV/ÿHz. Which, in general, is already quite comparable with fairly decent op-amps. With the slight difference that no op-amp can provide such an overload capacity. The amplifier is two-stage. All amplification is concentrated in the first stage, implemented in a cascode circuit on transistors VT1, VT2. In general,

I quite deliberately refused to use current sources in the VT1 drain circuit, the main reason is noise reduction. In addition, the series connection of two current sources (it can be conditionally considered that the cascode cascade is something close) requires an additional system for stabilizing the regime with direct current. The required gain is obtained by choosing a resistor in the drain circuit VT1 with a corresponding increase in the supply voltage. Along the way, this also provides a good overload capacity.


+530V X5
X3
+200V
C15 47.0x250
X4
X6
X7
C14 6.8x250V
R19 16k
R18 16k
L1
VD11
C11 0.47x630V
R16 16k
R17 16k
C12 47.0x25V
C13 47.0x25V
VT3 IRF830A
R15 100
VD9 1N5231
VD10 1N5231
VT4 IRF830A
VT5 BC547
24mA
R14 180
VD8
R13 100
VD7 1N5242
C10 47.0x250
C9 4.1n
R12 24k
R11 825
R10 10k
BZV85-C75
R9 10.5k
C8 29.05n
VD2
VD3
VD4
VD5
VD6
R8 20.5k
R7 *
+375V
R5 33k
R6 33k
+110V
VT1 STN3N40K3
VT2 2SK170GR
R3 100
R4 100
R2 47k
R1 47k
C5 200
C3 200
C2 100
C1 51
S1:1 S1:2 S1:3 S1:4
C4 47.0x400V
C6 1.0
C7 47.0x25V
VD1 1N5245
X1
X2

Picture 1

As a result, the supply voltage of the first stage is ÿ375 volts. The characteristics of the cascade, including the nature of the distortion, are almost completely determined by the VT2 transistor and its mode. The input capacitance is set by a set of capacitances C1-C5, switched by a DIP switch or simply by a jumper
kami on the board.

The input stage through the lumped correction circuit (R8-R11, C8, C9) works on the output source follower (VT3) with a choke load. The low output impedance of the follower and the rather high quiescent current of the stage significantly reduce the influence of parasitic parameters between block cables. In addition, the follower provides complete decoupling between the load and the first stage with a corrective circuit.

The question may arise: why such an exotic - a throttle? The answer lies in the subjective plane.
sound perception. It has long been noticed that cascades that have a transformer or choke at the output sound better subjectively, despite close objective parameters with similar cascades that do not use coil units (and this suggests that not all parameters that need to be controlled are controlled). Why this is so - there are a number of considerations. But this question is far beyond the scope of this article. Therefore, I will limit myself only to a statement of fact - the output stage, a repeater with a dross

lem.

The DC operation mode of the output follower is set by the current source on transistors VT4, VT5. The current source is shunted with capacitance C10. The disadvantage of this solution is that the signal current flows through the capacitance. The advantage of this solution is that the signal current flows through the capacitance, and the parasitic parameters and nonlinearities of the current source (especially at large swings) do not affect the signal. In addition, this also helps to reduce the noise level (although this is not particularly important in the output stage). The output of the corrector (X6) must be tied to the common wire with a 300 ÷ 500 kÿ resistor, the resistor is installed directly on the output connector.

To maximize the magnetization inductance of the inductor and pull the strip down, the inductor core is assembled without a gap. And to compensate for the quiescent current of the repeater, an additional winding W2 was introduced, the current through which is set by resistors R18, R19. In principle, this allows you to adjust the operating point of the throttle on the magnetization curve.

Supply system

I will not give a complete diagram of the power supply system, since there is no need to make it exactly like that, but I will determine the basic requirements. First - all supply voltages must be stabilized, and - well.

The requirements for the +530 volt circuit are moderate - it is quite enough to provide a ripple level within tens of millivolts and a stability of a couple of percent. Given the presence of a parametric stabilizer directly on the board, the stabilization will already turn out to be two-stage. In principle, a simple parametric stabilizer on a single transistor will do.

The requirements for the +200 volt circuit are more stringent - the level of noise and ripple at the output of the stabilizer should not exceed hundreds of microvolts. It is desirable to provide instability within 0.5÷1 percent. You can use one of the stabilizers listed on the site. A solution with two-stage stabilization is welcome - a primary stabilizer and channel-by-channel stabilization for each corrector channel. For secondary stabilizers, LM317s are great, of course, with appropriate protection. In principle, I have a power supply system and is implemented in a similar way -

primary stabilizer for both channels, secondary stabilizers for each channel separately. The main disadvantages of this approach are the increased power consumption.

Particular attention should be paid to reducing the switching noise of the rectifiers and the penetration of RF noise from the network. And the general recommendations are as follows - the mandatory presence of a shielding winding in a power transformer, the use of a rectifier with an average point for the main channel

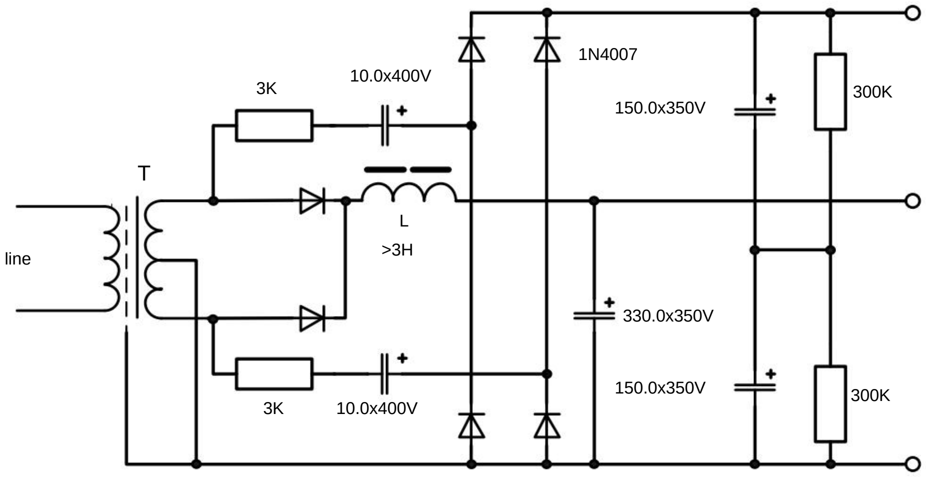


Figure 2

coy and a filter starting with an inductance. Figure 2 shows the implementation of this approach, in fact, this is the rectifier circuit used in the corrector.

Both necessary voltages are obtained from one winding with a midpoint.

Design, setup, details

I want to immediately draw the attention of readers to the fact that, despite the rather simple scheme, the repetition of the construction can cause certain difficulties. This is mainly due to the fact that good end results depend on the careful selection and selection of a number of components, which implies a sufficient number of them for manipulation.

The most troublesome procedure is the selection and selection of transistor VT2 in pairs. For transit For stores with this index, the typical value of the drain current at zero gate voltage is 4mA. Transistors with a drain current value in the region of 3.8÷4.2mA are suitable for the corrector. Since the curve graph is not a very common device, the simplest, and probably the most correct way is to control the parameters of transistors directly in the circuit. To do this, you need to assemble a layout of the input stage (and preferably a repeater according to a simplified scheme: exclude capacitance C10 and short-circuit the working winding of the inductor) and measure the parameters of the entire amplifier. Two parameters are controlled (required) - the voltage at the VT1 drain (or at the output of the repeater, taking into account the bias) and the gain. It is desirable to control the noise level. According to these parameters, the rejection is made. The allowable value of the voltage at the drain of VT1 is 120 ÷ 90 volts, and the gain is 800 - 1200. The value of the gain, in general, is not very important. Within very small limits, you can adjust the gain and quiescent current by introducing a resistor R7. When selecting in pairs, it is necessary to ensure the minimum difference between the values \u200b\u200bof this resistor in both channels. The value of this resistor lies within fractions - units of ohms.

It is also required to pair the input resistor R2 and elements of frequency correction circuits - R5, R6, R8÷R11, C8, C9. An accuracy of 0.5% is desirable. The accuracy of capacitances ÿ1÷ÿ5 is quite sufficient at 5%.

As R5, R6, it is desirable to use a resistor of the MF02W type, R8÷R11 can be of any type with good linearity and low noise level. Both MF0W4 and C2-36. Capacitances in the corrective chain K71-7. To other components, any special requirement
no.

It should be borne in mind that the variable component of the signal flows through the capacitances C4, C10, C14, C15. Accordingly, it is necessary to take care of the quality of these containers. With the correct assembly of the channel and the use of serviceable components, no additional adjustment is required. It is only necessary to check the value of the quiescent current of the output stage and the compensating current by the voltage drop across the resistors R14 and R18, R19 (having previously accurately measured their resistance).

Structurally, all elements of one channel (except for the output choke and capacitance C14) are placed on the printed circuit board. Transistors VT3, VT4 are installed on a cooler with an area of about 200 cm2
, SMD transistor VT1 is soldered to a printed polygon with an area of about 0.5 cm2 . Then the boards of both channels are connected into a single block, which is already attached to the carrier chassis. It will be quite good if the block is mounted on the chassis through shock-absorbing washers.

How it all looks assembled is shown in Figure 3.

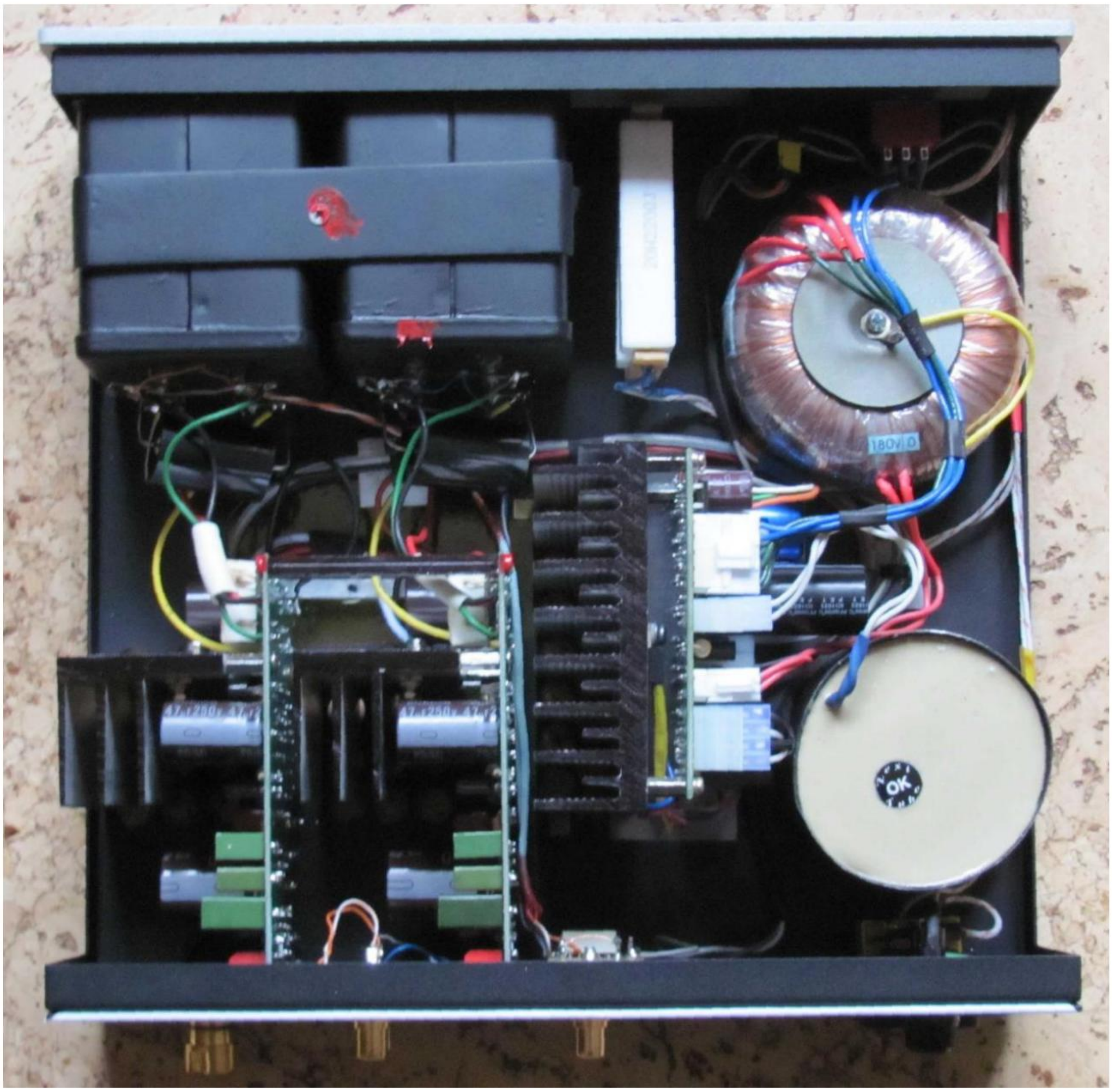
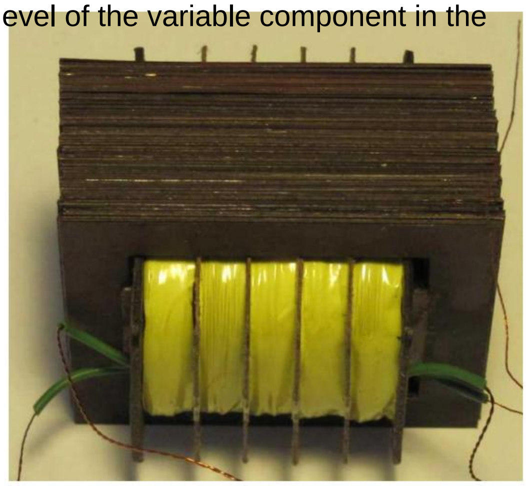


Figure 3

The output choke uses a ShP 20x28 core and deep vertical sectioning. Sectioning allows you to significantly reduce your own parasitic capacitance and attribute the resonant phenomena in the inductor far beyond the sound range. To reduce the change in inductance with the level of the variable component in the inductor and good performance in very weak fields,



a combined core of steel type 3416 (90% of the volume) and permalloy 50NU (10% of the volume) is used. The inductance of the inductor is in the range of 24-25 G.

First, a compensating winding is wound on the frame, containing 2500 turns of PET-155 wire d=0.13mm (500 turns per section, the active resistance of the winding is about 300 Ohm). After laying the interwinding gasket, the working winding is wound also 2500 turns with PET-155 wire d=0.19÷0.22mm. Both windings are wound in bulk. Poor magnetic connection between the windings is welcome. After assembly and testing, the choke is placed in a steel shielding case and sealed.

Conclusion

Giving subjective assessments is not a thankful task. The only thing I can say is that I like it. result.

But it makes sense to touch on some objective parameters. At an output voltage of up to 1 volt, only the second harmonic is present in the distortion spectrum. In fact, this is the nominal operating mode. As the output level decreases, there is an almost proportional decrease and level of the 2nd harmonic. With an output level of hundreds of millivolts, it is not so easy to detect the second harmonic, it is necessary to press the fundamental frequency with an additional filter (below -100dB). As the output level rises above 1 volt, higher harmonics begin to appear, in exactly the same way as it happens in a linear tube cascade. The envelope of the harmonic series falls off approximately exponentially. At the maximum output voltage of 40 volts, the maximum observed harmonic is the sixth, with a level of about -90dB, the second harmonic has a level of -34dB. The overall level of distortion increases to 1.9%. But this is just an outrageous regime.

Well, I just consider it necessary to remind readers who decide to repeat the circuit that rather high voltages and rather large capacitances are used in it. Any inaccuracy can be fatal for the circuit itself or guarantee a lot of discomfort for the designer. Be those are careful.