HYBRID AMPLIFIER

Evgeny Karpov

This article is of a purely practical nature and is devoted to the practical implementation of a hybrid amplifier. The main interest, of course, is the implementation of the output stage (the theoretical background of its work is described in detail in the article "Hybrid World"). Actually myself
the amplifier consists of several independent nodes - the output stage, the driver, the protection system output from overloads and a constant component, a prestabilizer. Here we will touch only the nodes of the audio path, the rest of the nodes can be implemented according to any known schemes. But
the driver can be completely different, including a solid state one.

If we return to the output stage, then we can conditionally say that this is the fourth generation devices built according to this ideology. The scheme has already eliminated most of the childhood diseases, it has good repeatability, and more than 5 years of operation of such amplifiers has shown them
high reliability. By the way, one of these amplifiers works for me and is used as a reference.

The output stage operates in class "A" and has mixed properties between push-pull and single-ended stages, but in terms of the nature of the introduced distortions and the short "tail" of harmonics, it is closer specifically for a single-cycle lamp circuit. If desired, you can consider it as a two-stroke asymmetrical cascade.

It is not so important how this scheme is classified, more interesting for readers will be the subjective sound rating. You can immediately say that fans of the classic single-cycle tube sound will probably not be satisfied with it. The absence of an output transformer and broadband (range of operating
frequencies of the output stage extends from a few hertz to hundreds of kilohertz), the high slew rate of the output signal leaves its mark on the sound. The sound is accurate and fast, all small nuances are transmitted. It has some of the sound of a classic solid state amp, but it doesn't have the dryness and scratchiness that comes with many deep feedback amps. Naturally, completely
there is no such unpleasant phenomenon as the growth or stabilization of the level of distortion at low output capacities.

The amplifier is behaving “correctly”, reducing the output power leads to a decrease in the level of distortion and the gradual disappearance of higher harmonic distortions, intermodulation distortions also fall. In the region of low and medium powers, the distortions of the tube driver become dominant. At maximum power (15W), the level of distortion of the entire path does not exceed
0.15%, and the maximum observed harmonic is the eighth. When the power is reduced to 10 watts, the level distortion drops to 0.07%, and the maximum observed harmonic is the third.

Output impedance - 0.3÷0.4 ohm, the amplifier works normally with almost any 8-ohm
acoustics with a sensitivity of more than 86÷87 dB. Because the output clipping level
is determined by the output stage and occurs quite abruptly, it is desirable to have a peak output power indicator in the amplifier.

The circuit of the output stage is shown in Figure 1. The only transistor VT1 is the amplifying element itself, all other components ensure the stabilization of its mode.

Op-amp DA1 stabilizes the zero potential at the output of the amplifier, transistors VT2, VT3, VT4 together with resistors R6, R8, R10 are a controlled current source with two inputs.

The potential at the first input (base VT4) sets the quiescent current of the output stage, through the second input (emitter VT4) a control signal is introduced that is proportional to the load current. Required coefficient proportionality is provided by a linear amplifier on the op-amp DA2. Basically, the use
an operational amplifier is optional, but allows you to reduce the resistance of the current sensor, which swarm directly affects the output impedance of the amplifier.

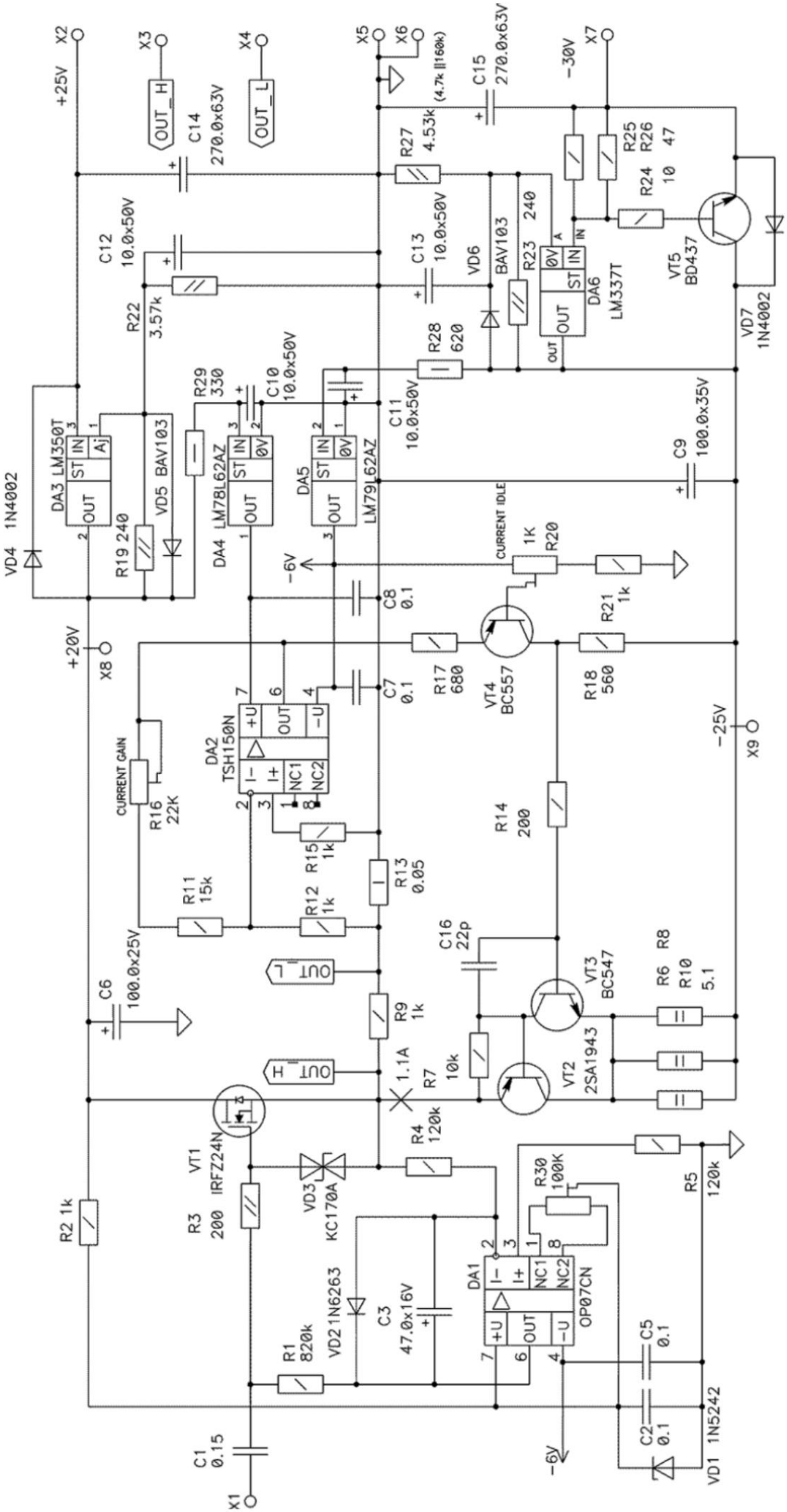

Рисунок 1

The output stage is powered by its own local stabilizers located in close proximity to it. In general, given the large number of components and broadband, it is advisable to implement the output stage on a separate printed circuit board of minimum dimensions.
(the use of SMD components is welcome), in which all power components are soldered. All the structure is attached to the cooler. The use of local stabilizers significantly reduces crosstalk, which allows one primary source to be used to power both output stages. And the main thing: a stabilized diet helps to reduce

all kinds of distortions of the sound path itself.

The primary bipolar power supply must ensure the instability of the output voltage of the order of 3÷4%, have sufficient energy capacity and maximum peak output current about 5 amps (2.5 amps per channel). You can use it as the simplest linear stabilizers with secondary side, and a group stabilizer with the inclusion of a regulating element from the primary side of the power transformer. The capacitance of the filter capacitors of 10000.0 micro farads per channel is quite sufficient.

The total power dissipated by such a module reaches 65 watts, respectively, with this it is necessary and choose a suitable cooler with an effective area of about 1300÷1500 cm2 . As a general recommendation, it is desirable to heat the module cooler to a temperature of 40÷50°C under normal conditions. There are no special requirements for components and their types, the main thing is that they should not be “left”, of an incomprehensible origin. Resistors R16, R20 are multi-turn. Attention should be paid to the quality of the capacitor C1, the current sensor R13 must be non-inductive (a resistor was used ERJL1WKF), op-amp DA2 must have a bandwidth of at least 150 MHz and a fast settling time.

With serviceable components and proper assembly, setting up the module is not difficult. The variable resistor sliders are set to the middle position, supply voltages are applied and set resistor R20 quiescent current. The output voltages of local stabilizers are checked, if necessary, they are adjusted, the circuit is allowed to warm up and the quiescent current is corrected. A sinusoidal signal of 1 kHz is fed to the input and, gradually increasing it, they achieve the minimum distortion level at maximum power by resistor R16. Incidentally, the tuning criteria can be different: the minimum distortion at maximum power, the minimum length of the "tail" of the harmonics at a power close to the maximum, the desired character of the decay rate of the "tail". For conscious manipulations during tuning, you need to use a spectrum analyzer, you can try this do by ear. In any case, the final adjustment of the coefficient in the stabilization loop should be carried out on a finished amplifier with alternate objective and subjective control.

The use of a lamp driver is not an end in itself and not a tribute to fashion, there are more technical prerequisites. The tube driver allows for a large output swing with good linearity without the use of deep feedback circuits, and in most cases it is possible to do without a common negative connection at all. It is impossible to get around the fact that the slight coloration, which the tube part of the path still brings, makes the sound more comfortable subjectively. Explain this relationship is not strictly possible at the moment, although a correlation between objective parameters and subjective perception is observed. So designers have the opportunity to experiment with both driver modes and implementation.

The driver circuit is shown in Figure 2. At the input of the driver, a cathode-coupled cascade is used and dynamic power. It provides small and stable input capacitance and large output voltage swing with good linearity.

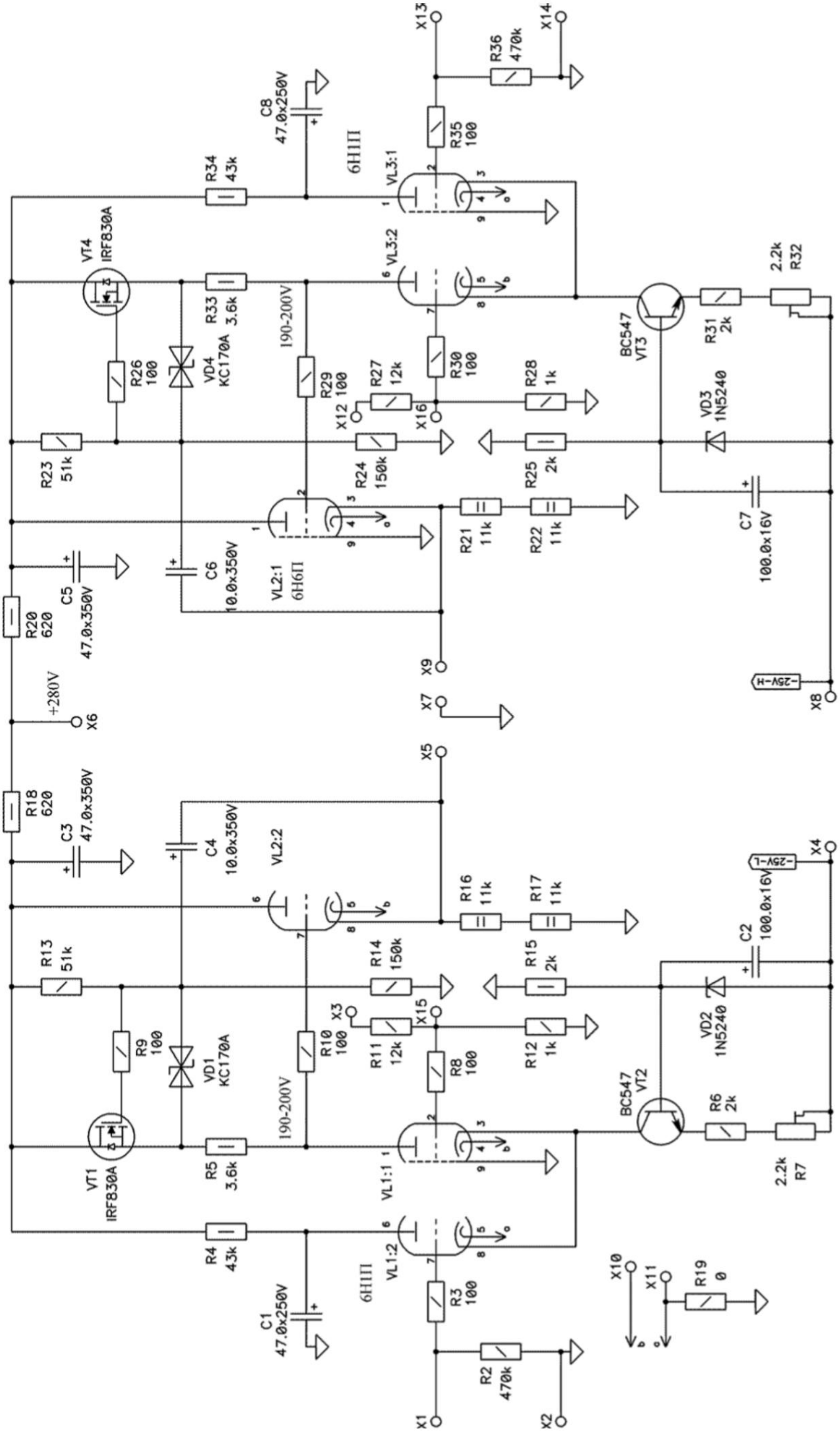

Рисунок 2

A cathode follower is installed at the output of the driver, separating the amplifying stage from the line communication with the output module and from the module itself. Although the presence of this cascade is not necessary, but it improves the frequency characteristics of the path and increases the linearity due to the unloading of the output of the first cascade. This also made it possible to choose the quiescent current of the first stage sufficiently small. The driver scheme provides for the possibility of introducing a shallow common operating system. To do this, on the second input of the first cascade (X3, X12) a signal is supplied from its output. If the OS circuit is not used, then the second input is grounded (X15, X16 are connected to a common wire). Driver gain approx.
is equal to the value of μ of the first lamp. With these lamps, the sensitivity of the amplifier turns out to be about 0.4 volts, which allows it to be used with most sources without preamplification
la, simply by setting the volume control at the input.

The driver is powered by two stabilized sources. The voltage of the anode source is 280 volts, the ripple level is not more than a few millivolts. The stabilizer can be any
including one of those described on the site (for example, “High-voltage stabilizer with a low level pulsations). If a group stabilizer is used, then you can get by with just a zener diode
medium power to the desired voltage. Special long-term stability is not required here, the ripples at its output will be decisive. Current consumption in this circuit is about 20mA. The negative voltage is taken from the stabilizer of "its" output stage. If the supply voltages are well filtered, then the level of noise and background at the output of the amplifier is not
exceeds – 97 dB.

Structurally, the driver can be implemented both by surface mounting on jointing panels and on a printed circuit board. Coolers for transistors VT1, VT4 are not required. Mounting requirements are standard for this type of device. The requirements for the components have not changed - high-quality and well-known manufacturers. Resistors R7, R32 are multi-turn. Imported analogues of Soviet lamps also work well (if it is important what is written on the lamp), naturally with mode adjustment. Lamps VL1:1 and VL3:2 should preferably be paired.

Setting up the driver is very simple, the resistor R7 (R32) on the anode of the lamp VL1: 1 (VL3: 2) was installed voltage is about 200 volts.

I want to draw the attention of readers that the article is aimed at fans of a fairly high qualification, since it only touches on the main issues of manufacturing an amplifier. All questions related to the power system, protection, construction are simply omitted on the assumption that the reader
knows what and how to do and has some experience in the manufacture of such devices. Also need
take into account that a large number of solid state devices, on the one hand, and the presence of high voltages, on the other hand, require both compliance with safety regulations and certain caution
during various manipulations with the device. Rough and hasty action can be fatal for half of the scheme. So before you take on the repetition, there is washed away objectively
weigh your options.

In conclusion, I want to add that the amplifier is very good paired with highly sensitive broadband acoustics, and fits perfectly into multiband amplification systems as a mid-high channel.