STABILIZED SINGLE STROKE CASCADE ON A VACUUM TRIODE

Part 2

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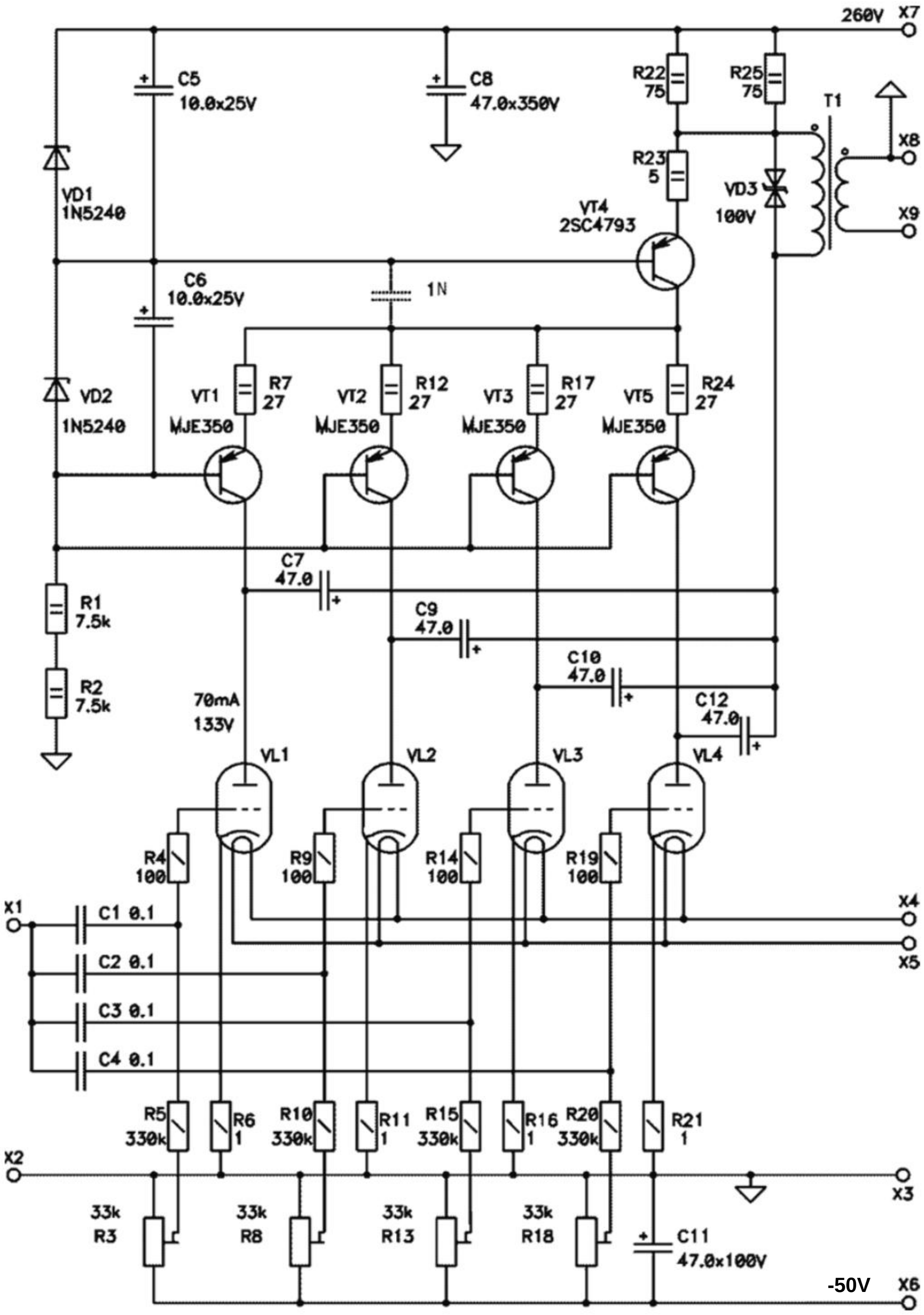
The circuit below is a practical example of how to implement a powerful ESE output stage.



Picture 1

The implementation of a sufficiently powerful output stage has a number of features, mainly related to the limitation elements base. The fact is that the nomenclature of high-power high-voltage PNP or P-MOSFET stores is very limited, and the circuit is most simply implemented on lamps with relatively low operating voltages. In principle, there are no theoretical restrictions on the type of lamp used, but the use The use of "high-voltage" lamps leads to some complication of the circuit. To get around these limitations, cascade implemented on four 6S19P lamps connected in parallel.

The lamps of the output stage are connected both in direct and in alternating current in parallel. For balance The circuit of the controlled cascode current source was slightly modified for the lamp currents. Actual current rest of the entire cascade sets the current source on the transistor VT4, dynamic control of the output current ka is carried out by introducing a signal proportional to the load current into the emitter of this transistor. the value coefficient K can be adjusted by changing the ratio of resistors R23 and R22 ÿÿ R25.

The total resistance of these resistors (R23 + R22 ÿÿ R25) must remain constant to ensure niya constant quiescent current of the cascade. At the time of tuning, it is advisable to replace these resistors with a powerful one. belt resistor.

The output stage of the current source is divided into four channels formed by transistors VT1, VT2, VT3, VT5. The inclusion of additional resistors in their emitters ensures uniform distribution of currents through lamps (the error does not exceed a few percent). This allows (with a stabilized helmet power supply) yes) load the lamp in terms of power by 90 ÷ 95% without the risk of damaging it. This construction of the cascade allows increasing to change the output power by simply connecting additional cells in parallel. All AC the anodes of the lamps are combined through summing capacitances (C7, C9, C10, C12). Equivalent output impedance cascade from the side of the anodes is at the level of 100 - 120 ohms. Very low output impedance and no bias in the transformer greatly facilitates its implementation and minimizes the effect non-linearity of the magnetizing current of the core.

The lamps operate with a fixed bias and the mode of operation of each lamp can be adjusted independently by resistors R3, R8, R13, R18. For alternating current, the grids of lamps are connected in parallel through a separate body containers. At first glance, this solution may seem cumbersome, but it allows you to use lamps without much prior selection, select 8 lamps in amateur conditions with identical characteristics teristics is quite difficult.

The negative point is the increased load on the driver due to grid resistors.

A suppressor (VD3) is connected in parallel with the primary winding, it protects the current source from damage when amplifier overload and transients when turned on. To completely eliminate the theoretical influence the suppressor can be replaced by a vacuum arrester with a response voltage of 90-100 volts.

The output stage itself has the following parameters:

Maximum output power Rated load impedance Gain	8W
(excluding output transformer) ÿ2.5	8ÿ
output impedance	ÿ1.2ÿ
Power band Excitation voltage	10Hz÷30kHz
Anode power consumption	ÿ18Vrms
	80W

From the point of view of an external observer, the circuit behaves like a classical single-cycle cascade, but has better linearity and better dynamic performance compared to the classical implementation. The large quiescent current allows the amplifier to handle complex loads well. Subjectively, this is expressed results in better detail and even tonal balance. Below are the dependences of the total coefficient Harmonic ratio and distribution of harmonic levels from the output power.

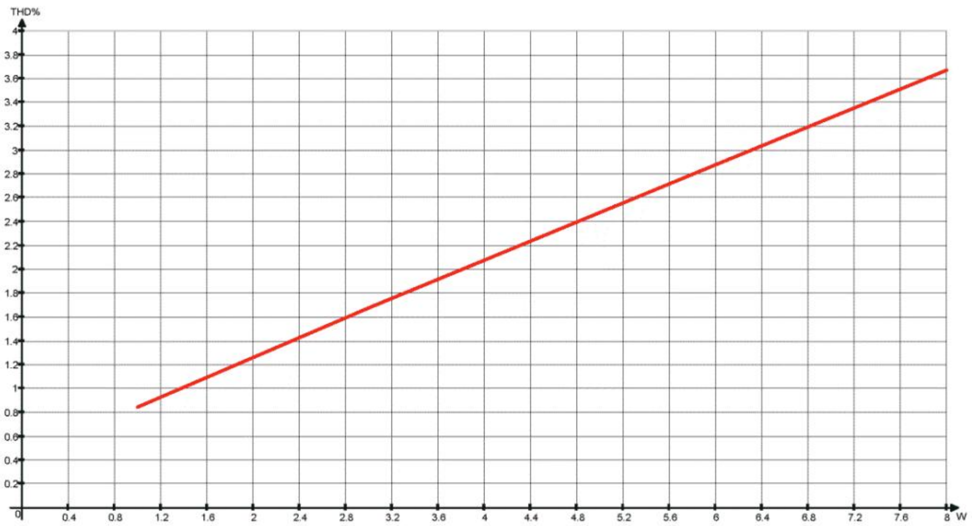


Figure 2

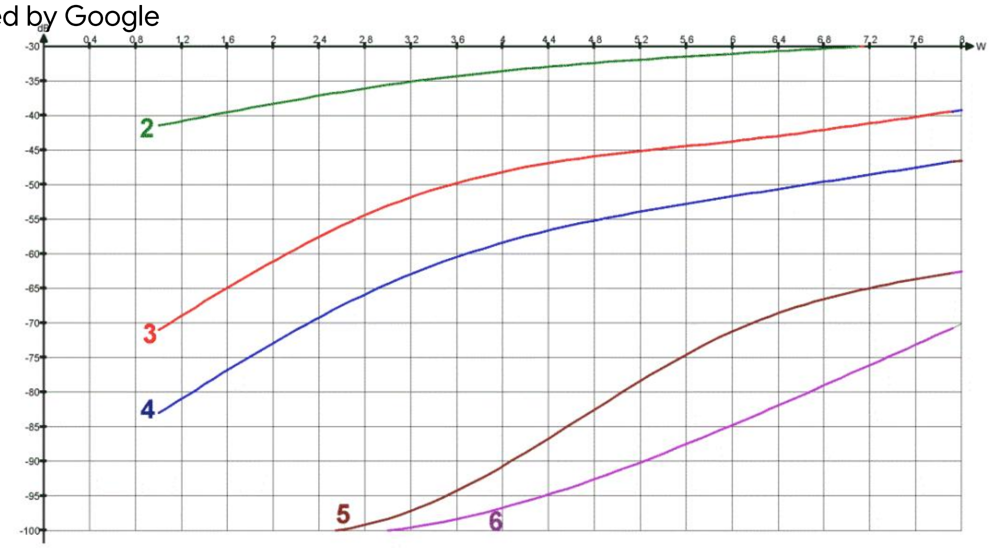


Figure 3

A pleasant surprise was the linear increase in distortion with increasing output power up to
the beginning of the limitation, and the fact that there are few harmonics - by itself. This suggests that the shape of the distortion envelope, close to favorable, is maintained over the entire range of output power. For a better understanding of ha-
The distortion factor in Figures 4 and 5 shows the spectrum at two output power levels (1W and 9W).

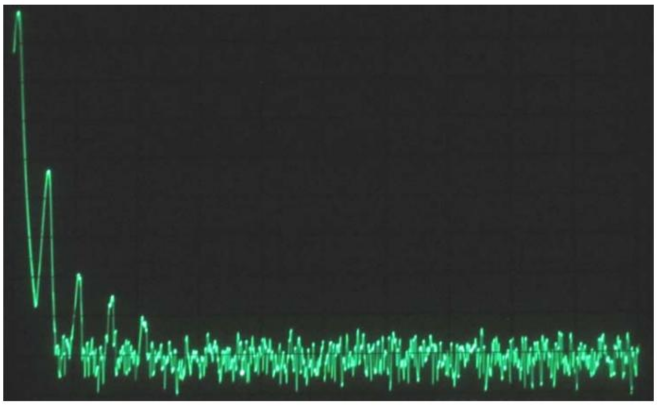


Figure 4

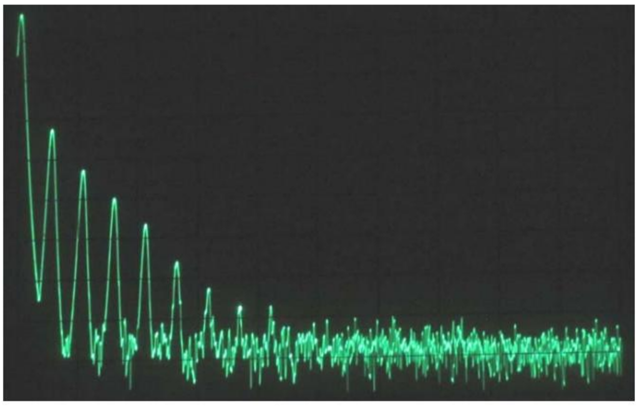


Figure 5

There are no special requirements for the implementation of such a cascade in hardware. The output transistors are many channel current source, it is desirable to place on a common radiator of the appropriate area (dissipated power of the order of 30 watts) to ensure the same temperature of the crystals. And the transistor VT4 - on a separate nom radiator with an area of about 100 cm2 . In the layout version, the current source was assembled as a separate unit with forced cooling with a low-speed fan. Separately, it is necessary to dwell on the summing capacities C7, C9, C10, C12. Nichicon containers were used in the layout, in principle, nothing prevents (except cost) from replacing thread them on film or paper containers and slightly reduce their face value. Here it should be borne in mind that a decrease in the capacitance rating leads to a shift in the resonance frequency of the circuit formed by an equivalent capacitance bone and magnetization inductance of the transformer in the audio frequency range. As a result, you can to receive an undesirable (or desirable) rise in the frequency response of the cascade in the low-frequency region.

The cascade supply voltage must be carefully filtered and the power supply must have sufficient new energy. The amplitude of the current consumed from the source can reach 360mA. The ideal option is to bilized power system.

The magnetization inductance of the transformer is chosen large enough - 2 Henry. This allows, taking into account the small output resistance of the cascade, minimize the influence of non-linear current components core magnetization. The transformer is wound on a core ShLM 25x32 made of steel 3413 with a deep section nirovanie.

The primary winding contains 7 sections of wire PEL-0.27 of 135 turns, between the sections of the primary winding 6 sections of the secondary winding of 36 turns of wire PEV2 -1.12 are wound. Line winding, intersectional insulation PET film 0.1 mm thick in two layers. This design results in exceptionally low leakage inductance. In principle, the core has somewhat oversized dimensions. For the prototype, the cores and winding wires available were used. As a result, the transformer window is not completely filled. So, if you wish, you can still work on the transformer in the direction of optimizing its parameters - reducing the resistance of the windings and increasing the magnetizing inductance. The widely used steels 3410, 3411 are also quite suitable for the core. When choosing a magnetic circuit, it is necessary to look for a core with approximately the same cross section, but a shorter magnetic line. It may be necessary to recalculate the number of turns of the windings, only it is necessary to save the value of the transformation ratio between the primary and secondary windings.

Establishing a cascade with proper assembly does not cause any particular difficulties. A bias voltage of the order of -35 volts is set on the grids of the lamps. The anode voltage is set at 160-170 volts, the voltage at the anodes of the lamps is set to about 130 volts (by adjusting the bias voltage), and the current of each lamp is controlled. If necessary, adjust the total current of the cascade by adjusting (R25 or R22). Permissible spread of lamp currents 2-3mA. Then the anode voltage is increased to the nominal voltage and the voltage at the anodes of the lamps is adjusted. If desired, by replacing the resistors R23, R22, R25 with a variable resistor (the transformer is connected to the middle terminal), you can adjust the value of the K coefficient by ear. Lastly, check the absence of self-excitation of the current source. In the presence of self-excitation (depending on the installation), a corrective capacitance is installed and selected.

In conclusion, I want to say that other types of lamps with similar parameters were tested in the cascade. Lamps 6N5S and 6N13S were tested, and this is what happened in such a scheme. The worst result was shown by the 6N13S lamp, 6N5S took second place, and the best result was obtained with 6S19P. Remarkably, the subjective perception is largely influenced not by the integral characteristic - the coefficient of harmonics, but by their envelope
schaya.

