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Pentode's ultralinear mode

pre-amp stages

When designing tube amplifiers, the problem often arises of obtaining a given clock transfer coefficient. Especially frustrating when you need to get a boost around 30÷40dB. A single stage on a triode cannot provide the desired gain, and a single stage on a pentode, given the requirements of good linearity, has gain more than necessary. Naturally, you want to get everything at once - the desired gain, the minimum number of stages and good linearity.

These generalized wishes were supplemented by specific requirements related to using cascade. The cascade was intended to compensate for losses in corrective preamplifier circuits and, accordingly, had to have a large input impedance and a low noise level. Since the overall OOS, covering several cascades, for true audiophiles, something like

a red rag for a bull, then this option was not even considered. To be fair, it should to say that in such rejection there is a share of objective factors that can be partially circumvented circuitry, but this leads to a significant complication of the circuit. Therefore, the main attention was paid to the cascade on the pentode and ways to reduce its gain to the desired value. In general, it turned out that feedback was indispensable. Another conversation - like her rea

lick.

What kind of troubles can be expected from the classic options for introducing a local OS, in general, it was clear, but I was interested in another option - introducing an OS into the circuit of the second pentode grid. This method has been known for a long time, it is widely used in the output stages of amplifiers, but very rarely. used in pre-stages. And judging by the results, completely in vain. I want to separately draw the attention of readers

to one very important point. According to formal features, the supply of a part of the output signal to the circuit of the second grid is feedback, but the mechanism of its action is essentially different. If the classical version of the introduction of the OS involves vector summation of the input and part of the output signal, then in the case of introducing a signal into circuit of the second grid, the dynamic characteristics of the lamp change. In general,

it makes no sense to describe all intermediate options for implementing the cascade, and Figure 1 shows its final version. To ensure the possibility of working on a sufficiently long interconnect cable, the cascade was supplemented with an output cathode follower. I want to say right away that the implementation variant was tested only on lamps, it did not show any objective or subjective advantages, and such a hybrid variant turns out to be simpler and more economical.

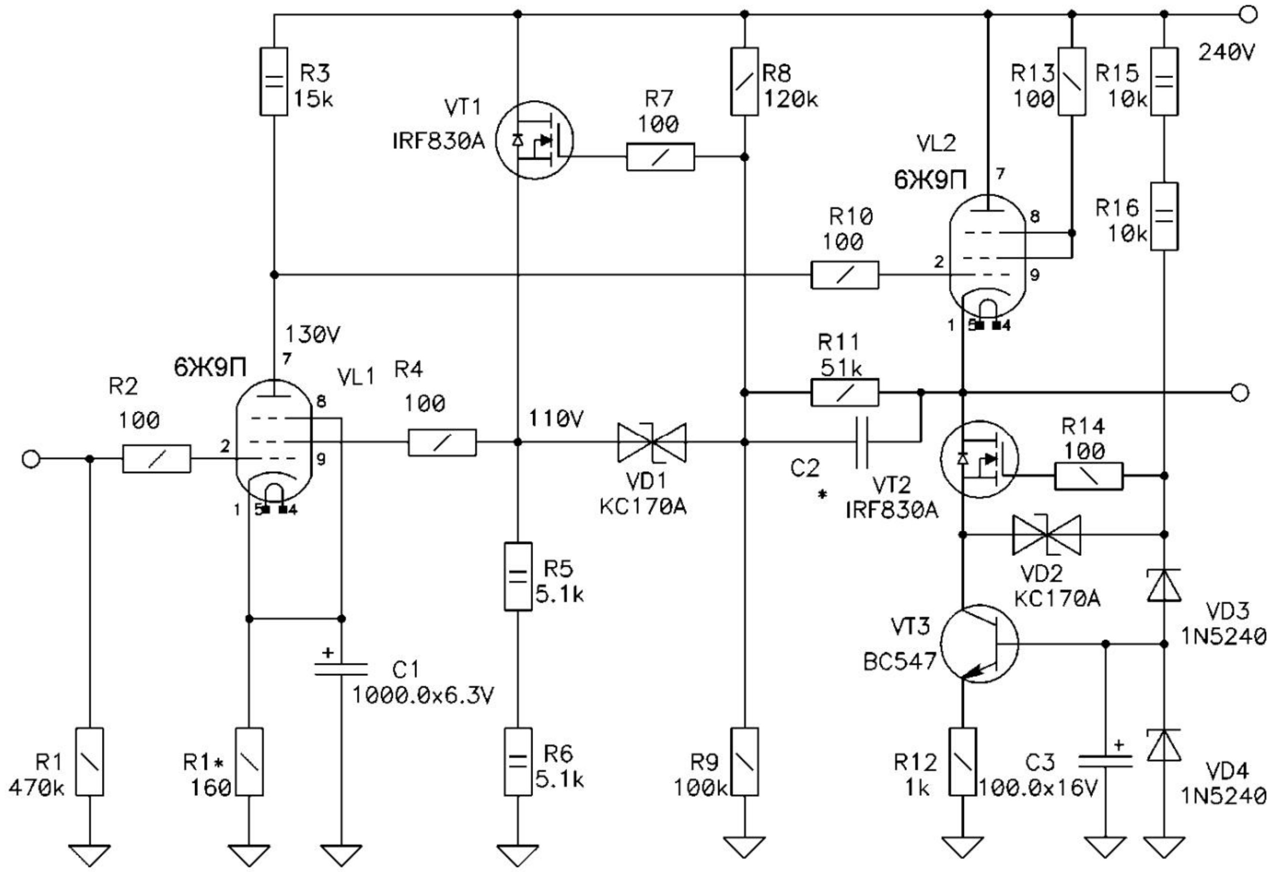
The amplifying stage (VL1) is made according to the classical scheme with automatic bias. The OS signal is introduced into the second grid circuit using a source follower (VT1) from the output cascade.

To obtain good linearity and a symmetrical impulse response in the output cathode The repeater uses a cascode current source.

Below are the main parameters of the cascade, all measurements were carried out in a mode close to the operating one - the output voltage is 2VRMS, the load resistance is 10kÿ, the load capacitance is 200pF.

Gain Power band Slew rate
Output impedance Input
capacitance Harmonic distortion Maximum output
voltage (THD = 0.07%)

60
10Hz÷1MHz
20V/µS 70ÿ
120pF
0.02%
10VRMS



Picture 1

The depth of the OS in such a cascade is determined not only by the magnitude of the OS voltage supplied to the second grid, but also the parameters of the lamp itself. By manipulating the value of the anode load of the amplifier tube VL1 (choosing the optimal operating point) and the ratio of the divider that determines the depth of the feedback (R8, R9, R11), you can get the desired gain with the maximum linearity of the cascade. Strictly speaking, mode optimization must be done for each specific lamp, but good

results are also obtained if such optimization is performed once for lamps of the same type.

The most interesting was the direct comparison of the cascade parameters with the introduction of the classical parallel OS and the OS introduced through the second grid (Table 1). In both cases, the mode lamps for direct current remained unchanged and, of course, the same lamp was studied.

Table 1

Working mode	Coefficient amplification	Level two harmonics (dB)	Level three Harmonics (dB)	Coefficient harmonics (%)
Without	150	-62 -66	-86 -83 -97	0.08 0.045
OS Parall.	60	-75		0.017
OS UL mode	60			

Harmonics of higher orders could not be registered. Or they are absent, or lie below -130dB.

As a matter of fact, the results speak for themselves - the conversion of the pentode to ultralinear the regime at a given gain made it possible to obtain a significantly better linearity than with the introduction of a classical FR. Note that in ultralinear mode both recorded harmonics are reduced, and with the introduction of a parallel OS, only second harmonic. The increase in the third harmonic turned out to be somewhat unexpected, although the depth of the FR is very small. In addition, in the ultralinear mode, the noise level of the cascade is slightly lower and the level of introduced distortions is practically independent of the frequency of the amplified signal.

The cascade has good dynamic characteristics, but despite the measures taken, everything However, there is a difference between the rate of rise and fall in the transmission of a pulsed signal. It is not worth counting on the full symmetry of the fronts in a single-ended amplifier, but if the amplifier has a rather high rate of rise of the front, this innate defect does not have such an effect. Of course, when working on a complex load, the output follower has the main influence on the transmission of a pulsed signal. The use of a current source in the cathode allows reduce the difference between the rate of rise and fall of the fronts by almost an order of magnitude. Should keep in mind that excessive capacitive loading on the output not only increases the duration front, but also leads to the appearance of pulses of emissions at the fronts (this is the myth of "sounding" cables). In principle, this is typical for cascades of any type, the main way to reduce emissions - an increase in the quiescent current and a decrease in the output resistance of the cascade. True, if the amplifier is generally not able to correctly transmit the front, then the problem of emissions becomes irrelevant. relevant. As an illustration, figures 2 and 3 show the pulse front at nominal (200pF) and increased (400pF) load capacitance.

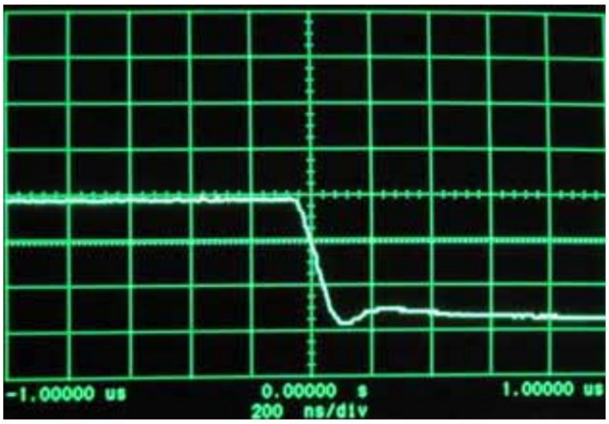


Figure 2

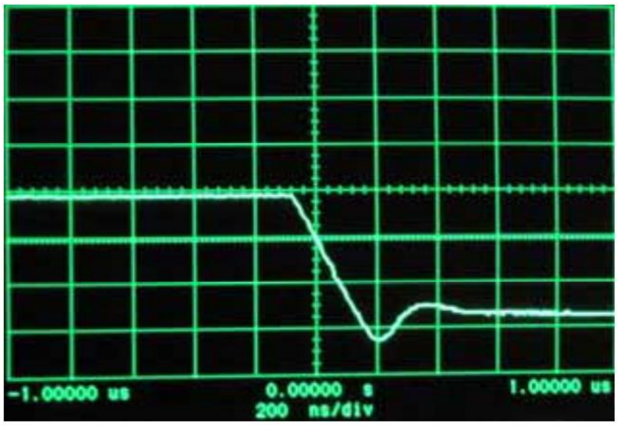


Figure 3

Lamps of different types were tested in the cascade. Tee lamps showed good results pa - 6Zh38P, 6Zh52P, EF86, but the lamp of the 6Zh9P type turned out to be out of competition (in general, the lamp is very good in the triode mode). The repetition of the cascade does not cause much difficulty. When installing, take into account broadband and pay special attention to the relative position of the components and the correct wiring "earth" circuits. The establishment of the cascade is to set the desired voltage on the anode VL1 (resistor R1) and adjusting the gain with resistor R11. After setting the transmission coefficient, it is necessary to re-adjust the VL1 lamp mode. Without deterioration of the cascade parameters, the transfer coefficient can be changed by 15–20% in both directions. When a significant decrease in the gain, re-optimization can be omitted; if the gain increases significantly, then it is desirable to re-optimize the cascade parameters. Capacitance C2 serves to equalize the frequency response in the high frequency range (700÷800 kHz), if you do not have the opportunity to check the frequency response in this area, then set the capacitance to 10÷15pF. The adjustment of the cascade can be somewhat simplified if the mode is "uncoupled" by the direct current of the anode and grid circuit VL1. To do this, a capacitance of several microfarads is connected in series with R11 (with an operating voltage not less than the supply voltage), this does not change the parameters of the cascade, but an extra component is required.

It is desirable to stabilize the power supply of the cascade and ensure a low level ripples of the anode voltage.

In conclusion, I want to note that this method of introducing the OS is not universal and in some degree can be considered a technical curiosity. But on the other hand, if the requirements for the cascade fit into the boundary conditions, allows you to create short audio paths with exceptionally high objective and subjective characteristics.

