NOISE OF THE INPUT STAGE

Evgeny Karpov

Experimental data on noise characteristics are given
resistive cascade when using different types of lamps.

One of the main issues in the design of correctors (which is what interested me mainly) and microphone amplifiers is to ensure a low level of their own noise. In general, recommendations for minimizing noise levels are well known. more attentive
Reading modern publications on this topic only increased the number of questions, and there were some doubts about the validity of some statements. There is no point in dwelling on my doubts, but it is interesting to note something else. There was a strong impression that there is some primary source, located somewhere in the depths of time, and as you move away from
the objectivity of information gradually decreased (entropy grew inexorably). As a result, there were general arguments and estimates by eye. *In passing from that mountain of literature that I looked through, I want to note two books. The clearest practical recommendations are given in*
book - Valve Amplifier (Morgan Jones, third edition), and theoretical issues are most thoroughly considered in the book - Tube Amplifiers Volume 2 (edited by V.I. Sushkevich).

In general, I decided to clarify something for myself. I was interested not so much in the noise resistance of the lamp itself, but in the noise of the entire cascade. It turned out to be not so easy to do this. I had to look for the right equipment, make a special source with a very low level
noise (the anode voltage source has noise and ripple not more than 200μV, the heating source
- no more than 500μV) and build a carefully shielded box to accommodate the test
cascade.

For testing, I took not only the types of lamps that are, by definition, low noise, but also
common types of lamps for a wide range of applications. The triodes were connected according to the circuit shown in Fig. figure 1, pentodes - according to the scheme shown in figure 2.

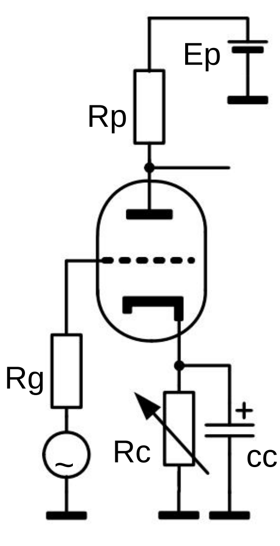

Figure 1 All

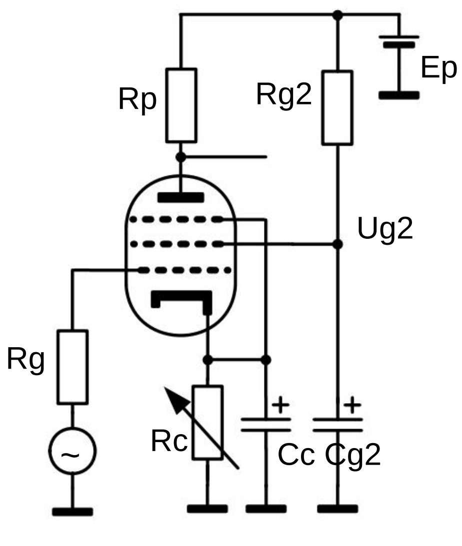

Figure 2

lamps tested were new and trained for an hour at a higher anode current. The tests were carried out under the same conditions: anode supply voltage (Ep) - 240V, filament voltage 6.3V, signal source resistance (Rg) - 600 Ohm, cathode capacitance (Cc) - 2200μF, shielding grid shunt capacitance (Cg2) - 100μF. Capacitances of the EB series (Panasonic), trimming resistor SP5-3, resistors C5-37, and BLP were used.

To measure the gain, the cascade was excited by a voltage of 5 mV with a frequency of 1 kHz, and the level of harmonics was also measured at the same input voltage. The operating mode of the lamp was set on the basis of the following considerations.

First, to obtain a low noise level, the following were chosen: the voltage on the first grid in the region of -1 volt, a relatively low voltage on the anode and the second grid, and a high cathode current. Secondly, the lamp mode had to provide acceptable linearity of the cascade during overload about +40dB. The requirements are generally contradictory, so some compromise was chosen with a bias towards minimum noise.

Now a few words about the method of carrying out the measurements themselves. The measurements were divided into two stage. To set the lamp mode using a spectrum analyzer, the nature and the level of the noise track (in the range 20Hz÷20kHz) and the level of distortion during overload. When the mode seemed satisfactory to me, measurements of the noise level were carried out at two points - at frequency 20Hz and 1kHz. The measurements were carried out with a selective voltmeter in the 3 Hz band with an averaging time of 300 mS. After looking at the noise tracks (very similar to each other), I came to the conclusion that these two points are sufficient to estimate the noise level of the cascade (for use in audio devices).

The measurement results are shown in the table. The following designations are accepted in the table -

IP is the anode current,
Rp is the resistance of the anode resistor,
Ug2 - voltage on the second grid,
K - stage gain,
Uh20 - the absolute value of the noise level at a frequency of 20Hz,
Uh1000 - the absolute value of the noise level at a frequency of 1000Hz,
U20 - noise level reduced to the input at a frequency of 20Hz,
U1000 - input noise level at 1000Hz,
H2 - level of the second harmonic,
H3 - level of the third harmonic.

Lamp type	IP (mA)	Rp (kÿ)	Ug2 (V)	K	Uh20 (µV)	Uh1000 (µV)	U20 (nV)	U1000 (nV)	H2 (dB)	H3 (dB)
6Zh32P	4.3	16	150	33 5.48			166	51	-66	-
6Zh38P	17	eight	100	80	6.7	1.7	83	24	-75	-79
6Zh51P	9	6.8	180	98	3.9	1.93 1.35 39.7 13.7 -54				-
6Zh52P	40	2.4	150	88	3		34	12.5 -55		-88
6Zh52P	19	4.7	1.1 150 140 3.7 2.1 31				26.4	fifteen	-57	-85
6S3P	16.2	8	-	1.55 0.52 34 4.25			50	16.7	-	-
6S15P	35	3.4	-	0.7 31 1.9 0.43 3.6			125	20	-74	-
6S45P	33	4.3	-	1.29 156 19 1.3 527 33.36			61	13.8 -81 56		-
6N1P	9	13	-	23	27 1.38 0.47 17.4			-78		-
6N2P	2.5	24	-	36	-76 25 3.64 0.51	1.45 20.432 47 3.42 65 -61				-
6N23P	11	13	-				51			-85
6Zh38P	21.5	6.5	-							-
6F12P	7.7	8.2	-			3.1	72			-

Some conclusions can already be drawn from the results obtained.

- Lamp noise is still colored. All lamps have a pronounced low frequency noise associated with the cathode flickering effect. The noise level gradually decreases with increasing frequency up to 200÷300Hz (for most types of lamps), and then practically does not change. Therefore, when choosing a lamp for the first stage, relying solely on its equivalent noise resistance is not entirely correct. This is especially important for lamp correctors that have a maximum gain in the low frequency region. A typical example is the 6S15P lamp, which has a very low noise level in the high frequencies (tens of megahertz), and significant low-frequency noise (I checked all five lamps on hand).

- From the above, we can conclude that the assertion found in the literature about the suitability of almost any lamp for correctors is somewhat exaggerated.
- It is necessary to select a lamp in the first cascades not so much by its noise resistance, but by the noise level reduced to the cascade input. Moreover, it is in the low frequency region.
- Pentodes with low noise resistance can compete with low noise triodes. The use of low noise pentodes makes it quite realistic to implement a corrector with only one amplifying stage. *(For example, one stage with a dynamic load on the 6Zh52P pentode has a gain of about 1000 and noise is not much inferior to a two-stage amplifier based on 6S3P triodes).*

In conclusion, I want to note that this small study does not claim to be an absolute the completeness and optimality of the choice of the operating mode of the lamp (since I was looking for a lamp to solve a specific problem and in the presence of certain technical limitations). Accordingly, the results obtained are not the ultimate truth. But although the regime change operation of the lamp and leads to a change in the noise characteristics of the cascade, these changes do not so significant as to level the difference between different types of lamps.

Therefore, I decided to publish the results obtained, since they make it possible to to evaluate effectively the potential noise characteristics of the cascade using different lamp types. And I hope that the above data will be useful to lovers of lamp technology.

