

SPECTRA

Eugene V. Karpov

The English version of the article has been edited
by Andrey Anin a Next Power business consultant.

An article discloses the output spectra of amplifier when using various tubes.

Testing mode

A need for spectra has evolved to choose the most appropriate tube for a SE output stage of a headphone amplifier. A definite schematic needs a triod (or a pentod in a triod mode) providing quite definite output spectrum. Therefore, a definite application of the tube has defined a mode of test: a value of plate current I_p has been chosen in a range of 20÷40 mA, and a value of loading has been chosen as 5 k Ω .

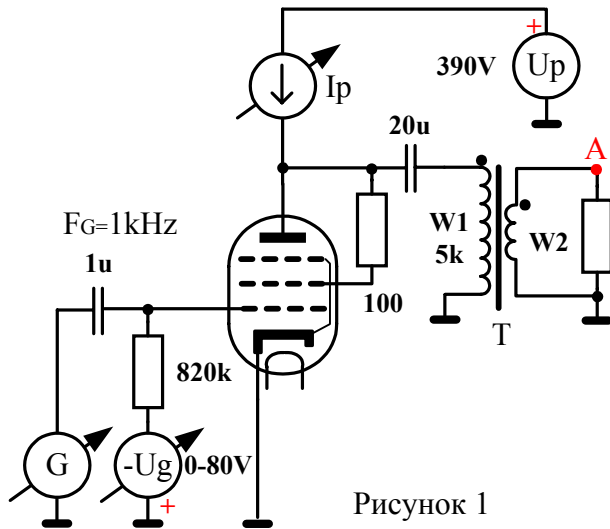


Рисунок 1

For several chosen types of tubes, an amplifier according to a schematic shown in FIG. 1 has been assembled and tested. A spectrum analyzer is connected to an "A" point. Of course, a transformer contributes to a general result, but such a contribution may be neglected at a frequency of 1 kHz.

The pentodes were tested in triode mode. For better convenience to compare results, all measurements have been carried out while with same value of output power equal to 1 Watt (in case a tube has been capable of providing such value).

The value of plate current has been set as high as possible, but not exceeding 40 mA. For the tube, an operational mode providing minimal harmonic distortion has been set.

The test results, to some certain and most careful extend, may be extrapolated to other operational modes of tubes. Such care should be taken especially of the high-power tubes since while being tested, these have not been loaded to a full power.

For bulk of tubes, the following considerations may be proposed.

Decreasing the load resistance with simultaneous increase of plate current quite unsubstancially effects upon a distribution of energy along the output spectrum.

Decreasing the load resistance while maintaining the same value of plate current results in increase of lower harmonics together with higher harmonics evolving.

The same effect is true for output voltage swing being increased. Moreover, in such a case, the higher harmonics increase more rapidly.

Test Results

Herein below, in FIGs. 2 to 16, the output spectra of tested tubes are shown together with operational mode parameters. In Appendix 1, a summarized diagram of output spectra is provided. In Table 1, the normalized levels of harmonics for all tested tubes are provided.

Table 1

Type	Number of a harmonic									Units	Stage Gain
	2	3	4	5	6	7	8	9	10		
6P14P	5,1	0,5	0,056	0,051	0	0	0	0	0	%	13,50
6P1P	4,96	0,36	0,08	0,018	0,016	0	0	0	0	%	7,10
6N6P	5,4	0,26	0,058	0,03	0	0	0	0	0	%	13,13
6S19P	4,3	0,197	0,327	0,09	0,057	0,019	0,013	0,0074	0,0069	%	1,76
6P15P	3,87	0,353	0,026	0,016	0,011	0,0039	0,005	0	0	%	19,00
6P3S	10	0,183	0,3	0,136	0,069	0,009	0,007	0,0068	0	%	5,02
6P21S	6,4	0,389	0,137	0,021	0,0097	0	0,003	0	0	%	5,50
6F5P	4,3	0,57	0,28	0,096	0,016	0,011	0	0	0	%	6,09
EL36	1,9	0,28	0,074	0,048	0,0155	0	0,006	0,0075	0	%	4,37
6P13S	5,6	0,509	0,009	0,076	0,053	0,009	0,013	0	0	%	5,70
6P9	2,8	0,54	0,067	0,058	0,01	0,011	0	0	0	%	15,50
EL37	3,7	0,362	0,07	0,068	0,026	0,0099	0,0083	0	0	%	9,20
6N13S	3,03	0,25	0,24	0,041	0,089	0	0,03	0,009	0	%	1,69
6P41S	2,31	0,25	0,1	0,04	0,013	0,0034	0,0069	0,0041	0	%	4,34
6P44S	3,55	0,33	0,0765	0,039	0,0165	0,0047	0,0044	0,0039	0	%	4,17

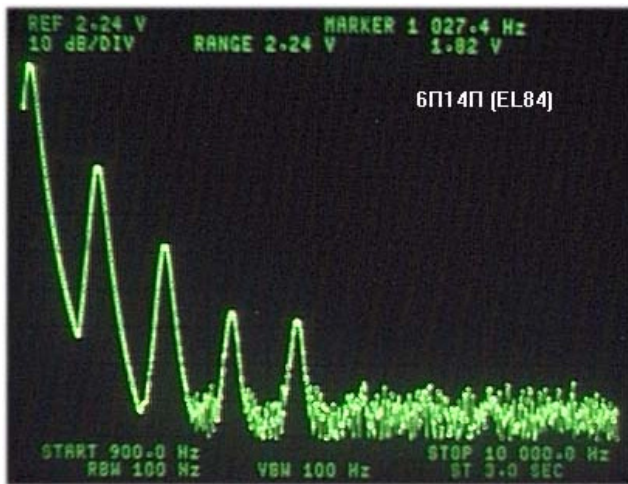


Figure 2
Up=263V, Ip=34.2mA Ug=-8.34V

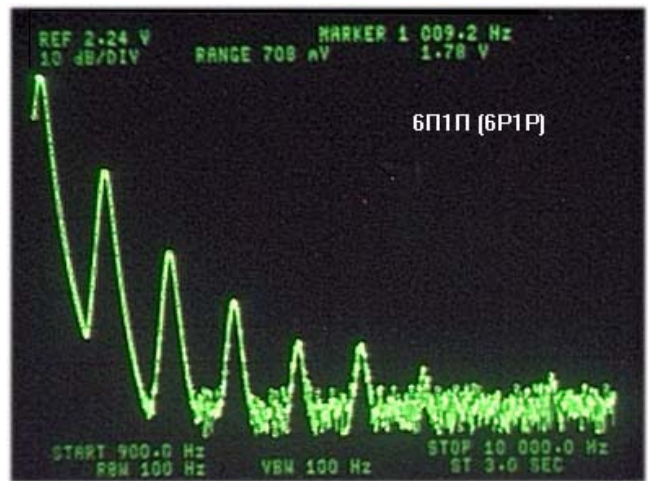


Figure 3
Up=243V, Ip=31mA, Ug=-15.76V

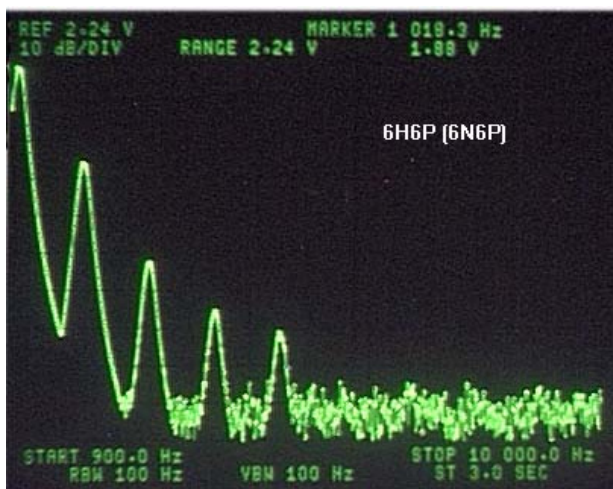


Figure 4
Up=232V, Ip=30mA, Ug=-10.26V

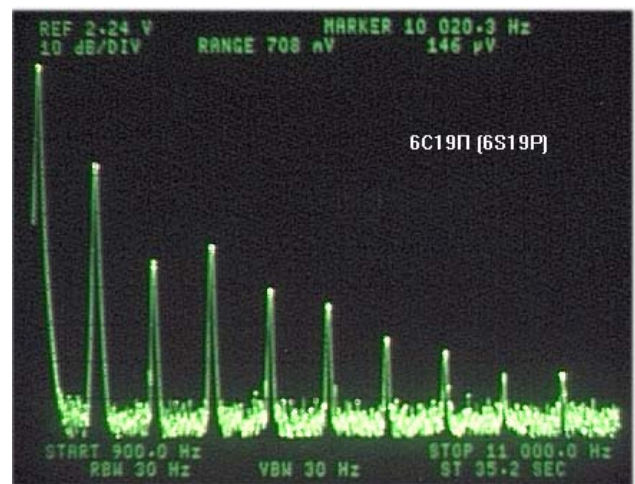


Figure 5
Up=185V, Ip=40mA, Ug=-70.4V

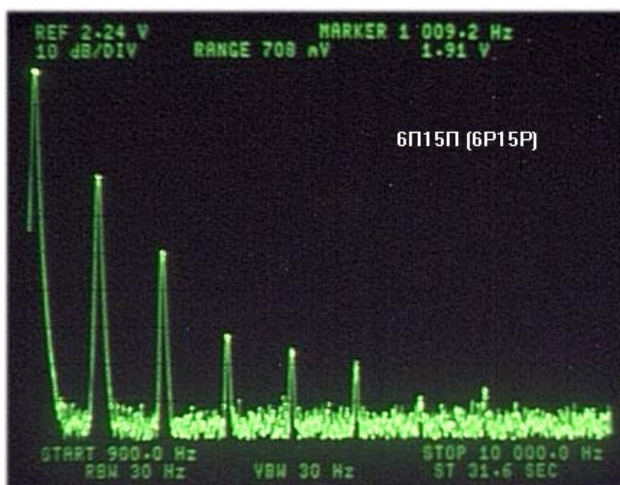


Figure 6
Up=230V, Ip=35mA, Ug=-5.75V

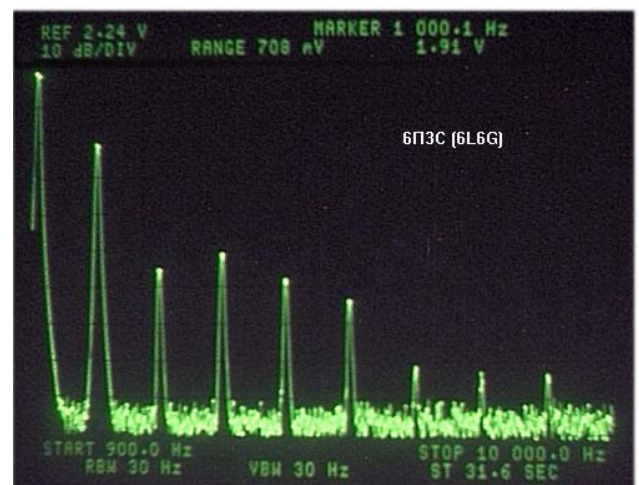


Figure 7
Up=230V, Ip=30mA, Ug=-25V

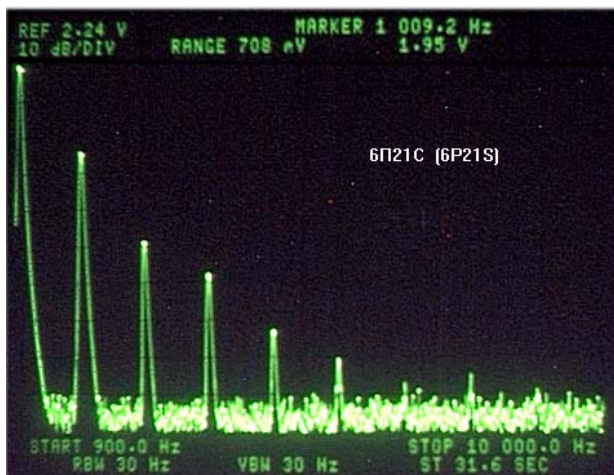


Figure 8
Up=257V, Ip=30mA, Ug=-25.4V

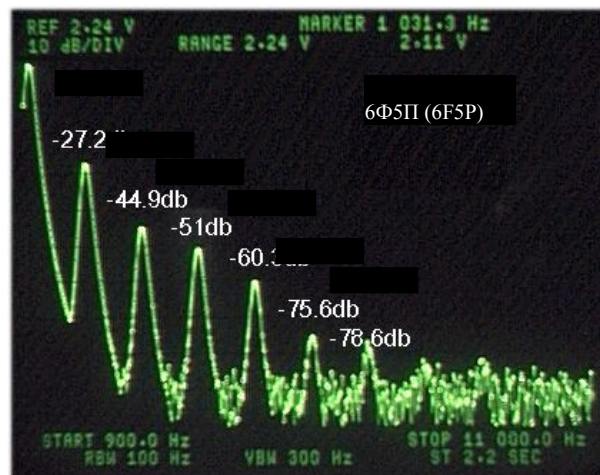


Figure 9
Up=257V, Ip=27mA, Ug=-24.2V

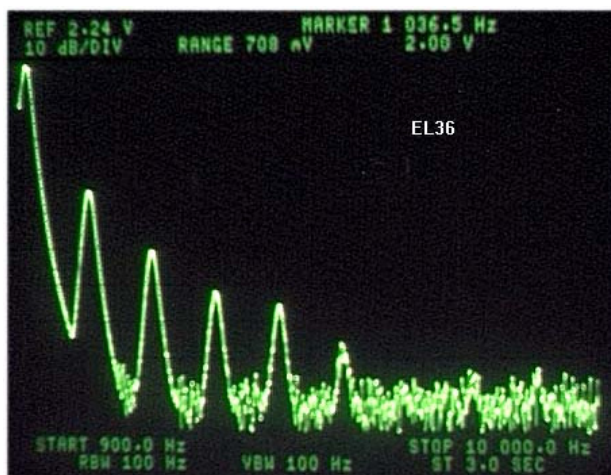


Figure 10
Up=240V, Ip=40mA, Ug=-39.2V

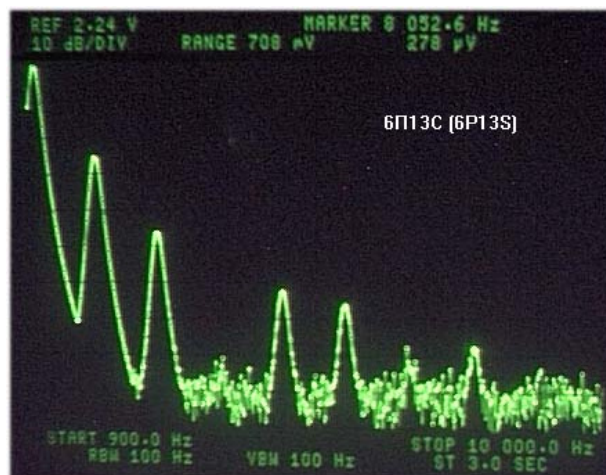


Figure 11
Up=250V, Ip=35mA, Ug=-27.4V

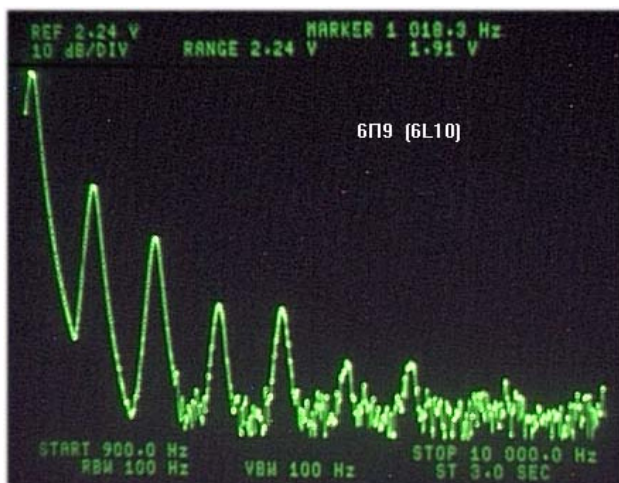


Figure 12
Up=239V, Ip=30mA, Ug=-8V

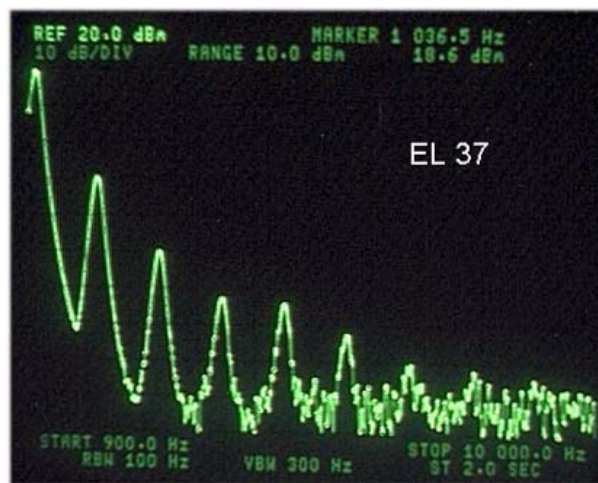


Figure 13
Up=247V, Ip=40mA, Ug=-15.09V

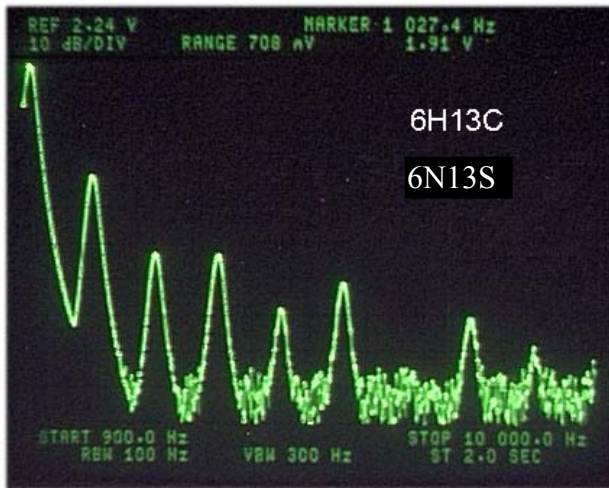


Figure 14
Up=190V, Ip=40mA, Ug=-91.4V

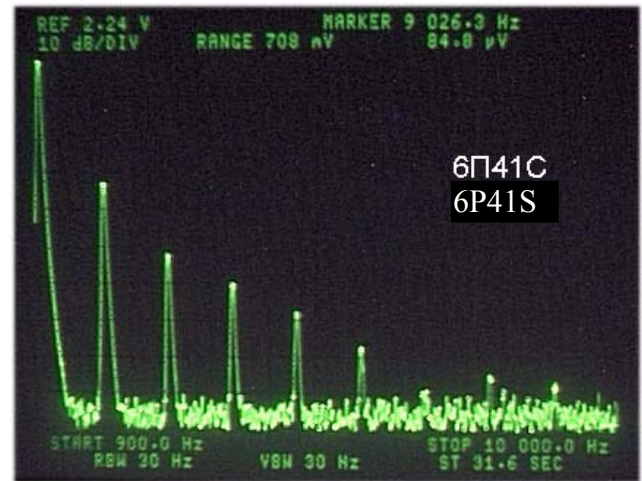


Figure 15
Up=243V, Ip=40mA, Ug=-41V

With test results obtained, some definite conclusions evolve concerning the most perspective or often employed vacuum tubes:

For simple amplifiers outputting the power of 1 to 2Watts, the 6P14P or 6P1P tubes would be the best choice.

For symmetric high-power driver stages, the 6P1P or 6N6P tubes would suite enough.

Hardly the 6S19P tube may be employed. Its third harmonic level is very low, but its whole tail of harmonics is the longest among the tubes.

The 6P9 tube of Soviet design unstably operates while at high power dissipation from the plate.

For more powerful SE output stages, the EL36 tube of Czech would suite enough. Of all the tubes tested, its output linearity is the best.

The 6P3S tube is quite inapplicable in SE stage. Its third harmonic level is very low, but its whole tail of harmonics is very long and its second harmonic level is inappropriately high. Therefore, it's better to employ it in push-pull stages.

The 6P41S tube looks more attractive to be employed for SE stages.

Due to extended level of even harmonics, the 6N13S tube is more applicable for PP stages.

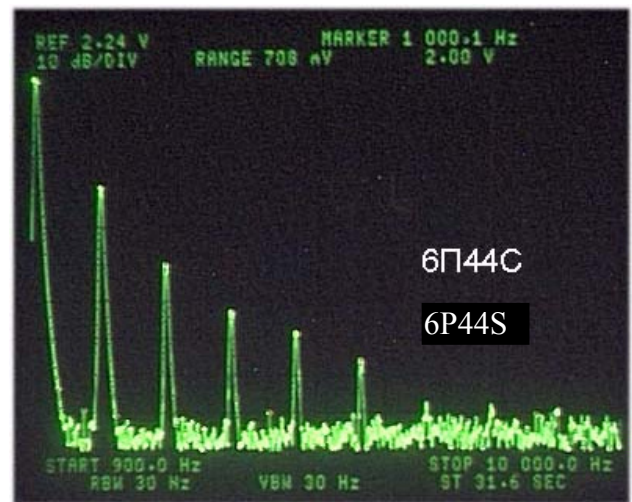


Figure 16
Up=246V, Ip=40mA, Ug=-44.2V

Resume

With my conclusions herein stated, I don't aim to recommend anything. My viewpoint of how some tested tubes may be employed is provided to you as certain results for your own consideration.

I hope, these would help you to choose your output tubes more appropriately.

