JLH-69 amplifier option in inverting connection

The idea from [1] was used as an amplifier prototype. To simplify the power supply and exclude the charge of the output capacitor at the time of power-up, it was decided to use a source with an artificial midpoint, fig. 1.

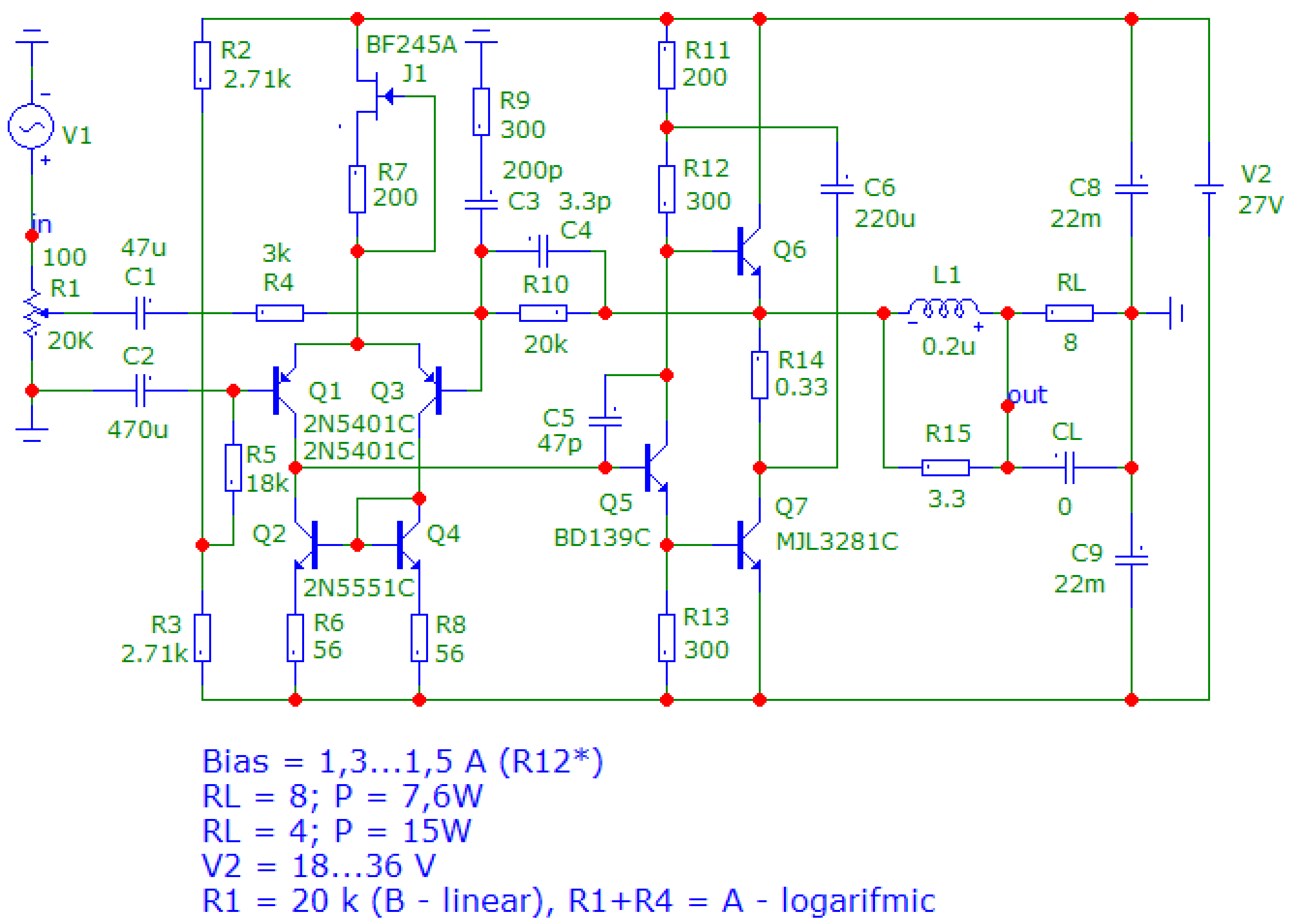

Fig. 1

The use of a differential stage with a load in the form of a current mirror makes it possible to more effectively close the transistor Q5 and thereby improve the opening of the transistor Q6.

In order to improve the SRPP (+) parameter, the current-setting resistor of the differential stage is replaced by a current sourse (generator) based on a JFET- transistor. The current is set by resistor R7 within 6 ... 7 mA. Capacitor C1 must be non-polar, or composed of two back-to-back polar capacitors. In parallel, it is desirable to include a film capacitor with a capacity of 1 ... 3 microfarads. The quiescent current (bias) in the range of 1.3 ... 1.5 A is set with a resistor R12.

The Bode diagram is shown in fig. 2.

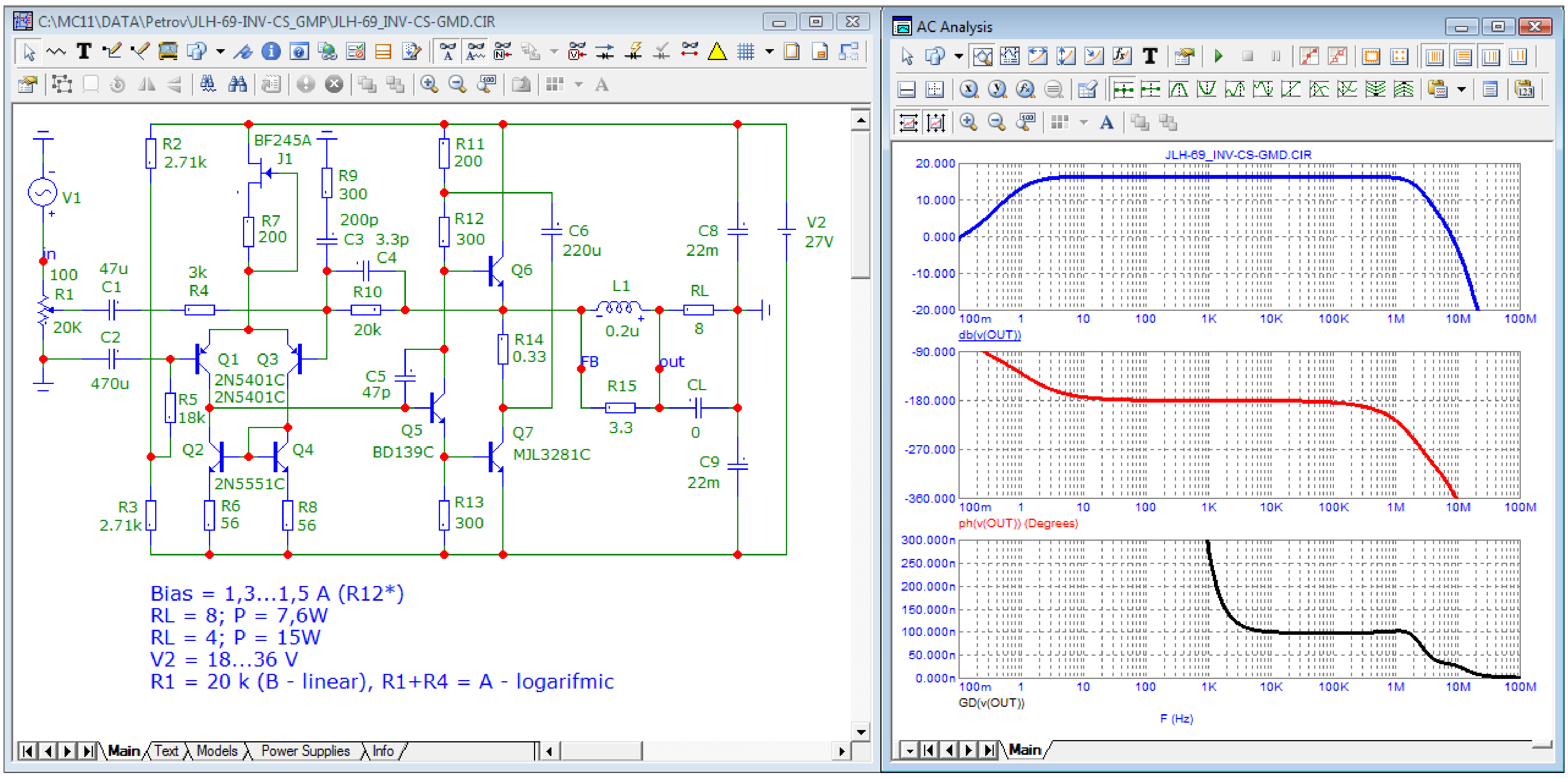

Fig. 2

It can be seen from the Bode diagram that the signal propagation delay time (time Propagation Delay) or in another group delay in the RF region is 100 ns and is almost constant up to almost 2 MHz. Then comes a gradual decline. Let's take a graph of the loop gain, fig. 3.

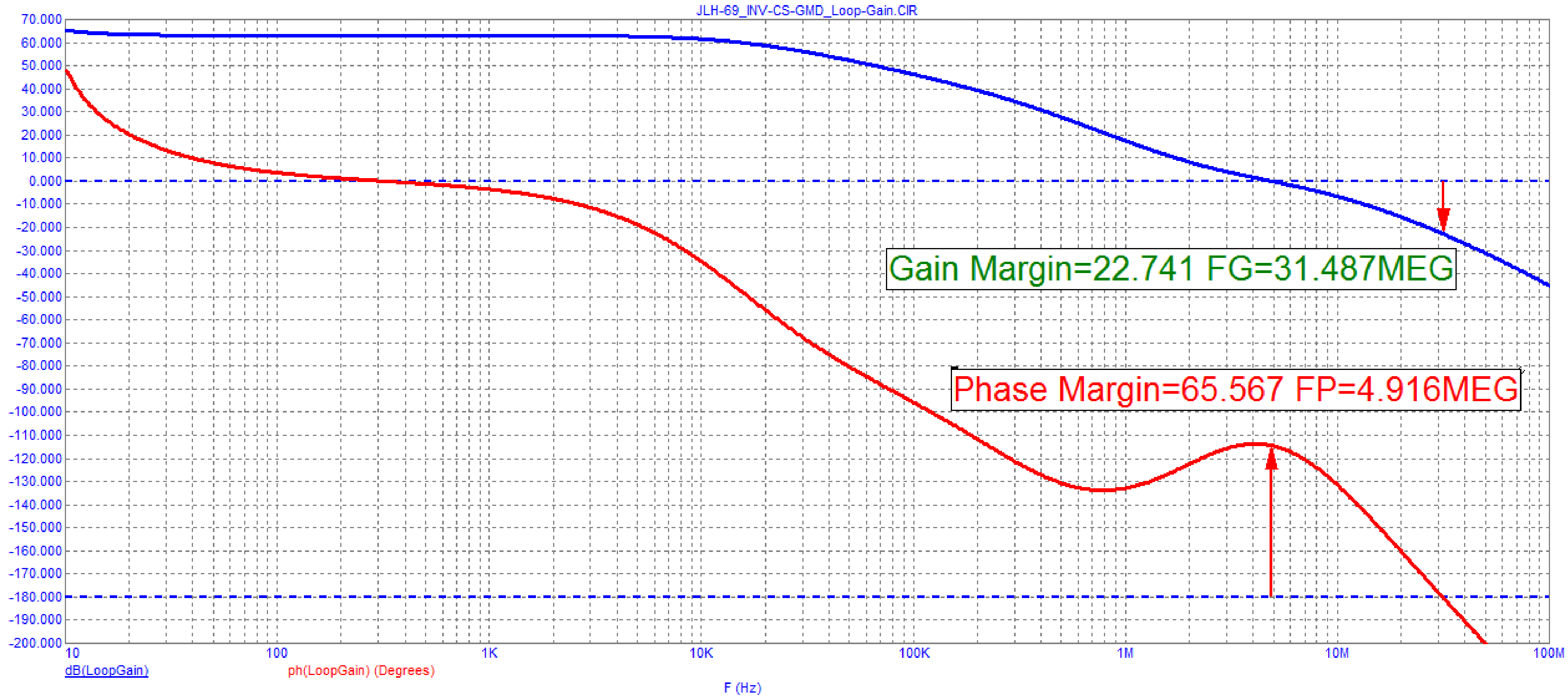

Fig. 3

Loop gain over the entire audio range of at least 60 dB. Thanks to the differential stage, the loop gain is increased by more than 30 dB (30 times). The phase margin is 65 degrees, and the gain margin is more than 22 dB. The constancy of the loop gain also guarantees the constancy of the output impedance.

Let us measure the distortion spectrum at a frequency of 20 kHz, fig. 4

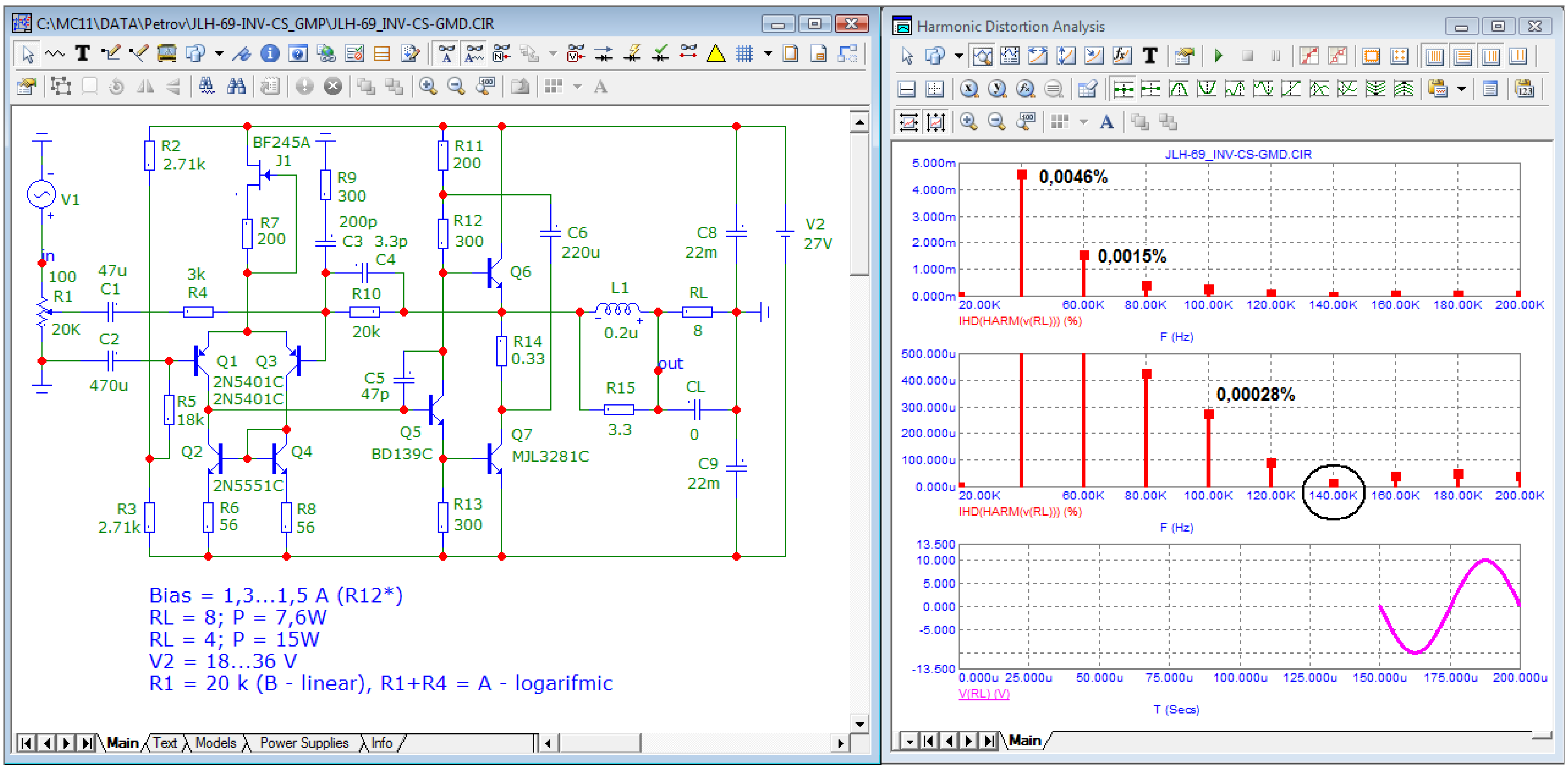

Fig. 4

It can be seen from the test that the spectrum is short, falling, in the spectrum there is mainly one 2nd harmonic. The fifth harmonic has a level of less than 0.0003%, and the 7th and 9th harmonics are negligible.

Let us measure the distortion spectrum at an output power of 1 watt, fig. 5

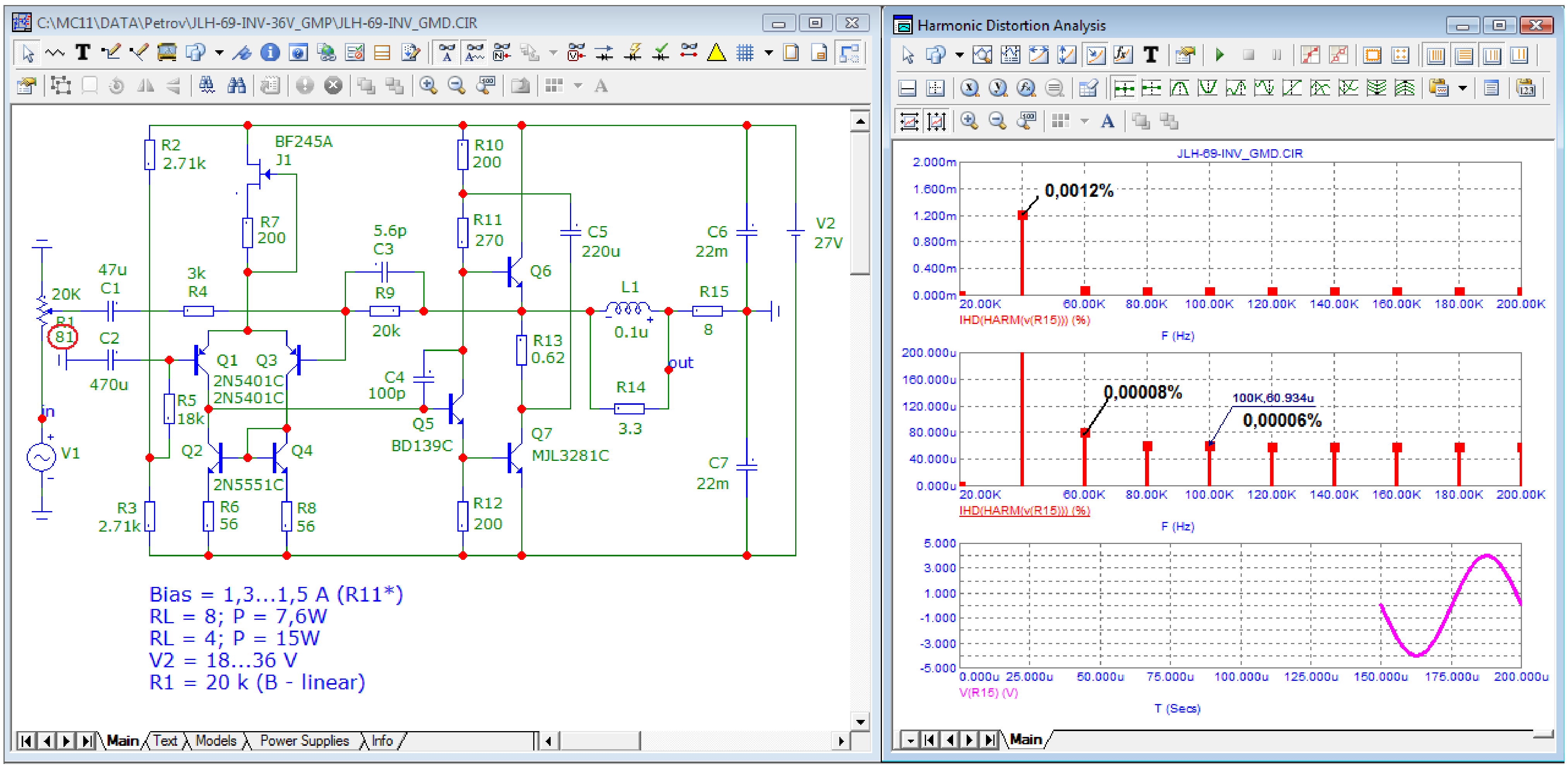

Fig. 5

The decrease in distortion at low volume is facilitated by an increase in the depth of the NFB due to an increase in the resistance of the signal source.

Let us measure the distortion at a frequency of 10 kHz using a notch filter, fig. 6

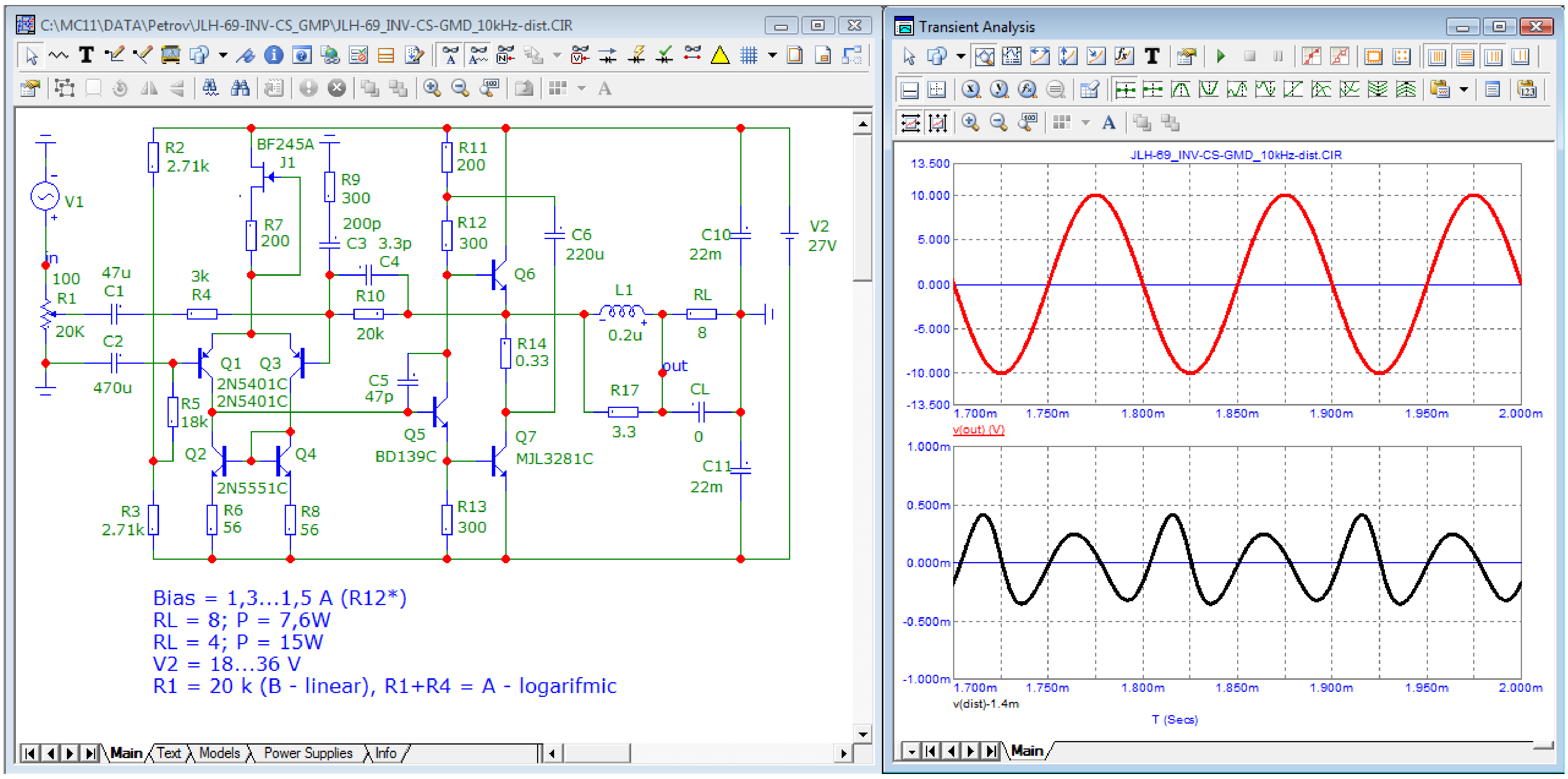

Fig. 6

The selection of distortion products using a notch filter also confirms that there is mainly one 2nd harmonic in the spectrum with a level of about 0.3 mV, which is 0.003% of the level of 10 V. This is confirmed by the standard THD test, fig. 6a). The 1.4 mV offset that occurs at the output is taken into account by subtracting this constant component from the distortion products.

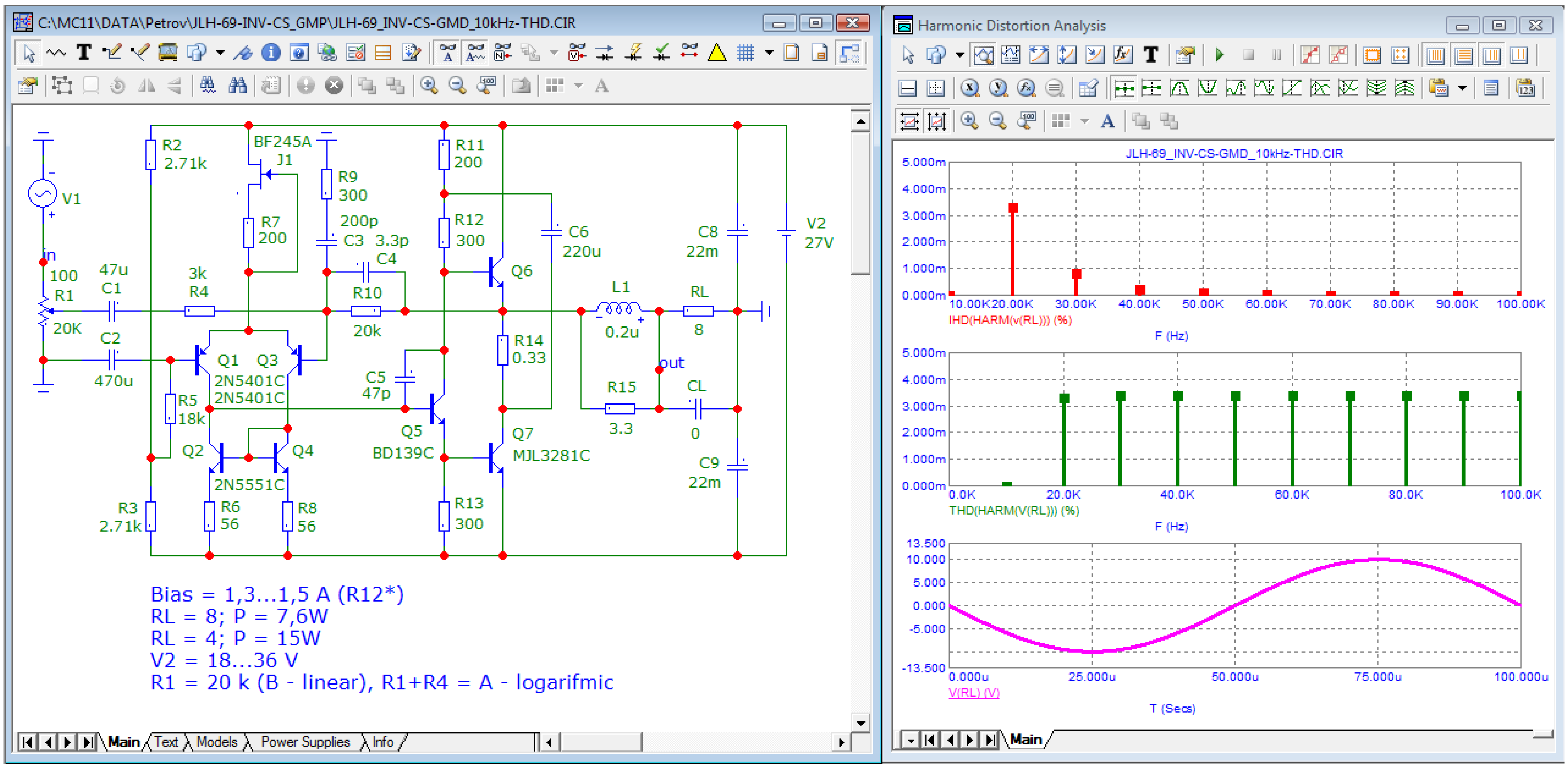

Fig. 6a

We will measure vector errors, as well as all types of distortions using the compensation method, fig. 7

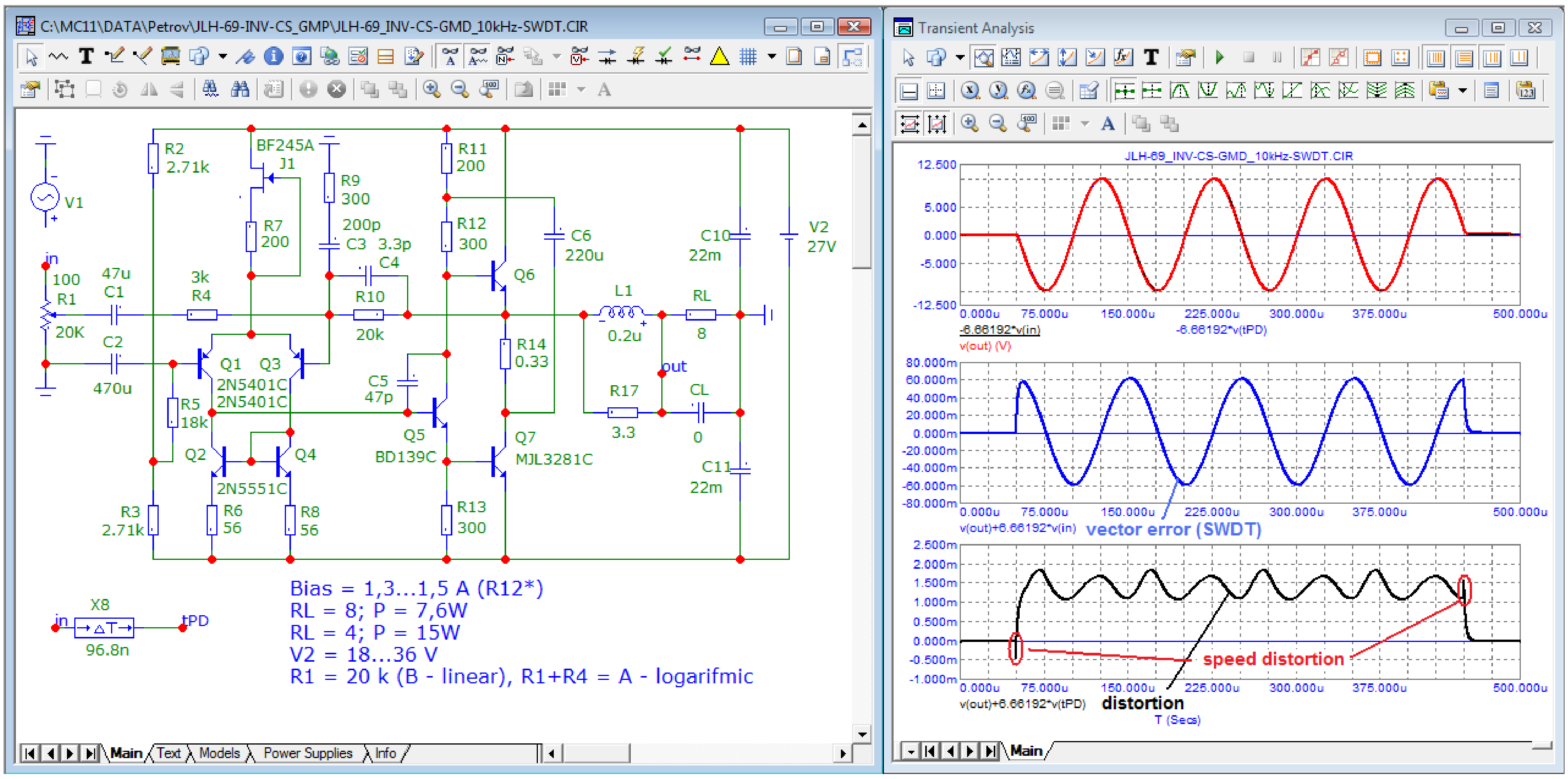

Fig. 7

Measurement of distortions by the compensation method gives the same amplitude and shape of distortion products in the steady state as in measurements with a notch filter (Fig. 6). The distortion products also have an offset of approximately 1.4 mV. The amplitude of high-speed distortion is approximately 0.5 mV - at the level of non-linear distortion in steady state. Let's carry out a similar test using a triangular signal, fig. 7a

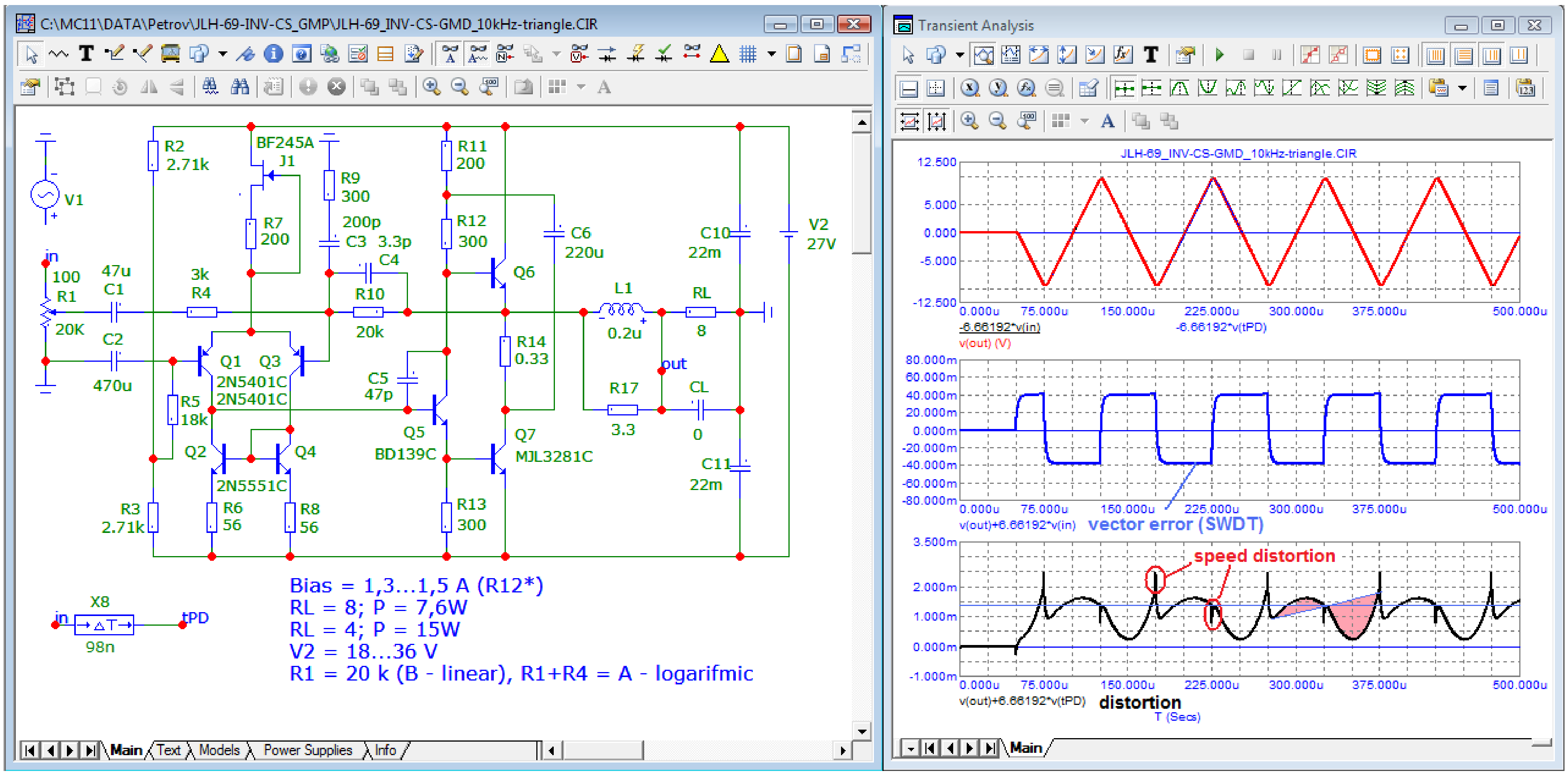

Fig. 7a

On a triangular signal, the distortion products clearly show the non-linearity of signal edge transmission (highlighted in pink). With a signal amplitude from peak to peak of 20 V, the maximum amplitude of the nonlinearity occurs at the trailing edge of the signal and is approximately 1.5 mV, which is 0.015% from 20 V. High-speed distortions are approximately at the same level as in the previous test and are of a short-term nature.

Let's measure intermodulation distortions, fig. 8

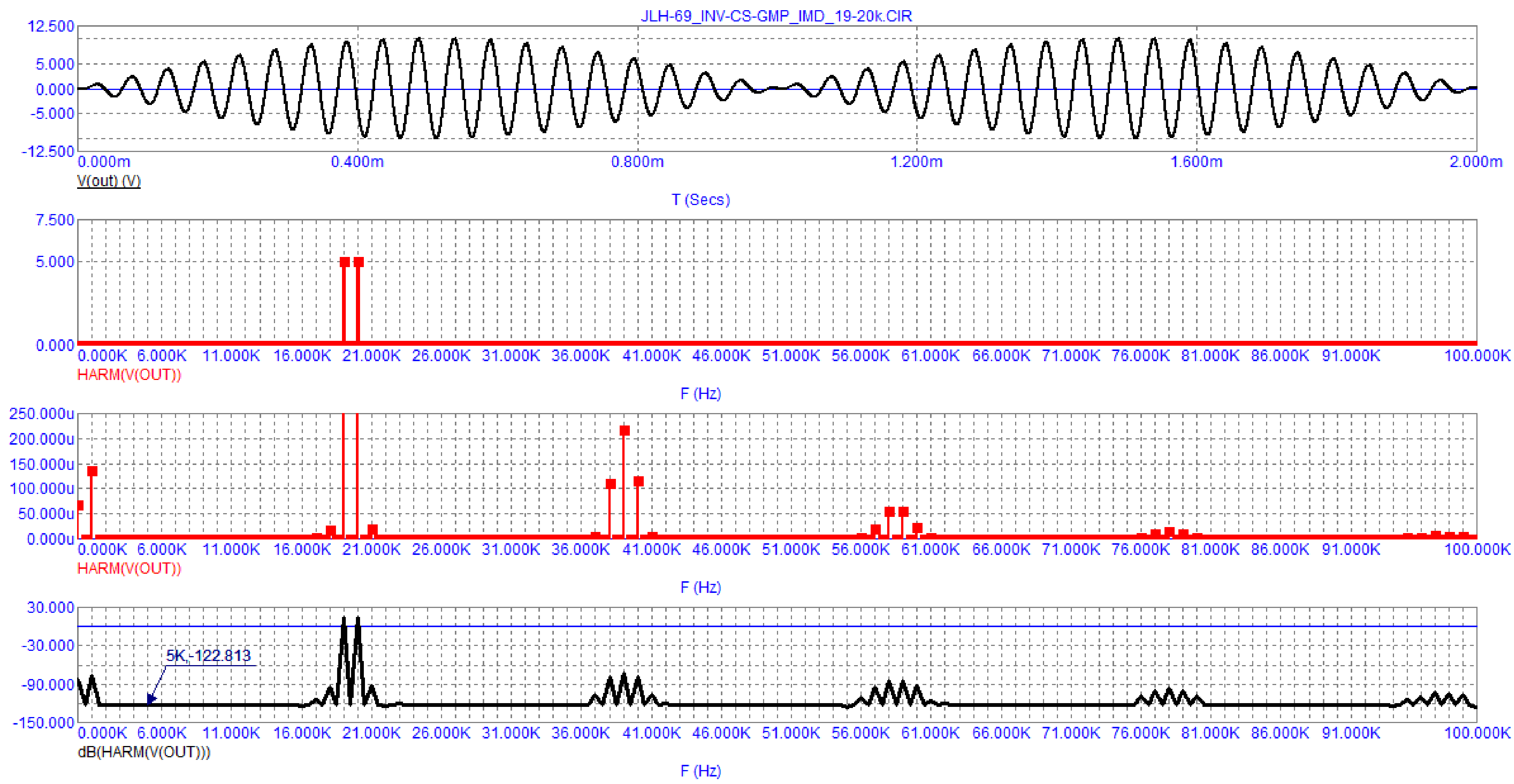

Fig. 8

The test shows that the level of the noise stand in the sound band is below -120 dB.

Let's check the performance of the amplifier at a frequency of 400 kHz, fig. 9

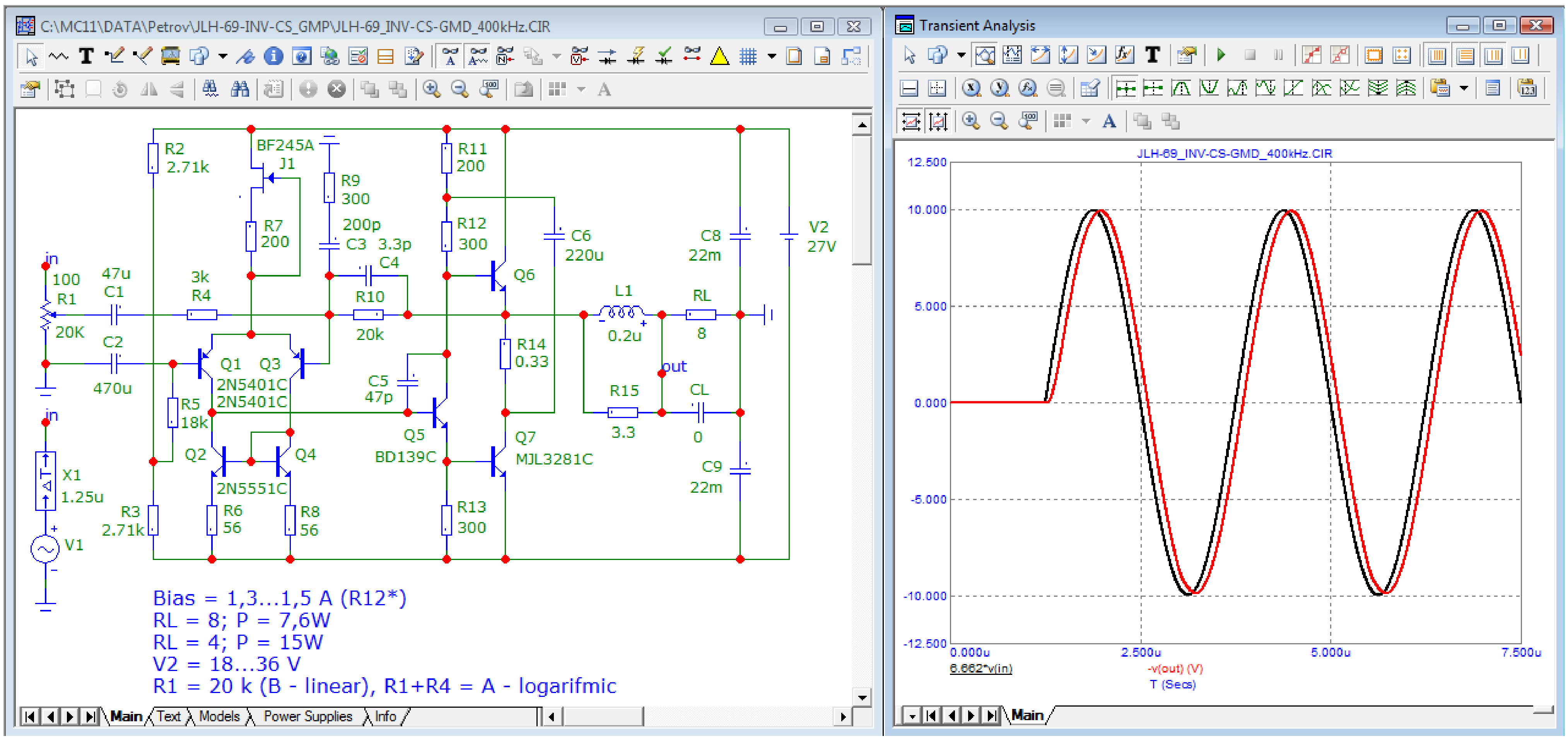

Fig. 9

As can be seen from the test, the amplifier copes well with a frequency of 400 kHz, there are no distortions visible to the naked eye, the voltage gain is the same as in the audio frequency region. There are only linear distortions in the form of a phase delay of the signal.

For comparison, we will conduct a similar test at a frequency of 250 kHz of the model of the original amplifier circuit JLH-69, fig. 9a.

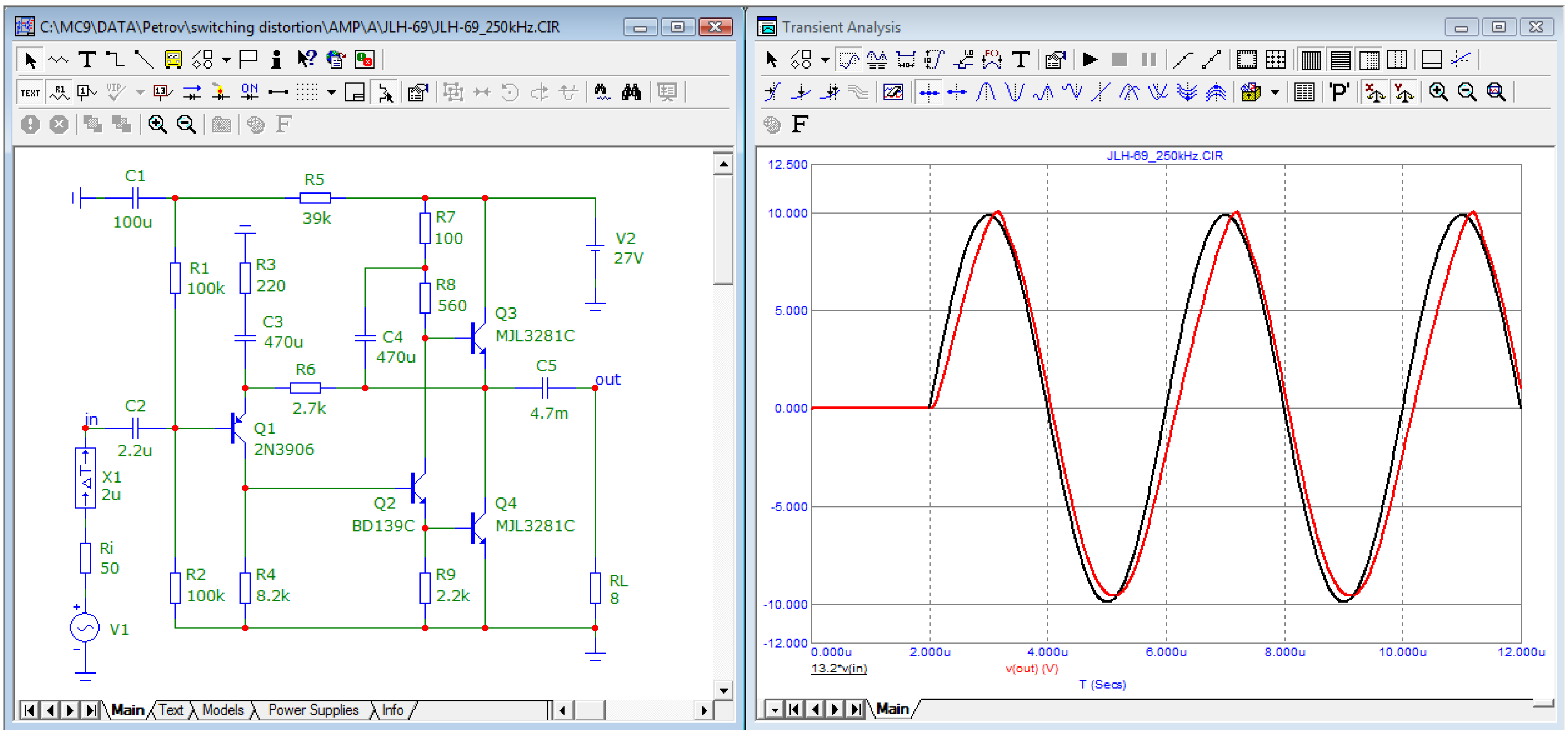

Fig. 9a

The full power bandwidth of the JLH-69 amplifier is half as low - only 200 kHz. At a frequency of 250 kHz, we already see the manifestation of TIM distortion on the positive edge of the signal, especially noticeable on the positive half-wave.

Let's apply to the input of the amplifier a rectangular signal with a frequency of 20 kHz, passed through a low-pass filter of 400 kHz, fig. 10

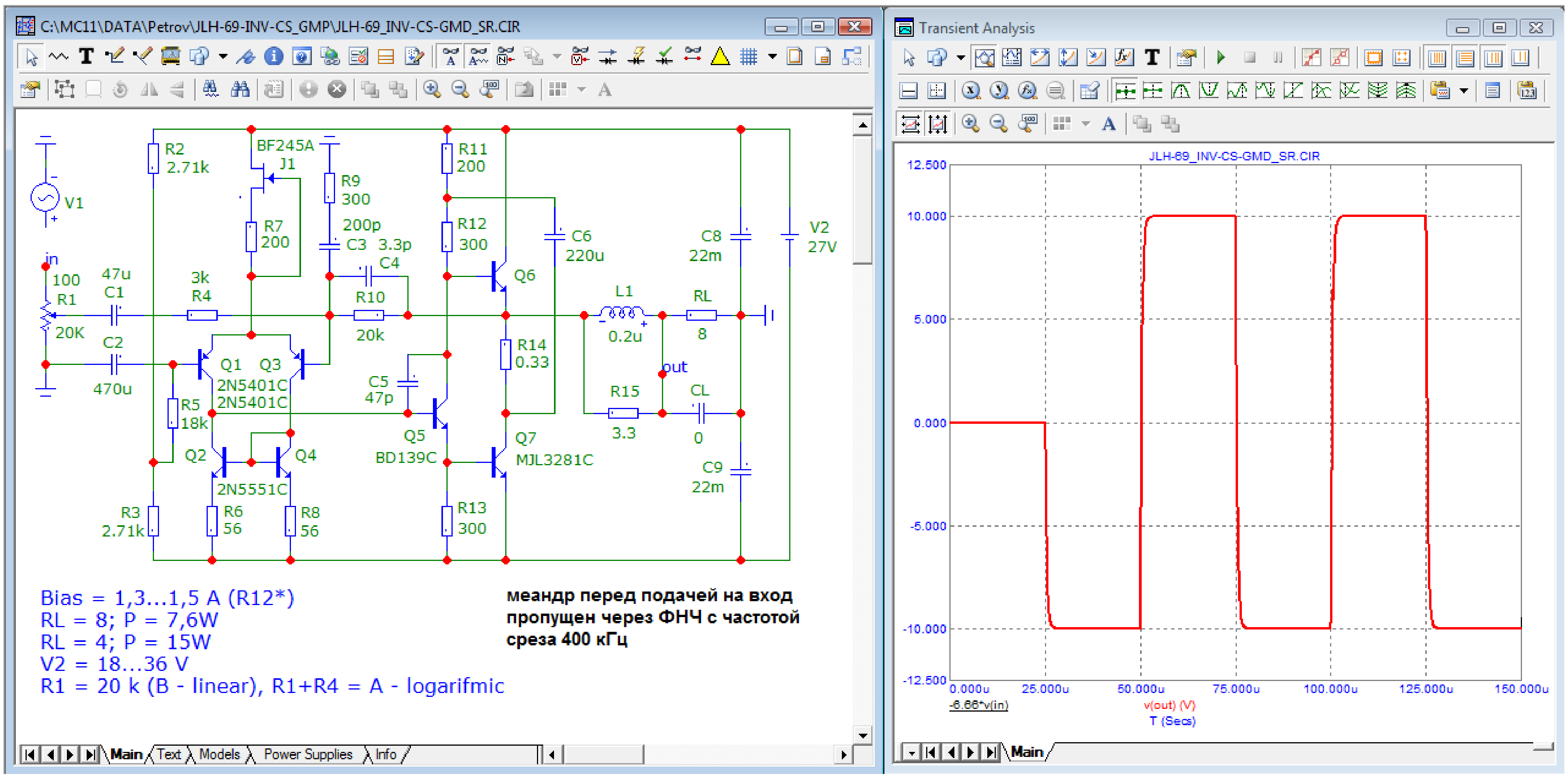

Fig. 10

The test shows that the output signal almost completely repeats the normalized input signal without visible distortion. To obtain a good square wave at a frequency of 20 Hz, it makes sense to increase the capacitances C1, fig. 11

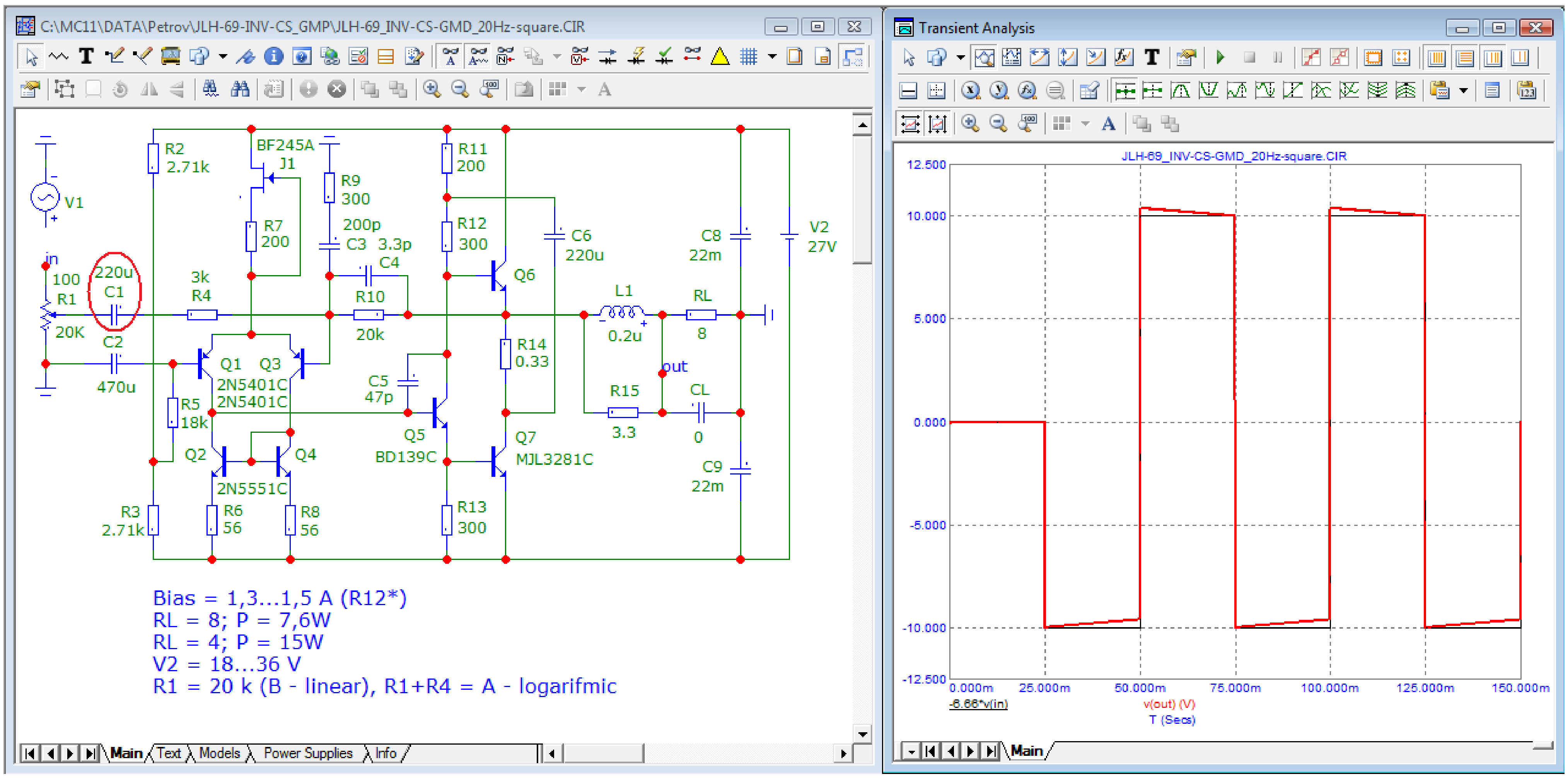

Fig. 11

For a frequency of 20 Hz, the slopes of the rectangular signal shelves are insignificant. To do this, it is enough to compare them with the slope of the shelves of the original amplifier [2] at a frequency of 100 Hz, Fig. 12

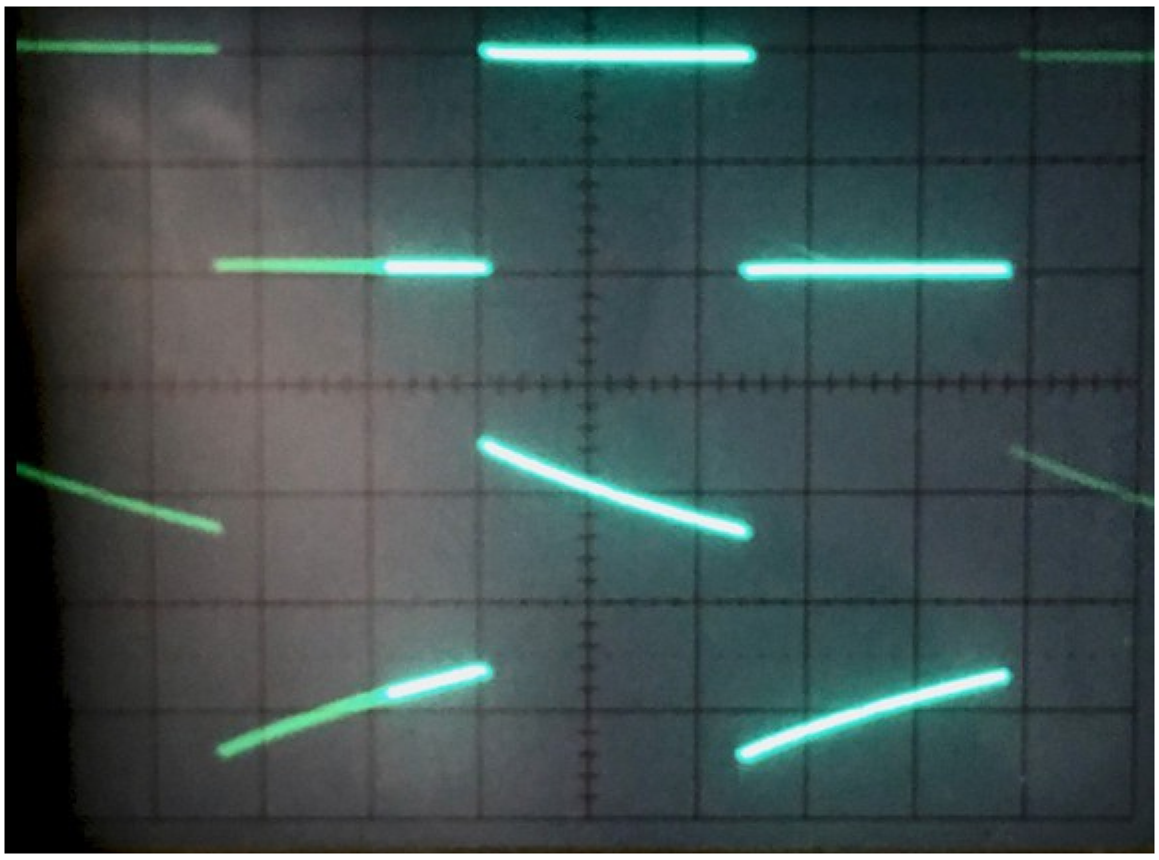

Fig. 12

The original amplifier JLH-69 has a low load capacity, so it is advisable to use it with high-impedance acoustics, for example, 12 ... 16 ohms.

An increase in the capacitances of capacitors C1 expands the constancy of the loop gain in the LF region to 7 Hz, fig. 12a

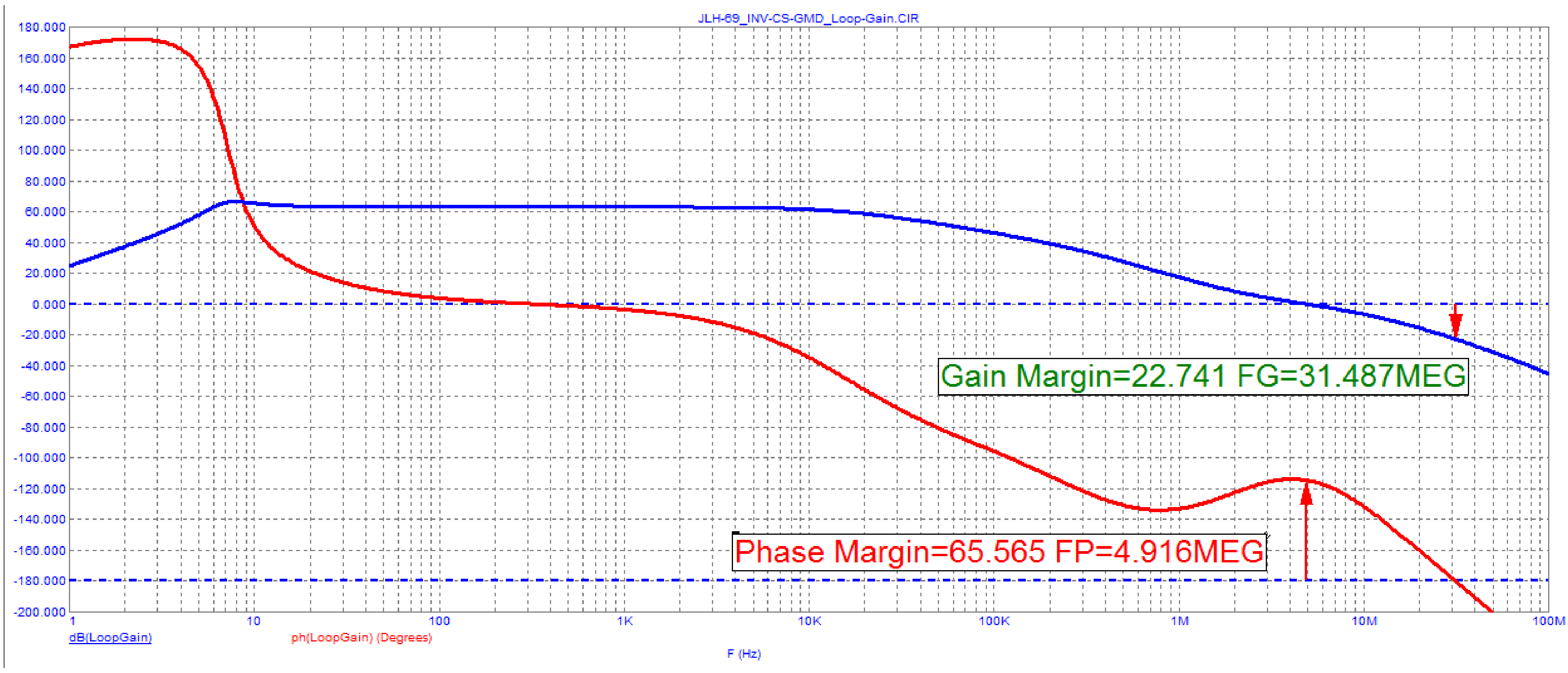

Fig. 12a

Let's check the inverting version of the amplifier in clipping mode at a load of 4 ohms, fig. 13

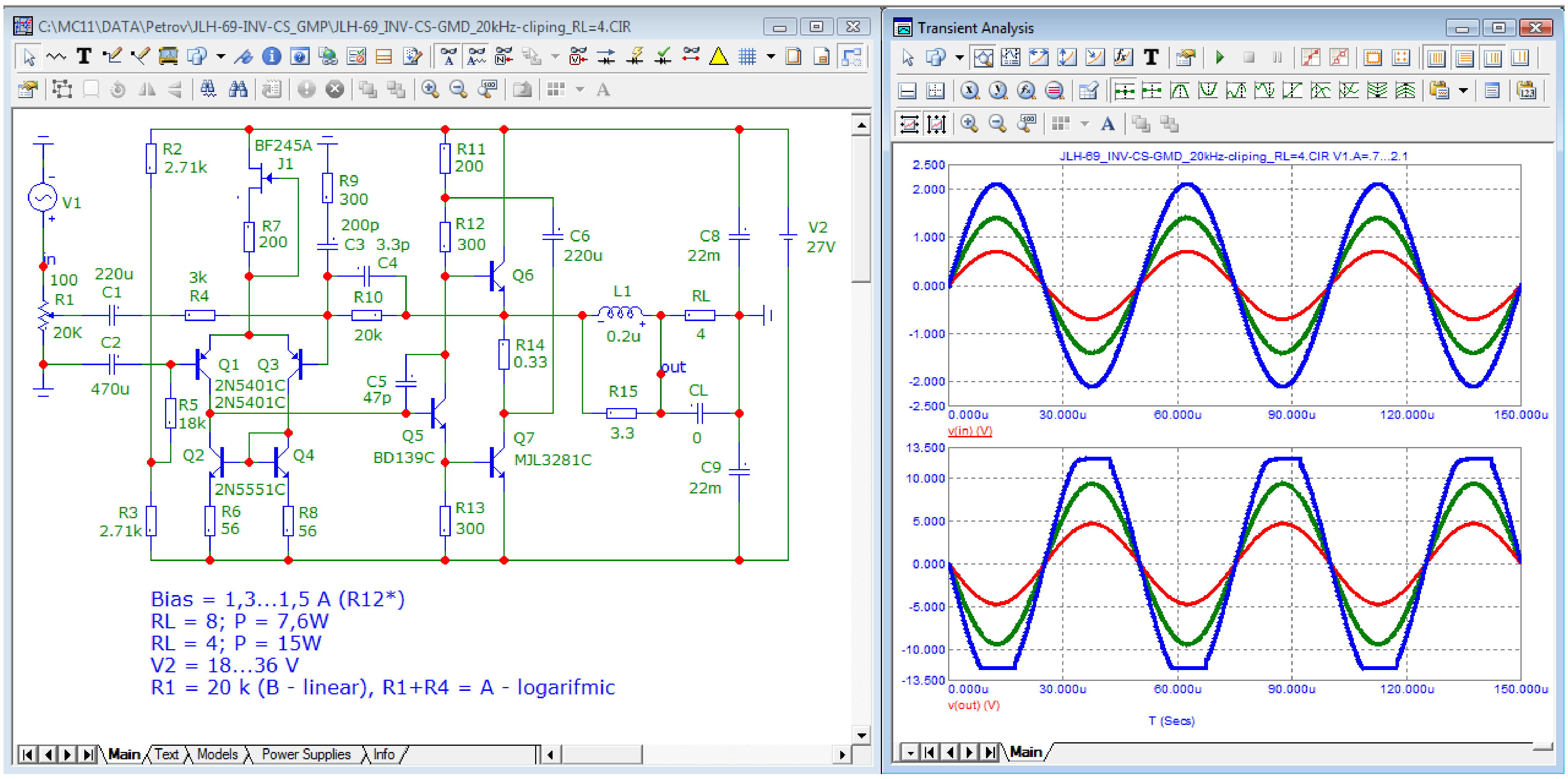

Fig. 13

The test showed that the signal clipping is symmetrical, and the output voltage is not much inferior to Rail-to-Rail. At a 3 ohm load, the output voltage is limited to 9 Vpk, which suggests that the amplifier will work fine at an 8 ohm load. A description of the original circuit and other materials (including the 2000 version) can be found in [3] and [4].

Let's check the noise immunity on the power supply of the original circuit, fig. 14

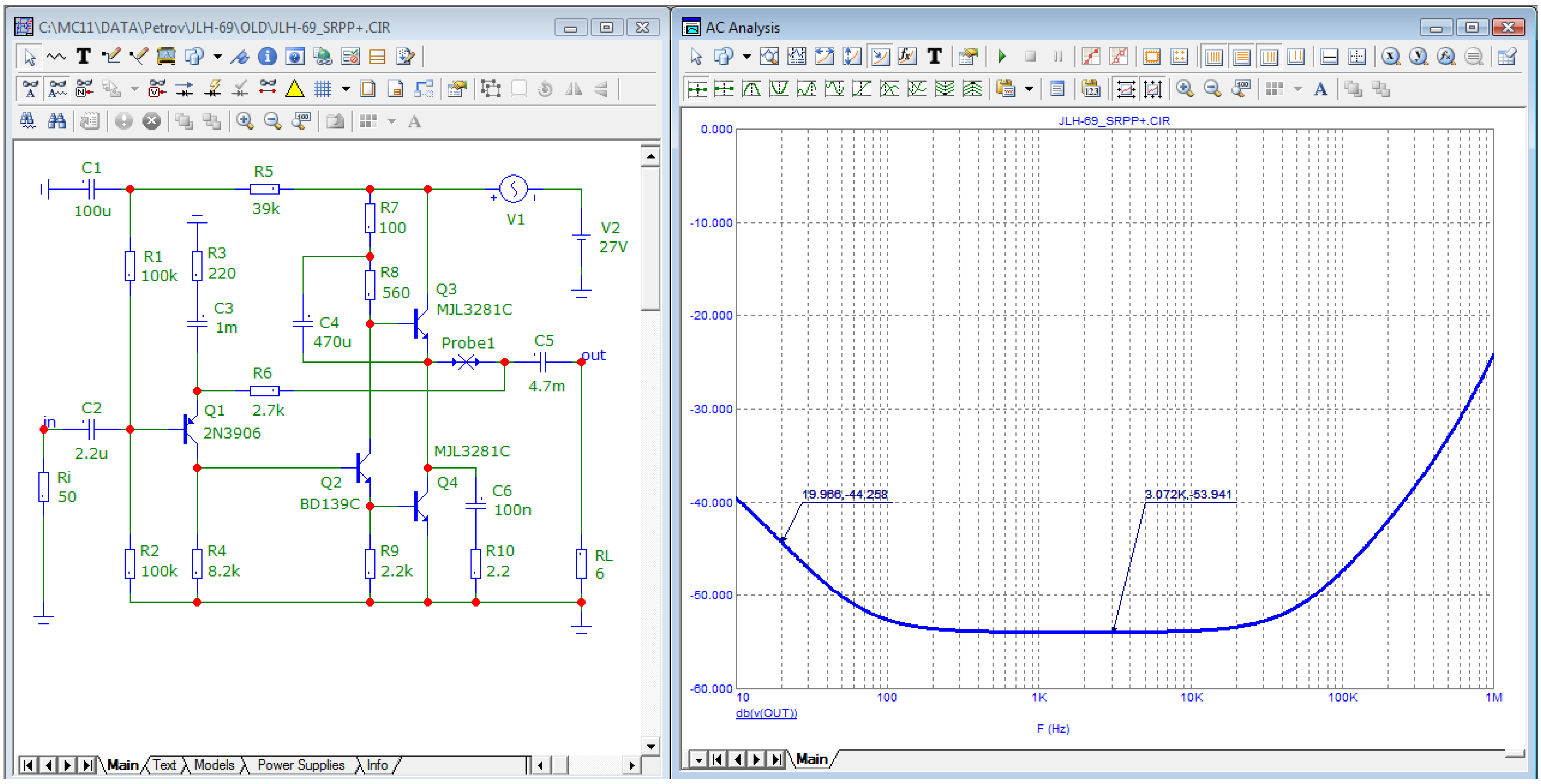

Fig. 14

In the region of the greatest hearing sensitivity, the suppression of power ripple is 54 dB, and at a frequency of 20 Hz - 44 dB.

The modified version has a bipolar power supply, so let's check SRPP (+) and SRPP (-), fig. 15 and fig. 16 respectively.

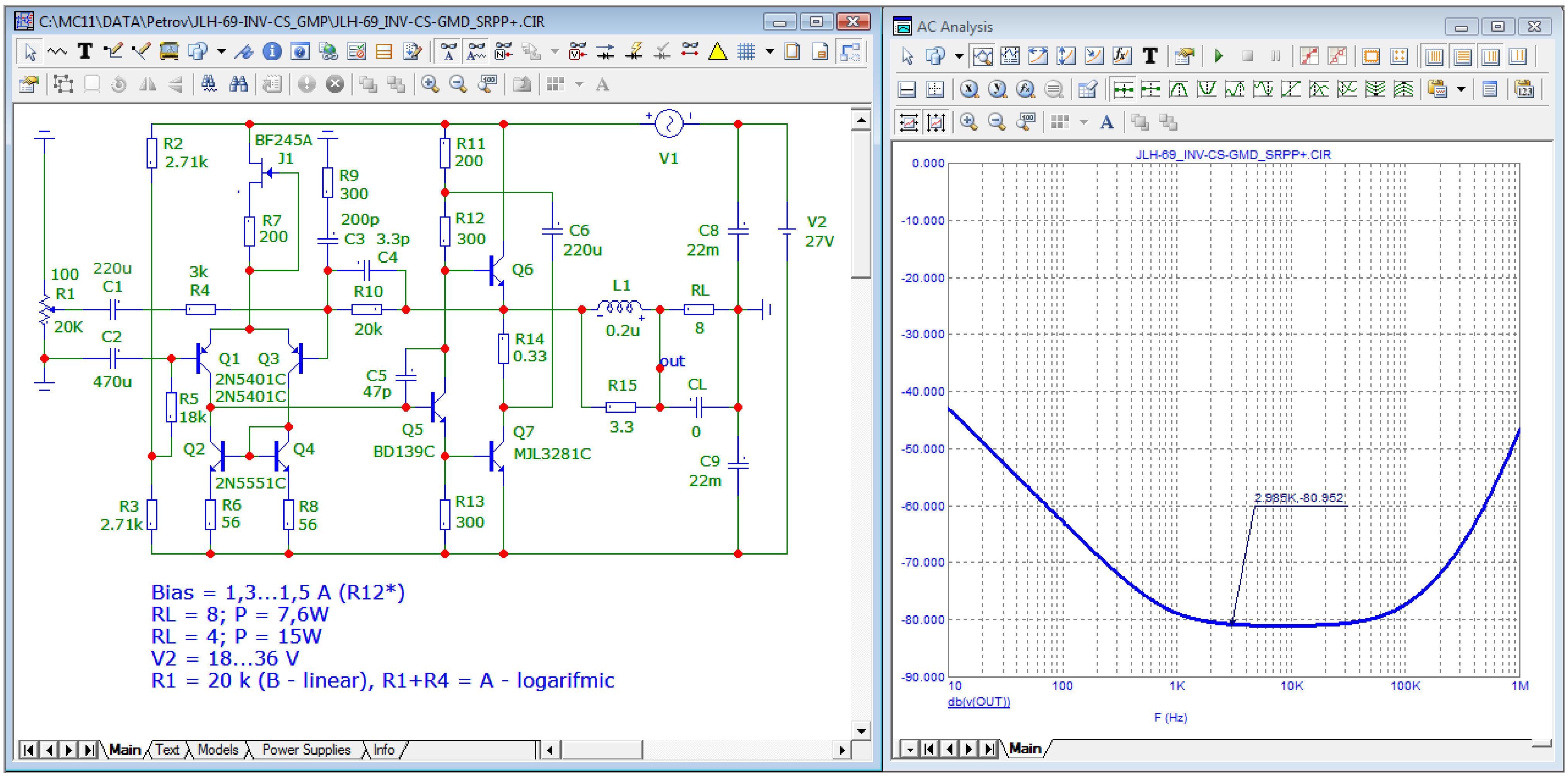

Fig. 15

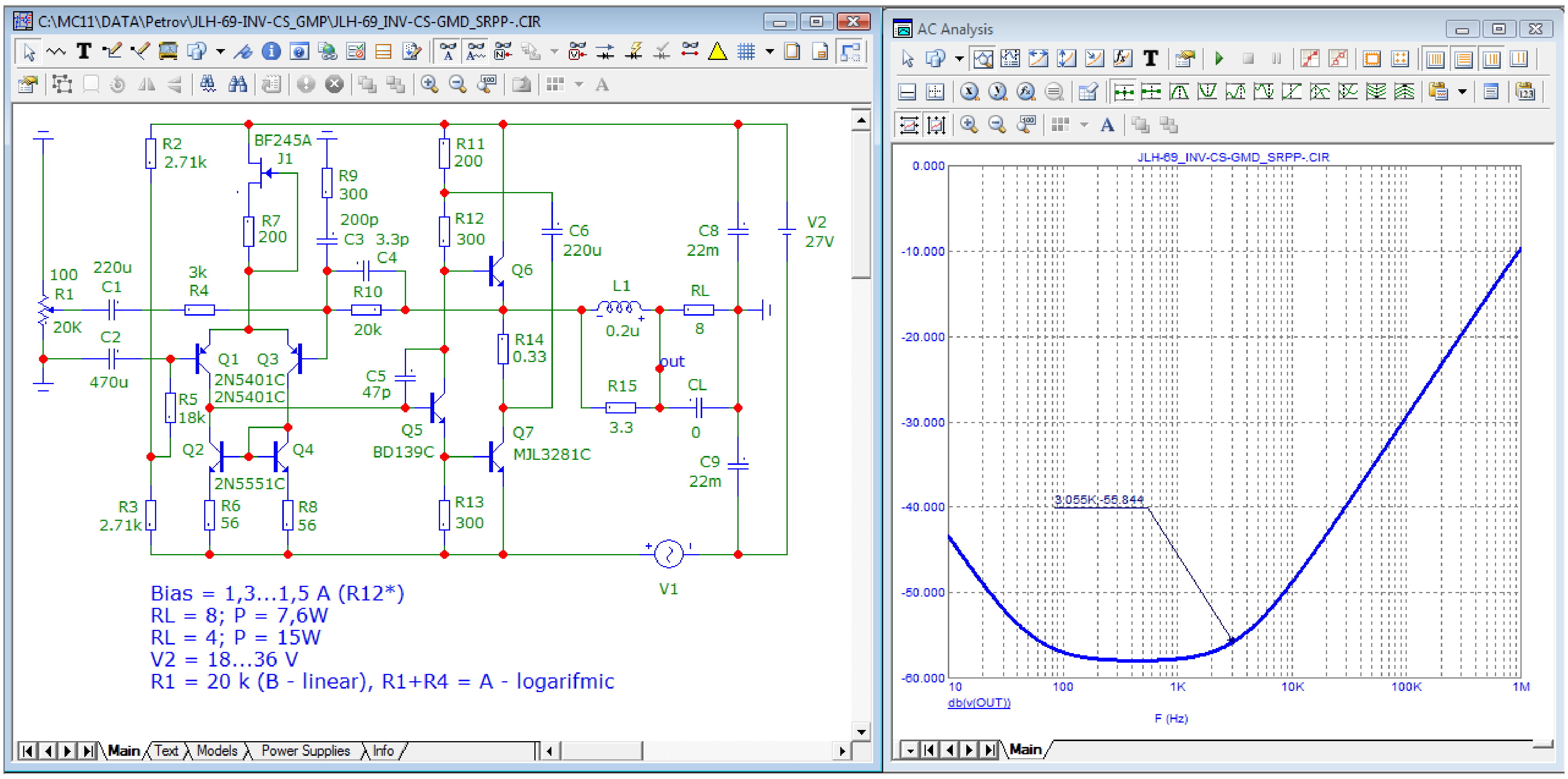

Fig.16

The test result showed that the penetration of interference from the positive power bus in the region of the highest hearing sensitivity is - 81 dB and from the negative - 56 dB.

Literature

1. https://www.diyaudio.com/community/threads/jlh-1969-explanation.331158/post-6404128
2. https://jelabs.blogspot.com/2019/03/john-linsley-hood-1969-class-amplifier.html
3. https://sound-au.com/jll_hood.htm
4. https://sound-au.com/tcaas/index-1.htm

Completed prototype development and tests

Alexander Petrov.