

## The order of development of audio frequency amplifiers

The development of UMZCH begins with a set of circuit models in the simulator. Let's look at this using the MicroCap simulator. When typing a model, it is advisable to use proven transistor models, or at least models from Bob Cordell (although there are a number of complaints about them). To begin with, we build a Bode plot including the frequency response, PFC and group delay, fig. 1.

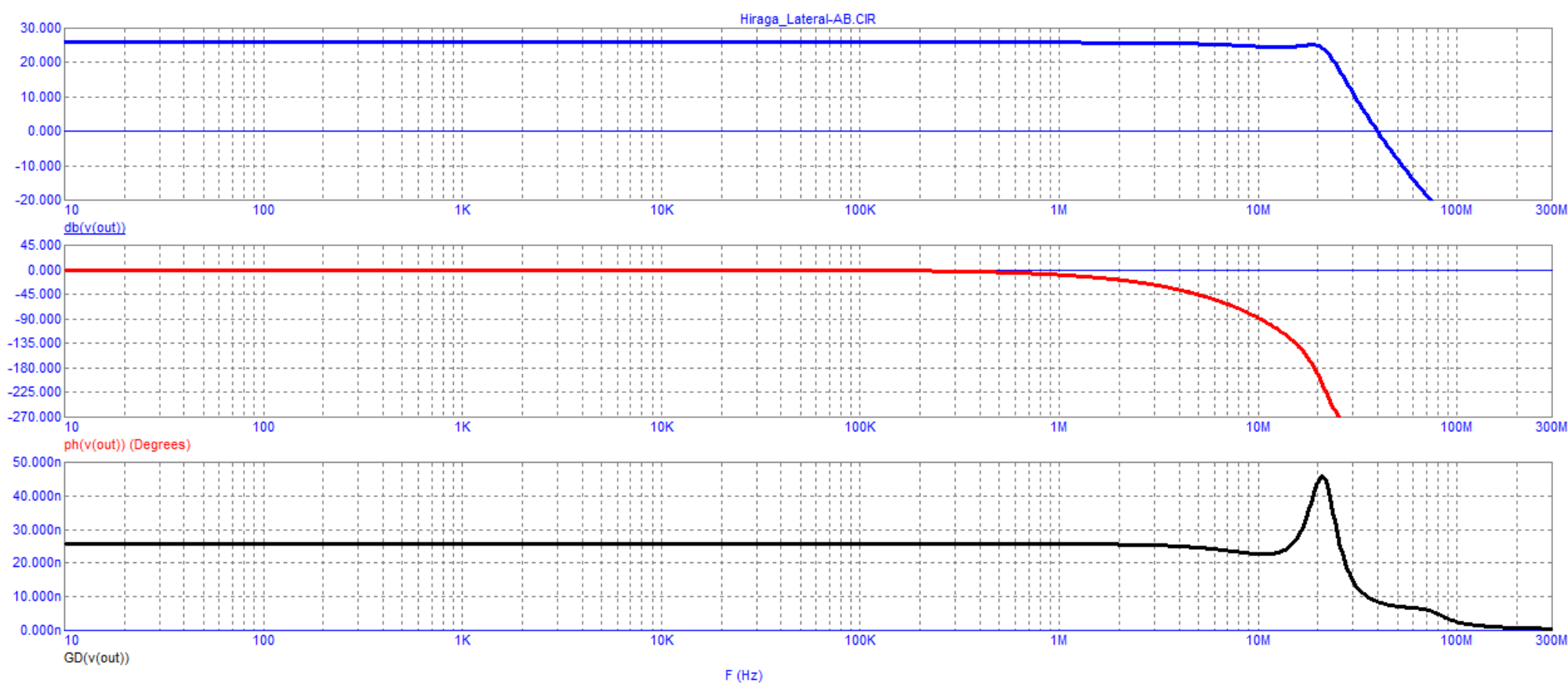


Рис. 1

The test showed that the gain is about 26 dB (~20 times), the group delay is constant from DC almost 10 MHz, a small group delay rise occurs at a frequency of about 20 MHz, which is far beyond the audio range. Using the injector, we will check the loop gain and the stability margins in phase and amplitude with an additional reactive load in the form of a capacitor connected in parallel with the load, fig. 2

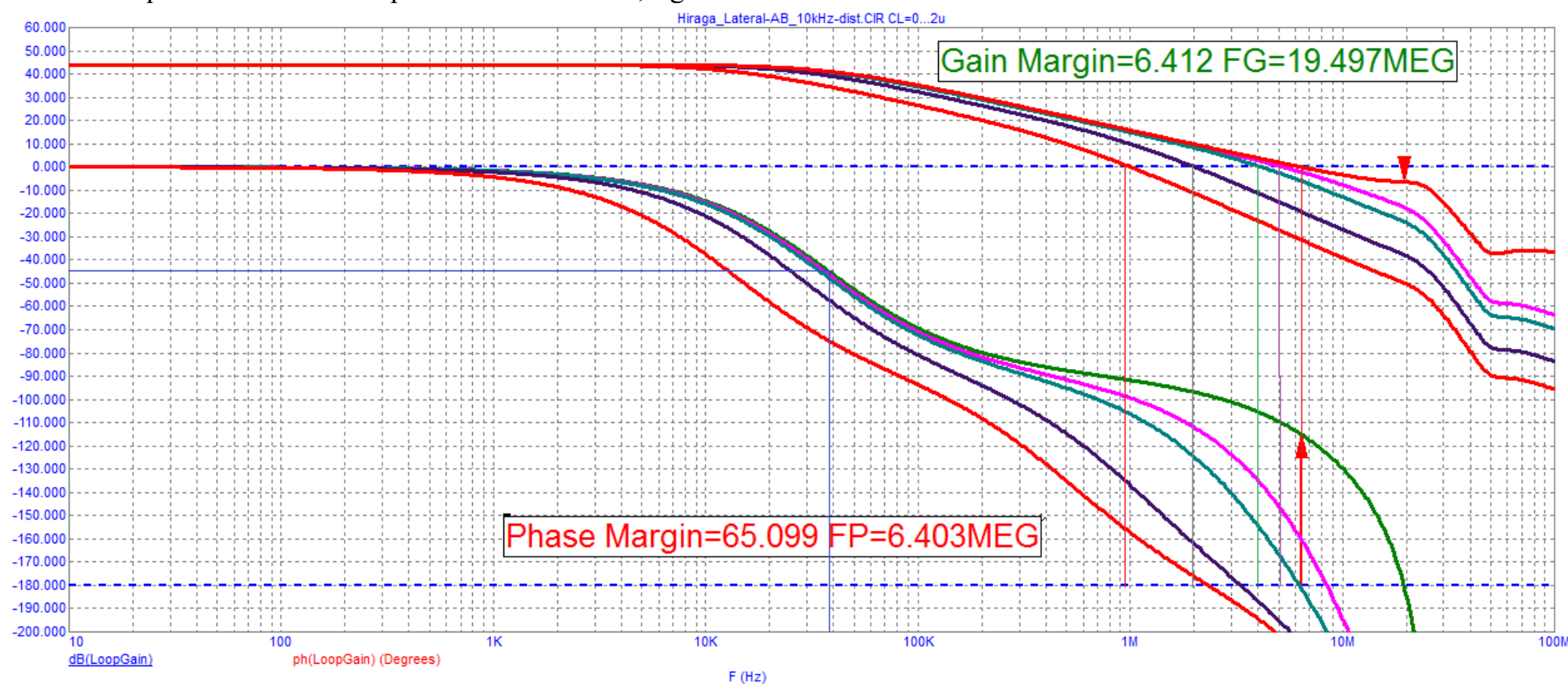


Рис. 2

Figure 2 shows that the model has a loop gain of more than 40 dB in the entire audio range, the reactive load does not bring the model out of a stable state (in the worst case, the phase margin was maintained at least 20 degrees. Let's estimate the frequency of the first pole. To do this, draw a horizontal straight line from -45 degrees to the intersection with the corresponding zero capacitance load capacitor curve. From the point of intersection, we lower the perpendicular to the frequency axis. The graph shows that the approximate value of the first pole is approximately equal to 40 kHz. To measure a more accurate value of the frequency of the first pole, we measure the Bode plot with an open-loop FOS, To do this, we include an inductance in the OS circuit, fig. 3

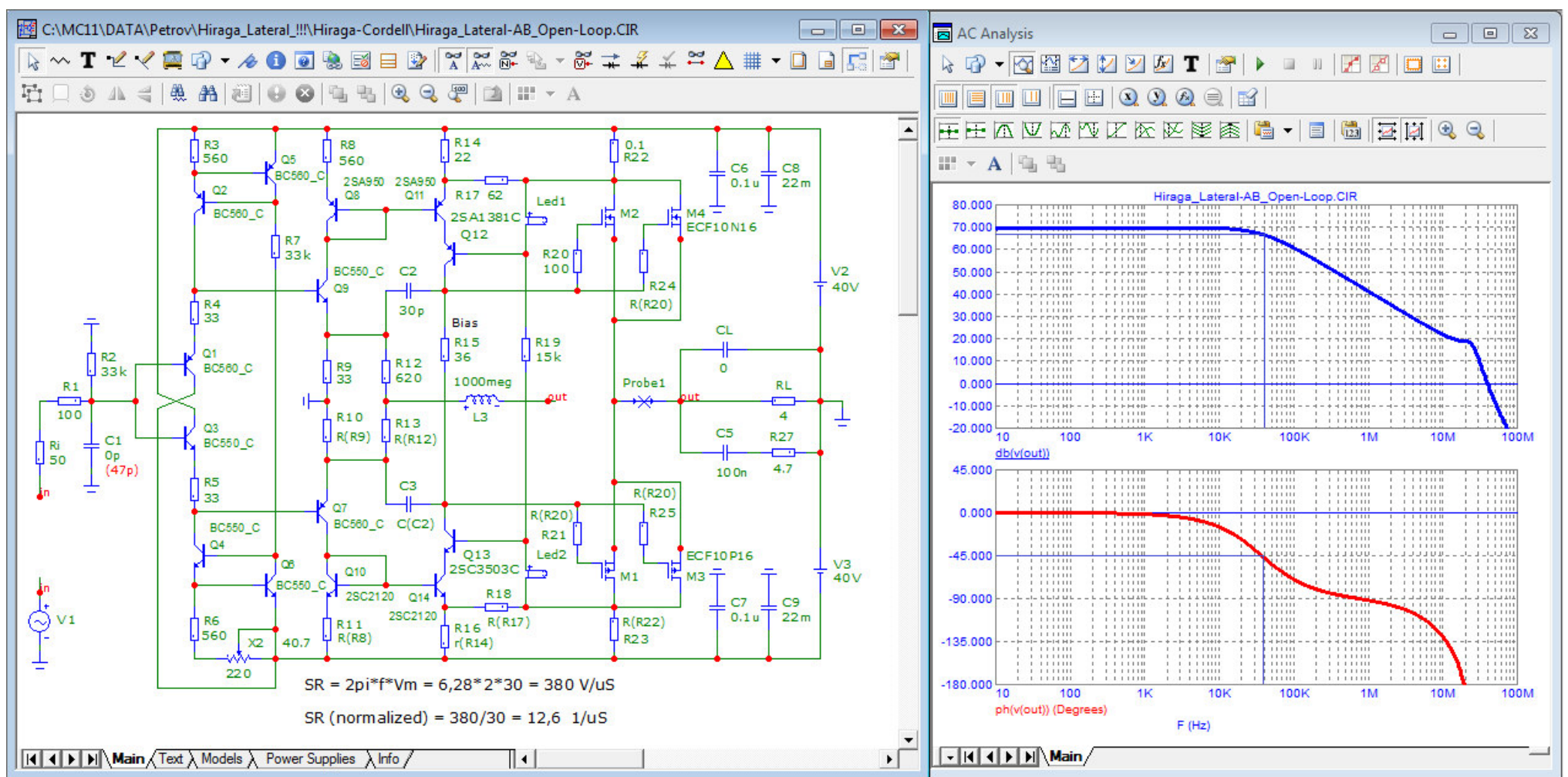


Рис. 3

With single-pole correction, the first pole corresponds to a phase of the output voltage of -45 degrees and a roll-off of the output voltage of -3 dB.

The first pole is measured at just under 40 kHz, which matches the approximate measurement on the loop gain graph. Let's measure the spectrum at a frequency of 20 kHz when the load changes from 2 ohms to 8 ohms, fig. 4

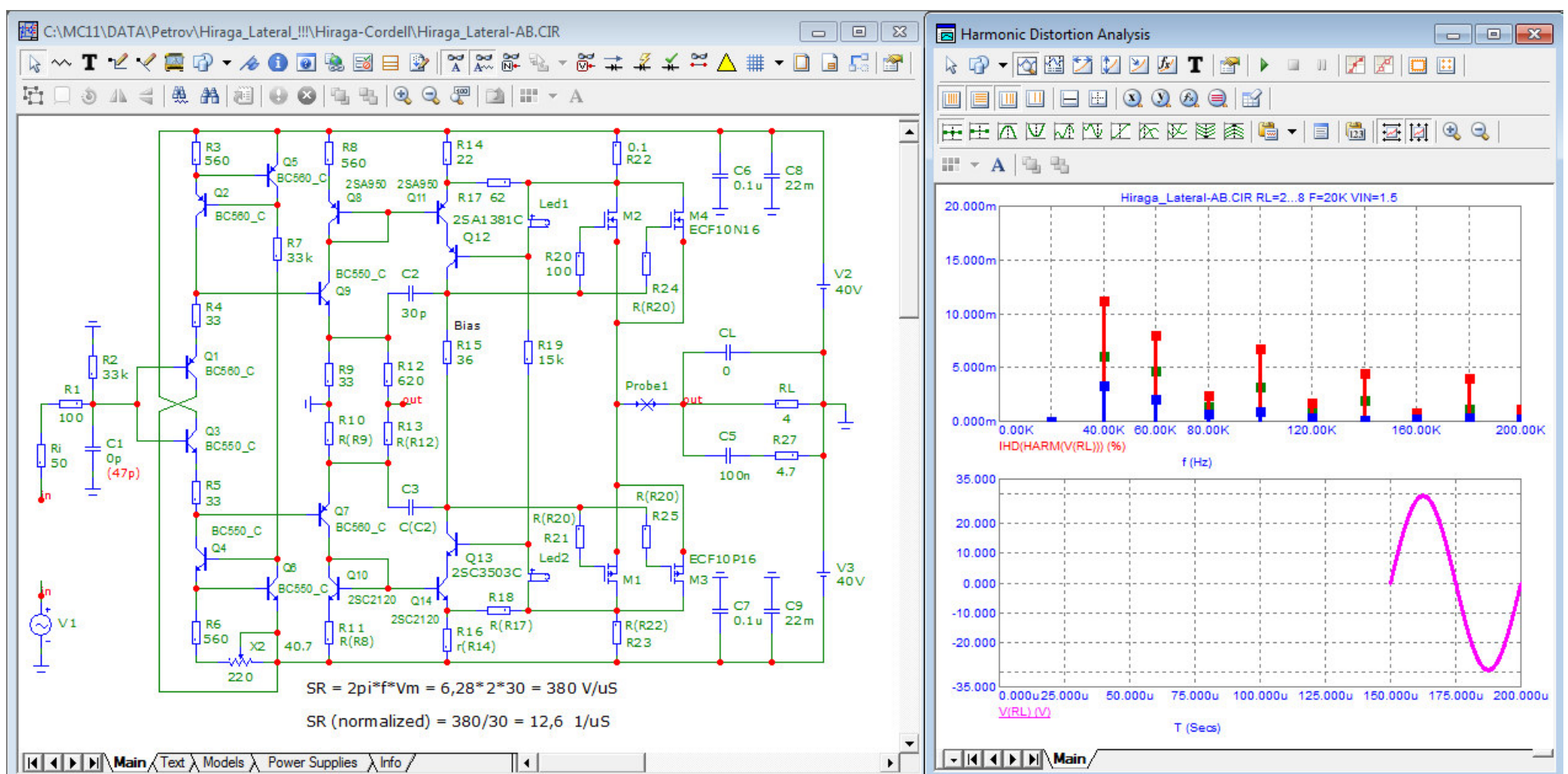


Рис. 4

It can be seen from the spectrum that the spectrum is decreasing, the 2nd harmonic prevails in the spectrum. At a load of 8 ohms, distortion is negligible, at a load of 2 ohms, the 2nd harmonic increases to 0.012%.

It is generally accepted that the sound quality determines the first watt. We measure the spectrum at an output voltage of 4 V (peak), Rice. 5.



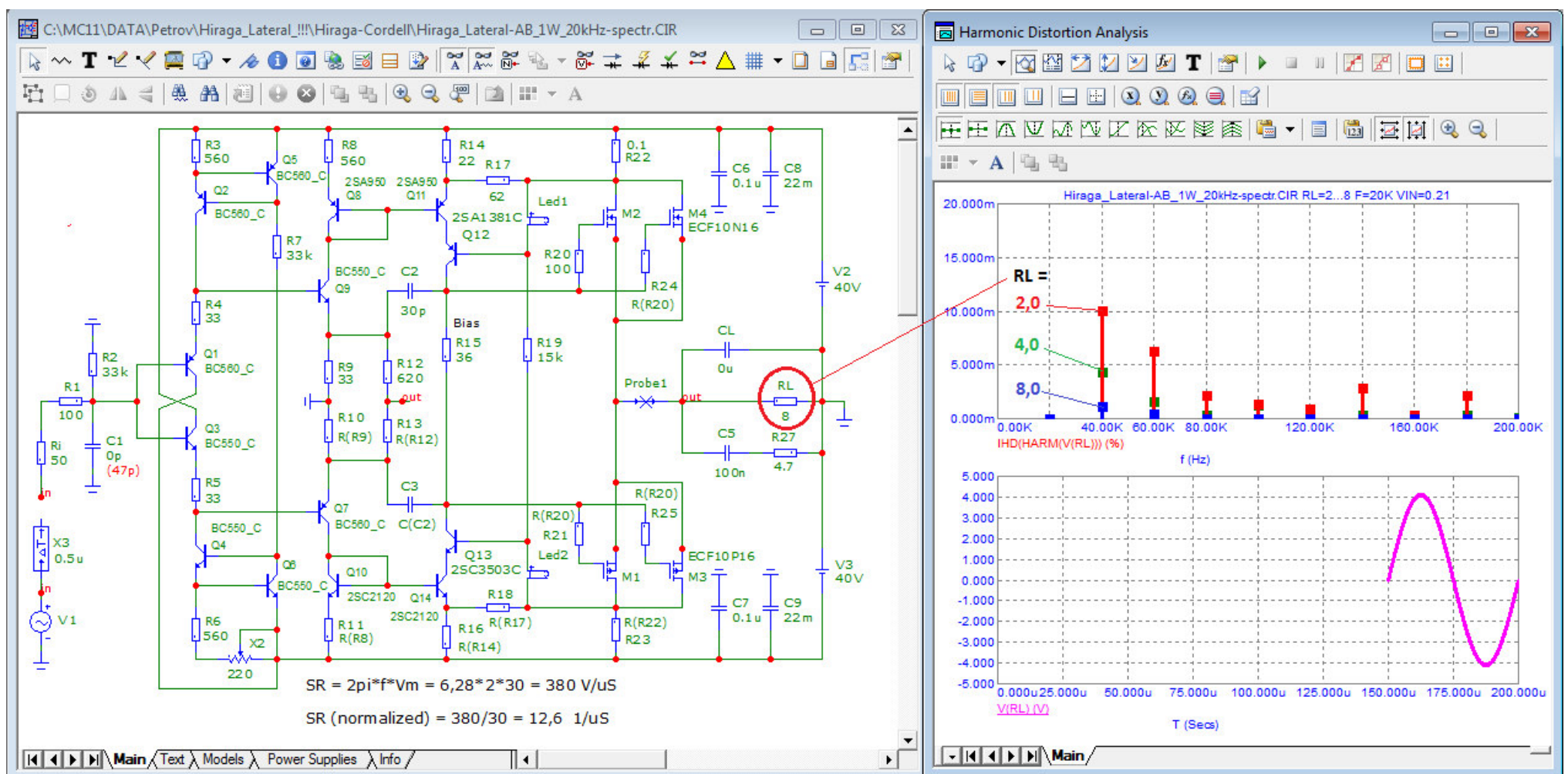


Рис. 5

And with an output voltage of 4 V (peak), the spectrum is pleasing to the eye.

Let us measure the vector errors of the model, as well as all types of distortions by the compensation method using bursts with a frequency of 10 kHz with alternating polarity of the first half-cycle, fig. 6

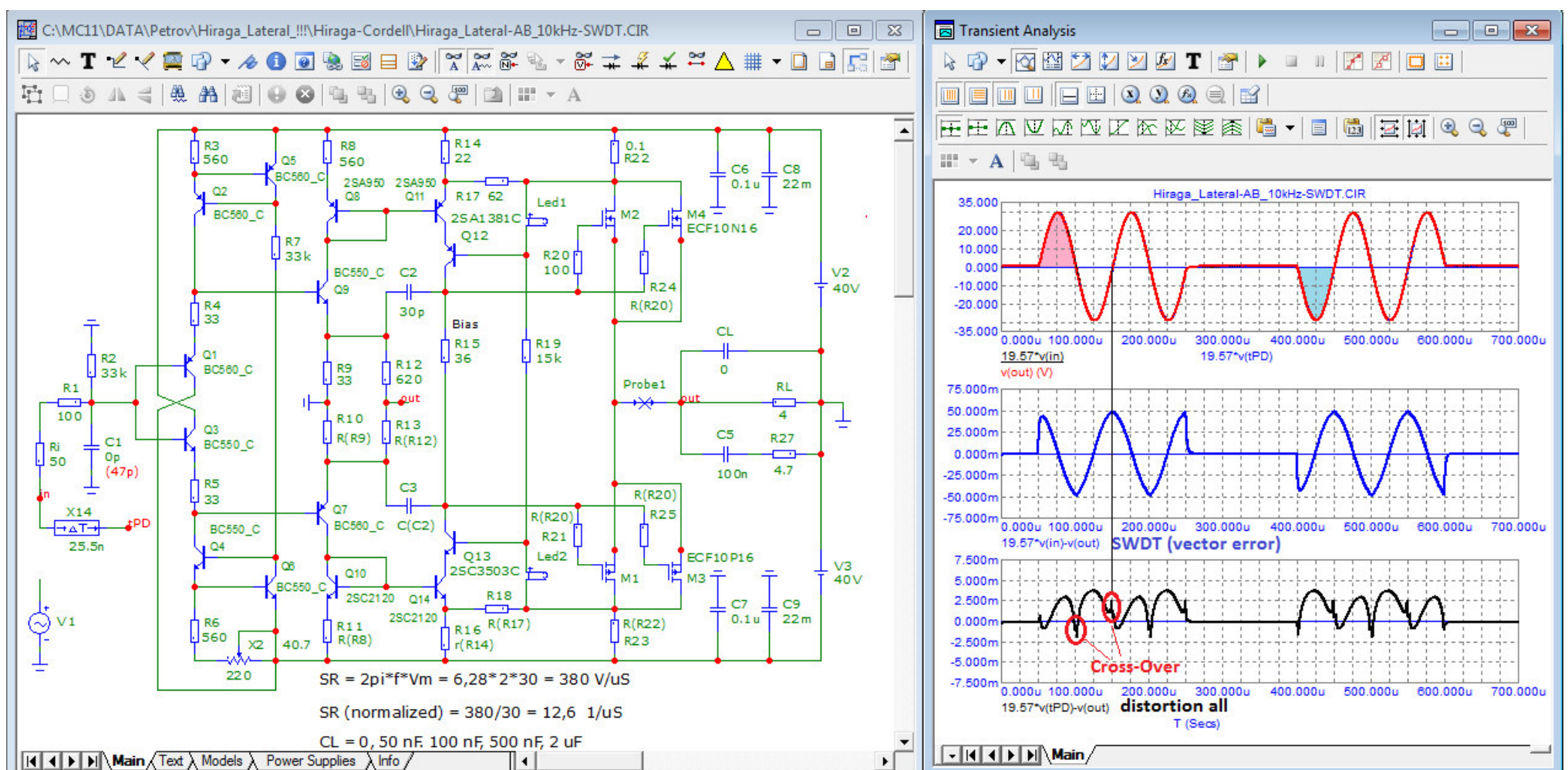


Рис. 6

With an output voltage amplitude from peak to peak of 60 V, the amplitude of the distortion products is slightly more than 2.5 mV, which is 0.004%. Opposite the zero crossings, there are small commutation distortions. High-speed distortions at the beginning of bursts and at their end are negligible - much less than switching distortions.

A good test for detecting losses in an amplified signal is the triangular signal test, fig. 7



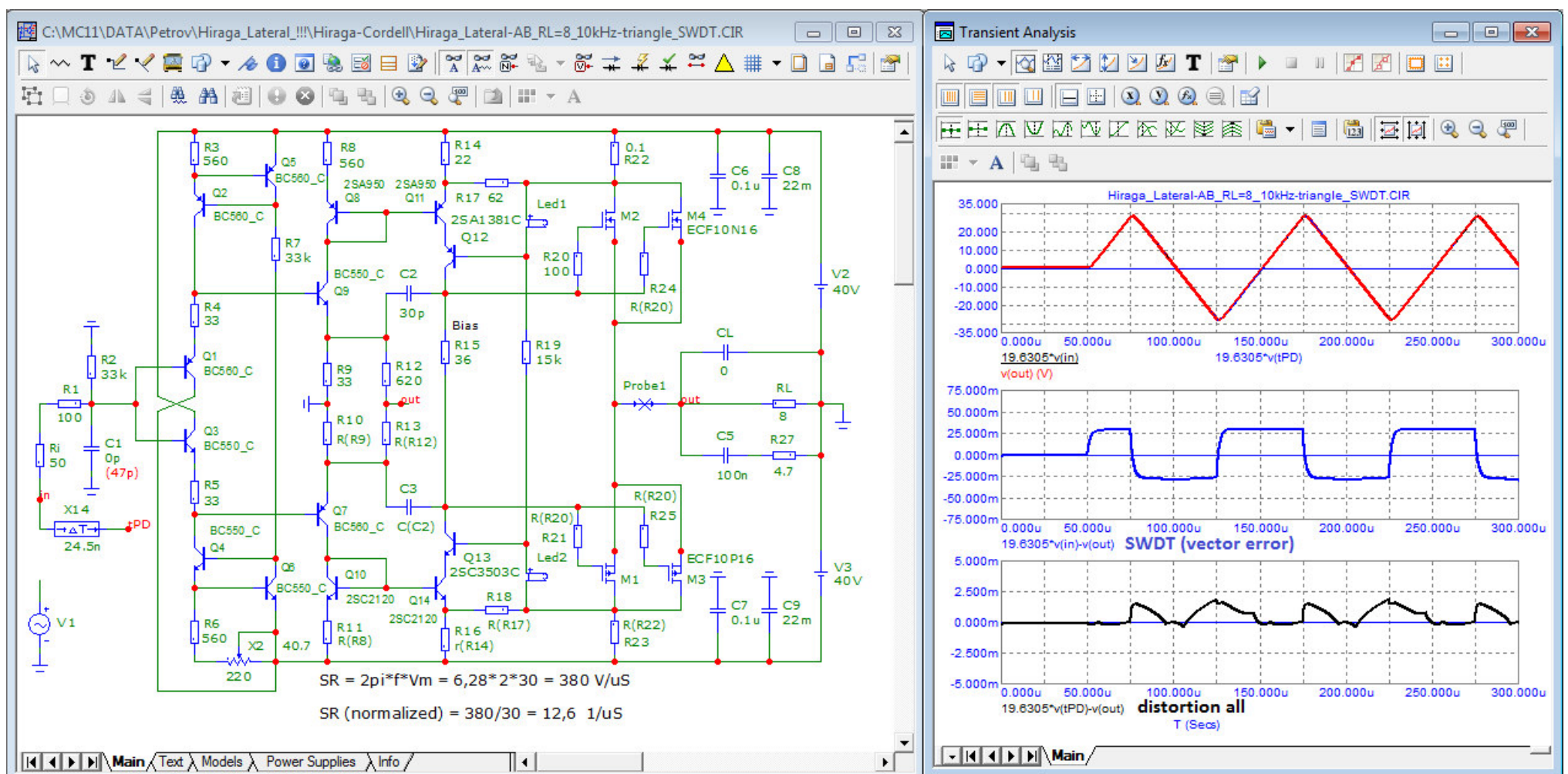


Рис. 7

The vector errors of a triangular signal look like a rectangular signal whose amplitude depends on the signal propagation delay. The slew rate of the triangular voltage is slightly lower than that of the sinusoidal voltage at the zero crossing points, therefore, the switching distortions opposite the zero crossings are also lower. The non-linearity of the linearly increasing voltage does not exceed 2 mV, which is 0.003%

In addition, we will check the performance of the model at a frequency of 2 MHz, Fig. 8

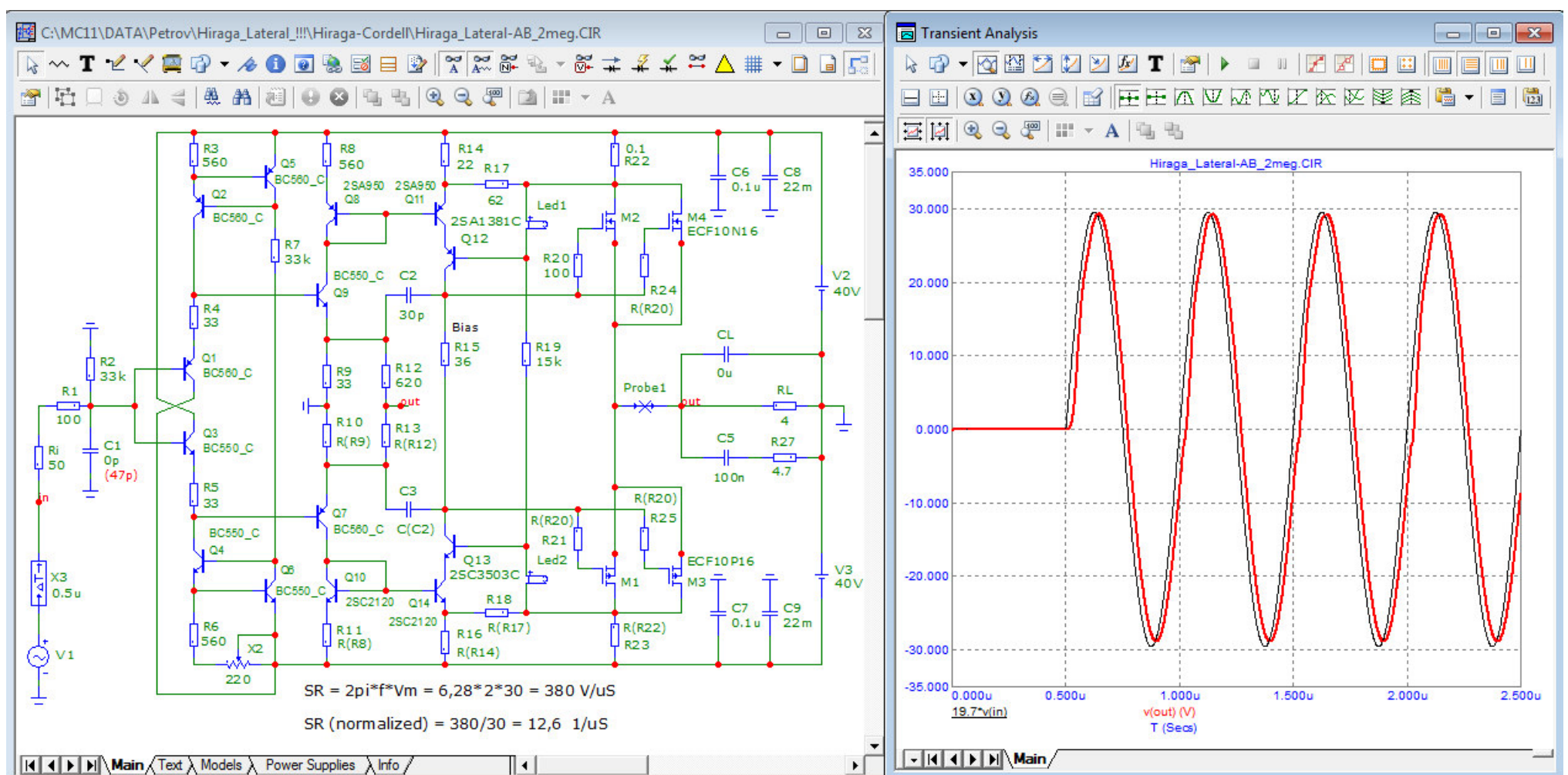


Рис. 8

Amplification of a signal with a frequency of 2 MHz passes without significant linear distortion: a decrease in the amplitude of a fraction of dB,