

# NEW UNIQUE TECHNIQUE TO MEASURE SIGNAL DEGRADATION

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The question about the signal distortions and audibility of them is a long period in the focus of discussions. There are well known contradictions between levels of measured distortions like THD, IMD and hearing impression of the reproduced signal by amplifiers or other channels of signal transfer.

The well known facts are:

- the nonlinear distortion of level  $\sim 1\%$  is difficult to detect by hearing;
- the distortion level  $\sim 0.001\%$  is important for high quality amplifier;

If to apply the polynomial [1] distortion to record and produce THD  $\sim 1\%$  -- in most tests people do not feel that there are distortions in the record! Same time the decreasing of THD from  $0.01\%$  to  $0.0001\%$  usually increases the quality of the amplifier.

The visible contradiction is well known but knowledge about it is not in use because there was no technique to select parts of audible and inaudible distortions up to now.

To find the answer which help to make better amps was interesting to me too and the answer was “in feeling” and used in stages with dynamic parameters stabilization published in “Radio” journal in Russian and discussed here [2].

Later I read some book about human senses and on psychoacoustics. It was visible that signals from ears, eyes are strongly predeveloped before recognition. Human eyes, for example, have “hypersharpness” possibility. The resolution of eyes is better then the characteristic size of one sensitive eye element. Excellent resolution it reached by the preprocessing of initial “rough” data up to the level of physical diffraction limit [3].

So it was an idea, that in hearing the strong preprocessing is also take place and hearing is a kind of ‘vision’ with limitation also determined by some main physical laws.

When you knock the door you immediately ‘see’ from what kind materials is this door, is it empty, is it heavy and filled, metal or wood, and most of you feelings are correct. The hearing is detect main basis of frequencies of the object in some long ( $<1\text{sec}$ ) interval of recognition and frequencies are stored in memory. So it is possible internally reproduce the basic frequencies and compare them with the new sound in recognition process. The extrapolation to future of expected sound is made and if ‘what you expect (in future)’ is different from ‘what you really listen’ the kind of ‘mistake’ signal generates. These features of hearing same time contain the possibilities easy to linearize polynomial-like distortion because the comparison of loud sound and same quiet sound can be done well when both are in linear form.

Linearization is also applied for ear own distortion correction and help people hear sound from speakers with  $5\%$  distortion as clear sound. But if nonlinearities of amplifier are the function of the part of the signal in some time interval, the preprocessing make hearing fast tied due to increasing amount of work. It makes depressive sound.

If the nonlinearities present, which depend on history of the signal, it looks for hearing ‘vision’ like unnatural object.

One idea which helped to find the technique was -- from the point of Fourier analyzes and THD, IMD measurements the word “world” is absolutely same as “dlrow” but difference is.

If people can hear the thin details of sound from CD for example it seems that usual audio card 16 bit (44100-48000) Hz should be enough for the detecting of audible distortions.

In first steps I did the comparison of output and input signals and was clear that each amplifier or stage are ideally the combination of  $R$ ,  $C$ ,  $L$  components, delay time  $\tau$  and some nonlinear ‘distorsion’. Equivalent to amplifier  $R$ ,  $C$ ,  $L$  components and delay time  $\tau$  is kind of linear distortion which mask the nonlinear distortion, which difficult to detect on the level of linear distortion.

Linear distortions, as equivalent of any combination of  $R$ ,  $C$ ,  $L$  components, delay time  $\tau$  (and gain) do not produce degradation of signal. They are reversible. The degradation is irreversible. If level of degradation is small its difficult to find it on the level of may be high reversible linear distortion.

Thinking about reversibility I decided to implement the following procedure, which looks first like unreal in practice.

First the symmetrical signal is prepared.

Next pictures illustrates the steps of measurement with short sweep tone. The normal full frequency tone is useful for measurements.

In the signal the central point exists (cross in red on Fig 1.) so that if to measure time from it:

$$U(-t)=U(t)$$

On Fig. 1 is (5000 Hz – 10000 Hz) + (10000 Hz – 5000 Hz) sweep tone.

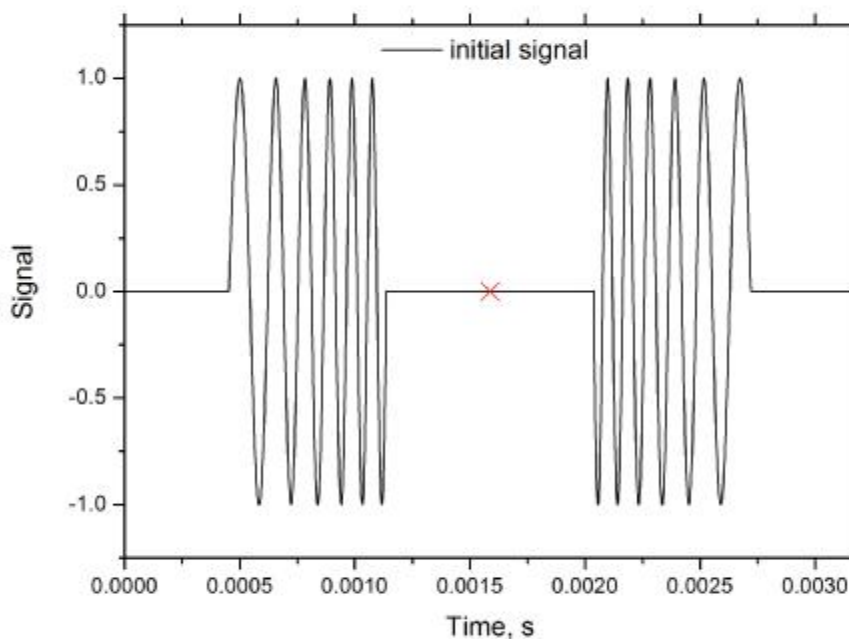


Fig. 1

The signal is applied to RC circuit (instead of real amp, for illustration) with cutoff frequency 4500 Hz and result signal is on Fig 2. The signal has linear distortion.

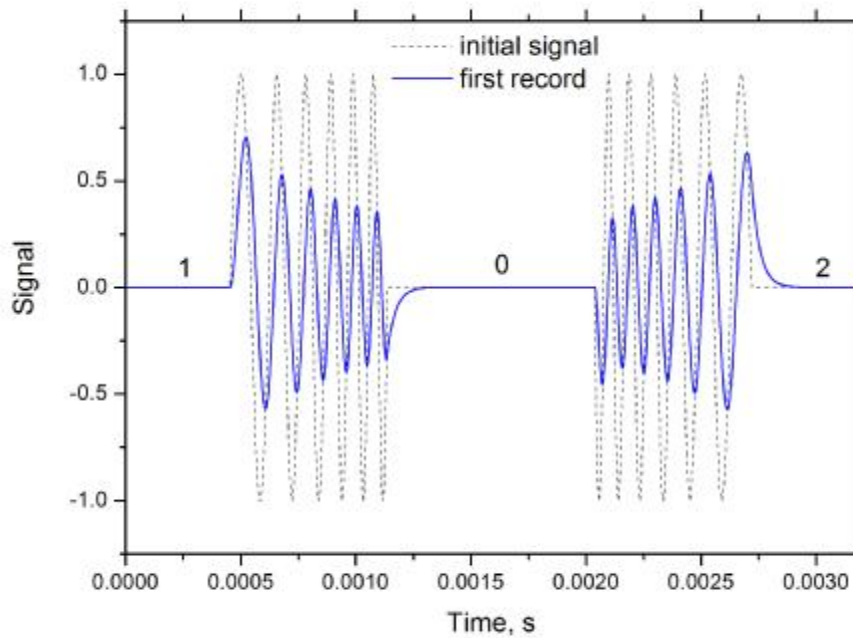


Fig. 2

Next step is to reverse the signal in time, the result is Fig. 3.

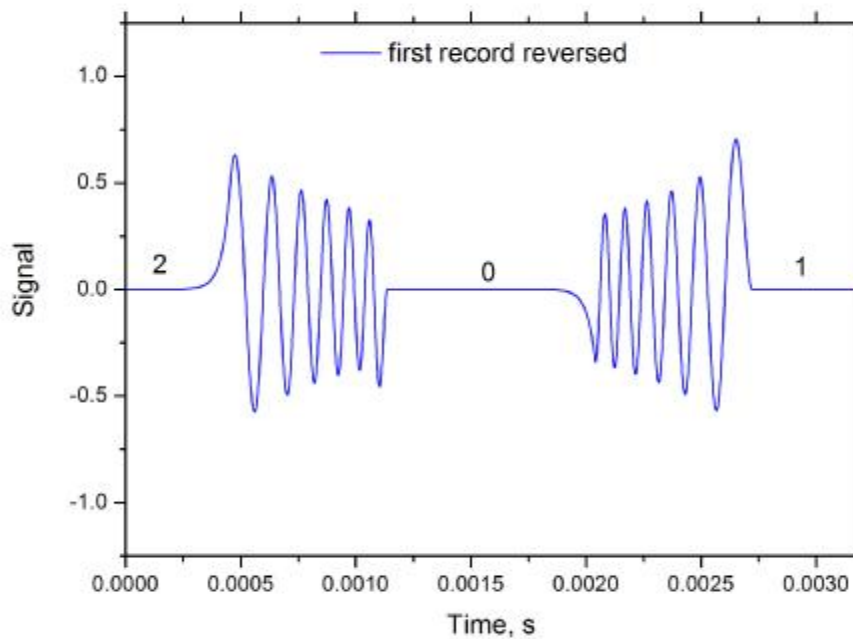


Fig. 3

And second pass through  $RC$  circuit (means through amp in measurement) is on Fig. 4.

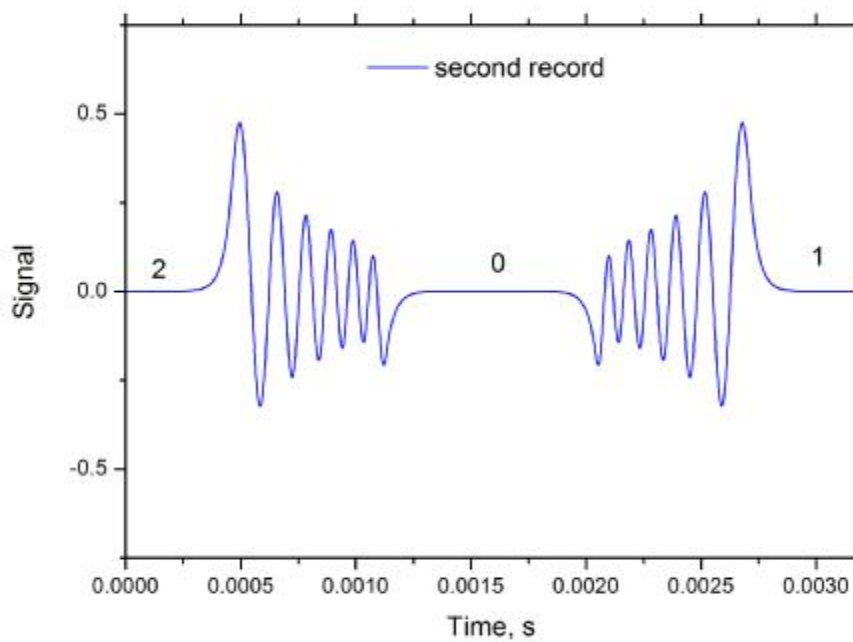


Fig. 4

For all circuits without signal **degradation** curve becomes symmetrical again, exactly symmetrical (Fig. 5).

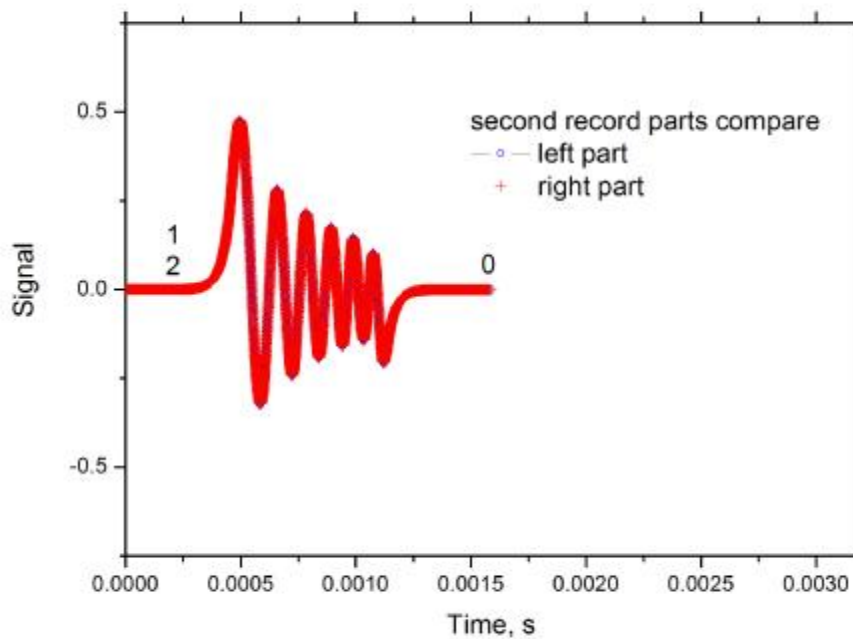


Fig. 5

If to compare left and right parts (one is reversed) they are same for linear distortion and nonlinear distortions without signal degradation and not equal for part of signal which undergo **degradation** or for irreversible part of signal.

**Only degraded part is what people really hear as the distortion.**

If the amplifier has polynomial non-linear input/output characteristics, even soft saturation, test will show small level of the distortion because output signal is symmetrical after two pass. Polynomial transform does not produce degradation.

Only the degradation of the signal cause most audible part of the distortion.

The difference from other tests and unique property of the technique is comparison of output signal with itself and not with the input one. Usual musical files can be used for test.

Test show degradation as asymmetry of signal after two pass.

There is another unique property of two pass reverse test.

(More about and some application results will be later)

Literature (preliminary):

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1--[http://en.wikipedia.org/wiki/Polynomial#Polynomial\\_functions](http://en.wikipedia.org/wiki/Polynomial#Polynomial_functions)

2--<http://www.diyaudio.com/forums/gtsearch.php?cx=014383023666666360058%3Aetltarduprk&cof=FORID%3A10&ie=UTF-8&q=kulish&sa=Search>

3--[http://en.wikipedia.org/wiki/Diffraction-limited\\_system](http://en.wikipedia.org/wiki/Diffraction-limited_system)

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