A DYNAMIC MEASURE OF HARMONIC DISTORTIONS

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The present article presents comparative analyses between a technical simulation measure of non-linear distortion and its practical realization. A dynamic control over the measuring within a wide frequency range has been offered which brings about the high precision of the measurement.

Keywords: dynamic measure, harmonic distortion, precision measurement

1. INTRODUCTION

The quality of work of low-frequency amplifiers is especially important in the contemporary technical development. The effective work of a low-frequency amplifier is determined by the introduced non-linear distortion and that's why its measurement and analysis is very significant. The present article analyses a sample technical measure of non-linear distortion. It compares the simulation and practical results of the research. An opportunity to preliminary correct and measure non-linear distortion within the full spectrum of the output signal is offered on this basis.

2. TASK OF THE ARTICLE – MEASUREMENT OF HARMONIC DISTORTIONS

The electric signals passing through a given amplification or correction chain suffer an unwanted change in their form and phase. This king of change is called non-linear distortion. The value of this distortion is characterized by the so-called coefficient of non-linear distortion – equation.1. This coefficient represents the relation between the geometric sum total of the effective values of all harmonic without the first one and the amplitude of the first harmonic.

$$(1)\quad K_{THD1} = \frac{\sqrt{U_2^2 + U_3^2 + U_4^2 + \ldots + U_n^2}}{U_1}$$

There is another way to represent mathematically the non-linear distortion coefficient – equation.2. Here we have the relation between the geometric sum total of the effective values of all the harmonics without the first one and the effective value of the full signal.

$$(2)\quad K_{THD2} = \frac{\sqrt{U_2^2 + U_3^2 + U_4^2 + \ldots + U_n^2}}{\sqrt{U_1^2 + U_2^2 + U_3^2 + U_4^2 + \ldots + U_n^2}} = \frac{\sqrt{U_2^2 + U_3^2 + U_4^2 + \ldots + U_n^2}}{U}$$

Equation.3. represent the relation between the two coefficients.

$$(3)\quad K_{THD1} = \frac{K_{THD2}}{\sqrt{1 - K_{THD2}}}$$

With non-linear distortion of the signal under 15% coefficients K_{THD1} and K_{THD2} are equal. The suggested method to measure the non-linear distortion coefficient is used mainly to measure low value distortion. The method gives precision of up to 0,01%. [1]

2.1.The general block scheme of the suggested measuring device of harmonic distortion is shown on fig.1.

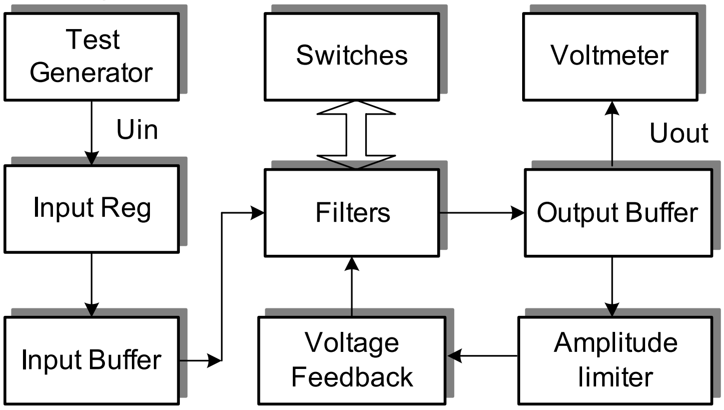

Fig.1. General block scheme of the THD meter

2.2. Requirements for the separate blocks:

- The input regulator: to support and artificially regulate the output level to reach a preliminary given value of 1V; to have a low personal input capacity in order not to change the parameters of the signal received by the test generator; a high input resistance in order not increase the voltage of the test generator; linear regulation within the whole frequency range.

- Input/Output buffer: to repeat the input voltage within the whole frequency range of research i.e. its own "amplitude characteristics" should be 10 times bigger than "amplitude characteristics" of research; to increase the input current in the outlet without this influencing the voltage value; to have a low input current and a low input voltage of asymmetry i.e. $U_{in} = OV$, $U_{out} = OV$; a low input capacity with input resistance R_{in} within $1 \div 2M\Omega$.

- Filters: to transmit an input signal in the outlet without fading in the permeable band; to be maximum steep within-20-30 db/oct; minimal suppression of neighbouring frequency within the given spectrum; to allow regulation and additional adjustment of rejection frequency; a full symmetry of two-arm schemes- this is achieved by the use of exact passive elements; not to influence the form, amplitude and the phase of the input signal- these signals are transmitted to the outlet with no change whatever.

- Switches: minimal transition resistance in the commutation change; frequency compatibility among all participant groups; low parasite L and C; to get the necessary frequency range two-side four-armed keys should be used; a synchronized commutation among the different switch arms.

- Feedback and Output limiter: to provide an increase in the current according to the output regulator signal and those to the separate filters; to provide a high steepness of rejection without directly taking part in the chain to define the output signal; to have a low personal noise and high CMRR; to change the qualitative factor of the ring without changing its frequency parameters (*frej*); not to influence the symmetry of the separate filters and to synchronically compensate the two participant – arms respectively; linearity and equal steepness to the low and high-frequency arm without interfering with the output signal.

- Voltmeter: to measure the effective value of the output voltage; to possess a high-frequency measurement band- up to 100 kHz for sinus signals; principle of functioning of the device – a voltmeter with a preliminary detection; to have a minimal measurement error lower than 0.01%; to possess a high linearity in the different measurement range; a low value of the parasite L and C.
On the basis of all of the above – mentioned requirements I suggest a sample measurement scheme, shown on fig.2.

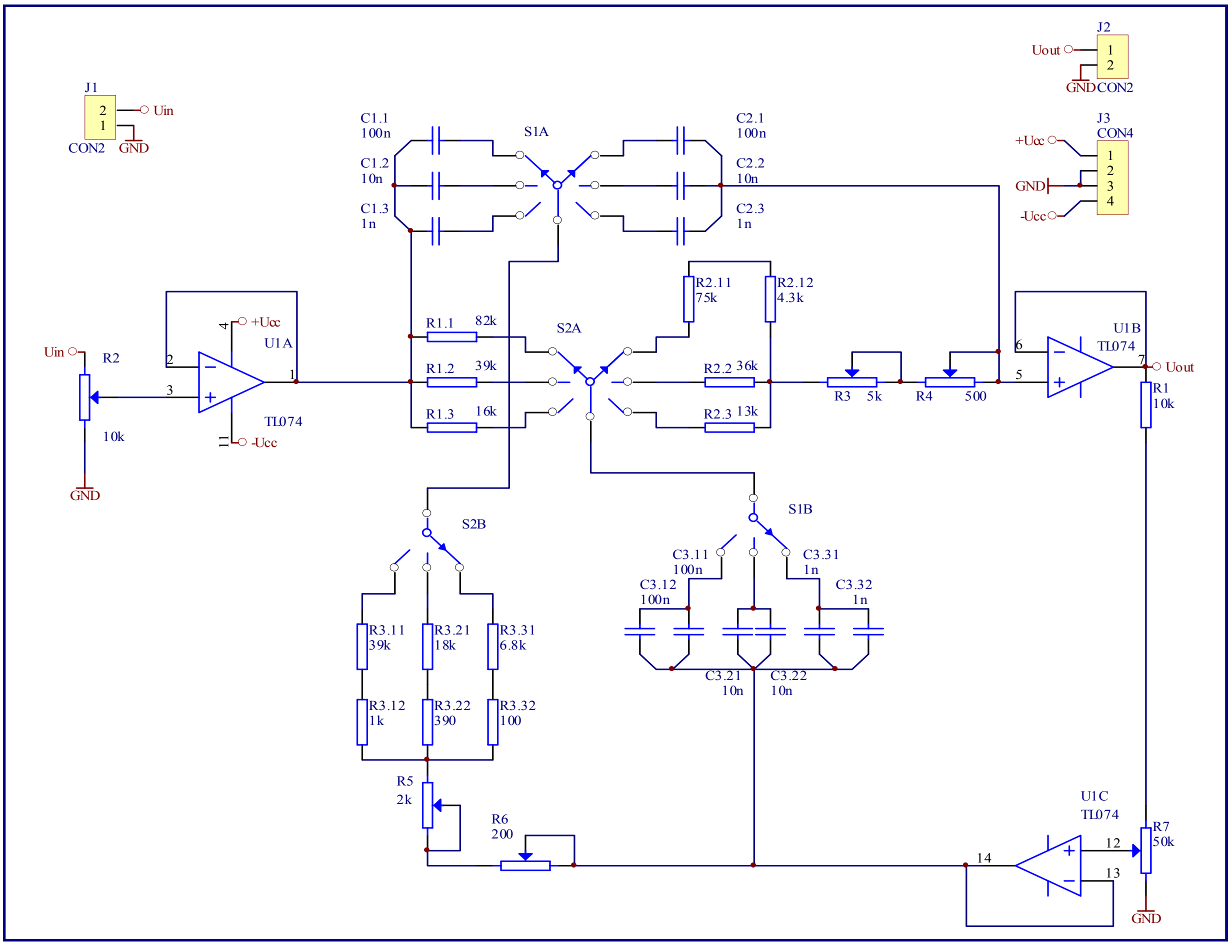

Fig.2. a sample measurement scheme for non-linear distortion

3. A PRACTICAL STUDY OF FADING. FUNCTION PRINCIPLE OF THE NON-LINEAR DISTORTION MEASUREMENT.

In this approach and solution to the problem to measure non-linear distortion, we

Таблица.1.

№	$f_r[Hz]$	$U_{out} - U_{in}[V]$	$20\lg U_{out}/U_{in}[db]$
F1	19,4	0,56	**-5,03**
F2	40,8	0,72	**-2,85**
F3	99,5	0,87	**-1,2**
F4	194	0,56	**-5,03**
F5	408	0,56	**-5,03**
F6	995	0,87	**-1,2**
F7	1,94к	0,56	**-5,03**
F8	4,08к	0,73	**-2,85**
F9	9,95к	0,88	**-1,11**
Additional five researches			
F10	420	0,72	**-2,85**
F11	1,85к	0,56	**-5,03**
F12	3,99к	0,71	**-2,97**
F13	4.2к	0,74	**-2,85**
F14	4,95к	0,86	**-1,31**

use a scheme realization and measurement of non-linear distortion according to the method of rejection filtration. To use this method within such a wide frequency range it is necessary to use more structural units making up the separate filtration. This is achieved by breaking the frequency range into nine sub-ranges with the help of which the necessary linearity in the transmission characteristics is achieved. An example of the breaking up of the separate frequency ranges has been shown in table 1. For the practical realization passive rejection filters of the type "double T-bridge" which filters the chosen sub-range has been used. A peculiarity in the choice of the separate rejection frequencies is totally in accordance with the distribution of sound reverberation in the frequency range up to 5kHz, where the basic harmonic carriers of the sound spectrum are. This exactly is the reason for the expanded analysis in the low-frequency range up to 5 kHz. The non-linear harmonic distortion in every low frequency amplifier is differentiated up to -10db compared to those in frequencies over 5 kHz i.e. the distortion in the low-frequency range in all research show that the overall distribution of harmonic distortion is basic in this low-frequency range. The passive filter realization is a high advantage of the scheme because it is impossible for them to introduce non-linear distortion whatever. The only disadvantage in this case is the higher and uneven fading of each one of the units. The analysis of this fading is experimentally defined for each of the used filters. The research results have been shown in table 1. Additional 5 researches have been carried out to define more precisely and correct the fading. To be able successfully to regulate the fading in the whole frequency range it is necessary to link additional resistors to the scheme. The linking is to the respective arms to regulate the resonance frequency of each one of the used filters. In this way an overlapping in the frequency range is achieved so that we are able to cover the full spectrum from 20Hz – 10 kHz. To ensure the best regulation and overlapping of the separate frequency characteristics we use key units (S1A, S2A, S1B, S2B – fig.2) with the help of which the chosen frequency band is switched over. In this way we can easily select the necessary frequency or a whole frequency range while preserving the linear transmission and measurement. The depth of the feedback in each of the used filters is automatically corrected by the use of an additional amplifier (U1C – fig.2.) The use of amplifiers U1A and U1B (fig.2) is sequenced to the inlet and respectively the outlet of the scheme. A contrastive analysis of Amplitude characteristics received in programmer simulation and those in practical research is shown in fig.3.

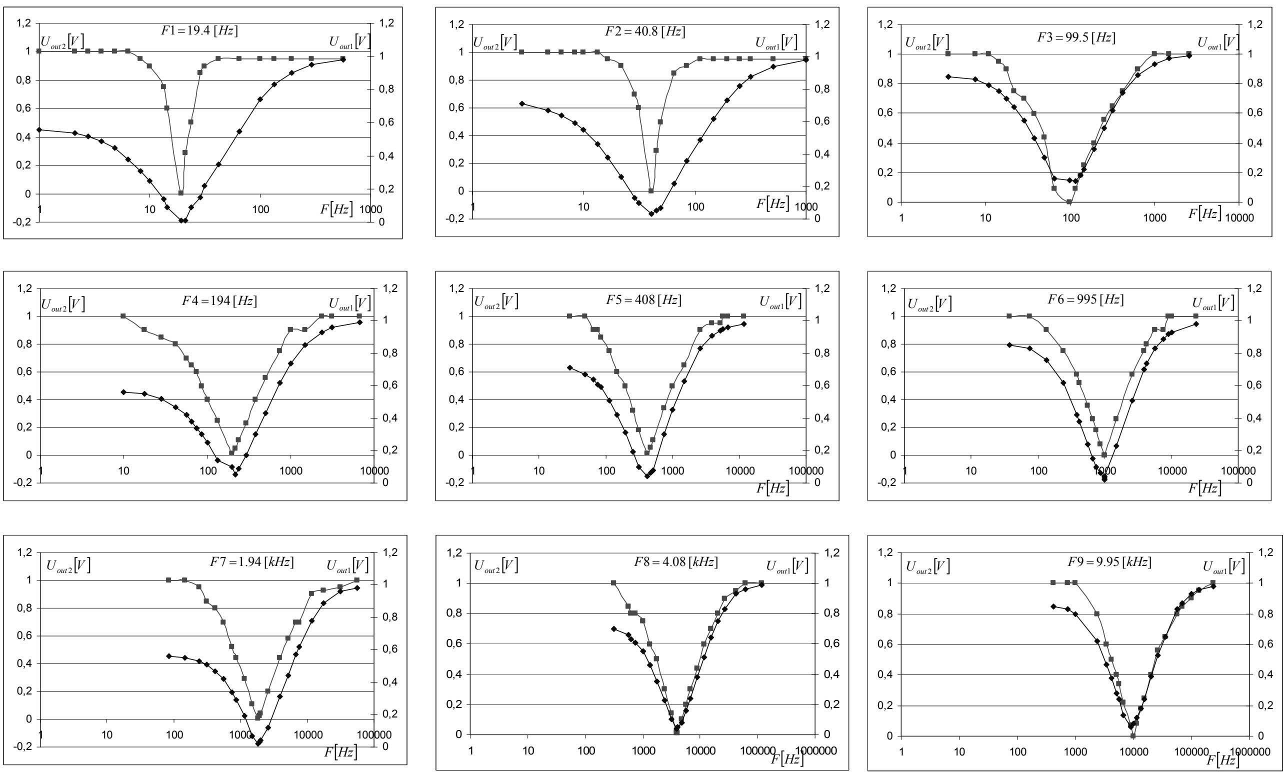

Fig.3 A comparison contrast of Amplitude characteristics in practical and simulation research.

Legend:

$F[Hz]$ - frequency of the voltage measurement;

$U_{out1}[db]$ - the result of the output voltage in an equivalent programmer simulation of the scheme with program product Electronics Work Bench 5.12 (student version);

$U_{out2}[V]$ - the result of the output voltage in the research of an experimental model of each of the rejection filters-a practical study of a rejection filter of second rank – "double T bridge"

In all the conducted analyses the amplitude of the input signal is Uin=1V

4. CONCLUSIONS

The conducted comparative analysis of rejection filtration defines the following more significant conclusions:

- rejection filtration with passive filters is preferred because of the absence of quoted non-linear distortion by the measurer i.e. high precision of the measured results.
- in the study of non-linear distortion it is important to make an analysis not only for two different frequencies but to involve the whole frequency spectrum;
- a preliminary simulation analysis for each one of the rejection frequencies has been made to give a clear idea of rejection before getting down to practical work;
- to improve the characteristics of the used rejection filters shown in the simulation and additional feedback for level correction is introduced. The aim is to deepen the negative feedback during rejection and in this way to improve the section band of the chosen filter.
- to improve additionally the characteristics of each of the used combination filters additional variable resistors for setting the amplitude in the place of rejection are used. The measurer is in coordination with buffer steps which are linked to the inlet and outlet of the system. These buffer steps have been chosen in such a way that their own non-linear characteristics are much smaller than those of the researched devices.
- in the course of the project a contrastive analysis among amplitude characteristics of all used passive filters was made. This simulation research is graphically compared to the practical data. Some differences in the characteristics have been seen in some places but these differences vary with the different filters. This shows that it is practically impossible to create ideally symmetrical filters like the ones that are used in simulation research. The reason for this is the difference in the margins of the used components

5. REFERENCES

[1] P. Angelov., "Measurement and contorl of total harmonic distortion in frequency range 0,02 - 10kHz" Sozopol Electronics forum 2005

[2] P. Angelov. Automatic computer system for measuring audio parameters including of total harmonic distortion (THD). Burgas Free University - NID Technical project 2006

[3] www.protel.com – Protel'99SE (trial version)

[4] Electronics Work Bench 5.12 (student version)