# Low Frequency Measurement and Control of the Load Impedance

Plamen A. Angelov[1]

*Abstract* – **The measuring and control of the load impedance in HiFi audio range has often been accompanied by many difficulties. Most of the well-known methods of analysis and design of low frequency amplifiers do not read the impedance character but they read only the load as active impedance. It is well-known, from the common theory, that while changing the frequency of a dynamic system, its characterizations are changed too. That's why the present article is aimed to explore the impedance characterization of a speaker where in the system is set intelligent feedback for control and linearization of the parameters of the separate modules.**

*Keywords* – **Measuring, control of impedance, frequency, resonance.**

## I. Task of the Article

Very often the research of the load impedance of a speaker has been a serious challenge for the buffering of the amplifiers. The change of the impedance with the change of the working frequency is the reason for occurring of non-linearities and not buffering correctly at the outlet. The frequency characteristic of the impedance is of basic importance for the linear and key audio stages. This article looks at the question of measuring and qualification of the non-linear in the impedance characteristics and together with it uses a specialized audio controller in order to decrease to minimum the influence of the test system. This is achieved at some stages of measuring - a. Measuring and calibration of the device; b. Measuring the impedance characteristics of a certain audio amplifier. For exploring the qualities of this resonant system, we use current amplifier in advance and in this way coordination is achieved between the sample signals from the testing generator and the ones directed to the load [1-4]. In order to linearize to a maximum extent the characteristics of exploration, the intelligent reverse connection is used. With its help, in a regime of calibration, the correction of the non-linearity of the system is achieved. The general block scheme of a measurer is shown on picture.1.

The way of measuring with this scheme requires calibration in advance with an opportunity for a smooth management of the frequency of the etalon generator.

A) calibration of the measurer:

In a regime of calibration, the output of the system is connected to "power ground".

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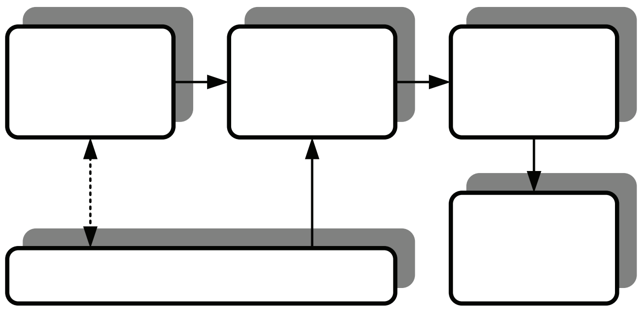
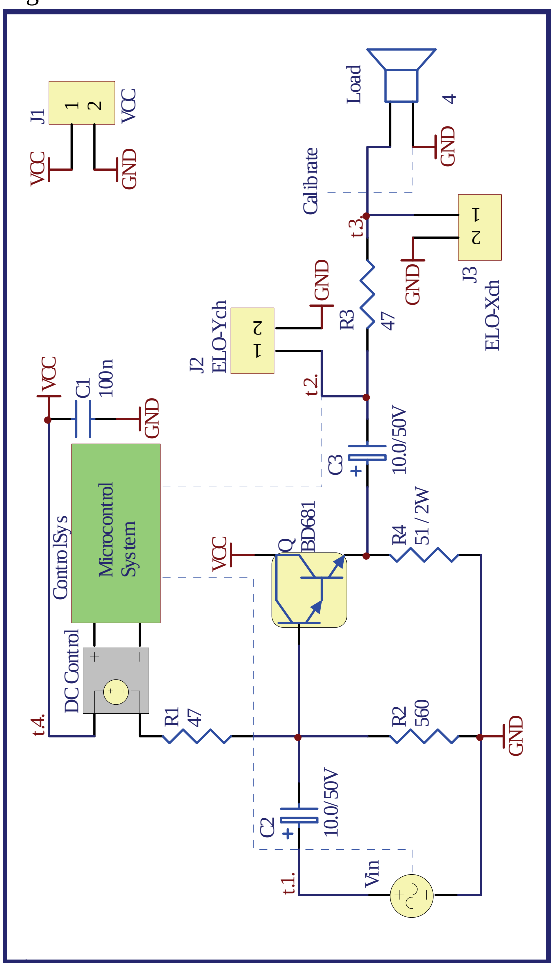


Picture.1. General measuring structure

After setting the system to such a regime, the microcontroller tests the linearity at the output and if necessary additional corrections to the input current amplifier or to the test generator are introduced- only in case such a set is possible. If during the calibration time the set parameters for output signal are not reached, a warning for a change of the test generator is issued.




Picture.2. Principle scheme of exploration

B) Regime of exploring of the impedance characteristics:

Once the system is successfully calibrated, it is necessary to switch at the output the explored amplifier.During the process of exploring, changes of the parameters of the test generator are not recommended.

In case it is necessary, the measuring system should be calibrated again.

Way of work and description of the materials used:

On picture 2 we use sample resistance which helps us restrict the maximum power running through the explored load. A signal from a generator is given to a transistor Q1 which increases the signal over the power. The input consists of a condenser C2 which plays the role of a galvanic result between the constant and changeable input component. In most cases, apart from the power-changing result, this condenser takes part in determining the frequency band. It also influences the non-linear distortions adjusted by the step.

In order to decrease this influence to the minimum, the condenser is chosen with minimum loses and a working temperature 1050 [C]. The group of the resistance R1, R2, R3 and the transistor Q1 comprise the current amplifier. The condenser C1 filters the input voltage.

The block scheme is shown on picture 2.

## II. Design and Analysis

In order to project this model we should give the following initial terms.

- The system is linear and does not need additional adjusting-that is to say the regulated voltage source is $U_{dc}$=0 [V];
- Switching on the microcontroller system to the output system (jumper J2) does not change the parameters of the system.
- Designing of the output divisor of voltage. The voltage from the amplifier of power is Uin=9V.I choose the power through the transistor collector Ic=0.2A
- Determining the value of the base resistor $R_t$

*The extent of the resistor $R_3$ is determined by the expression:*

[1] *Rt=Ut/Id [Ω]*

*After substituting we get:*

*Rt=1/0.2 = 5 [Ω]*

*We choose the standard value* $R_t$ = 4 [Ω]

Determining the value of the load resistor $R_4$

*The extent of the resistor $R_4$ is determined by the expression:*

[2] *R3=(Uin-Ut)/Id [Ω]*

*After substituting we get:*

*R3=(9-1)/0.2 = 40[Ω]*

*We choose the standard value* $R_3$ = 47 [Ω]

- Determining the extent of the separating capacitors $C_2$ и $C_3$:

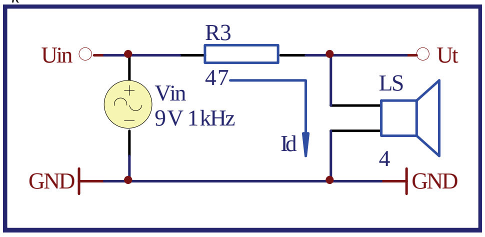
The extent of the capacitance is received by the expression:

[3] $$C_2 = C_3 = \frac{1}{2\pi . fn . \mathrm{Re} . \sqrt{M_2^2 - 1}} = \frac{1}{2.3{,}14.100.560.\sqrt{0{,}1^2 - 1}} = 2{,}84.10^{-6}$$ [F]

*we choose the standard value* $C_2 = C_3$ = 10 [uF]

- Setting the extent of the collector current $I_k$:

*$I_k$=300mA*




Picture.3. Amplifier circuit and sample load

-Determining the extent of the base current $I_b$:

*The extent of the base current $I_B$ is determined by the expression:*

[4] $$I_B = \frac{I_C}{\beta}\ [A]$$

*After substituting we get:*

$$I_B = \frac{I_C}{\beta} = \frac{300.10^{-3}}{750} = 0.4\,[mA]$$

-Determining the extent of a source voltage for powering the transistor T1 picture 4. The source voltage is U3=12V.The voltage to the transistor is UT=11.2V. I choose the current through Id=0.02 [A]

*The extent of the resistor R2 is determined by the expression:*

[5] *R2=$U_T$/Id [Ω]*

*After substituting we get:*

*R2=11,2/0,02[Ω]*

*We choose the standard value* $R_2$ = 560 [Ω]

- Determining the value of resistor $R_1$

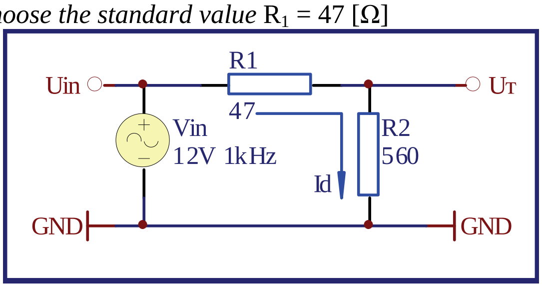
*The extent of the resistor $R_1$ is determined by the expression:*

[6] *R1=(U3-$U_T$)/Id [Ω]*

*After substituting we get:*

*R1=(12-11,2)/ 0,02=40[Ω]*

*We choose the standard value* $R_1$ = 47 [Ω]




Picture.4. A voltage divisor for transistor powering

## III. EXPERIMENT RESULT

The explored experiment results were made on the basis of a scheme from picture 2

Test point 1:

The input signal from the generator comes to a control point 1:-depending on the certain kind of measuring [4] this voltage is kept a constant at the two bordering values $U_{in1}$=10 [V]; $U_{in2}$=100 [mV] which is made with the help of the micro-controller system;

Test point 2:

The input signal at test point 2 is amplified by current from the transistor Q1, and the input voltage of the divisor consisting of R3 the measured speaker: U=6 [V] is measured;

Test point 3:

At test point 3 we explore the voltage change of the power load.

The performed experiments with a change of the input frequency and preserving the input frequency of the divisor [4] (U=100 [mV]) consisting of R3 and the amplifier which is measured. The results of this measuring are shown in a table and graphics.The data from tables 1 to 5 are shown in graphic 2.

- Voltage change in point 3 at input level Uin=100 [mV] (k.т. 2) and frequency range f=0.1÷0.9kHz table.1.

| | | | | | |
|---|---|---|---|---|---|
| *F [kHz]* | 0,1 | 0,2 | 0,3 | 0,4 | 0,45 |
| *U [mV]* | 109 | 110 | 126 | 126 | 126 |
| *F [kHz]* | 0,5 | 0,6 | 0,7 | 0,8 | 0,9 |
| *U [mV]* | 127 | 127 | 127 | 127 | 137 |

- Voltage change in point 3 at input level Uin=100 mV (k.т. 2) and frequency range f=1÷5 kHz table.2.

| | | | | | |
|---|---|---|---|---|---|
| *F [kHz]* | 1 | 1,5 | 2 | 2,5 | 3 |
| *U [mV]* | 137 | 157 | 178 | 178 | 178 |
| *F [kHz]* | 3 | 3,5 | 4 | 4,5 | 5 |
| *U [mV]* | 198 | 198 | 208 | 216 | 218 |

- Voltage change in point 3 at input level Uin=100 mV (k.т. 2) and frequency range f=5.6÷9.5kHz table.3

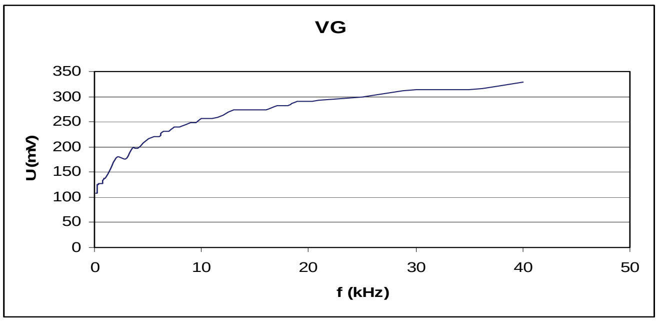
| | | | | | |
|---|---|---|---|---|---|
| *F [kHz]* | 5,6 | 6 | 6,5 | 7 | 7,5 |
| *U [mV]* | 220 | 220 | 231 | 231 | 239 |
| *F [kHz]* | 8 | 8,5 | 9 | 9,5 | 10 |
| *U [mV]* | 239 | 245 | 248 | 248 | 257 |

- Voltage change in point 3 at input level Uin=100 mV (k.т. 2) and frequency range f=10÷18 kHz table.4

| | | | | | |
|---|---|---|---|---|---|
| *F [kHz]* | 10 | 11 | 12 | 13 | 14 |
| *U [mV]* | 257 | 257 | 257 | 254 | 273 |
| *F [kHz]* | 15 | 16 | 17 | 18 | 19 |
| *U [mV]* | 273 | 273 | 273 | 282 | 282 |

- Voltage change in point 3 at input level Uin=100 mV (k.т. 2) and frequency range f=19÷40 kHz table.5

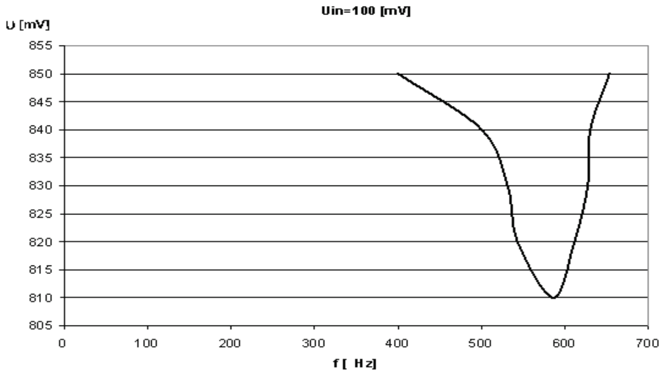
| | | | | | |
|---|---|---|---|---|---|
| *F [kHz]* | 19 | 20 | 25 | 30 | 40 |
| *U [mV]* | 290 | 290 | 300 | 315 | 329 |




Graphic 2 Frequency dependence of the measured voltage over the load

In table 6 and picture 3 is shown the mechanic resonance of the speaker.

| | | | | |
|---|---|---|---|---|
| *F [kHz]* | 400 | 500 | 531 | 543 |
| *U [mV]* | 850 | 840 | 830 | 810 |
| *F [kHz]* | 586 | 611 | 627 | 653 |
| *U [mV]* | 820 | 830 | 840 | 850 |




Graphic 3 Graphic showing the change in the area of the low frequency when presenting the speaker which is explored as a consecutive trembling circle

## IV. CONCLUSION

From the analysis and the experiments performed so far, we can make the following important conclusions:

1.Exploring the characteristics of the loudspeaker system – amplifier in HiFi frequency range;

2. Buffering of the explored source with the load by the current amplifier, the use of such an amplifier is conformed with the frequency band of exploration, and as an addition is used a component transistor and a micro controlling system;

3. The loudspeaker parameters of the amplifier directly depend on the power applied on it;

4. In any electro mechanic structure there is mechanic loudspeaker whose reach or passing through it in the area of the low frequency is limited by a sample resisting load;

5. The power of exploring is limited and is different for the type of amplifier which is explored;

6.There is a chance the explored data of the amplifier to be visualized by figures of ‘Lisaju’ without using the unwrapping of the electronic oscilloscope;

7. The practical explorations being made, show much loudspeaker system and the adjusted non-linearity in the characteristics: F = Z (f).

The present research suggests a practical way to achieve a programmed time delay. A system to suppress the output signal level has been introduced in order to limit the amplitude. This kind of stabilization does not produce a large harmonic distortion in the signal which makes if suitable for the Hi-Fi sound range. The enclosed simulation result show the principle of work and what has already been achieved By the project.

## REFERENCES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