CRITICAL ANALYSIS OF A METHOD FOR DETERMINING THE EFFICIENCY AT LINEAR AUDIO AMPLIFIERS

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The point of this article is the critical analysis of the method to determine the efficiency at linear audio amplifiers. The parameter efficiency shows the maximum advantage of the power supply with minimal lose. The present article shows the critical analysis of the method [1] to define the power consumption and enhances its advantages and disadvantages.

Keywords: analysis, efficiency, amplifier

1. INTRODUCTION

All new audio amplifiers are divided into two classes – linear and switching amplifiers. In the first class, the change of the input signal, during the process of amplifying, is linear compared to the change of the output signal which is the reason they are called 'Linear audio amplifiers. They are divided according to the regime of work of the output stage. This regime determines the efficiency of work and the THD in the output signal. Irrespective of the class of work of the linear stages, an identical model for their realization is used, which is shown on Figure 1.At this model, the input signal is connected to the pre-amplifier stage which amplifies the input voltage and co-ordinates the signal source with the stage. Next comes amplifying at voltage and powering of the driver circuit whose main role is to provide the current needed by the output stage to work. General structure scheme of a similar kind of an audio amplifier is shown on Figure 1. The switching audio amplifiers use modulation of the input signal and its following amplifying in a switching mode. A group for restoring of the low-frequency filter is used in the output stage. The way they work will not be subject of this article, but we must mention that this model of amplifiers is widely used in the micro-technological productions. The reason for this is that their efficiency reaches up to 90 %. [2]

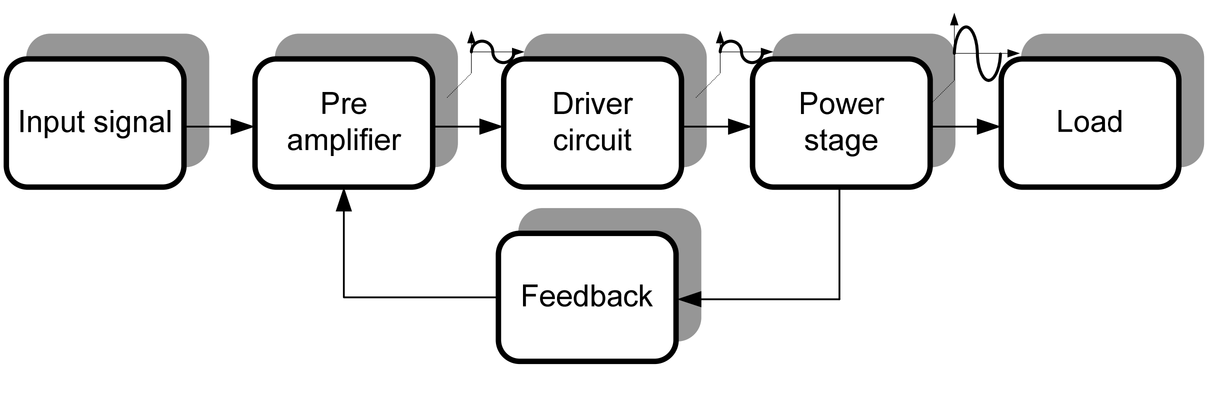

Fig.1. Block schematic of the linear audio amplifier

2. THE EFFICIENCY OF LOW-FREQUENCY AMPLIFIERS (LFA)

The efficiency of an LFA is expressed by the extent to which the energy consumed by the feeding source is transmitted to the outlet as a useful signal and by the amount of what is lost as warmth. At present, the known LFA are the amplifiers working in classes AB and G or H, the effective work in this case is good but is accompanied by a higher non-linear distortion and a limited dynamic range of the output signal [1]. To improve the output efficiency of the amplifier, the quoted non-linear distortion should be observed. To solve this problem a hybrid connection of amplifiers, working in different classes (G and H), is used, which results in effective signal amplification and quoted low non-linear distortion. The efficiency of the low-frequency amplifier /LFA/ is the relation between the quoted output power and the amplifier consumption. This can be expressed by the equation:

(1) $$\eta = \frac{P_o}{P_c}.100\ \%$$

Legend:
η - efficiency coefficient of LFA;
Po – output power;
Pc – consumed power.

It is known that we can write the equation:

(2) $$P_c = P_d + P_o\ [W]$$

Legend:
Po – output power;
Pc – consumed power;
Pd – power dissipation.

Then substituting Pc in the expression 1, we will get:

(3) $$\eta = \frac{P_o}{P_c} = \frac{P_o}{P_d + P_o}.100\ \% \Rightarrow \frac{P_d + P_o}{P_o} = \frac{1}{\eta} \Rightarrow \frac{P_d}{P_o} + 1 = \frac{1}{\eta} \Rightarrow \frac{P_d}{P_o} = \frac{1}{\eta} - 1 \Rightarrow$$
$$P_d = P_o.(\frac{1}{\eta} - 1)\ [W]$$

3. AN ANALYTICAL MODEL FOR DETERMINING THE POWER CONSUMPTION AT LINEAR AUDIO AMPLIFIERS

The method described in [1] determines the power consumption by the power supply, which is defined by this equation:

(4) $$P_c = \frac{1}{2.\pi}.\int_0^{\pi} \frac{U_{cc}}{2}.[1 - K.\sin(\omega.t)].\frac{U_{cc}}{2.R_L}.K.\sin(\omega.t).d(\omega.t) = \frac{U^2{}_{cc}}{8.\pi.R_L}.(\frac{2.K}{\pi} - \frac{K^2}{2})\ [W]$$

Legend:

U_{cc} $[V]$ supply voltage;

R_L $[\Omega]$ active load;

$\omega = 2.\pi.f$ $[rad/\sec]$ frequency;

$K = \frac{U_{L\max}}{U_{cc}}$ coefficient of use of the power supply.

The analytical presentation continues with an analysis of the function at change of two of the existing parameters – power supply $U_{cc}[V]$ and coefficient of use K. All the explorings listed below are limited by the following parameters: $R_L = 4[\Omega]$; $P_{onom} = 40[W]$; $P_{omax} = 70[W]$; $U_{cc} = 5\text{-}50[V]$; $THD < 0.1[\%]$, $f_{sq} = 1$ $[kHz]$.

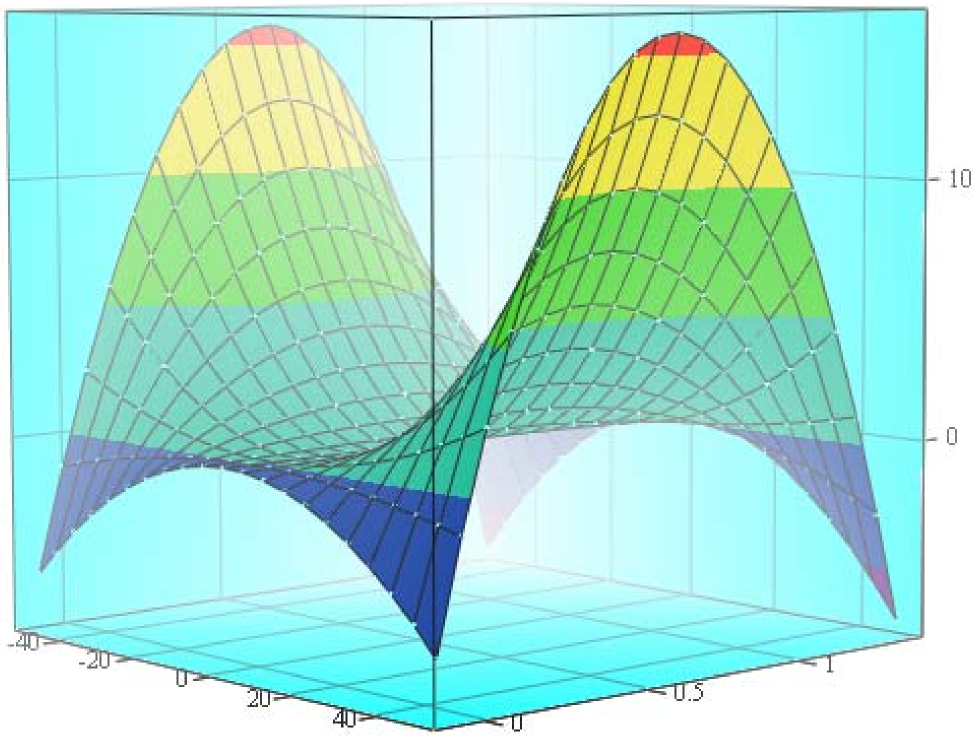

Fig.2. Analytical study of the consumption power *Pc[W]* with change of $U_{CC} = 0 \div \pm 50$ $[V]$ and $K = 0 - 1$

In the analytical study, shown on figure 2,the coefficient of use of the power supply - K and the supply voltage - $U_{cc}[V]$ is changed in this range $K = 0 - 1$, $U_{CC} = 0 \div \pm 50$ $[V]$, and the load remains constant $R_L = 4$ $[\Omega]$.The gained result is shown on Fig 2. From here, we can draw the conclusion that we have maximum of the function at $K = \frac{2}{\pi} = 0.637$. The comparison of the received result to the known analytical methods [3,4] shows more precise measuring of the output efficiency. This can be confirmation that this analytical model can express more precisely the change of the power consumption.

Now let's analyze the change of the power consumption with the change of the load in the range $R_L = 2 \div 12$ $[\Omega]$, the coefficient of use of the supply voltage $K = 0 - 1$

and the maximum supply voltage from $U_{CC} = \pm 50\,[V]$. The received change of the function is shown on Fig.3.

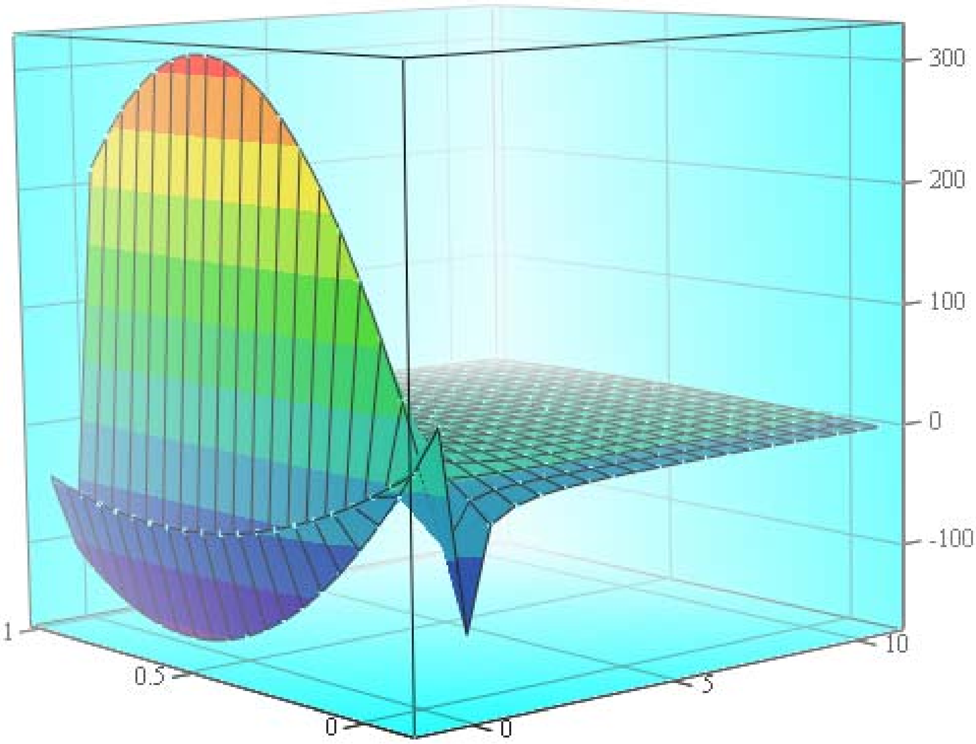

Fig.3. A study of the power consumption Pc[W] with a change of $R_L = 2 \div 12\,[\Omega]$ and $K = 0 - 1$

From the result achieved, we can conclude: at low values of the load $R_L = 0.1 \div 0.4\,[\Omega]$ the power consumed is critically high and reaches up to $P_C = 294\,[W]$.In a practical aspect, this value of the load is too low and in most cases it is taken as a by-pass in the output stage. In this case, in order to avoid damage, is used current protection. But this also has its disadvantages: limiting the picks in the signal of up to 12 %, increasing of total harmonic distortion at the output of up to 2%.

The study goes on with an analysis of the power consumption at change of the load and the voltage supply in the range $R_L = 2 \div 12\,[\Omega]$, voltage supply $U_{CC} = 0 \div \pm 50\,[V]$ at a parameter $K_{\max} = 0.637$. The result of the study which is received is shown on Fig.4

The received result shows us that at low values of the load $R_L = 0.1 \div 0.4\,[\Omega]$ the power consumed by the stage is critically high and in this case reaches up to $P_C = 302\,\,[W]$. The solution for this disadvantage is identical to the one in the case mentioned above (current protection).

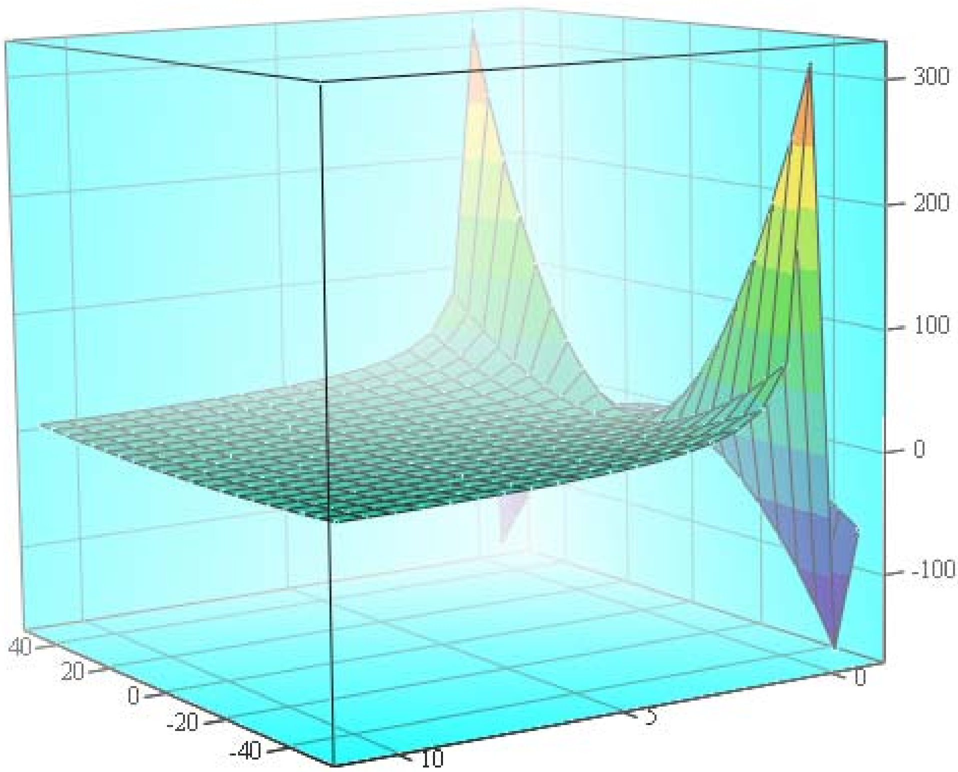

Fig.4.Study of the power consumption Pc[W] with a change of $R_L = 2 \div 12\ [\Omega]$ and $U_{CC} = 0 \div \pm 50\ [V]$

4. CONCLUSIONS

1. We can draw the conclusion that we have maximum of the function at $K = \frac{2}{\pi} = 0.637$. The comparison of the received result to the known analytical methods [3,4] shows more precise measuring of the output efficiency. This can be confirmation that this analytical model can express more precisely the change of the power consumption;
2. The study of the power consumption at changes of $R_L = 2 \div 12\ [\Omega]$, $K = 0 - 1$ and supply voltage $U_{CC} = 0 \div \pm 50\ [V]$ arises one and the same disadvantage - critically high consumption power at low values of the load $R_L = 0.1 \div 0.4\ [\Omega]$. In a practical aspect this range is too low and in most cases is accepted as by-pass in the output stage;
3. The presented analytical method measures the average value of the power consumption of the stage on the base of which the lose of the linear audio amplifiers can be determined. It must be pointed out that in these and some other known methods [5,6] are measured only the lose on the output stage . This lose of power determines, to a great extent, the efficiency of the stage at optimal loading. In another case, when the amplifier works at low output

power, the consumption of input stage and pre-amplifier reaches up to 5 % of the output power. It influences the effectiveness of the stage and must also be measured.

5. REFERENCES

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