Analysis of Linear Circuits With Real Operational Amplifier

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Abstract - **The technique and main principles of the analysis of linear circuits on operational amplifiers, allowing to take into account the frequency characteristic of the real operational amplifier. Features of the analysis of circuits of zero, first and second orders are specified. The universal method of designing of the filters is offered.**

Keywords - **Operational amplifier, Filters, Frequency characteristic, Topological model.**

I. Introduction

Typically, in the technical literature are expressions of transfer functions and characteristics of linear devices (amplifiers, filters) on the ideal operational amplifiers (OA), that is without taking into account the parameters of the real OA.

However, very often the question arises: "Can the analysis of a scheme to consider the ideal OA?" Or "What specific type of OA (with some parameters) should be used to the device characteristics is implemented differs from the ideal settlement no more than a given value?".

Finding answers to these important issues identified goals and objectives of the research: to choose the method of analysis to obtain the characteristics of devices for non-ideal OA, to assess the inaccuracy introduced by the real OA, to develop a methodology for calculating and selecting components for the realization of devices with characteristics similar to those given.

II. Instruction for Authors

For the analysis of linear circuits on OA is most suitable topological method of analysis based on the formulation of a generalized signal graph circuits and application of the formula to calculate the meson required characteristics [1, 2]. At the same time OA is replaced by a certain topological model (signal count). In [2] present a simple model of an ideal OA, and more complex models, which take into account non-ideal OA: the actual voltage gain K'_u, input currents, EMF bias, common mode rejection ratio, input and output impedance.

Among the above parameters, which can be considered in a topological model of the OA, there are no important parameters that characterize the OA in terms of its frequency properties. In the first place - is unity-gain frequency f_1. As is often the OA come with internal correction or corrective capacity is included in the scheme include the OA, the frequency of the second (and more so the third) pole transfer function OA is not important.

The synthesis problem of the topological model of the operational amplifier (Fig. 1), taking into account the frequency properties of the OA is solved in [1]. With great precision, the transfer function of the corrected OA can be represented by a transfer function corresponding to the low-pass filter (LPF) in the form of first-order

$$W'(p) = \frac{K'_u \cdot \omega'_c}{p + \omega'_c},$$

where p – Laplace operator $p = j\omega$, j – imaginary unit; ω'_c – low pass filter cutoff frequency, and $K'_u \cdot \omega'_c \cong \omega_1$, where $\omega_1 = 2 \cdot \pi \cdot f_1$ - reference frequency unity gain.

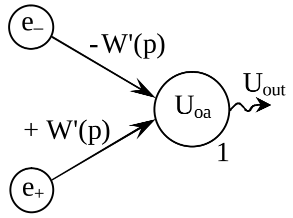

Fig.1 Topological model

Topological model of OA (Fig. 1), taking into account the frequency properties allows the analysis to get a much more accurate expression for the frequency characteristics of the devices on the real OA. For example, in [1], the results of analysis and method of calculating units of zero and first order, which, taking into account the frequency characteristics of OA is actually functioning as obtained 1st and 2nd order.

Analysis of second order in view of the model Figure 1 leads to the transfer function of the third order. In this case, to obtain analytical expressions for calculating the nominal passive filter elements should be up and solving systems of equations by equating the values $\underline{W}(\omega)$ for the characteristic frequencies required by the condition of values. The solution of this system of equations with a large number of points is difficult, therefore, more appropriate in this case, the parametric optimization.

III. Conclusion

Answers to these questions at the beginning of work depends on the parameters of the transfer function and concept of the filter. Therefore, as a universal method for filter design can be proposed as follows.

1. The choice of op amp with a minimum acceptable margin of frequency.
2. Calculation of simplified formulas of the initial values of elements of denominations.
3. Parametric optimization of component values to obtain the desired frequency response.

The described approach can also be used for the synthesis of filters with non-standard frequency characteristics.

References

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