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New Approach to Preamplifier-Shaper Design

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A new approach to design of amplification blocks (such as preamps, shapers) is described. The generalized block diagram and analytic expressions for its transfer function are presented. The particular cases of this structure are classical schemes, using either the voltage or current feedback, but not limited by them.
The discussed formulas can be useful for the design of a whole range of amplifier blocks, built according to both a traditional and a non-traditional structures. As a result of expression analysis the features of various particular cases are given. For example, those were confirmed by simulations and experimental data.

Summary

At R&D of analog building blocks, such as preamps and shapers, it is important to pay attention on new structural solutions of amplifier units. In the course of designing universal amplifier building blocks there are usually recalled op amps basics. There two basic classes of them are distinguished, differing in the type of feedback: voltage or current ones. However such classic circuits, used for calculation, do not comprise the whole variety of structural solutions. Practically as a rule, this contraction is engendered by the necessity to use a symmetrical differential stage at the inputs of channels. But that rather often is not an obligatory condition for analog front-end.
The given paper consider a new non-traditional structure of amplifiers and its transfer function. The peculiarity of the given circuit consists in the presence of an additional boosting amplifier between its differential inputs (instead of a follower, that may be noticed in the classic circuit with current feedback). The ultimate capabilities of the considered structural solution can be evaluated on the basis of the classic Ohm and Kirchhoff laws. For non-inverting configuration it is not difficult to write the transfer function of the structure, as: Kfb(p)=[1+R2/R1+R2/Rin-(1-A)]/[1+1/K(p)(1+R2/R1+R2/Rin-)], where R1,R2 – common feedback elements, K(p) – open loop gain of basic amplification block, A – gain of the boosting amplifier, Rin- – output resistance of the boosting block, seen at the inverting input. By analyzing the transfer function one may distinguish the following cases, where two first of them are traditional ones and other – non-traditional: 1) A=0 corresponds to the circuit of a classic voltage feedback amp; 2) A=1 (or as more practical one A≈1) corresponds to the circuit of a classic current feedback amp; 3) in the case of both A≠0 and A≠1, the analysis of expression conduces to a number of interesting circuits. For instance, when A»1 and Rin-<(-A)/[1+1/K(p)(R2/Rin-)]=(-A)/[Rin-/R2+1/K(p)]. One should note, that here despite of non-invertinig configuration a minus sign in the numerator means signal inversion for common feedback circuit. The analytic analysis was confirmed by both behavioral modeling, based on Cadence analogLib equivalent circuit, and transistor level simulations, based on 100 MHz rail-to-rail opamp IP, designed in 180 nm CMOS, as a building block. According to the described structure (in case of A≠0,1) there were implemented several ASICs of amplifier-shaper for microstrip detectors of CBM experiment. Thus a new approach to preamplifier-shaper design was described. The generalized block diagram and analytic expressions for its transfer function were presented. The formulas can be useful for the design of a whole range of amplifier blocks, built according to both a traditional and a non-traditional structures.

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