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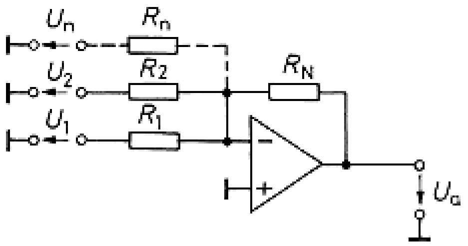
Linear and nonlinear analog computing circuits

Thanks to the advent of microcomputers and signal processors, it is now possible to perform mathematical operations with almost any accuracy. However, the processed values are often represented as continuous signals, for example, in the form of an analog electrical voltage. In this case, the digital computer additionally requires analog-to-digital and digital-to-analog converters. These devices are advantageous to use only when the requirements for the accuracy of calculations are so high that they cannot be provided with analog computing circuits. Existing analog calculators allow you to get an accuracy of no more than 0.1%.

Next, we will consider analog computing circuits on operational amplifiers that perform addition and subtraction of two or more signals.

1. Adder circuit



Drawing 1 - Inverting adder circuit

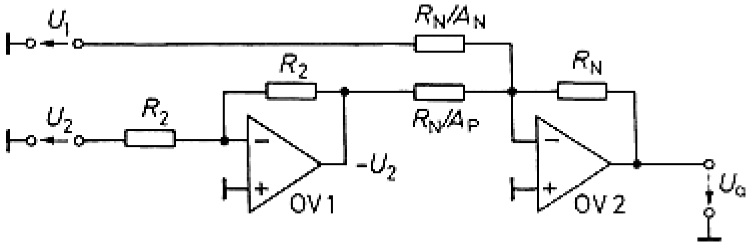
An operational amplifier with inverted input signal is used to sum multiple voltages. Input voltages ($U_1, U_2 \dots U_n$)they are fed through series-connected resistors to the inverting input when the non-inverting input is grounded. Output voltage $U_a$determined by the formula:

$$-U_a = \frac{R_N}{R_1}U_1 + \frac{R_N}{R_2}U_2 + \ldots + \frac{R_N}{R_n}U_n$$

2. Subtraction circuit

There are several schemes for implementing the subtraction of one signal from another:

2.1 Using the adder circuit



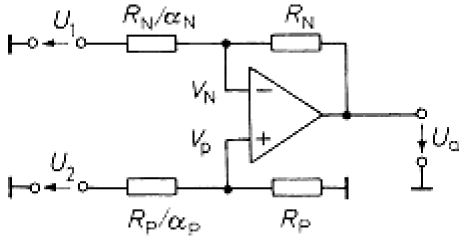
Drawing 2 - Subtraction circuit using the adder circuit

Subtraction can be reduced to addition with inverted subtractable voltages. The op amp OV1 inverts the input voltageU_2. Output voltage will be determined by the formula:

$$U_a = A_P U_2 - A_N U_1,$$

where A_p, A_N–gain factors.

2.2 The subtraction circuit on the operational amplifier

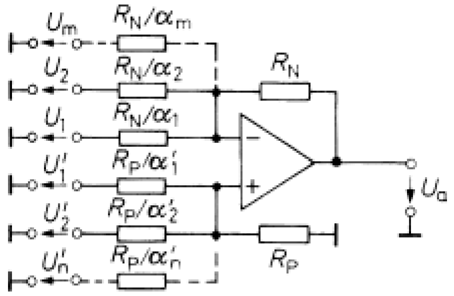


Drawing 3 - The subtraction circuit on the operational amplifier

In this circuit, the principle of operation is the same as in the previous one. Output voltage:

$$U_a = \alpha(U_2 - U_1),$$

where α – gain factor.



Drawing 4 - Subtraction circuit with any number of inputs

This circuit allows you to subtract any number of input voltages. Output voltage:

$$U_a = \sum_{i=1}^{n} \alpha'_i U'_i - \sum_{i=1}^{m} \alpha_i U_i.$$

In the input circuits of the considered circuits, there are internal resistances of the signal sources. So that they do not lead to calculation errors, their output resistances must be sufficiently low-resistance. If the signal sources are built on operational amplifiers with negative feedback, this condition is well met in most cases. With other signal sources, it is most often necessary to include a total resistance converter in the form of an electrometric amplifier at the inputs. The resulting circuit is called an electrometric subtractor (instrumental amplifier) and is used primarily in measuring technology.

Литература

1. Полупроводниковая схемотехника. 12е изд. Том II: Пер. с нем. – М.: ДМК Пресс, 2007. – 942 с.: ил.