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(54) ELECTRICAL FUNCTION GENERATOR

(71) I, TOOM AINOVICH PUNGAS, of Sypruse bulvar, 219, kv.3. Tallin, USSR., a citizen of the USSR., do hereby declare the invention, for which I pray that a patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement:-

The present invention relates to analog computers, and more particularly, to function generators for obtaining nonlinear relations between input and output electrical signals.

A function generator embodying the invention can be successfully used in automatic data handling systems, for example, as an a.-c.-to-d.-c. converter in automatic measuring systems.

The present invention provides an electrical function generator yielding an output signal nonlinearly related to an input signal, comprising a main amplifier to the input of which signals are arranged to be applied by way of an input resistor, a non-linear device electrically coupled between the input and output of the main amplifier, two main feedback resistors, connected in series between the input and output of the main amplifier, an auxiliary amplifier, two auxiliary smoothing capacitors, one lead of one said auxiliary capacitor being connected to the input and one lead of the other said auxiliary capacitor to the output of the auxiliary amplifier, the other lead of each of said auxiliary capacitors being connected to the junction of said main resistors, two auxiliary feedback resistors connected in series between the input and output of the auxiliary amplifier, and a main smoothing capacitor, connected between the junction of the auxiliary feedback resistors and ground.

The invention allows the ratio of the lower operating frequency to the cutoff frequency of an RC-network constituting the d.-c feedback path to be reduced, with a resulting drastic reduction of the restoration time of the function generator after accidental overloads and improved noise immunity.

In addition, the present invention permits selection of the most suitable transient characteristic (e.g., monotonic or equiripple).

Advantages of the present invention will become apparent from the following detailed description of a specific embodiment thereof, given with reference to the accompanying drawing which is a block diagram of a function generator for obtaining nonlinear relations between input and output electrical signals, according to the present invention.

The function generator for obtaining nonlinear relations between input and output electrical signals of which the circuit is shown in the drawing comprises an operational main amplifier 1 having its input 2 connected to one lead of an input resistor 3 at a junction 4 of the circuit; the other lead of said input resistor being connected to an input terminal 5. An output 6 of the main amplifier 1 is connected to one lead of a main feedback resistor 7 and to one lead of a nonlinear device 8 at a junction 9 of the circuit. The other lead of the nonlinear device 8 and one lead of another main feedback resistor 10 are connected to the junction 4. The other leads of the main feedback resistors 7, 10 and one lead of each of two auxiliary smoothing capacitors 11, 12 are coupled to a junction 13 of the circuit. An input 14 of an auxiliary operational amplifier 15, the other lead of the auxiliary smoothing capacitor 11 and one lead of an auxiliary feedback resistor 16 are coupled to a junction 17 of the circuit. The output 18 of the auxiliary operational amplifier 15, the other lead of the auxiliary smoothing capacitor 12 and one lead of an auxiliary feedback resistor 19 are coupled to a junction 20 of the circuit. The other leads of the auxiliary feedback resistors 16, 19 and one lead of a main smoothing capacitor 21 are coupled to a junction 22 of the circuit, while the other lead of the main smoothing capacitor 21 is grounded.

The above-described function generator for obtaining nonlinear relations between input and output electrical signals operates as follows.

An alternating voltage supplied to the input terminals 5 and 23 produces an alternating current in the input resistor 3, which is equal to the ratio of this alternating voltage to the resistance value of the input resistor 3. The current produced in the resistor 3 flows via the nonlinear device 8 to the output 6 of the main amplifier 1. Owing to the negative feedback, the input 2 of the main amplifier 1 represents a virtual earth point, as does the input 14 of auxiliary amplifier 15, so that the alternating voltage across the resistor 10 will be substantially zero and no current will flow in it. A voltage defined by the impedance of nonlinear device 8 and the alternating current flowing therein appears at the output 6 of the main amplifier 1. The voltage from the output 6 of the main amplifier 1 is fed via the main feedback resistor 7 to a d.-c. feedback path of the main amplifier 1. Filtering of the current passing through the d.-c. feedback path of the amplifier 1 is effected by the following components: the main feedback resistor 7, the auxiliary smoothing capacitors 11, 12, the main smoothing capacitor 21, the auxiliary feedback resistors 16, 19, and the auxiliary amplifier 15. The circuit made up of the above components has an input impedance dependent on the frequency of the alternating voltage being transformed and produces in the a.-c. feedback path of the main operational amplifier 1, a transfer function expressed by a cubic equation (not shown), and therefore having multiple poles, for the signal delivered from the output 6 of the operational amplifier 1 to the input 2 thereof via the resistors 7 and 10.

With such multiple poles in the transfer function, a drop in the gain of the operational amplifier 1 caused by its d.-c. feedback path is approximately equal to the third power of the ratio of the lowest operating frequency to the d.-c. feedback path cutoff frequency. For example, if the allowable static error is about 0.1%, the required feedback factor should be 1000, in which case the ratio of the lowest operating frequency, and the d.-c. feedback line cutoff frequency becomes equal to 10. The response time for the d.-c. output voltage of the main amplifier 1 and, consequently, for the function generator itself is inversely proportional to the cutoff frequency, i.e., it is equal to 10 cycles of the lowest operating frequency of the function generator.

For a definite nonlinear relation between input and output electrical signals, for instance, for transformation of the alternating input voltage into a direct voltage directly proportional to the mean absolute value of the input voltage, a transient of an oscillatory nature is allowed in the operational amplifier, because in that case the transformation error due to the transient oscillations is decreased according to a square law. Therefore, in carrying out the present invention, it is possible to select the values of the components in the d.-c. feedback path so that the poles of the transfer function in the d.-c. feedback path of the amplifier 1 occur at values, that yield an equi-ripple transient process wherein the values of periodic overshoot do not exceed a predetermined value.

Thus there occurs in the d.-c. feedback path of the amplifier 1, an oscillatory transient with a predetermined overshoot value, which is accompanied by an additional decrease in the response time of the d.-c. output voltage of the function generator.

It is apparent from the foregoing that the present invention offers definite technical and cost advantages.

Due to the auxiliary amplifier 15 added to the circuit in conjunction with the auxiliary feedback resistors 16, 19 and the auxiliary smoothing capacitors 11, 12, the cutoff frequency in the d.-c. feedback path may be increased by several orders in magnitude. As a result, expensive high-value large-size capacitors may be replaced by small low-capacitance components.

Moreover, the proposed circuit arrangement does not impose stringent requirements on the operational amplifier 15, because the latter is provided with a 100% d.-c. feedback.

Under such circumstances the function generator and all its complementary devices readily lend themselves for a microminiaturization approach.

Due to fast response of the function generator according to the present invention, the transformation effected is not interfered with by drift of the accuracy of transformation of low-value input signals. This also makes it possible to utilize less expensive operational amplifiers having substantial drift.

WHAT WE CLAIM IS:

1. An electrical function generator yielding an output signal nonlinearly related to an input signal, comprising a main amplifier, to the input of which signals are arranged to be applied by way of an input resistor, a nonlinear device electrically coupled between the input and output of the main amplifier, two main feedback resistors, connected in series between the input and output of the main amplifier, an auxiliary amplifier, two auxiliary smoothing capacitors, one lead of one said auxiliary smoothing capacitor being connected to the input and one lead of the other said auxiliary smoothing capacitor to the output of the auxiliary amplifier, the

other lead of each of said auxiliary smoothing capacitors being connected to the junction of said main feedback resistors, two auxiliary feedback resistors connected in series between the input and output of the auxiliary amplifier, and a main smoothing capacitor, connected between the junction of the auxiliary feedback resistors and ground.

2. An electrical function generator yielding an output signal nonlinearly related to an input signal, constructed and operating substantially as herein described with reference to the accompanying drawing.

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1565028 COMPLETE SPECIFICATION

1 SHEET

This drawing is a reproduction of the Original on a reduced scale