METHOD OF SYNTHESIZING A LINEAR SYSTEM

Z. D. Lerner

Izvestiya VUZ. Radioelektronika,
Vol. 35, No. 11, pp. 69-70, 1992

UDC 621.372:621.391

The method of synthesizing linear systems in the form of closed or open structures with integrators is used widely [1]. In the first case the transfer function, which in the general case is time-dependent, has the form

$$K(p,t) = \left(\sum_{i=0}^{m} a_i p^i\right) / \left(\sum_{i=0}^{n} b_i p^i\right), n \geq m. \tag{1}$$

In the second case

$$K(p,t) = \sum_{i=0}^{n} c_i (1/p)^i. \tag{2}$$

Here a_i, b_i, c_i are coefficients, which in the general case are time-dependent.

There are, however, problems in which the transfer function cannot be represented either in form (1) or in form (2).

Example 1. The simplest method of signal restoration [2] reduces to synthesis of an inverse filter. Whereas the transfer function of a linear system distorting a signal is equal to $W(p) = M(p)/N(p)$, where the degree of the polynomial $N(p)$ is higher than the degree of polynomial $M(p)$, the transfer function of the inverse filter is equal to $K(p) = W^{-1}(p) = N(p)/M(p)$ and cannot be synthesized in the form of a closed system with integrators.

Example 2. The transfer function of a delay line with a variable delay $T = T(t)K(p, t) = \exp(-T p)$ is easily represented in the form of a Taylor series in powers of the argument p and cannot be represented by a series in powers of $1/p$.

In the present work a method is proposed which makes it possible to realize synthesis in the form of structures with integrators also in these cases. The price for this is complication of the system due to the introduction of two additional signal converters.

The system realizing transfer function $K(p, t)$ is shown in Fig. 1 and consists of three cascade-connected converters. The conversions realized by the two identical converters 1 and 3 are integral transforms with kernel $(t/\tau)^\nu J_{2\nu}(2\sqrt{t\tau})$

$$y(t) = \int_0^\infty (t/\tau)^\nu J_{2\nu}(2\sqrt{t\tau})\, x(\tau)\, d\tau = \Pi\{x(t)\},$$

where $J_{2\nu}(\ldots)$ is a Bessel function of order 2ν.

If $x(t) \doteqdot X(p)$, then according to [3]

$$Y(p) = p^{-2\nu-1} X(p^{-1}). \tag{3}$$

Here $\doteqdot$ is the Laplace correspondence symbol. Incidentally, it follows from relation (3) that operator Π is self-adjoint ($\Pi\{\Pi\{x\}\} = x$), and realizes nonlinear conversion of the scale of the frequency coordinate of the signal spectrum $x(t)$.

Converter 2 in Fig. 1 is a linear converter with transfer function $K(p^{-1}, t)$. Then

REFERENCES

1. L. Zadeh and C. Desoer, Linear System Theory [Russian translation], GIFML, Nauka, Moscow, 1970.

2. W. Cappelini, A. J. Constantinidis, and P. Emiliani, Digital Filters and Their Use [Russian translation], Energoatomizdat, Moscow, 1983.

3. G. Bateman and A. Erdelyi, Tables of Integral Transforms [Russian translation], GIFML, Nauka, Moscow, vol. 1, 1969.

5 March 1992