СЕКЦІЯ 8: ТЕОРЕТИЧНА ЕЛЕКТРОТЕХНІКА

EXPERIMENTAL EVALUATION OF HIGHER ORDERS IMPULSE RSPONSES (VOLTERRA KERNELS) OF NONLINEAR SYSTEMS BY CORRELATION

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Introduction. In many areas of science and technology, linear models are widely used to analyze processes in real devices. This greatly simplifies the analysis and requires less resources. The use of linear models is appropriate when the error from the inadequacy of the model does not exceed the level of other methodological and hardware errors [1, 2].

Unlike linear models, for analysis of which a powerful mathematical apparatus has been developed, only methods for analyzing their individual types are developed and used for nonlinear models. One of these methods of analysis of nonlinear systems is the use of the Volterra functional series [3, 4]

$$\begin{aligned} y(t) = & \int_{-\infty}^{t} h_1(\tau_1) x(t-\tau_1)\, d\tau_1 + \\ & + \int_{-\infty}^{t}\int_{-\infty}^{t} h_2(\tau_1,\tau_2) x(t-\tau_1)\, x(t-\tau_2) d\tau_1 d\tau_2 + \\ & + \dots \\ & + \int_{-\infty}^{t} \dots \int_{-\infty}^{t} h_n(\tau_1,\dots,\tau_n) x(t-\tau_1)\dots x(t-\tau_n)\, d\tau_1 \dots d\tau_1 \end{aligned} \quad . \qquad 1)$$

where $x(t)$, $y(t)$ — input and output signals of the nonlinear system;

$h_1(\tau_1)$, $h_2(\tau_1, \tau_2)$, ..., $h_n(\tau_1, \tau_2, \dots, \tau_n)$ — impulse responses (Volterra kernels) of the first, second,…, n-th order.

In practice, it is enough to determine the impulse characteristics of only the first and second order to provide the given accuracy.

The purpose of the work. The purpose of the work is to develop the structure of the device for the experimental determination of impulse characteristics of nonlinear systems by the correlation method.

Materials and research results. To determine the impulse characteristics of nonlinear systems by the correlation method, a white noise is fed to the input of a nonlinear system. With the help of the convolution operation, the correlation function of the first, second, n-th order is sequentially determined between the output signal of the nonlinear system and the input signal. In papers [5, 6] it is proved that the impulse

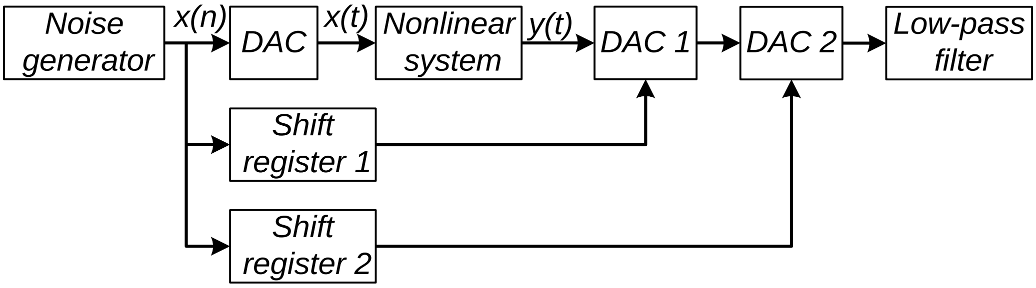

Figure 1 – Measuring device impulse responses

characteristic of the n-th order is directly proportional to the correlation function of the n-th order.

In fig. 1 shows the structure of the device for measuring impulse characteristics of nonlinear systems, which implements the correlation method. The noise generator is implemented by digital methods on shift registers. The output signal of the generator is a pseudo-random sequence, which, with a high degree of accuracy, simulates white noise [7]. The pseudo-random sequence of binary numbers is converted by a digital-analog converter (DAC) into an analog signal x (t) and is fed to the input of a nonlinear system. The pseudo-random sequence is also fed to shift registers that delay the signal in time.

The multiplication of the analog output signal of the investigated nonlinear system and the digital delayed input signal is carried out by multiplying digital-to-analog converters (DAC1 and DAC2). Multiplying digital-to-analog converters are much simpler digital multipliers and much more accurate and more stable analog multipliers.

Operation of integration is carried out by the analogue low pass filter.

Conclusion. The presented structure of the device for measuring impulse characteristics of nonlinear systems of the first and second order allows to carry out with sufficient accuracy the measurement of characteristics of complex objects with insignificant hardware costs.

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