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MODELLING THE PASSAGE OF INFORMATION SIGNAL AND NOISE THROUGH INDIVIDUAL UNITS WITHIN A COMMUNICATIONS CHAIN

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Abstract

Modeling of processes using methods of probability theory, random processes and statistical methods of analysis of radio-electronic systems allows developing skills in solving applied engineering problems that are a consequence of the statistical nature of signals and interference operating in the functional units of radio equipment.

Keywords: Modeling, communication systems, statistical characteristics, correlation function, energy spectrum, noise immunity.

1. Introduction

Analysis of the processes accompanying the passage of the sum of a signal and noise through individual elements of electronic equipment is a typical task of engineering research /1/.

The functional diagram of the simulated device is shown in Figure 1.

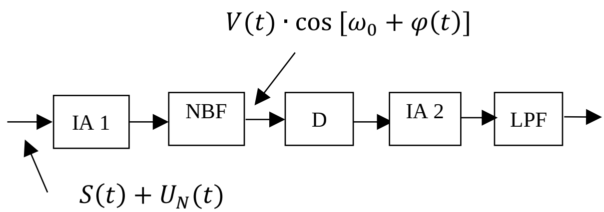

Figure 1. Functional diagram of the simulated device

It contains a series-connected:

– Intermediate Frequency Amplifier (first inertialess amplifier – IA 1 and a narrow-band filter – NBF);

– Detector (D, a nonlinear element);

– Low Frequency Amplifier (second inertialess amplifier – IA 2 and low-pass filters (LPF) and is an integral part of radio receiving devices.

The input of this device is affected by an additive mixture of a harmonic signal

$$S(t) = A_m \cdot \cos\,(\omega t + \theta_s)$$

and white noise with a spectral density N_0 .In the work it is assumed that the information message is a constant, previously unknown value and will be contained in the value of the amplitude, frequency or phase of the received signal. Since noise $U_N(t)$ is applied to the input of the device together with the useful signal S(t), this will lead to errors in the evaluation of the information message. The error in the evaluation of the information message is determined by the value of the mathematical expectation (constant component) and dispersion (power of the variable component) of the noise at the amplifier output. The task is to determine the noise dispersion at the output of the low-pass amplifier characterizing one of the components of the error in the assessment of the information message. In terms of its formulation and the solution method used, this problem is a traditional problem of assessing the noise immunity of signals reception.

2. General

The initial data for the simulation are: the noise spectral density N_0 and the harmonic signal amplitude A_m at the input of the device; the detector type; the bandwidth $\Delta\omega_1$ and the gain G_1 of the intermediate frequency amplifier; the bandwidth $\Delta\omega_2$ and the gain G_2 of the low-frequency amplifier.

The analysis is carried out in several stages:

a. Determining the signal-to-noise ratio at the detector input. Based on the known energy spectrum of the initial impact and the characteristics of the IF amplifier, it is necessary to determine the energy spectrum S(ω) and the correlation function R(τ) of the process at the IF amplifier output. This will allow us to determine the signal-to-noise ratio at the detector input

$$q = \frac{U_{ms}^2}{2\sigma^2}\,,$$

where U_{ms}^2 is the power of the useful signal at the IF amplifier output, σ^2 is the variance (power) of the noise at the IF amplifier output.

When determining the correlation function of the process at the IF amplifier output, the inverse Fourier transform can be used.

b. Determination of statistical characteristics of the process at the detector output. The initial data for solving this problem are the detector type and the signal/noise ratio. The statistical characteristics (correlation function and energy spectrum) of the U_D process at the output of the amplitude, phase and amplitude detectors are determined respectively by the statistical characteristics of the envelope, phase and frequency of the total oscillation at its input /1/.

c. Determining the noise dispersion at the output of the low-frequency amplifier. The energy spectrum of the process at the output of the low-frequency amplifier can be determined using the well-known formula /2/

$$S_{LFA}(\omega) = S_{DM}(\omega) \cdot G_2^2 \cdot |Y_2(\omega)|^2 \ ,$$

where $Y_2(\omega)$ is the normalized frequency response characteristic of the low-frequency amplifier.

To determine the noise dispersion at the output of the low-frequency amplifier, which characterizes the error in estimating the information message, it is necessary to calculate the integral of $S_{LFA}(\omega)$.

$$D = \frac{1}{\pi}\int_0^{\omega_{max}} S_{LFA}(\omega)d\omega \ .$$

Conclusion

Conclusion about the influence of the characteristics of the main functional elements of radio receiving devices on the width of the energy spectrum, correlation time and process dispersion at their output.

References

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