In the case when the brightness of the oscillograph line is uniformly reduced from the center to the peripheries (in both directions) which corresponds to a linear distribution law, the quadratic mean deviation is calculated from the formula:

$$\sigma = \frac{\lambda}{2\sqrt{2}}.$$

(11)

It is possible to obtain by means of the basic propositions of the theory of probability similar relationships for some of the other probability distribution laws of signal amplitudes.

LITERATURE CITED

1. V. N. Ivanov and I. G. Akopyan, Scientific proceedings of higher educational institutions. Radiotekhnika i elektrotronika, 1958, No. 3.

ERRORS IN MEASURING PEAK VALUES AND THE SWING OF COMPLEX HARMONIC OSCILLATIONS

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Translated from Izmeritel'naya Tekhnika, No. 4, pp. 31-33, April, 1962

Errors in peak values and swings of complex periodic processes are often evaluated by taking into consideration only the errors produced by nonuniform amplitude-frequency characteristics and nonlinear amplitude characteristics of the instrument, forgetting that phase distortions can also lead to considerable measurement errors.

These sometimes underestimated, since they have not been evaluated quantitatively in literature, and they are not taken into account either in designing or testing the instruments. Such errors, however, are characteristic for
uring channels which contain elements operating in the range of their natural resonance, for instance, loops of moving coil oscillographs, transducers for measuring the amplitude of oscillations constructed on the principle of vibration meters, various filters, etc.

This article deals with graphical and analytical computations of errors in measurements of peak values and swings in complex harmonic processes of the type of \( x = A_1 \sin \omega t + A_n \sin n\omega t \) obtained by means of an instrument which has a phase error.

The analysis has been made, for the sake of simplicity and greater clarity, for the case of a zero phase difference between the harmonics of the analyzed process.

For a uniform amplitude-frequency characteristic and in the absence of nonlinear distortions, the signal at the output of the measuring channel has the form

\[
y = kA_1 \sin \omega t + kA_n \sin (n\omega t + \varphi),
\]

where \( k \) is the gain of the instrument; \( n \) is the number of harmonics; \( \varphi \) is the equipment phase error which is nonlinear with respect to frequency and occurs in the frequency interval of \( \omega - \omega n \).

In the course of the analysis the extremal values of the functions of \( x \) and \( y \) were determined from formula

\[
\delta = \frac{y - y_0}{y_0},
\]

where \( y_0 = ky \), and the error in measuring the peak value of a complex harmonic process was determined.

It is known that a complex harmonic process, which contains even harmonics displaced in phase with respect to the fundamental, has two peak values which correspond to the movement of the oscillating point in the two directions from the neutral point. Processes containing even harmonics were analyzed, therefore, by considering measurement errors in peak values of the form

\[
\delta_y' = \frac{y' - y_0}{y_0} \quad \text{and} \quad \delta_y'' = \frac{y'' - y_0}{y_0}
\]

and errors in swings of the form

\[
\delta_{y'+y''} = \frac{y'+y'' - 2y_0}{2y_0},
\]

where \( y' \) and \( y'' \) are the peak values of the measured complex harmonic process at the output of the instrument.

The constant graphical relationships \( \delta = f(A_n/A_1) \) were analyzed for various values of the instrument's phase error \( \varphi \) and \( \delta = f(\varphi) \) and various values of the ratio \( A_n/A_1 \).

We established, by means of the above analysis, the following basic patterns in the variations of errors \( \delta_y', \delta_y'' \) and \( \delta_{y'+y''} \) with respect to the instrument's phase error and the ratio of the amplitudes of the harmonic components in the investigated process \( x = A_1 \sin \omega t + A_n \sin n\omega t \).

1. The functions of the variations in errors \( \delta_y', \delta_y'' \) and \( \delta_{y'+y''} \) with respect to the equipment phase error are periodic with a period of \( 2\pi/n \).

2. The errors \( \delta_y', \delta_y'' \) and \( \delta_{y'+y''} \) attain a maximum for \( A_n/A_1 = 1/n \) and an equipment phase error in the range of \( \omega = \omega n \) equal to \( \pi/2n + i\pi/n \) \( (i = 1, 2, 3...) \) in the case of processes containing even harmonics and equal to \( \pi/n + i2\pi/n \) \( (i = 1, 2, 3...) \) in the case of processes containing odd harmonics.

3. Errors \( \delta_y', \delta_y'' \) and \( \delta_{y'+y''} \) grow rapidly from zero to maximum in the range of \( 0 < A_n/A_1 < 1/n \) and decrease slowly to zero for \( A_n/A_1 = \infty \).

4. In the measurement of peak values and the swing of complex harmonic processes containing even harmonics, the errors \( \delta_y', \delta_y'' \) and \( \delta_{y'+y''} \) have different kinds of variations, signs and magnitudes.

The largest error is obtained in measuring the smaller (in the absolute value) of the two peak values; moreover, this error is negative.