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Modeling of Characteristics of a Multi-Frequency Retransmitting System

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Abstract—A model of a measuring multi-frequency retransmitting system is suggested. With the help of this model using the statistical testing method the statistical characteristics of amplitudes of signals, reflected from a set of elements, which are located is a limited volume of space and posses random coordinates and reflecting characteristics, are obtained.

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One of the ways to improve the measuring radio engineering systems intended for control, technological processes management and monitoring of environment inside and close to the production facilities is the application of the retransmitting method. Its main peculiarities during the work with determined point reflectors were discussed in [1, 2]. During the solution of problems connected with the use of the retransmitting method one has to deal with objects consisting of a set of fluctuating reflectors. In this case the estimations may be obtained with the help of a generalized model developed in the statistical theory of measuring systems [3]. However in this case the changes of the radio wave's parameters which occur during the secondary propagation and during reflection from the controlled object are not accounted for.

The changes to the generalized model of the measuring system in order to account for the main peculiarities of the retransmitting measurements method and the use of the modified model during the estimation of the statistical characteristics of signals are suggested in this article. In the given case a model is developed with the help of which the characteristics of the signal of the retransmission system may be obtained using the statistical testing method.

Continuous non-modulated microwave radiation with frequency ω_i, which is a component of the signal during multi-beam propagation [2], will be used as the signal. Let's limit ourselves to the consideration of the effects in the Fraunhoffer zone. The measurement scheme is represented in Fig. 1. It expects the determination of the signal's delay as well as the direction of the incoming radio wave. The following designations are made in Fig. 1: *1*, *2* are the reflecting elements which are located in the points with coordinates (x_j, y_j, z_j) and $(x_{j+1}, y_{j+1}, z_{j+1})$ correspondingly; *3* is the radiation source attached to antenna A_{tr}; *4* and *5* represent l and $l+1$ channels of the receiver attached to antennas $A_{\mathrm{rec}\,l}$ and $A_{\mathrm{rec}(l+1)}$; *6* stands for the processing unit; and *7* is a retransmitter connected to antenna A_{retr}. Channels with vertical antenna space separation are not shown in Fig. 1. The distances between the antennas of various channels of the retransmitting measurer and the radars base B are limited by a minimal value of $\lambda/2$, where λ is the wave length of the radiated signal. In this case during the modeling of the direction of the incoming radio wave a formula for the determination of the deviation angle of the perpendicular to the phase front with respect to the normal to the direction finder's base may be used [4].

Let's consider a multi-element model of local sources suggested by Kerr and Delano which was used in [5] to determine the statistical characteristics of the direction of incoming radio wave as the reflecting object; two elements from the set j and $(j+1)$ are shown in Fig. 1. Similarly to [5] let's consider a uniform distribution of the phases of signals reflected by elements to be within $-\pi\ldots+\pi$ and assume the reflecting capability to be random and distributed according to the exponential law $p(\sigma_{\mathrm{fl}\,j})=(\bar{\sigma}_{\mathrm{fl}\,j})^{-1}\exp(-\sigma_{\mathrm{fl}\,j}/\bar{\sigma}_{\mathrm{fl}\,j})$, where $\bar{\sigma}_{\mathrm{fl}\,j}$ is the mean value of the resulting EDA of the jth fluctuating element.

The changes to the generalized model of the measuring system should account for the additional radio wave transformations which occur in the channel of the retransmitting unit. Operators which perform these transformations are shown in Fig. 2, where the model of the retransmitting measurer is presented. Similarly to [3], the radiated signal determined by operator S_{tr} arrives to the input of operator A_{tr} which is antenna. In the given case the antenna may be oriented to the center of the controlled elements locations region C