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A METHOD FOR DESIGNING A TRACKING SYSTEM WITH DIGITAL FILTER IN THE TRACKING LOOP AND IMPROVED CONTROL ACCURACY

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A new method for designing a radioelectronic tracking system with a digital filter incorporated in the tracking circuit is considered. The method permits to synthesize the tracking systems of high precision (high control accuracy), thus providing additional opportunities in tracking the maneuvering objects.

Many radioelectronic tracking systems [1] use in their tracking loop a physical measuring element (discriminator or direction finder), a digital filter, and systems for trajectory tracking [2], whose circuits involve a mathematical measuring element (the gating unit). The class of such systems includes also radar stations with phased antenna arrays (PAA), where the task of tracking is regarded as an estimation task [3].

Figure 1 shows a block diagram of one of such systems. Introduce the following notation: $x(n)$ is the coordinate; $\hat{x}(n)$ is its estimate; $f(n)$ are measurement errors; $g(n)$ is additive mixture of the coordinate value with measurement errors; $U_1(n)$ is the controlling action applied to the beam control device; and $U(n)$ is the controlling action applied to the discriminator. Usually, for quality criterion of such systems we set some function of estimation error — $\varepsilon(n) = x(n) - \hat{x}(n)$.

If the discriminator and the beam control device are regarded as amplification circuits with gain factors k_{d} and k_{bcd} [3] then introduction of appropriate normalization (the units $1/k_{\text{d}}$ and $1/k_{\text{bcd}}$) makes it possible to eliminate their impact on the tracking system characteristics. The flowchart of this tracking system with PAA, equivalent to the purely digital system of automatic control, is shown in Fig. 2, where $k_{\text{f}}(z)$ is the transfer function of the digital filter (the estimation algorithm), and $F_{\text{e}}(z)$ is transfer function of the control unit (the control algorithm).

Since the action at the input of the digital estimating filter is the same as at the input of the whole system, its characteristics are specified by the control unit and by the estimating filter. As a rule, the control unit is incorporated in the estimating filter, i.e., simultaneously performs the function of estimation and control. A distinctive feature of these systems is that the observation (and, hence, the estimation) is possible only when meeting certain conditions depending on availability of the measuring elements [1, 4].

Particularly, $\widetilde{U}_i(n) = |x_i(n) - U_i(n)| < \widetilde{U}_{\text{lim}}$, where $\widetilde{U}_{\text{lim}}$ is the constraint imposed on the observation, and N is the number of targets under tracking. Fulfillment of these conditions is especially important when dealing with tracking of several maneuvering targets [2, 3]. Because of this, the issue of synthesis of radioelectronic tracking systems with improved accuracy characteristics is a pressing problem.

The purpose of this paper is development of the method of structural synthesis of a tracking system with a digital filter in the tracking circuit, and with improved control accuracy.

The essence of the new method of design of radioelectronic tracking systems with PAA is that the polynomials of the numerator and denominator of the estimation error operator in this tracking system are set equal to respective polynomials

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