Method of automatic target angle tracking by sum-and-difference monopulse radar invariant against the polarization jamming

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***Abstract*— Method of automatic target angle tracking by sum-and-difference monopulse radar covers radiolocation sphere and specifically monopulse direction finding systems. It can be used in order to increase guidance accuracy, for example, for antiaircraft missiles and of unmanned aerial vehicles (UAV) to radar targets such as: radio beacons; aerial vehicles reflecting the radio signal that illuminates them; aerial vehicles and ground-based devices radiating radio signals and jamming signals. The aim of the method consists in the assurance of reliability and stability and in the enhancement of guidance accuracy of automatic target angle tracking due to elimination of automatic tracking losses and great errors arising during the influence of the signals of orthogonal polarization or polarization close to it.**

The proposed method provides full protection from polarization jamming for all types monopulse radars.

I. Introduction

It is known that the presence of antenna cross-polarization radiation leads to reduction of direction finding accuracy; it can result in the complete failing of the monopulse direction finding system, i.e. automatic tracking loss. A phenomenon mentioned above takes place during direction finding of the targets with marked depolarization effect which the majority of real aerodynamic targets possess. But this problem is most important when so-called polarization interference is used as electronic countermeasures means [1],[2]. There is a method of target angle tracking by the sum-and-difference monopulse radio direction-finder, in which reception of signals from the target in the sum and difference channels on two orthogonal (cross) polarizations is used to decrease tracking errors [1]. Such direction-finders possess possibility to operate on the group of reception channels that have polarization most closely coinciding with the one of the reception channels. However, the drawback of the method mentioned above is doubling in the number of monopulse direction-finder reception channels (six instead of three), that makes this method virtually unacceptable for usage in the air-borne equipment of aerial vehicles because of weight and size restrictions. There is a method of target angle tracking, that is the closest to the proposed one, which is based on the usage of polarization filtering of electromagnetic waves coming from the target in the monopulse radio direction-finder [1]. In this case polarization filtering is carried out with the help of the polarization array mounted in the monopulse antenna mouth that allows to weaken an adverse effect of signals on cross polarization on the target direction finding accuracy. However the presence of diffraction effect on the edges of the polarization array doesn't allow to get a cross polarization level less than minus 35 dB with the help of polarization filtering which is insufficient to protect from modern polarization interference jammers that create interference exceeding the signal by 40 dB and more [1]. Besides that this mode is often inefficient when the monopulse direction-finder antenna is located under the blister (for example, an airplane or an UAV). The blister owing to the curvilinearity of its surface considerably (up to minus 30 - minus 15 dB) increases the cross polarization level of the receiving antenna with a polarization filter that heightens the susceptibility of the direction-finder to the influence of polarization interference and leads to the degradation of target tracking accuracy [2]. Thus, it is the actual problem of designing technical solutions that would eliminate the negative impact of signals on cross polarization on the accuracy of direction-finding purposes, subject to significant restrictions on size and weight for airborne radar aircraft.

II. Calculation of Location Characteristic

It is known that under interference conditions, the primary objective of angle tracking systems is to determine angle direction of a signal source with as few errors as possible [2]. In the process of angle tracking, the radar control system automatically minimizes an error signal obtained as a result of angular misalignment processing. At that, the work function is represented by location characteristic which has the following expression for sum-and-difference location pattern [1]:

$$S(\varphi) = \Re\left[\frac{\dot{F}_{\Delta}(\varphi)}{\dot{F}_{\Sigma}(\varphi)}\right] \qquad (1)$$

Here $\dot{F}_{\Delta}(\varphi)$ and $\dot{F}_{\Sigma}(\varphi)$ - complex difference-and-sum direction patterns of monopulse radar antenna, $\varphi = \varphi_c - \hat{\varphi}$ - the angle misalignment between true and measured target bearing. Here φ_c - target true position while $\hat{\varphi}$ - measured track angle of target in the basis of monopulse radar receiver antenna (its boresight). For unmanned aerial vehicles in order to reduce the cost of onboard equipment a monopulse is reasonable to use mirror antennas. Reflector antenna consists of antenna

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