Diagnostics of Headlights from Near Area on Place of Basing

Abstract. Methods of microwave diagnostics of a phased array allow reconstructing the amplitude-phase distribution in the antenna and implement on this basis methods for adapting the lattice control to those found in the amplitude-phase distribution to defects. The methods of microwave diagnostics from the near zone described in the well-known literature are realizable only in anechoic chambers or on specially equipped training grounds. To solve the problems of adapting a phased antenna array to a technical state and increasing its operating time under extreme conditions, it is necessary to have methods of integrated microwave diagnostics of a phased antenna array at its location. The aim of the article is to develop a method for microwave diagnostics of a phased array antenna, implemented from the near zone of the antenna at its location, and eliminating the influence of echo signals (ES) on the diagnostic results. The article proposes a method for microwave diagnostics of a phased array antenna from the near field, which allows to exclude the influence on the accuracy of diagnostics of the echo signal present at the measuring site and errors in the position of the measuring probe. The proposed method will make it possible to implement microwave diagnostics of the antenna from the near field at its location. The results of microwave diagnostics are supposed to be used to implement various methods of adapting a phased array to a technical condition, significantly increasing its life.

Keywords: antenna measurements, phased array antenna diagnostics, near field, microwave diagnostics

Introduction

The methods of control of phased antenna array (PAA) can conditionally be divided into methods of built-in control and methods of bench (polygon) tests. The first are implemented by control systems for amplitude-phase distribution (APD) control systems integrated into the phased antenna array and built-in factor control systems that distort the amplitude-phase field distribution in the antenna aperture [1].

The methods of stand (ground) tests of aerial include microwave diagnostics of main control nodes PAA – phase shifters (FS) and controlled attenuators (CA). These methods are described in [2-5] and realized both from a near area [2, 3] and from a distant area [4, 5]. The basis of all these methods is the transmission coefficient measurement procedure microwave canal between the generator of the probe signal supplying the phased antenna array in transmission mode and the output of the measuring probe located in the near or far zone of the antenna under study. Methods differ by the plans of management diagnostics and methods of treatment of results of measuring’s.

Advantage of methods of built-in control is circumstance that they are realized practically at any time in place of basing of PAA. Failing – methods do not give information about indeed realized in the aperture of aerial of APD. Only the number and channel numbers of the phased array are known, in which microwave devices fail.

Methods of microwave diagnostics of a phased array allow reconstructing the amplitude-phase distribution in the antenna and implement on this basis methods for adapting the lattice control to those found in the amplitude-phase distribution to defects, for example, as in [1, 5]. The methods of microwave diagnostics from the near zone described in the well-known literature [2, 3] are realizable only in anechoic chambers or on specially equipped training grounds.

To solve the problems of adapting a phased antenna array to a technical state and increasing its operating time under extreme conditions, it is necessary to have methods of integrated microwave diagnostics of a phased antenna array at its location.

The aim of the article is to develop a method for microwave diagnostics of a phased array antenna, implemented from the near zone of the antenna at its location, and eliminating the influence of echo signals (ES) on the diagnostic results.

Analysis of literature. Diagnostics of PAA from a near area is described in [2, 3], and from a distant area and in presence ES [6].

Using the method of measuring the transfer coefficient between the investigated phased antenna array and the probe in the near field [2, 3] and the method of accounting for ES from [6], it is possible to decide set the problem of diagnostics of PAA from the near zone in the presence of ES.

Main material

The structural diagram of the measuring and computing system and the studied represented by Fig. 1. The measuring probe is located in the direction normal to the aperture of the phased antenna array under study at a distance \( r_0 \) (in the near zone). The selection criterion \( r_0 \) is described in [2].

Imagine the transmission coefficient of the emitter paths (from the output of the probe signal generator to
the emitter input) $I_{el}(\phi)$ as the ratio of the excitation current to the complex amplitude (CA) of the PS, Fig.1:

$$I_{el}(\phi) = K_{pl} \Phi_i(\phi_i)[1 - \Gamma_i(\phi_i)], \quad i \in 0, N - 1; \quad (1)$$

where $\phi$ – grating phasing direction; $K_{pl}$ – TC of the distibutive system; $\Phi_i(\phi_i)$ – TC phase shifter when the beam is oriented in the direction $\phi_i$; $\Gamma_i(\phi_i)$ – reflection coefficient in the path of the i-th emitter due to the mutual coupling of emitters [7]; $N$ – a number of emitters in PAA.

In default of ES in MP pointed EMF [2, 3]:

$$X(\phi_i) = \sum_i I_{el}(\phi_i)G_i(\theta_i)\rho_i(\theta_i), \quad i \in 0, N - 1; \quad (2)$$

where $G_i(\theta_i)$ – counting the complex amplitude of the radiation pattern of the i-th emitter in the direction of the vector $\vec{r}_i$, connecting an i-th emitter with MP; $\rho_i(\theta_i)$ – TC from the output of i-th emitter to the exit MP; numeral, concordantly [2]:

$$\rho_i(\theta_i) = \frac{\sqrt{K_z}}{2k_0r_i} \exp(-\gamma_kr_i)g_z(-\theta_i), \quad (3)$$

where $r_i$ – distance between an i-th by an emitter and MP; $K_z, g_z$ – an amplification factor and rationed radiation pattern MP; $k_0 = 2\pi \lambda^{-1}$ – wave number.

In the presence of an echo of the signal (2) can be represented as:

$$X_1(\phi_i) = \sum_i I_{el}(\phi_i)G_i(\theta_i)\rho_i(\theta_i)M_i, \quad (4)$$

where $M_i = 1 + \mu_i = 1 + \sum_u \rho_{ui}R_{ui}G_{ui}/\rho_iG_i, \quad (5)$

$u \in 1, U$ – numbers of sources of ES; $\rho_{ui}$ – TC from the source of $u$-th ES to MP; $R_{ui}$ – reflectivity PS of $i$-th channel from the source of u-th ES; $G_{ui}$ – numeral value radiation pattern i-th emitter in the direction of source of u-th ES.

Complex coefficients $\mu_i$ unknown and depend on the number and coordinates of discrete points of formation of ES, as well as reflection coefficients in them $R_{ui}$. Such presentation $M_i$ is comfortable that a size $M_i$ does not depend on amplitude and phase of PS (it remained in a multiplier $I_{el}(\phi_i)$).

From (4) it is necessary that the presence of ES on a measuring ground results in distortion of response of probe. The combined action of ES can be compared to appearance on an entrance MP a modulating hindrance $M_i$, distorting the response of probe on a radiation from every channel of PAA. The purpose of diagnostics is determination of TC phase shifter $\Phi_i(\phi_i)$, reflectivities in highways emitters $\Gamma_i(\phi_i)$ and integral TC each of microwave paths.
where $\gamma_{i,n}(0) = \gamma_{i,n}(0) \Phi_i(0,0)$.

From this relation it is easy to determine the reflectance coefficient in the channels when phasing the antenna in the direction $\theta_{i,0}$:

$$\gamma_{i,n}(0) = 1 - \gamma_{i,n}(0) \frac{\Phi_i(0,0)}{\Phi_i(0,0)} \Phi_i(0,0) \Phi_i(0,0).$$

A remarkable property of the proposed diagnostic method is that the accuracy of the estimates of the transmission coefficients of the phase shifters and reflectance coefficients in the channels is practically independent of the presence of an echo signal at the measuring site, the accuracy of positioning with a measuring probe, and the accuracy of the information about the radiation pattern of the emitters in the grating $G_i(\theta_{i,0})$. The method is implemented in gratings agreed in the direction normal to its aperture and in the presence of a priori information about the phase shifter transmission coefficient in the initial (de-energized) state.

In the presence of a priori information about the radiation pattern of emitters $G_i(\theta_{i,0})$, (obtained from another experiment, for example [9-16]), it becomes possible to reconstruct the integral TC i-th channel from the input of the distribution system to the output of the emitter:

$$K_i(\theta_{i,0}) = K_p \Phi_i(\theta_{i,0}) \left[ 1 - \Gamma_i(\theta_{i,0}) \right] G_i(\theta_{i,0}) = I_{el}(\theta_{i,0}) G_i(\theta_{i,0}).$$

where $I_{el}(\theta_{i,0}) = \Phi_i(0,0) \Gamma_i(0,0) \Phi_i(0,0)$.

Reflection coefficients (RC) $\Gamma_i(0, n)$ and $\Gamma_i(0, n)$ characterize reflections in the PAA when the beam is oriented normal to the antenna aperture. In this position of the beam, as a rule, emitters with their paths are matched $\Gamma_i(0, n) = \Gamma_i(0, 0) = 0$. Therefore, from (10) we obtain that the desired TC PS:

$$\Phi_i(0, n) = \Phi_i(0, 0) \gamma_{i,n}.$$
dition according to the criterion of maximum approximation of the realized and desired amplitude-phase distribution in the aperture of the array.

**Conclusion**

Thus, a methodology for controlling microwave diagnostics of a phased antenna array is proposed, which eliminates the influence on the accuracy of diagnosis of the echo signal. Analyzing the results of microwave diagnostics, the proposed technique can be used to implement various methods of adapting a phased antenna array to a technical condition. In this case, the life of the antenna array will increase significantly.

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