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DIMINIZING METHOD OF MEASURE ERRORS OF PHASE RADIATION PATTERN MICROWAVE ANTENNAS

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Abstract

At design of same types of microwave range antennas (for example, reflector) measuring of not only amplitude radiation pattern is required, but also phase radiation pattern. As a rule, there are not problems at measuring of phase radiation pattern antennas in low-frequency part of microwave range — measuring phase difference between supporting and measuring signals is carried out directly on RF.

At measurings of phase radiation pattern antennas in high-frequency part of microwave range (centimetre and millimetric waves) signal frequency transformation is required downward on frequency (sometimes frequent), and then the phase difference of low intermediate frequency signals is measured.

Errors show up thus, conditioned nonidentical phase-frequency and amplitude-frequency characteristics measuring device parallel channels.

The offered method, based on parallel-cross commutation of signals in the measuring device channels, allows to remove these errors.

Keywords: phase radiation pattern, microwave antenna, measure error.

1. INTRODUCTION

At design of antennas of the radio electronic systems of different purpose primary attention is spared to the amplitude radiation pattern (RP) and diagrams on power, while phase and polarization radiation pattern are no less important, that angular dependences of phase and polarization of the field of radiation of antenna are in a far-field zone [1]. As marked in [1], knowing amplitude and phase radiation patterns, that complex radiation pattern, it is possible to find distributing of the field in an aperture.

Possibility of decision of reverse task is more frequent than all examined, that measuring of the amplitude-phase distributing is in the aperture of antenna, on which calculate a radiation pattern in far-field zone.

For this purpose drawn on the specialized measuring complexes [2], however much this method decides the problem of determination of phase center of antenna of one or another type, in-use, for example, as an feed of reflector antenna [3]. Exactness of these measurings is low from revolting influence moving in the aperture of the investigated antenna of measuring probe [2].

Examples of practical realization of measuring complexes, allowing to execute measurings of phase radiation pattern of antenna in a far-field zone sufficiently small (see, for example, [4, 6]), while a necessity for such measuring tools is present. It is constrained with wide introduction of phase and polarization methods in the modern radio electronic systems, that requires in same queue, as marked in [5], studies of optimum phase and polarization radiation pattern of antennas at presence of in it random errors. It requires creation of high-fidelity measuring tools and analysis of possibilities of minimization of measuring errors, both methodical and vehicle in same queue. To the decision of such task and the real article is devoted.

2. PHASE RADIATION PATTERN MEASURING METHOD

Basic properties of the electromagnetic field, radiated by antenna, it is possible to define, if the so-called complex rationed RP which in the far-field zone of antenna can be presented in a next kind is known

$$\vec{F}(\theta,\varphi) = F(\theta,\varphi)\vec{P}(\theta,\varphi)\exp\left[j\Phi(\theta,\varphi)\right],$$

where $F(\theta,\varphi)$ — is a rationed amplitude RP, vectorial function $\vec{P}(\theta,\varphi)$ describes polarization properties of the radiation field, and a function $\Phi(\theta,\varphi)$ determines the phase structure of the electromagnetic field and carries the name of phase PR of antenna on main polarization. At description $\Phi(\theta,\varphi)$ it is important expressly to specify position of beginning of the coordinate system R,θ,φ.

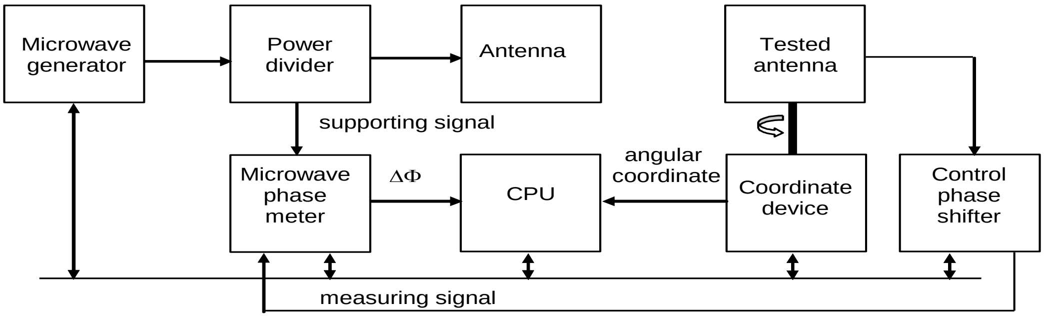

Fig. 1. Microwave antenna phase radiation pattern meter block diagram.

Phase RP determines the change of the electromagnetic field phase shift at moving of view on the surface of large sphere of radius point R. Along with phase RP the concept of equal phase surface is often used — to the surface on which the field phase is saved by unchanging for all corners of supervision.

Equalization of equal phase surface looks like

$$R(\theta,\varphi) = R_0 + \frac{\Phi(\theta,\varphi)}{k},$$

where $k = {}^{2\pi}\!/_{\lambda}$ — is a wave number; R_0 — it is a radius of large sphere in far-field zone.

In that case, when a equal phase surface is spherical, then the center of sphere is named the phase center of antenna, thus a phase center coincides with beginning of coordinates. Strictly speaking, on a spherical equal phase surface the gallops of phase are assumed on ± 180°, proper to the transition of amplitude RP through a zero. In this case phase RP is a permanent function, that $\Phi(\theta,\varphi) = \mathrm{const} \pm \pi$. Inconstancy of $\Phi(\theta,\varphi)$ can mean either the lack of coincidence of phase center with the chosen beginning of coordinates or testifies to absence of phase center.

The method of measuring of phase RP is based on traditional approach [6] and supposes the use of block diagram, represented on a fig. 1. The tested antenna is set on a coordinate-turning device and accepts the signal of auxiliary antenna. Control phase shifter is used for initial equalization of phase change between supporting and measuring signals, the difference of phases between which is measured by a microwave phase meter. However much channels of forming of supporting and measuring signals have substantial differences on the sizes of insertion phase shifts, which are conditioned by different structural execution of these channels. Insertion phase shifts possess also temporal changeability from the different sort of destabilizing factors (for example, temperature). In addition, direct measuring of difference of phases between signals in a microwave range with acceptable exactness possibly only in low-frequency part of microwave range. It is necessary to carry out transformation downward on frequency and to measure the difference of phases between the signals of intermediate frequency (IF), that adds additional differences in the sizes of insertion phase shifts in channels of supporting and measuring signals. This unidentity it is possible to remove by parallel-cross commutation of signals in channels of microwave phase meter [7].

3. PHASE DIFFERENCE MEASURING METHOD

The microwave phase meter block diagram, realizing the offered method [7], is represented on a fig. 2.

Supporting and measuring signals act on the inputs of microwave signal commutator. Microwave signal commutator and IF signal commutator work synchronously, in two times, here durations of times get out equal

$$\tau_e = \tau_o = T_c/2,$$

where T_c — is a commutation period; τ_e, τ_o — are durations of even and odd times, accordingly.

In odd times from a synchronizer which is controlled CPU, odd lock-on impulses act on the control inputs of commutators. Thus a supporting signal from the first input of microwave signal commutator acts on the first output of this commutator and further on the input of amplifying-downconvertor channel 1. Measuring signal from the second input of microwave signal commutator acts on its second output and further on the input of amplifying-downconvertor channel 2.

In even times of work of synchronizer supporting and measuring signals act on the second and first outputs of microwave signal commutator, accordingly, and further on the input of amplifying-downconvertor channel 1 and amplifying-downconvertor channel 2, accordingly.

The measurable phase difference $\Delta\Phi$ is equal

$$\Delta\Phi = \Phi_{ss} - \Phi_{ms},$$

where Φ_{ss} and Φ_{ms} are phases of supporting and measuring signals, accordingly.

The IF signals phase difference size on the input of IF signal commutator in odd times of synchronizer work equal

$$\Delta\Psi_o = \Psi_{1o} - \Psi_{2o} = (\Phi_{ss} + \Delta\varphi) - \Phi_{ms} = \Delta\Phi + \Delta\varphi,$$

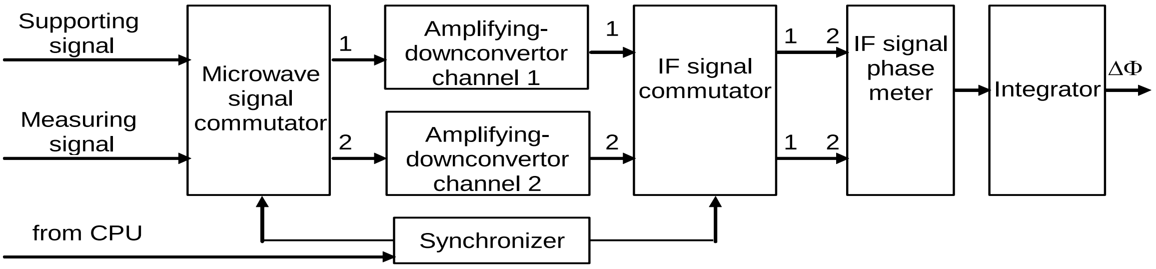

Fig. 2. Microwave phase meter block diagram.

where Ψ_{1o}, Ψ_{2o} — are IF signals phase on the output of amplifying-downconvertor channel 1 and amplifying-downconvertor channel 2 in odd times, accordingly; $\Delta\varphi$ — it is a phase raids difference in a channel 1 in relation to a channel 2, conditioned by the size difference of own phase raids in each of channels and, in addition, by a change them in time.

The IF signals phase difference size on the input of IF signal commutator in even times

$$\Delta\Psi_e = \Psi_{1e} - \Psi_{2e} = (\Phi_{ms} + \Delta\varphi) - \Phi_{ss} = -\Delta\Phi + \Delta\varphi,$$

where Ψ_{1e}, Ψ_{2e} — are IF signals phase on the output of channel 1 and channel 2 in even times, accordingly.

In odd times of synchronizer work signal IF from the output of channel 1 acts on the first input of IF signal commutator and further on the first input of phase meter, and signal from the output of channel 2 — on the second input of phase meter.

In even times cross commutation of IF signals is carried out and signals from the outputs of channel 1 and channel 2 act on the second and first input of phase meter, accordingly.

IF signals phase difference size on input of phase meter in odd times makes

$$\Delta\Psi'_o = \Delta\Psi_o = \Delta\Phi + \Delta\varphi,$$

in even times —

$$\Delta\Psi'_e = -\Delta\Psi_e = -(-\Delta\Phi + \Delta\varphi) = \Delta\Phi - \Delta\varphi.$$

The phase meter output signal is straight proportional to the phase difference of $\Delta\Psi'_o$ or $\Delta\Psi'_e$ and has a permanent constituent, amplitude of which depends on the measurable phase difference, and variable, constituent amplitude of which depends on the phase raids difference in channels.

As a result on the integrator output get a signal, amplitude U which corresponds to amplitude of permanent constituent of phase meter output signal

$$U = \frac{\Delta\Psi'_o + \Delta\Psi'_e}{2} = \frac{(\Delta\Phi + \Delta\varphi) + (\Delta\Phi - \Delta\varphi)}{2} = \Delta\Phi.$$

On the integrator output get a signal amplitude of which corresponds to the phase difference of supporting and measuring signals $\Delta\Phi$ and does not depend on a size and sign of phase raids difference in channels $\Delta\varphi$.

CONCLUSION

The offered method allows to minimize errors from unidentity of measuring device channels of microwave antenna phase radiation pattern.

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