A method of determining the single or partial phase center of an antenna using polarization measurements at two points of the radiation field in the antenna for zone is proposed. The method is based on a determination of the directions of the Poynting vector at these points. An example of the determination of the phase center of an antenna with a known axis is given.

When investigating an antenna experimentally or when checking it, the problem arises of determining the phase center of the antenna. If the antenna does not possess a single phase center, one finds the so-called partial phase centers [1], which occupy a certain region of space. This usually refers to antennas used as a radiator in an antenna system or to measurement antennas.

Existing methods, described, for example, in [1, 2], are very time consuming and impractical, since they require special additional apparatus and multiple phase measurements. These methods are based on determining the phase front of the radiation field in the far zone of the antenna, with subsequent approximation of its spherical surface, the center of which is taken as the phase center of the antenna.

In this paper we propose a method of determining a single or partial phase center of an antenna using polarization measurements at two spaced points in the far zone of the antenna radiation field [3]. The method is based on the idea that the phase center of the antenna can be thought of as a point from which "spherical waves emerge" [4]. To determine it, it is necessary and sufficient to obtain the directions of the Poynting vector \( \mathbf{\Pi} \), at two spaced points in the antenna radiation field, which are taken as the direction vectors of two straight lines, the point of intersection of which corresponds to the phase center of the antenna. The Poynting vector is directed along the normal to the plane of rotation of the electric (magnetic) vector (the plane of the polarization ellipse), the orientation of which, in turn, is determined by means of polarization measurements. The field is assumed to be locally plane in the neighborhood of the point where measurements are made.

The method requires polarization measurements to be made at only two spaced points of the antenna radiation field, which is very convenient and simplifies the measurements.

Consider an arbitrary antenna (Fig. 1) and a Cartesian system of coordinates \( X, Y, Z \) connected to it. In the far zone of the radiation field we choose two points with coordinates \((x_1, y_1, z_1)\) and \((x_2, y_2, z_2)\) and local systems of coordinates \( X_1, Y_1, Z_1 \) and \( X_2, Y_2, Z_2 \) connected with it, which we obtain by parallel translations of the system of coordinates \( X, Y, Z \). In local systems of coordinates the directions of the Poynting vector are specified by the direction cosines [5]

\[
\begin{align*}
\mathbf{n}_1 &= x_1 \cos \alpha_{x1} + y_1 \cos \alpha_{y1} + z_1 \cos \alpha_{z1}, \\
\mathbf{n}_2 &= x_2 \cos \alpha_{x2} + y_2 \cos \alpha_{y2} + z_2 \cos \alpha_{z2},
\end{align*}
\]

where \( \mathbf{n}_1 \) and \( \mathbf{n}_2 \) are the unit vectors of \( \Pi_1 \) and \( \Pi_2 \), and \( \alpha_{x,y,z1}, \alpha_{x,y,z2} \) are the angles between the vectors \( \mathbf{n}_1 \) and \( \mathbf{n}_2 \) and the unit vectors of the systems of coordinates \( X_1, Y_1, Z_1 \) and \( X_2, Y_2, Z_2 \) respectively.

Taking into account the fact that the local systems of coordinates are obtained by parallel translations of the basic system \( X, Y, Z \) and, therefore, the directions of the vectors \( \mathbf{n}_1 \) and \( \mathbf{n}_2 \) (the direction cosines) do not change on transferring from one system of coordinates to another, for the straight lines passing through the points with coordinates \((x_1, y_1, z_1), (x_2, y_2, z_2)\) with directional vectors \( \mathbf{n}_1 \) and \( \mathbf{n}_2 \), we can write the following equations in the basic system of coordinates \( X, Y, Z \) [6]:

\[ \text{Transcribed from Izmeritel'naya Tekhnika, No. 4, pp. 55-57, April, 1998.} \]
The solution of Eqs. (2) enables us to obtain the coordinates of the point of intersection of the straight lines which, according to the initial idea, is also the phase center of the antenna:

\[ x_0 = \frac{x_1 \cos \alpha_1 \cos \alpha_2 - x_2 \cos \alpha_2 \cos \alpha_1 + (y_2 - y_1) \cos \alpha_1 \cos \alpha_2}{\cos \alpha_1 \cos \alpha_2 \cos \alpha_1} \]

\[ y_0 = \frac{y_1 \cos \alpha_1 \cos \alpha_2 - y_2 \cos \alpha_2 \cos \alpha_1 + (x_2 - x_1) \cos \alpha_1 \cos \alpha_2}{\cos \alpha_1 \cos \alpha_2 \cos \alpha_1} \]

\[ z_0 = \frac{z_1 \cos \alpha_1 \cos \alpha_2 - z_2 \cos \alpha_2 \cos \alpha_1 + (y_2 - y_1) \cos \alpha_1 \cos \alpha_2}{\cos \alpha_1 \cos \alpha_2 \cos \alpha_1} \]

To determine the directions of the unit Poynting vectors \( n_1 \) and \( n_2 \) (the direction cosines in (1)), we will use the property that the vector \( \mathbf{n} \) is normal to the surface of the phase front. Assuming that, in the neighborhood of a point of the phase front, the field is locally plane, the Poynting vector is normal to the plane of rotation of the electric (magnetic) field vector (the plane of the polarization ellipse).

We will consider, in the general case, how to determine the angles of orientation of the plane of the polarization ellipse in a Cartesian system of coordinates, meaning by this the local systems \( X_1, Y_1, Z_1 \) and \( X_2, Y_2, Z_2 \), situated at points with coordinates \( (x_1, y_1, z_1), (x_2, y_2, z_2) \) (Fig. 2). In a Cartesian system of coordinates the vector \( \mathbf{E} \) can be characterized by three complex projections \( E_x e^{i\alpha_x}, E_y e^{i\alpha_y}, E_z e^{i\alpha_z} \). The vector \( \mathbf{E} \) in the general case describes a polarization ellipse in a certain plane. We will introduce an additional system of coordinates \( \xi, \eta, \zeta \) (see Fig. 2), connected with the plane of the polarization ellipse, such that its origin coincides with the origin of the system \( X, Y, Z \), and the polarization ellipse lies in the \( \xi, \eta \) plane.

We will also represent the relation between the unit vectors \( x, y, z \) and \( \xi, \eta, \zeta \) by direction cosines.