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THE TECHNIQUE OF CALCULATION THE PARAMETERS OF THE ELECTROMAGNETIC THE FIELDS SCATTERED BY THE BODY WITH COMPLEX FORM IN THE NEAR ZONE

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The paper is based on the methodology that uses the representation of an object of complex shape as a set of facets, we investigate the characteristics of scattered by this object in its near zone. It is shown how, using the calculated data to explore the effect of the spatial configuration of the field on the accuracy of measurement of angular coordinates of the object. The calculated dependence of the relative field amplitude of the object and the plate from the corner for the near zone to the far zone. The graphical analysis of the dependencies shows that in addition to monotonic attenuation length fields exist oscillating damped oscillations. It is believed that the antenna is moved around the object at random are averaged over all viewing angles characteristics of the scattered field. After calculating the parameters of the distribution law of a random variable from section to section, we can conclude about how changing the process in time. The analysis demonstrates that when we move from the far zone to the near, there is a shift of peak values of amplitudes and is an extension of the main lobe of the secondary radiation. The histograms of the distributions of amplitudes and phases of a complex object, after analysis it was found that the distribution of instantaneous values of the amplitudes of the scattered field by the object is described by Rayleigh. If we consider the distribution of the instantaneous phase of the scattered field, the shape of the histogram is close in form to the histogram of a uniform law. The analysis of the results allows to assert that the regularities of the distribution of values of amplitudes and phases of the scattered field related to the far and near zones will be the same.

Keywords: complex object, electromagnetic wave, near zone, scattering, diffraction.

Introduction. The problems associated with the consideration of the phenomena of change of the position of instantaneous centers of radar reflection that describes an object of complex shape are considered by developers of communication systems is already long enough [1 – 3]. The analysis is conducted under the condition of interference of waves scattered by different elements of the object. The construction of appropriate algorithms for the estimation of scattering characteristics of objects will allow to reduce the error of measurement of angular coordinates of objects, such as when the processes of direction finders.

Angular errors due to fluctuations of the fronts of the scattered objects of electromagnetic waves, which are propagated to the aperture of the receiving antenna [1-3]. We can observe fluctuations when there is movement of the antenna with respect to the analyzed object, since it crosses the spatial structure of the secondary field of this object. The value of their intensity is determined by the characteristics of the structure of the object, the trajectory and speed of the relative motion of the object and the receiving antenna. In addition, there is a connection of fluctuations that associated with the spatial structure of the substance as a result of the fact that there are displacements, rotations, vibrations of the investigated object and change the properties of the medium in which propagated electromagnetic wave.

Researchers have found theoretical and experimental way, that there may be fluctuations in the direction of bearing of objects that are larger than its angular size [4, 5]. In practice, the solution of this problem can be useful for controlling movement of a few close subjects.

The purpose of the work. The error of measurement of angular coordinates of the object appear due to the fact that distorted space-time structure of the scattered electromagnetic field. Therefore, it is required to determine the configuration of such a field in the area of location of the object, particularly in the region, which is adjacent to the object surface because of its irregularity has a strong influence on the structure of the field. In addition, in practice interest is the determination of regularities of the distributions of the instantaneous values of the amplitudes and phases of the scattered fields in the near zone of the object. Then, based on this data, it is possible to offer technical solutions leading to the reduction of the influence of the angular noise in the measurement of angular coordinates of objects in the near zone.

The analysis of literary sources on the problem. In publications on this topic, discusses various approaches and techniques to conduct the required assessment. Among the publications we can note the development of models based on different electrodynamic methods of processing of radar characteristics of objects having complex shape, for example, [6-8], as research shows that the more factors related to the formation of scattered fields, we can contribute to the model, the more opportunities to record and research of thin effects. There are works that address the statistical parameters of the fluctuations of the radiation sources of different types [9]. You can get acquainted with the peculiarities of the mathematical models that describe the amplitude, angular and distance measuring noise objects close to the boundaries of the media [10].

There are difficulties in the system management objects are also associated with the fact that the object may enter the components with nonlinear transfer characteristics. That is, there is a practical necessity in determining the parameters of nonstationary processes on the input of the antenna, which is located in the near zone of the object with a complicated shape.

In order to solve the problem, you need to calculate the electromagnetic field scattered by the object. Solutions based on analytical representations can be obtained only for a very limited set of objects, for example [11-13]. But with the use of numerical methods for solving a class of objects analyzed could be expanded substantially, including in the implementation of calculations for modern personal computers. This makes it possible for the complete replacement of physical experiments by calculations, which determines significant advantages, as the results for any given precision can be obtained much faster and cheaper [14, 15].

The technique. An object of complex shape can be represented as a set of facets [16], which are elements that have the same shape. On the basis of what is numerical integration of the densities of the surface currents, which are induced by the incident electromagnetic wave, is the calculation of fields reflected from each of the facets, and they are summarized. To accelerate the computation should apply the techniques on the basis of which integrate rapidly oscillating functions. After the calculations are obtained the amplitude and phase diagrams of the scattering fields for a given sector of angles. The method of calculation is characterized by several important advantages, among which we can indicate: there are no big restrictions on how the geometry of the object and how it changes, getting an accurate accounting on the phase relations of the fields, which are dispersed by the facets, capabilities in order to take into account the internal reflections between the components of the object.

In Figure1 shows an example of the object.

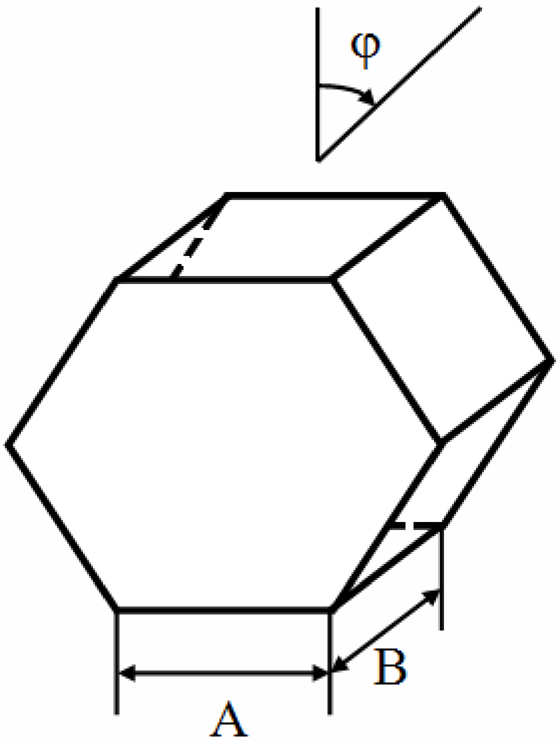


Figure 1- Example of an analyzed object, A=11λ, B=9λ.

Analysis of the results. Let us consider some results of calculations that were performed on the basis of the methodology. In Figure2 shows a diagram of the amplitude of the scattered field of the specified object to be combined of reception at different distances before him.

In the near zone of the object when there is an integration of fields that are scattered by the facets, the differences in their amplitudes are quite small, the calculations required to take into account the phase shift.

The fact that the vectors E and H to diffuse field is in addition to the transverse and longitudinal component, defines a more complex field structure in the near field than far field. The dependence on r is similar to the one that is in a spherical wave exp(-jkr)/r. Also, r there is a dependence and angular distributions of the amplitudes of the fields.

The analysis of Figure2 shows that when we move from the far zone to the near, there is a shift of the peak values of the amplitudes (4-5^{o}) and expanded main lobe of the secondary radiation. When the reduced distance r, then the observed duplication main lobe angular distribution of the field amplitudes of its partial merging with lateral petals.

In Figure3 given the dependence of the amplitude of the scattered field on the distance of the object, having maximum size of 29λ. Also, given the dependence of the amplitude of the field scattered by a perfectly conducting plate with a size of 30λ. The graphical analysis of the dependencies shows that in addition to monotonic attenuation length fields exist oscillating damped oscillations. Such oscillation amplitudes for the near-field zone can be explained by the fact that there is interference of waves, which are point observations from different Fresnel zones on the surface of the object, the frequency of such oscillations will be greater the smaller the distance between the observation point and the surface. Objects with complex surface shape the picture of the dependence of field amplitude on distance is normal, but there is a change in the mean amplitude values depending on which view of the movement to the object.

We will assume that the antenna is moved around the object randomly, so in order to solve the problem, you need to find the average for all viewing angles characteristics of the scattered field. Let the antenna moves in a straight line to the object being analyzed with a constant value of the radial speed V. the Value of r allows to determine the size of a random process at the input of the receiving antenna at time t. After calculating the parameters of the distribution law of a random variable from section to section, we can conclude about how changing the process in time.

The parameters of the distribution law of the random value can be found based on the accumulation of a certain amount of experimental data and further processed by the methods of mathematical statistics.

Held the histograms of the distributions of amplitudes and phases of the scattered field. For example, in Figure4 shows the histogram formed on the basis of these calculations in the near zone of the object.

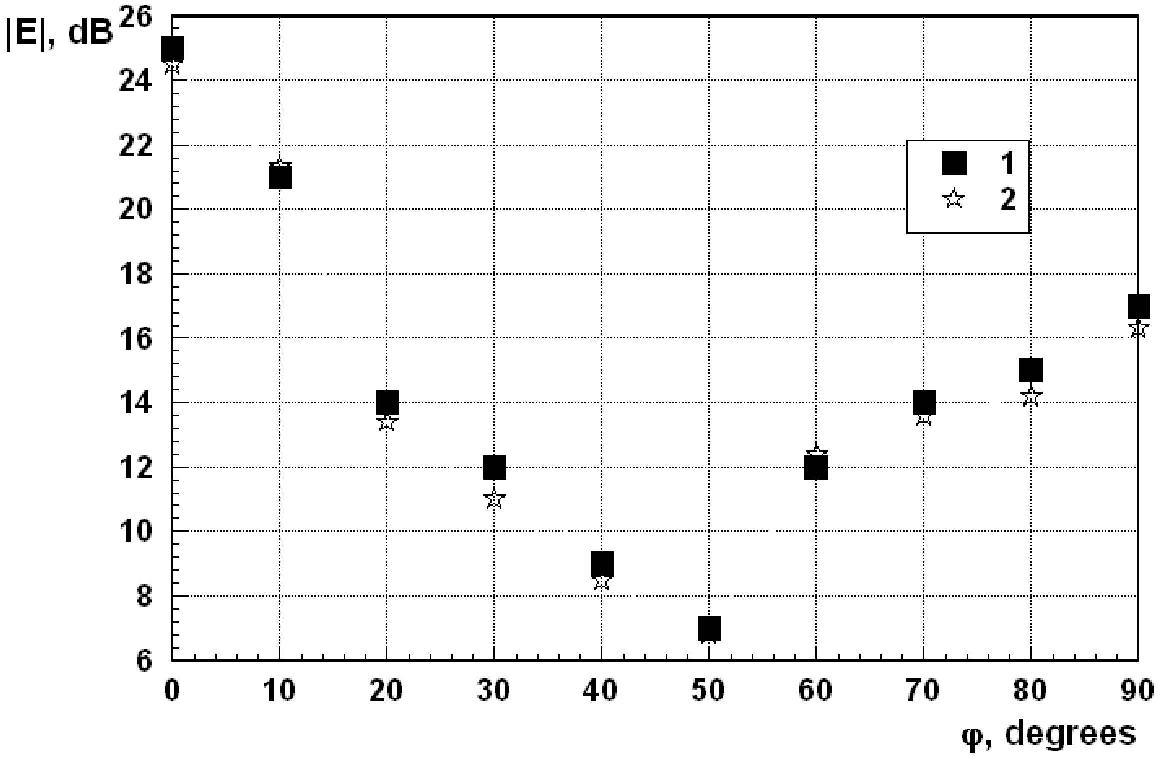


Figure 2 -The dependence of the relative field amplitude of the angle 1 for the near-field zone 2 – to the far zone

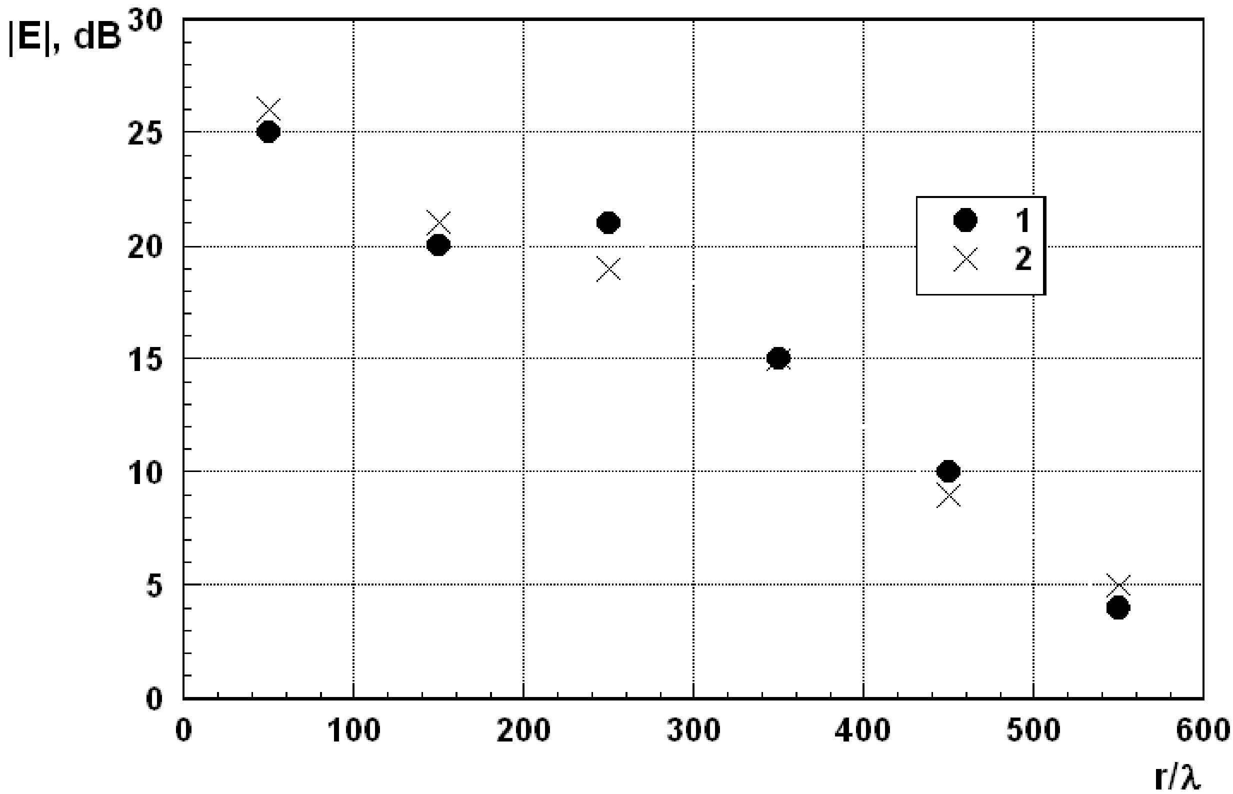
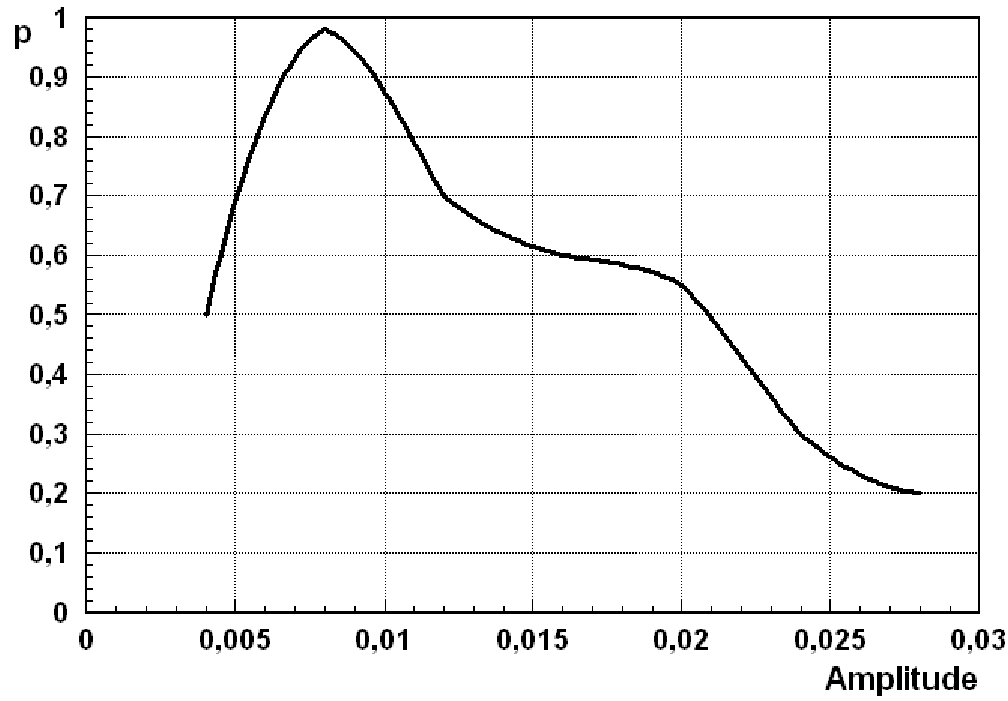
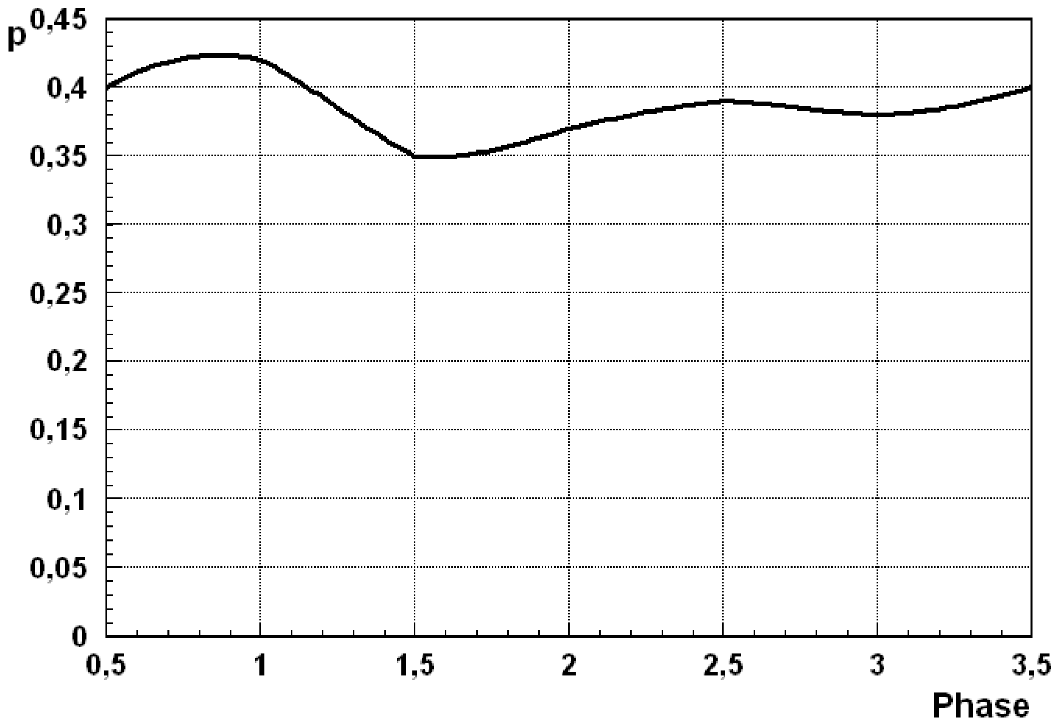


Figure 3-The amplitude of the scattered field on the distance to the object. 1 - object, 2 – plate.



a)



b)

Figure 4 - Histograms of the distributions of amplitudes and phases of a complex object

It was conducted by splitting the entire range of values of random variables for the number of intervals n=230. The amplitude and phase are deposited on the x-axis, relative frequencies that fall into the intervals: – amplitudes and – phases, respectively, on the y-axis. We solve the problem of alignment of the statistical series. That is required to determine this smooth function, based on which we can best make a description of this statistical distribution. The task associated with the alignment of the statistical series will be presented as a challenge to determine these parameter values for which the best match among the statistical and theoretical distributions. After the analysis Figure4 we determined that the distribution of instantaneous values of the amplitudes of the scattered field by the object is described by a Rayleigh.

The parameter of this distribution based on numerical method (in our example 0,00579).

If we consider the distribution of the instantaneous phase of the scattered field, the shape of the histogram is close in form to the histogram of a uniform law. The value of the relative frequencies of hit of values of the phase at selected intervals approximately equal to 0,258. This suggests that the number of elements in the sample is sufficient to assume that she is wealthy.

The analysis of the results allows to assert that the regularities of the distribution of values of amplitudes and phases of the scattered field related to the far and near zones will be the same. In addition, decreasing the distance to the object is the increase of standard deviation values of instantaneous amplitudes. This can be explained by the fact that the growing influence of the curvature of the surface of the object on the mechanism of formation of the scattered field. The regression function that approximates the many starting points with the least mean square error will be a straight-line equation where is the angular size of the considered complex object.

The value of the correlation coefficient among the obtained straight regression will be equal to 0,967. As a result, it was found that there is a linear dependence of the standard deviations of amplitudes of the field from the angular size of the field for both far and near zone.

Conclusions. The appearance of intensity fluctuations of the instantaneous field of radar reflection center, when there is a rapprochement between the antenna and the object, is due to two reasons: the antenna moves through the heterogeneous structure of the scattered field and the object can also move.

Through analysis of the magnitude of the dispersion of the signal, there is the possibility of a identification of class of objects according to their transverse dimensions.

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МЕТОДИКА РАСЧЕТА ПАРАМЕТРОВ ЭЛЕКТРОМАГНИТНОГО ПОЛЯ, РАССЕЯННОГО ТЕЛОМ СЛОЖНОЙ ФОРМЫ В БЛИЖНЕЙ ЗОНЕ

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В данной статье рассматривается представление тела сложной формы, в виде совокупности граней, на основе такой модели исследуются характеристики рассеянного поля в ближней зоне. Проведено сравнение расчетной угловой зависимости относительной амплитуды поля тела и пластины, имеющей такой же поперечный размер, от расстояния. Анализ полученных зависимостей продемонстрировал, что помимо монотонного затухания поля с увеличением расстояния возникают колебательные затухающие колебания. Считается, что антенна перемещается вокруг тела случайным образом, проведено усреднение для всех углов падения электромагнитной волны. После расчета параметров закона распределения случайной величины, можно сделать вывод о том, как меняются характеристики рассеяния во времени. Показано, что при переходе от дальней зоны к ближней, происходит смещение пиковых значений амплитуд и основного лепестка вторичного излучения расширяется. Анализ гистограмм распределений амплитуд и фаз мгновенных значений амплитуд рассеянного поля объекта показал, что они подчиняются закону Рэлея. В итоге было установлено, что, что закономерности распределения значений амплитуды и фаз рассеянного поля по дальней и ближней зонах будут одинаковыми.

Keywords: тело сложной формы, электромагнитная волна, ближняя зона, рассеяние, дифракция.