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EVALUATION OF THE EFFECTIVENESS OF RADIO-ABSORBING COATINGS FOR INFORMATION SECURITY PROBLEMS [1]

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Abstract. The paper investigates the weakening effects of screens of various kinds on the electromagnetic waves passing through them. With such solutions, it is possible to make estimates for the weakening effect of electromagnetic screens of arbitrary shape and for radiation with arbitrarily given characteristics.

Key words: radar absorbing material, electromagnetic radiation, absorption coefficient, effect of neutralization, information security.

Introduction

Protection of information processed by technical means is carried out with the use of passive and active methods and means.

Passive methods of information protection are aimed at [5; 6]:

– attenuation of side electromagnetic radiation (information signals) of technical means of information transmission at the border of the controlled zone to the values that ensure the impossibility of their allocation by means of intelligence against the background of natural noise;

– attenuation of interference of side electromagnetic radiation (information signals) from technical means of information transmission in foreign conductors and connecting lines of auxiliary technical means and systems beyond the controlled zone to the values that ensure the impossibility of their allocation by means of intelligence against the background of natural noise;

– exclusion (attenuation) of leakage of information signals of technical means of information transmission in the power supply circuit beyond the controlled zone to the values that ensure the impossibility of their allocation by means of intelligence against the background of natural noise.

Passive technical means of protection – the device providing concealment of the object of protection from technical methods of investigation by absorption, reflection or dispersion of its radiations [1; 3; 8]. Passive technical means of protection include shielding devices and structures, masks for various purposes, separation devices in power supply networks, protective filters, etc.

To completely eliminate the interference from the technical means of information transmission in rooms whose lines go beyond the controlled zone, it is necessary not only to suppress them in the wires departing from the source, but also to limit the scope of the electromagnetic field created in the immediate vicinity of the source by the system of its internal wiring. This problem is solved by applying shielding. Shielding is divided into:

– electrostatic;
– magnetostatic;
– electromagnetic.

Electrostatic and magnetostatic shielding is based on the closure of the screen, which in the first case has a high electrical conductivity, and in the second – the magnetic conductivity, respectively, of the electric and magnetic fields. At high frequency, electromagnetic shielding is used exclusively. The action of the electromagnetic shield based on the fact that high frequency electromagnetic field is weakened by his self-created (due to the formation in the thickness of the screen, eddy current) field of the reverse direction.

Radioabsorbing materials are materials whose composition and structure ensures effective absorption (with little reflection) of electromagnetic energy in a certain range of radio wavelengths. There is no universal classification of radioabsorbing materials. Conventionally, they can be classified by the composition and principle of action.

In modern developments of radioabsorbing materials for absorption of energy of electromagnetic waves the traditional electroconducting disperse (soot, graphite, metal particles), fibrous (carbon, metal, metallized polymeric) and magnetic (sintered ferrite plates, powders of ferrites, carbonyl iron, etc.) fillers applied both separately, and together are used for absorption forming difficult composite structures. Radioabsorbing materials made in the form of varnishes, paints, sealants, polymers, fabrics, tiles, foams, filled rubbers, building slabs, loose mixtures and other variants of various compositions are the main components in the creation of electromagnetic wave absorbers, which are used for the equipment of anechoic chambers [2; 4; 7].

In the simplest case, screens are the windows and walls of the room where the device is working; in other cases, a construction specially created for this design will perform the role of the screen.

In this regard, there is an urgent task to study the weakening effects of screens of various kinds on electromagnetic waves passing through them. The solution of such problems depends on the characteristics of spurious emissions, primarily from wave, its spectral composition and the radiation pattern and characteristics, namely its geometry and electromagnetic parameters of the material of which it is made.

Mathematically, problems of this kind are extremely complex and, in general, can only be solved approximately by numerical methods.

Accurate analytical solutions can be obtained only in the analysis of the simplest situations, such as the normal incidence of a plane harmonic linearly polarized wave on the screen in the form of a homogeneous plate.

Mathematical model

We formulate the initial relations of electrodynamics and the approximations that will be used in the calculations. We will divide all the space into three areas: the material of the screen and the air environment on both sides of it (Fig. 1).

An important characteristic of radioabsorbing materials is the absorption coefficient (A), which is found by formula 1:

$$\mathrm{A = 1 - R - T;} \tag{1}$$

R and T are the reflection and absorption coefficients, respectively, and are found by formulas 2 and 3.

$$R = \frac{U_R}{U_i}, \tag{2}$$

$$T = \frac{U_T}{U_i}, \tag{3}$$

U_i is the tension of the amplitude of the incident wave; U_R is the tension of the amplitude of the reflected wave; U_T is the tension of the amplitude of the transmitted wave.

Relationship between electric $E(x)$ and magnetic $H(x)$ field functions at the outer boundaries of the plate:

$$E^i(-0) = A, \quad E^r(-0) = R, \quad E^p(d+0) = T, \tag{4}$$

$$H^i(-0) = A/Z_0, \ H^r(-0) = -R/Z_0, \quad H^p(d+0) = T/Z_0 \tag{5}$$

Z_0 is the characteristic impedance of vacuum

$$Z_0 = \sqrt{\mu_0/\varepsilon_0}, \tag{6}$$

ε_0 is dielectric capacitivity, μ_0 is magnetic permeability.

Conjugation conditions for functions $E(x)$ and $H(x)$ at plate boundaries:

$$A + R = E(+0); \quad A - R = Z_0 H(+0); \quad T = E(d-0); \quad T = Z_0 H(d-0). \tag{7}$$

The amplitude reflection r_a and transmission t_a coefficients are calculated by the formulas:

$$r_a \equiv \frac{R}{A} = \frac{m_{11}Z_0 + m_{12} - m_{21} - m_{22}Z_0}{-m_{11}Z_0 + m_{12} + m_{21} - m_{22}Z_0}, \tag{8}$$

$$t_a \equiv \frac{T}{A} = \frac{2Z_0}{m_{11}Z_0 - m_{12} - m_{21} + m_{22}Z_0}. \tag{9}$$

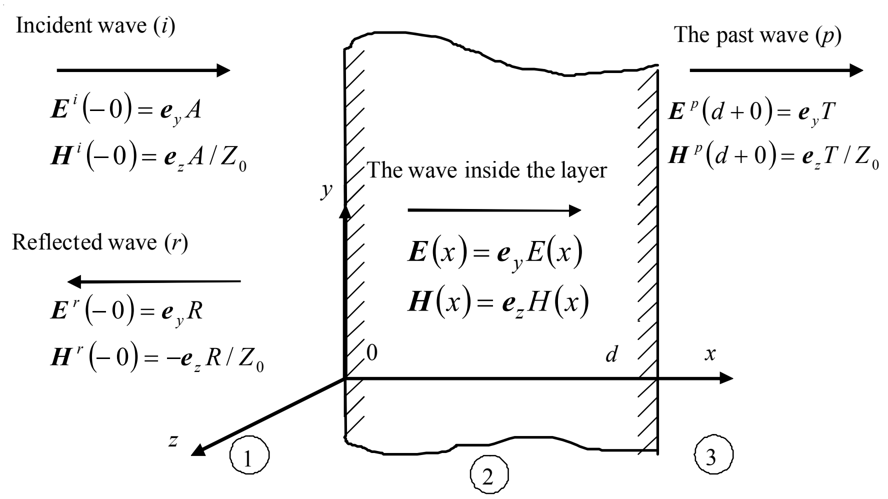

Fig. 1. Passage of a plane harmonic electromagnetic wave through a homogeneous plate

Here for brevity symbols m_{ij} denote elements of the Cauchy matrix *M*:

$$m_{11} = \cos k_0 nd; \; m_{12} = -\frac{iZ_0}{n} \sin k_0 nd;$$
$$m_{21} = -\frac{in}{Z_0} \sin k_0 nd; \; m_{22} = \cos k_0 nd. \tag{10}$$

The reflection r_e and transmittance t_e energy coefficients can be defined as:

$$r_e \equiv \frac{|\mathbf{S}^r|}{|\mathbf{S}^i|} = |r_a|^2; \quad t_e \equiv \frac{|\mathbf{S}^p|}{|\mathbf{S}^i|} = |t_a|^2, \tag{11}$$

S is Poynting vector for the corresponding wave.

Discussion

An example of the reflection and transmission coefficients calculation is shown in figures 2 and 3. The graphs are constructed as a function of the ratio d / λ at a constant real part of the refractive index *n* for three values of the imaginary part of this index (n = = 0; 3,5; 7).

Thus, the graphs give an idea of the behavior of the reflection and transmission coefficients depending on the wavelength of radiation and the absorption capacity of the material.

4. Conclusion

The proposed algorithm for calculating the reflection and transmission coefficients is easily generalized to the case where instead of a plate we have a layered medium. Thus, it is possible to solve the problem of calculating the coefficients of attenuation of electromagnetic radiation by dielectric screens of different designs.

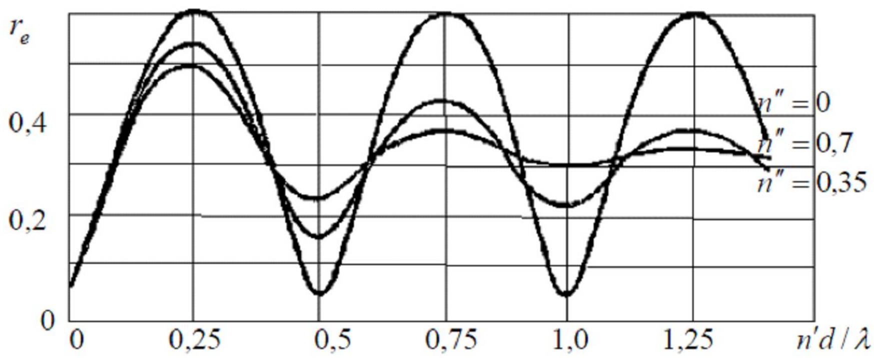

Fig. 2. The calculation of the reflection coefficient

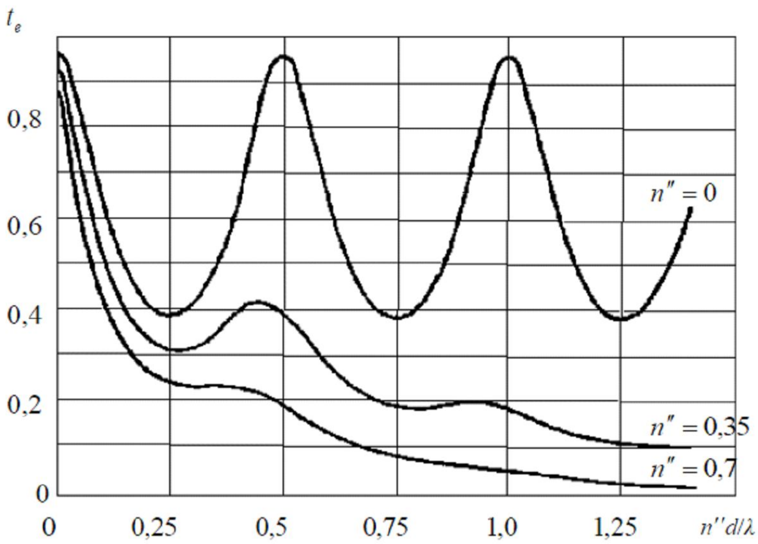

Fig. 3. The calculation of the transmittance coefficient

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ОЦЕНКА ЭФФЕКТИВНОСТИ РАДИОПОГЛОЩАЮЩИХ ПОКРЫТИЙ ДЛЯ РЕШЕНИЯ ЗАДАЧ ИНФОРМАЦИОННОЙ БЕЗОПАСНОСТИ

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Аннотация. В работе исследуется ослабляющее воздействие экранов различного типа на проходящие через них электромагнитные волны. С их помощью можно производить оценки ослабляющего эффекта электромагнитных экранов произвольной формы и излучения с произвольно заданными характеристиками.

Ключевые слова: радиопоглощающий материал, электромагнитное излучение, коэффициент поглощения, эффект нейтрализации, информационная безопасность.