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MATHEMATICAL MODEL OF THE CYLINDER WITH MODULATION OF SURFACE IMPEDANCE BY PERIODIC SEQUENCE OF GAUS FUNCTIONS

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Abstract

In the article the results of development of the mathematical model of the impedance cylinder with modulation by periodic sequence of Gaus functions are presented.

***Keywords*:** impedance cylinder, mathematical model, branched continual fractions.

1. INTRODUCTION

In article [1] the problem of excitation of an infinite impedance plane with δ - modulation of the surface impedance is solved. The solution of the problem made in the closed form. With this method a problem of excitation of the infinite circular impedance cylinder with modulation of the surface impedance by multiple periodic sequences of rectangular functions is solved in the work [2]. In the work [3] results of the solution of particular problems of excitation of some periodically heterogeneous structures are generalized. The recurrent formula which allows to build mathematical models of a wide class of the modulated impedance antennas was get. In the work [4] mathematical models of periodically heterogeneous structures, constructive parameters of which are modulated by a class of impulse functions, which are closed to δ – functions by properties, are developed. In the work [5] the mathematical model is constructed and features of field forming for structures with double modulation of constructive parameters are investigated. In the present article the mathematical model of the circular impedance cylinder modulated by periodic sequences of Gaus impulses is constructed and radiation patterns are calculated.

2. MATHEMATICAL MODEL

Let's look at the infinite impedance cylinder of circular section (Fig.1). The cylinder is described by concept surface impedance [3]:

$$Z_E(z) = E_z(z)/H_\varphi(z), \qquad (1)$$

where E_z, H_φ – electric and a magnetic field strength. Let the structure is excited by a ring of an inphase magnetic current:

$$I_\varphi^M(z) = I_0^M \delta(z'-0)\delta(r'-a),$$

where I_0^M -is an amplitude of a magnetic current.

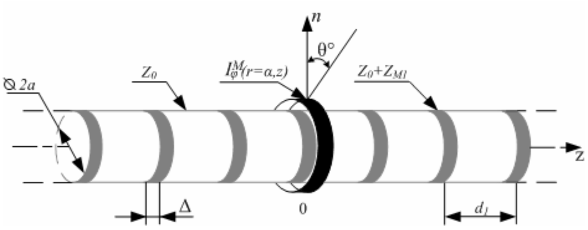

Fig. 1. Modulated impedance cylinder

Let the distribution of a surface impedance $Z_H(z)$ along axis z of the cylinder is described by the following ratio (Fig.2):

$$\hat{Z}_E(z) = \hat{Z}_0 + \hat{Z}_{M1}\sum_{n_1=-\infty}^{\infty}\exp[-(z-n_1d_1)^2/2b^2], \qquad (2)$$

where: $\hat{Z}_0$ - constant component of a surface impedance; $\hat{Z}_{M_1}$ - amplitude of impulse functions; d_1 - the period of spatial modulation of structures; b – parameter which defines a steepness of fronts of impulse functions.

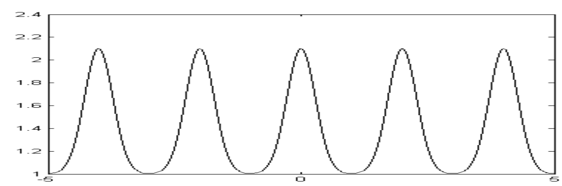

Fig. 2. Distribution of surface impedance

Such distribution of the surface impedance can be realized practically (Fig.3):

Fig. 3. Fragment of the experimental sample of periodically heterogeneous cylindrical impedance structure.

Radiation patterns of structures (Fig.1) for a case of modulation of a surface impedance by periodic sequence of Gaus functions (2) will be described by the following formula:

$$\xi_1(\theta^0) = \Phi_0 \xi_0(\theta^0) \xi_{1,\Delta}(\theta^0); \quad (3)$$

where:

$\xi_0(\theta^0) = \cos(\theta^0)/(R\cos(\theta^0) - \hat{Z}_0)$ - radiation patterns of the homogeneous cylinder with the surface impedance Z_0;

$$\xi_{1,\Delta}(\theta^0) = [A \sum_{n=-\infty}^{n=\infty} (C_n / (B_n(\theta^0) - \hat{Z}_0))]^{-1} \quad (4)$$

array factor;

$A = 1 + \hat{Z}_M \hat{\Delta} \sqrt{2\pi}$; $\hat{Z}_0 = Z_0 / W_0$;

$\hat{Z}_{M1} = Z_{M1} / W_0$; $W_0 = 120\pi$ [ohm];

$C_n = \exp(-2n^2 \pi^2 \hat{\Delta}^2)$; $\hat{\Delta} = b / d_1$;

$B_n(\theta^0) = R\sqrt{1 - [\sin(\theta^0) - n\lambda / d_1]^2}$;

$R(\alpha p) = H_0^2(\alpha p) / H_1^2(\alpha p)$; $p = \cos(\theta^0)$;

$\alpha = a / \lambda$; H_0^2, H_1^2 - Hankel function.

3. Results of calculations

On Fig. 4,5 the radiation patterns of the impedance cylinder are shown for different laws of distribution of the surface impedance:

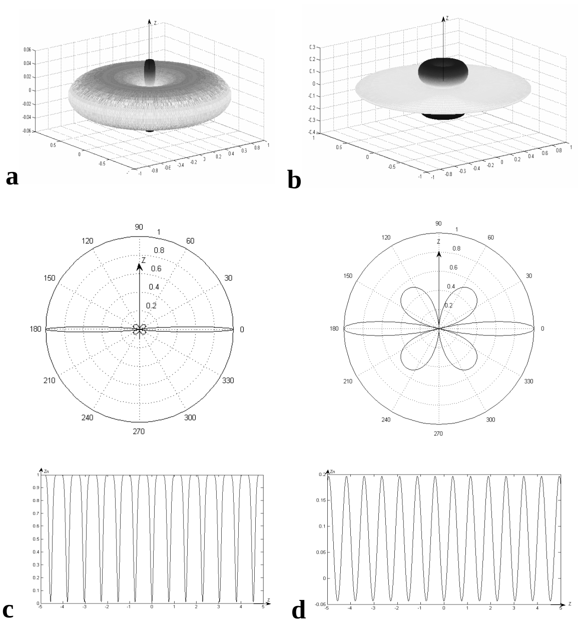

Fig. 4. Radiation patterns of the impedance cylinder are resulted (a,b) та laws of impedance distribution (c,d) for d_1=0.76λ; b=0.05λ; Z_0=1.0; Z_{M1}= - 0.99.

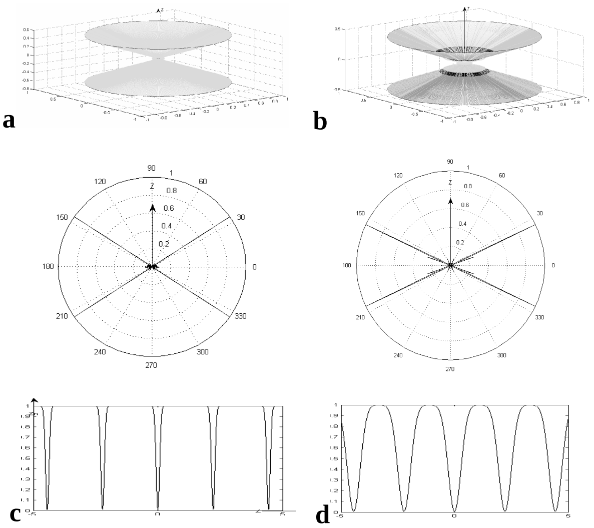

Fig. 5. Radiation patterns of the impedance cylinder are shown (a,b) and laws of impedance distribution (c,d) for d_1=2.28λ; b=0.2λ; Z_0=1.0; Z_{M1}= - 0.99.

4. Conclusion

The mathematical model of the antenna on the basis of periodically heterogeneous circular impedance cylinder is developed. Features of forming of the radiation field for a number of laws of modulation of the surface impedance by sequences of Gaus functions are investigated. The obtained results have the important applied value for info - communicational systems on the basis of modulated nano - dimensional structures.

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