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# COMPUTATIONAL METHODS IN MATHEMATICAL AND COMPUTER MODELING OF ELECTROMAGNETIC FIELD DISTRIBUTION BEHIND THE GRATE OF SCATTERERS

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## Abstract

The paper is devoted to the modeling of electromagnetic field distribution behind the grating of scatterers. The electromagnetic directivity diagram is simulated by hardware. The mathematical and technical design of electromagnetic field distribution in presence of one and a few scatterers, also as with regulations changes of the last ones is realized. The results can be used and allowed for antenna industries, radio station elements and other radio technical facilities manufacturing.

***Keywords:*** Mathematical modeling, electromagnetic field, grating of scatterers, Maxwell equations.

## 1. INTRODUCTION

### 1.1. PREAMBLE

The tasks of electromagnetic field scattering by particles are rather difficult to be solved practically or to be carried out in electrodynamics, radio physics and electromagnetic biology. However, some theory can be in use. In this case, such particles are explored that are spheres and their linear dimensions are much less than the fallen wave length. This allows to use the formulae for scattered field evaluations.

### 1.2. CONTENTS

The report includes:

- Algorithm description
- Models
- Modeling results

## 2. REPORT

### 2.1. ALGORITHM DESCRIPTION

Electromagnetic field using «Antenna toolbox» is formed by a dipole radiator. Frequency was chosen to be about 600 MHz. The radiator's surface is processed to equal surface elements and the distribution of surface currents are evaluated with «PDE toolbox».

The next stage after currents processing is electromagnetic radiated signal evaluation on the radiator surface in the explored space.

Electromagnetic field evaluation is accomplished using the dipole model. The method core means changing every surface element of the radiator for small dipole that has the same dipole moment. The field radiated by a small dipole, is an analytic form. The sought radiated field is evaluated then as a sum of fields formed by small dipoles.

### 2.2. MODELS

Using Green's function [1,2] the model can be expressed as Maxwell integral equations with border conditions on separating of two environments:

$$\begin{cases} \vec{E}(\vec{r}) = \vec{E}_0(\vec{r}) + \frac{1}{4\pi}\left(graddiv + k^2\right)\int\limits_V \left(\frac{\varepsilon}{\varepsilon_c} - 1\right)\vec{E}(\vec{r}\,')f\left(|\vec{r} - \vec{r}\,'|\right)d\vec{r}\,'; \\ \vec{H}(\vec{r}) = H_0(\vec{r}) + \frac{i\omega\varepsilon_c}{4\pi} rot \int\limits_V \left(\frac{\varepsilon}{\varepsilon_c} - 1\right)\vec{E}(\vec{r}\,')f\left(|\vec{r} - \vec{r}\,'|\right)d\vec{r}\,', \end{cases}$$

where $f\left(|\vec{r} - \vec{r}\,'|\right) = \frac{e^{-ik|\vec{r} - \vec{r}\,'|}}{|\vec{r} - \vec{r}\,'|}$, $\vec{E}_0(\vec{r})$ и $\vec{H}_0(\vec{r})$ (1)

are responsibly electric and magnetic fields which would be in $\vec{r}$ point in absence of the disseminator.

The scatterer is a sphere with radius r = 5 cm and dielectric permittivity $\varepsilon = 4.5$. For evaluation of field components [5] the formulae (2) and (3) are used:

$$\begin{aligned} \vec{E}^{(0)}(\vec{r}) &= \vec{E}_0^{(0)} + \frac{\tilde{A}}{4\pi\Delta}\left(\frac{\varepsilon}{\varepsilon_c} - 1\right)R\vec{E}_0^{(0)}; \\ \vec{H}^{(0)}(\vec{r}) &= \vec{H}_0^{(0)} + i\omega\varepsilon_c \frac{\tilde{A}}{4\pi\Delta}\left(\frac{\varepsilon}{\varepsilon_c} - 1\right)S\vec{E}_0^{(0)}, \end{aligned} \qquad (2)$$

where

$$\tilde{R} = \begin{Vmatrix} -\frac{4\pi}{3}+k^2W' & 0 & 0 \\ 0 & -\frac{4\pi}{3}+k^2W' & 0 \\ 0 & 0 & -\frac{4\pi}{3}+k^2W' \end{Vmatrix},$$

$$\tilde{S} = \begin{Vmatrix} 0 & \frac{4}{3}\pi z & -\frac{4}{3}\pi y \\ -\frac{4}{3}\pi z & 0 & \frac{4}{3}\pi x \\ \frac{4}{3}\pi y & -\frac{4}{3}\pi x & 0 \end{Vmatrix}, \qquad (3)$$

k is a wave number,

$\Delta$ is a system determinant and W' is Newton potential.

### 2.3. MODELING RESULTS

The illustration (fig.1) shows the electromagnetic field distribution behind the grate of scatterers when their permittivity is inconstant and increases across the OX axis. The mechanical movement of scatterers is rather difficult to be realized practically. The decision is the remote control of dielectric scatter permittivity. And the main electromagnetic ray is also controlled in an antenna.

The computer simulation is held successfully and gives possibilities for the further investigations such as 3D grating modeling. This could help to find out which material is the best for scatter production. Besides, the optimal number of these spheres should be obtained by solving the systems of linear equations mentioning the dipole moments.

The imitation model of this antenna can be further built where spheres' radiuses and dielectric permittivity would be accidental.

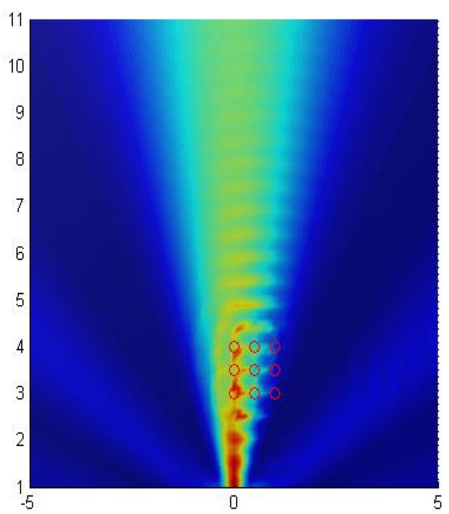


**Fig. 1.** Grating with inconstant permittivity of scatterers.

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