MOM Application for calculating the RCS Two-Dimensional Dielectric Geometric Shape (TE)

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ABSTRACT: RADAR Cross Section (RCS) is the magnitude that allows to quantify the reflective power of an object, or on the contrary its electromagnetic discretion. In this work, we intend to calculate the RCS of some two-dimensional structures in a homogeneous dielectric material. But first of all, we should begin by studying the theoretical basis of integral equations which allow to reach the calculation of this quantity, which is the RCS. We will describe the theoretical foundations on which the TEHD digital program is based and which we have developed to calculate the RCS of undefined cylindrical dielectrics upon which falls an incident TE wave ($E_z = 0$).

KEYWORDS: MoM method, RCS dielectrics, cylindrical, dielectric, shape (TE).

1 INTRODUCTION

RADAR and target to detect, at about one kilometer, are still much larger than the wavelengths involved, which are a few meters at the most. However, far from its source, the local structure of an electromagnetic wave is that of a plane wave. The electric fields $E$ and magnetic fields $H$ are contained on the orthogonal plane in the wave propagation direction[4].

The radar cross section (RCS), defined as a surface intercepting a quantity of power which will produce power density equal to that diffracted by a real object when radiated uniformly in all directions of space.

The diagram in Figure 1, illustrating what has been discussed above, is derived from a chart published by MI Skolnik representing the SER $\sigma / \sigma_0$ measured experimentally on the invader bombardment for a frequency of 3 GHz [5].

Fig. 1. Example of radar cross section diagram

2 CALCULATION OF THE RADAR CROSS SECTION (RCS) FOR TWO DIMENSIONAL PROBLEMS

Cause of the amplitude of the far field on two-dimensional problems, declines as $r^{-1/2}$ rather than $r^{-1}$ as the three-dimensional problems, the radar cross section is defined as for the wave TE incident.
We consider:

\[ E_z^{(l)}(x,y) = e^{-j\kappa|x\cos\phi + y\sin\phi|} \]  

(1)

and taking into consideration:

\[ E_z^{(l)}(x,y) = -j\kappa A_x \frac{\partial E_x}{\partial x} + \frac{\partial E_y}{\partial y} \]  

(2)

where:

\[ \int_{\partial A(x,y)} \int_{\partial A(x',y')} \frac{1}{4j} H_0^{(2)}(\kappa R)\,dx\,dy \]

(3)

\[ \vec{P} \tau \rightarrow \int_{\partial \Omega} \phi \, d\gamma \]  

(4)

with figure 2

\[ R = \sqrt{(x-x')^2 + (y-y')^2} \pm \sqrt{(x-x')^2 + (y-y')^2} \approx \sqrt{x' - \cos \phi + y' \sin \phi} \approx p - x' \cos \phi - y' \sin \phi \]  

(5)

takes into account the asymptotic behavior of the Hankel function:

\[ \lim_{\alpha \to \infty} H_2^{(2)}(\alpha) = \sqrt{\frac{\gamma}{\pi\alpha}} e^{-\alpha} \]  

(6)

**TM wave:**

\[ \sigma_{TM} = \frac{k}{4} \iint (\psi_x + \psi_y \cos \phi - \psi_y \sin \phi) e^{j\kappa(x\cos\phi + y\sin\phi)} \,dx\,dy \]  

(7)

By duality:

**TE wave:**

\[ \sigma_{TE} = \frac{k}{4} \iint (\psi_x - j\psi_y \sin \phi + j\psi_y \cos \phi) e^{j\kappa(x\cos\phi + y\sin\phi)} \,dx\,dy \]  

(8)

\[ \sigma_{TE} = \lim_{\rho \to \infty} \left[ \frac{\pi \rho^2 2\psi \psi'}{\rho^2 \psi'^2} \right] = \frac{1}{4} \sum_{n=-\infty}^{\infty} -\frac{1}{\kappa^{2n+1}} \frac{1}{\kappa^{2n+1}} \int_{\partial A} \int_{\partial A} (h_x \psi_x + h_y \psi_y) \int_{\partial A} \int_{\partial A} (h_x \psi_x + h_y \psi_y) \,d\alpha \,d\gamma \]  

(9)

where:

\[ i = \frac{\mu_l}{\epsilon_l} \quad e = \frac{\mu_e}{\epsilon_e} \]

\[ I_n \in \text{Bessel function of order } n \]

\[ H_2^{(2)}(k_x \alpha) \in \text{Hankel function of order } n, \text{ species } 2 \]

3 **RESULTS**

In order to verify the effectiveness of achieved codes, based on the method of moments (MoM), we presented in figure (3), the results of crosschecking, that is to say, the results obtained from our code and those obtained by the theoretical
formula of equation (9). We clearly notice the influence of discretization (number of cells in the structure) on the accuracy of the results.

Figure (4) shows the bistatic radar cross section (RCS) of a homogeneous dielectric cylinder without losses and undefined, concerning two values of the relative constant \(\varepsilon_r\): 4 and 10. Figure (5) refers to the same cylinder but with losses [\(\varepsilon_r = (4.3), (10.3)\)]. We note the importance of the RCS on the opposite side of the cylinder. All the results obtained for the circular cylinder, are compared to those theoretical at a resolution of 30 cells per wavelength unit (discretization). We note that there is a slight difference between theoretical results and MoM when the dielectric permittivity increases. Figure (6) shows the RCS of a homogeneous square dielectric cylinder on the side \(a = 0.2 \lambda\), for two values of the relative constant \(a\): \(\varepsilon_r\): 4 and 10.
CONCLUSION

This work has allowed us to learn about the numerical simulation of electromagnetic problems: study, in electrostatics, of charge density of a conductive plate, and the calculation of the RCS in the field of scattering of electromagnetic waves, homogeneous and indefinite dielectric cylinders. These simulations are done through the implementation of computer programs based on the numerical method called: method of moments (MoM).

REFERENCES